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USERS MANUAL: DONNER ALGORITHMS FOR RECONSTRUCTION TOMOGRAPHY

R.H. Huesman, G.T. Gullberg, W.L. Greenberg, and T.F. Budinger

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Donner Laboratory

Biology & Medicine Division

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RECLBL LIBRARY USERS MANUAL

Donner Algorithms for Reconstruction Tomography

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ACKNOWLEDGMENTS

The RECLBL Library evolved over the past 4 years from the first report giving Fortran listings of reconstruction methods for emission tomography (Budinger and Gullberg, LBL-2146). Drs. Judy Prewitt, William Pomerance, and others from the National Cancer Institute Advisory Committees provided continuing encouragement and support for the activities leading to the compilation of this manual. We are also indebted to students at the University of California, Berkeley, who, after using the RECLBL Library in course work, gave valuable criticisms for its organization.

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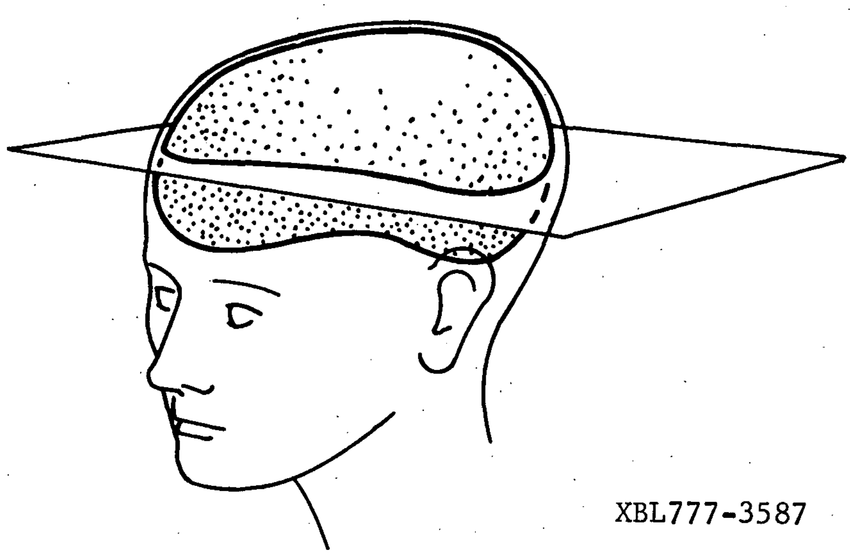
I. INTRODUCTION

1. The RECLBL Library Package

The RECLBL Library is a package of computational subroutines that apply to the reconstruction of transverse sections from projection data. The subroutines are written in the FORTRAN programming language (ANSI standard) and have been tested on CDC 6400, 6600, and 7600 computers and on a PDP 11/45 system. The package applies to three-dimensional reconstruction problems that arise in the medical and physical sciences. The package includes programs for medical applications that can be used both for the determination of tissue attenuation coefficients using x-ray transmission data and for the determination of radionuclide concentration using data from nuclear medicine detectors. This manual contains descriptive material that gives the physical and mathematical bases for the algorithms, examples of the use of the algorithms, and FORTRAN listings of the algorithms.

2. The Reconstruction Problem

The reconstruction problem consists of generating a two-dimensional picture from its projections. The reconstructed picture consists of a quantitative set of numbers specifying source density or attenuation coefficient on a two-dimensional grid. The picture represents a transverse section of an object such as a human head as shown in figure 1.



XBL777-3587

Figure 1. Concept of a transverse section.

The RECLBL Library applies to data that represent the projection of density along parallel or diverging sets of straight-line paths (rays) through an object. The algorithms transform one-dimensional projections from multiple angles around the object to a corresponding transverse section through the object. Three-dimensional information is obtained by stacking successive transverse sections.

3. Description of Library Contents

The reconstruction algorithms in the library are supplied as the following subroutines:

(1) BJECT - Simple back-projection.
(2) BKFIL - Back-projection of filtered projections (Fourier space).
(3) CONGR - Iterative least-squares minimization by the method of conjugate gradients.
(4) CONVO - Back-projection of convolved projections (configuration space).
(5) ENTPY - Iterative dual-space entropy maximization by the method of conjugate gradients.
(6) FILBK - Two-dimensional filtering of the simple back-projection (Fourier space).
(7) GVERS - Direct least-squares minimization using the generalized inverse.
(8) GRADY - Iterative least-squares minimization by the method of steepest descent.
(9) MARR - Direct least-squares minimization using orthogonal polynomials on the unit circle.

These reconstruction algorithms execute with the following geometry options:

(1) Parallel-beam geometry with weighting by the area of the pixel intersected by the ray.
(2) Parallel-beam geometry assuming that all the activity is in the center of the pixel.

(3) Parallel-beam geometry with weighting by the length of the line that traverses the pixel.
(4) Fan-beam geometry with weighting by the area of the pixel intersected by the diverging ray.
(5) Fan-beam geometry assuming that all the activity is in the center of the pixel.

The methods of compensating for attenuation use attenuation factors calculated by the subroutines:

(1) EVATN - Incorporation of attenuation from a user provided array of attenuation coefficients.
(2) EVATU - Incorporation of constant attenuation coefficient within a convex boundary.

An overview of the library is shown in figure 2. The figure gives the names of the essential library subroutines with which the user will need to be familiar.

Several reconstruction algorithms that this library does not contain (e.g., ART, the Algebraic Reconstruction Technique and SIRT, the Simultaneous Iterative Reconstruction Technique) may be found in G. T. Herman and S. W. Rowland, SNARK77: A Programming System for the Reconstruction of Pictures from Projections, State University of New York at Buffalo, Department of Computer Science, Technical Report No. 130 (1977).

4. Distribution of Documentation and Programs

Subscribers to the RECLBL Library will receive the Users Manual and the library source material, which is distributed on magnetic tape. The magnetic tape can be either 7 or 9 track, depending on the user's hardware requirements. A charge of $20.00 will be made for each magnetic tape provided to cover the cost of the tape and mailing. The user will receive library revisions and additions after they have been tested and implemented.

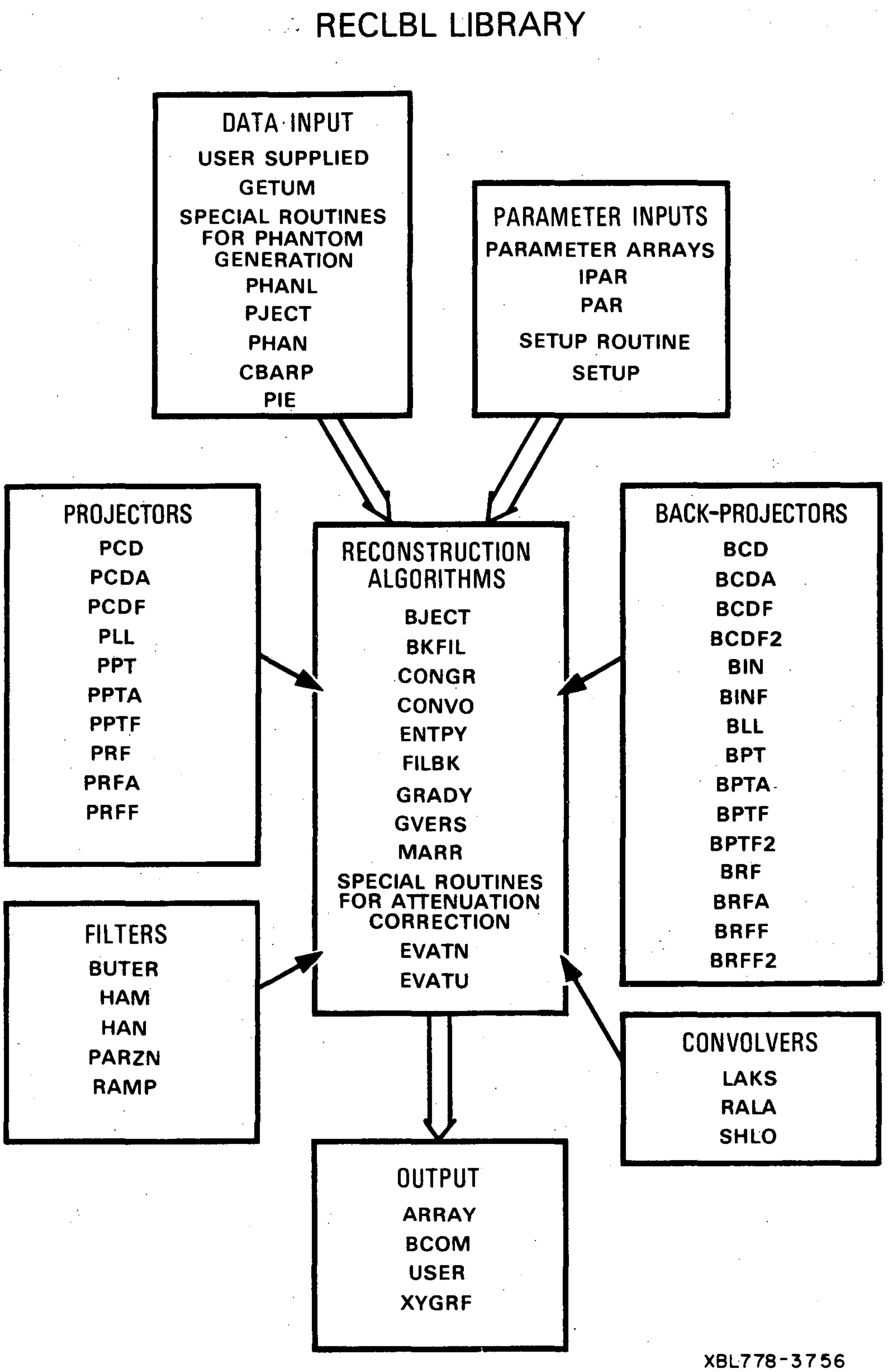


Figure 2. The RECLBL Library has 9 user called reconstruction subroutines. Projectors, back-projectors, convolvers and filters are passed to the reconstruction algorithms as external subroutines. The data are input using the subroutine GETUM, and the parameter arrays IPAR and PAR are input using the subroutine SETUP. The reconstructions may be displayed using special output subroutines.

The last page of this manual contains an order blank for a magnetic tape containing the source material of the RECLBL Library. The contents and format of the magnetic tape are given in section II.5.

Corrections or comments on the RECLBL Library or this manual should be sent to:

Research Medicine Group
Donner Laboratory
Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720
Attention: RECLBL Library

II. LIBRARY CHARACTERISTICS

1. Philosophy

The RECLBL Library is a collection of subroutines. The user is expected to have a working knowledge of the FORTRAN computer language. He must write a main program that calls various subroutines of the RECLBL Library. These include setup, data input, and display routines, as well as the major routines that execute the reconstruction algorithms.

The user must also be familiar with the names of another class of library subroutines that are used as external parameters of major reconstruction algorithms. These routines specify the type of weighting factor and the convolution or filter function to be used. All of the subroutine names that the user might need to use are shown in figure 2.

The structure of the RECLBL Library provides the user with a great deal of flexibility while requiring a minimum knowledge of computer programming.

2. Operating Environment

The programs have been designed to accommodate both small and large computer implementation. The RECLBL Library has been written and tested on CDC 6400, 6600, and 7600 computers. Parts of the library have been put into operation on PDP 11/45 and HP2100 systems. Because the HP2100 does not allow labeled common, this package must be modified for full implementation on that system.

The library has been designed to be used in an operating system that has the ability to load into memory only those routines that are necessary to execute the user's code. Because of the structure of the RECLBL Library, a minimum amount of computer memory is required.

3. Coding Conventions

The subroutines of the RECLBL Library were coded in the FORTRAN computer language using the guidelines of:

American National Standard FORTRAN
American National Standards X3.9-1966
United States of America Standards Institute
New York, 1966

Clarification of American National Standards X3.9-1966 was prepared by a Subcommittee of the American Standards Committee X3, Computers and Information Processing, and published in the Communications of the Association for Computing Machinery:

Clarification of Fortran Standards--Initial Progress, Comm. ACM, Vol. 12, No. 5, May 1969, pp. 289-294.
Clarification of Fortran Standards--Second Report, Comm. ACM, Vol. 14, No. 10, October 1971, pp. 628-642.

4. User Coding Restrictions

Within the RECLBL Library there are various common blocks and subroutines, with which the user need not be familiar, but whose names are a possible source of conflict with user-created common blocks and subroutines. In order that the library as a whole operate correctly, the user must not use the common block and subroutine names listed in table 1. Note that blank common (//) is one of the common blocks used by the library.

5. Magnetic Tape Structure

The following describes the file structure of the magnetic tapes containing the source code of the RECLBL Library routines. The first file of the tape is a label and contains information such as the version number, the date of the last revision, etc. The subsequent 80 files

Table 1. Common block and subroutine names used by the RECLBL Library.

	Common Blocks		
//	/FANCOM/	/OUTCOM/	/STRCOM/
/ATNCOM/	/FILCOM/	/PHNCOM/	/TRGCOM/
/CNVCOM/	/GNVCOM/	/PRTCOM/	/WRKCOM/
/DATCOM/	/ITRCOM/	/PTRCOM/	
/ENTCOM/	/MARCOM/	/RAYCOM/	
	Subroutines		
ARRAY	BUTER	GRADY	PPTF
ATENF	CBARP	GVERS	PRF
BCD	CISQ	HAM	PRFA
BCDA	CONGR	HAN	PRFF
BCDF	CONVO	IOCTL	RADAL
BCDF2	DOT	LAKS	RALA
BCOM	DULFC	LGTXT	RAMP
BIN	EMESG	MARR	RAYST
BINF	ENTPY	MEMST	RCHEK
BJECT	EVATN	PARZN	SETIT
BKFIL	EVATU	PCD	SETUP
BLL	FFTC	PCDA	SHLO
BPT	FFTR	PCDF	SQINT
BPTA	FFTR2	PHAN	SRCH
BPTF	FILBK	PHANL	STATN
BPTF2	FMCG	PIE	STPTR
BRF	FTATN	PJECT	XYGRF
BRFA	GETDE	PLL	ZERO
BRFF	GETDM	PPT	
BRFF2	GINV	PPTA	

(2-81) contain the routines that make up the library (cf. section X.2). The last 18 files (82-99) contain examples (cf. section IX). Two file marks follow the last example. The format of the tape depends on whether the tape is 7 or 9 track. Each record of each file on the magnetic tape contains an 80-character card image. Each character is represented by either 6 or 8 bits, depending on whether the tape is 7 or 9 tracks, respectively.

The 7-track magnetic tapes are written in EXTERNAL BCD format with 80 characters per record. This is an industry standard, even parity format. The 6-bit octal EXTERNAL BCD code for the standard FORTRAN character set is shown in table 2.

The 9-track magnetic tapes are written in either ASCII or EBCDIC format. These are both industry standard, odd parity formats. The 7-bit octal ASCII code and the 8-bit octal EBCDIC code for the standard FORTRAN character set are shown in table 2. Because of tape writing restrictions at the Lawrence Berkeley Laboratory Computer Center, the 9-track magnetic tapes contain 90 characters per record. The first 80 characters contain the 80-character card image, and the last 10 characters contain blank fill.

Table 2. EXTERNAL BCD, ASCII and EBCDIC octal codes for the standard FORTRAN character set.

Standard FORTRAN Character	6-Bit EXTERNAL BCD Octal Code	7-Bit ASCII Octal Code	8-Bit EBCDIC Octal Code
A	61	101	301
B	62	102	302
C	63	103	303
D	64	104	304
E	65	105	305
F	66	106	306
G	67	107	307
H	70	110	310
I	71	111	311
J	41	112	321
K	42	113	322
L	43	114	323
M	44	115	324
N	45	116	325
O	46	117	326
P	47	120	327
Q	50	121	330
R	51	122	331
S	22	123	342
T	23	124	343
U	24	125	344
V	25	126	345
W	26	127	346
X	27	130	347
Y	30	131	350
Z	31	132	351
0	12	060	360
1	01	061	361
2	02	062	362
3	03	063	363
4	04	064	364
5	05	065	365
6	06	066	366
7	07	067	367
8	10	070	370
9	11	071	371
+	60	053	116
-	40	055	140
*	54	052	134
/	21	057	141
(	34	050	115
)	74	051	135
$	53	044	133
=	13	075	176
blank	20	040	100
,	33	054	153
.	73	056	113

III. USER PROGRAM STRUCTURE

1. General Description

Since the RECLBL Library is a collection of subroutines, the user must provide a program that performs such functions as: set parameters that define the geometry as well as determine control operations within the library subroutines, call reconstruction subroutines of the library, call display routines of the library, and save results if desired. In addition, the user must provide a subroutine GETUM for data input. A skeleton program that outlines the recommended structure of a main program and a data input routine (GETUM) is shown in figure 3.

The variables LUNOUT and I80132 of COMMON/OUTCOM/ must be set by the user prior to the execution of any of the library subroutines.

LUNOUT is the logical unit number of the print file. The library communicates with the user via this file.

I80132 is a flag indicating whether to print 80 or 132 characters per line on LUNOUT. I80132=0 indicates 80 characters per line, otherwise the library prints 132 characters per line.

Before any of the reconstruction algorithms are called, the user must call the subroutine SETUP. The arguments of SETUP include control options that describe the geometry as well as some computer operation parameters. Subroutine SETUP is called as follows:

```
CALL  SETUP (IPAR,PAR,ANG)
```

Parameters of the IPAR and PAR arrays are described in sections III.2 and III.3 below. Throughout this manual they will be referred to by the variable names given in the EQUIVALENCE statement of figure 3. ANG is an array of projection angles and is needed only when MODANG=IPAR(4) is equal to zero or one.

Description	Code
Program card (machine/compiler dependent)	`PROGRAM MAIN (                )`
Reconstruction array and uncertainties	`DIMENSION X("NDIMU","NDIMU"),E("NDIMU,"NDIMU")`
Array of projection angles	`DIMENSION ANG("NANG")`
Working space in blank common (see section III.3)	`COMMON WORK(2000)`
Output file and flag for number of characters per line (see section III.1)	`COMMON/OUTCOM/LUNOUT,I80132`
Integer and real parameter arrays (see sections III.2 and III.3)	`DIMENSION IPAR(12),PAR(3)`

```
 EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)),
1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)),
2            (IMIT  ,IPAR( 7)),(NWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)),
3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)),
4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3))
```

Description	Code
Back-projection and convolution subroutines that are passed as externals (see section V.2)	`EXTERNAL BCK,CNV`
Output file (see section III.1)	`LUNOUT= ....`
Output line length flag (see section III.1) . . .	`I80132= ....`

Input parameters (see sections III.2 and III.3).

```
NDIMU= ....
ICIR= ....
IGEOM= ....
NANG= ....
MODANG= ....
KDIMU= ....
IMIT= ....
NWORK= ....
NFLOAT= ....
ISTORE= ....
IPRINT= ....
LUNATN= ....
PWID= ....
AXISU= ....
RFAN= ....
CALL SETUP(IPAR,PAR,ANG)
```

Description	Code
Reconstructs the array X using the convolution algorithm (see section V for a description of all the reconstruction algorithms	`CALL CONVO(X,E,CNV,BCK,1)`
Displays the reconstructed array X (see section IV.3)	`CALL ARRAY(X,NDIMU)`
	`END`
Data input routine (see section III.4)	`SUBROUTINE GETUM(M,DATA,ERR)`
M is the angle index, DATA is the projection data array, and ERR is an array of projection errors.	

```
DIMENSION DATA(1),ERR(1)
(Here is where data and errors for the Mth projection are supplied by
the user; see section III.4 and examples in section IX.)
RETURN
END
```

Figure 3. Skeleton program to show recommended user program structure.

A description of the input data format for the user provided subroutine GETUM (cf. figure 3) is given in section III.4.

2. Geometry Parameters

Of the 15 parameters of the IPAR and PAR arrays, 10 describe aspects of the geometry to be used in the reconstruction. In conjunction with the definitions given below the reader is referred to figures 4-7.

NDIMU is the linear dimension of the reconstruction array, i.e., a reconstruction algorithm will return an array of NDIMU x NDIMU values that represent reconstructed intensities on an NDIMU x NDIMU grid.

ICIR is a flag indicating whether the reconstructed intensities are to be calculated for the entire NDIMU x NDIMU square grid or only for points lying within a circle inscribed in the square. A 25% reduction in computer time can be expected for certain algorithms if only the inscribed circle is used. To reconstruct on a circle, set ICIR=0; otherwise the entire square will be reconstructed.

IGEOM is a flag indicating the type of geometry to be used in the reconstruction. IGEOM=0, 1, 2, 3 indicates parallel-beam, fan-beam (curved detector), fan-beam (flat detector), and ring geometry, respectively. These types of geometry are shown in figures 4-7.

NANG is the number of projection angles to be used for the reconstruction in parallel-beam or fan-beam geometries (IGEOM=0, 1, 2). For the ring geometry (IGEOM=3), NANG is the number of detectors around the circle (an even number). Therefore, the exact meaning of NANG depends on IGEOM.

MODANG is a mode flag for the input of projection angle values. For MODANG=0 or MODANG=1, the user supplies projection angles in the array ANG in degrees or radians, respectively. For MODANG=2 or MODANG=4, SETUP generates NANG projection angles equally spaced between 0 and π starting with 0.5 π/NANG or 0, respectively. For MODANG=3 or MODANG=5, SETUP generates NANG projection angles equally spaced between 0 and

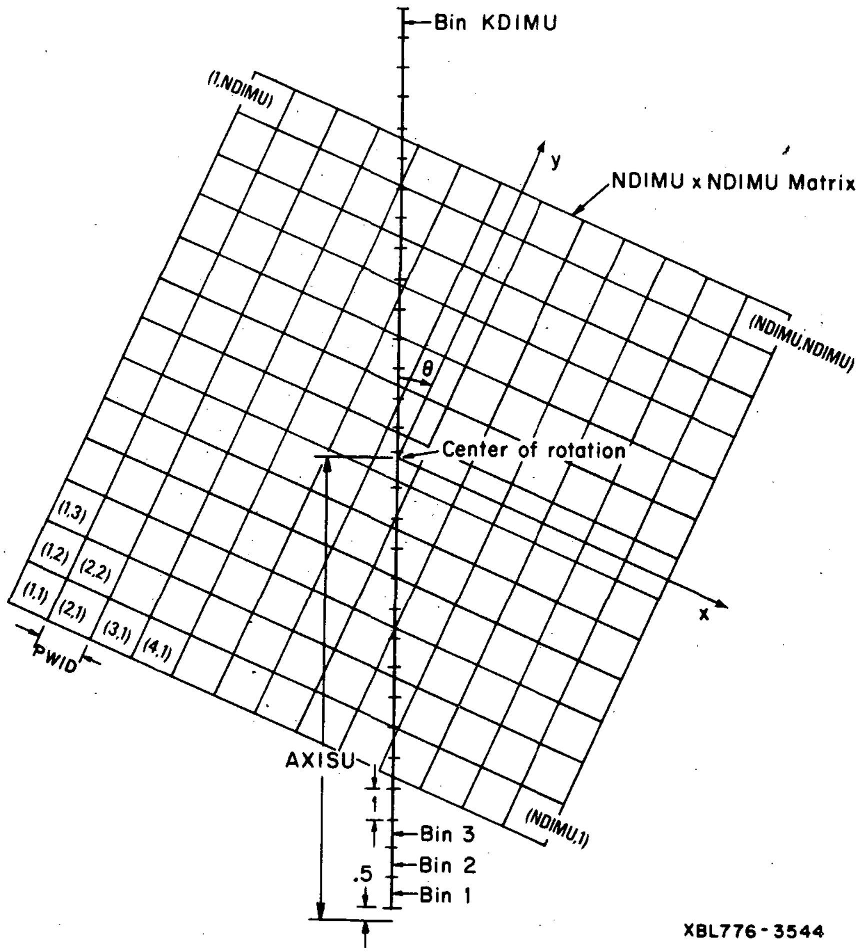


Figure 4. Parallel-beam geometry for data collected at projection angle θ. NDIMU may be either even or odd and the center of rotation is at the exact center of the NDIMU x NDIMU reconstruction array. The indices of the array are denoted by (I,J), each representing a pixel with linear dimension PWID, where projection bins are defined to have unit width. AXISU is 0.5 greater than the distance from the center of rotation to the lower bin edge of the first of KDIMU projection bins.

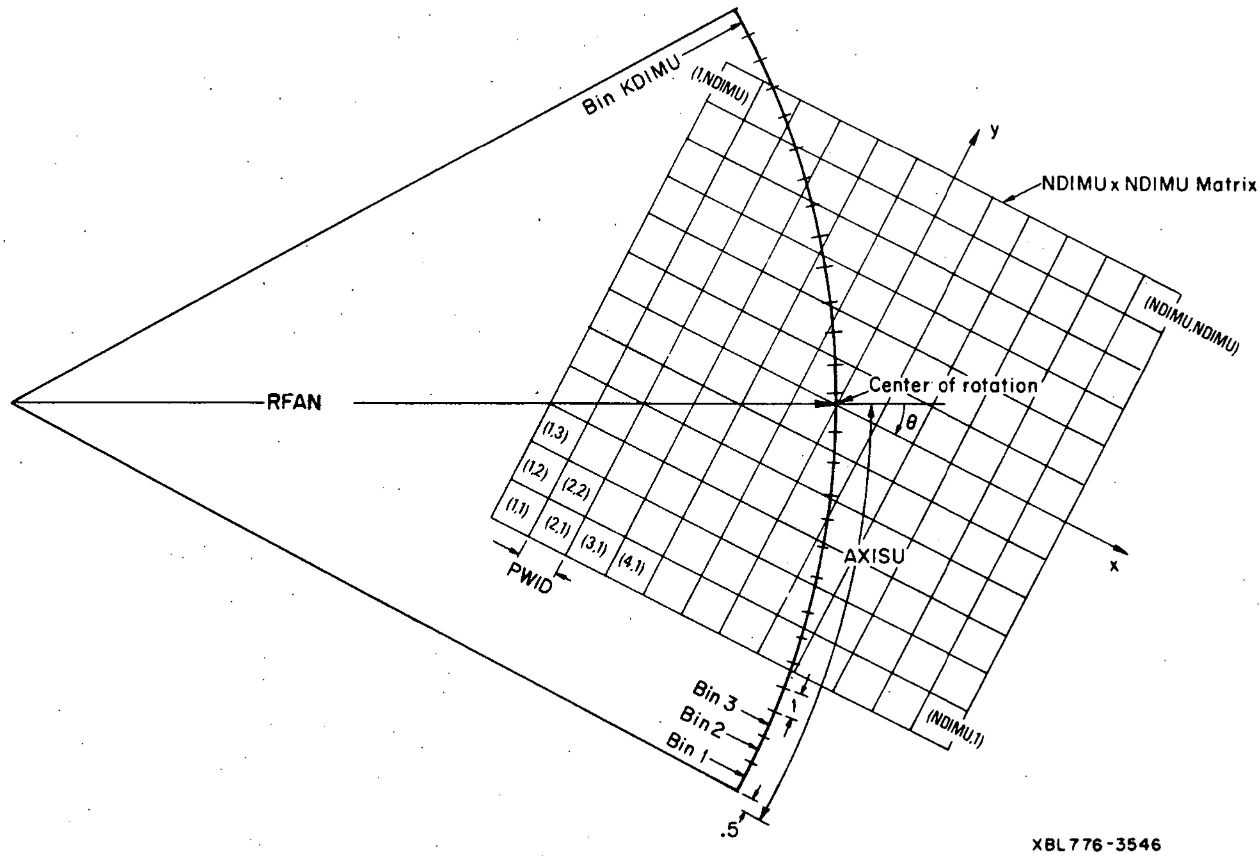


Figure 5. Fan-beam geometry for data collected at projection angle θ using a curved detector. NDIMU may be either even or odd and the center of rotation is at the exact center of the NDIMU x NDIMU reconstruction array. The indices of the array are denoted by (I,J), each representing a pixel with linear dimension PWID. The diverging projection bins are defined to have unit width measured at the center of rotation, a distance RFAN from the vertex of the fan. AXISU is 0.5 greater than the distance from the center of rotation to the lower bin edge of the first of KDIMU projection bins.

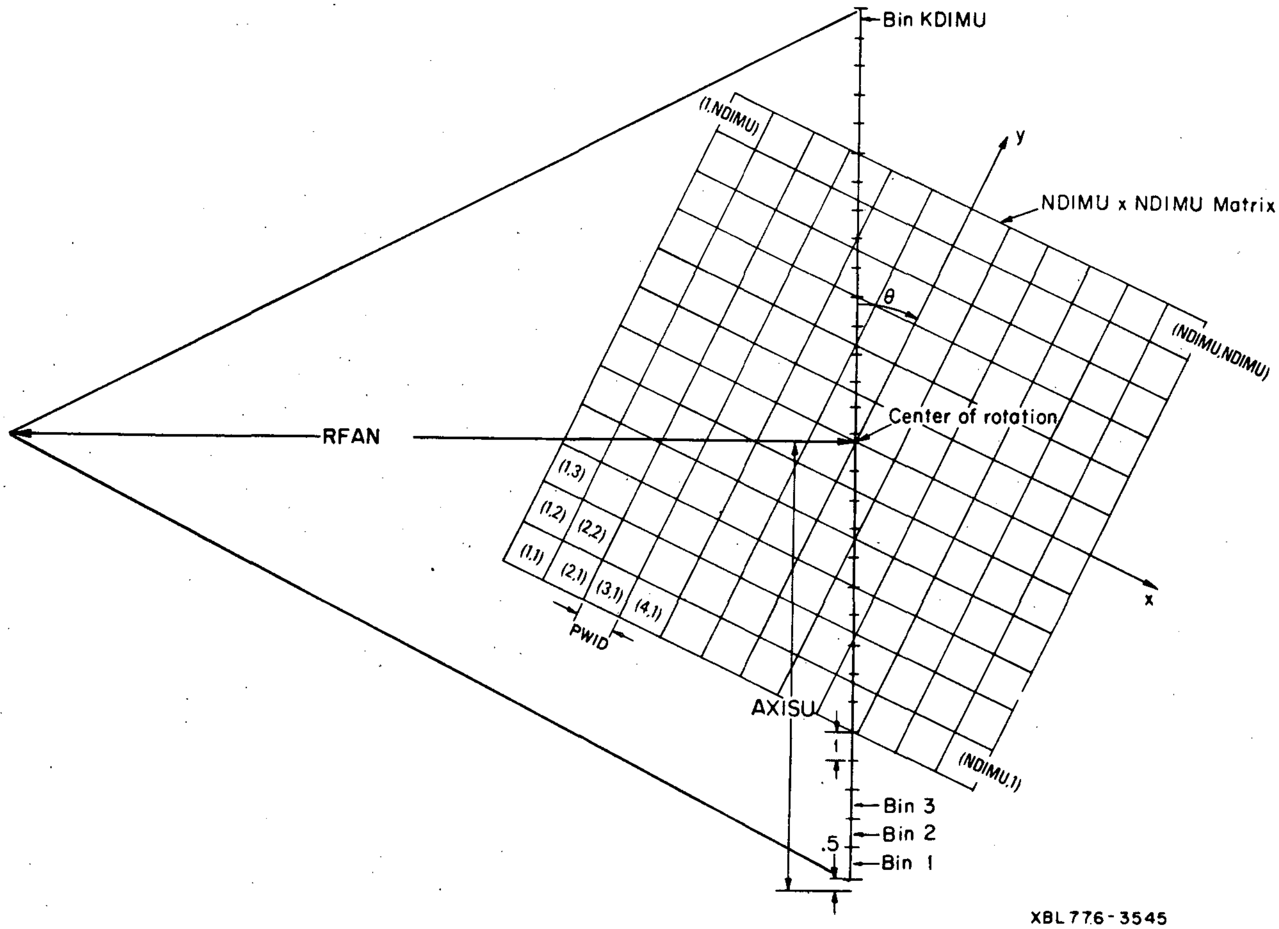


Figure 6. Fan-beam geometry for data collected at projection angle θ using a flat detector. NDIMU may be either even or odd and the center of rotation is at the exact center of the NDIMU x NDIMU reconstruction array. The indices of the array are denoted by (I,J), each representing a pixel with linear dimension PWID. The diverging projection bins are defined to have unit width measured at the center of rotation, a distance RFAN from the vertex of the fan. AXISU is 0.5 greater than the distance from the center of rotation to the lower bin edge of the first of KDIMU projection bins.

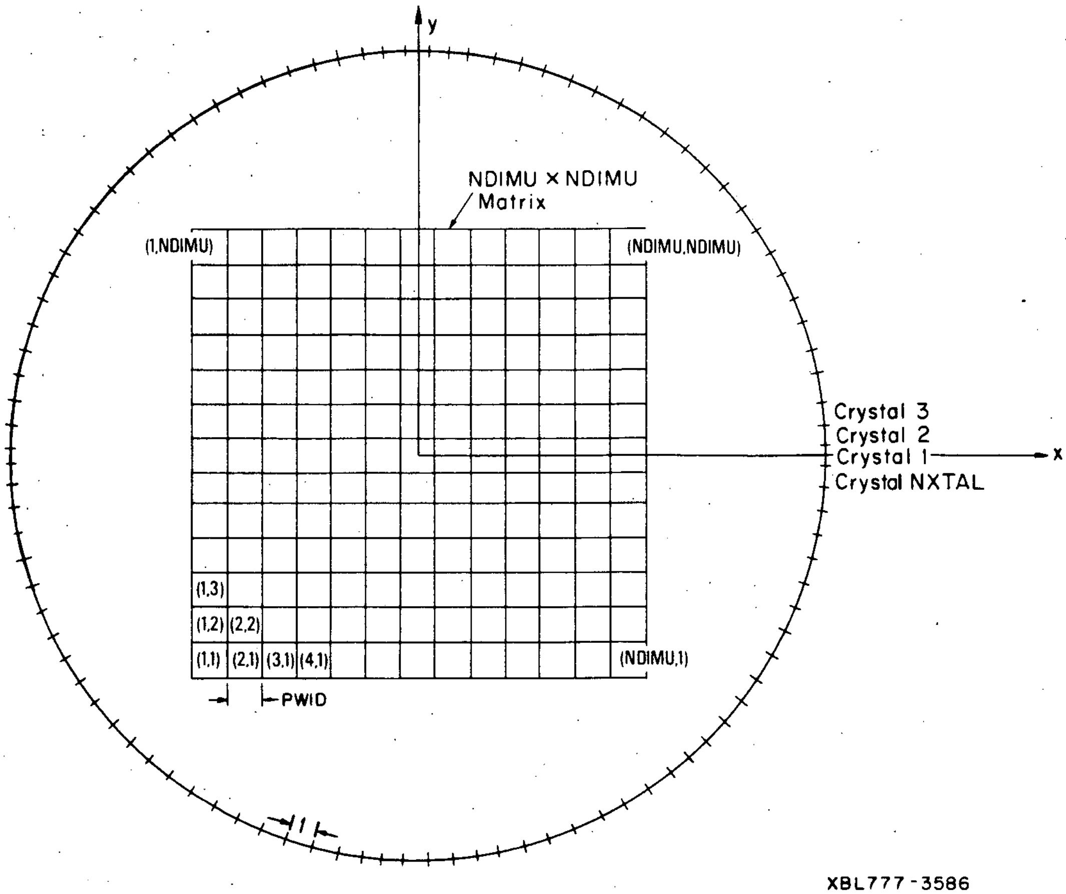


Figure 7. Geometry for data collected using a ring of NXTAL=NANG detectors. NDIMU may be either even or odd and the center of the ring is at the exact center of the NDIMU x NDIMU reconstruction array. The indices of the array are denoted by (I,J), each represing a pixel with linear dimension PWID, where the center-to-center distance between adjacent detectors is defined to be unity.

2π starting with π/NANG or 0, respectively. For MODANG between -2 and -5, SETUP generates the same angles as for MODANG between 2 and 5, respectively, but in reverse order.

KDIMU is the dimension of the user's projection array for all geometries except ring geometry (IGEOM=3). The user is expected to input a projection data array of length KDIMU for each projection angle using his own subroutine GETUM. Subroutine GETUM is described in section III.4 below.

IMIT is a flag indicating whether the reconstruction is of emission or transmission data. For emission data the reconstructed intensities will be in terms of events per pixel, i.e., for unattenuated data the sum of all reconstructed intensities should equal the sum of the projected data (for all angles). For transmission data the reconstructed intensities will be attenuation coefficients in units of inverse pixel width. To reconstruct emission data, set IMIT=0; if IMIT≠0 the library assumes transmission data.

PWID is the distance between neighboring reconstruction grid points relative to the projection bin width. Projection bin width for fan-beam geometries is described in the definition of RFAN below. Projection bin width for the ring geometry (IGEOM=3) is defined as the distance between the NANG equally spaced points on the circle.

AXISU is the location within the projection array (of length KDIMU) where the rotation axis is projected. The rotation axis is defined to be in the exact center of the NDIMU x NDIMU reconstruction grid. AXISU is assumed to be the same for every projection angle but need not be integer valued. AXISU will be an integer equal to the number of the projection bin into which the rotation axis projects if it projects into the exact center of a bin.

RFAN is the distance between the rotation axis and the origin of the fan for fan-beam geometries (IGEOM=1,2). RFAN is measured in terms of projection bin width, which is the distance between neighboring projection bins as they cross the rotation axis.

3. Computer Operation Parameters

The remaining five parameters of the IPAR array relate to the internal operations of the RECLBL subroutine package.

NWORK is the number of floating point words that have been set aside by the user in blank common (//). It must be set by the user to the dimension of WORK, the array in blank common. This space will be used as a working area by the library, and is not available to the user. See also the description of ISTORE below.

NFLOAT is the number of computer words required for the storage of a single floating point variable. (It is assumed that integer variables require one memory location.) NFLOAT is needed for the management of the working area in blank common.

ISTORE is a flag indicating whether to actually execute library code or to only estimate the size of blank common needed in order to accomplish the reconstruction. The amount of blank common needed is printed on the logical unit given by LUNOUT. To perform a reconstruction set ISTORE=0, otherwise only a storage size test is performed. In case the user has set NWORK too small, reconstruction will halt and from that point on only a storage size test will continue.

IPRINT is a flag that indicates the various print options for output onto the logical unit given by LUNOUT. The six low-order bits of IPRINT determine the following options:

- bit 0 - Print the number of floating point variables in blank common whenever changed.
- bit 1 - Print the projection data and uncertainties.
- bit 2 - Print the IPAR and PAR arrays when SETUP is called.
- bit 3 - Print the filter function for the convolution and filter routines.
- bit 4 - Print the values of the Lagrange multipliers and gradient of the function that is optimized in the maximum entropy reconstruction.
- bit 5 - Print pointers in blank common whenever changed (debug).

LUNATN is the logical unit number of a scratch file that is required when compensating for attenuation.

4. Data Input

Projection data (and possibly their uncertainties) must be supplied to the RECLBL Library subroutines by the user-coded subroutine GETUM. The arguments to this subroutine are:

```
SUBROUTINE GETUM (M,DATA,ERR)
```

where DATA is an array of projection data to be returned by the user, and ERR is an array of uncertainities of the respective values returned in DATA. The uncertainties, ERR, need only be supplied if the user desires to take account of uncertainties when using the algorithms CONGR, GRADY, or GVERS; or if the user desires that the resulting uncertainties of the reconstruction be calculated when using the algorithms CONVO or GVERS.

For parallel- or fan-beam geometries (IGEOM=0,1,2) M is the angle index number for which GETUM is to return projection data. KDIMU values are to be returned in the DATA array corresponding to the KDIMU projection bins for the M^{th} angle as shown in figures 4-6.

For ring geometry (IGEOM=3) there are NANG(NANG-1)/2 possible pairs of detectors and hence NANG(NANG-1)/2 different projection data values. M is an index that indicates the detector separation for the set of data values GETUM must supply. M will vary from 1 to NANG/2, and GETUM must supply NANG values in the DATA array for M between 1 and NANG/2-1. For M=NANG/2, GETUM need only supply NANG/2 values since for this case, the detectors are diametrically opposed. If K is an index that indicates the order in which the NANG (or NANG/2) values are to be returned in the DATA array, the projection data are from between the K^{th} and $(K+M)^{th}$ detectors.

IV. PROJECTION AND BACK-PROJECTION ROUTINES

1. Models of Intensity Distribution

In order to perform the reconstruction of a transverse section from its projections on a digital computer, it is necessary to characterize the two-dimensional intensity distribution by a finite number of parameters. In the RECLBL Library the transverse section is divided into $NDIMU^2$ small square areas (pixels), and the reconstruction results in an array of intensity values (one for each pixel). These values may represent either the intensity at the center of the pixel or the total (or average) intensity within the pixel.

The reconstruction algorithms of the RECLBL Library may be divided into two categories: those for which there is an implied distribution of intensity within each pixel, and those which are analytic by nature and require no such assumption. In the first category are the iterative methods (CONGR, GRADY), the maximum entropy method (ENTPY), and the generalized inverse method (GVERS). In all of these the reconstructed intensities are chosen such that when projected they are, in some sense, close to the user-supplied projection data. In order to perform this projection, the model of intensity distribution (distribution within each pixel) is required.

A natural choice for the model is that intensity within each pixel is uniformly distributed. This is the most realistic model in the library. The projection of one such pixel has a trapezoidal shape for all angles except multiples of $\pi/4$. Degenerate cases exist at multiples of $\pi/2$ (square shape) and odd multiples of $\pi/4$ (triangular shape).

A good approximation to the uniform square model is what has been termed the concave disk model. For this model the projection of a single pixel has a square shape independent of angle. This is a particularly good approximation when the pixel size is the same as the projection bin size (PWID=1). The third model of intensity distribution assumes that all intensity within a pixel is concentrated at its center, and is called the delta function model.

2. Relationship of Models and Geometry

Within the RECLBL Library the projection of a two-dimensional intensity distribution may be over infinitesimally narrow paths (line integrals) or over finite width paths (ray sums) where a single projection bin extends in width to both of its neighbors (without overlap). This section describes the relationship between the models of section IV.1 and the various geometry options of section III.2. Note that the projection operation is required only for the model-dependent algorithms: CONGR, GRADY, ENTPY, and GVERS.

Projection routines are intended to mimic the data-taking process under the assumptions of the model of intensity distribution within each pixel (excluding statistical fluctuations). In the RECLBL Library, projections may be performed using any of the four geometry options, which are described in section III.2 and illustrated in figures 4-7.

For the model of uniform intensity within each pixel, the projections may be performed either as line integrals or as ray sums. For parallel-beam geometry (IGEOM=0) the corresponding routines are PLL (line length) and PRF (ray factors), respectively. For fan-beam geometries (IGEOM=1,2) only ray sum projection exists at this time, and the routine is PRFF (ray factors, fan).

For the concave disk model and the delta function model only ray sum projection routines are necessary. For parallel-beam geometry the corresponding routines are PCD (concave disk) and PPT (point), respectively. For fan-beam geometries they are PCDF (concave disk, fan) and PPTF (point, fan).

The model-dependent algorithms must also perform a back-projection, that is, the adjoint or transpose of the projection operation. Thus the library contains the seven back-projection routines corresponding to the projection routines described above. In the names of these routines the first letter (P) has been replaced with the letter B: BLL, BRF, BRFF, BCD, BPT, BCDF and BPTF.

3. Incorporation of Attenuation

For x-ray imaging the transmitted beam intensity $I(\xi,\theta)$ is equal to

$$I(\xi,\theta) = I_0(\xi,\theta)\ \exp[-\iint \mu(x,y)\ K(\xi,\theta,x,y)\ dxdy] \quad , \tag{3.1}$$

where $\mu(x,y)$ is the distribution of attenuation coefficients, I_0 is the incident-beam intensity, and $K(\xi,\theta,x,y)$ is a function whose distribution corresponds to either parallel-beam, fan-beam, or ring geometry. The projection $p(\xi,\theta)$ is thus equal to

$$p(\xi,\theta) = -\log[I(\xi,\theta)/I_0(\xi,\theta)] = \iint \mu(x,y)\ K(\xi,\theta,x,y)\ dxdy \quad . \tag{3.2}$$

This equation does not represent the line integrals measured in emission tomography.

The projection $p_{\gamma\gamma}(\xi,\theta)$ for positron annihilation coincidence imaging is defined by the integral equation

$$p_{\gamma\gamma}(\xi,\theta) = \exp[-\iint \mu(x,y)\ K(\xi,\theta,x,y)\ dxdy] \cdot \iint \rho(x,y)\ K(\xi,\theta,x,y)\ dxdy \quad , \tag{3.3}$$

where $\rho(x,y)$ is the concentration of positron emitter. Therefore, the projection is the line integral of the positron concentration distribution multiplied by an exponential attenuation factor determined from the line integral of attenuation coefficients over the total ray path. The projection data that should be supplied to a RECLBL reconstruction algorithm are given by

$$p(\xi,\theta) = \exp[\iint \mu(x,y)\ K(\xi,\theta,x,y)\ dxdy]\ p_{\gamma\gamma}(\xi,\theta) = \iint \rho(x,y)\ K(\xi,\theta,x,y)\ dxdy \quad . \tag{3.4}$$

Thus, the user must modify the observed data $p_{\gamma\gamma}(\xi,\theta)$ by the appropriate attenuation factor.

The projection $p_{\gamma}(\xi,\theta)$ for single photon imaging in emission tomography is defined by the integral equation

$$p_{\gamma}(\xi,\theta) = \iint \rho(x,y) \exp - \left[\iint_{xy}^{\text{detector}} \mu(x',y') \, K(\xi,\theta,x',y') \, dx'dy' \right] K(\xi,\theta,x,y) \, dxdy \quad . \tag{3.5}$$

Note the difference between equations (3.4) and (3.5). A single photon projection is the summation of isotope concentration at points (x,y) modified by an exponential e^{-Z} where Z is the line integral of attenuation coefficients from the point (x,y) to the detector. Thus, the attenuation compensation needed for single photon emission computed tomography is not a simple multiplicative correction of the observed projection data as in the case of positron emission tomography.

The attenuation problem for single photon imaging is handled in a straight-forward manner in the model dependent algorithms (CONGR, GRADY, and GVERS). Using prior information of the attenuation coefficient distribution, equation (3.5) is implemented for the various models by the projection routines PRFA (ray factors, attenuated), PCDA (concave disk, attenuated) and PPTA (point, attenuated). Note that only parallel-beam geometry with ray sum routines have been implemented. The corresponding back-projection routines are BRFA, BCDA, and BPTA, respectively. For these reconstruction algorithms, the uncorrected projections of equation (3.5) should be supplied. When compensating for attenuation, one of the subroutines EVATN or EVATU must be called before these algorithms are executed (cf. section V.7).

For the model-independent algorithms (CONVO, BKFIL, FILBK, and MARR) the data must be preprocessed to take account of the attenuation problem. This problem is discussed in: T. F. Budinger and G. T. Gullberg in Reconstruction Tomography in Diagnostic Radiology and Nuclear Medicine, M. M. Ter-Pogossian, et al., eds., University Park Press, Baltimore, 1977, pp. 315-342.

4. Special Back-Projection Routines

Special back-projection routines can be used with the model-independent algorithms CONVO, BKFIL, and FILBK. The back-projection need not be the adjoint or transpose of a projection operation, but must be the digital approximation of an angular integral that is needed by these algorithms.

For parallel-beam geometry, the routine BIN (interpolation) is used to reconstruct the values of the intensity distribution at the centers of the pixels. Contributions to the back-projection image are calculated by linear interpolation between the appropriate projection bins. BIN can be used with each of the algorithms CONVO, BKFIL, and FILBK. The routines BRF, BCD, and BPT described above can also be used with these algorithms but give the average value of the intensity distribution within each pixel. BIN allows the calculation of one standard deviation statistical errors of the reconstructed intensity values when used with CONVO.

For fan-beam geometry, the routine BINF (interpolation, fan) is used with CONVO to reconstruct intensity values at the centers of the pixels. Like BIN it allows calculation of errors of the reconstructed values. In addition to the type of interpolation performed by BIN, the routine BINF applies weighting according to the relative positions of the image point (pixel center) and the origin of the fan. For a curved detector (cf. figure 5) the weighting factor is given by

$$\frac{(RFAN)^2}{[RFAN + r\cos(\phi - \theta)]^2 + [r\sin(\phi - \theta)]^2} \tag{4.1}$$

and for a flat detector (cf. figure 6) the weighting factor is given by

$$\frac{(RFAN)^2}{[RFAN + r\cos(\phi - \theta)]^2} \tag{4.2}$$

RFAN and θ are defined in figures 5 and 6 for equations (4.1) and (4.2), respectively, and (r,ϕ) are the polar coordinates of the image point. The denominators of equations (4.1) and (4.2) are the squares of the distance and the projected distance from the image point to the origin of the fan, respectively.

For FILBK, one of the back-projection routines BRFF2 (ray factors, fan), BCDF2 (concave disk, fan) or BPTF2 (point, fan) must be used for fan-beam geometry. Back-projection using these routines results in a convolution of 1/r with the source. (Deconvolution follows the back-projection.) A discussion of the function of BRFF2, BCDF2 and BPTF2 can be found in section V.3.

V. LIBRARY RECONSTRUCTION ALGORITHMS

1. Iterative Algorithms

a. The Function to be Minimized

Iterative methods within the RECLBL Library minimize the function

$$\chi^2(X) = \sum_{km} \Big(\sum_{ij} F_{ij}^{km} X_{ij} - p_{km} \Big)^2 / \sigma_{km}^2 \quad , \tag{1.1}$$

where p_{km} is the measured projection at the m^{th} angle and bin k; σ_{km} is the uncertainty with which p_{km} was measured; X_{ij} is the intensity in pixel (i,j) to be reconstructed; and F_{ij}^{km} is the fraction of X_{ij} that projects into p_{km}. F_{ij}^{km} depends on the model of intensity distribution within each pixel and whether attenuation compensation is involved (cf. section IV).

In order to simplify the notation in this section, equation (1.1) can be rewritten in matrix form by contraction of the double indices (i,j) and (k,m) to the single indices i and k, respectively,

$$\chi^2(X) = \sum_{k} \Big(\sum_{i} F_{ik} X_i - p_k \Big)^2 / \sigma_k = X \cdot MX - 2\, v \cdot X + c \quad , \tag{1.2}$$

where X is the vector of intensities to reconstruct, and

$$M_{ij} = \sum_k F_{ik} F_{jk} / \sigma_k^2 \quad , \tag{1.3}$$

$$v_i = \sum_k F_{ik} p_k / \sigma_k^2 \quad , \tag{1.4}$$

$$c = \sum_k p_k^2 / \sigma_k^2 \quad . \tag{1.5}$$

Methods that minimize $\chi^2(X)$ are called weighted least-squares methods. The weighting factors are $1/\sigma_k^2$ in equation (1.2). These weighting factors may also be set to unity, and some savings in memory requirements will be realized at the expense of the accuracy in the estimate of X.

The two iterative least-squares algorithms of this library are GRADY (gradient or steepest descent minimization) and CONGR (conjugate gradient minimization). Other notable algorithms of this class are ART and SIRT (cf. R. Gordon, R. Bender, and G. T. Herman, J. Theoret. Biol. 29, 1970, p. 471-481; P. F. C. Gilbert, J. Theoret. Biol. 36, 1972, pp. 105-117).

b. Step Length Calculation

The difference between the iterative algorithms of the RECLBL Library is the manner in which they choose the direction of the next step in the iterative process. Common to these algorithms is a step length calculation after the step direction has been chosen.

The direction of the n^{th} step is denoted by Δ^n, and the step length calculation consists of finding the factor a_n such that

$$X^{n+1} = X^n + a_n \Delta^n \qquad (1.6)$$

minimizes $\chi^2(X^{n+1})$. To accomplish this, set the derivative of $\chi^2(X^{n+1})$ (with respect to a_n) equal to zero and solve for a_n. The solution is

$$a_n = (\Delta^n \cdot \alpha^n)/(\Delta^n \cdot M\Delta^n) \quad , \qquad (1.7)$$

where the vector α^n is proportional to the gradient of $\chi^2(X)$ at the n^{th} step,

$$\alpha^n = -\frac{1}{2} \nabla\chi^2(X^n) = v - MX^n \quad . \qquad (1.8)$$

c. Parameter Scaling

In most cases, convergence of the iterative process may be accelerated by performing a scale change on the parameters. This is not true when the diagonal elements of the matrix M are nearly equal (i.e., for the case of parallel-beam geometry without attenuation and not using errors in the reconstruction). The scale change of variables performed on the pixel values is

$$Y = DX \quad , \tag{1.9}$$

where D is a diagonal matrix with diagonal elements equal to

$$D_{ii} = \sqrt{M_{ii}} \quad . \tag{1.10}$$

After substituting equation (1.10) into equation (1.2), the function to be minimized has the form

$$\chi^2(Y) = Y\cdot(D^{-1}MD^{-1})\,Y - 2(D^{-1}v)\cdot Y + c \quad . \tag{1.11}$$

Iterative stepping (using GRADY or CONGR) is performed on the transformed variables, Y, with M replaced by $D^{-1}MD^{-1}$ and v replaced by $D^{-1}v$. The final reconstructed values are obtained by the operation

$$X = D^{-1}Y \quad . \tag{1.12}$$

In this manual the parameter scaling described above is called "relaxation." When this scaling is performed in the gradient method (below) it becomes the iterative relaxation method (cf. M. Goitein, Nucl. Inst. Meth. 101, 1972, pp. 509-518).

d. Gradient Method or Method of Steepest Descent (GRADY)

The gradient method of reconstruction is implemented as follows:

```
CALL  GRADY(X,PRJ,BCK,ISTP,IRLX,IERR,IZER)
```

where

X is the reconstructed transverse section;

PRJ is the projection subroutine;

BCK is the back-projection subroutine;

ISTP is the number of iteration steps to take;
IRLX is nonzero for iterative relaxation;
IERR is nonzero for weighted least squares (otherwise σ=1 is assumed);
IZER is zero to zero the initial solution;

(cf. Examples 6, 8, 9, 10, 11, 12 of section IX).

The parameter PRJ can be one of the projection subroutines: PCD, PCDA, PCDF, PLL, PPT, PPTA, PPTF, PRF, PRFA, or PRFF; and the parameter BCK can be one of the back-projection subroutines: BCD, BCDA, BCDF, BLL, BPT, BPTA, BPTF, BRF, BRFA, or BRFF. These parameters are externals and should be declared in an EXTERNAL statement.

The gradient method takes as its step direction that direction in which $\chi^2(X)$ locally decreases most rapidly. This direction is opposite to the gradient so that

$$\Delta^n = \alpha^n \tag{1.13}$$

is chosen. The step length calculation is performed yielding a_n (equation (1.7)) and the step is calculated by

$$X^{n+1} = X^n + a_n\Delta^n \quad . \tag{1.14}$$

e. Conjugate Gradient Method (CONGR)

The conjugate gradient method of reconstruction is implemented as follows:

CALL CONGR(X,PRJ,BCK,ISTP,IRLX,IERR,IZER)

where

X is the reconstructed transverse section;
PRJ is the projection subroutine;
BCK is the back-projection subroutine;

ISTP is the number of iteration steps to take;

IRLX is nonzero for iterative relaxation;

IERR is nonzero for weighted least squares (otherwise $\sigma=1$ is assumed);

IZER is zero to zero the initial solution;

(cf. Examples 5, 7 of section IX).

The parameter PRJ can be one of the projection subroutines: PCD, PCDA, PCDF, PLL, PPT, PPTA, PPTF, PRF, PRFA, or PRFF; and the parameter BCK can be one of the back-projection subroutines: BCD, BCDA, BCDF, BLL, BPT, BPTA, BPTF, BRF, BRFA, or BRFF. These parameters are externals and should be declared in an EXTERNAL statement.

The conjugate gradient method improves convergence of the iterative process by making the step direction orthogonal to all previous steps (cf. J. M. Ortega and W. C. Rheinboldt, Iterative Solution of Nonlinear Equations in Several Variables, Academic Press, New York, 1970). The direction of the first step is taken the same as the gradient method,

$$\Delta^o = \alpha^o \quad , \tag{1.15}$$

$$X^1 = X^o + a_o\Delta^o \quad . \tag{1.16}$$

The succeeding step directions are given by

$$\Delta^n = \alpha^n - b_n\Delta^{n-1} \quad , \tag{1.17}$$

where

$$b_n = (\alpha^n \cdot M\Delta^{n-1})/(\Delta^{n-1} \cdot M\Delta^{n-1}) \quad . \tag{1.18}$$

This makes all steps orthogonal in the sense

$$\Delta^n \cdot M\Delta^m = 0 \text{ , for } m \neq n \quad . \tag{1.19}$$

The step length calculation is performed yielding a_n (equation (1.7)), and the step is calculated by

$$X^{n+1} = X^n + a_n\Delta^n \quad . \tag{1.20}$$

f. Subroutine USER

All of the iterative reconstruction subroutines in the RECLBL Library (CONGR, ENTPY, GRADY) call a subroutine named USER after each iteration. The library contains a default subroutine by that name, which prints out the iteration number and the value of the function being minimized. However, it has been anticipated that the user may be interested in more than this information. Thus, the user may supply a subroutine USER (along with the main program and subroutine GETUM) to satisfy his requirements. The arguments of the subroutine are

```
SUBROUTINE  USER(ITER,X,FCN)
```

where

ITER	is the iteration number;
X	is the array of fitted parameters, for CONGR and GRADY - reconstructed array, for ENTPY - Lagrange multipliers;
FCN	is the value of the function being optimized, for CONGR and GRADY - chi-square, for ENTPY - objective function of the dual program.

2. Configuration Space Convolution Algorithm

a. One-Dimensional Convolution (CONVO)

Reconstruction by the convolution method is accomplished using the statement

```
CALL  CONVO(X,XE,CNV,BCK,IERR)
```

where

X	is the reconstructed transverse section;
XE	is an array of uncertainties for X;
CNV	is the convolution subroutine;
BCK	is the back-projection subroutine;
IERR	is the error flag;

(cf. Example 2 of section IX).

The parameter CNV can be one of the three convolution functions: SHLO, RALA, or LAKS; and the parameter BCK can be one of the back-projection subroutines: BCD, BIN, BINF, BLL, BPT, or BRF. These parameters are externals and should be declared in an EXTERNAL statement. The routines LAKS and BINF are required for reconstructing fan-beam data. If XE (errors of the reconstruction X) are desired, then only the back-projection routines BIN or BINF can be used and IERR must be set nonzero.

The algorithm CONVO requires the projection angles to be equally spaced over at least π radians for parallel-beam geometry. To ensure this MODANG must not be 0 or 1 in the call to SETUP. When reconstructing fan-beam data, the projection angles must be equally spaced over 2π radians. Therefore MODANG must be 3, -3, 5, or -5 in the call to SETUP (cf. section III.2).

The algorithm performs the following operations: multiply the projection data by a weight function; convolve the projection data with a convolver; and back-project the modified projection data (cf. G. N. Ramachandran and A. V. Lakshminarayanan, Proc. Natl. Acad. Sci. U. S. 68, 1971, pp. 2236-2240). These algorithm operations are symbolized by the equation

$$X = \text{back-project}\left[(pd)*c\right] \quad , \qquad (2.1)$$

where X is the transverse section, p are the projection data, and c is the convolution function. The weight function d is unity for parallel-beam geometry. For fan-beam geometry there are two weight functions; one is used with a curved detector and the other is used with a flat detector. These functions are defined in section V.2.b.

The digital implementation of this algorithm by the RECLBL Library first multiplies the projection data by a weight function

$$p'_{km} = p_{km}d(k) \quad , \tag{2.2}$$

where k is the lateral index and m is the angular index. Then modified projections q_{km} are formed using the convolution equation

$$q_{km} = \sum_{k'} c(k - k')\ p'_{k'm} \quad , \tag{2.3}$$

where c is a symmetric convolution function. The convolved projections are then back-projected giving the reconstruction

$$X_{ij} = \frac{1}{NANG} \sum_{km} F_{ij}^{km} q_{km} \quad , \tag{2.4}$$

where F_{ij}^{km} are the weighting factors in the back-projection routines. A factor of π/NANG is required for the numerical calculation of the back-projection integral. However, a factor of 1/NANG is shown in the above equation and the other factor of π is incorporated in the convolution function.

The errors XE in the reconstructed image are returned if the error flag IERR is set nonzero. If errors are desired, then one of the back-projection routines BIN or BINF <u>must be used</u>, depending whether the user is reconstructing parallel- or fan-beam geometry, respectively. The BIN back-projection operator is represented by the equation

$$X_{ij} = \frac{1}{NANG} \sum_{m} \left[f_k q_{km} + (1 - f_k)\ q_{k+1,m} \right] \quad , \tag{2.5}$$

where the factors f_k are determined by linearly interpolating between adjacent bins and q_{km} are the convolved projections. Thus, the error matrix XE has elements given by the equation

$$(XE)_{ij} = \frac{1}{NANG}\left\{\sum_m\left[f_k^2 \ \mathrm{var}(q_{km}) + (1 - f_k)^2 \ \mathrm{var}(q_{k+1,m}) + 2f_k(1 - f_k) \ \mathrm{cov}(q_{km},q_{k+1,m})\right]\right\}^{1/2} \quad . \tag{2.6}$$

The variance of q_{km} is given by the equation

$$\mathrm{var}(q_{km}) = \sum_{k'} [c(k - k') \ d(k')]^2 \ \mathrm{var}(p_{km}) \quad , \tag{2.7}$$

and the covariance of q_{km} and $q_{k+1,m}$ is given by the equation

$$\mathrm{cov}(q_{km},q_{k+1,m}) = \sum_{k'} c(k - k') \ c(k + 1 - k') \ d(k')^2 \ \mathrm{var}(p_{k'm}) \quad . \tag{2.8}$$

The errors of the projection data, which equal the square roots of the variances ($\sqrt{\mathrm{var}(p_{km})}$), are input to the program using the subroutine GETUM (section III.4).

b. Convolvers and Weight Functions

The analytic expressions for the convolvers are shown below. Section IX, example 2 is an example program utilizing these convolvers with the convolution algorithm.

RALA Convolver

The RALA convolver (cf. G. N. Ramachandran, and A. V. Lakshminarayanan, Proc. Natl. Acad. Sci. U. S. 68, 1971, pp. 2236-2240) is defined by the equation

$$c(k) = \begin{cases} \frac{\pi}{4} & \text{if} \quad k = 0 \quad , \\ \frac{-1}{\pi k^2} & \text{if} \quad k \text{ odd} \quad , \\ 0 & \text{if} \quad k \text{ even} \quad . \end{cases} \tag{2.9}$$

This convolver must be used only for parallel-beam geometry, for which the weight function d in equation (2.2) is equal to 1 for all k. The RALA convolver is the digital representation of the RAMP convolution function given in section V.3.c.

SHLO Convolver

The SHLO convolver (cf. L. A. Shepp and B. F. Logan, IEEE Trans. Nucl. Sci. NS-21, 1974, pp. 21-43) is defined by the equation

$$c(k) = \begin{cases} \frac{2}{\pi} & \text{if} \quad k = 0 \quad , \\ \frac{-2}{\pi(4k^2 - 1)} & \text{if} \quad k \neq 0 \quad . \end{cases} \tag{2.10}$$

This convolver must be used only for parallel-beam geometry, for which the weight function d in equation (2.2) is equal to 1 for all k.

Figure 8 compares the graphs of the RALA and SHLO convolvers. The SHLO convolver is designed such that the convolution function c(x), which is equal to c(k) at x=k and linear in the intervening intervals, has a filter function that is the Fourier transform of c(x) equal to

$$\tilde{c}(f) = 2|\sin\pi f|\left(\frac{\sin\pi f}{\pi f}\right)^2 \quad . \tag{2.11}$$

The SHLO and RALA convolution functions have widths for the central lobe that are nearly the same. Therefore, the resolutions in the reconstructed images are similar for perfect data. However, the side

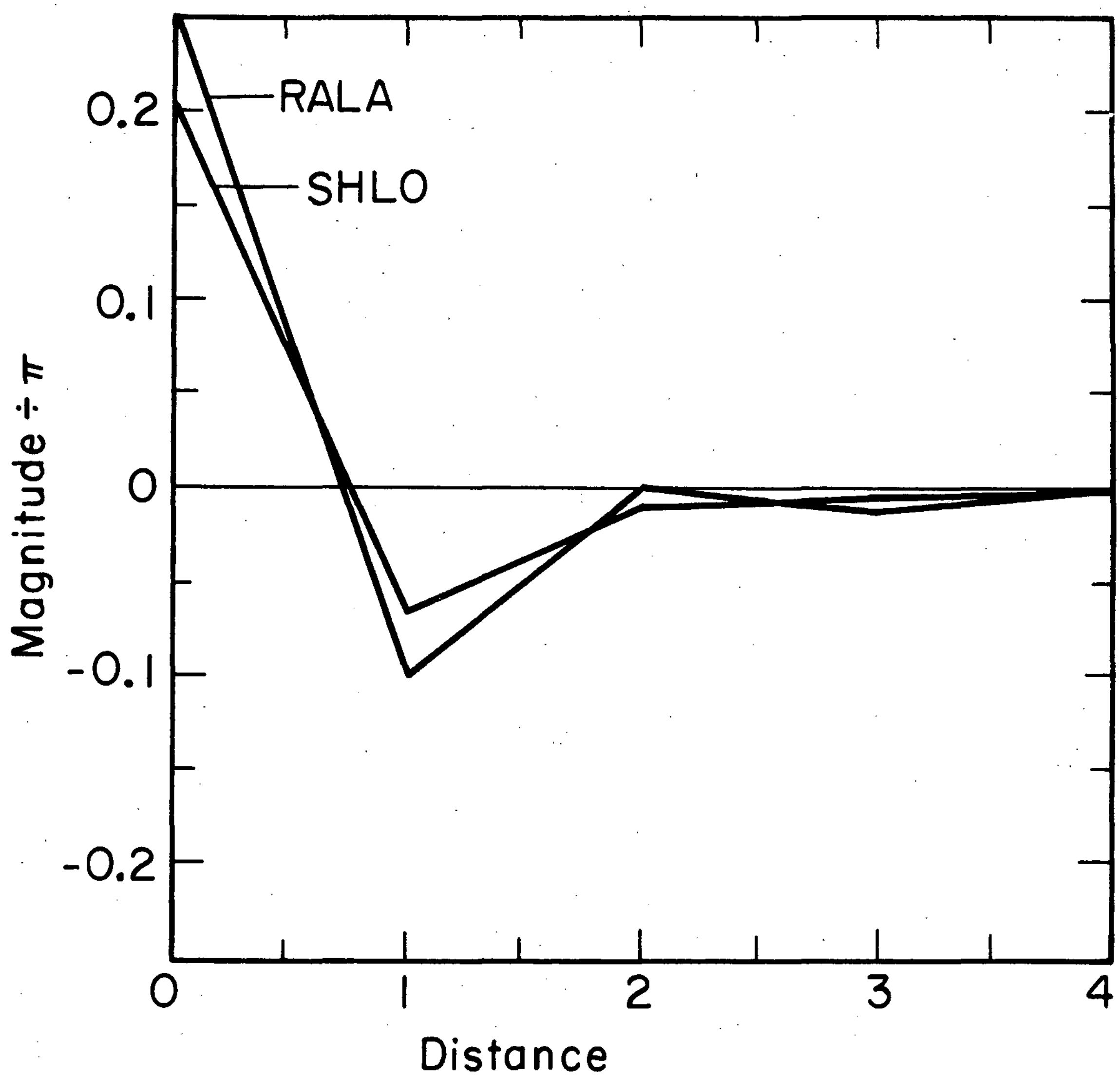


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Figure 8. Two convolvers in the RECLBL Library used with parallel-beam geometry.

lobes for the SHLO convolver are damped, reducing noise amplification for data with statistical fluctuations.

LAKS Convolver

The LAKS convolver (cf. G. T. Herman, A. V. Lakshminarayanan, and A. Naparstek, Comput. Biol. Med. 6, 1976, pp. 259-271) is used only for fan-beam geometry. For a curved detector the convolution function is defined by the equation

$$c(k) = \begin{cases} \frac{\pi}{4} & \text{if} \quad k = 0 \ , \\ \frac{-(1/RFAN)^2}{\pi \sin^2(k/RFAN)} & \text{if} \quad k \text{ odd} \ , \\ 0 & \text{if} \quad k \text{ even} \ , \end{cases} \tag{2.12}$$

with weights d(k) defined by the equation

$$d(k) = \cos(k/RFAN) \ . \tag{2.13}$$

For a flat detector the convolution function is defined by the equation

$$c(k) = \begin{cases} \frac{\pi}{4} & \text{if} \quad k = 0 \ , \\ \frac{-1}{\pi k^2} & \text{if} \quad k \text{ odd} \ , \\ 0 & \text{if} \quad k \text{ even} \ , \end{cases} \tag{2.14}$$

with weights d(k) defined by the equation

$$d(k) = \frac{1}{\sqrt{1 + (k/RFAN)^2}} \ . \tag{2.15}$$

3. Fourier Space Convolution Algorithms

a. Back-Projection of Filtered Projections Algorithm (BKFIL)

The back-projection of filtered projections algorithm is implemented as follows:

```
CALL  BKFIL(X,FIL,BCK,ORDERX,FREQX)
```

where

X	is the reconstructed transverse section;
FIL	is the filter subroutine;
BCK	is the back-projection subroutine;
ORDERX	is a filter parameter used only by the filter BUTER;
FREQX	is a filter parameter;

(cf. Example 3 of section IX).

The parameter FIL can be one of the five filters: BUTER, HAN, HAM, PARZN, or RAMP. The parameter BCK can be one of the back-projection subroutines: BCD, BIN, BLL, BPT, or BRF. These parameters are externals and should be declared in an EXTERNAL statement.

A description of the filter options and the appropriate values for ORDERX and FREQX parameters is found in section V.3.c. The cutoff frequency FREQX for the filters has units of cycles per projection bin. Thus, for a Nyquist frequency equal to 1 cycle per projection bin, one can choose FREQX=0.5 for most applications. Other appropriate values for FREQX are described in section V.3.c.

The algorithm BKFIL requires the projection angles to be equally spaced over at least π radians. To ensure this MODANG must not be 0 or 1 in the call to SETUP (cf. section III.2).

The algorithm performs the following sequence of operations: Fourier transform the projection data vector; multiply the complex values by one of the five optional filters; inverse Fourier transform these modified frequencies; and back-project the modified projection data (cf. T. F. Budinger and G. T. Gullberg, IEEE Trans. Nucl. Sci. NS-21, 1974, pp. 2-20). These algorithm operations are symbolized as:

$$X = \text{back-project} \left\{ \mathscr{F}_1^{-1} \left[\tilde{c} \quad \mathscr{F}_1(p) \right] \right\} \quad , \tag{3.1}$$

where X is the transverse section, p are the projection data, $\tilde{c}$ is the filter function, and $\mathscr{F}_1$ denotes one-dimensional Fourier transformation. The filter function $\tilde{c}$ is equal to the product of a window function w(R) and the absolute value of the frequency:

$$\tilde{c}(R) = |R| \; w(R) \quad . \tag{3.2}$$

Due to the Fourier convolution theorem, this method of reconstruction is equivalent to the convolution method except that the convolution of the projection data is carried out in frequency space. The filter function $\tilde{c}$ is the Fourier transform of the convolution function c. The rationale for performing the filter operation in Fourier space is given in section V.3.c.

The digital implementation of this algorithm by the RECLBL Library performs the discrete Fourier transform of the projection data given by the equation

$$\tilde{p}_{km} = \frac{1}{KDIMT} \sum_{l=0}^{KDIMT-1} p_{lm} \exp(-i2\pi kl/KDIMT) \quad , \tag{3.3}$$

where k is the projection bin index and m is the angle index. KDIMT is equal to 2^{IPOW2} where IPOW2=2x(the smallest power of two that is greater than or equal to KDIMU). The factor of 2 is required so that the convolution result of one period does not overlap the convolution result of the succeeding period when using the discrete Fourier transform. After discrete Fourier transforming the projection data, Fourier transformed values $\tilde{p}_{km}$ are multiplied by a filter function giving

$$\tilde{q}_{km} = \tilde{c}(k/KDIMT)\ \tilde{p}_{km} \quad . \tag{3.4}$$

Then the values $\tilde{q}_{km}$ are discrete inverse Fourier transformed giving the convolved projection

$$q_{km} = \sum_{l=0}^{KDIMT-1} \tilde{q}_{lm} \exp(i2\pi kl/KDIMT) \quad . \tag{3.5}$$

The convolved projection data are then back-projected as in the convolution method to give the reconstruction

$$X_{ij} = \frac{\pi}{NANG} \sum_{km} F_{ij}^{km} q_{km} \quad , \tag{3.6}$$

where F_{ij}^{km} are the weighting factors in the projection and back-projection routines. The factor π/NANG is the step size in the numerical calculation of the back-projection integral.

b. <u>Filter of the Back-Projection Algorithm (FILBK)</u>

Reconstruction by the filter of the back-projection method is accomplished using the statement

CALL FILBK(X,FIL,BCK,ORDERX,FREQX)

where

X	is the reconstructed transverse section;
FIL	is the filter subroutine;
BCK	is the back-projection subroutine;
ORDERX	is a filter parameter used only by the filter BUTER;
FREQX	is a filter parameter;

(cf. Example 4 of section IX).

The parameter FIL can be one of the five filters: BUTER, HAN, HAM, PARZN, or RAMP. The parameter BCK can be one of the back-projection subroutines: BCD, BCDF2, BIN, BLL, BPT, BPTF2, BRF, or BRFF2. These parameters are externals and should be declared in an EXTERNAL statement. The back-projection subroutines BCDF2, BPTF2, and BRFF2 are required for reconstructing fan-beam projection data since the filter of the back-projection algorithm requires special weighting for fan-beam geometry. When reconstructing fan-beam projection data with this algorithm, the user should not use BCDF, BPTF, or BRFF.

A description of the filter options and the appropriate values for the ORDERX and FREQX parameters is found in section V.3.c. The cutoff frequency FREQX for the filters has units of cycles per pixel. (In the algorithm BKFIL, FREQX has units of cycles per projection bin.) For most applications FREQX=0.5 gives good results.

The algorithm FILBK requires that the projection angles be equally spaced over at least π radians for parallel-beam geometry. To ensure this, MODANG must not be 0 or 1 in the call to SETUP. When reconstructing fan-beam data, the projection angles must be equally spaced over 2π radians. Therefore MODANG must be 3, -3, 5, or -5 in the call to SETUP (cf. section III.2).

This algorithm performs the following sequence of operations: back-project the projection data; Fourier transform the two-dimensional back-projection image; multiply the two-dimensionally distributed Fourier coefficients by one of the optional filter functions; and perform the two-dimensional inverse Fourier transform (cf. R. H. T. Bates and T. M. Peters, New Zealand J. Sci. 14, 1971, pp. 883-896). These algorithm operations are symbolized as:

$$X = \mathcal{F}_2^{-1} \left\{ \tilde{c} \, \mathcal{F}_2 \left[\text{back-project}(p) \right] \right\} \quad , \tag{3.7}$$

where X is the transverse section, p are the projection data, $\tilde{c}$ is the filter function, and $\mathcal{F}_2$ denotes the two-dimensional Fourier transform. The filter function $\tilde{c}$ is equal to the product of a window function w(R) and of the absolute value of the frequency:

$$\tilde{c}(R) = |R| \; w(R) \quad . \tag{3.8}$$

This method of reconstruction is equivalent to performing a two-dimensional convolution of a sharpening kernel with the back-projection data. The purpose of this method is to effect a deconvolution of the true image X from the back-projected image b given by the equation:

$$b(x,y) = \iint \frac{X(x',y')}{\sqrt{(x - x')^2 + (y - y')^2}} \, dx'dy' = X*r^{-1} \quad . \tag{3.9}$$

The derivation of the algorithm is based on the convolution theorem and the fact that $r^{-1} = \mathscr{F}_2^{-1}(R^{-1})$ where R is the frequency.

Three general geometries for back-projection are available: parallel-beam, fan-beam with curved detector and fan-beam with flat detector. The back-projection operation for parallel-beam geometry requires the summation of line integrals over the range of 180^o and is given by the equation

$$b_{=}(r,\phi) = \int_0^{\pi} p\Big[r \sin(\phi - \theta), \; \theta\Big] \, d\theta \quad . \tag{3.10}$$

The five choices of back-projection subroutines for parallel-beam are BCD, BIN, BLL, BPT, or BRF. Fan-beam geometries require samples around the full 360^o for use of this algorithm (cf. G. T. Gullberg, Lawrence Berkeley Laboratory Report LBL 5604, 1977). The back-projection operations for the fan-beam geometry are given for a curved detector by the equation

$$b_C(r,\phi) = \frac{1}{2} \int_0^{2\pi} p_C(\xi^*,\theta) \, d\theta \quad , \tag{3.11}$$

where

$$\xi^* = RFAN \tan^{-1}\left[\frac{r \sin(\phi - \theta)}{RFAN + r \cos(\phi - \theta)}\right] \quad ,$$

and for a flat detector by the equation

$$b_f(r,\phi) = \qquad (3.12)$$

$$\frac{1}{2}\int_0^{2\pi} \frac{p_f(\xi^*,\theta)\sqrt{r^2 + RFAN^2 + 2\ RFAN\ r\cos(\phi - \theta)}\ d\theta}{RFAN + r\cos(\phi - \theta)} \quad ,$$

where

$$\xi^* = \frac{RFAN\ r\sin(\phi - \theta)}{RFAN + r\cos(\phi - \theta)} \quad .$$

The variable RFAN is the distance of the source in transmission tomography or of the pinhole in emission tomography to the center of rotation. Notice in equation (3.12) that when using a flat detector a special weighting is required for the back-projection operation. The three choices of back-projection subroutines for fan-beam geometry are BCDF2, BPTF2, and BRFF2.

The digital implementation of this algorithm by the RECLBL Library first back-projects the projection data p_{km} using the equation

$$b_{ij} = \sum_{km} F_{ij}^{km} p_{km} \quad , \qquad (3.13)$$

where k is the projection bin index, m is the angle index, and F_{ij}^{km} are the weighting factors in the projection and back-projection routines. The back-projection image is then discrete Fourier transformed using the equation

$$\tilde{b}_{kl} = \qquad (3.14)$$

$$\frac{1}{NDIM^2} \sum_{n=0}^{NDIM-1} \sum_{m=0}^{NDIM-1} b_{nm} \exp\left[-2\pi i(kn + lm)/NDIM\right] \quad .$$

NDIM is equal to 2^{IPOW2} where IPOW2=2x(the smallest power of two that is greater than or equal to NDIMU). Next the discrete Fourier transformed values $\tilde{b}_{kl}$ are multiplied by a filter function $\tilde{c}$ giving

$$\tilde{X}_{kl} = \tilde{c}\left(\frac{\sqrt{k^2 + l^2}}{NDIM}\right)\tilde{b}_{kl} \quad . \tag{3.15}$$

Then the values $\tilde{X}_{kl}$ are inverse Fourier transformed and multiplied by a normalization factor to give the reconstruction

$$X_{nm} = \frac{\pi}{NANG*PWID} \sum_{k=0}^{NDIM-1} \sum_{l=0}^{NDIM-1} \tilde{X}_{kl} \exp\left[2\pi i(nk + ml)/NDIM\right] \quad . \tag{3.16}$$

The factor π/NANG is the step size in the numerical calculation of the back-projection integral. The factor 1/PWID is the result of scaling the reconstruction space.

c. Filter Functions

The algorithms BKFIL and FILBK require a filter to be designated. These algorithms have been developed with various options for frequency space filters because frequency space manipulation lends itself to easily changing the noise propagation vs. resolution properties of the convolution kernel. The user can improve resolution by changing the filter shape, but the noise amplification will increase. Alternatively, the user can suppress noise; however, this noise suppression will come at the cost of resolution. A second reason for incorporation of various filters with the Fourier space algorithms is that the computational method for reconstruction is more efficient using the Fast Fourier Transform than convolution in real space.

The particular filter desired by the user is evaluated by one of the five optional external subroutines: BUTER, HAM, HAN, PARZN, or RAMP. The external subroutine chosen must be designated in the main program (cf. example 3 of section IX). These five filters correspond to multiplying the ramp function in frequency space by one of the following windows: Butterworth, Hann, Hamming, Parzen, or rectangular. (A thorough discussion of these windows and their application is found in: R. K. Otnes and L. Enochson, Digital Time Series Analysis, John Wiley and Sons, 1972; R. W. Hamming, Digital Filters, Prentice Hall, 1977.)

Texts usually define a digital filter as the real space convolution equation:

$$q_n = \sum_k c_{n-k} p_k \qquad (3.17)$$

In this manual a convolver means the convolving sequence $\{c_k\}$ and a filter is the Fourier transform of a continuous convolution function c(x) such that $c_k = c(x=k)$.

Real space convolution and frequency filtering are equivalent operations. As is shown in examples 2 and 3 of section IX, the RAMP filter used with the algorithm BKFIL achieves the same result as the RALA convolution function used with CONVO. In BKFIL the operation of filtering is done by multiplying the filter values by the Fourier transform of the projection data, then inverse Fourier transforming the result. Projection data modified in the same fashion is obtained by convolving the projection data with the real space equivalent of the RAMP function. Symbolically we have

$$\text{Modified projection} = \mathscr{F}_1^{-1}\left[|R|\ w(R)\ \mathscr{F}_1(\text{projection data})\right] , \qquad (3.18)$$

where $\mathscr{F}_1$ denotes the one-dimensional Fourier transform and w(R) is one of the window functions defining the filter $|R|\ w(R)$. From the convolution theorem, the equivalent result can be obtained as

$$\text{Modified projection} = \left\{\mathscr{F}_1^{-1}\left[|R|w(R)\right]\right\} * \text{projection data} , \qquad (3.19)$$

where the convolver $\mathcal{F}^{-1}\left[|R|w(R)\right]$ is determined by the window function w and the symbol * denotes convolution.

The shapes of the window functions are shown in figure 9. The width of the window is measured as the distance between the closest zeros on each side of the center lobe of the inverse Fourier transform of the window function. Ideally, for good resolution, the window function should have a central lobe that is tall and narrow. The side lobes for the inverse Fourier transform of these window functions give rise to the Gibbs phenomenon, which is observed as artifacts that are contamination from adjacent parts of the reconstruction.

The RECLBL filters: HAN, HAM, PARZN, RAMP (figure 10 upper) are obtained by multiplying the ramp function by the window functions in figure 9: Hann, Hamming, Parzen, Rectangular, respectively. Figure 10 lower gives the graphs of the convolution functions that are the inverse Fourier transform of the filter functions given in figure 10 upper. The analytic expressions for the frequency filters and the corresponding real space convolution functions are shown below. The frequency parameter f_m is the frequency parameter FREQX, which is input to the subroutines BKFIL and FILBK.

<u>Rectangular Window and RAMP Filter</u>

The rectangular window is defined by the equation

$$w(f) = \begin{cases} 1 & \text{if } |f| \le f_m , \\ 0 & \text{if } |f| > f_m . \end{cases} \tag{3.20}$$

Multiplying the rectangular window by the ramp function in frequency space gives the RAMP filter

$$\tilde{c}(f) = \begin{cases} |f| & \text{if } |f| \le f_m , \\ 0 & \text{if } |f| > f_m . \end{cases} \tag{3.21}$$

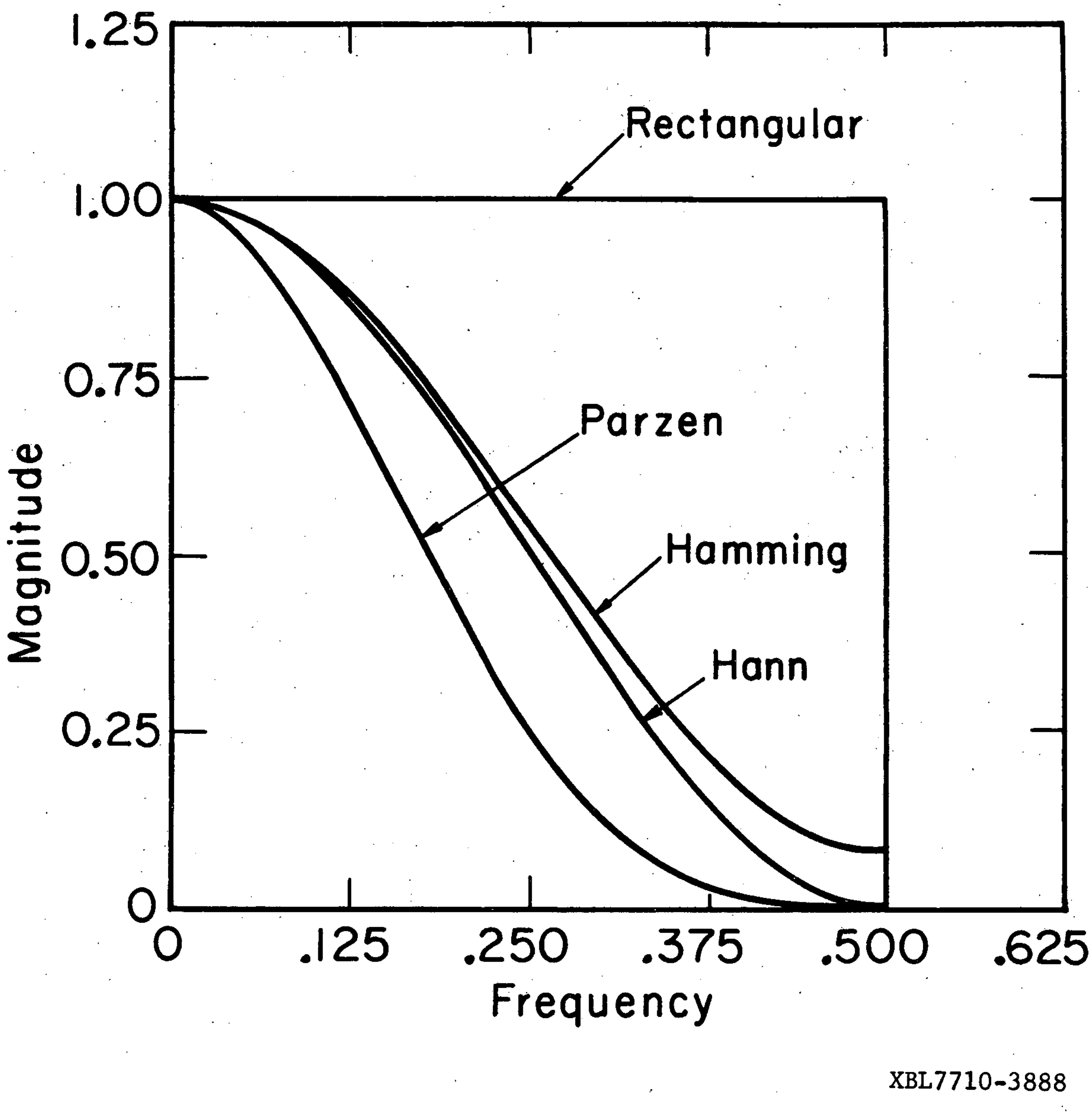

Figure 9. These window functions are multiplied by a ramp function giving the filters shown in figure 10.

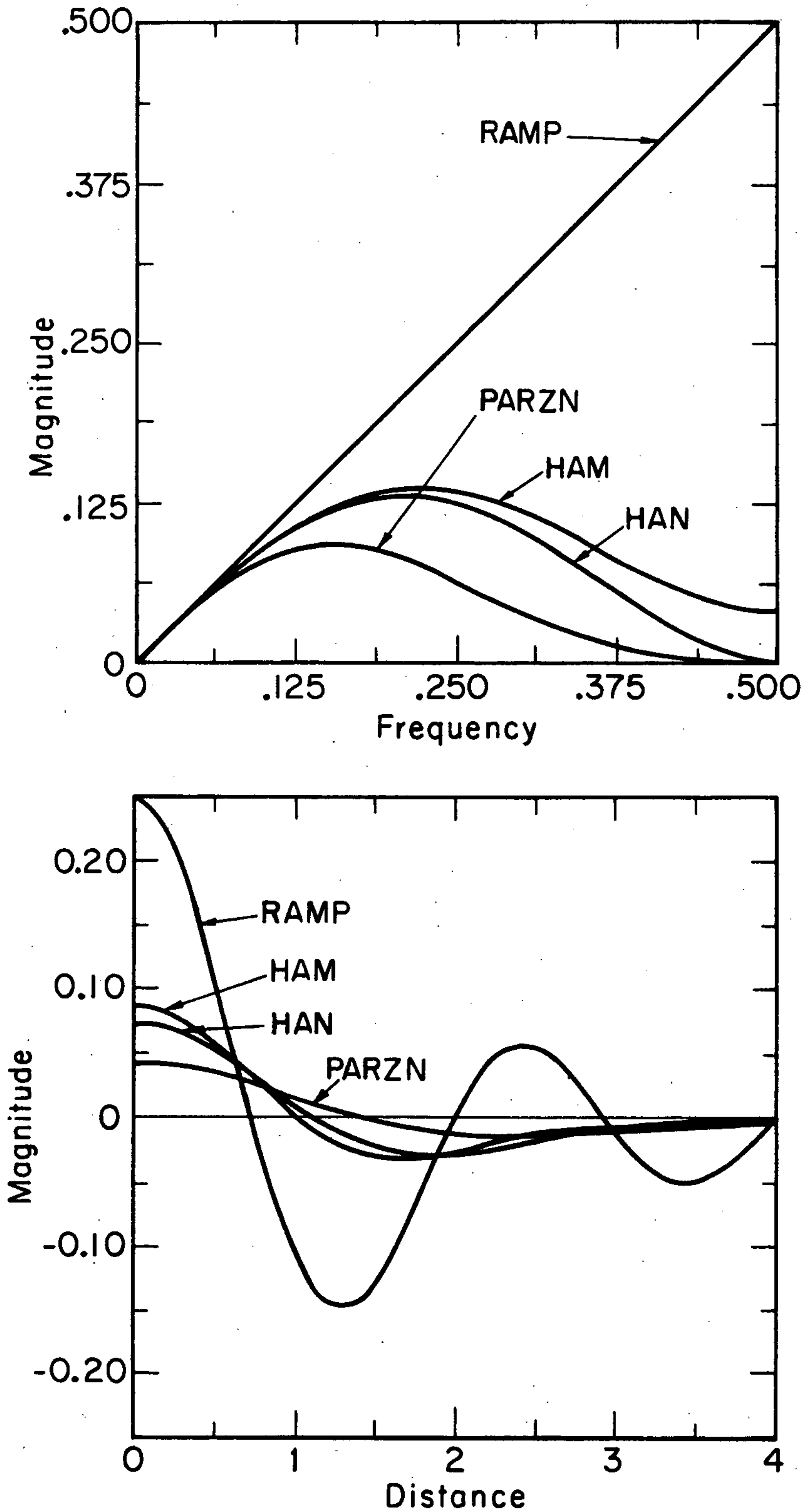

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Figure 10. Window functions of figure 9 multiplied by a ramp with a cutoff frequency FREQX=0.5 (upper). The inverse Fourier transform of the filters in the upper figure give the real space convolution functions (lower).

The inverse Fourier transform of the RAMP filter gives the convolution function

$$c(x) = 2f_m^2\left(\frac{\sin 2\pi f_m x}{2\pi f_m x}\right) - f_m^2\left(\frac{\sin \pi f_m x}{\pi f_m x}\right)^2 \quad . \tag{3.22}$$

The RAMP filter gives the best resolution in the reconstructed image for perfect data but amplifies noise for data with statistical fluctuations. The sharp cutoff gives rise to intensity oscillation in regions of sharp contrast and thus generates artifacts in the reconstructed image.

Hann Window and HAN Filter

The Hann window is defined by the equation

$$w(f) = \begin{cases} 0.5 + 0.5 \cos\pi f/f_m & \text{if } |f| \le f_m \quad , \\ 0 & \text{if } |f| > f_m \quad . \end{cases} \tag{3.23}$$

Multiplying the Hann window by the RAMP function gives the HAN filter

$$\tilde{c}(f) = \begin{cases} 0.5\ |f| + 0.5\ |f| \cos\pi f/f_m & \text{if } |f| \le f_m \quad , \\ 0 & \text{if } |f| > f_m \quad . \end{cases} \tag{3.24}$$

The inverse Fourier transform of the filter function gives the convolution function

$$c(x) = \frac{f_m^2}{2} \frac{\sin\left[f_m(2\pi x + \pi/f_m)\right]}{f_m(2\pi x + \pi/f_m)} - \frac{f_m^2}{4}\left(\frac{\sin\left[f_m(2\pi x + \pi/f_m)/2\right]}{f_m(2\pi x + \pi/f_m)/2}\right)^2$$

$$+ f_m^2 \frac{\sin 2\pi f_m x}{2\pi f_m x} - \frac{f_m^2}{2}\left(\frac{\sin \pi f_m}{\pi f_m x}\right)^2 \tag{3.25}$$

$$+ \frac{f_m^2}{2} \frac{\sin\left[f_m(2\pi x - \pi/f_m)\right]}{f_m(2\pi x - \pi/f_m)} - \frac{f_m^2}{4}\left(\frac{\sin\left[f_m(2\pi x - \pi/f_m)/2\right]}{f_m(2\pi x - \pi/f_m)/2}\right)^2 .$$

For the Hann window the central lobe of the convolution function $c(x)$ is wider than the central lobe of the corresponding convolution function for the rectangular window, but its side lobes are greatly reduced. Therefore, the reconstructed image has a smoother texture with a loss in resolution.

A frequency parameter f_m for the HAN filter, which is two times the value of the cutoff frequency for the RAMP filter, gives an approximation to the ramp function with a small rolloff near $f = f_m/2$. The RAMP and HAN filters give the same resolution in the reconstructed image when the RAMP has a cutoff frequency equal to one half that of the HAN (cf. D. A. Chesler and S. J. Riederer, Phys. Med. Biol. 20, 1975, pp. 632-636).

Hamming Window and HAM Filter

The Hamming window is defined by the equation

$$w(f) = \begin{cases} 0.54 + 0.46 \cos \pi f/f_m & \text{if } |f| \le f_m , \\ 0 & \text{if } |f| > f_m . \end{cases} \tag{3.26}$$

Multiplying the Hamming window by the ramp function in frequency space gives the HAM filter

$$\tilde{c}(f) = \begin{cases} 0.54\,|f| + 0.46\,|f| \cos \pi f/f_m & \text{if } |f| \le f_m \,, \\ 0 & \text{if } |f| > f_m \,. \end{cases} \tag{3.27}$$

The inverse Fourier transform gives the convolution function, which is merely equation (3.25) with terms 1, 2, 5 and 6 reduced by 1.08 and terms 3 and 4 increased by 1.08:

$$\begin{aligned} c(x) = {} & 0.46\, f_m^2 \frac{\sin f_m(2\pi x + \pi/f_m)}{f_m(2\pi x + \pi/f_m)} - 0.23\, f_m^2 \left(\frac{\sin f_m(2\pi x + \pi/f_m)/2}{f_m(2\pi x + \pi/f_m)/2}\right)^2 \\ & + 1.08\, f_m^2 \frac{\sin 2\pi f_m x}{2\pi f_m x} - 0.54\, f_m^2 \left(\frac{\sin \pi f_m x}{\pi f_m x}\right)^2 \\ & + 0.46\, f_m^2 \frac{\sin f_m(2\pi x - \pi/f_m)}{f_m(2\pi x - \pi/f_m)} - 0.23\, f_m^2 \left(\frac{\sin f_m(2\pi x - \pi/f_m)/2}{f_m(2\pi x - \pi/f_m)/2}\right)^2 \end{aligned} \tag{3.28}$$

The Hamming window has smaller extreme values in the side lobes than does the Hann window. The maximum side lobe for the Hamming window is approximately one-fifth that of the Hann window.

Parzen Window and PARZN Filter

The Parzen window is defined by the equation

$$w(f) = \begin{cases} 1 - 6\left(\frac{|f|}{f_m}\right)^2 \left(1 - \frac{|f|}{f_m}\right) & \text{if } |f| \le f_m/2 \,, \\ 2\left(1 - \frac{|f|}{f_m}\right)^3 & \text{if } f_m/2 < |f| \le f_m \,, \\ 0 & \text{if } |f| > f_m \,, \end{cases} \tag{3.29}$$

where f_m is the cutoff frequency. Multiplying the Parzen window by the ramp function gives the PARZN filter

$$\tilde{c}(f) = \begin{cases} |f| - 6|f|\left(\frac{|f|}{f_m}\right)^2\left(1 - \frac{|f|}{f_m}\right) & \text{if} \quad |f| \le f_m/2 \quad , \\ 2|f|\left(1 - \frac{|f|}{f_m}\right)^3 & \text{if} \quad f_m/2 < |f| \le f_m \quad , \\ 0 & \text{if} \quad |f| > f_m \quad . \end{cases} \tag{3.30}$$

The inverse Fourier transform gives the convolution function

$$c(x) = \left[48\pi\, f_m x \cos 2\pi f_m x - 96 \sin 2\pi f_m x - 96\pi\, f_m x \cos \pi f_m x + 384 \sin \pi f_m x - 16\pi^3 f_m^3 x^3 - 144\, \pi f_m x\right] / (32\pi^5 f_m^3 x^5) \tag{3.31}$$

and

$$c(0) = 0.175\, f_m^2 \quad . \tag{3.32}$$

The central lobe of the Parzen window is about 30% wider than either the Hann or the Hamming window. Thus the reconstructed image resolution will be less than can be achieved with either the HAN or HAM filter. On the other hand the PARZN filter suppresses noise. The side lobes for the Hann and Hamming window oscillate between positive and negative values, whereas with the Parzen window the side lobes always remain positive.

Butterworth Filter and BUTER Filter

The major advantage of the filter BUTER is that it can be modified to suit the user. The filter is derived by using the magnitude of the Butterworth filter as a window function:

$$R(f) = \frac{1}{\sqrt{1 + (f/f_m)^{2n}}} \quad , \tag{3.33}$$

where f_m is a frequency parameter and n is the order of the filter. This is multiplied by the ramp function giving the filter BUTER:

$$\frac{|f|}{\sqrt{1 + (|f|/f_m)^{2n}}} \tag{3.34}$$

The shape of the filter is designed by declaring values of FREQX=f_m and ORDERX=2n. Note that the order of a Butterworth filter (equation (3.33)) is given as n=ORDERX/2 if ORDERX is an even integer. However, the filter BUTER in the RECLBL Library allows ORDERX to be any real value.

Usually the Butterworth filter is used in connection with recursive filtering; however, in our application the amplitude of the Butterworth filter is multiplied with a ramp function to obtain a rolloff. A filter can be selected that gives the desired result in the reconstruction by using a value for ORDERX that may be in the range of 5 to 350 and a value for FREQX between 0.25 and 1.

A filter is designed by calculating the appropriate window widths between 0 and f_p and the corresponding transition bands between the pass-band frequency f_p and the stop-band frequency f_s as illustrated in figure 11. If the values of ε, A, f_p, and f_s are known for a particular

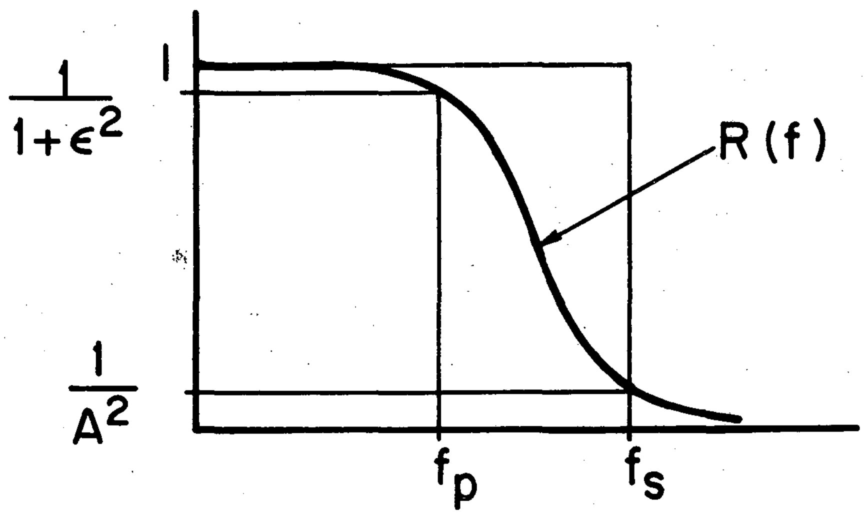


Figure 11. Method of designating a Butterworth filter. Parameters ε and A are calculated from ordinates at the user selected pass frequency f_p and stop frequency f_s.

window, then the parameters ORDERX and FREQX of the Butterworth filter are determined using the equations:

$$\text{ORDERX} = \frac{2\log(\varepsilon/\sqrt{A^2 - 1})}{\log(f_p/f_s)} \tag{3.35}$$

$$\text{FREQX} = \frac{f_p}{(\varepsilon)^{2/\text{ORDERX}}} \tag{3.36}$$

(cf. R. W. Hamming, Digital Filters, Prentice Hall, 1977, p. 189).

The window defined by the Butterworth filter can either be designed so that it has a narrow transition band between f_p and f_s, and thus approaches a rectangular window, or can be designed so that it has a wide transition band such as the Hann or Hamming window. For example, suppose a Hann window had FREQX=0.5 and we select f_p=0.23 and f_s=0.47, then equation (3.23) gives w(0.23)=0.563 and w(0.47)=0.009. A Butterworth filter that matches this Hann window at f_p and f_s is designed by solving equations (3.37) and (3.38) for A and ε:

$$R(0.23) = \frac{1}{1 + \varepsilon^2} = 0.563 \quad , \tag{3.37}$$

$$R(0.47) = \frac{1}{A^2} = 0.009 \quad . \tag{3.38}$$

This is illustrated in figure 11 and the results are A=10.624 and ε=0.882. From equations (3.35) and (3.36) we calculate the parameters of the Butterworth filter ORDERX=6.95 and FREQX=0.238. Figure 12 upper compares the window defined by the Butterworth filter for ORDERX=6, FREQX=0.23 with the Hann window for FREQX=0.5. Figure 12 lower compares the corresponding filters.

Designing a window function with a narrow transition band in frequency space is equivalent to having a narrow central lobe that will give good resolution in the reconstructed image, but concurrently the side lobes

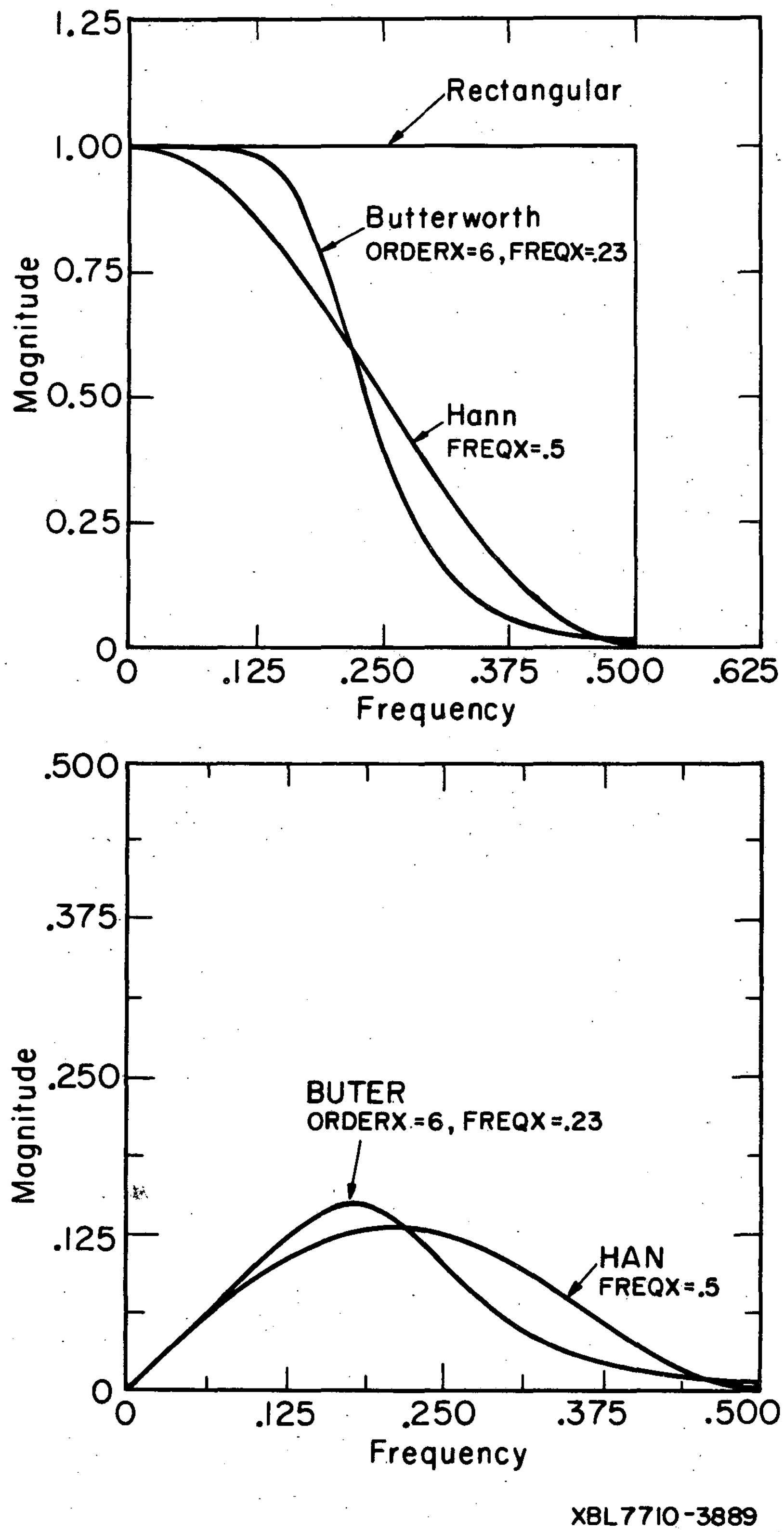


Figure 12. The upper figure shows the Hann window with a cutoff frequency FREQX=0.5 and the Butterworth filter with ORDERX=6 and FREQX=0.23. The lower figure is a plot of the filters BUTER and HAN obtained by multiplying these window functions by a simple ramp.

for such a window function are larger, thus amplifying noise. On the other hand, a wider transition band gives poorer resolution with reduced noise amplification.

4. Maximum Entropy Algorithm (ENTPY)

The maximum entropy method of reconstruction is designed for projection data samples that give a system of linear equations that are underdetermined. This method of reconstruction is accomplished using the statement

```
CALL  ENTPY(X,PRJ,BCK,LIMITX,ERENTX)
```

where

- X is the reconstructed transverse section;
- PRJ is the projection subroutine;
- BCK is the back-projection subroutine;
- LIMITX is the maximum number of iterations allowed to minimize the objective function for the dual program;
- ERENTX is the test value representing the expected absolute error between the true solution and the iterative solution;

(cf. Example 14 of section IX).

The parameter PRJ can be one of the projection subroutines: PCD, PCDF, PLL, PPT, PPTF, PRF, or PRFF; and the parameter BCK can be one of the back-projection subroutines: BCD, BCDF, BLL, BPT, BPTF, BRF, or BRFF. These parameters are externals and should be declared in an EXTERNAL statement.

The maximum entropy algorithm requires as many as 121 (LIMITX=121) iterations for a 21 x 21 reconstruction array if ERENTX=10^{-6}. Therefore, due to the computer time requirements the user might want to use this method for small array sizes and sample sizes. For larger arrays, computer tests have shown that if LIMITX=15, ENTPY gives a good reconstruction even when the iterative procedure has not yet converged to the maximum entropy solution. ERENTX should not be any smaller than 10^{-D}, where D is the number of significant digits in floating point representation.

When reconstructing fan-beam data, the projection angles must be equally spaced over 2π radians. Therefore MODANG must be 3, -3, 5, or -5 in the call to SETUP (cf. section III.2).

The maximum entropy method determines a solution for the reconstructed pixel values that maximizes an entropy function subject to a consistent system of projection constraints. The problem is stated formally as follows:

Find the maximum of

$$S(X) = -\sum_{ij} \frac{X_{ij}}{T} \ln\left(\frac{X_{ij}}{T}\right) \tag{4.1}$$

subject to the constraints

$$\sum_{ij} F_{ij}^{km} X_{ij} = p_{km} \quad \text{for all } k,m \quad , \tag{4.2}$$

$$\sum_{ij} X_{ij} = T \quad , \tag{4.3}$$

$$X_{ij} \geq 0 \quad . \tag{4.4}$$

The intensities X_{ij} are elements of the array X representing the reconstructed transverse section, which has a total intensity T. These intensities are related to the projection values p_{km} by the weighting factors F_{ij}^{km}, which are determined by the particular choice of the projection and back-projection subroutines.

A solution for the reconstructed transverse section is solved utilizing Lagrange multipliers and duality theory (cf. R. T. Rockafellar, Convex Analysis, Princeton University Press, 1970). Using conjugate gradient methods, a solution to the dual program:

Find the minimum of

$$g(\lambda) = \ln\left(\sum_{ij} \exp z_{ij}\right) - \sum_{km} \lambda_{km} p_{km}/T \tag{4.5}$$

where $z_{ij} = \sum_{km} F_{ij}^{km} \lambda_{km}$, gives the optimum solution for the Lagrange multipliers. This solution immediately gives an optimal solution for the reconstructed image from the equation

$$X_{ij} = \frac{T \exp z_{ij}}{\sum_{i'j'} \exp(z_{i'j'})} ,$$

where $z_{ij} = \sum_{km} F_{ij}^{km} \lambda_{km}$ and the λ_{km} are the optimum Lagrange multipliers (cf. G. T. Gullberg, in Information Processing in Scintigraphy, Proceedings of the IVth International Conference, Orsay, France, July 15-16, 1975, eds. C. Raynaud and A. Todd-Pokropek, pp. 325-332).

The maximum entropy reconstruction method will give an estimate for the reconstructed image which has less structure than any other possible solution, and thus avoids any bias while agreeing with the projection data.

5. Generalized Inverse Algorithm (GVERS)

The generalized inverse method of reconstruction is obtained by using the Fortran statement

```
CALL  GVERS(X,XE,PRJ,BCK,CHISQ,IERR)
```

where

X	is the reconstructed transverse section;
XE	are the errors in the reconstructed image;
PRJ	is the projection subroutine;
BCK	is the back-projection subroutine;

CHISQ is the resulting chi-square;

IERR is the error indicator;

(cf. Example 15 of section IX).

The parameter PRJ can be one of the projection subroutines: PCD, PCDA, PCDF, PLL, PPT, PPTA, PPTF, PRF, PRFA, or PRFF; and the parameter BCK can be one of the back-projection subroutines: BCD, BCDA, BCDF, BLL, BPT, BPTA, BPTF, BRF, BRFA, or BRFF. These parameters are externals and should be declared in an EXTERNAL statement. The chi-square, CHISQ, which is returned is defined by the equation

$$\mathrm{CHISQ} = \chi^2(X) = \sum_{km}\left(\sum_{ij} F_{ij}^{km} X_{ij} - p_{km}\right)^2 / \sigma_{km}^2 \quad , \qquad (5.1)$$

where F_{ij}^{km} are the weighting factors in the projection operation, p_{km} are the projection data, and σ_{km} are the errors in the projection data. If IERR=1, the input projection data uncertainties are used, but no errors are calculated for the reconstructed values. If IERR=2, the input uncertainties are used, and the errors are calculated for the reconstructed values. If IERR has any other value, then input data errors are not used, i.e., σ_{km}=1 is assumed, and errors for the reconstructed values are not calculated.

The generalized inverse method is a direct method, as opposed to the iterative methods, for minimizing equation (5.1). If H is defined as

$$H_{ij}^{km} = F_{ij}^{km} \sigma_{km}^{-1} \quad , \qquad (5.2)$$

equation (5.1) can be rewritten:

$$\chi^2(X) = \sum_{km}\left(\sum_{ij} H_{ij}^{km} X_{ij} - \sigma_{km}^{-1} p_{km}\right)^2 \quad . \qquad (5.3)$$

If H is considered a matrix with i and j contracted to the column index and k and m contracted to the row index, then $\hat{H}$, the Penrose generalized inverse of H, provides the reconstructed solution

$$X_{ij} = \sum_{km} \hat{H}^{ij}_{km} \sigma^{-1}_{km} p_{km} \quad , \tag{5.4}$$

which will minimize the χ^2 function. The error array XE is evaluated using

$$(XE)_{ij} = \left[\sum_{km} \left(\hat{H}^{ij}_{km} \right)^2 \right]^{1/2} \quad . \tag{5.5}$$

The magnitude of the ij and km indices of the matrix H in many applications are so large that the memory requirements for the generalized inverse method are the limiting factors of its usefulness.

6. Orthogonal Polynomial Expansion (MARR)

The method of orthogonal polynomial expansion parameterizes the distribution to be reconstructed by a set of coefficients of polynomials orthogonal on the unit circle. The transverse section is reconstructed using the statement

```
CALL  MARR (X,NDEG)
```

where

X — is the reconstructed transverse section;
NDEG — is the degree of the polynomial expansion;

(cf. Example 13 of section IX).

The maximum degree NDEG of the polynomial expansion is two less than the number of projection angles, which is the number of detectors. The subroutine MARR is a modification of the program ZHEAD (Version 2.0--12/10/71) supplied to us by R. Marr. (The algorithm is described in: R. B. Marr, J. Math. Anal. and Appl. 45, 1974, pp. 357-374.)

The data are assumed to be $N(N-1)/2$ line integrals of the source distribution for the transverse section between N equally spaced points on the periphery of a circle. In this geometry we can still represent the projection data p_{km} with k as a projection bin index and m as an angle index. With each projection measurement p_{km} there are associated two quantities z_k and θ_m, where z_k is the perpendicular distance of the center of the unit circle to the projected ray and θ_m is the angle of the projection. Polynomial coefficients ($\beta_{nn'}$ and $\gamma_{nn'}$) are calculated using the equations

$$\beta_{on'} = 0 \quad , \tag{6.1}$$

$$\gamma_{on'} = \frac{(2n' + 1)}{N^2} \sum_{km} \sin\left[(2n' + 1) \cos^{-1}(z_k)\right] p_{km} \tag{6.2}$$

$$\begin{Bmatrix} \beta_{nn'} \\ \gamma_{nn'} \end{Bmatrix} = \frac{2(n + 2n' + 1)}{N^2} \sum_{kn} \sin\left[(n + 2n' + 1) \cos^{-1}(z_k)\right] \begin{Bmatrix} \sin \\ \cos \end{Bmatrix} (n\theta_m)\, p_{km} \quad . \tag{6.3}$$

The reconstruction can then be calculated at the center of each pixel using

$$X_{ij} = \sum_{n=0}^{M} \sum_{n'=0}^{[(M-n)/2]} (\beta_{nn'} \sin n\phi_{ij} + \gamma_{nn'} \cos n\phi_{ij})\, r_{ij}^n Q_{nn'}\left(r_{ij}^2\right) , \tag{6.4}$$

where M=NDEG is the degree of the polynomial expansion, (r_{ij}, ϕ_{ij}) are the polar coordinates of pixel (i,j) with the center of the unit circle at the origin, and $Q_{nn'}(t)$ is a polynomial in t of degree n' with the explicit representation

$$Q_{nn'}(t) = \sum_{j=0}^{n'} (-1)^{n'-j} \binom{n'}{j} \binom{n+n'+j}{n'} t^j \tag{6.5}$$

The subroutine MARR is the only algorithm that reconstructs data explicitly for a ring geometry. However, by reorganization of the chords into parallel- or fan-beam projections, the same data can be used with other algorithms. Due to the ring geometry only the SETUP parameters: NDIMU, IGEOM, NANG, IMIT, NWORK, NFLOAT, ISTORE, IPRINT, and PWID have meaning (cf. section III). The others need not be assigned values.

Furthermore, while the definition of PWID is not different, the presence of detectors in an entire circle lends a different implication to the values it takes on. Remembering that NANG, the number of angles at which projections are collected (in the conventional sense) also represents the number of detectors comprising the ring, we can consider the case when the ring is inscribed in the NDIMU x NDIMU reconstruction region. Then the circumference of the circle in "projection bin widths" is just NANG so that

$$\text{NANG} = \pi \cdot \text{NDIMU} \cdot \text{PWID} \tag{6.6}$$

or

$$\text{PWID} = \text{NANG}/(\pi \cdot \text{NDIMU}) \quad . \tag{6.7}$$

To use PWID larger than this simply introduces zeroes in the reconstruction array outside the circle of detectors. The user can "zoom" in on the center of the reconstruction region by choosing PWID smaller than this value.

Before using the subroutine MARR the user <u>should study</u> section III.4, which describes the subroutine GETUM, since the data input is in a different format than for the other reconstruction algorithms.

7. Attenuation Correction

Transverse section emission imaging with single photon or positron annihilation photons requires compensating for attenuation effects. For positron imaging, the user must first correct the measured projection data by multiplying the sampled projection data by $\exp(\int\mu(x)dx)$, where $\int\mu(x)dx$ is the corresponding line integral of attenuation coefficients. The transverse section can then be reconstructed using one of the algorithms available in the RECLBL Library. For single photon imaging, the user can compensate for attenuation by using attenuation coefficients, which can be determined from a transmission experiment, or may be assumed constant over a convex region. Other methods of attenuation correction (cf. T. F. Budinger and G. T. Gullberg, in Reconstruction Tomography in Diagnostic Radiology and Nuclear Medicine, eds: M. M. Ter-Pogossian, et al., University Park Press, Baltimore, 1977, pp. 315-342) require either preprocessing the projection data or correcting the reconstructed but uncorrected transverse section using a correction matrix based on phantom studies.

The attenuation correction schemes used in the RECLBL Library assume that the projection data for the transverse section are the summation of pixel concentrations attenuated by a factor that is a function of the attenuation between the pixel and the edge of the object. The projections p_{km} are represented by

$$p_{km} = \sum_{ij} F_{ij}^{km} A_{ij}^{km} X_{ij} \quad , \tag{7.1}$$

where F_{ij}^{km} are weighting factors and A_{ij}^{km} are the attenuation factors, which are calculated by the subroutines EVATN or EVATU. The reconstructed pixel values X_{ij} can be determined by one of the iterative routines CONGR or GRADY using the appropriate projection and back-projection subroutines PPTA and BPTA, or PCDA and BCDA, or PRFA and BRFA.

The attenuation factors A_{ij}^{km} are evaluated from an array of attenuation coefficients by using the Fortran statement

CALL EVATN(B) ,

where

B is the array of attenuation coefficients.

The attenuation factors A_{ij}^{km} are evaluated using the equation

$$A_{ij}^{km} = \exp\left[\sum_{i'j'} L_{i'j'}^{km} B(i'j')\right] , \qquad (7.2)$$

where the summation is taken over the pixels (i',j') in the projection ray (k,m) from the pixel (i,j) in the direction of the measured projection. $L_{i'j'}^{km}$ is the length of that portion of a line centered in the projection ray (k,m) within the pixel (i',j'). For an NDIMU x NDIMU array and NANG projection angles, it is necessary to evaluate $(\mathrm{NDIMU})^2 \cdot \mathrm{NANG}$ attenuation factors. Due to the large number, the attenuation factors A_{ij}^{km} are stored on the file LUNATN, which is determined by the user as one of the SETUP input parameters.

A method of reconstructing single photon data and correcting for attenuation using attenuation coefficients evaluated from a transmission experiment is outlined as follows:

(1) Set parameter arrays IPAR and PAR and call SETUP (cf. section III).
(2) Input projection data from a transmission experiment using subroutine GETUM.
(3) Reconstruct the array B of attenuation coefficients using any appropriate reconstruction algorithm.
(4) Prepare for the emission reconstruction by resetting appropriate parameters in the arrays IPAR and PAR and call SETUP again.
(5) Evaluate the attenuation factors using the statement: CALL EVATN(B).
(6) Reconstruct the array of isotope concentrations using one of the iterative routines CONGR or GRADY with one of the back-projection subroutines BPTA, BCDA, BRFA, and correspondingly one of the projection subroutines PPTA, PCDA, PRFA.

Examples 8, 9, and 10 in section IX illustrate this method of attenuation correction, which requires two reconstructions: one for the transmission data to obtain the correction factors and one for the emission data to get the final reconstruction.

For the case of an object that has a constant attenuation coefficient, the attenuation factors A_{ij}^{km} can be determined using the statement

CALL EVATU (B,XLEV,ATENL) ,

where

- B is the transverse section that has not been corrected for attenuation;
- XLEV is the approximate ratio of the concentration in the object to the background for use by the boundary search routine;
- ATENL is the constant attenuation coefficient per pixel width.

The attenuation factors A_{ij}^{km} are evaluated using equation (7.2), where B(i',j')=ATENL for all pixels (i',j') within the boundary of the object. The boundary is determined using a search routine and the corresponding distribution of attenuation coefficients is displayed so that the user can change the parameter XLEV if necessary to obtain the true object shape. The user may desire to interact by varying XLEV until the desired object shape is obtained. The attenuation factors are stored on the file LUNATN and are read into memory in arrays of $NDIMU^2$ words when needed.

A method of reconstructing single photon data and correcting for attenuation assuming a constant attenuation coefficient is outlined as follows:

(1) Set parameter arrays IPAR and PAR and call SETUP.
(2) Input single photon projection data from an emission study using subroutine GETUM.
(3) Reconstruct the uncorrected transverse section B using one of the reconstruction algorithms.

(4) Evaluate the attenuation factors using the statement CALL EVATU(B,XLEV,ATENL).

(5) Reconstruct the array of isotope concentrations using one of the iterative routines CONGR or GRADY with one of the back-projection subroutines BPTA, BCDA, BRFA, and correspondingly one of the projection subroutines PPTA, PCDA, PRFA.

Examples 11 and 12 in section IX give example programs utilizing this method of attenuation correction.

VI. HOW TO USE THE LIBRARY

1. Summary of Reconstruction Procedures

To execute a reconstruction using the RECLBL Library, the user must prepare a main program with a declarative as well as an executable section. The declarative statements appear first in the sequence of program lines, but some are dependent on values or operations performed in the executable section. The set of declarative statements is

```
      DIMENSION B("NDIMU","NDIMU"), ANG("NANG")
      COMMON//WORK("NWORK")
      COMMON/OUTCOM/LUNOUT,I80132
      DIMENSION IPAR(12),PAR(3)
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)),
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)),
     2            (IMIT  ,IPAR( 7)),(NWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)),
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)),
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3))
      EXTERNAL "BCK","PRJ","CNV","FIL"
```

The meaning of each statement will become clear from the description of the executable statements below. Variable names enclosed in quotation marks represent a numeric constant whose value is dependent on the value given to that variable. For example, if NDIMU = 64, then the statement represented by DIMENSION B("NDIMU","NDIMU") is DIMENSION B(64,64). Of course, the variable names used are up to the user. The EQUIVALENCE statement has been included above for convenience, but is not a necessary declarative statement. In what follows, the elements of the IPAR and PAR arrays are referred to by the names given them in the EQUIVALENCE statement. Any additional declarative statements included by the user should carefully observe the reserved common block names given in table 1.

There are three basic steps to executing a reconstruction with the RECLBL Library. The first step is to establish the values of the input parameters using the SETUP subroutine. The second step is to actually execute the reconstruction. The third step is to display and/or save the resulting image.

There are 17 parametric values to be decided upon before SETUP can be called. These can be broken down into four categories: those describing the image that is to be reconstructed (3 parameters), those that describe the projection data that is to be input (7 parameters), those that describe the computational environment in which the reconstruction will be carried out (4 parameters), and those that control the output received from the library (3 parameters).

The first three parameters are NDIMU, ICIR and PWID. The value for NDIMU is usually related to the expected resolution in the image. If a pixel is chosen much smaller than the obtainable resolution, the library may calculate values that do not have physical significance and will cost the user memory space and computation time. If the pixel size is chosen much larger than the resolution, then resolution is lost. The parameter ICIR can save the user memory space and execution time. If the object to be reconstructed fits entirely within a circular domain of diameter $\leq$ NDIMU, then ICIR should be set to 0. It is important to note that the entire object to be imaged must lie within the NDIMU x NDIMU array. The parameter PWID gives the width of a pixel in projection bin units. For the most efficient use of memory PWID$\simeq$KDIMU/NDIMU. In most cases KDIMU (cf. section III.2 and below) is fixed by the data collection geometry, and thus PWID and NDIMU show an inverse relationship. If one of these is known (or its desired value is known) the value of the other is also determined. For example, it has been shown (cf. R. H. Huesman, Phys. Med. Biol. 22, 1977, pp. 511-521) that PWID should be at least 1.5 when using iterative reconstruction techniques. Thus, if KDIMU was 100 during data collection, NDIMU should be $\leq$66. Conversely, if the reconstruction phase is considered before data collection, then knowledge of PWID and NDIMU will dictate the required spatial sampling.

The second set of SETUP parameters describes how the projection data were collected for the number of angles, NANG. MODANG is a coded parameter that defines the initial angle, angular increment, and angular range of the NANG angles. Again, consideration of how the data will be reconstructed before their actual collection, may make the reconstruction phase easier. For MODANG≠0 or 1, the library generates angles equally spaced over π or 2π radians. If these angles have been used in data collection, the user may choose one of these values for MODANG and avoid having to supply the angles to SETUP (cf. section III.2 for MODANG options). Three reconstruction algorithms (i.e., CONVO, FILBK, BKFIL) rely on data having been collected at equally spaced angles in order to arive at a correct solution, and in some cases the library will not execute the reconstruction unless this is the case. Thus, the user is advised to let the library generate the data collection angles whenever possible. IGEOM describes the geometry (i.e., fan, parallel, ring) in which the data were collected. KDIMU is the parameter describing spatial sampling and represents the number of projection bins in each projection. IMIT indicates whether to reconstruct emission or transmission data.

AXISU describes where in the projection array the axis of rotation is projected. In general, if the axis is to fall in the exact center of the projection array, AXISU=(KDIMU+1)/2. It is very important to locate the AXIS of rotation as accurately as possible (to precision of less than 1 bin if possible), since even small errors may cause artifacts in the reconstruction. RFAN is the distance from the fan beam source to the center of rotation and is only meaningful under fan-beam geometry conditions.

The third group of SETUP parameters describes the computational environment in which the reconstruction is to be carried out. NWORK is the number of floating point variables that have been provided as working space for the library. There must be a COMMON//WORK("NWORK") statement reflecting the value given NWORK in the declarative portion of the main program. (For example, if NWORK=100, then there must be a COMMON//WORK(100) statement somewhere in the main program.) The minimum value of this parameter may be determined by running a "storage size test" (described below). NFLOAT gives the number of computer words that actually make up one floating point variable in the array WORK. (For example, if the computer has 16-bit words and floating point variables are represented in 32 bits, then NFLOAT=2.) LUNOUT (in common block/OUTCOM/) and LUNATN are logical unit numbers for printed output and attenuation factor scratch storage, respectively. If LUNOUT is not given a value the library cannot communicate with the user.

The fourth group of SETUP parameters governs the execution of the reconstruction and the format of the output. ISTORE may be used to implement a "storage size test" to determine the amount of blank common that is needed for the reconstruction. IPRINT contains six 1-bit print flags that govern what output is received during the reconstruction. I80132 (word 2 of common block/OUTCOM/) is a flag that determines the width of the output (either 80 or 132 characters/line).

After all of the above parameters are given values, SETUP is called using the statement:

```
CALL  SETUP (IPAR,PAR,ANG)    .
```

The second phase of execution involves the actual reconstruction. Several considerations must be made at this juncture. First, if attenuation compensation is to be done during the reconstruction, attenuation factors must be calculated first using the routines EVATN or EVATU (cf. section V.7). Calculation of these factors usually involves a reconstruction as well, as in the case of using a transmission scan to correct for the attenuation in an emission scan. The next step is to determine what type of weighting model is to be used in the projection/back-projection operations and/or what type of filter or convolution function is to be used. The names of the routines (such as BCD, PCD, SHLO, BUTER, etc.) decided upon should be entered in the EXTERNAL statement in the declarative portion of the program (see above). In addition, they are included in the calling sequence of the reconstruction routine.

Another integral part in the actual execution of the reconstruction is input of the projection data via the user-supplied subroutine GETUM. The user must supply a routine that returns the projection data one angle at a time with each projection being KDIMU in length. If appropriate, the measurement uncertainty for each projection value must also be returned.

If an iterative reconstruction method is being employed (GRADY, ENTPY or CONGR), subroutine USER will be called between each iteration. USER is a subroutine that allows the user access to the reconstruction array between steps in the iterative process. While it is not necessary that a subroutine of that name be supplied (since a default routine is supplied with the package), the user may desire more information than that supplied by the default routine and may supply a replacement.

When the reconstruction subroutine returns control to the main program, the reconstructed image is stored in the NDIMU x NDIMU array stipulated in the calling sequence. It is now up to the user to display it or save it as desired. Two display routines are provided in the RECLBL Library. ARRAY is a subroutine that displays a 2-dimensional, gray-scale image using an overprinting scheme. The second display routine, XYGRF, makes 1-dimensional slices through the 2-dimensional array and displays them graphically on the output device. All other graphical display or output of the image onto peripheral storage devices is left to the user.

A summary of the steps for the preparation of a FORTRAN program to obtain a reconstruction from the RECLBL Library follows:

(1) Set up declarative statements that are consistent with values given to SETUP parameters in the executable section including the common blocks /OUTCOM/ and blank common //, arrays IPAR and PAR, an array for the reconstruction and one for the projection angles (if MODANG=0 or 1).

(2) Choose the back-projection or projection weighting model or filter or convolution function to be used in the reconstruction as well as other options provided by the reconstruction routine. Be sure to declare these subroutines in an EXTERNAL statement.

(3) Assign values to the IPAR and PAR variables and the two variables in /OUTCOM/.

(4) Call SETUP.

(5) Call the reconstruction subroutine.

(6) Display and/or store the reconstructed image using ARRAY, XYGRF, or some user-supplied subroutine.

In addition the user must provide a subroutine GETUM for projection data input and, if appropriate, a subroutine USER.

2. Library Output

As the various subroutines in the library are executing, they communicate with the user via output on the file LUNOUT. While the output is intended to be self-explanatory, this section will attempt to clarify any ambiguities that remain and point out details that may be especially useful to the user.

The output obtained on any one run is, of course, a function of what subroutines are employed during the reconstruction and what print options are chosen by the user (cf. section III.3). However, many portions will be common to most runs. These are the ones that will be described here.

In most cases the first output received will be from the subroutine SETUP. Figure 13 shows sample output that was obtained during a test run. As with all user-called routines, SETUP alerts the user of its initiation by printing its name in large block letters. The first part of the listing contains the values input in the integer parameter array IPAR (cf. section III for details of their meanings) and the second part contains the values for the floating point array PAR. The first

```
 SSS  EEEEE TTTTT U   U PPPP
S     E       T   U   U P   P
 SSS  EEE     T   U   U PPPP
    S E       T   U   U P
 SSS  EEEEE   T    UUU  P


        INTEGER PARAMETER ARRAY  (IPAR)

 I   IPAR(I)     DESCRIPTION

 1      64       LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
 2       0       RECONSTRUCT IN A CIRCULAR ARRAY
 3       0       GEOMETRY FLAG
                 PARALLEL BEAM GEOMETRY
 4      50       NUMBER OF PROJECTION ANGLES
 5       2       MODE FOR PROJECTION ANGLE INPUT  (SEE FOLLOWING LINES)
                 ANGLES GENERATED BETWEEN ZERO AND PI
                 STARTING AT THE HALF ANGLE
 6     100       NUMBER OF RAYS FOR EACH PROJECTION
 7       0       EMISSION DATA
 8   18500       DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
 9       1       NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10       1       THIS IS A STORAGE SIZE TEST (NO RECONSTRUCTION)
11       5       PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES)
                 PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED
                 PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
12       X       LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE


        FLOATING POINT PARAMETER ARRAY  (PAR)

 I    PAR(I)   A   DESCRIPTION

 1     .750        PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
 2   50.500        LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
 3        0  (NA)  NOT APPLICABLE  (NOT FAN BEAM GEOMETRY)

BLANK COMMON REQUIRED         50   (    62)

BLANK COMMON REQUIRED        100   (   144)

BLANK COMMON REQUIRED        150   (   226)   —B

BLANK COMMON REQUIRED        350   (   536)

BLANK COMMON REQUIRED        478   (   736)
                                                      C       D
A TOTAL OF   52 ( 25 THRU  76) OF THE 100 USER PROJECTION BINS WILL BE USED

52 PROJECTION BINS WILL BE USED OF WHICH    0 HAVE BEEN ZEROED BY THE PROGRAM

   MAXIMUM SIZE OF BLANK COMMON THUS FAR=     478 FLOATING POINT WORDS.
                                                                   E
EEEEE N   N DDDD          SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D        S     E       T   U   U P   P
EEE   N N N D   D         SSS  EEE     T   U   U PPPP
E     N  NN D   D            S E       T   U   U P
EEEEE N   N DDDD          SSS  EEEEE   T    UUU  P
```

```
PPPP  H   H  AAA  N   N
P   P H   H A   A NN  N
PPPP  HHHHH A   A N N N
P     H   H AAAAA N  NN
P     H   H A   A N   N


PHANTOM GENERATED
  ARRAY SIZE   64 X  64   INTEGRATION FACTOR =  10   SCALING FACTOR =    1.333
  NUMBER OF ELIPSES AND/OR RECTANGLES =    4
  THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
       X,Y  - CENTER
       A,B  - LENGTH OF AXIS OR SIDE A AND B
       PHI  - ANGLE OF AXIS OR SIDE A
       DENS - INTENSITY
  THE PARENTHESIS INDICATES THE SCALED VALUE
   ITYPE                X          Y        A          B          PHI      DENS
     1   - ELLIPSE           0 ,        0   40.00 ,    40.00         0      5.00
                    (        0),(       0)(  53.33),(  53.33)          (   2.81)
     1   - ELLIPSE           0 ,   -10.00   10.00 ,    10.00         0     27.00
                    (        0),( -13.33)(  13.33),(  13.33)          (  15.19)
     1   - ELLIPSE      10.00 ,         0   14.00 ,    10.00      1.57     -4.00
                    (   13.33),(        0)(  18.67),(  13.33)          (  -2.25)
     1   - ELLIPSE     -10.00 ,         0   14.00 ,    10.00      1.57     -4.00
                    (  -13.33),(        0)(  18.67),(  13.33)          (  -2.25)


        EEEEE N   N DDDD       PPPP  H   H  AAA  N   N
        E     NN  N D   D      P   P H   H A   A NN  N
        EEE   N N N D   D      PPPP  HHHHH A   A N N N
        E     N  NN D   D      P     H   H AAAAA N  NN
        EEEEE N   N DDDD       P     H   H A   A N   N          F

BLANK COMMON REQUIRED        510   (   776)

BLANK COMMON REQUIRED        478   (   736)


                 CCC  OOOOO N   N V   V OOOOO
                C   C O   O NN  N V   V O   O
                C     O   O N N N  V V  O   O
                C   C O   O N  NN  V V  O   O
                 CCC  OOOOO N   N   V   OOOOO


          PARAMETERS FOR SUBROUTINE CONVO

                 DESCRIPTION
                                                            G
IERR -       0    DO NOT CALCULATE ERRORS

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG     FUNCTION          RAY WEIGHTING       ATTENUATION          FAN BEAM
BCK     BACKPROJECTION    LINE LENGTH             NO                   NO
CNV     CONVOLUTION           N/A                 NO                   NO

BLANK COMMON REQUIRED        582   (  1106)

BLANK COMMON REQUIRED        685   (  1255)

BLANK COMMON REQUIRED        686   (  1256)

BLANK COMMON REQUIRED        582   (  1106)

BLANK COMMON REQUIRED        479   (   737)

BLANK COMMON REQUIRED        478   (   736)

       MAXIMUM SIZE OF BLANK COMMON THUS FAR=    686 FLOATING POINT WORDS.


         EEEEE N   N DDDD       CCC  OOOOO N   N V   V OOOOO
         E     NN  N D   D     C   C O   O NN  N V   V O   O
         EEE   N N N D   D     C     O   O N N N  V V  O   O
         E     N  NN D   D     C   C O   O N  NN  V V  O   O
         EEEEE N   N DDDD       CCC  OOOOO N   N   V   OOOOO
```

Figure 13. Example of library output.

column gives the index of the parameter on that line. The second column gives the actual value input and the third column gives a description of what it means. Between the second and third columns flags will occasionally appear. They will be the letters NA or ER. NA means the value for this parameter is not applicable to the situation as defined by parameters above it. For example, in figure 13 the third line under the PAR heading the reader will see NA between columns 2 and 3 (labeled A). This indicates that the distance of the fan source from the center of rotation is not necessary since IPAR(3), the geometry flag, indicates the reconstruction will use parallel-beam geometry. If the ER flag is seen, it indicates that a fatal error has been detected in the input to SETUP. At the end of the SETUP output an error message will be printed telling how many errors were detected. The lines containing the ER flag indicate the input values that were in error.

The next portion of the SETUP output will be a few lines similar to those labeled B in the figure (assuming the appropriate print option has been indicated). These are lines output by the memory management routine that tell the user how much blank common is in use at the time the line is printed. The multiple lines indicate that several requests for memory allocation have been generated by the library. The first number in the line is the decimal number of floating point variables in use and the number enclosed in parentheses is its octal equivalent.

The next line of output, labeled C, indicates to the user which portion of the supplied projection array will be used during the reconstruction. In this case the user has supplied 100 bins when only 52 are necessary. Since the axis of rotation has been placed 50.5 projection bins from the beginning of the array, the library uses 26 on either side of it or bins 25 through 76.

Line D indicates how many bins will actually be used as the projection array during the reconstruction and how many, if any, are assumed to be zero in value. In this case a sufficient number of bins has been supplied. However, if the user's projection array is found not to be long enough to cover the entire reconstruction region, the library will add bins on either side until the projection array is long enough. These bins are assumed to have the value zero for all projection angles.

Line E is the closing line of the SETUP output (and several other routines). It informs the user of the largest amount of blank common that has been in use up to that point in the program. If one wishes to know the maximum amount that is ever in use, simply find the last time this message is printed during the job. SETUP indicates it has completed execution by printing END SETUP in large block letters.

In the job shown in figure 13 a phantom was generated using the subroutine PHAN (cf. section VII). The output from it is labeled F. All of the input values are printed. In this particular case the phantom was generated in a 64 x 64 pixel array. When a pixel was found to fall only partially inside one of the ellipses comprising the phantom, it was divided into 10 x 10 (or 100 total) "pixelettes" in order to determine what percentage of the full value should be assigned to that pixel. There are 1.33 pixels/projection bin. The entire phantom is composed of 4 ellipses. If the pixelized array is considered to have (x,y) coordinates with the origin in the exact center of the array, then the centers of the four ellipses are at the points (0,0), (0,-13.33), (13.33,0) and (-13.33,0). These values were arrived at by applying the conversion factor of 1.33 to the actual input values, which are in terms of projection bin width. The center points in units of projection bins are listed above the corresponding converted values that are in parentheses.

The major and minor axes of the ellipses are listed in a similar fashion as the center points under the columns headed A and B, respectively. The angle that the major axis makes with the x-axis is listed in the PHI column and the density assigned to each pixel in an ellipse is listed under DENS.

In summary, the first ellipse is centered at the origin (0,0); it has major and minor axes of 53.33 pixels (i.e., it is a circle); its major axis is colinear with the x-axis; and each pixel completely inside it has a value of 2.81. The fourth ellipse, however, is centered at (-13.33,0) in the pixel array; has major and minor axes of 18.67 and 13.33 pixels, respectively; its major axis makes an angle of 1.57 ($\pi/2$) radians with the x-axis and each pixel inside it has a value of -2.25.

The beginning of the next section of output is delimited by the large letters CONVO. This indicates that the user has called subroutine CONVO and is about to perform a convolution reconstruction. The first few lines of output from any of the major reconstruction routines (BKFIL, CONGR, CONVO, ENTPY, FILBK, GRADY, GVERS, or MARR) are a list of what the input values were and what the subroutine has interpreted them to mean. In this case the only input parameter to be interpreted is IERR. Its value was passed as 0 and CONVO interprets that to mean that the user does not want errors calculated for the reconstructed values. Next the algorithm must determine if the back-projection and projection (or filter or convolution) routines chosen by the user are compatible. There is a single routine in the package that is used to do this and typical output from it is labeled G.

This particular output indicates that the arguments specified in the call to CONVO were a back-projection routine and a convolution routine, which is correct for CONVO. Any other combination would be an error and an error message would be printed. For the other reconstruction methods, the correct combinations are:

(1) BKFIL and FILBK must have a back-projection and a filter routine,

(2) CONGR, ENTPY, GRADY, and GVERS must have a back-projection and a projection routine.

(3) The MARR reconstruction routine does not use back-projection, projection, convolution or filter routines.

The column labeled "ray weighting" explains what model is employed in the projection/back-projection operation. In this case the back-projection value assigned to a pixel is proportional to the length of the line emanating from the center of a projection bin that intersects that pixel. Other entries that may appear in this column are DELTA FUNCTION, CONCAVE DISK, UNIFORM SQUARE or INTERPOLATION (cf. section IV for full description of what these models imply). Since the convolution routine does not perform either a back-projection or projection operation the "ray weighting" column contains an N/A (not applicable) entry.

The next column indicates whether the routine in question uses attenuation factors in calculating projection/back-projection values. In this case neither does. If attenuation factors are to be used in the projection/back-projection operations, it is important that the user employ either of the subroutines EVATN or EVATU to store the coefficients on the file LUNATN before calling the main reconstruction routine. If this has not been done an error message will be generated and execution terminated.

The last column indicates whether the routine assumes fan-beam or parallel-beam geometry. In this case, both assume parallel-beam. It is important that both the back-projection and projection (or convolution or filter) routines make similar assumptions and use the same model in order that the reconstruction be correct. If this is not the case, an error message is generated. The output just described may be consulted to locate the exact cause of the error if an error message is printed.

In addition, certain reconstruction methods or options require that special purpose routines be used with them. If the user attempts to use a routine that cannot fulfill the task requested, a self-explanatory error message will be printed after the just described output. All of the limitations that must be observed with each reconstruction method are given in the appropriate parts of section V.

The remaining output from CONVO consists of lines from the memory management routine already described. It ends with the line informing the user of the largest amount of blank common storage used to that point in the program (also described above). Termination of the subroutine CONVO is indicated by the large block letter message END CONVO.

Output that was not encountered in this run, but may be seen in others (by selecting more print options and/or using other reconstruction routines) include a printout of the projection data and their uncertainties as they are input from the user-supplied subroutine GETUM, a printout of the values of the convolution function (for CONVO), the filter function in Fourier space (for FILBK or BKFIL) or the Lagrange multipliers and their gradient function (for ENTPY). When using the iterative reconstruction methods, the subroutine USER is called between successive iterations and output may be generated from that routine. (The default subroutine USER supplied with the package prints the value of the function being optimized and the iteration number.) All of these are accompanied by self-explanatory headings and messages.

3. Library Display Routines

The RECLBL Library provides the two display routines ARRAY and XYGRF. The subroutine ARRAY produces a two-dimensional gray-scale display using overprinting on the output device. The subroutine XYGRF produces a plot of intensities for one-dimensional slices through a two-dimensional array.

Any two-dimensional array may be displayed on an output device that has an overprinting capability using the statement

```
CALL  ARRAY(B,NXN)  ,
```

where

B   is the array to be imaged;

NXN   is the dimension of the array.

The subroutine is coded assuming the printing device has ten characters per inch and six lines per inch. The subroutine interpolates vertically between pixels in order that the array appear square. The format statements use carriage control statements, which are used by the line printer at Lawrence Berkeley Laboratory for implementing the overprinting capability. These statements assume that the carriage control is affected after the line has been printed. The subroutine is coded so that this gives a gray-scale image with 21 levels of gray (cf. I. D. G. McLeod, IEEE Trans. Computers C-19, 1970, pp. 160-162).

Cross-sectional plots of a two-dimensional array are graphically displayed using the statement

```
CALL  XYGRF(B,N,NP,BMAX,BMIN,IXY,ICOR,IL,IU)
```

where

B	is a square array from which plots are generated;
N	is the dimension of B (i.e., B(N,N));
NP	is the number of cross-sectional plots;
BMAX	is the maximum value for the plot; if BMAX = 999999., the maximum will be determined from the data;
BMIN	is the minimum value for the plot; if BMIN = 999999., the minimum will be determined from the data;
IXY	determines the direction of the cross section; if IXY = 0, the cross section is parallel to the x-axis; if IXY = 1, the cross section is parallel to the y-axis;
ICOR	is an array of x- or y-intercepts that determines the location of the cross section;
IL	is the lower coordinate for the plot;
IU	is the upper coordinate for the plot.

The maximum number of plots that can be displayed on the same graph is 10. If NP=1, then the cross-sectional plot will appear as a histogram where the spaces between the axis and the functional value are filled in with the symbol X. For NP>1, the functional value for each cross section will be given a different symbol and only one symbol will be plotted for each function at each coordinate value. It is assumed that the array is stored such that the array value B(I,J) corresponds to the value at the point (I,J) relative to a standard (x,y) coordinate system with (1,1) in the bottom left corner of the first quandrant of the xy-plane. Example 7 uses the subroutine XYGRF in the subroutine USER to graph one cross-sectional plot parallel to the x-axis for each iteration.

4. Error Handling

During execution of a reconstruction subroutine, if errors that result from inconsistent user requests, omission of input parameters, or inappropriate data input are detected, a self-explanatory error message is printed on the file LUNOUT. In addition, an error number is printed in large block letters. If the detecting routine is user-called, its name is also printed in large block letters. If the error is nonfatal, the program will continue; but if it is fatal then STOP is printed in large block letters on LUNOUT and program execution is terminated.

There are a small number of errors that under normal circumstances should never occur. However, user coding errors or yet-undetected library errors may result in destruction of portions of the executable code or internal variables causing a program stop with a message to the user of a SYSTEM ERROR rather than just a plain ERROR. If this should occur, the user should carefully check the main program and any user-supplied subroutines to be sure that no addressing errors (such as incorrect array subscripts) are the cause. Ample documentation of unresolved problems should be sent to the Donner Laboratory Research Medicine Group (cf. section I.4). Error messages, their identification numbers, the routine that detects them and whether they are fatal or not appear in table 3.

Table 3. RECLBL Library Error Messages.

Error No.	Routine	Fatal	Error Message
1		Y	SETUP must be called before ____________.
2	SETUP	Y	Errors in IPAR or PAR arrays.
3	MEMST	N	The amount of space in common block WORK is larger than the amount allocated by the user. This run is now a storage size test, no reconstruction will be executed.
4	STPTR	Y	The rotation axis (AXISU = XXXXX.XX) does not project into the reconstruction array. The projection is XXXXX bins long.
5	STPTR	Y	The fan source at a distance of XX.XXXEXXX is inside the reconstruction array. The distance from the fan source to the center of rotation must be at least XX.XXXEXXX.
6	STPTR	Y	The reconstruction array does not project into any user projection bins.
7	RCHEK	Y	These are inconsistent. Explanation: The combination of back-projector and projector/filter/convolver chosen by the user is inconsistent. Consult listing just above error message for description of the choices that were specified.
8	RCHEK	Y	Due to lack of appropriate filters, BKFIL cannot execute fan-beam reconstructions at the present time.

Table 3. Continued.

Error No.	Routine	Fatal	Error Message
9	RCHEK	Y	When using fan-beam geometry and the subroutine FILBK, one of the back-projection subroutines BCDF2, BPTF2, BRFF2, should be used.
10	RCHEK	Y	Should use BCDF2, BPTF2, BRFF2 only with the subroutine FILBK.
11	RCHEK	Y	Cannot use attenuation projection and back-projection subroutines with the subroutine ENTPY.
12	RCHEK	Y	The requested back-projection subroutine will not calculate errors for convolution reconstructions.
13	RCHEK	Y	For this weighting model pixels and projection bins must be the same size (PWID=PAR(3)=1.0).
14	RCHEK	Y	These subroutines are inconsistent with the fan-beam parameters seen by SETUP.
15	RCHEK	Y	Attempted call of a projection or back-projection subroutine requiring attenuation factors before the factors were evaluated.
16	RCHEK	Y	For convolution and Fourier reconstruction methods, projection angles must be equally spaced over at least π radians for parallel-beam geometry. To ensure this MODANG=IPAR(4) must not be 0 or 1 in the call to SETUP.

Table 3. Continued.

Error No.	Routine	Fatal	Error Message
17	RCHEK	Y	For convolution, Fourier, and entropy reconstruction methods, projection angles must be equally spaced over 2π radians for fan-beam geometry. To ensure this MODANG=IPAR(4) must be 3, -3, 5 or -5 in the call to SETUP.
18	RCHEK	Y	Must use BINF when performing convolution on fan-beam data.
19	RCHEK, BJECT, PJECT	Y	Must use the MARR reconstruction algorithm on ring geometry data.
20	CONGR, GRADY	Y	The number of steps NSTP=XXX is less than 0.
21	FMCG	Y	There is an error in the gradient calculated by the subroutine DULFC.
22	FMCG	N	Convergence was not obtained in the limit number of iterations.
23	FMCG	Y	The linear search technique indicates it is likely that there exists no minimum.
24	FILBK	Y	The dimension of the reconstruction array, NDIMU=IPAR(1), must be even for subroutine FILBK.
25	MARR	Y	The MARR reconstruction method can only be used for ring geometry (SETUP input parameter IGEOM=IPAR(3)=3).
26	MARR	Y	The number of crystals NXTAL=XXX is not even.

Table 3. Continued.

Error No.	Routine	Fatal	Error Message
27	MARR	N	A ring of XXX detectors and pixels that are XX.XXX the size of one detector implies that the entire ring will be inscribed in a square XXX pixels on a side. Using an array of XXX pixels on a side will only result in zeroes outside a radius of XX.XXX.
28	MARR	N	The maximum degree of the polynomials for a ring of XXX detectors is XXX. The reconstructed values will be computed to this degree.
29	BJECT	Y	The back-projection subroutine is inconsistent with the fan-beam parameters seen by SETUP.
30	BJECT	Y	Attempted call of a back-projection subroutine that uses attenuation factors before the factors were evaluated.
31	CBARP	Y	NREPS*NBARS=XXX is greater than 100.
32	EVATU	Y	Zero range in reconstructed array. No attenuation factors calculated.
33	EVATU	Y	Target to nontarget must be greater than 1. The value was .XXXEXXX.
34	GETUM	Y	A data input subroutine named GETUM must be supplied by the user.
35	PHANL	Y	There is a parameter error in the call to subroutine PHANL. (This is followed by a self-explanatory description of the rules for parameter values and a list of the values input.)

Table 3. Continued.

Error No.	Routine	Fatal	Error Message
36	PHANL	N	Warning . . . negative source (or attenuation) detected during generation of PHANL data.
37	PJECT	Y	The subroutine PJECT cannot be called during the execution of FILBK.
38	PJECT	Y	The projection subroutine is inconsistent with the fan-beam parameters seen by SETUP.
39	PJECT	Y	Attempted call of a projection subroutine that uses attenuation factors before the factors were evaluated.
40	XYGRF	Y	Input parameter IXY=XXX is not set properly.

System Error No.			
1	FTATN	Y	No message--just SYSTEM ERROR 1 in large letters.
2	MEMST	Y	XXXXXX is not a valid pointer.
3	MEMST	Y	LPTR is negative, but not -ISET (-XXXX).
4	PHAN	Y	No message--just SYSTEM ERROR 4 in large letters.
5	STATN	Y	No message--just SYSTEM ERROR 5 in large letters.

VII. GENERATION OF PHANTOMS AND PROJECTION DATA

The RECLBL Library has the ability to generate images of phantom objects and projection data that could theoretically be collected from them. If the user wishes to experiment with different reconstruction methods, he may employ the following subroutines to generate a variety of phantoms and corresponding projection data.

The general phantom generating subroutines of the RECLBL Library are PHAN and PHANL. These two subroutines have much in common and will therefore be described together. PHAN will generate a pixelized image of any phantom composed of ellipses and rectangles, and PHANL will generate analytic projections of any phantom that PHAN can generate. For purposes of simulating emission data with PHANL, each ellipse or rectangle can be specified as a source or attenuator. The value of each bin in the projection will be a line integral of source activity with attenuation included if appropriate. The amount of attenuation is a function of the density (attenuation coefficient) of the attenuator and the length of attenuating material that the source radiation must traverse on its path to the detector.

The phantom/phantom data generated by the routines PHAN/PHANL are from a superposition of rectangles and ellipses whose size and orientation are defined by the user in arrays that are arguments of these subroutines. The calling sequence for PHAN is

```
CALL  PHAN(N,INTG,ITYPE,DENS,X,Y,A,B,PHI,BB,NBB,PIXW)
```

where

- N — is the total number of ellipses and rectangles that make up the phantom.
- INTG — is an integration factor. PHAN generates the phantom in a discrete pixelized space. When the edges of an ellipse/rectangle do not coincide exactly with the boundary of a pixel, PHAN gives that pixel a fractional part of the full value according to what portion of the pixel lies

inside the phantom. To do this, PHAN divides each border pixel into INTG x INTG "pixelettes," each of which is tested for "insideness" and the final value given to the pixel is the full value times the fraction of pixelettes found inside the phantom. This border "integration" gives the image a smoother appearance. We have found a reasonable value for this is 10.

ITYPE is an array that describes the ellipses/rectangles. For the I^{th} ellipse/rectangle, ITYPE(I) can take on the following values:

1 for a source ellipse

2 for a source rectangle

DENS is an array that describes the density (or attenuation coefficient) of each shape. For transmission this is in units of inverse projection bin width, and for emission in units of inverse bin width squared.

X,Y are two arrays that describe the (x,y) coordinates of the center of each ellipse/rectangle relative to the center of the image array. These are in units of projection bin width.

A,B are two arrays that describe the major and minor axes, respectively, of the ellipses or the lengths of the sides of the rectangles.

PHI is an array giving the angle in radians that the major axis (A above) makes with the x-axis.

BB is the array in which the image is generated.

NBB is the dimension of BB, which is assumed square.

PIXW is the pixel width in units of bin width. Since X, Y, A and B are all given in units of bin width, this is the conversion factor from bins to pixels. The sign of PIXW is used to normalize the total number of "counts" in the image so that it can be directly compared to a reconstructed image. It should be positive (+) for transmission and negative (-) for emission.

The calling sequence for PHANL is

```
CALL  PHANL(N,ITYPE,DENS,X,Y,A,B,PHI,P,M)
```

where

- N — is the total number of ellipses and rectangles that make up the phantom.
- ITYPE — is an array that describes the ellipses/rectangles. For the I^{th} ellipse/rectangle ITYPE(I) can take on the following values:
  - 1 for a source ellipse
  - 2 for a source rectangle
  - -1 for an attenuating ellipse
  - -2 for an attenuating rectangle.
- DENS — is an array that describes the density (or attenuation coefficient) of each shape. For transmission data this is in units of inverse projection bin width, and for emission in units of inverse bin width squared.
- X,Y — are two arrays similar to ITYPE that describe the (x,y) coordinates of the center of each ellipse/rectangle. These are in units of projection bin width.
- A,B — are two arrays that describe the major and minor axes, respectively, of the ellipses or the lengths of the sides of the rectangle.
- PHI — is an array giving the angle in radians that the major axis (A above) makes with the x-axis.
- P — is an array at least KDIMU (SETUP input-parameter IPAR(6)) long in which PHANL generates the projection.
- M — is the angle index at which the projection is calculated (the angles are either supplied to or generated by SETUP).

Arrays X, Y, A, B, PHI, DENS, and ITYPE in both routines must be dimensioned at least as large as the number of ellipses/rectangles in the phantom. The I^{th} entry in each of these arrays is the appropriate parameter for the I^{th} shape. Only PHANL uses parameters from SETUP so phantom development can be done using PHAN without calling SETUP. PHANL and PHAN are conveniently used together since reconstruction of data generated by PHANL may be compared to the corresponding phantom generated by PHAN. However, it is not necessary to create a pixelized phantom image using PHAN in order that PHANL be able to generate projection data. Demonstrations of the use of these two routines are given in section IX.

In addition to the general phantom generators, two special phantom generators in the RECLBL Library are PIE and CBARP. PIE generates an image of a circle containing equal-sized, alternating black and white sectors. CBARP generates a circular bar phantom. This is a phantom consisting of alternating black and white bars superimposed on a circular domain. The bar pattern is generated such that the last bar in each repetition of the pattern is 1/2 as wide as the previous bar, 1/3 as wide as the third last, etc. (cf. Example 16, section IX). The bar pattern may be repeated as many times as desired across the circle with the limitation that the number of bars in the pattern times the number of repetitions of the pattern is less than 100. Projection data are obtained from these phantom generators using subroutine PJECT. PJECT generates projection data for any phantom that can be represented in a pixelized array. It gives the added freedom of allowing the user to choose which model of activity distribution he wishes to employ during the projection operation (see section IV for the choices available). However, it should be noted that PHANL comes the closest to mimicking the data that would be collected in a physical situation. (This can be closely approximated by use of the projector PLL in conjunction with PJECT.)

The calling sequence for PIE is

```
CALL  PIE(B1,N,R,X1,Y1,Z,INTFAC,NSLIPI,ISTART)
```

where

B1 is the array where the phantom is generated.

N is the dimension of the square array B1.

R is the radius of the circle (in pixel units)

X1,Y1 are the coordinates of the center of the circle with respect to the center of the array (in pixel units).

Z is the amplitude value to be assigned to pixels that are completely in a black section.

INTFAC is an integration factor (see description of INTG under PHAN above).

NSLIPI is the total number of slices in half of the pie (or the number of black slices in the whole pie).

ISTART is an indicator of the color of the first slice (counter-clockwise from straight up). If it is zero, the first section is white; otherwise it is black.

The calling sequence for CBARP is

```
CALL  CBARP(B1,N,R,X1,Y1,Z,INTFAC,NBAR,NREPS,IDIREC)
```

The meaning of the parameters is the same as for PIE with the following exceptions:

NBAR is the total number of bars in one repetition of the bar pattern.

NREPS is the number of repetitions of the pattern across the entire circle.

IDIREC is the direction the bars should be in:
0 = horizontal,
1 = vertical,
2 = annular rings.

The calling sequence for PJECT is

```
CALL  PJECT(B,P,M,PRJ)
```

where

B | is the array containing the image from which the projection is to be calculated.

P | is the array at least KDIMU (SETUP input parameter IPAR(6)) long in which the projection is generated.

M | the index of the angle at which the projection is to be taken (the angles are either supplied to or generated by SETUP).

PRJ | the name of the projection subroutine to be used in the projection operation. It must be declared in an EXTERNAL statement in the calling routine.

PJECT depends on values supplied to SETUP in its computations, and thus, SETUP must be called before PJECT can be used.

In section IX, Examples 5, 6 and 17 use PIE to generate a phantom and Examples 5 and 6 use PJECT to get projection data from it. Example 16 shows the use of CBARP.

VIII. STORAGE REQUIREMENTS AND TIMING

1. Storage Requirements

The amount of storage that must be allocated in blank common is a function of the SETUP parameters NDIMU, NANG and KDIMU. The terms that make up the function vary depending on the reconstruction algorithm, the back-projection/projection weighting model, and options selected for the reconstruction via arguments in the calling statement or other SETUP parameters. It is difficult to ascertain the exact amount of storage necessary for any given program without running a storage size test (cf. sections III.3 and VI.1).

The expressions below are given as functions of NDIMU, NANG, KDIMU, and KDIM. KDIM may be determined from NDIMU by the relations

$$\text{KDIM} = \text{NDIMU} + 4 \quad \text{if} \quad \text{ICIR} = 0 \quad ,$$
$$\text{KDIM} = \text{INT}\,(\sqrt{2}*\text{NDIMU}) + 4 \quad \text{if} \quad \text{ICIR} \neq 0 \quad .$$

When the storage requirements are dependent on values input to SETUP or the reconstruction routine, the appropriate portion of the equation is in the form of a logical statement. If the statement is true for the case being considered, then the preceding factor is included in the calculation; otherwise the value following the word "else" is used. For example, the expression

$$\text{M} = [\text{NDIMU}^2 \times (\pi/4 \text{ if ICIR=0, else } 1)] + [\text{KDIM*NANG} \times (1 \text{ if IERR=1, else } 0)]$$

would be interpreted to mean M is equal to NDIM^2 times $\pi/4$ if ICIR=0 plus KDIM*NANG if IERR=1. If IERR≠1, the last term is zero and if ICIR≠0 the $\pi/4$ term becomes 1 in the calculation.

All reconstruction routines require that SETUP be called to initialize the values of all input parameters and to set up storage that is used by all algorithms. This amount is

$S = 3*NANG + 2*KDIMU + 2*NDIMU + [NDIMU^2 \times (\pi/4 \text{ if } ICIR=0, \text{ else } 1)$
$\times (1 \text{ if using attenuation correction, else } 0)] + [62 \times NANG \times$
$(1 \text{ if using ray factors, else } 0)]$

and will be referred to below.

The storage requirements M for the nine reconstruction algorithms are as follows:

BJECT

$$M = KDIM + S \quad .$$

BKFIL

$$M = 3 \times 2^{(P-1)} + S$$

where

$$P = \text{smallest integer} \geq \log_2(2 \times KDIM).$$

CONGR

$$M = 2 \times KDIM + [3 \times NDIMU^2 \times (\pi/4 \text{ if } ICIR=0, \text{ else } 1)] + [KDIM \times NANG \times (1 \text{ if } IERR=1, \text{ else } 0)] + [NDIMU^2 \times (\pi/4 \text{ if } ICIR=0, \text{ else } 1) \times (1 \text{ if } IRLX=1, \text{ else } 0)] + S \quad .$$

CONVO

$$M = 4 \times KDIM + [KDIM \times (1 \text{ if } IGEOM=1 \text{ or } 2, \text{ else } 0)] + [6 \times KDIM \times (1 \text{ if } IERR=1, \text{ else } 0)] + S \quad .$$

ENTPY

$$M = 6 \times NANG \times KDIM + KDIM + [NDIMU^2 \times (\pi/4 \text{ if } ICIR=0, \text{ else } 1)] + S \quad .$$

FILBK

$$M = 2^P \times (2^P + 2 + \sqrt{2}) + 2 \times KDIMU + (3 \times NANG) + 4$$

where

$$P = \text{smallest integer} \geq \log_2(2 \times NDIMU) \quad .$$

GRADY

$$M = 2 \times KDIM + [2 \times NDIMU^2 \times (\pi/4 \text{ if } ICIR=0, \text{ else } 1)] + [KDIM \times NANG \times (1 \text{ if } IERR=1, \text{ else } 0)] + [NDIMU^2 \times (\pi/4 \text{ if } ICIR=0, \text{ else } 1) \times (1 \text{ if } IRLX=1, \text{ else } 0)] + S \quad .$$

GVERS

$$M = \{NDIMU^2 \times [NDIMU^2 \times (\pi/4 \text{ if } ICIR = 0, \text{ else } 1) + (KDIM \times NANG) + 2] \times (\pi/4 \text{ if } ICIR=0, \text{ else } 1)\} + [KDIM \times (NANG + 1)] + [KDIM \times (NANG + 1) \times (1 \text{ if } IERR=1, \text{ else } 0)] + S \quad .$$

MARR

$$M = NANG/2 \times (25 + NANG) - 4 \quad .$$

Table 4 shows a comparison of the estimates computed from the above expressions with the actual work space necessary for that reconstruction. The pertinent parameter values are as follows: NDIMU=32, ICIR=0, NANG=36, KDIMU=32, IGEOM=0 (except for MARR where IGEOM=3), IERR=0, IRLX=1 and using the projector/back-projector pair PCD, BCD.

Table 4. Comparison of estimates computed with actual work space necessary for reconstruction.

Reconstruction Subroutine	Actual	Estimate
BJECT	272	272
BKFIL	428	428
CONGR	3556	3525
CONVO	380	380
ENTPY	8860	8852
FILBK	4488	4496
GRADY	2744	2720
GVERS	1,714,888	1,692,296
MARR	1094	1094

2. Algorithm Timing

Table 5 gives the central processor times for reconstructing a circular array from 36 projection angles (NDIMU=32, NANG=36, ICIR=0) for various combinations of reconstruction algorithm and back-projection subroutine. These simulations were compiled using the MNF compiler and run on the CDC 7600 computer at the Lawrence Berkeley Laboratory. The times should be used only as a relative measure and not as an absolute measure of algorithm speed because speed is a function of the compiler and the particular computer used. We have found that during peak usage the computation time increases due to increased central processor overhead; thus the times listed in table 5 are only approximate values.

The speed of the algorithms BJECT, CONGR, ENTPY, and GRADY is determined entirely by the speed of the projection and back-projection subroutines. A major part of the effort of developing the RECLBL Library has been spent in optimizing the code for these subroutines. The time to project and back-project is a function of the size of the reconstruction array, the number of projections, the weighting scheme, and the type of geometry. This time is linear in both the number of elements to reconstruct and the number of projection angles.

The fan-beam projection and back-projection subroutines require the longest computation times. For example, in the CONGR and GRADY algorithms the time for fan-beam geometry with flat detector is increased more than a factor of ten over parallel-beam geometry: time for BCD is 3 sec as compared with the time for BCDF (flat detector) of 30 sec; time for BRF is 4 sec as compared with the time for BRFF (flat detector) of 69 sec. The increase in computation time of fan-beam over parallel-beam routines is less when using fan-beam geometry with a curved detector.

The data in table 5 for the algorithms CONGR and GRADY were obtained using the parameters IRLX=1, IERR=0, and NSTEP=10. Other tests were done for various combinations for IRLX and IERR but the computation

Table 5. Central processor times in seconds for constructing a 32 x 32 circular array from 36 projection angles for various combinations of reconstruction algorithms and back-projection subroutines.

Back-Projection Subroutines \ Reconstruction Subroutine	BJECT	BKFIL	CONGR for 10 Iterations	CONVO	ENTPY for 10 Iterations	FILBK	GRADY for 10 Iterations
Parallel Beam							
BPT	0.19	0.45	1.43	0.44	7.76	0.79	1.42
BCD	0.25	0.53	2.65	0.53	16.24	1.06	2.73
BIN	0.26	0.54		0.52		1.14	
BLL	0.36	0.64	5.41	0.62	31.70	1.52	5.53
BRF	0.32	0.61	4.28	0.63	23.98	1.38	4.32
Fan Beam Curved Detector							
BPTF	0.55		9.51		53.45		9.88
BPTF2	0.55					2.68	
BCDF	0.94		17.75		102.6		17.96
BCDF2	1.00					4.80	
BINF	0.54			0.91			
BRFF	2.57		52.87		310.2		54.01
BRFF2	2.58					13.28	
Fan Beam Flat Detector							
BPTF	0.27		3.29		17.98		3.25
BPTF2	0.47					2.03	
BCDF	1.47		30.16		169.8		30.19
BCDF2	1.54					8.36	
BINF	0.36			0.76			
BRFF	3.26		68.83		388.1		68.48
BRFF2	3.35					18.31	
Attenuation Correction							
BPTA	0.23		2.21				2.25
BCDA	0.29		3.80				3.72
BRFA	0.37		5.37				5.35
Other Reconstruction Subroutines							
GVERS *							
MARR 2.23							
Special Routines for Attenuation Correction							
EVATN 2.94							
EVATU 3.02							

*Timing could not be measured since the memory required to reconstruct a 32 x 32 array is larger than 170 K, which is the memory size of the CDC 7600 computer at the Lawrence Berkeley Laboratory.

times were the same. This is what one would expect when algorithm speed is primarily determined by the speed of the projection and back-projection subroutines. For these algorithms one projection and one back-projection must be done for each iteration. The reconstruction subroutine ENTPY required longer central processor time than any of the other algorithms. The reason for this is that the function optimized (equation (4.5) of section V) is not quadratic; thus more than two back-projection and projection operations are required for each iteration.

Attenuation correction increases computation time in CONGR and GRADY (BRF - 4.3 sec as compared with BRFA - 5.4 sec). These timings were measured after the attenuation factors were calculated. Notice that the time for calculation of the attenuation factors (EVATN - 2.9 sec and EVATU - 3.0 sec) is significant.

The speed of the algorithms BKFIL, CONVO, and FILBK is determined to a large extent by the speed of the back-projection subroutines. For these algorithms the filter or convolution operation also takes considerable time. BKFIL, CONVO, and FILBK require a single back-projection. However, FILBK requires longer computation time than BKFIL and CONVO since the data is back-projected into an array that is four times the size of the user's array.

IX. EXAMPLES OF LIBRARY USE

The sample programs illustrated in this section were run on the CDC 7600 computer at the Lawrence Berkeley Laboratory. These programs show how the user can set up his main program in order to use the RECLBL Library. The example programs are written in standard Fortran IV except for the nonstandard program statement:

```
PROGRAM XXXXX (INPUT,OUTPUT,TAPE2=OUTPUT)    .
```

The user may have to replace this statement with the appropriate program statement applicable for his computer or compiler.

All programs require the declaration statements:

```
DIMENSION B( ),AG( )
COMMON WORK( )
COMMON/PARM/IPAR(12),PAR(3)
COMMON/OUTCOM/LUNOUT,I80132
EXTERNAL BCK,PRJ
```

where B is the reconstruction array, AG is the array of angles, WORK is an array of blank common used for working space, IPAR is an integer array of input parameters, and PAR is a real array of input parameters. Besides the 15 input parameters in the IPAR and PAR arrays (cf. sections III.2-III.3), the user must specify the logical unit number LUNOUT for the output file and specify whether the output line will be 80 or 132 characters long by setting the parameter I80132 zero or nonzero, respectively (cf. section III.1). The EXTERNAL statement must specify each back-projection, projection, convolution or filter subroutine that is passed as a parameter to one of the reconstruction subroutines.

The user must supply his own subroutine GETUM, which is used for data input as explained in section III.4. The subroutine SETUP must be called before calling any of the reconstruction subroutines as discussed in section III.1.

1. Example 1 - Projection and Back-Projection of Parallel- and Fan-Beam Data

The program XBJECT gives an example of how the subroutines PJECT and BJECT are used to project and back-project data. The projection data are obtained from the array BX, representing a point source at position (48,48). Using parallel-beam geometry, PJECT is called (statement E1.058) to project data into the user's projection array P with KDIMU = 100 and AXISU = 50.0. In statement E1.059 the data are back-projected into the array B and the resulting image is displayed by the subroutine ARRAY. This simple back-projection image is blurred by approximately 1/r, where r is the distance from the point source to other elements in the image.

Next we perform a test to see how close the blurring function is approximated by 1/r. In statements E1.064 through E1.067, the back-projection result is multiplied by the distance each point (I,J) is from the point (48,48), i.e., $\sqrt{(I-48)^2 + (J-48)^2}$. Since the back-projection result gives a 1/r response for a point source, the multiplied image represents a nearly uniform distribution of intensities as can be seen from the displayed image. This same procedure is applied for fan-beam data projected for both curved and flat detectors. Notice that for the fan-beam geometry the back-projection subroutine BRFF2 (statements E1.081 and E1.103) is used instead of BRFF. The subroutine BRFF2 properly weights the projection data such that the result gives a 1/r response for a point source.

```
      PROGRAM XBJECT (INPUT,OUTPUT,TAPE2=OUTPUT)                        E1.001
C                                                                       E1.002
C        EXAMPLE 1                                                      E1.003
C                                                                       E1.004
C            THE PROGRAM XBJECT BACK-PROJECTS A POINT SOURCE PROJECTION E1.005
C        FUNCTION FOR PARALLEL BEAM, FAN BEAM CURVED DETECTOR, FAN BEAM E1.006
C        FLAT DETECTOR GEOMETPIES AND COMPARES THE RESULT WITH A 1/R    E1.007
C        RESPONSE.                                                      E1.008
C                                                                       E1.009
      DIMENSION B(4096),BX(4096),P(100),AG(180)                         E1.010
      DATA BX/4096*0./                                                  E1.011
      DATA BX(3056)/1./                                                 E1.012
      COMMON WORK(2600)                                                 E1.013
      COMMON/OUTCOM/LUNOUT,I80132                                       E1.014
C                                                                       E1.015
C          LUNOUT  - OUTPUT FILE                                        E1.016
C          I80132  - OUTPUT LINE LENGTH FLAG                            E1.017
C               =0     EACH LINE WILL BE WITHIN 80 CHARACTERS           E1.018
C                        (OTHERWISE 132 CHARACTERS)                     E1.019
C                                                                       E1.020
      COMMON/PARM/IPAR(12),PAR(3)                                       E1.021
C                                                                       E1.022
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)), E1.023
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)), E1.024
     2            (IMIT  ,IPAR( 7)),(NWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)), E1.025
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)), E1.026
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3))  E1.027
C                                                                       E1.028
C                                                                       E1.029
      EXTERNAL BRF,PRF,BRFF2,PRFF                                       E1.030
C                                                                       E1.031
      LUNOUT=2                                                          E1.032
      I80132=0                                                          E1.033
C                                                                       E1.034
C        THE INPUT PARAMETERS ARE                                       E1.035
C                                                                       E1.036
      NDIMU=64                                                          E1.037
      ICIR=1                                                            E1.038
      IGEOM=0                                                           E1.039
      NANG=180                                                          E1.040
      MODANG=5                                                          E1.041
      KDIMU=100                                                         E1.042
      IMIT=1                                                            E1.043
      NWORK=2600                                                        E1.044
      NFLOAT=1                                                          E1.045
      ISTORE=0                                                          E1.046
      IPRINT=7                                                          E1.047
      LUNATN=0                                                          E1.048
      PWID=1.                                                           E1.049
      AXISU=50.5                                                        E1.050
      RFAN=0.                                                           E1.051
C                                                                       E1.052
C        PARALLEL BEAM GEOMETRY                                         E1.053
C                                                                       E1.054
      CALL SETUP (IPAR,PAR,AG)                                          E1.055
C                                                                       E1.056
      DO 10 M=1,NANG                                                    E1.057
      CALL PJECT (BX,P,M,PRF)                                           E1.058
   10 CALL BJECT (B,P,M,BRF)                                            E1.059
C                                                                       E1.060
      WRITE (2,22)                                                      E1.061
      CALL ARRAY (B,NDIMU)                                              E1.062
C                                                                       E1.063
      DO 12 I=1,64                                                      E1.064
      DO 12 J=1,64                                                      E1.065
      K=(J-1)*64+I                                                      E1.066
   12 B(K)=B(K)*SQRT(FLOAT((I-48)**2+(J-48)**2))                        E1.067
C                                                                       E1.068
      WRITE (2,22)                                                      E1.069
      CALL ARRAY (B,NDIMU)                                              E1.070
```

```
C
C        FAN BEAM GEOMETRY - CURVED DETECTOR
C
      IGEOM=1
      RFAN=80.
C
      CALL SETUP (IPAR,PAR,AG)
C
      DO 14 M=1,NANG
      CALL PJECT (BX,P,M,PRFF)
   14 CALL BJECT (B,P,M,BRFF2)
C
      WRITE (2,24)
      CALL ARRAY (B,NDIMU)
C
      DO 16 I=1,64
      DO 16 J=1,64
      K=(J-1)*64+I
   16 B(K)=B(K)*SQRT(FLOAT((I-48)**2+(J-48)**2))
C
      WRITE (2,24)
      CALL ARRAY (B,NDIMU)
C
C        FAN BEAM GEOMETRY - FLAT DETECTOR
C
      IGEOM=2
      RFAN=80.
C
      CALL SETUP (IPAR,PAR,AG)
C
      DO 18 M=1,NANG
      CALL PJECT (BX,P,M,PRFF)
   18 CALL BJECT (B,P,M,BRFF2)
C
      WRITE (2,26)
      CALL ARRAY (B,NDIMU)
C
      DO 20 I=1,64
      DO 20 J=1,64
      K=(J-1)*64+I
   20 B(K)=B(K)*SQRT(FLOAT((I-48)**2+(J-48)**2))
C
      WRITE (2,26)
      CALL ARRAY (B,NDIMU)
C
C
C
   22 FORMAT(1X//23H PARALLEL BEAM GEOMETRY)
   24 FORMAT(1X//36H FAN BEAM GEOMETRY - CURVED DETECTOR)
   26 FORMAT(1X//34H FAN BEAM GEOMETRY - FLAT DETECTOR)
      END
```

```
  SSS  EEEEE TTTTT U   U PPPP
 S     E       T   U   U P   P
  SSS  EEE     T   U   U PPPP
     S E       T   U   U P
  SSS  EEEEE   T    UUU  P
```

```
        INTEGER PARAMETER ARRAY  (IPAR)

 I   IPAR(I)     DESCRIPTION

 1       64      LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
 2        1      RECONSTRUCT IN A SQUARE ARRAY
 3        0      GEOMETRY FLAG
                 PARALLEL BEAM GEOMETRY
 4      180      NUMBER OF PROJECTION ANGLES
 5        5      MODE FOR PROJECTION ANGLE INPUT  (SEE FOLLOWING LINES)
                 ANGLES GENERATED BETWEEN ZERO AND 2*PI
                 STARTING AT ZERO
 6      100      NUMBER OF RAYS FOR EACH PROJECTION
 7        1      TRANSMISSION DATA
 8     2600      DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
 9        1      NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10        0      EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11        7      PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES)
                 PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED
                 PRINT PROJECTION DATA AND UNCERTAINTIES
                 PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
12        0      LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE


        FLOATING POINT PARAMETER ARRAY  (PAR)

 I    PAR(I)     DESCRIPTION

 1     1.000     PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
 2    50.500     LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
 3        0  NA  NOT APPLICABLE  (NOT FAN BEAM GEOMETRY)

BLANK COMMON REQUIRED        180     (   264)

BLANK COMMON REQUIRED        360     (   550)

BLANK COMMON REQUIRED        540     (  1034)

BLANK COMMON REQUIRED        740     (  1344)

BLANK COMMON REQUIRED        868     (  1544)

A TOTAL OF  92 (  5 THRU  96) OF THE 100 USER PROJECTION BINS WILL BE USED

 92 PROJECTION BINS WILL BE USED OF WHICH   0 HAVE BEEN ZEROED BY THE PROGRAM

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=    868 FLOATING POINT WORDS.
```

```
EEEEE N   N DDDD        SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D      S     E       T   U   U P   P
EEE   N N N D   D       SSS  EEE     T   U   U PPPP
E     N  NN D   D          S E       T   U   U P
EEEEE N   N DDDD        SSS  EEEEE   T    UUU  P
```

```
PPPP      J EEEEE  CCC  TTTTT
P   P     J E     C   C   T
PPPP      J EEE   C       T
P     J   J E     C   C   T
P      JJJ  EEEEE  CCC    T
```

```
BLANK COMMON REQUIRED       960     (  1700)

BLANK COMMON REQUIRED      1140     (  2164)

BLANK COMMON REQUIRED      2543     (  4757)
```

```
BBBB      J EEEEE  CCC  TTTTT
B   B     J E     C   C   T
BBBB      J EEE   C       T
B   B J   J E     C   C   T
BBBB   JJJ  EEEEE  CCC    T
```

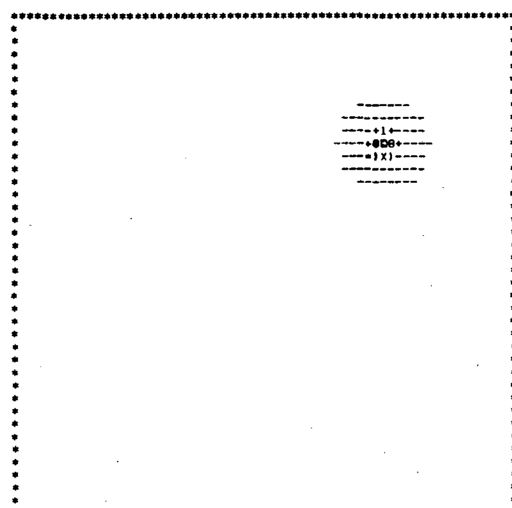
```
BLANK COMMON REQUIRED      2451     (  4623)

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=   2543 FLOATING POINT WORDS.
```

```
EEEEE N   N DDDD        PPPP      J EEEEE  CCC  TTTTT
E     NN  N D   D       P   P     J E     C   C   T
EEE   N N N D   D       PPPP      J EEE   C       T
E     N  NN D   D       P     J   J E     C   C   T
EEEEE N   N DDDD        P      JJJ  EEEEE  CCC    T
```

```
BLANK COMMON REQUIRED      2543     (  4757)

BLANK COMMON REQUIRED      2451     (  4623)

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=   2543 FLOATING POINT WORDS.
```

```
EEEEE N   N DDDD        BBBB      J EEEEE  CCC  TTTTT
E     NN  N D   D       B   B     J E     C   C   T
EEE   N N N D   D       BBBB      J EEE   C       T
E     N  NN D   D       B   B J   J E     C   C   T
EEEEE N   N DDDD        BBBB   JJJ  EEEEE  CCC    T
```

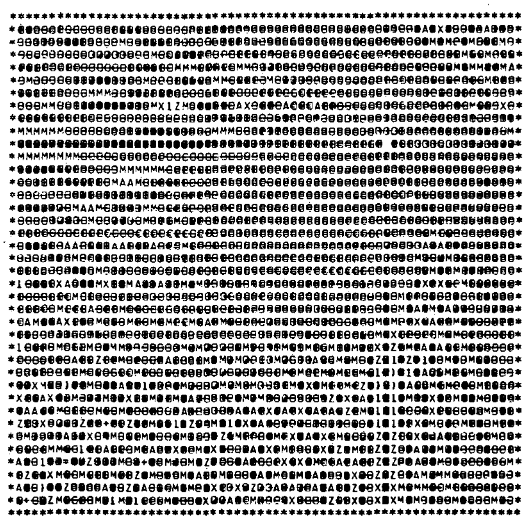
```
PARALLEL BEAM GEOMETRY

XMIN =    .49E-02    XMAX =    .21E+01    XSUM =    .2039E+03
```



```
              -           *           +           )           1           Z
 .4890E-02  .1634E+00  .3958E+00  .5015E+00  .5754E+00  .6600E+00  .7445E+00

Z           X           A           M           θ           θ           θ           θ
 .8185E+00  .8713E+00  .9241E+00  .1040E+01  .1157E+01  .1231E+01  .1315E+01

●           ●           ●           ●           ●           ●           ■           ■
 .1389E+01  .1547E+01  .1738E+01  .1843E+01  .1928E+01  .2012E+01  .2086E+01

■
 .2118E+01
```

PARALLEL BEAM GEOMETRY

XMIN =   0   XMAX =   .18E+01   XSUM =   .4099E+04



```
                 -            =            +            )            1            Z
      0  .1327E+00  .3274E+00  .4158E+00  .4778E+00  .5485E+00  .6193E+00

Z            X            A            M            9            8            @            @
.6813E+00  .7255E+00  .7697E+00  .8671E+00  .9644E+00  .1026E+01  .1097E+01

@            @            @            @            @            @            @            @
.1159E+01  .1292E+01  .1451E+01  .1539E+01  .1610E+01  .1681E+01  .1743E+01

@
.1770E+01
```

```
 SSS  EEEEE TTTTT U   U PPPP
S     E       T   U   U P   P
 SSS  EEE     T   U   U PPPP
    S E       T   U   U P
 SSS  EEEEE   T    UUU  P
```

INTEGER PARAMETEP ARRAY (IPAR)

I	IPAR(I)	DESCRIPTION
1	64	LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
2	1	RECONSTRUCT IN A SQUARE ARRAY
3	1	GEOMETRY FLAG
		FAN BEAM GEOMETRY (CURVED DETECTOR)
4	180	NUMBER OF PROJECTION ANGLES
5	5	MODE FOR PROJECTION ANGLE INPUT (SEE FOLLOWING LINES)
		ANGLES GENERATED BETWEEN ZERO AND 2*PI
		STARTING AT ZERO
6	100	NUMBER OF RAYS FOR EACH PROJECTION
7	1	TRANSMISSION DATA
8	2600	DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
9	1	NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10	0	EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11	7	PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES)
		PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED
		PRINT PROJECTION DATA AND UNCERTAINTIES
		PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
12	0	LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE

FLOATING POINT PARAMETER APPAY (PAR)

I	PAR(I)	DESCRIPTION
1	1.000	PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION
2	50.500	LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
3	80.000	DISTANCE FROM SOURCE TO CENTER OF ROTATION FOR FAN BEAM IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION

BLANK COMMON REQUIRED   180   (264)

BLANK COMMON REQUIRED   360   (550)

BLANK COMMON REQUIRED   540   (1034)

BLANK COMMON PEQUIRED   740   (1344)

BLANK COMMON REQUIRED   868   (1544)

A TOTAL OF 100 (1 THRU 100) OF THE 100 USER PROJECTION BINS WILL BE USED

100 PROJECTION BINS WILL BE USED OF WHICH   0 HAVE BEEN ZEROED BY THE PROGRAM

MAXIMUM SIZE OF BLANK COMMON THUS FAR=   2543 FLOATING POINT WORDS.

```
EEEEE N   N DDDD         SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D       S     E       T   U   U P   P
EEE   N N N D   D        SSS  EEE     T   U   U PPPP
E     N  NN D   D           S E       T   U   U P
EEEEE N   N DDDD         SSS  EEEEE   T    UUU  P
```

```
PPPP      J EEEEE  CCC  TTTTT
P   P     J E     C   C   T
PPPP      J EEE   C       T
P     J   J E     C   C   T
P      JJJ  EEEEE  CCC    T
```

BLANK COMMON REQUIRED   968   (1710)

```
BBBB      J EEEEE  CCC  TTTTT
B   B     J E     C   C   T
BBBB      J EEE   C       T
B   B J   J E     C   C   T
BBBB   JJJ  EEEEE  CCC    T
```

BLANK COMMON REQUIRED   868   (1544)

MAXIMUM SIZE OF BLANK COMMON THUS FAR=   2543 FLOATING POINT WORDS.

```
EEEEE N   N DDDD      PPPP      J EEEEE  CCC  TTTTT
E     NN  N D   D     P   P     J E     C   C   T
EEE   N N N D   D     PPPP      J EEE   C       T
E     N  NN D   D     P     J   J E     C   C   T
EEEEE N   N DDDD      P      JJJ  EEEEE  CCC    T
```

BLANK COMMON REQUIRED   968   (1710)

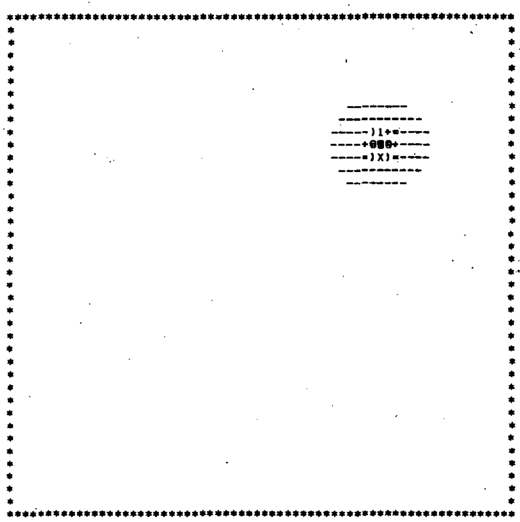
BLANK COMMON REQUIRED   868   (1544)

MAXIMUM SIZE OF BLANK COMMON THUS FAR=   2543 FLOATING POINT WORDS.

```
EEEEE N   N DDDD      BBBB      J EEEEE  CCC  TTTTT
E     NN  N D   D     B   B     J E     C   C   T
EEE   N N N D   D     BBBB      J EEE   C       T
E     N  NN D   D     B   B J   J E     C   C   T
EEEEE N   N DDDD      BBBB   JJJ  EEEEE  CCC    T
```

FAN BEAM GEOMETRY - CURVED DETECTOR

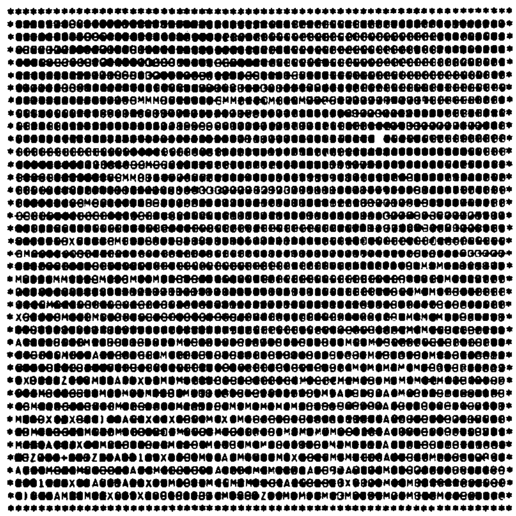
XMIN =   .55E-02   XMAX =   .21E+01   XSUM =   .2038E+03



```
                 -            =            +            )            1            Z
.5465E-02  .1601E+00  .3870E+00  .4501E+00  .5623E+00  .6448E+00  .7273E+00

Z            X            A            M            8            @            @            @
.7995E+00  .8510E+00  .9026E+00  .1016E+01  .1129E+01  .1202E+01  .1284E+01

@            @            @            @            @            @            @            @
.1356E+01  .1511E+01  .1697E+01  .1800E+01  .1882E+01  .1965E+01  .2037E+01

@
.2068E+01
```

FAN BEAM GEOMETRY - CURVED DETECTOR

XMIN = 0 XMAX = .16E+01 XSUM = .4098E+04



```
                -           =           +           )           1           Z
     0  .1216E+00  .2998E+00  .3809E+00  .4376E+00  .5024E+00  .5672E+00

Z          X          A          M          8          8          8          ■
.6240E+00  .6645E+00  .7050E+00  .7941E+00  .8833E+00  .9400E+00  .1005E+01

■          ■          ■          ■          ■          ■          ■          ■
.1062E+01  .1183E+01  .1329E+01  .1410E+01  .1475E+01  .1540E+01  .1596E+01

■
.1621E+01
```

```
 SSS  EEEEE TTTTT U   U PPPP
S     E       T   U   U P   P
 SSS  EEE     T   U   U PPPP
    S E       T   U   U P
 SSS  EEEEE   T    UUU  P
```

INTEGER PARAMETER ARRAY (IPAR)

I	IPAR(I)	DESCRIPTION
1	64	LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
2	1	RECONSTRUCT IN A SQUARE ARRAY
3	2	GEOMETRY FLAG FAN BEAM GEOMETRY (FLAT DETECTOR)
4	180	NUMBER OF PROJECTION ANGLES
5	5	MODE FOR PROJECTION ANGLE INPUT (SEE FOLLOWING LINES) ANGLES GENERATED BETWEEN ZERO AND 2*PI STARTING AT ZERO
6	100	NUMBER OF RAYS FOR EACH PROJECTION
7	1	TRANSMISSION DATA
8	2600	DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
9	1	NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10	0	EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11	7	PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES) PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED PRINT PROJECTION DATA AND UNCERTAINTIES PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
12	0	LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE

FLOATING POINT PARAMETER ARRAY (PAR)

I	PAR(I)	DESCRIPTION
1	1.000	PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION
2	50.500	LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
3	80.000	DISTANCE FROM SOURCE TO CENTER OF ROTATION FOR FAN BEAM IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION

BLANK COMMON REQUIRED 180 (264)

BLANK COMMON REQUIRED 360 (550)

BLANK COMMON REQUIRED 540 (1034)

BLANK COMMON REQUIRED 740 (1344)

BLANK COMMON REQUIRED 868 (1544)

A TOTAL OF 100 (1 THRU 100) OF THE 100 USER PROJECTION BINS WILL BE USED

112 PROJECTION BINS WILL BE USED OF WHICH 12 HAVE BEEN ZEROED BY THE PROGRAM

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 2543 FLOATING POINT WORDS.

```
EEEEE N   N DDDD        SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D      S     E       T   U   U P   P
EEE   N N N D   D       SSS  EEE     T   U   U PPPP
E     N  NN D   D          S E       T   U   U P
EEEEE N   N DDDD        SSS  EEEEE   T    UUU  P
```

```
PPPP      J EEEEE  CCC  TTTTT
P   P     J E     C   C   T
PPPP      J EEE   C       T
P     J   J E     C   C   T
P      JJJ  EEEEE  CCC    T
```

BLANK COMMON REQUIRED 980 (1724)

THE NUMBER OF BINS PROJECTED OUTSIDE THE USER PROJECTION ARRAY = 12

THE NUMBER OF BINS PROJECTED BELOW THE USER ARRAY = 6

THE NUMBER OF BINS PROJECTED ABOVE THE USER ARRAY = 6

```
BBBB      J EEEEE  CCC  TTTTT
B   B     J E     C   C   T
BBBB      J EEE   C       T
B   B J   J E     C   C   T
BBBB   JJJ  EEEEE  CCC    T
```

BLANK COMMON REQUIRED 868 (1544)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 2543 FLOATING POINT WORDS.

```
EEEEE N   N DDDD      PPPP      J EEEEE  CCC  TTTTT
E     NN  N D   D     P   P     J E     C   C   T
EEE   N N N D   D     PPPP      J EEE   C       T
E     N  NN D   D     P     J   J E     C   C   T
EEEEE N   N DDDD      P      JJJ  EEEEE  CCC    T
```

BLANK COMMON REQUIRED 980 (1724)

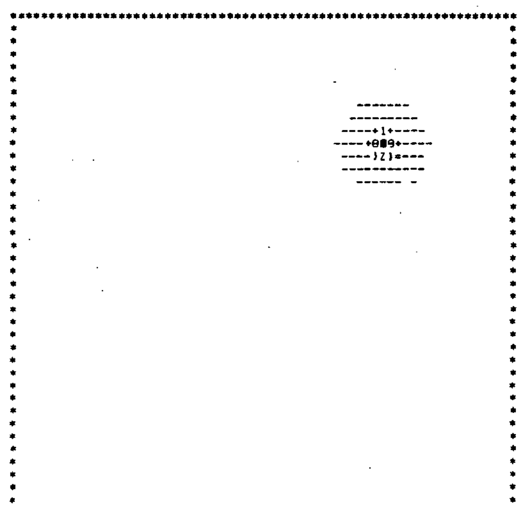
BLANK COMMON REQUIRED 868 (1544)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 2543 FLOATING POINT WORDS.

```
EEEEE N   N DDDD      BBBB      J EEEEE  CCC  TTTTT
E     NN  N D   D     B   B     J E     C   C   T
EEE   N N N D   D     BBBB      J EEE   C       T
E     N  NN D   D     B   B J   J E     C   C   T
EEEEE N   N DDDD      BBBB   JJJ  EEEEE  CCC    T
```

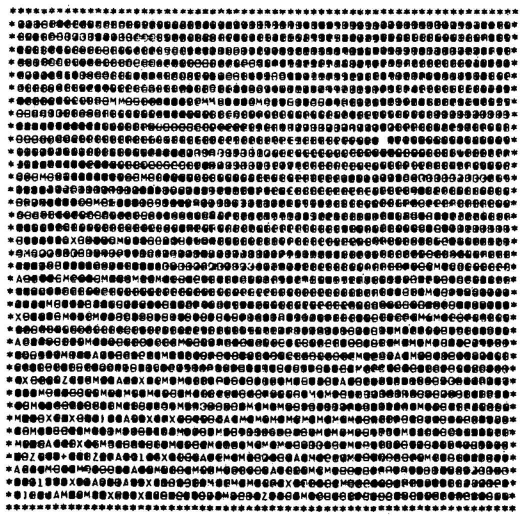
FAN BEAM GEOMETRY - FLAT DETECTOR

XMIN = .55E-02 XMAX = .22E+01 XSUM = .2039E+03



```
          -          =          +          )          1          Z
.5465E-02  .1674E+00  .4048E+00  .5128E+00  .5883E+00  .6747E+00  .7610E+00

Z          X          A          M          9          8          ■          ■
.8366E+00  .8905E+00  .9445E+00  .1063E+01  .1182E+01  .1258E+01  .1344E+01

■          ■          ■          ■          ■          ■          ■          ■
.1419E+01  .1581E+01  .1776E+01  .1884E+01  .1970E+01  .2056E+01  .2132E+01

■
.2164E+01
```

```
FAN BEAM GEOMETRY - FLA" DETECT"R

XMIN =          0     XMAX =    .16E+01      XSUM =    .4099E+04
```



```
            -          =          +          )          1          Z
  0  .1216E+00  .2998E+00  .3809E+00  .4376E+00  .5024E+00  .5673E+00

Z          X          A          M          B          B          B          ●
 .6240E+00  .6645E+00  .7050E+00  .7942E+00  .8833E+00  .9400E+00  .1005E+01

●          ●          ●          ■          ●          ■          ■          ■
 .1062E+01  .1183E+01  .1329E+01  .1410E+01  .1475E+01  .1540E+01  .1596E+01

■
 .1621E+01
```

2. Example 2 - Convolution

The program XCONVO uses the convolution algorithm to reconstruct emission and transmission projection data for parallel-beam, fan-beam geometry with curved detector, and fan-beam geometry with flat detector. For the parallel-beam geometry the reconstruction is performed using the convolvers SHLO and RALA in statements E2.058 and E2.071, respectively. For the fan-beam geometries the convolver LAKS is used to reconstruct simulated projection data in statement E2.091 for the curved detector and in statement E2.109 for the flat detector. The convolvers SHLO and RALA cannot be used for fan-beam geometry nor can the convolver LAKS be used for parallel-beam geometry.

The errors XE in the reconstructed image are displayed in statements E2.067, E2.080, E2.100, and E2.118. The projection errors are input by the subroutine GETUM and it is assumed that these errors are equal to the square root of the projections (statement E2.187) for emission data and are all equal to 1 (statement E2.192) for transmission data.

The largest number of floating point words required in blank common is evaluated in statement E2.122. The output indicates that this example requires a maximum of 1605 words for blank common.

The subroutine GETUM generates simulated projection data for a heart phantom. For the parallel-beam geometry the pixel width PWID is equal to 1 and there is no scaling of the image; however, for the fan-beam geometries the images are reduced in size by a scaling factor equal to 1/PWID = 0.752. This reduction in size is due to the fact that the parameters to the phantom generators are always in units of projection bin widths (= 1/PWID) and the images are displayed in units of pixel widths. Likewise for transmission data the intensity in each pixel, which represents the linear attenuation coefficient in units of inverse pixel width, is increased by a scaling factor PWID = 1.33. However, for emission data the intensity is in units of concentration per pixel and is therefore increased by a scaling factor $PWID^2 = 1.77$.

```
      PROGRAM XCONVO (INPUT,OUTPUT,TAPE2=OUTPUT)                          E2.001
C                                                                         E2.002
C        EXAMPLE 2                                                        E2.003
C                                                                         E2.004
C             THE PROGRAM XCONVO USES THE CONVOLUTION ALGORITHM TO        E2.005
C        RECONSTRUCT EMISSION AND TRANSMISSION PROJECTION DATA FOR        E2.006
C        PARALLEL BEAM, FAN BEAM CURVED DETECTOR, AND FAN BEAM FLAT       E2.007
C        DETECTOR.                                                        E2.008
C                                                                         E2.009
      DIMENSION X(4096),XE(4096)                                          E2.010
      COMMON WORK(2000)                                                   E2.011
      COMMON/OUTCOM/LUNOUT,I80132                                         E2.012
C                                                                         E2.013
C           LUNOUT  - OUTPUT FILE                                         E2.014
C           I80132  - OUTPUT LINE LENGTH FLAG                             E2.015
C                 =0    EACH LINE WILL BE WITHIN 80 CHARACTERS            E2.016
C                         (OTHERWISE 132 CHARACTERS)                      E2.017
C                                                                         E2.018
      COMMON/PARM/IPAR(12),PAR(3)                                         E2.019
C                                                                         E2.020
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)),  E2.021
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)),  E2.022
     2            (IMIT  ,IPAR( 7)),(NWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)),  E2.023
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)),  E2.024
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3))   E2.025
C                                                                         E2.026
      EXTERNAL BIN,BINF,SHLO,LAKS,RALA                                    E2.027
C                                                                         E2.028
      LUNOUT=2                                                            E2.029
      I80132=0                                                            E2.030
C                                                                         E2.031
C        THE INPUT PARAMETERS ARE                                         E2.032
C                                                                         E2.033
      NDIMU=64                                                            E2.034
      ICIR=0                                                              E2.035
      NANG=72                                                             E2.036
      MODANG=5                                                            E2.037
      KDIMU=100                                                           E2.038
      NWORK=2000                                                          E2.039
      NFLOAT=1                                                            E2.040
      ISTORE=0                                                            E2.041
      IPRINT=12                                                           E2.042
      LUNATN=0                                                            E2.043
      AXISU=50.5                                                          E2.044
C                                                                         E2.045
      IMIT=-1                                                             E2.046
      DO 10 I=1,2                                                         E2.047
      IMIT=IMIT+1                                                         E2.048
C                                                                         E2.049
      IGEOM=0                                                             E2.050
      PWID=1.                                                             E2.051
      RFAN=0.                                                             E2.052
C                                                                         E2.053
      CALL SETUP (IPAR,PAR,DUM)                                           E2.054
C                                                                         E2.055
C        RECONSTRUCTION OF PARALLEL BEAM GEOMETRY USING SHLO CONVOLVER    E2.056
C                                                                         E2.057
      CALL CONVO (X,XE,SHLO,BIN,1)                                        E2.058
C                                                                         E2.059
C        DISPLAY OF THE RECONSTRUCTED IMAGE X AND THE ERRORS XE           E2.060
C                                                                         E2.061
      WRITE (2,12)                                                        E2.062
      IF (IMIT.EQ.0) WRITE (2,22)                                         E2.063
      IF (IMIT.EQ.1) WRITE (2,24)                                         E2.064
      CALL ARRAY (X,NDIMU)                                                E2.065
      WRITE (2,14)                                                        E2.066
      CALL ARRAY (XE,NDIMU)                                               E2.067
C                                                                         E2.068
C        RECONSTRUCTION OF PARALLEL BEAM GEOMETRY USING RALA CONVOLVER    E2.069
C                                                                         E2.070
      CALL CONVO (X,XE,RALA,BIN,1)                                        E2.071
C                                                                         E2.072
C        DISPLAY OF THE RECONSTRUCTED IMAGE X AND THE ERRORS XE           E2.073
C                                                                         E2.074
      WRITE (2,16)                                                        E2.075
      IF (IMIT.EQ.0) WRITE (2,22)                                         E2.076
      IF (IMIT.EQ.1) WRITE (2,24)                                         E2.077
      CALL ARRAY (X,NDIMU)                                                E2.078
      WRITE (2,14)                                                        E2.079
      CALL ARRAY (XE,NDIMU)                                               E2.080
C                                                                         E2.081
      IGEOM=1                                                             E2.082
      PWID=1.33                                                           E2.083
      RFAN=125.                                                           E2.084
C                                                                         E2.085
      CALL SETUP (IPAR,PAR,DUM)                                           E2.086
C                                                                         E2.087
C        RECONSTRUCTION OF FAN BEAM GEOMETRY - CURVED DETECTOR USING      E2.088
C          LAKS CONVOLVER                                                 E2.089
C                                                                         E2.090
      CALL CONVO (X,XE,LAKS,BINF,1)                                       E2.091
C                                                                         E2.092
C        DISPLAY OF THE RECONSTRUCTED IMAGE X AND THE ERRORS XE           E2.093
C                                                                         E2.094
      WRITE (2,18)                                                        E2.095
      IF (IMIT.EQ.0) WRITE (2,22)                                         E2.096
      IF (IMIT.EQ.1) WRITE (2,24)                                         E2.097
      CALL ARRAY (X,NDIMU)                                                E2.098
      WRITE (2,14)                                                        E2.099
      CALL ARRAY (XE,NDIMU)                                               E2.100
C                                                                         E2.101
      IGEOM=2                                                             E2.102
C                                                                         E2.103
      CALL SETUP (IPAR,PAR,DUM)                                           E2.104
C                                                                         E2.105
C        RECONSTRUCTION OF FAN BEAM GEOMETRY - FLAT DETECTOR USING        E2.106
C          LAKS CONVOLVER                                                 E2.107
C                                                                         E2.108
      CALL CONVO (X,XE,LAKS,BINF,1)                                       E2.109
C                                                                         E2.110
C        DISPLAY OF THE RECONSTRUCTED IMAGE X AND THE ERRORS XE           E2.111
C                                                                         E2.112
      WRITE (2,20)                                                        E2.113
      IF (IMIT.EQ.0) WRITE (2,22)                                         E2.114
      IF (IMIT.EQ.1) WRITE (2,24)                                         E2.115
      CALL ARRAY (X,NDIMU)                                                E2.116
      WRITE (2,14)                                                        E2.117
      CALL ARRAY (XE,NDIMU)                                               E2.118
C                                                                         E2.119
   10 CONTINUE                                                            E2.120
C                                                                         E2.121
      CALL BCOM (MAXFW)                                                   E2.122
C                                                                         E2.123
C                                                                         E2.124
C                                                                         E2.125
   12 FORMAT(1X//63H RECONSTRUCTION FOR PARALLEL BEAM GEOMETRY USING SHL  E2.126
     1O CONVOLVER)                                                        E2.127
   14 FORMAT(1X//34H ERRORS IN THE RECONSTRUCTED IMAGE)                   E2.128
   16 FORMAT(1X//63H RECONSTRUCTION FOR PARALLEL BEAM GEOMETRY USING RAL  E2.129
     1A CONVOLVER)                                                        E2.130
   18 FORMAT(1X//76H RECONSTRUCTION FOR FAN BEAM GEOMETRY - CURVED DETEC  E2.131
     1TOR USING LAKS CONVOLVER)                                           E2.132
   20 FORMAT(1X//74H RECONSTRUCTION FOR FAN BEAM GEOMETRY - FLAT DETECTO  E2.133
     1R USING LAKS CONVOLVER)                                             E2.134
   22 FORMAT(14H EMISSION DATA)                                           E2.135
   24 FORMAT(18H TRANSMISSION DATA)                                       E2.136
      END                                                                 E2.137
```

```
      SUBROUTINE GETUM (M,DATA,ERR)
C
C        EXAMPLE 2
C
C              THE SUBROUTINE GETUM GIVES SIMULATED PROJECTION DATA FOR
C        A CHEST PHANTOM.  ERRORS IN PROJECTION DATA ARE GIVEN IF
C        IMIT = 0, IE. IF IT IS EMISSION DATA.
C
      DIMENSION DATA(1),ERR(1)
      DIMENSION B(4096)
      DIMENSION A1(4),B1(4),X1(4),Y1(4),PHI(4),Z(4),ITYPE(4)
      COMMON/OUTCOM/LUNOUT,I80132
C
C           LUNOUT  - OUTPUT FILE
C           I80132  - OUTPUT LINE LENGTH FLAG
C                =0     EACH LINE WILL BE WITHIN 80 CHARACTERS
C                          (OTHERWISE 132 CHARACTERS)
C
      COMMON/PARM/IPAR(12),PAR(3)
C
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)),
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)),
     2            (IMIT  ,IPAR( 7)),(NWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)),
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)),
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(PFAN  , PAR( 3))
C
      DATA ITYPE/1,1,1,1/
      DATA A1/40.,10.,14.,14./
      DATA B1/40.,10.,10.,10./
      DATA X1/0.,0.,10.,-10./
      DATA Y1/0.,-10.,0.,0./
      DATA PHI/0.,0.,1.57079633,1.57079633/
      DATA Z/5.,27.,-4.,-4./
C
      IF (M.NE.1) GO TO 10
C
      IF (IMIT.NE.0) PWIDTH=PWID
      IF (IMIT.EQ.0) PWIDTH=-PWID
      CALL PHAN (4,10,ITYPE,Z,X1,Y1,A1,B1,PHI,B,NDIMU,PWIDTH)
C
      CALL ARRAY (B,NDIMU)
C
   10 CALL PHANL (4,ITYPE,Z,X1,Y1,A1,B1,PHI,DATA,M)
C
      IF (IMIT.EQ.1) GO TO 14
C
      DO 12 K=1,KDIMU
      DK=DATA(K)
      IF (DK.LE.1.) DK=1.
   12 ERR(K)=SQRT(DK)
C
      RETURN
C
   14 DO 16 K=1,KDIMU
   16 ERR(K)=1.
C
      RETURN
C
      END
```

```
 SSS  EEEEE TTTTT U   U PPPP
S     E       T   U   U P   P
 SSS  EEE     T   U   U PPPP
    S E       T   U   U P
 SSS  EEEEE   T    UUU  P
```

INTEGER PARAMETER ARRAY (IPAR)

I	IPAR(I)	DESCRIPTION
1	64	LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
2	0	RECONSTRUCT IN A CIRCULAR ARRAY
3	0	GEOMETRY FLAG PARALLEL BEAM GEOMETRY
4	72	NUMBER OF PROJECTION ANGLES
5	5	MODE FOR PROJECTION ANGLE INPUT (SEE FOLLOWING LINES) ANGLES GENERATED BETWEEN ZERO AND 2*PI STARTING AT ZERO
6	100	NUMBER OF RAYS FOR EACH PROJECTION
7	0	EMISSION DATA
8	2000	DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
9	1	NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10	0	EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11	12	PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES) PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER ROUTINES
12	0	LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE

FLOATING POINT PARAMETER ARRAY (PAR)

I	PAR(I)	DESCRIPTION
1	1.000	PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
2	50.500	LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
3	0 NA	NOT APPLICABLE (NOT FAN BEAM GEOMETRY)

A TOTAL OF 68 (17 THRU 84) OF THE 100 USER PROJECTION BINS WILL BE USED

68 PROJECTION BINS WILL BE USED OF WHICH 0 HAVE BEEN ZEROED BY THE PROGRAM

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 544 FLOATING POINT WORDS.

```
EEEEE N   N DDDD         SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D       S     E       T   U   U P   P
EEE   N N N D   D        SSS  EEE     T   U   U PPPP
E     N  NN D   D           S E       T   U   U P
EEEEE N   N DDDD         SSS  EEEEE   T    UUU  P
```

```
 CCC  OOOOO N   N V   V OOOOO
C   C O   O NN  N V   V O   O
C     O   O N N N V   V O   O
C   C O   O N  NN  V V  O   O
 CCC  OOOOO N   N   V   OOOOO
```

PARAMETERS FOR SUBROUTINE CONVO

DESCRIPTION

IERR - 1 CALCULATE ERRORS

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	INTERPOLATION	NO	NO
CNV	CONVOLUTION	N/A	NO	NO

THE VALUES FOR THE FILTER IN REAL SPACE (CONVOL(I),I=0, 67)

.637E+00	-.212E+00	-.424E-01	-.182E-01	-.101E-01
-.643E-02	-.445E-02	-.326E-02	-.250E-02	-.197E-02
-.160E-02	-.132E-02	-.111E-02	-.943E-03	-.813E-03
-.708E-03	-.622E-03	-.551E-03	-.492E-03	-.441E-03
-.398E-03	-.361E-03	-.329E-03	-.301E-03	-.276E-03
-.255E-03	-.236E-03	-.218E-03	-.203E-03	-.189E-03
-.177E-03	-.166E-03	-.155E-03	-.146E-03	-.138E-03
-.130E-03	-.123E-03	-.116E-03	-.110E-03	-.105E-03
-.995E-04	-.947E-04	-.902E-04	-.861E-04	-.822E-04
-.786E-04	-.752E-04	-.721E-04	-.691E-04	-.663E-04
-.637E-04	-.612E-04	-.589E-04	-.567E-04	-.546E-04
-.526E-04	-.508E-04	-.490E-04	-.473E-04	-.457E-04
-.442E-04	-.428E-04	-.414E-04	-.401E-04	-.389E-04
-.377E-04	-.365E-04	-.355E-04		

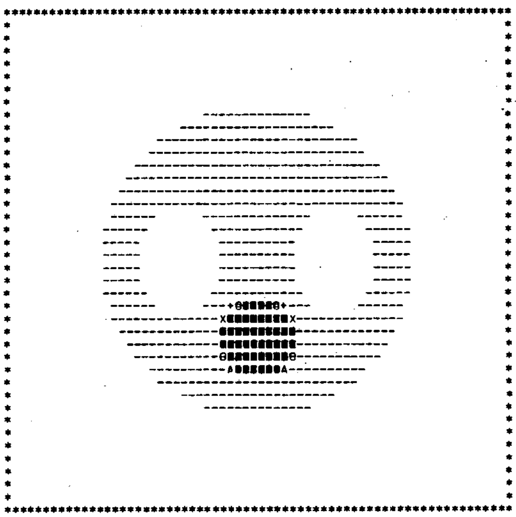
```
PPPP  H   H  AAA  N   N
P   P H   H A   A NN  N
PPPP  HHHHH A   A N N N
P     H   H AAAAA N  NN
P     H   H A   A N   N
```

PHANTOM GENERATED
ARRAY SIZE 64 X 64 INTEGRATION FACTOR = 10 SCALING FACTOR = 1.000
NUMBER OF ELIPSES AND/OR RECTANGLES = 4
THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
X,Y - CENTER
A,B - LENGTH OF AXIS OR SIDE A AND B
PHI - ANGLE OF AXIS OR SIDE A
DENS - INTENSITY
THE PARENTHESIS INDICATES THE SCALED VALUE

ITYPE	X	Y	A	B	PHI	DENS
1 - ELLIPSE	0 ,	0	40.00 ,	40.00	0	5.00
	(0),(	0)(	40.00),(	40.00)		(5.00)
1 - ELLIPSE	0 ,	-10.00	10.00 ,	10.00	0	27.00
	(0),(	-10.00)(	10.00),(	10.00)		(27.00)
1 - ELLIPSE	10.00 ,	0	14.00 ,	10.00	1.57	-4.00
	(10.00),(	0)(	14.00),(	10.00)		(-4.00)
1 - ELLIPSE	-10.00 ,	0	14.00 ,	10.00	1.57	-4.00
	(-10.00),(	0)(	14.00),(	10.00)		(-4.00)

```
EEEEE N   N DDDD         PPPP  H   H  AAA  N   N
E     NN  N D   D        P   P H   H A   A NN  N
EEE   N N N D   D        PPPP  HHHHH A   A N N N
E     N  NN D   D        P     H   H AAAAA N  NN
EEEEE N   N DDDD         P     H   H A   A N   N
```

XMIN = 0 XMAX = .32E+02 XSUM = .7526E+04



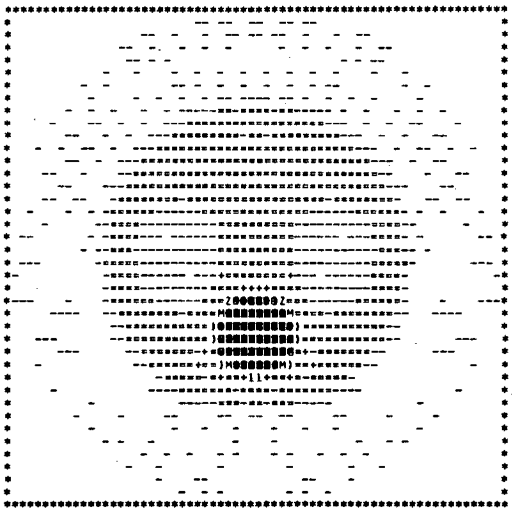
```
         -           =           +           )           1           Z
0   .2400E+01   .5920E+01   .7520E+01   .8640E+01   .9920E+01   .1120E+02

Z           X           A           M           B           B           B           B
 .1232E+02   .1312E+02   .1392E+02   .1568E+02   .1744E+02   .1856E+02   .1984E+02

B           B           B           B           B           B           B           B
 .2096E+02   .2336E+02   .2624E+02   .2784E+02   .2912E+02   .3040E+02   .3152E+02

B
 .3200E+02
```

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 1251 FLOATING POINT WORDS.

```
EEEEE N   N DDDD        CCC  OOOOO N   N V   V OOOOO
E     NN  N D   D      C   C O   O NN  N V   V O   O
EEE   N N N D   D      C     O   O N N N V   V O   O
E     N  NN D   D      C   C O   O N  NN  V V  O   O
EEEEE N   N DDDD        CCC  OOOOO N   N   V   OOOOO
```

RECONSTRUCTION FOR PARALLEL BEAM GEOMETRY USING SHLO CONVOLVER
EMISSION DATA

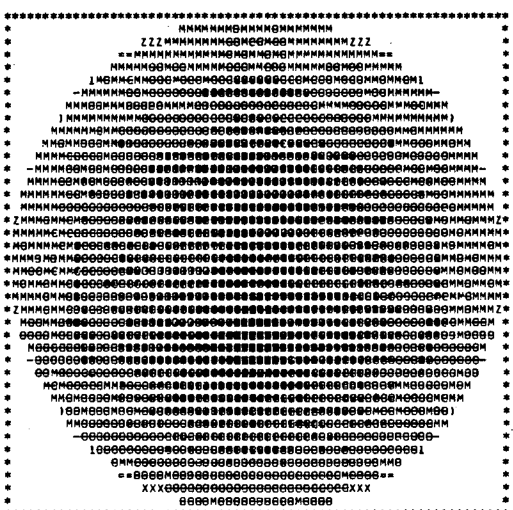
XMIN = -.23E+01 XMAX = .32E+02 XSUM = .7525E+04



```
                     -          =          +          )          1          Z
-.2305E+01  .2822E+00  .4077E+01  .5802E+01  .7009E+01  .8389E+01  .9769E+01

Z           X          A          M          θ          θ          ●          ●
 .1098E+02  .1184E+02  .1270E+02  .1460E+02  .1650E+02  .1770E+02  .1908E+02

●           ●          ●          ●          ●          ●          ●          ●
 .2029E+02  .2288E+02  .2598E+02  .2771E+02  .2909E+02  .3047E+02  .3167E+02

●
 .3219E+02
```

ERRORS IN THE RECONSTRUCTED IMAGE

XMIN = 0 XMAX = .12E+02 XSUM = .2086E+05



```
                     -          =          +          )          1          Z
         0  .8744E+00  .2157E+01  .2740E+01  .3148E+01  .3614E+01  .4081E+01

Z           X          A          M          θ          θ          ●          ●
 .4489E+01  .4780E+01  .5072E+01  .5713E+01  .6354E+01  .6762E+01  .7229E+01

●           ●          ●          ●          ●          ●          ●          ●
 .7637E+01  .8511E+01  .9561E+01  .1014E+02  .1061E+02  .1108E+02  .1148E+02

●
 .1166E+02
```

```
 CCC  OOOOO N   N V   V OOOOO
C   C O   O NN  N V   V O   O
C     O   O N N N V   V O   O
C   C O   O N  NN  V V  O   O
 CCC  OOOOO N   N   V   OOOOO
```

PARAMETERS FOR SUBROUTINE CONVO

DESCRIPTION

IERR - 1 CALCULATE ERRORS

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	INTERPOLATION	NO	NO
CNV	CONVOLUTION	N/A	NO	NO

THE VALUES FOR THE FILTER IN REAL SPACE (CONVOL(I),I=0, 67)

.785E+00	-.318E+00	0	-.354E-01	0
-.127E-01	0	-.650E-02	0	-.393E-02
0	-.263E-02	0	-.188E-02	0
-.141E-02	0	-.110E-02	0	-.882E-03
0	-.722E-03	0	-.602E-03	0
-.509E-03	0	-.437E-03	0	-.378E-03
0	-.331E-03	0	-.292E-03	0
-.260E-03	0	-.233E-03	0	-.209E-03
0	-.189E-03	0	-.172E-03	0
-.157E-03	0	-.144E-03	0	-.133E-03
0	-.122E-03	0	-.113E-03	0
-.105E-03	0	-.980E-04	0	-.914E-04
0	-.855E-04	0	-.802E-04	0
-.753E-04	0	-.709E-04		

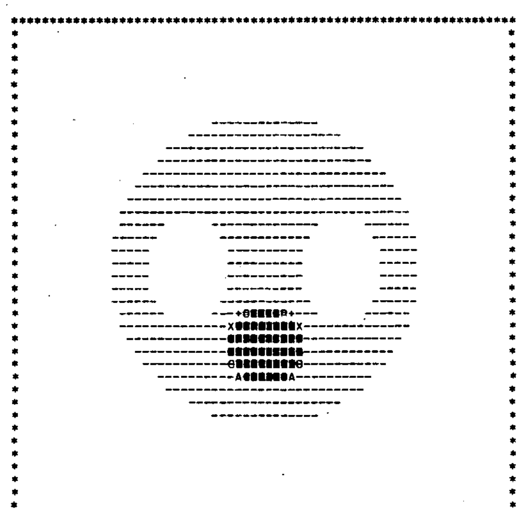
```
PPPP  H   H  AAA  N   N
P   P H   H A   A NN  N
PPPP  HHHHH A   A N N N
P     H   H AAAAA N  NN
P     H   H A   A N   N
```

PHANTOM GENERATED
ARRAY SIZE 64 X 64 INTEGRATION FACTOR = 10 SCALING FACTOR = 1.000
NUMBER OF ELIPSES AND/OR RECTANGLES = 4
THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
X,Y - CENTER
A,B - LENGTH OF AXIS OR SIDE A AND B
PHI - ANGLE OF AXIS OR SIDE A
DENS - INTENSITY
THE PARENTHESIS INDICATES THE SCALED VALUE

ITYPE	X	Y	A	B	PHI	DENS
1 - ELLIPSE	0 ,	0	40.00 ,	40.00	0	5.00
	(0),(	0)(	40.00),(	40.00)		(5.00)
1 - ELLIPSE	0 ,	-10.00	10.00 ,	10.00	0	27.00
	(0),(	-10.00)(	10.00),(	10.00)		(27.00)
1 - ELLIPSE	10.00 ,	0	14.00 ,	10.00	1.57	-4.00
	(10.00),(	0)(	14.00),(	10.00)		(-4.00)
1 - ELLIPSE	-10.00 ,	0	14.00 ,	10.00	1.57	-4.00
	(-10.00),(	0)(	14.00),(	10.00)		(-4.00)

```
EEEEE N   N DDDD     PPPP  H   H  AAA  N   N
E     NN  N D   D    P   P H   H A   A NN  N
EEE   N N N D   D    PPPP  HHHHH A   A N N N
E     N  NN D   D    P     H   H AAAAA N  NN
EEEEE N   N DDDD     P     H   H A   A N   N
```

XMIN = 0 XMAX = .32E+02 XSUM = .7526E+04



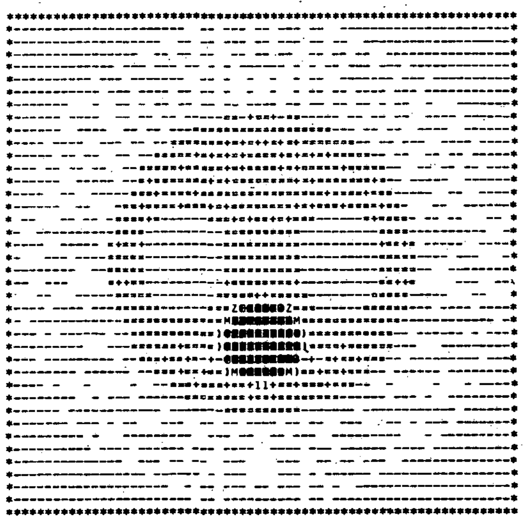
```
                     -          =          +          )          1          Z
         0  .2400E+01  .5920E+01  .7520E+01  .8640E+01  .9920E+01  .1120E+02

Z           X          A          M          θ          θ          ●          ●
 .1232E+02  .1312E+02  .1392E+02  .1568E+02  .1744E+02  .1856E+02  .1984E+02

●           ●          ●          ●          ●          ●          ●          ●
 .2096E+02  .2336E+02  .2624E+02  .2784E+02  .2912E+02  .3040E+02  .3152E+02

●
 .3200E+02
```

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 1251 FLOATING POINT WORDS.

```
EEEEE N   N DDDD         CCC  OOOOO N   N V   V OOOOO
E     NN  N D   D       C   C O   O NN  N V   V O   O
EEE   N N N D   D       C     O   O N N N  V V  O   O
E     N  NN D   D       C   C O   O N  NN  V V  O   O
EEEEE N   N DDDD         CCC  OOOOO N   N   V   OOOOO
```

RECONSTRUCTION FOR PARALLEL BEAM GEOMETRY USING RALA CONVOLVER
EMISSION DATA

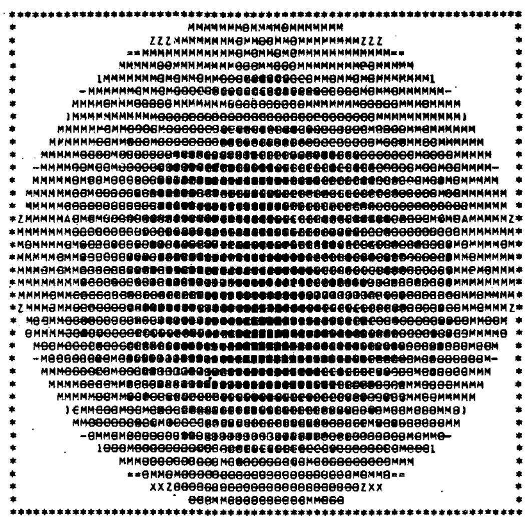
XMIN = -.28E+01 XMAX = .32E+02 XSUM = .7521E+04



```
                        -          =          +          )          L          Z
-.2819E+01 -.1807E+00 .3688E+01 .5447E+01 .6678E+01 .8085E+01 .9492E+01

Z          X          A          M          θ          ■          ■          ■
 .1072E+02 .1160E+02 .1248E+02 .1442E+02 .1635E+02 .1758E+02 .1899E+02

■          ■          ■          ■          ■          ■          ■          ■
 .2022E+02 .2286E+02 .2602E+02 .2778E+02 .2919E+02 .3060E+02 .3183E+02

■
 .3235E+02
```

ERRORS IN THE RECONSTRUCTED IMAGE

XMIN = 0 XMAX = .15E+02 XSUM = .2587E+05



```
                         -          =          +          )          L          Z
          0 .1099E+01 .2710E+01 .3442E+01 .3955E+01 .4541E+01 .5126E+01

Z          X          A          M          θ          ■          ■          ■
 .5639E+01 .6005E+01 .6371E+01 .7177E+01 .7983E+01 .8495E+01 .9081E+01

θ          ■          ■          ■          ■          ■          ■          ■
 .9594E+01 .1069E+02 .1201E+02 .1274E+02 .1333E+02 .1391E+02 .1443E+02

■
 .1465E+02
```

```
 SSS  EEEEE TTTTT U   U PPPP
S     E       T   U   U P   P
 SSS  EEE     T   U   U PPPP
    S E       T   U   U P
 SSS  EEEEE   T    UUU  P
```

INTEGER PARAMETER ARRAY (IPAR)

I	IPAR(I)	DESCRIPTION
1	64	LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
2	0	RECONSTRUCT IN A CIRCULAR ARRAY
3	1	GEOMETRY FLAG
		FAN BEAM GEOMETRY (CURVED DETECTOR)
4	72	NUMBER OF PROJECTION ANGLES
5	5	MODE FOR PROJECTION ANGLE INPUT (SEE FOLLOWING LINES)
		ANGLES GENERATED BETWEEN ZERO AND 2*PI
		STARTING AT ZERO
6	100	NUMBER OF RAYS FOR EACH PROJECTION
7	0	EMISSION DATA
8	2000	DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
9	1	NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10	0	EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11	12	PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES)
		PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
		PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER ROUTINES
12	0	LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE

FLOATING POINT PARAMETER ARRAY (PAR)

I	PAR(I)	DESCRIPTION
1	1.330	PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION
2	50.500	LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
3	125.000	DISTANCE FROM SOURCE TO CENTER OF ROTATION FOR FAN BEAM IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION

A TOTAL OF 90 (6 THRU 95) OF THE 100 USER PROJECTION BINS WILL BE USED

90 PROJECTION BINS WILL BE USED OF WHICH 0 HAVE BEEN ZEROED BY THE PROGRAM

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 1251 FLOATING POINT WORDS.

```
EEEEE N   N DDDD       SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D     S     E       T   U   U P   P
EEE   N N N D   D      SSS  EEE     T   U   U PPPP
E     N  NN D   D         S E       T   U   U P
EEEEE N   N DDDD       SSS  EEEEE   T    UUU  P
```

```
 CCC  OOOOO N   N V   V OOOOO
C   C O   O NN  N V   V O   O
C     O   O N N N  V V  O   O
C   C O   O N  NN  V V  O   O
 CCC  OOOOO N   N   V   OOOOO
```

PARAMETERS FOR SUBROUTINE CONVO

DESCRIPTION

IERR - 1 CALCULATE ERRORS

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	INTERPOLATION	NO	YES
CNV	CONVOLUTION	N/A	NO	YES

THE VALUES FOR THE FILTER IN REAL SPACE (CONVOL(I),I=0, 89)

.785E+00	-.318E+00	0	-.354E-01	0
-.127E-01	0	-.650E-02	0	-.394E-02
0	-.264E-02	0	-.189E-02	0
-.142E-02	0	-.111E-02	0	-.889E-03
0	-.729E-03	0	-.609E-03	0
-.516E-03	0	-.443E-03	0	-.385E-03
0	-.338E-03	0	-.299E-03	0
-.267E-03	0	-.239E-03	0	-.216E-03
0	-.196E-03	0	-.179E-03	0
-.164E-03	0	-.151E-03	0	-.140E-03
0	-.129E-03	0	-.120E-03	0
-.112E-03	0	-.105E-03	0	-.985E-04
0	-.927E-04	0	-.873E-04	0
-.825E-04	0	-.781E-04	0	-.741E-04
0	-.704E-04	0	-.670E-04	0
-.639E-04	0	-.610E-04	0	-.584E-04
0	-.559E-04	0	-.536E-04	0
-.515E-04	0	-.496E-04	0	-.477E-04

THE WEIGHTS USED FOR THE FAN BEAM CONVOLUTION (WEIGHT(I),I=1, 90)

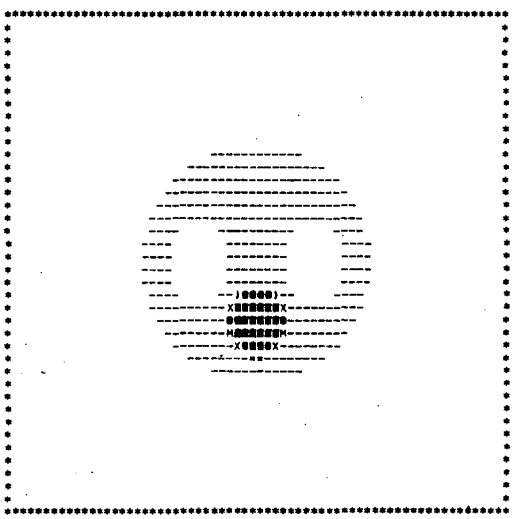
.937E+00	.940E+00	.943E+00	.945E+00	.948E+00
.950E+00	.953E+00	.955E+00	.958E+00	.960E+00
.962E+00	.964E+00	.966E+00	.968E+00	.970E+00
.972E+00	.974E+00	.976E+00	.978E+00	.979E+00
.981E+00	.982E+00	.984E+00	.985E+00	.987E+00
.988E+00	.989E+00	.990E+00	.991E+00	.992E+00
.993E+00	.994E+00	.995E+00	.996E+00	.996E+00
.997E+00	.998E+00	.998E+00	.999E+00	.999E+00
.999E+00	.100E+01	.100E+01	.100E+01	.100E+01
.100E+01	.100E+01	.100E+01	.100E+01	.999E+00
.999E+00	.999E+00	.998E+00	.998E+00	.997E+00
.996E+00	.996E+00	.995E+00	.994E+00	.993E+00
.992E+00	.991E+00	.990E+00	.989E+00	.988E+00
.987E+00	.985E+00	.984E+00	.982E+00	.981E+00
.979E+00	.978E+00	.976E+00	.974E+00	.972E+00
.970E+00	.968E+00	.966E+00	.964E+00	.962E+00
.960E+00	.958E+00	.955E+00	.953E+00	.950E+00
.948E+00	.945E+00	.943E+00	.940E+00	.937E+00

```
PPPP  H   H  AAA  N   N
P   P H   H A   A NN  N
PPPP  HHHHH A   A N N N
P     H   H AAAAA N  NN
P     H   H A   A N   N
```

```
PHANTOM GENERATED
  ARRAY SIZE   64 X  64   INTEGRATION FACTOR =  10   SCALING FACTOR =      .752
  NUMBER OF ELIPSES AND/OR RECTANGLES =    4
  THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
      X,Y  - CENTER
      A,B  - LENGTH OF AXIS OR SIDE A AND B
      PHI  - ANGLE OF AXIS OR SIDE A
      DENS - INTENSITY
  THE PARENTHESIS INDICATES THE SCALED VALUE
   ITYPE                  X           Y        A           B          PHI      DENS
     1   - ELLIPSE          .0 ,        0    40.00 ,    40.00          0      5.00
                       (        0),(       0)(  30.08),(  30.08)           (   8.84)
     1   - ELLIPSE          0 ,   -10.00    10.00 ,    10.00          0     27.00
                       (        0),(   -7.52)(   7.52),(   7.52)           (  47.76)
     1   - ELLIPSE      10.00 ,        0    14.00 ,    10.00       1.57     -4.00
                       (    7.52),(       0)(  10.53),(   7.52)           (  -7.08)
     1   - ELLIPSE     -10.00 ,        0    14.00 ,    10.00       1.57     -4.00
                       (   -7.52),(       0)(  10.53),(   7.52)           (  -7.08)
```

```
EEEEE N   N DDDD        PPPP  H   H  AAA  N   N
E     NN  N D   D       P   P H   H A   A NN  N
EEE   N N N D   D       PPPP  HHHHH A   A N N N
E     N  NN D   D       P     H   H AAAAA N  NN
EEEEE N   N DDDD        P     H   H A   A N   N
```

```
XMIN =         0    XMAX =    .57E+02    XSUM =    .7522E+04
```

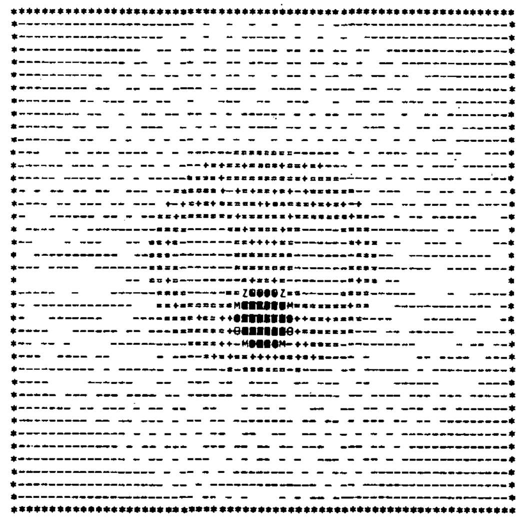


```
               -         =         +         )         1         Z
      0  .4245E+01  .1047E+02  .1330E+02  .1528E+02  .1755E+02  .1981E+02

Z          X         A         M         θ         θ         θ         θ
 .2179E+02  .2321E+02  .2462E+02  .2774E+02  .3085E+02  .3283E+02  .3509E+02

θ          ■         ■         ■         ■         ■         ■         ■
 .3708E+02  .4132E+02  .4642E+02  .4925E+02  .5151E+02  .5377E+02  .5576E+02

■
 .5660E+02
```

```
MAXIMUM SIZE OF BLANK COMMON THUS FAR=   1561 FLOATING POINT WORDS.
```

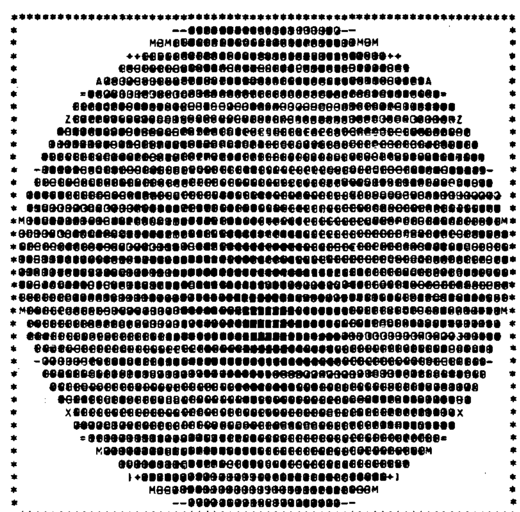
```
EEEEE N   N DDDD       CCC  OOOOO N   N V   V OOOOO
E     NN  N D   D     C   C O   O NN  N V   V O   O
EEE   N N N D   D     C     O   O N N N  V V  O   O
E     N  NN D   D     C   C O   O N  NN  V V  O   O
EEEEE N   N DDDD       CCC  OOOOO N   N   V   OOOOO
```

```
RECONSTRUCTION FOR FAN BEAM GEOMETRY - CURVED DETECTOR USING LAKS CONVOLVER
EMISSION DATA

XMIN =   -.50E+01    XMAX =    .57E+02    XSUM =    .7484E+04
```



```
                          -         =         +         )         1         Z
-.5040E+01 -.3791E+00  .6457E+01  .9565E+01  .1174E+02  .1423E+02  .1671E+02

Z          X         A         M         θ         θ         θ         θ
 .1889E+02  .2044E+02  .2199E+02  .2541E+02  .2883E+02  .3101E+02  .3349E+02

θ          ■         ■         ■         ■         ■         ■         ■
 .3567E+02  .4033E+02  .4592E+02  .4903E+02  .5151E+02  .5400E+02  .5618E+02

■
 .5711E+02
```

```
ERRORS IN THE RECONSTRUCTED IMAGE

XMIN =         0    XMAX =    .24E+02    XSUM =    .4675E+05
```



```
               -         =         +         )         1         Z
      0  .1776E+01  .4380E+01  .5564E+01  .6392E+01  .7339E+01  .8286E+01

Z          X         A         M         θ         θ         θ         θ
 .9115E+01  .9707E+01  .1030E+02  .1160E+02  .1290E+02  .1373E+02  .1468E+02

θ          ■         ■         ■         ■         ■         ■         ■
 .1551E+02  .1728E+02  .1941E+02  .2060E+02  .2154E+02  .2249E+02  .2332E+02

■
 .2368E+02
```

```
 SSS  EEEEE TTTTT U   U PPPP
S     E       T   U   U P   P
 SSS  EEE     T   U   U PPPP
    S E       T   U   U P
 SSS  EEEEE   T    UUU  P
```

INTEGER PARAMETER ARRAY (IPAR)

I	IPAR(I)	DESCRIPTION
1	64	LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
2	0	RECONSTRUCT IN A CIRCULAR ARRAY
3	2	GEOMETRY FLAG FAN BEAM GEOMETRY (FLAT DETECTOR)
4	72	NUMBER OF PROJECTION ANGLES
5	5	MODE FOR PROJECTION ANGLE INPUT (SEE FOLLOWING LINES) ANGLES GENERATED BETWEEN ZERO AND 2*PI STARTING AT ZERO
6	100	NUMBER OF RAYS FOR EACH PROJECTION
7	0	EMISSION DATA
8	2000	DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
9	1	NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10	0	EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11	12	PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES) PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER ROUTINES
12	0	LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE

FLOATING POINT PARAMETER ARRAY (PAR)

I	PAR(I)	DESCRIPTION
1	1.330	PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION
2	50.500	LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
3	125.000	DISTANCE FROM SOURCE TO CENTER OF ROTATION FOR FAN BEAM IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION

A TOTAL OF 94 (4 THRU 97) OF THE 100 USER PROJECTION BINS WILL BE USED

94 PROJECTION BINS WILL BE USED OF WHICH 0 HAVE BEEN ZEROED BY THE PROGRAM

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 1561 FLOATING POINT WORDS.

```
EEEEE N   N DDDD        SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D      S     E       T   U   U P   P
EEE   N N N D   D       SSS  EEE     T   U   U PPPP
E     N  NN D   D          S E       T   U   U P
EEEEE N   N DDDD        SSS  EEEEE   T    UUU  P
```

```
 CCC  OOOOO N   N V   V OOOOO
C   C O   O NN  N V   V O   O
C     O   O N N N  V V  O   O
C   C O   O N  NN  V V  O   O
 CCC  OOOOO N   N   V   OOOOO
```

PARAMETERS FOR SUBROUTINE CONVO

DESCRIPTION

IERR - 1 CALCULATE ERRORS

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	INTERPOLATION	NO	YES
CNV	CONVOLUTION	N/A	NO	YES

THE VALUES FOR THE FILTER IN REAL SPACE (CONVOL(I),I=0, 93)

.785E+00	-.318E+00	0	-.354E-01	0
-.127E-01	0	-.650E-02	0	-.393E-02
0	-.263E-02	0	-.188E-02	0
-.141E-02	0	-.110E-02	0	-.882E-03
0	-.722E-03	0	-.602E-03	0
-.509E-03	0	-.437E-03	0	-.378E-03
0	-.331E-03	0	-.292E-03	0
-.260E-03	0	-.233E-03	0	-.209E-03
0	-.189E-03	0	-.172E-03	0
-.157E-03	0	-.144E-03	0	-.133E-03
0	-.122E-03	0	-.113E-03	0
-.105E-03	0	-.980E-04	0	-.914E-04
0	-.855E-04	0	-.802E-04	0
-.753E-04	0	-.709E-04	0	-.669E-04
0	-.631E-04	0	-.597E-04	0
-.566E-04	0	-.537E-04	0	-.510E-04
0	-.485E-04	0	-.462E-04	0
-.441E-04	0	-.421E-04	0	-.402E-04
0	-.384E-04	0	-.368E-04	

THE WEIGHTS USED FOR THE FAN BEAM CONVOLUTION (WEIGHT(I),I=1, 94)

.937E+00	.940E+00	.942E+00	.944E+00	.947E+00
.949E+00	.951E+00	.954E+00	.956E+00	.958E+00
.960E+00	.962E+00	.964E+00	.966E+00	.968E+00
.970E+00	.971E+00	.973E+00	.975E+00	.977E+00
.978E+00	.980E+00	.981E+00	.983E+00	.984E+00
.986E+00	.987E+00	.988E+00	.989E+00	.990E+00
.991E+00	.992E+00	.993E+00	.994E+00	.995E+00
.996E+00	.996E+00	.997E+00	.998E+00	.998E+00
.999E+00	.999E+00	.999E+00	.100E+01	.100E+01
.100E+01	.100E+01	.100E+01	.100E+01	.100E+01
.100E+01	.999E+00	.999E+00	.999E+00	.998E+00
.998E+00	.997E+00	.996E+00	.996E+00	.995E+00
.994E+00	.993E+00	.992E+00	.991E+00	.990E+00
.989E+00	.988E+00	.987E+00	.986E+00	.984E+00
.983E+00	.981E+00	.980E+00	.978E+00	.977E+00
.975E+00	.973E+00	.971E+00	.970E+00	.968E+00
.966E+00	.964E+00	.962E+00	.960E+00	.958E+00
.956E+00	.954E+00	.951E+00	.949E+00	.947E+00
.944E+00	.942E+00	.940E+00	.937E+00	

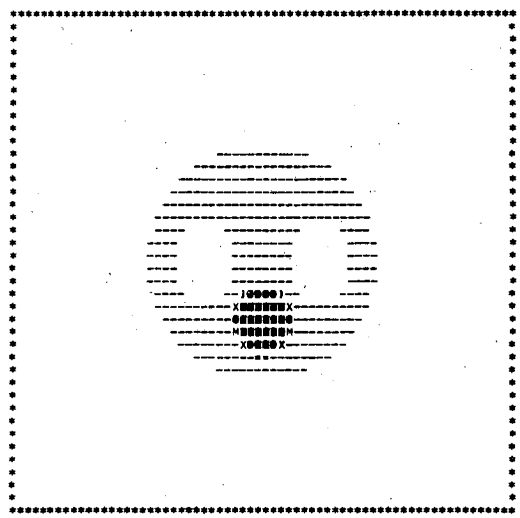
```
PPPP  H   H  AAA  N   N
P   P H   H A   A NN  N
PPPP  HHHHH A   A N N N
P     H   H AAAAA N  NN
P     H   H A   A N   N
```

PHANTOM GENERATED
ARRAY SIZE 64 X 64 INTEGRATION FACTOR = 10 SCALING FACTOR = .752
NUMBER OF ELIPSES AND/OR RECTANGLES = 4
THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
X,Y - CENTER
A,B - LENGTH OF AXIS OR SIDE A AND B
PHI - ANGLE OF AXIS OR SIDE A
DENS - INTENSITY
THE PARENTHESIS INDICATES THE SCALED VALUE

ITYPE	X	Y	A	B	PHI	DENS
1 - ELLIPSE	0 ,	0	40.00 ,	40.00	0	5.00
	(0),(	0)(	30.08),(	30.08)		(8.84)
1 - ELLIPSE	0 ,	-10.00	10.00 ,	10.00	0	27.00
	(0),(	-7.52)(	7.52),(	7.52)		(47.76)
1 - ELLIPSE	10.00 ,	0	14.00 ,	10.00	1.57	-4.00
	(7.52),(	0)(	10.53),(	7.52)		(-7.08)
1 - ELLIPSE	-10.00 ,	0	14.00 ,	10.00	1.57	-4.00
	(-7.52),(	0)(	10.53),(	7.52)		(-7.08)

```
EEEEE N   N DDDD        PPPP  H   H  AAA  N   N
E     NN  N D   D       P   P H   H A   A NN  N
EEE   N N N D   D       PPPP  HHHHH A   A N N N
E     N  NN D   D       P     H   H AAAAA N  NN
EEEEE N   N DDDD        P     H   H A   A N   N
```

XMIN = 0 XMAX = .57E+02 XSUM = .7522E+04

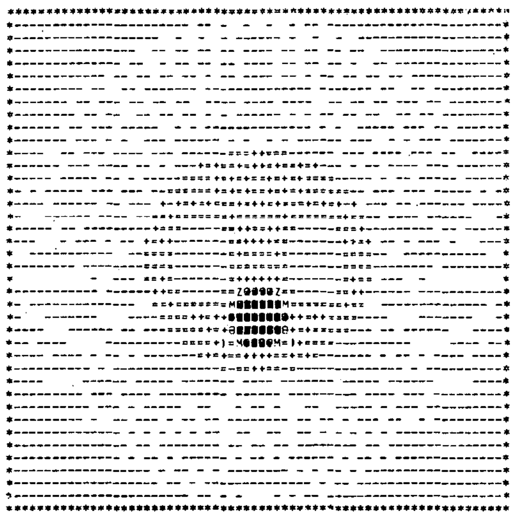


```
          -          =          +          )          1          Z
 0 .4245E+01 .1047E+02 .1330E+02 .1528E+02 .1755E+02 .1981E+02

Z          X          A          M          B          @          @          @
 .2179E+02 .2321E+02 .2462E+02 .2774E+02 .3085E+02 .3283E+02 .3509E+02

@          ■          ■          ■          ■          ■          ■          ■
 .3708E+02 .4132E+02 .4642E+02 .4925E+02 .5151E+02 .5377E+02 .5576E+02

■
 .5660E+02
```

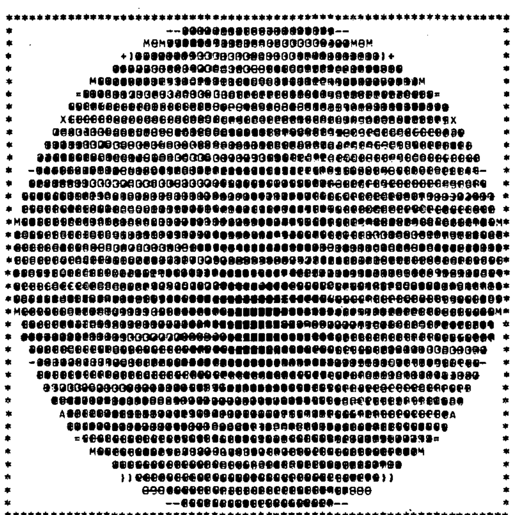
MAXIMUM SIZE OF BLANK COMMON THUS FAR= 1605 FLOATING POINT WORDS.

```
EEEEE N   N DDDD         CCC  OOOOO N   N V   V OOOOO
E     NN  N D   D       C   C O   O NN  N V   V O   O
EEE   N N N D   D       C     O   O N N N  V V  O   O
E     N  NN D   D       C   C O   O N  NN  V V  O   O
EEEEE N   N DDDD         CCC  OOOOO N   N   V   OOOOO
```

```
RECONSTRUCTION FOR FAN BEAM GEOMETRY - FLAT DETECTOR USING LAKS CONVOLVER
EMISSION DATA

XMIN =   -.53E+01     XMAX =    .57E+02     XSUM =    .7478E+04
```



```
                     -            =            +            )            1             Z
-.5349E+01  -.6650E+00   .6205E+01   .9328E+01   .1151E+02   .1401E+02   .1651E+02

 Z            X            A            M            Θ            θ            ▪            ●
 .1870E+02   .2026E+02   .2182E+02   .2525E+02   .2869E+02   .3087E+02   .3337E+02

 ●            ●            ●            ●            ●            ●            ●            ●
 .3556E+02   .4024E+02   .4586E+02   .4899E+02   .5148E+02   .5398E+02   .5617E+02

 ●
 .5710E+02

ERRORS IN THE RECONSTRUCTED IMAGE

XMIN =         0     XMAX =    .24E+02     XSUM =    .4759E+05
```



```
                     -            =            +            )            1             Z
          0   .1776E+01   .4382E+01   .5566E+01   .6395E+01   .7342E+01   .8290E+01

 Z            X            A            M            Θ            θ            Θ            ●
 .9119E+01   .9711E+01   .1030E+02   .1161E+02   .1291E+02   .1374E+02   .1468E+02

 ●            ●            ●            ●            ●            ●            ●            ●
 .1551E+02   .1729E+02   .1942E+02   .2061E+02   .2155E+02   .2250E+02   .2333E+02

 ●
 .2368E+02
```

```
 SSS  EEEEE TTTTT U   U PPPP
S     E       T   U   U P   P
 SSS  EEE     T   U   U PPPP
    S E       T   U   U P
 SSS  EEEEE   T    UUU  P
```

```
        INTEGER PARAMETER ARRAY  (IPAR)

 I   IPAR(I)      DESCRIPTION

 1       64       LINEAR DIMENSION OF THE RECCNSTRUCTION ARRAY
 2        0       RECONSTRUCT IN A CIRCULAR ARRAY
 3        0       GEOMETRY FLAG
                  PARALLEL BEAM GEOMETRY
 4       72       NUMBER OF PROJECTION ANGLES
 5        5       MODE FOR PROJECTION ANGLE INPUT  (SEE FOLLOWING LINES)
                  ANGLES GENERATED BETWEEN ZERO AND 2*PI
                  STARTING AT ZERO
 6      100       NUMBER OF RAYS FOR EACH PROJECTION
 7        1       TRANSMISSION DATA
 8     2000       DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
 9        1       NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10        0       EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11       12       PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES)
                  PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
                  PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER ROUTINES
12        0       LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE


        FLOATING POINT PARAMETER ARRAY  (PAR)

 I    PAR(I)      DESCRIPTION

 1     1.000      PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
 2    50.500      LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
 3         0  NA  NOT APPLICABLE  (NOT FAN BEAM GEOMETRY)

A TOTAL OF  68 ( 17 THRU  84) OF THE 100 USER PROJECTION BINS WILL BE USED

 68 PROJECTION BINS WILL BE USED OF WHICH    0 HAVE BEEN ZEROED BY THE PROGRAM

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=   1603 FLOATING POINT WORDS.
```

```
EEEEE N   N DDDD         SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D       S     E       T   U   U P   P
EEE   N N N D   D        SSS  EEE     T   U   U PPPP
E     N  NN D   D           S E       T   U   U P
EEEEE N   N DDDD         SSS  EEEEE   T    UUU  P
```

```
 CCC  OOOOO N   N V   V OOOOO
C   C O   O NN  N V   V O   O
C     O   O N N N V   V O   O
C   C O   O N  NN  V V  O   O
 CCC  OOOOO N   N   V   OOOOO
```

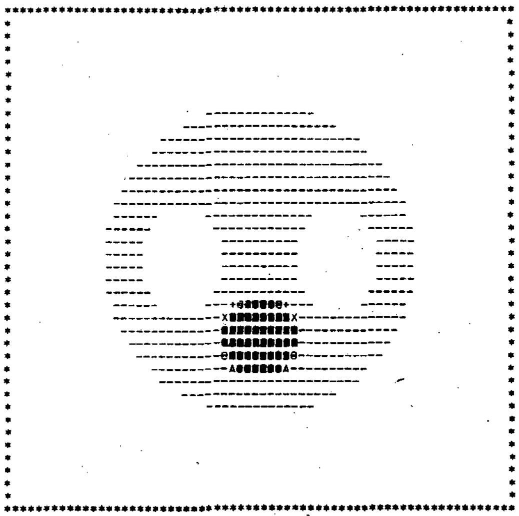
```
        PARAMETERS FOR SUBROUTINE CONVO

                DESCRIPTION

IERR -      1   CALCULATE ERRORS


BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG    FUNCTION          RAY WEIGHTING     ATTENUATION          FAN BEAM
BCK    BACKPROJECTION    INTERPOLATION         NO                  NO
CNV    CONVOLUTION            N/A              NO                  NO

THE VALUES FOR THE FILTER IN REAL SPACE (CONVOL(I),I=0, 67)
      .637E+00   -.212E+00   -.424E-01   -.182E-01   -.101E-01
     -.643E-02   -.445E-02   -.326E-02   -.250E-02   -.197E-02
     -.160E-02   -.132E-02   -.111E-02   -.943E-03   -.813E-03
     -.708E-03   -.622E-03   -.551E-03   -.492E-03   -.441E-03
     -.398E-03   -.361E-03   -.329E-03   -.301E-03   -.276E-03
     -.253E-03   -.236E-03   -.218E-03   -.203E-03   -.189E-03
     -.177E-03   -.166E-03   -.155E-03   -.146E-03   -.138E-03
     -.130E-03   -.123E-03   -.116E-03   -.110E-03   -.105E-03
     -.995E-04   -.947E-04   -.902E-04   -.861E-04   -.822E-04
     -.786E-04   -.752E-04   -.721E-04   -.691E-04   -.663E-04
     -.637E-04   -.612E-04   -.589E-04   -.567E-04   -.546E-04
     -.526E-04   -.508E-04   -.490E-04   -.473E-04   -.457E-04
     -.442E-04   -.428E-04   -.414E-04   -.401E-04   -.389E-04
     -.377E-04   -.365E-04   -.355E-04
```

```
PPPP  H   H  AAA  N   N
P   P H   H A   A NN  N
PPPP  HHHHH A   A N N N
P     H   H AAAAA N  NN
P     H   H A   A N   N
```

```
PHANTOM GENERATED
  ARRAY SIZE   64 X  64   INTEGRATION FACTOR =  10   SCALING FACTOR =    1.000
  NUMBER OF ELIPSES AND/OR RECTANGLES =    4
  THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
       X,Y  - CENTER
       A,B  - LENGTH OF AXIS OR SIDE A AND B
       PHI  - ANGLE OF AXIS OR SIDE A
       DENS - INTENSITY
  THE PARENTHESIS INDICATES THE SCALED VALUE
   ITYPE                 X          Y         A          B         PHI       DENS
     1   - ELLIPSE         0 ,        0    40.00 ,    40.00          0        5.00
                     (     0),(        0)(  40.00),(  40.00)            (     5.00)
     1   - ELLIPSE         0 ,   -10.00    10.00 ,    10.00          0       27.00
                     (     0),( -10.00)(  10.00),(  10.00)            (    27.00)
     1   - ELLIPSE     10.00 ,        0    14.00 ,    10.00       1.57       -4.00
                     ( 10.00),(       0)(  14.00),(  10.00)            (    -4.00)
     1   - ELLIPSE    -10.00 ,        0    14.00 ,    10.00       1.57       -4.00
                     (-10.00),(       0)(  14.00),(  10.00)            (    -4.00)
```

```
EEEEE N   N DDDD        PPPP  H   H  AAA  N   N
E     NN  N D   D       P   P H   H A   A NN  N
EEE   N N N D   D       PPPP  HHHHH A   A N N N
E     N  NN D   D       P     H   H AAAAA N  NN
EEEEE N   N DDDD        P     H   H A   A N   N
```

XMIN = 0 XMAX = .32E+02 XSUM = .7526E+04



0 .2400E+01 .5920E+01 .7520E+01 .8640E+01 .9920E+01 .1120E+02

.1232E+02 .1312E+02 .1392E+02 .1568E+02 .1744E+02 .1856E+02 .1984E+02

.2096E+02 .2336E+02 .2624E+02 .2784E+02 .2912E+02 .3040E+02 .3152E+02

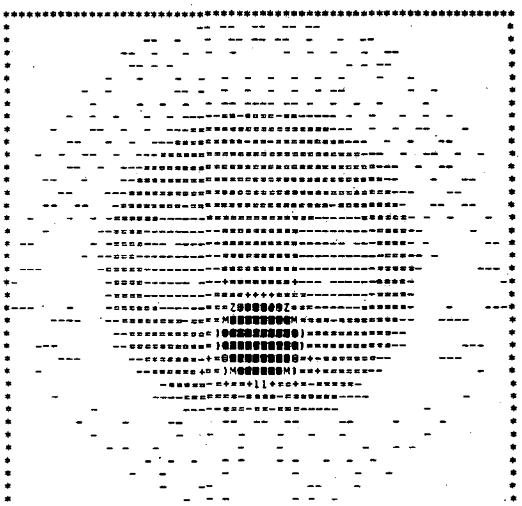
.3200E+02

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 1605 FLOATING POINT WORDS.

```
EEEEE N   N DDDD      CCC  OOOOO N   N V   V OOOOO
E     NN  N D   D    C   C O   O NN  N V   V O   O
EEE   N N N D   D    C     O   O N N N V   V O   O
E     N  NN D   D    C   C O   O N  NN  V V  O   O
EEEEE N   N DDDD      CCC  OOOOO N   N   V   OOOOO
```

RECONSTRUCTION FOR PARALLEL BEAM GEOMETRY USING SHLO.CONVOLVER
TRANSMISSION DATA

XMIN = -.23E+01 XMAX = .32E+02 XSUM = .7525E+04



-.2305E+01 .2822E+00 .4077E+01 .5802E+01 .7009E+01 .8389E+01 .9769E+01

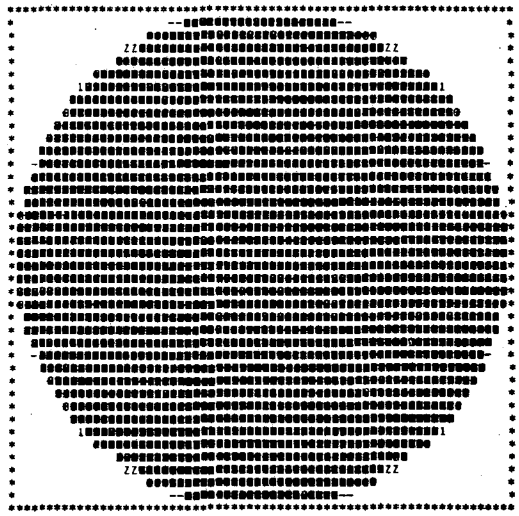
.1098E+02 .1184E+02 .1270E+02 .1460E+02 .1650E+02 .1770E+02 .1908E+02

.2029E+02 .2288E+02 .2598E+02 .2771E+02 .2909E+02 .3047E+02 .3167E+02

.3219E+02

ERRORS IN THE RECONSTRUCTED IMAGE

XMIN = 0 XMAX = .67E-01 XSUM = .1953E+03



0 .4994E-02 .1232E-01 .1565E-01 .1798E-01 .2064E-01 .2331E-01

.2564E-01 .2730E-01 .2897E-01 .3263E-01 .3629E-01 .3862E-01 .4129E-01

.4362E-01 .4861E-01 .5460E-01 .5793E-01 .6060E-01 .6326E-01 .6559E-01

.6659E-01

```
 CCC  OOOOO N   N V   V OOOOO
C   C O   O NN  N V   V O   O
C     O   O N N N V   V O   O
C   C O   O N  NN  V V  O   O
 CCC  OOOOO N   N   V   OOOOO
```

PARAMETERS FOR SUBROUTINE CONVO

DESCRIPTION

IERR - 1 CALCULATE ERRORS

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	INTERPOLATION	NO	NO
CNV	CONVOLUTION	N/A	NO	NO

THE VALUES FOR THE FILTER IN REAL SPACE (CONVOL(I),I=0, 67)

.785E+00	-.318E+00	0	-.354E-01	0
-.127E-01	0	-.650E-02	0	-.393E-02
0	-.263E-02	0	-.188E-02	0
-.141E-02	0	-.110E-02	0	-.882E-03
0	-.722E-03	0	-.602E-03	0
-.509E-03	0	-.437E-03	0	-.378E-03
0	-.331E-03	0	-.292E-03	0
-.260E-03	0	-.233E-03	0	-.209E-03
0	-.189E-03	0	-.172E-03	0
-.157E-03	0	-.144E-03	0	-.133E-03
0	-.122E-03	0	-.113E-03	0
-.105E-03	0	-.980E-04	0	-.914E-04
0	-.855E-04	0	-.802E-04	0
-.753E-04	0	-.709E-04		

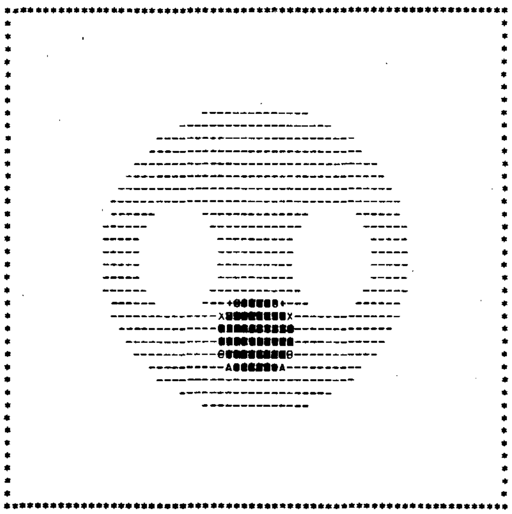
```
PPPP  H   H  AAA  N   N
P   P H   H A   A NN  N
PPPP  HHHHH A   A N N N
P     H   H AAAAA N  NN
P     H   H A   A N   N
```

PHANTOM GENERATED
ARRAY SIZE 64 X 64 INTEGRATION FACTOR = 10 SCALING FACTOR = 1.000
NUMBER OF ELIPSES AND/OR RECTANGLES = 4
THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
X,Y - CENTER
A,B - LENGTH OF AXIS OR SIDE A AND B
PHI - ANGLE OF AXIS OR SIDE A
DENS - INTENSITY
THE PARENTHESIS INDICATES THE SCALED VALUE

ITYPE		X	Y	A	B	PHI	DENS
1	- ELLIPSE	0 ,	0	40.00 ,	40.00	0	5.00
		(0),(	0)(	40.00),(	40.00)		(5.00)
1	- ELLIPSE	0 ,	-10.00	10.00 ,	10.00	0	27.00
		(0),(	-10.00)(	10.00),(	10.00)		(27.00)
1	- ELLIPSE	10.00 ,	0	14.00 ,	10.00	1.57	-4.00
		(10.00),(	0)(	14.00),(	10.00)		(-4.00)
1	- ELLIPSE	-10.00 ,	0	14.00 ,	10.00	1.57	-4.00
		(-10.00),(	0)(	14.00),(	10.00)		(-4.00)

END PHAN

XMIN = 0 XMAX = .32E+02 XSUM = .7526E+04



0 .2400E+01 .5920E+01 .7520E+01 .8640E+01 .9920E+01 .1120E+02

.1232E+02 .1312E+02 .1392E+02 .1568E+02 .1744E+02 .1856E+02 .1984E+02

.2096E+02 .2336E+02 .2624E+02 .2784E+02 .2912E+02 .3040E+02 .3152E+02

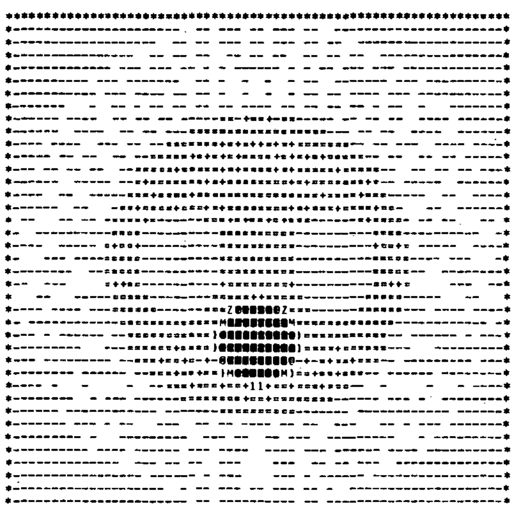
.3200E+02

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 1605 FLOATING POINT WORDS.

END CONVO

RECONSTRUCTION FOR PARALLEL BEAM GEOMETRY USING RALA CONVOLVER
TRANSMISSION DATA

XMIN = -.28E+01 XMAX = .32E+02 XSUM = .7521E+04



-.2819E+01 -.1807E+00 .3688E+01 .5447E+01 .6678E+01 .8085E+01 .9492E+01

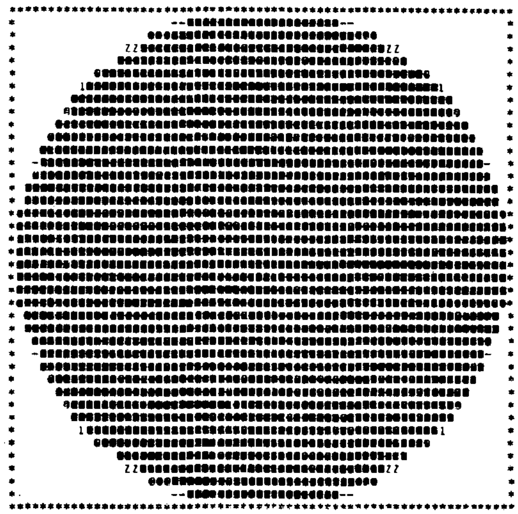
.1072E+02 .1160E+02 .1248E+02 .1442E+02 .1635E+02 .1758E+02 .1899E+02

.2022E+02 .2286E+02 .2602E+02 .2778E+02 .2919E+02 .3060E+02 .3183E+02

.3235E+02

ERRORS IN THE RECONSTRUCTED IMAGE

XMIN = 0 XMAX = .84E-01 XSUM = .2422E+03



0 .6274E-02 .1547E-01 .1966E-01 .2258E-01 .2593E-01 .2928E-01

.3220E-01 .3430E-01 .3639E-01 .4099E-01 .4559E-01 .4852E-01 .5186E-01

.5479E-01 .6106E-01 .6859E-01 .7277E-01 .7612E-01 .7947E-01 .8239E-01

.8365E-01

SETUP

INTEGER PARAMETER ARRAY (IPAR)

I	IPAR(I)	DESCRIPTION
1	64	LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
2	0	RECONSTRUCT IN A CIRCULAR ARRAY
3	1	GEOMETRY FLAG FAN BEAM GEOMETRY (CURVED DETECTOR)
4	72	NUMBER OF PROJECTION ANGLES
5	5	MODE FOR PROJECTION ANGLE INPUT (SEE FOLLOWING LINES) ANGLES GENERATED BETWEEN ZERO AND 2*PI STARTING AT ZERO
6	100	NUMBER OF RAYS FOR EACH PROJECTION
7	1	TRANSMISSION DATA
8	2000	DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
9	1	NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10	0	EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11	12	PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES) PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER ROUTINES
12	0	LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE

FLOATING POINT PARAMETER ARRAY (PAR)

I	PAR(I)	DESCRIPTION
1	1.330	PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION
2	50.500	LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
3	125.000	DISTANCE FROM SOURCE TO CENTER OF ROTATION FOR FAN BEAM IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION

A TOTAL OF 90 (6 THRU 95) OF THE 100 USER PROJECTION BINS WILL BE USED

90 PROJECTION BINS WILL BE USED OF WHICH 0 HAVE BEEN ZEROED BY THE PROGRAM

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 1605 FLOATING POINT WORDS.

```
EEEEE N   N DDDD          SSS   EEEEE TTTTT U   U PPPP
E     NN  N D   D        S      E       T   U   U P   P
EEE   N N N D   D         SSS   EEE     T   U   U PPPP
E     N  NN D   D            S  E       T   U   U P
EEEEE N   N DDDD          SSS   EEEEE   T    UUU  P
```

```
 CCC  OOOOO N   N V   V OOOOO
C   C O   O NN  N V   V O   O
C     O   O N N N  V V  O   O
C   C O   O N  NN  V V  O   O
 CCC  OOOOO N   N   V   OOOOO
```

PARAMETERS FOR SUBROUTINE CONVO

DESCRIPTION

IERR - 1 CALCULATE ERRORS

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	INTERPOLATION	NO	YES
CNV	CONVOLUTION	N/A	NO	YES

THE VALUES FOR THE FILTER IN REAL SPACE (CONVOL(I),I=0, 89)

.785E+00	-.318E+00	0	-.354E-01	0
-.127E-01	0	-.650E-02	0	-.394E-02
0	-.264E-02	0	-.189E-02	0
-.142E-02	0	-.111E-02	0	-.889E-03
0	-.729E-03	0	-.609E-03	0
-.516E-03	0	-.443E-03	0	-.385E-03
0	-.338E-03	0	-.299E-03	0
-.267E-03	0	-.239E-03	0	-.216E-03
0	-.196E-03	0	-.179E-03	0
-.164E-03	0	-.151E-03	0	-.140E-03
0	-.129E-03	0	-.120E-03	0
-.112E-03	0	-.105E-03	0	-.985E-04
0	-.927E-04	0	-.873E-04	0
-.825E-04	0	-.781E-04	0	-.741E-04
0	-.704E-04	0	-.670E-04	0
-.639E-04	0	-.610E-04	0	-.584E-04
0	-.559E-04	0	-.536E-04	0
-.515E-04	0	-.496E-04	0	-.477E-04

THE WEIGHTS USED FOR THE FAN BEAM CONVOLUTION (WEIGHT(I),I=1, 90)

.937E+00	.940E+00	.943E+00	.945E+00	.948E+00
.950E+00	.953E+00	.955E+00	.958E+00	.960E+00
.962E+00	.964E+00	.966E+00	.968E+00	.970E+00
.972E+00	.974E+00	.976E+00	.978E+00	.979E+00
.981E+00	.982E+00	.984E+00	.985E+00	.987E+00
.988E+00	.989E+00	.990E+00	.991E+00	.992E+00
.993E+00	.994E+00	.995E+00	.996E+00	.996E+00
.997E+00	.998E+00	.998E+00	.999E+00	.999E+00
.999E+00	.100E+01	.100E+01	.100E+01	.100E+01
.100E+01	.100E+01	.100E+01	.100E+01	.999E+00
.999E+00	.999E+00	.998E+00	.998E+00	.997E+00
.996E+00	.996E+00	.995E+00	.994E+00	.993E+00
.992E+00	.991E+00	.990E+00	.989E+00	.988E+00
.987E+00	.985E+00	.984E+00	.982E+00	.981E+00
.979E+00	.978E+00	.976E+00	.974E+00	.972E+00
.970E+00	.968E+00	.966E+00	.964E+00	.962E+00
.960E+00	.958E+00	.955E+00	.953E+00	.950E+00
.948E+00	.945E+00	.943E+00	.940E+00	.937E+00

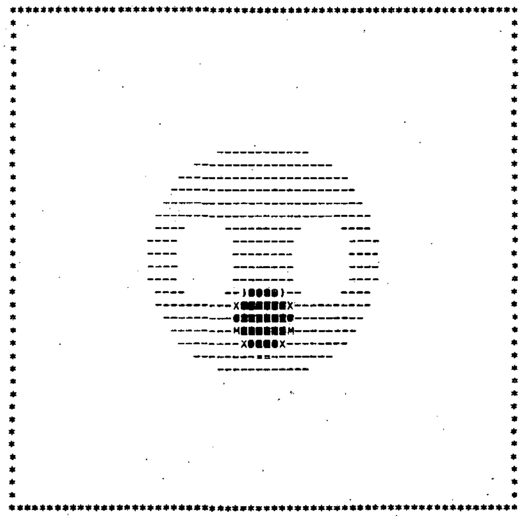
```
PPPP  H   H  AAA  N   N
P   P H   H A   A NN  N
PPPP  HHHHH A   A N N N
P     H   H AAAAA N  NN
P     H   H A   A N   N
```

PHANTOM GENERATED
ARRAY SIZE 64 X 64 INTEGRATION FACTOR = 10 SCALING FACTOR = .752
NUMBER OF ELIPSES AND/OR RECTANGLES = 4
THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
X,Y - CENTER
A,B - LENGTH OF AXIS OR SIDE A AND B
PHI - ANGLE OF AXIS OR SIDE A
DENS - INTENSITY
THE PARENTHESIS INDICATES THE SCALED VALUE

ITYPE	X	Y	A	B	PHI	DENS
1 - ELLIPSE	0 ,	0	40.00 ,	40.00	0	5.00
	(0),(	0)(	30.08),(	30.08)		(6.65)
1 - ELLIPSE	0 ,	-10.00	10.00 ,	10.00	0	27.00
	(0),(	-7.52)(	7.52),(	7.52)		(35.91)
1 - ELLIPSE	10.00 ,	0	14.00 ,	10.00	1.57	-4.00
	(7.52),(	0)(	10.53),(	7.52)		(-5.32)
1 - ELLIPSE	-10.00 ,	0	14.00 ,	10.00	1.57	-4.00
	(-7.52),(	0)(	10.53),(	7.52)		(-5.32)

```
EEEEE N   N DDDD          PPPP  H   H  AAA  N   N
E     NN  N D   D         P   P H   H A   A NN  N
EEE   N N N D   D         PPPP  HHHHH A   A N N N
E     N  NN D   D         P     H   H AAAAA N  NN
EEEEE N   N DDDD          P     H   H A   A N   N
```

XMIN = 0 XMAX = .43E+02 XSUM = .565cE+04



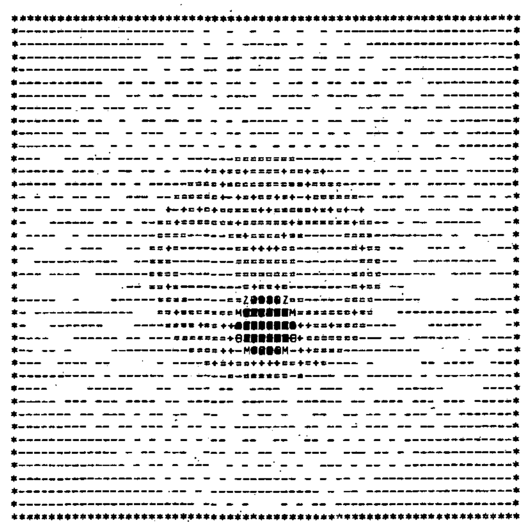
```
                 -           =           +           )           1           Z
   0  .3192E+01 .7874E+01  .1000E+02  .1149E+02  .1319E+02  .1490E+02

Z          X          A          M          B          B          B          B
 .1639E+02  .1745E+02  .1851E+02  .2085E+02  .2320E+02  .2468E+02  .2639E+02

B          ■          ■          ■          ■          ■          ■          ■
 .2788E+02  .3107E+02  .3490E+02  .3703E+02  .3973E+02  .4043E+02  .4192E+02

■
 .425oE+02
```

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 1605 FLOATING POINT WORDS.

```
EEEEE N   N DDDD          CCC  OOOOO N   N V   V OOOOO
E     NN  N D   D        C   C O   O NN  N V   V O   O
EEE   N N N D   D        C     O   O N N N  V V  O   O
E     N  NN D   D        C   C O   O N  NN  V V  O   O
EEEEE N   N DDDD          CCC  OOOOO N   N   V   OOOOO
```

RECONSTRUCTION FOR FAN BEAM GEOMETRY - CURVED DETECTOR USING LAKS CONVOLVER
TRANSMISSION DATA

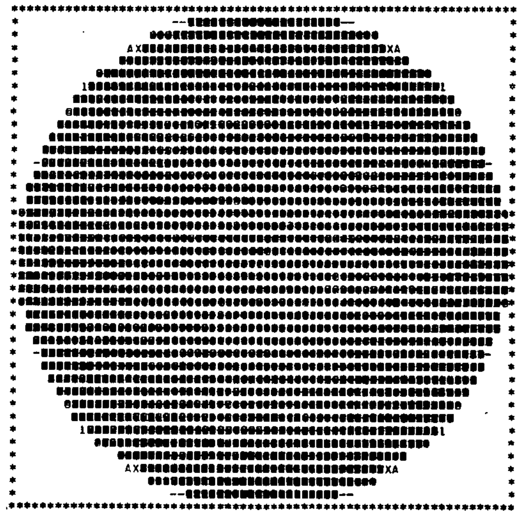
XMIN = -.38E+01 XMAX = .43E+02 XSUM = .5627E+04



```
                       -           =           +           )           1           Z
-.3790E+01 -.2851E+00 .4855E+01  .7191E+01  .8827E+01  .1070E+02  .1257E+02

Z          X          A          M          B          B          B          B
 .1420E+02  .1537E+02  .1654E+02  .1911E+02  .2168E+02  .2331E+02  .2518E+02

B          ■          ■          ■          ■          ■          ■          ■
 .2682E+02  .3032E+02  .3453E+02  .3686E+02  .3873E+02  .4060E+02  .4224E+02

■
 .4294E+02
```

ERRORS IN THE RECONSTRUCTED IMAGE

XMIN = 0 XMAX = .13E+00 XSUM = .3477E+03



```
          -         =         +         )         1         Z
0  .9540E-02 .2353E-01 .2985E-01 .3434E-01 .3943E-01 .4432E-01

Z         X         A         M         B         @         @         @
.4897E-01 .5215E-01 .5533E-01 .6232E-01 .6932E-01 .7377E-01 .7886E-01

@         @         @         @         @         @         @         @
.8331E-01 .9285E-01 .1043E+00 .1107E+00 .1157E+00 .1208E+00 .1253E+00

@
.1272E+00
```

```
 SSS  EEEEE TTTTT U   U PPPP
S     E       T   U   U P   P
 SSS  EEE     T   U   U PPPP
    S E       T   U   U P
 SSS  EEEEE   T    UUU  P
```

INTEGER PARAMETER ARRAY (IPAR)

I	IPAR(I)	DESCRIPTION
1	64	LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
2	0	RECONSTRUCT IN A CIRCULAR ARRAY
3	2	GEOMETRY FLAG FAN BEAM GEOMETRY (FLAT DETECTOR)
4	72	NUMBER OF PROJECTION ANGLES
5	5	MODE FOR PROJECTION ANGLE INPUT (SEE FOLLOWING LINES) ANGLES GENERATED BETWEEN ZERO AND 2*PI STARTING AT ZERO
6	100	NUMBER OF RAYS FOR EACH PROJECTION
7	1	TRANSMISSION DATA
8	2000	DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
9	1	NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10	0	EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11	12	PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES) PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER ROUTINES
12	0	LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE

FLOATING POINT PARAMETER ARRAY (PAR)

I	PAR(I)	DESCRIPTION
1	1.330	PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION
2	50.500	LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
3	125.000	DISTANCE FROM SOURCE TO CENTER OF ROTATION FOR FAN BEAM IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION

A TOTAL OF 94 (4 THRU 97) OF THE 100 USER PROJECTION BINS WILL BE USED

94 PROJECTION BINS WILL BE USED OF WHICH 0 HAVE BEEN ZEROED BY THE PROGRAM

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 1605 FLOATING POINT WORDS.

```
EEEEE N   N DDDD         SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D       S     E       T   U   U P   P
EEE   N N N D   D        SSS  EEE     T   U   U PPPP
E     N  NN D   D           S E       T   U   U P
EEEEE N   N DDDD         SSS  EEEEE   T    UUU  P
```

```
 CCC  OOOOO N   N V   V OOOOO
C   C O   O NN  N V   V O   O
C     O   O N N N  V V  O   O
C   C O   O N  NN  V V  O   O
 CCC  OOOOO N   N   V   OOOOO
```

PARAMETERS FOR SUBROUTINE CONVO

DESCRIPTION

IERR = 1 CALCULATE ERRORS

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	INTERPOLATION	NO	YES
CNV	CONVOLUTION	N/A	NO	YES

THE VALUES FOR THE FILTER IN REAL SPACE (CONVOL(I),I=0, 93)

.785E+00	-.318E+00	0	-.354E-01	0
-.127E-01	0	-.650E-02	0	-.393E-02
0	-.263E-02	0	-.188E-02	0
-.141E-02	0	-.110E-02	0	-.882E-03
0	-.722E-03	0	-.602E-03	0
-.509E-03	0	-.437E-03	0	-.378E-03
0	-.331E-03	0	-.292E-03	0
-.260E-03	0	-.233E-03	0	-.209E-03
0	-.189E-03	0	-.172E-03	0
-.157E-03	0	-.144E-03	0	-.133E-03
0	-.122E-03	0	-.113E-03	0
-.105E-03	0	-.980E-04	0	-.914E-04
0	-.855E-04	0	-.802E-04	0
-.753E-04	0	-.709E-04	0	-.669E-04
0	-.631E-04	0	-.597E-04	0
-.566E-04	0	-.537E-04	0	-.510E-04
0	-.485E-04	0	-.462E-04	0
-.441E-04	0	-.421E-04	0	-.402E-04
0	-.384E-04	0	-.368E-04	

THE WEIGHTS USED FOR THE FAN BEAM CONVOLUTION (WEIGHT(I),I=1, 94)

.937E+00	.940E+00	.942E+00	.944E+00	.947E+00
.949E+00	.951E+00	.954E+00	.956E+00	.958E+00
.960E+00	.962E+00	.964E+00	.966E+00	.968E+00
.970E+00	.971E+00	.973E+00	.975E+00	.977E+00
.978E+00	.980E+00	.981E+00	.983E+00	.984E+00
.986E+00	.987E+00	.988E+00	.989E+00	.990E+00
.991E+00	.992E+00	.993E+00	.994E+00	.995E+00
.996E+00	.996E+00	.997E+00	.998E+00	.998E+00
.999E+00	.999E+00	.999E+00	.100E+01	.100E+01
.100E+01	.100E+01	.100E+01	.100E+01	.100E+01
.100E+01	.999E+00	.999E+00	.999E+00	.998E+00
.998E+00	.997E+00	.996E+00	.996E+00	.995E+00
.994E+00	.993E+00	.992E+00	.991E+00	.990E+00
.989E+00	.988E+00	.987E+00	.986E+00	.984E+00
.983E+00	.981E+00	.980E+00	.978E+00	.977E+00
.975E+00	.973E+00	.971E+00	.970E+00	.968E+00
.966E+00	.964E+00	.962E+00	.960E+00	.958E+00
.956E+00	.954E+00	.951E+00	.949E+00	.947E+00
.944E+00	.942E+00	.940E+00	.937E+00	

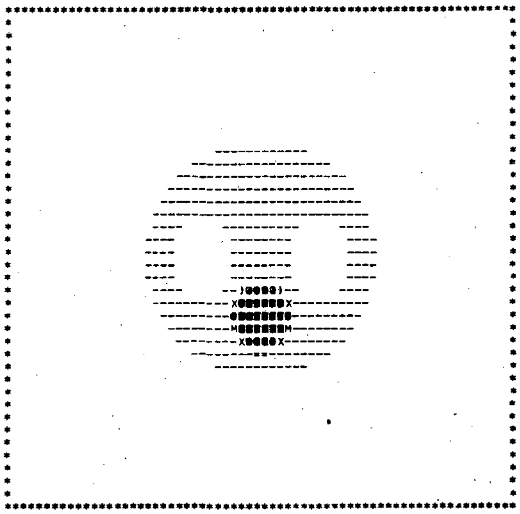
```
PPPP  H   H  AAA  N   N
P   P H   H A   A NN  N
PPPP  HHHHH A   A N N N
P     H   H AAAAA N  NN
P     H   H A   A N   N
```

PHANTOM GENERATED
ARRAY SIZE 64 X 64 INTEGRATION FACTOR = 10 SCALING FACTOR = .752
NUMBER OF ELIPSES AND/OR RECTANGLES = 4
THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
X,Y - CENTER
A,B - LENGTH OF AXIS OR SIDE A AND B
PHI - ANGLE OF AXIS OR SIDE A
DENS - INTENSITY
THE PARENTHESIS INDICATES THE SCALED VALUE

ITYPE		X	Y	A	B	PHI	DENS
1	- ELLIPSE	0 ,	0	40.00 ,	40.00	0	5.00
		(0),(	0)(	30.08),(	30.08)		(6.65)
1	- ELLIPSE	0 ,	-10.00	10.00 ,	10.00	0	27.00
		(0),(	-7.52)(	7.52),(	7.52)		(35.91)
1	- ELLIPSE	10.00 ,	0	14.00 ,	10.00	1.57	-4.00
		(7.52),(	0)(	10.53),(	7.52)		(-5.32)
1	- ELLIPSE	-10.00 ,	0	14.00 ,	10.00	1.57	-4.00
		(-7.52),(	0)(	10.53),(	7.52)		(-5.32)

```
EEEEE N   N DDDD      PPPP  H   H  AAA  N   N
E     NN  N D   D     P   P H   H A   A NN  N
EEE   N N N D   D     PPPP  HHHHH A   A N N N
E     N  NN D   D     P     H   H AAAAA N  NN
EEEEE N   N DDDD      P     H   H A   A N   N
```

XMIN = 0 XMAX = .43E+02 XSUM = .5656E+04



0 .3192E+01 .7874E+01 .1000E+02 .1149E+02 .1319E+02 .1490E+02

.1639E+02 .1745E+02 .1851E+02 .2085E+02 .2320E+02 .2468E+02 .2639E+02

.2788E+02 .3107E+02 .3490E+02 .3703E+02 .3873E+02 .4043E+02 .4192E+02

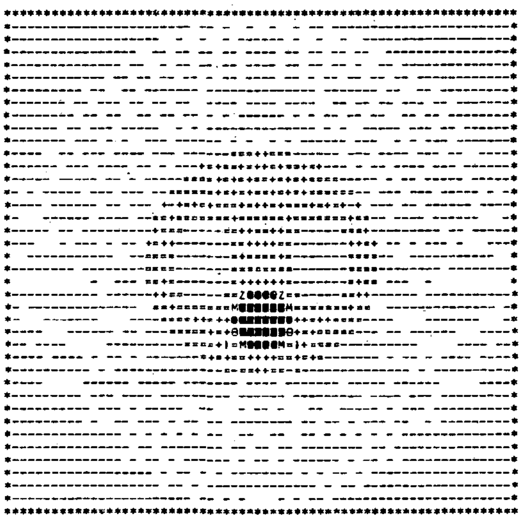
.4256E+02

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 1605 FLOATING POINT WORDS.

END CONVO

RECONSTRUCTION FOR FAN BEAM GEOMETRY - FLAT DETECTOR USING LAKS CONVOLVER
TRANSMISSION DATA

XMIN = -.40E+01 XMAX = .43E+02 XSUM = .5623E+04



-.4022E+01 -.5000E+00 .4665E+01 .7013E+01 .8657E+01 .1053E+02 .1241E+02

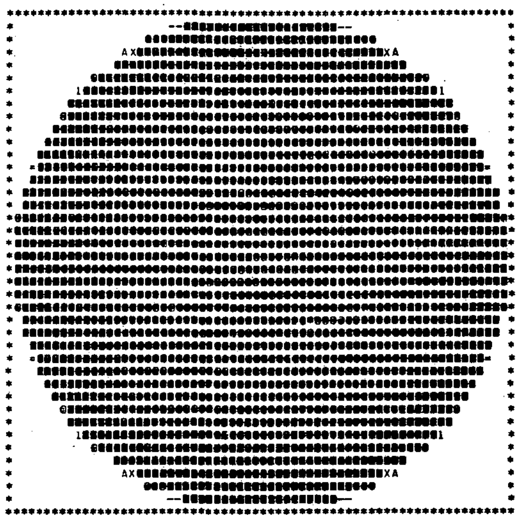
.1406E+02 .1523E+02 .1640E+02 .1899E+02 .2157E+02 .2321E+02 .2509E+02

.2674E+02 .3026E+02 .3448E+02 .3683E+02 .3871E+02 .4059E+02 .4223E+02

.4294E+02

ERRORS IN THE RECONSTRUCTED IMAGE

XMIN = 0 XMAX = .14E+00 XSUM = .3575E+03



0 .1015E-01 .2504E-01 .3180E-01 .3654E-01 .4195E-01 .4737E-01

.5210E-01 .5549E-01 .5887E-01 .6631E-01 .7376E-01 .7849E-01 .8391E-01

.8864E-01 .9880E-01 .1110E+00 .1177E+00 .1232E+00 .1286E+00 .1333E+00

.1353E+00

BCOM

***** THE LARGEST REQUIRED LENGTH OF BLANK COMMON THUS FAR IS 1605 *****

3. Example 3 - Back-Projection of Filtered Projections

The program XBKFIL uses the back-projection of filtered projections algorithm to reconstruct parallel-beam projection data utilizing the filters HAM, HAN, PARZN, and RAMP with a cutoff frequency FREQX set to 0.5 and the filter BUTER with parameters FREQX = 0.52 and ORDERX = 388. The parameter ORDERX is used only for the filter BUTER and is therefore set to zero for the other examples. The RAMP filter and BUTER filter for this example have narrow real-space convolution windows and thus the reconstructed images have sharp contrast but increased background artifact as compared to the other filters that have wider windows and decreased amplitude in the side lobes for their respective convolution functions. These latter filters give less background artifact but also poorer resolution in the reconstructed image than available for the RAMP and BUTER filters.

The subroutine GETUM gives simulated projection data for a heart phantom. A rectangular object in the upper right is added in order to compare the sharpness of the reconstructed image for the different filters.

```
      PROGRAM XBKFIL (INPUT,OUTPUT,TAPE2=OUTPUT)
C
C        EXAMPLE 3
C
C             THE PROGRAM XBKFIL USES THE BACK-PROJECTION OF THE
C        FILTERED PROJECTION ALGORITHM TO RECONSTRUCT PARALLEL BEAM
C        PROJECTION DATA FOR VARIOUS TYPES OF FILTERS
C
      DIMENSION B(4096),AG(180)
      COMMON/TYPE/LTYPE
      COMMON WORK(2000)
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT  - OUTPUT FILE
C          I80132  - OUTPUT LINE LENGTH FLAG
C                =0    EACH LINE WILL BE WITHIN 80 CHARACTERS
C                         (OTHERWISE 132 CHARACTERS)
C
      COMMON/PARM/IPAR(12),PAR(3)
C
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)),
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)),
     2            (IMIT  ,IPAR( 7)),(NWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)),
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)),
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3))
C
C
      EXTERNAL BRF,HAN,HAM,PARZN,BUTER,RAMP
C
      LUNOUT=2
      I80132=0
C
C        THE INPUT PARAMETERS ARE
C
      NDIMU=64
      ICIR=1
      IGEOM=0
      NANG=72
      MODANG=5
      KDIMU=100
      IMIT=1
      NWORK=2000
      NFLOAT=1
      ISTORE=0
      IPRINT=13
      LUNATN=0
      PWID=1.
      AXISU=50.5
      RFAN=0.
C
      CALL SETUP (IPAR,PAR,AG)
C
      DO 20 LTYPE=1,5
      GO TO (10,12,14,16,18),LTYPE
C
   10 ORDERX=0.
      FREQX=.5
      CALL BKFIL (B,RAMP,BRF,ORDEPX,FREQX)
      WRITE (LUNOUT,22)
      GO TO 20
C
   12 ORDERX=0.
      FREQX=.5
      CALL BKFIL (B,HAN,BRF,ORDERX,FREQX)
      WRITE (LUNOUT,24)
      GO TO 20
C
   14 ORDERX=0.
      FREQX=.5
      CALL BKFIL (B,HAM,BRF,ORDERX,FREQX)
      WRITE (LUNOUT,26)
      GO TO 20
C
   16 ORDERX=0.
      FREQX=.5
      CALL BKFIL (B,PARZN,BRF,ORDERX,FREQX)
      WRITE (LUNOUT,28)
      GO TO 20
C
   18 ORDERX=388.
      FREQX=.52
      CALL BKFIL (B,BUTER,BRF,ORDERX,FREQX)
      WRITE (LUNOUT,30)
C
   20 CALL ARRAY (B,NDIMU)
C
C
C
   22 FORMAT(1X//37H RECONSTRUCTION USING THE RAMP FILTER)
   24 FORMAT(1X//36H RECONSTRUCTION USING THE HAN FILTER)
   26 FORMAT(1X//36H RECONSTRUCTION USING THE HAM FILTER)
   28 FORMAT(1X//38H RECONSTRUCTION USING THE PARZN FILTER)
   30 FORMAT(1X//62H RECONSTRUCTION USING THE BUTER FILTER (ORDERX=388,
     1FREQX=.52))
      END


      SUBROUTINE GETUM (M,DATA,ERP)
C
C        EXAMPLE 3
C
C             THE SUBROUTINE GETUM GIVES SIMULATED PROJECTION DATA FOR
C        A CHEST PHANTOM CONSISTING OF A HEART, LUNGS AND SURROUNDING
C        TISSUE.
C
      DIMENSION DATA(1),ERR(1)
      DIMENSION B(4096)
      DIMENSION AMAJ(5),AMIN(5),X1(5),Y1(5),PHI(5),Z(5),ITYPE(5)
      COMMON/TYPE/LTYPE
```

```
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT  - OUTPUT FILE
C          I80132  - OUTPUT LINE LENGTH FLAG
C                =0    EACH LINE WILL BE WITHIN 80 CHARACTERS
C                        (OTHERWISE 132 CHARACTERS)
C
      COMMON/PARM/IPAR(12),PAR(3)
C
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)),
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)),
     2            (IMIT  ,IPAR( 7)),(MWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)),
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)),
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3))
C
      DATA ITYPE/1,1,1,1,2/
      DATA AMAJ/40.,10.,14.,14.,6./
      DATA AMIN/40.,10.,10.,10.,6./
      DATA X1/0.,0.,10.,-10.,26./
      DATA Y1/0.,-10.,0.,0.,26./
      DATA PHI/0.,0.,1.57079633,1.57079633,0./
      DATA Z/5.,27.,-4.,-4.,32./
C
      IF (M.NE.1) GO TO 10
      IF (LTYPE.GT.1) GO TO 10
C
      IF (IMIT.NE.0) PWIDTH=PWID
      IF (IMIT.EQ.0) PWIDTH=-PWID
      CALL PHAN (5,10,ITYPE,Z,X1,Y1,AMAJ,AMIN,PHI,B,NDIMU,PWIDTH)
C
      CALL ARRAY (B,NDIMU)
C
   10 CALL PHANL (5,ITYPE,Z,X1,Y1,AMAJ,AMIN,PHI,DATA,M)
C
      RETURN
C
      END
```

```
 SSS  EEEEE TTTTT U   U PPPP
S     E       T   U   U P   P
 SSS  EEE     T   U   U PPPP
    S E       T   U   U P
 SSS  EEEEE   T    UUU  P
```

INTEGER PARAMETER ARRAY (IPAR)

I	IPAR(I)	DESCRIPTION
1	64	LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
2	1	RECONSTRUCT IN A SQUARE ARRAY
3	0	GEOMETRY FLAG PARALLEL BEAM GEOMETRY
4	72	NUMBER OF PROJECTION ANGLES
5	5	MODE FOP PROJECTION ANGLE INPUT (SEE FOLLOWING LINES) ANGLES GENERATED BETWEEN ZERO AND 2*PI STARTING AT ZERO
6	100	NUMBER OF RAYS FOR EACH PROJECTION
7	1	TRANSMISSION DATA
8	2000	DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
9	1	NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10	0	EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11	13	PRINT FLAGS (OPTIONS SELECTED APE ON THE FOLLOWING LINES) PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER ROUTINES
12	0	LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE

FLOATING POINT PARAMETER ARRAY (PAR)

I	PAR(I)	DESCRIPTION
1	1.000	PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
2	50.500	LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
3	0 NA	NOT APPLICABLE (NOT FAN BEAM GEOMETRY)

BLANK COMMON REQUIRED 72 (110)

BLANK COMMON REQUIRED 144 (220)

BLANK COMMON REQUIRED 216 (330)

BLANK COMMON REQUIRED 416 (640)

BLANK COMMON REQUIRED 544 (1040)

A TOTAL OF 92 (5 THRU 96) OF THE 100 USER PROJECTION BINS WILL BE USED

92 PROJECTION BINS WILL BE USED OF WHICH, 0 HAVE BEEN ZEROED BY THE PROGRAM

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 544 FLOATING POINT WORDS.

```
EEEEE N   N DDDD       SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D     S     E       T   U   U P   P
EEE   N N N D   D      SSS  EEE     T   U   U PPPP
E     N  NN D   D         S E       T   U   U P
EEEEE N   N DDDD       SSS  EEEEE   T    UUU  P
```

```
BBBB  K   K FFFFF  III  L
B   B K  K  F       I   L
BBBB  KKK   FFF     I   L
B   B K  K  F       I   L
BBBB  K   K F      III  LLLLL
```

PARAMETERS FOR SUBROUTINE BKFIL

		DESCRIPTION
ORDERX -	0	FILTER PARAMETER USED ONLY BY THE FILTER BUTER.
FREQX -	.500	FREQUENCY PARAMETER FOR THE FILTER

BLANK COMMON REQUIRED 616 (1150)

BLANK COMMON REQUIRED 1226 (2312)

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	UNIFORM SQUARE	NO	NO
FIL	FILTER	N/A	NO	N/A

BLANK COMMON REQUIRED 1482 (2712)

BLANK COMMON REQUIRED 1610 (3112)

THE VALUES FOR THE FREQUENCY SPACE FILTER (FILT(I),I=0,128) WITH A FREQUENCY
SPACING OF 1/256 = .391E-02 CYCLES PER PROJECTION BIN ARE

0	.391E-02	.781E-02	.117E-01	.156E-01
.195E-01	.234E-01	.273E-01	.313E-01	.352E-01
.391E-01	.430E-01	.469E-01	.508E-01	.547E-01
.586E-01	.625E-01	.664E-01	.703E-01	.742E-01
.781E-01	.820E-01	.859E-01	.898E-01	.938E-01
.977E-01	.102E+00	.105E+00	.109E+00	.113E+00
.117E+00	.121E+00	.125E+00	.129E+00	.133E+00
.137E+00	.141E+00	.145E+00	.148E+00	.152E+00
.156E+00	.160E+00	.164E+00	.168E+00	.172E+00
.176E+00	.180E+00	.184E+00	.188E+00	.191E+00
.195E+00	.199E+00	.203E+00	.207E+00	.211E+00
.215E+00	.219E+00	.223E+00	.227E+00	.230E+00
.234E+00	.238E+00	.242E+00	.246E+00	.250E+00
.254E+00	.258E+00	.262E+00	.266E+00	.270E+00
.273E+00	.277E+00	.281E+00	.285E+00	.289E+00
.293E+00	.297E+00	.301E+00	.305E+00	.309E+00
.313E+00	.316E+00	.320E+00	.324E+00	.328E+00
.332E+00	.336E+00	.340E+00	.344E+00	.348E+00
.352E+00	.355E+00	.359E+00	.363E+00	.367E+00
.371E+00	.375E+00	.379E+00	.383E+00	.387E+00
.391E+00	.395E+00	.398E+00	.402E+00	.406E+00
.410E+00	.414E+00	.418E+00	.422E+00	.426E+00
.430E+00	.434E+00	.438E+00	.441E+00	.445E+00
.449E+00	.453E+00	.457E+00	.461E+00	.465E+00
.469E+00	.473E+00	.477E+00	.480E+00	.484E+00
.488E+00	.492E+00	.496E+00	.500E+00	

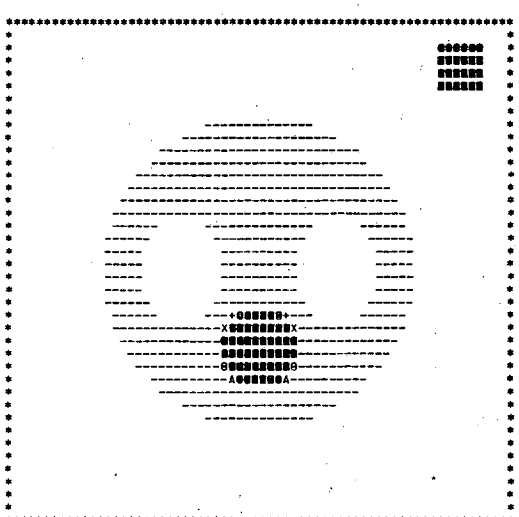
```
PPPP  H   H  AAA  N   N
P   P H   H A   A NN  N
PPPP  HHHHH A   A N N N
P     H   H AAAAA N  NN
P     H   H A   A N   N
```

PHANTOM GENERATED
ARRAY SIZE 64 X 64 INTEGRATION FACTOR = 10 SCALING FACTOR = 1.000
NUMBER OF ELIPSES AND/OR RECTANGLES = 5
THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
X,Y - CENTER
A,B - LENGTH OF AXIS OR SIDE A AND B
PHI - ANGLE OF AXIS OR SIDE A
DENS - INTENSITY
THE PARENTHESIS INDICATES THE SCALED VALUE

ITYPE		X	Y	A	B	PHI	DENS
1	- ELLIPSE	0 ,	0	40.00 ,	40.00	0	5.00
		(0),(	0)(	40.00),(	40.00)	(	5.00)
1	- ELLIPSE	0 ,	-10.00	10.00 ,	10.00	0	27.00
		(0),(	-10.00)(	10.00),(	10.00)	(	27.00)
1	- ELLIPSE	10.00 ,	0	14.00 ,	10.00	1.57	-4.00
		(10.00),(	0)(	14.00),(	10.00)	(	-4.00)
1	- ELLIPSE	-10.00 ,	0	14.00 ,	10.00	1.57	-4.00
		(-10.00),(	0)(	14.00),(	10.00)	(	-4.00)
2	- RECTANGLE	26.00 ,	26.00	6.00 ,	6.00	0	32.00
		(26.00),(	26.00)(	6.00),(	6.00)	(	32.00)

```
EEEEE N   N DDDD       PPPP  H   H  AAA  N   N
E     NN  N D   D      P   P H   H A   A NN  N
EEE   N N N D   D      PPPP  HHHHH A   A N N N
E     N  NN D   D      P     H   H AAAAA N  NN
EEEEE N   N DDDD       P     H   H A   A N   N
```

XMIN = 0 XMAX = .32E+02 XSUM = .8678E+04



```
                    -          =          +          )          1          Z
 0   .2400E+01  .5920E+01  .7520E+01  .8640E+01  .9920E+01  .1120E+02

 Z          X          A          M          @          @          @          @
 .1232E+02  .1312E+02  .1392E+02  .1568E+02  .1744E+02  .1856E+02  .1984E+02

 @          @          @          @          @          @          @          @
 .2096E+02  .2336E+02  .2624E+02  .2784E+02  .2912E+02  .3040E+02  .3152E+02

 @
 .3200E+02
```

BLANK COMMON REQUIRED 1650 (3162)

BLANK COMMON REQUIRED 1610 (3112)

BLANK COMMON REQUIRED 1354 (2512)

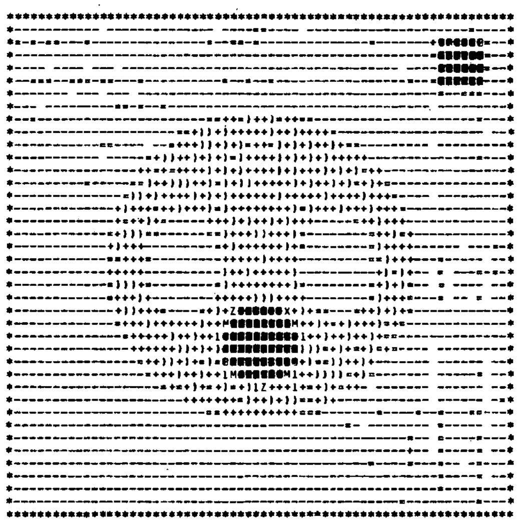
BLANK COMMON REQUIRED 1226 (2312)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 1650 FLOATING POINT WORDS.

```
EEEEE N   N DDDD       BBBB  K   K FFFFF  III  L
E     NN  N D   D      B   B K  K  F       I   L
EEE   N N N D   D      BBBB  KKK   FFF     I   L
E     N  NN D   D      B   B K  K  F       I   L
EEEEE N   N DDDD       BBBB  K   K F      III  LLLLL
```

RECONSTRUCTION USING THE RAMP FILTER

XMIN = -.51E+01 XMAX = .33E+02 XSUM = .8401E+04



```
                          -          =          +          )          1          Z
-.5146E+01 -.2262E+01  .1967E+01  .3890E+01  .5235E+01  .6773E+01  .8311E+01

 Z          X          A          M          @          @          @          @
 .9657E+01  .1062E+02  .1158E+02  .1369E+02  .1581E+02  .1715E+02  .1869E+02

 @          @          @          @          @          @          @          @
 .2004E+02  .2292E+02  .2638E+02  .2830E+02  .2984E+02  .3138E+02  .3273E+02

 @
 .3330E+02
```

```
BBBB  K   K FFFFF  III  L
B   B K  K  F       I   L
BBBB  KKK   FFF     I   L
B   B K  K  F       I   L
BBBB  K   K F      III  LLLLL
```

PARAMETERS FOR SUBROUTINE BKFIL

DESCRIPTION

ORDERX - 0 FILTER PARAMETER USED ONLY BY THE FILTER BUTEF
FREQX - .500 FREQUENCY PARAMETER FOR THE FILTER

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	UNIFORM SQUARE	NO	NO
FIL	FILTER	N/A	NO	N/A

BLANK COMMON REQUIRED 1482 (2712)

BLANK COMMON REQUIRED 1610 (3112)

THE VALUES FOR THE FREQUENCY SPACE FILTER (FILT(I),I=0,128) WITH A FREQUENCY SPACING OF 1/256 = .391E-02 CYCLES PER PROJECTION BIN ARE

0	.391E-02	.781E-02	.117E-01	.156E-01
.195E-01	.233E-01	.271E-01	.309E-01	.347E-01
.385E-01	.422E-01	.459E-01	.495E-01	.531E-01
.566E-01	.601E-01	.636E-01	.669E-01	.703E-01
.735E-01	.767E-01	.798E-01	.829E-01	.859E-01
.887E-01	.916E-01	.943E-01	.970E-01	.995E-01
.102E+00	.104E+00	.107E+00	.109E+00	.111E+00
.113E+00	.115E+00	.117E+00	.118E+00	.120E+00
.122E+00	.123E+00	.124E+00	.125E+00	.126E+00
.127E+00	.128E+00	.129E+00	.130E+00	.130E+00
.131E+00	.131E+00	.131E+00	.131E+00	.131E+00
.131E+00	.131E+00	.130E+00	.130E+00	.129E+00
.129E+00	.128E+00	.127E+00	.126E+00	.125E+00
.124E+00	.123E+00	.121E+00	.120E+00	.118E+00
.117E+00	.115E+00	.113E+00	.111E+00	.109E+00
.107E+00	.105E+00	.103E+00	.101E+00	.988E-01
.965E-01	.941E-01	.917E-01	.892E-01	.867E-01
.842E-01	.816E-01	.790E-01	.764E-01	.737E-01
.711E-01	.684E-01	.657E-01	.630E-01	.603E-01
.576E-01	.549E-01	.522E-01	.496E-01	.469E-01
.443E-01	.418E-01	.392E-01	.367E-01	.342E-01
.318E-01	.295E-01	.271E-01	.249E-01	.227E-01
.206E-01	.186E-01	.167E-01	.148E-01	.130E-01
.113E-01	.976E-02	.828E-02	.691E-02	.565E-02
.450E-02	.348E-02	.258E-02	.181E-02	.117E-02
.662E-03	.296E-03	.747E-04	0	

BLANK COMMON REQUIRED 1650 (3162)

BLANK COMMON REQUIRED 1610 (3112)

BLANK COMMON REQUIRED 1354 (2512)

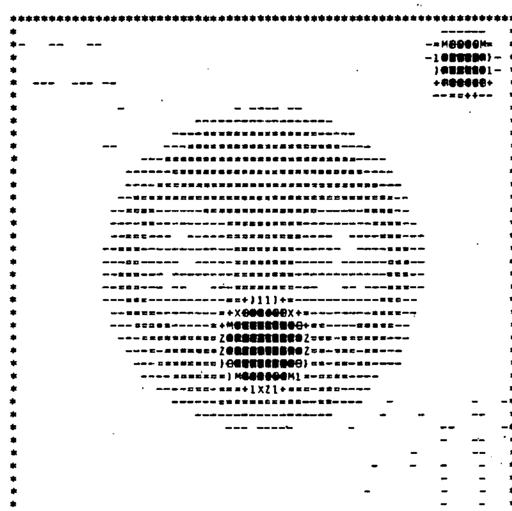
BLANK COMMON REQUIRED 1226 (2312)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 1650 FLOATING POINT WORDS.

```
EEEEE N   N DDDD       BBBB  K   K FFFFF  III  L
E     NN  N D   D      B   B K  K  F       I   L
EEE   N N N D   D      BBBB  KKK   FFF     I   L
E     N  NN D   D      B   B K  K  F       I   L
EEEEE N   N DDDD       BBBB  K   K F      III  LLLLL
```

RECONSTRUCTION USING THE HAN FILTER

XMIN = -.17E+01 XMAX = .32E+02 XSUM = .8402E+04



```
                          -          =          +          )          1          Z
-.1747E+01  .8163E+00  .4576E+01  .6284E+01  .7480E+01  .8847E+01  .1021E+02

 Z          X          A          M          @          @          @          @
 .1141E+02  .1226E+02  .1312E+02  .1500E+02  .1688E+02  .1807E+02  .1944E+02

 @          @          @          @          @          @          @          @
 .2064E+02  .2320E+02  .2628E+02  .2799E+02  .2935E+02  .3072E+02  .3152E+02

 @
 .3243E+02
```

```
BBBB  K   K FFFFF  III  L
B   B K  K  F       I   L
BBBB  KKK   FFF     I   L
B   B K  K  F       I   L
BBBB  K   K F      III  LLLLL
```

PARAMETERS FOR SUBROUTINE BKFIL

DESCRIPTION

ORDERX - 0 FILTER PARAMETER USED ONLY BY THE FILTER BUTER
FREQX - .500 FREQUENCY PARAMETER FOR THE FILTER

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTES ROUTINES
PERFOPM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	UNIFORM SQUARE	NO	NO
FIL	FILTER	N/A	NO	N/A

BLANK COMMON REQUIRED 1482 (2712)

BLANK COMMON REQUIRED 1610 (3112)

THE VALUES FOR THE FREQUENCY SPACE FILTER (FILT(I),I=0,128) WITH A FREQUENCY
SPACING OF 1/25c = .391E-02 CYCLES PER PROJECTION BIN ARE

0	.391E-02	.781E-02	.117E-01	.156E-01
.195E-01	.233E-01	.272E-01	.310E-01	.348E-01
.385E-01	.423E-01	.459E-01	.496E-01	.532E-01
.568E-01	.603E-01	.638E-01	.672E-01	.706E-01
.739E-01	.771E-01	.803E-01	.834E-01	.865E-01
.895E-01	.924E-01	.952E-01	.980E-01	.101E+00
.103E+00	.106E+00	.108E+00	.110E+00	.113E+00
.115E+00	.117E+00	.119E+00	.121E+00	.123E+00
.124E+00	.126E+00	.127E+00	.129E+00	.130E+00
.131E+00	.132E+00	.133E+00	.134E+00	.135E+00
.136E+00	.136E+00	.137E+00	.137E+00	.137E+00
.138E+00	.138E+00	.138E+00	.138E+00	.137E+00
.137E+00	.137E+00	.136E+00	.136E+00	.135E+00
.134E+00	.133E+00	.132E+00	.131E+00	.130E+00
.129E+00	.128E+00	.127E+00	.125E+00	.124E+00
.122E+00	.121E+00	.119E+00	.117E+00	.116E+00
.114E+00	.112E+00	.110E+00	.108E+00	.106E+00
.104E+00	.102E+00	.999E-01	.978E-01	.957E-01
.935E-01	.914E-01	.892E-01	.870E-01	.849E-01
.827E-01	.805E-01	.784E-01	.762E-01	.741E-01
.720E-01	.700E-01	.679E-01	.659E-01	.640E-01
.621E-01	.602E-01	.584E-01	.567E-01	.550E-01
.534E-01	.518E-01	.503E-01	.489E-01	.476E-01
.464E-01	.452E-01	.442E-01	.432E-01	.424E-01
.416E-01	.410E-01	.405E-01	.401E-01	.398E-01
.397E-01	.396E-01	.398E-01	.400E-01	

BLANK COMMON REQUIRED 1650 (3162)

BLANK COMMON REQUIRED 1610 (3112)

PLANK COMMON REQUIRED 1354 (2512)

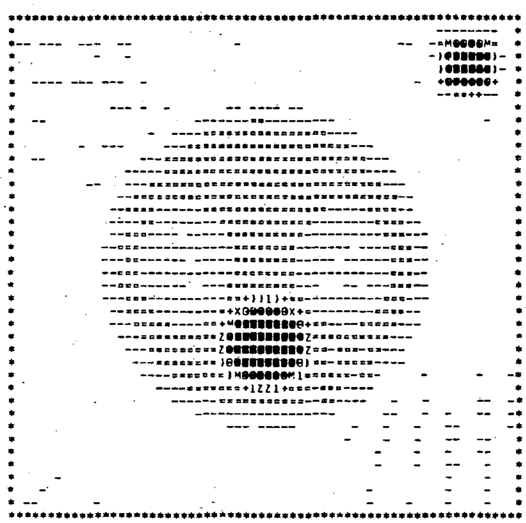
BLANK COMMON REQUIRED 1226 (2312)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 1650 FLOATING POINT WORDS.

```
EEEEE N   N DDDD      BBBB  K   K FFFFF  III  L
E     NN  N D   D     B   B K  K  F       I   L
EEE   N N N D   D     BBBB  KKK   FFF     I   L
E     N  NN D   D     B   B K  K  F       I   L
EEEEE N   N DDDD      BBBB  K   K F      III  LLLLL
```

RECONSTRUCTION USING THE HAM FILTER

XMIN = -.19E+01 XMAX = .32E+02 XSUM = .8402E+04



```
                       -          =          +          )          1          Z
-.1882E+01 .6965E+00 .4478E+01 .6197E+01 .7401E+01 .8776E+01 .1015E+02

Z          X          A          M          Θ          ⊕          @          ●
 .1135E+02 .1221E+02 .1307E+02 .1496E+02 .1686E+02 .1806E+02 .1943E+02

9          ●          ●          ●          ●          ■          ■          ■
 .2064E+02 .2322E+02 .2631E+02 .2803E+02 .2940E+02 .3078E+02 .3198E+02

■
 .3250E+02
```

```
BBBB  K   K FFFFF  III  L
B   B K  K  F       I   L
BBBB  KKK   FFF     I   L
B   B K  K  F       I   L
BBBB  K   K F      III  LLLLL
```

PARAMETERS FOR SUBROUTINE BKFIL

DESCRIPTION

ORDERX - 0 FILTER PARAMETER USED ONLY BY THE FILTER BUTER
FREQX - .500 FREQUENCY PARAMETER FOR THE FILTER

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	UNIFORM SQUARE	NO	NO
FIL	FILTER	N/A	NO	N/A

BLANK COMMON REQUIRED 1482 (2712)

PLANK COMMON REQUIRED 1610 (3112)

THE VALUES FOR THE FREQUENCY SPACE FILTER (FILT(I),I=0,128) WITH A FREQUENCY
SPACING OF 1/256 = .391E-02 CYCLES PER PROJECTION BIN ARE

0	.390E-02	.780E-02	.117E-01	.155E-01
.194E-01	.231E-01	.269E-01	.306E-01	.342E-01
.377E-01	.412E-01	.446E-01	.480E-01	.512E-01
.543E-01	.574E-01	.603E-01	.631E-01	.659E-01
.685E-01	.710E-01	.733E-01	.756E-01	.777E-01
.797E-01	.815E-01	.833E-01	.848E-01	.863E-01
.876E-01	.888E-01	.898E-01	.908E-01	.915E-01
.922E-01	.927E-01	.930E-01	.932E-01	.933E-01
.933E-01	.931E-01	.929E-01	.924E-01	.919E-01
.913E-01	.905E-01	.896E-01	.886E-01	.875E-01
.863E-01	.851E-01	.837E-01	.822E-01	.807E-01
.791E-01	.774E-01	.757E-01	.739E-01	.721E-01
.702E-01	.683E-01	.664E-01	.645E-01	.625E-01
.605E-01	.586E-01	.567E-01	.547E-01	.528E-01
.509E-01	.490E-01	.471E-01	.452E-01	.434E-01
.416E-01	.398E-01	.381E-01	.363E-01	.346E-01
.330E-01	.313E-01	.297E-01	.282E-01	.267E-01
.252E-01	.237E-01	.223E-01	.210E-01	.197E-01
.184E-01	.172E-01	.160E-01	.149E-01	.138E-01
.127E-01	.117E-01	.108E-01	.986E-02	.899E-02
.818E-02	.741E-02	.668E-02	.600E-02	.536E-02
.476E-02	.420E-02	.369E-02	.322E-02	.279E-02
.239E-02	.203E-02	.171E-02	.142E-02	.117E-02
.941E-03	.747E-03	.580E-03	.440E-03	.323E-03
.229E-03	.155E-03	.982E-04	.573E-04	.296E-04
.126E-04	.376E-05	.473E-06	0	

BLANK COMMON REQUIRED 1650 (3162)

BLANK COMMON REQUIRED 1610 (3112)

BLANK COMMON REQUIRED 1354 (2512)

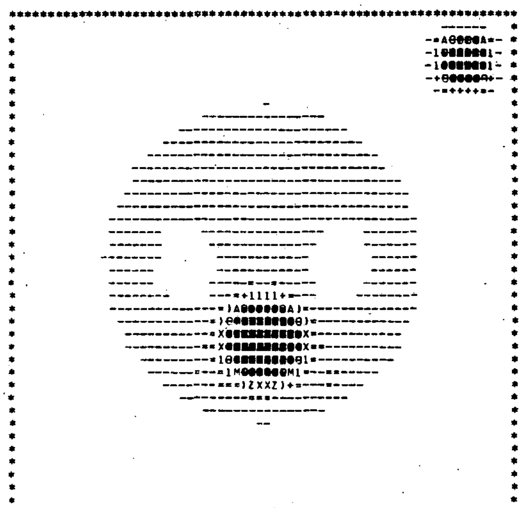
BLANK COMMON REQUIRED 1226 (2312)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 1650 FLOATING POINT WORDS.

```
EEEEE N   N DDDD      BBBB  K   K FFFFF  III  L
E     NN  N D   D     B   B K  K  F       I   L
EEE   N N N D   D     BBBB  KKK   FFF     I   L
E     N  NN D   D     B   B K  K  F       I   L
EEEEE N   N DDDD      BBBB  K   K F      III  LLLLL
```

RECONSTRUCTION USING THE PARZN FILTER

XMIN = -.94E+00 XMAX = .32E+02 XSUM = .8397E+04



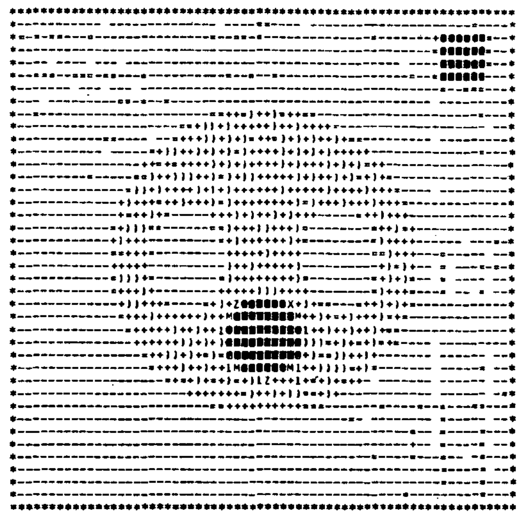
```
                       -          =          +          )          1          Z
-.9430E+00 .1516E+01 .5123E+01 .6763E+01 .7910E+01 .9222E+01 .1053E+02

Z          X          A          M          Θ          ⊕          ⊕          ●
 .1168E+02 .1250E+02 .1332E+02 .1512E+02 .1693E+02 .1808E+02 .1939E+02

⊕          ●          ●          ●          ■          ■          ■          ■
 .2053E+02 .2299E+02 .2594E+02 .2758E+02 .2890E+02 .3021E+02 .3135E+02

■
 .3185E+02
```

```
BBBB  K   K FFFFF  III  L
B   B K  K  F       I   L
BBBB  KKK   FFF     I   L
B   B K  K  F       I   L
BBBB  K   K F      III  LLLLL
```

```
        PARAMETERS FOR SUBROUTINE BKFIL

                DESCRIPTION

ORDERX -  388.0    FILTER PARAMETER USED ONLY BY THE FILTER BUTEP
FREQX  -   .520    FREQUENCY PARAMETER FOR THE FILTER

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG    FUNCTION          RAY WEIGHTING      ATTENUATION      FAN BEAM
BCK    BACKPROJECTION    UNIFORM SQUARE         NO              NO
FIL    FILTER                 N/A               NO             N/A

BLANK COMMON REQUIRED      1482    (  2712)

BLANK COMMON REQUIRED      1610    (  3112)

THE VALUES FOR THE FREQUENCY SPACE FILTER (FILT(I),I=0,128) WITH A FREQUENCY
  SPACING OF 1/256 = .391E-02 CYCLES PER PROJECTION BIN ARE
           0    .391E-02   .781E-02   .117E-01   .156E-01
    .195E-01    .234E-01   .273E-01   .313E-01   .352E-01
    .391E-01    .430E-01   .469E-01   .508E-01   .547E-01
    .586E-01    .625E-01   .664E-01   .703E-01   .742E-01
    .781E-01    .820E-01   .859E-01   .898E-01   .938E-01
    .977E-01    .102E+00   .105E+00   .109E+00   .113E+00
    .117E+00    .121E+00   .125E+00   .129E+00   .133E+00
    .137E+00    .141E+00   .145E+00   .148E+00   .152E+00
    .156E+00    .160E+00   .164E+00   .168E+00   .172E+00
    .176E+00    .180E+00   .184E+00   .188E+00   .191E+00
    .195E+00    .199E+00   .203E+00   .207E+00   .211E+00
    .215E+00    .219E+00   .223E+00   .227E+00   .230E+00
    .234E+00    .238E+00   .242E+00   .246E+00   .250E+00
    .254E+00    .258E+00   .262E+00   .266E+00   .270E+00
    .273E+00    .277E+00   .281E+00   .285E+00   .289E+00
    .293E+00    .297E+00   .301E+00   .305E+00   .309E+00
    .313E+00    .316E+00   .320E+00   .324E+00   .328E+00
    .332E+00    .336E+00   .340E+00   .344E+00   .348E+00
    .352E+00    .355E+00   .359E+00   .363E+00   .367E+00
    .371E+00    .375E+00   .379E+00   .383E+00   .387E+00
    .391E+00    .395E+00   .398E+00   .402E+00   .406E+00
    .410E+00    .414E+00   .418E+00   .422E+00   .426E+00
    .430E+00    .434E+00   .438E+00   .441E+00   .445E+00
    .449E+00    .453E+00   .457E+00   .461E+00   .465E+00
    .469E+00    .473E+00   .477E+00   .480E+00   .484E+00
    .488E+00    .492E+00   .496E+00   .500E+00

BLANK COMMON REQUIRED      1650    (  3162)

BLANK COMMON REQUIRED      1610    (  3112)

BLANK COMMON REQUIRED      1354    (  2512)

BLANK COMMON REQUIRED      1226    (  2312)

       MAXIMUM SIZE OF BLANK COMMON THUS FAR=    1650 FLOATING POINT WORDS.
```

```
EEEEE N    N DDDD      BBBB  K   K FFFFF  III  L
E     NN   N D   D     B   B K  K  F       I   L
EEE   N N  N D   D     BBBB  KKK   FFF     I   L
E     N   NN D   D     B   B K  K  F       I   L
EEEEE N    N DDDD      BBBB  K   K F      III  LLLLL
```

```
RECONSTRUCTION USING THE BUTER FILTER (ORDERX=388, FREQX=.52)

XMIN =   -.51E+01      XMAX =    .33E+02      XSUM =    .8401E+04
```



```
                           -           =           +           )           1           Z
-.5146E+01 -.2262E+01  .1967E+01  .3890E+01  .5235E+01  .6773E+01  .8311E+01

Z          X           A           M           Θ           ●           ●           ●
 .9657E+01  .1062E+02  .1158E+02  .1369E+02  .1581E+02  .1715E+02  .1869E+02

●          ●           ●           ●           ●           ■           ■           ■
 .2004E+02  .2292E+02  .2638E+02  .2830E+02  .2984E+02  .3138E+02  .3273E+02

■
 .3330E+02
```

4. Example 4 - Filter of the Back-Projection

The program XFILBK uses the filter of the back-projection algorithm to reconstruct simulated projection data for parallel-beam geometry, fan-beam geometry with curved detector, and fan-beam geometry with flat detector. These three geometries are reconstructed using the filter subroutine HAN which is declared as an external in statement E4.029. This method of reconstruction requires a larger allocation for the blank common array WORK than is required for either the convolution algorithm (Example 2) or the back-projection of filtered projections algorithm (Example 3).

The output results show good agreement between XMAX of the reconstructed images and the original phantom. However, the sum of the total intensities XSUM of the original phantom does not compare well with XSUM of the reconstructed images. The user should keep in mind that the algorithm reconstructs an array that is four times as large as the image array that is returned to the user by the subroutine FILBK. This is necessary in order to minimize the error due to the convolution result of one period overlapping the convolution result of the succeeding period when implementing the discrete Fourier transform. The XSUM for this larger reconstructed array is zero since the filter zeros the dc component of the Fourier transform of the back-projection. However, the XSUM for the reconstructed array returned to the user does not equal zero since it represents only a fourth of the larger array; but even so it only approximates XSUM of the original phantom.

```
      PROGRAM XFILBK (INPUT,OUTPUT,TAPE2=OUTPUT)
C
C        EXAMPLE 4
C
C             THE PROGRAM XFILBK USES THE FILTER OF THE BACK-PROJECTION
C        ALGORITHM TO RECONSTRUCT PROJECTION DATA FOR PARALLEL BEAM,
C        FAN BEAM - CURVED DETECTOR, AND FAN BEAM - FLAT DETECTOR
C        GEOMETRIES.
C
      DIMENSION B(4096),AG(180)
      COMMON WORK(18500)
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT  - OUTPUT FILE
C          I80132  - OUTPUT LINE LENGTH FLAG
C                =0    EACH LINE WILL BE WITHIN 80 CHARACTERS
C                        (OTHERWISE 132 CHARACTERS)
C
      COMMON/PARM/IPAR(12),PAR(3)
C
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)),
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)),
     2            (IMIT  ,IPAR( 7)),(NWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)),
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)),
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3))
C
C
      EXTERNAL BRF,BRFF2,HAN
C
      LUNOUT=2
      I80132=0
C
C        THE INPUT PARAMETERS ARE
C
      NDIMU=64
      ICIR=1
      IGEOM=0
      NANG=72
      MODANG=5
      KDIMU=129
      IMIT=1
      NWORK=18500
      NFLOAT=1
      ISTORE=0
      IPRINT=13
      LUNATN=0
      PWID=1.
      AXISU=50.5
      RFAN=0.
C
      CALL SETUP (IPAR,PAR,AG)
C
C        RECONSTRUCTION OF THE TRANSVERSE SECTION FOR PARALLEL BEAM
C          GEOMETRY
C
      ORDERX=0.
      FREQX=.5
C
      CALL FILBK (B,HAN,BRF,ORDERX,FREQX)
C
      WRITE (2,26)
      CALL ARRAY (B,NDIMU)
C
C        PRINTOUT THE VALUES FOR THE RECONSTRUCTED TRANSVERSE SECTION
C
      NMAT=NDIMU**2
      KK1=1
      KU=NDIMU/15+1
      DO 12 K=1,KU
      WRITE (2,22)
      KK2=15*K
      IF (KK2.GT.NDIMU) KK2=NDIMU
      DO 10 J=1,NDIMU
      ISUB1=NMAT-J*NDIMU+KK1
      ISUB2=NMAT-J*NDIMU+KK2
   10 WRITE (2,24) (B(I),I=ISUB1,ISUB2)
      KK1=KK2+1
   12 CONTINUE
C
      IGEOM=1
      IPRINT=5
      PWID=1.33
      RFAN=125.
C
      CALL SETUP (IPAR,PAR,AG)
C
C        RECONSTRUCTION OF THE TRANSVERSE SECTION FOR FAN BEAM GEOMETRY
C          WITH CURVED DETECTOR
C
      ORDERX=0.
      FREQX=.5
C
      CALL FILBK (B,HAN,BRFF2,ORDERX,FREQX)
C
      WRITE (2,28)
      CALL ARRAY (B,NDIMU)
C
C        PRINTOUT THE VALUES FOR THE RECONSTRUCTED TRANSVERSE SECTION
C
      KK1=1
      KU=NDIMU/15+1
      DO 16 K=1,KU
      WRITE (2,22)
      KK2=15*K
      IF (KK2.GT.NDIMU) KK2=NDIMU
      DO 14 J=1,NDIMU
      ISUB1=NMAT-J*NDIMU+KK1
      ISUB2=NMAT-J*NDIMU+KK2
   14 WRITE (2,24) (B(I),I=ISUB1,ISUB2)
      KK1=KK2+1
   16 CONTINUE
C
      IGEOM=2
C
      CALL SETUP (IPAR,PAR,AG)
C
C        RECONSTRUCTION OF THE TRANSVERSE SECTION FOR FAN BEAM GEOMETRY
C          WITH FLAT DETECTOR
C
      ORDERX=0.
      FREQX=.5
C
      CALL FILBK (B,HAN,BRFF2,ORDERX,FREQX)
C
      WRITE (2,30)
      CALL ARRAY (B,NDIMU)
C
C        PRINTOUT THE VALUES FOR THE RECONSTRUCTED TRANSVERSE SECTION
C
      KK1=1
      KU=NDIMU/15+1
      DO 20 K=1,KU
      WRITE (2,22)
      KK2=15*K
      IF (KK2.GT.NDIMU) KK2=NDIMU
      DO 18 J=1,NDIMU
      ISUB1=NMAT-J*NDIMU+KK1
      ISUB2=NMAT-J*NDIMU+KK2
   18 WRITE (2,24) (B(I),I=ISUB1,ISUB2)
      KK1=KK2+1
   20 CONTINUE
C
C
C
   22 FORMAT(1X///////)
   24 FORMAT(1X,15F5.1)
   26 FORMAT(1X//42H RECONSTRUCTION FOR PARALLEL BEAM GEOMETRY)
   28 FORMAT(1X//58H RECONSTRUCTION FOR FAN BEAM GEOMETRY WITH CURVED DE
     1TECTOR)
   30 FORMAT(1X//56H RECONSTRUCTION FOR FAN BEAM GEOMETRY WITH FLAT DETE
     1CTOR)
      END
```

```
      SUBROUTINE GETUM (M,DATA,ERR)
C
C        EXAMPLE 4
C
C             THE SUBROUTINE GETUM GIVES SIMULATED PROJECTION DATA FOR
C        A CHEST PHANTOM CONSISTING OF A HEART, LUNGS AND SURROUNDING
C        TISSUE.
C
      DIMENSION DATA(1),ERR(1)
      DIMENSION B(4096)
      DIMENSION AMAJ(4),AMIN(4),X1(4),Y1(4),PHI(4),Z(4),ITYPE(4)
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT  - OUTPUT FILE
C          I80132  - OUTPUT LINE LENGTH FLAG
C                =0    EACH LINE WILL BE WITHIN 80 CHARACTERS
C                        (OTHERWISE 132 CHARACTERS)
C
      COMMON/PARM/IPAR(12),PAR(3)
```

```
C
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)),
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)),
     2            (IMIT  ,IPAR( 7)),(NWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)),
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)),
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3))
C
      DATA ITYPE/1,1,1,1/
      DATA AMAJ/40.,10.,14.,14./
      DATA AMIN/40.,10.,10.,10./
      DATA X1/0.,0.,10.,-10./
      DATA Y1/0.,-10.,0.,0./
      DATA PHI/0.,0.,1.57079633,1.57079633/
      DATA Z/5.,27.,-4.,-4./
C
      IF (M.NE.1) GO TO 14
C
      IF (IMIT.NE.0) PWIDTH=PWID
      IF (IMIT.EQ.0) PWIDTH=-PWID
      CALL PHAN (4,10,ITYPE,Z,X1,Y1,AMAJ,AMIN,PHI,B,NDIMU,PWIDTH)
C
      CALL ARRAY (B,NDIMU)
C
C        PRINTOUT OF THE VALUES FOR THE PHANTOM
C
      NMAT=NDIMU**2
      KK1=1
      KU=NDIMU/15+1
      DO 12 K=1,KU
      WRITE (2,16)
      KK2=15*K
      IF (KK2.GT.NDIMU) KK2=NDIMU
      DO 10 J=1,NDIMU
      ISUB1=NMAT-J*NDIMU+KK1
      ISUB2=NMAT-J*NDIMU+KK2
   10 WRITE (2,18) (B(I),I=ISUB1,ISUB2)
      KK1=KK2+1
   12 CONTINUE
C
   14 CALL PHANL (4,ITYPE,Z,X1,Y1,AMAJ,AMIN,PHI,DATA,M)
C
      RETURN
C
C
C
   16 FORMAT(1X///////)
   18 FORMAT(1X,15F5.1)
      END
```

```
 SSS  EEEEE TTTTT U   U PPPP
S     E       T   U   U P   P
 SSS  EEE     T   U   U PPPP
    S E       T   U   U P
 SSS  EEEEE   T    UUU  P
```

INTEGER PARAMETER ARRAY (IPAR)

I	IPAR(I)	DESCRIPTION
1	64	LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
2	1	RECONSTRUCT IN A SQUARE ARRAY
3	0	GEOMETRY FLAG PARALLEL BEAM GEOMETRY
4	72	NUMBER OF PROJECTION ANGLES
5	5	MODE FOR PROJECTION ANGLE INPUT (SEE FOLLOWING LINES) ANGLES GENERATED BETWEEN ZERO AND 2*PI STARTING AT ZERO
6	129	NUMBER OF RAYS FOR EACH PROJECTION
7	1	TRANSMISSION DATA
8	18500	DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
9	1	NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10	0	EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11	13	PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES) PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER ROUTINES
12	0	LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE

FLOATING POINT PARAMETER ARRAY (PAR)

I	PAR(I)	DESCRIPTION
1	1.000	PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
2	50.500	LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
3	0 NA	NOT APPLICABLE (NOT FAN BEAM GEOMETRY)

```
BLANK COMMON REQUIRED        72    (    110)

BLANK COMMON REQUIRED       144    (    220)

BLANK COMMON REQUIRED       216    (    330)

BLANK COMMON REQUIRED       474    (    732)

BLANK COMMON REQUIRED       602    (   1132)

A TOTAL OF  92 (  5 THRU  96) OF THE 129 USER PROJECTION BINS WILL BE USED

 92 PROJECTION BINS WILL BE USED OF WHICH   0 HAVE BEEN ZEROED BY THE PROGRAM

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=    602 FLOATING POINT WORDS.
```

```
EEEEE N   N DDDD       SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D     S     E       T   U   U P   P
EEE   N N N D   D      SSS  EEE     T   U   U PPPP
E     N  NN D   D         S E       T   U   U P
EEEEE N   N DDDD       SSS  EEEEE   T    UUU  P
```

```
FFFFF III L     BBBB  K   K
F      I  L     B   B K  K
FFF    I  L     BBBB  KKK
F      I  L     B   B K  K
F     III LLLLL BBBB  K   K
```

PARAMETERS FOR SUBROUTINE FILBK

```
                  DESCRIPTION

ORDERX -      0    FILTER PARAMETER USED ONLY BY THE FILTER BUTER
FREQX  -   .500    FREQUENCY PARAMETER FOR THE FILTER

BLANK COMMON REQUIRED       674    (   1242)

BLANK COMMON REQUIRED      1284    (   2404)

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG    FUNCTION          RAY WEIGHTING      ATTENUATION      FAN BEAM
BCK    BACKPROJECTION    UNIFORM SQUARE         NO              NO
FIL    FILTER                 N/A               NO              N/A

     FILTERED BACK-PROJECTION RECONSTRUCTIONS MUST BE EXECUTED IN AN
     ARRAY WITH DIMENSIONS AT LEAST TWICE AS LARGE AS THE FINAL IMAGE.
     THUS, THE EFFECTIVE SIZE OF THE RECONSTRUCTION ARRAY WILL NOW
     BE INCREASED.

BLANK COMMON REQUIRED      1412    (   2604)

A TOTAL OF 129 (  1 THRU 129) OF THE 129 USER PROJECTION BINS WILL BE USED

182 PROJECTION BINS WILL BE USED OF WHICH  53 HAVE BEEN ZEROED BY THE PROGRAM

BLANK COMMON REQUIRED     17796    (  42604)

BLANK COMMON REQUIRED     17978    (  43072)

THE VALUES FOR THE FREQUENCY SPACE FILTER (FILT(I,J),I=0,J , J=0, 64) WITH A
  FREQUENCY SPACING OF 1/128 = .781E-02 CYCLES PER PIXEL ARE
J=  0            0
J=  1     .781E-02    .110E-01
J=  2     .156E-01    .174E-01    .220E-01
J=  3     .233E-01    .246E-01    .279E-01    .328E-01
J=  4     .309E-01    .319E-01    .345E-01    .385E-01    .433E-01

J=  5     .385E-01    .392E-01    .413E-01    .446E-01    .488E-01
          .536E-01
J=  6     .459E-01    .465E-01    .482E-01    .510E-01    .546E-01
          .588E-01    .635E-01
J=  7     .531E-01    .536E-01    .551E-01    .574E-01    .606E-01
          .643E-01    .684E-01    .729E-01
J=  8     .601E-01    .606E-01    .618E-01    .639E-01    .666E-01
          .698E-01    .735E-01    .775E-01    .817E-01
J=  9     .669E-01    .673E-01    .684E-01    .702E-01    .725E-01
          .754E-01    .787E-01    .823E-01    .861E-01    .900E-01
J= 10     .735E-01    .738E-01    .748E-01    .763E-01    .784E-01
          .809E-01    .838E-01    .871E-01    .905E-01    .941E-01
          .977E-01
J= 11     .798E-01    .801E-01    .809E-01    .823E-01    .841E-01
          .863E-01    .889E-01    .918E-01    .949E-01    .981E-01
          .101E+00    .105E+00
J= 12     .859E-01    .861E-01    .868E-01    .880E-01    .896E-01
          .916E-01    .939E-01    .964E-01    .991E-01    .102E+00
          .105E+00    .108E+00    .111E+00
J= 13     .916E-01    .918E-01    .924E-01    .934E-01    .949E-01
          .966E-01    .986E-01    .101E+00    .103E+00    .106E+00
          .108E+00    .111E+00    .114E+00    .116E+00
J= 14     .970E-01    .971E-01    .977E-01    .986E-01    .998E-01
          .101E+00    .103E+00    .105E+00    .107E+00    .110E+00
          .112E+00    .114E+00    .117E+00    .119E+00    .121E+00
J= 15     .102E+00    .102E+00    .103E+00    .103E+00    .105E+00
          .106E+00    .107E+00    .109E+00    .111E+00    .113E+00
          .115E+00    .117E+00    .119E+00    .121E+00    .123E+00
          .125E+00
J= 16     .107E+00    .107E+00    .107E+00    .108E+00    .109E+00
          .110E+00    .111E+00    .113E+00    .115E+00    .116E+00
          .118E+00    .120E+00    .122E+00    .123E+00    .125E+00
          .126E+00    .128E+00
J= 17     .111E+00    .111E+00    .111E+00    .112E+00    .113E+00
          .114E+00    .115E+00    .116E+00    .118E+00    .119E+00
          .121E+00    .122E+00    .124E+00    .125E+00    .126E+00
          .128E+00    .129E+00    .130E+00
J= 18     .115E+00    .115E+00    .115E+00    .116E+00    .117E+00
          .117E+00    .118E+00    .119E+00    .121E+00    .122E+00
          .123E+00    .124E+00    .126E+00    .127E+00    .128E+00
          .129E+00    .130E+00    .130E+00    .131E+00
J= 19     .118E+00    .119E+00    .119E+00    .119E+00    .120E+00
          .120E+00    .121E+00    .122E+00    .123E+00    .124E+00
          .125E+00    .126E+00    .127E+00    .128E+00    .129E+00
          .130E+00    .130E+00    .131E+00    .131E+00    .131E+00
J= 20     .122E+00    .122E+00    .122E+00    .122E+00    .123E+00
          .123E+00    .124E+00    .125E+00    .125E+00    .126E+00
          .127E+00    .128E+00    .129E+00    .129E+00    .130E+00
          .131E+00    .131E+00    .131E+00    .131E+00    .131E+00
          .131E+00
J= 21     .124E+00    .124E+00    .124E+00    .125E+00    .125E+00
          .126E+00    .126E+00    .127E+00    .127E+00    .128E+00
          .129E+00    .129E+00    .130E+00    .130E+00    .131E+00
          .131E+00    .131E+00    .131E+00    .131E+00    .131E+00
          .130E+00    .129E+00
J= 22     .126E+00    .126E+00    .127E+00    .127E+00    .127E+00
          .128E+00    .128E+00    .128E+00    .129E+00    .129E+00
          .130E+00    .130E+00    .131E+00    .131E+00    .131E+00
          .131E+00    .131E+00    .131E+00    .130E+00    .130E+00
          .129E+00    .128E+00    .127E+00
J= 23     .128E+00    .128E+00    .128E+00    .129E+00    .129E+00
          .129E+00    .129E+00    .130E+00    .130E+00    .130E+00
          .131E+00    .131E+00    .131E+00    .131E+00    .131E+00
          .131E+00    .131E+00    .130E+00    .130E+00    .129E+00
          .128E+00    .127E+00    .125E+00    .124E+00
J= 24     .130E+00    .130E+00    .130E+00    .130E+00    .130E+00
          .130E+00    .130E+00    .131E+00    .131E+00    .131E+00
          .131E+00    .131E+00    .131E+00    .131E+00    .131E+00
          .131E+00    .130E+00    .129E+00    .129E+00    .128E+00
          .127E+00    .125E+00    .124E+00    .122E+00    .120E+00
J= 25     .131E+00    .131E+00    .131E+00    .131E+00    .131E+00
          .131E+00    .131E+00    .131E+00    .131E+00    .131E+00
          .131E+00    .131E+00    .131E+00    .131E+00    .130E+00
          .130E+00    .129E+00    .128E+00    .127E+00    .126E+00
          .125E+00    .123E+00    .122E+00    .120E+00    .118E+00
          .115E+00
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J= 26	.131E+00	.131E+00	.131E+00	.131E+00	.131E+00
	.131E+00	.131E+00	.131E+00	.131E+00	.131E+00
	.131E+00	.131E+00	.130E+00	.130E+00	.129E+00
	.129E+00	.128E+00	.127E+00	.126E+00	.125E+00
	.123E+00	.121E+00	.120E+00	.118E+00	.115E+00
	.113E+00	.110E+00			
J= 27	.131E+00	.131E+00	.131E+00	.131E+00	.131E+00
	.131E+00	.131E+00	.131E+00	.131E+00	.130E+00
	.130E+00	.130E+00	.129E+00	.129E+00	.128E+00
	.127E+00	.126E+00	.125E+00	.124E+00	.123E+00
	.121E+00	.119E+00	.117E+00	.115E+00	.113E+00
	.110E+00	.107E+00	.105E+00		
J= 28	.131E+00	.131E+00	.131E+00	.131E+00	.131E+00
	.130E+00	.130E+00	.130E+00	.130E+00	.129E+00
	.129E+00	.129E+00	.128E+00	.127E+00	.126E+00
	.126E+00	.124E+00	.123E+00	.122E+00	.120E+00
	.119E+00	.117E+00	.115E+00	.112E+00	.110E+00
	.107E+00	.104E+00	.101E+00	.983E-01	
J= 29	.130E+00	.130E+00	.130E+00	.130E+00	.130E+00
	.129E+00	.129E+00	.129E+00	.129E+00	.128E+00
	.128E+00	.127E+00	.126E+00	.125E+00	.125E+00
	.123E+00	.122E+00	.121E+00	.119E+00	.118E+00
	.116E+00	.114E+00	.112E+00	.109E+00	.107E+00
	.104E+00	.101E+00	.982E-01	.950E-01	.916E-01
J= 30	.129E+00	.129E+00	.129E+00	.128E+00	.128E+00
	.128E+00	.128E+00	.127E+00	.127E+00	.126E+00
	.126E+00	.125E+00	.124E+00	.123E+00	.122E+00
	.121E+00	.120E+00	.118E+00	.117E+00	.115E+00
	.113E+00	.111E+00	.109E+00	.106E+00	.104E+00
	.101E+00	.979E-01	.948E-01	.913E-01	.881E-01
	.846E-01				
J= 31	.127E+00	.127E+00	.127E+00	.127E+00	.127E+00
	.126E+00	.126E+00	.125E+00	.125E+00	.124E+00
	.124E+00	.123E+00	.122E+00	.121E+00	.120E+00
	.118E+00	.117E+00	.115E+00	.114E+00	.112E+00
	.110E+00	.108E+00	.105E+00	.103E+00	.100E+00
	.973E-01	.943E-01	.911E-01	.879E-01	.844E-01
	.809E-01	.772E-01			
J= 32	.125E+00	.125E+00	.125E+00	.125E+00	.124E+00
	.124E+00	.124E+00	.123E+00	.123E+00	.122E+00
	.121E+00	.120E+00	.119E+00	.118E+00	.117E+00
	.116E+00	.114E+00	.112E+00	.111E+00	.109E+00
	.106E+00	.104E+00	.102E+00	.992E-01	.965E-01
	.936E-01	.906E-01	.874E-01	.841E-01	.807E-01
	.771E-01	.735E-01	.697E-01		
J= 33	.123E+00	.123E+00	.122E+00	.122E+00	.122E+00
	.122E+00	.121E+00	.121E+00	.120E+00	.119E+00
	.118E+00	.117E+00	.116E+00	.115E+00	.114E+00
	.112E+00	.111E+00	.109E+00	.107E+00	.105E+00
	.103E+00	.101E+00	.980E-01	.954E-01	.926E-01
	.897E-01	.867E-01	.835E-01	.802E-01	.767E-01
	.732E-01	.696E-01	.659E-01	.621E-01	
J= 34	.120E+00	.120E+00	.120E+00	.119E+00	.119E+00
	.119E+00	.118E+00	.118E+00	.117E+00	.116E+00
	.115E+00	.114E+00	.113E+00	.112E+00	.110E+00
	.109E+00	.107E+00	.105E+00	.103E+00	.101E+00
	.990E-01	.966E-01	.941E-01	.914E-01	.886E-01
	.857E-01	.826E-01	.795E-01	.761E-01	.727E-01
	.692E-01	.656E-01	.620E-01	.582E-01	.545E-01
J= 35	.117E+00	.117E+00	.116E+00	.116E+00	.116E+00
	.115E+00	.115E+00	.114E+00	.114E+00	.113E+00
	.112E+00	.111E+00	.109E+00	.109E+00	.107E+00
	.105E+00	.103E+00	.101E+00	.994E-01	.973E-01
	.950E-01	.926E-01	.900E-01	.873E-01	.845E-01
	.816E-01	.785E-01	.753E-01	.720E-01	.686E-01
	.652E-01	.616E-01	.580E-01	.544E-01	.507E-01
	.470E-01				
J= 36	.113E+00	.113E+00	.113E+00	.113E+00	.112E+00
	.112E+00	.111E+00	.111E+00	.110E+00	.109E+00
	.108E+00	.107E+00	.106E+00	.104E+00	.103E+00
	.101E+00	.992E-01	.973E-01	.953E-01	.931E-01
	.908E-01	.883E-01	.858E-01	.831E-01	.802E-01
	.773E-01	.742E-01	.711E-01	.678E-01	.645E-01
	.610E-01	.576E-01	.540E-01	.505E-01	.469E-01
	.432E-01	.397E-01			
J= 37	.109E+00	.109E+00	.109E+00	.109E+00	.109E+00
	.108E+00	.107E+00	.107E+00	.106E+00	.105E+00
	.104E+00	.103E+00	.101E+00	.100E+00	.985E-01
	.968E-01	.950E-01	.930E-01	.910E-01	.888E-01
	.864E-01	.840E-01	.814E-01	.787E-01	.758E-01
	.729E-01	.699E-01	.668E-01	.635E-01	.602E-01
	.569E-01	.535E-01	.500E-01	.465E-01	.430E-01
	.396E-01	.361E-01	.327E-01		
J= 38	.105E+00	.105E+00	.105E+00	.105E+00	.104E+00
	.104E+00	.103E+00	.103E+00	.102E+00	.101E+00
	.997E-01	.985E-01	.972E-01	.957E-01	.941E-01
	.924E-01	.906E-01	.886E-01	.865E-01	.843E-01
	.819E-01	.795E-01	.769E-01	.742E-01	.714E-01
	.685E-01	.655E-01	.624E-01	.592E-01	.560E-01
	.527E-01	.494E-01	.460E-01	.426E-01	.393E-01
	.359E-01	.326E-01	.293E-01	.261E-01	
J= 39	.101E+00	.101E+00	.101E+00	.101E+00	.100E+00
	.996E-01	.990E-01	.982E-01	.973E-01	.963E-01
	.952E-01	.940E-01	.926E-01	.911E-01	.895E-01
	.878E-01	.859E-01	.840E-01	.819E-01	.796E-01
	.773E-01	.748E-01	.723E-01	.696E-01	.668E-01
	.639E-01	.610E-01	.580E-01	.549E-01	.517E-01
	.485E-01	.453E-01	.420E-01	.388E-01	.355E-01
	.323E-01	.291E-01	.260E-01	.229E-01	.200E-01
J= 40	.965E-01	.964E-01	.962E-01	.959E-01	.955E-01
	.950E-01	.943E-01	.936E-01	.927E-01	.917E-01
	.906E-01	.893E-01	.879E-01	.864E-01	.848E-01
	.831E-01	.812E-01	.792E-01	.771E-01	.749E-01
	.726E-01	.701E-01	.676E-01	.649E-01	.622E-01
	.594E-01	.565E-01	.535E-01	.505E-01	.474E-01
	.443E-01	.412E-01	.381E-01	.349E-01	.318E-01
	.288E-01	.257E-01	.228E-01	.199E-01	.172E-01
	.145E-01				
J= 41	.917E-01	.916E-01	.914E-01	.911E-01	.907E-01
	.902E-01	.895E-01	.888E-01	.879E-01	.868E-01
	.857E-01	.844E-01	.831E-01	.816E-01	.799E-01
	.782E-01	.763E-01	.743E-01	.723E-01	.701E-01
	.678E-01	.653E-01	.628E-01	.602E-01	.576E-01
	.548E-01	.520E-01	.491E-01	.462E-01	.432E-01
	.402E-01	.372E-01	.342E-01	.312E-01	.282E-01
	.253E-01	.225E-01	.197E-01	.170E-01	.145E-01
	.121E-01	.981E-02			
J= 42	.867E-01	.867E-01	.865E-01	.862E-01	.858E-01
	.852E-01	.846E-01	.838E-01	.829E-01	.819E-01
	.807E-01	.795E-01	.781E-01	.766E-01	.749E-01
	.732E-01	.714E-01	.694E-01	.673E-01	.652E-01
	.629E-01	.605E-01	.581E-01	.555E-01	.529E-01
	.502E-01	.475E-01	.447E-01	.419E-01	.390E-01
	.361E-01	.333E-01	.304E-01	.275E-01	.247E-01
	.220E-01	.193E-01	.168E-01	.143E-01	.119E-01
	.976E-02	.773E-02	.590E-02		
J= 43	.816E-01	.816E-01	.814E-01	.811E-01	.807E-01
	.801E-01	.795E-01	.787E-01	.778E-01	.767E-01
	.756E-01	.743E-01	.730E-01	.715E-01	.699E-01
	.682E-01	.663E-01	.644E-01	.624E-01	.602E-01
	.580E-01	.557E-01	.533E-01	.508E-01	.483E-01
	.457E-01	.430E-01	.404E-01	.376E-01	.349E-01
	.321E-01	.294E-01	.267E-01	.240E-01	.214E-01
	.188E-01	.163E-01	.140E-01	.117E-01	.960E-02
	.764E-02	.586E-02	.427E-02	.290E-02	
J= 44	.764E-01	.763E-01	.761E-01	.758E-01	.754E-01
	.749E-01	.742E-01	.735E-01	.726E-01	.715E-01
	.704E-01	.692E-01	.678E-01	.663E-01	.648E-01
	.631E-01	.613E-01	.594E-01	.574E-01	.553E-01
	.531E-01	.509E-01	.486E-01	.462E-01	.437E-01
	.412E-01	.387E-01	.361E-01	.335E-01	.309E-01
	.283E-01	.257E-01	.231E-01	.206E-01	.182E-01
	.158E-01	.135E-01	.114E-01	.934E-02	.745E-02
	.573E-02	.420E-02	.288E-02	.178E-02	.922E-03
J= 45	.711E-01	.710E-01	.708E-01	.705E-01	.701E-01
	.696E-01	.689E-01	.682E-01	.673E-01	.663E-01
	.652E-01	.639E-01	.626E-01	.612E-01	.596E-01
	.580E-01	.562E-01	.544E-01	.524E-01	.504E-01
	.483E-01	.461E-01	.439E-01	.416E-01	.392E-01
	.368E-01	.344E-01	.319E-01	.295E-01	.270E-01
	.245E-01	.221E-01	.197E-01	.174E-01	.152E-01
	.130E-01	.109E-01	.898E-02	.718E-02	.553E-02
	.406E-02	.279E-02	.173E-02	.905E-03	.335E-03
	.389E-04				
J= 46	.657E-01	.656E-01	.655E-01	.652E-01	.648E-01
	.642E-01	.636E-01	.628E-01	.620E-01	.610E-01
	.599E-01	.587E-01	.574E-01	.560E-01	.545E-01
	.529E-01	.512E-01	.494E-01	.475E-01	.455E-01
	.435E-01	.414E-01	.393E-01	.370E-01	.348E-01
	.325E-01	.302E-01	.279E-01	.256E-01	.233E-01
	.210E-01	.187E-01	.165E-01	.144E-01	.123E-01
	.104E-01	.853E-02	.682E-02	.526E-02	.386E-02
	.265E-02	.164E-02	.857E-03	.315E-03	.356E-04
	0	0			
J= 47	.603E-01	.602E-01	.601E-01	.598E-01	.594E-01
	.589E-01	.582E-01	.575E-01	.567E-01	.557E-01
	.546E-01	.535E-01	.522E-01	.508E-01	.494E-01
	.478E-01	.462E-01	.444E-01	.426E-01	.408E-01
	.388E-01	.368E-01	.348E-01	.327E-01	.305E-01
	.284E-01	.262E-01	.240E-01	.218E-01	.197E-01
	.176E-01	.155E-01	.135E-01	.116E-01	.973E-02
	.799E-02	.638E-02	.491E-02	.360E-02	.246E-02
	.151E-02	.780E-03	.278E-03	.265E-04	0
	0	0	0		
J= 48	.549E-01	.549E-01	.547E-01	.544E-01	.540E-01
	.535E-01	.529E-01	.522E-01	.514E-01	.505E-01
	.494E-01	.483E-01	.471E-01	.457E-01	.443E-01
	.428E-01	.413E-01	.396E-01	.379E-01	.361E-01
	.342E-01	.323E-01	.304E-01	.284E-01	.264E-01
	.244E-01	.224E-01	.203E-01	.183E-01	.163E-01
	.144E-01	.125E-01	.107E-01	.901E-02	.738E-02
	.588E-02	.450E-02	.328E-02	.222E-02	.135E-02
	.577E-03	.226E-03	.144E-04	0	0
	0	0	0	0	
J= 49	.496E-01	.495E-01	.494E-01	.491E-01	.487E-01
	.482E-01	.477E-01	.470E-01	.462E-01	.453E-01
	.443E-01	.432E-01	.420E-01	.408E-01	.394E-01
	.380E-01	.365E-01	.349E-01	.333E-01	.316E-01
	.298E-01	.280E-01	.262E-01	.243E-01	.225E-01
	.206E-01	.187E-01	.169E-01	.150E-01	.132E-01
	.115E-01	.981E-02	.821E-02	.671E-02	.531E-02
	.405E-02	.292E-02	.195E-02	.116E-02	.556E-03
	.166E-03	.360E-05	0	0	0
	0	0	0	0	0
J= 50	.443E-01	.443E-01	.441E-01	.439E-01	.435E-01
	.430E-01	.425E-01	.418E-01	.411E-01	.402E-01
	.393E-01	.382E-01	.371E-01	.359E-01	.346E-01
	.333E-01	.318E-01	.303E-01	.288E-01	.272E-01
	.256E-01	.239E-01	.222E-01	.205E-01	.188E-01
	.170E-01	.153E-01	.136E-01	.120E-01	.104E-01
	.883E-02	.736E-02	.598E-02	.470E-02	.355E-02
	.252E-02	.165E-02	.946E-03	.425E-03	.103E-03
	0	0	0	0	0
	0	0	0	0	0
	0				
J= 51	.392E-01	.392E-01	.390E-01	.388E-01	.384E-01
	.380E-01	.374E-01	.368E-01	.361E-01	.353E-01
	.344E-01	.334E-01	.323E-01	.312E-01	.300E-01
	.287E-01	.274E-01	.260E-01	.245E-01	.231E-01
	.215E-01	.200E-01	.184E-01	.169E-01	.153E-01
	.137E-01	.122E-01	.107E-01	.921E-02	.780E-02
	.647E-02	.522E-02	.406E-02	.302E-02	.211E-02
	.134E-02	.728E-03	.292E-03	.478E-04	0
	0	0	0	0	0
	0	0	0	0	0
	0	0			
J= 52	.342E-01	.342E-01	.340E-01	.338E-01	.335E-01
	.331E-01	.326E-01	.320E-01	.313E-01	.305E-01
	.297E-01	.288E-01	.278E-01	.267E-01	.256E-01
	.244E-01	.231E-01	.218E-01	.205E-01	.191E-01
	.178E-01	.163E-01	.149E-01	.135E-01	.121E-01
	.107E-01	.934E-02	.802E-02	.675E-02	.555E-02
	.443E-02	.340E-02	.248E-02	.169E-02	.102E-02
	.512E-03	.169E-03	.972E-05	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0		
J= 53	.295E-01	.294E-01	.293E-01	.291E-01	.288E-01
	.284E-01	.279E-01	.273E-01	.267E-01	.260E-01
	.252E-01	.243E-01	.234E-01	.224E-01	.214E-01
	.203E-01	.191E-01	.180E-01	.168E-01	.155E-01
	.143E-01	.130E-01	.117E-01	.105E-01	.921E-02
	.799E-02	.682E-02	.569E-02	.463E-02	.364E-02
	.275E-02	.195E-02	.127E-02	.720E-03	.315E-03
	.707E-04	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	
J= 54	.249E-01	.249E-01	.247E-01	.245E-01	.243E-01
	.239E-01	.235E-01	.229E-01	.224E-01	.217E-01
	.210E-01	.202E-01	.193E-01	.184E-01	.175E-01
	.165E-01	.154E-01	.144E-01	.133E-01	.122E-01
	.111E-01	.994E-02	.883E-02	.773E-02	.666E-02
	.563E-02	.465E-02	.373E-02	.288E-02	.211E-02
	.144E-02	.881E-03	.447E-03	.152E-03	.106E-04
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
J= 55	.206E-01	.206E-01	.205E-01	.203E-01	.200E-01
	.197E-01	.193E-01	.188E-01	.183E-01	.177E-01
	.170E-01	.163E-01	.155E-01	.147E-01	.139E-01
	.130E-01	.121E-01	.111E-01	.102E-01	.918E-02
	.821E-02	.725E-02	.630E-02	.537E-02	.449E-02
	.364E-02	.286E-02	.215E-02	.151E-02	.972E-03
	.537E-03	.222E-03	.406E-04	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0				
J= 56	.167E-01	.166E-01	.165E-01	.163E-01	.161E-01
	.158E-01	.154E-01	.150E-01	.145E-01	.140E-01
	.134E-01	.128E-01	.121E-01	.114E-01	.106E-01
	.984E-02	.903E-02	.821E-02	.738E-02	.655E-02
	.573E-02	.493E-02	.415E-02	.340E-02	.270E-02
	.206E-02	.148E-02	.980E-03	.569E-03	.260E-03
	.662E-04	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0			

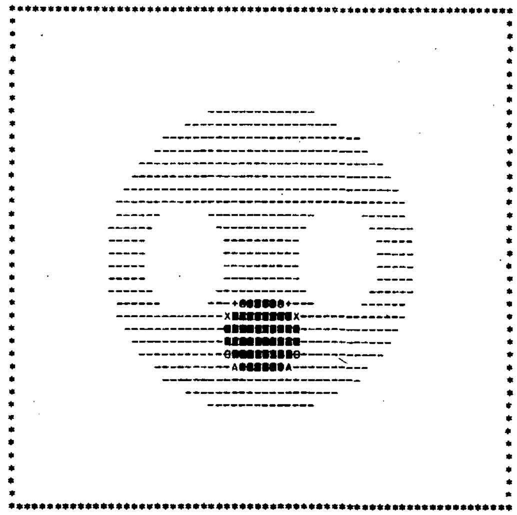
```
J= 57   .130E-01   .130E-01   .129E-01   .127E-01   .125E-01
        .123E-01   .119E-01   .116E-01   .111E-01   .107E-01
        .102E-01   .960E-02   .901E-02   .838E-02   .773E-02
        .706E-02   .638E-02   .569E-02   .500E-02   .432E-02
        .366E-02   .302E-02   .242E-02   .186E-02   .135E-02
        .905E-03   .537E-03   .256E-03   .730E-04   .662E-06
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0
J= 58   .976E-02   .973E-02   .965E-02   .952E-02   .934E-02
        .911E-02   .883E-02   .850E-02   .814E-02   .773E-02
        .729E-02   .682E-02   .632E-02   .579E-02   .526E-02
        .470E-02   .415E-02   .360E-02   .305E-02   .252E-02
        .202E-02   .155E-02   .113E-02   .757E-03   .447E-03
        .210E-03   .576E-04   .165E-06          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0
J= 59   .691E-02   .688E-02   .682E-02   .671E-02   .655E-02
        .636E-02   .613E-02   .586E-02   .555E-02   .522E-02
        .485E-02   .447E-02   .406E-02   .364E-02   .322E-02
        .279E-02   .236E-02   .195E-02   .155E-02   .118E-02
        .849E-03   .556E-03   .315E-03   .136E-03   .280E-04
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0
J= 60   .450E-02   .449E-02   .443E-02   .434E-02   .422E-02
        .406E-02   .388E-02   .366E-02   .342E-02   .316E-02
        .288E-02   .258E-02   .227E-02   .196E-02   .165E-02
        .135E-02   .106E-02   .787E-03   .544E-03   .335E-03
        .169E-03   .556E-04   .265E-05          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0
J= 61   .258E-02   .257E-02   .252E-02   .246E-02   .236E-02
        .225E-02   .211E-02   .195E-02   .178E-02   .159E-02
        .139E-02   .118E-02   .980E-03   .780E-03   .585E-03
        .413E-03   .260E-03   .136E-03   .478E-04   .360E-05
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0
J= 62   .117E-02   .116E-02   .113E-02   .108E-02   .102E-02
        .946E-03   .857E-03   .757E-03   .649E-03   .537E-03
        .425E-03   .315E-03   .214E-03   .127E-03   .576E-04
        .134E-04          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0
J= 63   .296E-03   .292E-03   .278E-03   .256E-03   .226E-03
        .191E-03   .152E-03   .112E-03   .730E-04   .389E-04
        .134E-04   .662E-06          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0
J= 64          0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0          0
               0          0          0          0
```

```
PPPP  H   H  AAA  N   N
P   P H   H A   A NN  N
PPPP  HHHHH A   A N N N
P     H   H AAAAA N  NN
P     H   H A   A N   N
```

```
PHANTOM GENERATED
  ARRAY SIZE   64 X  64    INTEGRATION FACTOR =  10    SCALING FACTOR =     1.000
  NUMBER OF ELIPSES AND/OR RECTANGLES =     4
  THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
       X,Y  - CENTER
       A,B  - LENGTH OF AXIS OR SIDE A AND B
       PHI  - ANGLE OF AXIS OR SIDE A
       DENS - INTENSITY
  THE PARENTHESIS INDICATES THE SCALED VALUE
   ITYPE                X          Y          A           B        PHI       DENS
    1   - ELLIPSE          0 ,         0    40.00 ,    40.00         0        5.00
                      (      0),(      0)(  40.00),(  40.00)             (    5.00)
    1   - ELLIPSE          0 ,    -10.00    10.00 ,    10.00         0       27.00
                      (      0),( -10.00)(  10.00),(  10.00)             (   27.00)
    1   - ELLIPSE      10.00 ,         0    14.00 ,    10.00      1.57       -4.00
                      (  10.00),(      0)(  14.00),(  10.00)             (   -4.00)
    1   - ELLIPSE     -10.00 ,         0    14.00 ,    10.00      1.57       -4.00
                      ( -10.00),(      0)(  14.00),(  10.00)             (   -4.00)
```

```
EEEEE N   N DDDD        PPPP  H   H  AAA  N   N
E     NN  N D   D       P   P H   H A   A NN  N
EEE   N N N D   D       PPPP  HHHHH A   A N N N
E     N  NN D   D       P     H   H AAAAA N  NN
EEEEE N   N DDDD        P     H   H A   A N   N
```

```
XMIN =          0     XMAX =    .32E+02     XSUM =    .7526E+04
```



```
            -           =           +           I           1           Z
0  .2400E+01  .5920E+01  .7520E+01  .8640E+01  .9920E+01  .1120F+02

Z           X           A           H           B           ■           ■           ■
 .1232E+02   .1312E+02   .1392E+02   .1568E+02   .1744E+02   .1856E+02   .1984E+02

■           ■           ■           ■           ■           ■           ■           ■
 .2096E+02   .2336E+02   .2624E+02   .2784E+02   .2912E+02   .3040E+02   .3152E+02

■
 .3200E+02
```

```
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0   .5
   0    0    0    0    0    0    0    0    0    0    0    0    0    0  2.9
   0    0    0    0    0    0    0    0    0    0    0    0    0   .6  4.9
   0    0    0    0    0    0    0    0    0    0    0    0    0  2.7  5.0
   0    0    0    0    0    0    0    0    0    0    0    0   .1  4.5  5.0
   0    0    0    0    0    0    0    0    0    0    0    0  1.1  5.0  5.0
   0    0    0    0    0    0    0    0    0    0    0    0  2.4  5.0  5.0
   0    0    0    0    0    0    0    0    0    0    0    0  3.4  5.0  5.0
   0    0    0    0    0    0    0    0    0    0    0    0  4.2  5.0  5.0
   0    0    0    0    0    0    0    0    0    0    0    0  4.7  5.0  5.0
   0    0    0    0    0    0    0    0    0    0    0    0  5.0  5.0  5.0
   0    0    0    0    0    0    0    0    0    0    0    0  5.0  5.0  5.0
   0    0    0    0    0    0    0    0    0    0    0    0  4.7  5.0  5.0
   0    0    0    0    0    0    0    0    0    0    0    0  4.2  5.0  5.0
   0    0    0    0    0    0    0    0    0    0    0    0  3.4  5.0  5.0
   0    0    0    0    0    0    0    0    0    0    0    0  2.4  5.0  5.0
   0    0    0    0    0    0    0    0    0    0    0    0  1.1  5.0  5.0
   0    0    0    0    0    0    0    0    0    0    0    0   .1  4.5  5.0
   0    0    0    0    0    0    0    0    0    0    0    0    0  2.7  5.0
   0    0    0    0    0    0    0    0    0    0    0    0    0   .6  4.9
   0    0    0    0    0    0    0    0    0    0    0    0    0    0  2.9
   0    0    0    0    0    0    0    0    0    0    0    0    0    0   .5
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
```

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	.1	1.1	2.4	3.4	4.2
0	0	0	0	0	0	0	0	.6	2.7	4.5	5.0	5.0	5.0	5.0
0	0	0	0	0	0	.5	2.9	4.9	5.0	5.0	5.0	5.0	5.0	5.0
0	0	0	0	0	1.8	4.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
0	0	0	.2	3.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
0	0	.2	3.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
0	.2	3.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
0	3.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
1.8	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
4.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
5.0	5.0	5.0	5.0	4.5	2.4	1.2	1.2	2.4	4.5	5.0	5.0	5.0	5.0	5.0
5.0	5.0	5.0	4.4	1.3	1.0	1.0	1.0	1.0	1.3	4.4	5.0	5.0	5.0	5.0
5.0	5.0	5.0	1.8	1.0	1.0	1.0	1.0	1.0	1.0	1.8	5.0	5.0	5.0	5.0
5.0	5.0	3.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.7	5.0	5.0	5.0
5.0	5.0	2.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.3	5.0	5.0	5.0
5.0	5.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	5.0	5.0	5.0
5.0	5.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	5.0	5.0	5.0
5.0	5.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	5.0	5.0	5.0
5.0	5.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	5.0	5.0	5.0
5.0	5.0	2.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.3	5.0	5.0	5.0
5.0	5.0	3.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.7	5.0	5.0	5.0
5.0	5.0	5.0	1.8	1.0	1.0	1.0	1.0	1.0	1.0	1.8	5.0	5.0	5.0	5.0
5.0	5.0	5.0	4.4	1.3	1.0	1.0	1.0	1.0	1.3	4.4	5.0	5.0	5.0	13.6
5.0	5.0	5.0	5.0	4.5	2.4	1.2	1.2	2.4	4.5	5.0	5.0	5.0	19.8	32.0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	13.6	32.0	32.0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	25.5	32.0	32.0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	31.2	32.0	32.0
4.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	31.2	32.0	32.0
1.8	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	25.5	32.0	32.0
0	3.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	13.6	32.0	32.0
0	.2	3.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	19.8	32.0
0	0	.2	3.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	13.6
0	0	0	.2	3.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
0	0	0	0	0	1.8	4.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
0	0	0	0	0	0	.5	2.9	4.9	5.0	5.0	5.0	5.0	5.0	5.0
0	0	0	0	0	0	0	0	.6	2.7	4.5	5.0	5.0	5.0	5.0
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.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.6	.2	0	0	0	0	0	0	0	0	0	0	0	0	0
5.0	3.6	.2	0	0	0	0	0	0	0	0	0	0	0	0
5.0	5.0	3.0	0	0	0	0	0	0	0	0	0	0	0	0
5.0	5.0	5.0	1.8	0	0	0	0	0	0	0	0	0	0	0
5.0	5.0	5.0	4.6	.5	0	0	0	0	0	0	0	0	0	0
5.0	5.0	5.0	5.0	2.9	0	0	0	0	0	0	0	0	0	0
5.0	5.0	5.0	5.0	4.9	.6	0	0	0	0	0	0	0	0	0
5.0	5.0	5.0	5.0	5.0	2.7	0	0	0	0	0	0	0	0	0
5.0	5.0	5.0	5.0	5.0	4.5	.1	0	0	0	0	0	0	0	0
4.4	5.0	5.0	5.0	5.0	5.0	1.1	0	0	0	0	0	0	0	0
1.8	5.0	5.0	5.0	5.0	5.0	2.4	0	0	0	0	0	0	0	0
1.0	3.7	5.0	5.0	5.0	5.0	3.4	0	0	0	0	0	0	0	0
1.0	2.3	5.0	5.0	5.0	5.0	4.2	0	0	0	0	0	0	0	0
1.0	1.5	5.0	5.0	5.0	5.0	4.7	0	0	0	0	0	0	0	0
1.0	1.0	5.0	5.0	5.0	5.0	5.0	0	0	0	0	0	0	0	0
1.0	1.0	5.0	5.0	5.0	5.0	5.0	0	0	0	0	0	0	0	0
1.0	1.5	5.0	5.0	5.0	5.0	4.7	0	0	0	0	0	0	0	0
1.0	2.3	5.0	5.0	5.0	5.0	4.2	0	0	0	0	0	0	0	0
1.0	3.7	5.0	5.0	5.0	5.0	3.4	0	0	0	0	0	0	0	0
1.8	5.0	5.0	5.0	5.0	5.0	2.4	0	0	0	0	0	0	0	0
4.4	5.0	5.0	5.0	5.0	5.0	1.1	0	0	0	0	0	0	0	0
5.0	5.0	5.0	5.0	5.0	4.5	.1	0	0	0	0	0	0	0	0
5.0	5.0	5.0	5.0	5.0	2.7	0	0	0	0	0	0	0	0	0
5.0	5.0	5.0	5.0	4.9	.6	0	0	0	0	0	0	0	0	0
5.0	5.0	5.0	5.0	2.9	0	0	0	0	0	0	0	0	0	0
5.0	5.0	5.0	4.6	.5	0	0	0	0	0	0	0	0	0	0
5.0	5.0	5.0	1.8	0	0	0	0	0	0	0	0	0	0	0
5.0	5.0	3.0	0	0	0	0	0	0	0	0	0	0	0	0
5.0	3.6	.2	0	0	0	0	0	0	0	0	0	0	0	0
3.6	.2	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.7	5.0	5.0	4.7	4.2	3.4	2.4	1.1	.1	0	0	0	0	0	0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.5	2.7	.6	0	0	0	0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.9	2.9	.5	0	0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.6	1.8	0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	3.0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
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5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.5	2.4	1.2	1.2	2.4	4.5
5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.4	1.3	1.0	1.0	1.0	1.0	1.3
5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	1.8	1.0	1.0	1.0	1.0	1.0	1.0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	3.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	2.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	2.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	3.7	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	1.8	1.0	1.0	1.0	1.0	1.0	1.0
25.5	31.2	31.2	25.5	13.6	5.0	5.0	5.0	4.4	1.3	1.0	1.0	1.0	1.0	1.3
32.0	32.0	32.0	32.0	32.0	19.8	5.0	5.0	5.0	4.5	2.4	1.2	1.2	2.4	4.5
32.0	32.0	32.0	32.0	32.0	32.0	13.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
32.0	32.0	32.0	32.0	32.0	32.0	25.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
32.0	32.0	32.0	32.0	32.0	32.0	31.2	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
32.0	32.0	32.0	32.0	32.0	32.0	31.2	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
32.0	32.0	32.0	32.0	32.0	32.0	25.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
32.0	32.0	32.0	32.0	32.0	32.0	13.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
32.0	32.0	32.0	32.0	32.0	19.8	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
25.5	31.2	31.2	25.5	13.6	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	3.0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.6	1.8	0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.9	2.9	.5	0	0
5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.5	2.7	.6	0	0	0	0
4.7	5.0	5.0	4.7	4.2	3.4	2.4	1.1	.1	0	0	0	0	0	0
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```
BLANK COMMON REQUIRED     18010    ( 43132)

BLANK COMMON REQUIRED     17978    ( 43072)

BLANK COMMON REQUIRED      1594    (  3072)

BLANK COMMON REQUIRED      1412    (  2604)
        THE FINAL RECONSTRUCTION IS RETURNED WITH DIMENSION NDIMU.
        NDIMU WILL NOW BE RETURNED TO ITS ORIGINAL VALUE.

BLANK COMMON REQUIRED      1284    (  2404)

A TOTAL OF  92 (  5 THRU  96) OF THE 129 USER PROJECTION BINS WILL BE USED

 92 PROJECTION BINS WILL BE USED OF WHICH    0 HAVE BEEN ZEROED BY THE PROGRAM

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=  18010 FLOATING POINT WORDS.

          EEEEE N    N DDDD          FFFFF  III  L      BBBB   K    K
          E     NN   N D    D        F       I   L      B    B K   K
          EEE   N N  N D    D        FFF     I   L      BBBB   KKK
          E     N   NN D    D        F       I   L      B    B K   K
          EEEEE N    N DDDD          F      III  LLLLL  BBBB   K    K

RECONSTRUCTION FOR PARALLEL BEAM GEOMETRY

XMIN =    -.12E+01     XMAX =     .32E+02     XSUM =     .6181E+04
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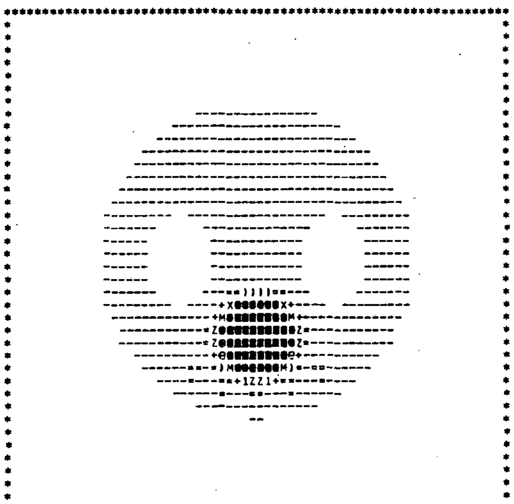

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                         -           =           +           )           1           Z
-.1190E+01  .1281E+01  .4905E+01  .6553E+01  .7706E+01  .9024E+01  .1034E+02

Z            X           A           M           @           8           8           @
 .1150E+02  .1232E+02  .1314E+02  .1495E+02  .1677E+02  .1792E+02  .1924E+02

 .2039E+02  .2286E+02  .2583E+02  .2748E+02  .2879E+02  .3011E+02  .3126E+02

 .3176E+02
```

-.0	-.2	-.4	-.3	-.5	-.8	-.5	.1	-.0	-.5	-.8	-.7	.1	.0	-.8
-.4	-.3	-.3	-.0	-.1	-.6	-.8	-.3	.1	-.2	-.8	-.9	-.1	.3	-.5
-.6	-.6	-.5	-.2	.1	-.2	-.8	-.7	-.0	.1	-.5	-1.1	-.5	.3	-.1
-.3	-.5	-.7	-.6	-.0	.0	-.5	-.9	-.4	.3	-.0	-1.0	-1.0	-.0	.3
-.1	-.1	-.5	-.8	-.3	.2	-.1	-.8	-.9	-.1	.3	-.5	-1.2	-.6	.3
-.2	.0	-.2	-.8	-.7	-.1	.2	-.3	-.9	-.6	.2	.1	-.9	-1.0	-.1
-.4	.0	.1	-.3	-.9	-.7	-.0	.2	-.6	-1.0	-.3	.3	-.3	-1.0	-.5
-.7	-.4	.1	.2	-.4	-.9	-.5	.3	.0	-.8	-.8	-.1	.1	-.7	-.8
-.8	-.9	-.4	.2	.1	-.6	-.9	-.2	.2	-.3	-.9	-.5	.1	-.3	-.8
-.1	-.8	-.8	-.2	.3	.0	-.7	-.8	-.1	-.0	-.5	-.6	-.1	-.1	-.5
.2	-.2	-.8	-.8	-.2	.3	-.1	-.7	-.6	-.1	-.3	-.6	-.4	-.1	-.3
-.4	.1	-.3	-.9	-.9	-.2	.1	-.3	-.6	-.3	-.2	-.5	-.5	-.3	-.4
-.9	-.2	.2	-.2	-.8	-.8	-.2	-.0	-.3	-.3	-.2	-.4	-.4	-.2	-.4
-.8	-.8	-.2	.2	-.2	-.7	-.6	-.3	-.3	-.3	-.2	-.4	-.5	-.2	-.2
-.2	-.8	-.8	-.2	.2	-.1	-.5	-.5	-.4	-.4	-.1	-.2	-.5	-.5	-.1
.3	-.2	-.8	-.8	-.3	.0	-.2	-.4	-.4	-.5	-.3	-.0	-.2	-.6	-.3
-.1	.2	-.2	-.6	-.7	-.3	-.2	-.2	-.2	-.4	-.6	-.3	.0	-.3	-.5
-.8	-.3	.1	-.1	-.5	-.5	-.3	-.3	-.2	-.1	-.5	-.7	-.3	-.0	-.4
-.7	-.8	-.4	-.2	-.3	-.4	-.3	-.2	-.3	-.1	-.1	-.6	-.6	-.2	-.3
-.1	-.5	-.6	-.5	-.4	-.5	-.5	-.2	-.2	-.2	-.2	-.3	-.5	-.5	-.2
-.1	-.1	-.3	-.4	-.3	-.5	-.7	-.6	-.1	-.1	-.2	-.2	-.3	-.3	.4
-.4	-.3	-.2	-.3	-.2	-.2	-.5	-.8	-.6	-.2	-.1	-.1	-.2	.1	1.4
-.4	-.4	-.3	-.4	-.4	-.3	-.1	-.4	-.8	-.8	-.3	-.1	.0	.8	2.5
-.2	-.3	-.3	-.2	-.4	-.5	-.2	-.0	-.3	-.7	-.7	-.4	.2	1.7	3.5
-.2	-.2	-.3	-.2	-.1	-.2	-.4	-.3	-.1	-.2	-.6	-.6	.4	2.4	4.0
-.4	-.3	-.3	-.4	-.3	-.2	-.3	-.4	-.3	-.2	-.4	-.4	.8	3.0	4.3
-.5	-.4	-.2	-.3	-.4	-.4	-.3	-.3	-.3	-.2	-.2	.0	1.5	3.6	4.5
-.5	-.6	-.5	-.2	-.1	-.3	-.3	-.3	-.2	-.2	-.1	.6	2.3	3.9	4.6
-.3	-.5	-.7	-.6	-.4	-.3	-.2	-.2	-.3	-.3	-.2	.8	2.8	4.2	4.5
-.3	-.2	-.3	-.5	-.6	-.6	-.4	-.3	-.3	-.4	-.3	.9	3.1	4.5	4.6
-.4	-.4	-.3	-.3	-.3	-.4	-.4	-.4	-.4	-.3	-.2	.9	3.1	4.5	4.7
-.2	-.3	-.4	-.4	-.3	-.3	-.4	-.5	-.4	-.3	-.1	1.0	3.1	4.3	4.7
-.2	-.1	-.1	-.2	-.3	-.3	-.4	-.5	-.5	-.4	-.2	1.2	3.4	4.4	4.6
-.5	-.3	-.3	-.2	-.2	-.2	-.2	-.2	-.3	-.4	-.3	1.0	3.2	4.5	4.6
-.2	-.3	-.3	-.4	-.2	-.2	-.2	-.2	-.2	-.3	-.3	.7	2.9	4.5	4.9
-.3	-.2	-.3	-.3	-.3	-.3	-.4	-.3	-.2	-.2	-.2	.7	2.7	4.2	4.7
-.7	-.7	-.7	-.6	-.5	-.5	-.4	-.3	-.2	-.2	-.2	.5	2.3	4.0	4.4
-.2	-.3	-.4	-.5	-.5	-.5	-.4	-.4	-.4	-.3	-.3	.2	1.9	3.9	4.7
-.2	-.2	-.1	-.2	-.3	-.4	-.5	-.5	-.5	-.5	-.4	-.2	1.2	3.3	4.5
-.4	-.3	-.3	-.2	-.2	-.2	-.2	-.3	-.4	-.4	-.5	-.4	.5	2.3	3.9
-.1	-.2	-.3	-.4	-.4	-.3	-.2	-.2	-.3	-.4	-.4	-.4	-.1	1.2	3.2
-.4	-.4	-.4	-.4	-.4	-.3	-.2	-.2	-.3	-.3	-.3	-.4	-.4	.5	2.3
-.4	-.4	-.3	-.2	-.2	-.3	-.4	-.4	-.3	-.3	-.4	-.3	-.3	.2	1.5
-.1	-.1	-.3	-.3	-.3	-.4	-.5	-.5	-.3	-.2	-.2	-.2	-.2	-.1	.6
-.5	-.6	-.6	-.6	-.5	-.4	-.3	-.3	-.2	-.1	-.2	-.3	-.3	-.3	-.1
-.5	-.3	-.2	-.2	-.2	-.2	-.2	-.3	-.3	-.2	-.2	-.3	-.3	-.2	-.3
-.2	-.1	-.1	-.2	-.2	-.3	-.4	-.3	-.3	-.2	-.1	-.3	-.4	-.4	-.4
-.5	-.5	-.5	-.5	-.6	-.5	-.4	-.3	-.2	-.2	-.4	-.5	-.6	-.5	-.4
-.3	-.3	-.3	-.4	-.4	-.2	-.1	-.2	-.3	-.4	-.5	-.5	-.3	-.2	-.2
-.3	-.4	-.3	-.2	-.1	-.1	-.2	-.4	-.6	-.6	-.4	-.3	-.2	-.2	-.3
-.5	-.4	-.2	-.1	-.2	-.4	-.5	-.5	-.5	-.3	-.2	-.2	-.3	-.4	-.5
-.1	-.0	-.1	-.4	-.5	-.6	-.4	-.2	-.1	-.1	-.2	-.4	-.4	-.4	-.3
-.2	-.4	-.7	-.7	-.6	-.5	-.2	-.2	-.2	-.3	-.5	-.5	-.3	-.3	-.3
-.6	-.6	-.5	-.3	-.2	-.2	-.2	-.3	-.3	-.4	-.4	-.4	-.3	-.3	-.4
-.4	-.3	-.2	-.2	-.2	-.1	-.2	-.4	-.5	-.5	-.5	-.5	-.5	-.4	-.3
-.3	-.3	-.4	-.3	-.2	-.1	-.4	-.5	-.6	-.6	-.5	-.4	-.3	-.2	-.3
-.3	-.3	-.2	-.1	-.2	-.5	-.8	-.6	-.4	-.4	-.3	-.2	-.2	-.3	-.4
-.3	-.3	-.2	-.5	-.8	-.8	-.6	-.3	-.2	-.2	-.2	-.3	-.3	-.4	-.5
-.5	-.5	-.6	-.7	-.5	-.2	-.2	-.2	-.3	-.3	-.3	-.3	-.4	-.5	-.4
-.4	-.5	-.3	-.4	-.1	-.1	-.4	-.4	-.3	-.3	-.3	-.4	-.4	-.4	-.3
-.3	-.4	-.3	-.3	-.4	-.5	-.4	-.2	-.2	-.3	-.3	-.4	-.4	-.4	-.3
-.7	-.5	-.4	-.4	-.4	-.3	-.1	-.2	-.4	-.4	-.3	-.5	-.5	-.3	-.4
-.6	-.2	-.3	-.3	-.1	-.2	-.4	-.4	-.4	-.2	-.4	-.6	-.4	-.3	-.3
.1	-.0	-.4	-.3	-.3	-.6	-.5	-.1	-.2	-.4	-.6	-.5	-.3	-.2	-.3

-.7	.1	-.1	-.7	-.6	.1	-.1	-.9	-.4	.3	-.5	-1.2	-.1	.3	-.7
-.9	-.2	.1	-.5	-.7	-.1	.1	-.7	-.6	.2	-.3	-1.2	-.3	.3	-.5
-.9	-.6	.1	-.2	-.7	-.3	.1	-.4	-.7	.0	-.2	-1.0	-.5	.3	-.4
-.6	-.8	-.1	.0	-.6	-.6	-.0	-.2	-.6	-.2	-.2	-.8	-.5	.2	-.3
-.1	-.8	-.4	-.0	-.4	-.6	-.2	-.1	-.5	-.3	-.1	-.7	-.6	-.0	-.2
.2	-.5	-.6	-.2	-.2	-.4	-.3	-.2	-.4	-.3	-.2	-.5	-.6	-.2	-.2
.1	-.2	-.6	-.3	-.2	-.3	-.3	-.3	-.3	-.3	-.3	-.5	-.5	-.3	-.3
-.2	-.1	-.4	-.4	-.3	-.2	-.2	-.4	-.4	-.3	-.4	-.4	-.3	-.4	-.4
-.5	-.1	-.2	-.3	-.4	-.3	-.2	-.4	-.5	-.2	-.3	-.4	-.2	-.5	-.5
-.5	-.3	-.2	-.2	-.4	-.4	-.1	-.3	-.5	-.1	-.3	-.4	-.1	-.6	-.5
-.5	-.4	-.4	-.2	-.3	-.5	-.2	-.2	-.5	-.2	-.3	-.5	-.1	-.4	-.5
-.5	-.4	-.5	-.3	-.1	-.4	-.3	-.2	-.5	-.2	-.1	-.1	.6	.6	.5
-.5	-.3	-.4	-.5	-.2	-.3	-.4	-.1	.0	.6	1.1	1.5	2.5	2.7	2.6
-.5	-.4	-.3	-.5	-.4	-.1	.0	.7	1.6	2.5	3.1	3.5	4.2	4.3	4.1
-.4	-.6	-.3	-.4	-.3	.5	1.4	2.5	3.5	4.2	4.4	4.3	4.7	4.7	4.5
-.2	-.5	-.4	.1	.7	2.0	3.2	4.0	4.5	4.7	4.6	4.5	4.7	4.8	4.6
-.2	-.4	-.1	1.2	2.5	3.5	4.3	4.7	4.8	4.8	4.7	4.5	4.7	4.8	4.7
-.3	.1	1.0	2.6	3.9	4.3	4.5	4.9	4.8	4.7	4.6	4.6	4.7	4.8	4.7
-.0	1.2	2.6	3.8	4.5	4.6	4.6	4.8	4.8	4.7	4.6	4.7	4.7	4.6	4.7
.8	2.6	3.8	4.2	4.6	4.8	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.6	4.8
1.9	3.7	4.5	4.4	4.5	4.8	4.8	4.7	4.6	4.8	4.8	4.7	4.8	4.7	4.8
3.1	4.2	4.7	4.6	4.4	4.6	4.7	4.7	4.6	4.7	4.8	4.7	4.8	4.8	4.8
4.0	4.4	4.5	4.6	4.5	4.6	4.7	4.7	4.7	4.7	4.6	4.6	4.8	4.8	4.8
4.6	4.7	4.5	4.6	4.7	4.7	4.6	4.6	4.7	4.7	4.6	4.6	4.7	4.8	4.8
4.7	4.9	4.7	4.5	4.3	4.0	3.8	3.8	4.1	4.5	4.6	4.5	4.7	4.8	4.7
4.6	4.8	4.7	4.2	3.2	2.2	2.0	2.2	2.7	3.6	4.3	4.5	4.7	4.8	4.7
4.6	4.6	4.4	3.4	2.1	1.0	.6	.8	1.3	2.2	3.4	4.2	4.7	4.8	4.7
4.7	4.4	3.6	2.3	1.2	.8	.5	.5	.7	1.2	2.4	3.7	4.6	4.8	4.6
4.7	4.3	2.9	1.4	.7	.6	.7	.7	.6	.8	1.6	3.0	4.4	4.8	4.5
4.6	4.2	2.6	1.1	.6	.5	.5	.6	.8	.8	1.1	2.4	4.1	4.7	4.6
4.5	3.8	2.2	1.2	.8	.7	.4	.4	.7	.9	.9	2.0	3.9	4.6	4.6
4.5	3.4	1.8	1.0	1.0	.9	.7	.5	.6	.7	.8	1.9	3.8	4.5	4.5
4.4	3.3	1.6	.7	.7	.8	.9	.8	.7	.7	.9	1.9	3.8	4.5	4.5
4.6	3.7	1.9	.7	.5	.6	.7	.6	.6	.8	1.2	2.3	4.0	4.5	4.5
4.9	4.2	2.5	.9	.5	.6	.7	.5	.3	.5	1.1	2.6	4.1	4.5	4.7
4.7	4.3	3.0	1.5	.7	.6	.7	.7	.5	.5	1.3	3.0	4.1	4.5	4.9
4.5	4.5	3.7	2.3	1.2	.6	.6	.8	.8	1.1	2.4	3.9	4.5	5.4	7.4
4.7	4.7	4.4	3.5	2.2	1.2	.8	1.0	1.4	2.1	3.4	4.5	6.0	9.9	15.6
4.8	4.7	4.6	4.3	3.6	2.6	2.0	2.0	2.6	3.4	4.1	5.3	9.8	17.9	25.3
4.6	4.7	4.6	4.6	4.5	4.1	3.7	3.7	4.0	4.4	4.6	7.3	15.5	25.3	30.5
4.3	4.5	4.6	4.7	4.8	4.8	4.7	4.6	4.6	4.6	5.0	9.9	20.4	29.1	31.7
3.7	4.3	4.5	4.6	4.7	4.8	4.8	4.7	4.6	4.6	5.3	11.5	23.0	30.4	31.7
3.2	4.2	4.5	4.4	4.4	4.5	4.7	4.7	4.7	4.8	5.3	11.2	23.0	30.6	31.8
2.2	3.8	4.5	4.5	4.4	4.4	4.5	4.5	4.6	4.8	5.0	9.4	20.4	29.3	31.7
.8	2.5	4.0	4.6	4.8	4.7	4.7	4.7	4.5	4.7	4.6	6.9	15.4	25.2	30.4
-.0	1.2	2.9	4.1	4.5	4.8	5.0	5.0	4.9	4.9	4.5	5.2	10.0	17.9	25.2
-.3	.2	1.3	2.6	3.7	4.5	4.8	4.8	5.1	5.0	4.5	4.8	6.5	10.1	15.7
-.4	-.4	-.1	.9	2.4	3.6	4.1	4.6	5.0	4.7	4.3	4.8	5.2	5.4	7.3
-.3	-.4	-.3	.1	.9	1.9	2.9	4.2	4.8	4.6	4.2	4.6	5.0	4.4	4.4
-.4	-.2	-.1	-.1	-.0	.3	1.3	2.7	3.6	3.8	4.0	4.4	4.9	4.7	4.3
-.3	-.1	-.1	-.3	-.4	-.3	.1	.8	1.3	2.0	2.9	3.6	4.4	4.5	4.1
-.1	-.1	-.3	-.5	-.6	-.5	-.2	-.1	-.1	.2	1.0	1.8	2.6	3.0	2.6
-.3	-.4	-.6	-.6	-.5	-.3	-.1	-.2	-.4	-.5	-.3	.2	.7	.9	.6
-.4	-.5	-.5	-.4	-.3	-.2	-.1	-.3	-.5	-.5	-.3	-.1	-.1	-.2	-.2
-.4	-.4	-.3	-.3	-.2	-.1	-.2	-.5	-.7	-.5	-.2	-.2	-.3	-.3	-.1
-.4	-.4	-.3	-.2	-.2	-.1	-.3	-.6	-.5	-.3	-.3	-.5	-.4	-.1	.1
-.5	-.3	-.2	-.2	-.2	-.3	-.4	-.4	-.2	-.3	-.6	-.6	-.3	.0	-.0
-.3	-.1	-.2	-.4	-.3	-.2	-.4	-.4	-.2	-.4	-.7	-.5	-.1	.1	-.0
-.2	-.2	-.4	-.4	-.2	-.1	-.3	-.4	-.5	-.5	-.5	-.3	-.1	-.0	-.1
-.3	-.4	-.4	-.3	-.1	-.2	-.4	-.5	-.6	-.4	-.3	-.3	-.2	-.1	-.3
-.4	-.4	-.3	-.2	-.1	-.4	-.5	-.6	-.6	-.3	-.2	-.4	-.2	-.1	-.4
-.4	-.3	-.2	-.2	-.2	-.4	-.6	-.5	-.5	-.2	-.2	-.4	-.2	-.2	-.4
-.3	-.2	-.2	-.3	-.3	-.5	-.6	-.4	-.3	-.1	-.3	-.5	-.2	-.3	-.5
-.2	-.2	-.3	-.3	-.4	-.6	-.5	-.3	-.2	-.2	-.4	-.5	-.2	-.4	-.5

-.8	.0	.0	-.8	-.7	.3	-.1	-1.2	-.5	.3	-.4	-.9	-.1	.1	-.6	-.3	-.4	-.2	-.0
-.8	-.0	-.0	-.8	-.5	.3	-.3	-1.2	-.3	.2	-.6	-.7	.1	-.1	-.7	-.0	-.3	-.3	-.4
-.8	-.1	-.1	-.8	-.4	.3	-.5	-1.0	-.2	.0	-.7	-.4	.1	-.3	-.7	-.2	-.5	-.6	-.6
-.8	-.2	-.2	-.8	-.3	.2	-.5	-.8	-.2	-.2	-.6	-.2	-.0	-.6	-.6	-.6	-.7	-.5	-.3
-.6	-.3	-.3	-.6	-.2	-.0	-.6	-.7	-.1	-.3	-.5	-.1	-.2	-.6	-.4	-.8	-.5	-.1	-.1
-.4	-.3	-.3	-.4	-.2	-.2	-.6	-.5	-.2	-.3	-.4	-.2	-.3	-.4	-.2	-.8	-.2	.0	-.2
-.3	-.4	-.4	-.3	-.3	-.3	-.5	-.5	-.3	-.3	-.3	-.3	-.3	-.3	-.2	-.3	.1	.0	-.4
-.1	-.5	-.5	-.1	-.4	-.4	-.3	-.4	-.4	-.3	-.4	-.4	-.2	-.2	-.3	.2	.1	-.4	-.7
-.0	-.5	-.5	-.0	-.5	-.5	-.2	-.4	-.3	-.2	-.5	-.4	-.2	-.3	-.4	.2	-.4	-.9	-.8
.1	-.5	-.5	.1	-.5	-.6	-.1	-.4	-.3	-.1	-.5	-.3	-.1	-.4	-.4	-.2	-.8	-.8	-.1
.1	-.2	-.2	.1	-.5	-.4	-.1	-.5	-.3	-.2	-.5	-.2	-.2	-.5	-.3	-.8	-.8	-.2	.2
1.2	1.1	1.1	1.2	.5	.6	.6	-.1	-.1	-.2	-.5	-.2	-.3	-.4	-.1	-.9	-.3	.1	-.4
3.2	3.3	3.3	3.2	2.6	2.7	2.5	1.3	1.1	.6	.0	-.1	-.4	-.3	-.2	-.2	.2	-.2	-.9
4.5	4.5	4.5	4.5	4.1	4.3	4.2	3.5	3.1	2.5	1.6	.7	.0	-.1	-.4	.2	-.2	-.8	-.8
4.6	4.6	4.6	4.6	4.5	4.7	4.7	4.3	4.4	4.2	3.5	2.5	1.4	.5	-.3	-.2	-.8	-.8	-.2
4.5	4.6	4.6	4.5	4.6	4.8	4.7	4.5	4.5	4.7	4.5	4.0	3.2	2.0	.7	-.8	-.8	-.2	.3
4.4	4.6	4.6	4.4	4.7	4.8	4.7	4.5	4.7	4.8	4.8	4.7	4.3	3.5	2.5	-.6	-.2	.2	-.1
4.5	4.6	4.6	4.5	4.7	4.8	4.7	4.6	4.6	4.7	4.8	4.9	4.5	4.3	3.9	-.1	.1	-.3	-.8
4.6	4.5	4.6	4.6	4.7	4.6	4.7	4.7	4.6	4.7	4.8	4.8	4.6	4.6	4.5	-.2	-.4	-.8	-.7
4.7	4.5	4.5	4.7	4.8	4.6	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.8	4.6	-.5	-.6	-.5	-.1
4.7	4.4	4.4	4.7	4.8	4.7	4.8	4.7	4.8	4.8	4.6	4.7	4.8	4.8	4.5	-.4	-.3	-.1	-.1
4.7	4.5	4.5	4.7	4.8	4.8	4.9	4.7	4.8	4.7	4.6	4.7	4.7	4.6	4.4	-.3	-.2	-.3	-.4
4.7	4.5	4.5	4.7	4.8	4.8	4.8	4.6	4.6	4.7	4.7	4.7	4.7	4.6	4.5	-.4	-.3	-.4	-.4
4.6	4.5	4.5	4.6	4.8	4.8	4.7	4.6	4.6	4.7	4.7	4.6	4.6	4.7	4.7	-.2	-.3	-.3	-.2
4.5	4.5	4.5	4.6	4.7	4.8	4.7	4.5	4.6	4.5	4.1	3.8	3.8	4.0	4.3	-.2	-.3	-.2	-.2
4.7	4.6	4.6	4.7	4.7	4.8	4.7	4.5	4.3	3.6	2.7	2.2	2.0	2.2	3.2	-.4	-.3	-.3	-.4
4.7	4.6	4.6	4.7	4.7	4.8	4.7	4.2	3.4	2.2	1.3	.8	.6	1.0	2.1	-.3	-.2	-.4	-.5
4.6	4.8	4.8	4.6	4.6	4.8	4.6	3.7	2.4	1.2	.7	.5	.5	.8	1.2	-.2	-.5	-.6	-.5
4.6	4.9	4.9	4.6	4.5	4.8	4.4	3.0	1.6	.8	.6	.7	.7	.6	.7	-.6	-.7	-.5	-.3
4.6	4.8	4.8	4.6	4.6	4.7	4.1	2.4	1.1	.8	.8	.6	.5	.5	.6	-.5	-.3	-.2	-.3
4.6	4.8	4.8	4.6	4.6	4.6	3.9	2.0	.9	.9	.7	.4	.4	.7	.8	-.3	-.3	-.4	-.4
4.7	4.9	4.9	4.7	4.5	4.5	3.8	1.9	.8	.7	.6	.5	.7	.9	1.0	-.4	-.4	-.3	-.2
4.7	4.7	4.7	4.7	4.5	4.5	3.8	1.9	.9	.7	.7	.8	.9	.8	.7	-.2	-.1	-.1	-.2
4.7	4.7	4.7	4.7	4.5	4.5	4.0	2.3	1.2	.8	.6	.6	.7	.6	.5	-.2	-.3	-.5	-.5
4.8	4.7	4.7	4.8	4.7	4.5	4.1	2.6	1.1	.5	.3	.5	.7	.6	.5	-.4	-.3	-.3	-.2
5.1	5.2	5.2	5.1	4.9	4.5	4.1	3.0	1.3	.5	.5	.7	.7	.6	.7	-.3	-.3	-.2	-.3
9.7	11.1	11.1	9.7	7.4	5.4	4.5	3.9	2.4	1.1	.8	.8	.6	.6	1.2	-.6	-.7	-.7	-.7
20.5	23.2	23.2	20.5	15.6	9.9	6.0	4.5	3.4	2.1	1.4	1.0	.8	1.2	2.2	-.5	-.4	-.3	-.2
29.3	30.7	30.7	29.3	25.3	17.9	9.8	5.3	4.1	3.4	2.6	2.0	2.0	2.6	3.6	-.2	-.1	-.2	-.2
31.6	31.6	31.6	31.6	30.5	23.3	15.5	7.3	4.6	4.4	4.0	3.7	3.7	4.1	4.5	-.2	-.3	-.3	-.4
31.6	31.6	31.6	31.6	31.7	29.1	20.4	9.9	5.0	4.6	4.6	4.6	4.7	4.8	4.6	-.4	-.3	-.2	-.1
31.7	31.7	31.7	31.7	31.7	30.4	23.0	11.5	5.3	4.6	4.6	4.7	4.8	4.8	4.7	-.4	-.4	-.4	-.4
31.7	31.7	31.7	31.7	31.8	30.5	23.0	11.2	5.3	4.8	4.7	4.7	4.7	4.5	4.4	-.2	-.3	-.4	-.4
31.7	31.6	31.6	31.7	31.7	29.3	20.4	9.4	5.0	4.8	4.6	4.5	4.5	4.4	4.4	-.3	-.3	-.1	-.1
31.7	31.6	31.6	31.7	30.4	25.2	15.4	6.9	4.6	4.7	4.5	4.7	4.7	4.7	4.8	-.6	-.6	-.6	-.5
29.2	30.4	30.4	29.2	25.2	17.9	10.0	5.2	4.5	4.9	4.9	5.0	5.0	4.8	4.5	-.2	-.2	-.3	-.5
20.7	23.1	23.1	20.7	15.7	10.1	6.5	4.8	4.5	5.0	5.1	4.8	4.8	4.5	3.7	-.2	-.1	-.1	-.2
10.0	11.6	11.6	10.0	7.3	5.4	5.2	4.8	4.3	4.7	5.0	4.6	4.1	3.6	2.4	-.5	-.5	-.5	-.5
5.1	5.4	5.4	5.1	4.4	4.4	5.0	4.6	4.2	4.6	4.8	4.2	2.9	1.9	.9	-.4	-.3	-.3	-.3
4.6	4.7	4.7	4.6	4.3	4.7	4.9	4.4	4.0	3.8	3.6	2.7	1.3	.3	-.0	-.2	-.3	-.4	-.3
4.2	4.6	4.6	4.2	4.1	4.3	4.4	3.6	2.5	2.0	1.3	.8	.1	-.3	-.4	-.1	-.2	-.4	-.5
2.7	3.5	3.5	2.7	2.6	3.0	2.6	1.8	1.0	.2	-.1	-.1	-.2	-.5	-.6	-.4	-.1	-.0	-.1
.7	1.3	1.3	.7	.6	.9	.7	.2	-.3	-.5	-.4	-.2	-.1	-.3	-.5	-.7	-.7	-.4	-.2
-.2	-.2	-.2	-.2	-.2	-.2	-.1	-.1	-.3	-.5	-.5	-.3	-.1	-.2	-.3	-.3	-.5	-.6	-.6
-.2	-.6	-.6	-.2	-.1	-.3	-.3	-.2	-.2	-.5	-.7	-.5	-.2	-.1	-.2	-.2	-.2	-.3	-.4
-.2	-.7	-.7	-.2	.1	-.1	-.4	-.5	-.3	-.3	-.3	-.6	-.3	-.1	-.2	-.3	-.4	-.3	-.3
-.3	-.7	-.7	-.3	-.0	.0	-.3	-.6	-.6	-.3	-.2	-.4	-.4	-.3	-.2	-.1	-.2	-.3	-.3
-.4	-.8	-.8	-.4	-.0	.1	-.1	-.5	-.7	-.4	-.2	-.4	-.4	-.2	-.3	-.5	-.2	-.3	-.3
-.4	-.7	-.7	-.4	-.1	-.0	-.1	-.3	-.5	-.5	-.5	-.4	-.3	-.1	-.2	-.7	-.6	-.3	-.5
-.5	-.5	-.5	-.5	-.3	-.1	-.2	-.3	-.3	-.4	-.6	-.5	-.4	-.2	-.1	-.4	-.5	-.5	-.4
-.6	-.3	-.3	-.6	-.4	-.1	-.2	-.4	-.2	-.3	-.6	-.6	-.5	-.4	-.1	-.3	-.3	-.4	-.3
-.4	-.2	-.2	-.4	-.4	-.2	-.2	-.4	-.2	-.2	-.5	-.5	-.6	-.4	-.2	-.4	-.4	-.5	-.7
-.3	-.3	-.3	-.3	-.5	-.3	-.2	-.5	-.3	-.1	-.3	-.4	-.6	-.5	-.3	-.3	-.3	-.2	-.6
-.2	-.3	-.3	-.2	-.5	-.4	-.2	-.5	-.4	-.2	-.2	-.3	-.5	-.6	-.4	-.3	-.4	-.0	.1

-.7	-.1	.1	-.7	-.8	.0	.1	-.7	-.8	-.5	-.0	.1	-.5	-.8	-.5
-.5	.1	-.2	-.9	-.5	.3	-.1	-.9	-.8	-.2	.1	-.3	-.8	-.6	-.1
-.2	.1	-.6	-.9	-.1	.3	-.5	-1.1	-.3	.1	-.0	-.7	-.8	-.2	.1
.0	-.1	-.8	-.6	.3	-.0	-1.0	-1.0	-.0	.3	-.4	-.9	-.5	.0	-.0
-.0	-.4	-.8	-.1	.3	-.6	-1.2	-.5	.3	-.1	-.9	-.8	-.1	.2	-.3
-.2	-.6	-.5	.2	-.1	-1.0	-.9	.1	.2	-.6	-.9	-.3	.2	-.1	-.7
-.3	-.6	-.2	.1	-.5	-1.0	-.3	.3	-.3	-1.0	-.6	.2	-.0	-.7	-.9
-.4	-.4	-.1	-.2	-.6	-.7	.1	-.1	-.8	-.8	.0	.3	-.5	-.9	-.4
-.3	-.2	-.1	-.5	-.8	-.3	.1	-.5	-.9	-.3	.2	-.2	-.9	-.6	.1
-.2	-.2	-.3	-.5	-.5	-.1	-.1	-.6	-.5	-.0	-.1	-.8	-.7	.0	.3
-.2	-.4	-.4	-.5	-.3	-.1	-.4	-.6	-.3	-.1	-.6	-.7	-.1	.3	-.2
-.3	-.5	-.4	-.5	-.4	-.3	-.5	-.5	-.2	-.3	-.6	-.3	.1	-.2	-.9
-.5	-.4	-.3	-.5	-.4	-.2	-.4	-.4	-.2	-.3	-.3	-.0	-.2	-.8	-.8
-.5	-.3	-.4	-.5	-.2	-.2	-.5	-.4	-.2	-.3	-.3	-.3	-.6	-.7	-.2
-.4	-.3	-.6	-.4	-.1	-.5	-.5	-.2	-.1	-.4	-.4	-.5	-.5	-.1	.2
.1	-.4	-.5	-.2	-.3	-.6	-.2	-.0	-.3	-.5	-.4	-.4	-.2	.0	-.3
1.2	-.1	-.4	-.2	-.5	-.3	.0	-.3	-.6	-.4	-.2	-.2	-.2	-.3	-.7
2.6	1.0	.1	-.3	-.4	-.0	-.3	-.7	-.5	-.1	-.2	-.3	-.3	-.5	-.5
3.8	2.6	1.2	-.0	-.3	-.2	-.6	-.6	-.1	-.1	-.3	-.2	-.3	-.4	-.3
4.2	3.6	2.6	.8	-.2	-.5	-.5	-.3	-.2	-.2	-.2	-.2	-.5	-.5	-.4
4.4	4.5	3.7	1.9	.4	-.3	-.3	-.2	-.2	-.1	-.1	-.6	-.7	-.5	-.3
4.5	4.7	4.2	3.1	1.4	.1	-.2	-.1	-.1	-.2	-.6	-.8	-.5	-.2	-.2
4.6	4.5	4.4	4.0	2.5	.8	.0	-.1	-.3	-.8	-.8	-.4	-.1	-.3	-.4
4.6	4.5	4.7	4.6	3.5	1.7	.2	-.4	-.7	-.7	-.3	-.0	-.2	-.5	-.4
4.5	4.7	4.9	4.7	4.0	2.4	.4	-.6	-.6	-.2	-.1	-.3	-.4	-.2	-.1
4.2	4.7	4.8	4.6	4.3	3.0	.8	-.4	-.4	-.2	-.3	-.4	-.3	-.2	-.3
3.4	4.4	4.6	4.5	4.5	3.6	1.5	.0	-.2	-.2	-.3	-.3	-.3	-.4	-.4
2.3	3.5	4.4	4.7	4.6	3.9	2.3	.6	-.1	-.2	-.2	-.3	-.3	-.3	-.1
1.4	2.9	4.3	4.7	4.5	4.2	2.8	.8	-.2	-.3	-.3	-.2	-.2	-.3	-.4
1.1	2.6	4.2	4.6	4.6	4.5	3.1	.8	-.3	-.4	-.3	-.3	-.4	-.6	-.6
1.2	2.2	3.8	4.5	4.7	4.5	3.1	.9	-.2	-.3	-.4	-.4	-.4	-.4	-.3
1.0	1.8	3.4	4.5	4.7	4.3	3.1	1.0	-.1	-.3	-.4	-.5	-.4	-.3	-.3
.7	1.6	3.3	4.4	4.6	4.4	3.4	1.2	-.2	-.4	-.5	-.5	-.4	-.3	-.3
.7	1.9	3.7	4.6	4.6	4.5	3.2	1.0	-.3	-.4	-.3	-.2	-.2	-.2	-.2
.9	2.5	4.2	4.9	4.9	4.5	2.9	.7	-.3	-.3	-.2	-.2	-.2	-.2	-.2
1.3	3.0	4.3	4.7	4.7	4.2	2.7	.7	-.2	-.2	-.2	-.3	-.4	-.3	-.3
2.3	3.7	4.5	4.5	4.4	4.0	2.3	.5	-.2	-.2	-.2	-.3	-.4	-.5	-.5
3.5	4.4	4.7	4.7	4.7	3.9	1.9	.2	-.3	-.3	-.4	-.4	-.4	-.5	-.5
4.3	4.6	4.7	4.8	4.5	3.3	1.2	-.2	-.4	-.5	-.5	-.5	-.5	-.4	-.3
4.5	4.6	4.7	4.6	3.9	2.3	.5	-.4	-.5	-.4	-.4	-.3	-.2	-.2	-.2
4.7	4.6	4.5	4.3	3.2	1.2	-.1	-.4	-.4	-.4	-.3	-.2	-.2	-.3	-.4
4.5	4.5	4.3	3.7	2.3	.5	-.4	-.4	-.3	-.3	-.3	-.2	-.2	-.3	-.4
4.4	4.5	4.2	3.2	1.5	.2	-.3	-.3	-.4	-.3	-.3	-.4	-.4	-.3	-.2
4.3	4.5	3.8	2.2	.6	-.1	-.2	-.2	-.2	-.2	-.3	-.5	-.5	-.4	-.3
4.6	4.0	2.5	.8	-.1	-.3	-.3	-.3	-.2	-.1	-.2	-.3	-.3	-.4	-.5
4.1	2.9	1.2	-.0	-.3	-.2	-.3	-.3	-.2	-.2	-.3	-.3	-.2	-.2	-.2
2.6	1.3	.2	-.3	-.4	-.4	-.4	-.3	-.1	-.2	-.3	-.3	-.4	-.3	-.2
.9	-.1	-.4	-.4	-.4	-.5	-.6	-.5	-.4	-.2	-.2	-.3	-.4	-.5	-.6
.1	-.3	-.4	-.3	-.2	-.2	-.3	-.5	-.5	-.4	-.3	-.2	-.1	-.2	-.4
-.1	-.1	-.2	-.4	-.3	-.2	-.2	-.3	-.4	-.6	-.6	-.4	-.2	-.1	-.1
-.3	-.1	-.1	-.3	-.5	-.4	-.3	-.2	-.2	-.3	-.5	-.5	-.5	-.4	-.2
-.5	-.3	-.1	-.1	-.3	-.4	-.4	-.4	-.2	-.1	-.1	-.2	-.4	-.6	-.5
-.0	-.6	-.4	-.3	-.3	-.3	-.3	-.5	-.5	-.3	-.2	-.2	-.2	-.5	-.6
-.4	-.5	-.5	-.4	-.4	-.3	-.3	-.4	-.4	-.4	-.3	-.3	-.2	-.2	-.2
-.3	-.3	-.4	-.4	-.3	-.4	-.5	-.5	-.5	-.5	-.5	-.4	-.2	-.1	-.2
-.2	-.3	-.4	-.4	-.3	-.2	-.3	-.4	-.5	-.6	-.6	-.5	-.4	-.1	-.2
-.2	-.2	-.3	-.5	-.4	-.3	-.2	-.2	-.3	-.4	-.4	-.6	-.8	-.5	-.2
-.4	-.2	-.1	-.3	-.5	-.4	-.3	-.3	-.2	-.2	-.2	-.3	-.6	-.8	-.6
-.4	-.4	-.2	-.2	-.4	-.5	-.4	-.3	-.3	-.3	-.3	-.2	-.2	-.2	-.5
-.3	-.4	-.4	-.3	-.3	-.4	-.4	-.4	-.3	-.3	-.3	-.4	-.4	-.1	-.1
-.2	-.3	-.4	-.4	-.3	-.4	-.4	-.4	-.3	-.3	-.2	-.2	-.4	-.5	-.4
-.2	-.2	-.3	-.4	-.4	-.3	-.5	-.5	-.3	-.4	-.4	-.2	-.1	-.3	-.4
-.3	-.2	-.2	-.3	-.3	-.3	-.4	-.6	-.4	-.2	-.4	-.4	-.4	-.2	-.1
-.3	-.3	-.2	-.2	-.3	-.2	-.3	-.3	-.6	-.4	-.2	-.1	-.5	-.6	-.3

```
 SSS  EEEEE TTTTT U   U PPPP
S     E       T   U   U P   P
 SSS  EEE     T   U   U PPPP
    S E       T   U   U P
 SSS  EEEEE   T    UUU  P
```

INTEGER PARAMETER ARRAY (IPAR)

I	IPAR(I)	DESCRIPTION
1	64	LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
2	1	RECONSTRUCT IN A SQUARE ARRAY
3	1	GEOMETRY FLAG FAN BEAM GEOMETRY (CURVED DETECTOR)
4	72	NUMBER OF PROJECTION ANGLES
5	5	MODE FOR PROJECTION ANGLE INPUT (SEE FOLLOWING LINES) ANGLES GENERATED BETWEEN ZERO AND 2*PI STARTING AT ZERO
6	129	NUMBER OF RAYS FOR EACH PROJECTION
7	1	TRANSMISSION DATA
8	18500	DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
9	1	NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10	0	EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11	5	PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES) PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
12	0	LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE

FLOATING POINT PARAMETER ARRAY (PAR)

I	PAR(I)	DESCRIPTION
1	1.330	PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION
2	50.300	LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
3	125.000	DISTANCE FROM SOURCE TO CENTER OF ROTATION FOR FAN BEAM IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION

BLANK COMMON REQUIRED 72 (110)

BLANK COMMON REQUIRED 144 (220)

BLANK COMMON REQUIRED 216 (330)

BLANK COMMON REQUIRED 474 (732)

BLANK COMMON REQUIRED 602 (1132)

A TOTAL OF 114 (1 THRU 114) OF THE 129 USER PROJECTION BINS WILL BE USED

128 PROJECTION BINS WILL BE USED OF WHICH 14 HAVE BEEN ZEROED BY THE PROGRAM

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 18010 FLOATING POINT WORDS.

```
EEEEE N   N DDDD        SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D      S     E       T   U   U P   P
EEE   N N N D   D       SSS  EEE     T   U   U PPPP
E     N  NN D   D          S E       T   U   U P
EEEEE N   N DDDD        SSS  EEEEE   T    UUU  P
```

```
FFFFF  III  L     BBBB  K   K
F       I   L     B   B K  K
FFF     I   L     BBBB  KKK
F       I   L     B   B K  K
F      III  LLLLL BBBB  K   K
```

PARAMETERS FOR SUBROUTINE FILBK

DESCRIPTION

ORDERX - 0 FILTER PARAMETER USED ONLY BY THE FILTER BUTER
FREQX - .500 FREQUENCY PARAMETER FOR THE FILTER

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	UNIFORM SQUARE	NO	YES
FIL	FILTER	N/A	NO	N/A

FILTERED BACK-PROJECTION RECONSTRUCTIONS MUST BE EXECUTED IN AN ARRAY WITH DIMENSIONS AT LEAST TWICE AS LARGE AS THE FINAL IMAGE. THUS, THE EFFECTIVE SIZE OF THE RECONSTRUCTION ARRAY WILL NOW BE INCREASED.

FOR FAN BEAM RECONSTRUCTIONS THE FAN SOURCE MUST BE OUTSIDE THIS LARGE ARRAY.

BLANK COMMON REQUIRED 730 (1332)

A TOTAL OF 129 (1 THRU 129) OF THE 129 USER PROJECTION BINS WILL BE USED

328 PROJECTION BINS WILL BE USED OF WHICH 199 HAVE BEEN ZEROED BY THE PROGRAM

BLANK COMMON REQUIRED 17114 (41332)

BLANK COMMON REQUIRED 17442 (42042)

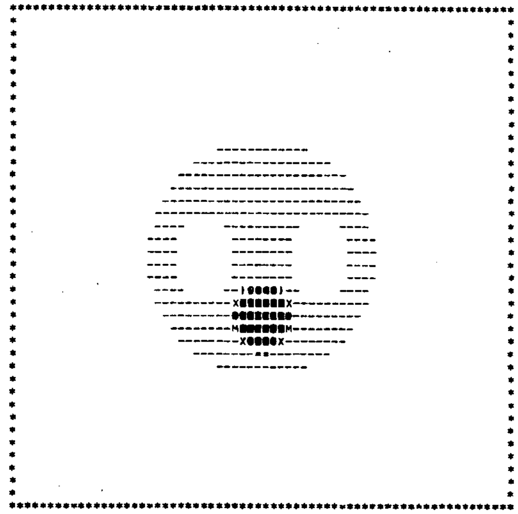
```
PPPP  H   H  AAA  N   N
P   P H   H A   A NN  N
PPPP  HHHHH A   A N N N
P     H   H AAAAA N  NN
P     H   H A   A N   N
```

PHANTOM GENERATED
ARRAY SIZE 64 X 64 INTEGRATION FACTOR = 10 SCALING FACTOR = .752
NUMBER OF ELIPSES AND/OR RECTANGLES = 4
THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
X,Y - CENTER
A,B - LENGTH OF AXIS OR SIDE A AND B
PHI - ANGLE OF AXIS OR SIDE A
DENS - INTENSITY
THE PARENTHESIS INDICATES THE SCALED VALUE

ITYPE	X	Y	A	B	PHI	DENS
1 - ELLIPSE	0 ,	0	40.00 ,	40.00	0	5.00
	(0),(	0)(	30.08),(	30.08)		(6.65)
1 - ELLIPSE	0 ,	-10.00	10.00 ,	10.00	0	27.00
	(0),(	-7.52)(	7.52),(	7.52)		(35.91)
1 - ELLIPSE	10.00 ,	0	14.00 ,	10.00	1.57	-4.00
	(7.52),(	0)(	10.53),(	7.52)		(-5.32)
1 - ELLIPSE	-10.00 ,	0	14.00 ,	10.00	1.57	-4.00
	(-7.52),(	0)(	10.53),(	7.52)		(-5.32)

```
EEEEE N   N DDDD        PPPP  H   H  AAA  N   N
E     NN  N D   D       P   P H   H A   A NN  N
EEE   N N N D   D       PPPP  HHHHH A   A N N N
E     N  NN D   D       P     H   H AAAAA N  NN
EEEEE N   N DDDD        P     H   H A   A N   N
```

XMIN = 0 XMAX = .43E+02 XSUM = .5656E+04



```
            -          =          +          )          1          Z
 0 .3192E+01 .7874E+01 .1000E+02 .1149E+02 .1319E+02 .1490E+02

Z          X          A          M          8          #          @          @
 .1639E+02 .1745E+02 .1851E+02 .2085E+02 .2320E+02 .2468E+02 .2635E+02

@          ■          ■          ■          ■          ■          ■          ■
 .2788E+02 .3107E+02 .3490E+02 .3703E+02 .3873E+02 .4043E+02 .4192E+02

■
 .4256E+02
```

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	.3	2.3	4.1	5.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	.6	3.7	6.3	6.7	6.7	6.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	2.7	6.3	6.7	6.7	6.7	6.7	6.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	.2	4.3	6.7	6.7	6.7	6.7	6.7	6.7	6.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	.2	4.8	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	4.3	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	2.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	.6	6.3	6.7	6.7	5.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	3.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	3.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	.3	6.3	6.7	6.7	6.7	6.7	6.2	5.3	6.2	6.7	6.7	6.7	6.7	6.3	.3	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	2.3	6.7	6.7	6.7	6.7	4.4	1.4	1.3	1.5	4.4	6.7	6.7	6.7	6.7	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	4.1	6.7	6.7	6.7	4.9	1.3	1.3	1.3	1.3	1.3	5.2	6.7	6.7	6.7	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	5.5	6.7	6.7	6.7	2.3	1.3	1.3	1.3	1.3	1.3	2.6	6.7	6.7	6.7	5.5	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	6.4	6.7	6.7	6.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	6.2	6.7	6.7	6.4	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	6.7	6.7	6.7	5.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	5.6	6.7	6.7	6.7	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	6.7	6.7	6.7	5.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	5.6	6.7	6.7	6.7	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	6.4	6.7	6.7	6.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	6.2	6.7	6.7	6.4	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	5.5	6.7	6.7	6.7	2.3	1.3	1.3	1.3	1.3	1.3	2.6	6.7	6.7	6.7	5.5	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	4.1	6.7	6.7	6.7	4.9	1.3	1.3	1.3	1.3	1.3	5.2	6.7	6.7	6.7	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	2.3	6.7	6.7	6.7	6.7	4.4	1.4	1.3	1.5	4.4	6.7	5.7	16.3	6.7	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	.3	6.3	6.7	6.7	6.7	6.7	6.2	5.3	6.2	6.7	6.7	13.1	41.5	6.3	.3	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	3.7	6.7	6.7	6.7	6.7	6.7	5.7	6.7	6.7	6.7	28.6	42.6	3.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	.6	6.3	6.7	6.7	6.7	6.7	6.7	6.7	6.7	5.7	33.6	42.6	.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	2.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	28.9	42.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	4.3	6.7	6.7	6.7	6.7	6.7	6.7	6.7	13.5	41.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	.2	4.8	6.7	6.7	6.7	6.7	6.7	6.7	6.7	18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	.2	4.3	6.7	6.7	6.7	6.7	6.7	6.7	6.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	2.7	6.3	6.7	6.7	6.7	6.7	6.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	.6	3.7	6.3	6.7	5.7	6.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	.3	2.3	4.1	5.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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6.4	6.7	6.7	6.4	5.5	4.1	2.3	.3	0	0	0	0	0	0	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.3	3.7	.6	0	0	0	0	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	5.3	2.7	0	0	0	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	4.3	.2	0	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	4.8	.2	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	4.3	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	2.7	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	5.7	6.7	6.7	6.7	6.7	6.3	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.2	5.3	6.2	6.7	6.7	6.7	6.7	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	4.4	1.5	1.3	1.4	4.4	6.7	6.7	6.7	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	5.2	1.3	1.3	1.3	1.3	1.3	4.9	6.7	6.7	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	2.6	1.3	1.3	1.3	1.3	1.3	2.3	6.7	6.7	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.2	1.3	1.3	1.3	1.3	1.3	1.3	1.3	6.0	6.7	0	0	0	0
6.7	6.7	6.7	6.7	6.7	5.6	1.3	1.3	1.3	1.3	1.3	1.3	1.3	5.3	6.7	0	0	0	0
6.7	6.7	6.7	6.7	6.7	5.6	1.3	1.3	1.3	1.3	1.3	1.3	1.3	5.3	6.7	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.2	1.3	1.3	1.3	1.3	1.3	1.3	1.3	6.0	6.7	0	0	0	0
6.7	6.7	5.7	6.7	6.7	6.7	2.6	1.3	1.3	1.3	1.3	1.3	2.3	6.7	6.7	0	0	0	0
7.4	13.1	13.1	7.4	6.7	6.7	5.2	1.3	1.3	1.3	1.3	1.3	4.9	6.7	6.7	0	0	0	0
39.0	42.6	42.6	39.0	16.3	6.7	6.7	4.4	1.5	1.3	1.4	4.4	6.7	6.7	6.7	0	0	0	0
42.6	42.6	42.6	42.6	41.5	13.1	6.7	6.7	6.2	5.3	6.2	6.7	6.7	6.7	6.7	0	0	0	0
42.6	42.6	42.6	42.6	42.6	28.6	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	0	0	0	0
42.6	42.6	42.6	42.6	42.6	33.6	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.3	0	0	0	0
42.6	42.6	42.6	42.6	42.6	28.9	6.7	6.7	6.7	6.7	6.7	5.7	6.7	6.7	2.7	0	0	0	0
42.6	42.6	42.6	42.6	41.8	13.5	6.7	6.7	6.7	6.7	6.7	6.7	6.7	4.3	0	0	0	0	0
39.3	42.6	42.6	39.3	18.5	6.7	6.7	6.7	6.7	6.7	6.7	6.7	4.8	.2	0	0	0	0	0
7.7	15.6	15.6	7.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	4.3	.2	0	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	5.3	2.7	0	0	0	0	0	0	0	0
5.7	6.7	6.7	6.7	6.7	6.7	6.7	6.3	3.7	.6	0	0	0	0	0	0	0	0	0
6.4	6.7	6.7	6.4	5.5	4.1	2.3	.3	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

```
BLANK COMMON REQUIRED     17474    ( 42102)

BLANK COMMON REQUIRED     17442    ( 42042)

BLANK COMMON REQUIRED      1058    (  2042)

BLANK COMMON REQUIRED       730    (  1332)

        THE FINAL RECONSTRUCTION IS RETURNED WITH DIMENSION NOIMU.
        NOIMU WILL NOW BE RETURNED TO ITS ORIGINAL VALUE.

BLANK COMMON REQUIRED       602    (  1132)

A TOTAL OF 114 (  1 THRU 114) OF THE 129 USER PROJECTION BINS WILL BE USED

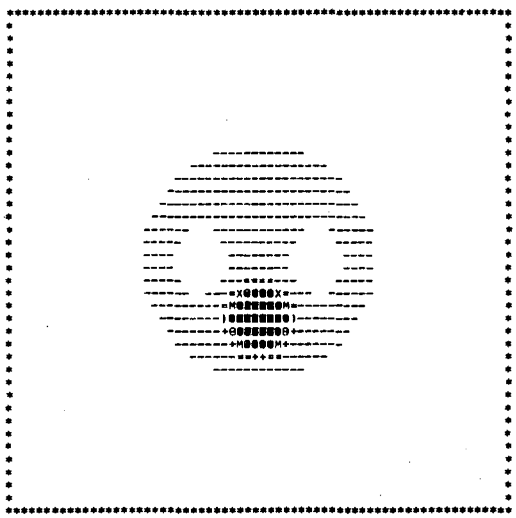
128 PROJECTION BINS WILL BE USED OF WHICH  14 HAVE BEEN ZEROED BY THE PROGRAM

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=  18010 FLOATING POINT WORDS.

          EEEEE N    N DDDD        FFFFF  III  L       BBBB  K   K
          E     NN   N D   D       F       I   L       B   B K  K
          EEE   N N  N D   D       FFF     I   L       BBBB  KKK
          E     N  NN  D   D       F       I   L       B   B K  K
          EEEEE N    N DDDD        F      III  LLLLL   BBBB  K   K

RECONSTRUCTION FOR FAN BEAM GEOMETRY WITH CURVED DETECTOR

XMIN =   -.88E+00     XMAX =    .43E+02     XSUM =    .4635E+04
```



```
             -           =           +           )           1           Z
-.8832E+00  .2377E+01  .7159E+01  .9333E+01  .1085E+02  .1259E+02  .1433E+02

Z           X           A           M           θ           ●           θ           Q
 .1585E+02  .1694E+02  .1803E+02  .2042E+02  .2281E+02  .2433E+02  .2607E+02

●           ●           ●           ●           ■           ■           ■           ■
 .2759E+02  .3085E+02  .3476E+02  .3694E+02  .3868E+02  .4042E+02  .4154E+02

■
 .4259E+02
```

-.5	.3	.2	-.6	-.9	-.3	.2	.1	-.5	-.8	-.5	.1	.1	-.4	-.7
-.9	-.2	.3	-.1	-.8	-.7	-.1	.2	-.1	-.6	-.7	-.3	.1	-.1	-.5
-.8	-.7	.1	.3	-.3	-.8	-.5	-.0	.1	-.2	-.6	-.6	-.1	.0	-.2
-.3	-.8	-.4	.2	.2	-.5	-.7	-.4	-.0	.0	-.3	-.6	-.4	-.1	-.1
.2	-.5	-.8	-.3	.2	-.1	-.5	-.5	-.2	-.0	-.2	-.4	-.4	-.3	-.0
.3	.1	-.5	-.6	-.1	.0	-.3	-.5	-.4	-.1	-.1	-.2	-.4	-.5	-.2
-.2	.2	-.1	-.5	-.4	-.0	-.0	-.4	-.5	-.3	-.2	-.2	-.2	-.4	-.5
-.7	-.1	.1	-.3	-.5	-.2	-.0	-.1	-.4	-.4	-.3	-.4	-.2	-.1	-.4
-.8	-.5	-.0	-.1	-.4	-.4	-.2	-.1	-.3	-.3	-.2	-.4	-.4	-.1	-.2
-.5	-.8	-.3	.0	-.1	-.3	-.3	-.1	-.2	-.4	-.2	-.1	-.5	-.3	-.0
-.2	-.7	-.8	-.3	-.1	-.2	-.3	-.1	-.0	-.4	-.4	-.1	-.3	-.5	-.2
.3	-.1	-.7	-.7	-.3	-.2	-.4	-.3	.0	-.1	-.4	-.3	-.1	-.4	-.4
.1	.3	-.1	-.6	-.5	-.2	-.2	-.4	-.3	.1	-.2	-.4	-.1	-.2	-.5
-.6	-.0	.2	-.2	-.6	-.5	-.1	-.2	-.5	-.2	.0	-.3	-.4	-.1	-.3
-.6	-.5	-.1	.1	-.2	-.6	-.4	-.1	-.3	-.4	-.1	-.1	-.4	-.2	-.1
-.2	-.5	-.5	-.1	.1	-.2	-.6	-.4	-.1	-.3	-.3	-.0	-.1	-.3	-.2
.0	-.2	-.5	-.5	-.1	.1	-.3	-.5	-.3	-.2	-.4	-.3	-.1	-.2	-.2
-.3	-.0	-.1	-.4	-.4	-.1	.0	-.3	-.4	-.2	-.2	-.3	-.3	-.2	-.2
-.6	-.4	-.2	-.2	-.4	-.4	-.2	-.1	-.3	-.4	-.2	-.2	-.3	-.3	-.3
-.2	-.5	-.4	-.2	-.2	-.3	-.4	-.2	-.2	-.4	-.3	-.1	-.1	-.2	-.3
.1	-.0	-.3	-.4	-.3	-.3	-.3	-.3	-.2	-.2	-.4	-.3	-.1	-.1	-.2
-.4	-.1	-.0	-.2	-.3	-.3	-.3	-.4	-.3	-.2	-.3	-.4	-.3	-.1	-.1
-.4	-.4	-.2	-.1	-.1	-.2	-.2	-.3	-.4	-.3	-.2	-.3	-.4	-.3	-.1
-.0	-.2	-.3	-.3	-.2	-.2	-.2	-.2	-.2	-.3	-.3	-.2	-.4	-.5	-.3
-.3	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.4	-.5
-.5	-.5	-.4	-.3	-.3	-.2	-.1	-.1	-.1	-.1	-.2	-.2	-.2	-.2	-.4
-.1	-.3	-.4	-.5	-.5	-.5	-.4	-.2	-.1	-.1	-.1	-.1	-.2	-.1	-.2
-.2	-.1	-.1	-.1	-.2	-.4	-.5	-.5	-.4	-.3	-.2	-.1	-.1	-.1	-.1
-.4	-.4	-.3	-.2	-.2	-.2	-.3	-.4	-.4	-.5	-.4	-.2	-.2	-.2	-.1
-.1	-.2	-.2	-.3	-.3	-.3	-.2	-.2	-.3	-.4	-.4	-.4	-.4	-.3	-.3
-.3	-.2	-.2	-.2	-.2	-.1	-.1	-.2	-.2	-.2	-.3	-.4	-.3	-.3	-.3
-.5	-.5	-.5	-.4	-.3	-.2	-.2	-.2	-.2	-.2	-.2	-.3	-.3	-.4	-.3
-.1	-.1	-.2	-.3	-.3	-.3	-.3	-.2	-.2	-.2	-.1	-.2	-.2	-.3	-.2
-.3	-.3	-.2	-.2	-.2	-.2	-.3	-.3	-.3	-.2	-.2	-.1	-.1	-.2	-.2
-.3	-.4	-.3	-.3	-.3	-.3	-.3	-.3	-.3	-.3	-.3	-.2	-.2	-.2	-.2
-.0	-.1	-.1	-.2	-.3	-.3	-.3	-.3	-.3	-.3	-.3	-.3	-.2	-.2	-.1
-.4	-.3	-.3	-.3	-.2	-.2	-.2	-.2	-.2	-.2	-.3	-.3	-.3	-.3	-.3
-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.3	-.4
-.0	-.1	-.1	-.1	-.2	-.2	-.2	-.2	-.2	-.1	-.1	-.2	-.2	-.2	-.2
-.5	-.5	-.4	-.3	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.3	-.2	-.2
-.1	-.1	-.2	-.2	-.3	-.3	-.3	-.3	-.3	-.3	-.2	-.2	-.2	-.2	-.3
-.2	-.2	-.2	-.3	-.3	-.3	-.2	-.2	-.2	-.3	-.3	-.3	-.4	-.4	-.3
-.6	-.4	-.4	-.3	-.2	-.2	-.3	-.3	-.3	-.4	-.4	-.4	-.3	-.2	-.2
.1	-.0	-.1	-.2	-.3	-.4	-.4	-.4	-.3	-.3	-.2	-.2	-.1	-.1	-.1
-.3	-.4	-.5	-.5	-.5	-.4	-.3	-.3	-.2	-.2	-.2	-.2	-.2	-.2	-.3
-.7	-.5	-.4	-.3	-.2	-.2	-.1	-.1	-.2	-.2	-.2	-.2	-.2	-.3	-.3
-.1	-.0	-.1	-.1	-.1	-.1	-.1	-.2	-.2	-.2	-.2	-.3	-.3	-.3	-.2
-.2	-.3	-.4	-.3	-.2	-.2	-.2	-.2	-.2	-.2	-.3	-.3	-.2	-.2	-.2
-.3	-.2	-.1	-.1	-.2	-.2	-.2	-.2	-.2	-.3	-.3	-.2	-.2	-.2	-.2
-.0	-.1	-.2	-.3	-.3	-.2	-.2	-.3	-.3	-.3	-.3	-.2	-.2	-.3	-.3
-.4	-.4	-.4	-.3	-.1	-.2	-.3	-.4	-.3	-.2	-.2	-.2	-.3	-.4	-.4
-.4	-.1	-.0	-.1	-.2	-.4	-.4	-.3	-.2	-.2	-.2	-.4	-.4	-.3	-.3
.1	.0	-.2	-.5	-.6	-.5	-.2	-.1	-.2	-.3	-.4	-.4	-.3	-.2	-.1
-.2	-.6	-.7	-.5	-.3	-.0	-.1	-.3	-.4	-.4	-.4	-.2	-.1	-.2	-.2
-.6	-.6	-.3	-.0	-.0	-.2	-.4	-.5	-.3	-.3	-.2	-.1	-.2	-.3	-.3
-.4	-.2	-.0	-.2	-.4	-.5	-.4	-.2	-.1	-.2	-.2	-.2	-.3	-.2	-.2
-.2	-.1	-.3	-.4	-.4	-.2	-.1	-.2	-.3	-.3	-.2	-.3	-.2	-.2	-.3
-.2	-.2	-.3	-.3	-.1	-.2	-.3	-.4	-.3	-.2	-.2	-.2	-.2	-.3	-.4
-.1	-.2	-.3	-.2	-.2	-.4	-.4	-.2	-.1	-.2	-.3	-.2	-.3	-.4	-.3
-.2	-.3	-.4	-.3	-.4	-.4	-.2	-.0	-.3	-.4	-.3	-.2	-.3	-.4	-.2
-.4	-.5	-.3	-.2	-.3	-.2	-.0	-.3	-.5	-.2	-.1	-.3	-.4	-.3	-.2
-.4	-.4	-.2	-.2	-.3	-.2	-.2	-.5	-.3	.0	-.3	-.6	-.3	-.1	-.3
-.4	-.3	-.2	-.3	-.3	-.2	-.3	-.3	-.1	-.2	-.6	-.4	.0	-.2	-.3
-.3	-.3	-.3	-.3	-.2	-.2	-.3	-.2	-.2	-.5	-.5	-.0	-.1	-.5	-.2

-.2	.1	-.1	-.6	-.4	.2	-.2	-.8	-.2	.2	-.5	-.7	.1	-.1	-.5
-.5	-.1	.1	-.4	-.6	.0	-.0	-.7	-.4	.2	-.4	-.7	.0	-.1	-.5
-.6	-.3	.1	-.2	-.6	-.1	.1	-.5	-.5	.2	-.4	-.7	-.0	-.1	-.4
-.4	-.5	-.0	-.0	-.6	-.3	.1	-.4	-.6	.1	-.3	-.7	-.0	-.1	-.4
-.1	-.5	-.3	.1	-.4	-.5	.1	-.2	-.6	.0	-.2	-.7	-.1	-.1	-.4
.0	-.3	-.5	-.0	-.2	-.5	-.0	-.1	-.6	-.1	-.1	-.7	-.1	-.1	-.4
-.1	-.1	-.4	-.2	-.1	-.4	-.2	-.1	-.5	-.2	-.1	-.6	-.2	-.1	-.4
-.4	-.0	-.2	-.4	-.1	-.3	-.3	-.1	-.4	-.3	-.2	-.5	-.2	-.2	-.4
-.5	-.2	-.1	-.3	-.3	-.2	-.3	-.1	-.3	-.3	-.2	-.4	-.2	-.2	-.4
-.3	-.5	-.1	-.1	-.3	-.3	-.2	-.1	-.3	-.3	-.2	-.4	-.3	-.2	-.3
-.1	-.5	-.4	-.1	-.2	-.3	-.2	-.1	-.3	-.3	-.2	-.4	-.3	-.3	-.3
-.0	-.2	-.5	-.3	-.0	-.3	-.3	-.1	-.2	-.3	-.2	-.3	-.3	-.3	-.3
-.3	.0	-.4	-.5	-.1	-.1	-.4	-.1	-.2	-.4	-.2	-.3	-.3	-.3	-.3
-.5	-.1	-.1	-.4	-.3	-.1	-.3	-.2	-.2	-.3	-.2	-.3	-.3	-.2	-.3
-.4	-.4	-.1	-.2	-.4	-.2	-.2	-.3	-.2	-.3	-.2	-.3	-.3	-.2	-.3
-.3	-.5	-.2	-.1	-.4	-.3	-.2	-.2	-.2	-.2	-.2	-.3	-.3	-.3	-.3
-.2	-.4	-.4	-.2	-.2	-.3	-.2	-.2	-.2	-.2	-.2	-.0	.3	.8	1.1
-.1	-.3	-.4	-.2	-.2	-.3	-.3	-.3	-.2	.1	.8	1.7	2.5	3.4	4.0
-.2	-.1	-.3	-.3	-.2	-.2	-.2	-.1	.7	1.9	3.3	4.5	5.1	5.6	6.0
-.3	-.2	-.2	-.3	-.3	-.2	.2	1.2	2.8	4.4	5.6	6.2	6.2	6.3	6.4
-.3	-.3	-.2	-.2	-.3	.1	1.5	3.4	5.1	6.0	6.4	6.5	6.3	6.3	6.4
-.2	-.3	-.3	-.2	.1	1.5	3.6	5.4	6.2	6.4	6.4	6.5	6.4	6.4	6.4
-.1	-.2	-.3	-.1	1.2	3.5	5.4	6.2	6.4	6.4	6.4	6.4	6.4	6.4	6.4
-.1	-.1	-.2	.6	2.8	5.1	6.2	6.4	6.4	6.4	6.4	6.4	6.3	6.5	6.4
-.3	-.1	.3	1.9	4.4	5.9	6.4	6.4	6.4	6.4	6.5	6.4	6.2	6.5	6.5
-.5	-.3	.9	3.4	5.6	6.3	6.3	6.3	6.2	6.1	6.2	6.3	6.2	6.5	6.6
-.4	-.2	1.6	4.5	6.2	6.5	6.2	5.6	5.0	4.7	5.0	5.5	6.0	6.5	6.6
-.2	.3	2.5	5.2	6.4	6.3	5.5	4.0	2.8	2.4	2.8	3.9	5.3	6.3	6.6
-.1	.9	3.5	5.7	6.4	5.8	4.2	2.4	1.5	1.2	1.4	2.3	4.2	5.8	6.5
-.2	1.2	4.1	6.1	6.4	5.3	3.2	1.5	1.1	1.1	1.1	1.5	3.1	5.2	6.3
-.3	1.3	4.4	6.1	6.1	4.8	2.7	1.4	1.1	1.1	1.1	1.2	2.4	4.7	6.3
-.1	1.6	4.6	6.1	5.8	4.2	2.2	1.3	1.2	1.2	1.2	1.2	2.0	4.4	6.3
-.0	1.7	4.7	6.2	5.9	4.1	1.9	1.0	1.1	1.1	1.2	1.3	2.1	4.4	6.2
-.2	1.4	4.4	6.3	6.2	4.6	2.3	1.1	1.0	1.0	1.0	1.2	2.4	4.7	6.2
-.1	1.2	4.1	6.1	6.4	5.3	3.1	1.5	1.1	1.1	1.1	1.4	3.0	5.0	6.5
-.0	1.0	3.6	5.8	6.4	5.9	4.3	2.4	1.4	1.3	1.7	2.6	4.2	6.5	10.2
-.3	.5	2.8	5.4	6.5	6.3	5.5	4.1	2.8	2.4	2.9	4.2	5.9	10.9	20.2
-.4	-.1	1.6	4.5	6.2	6.5	6.2	5.7	5.0	4.5	4.8	5.6	8.5	18.2	31.5
-.2	-.2	.6	3.0	5.3	6.2	6.3	6.3	6.2	6.1	6.1	6.4	11.2	24.6	37.8
-.2	-.2	.1	1.7	4.2	5.8	6.3	6.3	6.4	6.5	6.5	6.6	12.4	26.9	39.5
-.3	-.3	-.2	.8	3.0	5.2	6.2	6.4	6.3	6.3	6.3	6.5	11.3	24.7	37.8
-.3	-.2	-.2	.1	1.4	3.6	5.5	6.3	6.5	6.4	6.4	6.5	8.9	18.5	31.7
-.1	-.1	-.1	-.2	.1	1.5	3.6	5.4	6.3	6.5	6.6	6.7	7.1	11.3	20.8
-.2	-.2	-.2	-.2	-.2	.2	1.5	3.4	5.0	6.1	6.5	6.7	6.4	6.9	10.6
-.4	-.4	-.3	-.2	-.2	-.2	.2	1.2	2.8	4.5	5.7	6.2	6.3	6.0	6.6
-.3	-.3	-.2	-.2	-.3	-.2	-.2	-.0	.7	2.0	3.3	4.5	5.2	5.5	5.9
-.2	-.1	-.2	-.2	-.2	-.2	-.3	-.4	-.2	.1	.7	1.8	2.7	3.2	3.9
-.2	-.3	-.3	-.2	-.2	-.3	-.4	-.3	-.1	-.3	-.3	.1	.5	.6	1.0
-.3	-.4	-.3	-.3	-.3	-.4	-.3	-.1	-.1	-.3	-.3	-.1	-.2	-.5	-.3
-.3	-.3	-.2	-.2	-.3	-.3	-.2	-.1	-.2	-.4	-.2	-.1	-.3	-.6	-.3
-.3	-.2	-.2	-.3	-.3	-.2	-.1	-.2	-.3	-.3	-.1	-.2	-.4	-.5	-.2
-.2	-.1	-.2	-.3	-.3	-.2	-.1	-.2	-.3	-.2	-.2	-.3	-.3	-.3	-.3
-.2	-.2	-.3	-.3	-.2	-.1	-.1	-.2	-.3	-.3	-.3	-.2	-.2	-.4	-.4
-.2	-.3	-.3	-.3	-.2	-.1	-.2	-.3	-.3	-.3	-.3	-.1	-.2	-.4	-.4
-.3	-.3	-.3	-.2	-.2	-.1	-.2	-.3	-.4	-.4	-.2	-.0	-.2	-.5	-.4
-.3	-.3	-.3	-.2	-.1	-.1	-.3	-.4	-.4	-.3	-.1	-.0	-.3	-.5	-.4
-.4	-.3	-.2	-.1	-.1	-.2	-.4	-.4	-.3	-.1	-.1	-.1	-.3	-.4	-.3
-.3	-.2	-.2	-.1	-.1	-.3	-.5	-.4	-.1	-.1	-.2	-.2	-.3	-.4	-.3
-.2	-.2	-.1	-.1	-.2	-.5	-.4	-.2	-.1	-.1	-.2	-.3	-.3	-.3	-.3
-.2	-.2	-.1	-.2	-.4	-.5	-.3	-.1	-.2	-.2	-.2	-.3	-.3	-.2	-.3
-.2	-.1	-.2	-.3	-.4	-.4	-.2	-.1	-.2	-.2	-.2	-.3	-.3	-.2	-.3
-.2	-.1	-.3	-.4	-.4	-.3	-.2	-.1	-.2	-.3	-.2	-.3	-.3	-.2	-.3
-.1	-.3	-.4	-.3	-.4	-.2	-.1	-.2	-.3	-.3	-.2	-.3	-.2	-.2	-.3
-.1	-.5	-.4	-.2	-.3	-.2	-.1	-.3	-.3	-.3	-.3	-.3	-.1	-.2	-.4

-.3	-.2	-.2	-.3	-.5	-.1	.1	-.7	-.5	.2	-.2	-.8	-.2	.2	-.4
-.2	-.2	-.2	-.2	-.5	-.1	.0	-.7	-.4	.2	-.4	-.7	-.0	.0	-.6
-.2	-.2	-.2	-.2	-.4	-.1	-.0	-.7	-.4	.2	-.5	-.5	.1	-.1	-.6
-.2	-.3	-.3	-.2	-.4	-.1	-.0	-.7	-.3	.1	-.6	-.4	.1	-.3	-.6
-.2	-.2	-.2	-.2	-.4	-.1	-.1	-.7	-.2	.0	-.6	-.2	.1	-.5	-.4
-.2	-.2	-.2	-.2	-.4	-.1	-.1	-.7	-.1	-.1	-.6	-.1	-.0	-.5	-.2
-.2	-.2	-.2	-.2	-.4	-.1	-.2	-.6	-.1	-.2	-.5	-.1	-.2	-.4	-.1
-.2	-.2	-.2	-.2	-.4	-.2	-.2	-.5	-.2	-.3	-.4	-.1	-.3	-.3	-.1
-.2	-.2	-.2	-.2	-.4	-.2	-.2	-.4	-.2	-.3	-.3	-.1	-.3	-.2	-.3
-.2	-.2	-.2	-.2	-.3	-.2	-.3	-.4	-.2	-.3	-.3	-.1	-.2	-.3	-.3
-.1	-.2	-.2	-.1	-.3	-.3	-.3	-.4	-.2	-.3	-.3	-.1	-.2	-.3	-.2
-.1	-.2	-.2	-.1	-.3	-.3	-.3	-.3	-.2	-.3	-.2	-.1	-.3	-.3	-.0
-.2	-.2	-.2	-.2	-.3	-.3	-.3	-.3	-.2	-.4	-.2	-.1	-.4	-.1	-.1
-.2	-.2	-.2	-.2	-.3	-.2	-.2	-.3	-.2	-.4	-.2	-.2	-.3	-.1	-.3
-.2	-.2	-.2	-.2	-.3	-.2	-.3	-.3	-.2	-.3	-.2	-.3	-.2	-.2	-.4
-.1	.0	.0	-.1	-.3	-.3	-.3	-.3	-.2	-.2	-.2	-.2	-.2	-.3	-.4
1.5	1.7	1.7	1.5	1.1	.9	.3	-.0	-.2	-.2	-.2	-.2	-.2	-.3	-.2
4.5	4.8	4.8	4.5	4.0	3.4	2.5	1.7	.8	.1	-.2	-.3	-.3	-.3	-.2
6.2	6.3	6.3	6.2	6.0	5.6	5.1	4.5	3.3	1.9	.7	-.1	-.2	-.2	-.2
6.4	6.4	6.4	6.4	6.4	6.3	6.2	6.2	5.6	4.4	2.8	1.2	.2	-.2	-.3
6.4	6.5	6.5	6.4	6.4	6.3	6.3	6.5	6.4	6.0	5.1	3.4	1.5	.1	-.3
6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.5	6.4	6.4	6.2	5.4	3.6	1.5	.1
6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.2	5.4	3.5	1.2
6.4	6.5	6.5	6.4	6.4	6.5	6.3	6.4	6.4	6.4	6.4	6.4	6.2	5.1	2.8
6.4	6.5	6.5	6.4	6.5	6.5	6.2	6.4	6.5	6.4	6.4	6.4	6.4	5.5	4.4
6.4	6.5	6.5	6.4	6.6	6.5	6.2	6.3	6.2	5.1	6.2	6.3	6.3	6.3	5.6
6.5	6.4	6.4	6.5	6.6	6.5	6.0	5.5	5.0	4.7	5.0	5.6	6.2	6.5	6.2
6.5	6.3	6.3	6.5	6.6	6.3	5.3	3.5	2.8	2.4	2.8	4.0	5.5	6.3	6.4
6.3	6.4	6.4	6.5	6.5	5.8	4.2	2.3	1.4	1.2	1.5	2.4	4.2	5.8	6.4
6.5	6.5	6.5	6.5	6.3	5.2	3.1	1.5	1.1	1.1	1.1	1.5	3.2	5.3	6.4
6.5	6.5	6.5	6.5	6.3	4.7	2.4	1.2	1.1	1.1	1.1	1.4	2.7	4.8	6.1
6.5	6.4	6.4	6.5	6.3	4.4	2.0	1.2	1.2	1.2	1.2	1.3	2.2	4.2	5.8
6.5	6.5	6.5	6.5	6.2	4.4	2.1	1.3	1.2	1.1	1.1	1.0	1.9	4.1	5.9
6.4	6.4	6.4	6.4	6.2	4.7	2.4	1.2	1.0	1.0	1.0	1.1	2.3	4.6	6.2
7.3	8.0	8.0	7.3	6.5	5.0	3.0	1.4	1.1	1.1	1.1	1.5	3.1	5.3	6.4
14.8	18.0	18.0	14.8	10.2	6.5	4.2	2.6	1.7	1.3	1.4	2.4	4.3	5.9	6.4
29.1	33.7	33.7	29.1	20.2	10.9	5.9	4.2	2.9	2.4	2.8	4.1	5.5	6.3	6.5
39.5	41.8	41.8	39.5	31.5	18.2	8.5	5.6	4.8	4.5	5.0	5.7	6.2	6.5	6.2
42.4	42.4	42.4	42.4	37.8	24.6	11.2	6.4	6.1	6.1	6.2	6.3	6.3	6.2	5.3
42.6	42.3	42.3	42.6	39.5	26.9	12.4	6.6	6.5	6.5	6.4	6.3	6.3	5.8	4.2
42.3	42.4	42.4	42.3	37.6	24.7	11.3	6.5	6.3	6.3	6.3	6.4	6.2	5.2	3.0
39.6	41.6	41.6	39.6	31.7	18.5	8.9	6.5	6.4	6.4	6.5	6.3	5.5	3.6	1.4
29.9	34.2	34.2	29.9	20.8	11.3	7.1	6.7	6.6	6.5	6.3	5.4	3.6	1.5	.1
15.8	19.1	19.1	15.8	10.6	6.9	6.4	6.7	6.5	6.1	5.0	3.4	1.5	.2	-.2
7.6	8.4	8.4	7.6	6.6	6.0	6.3	6.2	5.7	4.5	2.8	1.2	.2	-.2	-.2
6.1	6.1	6.1	6.1	5.9	5.5	5.2	4.5	3.3	2.0	.7	-.0	-.2	-.2	-.3
4.5	4.7	4.7	4.5	3.9	3.2	2.7	1.8	.7	.1	-.2	-.4	-.3	-.2	-.2
1.5	1.8	1.8	1.5	1.0	.6	.5	.1	-.3	-.3	-.1	-.3	-.4	-.3	-.2
.0	.0	.0	.0	-.3	-.5	-.2	-.1	-.3	-.3	-.1	-.1	-.3	-.4	-.3
-.1	-.2	-.2	-.1	-.3	-.6	-.3	-.1	-.2	-.4	-.2	-.1	-.2	-.3	-.3
-.1	-.2	-.2	-.1	-.2	-.5	-.4	-.2	-.1	-.3	-.3	-.2	-.1	-.2	-.3
-.2	-.1	-.1	-.2	-.3	-.3	-.3	-.3	-.2	-.2	-.3	-.2	-.1	-.2	-.3
-.3	-.0	-.0	-.3	-.4	-.4	-.2	-.2	-.3	-.3	-.3	-.2	-.1	-.1	-.2
-.2	-.1	-.1	-.2	-.4	-.4	-.2	-.1	-.3	-.3	-.3	-.3	-.2	-.1	-.2
-.2	-.1	-.1	-.2	-.4	-.5	-.2	-.0	-.2	-.4	-.4	-.3	-.2	-.1	-.2
-.2	-.1	-.1	-.2	-.4	-.5	-.3	-.0	-.1	-.3	-.4	-.4	-.3	-.1	-.1
-.3	-.2	-.2	-.3	-.3	-.4	-.3	-.1	-.1	-.1	-.3	-.4	-.4	-.2	-.1
-.3	-.2	-.2	-.3	-.3	-.4	-.3	-.2	-.2	-.1	-.1	-.4	-.5	-.3	-.1
-.3	-.2	-.2	-.3	-.3	-.3	-.3	-.3	-.2	-.1	-.1	-.2	-.4	-.5	-.2
-.3	-.2	-.2	-.3	-.3	-.2	-.3	-.3	-.2	-.2	-.2	-.1	-.3	-.5	-.4
-.4	-.2	-.2	-.4	-.3	-.2	-.3	-.3	-.2	-.2	-.2	-.1	-.2	-.4	-.4
-.3	-.2	-.2	-.3	-.3	-.2	-.3	-.3	-.2	-.3	-.2	-.1	-.2	-.3	-.4
-.3	-.3	-.3	-.3	-.3	-.2	-.2	-.3	-.2	-.3	-.3	-.2	-.1	-.2	-.4
-.3	-.3	-.3	-.3	-.4	-.2	-.1	-.3	-.3	-.3	-.3	-.3	-.1	-.2	-.3

-.6	-.1	.1	-.2	-.7	-.4	.1	.1	-.5	-.8	-.5	.1	.2	-.3	-.9
-.4	.1	-.1	-.3	-.5	-.1	.1	-.3	-.7	-.6	-.1	.2	-.1	-.7	-.8
-.2	.1	-.3	-.6	-.2	.0	-.1	-.6	-.6	-.2	.1	-.0	-.5	-.8	-.3
-.0	-.0	-.5	-.4	-.1	-.1	-.4	-.6	-.3	.0	-.0	-.4	-.7	-.5	.2
.1	-.3	-.5	-.1	-.0	-.3	-.4	-.4	-.2	-.0	-.2	-.5	-.5	-.1	.2
-.0	-.5	-.3	.0	-.2	-.5	-.4	-.2	-.1	-.1	-.4	-.5	-.3	.0	-.1
-.2	-.4	-.1	-.1	-.5	-.4	-.2	-.2	-.2	-.3	-.5	-.4	-.0	-.0	-.4
-.4	-.2	-.0	-.4	-.4	-.1	-.2	-.4	-.3	-.4	-.4	-.1	-.0	-.2	-.5
-.3	-.1	-.2	-.5	-.2	-.1	-.4	-.4	-.2	-.3	-.3	-.1	-.2	-.4	-.4
-.1	-.1	-.3	-.3	-.0	-.3	-.5	-.1	-.2	-.4	-.2	-.1	-.3	-.3	-.1
-.1	-.4	-.5	-.1	-.2	-.5	-.3	-.1	-.4	-.4	-.0	-.1	-.3	-.2	-.1
-.3	-.5	-.2	-.0	-.4	-.4	-.1	-.3	-.4	-.1	.0	-.3	-.4	-.2	-.3
-.5	-.4	.0	-.3	-.5	-.2	-.1	-.4	-.2	.1	-.3	-.4	-.2	-.2	-.5
-.4	-.1	-.1	-.5	-.3	-.1	-.4	-.3	.0	-.2	-.5	-.2	-.1	-.5	-.6
-.2	-.1	-.4	-.4	-.1	-.2	-.4	-.1	-.1	-.4	-.3	-.1	-.4	-.6	-.2
-.1	-.2	-.5	-.3	-.2	-.3	-.1	-.0	-.3	-.3	-.1	-.4	-.6	-.2	.1
-.2	-.4	-.4	-.2	-.2	-.2	-.1	-.3	-.4	-.2	-.3	-.5	-.3	.1	-.1
-.2	-.4	-.3	-.1	-.2	-.2	-.3	-.3	-.2	-.2	-.4	-.3	.0	-.1	-.4
-.3	-.3	-.1	-.2	-.3	-.3	-.3	-.2	-.2	-.4	-.3	-.1	-.2	-.4	-.4
-.3	-.2	-.2	-.3	-.3	-.2	-.1	-.1	-.3	-.4	-.2	-.2	-.4	-.3	-.2
-.2	-.2	-.3	-.3	-.2	-.1	-.1	-.3	-.4	-.2	-.2	-.3	-.3	-.3	-.3
-.2	-.3	-.3	-.2	-.1	-.1	-.3	-.4	-.3	-.2	-.3	-.4	-.3	-.3	-.3
-.1	-.3	-.2	-.1	-.1	-.3	-.4	-.3	-.2	-.3	-.4	-.3	-.2	-.2	-.1
.6	-.2	-.1	-.1	-.3	-.5	-.4	-.2	-.3	-.3	-.2	-.2	-.2	-.2	-.2
1.9	.3	-.1	-.3	-.5	-.4	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2
3.4	.9	-.3	-.5	-.4	-.2	-.2	-.2	-.2	-.1	-.1	-.1	-.1	-.2	-.3
4.3	1.6	-.2	-.4	-.2	-.1	-.2	-.1	-.1	-.1	-.1	-.2	-.4	-.5	-.5
5.2	2.5	.3	-.2	-.1	-.1	-.1	-.1	-.2	-.3	-.4	-.5	-.5	-.4	-.2
5.7	3.5	.9	-.1	-.1	-.2	-.2	-.2	-.4	-.5	-.4	-.4	-.3	-.2	-.2
6.1	4.1	1.2	-.2	-.3	-.3	-.4	-.4	-.4	-.4	-.3	-.2	-.2	-.3	-.3
6.1	4.4	1.3	-.3	-.3	-.3	-.3	-.4	-.3	-.2	-.2	-.2	-.1	-.1	-.2
6.1	4.6	1.6	-.1	-.3	-.4	-.3	-.3	-.2	-.2	-.2	-.2	-.2	-.2	-.3
6.2	4.7	1.7	-.0	-.2	-.3	-.2	-.2	-.1	-.2	-.2	-.2	-.3	-.3	-.3
6.3	4.4	1.4	-.2	-.2	-.2	-.1	-.1	-.2	-.2	-.3	-.3	-.3	-.2	-.2
6.1	4.1	1.2	-.1	-.2	-.2	-.2	-.2	-.3	-.3	-.3	-.3	-.3	-.3	-.3
5.8	3.6	1.0	-.0	-.1	-.2	-.2	-.3	-.3	-.3	-.3	-.3	-.3	-.3	-.3
5.4	2.8	.5	-.3	-.3	-.3	-.3	-.3	-.3	-.2	-.2	-.2	-.2	-.2	-.2
4.5	1.6	-.1	-.4	-.4	-.3	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2
3.0	.6	-.2	-.2	-.2	-.2	-.2	-.2	-.1	-.1	-.2	-.2	-.2	-.2	-.2
1.7	.1	-.2	-.2	-.2	-.2	-.3	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2
.8	-.2	-.3	-.3	-.3	-.2	-.2	-.2	-.2	-.3	-.3	-.3	-.3	-.3	-.3
.1	-.2	-.2	-.3	-.3	-.4	-.4	-.3	-.3	-.3	-.2	-.2	-.2	-.3	-.3
-.2	-.1	-.1	-.1	-.2	-.2	-.3	-.4	-.4	-.4	-.3	-.3	-.3	-.2	-.2
-.2	-.2	-.2	-.2	-.1	-.1	-.1	-.2	-.2	-.3	-.3	-.4	-.4	-.4	-.3
-.2	-.3	-.4	-.4	-.3	-.2	-.2	-.2	-.2	-.2	-.2	-.3	-.3	-.4	-.5
-.2	-.2	-.3	-.3	-.3	-.3	-.2	-.2	-.2	-.2	-.2	-.1	-.1	-.2	-.2
-.2	-.2	-.1	-.2	-.2	-.3	-.3	-.3	-.2	-.2	-.2	-.2	-.1	-.1	-.1
-.2	-.3	-.3	-.2	-.2	-.2	-.2	-.3	-.3	-.2	-.2	-.2	-.2	-.2	-.2
-.3	-.3	-.4	-.3	-.2	-.2	-.2	-.2	-.3	-.3	-.2	-.2	-.2	-.2	-.2
-.2	-.2	-.3	-.3	-.3	-.3	-.2	-.2	-.3	-.3	-.3	-.3	-.2	-.2	-.3
-.3	-.2	-.2	-.3	-.4	-.4	-.3	-.2	-.2	-.2	-.3	-.4	-.3	-.2	-.1
-.3	-.2	-.1	-.2	-.3	-.3	-.4	-.4	-.2	-.2	-.2	-.3	-.4	-.4	-.2
-.3	-.3	-.2	-.2	-.1	-.2	-.3	-.4	-.4	-.3	-.2	-.1	-.2	-.5	-.6
-.3	-.3	-.3	-.2	-.2	-.2	-.1	-.2	-.4	-.4	-.4	-.3	-.1	-.0	-.3
-.2	-.3	-.3	-.3	-.3	-.3	-.2	-.1	-.2	-.3	-.3	-.5	-.4	-.2	-.0
-.2	-.3	-.3	-.3	-.2	-.2	-.3	-.2	-.2	-.2	-.1	-.2	-.4	-.5	-.4
-.1	-.2	-.3	-.4	-.3	-.2	-.2	-.3	-.2	-.3	-.3	-.2	-.1	-.2	-.4
-.1	-.2	-.2	-.3	-.4	-.3	-.2	-.2	-.2	-.2	-.3	-.4	-.3	-.2	-.1
-.1	-.1	-.2	-.2	-.3	-.4	-.3	-.2	-.3	-.2	-.1	-.2	-.4	-.4	-.2
-.2	-.1	-.2	-.2	-.2	-.4	-.3	-.2	-.3	-.4	-.3	-.0	-.2	-.4	-.4
-.3	-.2	-.1	-.2	-.2	-.3	-.4	-.3	-.1	-.2	-.5	-.3	-.0	-.2	-.3
-.4	-.3	-.1	-.2	-.3	-.1	-.3	-.6	-.3	.0	-.3	-.5	-.2	-.2	-.3
-.3	-.4	-.3	-.1	-.3	-.2	.0	-.4	-.6	-.2	-.1	-.3	-.3	-.2	-.3
-.2	-.4	-.5	-.1	-.2	-.5	-.1	-.0	-.5	-.5	-.2	-.2	-.3	-.2	-.2

-.6	.2	.3	-.5
-.1	.3	-.2	-.9
.3	.1	-.7	-.8
.2	-.4	-.8	-.3
-.3	-.8	-.5	.2
-.6	-.5	.1	.3
-.5	-.1	.2	-.2
-.3	.1	-.1	-.7
-.1	-.0	-.5	-.8
.0	-.3	-.8	-.5
-.3	-.8	-.7	-.2
-.7	-.7	-.1	.3
-.6	-.1	.3	.1
-.2	.2	-.0	-.6
.1	-.1	-.5	-.6
-.1	-.5	-.5	-.2
-.5	-.5	-.2	.0
-.4	-.1	-.0	-.3
-.2	-.2	-.4	-.6
-.2	-.4	-.5	-.2
-.4	-.3	-.0	.1
-.2	-.0	-.1	-.4
-.1	-.2	-.4	-.4
-.3	-.3	-.2	-.0
-.2	-.2	-.2	-.3
-.3	-.4	-.5	-.5
-.5	-.4	-.3	-.1
-.1	-.1	-.1	-.2
-.2	-.3	-.4	-.4
-.3	-.2	-.2	-.1
-.2	-.2	-.2	-.3
-.4	-.5	-.5	-.5
-.3	-.2	-.1	-.1
-.2	-.2	-.3	-.3
-.3	-.3	-.4	-.3
-.2	-.1	-.1	-.0
-.3	-.3	-.3	-.4
-.2	-.2	-.2	-.2
-.1	-.1	-.1	-.0
-.3	-.4	-.5	-.5
-.2	-.2	-.1	-.1
-.3	-.2	-.2	-.2
-.3	-.4	-.4	-.6
-.2	-.1	-.0	.1
-.5	-.5	-.4	-.3
-.3	-.4	-.5	-.7
-.1	-.1	-.0	-.1
-.3	-.4	-.3	-.2
-.1	-.1	-.2	-.3
-.3	-.2	-.1	-.0
-.3	-.4	-.4	-.4
-.1	-.0	-.1	-.4
-.5	-.2	.0	.1
-.5	-.7	-.6	-.2
-.0	-.3	-.6	-.6
-.2	-.0	-.2	-.4
-.4	-.3	-.1	-.2
-.3	-.3	-.2	-.2
-.2	-.3	-.2	-.1
-.3	-.4	-.3	-.2
-.2	-.3	-.5	-.4
-.2	-.2	-.4	-.4
-.3	-.2	-.3	-.4
-.3	-.3	-.3	-.3

```
 SSS  EEEEE TTTTT U   U PPPP
S     E       T   U   U P   P
 SSS  EEE     T   U   U PPPP
    S E       T   U   U P
 SSS  EEEEE   T    UUU  P
```

INTEGER PARAMETER ARRAY (IPAR)

I	IPAR(I)	DESCRIPTION
1	64	LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
2	1	RECONSTRUCT IN A SQUARE ARRAY
3	2	GEOMETRY FLAG FAN BEAM GEOMETRY (FLAT DETECTOR)
4	72	NUMBER OF PROJECTION ANGLES
5	5	MODE FOR PROJECTION ANGLE INPUT (SEE FOLLOWING LINES) ANGLES GENERATED BETWEEN ZERO AND 2*PI STARTING AT ZERO
6	129	NUMBER OF RAYS FOR EACH PROJECTION
7	1	TRANSMISSION DATA
8	18500	DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
9	1	NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10	0	EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11	5	PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES) PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
12	0	LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE

FLOATING POINT PARAMETER ARRAY (PAR)

I	PAR(I)	DESCRIPTION
1	1.330	PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION
2	50.500	LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
3	125.000	DISTANCE FROM SOURCE TO CENTER OF ROTATION FOR FAN BEAM IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION

BLANK COMMON REQUIRED 72 (110)

BLANK COMMON REQUIRED 144 (220)

BLANK COMMON REQUIRED 216 (330)

BLANK COMMON REQUIRED 474 (732)

BLANK COMMON REQUIRED 602 (1132)

A TOTAL OF 120 (1 THRU 120) OF THE 129 USER PROJECTION BINS WILL BE USED

140 PROJECTION BINS WILL BE USED OF WHICH 20 HAVE BEEN ZEROED BY THE PROGRAM

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 18010 FLOATING POINT WORDS.

```
EEEEE N   N DDDD        SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D      S     E       T   U   U P   P
EEE   N N N D   D       SSS  EEE     T   U   U PPPP
E     N  NN D   D          S E       T   U   U P
EEEEE N   N DDDD        SSS  EEEEE   T    UUU  P
```

```
FFFFF  III  L      BBBB  K   K
F       I   L      B   B K  K
FFF     I   L      BBBB  KKK
F       I   L      B   B K  K
F      III  LLLLL  BBBB  K   K
```

PARAMETERS FOR SUBROUTINE FILBK

DESCRIPTION

```
ORDERX -    0    FILTER PARAMETER USED ONLY BY THE FILTER RUTER
FREQX  -  .500   FREQUENCY PARAMETER FOR THE FILTER
```

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	UNIFORM SQUARE	NO	YES
FIL	FILTER	N/A	NO	N/A

FILTERED BACK-PROJECTION RECONSTRUCTIONS MUST BE EXECUTED IN AN ARRAY WITH DIMENSIONS AT LEAST TWICE AS LARGE AS THE FINAL IMAGE. THUS, THE EFFECTIVE SIZE OF THE RECONSTRUCTION ARRAY WILL NOW BE INCREASED.

FOR FAN BEAM RECONSTRUCTIONS THE FAN SOURCE MUST BE OUTSIDE THIS LARGE ARRAY.

BLANK COMMON REQUIRED   730   (1332)

A TOTAL OF 129 (1 THRU 129) OF THE 129 USER PROJECTION BINS WILL BE USED

896 PROJECTION BINS WILL BE USED OF WHICH 767 HAVE BEEN ZEROED BY THE PROGRAM

BLANK COMMON REQUIRED   17114   (41332)

BLANK COMMON REQUIRED   18010   (43132)

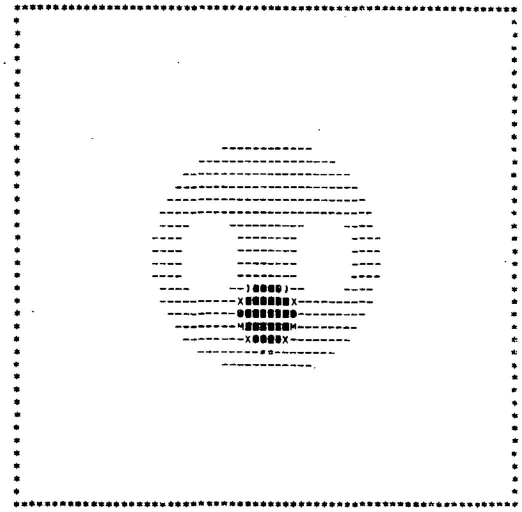
```
PPPP  H   H  AAA  N   N
P   P H   H A   A NN  N
PPPP  HHHHH A   A N N N
P     H   H AAAAA N  NN
P     H   H A   A N   N
```

PHANTOM GENERATED
ARRAY SIZE   64 X 64   INTEGRATION FACTOR = 10   SCALING FACTOR =   .752
NUMBER OF ELIPSES AND/OR RECTANGLES =   4
THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
X,Y - CENTER
A,B - LENGTH OF AXIS OR SIDE A AND B
PHI - ANGLE OF AXIS OR SIDE A
DENS - INTENSITY
THE PARENTHESIS INDICATES THE SCALED VALUE

ITYPE	X	Y	A	B	PHI	DENS
1 - ELLIPSE	0 ,	0	40.00 ,	40.00	0	5.00
	(0),(	0)(	30.08),(	30.08)		(6.65)
1 - ELLIPSE	0 ,	-10.00	10.00 ,	10.00	0	27.00
	(0),(	-7.52)(	7.52),(	7.52)		(35.91)
1 - ELLIPSE	10.00 ,	0	14.00 ,	10.00	1.57	-4.00
	(7.52),(	0)(	10.53),(	7.52)		(-5.32)
1 - ELLIPSE	-10.00 ,	0	14.00 ,	10.00	1.57	-4.00
	(-7.52),(	0)(	10.53),(	7.52)		(-5.32)

```
EEEEE N   N DDDD        PPPP  H   H  AAA  N   N
E     NN  N D   D       P   P H   H A   A NN  N
EEE   N N N D   D       PPPP  HHHHH A   A N N N
E     N  NN D   D       P     H   H AAAAA N  NN
EEEEE N   N DDDD        P     H   H A   A N   N
```

XMIN =   0   XMAX =   .43E+02   XSUM =   .565cE+04



```
                      -             *             +             )             1             Z
       0   .3192E+01   .7874E+01   .1000E+02   .1149E+02   .1319E+02   .1490E+02
Z           X           A           M           @           #           $           &
 .1639E+02   .1745E+02   .1851E+02   .2085E+02   .2320E+02   .2468E+02   .2639E+02
@           ■           ■           ■           ■           ■           ■           ■
 .2788E+02   .3107E+02   .3490E+02   .3703E+02   .3873E+02   .4043E+02   .4192E+02
■
 .4256E+02
```

```
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0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
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0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
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0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
```

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	.3	2.3	4.1	5.5
0	0	0	0	0	0	0	0	0	.6	3.7	6.3	6.7	6.7	6.7
0	0	0	0	0	0	0	0	2.7	6.3	6.7	6.7	6.7	6.7	6.7
0	0	0	0	0	0	.2	4.3	6.7	6.7	6.7	6.7	6.7	6.7	6.7
0	0	0	0	0	.2	4.8	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
0	0	0	0	0	4.3	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
0	0	0	0	2.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
0	0	0	.6	6.3	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
0	0	0	3.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
0	0	.3	6.3	6.7	6.7	6.7	6.7	6.2	5.3	6.2	6.7	6.7	6.7	6.7
0	0	2.3	6.7	6.7	6.7	6.7	4.4	1.4	1.3	1.5	4.4	6.7	6.7	6.7
0	0	4.1	6.7	6.7	6.7	4.9	1.3	1.3	1.3	1.3	1.3	5.2	6.7	6.7
0	0	5.5	6.7	6.7	6.7	2.3	1.3	1.3	1.3	1.3	1.3	2.6	6.7	6.7
0	0	6.4	6.7	6.7	6.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	6.2	6.7
0	0	6.7	6.7	6.7	5.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	5.6	6.7
0	0	6.7	6.7	6.7	5.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	5.6	6.7
0	0	6.4	6.7	6.7	6.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3	6.2	6.7
0	0	5.5	6.7	6.7	6.7	2.3	1.3	1.3	1.3	1.3	1.3	2.6	6.7	6.7
0	0	4.1	6.7	6.7	6.7	4.9	1.3	1.3	1.3	1.3	1.3	5.2	6.7	6.7
0	0	2.3	6.7	6.7	6.7	6.7	4.4	1.4	1.3	1.5	4.4	6.7	6.7	16.3
0	0	.3	6.3	6.7	6.7	6.7	6.7	6.2	5.3	6.2	6.7	6.7	13.1	41.5
0	0	0	3.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	28.6	42.6
0	0	0	.6	6.3	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	33.6	42.6
0	0	0	0	2.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	28.9	42.6
0	0	0	0	0	4.3	6.7	6.7	6.7	6.7	6.7	6.7	6.7	13.5	41.8
0	0	0	0	0	.2	4.8	6.7	6.7	6.7	6.7	6.7	6.7	6.7	18.5
0	0	0	0	0	0	.2	4.3	6.7	6.7	6.7	6.7	6.7	6.7	6.7
0	0	0	0	0	0	0	0	2.7	6.3	6.7	6.7	6.7	6.7	6.7
0	0	0	0	0	0	0	0	0	.6	3.7	6.3	6.7	6.7	6.7
0	0	0	0	0	0	0	0	0	0	0	.3	2.3	4.1	5.5
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.3	.3	0	0	0	0	0	0	0	0	0	0	0	0	0
6.7	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0
6.7	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0
6.7	5.5	0	0	0	0	0	0	0	0	0	0	0	0	0
6.7	6.4	0	0	0	0	0	0	0	0	0	0	0	0	0
6.7	6.7	0	0	0	0	0	0	0	0	0	0	0	0	0
6.7	6.7	0	0	0	0	0	0	0	0	0	0	0	0	0
6.7	6.4	0	0	0	0	0	0	0	0	0	0	0	0	0
6.7	5.5	0	0	0	0	0	0	0	0	0	0	0	0	0
6.7	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0
6.7	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0
6.3	.3	0	0	0	0	0	0	0	0	0	0	0	0	0
3.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.4	6.7	6.7	6.4	5.5	4.1	2.3	.3	0	0	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.3	3.7	.6	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.3	2.7	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	4.3	.2	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	4.8	.2	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	4.3	0
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6.7	6.7	6.7	6.7	6.7	6.7	6.7	4.4	1.5	1.3	1.4	4.4	6.7	6.7	6.7
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6.7	6.7	6.7	6.7	6.7	6.7	2.6	1.3	1.3	1.3	1.3	1.3	2.3	6.7	6.7
6.7	6.7	6.7	6.7	6.7	6.2	1.3	1.3	1.3	1.3	1.3	1.3	1.3	6.0	6.7
6.7	6.7	6.7	6.7	6.7	5.6	1.3	1.3	1.3	1.3	1.3	1.3	1.3	5.3	6.7
6.7	6.7	6.7	6.7	6.7	5.6	1.3	1.3	1.3	1.3	1.3	1.3	1.3	5.3	6.7
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6.7	6.7	6.7	6.7	6.7	6.7	2.6	1.3	1.3	1.3	1.3	1.3	2.3	6.7	6.7
7.4	13.1	13.1	7.4	6.7	6.7	5.2	1.3	1.3	1.3	1.3	1.3	4.9	6.7	6.7
39.0	42.6	42.6	39.0	16.3	6.7	6.7	4.4	1.5	1.3	1.4	4.4	6.7	6.7	6.7
42.6	42.6	42.6	42.6	41.5	13.1	6.7	6.7	6.2	5.3	6.2	6.7	6.7	6.7	6.7
42.6	42.6	42.6	42.6	42.6	28.6	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
42.6	42.6	42.6	42.6	42.6	33.6	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.3
42.6	42.6	42.6	42.6	42.6	28.9	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	2.7
42.6	42.6	42.6	42.6	41.8	13.5	6.7	6.7	6.7	6.7	6.7	6.7	6.7	4.3	0
39.3	42.6	42.6	39.3	18.5	6.7	6.7	6.7	6.7	6.7	6.7	6.7	4.8	.2	0
7.7	15.6	15.6	7.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	4.3	.2	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.3	2.7	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.3	3.7	.6	0	0	0	0	0
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```
BLANK COMMON REQUIRED     18042     ( 43172)

BLANK COMMON REQUIRED     18010     ( 43132)

BLANK COMMON REQUIRED      1626     (  3132)

BLANK COMMON REQUIRED       730     (  1332)

        THE FINAL RECONSTRUCTION IS RETURNED WITH DIMENSION NDIMU.
        NDIMU WILL NOW BE RETURNED TO ITS ORIGINAL VALUE.

BLANK COMMON REQUIRED       602     (  1132)

A TOTAL OF 120 (   1 THRU 120) OF THE 129 USER PROJECTION BINS WILL BE USED

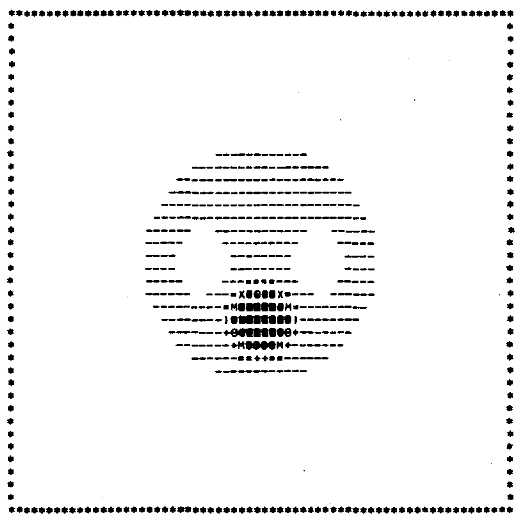
140 PROJECTION BINS WILL BE USED OF WHICH   20 HAVE BEEN ZEROED BY THE PROGRAM

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=  18042 FLOATING POINT WORDS.

            EEEEE N    N DDDD        FFFFF  III  L       BBBB  K   K
            E     NN   N D   D       F       I   L       B   B K  K
            EEE   N N  N D   D       FFF     I   L       BBBB  KKK
            E     N  NN  D   D       F       I   L       B   B K  K
            EEEEE N    N DDDD        F      III  LLLLL   BBBB  K   K

RECONSTRUCTION FOR FAN BEAM GEOMETRY WITH FLAT DETECTOR

XMIN =   -.88E+00     XMAX =     .43E+02     XSUM =    .4643E+04
```



```
                          -            =            +            )            1            Z
-.8809E+00  .2383E+01  .7171E+01  .9347E+01  .1087E+02  .1261E+02  .1435E+02

Z           X          A          M          B          ■          ■          ■
 .1588E+02  .1696E+02  .1805E+02  .2045E+02  .2284E+02  .2436E+02  .2610E+02

■           ■          ■          ■          ■          ■          ■          ■
 .2763E+02  .3089E+02  .3481E+02  .3698E+02  .3873E+02  .4047E+02  .4199E+02

■
 .4264E+02
```

-.6	.2	.2	-.5	-.9	-.3	.2	.1	-.5	-.8	-.5	.1	.1	-.4	-.7
-.9	-.2	.3	-.1	-.8	-.7	-.1	.2	-.1	-.6	-.7	-.3	.2	-.1	-.5
-.8	-.7	.1	.3	-.3	-.8	-.5	-.0	.1	-.2	-.6	-.6	-.1	.0	-.2
-.3	-.8	-.4	.2	.2	-.5	-.7	-.4	-.0	.0	-.3	-.6	-.4	-.1	-.1
.2	-.5	-.8	-.3	.2	-.1	-.5	-.6	-.2	-.0	-.1	-.4	-.5	-.3	-.0
.3	.1	-.6	-.6	-.1	.1	-.2	-.5	-.4	-.1	-.1	-.2	-.4	-.5	-.2
-.2	.2	-.1	-.5	-.4	-.0	-.0	-.4	-.5	-.3	-.2	-.2	-.2	-.4	-.5
-.7	-.1	.1	-.3	-.5	-.2	-.0	-.1	-.4	-.4	-.3	-.4	-.2	-.1	-.4
-.8	-.5	-.0	-.1	-.4	-.4	-.2	-.1	-.2	-.3	-.2	-.3	-.4	-.1	-.2
-.5	-.7	-.3	.0	-.1	-.3	-.3	-.1	-.2	-.4	-.2	-.1	-.5	-.3	-.0
-.2	-.7	-.7	-.3	-.1	-.2	-.3	-.1	-.0	-.4	-.4	-.1	-.3	-.5	-.2
.2	-.1	-.6	-.7	-.3	-.2	-.4	-.3	.0	-.1	-.4	-.3	-.1	-.4	-.4
.0	.3	-.1	-.5	-.5	-.2	-.2	-.5	-.3	.1	-.2	-.4	-.1	-.2	-.5
-.6	-.1	.1	-.2	-.5	-.4	-.1	-.2	-.5	-.2	.0	-.3	-.4	-.1	-.3
-.6	-.5	-.1	.1	-.2	-.6	-.4	-.1	-.3	-.4	-.1	-.1	-.4	-.3	-.1
-.1	-.5	-.5	-.1	.1	-.2	-.5	-.3	-.1	-.3	-.3	-.0	-.1	-.3	-.2
.0	-.2	-.5	-.5	-.1	.1	-.2	-.5	-.3	-.2	-.4	-.3	-.1	-.2	-.2
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-.6	-.4	-.1	-.1	-.4	-.4	-.2	-.1	-.3	-.3	-.2	-.2	-.3	-.3	-.3
-.2	-.5	-.4	-.2	-.2	-.3	-.4	-.2	-.2	-.3	-.3	-.2	-.1	-.2	-.3
.1	-.0	-.3	-.3	-.3	-.2	-.3	-.3	-.2	-.2	-.4	-.3	-.1	-.1	-.2
-.4	-.1	-.0	-.2	-.2	-.2	-.3	-.4	-.3	-.2	-.3	-.4	-.3	-.1	-.1
-.5	-.4	-.2	-.1	-.1	-.2	-.2	-.2	-.4	-.3	-.2	-.3	-.4	-.3	-.1
-.0	-.2	-.4	-.3	-.2	-.2	-.2	-.1	-.2	-.3	-.3	-.3	-.4	-.4	-.3
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-.1	-.3	-.4	-.5	-.5	-.5	-.4	-.2	-.1	-.1	-.1	-.1	-.2	-.2	-.2
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.1	-.0	-.1	-.2	-.2	-.4	-.4	-.4	-.3	-.3	-.3	-.2	-.1	-.1	-.1
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-.7	-.5	-.4	-.3	-.2	-.2	-.1	-.1	-.2	-.2	-.2	-.2	-.2	-.3	-.3
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-.2	-.3	-.4	-.3	-.2	-.2	-.3	-.2	-.2	-.2	-.3	-.3	-.2	-.2	-.2
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-.0	-.1	-.2	-.3	-.3	-.2	-.2	-.3	-.3	-.3	-.2	-.1	-.2	-.3	-.3
-.4	-.5	-.4	-.3	-.1	-.2	-.3	-.4	-.3	-.1	-.1	-.2	-.3	-.4	-.4
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-.3	.0	-.4	-.5	-.1	-.1	-.4	-.1	-.2	-.4	-.2	-.3	-.3	-.3	-.3
-.5	-.1	-.1	-.4	-.3	-.1	-.3	-.2	-.2	-.3	-.2	-.3	-.3	-.3	-.3
-.4	-.4	-.0	-.2	-.4	-.2	-.2	-.3	-.2	-.3	-.2	-.3	-.3	-.2	-.3
-.3	-.5	-.2	-.2	-.4	-.3	-.2	-.3	-.2	-.2	-.2	-.3	-.4	-.3	-.3
-.2	-.4	-.4	-.2	-.2	-.3	-.2	-.2	-.2	-.2	-.2	-.1	.2	.7	1.0
-.1	-.2	-.4	-.2	-.2	-.3	-.3	-.3	-.2	.1	.7	1.6	2.4	3.3	4.0
-.2	-.2	-.3	-.3	-.2	-.2	-.2	-.1	.6	1.8	3.2	4.5	5.2	5.7	6.1
-.3	-.2	-.2	-.3	-.3	-.3	.1	1.1	2.7	4.4	5.7	6.3	6.4	6.4	6.5
-.3	-.3	-.2	-.2	-.3	.1	1.4	3.4	5.1	6.1	6.5	6.6	6.4	6.4	6.4
-.2	-.3	-.3	-.2	.1	1.4	3.6	5.5	6.3	6.5	6.5	6.5	6.4	6.4	6.4
-.1	-.2	-.3	-.1	1.1	3.4	5.5	6.3	6.5	6.4	6.4	6.5	6.4	6.4	6.4
-.1	-.1	-.2	.5	2.7	5.2	6.4	6.5	6.5	6.5	6.5	6.4	6.3	6.5	6.4
-.3	-.1	.2	1.8	4.4	6.1	6.5	6.5	6.5	6.4	6.5	6.4	6.2	6.5	6.5
-.4	-.3	.8	3.3	5.7	6.4	6.4	6.4	6.3	6.1	6.2	6.2	6.2	6.5	6.5
-.3	-.2	1.5	4.5	6.4	6.6	6.3	5.7	5.0	4.7	5.0	5.5	6.0	6.5	6.6
-.2	.2	2.4	5.3	6.5	6.4	5.6	4.1	2.8	2.4	2.8	3.9	5.3	6.3	6.6
-.1	.8	3.4	5.8	6.5	5.9	4.2	2.4	1.5	1.2	1.4	2.3	4.1	5.8	6.5
-.2	1.1	4.1	6.2	6.5	5.4	3.2	1.5	1.1	1.1	1.1	1.5	3.1	5.2	6.3
-.3	1.2	4.4	6.3	6.2	4.9	2.7	1.3	1.1	1.1	1.1	1.2	2.3	4.6	6.2
-.2	1.5	4.6	6.2	5.9	4.3	2.2	1.3	1.2	1.2	1.2	1.1	2.0	4.3	6.2
-.1	1.6	4.7	6.3	6.0	4.2	1.9	1.0	1.1	1.1	1.2	1.2	2.1	4.4	6.2
-.2	1.2	4.4	6.4	6.4	4.7	2.3	1.1	1.0	1.0	1.0	1.2	2.4	4.7	6.2
-.2	1.1	4.0	6.2	6.5	5.4	3.2	1.5	1.1	1.1	1.1	1.4	3.0	5.0	6.4
-.1	.9	3.6	5.9	6.6	6.0	4.3	2.4	1.5	1.3	1.7	2.6	4.2	6.4	10.2
-.3	.3	2.7	5.5	6.6	6.5	5.6	4.1	2.9	2.4	2.9	4.2	5.9	10.9	20.2
-.4	-.2	1.5	4.5	6.4	6.6	6.3	5.7	5.0	4.5	4.9	5.6	8.5	18.2	31.5
-.1	-.2	.6	2.9	5.4	6.3	6.4	6.3	6.2	6.1	6.2	6.4	11.2	24.6	37.9
-.1	-.2	.0	1.6	4.3	6.0	6.4	6.4	6.4	6.5	6.5	6.7	12.4	27.0	39.5
-.3	-.4	-.2	.7	2.9	5.3	6.5	6.5	6.4	6.4	6.4	6.5	11.4	24.8	37.9
-.3	-.2	-.2	.0	1.2	3.5	5.6	6.5	6.6	6.5	6.5	6.6	9.0	18.6	31.9
-.1	-.1	-.2	-.3	-.0	1.3	3.6	5.5	6.4	6.6	6.7	6.8	7.1	11.3	20.9
-.2	-.2	-.2	-.3	-.3	.1	1.4	3.3	5.1	6.2	6.6	6.8	6.5	6.9	10.6
-.4	-.4	-.3	-.2	-.2	-.2	.1	1.1	2.7	4.5	5.8	6.4	6.4	6.1	6.6
-.3	-.3	-.2	-.2	-.3	-.2	-.2	-.0	.6	1.9	3.2	4.5	5.3	5.6	6.0
-.2	-.1	-.1	-.2	-.2	-.2	-.3	-.3	-.2	.1	.6	1.6	2.6	3.2	3.9
-.2	-.2	-.2	-.2	-.2	-.3	-.4	-.3	-.2	-.3	-.3	.0	.4	.5	.9
-.3	-.3	-.3	-.3	-.3	-.4	-.3	-.1	-.1	-.3	-.3	-.1	-.2	-.5	-.3
-.3	-.3	-.2	-.3	-.3	-.3	-.2	-.0	-.2	-.4	-.2	-.1	-.3	-.5	-.3
-.3	-.2	-.2	-.3	-.3	-.2	-.1	-.2	-.3	-.3	-.1	-.2	-.4	-.4	-.2
-.2	-.2	-.2	-.3	-.3	-.2	-.1	-.2	-.3	-.2	-.2	-.3	-.3	-.4	-.3
-.2	-.2	-.3	-.3	-.3	-.2	-.1	-.2	-.3	-.3	-.3	-.2	-.2	-.3	-.4
-.2	-.3	-.3	-.3	-.2	-.1	-.2	-.3	-.3	-.3	-.2	-.1	-.2	-.4	-.4
-.3	-.3	-.3	-.3	-.1	-.1	-.2	-.4	-.4	-.3	-.1	-.0	-.2	-.5	-.4
-.3	-.4	-.3	-.2	-.1	-.1	-.3	-.4	-.4	-.3	-.1	-.0	-.3	-.5	-.4
-.4	-.3	-.2	-.1	-.1	-.2	-.4	-.4	-.3	-.2	-.1	-.1	-.3	-.4	-.3
-.3	-.2	-.2	-.1	-.1	-.3	-.5	-.4	-.1	-.1	-.2	-.2	-.3	-.4	-.2
-.2	-.2	-.2	-.2	-.3	-.5	-.4	-.2	-.1	-.1	-.2	-.3	-.3	-.3	-.3
-.2	-.2	-.2	-.2	-.4	-.5	-.3	-.1	-.2	-.2	-.3	-.3	-.3	-.2	-.3
-.2	-.1	-.2	-.3	-.4	-.4	-.2	-.1	-.2	-.2	-.3	-.3	-.3	-.2	-.3
-.2	-.1	-.3	-.4	-.4	-.3	-.2	-.1	-.2	-.3	-.2	-.3	-.3	-.2	-.3
-.1	-.2	-.4	-.3	-.3	-.2	-.1	-.2	-.3	-.3	-.2	-.3	-.2	-.2	-.3
-.1	-.4	-.4	-.2	-.3	-.2	-.1	-.3	-.3	-.3	-.3	-.3	-.1	-.2	-.4

-.3	-.2	-.2	-.3	-.5	-.1	.1	-.7	-.5	.2	-.2	-.8	-.2	.2	-.4
-.3	-.2	-.2	-.3	-.5	-.1	.0	-.7	-.4	.2	-.4	-.7	-.0	.0	-.6
-.3	-.3	-.3	-.3	-.4	-.1	-.0	-.7	-.4	.2	-.5	-.5	.1	-.2	-.6
-.2	-.3	-.3	-.2	-.4	-.1	-.0	-.7	-.3	.1	-.6	-.4	.1	-.3	-.6
-.2	-.3	-.3	-.2	-.4	-.1	-.1	-.7	-.2	.0	-.6	-.2	.1	-.5	-.4
-.2	-.2	-.2	-.2	-.4	-.1	-.1	-.7	-.1	-.1	-.6	-.1	-.1	-.5	-.1
-.2	-.2	-.2	-.2	-.4	-.1	-.2	-.6	-.1	-.2	-.5	-.1	-.2	-.4	-.1
-.2	-.2	-.2	-.2	-.4	-.2	-.2	-.5	-.2	-.3	-.4	-.1	-.3	-.3	-.1
-.2	-.2	-.2	-.2	-.4	-.2	-.2	-.4	-.2	-.3	-.3	-.1	-.3	-.2	-.3
-.2	-.2	-.2	-.2	-.3	-.3	-.3	-.4	-.2	-.3	-.3	-.2	-.2	-.3	-.3
-.1	-.2	-.2	-.1	-.3	-.3	-.3	-.4	-.2	-.3	-.3	-.1	-.2	-.4	-.2
-.1	-.2	-.2	-.1	-.3	-.3	-.3	-.3	-.2	-.3	-.3	-.1	-.3	-.3	-.1
-.2	-.2	-.2	-.2	-.3	-.3	-.3	-.3	-.2	-.4	-.2	-.1	-.4	-.1	-.1
-.2	-.2	-.2	-.2	-.3	-.3	-.3	-.3	-.2	-.3	-.2	-.2	-.3	-.1	-.3
-.2	-.2	-.2	-.2	-.3	-.2	-.3	-.3	-.2	-.3	-.2	-.3	-.2	-.2	-.4
-.1	-.1	-.1	-.1	-.3	-.3	-.4	-.3	-.2	-.2	-.2	-.2	-.2	-.3	-.4
1.4	1.6	1.6	1.4	1.0	.7	.2	-.1	-.2	-.2	-.2	-.2	-.2	-.3	-.2
4.5	4.8	4.8	4.5	4.0	3.3	2.4	1.6	.7	.1	-.2	-.3	-.3	-.3	-.2
6.3	6.5	6.5	6.3	6.1	5.7	5.2	4.5	3.2	1.8	.6	-.1	-.2	-.2	-.2
6.5	6.5	6.5	6.5	6.5	6.4	6.4	6.3	5.7	4.4	2.7	1.1	.1	-.3	-.3
6.5	6.5	6.5	6.5	6.4	6.4	6.4	6.6	6.5	6.1	5.1	3.4	1.4	.1	-.3
6.5	6.5	6.5	6.5	6.4	6.4	6.4	6.5	6.5	6.5	6.3	5.5	3.6	1.4	.1
6.5	6.4	6.4	6.5	6.4	6.4	6.4	6.5	6.4	6.4	6.5	6.3	5.5	3.4	1.1
6.4	6.5	6.5	6.4	6.4	6.5	6.3	6.4	6.5	6.5	6.5	6.5	6.4	5.2	2.7
6.4	6.5	6.5	6.4	6.5	6.5	6.2	6.4	6.5	6.4	6.5	6.5	6.5	6.1	4.4
6.4	6.4	6.4	6.4	6.5	6.5	6.2	6.2	6.2	6.1	6.3	6.4	6.4	6.4	5.7
6.4	6.4	6.4	6.4	6.6	6.5	6.0	5.5	5.0	4.7	5.0	5.7	6.3	6.6	6.4
6.5	6.3	6.3	6.5	6.6	6.3	5.3	3.9	2.8	2.4	2.8	4.1	5.6	6.4	6.5
6.5	6.4	6.4	6.5	6.5	5.8	4.1	2.3	1.4	1.2	1.5	2.4	4.2	5.9	6.5
6.5	6.5	6.5	6.5	6.3	5.2	3.1	1.5	1.1	1.1	1.1	1.5	3.2	5.4	6.5
6.5	6.4	6.4	6.5	6.2	4.6	2.3	1.2	1.1	1.1	1.1	1.3	2.7	4.9	6.2
6.5	6.4	6.4	6.5	6.2	4.3	2.0	1.1	1.2	1.2	1.2	1.3	2.2	4.3	5.9
6.4	6.4	6.4	6.4	6.2	4.4	2.1	1.2	1.2	1.1	1.1	1.0	1.9	4.2	6.0
6.4	6.3	6.3	6.4	6.2	4.7	2.4	1.2	1.0	1.0	1.0	1.1	2.3	4.7	6.4
7.3	7.9	7.9	7.3	6.4	5.0	3.0	1.4	1.1	1.1	1.1	1.5	3.2	5.4	6.5
14.7	17.9	17.9	14.7	10.2	6.4	4.2	2.6	1.7	1.3	1.5	2.4	4.3	6.0	6.6
29.1	33.7	33.7	29.1	20.2	10.9	5.9	4.2	2.9	2.4	2.9	4.1	5.6	6.5	6.6
39.5	41.8	41.8	39.5	31.5	18.2	8.5	5.6	4.9	4.5	5.0	5.7	6.3	6.6	6.4
42.4	42.4	42.4	42.4	37.9	24.6	11.2	6.4	6.2	6.1	6.2	6.3	6.4	6.3	5.4
42.6	42.4	42.4	42.6	39.5	27.0	12.4	6.7	6.5	6.5	6.4	6.4	6.4	6.0	4.3
42.4	42.5	42.5	42.4	37.9	24.8	11.4	6.5	6.4	6.4	6.4	6.5	6.5	5.3	2.9
39.8	41.8	41.8	39.8	31.9	18.6	9.0	6.6	6.5	6.5	6.6	6.5	5.6	3.5	1.2
30.0	34.4	34.4	30.0	20.9	11.3	7.1	6.8	6.7	6.6	6.4	5.5	3.6	1.3	-.0
15.8	19.1	19.1	15.8	10.6	6.9	6.5	6.8	6.6	6.2	5.1	3.3	1.4	.1	-.3
7.7	8.4	8.4	7.7	6.6	6.1	6.4	6.4	5.8	4.5	2.7	1.1	.1	-.2	-.2
6.3	6.3	6.3	6.3	6.0	5.6	5.3	4.5	3.2	1.9	.6	-.0	-.2	-.2	-.3
4.5	4.8	4.8	4.5	3.9	3.2	2.6	1.6	.6	.1	-.2	-.3	-.3	-.2	-.2
1.4	1.6	1.6	1.4	.9	.5	.4	.0	-.3	-.3	-.2	-.3	-.4	-.3	-.2
-.0	-.1	-.1	-.0	-.3	-.5	-.2	-.1	-.3	-.3	-.1	-.1	-.3	-.4	-.3
-.1	-.2	-.2	-.1	-.3	-.5	-.3	-.1	-.2	-.4	-.2	-.0	-.2	-.3	-.3
-.2	-.2	-.2	-.2	-.2	-.4	-.4	-.2	-.1	-.3	-.3	-.2	-.1	-.2	-.3
-.3	-.1	-.1	-.3	-.3	-.4	-.3	-.3	-.2	-.2	-.3	-.2	-.1	-.2	-.3
-.3	-.0	-.0	-.3	-.4	-.4	-.2	-.2	-.3	-.3	-.3	-.2	-.1	-.2	-.3
-.2	-.1	-.1	-.2	-.4	-.4	-.2	-.1	-.2	-.3	-.3	-.3	-.2	-.1	-.2
-.2	-.1	-.1	-.2	-.4	-.5	-.2	-.0	-.1	-.3	-.4	-.4	-.2	-.1	-.1
-.2	-.1	-.1	-.2	-.4	-.5	-.3	-.0	-.1	-.3	-.4	-.4	-.3	-.1	-.1
-.3	-.2	-.2	-.3	-.3	-.4	-.3	-.1	-.1	-.2	-.3	-.4	-.4	-.2	-.1
-.3	-.2	-.2	-.3	-.2	-.4	-.3	-.2	-.2	-.1	-.1	-.4	-.5	-.3	-.1
-.3	-.2	-.2	-.3	-.3	-.3	-.3	-.3	-.2	-.1	-.1	-.2	-.4	-.5	-.3
-.4	-.2	-.2	-.4	-.3	-.2	-.3	-.3	-.2	-.2	-.2	-.1	-.3	-.5	-.4
-.4	-.2	-.2	-.4	-.3	-.2	-.3	-.3	-.3	-.2	-.2	-.1	-.2	-.4	-.4
-.3	-.2	-.2	-.3	-.3	-.2	-.3	-.3	-.2	-.3	-.2	-.1	-.2	-.3	-.4
-.3	-.3	-.3	-.3	-.3	-.2	-.2	-.3	-.2	-.3	-.3	-.2	-.1	-.2	-.3
-.3	-.3	-.3	-.3	-.4	-.2	-.1	-.3	-.3	-.3	-.3	-.3	-.1	-.2	-.3

-.6	-.2	.1	-.2	-.7	-.4	.1	.1	-.5	-.8	-.5	.1	.2	-.3	-.9
-.4	.1	-.1	-.5	-.5	-.1	.2	-.3	-.7	-.6	-.1	.2	-.1	-.7	-.8
-.2	.1	-.3	-.6	-.2	.0	-.1	-.6	-.6	-.2	.1	-.0	-.5	-.8	-.3
-.0	-.0	-.5	-.4	-.1	-.1	-.4	-.6	-.3	.0	-.0	-.4	-.7	-.5	.2
.1	-.3	-.5	-.1	-.0	-.3	-.5	-.4	-.1	-.0	-.2	-.6	-.5	-.1	.2
-.0	-.5	-.3	.0	-.2	-.5	-.4	-.2	-.1	-.1	-.4	-.5	-.2	.1	-.1
-.2	-.4	-.1	-.1	-.5	-.4	-.2	-.2	-.2	-.3	-.5	-.4	-.0	-.0	-.4
-.4	-.2	-.0	-.4	-.4	-.1	-.2	-.4	-.3	-.4	-.4	-.1	-.0	-.2	-.5
-.3	-.1	-.2	-.5	-.2	-.1	-.4	-.3	-.2	-.3	-.2	-.1	-.2	-.4	-.4
-.1	-.1	-.5	-.3	-.0	-.3	-.5	-.1	-.2	-.4	-.2	-.1	-.3	-.3	-.1
-.0	-.3	-.4	-.1	-.2	-.5	-.3	-.1	-.4	-.4	-.0	-.1	-.3	-.2	-.1
-.2	-.5	-.2	-.0	-.4	-.4	-.1	-.3	-.4	-.1	.0	-.3	-.4	-.2	-.3
-.5	-.4	.0	-.3	-.5	-.2	-.1	-.4	-.2	.1	-.3	-.5	-.2	-.2	-.5
-.4	-.1	-.1	-.5	-.3	-.1	-.4	-.3	.0	-.2	-.5	-.2	-.1	-.4	-.5
-.2	-.0	-.4	-.4	-.1	-.3	-.4	-.1	-.1	-.4	-.3	-.1	-.4	-.6	-.2
-.2	-.2	-.5	-.3	-.2	-.3	-.1	-.0	-.3	-.3	-.1	-.3	-.5	-.2	.1
-.2	-.4	-.4	-.2	-.2	-.2	-.1	-.3	-.4	-.2	-.3	-.5	-.2	.1	-.1
-.2	-.4	-.2	-.1	-.2	-.2	-.3	-.3	-.2	-.2	-.4	-.3	.0	-.2	-.5
-.3	-.3	-.2	-.2	-.3	-.3	-.3	-.2	-.2	-.3	-.3	-.1	-.2	-.4	-.4
-.3	-.2	-.2	-.3	-.3	-.2	-.1	-.2	-.3	-.3	-.2	-.2	-.4	-.3	-.2
-.2	-.2	-.3	-.3	-.2	-.1	-.1	-.3	-.4	-.2	-.2	-.3	-.3	-.2	-.3
-.2	-.3	-.3	-.2	-.1	-.1	-.3	-.4	-.3	-.2	-.3	-.4	-.3	-.2	-.2
-.1	-.3	-.2	-.1	-.1	-.3	-.4	-.3	-.2	-.3	-.4	-.2	-.2	-.2	-.1
.5	-.2	-.1	-.1	-.3	-.4	-.4	-.3	-.3	-.3	-.2	-.1	-.2	-.2	-.2
1.8	.2	-.1	-.3	-.5	-.4	-.3	-.3	-.3	-.2	-.1	-.2	-.2	-.2	-.2
3.3	.8	-.3	-.4	-.4	-.2	-.2	-.2	-.1	-.1	-.1	-.1	-.1	-.2	-.3
4.5	1.5	-.2	-.3	-.2	-.2	-.2	-.1	-.1	-.1	-.1	-.2	-.4	-.5	-.5
5.3	2.4	.2	-.2	-.1	-.1	-.1	-.1	-.2	-.3	-.4	-.5	-.5	-.4	-.2
5.8	3.4	.8	-.1	-.2	-.2	-.2	-.3	-.4	-.5	-.4	-.4	-.3	-.2	-.2
6.2	4.1	1.1	-.2	-.2	-.3	-.4	-.4	-.5	-.4	-.3	-.2	-.2	-.3	-.3
6.3	4.4	1.2	-.3	-.3	-.3	-.4	-.4	-.3	-.2	-.2	-.2	-.1	-.1	-.2
6.2	4.6	1.5	-.2	-.4	-.4	-.3	-.3	-.2	-.1	-.2	-.2	-.2	-.2	-.3
6.3	4.7	1.6	-.1	-.2	-.2	-.2	-.2	-.1	-.2	-.2	-.3	-.3	-.3	-.3
6.4	4.4	1.2	-.2	-.2	-.1	-.1	-.1	-.2	-.3	-.3	-.3	-.3	-.2	-.2
6.2	4.0	1.1	-.2	-.2	-.2	-.2	-.3	-.3	-.3	-.3	-.3	-.3	-.2	-.2
5.9	3.6	.9	-.1	-.1	-.2	-.3	-.3	-.3	-.2	-.2	-.2	-.2	-.2	-.2
5.5	2.7	.3	-.3	-.3	-.3	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.3
4.5	1.5	-.2	-.4	-.3	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2
2.9	.6	-.2	-.1	-.1	-.2	-.2	-.2	-.1	-.2	-.2	-.2	-.2	-.2	-.2
1.6	.0	-.2	-.1	-.2	-.2	-.3	-.3	-.2	-.2	-.2	-.2	-.2	-.2	-.2
.7	-.2	-.4	-.3	-.3	-.2	-.2	-.2	-.2	-.3	-.3	-.3	-.3	-.3	-.3
.0	-.2	-.2	-.3	-.3	-.4	-.4	-.3	-.3	-.3	-.2	-.2	-.2	-.3	-.4
-.3	-.2	-.1	-.1	-.2	-.3	-.3	-.4	-.4	-.4	-.3	-.3	-.3	-.2	-.2
-.3	-.2	-.2	-.2	-.1	-.1	-.1	-.2	-.3	-.3	-.3	-.4	-.4	-.4	-.2
-.2	-.3	-.4	-.4	-.3	-.2	-.2	-.2	-.2	-.2	-.2	-.3	-.3	-.4	-.5
-.2	-.2	-.3	-.3	-.3	-.3	-.2	-.2	-.2	-.2	-.2	-.1	-.1	-.2	-.2
-.2	-.1	-.1	-.2	-.2	-.3	-.3	-.2	-.2	-.2	-.2	-.2	-.2	-.1	-.1
-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.3	-.3	-.2	-.2	-.2	-.3	-.2	-.2
-.3	-.3	-.3	-.3	-.2	-.2	-.2	-.2	-.3	-.3	-.2	-.2	-.2	-.2	-.2
-.3	-.2	-.3	-.3	-.3	-.3	-.2	-.1	-.2	-.3	-.3	-.3	-.2	-.2	-.3
-.3	-.2	-.2	-.3	-.4	-.4	-.3	-.2	-.1	-.1	-.3	-.4	-.3	-.2	-.1
-.3	-.2	-.2	-.2	-.3	-.4	-.4	-.4	-.3	-.1	-.2	-.3	-.4	-.4	-.2
-.3	-.3	-.2	-.2	-.2	-.2	-.3	-.4	-.4	-.3	-.2	-.1	-.2	-.5	-.5
-.3	-.3	-.3	-.2	-.2	-.2	-.2	-.2	-.4	-.4	-.4	-.3	-.1	-.1	-.3
-.3	-.3	-.3	-.3	-.2	-.2	-.2	-.1	-.2	-.3	-.3	-.5	-.4	-.2	-.1
-.2	-.3	-.4	-.3	-.2	-.2	-.3	-.2	-.2	-.2	-.1	-.2	-.4	-.5	-.4
-.1	-.2	-.3	-.4	-.3	-.2	-.2	-.2	-.2	-.3	-.3	-.2	-.1	-.2	-.4
-.1	-.2	-.2	-.3	-.4	-.3	-.2	-.3	-.2	-.2	-.3	-.4	-.3	-.2	-.1
-.2	-.2	-.2	-.2	-.3	-.4	-.3	-.3	-.3	-.2	-.1	-.2	-.4	-.4	-.2
-.2	-.2	-.2	-.2	-.2	-.3	-.3	-.2	-.3	-.4	-.3	.0	-.1	-.4	-.3
-.3	-.2	-.1	-.2	-.2	-.2	-.4	-.3	-.0	-.3	-.5	-.3	-.0	-.2	-.3
-.4	-.3	-.1	-.2	-.3	-.1	-.2	-.6	-.3	.0	-.3	-.5	-.2	-.2	-.3
-.3	-.4	-.2	-.1	-.4	-.2	.0	-.4	-.6	-.2	-.1	-.3	-.3	-.2	-.3
-.2	-.4	-.4	-.1	-.2	-.5	-.1	-.0	-.4	-.4	-.2	-.2	-.3	-.2	-.2

-.5	.2	.2	-.6
-.1	.3	-.2	-.9
.3	.1	-.7	-.8
.2	-.4	-.8	-.3
-.3	-.8	-.5	.2
-.6	-.6	.1	.3
-.5	-.1	.2	-.2
-.3	.1	-.1	-.7
-.1	-.0	-.5	-.8
.0	-.3	-.7	-.5
-.3	-.7	-.7	-.2
-.7	-.6	-.1	.2
-.5	-.1	.3	.0
-.2	.1	-.1	-.6
.1	-.1	-.5	-.6
-.1	-.5	-.5	-.1
-.5	-.5	-.2	.0
-.4	-.1	-.0	-.3
-.2	-.1	-.4	-.6
-.2	-.4	-.5	-.2
-.3	-.3	-.0	.1
-.2	-.0	-.1	-.4
-.1	-.2	-.4	-.5
-.3	-.4	-.2	-.0
-.2	-.2	-.2	-.3
-.3	-.4	-.5	-.5
-.5	-.4	-.3	-.1
-.1	-.1	-.1	-.2
-.2	-.3	-.4	-.4
-.3	-.2	-.2	-.1
-.2	-.2	-.2	-.3
-.4	-.5	-.5	-.5
-.3	-.2	-.1	-.1
-.2	-.2	-.2	-.3
-.2	-.3	-.4	-.3
-.2	-.1	-.1	-.0
-.3	-.3	-.4	-.4
-.2	-.2	-.2	-.2
-.2	-.1	-.1	-.1
-.3	-.4	-.5	-.5
-.2	-.2	-.1	-.1
-.3	-.2	-.2	-.2
-.2	-.3	-.4	-.6
-.2	-.1	-.0	.1
-.5	-.5	-.4	-.3
-.3	-.4	-.5	-.7
-.1	-.1	-.0	-.1
-.3	-.4	-.3	-.2
-.1	-.1	-.2	-.3
-.3	-.2	-.1	-.0
-.3	-.4	-.5	-.4
-.1	-.0	-.1	-.4
-.4	-.2	.0	.1
-.5	-.6	-.5	-.2
-.1	-.3	-.6	-.6
-.2	-.0	-.2	-.5
-.4	-.3	-.2	-.3
-.3	-.3	-.2	-.2
-.2	-.3	-.2	-.1
-.3	-.4	-.4	-.2
-.2	-.3	-.4	-.3
-.2	-.2	-.3	-.4
-.3	-.2	-.3	-.3
-.3	-.3	-.3	-.3

5. Example 5 - Iterative Conjugate Gradient

The program XCONGR uses the iterative conjugate gradient algorithm to reconstruct parallel-beam projection data for a pie phantom. The parameters for the subroutine CONGR are set in statements E5.052 through E5.055. Where IRLX = 1 indicates that the iterative relaxation method is used and ISTP = 15 indicates the iterative procedure will stop after 15 steps. The other parameters IERR and IZER are set to zero, indicating that the iterative reconstruction procedure does not use errors for weighting and that the initial solution is equal to zero.

The subroutine GETUM generates a pie phantom in the array B (statement E5.095) before the first angle (M = 1) and for each angle the array B is projected using the subroutine PJECT. The values of the projection array are simulated line integrals obtained using the projection subroutine PLL. For these data the conjugate gradient algorithm gives a reconstruction with discernible background artifact but good resolution. A comparison of this algorithm (CONGR) to the iterative gradient algorithm GRADY (Example 6) reveals that the latter gives less apparent background artifact but less resolution for 15 iterations. After 15 iterations the conjugate gradient method has a chi-square equal to 447, whereas the gradient method has a chi-square six times greater.

```
      PROGRAM XCONGR (INPUT,OUTPUT,TAPE2=OUTPUT)                          E5.001
C                                                                         E5.002
C        EXAMPLE 5                                                        E5.003
C                                                                         E5.004
C              THE PROGRAM XCONGR USES THE ITERATIVE CONJUGATE GRADIENT   E5.005
C        ALGORITHM TO RECONSTRUCT PARALLEL BEAM PROJECTION DATA.          E5.006
C                                                                         E5.007
      DIMENSION B(4096),AG(180)                                           E5.008
      COMMON WORK(15000)                                                  E5.009
C                                                                         E5.010
      COMMON/OUTCOM/LUNOUT,I80132                                         E5.011
C                                                                         E5.012
C          LUNOUT  - OUTPUT FILE                                          E5.013
C          I80132  - OUTPUT LINE LENGTH FLAG                              E5.014
C                 =0    EACH LINE WILL BE WITHIN 80 CHARACTERS            E5.015
C                          (OTHERWISE 132 CHARACTERS)                     E5.016
C                                                                         E5.017
      COMMON/PARM/IPAR(12),PAR(3)                                         E5.018
C                                                                         E5.019
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)),  E5.020
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)),  E5.021
     2            (IMIT  ,IPAR( 7)),(NWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)),  E5.022
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)),  E5.023
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3))   E5.024
C                                                                         E5.025
C                                                                         E5.026
      EXTERNAL BRF,PRF                                                    E5.027
C                                                                         E5.028
      LUNOUT=2                                                            E5.029
      I80132=0                                                            E5.030
C                                                                         E5.031
C        THE INPUT PARAMETERS ARE                                         E5.032
C                                                                         E5.033
      NDIMU=64                                                            E5.034
      ICIR=0                                                              E5.035
      IGEOM=0                                                             E5.036
      NANG=72                                                             E5.037
      MODANG=4                                                            E5.038
      KDIMU=100                                                           E5.039
      IMIT=1                                                              E5.040
      NWORK=15000                                                         E5.041
      NFLOAT=1                                                            E5.042
      ISTORE=0                                                            E5.043
      IPRINT=7                                                            E5.044
      LUNATN=0                                                            E5.045
      PWID=1.                                                             E5.046
      AXISU=50.5                                                          E5.047
      RFAN=0.                                                             E5.048
C                                                                         E5.049
      CALL SETUP (IPAR,PAR,AG)                                            E5.050
C                                                                         E5.051
      ISTP=15                                                             E5.052
      IRLX=1                                                              E5.053
      IERR=0                                                              E5.054
      IZER=0                                                              E5.055
C                                                                         E5.056
      CALL CONGR (B,PRF,BRF,ISTP,IRLX,IERR,IZER)                          E5.057
C                                                                         E5.058
      CALL ARRAY (B,NDIMU)                                                E5.059
C                                                                         E5.060
C        PRINTOUT THE VALUES FOR THE RECONSTRUCTED TRANSVERSE SECTION     E5.061
C                                                                         E5.062
      NMAT=NDIMU**2                                                       E5.063
      KK1=1                                                               E5.064
      KU=NDIMU/15+1                                                       E5.065
      DO 12 K=1,KU                                                        E5.066
      WRITE (2,14)                                                        E5.067
      KK2=15*K                                                            E5.068
      IF (KK2.GT.NDIMU) KK2=NDIMU                                         E5.069
      DO 10 J=1,NDIMU                                                     E5.070
      ISUB1=NMAT-J*NDIMU+KK1                                              E5.071
      ISUB2=NMAT-J*NDIMU+KK2                                              E5.072
   10 WRITE (2,16) (B(I),I=ISUB1,ISUB2)                                   E5.073
      KK1=KK2+1                                                           E5.074
   12 CONTINUE                                                            E5.075
C                                                                         E5.076
C                                                                         E5.077
C                                                                         E5.078
   14 FORMAT(1X///////)                                                   E5.079
   16 FORMAT(1X,15F5.1)                                                   E5.080
      END                                                                 E5.081
      SUBROUTINE GETUM (M,DATA,ERP)                                       E5.082
C                                                                         E5.083
C        EXAMPLE 5                                                        E5.084
C                                                                         E5.085
C              THE SUBROUTINE GETUM GIVES SIMULATED PROJECTION DATA FOR   E5.086
C        A PIE PHANTOM.                                                   E5.087
C                                                                         E5.088
      DIMENSION B(4096),DATA(1),ERR(1)                                    E5.089
      DATA N,R,X1,Y1,Z,INTFR,NSLIPI,ISTART/64,30.,0.,0.,1.,10,10,1/       E5.090
      EXTERNAL PLL                                                        E5.091
C                                                                         E5.092
      IF (M.NE.1) GO TO 10                                                E5.093
C                                                                         E5.094
      CALL PIE (B,N,R,X1,Y1,Z,INTFR,NSLIPI,ISTART)                        E5.095
C                                                                         E5.096
      CALL ARRAY (B,N)                                                    E5.097
C                                                                         E5.098
   10 CALL PJECT (B,DATA,M,PLL)                                           E5.099
C                                                                         E5.100
      RETURN                                                              E5.101
C                                                                         E5.102
      END                                                                 E5.103
```

```
 SSS   EEEEE TTTTT U     U PPPP
S      E       T   U     U P   P
 SSS   EEE     T   U     U PPPP
    S  E       T   U     U P
 SSS   EEEEE   T    UUU    P
```

INTEGER PARAMETER ARRAY (IPAR)

I	IPAR(I)	DESCRIPTION
1	64	LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
2	0	RECONSTRUCT IN A CIRCULAR ARRAY
3	0	GEOMETRY FLAG
		PARALLEL BEAM GEOMETRY
4	72	NUMBER OF PROJECTION ANGLES
5	4	MODE FOR PROJECTION ANGLE INPUT (SEE FOLLOWING LINES)
		ANGLES GENERATED BETWEEN ZERO AND PI
		STARTING AT ZERO
6	100	NUMBER OF RAYS FOR EACH PROJECTION
7	1	TRANSMISSION DATA
8	15000	DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
9	1	NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10	0	EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11	7	PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES)
		PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED
		PRINT PROJECTION DATA AND UNCERTAINTIES
		PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
12	0	LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE

FLOATING POINT PARAMETER ARRAY (PAR)

I	PAR(I)	DESCRIPTION
1	1.000	PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
2	50.500	LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
3	0 NA	NOT APPLICABLE (NOT FAN BEAM GEOMETRY)

BLANK COMMON REQUIRED 72 (110)

BLANK COMMON REQUIRED 144 (220)

BLANK COMMON REQUIRED 216 (330)

BLANK COMMON REQUIRED 416 (640)

BLANK COMMON REQUIRED 544 (1040)

A TOTAL OF 68 (17 THRU 84) OF THE 100 USER PROJECTION BINS WILL BE USED

68 PROJECTION BINS WILL BE USED OF WHICH 0 HAVE BEEN ZEROED BY THE PROGRAM

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 544 FLOATING POINT WORDS.

```
EEEEE N     N DDDD          SSS   EEEEE TTTTT U     U PPPP
E     NN    N D   D        S      E       T   U     U P   P
EEE   N N   N D   D         SSS   EEE     T   U     U PPPP
E     N   NN  D   D            S  E       T   U     U P
EEEEE N     N DDDD          SSS   EEEEE   T    UUU    P
```

```
 CCC   OOOOO N     N  GGG   RRRR
C   C O     O NN    N G      R   R
C     O     O N N   N G      RRRR
C   C O     O N   NN G  GG  R  R
 CCC   OOOOO N     N  GGGG  R   R
```

PARAMETERS FOR SUBROUTINE CONGR

		DESCRIPTION
ISTP -	15	NUMBER OF ITERATION STEPS
IRLX -	1	ITERATIVE RELAXATION METHOD
IERR -	0	DO NOT USE ERROR ARRAY
IZER -	0	INITIAL SOLUTION IS ZERO

BLANK COMMON REQUIRED 616 (1150)

BLANK COMMON REQUIRED 1775 (3357)

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	UNIFORM SQUARE	NO	NO
PRJ	PROJECTION	UNIFORM SQUARE	NO	NO

BLANK COMMON REQUIRED 1911 (3567)

BLANK COMMON REQUIRED 5139 (12023)

BLANK COMMON REQUIRED 8367 (20257)

BLANK COMMON REQUIRED 11595 (26513)

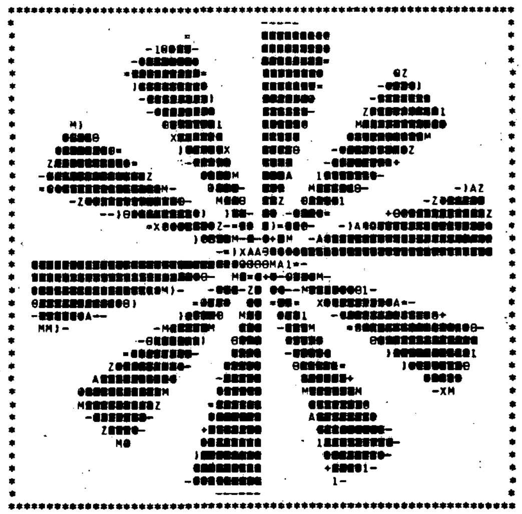
BLANK COMMON REQUIRED 14823 (34747)

```
PPPP   III  EEEEE
P   P   I   E
PPPP    I   EEE
P       I   E
P      III  EEEEE
```

PIE PHANTOM GENERATED
ARRAY SIZE 64X 64
CIRCLE RADIUS 30.00 AT (0, 0)
INT FACTOR 10
SECTOR WIDTH .314

```
EEEEE N     N DDDD        PPPP   III  EEEEE
E     NN    N D   D       P   P   I   E
EEE   N N   N D   D       PPPP    I   EEE
E     N   NN  D   D       P       I   E
EEEEE N     N DDDD        P      III  EEEEE
```

XMIN = 0. XMAX = .10E+01 XSUM = .1413E+04



```
                  -            =            +            )            I            Z
          0  .7500E-01  .1850E+00  .2350E+00  .2700E+00  .3100E+00  .3500E+00

Z            X            A            M            8            ●            8            ●
 .3850E+00  .4100E+00  .4350E+00  .4900E+00  .5450E+00  .5800E+00  .6200E+00

●            ●            ●            ●            ●            ●            ●            ■
 .6550E+00  .7300E+00  .8200E+00  .8700E+00  .9100E+00  .9500E+00  .9850E+00

●
 .1000E+01
```

```
PPPP        J EEEEE  CCC  TTTTT
P   P       J E     C   C   T
PPPP        J EEE   C       T
P       J   J E     C   C   T
P        JJJ  EEEEE  CCC    T
```

BLANK COMMON REQUIRED 14891 (35053)

PROJECTION DATA FOR ANGLE NO. 1 0 RADIANS 0 DEGREES

0	0	0	0	.541E+01
.943E+01	.120E+02	.141E+02	.158E+02	.173E+02
.187E+02	.198E+02	.210E+02	.219E+02	.228E+02
.236E+02	.244E+02	.250E+02	.257E+02	.262E+02
.268E+02	.272E+02	.277E+02	.281E+02	.284E+02
.287E+02	.290E+02	.292E+02	.295E+02	.296E+02
.298E+02	.299E+02	.299E+02	.329E+02	.299E+02
.299E+02	.298E+02	.297E+02	.296E+02	.294E+02
.292E+02	.290E+02	.287E+02	.284E+02	.280E+02
.276E+02	.272E+02	.267E+02	.262E+02	.256E+02
.250E+02	.243E+02	.235E+02	.227E+02	.218E+02
.208E+02	.197E+02	.185E+02	.172E+02	.157E+02
.139E+02	.118E+02	.912E+01	.465E+01	0
0	0	0		

PROJECTION DATA FOR ANGLE NO. 2 .044 RADIANS 2.500 DEGREES

0	0	0	0	.542E+01
.972E+01	.138E+02	.158E+02	.172E+02	.170E+02
.164E+02	.172E+02	.184E+02	.195E+02	.205E+02
.219E+02	.247E+02	.275E+02	.283E+02	.293E+02
.300E+02	.305E+02	.308E+02	.310E+02	.284E+02
.246E+02	.231E+02	.229E+02	.231E+02	.244E+02
.273E+02	.296E+02	.317E+02	.495E+02	.485E+02
.299E+02	.256E+02	.271E+02	.241E+02	.231E+02
.229E+02	.231E+02	.249E+02	.289E+02	.311E+02
.308E+02	.304E+02	.300E+02	.293E+02	.282E+02
.273E+02	.244E+02	.216E+02	.204E+02	.194E+02
.183E+02	.171E+02	.164E+02	.171E+02	.171E+02
.157E+02	.135E+02	.935E+01	.465E+01	0
0	0	0		

PROJECTION DATA FOR ANGLE NO. 3 .087 RADIANS 5.000 DEGREES

0	0	0	0	.457E+01
.893E+01	.145E+02	.166E+02	.180E+02	.177E+02
.170E+02	.163E+02	.171E+02	.186E+02	.205E+02
.233E+02	.262E+02	.290E+02	.311E+02	.308E+02
.305E+02	.309E+02	.310E+02	.279E+02	.244E+02
.218E+02	.200E+02	.214E+02	.223E+02	.219E+02
.236E+02	.272E+02	.417E+02	.546E+02	.541E+02
.404E+02	.258E+02	.234E+02	.220E+02	.224E+02
.213E+02	.200E+02	.220E+02	.247E+02	.282E+02
.311E+02	.308E+02	.305E+02	.309E+02	.310E+02
.287E+02	.259E+02	.231E+02	.203E+02	.185E+02
.170E+02	.164E+02	.170E+02	.178E+02	.179E+02
.164E+02	.141E+02	.838E+01	.403E+01	0
0	0	0		

PROJECTION DATA FOR ANGLE NO. 4 .131 RADIANS 7.500 DEGREES

0	0	0	0	.233E+01
.951E+01	.162E+02	.181E+02	.178E+02	.170E+02
.163E+02	.157E+02	.155E+02	.170E+02	.204E+02
.238E+02	.266E+02	.285E+02	.310E+02	.332E+02
.339E+02	.332E+02	.318E+02	.273E+02	.233E+02
.222E+02	.197E+02	.161E+02	.146E+02	.189E+02
.246E+02	.338E+02	.453E+02	.555E+02	.550E+02
.442E+02	.329E+02	.239E+02	.184E+02	.143E+02
.163E+02	.200E+02	.222E+02	.235E+02	.278E+02
.321E+02	.332E+02	.340E+02	.331E+02	.308E+02
.284E+02	.264E+02	.235E+02	.200E+02	.167E+02
.155E+02	.157E+02	.164E+02	.171E+02	.179E+02
.180E+02	.159E+02	.860E+01	.208E+01	0
0	0	0		

PROJECTION DATA FOR ANGLE NO. 5 .175 RADIANS 10.000 DEGREES

0	0	0	0	.177E+01
.104E+02	.145E+02	.179E+02	.178E+02	.173E+02
.168E+02	.160E+02	.159E+02	.180E+02	.201E+02
.224E+02	.255E+02	.285E+02	.317E+02	.347E+02
.343E+02	.328E+02	.298E+02	.273E+02	.254E+02
.222E+02	.190E+02	.169E+02	.142E+02	.166E+02
.255E+02	.347E+02	.454E+02	.555E+02	.550E+02
.443E+02	.341E+02	.248E+02	.159E+02	.140E+02
.171E+02	.191E+02	.227E+02	.256E+02	.274E+02
.301E+02	.330E+02	.345E+02	.346E+02	.313E+02
.283E+02	.253E+02	.222E+02	.199E+02	.178E+02
.158E+02	.161E+02	.168E+02	.173E+02	.178E+02
.178E+02	.143E+02	.959E+01	.149E+01	0
0	0	0		

PROJECTION DATA FOR ANGLE NO. 6 .218 RADIANS 12.500 DEGREES

0	0	0	.128E+00	.264E+01
.101E+02	.146E+02	.174E+02	.177E+02	.171E+02
.163E+02	.160E+02	.173E+02	.180E+02	.202E+02
.231E+02	.263E+02	.287E+02	.310E+02	.317E+02
.325E+02	.316E+02	.306E+02	.284E+02	.249E+02
.233E+02	.196E+02	.173E+02	.197E+02	.211E+02
.246E+02	.303E+02	.422E+02	.541E+02	.536E+02
.412E+02	.298E+02	.242E+02	.208E+02	.196E+02
.169E+02	.201E+02	.234E+02	.251E+02	.288E+02
.307E+02	.317E+02	.325E+02	.315E+02	.310E+02
.286E+02	.260E+02	.229E+02	.200E+02	.179E+02
.172E+02	.159E+02	.163E+02	.171E+02	.177E+02
.174E+02	.141E+02	.956E+01	.237E+01	.824E-01
0	0	0		

PROJECTION DATA FOR ANGLE NO. 7 .262 RADIANS 15.000 DEGREES

0	0	0	.309E+00	.379E+01
.942E+01	.137E+02	.152E+02	.177E+02	.175E+02
.171E+02	.176E+02	.184E+02	.197E+02	.212E+02
.230E+02	.250E+02	.279E+02	.291E+02	.301E+02
.287E+02	.298E+02	.302E+02	.296E+02	.262E+02
.234E+02	.231E+02	.228E+02	.244E+02	.256E+02
.269E+02	.283E+02	.324E+02	.501E+02	.491E+02
.316E+02	.284E+02	.265E+02	.255E+02	.243E+02
.229E+02	.230E+02	.234E+02	.267E+02	.296E+02
.302E+02	.297E+02	.289E+02	.302E+02	.290E+02
.277E+02	.247E+02	.230E+02	.210E+02	.195E+02
.183E+02	.176E+02	.171E+02	.175E+02	.175E+02
.150E+02	.134E+02	.919E+01	.349E+01	.209E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 8 .305 RADIANS 17.500 DEGREES

0	0	0	.501E+00	.491E+01
.895E+01	.125E+02	.142E+02	.155E+02	.173E+02
.181E+02	.196E+02	.209E+02	.214E+02	.221E+02
.233E+02	.251E+02	.249E+02	.265E+02	.270E+02
.279E+02	.265E+02	.281E+02	.284E+02	.288E+02
.273E+02	.280E+02	.288E+02	.284E+02	.288E+02
.294E+02	.305E+02	.292E+02	.345E+02	.340E+02
.293E+02	.305E+02	.292E+02	.289E+02	.283E+02
.290E+02	.277E+02	.274E+02	.287E+02	.284E+02
.278E+02	.268E+02	.280E+02	.269E+02	.264E+02
.248E+02	.251E+02	.231E+02	.221E+02	.215E+02
.208E+02	.195E+02	.181E+02	.171E+02	.156E+02
.140E+02	.123E+02	.884E+01	.461E+01	.356E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 9 .349 RADIANS 20.000 DEGREES

0	0	0	.610E+00	.601E+01
.875E+01	.110E+02	.133E+02	.145E+02	.168E+02
.200E+02	.212E+02	.221E+02	.236E+02	.243E+02
.244E+02	.229E+02	.233E+02	.231E+02	.246E+02
.252E+02	.257E+02	.253E+02	.269E+02	.297E+02
.332E+02	.331E+02	.336E+02	.326E+02	.323E+02
.317E+02	.322E+02	.296E+02	.151E+02	.163E+02
.300E+02	.321E+02	.315E+02	.324E+02	.327E+02
.337E+02	.331E+02	.332E+02	.295E+02	.266E+02
.253E+02	.259E+02	.252E+02	.245E+02	.230E+02
.233E+02	.229E+02	.245E+02	.243E+02	.234E+02
.220E+02	.212E+02	.197E+02	.168E+02	.143E+02
.131E+02	.108E+02	.871E+01	.572E+01	.444E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 10 .393 RADIANS 22.500 DEGREES

0	0	0	.737E+00	.689E+01
.880E+01	.914E+01	.117E+02	.142E+02	.172E+02
.205E+02	.228E+02	.242E+02	.247E+02	.255E+02
.245E+02	.231E+02	.213E+02	.212E+02	.216E+02
.227E+02	.234E+02	.241E+02	.275E+02	.312E+02
.347E+02	.373E+02	.385E+02	.373E+02	.359E+02
.344E+02	.328E+02	.204E+02	.773E+01	.836E+01
.212E+02	.330E+02	.343E+02	.360E+02	.375E+02
.384E+02	.375E+02	.344E+02	.310E+02	.271E+02
.241E+02	.233E+02	.228E+02	.214E+02	.212E+02
.212E+02	.233E+02	.246E+02	.255E+02	.246E+02
.241E+02	.227E+02	.205E+02	.171E+02	.139E+02
.115E+02	.914E+01	.883E+01	.663E+01	.562E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 11 .436 RADIANS 25.000 DEGREES

0	0	0	.759E+00	.756E+01
.895E+01	.852E+01	.103E+02	.136E+02	.176E+02
.208E+02	.239E+02	.257E+02	.264E+02	.251E+02
.241E+02	.229E+02	.212E+02	.199E+02	.193E+02
.204E+02	.215E+02	.253E+02	.279E+02	.321E+02
.352E+02	.383E+02	.412E+02	.430E+02	.408E+02
.358E+02	.270E+02	.157E+02	.584E+01	.628E+01
.163E+02	.273E+02	.362E+02	.409E+02	.431E+02
.409E+02	.385E+02	.349E+02	.319E+02	.278E+02
.252E+02	.214E+02	.202E+02	.194E+02	.198E+02
.215E+02	.229E+02	.241E+02	.252E+02	.263E+02
.255E+02	.238E+02	.207E+02	.173E+02	.133E+02
.102E+02	.856E+01	.901E+01	.728E+01	.597E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 12 .480 RADIANS 27.500 DEGREES

0	0	0	.729E+00	.764E+01
.910E+01	.870E+01	.941E+01	.139E+02	.176E+02
.208E+02	.239E+02	.265E+02	.263E+02	.255E+02
.239E+02	.227E+02	.217E+02	.193E+02	.189E+02
.187E+02	.220E+02	.253E+02	.287E+02	.320E+02
.355E+02	.386E+02	.413E+02	.448E+02	.435E+02
.343E+02	.254E+02	.146E+02	.549E+01	.587E+01
.151E+02	.256E+02	.348E+02	.438E+02	.447E+02
.411E+02	.386E+02	.352E+02	.318E+02	.287E+02
.250E+02	.220E+02	.185E+02	.188E+02	.195E+02
.218E+02	.228E+02	.239E+02	.257E+02	.262E+02
.265E+02	.240E+02	.205E+02	.174E+02	.137E+02
.932E+01	.876E+01	.910E+01	.736E+01	.586E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 13 .524 RADIANS 30.000 DEGREES

0	0	0	.717E+00	.723E+01
.922E+01	.922E+01	.107E+02	.134E+02	.174E+02
.208E+02	.238E+02	.249E+02	.257E+02	.256E+02
.241E+02	.229E+02	.217E+02	.201E+02	.199E+02
.213E+02	.222E+02	.248E+02	.283E+02	.313E+02
.348E+02	.385E+02	.405E+02	.408E+02	.387E+02
.361E+02	.288E+02	.170E+02	.638E+01	.672E+01
.175E+02	.290E+02	.364E+02	.387E+02	.408E+02
.405E+02	.383E+02	.345E+02	.312E+02	.283E+02
.246E+02	.223E+02	.212E+02	.197E+02	.203E+02
.216E+02	.229E+02	.241E+02	.255E+02	.258E+02
.250E+02	.237E+02	.206E+02	.173E+02	.133E+02
.107E+02	.922E+01	.920E+01	.695E+01	.619E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 14 .567 RADIANS 32.500 DEGREES

0	0	0	.605E+00	.642E+01
.934E+01	.979E+01	.122E+02	.138E+02	.169E+02
.209E+02	.224E+02	.232E+02	.241E+02	.247E+02
.246E+02	.231E+02	.219E+02	.221E+02	.223E+02
.238E+02	.244E+02	.249E+02	.274E+02	.300E+02
.342E+02	.368E+02	.360E+02	.358E+02	.345E+02
.335E+02	.325E+02	.251E+02	.952E+01	.993E+01
.256E+02	.324E+02	.337E+02	.346E+02	.357E+02
.363E+02	.366E+02	.339E+02	.300E+02	.274E+02
.249E+02	.244E+02	.237E+02	.223E+02	.222E+02
.218E+02	.231E+02	.246E+02	.246E+02	.242E+02
.232E+02	.222E+02	.207E+02	.168E+02	.139E+02
.121E+02	.971E+01	.934E+01	.617E+01	.553E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 15 .611 RADIANS 35.000 DEGREES

0	0	0	.446E+00	.533E+01
.943E+01	.114E+02	.136E+02	.154E+02	.167E+02
.196E+02	.205E+02	.217E+02	.225E+02	.230E+02
.245E+02	.237E+02	.240E+02	.248E+02	.251E+02
.259E+02	.264E+02	.267E+02	.275E+02	.287E+02
.309E+02	.316E+02	.312E+02	.310E+02	.312E+02
.309E+02	.305E+02	.305E+02	.226E+02	.230E+02
.305E+02	.303E+02	.310E+02	.312E+02	.309E+02
.314E+02	.315E+02	.307E+02	.289E+02	.273E+02
.268E+02	.264E+02	.257E+02	.252E+02	.247E+02
.240E+02	.237E+02	.243E+02	.231E+02	.224E+02
.216E+02	.205E+02	.193E+02	.167E+02	.153E+02
.135E+02	.114E+02	.935E+01	.516E+01	.423E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 16 .654 RADIANS 37.500 DEGREES

0	0	0	.311E+00	.422E+01
.947E+01	.128E+02	.147E+02	.168E+02	.173E+02
.174E+02	.189E+02	.200E+02	.208E+02	.218E+02
.226E+02	.252E+02	.269E+02	.272E+02	.277E+02
.283E+02	.285E+02	.291E+02	.292E+02	.278E+02
.255E+02	.257E+02	.266E+02	.270E+02	.277E+02
.279E+02	.285E+02	.299E+02	.420E+02	.415E+02
.299E+02	.285E+02	.279E+02	.277E+02	.269E+02
.267E+02	.255E+02	.254E+02	.280E+02	.291E+02
.291E+02	.285E+02	.281E+02	.279E+02	.272E+02
.270E+02	.252E+02	.224E+02	.219E+02	.206E+02
.200E+02	.189E+02	.172E+02	.174E+02	.167E+02
.147E+02	.129E+02	.927E+01	.410E+01	.305E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 17 .698 RADIANS 40.000 DEGREES

0	0	0	.205E+00	.344E+01
.964E+01	.143E+02	.161E+02	.177E+02	.174E+02
.165E+02	.170E+02	.180E+02	.191E+02	.206E+02
.227E+02	.256E+02	.286E+02	.299E+02	.304E+02
.304E+02	.310E+02	.308E+02	.287E+02	.262E+02
.233E+02	.208E+02	.214E+02	.224E+02	.242E+02
.257E+02	.273E+02	.373E+02	.519E+02	.517E+02
.370E+02	.273E+02	.257E+02	.242E+02	.224E+02
.215E+02	.207E+02	.233E+02	.264E+02	.287E+02
.310E+02	.310E+02	.302E+02	.305E+02	.299E+02
.285E+02	.256E+02	.226E+02	.204E+02	.191E+02
.182E+02	.169E+02	.165E+02	.174E+02	.176E+02
.163E+02	.143E+02	.948E+01	.335E+01	.205E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 18 .742 RADIANS 42.500 DEGREES

0	0	0	.873E-01	.259E+01
.954E+01	.150E+02	.176E+02	.179E+02	.173E+02
.167E+02	.159E+02	.162E+02	.175E+02	.202E+02
.233E+02	.260E+02	.285E+02	.311E+02	.329E+02
.330E+02	.328E+02	.307E+02	.275E+02	.254E+02
.225E+02	.199E+02	.178E+02	.170E+02	.195E+02
.230E+02	.318E+02	.434E+02	.540E+02	.540E+02
.432E+02	.318E+02	.229E+02	.195E+02	.171E+02
.178E+02	.199E+02	.225E+02	.255E+02	.275E+02
.308E+02	.328E+02	.329E+02	.329E+02	.311E+02
.285E+02	.259E+02	.232E+02	.201E+02	.174E+02
.163E+02	.157E+02	.167E+02	.173E+02	.177E+02
.178E+02	.149E+02	.945E+01	.257E+01	.867E-01
0	0	0		

PROJECTION DATA FOR ANGLE NO. 19 .785 RADIANS 45.000 DEGREES

0	0	0	0	.241E+01
.958E+01	.150E+02	.183E+02	.174E+02	.173E+02
.168E+02	.155E+02	.153E+02	.170E+02	.203E+02
.234E+02	.261E+02	.286E+02	.309E+02	.340E+02
.348E+02	.330E+02	.303E+02	.273E+02	.252E+02
.220E+02	.197E+02	.175E+02	.142E+02	.157E+02
.248E+02	.346E+02	.448E+02	.546E+02	.546E+02
.448E+02	.346E+02	.248E+02	.157E+02	.142E+02
.175E+02	.157E+02	.220E+02	.252E+02	.273E+02
.303E+02	.330E+02	.348E+02	.340E+02	.309E+02
.286E+02	.261E+02	.234E+02	.203E+02	.170E+02
.152E+02	.155E+02	.168E+02	.173E+02	.174E+02
.183E+02	.150E+02	.958E+01	.241E+01	0
0	0	0		

PROJECTION DATA FOR ANGLE NO. 20 .829 RADIANS 47.500 DEGREES

0	0	0	.867E-01	.257E+01
.945E+01	.149E+02	.178E+02	.177E+02	.173E+02
.167E+02	.158E+02	.165E+02	.175E+02	.201E+02
.232E+02	.259E+02	.285E+02	.311E+02	.329E+02
.329E+02	.328E+02	.308E+02	.275E+02	.255E+02
.225E+02	.198E+02	.176E+02	.171E+02	.195E+02
.229E+02	.318E+02	.432E+02	.540E+02	.540E+02
.434E+02	.318E+02	.229E+02	.195E+02	.170E+02
.177E+02	.199E+02	.225E+02	.254E+02	.275E+02
.307E+02	.328E+02	.330E+02	.329E+02	.311E+02
.285E+02	.259E+02	.233E+02	.202E+02	.175E+02
.164E+02	.159E+02	.167E+02	.173E+02	.179E+02
.176E+02	.150E+02	.954E+01	.259E+01	.873E-01
0	0	0		

PROJECTION DATA FOR ANGLE NO. 21 .873 RADIANS 50.000 DEGREES

0	0	0	.205E+00	.335E+01
.948E+01	.143E+02	.163E+02	.176E+02	.174E+02
.165E+02	.171E+02	.183E+02	.192E+02	.205E+02
.226E+02	.256E+02	.285E+02	.299E+02	.305E+02
.302E+02	.309E+02	.309E+02	.287E+02	.264E+02
.232E+02	.207E+02	.215E+02	.223E+02	.242E+02
.257E+02	.272E+02	.370E+02	.516E+02	.519E+02
.373E+02	.273E+02	.257E+02	.242E+02	.224E+02
.214E+02	.208E+02	.233E+02	.262E+02	.287E+02
.308E+02	.310E+02	.304E+02	.303E+02	.298E+02
.285E+02	.256E+02	.227E+02	.206E+02	.192E+02
.181E+02	.171E+02	.165E+02	.174E+02	.177E+02
.161E+02	.143E+02	.964E+01	.344E+01	.205E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 22 .916 RADIANS 52.500 DEGREES

0	0	0	.305E+00	.410E+01
.927E+01	.129E+02	.147E+02	.167E+02	.174E+02
.174E+02	.191E+02	.201E+02	.208E+02	.220E+02
.225E+02	.252E+02	.269E+02	.272E+02	.278E+02
.281E+02	.284E+02	.291E+02	.291E+02	.280E+02
.254E+02	.255E+02	.267E+02	.268E+02	.277E+02
.279E+02	.284E+02	.299E+02	.415E+02	.419E+02
.299E+02	.285E+02	.279E+02	.277E+02	.270E+02
.266E+02	.256E+02	.254E+02	.277E+02	.292E+02
.291E+02	.284E+02	.283E+02	.276E+02	.272E+02
.269E+02	.252E+02	.226E+02	.220E+02	.209E+02
.201E+02	.190E+02	.174E+02	.173E+02	.168E+02
.147E+02	.128E+02	.947E+01	.422E+01	.311E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 23 .960 RADIANS 55.000 DEGREES

0	0	0	.423E+00	.516E+01
.935E+01	.114E+02	.135E+02	.153E+02	.168E+02
.195E+02	.206E+02	.217E+02	.225E+02	.233E+02
.244E+02	.238E+02	.240E+02	.246E+02	.252E+02
.257E+02	.263E+02	.268E+02	.273E+02	.288E+02
.306E+02	.314E+02	.313E+02	.308E+02	.312E+02
.309E+02	.303E+02	.305E+02	.230E+02	.226E+02
.305E+02	.304E+02	.309E+02	.311E+02	.310E+02
.312E+02	.316E+02	.308E+02	.286E+02	.275E+02
.267E+02	.263E+02	.259E+02	.250E+02	.247E+02
.239E+02	.237E+02	.246E+02	.231E+02	.227E+02
.218E+02	.206E+02	.197E+02	.167E+02	.154E+02
.136E+02	.114E+02	.943E+01	.533E+01	.446E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 24 1.004 RADIANS 57.500 DEGREES

0	0	0	.553E+00	.617E+01
.934E+01	.971E+01	.121E+02	.140E+02	.169E+02
.208E+02	.224E+02	.233E+02	.244E+02	.248E+02
.247E+02	.233E+02	.220E+02	.222E+02	.223E+02
.236E+02	.244E+02	.248E+02	.273E+02	.299E+02
.339E+02	.365E+02	.362E+02	.356E+02	.345E+02
.336E+02	.324E+02	.255E+02	.986E+01	.945E+01
.250E+02	.325E+02	.335E+02	.344E+02	.357E+02
.360E+02	.367E+02	.342E+02	.299E+02	.274E+02
.248E+02	.244E+02	.238E+02	.223E+02	.221E+02
.219E+02	.233E+02	.247E+02	.248E+02	.242E+02
.233E+02	.225E+02	.210E+02	.171E+02	.138E+02
.122E+02	.979E+01	.934E+01	.642E+01	.605E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 25 1.047 RADIANS 60.000 DEGREES

0	0	0	.619E+00	.695E+01
.920E+01	.922E+01	.107E+02	.134E+02	.174E+02
.207E+02	.238E+02	.251E+02	.259E+02	.256E+02
.243E+02	.230E+02	.217E+02	.204E+02	.197E+02
.211E+02	.222E+02	.245E+02	.282E+02	.311E+02
.344E+02	.382E+02	.404E+02	.407E+02	.387E+02
.363E+02	.289E+02	.175E+02	.664E+01	.630E+01
.169E+02	.287E+02	.361E+02	.386E+02	.407E+02
.404E+02	.384E+02	.347E+02	.312E+02	.282E+02
.247E+02	.221E+02	.212E+02	.198E+02	.201E+02
.218E+02	.230E+02	.242E+02	.257E+02	.258E+02
.250E+02	.239E+02	.209E+02	.175E+02	.135E+02
.107E+02	.922E+01	.922E+01	.723E+01	.717E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 26 1.091 RADIANS 62.500 DEGREES

0	0	0	.586E+00	.736E+01
.910E+01	.876E+01	.943E+01	.138E+02	.175E+02
.206E+02	.241E+02	.266E+02	.263E+02	.258E+02
.240E+02	.229E+02	.219E+02	.196E+02	.190E+02
.185E+02	.219E+02	.249E+02	.286E+02	.317E+02
.351E+02	.385E+02	.410E+02	.446E+02	.437E+02
.347E+02	.255E+02	.150E+02	.576E+01	.538E+01
.145E+02	.253E+02	.342E+02	.434E+02	.447E+02
.412E+02	.385E+02	.354E+02	.319E+02	.286E+02
.252E+02	.219E+02	.186E+02	.190E+02	.195E+02
.218E+02	.228E+02	.240E+02	.256E+02	.264E+02
.266E+02	.240E+02	.210E+02	.177E+02	.140E+02
.945E+01	.870E+01	.910E+01	.764E+01	.729E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 27 1.134 RADIANS 65.000 DEGREES

0	0	0	.597E+00	.728E+01
.901E+01	.859E+01	.103E+02	.134E+02	.174E+02
.208E+02	.240E+02	.256E+02	.265E+02	.253E+02
.242E+02	.230E+02	.217E+02	.199E+02	.195E+02
.203E+02	.215E+02	.250E+02	.277E+02	.318E+02
.347E+02	.383E+02	.408E+02	.430E+02	.408E+02
.361E+02	.272E+02	.161E+02	.616E+01	.571E+01
.155E+02	.269E+02	.357E+02	.407E+02	.429E+02
.411E+02	.382E+02	.351E+02	.319E+02	.278E+02
.252E+02	.214E+02	.205E+02	.194E+02	.200E+02
.213E+02	.230E+02	.242E+02	.252E+02	.265E+02
.258E+02	.240E+02	.209E+02	.177E+02	.137E+02
.104E+02	.853E+01	.895E+01	.756E+01	.759E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 28 1.178 RADIANS 67.500 DEGREES

0	0	0	.562E+00	.663E+01
.883E+01	.925E+01	.116E+02	.140E+02	.172E+02
.206E+02	.228E+02	.242E+02	.248E+02	.256E+02
.247E+02	.234E+02	.213E+02	.213E+02	.215E+02
.229E+02	.234E+02	.242E+02	.269E+02	.309E+02
.343E+02	.373E+02	.383E+02	.373E+02	.358E+02
.342E+02	.328E+02	.211E+02	.820E+01	.757E+01
.203E+02	.326E+02	.342E+02	.358E+02	.371E+02
.383E+02	.372E+02	.346E+02	.310E+02	.273E+02
.240E+02	.235E+02	.228E+02	.217E+02	.213E+02
.214E+02	.232E+02	.246E+02	.256E+02	.248E+02
.243E+02	.229E+02	.207E+02	.173E+02	.143E+02
.118E+02	.920E+01	.881E+01	.689E+01	.737E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 29 1.222 RADIANS 70.000 DEGREES

0	+0	0	.444E+00	.572E+01
.872E+01	.109E+02	.132E+02	.144E+02	.169E+02
.199E+02	.213E+02	.221E+02	.235E+02	.244E+02
.246E+02	.230E+02	.234E+02	.231E+02	.246E+02
.253E+02	.260E+02	.254E+02	.267E+02	.293E+02
.330E+02	.329E+02	.335E+02	.325E+02	.322E+02
.313E+02	.319E+02	.298E+02	.161E+02	.149E+02
.295E+02	.320E+02	.315E+02	.321E+02	.324E+02
.334E+02	.329E+02	.331E+02	.295E+02	.268E+02
.254E+02	.258E+02	.253E+02	.247E+02	.232E+02
.234E+02	.230E+02	.245E+02	.244E+02	.237E+02
.222E+02	.213E+02	.201E+02	.169E+02	.146E+02
.134E+02	.111E+02	.876E+01	.601E+01	.610E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 30 1.265 RADIANS 72.500 DEGREES

0	0	0	.356E+00	.461E+01
.894E+01	.124E+02	.141E+02	.157E+02	.172E+02
.182E+02	.196E+02	.209E+02	.216E+02	.222E+02
.232E+02	.252E+02	.249E+02	.265E+02	.270E+02
.281E+02	.269E+02	.279E+02	.285E+02	.288E+02
.274E+02	.275E+02	.288E+02	.281E+02	.287E+02
.289E+02	.302E+02	.290E+02	.338E+02	.343E+02
.290E+02	.302E+02	.292E+02	.286E+02	.282E+02
.286E+02	.277E+02	.271E+02	.288E+02	.285E+02
.282E+02	.266E+02	.280E+02	.271E+02	.266E+02
.250E+02	.252E+02	.234E+02	.222E+02	.215E+02
.210E+02	.197E+02	.183E+02	.174E+02	.157E+02
.143E+02	.126E+02	.899E+01	.491E+01	.501E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 31 1.309 RADIANS 75.000 DEGREES

0	0	0	.209E+00	.349E+01
.930E+01	.135E+02	.151E+02	.176E+02	.176E+02
.172E+02	.177E+02	.184E+02	.196E+02	.211E+02
.231E+02	.248E+02	.278E+02	.291E+02	.303E+02
.290E+02	.298E+02	.303E+02	.297E+02	.268E+02
.235E+02	.230E+02	.226E+02	.240E+02	.252E+02
.262E+02	.281E+02	.313E+02	.488E+02	.498E+02
.321E+02	.280E+02	.266E+02	.252E+02	.241E+02
.225E+02	.228E+02	.234E+02	.263E+02	.297E+02
.303E+02	.300E+02	.288E+02	.302E+02	.293E+02
.280E+02	.251E+02	.231E+02	.213E+02	.198E+02
.185E+02	.177E+02	.172E+02	.176E+02	.178E+02
.153E+02	.138E+02	.953E+01	.380E+01	.309E+00
	0	0		

PROJECTION DATA FOR ANGLE NO. 32 1.353 RADIANS 77.500 DEGREES

0	0	0	.824E-01	.237E+01
.966E+01	.142E+02	.176E+02	.178E+02	.172E+02
.164E+02	.160E+02	.173E+02	.180E+02	.201E+02
.230E+02	.261E+02	.287E+02	.311E+02	.316E+02
.326E+02	.318E+02	.308E+02	.289E+02	.253E+02
.235E+02	.202E+02	.170E+02	.192E+02	.204E+02
.238E+02	.294E+02	.408E+02	.532E+02	.538E+02
.418E+02	.300E+02	.243E+02	.207E+02	.194E+02
.169E+02	.197E+02	.234E+02	.250E+02	.285E+02
.307E+02	.317E+02	.326E+02	.318E+02	.311E+02
.288E+02	.264E+02	.232E+02	.203E+02	.181E+02
.174E+02	.161E+02	.164E+02	.172E+02	.178E+02
.175E+02	.147E+02	.102E+02	.265E+01	.128E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 33 1.396 RADIANS 80.000 DEGREES

0	0	0	0	.159E+01
.969E+01	.144E+02	.179E+02	.179E+02	.174E+02
.169E+02	.162E+02	.159E+02	.179E+02	.200E+02
.223E+02	.254E+02	.284E+02	.314E+02	.347E+02
.346E+02	.331E+02	.302E+02	.275E+02	.257E+02
.228E+02	.192E+02	.172E+02	.141E+02	.156E+02
.243E+02	.337E+02	.438E+02	.546E+02	.550E+02
.449E+02	.342E+02	.250E+02	.162E+02	.139E+02
.170E+02	.191E+02	.223E+02	.255E+02	.274E+02
.299E+02	.329E+02	.344E+02	.348E+02	.318E+02
.287E+02	.256E+02	.225E+02	.202E+02	.181E+02
.160E+02	.161E+02	.169E+02	.174E+02	.179E+02
.180E+02	.146E+02	.105E+02	.181E+01	.170E-02
0	0	0		

PROJECTION DATA FOR ANGLE NO. 34 1.440 RADIANS 82.500 DEGREES

0	0	0	0	.218E+01
.870E+01	.160E+02	.181E+02	.180E+02	.172E+02
.165E+02	.158E+02	.156E+02	.168E+02	.201E+02
.236E+02	.265E+02	.285E+02	.309E+02	.332E+02
.341E+02	.334E+02	.322E+02	.279E+02	.236E+02
.223E+02	.201E+02	.164E+02	.144E+02	.185E+02
.237E+02	.322E+02	.435E+02	.544E+02	.548E+02
.446E+02	.331E+02	.239E+02	.187E+02	.147E+02
.162E+02	.198E+02	.223E+02	.234E+02	.274E+02
.319E+02	.333E+02	.340E+02	.333E+02	.311E+02
.286E+02	.267E+02	.239E+02	.205E+02	.171E+02
.156E+02	.158E+02	.164E+02	.171E+02	.179E+02
.182E+02	.163E+02	.961E+01	.244E+01	.101E-01
0	0	0		

PROJECTION DATA FOR ANGLE NO. 35 1.484 RADIANS 85.000 DEGREES

0	0	0	0	.413E+01
.848E+01	.142E+02	.165E+02	.180E+02	.179E+02
.171E+02	.165E+02	.171E+02	.186E+02	.204E+02
.232E+02	.260E+02	.288E+02	.311E+02	.310E+02
.306E+02	.309E+02	.312E+02	.283E+02	.248E+02
.221E+02	.201E+02	.214E+02	.225E+02	.221E+02
.235E+02	.258E+02	.394E+02	.530E+02	.535E+02
.407E+02	.262E+02	.236E+02	.220E+02	.224E+02
.215E+02	.201E+02	.219E+02	.245E+02	.280E+02
.311E+02	.310E+02	.306E+02	.309E+02	.312E+02
.291E+02	.263E+02	.234E+02	.206E+02	.187E+02
.172E+02	.164E+02	.171E+02	.178E+02	.181E+02
.167E+02	.146E+02	.903E+01	.468E+01	.100E-01
0	0	0		

PROJECTION DATA FOR ANGLE NO. 36 1.527 RADIANS 87.500 DEGREES

0	0	0	0	.475E+01
.945E+01	.136E+02	.158E+02	.172E+02	.172E+02
.165E+02	.172E+02	.184E+02	.195E+02	.205E+02
.217E+02	.245E+02	.274E+02	.283E+02	.294E+02
.301E+02	.305E+02	.309E+02	.312E+02	.290E+02
.250E+02	.232E+02	.230E+02	.232E+02	.242E+02
.272E+02	.297E+02	.300E+02	.467E+02	.473E+02
.300E+02	.297E+02	.274E+02	.245E+02	.232E+02
.230E+02	.232E+02	.247E+02	.285E+02	.311E+02
.309E+02	.306E+02	.301E+02	.294E+02	.284E+02
.276E+02	.248E+02	.220E+02	.206E+02	.196E+02
.185E+02	.173E+02	.165E+02	.171E+02	.173E+02
.159E+02	.139E+02	.982E+01	.552E+01	.100E-01
0	0	0		

PROJECTION DATA FOR ANGLE NO. 37 1.571 RADIANS 90.000 DEGREES

0	0	0	0	.475E+01
.922E+01	.119E+02	.140E+02	.158E+02	.173E+02
.186E+02	.198E+02	.209E+02	.219E+02	.228E+02
.236E+02	.244E+02	.251E+02	.257E+02	.263E+02
.268E+02	.273E+02	.277E+02	.281E+02	.285E+02
.288E+02	.291E+02	.293E+02	.295E+02	.297E+02
.298E+02	.299E+02	.300E+02	.300E+02	.270E+02
.300E+02	.300E+02	.299E+02	.297E+02	.296E+02
.293E+02	.291E+02	.288E+02	.285E+02	.282E+02
.278E+02	.273E+02	.269E+02	.263E+02	.258E+02
.251E+02	.245E+02	.237E+02	.229E+02	.220E+02
.211E+02	.199E+02	.188E+02	.174E+02	.159E+02
.142E+02	.121E+02	.953E+01	.551E+01	.100E-01
0	0	0		

PROJECTION DATA FOR ANGLE NO. 38 1.614 RADIANS 92.500 DEGREES

0	0	0	0	.475E+01
.921E+01	.109E+02	.119E+02	.141E+02	.173E+02
.206E+02	.224E+02	.234E+02	.243E+02	.251E+02
.255E+02	.242E+02	.227E+02	.231E+02	.233E+02
.235E+02	.241E+02	.246E+02	.251E+02	.281E+02
.326E+02	.349E+02	.357E+02	.359E+02	.352E+02
.326E+02	.303E+02	.300E+02	.116E+02	.103E+02
.282E+02	.301E+02	.323E+02	.351E+02	.359E+02
.357E+02	.351E+02	.330E+02	.285E+02	.252E+02
.246E+02	.241E+02	.236E+02	.232E+02	.231E+02
.227E+02	.241E+02	.254E+02	.252E+02	.244E+02
.235E+02	.225E+02	.209E+02	.176E+02	.143E+02
.121E+02	.110E+02	.952E+01	.552E+01	.100E-01
0	0	0		

PROJECTION DATA FOR ANGLE NO. 39 1.658 RADIANS 95.000 DEGREES

0	0	0	.191E-01	.649E+01
.904E+01	.909E+01	.113E+02	.138E+02	.177E+02
.201E+02	.229E+02	.245E+02	.251E+02	.251E+02
.240E+02	.227E+02	.213E+02	.203E+02	.216E+02
.230E+02	.237E+02	.243E+02	.279E+02	.324E+02
.356E+02	.380E+02	.373E+02	.366E+02	.374E+02
.360E+02	.338E+02	.196E+02	.597E+01	.524E+01
.180E+02	.324E+02	.359E+02	.372E+02	.367E+02
.371E+02	.382E+02	.360E+02	.329E+02	.285E+02
.245E+02	.238E+02	.231E+02	.218E+02	.203E+02
.211E+02	.225E+02	.239E+02	.251E+02	.250E+02
.245E+02	.231E+02	.205E+02	.180E+02	.142E+02
.115E+02	.924E+01	.901E+01	.742E+01	.106E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 40 1.702 RADIANS 97.500 DEGREES

0	0	0	.330E+00	.747E+01
.909E+01	.893E+01	.933E+01	.128E+02	.172E+02
.214E+02	.245E+02	.261E+02	.266E+02	.251E+02
.234E+02	.221E+02	.217E+02	.207E+02	.196E+02
.200E+02	.215E+02	.233E+02	.281E+02	.332E+02
.350E+02	.380E+02	.420E+02	.445E+02	.409E+02
.359E+02	.269E+02	.158E+02	.511E+01	.431E+01
.146E+02	.259E+02	.346E+02	.403E+02	.444E+02
.426E+02	.384E+02	.354E+02	.335E+02	.287E+02
.238E+02	.216E+02	.200E+02	.196E+02	.205E+02
.215E+02	.220E+02	.233E+02	.250E+02	.265E+02
.262E+02	.247E+02	.218E+02	.177E+02	.133E+02
.957E+01	.897E+01	.906E+01	.824E+01	.567E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 41 1.745 RADIANS 100.000 DEGREES

0	0	0	.460E+00	.762E+01
.915E+01	.886E+01	.103E+02	.140E+02	.163E+02
.202E+02	.238E+02	.264E+02	.259E+02	.251E+02
.246E+02	.234E+02	.220E+02	.203E+02	.182E+02
.192E+02	.214E+02	.251E+02	.285E+02	.312E+02
.348E+02	.388E+02	.414E+02	.449E+02	.433E+02
.351E+02	.260E+02	.158E+02	.522E+01	.440E+01
.146E+02	.249E+02	.339E+02	.428E+02	.449E+02
.417E+02	.392E+02	.352E+02	.314E+02	.289E+02
.255E+02	.217E+02	.194E+02	.182E+02	.201E+02
.219E+02	.233E+02	.244E+02	.250E+02	.258E+02
.265E+02	.241E+02	.207E+02	.167E+02	.143E+02
.107E+02	.890E+01	.912E+01	.844E+01	.734E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 42 1.789 RADIANS 102.500 DEGREES

0	0	0	.424E+00	.672E+01
.914E+01	.906E+01	.109E+02	.132E+02	.174E+02
.210E+02	.234E+02	.245E+02	.260E+02	.254E+02
.241E+02	.226E+02	.217E+02	.207E+02	.211E+02
.210E+02	.226E+02	.244E+02	.273E+02	.316E+02
.340E+02	.379E+02	.417E+02	.394E+02	.386E+02
.354E+02	.304E+02	.191E+02	.654E+01	.557E+01
.176E+02	.293E+02	.351E+02	.384E+02	.394E+02
.413E+02	.385E+02	.343E+02	.320E+02	.276E+02
.246E+02	.228E+02	.211E+02	.213E+02	.205E+02
.216E+02	.225E+02	.239E+02	.253E+02	.261E+02
.247E+02	.236E+02	.214E+02	.179E+02	.136E+02
.112E+02	.917E+01	.920E+01	.749E+01	.678E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 43 1.833 RADIANS 105.000 DEGREES

0	0	0	.329E+00	.563E+01
.918E+01	.105E+02	.124E+02	.143E+02	.165E+02
.201E+02	.224E+02	.230E+02	.239E+02	.248E+02
.244E+02	.237E+02	.222E+02	.224E+02	.225E+02
.247E+02	.246E+02	.250E+02	.263E+02	.303E+02
.342E+02	.352E+02	.359E+02	.347E+02	.338E+02
.329E+02	.313E+02	.285E+02	.112E+02	.941E+01
.270E+02	.313E+02	.328E+02	.337E+02	.345E+02
.359E+02	.351E+02	.343E+02	.307E+02	.267E+02
.252E+02	.245E+02	.248E+02	.226E+02	.224E+02
.221E+02	.235E+02	.244E+02	.249E+02	.240E+02
.231E+02	.225E+02	.205E+02	.168E+02	.146E+02
.127E+02	.107E+02	.939E+01	.631E+01	.579E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 44 1.876 RADIANS 107.500 DEGREES

0	0	0	.227E+00	.461E+01
.929E+01	.117E+02	.138E+02	.157E+02	.174E+02
.192E+02	.199E+02	.211E+02	.221E+02	.235E+02
.243E+02	.235E+02	.248E+02	.249E+02	.258E+02
.258E+02	.277E+02	.273E+02	.277E+02	.282E+02
.302E+02	.304E+02	.297E+02	.305E+02	.304E+02
.303E+02	.292E+02	.307E+02	.263E+02	.252E+02
.306E+02	.293E+02	.302E+02	.304E+02	.305E+02
.297E+02	.303E+02	.303E+02	.282E+02	.278E+02
.273E+02	.278E+02	.258E+02	.259E+02	.249E+02
.250E+02	.235E+02	.244E+02	.236E+02	.222E+02
.213E+02	.200E+02	.193E+02	.177E+02	.159E+02
.141E+02	.119E+02	.977E+01	.524E+01	.442E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 45 1.920 RADIANS 110.000 DEGREES

0	0	0	.117E+00	.364E+01
.924E+01	.130E+02	.150E+02	.168E+02	.178E+02
.174E+02	.185E+02	.195E+02	.206E+02	.211E+02
.225E+02	.258E+02	.267E+02	.281E+02	.281E+02
.286E+02	.286E+02	.299E+02	.295E+02	.276E+02
.245E+02	.250E+02	.247E+02	.263E+02	.268E+02
.279E+02	.276E+02	.300E+02	.432E+02	.456E+02
.306E+02	.278E+02	.280E+02	.270E+02	.263E+02
.248E+02	.252E+02	.243E+02	.272E+02	.293E+02
.300E+02	.286E+02	.287E+02	.281E+02	.282E+02
.269E+02	.262E+02	.228E+02	.211E+02	.208E+02
.196E+02	.186E+02	.175E+02	.178E+02	.170E+02
.152E+02	.134E+02	.991E+01	.425E+01	.271E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 46 1.963 RADIANS 112.500 DEGREES

0	0	0	.393E-01	.276E+01
.918E+01	.145E+02	.166E+02	.177E+02	.172E+02
.170E+02	.166E+02	.179E+02	.188E+02	.201E+02
.223E+02	.254E+02	.290E+02	.299E+02	.309E+02
.310E+02	.312E+02	.312E+02	.290E+02	.261E+02
.233E+02	.208E+02	.199E+02	.213E+02	.232E+02
.252E+02	.266E+02	.381E+02	.513E+02	.527E+02
.399E+02	.274E+02	.255E+02	.234E+02	.216E+02
.199E+02	.206E+02	.229E+02	.258E+02	.287E+02
.310E+02	.311E+02	.310E+02	.309E+02	.301E+02
.293E+02	.258E+02	.227E+02	.204E+02	.190E+02
.180E+02	.168E+02	.170E+02	.171E+02	.176E+02
.168E+02	.150E+02	.997E+01	.341E+01	.126E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 47 2.007 RADIANS 115.000 DEGREES

0	0	0	.533E-02	.223E+01
.911E+01	.150E+02	.177E+02	.183E+02	.172E+02
.164E+02	.161E+02	.159E+02	.175E+02	.199E+02
.232E+02	.255E+02	.285E+02	.315E+02	.328E+02
.333E+02	.333E+02	.301E+02	.285E+02	.252E+02
.228E+02	.197E+02	.176E+02	.158F+02	.183E+02
.232E+02	.319E+02	.431E+02	.532E+02	.543E+02
.446E+02	.333E+02	.243E+02	.187E+02	[illegible]
.172E+02	.194E+02	.224E+02	.248E+02	.281E+02
.298E+02	.331E+02	.332E+02	.330E+02	.317E+02
.289E+02	.258E+02	.236E+02	.204E+02	.177E+02
.161E+02	.161E+02	.163E+02	.171E+02	.182E+02
.180E+02	.156E+02	.987E+01	.299E+01	.265E-01
0	0	0		

PROJECTION DATA FOR ANGLE NO. 48 2.051 RADIANS 117.500 DEGREES

0	0	0	.567E-03	.208E+01
.903E+01	.147E+02	.184E+02	.180E+02	.173E+02
.166E+02	.156E+02	.155E+02	.171E+02	.200E+02
.229E+02	.260E+02	.279E+02	.319E+02	.335E+02
.348E+02	.330E+02	.304E+02	.276E+02	.253E+02
.226E+02	.195E+02	.175E+02	.145E+02	.154E+02
.245E+02	.336E+02	.443E+02	.536E+02	.547E+02
.458E+02	.349E+02	.259E+02	.162E+02	.142E+02
.171E+02	.192E+02	.223E+02	.249E+02	.272E+02
.300E+02	.325E+02	.347E+02	.338E+02	.322E+02
.282E+02	.264E+02	.233E+02	.205E+02	.175F+02
.155E+02	.155E+02	.165E+02	.172E+02	.179E+02
.187E+02	.154E+02	.983E+01	.291E+01	.144E-01
0	0	0		

PROJECTION DATA FOR ANGLE NO. 49 2.094 RADIANS 120.000 DEGREES

0	0	0	.240E-01	.237E+01
.892E+01	.143E+02	.172E+02	.181E+02	.173E+02
.166E+02	.159E+02	.166E+02	.182E+02	.197E+02
.231E+02	.254E+02	.285E+02	.308E+02	.329E+02
.322E+02	.323E+02	.311E+02	.279E+02	.258E+02
.231E+02	.200E+02	.180E+02	.180E+02	.206E+02
.232E+02	.301E+02	.418E+02	.528E+02	.540E+02
.434E+02	.316E+02	.237E+02	.210E+02	.182E+02
.180E+02	.195E+02	.229E+02	.253E+02	.277E+02
.307E+02	.322E+02	.323E+02	.329E+02	.311E+02
.287E+02	.258E+02	.234E+02	.200E+02	.184E+02
.168E+02	.159E+02	.166E+02	.172E+02	.181E+02
.175E+02	.148E+02	.975E+01	.315E+01	.858E-01
0	0	0		

PROJECTION DATA FOR ANGLE NO. 50 2.138 RADIANS 122.500 DEGREES

0	0	0	.510E-01	.318E+01
.886E+01	.139E+02	.156E+02	.176E+02	.178E+02
.167E+02	.174E+02	.186E+02	.195E+02	.210E+02
.222E+02	.255E+02	.279E+02	.293E+02	.300E+02
.300E+02	.300E+02	.306E+02	.289E+02	.269E+02
.238E+02	.214E+02	.221E+02	.232E+02	.248E+02
.259E+02	.272E+02	.336E+02	.495E+02	.513E+02
.354E+02	.275E+02	.260E+02	.250E+02	.233E+02
.222E+02	.214E+02	.234E+02	.265E+02	.286E+02
.306E+02	.299E+02	.300E+02	.301E+02	.292E+02
.282E+02	.258E+02	.226E+02	.211E+02	.196E+02
.188E+02	.175E+02	.167E+02	.177E+02	.177E+02
.159E+02	.141E+02	.972E+01	.391E+01	.173E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 51 2.182 RADIANS 125.000 DEGREES

0	0	0	.151E+00	.430E+01
.873E+01	.125E+02	.144E+02	.161E+02	.179E+02
.178E+02	.192E+02	.202E+02	.212E+02	.224E+02
.229E+02	.247E+02	.261E+02	.266E+02	.274E+02
.276E+02	.282E+02	.284E+02	.289E+02	.282E+02
.267E+02	.266E+02	.270E+02	.279E+02	.283E+02
.284E+02	.293E+02	.293E+02	.361E+02	.385E+02
.293E+02	.293E+02	.286E+02	.283E+02	.280E+02
.272E+02	.266E+02	.267E+02	.280E+02	.289E+02
.286E+02	.282E+02	.278E+02	.275E+02	.267E+02
.262E+02	.250E+02	.230E+02	.225E+02	.213E+02
.203E+02	.194E+02	.179E+02	.181E+02	.163E+02
.146E+02	.128E+02	.940E+01	.502E+01	.360E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 52 2.225 RADIANS 127.500 DEGREES

0	0	0	.244E+00	.547E+01
.882E+01	.107E+02	.132E+02	.146E+02	.170E+02
.198E+02	.207E+02	.218E+02	.230E+02	.236E+02
.246E+02	.237E+02	.230E+02	.243E+02	.246E+02
.253E+02	.260E+02	.263E+02	.271E+02	.289E+02
.319E+02	.328E+02	.319E+02	.320E+02	.316E+02
.317E+02	.311E+02	.302E+02	.198E+02	.170E+02
.299E+02	.308E+02	.318E+02	.317E+02	.320E+02
.317E+02	.327E+02	.321E+02	.294E+02	.271E+02
.264E+02	.261E+02	.254E+02	.248E+02	.243E+02
.231E+02	.235E+02	.246E+02	.237E+02	.231E+02
.219E+02	.209E+02	.201E+02	.173E+02	.148E+02
.134E+02	.110E+02	.903E+01	.627E+01	.550E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 53 2.269 RADIANS 130.000 DEGREES

0	0	0	.265E+00	.634E+01
.914E+01	.952E+01	.118E+02	.137E+02	.168E+02
.205E+02	.225E+02	.237E+02	.247E+02	.251E+02
.246E+02	.232E+02	.218E+02	.214E+02	.221E+02
.231E+02	.235E+02	.245E+02	.271E+02	.304E+02
.340E+02	.371E+02	.373E+02	.367E+02	.353E+02
.340E+02	.326E+02	.237E+02	.919E+01	.754E+01
.218E+02	.320E+02	.339E+02	.351E+02	.363E+02
.371E+02	.373E+02	.345E+02	.309E+02	.276E+02
.247E+02	.236E+02	.233E+02	.221E+02	.215E+02
.216E+02	.230E+02	.244E+02	.250E+02	.248E+02
.238E+02	.227E+02	.210E+02	.173E+02	.140E+02
.121E+02	.977E+01	.913E+01	.727E+01	.656E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 54 2.313 RADIANS 132.500 DEGREES

0	0	0	.205E+00	.670E+01
.899E+01	.889E+01	.102E+02	.135E+02	.170E+02
.203E+02	.236E+02	.254E+02	.263E+02	.255E+02
.241E+02	.229E+02	.216E+02	.204E+02	.194E+02
.206E+02	.217E+02	.243E+02	.286E+02	.310E+02
.350E+02	.378E+02	.406E+02	.422E+02	.400E+02
.371E+02	.288E+02	.172E+02	.677E+01	.552E+01
.158E+02	.271E+02	.363E+02	.397E+02	.417E+02
.410E+02	.383E+02	.353E+02	.315E+02	.291E+02
.247E+02	.220E+02	.207E+02	.195E+02	.203E+02
.215E+02	.227E+02	.240E+02	.253E+02	.263E+02
.255E+02	.240E+02	.207E+02	.175E+02	.140E+02
.106E+02	.894E+01	.895E+01	.771E+01	.629E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 55 2.356 RADIANS 135.000 DEGREES

0	0	0	.172E+00	.683E+01
.893E+01	.891E+01	.950E+01	.140E+02	.170E+02
.202E+02	.239E+02	.263E+02	.268E+02	.255E+02
.239E+02	.227E+02	.215E+02	.204E+02	.188E+02
.186E+02	.212E+02	.251E+02	.284E+02	.316E+02
.351E+02	.383E+02	.406E+02	.448E+02	.439E+02
.356E+02	.259E+02	.154E+02	.612E+01	.503E+01
.142E+02	.244E+02	.341E+02	.432E+02	.451E+02
.410E+02	.388E+02	.355E+02	.320E+02	.290E+02
.255E+02	.217E+02	.190E+02	.186E+02	.202E+02
.214E+02	.225E+02	.238E+02	.253E+02	.266E+02
.266E+02	.243E+02	.206E+02	.175E+02	.146E+02
.990E+01	.888E+01	.889E+01	.779E+01	.600E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 56 2.400 RADIANS 137.500 DEGREES

0	0	0	.205E+00	.670E+01
.899E+01	.889E+01	.102E+02	.135E+02	.170E+02
.203E+02	.236E+02	.252E+02	.262E+02	.256E+02
.241E+02	.229E+02	.217E+02	.204E+02	.194E+02
.206E+02	.217E+02	.243E+02	.286E+02	.310E+02
.350E+02	.378E+02	.406E+02	.422E+02	.400E+02
.371E+02	.288E+02	.172E+02	.678E+01	.553E+01
.158E+02	.272E+02	.363E+02	.397E+02	.418E+02
.410E+02	.383E+02	.353E+02	.315E+02	.291E+02
.247E+02	.220E+02	.208E+02	.195E+02	.203E+02
.215E+02	.227E+02	.240E+02	.253E+02	.263E+02
.254E+02	.239E+02	.207E+02	.175E+02	.140E+02
.106E+02	.894E+01	.895E+01	.771E+01	.629E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 57 2.443 RADIANS 140.000 DEGREES

0	0	0	.265E+00	.634E+01
.914E+01	.952E+01	.118E+02	.137E+02	.168E+02
.205E+02	.224E+02	.236E+02	.246E+02	.249E+02
.246E+02	.232E+02	.218E+02	.214E+02	.221E+02
.232E+02	.235E+02	.245E+02	.272E+02	.305E+02
.341E+02	.371E+02	.373E+02	.367E+02	.353E+02
.340E+02	.326E+02	.237E+02	.921E+01	.756E+01
.218E+02	.321E+02	.340E+02	.351E+02	.363E+02
.372E+02	.374E+02	.345E+02	.309E+02	.276E+02
.247E+02	.236E+02	.233E+02	.222E+02	.215E+02
.216E+02	.230E+02	.244E+02	.250E+02	.247E+02
.237E+02	.226E+02	.209E+02	.173E+02	.140E+02
.121E+02	.977E+01	.913E+01	.727E+01	.656E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 58 2.487 RADIANS 142.500 DEGREES

0	0	0	.244E+00	.547E+01
.882E+01	.107E+02	.132E+02	.146E+02	.170E+02
.197E+02	.206E+02	.217E+02	.229E+02	.234E+02
.245E+02	.237E+02	.231E+02	.243E+02	.247E+02
.254E+02	.260E+02	.263E+02	.271E+02	.290E+02
.319E+02	.328E+02	.320E+02	.320E+02	.317E+02
.317E+02	.312E+02	.302E+02	.198E+02	.170E+02
.299E+02	.308E+02	.318E+02	.318E+02	.320E+02
.318E+02	.327E+02	.322E+02	.294E+02	.272E+02
.264E+02	.261E+02	.254E+02	.248E+02	.243E+02
.232E+02	.236E+02	.246E+02	.236E+02	.230E+02
.218E+02	.208E+02	.200E+02	.173E+02	.148E+02
.134E+02	.110E+02	.903E+01	.627E+01	.550E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 59 2.531 RADIANS 145.000 DEGREES

0	0	0	.151E+00	.430E+01
.873E+01	.125E+02	.144E+02	.161E+02	.178E+02
.176E+02	.191E+02	.201E+02	.211E+02	.222E+02
.228E+02	.246E+02	.262E+02	.267E+02	.275E+02
.277E+02	.283E+02	.285E+02	.289E+02	.282E+02
.268E+02	.267E+02	.271E+02	.279E+02	.284E+02
.284E+02	.294E+02	.293E+02	.362E+02	.385E+02
.294E+02	.293E+02	.287E+02	.283E+02	.281E+02
.273E+02	.267E+02	.268E+02	.281E+02	.289E+02
.286E+02	.283E+02	.278E+02	.275E+02	.267E+02
.262E+02	.250E+02	.229E+02	.224E+02	.212E+02
.202E+02	.193E+02	.178E+02	.179E+02	.163E+02
.146E+02	.128E+02	.940E+01	.502E+01	.360E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 60 2.574 RADIANS 147.500 DEGREES

0	0	0	.510E-01	.318E+01
.886E+01	.139E+02	.156E+02	.176E+02	.177E+02
.165E+02	.172E+02	.185E+02	.194E+02	.208E+02
.221E+02	.254E+02	.278E+02	.293E+02	.301E+02
.300E+02	.300E+02	.307E+02	.290E+02	.270E+02
.239E+02	.215E+02	.222E+02	.232E+02	.249E+02
.260E+02	.272E+02	.336E+02	.495E+02	.514E+02
.355E+02	.275E+02	.260E+02	.250E+02	.234E+02
.223E+02	.214E+02	.234E+02	.266E+02	.286E+02
.307E+02	.300E+02	.301E+02	.302E+02	.293E+02
.282E+02	.257E+02	.225E+02	.210E+02	.195E+02
.186E+02	.174E+02	.165E+02	.176E+02	.177E+02
.159E+02	.141E+02	.972E+01	.391E+01	.173E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 61 2.618 RADIANS 150.000 DEGREES

0	0	0	.240E-01	.237E+01
.892E+01	.143E+02	.172E+02	.180E+02	.172E+02
.165E+02	.158E+02	.165E+02	.180E+02	.196E+02
.229E+02	.253E+02	.283E+02	.307E+02	.329E+02
.323E+02	.324E+02	.312E+02	.280E+02	.259E+02
.232E+02	.200E+02	.181E+02	.181E+02	.207E+02
.232E+02	.302E+02	.419E+02	.529E+02	.541E+02
.435E+02	.317E+02	.237E+02	.211E+02	.183E+02
.181E+02	.196E+02	.230E+02	.254E+02	.277E+02
.308E+02	.323E+02	.324E+02	.330E+02	.310E+02
.286E+02	.257E+02	.233E+02	.199E+02	.183E+02
.167E+02	.157E+02	.165E+02	.171E+02	.180E+02
.174E+02	.148E+02	.975E+01	.315E+01	.858E-01
0	0	0		

PROJECTION DATA FOR ANGLE NO. 62 2.662 RADIANS 152.500 DEGREES

0	0	0	.567E-03	.208E+01
.903E+01	.147E+02	.184E+02	.178E+02	.172E+02
.165E+02	.154E+02	.154E+02	.170E+02	.199E+02
.228E+02	.259E+02	.278E+02	.317E+02	.334E+02
.348E+02	.331E+02	.305E+02	.277E+02	.254E+02
.227E+02	.196E+02	.176E+02	.146E+02	.155E+02
.246E+02	.337E+02	.444E+02	.537E+02	.548E+02
.459E+02	.350E+02	.260E+02	.163E+02	.143E+02
.172E+02	.193E+02	.224E+02	.250E+02	.273E+02
.301E+02	.326E+02	.348E+02	.337E+02	.321E+02
.281E+02	.263E+02	.232E+02	.204E+02	.174E+02
.154E+02	.153E+02	.164E+02	.171E+02	.178E+02
.186E+02	.154E+02	.983E+01	.291E+01	.144E-01
0	0	0		

PROJECTION DATA FOR ANGLE NO. 63 2.705 RADIANS 155.000 DEGREES

0	0	0	.533E-02	.223E+01
.911E+01	.150E+02	.176E+02	.182E+02	.171E+02
.162E+02	.160E+02	.158E+02	.173E+02	.198E+02
.231E+02	.254E+02	.284E+02	.314E+02	.327E+02
.332E+02	.333E+02	.302E+02	.286E+02	.253E+02
.230E+02	.198E+02	.178E+02	.159E+02	.185E+02
.233E+02	.320E+02	.433E+02	.533E+02	.544E+02
.448E+02	.335E+02	.244E+02	.188E+02	.161E+02
.173E+02	.196E+02	.225E+02	.250E+02	.282E+02
.299E+02	.332E+02	.332E+02	.329E+02	.316E+02
.288E+02	.257E+02	.235E+02	.203E+02	.176E+02
.160E+02	.159E+02	.162E+02	.170E+02	.181E+02
.178E+02	.156E+02	.987E+01	.299E+01	.265E-01
0	0	0		

PROJECTION DATA FOR ANGLE NO. 64 2.749 RADIANS 157.500 DEGREES

0	0	0	.393E-01	.276E+01
.918E+01	.144E+02	.164E+02	.175E+02	.171E+02
.169E+02	.165E+02	.178E+02	.187E+02	.200E+02
.222E+02	.252E+02	.289E+02	.298E+02	.308E+02
.309E+02	.311E+02	.311E+02	.292E+02	.263E+02
.234E+02	.209E+02	.200E+02	.215E+02	.234E+02
.254E+02	.267E+02	.382E+02	.515E+02	.529E+02
.401E+02	.276E+02	.256E+02	.235E+02	.217E+02
.200E+02	.207E+02	.230E+02	.260E+02	.288E+02
.311E+02	.310E+02	.309E+02	.308E+02	.300E+02
.292E+02	.257E+02	.225E+02	.203E+02	.189E+02
.179E+02	.167E+02	.169E+02	.170E+02	.175E+02
.167E+02	.149E+02	.996E+01	.341E+01	.126E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 65 2.793 RADIANS 160.000 DEGREES

0	0	0	.117E+00	.364E+01
.924E+01	.129E+02	.149E+02	.167E+02	.177E+02
.173E+02	.184E+02	.194E+02	.205E+02	.210E+02
.224E+02	.257E+02	.266E+02	.280E+02	.280E+02
.285E+02	.285E+02	.298E+02	.294E+02	.277E+02
.247E+02	.252E+02	.249E+02	.264E+02	.270E+02
.281E+02	.278E+02	.302E+02	.434E+02	.458E+02
.308E+02	.280E+02	.282E+02	.272E+02	.265E+02
.250E+02	.254E+02	.245E+02	.274E+02	.294E+02
.299E+02	.285E+02	.286E+02	.280E+02	.281E+02
.268E+02	.261E+02	.227E+02	.210E+02	.207E+02
.195E+02	.185E+02	.174E+02	.177E+02	.169E+02
.151E+02	.133E+02	.989E+01	.425E+01	.271E+00
0	0	0		

PROJECTION DATA FOR ANGLE NO. 66 2.836 RADIANS 162.500 DEGREES

0	0	0	.227E+00	.461E+01
.925E+01	.115E+02	.137E+02	.156E+02	.173E+02
.191E+02	.197E+02	.210E+02	.220E+02	.234E+02
.242E+02	.234E+02	.247E+02	.248E+02	.257E+02
.257E+02	.276E+02	.272E+02	.276E+02	.281E+02
.303E+02	.306E+02	.299E+02	.307E+02	.306E+02
.305E+02	.294E+02	.309E+02	.265E+02	.254E+02
.309E+02	.296E+02	.304E+02	.306E+02	.307E+02
.300E+02	.306E+02	.306E+02	.282E+02	.277E+02
.272E+02	.276E+02	.257E+02	.258E+02	.248E+02
.249E+02	.234E+02	.243E+02	.235E+02	.221E+02
.212E+02	.199E+02	.192E+02	.176E+02	.158E+02
.140E+02	.118E+02	.966E+01	.523E+01	.442E+00
0	0	0		

```
PROJECTION DATA FOR ANGLE NO.  67     2.880 RADIANS    165.000 DEGREES
          0            0            0    .329E+00     .563E+01
    .908E+01     .104E+02     .123E+02    .142E+02     .164E+02
    .200E+02     .223E+02     .229E+02    .238E+02     .246E+02
    .243E+02     .236E+02     .221E+02    .223E+02     .224E+02
    .246E+02     .245E+02     .249E+02    .262E+02     .302E+02
    .341E+02     .352E+02     .362E+02    .350E+02     .341E+02
    .332E+02     .316E+02     .288E+02    .115E+02     .569E+01
    .273E+02     .316E+02     .331E+02    .340E+02     .348E+02
    .361E+02     .354E+02     .343E+02    .306E+02     .266E+02
    .250E+02     .244E+02     .247E+02    .225E+02     .223E+02
    .220E+02     .234E+02     .242E+02    .248E+02     .239E+02
    .230E+02     .224E+02     .204E+02    .167E+02     .145E+02
    .126E+02     .106E+02     .929E+01    .630E+01     .579E+00
          0            0            0

PROJECTION DATA FOR ANGLE NO.  68     2.923 RADIANS    167.500 DEGREES
          0            0            0    .424E+00     .672E+01
    .904E+01     .896E+01     .108E+02    .131E+02     .173E+02
    .209E+02     .233E+02     .244E+02    .259E+02     .253E+02
    .239E+02     .225E+02     .216E+02    .206E+02     .210E+02
    .209E+02     .225E+02     .243E+02    .272E+02     .315E+02
    .339E+02     .378E+02     .416E+02    .397E+02     .390E+02
    .358E+02     .308E+02     .194E+02    .690E+01     .593E+01
    .179E+02     .296E+02     .355E+02    .388E+02     .398E+02
    .417E+02     .384E+02     .342E+02    .319E+02     .275E+02
    .245E+02     .227E+02     .210E+02    .212E+02     .204E+02
    .215E+02     .224E+02     .238E+02    .252E+02     .260E+02
    .246E+02     .235E+02     .212E+02    .178E+02     .135E+02
    .111E+02     .907E+01     .909E+01    .748E+01     .678E+00
          0            0            0

PROJECTION DATA FOR ANGLE NO.  69     2.967 RADIANS    170.000 DEGREES
          0            0            0    .460E+00     .760E+01
    .905E+01     .876E+01     .102E+02    .139E+02     .162E+02
    .201E+02     .237E+02     .263E+02    .258E+02     .250E+02
    .245E+02     .233E+02     .219E+02    .202E+02     .181E+02
    .191E+02     .213E+02     .250E+02    .284E+02     .311E+02
    .347E+02     .387E+02     .413E+02    .448E+02     .436E+02
    .356E+02     .265E+02     .163E+02    .569E+01     .487E+01
    .151E+02     .253E+02     .343E+02    .433E+02     .452E+02
    .416E+02     .391E+02     .351E+02    .313E+02     .288E+02
    .254E+02     .216E+02     .193E+02    .181E+02     .200E+02
    .218E+02     .232E+02     .243E+02    .249E+02     .257E+02
    .264E+02     .240E+02     .206E+02    .166E+02     .142E+02
    .106E+02     .879E+01     .902E+01    .834E+01     .724E+00
          0            0            0

PROJECTION DATA FOR ANGLE NO.  70     3.011 RADIANS    172.500 DEGREES
          0            0            0    .330E+00     .737E+01
    .899E+01     .883E+01     .923E+01    .127E+02     .171E+02
    .213E+02     .244E+02     .260E+02    .265E+02     .250E+02
    .233E+02     .220E+02     .216E+02    .206E+02     .195E+02
    .199E+02     .214E+02     .232E+02    .280E+02     .331E+02
    .349E+02     .379E+02     .419E+02    .444E+02     .408E+02
    .361E+02     .276E+02     .164E+02    .577E+01     .498E+01
    .153E+02     .266E+02     .353E+02    .405E+02     .443E+02
    .425E+02     .383E+02     .353E+02    .334E+02     .286E+02
    .237E+02     .215E+02     .199E+02    .195E+02     .204E+02
    .214E+02     .219E+02     .232E+02    .249E+02     .264E+02
    .261E+02     .246E+02     .217E+02    .176E+02     .132E+02
    .947E+01     .887E+01     .896E+01    .814E+01     .556E+00
          0            0            0

PROJECTION DATA FOR ANGLE NO.  71     3.054 RADIANS    175.000 DEGREES
          0            0            0    .191E-01     .639E+01
    .894E+01     .899E+01     .112E+02    .137E+02     .176E+02
    .200E+02     .228E+02     .244E+02    .250E+02     .250E+02
    .239E+02     .226E+02     .212E+02    .202E+02     .215E+02
    .229E+02     .236E+02     .242E+02    .278E+02     .323E+02
    .355E+02     .379E+02     .372E+02    .365E+02     .373E+02
    .359E+02     .339E+02     .206E+02    .701E+01     .629E+01
    .190E+02     .335E+02     .359E+02    .371E+02     .366E+02
    .370E+02     .381E+02     .359E+02    .328E+02     .284E+02
    .244E+02     .236E+02     .230E+02    .217E+02     .202E+02
    .210E+02     .224E+02     .238E+02    .250E+02     .249E+02
    .244E+02     .230E+02     .204E+02    .179E+02     .141E+02
    .114E+02     .913E+01     .891E+01    .732E+01     .957E-01
          0            0            0
```

BLANK COMMON REQUIRED 14823 (34747)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 14891 FLOATING POINT WORDS.

```
EEEEE N   N DDDD         PPPP      J EEEEE  CCC  TTTTT
E     NN  N D   D        P   P     J E     C   C   T
EEE   N N N D   D        PPPP      J EEE   C       T
E     N  NN D   D        P     J   J E     C   C   T
EEEEE N   N DDDD         P      JJJ  EEEEE  CCC    T
```

```
PROJECTION DATA FOR ANGLE NO.  72     3.098 RADIANS    177.500 DEGREES
          0            0            0           0     .465E+01
    .911E+01     .108E+02     .118E+02    .140E+02     .172E+02
    .205E+02     .223E+02     .233E+02    .242E+02     .250E+02
    .254E+02     .241E+02     .226E+02    .230E+02     .232E+02
    .234E+02     .240E+02     .245E+02    .250E+02     .280E+02
    .325E+02     .348E+02     .356E+02    .358E+02     .351E+02
    .325E+02     .302E+02     .299E+02    .133E+02     .125E+02
    .299E+02     .300E+02     .322E+02    .350E+02     .358E+02
    .356E+02     .350E+02     .329E+02    .284E+02     .251E+02
    .245E+02     .240E+02     .235E+02    .231E+02     .230E+02
    .226E+02     .240E+02     .253E+02    .251E+02     .243E+02
    .234E+02     .224E+02     .208E+02    .175E+02     .142E+02
    .120E+02     .109E+02     .942E+01    .542E+01            0
          0            0            0
```

```
FOR CONGR AND GRADY FCN IS THE VALUE OF THE CHI-SQUARE
FOR ENTPY FCN IS EVALUATED BY THE SUBROUTINE DULFC
ITER  0     FCN     .274E+07
ITER  1     FCN     .140E+06
ITER  2     FCN     .150E+05
ITER  3     FCN     .839E+04
ITER  4     FCN     .400E+04
ITER  5     FCN     .252E+04
ITER  6     FCN     .155E+04
ITER  7     FCN     .934E+03
ITER  8     FCN     .797E+03
ITER  9     FCN     .650E+03
ITER 10     FCN     .563E+03
ITER 11     FCN     .520E+03
ITER 12     FCN     .481E+03
ITER 13     FCN     .473E+03
ITER 14     FCN     .459E+03
ITER 15     FCN     .447E+03
```

BLANK COMMON REQUIRED 14687 (34537)

BLANK COMMON REQUIRED 11459 (26303)

BLANK COMMON REQUIRED 8231 (20047)

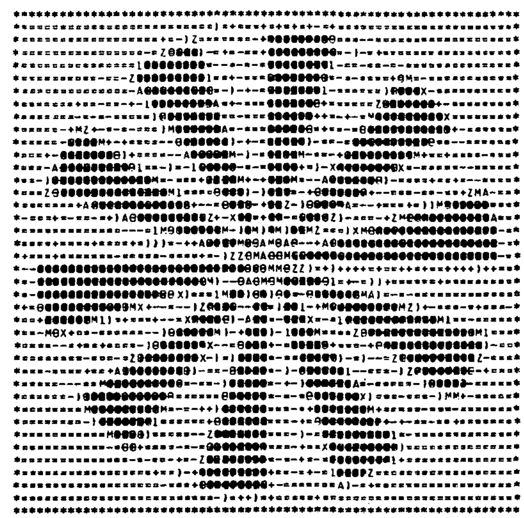
BLANK COMMON REQUIRED 5003 (11613)

BLANK COMMON REQUIRED 1775 (3357)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 14891 FLOATING POINT WORDS.

```
EEEEE N   N DDDD        CCC  OOOOO N   N  GGG  RRRR
E     NN  N D   D      C   C O   O NN  N G   G R   R
EEE   N N N D   D      C     O   O N N N G     RRRR
E     N  NN D   D      C   C O   O N  NN G  GG R  R
EEEEE N   N DDDD        CCC  OOOOO N   N  GGGG R   R
```

XMIN = -.35E+00   XMAX = .14E+01   XSUM = .1413E+04



```
             -           =           +           )           1           Z
-.3532E+00 -.2239E+00 -.3419E-01  .5204E-01  .1124E+00  .1814E+00  .2504E+00

Z           X           A           M           @           @           @           ●
 .3107E+00  .3538E+00  .3970E+00  .4918E+00  .5867E+00  .6470E+00  .7160E+00

●           ●           ●           ●           ●           ●           ●           ●
 .7764E+00  .9057E+00  .1061E+01  .1147E+01  .1216E+01  .1285E+01  .1345E+01

●
 .1371E+01
```

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	-.1
0	0	0	0	0	0	0	0	0	0	0	0	0	.0	.0
0	0	0	0	0	0	0	0	0	0	0	.1	-.1	-.0	.3
0	0	0	0	0	0	0	0	0	0	-.0	-.0	.1	-.0	.3
0	0	0	0	0	0	0	0	0	.0	-.1	.0	.0	-.1	-.0
0	0	0	0	0	0	0	0	-.0	-.1	.1	-.1	.0	.0	-.1
0	0	0	0	0	0	0	.1	-.0	-.0	-.1	-.0	.0	-.1	.1
0	0	0	0	0	0	0	-.1	.1	.0	.0	-.0	.0	-.0	-.0
0	0	0	0	0	0	.0	-.1	-.0	-.1	.0	-.1	-.0	.1	.0
0	0	0	0	0	-.1	.1	.2	.1	-.0	-.1	.1	-.0	-.0	-.1
0	0	0	0	0	-.0	.2	1.0	.8	.4	.0	-.1	-.0	.1	-.0
0	0	0	0	-.0	-.1	.8	1.0	1.1	1.0	.5	.1	-.1	.1	-.0
0	0	0	.0	-.2	.3	1.0	1.1	.9	1.0	1.1	.7	.2	.0	.0
0	0	0	.1	-.1	.9	.9	1.1	1.0	.9	1.0	1.0	.8	.2	.2
0	0	0	-.0	.3	1.1	1.0	1.0	1.1	1.0	1.0	.9	1.1	1.0	.4
0	0	.0	-.1	.6	1.0	.9	1.0	1.1	1.0	1.0	1.0	1.0	1.1	1.1
0	0	-.1	.2	1.1	1.1	1.0	.9	1.0	1.0	1.0	1.1	.9	.9	1.0
0	.0	.0	.5	1.0	1.0	1.0	1.1	1.0	1.1	1.0	1.0	1.1	1.1	1.0
0	.0	-.1	.0	.1	.4	.8	1.0	1.0	1.1	1.1	1.0	1.0	1.0	1.0
0	-.0	.0	.0	-.0	-.0	.0	.1	.4	.7	1.0	.9	.9	1.0	1.0
0	.1	.0	.0	-.0	-.1	-.0	.0	-.0	-.0	.1	.5	.7	1.0	1.1
-.0	-.0	-.0	-.0	.1	.0	-.0	.0	-.0	-.0	-.1	-.0	-.0	.2	.4
-.1	.1	.0	-.0	-.0	-.0	.1	.1	.1	.1	.1	.1	.1	-.0	-.0
.0	-.0	-.1	.0	-.0	-.1	-.1	-.1	-.1	-.1	-.1	-.1	.0	-.1	-.0
-.0	.0	.0	-.0	.1	-.0	.0	.0	.0	.1	.0	.0	.0	-.0	.1
.0	-.0	-.1	-.1	.0	-.1	-.0	.0	.0	-.0	-.0	.0	-.0	.0	-.0
.1	.0	.1	.1	.1	.0	.0	.1	.0	-.0	-.0	-.0	-.1	-.0	.0
-.0	-.1	.9	.9	1.0	.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
-.0	-.0	1.2	1.1	1.0	1.1	1.0	.9	1.1	1.1	1.0	1.0	1.1	1.0	1.0
.0	-.1	1.0	1.0	1.0	1.0	.9	1.0	1.0	.9	.9	1.0	.9	1.0	.9
.0	-.1	.9	1.1	1.1	1.0	1.1	1.1	1.1	1.1	1.2	1.1	1.0	1.0	1.0
.0	-.1	.8	1.0	1.1	1.0	1.0	.9	.9	.9	1.0	.9	.9	1.1	1.0
.1	.0	.6	1.0	.9	1.0	1.0	.9	1.1	1.1	1.0	1.0	1.1	.9	.6
0	-.1	.3	1.0	1.0	1.0	1.1	1.0	1.0	1.0	.9	.6	.3	.0	.0
0	.0	.0	1.1	1.0	1.0	1.0	1.0	.6	.4	.1	.1	.0	.1	.0
0	.1	-.1	.9	1.0	.7	.3	.0	.0	-.1	-.1	-.0	.0	.1	-.0
0	.0	-.1	.1	.1	.0	-.1	-.1	-.1	-.1	.0	-.0	-.1	-.1	-.0
0	0	.0	.0	-.2	-.1	.0	.1	.0	.0	-.1	-.0	.1	.0	.0
0	0	-.0	.1	.2	.1	.1	.0	-.1	-.0	-.0	.0	-.0	-.1	-.1
0	0	0	-.0	.0	-.1	-.1	-.0	-.0	-.0	-.0	-.0	-.1	.0	.4
0	0	0	-.1	-.0	-.0	.0	-.0	.1	-.0	.0	-.0	.2	.6	.9
0	0	0	-.0	.1	.1	.0	.0	.1	-.0	-.0	.2	.7	1.0	1.1
0	0	0	0	.0	-.0	-.0	-.1	.0	-.0	.4	.8	1.2	1.0	.9
0	0	0	0	0	-.0	.0	-.1	.1	.5	.9	1.2	1.0	.9	1.0
0	0	0	0	0	.1	-.1	.2	.8	1.0	1.1	1.0	1.0	1.0	1.1
0	0	0	0	0	0	.0	-.1	.8	1.1	1.0	1.0	1.0	1.0	1.0
0	0	0	0	0	0	0	.1	-.0	.9	.9	1.0	.9	1.0	1.0
0	0	0	0	0	0	0	-.0	-.1	.1	1.0	1.1	1.0	1.0	1.0
0	0	0	0	0	0	0	0	.0	-.0	-.0	1.0	.9	1.0	1.1
0	0	0	0	0	0	0	0	0	-.0	-.0	.1	.9	1.1	1.0
0	0	0	0	0	0	0	0	0	0	.0	-.1	-.0	.8	.8
0	0	0	0	0	0	0	0	0	0	0	-.0	.1	-.1	.2
0	0	0	0	0	0	0	0	0	0	0	0	0	.0	-.1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	.1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

-.0	.1	-.0	-.0	-.0	-.0	.0	.1	0	0	0	0	0	0	0
.0	.0	-.1	-.0	-.1	-.0	-.1	.0	-.1	.0	.1	.0	0	0	0
-.1	.1	.8	1.1	.9	.8	.6	.5	.2	-.0	-.1	-.1	.0	-.0	0
-.1	.1	.9	1.1	1.0	1.1	1.0	1.0	1.0	1.0	.7	.0	.0	.1	-.1
.0	.1	1.0	1.0	1.0	1.1	1.1	.9	1.0	1.1	.9	.1	-.1	.2	-.0
-.0	.0	.9	1.1	1.0	1.0	1.0	1.0	1.0	1.0	.6	.0	-.1	.1	-.1
-.1	.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.0	.2	-.1	.0	.0	-.1
.0	.1	1.0	.9	1.0	1.1	.9	1.0	1.0	1.0	.0	-.1	.1	.0	-.0
.0	.0	1.0	1.1	1.0	1.1	.9	1.1	1.0	.6	.0	-.1	.0	-.1	-.0
-.1	-.0	1.0	1.1	1.0	1.1	.9	1.0	1.0	.3	-.1	-.1	.0	-.0	.0
-.0	-.0	1.0	1.0	1.0	1.2	1.0	1.0	.9	.1	-.1	.0	.1	-.0	-.0
-.0	-.0	1.0	1.0	1.0	1.1	.9	1.0	.5	.1	-.0	-.0	-.0	.0	-.0
-.0	-.1	1.0	1.1	1.0	1.0	.9	1.1	.3	.0	.0	-.1	.0	-.0	-.1
.0	-.0	1.0	1.0	1.0	1.0	1.0	.9	.0	.1	.1	-.1	.1	-.1	.0
-.0	.0	1.0	1.0	.9	1.0	1.0	.6	.0	.1	-.0	-.0	.0	-.1	.4
-.1	.0	1.0	1.1	.9	1.1	1.0	.4	.0	.1	-.0	.0	-.2	.2	.9
-.1	-.0	1.0	1.1	1.0	1.1	.9	.1	-.1	.0	.0	-.1	.0	.7	1.1
-.1	.1	1.0	1.0	.8	1.2	.6	-.1	-.1	.1	-.1	-.0	.5	1.0	1.0
-.1	.0	1.0	1.1	.9	1.1	.2	-.1	.1	-.1	-.0	.2	.9	1.1	1.0
-.1	.0	.9	1.1	1.0	1.0	.1	.0	.1	-.1	.3	.9	1.0	1.0	.9
-.0	.0	.9	1.0	1.0	.8	-.0	-.0	.0	.1	.6	.9	1.0	1.0	1.0
-.1	.1	1.0	1.1	.9	.4	-.0	-.2	-.1	.4	.9	1.0	1.0	1.0	1.0
-.2	.1	.9	1.2	.9	.0	-.0	.0	.3	.9	1.1	.9	1.0	.9	.9
-.1	.2	.8	1.1	.6	.1	-.1	.2	.7	1.0	.9	1.1	.9	.6	.3
-.1	.1	.9	1.1	.3	-.0	.1	.5	.9	1.1	1.0	.9	.4	.1	-.1
-.2	-.0	1.0	1.1	.1	-.1	.5	.9	1.1	.9	.7	.3	-.1	.0	.1
.1	.1	.9	.8	-.2	.0	.8	1.1	.9	.5	.2	.0	-.2	-.0	.0
.4	.1	.9	.4	-.1	.8	1.3	.8	.5	.1	-.1	-.0	-.0	-.0	.1
.4	.1	1.0	.4	.5	1.1	.8	.0	-.1	-.0	.1	.0	.4	.8	1.0
.6	.4	.5	.5	.4	.5	-.1	-.2	.1	.3	.6	.9	.9	1.0	1.0
.6	.3	.6	.5	.5	.4	.4	.8	1.1	1.1	1.1	1.2	1.1	1.0	1.1
.4	.4	.6	.6	.5	1.0	.9	.9	1.0	.9	.8	.9	1.0	.9	.9
.7	.6	.5	.4	.5	.2	.2	.2	.1	.2	.3	.2	.2	.1	.1
.5	.6	.4	.6	.6	.4	.4	.1	-.1	-.1	-.1	-.2	-.1	-.0	-.1
.5	.4	.6	.4	.6	.6	1.1	1.1	.9	.6	.2	.0	.1	-.1	.0
.5	.9	.2	.6	.4	-.1	.3	1.0	1.2	1.1	.9	.9	.5	.2	-.1
.5	.8	.1	.6	1.1	.1	-.4	.3	.6	.9	1.0	1.0	1.0	1.0	.9
.9	.8	.1	.2	1.2	.9	.2	-.1	.1	.6	.9	1.0	1.1	1.0	1.1
1.1	.9	-.0	-.1	1.0	1.2	.4	.1	-.1	.0	.4	.7	1.2	1.0	.8
1.1	.9	.0	-.1	.7	1.1	.9	.4	.0	-.1	-.1	.1	.7	.9	1.0
1.1	.7	.2	-.1	.4	.9	1.0	.8	.3	-.1	.2	-.1	.0	.5	.8
1.2	.8	.1	-.2	.1	1.0	1.0	1.1	.6	.0	-.1	.1	-.0	.0	.3
1.1	.9	.1	-.1	.1	.7	1.0	1.1	1.2	.6	.0	-.0	.0	-.0	-.1
1.0	.8	.0	-.0	-.0	.3	1.0	1.0	1.0	1.0	.4	.1	-.0	-.0	.0
1.1	.8	.0	-.1	.0	-.1	1.0	1.1	.8	1.0	.7	.1	-.0	.0	.2
1.1	.9	.0	-.2	.1	-.0	.8	1.1	.9	1.0	1.0	.7	.0	-.1	-.1
1.0	.8	.1	-.1	.1	-.1	.4	1.0	1.1	.9	1.0	1.0	.5	.0	-.0
1.1	.9	-.0	-.1	.1	-.2	.2	.9	1.0	.9	1.0	1.2	.9	.3	-.0
1.1	.9	.0	-.1	.0	-.1	-.0	.8	1.0	.9	1.0	1.0	1.2	.7	.1
1.0	.9	.0	-.0	.1	-.0	-.0	.4	1.1	1.0	1.0	1.0	1.0	1.1	.5
1.0	.9	-.0	-.0	-.0	-.1	-.0	.2	1.0	1.0	1.0	1.1	1.0	1.1	1.0
1.1	.9	-.1	-.0	.0	.0	.1	-.0	.7	.9	1.0	1.1	.9	1.0	1.1
1.0	.9	-.0	-.0	.0	-.1	.1	-.0	.5	.9	1.0	1.0	1.1	1.0	.9
1.0	.9	-.0	-.0	.0	-.1	.1	-.1	.1	1.0	1.1	1.0	1.0	1.0	1.0
1.1	.9	-.0	-.0	.1	-.1	.1	-.1	-.0	.7	1.1	1.1	1.0	1.0	1.0
1.1	.9	.0	.0	.0	-.1	.1	-.0	-.0	.4	1.0	1.0	1.0	1.1	1.1
.9	.9	.1	.0	.0	-.1	.1	.0	.0	.1	1.0	1.1	.9	1.0	1.0
1.0	.9	.0	-.0	.0	-.1	.1	-.0	-.0	.0	.8	1.1	1.0	.9	1.0
1.1	.8	.0	-.1	-.0	-.1	-.0	.0	-.1	-.0	.4	1.0	1.1	1.0	1.1
1.0	.9	.1	-.0	.1	-.0	-.0	.1	-.0	-.0	.1	1.0	1.1	.6	.3
1.1	.8	.1	-.1	-.0	.0	-.0	-.0	-.0	.0	.0	.5	.2	-.1	-.0
1.2	.8	.1	-.1	.0	-.1	.0	-.0	.0	.0	-.1	.0	-.1	.0	0
-.0	-.1	.0	-.0	.0	-.0	.0	-.0	.1	-.0	.0	.0	0	0	0
-.0	-.0	.1	.0	-.0	.0	-.1	-.0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0	-.1	-.0	.0	.0
0	0	0	0	0	0	0	.0	-.0	-.0	.1	-.0	.1	-.0	.0
0	0	0	0	0	.0	-.1	.0	-.1	.0	.0	-.0	.0	-.1	.0
0	0	.0	.1	-.0	-.1	.2	.3	.0	.0	-.0	-.0	-.0	.0	-.0
0	-.0	-.1	-.1	.2	.6	1.1	.9	-.0	-.0	.0	.1	-.0	-.0	.0
-.0	-.1	.2	.8	1.1	.9	1.2	1.0	.3	-.1	-.1	.0	-.0	-.0	.0
.2	.8	.9	.9	1.0	.9	1.0	1.0	.7	.0	-.0	-.0	.0	-.1	.0
1.0	1.1	1.1	1.1	1.0	1.0	.9	1.1	.9	.0	-.0	.0	.1	-.1	.0
.9	1.0	.9	1.0	1.1	1.1	1.0	1.0	1.0	.3	-.0	.0	.1	-.1	.0
.5	1.0	1.0	.9	1.0	1.0	1.0	1.1	1.1	.5	-.0	-.0	.1	-.1	.1
.1	.7	1.1	1.0	1.0	1.0	1.0	.9	1.1	.9	.0	-.1	.1	-.1	.0
-.1	.2	.8	1.0	1.0	1.0	1.0	1.0	1.0	.9	.4	-.0	.1	-.1	.0
-.0	-.2	.4	.9	1.1	1.0	.9	1.1	1.0	.9	.6	-.0	.1	-.0	.0
.1	.0	.0	.4	1.0	1.1	.9	1.1	1.0	1.0	.9	.1	-.0	-.1	-.0
-.0	-.0	-.0	.2	.6	1.1	1.0	1.0	1.0	1.0	1.1	.3	-.0	-.0	.0
.0	-.0	.0	-.1	.2	.9	1.1	1.0	1.0	.9	1.0	.6	.0	-.1	.1
-.0	.0	.0	-.1	-.1	.5	.9	1.1	1.0	.9	1.0	.8	.1	-.2	.1
.0	.0	-.1	.1	-.0	.0	.7	1.0	1.0	.9	1.1	1.0	.3	-.1	.1
-.1	-.0	.0	-.1	-.1	-.1	.1	.9	1.0	1.0	.9	1.1	.6	-.0	.1
.1	-.0	-.0	-.1	.2	.0	-.1	.3	.8	1.0	.8	1.1	.9	-.1	.0
.7	.3	.0	-.1	.0	-.0	-.0	.0	.5	.9	1.0	1.0	1.0	.1	-.1
1.2	.9	.5	.0	-.0	-.0	.0	-.0	.0	.7	1.2	1.1	1.0	.5	.1
1.0	1.2	1.0	.7	.1	.1	-.0	.1	-.1	.1	.7	1.0	1.0	.9	.0
1.0	1.0	1.0	1.0	.7	.3	.0	-.1	.2	-.1	.4	.9	1.0	.9	.2
.9	.9	.9	1.0	1.0	.9	.6	.0	-.1	-.1	.0	.6	.9	1.1	.6
1.0	1.0	1.1	.9	.8	1.0	1.2	.6	.3	.0	-.1	.1	.6	1.2	.9
.8	.9	1.0	1.1	1.1	1.0	1.1	1.1	.8	.4	.1	-.1	.3	1.0	1.1
.0	.2	.4	.8	1.0	1.0	1.0	1.0	1.0	.9	.4	.2	-.4	.3	1.1
-.1	-.2	-.1	-.0	-.1	.3	.7	1.0	.9	1.1	1.2	.9	.1	-.1	.6
.0	.1	.1	.1	.0	-.0	.1	.1	.4	.7	1.0	1.2	1.1	.4	.6
-.1	-.1	-.1	-.2	-.1	-.0	-.1	-.2	-.1	-.1	-.1	.2	.6	.6	.4
.0	-.0	.1	.0	.0	.0	.1	.1	.2	.0	-.0	.1	.1	.2	.6
1.0	1.0	.9	1.0	.9	.9	1.0	.9	.8	1.0	1.0	.9	.9	1.0	.5
1.1	1.1	1.0	1.1	1.1	1.0	1.1	1.2	1.1	1.1	1.1	.9	.5	.5	.5
.9	1.0	.8	.9	1.0	1.0	.9	.9	.7	.4	.1	-.2	-.1	.5	.4
1.1	1.1	1.2	1.0	1.0	.9	.4	.1	.1	-.0	-.2	-.0	.7	1.1	.5
1.0	1.0	.7	.4	.2	-.0	-.0	-.0	-.1	.1	.5	.8	1.4	.7	-.1
.4	.1	-.1	-.1	-.0	-.0	-.2	.1	.2	.5	.9	1.1	.8	-.0	-.2
.0	-.1	-.1	.1	.1	-.0	-.1	.3	.7	1.0	1.1	.9	.5	-.2	.1
.1	.0	.1	-.0	-.1	.0	.4	.9	1.0	1.1	1.0	.5	.1	-.0	.4
.0	.0	-.1	-.0	.3	.5	.9	1.1	.9	1.0	.7	.2	-.1	.1	.7
-.0	-.1	-.0	.2	.8	.9	1.0	.9	1.1	.9	.3	.1	-.0	.1	.9
-.2	.0	.5	.9	1.0	1.0	1.0	1.0	.9	.4	-.1	-.2	-.0	.4	.9
.2	.6	1.0	1.1	1.0	1.0	1.0	.9	.5	.1	-.0	-.0	-.0	.9	1.0
.9	1.1	1.0	1.0	.9	1.0	1.0	.8	.3	-.1	.1	-.0	.2	1.0	1.0
1.1	1.0	1.0	1.0	1.0	1.1	.9	.2	-.0	-.0	.1	-.1	.4	1.0	.9
1.0	1.0	1.1	1.0	1.0	1.0	.5	-.0	-.1	.1	-.1	-.1	.7	1.2	.8
1.0	1.0	1.0	1.0	1.1	.6	.0	-.1	.0	.0	-.1	.1	1.0	1.1	1.0
1.0	1.0	1.0	1.1	.9	.2	-.2	-.0	.0	.1	.0	.4	1.0	1.1	.9
1.0	.9	1.1	.9	.4	-.1	.0	-.0	-.0	.0	.0	.6	1.0	1.0	.9
.9	1.0	1.0	.6	.0	-.1	.0	-.1	.1	.1	.0	.9	1.0	1.0	1.0
1.0	1.2	.7	.2	-.1	-.0	.1	-.1	.0	.0	.3	1.1	.9	1.0	.9
1.2	.8	.2	-.0	-.0	.0	-.0	-.0	-.0	.1	.6	1.0	.9	1.1	1.0
.9	.4	-.0	.0	-.0	-.0	.1	.0	-.1	.1	.9	1.0	1.0	1.2	.9
.5	-.0	-.0	-.0	.0	-.0	.0	-.1	-.1	.4	1.0	1.1	.9	1.1	.9
.1	.0	.1	.1	-.0	-.1	.0	-.1	.0	.6	1.0	1.1	.9	1.1	1.0
-.1	-.1	.0	-.0	-.0	.0	.1	-.1	.1	1.0	1.0	.9	.9	1.1	1.0
.0	-.0	.0	.0	-.1	.1	.0	-.1	.3	1.0	1.1	1.0	1.0	1.1	.9
-.0	-.0	.1	-.0	-.1	.1	-.1	.0	.7	1.0	1.0	1.0	1.0	1.0	1.0
0	.0	.1	-.0	.0	.2	-.2	.1	1.0	1.0	1.0	.9	1.1	1.1	1.0
0	0	-.0	-.1	-.0	.1	.0	.1	.9	1.1	1.0	1.0	1.0	1.1	1.0
0	0	0	0	0	.0	.0	-.1	-.1	.0	.3	.6	.7	.9	1.0
0	0	0	0	0	0	0	.0	.1	.0	-.1	.0	-.1	-.1	-.1
0	0	0	0	0	0	0	0	0	0	0	.1	.0	.0	-.0

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-.1	-.0	0	0	0	0	0	0	0	0	0	0	0	0	0
.0	.1	.0	0	0	0	0	0	0	0	0	0	0	0	0
-.0	.1	-.0	-.0	.1	0	0	0	0	0	0	0	0	0	0
.0	.0	-.1	.0	-.1	.0	0	0	0	0	0	0	0	0	0
-.0	.0	-.1	-.1	.1	-.1	.1	.0	0	0	0	0	0	0	0
.1	.0	.0	.2	.8	.6	-.1	-.1	.1	0	0	0	0	0	0
-.0	-.0	-.1	.5	1.0	1.1	.7	.1	-.0	-.0	0	0	0	0	0
-.0	-.0	.5	.9	1.1	1.0	.9	.8	-.1	-.0	.1	0	0	0	0
-.0	.3	.8	1.2	1.0	1.0	1.0	1.0	.8	.1	-.1	.0	0	0	0
.2	.7	1.2	1.0	1.0	1.0	.9	1.0	.9	.7	-.1	.1	0	0	0
.6	1.0	1.0	.9	1.0	1.0	1.0	1.0	1.0	1.1	.6	-.1	.0	0	0
.9	1.1	.9	1.0	1.1	1.0	1.0	1.0	1.1	1.0	.8	.1	-.1	.1	0
1.1	1.0	1.0	1.0	1.0	.9	1.0	1.2	.9	.5	.2	-.1	.0	-.0	0
1.0	1.0	1.0	1.0	.9	1.0	1.1	.8	.5	-.1	.0	-.1	-.1	-.0	.0
1.0	1.1	1.0	1.0	1.1	1.0	.7	.3	-.0	-.0	.0	.0	.0	.1	.1
1.0	1.0	1.0	1.1	.9	.6	.2	-.0	-.0	-.0	.1	-.0	.0	-.0	.0
1.0	1.0	1.1	.9	.4	.0	-.1	-.0	-.0	.0	-.0	-.0	-.1	-.1	-.0
1.1	1.0	.7	.2	-.1	-.1	-.0	.0	-.0	-.0	-.1	.0	.0	.1	.2
.9	.5	-.0	-.2	.0	.1	.0	-.0	.1	.0	.0	.1	.0	-.1	-.1
.2	-.0	-.1	.0	-.0	-.1	-.1	-.0	.0	-.1	-.1	-.1	-.1	.0	.1
-.0	-.1	.0	-.0	-.0	.1	.0	-.0	-.1	-.1	.0	.0	.2	.6	.9
-.1	.1	.0	.0	.1	.1	.0	.1	.1	.3	.6	1.0	1.0	1.0	1.1
.1	-.1	-.1	.0	.0	.0	.3	.5	.9	1.0	1.0	1.0	1.1	1.0	1.0
-.1	-.1	.1	.4	.6	.9	1.1	1.0	1.0	1.1	1.1	1.0	1.0	1.0	.9
.2	.6	.9	1.0	1.0	1.0	.9	.9	1.0	.9	.9	.9	1.0	1.0	1.1
1.1	1.2	1.1	1.1	1.0	1.0	1.0	1.1	1.2	1.1	1.1	1.1	1.0	1.0	1.1
.9	.8	1.0	.9	.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.1	1.0	1.1	1.1	1.0	1.0	1.1	1.0	1.0	1.1	1.1	.9	1.0	1.1	1.0
1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	.9	1.0
.1	.2	.1	.1	.1	.1	.0	.1	.1	.1	.1	.2	.2	.2	.2
-.1	-.0	-.1	-.1	-.0	.0	-.0	-.0	-.0	-.1	.0	.0	-.1	-.0	-.0
.1	.1	.1	.1	.0	-.0	.0	.0	.0	.1	.0	.0	.0	.0	.0
-.0	-.1	-.2	-.1	-.0	-.1	-.0	-.1	-.1	-.1	-.1	-.1	-.1	-.0	-.0
.6	.3	.1	-.0	-.0	-.0	.1	.1	.1	.1	.1	.1	.0	-.0	-.0
1.1	1.0	.8	.6	.3	.1	-.0	-.0	-.1	-.0	.0	.0	-.0	.0	.1
1.0	1.1	1.0	1.0	1.1	.9	.6	.4	.0	-.0	-.0	-.0	-.0	-.1	.0
1.0	.9	.9	.9	1.0	1.0	.9	.9	.9	.5	.3	.0	.0	-.1	-.0
1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.0	.9	.7	.3	-.0
.9	1.0	1.1	1.0	1.0	1.1	1.1	1.0	.9	1.1	1.0	1.1	1.0	1.0	.9
.1	.7	.9	1.1	1.0	.9	.9	1.0	1.0	1.0	1.0	.9	1.0	1.2	1.1
-.1	.0	.5	.9	1.1	1.1	1.0	1.0	1.0	1.0	1.1	1.0	.9	.9	.6
-.1	-.0	-.1	.2	.6	1.0	1.1	1.0	1.0	1.0	1.1	1.0	1.0	1.1	.2
-.1	.1	-.0	-.1	.2	.4	.9	1.0	1.0	.9	1.0	1.1	.9	.8	-.1
.0	-.1	.0	.0	-.0	.0	.4	.8	1.1	1.0	.9	1.1	.9	.2	-.1
-.0	.0	.0	-.0	-.0	.0	-.2	.2	.7	1.0	1.0	1.0	.8	-.1	-.0
-.1	.0	-.0	.0	-.0	.1	-.0	-.1	.1	.5	.9	1.0	.2	-.0	0
.2	.0	-.0	-.0	-.1	-.0	-.0	.1	-.1	-.0	.3	.3	.0	-.1	0
.2	.0	.1	.1	.0	.1	-.0	-.1	.0	-.1	-.0	-.0	.0	0	0
.8	.2	-.1	-.0	-.0	-.0	.0	.0	.0	.0	.1	-.1	0	0	0
1.0	.7	.1	-.1	.1	-.1	.0	-.0	-.1	.0	-.0	.1	0	0	0
1.0	1.1	.5	.0	-.1	.0	.0	-.1	.1	-.1	-.0	0	0	0	0
1.0	1.0	1.0	.4	-.0	-.1	.0	-.0	-.1	.0	0	0	0	0	0
1.0	.9	1.1	.8	.1	-.0	.1	-.0	-.0	0	0	0	0	0	0
1.1	1.1	1.0	1.0	.2	-.1	-.1	.1	0	0	0	0	0	0	0
.9	1.0	.8	.2	.1	.0	0	0	0	0	0	0	0	0	0
.9	.3	-.1	-.0	-.1	0	0	0	0	0	0	0	0	0	0
-.1	-.2	.0	0	0	0	0	0	0	0	0	0	0	0	0
.1	.0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

```
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
 -.0    0    0    0
 -.1    0    0    0
 -.1    0    0    0
  .1  -.0    0    0
  .0   .0    0    0
  .0  -.1   .0    0
  .7  -.1   .1    0
 1.0  -.0   .0    0
 1.0   .2  -.1    0
 1.0   .5   .0   .1
 1.0   .6  -.1   .0
 1.1   .8  -.0  -.0
 1.0   .9  -.1  -.0
 1.1  1.1  -.0  -.0
  .9   .8  -.1  -.0
  .2   .2   .1   .1
 -.1  -.1  -.0  -.0
 -.0   .0   .0   .0
  .0  -.1  -.0  -.0
 -.0   .0   .1  -.0
 -.0  -.0  -.0  -.1
 -.0   .0   .1    0
  .0   .0  -.0    0
  .0  -.1  -.0    0
  .3   .0   .0    0
  .2  -.1    0    0
 -.1   .0    0    0
 -.0    0    0    0
  .1    0    0    0
  .0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
   0    0    0    0
```

6. Example 6 - Iterative Gradient

The program XGRADY uses the iterative gradient method with relaxation to reconstruct parallel-beam projection data. The simulated data are the same as in Example 5 where the conjugate gradient method of reconstruction was used. After 15 iterations the gradient method has a chi-square equal to 2730, whereas the conjugate gradient method has a chi-square six times smaller.

```
      PROGRAM XGRADY (INPUT,OUTPUT,TAPE2=OUTPUT)
C
C        EXAMPLE 6
C
C             THE PROGRAM XGRADY USES THE ITERATIVE GRADIENT ALGORITHM
C        TO RECONSTRUCT PARALLEL BEAM PROJECTION DATA.
C
      DIMENSION B(4096),AG(180)
      COMMON WORK(12000)
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C           LUNOUT  - OUTPUT FILE
C           I80132  - OUTPUT LINE LENGTH FLAG
C                 =0     EACH LINE WILL BE WITHIN 80 CHARACTERS
C                          (OTHERWISE 132 CHARACTERS)
C
      COMMON/PARM/IPAR(12),PAR(3)
C
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)),
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)),
     2            (IMIT  ,IPAR( 7)),(NWORK ,IPA9( 8)),(NFLOAT,IPAR( 9)),
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)),
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3))
C
C
      EXTERNAL BRF,PRF
C
      LUNOUT=2
      I80132=0
C
C        THE INPUT PARAMETERS ARE
C
      NDIMU=64
      ICIR=0
      IGEOM=0
      NANG=72
      MODANG=4
      KDIMU=100
      IMIT=1
      NWORK=12000
      NFLOAT=1
      ISTORE=0
      IPRINT=5
      LUNATN=0
      PWID=1.
      AXISU=50.5
      RFAN=0.
C
      CALL SETUP (IPAR,PAR,AG)
C
      ISTP=15
      IRLX=1
      IERR=0
      IZER=0
C
      CALL GRADY (B,PRF,BRF,ISTP,IPLX,IERR,IZER)
C
      CALL ARRAY (B,NDIMU)
```

```
C
C         PRINTOUT THE VALUES FOR THE RECONSTRUCTED TRANSVERSE SECTION
C
      NMAT=NDIMU**2
      KK1=1
      KU=NDIMU/15+1
      DO 12 K=1,KU
      WRITE (2,14)
      KK2=15*K
      IF (KK2.GT.NDIMU) KK2=NDIMU
      DO 10 J=1,NDIMU
      ISUB1=NMAT-J*NDIMU+KK1
      ISUB2=NMAT-J*NDIMU+KK2
   10 WRITE (2,16) (B(I),I=ISUB1,ISUB2)
      KK1=KK2+1
   12 CONTINUE
C
C
C
   14 FORMAT(1X///////)
   16 FORMAT(1X,15F5.1)
      END
      SUBROUTINE GETUM (M,DATA,ERR)
C
C        EXAMPLE 6
C
C              THE SUBROUTINE GETUM GIVES SIMULATED PROJECTION DATA FOR
C        A PIE PHANTOM.
C
      DIMENSION B(4096),DATA(1),ERR(1)
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C           LUNOUT  - OUTPUT FILE
C           I80132  - OUTPUT LINE LENGTH FLAG
C                 =0    EACH LINE WILL BE WITHIN 80 CHARACTERS
C                          (OTHERWISE 132 CHARACTERS)
C
      COMMON/PARM/IPAR(12),PAR(3)
C
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)),
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)),
     2            (IMIT  ,IPAR( 7)),(NWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)),
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)),
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3))
C
C
      DATA R,X1,Y1,Z,INTFR,NSLIPI,ISTART/30.,0.,0.,1.,10,10,1/
      EXTERNAL PLL
C
      IF (M.NE.1) GO TO 10
C
      CALL PIE (B,NDIMU,R,X1,Y1,Z,INTFR,NSLIPI,ISTART)
C
      CALL ARRAY (B,NDIMU)
C
   10 CALL PJECT (B,DATA,M,PLL)
C
      RETURN
C
      END
```

```
     SSS   EEEEE TTTTT U    U PPPP
    S      E       T   U    U P    P
     SSS   EEE     T   U    U PPPP
        S  E       T   U    U P
     SSS   EEEEE   T    UUU   P
```

INTEGER PARAMETER ARRAY (IPAR)

I	IPAR(I)	DESCRIPTION
1	64	LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
2	0	RECONSTRUCT IN A CIRCULAR ARRAY
3	0	GEOMETRY FLAG
		PARALLEL BEAM GEOMETRY
4	72	NUMBER OF PROJECTION ANGLES
5	4	MODE FOR PROJECTION ANGLE INPUT (SEE FOLLOWING LINES)
		ANGLES GENERATED BETWEEN ZERO AND PI
		STARTING AT ZERO
6	100	NUMBER OF RAYS FOR EACH PROJECTION
7	1	TRANSMISSION DATA
8	12000	DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
9	1	NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10	0	EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11	5	PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES)
		PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED
		PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
12	0	LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE

FLOATING POINT PARAMETER ARRAY (PAR)

I	PAR(I)	DESCRIPTION
1	1.000	PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
2	50.500	LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
3	0 NA	NOT APPLICABLE (NOT FAN BEAM GEOMETRY)

```
BLANK COMMON REQUIRED        72    (    110)

BLANK COMMON REQUIRED       144    (    220)

BLANK COMMON REQUIRED       216    (    330)

BLANK COMMON REQUIRED       416    (    640)

BLANK COMMON REQUIRED       544    (   1040)

A TOTAL OF  68 ( 17 THRU  84) OF THE 100 USER PROJECTION BINS WILL BE USED

 68 PROJECTION BINS WILL BE USED OF WHICH    0 HAVE BEEN ZEROED BY THE PROGRAM

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=    544 FLOATING POINT WORDS.
```

```
     EEEEE N    N DDDD         SSS   EEEEE TTTTT U    U PPPP
     E     NN   N D   D       S      E       T   U    U P    P
     EEE   N N  N D   D        SSS   EEE     T   U    U PPPP
     E     N   NN D   D           S  E       T   U    U P
     EEEEE N    N DDDD         SSS   EEEEE   T    UUU   P
```

```
      GGG  RRRR    AAA  DDDD  Y   Y
     G   G R   R  A   A D   D  Y Y
     G     RRRR   A   A D   D   Y
     G  GG R  R   AAAAA D   D   Y
      GGGG R   R  A   A DDDD    Y
```

PARAMETERS FOR SUBROUTINE GRADY

```
                  DESCRIPTION

ISTP -      15    NUMBER OF ITERATION STEPS
IRLX -       1    ITERATIVE RELAXATION METHOD
IERR -       0    DO NOT USE ERROR ARRAY
IZER -       0    INITIAL SOLUTION IS ZERO

BLANK COMMON REQUIRED       616    (   1150)

BLANK COMMON REQUIRED      1775    (   3357)
```

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	UNIFORM SQUARE	NO	NO
PRJ	PROJECTION	UNIFORM SQUARE	NO	NO

```
BLANK COMMON REQUIRED      1911    (   3567)

BLANK COMMON REQUIRED      5139    (  12023)

BLANK COMMON REQUIRED      8367    (  20257)

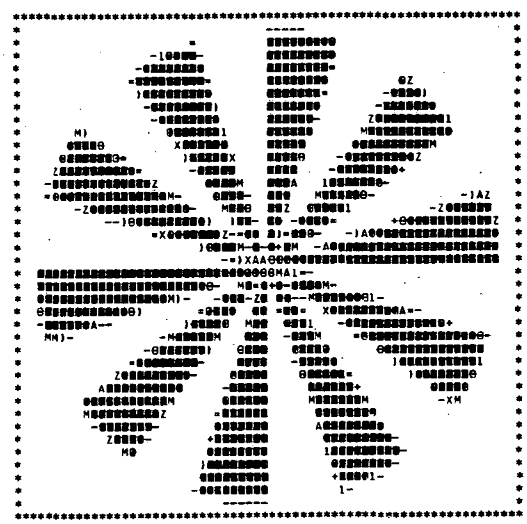
BLANK COMMON REQUIRED     11595    (  26513)
```

```
     PPPP   III  EEEEE
     P   P   I   E
     PPPP    I   EEE
     P       I   E
     P      III  EEEEE
```

```
PIE PHANTOM GENERATED
ARRAY SIZE    64X 64
CIRCLE RADIUS    30.00  AT  (   0,   0)
INT FACTOR   10
SECTOR WIDTH     .314
```

```
     EEEEE N    N DDDD        PPPP   III  EEEEE
     E     NN   N D   D       P   P   I   E
     EEE   N N  N D   D       PPPP    I   EEE
     E     N   NN D   D       P       I   E
     EEEEE N    N DDDD        P      III  EEEEE
```

```
XMIN =          0     XMAX =     .10E+01     XSUM =     .1413E+04
```



```
                -            =            +            )            1            Z
      0  .7500E-01  .1850E+00  .2350E+00  .2700E+00  .3100E+00  .3500E+00

Z          X          A          M          θ          @          ■          ■
 .3850E+00  .4100E+00  .4350E+00  .4900E+00  .5450E+00  .5800E+00  .6200E+00

@          ■          ■          ■          ■          ■          ■          ■
 .6550E+00  .7300E+00  .8200E+00  .8700E+00  .9100E+00  .9500E+00  .9850E+00

■
 .1000E+01
```

```
PPPP       J EEEEE  CCC  TTTTT
P   P      J E     C   C   T
PPPP       J EEE   C       T
P      J   J E     C   C   T
P       JJJ  EEEEE  CCC    T
```

BLANK COMMON REQUIRED   11663   (26617)

BLANK COMMON REQUIRED   11595   (26513)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 11663 FLOATING POINT WORDS.

```
EEEEE N    N DDDD        PPPP       J EEEEE  CCC  TTTTT
E     NN   N D   D       P   P      J E     C   C   T
EEE   N N  N D   D       PPPP       J EEE   C       T
E     N  N N D   D       P      J   J E     C   C   T
EEEEE N    N DDDD        P       JJJ  EEEEE  CCC    T
```

FOR CONGR AND GRADY FCN IS THE VALUE OF THE CHI-SQUARE
FOR ENTPY FCN IS EVALUATED BY THE SUBROUTINE DULFC

ITER	0	FCN	.274E+07
ITER	1	FCN	.140E+06
ITER	2	FCN	.207E+05
ITER	3	FCN	.132E+05
ITER	4	FCN	.102E+05
ITER	5	FCN	.868E+04
ITER	6	FCN	.747E+04
ITER	7	FCN	.650E+04
ITER	8	FCN	.570E+04
ITER	9	FCN	.504E+04
ITER	10	FCN	.448E+04
ITER	11	FCN	.401E+04
ITER	12	FCN	.362E+04
ITER	13	FCN	.328E+04
ITER	14	FCN	.298E+04
ITER	15	FCN	.273E+04

BLANK COMMON REQUIRED   11459   (26303)

BLANK COMMON REQUIRED   8231   (20047)

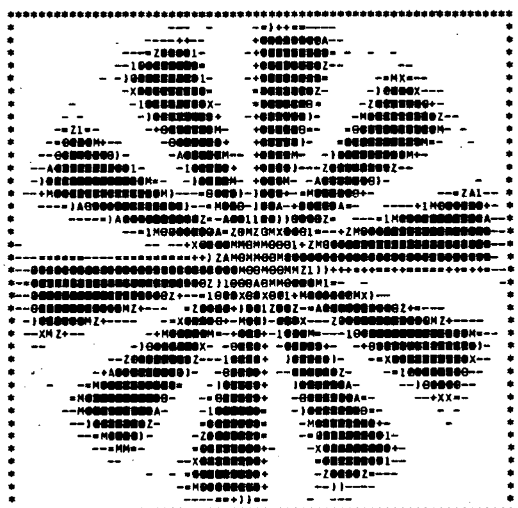
BLANK COMMON REQUIRED   5003   (11613)

BLANK COMMON REQUIRED   1775   (3357)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 11663 FLOATING POINT WORDS.

```
EEEEE N    N DDDD         GGG  RRRR   AAA  DDDD  Y   Y
E     NN   N D   D       G   G R   R A   A D   D  Y Y
EEE   N N  N D   D       G     RRRR  A   A D   D   Y
E     N  N N D   D       G  GG R  R  AAAAA D   D   Y
EEEEE N    N DDDD         GGGG R   R A   A DDDD    Y
```

XMIN =   -.84E-01   XMAX =   .11E+01   XSUM =   .1418E+04



symbol		-	=	+	)	1	Z
value	-.8423E-01	.4960E-02	.1358E+00	.1952E+00	.2369E+00	.2844E+00	.3320E+00
symbol	Z	X	A	M	θ	●	●
value	.3736E+00	.4034E+00	.4331E+00	.4985E+00	.5639E+00	.6055E+00	.6531E+00
symbol	●	●	●	●	●	●	●
value	.6947E+00	.7839E+00	.8910E+00	.9504E+00	.9980E+00	.1046E+01	.1087E+01
symbol	●						
value	.1105E+01						

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	.0
0	0	0	0	0	0	0	0	0	0	0	0	0	.1	.1
0	0	0	0	0	0	0	0	0	0	0	.0	-.0	.0	.3
0	0	0	0	0	0	0	0	0	0	-.0	-.0	.0	.0	.3
0	0	0	0	0	0	0	0	0	.0	-.0	-.0	-.0	-.0	.1
0	0	0	0	0	0	0	0	-.0	-.0	.0	-.1	-.0	-.0	.0
0	0	0	0	0	0	0	.0	-.0	-.0	-.0	-.0	-.0	-.0	.0
0	0	0	0	0	0	0	-.0	.0	-.0	-.0	-.0	.0	-.0	-.0
0	0	0	0	0	0	.0	-.0	.0	-.0	-.0	-.0	-.0	.0	-.0
0	0	0	0	0	.0	.1	.2	.2	.1	.0	-.0	-.0	-.0	-.0
0	0	0	0	0	.1	.3	.7	.7	.4	.2	.0	-.0	-.0	-.0
0	0	0	0	.0	.1	.6	.9	1.0	.8	.5	.2	.0	.0	-.0
0	0	0	.0	.0	.4	.8	1.0	1.0	1.0	.9	.6	.3	.1	.0
0	0	0	.1	.2	.7	.9	1.1	1.0	1.0	1.0	.9	.8	.4	.2
0	0	0	.1	.4	.9	1.0	1.0	1.1	1.0	1.0	1.0	1.0	.8	.5
0	0	.1	.1	.6	1.0	1.0	1.0	1.1	1.1	1.0	1.0	1.0	1.0	.9
0	0	.1	.3	.8	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.0
0	.0	.1	.3	.7	.9	1.0	1.0	1.0	1.1	1.0	1.1	1.0	1.0	1.0
0	.0	-.0	.1	.2	.5	.7	.8	.9	1.0	1.0	1.0	1.0	1.0	1.0
0	-.0	.0	.0	.1	.1	.2	.3	.4	.6	.8	.8	.9	1.0	1.0
0	.0	.0	-.0	-.0	-.1	-.0	.1	.1	.1	.3	.5	.6	.8	.9
-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	.0	.1	.2	.3	.5
-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	.0	.0	-.0	-.0	.0	.0	.1
.0	-.0	-.0	-.0	-.0	-.0	-.1	-.1	-.1	-.1	-.1	-.1	-.0	-.1	-.1
.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
.0	-.0	-.0	-.0	.0	-.0	-.0	.0	.0	-.0	-.0	-.0	-.0	.0	-.0
.0	.1	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
.0	.1	.6	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8
.0	.2	.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
.0	.2	.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
.0	.2	.7	1.0	1.1	1.0	1.0	1.1	1.0	1.1	1.1	1.1	1.0	1.0	1.1
.0	.1	.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.0
.0	.1	.5	.9	1.0	1.0	1.1	1.0	1.1	1.0	1.0	.9	.9	.7	.6
0	.1	.4	.9	1.0	1.1	1.1	1.0	.9	.8	.8	.6	.4	.3	.2
0	.1	.2	.8	.9	.9	.9	.8	.6	.4	.3	.2	.1	.1	.0
0	.0	.1	.6	.7	.6	.4	.2	.2	.1	-.0	-.0	-.0	-.0	-.0
0	.0	.0	.2	.2	.2	.1	-.0	-.0	-.0	-.0	-.1	-.1	-.1	-.1
0	0	.0	.0	-.0	-.0	.0	-.0	-.0	-.0	.0	-.0	-.0	-.0	-.0
0	0	.0	.0	.0	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0	.1
0	0	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	.0	.2	.4
0	0	0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	.0	.1	.3	.5	.8
0	0	0	-.0	.0	-.0	-.0	-.0	-.0	.0	.1	.3	.6	.9	1.0
0	0	0	0	.0	-.0	-.1	-.0	.0	.2	.4	.7	1.0	1.0	1.0
0	0	0	0	0	-.0	-.0	.0	.2	.5	.8	1.0	1.0	1.0	1.0
0	0	0	0	0	.0	-.0	.2	.6	.9	1.0	1.0	1.1	1.0	1.0
0	0	0	0	0	0	.0	.1	.6	.9	1.0	1.0	1.1	1.1	1.0
0	0	0	0	0	0	0	.1	.2	.7	.9	1.0	1.0	1.1	1.1
0	0	0	0	0	0	0	.0	.1	.3	.7	.9	1.0	1.0	1.0
0	0	0	0	0	0	0	0	.0	.1	.3	.7	.9	1.0	1.0
0	0	0	0	0	0	0	0	0	.0	.1	.3	.7	.9	.9
0	0	0	0	0	0	0	0	0	0	.0	.1	.2	.6	.6
0	0	0	0	0	0	0	0	0	0	0	.0	.1	.1	.2
0	0	0	0	0	0	0	0	0	0	0	0	0	.0	-.0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	.0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0	-.0	-.0	-.0	.0
0	0	0	0	0	0	0	.0	-.0	-.0	.0	-.0	-.0	-.0	-.0
0	0	0	0	0	.1	.0	.0	-.0	-.0	.0	-.0	-.0	-.0	-.0
0	0	.0	.1	.1	.1	.3	.3	.1	.0	-.0	-.0	-.0	-.0	-.0
0	.0	.0	.1	.4	.6	.8	.7	.2	.0	-.0	-.0	-.0	-.0	-.0
.1	.1	.4	.6	.9	.9	1.0	.9	.4	.1	-.1	-.0	-.0	-.0	-.0
.3	.6	.8	.9	1.0	1.0	1.0	1.0	.6	.1	-.0	-.0	-.0	-.1	-.0
.7	.9	1.0	1.0	1.0	1.0	1.0	1.0	.8	.2	.0	-.0	-.0	-.1	-.0
.7	1.0	1.0	1.0	1.1	1.1	1.0	1.0	.8	.4	.1	-.0	-.0	-.1	-.0
.5	.9	1.0	1.0	1.0	1.1	1.0	1.1	1.0	.5	.1	-.0	.0	-.1	-.0
.2	.6	.9	1.0	1.0	1.0	1.0	1.0	1.0	.7	.2	.0	-.0	-.1	-.0
.0	.3	.7	.9	1.0	1.0	1.1	1.1	1.0	.8	.4	.1	-.0	-.1	-.0
-.0	.1	.4	.8	1.0	1.0	1.0	1.0	1.0	.9	.5	.1	-.0	-.0	-.0
-.0	.0	.1	.5	.9	1.0	1.0	1.0	1.0	1.0	.7	.2	-.0	-.1	-.0
-.0	-.0	.0	.3	.6	1.0	1.0	1.0	1.0	1.0	.8	.4	.0	-.1	-.1
-.0	-.0	-.0	.0	.3	.7	1.0	1.1	1.0	1.0	.9	.6	.1	-.1	-.0
-.0	-.0	-.0	-.0	.1	.5	.8	1.1	1.0	1.0	1.0	.7	.2	-.1	-.0
-.0	-.0	-.1	-.0	-.0	.2	.6	.9	1.0	1.0	1.0	.9	.4	.0	.0
.0	-.0	-.0	-.1	-.0	-.0	.3	.7	.9	1.0	1.0	.9	.6	.1	.0
.2	.1	-.0	-.1	.0	-.0	.1	.4	.8	.9	1.0	1.0	.7	.2	-.0
.7	.4	.1	-.0	-.0	-.1	.0	.1	.5	.8	1.0	1.0	.8	.3	-.0
1.0	.8	.5	.2	.0	-.0	-.0	.0	.2	.6	1.0	1.0	.9	.5	.1
1.0	1.0	.9	.6	.3	.1	.0	.0	.0	.3	.7	1.0	1.0	.7	.2
1.0	1.0	1.0	.9	.7	.4	.2	.0	.0	.1	.4	.8	.9	.8	.3
1.0	1.0	1.0	1.0	.9	.8	.5	.2	.0	.0	.2	.5	.8	.9	.5
.9	1.0	1.0	1.0	1.0	1.0	.9	.6	.3	.1	.1	.2	.6	.9	.7
.6	.8	.9	1.0	1.0	1.0	1.0	.9	.7	.4	.2	.1	.3	.7	.8
.1	.3	.5	.7	.8	.8	.9	1.0	.9	.8	.5	.3	.1	.4	.7
-.1	-.0	.1	.1	.2	.4	.6	.8	.9	1.0	.9	.6	.3	.3	.5
-.1	-.0	.0	.0	.0	.0	.1	.2	.4	.6	.7	.8	.7	.5	.5
-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	.1	.1	.2	.4	.5	.5	.5
.2	.2	.2	.2	.2	.2	.2	.2	.3	.3	.3	.3	.4	.4	.6
.8	.8	.8	.8	.8	.8	.8	.8	.7	.8	.7	.7	.6	.6	.5
1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	.9	.9	.8	.6	.5	.5	.5
1.1	1.1	1.0	1.0	1.0	1.0	.9	.8	.7	.5	.4	.2	.3	.5	.5
1.1	1.0	1.0	.9	.8	.7	.5	.3	.2	.1	.1	.3	.6	.7	.5
.9	.8	.6	.4	.3	.2	.1	.0	.1	.2	.4	.7	.9	.6	.3
.4	.3	.1	.0	.0	-.0	-.0	.1	.3	.5	.8	.9	.7	.3	.2
.1	.0	-.0	.0	.0	.0	.1	.4	.6	.9	1.0	.8	.4	.1	.3
-.0	-.0	-.0	-.0	.1	.2	.4	.8	.9	1.0	.9	.5	.2	.1	.5
-.0	-.0	-.0	.1	.3	.5	.8	1.0	1.0	.9	.6	.3	.1	.2	.7
-.0	-.0	.1	.4	.7	.9	1.0	1.0	1.0	.7	.4	.1	.0	.3	.8
-.0	.2	.5	.8	.9	1.0	1.0	1.0	.8	.4	.1	-.0	.1	.5	.9
.3	.6	.8	1.0	1.0	1.1	1.0	.9	.5	.2	.0	-.0	.2	.7	1.0
.7	.9	1.0	1.0	1.0	1.0	.9	.7	.3	.1	.0	.0	.3	.8	1.0
1.0	1.0	1.0	1.1	1.0	1.0	.8	.4	.1	-.0	.0	.0	.4	.9	1.0
1.0	1.0	1.1	1.0	1.0	.8	.5	.1	-.0	-.0	-.0	.1	.6	1.0	1.0
1.0	1.0	1.0	1.0	.9	.6	.2	-.0	-.0	-.0	.0	.3	.8	1.0	1.0
1.1	1.0	1.0	1.0	.7	.3	-.0	-.0	-.0	-.0	.1	.4	.9	1.1	1.0
1.0	1.0	1.0	.8	.4	.1	-.0	-.1	-.0	.0	.2	.6	1.0	1.1	1.0
1.0	1.0	.9	.5	.2	-.0	-.0	-.1	-.0	.1	.3	.7	1.0	1.0	1.0
1.0	1.0	.6	.3	.0	-.0	-.0	-.1	-.0	.1	.4	.9	1.0	1.0	1.0
1.0	.7	.3	.1	-.0	-.0	-.0	-.1	-.0	.2	.6	.9	1.0	1.1	1.0
.8	.4	.1	.0	-.0	-.0	.0	-.0	-.0	.3	.8	1.0	1.1	1.1	1.0
.5	.2	.0	-.0	-.0	-.0	-.0	-.0	.1	.4	.8	1.0	1.0	1.1	1.0
.2	.0	-.0	-.0	-.0	-.0	-.0	-.0	.2	.6	.9	1.1	1.0	1.0	1.0
.0	-.0	-.0	-.0	-.0	.0	-.0	-.0	.3	.8	1.0	1.0	1.0	1.1	1.0
-.0	-.1	-.0	-.0	-.0	-.0	.0	.1	.4	.9	1.1	1.1	1.0	1.1	1.0
-.0	-.0	-.0	-.0	-.0	.0	-.0	.2	.6	.9	1.1	1.0	1.0	1.0	1.0
0	.0	.0	-.0	-.0	.0	-.0	.2	.7	.9	1.0	1.0	1.0	1.1	1.0
0	0	-.0	-.0	-.0	.0	.0	.2	.6	.8	.9	.9	1.0	1.0	1.0
0	0	0	0	0	.0	.0	.0	.1	.2	.4	.5	.6	.7	.8
0	0	0	0	0	0	0	.0	.0	.1	.1	.1	.1	.2	.1
0	0	0	0	0	0	0	0	0	0	0	.0	.0	.0	.0

.0	.0	.0	.0	.0	.0	.0	.0	0	0	0	0	0	0	0	0	0	0	0
-.0	.1	.1	.2	.1	.1	.1	.1	.0	.0	.0	.0	0	0	0	0	0	0	0
-.0	.2	.5	.8	.7	.7	.6	.5	.3	.2	.1	.0	.0	-.0	0	0	0	0	0
-.0	.2	.7	1.0	1.0	1.0	.9	.9	.8	.7	.5	.1	.0	.0	-.0	0	0	0	0
.0	.2	.8	1.0	1.0	1.1	1.0	1.0	1.0	.9	.7	.2	-.0	.0	-.0	0	0	0	0
-.0	.2	.8	1.0	1.0	1.0	1.0	1.0	1.1	.9	.6	.1	-.0	-.0	-.0	0	0	0	0
-.0	.2	.8	1.0	1.0	1.0	1.0	1.1	1.1	.8	.4	.0	.0	-.0	-.0	0	0	0	0
.0	.2	.8	1.0	1.0	1.1	1.0	1.0	1.0	.8	.2	-.0	-.0	.0	-.0	0	0	0	0
.0	.2	.8	1.0	1.0	1.0	1.0	1.1	.9	.6	.1	-.0	-.0	-.0	-.0	0	0	0	0
-.0	.2	.8	1.0	1.0	1.1	1.0	1.0	.8	.4	.0	-.0	-.0	-.0	-.0	0	0	0	0
-.0	.2	.8	1.0	1.0	1.1	1.1	1.0	.7	.3	-.0	-.0	.0	-.0	-.0	0	0	0	0
-.0	.2	.8	1.0	1.0	1.1	1.0	.9	.5	.2	-.0	-.1	-.0	-.0	-.0	0	0	0	0
.0	.2	.8	1.0	1.0	1.0	1.0	.9	.4	.1	-.0	-.1	-.0	-.0	.0	0	0	0	0
.0	.2	.8	1.0	1.0	1.0	1.0	.7	.2	.0	-.0	-.1	-.0	-.0	.2	0	0	0	0
-.0	.2	.8	1.0	1.0	1.1	.9	.5	.2	.0	-.0	-.1	-.0	.1	.4	0	0	0	0
-.0	.2	.8	1.0	1.0	1.1	.9	.4	.1	-.0	-.0	-.0	-.0	.3	.7	0	0	0	0
-.0	.2	.8	1.0	1.1	1.0	.8	.2	.0	-.0	-.0	-.0	.2	.6	.9	0	0	0	0
-.0	.2	.8	1.0	1.0	1.0	.6	.1	-.0	-.0	-.0	.1	.5	.9	1.0	-.0	0	0	0
-.0	.2	.8	1.0	1.0	.9	.4	.0	-.0	-.0	.1	.4	.8	1.0	1.0	-.0	0	0	0
-.0	.2	.8	1.0	1.0	.8	.3	.0	.0	.0	.3	.7	.9	1.0	1.0	-.0	0	0	0
-.0	.2	.8	1.0	1.0	.6	.2	-.0	.0	.2	.6	.9	1.0	1.1	1.0	.0	-.0	0	0
-.0	.2	.8	1.0	.9	.4	.1	-.0	.1	.5	.8	1.0	1.0	1.0	.9	.0	.0	0	0
-.0	.2	.8	1.0	.8	.2	.0	.1	.4	.8	1.0	1.0	1.0	.9	.7	.1	.0	.0	0
.0	.3	.7	.9	.6	.2	.1	.3	.6	.9	1.0	1.0	.8	.6	.3	.5	.1	.0	0
.1	.3	.7	.9	.4	.1	.2	.5	.9	1.0	.9	.8	.5	.2	.0	.7	.2	.0	0
.2	.3	.7	.8	.3	.1	.5	.8	1.0	.9	.6	.4	.1	.0	.0	.8	.3	.0	0
.3	.3	.7	.6	.2	.3	.7	.9	.8	.5	.3	.1	-.0	-.0	.0	.9	.5	.1	.0
.5	.4	.6	.5	.3	.6	.9	.7	.5	.2	.1	.0	.1	.2	.3	.9	.6	.1	.0
.5	.4	.6	.5	.5	.7	.6	.3	.1	.1	.2	.2	.4	.6	.8	1.0	.7	.1	.0
.5	.5	.4	.5	.5	.5	.3	.2	.3	.4	.6	.8	.9	1.0	1.0	1.0	.7	.1	.0
.6	.4	.5	.5	.5	.5	.5	.6	.8	.9	.9	1.0	1.0	1.0	1.0	1.0	.8	.2	.0
.5	.5	.5	.5	.5	.6	.6	.7	.7	.8	.8	.8	.8	.8	.8	.8	.6	.1	-.0
.5	.5	.5	.5	.5	.4	.4	.4	.3	.3	.3	.3	.3	.3	.3	.3	.2	.1	.0
.5	.5	.5	.6	.5	.5	.5	.3	.2	.1	.1	.0	-.0	.0	-.0	.0	-.0	-.0	.0
.5	.4	.5	.5	.5	.5	.7	.8	.7	.5	.3	.2	.1	-.0	-.0	-.0	-.0	-.0	.0
.5	.6	.4	.5	.5	.3	.4	.7	.9	.9	.8	.7	.5	.3	.2	-.0	-.0	-.0	-.0
.5	.6	.4	.5	.7	.3	.1	.3	.6	.8	.9	.9	.9	.8	.7	-.0	-.0	-.0	-.0
.6	.6	.3	.4	.8	.6	.3	.1	.2	.5	.8	1.0	1.0	1.0	1.0	-.0	-.0	-.0	-.0
.8	.7	.3	.2	.7	.9	.5	.2	.1	.2	.4	.7	1.0	1.0	1.0	-.0	.0	.0	0
.9	.7	.2	.1	.6	1.0	.8	.4	.1	.0	.1	.3	.6	.8	.9	.0	-.0	-.0	0
.9	.7	.3	.1	.4	.9	.9	.7	.3	.0	.0	.0	.2	.5	.8	.1	-.0	-.0	0
1.0	.7	.2	-.0	.2	.8	1.0	.9	.6	.2	.0	.0	.0	.1	.4	.3	.0	.0	0
1.0	.7	.2	-.0	.1	.6	.9	1.0	.9	.5	.2	.0	-.0	.0	.1	.3	.0	0	0
1.0	.7	.2	-.0	.0	.4	.8	1.0	1.0	.8	.4	.1	-.0	-.1	-.0	.1	.1	0	0
1.0	.7	.2	-.0	.0	.2	.8	1.0	1.0	.9	.7	.3	.0	-.0	.0	.1	0	0	0
1.0	.7	.2	-.0	.0	.1	.7	1.0	1.0	1.0	.9	.6	.2	-.0	-.1	.1	0	0	0
1.0	.7	.2	-.0	.0	.1	.5	.9	1.0	1.0	1.0	.9	.5	.1	-.0	.0	0	0	0
1.0	.7	.2	-.0	-.0	-.0	.3	.8	1.0	1.0	1.0	1.0	.8	.4	.1	0	0	0	0
1.0	.7	.2	-.0	-.1	-.1	.1	.6	.9	1.0	1.0	1.0	1.0	.7	.2	0	0	0	0
1.0	.7	.2	-.0	-.0	-.1	.1	.5	.9	1.0	1.0	1.0	1.0	.9	.5	0	0	0	0
1.0	.7	.2	-.0	-.0	-.1	.0	.3	.8	1.0	1.0	1.0	1.0	1.0	.8	0	0	0	0
1.0	.7	.2	-.0	-.0	-.0	.0	.2	.6	.9	1.0	1.0	1.0	1.0	1.0	0	0	0	0
1.0	.7	.2	-.0	-.0	-.1	-.0	.1	.5	.8	1.0	1.1	1.1	1.0	1.0	0	0	0	0
1.0	.7	.2	-.0	-.0	-.1	-.0	.0	.3	.8	1.0	1.0	1.0	1.0	1.0	0	0	0	0
1.0	.7	.2	-.0	-.0	-.1	.0	-.0	.1	.6	1.0	1.1	1.0	1.1	1.0	0	0	0	0
1.0	.7	.2	.0	-.0	-.1	.0	-.0	.1	.5	.9	1.0	1.0	1.1	1.1	0	0	0	0
1.0	.8	.2	.0	-.0	-.1	-.0	-.0	.1	.3	.8	1.0	1.0	1.0	1.0	0	0	0	0
1.0	.7	.2	-.0	-.0	-.1	-.0	-.0	-.0	.2	.7	1.0	1.0	1.0	1.0	0	0	0	0
1.0	.7	.2	-.0	-.0	-.0	-.0	-.0	-.1	.1	.5	.9	1.0	1.0	.9	0	0	0	0
1.0	.7	.2	.0	-.0	-.0	-.0	-.0	-.0	.1	.2	.7	.8	.6	.4	0	0	0	0
1.0	.7	.2	-.0	-.0	-.0	-.0	-.0	-.0	.0	.1	.3	.3	.1	.1	0	0	0	0
.8	.5	.2	-.0	-.0	-.0	-.0	-.0	.0	.0	-.0	.1	.1	.1	0	0	0	0	0
.2	.1	.1	-.0	-.0	-.0	-.0	-.0	.0	-.0	.0	.0	0	0	0	0	0	0	0
.0	-.0	.0	.0	.0	.0	-.0	-.0	0	0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-.0	-.0	0	0	0	0	0	0	0	0	0	0	0	0	0
-.0	.0	.0	0	0	0	0	0	0	0	0	0	0	0	0
-.0	-.0	-.0	-.0	.0	0	0	0	0	0	0	0	0	0	0
.0	-.0	-.1	-.0	-.0	.0	0	0	0	0	0	0	0	0	0
-.0	-.0	-.0	.0	.2	.1	.1	.0	0	0	0	0	0	0	0
-.0	-.0	.0	.3	.6	.5	.2	.0	.0	0	0	0	0	0	0
-.0	.0	.2	.5	.9	.9	.6	.2	.1	.0	0	0	0	0	0
.0	.1	.5	.8	1.0	1.0	.9	.7	.2	.1	.0	0	0	0	0
.1	.4	.7	1.0	1.0	1.0	1.0	.9	.7	.2	.0	.0	0	0	0
.3	.6	1.0	1.0	1.1	1.1	1.0	1.0	.9	.6	.2	.1	0	0	0
.5	.9	1.0	1.0	1.0	1.1	1.1	1.0	1.0	.9	.5	.1	.0	0	0
.8	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.0	.9	.6	.2	-.0	.0	0
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1.0	1.0	1.0	1.0	1.0	.9	.6	.4	.1	.0	-.0	-.0	-.0	-.0	.0
1.1	1.0	1.0	1.0	.8	.5	.3	.1	.0	-.0	-.0	-.0	.0	-.0	-.0
1.0	1.0	.9	.7	.4	.2	.0	-.0	-.0	-.0	-.0	-.0	-.1	-.0	-.0
1.0	.8	.6	.3	.1	-.0	-.0	-.0	-.0	-.0	-.0	.0	-.0	-.0	.0
.8	.5	.2	-.0	-.0	-.0	-.0	-.0	.0	-.0	-.0	-.0	.0	-.0	-.0
.4	.1	-.0	-.0	-.1	-.1	-.1	-.1	-.0	-.0	-.0	-.0	.0	.1	.2
.1	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	.0	.1	.2	.4	.6	.7
-.0	-.0	-.0	-.0	.0	.0	.1	.2	.3	.4	.6	.8	.8	.9	.9
-.0	-.0	.0	.1	.2	.2	.4	.5	.7	.8	.9	1.0	1.1	1.1	1.0
.0	.1	.2	.4	.5	.7	.9	.9	1.0	1.0	1.1	1.0	1.1	1.0	1.0
.4	.6	.8	.9	.9	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0
.9	1.0	1.0	1.1	1.1	1.0	1.0	1.1	1.1	1.1	1.0	1.1	1.0	1.0	1.1
1.0	1.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.0	1.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8	.8
.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3
-.0	-.0	-.0	-.0	.0	.0	.0	.0	-.0	-.0	.0	.0	.0	.0	.0
.0	.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0	-.0
.1	.0	-.1	-.1	-.1	-.1	-.0	-.1	-.1	-.1	-.1	-.1	-.1	-.0	-.0
.6	.4	.2	.1	.0	-.0	-.0	-.0	-.0	.0	-.0	-.0	-.0	-.0	-.0
.9	.9	.7	.6	.4	.2	.1	.1	.0	-.0	-.0	-.0	-.0	-.0	-.0
1.0	1.0	1.0	.9	.8	.7	.5	.4	.2	.1	.1	.0	-.0	-.1	-.0
1.0	1.0	1.0	1.0	1.0	1.0	.9	.8	.7	.5	.4	.2	.1	.1	.0
.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	.8	.8	.6	.4	.2
.7	.9	1.1	1.1	1.0	1.0	1.0	1.1	1.0	1.1	1.0	1.0	1.0	.9	.7
.3	.6	.8	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	.8
.0	.2	.5	.7	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.0	1.0	.9	.6
-.0	-.0	.1	.3	.6	.9	1.0	1.0	1.0	1.0	1.1	1.0	1.0	.9	.4
-.1	-.0	-.0	.0	.3	.5	.8	.9	1.0	1.0	1.0	1.0	.9	.6	.1
-.0	-.1	-.0	-.0	.0	.1	.4	.7	.9	1.0	1.0	1.0	.8	.4	.0
-.0	-.0	-.0	-.0	-.0	.0	.1	.3	.6	.9	1.0	.9	.6	.1	.0
.0	-.0	-.0	-.0	-.0	-.0	-.0	.0	.2	.5	.7	.7	.3	.1	0
.2	.0	-.0	-.0	-.0	-.0	-.0	.0	.0	.1	.3	.3	.1	.0	0
.4	.1	.0	-.0	-.0	.0	-.0	-.0	-.0	-.0	.0	.0	.1	0	0
.8	.3	.0	-.0	-.0	-.0	.0	-.0	-.0	-.0	.0	-.0	0	0	0
.9	.6	.2	.0	-.0	-.0	-.0	-.0	-.1	-.0	-.0	.0	0	0	0
1.0	.9	.5	.2	.0	-.0	-.0	-.0	.0	-.0	-.0	0	0	0	0
1.0	1.0	.8	.4	.1	-.0	-.0	-.0	-.0	.0	0	0	0	0	0
1.0	1.0	1.0	.7	.2	.0	.0	-.0	-.0	0	0	0	0	0	0
1.1	1.0	.9	.7	.2	-.0	-.0	.0	0	0	0	0	0	0	0
.9	.8	.6	.3	.1	.0	0	0	0	0	0	0	0	0	0
.7	.4	.1	.1	.0	0	0	0	0	0	0	0	0	0	0
.2	.0	.0	0	0	0	0	0	0	0	0	0	0	0	0
.1	.0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

7. Example 7 - Iterative Program for Fan-Beam Data

The program ITRFAN uses the conjugate gradient algorithm to reconstruct simulated fan-beam projection data from a transmission source using both a curved detector and a flat detector. The projection data for the curved detector are reconstructed by the algorithm CONGR at statement E7.061 and the projection data for the flat detector are reconstructed in statement E7.094. The geometry parameter IGEOM is set to 1 in statement E7.037 for the reconstruction of the curved detector data and set to 2 in statement E7.082 for the reconstruction of the flat detector data. Note that a change in the parameters for IPAR or PAR requires another call to SETUP. For this particular example the fan-beam source is at a distance RFAN equal to 65 bin-width units from the center of rotation and the pixel width PWID is equal to 1.33 bin-width units.

The subroutine GETUM in Example 7 gives simulated projection data for a heart phantom. Example 7 also demonstrates the use of the subroutine USER, which gives the user the option to retrieve certain results after each iteration as desired. In this example an image is displayed after each iteration (statement E7.193) along with a graph of the cross section through the image X(I,J) at the J coordinate = 15 (statement E7.204). If the user does not code a subroutine USER, the default subroutine USER in the RECLBL Library will print out only the iteration number and the corresponding chi-square for each iteration.

```
      PROGRAM ITRFAN (INPUT,OUTPUT,TAPE2=OUTPUT)                        E7.001
C                                                                       E7.002
C        EXAMPLE 7                                                      E7.003
C                                                                       E7.004
C              THE PROGRAM ITRFAN USES THE ITERATIVE CONJUGATE GRADIENT E7.005
C        ALGORITHM TO RECONSTRUCT FAN BEAM PROJECTION DATA COLLECTED    E7.006
C        USING BOTH A CURVED DETECTOR AND A FLAT DETECTOR.              E7.007
C                                                                       E7.008
      DIMENSION B(1024),AG(36)                                          E7.009
      COMMON WORK(5000)                                                 E7.010
C                                                                       E7.011
      COMMON/OUTCOM/LUNOUT,I80132                                       E7.012
C                                                                       E7.013
C          LUNOUT  - OUTPUT FILE                                        E7.014
C          I80132  - OUTPUT LINE LENGTH FLAG                            E7.015
C               =0    EACH LINE WILL BE WITHIN 80 CHARACTERS            E7.016
C                       (OTHERWISE 132 CHARACTERS)                      E7.017
C                                                                       E7.018
      COMMON/PARM/IPAR(12),PAR(3)                                       E7.019
C                                                                       E7.020
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)), E7.021
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)), E7.022
     2            (IMIT  ,IPAR( 7)),(NWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)), E7.023
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)), E7.024
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3))  E7.025
C                                                                       E7.026
C                                                                       E7.027
      EXTERNAL BCOF,PCOF                                                E7.028
C                                                                       E7.029
      LUNOUT=2                                                          E7.030
      I80132=0                                                          E7.031
C                                                                       E7.032
C        THE INPUT PARAMETERS ARE                                       E7.033
C                                                                       E7.034
      NDIMU=32                                                          E7.035
      ICIR=0                                                            E7.036
      IGEOM=1                                                           E7.037
      NANG=36                                                           E7.038
      MODANG=5                                                          E7.039
      KDIMU=67                                                          E7.040
      IMIT=1                                                            E7.041
      NWORK=5000                                                        E7.042
      NFLOAT=1                                                          E7.043
      ISTORE=0                                                          E7.044
      IPRINT=5                                                          E7.045
      LUNATN=0                                                          E7.046
      PWID=1.33                                                         E7.047
      AXISU=33.                                                         E7.048
      RFAN=65.                                                          E7.049
C                                                                       E7.050
      CALL SETUP (IPAR,PAR,AG)                                          E7.051
C                                                                       E7.052
C        RECONSTRUCTION OF THE TRANSVERSE SECTION FOR FAN BEAM GEOMETRY E7.053
C          WITH CURVED DETECTOR                                         E7.054
C                                                                       E7.055
      ISTEP=5                                                           E7.056
      IRLX=1                                                            E7.057
      IERR=0                                                            E7.058
      IZER=0                                                            E7.059
C                                                                       E7.060
      CALL CONGR (B,PCOF,BCOF,ISTEP,IRLX,IERR,IZER)                     E7.061
C                                                                       E7.062
      WRITE (2,22)                                                      E7.063
      CALL ARRAY (B,NDIMU)                                              E7.064
C                                                                       E7.065
C        PRINTOUT THE VALUES FOR THE RECONSTRUCTED TRANSVERSE SECTION   E7.066
C                                                                       E7.067
      NMAT=NDIMU**2                                                     E7.068
      KK1=1                                                             E7.069
      KU=NDIMU/15+1                                                     E7.070
      DO 12 K=1,KU                                                      E7.071
      WRITE (LUNOUT,18)                                                 E7.072
      KK2=15*K                                                          E7.073
      IF (KK2.GT.NDIMU) KK2=NDIMU                                       E7.074
      DO 10 J=1,NDIMU                                                   E7.075
      ISUB1=NMAT-J*NDIMU+KK1                                            E7.076
      ISUB2=NMAT-J*NDIMU+KK2                                            E7.077
   10 WRITE (LUNOUT,20) (B(I),I=ISUB1,ISUB2)                            E7.078
```

```
      KK1=KK2+1
   12 CONTINUE
C
      IGEOM=2
C
      CALL SETUP (IPAR,PAR,AG)
C
C        RECONSTRUCTION OF THE TRANSVERSE SECTION FOR FAN BEAM GEOMETRY
C          WITH FLAT DETECTOR
C
      ISTEP=5
      IRLX=1
      IERR=0
      IZER=0
C
      CALL CONGR (B,PCDF,BCDF,ISTEP,IRLX,IERR,IZER)
C
      WRITE (2,24)
      CALL ARRAY (B,NDIMU)
C
C        PRINTOUT THE VALUES FOR THE RECONSTRUCTED TRANSVERSE SECTION
C
      KK1=1
      KU=NDIMU/15+1
      DO 16 K=1,KU
      WRITE (LUNOUT,18)
      KK2=15*K
      IF (KK2.GT.NDIMU) KK2=NDIMU
      DO 14 J=1,NDIMU
      ISUB1=NMAT-J*NDIMU+KK1
      ISUB2=NMAT-J*NDIMU+KK2
   14 WRITE (LUNOUT,20) (B(I),I=ISUB1,ISUB2)
      KK1=KK2+1
   16 CONTINUE
C
C
C
   18 FORMAT(1X///////)
   20 FORMAT(1X,15F5.1)
   22 FORMAT(1X//58H RECONSTRUCTION FOR FAN BEAM GEOMETRY WITH CURVED DE
     1TECTOR)
   24 FORMAT(1X//56H RECONSTRUCTION FOR FAN BEAM GEOMETRY WITH FLAT DETE
     1CTOR)
      END
      SUBROUTINE GETUM (M,DATA,ERR)
C
C        EXAMPLE 7
C
C             THE SUBROUTINE GETUM GIVES SIMULATED PROJECTION DATA FOR
C        A CHEST PHANTOM CONSISTING OF A HEART, LUNGS AND SURROUNDING
C        TISSUE.
C
      DIMENSION DATA(1),ERR(1),B(4096)
      DIMENSION ITYPE(4),X1(4),Y1(4),A1(4),B1(4),Z(4),PHI(4)
      DATA ITYPE/1,1,1,1/
      DATA A1/26.6,6.65,9.31,9.31/
      DATA B1/26.6,6.65,6.65,6.65/
      DATA X1/0.,0.,6.65,-6.65/
      DATA Y1/0.,-6.65,0.,0./
      DATA PHI/0.,0.,1.57079633,1.57079633/
      DATA Z/5.,27.,-4.,-4./
C
      IF (M.NE.1) GO TO 14
C
      PWIDTH=1.33
      CALL PHAN (4,10,ITYPE,Z,X1,Y1,A1,B1,PHI,B,32,PWIDTH)
C
      WRITE (2,16)
      NDIMU=32
      CALL ARRAY (B,NDIMU)
C
C        PRINTOUT THE VALUES FOR THE PHANTOM
C
      NMAT=NDIMU**2
      KK1=1
      KU=NDIMU/15+1
      DO 12 K=1,KU
      WRITE (2,18)
      KK2=15*K
      IF (KK2.GT.NDIMU) KK2=NDIMU
      DO 10 J=1,NDIMU
      ISUB1=NMAT-J*NDIMU+KK1
      ISUB2=NMAT-J*NDIMU+KK2
   10 WRITE (2,20) (B(I),I=ISUB1,ISUB2)
      KK1=KK2+1
   12 CONTINUE
C
   14 CALL PHANL (4,ITYPE,Z,X1,Y1,A1,B1,PHI,DATA,M)
C
      RETURN
C
C
   16 FORMAT(1H1)
   18 FORMAT(1H1)
   20 FORMAT(1X,15F5.1)
      END
      SUBROUTINE USER (ITER,X,CHISQ)
C
C        EXAMPLE 7
C
C             THE SUBROUTINE USER PRINTS OUT THE CHI-SQUARE FOR EACH
C        ITERATION ALONG WITH A GRAY LEVEL PLOT OF THE IMAGE AND A CROSS
C        SECTIONAL PLOT THROUGH THE IMAGE.
C
      COMMON/OUTCOM/LUNOUT,I80132
C
      DIMENSION X(1)
C
      NDIMU=32
      IF (ITER.EQ.0) WRITE (LUNOUT,10)
      WRITE (LUNOUT,12) ITER,CHISQ
C
      IF (ITER.EQ.0) RETURN
C
      CALL ARRAY (X,NDIMU)
C
C        CROSS SECTIONAL PLOT PARALLEL TO THE X AXIS AT J = 15
C
      NI=1
      BMAX=999999.
      BMIN=999999.
      IXY=0
      ICOR=15
      IL=1
      IU=32
      CALL XYGRF (X,NDIMU,NI,BMAX,BMIN,IXY,ICOR,IL,IU)
C
      RETURN
C
C
C
   10 FORMAT(1X//)
   12 FORMAT(5H ITER,I3,8H   CHISQ,E12.3)
      END
```

```
                         SSS   EEEEE TTTTT U   U PPPP
                        S      E       T   U   U P   P
                         SSS   EEE     T   U   U PPPP
                            S  E       T   U   U P
                         SSS   EEEEE   T    UUU  P


          INTEGER PARAMETER ARRAY  (IPAR)

 I   IPAR(I)      DESCRIPTION

 1       32       LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
 2        0       RECONSTRUCT IN A CIRCULAR ARRAY
 3        1       GEOMETRY FLAG
                  FAN BEAM GEOMETRY (CURVED DETECTOR)
 4       36       NUMBER OF PROJECTION ANGLES
 5        5       MODE FOR PROJECTION ANGLE INPUT  (SEE FOLLOWING LINES)
                  ANGLES GENERATED BETWEEN ZERO AND 2*PI
                  STARTING AT ZERO
 6       67       NUMBER OF RAYS FOR EACH PROJECTION
 7        1       TRANSMISSION DATA
 8     5000       DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
 9        1       NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10        0       EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11        5       PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES)
                  PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED
                  PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
12        0       LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE


          FLOATING POINT PARAMETER ARRAY  (PAR)

 I    PAR(I)      DESCRIPTION

 1    1.330       PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF
                  ROTATION
 2   33.000       LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
 3   65.000       DISTANCE FROM SOURCE TO CENTER OF ROTATION FOR FAN BEAM IN
                  UNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION

BLANK COMMON REQUIRED         36    (    44)

BLANK COMMON REQUIRED         72    (   110)

BLANK COMMON REQUIRED        108    (   154)

BLANK COMMON REQUIRED        242    (   362)

BLANK COMMON REQUIRED        306    (   462)

A TOTAL OF  47 ( 10 THRU  56) OF THE  67 USER PROJECTION BINS WILL BE USED

 47 PROJECTION BINS WILL BE USED OF WHICH   0 HAVE BEEN ZEROED BY THE PROGRAM

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=    306 FLOATING POINT WORDS.


          EEEEE N   N DDDD        SSS  EEEEE TTTTT U   U PPPP
          E     NN  N D   D      S     E       T   U   U P   P
          EEE   N N N D   D       SSS  EEE     T   U   U PPPP
          E     N  NN D   D          S E       T   U   U P
          EEEEE N   N DDDD        SSS  EEEEE   T    UUU  P


                    CCC  OOOOO N   N  GGG  RRRR
                   C   C O   O NN  N G   G R   R
                   C     O   O N N N G     RRRR
                   C   C O   O N  NN G  GG R  R
                    CCC  OOOOO N   N  GGGG R   R


          PARAMETERS FOR SUBROUTINE CONGR

                  DESCRIPTION

ISTP -       5    NUMBER OF ITERATION STEPS
IRLX -       1    ITERATIVE RELAXATION METHOD
IERR -       0    DO NOT USE ERROR ARRAY
IZER -       0    INITIAL SOLUTION IS ZERO

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG     FUNCTION           RAY WEIGHTING        ATTENUATION          FAN BEAM
BCK     BACKPROJECTION     CONCAVE DISK             NO                    YES
PRJ     PROJECTION         CONCAVE DISK             NO                    YES

BLANK COMMON REQUIRED        400    (   620)

BLANK COMMON REQUIRED       1212    (  2274)

BLANK COMMON REQUIRED       2024    (  3750)

BLANK COMMON REQUIRED       2836    (  5424)

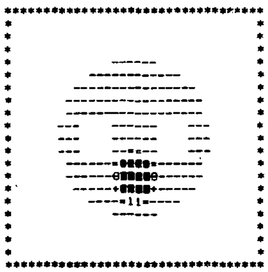
BLANK COMMON REQUIRED       3648    (  7100)


                   PPPP  H   H  AAA  N   N
                   P   P H   H A   A NN  N
                   PPPP  HHHHH A   A N N N
                   P     H   H AAAAA N  NN
                   P     H   H A   A N   N
```

```
PHANTOM GENERATED
  ARRAY SIZE   32 X  32    INTEGRATION FACTOR =  10    SCALING FACTOR =      .752
  NUMBER OF ELIPSES AND/OR RECTANGLES =    4
  THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
       X,Y  - CENTER
       A,B  - LENGTH OF AXIS OR SIDE A AND B
       PHI  - ANGLE OF AXIS OR SIDE A
       DENS - INTENSITY
  THE PARENTHESIS INDICATES THE SCALED VALUE
    ITYPE                     X          Y          A          B       PHI       DENS
      1   - ELLIPSE          0 ,        0     26.60 ,    26.60       0        5.00
                      (        0),(       0)(   20.00),(   20.00)         (     6.65)
      1   - ELLIPSE          0 ,    -6.65      6.65 ,     6.65       0       27.00
                      (        0),(   -5.00)(    5.00),(    5.00)         (    35.91)
      1   - ELLIPSE       6.65 ,        0      9.31 ,     6.65    1.57       -4.00
                      (     5.00),(       0)(    7.00),(    5.00)         (    -5.32)
      1   - ELLIPSE      -6.65 ,        0      9.31 ,     6.65    1.57       -4.00
                      (    -5.00),(       0)(    7.00),(    5.00)         (    -5.32)
```

```
EEEEE N   N DDDD       PPPP  H   H  AAA  N   N
E     NN  N D   D      P   P H   H A   A NN  N
EEE   N N N D   D      PPPP  HHHHH A   A N N N
E     N  NN D   D      P     H   H AAAAA N  NN
EEEEE N   N DDDD       P     H   H A   A N   N
```

XMIN =   0   XMAX =   .43E+02   XSUM =   .2507E+04



```
                -          =          +          )          1          Z
   0  .3192E+01  .7874E+01  .1000E+02  .1149E+02  .1319E+02  .1490E+02

Z          X          A          M          θ          ■          ■          ■
.1639E+02  .1745E+02  .1851E+02  .2085E+02  .2320E+02  .2468E+02  .2639E+02

■          ■          ■          ■          ■          ■          ■          ■
.2788E+02  .3107E+02  .3490E+02  .3703E+02  .3873E+02  .4043E+02  .4192E+02

■
.4256E+02
```

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	.2	2.4	4.5	5.8
0	0	0	0	0	0	0	0	0	0	2.3	6.0	6.7	6.7	6.7
0	0	0	0	0	0	0	0	.1	4.0	6.7	6.7	6.7	6.7	6.7
0	0	0	0	0	0	0	0	4.0	6.7	6.7	6.7	6.7	6.7	6.7
0	0	0	0	0	0	0	2.3	6.7	6.7	6.7	6.7	6.7	6.7	6.7
0	0	0	0	0	0	.2	6.0	6.7	6.7	6.7	6.7	6.7	6.7	6.7
0	0	0	0	0	0	2.4	6.7	6.7	6.5	4.5	4.5	6.5	6.7	6.7
0	0	0	0	0	0	4.5	6.7	6.7	2.8	1.3	1.3	2.8	6.7	6.7
0	0	0	0	0	0	5.8	6.7	5.3	1.3	1.3	1.3	1.3	5.3	6.7
0	0	0	0	0	0	6.6	6.7	4.1	1.3	1.3	1.3	1.3	4.1	6.7
0	0	0	0	0	0	6.6	6.7	4.1	1.3	1.3	1.3	1.3	4.1	6.7
0	0	0	0	0	0	5.8	6.7	5.3	1.3	1.3	1.3	1.3	5.3	6.7
0	0	0	0	0	0	4.5	6.7	6.7	2.8	1.3	1.3	2.8	6.7	9.5
0	0	0	0	0	0	2.4	6.7	6.7	6.5	4.5	4.5	6.5	9.5	39.0
0	0	0	0	0	0	.2	6.0	6.7	6.7	6.7	6.7	6.7	22.5	42.6
0	0	0	0	0	0	0	2.3	6.7	6.7	6.7	6.7	6.7	22.5	42.6
0	0	0	0	0	0	0	0	4.0	6.7	6.7	6.7	6.7	9.5	39.0
0	0	0	0	0	0	0	0	.1	4.0	6.7	6.7	6.7	6.7	9.5
0	0	0	0	0	0	0	0	0	0	2.3	6.0	6.7	6.7	6.7
0	0	0	0	0	0	0	0	0	0	0	.2	2.4	4.5	5.8
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.6	6.6	5.8	4.5	2.4	.2	0	0	0	0	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.0	2.3	0	0	0	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	4.0	.1	0	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	4.0	0	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	2.3	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.0	.2	0	0	0	0
6.7	6.7	6.7	6.7	6.5	4.5	4.5	6.5	6.7	6.7	2.4	0	0	0	0
6.7	6.7	6.7	6.7	2.8	1.3	1.3	2.8	6.7	6.7	4.5	0	0	0	0
6.7	6.7	6.7	5.3	1.3	1.3	1.3	1.3	5.3	6.7	5.8	0	0	0	0
6.7	6.7	6.7	4.1	1.3	1.3	1.3	1.3	4.1	6.7	6.6	0	0	0	0
6.7	6.7	6.7	4.1	1.3	1.3	1.3	1.3	4.1	6.7	6.6	0	0	0	0
6.7	6.7	6.7	5.3	1.3	1.3	1.3	1.3	5.3	6.7	5.8	0	0	0	0
22.5	22.5	9.5	6.7	2.8	1.3	1.3	2.8	6.7	6.7	4.5	0	0	0	0
42.6	42.6	39.0	9.5	6.5	4.5	4.5	6.5	6.7	6.7	2.4	0	0	0	0
42.6	42.6	42.6	22.5	6.7	6.7	6.7	6.7	6.7	6.0	.2	0	0	0	0
42.6	42.6	42.6	22.5	6.7	6.7	6.7	6.7	6.7	2.3	0	0	0	0	0
42.6	42.6	39.0	9.5	6.7	6.7	6.7	6.7	4.0	0	0	0	0	0	0
22.5	22.5	9.5	6.7	6.7	6.7	6.7	4.0	.1	0	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.0	2.3	0	0	0	0	0	0	0	0
6.6	6.6	5.8	4.5	2.4	.2	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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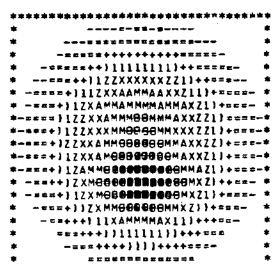
0	0

```
BLANK COMMON REQUIRED       3680    (  7140)

BLANK COMMON REQUIRED       3648    (  7100)

ITER  0   CHISQ      .208E+08
ITER  1   CHISQ      .449E+07

XMIN =          0     XMAX =     .11E+02     XSUM =     .2966E+04
```



```
                -          =          +          )          1          Z
   0  .8412E+00  .2075E+01  .2636E+01  .3028E+01  .3477E+01  .3926E+01

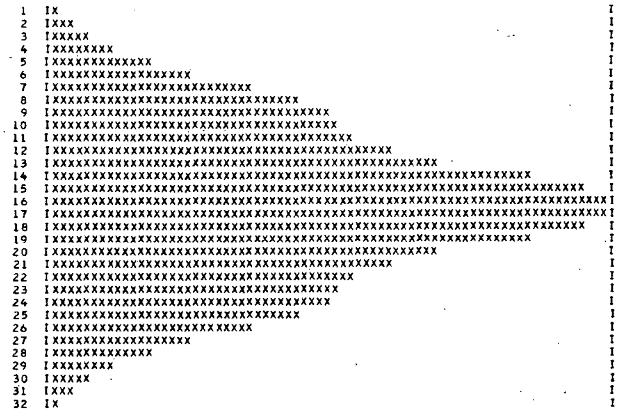
Z          X          A          M          θ          θ          θ          ■
.4318E+01  .4599E+01  .4879E+01  .5496E+01  .6113E+01  .6505E+01  .6954E+01

θ          ■          ■          ■          ■          ■          ■          ■
.7347E+01  .8188E+01  .9197E+01  .9758E+01  .1021E+02  .1066E+02  .1105E+02

■
.1122E+02
```

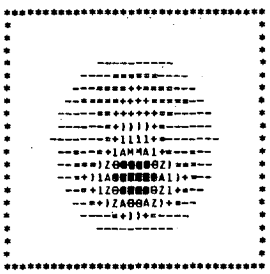
XYGRF PRINTOUT

SYMBOL	MINIMUM	MAXIMUM	INTERCEPT
*	.201E+01	.702E+01	THE Y-INTERCEPT = 15.
PLOT RANGE	.201E+01	.702E+01	



ITER 2 CHISQ .893E+06

XMIN = -.15E+01 XMAX = .32E+02 XSUM = .2449E+04



- = +) 1 Z
-.1489E+01 .1032E+01 .4730E+01 .6410E+01 .7587E+01 .8931E+01 .1028E+02

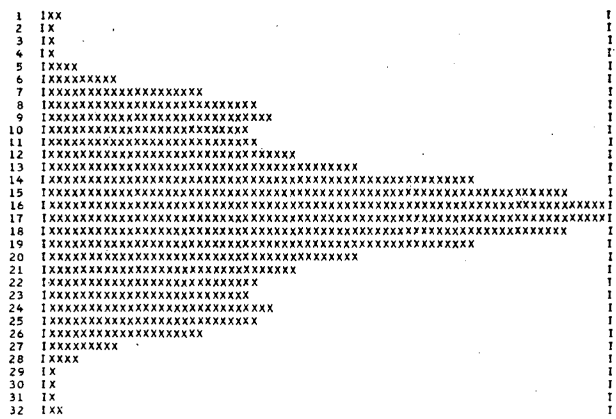
Z X A M θ
.1145E+02 .1229E+02 .1313E+02 .1498E+02 .1683E+02 .1801E+02 .1935E+02

.2053E+02 .2305E+02 .2607E+02 .2775E+02 .2910E+02 .3044E+02 .3162E+02

.3212E+02

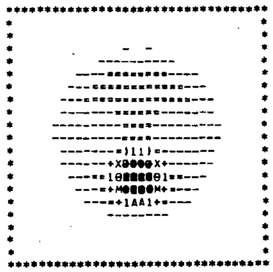
XYGRF PRINTOUT

SYMBOL	MINIMUM	MAXIMUM	INTERCEPT
*	-.773E+00	.130E+02	THE Y-INTERCEPT = 15.
PLOT RANGE	-.773E+00	.130E+02	



ITER 3 CHISQ .323E+06

XMIN = -.19E+01 XMAX = .41E+02 XSUM = .2469E+04



- = +) 1 Z
-.1885E+01 .1346E+01 .6085E+01 .8240E+01 .9748E+01 .1147E+02 .1319E+02

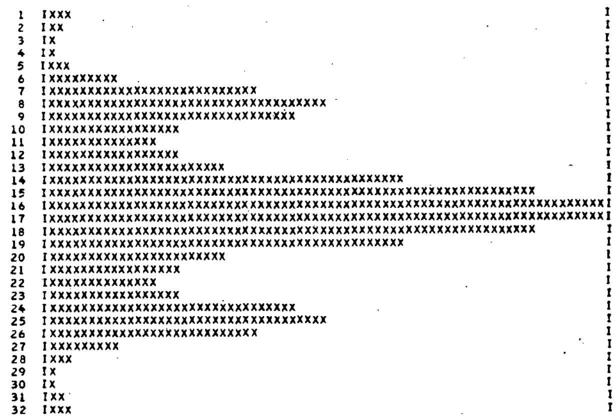
Z X A M θ
.1470E+02 .1578E+02 .1686E+02 .1923E+02 .2160E+02 .2310E+02 .2483E+02

.2634E+02 .2957E+02 .3344E+02 .3560E+02 .3732E+02 .3905E+02 .4055E+02

.4120E+02

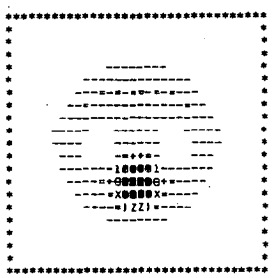
XYGRF PRINTOUT

SYMBOL	MINIMUM	MAXIMUM	INTERCEPT
*	-.543E+00	.110E+02	THE Y-INTERCEPT = 15.
PLOT RANGE	-.543E+00	.110E+02	



ITER 4 CHISQ .137E+06

XMIN = -.20E+01 XMAX = .46E+02 XSUM = .2509E+04



- = +) 1 Z
-.2020E+01 .1600E+01 .6910E+01 .9323E+01 .1101E+02 .1294E+02 .1487E+02

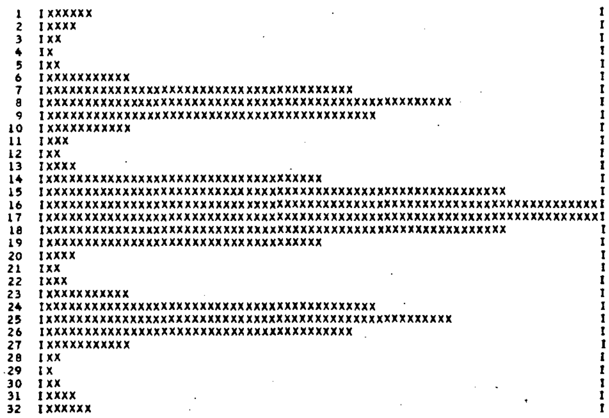
Z X A M θ
.1656E+02 .1777E+02 .1898E+02 .2163E+02 .2429E+02 .2598E+02 .2791E+02

.2960E+02 .3322E+02 .3756E+02 .3997E+02 .4190E+02 .4383E+02 .4552E+02

.4625E+02

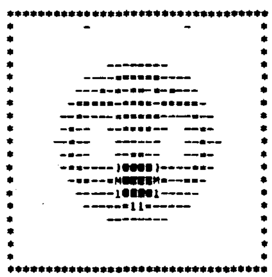
```
XYGRF PRINTOUT

SYMBOL           MINIMUM       MAXIMUM           INTERCEPT
   *            -.142E+00      .858E+01     THE Y-INTERCEPT =  15.
PLOT RANGE      -.142E+00      .858E+01
```



```
ITER  5   CHISQ    .771E+05

XMIN =    -.26E+01     XMAX =     .47E+02     XSUM =     .2502E+04
```



```
                            -           =           +           )           1           Z
-.2615E+01  .1107E+01  .6568E+01  .9050E+01  .1079E+02  .1277E+02  .1476E+02

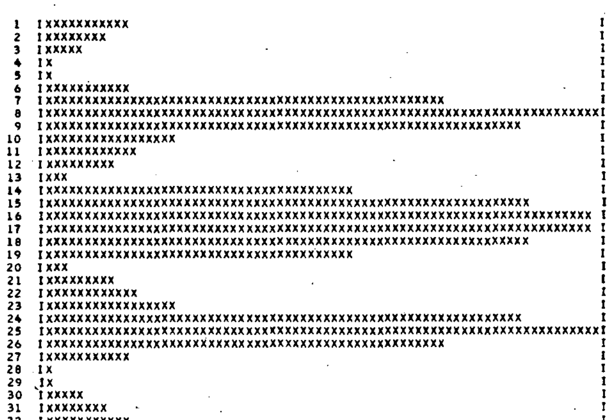
Z           X           A           M           B           ■           B           ■
 .1650E+02  .1774E+02  .1898E+02  .2171E+02  .2444E+02  .2618E+02  .2816E+02

■           ■           ■           ■           ■           ■           ■           ■
 .2990E+02  .3362E+02  .3809E+02  .4057E+02  .4256E+02  .4454E+02  .4628E+02

■
 .4702E+02
```

```
XYGRF PRINTOUT

SYMBOL           MINIMUM       MAXIMUM           INTERCEPT
   *            -.801E+00      .711E+01     THE Y-INTERCEPT =  15.
PLOT RANGE      -.801E+00      .711E+01
```



```
BLANK COMMON REQUIRED      3554    (  6742)

BLANK COMMON REQUIRED      2742    (  5266)

BLANK COMMON REQUIRED      1930    (  3612)

BLANK COMMON REQUIRED      1118    (  2136)

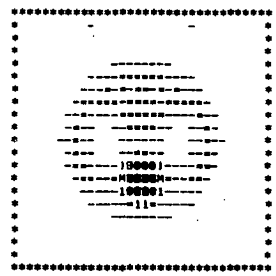
BLANK COMMON REQUIRED       306    (   462)

      MAXIMUM SIZE OF BLANK COMMON THUS FAR=   3680 FLOATING POINT WORDS.
```

```
EEEEE N   N DDDD        CCC  OOOOO N   N  GGG  RRRR
E     NN  N D   D      C   C O   O NN  N G   G R   R
EEE   N N N D   D      C     O   O N N N G     RRRR
E     N  NN D   D      C   C O   O N  NN G  GG R  R
EEEEE N   N DDDD        CCC  OOOOO N   N  GGGG R   R
```

```
RECONSTRUCTION FOR FAN BEAM GEOMETRY WITH CURVED DETECTOR

XMIN =    -.26E+01     XMAX =     .47E+02     XSUM =     .2502E+04
```



```
                            -           =           +           )           1           Z
-.2615E+01  .1107E+01  .6568E+01  .9050E+01  .1079E+02  .1277E+02  .1476E+02

Z           X           A           M           B           ■           B           ■
 .1650E+02  .1774E+02  .1898E+02  .2171E+02  .2444E+02  .2618E+02  .2816E+02

■           ■           ■           ■           ■           ■           ■           ■
 .2990E+02  .3362E+02  .3809E+02  .4057E+02  .4256E+02  .4454E+02  .4628E+02

■
 .4702E+02
```

0	0	0	0	0	0	0	0	0	0	0	0	.2	1.0	-1.1
0	0	0	0	0	0	0	0	0	1.3	.8	-1.5	.0	.9	-1.0
0	0	0	0	0	0	0	-.1	-2.6	.7	1.0	-1.0	.0	.3	-.4
0	0	0	0	0	0	1.0	.9	-1.7	-.3	.9	-.3	-.4	-.1	-.1
0	0	0	0	0	-1.1	.4	.6	-.1	-1.7	.5	.1	-.8	-.2	-.0
0	0	0	0	.8	-.7	-.2	.2	.3	-1.3	-.4	.1	-.3	.1	1.3
0	0	0	-.8	.7	-.2	-.9	-.1	-.4	.1	-1.0	1.0	3.9	3.7	5.5
0	0	.3	-.4	.0	.1	-.1	-.3	-.5	.2	3.6	4.3	6.8	6.6	7.1
0	0	.3	-.3	-.6	.3	-.8	.2	1.2	3.1	7.1	6.1	6.3	7.7	6.6
0	-.5	-.1	-.0	-.7	-.3	-.0	-.1	5.1	5.8	6.4	8.2	5.4	8.2	6.3
0	.2	-.6	.1	-.5	-.7	.3	3.0	6.2	8.3	5.9	7.9	6.4	7.2	6.9
0	.1	.1	-.7	.3	-.8	.4	6.1	7.0	7.8	6.9	7.0	7.4	6.2	7.5
.1	.2	-.1	-.2	-.8	.6	3.1	6.2	7.0	6.7	4.8	4.7	6.0	7.2	7.2
-.6	-.4	.1	.4	-.2	-.0	5.1	7.5	6.7	3.1	1.9	1.4	3.6	7.4	6.3
-.4	-.9	-.7	-.8	.2	1.2	5.3	7.6	6.0	1.8	.8	.6	2.3	5.0	6.9
.1	.2	-.4	-.7	-1.0	1.1	5.6	6.6	5.5	1.6	1.6	.6	.3	4.6	6.4
-.2	-.4	-.2	-.1	.1	1.3	6.1	6.9	4.1	1.4	.6	.6	.7	3.5	6.3
.3	.0	-.3	-.7	-.8	.3	4.9	7.1	6.0	1.0	.5	.1	-.5	3.5	6.0
-.3	.2	.8	.7	.7	1.0	4.8	6.9	7.0	3.6	.8	.5	2.4	5.6	11.0
.5	-.3	-1.0	-.9	-.9	.3	3.5	6.9	6.9	5.6	3.7	3.1	5.4	13.3	34.2
0	.3	.7	.6	.6	-.1	1.1	5.4	6.8	7.2	5.8	5.7	8.2	20.3	44.3
0	-1.0	-.9	-.9	-1.0	-1.0	-.2	3.6	6.6	7.3	7.1	6.4	6.2	21.2	44.1
0	.2	.0	.3	.3	.5	-.3	.3	4.0	5.8	6.1	5.1	4.7	12.9	35.5
0	0	.1	-.2	-.6	-.3	-.1	.1	.8	4.3	5.7	4.7	4.3	5.8	11.5
0	0	.2	.2	.7	1.0	.6	.0	.3	.1	2.1	4.1	5.1	5.7	6.3
0	0	0	.1	.4	-.9	-.6	.0	-.4	.5	-.5	1.1	2.4	3.3	4.1
0	0	0	0	-.3	.8	1.6	.1	.5	-.7	.1	-.1	-.6	-.2	.1
0	0	0	0	0	1.0	-.5	-.2	.9	-.4	.2	.2	-.1	-.8	-.0
0	0	0	0	0	0	.3	1.6	-1.1	.4	.4	.4	.4	-.6	.7
0	0	0	0	0	0	0	-.8	-.1	1.2	.6	-.3	1.1	-.5	1.0
0	0	0	0	0	0	0	0	0	-.0	.6	.1	.6	.3	.6
0	0	0	0	0	0	0	0	0	0	0	0	1.2	-.1	1.0

.4	.4	-1.1	1.0	.2	0	0	0	0	0	0	0	0	0	0
.3	.3	-1.0	.9	.0	-1.5	.8	1.3	0	0	0	0	0	0	0
.1	.1	-.4	.3	.0	-1.0	1.0	.7	-2.6	-.1	0	0	0	0	0
-.3	-.3	-.1	-.1	-.4	-.3	.9	-.3	-1.7	.9	1.0	0	0	0	0
-.6	-.6	-.0	-.2	-.8	.1	.5	-1.7	-.1	.6	.4	-1.1	0	0	0
.9	.9	1.3	.1	-.3	.1	-.4	-1.3	.3	.2	-.2	-.7	.6	0	0
5.6	5.6	5.5	3.7	3.9	1.0	-1.0	.1	-.4	-.1	-.9	-.2	.7	-.8	0
7.0	7.0	7.1	6.6	6.8	4.3	3.6	.2	-.5	-.3	-.1	.1	.0	-.4	.3
7.2	7.2	6.6	7.7	6.3	6.1	7.1	3.1	1.2	.2	-.8	.3	-.6	-.3	.3
7.4	7.4	6.3	8.2	5.4	8.2	6.4	5.8	5.1	-.1	-.0	-.3	-.7	-.0	-.1
7.0	7.0	6.9	7.2	6.4	7.9	5.9	8.3	6.2	3.0	.3	-.7	-.5	.1	-.6
6.6	6.6	7.5	6.2	7.4	7.0	6.9	7.8	7.0	6.1	.4	-.8	.3	-.7	.1
6.7	6.7	7.2	7.2	6.0	4.7	4.8	6.7	7.0	6.2	3.1	.6	-.8	-.2	-.1
7.3	7.3	6.3	7.4	3.6	1.4	1.9	3.1	6.7	7.5	5.1	-.0	-.2	.4	.1
6.6	6.6	6.9	5.0	2.3	.6	.8	1.8	6.0	7.6	5.3	1.2	.2	-.8	-.7
6.3	6.3	6.4	4.6	.3	.6	1.6	1.6	5.5	6.6	5.6	1.1	-1.0	-.7	-.4
5.4	5.4	6.3	3.5	.7	.6	.6	1.4	4.1	6.9	6.1	1.3	.1	-.1	-.2
6.9	6.9	6.0	3.5	-.5	.1	.5	1.0	6.0	7.1	4.9	.3	-.8	-.7	-.3
21.8	21.8	11.0	5.6	2.4	.5	.8	3.6	7.0	6.9	4.8	1.0	.7	.7	.8
44.6	44.6	34.2	13.3	5.4	3.1	3.7	5.6	6.9	6.9	3.5	.3	-.9	-.9	-1.0
47.0	47.0	44.3	20.3	8.2	5.7	5.8	7.2	6.8	5.4	1.1	-.1	.6	.6	.7
47.0	47.0	44.1	21.2	6.2	6.4	7.1	7.3	6.6	3.6	-.2	-1.0	-1.0	-.9	-.9
45.3	45.3	35.5	12.9	4.7	5.1	6.1	5.8	4.0	.3	-.3	.5	.3	.3	.0
20.9	20.9	11.5	5.8	4.3	4.7	5.7	4.3	.8	.1	-.1	-.3	-.6	-.2	.1
6.5	6.5	6.3	5.7	5.1	4.1	2.1	.1	.3	.0	.6	1.0	.7	.2	.2
4.7	4.7	4.1	3.3	2.4	1.1	-.5	.5	-.4	.0	-.6	-.9	.4	.1	0
1.0	1.0	.1	-.2	-.6	-.1	.1	-.7	.5	.1	1.6	.8	-.3	0	0
-.2	-.2	-.0	-.8	-.1	.2	.2	-.4	.9	-.2	-.5	1.0	0	0	0
-.1	-.1	.7	-.6	.4	.4	.4	.4	-1.1	1.6	.3	0	0	0	0
.2	.2	1.0	-.5	1.1	-.3	.6	1.2	-.1	-.8	0	0	0	0	0
.3	.3	.6	.3	.6	.1	.6	-.0	0	0	0	0	0	0	0
.1	.1	1.0	-.1	1.2	0	0	0	0	0	0	0	0	0	0

0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
-.5	0
.2	0
.1	0
.2	.1
-.4	-.6
-.9	-.4
.2	.1
-.4	-.2
.0	.3
.2	-.3
-.3	.5
.3	0
-1.0	0
.2	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0

```
 SSS  EEEEE TTTTT U   U PPPP
S     E       T   U   U P   P
 SSS  EEE     T   U   U PPPP
    S E       T   U   U P
 SSS  EEEEE   T    UUU  P
```

INTEGER PARAMETER ARRAY (IPAR)

I	IPAR(I)	DESCRIPTION
1	32	LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
2	0	RECONSTRUCT IN A CIRCULAR ARRAY
3	2	GEOMETRY FLAG FAN BEAM GEOMETRY (FLAT DETECTOR)
4	36	NUMBER OF PROJECTION ANGLES
5	5	MODE FOR PROJECTION ANGLE INPUT (SEE FOLLOWING LINES) ANGLES GENERATED BETWEEN ZERO AND 2*PI STARTING AT ZERO
6	67	NUMBER OF RAYS FOR EACH PROJECTION
7	1	TRANSMISSION DATA
8	3000	DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
9	1	NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10	0	EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11	5	PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES) PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
12	0	LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE

FLOATING POINT PARAMETER ARRAY (PAR)

I	PAR(I)	DESCRIPTION
1	1.330	PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION
2	33.000	LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
3	65.000	DISTANCE FROM SOURCE TO CENTER OF ROTATION FOR FAN BEAM IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION

BLANK COMMON REQUIRED 36 (44)

BLANK COMMON REQUIRED 72 (110)

BLANK COMMON REQUIRED 108 (154)

BLANK COMMON REQUIRED 242 (362)

BLANK COMMON REQUIRED 306 (462)

A TOTAL OF 49 (9 THRU 57) OF THE 67 USER PROJECTION BINS WILL BE USED

49 PROJECTION BINS WILL BE USED OF WHICH 0 HAVE BEEN ZEROED BY THE PROGRAM

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 3680 FLOATING POINT WORDS.

```
EEEEE N   N DDDD       SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D     S     E       T   U   U P   P
EEE   N N N D   D      SSS  EEE     T   U   U PPPP
E     N  NN D   D         S E       T   U   U P
EEEEE N   N DDDD       SSS  EEEEE   T    UUU  P
```

```
 CCC  OOOOO N   N  GGG  RRRR
C   C O   O NN  N G     R   R
C     O   O N N N G     RRRR
C   C O   O N  NN G  GG R  R
 CCC  OOOOO N   N  GGGG R   R
```

PARAMETERS FOR SUBROUTINE CONGR

		DESCRIPTION
ISTP -	5	NUMBER OF ITERATION STEPS
IRLX -	1	ITERATIVE RELAXATION METHOD
IERR -	0	DO NOT USE ERROR ARRAY
IZER -	0	INITIAL SOLUTION IS ZERO

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	CONCAVE DISK	NO	YES
PRJ	PROJECTION	CONCAVE DISK	NO	YES

BLANK COMMON REQUIRED 404 (624)

BLANK COMMON REQUIRED 1216 (2300)

BLANK COMMON REQUIRED 2028 (3754)

BLANK COMMON REQUIRED 2840 (5430)

BLANK COMMON REQUIRED 3652 (7104)

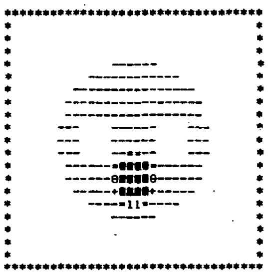
```
PPPP  H   H  AAA  N   N
P   P H   H A   A NN  N
PPPP  HHHHH A   A N N N
P     H   H AAAAA N  NN
P     H   H A   A N   N
```

PHANTOM GENERATED
ARRAY SIZE 32 X 32 INTEGRATION FACTOR = 10 SCALING FACTOR = .752
NUMBER OF ELIPSES AND/OR RECTANGLES = 4
THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
X,Y - CENTER
A,B - LENGTH OF AXIS OR SIDE A AND B
PHI - ANGLE OF AXIS OR SIDE A
DENS - INTENSITY
THE PARENTHESIS INDICATES THE SCALED VALUE

ITYPE		X	Y	A	B	PHI	DENS
1	- ELLIPSE	0 ,	0	26.60 ,	26.60	0	5.00
		(0),(	0)(	20.00),(	20.00)		(6.65)
1	- ELLIPSE	0 ,	-6.65	6.65 ,	6.65	0	27.00
		(0),(	-5.00)(	5.00),(	5.00)		(35.91)
1	- ELLIPSE	6.65 ,	0	9.31 ,	6.65	1.57	-4.00
		(5.00),(	0)(	7.00),(	5.00)		(-5.32)
1	- ELLIPSE	-6.65 ,	0	9.31 ,	6.65	1.57	-4.00
		(-5.00),(	0)(	7.00),(	5.00)		(-5.32)

```
EEEEE N   N DDDD       PPPP  H   H  AAA  N   N
E     NN  N D   D      P   P H   H A   A NN  N
EEE   N N N D   D      PPPP  HHHHH A   A N N N
E     N  NN D   D      P     H   H AAAAA N  NN
EEEEE N   N DDDD       P     H   H A   A N   N
```

XMIN = 0 XMAX = .43E+02 XSUM = .2507E+04



```
                -            =            +            )            1            Z
0  .3192E+01  .7874E+01  .1000E+02  .1149E+02  .1319E+02  .1490E+02

Z           X           A           M           @           ■           ■           ■
.1639E+02  .1745E+02  .1851E+02  .2085E+02  .2320E+02  .2468E+02  .2639E+02

■           ■           ■           ■           ■           ■           ■           ■
.2788E+02  .3107E+02  .3490E+02  .3703E+02  .3873E+02  .4043E+02  .4192E+02

■
.4256E+02
```

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	.2	2.4	4.5	5.8
0	0	0	0	0	0	0	0	0	0	2.3	6.0	6.7	6.7	6.7
0	0	0	0	0	0	0	0	.1	4.0	6.7	6.7	6.7	6.7	6.7
0	0	0	0	0	0	0	0	4.0	6.7	6.7	6.7	6.7	6.7	6.7
0	0	0	0	0	0	0	2.3	6.7	6.7	6.7	6.7	6.7	6.7	6.7
0	0	0	0	0	0	.2	6.0	6.7	6.7	6.7	6.7	6.7	6.7	6.7
0	0	0	0	0	0	2.4	6.7	6.7	6.5	4.5	4.5	6.5	6.7	6.7
0	0	0	0	0	0	4.5	6.7	6.7	2.8	1.3	1.3	2.8	6.7	6.7
0	0	0	0	0	0	5.8	6.7	5.3	1.3	1.3	1.3	1.3	5.3	6.7
0	0	0	0	0	0	6.6	6.7	4.1	1.3	1.3	1.3	1.3	4.1	6.7
0	0	0	0	0	0	6.6	6.7	4.1	1.3	1.3	1.3	1.3	4.1	6.7
0	0	0	0	0	0	5.8	6.7	5.3	1.3	1.3	1.3	1.3	5.3	6.7
0	0	0	0	0	0	4.5	6.7	6.7	2.8	1.3	1.3	2.8	6.7	9.5
0	0	0	0	0	0	2.4	6.7	6.7	6.5	4.5	4.5	6.5	9.5	39.0
0	0	0	0	0	0	.2	6.0	6.7	6.7	6.7	6.7	6.7	22.5	42.6
0	0	0	0	0	0	0	2.3	6.7	6.7	6.7	6.7	6.7	22.5	42.6
0	0	0	0	0	0	0	0	4.0	6.7	6.7	6.7	6.7	9.5	39.0
0	0	0	0	0	0	0	0	.1	4.0	6.7	6.7	6.7	6.7	9.5
0	0	0	0	0	0	0	0	0	0	2.3	6.0	6.7	6.7	6.7
0	0	0	0	0	0	0	0	0	0	0	.2	2.4	4.5	5.8
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.6	6.6	5.8	4.5	2.4	.2	0	0	0	0	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.0	2.3	0	0	0	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	4.0	.1	0	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	4.0	0	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	2.3	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.0	.2	0	0	0	0
6.7	6.7	6.7	6.7	6.5	4.5	4.5	6.5	6.7	6.7	2.4	0	0	0	0
6.7	6.7	6.7	6.7	2.8	1.3	1.3	2.8	6.7	6.7	4.5	0	0	0	0
6.7	6.7	6.7	5.3	1.3	1.3	1.3	1.3	5.3	6.7	5.8	0	0	0	0
6.7	6.7	6.7	4.1	1.3	1.3	1.3	1.3	4.1	6.7	6.6	0	0	0	0
6.7	6.7	6.7	4.1	1.3	1.3	1.3	1.3	4.1	6.7	6.6	0	0	0	0
6.7	6.7	6.7	5.3	1.3	1.3	1.3	1.3	5.3	6.7	5.8	0	0	0	0
22.5	22.5	9.5	6.7	2.8	1.3	1.3	2.8	6.7	6.7	4.5	0	0	0	0
42.6	42.6	39.0	9.5	6.5	4.5	4.5	6.5	6.7	6.7	2.4	0	0	0	0
42.6	42.6	42.6	22.5	6.7	6.7	6.7	6.7	6.7	6.0	.2	0	0	0	0
42.6	42.6	42.6	22.5	6.7	6.7	6.7	6.7	6.7	2.3	0	0	0	0	0
42.6	42.6	39.0	9.5	6.7	6.7	6.7	6.7	4.0	0	0	0	0	0	0
22.5	22.5	9.5	6.7	6.7	6.7	6.7	4.0	.1	0	0	0	0	0	0
6.7	6.7	6.7	6.7	6.7	6.0	2.3	0	0	0	0	0	0	0	0
6.6	6.6	5.8	4.5	2.4	.2	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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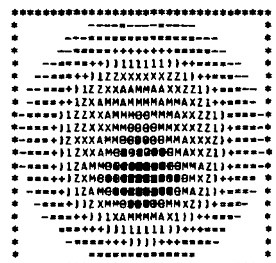
BLANK COMMON REQUIRED 3684 (7144)

BLANK COMMON REQUIRED 3652 (7104)

ITER 0 CHISQ .210E+08
ITER 1 CHISQ .450E+07

XMIN = 0 XMAX = .11E+02 XSUM = .2976E+04



```
                -            =            +            )            1            Z
0  .8473E+00  .2090E+01  .2655E+01  .3050E+01  .3502E+01  .3954E+01

Z           X           A           M           @           ■           ■           ■
.4349E+01  .4632E+01  .4914E+01  .5536E+01  .6157E+01  .6552E+01  .7004E+01

■           ■           ■           ■           ■           ■           ■           ■
.7400E+01  .8247E+01  .9263E+01  .9828E+01  .1028E+02  .1073E+02  .1113E+02

■
.1130E+02
```

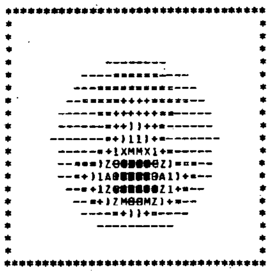
XYGRF PRINTOUT

SYMBOL	MINIMUM	MAXIMUM	INTERCEPT
*	.203E+01	.706E+01	THE Y-INTERCEPT = 15.
PLOT RANGE	.203E+01	.706E+01	

```
 1  IX                                                                             I
 2  IXXX                                                                           I
 3  IXXXXX                                                                         I
 4  IXXXXXXXX                                                                      I
 5  IXXXXXXXXXXXXX                                                                 I
 6  IXXXXXXXXXXXXXXXXXXXX                                                          I
 7  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                                 I
 8  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                          I
 9  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                       I
10  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                      I
11  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                    I
12  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                               I
13  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                        I
14  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX           I
15  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX    I
16  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXI
17  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXI
18  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX    I
19  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX           I
20  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                        I
21  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                               I
22  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                    I
23  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                      I
24  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                       I
25  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                          I
26  IXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                                 I
27  IXXXXXXXXXXXXXXXXXXXX                                                          I
28  IXXXXXXXXXXXXX                                                                 I
29  IXXXXXXXX                                                                      I
30  IXXXXX                                                                         I
31  IXXX                                                                           I
32  IX                                                                             I
```

ITER 2 CHISQ .895E+06

XMIN = -.15E+01 XMAX = .32E+02 XSUM = .2458E+04



- = +) 1 Z

-.1503E+01 .1037E+01 .4762E+01 .6456E+01 .7641E+01 .8995E+01 .1035E+02

Z X A M θ ■ ■ ■

.1154E+02 .1238E+02 .1323E+02 .1509E+02 .1695E+02 .1814E+02 .1949E+02

■ ■ ■ ■ ■ ■ ■ ■

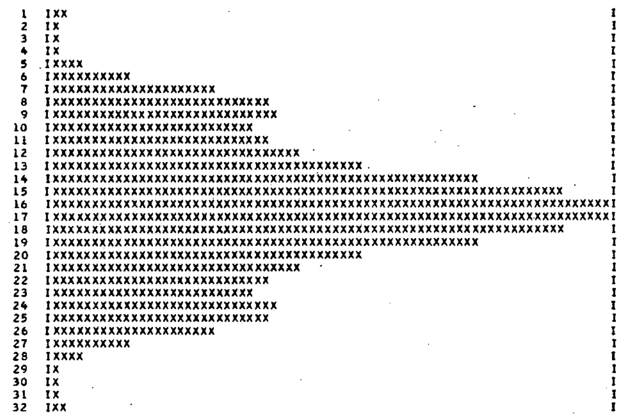
.2068E+02 .2322E+02 .2627E+02 .2796E+02 .2931E+02 .3067E+02 .3185E+02

■

.3236E+02

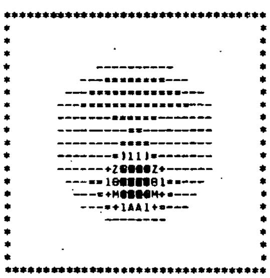
XYGRF PRINTOUT

SYMBOL MINIMUM MAXIMUM INTERCEPT
* -.777E+00 .130E+02 THE Y-INTERCEPT = 15.
PLOT RANGE -.777E+00 .130E+02



ITER 3 CHISQ .322E+06

XMIN = -.17E+01 XMAX = .41E+02 XSUM = .2477E+04



- = +) 1 Z

-.1750E+01 .1488E+01 .6237E+01 .8396E+01 .9907E+01 .1163E+02 .1336E+02

Z X A M θ ■ ■ ■

.1487E+02 .1595E+02 .1703E+02 .1940E+02 .2178E+02 .2329E+02 .2502E+02

■ ■ ■ ■ ■ ■ ■ ■

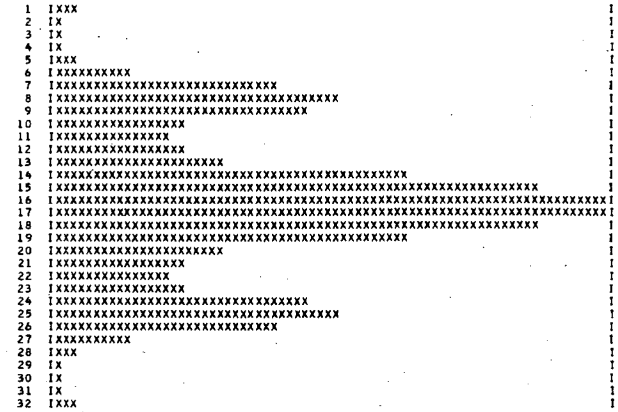
.2653E+02 .2977E+02 .3365E+02 .3581E+02 .3754E+02 .3926E+02 .4077E+02

■

.4142E+02

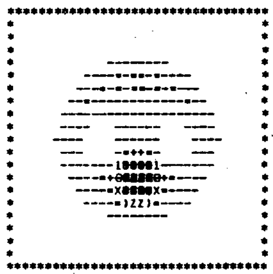
XYGRF PRINTOUT

SYMBOL MINIMUM MAXIMUM INTERCEPT
* -.547E+00 .109E+02 THE Y-INTERCEPT = 15.
PLOT RANGE -.547E+00 .109E+02



ITER 4 CHISQ .137E+06

XMIN = -.21E+01 XMAX = .46E+02 XSUM = .2519E+04



- = +) 1 Z

-.2071E+01 .1567E+01 .6903E+01 .9328E+01 .1103E+02 .1297E+02 .1491E+02

Z X A M θ ■ ■ ■

.1660E+02 .1782E+02 .1903E+02 .2170E+02 .2437E+02 .2606E+02 .2800E+02

■ ■ ■ ■ ■ ■ ■ ■

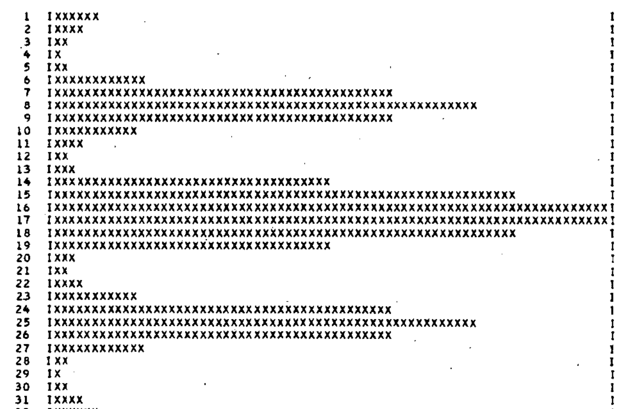
.2970E+02 .3334E+02 .3770E+02 .4013E+02 .4207E+02 .4401E+02 .4571E+02

■

.4644E+02

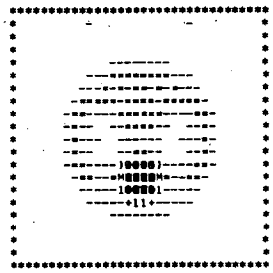
XYGRF PRINTOUT

SYMBOL MINIMUM MAXIMUM INTERCEPT
* -.166E+00 .844E+01 THE Y-INTERCEPT = 15.
PLOT RANGE -.166E+00 .844E+01



ITER 5 CHISQ .773E+05

XMIN = -.27E+01 XMAX = .47E+02 XSUM = .2511E+04



−.2687E+01 .1056E+01 - .6547E+01 = .9043E+01 + .1079E+02) .1279E+02 1 .1478E+02 Z

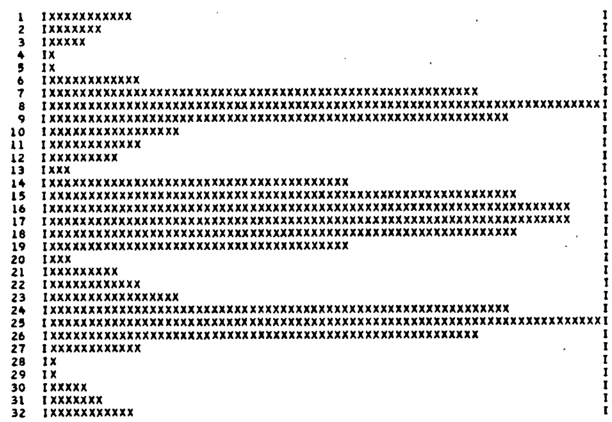
Z .1653E+02 X .1778E+02 A .1903E+02 M .2177E+02 @ .2452E+02 ■ .2626E+02 ■ .2826E+02 ■

■ .3001E+02 ■ .3375E+02 ■ .3824E+02 ■ .4074E+02 ■ .4274E+02 ■ .4473E+02 ■ .4648E+02 ■

■ .4723E+02

XYGRF PRINTOUT

SYMBOL	MINIMUM	MAXIMUM	INTERCEPT
*	−.802E+00	.725E+01	THE Y-INTERCEPT = 15.
PLOT RANGE	−.802E+00	.725E+01	



BLANK COMMON REQUIRED 3554 (6742)

BLANK COMMON REQUIRED 2742 (5266)

BLANK COMMON REQUIRED 1930 (3612)

BLANK COMMON REQUIRED 1118 (2136)

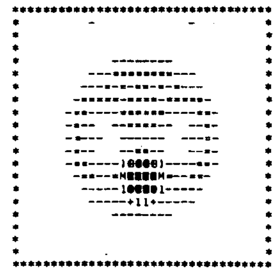
BLANK COMMON REQUIRED 306 (462)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 3684 FLOATING POINT WORDS.

```
EEEEE N   N DDDD      CCC  OOOOO N   N  GGG  RRRR
E     NN  N D   D    C   C O   O NN  N G   G R   R
EEE   N N N D   D    C     O   O N N N G     RRRR
E     N  NN D   D    C   C O   O N  NN G  GG R  R
EEEEE N   N DDDD      CCC  OOOOO N   N  GGGG R   R
```

RECONSTRUCTION FOR FAN BEAM GEOMETRY WITH FLAT DETECTOR

XMIN = -.27E+01 XMAX = .47E+02 XSUM = .2511E+04



−.2687E+01 .1056E+01 - .6547E+01 = .9043E+01 + .1079E+02) .1279E+02 1 .1478E+02 Z

Z .1653E+02 X .1778E+02 A .1903E+02 M .2177E+02 @ .2452E+02 ■ .2626E+02 @ .2826E+02 @

■ .3001E+02 ■ .3375E+02 ■ .3824E+02 ■ .4074E+02 ■ .4274E+02 ■ .4473E+02 ■ .4648E+02 ■

■ .4723E+02

0	0	0	0	0	0	0	0	0	0	0	0	.1	1.0	-1.0
0	0	0	0	0	0	0	0	0	1.4	.7	-1.5	.0	1.0	-1.0
0	0	0	0	0	0	0	-.1	-2.7	.6	1.0	-1.0	.1	.3	-.5
0	0	0	0	0	0	.9	.9	-1.7	-.3	.8	-.3	-.4	-.1	-.1
0	0	0	0	0	-1.0	.4	.6	-.1	-1.8	.4	.1	-.7	-.2	-.0
0	0	0	0	.8	-.6	-.2	.2	.2	-1.2	-.5	.2	-.3	-.1	1.1
0	0	0	-.7	.7	-.1	-.8	.0	-.4	.1	-1.1	.7	3.6	3.8	5.8
0	0	.2	-.4	.0	.1	-.2	-.3	-.7	-.1	3.4	4.5	7.1	6.7	7.2
0	0	.3	-.3	-.5	.4	-.8	.2	.9	3.1	7.4	6.3	6.5	7.8	6.7
0	-.5	-.2	-.0	-.8	-.2	-.1	-.4	5.1	6.1	6.6	8.2	5.4	8.3	6.3
0	.3	-.5	.1	-.5	-.6	.3	2.7	6.5	8.4	6.1	8.0	6.4	7.1	6.9
0	.1	.2	-.8	.4	-.9	.2	6.3	7.1	7.9	7.0	7.0	7.5	6.2	7.5
-.0	.2	-.1	-.1	-.8	.5	2.9	6.5	7.0	6.8	4.8	4.7	6.0	7.1	7.2
-.6	-.5	.0	.4	-.1	-.3	5.1	7.6	6.6	3.3	1.9	1.3	3.5	7.4	6.2
.1	-.7	-.7	-.9	.1	1.0	5.5	7.8	5.9	1.9	.8	.6	2.2	5.0	6.8
-.0	.4	-.1	-.6	-1.1	.7	6.1	6.8	5.3	1.7	1.6	.5	.2	4.5	6.4
-.3	-.5	-.3	.1	.3	.9	6.4	7.2	3.9	1.5	.6	.6	.7	3.5	6.2
.4	-.1	-.3	-.8	-.8	.4	5.4	7.3	5.9	1.0	.5	.1	-.5	3.5	5.9
-.4	.2	.7	.8	.7	.7	5.0	7.3	6.8	3.7	.7	.6	2.3	5.5	10.9
.4	-.3	-1.0	-.9	-1.0	.1	3.2	7.2	7.3	5.8	3.5	3.1	5.4	13.1	34.1
0	.2	.5	.4	.6	-.2	.7	5.4	6.7	7.5	6.3	5.6	8.2	20.4	44.3
0	-.9	-.6	-.8	-.9	-1.1	-.4	3.1	6.6	6.9	7.0	6.6	6.5	21.3	44.1
0	.3	-.1	.2	.2	.6	-.3	.1	4.0	6.1	6.1	4.8	4.3	13.1	35.4
0	0	.6	.3	-.1	.2	.4	.6	1.0	4.8	6.5	5.5	5.1	6.4	12.4
0	0	-.0	.0	.5	.8	.5	-.2	.0	-.3	1.9	4.2	5.1	5.4	6.4
0	0	0	.2	.5	-.8	-.6	.1	-.4	.4	-.9	.5	2.1	3.7	4.2
0	0	0	0	-.3	.7	1.5	-.1	.2	-.8	.0	.3	-.4	-.6	-.3
0	0	0	0	0	.9	-.6	-.3	.9	-.3	.4	.3	-.1	-1.0	-.0
0	0	0	0	0	0	.3	1.6	-.9	.6	.3	.3	.3	-.5	.7
0	0	0	0	0	0	0	-.6	-.3	1.0	.6	-.4	1.1	-.5	1.0
0	0	0	0	0	0	0	0	0	.0	.4	.1	.6	.4	.5
0	0	0	0	0	0	0	0	0	0	0	0	1.2	-.1	1.1

.4	.4	-1.0	1.0	.1	0	0	0	0	0	0	0	0	0	0
.3	.3	-1.0	1.0	.0	-1.5	.7	1.4	0	0	0	0	0	0	0
.1	.1	-.5	.3	.1	-1.0	1.0	.6	-2.7	-.1	0	0	0	0	0
-.3	-.3	-.1	-.1	-.4	-.3	.8	-.3	-1.7	.9	.9	0	0	0	0
-.6	-.6	-.0	-.2	-.7	.1	.4	-1.8	-.1	.6	.4	-1.0	0	0	0
.6	.6	1.1	-.1	-.3	.2	-.5	-1.2	.2	.2	-.2	-.6	.8	0	0
5.9	5.9	5.8	3.8	3.6	.7	-1.1	.1	-.4	.0	-.8	-.1	.7	-.7	0
7.2	7.2	7.2	6.7	7.1	4.5	3.4	-.1	-.7	-.3	-.2	.1	.0	-.4	.2
7.2	7.2	6.7	7.8	6.5	6.3	7.4	3.1	.9	.2	-.8	.4	-.5	-.3	.3
7.3	7.3	6.3	8.3	5.4	8.2	6.6	6.1	5.1	-.4	-.1	-.2	-.8	-.0	-.2
7.0	7.0	6.9	7.1	6.4	8.0	6.1	8.4	6.5	2.7	.3	-.6	-.5	.1	-.5
6.5	6.5	7.5	6.2	7.5	7.0	7.0	7.9	7.1	6.3	.2	-.9	.4	-.8	.2
6.7	6.7	7.2	7.1	6.0	4.7	4.8	6.8	7.0	6.5	2.9	.5	-.8	-.1	-.1
7.3	7.3	6.2	7.4	3.5	1.3	1.9	3.3	6.6	7.6	5.1	-.3	-.1	.4	.0
6.5	6.5	6.8	5.0	2.2	.6	.8	1.9	5.9	7.8	5.5	1.0	.1	-.9	-.7
6.2	6.2	6.4	4.5	.2	.5	1.6	1.7	5.3	6.8	6.1	.7	-1.1	-.6	-.1
5.3	5.3	6.2	3.5	.7	.6	.6	1.5	3.9	7.2	6.4	.9	.3	.1	-.3
6.8	6.8	5.9	3.5	-.5	.1	.5	1.0	5.9	7.3	5.4	.4	-.8	-.8	-.3
21.8	21.8	10.9	5.5	2.3	.6	.7	3.7	6.8	7.3	5.0	.7	.7	.8	.7
44.5	44.5	34.1	13.1	5.4	3.1	3.5	5.8	7.3	7.2	3.2	.1	-1.0	-.9	-1.0
46.9	46.9	44.3	20.4	8.2	5.6	6.3	7.5	6.7	5.4	.7	-.2	.6	.4	.5
47.2	47.2	44.1	21.3	6.5	6.6	7.0	6.9	6.6	3.1	-.4	-1.1	-.9	-.8	-.6
45.1	45.1	35.4	13.1	4.3	4.8	6.1	6.1	4.0	.1	-.3	.6	.2	.2	-.1
21.8	21.8	12.4	6.4	5.1	5.5	6.5	4.8	1.0	.6	.4	.2	-.1	.3	.6
6.7	6.7	6.4	5.4	5.1	4.2	1.9	-.3	.0	-.2	.5	.8	.5	.0	-.0
5.0	5.0	4.2	3.7	2.1	.5	-.9	.4	-.4	.1	-.6	-.8	.5	.2	0
.7	.7	-.3	-.6	-.4	.3	.0	-.8	.2	-.1	1.5	.7	-.3	0	0
-.4	-.4	-.0	-1.0	-.1	.3	.4	-.3	.9	-.3	-.6	.9	0	0	0
-.1	-.1	.7	-.5	.3	.3	.3	.6	-.9	1.6	.3	0	0	0	0
.1	.1	1.0	-.5	1.1	-.4	.6	1.0	-.3	-.6	0	0	0	0	0
.3	.3	.5	.4	.6	.1	.4	.0	0	0	0	0	0	0	0
-.0	-.0	1.1	-.1	1.2	0	0	0	0	0	0	0	0	0	0

```
   0    0
   0    0
   0    0
   0    0
   0    0
   0    0
   0    0
   0    0
   0    0
 -.5    0
  .3    0
  .1    0
  .2  -.0
 -.5  -.6
 -.7   .1
  .4  -.0
 -.5  -.3
 -.1   .4
  .2  -.4
 -.3   .4
  .2    0
 -.9    0
  .3    0
   0    0
   0    0
   0    0
   0    0
   0    0
   0    0
   0    0
   0    0
   0    0
```

8. Examples 8,9,10 - Attenuation Correction Using Attenuation Coefficients from a Transmission Experiment

The next three examples show how to use the RECLBL Library routines to reconstruct the true distribution of isotope concentration in a transverse section by compensating for attenuation in the projection data. In the program ATENX below, a transverse section of attenuation coefficients is first reconstructed from simulated projection data obtained from a transmission scan by using the reconstruction subroutine GRADY in statement E8.063. Using the reconstructed distribution of attenuation coefficients, the attenuation factors are evaluated with the subroutine EVATN in statement E8.091 and then the simulated emission data are reconstructed in statement E8.100 using the subroutine GRADY.

The subroutines BRF, PRF, BRFA, and PRFA (projection and back-projection routines) are declared externals in statement E8.030 and are passed as externals to the subroutine GRADY in statements E8.063 and E8.100. The back-projection and projection subroutines BRFA and PRFA are used for attenuation correction and should only be used after EVATN (or EVATU) has been called.

For the transmission study with MODANG equal to 4 (statement E8.041), the subroutine SETUP generates equal projection angles between 0 and π, while for the emission study MODANG equals 5 (statement E8.084) and SETUP generates equal projection angles between 0 and 2π. The parameter IMIT is set to 1 in statement E8.052 for reconstructing transmission data and set to 0 in statement E8.085 for reconstructing emission data in order to allow for the correct normalization of the reconstructed values.

In Example 8, the subroutine GETUM uses the subroutine PHANL to generate projection data for either a transmission study or an emission study. The variable LTYPE in the labeled common TYPE, determines whether transmission data are returned (LTYPE = 1) or whether emission data are returned (LTYPE = 2). The simulated projection data are for an elliptical source phantom with a concentration of 30 within an elliptical attenuator of the same size, which has an attenuation coefficient of 0.075 (in units of inverse pixel width). If the pixel width is 0.5 cm, then the attenuation coefficient is equal to 0.075/0.5 cm = 0.15 cm^{-1}, which is approximately the attenuation coefficient for 140 KeV photons in tissue.

```
      PROGRAM ATENX (INPUT,OUTPUT,TAPE3,TAPE4=OUTPUT)                   E8.001
C                                                                       E8.002
C        EXAMPLES 8, 9, AND 10                                          E8.003
C                                                                       E8.004
C             THE PROGRAM ATENX RECONSTRUCTS ATTENUATED DATA USING      E8.005
C        ATTENUATION FACTORS WHICH ARE EVALUATED FROM THE RECONSTRUCTION E8.006
C        OF THE ATTENUATION COEFFICIENTS FROM PROJECTIONS OBTAINED FROM E8.007
C        A TRANSMISSION SCAN.                                           E8.008
C                                                                       E8.009
      DIMENSION B(4096),AG(72)                                          E8.010
      COMMON/TYPE/LTYPE                                                 E8.011
      COMMON WORK(18000)                                                E8.012
C                                                                       E8.013
      COMMON/OUTCOM/LUNOUT,I80132                                       E8.014
C                                                                       E8.015
C          LUNOUT  - OUTPUT FILE                                        E8.016
C          I80132  - OUTPUT LINE LENGTH FLAG                            E8.017
C               =0     EACH LINE WILL BE WITHIN 80 CHARACTERS           E8.018
C                       (OTHERWISE 132 CHARACTERS)                      E8.019
C                                                                       E8.020
      COMMON/PARM/IPAR(12),PAR(3)                                       E8.021
C                                                                       E8.022
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)), E8.023
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)), E8.024
     2            (IMIT  ,IPAR( 7)),(NWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)), E8.025
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)), E8.026
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3))  E8.027
C                                                                       E8.028
C                                                                       E8.029
      EXTERNAL BRF,PRF,BRFA,PRFA                                        E8.030
C                                                                       E8.031
      LUNOUT=4                                                          E8.032
      I80132=0                                                          E8.033
C                                                                       E8.034
C        THE INPUT PARAMETERS ARE                                       E8.035
C                                                                       E8.036
      NDIMU=64                                                          E8.037
      ICIR=1                                                            E8.038
      IGEOM=0                                                           E8.039
      NANG=72                                                           E8.040
      MODANG=4                                                          E8.041
      KDIMU=100                                                         E8.042
      NWORK=18000                                                       E8.043
      NFLOAT=1                                                          E8.044
      ISTORE=0                                                          E8.045
      IPRINT=5                                                          E8.046
      LUNATN=3                                                          E8.047
      PWID=1.                                                           E8.048
      AXISU=50.5                                                        E8.049
      RFAN=0.                                                           E8.050
C                                                                       E8.051
      IMIT=1                                                            E8.052
      LTYPE=1                                                           E8.053
      CALL SETUP (IPAR,PAR,AG)                                          E8.054
C                                                                       E8.055
C        RECONSTRUCTION OF THE TRANSVERSE SECTION FOR A                 E8.056
C          TRANSMISSION SCAN                                            E8.057
C                                                                       E8.058
      ISTP=15                                                           E8.059
      IRLX=1                                                            E8.060
      IERR=0                                                            E8.061
      IZER=0                                                            E8.062
      CALL GRADY (B,PRF,BRF,ISTP,IRLX,IERR,IZER)                        E8.063
C                                                                       E8.064
      WRITE (4,24)                                                      E8.065
      CALL ARRAY (B,NDIMU)                                              E8.066
C                                                                       E8.067
C        PRINTOUT THE VALUES FOR THE ATTENUATION COEFFICIENTS           E8.068
C                                                                       E8.069
      NMAT=NDIMU**2                                                     E8.070
      KK1=1                                                             E8.071
      KU=NDIMU/15+1                                                     E8.072
      DO 12 K=1,KU                                                      E8.073
      WRITE (4,18)                                                      E8.074
      KK2=15*K                                                          E8.075
      IF (KK2.GT.NDIMU) KK2=NDIMU                                       E8.076
      DO 10 J=1,NDIMU                                                   E8.077
      ISUB1=NMAT-J*NDIMU+KK1                                            E8.078
      ISUB2=NMAT-J*NDIMU+KK2                                            E8.079
   10 WRITE (4,20) (B(I),I=ISUB1,ISUB2)                                 E8.080
      KK1=KK2+1                                                         E8.081
   12 CONTINUE                                                          E8.082
C                                                                       E8.083
      MODANG=5                                                          E8.084
      IMIT=0                                                            E8.085
      LTYPE=2                                                           E8.086
      CALL SETUP (IPAR,PAR,AG)                                          E8.087
C                                                                       E8.088
C        EVALUATE THE ATTENUATION FACTORS                               E9.089
C                                                                       E8.090
      CALL EVATN (B)                                                    E8.091
C                                                                       E8.092
C        RECONSTRUCTION OF THE TRANSVERSE SECTION FOR AN EMISSION SCAN  E8.093
C          WHICH IS CORRECTED FOR ATTENUATION                           E8.094
C                                                                       E8.095
      ISTP=15                                                           E8.096
      IRLX=1                                                            E8.097
      IERR=0                                                            E8.098
      IZER=0                                                            E8.099
      CALL GRADY (B,PRFA,BRFA,ISTP,IRLX,IERR,IZER)                      E8.100
C                                                                       E8.101
      WRITE (4,26)                                                      E8.102
      CALL ARRAY (B,NDIMU)                                              E8.103
C                                                                       E8.104
C        PRINTOUT THE VALUES FOR THE TRANSVERSE SECTION FOR THE         E8.105
C          EMISSION SCAN                                                E8.106
C                                                                       E8.107
      KK1=1                                                             E8.108
      KU=NDIMU/15+1                                                     E8.109
      DO 16 K=1,KU                                                      E8.110
      WRITE (4,18)                                                      E8.111
      KK2=15*K                                                          E8.112
      IF (KK2.GT.NDIMU) KK2=NDIMU                                       E8.113
      DO 14 J=1,NDIMU                                                   E8.114
      ISUB1=NMAT-J*NDIMU+KK1                                            E8.115
      ISUB2=NMAT-J*NDIMU+KK2                                            E8.116
   14 WRITE (4,22) (B(I),I=ISUB1,ISUB2)                                 E8.117
      KK1=KK2+1                                                         E8.118
   16 CONTINUE                                                          E8.119
C                                                                       E8.120
C                                                                       E8.121
C                                                                       E8.122
   18 FORMAT(1X///////)                                                 E8.123
   20 FORMAT(1X,15F5.3)                                                 E8.124
   22 FORMAT(1X,15F5.1)                                                 E8.125
   24 FORMAT(1X//41H RECONSTRUCTION FOR THE TRANSMISSION SCAN)          E8.126
   26 FORMAT(1X//63H RECONSTRUCTION FOR THE EMISSION SCAN CORRECTED FOR E8.127
     1ATTENUATION)                                                      E8.128
      END                                                               E8.129


      SUBROUTINE GETUM (M,DATA,ERR)                                     E8.130
C                                                                       E8.131
C        EXAMPLE 8                                                      E8.132
C                                                                       E8.133
C             THE SUBROUTINE GETUM GIVES SIMULATED PROJECTION DATA FOR  E8.134
C        AN ELIPICAL SOURCE PHANTOM AND ELIPICAL ATTENUATOR OF THE SAME E8.135
C        SIZE.                                                          E8.136
C             IF                                                        E8.137
C                  LTYPE = 1  GETUM RETURNS TRANSMISSION DATA OF THE    E8.138
C                                ATTENUATOR                             E8.139
C                  LTYPE = 2  GETUM RETURNS ATTENUATED PROJECTION DATA  E8.140
C                                OF THE SOURCE                          E8.141
C                                                                       E8.142
      DIMENSION DATA(1),ERR(1)                                          E8.143
      COMMON/TYPE/LTYPE                                                 E8.144
      DIMENSION ITYPE(2),Z(2),X1(2),Y1(2),A1(2),B1(2),PHI(2)            E8.145
      DATA Z/.075,30./                                                  E8.146
      DATA X1/0.,0./                                                    E8.147
      DATA Y1/0.,0./                                                    E8.148
      DATA A1/40.,40./                                                  E8.149
      DATA B1/60.,60./                                                  E8.150
      DATA PHI/0.,0./                                                   E8.151
```

```
C
      IF (LTYPE.EQ.1) GO TO 10
      IF (LTYPE.EQ.2) GO TO 12
C
   10 ITYPE(1)=1
      CALL PHANL (1,ITYPE,Z,X1,Y1,A1,B1,PHI,DATA,M)
C
      RETURN
C
   12 ITYPE(1)=-1
      ITYPE(2)=1
C
      CALL PHANL (2,ITYPE,Z,X1,Y1,A1,B1,PHI,DATA,M)
C
      RETURN
C
      END
```

```
  SSS  EEEEE TTTTT U   U PPPP
 S     E       T   U   U P   P
  SSS  EEE     T   U   U PPPP
     S E       T   U   U P
  SSS  EEEEE   T    UUU  P
```

```
          INTEGER PARAMETER ARRAY  (IPAR)

 I   IPAR(I)      DESCRIPTION

 1        64      LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
 2         1      RECONSTRUCT IN A SQUARE ARRAY
 3         0      GEOMETRY FLAG
                  PARALLEL BEAM GEOMETRY
 4        72      NUMBER OF PROJECTION ANGLES
 5         4      MODE FOR PROJECTION ANGLE INPUT  (SEE FOLLOWING LINES)
                  ANGLES GENERATED BETWEEN ZERO AND PI
                  STARTING AT ZERO
 6       100      NUMBER OF RAYS FOR EACH PROJECTION
 7         1      TRANSMISSION DATA
 8     18000      DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
 9         1      NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10         0      EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11         5      PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES)
                  PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED
                  PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
12         3      LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE


          FLOATING POINT PARAMETER ARRAY  (PAR)

 I    PAR(I)      DESCRIPTION

 1     1.000      PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
 2    50.500      LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
 3         0  NA  NOT APPLICABLE  (NOT FAN BEAM GEOMETRY)

BLANK COMMON REQUIRED        72   (   110)

BLANK COMMON REQUIRED       144   (   220)

BLANK COMMON REQUIRED       216   (   330)

BLANK COMMON REQUIRED       416   (   640)

BLANK COMMON REQUIRED       544   (  1040)

A TOTAL OF  92 (  5 THRU  96) OF THE 100 USER PROJECTION BINS WILL BE USED

 92 PROJECTION BINS WILL BE USED OF WHICH    0 HAVE BEEN ZEROED BY THE PROGRAM

         MAXIMUM SIZE OF BLANK COMMON THUS FAR=     544 FLOATING POINT WORDS.
```

```
 EEEEE N   N DDDD         SSS  EEEEE TTTTT U   U PPPP
 E     NN  N D   D       S     E       T   U   U P   P
 EEE   N N N D   D        SSS  EEE     T   U   U PPPP
 E     N  NN D   D           S E       T   U   U P
 EEEEE N   N DDDD         SSS  EEEEE   T    UUU  P
```

```
  GGG  RRRR    AAA  DDDD  Y   Y
 G     R   R  A   A D   D  Y Y
 G     RRRR   A   A D   D   Y
 G  GG R  R   AAAAA D   D   Y
  GGGG R   R  A   A DDDD    Y
```

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          PARAMETERS FOR SUBROUTINE GRADY

                  DESCRIPTION

ISTP -      15    NUMBER OF ITERATION STEPS
IRLX -       1    ITERATIVE RELAXATION METHOD
IERR -       0    DO NOT USE ERROR ARRAY
IZER -       0    INITIAL SOLUTION IS ZERO

BLANK COMMON REQUIRED       616   (  1150)

BLANK COMMON REQUIRED      1775   (  3357)

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG     FUNCTION           RAY WEIGHTING      ATTENUATION          FAN BEAM
BCK     BACKPROJECTION     UNIFORM SQUARE         NO                  NO
PRJ     PROJECTION         UNIFORM SQUARE         NO                  NO
```

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BLANK COMMON REQUIRED      1959   (  3647)

BLANK COMMON REQUIRED      6055   ( 13647)

BLANK COMMON REQUIRED     10151   ( 23647)

BLANK COMMON REQUIRED     14247   ( 33647)

BLANK COMMON REQUIRED     14255   ( 33657)

BLANK COMMON REQUIRED     14247   ( 33647)

FOR CONGR AND GRADY FCN IS THE VALUE OF THE CHI-SQUARE
FOR ENTPY FCN IS EVALUATED BY THE SUBROUTINE DULFC
ITER  0     FCN     .314E+05
ITER  1     FCN     .230E+04
ITER  2     FCN     .320E+03
ITER  3     FCN     .158E+03
ITER  4     FCN     .897E+02
ITER  5     FCN     .593E+02
ITER  6     FCN     .418E+02
ITER  7     FCN     .314E+02
ITER  8     FCN     .245E+02
ITER  9     FCN     .198E+02
ITER 10     FCN     .164E+02
ITER 11     FCN     .139E+02
ITER 12     FCN     .120E+02
ITER 13     FCN     .105E+02
ITER 14     FCN     .935E+01
ITER 15     FCN     .840E+01

BLANK COMMON REQUIRED     14063   ( 33357)

BLANK COMMON REQUIRED      9967   ( 23357)

BLANK COMMON REQUIRED      5871   ( 13357)

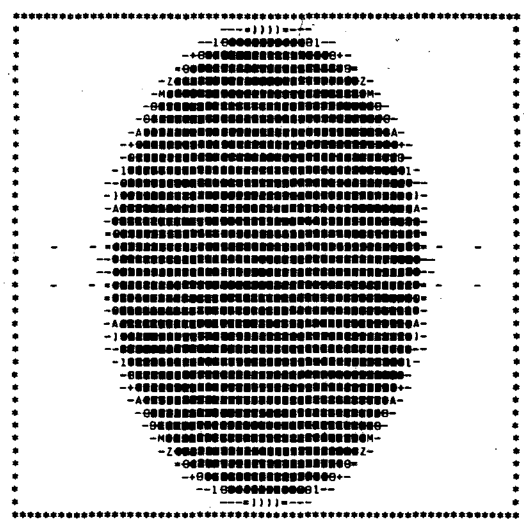
BLANK COMMON REQUIRED      1775   (  3357)

         MAXIMUM SIZE OF BLANK COMMON THUS FAR=  14255 FLOATING POINT WORDS.
```

```
 EEEEE N   N DDDD          GGG  RRRR    AAA  DDDD  Y   Y
 E     NN  N D   D        G     R   R  A   A D   D  Y Y
 EEE   N N N D   D        G     RRRR   A   A D   D   Y
 E     N  NN D   D        G  GG R  R   AAAAA D   D   Y
 EEEEE N   N DDDD          GGGG R   R  A   A DDDD    Y
```

```
RECONSTRUCTION FOR THE TRANSMISSION SCAN

XMIN =   -.42E-02     XMAX =    .82E-01       XSUM =    .1416E+03
```



```
                     -           =           +           )           1           Z
-.4238E-02  .2210E-02  .1167E-01  .1597E-01  .1898E-01  .2241E-01  .2585E-01

Z           X           A           M           0           ●           ●           ●
 .2886E-01  .3101E-01  .3316E-01  .3789E-01  .4262E-01  .4563E-01  .4907E-01

●           ●           ●           ●           ●           ●           ●           ●
 .5208E-01  .5852E-01  .6626E-01  .7056E-01  .7400E-01  .7744E-01  .8045E-01

●
 .8174E-01
```

.001	.000	.001	.001	.001	-.002	.000	-.000	.000	.001	.002	.001	.001	.001	.000
.001	-.001	.000	-.000	.000	-.000	.000	-.001	.000	.000	-.000	.000	.001	-.000	-.000
.000	.000	.000	-.000	-.001	.000	.000	-.001	.000	.000	.000	-.001	.001	.001	-.000
.000	.001	.000	-.000	-.000	.000	-.000	-.000	.000	-.000	-.000	.000	-.000	.001	.001
.001	.001	-.000	.000	-.000	.000	-.001	.000	.001	.001	-.000	.000	.000	-.000	.001
.000	.001	.000	.001	.000	-.000	-.002	.000	.001	.001	.000	.000	.001	.000	-.001
-.000	-.001	.001	.001	.001	-.000	-.001	.000	.001	.001	.001	-.000	-.001	-.002	-.002
-.000	-.000	.001	.001	.001	-.000	-.001	-.001	-.001	-.001	-.000	-.000	-.000	-.000	.000
-.001	.001	-.000	-.000	.001	-.000	-.001	-.002	-.002	-.000	-.000	.001	.002	.000	-.002
-.001	-.001	-.001	-.001	.000	.001	-.000	-.001	.000	.001	.001	.000	-.001	-.002	-.001
.001	-.002	-.000	.000	.000	.001	.001	.000	.001	.000	-.001	-.002	.000	.002	-.002
.002	-.001	-.000	.001	.001	.001	.001	-.001	-.001	-.001	.000	.001	-.001	-.002	.000
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.002	-.001	-.001	-.000	-.001	.001	-.000	.000	.000	-.004	.000	-.001	.003	.012	.055
-.002	-.000	.001	.002	-.001	-.002	.001	.002	-.003	-.001	-.001	.001	.003	.023	.062
-.001	.000	.002	.001	-.002	-.001	.001	-.001	-.001	-.001	.000	.001	.005	.035	.069
.001	-.001	-.000	.001	.001	-.001	-.002	.001	.000	-.003	-.000	.003	.010	.047	.071
.003	-.001	-.002	.001	.002	-.004	-.001	.002	-.002	-.002	-.002	.002	.016	.056	.073
.000	-.000	-.001	.000	-.001	.000	-.000	-.001	.002	-.003	-.000	.003	.025	.064	.073
.000	.002	-.000	-.003	.000	.002	-.002	.001	.001	-.002	-.002	.006	.031	.069	.077
.002	.001	-.001	-.002	.001	.001	-.001	.000	-.000	-.000	-.003	.005	.038	.069	.075
-.000	-.001	.001	-.000	-.001	.000	.001	-.004	.003	-.001	-.001	.009	.046	.072	.075
-.001	-.002	.002	.002	-.002	.001	.001	-.003	.000	.001	-.001	.012	.051	.073	.076
.001	-.000	-.000	.001	-.000	-.001	-.001	-.000	-.004	.003	-.003	.015	.054	.071	.076
.002	.002	-.002	-.001	.003	-.003	-.000	.000	-.004	.003	-.000	.013	.058	.071	.075
.001	.001	-.001	-.000	.001	-.001	-.000	-.001	-.001	-.001	.004	.010	.062	.073	.075
.001	-.001	.001	-.000	-.002	.001	-.002	-.000	.001	-.004	.006	.010	.061	.073	.076
.001	-.001	.001	-.000	-.002	.001	-.002	-.000	.001	-.004	.006	.010	.061	.073	.076
.001	.001	-.001	-.000	.001	-.001	-.000	-.001	-.001	-.001	.004	.010	.062	.073	.075
.002	.002	-.002	-.001	.003	-.003	-.000	.000	-.004	.003	-.000	.013	.058	.071	.075
.001	-.000	-.000	.001	-.000	-.001	-.001	-.000	-.004	.003	-.003	.015	.054	.071	.076
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.000	-.000	-.001	.000	-.001	.000	-.000	-.001	.002	-.003	-.000	.003	.025	.064	.073
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.001	.001	-.001	-.000	-.001	.000	.000	.000	.000	-.001	-.001	.001	-.000	-.000	-.000
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-.001	-.001	-.001	.000	-.001	.001	.001	.001	.003	.010	.029	.050	.064	.069	.070
.001	-.000	.001	-.001	-.002	-.003	-.001	.007	.022	.048	.064	.070	.073	.075	.075
-.001	-.002	-.003	-.003	-.000	.003	.010	.033	.060	.070	.077	.077	.076	.076	.076
-.003	-.000	.002	-.000	.001	.010	.037	.064	.075	.074	.077	.079	.078	.076	.075
-.000	-.000	-.001	.002	.010	.039	.065	.072	.076	.077	.075	.075	.076	.076	.077
-.003	.001	.000	.008	.035	.064	.073	.075	.075	.076	.078	.079	.076	.074	.073
-.000	-.000	.005	.027	.061	.074	.074	.077	.078	.074	.072	.074	.074	.074	.075
-.001	.003	.017	.052	.070	.076	.075	.072	.075	.076	.075	.077	.078	.076	.075
.001	.008	.041	.068	.072	.075	.080	.077	.079	.076	.074	.076	.076	.076	.076
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.073	.073	.075	.077	.075	.075	.077	.075	.076	.074	.076	.074	.077	.077	.076
.069	.076	.075	.075	.077	.075	.076	.075	.074	.075	.075	.073	.076	.077	.074
.059	.074	.077	.074	.077	.077	.074	.077	.074	.076	.074	.074	.077	.074	.075
.048	.069	.076	.077	.075	.076	.074	.076	.074	.076	.075	.075	.075	.075	.074
.026	.060	.076	.079	.075	.077	.075	.075	.075	.077	.075	.075	.075	.075	.074
.012	.050	.072	.072	.075	.075	.076	.075	.076	.077	.074	.076	.076	.074	.074
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-.001	.003	.017	.052	.070	.076	.075	.072	.075	.076	.075	.077	.078	.076	.075
-.000	-.000	.005	.027	.061	.074	.074	.077	.078	.074	.072	.074	.074	.074	.075
-.003	.001	.000	.008	.035	.064	.073	.075	.075	.076	.078	.079	.076	.074	.073
-.000	-.000	-.001	.002	.010	.039	.065	.072	.076	.077	.075	.075	.076	.076	.077
-.003	-.000	.002	-.000	.001	.010	.037	.064	.075	.074	.077	.079	.078	.076	.075
-.001	-.002	-.003	-.003	-.000	.003	.010	.033	.060	.070	.077	.077	.076	.076	.076
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-.001	-.002	-.000	.000	.000	-.002	-.001	-.001	-.001	-.000	.001	.001	.003	.006	.010
-.001	.000	.001	.002	.000	-.001	.001	.001	-.001	.001	.002	.001	-.000	.002	.002

.002	.003	.003	.002	.002	.002	-.000	.001	.002	.001	-.001	.001	.001	-.001	.000
.013	.017	.017	.013	.010	.006	.003	.001	.001	-.000	-.001	-.001	-.001	-.002	.000
.056	.057	.057	.056	.051	.038	.025	.014	.006	.004	.001	-.001	-.001	.000	-.001
.072	.072	.072	.072	.070	.069	.064	.050	.029	.010	.003	.001	.001	.001	-.001
.075	.077	.077	.075	.075	.075	.073	.070	.064	.048	.022	.007	-.001	-.003	-.002
.076	.074	.074	.076	.076	.076	.076	.077	.077	.070	.060	.033	.010	.003	-.000
.077	.078	.078	.077	.075	.076	.078	.079	.077	.074	.075	.064	.037	.010	.001
.076	.077	.077	.076	.077	.076	.076	.075	.075	.077	.076	.072	.065	.039	.010
.073	.072	.072	.073	.073	.074	.076	.079	.078	.076	.075	.075	.073	.064	.035
.076	.075	.075	.076	.075	.074	.074	.074	.072	.074	.078	.077	.074	.074	.061
.075	.075	.075	.075	.075	.076	.078	.077	.075	.076	.075	.072	.075	.076	.070
.074	.075	.075	.074	.076	.076	.076	.076	.074	.076	.079	.077	.080	.075	.072
.076	.075	.075	.076	.075	.075	.076	.076	.073	.075	.077	.074	.077	.075	.081
.075	.075	.075	.075	.074	.074	.076	.076	.074	.077	.076	.075	.076	.075	.075
.074	.076	.076	.074	.074	.075	.075	.075	.075	.077	.075	.075	.075	.077	.075
.075	.075	.075	.075	.074	.075	.075	.075	.075	.076	.074	.076	.074	.076	.075
.075	.074	.074	.075	.075	.074	.077	.074	.074	.076	.074	.077	.074	.077	.077
.074	.075	.075	.074	.074	.077	.076	.073	.075	.075	.074	.075	.076	.075	.077
.074	.075	.075	.074	.076	.077	.077	.074	.076	.074	.076	.075	.077	.075	.075
.076	.075	.075	.076	.075	.075	.076	.074	.075	.073	.077	.074	.074	.076	.075
.074	.074	.074	.074	.073	.076	.074	.074	.077	.074	.076	.075	.074	.076	.077
.074	.077	.077	.074	.075	.076	.074	.074	.076	.074	.076	.073	.074	.074	.075
.075	.075	.075	.075	.074	.076	.073	.077	.074	.077	.075	.074	.076	.075	.075
.074	.075	.075	.074	.075	.076	.073	.077	.073	.074	.076	.075	.074	.076	.078
.074	.075	.075	.074	.076	.077	.074	.075	.075	.073	.074	.077	.076	.074	.073
.073	.075	.075	.073	.077	.076	.076	.073	.076	.074	.073	.074	.076	.077	.076
.074	.074	.074	.074	.077	.073	.077	.074	.073	.075	.077	.077	.075	.074	.075
.074	.075	.075	.074	.078	.072	.075	.077	.076	.074	.073	.073	.074	.075	.076
.074	.076	.076	.074	.076	.075	.072	.073	.076	.077	.076	.076	.076	.076	.075
.077	.074	.074	.077	.072	.076	.078	.077	.077	.076	.075	.074	.075	.074	.075
.082	.073	.073	.082	.077	.074	.074	.074	.073	.074	.074	.075	.074	.074	.076
.073	.073	.073	.073	.074	.077	.075	.074	.075	.075	.074	.074	.077	.074	.075
.073	.073	.073	.073	.074	.077	.075	.074	.075	.075	.074	.074	.077	.074	.075
.082	.073	.073	.082	.077	.074	.074	.074	.073	.074	.074	.075	.074	.074	.076
.077	.074	.074	.077	.072	.076	.078	.077	.077	.076	.075	.074	.075	.074	.075
.074	.076	.076	.074	.076	.075	.072	.073	.076	.077	.076	.076	.076	.076	.075
.074	.075	.075	.074	.078	.072	.075	.077	.076	.074	.073	.073	.074	.075	.076
.074	.074	.074	.074	.077	.073	.077	.074	.073	.075	.077	.077	.075	.074	.075
.073	.075	.075	.073	.077	.076	.076	.073	.076	.074	.073	.074	.076	.077	.076
.074	.075	.075	.074	.076	.077	.074	.075	.075	.073	.074	.077	.076	.074	.073
.074	.075	.075	.074	.075	.076	.073	.077	.073	.074	.076	.075	.074	.076	.078
.075	.075	.075	.075	.074	.076	.073	.077	.074	.077	.075	.074	.076	.075	.075
.074	.077	.077	.074	.075	.076	.074	.074	.076	.074	.076	.073	.074	.074	.075
.074	.074	.074	.074	.073	.076	.074	.074	.077	.074	.076	.075	.074	.076	.077
.076	.075	.075	.076	.075	.075	.076	.074	.075	.073	.077	.074	.074	.076	.075
.074	.075	.075	.074	.076	.077	.077	.074	.076	.074	.076	.075	.077	.075	.075
.074	.075	.075	.074	.074	.077	.076	.073	.075	.075	.074	.075	.076	.075	.077
.075	.074	.074	.075	.075	.074	.077	.074	.074	.076	.074	.077	.074	.077	.077
.075	.075	.075	.075	.074	.075	.075	.075	.075	.076	.074	.076	.074	.076	.075
.074	.076	.076	.074	.074	.075	.075	.075	.075	.077	.075	.075	.075	.077	.075
.075	.075	.075	.075	.074	.074	.076	.076	.074	.077	.076	.075	.076	.075	.075
.076	.075	.075	.076	.075	.075	.076	.076	.073	.075	.077	.074	.077	.075	.081
.074	.075	.075	.074	.076	.076	.076	.076	.074	.076	.079	.077	.080	.075	.072
.075	.075	.075	.075	.075	.076	.078	.077	.075	.076	.075	.072	.075	.076	.070
.076	.075	.075	.076	.075	.074	.074	.074	.072	.074	.078	.077	.074	.074	.061
.073	.072	.072	.073	.073	.074	.076	.079	.078	.076	.075	.075	.073	.064	.035
.076	.077	.077	.076	.077	.076	.076	.075	.075	.077	.076	.072	.065	.039	.010
.077	.078	.078	.077	.075	.076	.078	.079	.077	.074	.075	.064	.037	.010	.001
.076	.074	.074	.076	.076	.076	.076	.077	.077	.070	.060	.033	.010	.003	-.000
.075	.077	.077	.075	.075	.075	.073	.070	.064	.048	.022	.007	-.001	-.003	-.002
.072	.072	.072	.072	.070	.069	.064	.050	.029	.010	.003	.001	.001	.001	-.001
.056	.057	.057	.056	.051	.038	.025	.014	.006	.004	.001	-.001	-.001	.000	-.001
.013	.017	.017	.013	.010	.006	.003	.001	.001	-.000	-.001	-.001	-.001	-.002	.000
.002	.003	.003	.002	.002	.002	-.000	.001	.002	.001	-.001	.001	.001	-.001	.000

.002	.001	.000	-.001	.000	.001	.001	.001	.002	.001	.000	-.000	.000	-.002	.001
.000	-.000	-.002	-.001	-.000	-.000	.001	.000	-.000	.000	.000	-.001	.000	-.000	.000
-.000	-.001	-.002	-.000	-.000	.001	.001	-.001	.000	.000	.000	-.001	.000	.000	-.001
.000	-.001	-.001	-.001	.001	.001	-.000	.000	-.000	-.000	.000	-.000	-.000	.000	-.000
-.001	.001	-.000	.001	.001	-.000	.000	.000	-.000	.001	.001	.000	-.001	.000	-.000
-.003	-.003	-.002	-.001	-.001	.000	.001	.000	.000	.001	.001	.000	-.002	-.000	.000
-.000	.002	-.000	-.003	-.002	-.002	-.001	-.000	.001	.001	.001	.000	-.001	-.000	.001
.002	-.001	-.000	-.000	.000	-.000	-.000	-.000	-.000	-.001	-.001	-.001	-.001	-.000	.001
.008	.000	.001	-.003	-.002	.000	.002	.001	-.000	-.000	-.002	-.002	-.001	-.000	.001
.027	.005	-.000	-.000	-.001	-.002	-.001	.000	.001	.001	.000	-.001	-.000	.001	.000
.032	.017	.003	-.001	-.002	.002	.000	-.002	-.001	.000	.001	.000	.001	.001	.000
.068	.041	.008	.001	.000	-.002	-.001	.001	.000	-.001	-.001	-.001	.001	.001	.001
.075	.061	.027	.004	-.002	.000	-.000	-.002	.001	.002	.000	-.002	-.001	.000	.001
.072	.072	.050	.012	-.000	-.000	-.000	.001	-.001	-.001	.000	.000	.000	.000	-.001
.079	.076	.060	.026	.004	-.002	-.000	-.001	.002	-.001	-.003	-.001	.001	.001	.001
.077	.076	.069	.048	.010	.000	-.001	.001	-.002	.001	-.001	-.002	-.001	.002	.002
.074	.077	.074	.059	.020	.003	.002	-.003	.001	-.002	-.002	.001	.001	-.000	-.001
.075	.075	.076	.069	.039	.007	.001	.001	-.002	-.001	-.003	.001	.002	.001	-.002
.077	.075	.073	.073	.055	.012	.003	-.001	.000	-.004	.000	.000	-.000	.001	-.001
.075	.077	.076	.073	.062	.023	.003	.001	-.001	-.001	-.003	.002	.001	-.002	-.001
.075	.075	.078	.075	.069	.035	.005	.001	.000	-.001	-.001	-.001	.001	-.001	-.002
.078	.077	.074	.073	.071	.047	.010	.003	-.000	-.003	.000	.001	-.002	-.001	.001
.075	.076	.078	.076	.073	.056	.016	.002	-.002	-.002	-.002	.002	-.001	-.004	.002
.076	.074	.075	.075	.073	.064	.025	.003	-.000	-.003	.002	-.001	-.000	.000	-.001
.075	.076	.077	.077	.077	.069	.031	.006	-.002	-.002	.001	.001	-.002	.002	.000
.076	.076	.075	.076	.075	.069	.038	.005	-.003	-.000	-.000	.000	-.001	.001	.001
.074	.074	.076	.076	.075	.072	.046	.009	-.001	-.001	.003	-.004	.001	.000	-.001
.077	.077	.078	.077	.076	.073	.051	.012	-.001	.001	.000	-.003	.001	.001	-.002
.077	.078	.075	.076	.076	.071	.054	.015	-.003	.003	-.004	-.000	-.001	-.001	-.000
.076	.075	.076	.075	.075	.071	.058	.013	-.000	.003	-.004	.000	-.000	-.003	.003
.075	.075	.076	.076	.075	.073	.062	.010	.004	-.001	-.001	-.001	-.000	-.001	.001
.075	.076	.075	.077	.076	.073	.061	.010	.006	-.004	.001	-.000	-.002	.001	-.002
.075	.076	.075	.077	.076	.073	.061	.010	.006	-.004	.001	-.000	-.002	.001	-.002
.075	.075	.076	.076	.075	.073	.062	.010	.004	-.001	-.001	-.001	-.000	-.001	.001
.076	.075	.076	.075	.075	.071	.058	.013	-.000	.003	-.004	.000	-.000	-.003	.003
.077	.078	.075	.076	.076	.071	.054	.015	-.003	.003	-.004	-.000	-.001	-.001	-.000
.077	.077	.078	.077	.076	.073	.051	.012	-.001	.001	.000	-.003	.001	.001	-.002
.074	.074	.076	.076	.075	.072	.046	.009	-.001	-.001	.003	-.004	.001	.000	-.001
.076	.076	.075	.076	.075	.069	.038	.005	-.003	-.000	-.000	.000	-.001	.001	.001
.075	.076	.077	.077	.077	.069	.031	.006	-.002	-.002	.001	.001	-.002	.002	.000
.076	.074	.075	.075	.073	.064	.025	.003	-.000	-.003	.002	-.001	-.000	.000	-.001
.075	.076	.078	.076	.073	.056	.016	.002	-.002	-.002	-.002	.002	-.001	-.004	.002
.078	.077	.074	.073	.071	.047	.010	.003	-.000	-.003	.000	.001	-.002	-.001	.001
.075	.075	.078	.075	.069	.035	.005	.001	.000	-.001	-.001	-.001	.001	-.001	-.002
.075	.077	.076	.073	.062	.023	.003	.001	-.001	-.001	-.003	.002	.001	-.002	-.001
.077	.075	.073	.073	.055	.012	.003	-.001	.000	-.004	.000	.000	-.000	.001	-.001
.075	.075	.076	.069	.039	.007	.001	.001	-.002	-.001	-.003	.001	.002	.001	-.002
.074	.077	.074	.059	.020	.003	.002	-.003	.001	-.002	-.002	.001	.001	-.000	-.001
.077	.076	.069	.048	.010	.000	-.001	.001	-.002	.001	-.001	-.002	-.001	.002	.002
.079	.076	.060	.026	.004	-.002	-.000	-.001	.002	-.001	-.003	-.001	.001	.001	.001
.072	.072	.050	.012	-.000	-.000	-.000	.001	-.001	-.001	.000	.000	.000	.000	-.001
.075	.061	.027	.004	-.002	.000	-.000	-.002	.001	.002	.000	-.002	-.001	.000	.001
.068	.041	.008	.001	.000	-.002	-.001	.001	.000	-.001	-.001	-.001	.001	.001	.001
.032	.017	.003	-.001	-.002	.002	.000	-.002	-.001	.000	.001	.000	.001	.001	.000
.027	.005	-.000	-.000	-.001	-.002	-.001	.000	.001	.001	.000	-.001	-.000	.001	.000
.008	.000	.001	-.003	-.002	.000	.002	.001	-.000	-.000	-.002	-.002	-.001	-.000	.001
.002	-.001	-.000	-.000	.000	-.000	-.000	-.000	-.000	-.001	-.001	-.001	-.001	-.000	.001
-.000	.002	-.000	-.003	-.002	-.002	-.001	-.000	.001	.001	.001	.000	-.001	-.000	.001
-.003	-.003	-.002	-.001	-.001	.000	.001	.000	.000	.001	.001	.000	-.002	-.000	.000
-.001	.001	-.000	.001	.001	-.000	.000	.000	-.000	.001	.001	.000	-.001	.000	-.000
.000	-.001	-.001	-.001	.001	.001	-.000	.000	-.000	-.000	.000	-.000	-.000	.000	-.000
-.000	-.001	-.002	-.000	-.000	.001	.001	-.001	.000	.000	.000	-.001	.000	.000	-.001
.000	-.000	-.002	-.001	-.000	-.000	.001	.000	-.000	.000	.000	-.001	.000	-.000	.000
.002	.001	.000	-.001	.000	.001	.001	.001	.002	.001	.000	-.000	.000	-.002	.001

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 .001 .001 .000 .001
-.000 .000-.001 .001
-.000 .000 .000 .000
-.000 .000 .001 .000
 .000-.000 .001 .001
 .001 .000 .001 .000
 .001 .001-.001-.000
 .001 .001-.000-.000
-.000-.000 .001-.001
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-.001-.000-.000-.000
-.001 .001 .001 .000
-.003 .001 .001 .001
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-.003-.000 .002 .000
-.002-.001 .001 .002
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 .002 .002-.002-.001
 .001-.000-.000 .001
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-.000-.001 .001 .001
-.000 .001-.001 .001
-.000 .001-.001 .001
-.000-.001 .001 .001
-.001-.002 .002 .002
 .001-.000-.000 .001
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-.003-.000 .002 .000
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 .001-.000-.001 .001
 .001 .002 .000-.001
 .002 .001-.000-.002
-.000-.001-.001 .002
-.003 .001 .001 .001
-.001 .001 .001 .000
-.001-.000-.000-.000
-.000-.003-.000 .001
-.000-.001 .001 .001
 .000 .000 .001 .001
 .001-.000-.001 .002
 .000-.000-.002 .001
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 .001 .001-.000-.000
 .001 .001-.001-.000
 .001 .000 .001 .000
 .000-.000 .001 .001
-.000 .000 .001 .000
-.000 .000 .000 .000
-.000 .000-.001 .001
 .001 .001 .000 .001
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  SSS  EEEEE TTTTT U   U PPPP
 S     E       T   U   U P   P
  SSS  EEE     T   U   U PPPP
     S E       T   U   U P
  SSS  EEEEE   T    UUU  P
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          INTEGER PARAMETER ARRAY  (IPAR)

 I   IPAR(I)      DESCRIPTION

 1       64       LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
 2        1       RECONSTRUCT IN A SQUARE ARRAY
 3        0       GEOMETRY FLAG
                  PARALLEL BEAM GEOMETRY
 4       72       NUMBER OF PROJECTION ANGLES
 5        5       MODE FOR PROJECTION ANGLE INPUT  (SEE FOLLOWING LINES)
                  ANGLES GENERATED BETWEEN ZERO AND 2*PI
                  STARTING AT ZERO
 6      100       NUMBER OF RAYS FOR EACH PROJECTION
 7        0       EMISSION DATA
 8    18000       DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
 9        1       NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10        0       EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11        5       PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES)
                  PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED
                  PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
12        3       LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE


          FLOATING POINT PARAMETER ARRAY  (PAR)

 I    PAR(I)      DESCRIPTION

 1     1.000      PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
 2    50.500      LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
 3         0  NA  NOT APPLICABLE  (NOT FAN BEAM GEOMETRY)

BLANK COMMON REQUIRED        72   (   110)

BLANK COMMON REQUIRED       144   (   220)

BLANK COMMON REQUIRED       216   (   330)

BLANK COMMON REQUIRED       416   (   640)

BLANK COMMON REQUIRED       544   (  1040)

A TOTAL OF  92 (  5 THRU  96) OF THE 100 USER PROJECTION BINS WILL BE USED

 92 PROJECTION BINS WILL BE USED OF WHICH   0 HAVE BEEN ZEROED BY THE PROGRAM
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        MAXIMUM SIZE OF BLANK COMMON THUS FAR=  14255 FLOATING POINT WORDS.


     EEEEE N   N DDDD       SSS  EEEEE TTTTT U   U PPPP
     E     NN  N D   D     S     E       T   U   U P   P
     EEE   N N N D   D      SSS  EEE     T   U   U PPPP
     E     N  NN D   D         S E       T   U   U P
     EEEEE N   N DDDD       SSS  EEEEE   T    UUU  P


                EEEEE V   V  AAA  TTTTT N   N
                E     V   V A   A   T   NN  N
                EEE    V V  A   A   T   N N N
                E      V V  AAAAA   T   N  NN
                EEEEE   V   A   A   T   N   N


BLANK COMMON REQUIRED      4640    ( 11040)

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=  14255 FLOATING POINT WORDS.


     EEEEE N   N DDDD       EEEEE V   V  AAA  TTTTT N   N
     E     NN  N D   D      E     V   V A   A   T   NN  N
     EEE   N N N D   D      EEE    V V  A   A   T   N N N
     E     N  NN D   D      E      V V  AAAAA   T   N  NN
     EEEEE N   N DDDD       EEEEE   V   A   A   T   N   N


                 GGG  RRRR   AAA  DDDD  Y   Y
                G   G R   R A   A D   D  Y Y
                G     RRRR  A   A D   D   Y
                G  GG R  R  AAAAA D   D   Y
                 GGGG R   R A   A DDDD    Y


         PARAMETERS FOR SUBROUTINE GRADY

                 DESCRIPTION

ISTP -      15   NUMBER OF ITERATION STEPS
IRLX -       1   ITERATIVE RELAXATION METHOD
IERR -       0   DO NOT USE ERROR ARRAY
IZER -       0   INITIAL SOLUTION IS ZERO

BLANK COMMON REQUIRED      4712    ( 11150)

BLANK COMMON REQUIRED      5322    ( 12312)

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG    FUNCTION         RAY WEIGHTING      ATTENUATION       FAN BEAM
BCK    BACKPROJECTION   UNIFORM SQUARE         YES              NO
PRJ    PROJECTION       UNIFORM SQUARE         YES              NO

BLANK COMMON REQUIRED      5506    ( 12602)

BLANK COMMON REQUIRED      9602    ( 22602)

BLANK COMMON REQUIRED     13698    ( 32602)

BLANK COMMON REQUIRED     17794    ( 42602)

BLANK COMMON REQUIRED     17810    ( 42622)

BLANK COMMON REQUIRED     17794    ( 42602)

FOR CONGR AND GRADY FCN IS THE VALUE OF THE CHI-SQUARE
FOR ENTPY FCN IS EVALUATED BY THE SUBROUTINE DULFC
ITER  0     FCN     .484E+09
ITER  1     FCN     .609E+08
ITER  2     FCN     .180E+08
ITER  3     FCN     .108E+08
ITER  4     FCN     .685E+07
ITER  5     FCN     .460E+07
ITER  6     FCN     .322E+07
ITER  7     FCN     .236E+07
ITER  8     FCN     .180E+07
ITER  9     FCN     .141E+07
ITER 10     FCN     .114E+07
ITER 11     FCN     .949E+06
ITER 12     FCN     .803E+06
ITER 13     FCN     .691E+06
ITER 14     FCN     .603E+06
ITER 15     FCN     .532E+06

BLANK COMMON REQUIRED     17610    ( 42312)

BLANK COMMON REQUIRED     13514    ( 32312)

BLANK COMMON REQUIRED      9418    ( 22312)

BLANK COMMON REQUIRED      5322    ( 12312)

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=  17810 FLOATING POINT WORDS.


     EEEEE N   N DDDD        GGG  RRRR   AAA  DDDD  Y   Y
     E     NN  N D   D      G   G R   R A   A D   D  Y Y
     EEE   N N N D   D      G     RRRR  A   A D   D   Y
     E     N  NN D   D      G  GG R  R  AAAAA D   D   Y
     EEEEE N   N DDDD        GGGG R   R A   A DDDD    Y
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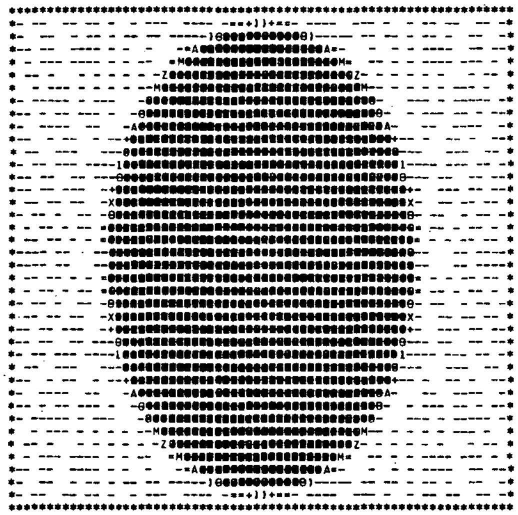
RECONSTRUCTION FOR THE EMISSION SCAN CORRECTED FOR ATTENUATION

XMIN = -.30E+01 XMAX = .35E+02 XSUM = .5690E+05



	-	=	+	)	1	Z
-.2954E+01 -.9939E-01	.4087E+01	.5990E+01	.7322E+01	.8844E+01	.1037E+02	

Z	X	A	M	@	●	@	●
.1170E+02	.1265E+02	.1360E+02	.1569E+02	.1779E+02	.1912E+02	.2064E+02	

■	■	■	■	■	■	■	■
.2197E+02	.2483E+02	.2825E+02	.3016E+02	.3168E+02	.3320E+02	.3453E+02	

■
.3510E+02

.3	-.2	1.0	.8	.0	-1.2	1.1	.6	-.7	1.2	.9	-.3	1.0	.1	-.3
-.1	-1.3	.0	.1	-.5	-1.5	.2	.1	-1.2	.4	.1	-.9	.8	-.5	-.4
1.1	-.1	.6	1.0	.4	-.6	.5	1.1	-.5	.8	.8	-.6	1.2	.1	.1
.7	-.3	-.4	.4	-.0	-1.2	-.7	.5	-1.0	-.1	.4	-.8	.8	-.2	.8
.6	.1	-.8	.7	.5	-.2	-.6	1.4	.0	.5	.7	-.7	.7	-.5	.9
1.0	1.0	-.4	.7	.5	-.4	-1.7	.8	-.0	.4	1.1	-.3	1.2	-.3	.4
-.4	.4	-.4	.3	.8	.3	-1.1	.9	.2	.2	1.0	-.8	-.0	-1.7	-.0
-.6	1.2	.4	.2	1.2	.5	-1.2	-.1	-.6	-1.4	.4	-.6	.7	-.8	1.4
-1.2	1.0	.3	-1.1	.1	-.4	-1.6	-.6	.2	-.5	.9	.0	1.6	-.6	-.2
-1.9	-1.0	-.3	-1.1	.6	1.2	-.3	-.8	.6	-.4	1.8	-.4	-.0	-1.4	.4
-.4	-.6	1.5	-.3	-.2	.8	.6	-.3	1.3	-1.2	.0	-1.2	.6	.8	.1
.3	-1.7	.3	.4	.4	1.4	.5	-1.8	-.1	-1.3	.9	.2	1.0	-.2	-.5
.3	-.1	.7	.9	-.5	.1	-.6	-1.6	.7	-.0	1.5	-.6	.5	-.2	-2.6
1.1	-.0	-1.2	.2	-1.6	.5	.7	-.8	.8	.2	.4	.2	.1	-.5	-2.6
.4	-1.0	-2.5	.7	.5	.1	1.3	-.1	-.6	-.2	1.3	-.7	-.0	-1.3	.3
-.1	.6	-.3	-.8	1.1	.5	1.1	-.8	-.9	.6	-.7	.1	-1.3	.1	3.5
.6	.5	-.2	-.9	1.2	-.4	.7	.8	-1.4	-.3	.5	-1.5	.4	.7	7.6
-.8	1.4	.8	-1.1	-.6	.0	1.4	.2	-1.7	.5	-1.2	.3	.1	2.1	14.8
.2	.8	.4	-1.2	-.4	1.0	-.3	.6	-.5	-1.4	.2	-.1	.7	4.0	21.4
.1	-1.1	.9	.8	-1.4	-.1	-.1	1.0	-1.7	.0	-.1	.3	.7	8.4	24.0
-.4	-.4	1.1	.7	-1.8	.5	-.1	-.6	.1	.1	.2	.4	1.4	13.8	26.7
1.3	.3	-1.1	.4	.5	-1.1	-.7	.5	.8	-1.0	.1	1.0	2.9	18.3	27.4
.9	-.2	-1.6	1.3	.5	-2.6	.5	.7	.5	-.6	-.3	.4	5.4	21.8	28.3
-1.0	.4	.6	-.9	-.3	-.3	.3	-.1	1.5	-1.0	-.2	.5	9.1	24.8	29.0
-.6	1.3	.2	-2.2	.9	.5	-.8	.5	1.5	-.5	-1.1	.8	11.9	26.6	30.4
.8	-.5	-.6	.1	-.4	1.1	-1.1	.7	.7	.4	-1.6	.2	15.3	27.3	29.4
.1	-1.9	1.1	.5	-.7	1.1	-.1	-.7	1.1	.0	-1.4	2.4	18.3	28.1	28.0
-.9	.5	-.4	1.1	.1	.0	.9	-1.7	.7	.7	-2.2	4.1	20.6	28.2	28.9
.9	.4	-.3	.8	.3	-.3	.5	-.5	-.6	1.3	-3.0	5.3	22.4	27.4	29.1
-.3	.7	.8	-.9	1.3	.1	-.4	.6	-1.6	1.1	-1.1	4.2	22.3	27.4	29.4
-.0	.2	.8	-.3	.5	.4	-.2	.5	-.9	-.8	1.0	2.9	25.0	29.2	28.2
1.0	.1	-.3	.8	-.7	.4	.5	-.4	.2	-2.0	1.9	2.9	24.4	28.4	29.5
1.0	.1	-.3	.8	-.7	.4	.5	-.4	.2	-2.0	1.9	2.9	24.4	28.4	29.5
-.0	.2	.8	-.3	.5	.4	-.2	.5	-.9	-.8	1.0	2.9	25.0	29.2	28.2
-.3	.7	.8	-.9	1.3	.1	-.4	.6	-1.6	1.1	-1.1	4.2	22.3	27.4	29.4
.9	.4	-.3	.8	.3	-.3	.5	-.5	-.6	1.3	-3.0	5.3	22.4	27.4	29.1
-.9	.5	-.4	1.1	.1	.0	.9	-1.7	.7	.7	-2.2	4.1	20.6	28.2	28.9
.1	-1.9	1.1	.5	-.7	1.1	-.1	-.7	1.1	.0	-1.4	2.4	18.3	28.1	28.0
.8	-.5	-.6	.1	-.4	1.1	-1.1	.7	.7	.4	-1.6	.2	15.3	27.3	29.4
-.6	1.3	.2	-2.2	.9	.5	-.8	.5	1.5	-.5	-1.1	.8	11.9	26.6	30.4
-1.0	.4	.6	-.9	-.3	-.3	.3	-.1	1.5	-1.0	-.2	.5	9.1	24.8	29.0
.9	-.2	-1.6	1.3	.5	-2.6	.5	.7	.5	-.6	-.3	.4	5.4	21.8	28.3
1.3	.3	-1.1	.4	.5	-1.1	-.7	.5	.8	-1.0	.1	1.0	2.9	18.3	27.4
-.4	-.4	1.1	.7	-1.8	.5	-.1	-.6	.1	.1	.2	.4	1.4	13.8	26.7
.1	-1.1	.9	.8	-1.4	-.1	-.1	1.0	-1.7	.0	-.1	.3	.7	8.4	24.0
.2	.8	.4	-1.2	-.4	1.0	-.3	.6	-.5	-1.4	.2	-.1	.7	4.0	21.4
-.8	1.4	.8	-1.1	-.6	.0	1.4	.2	-1.7	.5	-1.2	.3	.1	2.1	14.8
.6	.5	-.2	-.9	1.2	-.4	.7	.8	-1.4	-.3	.5	-1.5	.4	.7	7.6
-.1	.6	-.3	-.8	1.1	.5	1.1	-.8	-.9	.6	-.7	.1	-1.3	.1	3.5
.4	-1.0	-2.5	.7	.5	.1	1.3	-.1	-.6	-.2	1.3	-.7	-.0	-1.3	.3
1.1	-.0	-1.2	.2	-1.6	.5	.7	-.8	.8	.2	.4	.2	.1	-.5	-2.6
.3	-.1	.7	.9	-.5	.1	-.6	-1.6	.7	-.0	1.5	-.6	.5	-.2	-2.6
.3	-1.7	.3	.4	.4	1.4	.5	-1.8	-.1	-1.3	.9	.2	1.0	-.2	-.5
-.4	-.6	1.5	-.3	-.2	.8	.6	-.3	1.3	-1.2	.0	-1.2	.6	.8	.1
-1.9	-1.0	-.3	-1.1	.6	1.2	-.3	-.8	.6	-.4	1.8	-.4	-.0	-1.4	.4
-1.2	1.0	.3	-1.1	.1	-.4	-1.6	-.6	.2	-.5	.9	.0	1.6	-.6	-.2
-.6	1.2	.4	.2	1.2	.5	-1.2	-.1	-.6	-1.4	.4	-.6	.7	-.8	1.4
-.4	.4	-.4	.3	.8	.3	-1.1	.9	.2	.2	1.0	-.8	-.0	-1.7	-.0
1.0	1.0	-.4	.7	.5	-.4	-1.7	.8	-.0	.4	1.1	-.3	1.2	-.3	.4
.6	.1	-.8	.7	.5	-.2	-.6	1.4	.0	.5	.7	-.7	.7	-.5	.9
.7	-.3	-.4	.4	-.0	-1.2	-.7	.5	-1.0	-.1	.4	-.8	.8	-.2	.8
1.1	-.1	.6	1.0	.4	-.6	.5	1.1	-.5	.8	.8	-.6	1.2	.1	.1
-.1	-1.3	.0	.1	-.5	-1.5	.2	.1	-1.2	.4	.1	-.9	.8	-.5	-.4
.3	-.2	1.0	.8	.0	-1.2	1.1	.6	-.7	1.2	.9	-.3	1.0	.1	-.3

.5	-1.1	.7	.5	.4	-1.3	-.4	.1	.4	.9	1.0	-.1	-2.1	-2.0	-.3
.2	-1.7	.2	.6	.3	-1.0	-.5	.0	.3	.5	.3	-1.6	-.6	2.6	3.0
.3	-1.2	.0	.5	-.6	-.5	-.1	.3	.7	1.3	-.4	3.8	10.1	14.4	20.3
.1	-.4	.2	.9	-.9	.4	.9	1.0	.9	.2	10.8	20.8	26.0	27.5	28.7
.3	.1	.9	.1	-1.7	-1.5	-.5	2.5	5.3	19.2	26.7	27.9	30.2	29.6	30.9
-.9	-1.0	-.5	-1.8	-1.2	.4	3.9	10.6	24.3	28.5	31.0	31.5	30.5	29.9	32.0
-1.6	.1	1.5	-1.7	-1.3	5.3	12.9	25.3	30.2	29.2	30.9	32.9	31.2	30.6	31.1
-.8	-.0	-.9	-1.1	4.8	14.1	25.3	28.6	30.0	30.4	30.8	30.7	30.3	31.1	31.3
-2.5	1.1	-.9	1.9	14.1	25.2	29.1	29.8	29.5	30.4	32.2	32.4	30.5	29.9	29.4
-.4	.9	-1.6	11.9	24.1	29.2	28.7	30.7	31.4	30.0	29.1	29.9	30.3	30.2	30.5
-.9	-.2	5.4	21.4	26.8	30.1	29.9	28.7	30.6	30.7	30.8	32.2	31.3	31.6	30.8
-.3	.4	18.1	26.6	27.9	30.3	32.5	31.4	31.9	31.2	30.9	31.2	30.7	32.0	30.5
.5	10.4	24.8	29.1	31.7	29.7	30.9	30.6	32.0	31.2	30.3	30.7	31.1	31.1	29.0
4.4	21.3	28.1	28.2	29.9	30.6	30.6	30.1	31.0	31.7	30.9	30.8	30.7	29.6	29.2
10.2	23.8	29.3	30.7	29.6	30.8	30.5	30.9	31.0	32.8	31.5	29.2	30.6	30.0	30.1
19.7	27.4	29.6	30.3	30.1	30.9	30.0	30.5	30.4	31.5	30.8	30.1	31.5	29.5	29.8
23.8	29.2	30.2	29.3	31.1	31.7	30.3	31.5	30.9	31.9	29.7	29.3	31.8	28.5	30.9
27.1	29.8	29.8	29.9	31.0	30.7	31.9	30.6	30.6	31.8	30.6	29.5	31.8	31.7	28.7
28.1	28.8	29.8	30.5	30.1	30.8	31.9	30.6	31.5	31.3	30.0	30.1	30.4	32.5	30.2
28.1	30.6	30.8	30.0	31.1	31.2	30.4	30.2	32.1	30.8	29.4	31.0	30.2	29.5	30.9
28.9	31.2	30.5	30.6	31.1	31.2	30.3	30.5	32.3	31.7	30.8	30.5	30.4	29.5	27.6
28.0	29.9	31.4	31.7	30.5	30.5	29.9	30.5	31.2	32.2	31.3	28.5	28.9	31.0	29.9
28.7	31.3	30.9	30.7	30.6	30.8	30.5	30.0	32.0	30.4	31.9	32.3	29.6	30.3	29.4
28.8	30.5	30.7	31.0	31.3	31.6	30.3	31.2	35.1	29.7	29.2	31.0	28.9	30.3	29.5
30.0	31.2	32.0	31.1	30.3	31.2	31.4	30.9	30.3	30.1	30.0	30.4	30.0	32.2	30.3
30.1	29.9	31.6	30.5	29.7	31.3	30.9	33.5	30.0	30.2	30.3	29.4	30.2	31.6	32.0
30.0	29.5	31.1	30.9	31.1	31.0	28.7	33.9	31.9	31.1	30.1	30.1	30.8	28.4	31.1
31.4	31.2	32.9	31.4	30.1	30.9	29.6	31.5	30.8	31.0	30.8	31.1	30.0	27.9	30.7
29.6	29.3	32.7	33.4	30.2	29.3	31.2	31.6	31.6	32.9	32.0	29.3	28.6	29.7	30.2
29.8	31.8	30.2	32.0	32.1	28.0	31.9	31.5	31.3	31.4	31.6	30.6	30.4	30.3	27.9
29.2	32.0	30.6	31.2	31.9	28.6	31.4	32.4	31.5	30.3	29.6	30.1	30.1	28.6	30.2
31.2	29.8	30.3	32.8	30.3	29.0	32.9	31.6	30.8	30.3	30.5	29.3	30.4	32.2	30.0
31.2	29.8	30.3	32.8	30.3	29.0	32.9	31.6	30.8	30.3	30.5	29.3	30.4	32.2	30.0
29.2	32.0	30.6	31.2	31.9	28.6	31.4	32.4	31.5	30.3	29.6	30.1	30.1	28.6	30.2
29.8	31.8	30.2	32.0	32.1	28.0	31.9	31.5	31.3	31.4	31.6	30.6	30.4	30.3	27.9
29.6	29.3	32.7	33.4	30.2	29.3	31.2	31.6	31.6	32.9	32.0	29.3	28.6	29.7	30.2
31.4	31.2	32.9	31.4	30.1	30.9	29.6	31.5	30.8	31.0	30.8	31.1	30.0	27.9	30.7
30.0	29.5	31.1	30.9	31.1	31.0	28.7	33.9	31.9	31.1	30.1	30.1	30.8	28.4	31.1
30.1	29.9	31.6	30.5	29.7	31.3	30.9	33.5	30.0	30.2	30.3	29.4	30.2	31.6	32.0
30.0	31.2	32.0	31.1	30.3	31.2	31.4	30.9	30.3	30.1	30.0	30.4	30.0	32.2	30.3
28.8	30.5	30.7	31.0	31.3	31.6	30.3	31.2	35.1	29.7	29.2	31.0	28.9	30.3	29.5
28.7	31.3	30.9	30.7	30.6	30.8	30.5	30.0	32.0	30.4	31.9	32.3	29.6	30.3	29.4
28.0	29.9	31.4	31.7	30.5	30.5	29.9	30.5	31.2	32.2	31.3	28.5	28.9	31.0	29.9
28.9	31.2	30.5	30.6	31.1	31.2	30.3	30.5	32.3	31.7	30.8	30.5	30.4	29.5	27.6
28.1	30.6	30.8	30.0	31.1	31.2	30.4	30.2	32.1	30.8	29.4	31.0	30.2	29.5	30.9
28.1	28.8	29.8	30.5	30.1	30.8	31.9	30.6	31.5	31.3	30.0	30.1	30.4	32.5	30.2
27.1	29.8	29.8	29.9	31.0	30.7	31.9	30.6	30.6	31.8	30.6	29.5	31.8	31.7	28.7
23.8	29.2	30.2	29.3	31.1	31.7	30.3	31.5	30.9	31.9	29.7	29.3	31.8	28.5	30.9
19.7	27.4	29.6	30.3	30.1	30.9	30.0	30.5	30.4	31.5	30.8	30.1	31.5	29.5	29.8
10.2	23.8	29.3	30.7	29.6	30.8	30.5	30.9	31.0	32.8	31.5	29.2	30.6	30.0	30.1
4.4	21.3	28.1	28.2	29.9	30.6	30.6	30.1	31.0	31.7	30.9	30.8	30.7	29.6	29.2
.5	10.4	24.8	29.1	31.7	29.7	30.9	30.6	32.0	31.2	30.3	30.7	31.1	31.1	29.0
-.3	.4	18.1	26.6	27.9	30.3	32.5	31.4	31.9	31.2	30.9	31.2	30.7	32.0	30.5
-.9	-.2	5.4	21.4	26.8	30.1	29.9	28.7	30.6	30.7	30.8	32.2	31.3	31.6	30.8
-.4	.9	-1.6	11.9	24.1	29.2	28.7	30.7	31.4	30.0	29.1	29.9	30.3	30.2	30.5
-2.5	1.1	-.9	1.9	14.1	25.2	29.1	29.8	29.5	30.4	32.2	32.4	30.5	29.9	29.4
-.8	-.0	-.9	-1.1	4.8	14.1	25.3	28.6	30.0	30.4	30.8	30.7	30.3	31.1	31.3
-1.6	.1	1.5	-1.7	-1.3	5.3	12.9	25.3	30.2	29.2	30.9	32.9	31.2	30.6	31.1
-.9	-1.0	-.5	-1.8	-1.2	.4	3.9	10.6	24.3	28.5	31.0	31.5	30.5	29.9	32.0
.3	.1	.9	.1	-1.7	-1.5	-.5	2.5	5.3	19.2	26.7	27.9	30.2	29.6	30.9
.1	-.4	.2	.9	-.9	.4	.9	1.0	.9	.2	10.8	20.8	26.0	27.5	28.7
.3	-1.2	.0	.5	-.6	-.5	-.1	.3	.7	1.3	-.4	3.8	10.1	14.4	20.3
.2	-1.7	.2	.6	.3	-1.0	-.5	.0	.3	.5	.3	-1.6	-.6	2.6	3.0
.5	-1.1	.7	.5	.4	-1.3	-.4	.1	.4	.9	1.0	-.1	-2.1	-2.0	-.3

.5	-1.3	-1.3	.5	-.3	-2.0	-2.1	-.1	1.0	.9	.4	.1	-.4	-1.3	.4
3.4	4.9	4.9	3.4	3.0	2.6	-.6	-1.6	.3	.5	.3	.0	-.5	-1.0	.3
23.6	23.6	23.6	23.6	20.3	14.4	10.1	3.8	-.4	1.3	.7	.3	-.1	-.5	-.6
29.3	29.1	29.1	29.3	28.7	27.5	26.0	20.8	10.8	.2	.9	1.0	.9	.4	-.9
29.9	31.1	31.1	29.9	30.9	29.6	30.2	27.9	26.7	19.2	5.3	2.5	-.5	-1.5	-1.7
30.8	30.1	30.1	30.8	32.0	29.9	30.5	31.5	31.0	28.5	24.3	10.6	3.9	.4	-1.2
31.2	32.6	32.6	31.2	31.1	30.6	31.2	32.9	30.9	29.2	30.2	25.3	12.9	5.3	-1.3
30.8	31.8	31.8	30.8	31.3	31.1	30.3	30.7	30.8	30.4	30.0	28.6	25.3	14.1	4.8
29.6	29.4	29.4	29.6	29.4	29.9	30.5	32.4	32.2	30.4	29.5	29.8	29.1	25.2	14.1
30.8	30.5	30.5	30.8	30.5	30.2	30.3	29.9	29.1	30.0	31.4	30.7	28.7	29.2	24.1
30.2	30.5	30.5	30.2	30.8	31.6	31.3	32.2	30.8	30.7	30.6	28.7	29.9	30.1	26.8
30.0	30.0	30.0	30.0	30.5	32.0	30.7	31.2	30.9	31.2	31.9	31.4	32.5	30.3	27.9
31.4	29.8	29.8	31.4	29.0	31.1	31.1	30.7	30.3	31.2	32.0	30.6	30.9	29.7	31.7
30.9	30.1	30.1	30.9	29.2	29.6	30.7	30.8	30.9	31.7	31.0	30.1	30.6	30.6	29.9
28.8	30.6	30.6	28.8	30.1	30.0	30.6	29.2	31.5	32.8	31.0	30.9	30.5	30.8	29.6
29.3	30.8	30.8	29.3	29.8	29.5	31.5	30.1	30.8	31.5	30.4	30.5	30.0	30.9	30.1
30.9	28.7	28.7	30.9	30.9	28.5	31.8	29.3	29.7	31.9	30.9	31.5	30.3	31.7	31.1
29.5	29.1	29.1	29.5	28.7	31.7	31.8	29.5	30.6	31.8	30.6	30.6	31.9	30.7	31.0
28.8	30.4	30.4	28.8	30.2	32.5	30.4	30.1	30.0	31.3	31.5	30.6	31.9	30.8	30.1
30.9	28.8	28.8	30.9	30.9	29.5	30.2	31.0	29.4	30.8	32.1	30.2	30.4	31.2	31.1
28.8	29.3	29.3	28.8	27.6	29.5	30.4	30.5	30.8	31.7	32.3	30.5	30.3	31.2	31.1
29.0	31.2	31.2	29.0	29.9	31.0	28.9	28.5	31.3	32.2	31.2	30.5	29.9	30.5	30.5
30.1	29.2	29.2	30.1	29.4	30.3	29.6	32.3	31.9	30.4	32.0	30.0	30.5	30.8	30.6
29.4	28.7	28.7	29.4	29.5	30.3	28.9	31.0	29.2	29.7	35.1	31.2	30.3	31.6	31.3
28.1	28.6	28.6	28.1	30.3	32.2	30.0	30.4	30.0	30.1	30.3	30.9	31.4	31.2	30.3
28.1	28.6	28.6	28.1	32.0	31.6	30.2	29.4	30.3	30.2	30.0	33.5	30.9	31.3	29.7
29.3	27.8	27.8	29.3	31.1	28.4	30.8	30.1	30.1	31.1	31.9	33.9	28.7	31.0	31.1
29.3	28.2	28.2	29.3	30.7	27.9	30.0	31.1	30.8	31.0	30.8	31.5	29.6	30.9	30.1
28.3	30.7	30.7	28.3	30.2	29.7	28.6	29.3	32.0	32.9	31.6	31.6	31.2	29.3	30.2
31.0	28.7	28.7	31.0	27.9	30.3	30.4	30.6	31.6	31.4	31.3	31.5	31.9	28.0	32.1
32.1	26.5	26.5	32.1	30.2	28.6	30.1	30.1	29.6	30.3	31.5	32.4	31.4	28.6	31.9
28.5	27.6	27.6	28.5	30.0	32.2	30.4	29.3	30.5	30.3	30.8	31.6	32.9	29.0	30.3
28.5	27.6	27.6	28.5	30.0	32.2	30.4	29.3	30.5	30.3	30.8	31.6	32.9	29.0	30.3
32.1	26.5	26.5	32.1	30.2	28.6	30.1	30.1	29.6	30.3	31.5	32.4	31.4	28.6	31.9
31.0	28.7	28.7	31.0	27.9	30.3	30.4	30.6	31.6	31.4	31.3	31.5	31.9	28.0	32.1
28.3	30.7	30.7	28.3	30.2	29.7	28.6	29.3	32.0	32.9	31.6	31.6	31.2	29.3	30.2
29.3	28.2	28.2	29.3	30.7	27.9	30.0	31.1	30.8	31.0	30.8	31.5	29.6	30.9	30.1
29.3	27.8	27.8	29.3	31.1	28.4	30.8	30.1	30.1	31.1	31.9	33.9	28.7	31.0	31.1
28.1	28.6	28.6	28.1	32.0	31.6	30.2	29.4	30.3	30.2	30.0	33.5	30.9	31.3	29.7
28.1	28.6	28.6	28.1	30.3	32.2	30.0	30.4	30.0	30.1	30.3	30.9	31.4	31.2	30.3
29.4	28.7	28.7	29.4	29.5	30.3	28.9	31.0	29.2	29.7	35.1	31.2	30.3	31.6	31.3
30.1	29.2	29.2	30.1	29.4	30.3	29.6	32.3	31.9	30.4	32.0	30.0	30.5	30.8	30.6
29.0	31.2	31.2	29.0	29.9	31.0	28.9	28.5	31.3	32.2	31.2	30.5	29.9	30.5	30.5
28.8	29.3	29.3	28.8	27.6	29.5	30.4	30.5	30.8	31.7	32.3	30.5	30.3	31.2	31.1
30.9	28.8	28.8	30.9	30.9	29.5	30.2	31.0	29.4	30.8	32.1	30.2	30.4	31.2	31.1
28.8	30.4	30.4	28.8	30.2	32.5	30.4	30.1	30.0	31.3	31.5	30.6	31.9	30.8	30.1
29.5	29.1	29.1	29.5	28.7	31.7	31.8	29.5	30.6	31.8	30.6	30.6	31.9	30.7	31.0
30.9	28.7	28.7	30.9	30.9	28.5	31.8	29.3	29.7	31.9	30.9	31.5	30.3	31.7	31.1
29.3	30.8	30.8	29.3	29.8	29.5	31.5	30.1	30.8	31.5	30.4	30.5	30.0	30.9	30.1
28.8	30.6	30.6	28.8	30.1	30.0	30.6	29.2	31.5	32.8	31.0	30.9	30.5	30.8	29.6
30.9	30.1	30.1	30.9	29.2	29.6	30.7	30.8	30.9	31.7	31.0	30.1	30.6	30.6	29.9
31.4	29.8	29.8	31.4	29.0	31.1	31.1	30.7	30.3	31.2	32.0	30.6	30.9	29.7	31.7
30.0	30.0	30.0	30.0	30.5	32.0	30.7	31.2	30.9	31.2	31.9	31.4	32.5	30.3	27.9
30.2	30.5	30.5	30.2	30.8	31.6	31.3	32.2	30.8	30.7	30.6	28.7	29.9	30.1	26.8
30.8	30.5	30.5	30.8	30.5	30.2	30.3	29.9	29.1	30.0	31.4	30.7	28.7	29.2	24.1
29.6	29.4	29.4	29.6	29.4	29.9	30.5	32.4	32.2	30.4	29.5	29.8	29.1	25.2	14.1
30.8	31.8	31.8	30.8	31.3	31.1	30.3	30.7	30.8	30.4	30.0	28.6	25.3	14.1	4.8
31.2	32.6	32.6	31.2	31.1	30.6	31.2	32.9	30.9	29.2	30.2	25.3	12.9	5.3	-1.3
30.8	30.1	30.1	30.8	32.0	29.9	30.5	31.5	31.0	28.5	24.3	10.6	3.9	.4	-1.2
29.9	31.1	31.1	29.9	30.9	29.6	30.2	27.9	26.7	19.2	5.3	2.5	-.5	-1.5	-1.7
29.3	29.1	29.1	29.3	28.7	27.5	26.0	20.8	10.8	.2	.9	1.0	.9	.4	-.9
23.6	23.6	23.6	23.6	20.3	14.4	10.1	3.8	-.4	1.3	.7	.3	-.1	-.5	-.6
3.4	4.9	4.9	3.4	3.0	2.6	-.6	-1.6	.3	.5	.3	.0	-.5	-1.0	.3
.5	-1.3	-1.3	.5	-.3	-2.0	-2.1	-.1	1.0	.9	.4	.1	-.4	-1.3	.4

.5	.7	-1.1	.5	-.3	.1	1.0	-.3	.9	1.2	-.7	.6	1.1	-1.2	.0	.8	1.0	-.2	.3
.6	.2	-1.7	.2	-.4	-.5	.8	-.9	.1	.4	-1.2	.1	.2	-1.5	-.5	.1	.0	-1.3	-.1
.5	.0	-1.2	.3	.1	.1	1.2	-.6	.8	.8	-.5	1.1	.5	-.6	.4	1.0	.6	-.1	1.1
.9	.2	-.4	.1	.8	-.2	.8	-.8	.4	-.1	-1.0	.5	-.7	-1.2	-.0	.4	-.4	-.3	.7
.1	.9	.1	.3	.9	-.5	.7	-.7	.7	.5	.0	1.4	-.6	-.2	.5	.7	-.8	.1	.6
-1.8	-.5	-1.0	-.9	.4	-.3	1.2	-.3	1.1	.4	-.0	.8	-1.7	-.4	.5	.7	-.4	1.0	1.0
-1.7	1.5	.1	-1.6	-.0	-1.7	-.0	-.8	1.0	.2	.2	.9	-1.1	.3	.8	.3	-.4	.4	-.4
-1.1	-.9	-.0	-.8	1.4	-.8	.7	-.6	.4	-1.4	-.6	-.1	-1.2	.5	1.2	.2	.4	1.2	-.6
1.9	-.9	1.1	-2.5	-.2	-.6	1.6	.0	.9	-.5	.2	-.6	-1.6	-.4	.1	-1.1	.3	1.0	-1.2
11.9	-1.6	.9	-.4	.4	-1.4	-.0	-.4	1.8	-.4	.6	-.8	-.3	1.2	.6	-1.1	-.3	-1.0	-1.9
21.4	5.4	-.2	-.9	.1	.8	.6	-1.2	.0	-1.2	1.3	-.3	.6	.8	-.2	-.3	1.5	-.6	-.4
26.6	18.1	.4	-.3	-.5	-.2	1.0	.2	.9	-1.3	-.1	-1.8	.5	1.4	.4	.4	.3	-1.7	.3
29.1	24.8	10.4	.5	-2.6	-.2	.5	-.6	1.5	-.0	.7	-1.6	-.6	.1	-.5	.9	.7	-.1	.3
28.2	28.1	21.3	4.4	-2.6	-.5	.1	.2	.4	.2	.8	-.8	.7	.5	-1.6	.2	-1.2	-.0	1.1
30.7	29.3	23.8	10.2	.3	-1.3	-.0	-.7	1.3	-.2	-.6	-.1	1.3	.1	.5	.7	-2.5	-1.0	.4
30.3	29.6	27.4	19.7	3.5	.1	-1.3	.1	-.7	.6	-.9	-.8	1.1	.5	1.1	-.8	-.3	.6	-.1
29.3	30.2	29.2	23.8	7.6	.7	.4	-1.5	.5	-.3	-1.4	.8	.7	-.4	1.2	-.9	-.2	.5	.6
29.9	29.8	29.8	27.1	14.8	2.1	.1	.3	-1.2	.5	-1.7	.2	1.4	.0	-.6	-1.1	.8	1.4	-.8
30.5	29.8	28.8	28.1	21.4	4.0	.7	-.1	.2	-1.4	-.5	.6	-.3	1.0	-.4	-1.2	.4	.8	.2
30.0	30.8	30.6	28.1	24.0	8.4	.7	.3	-.1	.0	-1.7	1.0	-.1	-.1	-1.4	.8	.9	-1.1	.1
30.6	30.5	31.2	28.9	26.7	13.8	1.4	.4	.2	.1	.1	-.6	-.1	.5	-1.8	.7	1.1	-.4	-.4
31.7	31.4	29.9	28.0	27.4	18.3	2.9	1.0	.1	-1.0	.8	.5	-.7	-1.1	.5	.4	-1.1	.3	1.3
30.7	30.9	31.3	28.7	28.3	21.8	5.4	.4	-.3	-.6	.5	.7	.5	-2.6	.5	1.3	-1.6	-.2	.9
31.0	30.7	30.5	28.8	29.0	24.8	9.1	.5	-.2	-1.0	1.5	-.1	.3	-.3	-.3	-.9	.6	.4	-1.0
31.1	32.0	31.2	30.0	30.4	26.6	11.9	.8	-1.1	-.5	1.5	.5	-.8	.5	.9	-2.2	.2	1.3	-.6
30.5	31.6	29.9	30.1	29.4	27.3	15.3	.2	-1.6	.4	.7	.7	-1.1	1.1	-.4	.1	-.6	-.5	.8
30.9	31.1	29.5	30.0	28.0	28.1	18.3	2.4	-1.4	.0	1.1	-.7	-.1	1.1	-.7	.5	1.1	-1.9	.1
31.4	32.9	31.2	31.4	28.9	28.2	20.6	4.1	-2.2	.7	.7	-1.7	.9	.0	.1	1.1	-.4	.5	-.9
33.4	32.7	29.3	29.6	29.1	27.4	22.4	5.3	-3.0	1.3	-.6	-.5	.5	-.3	.3	.8	-.3	.4	.9
32.0	30.2	31.8	29.8	29.4	27.4	22.3	4.2	-1.1	1.1	-1.6	.6	-.4	.1	1.3	-.9	.8	.7	-.3
31.2	30.6	32.0	29.2	28.2	29.2	25.0	2.9	1.0	-.8	-.9	.5	-.2	.4	.5	-.3	.8	.2	-.0
32.8	30.3	29.8	31.2	29.5	28.4	24.4	2.9	1.9	-2.0	.2	-.4	.5	.4	-.7	.8	-.3	.1	1.0
32.8	30.3	29.8	31.2	29.5	28.4	24.4	2.9	1.9	-2.0	.2	-.4	.5	.4	-.7	.8	-.3	.1	1.0
31.2	30.6	32.0	29.2	28.2	29.2	25.0	2.9	1.0	-.8	-.9	.5	-.2	.4	.5	-.3	.8	.2	-.0
32.0	30.2	31.8	29.8	29.4	27.4	22.3	4.2	-1.1	1.1	-1.6	.6	-.4	.1	1.3	-.9	.8	.7	-.3
33.4	32.7	29.3	29.6	29.1	27.4	22.4	5.3	-3.0	1.3	-.6	-.5	.5	-.3	.3	.8	-.3	.4	.9
31.4	32.9	31.2	31.4	28.9	28.2	20.6	4.1	-2.2	.7	.7	-1.7	.9	.0	.1	1.1	-.4	.5	-.9
30.9	31.1	29.5	30.0	28.0	28.1	18.3	2.4	-1.4	.0	1.1	-.7	-.1	1.1	-.7	.5	1.1	-1.9	.1
30.5	31.6	29.9	30.1	29.4	27.3	15.3	.2	-1.6	.4	.7	.7	-1.1	1.1	-.4	.1	-.6	-.5	.8
31.1	32.0	31.2	30.0	30.4	26.6	11.9	.8	-1.1	-.5	1.5	.5	-.8	.5	.9	-2.2	.2	1.3	-.6
31.0	30.7	30.5	28.8	29.0	24.8	9.1	.5	-.2	-1.0	1.5	-.1	.3	-.3	-.3	-.9	.6	.4	-1.0
30.7	30.9	31.3	28.7	28.3	21.8	5.4	.4	-.3	-.6	.5	.7	.5	-2.6	.5	1.3	-1.6	-.2	.9
31.7	31.4	29.9	28.0	27.4	18.3	2.9	1.0	.1	-1.0	.8	.5	-.7	-1.1	.5	.4	-1.1	.3	1.3
30.6	30.5	31.2	28.9	26.7	13.8	1.4	.4	.2	.1	.1	-.6	-.1	.5	-1.8	.7	1.1	-.4	-.4
30.0	30.8	30.6	28.1	24.0	8.4	.7	.3	-.1	.0	-1.7	1.0	-.1	-.1	-1.4	.8	.9	-1.1	.1
30.5	29.8	28.8	28.1	21.4	4.0	.7	-.1	.2	-1.4	-.5	.6	-.3	1.0	-.4	-1.2	.4	.8	.2
29.9	29.8	29.8	27.1	14.8	2.1	.1	.3	-1.2	.5	-1.7	.2	1.4	.0	-.6	-1.1	.8	1.4	-.8
29.3	30.2	29.2	23.8	7.6	.7	.4	-1.5	.5	-.3	-1.4	.8	.7	-.4	1.2	-.9	-.2	.5	.6
30.3	29.6	27.4	19.7	3.5	.1	-1.3	.1	-.7	.6	-.9	-.8	1.1	.5	1.1	-.8	-.3	.6	-.1
30.7	29.3	23.8	10.2	.3	-1.3	-.0	-.7	1.3	-.2	-.6	-.1	1.3	.1	.5	.7	-2.5	-1.0	.4
28.2	28.1	21.3	4.4	-2.6	-.5	.1	.2	.4	.2	.8	-.8	.7	.5	-1.6	.2	-1.2	-.0	1.1
29.1	24.8	10.4	.5	-2.6	-.2	.5	-.6	1.5	-.0	.7	-1.6	-.6	.1	-.5	.9	.7	-.1	.3
26.6	18.1	.4	-.3	-.5	-.2	1.0	.2	.9	-1.3	-.1	-1.8	.5	1.4	.4	.4	.3	-1.7	.3
21.4	5.4	-.2	-.9	.1	.8	.6	-1.2	.0	-1.2	1.3	-.3	.6	.8	-.2	-.3	1.5	-.6	-.4
11.9	-1.6	.9	-.4	.4	-1.4	-.0	-.4	1.8	-.4	.6	-.8	-.3	1.2	.6	-1.1	-.3	-1.0	-1.9
1.9	-.9	1.1	-2.5	-.2	-.6	1.6	.0	.9	-.5	.2	-.6	-1.6	-.4	.1	-1.1	.3	1.0	-1.2
-1.1	-.9	-.0	-.8	1.4	-.8	.7	-.6	.4	-1.4	-.6	-.1	-1.2	.5	1.2	.2	.4	1.2	-.6
-1.7	1.5	.1	-1.6	-.0	-1.7	-.0	-.8	1.0	.2	.2	.9	-1.1	.3	.8	.3	-.4	.4	-.4
-1.8	-.5	-1.0	-.9	.4	-.3	1.2	-.3	1.1	.4	-.0	.8	-1.7	-.4	.5	.7	-.4	1.0	1.0
.1	.9	.1	.3	.9	-.5	.7	-.7	.7	.5	.0	1.4	-.6	-.2	.5	.7	-.8	.1	.6
.9	.2	-.4	.1	.8	-.2	.8	-.8	.4	-.1	-1.0	.5	-.7	-1.2	-.0	.4	-.4	-.3	.7
.5	.0	-1.2	.3	.1	.1	1.2	-.6	.8	.8	-.5	1.1	.5	-.6	.4	1.0	.6	-.1	1.1
.6	.2	-1.7	.2	-.4	-.5	.8	-.9	.1	.4	-1.2	.1	.2	-1.5	-.5	.1	.0	-1.3	-.1
.5	.7	-1.1	.5	-.3	.1	1.0	-.3	.9	1.2	-.7	.6	1.1	-1.2	.0	.8	1.0	-.2	.3

Example 9 uses the following subroutine GETUM and the same program ATENX to reconstruct simulated projection data for a heart phantom, which is attenuated by an attenuator consisting of chest tissue and lungs.

```
      SUBROUTINE GETUM (M,DATA,ERR)
C
C        EXAMPLE 9
C
C             THE SUBROUTINE GETUM GIVES SIMULATED PPOJECTION DATA FOR
C        A HEART PHANTOM WHICH IS ATTENUATED BY AN ATTENUATOR CONSISTING
C        OF CHEST TISSUE AND LUNGS.
C             IF
C                  LTYPE = 1  GETUM RETURNS TRANSMISSION DATA OF THE
C                               ATTENUATOR
C                  LTYPE = 2  GETUM RETURNS ATTENUATED PROJECTION DATA
C                               OF THE SOURCE
C
      DIMENSION DATA(1),ERR(1)
      COMMON/TYPE/LTYPE
      DIMENSION A1(4),B1(4),XMU(4),X1(4),Y1(4),PHI(4),ITYPE(4)
      DATA A1/40.,10.,10.,10./
      DATA B1/40.,14.,14.,10./
      DATA XMU/.10,-.07,-.07,30./
      DATA X1/0.,10.,-10.,0./
      DATA Y1/0.,0.,0.,-10./
      DATA PHI/0.,0.,0.,0./
C
      IF (LTYPE.EQ.1) GO TO 10
      IF (LTYPE.EQ.2) GO TO 12
C
   10 ITYPE(1)=1
      ITYPE(2)=1
      ITYPE(3)=1
      CALL PHANL (3,ITYPE,XMU,X1,Y1,A1,B1,PHI,DATA,M)
C
      RETURN
C
   12 ITYPE(1)=-1
      ITYPE(2)=-1
      ITYPE(3)=-1
      ITYPE(4)=1
C
      CALL PHANL (4,ITYPE,XMU,X1,Y1,A1,B1,PHI,DATA,M)
C
      RETURN
C
      END
```

```
                 SSS  EEEEE TTTTT U   U PPPP
                S     E       T   U   U P   P
                 SSS  EEE     T   U   U PPPP
                    S E       T   U   U P
                 SSS  EEEEE   T    UUU  P
```

INTEGER PARAMETER ARRAY (IPAR)

I	IPAR(I)	DESCRIPTION
1	64	LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
2	1	RECONSTRUCT IN A SQUARE ARRAY
3	0	GEOMETRY FLAG PARALLEL BEAM GEOMETRY
4	72	NUMBER OF PROJECTION ANGLES
5	4	MODE FOR PROJECTION ANGLE INPUT (SEE FOLLOWING LINES) ANGLES GENERATED BETWEEN ZERO AND PI STARTING AT ZERO
6	100	NUMBER OF RAYS FOR EACH PROJECTION
7	1	TRANSMISSION DATA
8	18000	DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
9	1	NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10	0	EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11	5	PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES) PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
12	3	LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE

FLOATING POINT PARAMETER ARRAY (PAR)

I	PAR(I)	DESCRIPTION
1	1.000	PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
2	50.500	LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
3	0 NA	NOT APPLICABLE (NOT FAN BEAM GEOMETRY)

```
BLANK COMMON REQUIRED        72    (   110)

BLANK COMMON REQUIRED       144    (   220)

BLANK COMMON REQUIRED       216    (   330)

BLANK COMMON REQUIRED       416    (   640)

BLANK COMMON REQUIRED       544    (  1040)

A TOTAL OF  92 (  5 THRU  96) OF THE 100 USER PROJECTION BINS WILL BE USED

 92 PROJECTION BINS WILL BE USED OF WHICH   0 HAVE BEEN ZEROED BY THE PROGRAM

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=    544 FLOATING POINT WORDS.
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ENDS SETUP

GRADY

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PARAMETERS FOR SUBROUTINE GRADY

        DESCRIPTION

ISTP -    15   NUMBER OF ITERATION STEPS
IRLX -     1   ITERATIVE RELAXATION METHOD
IERR -     0   DO NOT USE ERROR ARRAY
IZER -     0   INITIAL SOLUTION IS ZERO

BLANK COMMON REQUIRED       616    (  1150)

BLANK COMMON REQUIRED      1775    (  3357)

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG    FUNCTION          RAY WEIGHTING      ATTENUATION        FAN BEAM
BCK    BACKPROJECTION    UNIFORM SQUARE         NO                 NO
PRJ    PROJECTION        UNIFORM SQUARE         NO                 NO

BLANK COMMON REQUIRED      1959    (  3647)

BLANK COMMON REQUIRED      6055    ( 13647)

BLANK COMMON REQUIRED     10151    ( 23647)

BLANK COMMON REQUIRED     14247    ( 33647)

BLANK COMMON REQUIRED     14271    ( 33677)

BLANK COMMON REQUIRED     14247    ( 33647)

FOR CONGR AND GRADY FCN IS THE VALUE OF THE CHI-SQUARE
FOR ENTPY FCN IS EVALUATED BY THE SUBROUTINE OULFC
ITER  0     FCN    .235E+05
ITER  1     FCN    .307E+04
ITER  2     FCN    .655E+03
ITER  3     FCN    .324E+03
ITER  4     FCN    .184E+03
ITER  5     FCN    .119E+03
ITER  6     FCN    .817E+02
ITER  7     FCN    .591E+02
ITER  8     FCN    .444E+02
ITER  9     FCN    .346E+02
ITER 10     FCN    .277E+02
ITER 11     FCN    .228E+02
ITER 12     FCN    .192E+02
ITER 13     FCN    .165E+02
ITER 14     FCN    .143E+02
ITER 15     FCN    .126E+02

BLANK COMMON REQUIRED     14063    ( 33357)

BLANK COMMON REQUIRED      9967    ( 23357)

BLANK COMMON REQUIRED      5871    ( 13357)

BLANK COMMON REQUIRED      1775    (  3357)

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=  14271 FLOATING POINT WORDS.
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ENDS GRADY

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RECONSTRUCTION FOR THE TRANSMISSION SCAN

XMIN =    -.22E-02     XMAX =     .11E+00     XSUM =     .1106E+03
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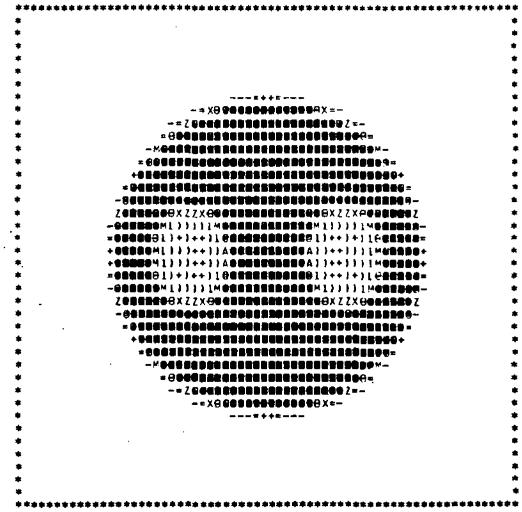

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                           -           =           +           )           1          Z
-.2158E-02  .6188E-02  .1843E-01  .2399E-01  .2789E-01  .3234E-01  .3679E-01

Z           X           A           M           θ
.4068E-01  .4347E-01  .4625E-01  .5237E-01  .5849E-01  .6238E-01  .6683E-01

.7073E-01  .7907E-01  .8909E-01  .9465E-01  .9910E-01  .1036E+00  .1075E+00

.1091E+00
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 .101 .100 .100 .101 .101 .103 .103 .099 .101 .101 .102 .102 .100 .094 .086
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 .098 .100 .100 .098 .102 .103 .099 .096 .097 .079 .059 .049 .030 .062 .083
 .099 .099 .099 .099 .103 .098 .101 .094 .076 .050 .037 .034 .033 .036 .050
 .100 .100 .100 .100 .103 .099 .098 .089 .056 .034 .029 .028 .028 .030 .035
 .099 .103 .103 .099 .103 .100 .092 .070 .040 .031 .029 .028 .028 .030 .032
 .104 .099 .099 .104 .097 .100 .096 .059 .036 .030 .028 .027 .028 .028 .030
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 .098 .098 .098 .098 .097 .098 .087 .045 .032 .029 .028 .027 .029 .028 .029
 .098 .098 .098 .098 .097 .098 .087 .045 .032 .029 .028 .027 .029 .028 .029
 .109 .099 .099 .109 .103 .096 .088 .049 .031 .028 .028 .028 .027 .028 .031
 .104 .099 .099 .104 .097 .100 .096 .059 .036 .030 .028 .027 .028 .028 .030
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 .002-.001 .002-.001
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                 SSS  EEEEE TTTTT U   U PPPP
                S     E       T   U   U P   P
                 SSS  EEE     T   U   U PPPP
                    S E       T   U   U P
                 SSS  EEEEE   T    UUU  P


        INTEGER PARAMETER ARRAY  (IPAR)

 I    IPAR(I)       DESCRIPTION

 1       64         LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
 2        1         RECONSTRUCT IN A SQUARE ARRAY
 3        0         GEOMETRY FLAG
                    PARALLEL BEAM GEOMETRY
 4       72         NUMBER OF PROJECTION ANGLES
 5        5         MODE FOR PROJECTION ANGLE INPUT  (SEE FOLLOWING LINES)
                    ANGLES GENERATED BETWEEN ZERO AND 2*PI
                    STARTING AT ZERO
 6      100         NUMBER OF RAYS FOR EACH PROJECTION
 7        0         EMISSION DATA
 8    18000         DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
 9        1         NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10        0         EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11        5         PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES)
                    PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED
                    PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
12        3         LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE


        FLOATING POINT PARAMETER ARRAY  (PAR)

 I    PAR(I)        DESCRIPTION

 1     1.000        PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
 2    50.500        LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
 3         0  NA    NOT APPLICABLE  (NOT FAN BEAM GEOMETRY)

BLANK COMMON REQUIRED        72   (   110)

BLANK COMMON REQUIRED       144   (   220)

BLANK COMMON REQUIRED       216   (   330)

BLANK COMMON REQUIRED       416   (   640)

BLANK COMMON REQUIRED       544   (  1040)

A TOTAL OF  92 (  5 THRU  96) OF THE 100 USER PROJECTION BINS WILL BE USED

 92 PROJECTION BINS WILL BE USED OF WHICH   0 HAVE BEEN ZEROED BY THE PROGRAM

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=  14271 FLOATING POINT WORDS.

           EEEEE N   N DDDD          SSS  EEEEE TTTTT U   U PPPP
           E     NN  N D   D        S     E       T   U   U P   P
           EEE   N N N D   D         SSS  EEE     T   U   U PPPP
           E     N  NN D   D            S E       T   U   U P
           EEEEE N   N DDDD          SSS  EEEEE   T    UUU  P


                 EEEEE V   V  AAA  TTTTT N   N
                 E     V   V A   A   T   NN  N
                 EEE    V V  A   A   T   N N N
                 E      V V  AAAAA   T   N  NN
                 EEEEE   V   A   A   T   N   N

BLANK COMMON REQUIRED      4640   ( 11040)

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=  14271 FLOATING POINT WORDS.

           EEEEE N   N DDDD          EEEEE V   V  AAA  TTTTT N   N
           E     NN  N D   D         E     V   V A   A   T   NN  N
           EEE   N N N D   D         EEE    V V  A   A   T   N N N
           E     N  NN D   D         E      V V  AAAAA   T   N  NN
           EEEEE N   N DDDD          EEEEE   V   A   A   T   N   N


                  GGG  RRRR   AAA  DDDD  Y   Y
                 G   G R   R A   A D   D  Y Y
                 G     RRRR  A   A D   D   Y
                 G  GG R  R  AAAAA D   D   Y
                  GGGG R   R A   A DDDD    Y


        PARAMETERS FOR SUBROUTINE GRADY

                    DESCRIPTION

ISTP -     15       NUMBER OF ITERATION STEPS
IRLX -      1       ITERATIVE RELAXATION METHOD
IERR -      0       DO NOT USE ERROR ARRAY
IZER -      0       INITIAL SOLUTION IS ZERO

BLANK COMMON REQUIRED      4712   ( 11150)

BLANK COMMON REQUIRED      5322   ( 12312)

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG    FUNCTION          RAY WEIGHTING      ATTENUATION        FAN BEAM
BCK    BACKPROJECTION    UNIFORM SQUARE         YES               NO
PRJ    PROJECTION        UNIFORM SQUARE         YES               NO

BLANK COMMON REQUIRED      5506   ( 12602)

BLANK COMMON REQUIRED      9602   ( 22602)

BLANK COMMON REQUIRED     13698   ( 32602)

BLANK COMMON REQUIRED     17794   ( 42602)

BLANK COMMON REQUIRED     17826   ( 42642)

BLANK COMMON REQUIRED     17794   ( 42602)

FOR CONGR AND GRADY FCN IS THE VALUE OF THE CHI-SQUARE
FOR ENTPY FCN IS EVALUATED BY THE SUBROUTINE DULFC
ITER  0     FCN     .270E+07
ITER  1     FCN     .107E+07
ITER  2     FCN     .570E+06
ITER  3     FCN     .347E+06
ITER  4     FCN     .230E+06
ITER  5     FCN     .161E+06
ITER  6     FCN     .118E+06
ITER  7     FCN     .900E+05
ITER  8     FCN     .708E+05
ITER  9     FCN     .573E+05
ITER 10     FCN     .474E+05
ITER 11     FCN     .400E+05
ITER 12     FCN     .343E+05
ITER 13     FCN     .299E+05
ITER 14     FCN     .263E+05
ITER 15     FCN     .234E+05

BLANK COMMON REQUIRED     17610   ( 42312)

BLANK COMMON REQUIRED     13514   ( 32312)

BLANK COMMON REQUIRED      9418   ( 22312)

BLANK COMMON REQUIRED      5322   ( 12312)

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=  17826 FLOATING POINT WORDS.

           EEEEE N   N DDDD         GGG  RRRR   AAA  DDDD  Y   Y
           E     NN  N D   D       G   G R   R A   A D   D  Y Y
           EEE   N N N D   D       G     RRRR  A   A D   D   Y
           E     N  NN D   D       G  GG R  R  AAAAA D   D   Y
           EEEEE N   N DDDD         GGGG R   R A   A DDDD    Y


RECONSTRUCTION FOR THE EMISSION SCAN CORRECTED FOR ATTENUATION

XMIN =   -.12E+01     XMAX =   .32E+02     XSUM =   .2416E+04
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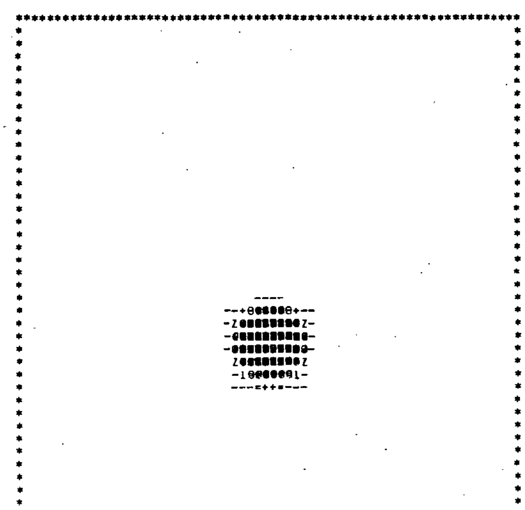

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            .           -           =           +           )           1           Z
-.1183E+01  .1323E+01  .4998E+01  .6668E+01  .7838E+01  .9174E+01  .1051E+02

Z           X           A           M           0           @           ■           ■
 .1168E+02  .1252E+02  .1335E+02  .1519E+02  .1703E+02  .1819E+02  .1953E+02

■           ■           ■           ■           ■           ■           ■           ■
 .2070E+02  .2321E+02  .2621E+02  .2788E+02  .2922E+02  .3056E+02  .3173E+02

■
 .3223E+02
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.0	-.0	.0	.0	.0	.0	-.1	.0	.1	-.0	-.0	-.1	.1	.0	-.0
.0	-.0	-.0	.1	.0	.0	-.0	-.1	.1	.0	-.0	-.1	.0	.0	-.0
.0	.0	-.0	.0	.0	.0	-.0	-.1	.0	.1	.0	-.0	-.0	.1	.0
.1	-.0	-.0	-.1	.1	.0	.0	-.0	-.0	.1	.1	-.0	-.1	.1	.0
.1	.0	-.0	-.0	-.0	.1	.0	-.0	-.1	.0	.1	.0	-.1	-.0	.1
.0	.1	.0	-.0	-.1	.0	.1	.0	-.0	-.0	.1	.1	-.0	-.1	.1
-.0	.0	.1	.0	-.0	-.0	.1	.1	-.0	-.1	.0	.1	.0	-.1	.0
-.0	-.0	.1	.1	.0	-.1	.0	.1	.0	-.0	-.0	.1	.0	-.0	-.0
-.0	-.0	.0	.1	.1	.0	-.1	.0	.1	.0	-.1	.0	.0	.0	-.1
.0	-.1	-.1	.0	.1	.0	-.0	-.0	.0	.1	-.0	-.0	.1	.0	-.0
.1	.0	-.1	-.0	.0	.1	.0	-.0	.0	.1	.0	-.1	.0	.0	-.0
.0	.1	.0	-.1	-.0	.0	.1	.0	-.0	.0	.0	-.0	-.0	.0	.0
-.1	.0	.1	.0	-.1	-.0	.0	.0	-.0	.0	.0	.0	-.0	.1	.0
-.0	-.1	.1	.1	.0	-.1	-.0	.0	.0	-.0	.1	.0	-.0	.0	.0
.0	-.0	-.1	.1	.1	.0	-.0	-.0	.0	-.0	.0	.1	-.0	-.0	.1
.1	.0	-.0	-.1	.1	.1	.0	.0	-.0	.0	-.0	.1	.1	-.1	.0
.1	.1	.0	-.0	-.0	.0	.0	.0	.0	-.0	-.0	.0	.1	.0	-.1
-.1	.0	.0	.0	-.1	-.0	.0	.0	.0	.0	-.0	-.1	.1	.1	-.0
-.0	-.1	-.0	.0	.0	-.1	.0	.1	-.0	.0	.1	-.0	-.1	.1	.0
.1	.0	-.0	-.0	.0	-.0	-.1	.1	.1	-.0	.0	.1	-.1	-.0	.0
.0	.0	.0	.0	-.0	-.0	-.1	-.1	.1	.0	.0	.0	.0	-.0	-.0
-.0	.0	.0	.0	.0	.1	-.0	-.1	-.1	.1	.0	.0	.0	-.0	.0
.0	.0	.0	-.0	-.0	.0	.1	.0	-.1	-.1	.1	.1	.1	.0	-.1
.0	.0	.0	.1	.0	-.1	.0	.1	.1	-.1	-.1	.0	.1	.1	.0
.0	.0	.0	.0	.1	.1	-.0	-.0	.0	.1	-.1	-.1	-.1	.1	.1
.0	.0	.0	-.0	.0	.0	.1	.0	.0	.0	.0	-.1	.0	-.1	.0
-.0	.0	.0	.0	-.0	-.0	.0	.1	.0	.1	.1	-.0	-.1	.1	-.0
-.0	-.0	-.0	.1	.1	.0	-.0	.0	.0	-.0	.1	.1	.0	-.1	.0
-.0	-.1	-.1	-.1	.0	.1	.1	.0	.0	.0	-.0	.0	.1	-.0	-.0
.0	.1	.1	-.0	-.1	-.1	-.0	.0	.0	.1	.1	-.0	.0	.1	-.1
-.0	-.0	.0	.1	.1	.0	-.0	-.0	-.0	-.0	-.0	.0	.1	.1	.1
.0	-.0	-.1	-.1	-.0	.0	.0	-.0	.0	.1	.0	-.0	-.1	-.0	.1
.1	.1	.1	.0	.0	.0	-.0	.0	-.1	-.1	-.0	.0	.1	.1	.0
-.1	-.1	-.0	.0	.0	.0	.0	.1	.1	.1	.0	.0	.0	.1	-.0
.1	.0	-.0	-.1	-.0	-.0	-.0	-.0	-.0	-.0	.0	-.0	-.0	.1	.2
.0	.1	.1	.1	.0	.0	.0	.1	.0	.0	.0	.0	.1	.0	.1
-.1	-.1	-.1	-.1	.0	.0	-.0	-.1	-.0	.0	-.0	-.1	-.1	-.1	-.1
.1	.1	.0	-.0	-.0	-.0	.0	.1	.1	.0	.1	.1	.1	.1	.0
.0	.0	.1	.0	.0	-.0	-.1	-.1	-.1	-.0	-.0	-.0	-.0	.1	.1
-.1	-.0	-.0	.0	.0	.0	.1	.1	.1	.0	-.0	-.0	.0	-.0	-.1
.1	.1	.1	.0	.0	.0	.0	-.0	-.0	-.0	-.0	-.0	-.1	-.0	.0
-.0	-.0	-.0	-.0	-.0	-.0	-.0	.0	.0	.0	.0	.0	-.0	-.1	-.1
-.1	-.0	-.0	-.0	.0	.0	.0	.0	.0	-.0	-.0	-.0	.0	.1	.1
.1	.1	.1	.1	.0	-.0	-.1	-.0	-.0	.0	.1	.1	.1	.1	.0
-.1	-.1	-.1	-.0	.0	.0	.1	.1	.1	.0	.0	.0	.0	-.0	.0
-.0	.0	.0	.0	.0	-.0	-.0	-.0	-.0	-.0	.0	-.0	.0	.1	.0
.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	-.0	-.0
-.1	-.1	-.1	-.1	-.0	-.0	-.0	-.0	-.0	.0	-.0	-.1	-.1	-.0	.0
.0	.1	.1	.1	.0	.0	.1	.1	.1	.0	-.0	.1	.1	.1	.1
.1	.0	-.0	-.0	.0	.0	.0	-.0	-.1	-.1	.0	-.0	.0	.0	-.0
-.1	-.0	.0	.0	.0	.0	-.0	-.0	.1	.1	.1	.1	.1	-.0	-.0
.1	.1	.1	.1	-.0	-.0	.0	.1	.0	.0	.0	.0	-.1	-.0	.0
.1	.0	-.0	-.1	-.1	.0	.0	.0	.1	.1	.0	-.1	.0	.0	.1
-.1	-.1	-.0	.1	.1	.0	.0	.0	.1	-.0	-.1	.1	.0	.0	-.1
.0	.1	.1	.0	-.0	.0	.0	.0	-.0	-.0	.1	-.1	-.1	-.0	.0
.1	.0	-.0	-.0	.0	.1	.1	-.0	-.1	-.1	-.1	.0	.1	.1	.0
-.0	-.0	.1	.1	.1	-.0	-.2	-.1	-.0	-.0	.1	.1	.1	-.1	.0
.1	.1	.1	-.1	-.2	-.2	.0	.1	.0	.1	.1	-.1	-.0	.1	-.1
-.0	-.1	-.1	-.1	-.1	.1	.1	.0	.0	-.0	.0	.0	.0	-.0	-.1
-.0	.0	-.0	-.0	.1	.1	-.1	-.1	.0	.1	-.0	-.0	.0	-.1	.2
.1	-.0	.0	.1	-.0	-.1	.0	.1	.1	-.0	-.0	.0	-.1	.1	-.1
-.0	.0	-.0	-.1	-.1	.1	.1	.0	-.0	-.1	.1	.0	-.0	-.0	-.0
-.1	-.0	.0	-.0	.1	.1	.0	-.1	-.1	.1	.0	-.2	.0	.0	.0
.0	.1	.0	.0	.0	.0	-.1	-.0	.1	.0	-.2	.1	.1	-.0	.1

-.0	.0	.0	-.0	-.0	.0	.0	-.0	.0	.0	.0	-.0	.0	.0	-.0
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-.0	.0	.0	-.0	.0	.0	.0	-.0	.0	.0	.0	-.0	.0	.0	-.0
-.0	.0	.0	-.0	.0	.0	.0	-.0	.0	.0	-.0	-.0	.1	.0	-.0
-.0	.0	.0	-.0	.0	.0	-.0	-.0	.0	.0	-.0	-.0	.0	-.0	-.0
.0	.0	.0	.0	.0	.0	-.0	.0	.0	.0	-.0	.0	.0	-.0	-.0
.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	-.0	.0	.0	-.0	.0
.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	-.0	.0	.0	-.0	.0
.0	-.0	-.0	.0	-.0	-.0	.0	-.0	.0	.0	-.0	.0	.0	-.0	.0
.0	-.0	-.0	.0	-.0	-.0	.0	-.0	.0	.0	-.0	.0	.0	-.0	.0
.0	-.0	-.0	.0	-.0	-.0	.0	-.0	.0	.0	-.0	.0	.0	-.0	.0
.0	-.0	-.0	.0	-.0	.0	.0	-.0	.0	.0	-.0	.0	-.0	-.0	.1
.0	.0	.0	.0	-.0	.0	.0	-.0	.0	.0	.0	.0	-.0	.0	.0
.0	.0	.0	.0	-.0	.0	.0	-.0	.0	.0	.0	-.0	-.0	.1	-.0
.0	.0	.0	.0	-.0	.0	.0	-.0	.0	.0	.0	-.0	.0	.0	-.0
-.0	.0	.0	-.0	.0	.0	.0	-.0	.0	.0	.0	-.0	.0	-.0	-.0
-.1	.0	.0	-.1	.1	.0	.1	-.0	.1	.0	-.0	.0	.0	-.0	.0
-.1	.0	.0	-.1	.1	-.0	.1	-.0	.1	-.0	-.0	.1	-.0	.0	.0
-.0	.0	.0	-.0	.1	-.0	.1	-.0	.1	-.0	.0	.0	-.0	.0	.0
-.0	.0	.0	-.0	.1	-.0	.1	-.0	.0	-.0	.0	-.1	.1	.0	.1
.0	-.0	-.0	.0	.1	-.0	.1	-.1	.1	-.0	-.0	-.0	.1	.0	.1
.0	-.0	-.0	.0	.1	.0	.1	-.1	.1	-.2	.0	.1	-.0	.2	-.1
.1	-.0	-.0	.1	.1	.1	.1	-.1	.0	-.2	.1	.1	.1	.2	-.1
.1	-.0	-.0	.1	.1	.1	.1	-.1	-.1	-.1	.1	.0	.1	.1	-.0
.1	-.0	-.0	.1	.1	.1	.2	-.2	-.1	-.1	.2	.1	.3	-.1	-.0
.2	-.0	-.0	.2	.1	.2	.1	-.3	-.1	-.0	.2	.2	.2	-.4	.1
.3	.1	.1	.3	-.0	.3	-.1	-.3	-.1	.2	.3	.2	-.2	-.1	.0
.0	.2	.2	.0	.1	.1	-.0	-.5	.0	.4	.1	.1	-.3	.2	-.1
-.1	.4	.4	-.1	.2	.0	-.1	-.5	.4	.3	-.1	.1	-.1	.1	-.2
.2	.3	.3	.2	-.1	.1	-.5	-.1	.2	.2	.2	-.0	-.0	-.3	.1
.2	.5	.5	.2	.1	-.4	-.3	-.1	.2	.3	.2	-.5	-.1	.0	.2
.3	.7	.7	.3	-.4	-.3	-.5	.2	.4	-.0	-.1	-.2	.0	.3	-.0
.1	.5	.5	.1	-.3	-.7	.0	.2	-.1	.0	-.1	.2	.1	.0	.0
-.0	.4	.4	-.0	-.7	-.3	-.4	.2	.4	.2	-.2	-.2	-.0	-.2	-.0
-.1	.1	.1	-.1	-.5	-.5	.4	.3	-.1	-.3	-.4	-.3	-.2	.1	-.3
.2	-.0	-.0	.2	.5	-.8	-.7	-.3	-.1	-.4	-.3	-.0	.1	-.1	-.0
3.1	4.2	4.2	3.1	1.7	.7	.5	.7	.2	-.4	-.1	-.0	.1	-.0	.3
19.4	22.9	22.9	19.4	12.9	5.0	2.3	1.4	.5	.1	.2	.4	-.0	.3	.1
28.3	29.9	29.9	28.3	26.1	15.7	5.2	2.3	.6	.3	.5	-.1	.0	-.3	-.2
30.6	31.5	31.5	30.6	30.2	26.1	11.6	2.7	.1	-.1	-1.0	-.9	-1.1	-.6	-.5
31.6	31.8	31.8	31.6	31.2	29.4	18.2	4.0	-.3	-1.1	-1.2	-.6	-.2	-.2	.1
32.1	32.0	32.0	32.1	31.5	30.3	21.7	5.4	-.4	-1.2	-.4	-.5	.0	.2	.1
31.6	32.2	32.2	31.6	31.1	29.3	20.8	3.8	-.6	-.0	-.6	.4	.1	-.1	.1
28.3	28.7	28.7	28.3	27.2	25.8	17.4	1.6	.7	-.3	.6	-.3	-.0	.1	-.0
29.0	28.5	28.5	29.0	27.9	22.6	9.9	1.1	.7	-.1	-.2	.4	.0	.2	.3
25.8	27.8	27.8	25.8	22.8	14.4	4.5	.7	.3	.9	.1	.3	.5	.1	-.0
17.7	20.0	20.0	17.7	11.7	5.1	3.3	1.0	.1	.7	.3	-.0	.2	.2	-.0
6.4	8.2	8.2	6.4	4.4	1.4	1.9	.7	-.1	.2	.3	.0	-.1	.1	.1
2.1	2.6	2.6	2.1	.8	.7	.8	.5	-.0	.0	.2	.1	-.1	-.1	.0
.9	.5	.5	.9	-.1	.3	.2	-.1	-.2	-.1	.1	.0	-.1	-.1	.0
-.0	.0	.0	-.0	-.3	.1	.2	-.2	-.1	-.3	-.2	-.1	.0	.1	-.0
-.7	.1	.1	-.7	-.2	.0	-.2	.0	-.1	-.3	-.0	.1	-.0	-.2	-.1
-.3	-.0	-.0	-.3	-.3	.0	.1	-.2	-.1	-.0	-.1	.0	.1	.1	-.0
-.1	-.2	-.2	-.1	-.1	-.2	.1	.1	-.0	-.1	-.1	.1	.1	.0	.0
.0	-.2	-.2	.0	.1	-.1	-.1	.1	.1	-.0	-.2	-.0	.1	.1	.0
.0	-.2	-.2	.0	.1	.1	-.1	-.1	.0	.0	-.0	-.1	-.0	.1	.1
.0	-.1	-.1	.0	.1	.1	.1	-.2	-.0	.0	.0	-.0	-.0	-.0	.1
-.0	-.1	-.1	-.0	.1	.1	.1	-.0	-.1	.0	.1	-.1	.0	.0	-.0
.0	-.1	-.1	.0	.0	.0	.1	.0	-.0	-.1	.0	-.1	.0	.0	.0
-.0	-.0	-.0	-.0	-.0	.0	.1	.0	.0	-.0	-.2	-.0	.0	.0	.0
-.1	.0	.0	-.1	.0	.1	.0	.0	.1	.1	-.2	-.0	-.1	.0	.1
-.1	.1	.1	-.1	.0	-.1	.1	-.0	.0	.1	-.0	-.1	-.1	.0	.0
.0	.0	.0	.0	-.1	-.0	.1	-.1	.1	-.0	.0	.1	-.2	.0	-.0
.1	.0	.0	.1	-.1	.1	-.0	-.0	.1	.0	.0	.0	-.0	-.2	.1

-.0	.0	.0	-.0	-.0	.0	.0	-.0	.0	.0	.0	-.0	.0	.0	-.0
-.0	.0	.0	-.0	-.0	.0	.0	-.0	.0	.0	.0	-.0	.0	.0	.0
-.0	-.0	.0	.0	-.0	.0	.0	-.0	.0	.0	.0	-.0	.0	.0	.0
-.0	-.0	.0	.0	-.0	.0	.1	-.0	-.0	.0	.0	-.0	.0	.0	.0
-.0	-.0	.0	.0	-.0	-.0	.0	-.0	-.0	.0	.0	-.0	-.0	.0	.0
.0	-.0	-.0	.0	-.0	-.0	.0	.0	-.0	.0	.0	.0	-.0	.0	.0
.1	-.0	-.0	.0	.0	-.0	.0	.0	-.0	.0	.0	.0	.0	.0	.0
.1	-.0	-.0	.0	.0	-.0	.0	.0	-.0	.0	.0	.0	.0	.0	.0
.0	.0	-.0	.0	.0	-.0	.0	.0	-.0	.0	.0	-.0	.0	-.0	-.0
-.0	.0	-.0	.0	.0	-.0	.0	.0	-.0	.0	.0	-.0	.0	-.0	-.0
-.0	.0	-.0	-.0	.0	-.0	.0	.0	-.0	.0	.0	-.0	.0	-.0	-.0
-.1	.1	.0	-.0	.1	-.0	-.0	.0	-.0	.0	.0	-.0	.0	.0	-.0
-.1	.0	.0	-.0	.0	.0	-.0	.0	.0	.0	.0	-.0	.0	.0	-.0
-.0	-.0	.1	-.0	-.0	.1	-.0	-.0	.0	.0	.0	-.0	.0	.0	-.0
.0	-.1	.1	.0	-.0	.0	.0	-.0	.0	.0	.0	-.0	.0	.0	-.0
.1	-.0	-.0	.1	-.0	-.0	.0	-.0	.0	.0	.0	-.0	.0	.0	.0
.1	.0	-.1	.1	.0	-.0	.0	.0	-.0	.0	.1	-.0	.1	.0	.1
.0	.1	-.1	.0	.0	.0	-.0	.1	-.0	-.0	.1	-.0	.1	-.0	.1
-.0	.1	.0	-.0	.0	.0	-.0	.0	.0	-.0	.1	-.0	.1	-.0	.1
-.0	.1	.0	-.1	.1	.0	.1	-.1	.0	-.0	.0	-.0	.1	-.0	.1
-.0	.0	.1	-.1	.1	.0	.1	-.0	-.0	-.0	.1	-.1	.1	-.0	.1
-.0	-.1	.2	.0	-.1	.2	-.0	.1	.0	-.2	.1	-.1	.1	.0	.1
.1	-.1	-.1	.2	-.1	.2	.1	.1	.1	-.2	.0	-.1	.1	.1	.1
-.0	.1	-.3	.1	-.0	.1	.1	.0	.1	-.1	-.1	-.1	.1	.1	.1
-.0	.1	.0	-.1	-.0	-.1	.3	.1	.2	-.1	-.1	-.2	.2	.1	.1
.1	.0	.2	-.2	.1	-.4	.2	.2	.2	-.0	-.1	-.3	.1	.2	.1
-.0	-.0	.1	.0	.0	-.1	-.2	.2	.3	.2	-.1	-.3	-.1	.3	-.0
.1	.0	-.2	.1	-.1	.2	-.3	.1	.1	.4	.0	-.5	-.0	.1	.1
.0	.1	.1	-.0	-.2	.1	-.1	.1	-.1	.3	.4	-.5	-.1	.0	.2
-.0	.2	.1	.0	.1	-.3	-.0	-.0	.2	.2	.2	-.1	-.5	.1	-.1
-.1	.0	.1	.0	.2	.0	-.1	-.5	.2	.3	.2	-.1	-.3	-.4	.1
.1	-.2	-.0	.2	-.0	.3	.0	-.2	-.1	-.0	.4	.2	-.5	-.3	-.4
.0	-.1	-.4	-.0	.0	.0	.1	.2	-.1	.0	-.1	.2	.0	-.7	-.3
.0	.2	.0	-.3	-.0	-.2	-.0	-.2	-.2	.2	.4	.2	-.4	-.3	-.7
.2	.1	.2	.0	-.3	.1	-.2	-.3	-.4	-.3	-.1	.3	.4	-.5	-.5
.1	.2	.1	.2	-.0	-.1	.1	-.0	-.3	-.4	-.1	-.3	-.7	-.8	.5
-.0	.1	.2	.2	.3	-.0	.1	-.0	-.1	-.4	.2	.7	.5	.7	1.7
-.1	-.2	-.1	.1	.1	.3	-.0	.4	.2	.1	.5	1.4	2.3	5.0	12.9
.1	.0	-.1	-.2	-.2	-.3	.0	-.1	.5	.3	.6	2.3	5.2	15.7	26.1
-.0	-.0	-.1	-.2	-.5	-.6	-1.1	-.9	-1.0	-.1	.1	2.7	11.6	26.1	30.2
.0	.0	-.0	.0	.1	-.2	-.2	-.6	-1.2	-1.1	-.3	4.0	18.2	29.4	31.2
-.1	-.0	.1	.2	.1	.2	.0	-.5	-.4	-1.2	-.4	5.4	21.7	30.3	31.5
.1	.0	-.0	-.0	.1	-.1	.1	.4	-.6	-.0	-.6	3.8	20.8	29.3	31.1
.0	.1	.2	.1	-.0	.1	-.0	-.3	.6	-.3	.7	1.6	17.4	25.8	27.2
.1	.0	-.0	.1	.3	.2	.0	.4	-.2	-.1	.7	1.1	9.9	22.6	27.9
-.0	-.0	.1	.1	-.0	.1	.5	.3	.1	.9	.3	.7	4.5	14.4	22.8
.1	.1	.1	-.1	-.0	.2	.2	-.0	.3	.7	.1	1.0	3.3	5.1	11.7
.0	-.0	-.1	-.0	.1	.1	-.1	.0	.3	.2	-.1	.7	1.9	1.4	4.4
.0	-.0	-.0	.1	.0	-.1	-.1	.1	.2	.0	-.0	.5	.8	.7	.8
-.0	.1	.1	.1	.0	-.1	-.1	.0	.1	-.1	-.2	-.1	.2	.3	-.1
.0	.1	.0	-.0	-.0	.1	.0	-.1	-.2	-.3	-.1	-.2	.2	.1	-.3
.1	.1	.1	.0	-.1	-.2	-.0	.1	-.0	-.3	-.1	.0	-.2	.0	-.2
.1	-.0	-.1	-.2	-.0	.1	.1	.0	-.1	-.0	-.1	-.2	.1	.0	-.3
-.1	-.0	-.0	.0	.0	.0	.1	.1	-.1	-.1	-.0	.1	.1	-.2	-.1
.1	.0	-.0	-.0	.0	.1	.1	-.0	-.2	-.0	.1	.1	-.1	-.1	.1
-.1	-.1	.0	.1	.1	.1	-.0	-.1	-.0	.0	.0	-.1	-.1	.1	.1
-.1	.0	.0	.1	.1	-.0	-.0	-.0	.0	.0	-.0	-.2	.1	.1	.1
.0	.0	.1	-.0	-.0	.0	.0	-.1	.1	.0	-.1	-.0	.1	.1	.1
.1	.1	-.1	.0	.0	.0	.0	-.1	.0	-.1	-.0	.0	.1	.0	.0
-.0	-.0	.0	.0	.0	.0	.0	-.0	-.2	-.0	.0	.0	.1	.0	-.0
-.0	.1	.0	.0	.1	.0	-.1	-.0	-.2	.1	.1	.0	.0	.1	.0
.1	-.0	.0	.1	.0	.0	-.1	-.1	-.0	.1	.0	-.0	.1	-.1	.0
.0	-.0	.1	.0	-.0	.0	-.2	.1	.0	-.0	.1	-.1	.1	-.0	-.1
-.0	.1	.0	-.0	.1	-.2	-.0	.0	.0	.0	.1	-.0	-.0	.1	-.1

-.0	.0	.0	-.0	-.0	.0	.1	-.1	-.0	-.0	.1	.0	-.1	.0	.0
-.0	.0	.0	-.0	-.0	.0	.0	-.1	-.0	.0	.1	-.1	-.0	.0	.0
.0	.0	-.0	-.0	.0	.1	-.0	-.0	.0	.1	.0	-.1	-.0	.0	.0
.0	.0	-.0	-.0	.0	.1	-.1	-.0	.1	.1	-.0	-.0	.0	.0	.1
.0	.0	-.0	-.0	.1	-.0	-.1	.0	.1	.0	-.1	-.0	.0	.1	-.0
.0	-.0	-.0	.0	.1	-.1	-.0	.1	.1	-.0	-.0	.0	.1	.0	-.1
.0	-.0	-.0	.1	.0	-.1	.0	.1	.0	-.1	-.0	.1	.1	-.0	-.0
.0	-.0	-.0	.1	-.0	-.0	.0	.1	-.0	-.0	.0	.1	.0	-.1	.0
.0	-.0	.0	.0	-.1	.0	.0	.0	-.1	.0	.1	.0	-.1	.0	.1
.0	-.0	.0	-.0	-.0	.0	.1	-.0	-.0	.1	.0	-.0	-.0	.0	.1
-.0	-.0	.0	-.0	-.0	.0	.0	-.1	.0	.1	.0	-.0	.0	.1	.0
-.0	.0	.1	-.1	.0	.0	-.0	-.0	.0	.0	-.0	.0	.1	.0	-.0
-.0	.0	.0	-.1	.0	.1	-.0	.0	.0	.0	-.0	.0	.0	-.0	-.1
-.0	.1	-.0	-.0	.0	.0	-.0	.0	.1	-.0	.0	.0	-.0	-.1	.0
.0	.1	-.1	.0	.1	-.0	-.0	.1	.0	-.0	.0	-.0	-.0	.0	.1
.1	-.0	-.0	.1	.0	-.1	.1	.1	-.0	.0	-.0	.0	.0	.1	.1
.1	-.1	.0	.1	-.1	.0	.1	.0	-.0	-.0	.0	.0	.0	.0	-.0
.0	-.1	.1	.0	-.0	.1	.1	-.1	-.0	.0	.0	.0	.0	-.0	-.1
-.0	.0	.1	-.0	.0	.1	-.1	-.0	.1	.0	-.0	.1	.0	-.1	.0
-.1	.0	.1	-.0	.0	-.0	-.1	.1	.0	-.0	.1	.1	-.1	-.0	.0
-.1	.1	.0	-.0	-.0	-.0	.0	.0	.0	.0	.1	-.1	-.1	-.0	-.0
.0	.2	-.1	-.0	.0	-.0	.0	.0	.0	.1	-.1	-.1	-.0	.1	.0
.2	-.1	-.1	.1	-.1	.0	.1	.1	.1	-.1	-.1	.0	.1	.0	-.0
.1	-.3	.1	-.0	.0	.1	.1	.0	-.1	-.1	.1	.1	.0	-.1	.0
-.1	.0	.1	-.0	.1	.1	-.1	-.1	-.1	.1	.0	-.0	-.0	.1	.1
-.2	.2	.0	.1	.0	-.1	.0	-.1	.0	.0	.0	.0	.1	.0	.0
.0	.1	-.0	-.0	-.0	.1	-.1	-.0	.1	.1	.0	.1	.0	-.0	-.0
.1	-.2	.0	.1	.0	-.1	.0	.1	.1	-.0	.0	.0	-.0	.0	.1
-.0	.1	.1	.0	-.0	-.0	.1	.0	-.0	.0	.0	.0	.1	.1	.0
.0	.1	.2	-.0	-.1	.1	.0	-.0	.1	.1	.0	.0	-.0	-.1	-.1
.0	.1	.0	-.1	.1	.1	.1	.0	-.0	-.0	-.0	-.0	-.0	.0	.1
.2	-.0	-.2	.1	.1	-.0	-.1	-.0	.0	.1	.0	-.0	.0	.0	-.0
-.0	-.4	-.1	.0	.0	.1	.1	.0	-.0	-.1	-.1	.0	-.0	.0	.0
-.3	.0	.2	.0	-.0	.1	.0	.0	.0	.1	.1	.1	.0	.0	.0
.0	.2	.1	.2	.2	.1	-.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	-.0
.2	.1	.2	.1	.1	.0	.1	.0	.0	.0	.0	.1	.0	.0	.0
.2	.2	.1	-.0	-.1	-.1	-.1	-.1	-.0	.0	-.0	-.1	-.0	.0	.0
.1	-.1	-.2	-.1	.0	.1	.1	.1	.1	.0	.1	.1	.0	-.0	-.0
-.2	-.1	.0	.1	.1	.1	-.0	-.0	-.0	-.0	-.1	-.1	-.1	-.0	.0
-.2	-.1	-.0	-.0	-.1	-.0	.0	-.0	-.0	.0	.1	.1	.1	.0	.0
.0	-.0	.0	.0	.0	-.0	-.1	-.0	-.0	-.0	-.0	-.0	.0	.0	.0
.2	.1	-.0	-.1	-.1	-.1	-.0	.0	.0	.0	.0	.0	-.0	-.0	-.0
-.0	-.0	.0	.1	.1	.1	.0	-.0	-.0	-.0	.0	.0	.0	.0	.0
.1	.2	.1	.0	.0	.1	.1	.1	.1	.0	-.0	-.0	-.1	-.0	.0
.1	-.0	.0	.1	.0	-.0	.0	.0	.0	.0	.1	.1	.1	.0	.0
.1	.1	-.0	-.0	.0	.1	.0	-.0	.0	-.0	-.0	-.0	-.0	-.0	.0
-.1	.1	.1	.1	-.0	-.0	.1	.1	.1	.1	.1	.1	.1	.1	.1
-.0	-.1	-.0	.0	.0	-.0	-.1	-.1	-.0	.0	-.0	-.0	-.0	-.0	-.0
.1	-.0	-.0	.0	.1	.1	.1	.1	-.0	.0	.1	.1	.1	.0	.0
.1	.1	.1	-.0	-.0	.0	.0	-.0	.0	-.1	-.1	-.0	.0	.0	.0
-.0	.0	.1	.0	-.0	-.0	.1	.1	.1	.1	.1	-.0	-.0	.0	.0
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-.2	-.1	-.0	.1	.1	.0	.0	-.1	.0	.1	.1	.0	.0	.0	-.1
.0	-.0	-.0	-.1	-.1	.0	.0	.1	-.1	-.0	.1	.0	.0	.0	.1
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.1	.0	-.1	-.1	.0	.1	.1	.0	-.1	-.1	-.1	-.0	.1	.1	.0
.1	.0	.0	-.1	.0	-.1	.1	.1	.1	-.0	-.0	-.1	-.2	-.0	.1
-.0	.1	.0	.0	-.1	.1	-.0	-.1	.1	.1	.0	.1	.0	-.2	-.2
.0	-.1	.1	.1	-.1	-.0	.0	.0	.0	-.0	.0	.0	.1	.1	-.1
.0	.0	-.0	-.0	.2	-.1	.0	-.0	-.0	.1	.0	-.1	-.1	.1	.1
.0	.0	.1	-.0	-.1	.1	-.1	.0	-.0	-.0	.1	.1	.0	-.1	-.0
.1	.0	-.0	.1	-.0	-.0	-.0	.0	.1	-.1	-.0	.0	.1	.1	-.1
.0	.1	-.0	.0	.0	.0	.0	-.2	.0	.1	-.1	-.1	.0	.1	.1
-.0	.0	.1	-.0	.1	-.0	.1	.1	-.2	.0	.1	-.0	-.1	.0	.0

```
 .0   .0  -.0   .0
 .1  -.0  -.0   .0
 .0  -.0   .0   .0
-.1  -.0  -.0   .1
-.0  -.0   .0   .1
-.0   .0   .1   .0
 .0   .1   .0  -.0
 .1   .1  -.0  -.0
 .1   .0  -.0  -.0
 .0  -.1  -.1   .0
-.0  -.1   .0   .1
-.1   .0   .1   .0
 .0   .1   .0  -.1
 .1   .1  -.1  -.0
 .1  -.1  -.0   .0
-.1  -.0   .0   .1
-.0   .0   .1   .1
 .0   .0   .0  -.1
 .0  -.0  -.1  -.0
-.0  -.0   .0   .1
 .0   .0   .0   .0
 .0   .0   .0  -.0
-.0   .0   .0   .0
 .1   .0   .0   .0
 .0   .0   .0   .0
-.0   .0   .0   .0
 .0   .0   .0  -.0
 .1  -.0  -.0  -.0
-.1  -.1  -.1  -.0
-.0   .1   .1   .0
 .1   .0  -.0  -.0
-.1  -.1  -.0   .0
 .0   .1   .1   .1
 .0  -.0  -.1  -.1
-.1  -.0   .0   .1
 .1   .1   .1   .0
-.1  -.1  -.1  -.1
-.0   .0   .1   .1
 .0   .1   .0   .0
 .0  -.0  -.0  -.1
 .0   .1   .1   .1
-.0  -.0  -.0  -.0
-.0  -.0  -.0  -.1
 .1   .1   .1   .1
-.0  -.1  -.1  -.1
 .0   .0   .0  -.0
 .1   .1   .1   .1
-.1  -.1  -.1  -.1
 .1   .1   .1   .0
-.0  -.0   .0   .1
 .0   .0  -.0  -.1
 .1   .1   .1   .1
-.1  -.0   .0   .1
 .1  -.0  -.1  -.1
 .0   .1   .1   .0
-.0  -.0   .0   .1
 .1   .1  -.0  -.0
-.1   .1   .1   .1
-.1  -.1  -.1  -.0
-.0  -.0   .0  -.0
 .1   .0  -.0   .1
-.1  -.0   .0  -.0
-.0   .0  -.0  -.1
 .0   .0   .1   .0
```

Example 10 uses the following subroutine GETUM and the same program ATENX to reconstruct simulated projection data for a phantom with a circular annulus and a central circular source, which is attenuated by a circular attenuator.

```
      SUBROUTINE GETUM (M,DATA,ERR)
C
C        EXAMPLE 10
C
C              THE SUBROUTINE GETUM GIVES SIMULATED PROJECTION DATA FOR
C        A PHANTOM WITH A CIRCULAR ANNULUS AND A CENTRAL CIRCULAR SOURCE
C        WHICH IS ATTENUATED BY A CIRCULAR ATTENUATOR.
C              IF
C                   LTYPE = 1  GETUM RETURNS TRANSMISSION DATA OF THE
C                                  ATTENUATOR
C                   LTYPE = 2  GETUM RETURNS ATTENUATED PROJECTION DATA
C                                  OF THE SOURCE
C
      DIMENSION DATA(1),ERR(1)
      COMMON/TYPE/LTYPE
      DIMENSION ITYPE(4),Z(4),X1(4),Y1(4),A1(4),B1(4),PI(4)
      DATA ITYPE/-1,1,1,1/
      DATA Z/.075,30.,-30.,30./
      DATA X1/0.,0.,0.,0./
      DATA Y1/0.,0.,0.,0./
      DATA A1/60.,60.,40.,20./
      DATA B1/60.,60.,40.,20./
      DATA PHI/0.,0.,0.,0./
      DATA ITYPEX,ZX,XX,YY,AX,BX,PHIX/1,.075,0.,0.,60.,60.,0./
C
      IF (LTYPE.EQ.1) GO TO 10
      IF (LTYPE.EQ.2) GO TO 12
C
   10 CALL PHANL (1,ITYPEX,ZX,XX,YY,AX,BX,PHIX,DATA,M)
C
      RETURN
C
   12 CALL PHANL (4,ITYPE,Z,X1,Y1,A1,B1,PHI,DATA,M)
C
      RETURN
C
      END
```

```
                SSS  EEEEE TTTTT U   U PPPP
               S     E       T   U   U P   P
                SSS  EEE     T   U   U PPPP
                   S E       T   U   U P
                SSS  EEEEE   T    UUU  P


        INTEGER PARAMETER ARRAY  (IPAR)

  I   IPAR(I)      DESCRIPTION

  1       64       LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
  2        1       RECONSTRUCT IN A SQUARE ARRAY
  3        0       GEOMETRY FLAG
           .       PARALLEL BEAM GEOMETRY
  4       72       NUMBER OF PROJECTION ANGLES
  5        4       MODE FOR PROJECTION ANGLE INPUT  (SEE FOLLOWING LINES)
                   ANGLES GENERATED BETWEEN ZERO AND PI
                   STARTING AT ZERO
  6      100       NUMBER OF RAYS FOR EACH PROJECTION
  7        1       TRANSMISSION DATA
  8    18000       DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
  9        1       NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
 10        0       EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
 11        5       PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES)
                   PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED
                   PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
 12        3       LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE


        FLOATING POINT PARAMETER ARRAY  (PAR)

  I    PAR(I)      DESCRIPTION

  1     1.000      PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
  2    50.500      LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
  3         0  NA  NOT APPLICABLE  (NOT FAN BEAM GEOMETRY)
```

```
BLANK COMMON REQUIRED        72    (   110)

BLANK COMMON REQUIRED       144    (   220)

BLANK COMMON REQUIRED       216    (   330)

BLANK COMMON REQUIRED       416    (   640)

BLANK COMMON REQUIRED       544    (  1040)

A TOTAL OF  92 (  5 THRU  96) OF THE 100 USER PROJECTION BINS WILL BE USED

 92 PROJECTION BINS WILL BE USED OF WHICH   0 HAVE BEEN ZEROED BY THE PROGRAM

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=    544 FLOATING POINT WORDS.
```

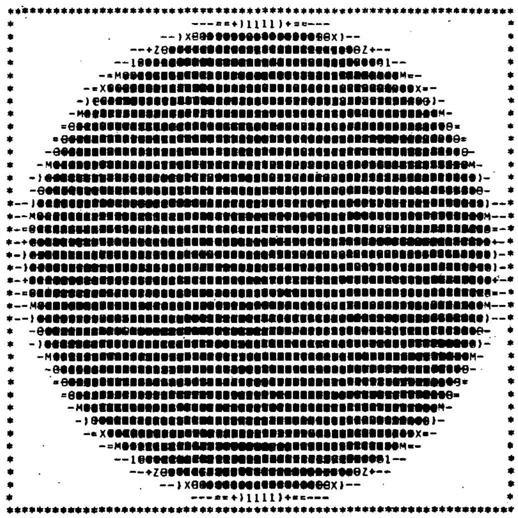
```
EEEEE N   N DDDD        SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D      S     E       T   U   U P   P
EEE   N N N D   D       SSS  EEE     T   U   U PPPP
E     N  NN D   D          S E       T   U   U P
EEEEE N   N DDDD        SSS  EEEEE   T    UUU  P
```

```
 GGG  RRRR   AAA  DDDD  Y   Y
G   G R   R A   A D   D  Y Y
G     RRRR  A   A D   D   Y
G  GG R  R  AAAAA D   D   Y
 GGGG R   R A   A DDDD    Y
```

```
          PARAMETERS FOR SUBROUTINE GRADY

                  DESCRIPTION

ISTP -      15    NUMBER OF ITERATION STEPS
IRLX -       1    ITERATIVE RELAXATION METHOD
IERR -       0    DO NOT USE ERROR ARRAY
IZER -       0    INITIAL SOLUTION IS ZERO

BLANK COMMON REQUIRED       616    (  1150)

BLANK COMMON REQUIRED      1775    (  3357)

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG     FUNCTION          RAY WEIGHTING     ATTENUATION         FAN BEAM
BCK     BACKPROJECTION    UNIFORM SQUARE        NO                 NO
PRJ     PROJECTION        UNIFORM SQUARE        NO                 NO

BLANK COMMON REQUIRED      1959    (  3647)

BLANK COMMON REQUIRED      6055    ( 13647)

BLANK COMMON REQUIRED     10151    ( 23647)

BLANK COMMON REQUIRED     14247    ( 33647)

BLANK COMMON REQUIRED     14255    ( 33657)

BLANK COMMON REQUIRED     14247    ( 33647)

FOR CONGR AND GRADY FCN IS THE VALUE OF THE CHI-SQUARE
FOR ENTPY FCN IS EVALUATED BY THE SUBROUTINE DULFC
ITER  0     FCN    .583E+05
ITER  1     FCN    .132E+04
ITER  2     FCN    .222E+03
ITER  3     FCN    .147E+03
ITER  4     FCN    .107E+03
ITER  5     FCN    .817E+02
ITER  6     FCN    .646E+02
ITER  7     FCN    .523E+02
ITER  8     FCN    .431E+02
ITER  9     FCN    .361E+02
ITER 10     FCN    .306E+02
ITER 11     FCN    .263E+02
ITER 12     FCN    .228E+02
ITER 13     FCN    .200E+02
ITER 14     FCN    .177E+02
ITER 15     FCN    .157E+02

BLANK COMMON REQUIRED     14063    ( 33357)

BLANK COMMON REQUIRED      9967    ( 23357)

BLANK COMMON REQUIRED      5871    ( 13357)

BLANK COMMON REQUIRED      1775    (  3357)

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=  14255 FLOATING POINT WORDS.
```

```
EEEEE N   N DDDD        GGG  RRRR   AAA  DDDD  Y   Y
E     NN  N D   D      G   G R   R A   A D   D  Y Y
EEE   N N N D   D      G     RRRR  A   A D   D   Y
E     N  NN D   D      G  GG R  R  AAAAA D   D   Y
EEEEE N   N DDDD        GGGG R   R A   A DDDD    Y
```

```
RECONSTRUCTION FOR THE TRANSMISSION SCAN

XMIN =   -.16E-02     XMAX =    .82E-01     XSUM =    .2130E+03
```



```
                          -         =          +          )          1          Z
-.1633E-02  .4636E-02  .1383E-01  .1801E-01  .2094E-01  .2428E-01  .2762E-01

Z          X          A          M          B          @          @          ●
 .3055E-01  .3264E-01  .3473E-01  .3933E-01  .4393E-01  .4685E-01  .5019E-01

●          ●          ●          ●          ●          ●          ●          ●
 .5312E-01  .5939E-01  .6691E-01  .7109E-01  .7444E-01  .7778E-01  .8071E-01

●
 .8196E-01
```

.001	.001	.001	.001	.001	-.000	-.000	.001	.001	.000	.001	.001	.000	.000	.001
.001	-.001	-.001	-.001	-.000	.000	-.001	-.001	-.001	-.001	-.001	-.000	.000	-.001	-.001
.001	-.001	-.001	-.001	-.001	-.000	-.000	-.001	-.001	-.001	-.001	-.002	-.001	-.001	-.001
.001	-.001	-.001	-.001	-.001	-.001	-.000	-.000	-.001	-.001	-.001	-.001	-.001	-.000	-.000
.001	-.000	-.001	-.001	-.001	-.001	-.001	-.000	-.000	-.001	-.001	-.001	-.001	-.000	.001
-.000	.000	-.000	-.001	-.001	-.002	-.001	-.001	-.000	-.000	-.001	-.000	-.000	.001	.003
-.000	-.001	-.000	-.000	-.001	-.001	-.001	-.001	-.001	-.000	.001	.001	.002	.005	.010
.001	-.001	-.001	-.000	-.000	-.001	-.001	-.001	-.001	.000	.002	.003	.007	.015	.037
.001	-.001	-.001	-.001	-.000	-.000	-.001	-.001	.000	.001	.003	.009	.020	.045	.060
.000	-.001	-.001	-.001	-.001	-.000	-.000	.000	.001	.003	.009	.023	.049	.063	.069
.001	-.001	-.001	-.001	-.001	-.001	.001	.002	.003	.009	.025	.049	.064	.071	.074
.001	-.000	-.002	-.001	-.001	-.000	.001	.003	.009	.023	.049	.064	.070	.072	.076
.000	.000	-.001	-.001	-.001	-.000	.002	.007	.020	.049	.064	.070	.072	.076	.077
.000	-.001	-.001	-.000	-.000	.001	.005	.015	.045	.063	.071	.072	.076	.080	.076
.001	-.001	-.001	-.000	.001	.003	.010	.037	.060	.069	.074	.076	.077	.076	.073
.000	-.001	-.001	-.001	.003	.007	.026	.053	.065	.071	.073	.074	.074	.076	.075
.001	-.001	-.001	.001	.004	.015	.045	.063	.071	.074	.075	.075	.079	.081	.072
.002	-.000	-.000	.001	.008	.033	.060	.070	.073	.075	.075	.075	.075	.076	.077
.002	-.000	.001	.004	.016	.049	.065	.072	.074	.074	.075	.075	.078	.073	.079
.002	.001	.002	.007	.033	.059	.069	.073	.075	.076	.074	.073	.081	.075	.074
.002	.001	.004	.013	.048	.067	.072	.074	.074	.076	.077	.075	.075	.075	.076
.003	.001	.006	.026	.055	.068	.071	.074	.075	.074	.075	.080	.076	.076	.075
.003	.003	.009	.039	.065	.073	.074	.073	.075	.077	.071	.077	.074	.074	.075
.004	.005	.015	.047	.064	.074	.076	.075	.075	.077	.075	.079	.077	.076	.075
.006	.006	.023	.055	.068	.073	.074	.076	.075	.073	.076	.076	.075	.077	.078
.007	.008	.032	.059	.069	.077	.076	.074	.077	.071	.075	.074	.073	.074	.075
.006	.011	.041	.065	.069	.076	.078	.074	.078	.074	.077	.077	.077	.076	.075
.007	.013	.045	.067	.072	.074	.077	.075	.075	.074	.078	.077	.076	.076	.075
.008	.016	.049	.067	.073	.074	.075	.076	.073	.074	.077	.076	.075	.074	.075
.009	.018	.055	.067	.072	.075	.074	.076	.073	.075	.076	.076	.075	.074	.074
.009	.020	.055	.068	.073	.075	.076	.076	.073	.075	.075	.075	.076	.075	.074
.011	.022	.054	.068	.074	.072	.078	.077	.072	.075	.075	.075	.075	.075	.076
.011	.022	.054	.068	.074	.072	.078	.077	.072	.075	.075	.075	.075	.075	.076
.009	.020	.055	.068	.073	.075	.076	.076	.073	.075	.075	.075	.076	.075	.074
.009	.018	.055	.067	.072	.075	.074	.076	.073	.075	.076	.076	.075	.074	.074
.008	.016	.049	.067	.073	.074	.075	.076	.073	.074	.077	.076	.075	.074	.075
.007	.013	.045	.067	.072	.074	.077	.075	.075	.074	.078	.077	.076	.076	.075
.006	.011	.041	.065	.069	.076	.078	.074	.078	.074	.077	.077	.077	.076	.075
.007	.008	.032	.059	.069	.077	.076	.074	.077	.071	.075	.074	.073	.074	.075
.006	.006	.023	.055	.068	.073	.074	.076	.075	.073	.076	.076	.075	.077	.078
.004	.005	.015	.047	.064	.074	.076	.075	.075	.077	.075	.079	.077	.076	.075
.003	.003	.009	.039	.065	.073	.074	.073	.075	.077	.071	.077	.074	.074	.075
.003	.001	.006	.026	.055	.068	.071	.074	.075	.074	.075	.080	.076	.076	.075
.002	.001	.004	.013	.048	.067	.072	.074	.074	.076	.077	.075	.075	.075	.076
.002	.001	.002	.007	.033	.059	.069	.073	.075	.076	.074	.073	.081	.075	.074
.002	-.000	.001	.004	.016	.049	.065	.072	.074	.074	.075	.075	.078	.073	.079
.002	-.000	-.000	.001	.008	.033	.060	.070	.073	.075	.075	.075	.075	.076	.077
.001	-.001	-.001	.001	.004	.015	.045	.063	.071	.074	.075	.075	.079	.081	.072
.000	-.001	-.001	-.001	.003	.007	.026	.053	.065	.071	.073	.074	.074	.076	.075
.001	-.001	-.001	-.000	.001	.003	.010	.037	.060	.069	.074	.076	.077	.076	.073
.000	-.001	-.001	-.000	-.000	.001	.005	.015	.045	.063	.071	.072	.076	.080	.076
.000	.000	-.001	-.001	-.001	-.000	.002	.007	.020	.049	.064	.070	.072	.076	.077
.001	-.000	-.002	-.001	-.001	-.000	.001	.003	.009	.023	.049	.064	.070	.072	.076
.001	-.001	-.001	-.001	-.001	-.001	.001	.002	.003	.009	.025	.049	.064	.071	.074
.000	-.001	-.001	-.001	-.001	-.000	-.000	.000	.001	.003	.009	.023	.049	.063	.069
.001	-.001	-.001	-.001	-.000	-.000	-.001	-.001	.000	.001	.003	.009	.020	.045	.060
.001	-.001	-.001	-.000	-.000	-.001	-.001	-.001	-.001	.000	.002	.003	.007	.015	.037
-.000	-.001	-.000	-.000	-.001	-.001	-.001	-.001	-.001	-.000	.001	.001	.002	.005	.010
-.000	.000	-.000	-.001	-.001	-.002	-.001	-.001	-.000	-.000	-.001	-.000	-.000	.001	.003
.001	-.000	-.001	-.001	-.001	-.001	-.001	-.000	-.000	-.001	-.001	-.001	-.001	-.000	.001
.001	-.001	-.001	-.001	-.001	-.001	-.000	-.000	-.001	-.001	-.001	-.001	-.001	-.000	-.000
.001	-.001	-.001	-.001	-.001	-.000	-.000	-.001	-.001	-.001	-.001	-.002	-.001	-.001	-.001
.001	-.001	-.001	-.001	-.000	.000	-.001	-.001	-.001	-.001	-.001	-.000	.000	-.001	-.001
.001	.001	.001	.001	.001	-.000	-.000	.001	.001	.000	.001	.001	.000	.000	.001

.000	.001	.002	.002	.002	.002	.003	.003	.004	.006	.007	.006	.007	.008	.009
-.001	-.001	-.000	-.000	.001	.001	.001	.003	.005	.006	.008	.011	.013	.016	.018
-.001	-.001	-.000	.001	.002	.004	.006	.009	.015	.023	.032	.041	.045	.049	.055
-.001	.001	.001	.004	.007	.013	.026	.039	.047	.055	.059	.065	.067	.067	.067
.003	.004	.008	.016	.033	.048	.055	.065	.064	.068	.069	.069	.072	.073	.072
.007	.015	.033	.049	.059	.067	.068	.073	.074	.073	.077	.076	.074	.074	.075
.026	.045	.060	.065	.069	.072	.071	.074	.076	.074	.076	.078	.077	.075	.074
.053	.063	.070	.072	.073	.074	.074	.073	.075	.076	.074	.074	.075	.076	.076
.065	.071	.073	.074	.075	.074	.075	.075	.075	.075	.077	.078	.075	.073	.073
.071	.074	.075	.074	.076	.076	.074	.077	.077	.073	.071	.074	.074	.074	.075
.073	.075	.075	.075	.074	.077	.075	.071	.075	.076	.075	.077	.078	.077	.076
.074	.075	.075	.075	.073	.075	.080	.077	.079	.076	.074	.077	.077	.076	.076
.074	.079	.075	.078	.081	.075	.076	.074	.077	.075	.073	.077	.076	.075	.075
.076	.081	.076	.073	.075	.075	.076	.074	.076	.077	.074	.076	.076	.074	.074
.075	.072	.077	.079	.074	.076	.075	.075	.075	.078	.075	.075	.075	.075	.074
.081	.074	.076	.076	.074	.076	.073	.076	.075	.076	.075	.075	.076	.075	.075
.074	.076	.076	.073	.076	.077	.073	.077	.074	.076	.074	.075	.077	.075	.075
.076	.076	.075	.074	.076	.075	.076	.076	.074	.075	.075	.073	.077	.077	.074
.076	.073	.074	.076	.074	.075	.077	.075	.076	.074	.076	.074	.077	.077	.076
.074	.076	.076	.074	.075	.076	.074	.074	.077	.073	.076	.074	.076	.075	.075
.076	.077	.075	.075	.076	.075	.073	.075	.076	.074	.077	.074	.074	.076	.074
.073	.073	.076	.077	.074	.073	.074	.076	.073	.076	.076	.074	.074	.076	.075
.076	.077	.076	.075	.074	.075	.076	.074	.075	.077	.074	.077	.073	.076	.075
.075	.074	.074	.076	.077	.076	.073	.075	.076	.075	.073	.077	.073	.077	.075
.076	.076	.075	.074	.073	.074	.076	.077	.075	.073	.075	.075	.074	.077	.076
.075	.074	.075	.076	.076	.077	.076	.074	.073	.075	.076	.073	.076	.076	.077
.075	.075	.073	.074	.074	.074	.074	.077	.077	.075	.073	.074	.077	.073	.078
.076	.077	.077	.077	.076	.074	.074	.073	.073	.074	.076	.077	.075	.072	.078
.075	.075	.077	.077	.075	.076	.076	.076	.077	.077	.076	.073	.072	.076	.077
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.007	.002	.001	.002
.004	.001	-.000	.002
.001	-.000	-.000	.002
.001	-.001	-.001	.001
-.001	-.001	-.001	.000
-.000	-.001	-.001	.001
-.000	-.001	-.001	.000
-.001	-.001	.000	.000
-.001	-.002	-.000	.001
-.001	-.001	-.001	.001
-.001	-.001	-.001	.000
-.001	-.001	-.001	.001
-.000	-.001	-.001	.001
-.000	-.000	-.001	-.000
-.001	-.000	.000	-.000
-.001	-.001	-.000	.001
-.001	-.001	-.001	.001
-.001	-.001	-.001	.001
-.001	-.001	-.001	.001
.001	.001	.001	.001

```
 SSS  EEEEE TTTTT U   U PPPP
S     E       T   U   U P   P
 SSS  EEE     T   U   U PPPP
    S E       T   U   U P
 SSS  EEEEE   T    UUU  P
```

INTEGER PARAMETER ARRAY (IPAR)

I	IPAR(I)	DESCRIPTION
1	64	LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
2	1	RECONSTRUCT IN A SQUARE ARRAY
3	0	GEOMETRY FLAG PARALLEL BEAM GEOMETRY
4	72	NUMBER OF PROJECTION ANGLES
5	5	MODE FOR PROJECTION ANGLE INPUT (SEE FOLLOWING LINES) ANGLES GENERATED BETWEEN ZERO AND 2*PI STARTING AT ZERO
6	100	NUMBER OF RAYS FOR EACH PROJECTION
7	0	EMISSION DATA
8	18000	DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
9	1	NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10	0	EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11	5	PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES) PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
12	3	LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE

FLOATING POINT PARAMETER ARRAY (PAR)

I	PAR(I)	DESCRIPTION
1	1.000	PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
2	50.500	LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
3	0 NA	NOT APPLICABLE (NOT FAN BEAM GEOMETRY)

BLANK COMMON REQUIRED 72 (110)

BLANK COMMON REQUIRED 144 (220)

BLANK COMMON REQUIRED 216 (330)

BLANK COMMON REQUIRED 416 (640)

BLANK COMMON REQUIRED 544 (1040)

A TOTAL OF 92 (5 THRU 96) OF THE 100 USER PROJECTION BINS WILL BE USED

92 PROJECTION BINS WILL BE USED OF WHICH 0 HAVE BEEN ZEROED BY THE PROGRAM

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 14255 FLOATING POINT WORDS.

```
EEEEE N   N DDDD        SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D      S     E       T   U   U P   P
EEE   N N N D   D       SSS  EEE     T   U   U PPPP
E     N  NN D   D          S E       T   U   U P
EEEEE N   N DDDD        SSS  EEEEE   T    UUU  P
```

```
EEEEE V   V  AAA  TTTTT N   N
E     V   V A   A   T   NN  N
EEE    V V  A   A   T   N N N
E      V V  AAAAA   T   N  NN
EEEEE   V   A   A   T   N   N
```

BLANK COMMON REQUIRED 4640 (11040)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 14255 FLOATING POINT WORDS.

```
EEEEE N   N DDDD        EEEEE V   V  AAA  TTTTT N   N
E     NN  N D   D       E     V   V A   A   T   NN  N
EEE   N N N D   D       EEE    V V  A   A   T   N N N
E     N  NN D   D       E      V V  AAAAA   T   N  NN
EEEEE N   N DDDD        EEEEE   V   A   A   T   N   N
```

```
 GGG  RRRR   AAA  DDDD  Y   Y
G     R   R A   A D   D  Y Y
G     RRRR  A   A D   D   Y
G  GG R  R  AAAAA D   D   Y
 GGGG R   R A   A DDDD    Y
```

PARAMETERS FOR SUBROUTINE GRADY

		DESCRIPTION
ISTP -	15	NUMBER OF ITERATION STEPS
IRLX -	1	ITERATIVE RELAXATION METHOD
IERR -	0	DO NOT USE ERROR ARRAY
IZER -	0	INITIAL SOLUTION IS ZERO

BLANK COMMON REQUIRED 4712 (11150)

BLANK COMMON REQUIRED 5322 (12312)

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	UNIFORM SQUARE	YES	NO
PRJ	PROJECTION	UNIFORM SQUARE	YES	NO

BLANK COMMON REQUIRED 5506 (12602)

BLANK COMMON REQUIRED 9602 (22602)

BLANK COMMON REQUIRED 13698 (32602)

BLANK COMMON REQUIRED 17794 (42602)

BLANK COMMON REQUIRED 17826 (42642)

BLANK COMMON REQUIRED 17794 (42602)

FOR CONGR AND GRADY FCN IS THE VALUE OF THE CHI-SQUARE
FOR ENTPY FCN IS EVALUATED BY THE SUBROUTINE DULFC

ITER 0	FCN	.392E+09
ITER 1	FCN	.579E+08
ITER 2	FCN	.159E+08
ITER 3	FCN	.863E+07
ITER 4	FCN	.529E+07
ITER 5	FCN	.354E+07
ITER 6	FCN	.247E+07
ITER 7	FCN	.180E+07
ITER 8	FCN	.137E+07
ITER 9	FCN	.107E+07
ITER 10	FCN	.870E+06
ITER 11	FCN	.724E+06
ITER 12	FCN	.616E+06
ITER 13	FCN	.534E+06
ITER 14	FCN	.469E+06
ITER 15	FCN	.417E+06

BLANK COMMON REQUIRED 17610 (42312)

BLANK COMMON REQUIRED 13514 (32312)

BLANK COMMON REQUIRED 9418 (22312)

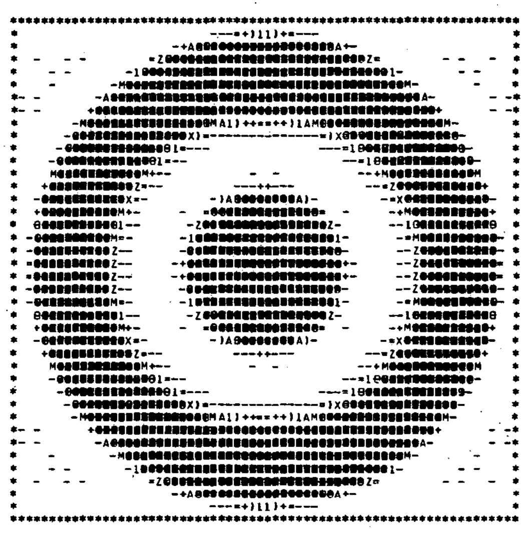
BLANK COMMON REQUIRED 5322 (12312)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 17826 FLOATING POINT WORDS.

```
EEEEE N   N DDDD        GGG  RRRR   AAA  DDDD  Y   Y
E     NN  N D   D      G     R   R A   A D   D  Y Y
EEE   N N N D   D      G     RRRR  A   A D   D   Y
E     N  NN D   D      G  GG R  R  AAAAA D   D   Y
EEEEE N   N DDDD        GGGG R   R A   A DDDD    Y
```

RECONSTRUCTION FOR THE EMISSION SCAN CORRECTED FOR ATTENUATION

XMIN = -.22E+01 XMAX = .34E+02 XSUM = .5710E+05



-.2193E+01	- .5104E+00	= .4476E+01	+ .6278E+01	) .7540E+01	1 .8982E+01	Z .1042E+02
Z .1169E+02	X .1259E+02	A .1349E+02	M .1547E+02	Θ .1745E+02	● .1872E+02	● .2016E+02
● .2142E+02	● .2412E+02	● .2737E+02	● .2917E+02	● .3061E+02	● .3205E+02	● .3332E+02
● .3386E+02						

.4	-.7	1.2	.2	.1	1.1	-.5	1.2	.1	.6	.5	.9	.4	.5	.4
-.7	-1.8	-.3	-1.3	-.9	-.0	-1.5	.3	-1.1	.2	-1.4	.4	-1.1	.2	-.8
1.2	-.3	1.2	.1	.5	.9	.1	.9	-.2	1.1	-.2	.8	.1	-.3	.2
.2	-1.3	.1	-1.1	-.6	-.7	-.5	-.8	-.9	-.9	-.3	-.6	.5	-.0	.0
.1	-.9	.5	-.6	.3	-.1	1.1	.3	1.4	-.3	.2	-.6	-1.0	-.3	-.2
1.1	-.0	.9	-.7	-.1	-1.5	-.2	-1.7	.4	.2	-.2	.4	-.5	-.9	-1.0
-.5	-1.5	.1	-.5	1.1	-.2	1.6	-.1	-.6	-.2	-.3	-.5	-1.0	-.6	-.3
1.2	.3	.9	-.8	.3	-1.7	-.1	.5	-.3	.2	-.3	-.2	-.9	2.5	15.7
.1	-1.1	-.2	-.9	1.4	.4	-.6	-.3	-.1	-.5	-.7	-.3	4.7	20.1	27.0
.6	.2	1.1	-.9	-.3	.2	-.2	.2	-.5	-.5	-.5	7.5	22.2	27.8	29.0
.5	-1.4	-.2	-.3	.2	-.2	-.3	-.3	-.7	-.5	7.4	22.6	26.9	29.1	30.5
.9	.4	.8	-.6	-.6	.4	-.5	-.2	-.3	7.5	22.6	27.7	28.8	29.3	30.8
.4	-1.1	.1	.5	-1.0	-.5	-1.0	-.9	4.7	22.2	26.9	28.8	29.9	30.9	31.4
.5	.2	-.3	-.0	-.3	-.9	-.6	2.5	20.1	27.8	29.1	29.3	30.9	31.6	31.3
.4	-.8	.2	.0	-.2	-1.0	-.3	15.7	27.0	29.0	30.5	30.8	31.4	31.3	28.9
.0	.1	-.7	-.3	-.5	-.8	8.8	24.0	28.2	29.0	29.5	29.8	30.1	30.9	29.8
-.0	-.3	.2	-.8	-.8	2.1	20.8	26.6	29.5	29.9	30.7	30.5	32.5	32.8	28.2
.8	-.2	-.4	-1.1	-.5	13.5	26.2	29.6	30.1	30.3	30.6	29.7	30.3	31.0	31.3
-.1	.3	-.9	-.6	3.1	22.6	27.2	29.6	29.6	30.3	30.2	30.9	32.0	29.1	30.3
.5	-.1	-1.0	-.7	12.9	26.3	28.4	30.1	30.2	31.4	29.5	29.4	32.4	29.6	27.4
-.7	.2	-1.0	1.9	22.2	28.5	29.9	29.8	30.1	31.3	31.6	31.5	29.8	29.0	26.2
.1	-.3	-1.1	8.6	25.3	28.6	29.0	29.9	31.0	29.6	30.6	32.4	29.4	27.0	20.9
-.5	-.6	.2	16.9	28.3	30.4	29.7	29.9	30.9	31.5	29.1	31.0	28.5	24.4	14.0
.2	-.2	1.9	21.9	26.6	30.0	31.4	30.3	30.1	30.9	29.9	30.4	28.6	20.3	9.9
.3	-.5	6.7	25.3	28.5	30.0	29.8	31.1	30.7	29.5	29.8	29.4	26.1	15.4	7.5
-.2	-.4	13.1	26.9	28.6	31.5	31.2	30.3	31.5	28.3	29.6	28.6	22.6	11.2	4.6
-.4	-.1	17.9	28.5	28.0	31.1	32.8	29.9	31.8	28.5	31.1	27.8	19.2	8.7	2.9
-.8	1.5	20.3	29.2	29.9	30.7	30.8	30.1	30.0	29.4	29.9	26.9	16.1	6.6	2.0
-.5	3.0	22.4	28.2	29.5	29.2	30.9	31.1	29.2	29.1	29.9	26.2	13.6	4.9	1.7
-.8	4.2	24.9	28.9	30.2	31.7	30.4	31.3	28.6	29.3	29.0	24.7	10.9	4.3	1.3
-.7	5.6	25.7	28.8	29.3	30.0	31.2	30.9	28.9	29.8	28.1	22.9	11.6	4.0	1.2
-.4	6.5	24.4	28.7	30.5	29.3	32.3	31.7	28.6	29.5	28.3	22.5	10.0	3.8	1.6
-.4	6.5	24.4	28.7	30.5	29.3	32.3	31.7	28.6	29.5	28.3	22.5	10.0	3.8	1.6
-.7	5.6	25.7	28.8	29.3	30.0	31.2	30.9	28.9	29.8	28.1	22.9	11.6	4.0	1.2
-.8	4.2	24.9	28.9	30.2	31.7	30.4	31.3	28.6	29.3	29.0	24.7	10.9	4.3	1.3
-.5	3.0	22.4	28.2	29.5	29.2	30.9	31.1	29.2	29.1	29.9	26.2	13.6	4.9	1.7
-.8	1.5	20.3	29.2	29.9	30.7	30.8	30.1	30.0	29.4	29.9	26.9	16.1	6.6	2.0
-.4	-.1	17.9	28.5	28.0	31.1	32.8	29.9	31.8	28.5	31.1	27.8	19.2	8.7	2.9
-.2	-.4	13.1	26.9	28.6	31.5	31.2	30.3	31.5	28.3	29.6	28.6	22.6	11.2	4.6
.3	-.5	6.7	25.3	28.5	30.0	29.8	31.1	30.7	29.5	29.8	29.4	26.1	15.4	7.5
.2	-.2	1.9	21.9	26.6	30.0	31.4	30.3	30.1	30.9	29.9	30.4	28.6	20.3	9.9
-.5	-.6	.2	16.9	28.3	30.4	29.7	29.9	30.9	31.5	29.1	31.0	28.5	24.4	14.0
.1	-.3	-1.1	8.6	25.3	28.6	29.0	29.9	31.0	29.6	30.6	32.4	29.4	27.0	20.9
-.7	.2	-1.0	1.9	22.2	28.5	29.9	29.8	30.1	31.3	31.6	31.5	29.8	29.0	26.2
.5	-.1	-1.0	-.7	12.9	26.3	28.4	30.1	30.2	31.4	29.5	29.4	32.4	29.6	27.4
-.1	.3	-.9	-.6	3.1	22.6	27.2	29.6	29.6	30.3	30.2	30.9	32.0	29.1	30.3
.8	-.2	-.4	-1.1	-.5	13.5	26.2	29.6	30.1	30.3	30.6	29.7	30.3	31.0	31.3
-.0	-.3	.2	-.8	-.8	2.1	20.8	26.6	29.5	29.9	30.7	30.5	32.5	32.8	28.2
.0	.1	-.7	-.3	-.5	-.8	8.8	24.0	28.2	29.0	29.5	29.8	30.1	30.9	29.8
.4	-.8	.2	.0	-.2	-1.0	-.3	15.7	27.0	29.0	30.5	30.8	31.4	31.3	28.9
.5	.2	-.3	-.0	-.3	-.9	-.6	2.5	20.1	27.8	29.1	29.3	30.9	31.6	31.3
.4	-1.1	.1	.5	-1.0	-.5	-1.0	-.9	4.7	22.2	26.9	28.8	29.9	30.9	31.4
.9	.4	.8	-.6	-.6	.4	-.5	-.2	-.3	7.5	22.6	27.7	28.8	29.3	30.8
.5	-1.4	-.2	-.3	.2	-.2	-.3	-.3	-.7	-.5	7.4	22.6	26.9	29.1	30.5
.6	.2	1.1	-.9	-.3	.2	-.2	.2	-.5	-.5	-.5	7.5	22.2	27.8	29.0
.1	-1.1	-.2	-.9	1.4	.4	-.6	-.3	-.1	-.5	-.7	-.3	4.7	20.1	27.0
1.2	.3	.9	-.8	.3	-1.7	-.1	.5	-.3	.2	-.3	-.2	-.9	2.5	15.7
-.5	-1.5	.1	-.5	1.1	-.2	1.6	-.1	-.6	-.2	-.3	-.5	-1.0	-.6	-.3
1.1	-.0	.9	-.7	-.1	-1.5	-.2	-1.7	.4	.2	-.2	.4	-.5	-.9	-1.0
.1	-.9	.5	-.6	.3	-.1	1.1	.3	1.4	-.3	.2	-.6	-1.0	-.3	-.2
.2	-1.3	.1	-1.1	-.6	-.7	-.5	-.8	-.9	-.9	-.3	-.6	.5	-.0	.0
1.2	-.3	1.2	.1	.5	.9	.1	.9	-.2	1.1	-.2	.8	.1	-.3	.2
-.7	-1.8	-.3	-1.3	-.9	-.0	-1.5	.3	-1.1	.2	-1.4	.4	-1.1	.2	-.8
.4	-.7	1.2	.2	.1	1.1	-.5	1.2	.1	.6	.5	.9	.4	.5	.4

-.7	-.4	-.4	-.7	-.8	-.5	-.8	-.4	-.2	.3	.2	-.5	.1	-.7	.5
5.6	6.5	6.5	5.6	4.2	3.0	1.5	-.1	-.4	-.5	-.2	-.6	-.3	.2	-.1
25.7	24.4	24.4	25.7	24.9	22.4	20.3	17.9	13.1	6.7	1.9	.2	-1.1	-1.0	-1.0
28.8	28.7	28.7	28.8	28.9	28.2	29.2	28.5	26.9	25.3	21.9	16.9	8.6	1.9	-.7
29.3	30.5	30.5	29.3	30.2	29.5	29.9	28.0	28.6	28.5	26.6	28.3	25.3	22.2	12.9
30.0	29.3	29.3	30.0	31.7	29.2	30.7	31.1	31.5	30.0	30.0	30.4	28.6	28.5	26.3
31.2	32.3	32.3	31.2	30.4	30.9	30.8	32.8	31.2	29.8	31.4	29.7	29.0	29.9	28.4
30.9	31.7	31.7	30.9	31.3	31.1	30.1	29.9	30.3	31.1	30.3	29.9	29.9	29.8	30.1
28.9	28.6	28.6	28.9	28.6	29.2	30.0	31.8	31.5	30.7	30.1	30.9	31.0	30.1	30.2
29.8	29.5	29.5	29.8	29.3	29.1	29.4	28.5	28.3	29.5	30.9	31.5	29.6	31.3	31.4
28.1	28.3	28.3	28.1	29.0	29.9	29.9	31.1	29.6	29.8	29.9	29.1	30.6	31.6	29.5
22.9	22.5	22.5	22.9	24.7	26.2	26.9	27.8	28.6	29.4	30.4	31.0	32.4	31.5	29.4
11.6	10.0	10.0	11.6	10.9	13.6	16.1	19.2	22.6	26.1	28.6	28.5	29.4	29.8	32.4
4.0	3.8	3.8	4.0	4.3	4.9	6.6	8.7	11.2	15.4	20.3	24.4	27.0	29.0	29.6
1.2	1.6	1.6	1.2	1.3	1.7	2.0	2.9	4.6	7.5	9.9	14.0	20.9	26.2	27.4
.7	-.0	-.0	.7	-.4	-.0	.3	1.1	1.9	2.5	4.5	6.1	10.2	16.9	24.5
.1	-1.7	-1.7	.1	-.7	-.9	.3	.2	-.4	.6	1.5	3.3	4.2	8.8	14.7
-1.4	-1.7	-1.7	-1.4	-1.8	.3	-.8	-1.3	-1.1	-.8	-.4	.4	3.0	4.4	7.4
-1.9	-1.2	-1.2	-1.9	-.1	-.1	-.9	-1.3	-1.5	-1.5	-.5	.5	1.3	2.3	3.2
.6	-.9	-.9	.6	-.4	-2.2	.0	-.6	-1.5	-1.9	-.8	.2	-1.5	.2	2.5
.3	.8	.8	.3	-.7	-.1	-1.3	-1.1	-.3	-.8	-.5	-1.4	-1.1	-.7	.2
4.7	7.9	7.9	4.7	3.2	1.8	.2	-.7	.3	.6	-1.3	-1.5	-1.1	-1.1	-1.5
21.6	21.8	21.8	21.6	17.7	13.2	6.4	3.2	.5	-.4	-.8	-1.4	-1.5	-1.4	.2
28.8	28.3	28.3	28.8	26.9	25.0	20.6	13.3	3.6	-.1	-.4	-.8	-1.3	-.5	-.8
29.2	29.6	29.6	29.2	30.8	32.0	28.0	23.5	16.8	4.6	-.1	-.4	.6	-.8	-1.9
30.1	30.7	30.7	30.1	32.9	31.9	30.7	27.9	24.1	16.8	3.6	.5	.3	-.3	-1.5
31.4	29.8	29.8	31.4	32.5	29.4	31.9	30.1	27.9	23.5	13.3	3.2	-.7	-1.1	-.6
30.4	30.8	30.8	30.4	32.0	29.8	30.7	31.9	30.7	28.0	20.6	6.4	.2	-1.3	.0
30.0	33.9	33.9	30.0	31.5	31.5	29.8	29.4	31.9	32.0	25.0	13.2	1.8	-.1	-2.2
31.7	30.8	30.8	31.7	28.3	31.5	32.0	32.5	32.9	30.8	26.9	17.7	3.2	-.7	-.4
33.1	28.5	28.5	33.1	31.7	30.0	30.4	31.4	30.1	29.2	28.8	21.6	4.7	.3	.6
28.5	29.8	29.8	28.5	30.8	33.9	30.8	29.8	30.7	29.6	28.3	21.8	7.9	.8	-.9
28.5	29.8	29.8	28.5	30.8	33.9	30.8	29.8	30.7	29.6	28.3	21.8	7.9	.8	-.9
33.1	28.5	28.5	33.1	31.7	30.0	30.4	31.4	30.1	29.2	28.8	21.6	4.7	.3	.6
31.7	30.8	30.8	31.7	28.3	31.5	32.0	32.5	32.9	30.8	26.9	17.7	3.2	-.7	-.4
30.0	33.9	33.9	30.0	31.5	31.5	29.8	29.4	31.9	32.0	25.0	13.2	1.8	-.1	-2.2
30.4	30.8	30.8	30.4	32.0	29.8	30.7	31.9	30.7	28.0	20.6	6.4	.2	-1.3	.0
31.4	29.8	29.8	31.4	32.5	29.4	31.9	30.1	27.9	23.5	13.3	3.2	-.7	-1.1	-.6
30.1	30.7	30.7	30.1	32.9	31.9	30.7	27.9	24.1	16.8	3.6	.5	.3	-.3	-1.5
29.2	29.6	29.6	29.2	30.8	32.0	28.0	23.5	16.8	4.6	-.1	-.4	.6	-.8	-1.9
28.8	28.3	28.3	28.8	26.9	25.0	20.6	13.3	3.6	-.1	-.4	-.8	-1.3	-.5	-.8
21.6	21.8	21.8	21.6	17.7	13.2	6.4	3.2	.5	-.4	-.8	-1.4	-1.5	-1.4	.2
4.7	7.9	7.9	4.7	3.2	1.8	.2	-.7	.3	.6	-1.3	-1.5	-1.1	-1.1	-1.5
.3	.8	.8	.3	-.7	-.1	-1.3	-1.1	-.3	-.8	-.5	-1.4	-1.1	-.7	.2
.6	-.9	-.9	.6	-.4	-2.2	.0	-.6	-1.5	-1.9	-.8	.2	-1.5	.2	2.5
-1.9	-1.2	-1.2	-1.9	-.1	-.1	-.9	-1.3	-1.5	-1.5	-.5	.5	1.3	2.3	3.2
-1.4	-1.7	-1.7	-1.4	-1.8	.3	-.8	-1.3	-1.1	-.8	-.4	.4	3.0	4.4	7.4
.1	-1.7	-1.7	.1	-.7	-.9	.3	.2	-.4	.6	1.5	3.3	4.2	8.8	14.7
.7	-.0	-.0	.7	-.4	-.0	.3	1.1	1.9	2.5	4.5	6.1	10.2	16.9	24.5
1.2	1.6	1.6	1.2	1.3	1.7	2.0	2.9	4.6	7.5	9.9	14.0	20.9	26.2	27.4
4.0	3.8	3.8	4.0	4.3	4.9	6.6	8.7	11.2	15.4	20.3	24.4	27.0	29.0	29.6
11.6	10.0	10.0	11.6	10.9	13.6	16.1	19.2	22.6	26.1	28.6	28.5	29.4	29.8	32.4
22.9	22.5	22.5	22.9	24.7	26.2	26.9	27.8	28.6	29.4	30.4	31.0	32.4	31.5	29.4
28.1	28.3	28.3	28.1	29.0	29.9	29.9	31.1	29.6	29.8	29.9	29.1	30.6	31.6	29.5
29.8	29.5	29.5	29.8	29.3	29.1	29.4	28.5	28.3	29.5	30.9	31.5	29.6	31.3	31.4
28.9	28.6	28.6	28.9	28.6	29.2	30.0	31.8	31.5	30.7	30.1	30.9	31.0	30.1	30.2
30.9	31.7	31.7	30.9	31.3	31.1	30.1	29.9	30.3	31.1	30.3	29.9	29.9	29.8	30.1
31.2	32.3	32.3	31.2	30.4	30.9	30.8	32.8	31.2	29.8	31.4	29.7	29.0	29.9	28.4
30.0	29.3	29.3	30.0	31.7	29.2	30.7	31.1	31.5	30.0	30.0	30.4	28.6	28.5	26.3
29.3	30.5	30.5	29.3	30.2	29.5	29.9	28.0	28.6	28.5	26.6	28.3	25.3	22.2	12.9
28.8	28.7	28.7	28.8	28.9	28.2	29.2	28.5	26.9	25.3	21.9	16.9	8.6	1.9	-.7
25.7	24.4	24.4	25.7	24.9	22.4	20.3	17.9	13.1	6.7	1.9	.2	-1.1	-1.0	-1.0
5.6	6.5	6.5	5.6	4.2	3.0	1.5	-.1	-.4	-.5	-.2	-.6	-.3	.2	-.1
-.7	-.4	-.4	-.7	-.8	-.5	-.8	-.4	-.2	.3	.2	-.5	.1	-.7	.5

.0	-.0	.8	-.1	.5	-.7	.1	-.5	.2	.3	-.2	-.4	-.8	-.5	-.8
.1	-.3	-.2	.3	-.1	.2	-.3	-.6	-.2	-.5	-.4	-.1	1.5	3.0	4.2
-.7	.2	-.4	-.9	-1.0	-1.0	-1.1	.2	1.9	6.7	13.1	17.9	20.3	22.4	24.9
-.3	-.8	-1.1	-.6	-.7	1.9	8.6	16.9	21.9	25.3	26.9	28.5	29.2	28.2	28.9
-.5	-.8	-.5	3.1	12.9	22.2	25.3	28.3	26.6	28.5	28.6	28.0	29.9	29.5	30.2
-.8	2.1	13.5	22.6	26.3	28.5	28.6	30.4	30.0	30.0	31.5	31.1	30.7	29.2	31.7
8.8	20.8	26.2	27.2	28.4	29.9	29.0	29.7	31.4	29.8	31.2	32.8	30.8	30.9	30.4
24.0	26.6	29.6	29.6	30.1	29.8	29.9	29.9	30.3	31.1	30.3	29.9	30.1	31.1	31.3
28.2	29.5	30.1	29.6	30.2	30.1	31.0	30.9	30.1	30.7	31.5	31.8	30.0	29.2	28.6
29.0	29.9	30.3	30.3	31.4	31.3	29.6	31.5	30.9	29.5	28.3	28.5	29.4	29.1	29.3
29.5	30.7	30.6	30.2	29.5	31.6	30.6	29.1	29.9	29.8	29.6	31.1	29.9	29.9	29.0
29.8	30.5	29.7	30.9	29.4	31.5	32.4	31.0	30.4	29.4	28.6	27.8	26.9	26.2	24.7
30.1	32.5	30.3	32.0	32.4	29.8	29.4	28.5	28.6	26.1	22.6	19.2	16.1	13.6	10.9
30.9	32.8	31.0	29.1	29.6	29.0	27.0	24.4	20.3	15.4	11.2	8.7	6.6	4.9	4.3
29.8	28.2	31.3	30.3	27.4	26.2	20.9	14.0	9.9	7.5	4.6	2.9	2.0	1.7	1.3
33.4	30.1	29.2	27.6	24.5	16.9	10.2	6.1	4.5	2.5	1.9	1.1	.3	-.0	-.4
30.1	29.8	27.6	21.8	14.7	8.8	4.2	3.3	1.5	.6	-.4	.2	.3	-.9	-.7
29.2	27.6	22.2	12.5	7.4	4.4	3.0	.4	-.4	-.8	-1.1	-1.3	-.8	.3	-1.8
27.6	21.8	12.5	6.7	3.2	2.3	1.3	.5	-.5	-1.5	-1.5	-1.3	-.9	-.1	-.1
24.5	14.7	7.4	3.2	2.5	.2	-1.5	.2	-.8	-1.9	-1.5	-.6	.0	-2.2	-.4
16.9	8.8	4.4	2.3	.2	-.7	-1.1	-1.4	-.5	-.8	-.3	-1.1	-1.3	-.1	-.7
10.2	4.2	3.0	1.3	-1.5	-1.1	-1.1	-1.5	-1.3	.6	.3	-.7	.2	1.8	3.2
6.1	3.3	.4	.5	.2	-1.4	-1.5	-1.4	-.8	-.4	.5	3.2	6.4	13.2	17.7
4.5	1.5	-.4	-.5	-.8	-.5	-1.3	-.8	-.4	-.1	3.6	13.3	20.6	25.0	26.9
2.5	.6	-.8	-1.5	-1.9	-.8	.6	-.4	-.1	4.6	16.8	23.5	28.0	32.0	30.8
1.9	-.4	-1.1	-1.5	-1.5	-.3	.3	.5	3.6	16.8	24.1	27.9	30.7	31.9	32.9
1.1	.2	-1.3	-1.3	-.6	-1.1	-.7	3.2	13.3	23.5	27.9	30.1	31.9	29.4	32.5
.3	.3	-.8	-.9	.0	-1.3	.2	6.4	20.6	28.0	30.7	31.9	30.7	29.8	32.0
-.0	-.9	.3	-.1	-2.2	-.1	1.8	13.2	25.0	32.0	31.9	29.4	29.8	31.5	31.5
-.4	-.7	-1.8	-.1	-.4	-.7	3.2	17.7	26.9	30.8	32.9	32.5	32.0	31.5	28.3
.7	.1	-1.4	-1.9	.6	.3	4.7	21.6	28.8	29.2	30.1	31.4	30.4	30.0	31.7
-.0	-1.7	-1.7	-1.2	-.9	.8	7.9	21.8	28.3	29.6	30.7	29.8	30.8	33.9	30.8
-.0	-1.7	-1.7	-1.2	-.9	.8	7.9	21.8	28.3	29.6	30.7	29.8	30.8	33.9	30.8
.7	.1	-1.4	-1.9	.6	.3	4.7	21.6	28.8	29.2	30.1	31.4	30.4	30.0	31.7
-.4	-.7	-1.8	-.1	-.4	-.7	3.2	17.7	26.9	30.8	32.9	32.5	32.0	31.5	28.3
-.0	-.9	.3	-.1	-2.2	-.1	1.8	13.2	25.0	32.0	31.9	29.4	29.8	31.5	31.5
.3	.3	-.8	-.9	.0	-1.3	.2	6.4	20.6	28.0	30.7	31.9	30.7	29.8	32.0
1.1	.2	-1.3	-1.3	-.6	-1.1	-.7	3.2	13.3	23.5	27.9	30.1	31.9	29.4	32.5
1.9	-.4	-1.1	-1.5	-1.5	-.3	.3	.5	3.6	16.8	24.1	27.9	30.7	31.9	32.9
2.5	.6	-.8	-1.5	-1.9	-.8	.6	-.4	-.1	4.6	16.8	23.5	28.0	32.0	30.8
4.5	1.5	-.4	-.5	-.8	-.5	-1.3	-.8	-.4	-.1	3.6	13.3	20.6	25.0	26.9
6.1	3.3	.4	.5	.2	-1.4	-1.5	-1.4	-.8	-.4	.5	3.2	6.4	13.2	17.7
10.2	4.2	3.0	1.3	-1.5	-1.1	-1.1	-1.5	-1.3	.6	.3	-.7	.2	1.8	3.2
16.9	8.8	4.4	2.3	.2	-.7	-1.1	-1.4	-.5	-.8	-.3	-1.1	-1.3	-.1	-.7
24.5	14.7	7.4	3.2	2.5	.2	-1.5	.2	-.8	-1.9	-1.5	-.6	.0	-2.2	-.4
27.6	21.8	12.5	6.7	3.2	2.3	1.3	.5	-.5	-1.5	-1.5	-1.3	-.9	-.1	-.1
29.2	27.6	22.2	12.5	7.4	4.4	3.0	.4	-.4	-.8	-1.1	-1.3	-.8	.3	-1.8
30.1	29.8	27.6	21.8	14.7	8.8	4.2	3.3	1.5	.6	-.4	.2	.3	-.9	-.7
33.4	30.1	29.2	27.6	24.5	16.9	10.2	6.1	4.5	2.5	1.9	1.1	.3	-.0	-.4
29.8	28.2	31.3	30.3	27.4	26.2	20.9	14.0	9.9	7.5	4.6	2.9	2.0	1.7	1.3
30.9	32.8	31.0	29.1	29.6	29.0	27.0	24.4	20.3	15.4	11.2	8.7	6.6	4.9	4.3
30.1	32.5	30.3	32.0	32.4	29.8	29.4	28.5	28.6	26.1	22.6	19.2	16.1	13.6	10.9
29.8	30.5	29.7	30.9	29.4	31.5	32.4	31.0	30.4	29.4	28.6	27.8	26.9	26.2	24.7
29.5	30.7	30.6	30.2	29.5	31.6	30.6	29.1	29.9	29.8	29.6	31.1	29.9	29.9	29.0
29.0	29.9	30.3	30.3	31.4	31.3	29.6	31.5	30.9	29.5	28.3	28.5	29.4	29.1	29.3
28.2	29.5	30.1	29.6	30.2	30.1	31.0	30.9	30.1	30.7	31.5	31.8	30.0	29.2	28.6
24.0	26.6	29.6	29.6	30.1	29.8	29.9	29.9	30.3	31.1	30.3	29.9	30.1	31.1	31.3
8.8	20.8	26.2	27.2	28.4	29.9	29.0	29.7	31.4	29.8	31.2	32.8	30.8	30.9	30.4
-.8	2.1	13.5	22.6	26.3	28.5	28.6	30.4	30.0	30.0	31.5	31.1	30.7	29.2	31.7
-.5	-.8	-.5	3.1	12.9	22.2	25.3	28.3	26.6	28.5	28.6	28.0	29.9	29.5	30.2
-.3	-.8	-1.1	-.6	-.7	1.9	8.6	16.9	21.9	25.3	26.9	28.5	29.2	28.2	28.9
-.7	.2	-.4	-.9	-1.0	-1.0	-1.1	.2	1.9	6.7	13.1	17.9	20.3	22.4	24.9
.1	-.3	-.2	.3	-.1	.2	-.3	-.6	-.2	-.5	-.4	-.1	1.5	3.0	4.2
.0	-.0	.8	-.1	.5	-.7	.1	-.5	.2	.3	-.2	-.4	-.8	-.5	-.8

-.1	.8	-.0	.0	.4	.5	.4	.9	.5	.6	.1	1.2	-.5	1.1	.1
.3	-.2	-.3	.1	-.8	.2	-1.1	.4	-1.4	.2	-1.1	.3	-1.5	-.0	-.9
-.9	-.4	.2	-.7	.2	-.3	.1	.8	-.2	1.1	-.2	.9	.1	.9	.5
-.6	-1.1	-.8	-.3	.0	-.0	.5	-.6	-.3	-.9	-.9	-.8	-.5	-.7	-.6
3.1	-.5	-.8	-.5	-.2	-.3	-1.0	-.6	.2	-.3	1.4	.3	1.1	-.1	.3
22.6	13.5	2.1	-.8	-1.0	-.9	-.5	.4	-.2	.2	.4	-1.7	-.2	-1.5	-.1
27.2	26.2	20.8	8.8	-.3	-.6	-1.0	-.5	-.3	-.2	-.6	-.1	1.6	-.2	1.1
29.6	29.6	26.6	24.0	15.7	2.5	-.9	-.2	-.3	.2	-.3	.5	-.1	-1.7	.3
29.6	30.1	29.5	28.2	27.0	20.1	4.7	-.3	-.7	-.5	-.1	-.3	-.6	.4	1.4
30.3	30.3	29.9	29.0	29.0	27.8	22.2	7.5	-.5	-.5	-.5	.2	-.2	.2	-.3
30.2	30.6	30.7	29.5	30.5	29.1	26.9	22.6	7.4	-.5	-.7	-.3	-.3	-.2	.2
30.9	29.7	30.5	29.8	30.8	29.3	28.8	27.7	22.6	7.5	-.3	-.2	-.5	.4	-.6
32.0	30.3	32.5	30.1	31.4	30.9	29.9	28.8	26.9	22.2	4.7	-.9	-1.0	-.5	-1.0
29.1	31.0	32.8	30.9	31.3	31.6	30.9	29.3	29.1	27.8	20.1	2.5	-.6	-.9	-.3
30.3	31.3	28.2	29.8	28.9	31.3	31.4	30.8	30.5	29.0	27.0	15.7	-.3	-1.0	-.2
27.6	29.2	30.1	33.4	29.8	30.9	30.1	29.8	29.5	29.0	28.2	24.0	8.8	-.8	-.5
21.8	27.6	29.8	30.1	28.2	32.8	32.5	30.5	30.7	29.9	29.5	26.6	20.8	2.1	-.8
12.5	22.2	27.6	29.2	31.3	31.0	30.3	29.7	30.6	30.3	30.1	29.6	26.2	13.5	-.5
6.7	12.5	21.8	27.6	30.3	29.1	32.0	30.9	30.2	30.3	29.6	29.6	27.2	22.6	3.1
3.2	7.4	14.7	24.5	27.4	29.6	32.4	29.4	29.5	31.4	30.2	30.1	28.4	26.3	12.9
2.3	4.4	8.8	16.9	26.2	29.0	29.8	31.5	31.6	31.3	30.1	29.8	29.9	28.5	22.2
1.3	3.0	4.2	10.2	20.9	27.0	29.4	32.4	30.6	29.6	31.0	29.9	29.0	28.6	25.3
.5	.4	3.3	6.1	14.0	24.4	28.5	31.0	29.1	31.5	30.9	29.9	29.7	30.4	28.3
-.5	-.4	1.5	4.5	9.9	20.3	28.6	30.4	29.9	30.9	30.1	30.3	31.4	30.0	26.6
-1.5	-.8	.6	2.5	7.5	15.4	26.1	29.4	29.8	29.5	30.7	31.1	29.8	30.0	28.5
-1.5	-1.1	-.4	1.9	4.6	11.2	22.6	28.6	29.6	28.3	31.5	30.3	31.2	31.5	28.6
-1.3	-1.3	.2	1.1	2.9	8.7	19.2	27.8	31.1	28.5	31.8	29.9	32.8	31.1	28.0
-.9	-.8	.3	.3	2.0	6.6	16.1	26.9	29.9	29.4	30.0	30.1	30.8	30.7	29.9
-.1	.3	-.9	-.0	1.7	4.9	13.6	26.2	29.9	29.1	29.2	31.1	30.9	29.2	29.5
-.1	-1.8	-.7	-.4	1.3	4.3	10.9	24.7	29.0	29.3	28.6	31.3	30.4	31.7	30.2
-1.9	-1.4	.1	.7	1.2	4.0	11.6	22.9	28.1	29.8	28.9	30.9	31.2	30.0	29.3
-1.2	-1.7	-1.7	-.0	1.6	3.8	10.0	22.5	28.3	29.5	28.6	31.7	32.3	29.3	30.5
-1.2	-1.7	-1.7	-.0	1.6	3.8	10.0	22.5	28.3	29.5	28.6	31.7	32.3	29.3	30.5
-1.9	-1.4	.1	.7	1.2	4.0	11.6	22.9	28.1	29.8	28.9	30.9	31.2	30.0	29.3
-.1	-1.8	-.7	-.4	1.3	4.3	10.9	24.7	29.0	29.3	28.6	31.3	30.4	31.7	30.2
-.1	.3	-.9	-.0	1.7	4.9	13.6	26.2	29.9	29.1	29.2	31.1	30.9	29.2	29.5
-.9	-.8	.3	.3	2.0	6.6	16.1	26.9	29.9	29.4	30.0	30.1	30.8	30.7	29.9
-1.3	-1.3	.2	1.1	2.9	8.7	19.2	27.8	31.1	28.5	31.8	29.9	32.8	31.1	28.0
-1.5	-1.1	-.4	1.9	4.6	11.2	22.6	28.6	29.6	28.3	31.5	30.3	31.2	31.5	28.6
-1.5	-.8	.6	2.5	7.5	15.4	26.1	29.4	29.8	29.5	30.7	31.1	29.8	30.0	28.5
-.5	-.4	1.5	4.5	9.9	20.3	28.6	30.4	29.9	30.9	30.1	30.3	31.4	30.0	26.6
.5	.4	3.3	6.1	14.0	24.4	28.5	31.0	29.1	31.5	30.9	29.9	29.7	30.4	28.3
1.3	3.0	4.2	10.2	20.9	27.0	29.4	32.4	30.6	29.6	31.0	29.9	29.0	28.6	25.3
2.3	4.4	8.8	16.9	26.2	29.0	29.8	31.5	31.6	31.3	30.1	29.8	29.9	28.5	22.2
3.2	7.4	14.7	24.5	27.4	29.6	32.4	29.4	29.5	31.4	30.2	30.1	28.4	26.3	12.9
6.7	12.5	21.8	27.6	30.3	29.1	32.0	30.9	30.2	30.3	29.6	29.6	27.2	22.6	3.1
12.5	22.2	27.6	29.2	31.3	31.0	30.3	29.7	30.6	30.3	30.1	29.6	26.2	13.5	-.5
21.8	27.6	29.8	30.1	28.2	32.8	32.5	30.5	30.7	29.9	29.5	26.6	20.8	2.1	-.8
27.6	29.2	30.1	33.4	29.8	30.9	30.1	29.8	29.5	29.0	28.2	24.0	8.8	-.8	-.5
30.3	31.3	28.2	29.8	28.9	31.3	31.4	30.8	30.5	29.0	27.0	15.7	-.3	-1.0	-.2
29.1	31.0	32.8	30.9	31.3	31.6	30.9	29.3	29.1	27.8	20.1	2.5	-.6	-.9	-.3
32.0	30.3	32.5	30.1	31.4	30.9	29.9	28.8	26.9	22.2	4.7	-.9	-1.0	-.5	-1.0
30.9	29.7	30.5	29.8	30.8	29.3	28.8	27.7	22.6	7.5	-.3	-.2	-.5	.4	-.6
30.2	30.6	30.7	29.5	30.5	29.1	26.9	22.6	7.4	-.5	-.7	-.3	-.3	-.2	.2
30.3	30.3	29.9	29.0	29.0	27.8	22.2	7.5	-.5	-.5	-.5	.2	-.2	.2	-.3
29.6	30.1	29.5	28.2	27.0	20.1	4.7	-.3	-.7	-.5	-.1	-.3	-.6	.4	1.4
29.6	29.6	26.6	24.0	15.7	2.5	-.9	-.2	-.3	.2	-.3	.5	-.1	-1.7	.3
27.2	26.2	20.8	8.8	-.3	-.6	-1.0	-.5	-.3	-.2	-.6	-.1	1.6	-.2	1.1
22.6	13.5	2.1	-.8	-1.0	-.9	-.5	.4	-.2	.2	.4	-1.7	-.2	-1.5	-.1
3.1	-.5	-.8	-.5	-.2	-.3	-1.0	-.6	.2	-.3	1.4	.3	1.1	-.1	.3
-.6	-1.1	-.8	-.3	.0	-.0	.5	-.6	-.3	-.9	-.9	-.8	-.5	-.7	-.6
-.9	-.4	.2	-.7	.2	-.3	.1	.8	-.2	1.1	-.2	.9	.1	.9	.5
.3	-.2	-.3	.1	-.8	.2	-1.1	.4	-1.4	.2	-1.1	.3	-1.5	-.0	-.9
-.1	.8	-.0	.0	.4	.5	.4	.9	.5	.6	.1	1.2	-.5	1.1	.1

.2	1.2	-.7	.4
-1.3	-.3	-1.8	-.7
.1	1.2	-.3	1.2
-1.1	.1	-1.3	.2
-.6	.5	-.9	.1
-.7	.9	-.0	1.1
-.5	.1	-1.5	-.5
-.8	.9	.3	1.2
-.9	-.2	-1.1	.1
-.9	1.1	.2	.6
-.3	-.2	-1.4	.5
-.6	.8	.4	.9
.5	.1	-1.1	.4
-.0	-.3	.2	.5
.0	.2	-.8	.4
-.3	-.7	.1	.0
-.8	.2	-.3	-.0
-1.1	-.4	-.2	.8
-.6	-.9	.3	-.1
-.7	-1.0	-.1	.5
1.9	-1.0	.2	-.7
8.6	-1.1	-.3	.1
16.9	.2	-.6	-.5
21.9	1.9	-.2	.2
25.3	6.7	-.5	.3
26.9	13.1	-.4	-.2
28.5	17.9	-.1	-.4
29.2	20.3	1.5	-.8
28.2	22.4	3.0	-.5
28.9	24.9	4.2	-.8
28.8	25.7	5.6	-.7
28.7	24.4	6.5	-.4
28.7	24.4	6.5	-.4
28.8	25.7	5.6	-.7
28.9	24.9	4.2	-.8
28.2	22.4	3.0	-.5
29.2	20.3	1.5	-.8
28.5	17.9	-.1	-.4
26.9	13.1	-.4	-.2
25.3	6.7	-.5	.3
21.9	1.9	-.2	.2
16.9	.2	-.6	-.5
8.6	-1.1	-.3	.1
1.9	-1.0	.2	-.7
-.7	-1.0	-.1	.5
-.6	-.9	.3	-.1
-1.1	-.4	-.2	.8
-.8	.2	-.3	-.0
-.3	-.7	.1	.0
.0	.2	-.8	.4
-.0	-.3	.2	.5
.5	.1	-1.1	.4
-.6	.8	.4	.9
-.3	-.2	-1.4	.5
-.9	1.1	.2	.6
-.9	-.2	-1.1	.1
-.8	.9	.3	1.2
-.5	.1	-1.5	-.5
-.7	.9	-.0	1.1
-.6	.5	-.9	.1
-1.1	.1	-1.3	.2
.1	1.2	-.3	1.2
-1.3	-.3	-1.8	-.7
.2	1.2	-.7	.4

9. Examples 11,12 - Attenuation Correction Assuming a Constant Attenuation Coefficient

Examples 11 and 12 show how to code a program that reconstructs emission projection data with attenuation compensation implemented by assuming a constant attenuation coefficient. The simulated emission data are first reconstructed giving an approximate reconstruction using the subroutine GRADY in statement E11.062. The projection and back-projection subroutines PRF and BRF are used in this example. The attenuation factors are then evaluated by EVATU in statement E11.089 with the constant attenuation coefficient ATENL equal to 0.075 (in units of inverse pixel width). The object-to-background ratio XLEV is used for the automatic border-searching routine and is set to 3.5 here. The subroutine EVATU first does a boundary search on the approximated reconstructed image B and then displays the object with an array plot showing the distribution of the constant attenuation coefficient ATENL. The user can vary XLEV until the desired object shape is obtained.

The corrected transverse section is then reconstructed in statement E11.099. The projection and back-projection subroutines PRFA and BRFA should only be used when correcting for attenuation with one of the iterative routines (GRADY or CONGR) and only after the subroutine EVATU has been implemented.

Example 11 uses the subroutine GETUM to input simulated projection data for an elliptical source phantom with a concentration of 30 and an elliptical attenuator of the same size, which has an attenuation coefficient of 0.075. This is the same phantom reconstructed in Example 8 where a transmission study was first reconstructed to determine the distribution of attenuation coefficients. If the attenuation coefficient is constant and if the source has the same distribution domain as the attenuator, then the following program will give good results without a separate transmission study.

```
      PROGRAM ATENUX (INPUT,OUTPUT,TAPE3,TAPE4=OUTPUT)                  E11.001
C                                                                       E11.002
C        EXAMPLES 11 AND 12                                             E11.003
C                                                                       E11.004
C              THE PROGRAM ATENUX RECONSTRUCTS ATTENUATED DATA ASSUMING E11.005
C        A CONSTANT ATTENUATION COEFFICIENT AND USING ATTENUATION       E11.006
C        FACTORS WHICH ARE EVALUATED AFTER DETERMINING THE BOUNDARY OF  E11.007
C        THE OBJECT BY AN APPROXIMATED RECONSTRUCTION.                  E11.008
C                                                                       E11.009
      DIMENSION B(4096),AG(72)                                          E11.010
      COMMON WORK(18000)                                                E11.011
C                                                                       E11.012
      COMMON/OUTCOM/LUNOUT,I80132                                       E11.013
C                                                                       E11.014
C           LUNOUT  - OUTPUT FILE                                       E11.015
C           I80132  - OUTPUT LINE LENGTH FLAG                           E11.016
C                 =0    EACH LINE WILL BE WITHIN 80 CHARACTERS          E11.017
C                         (OTHERWISE 132 CHARACTERS)                    E11.018
C                                                                       E11.019
      COMMON/PARM/IPAR(12),PAR(3)                                       E11.020
C                                                                       E11.021
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)), E11.022
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)), E11.023
     2            (IMIT  ,IPAR( 7)),(NWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)), E11.024
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)), E11.025
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3))  E11.026
C                                                                       E11.027
C                                                                       E11.028
      EXTERNAL BRF,PRF,BRFA,PRFA                                        E11.029
C                                                                       E11.030
      LUNOUT=4                                                          E11.031
      I80132=0                                                          E11.032
C                                                                       E11.033
C        THE INPUT PARAMETERS ARE                                       E11.034
C                                                                       E11.035
      NDIMU=64                                                          E11.036
      ICIR=1                                                            E11.037
      IGEOM=0                                                           E11.038
      NANG=72                                                           E11.039
      MODANG=5                                                          E11.040
      KDIMU=100                                                         E11.041
      IMIT=0                                                            E11.042
      NWORK=18000                                                       E11.043
      NFLOAT=1                                                          E11.044
      ISTORE=0                                                          E11.045
      IPRINT=5                                                          E11.046
      LUNATN=3                                                          E11.047
      PWID=1.                                                           E11.048
      AXISU=50.5                                                        E11.049
      RFAN=0.                                                           E11.050
C                                                                       E11.051
      CALL SETUP (IPAR,PAR,AG)                                          E11.052
C                                                                       E11.053
C        RECONSTRUCTION OF THE TRANSVERSE SECTION WITH NO CORRECTION    E11.054
C          FOR ATTENUATION                                              E11.055
C                                                                       E11.056
      ISTP=15                                                           E11.057
      IRLX=1                                                            E11.058
      IERR=0                                                            E11.059
      IZER=0                                                            E11.060
C                                                                       E11.061
      CALL GRADY (B,PRF,BRF,ISTP,IRLX,IERR,IZER)                        E11.062
C                                                                       E11.063
      WRITE (4,22)                                                      E11.064
      CALL ARRAY (B,NDIMU)                                              E11.065
C                                                                       E11.066
C        PRINTOUT THE VALUES FOR THE APPROXIMATED RECONSTRUCTION        E11.067
C                                                                       E11.068
      NMAT=NDIMU**2                                                     E11.069
      KK1=1                                                             E11.070
      KU=NDIMU/15+1                                                     E11.071
      DO 12 K=1,KU                                                      E11.072
      WRITE (4,18)                                                      E11.073
      KK2=15*K                                                          E11.074
      IF (KK2.GT.NDIMU) KK2=NDIMU                                       E11.075
      DO 10 J=1,NDIMU                                                   E11.076
      ISUB1=NMAT-J*NDIMU+KK1                                            E11.077
      ISUB2=NMAT-J*NDIMU+KK2                                            E11.078
   10 WRITE (4,20) (B(I),I=ISUB1,ISUB2)                                 E11.079
      KK1=KK2+1                                                         E11.080
   12 CONTINUE                                                          E11.081
C                                                                       E11.082
C        EVALUATE THE ATTENUATION FACTORS ASSUMING A CONSTANT           E11.083
C          ATTENUATION COEFFICIENT                                      E11.084
C                                                                       E11.085
      XLEV=3.5                                                          E11.086
      ATENL=.075                                                        E11.087
C                                                                       E11.088
      CALL EVATU (B,XLEV,ATENL)                                         E11.089
C                                                                       E11.090
C        RECONSTRUCTION OF THE TRANSVERSE SECTIONS FOR AN EMISSION SCAN E11.091
C          WHICH IS CORRECTED FOR ATTENUATION                           E11.092
C                                                                       E11.093
      ISTP=15                                                           E11.094
      IRLX=1                                                            E11.095
      IERR=0                                                            E11.096
      IZER=0                                                            E11.097
C                                                                       E11.098
      CALL GRADY (B,PRFA,BRFA,ISTP,IRLX,IERR,IZER)                      E11.099
C                                                                       E11.100
      WRITE (4,24)                                                      E11.101
      CALL ARRAY (B,NDIMU)                                              E11.102
C                                                                       E11.103
C        PRINTOUT THE VALUES FOR THE CORRECTED RECONSTRUCTION           E11.104
C                                                                       E11.105
      KK1=1                                                             E11.106
      KU=NDIMU/15+1                                                     E11.107
      DO 16 K=1,KU                                                      E11.108
      WRITE (4,18)                                                      E11.109
      KK2=15*K                                                          E11.110
      IF (KK2.GT.NDIMU) KK2=NDIMU                                       E11.111
      DO 14 J=1,NDIMU                                                   E11.112
      ISUB1=NMAT-J*NDIMU+KK1                                            E11.113
      ISUB2=NMAT-J*NDIMU+KK2                                            E11.114
   14 WRITE (4,20) (B(I),I=ISUB1,ISUB2)                                 E11.115
      KK1=KK2+1                                                         E11.116
   16 CONTINUE                                                          E11.117
C                                                                       E11.118
C                                                                       E11.119
C                                                                       E11.120
   18 FORMAT(1X///////)                                                 E11.121
   20 FORMAT(1X,15F5.1)                                                 E11.122
   22 FORMAT(1X//53H THE APPROXIMATED RECONSTRUCTION FOR AN EMISSION SCA E11.123
     1N)                                                                E11.124
   24 FORMAT(1X//63H RECONSTRUCTION FOR THE EMISSION SCAN CORRECTED FOR  E11.125
     1ATTENUATION)                                                      E11.126
      END                                                               E11.127


      SUBROUTINE GETUM (M,DATA,ERR)                                     E11.128
C                                                                       E11.129
C        EXAMPLE 11                                                     E11.130
C                                                                       E11.131
C              THE SUBROUTINE GETUM GIVES SIMULATED PROJECTION DATA FOR E11.132
C        AN ELLIPICAL SOURCE PHANTOM AND ELLIPICAL ATTENUATOR OF THE    E11.133
C        SAME SIZE.                                                     E11.134
C                                                                       E11.135
      DIMENSION DATA(1),ERR(1)                                          E11.136
      DIMENSION ITYPE(2),Z(2),X1(2),Y1(2),A1(2),B1(2),PHI(2)            E11.137
      DATA ITYPE/1,-1/                                                  E11.138
      DATA Z/30.,.075/                                                  E11.139
      DATA X1/0.,0./                                                    E11.140
      DATA Y1/0.,0./                                                    E11.141
      DATA A1/40.,40./                                                  E11.142
      DATA B1/60.,60./                                                  E11.143
      DATA PHI/0.,0./                                                   E11.144
C                                                                       E11.145
      CALL PHANL (2,ITYPE,Z,X1,Y1,A1,B1,PHI,DATA,M)                     E11.146
C                                                                       E11.147
      RETURN                                                            E11.148
C                                                                       E11.149
      END                                                               E11.150
```

```
 SSS  EEEEE TTTTT U   U PPPP
S     E       T   U   U P   P
 SSS  EEE     T   U   U PPPP
    S E       T   U   U P
 SSS  EEEEE   T    UUU  P
```

INTEGER PARAMETER ARRAY (IPAR)

I	IPAR(I)	DESCRIPTION
1	64	LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
2	1	RECONSTRUCT IN A SQUARE ARRAY
3	0	GEOMETRY FLAG PARALLEL BEAM GEOMETRY
4	72	NUMBER OF PROJECTION ANGLES
5	5	MODE FOR PROJECTION ANGLE INPUT (SEE FOLLOWING LINES) ANGLES GENERATED BETWEEN ZERO AND 2*PI STARTING AT ZERO
6	100	NUMBER OF RAYS FOR EACH PROJECTION
7	0	EMISSION DATA
8	18000	DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
9	1	NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10	0	EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11	5	PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES) PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
12	3	LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE

FLOATING POINT PARAMETER ARRAY (PAR)

I	PAR(I)	DESCRIPTION
1	1.000	PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
2	50.500	LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
3	0 NA	NOT APPLICABLE (NOT FAN BEAM GEOMETRY)

BLANK COMMON REQUIRED 72 (110)

BLANK COMMON REQUIRED 144 (220)

BLANK COMMON REQUIRED 216 (330)

BLANK COMMON REQUIRED 416 (640)

BLANK COMMON REQUIRED 544 (1040)

A TOTAL OF 92 (5 THRU 96) OF THE 100 USER PROJECTION BINS WILL BE USED

92 PROJECTION BINS WILL BE USED OF WHICH 0 HAVE BEEN ZEROED BY THE PROGRAM

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 544 FLOATING POINT WORDS.

```
EEEEE N   N DDDD        SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D      S     E       T   U   U P   P
EEE   N N N D   D       SSS  EEE     T   U   U PPPP
E     N  NN D   D          S E       T   U   U P
EEEEE N   N DDDD        SSS  EEEEE   T    UUU  P

 GGG  RRRR   AAA  DDDD  Y   Y
G   G R   R A   A D   D  Y Y
G     RRRR  A   A D   D   Y
G  GG R  R  AAAAA D   D   Y
 GGGG R   R A   A DDDD    Y
```

PARAMETERS FOR SUBROUTINE GRADY

		DESCRIPTION
ISTP -	15	NUMBER OF ITERATION STEPS
IRLX -	1	ITERATIVE RELAXATION METHOD
IERR -	0	DO NOT USE ERROR ARRAY
IZER -	0	INITIAL SOLUTION IS ZERO

BLANK COMMON REQUIRED 616 (1150)

BLANK COMMON REQUIRED 1226 (2312)

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	UNIFORM SQUARE	NO	NO
PRJ	PROJECTION	UNIFORM SQUARE	NO	NO

BLANK COMMON REQUIRED 1410 (2602)

BLANK COMMON REQUIRED 5506 (12602)

BLANK COMMON REQUIRED 9602 (22602)

BLANK COMMON REQUIRED 13698 (32602)

BLANK COMMON REQUIRED 13714 (32622)

BLANK COMMON REQUIRED 13698 (32602)

FOR CONGR AND GRADY FCN IS THE VALUE OF THE CHI-SQUARE
FOR ENTPY FCN IS EVALUATED BY THE SUBROUTINE DULFC

ITER	0	FCN	.484E+09
ITER	1	FCN	.371E+08
ITER	2	FCN	.132E+08
ITER	3	FCN	.108E+08
ITER	4	FCN	.936E+07
ITER	5	FCN	.844E+07
ITER	6	FCN	.779E+07
ITER	7	FCN	.730E+07
ITER	8	FCN	.693E+07
ITER	9	FCN	.664E+07
ITER	10	FCN	.641E+07
ITER	11	FCN	.622E+07
ITER	12	FCN	.606E+07
ITER	13	FCN	.593E+07
ITER	14	FCN	.582E+07
ITER	15	FCN	.572E+07

BLANK COMMON REQUIRED 13514 (32312)

BLANK COMMON REQUIRED 9418 (22312)

BLANK COMMON REQUIRED 5322 (12312)

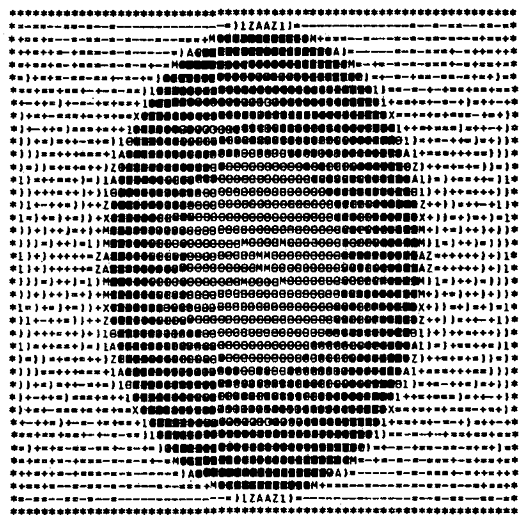
BLANK COMMON REQUIRED 1226 (2312)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 13714 FLOATING POINT WORDS.

```
EEEEE N   N DDDD        GGG  RRRR   AAA  DDDD  Y   Y
E     NN  N D   D      G   G R   R A   A D   D  Y Y
EEE   N N N D   D      G     RRRR  A   A D   D   Y
E     N  NN D   D      G  GG R  R  AAAAA D   D   Y
EEEEE N   N DDDD        GGGG R   R A   A DDDD    Y
```

THE APPROXIMATED RECONSTRUCTION FOR AN EMISSION SCAN

XMIN = -.36E+01 XMAX = .15E+02 XSUM = .1841E+05



```
                          -            =            +            )            1            Z
-.3646E+01  -.2261E+01  -.2311E+00   .6917E+00   .1338E+01   .2076E+01   .2814E+01

Z            X            A            M            θ            ●            ●            ●
 .3460E+01   .3922E+01   .4383E+01   .5398E+01   .6413E+01   .7059E+01   .7798E+01

●            ●            ●            ●            ●            ●            ●            ●
 .8444E+01   .9828E+01   .1149E+02   .1241E+02   .1315E+02   .1389E+02   .1453E+02

●
 .1481E+02
```

.5	.2	1.2	1.0	.1	-1.0	.6	.2	-.8	.4	.1	-1.0	-.0	-.7	-1.3
.0	-.8	.3	.3	-.4	-1.2	-.2	-.2	-1.1	-.2	-.4	-1.3	-.1	-1.0	-1.3
1.1	.3	.7	1.1	.5	-.4	.1	.6	-.5	.3	.3	-.8	.5	-.4	-.5
1.0	.2	.1	.7	.3	-.6	-.6	.4	-.8	-.2	.1	-.8	.2	-.4	-.0
1.0	.4	-.3	.9	.7	.0	-.5	1.1	.1	.2	.5	-.7	.4	-.6	.1
1.4	1.1	.0	.8	.7	-.0	-1.1	.7	-.0	.1	.6	-.3	.7	-.4	-.1
.4	.8	.1	.4	.9	.5	-.5	.8	.2	.0	.7	-.6	.0	-1.2	-.2
.4	1.6	.7	.4	1.2	.7	-.4	.2	-.1	-1.0	.3	-.5	.5	-.5	.8
.1	1.5	.8	-.4	.5	.1	-.8	-.3	.4	-.2	.8	.0	1.1	-.3	.1
-.3	.1	.5	-.3	.7	1.2	.2	-.3	.7	-.2	1.4	-.2	.2	-.8	.5
.7	.3	1.8	.4	.2	.9	.8	.0	1.2	-.6	.3	-.6	.6	.7	.6
1.3	-.2	.9	.8	.7	1.4	.8	-.8	.3	-.7	.8	.5	1.1	.2	.6
1.3	.8	1.0	1.2	.1	.6	.1	-.7	.8	.3	1.2	.1	.8	.5	-.2
2.1	1.0	-.1	.9	-.5	.7	1.0	.0	.8	.6	.6	.5	.8	.6	.2
1.8	.6	-.8	1.0	1.0	.6	1.4	.7	.1	.4	1.2	.2	.9	.5	2.1
1.3	1.5	.6	.1	1.4	.8	1.4	.3	-.1	1.1	.1	.6	.5	1.8	4.2
1.7	1.6	.8	.1	1.5	.4	1.0	1.1	-.3	.5	.9	-.0	1.8	2.7	6.2
.8	2.1	1.5	.1	.4	.7	1.4	.9	-.5	1.1	-.1	1.2	1.8	3.7	9.6
1.8	1.7	1.4	.1	.4	1.6	.4	1.0	.5	-.0	.9	1.3	2.6	4.7	12.3
1.9	.5	1.5	1.4	-.0	.7	.6	1.5	-.2	.7	1.0	1.7	2.9	6.9	13.0
1.4	1.0	1.8	1.3	-.4	.9	.8	.4	.9	.9	1.3	2.1	3.4	9.2	13.8
2.8	1.6	.3	1.1	1.1	.0	.4	1.1	1.5	.3	1.5	2.7	4.3	11.0	13.4
2.6	1.3	-.0	1.8	1.3	-.9	1.1	1.3	1.3	.9	1.3	2.5	5.5	12.1	13.3
1.1	1.6	1.7	.3	.6	.7	.8	.8	1.8	.8	1.6	2.6	7.3	13.2	12.9
1.4	2.2	1.3	-.5	1.4	1.2	.2	1.4	1.9	1.0	1.3	3.0	8.4	13.9	13.1
2.6	1.2	.7	1.2	.6	1.6	.4	1.3	1.5	1.6	.9	2.8	10.0	13.8	12.2
2.2	.3	1.8	1.4	.6	1.7	1.0	.5	1.7	1.6	1.4	3.8	11.2	13.8	11.4
1.3	1.8	.8	1.8	1.1	.8	1.6	-.0	1.6	1.9	1.1	4.7	12.0	13.5	11.6
2.4	1.7	1.0	1.4	1.2	.7	1.4	.8	.8	2.2	.7	5.7	12.7	13.0	11.4
1.7	1.9	1.8	.6	1.9	1.2	.7	1.6	.2	2.3	1.6	5.0	12.6	12.7	11.4
2.0	1.6	1.8	1.0	1.3	1.4	.9	1.5	.7	1.2	2.9	4.2	14.1	13.3	10.7
2.6	1.7	1.0	1.6	.8	1.2	1.5	.8	1.4	.4	3.5	4.1	13.7	13.0	11.3
2.6	1.7	1.0	1.6	.8	1.2	1.5	.8	1.4	.4	3.5	4.1	13.7	13.0	11.3
2.0	1.6	1.8	1.0	1.3	1.4	.9	1.5	.7	1.2	2.9	4.2	14.1	13.3	10.7
1.7	1.9	1.8	.6	1.9	1.2	.7	1.6	.2	2.3	1.6	5.0	12.6	12.7	11.4
2.4	1.7	1.0	1.4	1.2	.7	1.4	.8	.8	2.2	.7	5.7	12.7	13.0	11.4
1.3	1.8	.8	1.8	1.1	.8	1.6	-.0	1.6	1.9	1.1	4.7	12.0	13.5	11.6
2.2	.3	1.8	1.4	.6	1.7	1.0	.5	1.7	1.6	1.4	3.8	11.2	13.8	11.4
2.6	1.2	.7	1.2	.6	1.6	.4	1.3	1.5	1.6	.9	2.8	10.0	13.8	12.2
1.4	2.2	1.3	-.5	1.4	1.2	.2	1.4	1.9	1.0	1.3	3.0	8.4	13.9	13.1
1.1	1.6	1.7	.3	.6	.7	.8	.8	1.8	.8	1.6	2.6	7.3	13.2	12.9
2.6	1.3	-.0	1.8	1.3	-.9	1.1	1.3	1.3	.9	1.3	2.5	5.5	12.1	13.3
2.8	1.6	.3	1.1	1.1	.0	.4	1.1	1.5	.3	1.5	2.7	4.3	11.0	13.4
1.4	1.0	1.8	1.3	-.4	.9	.8	.4	.9	.9	1.3	2.1	3.4	9.2	13.8
1.9	.5	1.5	1.4	-.0	.7	.6	1.5	-.2	.7	1.0	1.7	2.9	6.9	13.0
1.8	1.7	1.4	.1	.4	1.6	.4	1.0	.5	-.0	.9	1.3	2.6	4.7	12.3
.8	2.1	1.5	.1	.4	.7	1.4	.9	-.5	1.1	-.1	1.2	1.8	3.7	9.6
1.7	1.6	.8	.1	1.5	.4	1.0	1.1	-.3	.5	.9	-.0	1.8	2.7	6.2
1.3	1.5	.6	.1	1.4	.8	1.4	.3	-.1	1.1	.1	.6	.5	1.8	4.2
1.8	.6	-.8	1.0	1.0	.6	1.4	.7	.1	.4	1.2	.2	.9	.5	2.1
2.1	1.0	-.1	.9	-.5	.7	1.0	.0	.8	.6	.6	.5	.8	.6	.2
1.3	.8	1.0	1.2	.1	.6	.1	-.7	.8	.3	1.2	.1	.8	.5	-.2
1.3	-.2	.9	.8	.7	1.4	.8	-.8	.3	-.7	.8	.5	1.1	.2	.6
.7	.3	1.8	.4	.2	.9	.8	.0	1.2	-.6	.3	-.6	.6	.7	.6
-.3	.1	.5	-.3	.7	1.2	.2	-.3	.7	-.2	1.4	-.2	.2	-.8	.5
.1	1.5	.8	-.4	.5	.1	-.8	-.3	.4	-.2	.8	.0	1.1	-.3	.1
.4	1.6	.7	.4	1.2	.7	-.4	.2	-.1	-1.0	.3	-.5	.5	-.5	.8
.4	.8	.1	.4	.9	.5	-.5	.8	.2	.0	.7	-.6	.0	-1.2	-.2
1.4	1.1	.0	.8	.7	-.0	-1.1	.7	-.0	.1	.6	-.3	.7	-.4	-.1
1.0	.4	-.3	.9	.7	.0	-.5	1.1	.1	.2	.5	-.7	.4	-.6	.1
1.0	.2	.1	.7	.3	-.6	-.6	.4	-.8	-.2	.1	-.8	.2	-.4	-.0
1.1	.3	.7	1.1	.5	-.4	.1	.6	-.5	.3	.3	-.8	.5	-.4	-.5
.0	-.8	.3	.3	-.4	-1.2	-.2	-.2	-1.1	-.2	-.4	-1.3	-.1	-1.0	-1.3
.5	.2	1.2	1.0	.1	-1.0	.6	.2	-.8	.4	.1	-1.0	-.0	-.7	-1.3

-.6	-2.0	-1.1	-1.4	-1.5	-2.8	-2.4	-2.2	-2.1	-1.8	-1.7	-2.3	-3.6	-3.4	-2.2
-.7	-2.2	-1.1	-1.0	-1.1	-2.2	-1.9	-1.4	-1.3	-1.2	-1.1	-2.0	-1.2	.9	1.4
-.3	-1.6	-.7	-.6	-1.3	-1.3	-1.0	-.6	-.2	.3	-.2	2.3	6.0	8.2	11.1
-.4	-1.0	-.5	-.0	-1.3	-.5	.2	.6	.9	.9	6.5	11.5	13.7	14.0	14.2
-.2	-.6	.0	-.4	-1.4	-1.0	.1	2.4	4.0	10.9	14.1	14.0	14.4	13.4	13.8
-.8	-1.1	-.6	-1.2	-.7	1.1	3.6	7.0	13.3	14.6	14.7	14.1	12.9	12.1	12.7
-1.2	-.2	.9	-.6	.3	4.4	8.4	13.7	14.8	13.3	13.1	13.2	11.8	11.3	11.2
-.5	.2	-.2	.4	4.3	9.0	13.6	14.1	13.3	12.4	11.9	11.2	10.5	10.5	10.3
-1.4	1.1	.7	2.7	9.2	13.6	14.3	13.1	11.8	11.3	11.4	10.7	9.8	9.5	9.1
.3	1.5	1.0	8.2	13.4	14.4	12.6	12.1	11.5	10.4	9.5	9.3	9.2	8.9	8.9
.2	1.7	4.7	12.5	13.6	13.3	12.0	10.6	10.4	9.8	9.3	9.3	8.9	8.8	8.5
1.0	2.5	11.0	14.0	13.1	12.4	11.8	10.4	10.0	9.3	8.9	8.6	8.2	8.6	8.0
2.2	7.5	13.8	13.8	13.1	11.1	10.5	9.7	9.6	8.8	8.1	8.1	8.0	7.9	7.3
4.8	12.5	14.2	12.6	11.7	10.7	9.8	8.8	8.7	8.4	8.0	7.8	7.6	7.3	7.1
7.7	13.1	13.5	12.3	10.6	10.0	9.2	8.7	8.4	8.5	7.8	7.1	7.3	7.2	7.1
12.0	14.0	12.9	11.4	10.1	9.5	8.5	8.1	7.7	7.7	7.4	7.2	7.4	6.7	6.7
13.2	13.7	12.2	10.4	10.0	9.4	8.4	8.3	7.7	7.6	6.9	6.7	7.1	6.4	6.9
14.1	13.0	11.2	10.0	9.5	8.6	8.4	7.7	7.3	7.4	7.0	6.7	7.0	6.9	6.3
13.5	11.8	10.6	9.6	8.7	8.3	8.0	7.4	7.2	7.0	6.6	6.5	6.6	6.9	6.4
12.8	11.8	10.5	9.1	8.7	8.2	7.5	7.1	7.2	6.7	6.4	6.5	6.3	6.2	6.4
12.5	11.5	9.8	9.0	8.5	7.9	7.3	7.0	7.1	6.8	6.5	6.3	6.2	6.0	5.6
11.4	10.5	9.8	9.0	8.0	7.5	7.0	6.9	6.7	6.7	6.4	5.8	5.9	6.2	6.0
11.4	10.6	9.2	8.4	7.7	7.3	7.0	6.5	6.7	6.4	6.5	6.6	6.0	6.1	5.9
11.0	10.0	8.9	8.4	8.0	7.5	7.0	6.8	7.2	6.2	5.9	6.2	5.8	6.0	5.8
11.1	10.0	9.1	8.2	7.5	7.3	7.1	6.6	6.2	6.1	6.0	6.0	5.9	6.1	5.9
10.7	9.3	8.8	7.8	7.2	7.2	6.9	6.9	6.0	6.1	6.1	5.8	5.9	6.0	6.1
10.3	8.9	8.3	7.8	7.4	7.0	6.3	7.0	6.4	6.1	5.9	5.8	6.0	5.5	5.9
10.8	9.4	8.9	7.9	7.1	7.0	6.4	6.3	6.0	6.1	6.1	6.0	5.8	5.4	5.9
9.9	8.7	8.7	8.2	7.2	6.7	6.6	6.5	6.3	6.4	6.1	5.6	5.5	5.7	5.7
9.9	9.3	8.0	7.7	7.4	6.3	6.6	6.3	6.2	6.2	6.1	6.0	5.9	5.8	5.4
9.6	9.3	8.0	7.5	7.4	6.5	6.6	6.4	6.1	5.9	5.7	5.7	5.7	5.6	5.8
10.2	8.7	8.0	7.8	7.1	6.5	6.8	6.3	6.0	5.8	5.8	5.6	5.7	5.9	5.5
10.2	8.7	8.0	7.8	7.1	6.5	6.8	6.3	6.0	5.8	5.8	5.6	5.7	5.9	5.5
9.6	9.3	8.0	7.5	7.4	6.5	6.6	6.4	6.1	5.9	5.7	5.7	5.7	5.6	5.8
9.9	9.3	8.0	7.7	7.4	6.3	6.6	6.3	6.2	6.2	6.1	6.0	5.9	5.8	5.4
9.9	8.7	8.7	8.2	7.2	6.7	6.6	6.5	6.3	6.4	6.1	5.6	5.5	5.7	5.7
10.8	9.4	8.9	7.9	7.1	7.0	6.4	6.3	6.0	6.1	6.1	6.0	5.8	5.4	5.9
10.3	8.9	8.3	7.8	7.4	7.0	6.3	7.0	6.4	6.1	5.9	5.8	6.0	5.5	5.9
10.7	9.3	8.8	7.8	7.2	7.2	6.9	6.9	6.0	6.1	6.1	5.8	5.9	6.0	6.1
11.1	10.0	9.1	8.2	7.5	7.3	7.1	6.6	6.2	6.1	6.0	6.0	5.9	6.1	5.9
11.0	10.0	8.9	8.4	8.0	7.5	7.0	6.8	7.2	6.2	5.9	6.2	5.8	6.0	5.8
11.4	10.6	9.2	8.4	7.7	7.3	7.0	6.5	6.7	6.4	6.5	6.6	6.0	6.1	5.9
11.4	10.5	9.8	9.0	8.0	7.5	7.0	6.9	6.7	6.7	6.4	5.8	5.9	6.2	6.0
12.5	11.5	9.8	9.0	8.5	7.9	7.3	7.0	7.1	6.8	6.5	6.3	6.2	6.0	5.6
12.8	11.8	10.5	9.1	8.7	8.2	7.5	7.1	7.2	6.7	6.4	6.5	6.3	6.2	6.4
13.5	11.8	10.6	9.6	8.7	8.3	8.0	7.4	7.2	7.0	6.6	6.5	6.6	6.9	6.4
14.1	13.0	11.2	10.0	9.5	8.6	8.4	7.7	7.3	7.4	7.0	6.7	7.0	6.9	6.3
13.2	13.7	12.2	10.4	10.0	9.4	8.4	8.3	7.7	7.6	6.9	6.7	7.1	6.4	6.9
12.0	14.0	12.9	11.4	10.1	9.5	8.5	8.1	7.7	7.7	7.4	7.2	7.4	6.7	6.7
7.7	13.1	13.5	12.3	10.6	10.0	9.2	8.7	8.4	8.5	7.8	7.1	7.3	7.2	7.1
4.8	12.5	14.2	12.6	11.7	10.7	9.8	8.8	8.7	8.4	8.0	7.8	7.6	7.3	7.1
2.2	7.5	13.8	13.8	13.1	11.1	10.5	9.7	9.6	8.8	8.1	8.1	8.0	7.9	7.3
1.0	2.5	11.0	14.0	13.1	12.4	11.8	10.4	10.0	9.3	8.9	8.6	8.2	8.6	8.0
.2	1.7	4.7	12.5	13.6	13.3	12.0	10.6	10.4	9.8	9.3	9.3	8.9	8.8	8.5
.3	1.5	1.0	8.2	13.4	14.4	12.6	12.1	11.5	10.4	9.5	9.3	9.2	8.9	8.9
-1.4	1.1	.7	2.7	9.2	13.6	14.3	13.1	11.8	11.3	11.4	10.7	9.8	9.5	9.1
-.5	.2	-.2	.4	4.3	9.0	13.6	14.1	13.3	12.4	11.9	11.2	10.5	10.5	10.3
-1.2	-.2	.9	-.6	.3	4.4	8.4	13.7	14.8	13.3	13.1	13.2	11.8	11.3	11.2
-.8	-1.1	-.6	-1.2	-.7	1.1	3.6	7.0	13.3	14.6	14.7	14.1	12.9	12.1	12.7
-.2	-.6	.0	-.4	-1.4	-1.0	.1	2.4	4.0	10.9	14.1	14.0	14.4	13.4	13.8
-.4	-1.0	-.5	-.0	-1.3	-.5	.2	.6	.9	.9	6.5	11.5	13.7	14.0	14.2
-.3	-1.6	-.7	-.6	-1.3	-1.3	-1.0	-.6	-.2	.3	-.2	2.3	6.0	8.2	11.1
-.7	-2.2	-1.1	-1.0	-1.1	-2.2	-1.9	-1.4	-1.3	-1.2	-1.1	-2.0	-1.2	.9	1.4
-.6	-2.0	-1.1	-1.4	-1.5	-2.8	-2.4	-2.2	-2.1	-1.8	-1.7	-2.3	-3.6	-3.4	-2.2

-1.7	-2.6	-2.6	-1.7	-2.2	-3.4	-3.6	-2.3	-1.7	-1.8	-2.1	-2.2	-2.4	-2.8	-1.5
1.6	2.5	2.5	1.6	1.4	.9	-1.2	-2.0	-1.1	-1.2	-1.3	-1.4	-1.9	-2.2	-1.1
12.6	12.5	12.5	12.6	11.1	8.2	6.0	2.3	-.2	.3	-.2	-.6	-1.0	-1.3	-1.3
14.2	13.9	13.9	14.2	14.2	14.0	13.7	11.5	6.5	.9	.9	.6	.2	-.5	-1.3
12.9	13.3	13.3	12.9	13.8	13.4	14.4	14.0	14.1	10.9	4.0	2.4	.1	-1.0	-1.4
11.9	11.6	11.6	11.9	12.7	12.1	12.9	14.1	14.7	14.6	13.3	7.0	3.6	1.1	-.7
11.0	11.4	11.4	11.0	11.2	11.3	11.8	13.2	13.1	13.3	14.8	13.7	8.4	4.4	.3
10.1	10.3	10.3	10.1	10.3	10.5	10.5	11.2	11.9	12.4	13.3	14.1	13.6	9.0	4.3
9.1	9.0	9.0	9.1	9.1	9.5	9.8	10.7	11.4	11.3	11.8	13.1	14.3	13.6	9.2
8.9	8.8	8.8	8.9	8.9	8.9	9.2	9.3	9.5	10.4	11.5	12.1	12.6	14.4	13.4
8.2	8.2	8.2	8.2	8.5	8.8	8.9	9.3	9.3	9.8	10.4	10.6	12.0	13.3	13.6
7.8	7.8	7.8	7.8	8.0	8.6	8.2	8.6	8.9	9.3	10.0	10.4	11.8	12.4	13.1
7.8	7.5	7.5	7.8	7.3	7.9	8.0	8.1	8.1	8.8	9.6	9.7	10.5	11.1	13.1
7.5	7.3	7.3	7.5	7.1	7.3	7.6	7.8	8.0	8.4	8.7	8.8	9.8	10.7	11.7
6.7	7.2	7.2	6.7	7.1	7.2	7.3	7.1	7.8	8.5	8.4	8.7	9.2	10.0	10.6
6.6	7.0	7.0	6.6	6.7	6.7	7.4	7.2	7.4	7.7	7.7	8.1	8.5	9.5	10.1
6.8	6.4	6.4	6.8	6.9	6.4	7.1	6.7	6.9	7.6	7.7	8.3	8.4	9.4	10.0
6.3	6.3	6.3	6.3	6.3	6.9	7.0	6.7	7.0	7.4	7.3	7.7	8.4	8.6	9.5
6.2	6.5	6.5	6.2	6.4	6.9	6.6	6.5	6.6	7.0	7.2	7.4	8.0	8.3	8.7
6.3	6.0	6.0	6.3	6.4	6.2	6.3	6.5	6.4	6.7	7.2	7.1	7.5	8.2	8.7
5.8	5.9	5.9	5.8	5.6	6.0	6.2	6.3	6.5	6.8	7.1	7.0	7.3	7.9	8.5
6.0	6.2	6.2	6.0	6.0	6.2	5.9	5.8	6.4	6.7	6.7	6.9	7.0	7.5	8.0
6.0	5.9	5.9	6.0	5.9	6.1	6.0	6.6	6.5	6.4	6.7	6.5	7.0	7.3	7.7
5.9	5.7	5.7	5.9	5.8	6.0	5.8	6.2	5.9	6.2	7.2	6.8	7.0	7.5	8.0
5.6	5.6	5.6	5.6	5.9	6.1	5.9	6.0	6.0	6.1	6.2	6.6	7.1	7.3	7.5
5.6	5.7	5.7	5.6	6.1	6.0	5.9	5.8	6.1	6.1	6.0	6.9	6.9	7.2	7.2
5.6	5.5	5.5	5.6	5.9	5.5	6.0	5.8	5.9	6.1	6.4	7.0	6.3	7.0	7.4
5.6	5.6	5.6	5.6	5.9	5.4	5.8	6.0	6.1	6.1	6.0	6.3	6.4	7.0	7.1
5.5	5.8	5.8	5.5	5.7	5.7	5.5	5.6	6.1	6.4	6.3	6.5	6.6	6.7	7.2
5.8	5.6	5.6	5.8	5.4	5.8	5.9	6.0	6.1	6.2	6.2	6.3	6.6	6.3	7.4
6.0	5.4	5.4	6.0	5.8	5.6	5.7	5.7	5.7	5.9	6.1	6.4	6.6	6.5	7.4
5.3	5.4	5.4	5.3	5.5	5.9	5.7	5.6	5.8	5.8	6.0	6.3	6.8	6.5	7.1
5.3	5.4	5.4	5.3	5.5	5.9	5.7	5.6	5.8	5.8	6.0	6.3	6.8	6.5	7.1
6.0	5.4	5.4	6.0	5.8	5.6	5.7	5.7	5.7	5.9	6.1	6.4	6.6	6.5	7.4
5.8	5.6	5.6	5.8	5.4	5.8	5.9	6.0	6.1	6.2	6.2	6.3	6.6	6.3	7.4
5.5	5.8	5.8	5.5	5.7	5.7	5.5	5.6	6.1	6.4	6.3	6.5	6.6	6.7	7.2
5.6	5.6	5.6	5.6	5.9	5.4	5.8	6.0	6.1	6.1	6.0	6.3	6.4	7.0	7.1
5.6	5.5	5.5	5.6	5.9	5.5	6.0	5.8	5.9	6.1	6.4	7.0	6.3	7.0	7.4
5.6	5.7	5.7	5.6	6.1	6.0	5.9	5.8	6.1	6.1	6.0	6.9	6.9	7.2	7.2
5.6	5.6	5.6	5.6	5.9	6.1	5.9	6.0	6.0	6.1	6.2	6.6	7.1	7.3	7.5
5.9	5.7	5.7	5.9	5.8	6.0	5.8	6.2	5.9	6.2	7.2	6.8	7.0	7.5	8.0
6.0	5.9	5.9	6.0	5.9	6.1	6.0	6.6	6.5	6.4	6.7	6.5	7.0	7.3	7.7
6.0	6.2	6.2	6.0	6.0	6.2	5.9	5.8	6.4	6.7	6.7	6.9	7.0	7.5	8.0
5.8	5.9	5.9	5.8	5.6	6.0	6.2	6.3	6.5	6.8	7.1	7.0	7.3	7.9	8.5
6.3	6.0	6.0	6.3	6.4	6.2	6.3	6.5	6.4	6.7	7.2	7.1	7.5	8.2	8.7
6.2	6.5	6.5	6.2	6.4	6.9	6.6	6.5	6.6	7.0	7.2	7.4	8.0	8.3	8.7
6.3	6.3	6.3	6.3	6.3	6.9	7.0	6.7	7.0	7.4	7.3	7.7	8.4	8.6	9.5
6.8	6.4	6.4	6.8	6.9	6.4	7.1	6.7	6.9	7.6	7.7	8.3	8.4	9.4	10.0
6.6	7.0	7.0	6.6	6.7	6.7	7.4	7.2	7.4	7.7	7.7	8.1	8.5	9.5	10.1
6.7	7.2	7.2	6.7	7.1	7.2	7.3	7.1	7.8	8.5	8.4	8.7	9.2	10.0	10.6
7.5	7.3	7.3	7.5	7.1	7.3	7.6	7.8	8.0	8.4	8.7	8.8	9.8	10.7	11.7
7.8	7.5	7.5	7.8	7.3	7.9	8.0	8.1	8.1	8.8	9.6	9.7	10.5	11.1	13.1
7.8	7.8	7.8	7.8	8.0	8.6	8.2	8.6	8.9	9.3	10.0	10.4	11.8	12.4	13.1
8.2	8.2	8.2	8.2	8.5	8.8	8.9	9.3	9.3	9.8	10.4	10.6	12.0	13.3	13.6
8.9	8.8	8.8	8.9	8.9	8.9	9.2	9.3	9.5	10.4	11.5	12.1	12.6	14.4	13.4
9.1	9.0	9.0	9.1	9.1	9.5	9.8	10.7	11.4	11.3	11.8	13.1	14.3	13.6	9.2
10.1	10.3	10.3	10.1	10.3	10.5	10.5	11.2	11.9	12.4	13.3	14.1	13.6	9.0	4.3
11.0	11.4	11.4	11.0	11.2	11.3	11.8	13.2	13.1	13.3	14.8	13.7	8.4	4.4	.3
11.9	11.6	11.6	11.9	12.7	12.1	12.9	14.1	14.7	14.6	13.3	7.0	3.6	1.1	-.7
12.9	13.3	13.3	12.9	13.8	13.4	14.4	14.0	14.1	10.9	4.0	2.4	.1	-1.0	-1.4
14.2	13.9	13.9	14.2	14.2	14.0	13.7	11.5	6.5	.9	.9	.6	.2	-.5	-1.3
12.6	12.5	12.5	12.6	11.1	8.2	6.0	2.3	-.2	.3	-.2	-.6	-1.0	-1.3	-1.3
1.6	2.5	2.5	1.6	1.4	.9	-1.2	-2.0	-1.1	-1.2	-1.3	-1.4	-1.9	-2.2	-1.1
-1.7	-2.6	-2.6	-1.7	-2.2	-3.4	-3.6	-2.3	-1.7	-1.8	-2.1	-2.2	-2.4	-2.8	-1.5

-1.4	-1.1	-2.0	-.6	-1.3	-.7	-.0	-1.0	.1	.4	-.8	.2	.6	-1.0	.1
-1.0	-1.1	-2.2	-.7	-1.3	-1.0	-.1	-1.3	-.4	-.2	-1.1	-.2	-.2	-1.2	-.4
-.6	-.7	-1.6	-.3	-.5	-.4	.5	-.8	.3	.3	-.5	.6	.1	-.4	.5
-.0	-.5	-1.0	-.4	-.0	-.4	.2	-.8	.1	-.2	-.8	.4	-.6	-.6	.3
-.4	.0	-.6	-.2	.1	-.6	.4	-.7	.5	.2	.1	1.1	-.5	.0	.7
-1.2	-.6	-1.1	-.8	-.1	-.4	.7	-.3	.6	.1	-.0	.7	-1.1	-.0	.7
-.6	.9	-.2	-1.2	-.2	-1.2	.0	-.6	.7	.0	.2	.8	-.5	.5	.9
.4	-.2	.2	-.5	.8	-.5	.5	-.5	.3	-1.0	-.1	.2	-.4	.7	1.2
2.7	.7	1.1	-1.4	.1	-.3	1.1	.0	.8	-.2	.4	-.3	-.8	.1	.5
8.2	1.0	1.5	.3	.5	-.8	.2	-.2	1.4	-.2	.7	-.3	.2	1.2	.7
12.5	4.7	1.7	.2	.6	.7	.6	-.6	.3	-.6	1.2	.0	.8	.9	.2
14.0	11.0	2.5	1.0	.6	.2	1.1	.5	.8	-.7	.3	-.8	.8	1.4	.7
13.8	13.8	7.5	2.2	-.2	.5	.8	.1	1.2	.3	.8	-.7	.1	.6	.1
12.6	14.2	12.5	4.8	.2	.6	.8	.5	.6	.6	.8	.0	1.0	.7	-.5
12.3	13.5	13.1	7.7	2.1	.5	.9	.2	1.2	.4	.1	.7	1.4	.6	1.0
11.4	12.9	14.0	12.0	4.2	1.8	.5	.6	.1	1.1	-.1	.3	1.4	.8	1.4
10.4	12.2	13.7	13.2	6.2	2.7	1.8	-.0	.9	.5	-.3	1.1	1.0	.4	1.5
10.0	11.2	13.0	14.1	9.6	3.7	1.8	1.2	-.1	1.1	-.5	.9	1.4	.7	.4
9.6	10.6	11.8	13.5	12.3	4.7	2.6	1.3	.9	-.0	.5	1.0	.4	1.6	.4
9.1	10.5	11.8	12.8	13.0	6.9	2.9	1.7	1.0	.7	-.2	1.5	.6	.7	-.0
9.0	9.8	11.5	12.5	13.8	9.2	3.4	2.1	1.3	.9	.9	.4	.8	.9	-.4
9.0	9.8	10.5	11.4	13.4	11.0	4.3	2.7	1.5	.3	1.5	1.1	.4	.0	1.1
8.4	9.2	10.6	11.4	13.3	12.1	5.5	2.5	1.3	.9	1.3	1.3	1.1	-.9	1.3
8.4	8.9	10.0	11.0	12.9	13.2	7.3	2.6	1.6	.8	1.8	.8	.8	.7	.6
8.2	9.1	10.0	11.1	13.1	13.9	8.4	3.0	1.3	1.0	1.9	1.4	.2	1.2	1.4
7.8	8.8	9.3	10.7	12.2	13.8	10.0	2.8	.9	1.6	1.5	1.3	.4	1.6	.6
7.8	8.3	8.9	10.3	11.4	13.8	11.2	3.8	1.4	1.6	1.7	.5	1.0	1.7	.6
7.9	8.9	9.4	10.8	11.6	13.5	12.0	4.7	1.1	1.9	1.6	-.0	1.6	.8	1.1
8.2	8.7	8.7	9.9	11.4	13.0	12.7	5.7	.7	2.2	.8	.8	1.4	.7	1.2
7.7	8.0	9.3	9.9	11.4	12.7	12.6	5.0	1.6	2.3	.2	1.6	.7	1.2	1.9
7.5	8.0	9.3	9.6	10.7	13.3	14.1	4.2	2.9	1.2	.7	1.5	.9	1.4	1.3
7.8	8.0	8.7	10.2	11.3	13.0	13.7	4.1	3.5	.4	1.4	.8	1.5	1.2	.8
7.8	8.0	8.7	10.2	11.3	13.0	13.7	4.1	3.5	.4	1.4	.8	1.5	1.2	.8
7.5	8.0	9.3	9.6	10.7	13.3	14.1	4.2	2.9	1.2	.7	1.5	.9	1.4	1.3
7.7	8.0	9.3	9.9	11.4	12.7	12.6	5.0	1.6	2.3	.2	1.6	.7	1.2	1.9
8.2	8.7	8.7	9.9	11.4	13.0	12.7	5.7	.7	2.2	.8	.8	1.4	.7	1.2
7.9	8.9	9.4	10.8	11.6	13.5	12.0	4.7	1.1	1.9	1.6	-.0	1.6	.8	1.1
7.8	8.3	8.9	10.3	11.4	13.8	11.2	3.8	1.4	1.6	1.7	.5	1.0	1.7	.6
7.8	8.8	9.3	10.7	12.2	13.8	10.0	2.8	.9	1.6	1.5	1.3	.4	1.6	.6
8.2	9.1	10.0	11.1	13.1	13.9	8.4	3.0	1.3	1.0	1.9	1.4	.2	1.2	1.4
8.4	8.9	10.0	11.0	12.9	13.2	7.3	2.6	1.6	.8	1.8	.8	.8	.7	.6
8.4	9.2	10.6	11.4	13.3	12.1	5.5	2.5	1.3	.9	1.3	1.3	1.1	-.9	1.3
9.0	9.8	10.5	11.4	13.4	11.0	4.3	2.7	1.5	.3	1.5	1.1	.4	.0	1.1
9.0	9.8	11.5	12.5	13.8	9.2	3.4	2.1	1.3	.9	.9	.4	.8	.9	-.4
9.1	10.5	11.8	12.8	13.0	6.9	2.9	1.7	1.0	.7	-.2	1.5	.6	.7	-.0
9.6	10.6	11.8	13.5	12.3	4.7	2.6	1.3	.9	-.0	.5	1.0	.4	1.6	.4
10.0	11.2	13.0	14.1	9.6	3.7	1.8	1.2	-.1	1.1	-.5	.9	1.4	.7	.4
10.4	12.2	13.7	13.2	6.2	2.7	1.8	-.0	.9	.5	-.3	1.1	1.0	.4	1.5
11.4	12.9	14.0	12.0	4.2	1.8	.5	.6	.1	1.1	-.1	.3	1.4	.8	1.4
12.3	13.5	13.1	7.7	2.1	.5	.9	.2	1.2	.4	.1	.7	1.4	.6	1.0
12.6	14.2	12.5	4.8	.2	.6	.8	.5	.6	.6	.8	.0	1.0	.7	-.5
13.8	13.8	7.5	2.2	-.2	.5	.8	.1	1.2	.3	.8	-.7	.1	.6	.1
14.0	11.0	2.5	1.0	.6	.2	1.1	.5	.8	-.7	.3	-.8	.8	1.4	.7
12.5	4.7	1.7	.2	.6	.7	.6	-.6	.3	-.6	1.2	.0	.8	.9	.2
8.2	1.0	1.5	.3	.5	-.8	.2	-.2	1.4	-.2	.7	-.3	.2	1.2	.7
2.7	.7	1.1	-1.4	.1	-.3	1.1	.0	.8	-.2	.4	-.3	-.8	.1	.5
.4	-.2	.2	-.5	.8	-.5	.5	-.5	.3	-1.0	-.1	.2	-.4	.7	1.2
-.6	.9	-.2	-1.2	-.2	-1.2	.0	-.6	.7	.0	.2	.8	-.5	.5	.9
-1.2	-.6	-1.1	-.8	-.1	-.4	.7	-.3	.6	.1	-.0	.7	-1.1	-.0	.7
-.4	.0	-.6	-.2	.1	-.6	.4	-.7	.5	.2	.1	1.1	-.5	.0	.7
-.0	-.5	-1.0	-.4	-.0	-.4	.2	-.8	.1	-.2	-.8	.4	-.6	-.6	.3
-.6	-.7	-1.6	-.3	-.5	-.4	.5	-.8	.3	.3	-.5	.6	.1	-.4	.5
-1.0	-1.1	-2.2	-.7	-1.3	-1.0	-.1	-1.3	-.4	-.2	-1.1	-.2	-.2	-1.2	-.4
-1.4	-1.1	-2.0	-.6	-1.3	-.7	-.0	-1.0	.1	.4	-.8	.2	.6	-1.0	.1

1.0	1.2	.2	.5
.3	.3	-.8	.0
1.1	.7	.3	1.1
.7	.1	.2	1.0
.9	-.3	.4	1.0
.8	.0	1.1	1.4
.4	.1	.8	.4
.4	.7	1.6	.4
-.4	.8	1.5	.1
-.3	.5	.1	-.3
.4	1.8	.3	.7
.8	.9	-.2	1.3
1.2	1.0	.8	1.3
.9	-.1	1.0	2.1
1.0	-.8	.6	1.8
.1	.6	1.5	1.3
.1	.8	1.6	1.7
.1	1.5	2.1	.8
.1	1.4	1.7	1.8
1.4	1.5	.5	1.9
1.3	1.8	1.0	1.4
1.1	.3	1.6	2.8
1.8	-.0	1.3	2.6
.3	1.7	1.6	1.1
-.5	1.3	2.2	1.4
1.2	.7	1.2	2.6
1.4	1.8	.3	2.2
1.8	.8	1.8	1.3
1.4	1.0	1.7	2.4
.6	1.8	1.9	1.7
1.0	1.8	1.6	2.0
1.6	1.0	1.7	2.6
1.6	1.0	1.7	2.6
1.0	1.8	1.6	2.0
.6	1.8	1.9	1.7
1.4	1.0	1.7	2.4
1.8	.8	1.8	1.3
1.4	1.8	.3	2.2
1.2	.7	1.2	2.6
-.5	1.3	2.2	1.4
.3	1.7	1.6	1.1
1.8	-.0	1.3	2.6
1.1	.3	1.6	2.8
1.3	1.8	1.0	1.4
1.4	1.5	.5	1.9
.1	1.4	1.7	1.8
.1	1.5	2.1	.8
.1	.8	1.6	1.7
.1	.6	1.5	1.3
1.0	-.8	.6	1.8
.9	-.1	1.0	2.1
1.2	1.0	.8	1.3
.8	.9	-.2	1.3
.4	1.8	.3	.7
-.3	.5	.1	-.3
-.4	.8	1.5	.1
.4	.7	1.6	.4
.4	.1	.8	.4
.8	.0	1.1	1.4
.9	-.3	.4	1.0
.7	.1	.2	1.0
1.1	.7	.3	1.1
.3	.3	-.8	.0
1.0	1.2	.2	.5

```
EEEEE V   V  AAA  TTTTT U   U
E     V   V A   A   T   U   U
EEE    V V  A   A   T   U   U
E      V V  AAAAA   T   U   U
EEEEE   V   A   A   T    UUU
```

PARAMETERS FOR SUBROUTINE EVATU

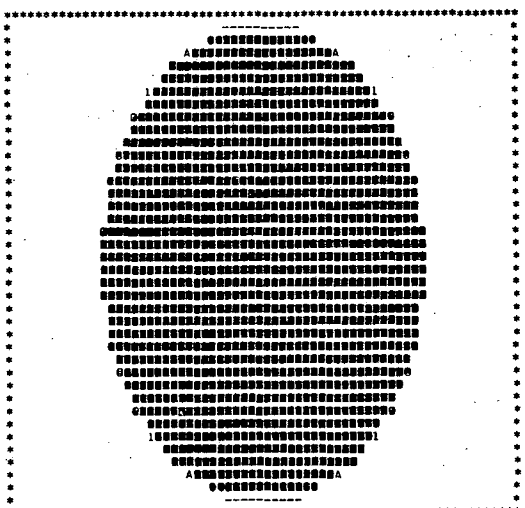
DESCRIPTION

```
XLEV  -    3.500    THE TARGET-TO-NONTARGET RATIO
ATENL -     .075    ATTENUATION COEFFICIENT
```

BLANK COMMON REQUIRED 5322 (12312)

BLANK COMMON REQUIRED 9418 (22312)

XMIN = 0 XMAX = .75E-01 XSUM = .1494E+03



```
     0 .5625E-02  .1388E-01  .1763E-01  .2025E-01  .2325E-01  .2625E-01
                 -          =          +          )          1          Z
Z          X          A          M          B          @          @          @
 .2887E-01  .3075E-01  .3263E-01  .3675E-01  .4088E-01  .4350E-01  .4650E-01
@          @          @          @          ■          ■          ■          ■
 .4913E-01  .5475E-01  .6150E-01  .6525E-01  .6825E-01  .7125E-01  .7388E-01
■
 .7500E-01
```

BLANK COMMON REQUIRED 5322 (12312)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 13714 FLOATING POINT WORDS.

```
EEEEE N   N DDDD        EEEEE V   V  AAA  TTTTT U   U
E     NN  N D   D       E     V   V A   A   T   U   U
EEE   N N N D   D       EEE    V V  A   A   T   U   U
E     N  NN D   D       E      V V  AAAAA   T   U   U
EEEEE N   N DDDD        EEEEE   V   A   A   T    UUU
```

```
 GGG  RRRR   AAA  DDDD  Y   Y
G   G R   R A   A D   D  Y Y
G     RRRR  A   A D   D   Y
G  GG R  R  AAAAA D   D   Y
 GGGG R   R A   A DDDD    Y
```

PARAMETERS FOR SUBROUTINE GRADY

DESCRIPTION

```
ISTP -     15    NUMBER OF ITERATION STEPS
IRLX -      1    ITERATIVE RELAXATION METHOD
IERR -      0    DO NOT USE ERROR ARRAY
IZER -      0    INITIAL SOLUTION IS ZERO
```

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	UNIFORM SQUARE	YES	NO
PRJ	PROJECTION	UNIFORM SQUARE	YES	NO

BLANK COMMON REQUIRED 5506 (12602)

BLANK COMMON REQUIRED 9602 (22602)

BLANK COMMON REQUIRED 13698 (32602)

BLANK COMMON REQUIRED 17794 (42602)

BLANK COMMON REQUIRED 17810 (42622)

BLANK COMMON REQUIRED 17794 (42602)

FOR CONGR AND GRADY FCN IS THE VALUE OF THE CHI-SQUARE
FOR ENTPY FCN IS EVALUATED BY THE SUBROUTINE DULFC

```
ITER  0    FCN    .484E+09
ITER  1    FCN    .596E+08
ITER  2    FCN    .186E+08
ITER  3    FCN    .115E+08
ITER  4    FCN    .758E+07
ITER  5    FCN    .528E+07
ITER  6    FCN    .385E+07
ITER  7    FCN    .295E+07
ITER  8    FCN    .234E+07
ITER  9    FCN    .192E+07
ITER 10    FCN    .162E+07
ITER 11    FCN    .139E+07
ITER 12    FCN    .122E+07
ITER 13    FCN    .108E+07
ITER 14    FCN    .967E+06
ITER 15    FCN    .876E+06
```

BLANK COMMON REQUIRED 17610 (42312)

BLANK COMMON REQUIRED 13514 (32312)

BLANK COMMON REQUIRED 9418 (22312)

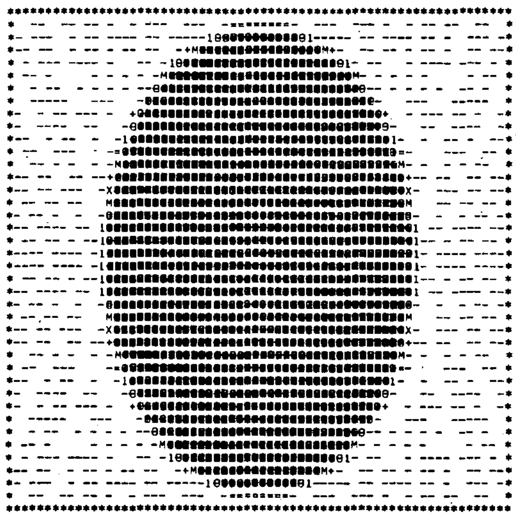
BLANK COMMON REQUIRED 5322 (12312)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 17810 FLOATING POINT WORDS.

```
EEEEE N   N DDDD         GGG  RRRR   AAA  DDDD  Y   Y
E     NN  N D   D       G   G R   R A   A D   D  Y Y
EEE   N N N D   D       G     RRRR  A   A D   D   Y
E     N  NN D   D       G  GG R  R  AAAAA D   D   Y
EEEEE N   N DDDD         GGGG R   R A   A DDDD    Y
```

RECONSTRUCTION FOR THE EMISSION SCAN CORRECTED FOR ATTENUATION

XMIN = -.30E+01 XMAX = .36E+02 XSUM = .5996E+05



-.2975E+01 -.5850E-01 .4219E+01 .6164E+01 .7525E+01 .9080E+01 .1064E+02

.1200E+02 .1297E+02 .1394E+02 .1608E+02 .1822E+02 .1958E+02 .2114E+02

.2230E+02 .2541E+02 .2891E+02 .3086E+02 .3241E+02 .3397E+02 .3533E+02

.3591E+02

.7	-.6	.5	.5	.4	-1.0	-.5	-.2	.2	.6	.6	-.3	-1.8	-2.1	-1.2
.2	-1.1	.2	.6	.4	-.8	-.4	.1	.1	.1	-.1	-1.5	.4	2.9	2.2
.4	-.7	.3	.6	-.2	-.4	-.2	.2	.5	.8	-.5	3.8	12.6	17.0	21.3
.4	-.2	.5	1.0	-.3	.6	.7	.9	.9	.2	12.3	21.9	28.2	29.8	29.9
.6	.2	1.4	.6	-1.0	-1.3	-1.1	2.7	7.8	20.6	28.3	29.8	31.8	30.9	31.8
-.5	-1.1	-.1	-.9	.4	1.4	3.8	12.2	26.7	30.5	32.3	32.1	31.7	30.5	32.4
-.9	.1	1.7	-.5	1.5	9.7	16.2	27.5	32.2	30.8	32.5	33.6	31.8	31.4	31.5
-.4	-.1	-.9	-.2	9.4	20.3	29.5	31.7	32.0	31.7	31.9	31.3	31.0	31.9	32.2
-2.3	.5	-1.2	2.0	17.9	30.1	32.4	32.2	31.2	31.5	33.0	32.6	31.3	30.3	29.7
-.4	.8	-.7	14.3	27.1	32.7	31.5	32.5	33.0	31.5	30.2	30.2	30.8	31.2	31.2
-1.5	-.3	8.8	25.1	30.3	33.4	31.8	31.0	32.1	31.4	32.5	33.0	31.9	32.2	32.1
-1.0	.7	20.6	29.6	30.7	32.5	34.1	32.1	33.1	32.0	31.6	31.4	31.1	32.0	30.9
1.8	13.2	27.5	31.9	34.2	31.7	32.1	31.9	32.9	31.5	31.8	30.9	31.7	32.1	29.2
8.9	26.3	31.2	30.6	32.7	32.6	32.3	31.5	32.3	31.9	32.4	31.4	31.5	30.7	29.9
15.0	28.1	32.4	33.0	31.3	32.8	31.9	31.9	32.4	33.5	32.4	29.6	31.4	30.3	31.2
22.2	30.4	32.5	32.3	31.9	32.1	31.2	31.5	30.8	31.8	31.3	29.7	32.6	29.5	30.6
26.4	32.2	32.5	31.4	33.4	33.4	31.3	33.4	32.1	32.5	31.7	29.7	32.8	29.6	31.6
30.6	32.1	32.2	31.5	33.0	32.3	32.2	31.4	31.7	31.9	31.2	29.7	31.9	31.1	29.0
31.6	31.7	32.3	32.4	31.9	33.0	33.1	31.4	33.2	31.6	31.0	30.9	31.4	33.4	30.8
31.4	33.3	33.3	31.9	32.5	32.7	31.7	31.0	33.1	31.7	30.0	31.5	30.7	29.9	30.7
32.2	33.4	32.4	32.4	32.5	32.3	31.3	31.3	32.8	31.7	30.8	30.9	30.5	28.6	28.5
31.4	32.7	33.6	33.2	32.4	32.4	31.2	31.7	32.7	32.5	32.2	29.3	30.1	31.9	30.3
31.7	33.6	33.1	32.3	32.2	32.2	31.0	31.1	33.0	31.1	32.7	31.8	29.7	30.9	30.1
31.7	32.9	33.0	32.3	32.6	32.8	31.5	31.8	35.9	30.2	30.2	30.7	29.3	31.1	30.0
32.7	33.3	34.3	32.7	32.1	32.6	32.1	32.0	31.0	30.2	31.0	31.0	30.8	31.9	29.4
32.9	32.4	33.6	31.8	31.4	32.3	31.3	34.6	30.9	30.7	31.4	29.5	31.3	31.0	33.3
32.8	31.3	33.1	32.5	32.7	32.0	29.7	34.3	32.4	31.6	30.2	29.2	30.9	29.3	30.1
34.5	33.1	35.0	32.9	31.6	32.4	30.9	32.3	31.7	31.7	31.8	32.1	31.2	27.9	32.0
32.6	31.2	34.2	34.7	31.5	30.1	31.5	32.4	33.0	32.2	32.7	29.4	28.8	29.7	30.4
32.7	33.8	32.2	33.4	33.2	29.6	31.8	32.8	32.0	31.3	31.6	29.7	31.9	29.6	28.2
31.9	34.2	32.9	32.6	33.6	29.7	32.6	32.9	31.5	31.4	30.7	30.5	29.2	29.8	29.6
34.0	31.9	32.5	34.0	31.7	29.9	33.6	32.5	32.1	30.0	31.8	28.8	31.9	32.2	29.4
34.0	31.9	32.5	34.0	31.7	29.9	33.6	32.5	32.1	30.0	31.8	28.8	31.9	32.2	29.4
31.9	34.2	32.9	32.6	33.6	29.7	32.6	32.9	31.5	31.4	30.7	30.5	29.2	29.8	29.6
32.7	33.8	32.2	33.4	33.2	29.6	31.8	32.8	32.0	31.3	31.6	29.7	31.9	29.6	28.2
32.6	31.2	34.2	34.7	31.5	30.1	31.5	32.4	33.0	32.2	32.7	29.4	28.8	29.7	30.4
34.5	33.1	35.0	32.9	31.6	32.4	30.9	32.3	31.7	31.7	31.8	32.1	31.2	27.9	32.0
32.8	31.3	33.1	32.5	32.7	32.0	29.7	34.3	32.4	31.6	30.2	29.2	30.9	29.3	30.1
32.9	32.4	33.6	31.8	31.4	32.3	31.3	34.6	30.9	30.7	31.4	29.5	31.3	31.0	33.3
32.7	33.3	34.3	32.7	32.1	32.6	32.1	32.0	31.0	30.2	31.0	31.0	30.8	31.9	29.4
31.7	32.9	33.0	32.3	32.6	32.8	31.5	31.8	35.9	30.2	30.2	30.7	29.3	31.1	30.0
31.7	33.6	33.1	32.3	32.2	32.2	31.0	31.1	33.0	31.1	32.7	31.8	29.7	30.9	30.1
31.4	32.7	33.6	33.2	32.4	32.4	31.2	31.7	32.7	32.5	32.2	29.3	30.1	31.9	30.3
32.2	33.4	32.4	32.4	32.5	32.3	31.3	31.3	32.8	31.7	30.8	30.9	30.5	28.6	28.5
31.4	33.3	33.3	31.9	32.5	32.7	31.7	31.0	33.1	31.7	30.0	31.5	30.7	29.9	30.7
31.6	31.7	32.3	32.4	31.9	33.0	33.1	31.4	33.2	31.6	31.0	30.9	31.4	33.4	30.8
30.6	32.1	32.2	31.5	33.0	32.3	32.2	31.4	31.7	31.9	31.2	29.7	31.9	31.1	29.0
26.4	32.2	32.5	31.4	33.4	33.4	31.3	33.4	32.1	32.5	31.7	29.7	32.8	29.6	31.6
22.2	30.4	32.5	32.3	31.9	32.1	31.2	31.5	30.8	31.8	31.3	29.7	32.6	29.5	30.6
15.0	28.1	32.4	33.0	31.3	32.8	31.9	31.9	32.4	33.5	32.4	29.6	31.4	30.3	31.2
8.9	26.3	31.2	30.6	32.7	32.6	32.3	31.5	32.3	31.9	32.4	31.4	31.5	30.7	29.9
1.8	13.2	27.5	31.9	34.2	31.7	32.1	31.9	32.9	31.5	31.8	30.9	31.7	32.1	29.2
-1.0	.7	20.6	29.6	30.7	32.5	34.1	32.1	33.1	32.0	31.6	31.4	31.1	32.0	30.9
-1.5	-.3	8.8	25.1	30.3	33.4	31.8	31.0	32.1	31.4	32.5	33.0	31.9	32.2	32.1
-.4	.8	-.7	14.3	27.1	32.7	31.5	32.5	33.0	31.5	30.2	30.2	30.8	31.2	31.2
-2.3	.5	-1.2	2.0	17.9	30.1	32.4	32.2	31.2	31.5	33.0	32.6	31.3	30.3	29.7
-.4	-.1	-.9	-.2	9.4	20.3	29.5	31.7	32.0	31.7	31.9	31.3	31.0	31.9	32.2
-.9	.1	1.7	-.5	1.5	9.7	16.2	27.5	32.2	30.8	32.5	33.6	31.8	31.4	31.5
-.5	-1.1	-.1	-.9	.4	1.4	3.8	12.2	26.7	30.5	32.3	32.1	31.7	30.5	32.4
.6	.2	1.4	.6	-1.0	-1.3	-1.1	2.7	7.8	20.6	28.3	29.8	31.8	30.9	31.8
.4	-.2	.5	1.0	-.3	.6	.7	.9	.9	.2	12.3	21.9	28.2	29.8	29.9
.4	-.7	.3	.6	-.2	-.4	-.2	.2	.5	.8	-.5	3.8	12.6	17.0	21.3
.2	-1.1	.2	.6	.4	-.8	-.4	.1	.1	.1	-.1	-1.5	.4	2.9	2.2
.7	-.6	.5	.5	.4	-1.0	-.5	-.2	.2	.6	.6	-.3	-1.8	-2.1	-1.2

.3	-.1	1.2	1.0	-.2	-.8	1.2	.3	-.3	1.0	.7	-.3	1.2	.2	.0
-.4	-1.2	.0	.1	-.6	-1.3	.1	-.1	-1.0	.4	-.1	-.9	.8	-.5	-.3
1.3	-.1	.9	1.2	.5	-.3	.7	.9	-.2	.9	.7	-.4	1.3	.1	.2
.6	-.5	-.3	.5	-.1	-1.1	-.6	.3	-1.1	.0	.1	-.7	.8	-.1	.7
.6	-.0	-.6	.8	.7	-.2	-.2	1.3	-.1	.7	.6	-.6	.8	-.3	.7
1.1	.8	-.6	.7	.5	-.6	-1.3	.7	-.3	.4	.8	-.2	1.2	-.1	.1
-.3	.3	-.6	.3	.9	.2	-.5	1.0	.2	.4	.7	-.8	.0	-1.2	-.3
-.2	1.3	.3	.3	1.2	.4	-.8	-.1	-.6	-1.2	.3	-.6	.6	-.3	1.1
-.9	1.0	.1	-1.1	.0	-.5	-1.3	-.4	.1	-.4	.7	-.1	1.2	-.3	-.4
-1.6	-.8	-.3	-1.0	.7	1.0	-.4	-.6	.5	-.1	1.5	-.4	-.2	-1.3	.1
-.4	-.2	1.5	-.3	-.1	.7	.4	.1	1.0	-.9	-.1	-1.1	.3	.7	.0
-.1	-1.4	.3	.2	.4	1.2	.2	-1.4	-.4	-1.0	.4	.2	.7	-.4	-.5
.2	-.1	.7	.8	-.7	.2	-.7	-1.2	.4	.1	1.1	-.7	.4	-.5	-1.7
1.0	-.1	-.9	.3	-1.5	.6	.5	-.5	.8	.1	.2	-.1	-.0	-.8	-1.0
.4	-1.1	-2.0	.7	.3	.2	1.1	.1	-.5	-.2	1.0	-1.1	-.4	-1.9	.0
-.0	.5	-.3	-.8	.8	.3	.9	-.7	-.8	.5	-.9	-.3	-1.6	-.8	2.9
.7	.5	-.2	-.4	1.2	-.4	.8	.6	-.9	-.3	.3	-1.8	-.1	.4	10.4
-.8	1.3	.6	-.9	-.4	-.2	1.1	-.1	-1.4	.1	-1.1	-.0	.5	2.8	17.7
.2	.9	.4	-1.1	-.1	.8	-.2	.3	-.3	-1.2	.2	-.2	1.6	8.2	25.5
-.0	-1.0	.8	.5	-1.0	-.1	-.2	.9	-1.3	-.1	.1	-.3	1.4	13.3	28.5
-.4	-.4	1.0	.4	-1.5	.3	-.3	-.5	-.0	-.2	.4	.5	2.7	17.4	30.8
1.4	.2	-.9	.4	.4	-.7	-.7	.5	.8	-.9	.5	2.1	7.9	23.9	31.4
.9	-.2	-1.4	1.2	.1	-2.1	.3	.8	.2	-.4	-.1	1.5	11.5	27.4	32.2
-.8	.6	.4	-.7	-.2	-.3	.3	-.2	1.1	-1.0	-.6	.4	14.2	29.1	32.6
-.7	1.2	.1	-1.8	.8	.5	-.7	.3	1.3	-.7	-2.1	-.1	15.3	29.8	33.3
.5	-.3	-.4	-.0	-.1	.9	-.8	.7	.5	-.1	-3.0	-1.2	17.2	30.5	32.3
.1	-1.7	1.0	.3	-.5	.7	.0	-.9	.9	-.3	-2.0	2.0	19.9	31.2	30.7
-.5	.5	-.3	1.0	.0	.3	.8	-1.1	.7	.7	-.5	8.3	25.1	32.0	31.8
.9	.3	-.3	.8	.2	-.1	.3	-.1	-.4	1.4	-.4	11.6	29.1	31.8	32.2
-.4	.7	.7	-.8	1.4	.0	-.2	.6	-1.2	1.5	.6	10.3	28.5	31.8	33.0
-.2	.4	.7	-.3	.7	.3	.1	.3	-.4	-.3	2.2	9.0	31.1	34.0	31.5
1.0	-.0	-.1	.9	-.6	.5	.4	-.1	.4	-1.5	2.8	9.1	30.3	32.8	32.8
1.0	-.0	-.1	.9	-.6	.5	.4	-.1	.4	-1.5	2.8	9.1	30.3	32.8	32.8
-.2	.4	.7	-.3	.7	.3	.1	.3	-.4	-.3	2.2	9.0	31.1	34.0	31.5
-.4	.7	.7	-.8	1.4	.0	-.2	.6	-1.2	1.5	.6	10.3	28.5	31.8	33.0
.9	.3	-.3	.8	.2	-.1	.3	-.1	-.4	1.4	-.4	11.6	29.1	31.8	32.2
-.5	.5	-.3	1.0	.0	.3	.8	-1.1	.7	.7	-.5	8.3	25.1	32.0	31.8
.1	-1.7	1.0	.3	-.5	.7	.0	-.9	.9	-.3	-2.0	2.0	19.9	31.2	30.7
.5	-.3	-.4	-.0	-.1	.9	-.8	.7	.5	-.1	-3.0	-1.2	17.2	30.5	32.3
-.7	1.2	.1	-1.8	.8	.5	-.7	.3	1.3	-.7	-2.1	-.1	15.3	29.8	33.3
-.8	.6	.4	-.7	-.2	-.3	.3	-.2	1.1	-1.0	-.6	.4	14.2	29.1	32.6
.9	-.2	-1.4	1.2	.1	-2.1	.3	.8	.2	-.4	-.1	1.5	11.5	27.4	32.2
1.4	.2	-.9	.4	.4	-.7	-.7	.5	.8	-.9	.5	2.1	7.9	23.9	31.4
-.4	-.4	1.0	.4	-1.5	.3	-.3	-.5	-.0	-.2	.4	.5	2.7	17.4	30.8
-.0	-1.0	.8	.5	-1.0	-.1	-.2	.9	-1.3	-.1	.1	-.3	1.4	13.3	28.5
.2	.9	.4	-1.1	-.1	.8	-.2	.3	-.3	-1.2	.2	-.2	1.6	8.2	25.5
-.8	1.3	.6	-.9	-.4	-.2	1.1	-.1	-1.4	.1	-1.1	-.0	.5	2.8	17.7
.7	.5	-.2	-.4	1.2	-.4	.8	.6	-.9	-.3	.3	-1.8	-.1	.4	10.4
-.0	.5	-.3	-.8	.8	.3	.9	-.7	-.8	.5	-.9	-.3	-1.6	-.8	2.9
.4	-1.1	-2.0	.7	.3	.2	1.1	.1	-.5	-.2	1.0	-1.1	-.4	-1.9	.0
1.0	-.1	-.9	.3	-1.5	.6	.5	-.5	.8	.1	.2	-.1	-.0	-.8	-1.0
.2	-.1	.7	.8	-.7	.2	-.7	-1.2	.4	.1	1.1	-.7	.4	-.5	-1.7
-.1	-1.4	.3	.2	.4	1.2	.2	-1.4	-.4	-1.0	.4	.2	.7	-.4	-.5
-.4	-.2	1.5	-.3	-.1	.7	.4	.1	1.0	-.9	-.1	-1.1	.3	.7	.0
-1.6	-.8	-.3	-1.0	.7	1.0	-.4	-.6	.5	-.1	1.5	-.4	-.2	-1.3	.1
-.9	1.0	.1	-1.1	.0	-.5	-1.3	-.4	.1	-.4	.7	-.1	1.2	-.3	-.4
-.2	1.3	.3	.3	1.2	.4	-.8	-.1	-.6	-1.2	.3	-.6	.6	-.3	1.1
-.3	.3	-.6	.3	.9	.2	-.5	1.0	.2	.4	.7	-.8	.0	-1.2	-.3
1.1	.8	-.6	.7	.5	-.6	-1.3	.7	-.3	.4	.8	-.2	1.2	-.1	.1
.6	-.0	-.6	.8	.7	-.2	-.2	1.3	-.1	.7	.6	-.6	.8	-.3	.7
.6	-.5	-.3	.5	-.1	-1.1	-.6	.3	-1.1	.0	.1	-.7	.8	-.1	.7
1.3	-.1	.9	1.2	.5	-.3	.7	.9	-.2	.9	.7	-.4	1.3	.1	.2
-.4	-1.2	.0	.1	-.6	-1.3	.1	-.1	-1.0	.4	-.1	-.9	.8	-.5	-.3
.3	-.1	1.2	1.0	-.2	-.8	1.2	.3	-.3	1.0	.7	-.3	1.2	.2	.0

-1.0	-2.8	-2.8	-1.0	-1.2	-2.1	-1.8	-.3	.6	.6	.2	-.2	-.5	-1.0	.4
2.0	2.9	2.9	2.0	2.2	2.9	.4	-1.5	-.1	.1	.1	.1	-.4	-.8	.4
23.2	22.7	22.7	23.2	21.3	17.0	12.6	3.8	-.5	.8	.5	.2	-.2	-.4	-.2
29.5	29.0	29.0	29.5	29.9	29.8	28.2	21.9	12.3	.2	.9	.9	.7	.6	-.3
30.3	31.1	31.1	30.3	31.8	30.9	31.8	29.8	28.3	20.6	7.8	2.7	-1.1	-1.3	-1.0
30.9	30.2	30.2	30.9	32.4	30.5	31.7	32.1	32.3	30.5	26.7	12.2	3.8	1.4	.4
31.7	33.0	33.0	31.7	31.5	31.4	31.8	33.6	32.5	30.8	32.2	27.5	16.2	9.7	1.5
31.2	32.2	32.2	31.2	32.2	31.9	31.0	31.3	31.9	31.7	32.0	31.7	29.5	20.3	9.4
30.2	29.7	29.7	30.2	29.7	30.3	31.3	32.6	33.0	31.5	31.2	32.2	32.4	30.1	17.9
31.6	31.1	31.1	31.6	31.2	31.2	30.8	30.2	30.2	31.5	33.0	32.5	31.5	32.7	27.1
30.6	31.5	31.5	30.6	32.1	32.2	31.9	33.0	32.5	31.4	32.1	31.0	31.8	33.4	30.3
30.6	30.4	30.4	30.6	30.9	32.0	31.1	31.4	31.6	32.0	33.1	32.1	34.1	32.5	30.7
32.0	30.7	30.7	32.0	29.2	32.1	31.7	30.9	31.8	31.5	32.9	31.9	32.1	31.7	34.2
32.0	30.9	30.9	32.0	29.9	30.7	31.5	31.4	32.4	31.9	32.3	31.5	32.3	32.6	32.7
29.3	31.1	31.1	29.3	31.2	30.3	31.4	29.6	32.4	33.5	32.4	31.9	31.9	32.8	31.3
29.3	31.3	31.3	29.3	30.6	29.5	32.6	29.7	31.3	31.8	30.8	31.5	31.2	32.1	31.9
31.9	29.6	29.6	31.9	31.6	29.6	32.8	29.7	31.7	32.5	32.1	33.4	31.3	33.4	33.4
29.9	29.1	29.1	29.9	29.0	31.1	31.9	29.7	31.2	31.9	31.7	31.4	32.2	32.3	33.0
29.6	31.1	31.1	29.6	30.8	33.4	31.4	30.9	31.0	31.6	33.2	31.4	33.1	33.0	31.9
31.5	29.4	29.4	31.5	30.7	29.9	30.7	31.5	30.0	31.7	33.1	31.0	31.7	32.7	32.5
29.1	29.1	29.1	29.1	28.5	28.6	30.5	30.9	30.8	31.7	32.8	31.3	31.3	32.3	32.5
30.2	31.8	31.8	30.2	30.3	31.9	30.1	29.3	32.2	32.5	32.7	31.7	31.2	32.4	32.4
29.5	30.1	30.1	29.5	30.1	30.9	29.7	31.8	32.7	31.1	33.0	31.1	31.0	32.2	32.2
30.0	29.2	29.2	30.0	30.0	31.1	29.3	30.7	30.2	30.2	35.9	31.8	31.5	32.8	32.6
29.3	28.4	28.4	29.3	29.4	31.9	30.8	31.0	31.0	30.2	31.0	32.0	32.1	32.6	32.1
28.3	29.3	29.3	28.3	33.3	31.0	31.3	29.5	31.4	30.7	30.9	34.6	31.3	32.3	31.4
28.0	28.5	28.5	28.0	30.1	29.3	30.9	29.2	30.2	31.6	32.4	34.3	29.7	32.0	32.7
30.2	28.8	28.8	30.2	32.0	27.9	31.2	32.1	31.8	31.7	31.7	32.3	30.9	32.4	31.6
28.4	30.3	30.3	28.4	30.4	29.7	28.8	29.4	32.7	32.2	33.0	32.4	31.5	30.1	31.5
30.7	29.7	29.7	30.7	28.2	29.6	31.9	29.7	31.6	31.3	32.0	32.8	31.8	29.6	33.2
32.1	26.3	26.3	32.1	29.6	29.8	29.2	30.5	30.7	31.4	31.5	32.9	32.6	29.7	33.6
30.0	27.8	27.8	30.0	29.4	32.2	31.9	28.8	31.8	30.0	32.1	32.5	33.6	29.9	31.7
30.0	27.8	27.8	30.0	29.4	32.2	31.9	28.8	31.8	30.0	32.1	32.5	33.6	29.9	31.7
32.1	26.3	26.3	32.1	29.6	29.8	29.2	30.5	30.7	31.4	31.5	32.9	32.6	29.7	33.6
30.7	29.7	29.7	30.7	28.2	29.6	31.9	29.7	31.6	31.3	32.0	32.8	31.8	29.6	33.2
28.4	30.3	30.3	28.4	30.4	29.7	28.8	29.4	32.7	32.2	33.0	32.4	31.5	30.1	31.5
30.2	28.8	28.8	30.2	32.0	27.9	31.2	32.1	31.8	31.7	31.7	32.3	30.9	32.4	31.6
28.0	28.5	28.5	28.0	30.1	29.3	30.9	29.2	30.2	31.6	32.4	34.3	29.7	32.0	32.7
28.3	29.3	29.3	28.3	33.3	31.0	31.3	29.5	31.4	30.7	30.9	34.6	31.3	32.3	31.4
29.3	28.4	28.4	29.3	29.4	31.9	30.8	31.0	31.0	30.2	31.0	32.0	32.1	32.6	32.1
30.0	29.2	29.2	30.0	30.0	31.1	29.3	30.7	30.2	30.2	35.9	31.8	31.5	32.8	32.6
29.5	30.1	30.1	29.5	30.1	30.9	29.7	31.8	32.7	31.1	33.0	31.1	31.0	32.2	32.2
30.2	31.8	31.8	30.2	30.3	31.9	30.1	29.3	32.2	32.5	32.7	31.7	31.2	32.4	32.4
29.1	29.1	29.1	29.1	28.5	28.6	30.5	30.9	30.8	31.7	32.8	31.3	31.3	32.3	32.5
31.5	29.4	29.4	31.5	30.7	29.9	30.7	31.5	30.0	31.7	33.1	31.0	31.7	32.7	32.5
29.6	31.1	31.1	29.6	30.8	33.4	31.4	30.9	31.0	31.6	33.2	31.4	33.1	33.0	31.9
29.9	29.1	29.1	29.9	29.0	31.1	31.9	29.7	31.2	31.9	31.7	31.4	32.2	32.3	33.0
31.9	29.6	29.6	31.9	31.6	29.6	32.8	29.7	31.7	32.5	32.1	33.4	31.3	33.4	33.4
29.3	31.3	31.3	29.3	30.6	29.5	32.6	29.7	31.3	31.8	30.8	31.5	31.2	32.1	31.9
29.3	31.1	31.1	29.3	31.2	30.3	31.4	29.6	32.4	33.5	32.4	31.9	31.9	32.8	31.3
32.0	30.9	30.9	32.0	29.9	30.7	31.5	31.4	32.4	31.9	32.3	31.5	32.3	32.6	32.7
32.0	30.7	30.7	32.0	29.2	32.1	31.7	30.9	31.8	31.5	32.9	31.9	32.1	31.7	34.2
30.6	30.4	30.4	30.6	30.9	32.0	31.1	31.4	31.6	32.0	33.1	32.1	34.1	32.5	30.7
30.6	31.5	31.5	30.6	32.1	32.2	31.9	33.0	32.5	31.4	32.1	31.0	31.8	33.4	30.3
31.6	31.1	31.1	31.6	31.2	31.2	30.8	30.2	30.2	31.5	33.0	32.5	31.5	32.7	27.1
30.2	29.7	29.7	30.2	29.7	30.3	31.3	32.6	33.0	31.5	31.2	32.2	32.4	30.1	17.9
31.2	32.2	32.2	31.2	32.2	31.9	31.0	31.3	31.9	31.7	32.0	31.7	29.5	20.3	9.4
31.7	33.0	33.0	31.7	31.5	31.4	31.8	33.6	32.5	30.8	32.2	27.5	16.2	9.7	1.5
30.9	30.2	30.2	30.9	32.4	30.5	31.7	32.1	32.3	30.5	26.7	12.2	3.8	1.4	.4
30.3	31.1	31.1	30.3	31.8	30.9	31.8	29.8	28.3	20.6	7.8	2.7	-1.1	-1.3	-1.0
29.5	29.0	29.0	29.5	29.9	29.8	28.2	21.9	12.3	.2	.9	.9	.7	.6	-.3
23.2	22.7	22.7	23.2	21.3	17.0	12.6	3.8	-.5	.8	.5	.2	-.2	-.4	-.2
2.0	2.9	2.9	2.0	2.2	2.9	.4	-1.5	-.1	.1	.1	.1	-.4	-.8	.4
-1.0	-2.8	-2.8	-1.0	-1.2	-2.1	-1.8	-.3	.6	.6	.2	-.2	-.5	-1.0	.4

.5	.5	-.6	.7	.0	.2	1.2	-.3	.7	1.0	-.3	.3	1.2	-.8	-.2
.6	.2	-1.1	.2	-.3	-.5	.8	-.9	-.1	.4	-1.0	-.1	.1	-1.3	-.6
.6	.3	-.7	.4	.2	.1	1.3	-.4	.7	.9	-.2	.9	.7	-.3	.5
1.0	.5	-.2	.4	.7	-.1	.8	-.7	.1	.0	-1.1	.3	-.6	-1.1	-.1
.6	1.4	.2	.6	.7	-.3	.8	-.6	.6	.7	-.1	1.3	-.2	-.2	.7
-.9	-.1	-1.1	-.5	.1	-.1	1.2	-.2	.8	.4	-.3	.7	-1.3	-.6	.5
-.5	1.7	.1	-.9	-.3	-1.2	.0	-.8	.7	.4	.2	1.0	-.5	.2	.9
-.2	-.9	-.1	-.4	1.1	-.3	.6	-.6	.3	-1.2	-.6	-.1	-.8	.4	1.2
2.0	-1.2	.5	-2.3	-.4	-.3	1.2	-.1	.7	-.4	.1	-.4	-1.3	-.5	.0
14.3	-.7	.8	-.4	.1	-1.3	-.2	-.4	1.5	-.1	.5	-.6	-.4	1.0	.7
25.1	8.8	-.3	-1.5	.0	.7	.3	-1.1	-.1	-.9	1.0	.1	.4	.7	-.1
29.6	20.6	.7	-1.0	-.5	-.4	.7	.2	.4	-1.0	-.4	-1.4	.2	1.2	.4
31.9	27.5	13.2	1.8	-1.7	-.5	.4	-.7	1.1	.1	.4	-1.2	-.7	.2	-.7
30.6	31.2	26.3	8.9	-1.0	-.8	-.0	-.1	.2	.1	.8	-.5	.5	.6	-1.5
33.0	32.4	28.1	15.0	.0	-1.9	-.4	-1.1	1.0	-.2	-.5	.1	1.1	.2	.3
32.3	32.5	30.4	22.2	2.9	-.8	-1.6	-.3	-.9	.5	-.8	-.7	.9	.3	.8
31.4	32.5	32.2	26.4	10.4	.4	-.1	-1.8	.3	-.3	-.9	.6	.8	-.4	1.2
31.5	32.2	32.1	30.6	17.7	2.8	.5	-.0	-1.1	.1	-1.4	-.1	1.1	-.2	-.4
32.4	32.3	31.7	31.6	25.5	8.2	1.6	-.2	.2	-1.2	-.3	.3	-.2	.8	-.1
31.9	33.3	33.3	31.4	28.5	13.3	1.4	-.3	.1	-.1	-1.3	.9	-.2	-.1	-1.0
32.4	32.4	33.4	32.2	30.8	17.4	2.7	.5	.4	-.2	-.0	-.5	-.3	.3	-1.5
33.2	33.6	32.7	31.4	31.4	23.9	7.9	2.1	.5	-.9	.8	.5	-.7	-.7	.4
32.3	33.1	33.6	31.7	32.2	27.4	11.5	1.5	-.1	-.4	.2	.8	.3	-2.1	.1
32.3	33.0	32.9	31.7	32.6	29.1	14.2	.4	-.6	-1.0	1.1	-.2	.3	-.3	-.2
32.7	34.3	33.3	32.7	33.3	29.8	15.3	-.1	-2.1	-.7	1.3	.3	-.7	.5	.8
31.8	33.6	32.4	32.9	32.3	30.5	17.2	-1.2	-3.0	-.1	.5	.7	-.8	.9	-.1
32.5	33.1	31.3	32.8	30.7	31.2	19.9	2.0	-2.0	-.3	.9	-.9	.0	.7	-.5
32.9	35.0	33.1	34.5	31.8	32.0	25.1	8.3	-.5	.7	.7	-1.1	.8	.3	.0
34.7	34.2	31.2	32.6	32.2	31.8	29.1	11.6	-.4	1.4	-.4	-.1	.3	-.1	.2
33.4	32.2	33.8	32.7	33.0	31.8	28.5	10.3	.6	1.5	-1.2	.6	-.2	.0	1.4
32.6	32.9	34.2	31.9	31.5	34.0	31.1	9.0	2.2	-.3	-.4	.3	.1	.3	.7
34.0	32.5	31.9	34.0	32.8	32.8	30.3	9.1	2.8	-1.5	.4	-.1	.4	.5	-.6
34.0	32.5	31.9	34.0	32.8	32.8	30.3	9.1	2.8	-1.5	.4	-.1	.4	.5	-.6
32.6	32.9	34.2	31.9	31.5	34.0	31.1	9.0	2.2	-.3	-.4	.3	.1	.3	.7
33.4	32.2	33.8	32.7	33.0	31.8	28.5	10.3	.6	1.5	-1.2	.6	-.2	.0	1.4
34.7	34.2	31.2	32.6	32.2	31.8	29.1	11.6	-.4	1.4	-.4	-.1	.3	-.1	.2
32.9	35.0	33.1	34.5	31.8	32.0	25.1	8.3	-.5	.7	.7	-1.1	.8	.3	.0
32.5	33.1	31.3	32.8	30.7	31.2	19.9	2.0	-2.0	-.3	.9	-.9	.0	.7	-.5
31.8	33.6	32.4	32.9	32.3	30.5	17.2	-1.2	-3.0	-.1	.5	.7	-.8	.9	-.1
32.7	34.3	33.3	32.7	33.3	29.8	15.3	-.1	-2.1	-.7	1.3	.3	-.7	.5	.8
32.3	33.0	32.9	31.7	32.6	29.1	14.2	.4	-.6	-1.0	1.1	-.2	.3	-.3	-.2
32.3	33.1	33.6	31.7	32.2	27.4	11.5	1.5	-.1	-.4	.2	.8	.3	-2.1	.1
33.2	33.6	32.7	31.4	31.4	23.9	7.9	2.1	.5	-.9	.8	.5	-.7	-.7	.4
32.4	32.4	33.4	32.2	30.8	17.4	2.7	.5	.4	-.2	-.0	-.5	-.3	.3	-1.5
31.9	33.3	33.3	31.4	28.5	13.3	1.4	-.3	.1	-.1	-1.3	.9	-.2	-.1	-1.0
32.4	32.3	31.7	31.6	25.5	8.2	1.6	-.2	.2	-1.2	-.3	.3	-.2	.8	-.1
31.5	32.2	32.1	30.6	17.7	2.8	.5	-.0	-1.1	.1	-1.4	-.1	1.1	-.2	-.4
31.4	32.5	32.2	26.4	10.4	.4	-.1	-1.8	.3	-.3	-.9	.6	.8	-.4	1.2
32.3	32.5	30.4	22.2	2.9	-.8	-1.6	-.3	-.9	.5	-.8	-.7	.9	.3	.8
33.0	32.4	28.1	15.0	.0	-1.9	-.4	-1.1	1.0	-.2	-.5	.1	1.1	.2	.3
30.6	31.2	26.3	8.9	-1.0	-.8	-.0	-.1	.2	.1	.8	-.5	.5	.6	-1.5
31.9	27.5	13.2	1.8	-1.7	-.5	.4	-.7	1.1	.1	.4	-1.2	-.7	.2	-.7
29.6	20.6	.7	-1.0	-.5	-.4	.7	.2	.4	-1.0	-.4	-1.4	.2	1.2	.4
25.1	8.8	-.3	-1.5	.0	.7	.3	-1.1	-.1	-.9	1.0	.1	.4	.7	-.1
14.3	-.7	.8	-.4	.1	-1.3	-.2	-.4	1.5	-.1	.5	-.6	-.4	1.0	.7
2.0	-1.2	.5	-2.3	-.4	-.3	1.2	-.1	.7	-.4	.1	-.4	-1.3	-.5	.0
-.2	-.9	-.1	-.4	1.1	-.3	.6	-.6	.3	-1.2	-.6	-.1	-.8	.4	1.2
-.5	1.7	.1	-.9	-.3	-1.2	.0	-.8	.7	.4	.2	1.0	-.5	.2	.9
-.9	-.1	-1.1	-.5	.1	-.1	1.2	-.2	.8	.4	-.3	.7	-1.3	-.6	.5
.6	1.4	.2	.6	.7	-.3	.8	-.6	.6	.7	-.1	1.3	-.2	-.2	.7
1.0	.5	-.2	.4	.7	-.1	.8	-.7	.1	.0	-1.1	.3	-.6	-1.1	-.1
.6	.3	-.7	.4	.2	.1	1.3	-.4	.7	.9	-.2	.9	.7	-.3	.5
.6	.2	-1.1	.2	-.3	-.5	.8	-.9	-.1	.4	-1.0	-.1	.1	-1.3	-.6
.5	.5	-.6	.7	.0	.2	1.2	-.3	.7	1.0	-.3	.3	1.2	-.8	-.2

1.0	1.2	-.1	.3
.1	.0	-1.2	-.4
1.2	.9	-.1	1.3
.5	-.3	-.5	.6
.8	-.6	-.0	.6
.7	-.6	.8	1.1
.3	-.6	.3	-.3
.3	.3	1.3	-.2
-1.1	.1	1.0	-.9
-1.0	-.3	-.8	-1.6
-.3	1.5	-.2	-.4
.2	.3	-1.4	-.1
.8	.7	-.1	.2
.3	-.9	-.1	1.0
.7	-2.0	-1.1	.4
-.8	-.3	.5	-.0
-.4	-.2	.5	.7
-.9	.6	1.3	-.8
-1.1	.4	.9	.2
.5	.8	-1.0	-.0
.4	1.0	-.4	-.4
.4	-.9	.2	1.4
1.2	-1.4	-.2	.9
-.7	.4	.6	-.8
-1.8	.1	1.2	-.7
-.0	-.4	-.3	.5
.3	1.0	-1.7	.1
1.0	-.3	.5	-.5
.8	-.3	.3	.9
-.8	.7	.7	-.4
-.3	.7	.4	-.2
.9	-.1	-.0	1.0
.9	-.1	-.0	1.0
-.3	.7	.4	-.2
-.8	.7	.7	-.4
.8	-.3	.3	.9
1.0	-.3	.5	-.5
.3	1.0	-1.7	.1
-.0	-.4	-.3	.5
-1.8	.1	1.2	-.7
-.7	.4	.6	-.8
1.2	-1.4	-.2	.9
.4	-.9	.2	1.4
.4	1.0	-.4	-.4
.5	.8	-1.0	-.0
-1.1	.4	.9	.2
-.9	.6	1.3	-.8
-.4	-.2	.5	.7
-.8	-.3	.5	-.0
.7	-2.0	-1.1	.4
.3	-.9	-.1	1.0
.8	.7	-.1	.2
.2	.3	-1.4	-.1
-.3	1.5	-.2	-.4
-1.0	-.3	-.8	-1.6
-1.1	.1	1.0	-.9
.3	.3	1.3	-.2
.3	-.6	.3	-.3
.7	-.6	.8	1.1
.8	-.6	-.0	.6
.5	-.3	-.5	.6
1.2	.9	-.1	1.3
.1	.0	-1.2	-.4
1.0	1.2	-.1	.3

Example 12 uses the same program ATENUX as Example 11 to reconstruct simulated projection data for a phantom with a circular annulus and a central circular source, which is attenuated by a circular attenuator. This example was also reconstructed in Example 10, where the distribution of attenuation coefficients was determined by a transmission study.

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      SUBROUTINE GETUM (M,DATA,ERR)                                     E12.128
C                                                                       E12.129
C        EXAMPLE 12                                                     E12.130
C                                                                       E12.131
C           THE SUBROUTINE GETUM GIVES SIMULATED PROJECTION DATA FOR    E12.132
C        A PHANTOM WITH A CIRCULAR ANNULUS AND A CENTRAL CIRCULAR SOURCE E12.133
C        WHICH IS ATTENUATED BY A CIRCULAR ATTENUATOR.                  E12.134
C                                                                       E12.135
      DIMENSION DATA(1),ERR(1)                                          E12.136
      DIMENSION ITYPE(4),Z(4),X1(4),Y1(4),A1(4),B1(4),PI(4)             E12.137
      DATA ITYPE/-1,1,1,1/                                              E12.138
      DATA Z/.075,30.,-30.,30./                                         E12.139
      DATA X1/0.,0.,0.,0./                                              E12.140
      DATA Y1/0.,0.,0.,0./                                              E12.141
      DATA A1/60.,60.,40.,20./                                          E12.142
      DATA B1/60.,60.,40.,20./                                          E12.143
      DATA PHI/0.,0.,0.,0./                                             E12.144
C                                                                       E12.145
      CALL PHANL (4,ITYPE,Z,X1,Y1,A1,B1,PHI,DATA,M)                     E12.146
C                                                                       E12.147
      RETURN                                                            E12.148
C                                                                       E12.149
      END                                                               E12.150
```

```
           SSS  EEEEE TTTTT U   U PPPP
          S     E       T   U   U P   P
           SSS  EEE     T   U   U PPPP
              S E       T   U   U P
           SSS  EEEEE   T    UUU  P
```

```
            INTEGER PARAMETER ARRAY  (IPAR)

  I    IPAR(I)      DESCRIPTION

  1        64       LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
  2         1       RECONSTRUCT IN A SQUARE ARRAY
  3         0       GEOMETRY FLAG
                    PARALLEL BEAM GEOMETRY
  4        72       NUMBER OF PROJECTION ANGLES
  5         5       MODE FOR PROJECTION ANGLE INPUT  (SEE FOLLOWING LINES)
                    ANGLES GENERATED BETWEEN ZERO AND 2*PI
                    STARTING AT ZERO
  6       100       NUMBER OF RAYS FOR EACH PROJECTION
  7         0       EMISSION DATA
  8     18000       DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
  9         1       NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
 10         0       EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
 11         5       PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES)
                    PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED
                    PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
 12         3       LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE


            FLOATING POINT PARAMETER ARRAY  (PAR)

  I     PAR(I)      DESCRIPTION

  1      1.000      PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
  2     50.500      LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
  3          0  NA  NOT APPLICABLE  (NOT FAN BEAM GEOMETRY)
```

```
BLANK COMMON REQUIRED        72    (   110)

BLANK COMMON REQUIRED       144    (   220)

BLANK COMMON REQUIRED       216    (   330)

BLANK COMMON REQUIRED       416    (   640)

BLANK COMMON REQUIRED       544    (  1040)

A TOTAL OF  92 (  5 THRU  96) OF THE 100 USER PROJECTION BINS WILL BE USED

 92 PROJECTION BINS WILL BE USED OF WHICH   0 HAVE BEEN ZEROED BY THE PROGRAM

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=    544 FLOATING POINT WORDS.


    EEEEE N    N DDDD         SSS  EEEEE TTTTT U    U PPPP
    E     NN   N D   D       S     E       T   U    U P   P
    EEE   N N  N D   D        SSS  EEE     T   U    U PPPP
    E     N  NN  D   D           S E       T   U    U P
    EEEEE N    N DDDD         SSS  EEEEE   T    UUU   P


              GGG  RRRR   AAA  DDDD  Y   Y
             G   G R   R A   A D   D  Y Y
             G     RRRR  A   A D   D   Y
             G  GG R  R  AAAAA D   D   Y
              GGGG R   R A   A DDDD    Y


          PARAMETERS FOR SUBROUTINE GRADY

                   DESCRIPTION

ISTP -      15     NUMBER OF ITERATION STEPS
IRLX -       1     ITERATIVE RELAXATION METHOD
IERR -       0     DO NOT USE ERROR ARRAY
IZER -       0     INITIAL SOLUTION IS ZERO

BLANK COMMON REQUIRED       616    (  1150)

BLANK COMMON REQUIRED      1226    (  2312)

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG    FUNCTION          RAY WEIGHTING        ATTENUATION          FAN BEAM
BCK    BACKPROJECTION    UNIFORM SQUARE           NO                  NO
PRJ    PROJECTION        UNIFORM SQUARE           NO                  NO

BLANK COMMON REQUIRED      1410    (  2602)

BLANK COMMON REQUIRED      5506    ( 12602)

BLANK COMMON REQUIRED      9602    ( 22602)

BLANK COMMON REQUIRED     13698    ( 32602)

BLANK COMMON REQUIRED     13730    ( 32642)

BLANK COMMON REQUIRED     13698    ( 32602)

FOR CONGR AND GRADY FCN IS THE VALUE OF THE CHI-SQUARE
FOR ENTPY FCN IS EVALUATED BY THE SUBROUTINE DULFC
ITER  0     FCN     .392E+09
ITER  1     FCN     .360E+08
ITER  2     FCN     .102E+08
ITER  3     FCN     .678E+07
ITER  4     FCN     .497E+07
ITER  5     FCN     .390E+07
ITER  6     FCN     .315E+07
ITER  7     FCN     .262E+07
ITER  8     FCN     .223E+07
ITER  9     FCN     .192E+07
ITER 10     FCN     .168E+07
ITER 11     FCN     .149E+07
ITER 12     FCN     .133E+07
ITER 13     FCN     .120E+07
ITER 14     FCN     .109E+07
ITER 15     FCN     .991E+06

BLANK COMMON REQUIRED     13514    ( 32312)

BLANK COMMON REQUIRED      9418    ( 22312)

BLANK COMMON REQUIRED      5322    ( 12312)

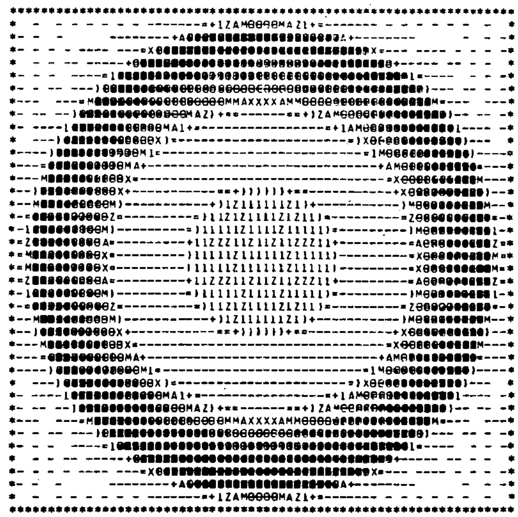
BLANK COMMON REQUIRED      1226    (  2312)

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=  13730 FLOATING POINT WORDS.


    EEEEE N    N DDDD         GGG  RRRR   AAA  DDDD  Y   Y
    E     NN   N D   D       G   G R   R A   A D   D  Y Y
    EEE   N N  N D   D       G     RRRR  A   A D   D   Y
    E     N  NN  D   D       G  GG R  R  AAAAA D   D   Y
    EEEEE N    N DDDD         GGGG R   R A   A DDDD    Y
```

```
THE APPROXIMATED RECONSTRUCTION FOR AN EMISSION SCAN

XMIN =   -.13E+01      XMAX =    .14E+02      XSUM =    .1794E+05
```



```
                 -            =            +            )            1            Z
-.1282E+01 -.1431E+00  .1527E+01  .2287E+01  .2818E+01  .3426E+01  .4033E+01

Z          X          A          M          B          @          @          @
 .4565E+01  .4945E+01  .5324E+01  .6160E+01  .6995E+01  .7526E+01  .8134E+01

@          @          @          @          @          @          @          @
 .8665E+01  .9804E+01  .1117E+02  .1193E+02  .1254E+02  .1315E+02  .1368E+02

@
 .1391E+02
```

.1	-.5	.9	.2	-.1	.6	-.3	.7	.1	.2	.2	.4	.2	.1	.2
-.5	-1.3	-.0	-.7	-.8	-.1	-1.0	.1	-.6	-.0	-.9	.1	-.9	-.0	-.6
.9	-.0	1.1	.3	.3	.6	.0	.5	-.2	.6	-.1	.6	-.1	-.1	.2
.2	-.7	.3	-.5	-.3	-.3	-.4	-.5	-.7	-.6	-.5	-.4	.1	-.1	.2
-.1	-.8	.3	-.3	-.0	-.1	.5	.1	.7	-.2	.1	-.4	-.5	.1	.2
.6	-.1	.6	-.3	-.1	-.9	-.2	-1.1	.0	-.1	-.1	.4	-.0	.2	.6
-.3	-1.0	.0	-.4	.5	-.2	.9	-.1	-.4	-.1	-.2	.1	.4	1.2	2.3
.7	.1	.5	-.5	.1	-1.1	-.1	.1	-.2	.4	.3	.8	1.3	3.8	9.5
.1	-.6	-.2	-.7	.7	.0	-.4	-.2	-.0	.1	.7	1.9	4.5	11.3	13.7
.2	-.0	.6	-.6	-.2	-.1	-.1	.4	.1	.8	1.9	6.0	12.1	13.6	13.0
.2	-.9	-.1	-.5	.1	-.1	-.2	.3	.7	1.9	5.8	12.2	13.1	12.7	12.0
.4	.1	.6	-.4	-.4	.4	.1	.8	1.9	6.0	12.2	13.7	12.7	11.4	10.9
.2	-.9	-.1	.1	-.5	-.0	.4	1.3	4.5	12.1	13.1	12.7	11.6	10.7	10.2
.1	-.0	-.1	-.1	.1	.2	1.2	3.8	11.3	13.6	12.7	11.4	10.7	9.9	9.1
.2	-.6	.2	.2	.2	.6	2.3	9.5	13.7	13.0	12.0	10.9	10.2	9.1	7.9
-.3	-.1	-.4	.1	.5	1.6	6.7	12.7	13.2	11.9	10.9	9.8	9.1	8.5	7.9
-.1	-.4	.4	.0	1.0	3.4	11.6	12.9	12.7	11.2	10.3	9.1	9.0	8.5	7.0
.3	-.2	.1	.4	2.0	8.7	13.3	13.1	11.6	10.4	9.5	8.5	8.1	7.7	7.3
-.0	.1	.2	1.2	4.1	12.4	12.8	12.2	10.8	9.9	8.9	8.2	7.9	7.1	[illegible]
.3	.1	.4	1.8	8.3	13.3	12.6	11.5	10.1	9.5	8.2	7.7	7.8	7.0	[illegible]
-.4	.5	.8	3.3	12.2	13.5	12.3	10.7	9.7	9.1	8.4	7.8	7.0	6.6	[illegible]
.3	.4	1.4	6.3	13.1	12.9	11.2	10.0	9.4	8.2	8.0	7.7	6.8	6.1	4.4
.1	.7	2.5	10.0	13.9	12.7	10.9	9.7	8.9	8.4	7.4	7.1	6.4	5.3	2.9
.7	1.2	3.5	11.9	12.4	11.9	10.8	9.4	8.5	8.1	7.4	7.0	6.4	4.3	2.0
.9	1.2	5.5	13.1	12.7	11.5	10.0	9.2	8.3	7.5	7.1	6.6	5.7	3.2	1.6
1.0	1.8	8.4	13.4	12.5	11.6	10.1	8.9	8.5	7.1	6.9	6.5	4.8	2.3	1.0
1.1	2.3	10.4	13.7	11.7	11.2	10.3	8.6	8.3	7.1	7.2	6.2	4.0	1.7	.7
1.1	3.1	11.2	13.7	12.1	10.7	9.3	8.3	7.7	7.2	6.8	5.9	3.3	1.4	.6
1.4	3.9	12.1	12.8	11.4	9.8	9.3	8.5	7.6	7.0	6.8	5.8	2.8	1.0	.6
1.5	4.3	13.2	13.0	11.7	10.7	9.1	8.4	7.4	7.1	6.5	5.2	2.2	.9	.5
1.7	5.2	13.5	12.9	11.2	9.9	9.1	8.3	7.4	7.1	6.3	4.9	2.3	.9	.5
1.9	5.5	12.7	12.7	11.5	9.8	9.4	8.5	7.3	7.0	6.4	4.8	2.0	.9	.7
1.9	5.5	12.7	12.7	11.5	9.8	9.4	8.5	7.3	7.0	6.4	4.8	2.0	.9	.7
1.7	5.2	13.5	12.9	11.2	9.9	9.1	8.3	7.4	7.1	6.3	4.9	2.3	.9	.5
1.5	4.3	13.2	13.0	11.7	10.7	9.1	8.4	7.4	7.1	6.5	5.2	2.2	.9	.5
1.4	3.9	12.1	12.8	11.4	9.8	9.3	8.5	7.6	7.0	6.8	5.8	2.8	1.0	.6
1.1	3.1	11.2	13.7	12.1	10.7	9.3	8.3	7.7	7.2	6.8	5.9	3.3	1.4	.6
1.1	2.3	10.4	13.7	11.7	11.2	10.3	8.6	8.3	7.1	7.2	6.2	4.0	1.7	.7
1.0	1.8	8.4	13.4	12.5	11.6	10.1	8.9	8.5	7.1	6.9	6.5	4.8	2.3	1.0
.9	1.2	5.5	13.1	12.7	11.5	10.0	9.2	8.3	7.5	7.1	6.6	5.7	3.2	1.6
.7	1.2	3.5	11.9	12.4	11.9	10.8	9.4	8.5	8.1	7.4	7.0	6.4	4.3	2.0
.1	.7	2.5	10.0	13.9	12.7	10.9	9.7	8.9	8.4	7.4	7.1	6.4	5.3	2.9
.3	.4	1.4	6.3	13.1	12.9	11.2	10.0	9.4	8.2	8.0	7.7	6.8	6.1	4.4
-.4	.5	.8	3.3	12.2	13.5	12.3	10.7	9.7	9.1	8.4	7.8	7.0	6.6	5.8
.3	.1	.4	1.8	8.3	13.3	12.6	11.5	10.1	9.5	8.2	7.7	7.8	7.0	6.1
-.0	.1	.2	1.2	4.1	12.4	12.8	12.2	10.8	9.9	8.9	8.2	7.9	7.1	6.9
.3	-.2	.1	.4	2.0	8.7	13.3	13.1	11.6	10.4	9.5	8.5	8.1	7.7	7.3
-.1	-.4	.4	.0	1.0	3.4	11.6	12.9	12.7	11.2	10.3	9.1	9.0	8.5	7.0
-.3	-.1	-.4	.1	.5	1.6	6.7	12.7	13.2	11.9	10.9	9.8	9.1	8.5	7.9
.2	-.6	.2	.2	.2	.6	2.3	9.5	13.7	13.0	12.0	10.9	10.2	9.1	7.9
.1	-.0	-.1	-.1	.1	.2	1.2	3.8	11.3	13.6	12.7	11.4	10.7	9.9	9.1
.2	-.9	-.1	.1	-.5	-.0	.4	1.3	4.5	12.1	13.1	12.7	11.6	10.7	10.2
.4	.1	.6	-.4	-.4	.4	.1	.8	1.9	6.0	12.2	13.7	12.7	11.4	10.9
.2	-.9	-.1	-.5	.1	-.1	-.2	.3	.7	1.9	5.8	12.2	13.1	12.7	12.0
.2	-.0	.6	-.6	-.2	-.1	-.1	.4	.1	.8	1.9	6.0	12.1	13.6	13.0
.1	-.6	-.2	-.7	.7	.0	-.4	-.2	-.0	.1	.7	1.9	4.5	11.3	13.7
.7	.1	.5	-.5	.1	-1.1	-.1	.1	-.2	.4	.3	.8	1.3	3.8	9.5
-.3	-1.0	.0	-.4	.5	-.2	.9	-.1	-.4	-.1	-.2	.1	.4	1.2	2.3
.6	-.1	.6	-.3	-.1	-.9	-.2	-1.1	.0	-.1	-.1	.4	-.0	.2	.6
-.1	-.8	.3	-.3	-.0	-.1	.5	.1	.7	-.2	.1	-.4	-.5	.1	.2
.2	-.7	.3	-.5	-.3	-.3	-.4	-.5	-.7	-.6	-.5	-.4	.1	-.1	.2
.9	-.0	1.1	.3	.3	.6	.0	.5	-.2	.6	-.1	.6	-.1	-.1	.2
-.5	-1.3	-.0	-.7	-.8	-.1	-1.0	.1	-.6	-.0	-.9	.1	-.9	-.0	-.6
.1	-.5	.9	.2	-.1	.6	-.3	.7	.1	.2	.2	.4	.2	.1	.2

-.3	-.1	.3	-.0	.3	-.4	.3	.1	.7	.9	1.0	1.1	1.1	1.4	1.5
-.1	-.4	-.2	.1	.1	.5	.4	.7	1.2	1.2	1.8	2.3	3.1	3.9	4.3
-.4	.4	.1	.2	.4	.8	1.4	2.5	3.5	5.5	8.4	10.4	11.2	12.1	13.2
.1	.0	.4	1.2	1.8	3.3	6.3	10.0	11.9	13.1	13.4	13.7	13.7	12.8	13.0
.5	1.0	2.0	4.1	8.3	12.2	13.1	13.9	12.4	12.7	12.5	11.7	12.1	11.4	11.7
1.6	3.4	8.7	12.4	13.3	13.5	12.9	12.7	11.9	11.5	11.6	11.2	10.7	9.8	10.7
6.7	11.6	13.3	12.8	12.6	12.3	11.2	10.9	10.8	10.0	10.1	10.3	9.3	9.3	9.1
12.7	12.9	13.1	12.2	11.5	10.7	10.0	9.7	9.4	9.2	8.9	8.6	8.3	8.5	8.4
13.2	12.7	11.6	10.8	10.1	9.7	9.4	8.9	8.5	8.3	8.5	8.3	7.7	7.6	7.4
11.9	11.2	10.4	9.9	9.5	9.1	8.2	8.4	8.1	7.5	7.1	7.1	7.2	7.0	7.1
10.9	10.3	9.5	8.9	8.2	8.4	8.0	7.4	7.4	7.1	6.9	7.2	6.8	6.8	6.5
9.8	9.1	8.5	8.2	7.7	7.8	7.7	7.1	7.0	6.6	6.5	6.2	5.9	5.8	5.2
9.1	9.0	8.1	7.9	7.8	7.0	6.8	6.4	6.4	5.7	4.8	4.0	3.3	2.8	2.2
8.5	8.5	7.7	7.1	7.0	6.6	6.1	5.3	4.3	3.2	2.3	1.7	1.4	1.0	.9
7.9	7.0	7.3	6.9	6.1	5.8	4.4	2.9	2.0	1.6	1.0	.7	.6	.6	.5
8.2	7.1	6.8	6.2	5.3	3.6	1.9	1.3	1.0	.7	.7	.6	.6	.4	.4
7.1	6.9	6.3	4.8	3.0	1.8	.9	.8	.6	.5	.4	.4	.6	.4	.5
6.8	6.3	4.7	2.5	1.5	.9	.9	.5	.4	.5	.3	.3	.5	.6	.3
6.2	4.8	2.5	1.3	.8	.8	.6	.5	.5	.4	.3	.3	.5	.6	.5
5.3	3.0	1.5	.8	.8	.5	.3	.5	.4	.3	.3	.5	.5	.4	.5
3.6	1.8	.9	.8	.5	.3	.4	.4	.4	.5	.5	.4	.4	.5	.5
1.9	.9	.9	.6	.3	.4	.5	.4	.4	.6	.6	.5	.6	.8	1.0
1.3	.8	.5	.5	.5	.4	.4	.3	.5	.6	.7	1.0	1.4	2.2	2.6
1.0	.6	.4	.5	.4	.4	.4	.5	.6	.6	1.0	2.2	2.9	3.4	3.6
.7	.5	.5	.4	.3	.5	.6	.6	.6	1.2	2.5	3.3	3.7	4.1	4.0
.7	.4	.3	.3	.3	.5	.6	.7	1.0	2.5	3.4	3.6	4.0	4.1	4.2
.6	.4	.3	.3	.5	.4	.5	1.0	2.2	3.3	3.6	3.8	4.1	3.8	4.1
.6	.6	.5	.5	.5	.4	.6	1.4	2.9	3.7	4.0	4.1	4.0	3.8	4.1
.4	.4	.6	.6	.4	.5	.8	2.2	3.4	4.1	4.1	3.8	3.8	4.0	4.0
.4	.5	.3	.5	.5	.5	1.0	2.6	3.6	4.0	4.2	4.1	4.1	4.0	3.8
.5	.5	.3	.4	.6	.6	1.3	3.0	3.8	3.9	3.9	4.0	3.9	3.9	4.0
.6	.3	.3	.4	.5	.7	1.6	3.1	3.7	3.8	3.9	3.9	3.9	4.2	3.9
.6	.3	.3	.4	.5	.7	1.6	3.1	3.7	3.8	3.9	3.9	3.9	4.2	3.9
.5	.5	.3	.4	.6	.6	1.3	3.0	3.8	3.9	3.9	4.0	3.9	3.9	4.0
.4	.5	.3	.5	.5	.5	1.0	2.6	3.6	4.0	4.2	4.1	4.1	4.0	3.8
.4	.4	.6	.6	.4	.5	.8	2.2	3.4	4.1	4.1	3.8	3.8	4.0	4.0
.6	.6	.5	.5	.5	.4	.6	1.4	2.9	3.7	4.0	4.1	4.0	3.8	4.1
.6	.4	.3	.3	.5	.4	.5	1.0	2.2	3.3	3.6	3.8	4.1	3.8	4.1
.7	.4	.3	.3	.3	.5	.6	.7	1.0	2.5	3.4	3.6	4.0	4.1	4.2
.7	.5	.5	.4	.3	.5	.6	.6	.6	1.2	2.5	3.3	3.7	4.1	4.0
1.0	.6	.4	.5	.4	.4	.4	.5	.6	.6	1.0	2.2	2.9	3.4	3.6
1.3	.8	.5	.5	.5	.4	.4	.3	.5	.6	.7	1.0	1.4	2.2	2.6
1.9	.9	.9	.6	.3	.4	.5	.4	.4	.6	.6	.5	.6	.8	1.0
3.6	1.8	.9	.8	.5	.3	.4	.4	.4	.5	.5	.4	.4	.5	.5
5.3	3.0	1.5	.8	.8	.5	.3	.5	.4	.3	.3	.5	.5	.4	.5
6.2	4.8	2.5	1.3	.8	.8	.6	.5	.5	.4	.3	.3	.5	.6	.5
6.8	6.3	4.7	2.5	1.5	.9	.9	.5	.4	.5	.3	.3	.5	.6	.3
7.1	6.9	6.3	4.8	3.0	1.8	.9	.8	.6	.5	.4	.4	.6	.4	.5
8.2	7.1	6.8	6.2	5.3	3.6	1.9	1.3	1.0	.7	.7	.6	.6	.4	.4
7.9	7.0	7.3	6.9	6.1	5.8	4.4	2.9	2.0	1.6	1.0	.7	.6	.6	.5
8.5	8.5	7.7	7.1	7.0	6.6	6.1	5.3	4.3	3.2	2.3	1.7	1.4	1.0	.9
9.1	9.0	8.1	7.9	7.8	7.0	6.8	6.4	6.4	5.7	4.8	4.0	3.3	2.8	2.2
9.8	9.1	8.5	8.2	7.7	7.8	7.7	7.1	7.0	6.6	6.5	6.2	5.9	5.8	5.2
10.9	10.3	9.5	8.9	8.2	8.4	8.0	7.4	7.4	7.1	6.9	7.2	6.8	6.8	6.5
11.9	11.2	10.4	9.9	9.5	9.1	8.2	8.4	8.1	7.5	7.1	7.1	7.2	7.0	7.1
13.2	12.7	11.6	10.8	10.1	9.7	9.4	8.9	8.5	8.3	8.5	8.3	7.7	7.6	7.4
12.7	12.9	13.1	12.2	11.5	10.7	10.0	9.7	9.4	9.2	8.9	8.6	8.3	8.5	8.4
6.7	11.6	13.3	12.8	12.6	12.3	11.2	10.9	10.8	10.0	10.1	10.3	9.3	9.3	9.1
1.6	3.4	8.7	12.4	13.3	13.5	12.9	12.7	11.9	11.5	11.6	11.2	10.7	9.8	10.7
.5	1.0	2.0	4.1	8.3	12.2	13.1	13.9	12.4	12.7	12.5	11.7	12.1	11.4	11.7
.1	.0	.4	1.2	1.8	3.3	6.3	10.0	11.9	13.1	13.4	13.7	13.7	12.8	13.0
-.4	.4	.1	.2	.4	.8	1.4	2.5	3.5	5.5	8.4	10.4	11.2	12.1	13.2
-.1	-.4	-.2	.1	.1	.5	.4	.7	1.2	1.2	1.8	2.3	3.1	3.9	4.3
-.3	-.1	.3	-.0	.3	-.4	.3	.1	.7	.9	1.0	1.1	1.1	1.4	1.5

-.0	.3	-.1	-.3	.2	.1	.2	.4	.2	.2	.1	.7	-.3	.6	-.1
.1	-.2	-.4	-.1	-.6	-.0	-.9	.1	-.9	-.0	-.6	.1	-1.0	-.1	-.8
.2	.1	.4	-.4	.2	-.1	-.1	.6	-.1	.6	-.2	.5	.0	.6	.3
1.2	.4	.0	.1	.2	-.1	.1	-.4	-.5	-.6	-.7	-.5	-.4	-.3	-.3
4.1	2.0	1.0	.5	.2	.1	-.5	-.4	.1	-.2	.7	.1	.5	-.1	-.0
12.4	8.7	3.4	1.6	.6	.2	-.0	.4	-.1	-.1	.0	-1.1	-.2	-.9	-.1
12.8	13.3	11.6	6.7	2.3	1.2	.4	.1	-.2	-.1	-.4	-.1	.9	-.2	.5
12.2	13.1	12.9	12.7	9.5	3.8	1.3	.8	.3	.4	-.2	.1	-.1	-1.1	.1
10.8	11.6	12.7	13.2	13.7	11.3	4.5	1.9	.7	.1	-.0	-.2	-.4	.0	.7
9.9	10.4	11.2	11.9	13.0	13.6	12.1	6.0	1.9	.8	.1	.4	-.1	-.1	-.2
8.9	9.5	10.3	10.9	12.0	12.7	13.1	12.2	5.8	1.9	.7	.3	-.2	-.1	.1
8.2	8.5	9.1	9.8	10.9	11.4	12.7	13.7	12.2	6.0	1.9	.8	.1	.4	-.4
7.9	8.1	9.0	9.1	10.2	10.7	11.6	12.7	13.1	12.1	4.5	1.3	.4	-.0	-.5
7.1	7.7	8.5	8.5	9.1	9.9	10.7	11.4	12.7	13.6	11.3	3.8	1.2	.2	.1
6.9	7.3	7.0	7.9	7.9	9.1	10.2	10.9	12.0	13.0	13.7	9.5	2.3	.6	.2
6.2	6.8	7.1	8.2	7.9	8.5	9.1	9.8	10.9	11.9	13.2	12.7	6.7	1.6	.5
4.8	6.3	6.9	7.1	7.0	8.5	9.0	9.1	10.3	11.2	12.7	12.9	11.6	3.4	1.0
2.5	4.7	6.3	6.8	7.3	7.7	8.1	8.5	9.5	10.4	11.6	13.1	13.3	8.7	2.0
1.3	2.5	4.8	6.2	6.9	7.1	7.9	8.2	8.9	9.9	10.8	12.2	12.8	12.4	4.1
.8	1.5	3.0	5.3	6.1	7.0	7.8	7.7	8.2	9.5	10.1	11.5	12.6	13.3	8.3
.8	.9	1.8	3.6	5.8	6.6	7.0	7.8	8.4	9.1	9.7	10.7	12.3	13.5	12.2
.6	.9	.9	1.9	4.4	6.1	6.8	7.7	8.0	8.2	9.4	10.0	11.2	12.9	13.1
.5	.5	.8	1.3	2.9	5.3	6.4	7.1	7.4	8.4	8.9	9.7	10.9	12.7	13.9
.5	.4	.6	1.0	2.0	4.3	6.4	7.0	7.4	8.1	8.5	9.4	10.8	11.9	12.4
.4	.5	.5	.7	1.6	3.2	5.7	6.6	7.1	7.5	8.3	9.2	10.0	11.5	12.7
.3	.3	.4	.7	1.0	2.3	4.8	6.5	6.9	7.1	8.5	8.9	10.1	11.6	12.5
.3	.3	.4	.6	.7	1.7	4.0	6.2	7.2	7.1	8.3	8.6	10.3	11.2	11.7
.5	.5	.6	.6	.6	1.4	3.3	5.9	6.8	7.2	7.7	8.3	9.3	10.7	12.1
.6	.6	.4	.4	.6	1.0	2.8	5.8	6.8	7.0	7.6	8.5	9.3	9.8	11.4
.5	.3	.5	.4	.5	.9	2.2	5.2	6.5	7.1	7.4	8.4	9.1	10.7	11.7
.4	.3	.5	.5	.5	.9	2.3	4.9	6.3	7.1	7.4	8.3	9.1	9.9	11.2
.4	.3	.3	.6	.7	.9	2.0	4.8	6.4	7.0	7.3	8.5	9.4	9.8	11.5
.4	.3	.3	.6	.7	.9	2.0	4.8	6.4	7.0	7.3	8.5	9.4	9.8	11.5
.4	.3	.5	.5	.5	.9	2.3	4.9	6.3	7.1	7.4	8.3	9.1	9.9	11.2
.5	.3	.5	.4	.5	.9	2.2	5.2	6.5	7.1	7.4	8.4	9.1	10.7	11.7
.6	.6	.4	.4	.6	1.0	2.8	5.8	6.8	7.0	7.6	8.5	9.3	9.8	11.4
.5	.5	.6	.6	.6	1.4	3.3	5.9	6.8	7.2	7.7	8.3	9.3	10.7	12.1
.3	.3	.4	.6	.7	1.7	4.0	6.2	7.2	7.1	8.3	8.6	10.3	11.2	11.7
.3	.3	.4	.7	1.0	2.3	4.8	6.5	6.9	7.1	8.5	8.9	10.1	11.6	12.5
.4	.5	.5	.7	1.6	3.2	5.7	6.6	7.1	7.5	8.3	9.2	10.0	11.5	12.7
.5	.4	.6	1.0	2.0	4.3	6.4	7.0	7.4	8.1	8.5	9.4	10.8	11.9	12.4
.5	.5	.8	1.3	2.9	5.3	6.4	7.1	7.4	8.4	8.9	9.7	10.9	12.7	13.9
.6	.9	.9	1.9	4.4	6.1	6.8	7.7	8.0	8.2	9.4	10.0	11.2	12.9	13.1
.8	.9	1.8	3.6	5.8	6.6	7.0	7.8	8.4	9.1	9.7	10.7	12.3	13.5	12.2
.8	1.5	3.0	5.3	6.1	7.0	7.8	7.7	8.2	9.5	10.1	11.5	12.6	13.3	8.3
1.3	2.5	4.8	6.2	6.9	7.1	7.9	8.2	8.9	9.9	10.8	12.2	12.8	12.4	4.1
2.5	4.7	6.3	6.8	7.3	7.7	8.1	8.5	9.5	10.4	11.6	13.1	13.3	8.7	2.0
4.8	6.3	6.9	7.1	7.0	8.5	9.0	9.1	10.3	11.2	12.7	12.9	11.6	3.4	1.0
6.2	6.8	7.1	8.2	7.9	8.5	9.1	9.8	10.9	11.9	13.2	12.7	6.7	1.6	.5
6.9	7.3	7.0	7.9	7.9	9.1	10.2	10.9	12.0	13.0	13.7	9.5	2.3	.6	.2
7.1	7.7	8.5	8.5	9.1	9.9	10.7	11.4	12.7	13.6	11.3	3.8	1.2	.2	.1
7.9	8.1	9.0	9.1	10.2	10.7	11.6	12.7	13.1	12.1	4.5	1.3	.4	-.0	-.5
8.2	8.5	9.1	9.8	10.9	11.4	12.7	13.7	12.2	6.0	1.9	.8	.1	.4	-.4
8.9	9.5	10.3	10.9	12.0	12.7	13.1	12.2	5.8	1.9	.7	.3	-.2	-.1	.1
9.9	10.4	11.2	11.9	13.0	13.6	12.1	6.0	1.9	.8	.1	.4	-.1	-.1	-.2
10.8	11.6	12.7	13.2	13.7	11.3	4.5	1.9	.7	.1	-.0	-.2	-.4	.0	.7
12.2	13.1	12.9	12.7	9.5	3.8	1.3	.8	.3	.4	-.2	.1	-.1	-1.1	.1
12.8	13.3	11.6	6.7	2.3	1.2	.4	.1	-.2	-.1	-.4	-.1	.9	-.2	.5
12.4	8.7	3.4	1.6	.6	.2	-.0	.4	-.1	-.1	.0	-1.1	-.2	-.9	-.1
4.1	2.0	1.0	.5	.2	.1	-.5	-.4	.1	-.2	.7	.1	.5	-.1	-.0
1.2	.4	.0	.1	.2	-.1	.1	-.4	-.5	-.6	-.7	-.5	-.4	-.3	-.3
.2	.1	.4	-.4	.2	-.1	-.1	.6	-.1	.6	-.2	.5	.0	.6	.3
.1	-.2	-.4	-.1	-.6	-.0	-.9	.1	-.9	-.0	-.6	.1	-1.0	-.1	-.8
-.0	.3	-.1	-.3	.2	.1	.2	.4	.2	.2	.1	.7	-.3	.6	-.1

1.7	1.9	1.9	1.7	1.5	1.4	1.1	1.1	1.0	.9	.7	.1	.3	-.4	.3
5.2	5.5	5.5	5.2	4.3	3.9	3.1	2.3	1.8	1.2	1.2	.7	.4	.5	.1
13.5	12.7	12.7	13.5	13.2	12.1	11.2	10.4	8.4	5.5	3.5	2.5	1.4	.8	.4
12.9	12.7	12.7	12.9	13.0	12.8	13.7	13.7	13.4	13.1	11.5	10.0	6.3	3.3	1.8
11.2	11.5	11.5	11.2	11.7	11.4	12.1	11.7	12.5	12.7	12.4	13.9	13.1	12.2	8.3
9.9	9.8	9.8	9.9	10.7	9.8	10.7	11.2	11.6	11.5	11.9	12.7	12.9	13.5	13.3
9.1	9.4	9.4	9.1	9.1	9.3	9.3	10.3	10.1	10.0	10.8	10.9	11.2	12.3	12.6
8.3	8.5	8.5	8.3	8.4	8.5	8.3	8.6	8.9	9.2	9.4	9.7	10.0	10.7	11.5
7.4	7.3	7.3	7.4	7.4	7.6	7.7	8.3	8.5	8.3	8.5	8.9	9.4	9.7	10.1
7.1	7.0	7.0	7.1	7.1	7.0	7.2	7.1	7.1	7.5	8.1	8.4	8.2	9.1	9.5
6.3	6.4	6.4	6.3	6.5	6.8	6.8	7.2	6.9	7.1	7.4	7.4	8.0	8.4	8.2
4.9	4.8	4.8	4.9	5.2	5.8	5.9	6.2	6.5	6.6	7.0	7.1	7.7	7.8	7.7
2.3	2.0	2.0	2.3	2.2	2.8	3.3	4.0	4.8	5.7	6.4	6.4	6.8	7.0	7.8
.9	.9	.9	.9	.9	1.0	1.4	1.7	2.3	3.2	4.3	5.3	6.1	6.6	7.0
.5	.7	.7	.5	.5	.6	.6	.7	1.0	1.6	2.0	2.9	4.4	5.8	6.1
.5	.6	.6	.5	.4	.4	.6	.6	.7	.7	1.0	1.3	1.9	3.6	5.3
.5	.3	.3	.5	.5	.4	.6	.4	.4	.5	.6	.8	.9	1.8	3.0
.3	.3	.3	.3	.3	.6	.5	.3	.3	.5	.4	.5	.9	.9	1.5
.4	.4	.4	.4	.5	.6	.5	.3	.3	.4	.5	.5	.6	.8	.8
.6	.5	.5	.6	.5	.4	.5	.5	.3	.3	.4	.5	.3	.5	.8
.6	.7	.7	.6	.5	.5	.4	.4	.5	.5	.4	.4	.4	.3	.5
1.3	1.6	1.6	1.3	1.0	.8	.6	.5	.6	.6	.4	.4	.5	.4	.3
3.0	3.1	3.1	3.0	2.6	2.2	1.4	1.0	.7	.6	.5	.3	.4	.4	.5
3.8	3.7	3.7	3.8	3.6	3.4	2.9	2.2	1.0	.6	.6	.5	.4	.4	.4
3.9	3.8	3.8	3.9	4.0	4.1	3.7	3.3	2.5	1.2	.6	.6	.6	.5	.3
3.9	3.9	3.9	3.9	4.2	4.1	4.0	3.6	3.4	2.5	1.0	.7	.6	.5	.3
4.0	3.9	3.9	4.0	4.1	3.8	4.1	3.8	3.6	3.3	2.2	1.0	.5	.4	.5
3.9	3.9	3.9	3.9	4.1	3.8	4.0	4.1	4.0	3.7	2.9	1.4	.6	.4	.5
3.9	4.2	4.2	3.9	4.0	4.0	3.8	3.8	4.1	4.1	3.4	2.2	.8	.5	.4
4.0	3.9	3.9	4.0	3.8	4.0	4.1	4.1	4.2	4.0	3.6	2.6	1.0	.5	.5
4.2	3.7	3.7	4.2	4.0	3.9	3.9	4.0	3.9	3.9	3.8	3.0	1.3	.6	.6
3.7	3.8	3.8	3.7	3.9	4.2	3.9	3.9	3.9	3.8	3.7	3.1	1.6	.7	.5
3.7	3.8	3.8	3.7	3.9	4.2	3.9	3.9	3.9	3.8	3.7	3.1	1.6	.7	.5
4.2	3.7	3.7	4.2	4.0	3.9	3.9	4.0	3.9	3.9	3.8	3.0	1.3	.6	.6
4.0	3.9	3.9	4.0	3.8	4.0	4.1	4.1	4.2	4.0	3.6	2.6	1.0	.5	.5
3.9	4.2	4.2	3.9	4.0	4.0	3.8	3.8	4.1	4.1	3.4	2.2	.8	.5	.4
3.9	3.9	3.9	3.9	4.1	3.8	4.0	4.1	4.0	3.7	2.9	1.4	.6	.4	.5
4.0	3.9	3.9	4.0	4.1	3.8	4.1	3.8	3.6	3.3	2.2	1.0	.5	.4	.5
3.9	3.9	3.9	3.9	4.2	4.1	4.0	3.6	3.4	2.5	1.0	.7	.6	.5	.3
3.9	3.8	3.8	3.9	4.0	4.1	3.7	3.3	2.5	1.2	.6	.6	.6	.5	.3
3.8	3.7	3.7	3.8	3.6	3.4	2.9	2.2	1.0	.6	.6	.5	.4	.4	.4
3.0	3.1	3.1	3.0	2.6	2.2	1.4	1.0	.7	.6	.5	.3	.4	.4	.5
1.3	1.6	1.6	1.3	1.0	.8	.6	.5	.6	.6	.4	.4	.5	.4	.3
.6	.7	.7	.6	.5	.5	.4	.4	.5	.5	.4	.4	.4	.3	.5
.6	.5	.5	.6	.5	.4	.5	.5	.3	.3	.4	.5	.3	.5	.8
.4	.4	.4	.4	.5	.6	.5	.3	.3	.4	.5	.5	.6	.8	.8
.3	.3	.3	.3	.3	.6	.5	.3	.3	.5	.4	.5	.9	.9	1.5
.5	.3	.3	.5	.5	.4	.6	.4	.4	.5	.6	.8	.9	1.8	3.0
.5	.6	.6	.5	.4	.4	.6	.6	.7	.7	1.0	1.3	1.9	3.6	5.3
.5	.7	.7	.5	.5	.6	.6	.7	1.0	1.6	2.0	2.9	4.4	5.8	6.1
.9	.9	.9	.9	.9	1.0	1.4	1.7	2.3	3.2	4.3	5.3	6.1	6.6	7.0
2.3	2.0	2.0	2.3	2.2	2.8	3.3	4.0	4.8	5.7	6.4	6.4	6.8	7.0	7.8
4.9	4.8	4.8	4.9	5.2	5.8	5.9	6.2	6.5	6.6	7.0	7.1	7.7	7.8	7.7
6.3	6.4	6.4	6.3	6.5	6.8	6.8	7.2	6.9	7.1	7.4	7.4	8.0	8.4	8.2
7.1	7.0	7.0	7.1	7.1	7.0	7.2	7.1	7.1	7.5	8.1	8.4	8.2	9.1	9.5
7.4	7.3	7.3	7.4	7.4	7.6	7.7	8.3	8.5	8.3	8.5	8.9	9.4	9.7	10.1
8.3	8.5	8.5	8.3	8.4	8.5	8.3	8.6	8.9	9.2	9.4	9.7	10.0	10.7	11.5
9.1	9.4	9.4	9.1	9.1	9.3	9.3	10.3	10.1	10.0	10.8	10.9	11.2	12.3	12.6
9.9	9.8	9.8	9.9	10.7	9.8	10.7	11.2	11.6	11.5	11.9	12.7	12.9	13.5	13.3
11.2	11.5	11.5	11.2	11.7	11.4	12.1	11.7	12.5	12.7	12.4	13.9	13.1	12.2	8.3
12.9	12.7	12.7	12.9	13.0	12.8	13.7	13.7	13.4	13.1	11.9	10.0	6.3	3.3	1.8
13.5	12.7	12.7	13.5	13.2	12.1	11.2	10.4	8.4	5.5	3.5	2.5	1.4	.8	.4
5.2	5.5	5.5	5.2	4.3	3.9	3.1	2.3	1.8	1.2	1.2	.7	.4	.5	.1
1.7	1.9	1.9	1.7	1.5	1.4	1.1	1.1	1.0	.9	.7	.1	.3	-.4	.3

.2	.9	-.5	.1
-.7	-.0	-1.3	-.5
.3	1.1	-.0	.9
-.5	.3	-.7	.2
-.3	.3	-.8	-.1
-.3	.6	-.1	.6
-.4	.0	-1.0	-.3
-.5	.5	.1	.7
-.7	-.2	-.6	.1
-.6	.6	-.0	.2
-.5	-.1	-.9	.2
-.4	.6	.1	.4
.1	-.1	-.9	.2
-.1	-.1	-.0	.1
.2	.2	-.6	.2
.1	-.4	-.1	-.3
.0	.4	-.4	-.1
.4	.1	-.2	.3
1.2	.2	.1	-.0
1.8	.4	.1	.3
3.3	.8	.5	-.4
6.3	1.4	.4	.3
10.0	2.5	.7	.1
11.9	3.5	1.2	.7
13.1	5.5	1.2	.9
13.4	8.4	1.8	1.0
13.7	10.4	2.3	1.1
13.7	11.2	3.1	1.1
12.8	12.1	3.9	1.4
13.0	13.2	4.3	1.5
12.9	13.5	5.2	1.7
12.7	12.7	5.5	1.9
12.7	12.7	5.5	1.9
12.9	13.5	5.2	1.7
13.0	13.2	4.3	1.5
12.8	12.1	3.9	1.4
13.7	11.2	3.1	1.1
13.7	10.4	2.3	1.1
13.4	8.4	1.8	1.0
13.1	5.5	1.2	.9
11.9	3.5	1.2	.7
10.0	2.5	.7	.1
6.3	1.4	.4	.3
3.3	.8	.5	-.4
1.8	.4	.1	.3
1.2	.2	.1	-.0
.4	.1	-.2	.3
.0	.4	-.4	-.1
.1	-.4	-.1	-.3
.2	.2	-.6	.2
-.1	-.1	-.0	.1
.1	-.1	-.9	.2
-.4	.6	.1	.4
-.5	-.1	-.9	.2
-.6	.6	-.0	.2
-.7	-.2	-.6	.1
-.5	.5	.1	.7
-.4	.0	-1.0	-.3
-.3	.6	-.1	.6
-.3	.3	-.8	-.1
-.5	.3	-.7	.2
.3	1.1	-.0	.9
-.7	-.0	-1.3	-.5
.2	.9	-.5	.1

```
EEEEE V   V  AAA  TTTTT U   U
E     V   V A   A   T   U   U
EEE    V V  A   A   T   U   U
E      V V  AAAAA   T   U   U
EEEEE   V   A   A   T    UUU
```

PARAMETERS FOR SUBROUTINE EVATU

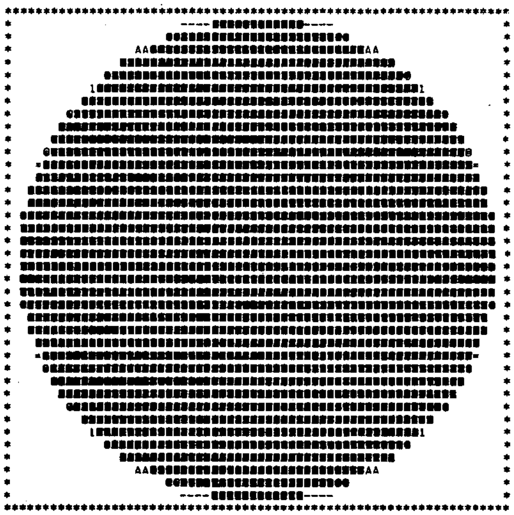
DESCRIPTION

```
XLEV  -   3.500    THE TARGET-TO-NONTARGET RATIO
ATENL -    .075    ATTENUATION COEFFICIENT
```

BLANK COMMON REQUIRED 5322 (12312)

BLANK COMMON REQUIRED 9418 (22312)

XMIN = 0 XMAX = .75E-01 XSUM = .2268E+03



```
              -          =          +          )          1          Z
    0  .5625E-02  .1388E-01  .1763E-01  .2025E-01  .2325E-01  .2625E-01

Z          X          A          M          θ          8          θ          @
.2887E-01  .3075E-01  .3263E-01  .3675E-01  .4088E-01  .4350E-01  .4650E-01

@          @          @          @          @          @          ■          ■
.4913E-01  .5475E-01  .6150E-01  .6525E-01  .6825E-01  .7125E-01  .7388E-01

■
.7500E-01
```

BLANK COMMON REQUIRED 5322 (12312)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 13730 FLOATING POINT WORDS.

```
EEEEE N   N DDDD      EEEEE V   V  AAA  TTTTT U   U
E     NN  N D   D     E     V   V A   A   T   U   U
EEE   N N N D   D     EEE    V V  A   A   T   U   U
E     N  NN D   D     E      V V  AAAAA   T   U   U
EEEEE N   N DDDD      EEEEE   V   A   A   T    UUU

 GGG  RRRR   AAA  DDDD  Y   Y
G     R   R A   A D   D  Y Y
G     RRRR  A   A D   D   Y
G  GG R  R  AAAAA D   D   Y
 GGGG R   R A   A DDDD    Y
```

PARAMETERS FOR SUBROUTINE GRADY

DESCRIPTION

```
ISTP -   15   NUMBER OF ITERATION STEPS
IRLX -    1   ITERATIVE RELAXATION METHOD
IERR -    0   DO NOT USE ERROR ARRAY
IZER -    0   INITIAL SOLUTION IS ZERO
```

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	UNIFORM SQUARE	YES	NO
PRJ	PROJECTION	UNIFORM SQUARE	YES	NO

BLANK COMMON REQUIRED 5506 (12602)

BLANK COMMON REQUIRED 9602 (22602)

BLANK COMMON REQUIRED 13698 (32602)

BLANK COMMON REQUIRED 17794 (42602)

BLANK COMMON REQUIRED 17826 (42642)

BLANK COMMON REQUIRED 17794 (42602)

FOR CONGR AND GRADY FCN IS THE VALUE OF THE CHI-SQUARE
FOR ENTPY FCN IS EVALUATED BY THE SUBROUTINE DULFC

```
ITER  0    FCN   .392E+09
ITER  1    FCN   .609E+08
ITER  2    FCN   .179E+08
ITER  3    FCN   .102E+08
ITER  4    FCN   .648E+07
ITER  5    FCN   .451E+07
ITER  6    FCN   .328E+07
ITER  7    FCN   .250E+07
ITER  8    FCN   .197E+07
ITER  9    FCN   .161E+07
ITER 10    FCN   .135E+07
ITER 11    FCN   .116E+07
ITER 12    FCN   .101E+07
ITER 13    FCN   .893E+06
ITER 14    FCN   .800E+06
ITER 15    FCN   .723E+06
```

BLANK COMMON REQUIRED 17610 (42312)

BLANK COMMON REQUIRED 13514 (32312)

BLANK COMMON REQUIRED 9418 (22312)

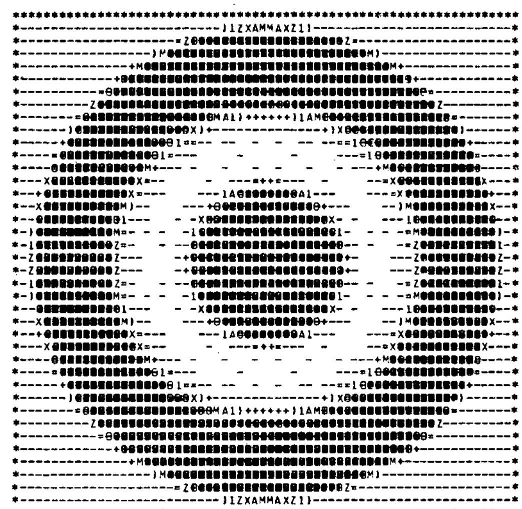
BLANK COMMON REQUIRED 5322 (12312)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 17826 FLOATING POINT WORDS.

```
EEEEE N   N DDDD       GGG  RRRR   AAA  DDDD  Y   Y
E     NN  N D   D     G   G R   R A   A D   D  Y Y
EEE   N N N D   D     G     RRRR  A   A D   D   Y
E     N  NN D   D     G  GG R  R  AAAAA D   D   Y
EEEEE N   N DDDD       GGGG R   R A   A DDDD    Y
```

RECONSTRUCTION FOR THE EMISSION SCAN CORRECTED FOR ATTENUATION

XMIN = -.51E+01 XMAX = .36E+02 XSUM = .6106E+05



```
                              -          =          +          )          1          Z
-.5107E+01  -.2034E+01  .2474E+01  .4523E+01  .5957E+01  .7596E+01  .9235E+01

Z           X           A          M          θ          θ          @          @
.1067E+02   .1169E+02   .1272E+02  .1497E+02  .1723E+02  .1866E+02  .2030E+02

@           @           @          @          @          ■          ■          ■
.2173E+02   .2481E+02   .2850E+02  .3054E+02  .3218E+02  .3382E+02  .3526E+02

■
.3587E+02
```

.3	-.7	1.3	.0	.1	.8	-.4	.9	.1	.4	.3	.6	.2	.2	.3
-.7	-1.6	-.0	-1.2	-.8	-.2	-1.2	.1	-.8	.1	-1.3	.3	-1.1	.1	-.6
1.3	-.0	1.5	.2	.6	.8	.2	.7	-.2	.8	-.1	.7	.0	-.2	.4
.0	-1.2	.2	-1.0	-.4	-.5	-.2	-.7	-.7	-.7	-.4	-.6	.3	-.1	-.0
.1	-.8	.6	-.4	.3	-.1	1.0	.3	1.2	-.2	.1	-.5	-.7	-.1	-.1
.8	-.2	.8	-.5	-.1	-1.2	-.1	-1.4	.2	.1	-.3	.3	-.2	-.0	-.0
-.4	-1.2	.2	-.2	1.0	-.1	1.6	.1	-.4	-.2	-.4	-.4	-.7	1.2	4.2
.9	.1	.7	-.7	.3	-1.4	.1	.5	-.3	.0	-.7	-.8	-.3	6.6	21.9
.1	-.8	-.2	-.7	1.2	.2	-.4	-.3	-.5	-1.0	-1.5	-.6	7.9	24.9	32.5
.4	.1	.8	-.7	-.2	.1	-.2	.0	-1.0	-1.6	-1.1	10.6	26.2	32.3	33.8
.3	-1.3	-.1	-.4	.1	-.3	-.4	-.7	-1.5	-1.1	10.1	26.4	31.2	33.2	34.4
-.6	.3	.7	-.6	-.5	.3	-.4	-.8	-.6	10.6	26.4	31.9	33.1	33.3	34.2
.2	-1.1	.0	.3	-.7	-.2	-.7	-.3	7.9	26.2	31.2	33.1	33.9	34.2	34.3
.2	.1	-.2	-.1	-.1	-.0	1.2	6.6	24.9	32.3	33.2	33.3	34.2	33.9	33.7
.3	-.6	.4	-.0	-.1	-.0	4.2	21.9	32.5	33.8	34.4	34.2	34.3	33.7	31.3
-.0	-.0	-.4	-.3	-.9	.2	13.5	29.6	33.1	32.7	32.6	32.6	32.3	33.0	31.6
.1	-.3	.3	-1.2	-1.0	5.2	25.8	31.8	34.1	33.7	34.2	33.3	34.5	34.8	30.4
.7	-.4	-.6	-1.5	-.6	17.1	31.2	34.2	33.7	33.2	33.2	31.6	32.1	32.4	32.7
-.2	-.2	-1.0	-1.1	5.9	26.7	32.5	33.7	33.3	33.7	32.9	33.4	34.3	31.0	31.9
.0	-.3	-1.4	-.7	16.2	31.0	33.3	34.4	33.1	34.1	31.7	31.3	33.7	30.5	28.4
-.6	-.3	-.7	4.9	26.9	33.5	34.4	33.5	33.1	33.8	33.6	33.3	31.5	30.5	27.6
-.0	-.4	.4	12.6	30.4	33.4	33.2	33.6	33.7	31.8	32.2	33.7	30.0	27.9	21.0
-.5	.1	4.5	22.6	33.6	35.1	33.5	33.2	33.7	33.5	31.1	32.4	30.0	24.9	14.0
-.1	-.0	7.0	28.2	31.7	34.3	34.9	32.6	32.7	32.9	31.4	31.8	29.1	20.4	9.0
-.4	-1.9	10.6	31.1	33.8	33.9	33.3	34.0	32.5	31.8	30.9	30.9	26.6	15.0	6.4
-.7	-.9	15.9	32.0	33.6	35.2	33.8	32.8	33.4	30.0	31.2	28.9	23.1	10.1	2.9
.6	3.1	23.5	33.8	32.4	34.9	35.9	31.5	34.0	29.6	32.7	28.9	19.1	8.3	1.3
.6	6.2	26.6	34.6	34.0	34.3	33.7	32.1	31.7	31.0	30.6	28.2	15.5	4.6	1.0
.1	7.5	28.4	33.5	33.5	32.4	33.7	33.6	31.0	30.7	31.6	26.6	12.7	3.5	.1
-.8	7.9	30.8	34.0	34.4	35.0	33.0	33.6	30.5	31.0	29.9	25.2	9.8	2.9	.2
-1.4	9.4	31.2	33.7	33.5	33.2	34.0	32.8	30.8	31.4	29.1	23.1	11.0	2.3	-.6
-1.3	10.2	29.7	33.5	35.1	32.3	35.1	33.8	30.1	30.8	29.7	22.7	9.2	1.8	.2
-1.3	10.2	29.7	33.5	35.1	32.3	35.1	33.8	30.1	30.8	29.7	22.7	9.2	1.8	.2
-1.4	9.4	31.2	33.7	33.5	33.2	34.0	32.8	30.8	31.4	29.1	23.1	11.0	2.3	-.6
-.8	7.9	30.8	34.0	34.4	35.0	33.0	33.6	30.5	31.0	29.9	25.2	9.8	2.9	.2
.1	7.5	28.4	33.5	33.5	32.4	33.7	33.6	31.0	30.7	31.6	26.6	12.7	3.5	.1
.6	6.2	26.6	34.6	34.0	34.3	33.7	32.1	31.7	31.0	30.6	28.2	15.5	4.6	1.0
.6	3.1	23.5	33.8	32.4	34.9	35.9	31.5	34.0	29.6	32.7	28.9	19.1	8.3	1.3
-.7	-.9	15.9	32.0	33.6	35.2	33.8	32.8	33.4	30.0	31.2	28.9	23.1	10.1	2.9
-.4	-1.9	10.6	31.1	33.8	33.9	33.3	34.0	32.5	31.8	30.9	30.9	26.6	15.0	6.4
-.1	-.0	7.0	28.2	31.7	34.3	34.9	32.6	32.7	32.9	31.4	31.8	29.1	20.4	9.0
-.5	.1	4.5	22.6	33.6	35.1	33.5	33.2	33.7	33.5	31.1	32.4	30.0	24.9	14.0
-.0	-.4	.4	12.6	30.4	33.4	33.2	33.6	33.7	31.8	32.2	33.7	30.0	27.9	21.0
-.6	-.3	-.7	4.9	26.9	33.5	34.4	33.5	33.1	33.8	33.6	33.3	31.5	30.5	27.6
.0	-.3	-1.4	-.7	16.2	31.0	33.3	34.4	33.1	34.1	31.7	31.3	33.7	30.5	28.4
-.2	-.2	-1.0	-1.1	5.9	26.7	32.5	33.7	33.3	33.7	32.9	33.4	34.3	31.0	31.9
.7	-.4	-.6	-1.5	-.6	17.1	31.2	34.2	33.7	33.2	33.2	31.6	32.1	32.4	32.7
.1	-.3	.3	-1.2	-1.0	5.2	25.8	31.8	34.1	33.7	34.2	33.3	34.5	34.8	30.4
-.0	-.0	-.4	-.3	-.5	.2	13.5	29.6	33.1	32.7	32.6	32.6	32.3	33.0	31.6
.3	-.6	.4	-.0	-.1	-.0	4.2	21.9	32.5	33.8	34.4	34.2	34.3	33.7	31.3
.2	.1	-.2	-.1	-.1	-.0	1.2	6.6	24.9	32.3	33.2	33.3	34.2	33.9	33.7
.2	-1.1	.0	.3	-.7	-.2	-.7	-.3	7.9	26.2	31.2	33.1	33.9	34.2	34.3
.6	.3	.7	-.6	-.5	.3	-.4	-.8	-.6	10.6	26.4	31.9	33.1	33.3	34.2
.3	-1.3	-.1	-.4	.1	-.3	-.4	-.7	-1.5	-1.1	10.1	26.4	31.2	33.2	34.4
.4	.1	.8	-.7	-.2	.1	-.2	.0	-1.0	-1.6	-1.1	10.6	26.2	32.3	33.8
.1	-.8	-.2	-.7	1.2	.2	-.4	-.3	-.5	-1.0	-1.5	-.6	7.9	24.9	32.5
.9	.1	.7	-.7	.3	-1.4	.1	.5	-.3	.0	-.7	-.8	-.3	6.6	21.9
-.4	-1.2	.2	-.2	1.0	-.1	1.6	.1	-.4	-.2	-.4	-.4	-.7	1.2	4.2
.8	-.2	.8	-.5	-.1	-1.2	-.1	-1.4	.2	.1	-.3	.3	-.2	-.0	-.0
.1	-.8	.6	-.4	.3	-.1	1.0	.3	1.2	-.2	.1	-.5	-.7	-.1	-.1
.0	-1.2	.2	-1.0	-.4	-.5	-.2	-.7	-.7	-.7	-.4	-.6	.3	-.1	-.0
1.3	-.0	1.5	.2	.6	.8	.2	.7	-.2	.8	-.1	.7	.0	-.2	.4
-.7	-1.6	-.0	-1.2	-.8	-.2	-1.2	.1	-.8	.1	-1.3	.3	-1.1	.1	-.6
.3	-.7	1.3	.0	.1	.8	-.4	.9	.1	.4	.3	.6	.2	.2	3

-.0	.1	.7	-.2	.0	-.6	-.0	-.5	-.1	-.4	-.7	.6	.6	.1	-.8
-.0	-.3	-.4	-.2	-.3	-.3	-.4	.1	-.0	-1.9	-.9	3.1	6.2	7.5	7.9
-.4	.3	-.6	-1.0	-1.4	-.7	.4	4.5	7.0	10.6	15.9	23.5	26.6	28.4	30.8
-.3	-1.2	-1.5	-1.1	-.7	4.9	12.6	22.6	28.2	31.1	32.0	33.8	34.6	33.5	34.0
-.9	-1.0	-.6	5.9	16.2	26.9	30.4	33.6	31.7	33.8	33.6	32.4	34.0	33.5	34.4
.2	5.2	17.1	26.7	31.0	33.5	33.4	35.1	34.3	33.9	35.2	34.9	34.3	32.4	35.0
13.5	25.8	31.2	32.5	33.3	34.4	33.2	33.5	34.9	33.3	33.8	35.9	33.7	33.7	33.0
29.6	31.8	34.2	33.7	34.4	33.5	33.6	33.2	32.6	34.0	32.8	31.5	32.1	33.6	33.6
33.1	34.1	33.7	33.3	33.1	33.1	33.7	33.7	32.7	32.5	33.4	34.0	31.7	31.0	30.5
32.7	33.7	33.2	33.7	34.1	33.8	31.8	33.5	32.9	31.8	30.0	29.6	31.0	30.7	31.0
32.6	34.2	33.2	32.9	31.7	33.6	32.2	31.1	31.4	30.9	31.2	32.7	30.6	31.6	29.9
32.6	33.3	31.6	33.4	31.3	33.3	33.7	32.4	31.8	30.9	28.9	28.9	28.2	26.6	25.2
32.3	34.5	32.1	34.3	33.7	31.5	30.0	30.0	29.1	26.6	23.1	19.1	15.5	12.7	9.8
33.0	34.8	32.4	31.0	30.5	30.5	27.9	24.9	20.4	15.0	10.1	8.3	4.6	3.5	2.9
31.6	30.4	32.7	31.9	28.4	27.6	21.0	14.0	9.0	6.4	2.9	1.3	1.0	.1	.2
35.1	31.4	29.9	28.7	24.8	16.9	9.5	5.2	3.1	.4	.3	-1.2	-2.1	-2.4	-2.5
31.4	31.7	28.1	22.9	14.2	8.2	2.3	2.3	-.1	-.5	-2.6	-.3	-1.7	-2.1	-2.6
29.9	28.1	22.2	12.2	6.1	3.3	1.0	-.8	-3.4	-2.4	-3.9	-2.8	-3.6	-1.8	-3.9
28.7	22.9	12.2	5.7	1.8	.9	-.5	-1.4	-2.0	-2.9	-2.7	-3.4	-2.3	-1.1	-1.4
24.8	14.2	6.1	1.8	1.1	-1.8	-3.4	-1.8	-2.7	-4.4	-4.0	-1.8	-1.9	-5.1	-2.5
16.9	8.2	3.3	.9	-1.8	-2.6	-2.9	-2.7	-1.9	-2.8	-1.9	-1.6	-3.0	-1.3	-1.5
9.5	2.3	1.0	-.5	-3.4	-2.9	-3.4	-3.3	-3.7	-1.3	-2.1	-3.3	-1.4	-.1	1.3
5.2	2.3	-.8	-1.4	-1.8	-2.7	-3.3	-2.8	-2.0	-1.8	-1.1	2.7	6.0	13.0	18.7
3.1	-.1	-3.4	-2.0	-2.7	-1.9	-3.7	-2.0	-2.0	-1.9	2.3	13.6	19.4	24.1	28.8
.4	-.5	-2.4	-2.9	-4.4	-2.8	-1.3	-1.8	-1.9	3.6	16.4	25.3	29.5	33.4	30.2
.3	-2.6	-3.9	-2.7	-4.0	-1.9	-2.1	-1.1	2.3	16.4	22.8	28.1	30.8	33.5	31.1
-1.2	-.3	-2.8	-3.4	-1.8	-1.6	-3.3	2.7	13.6	25.3	28.1	33.0	33.3	30.7	33.8
-2.1	-1.7	-3.6	-2.3	-1.9	-3.0	-1.4	6.0	19.4	29.5	30.8	33.3	30.6	31.4	35.5
-2.4	-2.1	-1.8	-1.1	-5.1	-1.3	-.1	13.0	24.1	33.4	33.5	30.7	31.4	30.0	31.6
-2.5	-2.6	-3.9	-1.4	-2.5	-1.5	1.3	18.7	28.8	30.2	31.1	33.8	35.5	31.6	28.1
-1.0	-1.0	-3.6	-3.1	-1.1	-.8	4.3	21.8	29.9	30.4	33.1	32.3	29.3	31.1	32.7
-2.2	-3.1	-4.2	-2.4	-2.8	-.1	6.6	21.4	30.4	30.4	30.9	32.2	30.8	35.6	32.4
-2.2	-3.1	-4.2	-2.4	-2.8	-.1	6.6	21.4	30.4	30.4	30.9	32.2	30.8	35.6	32.4
-1.0	-1.0	-3.6	-3.1	-1.1	-.8	4.3	21.8	29.9	30.4	33.1	32.3	29.3	31.1	32.7
-2.5	-2.6	-3.9	-1.4	-2.5	-1.5	1.3	18.7	28.8	30.2	31.1	33.8	35.5	31.6	28.1
-2.4	-2.1	-1.8	-1.1	-5.1	-1.3	-.1	13.0	24.1	33.4	33.5	30.7	31.4	30.0	31.6
-2.1	-1.7	-3.6	-2.3	-1.9	-3.0	-1.4	6.0	19.4	29.5	30.8	33.3	30.6	31.4	35.5
-1.2	-.3	-2.8	-3.4	-1.8	-1.6	-3.3	2.7	13.6	25.3	28.1	33.0	33.3	30.7	33.8
.3	-2.6	-3.9	-2.7	-4.0	-1.9	-2.1	-1.1	2.3	16.4	22.8	28.1	30.8	33.5	31.1
.4	-.5	-2.4	-2.9	-4.4	-2.8	-1.3	-1.8	-1.9	3.6	16.4	25.3	29.5	33.4	30.2
3.1	-.1	-3.4	-2.0	-2.7	-1.9	-3.7	-2.0	-2.0	-1.9	2.3	13.6	19.4	24.1	28.8
5.2	2.3	-.8	-1.4	-1.8	-2.7	-3.3	-2.8	-2.0	-1.8	-1.1	2.7	6.0	13.0	18.7
9.5	2.3	1.0	-.5	-3.4	-2.9	-3.4	-3.3	-3.7	-1.3	-2.1	-3.3	-1.4	-.1	1.3
16.9	8.2	3.3	.9	-1.8	-2.6	-2.9	-2.7	-1.9	-2.8	-1.9	-1.6	-3.0	-1.3	-1.5
24.8	14.2	6.1	1.8	1.1	-1.8	-3.4	-1.8	-2.7	-4.4	-4.0	-1.8	-1.9	-5.1	-2.5
28.7	22.9	12.2	5.7	1.8	.9	-.5	-1.4	-2.0	-2.9	-2.7	-3.4	-2.3	-1.1	-1.4
29.9	28.1	22.2	12.2	6.1	3.3	1.0	-.8	-3.4	-2.4	-3.9	-2.8	-3.6	-1.8	-3.9
31.4	31.7	28.1	22.9	14.2	8.2	2.3	2.3	-.1	-.5	-2.6	-.3	-1.7	-2.1	-2.6
35.1	31.4	29.9	28.7	24.8	16.9	9.5	5.2	3.1	.4	.3	-1.2	-2.1	-2.4	-2.5
31.6	30.4	32.7	31.9	28.4	27.6	21.0	14.0	9.0	6.4	2.9	1.3	1.0	.1	.2
33.0	34.8	32.4	31.0	30.5	30.5	27.9	24.9	20.4	15.0	10.1	8.3	4.6	3.5	2.9
32.3	34.5	32.1	34.3	33.7	31.5	30.0	30.0	29.1	26.6	23.1	19.1	15.5	12.7	9.8
32.6	33.3	31.6	33.4	31.3	33.3	33.7	32.4	31.8	30.9	28.9	28.9	28.2	26.6	25.2
32.6	34.2	33.2	32.9	31.7	33.6	32.2	31.1	31.4	30.9	31.2	32.7	30.6	31.6	29.9
32.7	33.7	33.2	33.7	34.1	33.8	31.8	33.5	32.9	31.8	30.0	29.6	31.0	30.7	31.0
33.1	34.1	33.7	33.3	33.1	33.1	33.7	33.7	32.7	32.5	33.4	34.0	31.7	31.0	30.5
29.6	31.8	34.2	33.7	34.4	33.5	33.6	33.2	32.6	34.0	32.8	31.5	32.1	33.6	33.6
13.5	25.8	31.2	32.5	33.3	34.4	33.2	33.5	34.9	33.3	33.8	35.9	33.7	33.7	33.0
.2	5.2	17.1	26.7	31.0	33.5	33.4	35.1	34.3	33.9	35.2	34.9	34.3	32.4	35.0
-.9	-1.0	-.6	5.9	16.2	26.9	30.4	33.6	31.7	33.8	33.6	32.4	34.0	33.5	34.4
-.3	-1.2	-1.5	-1.1	-.7	4.9	12.6	22.6	28.2	31.1	32.0	33.8	34.6	33.5	34.0
-.4	.3	-.6	-1.0	-1.4	-.7	.4	4.5	7.0	10.6	15.9	23.5	26.6	28.4	30.8
-.0	-.3	-.4	-.2	-.3	-.3	-.4	.1	-.0	-1.9	-.9	3.1	6.2	7.5	7.9
-.0	.1	.7	-.2	.0	-.6	-.0	-.5	-.1	-.4	-.7	.6	.6	.1	-.8

-1.4	-1.3	-1.3	-1.4	-.8	.1	.6	.6	-.7	-.4	-.1	-.5	-.0	-.6	.0
9.4	10.2	10.2	9.4	7.9	7.5	6.2	3.1	-.9	-1.9	-.0	.1	-.4	-.3	-.3
31.2	29.7	29.7	31.2	30.8	28.4	26.6	23.5	15.9	10.6	7.0	4.5	.4	-.7	-1.4
33.7	33.5	33.5	33.7	34.0	33.5	34.6	33.8	32.0	31.1	28.2	22.6	12.6	4.9	-.7
33.5	35.1	35.1	33.5	34.4	33.5	34.0	32.4	33.6	33.8	31.7	33.6	30.4	26.9	16.2
33.2	32.3	32.3	33.2	35.0	32.4	34.3	34.9	35.2	33.9	34.3	35.1	33.4	33.5	31.0
34.0	35.1	35.1	34.0	33.0	33.7	33.7	35.9	33.8	33.3	34.9	33.5	33.2	34.4	33.3
32.8	33.8	33.8	32.8	33.6	33.6	32.1	31.5	32.8	34.0	32.6	33.2	33.6	33.5	34.4
30.8	30.1	30.1	30.8	30.5	31.0	31.7	34.0	33.4	32.5	32.7	33.7	33.7	33.1	33.1
31.4	30.8	30.8	31.4	31.0	30.7	31.0	29.6	30.0	31.8	32.9	33.5	31.8	33.8	34.1
29.1	29.7	29.7	29.1	29.9	31.6	30.6	32.7	31.2	30.9	31.4	31.1	32.2	33.6	31.7
23.1	22.7	22.7	23.1	25.2	26.6	28.2	28.9	28.9	30.9	31.8	32.4	33.7	33.3	31.3
11.0	9.2	9.2	11.0	9.8	12.7	15.5	19.1	23.1	26.6	29.1	30.0	30.0	31.5	33.7
2.3	1.8	1.8	2.3	2.9	3.5	4.6	8.3	10.1	15.0	20.4	24.9	27.9	30.5	30.5
-.6	.2	.2	-.6	.2	.1	1.0	1.3	2.9	6.4	9.0	14.0	21.0	27.6	28.4
-1.0	-2.2	-2.2	-1.0	-2.5	-2.4	-2.1	-1.2	.3	.4	3.1	5.2	9.5	16.9	24.8
-1.0	-3.1	-3.1	-1.0	-2.6	-2.1	-1.7	-.3	-2.6	-.5	-.1	2.3	2.3	8.2	14.2
-3.6	-4.2	-4.2	-3.6	-3.9	-1.8	-3.6	-2.8	-3.9	-2.4	-3.4	-.8	1.0	3.3	6.1
-3.1	-2.4	-2.4	-3.1	-1.4	-1.1	-2.3	-3.4	-2.7	-2.9	-2.0	-1.4	-.5	.9	1.8
-1.1	-2.8	-2.8	-1.1	-2.5	-5.1	-1.9	-1.8	-4.0	-4.4	-2.7	-1.8	-3.4	-1.8	1.1
-.8	-.1	-.1	-.8	-1.5	-1.3	-3.0	-1.6	-1.9	-2.8	-1.9	-2.7	-2.9	-2.6	-1.8
4.3	6.6	6.6	4.3	1.3	-.1	-1.4	-3.3	-2.1	-1.3	-3.7	-3.3	-3.4	-2.9	-3.4
21.8	21.4	21.4	21.8	18.7	13.0	6.0	2.7	-1.1	-1.8	-2.0	-2.8	-3.3	-2.7	-1.8
29.9	30.4	30.4	29.9	28.8	24.1	19.4	13.6	2.3	-1.9	-2.0	-2.0	-3.7	-1.9	-2.7
30.4	30.4	30.4	30.4	30.2	33.4	29.5	25.3	16.4	3.6	-1.9	-1.8	-1.3	-2.8	-4.4
33.1	30.9	30.9	33.1	31.1	33.5	30.8	28.1	22.8	16.4	2.3	-1.1	-2.1	-1.9	-4.0
32.3	32.2	32.2	32.3	33.8	30.7	33.3	33.0	28.1	25.3	13.6	2.7	-3.3	-1.6	-1.8
29.3	30.8	30.8	29.3	35.5	31.4	30.6	33.3	30.8	29.5	19.4	6.0	-1.4	-3.0	-1.9
31.1	35.6	35.6	31.1	31.6	30.0	31.4	30.7	33.5	33.4	24.1	13.0	-.1	-1.3	-5.1
32.7	32.4	32.4	32.7	28.1	31.6	35.5	33.8	31.1	30.2	28.8	18.7	1.3	-1.5	-2.5
33.7	28.2	28.2	33.7	32.7	31.1	29.3	32.3	33.1	30.4	29.9	21.8	4.3	-.8	-1.1
28.2	31.9	31.9	28.2	32.4	35.6	30.8	32.2	30.9	30.4	30.4	21.4	6.6	-.1	-2.8
28.2	31.9	31.9	28.2	32.4	35.6	30.8	32.2	30.9	30.4	30.4	21.4	6.6	-.1	-2.8
33.7	28.2	28.2	33.7	32.7	31.1	29.3	32.3	33.1	30.4	29.9	21.8	4.3	-.8	-1.1
32.7	32.4	32.4	32.7	28.1	31.6	35.5	33.8	31.1	30.2	28.8	18.7	1.3	-1.5	-2.5
31.1	35.6	35.6	31.1	31.6	30.0	31.4	30.7	33.5	33.4	24.1	13.0	-.1	-1.3	-5.1
29.3	30.8	30.8	29.3	35.5	31.4	30.6	33.3	30.8	29.5	19.4	6.0	-1.4	-3.0	-1.9
32.3	32.2	32.2	32.3	33.8	30.7	33.3	33.0	28.1	25.3	13.6	2.7	-3.3	-1.6	-1.8
33.1	30.9	30.9	33.1	31.1	33.5	30.8	28.1	22.8	16.4	2.3	-1.1	-2.1	-1.9	-4.0
30.4	30.4	30.4	30.4	30.2	33.4	29.5	25.3	16.4	3.6	-1.9	-1.8	-1.3	-2.8	-4.4
29.9	30.4	30.4	29.9	28.8	24.1	19.4	13.6	2.3	-1.9	-2.0	-2.0	-3.7	-1.9	-2.7
21.8	21.4	21.4	21.8	18.7	13.0	6.0	2.7	-1.1	-1.8	-2.0	-2.8	-3.3	-2.7	-1.8
4.3	6.6	6.6	4.3	1.3	-.1	-1.4	-3.3	-2.1	-1.3	-3.7	-3.3	-3.4	-2.9	-3.4
-.8	-.1	-.1	-.8	-1.5	-1.3	-3.0	-1.6	-1.9	-2.8	-1.9	-2.7	-2.9	-2.6	-1.8
-1.1	-2.8	-2.8	-1.1	-2.5	-5.1	-1.9	-1.8	-4.0	-4.4	-2.7	-1.8	-3.4	-1.8	1.1
-3.1	-2.4	-2.4	-3.1	-1.4	-1.1	-2.3	-3.4	-2.7	-2.9	-2.0	-1.4	-.5	.9	1.8
-3.6	-4.2	-4.2	-3.6	-3.9	-1.8	-3.6	-2.8	-3.9	-2.4	-3.4	-.8	1.0	3.3	6.1
-1.0	-3.1	-3.1	-1.0	-2.6	-2.1	-1.7	-.3	-2.6	-.5	-.1	2.3	2.3	8.2	14.2
-1.0	-2.2	-2.2	-1.0	-2.5	-2.4	-2.1	-1.2	.3	.4	3.1	5.2	9.5	16.9	24.8
-.6	.2	.2	-.6	.2	.1	1.0	1.3	2.9	6.4	9.0	14.0	21.0	27.6	28.4
2.3	1.8	1.8	2.3	2.9	3.5	4.6	8.3	10.1	15.0	20.4	24.9	27.9	30.5	30.5
11.0	9.2	9.2	11.0	9.8	12.7	15.5	19.1	23.1	26.6	29.1	30.0	30.0	31.5	33.7
23.1	22.7	22.7	23.1	25.2	26.6	28.2	28.9	28.9	30.9	31.8	32.4	33.7	33.3	31.3
29.1	29.7	29.7	29.1	29.9	31.6	30.6	32.7	31.2	30.9	31.4	31.1	32.2	33.6	31.7
31.4	30.8	30.8	31.4	31.0	30.7	31.0	29.6	30.0	31.8	32.9	33.5	31.8	33.8	34.1
30.8	30.1	30.1	30.8	30.5	31.0	31.7	34.0	33.4	32.5	32.7	33.7	33.7	33.1	33.1
32.8	33.8	33.8	32.8	33.6	33.6	32.1	31.5	32.8	34.0	32.6	33.2	33.6	33.5	34.4
34.0	35.1	35.1	34.0	33.0	33.7	33.7	35.9	33.8	33.3	34.9	33.5	33.2	34.4	33.3
33.2	32.3	32.3	33.2	35.0	32.4	34.3	34.9	35.2	33.9	34.3	35.1	33.4	33.5	31.0
33.5	35.1	35.1	33.5	34.4	33.5	34.0	32.4	33.6	33.8	31.7	33.6	30.4	26.9	16.2
33.7	33.5	33.5	33.7	34.0	33.5	34.6	33.8	32.0	31.1	28.2	22.6	12.6	4.9	-.7
31.2	29.7	29.7	31.2	30.8	28.4	26.6	23.5	15.9	10.6	7.0	4.5	.4	-.7	-1.4
9.4	10.2	10.2	9.4	7.9	7.5	6.2	3.1	-.9	-1.9	-.0	.1	-.4	-.3	-.3
-1.4	-1.3	-1.3	-1.4	-.8	.1	.6	.6	-.7	-.4	-.1	-.5	-.0	-.6	.0

-.2	.7	.1	-.0	.3	.2	.2	.6	.3	.4	.1	.9	-.4	.8	.1
-.2	-.4	-.3	-.0	-.6	.1	-1.1	.3	-1.3	.1	-.8	.1	-1.2	-.2	-.8
-1.0	-.6	.3	-.4	.4	-.2	.0	.7	-.1	.8	-.2	.7	.2	.8	.6
-1.1	-1.5	-1.2	-.3	-.0	-.1	.3	-.6	-.4	-.7	-.7	-.7	-.2	-.5	-.4
5.9	-.6	-1.0	-.9	-.1	-.1	-.7	-.5	.1	-.2	1.2	.3	1.0	-.1	.3
26.7	17.1	5.2	.2	-.0	-.0	-.2	.3	-.3	.1	.2	-1.4	-.1	-1.2	-.1
32.5	31.2	25.8	13.5	4.2	1.2	-.7	-.4	-.4	-.2	-.4	.1	1.6	-.1	1.0
33.7	34.2	31.8	29.6	21.9	6.6	-.3	-.8	-.7	.0	-.3	.5	.1	-1.4	.3
33.3	33.7	34.1	33.1	32.5	24.9	7.9	-.6	-1.5	-1.0	-.5	-.3	-.4	.2	1.2
33.7	33.2	33.7	32.7	33.8	32.3	26.2	10.6	-1.1	-1.6	-1.0	.0	-.2	.1	-.2
32.9	33.2	34.2	32.6	34.4	33.2	31.2	26.4	10.1	-1.1	-1.5	-.7	-.4	-.3	.1
33.4	31.6	33.3	32.6	34.2	33.3	33.1	31.9	26.4	10.6	-.6	-.8	-.4	.3	-.5
34.3	32.1	34.5	32.3	34.3	34.2	33.9	33.1	31.2	26.2	7.9	-.3	-.7	-.2	-.7
31.0	32.4	34.8	33.0	33.7	33.9	34.2	33.3	33.2	32.3	24.9	6.6	1.2	-.0	-.1
31.9	32.7	30.4	31.6	31.3	33.7	34.3	34.2	34.4	33.8	32.5	21.9	4.2	-.0	-.1
28.7	29.9	31.4	35.1	31.6	33.0	32.3	32.6	32.6	32.7	33.1	29.6	13.5	.2	-.9
22.9	28.1	31.7	31.4	30.4	34.8	34.5	33.3	34.2	33.7	34.1	31.8	25.8	5.2	-1.0
12.2	22.2	28.1	29.9	32.7	32.4	32.1	31.6	33.2	33.2	33.7	34.2	31.2	17.1	-.6
5.7	12.2	22.9	28.7	31.9	31.0	34.3	33.4	32.9	33.7	33.3	33.7	32.5	26.7	5.9
1.8	6.1	14.2	24.8	28.4	30.5	33.7	31.3	31.7	34.1	33.1	34.4	33.3	31.0	16.2
.9	3.3	8.2	16.9	27.6	30.5	31.5	33.3	33.6	33.8	33.1	33.5	34.4	33.5	26.9
-.5	1.0	2.3	9.5	21.0	27.9	30.0	33.7	32.2	31.8	33.7	33.6	33.2	33.4	30.4
-1.4	-.8	2.3	5.2	14.0	24.9	30.0	32.4	31.1	33.5	33.7	33.2	33.5	35.1	33.6
-2.0	-3.4	-.1	3.1	9.0	20.4	29.1	31.8	31.4	32.9	32.7	32.6	34.9	34.3	31.7
-2.9	-2.4	-.5	.4	6.4	15.0	26.6	30.9	30.9	31.8	32.5	34.0	33.3	33.9	33.8
-2.7	-3.9	-2.6	.3	2.9	10.1	23.1	28.9	31.2	30.0	33.4	32.8	33.8	35.2	33.6
-3.4	-2.8	-.3	-1.2	1.3	8.3	19.1	28.9	32.7	29.6	34.0	31.5	35.9	34.9	32.4
-2.3	-3.6	-1.7	-2.1	1.0	4.6	15.5	28.2	30.6	31.0	31.7	32.1	33.7	34.3	34.0
-1.1	-1.8	-2.1	-2.4	.1	3.5	12.7	26.6	31.6	30.7	31.0	33.6	33.7	32.4	33.5
-1.4	-3.9	-2.6	-2.5	.2	2.9	9.8	25.2	29.9	31.0	30.5	33.6	33.0	35.0	34.4
-3.1	-3.6	-1.0	-1.0	-.6	2.3	11.0	23.1	29.1	31.4	30.8	32.8	34.0	33.2	33.5
-2.4	-4.2	-3.1	-2.2	.2	1.8	9.2	22.7	29.7	30.8	30.1	33.8	35.1	32.3	35.1
-2.4	-4.2	-3.1	-2.2	.2	1.8	9.2	22.7	29.7	30.8	30.1	33.8	35.1	32.3	35.1
-3.1	-3.6	-1.0	-1.0	-.6	2.3	11.0	23.1	29.1	31.4	30.8	32.8	34.0	33.2	33.5
-1.4	-3.9	-2.6	-2.5	.2	2.9	9.8	25.2	29.9	31.0	30.5	33.6	33.0	35.0	34.4
-1.1	-1.8	-2.1	-2.4	.1	3.5	12.7	26.6	31.6	30.7	31.0	33.6	33.7	32.4	33.5
-2.3	-3.6	-1.7	-2.1	1.0	4.6	15.5	28.2	30.6	31.0	31.7	32.1	33.7	34.3	34.0
-3.4	-2.8	-.3	-1.2	1.3	8.3	19.1	28.9	32.7	29.6	34.0	31.5	35.9	34.9	32.4
-2.7	-3.9	-2.6	.3	2.9	10.1	23.1	28.9	31.2	30.0	33.4	32.8	33.8	35.2	33.6
-2.9	-2.4	-.5	.4	6.4	15.0	26.6	30.9	30.9	31.8	32.5	34.0	33.3	33.9	33.8
-2.0	-3.4	-.1	3.1	9.0	20.4	29.1	31.8	31.4	32.9	32.7	32.6	34.9	34.3	31.7
-1.4	-.8	2.3	5.2	14.0	24.9	30.0	32.4	31.1	33.5	33.7	33.2	33.5	35.1	33.6
-.5	1.0	2.3	9.5	21.0	27.9	30.0	33.7	32.2	31.8	33.7	33.6	33.2	33.4	30.4
.9	3.3	8.2	16.9	27.6	30.5	31.5	33.3	33.6	33.8	33.1	33.5	34.4	33.5	26.9
1.8	6.1	14.2	24.8	28.4	30.5	33.7	31.3	31.7	34.1	33.1	34.4	33.3	31.0	16.2
5.7	12.2	22.9	28.7	31.9	31.0	34.3	33.4	32.9	33.7	33.3	33.7	32.5	26.7	5.9
12.2	22.2	28.1	29.9	32.7	32.4	32.1	31.6	33.2	33.2	33.7	34.2	31.2	17.1	-.6
22.9	28.1	31.7	31.4	30.4	34.8	34.5	33.3	34.2	33.7	34.1	31.8	25.8	5.2	-1.0
28.7	29.9	31.4	35.1	31.6	33.0	32.3	32.6	32.6	32.7	33.1	29.6	13.5	.2	-.9
31.9	32.7	30.4	31.6	31.3	33.7	34.3	34.2	34.4	33.8	32.5	21.9	4.2	-.0	-.1
31.0	32.4	34.8	33.0	33.7	33.9	34.2	33.3	33.2	32.3	24.9	6.6	1.2	-.0	-.1
34.3	32.1	34.5	32.3	34.3	34.2	33.9	33.1	31.2	26.2	7.9	-.3	-.7	-.2	-.7
33.4	31.6	33.3	32.6	34.2	33.3	33.1	31.9	26.4	10.6	-.6	-.8	-.4	.3	-.5
32.9	33.2	34.2	32.6	34.4	33.2	31.2	26.4	10.1	-1.1	-1.5	-.7	-.4	-.3	.1
33.7	33.2	33.7	32.7	33.8	32.3	26.2	10.6	-1.1	-1.6	-1.0	.0	-.2	.1	-.2
33.3	33.7	34.1	33.1	32.5	24.9	7.9	-.6	-1.5	-1.0	-.5	-.3	-.4	.2	1.2
33.7	34.2	31.8	29.6	21.9	6.6	-.3	-.8	-.7	.0	-.3	.5	.1	-1.4	.3
32.5	31.2	25.8	13.5	4.2	1.2	-.7	-.4	-.4	-.2	-.4	.1	1.6	-.1	1.0
26.7	17.1	5.2	.2	-.0	-.0	-.2	.3	-.3	.1	.2	-1.4	-.1	-1.2	-.1
5.9	-.6	-1.0	-.9	-.1	-.1	-.7	-.5	.1	-.2	1.2	.3	1.0	-.1	.3
-1.1	-1.5	-1.2	-.3	-.0	-.1	.3	-.6	-.4	-.7	-.7	-.7	-.2	-.5	-.4
-1.0	-.6	.3	-.4	.4	-.2	.0	.7	-.1	.8	-.2	.7	.2	.8	.6
-.2	-.4	-.3	-.0	-.6	.1	-1.1	.3	-1.3	.1	-.8	.1	-1.2	-.2	-.8
-.2	.7	.1	-.0	.3	.2	.2	.6	.3	.4	.1	.9	-.4	.8	.1

.0	1.3	-.7	.3
-1.2	-.0	-1.6	-.7
.2	1.5	-.0	1.3
-1.0	.2	-1.2	.0
-.4	.6	-.8	.1
-.5	.8	-.2	.8
-.2	.2	-1.2	-.4
-.7	.7	.1	.9
-.7	-.2	-.8	.1
-.7	.8	.1	.4
-.4	-.1	-1.3	.3
-.6	.7	.3	.6
.3	.0	-1.1	.2
-.1	-.2	.1	.2
-.0	.4	-.6	.3
-.3	-.4	-.0	-.0
-1.2	.3	-.3	.1
-1.5	-.6	-.4	.7
-1.1	-1.0	-.2	-.2
-.7	-1.4	-.3	.0
4.9	-.7	-.3	-.6
12.6	.4	-.4	-.0
22.6	4.5	.1	-.5
28.2	7.0	-.0	-.1
31.1	10.6	-1.9	-.4
32.0	15.9	-.9	-.7
33.8	23.5	3.1	.6
34.6	26.6	6.2	.6
33.5	28.4	7.5	.1
34.0	30.8	7.9	-.8
33.7	31.2	9.4	-1.4
33.5	29.7	10.2	-1.3
33.5	29.7	10.2	-1.3
33.7	31.2	9.4	-1.4
34.0	30.8	7.9	-.8
33.5	28.4	7.5	.1
34.6	26.6	6.2	.6
33.8	23.5	3.1	.6
32.0	15.9	-.9	-.7
31.1	10.6	-1.9	-.4
28.2	7.0	-.0	-.1
22.6	4.5	.1	-.5
12.6	.4	-.4	-.0
4.9	-.7	-.3	-.6
-.7	-1.4	-.3	.0
-1.1	-1.0	-.2	-.2
-1.5	-.6	-.4	.7
-1.2	.3	-.3	.1
-.3	-.4	-.0	-.0
-.0	.4	-.6	.3
-.1	-.2	.1	.2
.3	.0	-1.1	.2
-.6	.7	.3	.6
-.4	-.1	-1.3	.3
-.7	.8	.1	.4
-.7	-.2	-.8	.1
-.7	.7	.1	.9
-.2	.2	-1.2	-.4
-.5	.8	-.2	.8
-.4	.6	-.8	.1
-1.0	.2	-1.2	.0
.2	1.5	-.0	1.3
-1.2	-.0	-1.6	-.7
.0	1.3	-.7	.3

10. Example 13 - Orthogonal Polynomial Expansion

The program XMARR reconstructs projection data for a ring detector using the algorithm developed by R. Marr for representing the reconstructed image as an expansion of orthogonal polynomials. The simulated data for Example 13 are for a ring detector of 64 crystals, which is equivalent to 64 projection angles. The reconstructed image has a polynomial expansion with maximum degree equal to 62 (statement E13.053).

The user should study the description of GETUM in section III.4 before using the MARR reconstruction algorithm. The MARR algorithm requires that the data are input first for adjacent detectors, then for detectors spaced 2 apart, and so forth. This data format is illustrated in the printout given in this example.

```
      PROGRAM XMARR (INPUT,OUTPUT,TAPE1,TAPE2=OUTPUT)
C
C        EXAMPLE 13
C
C             THE PROGRAM XMARR RECONSTRUCTS PROJECTION DATA FOR A RING
C        DETECTOR USING THE ALGORITHM DEVELOPED BY MARR FOR REPRESENTING
C        THE RECONSTRUCTED IMAGE AS AN EXPANSION OF ORTHOGONAL
C        POLYNOMIALS.
C
      DIMENSION B(4096)
      COMMON WORK(3000)
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT  - OUTPUT FILE
C          I80132  - OUTPUT LINE LENGTH FLAG
C                =0    EACH LINE WILL BE WITHIN 80 CHARACTERS
C                        (OTHERWISE 132 CHARACTERS)
C
      COMMON/PARM/IPAR(12),PAR(3)
C
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)),
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)),
     2            (IMIT  ,IPAR( 7)),(NWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)),
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)),
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3))
C
C
      LUNOUT=2
      I80132=0
C
C        THE INPUT PARAMETERS ARE
C
      NDIMU=64
      ICIR=0
      IGEOM=3
      NANG=64
      MODANG=5
      KDIMU=100
      IMIT=1
      NWORK=3000
      NFLOAT=1
      ISTORE=0
      IPRINT=7
      LUNATN=0
      PI=4.*ATAN(1.)
      PWID=FLOAT(NANG)/(PI*FLOAT(NDIMU))
      AXISU=50.5
      RFAN=0.
C
      CALL SETUP (IPAR,PAR,AG)
C
      NDEG=62
      CALL MARR (B,NDEG)
C
      CALL ARRAY (B,NDIMU)
C
C        PRINTOUT OF THE VALUES FOR THE RECONSTRUCTED TRANSVERSE SECTION
C
      NMAT=NDIMU**2
      KK1=1
      KU=NDIMU/15+1
      DO 12 K=1,KU
      WRITE (2,14)
      KK2=15*K
      IF (KK2.GT.NDIMU) KK2=NDIMU
      DO 10 J=1,NDIMU
      ISUB1=NMAT-J*NDIMU+KK1
      ISUB2=NMAT-J*NDIMU+KK2
   10 WRITE (2,16) (B(I),I=ISUB1,ISUB2)
      KK1=KK2+1
   12 CONTINUE
C
C
C
   14 FORMAT(1X///////)
   16 FORMAT(1X,15F5.1)
      END
```

```
      SUBROUTINE GETUM (M,D,E)
C
C        EXAMPLE 13
C
C             THIS GETUM SUBROUTINE GENERATES PROJECTION DATA FOR A RING
C        DETECTOR OF A CHEST PHANTOM CONSISTING OF A HEART, LUNGS AND
C        SURROUNDING TISSUE.
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT  - OUTPUT FILE
C          I80132  - OUTPUT LINE LENGTH FLAG
C                =0    EACH LINE WILL BE WITHIN 80 CHARACTERS
C                        (OTHERWISE 132 CHARACTERS)
C
      COMMON/PARM/IPAR(12),PAR(3)
C
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)),
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)),
     2            (IMIT  ,IPAR( 7)),(NWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)),
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)),
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3))
C
      DIMENSION D(1),E(1),B2(4096)
      DIMENSION A(5),B(5),X(5),Y(5),Z(5),PHI(5),ITYPE(5)
      DATA NPHAN/4/,
     1A/40.,10.,14.,14./,
     2B/40.,10.,10.,10./,
     3X/0.,0.,10.,-10./,
     4Y/0.,-10.,0.,0./,
     5Z/5.,27.,-4.,-4./,
     6PHI/0.,0.,0.,0./,
     7ITYPE/1,1,1,1/
C
      DATA IFLG/0/
C
      IF (IFLG.NE.0) GO TO 12
      IFLG=1
      PI=4.*ATAN(1.)
      PHI(3)=PI/2.
      PHI(4)=PI/2.
C
C        SCALE PHANTOM PARAMETERS TO SIZE OF RING
C
      FAC=FLOAT(NDIMU)/64.*PWID
      DO 10 I=1,NPHAN
      A(I)=A(I)*FAC
      B(I)=B(I)*FAC
      X(I)=X(I)*FAC
      Y(I)=Y(I)*FAC
   10 CONTINUE
C
      PWIDTH=PWID
      IF (IMIT.EQ.0) PWIDTH=-PWID
      CALL PHAN (NPHAN,10,ITYPE,Z,X,Y,A,B,PHI,B2,NDIMU,PWIDTH)
      CALL ARRAY (B2,NDIMU)
C
   12 CALL PHANL (NPHAN,ITYPE,Z,X,Y,A,B,PHI,D,E,M)
C
      RETURN
C
      END
```

```
 SSS  EEEEE TTTTT U   U PPPP
S     E       T   U   U P   P
 SSS  EEE     T   U   U PPPP
    S E       T   U   U P
 SSS  EEEEE   T    UUU  P
```

INTEGER PARAMETER ARRAY (IPAR)

I	IPAR(I)		DESCRIPTION
1	64		LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
2	0	NA	NOT APPLICABLE (RING GEOMETRY)
3	3		GEOMETRY FLAG RING DETECTOR GEOMETRY
4	64		NUMBER OF PROJECTION ANGLES (EQUAL TO NUMBER OF CRYSTALS)
5	5	NA	NOT APPLICABLE (RING GEOMETRY)
6	100	NA	NOT APPLICABLE (RING GEOMETRY)
7	1		TRANSMISSION DATA
8	3000		DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
9	1		NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10	0		EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11	7		PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES) PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED PRINT PROJECTION DATA AND UNCERTAINTIES PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
12	0	NA	NOT APPLICABLE (RING GEOMETRY)

FLOATING POINT PARAMETER ARRAY (PAR)

I	PAR(I)		DESCRIPTION
1	.318		PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
2	50.500	NA	NOT APPLICABLE (RING GEOMETRY)
3	0	NA	NOT APPLICABLE (RING GEOMETRY)

```
BLANK COMMON REQUIRED       128    (   200)

BLANK COMMON REQUIRED       256    (   400)

BLANK COMMON REQUIRED       384    (   600)

BLANK COMMON REQUIRED       512    (  1000)

       MAXIMUM SIZE OF BLANK COMMON THUS FAR=    512 FLOATING POINT WORDS.
```

```
EEEEE N   N DDDD         SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D       S     E       T   U   U P   P
EEE   N N N D   D        SSS  EEE     T   U   U PPPP
E     N  NN D   D           S E       T   U   U P
EEEEE N   N DDDD         SSS  EEEEE   T    UUU  P
```

```
M   M  AAA  RRRR  RRRR
MM MM A   A R   R R   R
M M M A   A RRRR  RRRR
M   M AAAAA R  R  R  R
M   M A   A R   R R   R
```

PARAMETERS FOR SUBROUTINE MARR

		DESCRIPTION
NXTAL -	64	NUMBER OF CRYSTALS
NDEG -	62	DEGREE OF THE POLYNOMIAL

```
BLANK COMMON REQUIRED      2528    (  4740)

BLANK COMMON REQUIRED      2656    (  5140)

BLANK COMMON REQUIRED      2718    (  5236)

BLANK COMMON REQUIRED      2780    (  5334)

BLANK COMMON REQUIRED      2812    (  5374)

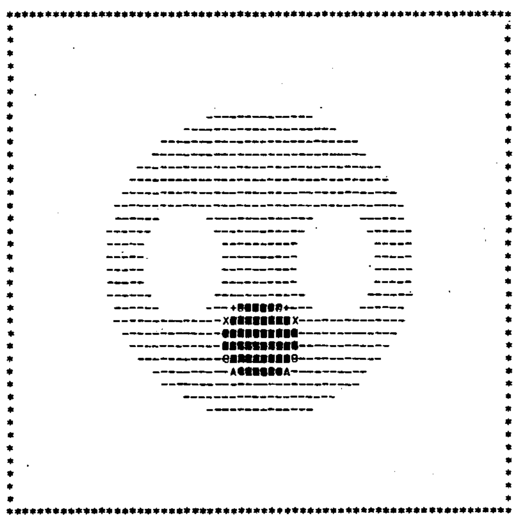
BLANK COMMON REQUIRED      2844    (  5434)
```

```
PPPP  H   H  AAA  N   N
P   P H   H A   A NN  N
PPPP  HHHHH A   A N N N
P     H   H AAAAA N  NN
P     H   H A   A N   N
```

```
PHANTOM GENERATED
  ARRAY SIZE   64 X  64   INTEGRATION FACTOR =  10   SCALING FACTOR =    3.142
  NUMBER OF ELIPSES AND/OR RECTANGLES =    4
  THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
       X,Y   - CENTER
       A,B   - LENGTH OF AXIS OR SIDE A AND B
       PHI   - ANGLE OF AXIS OR SIDE A
       DENS  - INTENSITY
  THE PARENTHESIS INDICATES THE SCALED VALUE
   ITYPE                  X          Y        A         B         PHI      DENS
     1   - ELLIPSE          0 ,        0   12.73 ,   12.73         0       5.00
                   (        0),(       0)( 40.00),(  40.00)             (   1.59)
     1   - ELLIPSE          0 ,    -3.18    3.18 ,    3.18         0      27.00
                   (        0),( -10.00)( 10.00),(  10.00)             (   8.59)
     1   - ELLIPSE       3.18 ,        0    4.46 ,    3.18      1.57      -4.00
                   (  10.00),(       0)( 14.00),(  10.00)             (  -1.27)
     1   - ELLIPSE      -3.18 ,        0    4.46 ,    3.18      1.57      -4.00
                   ( -10.00),(       0)( 14.00),(  10.00)             (  -1.27)
```

```
EEEEE N   N DDDD        PPPP  H   H  AAA  N   N
E     NN  N D   D       P   P H   H A   A NN  N
EEE   N N N D   D       PPPP  HHHHH A   A N N N
E     N  NN D   D       P     H   H AAAAA N  NN
EEEEE N   N DDDD        P     H   H A   A N   N
```

```
XMIN =          0    XMAX =    .10E+02     XSUM =    .2395E+04
```



```
                -          =          +          )          1          Z
      0  .7639E+00  .1884E+01  .2394E+01  .2750E+01  .3158E+01  .3565E+01

Z          X          A          M          B          B          ■          ●
 .3922E+01  .4176E+01  .4431E+01  .4991E+01  .5531E+01  .5908E+01  .6315E+01

■          ■          ■          ■          ■          ■          ■          ■
 .6672E+01  .7436E+01  .8352E+01  .8862E+01  .9269E+01  .9677E+01  .1003E+02

■
 .1019E+02

BLANK COMMON REQUIRED       2876     (  5474)
```

RING DATA FOR DETECTORS SPACED   1 APART

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	

RING DATA FOR DETECTORS SPACED   2 APART

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	

RING DATA FOR DETECTORS SPACED   3 APART

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	

RING DATA FOR DETECTORS SPACED   4 APART

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	

RING DATA FOR DETECTORS SPACED   5 APART

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	

RING DATA FOR DETECTORS SPACED   6 APART

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	

RING DATA FOR DETECTORS SPACED   7 APART

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	

RING DATA FOR DETECTORS SPACED   8 APART

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	

RING DATA FOR DETECTORS SPACED   9 APART

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	

RING DATA FOR DETECTORS SPACED 10 APART

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	

RING DATA FOR DETECTORS SPACED 11 APART

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	

RING DATA FOR DETECTORS SPACED 12 APART

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	

RING DATA FOR DETECTORS SPACED 13 APART

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	

RING DATA FOR DETECTORS SPACED 14 APART

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	

RING DATA FOR DETECTORS SPACED 15 APART

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	

RING DATA FOR DETECTORS SPACED 16 APART

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	

RING DATA FOR DETECTORS SPACED 17 APART

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	

RING DATA FOR DETECTORS SPACED 18 APART

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	

RING DATA FOR DETECTORS SPACED 19 APART

.189E+01	.189E+01	.189E+01	.189E+01	.189E+01
.189E+01	.189E+01	.189E+01	.189E+01	.189E+01
.189E+01	.189E+01	.189E+01	.189E+01	.189E+01
.189E+01	.189E+01	.189E+01	.189E+01	.189E+01
.189E+01	.189E+01	.189E+01	.189E+01	.189E+01
.189E+01	.189E+01	.189E+01	.189E+01	.189E+01
.189E+01	.189E+01	.189E+01	.189E+01	.189E+01
.189E+01	.189E+01	.189E+01	.189E+01	.189E+01
.189E+01	.189E+01	.189E+01	.189E+01	.189E+01
.189E+01	.189E+01	.189E+01	.189E+01	.189E+01
.189E+01	.189E+01	.189E+01	.189E+01	.189E+01
.189E+01	.189E+01	.189E+01	.189E+01	.189E+01
.189E+01	.189E+01	.189E+01	.189E+01	

RING DATA FOR DETECTORS SPACED 20 APART

.286E+01	.286E+01	.286E+01	.286E+01	.286E+01
.286E+01	.286E+01	.286E+01	.286E+01	.286E+01
.286E+01	.286E+01	.286E+01	.286E+01	.286E+01
.286E+01	.286E+01	.286E+01	.286E+01	.286E+01
.286E+01	.286E+01	.286E+01	.286E+01	.286E+01
.286E+01	.286E+01	.286E+01	.286E+01	.286E+01
.286E+01	.286E+01	.286E+01	.286E+01	.286E+01
.286E+01	.286E+01	.286E+01	.286E+01	.286E+01
.286E+01	.286E+01	.286E+01	.286E+01	.286E+01
.286E+01	.286E+01	.286E+01	.286E+01	.286E+01
.286E+01	.286E+01	.286E+01	.286E+01	.286E+01
.286E+01	.286E+01	.286E+01	.286E+01	.286E+01
.286E+01	.286E+01	.286E+01	.286E+01	

RING DATA FOR DETECTORS SPACED 21 APART

.355E+01	.355E+01	.355E+01	.355E+01	.355E+01
.355E+01	.355E+01	.355E+01	.355E+01	.355E+01
.355E+01	.355E+01	.355E+01	.355E+01	.355E+01
.355E+01	.355E+01	.355E+01	.355E+01	.355E+01
.355E+01	.355E+01	.355E+01	.355E+01	.355E+01
.355E+01	.355E+01	.355E+01	.355E+01	.355E+01
.355E+01	.355E+01	.355E+01	.355E+01	.355E+01
.355E+01	.355E+01	.355E+01	.355E+01	.355E+01
.355E+01	.355E+01	.355E+01	.355E+01	.355E+01
.355E+01	.355E+01	.355E+01	.355E+01	.355E+01
.355E+01	.355E+01	.355E+01	.355E+01	.355E+01
.355E+01	.355E+01	.355E+01	.355E+01	.355E+01
.355E+01	.355E+01	.355E+01	.355E+01	

RING DATA FOR DETECTORS SPACED 22 APART

.410E+01	.410E+01	.410E+01	.410E+01	.410E+01
.410E+01	.410E+01	.410E+01	.410E+01	.410E+01
.410E+01	.410E+01	.410E+01	.410E+01	.410E+01
.410E+01	.410E+01	.410E+01	.410E+01	.410E+01
.410E+01	.410E+01	.410E+01	.410E+01	.410E+01
.410E+01	.410E+01	.410E+01	.410E+01	.410E+01
.410E+01	.410E+01	.410E+01	.410E+01	.410E+01
.410E+01	.410E+01	.410E+01	.410E+01	.410E+01
.410E+01	.410E+01	.410E+01	.410E+01	.410E+01
.410E+01	.410E+01	.410E+01	.410E+01	.410E+01
.410E+01	.410E+01	.410E+01	.410E+01	.410E+01
.410E+01	.410E+01	.410E+01	.410E+01	.410E+01
.410E+01	.410E+01	.410E+01	.410E+01	

RING DATA FOR DETECTORS SPACED 23 APART

.456E+01	.456E+01	.456E+01	.456E+01	.456E+01
.456E+01	.456E+01	.456E+01	.456E+01	.456E+01
.456E+01	.456E+01	.456E+01	.456E+01	.423E+01
.392E+01	.373E+01	.358E+01	.348E+01	.341E+01
.338E+01	.338E+01	.341E+01	.348E+01	.358E+01
.373E+01	.392E+01	.423E+01	.456E+01	.456E+01
.456E+01	.456E+01	.769E+01	.896E+01	.966E+01
.101E+02	.102E+02	.102E+02	.101E+02	.966E+01
.896E+01	.769E+01	.456E+01	.456E+01	.456E+01
.456E+01	.423E+01	.392E+01	.373E+01	.358E+01
.348E+01	.341E+01	.338E+01	.338E+01	.341E+01
.348E+01	.358E+01	.373E+01	.392E+01	.423E+01
.456E+01	.456E+01	.456E+01	.456E+01	

RING DATA FOR DETECTORS SPACED 24 APART

.494E+01	.494E+01	.494E+01	.494E+01	.494E+01
.494E+01	.494E+01	.494E+01	.494E+01	.494E+01
.494E+01	.447E+01	.419E+01	.399E+01	.383E+01
.370E+01	.359E+01	.350E+01	.343E+01	.339E+01
.338E+01	.339E+01	.343E+01	.350E+01	.359E+01
.370E+01	.383E+01	.399E+01	.419E+01	.809E+01
.102E+02	.111E+02	.117E+02	.121E+02	.123E+02
.124E+02	.125E+02	.124E+02	.123E+02	.121E+02
.117E+02	.111E+02	.102E+02	.809E+01	.419E+01
.399E+01	.383E+01	.370E+01	.359E+01	.350E+01
.343E+01	.339E+01	.338E+01	.339E+01	.343E+01
.350E+01	.359E+01	.370E+01	.383E+01	.399E+01
.419E+01	.447E+01	.494E+01	.494E+01	

RING DATA FOR DETECTORS SPACED 25 APART

.526E+01	.526E+01	.526E+01	.526E+01	.526E+01
.526E+01	.526E+01	.526E+01	.497E+01	.459E+01
.437E+01	.420E+01	.406E+01	.393E+01	.383E+01
.374E+01	.366E+01	.360E+01	.356E+01	.354E+01
.354E+01	.356E+01	.360E+01	.366E+01	.374E+01
.383E+01	.616E+01	.897E+01	.104E+02	.114E+02
.122E+02	.129E+02	.134E+02	.135E+02	.136E+02
.136E+02	.136E+02	.136E+02	.135E+02	.134E+02
.129E+02	.122E+02	.114E+02	.104E+02	.897E+01
.616E+01	.383E+01	.374E+01	.366E+01	.360E+01
.356E+01	.354E+01	.354E+01	.356E+01	.360E+01
.366E+01	.374E+01	.383E+01	.393E+01	.406E+01
.420E+01	.437E+01	.459E+01	.497E+01	

RING DATA FOR DETECTORS SPACED 26 APART

.507E+01	.553E+01	.553E+01	.553E+01	.553E+01
.553E+01	.507E+01	.477E+01	.458E+01	.443E+01
.430E+01	.420E+01	.410E+01	.402E+01	.395E+01
.390E+01	.385E+01	.383E+01	.381E+01	.380E+01
.381E+01	.383E+01	.385E+01	.390E+01	.736E+01
.963E+01	.109E+02	.118E+02	.123E+02	.127E+02
.130E+02	.132E+02	.135E+02	.139E+02	.139E+02
.139E+02	.139E+02	.139E+02	.135E+02	.132E+02
.130E+02	.127E+02	.123E+02	.118E+02	.109E+02
.963E+01	.736E+01	.390E+01	.385E+01	.383E+01
.381E+01	.380E+01	.381E+01	.383E+01	.385E+01
.390E+01	.395E+01	.402E+01	.410E+01	.420E+01
.430E+01	.443E+01	.458E+01	.477E+01	

RING DATA FOR DETECTORS SPACED 27 APART

.496E+01	.523E+01	.576E+01	.576E+01	.523E+01
.496E+01	.478E+01	.464E+01	.453E+01	.444E+01
.436E+01	.430E+01	.425E+01	.421E+01	.419E+01
.418E+01	.418E+01	.419E+01	.419E+01	.419E+01
.419E+01	.418E+01	.817E+01	.102E+02	.114E+02
.121E+02	.125E+02	.128E+02	.129E+02	.129E+02
.128E+02	.127E+02	.127E+02	.129E+02	.133E+02
.133E+02	.129E+02	.127E+02	.127E+02	.128E+02
.129E+02	.129E+02	.128E+02	.125E+02	.121E+02
.114E+02	.102E+02	.817E+01	.418E+01	.419E+01
.419E+01	.419E+01	.419E+01	.418E+01	.418E+01
.419E+01	.421E+01	.425E+01	.430E+01	.436E+01
.444E+01	.453E+01	.464E+01	.478E+01	

RING DATA FOR DETECTORS SPACED 28 APART

.495E+01	.511E+01	.481E+01	.511E+01	.495E+01
.482E+01	.473E+01	.465E+01	.459E+01	.454E+01
.451E+01	.450E+01	.451E+01	.453E+01	.458E+01
.464E+01	.471E+01	.476E+01	.478E+01	.476E+01
.904E+01	.109E+02	.120E+02	.126E+02	.129E+02
.129E+02	.128E+02	.126E+02	.123E+02	.119E+02
.115E+02	.111E+02	.109E+02	.108E+02	.104E+02
.108E+02	.109E+02	.111E+02	.115E+02	.119E+02
.123E+02	.126E+02	.128E+02	.129E+02	.129E+02
.126E+02	.120E+02	.109E+02	.904E+01	.476E+01
.478E+01	.476E+01	.471E+01	.464E+01	.458E+01
.453E+01	.451E+01	.450E+01	.451E+01	.454E+01
.459E+01	.465E+01	.473E+01	.482E+01	

RING DATA FOR DETECTORS SPACED 29 APART

.438E+01	.424E+01	.424E+01	.438E+01	.488E+01
.481E+01	.477E+01	.474E+01	.473E+01	.474E+01
.477E+01	.484E+01	.495E+01	.511E+01	.534E+01
.569E+01	.608E+01	.508E+01	.106E+02	.125E+02
.132E+02	.135E+02	.135E+02	.134E+02	.130E+02
.125E+02	.118E+02	.110E+02	.101E+02	.894E+01
.760E+01	.488E+01	.438E+01	.424E+01	.424E+01
.438E+01	.488E+01	.760E+01	.894E+01	.101E+02
.110E+02	.118E+02	.125E+02	.130E+02	.134E+02
.135E+02	.135E+02	.132E+02	.125E+02	.106E+02
.508E+01	.608E+01	.569E+01	.534E+01	.511E+01
.495E+01	.484E+01	.477E+01	.474E+01	.473E+01
.474E+01	.477E+01	.481E+01	.488E+01	

RING DATA FOR DETECTORS SPACED 30 APART

.397E+01	.394E+01	.397E+01	.407E+01	.429E+01
.488E+01	.489E+01	.491E+01	.497E+01	.508E+01
.524E+01	.553E+01	.617E+01	.617E+01	.617E+01
.617E+01	.110E+02	.127E+02	.138E+02	.144E+02
.146E+02	.145E+02	.142E+02	.129E+02	.117E+02
.103E+02	.831E+01	.491E+01	.489E+01	.488E+01
.429E+01	.407E+01	.397E+01	.394E+01	.397E+01
.407E+01	.429E+01	.488E+01	.489E+01	.491E+01
.831E+01	.103E+02	.117E+02	.129E+02	.142E+02
.145E+02	.146E+02	.144E+02	.138E+02	.127E+02
.110E+02	.617E+01	.617E+01	.617E+01	.617E+01
.553E+01	.524E+01	.508E+01	.497E+01	.491E+01
.489E+01	.488E+01	.429E+01	.407E+01	

RING DATA FOR DETECTORS SPACED 31 APART

.380E+01	.380E+01	.384E+01	.394E+01	.411E+01
.440E+01	.511E+01	.523E+01	.545E+01	.591E+01
.623E+01	.623E+01	.623E+01	.754E+01	.113E+02
.129E+02	.139E+02	.145E+02	.147E+02	.145E+02
.141E+02	.133E+02	.121E+02	.103E+02	.591E+01
.545E+01	.523E+01	.511E+01	.440E+01	.411E+01
.394E+01	.384E+01	.380E+01	.380E+01	.384E+01
.394E+01	.411E+01	.440E+01	.511E+01	.523E+01
.545E+01	.591E+01	.103E+02	.121E+02	.133E+02
.141E+02	.145E+02	.147E+02	.145E+02	.139E+02
.129E+02	.113E+02	.754E+01	.623E+01	.623E+01
.623E+01	.591E+01	.545E+01	.523E+01	.511E+01
.440E+01	.411E+01	.394E+01	.384E+01	

RING DATA FOR DETECTORS SPACED 32 APART

.375E+01	.377E+01	.383E+01	.394E+01	.411E+01
.439E+01	.487E+01	.625E+01	.625E+01	.625E+01
.625E+01	.906E+01	.117E+02	.131E+02	.140E+02
.145E+02	.147E+02	.145E+02	.140E+02	.131E+02
.117E+02	.906E+01	.625E+01	.625E+01	.625E+01
.625E+01	.487E+01	.439E+01	.411E+01	.394E+01
.383E+01	.377E+01			

BLANK COMMON REQUIRED 850 (1534)

BLANK COMMON REQUIRED 732 (1334)

BLANK COMMON REQUIRED 670 (1236)

BLANK COMMON REQUIRED 608 (1140)

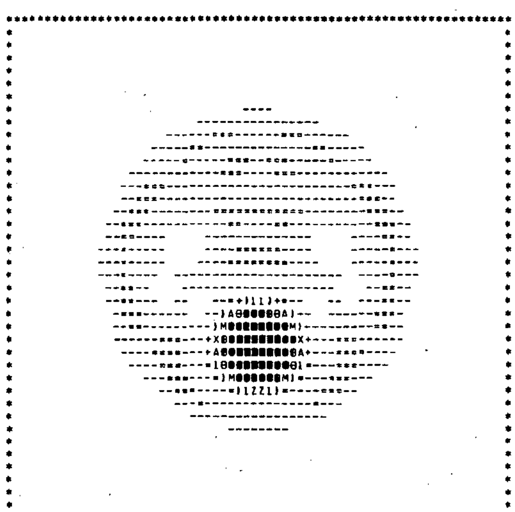
BLANK COMMON REQUIRED 576 (1100)

BLANK COMMON REQUIRED 544 (1040)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 2875 FLOATING POINT WORDS.

```
EEEEE N   N DDDD        M   M  AAA  RRRR  RRRR
E     NN  N D   D       MM MM A   A R   R R   R
EEE   N N N D   D       M M M A   A RRRR  RRRR
E     N  NN D   D       M   M AAAAA R  R  R  R
EEEEE N   N DDDD        M   M A   A R   R R   R
```

XMIN = -.57E+00 XMAX = .12E+02 XSUM = .2386E+04



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            -          =          +          )          1          Z
-.5558E+00  .3438E+00  .1679E+01  .2286E+01  .2711E+01  .3197E+01  .3683E+01

Z           X          A          M          9          8          3          ■
 .4108E+01  .4411E+01  .4715E+01  .5382E+01  .6050E+01  .6475E+01  .6961E+01

■           ■          ■          ■          ■          ■          ■          ■
 .7386E+01  .8296E+01  .9389E+01  .9996E+01  .1048E+02  .1097E+02  .1139E+02

■
 .1157E+02
```

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	.1
0	0	0	0	0	0	0	0	0	0	0	0	0	.1	-.0
0	0	0	0	0	0	0	0	0	0	0	.0	.1	.1	.0
0	0	0	0	0	0	0	0	0	0	-.2	.1	.1	.0	.0
0	0	0	0	0	0	0	0	0	-.2	-.0	-.1	-.0	.1	.1
0	0	0	0	0	0	0	0	.0	.0	-.1	-.1	.0	.1	.0
0	0	0	0	0	0	0	.2	.1	-.1	-.1	.0	.0	-.1	-.1
0	0	0	0	0	0	0	.1	.0	-.1	.0	.0	-.1	-.1	-.0
0	0	0	0	0	0	-.0	.1	.0	.1	.1	-.1	-.2	-.1	.1
0	0	0	0	0	.0	-.0	.0	.1	.1	.0	-.1	-.1	.0	.1
0	0	0	0	0	-.1	.0	.0	.1	.1	-.0	-.0	.1	.1	-.0
0	0	0	0	.1	-.0	.0	-.0	.0	.0	.0	.1	.1	.0	-.2
0	0	0	-.3	-.1	.1	-.1	-.1	.0	.0	.0	.1	.1	-.0	-.2
0	0	0	.0	.1	.0	-.1	.0	.0	-.0	.0	.1	.1	-.1	-.1
0	0	0	-.2	.2	-.1	-.1	.1	-.0	-.1	.0	.1	.0	-.1	.1
0	0	.1	-.1	.0	-.2	.1	.1	-.1	-.1	.0	.0	-.0	-.0	.2
0	0	-.2	.1	-.1	-.1	.1	.0	-.2	-.1	.0	.0	-.1	.0	.5
0	.0	-.1	.1	-.2	-.0	.1	-.1	-.1	-.0	.1	-.0	-.1	.1	.7
0	.2	.1	.0	-.1	.1	.0	-.1	-.1	.1	.1	-.1	-.1	.3	1.0
0	.1	.2	.0	.0	.1	-.0	-.1	.0	.1	-.0	-.1	.0	.6	1.3
0	.1	.1	.1	.1	.1	-.0	.0	.1	.1	-.1	-.1	.2	.9	1.6
.1	.1	.0	.2	.1	.0	.0	.1	.1	-.0	-.1	.0	.5	1.2	1.8
-.2	.0	-.1	.2	.1	-.0	.1	.2	.1	-.1	-.1	.2	.8	1.4	1.9
-.3	-.1	-.2	.1	-.0	-.1	.1	.2	.0	-.2	-.1	.3	1.0	1.6	1.9
-.2	-.2	-.2	.0	-.1	-.1	.1	.2	-.0	-.2	-.1	.5	1.1	1.6	1.8
-.1	-.2	-.2	-.0	-.2	-.2	.1	.1	-.1	-.2	-.0	.5	1.1	1.6	1.7
-.1	-.1	-.1	-.0	-.2	-.2	.0	.0	-.1	-.2	-.0	.5	1.1	1.5	1.7
-.0	.0	.0	.0	-.2	-.2	-.0	-.0	-.2	-.2	-.0	.4	1.0	1.5	1.7
.0	.1	.1	.1	-.1	-.1	-.0	-.1	-.1	-.2	-.0	.3	.9	1.4	1.8
.1	.0	.1	.1	.1	.0	-.0	-.1	-.1	-.1	-.1	.2	.8	1.4	1.9
.2	-.0	.1	.0	.1	.1	.0	-.0	-.0	-.0	-.0	.1	.7	1.4	1.9
.2	-.1	.1	-.1	.1	.2	.0	-.0	.1	.1	-.0	.0	.5	1.3	1.9
-.4	-.2	.1	-.2	.0	.2	.0	-.0	.1	.2	.0	-.0	.4	1.1	1.8
0	-.2	.2	-.1	-.1	.2	.0	-.1	.1	.2	.1	-.1	.2	.9	1.7
0	-.1	.2	-.0	-.1	.1	.0	-.1	.0	.2	.1	-.1	.1	.7	1.4
0	.2	.1	.1	-.1	.1	.0	-.2	-.1	.1	.0	-.2	-.1	.5	1.2
0	-.2	-.1	.1	-.1	.0	.0	-.2	-.1	.1	-.0	-.2	-.2	.3	1.0
0	0	-.2	.0	-.1	-.0	.0	-.2	-.1	.0	.0	-.2	-.3	.1	.7
0	0	.0	-.1	-.1	-.0	.1	-.1	-.1	.1	.1	-.1	-.3	-.1	.4
0	0	0	-.1	-.1	-.1	.1	-.1	-.1	.1	.2	.0	-.3	-.2	.1
0	0	0	-.1	.0	-.1	.1	.0	-.1	.0	.2	.2	-.1	-.3	-.1
0	0	0	.2	.2	-.1	.0	.1	-.1	-.1	.1	.2	.0	-.2	-.2
0	0	0	0	-.1	.1	-.1	.2	.0	-.2	-.0	.2	.1	-.1	-.2
0	0	0	0	0	.2	-.1	.0	.1	-.1	-.2	-.0	.1	.0	-.1
0	0	0	0	0	-.2	.1	-.2	.1	.1	-.1	-.1	-.0	-.0	-.0
0	0	0	0	0	0	-.1	-.1	-.1	.1	-.0	-.1	-.0	-.0	-.1
0	0	0	0	0	0	0	.0	-.1	-.0	.0	-.0	.1	.1	-.1
0	0	0	0	0	0	0	-.0	.1	.0	.0	-.0	.0	.2	.1
0	0	0	0	0	0	0	0	.0	.0	.1	.0	-.1	.0	.2
0	0	0	0	0	0	0	0	0	.1	-.1	.2	.1	-.2	-.1
0	0	0	0	0	0	0	0	0	0	.2	-.2	.1	.1	-.2
0	0	0	0	0	0	0	0	0	0	0	-.2	-.2	.0	.2
0	0	0	0	0	0	0	0	0	0	0	0	0	.1	-.2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	.5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0	0	-.6	.2	.2	.1
0	0	0	0	0	0	0	-.3	.2	-.0	-.2	-.1	-.1	-.0	.1
0	0	0	0	0	.2	-.3	-.2	.1	.3	.3	.2	-.0	-.2	-.2
0	0	-.2	.1	-.0	.1	.1	.0	-.0	-.1	-.1	-.2	-.2	-.2	-.1
0	-.1	-.1	.2	.2	-.0	-.2	-.2	-.1	.0	.1	.2	.2	.2	.2
-.2	-.0	.1	-.0	-.1	-.1	.0	.1	.2	.1	.1	.1	-.0	-.1	-.1
-.0	-.1	-.1	-.0	.1	.2	.2	.1	-.1	-.1	-.2	-.2	-.2	-.2	-.2
-.1	-.1	.0	.1	.1	.0	-.1	-.2	-.2	-.1	-.1	.0	.1	.1	.2
.0	.0	.0	-.0	-.1	-.1	-.1	-.0	.1	.2	.2	.2	.2	.2	.2
.1	-.0	-.1	-.1	-.1	.0	.1	.2	.2	.2	.1	-.0	-.1	-.2	-.2
-.0	-.0	-.0	.0	.1	.1	.1	.1	.0	-.1	-.2	-.3	-.3	-.3	-.3
-.0	.1	.1	.1	.1	-.0	-.1	-.2	-.2	-.2	-.1	-.0	.1	.2	.3
.1	.2	.1	.0	-.1	-.2	-.2	-.2	-.0	.2	.4	.7	.9	1.1	1.2
.1	.1	-.0	-.1	-.2	-.1	.0	.2	.5	.8	1.1	1.4	1.6	1.7	1.7
-.0	-.1	-.2	-.1	.0	.3	.6	.9	1.2	1.4	1.6	1.7	1.8	1.7	1.7
-.2	-.2	-.1	.1	.5	.8	1.2	1.4	1.6	1.7	1.7	1.7	1.6	1.6	1.5
-.2	-.1	.1	.5	.9	1.3	1.5	1.7	1.7	1.7	1.6	1.6	1.5	1.5	1.4
-.1	.1	.5	.9	1.3	1.5	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.6
.1	.5	.9	1.2	1.5	1.6	1.7	1.7	1.6	1.6	1.6	1.6	1.7	1.8	1.8
.4	.9	1.2	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.7	1.7	1.8	1.8
.7	1.2	1.6	1.7	1.7	1.7	1.7	1.6	1.6	1.5	1.5	1.6	1.6	1.6	1.6
1.1	1.6	1.8	1.8	1.7	1.7	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.4
1.4	1.8	2.0	1.9	1.7	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.6	1.6	1.5
1.7	2.0	2.0	1.7	1.5	1.4	1.4	1.5	1.5	1.5	1.6	1.7	1.8	1.8	1.7
1.8	2.0	1.8	1.5	1.2	1.1	1.2	1.3	1.4	1.5	1.6	1.8	1.9	2.0	1.9
1.9	1.9	1.5	1.1	.9	.8	.9	1.0	1.1	1.3	1.4	1.7	1.8	1.9	1.9
1.9	1.7	1.3	.9	.6	.6	.6	.7	.8	.9	1.1	1.4	1.6	1.7	1.6
1.9	1.6	1.1	.7	.5	.4	.3	.3	.4	.5	.7	1.0	1.3	1.4	1.4
1.8	1.4	1.0	.7	.4	.3	.2	.1	.0	.1	.4	.8	1.2	1.4	1.5
1.7	1.3	1.0	.7	.5	.3	.1	-.0	-.1	.0	.4	.9	1.3	1.6	1.7
1.6	1.3	.9	.7	.5	.3	.2	.1	.0	.2	.5	1.0	1.5	1.8	2.0
1.6	1.2	.9	.6	.4	.3	.3	.2	.3	.4	.8	1.2	1.6	1.9	2.0
1.6	1.2	.8	.5	.3	.3	.3	.4	.5	.6	.8	1.1	1.4	1.5	1.6
1.7	1.3	.7	.3	.1	.2	.4	.5	.6	.6	.7	.8	.9	1.0	1.1
1.8	1.4	.7	.2	-.0	.1	.3	.5	.5	.4	.4	.4	.6	.8	1.0
2.0	1.5	.8	.2	.0	.2	.4	.4	.3	.2	.1	.3	.7	1.2	1.6
2.1	1.7	1.0	.4	.3	.4	.5	.4	.2	.0	.1	.6	1.4	2.4	3.3
2.1	1.8	1.2	.7	.6	.7	.8	.6	.2	.1	.4	1.3	2.7	4.1	5.4
2.0	1.8	1.4	1.1	1.1	1.2	1.1	.8	.4	.4	1.0	2.3	4.1	6.0	7.6
1.8	1.8	1.5	1.4	1.5	1.6	1.5	1.1	.7	.8	1.7	3.3	5.4	7.5	9.1
1.7	1.7	1.6	1.6	1.7	1.9	1.7	1.3	1.0	1.2	2.2	4.1	6.4	8.5	10.1
1.5	1.6	1.6	1.7	1.5	2.0	1.8	1.4	1.1	1.4	2.6	4.6	6.9	9.0	10.5
1.3	1.5	1.5	1.7	1.9	2.0	1.8	1.4	1.1	1.4	2.6	4.7	7.0	9.1	10.6
1.0	1.3	1.4	1.6	1.9	2.0	1.8	1.4	1.0	1.1	2.2	4.2	6.6	8.7	10.3
.6	.9	1.2	1.4	1.8	2.0	1.9	1.4	.9	.8	1.6	3.3	5.5	7.7	9.4
.2	.5	.7	1.1	1.5	1.9	2.0	1.6	1.0	.7	1.0	2.1	3.9	5.9	7.6
-.1	.1	.3	.6	1.1	1.7	2.0	1.9	1.4	.8	.7	1.2	2.3	3.8	5.2
-.1	-.1	-.1	.1	.5	1.2	1.8	2.0	1.8	1.3	.9	.8	1.2	2.0	2.9
-.1	-.1	-.1	-.2	.0	.5	1.2	1.8	2.0	1.8	1.4	1.1	.9	1.1	1.4
.0	.1	.0	-.1	-.2	-.1	.4	1.0	1.6	1.8	1.8	1.5	1.3	1.1	1.1
-.0	.1	.2	.1	-.1	-.3	-.2	.2	.7	1.2	1.5	1.6	1.5	1.4	1.3
-.1	-.0	.2	.3	.2	-.0	-.3	-.3	-.1	.2	.6	.9	1.1	1.3	1.3
-.1	-.2	-.1	.1	.3	.3	.1	-.2	-.4	-.4	-.3	-.1	.2	.5	.7
.2	-.1	-.2	-.2	.1	.3	.3	.2	-.1	-.4	-.5	-.5	-.4	-.3	-.1
.2	.2	.0	-.2	-.2	-.0	.2	.3	.3	.1	-.1	-.3	-.4	-.4	-.4
-.2	.1	.3	.2	-.1	-.2	-.2	-.0	.1	.2	.3	.2	.1	.1	.0
-.1	-.3	-.0	.2	.3	.1	-.2	-.3	-.3	-.1	.0	.2	.3	.3	.3
.3	.1	-.2	-.1	.1	.2	.2	-.0	-.2	-.3	-.3	-.2	-.1	.0	.0
-.3	.1	.3	.0	-.2	-.1	.0	.2	.2	.1	-.0	-.1	-.1	-.2	-.2
0	.1	-.3	.2	.2	-.1	-.2	-.2	-.0	.1	.2	.2	.2	.1	.1
0	0	-.5	.0	-.2	.1	.2	-.0	-.1	-.2	-.1	-.0	-.0	.0	.1
0	0	0	0	0	.2	-.2	-.1	.1	.2	.1	.0	-.1	-.1	-.1
0	0	0	0	0	0	0	-.2	.1	-.1	-.1	-.0	.1	.1	.1
0	0	0	0	0	0	0	0	0	0	0	-.2	.1	.1	-.0

.0	.1	.1	.0	.1	.2	.2	-.6	0	0	0	0	0	0	0
.2	.3	.3	.2	.1	-.0	-.1	-.1	-.2	-.0	.2	-.3	0	0	0
-.2	-.1	-.1	-.2	-.2	-.2	-.0	.2	.3	.3	.1	-.2	-.3	.2	0
-.0	.1	.1	-.0	-.1	-.2	-.2	-.2	-.1	-.1	-.0	.0	.1	.1	-.0
.2	.2	.2	.2	.2	.2	.2	.2	.1	.0	-.1	-.2	-.2	-.0	.2
-.2	-.2	-.2	-.2	-.1	-.1	-.0	.1	.1	.1	.2	.1	.0	-.1	-.1
-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.2	-.1	-.1	.1	.2	.2	.1
.2	.2	.2	.2	.2	.1	.1	.0	-.1	-.1	-.2	-.2	-.1	.0	.1
.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.1	-.0	-.1	-.1	-.1
-.2	-.2	-.2	-.2	-.2	-.2	-.1	-.0	.1	.2	.2	.2	.1	.0	-.1
-.3	-.2	-.2	-.3	-.3	-.3	-.3	-.3	-.2	-.1	.0	.1	.1	.1	.1
.4	.4	.4	.4	.3	.2	.1	-.0	-.1	-.2	-.2	-.2	-.1	-.0	.1
1.2	1.2	1.2	1.2	1.2	1.1	.9	.7	.4	.2	-.0	-.2	-.2	-.2	-.1
1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.4	1.1	.8	.5	.2	.0	-.1	-.2
1.7	1.6	1.6	1.7	1.7	1.7	1.8	1.7	1.6	1.4	1.2	.5	.6	.3	.0
1.4	1.4	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.6	1.4	1.2	.8	.5
1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.7	1.5	1.3	.9
1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.5	1.3
1.8	1.7	1.7	1.8	1.8	1.8	1.7	1.6	1.6	1.6	1.6	1.7	1.7	1.6	1.5
1.7	1.6	1.6	1.7	1.8	1.8	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.6
1.5	1.4	1.4	1.5	1.6	1.6	1.6	1.6	1.5	1.5	1.6	1.6	1.7	1.7	1.7
1.3	1.2	1.2	1.3	1.4	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.7	1.7
1.4	1.3	1.3	1.4	1.5	1.6	1.6	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.7
1.6	1.5	1.5	1.6	1.7	1.8	1.8	1.7	1.6	1.5	1.5	1.5	1.4	1.4	1.5
1.8	1.7	1.7	1.8	1.9	2.0	1.9	1.8	1.6	1.5	1.4	1.3	1.2	1.1	1.2
1.8	1.7	1.7	1.8	1.9	1.9	1.8	1.7	1.4	1.3	1.1	1.0	.9	.8	.9
1.5	1.4	1.4	1.5	1.6	1.7	1.6	1.4	1.1	.9	.8	.7	.6	.6	.6
1.3	1.2	1.2	1.3	1.4	1.4	1.3	1.0	.7	.5	.4	.3	.3	.4	.5
1.4	1.3	1.3	1.4	1.5	1.4	1.2	.8	.4	.1	.0	.1	.2	.3	.4
1.7	1.7	1.7	1.7	1.7	1.6	1.3	.8	.4	.0	-.1	-.0	.1	.3	.5
2.0	2.0	2.0	2.0	2.0	1.8	1.5	1.0	.5	.2	.0	.1	.2	.3	.5
2.0	2.0	2.0	2.0	2.0	1.9	1.6	1.2	.8	.4	.3	.2	.3	.3	.4
1.6	1.6	1.6	1.6	1.6	1.5	1.4	1.1	.8	.6	.5	.4	.3	.3	.3
1.1	1.1	1.1	1.1	1.1	1.0	.9	.8	.7	.6	.6	.5	.4	.2	.1
1.0	1.1	1.1	1.0	1.0	.8	.6	.4	.4	.4	.5	.5	.3	.1	-.0
2.0	2.1	2.1	2.0	1.6	1.2	.7	.3	.1	.2	.3	.4	.4	.2	.0
3.9	4.2	4.2	3.9	3.3	2.4	1.4	.6	.1	.0	.2	.4	.5	.4	.3
6.4	6.8	6.8	6.4	5.4	4.1	2.7	1.3	.4	.1	.2	.5	.8	.7	.6
8.6	9.2	9.2	8.6	7.6	6.0	4.1	2.3	1.0	.4	.4	.8	1.1	1.2	1.1
10.2	10.7	10.7	10.2	9.1	7.5	5.4	3.3	1.7	.8	.7	1.1	1.5	1.6	1.5
11.0	11.4	11.4	11.0	10.1	8.5	6.4	4.1	2.2	1.2	1.0	1.3	1.7	1.9	1.7
11.2	11.5	11.5	11.2	10.5	9.0	6.9	4.6	2.6	1.4	1.1	1.4	1.8	2.0	1.9
11.3	11.6	11.6	11.3	10.6	9.1	7.0	4.7	2.6	1.4	1.1	1.4	1.8	2.0	1.9
11.2	11.5	11.5	11.2	10.3	8.7	6.6	4.2	2.2	1.1	1.0	1.4	1.8	2.0	1.9
10.5	11.0	11.0	10.5	9.4	7.7	5.5	3.3	1.6	.8	.9	1.4	1.9	2.0	1.8
8.8	9.4	9.4	8.8	7.6	5.9	3.9	2.1	1.0	.7	1.0	1.6	2.0	1.9	1.5
6.3	6.9	6.9	6.3	5.2	3.8	2.3	1.2	.7	.8	1.4	1.9	2.0	1.7	1.1
3.7	4.1	4.1	3.7	2.9	2.0	1.2	.8	.9	1.3	1.8	2.0	1.8	1.2	.5
1.8	2.0	2.0	1.8	1.4	1.1	.9	1.1	1.4	1.8	2.0	1.8	1.2	.5	.0
1.1	1.2	1.2	1.1	1.1	1.1	1.3	1.5	1.8	1.8	1.6	1.0	.4	-.1	-.2
1.3	1.3	1.3	1.3	1.3	1.4	1.5	1.6	1.5	1.2	.7	.2	-.2	-.3	-.1
1.4	1.4	1.4	1.4	1.3	1.3	1.1	.9	.6	.2	-.1	-.3	-.3	-.0	.2
.8	.9	.9	.8	.7	.5	.2	-.1	-.3	-.4	-.4	-.2	.1	.3	.3
.0	.1	.1	.0	-.1	-.3	-.4	-.5	-.5	-.4	-.1	.2	.3	.3	.1
-.3	-.3	-.3	-.3	-.4	-.4	-.4	-.3	-.1	.1	.3	.3	.2	-.0	-.2
-.0	-.0	-.0	-.0	.0	.1	.1	.2	.3	.2	.1	-.0	-.2	-.2	-.1
.3	.3	.3	.3	.3	.3	.3	.2	.0	-.1	-.3	-.3	-.2	.1	.3
.0	.0	.0	.0	.0	.0	-.1	-.2	-.3	-.3	-.2	-.0	.2	.2	.1
-.2	-.2	-.2	-.2	-.2	-.2	-.1	-.1	-.0	.1	.2	.2	.0	-.1	-.2
.1	.0	.0	.1	.1	.1	.2	.2	.2	.1	-.0	-.2	-.2	-.1	.2
.1	.1	.1	.1	.1	.0	-.0	-.0	-.1	-.2	-.1	-.0	.2	.1	-.2
-.1	-.1	-.1	-.1	-.1	-.1	-.1	.0	.1	.2	.1	-.1	-.2	.2	0
.1	.1	.1	.1	.1	.1	.1	-.0	-.1	-.1	.1	-.2	0	0	0
-.0	-.0	-.0	-.0	-.0	.1	.1	-.2	0	0	0	0	0	0	0

0	0	0	0
0	0	0	0
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0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
-.3	0	0	0
.0	0	0	0
-.2	0	0	0
-.1	.1	0	0
.1	-.2	0	0
.1	-.1	.0	0
.0	.1	.2	0
.0	.2	.1	0
.1	.1	.1	0
.2	.0	.1	.1
.2	-.1	-.0	-.2
.1	-.2	-.1	-.3
.0	-.2	-.2	-.2
-.0	-.2	-.2	-.1
-.0	-.1	-.1	-.1
.0	.0	.0	-.0
.1	.1	.1	.0
.1	.1	.0	.1
.0	.1	-.0	.2
-.1	.1	-.1	.2
-.2	.1	-.2	-.4
-.1	.2	-.2	0
-.0	.2	-.1	0
.1	.1	.2	0
.1	-.1	-.2	0
.0	-.2	0	0
-.1	.0	0	0
-.1	0	0	0
-.1	0	0	0
.2	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
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0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.1	-.2	0	0	0	0	0	0	0	0	0	0	0	0	0
.2	-.1	-.1	0	0	0	0	0	0	0	0	0	0	0	0
-.0	.1	-.0	-.2	.1	0	0	0	0	0	0	0	0	0	0
-.0	-.1	-.1	-.0	-.0	.1	0	0	0	0	0	0	0	0	0
.1	.0	-.1	-.1	.0	.1	.1	.0	0	0	0	0	0	0	0
-.0	.0	.0	.0	.0	.0	.1	.1	-.2	0	0	0	0	0	0
-.1	-.1	-.0	.1	.1	.1	-.0	-.1	-.0	-.2	0	0	0	0	0
.0	-.0	-.0	-.0	.0	.1	.0	-.1	-.1	.0	0	0	0	0	0
.1	.1	.1	-.0	-.1	-.1	.0	.0	-.1	-.1	.1	.2	0	0	0
.0	.1	.2	.1	-.0	-.1	-.1	.0	.0	-.1	.0	.1	0	0	0
-.1	-.0	.1	.1	.1	-.1	-.2	-.1	.1	.1	.0	.1	-.0	0	0
-.1	-.2	-.1	-.0	.1	.0	-.1	-.1	.0	.1	.1	.0	.0	.0	0
.1	-.1	-.2	-.2	-.0	.1	.1	-.0	-.0	.1	.1	.0	-.0	-.1	0
.5	.1	-.1	-.2	-.2	.0	.1	.1	.0	.0	-.0	-.0	-.0	-.0	.1
.9	.5	.1	-.1	-.2	-.0	.1	.1	.0	.0	.0	-.1	-.1	.1	-.1
1.2	.9	.5	.1	-.1	-.1	.1	.1	.0	-.0	.0	.0	.0	.0	.1
1.5	1.2	.9	.4	.1	-.1	.0	.1	.0	-.1	-.0	.1	-.1	-.1	.2
1.7	1.6	1.2	.7	.2	-.0	-.0	.0	.0	-.1	-.1	.1	.1	-.2	.0
1.8	1.8	1.6	1.1	.5	.0	-.1	.0	.0	-.1	-.2	.0	.1	.1	-.1
1.9	2.0	1.8	1.4	.7	.1	-.1	-.0	.1	-.0	-.1	-.1	.1	-.0	-.2
1.7	2.0	2.0	1.7	1.0	.3	-.1	-.1	.1	.1	-.1	-.1	.0	.1	-.1
1.5	1.8	2.0	1.8	1.3	.6	.0	-.1	-.0	.1	.0	-.1	-.0	.1	.0
1.1	1.5	1.9	1.9	1.6	.9	.2	-.1	-.1	.1	.1	.0	-.0	.1	.1
.9	1.3	1.7	1.9	1.8	1.2	.5	.0	-.1	-.0	.1	.1	.0	.0	.1
.7	1.1	1.6	1.9	1.9	1.4	.8	.2	-.1	-.1	.1	.2	.1	-.0	.1
.7	1.0	1.4	1.8	1.9	1.6	1.0	.3	-.1	-.2	.0	.2	.1	-.1	-.0
.7	1.0	1.3	1.7	1.8	1.6	1.1	.5	-.1	-.2	-.0	.2	.1	-.1	-.1
.7	.9	1.3	1.6	1.7	1.6	1.1	.5	-.0	-.2	-.1	.1	.1	-.2	-.2
.6	.9	1.2	1.6	1.7	1.5	1.1	.5	-.0	-.2	-.1	.0	.0	-.2	-.2
.5	.8	1.2	1.6	1.7	1.5	1.0	.4	-.0	-.2	-.2	-.0	-.0	-.2	-.2
.3	.7	1.3	1.7	1.8	1.4	.9	.3	-.0	-.2	-.1	-.1	-.0	-.1	-.1
.2	.7	1.4	1.8	1.9	1.4	.8	.2	-.1	-.1	-.1	-.1	-.0	.0	.1
.2	.8	1.5	2.0	1.9	1.4	.7	.1	-.0	-.0	-.0	-.0	.0	.1	.1
.4	1.0	1.7	2.1	1.9	1.3	.5	.0	-.0	.1	.1	-.0	.0	.2	.1
.7	1.2	1.8	2.1	1.8	1.1	.4	-.0	.0	.2	.1	-.0	.0	.2	.0
1.1	1.4	1.8	2.0	1.7	.9	.2	-.1	.1	.2	.1	-.1	.0	.2	-.1
1.4	1.5	1.8	1.8	1.4	.7	.1	-.1	.1	.2	.0	-.1	.0	.1	-.1
1.6	1.6	1.7	1.7	1.2	.5	-.1	-.2	.0	.1	-.1	-.2	.0	.1	-.1
1.7	1.6	1.6	1.5	1.0	.3	-.2	-.2	-.0	.1	-.1	-.2	.0	.0	-.1
1.7	1.6	1.5	1.3	.7	.1	-.3	-.2	.0	.0	-.1	-.2	.0	-.0	-.1
1.6	1.4	1.3	1.0	.4	-.1	-.3	-.1	.1	.1	-.1	-.1	.1	-.0	-.1
1.4	1.2	.9	.6	.1	-.2	-.3	.0	.2	.1	-.1	-.1	.1	-.1	-.1
1.1	.7	.5	.2	-.1	-.3	-.1	.2	.2	.0	-.1	.0	.1	-.1	.0
.6	.3	.1	-.1	-.2	-.2	.0	.2	.1	-.1	-.1	.1	.0	-.1	.2
.1	-.1	-.1	-.1	-.2	-.1	.1	.2	-.0	-.2	.0	.2	-.1	.1	-.1
-.2	-.1	-.1	-.1	-.1	.0	.1	-.0	-.2	-.1	.1	.0	-.1	.2	0
-.1	.0	.1	.0	-.0	-.0	-.0	-.1	-.1	.1	.1	-.2	.1	-.2	0
.1	.2	.1	-.0	-.1	-.0	-.0	-.1	-.0	.1	-.1	-.1	-.1	0	0
.3	.2	-.0	-.1	-.1	.1	.1	-.0	.0	-.0	-.1	.0	0	0	0
.1	-.1	-.2	-.1	.1	.2	.0	-.0	.0	.0	.1	-.0	0	0	0
-.2	-.2	-.1	.2	.2	.0	-.1	.0	.1	.0	.0	0	0	0	0
-.2	.0	.2	.2	-.1	-.2	.1	.2	-.1	.1	0	0	0	0	0
.2	.3	.1	-.2	-.2	.1	.1	-.2	.2	0	0	0	0	0	0
.2	-.0	-.3	-.1	.2	.0	-.2	-.2	0	0	0	0	0	0	0
-.1	-.2	.1	.3	-.2	.1	0	0	0	0	0	0	0	0	0
.0	.3	.1	-.3	.5	0	0	0	0	0	0	0	0	0	0
.2	-.3	.1	0	0	0	0	0	0	0	0	0	0	0	0
.0	-.5	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

11. Example 14 - Maximum Entropy

The program XENTPY reconstructs parallel-beam projection data by maximizing the entropy of the reconstructed image while satisfying projection constraints. This method of reconstruction should be used for projection data samples that give a system of linear equations that are underdetermined. Also, due to the computer time requirements, this method of reconstruction is best for small array sizes and sample sizes (cf. section VIII). For the example given below, the array size NDIMU is equal to 21 and the number of angles NANG is equal to 4. The maximum number of iterations LIMITX allowed for the determination of the optimum solution is set to 1000 in statement E14.052 and the convergence criterion ERENTX is set to 10^{-6} in statement E14.053. The convergence criterion is satisfied in 127 iterations; therefore the user may want to vary LIMITX and ERENTX to obtain the best results within certain computer time requirements. The value for the entropy of the reconstruction, subject to the constraints, is 5.79.

The subroutine GETUM gives simulated projection data for two rectangular phantoms within a circular disk of a higher intensity. The data are projected using the subroutine PJECT to assure that the data give a system of linear equations that are consistent.

```
      PROGRAM XENTPY (INPUT,OUTPUT,TAPE2=OUTPUT)                         E14.001
C                                                                        E14.002
C        EXAMPLE 14                                                      E14.003
C                                                                        E14.004
C             THE PROGRAM XENTPY RECONSTRUCTS PARALLEL BEAM PROJECTION   E14.005
C        DATA BY MAXIMIZING THE ENTROPY OF THE RECONSTRUCTED IMAGE.      E14.006
C                                                                        E14.007
      DIMENSION B(441),AG(4)                                             E14.008
      COMMON WORK(1500)                                                  E14.009
C                                                                        E14.010
      COMMON/OUTCOM/LUNOUT,I80132                                        E14.011
C                                                                        E14.012
C          LUNOUT  - OUTPUT FILE                                         E14.013
C          I80132  - OUTPUT LINE LENGTH FLAG                             E14.014
C               =0    EACH LINE WILL BE WITHIN 80 CHARACTERS             E14.015
C                       (OTHERWISE 132 CHARACTERS)                       E14.016
C                                                                        E14.017
      COMMON/PARM/IPAR(12),PAR(3)                                        E14.018
C                                                                        E14.019
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)), E14.020
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)), E14.021
     2            (IMIT  ,IPAR( 7)),(NWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)), E14.022
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)), E14.023
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3))  E14.024
C                                                                        E14.025
C                                                                        E14.026
      EXTERNAL BRF,PRF                                                   E14.027
C                                                                        E14.028
      LUNOUT=2                                                           E14.029
      I80132=0                                                           E14.030
C                                                                        E14.031
C        THE INPUT PARAMETERS ARE                                        E14.032
C                                                                        E14.033
      NDIMU=21                                                           E14.034
      ICIR=0                                                             E14.035
      IGEOM=0                                                            E14.036
      NANG=4                                                             E14.037
      MODANG=4                                                           E14.038
      KDIMU=25                                                           E14.039
      IMIT=1                                                             E14.040
      NWORK=1500                                                         E14.041
      NFLOAT=1                                                           E14.042
      ISTORE=0                                                           E14.043
      IPRINT=23                                                          E14.044
      LUNATN=0                                                           E14.045
      PWID=1.                                                            E14.046
      AXISU=13.                                                          E14.047
      RFAN=0.                                                            E14.048
C                                                                        E14.049
      CALL SETUP (IPAR,PAR,AG)                                           E14.050
C                                                                        E14.051
      LIMITX=1000                                                        E14.052
      ERENTX=.000001                                                     E14.053
C                                                                        E14.054
      CALL ENTPY (B,PRF,BRF,LIMITX,ERENTX)                               E14.055
C                                                                        E14.056
      CALL ARRAY (B,NDIMU)                                               E14.057
C                                                                        E14.058
C        PRINTOUT THE VALUES FOR THE RECONSTRUCTED TRANSVERSE SECTION    E14.059
C                                                                        E14.060
      NMAT=NDIMU**2                                                      E14.061
      KK1=1                                                              E14.062
      KU=NDIMU/15+1                                                      E14.063
      DO 12 K=1,KJ                                                       E14.064
      WRITE (LUNOUT,14)                                                  E14.065
      KK2=15*K                                                           E14.066
      IF (KK2.GT.NDIMU) KK2=NDIMU                                        E14.067
      DO 10 J=1,NDIMU                                                    E14.068
      ISUB1=NMAT-J*NDIMU+KK1                                             E14.069
      ISUB2=NMAT-J*NDIMU+KK2                                             E14.070
   10 WRITE (LUNOUT,16) (B(I),I=ISUB1,ISUB2)                             E14.071
      KK1=KK2+1                                                          E14.072
   12 CONTINUE                                                           E14.073
C                                                                        E14.074
C                                                                        E14.075
C                                                                        E14.076
   14 FORMAT(1X///////)                                                  E14.077
   16 FORMAT(1X,15F5.1)                                                  E14.078
      END                                                                E14.079


      SUBROUTINE GETUM (M,DATA,ERR)                                      E14.080
C                                                                        E14.081
C        EXAMPLE 14                                                      E14.082
C                                                                        E14.083
C             THE SUBROUTINE GETUM GIVES SIMULATED PROJECTION DATA FOR   E14.084
C        A CIRCULAR PHANTOM WITH TWO RECTANGULAR HOLES.                  E14.085
C                                                                        E14.086
      DIMENSION DATA(1),ERR(1)                                           E14.087
      DIMENSION B(441)                                                   E14.088
      DIMENSION ITYPE(3),X1(3),Y1(3),A1(3),B1(3),PHI(3),Z(3)             E14.089
C                                                                        E14.090
      COMMON/OUTCOM/LUNOUT,I80132                                        E14.091
C                                                                        E14.092
C          LUNOUT  - OUTPUT FILE                                         E14.093
C          I80132  - OUTPUT LINE LENGTH FLAG                             E14.094
C               =0    EACH LINE WILL BE WITHIN 80 CHARACTERS             E14.095
C                       (OTHERWISE 132 CHARACTERS)                       E14.096
C                                                                        E14.097
```

```
      COMMON/PARM/IPAR(12),PAR(3)
C
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)),
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)),
     2            (IMIT  ,IPAR( 7)),(NWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)),
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)),
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3))
C
C
      DATA ITYPE/1,2,2/
      DATA X1/0.,-3.,2./
      DATA Y1/0.,0.,-2./
      DATA A1/20.,3.,5./
      DATA B1/20.,7.,3./
      DATA PHI/0.,0.,0./
      DATA Z/20.,-15.,-15./
      DATA NPHAN,INTG/3,10/
C
      EXTERNAL PRF
C
      IF (M.NE.1) GO TO 14
C
      IF (IMIT.NE.0) PWIDTH=PWID
      IF (IMIT.EQ.0) PWIDTH=-PWID
      CALL PHAN (NPHAN,INTG,ITYPE,Z,X1,Y1,A1,B1,PHI,B,NDIMU,PWIDTH)
C
      CALL ARRAY (B,NDIMU)
C
C        PRINTOUT THE VALUES FOR THE PHANTOM
C
      NMAT=NDIMU**2
      KK1=1
      KU=NDIMU/15+1
      DO 12 K=1,KU
      WRITE (LUNOUT,16)
      KK2=15*K
      IF (KK2.GT.NDIMU) KK2=NDIMU
      DO 10 J=1,NDIMU
      ISUB1=NMAT-J*NDIMU+KK1
      ISUB2=NMAT-J*NDIMU+KK2
   10 WRITE (LUNOUT,18) (B(I),I=ISUB1,ISUB2)
      KK1=KK2+1
   12 CONTINUE
C
   14 CALL PJECT (B,DATA,M,PRF)
C
      RETURN
C
C
C
   16 FORMAT(1X///////)
   18 FORMAT(1X,15F5.1)
      END
```

```
  SSS  EEEEE TTTTT U   U PPPP
 S     E       T   U   U P   P
  SSS  EEE     T   U   U PPPP
     S E       T   U   U P
  SSS  EEEEE   T    UUU  P
```

INTEGER PARAMETER ARRAY (IPAR)

I	IPAR(I)	DESCRIPTION
1	21	LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
2	0	RECONSTRUCT IN A CIRCULAR ARRAY
3	0	GEOMETRY FLAG
		PARALLEL BEAM GEOMETRY
4	4	NUMBER OF PROJECTION ANGLES
5	4	MODE FOR PROJECTION ANGLE INPUT (SEE FOLLOWING LINES)
		ANGLES GENERATED BETWEEN ZERO AND PI
		STARTING AT ZERO
6	25	NUMBER OF RAYS FOR EACH PROJECTION
7	1	TRANSMISSION DATA
8	1500	DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
9	1	NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10	0	EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11	23	PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES)
		PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED
		PRINT PROJECTION DATA AND UNCERTAINTIES
		PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
		PRINT VALUES FOR THE LAGRANGE MULTIPLIERS AND THE GRADIENT FOR THE FUNCTION OF LAGRANGE MULTIPLIERS FOR THE ENTROPY RECONSTRUCTION
12	0	LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE

FLOATING POINT PARAMETER ARRAY (PAR)

I	PAR(I)	DESCRIPTION
1	1.000	PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
2	13.000	LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
3	0 NA	NOT APPLICABLE (NOT FAN BEAM GEOMETRY)

BLANK COMMON REQUIRED 4 (4)

BLANK COMMON REQUIRED 8 (10)

BLANK COMMON REQUIRED 12 (14)

BLANK COMMON REQUIRED 62 (76)

BLANK COMMON REQUIRED 104 (150)

A TOTAL OF 25 (1 THRU 25) OF THE 25 USER PROJECTION BINS WILL BE USED

25 PROJECTION BINS WILL BE USED OF WHICH 0 HAVE BEEN ZEROED BY THE PROGRAM

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 104 FLOATING POINT WORDS.

```
EEEEE N   N DDDD         SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D       S     E       T   U   U P   P
EEE   N N N D   D        SSS  EEE     T   U   U PPPP
E     N  NN D   D           S E       T   U   U P
EEEEE N   N DDDD         SSS  EEEEE   T    UUU  P
```

```
EEEEE N   N TTTTT PPPP  Y   Y
E     NN  N   T   P   P  Y Y
EEE   N N N   T   PPPP    Y
E     N  NN   T   P       Y
EEEEE N   N   T   P       Y
```

PARAMETERS FOR SUBROUTINE ENTPY

DESCRIPTION

LIMITX - 1000 MAXIMUM NUMBER OF ITERATIONS ALLOWED TO MAXIMIZE THE OBJECTIVE FUNCTION FOR THE DUAL PROGRAM
ERENTX - .1E-05 TEST VALUE REPRESENTING THE EXPECTED ABSOLUTE ERROR

BLANK COMMON REQUIRED 108 (154)

BLANK COMMON REQUIRED 230 (346)

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG	FUNCTION	RAY WEIGHTING	ATTENUATION	FAN BEAM
BCK	BACKPROJECTION	UNIFORM SQUARE	NO	NO
PRJ	PROJECTION	UNIFORM SQUARE	NO	NO

BLANK COMMON REQUIRED 355 (543)

BLANK COMMON REQUIRED 704 (1300)

BLANK COMMON REQUIRED 804 (1444)

BLANK COMMON REQUIRED 904 (1610)

BLANK COMMON REQUIRED 1004 (1754)

BLANK COMMON REQUIRED 1204 (2264)

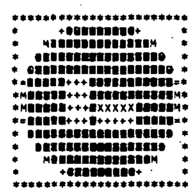
```
PPPP  H   H  AAA  N   N
P   P H   H A   A NN  N
PPPP  HHHHH A   A N N N
P     H   H AAAAA N  NN
P     H   H A   A N   N
```

PHANTOM GENERATED
ARRAY SIZE 21 X 21 INTEGRATION FACTOR = 10 SCALING FACTOR = 1.000
NUMBER OF ELIPSES AND/OR RECTANGLES = 3
THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
X,Y - CENTER
A,B - LENGTH OF AXIS OR SIDE A AND B
PHI - ANGLE OF AXIS OR SIDE A
DENS - INTENSITY
THE PARENTHESIS INDICATES THE SCALED VALUE

ITYPE	X	Y	A	B	PHI	DENS
1 - ELLIPSE	0 ,	0	20.00 ,	20.00	0	20.00
	(0),(	0)(	20.00),(	20.00)		(20.00)
2 - RECTANGLE	-3.00 ,	0	3.00 ,	7.00	0	-15.00
	(-3.00),(	0)(	3.00),(	7.00)		(-15.00)
2 - RECTANGLE	2.00 ,	-2.00	5.00 ,	3.00	0	-15.00
	(2.00),(	-2.00)(	5.00),(	3.00)		(-15.00)

```
EEEEE N   N DDDD         PPPP  H   H  AAA  N   N
E     NN  N D   D        P   P H   H A   A NN  N
EEE   N N N D   D        PPPP  HHHHH A   A N N N
E     N  NN D   D        P     H   H AAAAA N  NN
EEEEE N   N DDDD         P     H   H A   A N   N
```

XMIN = 0 XMAX = .20E+02 XSUM = .5746E+04



```
             -           =           +           )           I           Z
0 .1500E+01 .3700E+01 .4700E+01 .5400E+01 .6200E+01 .7000E+01

Z           X           A           M           B           ■           B           ●
.7700E+01 .8200E+01 .8700E+01 .9800E+01 .1090E+02 .1160E+02 .1240E+02

●           ●           ●           ■           ■           ■           ■           ■
.1310E+02 .1460E+02 .1640E+02 .1740E+02 .1820E+02 .1900E+02 .1970E+02

■
.2000E+02
```

```
   0     0     0     0     0     0     0   1.2   5.8   9.0  10.0   9.0   5.8   1.2     0
   0     0     0     0     0   3.4  13.2  19.6  20.0  20.0  20.0  20.0  20.0  19.6  13.2
   0     0     0    .2   9.8  19.6  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0
   0     0    .2  12.8  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0
   0     0   9.8  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0
   0   3.4  19.6  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0
   0  13.2  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0
 1.2  19.6  20.0  20.0  20.0  20.0   5.0   5.0   5.0  20.0  20.0  20.0  20.0  20.0  20.0
 5.8  20.0  20.0  20.0  20.0  20.0   5.0   5.0   5.0  20.0  20.0  20.0  20.0  20.0  20.0
 9.0  20.0  20.0  20.0  20.0  20.0   5.0   5.0   5.0  20.0  20.0  20.0  20.0  20.0  20.0
10.0  20.0  20.0  20.0  20.0  20.0   5.0   5.0   5.0  20.0  20.0  20.0  20.0  20.0  20.0
 9.0  20.0  20.0  20.0  20.0  20.0   5.0   5.0   5.0  20.0   5.0   5.0   5.0   5.0   5.0
 5.8  20.0  20.0  20.0  20.0  20.0   5.0   5.0   5.0  20.0   5.0   5.0   5.0   5.0   5.0
 1.2  19.6  20.0  20.0  20.0  20.0   5.0   5.0   5.0  20.0   5.0   5.0   5.0   5.0   5.0
   0  13.2  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0
   0   3.4  19.6  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0
   0     0   9.8  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0
   0     0    .2  12.8  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0
   0     0     0    .2   9.8  19.6  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0  20.0
   0     0     0     0     0   3.4  13.2  19.6  20.0  20.0  20.0  20.0  20.0  19.6  13.2
   0     0     0     0     0     0     0   1.2   5.8   9.0  10.0   9.0   5.8   1.2     0
```

```
   0     0     0     0     0     0
 3.4     0     0     0     0     0
19.6   9.8    .2     0     0     0
20.0  20.0  12.8    .2     0     0
20.0  20.0  20.0   9.8     0     0
20.0  20.0  20.0  19.6   3.4     0
20.0  20.0  20.0  20.0  13.2     0
20.0  20.0  20.0  20.0  19.6   1.2
20.0  20.0  20.0  20.0  20.0   5.8
20.0  20.0  20.0  20.0  20.0   9.0
20.0  20.0  20.0  20.0  20.0  10.0
20.0  20.0  20.0  20.0  20.0   9.0
20.0  20.0  20.0  20.0  20.0   5.8
20.0  20.0  20.0  20.0  19.6   1.2
20.0  20.0  20.0  20.0  13.2     0
20.0  20.0  20.0  19.6   3.4     0
20.0  20.0  20.0   9.8     0     0
20.0  20.0  12.8    .2     0     0
19.6   9.8    .2     0     0     0
 3.4     0     0     0     0     0
   0     0     0     0     0     0
```

```
PPPP        J EEEEE  CCC  TTTTT
P   P       J E     C   C   T
PPPP        J EEE   C       T
P       J   J E     C   C   T
P        JJJ  EEEEE  CCC    T
```

```
BLANK COMMON REQUIRED       1229     (   2315)

PROJECTION DATA FOR ANGLE NO.   1          0 RADIANS            0 DEGREES
             0            0     .420E+02     .172E+03     .239E+03
      .286E+03     .320E+03     .346E+03     .366E+03     .262E+03
      .272E+03     .278E+03     .355E+03     .353E+03     .347E+03
      .337E+03     .366E+03     .346E+03     .320E+03     .286E+03
      .239E+03     .172E+03     .420E+02            0            0

PROJECTION DATA FOR ANGLE NO.   2       .785 RADIANS      45.000 DEGREES
             0     .450E+00     .530E+02     .169E+03     .237E+03
      .279E+03     .321E+03     .327E+03     .323E+03     .310E+03
      .330E+03     .357E+03     .358E+03     .336E+03     .324E+03
      .310E+03     .323E+03     .327E+03     .321E+03     .279E+03
      .237E+03     .169E+03     .530E+02     .450E+00            0

PROJECTION DATA FOR ANGLE NO.   3      1.571 RADIANS      90.000 DEGREES
             0            0     .420E+02     .172E+03     .239E+03
      .286E+03     .320E+03     .346E+03     .321E+03     .337E+03
      .347E+03     .353E+03     .355E+03     .398E+03     .287E+03
      .277E+03     .261E+03     .346E+03     .320E+03     .286E+03
      .239E+03     .172E+03     .420E+02            0            0

BLANK COMMON REQUIRED       1204     (   2264)


         MAXIMUM SIZE OF BLANK COMMON THUS FAR=    1229 FLOATING POINT WORDS.
```

```
EEEEE N    N DDDD         PPPP        J EEEEE  CCC  TTTTT
E     NN   N D   D        P   P       J E     C   C   T
EEE   N N  N D   D        PPPP        J EEE   C       T
E     N   NN D   D        P       J   J E     C   C   T
EEEEE N    N DDDD         P        JJJ  EEEEE  CCC    T
```

```
PROJECTION DATA FOR ANGLE NO.   4      2.356 RADIANS     135.000 DEGREES
             0     .450E+00     .530E+02     .169E+03     .237E+03
      .279E+03     .321E+03     .346E+03     .373E+03     .372E+03
      .362E+03     .333E+03     .298E+03     .282E+03     .300E+03
      .309E+03     .323E+03     .327E+03     .321E+03     .279E+03
      .237E+03     .169E+03     .530E+02     .450E+00            0

INITIAL ESTIMATE FOR THE LAGRANGE MULTIPILERS


THE INITIAL SOLUTION FOR XLAGR(I),I=1, 100
      .174E-03     .174E-03     .731E-02     .300E-01     .416E-01
      .497E-01     .556E-01     .602E-01     .638E-01     .455E-01
      .473E-01     .484E-01     .618E-01     .615E-01     .603E-01
      .586E-01     .638E-01     .602E-01     .556E-01     .497E-01
      .416E-01     .300E-01     .731E-02     .174E-03     .174E-03
      .174E-03     .783E-04     .922E-02     .295E-01     .413E-01
      .486E-01     .558E-01     .568E-01     .562E-01     .541E-01
      .574E-01     .621E-01     .624E-01     .586E-01     .564E-01
      .541E-01     .562E-01     .568E-01     .558E-01     .486E-01
      .413E-01     .295E-01     .922E-02     .783E-04     .174E-03
      .174E-03     .174E-03     .731E-02     .300E-01     .416E-01
      .497E-01     .556E-01     .602E-01     .560E-01     .586E-01
      .603E-01     .615E-01     .618E-01     .693E-01     .499E-01
      .482E-01     .455E-01     .602E-01     .556E-01     .497E-01
      .416E-01     .300E-01     .731E-02     .174E-03     .174E-03
      .174E-03     .783E-04     .922E-02     .295E-01     .413E-01
      .486E-01     .559E-01     .603E-01     .650E-01     .647E-01
      .631E-01     .580E-01     .519E-01     .491E-01     .522E-01
      .538E-01     .562E-01     .568E-01     .558E-01     .486E-01
      .413E-01     .295E-01     .922E-02     .783E-04     .174E-03
```

```
THE ESTIMATE OF THE MINIMUM IS EST =  5.8551 .

FOR CONGR AND GRADY FCN IS THE VALUE OF THE CHI-SQUARE
FOR ENTPY FCN IS EVALUATED BY THE SUBROUTINE DULFC
ITER  0       FCN      .585E+01
ITER  1       FCN      .581E+01
ITER  2       FCN      .580E+01
ITER  3       FCN      .580E+01
ITER  4       FCN      .579E+01
ITER  5       FCN      .579E+01
ITER  6       FCN      .579E+01
ITER  7       FCN      .579E+01
ITER  8       FCN      .579E+01
ITER  9       FCN      .579E+01
ITER 10       FCN      .579E+01
ITER 11       FCN      .579E+01
ITER 12       FCN      .579E+01
ITER 13       FCN      .579E+01
ITER 14       FCN      .579E+01
ITER 15       FCN      .579E+01
ITER 16       FCN      .579E+01
ITER 17       FCN      .579E+01
ITER 18       FCN      .579E+01
ITER 19       FCN      .579E+01
ITER 20       FCN      .579E+01
ITER 21       FCN      .579E+01
ITER 22       FCN      .579E+01
ITER 23       FCN      .579E+01
ITER 24       FCN      .579E+01
ITER 25       FCN      .579E+01
ITER 26       FCN      .579E+01
ITER 27       FCN      .579E+01
ITER 28       FCN      .579E+01
ITER 29       FCN      .579E+01
ITER 30       FCN      .579E+01
ITER 31       FCN      .579E+01
ITER 32       FCN      .579E+01
ITER 33       FCN      .579E+01
ITER 34       FCN      .579E+01
ITER 35       FCN      .579E+01
ITER 36       FCN      .579E+01
ITER 37       FCN      .579E+01
ITER 38       FCN      .579E+01
ITER 39       FCN      .579E+01
ITER 40       FCN      .579E+01
ITER 41       FCN      .579E+01
ITER 42       FCN      .579E+01
ITER 43       FCN      .579E+01
ITER 44       FCN      .579E+01
ITER 45       FCN      .579E+01
ITER 46       FCN      .579E+01
ITER 47       FCN      .579E+01
ITER 48       FCN      .579E+01
ITER 49       FCN      .579E+01
ITER 50       FCN      .579E+01
ITER 51       FCN      .579E+01
ITER 52       FCN      .579E+01
ITER 53       FCN      .579E+01
ITER 54       FCN      .579E+01
ITER 55       FCN      .579E+01
ITER 56       FCN      .579E+01
ITER 57       FCN      .579E+01
ITER 58       FCN      .579E+01
ITER 59       FCN      .579E+01
ITER 60       FCN      .579E+01
ITER 61       FCN      .579E+01
ITER 62       FCN      .579E+01
ITER 63       FCN      .579E+01
ITER 64       FCN      .579E+01
ITER 65       FCN      .579E+01
ITER 66       FCN      .579E+01
ITER 67       FCN      .579E+01
ITER 68       FCN      .579E+01
ITER 69       FCN      .579E+01
ITER 70       FCN      .579E+01
ITER 71       FCN      .579E+01
ITER 72       FCN      .579E+01
ITER 73       FCN      .579E+01
ITER 74       FCN      .579E+01
ITER 75       FCN      .579E+01
ITER 76       FCN      .579E+01
ITER 77       FCN      .579E+01
ITER 78       FCN      .579E+01
ITER 79       FCN      .579E+01
ITER 80       FCN      .579E+01
ITER 81       FCN      .579E+01
ITER 82       FCN      .579E+01
ITER 83       FCN      .579E+01
ITER 84       FCN      .579E+01
ITER 85       FCN      .579E+01
ITER 86       FCN      .579E+01
ITER 87       FCN      .579E+01
ITER 88       FCN      .579E+01
ITER 89       FCN      .579E+01
ITER 90       FCN      .579E+01
ITER 91       FCN      .579E+01
ITER 92       FCN      .579E+01
ITER 93       FCN      .579E+01
ITER 94       FCN      .579E+01
ITER 95       FCN      .579E+01
ITER 96       FCN      .579E+01
ITER 97       FCN      .579E+01
ITER 98       FCN      .579E+01
ITER 99       FCN      .579E+01
ITER100       FCN      .579E+01
ITER101       FCN      .579E+01
ITER102       FCN      .579E+01
ITER103       FCN      .579E+01
ITER104       FCN      .579E+01
ITER105       FCN      .579E+01
ITER106       FCN      .579E+01
ITER107       FCN      .579E+01
ITER108       FCN      .579E+01
ITER109       FCN      .579E+01
ITER110       FCN      .579E+01
ITER111       FCN      .579E+01
ITER112       FCN      .579E+01
ITER113       FCN      .579E+01
ITER114       FCN      .579E+01
ITER115       FCN      .579E+01
ITER116       FCN      .579E+01
ITER117       FCN      .579E+01
ITER118       FCN      .579E+01
ITER119       FCN      .579E+01
ITER120       FCN      .579E+01
ITER121       FCN      .579E+01
ITER122       FCN      .579E+01
ITER123       FCN      .579E+01
ITER124       FCN      .579E+01
ITER125       FCN      .579E+01
ITER126       FCN      .579E+01
```

THE OPTIMUM SOLUTION FOR THE LAGRANGE MULTIPILERS
WAS DETERMINED IN 127 ITERATIONS.

FINAL SOLUTION FOR THE LAGRANGE MULTIPILERS

THE FINAL SOLUTION FOR XLAGR(I),I=1, 100

.174E-03	.174E-03	-.175E+00	.776E+00	.761E+00
.625E+00	.446E+00	.255E+00	.116E+00	-.376E+00
-.422E+00	-.445E+00	-.226E+00	-.237E+00	-.243E+00
-.234E+00	-.365E-01	.676E-02	.117E+00	.231E+00
.329E+00	.341E+00	-.591E+00	.174E-03	.174E-03
.174E-03	.282E+01	-.257E+01	-.124E+01	-.856E+00
-.647E+00	-.482E+00	-.425E+00	-.322E+00	-.262E+00
-.790E-01	.665E-01	.135E+00	.777E-01	.158E+00
.929E-01	.187E+00	.202E+00	.251E+00	.193E+00
.128E+00	-.930E-01	-.136E+01	.502E+01	.174E-03
.174E-03	.174E-03	.344E+00	.113E+01	.102E+01
.821E+00	.626E+00	.437E+00	.156E+00	.218E-01
-.756E-01	-.157E+00	-.230E+00	-.177E+00	-.547E+00
-.593E+00	-.590E+00	-.200E+00	-.875E-01	.157E-01
.633E-01	.212E-02	-.981E+00	.174E-03	.174E-03
.174E-03	-.127E+01	-.177E+01	-.551E+00	-.245E+00
-.825E-01	.609E-01	.198E+00	.394E+00	.461E+00
.525E+00	.418E+00	.330E+00	.245E+00	.404E+00
.366E+00	.410E+00	.426E+00	.488E+00	.413E+00
.292E+00	-.364E-01	-.132E+01	.851E+00	.174E-03

THE VALUE OF THE MINIMUM IS 5.7919 .

THE GRADIENT GRAD(I),I=1, 100

0	0	.882E-08	-.146E-08	-.176E-09
-.224E-08	.207E-09	.510E-08	-.187E-09	-.837E-08
-.189E-08	-.616E-08	-.925E-09	-.467E-08	-.620E-08
-.289E-08	-.347E-08	.753E-08	.475E-08	.423E-08
.462E-08	.342E-08	-.366E-10	0	0
0	.178E-08	-.659E-08	-.125E-08	-.231E-08
-.117E-08	-.524E-08	-.170E-08	.151E-08	-.225E-08
.541E-10	.722E-08	.700E-08	.703E-08	-.139E-09
.774E-08	-.260E-08	.644E-09	.323E-09	.738E-10
-.317E-08	-.649E-08	-.600E-09	-.277E-08	0
0	0	.488E-08	-.259E-08	.539E-09
-.429E-08	-.386E-08	.371E-08	.114E-08	-.763E-09
-.590E-08	.382E-08	-.336E-09	-.408E-08	-.110E-08
-.697E-08	.298E-09	.118E-08	.708E-08	.532E-08
-.158E-09	.761E-08	-.706E-08	0	0
0	.137E-08	-.284E-08	-.244E-08	-.266E-08
-.294E-08	.127E-08	.317E-08	-.110E-08	-.326E-08
-.921E-09	.422E-08	.239E-08	.109E-09	.448E-08
.979E-09	.113E-09	.270E-08	.271E-08	.144E-08
-.158E-08	-.365E-08	-.959E-09	-.260E-08	0

THE ENTROPY OF THE RECONSTRUCTION IS 5.7919 .

BLANK COMMON REQUIRED 1079 (2067)

BLANK COMMON REQUIRED 730 (1332)

BLANK COMMON REQUIRED 630 (1166)

BLANK COMMON REQUIRED 530 (1022)

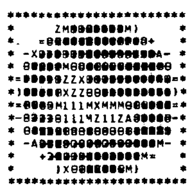
BLANK COMMON REQUIRED 430 (656)

BLANK COMMON REQUIRED 230 (346)

MAXIMUM SIZE OF BLANK COMMON THUS FAR= 1229 FLOATING POINT WORDS.

```
EEEEE N   N DDDD        EEEEE N   N TTTTT PPPP  Y   Y
E     NN  N D   D       E     NN  N   T   P   P  Y Y
EEE   N N N D   D       EEE   N N N   T   PPPP    Y
E     N  NN D   D       E     N  NN   T   P       Y
EEEEE N   N DDDD        EEEEE N   N   T   P       Y
```

XMIN = 0 XMAX = .27E+02 XSUM = .5744E+04



	-	=	+	)	1	Z
0	.2060E+01	.5081E+01	.6454E+01	.7415E+01	.8514E+01	.9612E+01
Z	X	A	M	8	8	8
.1057E+02	.1126E+02	.1195E+02	.1346E+02	.1497E+02	.1593E+02	.1703E+02
8	■	■	■	■	■	■
.1799E+02	.2005E+02	.2252E+02	.2389E+02	.2499E+02	.2609E+02	.2705E+02
■						
.2746E+02						

0	0	0	0	0	0	0	4.0	5.2	7.8	7.0	6.9	6.3	4.7	0
0	0	0	0	0	8.3	12.7	16.3	16.6	22.8	20.7	20.1	18.5	16.8	12.9
0	0	0	0	9.0	20.3	18.1	19.5	20.0	26.1	22.4	21.3	20.6	19.1	17.4
0	0	0	8.0	18.3	23.9	19.4	19.4	20.3	27.5	21.8	20.8	19.8	18.8	19.9
0	0	7.3	15.9	21.0	22.6	17.2	19.0	19.0	25.4	22.2	19.8	18.5	19.6	19.3
0	6.6	17.0	20.3	20.0	20.0	15.1	16.1	17.3	23.5	20.4	19.6	19.3	18.3	18.9
0	14.9	21.4	23.7	20.5	18.4	13.3	13.7	15.1	22.2	19.2	20.7	20.0	18.8	20.1
4.8	17.6	20.7	20.3	19.7	16.0	10.1	10.6	11.4	16.7	17.7	17.4	17.7	18.9	17.9
6.9	20.0	22.0	21.5	19.0	16.9	10.3	9.5	10.1	16.4	15.8	17.8	19.1	19.2	19.1
7.8	22.0	23.4	22.1	18.9	16.3	10.9	9.4	10.0	14.8	14.7	17.5	19.3	18.8	18.5
7.8	23.2	24.8	21.9	19.3	16.1	10.2	11.0	10.1	13.8	14.5	15.9	17.1	18.0	16.9
6.0	17.6	19.2	18.2	15.0	12.7	8.8	8.3	8.7	11.9	10.4	11.1	11.6	11.8	13.5
5.1	15.9	18.3	17.7	15.3	13.8	8.8	8.5	9.0	12.8	10.3	9.6	9.6	10.7	12.4
3.5	13.6	16.7	16.7	16.8	14.4	9.2	9.4	9.2	12.2	10.7	9.0	8.9	10.0	11.3
0	14.6	21.7	26.2	24.8	23.2	16.3	14.9	14.4	18.3	14.7	15.3	14.4	14.2	16.6
0	6.4	18.0	23.9	25.6	26.1	17.9	16.7	15.0	18.6	16.3	16.4	16.9	16.2	16.7
0	0	8.2	19.5	26.7	27.4	19.0	18.0	16.4	21.5	19.2	18.7	19.0	20.1	18.5
0	0	0	9.6	20.9	25.4	18.6	17.6	18.5	25.6	21.6	21.9	21.7	20.7	20.6
0	0	0	0	8.8	17.9	15.3	17.3	19.0	27.1	24.6	23.7	22.4	20.5	18.3
0	0	0	0	0	6.2	10.1	14.0	16.3	24.8	23.3	22.2	19.6	16.9	12.5
0	0	0	0	0	0	0	3.4	5.0	8.1	7.5	7.2	6.3	4.4	0

0	0	0	0	0	0
6.7	0	0	0	0	0
17.0	8.0	0	0	0	0
21.0	17.6	9.0	0	0	0
22.1	23.2	18.9	8.7	0	0
23.4	23.8	22.5	17.2	6.8	0
23.3	23.6	22.7	20.0	14.8	0
19.8	19.7	18.7	18.9	16.9	5.0
19.6	18.5	19.5	20.3	18.5	6.7
19.8	19.5	20.4	21.1	20.3	7.6
20.2	21.8	21.2	22.2	21.3	7.7
16.2	17.4	18.8	18.5	16.5	5.8
16.2	17.8	19.3	19.3	15.9	5.2
15.2	18.2	18.7	18.4	15.3	4.0
21.9	24.8	27.2	25.1	17.7	0
20.8	22.8	23.4	20.0	8.5	0
20.0	20.5	17.6	9.1	0	0
19.8	15.2	7.9	0	0	0
16.5	7.2	0	0	0	0
6.5	0	0	0	0	0
0	0	0	0	0	0

12. Example 15 - Generalized Inverse

The sample program XGVERS uses the generalized inverse to reconstruct parallel-beam projection data and compares the result with the conjugate gradient method of reconstruction. Due to memory requirements, the generalized inverse method can reconstruct only small matrices. For example, a small matrix 12 x 12 (NDIMU = 12) requires that the array WORK in blank common have dimension equal to 46000. The reconstructed array B is returned in statement E15.055 along with the error matrix BE, which gives the statistical errors in the reconstruction; i.e., $BE(I,J) = \sqrt{VAR\ B(I,J)}$. The printout indicates that the largest errors are for the reconstructed values in the center four pixels. The chi-square for the conjugate gradient solution after 15 iterations is equal to 5.23×10^{-4} as compared to a chi-square equal to 1.01×10^{-12} for the generalized inverse solution. (The chi-square for the generalized inverse is nonzero due to computer rounding.)

```
      PROGRAM XGVERS (INPUT,OUTPUT,TAPE2=OUTPUT)                        E15.001
C                                                                       E15.002
C        EXAMPLE 15                                                     E15.003
C                                                                       E15.004
C             THE PROGRAM XGVERS USES THE GENERALIZED INVERSE TO        E15.005
C        RECONSTRUCT PARALLEL BEAM PROJECTION DATA AND COMPARES         E15.006
C        THE RESULT WITH THE CONJUGATE GRADIENT METHOD OF RECONS-       E15.007
C        TRUCTION.                                                      E15.008
C                                                                       E15.009
      DIMENSION B(144),BE(144),ANG(18)                                  E15.010
      COMMON WORK(46000)                                                E15.011
C                                                                       E15.012
      COMMON/OUTCOM/LUNOUT,I80132                                       E15.013
C                                                                       E15.014
C          LUNOUT  - OUTPUT FILE                                        E15.015
C          I80132  - OUTPUT LINE LENGTH FLAG                            E15.016
C              =0    EACH LINE WILL BE WITHIN 80 CHARACTERS             E15.017
C                    (OTHERWISE 132 CHARACTERS)                         E15.018
C                                                                       E15.019
      COMMON/PARM/IPAR(12),PAR(3)                                       E15.020
C                                                                       E15.021
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)), E15.022
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)), E15.023
     2            (IMIT  ,IPAR( 7)),(NWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)), E15.024
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)), E15.025
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3)) E15.026
C                                                                       E15.027
      EXTERNAL BLL,PLL                                                  E15.028
C                                                                       E15.029
      LUNOUT=2                                                          E15.030
      I80132=0                                                          E15.031
C                                                                       E15.032
C        THE INPUT PARAMETERS ARE                                       E15.033
C                                                                       E15.034
      NDIMU=12                                                          E15.035
      ICIR=0                                                            E15.036
      IGEOM=0                                                           E15.037
      NANG=18                                                           E15.038
      MODANG=2                                                          E15.039
      KDIMU=12                                                          E15.040
      IMIT=0                                                            E15.041
      NWORK=46000                                                       E15.042
      NFLOAT=1                                                          E15.043
      ISTORE=0                                                          E15.044
      IPRINT=7                                                          E15.045
      LUNATN=0                                                          E15.046
      PWID=1.                                                           E15.047
      AXISU=6.5                                                         E15.048
      RFAN=0.                                                           E15.049
C                                                                       E15.050
      CALL SETUP (IPAR,PAR,AG)                                          E15.051
C                                                                       E15.052
      IERR=2                                                            E15.053
C                                                                       E15.054
      CALL GVERS (B,BE,PLL,BLL,CHISQ,IERR)                              E15.055
C                                                                       E15.056
      WRITE (2,24) CHISQ                                                E15.057
C                                                                       E15.058
      CALL ARRAY (B,NDIMU)                                              E15.059
C                                                                       E15.060
C        PRINTOUT OF THE VALUES FOR THE RECONSTRUCTED TRANSVERSE SECTION E15.061
C                                                                       E15.062
      NMAT=NDIMU**2                                                     E15.063
      KK1=1                                                             E15.064
      KU=NDIMU/15+1                                                     E15.065
      DO 12 K=1,KU                                                      E15.066
      WRITE (2,22)                                                      E15.067
      KK2=15*K                                                          E15.068
      IF (KK2.GT.NDIMU) KK2=NDIMU                                       E15.069
      DO 10 J=1,NDIMU                                                   E15.070
      ISUB1=NMAT-J*NDIMU+KK1                                            E15.071
      ISUB2=NMAT-J*NDIMU+KK2                                            E15.072
   10 WRITE (2,26) (B(I),I=ISUB1,ISUB2)                                 E15.073
      KK1=KK2+1                                                         E15.074
   12 CONTINUE                                                          E15.075
C                                                                       E15.076
      CALL ARRAY (BE,NDIMU)                                             E15.077
C                                                                       E15.078
C        PRINTOUT THE VALUES FOR THE RECONSTRUCTION ERRORS              E15.079
C                                                                       E15.080
      KK1=1                                                             E15.081
      KU=NDIMU/15+1                                                     E15.082
      DO 16 K=1,KU                                                      E15.083
      WRITE (2,22)                                                      E15.084
      KK2=15*K                                                          E15.085
      IF (KK2.GT.NDIMU) KK2=NDIMU                                       E15.086
      DO 14 J=1,NDIMU                                                   E15.087
      ISUB1=NMAT-J*NDIMU+KK1                                            E15.088
      ISUB2=NMAT-J*NDIMU+KK2                                            E15.089
   14 WRITE (2,26) (BE(I),I=ISUB1,ISUB2)                                E15.090
      KK1=KK2+1                                                         E15.091
   16 CONTINUE                                                          E15.092
C                                                                       E15.093
C        COMPARE THE GENERALIZED INVERSE METHOD WITH THE CONJUGATE      E15.094
C          GRADIENT METHOD                                              E15.095
C                                                                       E15.096
      ISTP=15                                                           E15.097
      IRLX=1                                                            E15.098
      IERR=1                                                            E15.099
      IZER=0                                                            E15.100
C                                                                       E15.101
      CALL CONGR (B,PLL,BLL,ISTP,IRLX,IERR,IZER)                        E15.102
C                                                                       E15.103
      CALL ARRAY (B,NDIMU)                                              E15.104
C                                                                       E15.105
C        PRINTOUT OF THE VALUES FOR THE RECONSTRUCTED TRANSVERSE SECTION E15.106
C                                                                       E15.107
      KK1=1                                                             E15.108
      KU=NDIMU/15+1                                                     E15.109
      DO 20 K=1,KU                                                      E15.110
      WRITE (2,22)                                                      E15.111
      KK2=15*K                                                          E15.112
      IF (KK2.GT.NDIMU) KK2=NDIMU                                       E15.113
      DO 18 J=1,NDIMU                                                   E15.114
      ISUB1=NMAT-J*NDIMU+KK1                                            E15.115
      ISUB2=NMAT-J*NDIMU+KK2                                            E15.116
   18 WRITE (2,26) (B(I),I=ISUB1,ISUB2)                                 E15.117
      KK1=KK2+1                                                         E15.118
   20 CONTINUE                                                          E15.119
C                                                                       E15.120
C                                                                       E15.121
C                                                                       E15.122
   22 FORMAT(1X///////)                                                 E15.123
   24 FORMAT(1X//9H CHISQ = ,E15.7)                                     E15.124
   26 FORMAT(1X,15F5.1)                                                 E15.125
      END                                                               E15.126
```

```
      SUBROUTINE GETUM (M,DATA,ERR)
C
C        EXAMPLE 15
C
C             THE SUBROUTINE GETUM GIVES SIMULATED PROJECTION DATA FOR
C        TWO RECTANGLES.
C
      DIMENSION DATA(1),ERR(1)
      DIMENSION B(144)
      DIMENSION A1(2),B1(2),X1(2),Y1(2),PHI(2),Z(2),ITYPE(2)
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT  - OUTPUT FILE
C          I80132  - OUTPUT LINE LENGTH FLAG
C                =0    EACH LINE WILL BE WITHIN 80 CHARACTERS
C                        (OTHERWISE 132 CHARACTERS)
C
      COMMON/PARM/IPAR(12),PAR(3)
C
      EQUIVALENCE (NDIMU ,IPAR( 1)),(ICIR  ,IPAR( 2)),(IGEOM ,IPAR( 3)),
     1            (NANG  ,IPAR( 4)),(MODANG,IPAR( 5)),(KDIMU ,IPAR( 6)),
     2            (IMIT  ,IPAR( 7)),(NWORK ,IPAR( 8)),(NFLOAT,IPAR( 9)),
     3            (ISTORE,IPAR(10)),(IPRINT,IPAR(11)),(LUNATN,IPAR(12)),
     4            (PWID  , PAR( 1)),(AXISU , PAR( 2)),(RFAN  , PAR( 3))
C
C
      DATA ITYPE/2,2/
      DATA A1/3.,5./
      DATA B1/8.,4./
      DATA X1/-3.5,2.5/
      DATA Y1/0.,0./
      DATA PHI/0.,0./
      DATA Z/1.,1./
C
      IF (M.NE.1) GO TO 10
C
      IF (IMIT.NE.0) PWIDTH=PWID
      IF (IMIT.EQ.0) PWIDTH=-PWID
      CALL PHAN (2,10,ITYPE,Z,X1,Y1,A1,B1,PHI,B,NDIMU,PWIDTH)
C
   10 CALL PHANL (2,ITYPE,Z,X1,Y1,A1,B1,PHI,DATA,M)
C
      DO 12 I=1,12
      IF (DATA(I).GT.0.) ERR(I)=SQRT(DATA(I))
   12 IF (DATA(I).LE.0.) ERR(I)=1.
C
      RETURN
C
      END
```

```
  SSS  EEEEE TTTTT U   U PPPP
 S     E       T   U   U P   P
  SSS  EEE     T   U   U PPPP
     S E       T   U   U P
  SSS  EEEEE   T    UUU  P
```

```
        INTEGER PARAMETER ARRAY   (IPAR)

 I   IPAR(I)     DESCRIPTION

 1       12      LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
 2        0      RECONSTRUCT IN A CIRCULAR ARRAY
 3        0      GEOMETRY FLAG
                 PARALLEL BEAM GEOMETRY
 4       18      NUMBER OF PROJECTION ANGLES
 5        2      MODE FOR PROJECTION ANGLE INPUT  (SEE FOLLOWING LINES)
                 ANGLES GENERATED BETWEEN ZERO AND PI
                 STARTING AT THE HALF ANGLE
 6       12      NUMBER OF RAYS FOR EACH PROJECTION
 7        0      EMISSION DATA
 8    46000      DIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK
 9        1      NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
10        0      EXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST)
11        7      PRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES)
                 PRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED
                 PRINT PROJECTION DATA AND UNCERTAINTIES
                 PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
12        0      LOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE


        FLOATING POINT PARAMETER ARRAY  (PAR)

 I    PAR(I)     DESCRIPTION

 1    1.000      PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
 2    6.500      LOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY
 3        0  NA  NOT APPLICABLE  (NOT FAN BEAM GEOMETRY)

BLANK COMMON REQUIRED        18    (    22)

BLANK COMMON REQUIRED        36    (    44)

BLANK COMMON REQUIRED        54    (    66)

BLANK COMMON REQUIRED        78    (   116)

BLANK COMMON REQUIRED       102    (   146)

A TOTAL OF  12 (  1 THRU  12) OF THE  12 USER PROJECTION BINS WILL BE USED

 16 PROJECTION BINS WILL BE USED OF WHICH   4 HAVE BEEN ZEROED BY THE PROGRAM

       MAXIMUM SIZE OF BLANK COMMON THUS FAR=    102 FLOATING POINT WORDS.
```

```
EEEEE N   N DDDD        SSS  EEEEE TTTTT U   U PPPP
E     NN  N D   D      S     E       T   U   U P   P
EEE   N N N D   D       SSS  EEE     T   U   U PPPP
E     N  NN D   D          S E       T   U   U P
EEEEE N   N DDDD        SSS  EEEEE   T    UUU  P
```

```
  GGG  V   V EEEEE RRRR   SSS
 G   G V   V E     R   R S
 G      V V  EEE   RRRR   SSS
 G  GG  V V  E     R  R      S
  GGGG   V   EEEEE R   R  SSS
```

```
        PARAMETERS FOR SUBROUTINE GVERS

                DESCRIPTION

IERR -      2    USE UNCERTAINTIES AND CALCULATE ERRORS

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG     FUNCTION           RAY WEIGHTING      ATTENUATION        FAN BEAM
BCK     BACKPROJECTION     LINE LENGTH            NO                 NO
PRJ     PROJECTION         LINE LENGTH            NO                 NO


BLANK COMMON REQUIRED     32358    ( 77146)


BLANK COMMON REQUIRED     44902    (127546)


BLANK COMMON REQUIRED     45014    (127726)


BLANK COMMON REQUIRED     45126    (130106)


BLANK COMMON REQUIRED     45702    (131206)


BLANK COMMON REQUIRED     45734    (131246)
```

```
PPPP  H   H  AAA  N   N
P   P H   H A   A NN  N
PPPP  HHHHH A   A N N N
P     H   H AAAAA N  NN
P     H   H A   A N   N
```

```
PHANTOM GENERATED
  ARRAY SIZE   12 X  12   INTEGRATION FACTOR =  10   SCALING FACTOR =    1.000
  NUMBER OF ELIPSES AND/OR RECTANGLES =    2
  THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
       X,Y  - CENTER
       A,B  - LENGTH OF AXIS OR SIDE A AND B
       PHI  - ANGLE OF AXIS OR SIDE A
       DENS - INTENSITY
  THE PARENTHESIS INDICATES THE SCALED VALUE
    ITYPE                  X          Y          A          B         PHI       DENS
     2    - RECTANGLE    -3.50 ,       0      3.00 ,     8.00          0        1.00
                       (  -3.50),(     0)(    3.00),(    8.00)              (    1.00)
     2    - RECTANGLE     2.50 ,       0      5.00 ,     4.00          0        1.00
                       (   2.50),(     0)(    5.00),(    4.00)              (    1.00)
```

```
EEEEE N   N DDDD        PPPP  H   H  AAA  N   N
E     NN  N D   D       P   P H   H A   A NN  N
EEE   N N N D   D       PPPP  HHHHH A   A N N N
E     N  NN D   D       P     H   H AAAAA N  NN
EEEEE N   N DDDD        P     H   H A   A N   N
```

```
BLANK COMMON REQUIRED     45750    (131266)

PROJECTION DATA FOR ANGLE NO.   1       .087 RADIANS      5.000 DEGREES
          0           0           0           0    .167E+00
   .167E+00    .446E+00    .446E+00    .446E+00    .446E+00
   .167E+00    .167E+00           0           0           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.   1
   .100E+01    .100E+01    .100E+01    .100E+01    .409E+00
   .409E+00    .668E+00    .668E+00    .668E+00    .668E+00
   .409E+00    .409E+00    .100E+01    .100E+01    .100E+01
   .100E+01

PROJECTION DATA FOR ANGLE NO.   2       .262 RADIANS     15.000 DEGREES
          0           0           0           0           0
   .334E+00    .460E+00    .460E+00    .460E+00    .269E+00
   .173E+00    .173E+00    .146E+00           0           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.   2
   .100E+01    .100E+01    .100E+01    .100E+01    .100E+01
   .578E+00    .678E+00    .678E+00    .678E+00    .518E+00
   .415E+00    .415E+00    .382E+00    .100E+01    .100E+01
   .100E+01

PROJECTION DATA FOR ANGLE NO.   3       .436 RADIANS     25.000 DEGREES
          0           0           0           0    .617E-01
   .247E+00    .490E+00    .490E+00    .374E+00    .229E+00
   .184E+00    .184E+00    .180E+00    .346E-01           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.   3
   .100E+01    .100E+01    .100E+01    .100E+01    .248E+00
   .497E+00    .700E+00    .700E+00    .612E+00    .479E+00
   .429E+00    .429E+00    .424E+00    .186E+00    .100E+01
   .100E+01

PROJECTION DATA FOR ANGLE NO.   4       .611 RADIANS     35.000 DEGREES
          0           0           0    .731E-03    .119E+00
   .237E+00    .414E+00    .446E+00    .338E+00    .220E+00
   .203E+00    .203E+00    .194E+00    .762E-01           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.   4
   .100E+01    .100E+01    .100E+01    .270E-01    .345E+00
   .487E+00    .643E+00    .667E+00    .581E+00    .469E+00
   .451E+00    .451E+00    .441E+00    .276E+00    .100E+01
   .100E+01

PROJECTION DATA FOR ANGLE NO.   5       .785 RADIANS     45.000 DEGREES
          0           0           0    .500E-01    .161E+00
   .272E+00    .314E+00    .314E+00    .314E+00    .236E+00
   .236E+00    .236E+00    .207E+00    .960E-01           0
          0
```

```
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.   5
      .100E+01     .100E+01     .100E+01     .224E+00     .401E+00
      .522E+00     .561E+00     .561E+00     .561E+00     .485E+00
      .485E+00     .485E+00     .455E+00     .310E+00     .100E+01
      .100E+01

PROJECTION DATA FOR ANGLE NO.   6       .960 RADIANS     55.000 DEGREES
             0            0            0     .878E-01     .206E+00
      .271E+00     .271E+00     .213E+00     .213E+00     .255E+00
      .291E+00     .291E+00     .223E+00     .105E+00            0
             0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.   6
      .100E+01     .100E+01     .100E+01     .296E+00     .454E+00
      .521E+00     .521E+00     .462E+00     .462E+00     .505E+00
      .539E+00     .539E+00     .473E+00     .324E+00     .100E+01
      .100E+01

PROJECTION DATA FOR ANGLE NO.   7      1.134 RADIANS     65.000 DEGREES
             0            0            0     .127E+00     .245E+00
      .245E+00     .245E+00     .195E+00     .105E+00     .200E+00
      .345E+00     .394E+00     .250E+00     .105E+00            0
             0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.   7
      .100E+01     .100E+01     .100E+01     .357E+00     .495E+00
      .495E+00     .495E+00     .442E+00     .324E+00     .447E+00
      .587E+00     .628E+00     .500E+00     .324E+00     .100E+01
      .100E+01

PROJECTION DATA FOR ANGLE NO.   8      1.309 RADIANS     75.000 DEGREES
             0            0            0     .188E+00     .230E+00
      .230E+00     .230E+00     .226E+00     .392E-02     .134E+00
      .356E+00     .460E+00     .303E+00     .811E-01            0
             0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.   8
      .100E+01     .100E+01     .100E+01     .434E+00     .480E+00
      .480E+00     .480E+00     .476E+00     .626E-01     .366E+00
      .597E+00     .678E+00     .551E+00     .285E+00     .100E+01
      .100E+01

PROJECTION DATA FOR ANGLE NO.   9      1.484 RADIANS     85.000 DEGREES
             0            0            0     .223E+00     .223E+00
      .223E+00     .223E+00     .223E+00            0            0
      .446E+00     .446E+00     .446E+00            0            0
             0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.   9
      .100E+01     .100E+01     .100E+01     .472E+00     .472E+00
      .472E+00     .472E+00     .472E+00     .100E+01     .100E+01
      .668E+00     .668E+00     .668E+00     .100E+01     .100E+01
      .100E+01

PROJECTION DATA FOR ANGLE NO.  10      1.658 RADIANS     95.000 DEGREES
             0            0            0     .223E+00     .223E+00
      .223E+00     .223E+00     .223E+00            0            0
      .446E+00     .446E+00     .446E+00            0            0
             0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.  10
      .100E+01     .100E+01     .100E+01     .472E+00     .472E+00
      .472E+00     .472E+00     .472E+00     .100E+01     .100E+01
      .668E+00     .668E+00     .668E+00     .100E+01     .100E+01
      .100E+01

PROJECTION DATA FOR ANGLE NO.  11      1.833 RADIANS    105.000 DEGREES
             0            0            0     .188E+00     .230E+00
      .230E+00     .230E+00     .226E+00     .392E-02     .134E+00
      .356E+00     .460E+00     .303E+00     .811E-01            0
             0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.  11
      .100E+01     .100E+01     .100E+01     .434E+00     .480E+00
      .480E+00     .480E+00     .476E+00     .626E-01     .366E+00
      .597E+00     .678E+00     .551E+00     .285E+00     .100E+01
      .100E+01

PROJECTION DATA FOR ANGLE NO.  12      2.007 RADIANS    115.000 DEGREES
             0            0            0     .127E+00     .245E+00
      .245E+00     .245E+00     .195E+00     .105E+00     .200E+00
      .345E+00     .394E+00     .250E+00     .105E+00            0
             0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.  12
      .100E+01     .100E+01     .100E+01     .357E+00     .495E+00
      .495E+00     .495E+00     .442E+00     .324E+00     .447E+00
      .587E+00     .628E+00     .500E+00     .324E+00     .100E+01
      .100E+01

PROJECTION DATA FOR ANGLE NO.  13      2.182 RADIANS    125.000 DEGREES
             0            0            0     .878E-01     .206E+00
      .271E+00     .271E+00     .213E+00     .213E+00     .255E+00
      .291E+00     .291E+00     .223E+00     .105E+00            0
             0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.  13
      .100E+01     .100E+01     .100E+01     .296E+00     .454E+00
      .521E+00     .521E+00     .462E+00     .462F+00     .505E+00
      .539E+00     .539E+00     .473E+00     .324E+00     .100E+01
      .100E+01

PROJECTION DATA FOR ANGLE NO.  14      2.356 RADIANS    135.000 DEGREES
             0            0            0     .500E-01     .161E+00
      .272E+00     .314E+00     .314E+00     .314E+00     .236E+00
      .236E+00     .236E+00     .207E+00     .960E-01            0
             0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.  14
      .100E+01     .100E+01     .100E+01     .224E+00     .401E+00
      .522E+00     .561E+00     .561E+00     .561E+00     .485E+00
      .485E+00     .485E+00     .455E+00     .310E+00     .100E+01
      .100E+01

PROJECTION DATA FOR ANGLE NO.  15      2.531 RADIANS    145.000 DEGREES
             0            0            0     .731E-03     .119E+00
      .237E+00     .414E+00     .446E+00     .338E+00     .220E+00
      .203E+00     .203E+00     .194E+00     .762F-01            0
             0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.  15
      .100E+01     .100E+01     .100E+01     .270E-01     .345E+00
      .487E+00     .643E+00     .667E+00     .581E+00     .469E+00
      .451E+00     .451E+00     .441E+00     .276E+00     .100E+01
      .100E+01

PROJECTION DATA FOR ANGLE NO.  16      2.705 RADIANS    155.000 DEGREES
             0            0            0            0     .617E-01
      .247E+00     .490E+00     .490E+00     .374E+00     .229E+00
      .184E+00     .184E+00     .180E+00     .346E-01            0
             0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.  16
      .100E+01     .100E+01     .100E+01     .100E+01     .248E+00
      .497E+00     .700E+00     .700E+00     .612E+00     .479E+00
      .429E+00     .429E+00     .424E+00     .186E+00     .100E+01
      .100E+01

PROJECTION DATA FOR ANGLE NO.  17      2.880 RADIANS    165.000 DEGREES
            .0            0            0            0            0
      .334E+00     .460E+00     .460E+00     .460E+00     .269E+00
      .173E+00     .173E+00     .146E+00            0            0
             0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.  17
      .100E+01     .100E+01     .100E+01     .100E+01     .100E+01
      .578E+00     .678E+00     .678E+00     .678E+00     .518E+00
      .415E+00     .415E+00     .382E+00     .100E+01     .100E+01
      .100E+01
```

```
BLANK COMMON REQUIRED     45734    (131246)

PROJECTION DATA FOR ANGLE NO.  18      3.054 RADIANS    175.000 DEGREES
             0            0            0            0     .167E+00
      .167E+00     .446E+00     .446E+00     .446E+00     .446E+00
      .167E+00     .167E+00            0            0            0
             0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.  18
      .100E+01     .100E+01     .100E+01     .100F+01     .409E+00
      .409E+00     .668E+00     .668E+00     .668E+00     .668E+00
      .409E+00     .409E+00     .100E+01     .100E+01     .100E+01
      .100E+01

BLANK COMMON REQUIRED     13478    ( 32246)

BLANK COMMON REQUIRED       934    (  1646)

BLANK COMMON PEQUIRED       822    (  1466)

BLANK COMMON REQUIRED       710    (  1306)

BLANK COMMON REQUIRED       678    (  1246)

BLANK COMMON REQUIRED       102    (   146)

        MAXIMUM SIZE OF BLANK COMMON THUS FAR=  45750 FLOATING POINT WORDS.

          EEEEE N   N DDDD        GGG  V   V EEEEE RRRR   SSS
          E     NN  N D   D      G   G V   V E     R   R S
          EEE   N N N D   D      G     V V   EEE   RRRR   SSS
          E     N  NN D   D      G  GG  V V  E     R  R      S
          EEEEE N   N DDDD        GGGG   V   EEEEE R   R  SSS

CHISQ =    .1014746E-11

XMIN =   -.37E-05      XMAX =    .10E+01      XSUM =    .4400E+02

                        **************
                        *            *
                        * ###        *
                        * ###  ##### *
                        * ###  ##### *
                        * ###  ##### *
                        * ###        *
                        *            *
                        **************

                    -          =          +          )          1          Z
-.3688E-05  .7500E-01  .1850E+00  .2350E+00  .2700E+00  .3100E+00  .3500E+00

Z          X          A          M          &          #          #          >
 .3850E+00  .4100E+00  .4350E+00  .4900E+00  .5450E+00  .5800E+00  .6200E+00

#          #          #          #          #          #          #          #
 .6550E+00  .7300E+00  .8200E+00  .8700E+00  .9100E+00  .9500E+00  .9850E+00

#
 .1000E+01

   0    0    0    0   .0   .0  -.0   .0    0    0    0    0
   0    0   .0   .0   .0   .0   .0  -.0   .0  -.0    0    0
   0  1.0  1.0  1.0   .0   .0  -.0  -.0   .0  -.0  -.0    0
   0  1.0  1.0  1.0  -.0   .0  -.0   .0   .0   .0   .0    0
  .0  1.0  1.0  1.0  -.0   .0  1.0  1.0  1.0  1.0  1.0   .0
  .0  1.0  1.0  1.0   .0  -.0  1.0  1.0  1.0  1.0  1.0  -.0
  .0  1.0  1.0  1.0  -.0   .0  1.0  1.0  1.0  1.0  1.0   .0
  .0  1.0  1.0  1.0   .0  -.0  1.0  1.0  1.0  1.0  1.0   .0
   0  1.0  1.0  1.0   .0  -.0   .0  -.0  -.0   .0  -.0    0
   0  1.0  1.0  1.0  -.0  -.0   .0   .0   .0   .0  -.0    0
   0    0   .0   .0  -.0   .0  -.0  -.0   .0   .0    0    0
   0    0    0    0  -.0   .0   .0   .0    0    0    0    0

XMIN =           0     XMAX =    .29E+02      XSUM =    .3333E+03

                        **************
                        *  -=-----=-  *
                        * -+)11111)+- *
                        *-=)11111)Z)--*
                        *--))+##+1)--*
                        *-=)11)))Z)--*
                        * -+)11111)+- *
                        *  -=-----=-  *
                        **************

                -          =          +          )          1          Z
         0  .2154E+01  .5314E+01  .6750E+01  .7756E+01  .9905E+01  .1003E+02

Z          X          A          M          &          #          #          >
 .1106E+02  .1178E+02  .1250E+02  .1408E+02  .1566E+02  .1656E+02  .1751E+02

#          #          #          #          #          #          #          #
 .1882E+02  .2057E+02  .2355E+02  .2499E+02  .2614E+02  .2720E+02  .2324E+02

#
 .2873E+02
```

```
   0     0     0     0   4.0   3.9   4.3   4.1     0     0     0     0
   0     0   3.9   6.0   5.2   5.2   5.3   5.0   5.6   4.2     0     0
   0   3.7   6.8   7.6   8.6   8.6   8.6   8.2   7.7   6.5   4.3     0
   0   6.0   8.1   8.1  10.7  10.1   9.8  10.2   8.1   7.9   5.8     0
 4.1   5.4   8.2   9.9   9.2   8.4   8.4   8.9  10.7   8.1   5.0   3.8
 3.8   5.3   8.6   8.7   6.8  28.7  28.7   7.0   9.8   8.2   4.9   4.1
 3.8   5.3   8.6   8.7   6.8  28.7  28.7   7.0   9.8   8.2   4.9   4.1
 4.1   5.4   8.2   9.9   9.2   8.4   8.4   8.9  10.7   8.1   5.0   3.8
   0   6.0   8.1   8.1  10.7  10.1   9.8  10.2   8.1   7.9   5.8     0
   0   3.7   6.8   7.6   8.6   8.6   8.6   8.2   7.7   6.5   4.3     0
   0     0   3.9   6.0   5.2   5.2   5.3   5.0   5.6   4.2     0     0
   0     0     0     0   4.0   3.9   4.3   4.1     0     0     0     0
```

```
  CCC   OOOOO N   N  GGG  RRRR
 C   C O   O NN  N G   G R   R
 C     O   O N N N G     RRRR
 C   C O   O N  NN G  GG R  R
  CCC   OOOOO N   N  GGGG R   R
```

```
          PARAMETERS FOR SUBROUTINE CONGR

                  DESCRIPTION

ISTP -       15    NUMBER OF ITERATION STEPS
IRLX -        1    ITERATIVE RELAXATION METHOD
IERR -        1    USE ERROR ARRAY
IZER -        0    INITIAL SOLUTION IS ZERO

BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER ROUTINES
PERFORM THE FOLLOWING FUNCTIONS

ARG    FUNCTION          RAY WEIGHTING       ATTENUATION          FAN BEAM
BCK    BACKPROJECTION    LINE LENGTH             NO                  NO
PRJ    PROJECTION        LINE LENGTH             NO                  NO


BLANK COMMON REQUIRED      134    (   206)


BLANK COMMON REQUIRED      246    (   366)


BLANK COMMON REQUIRED      534    (  1026)


BLANK COMMON REQUIRED      646    (  1206)


BLANK COMMON REQUIRED      758    (  1366)


BLANK COMMON REQUIRED      870    (  1546)
```

```
 PPPP  H   H  AAA  N   N
 P   P H   H A   A NN  N
 PPPP  HHHHH A   A N N N
 P     H   H AAAAA N  NN
 P     H   H A   A N   N
```

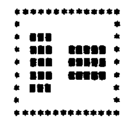
```
PHANTOM GENERATED
  ARRAY SIZE   12 X  12   INTEGRATION FACTOR =  10   SCALING FACTOR =    1.000
  NUMBER OF ELIPSES AND/OR RECTANGLES =     2
  THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
       X,Y   - CENTER
       A,B   - LENGTH OF AXIS OR SIDE A AND B
       PHI   - ANGLE OF AXIS OR SIDE A
       DENS  - INTENSITY
  THE PARENTHESIS INDICATES THE SCALED VALUE
    ITYPE                X           Y         A          B        PHI       DENS
     2    - RECTANGLE    -3.50 ,     0      3.00 ,     8.00          0      1.00
                     (  -3.50),(     0)(    3.00),(    8.00)           (    1.00)
     2    - RECTANGLE     2.50 ,     0      5.00 ,     4.00          0      1.00
                     (   2.50),(     0)(    5.00),(    4.00)           (    1.00)
```

```
 EEEEE N   N DDDD       PPPP  H   H  AAA  N   N
 E     NN  N D   D      P   P H   H A   A NN  N
 EEE   N N N D   D      PPPP  HHHHH A   A N N N
 E     N  NN D   D      P     H   H AAAAA N  NN
 EEEEE N   N DDDD       P     H   H A   A N   N
```

```
BLANK COMMON REQUIRED       886    (  1566)

PROJECTION DATA FOR ANGLE NO.   1       .087 RADIANS      5.000 DEGREES
          0          0          0          0    .167E+00
   .167E+00   .446E+00   .446E+00   .446E+00    .446E+00
   .167E+00   .167E+00          0          0           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.   1
   .100E+01   .100E+01   .100E+01   .100E+01    .409E+00
   .409E+00   .668E+00   .668E+00   .668E+00    .668E+00
   .409E+00   .409E+00   .100E+01   .100E+01    .100E+01
   .100E+01

PROJECTION DATA FOR ANGLE NO.   2       .262 RADIANS     15.000 DEGREES
          0          0          0          0           0
   .334E+00   .460E+00   .460E+00   .460E+00    .269E+00
   .173E+00   .173E+00   .146E+00          0           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.   2
   .100E+01   .100E+01   .100E+01   .100E+01    .100E+01
   .578E+00   .678E+00   .678E+00   .678E+00    .518E+00
   .415E+00   .415E+00   .382E+00   .100E+01    .100E+01
   .100E+01

PROJECTION DATA FOR ANGLE NO.   3       .436 RADIANS     25.000 DEGREES
          0          0          0          0    .617E-01
   .247E+00   .490E+00   .490E+00   .374E+00    .229E+00
   .184E+00   .184E+00   .180E+00   .346E-01           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.   3
   .100E+01   .100E+01   .100E+01   .100E+01    .248E+00
   .497E+00   .700E+00   .700E+00   .612E+00    .479E+00
   .429E+00   .429E+00   .424E+00   .186E+00    .100E+01
   .100E+01

PROJECTION DATA FOR ANGLE NO.   4       .611 RADIANS     35.000 DEGREES
          0          0          0   .731E-03    .119E+00
   .237E+00   .414E+00   .446E+00   .338E+00    .220E+00
   .203E+00   .203E+00   .194E+00   .762E-01           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.   4
   .100E+01   .100E+01   .100E+01   .270E-01    .345E+00
   .487E+00   .643E+00   .667E+00   .581E+00    .469E+00
   .451E+00   .451E+00   .441E+00   .276E+00    .100E+01
   .100E+01

PROJECTION DATA FOR ANGLE NO.   5       .785 RADIANS     45.000 DEGREES
          0          0          0   .500E-01    .161E+00
   .272E+00   .314E+00   .314E+00   .314E+00    .236E+00
   .236E+00   .236E+00   .207E+00   .960E-01           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.   5
   .100E+01   .100E+01   .100E+01   .224E+00    .401E+00
   .522E+00   .561E+00   .561E+00   .561E+00    .485E+00
   .485E+00   .485E+00   .455E+00   .310E+00    .100E+01
   .100E+01

PROJECTION DATA FOR ANGLE NO.   6       .960 RADIANS     55.000 DEGREES
          0          0          0   .878E-01    .206E+00
   .271E+00   .271E+00   .213E+00   .213E+00    .255E+00
   .291E+00   .291E+00   .223E+00   .105E+00           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.   6
   .100E+01   .100E+01   .100E+01   .296E+00    .454E+00
   .521E+00   .521E+00   .462E+00   .462E+00    .505E+00
   .539E+00   .539E+00   .473E+00   .324E+00    .100E+01
   .100E+01

PROJECTION DATA FOR ANGLE NO.   7      1.134 RADIANS     65.000 DEGREES
          0          0          0   .127E+00    .245E+00
   .245E+00   .245E+00   .195E+00   .105E+00    .200E+00
   .345E+00   .394E+00   .250E+00   .105E+00           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.   7
   .100E+01   .100E+01   .100E+01   .357E+00    .495E+00
   .495E+00   .495E+00   .442E+00   .324E+00    .447E+00
   .587E+00   .628E+00   .500E+00   .324E+00    .100E+01
   .100E+01

PROJECTION DATA FOR ANGLE NO.   8      1.309 RADIANS     75.000 DEGREES
          0          0          0   .188E+00    .230E+00
   .230E+00   .230E+00   .226E+00   .392E-02    .134E+00
   .356E+00   .460E+00   .303E+00   .811E-01           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.   8
   .100E+01   .100E+01   .100E+01   .434E+00    .480E+00
   .480E+00   .480E+00   .476E+00   .626E-01    .366E+00
   .597E+00   .678E+00   .551E+00   .285E+00    .100E+01
   .100E+01

PROJECTION DATA FOR ANGLE NO.   9      1.484 RADIANS     85.000 DEGREES
          0          0          0   .223E+00    .223E+00
   .223E+00   .223E+00   .223E+00          0           0
   .446E+00   .446E+00   .446E+00          0           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.   9
   .100E+01   .100E+01   .100E+01   .472E+00    .472E+00
   .472E+00   .472E+00   .472E+00   .100E+01    .100E+01
   .668E+00   .668E+00   .668E+00   .100E+01    .100E+01
   .100E+01

PROJECTION DATA FOR ANGLE NO.  10      1.658 RADIANS     95.000 DEGREES
          0          0          0   .223E+00    .223E+00
   .223E+00   .223E+00   .223E+00          0           0
   .446E+00   .446E+00   .446E+00          0           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.  10
   .100E+01   .100E+01   .100E+01   .472E+00    .472E+00
   .472E+00   .472E+00   .472E+00   .100E+01    .100E+01
   .668E+00   .668E+00   .668E+00   .100E+01    .100E+01
   .100E+01

PROJECTION DATA FOR ANGLE NO.  11      1.833 RADIANS    105.000 DEGREES
          0          0          0   .188E+00    .230E+00
   .230E+00   .230E+00   .226E+00   .392E-02    .134E+00
   .356E+00   .460E+00   .303E+00   .811E-01           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.  11
   .100E+01   .100E+01   .100E+01   .434E+00    .480E+00
   .480E+00   .480E+00   .476E+00   .626E-01    .366E+00
   .597E+00   .678E+00   .551E+00   .285E+00    .100E+01
   .100E+01

PROJECTION DATA FOR ANGLE NO.  12      2.007 RADIANS    115.000 DEGREES
          0          0          0   .127E+00    .245E+00
   .245E+00   .245E+00   .195E+00   .105E+00    .200E+00
   .345E+00   .394E+00   .250E+00   .105E+00           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.  12
   .100E+01   .100E+01   .100E+01   .357E+00    .495E+00
   .495E+00   .495E+00   .442E+00   .324E+00    .447E+00
   .587E+00   .628E+00   .500E+00   .324E+00    .100E+01
   .100E+01

PROJECTION DATA FOR ANGLE NO.  13      2.182 RADIANS    125.000 DEGREES
          0          0          0   .878E-01    .206E+00
   .271E+00   .271E+00   .213E+00   .213E+00    .255E+00
   .291E+00   .291E+00   .223E+00   .105E+00           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.  13
   .100E+01   .100E+01   .100E+01   .296E+00    .454E+00
   .521E+00   .521E+00   .462E+00   .462E+00    .505E+00
   .539E+00   .539E+00   .473E+00   .324E+00    .100E+01
   .100E+01

PROJECTION DATA FOR ANGLE NO.  14      2.356 RADIANS    135.000 DEGREES
          0          0          0   .500E-01    .161E+00
   .272E+00   .314E+00   .314E+00   .314E+00    .236E+00
   .236E+00   .236E+00   .207E+00   .960E-01           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.  14
   .100E+01   .100E+01   .100E+01   .224E+00    .401E+00
   .522E+00   .561E+00   .561E+00   .561E+00    .485E+00
   .485E+00   .485E+00   .455E+00   .310E+00    .100E+01
   .100E+01

PROJECTION DATA FOR ANGLE NO.  15      2.531 RADIANS    145.000 DEGREES
          0          0          0   .731E-03    .119E+00
   .237E+00   .414E+00   .446E+00   .338E+00    .220E+00
   .203E+00   .203E+00   .194E+00   .762E-01           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.  15
   .100E+01   .100E+01   .100E+01   .270E-01    .345E+00
   .487E+00   .643E+00   .667E+00   .581E+00    .469E+00
   .451E+00   .451E+00   .441E+00   .276E+00    .100E+01
   .100E+01

PROJECTION DATA FOR ANGLE NO.  16      2.705 RADIANS    155.000 DEGREES
          0          0          0          0    .617E-01
   .247E+00   .490E+00   .490E+00   .374E+00    .229E+00
   .184E+00   .184E+00   .180E+00   .346E-01           0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.  16
   .100E+01   .100E+01   .100E+01   .100E+01    .248E+00
   .497E+00   .700E+00   .700E+00   .612E+00    .479E+00
   .429E+00   .429E+00   .424E+00   .186E+00    .100E+01
   .100E+01
```

```
PROJECTION DATA FOR ANGLE NO.  17      2.880 RADIANS   165.000 DEGREES
          0          0          0          0          0
     .334E+00   .460E+00   .460E+00   .460E+00   .269E+00
     .173E+00   .173E+00   .146E+00          0          0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.  17
     .100E+01   .100E+01   .100E+01   .100E+01   .100E+01
     .578E+00   .678E+00   .678E+00   .678E+00   .518E+00
     .415E+00   .415E+00   .382E+00   .100E+01   .100E+01
     .100E+01

BLANK COMMON REQUIRED       870    (  1546)

PROJECTION DATA FOR ANGLE NO.  18      3.054 RADIANS   175.000 DEGREES
          0          0          0          0   .167E+00
     .167E+00   .446E+00   .446E+00   .446E+00   .446E+00
     .167E+00   .167E+00          0          0          0
          0
PROJECTION DATA UNCERTAINTY FOR ANGLE NO.  18
     .100E+01   .100E+01   .100E+01   .100E+01   .409E+00
     .409E+00   .668E+00   .668E+00   .668E+00   .668E+00
     .409E+00   .409E+00   .100E+01   .100E+01   .100E+01
     .100E+01

FOR CONGR AND GRADY FCN IS THE VALUE OF THE CHI-SQUARE
FOR ENTPY FCN IS EVALUATED BY THE SUBROUTINE DULFC
ITER  0      FCN     .441E+02
ITER  1      FCN     .540E+01
ITER  2      FCN     .193E+01
ITER  3      FCN     .378E+00
ITER  4      FCN     .135E+00
ITER  5      FCN     .845E-01
ITER  6      FCN     .387E-01
ITER  7      FCN     .150E-01
ITER  8      FCN     .613E-02
ITER  9      FCN     .318E-02
ITER 10      FCN     .208E-02
ITER 11      FCN     .141E-02
ITER 12      FCN     .126E-02
ITER 13      FCN     .866E-03
ITER 14      FCN     .611E-03
ITER 15      FCN     .523E-03

BLANK COMMON REQUIRED      838    (  1506)

BLANK COMMON REQUIRED      726    (  1326)

BLANK COMMON REQUIRED      438    (   666)

BLANK COMMON REQUIRED      326    (   506)

BLANK COMMON REQUIRED      214    (   326)

BLANK COMMON REQUIRED      102    (   146)
```

```
MAXIMUM SIZE OF BLANK COMMON THUS FAR=  45750 FLOATING POINT WORDS.

EEEEE N    N DDDD        CCC   OOOOO N    N  GGG   RRRR
E     NN   N D   D      C   C O    O NN   N G    G R    R
EEE   N N  N D   D      C     O    O N N  N G      RRRR
E     N  NN  D   D      C   C O    O N   NN G   GG R   R
EEEEE N    N DDDD        CCC   OOOOO N    N  GGGG R    R

XMIN =   -.31E-01     XMAX =    .10E+01     XSUM =    .4402E+02
```



```
                     -          =          +          )          1          Z
-.3141E-01 .4815E-01 .1648E+00 .2179E+00 .2550E+00 .2974E+00 .3399E+00

Z          X          A          M          Θ          ■          ■          ■
 .3770E+00 .4035E+00 .4300E+00 .4884E+00 .5467E+00 .5839E+00 .6263E+00

■          ■          ■          ■          ■          ■          ■          ■
 .6634E+00 .7430E+00 .8385E+00 .8915E+00 .9339E+00 .9764E+00 .1014E+01

■
 .1029E+01
```

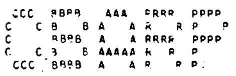
```
   0    0    0    0   .0  -.0  -.0   .0    0    0    0    0
   0    0  -.0   .0  -.0  -.0  -.0   .0  -.0   .0    0    0
   0  1.0  1.0  1.0   .0  -.0   .0  -.0  -.0  -.0   .0    0
   0  1.0  1.0  1.0  -.0   .0  -.0   .0   .0   .0   .0    0
  .0  1.0  1.0  1.0   .0  -.0  1.0  1.0  1.0  1.0  1.0   .0
 -.0  1.0  1.0  1.0  -.0   .0  1.0  1.0  1.0  1.0  1.0   .0
 -.0  1.0  1.0  1.0  -.0   .0  1.0  1.0  1.0  1.0  1.0   .0
  .0  1.0  1.0  1.0   .0  -.0  1.0  1.0  1.0  1.0  1.0   .0
   0  1.0  1.0  1.0  -.0   .0  -.0   .0   .0   .0   .0    0
   0  1.0  1.0  1.0   .0  -.0   .0  -.0  -.0  -.0   .0    0
   0    0  -.0   .0  -.0  -.0  -.0   .0  -.0   .0    0    0
   0    0    0    0   .0  -.0  -.0   .0    0    0    0    0
```

13. Examples 16,17,18 - Phantoms

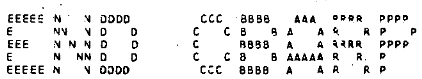
The programs CBARPX, PIEX, and RECT give examples of the phantoms that can be generated using the RECLBL Library. The program CBARPX generates a circular bar phantom using the subroutine CBARP. The program PIEX generates a pie phantom with intensity that alternates between 0 and 1 for 20 slices of a circular disk using the subroutine PIE. The parameter NSLIPI = 10 used by the subroutine PIE is the number of equal slices of the disk in π radians. The program RECT generates two rectangular and two elliptical phantoms using the subroutine PHAN.

In order to obtain projection data for the circular bar phantom and the pie phantom, the subroutine PJECT is used as illustrated in the subroutine GETUM of Example 5. However, the projection data for the rectangular and elliptical phantoms can be generated using the subroutine PHANL. The calling sequences for both PHANL and PHAN are similar in that the parameters that describe the phantoms for both subroutines are identical.

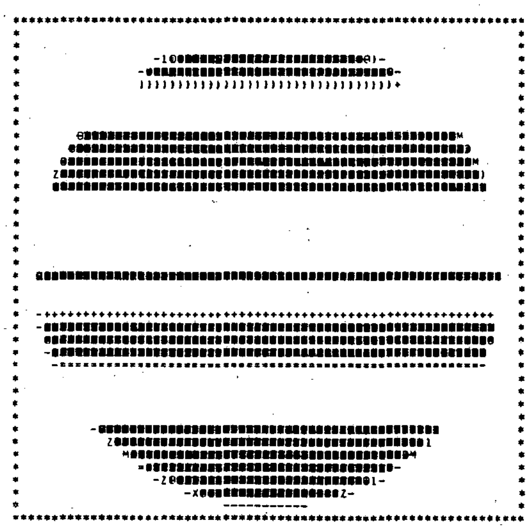
```
      PROGRAM CBARPX (INPUT,OUTPUT,TAPE2=OUTPUT)                        E16.001
C                                                                       E16.002
C        EXAMPLE 16                                                     E16.003
C                                                                       E16.004
C              THE PROGRAM CBARPX GENERATES A CIRCULAR BAR PHANTOM.     E16.005
C                                                                       E16.006
      COMMON/OUTCOM/LUNOUT,I80132                                       E16.007
C                                                                       E16.008
      DIMENSION B(4096)                                                 E16.009
C                                                                       E16.010
      LUNOUT=2                                                          E16.011
      I80132=0                                                          E16.012
C                                                                       E16.013
      NDIMU=64                                                          E16.014
      R=30.                                                             E16.015
      X1=0.                                                             E16.016
      Y1=0.                                                             E16.017
      Z=1.                                                              E16.018
      INTFAC=10                                                         E16.019
      NBAR=5                                                            E16.020
      NREPS=2                                                           E16.021
      IDIREC=1                                                          E16.022
C                                                                       E16.023
      CALL CBARP (B,NDIMU,R,X1,Y1,Z,INTFAC,NBAR,NREPS,IDIREC)           E16.024
C                                                                       E16.025
      CALL ARRAY (B,NDIMU)                                              E16.026
C                                                                       E16.027
      END                                                               E16.028
```



```
BAR PATTERN PHANTOM GENERATED
ARRAY SIZE    64X 64
CIRCLE RADIUS    30.00  AT  (  0,  0)
INT FACTOR   10
NO. OF BARS     5
```

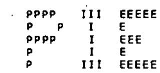


```
XMIN =          0     XMAX =    .10E+01     XSUM =    .1313E+04
```

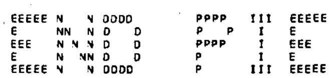


```
     0   .7500E-01  .1850E+00  .2350E+00  .2700E+00  .3100E+00  .3500E+00
 .3850E+00  .4100E+00  .4350E+00  .4900E+00  .5450E+00  .5800E+00  .6200E+00
 .6550E+00  .7300E+00  .8200E+00  .8700E+00  .9100E+00  .9500E+00  .9850E+00
 .1000E+01
```

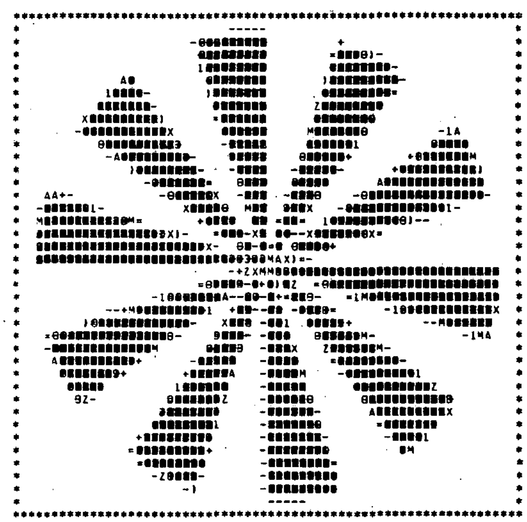
```
      PROGRAM PIEX (INPUT,OUTPUT,TAPE2=OUTPUT)                          E17.001
C                                                                       E17.002
C        EXAMPLE 17                                                     E17.003
C                                                                       E17.004
C              THE PROGRAM PIEX SHOWS HOW TO GENERATE A PIE PHANTOM.    E17.005
C                                                                       E17.006
      DIMENSION B(4096)                                                 E17.007
      COMMON/OUTCOM/LUNOUT,I80132                                       E17.008
C                                                                       E17.009
      LUNOUT=2                                                          E17.010
      I80132=0                                                          E17.011
C                                                                       E17.012
      NDIMU=64                                                          E17.013
      R=30.                                                             E17.014
      X1=0.                                                             E17.015
      Y1=0.                                                             E17.016
      Z=1.                                                              E17.017
      INTFAC=10                                                         E17.018
      NSLIPI=10                                                         E17.019
      ISTART=0                                                          E17.020
C                                                                       E17.021
      CALL PIE (B,NDIMU,R,X1,Y1,Z,INTFAC,NSLIPI,ISTART)                 E17.022
C                                                                       E17.023
      CALL ARRAY (B,NDIMU)                                              E17.024
C                                                                       E17.025
      END                                                               E17.026
```



```
PIE PHANTOM GENERATED
ARRAY SIZE    64X 64
CIRCLE RADIUS    30.00  AT  (  0,  0)
INT FACTOR   10
SECTOR WIDTH    .314
```



```
XMIN =          0     XMAX =    .10E+01     XSUM =    .1413E+04
```



```
     0   .7500E-01  .1850E+00  .2350E+00  .2700E+00  .3100E+00  .3500E+00
 .3850E+00  .4100E+00  .4350E+00  .4900E+00  .5450E+00  .5800E+00  .6200E+00
 .6550E+00  .7300E+00  .8200E+00  .8700E+00  .9100E+00  .9500E+00  .9850E+00
 .1000E+01
```

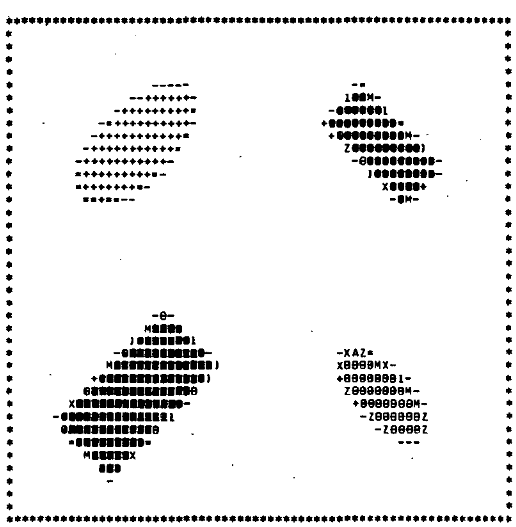
```
      PROGRAM RECT (INPUT,OUTPUT,TAPE2=OUTPUT)
C
C        EXAMPLE 18
C
C             THE PROGRAM RECT SHOWS HOW TO GENERATE RECTANGULAR AND
C        ELLIPICAL PHANTOMS.
C
      DIMENSION B(4096)
      DIMENSION ITYPE(4),A1(4),B1(4),X1(4),Y1(4),PHI(4),Z(4)
      DATA ITYPE/1,1,2,2/
      COMMON/OUTCOM/LUNOUT,I80132
      DATA A1/20.,15.,15.,20./
      DATA B1/10.,7.,7.,10./
      DATA X1/-16.,16.,16.,-16./
      DATA Y1/16.,-16.,16.,-16./
      DATA PHI/.785398,2.356194,2.356194,.785398/
      DATA Z/1.,2.,3.,4./
C
      LUNOUT=2
      I80132=0
C
      NPHAN=4
      INTG=10
      NDIMU=64
      PWID=1.
      CALL PHAN (NPHAN,INTG,ITYPE,Z,X1,Y1,A1,B1,PHI,B,NDIMU,PWID)
C
      CALL ARRAY (B,NDIMU)
C
      END
```

```
PPPP  H   H  AAA  N   N
P   P H   H A   A NN  N
PPPP  HHHHH A   A N N N
P     H   H AAAAA N  NN
P     H   H A   A N   N
```

```
PHANTOM GENERATED
  ARRAY SIZE   64 X  64   INTEGRATION FACTOR =  10   SCALING FACTOR =    1.000
  NUMBER OF ELIPSES AND/OR RECTANGLES =    4
  THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES ARE
       X,Y  - CENTER
       A,B  - LENGTH OF AXIS OR SIDE A AND B
       PHI  - ANGLE OF AXIS OR SIDE A
       DENS - INTENSITY
  THE PARENTHESIS INDICATES THE SCALED VALUE
    ITYPE                  X          Y          A          B          PHI       DENS
      1    - ELLIPSE     -16.00 ,   16.00      20.00 ,    10.00        .79       1.00
                       ( -16.00),(  16.00)(   20.00),(   10.00)              (   1.00)
      1    - ELLIPSE      16.00 ,  -16.00      15.00 ,     7.00       2.36       2.00
                       (  16.00),( -16.00)(   15.00),(    7.00)              (   2.00)
      2    - RECTANGLE    16.00 ,   16.00      15.00 ,     7.00       2.36       3.00
                       (  16.00),(  16.00)(   15.00),(    7.00)              (   3.00)
      2    - RECTANGLE   -16.00 ,  -16.00      20.00 ,    10.00        .79       4.00
                       ( -16.00),( -16.00)(   20.00),(   10.00)              (   4.00)
```

```
EEEEE N   N DDDD      PPPP  H   H  AAA  N   N
E     NN  N D   D     P   P H   H A   A NN  N
EEE   N N N D   D     PPPP  HHHHH A   A N N N
E     N  NN D   D     P     H   H AAAAA N  NN
EEEEE N   N DDDD      P     H   H A   A N   N
```

```
XMIN =          0.    XMAX =     .40E+01     XSUM =    .1436E+04
```



```
         -           =           +           )           1           Z
0  .3000E+00  .7400E+00  .9400E+00  .1080E+01  .1240E+01  .1400E+01

Z          X          A          M          @          @          @          ■
.1540E+01  .1640E+01  .1740E+01  .1960E+01  .2180E+01  .2320E+01  .2480E+01

■          ■          ■          ■          ■          ■          ■          ■
.2620E+01  .2920E+01  .3280E+01  .3480E+01  .3640E+01  .3800E+01  .3940E+01

■
.4000E+01
```

X. LIBRARY LISTING

1. Quick Reference

a. Parameter Input

SUBROUTINE SETUP (IPAR,PAR,ANGL)

The subroutine SETUP initializes certain RECLBL common blocks and must be called before any of the reconstruction subroutines.

IPAR - Integer parameter array.
PAR - Floating point parameter array.
ANGL - Array of projection angles.

The elements of the IPAR and PAR arrays are defined as follows:

IPAR(1) = Linear dimension of the reconstruction array.
IPAR(2) = 0 to reconstruct a circular array otherwise reconstruct a square array.
IPAR(3) = 0 parallel-beam geometry.
1 fan-beam geometry (curved detector).
2 fan-beam geometry (flat detector).
3 ring-detector geometry.
IPAR(4) = Number of projection angles.
IPAR(5) = 0 user supplies projection angles in degrees.
1 user supplies projection angles in radians.
2 projection angles generated between zero and π starting at the half angle.
3 projection angles generated between zero and 2π starting at the half angle.
4 projection angles generated between zero and π starting at zero.
5 projection angles generated between zero and 2π starting at zero.
-I where I is between 2 and 5 does the same as above with the order of angles reversed.

IPAR(6) = Number of bins for each projection angle.

IPAR(7) = 0 to reconstruct emission data, otherwise reconstruct transmission data.

IPAR(8) = Dimension of blank common set by the user.

IPAR(9) = Number of words for a floating point variable.

IPAR(10) = 0 to perform a reconstruction, otherwise only do a storage size test.

IPAR(11) = Print flags (Bit 0 = least significant bit)

- Bit 0 Print required floating point blank common whenever changed.
- Bit 1 Print projection data and uncertainties.
- Bit 2 Print setup values from IPAR and PAR arrays.
- Bit 3 Print filter function for convolution and filter routines.
- Bit 4 Print values for the Lagrange multipliers for the entropy reconstruction.
- Bit 5 Print pointers in blank common whenever changed (debug).

IPAR(12) = Logical unit number for attenuation factor storage.

PAR(1) = Pixel width in units of projection bin width.

PAR(2) = Location of the rotation axis in the projection array.

PAR(3) = The distance from the source to the center of rotation for fan-beam geometry (measured in units of projection bin widths at the center of rotation).

b. Data Input

SUBROUTINE GETUM (M,DATA,ERR)

The subroutine GETUM is a subroutine supplied by the user that returns projection data and uncerainties for each angle.

M - Angle index number.

DATA - Projection data array for angle M.

ERR - Array of uncertainties of DATA.

c. Reconstructors

SUBROUTINE BJECT (B,P,M,BCK)

The subroutine BJECT back-projects a single projection array P of length KDIMU with rotation axis equal to AXISU into the array B. This allows the user to use the system back-projection subroutines and back-project user data into the user's own array.

B	- The back-projection array.
P	- The projection array.
M	- The angle index.
BCK	- The back-projection subroutine.

SUBROUTINE BKFIL (X,FIL,BCK,ORDERX,FREQX)

The subroutine BKFIL reconstructs the array X using the back-projection of filtered projections algorithm.

X	- The reconstruction array.
FIL	- The filter subroutine.
BCK	- The back-projection subroutine.
ORDERX	- Filter parameter used only by the filter BUTER.
FREQX	- Filter parameter.

SUBROUTINE CONGR (X,PRJ,BCK,ISTP,IRLX,IERR,IZER)

The subroutine CONGR reconstructs the array X by minimizing the chi-square using the method of conjugate gradients.

X	- The reconstruction array.
PRJ	- The projection subroutine.
BCK	- The back-projection subroutine.
ISTP	- Number of iteration steps.
IRLX	- IRLX is not equal to 0 for iterative relaxation.
IERR	- IERR is not equal to 0 for weighted least-squares.
IZER	- IZER is equal to 0 if initial solution equals 0.

SUBROUTINE CONVO (X,XE,CNV,BCK,IERR)

The subroutine CONVO reconstructs the array X using the back-projection of the convolved projections.

X	- The reconstruction array.
XE	- The errors in the reconstructed array.
CNV	- The convolution subroutine.
BCK	- The back-projection subroutine.
IERR	- The error flag (set nonzero to return XE).

SUBROUTINE ENTPY (X,PRJ,BCK,LIMITX,ERENTX)

The subroutine ENTPY reconstructs the array X using a maximum entropy criterion for the reconstructed image.

X	- The reconstruction array.
PRJ	- The projection subroutine.
BCK	- The back-projection subroutine.
LIMITX	- Maximum number of iterations allowed to minimize the objective function for the dual program.
ERENTX	- Test value representing the expected absolute error between successive iterations.

SUBROUTINE FILBK (X,FIL,BCK,ORDERX,FREQX)

The subroutine FILBK reconstructs the array X using the filter of the back-projection algorithm.

X	- The reconstruction array.
FIL	- The filter subroutine.
BCK	- The back-projection subroutine.
ORDERX	- Filter parameter used only by the filter BUTER.
FREQX	- Filter parameter.

SUBROUTINE GRADY (X,PRJ,BCK,ISTP,IRLX,IERR,IZER)

The subroutine GRADY reconstructs the array X by minimizing the chi-square using the method of steepest descent.

X	- The reconstruction array.
PRJ	- The projection subroutine.
BCK	- The back-projection subroutine.
ISTP	- Number of iteration steps.
IRLX	- IRLX is not equal to 0 for iterative relaxation.
IERR	- IERR is not equal to 0 for weighted least-squares.
IZER	- IZER is equal to 0 if initial solution equals 0.

SUBROUTINE GVERS (X,XE,PRJ,BCK,CHISQ,IERR)

The subroutine GVERS reconstructs the array X using generalized matrix inversion.

X	- The reconstruction array.
XE	- Array in which errors in the reconstructed values are returned if IERR is set to 2. Should be the same dimension as X.
PRJ	- The projection subroutine.
BCK	- The back-projection subroutine.
CHISQ	- The resulting chi-square.
IERR	- Error indicator, set as follows: 1 - Input data uncertainties used, but no errors calculated for reconstructed values. 2 - Input data uncertainties used and errors are calculated for the reconstructed values. Otherwise - Input data uncertainties not used and errors not calculated.

SUBROUTINE MARR (X,NDEG)

The subroutine MARR reconstructs the array X for a given set of chords from positron annihilation events detected with a ring of crystals using orthogonal polynomial expansion.

X - The reconstruction array.

NDEG - Degree of the polynomial expansion.

d. Back-Projectors and Projectors

BCD/PCD - Back-projector/projector using the concave disk model (i.e., any pixel projects as a square wave at any angle using parallel-beam geometry.)

BCDA/PCDA - Same as BCD/PCD, but compensating for attenuation effects using factors from the file LUNATN.

BCDF/PCDF - Same as BCD/PCD, but using fan-beam geometry.

BCDF2 - Back-projector using the concave disk model in fan-beam geometry that uses special weighting to achieve a true back-projection image. Should only be used with FILBK.

BIN - Back-projector that uses a linear interpolation model similar to concave disk for parallel-beam geometry when projection bins and pixels are of unequal size (PWID≠1.0).

BLL/PLL - Back-projector/projector using the uniform distribution model with weighting according to line length for parallel-beam geometry.

BPT/PPT - Back-projector/projector using the delta function model for parallel-beam geometry.

BPTA/PPTA - Same as BPT/PPT, but compensating for attenuation using factors from file LUNATN.

BPTF/PPTF - Same as BPT/PPT, but using fan-beam geometry.

BPTF2 - Same as BPTF, but using special weighting to obtain a true back-projection image. Should only be used with FILBK.

BRF/PRF - Back-projector/projector using the uniform distribution model with weighting by ray sums using parallel-beam geometry.

BRFA/PRFA - Same as BRF/PRF, but compensating for attenuation using factors from the file LUNATN.

BRFF/PRFF - Same as BRF/PRF, but using fan-beam geometry.

BRFF2 - Same as BRFF, but using special weighting to achieve a true back-projection image. Should only be used with FILBK.

e. Convolvers (used only with CONVO)

LAKS - Convolver used for fan-beam reconstruction (after Herman, Lakshminarayanan and Naparstek).

RALA - Convolver used for parallel-beam reconstruction (after Ramachandran and Lakshminarayanan).

SHLO - Convolver used for parallel-beam reconstruction (after Shepp and Logan).

f. Filters (used only with BKFIL and FILBK)

BUTER - Uses the Butterworth filter as a window on the ramp filter.

HAM - Uses the Hamming window on the ramp filter.

HAN - Uses the Hann window on the ramp filter.

PARZN - Uses the Parzen window on the ramp filter.

RAMP - Generates the values in frequency space for a ramp filter.

g. Phantom and Projection Generators

SUBROUTINE PHAN (NPHAN,INTG,ITYPE,DENS,X,Y,A,B,PHI,BB,N,PIXW)

Subroutine PHAN generates a phantom consisting of ellipses and rectangles in the square array BB which has dimension (N,N).

NPHAN - The total number of ellipses and rectangles.

INTG - An integration factor. When a pixel lies partly inside and partly outside a boundary, it is divided into INTG x INTG pixelettes, which are each checked for insideness. The final value assigned to the large pixel is the value of DENS multiplied by the fraction of pixelettes that were found to lie inside the boundary (a good value is 10).

ITYPE - An array of descriptors for the ellipses/rectangles.
1 for an ellipse.
2 for a rectangle.

DENS - An array of densities of the ellipses/rectangles.
For transmission the units are inverse projection bin width.
For emission the units are inverse (projection bin width)^2.

X,Y - Arrays giving the (x,y) coordinates of the centers of the ellipses/rectangles with respect to the center of rotation (in units of projection bin width).

A,B - Arrays giving the major and minor axes of ellipses or the lengths of the sides of rectangles (in units of projection bin width).

PHI - An array of angles (in radians) that the major axes of the ellipses or the -A- sides of the rectangles make with the x-axis.

BB - Array where phantom is generated.

N - The dimension of BB.

PIXW - Pixel width that is utilized by this routine in order that the values for BB be as reconstructed (+ for transmission, - for emission).

<u>SUBROUTINE PHANL (N,ITYPE,DENS,X,Y,A,B,PHI,P,M)</u>

Subroutine PHANL generates the line integral projections of a set of source ellipses and rectangles attenuated by another set of attenuating ellipses and rectangles.

N - The total number of ellipses and rectangles.

ITYPE - An array of descriptors for the ellipses/rectangles.
1 for a source ellipse.
2 for a source rectangle.
-1 for an attenuating ellipse.
-2 for an attenuating rectangle.

DENS - An array of source densities or attenuation coefficients of the ellipses/rectangles.
For transmission the units are inverse projection bin width.
For emission the units are inverse (projection bin width)^2.

X,Y - Arrays giving the (x,y) coordinates of the centers of the ellipses/rectangles with respect to the center of rotation (in units of projection bin width).

A,B - Arrays giving the major and minor axes of ellipses or the lengths of the sides of rectangles (in units of projection bin width).

PHI - An array of angles (in radians) that the major axes of the ellipses or the -A- sides of the rectangles make with the x-axis.

P - The array into which the projection is generated.

M - The projection angle index as defined in SETUP.

<u>SUBROUTINE CBARP (B1,N,R,X1,Y1,Z,INTFAC,NBAR,NREPS,IDIREC)</u>

The subroutine CBARP gives a circular bar phantom.

B1 - Array where phantom is generated.

N - Dimension of the square array B1.

R - Radius of circle phantom.

X1,Y1 - Center of circle relative to the center of array.

Z - Full value of function.

INTFAC - Integration factor. Each border pixel is divided into INTFAC^2 pixelettes for integration.

NBAR - Number of bars per pattern repetition in phantom.

NREPS - Number of repetitions of the bar pattern.
NBAR*NREPS must be less than or equal to 100.

IDIREC - Parameter telling direction of bars.
0 Horizontal.
1 Vertical.
2 Circular (concentric).

SUBROUTINE PIE (B1,N,R,X1,Y1,Z,INTFAC,NSLIPI,ISTART)

The subroutine PIE gives a pie phantom.

B1	-	Array where phantom is generated.
N	-	Dimension of the square array B1.
R	-	Radius of circle phantom.
X1,Y1	-	Center of circle relative to the center of array.
Z	-	Full value of function.
INTFAC	-	Integration factor. Each border pixel is divided into $INTFAC^2$ pixelettes for integration.
NSLIPI	-	Number of slices in half the pie (in π radians).
ISTART	-	Indicator of the color of the first (counterclockwise) slice. 0 = white, else it is black.

SUBROUTINE PJECT (B,P,M,PRJ)

The subroutine PJECT projects from the array B into a single projection array P of length KDIMU with rotation axis equal to AXISU. This allows the user to use the system projection subroutines and project data into the user's own projection array.

B	-	The array of data for the transverse section.
P	-	The projection array.
M	-	The angle index.
PRJ	-	The system projection subroutine.

h. Attenuation Correction

SUBROUTINE EVATN (B)

The subroutine EVATN evaluates the attenuation factors required to correct for attenuation in an emission scan.

B	-	Array of attenuation coefficients.

SUBROUTINE EVATU (B,XLEV,ATENL)

The subroutine EVATU evaluates the attenuation factors required to correct for attenuation in an emission scan, assuming a constant attenuation coefficient.

B	- Transverse section that has not been corrected for attenuation.
XLEV	- Approximate ratio of the concentration in the object to the background.
ATENL	- Constant attenuation coefficient.

i. Output

SUBROUTINE ARRAY (B,NXN)

The subroutine ARRAY gives an image of the array B on computer output paper where the distinct gray levels are accomplished by overprinting.

B	- The array to be imaged.
NXN	- The dimension of the array.

SUBROUTINE BCOM (MAXFW)

Subroutine BCOM prints out and returns the largest number of floating point words required in blank common (MAXFW).

MAXFW	- Maximum number of floating point words needed in blank common so far.

SUBROUTINE USER (ITER,X,FCN)

The subroutine USER gives the user the opportunity to investigate the partial reconstruction between iterations.

ITER	-	Iteration number.
X	-	Array of fitted parameters: for CONGR and GRADY, reconstruction array; for ENTPY, Lagrange multipliers.
FCN	-	Value of function being optimized: for CONGR and GRADY, chi-square; for ENTPY, objective function for the dual program.

SUBROUTINE XYGRF (B,N,NP,BMAX,BMIN,IXY,ICOR,IL,IU)

The subroutine XYGRF displays NP plots of the cross-section intensities for the N x N array B.

B	-	Square array from which plots are generated.
N	-	Dimension of B is (N,N).
NP	-	Number of cross-sectional plots.
BMAX	-	Maximum value for the plot. If BMAX = 999999., the maximum will be determined from the data.
BMIN	-	Minimum value for the plot. If BMIN = 999999., the minimum will be determined from the data.
IXY	-	Equals 0 if the cross section is parallel to the x-axis. Equals 1 if the cross section is parallel to the y-axis.
ICOR	-	Array of x- or y-intercepts that determines the location of the cross section.
IL	-	Lower coordinate for the plot.
IU	-	Upper coordinate for the plot.

2. Listing

A complete listing of the RECLBL Library source material follows.

ARRAY

```
      SUBROUTINE ARRAY (B,NXN)
C
C     ****************************************************************
C     *       RECLBL     --          VERSION 1.0     --        17OCT77  *
C     ****************************************************************
C
C          THE SUBROUTINE ARRAY GIVES AN IMAGE OF THE ARRAY B ON
C       COMPUTER OUTPUT PAPER WHERE THE DISTINCT GRAY LEVELS ARE
C       ACCOMPLISHED BY OVERPRINTING.  THE SUBROUTINE ASSUMES THAT THE
C       PRINTER PRINTS 10 CHARACTERS PER INCH AND 6 LINES PER INCH.
C       THE DENSITY VALUES FOR THE VARIOUS COMBINATION OF OVERPPRINTING
C       CHARACTERS IS GIVEN IN THE ARTICLE - I.D.G. MC LEOD, PICTORIAL
C       OUTPUT FROM A LINE-PRINTER, IEEE TRANS. COMPUTERS, C-19(1970),
C       PP 160-162.
C
C         B      - THE ARRAY TO BE IMAGED
C         NXN    - THE DIMENSION OF THE ARRAY
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINE - LGTXT
C
C       LANGUAGE - FORTRAN
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT  - LOGICAL UNIT NUMBER FOR OUTPUT
C          I80132  - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                       OUTPUT ON LUNOUT
C                 0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      DIMENSION B(NXN,NXN),LN(130,7),DEN(21)
      DIMENSION RLEG(11)
      DIMENSION MESGP(14)
      INTEGER GRAY(21,7),NLN(21)
      DATA GRAY/ 1H , 1H-, 1H=, 1H+, 1H), 1H1, 1HZ, 1HX, 1HA, 1HM,
     1          1HO, 1HO, 1HO, 1HO, 1HO, 1HO, 1HO, 1HO, 1HO, 1HO, 1HO,
     2          1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H ,
     3          1H-, 1H=, 1H+, 1H+, 1H+, 1H+, 1HX, 1HX, 1HX, 1HX, 1HX,
     4          1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H ,
     5          1H , 1H , 1H , 1H., 1H=, 1H., 1H., 1H., 1H., 1H., 1H.,
     6          1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H ,
     7          1H , 1H , 1H , 1H , 1H , 1H=, 1H-, 1HH, 1HH, 1HH, 1HH,
     8          1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H ,
     9          1H , 1H , 1H , 1H , 1H , 1H , 1H , 1HC, 1HB, 1HB, 1HB,
     $          1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H ,
     $          1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H , 1HV, 1HV,
     $          1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H ,
     $          1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H , 1H , 1HA/
      DATA DEN/  .0 , .15, .22, .25, .29, .33, .37, .40, .42, .45,
     1          .53, .56, .60, .64, .67, .79, .85, .89, .93, .97, 1.0/
      DATA NLN/   1,   1,   1,   1,   1,   1,   1,   1,   1,   1,
     1            2,   2,   2,   3,   3,   4,   4,   5,   5,   6,   7/
      DATA CHAR/.6/
      DATA IBLANK,ISTAR/1H ,1H*/
      DATA MESGP/1HP,1HL,1HO,1HT,1HS,1HU,1HP,1HP,1HR,1HE,1HS,1HS,1HE,1HD
     1/
C
      IF (I80132.NE.0) WRITE (LUNOUT,66)
      IF (I80132.EQ.0) WRITE (LUNOUT,68)
      J80132=130
      IF (I80132.EQ.0) J80132=78
      XMIN=B(1,1)
      XMAX=B(1,1)
      XSUM=0.
      DO 16 I=1,NXN
      DO 16 J=1,NXN
      XSUM=XSUM+B(I,J)
      IF (XMIN-B(I,J)) 12,12,10
   10 XMIN=B(I,J)
   12 IF (XMAX-B(I,J)) 14,16,16
   14 XMAX=B(I,J)
   16 CONTINUE
      N1=FLOAT(NXN)*CHAR
      XDIST=FLOAT(NXN)/FLOAT(N1+1)
      WRITE (LUNOUT,70) XMIN,XMAX,XSUM
      IF (XMAX-XMIN.GT.1.E-10) GO TO 18
      CALL LGTXT (MESGP,4)
      CALL LGTXT (MESGP(5),10)
      IF (I80132.NE.0) WRITE (LUNOUT,72)
      RETURN
   18 IF (NXN+2.GT.J80132) RETURN
      FRAC=1./(XMAX-XMIN)
      IF (NXN.GT.100) GO TO 22
      NN=(60-N1)/4-1
      IF (I80132.EQ.0) NN=2
      DO 20 I=1,NN
      WRITE (LUNOUT,68)
   20 CONTINUE
   22 DO 24 I=1,130
      DO 24 J=1,7
      LN(I,J)=IBLANK
   24 CONTINUE
      IMIN=(J80132-NXN)/2
      IMAX=IMIN+NXN-1
      II1=IMIN-1
      II2=IMAX+1
      DO 26 I=II1,II2
      LN(I,1)=ISTAR
   26 CONTINUE
      WRITE (LUNOUT,74) (LN(I,1),I=1,J80132)
      Y=FLOAT(NXN)+.5
      DO 46 K=1,N1
      Y=Y-XDIST
      J1=Y
      Y1=FLOAT(J1)
      J2=J1+1
      I1=0
      LMAX=0
      DO 40 I=IMIN,IMAX
      I1=I1+1
      D=(B(I1,J1)+(B(I1,J2)-B(I1,J1))*(Y-FLOAT(J1))-XMIN)*FRAC
      DO 28 M=1,21
      IF (D-DEN(M)) 30,36,28
   28 CONTINUE
   30 M1=M-1
      M2=M
      T=(DEN(M2)+DEN(M1))/2.
      IF (D-T) 32,32,34
   32 L=M1
      GO TO 38
   34 L=M2
      GO TO 38
   36 L=M
   38 DO 40 J=1,7
      IF (L.GT.LMAX) LMAX=L
      LN(I,J)=GRAY(L,J)
   40 CONTINUE
      NJ=NLN(LMAX)-1
      IF (NJ.LE.0) GO TO 44
      DO 42 J=1,NJ
      WRITE (LUNOUT,76) (LN(I,J),I=1,J80132)
   42 CONTINUE
   44 WRITE (LUNOUT,79) (LN(I,NJ+1),I=1,J80132)
   46 CONTINUE
      DO 48 I=II1,II2
      LN(I,1)=ISTAR
   48 CONTINUE
      WRITE (LUNOUT,74) (LN(I,1),I=1,J80132)
      MLEG=J80132/11
      NLEG=22/MLEG
      DO 56 II=1,NLEG
      DO 50 J=1,7
      DO 50 I=1,130
      LN(I,J)=IBLANK
   50 CONTINUE
      DO 52 J=1,11
      ISUB1=(J-1)*11+1
      ISUB2=(J-1)+(II-1)*MLEG
      ISUB3=ISUB2+1
      IF (ISUB2.LE.0) ISUB2=1
      IF (ISUB3.GT.21) ISUB3=21
      RLEG(J)=(DEN(ISUB2)+DEN(ISUB3))/(FRAC*2.)+XMIN
      DO 52 K=1,7
      LN(ISUB1,K)=GRAY(ISUB2,K)
   52 CONTINUE
      WRITE (LUNOUT,68)
      DO 54 I=1,6
   54 WRITE (LUNOUT,76) (LN(J,I),J=1,J80132)
      WRITE (LUNOUT,78) (LN(J,7),J=1,J80132)
      WRITE (LUNOUT,80) (RLEG(J),J=1,MLEG)
   56 CONTINUE
      IF (I80132.NE.0) GO TO 64
      DO 58 J=1,7
      DO 58 I=1,130
      LN(I,J)=IBLANK
   58 CONTINUE
      RLEG(1)=DEN(21)/FRAC+XMIN
      DO 60 K=1,7
      LN(1,K)=GRAY(21,K)
   60 CONTINUE
      WRITE (LUNOUT,68)
      DO 62 I=1,6
   62 WRITE (LUNOUT,76) LN(1,I)
      WRITE (LUNOUT,78) LN(1,7)
      WRITE (LUNOUT,80) RLEG(1)
   64 CONTINUE
      IF (I80132.NE.0) WRITE (LUNOUT,72)
      RETURN
C
C
   66 FORMAT(6H1*OVF*)
   68 FORMAT(/)
   70 FORMAT(1X,7HXMIN = ,E10.2,5X,7HXMAX = ,E10.2,5X,7HXSUM = ,E12.4)
   72 FORMAT(6H1*OVN*)
   74 FORMAT(1X,130A1)
   76 FORMAT(1H+,130A1)
   78 FORMAT(1H ,130A1)
   80 FORMAT(11(1X,E10.4))
      END
```

ATENF

```
      SUBROUTINE ATENF (IBGN,JBGN,M,BCOEF,ZFAC)
C
C     ****************************************************************
C     *       RECLBL     --          VERSION 1.0     --        17OCT77  *
C     ****************************************************************
C
C          THE SUBROUTINE ATENF EVALUATES THE ATTENUATION INTEGRAL
C       FROM THE POINT (IBGN,JBGN) IN THE DIRECTION OF THE ANGLE
C       ANG(M).
C
C         IBGN     - THE X-COORDINATE OF THE INITIAL POINT
C         JBGN     - THE Y-COORDINATE OF THE INITIAL POINT
C         M        - ANGLE INDEX
C         BCOEF    - ARRAY OF ATTENUATION COEFFICIENTS
C         ZFAC     - THE LINE INTEGRAL OF ATTENUATION COEFFICIENTS
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                       COMMON
C          IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                       SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                       FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                       EXECUTING.
C          WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                       NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                       THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                       IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
```

```
C
C         IGEOM    - GEOMETRY FLAG
C               0 = PARALLEL BEAM GEOMETRY
C               1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C               2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C               3 = RING DETECTOR GEOMETRY
C         KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                      BY THE USER
C         AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                      AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                      IN THE CENTER OF A PROJECTION BIN.)
C         BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                      ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                      ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C         KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE LAST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                      TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                      KDIM=KDIMU.
C         AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY, USUALLY AXIS=AXISU.
C         LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                      INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                      VECTOR
C         NANG     - NUMBER OF PROJECTIONS
C         MODANG   - MODE FOR PROJECTION ANGLE INPUT
C         LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                      PROJECTION ANGLES IN RADIANS
C         LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                      SINE OF THE PROJECTION ANGLES
C         LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                      COSINE OF THE PROJECTION ANGLES
C         LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                      USER PROJECTION DATA AND UNCERTAINTIES
C         TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                      FALSE FOR TRANSMISSION DATA
C
      DIMENSION BCOEF(1)
      DATA EPS/1.E-6/
C
C        *SET IJ FOR INITIAL PIXEL
C
      I=IBGN
      J=JBGN
      IJ=I+NDIM*(J-1)
C
C        *SET SIN AND COS
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)
C
C        *CHECK FOR VERY SMALL ANGLES
C        *DXL AND DYL ARE TO STEP THROUGH THE BCOEF ARRAY
C        *(DISTANCE TO STEP ALONG THE LINE)
C
      IF (ABS(C).LT.EPS) GO TO 10
      DXL=1./ABS(C)
      GO TO 12
   10 DXL=10*NDIM
   12 IF (ABS(S).LT.EPS) GO TO 14
      DYL=1./ABS(S)
      GO TO 16
   14 DYL=10*NDIM
C
C        *KI IS THE I INCREMENT AS WE STEP ALONG THE LINE
C        *IOUT TAKES US OUT OF THE ARRAY
C
   16 IF (C.LT.0.) GO TO 18
      KI=1
      IOUT=NDIM+1
      GO TO 20
   18 KI=-1
      IOUT=0
C
C        *KJ AND JOUT ARE ANALAGOUS TO KI AND IOUT RESPECTIVELY
C        *KJN IS THE IJ INCREMENT
C
   20 IF (S.LT.0.) GO TO 22
      KJ=1
      JOUT=NDIM+1
      KJN=NDIM
      GO TO 24
   22 KJ=-1
      JOUT=0
      KJN=-NDIM
C
C        *SET-UP INITIAL STEPS AND GO STEP THRU THE BCOEF ARRAY
C
C        *ZFAC IS INCREMENTED BY BCOEF ARRAY TIMES LINE LENTGH
C
   24 XL=.5*DXL
      YL=.5*DYL
      ZFAC=0.
      IF (XL.GE.YL) GO TO 28
C
C        *X HIT
C
   26 ZFAC=ZFAC+XL*BCOEF(IJ)
      I=I+KI
      IF (I.EQ.IOUT) RETURN
      IJ=IJ+KI
      YL=YL-XL
      XL=DXL
      IF (XL.LT.YL) GO TO 26
C
C        *Y HIT
C
   28 ZFAC=ZFAC+YL*BCOEF(IJ)
      J=J+KJ
      IF (J.EQ.JOUT) RETURN
      IJ=IJ+KJN
      XL=XL-YL
      YL=DYL
      IF (YL.LT.XL) GO TO 28
      GO TO 26
C
      END
```

BCD

```
      SUBROUTINE BCD (B,P,M)
C
C     ******************************************************************
C     *        RECLBL    --        VERSION 1.0     --         17OCT77   *
C     ******************************************************************
C
C           THE SUBROUTINE BCD BACK-PROJECTS A SINGLE PROJECTION
C        ARRAY P INTO THE ARRAY B.  THE PROJECTION HAS THE ANGLE ANG(M)
C        WHERE M IS THE INDEX OF THE ANGLE.  THE PROJECTION BINS AND THE
C        BACK-PROJECTION CELLS MUST BE THE SAME SIZE.  FOR THESE CONDIT-
C        IONS THE SUBROUTINE BCD GIVES AN APPROXIMATION FOR A MODEL WITH
C        UNIFORM DENSITY IN EACH CELL SUCH THAT EACH CELL PROJECTS AS A
C        SQUARE WAVE.  THE B ARRAY IS ZEROED IF M=1.
C
C          B         - THE BACK-PROJECTION ARRAY
C          P         - THE PROJECTION ARRAY
C          M         - THE ANGLE INDEX
C                    - IF M .LE. 0, ONLY A SET OF FLAGS IS RETURNED IN B
C                      NO BACK-PROJECTION OPERATION IS PERFORMED
C                      (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - ZERO
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        LANGUARE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                      COMMON
C         IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                      SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                      FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                      EXECUTING.
C         WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C         NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C         NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C         PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C         TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C         NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C         LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                      NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                      THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C         KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                      IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C         IGEOM    - GEOMETRY FLAG
C               0 = PARALLEL BEAM GEOMETRY
C               1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C               2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C               3 = RING DETECTOR GEOMETRY
C         KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                      BY THE USER
C         AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                      AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                      IN THE CENTER OF A PROJECTION BIN.)
C         BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                      ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                      ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C         KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE LAST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                      TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                      KDIM=KDIMU.
C         AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY, USUALLY AXIS=AXISU.
C         LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                      INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                      VECTOR
C         NANG     - NUMBER OF PROJECTIONS
C         MODANG   - MODE FOR PROJECTION ANGLE INPUT
C         LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                      PROJECTION ANGLES IN RADIANS
C         LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                      SINE OF THE PROJECTION ANGLES
C         LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                      COSINE OF THE PROJECTION ANGLES
C         LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                      USER PROJECTION DATA AND UNCERTAINTIES
C         TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                      FALSE FOR TRANSMISSION DATA
C
      DIMENSION P(1),B(1)
C        BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/0.,1.,0.,0./
C
      IF (M.LE.0) GO TO 14
C
      IF (M.EQ.1) CALL ZERO (B,NMAT)
```

```
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)
      ZN=.5*FLOAT(NDIM+1)
      HS=.5*S
      ZZ=ZN*(S-C)+AXIS
      IJL=1
      DO 12 J=1,NDIM
      ZZ=ZZ+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 10 IJ=IJL,IJU
      Z=Z-S
      K=Z
   10 B(IJ)=B(IJ)+(FLOAT(K+1)-Z)*P(K)+(Z-FLOAT(K))*P(K+1)
   12 IJL=IJL+NN
      RETURN
C
   14 DO 16 I=1,4
   16 B(I)=FLAGS(I)
      RETURN
      END
```

BCDA

```
      SUBROUTINE BCDA (B,P,M)
C
C     ******************************************************************
C     *     RECLBL     --        VERSION 1.0      --        17OCT77    *
C     ******************************************************************
C
C           THE SUBROUTINE BCDA BACK-PROJECTS A SINGLE PROJECTION
C       ARRAY P INTO THE ARRAY B.  THE PROJECTION HAS THE ANGLE ANG(M)
C       WHERE M IS THE INDEX OF THE ANGLE.  THE PROJECTION BINS AND THE
C       BACK-PROJECTION CELLS MUST BE THE SAME SIZE.  FOR THESE CONDIT-
C       IONS THE SUBROUTINE BCDA GIVES AN APPROXIMATION FOR A MODEL
C       WITH UNIFORM DENSITY IN EACH CELL SUCH THAT EACH CELL PROJECTS
C       AS A SQUARE WAVE WHICH IS ATTENUATED BY AN ATTENUATION FACTOR.
C       THE B ARRAY IS ZEROED IF M=1.
C
C           B        - THE BACK-PROJECTION ARRAY
C           P        - THE PROJECTION ARRAY
C           M        - THE ANGLE INDEX
C                    - IF M .LE. 0, ONLY A SET OF FLAGS IS RETURNED IN B
C                      NO BACK-PROJECTION OPERATION IS PERFORMED
C                      (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - FTATN, ZERO
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                     COMMON
C         IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                     SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                     FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                     EXECUTING.
C         WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/ATNCOM/LATEN,LBMAP,TATEN,LUNATN
      LOGICAL TATEN
      DIMENSION ATEN(1),BMAP(1)
      EQUIVALENCE (WORK(1),ATEN(1),BMAP(1))
C
C         LATEN   - POINTER TO THE ARRAY ATEN IN BLANK COMMON
C                     STORES ATTENUATION FACTORS FOR ONE ANGLE
C         LBMAP   - POINTER TO THE ARRAY BMAP IN BLANK COMMON
C                     A MATRIX USED TO STORE THE CONSTANT ATTENUATION
C                     COEFFICIENTS
C         TATEN   - LOGICAL VARIABLE SET TRUE FOR ATTENUATION
C                     RECONSTRUCTION
C         LUNATN  - LOGICAL UNIT NUMBER FOR ATTENUATION FACTOR STORAGE
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C         NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C         NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C         PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C         TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C         NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C         LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                     NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                     THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C         KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                     IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C         IGEOM   - GEOMETRY FLAG
C                 0 = PARALLEL BEAM GEOMETRY
C                 1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                 2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                 3 = RING DETECTOR GEOMETRY
C         KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                     BY THE USER
C         AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                     PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                     AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                     IN THE CENTER OF A PROJECTION BIN.)
C         BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                     ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                     ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C         KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                     THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                     IS GOING TO BE USED.
C         KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                     THE DATA OF THE LAST USER PROJECTION BIN THAT
C                     IS GOING TO BE USED.
C         KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                     TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                     KDIM=KDIMU.
C         AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                     PROJECTION ARRAY, USUALLY AXIS=AXISU.
C         LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                     INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                     VECTOR
C         NANG    - NUMBER OF PROJECTIONS
C         MODANG  - MODE FOR PROJECTION ANGLE INPUT
C         LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                     PROJECTION ANGLES IN RADIANS
C         LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                     SINE OF THE PROJECTION ANGLES
C         LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                     COSINE OF THE PROJECTION ANGLES
C         LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                     USER PROJECTION DATA AND UNCERTAINTIES
C         TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                     FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1),P(1)
C         BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/0.,1.,1.,0./
C
      IF (M.LE.0) GO TO 14
C
      IF (M.EQ.1) CALL ZERO (B,NMAT)
      CALL FTATN (M,ATEN(LATEN),NMAT)
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)
      HS=.5*S
      ZN=.5*FLOAT(NDIM+1)
      ZZ=ZN*(S-C)+AXIS
      IJL=1
      DO 12 J=1,NDIM
      ZZ=ZZ+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 10 IJ=IJL,IJU
      Z=Z-S
      K=Z
      ISUB=LATEN+IJ-1
   10 B(IJ)=B(IJ)+ATEN(ISUB)*((FLOAT(K+1)-Z)*P(K)+(Z-FLOAT(K))*P(K+1))
   12 IJL=IJL+NN
      RETURN
C
   14 DO 16 I=1,4
   16 B(I)=FLAGS(I)
      RETURN
      END
```

BCDF

```
      SUBROUTINE BCDF (B,P,M)
C
C     ******************************************************************
C     *     RECLBL     --        VERSION 1.0      --        17OCT77    *
C     ******************************************************************
C
C           THE SUBROUTINE BCDF BACK-PROJECTS A SINGLE PROJECTION
C       ARRAY P INTO THE ARRAY B USING A FAN BEAM GEOMETRY.  THE PROJ-
C       ECTION HAS THE ANGLE ANG(M) WHERE M IS THE INDEX OF THE ANGLE.
C       THE SUBROUTINE BCDF GIVES AN APPROXIMATION FOR A MODEL WITH
C       UNIFORM DENSITY IN EACH CELL SUCH THAT EACH CELL PROJECTS AS A
C       SQUARE WAVE.  THE B ARRAY IS ZEROED IF M=1.
C
C           B        - THE BACK-PROJECTION ARRAY
C           P        - THE PROJECTION ARRAY
C           M        - THE ANGLE INDEX
C                    - IF M .LE. 0, ONLY A SET OF FLAGS IS RETURNED IN B
C                      NO BACK-PROJECTION OPERATION IS PERFORMED
C                      (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - ZERO
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                     COMMON
C         IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                     SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                     FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                     EXECUTING.
C         WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/FANCOM/RFAN,TFANC,TFANF
      LOGICAL TFANC,TFANF
C
C         RFAN    - FOR FAN BEAM GEOMETRY RFAN IS THE DISTANCE FROM
C                     THE SOURCE TO THE CENTER OF ROTATION.  RFAN
C                     IS MEASURED IN UNITS OF PROJECTION BIN WIDTHS AT
C                     THE CENTER OF ROTATION.
C         TFANC   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                     CURVED DETECTOR
C         TFANF   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                     FLAT DETECTOR
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
```

```
C
C        NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C        NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C        PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C        TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C        NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C        LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                   NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                   THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C        KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                   IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C        IGEOM   - GEOMETRY FLAG
C                0 = PARALLEL BEAM GEOMETRY
C                1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                3 = RING DETECTOR GEOMETRY
C        KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                   BY THE USER
C        AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                   PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                   AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                   IN THE CENTER OF A PROJECTION BIN.)
C        BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C        KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                   ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                   ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C        KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                   THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                   IS GOING TO BE USED.
C        KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                   THE DATA OF THE LAST USER PROJECTION BIN THAT
C                   IS GOING TO BE USED.
C        KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                   TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                   KDIM=KDIMU.
C        AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                   PROJECTION ARRAY, USUALLY AXIS=AXISU.
C        LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                   INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                   VECTOR
C        NANG    - NUMBER OF PROJECTIONS
C        MODANG  - MODE FOR PROJECTION ANGLE INPUT
C        LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                   PROJECTION ANGLES IN RADIANS
C        LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                   SINE OF THE PROJECTION ANGLES
C        LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                   COSINE OF THE PROJECTION ANGLES
C        LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                   USER PROJECTION DATA AND UNCERTAINTIES
C        TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                   FALSE FOR TRANSMISSION DATA
C
C
C     ***THESE VARIABLES ARE USED IN THIS SUBROUTINE
C
C          DH     - THE DISTANCE BETWEEN THE SOURCE AND THE PIXEL
C          ARC    - THE ARC DISTANCE BETWEEN THE CENTER AXIS AND THE
C                    IMAGE OF THE PIXEL
C          BETAU  - THE ANGLE BETWEEN THE CENTER AXIS AND THE LINE
C                    PASSING ABOVE THE PIXEL
C          BETAL  - THE ANGLE BETWEEN THE CENTER AXIS AND THE LINE
C                    PASSING BELOW THE PIXEL.
C          BETAP  - THE ANGLE BETWEEN THE CENTER AXIS AND LINE
C                    PASSING THROUGH THE PIXEL
C          THETAU - THE ANGLE BETWEEN THE LINE PASSING THROUGH THE
C                    PIXEL AND A LINE ABOVE
C          THETAL - THE ANGLE BETWEEN THE LINE PASSING THROUGH THE
C                    PIXEL AND A LINE BELOW
C          DU     - THE PERPENDICULAR DISTANCE BETWEEN THE PIXEL AND
C                    A LINE ABOVE
C          DL     - THE PERPENDICULAR DISTANCE BETWEEN THE PIXEL AND
C                    A LINE BELOW
C          ALPHAU - THE ANGLE THE LINE ABOVE THE PIXEL MAKES WITH
C                    THE SIDE OF THE SQUARE
C          ALPHAL - THE ANGLE THE LINE BELOW THE PIXEL MAKES WITH
C                    THE SIDE OF THE SQUARE
C          ANGLE  - THE ANGLE BETWEEN THE RAYS IN THE FAN BEAM
C
      DIMENSION B(1),P(1)
C        BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/0.,1.,0.,1./
      DATA Z/.499999/
C
      IF (M.LE.0) GO TO 34
C
      IF (M.NE.1) GO TO 10
      CALL ZERO (B,NMAT)
      ANGLE=1./RFAN
C
   10 CONTINUE
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      HS=.5*S
      HC=.5*C
      ZN=.5*FLOAT(NDIM+1)
      ZX=RFAN-ZN*(C+S)
      ZY=ZN*(S-C)
      RFP=RFAN*PWID
      IJL=1
C
      IF (TFANF) GO TO 22
C
      DO 20 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 18 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      ARCTAN=ATAN(ZYY/ZXX)
      ARC=RFAN*ARCTAN
      K=ARC+AXIS+.5
      BETAU=(FLOAT(K)-AXIS+.5)*ANGLE
      BETAL=BETAU-ANGLE
      BETAP=ARCTAN
      THETAU=BETAU-BETAP
      THETAL=BETAP-BETAL
      DU=DH*BWID*THETAU
      DL=DH*BWID*THETAL
      AREA1=AMIN1(.5,DU)
      AREA2=AMIN1(.5,DL)
      AREA=AREA1+AREA2
      MK=K
      MK1=MK
      MK2=MK
      B(IJ)=B(IJ)+AREA*P(MK)*RFP/DH
      AREAX=AREA1
      AREAY=AREA2
      IF (AREA1.GT.Z) GO TO 14
   12 MK2=MK2+1
      THETAU=THETAU+ANGLE
      DU=DH*BWID*THETAU
      AREAU1=AMIN1(.5,DU)
      AREAU=AREAU1-AREAX
      AREAX=AREAU1
      B(IJ)=B(IJ)+AREAU*P(MK2)*RFP/DH
      IF (AREAU1.LE.Z) GO TO 12
   14 IF (AREA2.GT.Z) GO TO 18
   16 MK1=MK1-1
      THETAL=THETAL+ANGLE
      DL=DH*BWID*THETAL
      AREAL1=AMIN1(.5,DL)
      AREAL=AREAL1-AREAY
      AREAY=AREAL1
      B(IJ)=B(IJ)+AREAL*P(MK1)*RFP/DH
      IF (AREAL1.LE.Z) GO TO 16
   18 CONTINUE
   20 IJL=IJL+NN
      RETURN
C
   22 DO 32 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 30 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      ARCTAN=ATAN(ZYY/ZXX)
      YCENTR=ZYY/ZXX*RFAN
      K=YCENTR+AXIS+.5
      BETAU=ATAN((FLOAT(K)-AXIS+.5)/RFAN)
      BETAL=ATAN((FLOAT(K-1)-AXIS+.5)/RFAN)
      BETAP=ARCTAN
      THETAU=BETAU-BETAP
      THETAL=BETAP-BETAL
      DU=DH*BWID*THETAU
      DL=DH*BWID*THETAL
      AREA1=AMIN1(.5,DU)
      AREA2=AMIN1(.5,DL)
      AREA=AREA1+AREA2
      MK=K
      MK1=MK
      MK2=MK
      B(IJ)=B(IJ)+AREA*P(MK)*RFP/ZXX
      AREAX=AREA1
      AREAY=AREA2
      IF (AREA1.GT.Z) GO TO 26
   24 MK2=MK2+1
      ANGLE=ATAN(RFAN/(RFAN**2+(FLOAT(MK2)-AXIS)**2-.25))
      THETAU=THETAU+ANGLE
      DU=DH*BWID*THETAU
      AREAU1=AMIN1(.5,DU)
      AREAU=AREAU1-AREAX
      AREAX=AREAU1
      B(IJ)=B(IJ)+AREAU*P(MK2)*RFP/ZXX
      IF (AREAU1.LE.Z) GO TO 24
   26 IF (AREA2.GT.Z) GO TO 30
   28 MK1=MK1-1
      ANGLE=ATAN(RFAN/(RFAN**2+(FLOAT(MK1)-AXIS)**2-.25))
      THETAL=THETAL+ANGLE
      DL=DH*BWID*THETAL
      AREAL1=AMIN1(.5,DL)
      AREAL=AREAL1-AREAY
      AREAY=AREAL1
      B(IJ)=B(IJ)+AREAL*P(MK1)*RFP/ZXX
      IF (AREAL1.LE.Z) GO TO 28
   30 CONTINUE
   32 IJL=IJL+NN
C
      RETURN
C
   34 DO 36 I=1,4
   36 B(I)=FLAGS(I)
      RETURN
      END
```

BCDF2

```
      SUBROUTINE BCDF2 (B,P,M)
C
C     ******************************************************************
C     *        RECLBL    --        VERSION 1.0     --         17OCT77   *
C     ******************************************************************
C
C              THE SUBROUTINE BCDF2 BACK-PROJECTS A SINGLE PROJECTION
C        ARRAY P INTO THE ARRAY B USING A FAN BEAM GEOMETRY.  THE PROJ-
C        ECTION HAS THE ANGLE ANG(M) WHERE M IS THE INDEX OF THE ANGLE.
C        THE SUBROUTINE BCDF2 GIVES AN APPROXIMATION FOR A MODEL WITH
C        UNIFORM DENSITY IN EACH CELL SUCH THAT EACH CELL PROJECTS AS A
C        SQUARE WAVE.  THE B ARRAY IS ZEROED IF M=1.
C              THE SUBROUTINE BCDF2 USES A SPECIAL WEIGHTING SO THAT THE
C        BACK-PROJECTION FOR A FLAT DETECTOR GIVES A CONVOLUTION WITH
C        THE TRUE DENSITY AND SHOULD ONLY BE USED WITH THE FILTER OF THE
C        BACK-PROJECTION ALGORITHM (SUBROUTINE FILBK).
C
C          B        - THE BACK-PROJECTION ARRAY
C          P        - THE PROJECTION ARRAY
C          M        - THE ANGLE INDEX
C                   - IF M .LE. 0, ONLY A SET OF FLAGS IS RETURNED IN B
C                     NO BACK-PROJECTION OPERATION IS PERFORMED
C                     (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - ZERO
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
```

```
C         LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C           NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                        COMMON
C           IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C           NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C           ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                        SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                        FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                        EXECUTING.
C           WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/FANCOM/RFAN,TFANC,TFANF
      LOGICAL TFANC,TFANF
C
C           RFAN     - FOR FAN BEAM GEOMETRY RFAN IS THE DISTANCE FROM
C                        THE SOURCE TO THE CENTER OF ROTATION.  RFAN
C                        IS MEASURED IN UNITS OF PROJECTION BIN WIDTHS AT
C                        THE CENTER OF ROTATION.
C           TFANC    - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                        CURVED DETECTOR
C           TFANF    - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                        FLAT DETECTOR
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C           NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C           NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C           PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C           TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C           NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C           LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                        NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                        THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C           KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                        IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C           IGEOM    - GEOMETRY FLAG
C                  0 = PARALLEL BEAM GEOMETRY
C                  1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                  2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                  3 = RING DETECTOR GEOMETRY
C           KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                        BY THE USER
C           AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                        AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                        IN THE CENTER OF A PROJECTION BIN.)
C           BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C           KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                        ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                        ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C           KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C           KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE LAST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C           KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                        TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                        KDIM=KDIMU.
C           AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY, USUALLY AXIS=AXISU.
C           LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                        INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                        VECTOR
C           NANG     - NUMBER OF PROJECTIONS
C           MODANG   - MODE FOR PROJECTION ANGLE INPUT
C           LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                        PROJECTION ANGLES IN RADIANS
C           LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                        SINE OF THE PROJECTION ANGLES
C           LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                        COSINE OF THE PROJECTION ANGLES
C           LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                        USER PROJECTION DATA AND UNCERTAINTIES
C           TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                        FALSE FOR TRANSMISSION DATA
C
C
C        ***THESE VARIABLES ARE USED IN THIS SUBROUTINE
C
C             DH       - THE DISTANCE BETWEEN THE SOURCE AND THE PIXEL
C             ARC      - THE ARC DISTANCE BETWEEN THE CENTER AXIS AND THE
C                          IMAGE OF THE PIXEL
C             BETAU    - THE ANGLE BETWEEN THE CENTER AXIS AND THE LINE
C                          PASSING ABOVE THE PIXEL
C             BETAL    - THE ANGLE BETWEEN THE CENTER AXIS AND THE LINE
C                          PASSING BELOW THE PIXEL
C             BETAP    - THE ANGLE BETWEEN THE CENTER AXIS AND LINE
C                          PASSING THROUGH THE PIXEL
C             THETAU   - THE ANGLE BETWEEN THE LINE PASSING THROUGH THE
C                          PIXEL AND A LINE ABOVE
C             THETAL   - THE ANGLE BETWEEN THE LINE PASSING THROUGH THE
C                          PIXEL AND A LINE BELOW
C             DU       - THE PERPENDICULAR DISTANCE BETWEEN THE PIXEL AND
C                          A LINE ABOVE
C             DL       - THE PERPENDICULAR DISTANCE BETWEEN THE PIXEL AND
C                          A LINE BELOW
C             ALPHAU   - THE ANGLE THE LINE ABOVE THE PIXEL MAKES WITH
C                          THE SIDE OF THE SQUARE
C             ALPHAL   - THE ANGLE THE LINE BELOW THE PIXEL MAKES WITH
C                          THE SIDE OF THE SQUARE
C             ANGLE    - THE ANGLE BETWEEN THE RAYS IN THE FAN BEAM
C
      DIMENSION B(1),P(1)
C        BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/0.,21.,0.,1./
      DATA Z/.499999/
C
      IF (M.LE.0) GO TO 34
C
      IF (M.NE.1) GO TO 10
      CALL ZERO (B,NMAT)
      ANGLE=1./RFAN
C
   10 CONTINUE
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      HS=.5*S
      HC=.5*C
      ZN=.5*FLOAT(NDIM+1)
      ZX=RFAN-ZN*(C+S)
      ZY=ZN*(S-C)
      IJL=1
C
      IF (TFANF) GO TO 22
C
      DO 20 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 18 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      ARCTAN=ATAN(ZYY/ZXX)
      ARC=RFAN*ARCTAN
      K=ARC+AXIS+.5
      IF (K.LT.1.OR.K.GT.KDIM) GO TO 18
      BETAU=(FLOAT(K)-AXIS+.5)*ANGLE
      BETAL=BETAU-ANGLE
      BETAP=ARCTAN
      THETAU=BETAU-BETAP
      THETAL=BETAP-BETAL
      DU=DH*BWID*THETAU
      DL=DH*BWID*THETAL
      AREA1=AMIN1(.5,DU)
      AREA2=AMIN1(.5,DL)
      AREA=AREA1+AREA2
      MK=K
      MK1=MK
      MK2=MK
      B(IJ)=B(IJ)+AREA*P(MK)*PWID
      AREAX=AREA1
      AREAY=AREA2
      IF (AREA1.GT.Z) GO TO 14
   12 MK2=MK2+1
      IF (MK2.GT.KDIM) GO TO 18
      THETAU=THETAU+ANGLE
      DU=DH*BWID*THETAU
      AREAU1=AMIN1(.5,DU)
      AREAU=AREAU1-AREAX
      AREAX=AREAU1
      B(IJ)=B(IJ)+AREAU*P(MK2)*PWID
      IF (AREAU1.LE.Z) GO TO 12
   14 IF (AREA2.GT.Z) GO TO 18
   16 MK1=MK1-1
      IF (MK1.LT.1) GO TO 18
      THETAL=THETAL+ANGLE
      DL=DH*BWID*THETAL
      AREAL1=AMIN1(.5,DL)
      AREAL=AREAL1-AREAY
      AREAY=AREAL1
      B(IJ)=B(IJ)+AREAL*P(MK1)*PWID
      IF (AREAL1.LE.Z) GO TO 16
   18 CONTINUE
   20 IJL=IJL+NN
      RETURN
C
   22 DO 32 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 30 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      ARCTAN=ATAN(ZYY/ZXX)
      YCENTR=ZYY/ZXX*RFAN
      K=YCENTR+AXIS+.5
      IF (K.LT.1.OR.K.GT.KDIM) GO TO 30
      BETAU=ATAN((FLOAT(K)-AXIS+.5)/RFAN)
      BETAL=ATAN((FLOAT(K-1)-AXIS+.5)/RFAN)
      BETAP=ARCTAN
      THETAU=BETAU-BETAP
      THETAL=BETAP-BETAL
      DU=DH*BWID*THETAU
      DL=DH*BWID*THETAL
      AREA1=AMIN1(.5,DU)
      AREA2=AMIN1(.5,DL)
      AREA=AREA1+AREA2
      MK=K
      MK1=MK
      MK2=MK
      B(IJ)=B(IJ)+AREA*P(MK)*PWID*DH/ZXX
      AREAX=AREA1
      AREAY=AREA2
      IF (AREA1.GT.Z) GO TO 26
   24 MK2=MK2+1
      IF (MK2.GT.KDIM) GO TO 30
      ANGLE=ATAN(RFAN/(RFAN**2+(FLOAT(MK2)-AXIS)**2-.25))
      THETAU=THETAU+ANGLE
      DU=DH*BWID*THETAU
      AREAU1=AMIN1(.5,DU)
      AREAU=AREAU1-AREAX
      AREAX=AREAU1
      B(IJ)=B(IJ)+AREAU*PWID*P(MK2)*DH/ZXX
      IF (AREAU1.LE.Z) GO TO 24
   26 IF (AREA2.GT.Z) GO TO 30
   28 MK1=MK1-1
      IF (MK1.LT.1) GO TO 30
      ANGLE=ATAN(RFAN/(RFAN**2+(FLOAT(MK1)-AXIS)**2-.25))
      THETAL=THETAL+ANGLE
      DL=DH*BWID*THETAL
      AREAL1=AMIN1(.5,DL)
      AREAL=AREAL1-AREAY
      AREAY=AREAL1
      B(IJ)=B(IJ)+AREAL*PWID*P(MK1)*DH/ZXX
      IF (AREAL1.LE.Z) GO TO 28
   30 CONTINUE
   32 IJL=IJL+NN
C
      RETURN
C
   34 DO 36 I=1,4
   36 B(I)=FLAGS(I)
      RETURN
      END
```

BCOM

```
      SUBROUTINE BCOM (MAXFW)
C
C     ****************************************************************
C     *       RECLBL     --         VERSION 1.0     --        17OCT77   *
C     ****************************************************************
C
C           SUBROUTINE BCOM PRINTS OUT AND RETURNS THE LARGEST NUMBER
C        OF FLOATING POINT WORDS REQUIRED IN BLANK COMMON  (MAXFW).
C        MAXFW IS KEPT TRACK OF IN SUBROUTINE MEMST.
C
C          MAXFW    - MAXIMUM NUMBER OF FLOATING POINT WORDS NEEDED IN
C                        BLANK COMMON SO FAR
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                        COMMON
C          IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                        SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                        FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                        EXECUTING.
C          WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT   - LOGICAL UNIT NUMBER FOR OUTPUT
C          I80132   - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                        OUTPUT ON LUNOUT
C                0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      DIMENSION ITXT(4)
      DATA NTXT,ITXT/4,1HB,1HC,1HO,1HM/
      DATA IOK/2HOK/
C
      IF (ISETUP.NE.IOK) GO TO 10
C
      WRITE (LUNOUT,12)
      CALL LGTXT (ITXT,NTXT)
      CALL MEMST (MAXFW,-1)
      WRITE (LUNOUT,14) MAXFW
      RETURN
C
   10 MAXFW=0
      RETURN
C
C
C
   12 FORMAT(  //)
   14 FORMAT(  //5X,61H***** THE LARGEST REQUIRED LENGTH OF BLANK COMMON
     1 THUS FAR IS,I7,6H *****)
      END
```

BIN

```
      SUBROUTINE BIN (B,P,MM)
C
C           THE SUBROUTINE BIN BACK-PROJECTS A SINGLE CONVOLVED
C        PROJECTION P INTO THE ARRAY B.  THE PROJECTION HAS THE ANGLE
C        ANG(M) WHERE M IS THE INDEX OF THE ANGLE.  THE B ARRAY IS
C        ZEROED IF MM=1.  IF MM IS NEGATIVE THEN THE BACK-PROJECTION
C        VARIANCES ARE CALCULATED INSTEAD AND RETURNED IN THE ARRAY B.
C        THE SUBROUTINE BIN IS TO BE USED ONLY WITH THE CONVOLUTION
C        ALGORITHM (SUBROUTINE CONVO).
C
C          B        - THE BACK-PROJECTION ARRAY
C          P        - THE CONVOLVED PROJECTION ARRAY
C          MM       - +/- THE ANGLE INDEX
C                   - IF M .LE. 0, ONLY A SET OF FLAGS IS RETURNED IN B
C                     NO BACK-PROJECTION IS PERFORMED
C                     (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - ZERO
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        LANGUARE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                        COMMON
C          IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                        SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                        FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                        EXECUTING.
C          WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                        NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                        THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                        IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C          IGEOM    - GEOMETRY FLAG
C                0 = PARALLEL BEAM GEOMETRY
C                1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                3 = RING DETECTOR GEOMETRY
C          KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                        BY THE USER
C          AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                        AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                        IN THE CENTER OF A PROJECTION BIN.)
C          BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C          KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                        ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                        ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C          KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C          KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE LAST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C          KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                        TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                        KDIM=KDIMU.
C          AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                        INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                        VECTOR
C          NANG     - NUMBER OF PROJECTIONS
C          MODANG   - MODE FOR PROJECTION ANGLE INPUT
C          LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                        PROJECTION ANGLES IN RADIANS
C          LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                        SINE OF THE PROJECTION ANGLES
C          LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                        COSINE OF THE PROJECTION ANGLES
C          LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                        USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                        FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1),P(1)
      LOGICAL TER
      DIMENSION FLAGS(4)
      DATA FLAGS/0.,4.,0.,0./
C
      IF (MM.EQ.0) GO TO 20
C
      M=IABS(MM)
      TER=MM.LT.0
      IF (M.NE.1) GO TO 10
      CALL ZERO (B,NMAT)
   10 CONTINUE
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      ZN=.5*FLOAT(NDIM+1)
      HS=.5*S
      ZZ=ZN*(S-C)+AXIS
      IJL=1
C
      DO 18 J=1,NDIM
      ZZ=ZZ+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
C
      IF (TER) GO TO 14
      DO 12 IJ=IJL,IJU
      Z=Z-S
      K=Z
   12 B(IJ)=B(IJ)+((FLOAT(K+1)-Z)*P(K)+(Z-FLOAT(K))*P(K+1))*PWID
      GO TO 18
   14 CONTINUE
C
      DO 16 IJ=IJL,IJU
      Z=Z-S
      K=Z
      KK=2*K-1
   16 B(IJ)=B(IJ)+((FLOAT(K+1)-Z)**2*P(KK)+(Z-FLOAT(K))**2*P(KK+2)+2.*(F
     1LOAT(K+1)-Z)*(Z-FLOAT(K))*P(KK+1))*PWID**2
   18 IJL=IJL+NN
      RETURN
C
   20 DO 22 I=1,4
   22 B(I)=FLAGS(I)
      RETURN
      END
```

BINF

```
      SUBROUTINE BINF (B,P,MM)
C
C     ****************************************************************
C     *       RECLBL     --         VERSION 1.0     --        17OCT77   *
C     ****************************************************************
C
C           THE SUBROUTINE BINF BACK-PROJECTS A SINGLE CONVOLVED
C        FAN-BEAM PROJECTION ARRAY P INTO THE ARRAY B.  THE PROJECTION
C        HAS THE ANGLE ANG(M) WHERE M IS THE INDEX OF THE ANGLE.  THE
C        ARRAY B IS ZEROED IF M=1 WHERE M=IABS(MM).  IF MM IS NEGATIVE
C        THE BACK-PROJECTION VARIANCES ARE CALCULATED INSTEAD AND RE-
C        TURNED IN THE ARRAY B.  THE SUBROUTINE BINF IS TO BE USED ONLY
C        WITH THE CONVOLUTION ALGORITHM (SUBROUTINE CONVO).
C
C          B        - THE BACK-PROJECTION ARRAY
C          P        - THE CONVOLVED PROJECTION ARRAY
C          MM       - +/- THE ANGLE INDEX
C                   - IF M .LE. 0, ONLY A SET OF FLAGS IS RETURNED IN B
C                     NO BACK-PROJECTION OPERATION IS PERFORMED
C                     (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
```

```
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - ZERO
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                      COMMON
C         IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                      SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                      FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                      EXECUTING.
C         WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/FANCOM/RFAN,TFANC,TFANF
      LOGICAL TFANC,TFANF
C
C         RFAN    - FOR FAN BEAM GEOMETRY RFAN IS THE DISTANCE FROM
C                      THE SOURCE TO THE CENTER OF ROTATION.  RFAN
C                      IS MEASURED IN UNITS OF PROJECTION BIN WIDTHS AT
C                      THE CENTER OF ROTATION.
C         TFANC   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                      CURVED DETECTOR
C         TFANF   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                      FLAT DETECTOR
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C         NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C         NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C         PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C         TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C         NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C         LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                      NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                      THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C         KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                      IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C         IGEOM   - GEOMETRY FLAG
C               0 = PARALLEL BEAM GEOMETRY
C               1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C               2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C               3 = RING DETECTOR GEOMETRY
C         KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                      BY THE USER
C         AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                      AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                      IN THE CENTER OF A PROJECTION BIN.)
C         BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                      ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                      ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C         KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE LAST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                      TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                      KDIM=KDIMU.
C         AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY, USUALLY AXIS=AXISU.
C         LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                      INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                      VECTOR
C         NANG    - NUMBER OF PROJECTIONS
C         MODANG  - MODE FOR PROJECTION ANGLE INPUT
C         LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                      PROJECTION ANGLES IN RADIANS
C         LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                      SINE OF THE PROJECTION ANGLES
C         LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                      COSINE OF THE PROJECTION ANGLES
C         LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                      USER PROJECTION DATA AND UNCERTAINTIES
C         TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                      FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1),P(1)
      LOGICAL TER
      DIMENSION FLAGS(4)
      DATA FLAGS/0.,4.,0.,1./
C
      IF (MM.EQ.0) GO TO 28
C
      M=IABS(MM)
      TER=MM.LT.0
      IF (M.NE.1) GO TO 10
      CALL ZERO (B,NMAT)
   10 CONTINUE
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      ZN=.5*FLOAT(NDIM+1)
      HS=.5*S
      HC=.5*C
      ZZ=ZN*(S-C)
      WW=RFAN-ZN*(S+C)
      IJL=1
C
      DO 26 J=1,NDIM
      ZZ=ZZ+C
      WW=WW+S
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
      W=WW+FLOAT(NDIM-NN)*HC
      IJU=IJL+NN-1
C
      IF (TER) GO TO 18
      IF (TFANF) GO TO 14
      DO 12 IJ=IJL,IJU
      Z=Z-S
      W=W+C
      ZF=RFAN*ATAN(Z/W)+AXIS
      U2=(W**2+Z**2)/(PWID*RFAN**2)
      K=ZF
   12 B(IJ)=B(IJ)+((FLOAT(K+1)-ZF)*P(K)+(ZF-FLOAT(K))*P(K+1))/U2
      GO TO 26
C
   14 DO 16 IJ=IJL,IJU
      Z=Z-S
      W=W+C
      ZF=RFAN*Z/W+AXIS
      U2=(W/RFAN)**2/PWID
      K=ZF
   16 B(IJ)=B(IJ)+((FLOAT(K+1)-ZF)*P(K)+(ZF-FLOAT(K))*P(K+1))/U2
      GO TO 26
C
   18 IF (TFANF) GO TO 22
      DO 20 IJ=IJL,IJU
      Z=Z-S
      W=W+C
      ZF=RFAN*ATAN(Z/W)+AXIS
      U2=(W**2+Z**2)/(PWID*RFAN**2)
      K=ZF
      KK=2*K-1
   20 B(IJ)=B(IJ)+((FLOAT(K+1)-ZF)**2*P(KK)+(ZF-FLOAT(K))**2*P(KK+2)+2.*
     1(FLOAT(K+1)-ZF)*(ZF-FLOAT(K))*P(KK+1))/U2**2
      GO TO 26
C
   22 DO 24 IJ=IJL,IJU
      Z=Z-S
      W=W+C
      ZF=RFAN*Z/W+AXIS
      U2=(W/RFAN)**2/PWID
      K=ZF
      KK=2*K-1
   24 B(IJ)=B(IJ)+((FLOAT(K+1)-ZF)**2*P(KK)+(ZF-FLOAT(K))**2*P(KK+2)+2.*
     1(FLOAT(K+1)-ZF)*(ZF-FLOAT(K))*P(KK+1))/U2**2
C
   26 IJL=IJL+NN
      RETURN
C
   28 DO 30 I=1,4
   30 B(I)=FLAGS(I)
      RETURN
      END
```

BJECT

```
      SUBROUTINE BJECT (B,P,M,BCK)
C
C     ****************************************************************
C     *      RECLBL    --        VERSION 1.0     --         17OCT77    *
C     ****************************************************************
C
C           THE SUBROUTINE BJECT BACK-PROJECTS A SINGLE PROJECTION
C        ARRAY P OF LENGTH KDIMU WITH ROTATION AXIS EQUAL TO AXISU INTO
C        THE ARRAY B.  THE PROJECTION HAS THE ANGLE ANG(M) WHERE M IS
C        THE INDEX OF THE ANGLE.  THE SUBROUTINE BJECT REQUIRES THE
C        USER TO CALL THE DESIRED SYSTEM BACK-PROJECTION SUBROUTINE BCK.
C        THIS ALLOWS THE USER TO USE THE SYSTEM BACK-PROJECTION SUB-
C        ROUTINES AND BACK-PROJECT USER DATA INTO THE USERS OWN ARRAY.
C
C        NOTE -- BJECT DOES NOT DEMAND THAT THE ANGLE INDICES BE
C          SEQUENTIAL IN THE SET OF CALLS THAT WOULD NORMALLY BE
C          EXECUTED TO FORM AN ENTIRE BACK-PROJECTION IMAGE.  HOWEVER,
C          THE USER SHOULD BE AWARE THAT THE BACK-PROJECTION ROUTINES
C          ZERO OUT THE B ARRAY WHEN THE ANGLE INDEX IS EQUAL TO 1
C
C
C          B        - THE BACK-PROJECTION ARRAY
C          P        - THE PROJECTION ARRAY
C          M        - THE ANGLE INDEX
C          BCK      - THE BACK-PROJECTION SUBROUTINE
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - CISO, MEMST
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        EXTERNAL RECLBL SUBROUTINES - BCK
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                      COMMON
C         IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                      SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                      FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                      EXECUTING.
C         WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/ATNCOM/LATEN,LBMAP,TATEN,LUNATN
      LOGICAL TATEN
      DIMENSION ATEN(1),BMAP(1)
      EQUIVALENCE (WORK(1),ATEN(1),BMAP(1))
C
C         LATEN   - POINTER TO THE ARRAY ATEN IN BLANK COMMON
C                      STORES ATTENUATION FACTORS FOR ONE ANGLE
C         LBMAP   - POINTER TO THE ARRAY BMAP IN BLANK COMMON
C                      A MATRIX USED TO STORE THE CONSTANT ATTENUATION
C                      COEFFICIENTS
C         TATEN   - LOGICAL VARIABLE SET TRUE FOR ATTENUATION
C                      RECONSTRUCTION
C         LUNATN  - LOGICAL UNIT NUMBER FOR ATTENUATION FACTOR STORAGE
C
      COMMON/DATCOM/LDATA
      DIMENSION DATA(1)
      EQUIVALENCE (WORK(1),DATA(1))
C
C         LDATA   - POINTER TO THE ARRAY DATA IN BLANK COMMON
C         DATA    - AN INTERMEDIATE PROJECTION ARRAY
C
      COMMON/FANCOM/RFAN,TFANC,TFANF
      LOGICAL TFANC,TFANF
C
C         RFAN    - FOR FAN BEAM GEOMETRY RFAN IS THE DISTANCE FROM
C                      THE SOURCE TO THE CENTER OF ROTATION.  RFAN
C                      IS MEASURED IN UNITS OF PROJECTION BIN WIDTHS AT
C                      THE CENTER OF ROTATION.
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C         TFANC   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                      CURVED DETECTOR
C         TFANF   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                      FLAT DETECTOR
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C         LUNOUT  - LOGICAL UNIT NUMBER FOR OUTPUT
C         I80132  - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                      OUTPUT ON LUNOUT
C               0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C         NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C         NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C         PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C         TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C         NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C         LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                      NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                      THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C         KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                      IS AN INTEGER VARIABLE
C
      COMMON/STRCOM/TSTORE
      LOGICAL TSTORE
C
C         TSTORE  - LOGICAL VARIABLE SET TRUE WHEN TESTING STORAGE SIZE
C                      SETS TPRINT(1) = .TRUE.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C         IGEOM   - GEOMETRY FLAG
C               0 = PARALLEL BEAM GEOMETRY
C               1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C               2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C               3 = RING DETECTOR GEOMETRY
C         KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                      BY THE USER
C         AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                      AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                      IN THE CENTER OF A PROJECTION BIN.)
C         BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                      ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                      ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C         KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE LAST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                      TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                      KDIM=KDIMU.
C         AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY, USUALLY AXIS=AXISU.
C         LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                      INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                      VECTOR
C         NANG    - NUMBER OF PROJECTIONS
C         MODANG  - MODE FOR PROJECTION ANGLE INPUT
C         LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                      PROJECTION ANGLES IN RADIANS
C         LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                      SINE OF THE PROJECTION ANGLES
C         LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                      COSINE OF THE PROJECTION ANGLES
C         LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                      USER PROJECTION DATA AND UNCERTAINTIES
C         TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                      FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1),P(1)
      DIMENSION BFLG(4)
      DIMENSION NAMER(9)
      LOGICAL TFANN,TATENN
      EXTERNAL BCK
      DATA IOK/2HOK/
      DATA NAMER/1HE,1HN,1HD,1H ,1HB,1HJ,1HE,1HC,1HT/
C
C        *BE SURE THAT SETUP HAS BEEN CALLED
C
      IF (ISETUP.NE.IOK) CALL EMESG (1,NAMER(5),1)
C
      IF (IGEOM.NE.3) GO TO 10
      WRITE (LUNOUT,20)
      CALL EMESG (36,NAMER(5),1)
   10 IF (LDATA.LE.0) CALL MEMST (LDATA,KDIM)
      IF (LDATA.LE.0) CALL MEMST (LDATA,KDIM)
      IF (M.EQ.1) CALL LGTXT (NAMER(5),5)
      CALL BCK (BFLG,DUM,0)
C
      ITYP=BFLG(1)
      IWTT=BFLG(2)
      IATEN=BFLG(3)
      IFAN=BFLG(4)
C
      TFANN=IFAN.EQ.1
      TATENN=IATEN.EQ.1
C
      IF ((TFANC.OR.TFANF).AND.TFANN.OR..NOT.((TFANC.OR.TFANF).OR.TFANN)
     1) GO TO 12
      WRITE (LUNOUT,22)
      CALL EMESG (2,NAMER(5),1)
C
   12 IF (TATEN.AND.TATENN.OR..NOT.(TATEN.OR.TATENN)) GO TO 14
      WRITE (LUNOUT,24)
      CALL EMESG (3,NAMER(5),1)
C
C
   14 IF (TSTORE) GO TO 18
      IF (M.NE.1.AND.TCIR) CALL CISQ (B,B,2)
      CALL ZERO (DATA(LDATA),KDIM)
C
      PI=4.*ATAN(1.)
      FAC=PI
      IF (.NOT.TEMIT) FAC=PI/(FLOAT(NANG)*PWID)
      KSUB1=KMIN-KMOV
      KSUB2=LDATA+KMIN-1
      DO 16 K=KMIN,KMAX
      DATA(KSUB2)=P(KSUB1)*FAC
      KSUB1=KSUB1+1
      KSUB2=KSUB2+1
   16 CONTINUE
C
      CALL BCK (B,DATA(LDATA),M)
C
      IF (TCIR) CALL CISQ (B,B,1)
   18 IF (M.NE.NANG) RETURN
      CALL MEMST (LDATA,0)
      CALL MEMST (MAXFW,-1)
      WRITE (LUNOUT,26) MAXFW
      CALL LGTXT (NAMER,9)
C
      RETURN
C
C
C
   20 FORMAT(//10X,39HBJECT CANNOT BE USED WITH RING GEOMETRY/
     110X,49H(SETUP INPUT PARAMETER IGEOM=IPAR(5) CANNOT BE 3))
   22 FORMAT(/10X,55HTHE BACK-PROJECTION SUBROUTINE IS INCONSISTENT WITH
     1 THE/15X,34HFAN BEAM PARAMETERS SEEN BY SETUP.)
   24 FORMAT(1X,77HATTEMPTED CALL OF A BACK-PROJECTION SUBROUTINE WHICH
     1USES ATTENUATION FACTORS/
     25X,34HBEFORE THE FACTORS WERE EVALUATED.)
   26 FORMAT(//10X,38HMAXIMUM SIZE OF BLANK COMMON THUS FAR=,I7,
     122H FLOATING POINT WORDS.)
      END
```

BKFIL

```
      SUBROUTINE BKFIL (X,FIL,BCK,ORDERX,FREQX)
C
C     ****************************************************************
C     *      RECLBL    --        VERSION 1.0     --        17OCT77     *
C     ****************************************************************
C
C            THE SUBROUTINE BKFIL RECONSTRUCTS THE ARRAY X USING THE
C        BACK-PROJECTION OF THE FILTERED PROJECTIONS ALGORITHM.
C
C          X       - THE RECONSTRUCTION ARRAY
C          FIL     - THE FILTER SUBROUTINE
C          BCK     - THE BACK-PROJECTION SUBROUTINE
C          ORDERX  - FILTER PARAMETER USED ONLY BY THE FILTER BUTER
C          FREQX   - FILTER PARAMETER
C
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - CISQ, EMESG, FFTR,
C          GETDE, LGTXT, MEMST, RCHEK, ZERO
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        EXTERNAL RECLBL SUBROUTINES - BCK, FIL
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                      COMMON
C         IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                      SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                      FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                      EXECUTING.
C         WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/FILCOM/ORDER,FREQ,LBCKA,LPRJA,LFILT
      DIMENSION BCKA(1),PRJA(1),FILT(1)
      EQUIVALENCE (WORK(1),BCKA(1),PRJA(1),FILT(1))
C
C         ORDER   - FILTER PARAMETER USED ONLY BY THE FILTER BUTER
C         FREQ    - FILTER PARAMETER
C         LBCKA   - POINTER TO THE ARRAY BCKA IN BLANK COMMON
C                      BACK-PROJECTION ARRAY WHICH HAS THE DIMENSION
C                      NDIM X NDIM
C         LPRJA   - POINTER TO THE ARRAY PRJA IN BLANK COMMON
C                      A PROJECTION ARRAY FOR ONE ANGLE
C         LFILT   - POINTER TO THE ARRAY FILT IN BLANK COMMON
C                      ARRAY OF FILTER VALUES
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C         LUNOUT  - LOGICAL UNIT NUMBER FOR OUTPUT
C         I80132  - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                      OUTPUT ON LUNOUT
C               0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      COMMON/PRTCOM/TPRINT(8)
      LOGICAL TPRINT
C
C         TPRINT  - LOGICAL PRINT FLAGS
C               1 - PRINT REQUIRED FLOATING POINT BLANK COMMON
C                      WHENEVER CHANGED
C               2 - PRINT PROJECTION DATA AND UNCERTAINTIES
C               3 - PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
C               4 - PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER
C                      ROUTINES
C               5 - PRINT VALUES FOR THE LAGRANGE MULTIPILERS AND
C                      THE GRADIENT FOR THE FUNCTION OF LAGRANGE MULTI-
C                      PILERS FOR THE ENTROPY RECONSTRUCTION
C               6 - PRINT POINTERS IN BLANK COMMON WHENEVER CHANGED
C                      (DEBUG)
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C         NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C         NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C         PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C         TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C         NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C         LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                      NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                      THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C         KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                      IS AN INTEGER VARIABLE
C
      COMMON/STRCOM/TSTORE
      LOGICAL TSTORE
C
C         TSTORE  - LOGICAL VARIABLE SET TRUE WHEN TESTING STORAGE SIZE
C                      SETS TPRINT(1) = .TRUE.
```

```
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C          IGEOM   - GEOMETRY FLAG
C                0 = PARALLEL BEAM GEOMETRY
C                1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                3 = RING DETECTOR GEOMETRY
C          KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                      BY THE USER
C          AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                      AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                      IN THE CENTER OF A PROJECTION BIN.)
C          BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C          KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                      ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                      ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C          KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C          KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE LAST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C          KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                      TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                      KDIM=KDIMU.
C          AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                      INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                      VECTOR
C          NANG    - NUMBER OF PROJECTIONS
C          MODANG  - MODE FOR PROJECTION ANGLE INPUT
C          LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                      PROJECTION ANGLES IN RADIANS
C          LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                      SINE OF THE PROJECTION ANGLES
C          LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                      COSINE OF THE PROJECTION ANGLES
C          LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                      USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                      FALSE FOR TRANSMISSION DATA
C
      EXTERNAL FIL,BCK
      DIMENSION X(1)
      DIMENSION NAMER(9)
      LOGICAL T80,T132
      DATA NAMER/1HE,1HN,1HD,1H ,1HB,1HK,1HF,1HI,1HL/
      DATA IOK/2HOK/
C
      T80=TPRINT(4).AND.I80132.EQ.0
      T132=TPRINT(4).AND.I80132.NE.0
C
C         *BE SURE THAT SETUP HAS BEEN CALLED
C
      IF (ISETUP.NE.IOK) CALL EMESG (1,NAMER(5),1)
C
      ORDER=ORDERX
      FREQ=FREQX
      CALL LGTXT (NAMER(5),5)
      WRITE (LUNOUT,20)
      WRITE (LUNOUT,22) ORDER
      WRITE (LUNOUT,24) FREQ
C
      CALL RCHEK (BCK,FIL,3)
C
      IPOW2=INT(ALOG(FLOAT(KDIM)-.5)/ALOG(2.))+2
C
C         *IPOW2 SATISFIES KDIM=2**IPOW2 WHERE KDIM IS 2 TIMES THE
C           SMALLEST INTEGER THAT IS A POWER OF 2 AND GREATER THAN
C           OR EQUAL TO KDIM.
C
      KDIMT=2**IPOW2
      KHALF=KDIMT/2
C
      CALL MEMST (LPRJA,KDIMT)
      CALL MEMST (LFILT,KHALF)
C
      IF (TSTORE) GO TO 18
C
C         *STORE THE FILTER VALUES IN FILT
C
      ISUB=LFILT
      DO 10 K=1,KHALF
      CALL FIL (FILT(ISUB),FLOAT(K)/FLOAT(KDIMT),1)
   10 ISUB=ISUB+1
C
      ISUB1=LFILT
      ISUB2=LFILT+KHALF-1
      ZZRO=0.
      FREQSP=1./FLOAT(KDIMT)
      IF (T80) WRITE (LUNOUT,26) KHALF,KDIMT,FREQSP,ZZRO,(FILT(ISUB),
     1ISUB=ISUB1,ISUB2)
      IF (T132) WRITE (LUNOUT,28) KHALF,KDIMT,FREQSP,ZZRO,(FILT(ISUB),
     1ISUB=ISUB1,ISUB2)
C
      DO 14 M=1,NANG
      CALL ZERO (PRJA(LPRJA),KDIMT)
      CALL GETDE (M,PRJA(LPRJA),DUM)
C
C         *FOURIER TRANSFORM THE PROJECTION
C
      CALL FFTR (PRJA(LPRJA),IPOW2)
C
C         *FILTER THE FOURIER TRANSFORM
C
      PRJA(LPRJA)=0.
      ISUB=LFILT+KHALF-1
      PRJA(LPRJA+1)=PRJA(LPRJA+1)*FILT(ISUB)
      KH1=KHALF-1
      ISUB1=LPRJA+2
      ISUB2=LFILT
      DO 12 K=1,KH1
      PRJA(ISUB1)=PRJA(ISUB1)*FILT(ISUB2)
      PRJA(ISUB1+1)=PRJA(ISUB1+1)*FILT(ISUB2)
      ISUB1=ISUB1+2
   12 ISUB2=ISUB2+1
C
C         *INVERSE FOURIER TRANSFORM THE FILTERED PROJECTION
C
      CALL FFTR (PRJA(LPRJA),-IPOW2)
C
C         *BACK-PROJECT THE PROJECTION
C
   14 CALL BCK (X,PRJA(LPRJA),M)
C
      PI=4.*ATAN(1.)
      FAC=PI/FLOAT(NANG)
      DO 16 I=1,NMAT
   16 X(I)=X(I)*FAC
C
      IF (TCIR) CALL CISQ (X,X,1)
C
   18 CALL MEMST (LPRJA,0)
      CALL MEMST (LFILT,0)
C
      CALL MEMST (MAXFW,-1)
      WRITE (LUNOUT,30) MAXFW
      CALL LGTXT (NAMER,9)
      RETURN
C
C
C
   20 FORMAT(  ////11X,31HPARAMETERS FOR SUBROUTINE BKFIL//19X,11HDESCRI
     1PTION/1X)
   22 FORMAT(10H ORDERX - ,F6.1,4X,46HFILTER PARAMETER USED ONLY BY THE
     1FILTER BUTER)
   24 FORMAT(10H FREQX  - ,F6.3,4X,34HFREQUENCY PARAMETER FOR THE FILTER
     1)
   26 FORMAT(/1X,55HTHE VALUES FOR THE FREQUENCY SPACE FILTER (FILT(I),I
     1=0.,I3,18H) WITH A FREQUENCY/2X,14H SPACING OF 1/,I3,2H =,E9.3,30H
     2 CYCLES PER PROJECTION BIN ARE/(3X,5E12.3))
   28 FORMAT(/1X,55HTHE VALUES FOR THE FREQUENCY SPACE FILTER (FILT(I),I
     1=0.,I3,18H) WITH A FREQUENCY/2X,14H SPACING OF 1/,I3,2H =,E9.3,30H
     2 CYCLES PER PROJECTION BIN ARE/(3X,10E12.3))
   30 FORMAT(//10X,38HMAXIMUM SIZE OF BLANK COMMON THUS FAR=,I7,
     122H FLOATING POINT WORDS.)
      END
```

BLL

```
      SUBROUTINE BLL (B,P,M)
C
C     ****************************************************************
C     *       RECLBL    --        VERSION 1.0    --         17OCT77   *
C     ****************************************************************
C
C          THE SUBROUTINE BLL BACK-PROJECTS A SINGLE PROJECTION ARRAY
C       P INTO THE ARRAY B.  THE PROJECTION HAS THE ANGLE ANG(M) WHERE
C       M IS THE INDEX OF THE ANGLE.  THE VALUE GIVEN EACH CELL IS
C       WEIGHTED ACCORDING TO THE LENGTH OF THE RAY INTERSECTING EACH
C       CELL.  THE B ARRAY IS ZEROED IF M=1.
C
C         B        - THE BACK-PROJECTION ARRAY
C         P        - THE PROJECTION ARRAY
C         M        - THE ANGLE INDEX
C                  - IF M .LE. 0, ONLY A SET OF FLAGS IS RETURNED IN B
C                    NO BACK-PROJECTION OPERATION IS PERFORMED
C                    (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - ZERO
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                      COMMON
C          IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                      SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                      FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                      EXECUTING.
C          WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                      NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                      THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                      IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C          IGEOM   - GEOMETRY FLAG
C                0 = PARALLEL BEAM GEOMETRY
C                1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                3 = RING DETECTOR GEOMETRY
C          KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                      BY THE USER
C          AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                      AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                      IN THE CENTER OF A PROJECTION BIN.)
C          BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C          KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                      ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                      ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C          KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C          KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE LAST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C          KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                      TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                      KDIM=KDIMU.
C          AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                      INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                      VECTOR
C          NANG    - NUMBER OF PROJECTIONS
C          MODANG  - MODE FOR PROJECTION ANGLE INPUT
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C          LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                       PROJECTION ANGLES IN RADIANS
C          LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                       SINE OF THE PROJECTION ANGLES
C          LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                       COSINE OF THE PROJECTION ANGLES
C          LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                       USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                       FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1),P(1)
      DIMENSION FLAGS(4)
      DATA FLAGS/0.,3.,0.,0./
      DATA EPS/1.E-6/
C
      IF (M.LE.0) GO TO 58
C
      IF (M.EQ.1) CALL ZERO (B,NMAT)
C
C        *SET ZEROTH PROJECTION INTERSECTION AND OFFSET
C
      Z=-AXIS*BWID
      H=.5*FLOAT(NDIM)
C
C        *SET SIN AND COS AND CHECK FOR VERY SMALL ANGLES
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)
      IF (ABS(S).LT.EPS) GO TO 38
      IF (ABS(C).LT.EPS) GO TO 48
C
C        *DXL AND DYL ARE TO STEP THROUGH THE B ARRAY
C        *(DISTANCE TO STEP ALONG THE LINE)
C
      DXL=1./ABS(C)
      DYL=1./ABS(S)
C
C        *DX AND DY ARE TO FIND LARGE INTERSECTIONS
C        *(SIDEWAYS INCREMENTS FROM ONE LINE TO THE NEXT)
C
      DX=-BWID/S
      DY=BWID/C
C
C        *KI IS THE I INCREMENT AS WE STEP ALONG THE LINE
C        *I1ST IS THE FIRST I FOR LARGE X INTERSECTIONS
C        *IOUT TAKES US OUT OF THE ARRAY
C        *XOFF MAKES THE ROUNDING OF (I-X) OK FOR NEGATIVE KI
C
      IF (C.LT.0.) GO TO 10
      KI=1
      I1ST=1
      IOUT=NDIM+1
      XOFF=0.
      GO TO 12
C
   10 KI=-1
      I1ST=NDIM
      IOUT=0
      XOFF=1.
C
C        *KJ, J1ST, JOUT AND YOFF ARE ANALAGOUS TO
C        *KI, I1ST, IOUT AND XOFF RESPECTIVELY
C
   12 IF (S.LT.0.) GO TO 14
      KJ=1
      J1ST=1
      JOUT=NDIM+1
      YOFF=0.
      GO TO 16
C
   14 KJ=-1
      J1ST=NDIM
      JOUT=0
      YOFF=1.
C
C        *X AND Y ARE FOR LARGE INTERSECTIONS
C        *EPS INSURES THAT NONE FALL THROUGH THE CRACKS
C
   16 X=(-FLOAT(KJ)*H*C-Z)/S+H+FLOAT(KI)*EPS
      Y=(-FLOAT(KI)*H*S+Z)/C+H+FLOAT(KJ)*EPS
      IJLAST=1
      IF (KI.NE.KJ) IJLAST=2
C
C        *LOOP THRU THE PROJECTION BINS
C
      DO 36 K=1,KDIM
C
C        *UPDATE THE POSSIBLE LARGE INTERSECTIONS AND START SEARCHING
C              WHERE THE LAST ONE WAS FOUND
C
      X=X+DX
      Y=Y+DY
      GO TO (18,22),IJLAST
C
C        *IS THERE A LARGE X INTERSECTION
C
   18 I=X+1.
      IF (I.GE.1.AND.I.LE.NDIM) GO TO 20
      GO TO (22,36),IJLAST
   20 IJLAST=1
      J=J1ST
      XL=ABS((FLOAT(I)-X-XOFF)*DXL)
      YL=DYL
      GO TO 26
C
C        * IS THERE A LARGE Y INTERSECTION
C
   22 J=Y+1.
      IF (J.GE.1.AND.J.LE.NDIM) GO TO 24
      GO TO (36,18),IJLAST
   24 IJLAST=2
      I=I1ST
      YL=ABS((FLOAT(J)-Y-YOFF)*DYL)
      XL=DXL
C
C        *STEP THRU THE B ARRAY
C
C        *THE B ARRAY IS INCREMENTED BY P ARRAY TIMES LINE LENGTH
C
   26 ISUB=LNI+J-1
      NN=NI(ISUB)
      IL=(NDIM-NN)/2+1
      IU=IL+NN-1
      ISUB=ISUB+NDIM
      IJ=I+NI(ISUB)
      IF (XL.GE.YL) GO TO 32
C
C        *X HIT
C
   28 IF (I.LT.IL.OR.I.GT.IU) GO TO 30
      B(IJ)=B(IJ)+XL*P(K)
   30 I=I+KI
      IF (I.EQ.IOUT) GO TO 36
      IJ=IJ+KI
      YL=YL-XL
      XL=DXL
      IF (XL.LT.YL) GO TO 28
C
C        *Y HIT
C
   32 IF (I.LT.IL.OR.I.GT.IU) GO TO 34
      B(IJ)=B(IJ)+YL*P(K)
   34 J=J+KJ
      IF (J.EQ.JOUT) GO TO 36
      ISUB=LNI+J-1
      NN=NI(ISUB)
      IL=(NDIM-NN)/2+1
      IU=IL+NN-1
      ISUB=ISUB+NDIM
      IJ=I+NI(ISUB)
      XL=XL-YL
      YL=DYL
      IF (YL.LT.XL) GO TO 32
      GO TO 28
   36 CONTINUE
      RETURN
C
C        *ANGLE IS VERY NEAR 0 OR PI
C
   38 Y=Z/C+H
      DY=BWID/C
      DO 46 K=1,KDIM
      Y=Y+DY
      J=Y+1.
C
C        *SEE IF THE LINE IS VERY CLOSE TO A PIXEL BOUNDARY
C
      JJ=Y+1.+EPS
      IF (JJ.EQ.J) JJ=Y+1.-EPS
      FAC=1.
      IF (JJ.EQ.J) GO TO 42
      FAC=.5
      IF (JJ.LT.1.OR.JJ.GT.NDIM) GO TO 42
      ISUB=LNI+JJ-1
      NN=NI(ISUB)
      IL=(NDIM-NN)/2+1
      IU=IL+NN-1
      ISUB=ISUB+NDIM
      IJL=IL+NI(ISUB)
      IJU=IU+NI(ISUB)
      DO 40 IJ=IJL,IJU
   40 B(IJ)=B(IJ)+FAC*P(K)
   42 IF (J.LT.1.OR.J.GT.NDIM) GO TO 46
      ISUB=LNI+J-1
      NN=NI(ISUB)
      IL=(NDIM-NN)/2+1
      IU=IL+NN-1
      ISUB=ISUB+NDIM
      IJL=IL+NI(ISUB)
      IJU=IU+NI(ISUB)
      DO 44 IJ=IJL,IJU
   44 B(IJ)=B(IJ)+FAC*P(K)
   46 CONTINUE
      RETURN
C
C        *ANGLE IS VERY NEAR PI/2 OR 3PI/2
C
   48 X=-Z/S+H
      DX=-BWID/S
      DO 56 K=1,KDIM
      X=X+DX
      I=X+1.
C
C        *SEE IF THE LINE IS VERY CLOSE TO A PIXEL BOUNDARY
C
      II=X+1.+EPS
      IF (II.EQ.I) II=X+1.-EPS
      FAC=1.
      IF (II.EQ.I) GO TO 52
      FAC=.5
      IF (II.LT.1.OR.II.GT.NDIM) GO TO 52
      ISUB=LNI+II-1
      NN=NI(ISUB)
      JL=(NDIM-NN)/2+1
      JU=JL+NN-1
      ISUB=LNI+NDIM+JL-1
      DO 50 J=JL,JU
      IJ=II+NI(ISUB)
      B(IJ)=B(IJ)+FAC*P(K)
   50 ISUB=ISUB+1
   52 IF (I.LT.1.OR.I.GT.NDIM) GO TO 56
      ISUB=LNI+I-1
      NN=NI(ISUB)
      JL=(NDIM-NN)/2+1
      JU=JL+NN-1
      ISUB=LNI+NDIM+JL-1
      DO 54 J=JL,JU
      IJ=I+NI(ISUB)
      B(IJ)=B(IJ)+FAC*P(K)
   54 ISUB=ISUB+1
   56 CONTINUE
      RETURN
C
   58 DO 60 I=1,4
   60 B(I)=FLAGS(I)
      RETURN
      END
```

BPT

```
      SUBROUTINE BPT (B,P,M)
C
C     ****************************************************************
C     *      RECLBL     --          VERSION 1.0     --         17OCT77  *
C     ****************************************************************
C
C          THE SUBROUTINE BPT BACK-PROJECTS A SINGLE PROJECTION ARRAY
C       P INTO THE ARRAY B.  THE PROJECTION HAS THE ANGLE ANG(M) WHERE
C       M IS THE INDEX OF THE ANGLE.  THE MODEL ASSUMES THAT EACH CELL
C       IS REPRESENTED BY A DELTA FUNCTION WITH ALL THE DENSITY AT THE
C       CENTER OF THE CELL.  THE ARRAY B IS ZEROED IF M=1.
C
C         B        - THE BACK-PROJECTION ARRAY
C         P        - THE PROJECTION ARRAY
C         M        - THE ANGLE INDEX
C                  - IF M .LE. 0, ONLY A SET OF FLAGS IS RETURNED IN B
C                    NO BACK-PROJECTION OPERATION IS PERFORMED
C                    (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - ZERO
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                     COMMON
C         IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                     SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                     FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                     EXECUTING.
C         WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/PTRCOM/NOIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C         NOIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C         NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C         PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C         TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C         NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C         LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                     NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                     THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C         KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                     IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C         IGEOM   - GEOMETRY FLAG
C               0 = PARALLEL BEAM GEOMETRY
C               1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C               2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C               3 = RING DETECTOR GEOMETRY
C         KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                     BY THE USER
C         AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                     PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                     AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                     IN THE CENTER OF A PROJECTION BIN.)
C         BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                     ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                     ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C         KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                     THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                     IS GOING TO BE USED.
C         KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                     THE DATA OF THE LAST USER PROJECTION BIN THAT
C                     IS GOING TO BE USED.
C         KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                     TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                     KDIM=KDIMU.
C         AXIS.   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                     PROJECTION ARRAY, USUALLY AXIS=AXISU.
C         LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                     INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                     VECTOR
C         NANG    - NUMBER OF PROJECTIONS
C         MODANG  - MODE FOR PROJECTION ANGLE INPUT
C         LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                     PROJECTION ANGLES IN RADIANS
C         LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                     SINE OF THE PROJECTION ANGLES
C         LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                     COSINE OF THE PROJECTION ANGLES
C         LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                     USER PROJECTION DATA AND UNCERTAINTIES
C         TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                     FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1),P(1)
C       BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/0.,0.,0.,0./
C
      IF (M.LE.0) GO TO 14
C
      IF (M.EQ.1) CALL ZERO (B,NMAT)
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      HS=.5*S
      ZN=.5*FLOAT(NDIM+1)
      ZZ=ZN*(S-C)+AXIS+.5
      IJL=1
      DO 12 J=1,NDIM
      ZZ=ZZ+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 10 IJ=IJL,IJU
      Z=Z-S
      K=Z
   10 B(IJ)=B(IJ)+P(K)*PWID
   12 IJL=IJL+NN
      RETURN
C
   14 DO 16 I=1,4
   16 B(I)=FLAGS(I)
      RETURN
      END
```

BPTA

```
      SUBROUTINE BPTA (B,P,M)
C
C     ****************************************************************
C     *      RECLBL     --          VERSION 1.0     --         17OCT77  *
C     ****************************************************************
C
C          THE SUBROUTINE BPTA BACK-PROJECTS A SINGLE PROJECTION
C       ARRAY P INTO THE ARRAY B.  THE PROJECTION HAS THE ANGLE ANG(M)
C       WHERE M IS THE INDEX OF THE ANGLE.  THE MODEL ASSUMES THAT EACH
C       CELL IS REPRESENTED BY A DELTA FUNCTION WITH ALL THE DENSITY AT
C       THE CENTER OF THE CELL.  THE VALUE GIVEN EACH CELL IS WEIGHTED
C       BY AN ATTENUATION FACTOR.  THE ARRAY B IS ZEROED IF M=1.
C
C         B        - THE BACK-PROJECTION ARRAY
C         P        - THE PROJECTION ARRAY
C         M        - THE ANGLE INDEX
C                  - IF M .LE. 0, ONLY A SET OF FLAGS IS RETURNED IN B
C                    NO BACK-PROJECTION OPERATION IS PERFORMED
C                    (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - FTATN, ZERO
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                     COMMON
C         IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                     SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                     FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                     EXECUTING.
C         WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/ATNCOM/LATEN,LBMAP,TATEN,LUNATN
      LOGICAL TATEN
      DIMENSION ATEN(1),BMAP(1)
      EQUIVALENCE (WORK(1),ATEN(1),BMAP(1))
C
C         LATEN   - POINTER TO THE ARRAY ATEN IN BLANK COMMON
C                     STORES ATTENUATION FACTORS FOR ONE ANGLE
C         LBMAP   - POINTER TO THE ARRAY BMAP IN BLANK COMMON
C                     A MATRIX USED TO STORE THE CONSTANT ATTENUATION
C                     COEFFICIENTS
C         TATEN   - LOGICAL VARIABLE SET TRUE FOR ATTENUATION
C                     RECONSTRUCTION
C         LUNATN  - LOGICAL UNIT NUMBER FOR ATTENUATION FACTOR STORAGE
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C         NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C         NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C         PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C         TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C         NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C         LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                     NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                     THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C         KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                     IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C         IGEOM   - GEOMETRY FLAG
C               0 = PARALLEL BEAM GEOMETRY
C               1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C               2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C               3 = RING DETECTOR GEOMETRY
C         KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                     BY THE USER
C         AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                     PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                     AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                     IN THE CENTER OF A PROJECTION BIN.)
C         BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                     ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                     ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C         KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                     THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                     IS GOING TO BE USED.
C         KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                     THE DATA OF THE LAST USER PROJECTION BIN THAT
C                     IS GOING TO BE USED.
C         KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                     TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                     KDIM=KDIMU.
C         AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                     PROJECTION ARRAY, USUALLY AXIS=AXISU.
C         LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                     INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                     VECTOR
C         NANG    - NUMBER OF PROJECTIONS
```

```
C           MODANG  - MODE FOR PROJECTION ANGLE INPUT
C           LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                       PROJECTION ANGLES IN RADIANS
C           LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                       SINE OF THE PROJECTION ANGLES
C           LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                       COSINE OF THE PROJECTION ANGLES
C           LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                       USER PROJECTION DATA AND UNCERTAINTIES
C           TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                       FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1),P(1)
C        BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/0.,0.,1.,0./
C
      IF (M.LE.0) GO TO 14
C
      IF (M.EQ.1) CALL ZERO (B,NMAT)
      CALL FTATN (M,ATEN(LATEN),NMAT)
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      HS=.5*S
      ZN=.5*FLOAT(NDIM+1)
      ZZ=ZN*(S-C)+AXIS+.5
      IJL=1
      DO 12 J=1,NDIM
      ZZ=ZZ+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 10 IJ=IJL,IJU
      Z=Z-S
      K=Z
      ISUB=LATEN+IJ-1
   10 B(IJ)=B(IJ)+ATEN(ISUB)*P(K)*PWID
   12 IJL=IJL+NN
      RETURN
C
   14 DO 16 I=1,4
   16 B(I)=FLAGS(I)
      RETURN
      END
```

BPTF

```
      SUBROUTINE BPTF (B,P,M)
C
C     ****************************************************************
C     *       RECLBL     --          VERSION 1.0     --     17OCT77   *
C     ****************************************************************
C
C           THE SUBROUTINE BPTF BACK-PROJECTS A SINGLE PROJECTION
C        ARRAY P INTO THE ARRAY B FOR A FAN BEAM GEOMETRY.  THE PROJECT-
C        ION HAS THE ANGLE ANG(M) WHERE M IS THE INDEX OF THE ANGLE.
C        THE MODEL ASSUMES THAT EACH CELL IS REPRESENTED BY A DELTA
C        FUNCTION WITH ALL THE DENSITY AT THE CENTER OF THE CELL.  THE
C        ARRAY B IS ZEROED IF M=1.
C
C           B       - THE BACK-PROJECTION ARRAY
C           P       - THE PROJECTION ARRAY
C           M       - THE ANGLE INDEX
C                   - IF M .LE. 0, ONLY A SET OF FLAGS IS RETURNED IN B
C                     NO BACK-PROJECTION OPERATION IS PERFORMED
C                     (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - ZERO
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C           NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                       COMMON
C           IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C           NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C           ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                       SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                       FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                       EXECUTING.
C           WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/FANCOM/RFAN,TFANC,TFANF
      LOGICAL TFANC,TFANF
C
C           RFAN    - FOR FAN BEAM GEOMETRY RFAN IS THE DISTANCE FROM
C                       THE SOURCE TO THE CENTER OF ROTATION.  RFAN
C                       IS MEASURED IN UNITS OF PROJECTION BIN WIDTHS AT
C                       THE CENTER OF ROTATION.
C           TFANC   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                       CURVED DETECTOR
C           TFANF   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                       FLAT DETECTOR
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C           NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C           NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C           PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C           TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C           NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C           LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                       NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                       THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C           KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                       IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C           IGEOM   - GEOMETRY FLAG
C                 0 = PARALLEL BEAM GEOMETRY
C                 1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                 2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                 3 = RING DETECTOR GEOMETRY
C           KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                       BY THE USER
C           AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                       PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                       AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                       IN THE CENTER OF A PROJECTION BIN.)
C           BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C           KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                       ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                       ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C           KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                       THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                       IS GOING TO BE USED.
C           KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                       THE DATA OF THE LAST USER PROJECTION BIN THAT
C                       IS GOING TO BE USED.
C           KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                       TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                       KDIM=KDIMU.
C           AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                       PROJECTION ARRAY, USUALLY AXIS=AXISU.
C           LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                       INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                       VECTOR
C           NANG    - NUMBER OF PROJECTIONS
C           MODANG  - MODE FOR PROJECTION ANGLE INPUT
C           LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                       PROJECTION ANGLES IN RADIANS
C           LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                       SINE OF THE PROJECTION ANGLES
C           LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                       COSINE OF THE PROJECTION ANGLES
C           LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                       USER PROJECTION DATA AND UNCERTAINTIES
C           TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                       FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1),P(1)
C        BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/0.,0.,0.,1./
      DATA Z/.499999/
C
      IF (M.LE.0) GO TO 22
C
      IF (M.NE.1) GO TO 10
      CALL ZERO (B,NMAT)
C
   10 CONTINUE
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      HS=.5*S
      HC=.5*C
      ZN=.5*FLOAT(NDIM+1)
      ZX=RFAN-ZN*(C+S)
      ZY=ZN*(S-C)
      RFP=RFAN*PWID
      IJL=1
C
      IF (TFANF) GO TO 16
C
      DO 14 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 12 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      ARC=RFAN*ATAN(ZYY/ZXX)
      K=ARC+AXIS+.5
   12 B(IJ)=B(IJ)+P(K)*RFP/DH
   14 IJL=IJL+NN
      RETURN
C
   16 DO 20 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 18 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      YCENTR=ZYY/ZXX*RFAN
      K=YCENTR+AXIS+.5
   18 B(IJ)=B(IJ)+P(K)*RFP/ZXX
   20 IJL=IJL+NN
      RETURN
C
   22 DO 24 I=1,4
   24 B(I)=FLAGS(I)
      RETURN
      END
```

BPTF2

```
      SUBROUTINE BPTF2 (B,P,M)
C
C     ******************************************************************
C     *        RECLBL     --         VERSION 1.0     --        17OCT77 *
C     ******************************************************************
C
C          THE SUBROUTINE BPTF2 BACK-PROJECTS A SINGLE PROJECTION
C       ARRAY P INTO THE ARRAY B USING A FAN BEAM GEOMETRY.  THE PRO-
C       JECTION HAS THE ANGLE ANG(M) WHERE M IS THE INDEX OF THE ANGLE.
C       THE MODEL ASSUMES THAT EACH CELL IS REPRESENTED BY A DELTA
C       FUNCTION WITH ALL THE DENSITY AT THE CENTER OF THE CELL.  THE
C       ARRAY B IS ZEROED IF M=1.
C          THE SUBROUTINE BPTF2 USES A SPECIAL WEIGHTING SO THAT THE
C       BACK-PROJECTION FOR A FLAT DETECTOR GIVES A CONVOLUTION WITH
C       THE TRUE DENSITY AND SHOULD ONLY BE USED WITH THE FILTER OF THE
C       BACK-PROJECTION ALGORITHM (SUBROUTINE FILBK)
C
C         B        - THE BACK-PROJECTION ARRAY
C         P        - THE PROJECTION ARRAY
C         M        - THE ANGLE INDEX
C                  - IF M .LE. 0, ONLY A SET OF FLAGS IS RETURNED IN B
C                    NO BACK-PROJECTION OPERATION IS PERFORMED
C                    (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - ZERO
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                      COMMON
C         IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                      SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                      FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                      EXECUTING.
C         WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/FANCOM/RFAN,TFANC,TFANF
      LOGICAL TFANC,TFANF
C
C         RFAN     - FOR FAN BEAM GEOMETRY RFAN IS THE DISTANCE FROM
C                      THE SOURCE TO THE CENTER OF ROTATION.  RFAN
C                      IS MEASURED IN UNITS OF PROJECTION BIN WIDTHS AT
C                      THE CENTER OF ROTATION.
C         TFANC    - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                      CURVED DETECTOR
C         TFANF    - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                      FLAT DETECTOR
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C         NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C         NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C         PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C         TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C         NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C         LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                      NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                      THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C         KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                      IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C         IGEOM    - GEOMETRY FLAG
C                0 = PARALLEL BEAM GEOMETRY
C                1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                3 = RING DETECTOR GEOMETRY
C         KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                      BY THE USER
C         AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                      AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                      IN THE CENTER OF A PROJECTION BIN.)
C         BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                      ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                      ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C         KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE LAST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                      TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                      KDIM=KDIMU.
C         AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY, USUALLY AXIS=AXISU.
C         LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                      INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                      VECTOR
C         NANG     - NUMBER OF PROJECTIONS
C         MODANG   - MODE FOR PROJECTION ANGLE INPUT
C         LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                      PROJECTION ANGLES IN RADIANS
C         LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                      SINE OF THE PROJECTION ANGLES
C         LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                      COSINE OF THE PROJECTION ANGLES
C         LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                      USER PROJECTION DATA AND UNCERTAINTIES
C         TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                      FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1),P(1)
C        BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/0.,20.,0.,1./
      DATA Z/.499999/
C
      IF (M.LE.0) GO TO 22
C
      IF (M.NE.1) GO TO 10
      CALL ZERO (B,NMAT)
      ANGLE=1./RFAN
C
   10 CONTINUE
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      HS=.5*S
      HC=.5*C
      ZN=.5*FLOAT(NDIM+1)
      ZX=RFAN-ZN*(C+S)
      ZY=ZN*(S-C)
      IJL=1
C
      IF (TFANF) GO TO 16
C
      DO 14 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 12 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      ARC=RFAN*ATAN(ZYY/ZXX)
      K=ARC+AXIS+.5
   12 B(IJ)=B(IJ)+P(K)*PWID
   14 IJL=IJL+NN
      RETURN
C
   16 DO 20 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 18 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      YCENTR=ZYY/ZXX*RFAN
      K=YCENTR+AXIS+.5
   18 B(IJ)=B(IJ)+P(K)*PWID*DH/ZXX
   20 IJL=IJL+NN
      RETURN
C
   22 DO 24 I=1,4
   24 B(I)=FLAGS(I)
      RETURN
      END
```

BRF

```
      SUBROUTINE BRF (B,P,M)
C
C     ******************************************************************
C     *        RECLBL     --         VERSION 1.0     --        17OCT77 *
C     ******************************************************************
C
C          THE SUBROUTINE BRF BACK-PROJECTS A SINGLE PROJECTION
C       ARRAY P INTO THE ARRAY B.  THE PROJECTION HAS THE ANGLE ANG(M)
C       WHERE M IS THE INDEX OF THE ANGLE.  THE PROJECTION BINS AND THE
C       BACK-PROJECTION CELLS MUST BE THE SAME SIZE.  THE MODEL ASSUMES
C       A UNIFORM DENSITY FOR EACH CELL SUCH THAT THE VALUE GIVEN EACH
C       CELL IS WEIGHTED ACCORDING TO THE FRACTION EACH CELL INTERSECTS
C       A PROJECTION RAY.  THE RAY FACTORS ARE STORED IN A LOOK-UP
C       TABLE SUCH THAT EACH CELL-RAY INTERSECTION IS EQUAL TO ONE OF
C       20 VALUES WHICH DEPENDS ON WHERE THE CENTER OF THE CELL FALLS
C       WITH RESPECT TO THE 20 EQUAL INTERVALS THAT DIVIDE EACH RAY.
C       THE ARRAY B IS ZEROED IF M=1.
C
C
C         B        - THE BACK-PROJECTION ARRAY
C         P        - THE PROJECTION ARRAY
C         M        - THE ANGLE INDEX
C                  - IF M .LE. 0, ONLY A SET OF FLAGS IS RETURNED IN B
C                    NO BACK-PROJECTION OPERATION IS PERFORMED
C                    (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - ZERO
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                      COMMON
C         IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                      SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                      FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                      EXECUTING.
C         WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C         NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C         NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C         PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C         TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
```

```
C         NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C         LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                     NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                     THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C         KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                     IS AN INTEGER VARIABLE
C
      COMMON/RAYCOM/NLEV,LMRFAC,KMRFAC,LRFAC
      DIMENSION MRFAC(1),RFAC(1)
      EQUIVALENCE(WORK(1),MRFAC(1),RFAC(1))
C
C         NLEV    - NUMBER OF FRACTION LEVELS
C         LMRFAC  - POINTER TO THE ARRAY MRFAC IN BLANK COMMON
C                     MRFAC(MANGLE) POINTS TO THE LOCATION IN BLANK
C                     COMMON WHERE RFAC(MRFAC(MANGLE)) IS STORED.
C                     RFAC(MRFAC(MANGLE)) IS THE FRACTION OF THE CELL
C                     WITHIN THE RAY WHEN THE CENTER OF THE CELL IS IN
C                     THE CENTER OF THE RAY AT THE ANGLE MANGLE.
C         KMRFAC  - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE MRFAC
C                     IS AN INTEGER VARIABLE
C         LRFAC   - POINTER TO THE ARRAY RFAC IN BLANK COMMON
C                     FRACTIONAL AREAS OF A CELL WHICH INTERSECT
C                     A RAY AND THIS FRACTION IS MEASURED AS A FUNCTION
C                     OF THE DISTANCE THE CENTER OF THE CELL IS FROM
C                     THE CENTER OF THE RAY.  THE TOTAL DIMENSION OF
C                     THE ARRAY RFAC IS NRFAC=LL*EQANG, WHERE
C                                3*NLEV+2  IF NLEV IS EVEN
C                          LL =
C                                3*NLEV+1  IF NLEV IS ODD
C                     AND EQANG IS THE SIZE OF THE SET OF ANGLES FORMED
C                     FROM THE SET OF TOTAL ANGLES WITH MOD OPERATION
C                     OF PHI/2 THEN REFLECTION ABOUT PHI/4.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C         IGEOM   - GEOMETRY FLAG
C               0 = PARALLEL BEAM GEOMETRY
C               1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C               2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C               3 = RING DETECTOR GEOMETRY
C         KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                     BY THE USER
C         AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                     PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                     AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                     IN THE CENTER OF A PROJECTION BIN.)
C         BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                     ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                     ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C         KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                     THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                     IS GOING TO BE USED.
C         KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                     THE DATA OF THE LAST USER PROJECTION BIN THAT
C                     IS GOING TO BE USED.
C         KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                     TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                     KDIM=KDIMU.
C         AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                     PROJECTION ARRAY, USUALLY AXIS=AXISU.
C         LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                     INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                     VECTOR
C         NANG    - NUMBER OF PROJECTIONS
C         MODANG  - MODE FOR PROJECTION ANGLE INPUT
C         LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                     PROJECTION ANGLES IN RADIANS
C         LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                     SINE OF THE PROJECTION ANGLES
C         LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                     COSINE OF THE PROJECTION ANGLES
C         LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                     USER PROJECTION DATA AND UNCERTAINTIES
C         TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                     FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1),P(1)
C        BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/0.,2.,0.,0./
C
      IF (M.LE.0) GO TO 14
C
      IF (M.EQ.1) CALL ZERO (B,NMAT)
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)
      ISUB=LMRFAC+M-1
      ZL=FLOAT(LRFAC+MRFAC(ISUB))+.5*FLOAT(NLEV+1)
      HS=.5*S
      ZN=.5*FLOAT(NDIM+1)
      ZZ=ZN*(S-C)+AXIS+.5
      IJL=1
      DO 12 J=1,NDIM
      ZZ=ZZ+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 10 IJ=IJL,IJU
      Z=Z-S
      K=Z
      L=ZL-FLOAT(NLEV)*(Z-FLOAT(K))
      LP=L+NLEV
      LM=L-NLEV
   10 B(IJ)=B(IJ)+RFAC(LP)*P(K+1)+RFAC(L)*P(K)+RFAC(LM)*P(K-1)
   12 IJL=IJL+NN
      RETURN
C
   14 DO 16 I=1,4
   16 B(I)=FLAGS(I)
      IF (LRFAC.LT.0) CALL RAYST
      RETURN
      END
```

BRFA

```
      SUBROUTINE BRFA (B,P,M)
C
C     ****************************************************************
C     *       RECLBL     --        VERSION 1.0     --       17OCT77   *
C     ****************************************************************
C
C          THE SUBROUTINE BRFA BACK-PROJECTS A SINGLE PROJECTION
C       ARRAY P INTO THE ARRAY B.  THE PROJECTION HAS THE ANGLE ANG(M)
C       WHERE M IS THE INDEX OF THE ANGLE.  THE PROJECTION BINS AND THE
C       BACK-PROJECTION CELLS MUST BE THE SAME SIZE.  THE MODEL ASSUMES
C       A UNIFORM DENSITY FOR EACH CELL SUCH THAT THE VALUE GIVEN EACH
C       CELL IS WEIGHTED BY AN ATTENUATION FACTOR AND THE FRACTION
C       EACH RAY INTERSECTS EACH CELL.  THE RAY FACTORS ARE STORED IN
C       A LOOK-UP TABLE SUCH THAT EACH CELL-RAY INTERSECTION IS EQUAL
C       TO ONE OF 20 VALUES WHICH DEPENDS ON WHERE THE CENTER OF THE
C       CELL FALLS WITH RESPECT TO THE 20 EQUAL INTERVALS THAT DIVIDE
C       EACH RAY.  THE ARRAY B IS ZEROED IF M=1.
C
C         B       - THE BACK-PROJECTION ARRAY
C         P       - THE PROJECTION ARRAY
C         M       - THE ANGLE INDEX
C                 - IF M .LE. 0, ONLY A SET OF FLAGS IS RETURNED IN B
C                   NO BACK-PROJECTION OPERATION IS PERFORMED
C                   (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - FTATN, ZERO
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                     COMMON
C         IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                     SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                     FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                     EXECUTING.
C         WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/ATNCOM/LATEN,LBMAP,TATEN,LUNATN
      LOGICAL TATEN
      DIMENSION ATEN(1),BMAP(1)
      EQUIVALENCE (WORK(1),ATEN(1),BMAP(1))
C
C         LATEN   - POINTER TO THE ARRAY ATEN IN BLANK COMMON
C                     STORES ATTENUATION FACTORS FOR ONE ANGLE
C         LBMAP   - POINTER TO THE ARRAY BMAP IN BLANK COMMON
C                     A MATRIX USED TO STORE THE CONSTANT ATTENUATION
C                     COEFFICIENTS
C         TATEN   - LOGICAL VARIABLE SET TRUE FOR ATTENUATION
C                     RECONSTRUCTION
C         LUNATN  - LOGICAL UNIT NUMBER FOR ATTENUATION FACTOR STORAGE
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C         NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C         NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C         PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C         TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C         NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C         LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                     NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                     THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C         KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                     IS AN INTEGER VARIABLE
C
      COMMON/RAYCOM/NLEV,LMRFAC,KMRFAC,LRFAC
      DIMENSION MRFAC(1),RFAC(1)
      EQUIVALENCE(WORK(1),MRFAC(1),RFAC(1))
C
C         NLEV    - NUMBER OF FRACTION LEVELS
C         LMRFAC  - POINTER TO THE ARRAY MRFAC IN BLANK COMMON
C                     MRFAC(MANGLE) POINTS TO THE LOCATION IN BLANK
C                     COMMON WHERE RFAC(MRFAC(MANGLE)) IS STORED.
C                     RFAC(MRFAC(MANGLE)) IS THE FRACTION OF THE CELL
C                     WITHIN THE RAY WHEN THE CENTER OF THE CELL IS IN
C                     THE CENTER OF THE RAY AT THE ANGLE MANGLE.
C         KMRFAC  - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE MRFAC
C                     IS AN INTEGER VARIABLE
C         LRFAC   - POINTER TO THE ARRAY RFAC IN BLANK COMMON
C                     FRACTIONAL AREAS OF A CELL WHICH INTERSECT
C                     A RAY AND THIS FRACTION IS MEASURED AS A FUNCTION
C                     OF THE DISTANCE THE CENTER OF THE CELL IS FROM
C                     THE CENTER OF THE RAY.  THE TOTAL DIMENSION OF
C                     THE ARRAY RFAC IS NRFAC=LL*EQANG, WHERE
C                                3*NLEV+2  IF NLEV IS EVEN
C                          LL =
C                                3*NLEV+1  IF NLEV IS ODD
C                     AND EQANG IS THE SIZE OF THE SET OF ANGLES FORMED
C                     FROM THE SET OF TOTAL ANGLES WITH MOD OPERATION
C                     OF PHI/2 THEN REFLECTION ABOUT PHI/4.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C         IGEOM   - GEOMETRY FLAG
C               0 = PARALLEL BEAM GEOMETRY
C               1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C               2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C               3 = RING DETECTOR GEOMETRY
C         KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                     BY THE USER
C         AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                     PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                     AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                     IN THE CENTER OF A PROJECTION BIN.)
C         BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                     ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                     ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
```

```
C          KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C          KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE LAST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C          KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                      TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                      KDIM=KDIMU.
C          AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                      INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                      VECTOR
C          NANG    - NUMBER OF PROJECTIONS
C          MODANG  - MODE FOR PROJECTION ANGLE INPUT
C          LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                      PROJECTION ANGLES IN RADIANS
C          LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                      SINE OF THE PROJECTION ANGLES
C          LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                      COSINE OF THE PROJECTION ANGLES
C          LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                      USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                      FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1),P(1)
C        BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/0.,2.,1.,0./
C
      IF (M.LE.0) GO TO 14
C
      IF (M.EQ.1) CALL ZERO (B,NMAT)
      CALL FTATN (M,ATEN(LATEN),NMAT)
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)
      ISUB=LMRFAC+M-1
      ZL=FLOAT(LRFAC+MRFAC(ISUB))+.5*FLOAT(NLEV+1)
      HS=.5*S
      ZN=.5*FLOAT(NDIM+1)
      ZZ=ZN*(S-C)+AXIS+.5
      IJL=1
      DO 12 J=1,NDIM
      ZZ=ZZ+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 10 IJ=IJL,IJU
      Z=Z-S
      K=Z
      L=ZL-FLOAT(NLEV)*(Z-FLOAT(K))
      LP=L+NLEV
      LM=L-NLEV
      ISUB=LATEN+IJ-1
   10 B(IJ)=B(IJ)+ATEN(ISUB)*(RFAC(LP)*P(K+1)+RFAC(L)*P(K)+RFAC(LM)*P(K-
     11))
   12 IJL=IJL+NN
      RETURN
C
   14 DO 16 I=1,4
   16 B(I)=FLAGS(I)
      IF (LRFAC.LT.0) CALL RAYST
      RETURN
      END
```

BRFF

```
      SUBROUTINE BRFF (B,P,M)
C
C     ******************************************************************
C     *       RECLBL     --         VERSION 1.0     --        17OCT77   *
C     ******************************************************************
C
C           THE SUBROUTINE BRFF BACK-PROJECTS A SINGLE PROJECTION
C       ARRAY P INTO THE ARRAY B FOR A FAN BEAM GEOMETRY.  THE PROJECT-
C       ION HAS THE ANGLE ANG(M) WHERE M IS THE INDEX OF THE ANGLE.
C       THE MODEL ASSUMES A UNIFORM DENSITY FOR EACH CELL SUCH THAT
C       THE VALUE GIVEN EACH CELL IS WEIGHTED ACCORDING TO THE FRACTION
C       EACH CELL INTERSECTS A FAN BEAM RAY.  THE ARRAY B IS ZEROED
C       IF M=1.
C
C          B       - THE BACK-PROJECTION ARRAY
C          P       - THE PROJECTION ARRAY
C          M       - THE ANGLE INDEX
C                  - IF M .LE. 0, ONLY A SET OF FLAGS IS RETURNED IN B
C                      NO BACK-PROJECTION OPERATION IS PERFORMED
C                      (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - SQINT, ZERO
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                      COMMON
C          IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                      SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                      FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                      EXECUTING.
C          WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/FANCOM/RFAN,TFANC,TFANF
      LOGICAL TFANC,TFANF
C
C          RFAN    - FOR FAN BEAM GEOMETRY RFAN IS THE DISTANCE FROM
C                      THE SOURCE TO THE CENTER OF ROTATION.  RFAN
C                      IS MEASURED IN UNITS OF PROJECTION BIN WIDTHS AT
C                      THE CENTER OF ROTATION.
C          TFANC   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                      CURVED DETECTOR
C          TFANF   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                      FLAT DETECTOR
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                      NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                      THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                      IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C          IGEOM   - GEOMETRY FLAG
C                0 = PARALLEL BEAM GEOMETRY
C                1 = FAN BEAM GEOMETRY   (CURVED DETECTOR)
C                2 = FAN BEAM GEOMETRY   (FLAT DETECTOR)
C                3 = RING DETECTOR GEOMETRY
C          KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                      BY THE USER
C          AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                      AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                      IN THE CENTER OF A PROJECTION BIN.)
C          BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C          KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                      ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                      ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C          KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C          KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE LAST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C          KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                      TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                      KDIM=KDIMU.
C          AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                      INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                      VECTOR
C          NANG    - NUMBER OF PROJECTIONS
C          MODANG  - MODE FOR PROJECTION ANGLE INPUT
C          LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                      PROJECTION ANGLES IN RADIANS
C          LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                      SINE OF THE PROJECTION ANGLES
C          LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                      COSINE OF THE PROJECTION ANGLES
C          LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                      USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                      FALSE FOR TRANSMISSION DATA
C
C
C       ***THESE VARIABLES ARE USED IN THIS SUBROUTINE
C
C            DH      - THE DISTANCE BETWEEN THE SOURCE AND THE PIXEL
C            ARC     - THE ARC DISTANCE BETWEEN THE CENTER AXIS AND THE
C                        IMAGE OF THE PIXEL
C            BETAU   - THE ANGLE BETWEEN THE CENTER AXIS AND THE LINE
C                        PASSING ABOVE THE PIXEL
C            BETAL   - THE ANGLE BETWEEN THE CENTER AXIS AND THE LINE
C                        PASSING BELOW THE PIXEL
C            BETAP   - THE ANGLE BETWEEN THE CENTER AXIS AND LINE
C                        PASSING THROUGH THE PIXEL
C            THETAU  - THE ANGLE BETWEEN THE LINE PASSING THROUGH THE
C                        PIXEL AND A LINE ABOVE
C            THETAL  - THE ANGLE BETWEEN THE LINE PASSING THROUGH THE
C                        PIXEL AND A LINE BELOW
C            DU      - THE PERPENDICULAR DISTANCE BETWEEN THE PIXEL AND
C                        A LINE ABOVE
C            DL      - THE PERPENDICULAR DISTANCE BETWEEN THE PIXEL AND
C                        A LINE BELOW
C            ALPHAU  - THE ANGLE THE LINE ABOVE THE PIXEL MAKES WITH
C                        THE SIDE OF THE SQUARE
C            ALPHAL  - THE ANGLE THE LINE BELOW THE PIXEL MAKES WITH
C                        THE SIDE OF THE SQUARE
C            ANGLE   - THE ANGLE BETWEEN THE RAYS IN THE FAN BEAM
C
      DIMENSION B(1),P(1)
C        BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/0.,2.,0.,1./
      DATA Z/.499999/
C
      IF (M.LE.0) GO TO 34
C
      IF (M.NE.1) GO TO 10
      CALL ZERO (B,NMAT)
      ANGLE=1./RFAN
C
   10 CONTINUE
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      HS=.5*S
      HC=.5*C
      ZN=.5*FLOAT(NDIM+1)
      ZX=RFAN-ZN*(C+S)
      ZY=ZN*(S-C)
      RFP=RFAN*PWID
      IJL=1
C
      IF (TFANF) GO TO 22
C
      DO 20 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 18 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
```

```
      DH=SQRT(ZXX**2+ZYY**2)
      ARCTAN=ATAN(ZYY/ZXX)
      ARC=RFAN*ARCTAN
      K=ARC+AXIS+.5
      BETAU=(FLOAT(K)-AXIS+.5)*ANGLE
      BETAL=BETAU-ANGLE
      BETAP=ARCTAN
      THETAU=BETAU-BETAP
      THETAL=BETAP-BETAL
      DU=DH*BWID*THETAU
      DL=DH*BWID*THETAL
      ISUB=LANG+M-1
      ALPHAU=BETAU+ANG(ISUB)
      AREA1=SQINT(DU,ALPHAU)
      ALPHAL=BETAL+ANG(ISUB)
      AREA2=SQINT(DL,ALPHAL)
      AREA=AREA1+AREA2
      MK=K
      MK1=MK
      MK2=MK
      B(IJ)=B(IJ)+AREA*P(MK)*RFP/DH
      AREAX=AREA1
      AREAY=AREA2
      IF (AREA1.GT.Z) GO TO 14
   12 MK2=MK2+1
      THETAU=THETAU+ANGLE
      DU=DH*BWID*THETAU
      ALPHAU=ALPHAU+ANGLE
      AREAU1=SQINT(DU,ALPHAU)
      AREAU=AREAU1-AREAX
      AREAX=AREAU1
      B(IJ)=B(IJ)+AREAU*P(MK2)*RFP/DH
      IF (AREAU1.LE.Z) GO TO 12
   14 IF (AREA2.GT.Z) GO TO 18
   16 MK1=MK1-1
      THETAL=THETAL+ANGLE
      DL=DH*BWID*THETAL
      ALPHAL=ALPHAL+ANGLE
      AREAL1=SQINT(DL,ALPHAL)
      AREAL=AREAL1-AREAY
      AREAY=AREAL1
      B(IJ)=B(IJ)+AREAL*P(MK1)*RFP/DH
      IF (AREAL1.LE.Z) GO TO 16
   18 CONTINUE
   20 IJL=IJL+NN
      RETURN
C
   22 DO 32 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 30 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      ARCTAN=ATAN(ZYY/ZXX)
      YCENTR=ZYY/ZXX*RFAN
      K=YCENTR+AXIS+.5
      BETAU=ATAN((FLOAT(K)-AXIS+.5)/RFAN)
      BETAL=ATAN((FLOAT(K-1)-AXIS+.5)/RFAN)
      BETAP=ARCTAN
      THETAU=BETAU-BETAP
      THETAL=BETAP-BETAL
      DU=DH*BWID*THETAU
      DL=DH*BWID*THETAL
      ISUB=LANG+M-1
      ALPHAU=BETAU+ANG(ISUB)
      AREA1=SQINT(DU,ALPHAU)
      ALPHAL=BETAL+ANG(ISUB)
      AREA2=SQINT(DL,ALPHAL)
      AREA=AREA1+AREA2
      MK=K
      MK1=MK
      MK2=MK
      B(IJ)=B(IJ)+AREA*P(MK)*RFP/ZXX
      AREAX=AREA1
      AREAY=AREA2
      IF (AREA1.GT.Z) GO TO 26
   24 MK2=MK2+1
      ANGLE=ATAN(RFAN/(RFAN**2+(FLOAT(MK2)-AXIS)**2-.25))
      THETAU=THETAU+ANGLE
      DU=DH*BWID*THETAU
      ALPHAU=ALPHAU+ANGLE
      AREAU1=SQINT(DU,ALPHAU)
      AREAU=AREAU1-AREAX
      AREAX=AREAU1
      B(IJ)=B(IJ)+AREAU*P(MK2)*RFP/ZXX
      IF (AREAU1.LE.Z) GO TO 24
   26 IF (AREA2.GT.Z) GO TO 30
   28 MK1=MK1-1
      ANGLE=ATAN(RFAN/(RFAN**2+(FLOAT(MK1)-AXIS)**2-.25))
      THETAL=THETAL+ANGLE
      DL=DH*BWID*THETAL
      ALPHAL=ALPHAL+ANGLE
      AREAL1=SQINT(DL,ALPHAL)
      AREAL=AREAL1-AREAY
      AREAY=AREAL1
      B(IJ)=B(IJ)+AREAL*P(MK1)*RFP/ZXX
      IF (AREAL1.LE.Z) GO TO 28
   30 CONTINUE
   32 IJL=IJL+NN
C
      RETURN
C
   34 DO 36 I=1,4
   36 B(I)=FLAGS(I)
      RETURN
      END
```

BRFF2

```
      SUBROUTINE BRFF2 (B,P,M)
C
C     ****************************************************************
C     *      RECLBL    --         VERSION 1.0    --        17OCT77     *
C     ****************************************************************
C
C          THE SUBROUTINE BRFF2 BACK-PROJECTS A SINGLE PROJECTION
C       ARRAY P INTO THE ARRAY B FOR A FAN BEAM GEOMETRY.  THE PROJECT-
C       ION HAS THE ANGLE ANG(M) WHERE M IS THE INDEX OF THE ANGLE.
C       THE MODEL ASSUMES A UNIFORM DENSITY FOR EACH CELL SUCH THAT
C       THE VALUE GIVEN EACH CELL IS WEIGHTED ACCORDING TO THE FRACTION
C       EACH CELL INTERSECTS A FAN BEAM RAY.  THE ARRAY B IS ZEROED
C       IF M=1.
C          THE SUBROUTINE BRFF2 USES A SPECIAL WEIGHTING SO THAT THE
C       BACK-PROJECTION FOR A FLAT DETECTOR GIVES A CONVOLUTION WITH
C       THE TRUE DENSITY AND SHOULD ONLY BE USED WITH THE FILTER OF THE
C       BACK-PROJECTION ALGORITHM (SUBROUTINE FILBK).
C
C         B        - THE BACK-PROJECTION ARRAY
C         P        - THE PROJECTION ARRAY
C         M        - THE ANGLE INDEX
C                  - IF M .LE. 0, ONLY A SET OF FLAGS IS RETURNED IN B
C                    NO BACK-PROJECTION OPERATION IS PERFORMED
C                    (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - SQINT, ZERO
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                      COMMON
C          IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                      SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                      FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                      EXECUTING.
C          WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/FANCOM/RFAN,TFANC,TFANF
      LOGICAL TFANC,TFANF
C
C          RFAN    - FOR FAN BEAM GEOMETRY RFAN IS THE DISTANCE FROM
C                      THE SOURCE TO THE CENTER OF ROTATION.  RFAN
C                      IS MEASURED IN UNITS OF PROJECTION BIN WIDTHS AT
C                      THE CENTER OF ROTATION.
C          TFANC   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                      CURVED DETECTOR
C          TFANF   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                      FLAT DETECTOR
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                      NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                      THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                      IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C          IGEOM   - GEOMETRY FLAG
C                0 = PARALLEL BEAM GEOMETRY
C                1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                3 = RING DETECTOR GEOMETRY
C          KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                      BY THE USER
C          AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                      AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                      IN THE CENTER OF A PROJECTION BIN.)
C          BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C          KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                      ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                      ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C          KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C          KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE LAST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C          KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                      TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                      KDIM=KDIMU.
C          AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                      INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                      VECTOR
C          NANG    - NUMBER OF PROJECTIONS
C          MODANG  - MODE FOR PROJECTION ANGLE INPUT
C          LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                      PROJECTION ANGLES IN RADIANS
C          LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                      SINE OF THE PROJECTION ANGLES
C          LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                      COSINE OF THE PROJECTION ANGLES
C          LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                      USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                      FALSE FOR TRANSMISSION DATA
C
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C
C        ***THESE VARIABLES ARE USED IN THIS SUBROUTINE
C
C             DH     - THE DISTANCE BETWEEN THE SOURCE AND THE PIXEL
C             ARC    - THE ARC DISTANCE BETWEEN THE CENTER AXIS AND THE
C                         IMAGE OF THE PIXEL
C             BETAU  - THE ANGLE BETWEEN THE CENTER AXIS AND THE LINE
C                         PASSING ABOVE THE PIXEL
C             BETAL  - THE ANGLE BETWEEN THE CENTER AXIS AND THE LINE
C                         PASSING BELOW THE PIXEL
C             BETAP  - THE ANGLE BETWEEN THE CENTER AXIS AND LINE
C                         PASSING THROUGH THE PIXEL
C             THETAU - THE ANGLE BETWEEN THE LINE PASSING THROUGH THE
C                         PIXEL AND A LINE ABOVE
C             THETAL - THE ANGLE BETWEEN THE LINE PASSING THROUGH THE
C                         PIXEL AND A LINE BELOW
C             DU     - THE PERPENDICULAR DISTANCE BETWEEN THE PIXEL AND
C                         A LINE ABOVE
C             DL     - THE PERPENDICULAR DISTANCE BETWEEN THE PIXEL AND
C                         A LINE BELOW
C             ALPHAU - THE ANGLE THE LINE ABOVE THE PIXEL MAKES WITH
C                         THE SIDE OF THE SQUARE
C             ALPHAL - THE ANGLE THE LINE BELOW THE PIXEL MAKES WITH
C                         THE SIDE OF THE SQUARE
C             ANGLE  - THE ANGLE BETWEEN THE RAYS IN THE FAN BEAM
C
      DIMENSION B(1),P(1)
C        BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/0.,22.,0.,1./
      DATA Z/.499999/
C
      IF (M.LE.0) GO TO 34
C
      IF (M.NE.1) GO TO 10
      CALL ZERO (B,NMAT)
      ANGLE=1./RFAN
C
   10 CONTINUE
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      HS=.5*S
      HC=.5*C
      ZN=.5*FLOAT(NDIM+1)
      ZX=RFAN-ZN*(C+S)
      ZY=ZN*(S-C)
      IJL=1
C
      IF (TFANF) GO TO 22
C
      DO 20 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 18 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      ARCTAN=ATAN(ZYY/ZXX)
      ARC=RFAN*ARCTAN
      K=ARC+AXIS+.5
      IF (K.LT.1.OR.K.GT.KDIM) GO TO 18
      BETAU=(FLOAT(K)-AXIS+.5)*ANGLE
      BETAL=BETAU-ANGLE
      BETAP=ARCTAN
      THETAU=BETAU-BETAP
      THETAL=BETAP-BETAL
      DU=DH*BWID*THETAU
      DL=DH*BWID*THETAL
      ISUB=LANG+M-1
      ALPHAU=BETAU+ANG(ISUB)
      AREA1=SQINT(DU,ALPHAU)
      ALPHAL=BETAL+ANG(ISUB)
      AREA2=SQINT(DL,ALPHAL)
      AREA=AREA1+AREA2
      MK=K
      MK1=MK
      MK2=MK
      B(IJ)=B(IJ)+AREA*P(MK)*PWID
      AREAX=AREA1
      AREAY=AREA2
      IF (AREA1.GT.Z) GO TO 14
   12 MK2=MK2+1
      IF (MK2.GT.KDIM) GO TO 18
      THETAU=THETAU+ANGLE
      DU=DH*BWID*THETAU
      ALPHAU=ALPHAU+ANGLE
      AREAU1=SQINT(DU,ALPHAU)
      AREAU=AREAU1-AREAX
      AREAX=AREAU1
      B(IJ)=B(IJ)+AREAU*P(MK2)*PWID
      IF (AREAU1.LE.Z) GO TO 12
   14 IF (AREA2.GT.Z) GO TO 18
   16 MK1=MK1-1
      IF (MK1.LT.1) GO TO 18
      THETAL=THETAL+ANGLE
      DL=DH*BWID*THETAL
      ALPHAL=ALPHAL+ANGLE
      AREAL1=SQINT(DL,ALPHAL)
      AREAL=AREAL1-AREAY
      AREAY=AREAL1
      B(IJ)=B(IJ)+AREAL*P(MK1)*PWID
      IF (AREAL1.LE.Z) GO TO 16
   18 CONTINUE
   20 IJL=IJL+NN
      RETURN
C
   22 DO 32 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 30 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      ARCTAN=ATAN(ZYY/ZXX)
      YCENTR=ZYY/ZXX*RFAN
      K=YCENTR+AXIS+.5
      IF (K.LT.1.OR.K.GT.KDIM) GO TO 30
      BETAU=ATAN((FLOAT(K)-AXIS+.5)/RFAN)
      BETAL=ATAN((FLOAT(K-1)-AXIS+.5)/RFAN)
      BETAP=ARCTAN
      THETAU=BETAU-BETAP
      THETAL=BETAP-BETAL
      DU=DH*BWID*THETAU
      DL=DH*BWID*THETAL
      ISUB=LANG+M-1
      ALPHAU=BETAU+ANG(ISUB)
      AREA1=SQINT(DU,ALPHAU)
      ALPHAL=BETAL+ANG(ISUB)
      AREA2=SQINT(DL,ALPHAL)
      AREA=AREA1+AREA2
      MK=K
      MK1=MK
      MK2=MK
      B(IJ)=B(IJ)+AREA*P(MK)*PWID*DH/ZXX
      AREAX=AREA1
      AREAY=AREA2
      IF (AREA1.GT.Z) GO TO 26
   24 MK2=MK2+1
      IF (MK2.GT.KDIM) GO TO 30
      ANGLE=ATAN(RFAN/(RFAN**2+(FLOAT(MK2)-AXIS)**2-.25))
      THETAU=THETAU+ANGLE
      DU=DH*BWID*THETAU
      ALPHAU=ALPHAU+ANGLE
      AREAU1=SQINT(DU,ALPHAU)
      AREAU=AREAU1-AREAX
      AREAX=AREAU1
      B(IJ)=B(IJ)+AREAU*P(MK2)*PWID*DH/ZXX
      IF (AREAU1.LE.Z) GO TO 24
   26 IF (AREA2.GT.Z) GO TO 30
   28 MK1=MK1-1
      IF (MK1.LT.1) GO TO 30
      ANGLE=ATAN(RFAN/(RFAN**2+(FLOAT(MK1)-AXIS)**2-.25))
      THETAL=THETAL+ANGLE
      DL=DH*BWID*THETAL
      ALPHAL=ALPHAL+ANGLE
      AREAL1=SQINT(DL,ALPHAL)
      AREAL=AREAL1-AREAY
      AREAY=AREAL1
      B(IJ)=B(IJ)+AREAL*P(MK1)*PWID*DH/ZXX
      IF (AREAL1.LE.Z) GO TO 28
   30 CONTINUE
   32 IJL=IJL+NN
C
      RETURN
C
   34 DO 36 I=1,4
   36 B(I)=FLAGS(I)
      RETURN
      END
```

BUTER

```
      SUBROUTINE BUTER (BUT,XI,M)
C
C     ******************************************************************
C     *        RECLBL      --          VERSION 1.0     --        17OCT77   *
C     ******************************************************************
C
C             THE SUBROUTINE BUTER EVALUATES AT THE POINT XI THE VALUE
C        OF THE FILTER OBTAINED BY MULTIPLYING THE MAGNITUDE OF THE
C        BUTTERWORTH FILTER BY THE ABSOLUTE VALUE OF THE MEASURE,
C        ABS(XI).
C
C          BUT      - THE FUNCTIONAL VALUE
C          XI       - THE INDEPENDENT VARIABLE
C          M        - HAS THE FOLLOWING VALUES
C                      .LE. 0 THE FLAGS ARE RETURNED IN BUT
C                      .GT. 0 THE FUNCTIONAL VALUE IS RETURNED IN BUT
C
C        THE FILTER PARAMETERS ORDER AND FREQ ARE PASSED IN THE COMMON
C        BLOCK FILCOM.
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                         COMMON
C          IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                         SUBROUTINES WHICH REQUIPE THAT SETUP IS CALLED
C                         FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                         EXECUTING.
C          WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/FILCOM/ORDER,FREQ,LBCKA,LPRJA,LFILT
      DIMENSION BCKA(1),PRJA(1),FILT(1)
      EQUIVALENCE (WORK(1),BCKA(1),PRJA(1),FILT(1))
C
C          ORDER    - FILTER PARAMETER USED ONLY BY THE FILTER BUTER
C          FREQ     - FILTER PARAMETER
C          LBCKA    - POINTER TO THE ARPAY BCKA IN BLANK COMMON
C                         BACK-PROJECTION ARRAY WHICH HAS THE DIMENSION
C                         NDIM X NDIM
C          LPRJA    - POINTER TO THE ARRAY PRJA IN BLANK COMMON
C                         A PROJECTION ARRAY FOR ONE ANGLE
C          LFILT    - POINTER TO THE ARRAY FILT IN BLANK COMMON
C                         ARRAY OF FILTER VALUES
C
      DIMENSION BUT(1)
C
C        BCK/PRJ/CNV/2OF,WT,ATEN,FAN ARE THE J FLAGS RETURNED IN BUT
C          IF M .LE. 0
C
      DIMENSION FLAGS(4)
      DATA FLAGS/3.,-1.,0.,-1./
C
      IF (M.LE.0) GO TO 10
C
      BUT(1)=SQRT(1./(1.+(XI/FREQ)**ORDER))*XI
C
      RETURN
C
   10 DO 12 I=1,4
   12 BUT(I)=FLAGS(I)
C
      RETURN
      END
```

CBARP

```
      SUBROUTINE CBARP (B1,N,R,X1,Y1,Z,INTFAC,NBAR,NREPS,IDIREC)
C
C     ****************************************************************
C     *      RECLBL     --        VERSION 1.0     --        17OCT77     *
C     ****************************************************************
C
C          THE SUBROUTINE CBARP  GIVES  A CIRCULAR BAR PHANTOM.
C       THE PHANTOM CONSISTS OF NREP REPETITIONS OF A BAR PATTERN.
C       THE PATTERN CONTAINS NBAR BARS.  THE WIDTH OF THE LAST BAR IS
C       1/2 THE WIDTH OF THE SECOND LAST BAR, 1/3 THE WIDTH OF THE
C       THIRD LAST BAR AND 1/NBAR THE WIDTH OF THE FIRST BAR.
C
C         B1       - ARRAY WHERE PHANTOM IS GENERATED
C         N        - DIMENSION OF THE SQUARE ARRAY B1
C         R        - RADIUS OF CIRCLE PHANTOM
C         X1,Y1    - CENTER OF CIRCLE RELATIVE TO THE CENTER
C                      OF ARRAY
C         Z        - FULL VALUE OF FUNCTION
C         INTFAC   - INTEGRATION FACTOR.  EACH BORDER PIXEL IS DIVIDED
C                      INTO INTFAC**2 PIXELETTES FOR INTEGRATION
C         NBAR     - NO. OF BARS PER PATTERN REPETITION IN PHANTOM
C         NREPS    - NO. OF REPETITIONS OF THE BAR PATTERN
C                      NBAR*NREPS MUST BE LESS THAN OR EQUAL TO 100
C         IDIREC   - PARAMETER TELLING DIRECTION OF BARS
C               0 - HORIZONTAL
C               1 - VERTICAL
C               2 - CIRCULAR(CONCENTRIC)
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - EMESG, LGTXT, MEMST,
C         ZERO
C
C       LANGUAGE - FORTRAN
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C         LUNOUT   - LOGICAL UNIT NUMBER FOR OUTPUT
C         I80132   - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                      OUTPUT ON LUNOUT
C               0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      DIMENSION B1(N,N),WURK(100)
      DIMENSION NAMER(9)
      DATA NAMER/1HE,1HN,1HD,1H ,1HC,1HB,1HA,1HR,1HP/
      DATA IOK/2HOK/
C
      CALL LGTXT (NAMER(5),5)
      CALL ZERO (B1,N)
      NWURK=NREPS*NBAR
      IF (NWURK.LE.100) GO TO 10
      WRITE (LUNOUT,62) NWURK
      CALL EMESG (4,NAMER(5),1)
   10 CONTINUE
C
      CONST=Z/FLOAT(INTFAC*INTFAC)
C
      HALFN=FLOAT(N+1)/2.
C        BARS ARE OF WIDTH W-(N-1)*D WHERE N IS THE NUMBER OF THE BAR
C
      D=4.*R/FLOAT(NBAR*(NBAR+1)*NREPS)
      ACCUM=-R
      IF (IDIREC.NE.2) GO TO 12
      D=.5*D
      ACCUM=0.
   12 W=D*FLOAT(NBAR)
C
C        *SET UP TABLE OF BOUNDARY VALUES FOR EACH BAR
C
      DO 16 J=1,NREPS
      DO 14 I=1,NBAR
      ACCUM=ACCUM+W-FLOAT(I-1)*D
      I1=I+(J-1)*NBAR
      WURK(I1)=ACCUM
   14 CONTINUE
   16 CONTINUE
      DO 60 I=1,N
      RI=FLOAT(I)-HALFN
      DO 60 J=1,N
      RJ=FLOAT(J)-HALFN
      ACCUM=0.
      SIGN1=.5
      SIGN2=.5
      IFLG1=0
      IFLG2=0
      IFLG3=0
      IFLG4=0
C
C        *CHECK THE FOUR CORNERS OF CURRENT PIXEL FOR POSITION
C
      DO 38 I1=1,2
      DO 36 I2=1,2
      X=RI+SIGN1-X1
      Y=RJ+SIGN2-Y1
C        ARE WE INSIDE CIRCLE
      IF (X*X+Y*Y-R*R) 20,20,18
C
C              FLAG 1 MEANS OUTSIDE CIRCLE
C              FLAG 2 MEANS INSIDE CIRCLE
C              FLAG 3 MEANS 1 BAR (ODD BARS)
C              FLAG 4 MEANS A 0 BAR (EVEN BARS)
C
C
   18 IFLG1=1
      GO TO 30
   20 IFLG2=1
C
C        FIND WHAT BAR WE ARE IN.
C
C        CHECK THE DIRECTION OF THE BARS
      XX=X
      IF (IDIREC.EQ.1) XX=Y
      IF (IDIREC.EQ.2) XX=SORT(X*X+Y*Y)
      DO 22 I3=1,NWURK
      ISUB=I3
      IF (WURK(I3).GE.XX) GO TO 24
   22 CONTINUE
      I3=NBAR
C
C        IS THE BAR A 1 OR 0
C
   24 IF (I3/2*2-I3) 26,28,26
   26 IFLG3=1
      GO TO 30
   28 IFLG4=1
C
C        IF ALL THE FLAGS ARE UP, WE CAN BEGIN INTEGRATION
C        ELSE CHECK THE OTHER CORNERS
C
   30 IF (IFLG1-IFLG2) 34,32,34
   32 IF (IFLG3+IFLG4-2) 34,46,34
C
C        TOGGLE SIGNS, GO TO ANOTHER CORNER
C
   34 SIGN1=-SIGN1
   36 CONTINUE
      SIGN2=-SIGN2
   38 CONTINUE
C
C        *ARE WE IN THE CIRCLE AND A 1 SECTION
C        OR ARE WE STRADDLING ANY LINES
C
      IF (IFLG1-IFLG2) 40,44,58
   40 IF (IFLG3-IFLG4) 58,46,42
   42 ACCUM=Z
      GO TO 58
   44 IF (IFLG3-IFLG4) 58,46,46
C
C        2-D INTEGRATION ROUTINE
C
   46 DO 56 K=1,INTFAC
      DO 56 L=1,INTFAC
C
C        *COMPUTE THE POSITION OF PIXELLETTE RELATIVE TO THE CENTER
C             OF THE CIRCLE
C
      X=RI+FLOAT(K)/FLOAT(INTFAC)-.5-X1
      Y=RJ+FLOAT(L)/FLOAT(INTFAC)-.5-Y1
C        ARE WE INSIDE CIRCLE
      IF (X*X+Y*Y-R*R) 48,48,56
C
C        *CHECK DIRECTION OF BARS
C
   48 XX=X
      IF (IDIREC.EQ.1) XX=Y
      IF (IDIREC.EQ.2) XX=SQRT(X*X+Y*Y)
C
C        WHAT SIDE OF THE LINE ARE WE ON
C
      IF (WURK(ISUB)-XX) 52,50,50
C
C        *LEFT SIDE OF BOUNDARY LINE
C
   50 IF (I3/2*2-I3) 54,56,54
C
C        *RIGHT SIDE OF BOUNDARY LINE
C
   52 IF (I3/2*2-I3) 56,54,56
C
C        ADD PIXELETTE VALUE IF WE ARE INSIDE CIRCLE AND A 1 BAR
C
   54 ACCUM=ACCUM+CONST
   56 CONTINUE
   58 B1(I,J)=ACCUM
   60 CONTINUE
C
      WRITE (LUNOUT,64) N,N,R,X1,Y1,INTFAC,NBAR
C
      CALL LGTXT (NAMER,9)
      RETURN
C
C
   62 FORMAT(   14HONREPS*NBAR = ,I4,35HIS GREATER THAN 100.     ...STOP
     1...)
   64 FORMAT( ////30H BAR PATTERN PHANTOM GENERATED/13H ARRAY SIZE  ,I3,
     11HX,I3/16H CIRCLE RADIUS  ,F6.2,7H  AT  (,F3.0,1H,,F3.0,1H)/
     213H INT FACTOR  ,I3/14H NO. OF BARS  ,I3)
      END
```

CISQ

```
      SUBROUTINE CISQ (CIR,SQU,IDIR)
C
C     ****************************************************************
C     *      RECLBL     --        VERSION 1.0     --        17OCT77     *
C     ****************************************************************
C
C          FOR IDIR=1, CISQ TRANSFORMS THE CIRCULAR ARRAY CIR TO
C       SQUARE FORM AND STORES IT IN SQU.  THE CORNERS OF SQU ARE SET
C       TO ZERO.
C          FOR IDIR=2, CISQ PERFORMS THE OPPOSITE OPERATION RESTORING
C       THE SQUARE ARRAY SQU TO CIRCULAR FORM AND STORRING IT IN CIR.
C          CALL CISQ(A,A,IDIR) IS LEGAL.
C
C         CIR      - ARRAY IN CIRCULAR FORM
C         SQU      - ARRAY IN SQUARE FORM
C         IDIR     - DIRECTION OF TRANSFORMATION
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - ZERO
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                      COMMON
C         IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                      SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                      FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                      EXECUTING.
C         WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C         NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C         NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C         PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C         TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C         NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
```

```
C         LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                     NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                     THE SQUARE OF CIRCULAR FORM OF THE ARRAY
C         KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                     IS AN INTEGER VARIABLE
C
      DIMENSION CIR(1),SQU(1)
C
      IF (.NOT.TCIR) RETURN
      GO TO (10,16),IDIR
C
   10 IJ=NMAT+1
      DO 14 J=1,NDIM
      ISUB=LNI+NDIM-J
      NN=NI(ISUB)
      IN=NDIM*(NDIM-J)+1
      I=IN+(NDIM+NN)/2
C
      IF (NDIM.GT.NN) CALL ZERO (SQU(I),(NDIM-NN)/2)
C
      DO 12 II=1,NN
      IJ=IJ-1
      I=I-1
   12 SQU(I)=CIR(IJ)
C
      IF (NDIM.GT.NN) CALL ZERO (SQU(IN),(NDIM-NN)/2)
C
   14 CONTINUE
      RETURN
C
   16 IJ=0
      DO 18 J=1,NDIM
      ISUB=LNI+J-1
      NN=NI(ISUB)
      I=NDIM*(J-1)+(NDIM-NN)/2
C
      DO 18 II=1,NN
      IJ=IJ+1
      I=I+1
   18 CIR(IJ)=SQU(I)
      RETURN
      END
```

CONGR

```
      SUBROUTINE CONGR (X,PRJ,BCK,ISTP,IRLX,IERR,IZER)
C
C     ****************************************************************
C     *       RECLBL     --         VERSION 1.0     --         17OCT77      *
C     ****************************************************************
C
C           THE SUBROUTINE CONGR RECONSTRUCTS THE ARRAY X BY MINIMIZ-
C       ING A CHI-SQUARE USING THE METHOD OF CONJUGATE GRADIENTS.
C           THE ALGORITHM HAS THE OPTION OF MINIMIZING A CHI-SQUARE BY
C       METHOD OF CONJUGATE GRADIENTS WHERE THE PARAMETERS X HAVE BEEN
C       TRANSFORMED INTO A NEW SPACE BY Y=DX.  THE MATRIX D WHICH
C       DEFINES THE TRANSFORMATION IS A DIAGONAL MATRIX SUCH THAT
C       D(I) = SQRT(M(I,I)) WHERE CHISQ = X M X - V X + C.
C
C         X       - THE RECONSTRUCTION ARRAY
C         PRJ     - THE PROJECTION SUBROUTINE
C         BCK     - THE BACK-PROJECTION SUBROUTINE
C         ISTP    - NUMBER OF ITERATION STEPS
C         IRLX    - IRLX IS NON-ZERO FOR ITERATIVE RELAXATION
C         IERR    - IERR IS NON-ZERO FOR WEIGHTED LEAST SQUARE
C         IZER    - IZER IS EQUAL TO 0 IF INITIAL SOLUTION EQUALS 0
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - CISQ, DOT, EMESG, LGTXT
C         MEMST, RCHEK, SETIT, USER, ZERO
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       EXTERNAL RECLBL SUBROUTINES - BCK, PRJ
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                     COMMON
C         IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                     SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                     FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                     EXECUTING.
C         WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/ITRCOM/NSTP,TRLX,TERR,TZER,LWGT,LDEL,LTEMP,LCDEL,LTRAN
      LOGICAL TRLX,TERR,TZER
      DIMENSION WGT(1),DEL(1),TEMP(1),CDEL(1),TRAN(1)
      EQUIVALENCE (WORK(1),WGT(1),DEL(1),TEMP(1),CDEL(1),TRAN(1))
C
C         NSTP    - NUMBER OF ITERATION STEPS
C         TRLX    - LOGICAL VARIABLE SET TRUE FOR RELAXATION
C         TERR    - LOGICAL VARIABLE SET TRUE FOR WEIGHTED LEAST SQUARE
C         TZER    - LOGICAL VARIABLE SET TRUE TO ZERO INITIAL SOLUTION
C         LWGT    - POINTER TO THE ARRAY WGT IN BLANK COMMON
C                     WEIGHTS FOR WEIGHTED LEAST SQUARES (SEE TERR)
C         LDEL    - POINTER TO THE ARRAY DEL IN BLANK COMMON
C                     GRADIENT VECTOR
C         LTEMP   - POINTER TO THE ARRAY TEMP IN BLANK COMMON
C                     TEMPORARY STORAGE TO INCREASE SPEED
C         LCDEL   - POINTER TO THE ARRAY CDEL IN BLANK COMMON
C                     STEP DIRECTION FOR CONJUGATE GRADIENTS
C         LTRAN   - POINTER TO THE ARRAY TRAN IN BLANK COMMON
C                     TRANSFORMATION MATRIX FOR RELAXATION (SEE TRLX)
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C         LUNOUT  - LOGICAL UNIT NUMBER FOR OUTPUT
C         I80132  - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                     OUTPUT ON LUNOUT
C               0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C         NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C         NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C         PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C         TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C         NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C         LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                     NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                     THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C         KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                     IS AN INTEGER VARIABLE
C
      COMMON/STRCOM/TSTORE
      LOGICAL TSTORE
C
C         TSTORE  - LOGICAL VARIABLE SET TRUE WHEN TESTING STORAGE SIZE
C                     SETS TPRINT(1) = .TRUE.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C         IGEOM   - GEOMETRY FLAG
C               0 = PARALLEL BEAM GEOMETRY
C               1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C               2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C               3 = RING DETECTOR GEOMETRY
C         KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                     BY THE USER
C         AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                     PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                     AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                     IN THE CENTER OF A PROJECTION BIN.)
C         BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                     ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                     ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C         KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                     THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                     IS GOING TO BE USED.
C         KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                     THE DATA OF THE LAST USER PROJECTION BIN THAT
C                     IS GOING TO BE USED.
C         KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                     TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                     KDIM=KDIMU.
C         AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                     PROJECTION ARRAY, USUALLY AXIS=AXISU.
C         LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                     INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                     VECTOR
C         NANG    - NUMBER OF PROJECTIONS
C         MODANG  - MODE FOR PROJECTION ANGLE INPUT
C         LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                     PROJECTION ANGLES IN RADIANS
C         LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                     SINE OF THE PROJECTION ANGLES
C         LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                     COSINE OF THE PROJECTION ANGLES
C         LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                     USER PROJECTION DATA AND UNCERTAINTIES
C         TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                     FALSE FOR TRANSMISSION DATA
C
      EXTERNAL PRJ,BCK
      DIMENSION X(1)
      DIMENSION NAMER(9)
      DATA NAMER/1HE,1HN,1HD,1H ,1HC,1HO,1HN,1HG,1HR/
      DATA IOK/2HOK/
C
C        *BE SURE THAT SETUP HAS BEEN CALLED
C
      IF (ISETUP.NE.IOK) CALL EMESG (1,NAMER(5),1)
C
      CALL LGTXT (NAMER(5),5)
      NSTP=ISTP
      TRLX=IRLX.NE.0
      TERR=IERR.NE.0
      TZER=IZER.EQ.0
      WRITE (LUNOUT,36)
      WRITE (LUNOUT,38) NSTP
      IF (TRLX) WRITE (LUNOUT,40) IRLX
      IF (.NOT.TRLX) WRITE (LUNOUT,42) IRLX
      IF (TERR) WRITE (LUNOUT,44) IERR
      IF (.NOT.TERR) WRITE (LUNOUT,46) IERR
      IF (TZER) WRITE (LUNOUT,48) IZER
      IF (.NOT.TZER) WRITE (LUNOUT,50) IZER
C
      CALL RCHEK (BCK,PRJ,1)
C
      CALL MEMST (LPROJ,2*KDIM)
      CALL MEMST (LDEL,NMAT)
      IF (TERR) CALL MEMST (LWGT,KDIM*NANG)
      IF (TRLX) CALL MEMST (LTRAN,NMAT)
      CALL MEMST (LCDEL,NMAT)
      CALL MEMST (LTEMP,NMAT)
      IF (TSTORE) GO TO 34
C
      IF (TCIR.AND..NOT.TZER) CALL CISQ (X,X,2)
      CALL SETIT (X,CHI,PRJ,BCK)
C
      CALL ZERO (CDEL(LCDEL),NMAT)
C
      ITER=0
      Q=0.
      IF (TCIR) CALL CISQ (X,X,1)
      CALL USER (ITER,X,CHI)
      IF (TCIR) CALL CISQ (X,X,2)
      IF (NSTP.GT.0) GO TO 10
      WRITE (LUNOUT,52) NSTP
      CALL EMESG (5,NAMER(5),1)
C
C
C        *CORRECT STEP DIRECTION
C
   10 DELSQ=DOT(DEL(LDEL),1,DEL(LDEL),1,NMAT)
      Q=Q*DELSQ
      IF (TRLX) GO TO 14
      DO 12 I=1,NMAT
      ISUB1=LCDEL+I-1
      ISUB2=LDEL+I-1
   12 CDEL(ISUB1)=DEL(ISUB2)-Q*CDEL(ISUB1)
      GO TO 18
   14 DO 16 I=1,NMAT
      ISUB1=LCDEL+I-1
      ISUB2=LDEL+I-1
      ISUB3=LTRAN+I-1
   16 CDEL(ISUB1)=DEL(ISUB2)*TRAN(ISUB3)-Q*CDEL(ISUB1)
   18 Q=-1./DELSQ
C
C        *PROJECTION OF THE GRADIENT THEN BACKPROJECTION
C
```

```
      DO 22 M=1,NANG
      CALL PRJ (CDEL(LCDEL),PROJ(LPROJ),M)
      IF (.NOT.TERR) GO TO 22
      DO 20 I=1,KDIM
      ISUB1=LPROJ+I-1
      ISUB2=LWGT+(M-1)*KDIM+I-1
   20 PROJ(ISUB1)=PROJ(ISUB1)*WGT(ISUB2)
   22 CALL BCK (TEMP(LTEMP),PROJ(LPROJ),M)
      P=DELSQ/DOT(CDEL(LCDEL),1,TEMP(LTEMP),1,NMAT)
C
C        *THE NEW SOLUTION FOR THE RECONSTRUCTED ARRAY
C
      DO 24 I=1,NMAT
      ISUB=LCDEL+I-1
   24 X(I)=X(I)+P*CDEL(ISUB)
C
      IF (TRLX) GO TO 28
      DO 26 I=1,NMAT
      ISUB1=LDEL+I-1
      ISUB2=LTEMP+I-1
   26 DEL(ISUB1)=DEL(ISUB1)-P*TEMP(ISUB2)
      GO TO 32
   28 DO 30 I=1,NMAT
      ISUB1=LDEL+I-1
      ISUB2=LTEMP+I-1
      ISUB3=LTRAN+I-1
   30 DEL(ISUB1)=DEL(ISUB1)-P*TEMP(ISUB2)*TRAN(ISUB3)
C
C        *THE NEW CHI-SQUARE
C
   32 ITER=ITER+1
      CHI=CHI-P*DELSQ
      IF (TCIR) CALL CISQ (X,X,1)
      CALL USER (ITER,X,CHI)
      IF (TCIR) CALL CISQ (X,X,2)
      IF (ITER.LT.NSTP) GO TO 10
      IF (TCIR) CALL CISQ (X,X,1)
C
   34 CALL MEMST (LPROJ,0)
      CALL MEMST (LDEL,0)
      IF (TERR) CALL MEMST (LWGT,0)
      IF (TRLX) CALL MEMST (LTRAN,0)
      CALL MEMST (LCDEL,0)
      CALL MEMST (LTEMP,0)
      TERR=.FALSE.
C
      CALL MEMST (MAXFW,-1)
      WRITE (LUNOUT,54) MAXFW
      CALL LGTXT (NAMER,9)
      RETURN
C
C
C
   36 FORMAT(  ////11X,31HPARAMETERS FOR SUBROUTINE CONGR//19X,11HDESCRI
     1PTION/1X)
   38 FORMAT(9H ISTP -  ,I6,4X,25HNUMBER OF ITERATION STEPS)
   40 FORMAT(9H IRLX -  ,I6,4X,27HITERATIVE RELAXATION METHOD)
   42 FORMAT(9H IRLX -  ,I6,4X,25HITERATIVE GRADIENT METHOD)
   44 FORMAT(9H IERR -  ,I6,4X,15HUSE ERROR ARRAY)
   46 FORMAT(9H IERR -  ,I6,4X,22HDO NOT USE ERROR ARRAY)
   48 FORMAT(9H IZER -  ,I6,4X,24HINITIAL SOLUTION IS ZERO)
   50 FORMAT(9H IZER -  ,I6,4X,33HINITIAL SOLUTION SUPPLIED BY USER)
   52 FORMAT( //27HTHE NUMBER OF STEPS NSTP = ,I3,16H IS LESS THAN 0.)
   54 FORMAT(//10X,38HMAXIMUM SIZE OF BLANK COMMON THUS FAR=,I7,
     122H FLOATING POINT WORDS.)
      END
```

CONVO

```
      SUBROUTINE CONVO (X,XE,CNV,BCK,IERR)
C
C     ******************************************************************
C     *        RECLBL    --         VERSION 1.0     --        17OCT77     *
C     ******************************************************************
C
C           THE SUBROUTINE CONVO RECONSTRUCTS THE ARRAY X USING THE
C        BACK-PROJECTION OF THE FILTERED PROJECTIONS (CONVOLUTION
C        METHOD).  ONE STANDARD DEVIATION ERRORS OF THE RECONSTRUCTED
C        VALUES ARE RETURNED IN XE IF IERR IS SET NON-ZERO.
C
C          X         - THE RECONSTRUCTION ARRAY
C          XE        - THE ERRORS IN THE RECONSTRUCTED ARRAY
C          CNV       - THE SUBROUTINE GIVING THE CONVOLUTION FUNCTION
C          BCK       - THE BACK-PROJECTION SUBROUTINE
C          IERR      - THE ERROR FLAG (SET NON-ZERO TO RETURN XE)
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - CISQ, DOT, EMESG,
C          GETDE, LGTXT, MEMST, RCHEK
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        EXTERNAL RECLBL SUBROUTINES - BCK, CNV
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK     - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                        COMMON
C          IWUSED    - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT    - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP    - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                        SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                        FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                        EXECUTING.
C          WORK      - BLANK COMMON WORKING ARRAY
C
      COMMON/CNVCOM/LCONV,LCONE
      DIMENSION CONVOL(1),CONE(1)
      EQUIVALENCE (WORK(1),CONVOL(1),CONE(1))
C
C          LCONV     - POINTER TO THE ARRAY CONV IN BLANK COMMON
C                        ARRAY OF CONVOLUTION FACTORS
C          LCONE     - POINTER TO THE ARRAY CONE IN BLANK COMMON
C                        ARRAY OF VARIANCES (AND COVARIANCES OF ADJACENT
C                        BINS) OF THE CONVOLVED PROJECTIONS
C
      COMMON/FANCOM/RFAN,TFANC,TFANF
      LOGICAL TFANC,TFANF
C
C          RFAN      - FOR FAN BEAM GEOMETRY RFAN IS THE DISTANCE FROM
C                        THE SOURCE TO THE CENTER OF ROTATION.  RFAN
C                        IS MEASURED IN UNITS OF PROJECTION BIN WIDTHS AT
C                        THE CENTER OF ROTATION.
C          TFANC     - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                        CURVED DETECTOR
C          TFANF     - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                        FLAT DETECTOR
C
      COMMON/ITRCOM/NSTP,TRLX,TERR,TZER,LWGT,LDEL,LTEMP,LCDEL,LTRAN
      LOGICAL TRLX,TERR,TZER
      DIMENSION WGT(1),DEL(1),TEMP(1),CDEL(1),TRAN(1)
      EQUIVALENCE (WORK(1),WGT(1),DEL(1),TEMP(1),CDEL(1),TRAN(1))
C
C          NSTP      - NUMBER OF ITERATION STEPS
C          TRLX      - LOGICAL VARIABLE SET TRUE FOR RELAXATION
C          TERR      - LOGICAL VARIABLE SET TRUE FOR WEIGHTED LEAST SQUARE
C          TZER      - LOGICAL VARIABLE SET TRUE TO ZERO INITIAL SOLUTION
C          LWGT      - POINTER TO THE ARRAY WGT IN BLANK COMMON
C                        WEIGHTS FOR WEIGHTED LEAST SQUARES (SEE TERR)
C          LDEL      - POINTER TO THE ARRAY DEL IN BLANK COMMON
C                        GRADIENT VECTOR
C          LTEMP     - POINTER TO THE ARRAY TEMP IN BLANK COMMON
C                        TEMPORARY STORAGE TO INCREASE SPEED
C          LCDEL     - POINTER TO THE ARRAY CDEL IN BLANK COMMON
C                        STEP DIRECTION FOR CONJUGATE GRADIENTS
C          LTRAN     - POINTER TO THE ARRAY TRAN IN BLANK COMMON
C                        TRANSFORMATION MATRIX FOR RELAXATION (SEE TRLX)
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT    - LOGICAL UNIT NUMBER FOR OUTPUT
C          I80132    - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                        OUTPUT ON LUNOUT
C                  0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      COMMON/PRTCOM/TPRINT(8)
      LOGICAL TPRINT
C
C          TPRINT    - LOGICAL PRINT FLAGS
C                  1 - PRINT REQUIRED FLOATING POINT BLANK COMMON
C                        WHENEVER CHANGED
C                  2 - PRINT PROJECTION DATA AND UNCERTAINTIES
C                  3 - PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
C                  4 - PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER
C                        ROUTINES
C                  5 - PRINT VALUES FOR THE LAGRANGE MULTIPILERS AND
C                        THE GRADIENT FOR THE FUNCTION OF LAGRANGE MULTI-
C                        PILERS FOR THE ENTROPY RECONSTRUCTION
C                  6 - PRINT POINTERS IN BLANK COMMON WHENEVER CHANGED
C                        (DEBUG)
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU     - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM      - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID      - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR      - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT      - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI       - POINTER TO THE ARRAY NI IN BLANK COMMON
C                        NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                        THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI       - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                        IS AN INTEGER VARIABLE
C
      COMMON/STRCOM/TSTORE
      LOGICAL TSTORE
C
C          TSTORE    - LOGICAL VARIABLE SET TRUE WHEN TESTING STORAGE SIZE
C                        SETS TPRINT(1) = .TRUE.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C          IGEOM     - GEOMETRY FLAG
C                  0 = PARALLEL BEAM GEOMETRY
C                  1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                  2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                  3 = RING DETECTOR GEOMETRY
C          KDIMU     - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                        BY THE USER
C          AXISU     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                        AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                        IN THE CENTER OF A PROJECTION BIN.)
C          BWID      - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C          KMOV      - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                        ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                        ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C          KMIN      - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C          KMAX      - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE LAST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C          KDIM      - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                        TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                        KDIM=KDIMU.
C          AXIS      - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ     - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                        INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                        VECTOR
C          NANG      - NUMBER OF PROJECTIONS
C          MODANG    - MODE FOR PROJECTION ANGLE INPUT
C          LANG      - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                        PROJECTION ANGLES IN RADIANS
C          LSINE     - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                        SINE OF THE PROJECTION ANGLES
C          LCOSIN    - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                        COSINE OF THE PROJECTION ANGLES
C          LDATER    - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                        USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT     - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                        FALSE FOR TRANSMISSION DATA
C
      EXTERNAL BCK,CNV
      DIMENSION X(1),XE(1),RA(2)
      DIMENSION NAMER(9)
      LOGICAL TFAN,T80,T132
      DATA NAMER/1HE,1HN,1HD,1H ,1HC,1HO,1HN,1HV,1HO/
      DATA IOK/2HOK/
C
      T80=TPRINT(4).AND.I80132.EQ.0
      T132=TPRINT(4).AND.I80132.NE.0
C
C        *BE SURE THAT SETUP HAS BEEN CALLED
C
```

```
      IF (ISETUP.NE.IOK) CALL EMESG (1,NAMER(5),1)
C
      CALL LGTXT (NAMER(5),5)
      TERR=IERR.NE.0
C
      WRITE (LUNOUT,36)
      IF (TERR) WRITE (LUNOUT,38) IERR
      IF (.NOT.TERR) WRITE (LUNOUT,40) IERR
C
      CALL RCHEK (BCK,CNV,2)
C
      CALL MEMST (LPROJ,2*KDIM)
      TFAN=TFANC.OR.TFANF
      IF (TFAN) CALL MEMST (LCONV,3*KDIM-1)
      IF (.NOT.TFAN) CALL MEMST (LCONV,2*KDIM-1)
      KK=2*KDIM-1
      IF (TERR) CALL MEMST (LCONE,3*KK-1)
      IF (.NOT.TERR) CALL MEMST (LCONE,1)
C
      IF (TSTORE) GO TO 34
      RA(1)=RFAN
      IF (TFANF) RA(1)=-RFAN
      RA(2)=AXIS
      CALL CNV (CONVOL(LCONV),RA,KDIM)
C
C        *PRINT OUT CONVOLUTION FUNCTION AND WEIGHT FUNCTION
C
      ISUB1=LCONV+KDIM-1
      ISUB2=LCONV+2*KDIM-2
      KDMM=KDIM-1
      IF (T80) WRITE (LUNOUT,42) KDMM,(CONVOL(ISUB),ISUB=ISUB1,ISUB2)
      IF (T132) WRITE (LUNOUT,44) KDMM,(CONVOL(ISUB),ISUB=ISUB1,ISUB2)
      ISUB1=LCONV+2*KDIM-1
      ISUB2=LCONV+3*KDIM-2
      IF (T80.AND.TFAN) WRITE (LUNOUT,46) KDIM,(CONVOL(ISUB),ISUB=ISUB1,
     1ISUB2)
      IF (T132.AND.TFAN) WRITE (LUNOUT,48) KDIM,(CONVOL(ISUB),ISUB=ISUB1
     1,ISUB2)
C
C        *IF TERR IS TRUE, SETUP INTERMEDIATE FACTORS FOR THE COMPUT-
C          ATION OF CONVOLUTION COVARIANCES.
C
      IF (.NOT.TERR) GO TO 12
      KK=2*KDIM-1
      ISUB1=LCONV
      ISUB2=LCONE+KK
      ISUB3=LCONE+2*KK
      KK=KK-1
      DO 10 K=1,KK
      CONE(ISUB2)=CONVOL(ISUB1)**2
      CONE(ISUB3)=CONVOL(ISUB1)*CONVOL(ISUB1+1)
      ISUB1=ISUB1+1
      ISUB2=ISUB2+1
   10 ISUB3=ISUB3+1
      CONE(ISUB2)=CONVOL(ISUB1)**2
   12 CONTINUE
C
C        *LOOP OVER THE ANGLES
C
      DO 28 M=1,NANG
      ISUB=LPROJ+KDIM
      CALL GETDE (M,PROJ(LPROJ),PROJ(ISUB))
C
C        *SPECIAL WEIGHTING FOR FAN BEAMS
C
      IF (.NOT.TFAN) GO TO 18
      ISUB1=LPROJ
      ISUB2=LCONV+2*KDIM-1
      DO 14 K=1,KDIM
      PROJ(ISUB1)=PROJ(ISUB1)*CONVOL(ISUB2)
      ISUB1=ISUB1+1
   14 ISUB2=ISUB2+1
      IF (.NOT.TERR) GO TO 18
      ISUB1=LPROJ+KDIM
      ISUB2=LCONV+2*KDIM-1
      DO 16 K=1,KDIM
      PROJ(ISUB1)=PROJ(ISUB1)*CONVOL(ISUB2)
      ISUB1=ISUB1+1
   16 ISUB2=ISUB2+1
   18 CONTINUE
C
C        *COMPUTE THE CONVOLUTION COVARIANCES AND PERFORM THE BACK-
C          PROJECTION
C
      IF (.NOT.TERR) GO TO 24
      DO 20 K=1,KDIM
      ISUB1=ISUB+K-1
   20 PROJ(ISUB1)=PROJ(ISUB1)**2
      KK=2*KDIM-1
      ISUB1=LCONE
      ISUB2=LCONE+KK+KDIM-1
      ISUB3=LCONE+2*KK+KDIM-2
      DO 22 K=1,KDIM
      CONE(ISUB1)=DOT(PROJ(ISUB),1,CONE(ISUB2),1,KDIM)
      IF (K.EQ.KDIM) GO TO 22
      CONE(ISUB1+1)=DOT(PROJ(ISUB),1,CONE(ISUB3),1,KDIM)
      ISUB1=ISUB1+2
      ISUB2=ISUB2-1
   22 ISUB3=ISUB3-1
      CALL BCK (XE,CONE(LCONE),-M)
   24 CONTINUE
C
C        *FORM THE CONVOLUTION AND PERFORM THE BACK-PROJECTION
C
      DO 26 K=1,KDIM
      ISUB1=ISUB+K-1
      ISUB2=LCONV+KDIM-K
   26 PROJ(ISUB1)=DOT(PROJ(LPROJ),1,CONVOL(ISUB2),1,KDIM)
   28 CALL BCK (X,PROJ(ISUB),M)
C
C        *NORMALIZE THE RECONSTRUCTION
C
      FAC=1./FLOAT(NANG)
      DO 30 I=1,NMAT
   30 X(I)=X(I)*FAC
      IF (TCIR) CALL CISQ (X,X,1)
C
      IF (.NOT.TERR) GO TO 34
      DO 32 I=1,NMAT
   32 XE(I)=SQRT(XE(I))*FAC
      IF (TCIR) CALL CISQ (XE,XE,1)
C
C
   34 CALL MEMST (LPROJ,0)
      CALL MEMST (LCONV,0)
      CALL MEMST (LCONE,0)
      CALL MEMST (MAXFW,-1)
      WRITE (LUNOUT,50) MAXFW
      CALL LGTXT (NAMER,9)
C
C
      RETURN
C
   36 FORMAT(  ////11X,31HPARAMETERS FOR SUBROUTINE CONVO//19X,11HDESCRI
     1PTION/1X)
   38 FORMAT(9H IERR -  ,I6,4X,16HCALCULATE ERRORS)
   40 FORMAT(9H IERR -  ,I6,4X,23HDO NOT CALCULATE ERRORS)
   42 FORMAT(/1X,55HTHE VALUES FOR THE FILTER IN REAL SPACE (CONVOL(I),I
     1=0,,I3,1H)/(3X,5E12.3))
   44 FORMAT(/1X,55HTHE VALUES FOR THE FILTER IN REAL SPACE (CONVOL(I),I
     1=0,,I3,1H)/(3X,10E12.3))
   46 FORMAT(/1X,61HTHE WEIGHTS USED FOR THE FAN BEAM CONVOLUTION (WEIGH
     1T(I),I=1,,I3,1H)/(3X,5E12.3))
   48 FORMAT(/1X,61HTHE WEIGHTS USED FOR THE FAN BEAM CONVOLUTION (WEIGH
     1T(I),I=1,,I3,1H)/(3X,10E12.3))
   50 FORMAT(//10X,38HMAXIMUM SIZE OF BLANK COMMON THUS FAR=,I7,
     122H FLOATING POINT WORDS.)
      END
```

DOT

```
      FUNCTION DOT (X,JX,Y,JY,N)
C
C     ******************************************************************
C     *       RECLBL     --          VERSION 1.0     --          17OCT77   *
C     ******************************************************************
C
C           THE FUNCTION DOT GIVES THE DOT PRODUCT OF THE VECTORS
C        X AND Y WHERE THE DOT PRODUCT IS PERFORMED  ONLY BETWEEN
C        ELEMENTS THAT ARE STORED JX AND JY APART FOR X AND Y
C        RESPECTIVELY.
C
C          X        - VECTOR
C          JX       - THE INTERVAL BETWEEN SUCCESIVE FACTORS OF X IN
C                       THE DOT PRODUCT
C          Y        - VECTOR
C          JY       - THE INTERVAL BETWEEN SUCCESIVE FACTORS OF Y IN
C                       THE DOT PRODUCT
C          N        - THE NUMBER OF PRODUCTS IN THE DOT PRODUCT
C
C        LANGUAGE - FORTRAN
C
      DIMENSION X(1),Y(1)
      I=1
      J=1
      DOT=0.
      DO 10 K=1,N
      DOT=DOT+X(I)*Y(J)
      I=I+JX
   10 J=J+JY
      RETURN
      END
```

DULFC

```
      SUBROUTINE DULFC (FCN,PRJ,BCK)
C
C     ******************************************************************
C     *       RECLBL     --          VERSION 1.0     --          17OCT77   *
C     ******************************************************************
C
C           THE SUBROUTINE DULFC GIVES THE GRADIENT AND FUNCTIONAL
C        VALUE OF THE FUNCTION OF LAGRANGE MULTIPLIERS WHICH IS THE
C        OBJECTIVE FUNCTION FOR THE DUAL PROBLEM THAT OPTIMIZES ENTROPY
C        AS A RECONSTRUCTION CRITERION.
C
C          FCN      - FUNCTIONAL VALUE
C          PRJ      - THE PROJECTION SUBROUTINE
C          BCK      - THE BACK-PROJECTION SUBROUTINE
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - ENTPY, SETUP
C
C        EXTERNAL RECLBL SUBROUTINES - PRJ, BCK
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                       COMMON
C          IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                       SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                       FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                       EXECUTING.
C          WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/ENTCOM/LIMIT,ERENT,LXLAGR,LGRAD,LHWORK,LBCKE,LPRJE
      DIMENSION XLAGR(1),GRAD(1),HWORK(1),BCKE(1),PRJE(1)
      EQUIVALENCE(WORK(1),XLAGR(1),GRAD(1),HWORK(1),BCKE(1),PRJE(1))
C
C          LIMIT    - MAXIMUM NUMBER OF ITERATIONS ALLOWED TO MINIMIZE
C                       THE OBJECTIVE FUNCTION FOR THE DUAL PROGRAM
C          ERENT    - TEST VALUE REPRESENTING THE EXPECTED ABSOLUTE ERROR
C                       ERENTX SHOULD NOT BE ANY SMALLER THAN 10**(-D),
C                       WHERE D IS THE NUMBER OF SIGNIFICANT DIGITS IN
C                       FLOATING POINT REPRESENTATION.
C          LXLAGR   - POINTER TO THE ARRAY XLAGR IN BLANK COMMON
C                       ARRAY OF LAGRANGE MULTIPLIERS FOR THE DUAL
C                       PROBLEM USED TO OPTIMIZE ENTROPY AS A
C                       RECONSTRUCTION CRITERION
C          LGRAD    - POINTER TO THE ARRAY GRAD IN BLANK COMMON
C                       THE GRADIENT ARRAY FOR THE FUNCTION OF LAGRANGE
C                       MULTIPLIERS
C          LHWORK   - POINTER TO THE ARRAY HWORK IN BLANK COMMON
C                       WORKING STORAGE OF DIMENSION 2*(NO. OF LAGRANGE
C                       MULTIPLIERS)
C          LBCKE    - POINTER TO THE ARRAY BCKE IN BLANK COMMON
C                       A TEMPORARY BACK-PROJECTION ARRAY
C          LPRJE    - POINTER TO THE ARRAY PRJE IN BLANK COMMON
C                       A PROJECTION ARRAY
```

```
C
      COMMON/PTPCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                        NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                        THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                        IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LOATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C          IGEOM    - GEOMETRY FLAG
C                 0 = PARALLEL BEAM GEOMETRY
C                 1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                 2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                 3 = RING DETECTOR GEOMETRY
C          KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                        BY THE USER
C          AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                        AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                        IN THE CENTER OF A PROJECTION BIN.)
C          BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C          KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                        ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                        ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C          KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C          KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE LAST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C          KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                        TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                        KDIM=KDIMU.
C          AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                        INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                        VECTOR
C          NANG     - NUMBER OF PROJECTIONS
C          MODANG   - MODE FOR PROJECTION ANGLE INPUT
C          LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                        PROJECTION ANGLES IN RADIANS
C          LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                        SINE OF THE PROJECTION ANGLES
C          LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                        COSINE OF THE PROJECTION ANGLES
C          LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                        USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                        FALSE FOR TRANSMISSION DATA
C
      EXTERNAL PRJ,BCK
C
      NDATA=KDIM*NANG
C
C        *FUNCTION
C
      L=LXLAGR
      DO 10 M=1,NANG
      CALL BCK (BCKE(LBCKE),XLAGR(L),M)
   10 L=L+KDIM
C
      Z=0.
      DO 12 I=1,NMAT
      ISUB=LBCKE+I-1
   12 Z=Z+EXP(BCKE(ISUB))
C
      FCN=ALOG(Z)
      DO 14 K=1,NDATA
      ISUB1=LXLAGR+K-1
      ISUB2=LPROJ+K-1
   14 FCN=FCN-XLAGR(ISUB1)*PROJ(ISUB2)
C
C        *GRADIENT
C
      DO 16 I=1,NMAT
      ISUB=LBCKE+I-1
   16 BCKE(ISUB)=EXP(BCKE(ISUB))
C
      L=LPRJE
      DO 18 M=1,NANG
      CALL PRJ (BCKE(LBCKE),PRJE(L),M)
   18 L=L+KDIM
C
      DO 20 I=1,NDATA
      ISUB1=LGRAD+I-1
      ISUB2=LPRJE+I-1
      ISUB3=LPROJ+I-1
   20 GRAD(ISUB1)=PRJE(ISUB2)/Z-PROJ(ISUB3)
C
      RETURN
C
      END
```

EMESG

```
      SUBROUTINE EMESG (NERR,NAME,IFATAL)
C
C     ****************************************************************
C     *       RECLBL    --         VERSION 1.0    --         17OCT77   *
C     ****************************************************************
C
C              THE SUBROUTINE EMESG IS CALLED AFTER A ROUTINE DETECTS AN
C        ERROR.  IT PRINTS A MESSAGE CONTAINING THE ERROR AND THE NAME
C        OF THE DETECTING ROUTINE IN EXTRA LARGE LETTERS ON LUNOUT TO
C        ATTRACT THE USERS ATTENTION.  IF THE ERROR IS FATAL EXECUTION
C        IS HALTED IN THIS ROUTINE.  THE ARGUMENTS ARE
C
C          NERR     - ERROR INDEX
C          NAME     - NAME OF THE DETECTING ROUTINE (ONE LETTER PER WORD
C                        LEFT JUSTIFIED)
C          IFATAL   - FLAG SET POSITIVE IF THE ERROR IS FATAL
C                   - NEGATIVE = NONFATAL ERROR BY SYSTEM CALLED ROUTINE
C                   - 0 = NONFATAL ERROR BY USER-CALLED ROUTINE
C                   - 1 = FATAL ERROR BY USER-CALLED ROUTINE
C                   - 2 = CATASTROPHIC ERROR -- SYSTEM CODE HAS BEEN
C                            CLOBBERRED
C                   - 3 = FATAL ERROR BY SYSTEM CALLED ROUTINE
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINE - LGTXT
C
C        LANGUAGE - FORTRAN
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT   - LOGICAL UNIT NUMBER FOR OUTPUT
C          I80132   - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                        OUTPUT ON LUNOUT
C                 0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      INTEGER NAME(5),EMESS(10),ESTOP(4),CHARS(10),ESYS(6),MERR(46)
C
      DATA ESYS/1HS,1HY,1HS,1HT,1HE,1HM/
      DATA MERR/1,29,30,31,20,24,0,26,3,35,36,37,38,39,10,7,12,13,14,15,
     19,2,4,5,6,40,1,2,3,4,5,16,17,32,33,19,8,25,34,27,28,18,21,22,23,11
     2/
      DATA EMESS/1HE,1HR,1HR,1HO,1HR,5*1H /
      DATA ESTOP/1HS,1HT,1HO,1HP/
      DATA CHARS/1H0,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9/
C
      IF (NERR.EQ.1) WRITE (LUNOUT,12) NAME
      LERR=MERR(NERR)
      N1=LERR-LERR/10*10+1
      N2=LERR/10-LERR/100*10+1
      EMESS(7)=CHARS(N2)
      EMESS(8)=CHARS(N1)
      IF (IFATAL.EQ.2) CALL LGTXT (ESYS,6)
      CALL LGTXT (EMESS,8)
      IF (IFATAL.GE.2) GO TO 10
      IF (IFATAL.LT.0) RETURN
      WRITE (LUNOUT,14)
      CALL LGTXT (NAME,5)
      IF (IFATAL.EQ.0) RETURN
   10 CALL LGTXT (ESTOP,4)
      STOP
C
   12 FORMAT(5X,33H*****SETUP MUST BE CALLED BEFORE ,5A1,6H *****)
   14 FORMAT(//35X,11HDETECTED BY)
      END
```

ENTPY

```
      SUBROUTINE ENTPY (X,PRJ,BCK,LIMITX,ERENTX)
C
C     ****************************************************************
C     *       RECLBL    --         VERSION 1.0    --         17OCT77   *
C     ****************************************************************
C
C              THE SUBROUTINE ENTPY RECONSTRUCTS THE ARRAY X FROM A SET
C        OF PROJECTIONS USING A MAXIMUM ENTROPY CRITERION FOR THE
C        RECONSTRUCTED IMAGE.  THE METHOD IS DESCRIBED IN
C          G. T. GULLBERG, ENTROPY AND TRANSVERSE SECTION RECONS-
C          TRUCTION.  IN INFORMATION PROCESSING IN SCINTIGRAPHY
C          (PROCEEDINGS OF THE IV TH INTERNATIONAL CONFERENCE,
C          ORSAY, FRANCE, JULY 15-16, 1975, EDS. C. RAYNAUD AND
C          A. TODD-POKROPEK, PP 325-332).
C
C          X        - THE RECONSTRUCTION ARRAY
C          PRJ      - THE PROJECTION SUBROUTINE
C          BCK      - THE BACK-PROJECTION SUBROUTINE
C          LIMITX   - MAXIMUM NUMBER OF ITERATIONS ALLOWED TO MINIMIZE
C                        THE OBJECTIVE FUNCTION FOR THE DUAL PROGRAM
C          ERENTX   - TEST VALUE REPRESENTING THE EXPECTED ABSOLUTE ERROR
C                        BETWEEN SUCCESSIVE ITERATIONS.  ERENTX SHOULD NOT
C                        BE ANY SMALLER THAN 10**(-D), WHERE D IS THE
C                        NUMBER OF SIGNIFICANT DIGITS IN FLOATING POINT
C                        REPRESENTATION.
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - CISQ, EMESG, FMCG,
C          GETDE, LGTXT, MEMST, RCHEK
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        EXTERNAL RECLBL SUBROUTINES - BCK, PRJ
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                        COMMON
C          IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                        SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                        FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                        EXECUTING.
C          WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/ENTCOM/LIMIT,ERENT,LXLAGR,LGRAD,LHWORK,LBCKE,LPRJE
      DIMENSION XLAGR(1),GRAD(1),HWORK(1),BCKE(1),PRJE(1)
      EQUIVALENCE(WORK(1),XLAGR(1),GRAD(1),HWORK(1),BCKE(1),PRJE(1))
C
C          LIMIT    - MAXIMUM NUMBER OF ITERATIONS ALLOWED TO MINIMIZE
C                        THE OBJECTIVE FUNCTION FOR THE DUAL PROGRAM
C          ERENT    - TEST VALUE REPRESENTING THE EXPECTED ABSOLUTE ERROR
C                        ERENTX SHOULD NOT BE ANY SMALLER THAN 10**(-D),
C                        WHERE D IS THE NUMBER OF SIGNIFICANT DIGITS IN
C                        FLOATING POINT REPRESENTATION.
C          LXLAGR   - POINTER TO THE ARRAY XLAGR IN BLANK COMMON
C                        ARRAY OF LAGRANGE MULTIPLIERS FOR THE DUAL
C                        PROBLEM USED TO OPTIMIZE ENTROPY AS A
C                        RECONSTRUCTION CRITERION
C          LGRAD    - POINTER TO THE ARRAY GRAD IN BLANK COMMON
C                        THE GRADIENT ARRAY FOR THE FUNCTION OF LAGRANGE
C                        MULTIPLIERS
C          LHWORK   - POINTER TO THE ARRAY HWORK IN BLANK COMMON
C                        WORKING STORAGE OF DIMENSION 2*(NO. OF LAGRANGE
C                        MULTIPLIERS)
C          LBCKE    - POINTER TO THE ARRAY BCKE IN BLANK COMMON
C                        A TEMPORARY BACK-PROJECTION ARRAY
C          LPRJE    - POINTER TO THE ARRAY PRJE IN BLANK COMMON
C                        A PROJECTION ARRAY
```

```
C
      COMMON/FANCOM/RFAN,TFANC,TFANF
      LOGICAL TFANC,TFANF
C
C          RFAN     - FOR FAN BEAM GEOMETRY RFAN IS THE DISTANCE FROM
C                       THE SOURCE TO THE CENTER OF ROTATION.  RFAN
C                       IS MEASURED IN UNITS OF PROJECTION BIN WIDTHS AT
C                       THE CENTER OF ROTATION.
C          TFANC    - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                       CURVED DETECTOR
C          TFANF    - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                       FLAT DETECTOR
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT   - LOGICAL UNIT NUMBER FOR OUTPUT
C          I80132   - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                       OUTPUT ON LUNOUT
C                 0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      COMMON/PRTCOM/TPRINT(8)
      LOGICAL TPRINT
C
C          TPRINT   - LOGICAL PRINT FLAGS
C                 1 - PRINT REQUIRED FLOATING POINT BLANK COMMON
C                       WHENEVER CHANGED
C                 2 - PRINT PROJECTION DATA AND UNCERTAINTIES
C                 3 - PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
C                 4 - PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER
C                       ROUTINES
C                 5 - PRINT VALUES FOR THE LAGRANGE MULTIPILERS AND
C                       THE GRADIENT FOR THE FUNCTION OF LAGRANGE MULTI-
C                       PILERS FOR THE ENTROPY RECONSTRUCTION
C                 6 - PRINT POINTERS IN BLANK COMMON WHENEVER CHANGED
C                       (DEBUG)
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                       NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                       THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                       IS AN INTEGER VARIABLE
C
      COMMON/STRCOM/TSTORE
      LOGICAL TSTORE
C
C          TSTORE   - LOGICAL VARIABLE SET TRUE WHEN TESTING STORAGE SIZE
C                       SETS TPRINT(1) = .TRUE.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C          IGEOM    - GEOMETRY FLAG
C                 0 = PARALLEL BEAM GEOMETRY
C                 1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                 2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                 3 = RING DETECTOR GEOMETRY
C          KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                       BY THE USER
C          AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                       PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                       AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                       IN THE CENTER OF A PROJECTION BIN.)
C          BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C          KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                       ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                       ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C          KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                       THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                       IS GOING TO BE USED.
C          KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                       THE DATA OF THE LAST USER PROJECTION BIN THAT
C                       IS GOING TO BE USED.
C          KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                       TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                       KDIM=KDIMU.
C          AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                       PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                       INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                       VECTOR
C          NANG     - NUMBER OF PROJECTIONS
C          MODANG   - MODE FOR PROJECTION ANGLE INPUT
C          LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                       PROJECTION ANGLES IN RADIANS
C          LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                       SINE OF THE PROJECTION ANGLES
C          LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                       COSINE OF THE PROJECTION ANGLES
C          LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                       USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                       FALSE FOR TRANSMISSION DATA
C
      EXTERNAL PRJ,BCK
      DIMENSION X(1)
      DIMENSION NAMER(9)
      LOGICAL T80,T132
      DATA NAMER/1HE,1HN,1HD,1H ,1HE,1HN,1HT,1HP,1HY/
      DATA IOK,EPS/2HOK,1.E-6/
C
      T80=I80132.EQ.0.AND.TPRINT(5)
      T132=I80132.NE.0.AND.TPRINT(5)
C
C        *BE SURE THAT SETUP HAS BEEN CALLED
C
      IF (ISETUP.NE.IOK) CALL EMESG (1,NAMER(5),1)
C
      LIMIT=LIMITX
      ERENT=ERENTX
      CALL LGTXT (NAMER(5),5)
      WRITE (LUNOUT,30)
      WRITE (LUNOUT,32) LIMIT
      WRITE (LUNOUT,34) ERENT
C
      CALL RCHEK (BCK,PRJ,5)
C
      NDATA=KDIM*NANG
      CALL MEMST (LPROJ,NDATA+KDIM)
      CALL MEMST (LBCKE,NMAT)
      CALL MEMST (LPRJE,NDATA)
      CALL MEMST (LXLAGR,NDATA)
      CALL MEMST (LGRAD,NDATA!
      CALL MEMST (LHWORK,2*NDATA)
C
      IF (TSTORE) GO TO 28
C
C        *GET THE PROJECTION DATA
C
      LMKDIM=0
      LWGTE=LPROJ+NDATA
      DO 10 M=1,NANG
      ISUB=LMKDIM+LPROJ
      CALL GETDE (M,PROJ(ISUB),PROJ(LWGTE))
   10 LMKDIM=LMKDIM+KDIM
C
C        *DETERMINE TOTAL DENSITY OF TRANSVERSE SECTION
C
      TOTDEN=0.
      LMKDIM=0
      DO 14 M=1,NANG
      ISUB=LMKDIM+LPROJ
      DO 12 K=1,KDIM
      ISUB1=ISUB+K-1
      IF (.NOT.(TFANC.OR.TFANF)) TOTDEN=TOTDEN+PROJ(ISUB1)
      IF (TFANC) TOTDEN=TOTDEN+PROJ(ISUB1)*COS((FLOAT(K)-AXIS)/RFAN)
      IF (TFANF) TOTDEN=TOTDEN+PROJ(ISUB1)*(1.+((FLOAT(K)-AXIS)/RFAN)**2
     1)**(-1.5)
   12 CONTINUE
   14 LMKDIM=LMKDIM+KDIM
C
      TOTDEN=TOTDEN/FLOAT(NANG)
C
C        *SET UP INITIAL SOLUTION
C
      LMKDIM=0
      DO 18 M=1,NANG
      ISUB=LMKDIM+LPROJ
      ISUBB=LMKDIM+LXLAGR
      DO 16 K=1,KDIM
      ISUB1=ISUB+K-1
      ISUB2=ISUBB+K-1
      PROJ(ISUB1)=PROJ(ISUB1)/TOTDEN
      XLAGR(ISUB2)=PROJ(ISUB1)
      IF (ABS(XLAGR(ISUB2)).LT.EPS) XLAGR(ISUB2)=1./TOTDEN
   16 CONTINUE
   18 LMKDIM=LMKDIM+KDIM
C
C        *OPTIMIZE THE DUAL PROGRAM
C
      IF (TPRINT(5)) WRITE (LUNOUT,36)
      IF (TPRINT(5)) WRITE (LUNOUT,38) NDATA
      K1=LXLAGR
      K2=LXLAGR+NDATA-1
      IF (T80) WRITE (LUNOUT,40) (XLAGR(K),K=K1,K2)
      IF (T132) WRITE (LUNOUT,42) (XLAGR(K),K=K1,K2)
C
      CALL FMCG (FCN,IER,PRJ,BCK)
C
      IF (TPRINT(5)) WRITE (LUNOUT,44)
      IF (TPRINT(5)) WRITE (LUNOUT,46) NDATA
      K1=LXLAGR
      K2=LXLAGR+NDATA-1
      IF (T80) WRITE (LUNOUT,40) (XLAGR(K),K=K1,K2)
      IF (T132) WRITE (LUNOUT,42) (XLAGR(K),K=K1,K2)
      IF (TPRINT(5)) WRITE (LUNOUT,48) FCN
      IF (TPRINT(5)) WRITE (LUNOUT,52) NDATA
      K1=LGRAD
      K2=LGRAD+NDATA-1
      IF (T80) WRITE (LUNOUT,40) (GRAD(K),K=K1,K2)
      IF (T132) WRITE (LUNOUT,42) (GRAD(K),K=K1,K2)
C
C        *EVALUATE THE OPTIMUM FOR THE ENTROPY FUNCTION
C           DETERMINE THE PRIME SOLUTIONS
C
      ISUB=LXLAGR
      DO 20 M=1,NANG
      CALL BCK (X,XLAGR(ISUB),M)
   20 ISUB=ISUB+KDIM
C
      Z=0.
      DO 22 I=1,NMAT
   22 Z=Z+EXP(X(I))
C
      RTOTDN=0.
      DO 24 I=1,NMAT
      X(I)=TOTDEN*EXP(X(I))/Z
   24 RTOTDN=RTOTDN+X(I)
C
      ENTRPY=0.
      DO 26 I=1,NMAT
      IF (X(I).LE.0.) GO TO 26
      ENTRPY=ENTRPY-X(I)/RTOTDN*ALOG(X(I)/RTOTDN)
   26 CONTINUE
C
      IF (TPRINT(5)) WRITE (LUNOUT,50) ENTRPY
C
      IF (TCIR) CALL CISQ (X,X,1)
C
   28 CALL MEMST (LPROJ,0)
      CALL MEMST (LBCKE,0)
      CALL MEMST (LPRJE,0)
      CALL MEMST (LXLAGR,0)
      CALL MEMST (LGRAD,0)
      CALL MEMST (LHWORK,0)
      CALL MEMST (MAXFW,-1)
      WRITE (LUNOUT,54) MAXFW
      CALL LGTXT (NAMER,9)
C
      RETURN
C
C
C
   30 FORMAT(  ////11X,31HPARAMETERS FOR SUBROUTINE ENTPY//19X,11HDESCRI
     1PTION/1X)
   32 FORMAT(10H LIMITX - ,I8,2X,52HMAXIMUM NUMBER OF ITERATIONS ALLOWED
     1 TO MAXIMIZE THE/22X,39HOBJECTIVE FUNCTION FOR THE DUAL PROGRAM)
   34 FORMAT(10H ERENTX - ,E8.1,2X,51HTEST VALUE REPRESENTING THE EXPECT
     1ED ABSOLUTE ERROR)
   36 FORMAT(  //46H INITIAL ESTIMATE FOR THE LAGRANGE MULTIPILERS)
   38 FORMAT( //39H THE INITIAL SOLUTION FOR XLAGR(I),I=1,,I4)
   40 FORMAT(1X,5E12.3)
   42 FORMAT(1X,10E12.3)
   44 FORMAT(  //44H FINAL SOLUTION FOR THE LAGRANGE MULTIPILERS)
   46 FORMAT(  //37H THE FINAL SOLUTION FOR XLAGR(I),I=1,,I4)
   48 FORMAT(//29H THE VALUE OF THE MINIMUM IS ,F7.4,2H .)
   50 FORMAT(//38H THE ENTROPY OF THE RECONSTRUCTION IS ,F7.4,2H .)
   52 FORMAT(  //26H THE GRADIENT GRAD(I),I=1,,I4)
   54 FORMAT(//10X,38HMAXIMUM SIZE OF BLANK COMMON THUS FAR=,I7,
     122H FLOATING POINT WORDS.)
      END
```

EVATN

```
      SUBROUTINE EVATN (B)
C
C     ****************************************************************
C     *       RECLBL    --        VERSION 1.0     --        17OCT77    *
C     ****************************************************************
C
C          THE SUBROUTINE EVATN EVALUATES THE ATTENUATION FACTORS
C        REQUIRED TO CORRECT FOR ATTENUATION IN AN EMISSION SCAN.  THE
C        ATTENUATION FACTORS FOR EACH CELL (I,J) IS EXP(-Z) WHERE Z IS
C        THE INTEGRAL OF ATTENUATION COEFFICIENTS IN THE DIRECTION OF
C        THE ANGLE ANG(M).  FOR A NXN ARRAY IT IS NECESSARY TO EVALUATE
C        N*N*NANG ATTENUATION FACTORS WHERE NANG IS THE NUMBER OF
C        PROJECTION ANGLES.  DUE TO THE LARGE NUMBER, THE FACTORS ARE
C        STORED ON FILE LUNATN.
C
C          B        - ARRAY OF ATTENUATION COEFFICIENTS
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - ATENF, EMESG, LGTXT,
C          MEMST, STATN
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                       COMMON
C          IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                       SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                       FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                       EXECUTING.
C          WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/ATNCOM/LATEN,LBMAP,TATEN,LUNATN
      LOGICAL TATEN
      DIMENSION ATEN(1),BMAP(1)
      EQUIVALENCE (WORK(1),ATEN(1),BMAP(1))
C
C          LATEN    - POINTER TO THE ARRAY ATEN IN BLANK COMMON
C                       STORES ATTENUATION FACTORS FOR ONE ANGLE
C          LBMAP    - POINTER TO THE ARRAY BMAP IN BLANK COMMON.
C                       A MATRIX USED TO STORE THE CONSTANT ATTENUATION
C                       COEFFICIENTS
C          TATEN    - LOGICAL VARIABLE SET TRUE FOR ATTENUATION
C                       RECONSTRUCTION
C          LUNATN   - LOGICAL UNIT NUMBER FOR ATTENUATION FACTOR STORAGE
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT   - LOGICAL UNIT NUMBER FOR OUTPUT
C          I80132   - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                       OUTPUT ON LUNOUT
C                 0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                       NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                       THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                       IS AN INTEGER VARIABLE
C
      COMMON/STRCOM/TSTORE
      LOGICAL TSTORE
C
C          TSTORE   - LOGICAL VARIABLE SET TRUE WHEN TESTING STORAGE SIZE
C                       SETS TPRINT(1) = .TRUE.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C          IGEOM    - GEOMETRY FLAG
C                 0 = PARALLEL BEAM GEOMETRY
C                 1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                 2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                 3 = RING DETECTOR GEOMETRY
C          KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                       BY THE USER
C          AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                       PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                       AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                       IN THE CENTER OF A PROJECTION BIN.)
C          BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C          KMCV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                       ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                       ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C          KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                       THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                       IS GOING TO BE USED.
C          KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                       THE DATA OF THE LAST USER PROJECTION BIN THAT
C                       IS GOING TO BE USED.
C          KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                       TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                       KDIM=KDIMU.
C          AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                       PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                       INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                       VECTOR
C          NANG     - NUMBER OF PROJECTIONS
C          MODANG   - MODE FOR PROJECTION ANGLE INPUT
C          LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                       PROJECTION ANGLES IN RADIANS
C          LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                       SINE OF THE PROJECTION ANGLES
C          LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                       COSINE OF THE PROJECTION ANGLES
C          LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                       USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                       FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1)
      DIMENSION NAMER(9)
      DATA NAMER/1HE,1HN,1HD,1H ,1HE,1HV,1HA,1HT,1HN/
      DATA IOK/2HOK/
C
C        *BE SURE THAT SETUP HAS BEEN CALLED
C
      IF (ISETUP.NE.IOK) CALL EMESG (1,NAMER(5),1)
C
      CALL LGTXT (NAMER(5),5)
      TATEN=.TRUE.
C
      CALL MEMST (LATEN,NMAT)
C
      IF (TSTORE) RETURN
C
      DO 12 M=1,NANG
      IJ=0
      DO 10 J=1,NDIM
      ISUB=LNI+J-1
      NN=NI(ISUB)
      DO 10 II=1,NN
      IJ=IJ+1
      I=(NDIM-NN)/2+II
C
C        *EVALUATE THE ATENUATION FACTOR  FOR THE CELL (I,J) IN THE
C          DIRECTION OF THE ANGLE ANG(M)
C
      CALL ATENF (I,J,M,B,Z)
      ISUB=LATEN+IJ-1
   10 ATEN(ISUB)=EXP(-Z)
C
C        *STORE THE ATENUATION FACTORS FOR ALL CELLS FOR THE ANGLE
C          ANG(M)
C
   12 CALL STATN (M,ATEN(LATEN),NMAT)
      CALL MEMST (MAXFW,-1)
      WRITE (LUNOUT,14) MAXFW
      CALL LGTXT (NAMER,9)
C
      RETURN
C
C
C
   14 FORMAT(//10X,38HMAXIMUM SIZE OF BLANK COMMON THUS FAR=,I7,
     122H FLOATING POINT WORDS.)
      END
```

EVATU

```
      SUBROUTINE EVATU (B,XLEV,ATENL)
C
C     ****************************************************************
C     *       RECLBL    --        VERSION 1.0     --        17OCT77    *
C     ****************************************************************
C
C          THE SUBROUTINE EVATU EVALUATES THE ATTENUATION FACTORS
C        REQUIRED TO CORRECT FOR ATTENUATION IN AN EMISSION SCAN ASSUM-
C        ING A CONSTANT ATTENUATION COEFFICIENT.  THE ATTENUATION
C        FACTORS FOR EACH CELL (I,J) IS EXP(-Z) WHERE Z IS THE INTEGRAL
C        OF ATTENUATION COEFFICIENTS IN THE DIRECTION OF THE ANGLE
C        ANG(M).  THE INTEGRAL IS EVALUATED ASSUMING A CONSTANT ATTENUA-
C        TION COEFFICIENT ATENL.  FOR A NXN ARRAY IT IS NECESSARY TO
C        EVALUATE N*N*NANG ATTENUATION FACTORS WHERE NANG IS THE NUMBER
C        OF PROJECTION ANGLES.  DUE TO THE LARGE NUMBER, THE FACTORS
C        ARE STORED ON FILE LUNATN.
C
C          B        - TRANSVERSE SECTION WHICH HAS NOT BEEN CORRECTED
C                       FOR ATENUATION
C          XLEV     - APPROXIMATE RATIO OF THE CONCENTRATION IN THE
C                       OBJECT TO THE BACKGROUND
C          ATENL    - CONSTANT ATTENUATION COEFFICIENT
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - ARRAY, ATENF, EMESG,
C          LGTXT, MEMST, SRCH, STATN
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                       COMMON
C          IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                       SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                       FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                       EXECUTING.
C          WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/ATNCOM/LATEN,LBMAP,TATEN,LUNATN
      LOGICAL TATEN
      DIMENSION ATEN(1),BMAP(1)
      EQUIVALENCE (WORK(1),ATEN(1),BMAP(1))
C
C          LATEN    - POINTER TO THE ARRAY ATEN IN BLANK COMMON
C                       STORES ATTENUATION FACTORS FOR ONE ANGLE
C          LBMAP    - POINTER TO THE ARRAY BMAP IN BLANK COMMON
C                       A MATRIX USED TO STORE THE CONSTANT ATTENUATION
C                       COEFFICIENTS
C          TATEN    - LOGICAL VARIABLE SET TRUE FOR ATTENUATION
C                       RECONSTRUCTION
C          LUNATN   - LOGICAL UNIT NUMBER FOR ATTENUATION FACTOR STORAGE
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT   - LOGICAL UNIT NUMBER FOR OUTPUT
C          I80132   - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                       OUTPUT ON LUNOUT
C                 0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
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C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C           NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C           NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C           PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C           TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C           NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C           LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                        NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                        THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C           KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                        IS AN INTEGER VARIABLE
C
      COMMON/STRCOM/TSTORE
      LOGICAL TSTORE
C
C           TSTORE  - LOGICAL VARIABLE SET TRUE WHEN TESTING STORAGE SIZE
C                        SETS TPRINT(1) = .TRUE.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C           IGEOM   - GEOMETRY FLAG
C                 0 = PARALLEL BEAM GEOMETRY
C                 1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                 2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                 3 = RING DETECTOR GEOMETRY
C           KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                        BY THE USER
C           AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                        AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                        IN THE CENTER OF A PROJECTION BIN.)
C           BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C           KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                        ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                        ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C           KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C           KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE LAST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C           KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                        TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                        KDIM=KDIMU.
C           AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY, USUALLY AXIS=AXISU.
C           LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                        INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                        VECTOR
C           NANG    - NUMBER OF PROJECTIONS
C           MODANG  - MODE FOR PROJECTION ANGLE INPUT
C           LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                        PROJECTION ANGLES IN RADIANS
C           LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                        SINE OF THE PROJECTION ANGLES
C           LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                        COSINE OF THE PROJECTION ANGLES
C           LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                        USER PROJECTION DATA AND UNCERTAINTIES
C           TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                        FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1)
      DIMENSION NAMER(9)
      DATA NAMER/1HE,1HN,1HD,1H ,1HE,1HV,1HA,1HT,1HU/
      DATA IOK/2HOK/
C
C        *BE SURE THAT SETUP HAS BEEN CALLED
C
      IF (ISETUP.NE.IOK) CALL EMESG (1,NAMER(5),1)
C
      CALL LGTXT (NAMER(5),5)
      WRITE (LUNOUT,20)
      WRITE (LUNOUT,22) XLEV
      WRITE (LUNOUT,24) ATENL
C
      TATEN=.TRUE.
C
      CALL MEMST (LATEN,NMAT)
      CALL MEMST (LBMAP,NMAT)
C
      IF (TSTORE) GO TO 18
C
      CALL SRCH (B,BMAP(LBMAP),ATENL,XLEV)
      IF (BMAP(LBMAP).GT.-.5) GO TO 12
      IF (BMAP(LBMAP).LT.-1.5) GO TO 10
      WRITE (LUNOUT,26)
      CALL EMESG (34,NAMER(5),1)
   10 WRITE (LUNOUT,28) XLEV
      CALL EMESG (35,NAMER(5),1)
C
   12 CALL ARRAY (BMAP(LBMAP),NDIM)
C
      DO 16 M=1,NANG
      IJ=0
      DO 14 J=1,NDIM
      ISUB=LNI+J-1
      NN=NI(ISUB)
      DO 14 II=1,NN
      IJ=IJ+1
      I=(NDIM-NN)/2+II
C
C        *EVALUATE THE ATENUATION FACTOR FOR THE CELL (I,J) IN THE
C          DIRECTION OF THE ANGLE ANG(M)
C
      CALL ATENF (I,J,M,BMAP(LBMAP),Z)
      ISUB=LATEN+IJ-1
   14 ATEN(ISUB)=EXP(-Z)
C
C        *STORE THE ATENUATION FACTORS FOR ALL CELLS FOR THE ANGLE
C          ANG(M)
C
   16 CALL STATN (M,ATEN(LATEN),NMAT)
C
   18 CALL MEMST (LBMAP,0)
      CALL MEMST (MAXFW,-1)
      WRITE (LUNOUT,30) MAXFW
      CALL LGTXT (NAMER,9)
C
      RETURN
C
C
C
   20 FORMAT(  ////11X,31HPARAMETERS FOR SUBROUTINE EVATU//19X,11HDESCRI
     1PTION/1X)
   22 FORMAT(9H XLEV  - ,F8.3,4X,29HTHE TARGET-TO-NONTARGET RATIO)
   24 FORMAT(9H ATENL - ,F8.3,4X,23HATTENUATION COEFFICIENT)
   26 FORMAT(/10X,69HZERO RANGE IN RECONSTRUCTED ARRAY. NO ATTENUATION F
     1ACTORS CALCULATED.)
   28 FORMAT(/10X,59HTARGET TO NON-TARGET MUST BE GREATER THAN 1. THE VA
     1LUE WAS ,E10.3)
   30 FORMAT(//10X,38HMAXIMUM SIZE OF BLANK COMMON THUS FAR=,I7,
     122H FLOATING POINT WORDS.)
      END
```

FFTC

```
      SUBROUTINE FFTC (BR,BI,LN,KS)
C
C     ****************************************************************
C     *       RECLBL     --        VERSION 1.0     --        17OCT77  *
C     ****************************************************************
C
C          THE SUBROUTINE FFTC GIVES THE 1-DIMENSIONAL FAST FOURIER
C     TRANSFORM OF AN ARRAY WITH REAL ELEMENTS STORED IN THE ARRAY
C     BR AND COMPLEX ELEMENTS STORED IN THE ARRAY BI.  THE COMPLEX
C     ARRAY IS TRANSFORMED IN PLACE.
C          THE SUBROUTINE FFTC USES THE FOLLOWING DEFINITION OF THE
C     DISCRETE FOURIER TRANSFORM
C
C       F(K) = (G(0) + G(1)*EXP(-I*2*PI*K/N)
C                    + G(2)*EXP(-I*2*PI*2*K/N) + .........
C                    + G(N-1)*EXP(-I*2*PI*(N-1)*K/N))/N
C
C     WHERE F IS THE DISCRETE FOURIER TRANSFORM AND G IS THE FUNCTION
C     BEING TRANSFORMED.
C          THE COMPLEX ARRAY A OF LENGTH 2**LN COMPLEX ELEMENTS MAY
C     BE TRANSFORMED IN THE FOLLOWING MANNER,
C
C       COMPLEX A(...)
C       DIMENSION B(2,1)
C       EQUIVALENCE(A,B)
C       CALL FFTC (B(1,1),B(2,1),LN,2)
C
C     I.E. THE ADDRESS OF THE FIRST REAL PART IS PASSED IN BR, THE
C     ADDRESS OF THE FIRST IMAGINARY PART IS PASSED IN BI.  2**LN IS
C     THE NUMBER OF COMPLEX ELEMENTS TO BE TRANSFORMED.  LN MUST BE
C     LESS THAN OR EQUAL TO 15.  (2**15 = 32K)  IABS(KS) IS THE
C     SPACING BETWEEN ELEMENTS.  (USUALLY 2)  THE SIGN OF KS
C     DETERMINES THE DIRECTION OF THE TRANSFORM.
C
C       BR       - REAL ELEMENTS OF THE COMPLEX ARRAY
C       BI       - IMAGINARY ELEMENTS OF THE COMPLEX ARRAY
C       LN       - 2**LN IS THE NUMBER OF COMPLEX ELEMENTS TO BE
C                     TRANSFORMED.
C       KS       - IABS(KS) IS THE SPACING BETWEEN ELEMENTS.
C                     IF POSITIVE THEN FFTC GIVES FOURIER TRANSFORM
C                     IF NEGATIVE THEN FFTC GIVES INVERSE FOURIER
C                       TRANSFORM.
C
C     LANGUAGE - FORTRAN
C
      DIMENSION BR(1),BI(1)
      INTEGER B3,B4,B5,B6,B7,B56
      DIMENSION TAB1(15)
      DATA TAB1/             9.58737990959775E-05, 1.91747597310703E-04,
     1 3.83495187571395E-04, 7.66990318742704E-04, 1.53398018628476E-03,
     2 3.06795676296598E-03, 6.13588464915449E-03, 1.22715382857199E-02,
     3 2.45412285229123E-02, 4.90676743274181E-02, 9.80171403295604E-02,
     4 1.95090322016128E-01, 3.82683432365090E-01, 7.07106781186546E-01,
     5 1.00000000000000E+00/
C
      N=2**LN
      K=IABS(KS)
      L=16-LN
      B3=N*K
      B6=B3
      B7=K
      SGN=1.
      IF (KS.LT.0) GO TO 12
      SGN=-1.
      RNI=1./FLOAT(N)
      J=1
      DO 10 I=1,N
      BR(J)=BR(J)*RNI
      BI(J)=BI(J)*RNI
   10 J=J+K
C
   12 B6=B6/2
      B5=B6
      B4=2*B6
      B56=B5-B6
C
   14 TR1=BR(B5+1)
      TI1=BI(B5+1)
      TR2=BR(B56+1)
      TI2=BI(B56+1)
C
      BR(B5+1)=TR2-TR1
      BI(B5+1)=TI2-TI1
      BR(B56+1)=TR1+TR2
      BI(B56+1)=TI1+TI2
C
      B5=B5+B4
      B56=B5-B6
      IF (B5.LE.B3) GO TO 14
      IF (B6.EQ.B7) GO TO 20
C
      B4=B7
      CC=2.*TAB1(L)**2
      C=1.-CC
      L=L+1
      SS=SGN*TAB1(L)
      S=SS
C
   16 B5=B6+B4
      B4=2*B6
      B56=B5-B6
C
   18 TR1=BR(B5+1)
      TI1=BI(B5+1)
      TR2=BR(B56+1)
      TI2=BI(B56+1)
```

```
      BR(B5+1)=C*(TR2-TR1)-S*(TI2-TI1)
      BI(B5+1)=S*(TR2-TR1)+C*(TI2-TI1)
      BR(B56+1)=TR1+TR2
      BI(B56+1)=TI1+TI2
C
      B5=B5+B4
      B56=B5-B6
      IF (B5.LE.B3) GO TO 18
      B4=B5-B6
      B5=B4-B3
      C=-C
      B4=B6-B5
      IF (B5.LT.B4) GO TO 16
      B4=B4+B7
      IF (B4.GE.B5) GO TO 12
C
      T=C-CC*C-SS*S
      S=S+SS*C-CC*S
      C=T
      GO TO 16
C
   20 IX0=B3/2
      B3=B3-B7
      B4=0
      B5=0
      B6=IX0
      IX1=0
      IF (B6.EQ.B7) RETURN
C
   22 B4=B3-B4
      B5=B3-B5
      X2=BR(B4+1)
      X3=BR(B5+1)
      X4=BI(B4+1)
      X5=BI(B5+1)
      BR(B4+1)=X3
      BR(B5+1)=X2
      BI(B4+1)=X5
      BI(B5+1)=X4
      IF (B6.LT.B4) GO TO 22
C
   24 B4=B4+B7
      B5=B6+B5
      X2=BR(B4+1)
      X3=BR(B5+1)
      X4=BI(B4+1)
      X5=BI(B5+1)
      BR(B4+1)=X3
      BR(B5+1)=X2
      BI(B4+1)=X5
      BI(B5+1)=X4
      IX0=B6
C
   26 IX0=IX0/2
      IX1=IX1-IX0
      IF (IX1.GE.0) GO TO 26
C
      IX0=2*IX0
      B4=B4+B7
      IX1=IX1+IX0
      B5=IX1
      IF (B5.GE.B4) GO TO 22
      IF (B4.LT.B6) GO TO 24
C
      RETURN
      END
```

FFTR

```
      SUBROUTINE FFTR (X,NV)
C
C     ******************************************************************
C     *       RECLBL     --        VERSION 1.0     --       17OCT77     *
C     ******************************************************************
C
C          THE SUBROUTINE FFTR GIVES THE FOURIER TRANSFORM OF THE
C       REAL ARRAY X AND RETURNS THE RESULT IN THE ARRAY X.  THE
C       DIMENSION OF X IS 2**ABS(NV) AND THE FOURIER TRANSFORM HAS
C       VALUES FOR POINTS FROM 0 TO ABS(NV)/2-1 IN FREQUENCY SPACE.
C       THESE VALUES ARE STORED IN THE ARRAY X AS FOLLOWS
C
C       FOR N = 2**ABS(NV)
C
C               X(1)      - REAL VALUE FOR THE POINT (0,0)
C               X(2)      - REAL VALUE FOR THE POINT N/2
C               X(3)      - REAL VALUE FOR THE POINT 1
C               X(4)      - IMAGINARY VALUE FOR THE POINT 1
C               .
C               .
C               .
C               X(N-1)    - REAL VALUE FOR THE POINT N/2-1
C               X(N)      - IMAGINARY VALUE FOR THE POINT N/2-1
C
C         X        - ARRAY
C         NV       - A POWER OF 2 SUCH THAT THE DIMENSION OF X EQUALS
C                      2**ABS(NV)
C                      IF NV POSITIVE THEN FFTR GIVES FOURIER TRANSFORM
C                      IF NV NEGATIVE THEN FFTR GIVES INVERSE FOURIER
C                        TRANSFORM
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - FFTC
C
C       LANGUAGE - FORTRAN
C
      DIMENSION X(2,1)
      DIMENSION TAB1(15)
      DATA TAB1/           9.58737990959775E-05, 1.91747597310703E-04,
     1 3.83495187571395E-04, 7.66990318742704E-04, 1.53398018628476E-03,
     2 3.06795676296598E-03, 6.13588464915449E-03, 1.22715382857199E-02,
     3 2.45412285229123E-02, 4.90676743274181E-02, 9.80171403295604E-02,
     4 1.95090322016128E-01, 3.82683432365090E-01, 7.07106781186546E-01,
     5 1.00000000000000E+00/
C
      NU=IABS(NV)
      INV=NV/NU
      NU1=NU-1
      N=2**NU1
      ISUB=16-NU1
      SS=TAB1(ISUB)
      CC=-2.*TAB1(ISUB-1)**2
      C=1.
      S=0.
      N2=N/2
      IF (INV.LT.0) GO TO 12
      CALL FFTC (X(1,1),X(2,1),NU1,2)
      TR=X(1,1)
      TI=X(2,1)
      X(1,1)=.5*(TR+TI)
      X(2,1)=.5*(TR-TI)
      DO 10 I=1,N2
      I1=I+1
      I2=N-I+1
      TR1=X(1,I1)
      TR2=X(1,I2)
      TI1=X(2,I1)
      TI2=X(2,I2)
      T=(CC*C-SS*S)+C
      S=(CC*S+SS*C)+S
      C=T
      X(1,I1)=.25*((TR1+TR2)+(TI1+TI2)*C-(TR1-TR2)*S)
      X(1,I2)=.25*((TR1+TR2)-(TI1+TI2)*C+(TR1-TR2)*S)
      X(2,I1)=.25*((TI1-TI2)-(TI1+TI2)*S-(TR1-TR2)*C)
   10 X(2,I2)=.25*(-(TI1-TI2)-(TI1+TI2)*S-(TR1-TR2)*C)
      RETURN
   12 TR=X(1,1)
      TI=X(2,1)
      X(1,1)=(TR+TI)
      X(2,1)=(TR-TI)
      DO 14 I=1,N2
      I1=I+1
      I2=N-I+1
      TR1=X(1,I1)
      TR2=X(1,I2)
      TI1=X(2,I1)
      TI2=X(2,I2)
      T=(CC*C-SS*S)+C
      S=(CC*S+SS*C)+S
      C=T
      X(1,I1)=((TR1+TR2)-(TR1-TR2)*S-(TI1+TI2)*C)
      X(1,I2)=((TR1+TR2)+(TR1-TR2)*S+(TI1+TI2)*C)
      X(2,I1)=((TI1-TI2)+(TR1-TR2)*C-(TI1+TI2)*S)
   14 X(2,I2)=(-(TI1-TI2)+(TR1-TR2)*C-(TI1+TI2)*S)
      CALL FFTC (X(1,1),X(2,1),NU1,-2)
      RETURN
      END
```

FFTR2

```
      SUBROUTINE FFTR2 (X,NV)
C
C     ******************************************************************
C     *       RECLBL     --        VERSION 1.0     --       17OCT77     *
C     ******************************************************************
C
C          THE SUBROUTINE FFTR2 GIVES THE TWO DIMENSIONAL FOURIER
C       TRANSFORM OF THE REAL ARRAY X AND RETURNS THE RESULT IN THE
C       ARRAY X.  THE DIMENSION OF THE ARRAY X IS 2**ABS(NV)**2.  THE
C       VALUES OF THE FOURIER TRANSFORM ARE RETURNED IN THE ARRAY X
C       WHICH IS EQUIVALENT TO A TWO-DIMENSIONAL ARRAY A(I,J) (A(I,J) =
C       X((J-1)*2**ABS(NV)+I)) IN WHICH THE TRANSFORMED VALUES ARE
C       STORED AS FOLLOWS
C
C       FOR N = 2**ABS(NV)
C
C            A(1,1)      - REAL VALUE FOR THE POINT (0,0)
C            A(2,1)      - REAL VALUE FOR THE POINT (N/2,0)
C            A(3,1)      - REAL VALUE FOR THE POINT (1,0)
C            A(4,1)      - IMAGINARY VALUE FOR THE POINT (1,0)
C            .
C            .
C            .
C            A(N-1,1)    - REAL VALUE FOR THE POINT (N/2-1,0)
C            A(N,1)      - IMAGINARY VALUE FOR THE POINT (N/2-1,0)
C            A(1,2)      - REAL VALUE FOR THE POINT (0,N/2)
C            A(2,2)      - REAL VALUE FOR THE POINT (N/2,N/2)
C            A(3,2)      - REAL VALUE FOR THE POINT (1,N/2)
C            A(4,2)      - IMAGINARY VALUE FOR THE POINT (1,N/2)
C            A(N-1,2)    - REAL VALUE FOR THE POINT (N/2-1,N/2)
C            A(N,2)      - IMAGINARY VALUE FOR THE POINT (N/2-1,N/2)
C            A(1,3)      - REAL VALUE FOR THE POINT (0,1)
C            A(2,3)      - REAL VALUE FOR THE POINT (N/2,1)
C            A(3,3)      - SUMMATION, K, L = 0, N-1,
C                            COS(2*PI*K/N)*COS(2*PI*L/N)
C                          FOR THE POINT (1,1)
C            A(4,3)      - SUMMATION, K, L = 0, N-1,
C                            -SIN(2*PI*K/N)*COS(2*PI*L/N)
C                          FOR THE POINT (1,1)
C            .
C            .
C            .
C            A(N-1,3)    - SUMMATION, K, L = 0, N-1,
C                            COS(2*PI*(N/2-1)*K/N)*COS(2*PI*L/N)
C                          FOR THE POINT (N/2-1,1)
C            A(N,3)      - SUMMATION, K, L = 0, N-1,
C                            -SIN(2*PI*(N/2-1)*K/N)*COS(2*PI*L/N)
C                          FOR THE POINT (N/2-1,1)
C            A(1,4)      - IMAGINARY VALUE FOR THE POINT (0,1)
C            A(2,4)      - IMAGINARY VALUE FOR THE POINT (N/2,1)
C            A(3,4)      - SUMMATION, K, L = 0, N-1
C                            -COS(2*PI*K/N)*SIN(2*PI*L/N)
C                          FOR THE POINT (1,1)
C            A(4,4)      - SUMMATION, K, L = 0, N-1
C                            SIN(2*PI*K/N)*SIN(2*PI*L/N)
C                          FOR THE POINT (1,1)
C            .
C            .
C            .
C            A(N-1,4)    - SUMMATION, K, L = 0, N-1,
C                            -COS(2*PI*(N/2-1)*K/N)*SIN(2*PI*L/N)
C                          FOR THE POINT (N/2-1,1)
C            A(N,4)      - SUMMATION, K, L = 0, N-1,
C                            SIN(2*PI*(N/2-1)*K/N)*SIN(2*PI*L/N)
C                          FOR THE POINT (N/2-1,1)
C            .
C            .
C            .
C            A(1,N-1)    - REAL VALUE FOR THE POINT (0,N/2-1)
C            A(2,N-1)    - REAL VALUE FOR THE POINT (N/2,N/2-1)
C            A(3,N-1)    - SUMMATION, K, L = 0, N-1,
C                            COS(2*PI*K/N)*COS(2*PI*(N/2-1)*L/N)
C                          FOR THE POINT (1,N/2-1)
C            A(4,N-1)    - SUMMATION, K, L = 0, N-1,
C                            -SIN(2*PI*K/N)*COS(2*PI*(N/2-1)*L/N)
C                          FOR THE POINT (1,N/2-1)
```

```
C          .
C          .
C          .
C          A(N-1,N-1) - SUMMATION, K, L = 0, N-1,
C                          COS(2*PI*(N/2-1)*K/N)*COS(2*PI*(N/2-1)*L/N)
C                       FOR THE POINT (N/2-1,N/2-1)
C          A(N,N-1)   - SUMMATION, K, L = 0, N-1
C                          -SIN(2*PI*(N/2-1)*K/N)*COS(2*PI*(N/2-1)*L/N)
C                       FOR THE POINT (N/2-1,N/2-1)
C          A(1,N)     - IMAGINARY VALUE FOR THE POINT (0,N/2-1)
C          A(2,N)     - IMAGINARY VALUE FOR THE POINT (N/2,N/2-1)
C          A(3,N)     - SUMMATION, K, L = 0, N-1,
C                          -COS(2*PI*K/N)*SIN(2*PI*(N/2-1)*L/N)
C                       FOR THE POINT (1,N/2-1)
C          A(4,N)     - SUMMATION, K, L = 0, N-1
C                          SIN(2*PI*K/N)*SIN(2*PI*(N/2-1)*L/N)
C                       FOR THE POINT (1,N/2-1)
C          .
C          .
C          .
C          A(N-1,N)   - SUMMATION, K, L = 0, N-1,
C                          -COS(2*PI*(N/2-1)*K/N)*SIN(2*PI*(N/2-1)*L/N)
C                       FOR THE POINT (N/2-1,N/2-1)
C          A(N,N)     - SUMMATION K, L = 0, N-1
C                          SIN(2*PI*(N/2-1)*K/N)*SIN(2*PI*(N/2-1)*L/N)
C                       FOR THE POINT (N/2-1,N/2-1)
C
C           FOR THE POINT (I,J), I, J = 1, N/2-1,
C
C          A(2*I+1,2*J+1) = SUMMATION, K, L = 0, N-1,
C                              COS(2*PI*I*K/N)*COS(2*PI*J*L/N)
C          A(2*I+2,2*J+1) = SUMMATION, K, L = 0, N-1,
C                              -SIN(2*PI*I*K/N)*COS(2*PI*J*L/N)
C          A(2*I+1,2*J+2) = SUMMATION, K, L = 0, N-1,
C                              -COS(2*PI*I*K/N)*SIN(2*PI*J*L/N)
C          A(2*I+2,2*J+2) = SUMMATION, K, L = 0, N-1
C                              SIN(2*PI*I*K/N)*SIN(2*PI*J*L/N)
C
C           THE VALUE OF THE FOURIER TRANSFORM SATISFIES
C
C       FOR (I,J)
C          REAL      =  A(2*I+1,2*J+1) - A(2*I+2,2*J+2)
C          IMAGINARY =  A(2*I+1,2*J+2) + A(2*I+2,2*J+1)
C
C       FOR (-I,J)
C          REAL      =  A(2*I+1,2*J+1) + A(2*I+2,2*J+2)
C          IMAGINARY =  A(2*I+1,2*J+2) - A(2*I+2,2*J+1)
C
C       FOR (I,-J)
C          REAL      =  A(2*I+1,2*J+1) + A(2*I+2,2*J+2)
C          IMAGINARY = -A(2*I+1,2*J+2) + A(2*I+2,2*J+1)
C
C       FOR (-I,-J)
C          REAL      =  A(2*I+1,2*J+1) - A(2*I+2,2*J+2)
C          IMAGINARY = -A(2*I+1,2*J+2) - A(2*I+2,2*J+1)
C
C       WHERE I, J = 1, N/2-1.
C
C         X       - ARRAY
C         NV      - A POWER OF 2 SUCH THAT THE DIMENSION OF X EQUALS
C                      2**ABS(NV)
C                      IF NV POSITIVE THEN FFTR2 GIVES FOURIER TRANSFORM
C                      IF NV NEGATIVE THEN FFTR2 GIVES INVERSE FOURIER
C                        TRANSFORM
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - FFTR
C
C       LANGUAGE - FORTRAN
C
      DIMENSION X(1)
C
C            THE ALGORITHM DOES A ONE-DIMENSIONAL FOURIER TRANSFORM
C       ON THE COLUMNS OF THE ARRAY X, TRANSPOSES THE ARRAY X, DOES
C       ANOTHER ONE-DIMENSIONAL TRANSFORM ON THE COLUMNS OF THE
C       TRANSPOSED ARRAY AND FINALLY TRANSPOSES X AGAIN TO GIVE THE
C       FOURIER TRANSFORM OF THE ORIGINAL ARRAY.
C
      N=2**IABS(NV)
      DO 14 L=1,2
      IJ=1
      DO 10 J=1,N
      CALL FFTR (X(IJ),NV)
   10 IJ=IJ+N
      NJ=N+1
      DO 12 J=2,N
      JI=J
      IJ=NJ
      NJ=NJ+N
      JJ=J-1
      DO 12 I=1,JJ
      XX=X(IJ)
      X(IJ)=X(JI)
      X(JI)=XX
      IJ=IJ+1
   12 JI=JI+N
   14 CONTINUE
      RETURN
      END
```

FILBK

```
      SUBROUTINE FILBK (X,FIL,BCK,ORDERX,FREQX)
C
C     ******************************************************************
C     *       RECLBL    --         VERSION 1.0    --         17OCT77    *
C     ******************************************************************
C
C            THE SUBROUTINE FILBK RECONSTRUCTS THE ARRAY X USING THE
C       FILTER OF THE BACK-PROJECTION ALGORITHM.
C
C         X       - THE RECONSTRUCTION ARRAY
C         FIL     - THE FILTER SUBROUTINE
C         BCK     - THE BACK-PROJECTION SUBROUTINE
C         ORDERX  - FILTER PARAMETER USED ONLY BY THE FILTER BUTER
C         FREQX   - FILTER PARAMETER
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - CISQ, EMESG, FFTR2,
C         GETDE, LGTXT, MEMST, RCHEK, STPTR
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       EXTERNAL RECLBL SUBROUTINES - BCK, FIL
C
C       LANGUAGE - FORTRAN
C
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                        COMMON
C          IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                        SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                        FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                        EXECUTING.
C          WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/FILCOM/ORDER,FREQ,LBCKA,LPRJA,LFILT
      DIMENSION BCKA(1),PRJA(1),FILT(1)
      EQUIVALENCE (WORK(1),BCKA(1),PRJA(1),FILT(1))
C
C          ORDER    - FILTER PARAMETER USED ONLY BY THE FILTER BUTER
C          FREQ     - FILTER PARAMETER
C          LBCKA    - POINTER TO THE ARRAY BCKA IN BLANK COMMON
C                        BACK-PROJECTION ARRAY WHICH HAS THE DIMENSION
C                        NDIM X NDIM
C          LPRJA    - POINTER TO THE ARRAY PRJA IN BLANK COMMON
C                        A PROJECTION ARRAY FOR ONE ANGLE
C          LFILT    - POINTER TO THE ARRAY FILT IN BLANK COMMON
C                        ARRAY OF FILTER VALUES
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT   - LOGICAL UNIT NUMBER FOR OUTPUT
C          I80132   - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                        OUTPUT ON LUNOUT
C                0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      COMMON/PRTCOM/TPRINT(8)
      LOGICAL TPRINT
C
C          TPRINT   - LOGICAL PRINT FLAGS
C                1 - PRINT REQUIRED FLOATING POINT BLANK COMMON
C                       WHENEVER CHANGED
C                2 - PRINT PROJECTION DATA AND UNCERTAINTIES
C                3 - PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
C                4 - PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER
C                       ROUTINES
C                5 - PRINT VALUES FOR THE LAGRANGE MULTIPILERS AND
C                       THE GRADIENT FOR THE FUNCTION OF LAGRANGE MULTI-
C                       PILERS FOR THE ENTROPY RECONSTRUCTION
C                6 - PRINT POINTERS IN BLANK COMMON WHENEVER CHANGED
C                       (DEBUG)
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                        NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                        THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                        IS AN INTEGER VARIABLE
C
      COMMON/STRCOM/TSTORE
      LOGICAL TSTORE
C
C          TSTORE   - LOGICAL VARIABLE SET TRUE WHEN TESTING STORAGE SIZE
C                        SETS TPRINT(1) = .TRUE.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C          IGEOM    - GEOMETRY FLAG
C                0 = PARALLEL BEAM GEOMETRY
C                1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                3 = RING DETECTOR GEOMETRY
C          KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                        BY THE USER
C          AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                        AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                        IN THE CENTER OF A PROJECTION BIN.)
C          BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C          KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                        ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                        ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C          KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C          KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE LAST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C          KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                        TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                        KDIM=KDIMU.
C          AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                        INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                        VECTOR
C          NANG     - NUMBER OF PROJECTIONS
C          MODANG   - MODE FOR PROJECTION ANGLE INPUT
C          LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                        PROJECTION ANGLES IN RADIANS
C          LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                        SINE OF THE PROJECTION ANGLES
C          LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                        COSINE OF THE PROJECTION ANGLES
C          LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                        USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                        FALSE FOR TRANSMISSION DATA
C
      EXTERNAL FIL,BCK
      DIMENSION X(1)
      DIMENSION NAMER(9)
      LOGICAL TSAVE,T80,T132
      DATA NAMER/1HE,1HN,1HD,1H ,1HF,1HI,1HL,1HB,1HK/
      DATA IOK/2HOK/
C
      T80=I80132.EQ.0
      T132=I80132.NE.0
C
C        *BE SURE THAT SETUP HAS BEEN CALLED
C
      IF (ISETUP.NE.IOK) CALL EMESG (1,NAMER(5),1)
```

```
C
      ORDER=ORDERX
      FREQ=FREQX
      CALL LGTXT (NAMER(5),5)
      WRITE (LUNOUT,26)
      WRITE (LUNOUT,28) ORDER
      WRITE (LUNOUT,30) FREQ
C
      CALL RCHEK (BCK,FIL,4)
C
      IF (2*(NDIM/2).EQ.NDIM) GO TO 10
      WRITE (LUNOUT,32)
      CALL EMESG (6,NAMER(5),1)
C
   10 NDIMU=NDIM
      IPOW2=INT(ALOG(FLOAT(NDIMU)-.5)/ALOG(2.))+2
C
C        *IPOW2 SATISFIES NDIM=2**IPOW2 WHERE NDIM IS 2 TIMES THE
C          SMALLEST INTEGER THAT IS A POWER OF 2 AND GREATER THAN OR
C          EQUAL TO NDIMU.
C
      NDIM=2**IPOW2
      TSAVE=TCIR
      TCIR=.FALSE.
      WRITE (LUNOUT,34)
      IF (IGEOM.EQ.1.OR.IGEOM.EQ.2) WRITE (LUNOUT,36)
      CALL STPTR
C
      CALL MEMST (LBCKA,NMAT)
      CALL MEMST (LPRJA,KDIM)
C
      IF (TSTORE) GO TO 24
C
      N2=NDIM/2
C
      IF (.NOT.TPRINT(4)) GO TO 16
C
C        *PRINT OUT THE FILTER VALUES
C
      FREQSP=1./FLOAT(NDIM)
      WRITE (LUNOUT,38) N2,NDIM,FREQSP
      NU=1
      N21=N2+1
      DO 14 I=1,N21
      DO 12 J=1,NU
      Z=SQRT(FLOAT((I-1)**2+(J-1)**2))/FLOAT(NDIM)
      ISUB=LBCKA+J-1
   12 CALL FIL (BCKA(ISUB),Z,1)
      ISUB1=LBCKA
      ISUB2=LBCKA+NU-1
      JJ=I-1
      IF (T80) WRITE (LUNOUT,40) JJ,(BCKA(II),II=ISUB1,ISUB2)
      IF (T132) WRITE (LUNOUT,42) JJ,(BCKA(II),II=ISUB1,ISUB2)
      NU=NU+1
   14 CONTINUE
   16 CONTINUE
C
C
C        *BACK-PROJECTION OF DATA
C
      DO 18 M=1,NANG
      CALL GETDE (M,PRJA(LPRJA),DUM)
   18 CALL BCK (BCKA(LBCKA),PRJA(LPRJA),M)
C
C        *FOURIER TRANSFORM THE BACK-PROJECTION
C
      CALL FFTR2 (BCKA(LBCKA),IPOW2)
C
C        *FILTER THE FOURIER TRANSFORM
C
      N2=NDIM/2
      CALL FIL (F,FLOAT(N2)/FLOAT(NDIM),1)
      BCKA(LBCKA)=0.
      BCKA(LBCKA+1)=BCKA(LBCKA+1)*F
      ISUB=LBCKA+NDIM
      BCKA(ISUB)=BCKA(ISUB)*F
      CALL FIL (F,SQRT(2.)*FLOAT(N2)/FLOAT(NDIM),1)
      BCKA(ISUB+1)=BCKA(ISUB+1)*F
C
      N21=N2-1
      DO 20 J=1,N21
      Y2=FLOAT(J)**2
      CALL FIL (FO,FLOAT(J)/FLOAT(NDIM),1)
      CALL FIL (FN,SQRT(FLOAT(N2)**2+Y2)/FLOAT(NDIM),1)
      IJ=LBCKA+2*NDIM*J
      IJN=IJ+NDIM
      BCKA(IJ)=BCKA(IJ)*FO
      BCKA(IJ+1)=BCKA(IJ+1)*FN
      BCKA(IJN)=BCKA(IJN)*FO
      BCKA(IJN+1)=BCKA(IJN+1)*FN
C
      JI=LBCKA+2*J
      JIN=JI+NDIM
      BCKA(JI)=BCKA(JI)*FO
      BCKA(JI+1)=BCKA(JI+1)*FO
      BCKA(JIN)=BCKA(JIN)*FN
      BCKA(JIN+1)=BCKA(JIN+1)*FN
C
      DO 20 I=1,J
      CALL FIL (F,SQRT(FLOAT(I)**2+Y2)/FLOAT(NDIM),1)
      IJ=IJ+2
      IJN=IJ+NDIM
      BCKA(IJ)=BCKA(IJ)*F
      BCKA(IJ+1)=BCKA(IJ+1)*F
      BCKA(IJN)=BCKA(IJN)*F
      BCKA(IJN+1)=BCKA(IJN+1)*F
      IF (I.EQ.J) GO TO 20
C
      JI=JI+2*NDIM
      JIN=JI+NDIM
      BCKA(JI)=BCKA(JI)*F
      BCKA(JI+1)=BCKA(JI+1)*F
      BCKA(JIN)=BCKA(JIN)*F
      BCKA(JIN+1)=BCKA(JIN+1)*F
   20 CONTINUE
C
C        *INVERSE FOURIER TRANSFORM GIVES THE RECONSTRUCTED ARRAY
C
      CALL FFTR2 (BCKA(LBCKA),-IPOW2)
C
C        *MAP THE LARGER ARRAY INTO THE RECONSTRUCTION ARRAY X
C
      PI=4.*ATAN(1.)
      FAC=PI/(FLOAT(NANG)*PWID)
      NX=(NDIM-NDIMU)/2
      L=1
      DO 22 J=1,NDIMU
      K=LBCKA+NX+NDIM*(J+NX-1)
      DO 22 I=1,NDIMU
      X(L)=BCKA(K)*FAC
      K=K+1
   22 L=L+1
C
   24 CALL MEMST (LBCKA,0)
      CALL MEMST (LPRJA,0)
      NDIM=NDIMU
      TCIR=TSAVE
      WRITE (LUNOUT,44)
      CALL STPTR
C
      CALL MEMST (MAXFW,-1)
      WRITE (LUNOUT,46) MAXFW
      CALL LGTXT (NAMEP,9)
      IF (TSTORE.OR..NOT.TCIR) RETURN
      CALL CISQ (X,X,2)
      CALL CISQ (X,X,1)
      RETURN
C
C
C
   26 FORMAT(  ////11X,31HPARAMETERS FOR SUBROUTINE FILBK//19X,11HDESCRI
     1PTION/1X)
   28 FORMAT(10H ORDERX - ,F6.1,4X,46HFILTER PARAMETER USED ONLY BY THE
     1FILTER BUTER)
   30 FORMAT(10H FREQX  - ,F6.3,4X,34HFREQUENCY PARAMETER FOR THE FILTER
     1)
   32 FORMAT(/1X,51HNDIM MUST BE EVEN FOR SUBROUTINE FILBK   ...STOP...)
   34 FORMAT(//10X,63HFILTERED BACK-PROJECTION RECONSTRUCTIONS MUST BE E
     1XECUTED IN AN/10X,65HARRAY WITH DIMENSIONS AT LEAST TWICE AS LARGE
     2 AS THE FINAL IMAGE.
     3/10X,61HTHUS, THE EFFECTIVE SIZE OF THE RECONSTRUCTION ARRAY WILL
     4NOW/10X,13HBE INCREASED.)
   36 FORMAT(/78H FOR FAN BEAM RECONSTRUCTIONS THE FAN SOURCE MUST BE OU
     1TSIDE THIS LARGE ARRAY.)
   38 FORMAT(/1X,65HTHE VALUES FOR THE FREQUENCY SPACE FILTER (FILT(I,J)
     1,I=0,J , J=0,,I3,8H) WITH A/2X,24H FREQUENCY SPACING OF 1/,I3, 2H
     2=,E9.3,21H CYCLES PER PIXEL ARE)
   40 FORMAT(3H J=,I3,5E12.3/(6X,5E12.3))
   42 FORMAT(3H J=,I3,10E12.3/(6X,10E12.3))
   44 FORMAT(/10X,58HTHE FINAL RECONSTRUCTION IS RETURNED WITH DIMENSION
     1 NDIMU./10X,49HNDIMU WILL NOW BE RETURNED TO ITS ORIGINAL VALUE.)
   46 FORMAT(//10X,38HMAXIMUM SIZE OF BLANK COMMON THUS FAR=,I7,
     122H FLOATING POINT WORDS.)
      END
```

FMCG

```
      SUBROUTINE FMCG (FCN,IER,PRJ,BCK)
C
C     ****************************************************************
C     *       RECLBL    --         VERSION 1.0    --       17OCT77   *
C     ****************************************************************
C
C           THE SUBROUTINE FMCG DETERMINES THE LOCAL MINIMUM OF A
C        FUNCTION OF SEVERAL VARIABLES BY THE METHOD OF CONJUGATE
C        GRADIENTS.  THIS PROGRAM WAS MODIFIED FROM THE SUBROUTINE FMCG
C        IN THE IBM SYSTEM/360 SCIENTIFIC SUBROUTINE PACKAGE, VERSION 3,
C        PROGRAMMERS MANUAL, PROGRAM NUMBER 360A-CM-03X.
C
C          FCN     - SINGLE VARIABLE CONTAINING THE MINIMUM FUNCTION
C                      VALUE ON RETURN, I.E. F=F(X).
C          IER     - ERROR PARAMETER
C                    IER = 0 MEANS CONVERGENCE WAS OBTAINED
C                    IER = 1 MEANS NO CONVERGENCE IN LIMIT ITERATIONS
C                    IER =-1 MEANS ERRORS IN GRADIENT CALCULATION
C                    IER = 2 MEANS LINEAR SEARCH TECHNIQUE INDICATES
C                    IT IS LIKELY THAT THERE EXISTS NO MINIMUM.
C          PRJ     - THE PROJECTION SUBROUTINE
C          BCK     - THE BACK-PROJECTION SUBROUTINE
C
C        REMARKS
C          I) IER IS SET TO 2 IF, STEPPING IN ONE OF THE COMPUTED
C             DIRECTIONS, THE FUNCTION WILL NEVER INCREASE WITHIN
C             A TOLERABLE RANGE OF THE ARGUMENT.
C             IER = 2 MAY OCCUR ALSO IF THE INTERVAL WHERE F
C             INCREASES IS SMALL AND THE INITIAL ARGUMENT WAS
C             RELATIVELY FAR AWAY FROM THE MINIMUM SUCH THAT THE
C             MINIMUM WAS OVERLEAPED.  THIS IS DUE TO THE SEARCH
C             TECHNIQUE WHICH DOUBLES THE STEPSIZE UNTIL A POINT
C             IS FOUND WHERE THE FUNCTION INCREASES.
C         II) THE METHOD IS DESCRIBED IN THE FOLLOWING ARTICLE
C             R. FLETCHER AND C. M. REEVES, FUNCTION MINIMIZATION BY
C             CONJUGATE GRADIENTS,
C             COMPUTER JOURNAL VOL. 7, ISS. 2, 1964, PP. 149-154.
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - DULFC, EMESG, MEMST
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - ENTPY, SETUP
C
C        EXTERNAL RECLBL SUBROUTINES - BCK, PRJ
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                      COMMON
C          IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                      SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                      FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                      EXECUTING.
C          WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/ENTCOM/LIMIT,ERENT,LXLAGR,LGRAD,LHWORK,LBCKE,LPRJE
      DIMENSION XLAGR(1),GRAD(1),HWORK(1),BCKE(1),PRJE(1)
      EQUIVALENCE(WORK(1),XLAGR(1),GRAD(1),HWORK(1),BCKE(1),PRJE(1))
C
C          LIMIT   - MAXIMUM NUMBER OF ITERATIONS ALLOWED TO MINIMIZE
C                      THE OBJECTIVE FUNCTION FOR THE DUAL PROGRAM
C          ERENT   - TEST VALUE REPRESENTING THE EXPECTED ABSOLUTE ERROR
C                      ERENTX SHOULD NOT BE ANY SMALLER THAN 10**(-D),
C                      WHERE D IS THE NUMBER OF SIGNIFICANT DIGITS IN
C                      FLOATING POINT REPRESENTATION.
C          LXLAGR  - POINTER TO THE ARRAY XLAGR IN BLANK COMMON
C                      ARRAY OF LAGRANGE MULTIPLIERS FOR THE DUAL
C                      PROBLEM USED TO OPTIMIZE ENTROPY AS A
C                      RECONSTRUCTION CRITERION
C          LGRAD   - POINTER TO THE ARRAY GRAD IN BLANK COMMON
C                      THE GRADIENT ARRAY FOR THE FUNCTION OF LAGRANGE
C                      MULTIPLIERS
C          LHWORK  - POINTER TO THE ARRAY HWORK IN BLANK COMMON
C                      WORKING STORAGE OF DIMENSION 2*(NO. OF LAGRANGE
C                      MULTIPLIERS)
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```
C         LBCKE   - POINTER TO THE ARRAY BCKE IN BLANK COMMON
C                      A TEMPORARY BACK-PROJECTION ARRAY
C         LPRJE   - POINTER TO THE ARRAY PRJE IN BLANK COMMON
C                      A PROJECTION ARRAY
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C         LUNOUT  - LOGICAL UNIT NUMBER FOR OUTPUT
C         I80132  - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                      OUTPUT ON LUNOUT
C                0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      COMMON/PRTCOM/TPRINT(8)
      LOGICAL TPRINT
C
C         TPRINT  - LOGICAL PRINT FLAGS
C                1 - PRINT REQUIRED FLOATING POINT BLANK COMMON
C                      WHENEVER CHANGED
C                2 - PRINT PROJECTION DATA AND UNCERTAINTIES
C                3 - PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
C                4 - PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER
C                      ROUTINES
C                5 - PRINT VALUES FOR THE LAGRANGE MULTIPILERS AND
C                      THE GRADIENT FOR THE FUNCTION OF LAGRANGE MULTI-
C                      PILERS FOR THE ENTROPY RECONSTRUCTION
C                6 - PRINT POINTERS IN BLANK COMMON WHENEVER CHANGED
C                      (DEBUG)
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C         NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C         NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C         PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C         TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C         NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C         LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                      NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                      THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C         KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                      IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C         IGEOM   - GEOMETRY FLAG
C                0 = PARALLEL BEAM GEOMETRY
C                1 = FAN BEAM GEOMETRY   (CURVED DETECTOR)
C                2 = FAN BEAM GEOMETRY   (FLAT DETECTOR)
C                3 = RING DETECTOR GEOMETRY
C         KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                      BY THE USER
C         AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                      AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                      IN THE CENTER OF A PROJECTION BIN.)
C         BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                      ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                      ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C         KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE LAST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                      TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                      KDIM=KDIMU.
C         AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY, USUALLY AXIS=AXISU.
C         LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                      INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                      VECTOR
C         NANG    - NUMBER OF PROJECTIONS
C         MODANG  - MODE FOR PROJECTION ANGLE INPUT
C         LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                      PROJECTION ANGLES IN RADIANS
C         LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                      SINE OF THE PROJECTION ANGLES
C         LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                      COSINE OF THE PROJECTION ANGLES
C         LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                      USER PROJECTION DATA AND UNCERTAINTIES
C         TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                      FALSE FOR TRANSMISSION DATA
C
      EXTERNAL PRJ,BCK
      DIMENSION NAMER(4)
      DATA NAMER/1HF,1HM,1HC,1HG/
C
      NDATA=KDIM*NANG
      RNX=FLOAT(NMAT)
C
C      *EST IS AN ESTIMATE OF THE MINIMUM FUNCTION VALUE
C
      EST=ALOG(RNX)
      IF (TPRINT(5)) WRITE (LUNOUT,114) EST
C
C      COMPUTE THE FUNCTION VALUE AND GRADIENT VECTOR FOR THE
C         INITIAL ARGUMENT
C
      CALL DULFC (FCN,PRJ,BCK)
C
C      RESET ITERATION COUNTER
C
      KOUNT=0
      IER=0
      N1=NDATA+1
C
C      START ITERATION CYCLE FOR EVERY NDATA+1 ITERATIONS
C
   10 DO 104 II=1,N1
C
      CALL USER (KOUNT,XLAGR(LXLAGR),FCN)
C
C      STEP ITERATION COUNTER AND SAVE FUNCTION VALUE
C
      KOUNT=KOUNT+1
      OLDF=FCN
      GNRM=0.
C
C      COMPUTE SQUARE OF GRADIENT AND TERMINATE IF ZERO
C
      DO 12 J=1,NDATA
      ISUB=LGRAD+J-1
   12 GNRM=GNRM+GRAD(ISUB)*GRAD(ISUB)
      IF (GNRM) 112,112,14
C
C      EACH TIME THE ITERATION LOOP IS EXECUTED, THE FIRST STEP WILL
C         BE IN DIRECTION OF STEEPEST DESCENT
C
   14 IF (II-1) 16,16,20
   16 DO 18 J=1,NDATA
      ISUB1=LHWORK+J-1
      ISUB2=LGRAD+J-1
   18 HWORK(ISUB1)=-GRAD(ISUB2)
      GO TO 24
C
C      FURTHER DIRECTION VECTORS H WILL BE CHOSEN CORRESPONDING
C         TO THE CONJUGATE GRADIENT METHOD
C
   20 AMBDA=GNRM/OLDG
      DO 22 J=1,NDATA
      ISUB1=LHWORK+J-1
      ISUB2=LGRAD+J-1
   22 HWORK(ISUB1)=AMBDA*HWORK(ISUB1)-GRAD(ISUB2)
C
C      COMPUTE TEST VALUE FOR DIRECTIONAL VECTOR AND DIRECTIONAL
C         DERIVATIVE
C
   24 DY=0.
      HNRM=0.
      DO 26 J=1,NDATA
      K=J+NDATA
C
C      SAVE THE ARGUMENT VECTOR
C
      ISUB1=LHWORK+K-1
      ISUB2=LXLAGR+J-1
      ISUB3=LHWORK+J-1
      HWORK(ISUB1)=XLAGR(ISUB2)
      HNRM=HNRM+ABS(HWORK(ISUB3))
      ISUB4=LGRAD+J-1
   26 DY=DY+HWORK(ISUB3)*GRAD(ISUB4)
C
C      CHECK WHETHER THE FUNCTION WILL DECREASE STEPPING ALONG HWORK
C         AND LINEAR SEARCH ROUTINE IF NOT
C
      IF (DY) 28,102,102
C
C      COMPUTE SCALE FACTOR USED IN LINEAR SEARCH ROUTINE
C
   28 SNRM=1./HNRM
C
C      SEARCH FOR MINIMUM ALONG DIRECTION HWORK AND SEARCH ALONG
C         HWORK FOR POSITIVE DIRECTION DERIVATIVE
C
      FY=FCN
      ALFA=2.*(EST-FCN)/DY
      AMBDA=SNRM
C
C      USE ESTIMATE FOR STEPSIZE ONLY IF IT IS POSITIVE AND .LT.SNRM.
C         OTHERWISE TAKE SNRM AS STEPSIZE.
C
      IF (ALFA) 34,34,30
   30 IF (ALFA-AMBDA) 32,34,32
   32 AMBDA=ALFA
   34 ALFA=0.
C
C      SAVE FUNCTION AND DERIVATIVE VALUES FOR OLD ARGUMENT
C
   36 FX=FY
      DX=DY
C
C      STEP ARGUMENT ALONG HWORK
C
      DO 38 I=1,NDATA
      ISUB1=LXLAGR+I-1
      ISUB2=LHWORK+I-1
   38 XLAGR(ISUB1)=XLAGR(ISUB1)+AMBDA*HWORK(ISUB2)
C
C      COMPUTE FUNCTION VALUE AND GRADIENT FOR NEW ARGUMENT
C
      CALL DULFC (FCN,PRJ,BCK)
      FY=FCN
C
C      COMPUTE DIRECTIONAL DERIVATIVE DY FOR NEW ARGUMENT.  TERMINATE
C         SEARCH IF POSITIVE.  IF DY IS ZERO THE MINIMUM IS FOUND.
C
      DY=0.
      DO 40 I=1,NDATA
      ISUB1=LGRAD+I-1
      ISUB2=LHWORK+I-1
   40 DY=DY+GRAD(ISUB1)*HWORK(ISUB2)
      IF (DY) 42,94,50
C
C      TERMINATE SEARCH ALSO IF THE FUNCTION VALUE INDICATES THAT A
C         MINIMUM HAS BEEN PASSED
C
   42 IF (FY-FX) 44,50,50
C
C      REPEAT SEARCH AND DOUBLE STEPSIZE FOR FUTURE SEARCHES
C
   44 AMBDA=AMBDA+ALFA
      ALFA=AMBDA
C
C      TERMINATE IF THE CHANGE IN ARGUMENT GETS VERY LARGE
C
      IF (HNRM*AMBDA-1.E10) 36,36,46
C
C      LINEAR SEARCH TECHNIQUE INDICATES THAT NO MINIMUM EXISTS
C
   46 IER=2
C
C      RESTORE OLD VALUES OF FUNCTION AND ARGUMENTS
C
      FCN=OLDF
      DO 48 J=1,NDATA
      ISUB1=LGRAD+J-1
      ISUB2=LHWORK+J-1
      GRAD(ISUB1)=HWORK(ISUB2)
      ISUB1=LXLAGR+J-1
      ISUB2=LHWORK+NDATA+J-1
   48 XLAGR(ISUB1)=HWORK(ISUB2)
C
      WRITE (LUNOUT,116) IER
      CALL EMESG (45,NAMER,3)
C
C      END OF SEARCH LOOP
C
C      INTERPOLATE CUBICALLY IN THE INTERVAL DEFINED BY THE SEARCH
C         ABOVE AND COMPUTE THE ARGUMENT XLAGR FOR WHICH THE
C         INTERPOLATION POLYNOMIAL IS MINIMIZED
C
   50 T=0.
   52 IF (AMBDA) 54,94,54
   54 Z=3.*(FX-FY)/AMBDA+DX+DY
      ALFA=AMAX1(ABS(Z),ABS(DX),ABS(DY))
      DALFA=(Z*Z-DX*DY)/(ALFA*ALFA)
      IF (DALFA) 56,66,66
C
C      RESTORE OLD VALUES OF FUNCTION AND ARGUMENT
```

```
C
   56 DO 58 J=1,NDATA
      ISUB1=LXLAGR+J-1
      ISUB2=LHWORK+NDATA+J-1
   58 XLAGR(ISUB1)=HWORK(ISUB2)
C
      CALL DULFC (FCN,PRJ,BCK)
C
C        CHECK FOR REPEATED FAILURE OF ITERATION
C
   60 IF (IER) 62,64,62
   62 WRITE (LUNOUT,122) IER
      CALL EMESG (43,NAMER,3)
   64 IER=-1
      GO TO 10
   66 W=ALFA*SQRT(DALFA)
      ALFA=DY-DX+W+W
      IF (ALFA) 68,70,68
   68 ALFA=(DY-Z+W)/ALFA
      GO TO 72
   70 ALFA=(Z+DY-W)/(Z+DX+Z+DY)
   72 ALFA=ALFA*AMBDA
      DO 74 I=1,NDATA
      ISUB1=LXLAGR+I-1
      ISUB2=LHWORK+I-1
   74 XLAGR(ISUB1)=XLAGR(ISUB1)+(T-ALFA)*HWORK(ISUB2)
C
C        TERMINATE, IF THE VALUE OF THE ACTUAL FUNCTION AT XLAGR IS LESS
C          THAN FUNCTION VALUES AT THE INTERVAL ENDS.  OTHERWISE REDUCE
C          THE INTERVAL BY CHOOSING ONE END-POINT EQUAL TO XLAGR AND
C          REPEAT THE INTERPOLATION WHICH END-POINT IS CHOSEN DEPENDS
C          ON THE VALUE OF THE FUNCTION AND ITS GRADIENT AT XLAGR.
C
      CALL DULFC (FCN,PRJ,BCK)
C
      IF (FCN-FX) 76,76,78
   76 IF (FCN-FY) 94,94,78
C
C        COMPUTE THE DIRECTIONAL DERIVATIVE
C
   78 DALFA=0.
      DO 80 I=1,NDATA
      ISUB1=LGRAD+I-1
      ISUB2=LHWORK+I-1
   80 DALFA=DALFA+GRAD(ISUB1)*HWORK(ISUB2)
      IF (DALFA) 82,88,88
   82 IF (FCN-FX) 86,84,88
   84 IF (DX-DALFA) 86,94,86
   86 FX=FCN
      DX=DALFA
      T=ALFA
      AMBDA=ALFA
      GO TO 52
   88 IF (FY-FCN) 92,90,92
   90 IF (DY-DALFA) 92,94,92
   92 FY=FCN
      DY=DALFA
      AMBDA=AMBDA-ALFA
      GO TO 50
C
C        TERMINATE, IF FUNCTION HAS NOT DECREASED DURING LAST ITERATION
C          OTHERWISE, SAVE GRADIENT NORM
C
   94 IF (OLDF-FCN+ERENT) 46,60,96
   96 OLDG=GNRM
C
C        COMPUTE DIFFERENCE OF NEW AND OLD ARGUMENT VECTOR
C
      T=0.
      DO 98 J=1,NDATA
      ISUB1=LHWORK+NDATA+J-1
      ISUB2=LXLAGR+J-1
      HWORK(ISUB1)=XLAGR(ISUB2)-HWORK(ISUB1)
   98 T=T+ABS(HWORK(ISUB1))
C
C        TEST LENGTH OF DIFFERENCE VECTOR IF AT LEAST NDATA+1 ITERATIONS
C          HAVE EXECUTED.  TERMINATE, IF LENGTH IS LESS THAN ERENT.
C
      IF (KOUNT-N1) 102,100,100
  100 IF (T-ERENT) 110,110,102
C
C        TERMINATE, IF NUMBER OF ITERATIONS WOULD EXCEED LIMIT
C
  102 IF (KOUNT-LIMIT) 104,106,106
  104 IER=0
C
C        END OF ITERATION CYCLE
C
C        START NEXT ITERATION CYCLE
C
      GO TO 10
C
C        NO CONVERGENCE AFTER LIMIT ITERATIONS
C
  106 IER=1
      IF (GNRM-ERENT) 112,112,108
  108 WRITE (LUNOUT,120) IER,KOUNT
      CALL EMESG (44,NAMER,-1)
      RETURN
C
C        TEST FOR SUFFICIENTLY SMALL GRADIENT
C
  110 IF (GNRM-ERENT) 112,112,60
  112 IER=0
      IF (TPRINT(5)) WRITE (LUNOUT,118) KOUNT
      RETURN
C
C
C
  114 FORMAT(  //38H THE ESTIMATE OF THE MINIMUM IS EST = ,F7.4,2H .)
  116 FORMAT(//27H THE ERROR PARAMETER IER = ,I3,49H MEANS THAT THE LINE
     1AR SEARCH TECHNIQUE INDICATES/3X,42HIT IS LIKELY THAT THERE EXISTS
     2 NO MINIMUM.)
  118 FORMAT(  //50H THE OPTIMUM SOLUTION FOR THE LAGRANGE MULTIPILERS/
     14X,18HWAS DETERMINED IN ,I4,12H ITERATIONS.)
  120 FORMAT(//27H THE ERROR PARAMETER IER = ,I3,33H MEANS NO CONVERGENC
     1E IN LIMIT = ,I4,12H ITERATIONS.)
  122 FORMAT(//27H THE ERROR PARAMETER IER = ,I3,38H MEANS ERRORS IN GRA
     1DIENT CALCULATION.)
      END
```

FTATN

```
      SUBROUTINE FTATN (M,A,N)
C
C     ****************************************************************
C     *       RECLBL    --         VERSION 1.0     --         17OCT77    *
C     ****************************************************************
C
C          THE SUBROUTINE FTATN READS FROM FILE LUNATN INTO CORE N
C       ATTENUATION FACTORS REQUIRED FOR THE ANGLE ANG(M).  SEE THE
C       DESCRIPTION FOR THE SUBROUTINES EVATC, EVATN, EVATU FOR AN
C       EXPLANATION OF HOW THE FACTORS ARE EVALUATED AND SEE SUBROUTINE
C       STATN FOR A DESCRIPTION OF HOW THEY ARE STORED.
C
C         M        - THE ANGLE INDEX
C         A        - ARRAY OF ATTENUATION FACTORS
C         N        - NUMBER OF FACTORS
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                      COMMON
C         IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                      SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                      FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                      EXECUTING.
C         WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/ATNCOM/LATEN,LBMAP,TATEN,LUNATN
      LOGICAL TATEN
      DIMENSION ATEN(1),BMAP(1)
      EQUIVALENCE (WORK(1),ATEN(1),BMAP(1))
C
C         LATEN    - POINTER TO THE ARRAY ATEN IN BLANK COMMON
C                      STORES ATTENUATION FACTORS FOR ONE ANGLE
C         LBMAP    - POINTER TO THE ARRAY BMAP IN BLANK COMMON
C                      A MATRIX USED TO STORE THE CONSTANT ATTENUATION
C                      COEFFICIENTS
C         TATEN    - LOGICAL VARIABLE SET TRUE FOR ATTENUATION
C                      RECONSTRUCTION
C         LUNATN   - LOGICAL UNIT NUMBER FOR ATTENUATION FACTOR STORAGE
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C         LUNOUT   - LOGICAL UNIT NUMBER FOR OUTPUT
C         I80132   - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                      OUTPUT ON LUNOUT
C                0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      DIMENSION A(1)
      DIMENSION NAMER(5)
      DATA NAMER/1HF,1HT,1HA,1HT,1HN/
      DATA MEQ/-1/
C
      IF (MEQ.EQ.M) RETURN
      IF (M.NE.1) GO TO 10
      REWIND LUNATN
      GO TO 12
   10 IF (M.NE.MEQ+1) CALL EMESG (27,NAMER,2)
C
   12 MEQ=M
      READ (LUNATN) (A(K),K=1,N)
      RETURN
C
C
      END
```

GETDE

```
      SUBROUTINE GETDE (M,D,E)
C
C     ****************************************************************
C     *       RECLBL    --         VERSION 1.0     --         17OCT77    *
C     ****************************************************************
C
C          THE SUBROUTINE GETDE STORES THE PROJECTION DATA AND ERRORS
C       IN THE PROPER LOCATIONS IN THE ARRAYS D AND E SO THAT THE
C       SYSTEM PROJECTION AND BACK-PROJECTION ROUTINES CAN OPERATE
C       ON THE DATA.  THE DATA IS PRINTED IF APPPROPRIATE PRINT OPTIONS .
C       HAS BEEN SELECTED BY THE USER.
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - GETUM, EMESG, MEMST,
C         ZERO
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                      COMMON
C         IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                      SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                      FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                      EXECUTING.
C         WORK     - BLANK COMMON WORKING ARRAY
C
```

```
      COMMON/ITRCOM/NSTP,TRLX,TERR,TZER,LWGT,LDEL,LTEMP,LCDEL,LTRAN
      LOGICAL TRLX,TERR,TZER
      DIMENSION WGT(1),DEL(1),TEMP(1),CDEL(1),TRAN(1)
      EQUIVALENCE (WORK(1),WGT(1),DEL(1),TEMP(1),CDEL(1),TRAN(1))
C
C          NSTP    - NUMBER OF ITERATION STEPS
C          TRLX    - LOGICAL VARIABLE SET TRUE FOR RELAXATION
C          TERR    - LOGICAL VARIABLE SET TRUE FOR WEIGHTED LEAST SQUARE
C          TZER    - LOGICAL VARIABLE SET TRUE TO ZERO INITIAL SOLUTION
C          LWGT    - POINTER TO THE ARRAY WGT IN BLANK COMMON
C                      WEIGHTS FOR WEIGHTED LEAST SQUARES (SEE TERR)
C          LDEL    - POINTER TO THE ARRAY DEL IN BLANK COMMON
C                      GRADIENT VECTOR
C          LTEMP   - POINTER TO THE ARRAY TEMP IN BLANK COMMON
C                      TEMPORARY STORAGE TO INCREASE SPEED
C          LCDEL   - POINTER TO THE ARRAY CDEL IN BLANK COMMON
C                      STEP DIRECTION FOR CONJUGATE GRADIENTS
C          LTRAN   - POINTER TO THE ARRAY TRAN IN BLANK COMMON
C                      TRANSFORMATION MATRIX FOR RELAXATION (SEE TRLX)
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT  - LOGICAL UNIT NUMBER FOR OUTPUT
C          I80132  - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                      OUTPUT ON LUNOUT
C                0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      COMMON/PRTCOM/TPRINT(8)
      LOGICAL TPRINT
C
C          TPRINT  - LOGICAL PRINT FLAGS
C                1 - PRINT REQUIRED FLOATING POINT BLANK COMMON
C                      WHENEVER CHANGED
C                2 - PRINT PROJECTION DATA AND UNCERTAINTIES
C                3 - PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
C                4 - PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER
C                      ROUTINES
C                5 - PRINT VALUES FOR THE LAGRANGE MULTIPILERS AND
C                      THE GRADIENT FOR THE FUNCTION OF LAGRANGE MULTI-
C                      PILERS FOR THE ENTROPY RECONSTRUCTION
C                6 - PRINT POINTERS IN BLANK COMMON WHENEVER CHANGED
C                      (DEBUG)
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                      NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                      THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                      IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C          IGEOM   - GEOMETRY FLAG
C                0 = PARALLEL BEAM GEOMETRY
C                1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                3 = RING DETECTOR GEOMETRY
C          KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                      BY THE USER
C          AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                      AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                      IN THE CENTER OF A PROJECTION BIN.)
C          BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C          KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                      ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                      ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C          KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C          KMAX    + LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE LAST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C          KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                      TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                      KDIM=KDIMU.
C          AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                      INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                      VECTOR
C          NANG    - NUMBER OF PROJECTIONS
C          MODANG  - MODE FOR PROJECTION ANGLE INPUT
C          LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                      PROJECTION ANGLES IN RADIANS
C          LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                      SINE OF THE PROJECTION ANGLES
C          LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                      COSINE OF THE PROJECTION ANGLES
C          LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                      USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                      FALSE FOR TRANSMISSION DATA
C
      DIMENSION D(1),E(1)
      LOGICAL T80,T132
      DIMENSION NAMER(5)
      DATA NAMER/1HG,1HE,1HT,1HD,1HE/
C
      T80=TPRINT(2).AND.I80132.EQ.0
      T132=TPRINT(2).AND.I80132.NE.0
C
      CALL ZERO (D,KDIM)
      IF (.NOT.TERR) GO TO 12
      DO 10 K=1,KDIM
   10 E(K)=1.
   12 CONTINUE
C
      ISUB1=LDATER
      ISUB2=LDATER+KDIMU
      CALL GETUM (M,DATER(ISUB1),DATER(ISUB2))
C
      ISUB1=ISUB1+KMIN-KMOV-1
      ISUB2=ISUB2+KMIN-KMOV-1
      DO 14 K=KMIN,KMAX
      D(K)=DATER(ISUB1)
      ISUB1=ISUB1+1
      IF (.NOT.TERR) GO TO 14
      IF (DATER(ISUB2).LE.0.) GO TO 18
      E(K)=DATER(ISUB2)
      ISUB2=ISUB2+1
   14 CONTINUE
C
      ISUB=LANG+M-1
      PI=4.*ATAN(1.)
      ANGD=ANG(ISUB)*180./PI
      IF (T80) WRITE (LUNOUT,20) M,ANG(ISUB),ANGD,(D(K),K=1,KDIM)
      IF (T132) WRITE (LUNOUT,22) M,ANG(ISUB),ANGD,(D(K),K=1,KDIM)
      IF (T80.AND.TERR) WRITE (LUNOUT,24) M,(E(K),K=1,KDIM)
      IF (T132.AND.TERR) WRITE (LUNOUT,26) M,(E(K),K=1,KDIM)
C
C        *ADJUST PROJECTIONS AND ERRORS SO THAT SUM OF PIXELS WILL
C        *EQUAL SUM OF PROJECTIONS.
C
      FAC=1.
      IF (TEMIT) FAC=FLOAT(NANG)*PWID
      DO 16 K=1,KDIM
      D(K)=D(K)*FAC
      IF (.NOT.TERR) GO TO 16
      E(K)=E(K)*FAC
   16 CONTINUE
      RETURN
C
   18 WRITE (LUNOUT,28) M,K,DATER(ISUB2)
      CALL EMESG (7,NAMER,3)
      STOP
C
C
   20 FORMAT(  /30H PROJECTION DATA FOR ANGLE NO.,I4,F10.3,8H RADIANS
     1,F10.3,8H DEGREES/(3X,5E12.3))
   22 FORMAT(  /30H PROJECTION DATA FOR ANGLE NO.,I4,F10.3,8H RADIANS
     1,F10.3,8H DEGREES/(3X,10E12.3))
   24 FORMAT(42H PROJECTION DATA UNCERTAINTY FOR ANGLE NO.,I4
     1/(3X,5E12.3))
   26 FORMAT(42H PROJECTION DATA UNCERTAINTY FOR ANGLE NO.,I4
     1/(3X,10E12.3))
   28 FORMAT(//16H ERROR FOR ANGLE,I3,4H BIN,I3,17H NEGATIVE OR ZERO,F15
     1.5)
      END
```

GETDM

```
      SUBROUTINE GETDM (M,D)
C
C     ******************************************************************
C     *      RECLBL    --         VERSION 1.0     --        17OCT77     *
C     ******************************************************************
C
C             THE SUBROUTINE GETDM IS THE EQUIVALENT OF GETDE, BUT
C        HANDLES ONLY CHORD DATA FOR RING GEOMETRY.  IF ANY ERRORS ARE
C        PASSED TO IT BY GETUM, THEY ARE IGNORED SINCE NO RING GEOMETRY
C        RECONSTRUCTION ROUTINES CAN USE ERRORS.
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - GETUM, ZERO
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                      COMMON
C          IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                      SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                      FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                      EXECUTING.
C          WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT  - LOGICAL UNIT NUMBER FOR OUTPUT
C          I80132  - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                      OUTPUT ON LUNOUT
C                0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      COMMON/PRTCOM/TPRINT(8)
      LOGICAL TPRINT
C
C          TPRINT  - LOGICAL PRINT FLAGS
C                1 - PRINT REQUIRED FLOATING POINT BLANK COMMON
C                      WHENEVER CHANGED
C                2 - PRINT PROJECTION DATA AND UNCERTAINTIES
C                3 - PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
C                4 - PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER
C                      ROUTINES
C                5 - PRINT VALUES FOR THE LAGRANGE MULTIPILERS AND
C                      THE GRADIENT FOR THE FUNCTION OF LAGRANGE MULTI-
C                      PILERS FOR THE ENTROPY RECONSTRUCTION
C                6 - PRINT POINTERS IN BLANK COMMON WHENEVER CHANGED
C                      (DEBUG)
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C          IGEOM   - GEOMETRY FLAG
C                0 = PARALLEL BEAM GEOMETRY
C                1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                3 = RING DETECTOR GEOMETRY
C          KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                      BY THE USER
C          AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                      AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                      IN THE CENTER OF A PROJECTION BIN.)
C          BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C          KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                      ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                      ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C          KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C          KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE LAST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C          KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                      TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                      KDIM=KDIMU.
```

```
C          AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                        INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                        VECTOR
C          NANG     - NUMBER OF PROJECTIONS
C          MODANG   - MODE FOR PROJECTION ANGLE INPUT
C          LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                        PROJECTION ANGLES IN RADIANS
C          LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                        SINE OF THE PROJECTION ANGLES
C          LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                        COSINE OF THE PROJECTION ANGLES
C          LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                        USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                        FALSE FOR TRANSMISSION DATA
C
      DIMENSION D(1)
      LOGICAL T80,T132
      T80=TPRINT(2).AND.I80132.EQ.0
      T132=TPRINT(2).AND.I80132.NE.0
      CALL ZERO (D,NANG)
      ISUB1=LDATER+NANG
      CALL GETUM (M,DATER(LDATER),DATER(ISUB1))
      NANG1=NANG
      IF (M.EQ.NANG/2) NANG1=NANG/2
      DO 10 I=1,NANG1
      ISUB=LDATER+I-1
      D(I)=DATER(ISUB)
   10 CONTINUE
      IF (T80) WRITE (LUNOUT,14) M,(D(I),I=1,NANG1)
      IF (T132) WRITE (LUNOUT,12) M,(D(I),I=1,NANG1)
      RETURN
C
C
   12 FORMAT(/32H RING DATA FOR DETECTORS SPACED ,I3,6H APART/(3X,10E12.
     13))
   14 FORMAT(/32H RING DATA FOR DETECTORS SPACED ,I3,6H APART/(3X, 5E12.
     13))
      END
```

GETUM

```
      SUBROUTINE GETUM (M,DATA,ERR)
C
C     ******************************************************************
C     *       RECLBL    --         VERSION 1.0    --         17OCT77   *
C     ******************************************************************
C
C          THE SUBROUTINE GETUM IS THE DATA INPUT ROUTINE FOR THE
C       RECLBL LIBRARY.  SINCE THE DATA MAY BE IN ARBITRARY FORMAT,
C       THE USER MUST SUPPLY A GETUM ROUTINE THAT OBTAINS THE INPUT AND
C       INSURES THAT IT IS IN THE PROPER FORMAT FOR USE BY RECLBL.
C          IF SUCH A ROUTINE IS NOT PROVIDED, THIS ROUTINE WILL BE
C       LOADED AND WHEN INVOKED WILL GENERATE A FATAL ERROR.
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - EMESG
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       LANGUAGE - FORTRAN
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT  - LOGICAL UNIT NUMBER FOR OUTPUT
C          I80132  - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                       OUTPUT ON LUNOUT
C               0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      DIMENSION NAMER(5)
      DATA NAMER/1HG,1HE,1HT,1HU,1HM/
C
      WRITE (LUNOUT,10)
      CALL EMESG (39,NAMER,1)
      RETURN
C
C
   10 FORMAT(//10X,65HA DATA INPUT SUBROUTINE NAMED GETUM MUST BE SUPPLI
     1ED BY THE USER.)
      END
```

GINV

```
      SUBROUTINE GINV (A,U,IFLAG,ATEMP,NR,NC)
C
C     ******************************************************************
C     *       RECLBL    --         VERSION 1.0    --         17OCT77   *
C     ******************************************************************
C
C          THE SUBROUTINE GINV CALCULATES THE GENERALIZED INVERSE OF
C       THE MATRIX A AND STORES THE TRANSPOSE OF IT IN THE MATRIX A.
C       THIS CODE IS A MODIFICATION OF THE ALGROITHM OF B. RUST,
C       W. R. BURRUS, AND C. SCHNEEBERGER, A SIMPLE ALGORTIHM
C       COMPUTING THE GENERALIZED INVERSE OF A MATRIX, COMM ACM,
C       9(1966), PP 381-386.
C
C         A        - MATRIX
C         U        - BOOKKEEPING MATRIX
C         IFLAG    - TEMPORARY WORKING STORAGE
C         ATEMP    - TEMPORARY WORKING STORAGE
C         NR       - THE NUMBER OF ROWS IN THE MATRIX A
C         NC       - THE NUMBER OF COLUMNS IN THE MATRIX A
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - DOT, ZERO
C
C       LANGUAGE - FORTRAN
C
      DIMENSION A(NR,NC),U(NC,NC),IFLAG(NC),ATEMP(NC)
C
      CALL ZERO (U,NC**2)
      DO 10 I=1,NC
   10 U(I,I)=1.0
C
      DO 12 J=1,NC
      DOT1=DOT(A(1,J),1,A(1,J),1,NR)
      IF (DOT1.GT.0.) GO TO 14
   12 CONTINUE
      RETURN
C
   14 JFLAG=J
      FAC=1./SQRT(DOT1)
      DO 16 I=1,NR
      T=A(I,JFLAG)
      A(I,JFLAG)=A(I,1)
   16 A(I,1)=FAC*T
C
      U(1,1)=FAC
      IFLAG(1)=1
C
C     DEPENDENT COL TOLERANCE FOR N BIT FLOATING POINT FRACTION
C
      N=27
      TOL=(10.*0.5**N)**2
C
      IF (NC.EQ.1) GO TO 46
      DO 44 J=2,NC
      DOT1=DOT(A(1,J),1,A(1,J),1,NR)
      JM1=J-1
      IF (DOT1.LE.0.) GO TO 30
      DO 28 L=1,2
      DO 18 K=1,JM1
   18 ATEMP(K)=DOT(A(1,J),1,A(1,K),1,NR)
      DO 26 K=1,JM1
      IF (IFLAG(K).EQ.0) GO TO 22
      DO 20 I=1,NR
   20 A(I,J)=A(I,J)-ATEMP(K)*A(I,K)
   22 DO 24 I=1,NC
   24 U(I,J)=U(I,J)-ATEMP(K)*U(I,K)
   26 CONTINUE
   28 CONTINUE
C
      DOT2=DOT(A(1,J),1,A(1,J),1,NR)
      IF (DOT2.GT.TOL*DOT1) GO TO 36
   30 DO 32 K=1,JM1
      ATEMP(K)=0.
      IF (IFLAG(K).EQ.0) GO TO 32
      ATEMP(K)=DOT(U(1,K),1,U(1,J),1,K)
   32 CONTINUE
      DO 34 I=1,NR
   34 A(I,J)=-DOT(A(I,1),NR,ATEMP,1,JM1)
      IFLAG(J)=0
      FAC=1./SQRT(DOT(U(1,J),1,U(1,J),1,NC))
      GO TO 38
   36 IFLAG(J)=1
      FAC=1.0/SQRT(DOT2)
   38 DO 40 I=1,NR
   40 A(I,J)=A(I,J)*FAC
      DO 42 I=1,NC
   42 U(I,J)=U(I,J)*FAC
   44 CONTINUE
C
   46 DO 48 J=1,NC
      DO 48 I=1,NR
   48 A(I,J)=DOT(A(I,J),NR,U(J,J),NC,NC-J+1)
C
      IF (JFLAG.EQ.1) RETURN
      DO 50 I=1,NR
      T=A(I,JFLAG)
      A(I,JFLAG)=A(I,1)
   50 A(I,1)=T
      RETURN
      END
```

GRADY

```
      SUBROUTINE GRADY (X,PRJ,BCK,ISTP,IRLX,IERR,IZER)
C
C     ******************************************************************
C     *       RECLBL    --         VERSION 1.0    --         17OCT77   *
C     ******************************************************************
C
C          THE SUBROUTINE GRADY RECONSTRUCTS THE ARRAY X BY MINIMIZ-
C       ING A CHI-SQUARE USING THE METHOD OF STEEPEST DESCENT.
C          THE ALGORITHM HAS THE OPTION OF MINIMIZING A CHI-SQUARE BY
C       METHOD OF STEEPEST DESCENT WHERE THE PARAMETERS X HAVE BEEN
C       TRANSFORMED INTO A NEW SPACE BY Y=DX.  THE MATRIX D WHICH
C       DEFINES THE TRANSFORMATION IS A DIAGONAL MATRIX SUCH THAT
C       D(I) = SQRT(M(I,I)) WHERE CHISQ = X M X - V X + C.  THIS IS
C       THE SAME ALGORITHM DUE TO GOITEIN - THREE-DIMENSIONAL DENSITY
C       RECONSTRUCTION FROM A SERIES OF TWO-DIMENSIONAL PROJECTIONS,
C       NUCLEAR INSTRUMENTS AND METHODS 101(1972) 509-518.
C
C         X        - THE RECONSTRUCTION ARRAY
C         PRJ      - THE PROJECTION SUBROUTINE
C         BCK      - THE BACK-PROJECTION SUBROUTINE
C         ISTP     - NUMBER OF ITERATION STEPS
C         IRLX     - IRLX IS NON-ZERO FOR ITERATIVE RELAXATION
C         IERR     - IERR IS NON-ZERO FOR WEIGHTED LEAST SQUARE
C         IZER     - IZER IS EQUAL TO 0 IF INITIAL SOLUTION EQUALS 0
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - CISQ, DOT, EMESG,
C         LGTXT, RCHEK, SETIT, USER
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       EXTERNAL RECLBL SUBROUTINES - BCK, PRJ
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                       COMMON
C         IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                       SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                       FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                       EXECUTING.
C         WORK     - BLANK COMMON WORKING ARRAY
```

```
C
      COMMON/ITRCOM/NSTP,TRLX,TERR,TZER,LWGT,LDEL,LTEMP,LCDEL,LTRAN
      LOGICAL TRLX,TERR,TZER
      DIMENSION WGT(1),DEL(1),TEMP(1),CDEL(1),TRAN(1)
      EQUIVALENCE (WORK(1),WGT(1),DEL(1),TEMP(1),CDEL(1),TRAN(1))
C
C        NSTP    - NUMBER OF ITERATION STEPS
C        TRLX    - LOGICAL VARIABLE SET TRUE FOR RELAXATION
C        TERR    - LOGICAL VARIABLE SET TRUE FOR WEIGHTED LEAST SQUARE
C        TZER    - LOGICAL VARIABLE SET TRUE TO ZERO INITIAL SOLUTION
C        LWGT    - POINTER TO THE ARRAY WGT IN BLANK COMMON
C                     WEIGHTS FOR WEIGHTED LEAST SQUARES (SEE TERR)
C        LDEL    - POINTER TO THE ARRAY DEL IN BLANK COMMON
C                     GRADIENT VECTOR
C        LTEMP   - POINTER TO THE ARRAY TEMP IN BLANK COMMON
C                     TEMPORARY STORAGE TO INCREASE SPEED
C        LCDEL   - POINTER TO THE ARRAY CDEL IN BLANK COMMON
C                     STEP DIRECTION FOR CONJUGATE GRADIENTS
C        LTRAN   - POINTER TO THE ARRAY TRAN IN BLANK COMMON
C                     TRANSFORMATION MATRIX FOR RELAXATION (SEE TRLX)
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C        LUNOUT  - LOGICAL UNIT NUMBER FOR OUTPUT
C        I80132  - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                     OUTPUT ON LUNOUT
C                0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C        NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C        NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C        PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C        TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C        NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C        LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                     NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                     THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C        KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                     IS AN INTEGER VARIABLE
C
      COMMON/STRCOM/TSTORE
      LOGICAL TSTORE
C
C        TSTORE  - LOGICAL VARIABLE SET TRUE WHEN TESTING STORAGE SIZE
C                     SETS TPRINT(1) = .TRUE.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C        IGEOM   - GEOMETRY FLAG
C              0 = PARALLEL BEAM GEOMETRY
C              1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C              2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C              3 = RING DETECTOR GEOMETRY
C        KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                     BY THE USER
C        AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                     PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                     AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                     IN THE CENTER OF A PROJECTION BIN.)
C        BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C        KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                     ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                     ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C        KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                     THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                     IS GOING TO BE USED.
C        KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                     THE DATA OF THE LAST USER PROJECTION BIN THAT
C                     IS GOING TO BE USED.
C        KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                     TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                     KDIM=KDIMU.
C        AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                     PROJECTION ARRAY, USUALLY AXIS=AXISU.
C        LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                     INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                     VECTOR
C        NANG    - NUMBER OF PROJECTIONS
C        MODANG  - MODE FOR PROJECTION ANGLE INPUT
C        LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                     PROJECTION ANGLES IN RADIANS
C        LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                     SINE OF THE PROJECTION ANGLES
C        LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                     COSINE OF THE PROJECTION ANGLES
C        LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                     USER PROJECTION DATA AND UNCERTAINTIES
C        TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                     FALSE FOR TRANSMISSION DATA
C
      EXTERNAL PRJ,BCK
      DIMENSION X(1)
      DIMENSION NAMER(9)
      DATA NAMER/1HE,1HN,1HD,1H ,1HG,1HR,1HA,1HD,1HY/
      DATA IOK/2HOK/
C
C        *BE SURE THAT SETUP HAS BEEN CALLED
C
      IF (ISETUP.NE.IOK) CALL EMESG (1,NAMER(5),1)
C
      CALL LGTXT (NAMER(5),5)
      NSTP=ISTP
      TRLX=IRLX.NE.0
      TERR=IERR.NE.0
      TZER=IZER.EQ.0
      WRITE (LUNOUT,34)
      WRITE (LUNOUT,36) NSTP
      IF (TRLX) WRITE (LUNOUT,38) IRLX
      IF (.NOT.TRLX) WRITE (LUNOUT,40) IRLX
      IF (TERR) WRITE (LUNOUT,42) IERR
      IF (.NOT.TERR) WRITE (LUNOUT,44) IERR
      IF (TZER) WRITE (LUNOUT,46) IZER
      IF (.NOT.TZER) WRITE (LUNOUT,48) IZER
C
      CALL RCHEK (BCK,PRJ,1)
C
      CALL MEMST (LPROJ,2*KDIM)
      IF (TERR) CALL MEMST (LWGT,KDIM*NANG)
      IF (TRLX) CALL MEMST (LTRAN,NMAT)
      CALL MEMST (LDEL,NMAT)
      CALL MEMST (LTEMP,NMAT)
      IF (TSTORE) GO TO 32
C
      IF (TCIR.AND..NOT.TZER) CALL CISQ (X,X,2)
      CALL SETIT (X,CHI,PRJ,BCK)
C
      ITER=0
      IF (TCIR) CALL CISQ (X,X,1)
      CALL USER (ITER,X,CHI)
      IF (TCIR) CALL CISQ (X,X,2)
      IF (NSTP.LE.0) WRITE (LUNOUT,50)
      IF (NSTP.LE.0) CALL EMESG (5,NAMER(5),1)
C
   10 DELSQ=DOT(DEL(LDEL),1,DEL(LDEL),1,NMAT)
C
C        *PROJECTION OF THE GRADIENT THEN BACKPROJECTION
C
      IF (.NOT.TRLX) GO TO 14
      DO 12 I=1,NMAT
      ISUB1=LDEL+I-1
      ISUB2=LTRAN+I-1
   12 DEL(ISUB1)=DEL(ISUB1)*TRAN(ISUB2)
   14 CONTINUE
      DO 18 M=1,NANG
      CALL PRJ (DEL(LDEL),PROJ(LPROJ),M)
      IF (.NOT.TERR) GO TO 18
      DO 16 I=1,KDIM
      ISUB1=LPROJ+I-1
      ISUB2=LWGT+(M-1)*KDIM+I-1
   16 PROJ(ISUB1)=PROJ(ISUB1)*WGT(ISUB2)
   18 CALL BCK (TEMP(LTEMP),PROJ(LPROJ),M)
      DOTP=DOT(DEL(LDEL),1,TEMP(LTEMP),1,NMAT)
      IF (ABS(DOTP).GT.0.) GO TO 20
      WRITE (LUNOUT,52)
      IF (TCIR) CALL CISQ (X,X,1)
      GO TO 32
   20 P=DELSQ/DOTP
C
C        *THE NEW SOLUTION FOR THE RECONSTRUCTED ARRAY
C
      DO 22 I=1,NMAT
      ISUB=LDEL+I-1
   22 X(I)=X(I)+P*DEL(ISUB)
      IF (.NOT.TRLX) GO TO 26
      DO 24 I=1,NMAT
      ISUB1=LDEL+I-1
      ISUB2=LTRAN+I-1
      ISUB3=LTEMP+I-1
   24 DEL(ISUB1)=DEL(ISUB1)/TRAN(ISUB2)-P*TEMP(ISUB3)*TRAN(ISUB2)
      GO TO 30
   26 DO 28 I=1,NMAT
      ISUB1=LDEL+I-1
      ISUB2=LTEMP+I-1
   28 DEL(ISUB1)=DEL(ISUB1)-P*TEMP(ISUB2)
C
C        *THE NEW CHI-SQUARE
C
   30 ITER=ITER+1
      CHI=CHI-P*DELSQ
      IF (TCIR) CALL CISQ (X,X,1)
      CALL USER (ITER,X,CHI)
      IF (TCIR) CALL CISQ (X,X,2)
      IF (ITER.LT.NSTP) GO TO 10
      IF (TCIR) CALL CISQ (X,X,1)
C
   32 CALL MEMST (LPROJ,0)
      IF (TERR) CALL MEMST (LWGT,0)
      IF (TRLX) CALL MEMST (LTRAN,0)
      CALL MEMST (LDEL,0)
      CALL MEMST (LTEMP,0)
      TERR=.FALSE.
C
      CALL MEMST (MAXFW,-1)
      WRITE (LUNOUT,54) MAXFW
      CALL LGTXT (NAMER,9)
      RETURN
C
C
C
   34 FORMAT(  ////11X,31HPARAMETERS FOR SUBROUTINE GRADY//19X,11HDESCRI
     1PTION/1X)
   36 FORMAT(9H ISTP -  ,I6,4X,25HNUMBER OF ITERATION STEPS)
   38 FORMAT(9H IRLX -  ,I6,4X,27HITERATIVE RELAXATION METHOD)
   40 FORMAT(9H IRLX -  ,I6,4X,25HITERATIVE GRADIENT METHOD)
   42 FORMAT(9H IERR -  ,I6,4X,15HUSE ERROR ARRAY)
   44 FORMAT(9H IERR -  ,I6,4X,22HDO NOT USE ERROR ARRAY)
   46 FORMAT(9H IZER -  ,I6,4X,24HINITIAL SOLUTION IS ZERO)
   48 FORMAT(9H IZER -  ,I6,4X,33HINITIAL SOLUTION SUPPLIED BY USER)
   50 FORMAT(//10X,27HTHE NUMBER OF STEPS NSTP = ,I3,16H IS LESS THAN 0.
     1)
   52 FORMAT(//1X,44H***THE GRADIENT IS EQUAL TO ZERO***          )
   54 FORMAT(//10X,38HMAXIMUM SIZE OF BLANK COMMON THUS FAR=,I7,
     122H FLOATING POINT WORDS.)
      END
```

GVERS

```
      SUBROUTINE GVERS (X,XE,PRJ,BCK,CHISQ,IERR)
C
C     ******************************************************************
C     *      RECLBL     --          VERSION 1.0     --          17OCT77    *
C     ******************************************************************
C
C           THE SUBROUTINE GVERS RECONSTRUCTS THE ARRAY X USING
C        GENERALIZED MATRIX INVERSION.
C
C          X        - THE RECONSTRUCTION ARRAY
C          XE       - ARRAY IN WHICH ERRORS ON THE RECONSTRUCTED VALUES
C                       ARE RETURNED IF IERR IS SET TO 2. SHOULD BE THE
C                       SAME DIMENSION AS X.
C          PRJ      - THE PROJECTION SUBROUTINE
C          BCK      - THE BACK PROJECTION SUBROUTINE
C          CHISQ    - THE RESULTING CHI-SQUARE
C          IERR     - ERROR INDICATOR, SET AS FOLLOWS
C                     1 - INPUT DATA UNCERTAINTIES USED, BUT NO ERRORS
C                             CALCULATED FOR RECONSTRUCTED VALUES
C                     2 - INPUT DATA UNCERTAINTIES USED AND ERRORS ARE
C                             CALCULATED FOR THE RECONSTRUCTED VALUES.
C                     OTHERWISE - INPUT DATA UNCERTAINTIES NOT USED AND
C                                   ERRORS NOT CALCULATED
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - EMESG,GETDE, GINV,
C          LGTXT, MEMST, RCHEK, ZERO
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        EXTERNAL RECLBL SUBROUTINES - BCK, PRJ
C
C        LANGUAGE - FORTRAN
C
C
```

```
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                        COMMON
C          IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT   - NUMBER OF WORDS FOR A FLCATING POINT VARIABLE
C          ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                        SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                        FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                        EXECUTING.
C          WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/GNVCOM/LGMAT,LUMAT,LIGFLG,KIGFLG,LGTEMP,LGVEC
      DIMENSION GMAT(1),UMAT(1),IGFLG(1),GTEMP(1),GVEC(1)
      EQUIVALENCE (WORK(1),GMAT(1),UMAT(1),IGFLG(1),GTEMP(1),GVEC(1))
C
C          LGMAT    - POINTER TO THE ARRAY GMAT IN BLANK COMMON
C                        MATRIX TO INVERT IN GVERS
C          LUMAT    - POINTER TO THE ARRAY UMAT IN BLANK COMMON
C                        BOOKKEEPING MATRIX FOR GVERS
C          LIGFLG   - POINTER TO THE ARRAY IGFLG IN BLANK COMMON
C                        FLAGS FOR GVERS
C          KIGFLG   - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE IGFLG
C                        IS AN INTEGER
C          LGTEMP   - POINTER TO THE ARRAY GTEMP IN BLANK COMMON
C                        TEMPORARY STORAGE FOR GVERS
C          LGVEC    - POINTER TO THE ARRAY GVEC IN BLANK COMMON
C                        PROJECTION STORAGE FOR GVERS
C
      COMMON/ITRCOM/NSTP,TRLX,TERR,TZER,LWGT,LDEL,LTEMP,LCDEL,LTRAN
      LOGICAL TRLX,TERR,TZER
      DIMENSION WGT(1),DEL(1),TEMP(1),CDEL(1),TRAN(1)
      EQUIVALENCE (WORK(1),WGT(1),DEL(1),TEMP(1),CDEL(1),TRAN(1))
C
C          NSTP     - NUMBER OF ITERATION STEPS
C          TRLX     - LOGICAL VARIABLE SET TRUE FOR RELAXATION
C          TERR     - LOGICAL VARIABLE SET TRUE FOR WEIGHTED LEAST SQUARE
C          TZER     - LOGICAL VARIABLE SET TRUE TO ZERO INITIAL SOLUTION
C          LWGT     - POINTER TO THE ARRAY WGT IN BLANK COMMON
C                        WEIGHTS FOR WEIGHTED LEAST SQUARES (SEE TERR)
C          LDEL     - POINTER TO THE ARRAY DEL IN BLANK COMMON
C                        GRADIENT VECTOR
C          LTEMP    - POINTER TO THE ARRAY TEMP IN BLANK COMMON
C                        TEMPORARY STORAGE TO INCREASE SPEED
C          LCDEL    - POINTER TO THE ARRAY CDEL IN BLANK COMMON
C                        STEP DIRECTION FOR CONJUGATE GRADIENTS
C          LTRAN    - POINTER TO THE ARRAY TRAN IN BLANK COMMON
C                        TRANSFORMATION MATRIX FOR RELAXATION (SEE TRLX)
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT   - LOGICAL UNIT NUMBER FOR OUTPUT
C          I80132   - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                        OUTPUT ON LUNOUT
C                 0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                        NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                        THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                        IS AN INTEGER VARIABLE
C
      COMMON/STRCOM/TSTORE
      LOGICAL TSTORE
C
C          TSTORE   - LOGICAL VARIABLE SET TRUE WHEN TESTING STORAGE SIZE
C                        SETS TPRINT(1) = .TRUE.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C          IGEOM    - GEOMETRY FLAG
C                 0 = PARALLEL BEAM GEOMETRY
C                 1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                 2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                 3 = RING DETECTOR GEOMETRY
C          KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                        BY THE USER
C          AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                        AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                        IN THE CENTER OF A PROJECTION BIN.)
C          BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C          KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                        ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                        ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C          KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C          KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE LAST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C          KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                        TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                        KDIM=KDIMU.
C          AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                        INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                        VECTOR
C          NANG     - NUMBER OF PROJECTIONS
C          MODANG   - MODE FOR PROJECTION ANGLE INPUT
C          LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                        PROJECTION ANGLES IN RADIANS
C          LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                        SINE OF THE PROJECTION ANGLES
C          LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                        COSINE OF THE PROJECTION ANGLES
C          LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                        USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                        FALSE FOR TRANSMISSION DATA
C
      EXTERNAL BCK,PRJ
      DIMENSION X(1),XE(1),NAMER(9)
      LOGICAL TERR1,TERR2
      DATA NAMER/1HE,1HN,1HD,1H ,1HG,1HV,1HE,1HR,1HS/
      DATA IOK/2HOK/
C
C        *BE SURE THAT SETUP HAS BEEN CALLED
C
      IF (ISETUP.NE.IOK) CALL EMESG (1,NAMER(5),1)
C
      TERR1=IERR.EQ.1
      TERR2=IERR.EQ.2
      TERR=TERR1.OR.TERR2
C
      CALL LGTXT (NAMER(5),5)
      WRITE (LUNOUT,26)
      IF (TERR1) WRITE (LUNOUT,28) IERR
      IF (TERR2) WRITE (LUNOUT,30) IERR
      IF (.NOT.TERR) WRITE (LUNOUT,32) IERR
C
      CALL RCHEK (BCK,PRJ,1)
C
      NDAT=KDIM*NANG
      CALL MEMST (LGMAT,NDAT*NMAT)
      CALL MEMST (LUMAT,NMAT**2)
      CALL MEMST (KIGFLG,NMAT)
      CALL MEMST (LGTEMP,NMAT)
      IF (TERR) CALL MEMST (LGVEC,2*NDAT)
      IF (.NOT.TERR) CALL MEMST (LGVEC,NDAT)
      IF (TERR) CALL MEMST (LPROJ,2*KDIM)
      IF (.NOT.TERR) CALL MEMST (LPROJ,KDIM)
      IF (TSTORE) GO TO 24
C
      CALL ZERO (UMAT(LUMAT),KDIM)
      KM=0
      DO 12 M=1,NANG
      ISUB=LPROJ+KDIM
      CALL GETDE (M,PROJ(LPROJ),PROJ(ISUB))
C
      DO 12 K=1,KDIM
      KM=KM+1
      CALL ZERO (GTEMP(LGTEMP),NMAT)
      ISUB=LUMAT+K-1
      UMAT(ISUB)=1.
      CALL BCK (GTEMP(LGTEMP),UMAT(LUMAT),M)
      UMAT(ISUB)=0.
C
      FAC=1.
      IF (.NOT.TERR) GO TO 10
      ISUB=LPROJ+KDIM+K-1
      FAC=1./PROJ(ISUB)
      ISUB=LGVEC+KM+NDAT-1
      GVEC(ISUB)=FAC
C
   10 ISUB1=LGVEC+KM-1
      ISUB2=LPROJ+K-1
      GVEC(ISUB1)=FAC*PROJ(ISUB2)
C
      ISUB1=LGMAT+KM-1
      ISUB2=LGTEMP
      DO 12 IJ=1,NMAT
      GMAT(ISUB1)=FAC*GTEMP(ISUB2)
      ISUB1=ISUB1+NDAT
      ISUB2=ISUB2+1
   12 CONTINUE
C
      CALL GINV (GMAT(LGMAT),UMAT(LUMAT),IGFLG(LIGFLG),GTEMP(LGTEMP),NDA
     1T,NMAT)
C
      ISUB=LGMAT
      DO 14 IJ=1,NMAT
      X(IJ)=DOT(GVEC(LGVEC),1,GMAT(ISUB),1,NDAT)
      IF (TERR2) XE(IJ)=SQRT(DOT(GMAT(ISUB),1,GMAT(ISUB),1,NDAT))
   14 ISUB=ISUB+NDAT
C
      CHISQ=0.
      IF (.NOT.TERR) GO TO 18
C
      DO 16 M=1,NANG
      CALL PRJ (X,PROJ(LPROJ),M)
      ISUB1=LPROJ
      ISUB2=LGVEC+NDAT+KDIM*(M-1)
      ISUB3=ISUB2-NDAT
      DO 16 K=1,KDIM
      CHISQ=CHISQ+(PROJ(ISUB1)*GVEC(ISUB2)-GVEC(ISUB3))**2
      ISUB1=ISUB1+1
      ISUB2=ISUB2+1
   16 ISUB3=ISUB3+1
      GO TO 22
C
   18 DO 20 M=1,NANG
      CALL PRJ (X,PROJ(LPROJ),M)
      ISUB1=LPROJ
      ISUB3=LGVEC+KDIM*(M-1)
      DO 20 K=1,KDIM
      CHISQ=CHISQ+(PROJ(ISUB1)-GVEC(ISUB3))**2
      ISUB1=ISUB1+1
   20 ISUB3=ISUB3+1
C
   22 IF (TCIR) CALL CISQ (X,X,1)
      IF (TCIR.AND.TERR2) CALL CISQ (XE,XE,1)
C
   24 CALL MEMST (LGMAT,0)
      CALL MEMST (LUMAT,0)
      CALL MEMST (KIGFLG,0)
      CALL MEMST (LGTEMP,0)
      CALL MEMST (LPROJ,0)
      CALL MEMST (LGVEC,0)
      CALL MEMST (MAXFW,-1)
      WRITE (LUNOUT,34) MAXFW
      CALL LGTXT (NAMER,9)
      TERR=.FALSE.
      RETURN
C
C
   26 FORMAT(////11X,31HPARAMETERS FOR SUBROUTINE GVERS//19X,11HDESCRIPT
     1ION/)
   28 FORMAT(9H IERR -   ,I6,4X,42HUSE UNCERTAINTIES, DO NOT CALCULATE ER
     1RORS)
   30 FORMAT(9H IERR -   ,I6,4X,38HUSE UNCERTAINTIES AND CALCULATE ERRORS
     1)
   32 FORMAT(9H IERR -   ,I6,4X,24HDO NOT USE UNCERTAINTIES)
   34 FORMAT(//10X,38HMAXIMUM SIZE OF BLANK COMMON THUS FAR=,I7,
     122H FLOATING POINT WORDS.)
      END
```

HAM

```
      SUBROUTINE HAM (H,XI,M)
C
C     ****************************************************************
C     *       RECLBL    --          VERSION 1.0    --        17OCT77   *
C     ****************************************************************
C
C           THE SUBROUTINE HAM EVALUATES AT THE POINT XI THE VALUE OF
C        THE FILTER OBTAINED BY MULTIPLYING THE HAMMING WINDOW BY THE
C        ABSOLUTE VALUE OF THE MEASURE, ABS(XI).
C
C           H       - THE FUNCTIONAL VALUE
C           XI      - THE INDEPENDENT VARIABLE
C           M       - HAS THE FOLLOWING VALUES
C                     .LE. 0 THE FLAGS ARE RETURNED IN H
C                     .GT. 0 THE FUNCTIONAL VALUE IS RETURNED IN H
C
C        THE FILTER PARAMETER FREQ IS PASSED IN THE COMMON BLOCK FILCOM.
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C           NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                        COMMON
C           IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C           NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C           ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                        SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                        FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                        EXECUTING.
C           WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/FILCOM/ORDER,FREQ,LBCKA,LPRJA,LFILT
      DIMENSION BCKA(1),PRJA(1),FILT(1)
      EQUIVALENCE (WORK(1),BCKA(1),PRJA(1),FILT(1))
C
C           ORDER   - FILTER PARAMETER USED ONLY BY THE FILTER BUTER
C           FREQ    - FILTER PARAMETER
C           LBCKA   - POINTER TO THE ARRAY BCKA IN BLANK COMMON
C                        BACK-PROJECTION ARRAY WHICH HAS THE DIMENSION
C                        NDIM X NDIM
C           LPRJA   - POINTER TO THE ARRAY PRJA IN BLANK COMMON
C                        A PROJECTION ARRAY FOR ONE ANGLE
C           LFILT   - POINTER TO THE ARRAY FILT IN BLANK COMMON
C                        ARRAY OF FILTER VALUES
C
      DIMENSION H(1)
C
C        BCK/PRJ/CNV/2DF,WT,ATEN,FAN ARE THE J FLAGS RETURNED IN H
C           IF M .LE. 0
C
      DIMENSION FLAGS(4)
      DATA FLAGS/3.,-1.,0.,-1./
C
      IF (M.LE.0) GO TO 14
C
      PI=4.*ATAN(1.)
      HA=0.
      IF (XI.GT.FREQ) GO TO 12
      HA=(.54+.46*COS(PI*XI/FREQ))*XI
      IF (HA) 10,12,12
   10 HA=0.
   12 H(1)=HA
      RETURN
C
   14 DO 16 I=1,4
   16 H(I)=FLAGS(I)
C
      RETURN
      END
```

HAN

```
      SUBROUTINE HAN (H,XI,M)
C
C     ****************************************************************
C     *       RECLBL    --          VERSION 1.0    --        17OCT77   *
C     ****************************************************************
C
C           THE SUBROUTINE HAN EVALUATES AT THE POINT XI THE VALUE OF
C        THE FILTER OBTAINED BY MULTIPLYING THE HANN WINDOW BY THE
C        ABSOLUTE VALUE OF THE MEASURE, ABS(XI).
C
C           H       - THE FUNCTIONAL VALUE
C           XI      - THE INDEPENDENT VARIABLE
C           M       - HAS THE FOLLOWING VALUES
C                     .LE. 0 THE FLAGS ARE RETURNED IN H
C                     .GT. 0 THE FUNCTIONAL VALUE IS RETURNED IN H
C
C        THE FILTER PARAMETER FREQ IS PASSED IN THE COMMON BLOCK FILCOM.
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C           NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                        COMMON
C           IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C           NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C           ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                        SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                        FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                        EXECUTING.
C           WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/FILCOM/ORDER,FREQ,LBCKA,LPRJA,LFILT
      DIMENSION BCKA(1),PRJA(1),FILT(1)
      EQUIVALENCE (WORK(1),BCKA(1),PRJA(1),FILT(1))
C
C           ORDER   - FILTER PARAMETER USED ONLY BY THE FILTER BUTER
C           FREQ    - FILTER PARAMETER
C           LBCKA   - POINTER TO THE ARRAY BCKA IN BLANK COMMON
C                        BACK-PROJECTION ARRAY WHICH HAS THE DIMENSION
C                        NDIM X NDIM
C           LPRJA   - POINTER TO THE ARRAY PRJA IN BLANK COMMON
C                        A PROJECTION ARRAY FOR ONE ANGLE
C           LFILT   - POINTER TO THE ARRAY FILT IN BLANK COMMON
C                        ARRAY OF FILTER VALUES
C
      DIMENSION H(1)
C
C        BCK/PRJ/CNV/2DF,WT,ATEN,FAN ARE THE J FLAGS RETURNED IN H
C           IF M .LE. 0
C
      DIMENSION FLAGS(4)
      DATA FLAGS/3.,-1.,0.,-1./
C
      IF (M.LE.0) GO TO 14
C
      PI=4.*ATAN(1.)
      HA=0.
      IF (XI.GT.FREQ) GO TO 12
      HA=.5*(1.+COS(PI*XI/FREQ))*XI
      IF (HA) 10,12,12
   10 HA=0.
   12 H(1)=HA
      RETURN
C
   14 DO 16 I=1,4
   16 H(I)=FLAGS(I)
C
      RETURN
      END
```

IOCTL

```
      FUNCTION IOCTL (IDEC)
C
C     ****************************************************************
C     *       RECLBL    --          VERSION 1.0    --        17OCT77   *
C     ****************************************************************
C
C           THE FUNCTION IOCTL RETURNS A NUMBER WHOSE DECIMAL DIGITS
C        REPRESENT THE OCTAL DIGITS OF IDEC.  BY USING THIS FUNCTION
C        THE RESULT CAN BE PRINTED IN I-FORMAT GIVING THE OCTAL
C        REPRESENTATION OF IDEC.
C
C           IDEC    - DECIMAL REPRESENTATION OF THE VALUE TO BE CONVERTED
C
C        LANGUAGE - FORTRAN
C
      IO=MOD(IDEC,8)
      ID=IDEC/8
C
      DO 10 I=1,19
      IF (ID.EQ.0) GO TO 12
      L=MOD(ID,8)
      IO=IO+L*10**I
   10 ID=ID/8
C
   12 IOCTL=IO
      RETURN
      END
```

LAKS

```
      SUBROUTINE LAKS (X,RA,M)
C
C     ****************************************************************
C     *       RECLBL    --          VERSION 1.0    --        17OCT77   *
C     ****************************************************************
C
C           SUBROUTINE LAKS GENERATES THE CONVOLUTION AND WEIGHT
C        FUNCTIONS FOR CONVOLUTION RECONSTRUCTION OF FAN BEAM DATA.
C        TWO DIFFERENT SETS OF FUNCTIONS ARE AVAILABLE FOR CURVED AND
C        FLAT DETECTORS.  THESE FUNCTIONS ARE TAKEN FROM THE ARTICLE BY
C        HERMAN, LAKSHMINARAYANAN AND NAPARSTEK, COMPUT. BIO. MED.,
C        VOL. 6, P. 259, (1976).
C
C           X       - ARRAY IN WHICH THE CONVOLUTION AND WEIGHT FUNCTIONS
C                        ARE RETURNED
C           RA(1)   - DISTANCE FROM THE SOURCE TO THE CENTER OF ROTATION
C                        (POSITIVE FOR CURVED DETECTOR, NEGATIVE FOR FLAT
C                        DETECTOR)
C           RA(2)   - THE PROJECTED LOCATION OF THE ROTATION AXIS
C           M       - IF M IS LESS THAN OR EQUAL TO ZERO THEN FLAGS ARE
C                        RETURNED IN THE ARRAY X.  OTHERWISE THE
C                        CONVOLUTION FUNCTION (LENGTH=2*M-1) AND THE
C                        WEIGHT FUNCTION (LENGTH=M) ARE RETURNED
C
C        LANGUAGE - FORTRAN
C
      DIMENSION X(1),RA(2)
      DIMENSION FLAGS(4)
      DATA FLAGS/2.,-1.,0.,1./
C
      IF (M.LE.0) GO TO 22
C
      R=ABS(RA(1))
      AX=RA(2)
      ALPHA=1./R
      PI=4.*ATAN(1.)
      M1=M-1
      M2=M+1
```

```
C
      ISUB1=M1-1
      ISUB2=M2+1
      DO 10 K=2,M1,2
      X(ISUB1)=0.
      X(ISUB2)=0.
      ISUB1=ISUB1-2
   10 ISUB2=ISUB2+2
C
      X(M)=.25*PI
      ISUB1=M1
      ISUB2=M2
      IF (RA(1).LT.0.) GO TO 16
C
C        *CURVED DETECTOR
C
      DO 12 K=1,M1,2
      X(ISUB1)=-ALPHA**2/(PI*SIN(FLOAT(K)*ALPHA)**2)
      X(ISUB2)=X(ISUB1)
      ISUB1=ISUB1-2
   12 ISUB2=ISUB2+2
C
      ISUB=2*M
      DO 14 K=1,M
      X(ISUB)=COS((FLOAT(K)-AX)*ALPHA)
   14 ISUB=ISUB+1
      RETURN
C
C        *FLAT DETECTOR
C
   16 DO 18 K=1,M1,2
      X(ISUB1)=-1./(PI*FLOAT(K)**2)
      X(ISUB2)=X(ISUB1)
      ISUB1=ISUB1-2
   18 ISUB2=ISUB2+2
C
      ISUB=2*M
      DO 20 K=1,M
      X(ISUB)=1./SQRT(1.+((FLOAT(K)-AX)*ALPHA)**2)
   20 ISUB=ISUB+1
      RETURN
C
   22 DO 24 I=1,4
   24 X(I)=FLAGS(I)
      RETURN
      END
```

LGTXT

```
      SUBROUTINE LGTXT (MESG,LEN)
C
C     ****************************************************************
C     *      RECLBL    --        VERSION 1.0     --         17OCT77   *
C     ****************************************************************
C
C            THE SUBROUTINE LGTXT WRITES OUT LARGER-THAN-LIFE TEXT
C        ON THE FILE LUNOUT.  THE TEXT IS EXPECTED TO BE FOUND IN THE
C        ARRAY MESG, ONE CHARACTER PER WORD, IN A1 FORMAT.  THE NUMBER
C        OF CHARACTERS IS LEN WHICH MUST BE NO LARGER THAN 20.
C
C          MESG     - TEXT ARRAY WITH EACH WORD CONTAINING ONE CHARACTER
C                       LEFT JUSTIFIED WITH BLANK FILL
C          LEN      - NUMBER OF CHARACTERS IN MESG
C
C        LANGUAGE - FORTRAN
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                       COMMON
C          IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                       SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                       FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                       EXECUTING.
C          WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT   - LOGICAL UNIT NUMBER FOR OUTPUT
C          I80132   - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                       OUTPUT ON LUNOUT
C              0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      INTEGER MESG(1),CHAR(3,5,47),LETR(47),INDX(20),IBUF(60)
C
      INTEGER A(15),B(15),C(15),D(15),E(15),F(15),G(15),H(15),I(15),
     1        J(15),K(15),L(15),M(15),N(15),O(15),P(15),Q(15),R(15),
     2        S(15),T(15),U(15),V(15),W(15),X(15),Y(15),Z(15)
C
      INTEGER NO(15),N1(15),N2(15),N3(15),N4(15),N5(15),N6(15),N7(15),
     1        N8(15),N9(15),PL(15),MI(15),AS(15),SL(15),OP(15),CP(15),
     2        DS(15),EQ(15),BL(15),CM(15),PD(15)
C
      EQUIVALENCE           (A(1),CHAR(1,1, 1)),(B(1),CHAR(1,1, 2)),
     1 (C(1),CHAR(1,1, 3)),(D(1),CHAR(1,1, 4)),(E(1),CHAR(1,1, 5)),
     2 (F(1),CHAR(1,1, 6)),(G(1),CHAR(1,1, 7)),(H(1),CHAR(1,1, 8)),
     3 (I(1),CHAR(1,1, 9)),(J(1),CHAR(1,1,10)),(K(1),CHAR(1,1,11)),
     4 (L(1),CHAR(1,1,12)),(M(1),CHAR(1,1,13)),(N(1),CHAR(1,1,14)),
     5 (O(1),CHAR(1,1,15)),(P(1),CHAR(1,1,16)),(Q(1),CHAR(1,1,17)),
     6 (R(1),CHAR(1,1,18)),(S(1),CHAR(1,1,19)),(T(1),CHAR(1,1,20)),
     7 (U(1),CHAR(1,1,21)),(V(1),CHAR(1,1,22)),(W(1),CHAR(1,1,23)),
     8 (X(1),CHAR(1,1,24)),(Y(1),CHAR(1,1,25)),(Z(1),CHAR(1,1,26))
C
      EQUIVALENCE           (NO(1),CHAR(1,1,27)),(N1(1),CHAR(1,1,28)),
     1 (N2(1),CHAR(1,1,29)),(N3(1),CHAR(1,1,30)),(N4(1),CHAR(1,1,31)),
     2 (N5(1),CHAR(1,1,32)),(N6(1),CHAR(1,1,33)),(N7(1),CHAR(1,1,34)),
     3 (N8(1),CHAR(1,1,35)),(N9(1),CHAR(1,1,36)),(PL(1),CHAR(1,1,37)),
     4 (MI(1),CHAR(1,1,38)),(AS(1),CHAR(1,1,39)),(SL(1),CHAR(1,1,40)),
     5 (OP(1),CHAR(1,1,41)),(CP(1),CHAR(1,1,42)),(DS(1),CHAR(1,1,43)),
     6 (EQ(1),CHAR(1,1,44)),(BL(1),CHAR(1,1,45)),(CM(1),CHAR(1,1,46)),
     7 (PD(1),CHAR(1,1,47))
C
      DATA LETR/1HA,1HB,1HC,1HD,1HE,1HF,1HG,1HH,1HI,1HJ,1HK,1HL,1HM,1HN,
     1          1HO,1HP,1HQ,1HR,1HS,1HT,1HU,1HV,1HW,1HX,1HY,1HZ,1HO,1H1,
     2          1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9,1H+,1H-,1H*,1H/,1H(,1H),
     3          1H$,1H=,1H ,1H,,1H./
C
      DATA A /2H A,2HAA,2H  , 2HA ,2H  ,2HA , 2HA ,2H  ,2HA ,
     1        2HAA,2HAA,2HA , 2HA ,2H  ,2HA /
      DATA B /2HBB,2HBB,2H  , 2HB ,2H  ,2HB , 2HBB,2HBB,2H  ,
     1        2HB ,2H  ,2HB , 2HBB,2HBB,2H  /
      DATA C /2H C,2HCC,2H  , 2HC ,2H  ,2HC , 2HC ,2H  ,2H  ,
     1        2HC ,2H  ,2HC , 2H C,2HCC,2H  /
      DATA D /2HDD,2HDD,2H  , 2HD ,2H  ,2HD , 2HD ,2H  ,2HD ,
     1        2HD ,2H  ,2HD , 2HDD,2HDD,2H  /
      DATA E /2HEE,2HEE,2HE , 2HE ,2H  ,2H  , 2HEE,2HE ,2H  ,
     1        2HE ,2H  ,2H  , 2HEE,2HEE,2HE /
      DATA F /2HFF,2HFF,2HF , 2HF ,2H  ,2H  , 2HFF,2HF ,2H  ,
     1        2HF ,2H  ,2H  , 2HF ,2H  ,2H  /
      DATA G /2H G,2HGG,2H  , 2HG ,2H  ,2HG , 2HG ,2H  ,2H  ,
     1        2HG ,2H G,2HG , 2H G,2HGG,2HG /
      DATA H /2HH ,2H  ,2HH , 2HH ,2H  ,2HH , 2HHH,2HHH,2HH ,
     1        2HH ,2H  ,2HH , 2HH ,2H  ,2HH /
      DATA I /2H I,2HII,2H  , 2H  ,2HI ,2H  , 2H  ,2HI ,2H  ,
     1        2H  ,2HI ,2H  , 2H I,2HII,2H  /
      DATA J /2H  ,2H  ,2HJ , 2H  ,2H  ,2HJ , 2H  ,2H  ,2HJ ,
     1        2HJ ,2H  ,2HJ , 2H J,2HJJ,2H  /
      DATA K /2HK ,2H  ,2HK , 2HK ,2H K,2H  , 2HKK,2HK ,2H  ,
     1        2HK ,2H K,2H  , 2HK ,2H  ,2HK /
      DATA L /2HL ,2H  ,2H  , 2HL ,2H  ,2H  , 2HL ,2H  ,2H  ,
     1        2HL ,2H  ,2H  , 2HLL,2HLL,2HL /
      DATA M /2HM ,2H  ,2HM , 2HMM,2H M,2HM , 2HM ,2HM ,2HM ,
     1        2HM ,2H  ,2HM , 2HM ,2H  ,2HM /
      DATA N /2HN ,2H  ,2HN , 2HNN,2H  ,2HN , 2HN ,2HN ,2HN ,
     1        2HN ,2H N,2HN , 2HN ,2H  ,2HN /
      DATA O /2HOO,2HOO,2HO , 2HO ,2H  ,2HO , 2HO ,2H  ,2HO ,
     1        2HO ,2H  ,2HO , 2HOO,2HOO,2HO /
      DATA P /2HPP,2HPP,2H  , 2HP ,2H  ,2HP , 2HPP,2HPP,2H  ,
     1        2HP ,2H  ,2H  , 2HP ,2H  ,2H  /
      DATA Q /2H Q,2HQQ,2H  , 2HQ ,2H  ,2HQ , 2HQ ,2H  ,2HQ ,
     1        2HQ ,2H Q,2HQ , 2H C,2HQQ,2HQ /
      DATA R /2HRR,2HRR,2H  , 2HR ,2H  ,2HR , 2HRR,2HRR,2H  ,
     1        2HR ,2H R,2H  , 2HR ,2H  ,2HR /
      DATA S /2H S,2HSS,2H  , 2HS ,2H  ,2H  , 2H S,2HSS,2H  ,
     1        2H  ,2H  ,2HS , 2H S,2HSS,2H  /
      DATA T /2HTT,2HTT,2HT , 2H  ,2HT ,2H  , 2H  ,2HT ,2H  ,
     1        2H  ,2HT ,2H  , 2H  ,2HT ,2H  /
      DATA U /2HU ,2H  ,2HU , 2HU ,2H  ,2HU , 2HU ,2H  ,2HU ,
     1        2HU ,2H  ,2HU , 2H U,2HUU,2H  /
      DATA V /2HV ,2H  ,2HV , 2HV ,2H  ,2HV , 2H V,2H V,2H  ,
     1        2H V,2H V,2H  , 2H  ,2HV ,2H  /
      DATA W /2HW ,2H  ,2HW , 2HW ,2H  ,2HW , 2HW ,2H  ,2HW ,
     1        2HW ,2HW ,2HW , 2H W,2H W,2H  /
      DATA X /2HX ,2H  ,2HX , 2H X,2H X,2H  , 2H  ,2HX ,2H  ,
     1        2H X,2H X,2H  , 2HX ,2H  ,2HX /
      DATA Y /2HY ,2H  ,2HY , 2H Y,2H Y,2H  , 2H  ,2HY ,2H  ,
     1        2H  ,2HY ,2H  , 2H  ,2HY ,2H  /
      DATA Z /2HZZ,2HZZ,2HZ , 2H  ,2H Z,2H  , 2H  ,2HZ ,2H  ,
     1        2H Z,2H  ,2H  , 2HZZ,2HZZ,2HZ /
      DATA NO/2H O,2HOO,2H  , 2HO ,2H  ,2HO , 2HO ,2H  ,2HO ,
     1        2HO ,2H  ,2HO , 2H O,2HOO,2H  /
      DATA N1/2H  ,2H1 ,2H  , 2H 1,2H1 ,2H  , 2H  ,2H1 ,2H  ,
     1        2H  ,2H1 ,2H  , 2H  ,2H1 ,2H  /
      DATA N2/2H 2,2H22,2H  , 2H2 ,2H  ,2H2 , 2H  ,2H22,2H  ,
     1        2H 2,2H  ,2H  , 2H22,2H22,2H2 /
      DATA N3/2H33,2H33,2H3 , 2H  ,2H  ,2H3 , 2H  ,2H 3,2H  ,
     1        2H3 ,2H  ,2H3 , 2H 3,2H33,2H  /
      DATA N4/2H  ,2H 4,2H  , 2H  ,2H44,2H  , 2H 4,2H 4,2H  ,
     1        2H44,2H44,2H4 , 2H  ,2H 4,2H  /
      DATA N5/2H55,2H55,2H5 , 2H5 ,2H  ,2H  , 2H55,2H55,2H  ,
     1        2H  ,2H  ,2H5 , 2H 5,2H55,2H  /
      DATA N6/2H  ,2H 6,2H  , 2H  ,2H6 ,2H  , 2H 6,2H66,2H  ,
     1        2H6 ,2H  ,2H6 , 2H 6,2H66,2H  /
      DATA N7/2H77,2H77,2H7 , 2H  ,2H  ,2H7 , 2H  ,2H 7,2H  ,
     1        2H  ,2H7 ,2H  , 2H 7,2H  ,2H  /
      DATA N8/2H 8,2H88,2H  , 2H8 ,2H  ,2H8 , 2H 8,2H88,2H  ,
     1        2H8 ,2H  ,2H8 , 2H 8,2H88,2H  /
      DATA N9/2H 9,2H99,2H  , 2H9 ,2H  ,2H9 , 2H 9,2H99,2H  ,
     1        2H  ,2H9 ,2H  , 2H 9,2H  ,2H  /
      DATA PL/2H  ,2H+ ,2H  , 2H  ,2H+ ,2H  , 2H++,2H++,2H+ ,
     1        2H  ,2H+ ,2H  , 2H  ,2H+ ,2H  /
      DATA MI/2H  ,2H  ,2H  , 2H  ,2H  ,2H  , 2H--,2H--,2H- ,
     1        2H  ,2H  ,2H  , 2H  ,2H  ,2H  /
      DATA AS/2H* ,2H* ,2H* , 2H *,2H**,2H  , 2H**,2H**,2H* ,
     1        2H *,2H**,2H  , 2H* ,2H* ,2H* /
      DATA SL/2H  ,2H  ,2H/ , 2H  ,2H /,2H  , 2H  ,2H/ ,2H  ,
     1        2H /,2H  ,2H  , 2H/ ,2H  ,2H  /
      DATA OP/2H  ,2H( ,2H  , 2H (,2H  ,2H  , 2H (,2H  ,2H  ,
     1        2H (,2H  ,2H  , 2H  ,2H( ,2H  /
      DATA CP/2H ),2H  ,2H  , 2H  ,2H) ,2H  , 2H  ,2H) ,2H  ,
     1        2H  ,2H) ,2H  , 2H ),2H  ,2H  /
      DATA DS/2H $,2H$$,2H  , 2H$ ,2H$ ,2H  , 2H $,2H$$,2H  ,
     1        2H  ,2H$ ,2H$ , 2H $,2H$$,2H  /
      DATA EQ/2H  ,2H  ,2H  , 2H==,2H==,2H= , 2H  ,2H  ,2H  ,
     1        2H==,2H==,2H= , 2H  ,2H  ,2H  /
      DATA BL/2H  ,2H  ,2H  , 2H  ,2H  ,2H  , 2H  ,2H  ,2H  ,
     1        2H  ,2H  ,2H  , 2H  ,2H  ,2H  /
      DATA CM/2H  ,2H  ,2H  , 2H  ,2H  ,2H  , 2H  ,2H  ,2H  ,
     1        2H,,,2H  ,2H  , 2H, ,2H  ,2H  /
      DATA PD/2H  ,2H  ,2H  , 2H  ,2H  ,2H  , 2H  ,2H  ,2H  ,
     1        2H..,2H  ,2H  , 2H..,2H  ,2H  /
C
      IF (LEN.GT.13) RETURN
      IF (LEN.LT.1) RETURN
C
      LENG=0
      DO 14 II=1,LEN
      DO 10 JJ=1,47
      IF (MESG(II).EQ.LETR(JJ)) GO TO 12
   10 CONTINUE
      GO TO 14
   12 LENG=LENG+1
      INDX(LENG)=JJ
   14 CONTINUE
      IF (LENG.EQ.0) RETURN
      LLL=(39-3*LENG)/2
      IF (LLL.EQ.0) GO TO 18
      DO 16 II=1,LLL
   16 IBUF(II)=LETR(45)
   18 CONTINUE
      WRITE (LUNOUT,24)
C
      DO 22 LINE=1,5
      LL=LLL
      DO 20 II=1,LENG
      JJ=INDX(II)
      IBUF(LL+1)=CHAR(1,LINE,JJ)
      IBUF(LL+2)=CHAR(2,LINE,JJ)
      IBUF(LL+3)=CHAR(3,LINE,JJ)
   20 LL=LL+3
   22 WRITE (LUNOUT,26) (IBUF(LLL),LLL=1,LL)
      WRITE (LUNOUT,28)
C
      RETURN
C
   24 FORMAT(   //)
   26 FORMAT(2X,60A2)
   28 FORMAT(1X)
      END
```

MARR

```
      SUBROUTINE MARR (X,NDEG)
C
C     ******************************************************************
C     *       RECLBL     --         VERSION 1.0     --        17OCT77   *
C     ******************************************************************
C
C          THE SUBROUTINE MARR RECONSTRUCTS THE ARRAY X FOR A GIVEN
C       SET OF CORDS FROM POSITRON ANNILIATION EVENTS DETECTED WITH
C       A RING OF CRYSTALS.
C          THE SUBROUTINE IS A MODIFICATION OF THE PROGRAM ZHEAD
C       (*** VERSION 2.0 -- 12/10/71) SUPPLIED TO US BY R. MARR.  THE
C       CODE HAS BEEN CHANGED TO COMPLY WITH THE RECLBL LIBRARY.  THE
C       ALGORITHM IS DESCRIBED IN THE ARTICLE - R. B. MARR, ON THE
C       RECONSTRUCTION OF A FUNCTION ON A CIRCULAR DOMAIN FROM A
C       SAMPLING OF ITS LINE INTEGRALS, J. MATH ANALYSIS AND APPLICAT-
C       IONS, 45(1974), PP357-374.
C
C         X        - THE RECONSTRUCTION ARRAY
C         NDEG     - DEGREE OF THE POLYNOMIAL EXPANSION
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - EMESG, GETOM, LGTXT,
C         MEMST, RADAL
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                       COMMON
C          IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                       SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                       FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                       EXECUTING.
C          WORK    - BLANK COMMON WORKING ARRAY
C
C
      COMMON/MARCOM/LGAM,LGPRJ,LBBMR,LAAMR,LAMAR,LBMAR
      DIMENSION GAM(1),GPRJ(1),BBMR(1),AAMR(1),AMAR(1),BMAR(1)
      EQUIVALENCE (WORK(1),GAM(1),GPRJ(1),BBMR(1),AAMR(1),AMAR(1),
     1            BMAR(1))
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT  - LOGICAL UNIT NUMBER FOR OUTPUT
C          I80132  - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                       OUTPUT ON LUNOUT
C                0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      COMMON/PRTCOM/TPRINT(8)
      LOGICAL TPRINT
C
C          TPRINT  - LOGICAL PRINT FLAGS
C                1 - PRINT REQUIRED FLOATING POINT BLANK COMMON
C                       WHENEVER CHANGED
C                2 - PRINT PROJECTION DATA AND UNCERTAINTIES
C                3 - PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
C                4 - PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER
C                       ROUTINES
C                5 - PRINT VALUES FOR THE LAGRANGE MULTIPILERS AND
C                       THE GRADIENT FOR THE FUNCTION OF LAGRANGE MULTI-
C                       PILERS FOR THE ENTROPY RECONSTRUCTION
C                6 - PRINT POINTERS IN BLANK COMMON WHENEVER CHANGED
C                       (DEBUG)
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                       NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                       THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                       IS AN INTEGER VARIABLE
C
      COMMON/STRCOM/TSTORE
      LOGICAL TSTORE
C
C          TSTORE  - LOGICAL VARIABLE SET TRUE WHEN TESTING STORAGE SIZE
C                       SETS TPRINT(1) = .TRUE.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1             LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C          IGEOM   - GEOMETRY FLAG
C                0 = PARALLEL BEAM GEOMETRY
C                1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                3 = RING DETECTOR GEOMETRY
C          KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                       BY THE USER
C          AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                       PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                       AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                       IN THE CENTER OF A PROJECTION BIN.)
C          BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C          KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                       ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                       ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C          KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                       THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                       IS GOING TO BE USED.
C          KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                       THE DATA OF THE LAST USER PROJECTION BIN THAT
C                       IS GOING TO BE USED.
C          KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                       TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                       KDIM=KDIMU.
C          AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                       PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                       INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                       VECTOR
C          NANG    - NUMBER OF PROJECTIONS
C          MODANG  - MODE FOR PROJECTION ANGLE INPUT
C          LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                       PROJECTION ANGLES IN RADIANS
C          LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                       SINE OF THE PROJECTION ANGLES
C          LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                       COSINE OF THE PROJECTION ANGLES
C          LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                       USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                       FALSE FOR TRANSMISSION DATA
C
      DIMENSION X(1)
      LOGICAL TSAVE
      REAL MSGN
      DIMENSION NAMER(9)
      DATA NAMER/1HE,1HN,1HD,1H ,1HM,1HA,1HR,1HR,1H /
      DATA IOK/2HOK/
C
C        *BE SURE THAT SETUP HAS BEEN CALLED
C
      IF (ISETUP.NE.IOK) CALL EMESG (1,NAMER(5),1)
C
      CALL LGTXT (NAMER(5),5)
      PI=4.*ATAN(1.)
      NDIMM=FLOAT(NANG)/(PI*PWID)
      IF (NDIMM.GE.NDIM) GO TO 10
      HNDIM=FLOAT(NDIMM)/2.
      WRITE (LUNOUT,56) NANG,PWID,NDIMM,NDIM,HNDIM
      CALL EMESG (40,NAMER(5),0)
   10 NXTAL=NANG
      IF (IGEOM.EQ.3) GO TO 12
      WRITE (LUNOUT,58)
      CALL EMESG (38,NAMER(5),1)
   12 M=NDEG
      N2XTL=2*NXTAL
      NXTL2=NXTAL/2
C
      IF (2*NXTL2.EQ.NXTAL) GO TO 14
      WRITE (LUNOUT,60) NXTAL
      CALL EMESG (8,NAMER(5),1)
C
   14 WRITE (LUNOUT,62)
      WRITE (LUNOUT,64) NXTAL
      WRITE (LUNOUT,66) NDEG
C
      CALL MEMST (LGAM,(NXTAL-1)*NXTL2)
      CALL MEMST (LGPRJ,2*NXTAL)
      CALL MEMST (LBBMR,NXTAL-2)
      CALL MEMST (LAAMR,NXTAL-2)
      CALL MEMST (LAMAR,NXTL2)
      CALL MEMST (LBMAR,NXTL2)
C
      IF (TSTORE) GO TO 54
C
C     **COMPUTE N=0 COEFFICIENTS
C
      IMX=NXTAL
      DO 18 J=1,NXTL2
      IF (J.EQ.NXTL2) IMX=NXTL2
      T=0.
      CALL GETOM (J,GPRJ(LGPRJ))
      DO 16 I=1,IMX
      ISUB=LGPRJ+I-1
   16 T=T+GPRJ(ISUB)
      ISUB=LBMAR+J-1
   18 BMAR(ISUB)=T
C
      KK=0
      LDMX=NXTAL-1
      DO 22 LD=1,LDMX,2
      KK=KK+1
C
C     ** LD=2*K+1 AND KK=K+1
C
      L=0
      T=0.
      DO 20 J=1,NXTL2
      L=L+LD
      IF (L.GT.N2XTL) L=L-N2XTL
      ISUB1=LSINE+L-1
      ISUB2=LBMAR+J-1
   20 T=T+SINE(ISUB1)*BMAR(ISUB2)
      ISUB=LGAM+(KK-1)*(NXTAL-1)
   22 GAM(ISUB)=T*FLOAT(LD)/FLOAT(NXTAL**2)*2.
      TSAVE=TPRINT(2)
      TPRINT(2)=.FALSE.
C
      DO 34 N=1,NXTL2
      L1=N-2*(N/2)+1
C
C     ** L1=1 (2)  FOR N EVEN (ODD).
C
      JMX=NXTL2+1-L1
C
C     ** JMX = 16 (15)  FOR N EVEN (ODD).
C
      LD=N+N
      LZ=-LD
      IMX=NXTAL
C
C     ** COMPUTE NTH FOURIER COEFFICIENTS AT EACH VALUE OF J.
C
      DO 26 J=1,JMX
      IF (J.EQ.NXTL2) IMX=NXTL2
      LZ=LZ+N
      IF (LZ.GT.N2XTL) LZ=LZ-N2XTL
C
C     ** EQUIVALENTLY-- LZ=(J-2)*N
C
      CALL GETOM (J,GPRJ(LGPRJ))
C
      T=0.
      U=0.
      L=LZ
      DO 24 I=1,IMX
      L=L+LD
      IF (L.GT.N2XTL) L=L-N2XTL
C
C     ** EQUIVALENTLY-- L=(2*I-2+J)*N
C
      ISUB1=LCOSIN+L-1
      ISUB2=LGPRJ+I-1
      ISUB3=LSINE+L-1
      T=T+COSINE(ISUB1)*GPRJ(ISUB2)
   24 U=U+SINE(ISUB3)*GPRJ(ISUB2)
      ISUB=LBMAR+J-1
      BMAR(ISUB)=T
      ISUB=LAMAR+J-1
```

```
   26 AMAR(ISUB)=U
C
C     WHEN N=NXTL2, AMAR(LAMAR+J-1)=0 FOR EVEN J
C     AND BMAR(LBMAR+J-1)=0 FOR ODD J AUTOMATICALLY
C
      LDMX=NXTAL-1
      DO 32 LD=L1,LDMX,2
      L=0
      T=0.
      U=0.
      DO 28 J=1,JMX
      L=L+LD
      IF (L.GT.N2XTL) L=L-N2XTL
C
C     ** EQUIVALENTLY-- L=J*LD
C
      ISUB1=LSINE+L-1
      ISUB2=LBMAR+J-1
      ISUB3=LAMAR+J-1
      T=T+SINE(ISUB1)*BMAR(ISUB2)
   28 U=U+SINE(ISUB1)*AMAR(ISUB3)
C
      IF (LD.LT.N) GO TO 30
C
C     FOR LD.GT.N WE ARE COMPUTING
C     ALPHA AND BETA FOR INDICES N,K
C     WHERE LD=N+2*K+1
C
      IF (N.EQ.NXTL2) GO TO 34
C
C     WHEN N=NXTL2, COEFFICIENTS HAVE ALREADY BEEN COMPUTED
C        IN (LD.LT.N) BRANCH
C
      COEFF=FLOAT(LD)/FLOAT(NXTAL**2)*4.
      K=(LD-N-1)/2
C
C     STORE BETA(N,K)-
C
      ISUB=LGAM+(NXTAL-1)*K+N
      GAM(ISUB)=COEFF*T
C
C     STORE ALPHA(N,K) IN PACKED ARRAY-
C
      ISUB=LGAM+(NXTAL-1)*(NXTL2-K-1)+NXTAL-N-1
      GAM(ISUB)=COEFF*U
      GO TO 32
C
C     *** FOR LD.LT.N, WE ARE COMPUTING  -BETA AND ALPHA FOR
C        INDICES NXTAL-N, WHERE LD=N-2*K-1.
C
   30 COEFF=FLOAT(NXTAL-LD)/FLOAT(NXTAL**2)*4.
      K=(N-LD-1)/2
C
C     *** STORE BETA(NXTAL-N,K) AND ALPHA(NXTAL-N,K) IN PACKED ARRAY--
C
      ISUB=(NXTAL-1)*K+NXTAL-N+LGAM
      GAM(ISUB)=-COEFF*T
      ISUB=(NXTAL-1)*(NXTL2-K-1)+N+LGAM-1
      GAM(ISUB)=COEFF*U
   32 CONTINUE
   34 CONTINUE
      TPRINT(2)=TSAVE
C
C
C     *  M= DEGREE OF POLYNOMIAL TO BE USED IN DISPLAY.
C
      IF (M.LE.NXTAL-2) GO TO 36
      M=NXTAL-2
      WRITE (LUNOUT,68) NXTAL,M
      CALL EMESG (41,NAMER(5),0)
C
C        ****  CLEAR DISPLAY AREA  ******
C
   36 NSQ=NDIM*NDIM
      DO 38 I=1,NSQ
   38 X(I)=0.
C
      DELTA=PWID*2.*PI/FLOAT(NANG)
      FAC=PWID
      IF (TEMIT) FAC=PWID*PWID
      MO=MOD(NDIM,2)
      IZ=(NDIM+1)/2
      DH=FLOAT(1-MO)*.5*DELTA
      IF (MD.EQ.0) GO TO 42
C
C******      IF NDIM IS ODD COMPUTE DENSITY AT CENTER POINT   ******
C
      IZ=NDIM/2+1
      D1=GAM(LGAM)
      KMX=M/2
      OSGN=1.
      DO 40 K=1,KMX
      OSGN=-OSGN
      ISUB=LGAM+(NXTAL-1)*K
   40 D1=D1+GAM(ISUB)*OSGN
      ISUB=NDIM*(IZ-1)+IZ
      X(ISUB)=D1*FAC
C
C*********           THEN REMAINING POINTS,  ONE POINT IN EACH OF
C       EIGHT SECTORS AT A TIME  *************
C
   42 IMX=NDIM/2
      DO 52 I=1,IMX
      XX=FLOAT(I)*DELTA-DH
      XSQ=XX*XX
      I1=I+MD
      DO 50 JJ=1,I1
      J=JJ-MD
      Y=FLOAT(J)*DELTA-DH
      RSQ=XSQ+Y*Y
      IF (RSQ.GT.1.) GO TO 52
C
      CALL RADAL (RSQ,M,NXTAL,BBZ)
C
      IP=IZ+I
      IM=NDIM+1-IP
      JP=IZ+J
      JM=NDIM+1-JP
      C=1.
      S=0.
      OSGN=1.
      MSGN=1.
      D1=BBZ
      D2=BBZ
      D3=BBZ
      D4=BBZ
      E1=BBZ
      E2=BBZ
      E3=BBZ
      E4=BBZ
      DO 48 N=1,M
      CTEMP=XX*C-Y*S
      S=XX*S+Y*C
      C=CTEMP
C**** (C,S)=(REAL,IMAG) PART OF (X+Y*SQRT(-1))**N
CXXX            =(R**N)*(COS(N*THETA),SIN(N*THETA))
      OSGN=-OSGN
      ISUB1=LBBMR+N-1
      ISUB2=LAAMR+N-1
      T1=C*BBMR(ISUB1)
      T2=S*AAMR(ISUB2)
      D1=D1+T1+T2
      D4=D4+T1-T2
      D2=D2+OSGN*(T1-T2)
      D3=D3+OSGN*(T1+T2)
      IF (I.EQ.J) GO TO 48
      IF (OSGN.LT.0.) GO TO 44
      T3=MSGN*T1
      T4=-MSGN*T2
      GO TO 46
   44 ISUB1=LBBMR+N-1
      ISUB2=LAAMR+N-1
      T3=MSGN*S*BBMR(ISUB1)
      T4=MSGN*C*AAMR(ISUB2)
      MSGN=-MSGN
   46 E1=E1+T3+T4
      E4=E4+T3-T4
      E2=E2+OSGN*(T3-T4)
      E3=E3+OSGN*(T3+T4)
   48 CONTINUE
C
      ISUB=NDIM*(JP-1)
      ISUB1=ISUB+IP
      ISUB2=ISUB+IM
      X(ISUB1)=D1*FAC
      X(ISUB2)=D2*FAC
      ISUB=NDIM*(JM-1)
      ISUB1=ISUB+IM
      ISUB2=ISUB+IP
      X(ISUB1)=D3*FAC
      X(ISUB2)=D4*FAC
C
      IF (I.EQ.J) GO TO 50
C
      ISUB=NDIM*(IP-1)
      ISUB1=ISUB+JP
      ISUB2=ISUB+JM
      X(ISUB1)=E1*FAC
      X(ISUB2)=E2*FAC
      ISUB=NDIM*(IM-1)
      ISUB1=ISUB+JM
      ISUB2=ISUB+JP
      X(ISUB1)=E3*FAC
      X(ISUB2)=E4*FAC
C
   50 CONTINUE
   52 CONTINUE
C
   54 CALL MEMST (LGAM,0)
      CALL MEMST (LGPRJ,0)
      CALL MEMST (LBBMR,0)
      CALL MEMST (LAAMR,0)
      CALL MEMST (LAMAR,0)
      CALL MEMST (LBMAR,0)
C
      CALL MEMST (MAXFW,-1)
      WRITE (LUNOUT,70) MAXFW
      CALL LGTXT (NAMER,9)
      RETURN
C
C
C
   56 FORMAT(//25X,10(1H*),7HWARNING,10(1H*)//
     15X,10HA RING OF ,I3,31H DETECTORS AND PIXELS THAT ARE ,F6.3,
     226H THE SIZE OF ONE DETECTOR,/5X,59HIMPLIES THAT THE ENTIRE RING W
     3ILL BE INSCRIBED IN A SQUARE ,I3,7H PIXELS/
     45X,29HON A SIDE. USING AN ARRAY OF ,I3,18H PIXELS ON A SIDE
     5/5X,61HWILL ONLY RESULT IN ZEROES IN ALL PIXELS OUTSIDE A RADIUS O
     6F ,F6.3,1H.)
   58 FORMAT(//10X,65HTHE MARR RECONSTRUCTION METHOD CAN ONLY BE USED FO
     1R RING GEOMETRY/15X,39H(SETUP INPUT PARAMETER IGEOM=IPAR(5)=3))
   60 FORMAT(//10X,68HTHE MARR RECONSTRUCTION METHOD REQUIRES AN EVEN NU
     1MBER OF DETECTORS./10X,33HTHE NUMBER OF DETECTORS WAS NANG=,I3)
   62 FORMAT(  ////11X,31HPARAMETERS FOR SUBROUTINE MARR //19X,11HDESCRI
     1PTION/1X)
   64 FORMAT(9H NXTAL - ,I6,4X,18HNUMBER OF CRYSTALS)
   66 FORMAT(9H NDEG  - ,I6,4X,24HDEGREE OF THE POLYNOMIAL)
   68 FORMAT(//5X,51HTHE MAXIMUM DEGREE OF THE POLYNOMIALS FOR A RING OF
     1,I3,14H DETECTORS IS ,I3/5x,57HTHE RECONSTRUCTED VALUES WILL BE CO
     2MPUTED TO THIS DEGREE.)
   70 FORMAT(//10X,38HMAXIMUM SIZE OF BLANK COMMON THUS FAR=,I7,
     122H FLOATING POINT WORDS.)
      END
```

MEMST

```
      SUBROUTINE MEMST (LPOINT,MEMSIZ)
C
C     ****************************************************************
C     *       RECLBL    --         VERSION 1.0    --        17OCT77   *
C     ****************************************************************
C
C            SUBROUTINE MEMST RESERVES SPACE IN BLANK COMMON AND SETS
C        POINTERS TO THESE LOCATIONS.  LPOINT CONTAINS THE CURRENT VALUE
C        OF THE POINTER AND MEMSIZ CONTAINS THE NUMBER OF WORDS TO
C        BE RESERVED.  THIS ROUTINE IS ALSO CAPABLE OF CHANGING THE
C        SPACE ALOCATED TO A POINTER OR OF DELETING A POINTER AND ITS
C        SPACE COMPLETELY.
C            WHEN CALLED WITH LPOINT ZERO ALL POINTERS ARE RESET.
C            WHEN CALLED WITH MEMSIZ=-1, LPOINT IS RETURNED WITH THE
C                 LARGEST AMOUNT OF BLANK COMMON NEEDED THUS FAR
C
C          LPOINT  - THE CURRENT VALUE OF THE POINTER
C          MEMSIZ  - THE NUMBER OF WORDS TO BE RESERVED
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - EMESG, IOCTL, MEMOV
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                        COMMON
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C          IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                       SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                       FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                       EXECUTING.
C          WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/ATNCOM/LATEN,LBMAP,TATEN,LUNATN
      LOGICAL TATEN
      DIMENSION ATEN(1),BMAP(1)
      EQUIVALENCE (WORK(1),ATEN(1),BMAP(1))
C
C          LATEN   - POINTER TO THE ARRAY ATEN IN BLANK COMMON
C                       STORES ATTENUATION FACTORS FOR ONE ANGLE
C          LBMAP   - POINTER TO THE ARRAY BMAP IN BLANK COMMON
C                       A MATRIX USED TO STORE THE CONSTANT ATTENUATION
C                       COEFFICIENTS
C          TATEN   - LOGICAL VARIABLE SET TRUE FOR ATTENUATION
C                       RECONSTRUCTION
C          LUNATN  - LOGICAL UNIT NUMBER FOR ATTENUATION FACTOR STORAGE
C
      COMMON/CNVCOM/LCONV,LCONE
      DIMENSION CONVOL(1),CONE(1)
      EQUIVALENCE (WORK(1),CONVOL(1),CONE(1))
C
C          LCONV   - POINTER TO THE ARRAY CONV IN BLANK COMMON
C                       ARRAY OF CONVOLUTION FACTORS
C          LCONE   - POINTER TO THE ARRAY CONE IN BLANK COMMON
C                       ARRAY OF VARIANCES (AND COVARIANCES OF ADJACENT
C                       BINS) OF THE CONVOLVED PROJECTIONS
C
      COMMON/DATCOM/LDATA
      DIMENSION DATA(1)
      EQUIVALENCE (WORK(1),DATA(1))
C
C          LDATA   - POINTER TO THE ARRAY DATA IN BLANK COMMON
C          DATA    - AN INTERMEDIATE PROJECTION ARRAY
C
      COMMON/ENTCOM/LIMIT,ERENT,LXLAGR,LGRAD,LHWORK,LBCKE,LPRJE
      DIMENSION XLAGR(1),GRAD(1),HWORK(1),BCKE(1),PRJE(1)
      EQUIVALENCE(WORK(1),XLAGR(1),GRAD(1),HWORK(1),BCKE(1),PRJE(1))
C
C          LIMIT   - MAXIMUM NUMBER OF ITERATIONS ALLOWED TO MINIMIZE
C                       THE OBJECTIVE FUNCTION FOR THE DUAL PROGRAM
C          ERENT   - TEST VALUE REPRESENTING THE EXPECTED ABSOLUTE ERROR
C                       ERENTX SHOULD NOT BE ANY SMALLER THAN 10**(-D),
C                       WHERE D IS THE NUMBER OF SIGNIFICANT DIGITS IN
C                       FLOATING POINT REPRESENTATION.
C          LXLAGR  - POINTER TO THE ARRAY XLAGR IN BLANK COMMON
C                       ARRAY OF LAGRANGE MULTIPLIERS FOR THE DUAL
C                       PROBLEM USED TO OPTIMIZE ENTROPY AS A
C                       RECONSTRUCTION CRITERION
C          LGRAD   - POINTER TO THE ARRAY GRAD IN BLANK COMMON
C                       THE GRADIENT ARRAY FOR THE FUNCTION OF LAGRANGE
C                       MULTIPLIERS
C          LHWORK  - POINTER TO THE ARRAY HWORK IN BLANK COMMON
C                       WORKING STORAGE OF DIMENSION 2*(NO. OF LAGRANGE
C                       MULTIPLIERS)
C          LBCKE   - POINTER TO THE ARRAY BCKE IN BLANK COMMON
C                       A TEMPORARY BACK-PROJECTION ARRAY
C          LPRJE   - POINTER TO THE ARRAY PRJE IN BLANK COMMON
C                       A PROJECTION ARRAY
C
      COMMON/FILCOM/ORDER,FREQ,LBCKA,LPRJA,LFILT
      DIMENSION BCKA(1),PRJA(1),FILT(1)
      EQUIVALENCE (WORK(1),BCKA(1),PRJA(1),FILT(1))
C
C          ORDER   - FILTER PARAMETER USED ONLY BY THE FILTER BUTER
C          FREQ    - FILTER PARAMETER
C          LBCKA   - POINTER TO THE ARRAY BCKA IN BLANK COMMON
C                       BACK-PPOJECTION ARRAY WHICH HAS THE DIMENSION
C                       NDIM X NDIM
C          LPRJA   - POINTER TO THE APRAY PRJA IN BLANK COMMON
C                       A PROJECTION ARRAY FOR ONE ANGLE
C          LFILT   - POINTER TO THE ARRAY FILT IN BLANK COMMON
C                       ARRAY OF FILTER VALUES
C
      COMMON/GNVCOM/LGMAT,LUMAT,LIGFLG,KIGFLG,LGTEMP,LGVEC
      DIMENSION GMAT(1),UMAT(1),IGFLG(1),GTEMP(1),GVEC(1)
      EQUIVALENCE (WORK(1),GMAT(1),UMAT(1),IGFLG(1),GTEMP(1),GVEC(1))
C
C          LGMAT   - POINTER TO THE ARRAY GMAT IN BLANK COMMON
C                       MATRIX TO INVERT IN GVERS
C          LUMAT   - POINTER TO THE ARRAY UMAT IN BLANK COMMON
C                       BOOKKEEPING MATRIX FOR GVERS
C          LIGFLG  - POINTER TO THE ARRAY IGFLG IN BLANK COMMON
C                       FLAGS FOR GVERS
C          KIGFLG  - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE IGFLG
C                       IS AN INTEGER
C          LGTEMP  - POINTER TO THE ARRAY GTEMP IN BLANK COMMON
C                       TEMPORARY STORAGE FOR GVERS
C          LGVEC   - POINTER TO THE ARRAY GVEC IN BLANK COMMON
C                       PROJECTION STORAGE FOR GVERS
C
      COMMON/ITRCOM/NSTP,TRLX,TERR,TZER,LWGT,LDEL,LTEMP,LCDEL,LTRAN
      LOGICAL TRLX,TERR,TZER
      DIMENSION WGT(1),DEL(1),TEMP(1),CDEL(1),TRAN(1)
      EQUIVALENCE (WORK(1),WGT(1),DEL(1),TEMP(1),CDEL(1),TRAN(1))
C
C          NSTP    - NUMBER OF ITERATION STEPS
C          TRLX    - LOGICAL VARIABLE SET TRUE FOR RELAXATION
C          TERR    - LOGICAL VARIABLE SET TRUE FOR WEIGHTED LEAST SQUARE
C          TZER    - LOGICAL VARIABLE SET TRUE TO ZERO INITIAL SOLUTION
C          LWGT    - POINTER TO THE ARRAY WGT IN BLANK COMMON
C                       WEIGHTS FOR WEIGHTED LEAST SQUARES (SEE TERR)
C          LDEL    - POINTER TO THE ARRAY DEL IN BLANK COMMON
C                       GRADIENT VECTOR
C          LTEMP   - POINTER TO THE ARRAY TEMP IN BLANK COMMON
C                       TEMPORARY STORAGE TO INCREASE SPEED
C          LCDEL   - POINTER TO THE ARRAY CDEL IN BLANK COMMON
C                       STEP DIRECTION FOR CONJUGATE GRADIENTS
C          LTRAN   - POINTER TO THE ARRAY TRAN IN BLANK COMMON
C                       TRANSFORMATION MATRIX FOR RELAXATION (SEE TRLX)
C
C
      COMMON/MARCOM/LGAM,LGPRJ,LBBMR,LAAMR,LAMAR,LBMAR
      DIMENSION GAM(1),GPRJ(1),BBMR(1),AAMR(1),AMAR(1),BMAR(1)
      EQUIVALENCE (WORK(1),GAM(1),GPRJ(1),BBMR(1),AAMR(1),AMAR(1),
     1            BMAR(1))
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT  - LOGICAL UNIT NUMBER FOR OUTPUT
C          I80132  - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                       OUTPUT ON LUNOUT
C                 0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      COMMON/PHNCOM/LPHAN
      DIMENSION PHAN(1)
      EQUIVALENCE (WORK(1),PHAN(1))
C
C          LPHAN   - POINTER TO THE ARRAY PHAN IN BLANK COMMON
C                       WORKING STORAGE FOR PHANTOM GENERATING ROUTINES
C
      COMMON/PRTCOM/TPRINT(8)
      LOGICAL TPRINT
C
C          TPRINT  - LOGICAL PRINT FLAGS
C                 1 - PRINT REQUIRED FLOATING POINT BLANK COMMON
C                       WHENEVER CHANGED
C                 2 - PRINT PROJECTION DATA AND UNCERTAINTIES
C                 3 - PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
C                 4 - PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER
C                       ROUTINES
C                 5 - PRINT VALUES FOR THE LAGRANGE MULTIPILERS AND
C                       THE GRADIENT FOR THE FUNCTION OF LAGRANGE MULTI-
C                       PILERS FOR THE ENTROPY RECONSTRUCTION
C                 6 - PRINT POINTERS IN BLANK COMMON WHENEVER CHANGED
C                       (DEBUG)
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                       NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                       THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                       IS AN INTEGER VARIABLE
C
      COMMON/RAYCOM/NLEV,LMRFAC,KMRFAC,LRFAC
      DIMENSION MRFAC(1),RFAC(1)
      EQUIVALENCE(WORK(1),MRFAC(1),RFAC(1))
C
C          NLEV    - NUMBER OF FRACTION LEVELS
C          LMRFAC  - POINTER TO THE ARRAY MRFAC IN BLANK COMMON
C                       MRFAC(MANGLE) POINTS TO THE LOCATION IN BLANK
C                       COMMON WHERE RFAC(MRFAC(MANGLE)) IS STORED.
C                       RFAC(MRFAC(MANGLE)) IS THE FRACTION OF THE CELL
C                       WITHIN THE RAY WHEN THE CENTER OF THE CELL IS IN
C                       THE CENTER OF THE RAY AT THE ANGLE MANGLE.
C          KMRFAC  - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE MRFAC
C                       IS AN INTEGER VARIABLE
C          LRFAC   - POINTER TO THE ARRAY RFAC IN BLANK COMMON
C                       FRACTIONAL AREAS OF A CELL WHICH INTERSECT
C                       A RAY AND THIS FRACTION IS MEASURED AS A FUNCTION
C                       OF THE DISTANCE THE CENTER OF THE CELL IS FROM
C                       THE CENTER OF THE RAY.  THE TOTAL DIMENSION OF
C                       THE ARRAY PFAC IS NRFAC=LL*EQANG, WHERE
C                                 3*NLEV+2  IF NLEV IS EVEN
C                            LL =
C                                 3*NLEV+1  IF NLEV IS ODD
C                       AND EQANG IS THE SIZE OF THE SET OF ANGLES FORMED
C                       FROM THE SET OF TOTAL ANGLES WITH MOD OPERATION
C                       OF PHI/2 THEN REFLECTION ABOUT PHI/4.
C
      COMMON/STRCOM/TSTORE
      LOGICAL TSTORE
C
C          TSTORE  - LOGICAL VARIABLE SET TRUE WHEN TESTING STORAGE SIZE
C                       SETS TPRINT(1) = .TRUE.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C          IGEOM   - GEOMETRY FLAG
C                 0 = PARALLEL BEAM GEOMETRY
C                 1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                 2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                 3 = RING DETECTOR GEOMETRY
C          KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                       BY THE USER
C          AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                       PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                       AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                       IN THE CENTER OF A PROJECTION BIN.)
C          BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C          KMCV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                       ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                       ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C          KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                       THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                       IS GOING TO BE USED.
C          KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                       THE DATA OF THE LAST USER PROJECTION BIN THAT
C                       IS GOING TO BE USED.
C          KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                       TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                       KDIM=KDIMU.
C          AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                       PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                       INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                       VECTOR
C          NANG    - NUMBER OF PROJECTIONS
C          MODANG  - MODE FOR PROJECTION ANGLE INPUT
C          LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                       PROJECTION ANGLES IN RADIANS
C          LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                       SINE OF THE PROJECTION ANGLES
C          LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                       COSINE OF THE PROJECTION ANGLES
C          LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                       USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                       FALSE FOR TRANSMISSION DATA
C
      DIMENSION NAME(3,38),KPTR(38),INDX(38),NAMER(5)
      LOGICAL TSTORS
      DATA NPTR/38/
      DATA NAME/   2HLA,2HTE,2HN ,      2HLW,2HGT,2H  ,
     1             2HLD,2HEL,2H  ,      2HLT,2HEM,2HP ,
     2             2HLC,2HDE,2HL ,      2HLT,2HRA,2HN ,
     3             2HLP,2HRO,2HJ ,      2HLN,2HI ,2H  ,
     4             2HLM,2HRF,2HAC,      2HLA,2HNG,2H  ,
     5             2HLS,2HIN,2HE ,      2HLC,2HOS,2HIN,
     6             2HLC,2HON,2HV ,      2HLX,2HLA,2HGR,
     7             2HLG,2HRA,2HD ,      2HLH,2HWO,2HRK,
     8             2HLB,2HCK,2HE ,      2HLP,2HRJ,2HE ,
     9             2HLB,2HCK,2HA ,      2HLP,2HRJ,2HA ,
     $             2HLF,2HIL,2HT ,      2HLR,2HFA,2HC ,
     $             2HLB,2HMA,2HP ,      2HLD,2HAT,2HER,
     $             2HLD,2HAT,2HA ,      2HLG,2HTE,2HMP,
     $             2HLG,2HVE,2HC ,      2HLG,2HAM,2H  ,
     $             2HLG,2HPR,2HJ ,      2HLB,2HBM,2HR ,
     $             2HLA,2HAM,2HR ,      2HLA,2HMA,2HR ,
     $             2HLB,2HMA,2HR ,      2HLC,2HON,2HE ,
     $             2HLP,2HHA,2HN ,      2HLG,2HMA,2HT ,
     $             2HLU,2HMA,2HT ,      2HLI,2HGF,2HLG/
C
```

```
      DATA NAMER/1HM,1HE,1HM,1HS,1HT/
      DATA MAXFW/0/
      DATA TSTORS/.FALSE./
C
      LPTR=LPOINT
      MSIZ=MEMSIZ
C
C        *SEE IF WE NEED ONLY RETURN MAXFW OR RESET POINTERS
C
      IF (MSIZ.GE.0) GO TO 14
      IF (MSIZ.NE.-1) GO TO 10
      LPOINT=MAXFW
      RETURN
   10 IF (TSTORS) TSTORE=.TRUE.
C
C        *RESET ALL POINTERS
C
      DO 12 I=1,NPTR
   12 KPTR(I)=-I
      GO TO 38
   14 CONTINUE
C
C        SET KPTR TO POINTER VALUES
C
      KPTR(1)=LATEN
      KPTR(2)=LWGT
      KPTR(3)=LDEL
      KPTR(4)=LTEMP
      KPTR(5)=LCDEL
      KPTR(6)=LTRAN
      KPTR(7)=LPROJ
      KPTR(8)=KNI
      KPTR(9)=KMRFAC
      KPTR(10)=LANG
      KPTR(11)=LSINE
      KPTR(12)=LCOSIN
      KPTR(13)=LCONV
      KPTR(14)=LXLAGR
      KPTR(15)=LGRAD
      KPTR(16)=LHWORK
      KPTR(17)=LBCKE
      KPTR(18)=LPRJE
      KPTR(19)=LBCKA
      KPTR(20)=LPRJA
      KPTR(21)=LFILT
      KPTR(22)=LRFAC
      KPTR(23)=LBMAP
      KPTR(24)=LDATER
      KPTR(25)=LDATA
      KPTR(26)=LGTEMP
      KPTR(27)=LGVEC
      KPTR(28)=LGAM
      KPTR(29)=LGPRJ
      KPTR(30)=LBBMR
      KPTR(31)=LAAMR
      KPTR(32)=LAMAR
      KPTR(33)=LBMAR
      KPTR(34)=LCONE
      KPTR(35)=LPHAN
      KPTR(36)=LGMAT
      KPTR(37)=LUMAT
      KPTR(38)=KIGFLG
C
C        SEE IF LPTR IS VALID
C
      ISET=0
      DO 16 I=1,NPTR
   16 IF (LPTR.EQ.KPTR(I)) ISET=I
C
      IF (ISET.EQ.0) WRITE (LUNOUT,58) LPTR
      IF (ISET.EQ.0) CALL EMESG (28,NAMER,2)
      IF (LPTR.LT.O.AND.ISET.NE.-LPTR) WRITE (LUNOUT,60) LPTR,ISET
      IF (LPTR.LT.O.AND.ISET.NE.-LPTR) CALL EMESG (29,NAMER,2)
C
C        SPECIAL FOR POINTERS TO INTEGER ARRAYS
C
      IF (ISET.EQ.8.OR.ISET.EQ.9.OR.ISET.EQ.38) MSIZ=(MSIZ+NFLOAT-1)/NFL
     1OAT
C
C        FIND THE ORDER OF POINTERS ALREADY SET.
C        INDX WILL CONTAIN THE INDICES OF THE POINTERS WHICH HAVE BEEN
C        SET (IN ASCENDING ORDER).
C
C        SET LARGE BIGGER THAN ALL POINTERS
C
      LARGE=0
      DO 18 I=1,NPTR
   18 IF (KPTR(I).GE.LARGE) LARGE=KPTR(I)+1
C
      MOVE=0
      NSET=0
      MSET=0
      DO 22 I=1,NPTR
C
      MPTR=LARGE
      DO 20 J=1,NPTR
      IF (KPTR(J).LE.0) GO TO 20
      IF (KPTR(J).GT.MPTR) GO TO 20
      JPTR=J
      MPTR=KPTR(J)
   20 CONTINUE
      IF (MPTR.EQ.LARGE) GO TO 24
C
      NSET=NSET+1
      IF (LPTR.EQ.KPTR(JPTR)) MSET=NSET
      INDX(NSET)=JPTR
   22 KPTR(JPTR)=-KPTR(JPTR)
C
C
C        RESET KPTR
C
   24 IF (NSET.EQ.0) GO TO 28
      DO 26 I=1,NSET
      J=INDX(I)
   26 KPTR(J)=-KPTR(J)
C
   28 IF (MSET.NE.0) GO TO 30
      IF (MSIZ.LE.0) GO TO 38
C
C        MAME NOT SET AND MSIZ .GT. 0 SO INITIATE NEW POINTER
C
      NSET=NSET+1
      INDX(NSET)=ISET
      KPTR(ISET)=IWUSED+1
      IWUSED=IWUSED+MSIZ
      GO TO 38
C
C        MAME ALREADY SET SO ALTER THE EXISTING POINTERS
C
   30 IF (MSET.NE.NSET) GO TO 34
C
C        MAME WAS THE LAST ONE SET SO JUST CHANGE IWUSED
C
      IWUSED=KPTR(ISET)-1
      IF (MSIZ.LE.0) GO TO 32
      IWUSED=IWUSED+MSIZ
      GO TO 38
C
C        MSIZ .LE. 0 SO CLOBBER MAME
C
   32 KPTR(ISET)=-ISET
      INDX(MSET)=0
      GO TO 38
C
C        MAME WAS NOT THE LAST ONE SET SO ALTER ALL POINTERS SET AFTER
C
   34 MM=INDX(MSET+1)
      MOVE=KPTR(ISET)-KPTR(MM)
      IF (MSIZ.GT.0) MOVE=MOVE+MSIZ
      MSET1=MSET+1
      DO 36 J=MSET1,NSET
      I=INDX(J)
   36 KPTR(I)=KPTR(I)+MOVE
      IWUSED=IWUSED+MOVE
      IF (MSIZ.GT.0) GO TO 38
C
C        MSIZ .LE. 0 SO CLOBBER MAME
C
      KPTR(ISET)=-ISET
      INDX(MSET)=0
C
C        RESET POINTER VALUES FROM KPTR
C
   38 IF (IWUSED.GT.MAXFW) MAXFW=IWUSED
      LATEN=KPTR(1)
      LWGT=KPTR(2)
      LDEL=KPTR(3)
      LTEMP=KPTR(4)
      LCDEL=KPTR(5)
      LTRAN=KPTR(6)
      LPROJ=KPTR(7)
      KNI=KPTR(8)
      LNI=1+(KNI-1)*NFLOAT
      KMRFAC=KPTR(9)
      LMRFAC=1+(KMRFAC-1)*NFLOAT
      LANG=KPTR(10)
      LSINE=KPTR(11)
      LCOSIN=KPTR(12)
      LCONV=KPTR(13)
      LXLAGR=KPTR(14)
      LGRAD=KPTR(15)
      LHWORK=KPTR(16)
      LBCKE=KPTR(17)
      LPRJE=KPTR(18)
      LBCKA=KPTR(19)
      LPRJA=KPTR(20)
      LFILT=KPTR(21)
      LRFAC=KPTR(22)
      LBMAP=KPTR(23)
      LDATER=KPTR(24)
      LDATA=KPTR(25)
      LGTEMP=KPTR(26)
      LGVEC=KPTR(27)
      LGAM=KPTR(28)
      LGPRJ=KPTR(29)
      LBBMR=KPTR(30)
      LAAMR=KPTR(31)
      LAMAR=KPTR(32)
      LBMAR=KPTR(33)
      LCONE=KPTR(34)
      LPHAN=KPTR(35)
      LGMAT=KPTR(36)
      LUMAT=KPTR(37)
      KIGFLG=KPTR(38)
      LIGFLG=1+(KIGFLG-1)*NFLOAT
      IF (MSIZ.LT.0) RETURN
      IF (IWUSED.GT.NWORK.OR.TPRINT(1)) GO TO 40
      IF (MOVE.NE.0) GO TO 52
      RETURN
C
C        PRINT OUT POINTERS AND CHECK FOR OVERFLOW
C
   40 IF (NSET.EQ.0) GO TO 50
      IF (.NOT.TPRINT(6)) GO TO 46
      WRITE (LUNOUT,62)
      JJ=0
      DO 44 I=1,NSET
      J=INDX(I)
      IF (J.LE.0) GO TO 44
      IF (JJ.EQ.0) GO TO 42
      LEN=KPTR(J)-KPTR(JJ)
      KPOCT=IOCTL(KPTR(JJ))
      WRITE (LUNOUT,64) (NAME(K,JJ),K=1,3),KPTR(JJ),KPOCT,LEN
   42 JJ=J
   44 CONTINUE
      LEN=IWUSED-KPTR(JJ)+1
      KPOCT=IOCTL(KPTR(JJ))
      WRITE (LUNOUT,64) (NAME(K,JJ),K=1,3),KPTR(JJ),KPOCT,LEN
C
   46 IWOCT=IOCTL(IWUSED)
      WRITE (LUNOUT,66) IWUSED,IWOCT
      IF (TSTORE) GO TO 48
      IF (NWORK.GE.IWUSED) GO TO 48
      NWOCT=IOCTL(NWORK)
      WRITE (LUNOUT,68) NWORK,NWOCT
      WRITE (LUNOUT,70)
      CALL EMESG (9,NAMER,-1)
      TSTORS=.TRUE.
      TSTORE=.TRUE.
      TPRINT(1)=.TRUE.
   48 IF (MOVE.NE.0) GO TO 52
      RETURN
C
   50 WRITE (LUNOUT,72)
      RETURN
C
C        MOVE THE VARIOUS SECTORS OF BLANK COMMON TO CORRECT POSITIONS
C
   52 IF (TSTORE) RETURN
C
      II=IWUSED-KPTR(MM)+1
      ISUB1=KPTR(MM)
      INC=1
      IF (MOVE.LT.0) GO TO 54
      ISUB1=IWUSED
      INC=-1
C
   54 DO 56 I=1,II
      ISUB2=ISUB1-MOVE
      WORK(ISUB1)=WORK(ISUB2)
   56 ISUB1=ISUB1+INC
C
      RETURN
C
C
   58 FORMAT(1X,I6,36H IS NOT A VALID POINTER   ...STOP...)
   60 FORMAT(19H LPTR IS NEGATIVE (,I6,18H) BUT NOT -ISET (-,I4,
     114H)   ...STOP...)
   62 FORMAT(  //11H POINTER   ,15X,10HDECIMAL   ,10H   OCTAL  ,9H   LEN
     1GTH)
   64 FORMAT(1X,3A2,19X,I6,4X,1H(,I6,1H),4X,I6)
   66 FORMAT(  //26H BLANK COMMON REQUIRED     ,I6,4X,1H(,I6,1H))
   68 FORMAT(26H BLANK COMMON SUPPLIED     ,I6,4X,1H(,I6,1H))
   70 FORMAT(  //1X,80(1H*)/
     11X,1H*,7X,64HTHE AMOUNT OF SPACE REQUIRED IN COMMON BLOCK WORK IS
     2LARGER THAN,7X,1H*/
     31X,80H*  THE AMOUNT ALLOCATED BY THE USER.  THIS RUN IS NOW A STOR
     4AGE SIZE TEST, NO  */
     51X,1H*,23X,31HRECONSTRUCTION WILL BE EXECUTED,24X,1H*/1X,80(1H*))
   72 FORMAT(  //16H NO POINTERS SET)
      END
```

PARZN

```
      SUBROUTINE PARZN (P,XI,M)
C
C     ****************************************************************
C     *       RECLBL    --         VERSION 1.0     --       17OCT77     *
C     ****************************************************************
C
C           THE SUBROUTINE PARZN EVALUATES AT THE POINT XI THE VALUE
C        OF THE FILTER OBTAINED BY MULTIPLYING THE PARZEN WINDOW BY THE
C        ABSOLUTE VALUE OF THE MEASURE, ABS(XI).
C
C          P        - THE FUNCTIONAL VALUE
C          XI       - THE INDEPENDENT VARIABLE
C          M        - HAS THE FOLLOWING VALUES
C                      .LE. 0 THE FLAGS ARE RETURNED IN P
C                      .GT. 0 THE FUNCTIONAL VALUE IS RETURNED IN P
C
C        THE FILTER PARAMETER FREQ IS PASSED IN THE COMMON BLOCK FILCOM.
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                        COMMON
C          IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                        SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                        FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                        EXECUTING.
C          WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/FILCOM/ORDER,FREQ,LBCKA,LPRJA,LFILT
      DIMENSION BCKA(1),PRJA(1),FILT(1)
      EQUIVALENCE (WORK(1),BCKA(1),PRJA(1),FILT(1))
C
C          ORDER    - FILTER PARAMETER USED ONLY BY THE FILTER BUTER
C          FREQ     - FILTER PARAMETER
C          LBCKA    - POINTER TO THE ARRAY BCKA IN BLANK COMMON
C                        BACK-PROJECTION ARRAY WHICH HAS THE DIMENSION
C                        NDIM X NDIM
C          LPRJA    - POINTER TO THE ARRAY PRJA IN BLANK COMMON
C                        A PROJECTION ARRAY FOR ONE ANGLE
C          LFILT    - POINTER TO THE ARRAY FILT IN BLANK COMMON
C                        ARRAY OF FILTER VALUES
C
      DIMENSION P(1)
C
C        BCK/PRJ/CNV/2 DF,WT,ATEN,FAN, ARE THE JFLAGS RETURNED IN P
C          IF M .LE. 0
C
      DIMENSION FLAGS(4)
      DATA FLAGS/3.,-1.,0.,-1./
C
      IF (M.LE.0) GO TO 18
C
      PARZ=0.
      IF (XI-FREQ) 10,10,16
   10 IF (XI-FREQ/2.) 12,12,14
   12 PARZ=(1.-6.*(XI/FREQ)**2*(1.-XI/FREQ))*XI
      GO TO 16
   14 PARZ=2.*(1.-XI/FREQ)**3*XI
   16 P(1)=PARZ
      RETURN
C
   18 DO 20 I=1,4
   20 P(I)=FLAGS(I)
C
      RETURN
      END
```

PCD

```
      SUBROUTINE PCD (B,P,M)
C
C     ****************************************************************
C     *       RECLBL    --         VERSION 1.0     --       17OCT77     *
C     ****************************************************************
C
C           THE SUBROUTINE PCD PROJECTS FROM THE ARRAY B A SINGLE
C        PROJECTION INTO THE ARRAY P.  THE PROJECTION HAS THE ANGLE
C        ANG(M) WHERE M IS THE INDEX OF THE ANGLE.  THE PROJECTION BINS
C        AND THE TRANSVERSE SECTION CELLS MUST BE THE SAME SIZE.  FOR
C        THESE CONDITIONS THE SUBROUTINE PCDA GIVES AN APPROXIMATION FOR
C        A MODEL WITH UNIFORM DENSITY IN EACH CELL SUCH THAT EACH CELL
C        PROJECTS AS A SQUARE WAVE.
C
C          B        - THE ARRAY OF DATA FOR THE TRANSVERSE SECTION
C          P        - THE PROJECTION ARRAY
C          M        - THE ANGLE INDEX
C                   - IF M .EQ. 0 ONLY A SET OF FLAGS IS RETURNED IN B
C                     NO PROJECTION OPERATION IS PERFORMED
C                     (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C                   - IF M .LT. 0, ITS ABSOLUTE VALUE IS USED AS ANGLE
C                     INDEX.  HOWEVER, RATHER THAN A PROJECTION OPERATION
C                     BEING PERFORMED, A WEIGHTED BACK-PROJECTION IS
C                     CALCULATED.  IT IS USED BY THE ITERATIVE RELAXATION
C                     RECONSTRUCTION METHOD.
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - ZERO
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                        COMMON
C          IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                        SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                        FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                        EXECUTING.
C          WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                        NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                        THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                        IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C          IGEOM    - GEOMETRY FLAG
C                  0 = PARALLEL BEAM GEOMETRY
C                  1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                  2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                  3 = RING DETECTOR GEOMETRY
C          KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                        BY THE USER
C          AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                        AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                        IN THE CENTER OF A PROJECTION BIN.)
C          BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C          KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                        ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                        ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C          KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C          KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE LAST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C          KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                        TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                        KDIM=KDIMU.
C          AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                        INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                        VECTOR
C          NANG     - NUMBER OF PROJECTIONS
C          MODANG   - MODE FOR PROJECTION ANGLE INPUT
C          LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                        PROJECTION ANGLES IN RADIANS
C          LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                        SINE OF THE PROJECTION ANGLES
C          LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                        COSINE OF THE PROJECTION ANGLES
C          LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                        USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                        FALSE FOR TRANSMISSION DATA
C
      DIMENSION P(1),B(1)
C        BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/1.,1.,0.,0./
C
      IF (M.LE.0) GO TO 20
C
      CALL ZERO (P,KDIM)
      ISUB=LSINE+M-1
      S=SINE(ISUB)
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)
      ZN=.5*FLOAT(NDIM+1)
      HS=.5*S
      ZZ=ZN*(S-C)+AXIS
      IJL=1
      DO 12 J=1,NDIM
      ZZ=ZZ+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 10 IJ=IJL,IJU
      Z=Z-S
      K=Z
      P(K)=P(K)+B(IJ)*(FLOAT(K+1)-Z)
   10 P(K+1)=P(K+1)+B(IJ)*(Z-FLOAT(K))
   12 IJL=IJL+NN
      RETURN
C
   14 M=-M
      IF (M.EQ.1) CALL ZERO (B,NMAT)
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)
      ZN=.5*FLOAT(NDIM+1)
      HS=.5*S
      ZZ=ZN*(S-C)+AXIS
      IJL=1
      DO 18 J=1,NDIM
      ZZ=ZZ+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 16 IJ=IJL,IJU
      Z=Z-S
      K=Z
   16 B(IJ)=B(IJ)+(FLOAT(K+1)-Z)**2*P(K)+(Z-FLOAT(K))**2*P(K+1)
   18 IJL=IJL+NN
      M=-M
      RETURN
C
   20 IF (M.LT.0) GO TO 14
      DO 22 I=1,4
   22 B(I)=FLAGS(I)
      RETURN
      END
```

PCDA

```
      SUBROUTINE PCDA (B,P,M)
C
C     ******************************************************************
C     *       RECLBL    --          VERSION 1.0     --         17OCT77   *
C     ******************************************************************
C
C          THE SUBROUTINE PCDA PROJECTS FROM THE ARRAY B A SINGLE
C     PROJECTION INTO THE ARRAY P.  THE PROJECTION HAS THE ANGLE
C     ANG(M) WHERE M IS THE INDEX OF THE ANGLE.  THE PROJECTION BINS
C     AND THE TRANSVERSE SECTION CELLS MUST BE THE SAME SIZE.  FOR
C     THESE CONDITIONS THE SUBROUTINE PCDA GIVES AN APPROXIMATION FOR
C     A MODEL WITH UNIFORM DENSITY IN EACH CELL SUCH THAT EACH CELL
C     PROJECTS AS A SQUARE WAVE WHICH IS ATTENUATED BY AN ATTENUATION
C     FACTOR.
C
C       B         - THE APRAY OF DATA FOR THE TRANSVERSE SECTION
C       P         - THE PROJECTION ARRAY
C       M         - THE ANGLE INDEX
C                 - IF M .EQ. 0 ONLY A SET OF FLAGS IS RETURNED IN B
C                   NO PROJECTION OPERATION IS PERFORMED
C                   (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C                 - IF M .LT. 0, ITS ABSOLUTE VALUE IS USED AS ANGLE
C                   INDEX.  HOWEVER, RATHER THAN A PROJECTION OPERATION
C                   BEING PERFORMED, A WEIGHTED BACK-PROJECTION IS
C                   CALCULATED.  IT IS USED BY THE ITERATIVE RELAXATION
C                   RECONSTRUCTION METHOD.
C
C     THIS SUBROUTINE CALLS RECLBL ROUTINES - FTATN, ZERO
C
C     RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C     LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                     COMMON
C         IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                     SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                     FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                     EXECUTING.
C         WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/ATNCOM/LATEN,LBMAP,TATEN,LUNATN
      LOGICAL TATEN
      DIMENSION ATEN(1),BMAP(1)
      EQUIVALENCE (WORK(1),ATEN(1),BMAP(1))
C
C         LATEN   - POINTER TO THE ARRAY ATEN IN BLANK COMMON
C                     STORES ATTENUATION FACTORS FOR ONE ANGLE
C         LBMAP   - POINTER TO THE ARRAY BMAP IN BLANK COMMON
C                     A MATRIX USED TO STOPE THE CONSTANT ATTENUATION
C                     COEFFICIENTS
C         TATEN   - LOGICAL VARIABLE SET TRUE FOP ATTENUATION
C                     RECONSTPUCTION
C         LUNATN  - LOGICAL UNIT NUMBER FOR ATTENUATION FACTOP STORAGE
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C         NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C         NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGPAM
C         PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C         TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C         NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C         LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                     NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                     THE SQUARE OR CIRCULAR FORM OF THE ARPAY
C         KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                     IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C         IGEOM   - GEOMETRY FLAG
C               0 = PARALLEL BEAM GEOMETRY
C               1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C               2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C               3 = RING DETECTOR GEOMETRY
C         KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                     BY THE USER
C         AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                     PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                     AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                     IN THE CENTER OF A PROJECTION BIN.)
C         BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                     ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                     ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C         KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                     THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                     IS GOING TO BE USED.
C         KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                     THE DATA OF THE LAST USER PROJECTION BIN THAT
C                     IS GOING TO BE USED.
C         KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                     TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                     KDIM=KDIMU.
C         AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                     PROJECTION ARRAY, USUALLY AXIS=AXISU.
C         LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                     INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                     VECTOR
C         NANG    - NUMBER OF PROJECTIONS
C         MODANG  - MODE FOR PROJECTION ANGLE INPUT
C         LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                     PROJECTION ANGLES IN RADIANS
C         LSINE   - POINTER TO THE ARRAY SINE IN PLANK COMMON
C                     SINE OF THE PROJECTION ANGLES
C         LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                     COSINE OF THE PROJECTION ANGLES
C         LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                     USER PROJECTION DATA AND UNCERTAINTIES
C         TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                     FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1),P(1)
C        BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/1.,1.,1.,0./
C
      IF (M.LE.0) GO TO 20
C
      CALL FTATN (M,ATEN(LATEN),NMAT)
      CALL ZERO (P,KDIM)
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)
      HS=.5*S
      ZN=.5*FLOAT(NDIM+1)
      ZZ=ZN*(S-C)+AXIS
      IJL=1
      DO 12 J=1,NDIM
      ZZ=ZZ+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 10 IJ=IJL,IJU
      Z=Z-S
      K=Z
      ISUB=LATEN+IJ-1
      FACT=B(IJ)*ATEN(ISUB)
      P(K)=P(K)+FACT*(FLOAT(K+1)-Z)
   10 P(K+1)=P(K+1)+FACT*(Z-FLOAT(K))
   12 IJL=IJL+NN
      RETURN
C
   14 M=-M
      IF (M.EQ.1) CALL ZERO (B,NMAT)
      CALL FTATN (M,ATEN(LATEN),NMAT)
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)
      HS=.5*S
      ZN=.5*FLOAT(NDIM+1)
      ZZ=ZN*(S-C)+AXIS
      IJL=1
      DO 18 J=1,NDIM
      ZZ=ZZ+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 16 IJ=IJL,IJU
      Z=Z-S
      K=Z
      ISUB=LATEN+IJ-1
      FACT=ATEN(ISUB)
   16 B(IJ)=B(IJ)+FACT**2*((FLOAT(K+1)-Z)**2*P(K)+(Z-FLOAT(K))**2*P(K+1)
     1)
   18 IJL=IJL+NN
      M=-M
      RETURN
   20 IF (M.LT.0) GO TO 14
      DO 22 I=1,4
   22 B(I)=FLAGS(I)
      RETURN
      END
```

PCDF

```
      SUBROUTINE PCDF (B,P,M)
C
C     ******************************************************************
C     *       RECLBL    --          VERSION 1.0     --         17OCT77   *
C     ******************************************************************
C
C          THE SUBROUTINE PCDF PROJECTS FROM THE ARRAY B A SINGLE
C     PROJECTION INTO THE ARRAY P USING A FAN BEAM GEOMETRY.  THE
C     PROJECTION HAS THE ANGLE ANG(M) WHERE M IS THE INDEX OF THE
C     ANGLE.  THE SUBROUTINE BCDF GIVES AN APPROXIMATION FOR A MODEL
C     WITH UNIFORM DENSITY IN EACH CELL SUCH THAT EACH CELL PROJECTS
C     AS A SQUARE WAVE.
C
C       B         - THE ARRAY OF DATA FOR THE TRANSVERSE SECTION
C       P         - THE PROJECTION ARRAY
C       M         - THE ANGLE INDEX
C                 - IF M .EQ. 0 ONLY A SET OF FLAGS IS RETURNED IN B
C                   NO PROJECTION OPERATION IS PERFORMED
C                   (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C                 - IF M .LT. 0, ITS ABSOLUTE VALUE IS USED AS ANGLE
C                   INDEX.  HOWEVER, RATHER THAN A PROJECTION OPERATION
C                   BEING PERFORMED, A WEIGHTED BACK-PROJECTION IS
C                   CALCULATED.  IT IS USED BY THE ITERATIVE RELAXATION
C                   RECONSTRUCTION METHOD.
C
C
C     THIS SUBROUTINE CALLS RECLBL ROUTINES - ZERO
C
C     RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C     LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                     COMMON
C         IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                     SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                     FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                     EXECUTING.
C         WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/FANCOM/RFAN,TFANC,TFANF
      LOGICAL TFANC,TFANF
C
C         RFAN    - FOR FAN BEAM GEOMETRY RFAN IS THE DISTANCE FROM
C                     THE SOURCE TO THE CENTER OF ROTATION.  RFAN
C                     IS MEASURED IN UNITS OF PROJECTION BIN WIDTHS AT
C                     THE CENTER OF ROTATION.
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C         TFANC   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                      CURVED DETECTOR
C         TFANF   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                      FLAT DETECTOR
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C         NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C         NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C         PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C         TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C         NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C         LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                      NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                      THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C         KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                      IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C         IGEOM   - GEOMETRY FLAG
C               0 = PARALLEL BEAM GEOMETRY
C               1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C               2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C               3 = RING DETECTOR GEOMETRY
C         KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                      BY THE USER
C         AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                      AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                      IN THE CENTER OF A PROJECTION BIN.)
C         BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                      ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                      ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C         KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE LAST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                      TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                      KDIM=KDIMU.
C         AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY, USUALLY AXIS=AXISU.
C         LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                      INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                      VECTOR
C         NANG    - NUMBER OF PROJECTIONS
C         MODANG  - MODE FOR PROJECTION ANGLE INPUT
C         LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                      PROJECTION ANGLES IN RADIANS
C         LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                      SINE OF THE PROJECTION ANGLES
C         LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                      COSINE OF THE PROJECTION ANGLES
C         LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                      USER PROJECTION DATA AND UNCERTAINTIES
C         TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                      FALSE FOR TRANSMISSION DATA
C
C
C     ***THESE VARIABLES ARE USED IN THIS SUBROUTINE
C
C          DH     - THE DISTANCE BETWEEN THE SOURCE AND THE PIXEL
C          ARC    - THE ARC DISTANCE BETWEEN THE CENTER AXIS AND THE
C                      IMAGE OF THE PIXEL
C          BETAU  - THE ANGLE BETWEEN THE CENTER AXIS AND THE LINE
C                      PASSING ABOVE THE PIXEL
C          BETAL  - THE ANGLE BETWEEN THE CENTER AXIS AND THE LINE
C                      PASSING BELOW THE PIXEL
C          BETAP  - THE ANGLE BETWEEN THE CENTER AXIS AND LINE
C                      PASSING THROUGH THE PIXEL
C          THETAU - THE ANGLE BETWEEN THE LINE PASSING THROUGH THE
C                      PIXEL AND A LINE ABOVE
C          THETAL - THE ANGLE BETWEEN THE LINE PASSING THROUGH THE
C                      PIXEL AND A LINE BELOW
C          DU     - THE PERPENDICULAR DISTANCE BETWEEN THE PIXEL AND
C                      A LINE ABOVE
C          DL     - THE PERPENDICULAR DISTANCE BETWEEN THE PIXEL AND
C                      A LINE BELOW
C          ALPHAU - THE ANGLE THE LINE ABOVE THE PIXEL MAKES WITH
C                      THE SIDE OF THE SQUARE
C          ALPHAL - THE ANGLE THE LINE BELOW THE PIXEL MAKES WITH
C                      THE SIDE OF THE SQUARE
C          ANGLE  - THE ANGLE BETWEEN THE RAYS IN THE FAN BEAM
C
      DIMENSION B(1),P(1)
C        BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/1.,1.,0.,1./
      DATA Z/.499999/
C
      IF (M.LE.0) GO TO 58
C
      CALL ZERO (P,KDIM)
      ANGLE=1./RFAN
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      HS=.5*S
      HC=.5*C
      ZN=.5*FLOAT(NDIM+1)
      ZX=RFAN-ZN*(C+S)
      ZY=ZN*(S-C)
      RFP=RFAN*PWID
      IJL=1
C
      IF (TFANF) GO TO 20
C
      DO 18 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 16 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      ARCTAN=ATAN(ZYY/ZXX)
      ARC=RFAN*ARCTAN
      K=ARC+AXIS+.5
      BETAU=(FLOAT(K)-AXIS+.5)*ANGLE
      BETAL=BETAU-ANGLE
      BETAP=ARCTAN
      THETAU=BETAU-BETAP
      THETAL=BETAP-BETAL
      DU=DH*BWID*THETAU
      DL=DH*BWID*THETAL
      AREA1=AMIN1(.5,DU)
      AREA2=AMIN1(.5,DL)
      AREA=AREA1+AREA2
      MK=K
      MK1=MK
      MK2=MK
      P(MK)=P(MK)+B(IJ)*AREA*RFP/DH
      AREAX=AREA1
      AREAY=AREA2
      IF (AREA1.GT.Z) GO TO 12
   10 THETAU=THETAU+ANGLE
      DU=DH*BWID*THETAU
      AREAU1=AMIN1(.5,DU)
      AREAU=AREAU1-AREAX
      AREAX=AREAU1
      MK2=MK2+1
      P(MK2)=P(MK2)+B(IJ)*AREAU*RFP/DH
      IF (AREAU1.LE.Z) GO TO 10
   12 IF (AREA2.GT.Z) GO TO 16
   14 THETAL=THETAL+ANGLE
      DL=DH*BWID*THETAL
      AREAL1=AMIN1(.5,DL)
      AREAL=AREAL1-AREAY
      AREAY=AREAL1
      MK1=MK1-1
      P(MK1)=P(MK1)+B(IJ)*AREAL*RFP/DH
      IF (AREAL1.LE.Z) GO TO 14
   16 CONTINUE
   18 IJL=IJL+NN
      RETURN
C
   20 DO 30 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 28 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      ARCTAN=ATAN(ZYY/ZXX)
      YCENTR=ZYY/ZXX*RFAN
      K=YCENTR+AXIS+.5
      BETAU=ATAN((FLOAT(K)-AXIS+.5)/RFAN)
      BETAL=ATAN((FLOAT(K-1)-AXIS+.5)/RFAN)
      BETAP=ARCTAN
      THETAU=BETAU-BETAP
      THETAL=BETAP-BETAL
      DU=DH*BWID*THETAU
      DL=DH*BWID*THETAL
      AREA1=AMIN1(.5,DU)
      AREA2=AMIN1(.5,DL)
      AREA=AREA1+AREA2
      MK=K
      MK1=MK
      MK2=MK
      P(MK)=P(MK)+B(IJ)*AREA*RFP/ZXX
      AREAX=AREA1
      AREAY=AREA2
      IF (AREA1.GT.Z) GO TO 24
   22 MK2=MK2+1
      ANGLE=ATAN(RFAN/(RFAN**2+(FLOAT(MK2)-AXIS)**2-.25))
      THETAU=THETAU+ANGLE
      DU=DH*BWID*THETAU
      AREAU1=AMIN1(.5,DU)
      AREAU=AREAU1-AREAX
      AREAX=AREAU1
      P(MK2)=P(MK2)+B(IJ)*AREAU*RFP/ZXX
      IF (AREAU1.LE.Z) GO TO 22
   24 IF (AREA2.GT.Z) GO TO 28
   26 MK1=MK1-1
      ANGLE=ATAN(RFAN/(RFAN**2+(FLOAT(MK1)-AXIS)**2-.25))
      THETAL=THETAL+ANGLE
      DL=DH*BWID*THETAL
      AREAL1=AMIN1(.5,DL)
      AREAL=APEAL1-AREAY
      AREAY=AREAL1
      P(MK1)=P(MK1)+B(IJ)*AREAL*RFP/ZXX
      IF (AREAL1.LE.Z) GO TO 26
   28 CONTINUE
   30 IJL=IJL+NN
C
      RETURN
C
   32 M=-M
      IF (M.NE.1) GO TO 34
      CALL ZERO (B,NMAT)
      ANGLE=1./RFAN
C
   34 CONTINUE
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      HS=.5*S
      HC=.5*C
      ZN=.5*FLOAT(NDIM+1)
      ZX=RFAN-ZN*(C+S)
      ZY=ZN*(S-C)
      RFP=RFAN*PWID
      IJL=1
C
      IF (TFANF) GO TO 46
C
      DO 44 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 42 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      ARCTAN=ATAN(ZYY/ZXX)
      ARC=RFAN*ARCTAN
      K=ARC+AXIS+.5
      BETAU=(FLOAT(K)-AXIS+.5)*ANGLE
      BETAL=BETAU-ANGLE
      BETAP=ARCTAN
      THETAU=BETAU-BETAP
      THETAL=BETAP-BETAL
```

```
      DU=DH*BWID*THETAU
      DL=DH*BWID*THETAL
      AREA1=AMIN1(.5,DU)
      AREA2=AMIN1(.5,DL)
      AREA=AREA1+AREA2
      MK=K
      MK1=MK
      MK2=MK
      B(IJ)=B(IJ)+P(MK)*(AREA*RFP/DH)**2
      AREAX=AREA1
      AREAY=AREA2
      IF (AREA1.GT.Z) GO TO 38
   36 THETAU=THETAU+ANGLE
      DU=DH*BWID*THETAU
      AREAU1=AMIN1(.5,DU)
      AREAU=AREAU1-AREAX
      AREAX=AREAU1
      MK2=MK2+1
      B(IJ)=B(IJ)+P(MK2)*(AREAU*RFP/DH)**2
      IF (AREAU1.LE.Z) GO TO 36
   38 IF (AREA2.GT.Z) GO TO 42
   40 THETAL=THETAL+ANGLE
      DL=DH*BWID*THETAL
      AREAL1=AMIN1(.5,DL)
      AREAL=AREAL1-AREAY
      AREAY=AREAL1
      MK1=MK1-1
      B(IJ)=B(IJ)+P(MK1)*(AREAL*RFP/DH)**2
      IF (AREAL1.LE.Z) GO TO 40
   42 CONTINUE
   44 IJL=IJL+NN
      M=-M
      RETURN
C
   46 DO 56 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 54 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      ARCTAN=ATAN(ZYY/ZXX)
      YCENTR=ZYY/ZXX*RFAN
      K=YCENTR+AXIS+.5
      BETAU=ATAN((FLOAT(K)-AXIS+.5)/RFAN)
      BETAL=ATAN((FLOAT(K-1)-AXIS+.5)/RFAN)
      BETAP=ARCTAN
      THETAU=BETAU-BETAP
      THETAL=BETAP-BETAL
      DU=DH*BWID*THETAU
      DL=DH*BWID*THETAL
      AREA1=AMIN1(.5,DU)
      AREA2=AMIN1(.5,DL)
      AREA=AREA1+AREA2
      MK=K
      MK1=MK
      MK2=MK
      B(IJ)=B(IJ)+P(MK)*(AREA*RFP/ZXX)**2
      AREAX=AREA1
      AREAY=AREA2
      IF (AREA1.GT.Z) GO TO 50
   48 MK2=MK2+1
      ANGLE=ATAN(RFAN/(RFAN**2+(FLOAT(MK2)-AXIS)**2-.25))
      THETAU=THETAU+ANGLE
      DU=DH*BWID*THETAU
      AREAU1=AMIN1(.5,DU)
      AREAU=AREAU1-AREAX
      AREAX=AREAU1
      B(IJ)=B(IJ)+P(MK2)*(AREAU*RFP/ZXX)**2
      IF (AREAU1.LE.Z) GO TO 48
   50 IF (AREA2.GT.Z) GO TO 54
   52 MK1=MK1-1
      ANGLE=ATAN(RFAN/(RFAN**2+(FLOAT(MK1)-AXIS)**2-.25))
      THETAL=THETAL+ANGLE
      DL=DH*BWID*THETAL
      AREAL1=AMIN1(.5,DL)
      AREAL=AREAL1-AREAY
      AREAY=AREAL1
      B(IJ)=B(IJ)+P(MK1)*(AREAL*RFP/ZXX)**2
      IF (AREAL1.LE.Z) GO TO 52
   54 CONTINUE
   56 IJL=IJL+NN
      M=-M
      RETURN
C
   58 IF (M.LT.0) GO TO 32
      DO 60 I=1,4
   60 B(I)=FLAGS(I)
      RETURN
      END
```

PHAN

```
      SUBROUTINE PHAN (NPHAN,INTG,ITYPE,DENS,X,Y,A,B,PHI,BB,N,PIXW)
C
C     ******************************************************************
C     *       RECLBL     --          VERSION 1.0     --        17OCT77   *
C     ******************************************************************
C
C           SUBROUTINE PHAN GENERATES A PHANTOM CONSISTING OF ELLIPSES
C       AND RECTANGLES IN THE SQUARE ARRAY BB WHICH HAS DIMENSIONS
C       N X N.  THE INPUT PARAMETERS ARE
C
C         NPHAN    - THE TOTAL NUMBER OF ELLIPSES AND RECTANGLES
C         INTG     - AN INTEGRATION FACTOR.  WHEN A PIXEL LIES PARTLY
C                      INSIDE AND PARTLY OUTSIDE A BOUNDARY IT IS
C                      DIVIDED INTO INTG X INTG PIXELETTES WHICH ARE
C                      EACH CHECKED FOR INSIDENESS.  THE FINAL VALUE
C                      ASSIGNED TO THE LARGE PIXEL IS THE VALUE OF DENS
C                      MULTIPLIED BY THE FRACTION OF PIXELETTES THAT
C                      WERE FOUND TO LIE INSIDE THE BOUNDARY.  (A GOOD
C                      VALUE IS 10)
C         ITYPE    - AN ARRAY OF DESCRIPTORS FOR THE ELLIPSES/RECTANGLES
C                      1 FOR A ELLIPSE
C                      2 FOR A RECTANGLE
C         DENS     - AN ARRAY OF DENSITIES OF THE ELLIPSES/RECTANGLES
C                      FOR TRANSMISSION THE UNITS ARE PER PROJECTION
C                      BIN WIDTH
C                      FOR EMISSION THE UNITS ARE PER (PROJECTION
C                      BIN WIDTH)**2
C         X,Y      - ARRAYS GIVING THE X,Y COORDINATES OF THE CENTERS
C                      OF THE ELLIPSES/RECTANGLES WITH RESPECT TO THE
C                      CENTER OF ROTATION. (IN UNITS OF PROJECTION
C                      BIN WIDTH)
C         A,B      - ARRAYS GIVING THE MAJOR AND MINOR AXES OF
C                      ELLIPSES OR THE LENGTHS OF THE SIDES OF RECT-
C                      ANGLES (IN UNITS OF PROJECTION BIN WIDTH)
C         PHI      - AN ARRAY OF ANGLES (IN RADIANS) WHICH THE MAJOR
C                      AXES OF THE ELLIPSES OR THE -A- SIDES OF THE
C                      RECTANGLES MAKE WITH THE X-AXIS
C         BB       - SQUARE ARRAY WHICH STORES THE PHANTOM
C         N        - THE DIMENSION OF B
C         PIXW     - PIXEL WIDTH WHICH IS UTILIZED BY THIS ROUTINE
C                      IN ORDER THAT THE VALUES FOR BB BE AS RECONS-
C                      TRUCTED. (+ FOR TRANSMISSION - FOR EMISSION)
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - EMESG, LGTXT, ZERO
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C         LUNOUT  - LOGICAL UNIT NUMBER FOR OUTPUT
C         I80132  - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                     OUTPUT ON LUNOUT
C                0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      DIMENSION BB(N,N)
      DIMENSION A(1),B(1),X(1),Y(1),PHI(1),DENS(1),ITYPE(1)
      DIMENSION IELIPS(5),IRECT(5)
      DIMENSION NAMER(9)
      DATA NAMER/1HE,1HN,1HD,1H ,1HP,1HH,1HA,1HN,1H /
      DATA IELIPS,IRECT/2HEL,2HLI,2HPS,2HE ,2H  ,
     1                  2HRE,2HCT,2HAN,2HGL,2HE /
C
      CALL LGTXT (NAMER(5),5)
      LUN=LUNOUT
      CALL ZERO (BB,N**2)
C
C       *SET SCALE FACTOR TO CORRESPOND TO EITHER TRANSMISSION (+) OR
C         EMISSION (-)
C
      DALE=ABS(PIXW)
      SCALE=1./DALE
      IF (PIXW.LT.0.) DALE=PIXW**2
C
      HALFN=(FLOAT(N)+1.)/2.
      DO 48 IPH=1,NPHAN
      CONST=DALE*DENS(IPH)/FLOAT(INTG)**2
      X2=X(IPH)*SCALE
      Y2=Y(IPH)*SCALE
      R1=.5*A(IPH)*SCALE
      R2=.5*B(IPH)*SCALE
      S=-SIN(PHI(IPH))
      C=COS(PHI(IPH))
      JTYPE=ITYPE(IPH)
      DO 46 I=1,N
C
C           CONVERT PIXEL NUMBERS TO X,Y COORDINATES
C
      TI=FLOAT(I)-HALFN
      DO 46 J=1,N
      TJ=FLOAT(J)-HALFN
C
C           INITIALIZE FLAGS AND LOCAL VARIABLES
C
      ACCUM=0.
      IFLG2=0
      IFLG1=0
      SIGN1=.5
      SIGN2=.5
C
C           CHECK EACH OF THE 4 CORNERS FOR INSIDENESS
C
      DO 26 I2=1,2
      DO 24 I1=1,2
      X1=TI+SIGN1-X2
      Y1=TJ+SIGN2-Y2
C
C           ROTATE TO THE RECTANGLES COORDINATE SYSTEM
C
      X3=ABS(X1*C-Y1*S)
      Y3=ABS(X1*S+Y1*C)
      IF (JTYPE-1) 48,10,12
   10 IF ((X3/R1)**2+(Y3/R2)**2-1.) 14,14,18
   12 IF ((X3-R1).GT.0..OR.(Y3-R2).GT.0.) GO TO 18
C           IFLG1 POSITIVE MEANS WE HAVE FOUND AT LEAST ONE CORNER INSIDE
C           IFLG2 POSITIVE MEANS WE HAVE FOUND AT LEAST ONE CORNER OUTSID
C
   14 IF (IFLG2) 16,16,34
   16 IFLG1=1
      GO TO 22
   18 IF (IFLG1) 20,20,34
   20 IFLG2=1
   22 SIGN1=-SIGN1
   24 CONTINUE
      SIGN2=-SIGN2
   26 CONTINUE
C
C           IF ONLY IFLG1 IS ON THE PIXEL IS COMPLETELY INSIDE
C
      IF (IFLG1) 28,28,32
C
C           IF ONLY IFLG2 IS ON THE PIXEL IS COMPLETELY OUTSIDE
C
   28 IF (IFLG2) 30,30,44
   30 CALL EMESG (30,NAMER(5),2)
   32 ACCUM=DALE*DENS(IPH)
      GO TO 44
C
C           IF BOTH FLAGS ARE ON THE PIXEL IS ON THE BORDER AND WE MUST
C                   INTEGRATE
C
   34 XINC=1./FLOAT(INTG)
      X1=TI-X2-.5*(1.+XINC)
      DO 42 K=1,INTG
      Y1=TJ-Y2-.5*(1.+XINC)
      X1=X1+XINC
      DO 42 L=1,INTG
      Y1=Y1+XINC
      X3=ABS(X1*C-Y1*S)
      Y3=ABS(X1*S+Y1*C)
      IF (JTYPE-1) 48,36,38
   36 IF ((X3/R1)**2+(Y3/R2)**2-1.) 40,40,42
   38 IF ((X3-R1).GT.0..OR.(Y3-R2).GT.0.) GO TO 42
   40 ACCUM=ACCUM+CONST
   42 CONTINUE
   44 BB(I,J)=BB(I,J)+ACCUM
   46 CONTINUE
   48 CONTINUE
C
      WRITE (LUN,52) N,N,INTG,SCALE
      WRITE (LUN,54) NPHAN
      WRITE (LUN,56)
      WRITE (LUN,58)
      WRITE (LUN,60)
```

```
      WRITE (LUN,62)
      WRITE (LUN,64)
      WRITE (LUN,66)
      WRITE (LUN,68)
      DO 50 I=1,NPHAN
      IF (ITYPE(I).EQ.1) WRITE (LUN,70) ITYPE(I),IELIPS,X(I),Y(I),A(I),B
     1(I),PHI(I),DENS(I)
      IF (ITYPE(I).EQ.2) WRITE (LUN,70) ITYPE(I),IPECT,X(I),Y(I),A(I),B(
     1I),PHI(I),DENS(I)
      XSC=SCALE*X(I)
      YSC=SCALE*Y(I)
      ASC=SCALE*A(I)
      BSC=SCALE*B(I)
      DENSC=DALE*DENS(I)
      WRITE (LUN,72) XSC,YSC,ASC,BSC,DENSC
   50 CONTINUE
C
      CALL LGTXT (NAMER,9)
      RETURN
C
C
C
   52 FORMAT( ////18H PHANTOM GENERATED/15H   ARRAY SIZE  ,I3,3H X ,I3,3
     1X,21HINTEGRATION FACTOR = ,I3,3X,17HSCALING FACTOR = ,F8.3)
   54 FORMAT(1X,41H  NUMBER OF ELIPSES AND/OR RECTANGLES =  ,I3)
   56 FORMAT(1X,55H  THE PARAMETERS FOR THE ELLIPSES AND/OR RECTANGLES A
     1RE)
   58 FORMAT(8X,13HX,Y  - CENTER)
   60 FORMAT(8X,37HA,B  - LENGTH OF AXIS OR SIDE A AND B)
   62 FORMAT(8X,30HPHI  - ANGLE OF AXIS OR SIDE A)
   64 FORMAT(8X,16HDENS - INTENSITY)
   66 FORMAT(1X,44H  THE PARENTHESIS INDICATES THE SCALED VALUE)
   68 FORMAT(5X,5HITYPE,18X,1HX,9X,1HY,8X,1HA,9X,1HB,7X,3HPHI,6X,4HDENS)
   70 FORMAT(5X,I3,3X,2H- ,5A2,2X,F7.2,3H , ,F7.2,2X,F7.2,3H , ,F7.2,2X,
     1F7.2,2X,F7.2)
   72 FORMAT(24X,1H(,F7.2,3H),(,F7.2,2H)(,F7.2,3H),(,F7.2,1H),9X,1H(,F7.
     12,1H))
      END
```

PHANL

```
      SUBROUTINE PHANL (N,ITYPE,DENS,X,Y,A,B,PHI,P,M)
C
C     ******************************************************************
C     *      RECLBL    --         VERSION 1.0    --         17OCT77    *
C     ******************************************************************
C
C          SUBROUTINE PHANL GENERATES THE LINE INTEGRAL PROJECTIONS
C     OF A SET OF SOURCE ELLIPSES AND RECTANGLES ATTENUATED BY
C     ANOTHER SET OF ATTENUATING ELLIPSES AND RECTANGLES.  THE INPUT
C     PARAMETERS ARE,
C
C        N       - THE TOTAL NUMBER OF ELLIPSES AND RECTANGLES
C        ITYPE   - AN ARRAY OF DESCRIPTORS FOR THE ELLIPSES/RECTANGLES
C                    1 FOR A SOURCE ELLIPSE
C                    2 FOR A SOURCE RECTANGLE
C                   -1 FOR AN ATTENUATING ELLIPSE
C                   -2 FOR AN ATTENUATING RECTANGLE
C        DENS    - AN ARRAY OF SOUCRE DENSITIES OR ATTENUATION COEF-
C                    FICIENTS OF THE ELLIPSES/RECTANGLES
C                    FOR TRANSMISSION THE UNITS ARE PER PROJECTION
C                    BIN WIDTH
C                    FOR EMISSION THE UNITS ARE PER (PROJECTION
C                    BIN WIDTH)**2
C        X,Y     - ARRAYS GIVING THE X,Y COORDINATES OF THE CENTERS
C                    OF THE ELLIPSES/RECTANGLES WITH RESPECT TO THE
C                    CENTER OF ROTATION. (IN UNITS OF PROJECTION
C                    BIN WIDTH)
C        A,B     - ARRAYS GIVING THE MAJOR AND MINOR AXES OF
C                    ELLIPSES OR THE LENGTHS OF THE SIDES OF RECT-
C                    ANGLES (IN UNITS OF PROJECTION BIN WIDTH)
C        PHI     - AN ARRAY OF ANGLES (IN RADIANS) WHICH THE MAJOR
C                    AXES OF THE ELLIPSES OR THE -A- SIDES OF THE
C                    RECTANGLES MAKE WITH THE X-AXIS
C        P       - THE ARRAY INTO WHICH THE PROJECTION IS GENERATED
C        M       - THE PROJECTION ANGLE INDEX AS DEFINED IN SETUP
C
C     THIS SUBROUTINE CALLS RECLBL ROUTINE - EMESG
C
C     RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C     LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C        NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                    COMMON
C        IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C        NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C        ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                    SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                    FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                    EXECUTING.
C        WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/FANCOM/RFAN,TFANC,TFANF
      LOGICAL TFANC,TFANF
C
C        RFAN    - FOR FAN BEAM GEOMETRY RFAN IS THE DISTANCE FROM
C                    THE SOURCE TO THE CENTER OF ROTATION.  RFAN
C                    IS MEASURED IN UNITS OF PROJECTION BIN WIDTHS AT
C                    THE CENTER OF ROTATION.
C        TFANC   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                    CURVED DETECTOR
C        TFANF   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                    FLAT DETECTOR
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C        LUNOUT  - LOGICAL UNIT NUMBER FOR OUTPUT
C        I80132  - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                    OUTPUT ON LUNOUT
C              0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      COMMON/PHNCOM/LPHAN
      DIMENSION PHAN(1)
      EQUIVALENCE (WORK(1),PHAN(1))
C
C        LPHAN   - POINTER TO THE ARRAY PHAN IN BLANK COMMON
C                    WORKING STORAGE FOR PHANTOM GENERATING ROUTINES
C
      COMMON/STRCOM/TSTORE
      LOGICAL TSTORE
C
C        TSTORE  - LOGICAL VARIABLE SET TRUE WHEN TESTING STORAGE SIZE
C                    SETS TPRINT(1) = .TRUE.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C        IGEOM   - GEOMETRY FLAG
C              0 = PARALLEL BEAM GEOMETRY
C              1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C              2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C              3 = RING DETECTOR GEOMETRY
C        KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                    BY THE USER
C        AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                    PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                    AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                    IN THE CENTER OF A PROJECTION BIN.)
C        BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C        KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                    ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                    ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C        KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                    THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                    IS GOING TO BE USED.
C        KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                    THE DATA OF THE LAST USER PROJECTION BIN THAT
C                    IS GOING TO BE USED.
C        KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                    TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                    KDIM=KDIMU.
C        AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                    PROJECTION ARRAY, USUALLY AXIS=AXISU.
C        LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                    INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                    VECTOR
C        NANG    - NUMBER OF PROJECTIONS
C        MODANG  - MODE FOR PROJECTION ANGLE INPUT
C        LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                    PROJECTION ANGLES IN RADIANS
C        LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                    SINE OF THE PROJECTION ANGLES
C        LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                    COSINE OF THE PROJECTION ANGLES
C        LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                    USER PROJECTION DATA AND UNCERTAINTIES
C        TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                    FALSE FOR TRANSMISSION DATA
C
      DIMENSION ITYPE(1),X(1),Y(1),A(1),B(1),PHI(1),DENS(1),P(1)
      DIMENSION RX(4),RY(4),RZ(2)
      DIMENSION NAMER(9)
      DATA NAMER/1HE,1HN,1HD,1H ,1HP,1HH,1HA,1HN,1HL/
      DATA IOK,EPS,NSAVE/2HOK,1.E-6,0/
C
C        *BE SURE THAT SETUP HAS BEEN CALLED
C
      IF (ISETUP.NE.IOK) CALL EMESG (1,NAMER(5),1)
C
      FAC=1.
      IF (TEMIT) FAC=1./FLOAT(NANG)
      KATEN=0
      IERS=0
      IERA=0
C
      ISUB=LSINE+M-1
      ST=SINE(ISUB)
      ISUB=LCOSIN+M-1
      CT=COSINE(ISUB)
C
C        *CHECK THE PARAMETERS AND STORE AWAY SINES AND COSINES
C
      IF (N.LT.1) GO TO 62
      IF (LPHAN.LT.0.OR.N.NE.NSAVE) CALL MEMST (LPHAN,8*N)
      NSAVE=N
      IF (TSTORE) GO TO 60
      ISUB=LPHAN+6*N
      DO 10 I=1,N
      IF (ITYPE(I).LT.0) KATEN=1
      IF (IABS(ITYPE(I)).EQ.0.OR.IABS(ITYPE(I)).GT.2) GO TO 62
      IF (A(I).LT.EPS) GO TO 62
      IF (B(I).LT.EPS) GO TO 62
      PHAN(ISUB)=SIN(PHI(I))
      PHAN(ISUB+1)=COS(PHI(I))
   10 ISUB=ISUB+2
C
C        *SET IPCFR ACCORDING TO PARALLEL, CURVED FAN, FLAT FAN OR RING
C
      KLIM=KDIMU
      IPCFR=IGEOM+1
      GO TO (12,14,18,16),IPCFR
   12 S=ST
      C=CT
      GO TO 18
   14 DPSI=1./RFAN
      PSI=-AXISU*DPSI
      SP=SIN(PSI)
      CP=COS(PSI)
      S=ST*CP+CT*SP
      C=CT*CP-ST*SP
      SDP=SIN(DPSI)
      CDP=COS(DPSI)
      GO TO 18
   16 KLIM=NANG
      IF (M.EQ.NANG/2) KLIM=NANG/2
      PI=4.*ATAN(1.)
      ZK=FLOAT(NANG)*CT/(2.*PI)
      FAC=2.*PI/FLOAT(NANG)
   18 CONTINUE
C
C        *LOOP OVER THE PROJECTION BINS FOR THIS ANGLE
C
      DO 58 K=1,KLIM
C
      GO TO (20,22,24,26),IPCFR
   20 ZK=FLOAT(K)-AXISU
      GO TO 28
   22 T=S*CDP+C*SDP
      C=C*CDP-S*SDP
      S=T
      ZK=RFAN*(S*CT-C*ST)
      GO TO 28
   24 ZK=FLOAT(K)-AXISU
      ZRI=1./SQRT(ZK**2+RFAN**2)
      SP=ZK*ZRI
      CP=RFAN*ZRI
      ZK=RFAN*SP
      S=ST*CP+CT*SP
```

```
      C=CT*CP-ST*SP
      GO TO 28
   26 MMM=2*K+M-3
      IF (MMM.GE.2*NANG) MMM=MMM-2*NANG
      ISUB=LSINE+MMM
      C=SINE(ISUB)
      ISUB=LCOSIN+MMM
      S=-COSINE(ISUB)
   28 CONTINUE
C
C        *THE FOLLOWING LOOP FINDS INTERSECTIONS
C
      NIN=0
      ISUB=LPHAN
      ISC=LPHAN+6*N
      DO 44 I=1,N
      SS=PHAN(ISC)*C-PHAN(ISC+1)*S
      CC=PHAN(ISC+1)*C+PHAN(ISC)*S
      D=ZK+X(I)*S-Y(I)*C
      DD=X(I)*C+Y(I)*S
C
      IF (IABS(ITYPE(I)).EQ.2) GO TO 30
C
C        *THIS IS FOR AN ELLIPSE
C
      ASBC=(A(I)*SS)**2+(B(I)*CC)**2
      ASBCD=.25*ASBC-D**2
      IF (ASBCD.LE.0.) GO TO 44
      ZPM=ABS(A(I)*B(I))*SQRT(ASBCD)/ASBC
      ZP=D*SS*CC*(A(I)**2-B(I)**2)/ASBC+DD
      PHAN(ISUB)=ZP+ZPM
      PHAN(ISUB+3)=ZP-ZPM
      GO TO 38
C
C        *THIS IS FOR A RECTANGLE
C
   30 RY(1)=.5*(A(I)*SS+B(I)*CC)
      RY(2)=.5*(-A(I)*SS+B(I)*CC)
      RY(3)=.5*(-A(I)*SS-B(I)*CC)
      RY(4)=.5*(A(I)*SS-B(I)*CC)
      RYM=RY(1)
      IF (RY(2).GE.RYM) RYM=RY(2)
      IF (RY(3).GE.RYM) RYM=RY(3)
      IF (RY(4).GE.RYM) RYM=RY(4)
      IF (ABS(D).GE.RYM) GO TO 44
      RX(1)=.5*(A(I)*CC-B(I)*SS)
      RX(2)=.5*(-A(I)*CC-B(I)*SS)
      RX(3)=.5*(-A(I)*CC+B(I)*SS)
      RX(4)=.5*(A(I)*CC+B(I)*SS)
C
      J=1
      DO 32 II=1,4
      JJ=1+MOD(II,4)
      RYJI=RY(JJ)-RY(II)
      IF (ABS(RYJI).LT.EPS) GO TO 32
      IF (ABS(.5*(RY(JJ)+RY(II))-D).GT..5*ABS(RYJI)) GO TO 32
      RZ(J)=(RX(II)*(RY(JJ)-D)+RX(JJ)*(D-RY(II)))/RYJI
      IF (J.EQ.2) GO TO 34
      J=2
   32 CONTINUE
      GO TO 44
   34 IF (RZ(2).GE.RZ(1)) GO TO 36
      PHAN(ISUB)=RZ(1)+DD
      PHAN(ISUB+3)=RZ(2)+DD
      GO TO 38
   36 PHAN(ISUB)=RZ(2)+DD
      PHAN(ISUB+3)=RZ(1)+DD
C
C        *BOTH ELLIPSES AND RECTANGLES COME HERE
C
   38 IF (ITYPE(I).LT.0) GO TO 40
C
C        *SOURCES
C
      PHAN(ISUB+1)=DENS(I)
      PHAN(ISUB+2)=0.
      PHAN(ISUB+4)=-DENS(I)
      PHAN(ISUB+5)=0.
      GO TO 42
C
C        *ATTENUATORS
C
   40 PHAN(ISUB+1)=0.
      PHAN(ISUB+2)=DENS(I)
      PHAN(ISUB+4)=0.
      PHAN(ISUB+5)=-DENS(I)
C
   42 NIN=NIN+2
      ISUB=ISUB+6
C
   44 ISC=ISC+2
C
C        *IF NO INTERSECTIONS JUMP IMMEDIATELY
C
      SACT=0.
      IF (NIN.LE.0) GO TO 58
C
C        *THE FOLLOWING LOOP ORDERS ALL INTERSECTIONS
C
      NINM=NIN-1
      ISUB=LPHAN
      DO 48 I=1,NINM
      ZMAX=PHAN(ISUB)
      ISUBM=ISUB
      JJ=I+1
      ISUBJ=ISUB+3
      DO 46 J=JJ,NIN
      IF (PHAN(ISUBJ).LE.ZMAX) GO TO 46
      ISUBM=ISUBJ
      ZMAX=PHAN(ISUBJ)
   46 ISUBJ=ISUBJ+3
      IF (ISUBM.EQ.ISUB) GO TO 48
      T=PHAN(ISUB)
      PHAN(ISUB)=PHAN(ISUBM)
      PHAN(ISUBM)=T
      T=PHAN(ISUB+1)
      PHAN(ISUB+1)=PHAN(ISUBM+1)
      PHAN(ISUBM+1)=T
      T=PHAN(ISUB+2)
      PHAN(ISUB+2)=PHAN(ISUBM+2)
      PHAN(ISUBM+2)=T
   48 ISUB=ISUB+3
C
C        *THE FOLLOWING LOOP MAKES INTERVALS OUT OF THE INTERSECTIONS
C
      NINL=0
      ISUBL=LPHAN
      Z=PHAN(ISUBL)
      SD=PHAN(ISUBL+1)
      AC=PHAN(ISUBL+2)
      ISUB=ISUBL+3
      DO 52 I=2,NIN
      IF (Z-PHAN(ISUB).LE.EPS) GO TO 50
      NINL=NINL+1
      PHAN(ISUBL)=Z-PHAN(ISUB)
      Z=PHAN(ISUB)
      PHAN(ISUBL+1)=SD
      PHAN(ISUBL+2)=AC
      ISUBL=ISUBL+3
   50 SD=SD+PHAN(ISUB+1)
      AC=AC+PHAN(ISUB+2)
   52 ISUB=ISUB+3
C
C        *THE FOLLOWING LOOP CALCULATES THE PROJECTED, ATTENUATED
C           ACTIVITY
C
      ATTN=0.
      ISUB=LPHAN
      DO 56 I=1,NINL
      Z=PHAN(ISUB)
      SD=PHAN(ISUB+1)
      IF (SD.LE.-EPS) IERS=1
      AC=PHAN(ISUB+2)
      IF (AC.LE.-EPS) IERA=1
      IF (SD.LT.EPS) GO TO 54
      IF (AC.LT.EPS) SZ=SD*Z
      IF (AC.GE.EPS) SZ=(SD/AC)*(1.-EXP(-AC*Z))
      SACT=SACT+SZ*EXP(-ATTN)
   54 ATTN=ATTN+AC*Z
   56 ISUB=ISUB+3
C
C        *SACT IS THE PROJECTED, ATTENUATED SOURCE ACTIVITY
C
   58 P(K)=SACT*FAC
C
   60 IF (M.EQ.NANG) CALL MEMST (LPHAN,0)
      IF (KATEN.EQ.0) RETURN
      IF (IERS.NE.0) WRITE (LUNOUT,66)
      IF (IERA.NE.0) WRITE (LUNOUT,68)
      IF (IERS+IERA.NE.0) CALL EMESG (11,NAMER(5),0)
      RETURN
C
   62 WRITE (LUNOUT,70) N
      IF (N.LT.1) GO TO 64
      WRITE (LUNOUT,72) (ITYPE(I),X(I),Y(I),A(I),B(I),PHI(I),DENS(I),I=1
     1,N)
   64 CALL EMESG (10,NAMER(5),1)
      RETURN
C
C
C
   66  FORMAT(/1X,77H WARNING... NEGATIVE SOURCE ACTIVITY DETECTED DURIN
     1G GENERATION OF PHANL DATA)
   68 FORMAT(/1X,73H WARNING... NEGATIVE ATTENUATION DETECTED DURING GEN
     1ERATION OF PHANL DATA)
   70 FORMAT(  //73H THERE IS A PARAMETER ERROR IN THE CALL TO SUBROUTIN
     1E PHANL   ...STOP..../
     2           / 14H THE RULES ARE/
     3        5X, 19H N MUST BE POSITIVE/
     4        5X, 30H ITYPE MUST BE 1, 2, -1, OR -2/
     5        5X, 25H A AND B MUST BE POSITIVE/
     6       10X,  4H N =,I4)
   72 FORMAT(/10X,5HITYPE,9X,1HX,9X,1HY,9X,1HA,9X,1HB,7X,3HPHI,
     1             6X,4HDENS/
     2            /(5X,I10,6F10.3))
      END
```

PIE

```
      SUBROUTINE PIE (B1,N,R,X1,Y1,Z,INTFAC,NSLIPI,ISTART)
C
C     ****************************************************************
C     *    RECLBL    --          VERSION 1.0     --        17OCT77   *
C     ****************************************************************
C
C           THE SUBROUTINE PIE GIVES A PIE PHANTOM CONSISTING OF
C        2*NSLIPI SLICES ALTERNATING BLACK AND WHITE
C
C        B1      - ARRAY WHERE PHANTOM IS GENERATED
C        N       - DIMENSION OF THE SQUARE ARRAY B1
C        R       - RADIUS OF CIRCLE PHANTOM
C        X1,Y1   - CENTER OF CIRCLE RELATIVE TO THE CENTER
C                     OF ARRAY
C        Z       - FULL VALUE OF FUNCTION
C        INTFAC  - INTEGRATION FACTOR.  EACH BORDER PIXEL IS DIVIDED
C                     INTO INTFAC**2 PIXELETTES FOR INTEGRATION
C        NSLIPI  - NUMBER OF SLICES IN HALF THE PIE ( IN PI RADIANS)
C        ISTART  - INDICATOR OF THE COLOR OF THE FIRST (COUNTERCLOCK-
C                     WISE) SLICE.  0 = WHITE ELSE IT IS BLACK.
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - LGTXT
C        LANGUAGE - FORTRAN
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C           LUNOUT  - LOGICAL UNIT NUMBER FOR OUTPUT
C           I80132  - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                        OUTPUT ON LUNOUT
C                  0 = 80 CHARACTERS   (132 CHARACTERS OTHERWISE)
C
      DIMENSION B1(N,N)
      DIMENSION NAMER(9)
      DATA NAMER/1HE,1HN,1HD,1H ,1HP,1HI,1HE,1H ,1H /
      DATA IOK,EPS/2HOK,1.E-6/
C
      CALL LGTXT (NAMER(5),5)
      PI=4.*ATAN(1.)
      THETAO=PI/FLOAT(NSLIPI)
C
C        VALUE OF ONE PIXELETTE DURING INTEGRATION
C
      CONST=Z/FLOAT(INTFAC*INTFAC)
      HALFN=FLOAT(N+1)/2.
      IF (ISTART.NE.0) ISTART=1
      DO 56 I=1,N
      TI=FLOAT(I)-HALFN
      DO 56 J=1,N
      TJ=FLOAT(J)-HALFN
      ACCUM=0.
      SIGN1=.5
      SIGN2=.5
      IFLG1=0
      IFLG2=0
      IFLG3=0
      IFLG4=0
C
C        *CHECK THE FOUR CORNERS OF CURRENT PIXEL FOR POSITION
C
```

```
      DO 30 I1=1,2
      DO 28 I2=1,2
      X=TI+SIGN1-X1
      Y=TJ+SIGN2-Y1
C
C        *COMPUTE NUMBER OF SECTION WE ARE IN
C
      IF (ABS(X).GE.EPS.OR.ABS(Y).GE.EPS) GO TO 10
      THETA=0.
      GO TO 12
   10 THETA=ATAN2(Y,X)
      IF (THETA.LT.0.) THETA=2.*PI+THETA
   12 IPARAM=THETA/THETAO
C
C        ARE WE INSIDE CIRCLE
C
      IF (X*X+Y*Y-R*R) 16,16,14
   14 IFLG1=1
      GO TO 22
   16 IFLG2=1
C
C              FLAG 1 MEANS OUTSIDE CIRCLE
C              FLAG 2 MEANS INSIDE CIRCLE
C              FLAG 3 MEANS AN ODD SECTION
C              FLAG 4 MEANS AN EVEN SECTION
C
C        WHAT COLOR IS THE SECTION WE ARE IN
C
      IF (I1+I2.NE.2.AND.IPARAM.NE.IPOLD) GO TO 42
      IF (IPARAM/2*2-IPARAM) 18,20,18
   18 IFLG3=1
      GO TO 22
   20 IFLG4=1
C
C        IF ALL THE FLAGS ARE UP, WE CAN BEGIN INTEGRATION
C        ELSE CHECK THE OTHER CORNERS
C
   22 IF (IFLG1-IFLG2) 26,24,26
   24 IF (IFLG3+IFLG4-2) 26,42,26
C
C        TOGGLE SIGNS, GO TO ANOTHER CORNER
C
   26 SIGN1=-SIGN1
      IPOLD=IPARAM
   28 CONTINUE
      SIGN2=-SIGN2
   30 CONTINUE
C
C        IF WE START WITH A ONE SECTION, THEN WE ARE BACKWARDS
C
      IF (ISTART) 32,34,32
   32 IT=IFLG3
      IFLG3=IFLG4
      IFLG4=IT
C
C        *ARE WE IN THE CIRCLE AND A 1 SECTION
C        OR ARE WE STRADDLING ANY LINES
   34 IF (IFLG1-IFLG2) 36,40,54
   36 IF (IFLG3-IFLG4) 54,42,38
   38 ACCUM=Z
      GO TO 54
   40 IF (IFLG3-IFLG4) 54,42,42
C
C        2-D INTEGRATION ROUTINE
C
   42 DO 52 K=1,INTFAC
      DO 52 L=1,INTFAC
      X=TI+FLOAT(K)/FLOAT(INTFAC)-.5-X1
      Y=TJ+FLOAT(L)/FLOAT(INTFAC)-.5-Y1
C
C        *COMPUTE THE POSITION OF PIXELLETTE RELATIVE TO THE CENTER OF
C             THE CIRCLE
C
      IF (X*X+Y*Y-R*R) 44,44,52
C
C        ATAN2 BLOWS UP AT (0,0)
C
   44 IF (ABS(X)+ABS(Y).GT.EPS) GO TO 46
      THETA=0.
      GO TO 48
C
C        *COMPUTE ANGLE OF OUR POSITION
C
   46 THETA=ATAN2(Y,X)
   48 IF (THETA.LT.0.) THETA=2.*PI+THETA
C
C        *COMPUTE THE NUMBER OF OUR SECTION
C
      IPARAM=IFIX(THETA/THETAO)
C
C        WHAT COLOR IS IT (1 OR 0)
C
      IF (IPARAM-IPARAM/2*2-ISTART) 50,52,50
C
C        ADD ONE PIXELLETE VALUE IF WE ARE INSIDE AND IN A 1 AREA.
C
   50 ACCUM=ACCUM+CONST
   52 CONTINUE
   54 B1(I,J)=ACCUM
   56 CONTINUE
C
      WRITE (LUNOUT,58) N,N,R,X1,Y1,INTFAC,THETAO
      CALL LGTXT (NAMER,9)
      RETURN
C
C
   58 FORMAT(  ///22H PIE PHANTOM GENERATED/13H ARRAY SIZE   ,I3,
     11HX,I3/16H CIRCLE RADIUS  ,F6.2,7H  AT  (,F3.0,1H,,F3.0,1H)/
     213H INT FACTOR  ,I3/15H SECTOR WIDTH  ,F6.3)
      END
```

PJECT

```
      SUBROUTINE PJECT (B,P,M,PRJ)
C
C     ****************************************************************
C     *       RECLBL    --         VERSION 1.0     --       17OCT77  *
C     ****************************************************************
C
C           THE SUBROUTINE PJECT PROJECTS FROM THE ARRAY B INTO A
C       SINGLE PROJECTION ARRAY P OF LENGTH KDIMU WITH ROTATION AXIS
C       EQUAL TO AXISU.  THE PROJECTION HAS THE ANGLE ANG(M) WHERE M IS
C       THE INDEX OF THE ANGLE.  THE SUBROUTINE PJECT REQUIRES THE
C       USER TO SET THE DESIRED SYSTEM PROJECTION SUBROUTINE PRJ.  THIS
C       ALLOWS THE USER TO USE THE SYSTEM PROJECTION SUBROUTINES AND
C       PROJECT DATA INTO THE USER S OWN PROJECTION ARRAY.
C
C          B        - THE ARRAY OF DATA FOR THE TRANSEVERSE SECTION
C          P        - THE PROJECTION ARRAY
C          M        - THE ANGLE INDEX
C          PRJ      - THE SYSTEM PROJECTION SUBROUTINE
C
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - CISO, EMESG, LGTXT,
C         MEMST, ZERO
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       EXTERNAL RECLBL SUBROUTINES - PRJ
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                       COMMON
C          IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                       SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                       FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                       EXECUTING.
C          WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/ATNCOM/LATEN,LBMAP,TATEN,LUNATN
      LOGICAL TATEN
      DIMENSION ATEN(1),BMAP(1)
      EQUIVALENCE (WORK(1),ATEN(1),BMAP(1))
C
C          LATEN    - POINTER TO THE ARRAY ATEN IN BLANK COMMON
C                       STORES ATTENUATION FACTORS FOR ONE ANGLE
C          LBMAP    - POINTER TO THE ARRAY BMAP IN BLANK COMMON
C                       A MATRIX USED TO STORE THE CONSTANT ATTENUATION
C                       COEFFICIENTS
C          TATEN    - LOGICAL VARIABLE SET TRUE FOR ATTENUATION
C                       RECONSTRUCTION
C          LUNATN   - LOGICAL UNIT NUMBER FOR ATTENUATION FACTOR STORAGE
C
      COMMON/DATCOM/LDATA
      DIMENSION DATA(1)
      EQUIVALENCE (WORK(1),DATA(1))
C
C          LDATA    - POINTER TO THE ARRAY DATA IN BLANK COMMON
C          DATA     - AN INTERMEDIATE PROJECTION ARRAY
C
      COMMON/FANCOM/RFAN,TFANC,TFANF
      LOGICAL TFANC,TFANF
C
C          RFAN     - FOR FAN BEAM GEOMETRY RFAN IS THE DISTANCE FROM
C                       THE SOURCE TO THE CENTER OF ROTATION.  RFAN
C                       IS MEASURED IN UNITS OF PROJECTION BIN WIDTHS AT
C                       THE CENTER OF ROTATION.
C          TFANC    - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                       CURVED DETECTOR
C          TFANF    - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                       FLAT DETECTOR
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT   - LOGICAL UNIT NUMBER FOR OUTPUT
C          I80132   - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                       OUTPUT ON LUNOUT
C               0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                       NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                       THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                       IS AN INTEGER VARIABLE
C
      COMMON/STRCOM/TSTORE
      LOGICAL TSTORE
C
C          TSTORE   - LOGICAL VARIABLE SET TRUE WHEN TESTING STORAGE SIZE
C                       SETS TPRINT(1) = .TRUE.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C          IGEOM    - GEOMETRY FLAG
C                0 = PARALLEL BEAM GEOMETRY
C                1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                3 = RING DETECTOR GEOMETRY
C          KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                       BY THE USER
C          AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                       PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                       AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                       IN THE CENTER OF A PROJECTION BIN.)
C          BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C          KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                       ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                       ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C          KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                       THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                       IS GOING TO BE USED.
C          KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                       THE DATA OF THE LAST USER PROJECTION BIN THAT
C                       IS GOING TO BE USED.
C          KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                       TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                       KDIM=KDIMU.
C          AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                       PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                       INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                       VECTOR
C          NANG     - NUMBER OF PROJECTIONS
C          MODANG   - MODE FOR PROJECTION ANGLE INPUT
C          LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                       PROJECTION ANGLES IN RADIANS
C          LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                       SINE OF THE PROJECTION ANGLES
C          LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                       COSINE OF THE PROJECTION ANGLES
C          LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                       USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                       FALSE FOR TRANSMISSION DATA
```

```
C
      DIMENSION B(1),P(1)
      DIMENSION PFLG(4)
      DIMENSION NAMER(9)
      LOGICAL TFANN,TATENN
      EXTERNAL PRJ
      DATA NAMER/1HE,1HN,1HD,1H ,1HP,1HJ,1HE,1HC,1HT/
      DATA IOK/2HOK/
C
C        *BE SURE THAT SETUP HAS BEEN CALLED
C
      IF (ISETUP.NE.IOK) CALL EMESG (1,NAMER(5),1)
C
      IF (IGEOM.LT.3) GO TO 10
      WRITE (LUNOUT,24)
      CALL EMESG (36,NAMER(5),1)
   10 IF (M.EQ.1) CALL LGTXT (NAMER(5),5)
      IF (NDIM.EQ.NDIMU) GO TO 12
      WRITE (LUNOUT,26)
      CALL EMESG (12,NAMER(5),1)
   12 CONTINUE
C
      IF (LDATA.LE.0) CALL MEMST (LDATA,KDIM)
C
      CALL PRJ (PFLG,DUM,0)
C
      IWTT=PFLG(2)
      IATEN=PFLG(3)
      IFAN=PFLG(4)
C
      TFANN=IFAN.EQ.1
      TATENN=IATEN.EQ.1
C
      IF ((TFANC.OR.TFANF).AND.TFANN.OR..NOT.((TFANC.OR.TFANF).OR.TFANN)
     1) GO TO 14
      WRITE (LUNOUT,28)
      CALL EMESG (13,NAMER(5),1)
C
   14 IF (TATEN.AND.TATENN.OR..NOT.(TATEN.OR.TATENN)) GO TO 16
      WRITE (LUNOUT,30)
      CALL EMESG (14,NAMER(5),1)
C
C        THE NUMBER OF BINS PROJECTED OUTSIDE THE USER PROJECTION
C          ARRAY = KDIM-KMAX+KMIN-1
C        THE NUMBER OF BINS PROJECTED BELOW THE USER ARRAY IS KMIN-1
C        THE NUMBER OF BINS PROJECTED ABOVE THE USER ARRAY IS KDIM-KMAX
C
   16 IF (M.NE.1) GO TO 18
      KXBINS=KDIM-KMAX+KMIN-1
      IF (KXBINS.LE.0) GO TO 18
      KXBINL=KMIN-1
      KXBINU=KDIM-KMAX
      WRITE (LUNOUT,32) KXBINS
      IF (KXBINL.GT.0) WRITE (LUNOUT,34) KXBINL
      IF (KXBINU.GT.0) WRITE (LUNOUT,36) KXBINU
C
   18 IF (TSTORE) GO TO 22
      IF (TCIR) CALL CISQ (B,B,2)
C
      FAC=1.
      IF (TEMIT) FAC=1./(FLOAT(NANG)*PWID)
C
      CALL PRJ (B,DATA(LDATA),M)
C
      CALL ZERO (P,KDIMU)
C
      KSUB1=KMIN-KMOV
      KSUB2=LDATA+KMIN-1
      DO 20 K=KMIN,KMAX
      P(KSUB1)=DATA(KSUB2)*FAC
      KSUB1=KSUB1+1
      KSUB2=KSUB2+1
   20 CONTINUE
C
      IF (TCIR) CALL CISQ (B,B,1)
   22 IF (M.NE.NANG) RETURN
      CALL MEMST (LDATA,0)
      CALL MEMST (MAXFW,-1)
      WRITE (LUNOUT,38) MAXFW
      CALL LGTXT (NAMER,9)
C
      RETURN
C
C
   24 FORMAT(//10X,39HPJECT CANNOT BE USED WITH RING GEOMETRY/
     110X,49H(SETUP INPUT PARAMETER IGEOM=IPAR(5) CANNOT BE 3))
   26 FORMAT(/1X,80HTHE SUBROUTINE PJECT CANNOT BE CALLED DURING THE EXE
     1CUTION OF FILBK    ...STOP...)
   28 FORMAT(/10X,50HTHE PROJECTION SUBROUTINE IS INCONSISTENT WITH THE/
     115X,33HFAN BEAM PARAMETERS SEEN BY SETUP)
   30 FORMAT(/1X,71HATTEMPTED CALL OF A PROJECTION SUBROUTINE WHICH USES
     1ATTENUATION FACTORS/5X,34HBEFORE THE FACTORS WERE EVALUATED.)
   32 FORMAT(/1X,65HTHE NUMBER OF BINS PROJECTED OUTSIDE THE USER PROJEC
     1TION ARRAY = ,I5)
   34 FORMAT(/5X,52HTHE NUMBER OF BINS PROJECTED BELOW THE USER ARRAY =
     1,I5)
   36 FORMAT(/5X,52HTHE NUMBER OF BINS PROJECTED ABOVE THE USER ARRAY =
     1,I5)
   38 FORMAT(//10X,38HMAXIMUM SIZE OF BLANK COMMON THUS FAR=,I7,
     122H FLOATING POINT WORDS.)
      END
```

PLL

```
      SUBROUTINE PLL (B,P,MM)
C
C     ******************************************************************
C     *     RECLBL    --        VERSION 1.0    --        17OCT77       *
C     ******************************************************************
C            THE SUBROUTINE PLL PROJECTS FROM THE ARRAY B A SINGLE
C        PROJECTION INTO THE ARRAY P.  THE PROJECTION HAS THE ANGLE
C        ANG(M) WHERE M IS THE INDEX OF THE ANGLE.  THE VALUE FROM EACH
C        CELL IS WEIGHTED ACCORDING TO THE LENGTH OF THE RAY INTERSECT-
C        ING THE CELL.
C
C           B        - THE ARRAY OF DATA FOR THE TRANSEVERSE SECTION
C           P        - THE PROJECTION ARRAY
C           M        - THE ANGLE INDEX
C                    - IF M .EQ. 0 ONLY A SET OF FLAGS IS RETURNED IN B
C                      NO PROJECTION OPERATION IS PERFORMED
C                      (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C                    - IF M .LT. 0, ITS ABSOLUTE VALUE IS USED AS ANGLE
C                      INDEX.  HOWEVER, RATHER THAN A PROJECTION OPERATION
C                      BEING PERFORMED, A WEIGHTED BACK-PROJECTION IS
C                      CALCULATED.  IT IS USED BY THE ITERATIVE RELAXATION
C                      RECONSTRUCTION METHOD.
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - ZERO
C
C        RECLPL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C           NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                        COMMON
C           IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C           NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C           ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                        SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                        FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                        EXECUTING.
C           WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C           NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C           NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C           PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C           TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C           NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C           LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                        NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                        THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C           KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                        IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C           IGEOM    - GEOMETRY FLAG
C                   0 = PARALLEL BEAM GEOMETRY
C                   1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                   2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                   3 = RING DETECTOR GEOMETRY
C           KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                        BY THE USER
C           AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                        AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                        IN THE CENTER OF A PROJECTION BIN.)
C           BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C           KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                        ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                        ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C           KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C           KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE LAST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C           KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                        TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                        KDIM=KDIMU.
C           AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY, USUALLY AXIS=AXISU.
C           LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                        INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                        VECTOR
C           NANG     - NUMBER OF PROJECTIONS
C           MODANG   - MODE FOR PROJECTION ANGLE INPUT
C           LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                        PROJECTION ANGLES IN RADIANS
C           LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                        SINE OF THE PROJECTION ANGLES
C           LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                        COSINE OF THE PROJECTION ANGLES
C           LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                        USER PROJECTION DATA AND UNCERTAINTIES
C           TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                        FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1),P(1)
      DIMENSION FLAGS(4)
      DATA FLAGS/1.,3.,0.,0./
      DATA EPS/1.E-6/
C
      M=IABS(MM)
      IF (M.LE.0) GO TO 88
      IF (MM.GT.0) CALL ZERO (P,KDIM)
      IF (MM.EQ.-1) CALL ZERO (B,NMAT)
C
C        *SET ZEROTH PROJECTION INTERSECTION AND OFFSET
C
      Z=-AXIS*BWID
      H=.5*FLOAT(NDIM)
C
C        *SET SIN AND COS AND CHECK FOR VERY SMALL ANGLES
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)
      IF (ABS(S).LT.EPS) GO TO 48
      IF (ABS(C).LT.EPS) GO TO 68
C
C        *DXL AND DYL ARE TO STEP THROUGH THE B ARRAY
C        *(DISTANCE TO STEP ALONG THE LINE)
C
      DXL=1./ABS(C)
      DYL=1./ABS(S)
C
C        *DX AND DY ARE TO FIND LARGE INTERSECTIONS
C        *(SIDEWAYS INCREMENTS FROM ONE LINE TO THE NEXT)
C
      DX=-BWID/S
      DY=BWID/C
C
C        *KI IS THE I INCREMENT AS WE STEP ALONG THE LINE
C        *IIST IS THE FIRST I FOR LARGE X INTERSECTIONS
C        *IOUT TAKES US OUT OF THE ARRAY
C        *XOFF MAKES THE ROUNDING OF (I-X) OK FOR NEGATIVE KI
C
      IF (C.LT.0.) GO TO 10
      KI=1
      IIST=1
      IOUT=NDIM+1
      XOFF=0.
      GO TO 12
C
   10 KI=-1
      IIST=NDIM
      IOUT=0
      XOFF=1.
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C
C        *KJ, J1ST, JOUT AND YOFF ARE ANALAGOUS TO
C        *KI, I1ST, IOUT AND XOFF RESPECTIVELY
C
   12 IF (S.LT.0.) GO TO 14
      KJ=1
      J1ST=1
      JOUT=NDIM+1
      YOFF=0.
      GO TO 16
C
   14 KJ=-1
      J1ST=NDIM
      JOUT=0
      YOFF=1.
C
C        *X AND Y ARE FOR LARGE INTERSECTIONS
C        *EPS INSURES THAT NONE FALL THROUGH THE CRACKS
C
   16 X=(-FLOAT(KJ)*H*C-Z)/S+H+FLOAT(KI)*EPS
      Y=(-FLOAT(KI)*H*S+Z)/C+H+FLOAT(KJ)*EPS
      IJLAST=1
      IF (KI.NE.KJ) IJLAST=2
C
C        *LOOP THRU THE PROJECTION BINS
C
      DO 46 K=1,KDIM
C
C        *UPDATE THE POSSIBLE LARGE INTERSECTIONS AND START SEARCHING
C             WHERE THE LAST ONE WAS FOUND
C
      X=X+DX
      Y=Y+DY
      GO TO (18,22),IJLAST
C
C        * IS THERE A LARGE X INTERSECTION
C
   18 I=X+1.
      IF (I.GE.1.AND.I.LE.NDIM) GO TO 20
      GO TO (22,46),IJLAST
   20 IJLAST=1
      J=J1ST
      XL=ABS((FLOAT(I)-X-XOFF)*DXL)
      YL=DYL
      GO TO 26
C
C        * IS THERE A LARGE Y INTERSECTION
C
   22 J=Y+1.
      IF (J.GE.1.AND.J.LE.NDIM) GO TO 24
      GO TO (46,18),IJLAST
   24 IJLAST=2
      I=I1ST
      YL=ABS((FLOAT(J)-Y-YOFF)*DYL)
      XL=DXL
C
C        *STEP THRU THE B ARRAY
C
C        *P ARRAY EQUAL TO THE SUM OF B ARRAY TIMES LINE LENGTH
C
   26 ISUB=LNI+J-1
      NN=NI(ISUB)
      IL=(NDIM-NN)/2+1
      IU=IL+NN-1
      ISUB=ISUB+NDIM
      IJ=I+NI(ISUB)
      IF (MM.LT.0) GO TO 36
      IF (XL.GE.YL) GO TO 32
C
C        *X HIT
C
   28 IF (I.LT.IL.OR.I.GT.IU) GO TO 30
      P(K)=P(K)+XL*B(IJ)
   30 I=I+KI
      IF (I.EQ.IOUT) GO TO 46
      IJ=IJ+KI
      YL=YL-XL
      XL=DXL
      IF (XL.LT.YL) GO TO 28
C
C        *Y HIT
C
   32 IF (I.LT.IL.OR.I.GT.IU) GO TO 34
      P(K)=P(K)+YL*B(IJ)
   34 J=J+KJ
      IF (J.EQ.JOUT) GO TO 46
      ISUB=LNI+J-1
      NN=NI(ISUB)
      IL=(NDIM-NN)/2+1
      IU=IL+NN-1
      ISUB=ISUB+NDIM
      IJ=I+NI(ISUB)
      XL=XL-YL
      YL=DYL
      IF (YL.LT.XL) GO TO 32
      GO TO 28
C
C        *51,52 TAKE THE PLACE OF 24,25 WHEN (MM .LT. 0)
C
   36 IF (XL.GE.YL) GO TO 42
   38 IF (I.LT.IL.OR.I.GT.IU) GO TO 40
      B(IJ)=B(IJ)+XL**2*P(K)
   40 I=I+KI
      IF (I.EQ.IOUT) GO TO 46
      IJ=IJ+KI
      YL=YL-XL
      XL=DXL
      IF (XL.LT.YL) GO TO 38
   42 IF (I.LT.IL.OR.I.GT.IU) GO TO 44
      B(IJ)=B(IJ)+YL**2*P(K)
   44 J=J+KJ
      IF (J.EQ.JOUT) GO TO 46
      ISUB=LNI+J-1
      NN=NI(ISUB)
      IL=(NDIM-NN)/2+1
      IU=IL+NN-1
      ISUB=ISUB+NDIM
      IJ=I+NI(ISUB)
      XL=XL-YL
      YL=DYL
      IF (YL.LT.XL) GO TO 42
      GO TO 38
C
   46 CONTINUE
      RETURN
C
C        *ANGLE IS VERY NEAR 0 OR PI
C
   48 Y=Z/C+H
      DY=BWID/C
      IF (MM.LT.0) GO TO 58
      DO 56 K=1,KDIM
      Y=Y+DY
      J=Y+1.
C
C        *SEE IF THE LINE IS VERY CLOSE TO A PIXEL BOUNDARY
C
      JJ=Y+1.+EPS
      IF (JJ.EQ.J) JJ=Y+1.-EPS
      FAC=1.
      IF (JJ.EQ.J) GO TO 52
      FAC=.5
      IF (JJ.LT.1.OR.JJ.GT.NDIM) GO TO 52
      ISUB=LNI+JJ-1
      NN=NI(ISUB)
      IL=(NDIM-NN)/2+1
      IU=IL+NN-1
      ISUB=ISUB+NDIM
      IJL=IL+NI(ISUB)
      IJU=IU+NI(ISUB)
      DO 50 IJ=IJL,IJU
   50 P(K)=P(K)+FAC*B(IJ)
   52 IF (J.LT.1.OR.J.GT.NDIM) GO TO 56
      ISUB=LNI+J-1
      NN=NI(ISUB)
      IL=(NDIM-NN)/2+1
      IU=IL+NN-1
      ISUB=ISUB+NDIM
      IJL=IL+NI(ISUB)
      IJU=IU+NI(ISUB)
      DO 54 IJ=IJL,IJU
   54 P(K)=P(K)+FAC*B(IJ)
   56 CONTINUE
      RETURN
C
C        *60-64 TAKE THE PLACE OF 30-34 WHEN (MM .LT. 0)
C
   58 DO 66 K=1,KDIM
      Y=Y+DY
      J=Y+1.
      JJ=Y+1.+EPS
      IF (JJ.EQ.J) JJ=Y+1.-EPS
      FAC=1.
      IF (JJ.EQ.J) GO TO 62
      FAC=.25
      IF (JJ.LT.1.OR.JJ.GT.NDIM) GO TO 62
      ISUB=LNI+JJ-1
      NN=NI(ISUB)
      IL=(NDIM-NN)/2+1
      IU=IL+NN-1
      ISUB=ISUB+NDIM
      IJL=IL+NI(ISUB)
      IJU=IU+NI(ISUB)
      DO 60 IJ=IJL,IJU
   60 B(IJ)=B(IJ)+FAC*P(K)
   62 IF (J.LT.1.OR.J.GT.NDIM) GO TO 66
      ISUB=LNI+J-1
      NN=NI(ISUB)
      IL=(NDIM-NN)/2+1
      IU=IL+NN-1
      ISUB=ISUB+NDIM
      IJL=IL+NI(ISUB)
      IJU=IU+NI(ISUB)
      DO 64 IJ=IJL,IJU
   64 B(IJ)=B(IJ)+FAC*P(K)
   66 CONTINUE
      RETURN
C
C        *ANGLE IS VERY NEAR PI/2 OR 3PI/2
C
   68 X=-Z/S+H
      DX=-BWID/S
      IF (MM.LT.0) GO TO 78
      DO 76 K=1,KDIM
      X=X+DX
      I=X+1.
C
C        *SEE IF THE LINE IS VERY CLOSE TO A PIXEL BOUNDARY
C
      II=X+1.+EPS
      IF (II.EQ.I) II=X+1.-EPS
      FAC=1.
      IF (II.EQ.I) GO TO 72
      FAC=.5
      IF (II.LT.1.OR.II.GT.NDIM) GO TO 72
      ISUB=LNI+II-1
      NN=NI(ISUB)
      JL=(NDIM-NN)/2+1
      JU=JL+NN-1
      ISUB=LNI+NDIM+JL-1
      DO 70 J=JL,JU
      IJ=II+NI(ISUB)
      P(K)=P(K)+FAC*B(IJ)
   70 ISUB=ISUB+1
   72 IF (I.LT.1.OR.I.GT.NDIM) GO TO 76
      ISUB=LNI+I-1
      NN=NI(ISUB)
      JL=(NDIM-NN)/2+1
      JU=JL+NN-1
      ISUB=LNI+NDIM+JL-1
      DO 74 J=JL,JU
      IJ=I+NI(ISUB)
      P(K)=P(K)+FAC*B(IJ)
   74 ISUB=ISUB+1
   76 CONTINUE
      RETURN
C
C        *65-69 TAKE THE PLACE OF 35-39 WHEN (MM .LT. 0)
C
   78 DO 86 K=1,KDIM
      X=X+DX
      I=X+1.
      II=X+1.+EPS
      IF (II.EQ.I) II=X+1.-EPS
      FAC=1.
      IF (II.EQ.I) GO TO 82
      FAC=.25
      IF (II.LT.1.OR.II.GT.NDIM) GO TO 82
      ISUB=LNI+II-1
      NN=NI(ISUB)
      JL=(NDIM-NN)/2+1
      JU=JL+NN-1
      ISUB=LNI+NDIM+JL-1
      DO 80 J=JL,JU
      IJ=II+NI(ISUB)
      B(IJ)=B(IJ)+FAC*P(K)
   80 ISUB=ISUB+1
   82 IF (I.LT.1.OR.I.GT.NDIM) GO TO 86
      ISUB=LNI+I-1
      NN=NI(ISUB)
      JL=(NDIM-NN)/2+1
      JU=JL+NN-1
      ISUB=LNI+NDIM+JL-1
      DO 84 J=JL,JU
      IJ=I+NI(ISUB)
      B(IJ)=B(IJ)+FAC*P(K)
   84 ISUB=ISUB+1
   86 CONTINUE
      RETURN
C
   88 DO 90 I=1,4
   90 B(I)=FLAGS(I)
      RETURN
      END
```

PPT

```
      SUBROUTINE PPT (B,P,M)
C
C     ****************************************************************
C     *        RECLBL     --        VERSION 1.0     --        17OCT77     *
C     ****************************************************************
C           THE SUBROUTINE PPT PROJECTS FROM THE ARRAY B A SINGLE
C        PROJECTION INTO THE ARRAY P.  THE PROJECTION HAS THE ANGLE
C        ANG(M) WHERE M IS THE INDEX OF THE ANGLE.  THE MODEL ASSUMES
C        THAT EACH CELL IS REPRESENTED BY A DELTA FUNCTION WITH ALL THE
C        DENSITY AT THE CENTER OF THE CELL.
C
C          B         - THE ARRAY OF DATA FOR THE TRANSEVERSE SECTION
C          P         - THE PROJECTION ARRAY
C          M         - THE ANGLE INDEX
C                    - IF M .EQ. 0 ONLY A SET OF FLAGS IS RETURNED IN B
C                      NO PROJECTION OPERATION IS PERFORMED
C                      (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C                    - IF M .LT. 0, ITS ABSOLUTE VALUE IS USED AS ANGLE
C                      INDEX.  HOWEVER, RATHER THAN A PROJECTION OPERATION
C                      BEING PERFORMED, A WEIGHTED BACK-PROJECTION IS
C                      CALCULATED.  IT IS USED BY THE ITERATIVE RELAXATION
C                      RECONSTRUCTION METHOD.
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - ZERO
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                        COMMON
C          IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                        SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                        FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                        EXECUTING.
C          WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                        NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                        THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                        IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C          IGEOM    - GEOMETRY FLAG
C                  0 = PARALLEL BEAM GEOMETRY
C                  1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                  2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                  3 = RING DETECTOR GEOMETRY
C          KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                        BY THE USER
C          AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                        AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                        IN THE CENTER OF A PROJECTION BIN.)
C          BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C          KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                        ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                        ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C          KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C          KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE LAST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C          KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                        TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                        KDIM=KDIMU.
C          AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                        INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                        VECTOR
C          NANG     - NUMBER OF PROJECTIONS
C          MODANG   - MODE FOR PROJECTION ANGLE INPUT
C          LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                        PROJECTION ANGLES IN RADIANS
C          LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                        SINE OF THE PROJECTION ANGLES
C          LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                        COSINE OF THE PROJECTION ANGLES
C          LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                        USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                        FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1),P(1)
C        BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/1.,0.,0.,0./
C
      IF (M.LE.0) GO TO 20
C
      CALL ZERO (P,KDIM)
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      HS=.5*S
      ZN=.5*FLOAT(NDIM+1)
      ZZ=ZN*(S-C)+AXIS+.5
      IJL=1
      DO 12 J=1,NDIM
      ZZ=ZZ+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 10 IJ=IJL,IJU
      Z=Z-S
      K=Z
   10 P(K)=P(K)+B(IJ)*PWID
   12 IJL=IJL+NN
      RETURN
C
   14 M=-M
      IF (M.EQ.1) CALL ZERO (B,NMAT)
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      HS=.5*S
      ZN=.5*FLOAT(NDIM+1)
      ZZ=ZN*(S-C)+AXIS+.5
      IJL=1
      DO 18 J=1,NDIM
      ZZ=ZZ+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 16 IJ=IJL,IJU
      Z=Z-S
      K=Z
   16 B(IJ)=B(IJ)+P(K)*PWID**2
   18 IJL=IJL+NN
      M=-M
      RETURN
C
   20 IF (M.LT.0) GO TO 14
      DO 22 I=1,4
   22 B(I)=FLAGS(I)
      RETURN
      END
```

PPTA

```
      SUBROUTINE PPTA (B,P,M)
C
C     ****************************************************************
C     *        RECLBL     --        VERSION 1.0     --        17OCT77     *
C     ****************************************************************
C
C           THE SUBROUTINE PPTA PROJECTS FROM THE ARRAY B A SINGLE
C        PROJECTION INTO THE ARRAY P.  THE PROJECTION HAS THE ANGLE
C        ANG(M) WHERE M IS THE INDEX OF THE ANGLE.  THE MODEL ASSUMES
C        THAT EACH CELL IS REPRESENTED BY A DELTA FUNCTION WITH ALL THE
C        DENSITY AT THE CENTER OF THE CELL.  THE VALUE PROJECTED FROM
C        EACH CELL IS WEIGHTED BY AN ATTENUATION FACTOR.
C
C          B         - THE ARRAY OF DATA FOR THE TRANSVERSE SECTION
C          P         - THE PROJECTION ARRAY
C          M         - THE ANGLE INDEX
C                    - IF M .EQ. 0 ONLY A SET OF FLAGS IS RETURNED IN B
C                      NO PROJECTION OPERATION IS PERFORMED
C                      (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C                    - IF M .LT. 0, ITS ABSOLUTE VALUE IS USED AS ANGLE
C                      INDEX.  HOWEVER, RATHER THAN A PROJECTION OPERATION
C                      BEING PERFORMED, A WEIGHTED BACK-PROJECTION IS
C                      CALCULATED.  IT IS USED BY THE ITERATIVE RELAXATION
C                      RECONSTRUCTION METHOD.
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - FTATN, ZERO
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                        COMMON
C          IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                        SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                        FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                        EXECUTING.
C          WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/ATNCOM/LATEN,LBMAP,TATEN,LUNATN
      LOGICAL TATEN
      DIMENSION ATEN(1),BMAP(1)
      EQUIVALENCE (WORK(1),ATEN(1),BMAP(1))
C
C          LATEN    - POINTER TO THE ARRAY ATEN IN BLANK COMMON
C                        STORES ATTENUATION FACTORS FOR ONE ANGLE
C          LBMAP    - POINTER TO THE ARRAY BMAP IN BLANK COMMON
C                        A MATRIX USED TO STORE THE CONSTANT ATTENUATION
C                        COEFFICIENTS
C          TATEN    - LOGICAL VARIABLE SET TRUE FOR ATTENUATION
C                        RECONSTRUCTION
C          LUNATN   - LOGICAL UNIT NUMBER FOR ATTENUATION FACTOR STORAGE
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                        NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                        THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                        IS AN INTEGER VARIABLE
C
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```
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C         IGEOM    - GEOMETRY FLAG
C                0 = PARALLEL BEAM GEOMETRY
C                1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                3 = RING DETECTOR GEOMETRY
C         KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                      BY THE USER
C         AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                      AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                      IN THE CENTER OF A PROJECTION BIN.)
C         BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                      ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                      ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C         KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE LAST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                      TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                      KDIM=KDIMU.
C         AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY, USUALLY AXIS=AXISU.
C         LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                      INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                      VECTOR
C         NANG     - NUMBER OF PROJECTIONS
C         MODANG   - MODE FOR PROJECTION ANGLE INPUT
C         LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                      PROJECTION ANGLES IN RADIANS
C         LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                      SINE OF THE PROJECTION ANGLES
C         LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                      COSINE OF THE PROJECTION ANGLES
C         LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                      USER PROJECTION DATA AND UNCERTAINTIES
C         TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                      FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1),P(1)
C        BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/1.,0.,1.,0./
C
      IF (M.LE.0) GO TO 20
C
      CALL FTATN (M,ATEN(LATEN),NMAT)
      CALL ZERO (P,KDIM)
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      HS=.5*S
      ZN=.5*FLOAT(NDIM+1)
      ZZ=ZN*(S-C)+AXIS+.5
      IJL=1
      DO 12 J=1,NDIM
      ZZ=ZZ+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 10 IJ=IJL,IJU
      Z=Z-S
      K=Z
      ISUB=LATEN+IJ-1
   10 P(K)=P(K)+ATEN(ISUB)*B(IJ)*PWID
   12 IJL=IJL+NN
      RETURN
C
   14 M=-M
      IF (M.EQ.1) CALL ZERO (B,NMAT)
      CALL FTATN (M,ATEN(LATEN),NMAT)
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      HS=.5*S
      ZN=.5*FLOAT(NDIM+1)
      ZZ=ZN*(S-C)+AXIS+.5
      IJL=1
      DO 18 J=1,NDIM
      ZZ=ZZ+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 16 IJ=IJL,IJU
      Z=Z-S
      K=Z
      ISUB=LATEN+IJ-1
   16 B(IJ)=B(IJ)+(ATEN(ISUB)*PWID)**2*P(K)
   18 IJL=IJL+NN
      M=-M
      RETURN
C
   20 IF (M.LT.0) GO TO 14
      DO 22 I=1,4
   22 B(I)=FLAGS(I)
      RETURN
      END
```

PPTF

```
      SUBROUTINE PPTF (B,P,M)
C
C     ****************************************************************
C     *       RECLBL    --         VERSION 1.0    --        17OCT77    *
C     ****************************************************************
C
C           THE SUBROUTINE PPTF PROJECTS FROM THE ARRAY B A SINGLE
C        PROJECTION INTO THE ARRAY P FOR A FAN BEAM GEOMETRY.  THE PRO-
C        JECTION HAS THE ANGLE ANG(M) WHERE M IS THE INDEX OF THE ANGLE.
C        THE MODEL ASSUMES THAT EACH CELL IS REPRESENTED BY A DELTA
C        FUNCTION WITH ALL THE DENSITY AT THE CENTER OF THE CELL.
C
C         B        - THE ARRAY OF DATA FOR THE TRANSVERSE SECTION
C         P        - THE PROJECTION ARRAY
C         M        - THE ANGLE INDEX
C                  - IF M .EQ. 0 ONLY A SET OF FLAGS IS RETURNED IN B
C                    NO PROJECTION OPERATION IS PERFORMED
C                    (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C                  - IF M .LT. 0, ITS ABSOLUTE VALUE IS USED AS ANGLE
C                    INDEX.  HOWEVER, RATHER THAN A PROJECTION OPERATION
C                    BEING PERFORMED, A WEIGHTED BACK-PROJECTION IS
C                    CALCULATED.  IT IS USED BY THE ITERATIVE RELAXATION
C                    RECONSTRUCTION METHOD.
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - ZERO
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                      COMMON
C         IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                      SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                      FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                      EXECUTING.
C         WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/FANCOM/RFAN,TFANC,TFANF
      LOGICAL TFANC,TFANF
C
C         RFAN     - FOR FAN BEAM GEOMETRY RFAN IS THE DISTANCE FROM
C                      THE SOURCE TO THE CENTER OF ROTATION.  RFAN
C                      IS MEASURED IN UNITS OF PROJECTION BIN WIDTHS AT
C                      THE CENTER OF ROTATION.
C         TFANC    - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                      CURVED DETECTOR
C         TFANF    - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                      FLAT DETECTOR
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C         NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C         NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C         PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C         TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C         NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C         LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                      NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                      THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C         KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                      IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C         IGEOM    - GEOMETRY FLAG
C                0 = PARALLEL BEAM GEOMETRY
C                1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                3 = RING DETECTOR GEOMETRY
C         KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                      BY THE USER
C         AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                      AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                      IN THE CENTER OF A PROJECTION BIN.)
C         BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                      ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                      ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C         KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE LAST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                      TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                      KDIM=KDIMU.
C         AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY, USUALLY AXIS=AXISU.
C         LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                      INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                      VECTOR
C         NANG     - NUMBER OF PROJECTIONS
C         MODANG   - MODE FOR PROJECTION ANGLE INPUT
C         LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                      PROJECTION ANGLES IN RADIANS
C         LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                      SINE OF THE PROJECTION ANGLES
C         LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                      COSINE OF THE PROJECTION ANGLES
C         LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                      USER PROJECTION DATA AND UNCERTAINTIES
C         TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                      FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1),P(1)
C        BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/1.,0.,0.,1./
      DATA Z/.499999/
C
      IF (M.LE.0) GO TO 34
C
      CALL ZERO (P,KDIM)
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      HS=.5*S
      HC=.5*C
      ZN=.5*FLOAT(NDIM+1)
      ZX=RFAN-ZN*(C+S)
      ZY=ZN*(S-C)
      RFP=RFAN*PWID
      IJL=1
C
      IF (TFANF) GO TO 14
C
      DO 12 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
```

```
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 10 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      ARC=RFAN*ATAN(ZYY/ZXX)
      K=ARC+AXIS+.5
   10 P(K)=P(K)+B(IJ)*RFP/DH
   12 IJL=IJL+NN
      RETURN
C
   14 DO 18 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 16 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      YCENTR=ZYY/ZXX*RFAN
      K=YCENTR+AXIS+.5
   16 P(K)=P(K)+B(IJ)*RFP/ZXX
   18 IJL=IJL+NN
      RETURN
C
   20 M=-M
      IF (M.NE.1) GO TO 22
      CALL ZERO (B,NMAT)
C
   22 CONTINUE
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      HS=.5*S
      HC=.5*C
      ZN=.5*FLOAT(NDIM+1)
      ZX=RFAN-ZN*(C+S)
      ZY=ZN*(S-C)
      RFP=RFAN*PWID
      IJL=1
C
      IF (TFANF) GO TO 28
C
      DO 26 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 24 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      ARC=RFAN*ATAN(ZYY/ZXX)
      K=ARC+AXIS+.5
   24 B(IJ)=B(IJ)+(RFP/DH)**2*P(K)
   26 IJL=IJL+NN
      M=-M
      RETURN
C
   28 DO 32 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 30 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      YCENTR=ZYY/ZXX*RFAN
      K=YCENTR+AXIS+.5
   30 B(IJ)=B(IJ)+(RFP/ZXX)**2*P(K)
   32 IJL=IJL+NN
      M=-M
      RETURN
C
   34 IF (M.LT.0) GO TO 20
      DO 36 I=1,4
   36 B(I)=FLAGS(I)
      RETURN
      END
```

PRF

```
      SUBROUTINE PRF (B,P,M)
C
C     ******************************************************************
C     *       RECLBL   --          VERSION 1.0    --          17OCT77  *
C     ******************************************************************
C
C          THE SUBROUTINE PRF PROJECTS FROM THE ARRAY B A SINGLE
C       PROJECTION INTO THE ARRAY P.  THE PROJECTION BINS AND THE
C       TRANSVERSE SECTION CELLS MUST BE THE SAME SIZE.  THE MODEL
C       ASSUMES A UNIFORM DENSITY FOR EACH CELL SUCH THAT THE VALUE
C       PROJECTED FOR EACH CELL IS WEIGHTED ACCORDING TO THE FRACTION
C       EACH CELL INTERSECTS A PROJECTION RAY.  THE RAY FACTORS ARE
C       STORED IN A LOOK-UP TABLE SUCH THAT EACH CELL-RAY INTERSECTION
C       IS EQUAL TO ONE OF 20 VALUES WHICH DEPENDS ON WHERE THE CENTER
C       OF THE CELL FALLS WITH RESPECT TO THE 20 EQUAL INTERVALS THAT
C       DIVIDE EACH RAY.
C
C         B        - THE ARRAY OF DATA FOR THE TRANSVERSE SECTION
C         P        - THE PROJECTION ARRAY
C         M        - THE ANGLE INDEX
C                  - IF M .EQ. 0 ONLY A SET OF FLAGS IS RETURNED IN B
C                    NO PROJECTION OPERATION IS PERFORMED
C                    (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C                  - IF M .LT. 0, ITS ABSOLUTE VALUE IS USED AS ANGLE
C                    INDEX.  HOWEVER, RATHER THAN A PROJECTION OPERATION
C                    BEING PERFORMED, A WEIGHTED BACK-PROJECTION IS
C                    CALCULATED.  IT IS USED BY THE ITERATIVE RELAXATION
C                    RECONSTRUCTION METHOD.
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - ZERO
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                      COMMON
C         IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                      SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                      FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                      EXECUTING.
C         WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C         NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C         NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C         PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C         TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C         NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C         LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                      NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                      THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C         KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                      IS AN INTEGER VARIABLE
C
      COMMON/RAYCOM/NLEV,LMRFAC,KMRFAC,LRFAC
      DIMENSION MRFAC(1),RFAC(1)
      EQUIVALENCE(WORK(1),MRFAC(1),RFAC(1))
C
C         NLEV     - NUMBER OF FRACTION LEVELS
C         LMRFAC   - POINTER TO THE ARRAY MRFAC IN BLANK COMMON
C                      MRFAC(MANGLE) POINTS TO THE LOCATION IN BLANK
C                      COMMON WHERE RFAC(MRFAC(MANGLE)) IS STORED.
C                      RFAC(MRFAC(MANGLE)) IS THE FRACTION OF THE CELL
C                      WITHIN THE RAY WHEN THE CENTER OF THE CELL IS IN
C                      THE CENTER OF THE RAY AT THE ANGLE MANGLE.
C         KMRFAC   - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE MRFAC
C                      IS AN INTEGER VARIABLE
C         LRFAC    - POINTER TO THE ARRAY RFAC IN BLANK COMMON
C                      FRACTIONAL AREAS OF A CELL WHICH INTERSECT
C                      A RAY AND THIS FRACTION IS MEASURED AS A FUNCTION
C                      OF THE DISTANCE THE CENTER OF THE CELL IS FROM
C                      THE CENTER OF THE RAY.  THE TOTAL DIMENSION OF
C                      THE ARRAY RFAC IS NRFAC=LL*EQANG, WHERE
C                               3*NLEV+2  IF NLEV IS EVEN
C                          LL =
C                               3*NLEV+1  IF NLEV IS ODD
C                      AND EQANG IS THE SIZE OF THE SET OF ANGLES FORMED
C                      FROM THE SET OF TOTAL ANGLES WITH MOD OPERATION
C                      OF PHI/2 THEN REFLECTION ABOUT PHI/4.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C         IGEOM    - GEOMETRY FLAG
C                0 = PARALLEL BEAM GEOMETRY
C                1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                3 = RING DETECTOR GEOMETRY
C         KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                      BY THE USER
C         AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                      AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                      IN THE CENTER OF A PROJECTION BIN.)
C         BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                      ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                      ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C         KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE LAST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                      TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                      KDIM=KDIMU.
C         AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY, USUALLY AXIS=AXISU.
C         LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                      INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                      VECTOR
C         NANG     - NUMBER OF PROJECTIONS
C         MODANG   - MODE FOR PROJECTION ANGLE INPUT
C         LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                      PROJECTION ANGLES IN RADIANS
C         LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                      SINE OF THE PROJECTION ANGLES
C         LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                      COSINE OF THE PROJECTION ANGLES
C         LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                      USER PROJECTION DATA AND UNCERTAINTIES
C         TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                      FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1),P(1)
C        BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/1.,2.,0.,0./
C
      IF (M.LE.0) GO TO 20
C
      CALL ZERO (P,KDIM)
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)
      ISUB=LMRFAC+M-1
      ZL=FLOAT(LRFAC+MRFAC(ISUB))+.5*FLOAT(NLEV+1)
      HS=.5*S
      ZN=.5*FLOAT(NDIM+1)
      ZZ=ZN*(S-C)+AXIS+.5
      IJL=1
      DO 12 J=1,NDIM
      ZZ=ZZ+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
```

```
      IJU=IJL+NN-1
      DO 10 IJ=IJL,IJU
      Z=Z-S
      K=Z
      L=ZL-FLOAT(NLEV)*(Z-FLOAT(K))
      LM=L-NLEV
      P(K-1)=P(K-1)+B(IJ)*RFAC(LM)
      P(K)=P(K)+B(IJ)*RFAC(L)
      LP=L+NLEV
   10 P(K+1)=P(K+1)+B(IJ)*RFAC(LP)
   12 IJL=IJL+NN
      RETURN
C
   14 M=-M
      IF (M.EQ.1) CALL ZERO (B,NMAT)
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)
      ISUB=LMRFAC+M-1
      ZL=FLOAT(LRFAC+MRFAC(ISUB))+.5*FLOAT(NLEV+1)
      HS=.5*S
      ZN=.5*FLOAT(NDIM+1)
      ZZ=ZN*(S-C)+AXIS+.5
      IJL=1
      DO 18 J=1,NDIM
      ZZ=ZZ+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 16 IJ=IJL,IJU
      Z=Z-S
      K=Z
      L=ZL-FLOAT(NLEV)*(Z-FLOAT(K))
      LP=L+NLEV
      LM=L-NLEV
   16 B(IJ)=B(IJ)+RFAC(LP)**2*P(K+1)+RFAC(L)**2*P(K)+RFAC(LM)**2*P(K-1)
   18 IJL=IJL+NN
      M=-M
      RETURN
C
   20 IF (M.LT.0) GO TO 14
      DO 22 I=1,4
   22 B(I)=FLAGS(I)
      IF (LRFAC.LT.0) CALL RAYST
      RETURN
      END
```

PRFA

```
      SUBROUTINE PRFA (B,P,M)
C
C     ******************************************************************
C     *      RECLBL     --         VERSION 1.0     --          17OCT77     *
C     ******************************************************************
C
C           THE SUBROUTINE PRFA PROJECTS FROM THE ARRAY B A SINGLE
C        PROJECTION INTO THE ARRAY P.  THE PROJECTION BINS AND THE
C        TRANSVERSE SECTION CELLS MUST BE THE SAME SIZE.  THE MODEL
C        ASSUMES A UNIFORM DENSITY FOR EACH CELL SUCH THAT THE VALUE
C        PROJECTED FOR EACH CELL IS WEIGHTED BY AN ATTENUATION FACTOR
C        AND THE FRACTION EACH RAY INTERSECTS EACH CELL.  THE RAY FAC-
C        TORS ARE STORED IN A LOOK-UP TABLE SUCH THAT EACH CELL-RAY
C        INTERSECTION IS EQUAL TO ONE OF 20 VALUES WHICH DEPENDS ON
C        WHERE THE CENTER OF THE CELL FALLS WITH RESPECT TO THE 20 EQUAL
C        INTERVALS THAT DIVIDE EACH RAY.
C
C          B        - THE ARRAY OF DATA FOR THE TRANSVERSE SECTION
C          P        - THE PROJECTION ARRAY
C          M        - THE ANGLE INDEX
C                   - IF M .EQ. 0 ONLY A SET OF FLAGS IS RETURNED IN B
C                     NO PROJECTION OPERATION IS PERFORMED
C                     (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C                   - IF M .LT. 0, ITS ABSOLUTE VALUE IS USED AS ANGLE
C                     INDEX.  HOWEVER, RATHER THAN A PROJECTION OPERATION
C                     BEING PERFORMED, A WEIGHTED BACK-PROJECTION IS
C                     CALCULATED.  IT IS USED BY THE ITERATIVE RELAXATION
C                     RECONSTRUCTION METHOD.
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - FTATN, ZERO
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                        COMMON
C          IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                        SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                        FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                        EXECUTING.
C          WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/ATNCOM/LATEN,LBMAP,TATEN,LUNATN
      LOGICAL TATEN
      DIMENSION ATEN(1),BMAP(1)
      EQUIVALENCE (WORK(1),ATEN(1),BMAP(1))
C
C          LATEN    - POINTER TO THE ARRAY ATEN IN BLANK COMMON
C                        STORES ATTENUATION FACTORS FOR ONE ANGLE
C          LBMAP    - POINTER TO THE ARRAY BMAP IN BLANK COMMON
C                        A MATRIX USED TO STORE THE CONSTANT ATTENUATION
C                        COEFFICIENTS
C          TATEN    - LOGICAL VARIABLE SET TRUE FOR ATTENUATION
C                        RECONSTRUCTION
C          LUNATN   - LOGICAL UNIT NUMBER FOR ATTENUATION FACTOR STORAGE
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                        NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                        THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                        IS AN INTEGER VARIABLE
C
      COMMON/RAYCOM/NLEV,LMRFAC,KMRFAC,LRFAC
      DIMENSION MRFAC(1),RFAC(1)
      EQUIVALENCE(WORK(1),MRFAC(1),RFAC(1))
C
C          NLEV     - NUMBER OF FRACTION LEVELS
C          LMRFAC   - POINTER TO THE ARRAY MRFAC IN BLANK COMMON
C                        MRFAC(MANGLE) POINTS TO THE LOCATION IN BLANK
C                        COMMON WHERE RFAC(MRFAC(MANGLE)) IS STORED.
C                        RFAC(MRFAC(MANGLE)) IS THE FRACTION OF THE CELL
C                        WITHIN THE RAY WHEN THE CENTER OF THE CELL IS IN
C                        THE CENTER OF THE RAY AT THE ANGLE MANGLE.
C          KMRFAC   - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE MRFAC
C                        IS AN INTEGER VARIABLE
C          LRFAC    - POINTER TO THE ARRAY RFAC IN BLANK COMMON
C                        FRACTIONAL AREAS OF A CELL WHICH INTERSECT
C                        A RAY AND THIS FRACTION IS MEASURED AS A FUNCTION
C                        OF THE DISTANCE THE CENTER OF THE CELL IS FROM
C                        THE CENTER OF THE RAY.  THE TOTAL DIMENSION OF
C                        THE ARRAY RFAC IS NRFAC=LL*EQANG, WHERE
C                                  3*NLEV+2  IF NLEV IS EVEN
C                           LL =
C                                  3*NLEV+1  IF NLEV IS ODD
C                        AND EQANG IS THE SIZE OF THE SET OF ANGLES FORMED
C                        FROM THE SET OF TOTAL ANGLES WITH MOD OPERATION
C                        OF PHI/2 THEN REFLECTION ABOUT PHI/4.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C          IGEOM    - GEOMETRY FLAG
C                 0 = PARALLEL BEAM GEOMETRY
C                 1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                 2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                 3 = RING DETECTOR GEOMETRY
C          KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                        BY THE USER
C          AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                        AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                        IN THE CENTER OF A PROJECTION BIN.)
C          BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C          KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                        ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                        ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C          KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C          KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE LAST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C          KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                        TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                        KDIM=KDIMU.
C          AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY, USUALLY AXIS=AXISU.
C          LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                        INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                        VECTOR
C          NANG     - NUMBER OF PROJECTIONS
C          MODANG   - MODE FOR PROJECTION ANGLE INPUT
C          LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                        PROJECTION ANGLES IN RADIANS
C          LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                        SINE OF THE PROJECTION ANGLES
C          LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                        COSINE OF THE PROJECTION ANGLES
C          LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                        USER PROJECTION DATA AND UNCERTAINTIES
C          TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                        FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1),P(1)
C        BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/1.,2.,1.,0./
C
      IF (M.LE.0) GO TO 20
C
      CALL FTATN (M,ATEN(LATEN),NMAT)
      CALL ZERO (P,KDIM)
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)
      ISUB=LMRFAC+M-1
      ZL=FLOAT(LRFAC+MRFAC(ISUB))+.5*FLOAT(NLEV+1)
      HS=.5*S
      ZN=.5*FLOAT(NDIM+1)
      ZZ=ZN*(S-C)+AXIS+.5
      IJL=1
      DO 12 J=1,NDIM
      ZZ=ZZ+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 10 IJ=IJL,IJU
      Z=Z-S
      K=Z
      L=ZL-FLOAT(NLEV)*(Z-FLOAT(K))
      ISUB=LATEN+IJ-1
      FACT=ATEN(ISUB)
      LM=L-NLEV
      P(K-1)=P(K-1)+FACT*B(IJ)*RFAC(LM)
      P(K)=P(K)+FACT*B(IJ)*RFAC(L)
      LP=L+NLEV
   10 P(K+1)=P(K+1)+FACT*B(IJ)*RFAC(LP)
   12 IJL=IJL+NN
      RETURN
C
   14 M=-M
      IF (M.EQ.1) CALL ZERO (B,NMAT)
      CALL FTATN (M,ATEN(LATEN),NMAT)
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)
      ISUB=LMRFAC+M-1
      ZL=FLOAT(LRFAC+MRFAC(ISUB))+.5*FLOAT(NLEV+1)
      HS=.5*S
      ZN=.5*FLOAT(NDIM+1)
      ZZ=ZN*(S-C)+AXIS+.5
      IJL=1
      DO 18 J=1,NDIM
      ZZ=ZZ+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      Z=ZZ-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 16 IJ=IJL,IJU
      Z=Z-S
```

```
      K=Z
      L=ZL-FLOAT(NLEV)*(Z-FLOAT(K))
      ISUB=LATEN+IJ-1
      LP=L+NLEV
      LM=L-NLEV
   16 B(IJ)=B(IJ)+ATEN(ISUB)**2*(RFAC(LP)**2*P(K+1)+RFAC(L)**2*P(K)+RFAC
     1(LM)**2*P(K-1))
   18 IJL=IJL+NN
      M=-M
      RETURN
C
   20 IF (M.LT.0) GO TO 14
      DO 22 I=1,4
   22 B(I)=FLAGS(I)
      IF (LRFAC.LT.0) CALL RAYST
      RETURN
      END
```

PRFF

```
      SUBROUTINE PRFF (B,P,M)
C
C     ******************************************************************
C     *       RECLBL    --         VERSION 1.0     --          17OCT77  *
C     ******************************************************************
C
C          THE SUBROUTINE PRFF PROJECTS FROM THE ARRAY B A SINGLE
C       PROJECTION INTO THE ARRAY P USING A FAN BEAM GEOMETRY.  THE
C       PROJECTION HAS THE ANGLE ANG(M) WHERE M IS THE INDEX OF THE
C       ANGLE.  THE MODEL ASSUMES A UNIFORM DENSITY FOR EACH CELL SUCH
C       THAT THE VALUE PROJECTED FOR EACH CELL IS WEIGHTED ACCORDING TO
C       THE FRACTION EACH CELL INTERSECTS A FAN BEAM RAY.
C
C         B        - THE ARRAY OF DATA FOR THE TRANSVERSE SECTION
C         P        - THE PROJECTION ARRAY
C         M        - THE ANGLE INDEX
C                  - IF M .EQ. 0 ONLY A SET OF FLAGS IS RETURNED IN B
C                    NO PROJECTION OPERATION IS PERFORMED
C                    (SEE THE SUBROUTINE RCHEK FOR EACH FLAGS MEANING)
C                  - IF M .LT. 0, ITS ABSOLUTE VALUE IS USED AS ANGLE
C                    INDEX.  HOWEVER, RATHER THAN A PROJECTION OPERATION
C                    BEING PERFORMED, A WEIGHTED BACK-PROJECTION IS
C                    CALCULATED.  IT IS USED BY THE ITERATIVE RELAXATION
C                    RECONSTRUCTION METHOD.
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - SQINT, ZERO
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                      COMMON
C         IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                      SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                      FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                      EXECUTING.
C         WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/FANCOM/RFAN,TFANC,TFANF
      LOGICAL TFANC,TFANF
C
C         RFAN     - FOR FAN BEAM GEOMETRY RFAN IS THE DISTANCE FROM
C                      THE SOURCE TO THE CENTER OF ROTATION.  RFAN
C                      IS MEASURED IN UNITS OF PROJECTION BIN WIDTHS AT
C                      THE CENTER OF ROTATION.
C         TFANC    - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                      CURVED DETECTOR
C         TFANF    - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                      FLAT DETECTOR
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C         NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C         NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C         PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C         TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C         NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C         LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                      NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                      THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C         KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                      IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C         IGEOM    - GEOMETRY FLAG
C                0 = PARALLEL BEAM GEOMETRY
C                1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                3 = RING DETECTOR GEOMETRY
C         KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                      BY THE USER
C         AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                      AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                      IN THE CENTER OF A PROJECTION BIN.)
C         BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                      ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                      ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C         KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                      THE DATA OF THE LAST USER PROJECTION BIN THAT
C                      IS GOING TO BE USED.
C         KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                      TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                      KDIM=KDIMU.
C         AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                      PROJECTION ARRAY, USUALLY AXIS=AXISU.
C         LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                      INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                      VECTOR
C         NANG     - NUMBER OF PROJECTIONS
C         MODANG   - MODE FOR PROJECTION ANGLE INPUT
C         LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                      PROJECTION ANGLES IN RADIANS
C         LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                      SINE OF THE PROJECTION ANGLES
C         LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                      COSINE OF THE PROJECTION ANGLES
C         LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                      USER PROJECTION DATA AND UNCERTAINTIES
C         TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                      FALSE FOR TRANSMISSION DATA
C
C
C     ***THESE VARIABLES ARE USED IN THIS SUBROUTINE
C
C           DH     - THE DISTANCE BETWEEN THE SOURCE AND THE PIXEL
C           ARC    - THE ARC DISTANCE BETWEEN THE CENTER AXIS AND THE
C                      IMAGE OF THE PIXEL
C           BETAU  - THE ANGLE BETWEEN THE CENTER AXIS AND THE LINE
C                      PASSING ABOVE THE PIXEL
C           BETAL  - THE ANGLE BETWEEN THE CENTER AXIS AND THE LINE
C                      PASSING BELOW THE PIXEL
C           BETAP  - THE ANGLE BETWEEN THE CENTER AXIS AND LINE
C                      PASSING THROUGH THE PIXEL
C           THETAU - THE ANGLE BETWEEN THE LINE PASSING THROUGH THE
C                      PIXEL AND A LINE ABOVE
C           THETAL - THE ANGLE BETWEEN THE LINE PASSING THROUGH THE
C                      PIXEL AND A LINE BELOW
C           DU     - THE PERPENDICULAR DISTANCE BETWEEN THE PIXEL AND
C                      A LINE ABOVE
C           DL     - THE PERPENDICULAR DISTANCE BETWEEN THE PIXEL AND
C                      A LINE BELOW
C           ALPHAU - THE ANGLE THE LINE ABOVE THE PIXEL MAKES WITH
C                      THE SIDE OF THE SQUARE
C           ALPHAL - THE ANGLE THE LINE BELOW THE PIXEL MAKES WITH
C                      THE SIDE OF THE SQUARE
C           ANGLE  - THE ANGLE BETWEEN THE RAYS IN THE FAN BEAM
C
      DIMENSION B(1),P(1)
C        BCK/PRJ,WT,ATEN,FAN ARE THE 4 FLAGS RETURNED IN B IF M .LE. 0
      DIMENSION FLAGS(4)
      DATA FLAGS/1.,2.,0.,1./
      DATA Z/.499999/
C
      IF (M.LE.0) GO TO 58
C
      CALL ZERO (P,KDIM)
      ANGLE=1./RFAN
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      HS=.5*S
      HC=.5*C
      ZN=.5*FLOAT(NDIM+1)
      ZX=RFAN-ZN*(C+S)
      ZY=ZN*(S-C)
      RFP=RFAN*PWID
      IJL=1
C
      IF (TFANF) GO TO 20
C
      DO 18 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 16 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      ARCTAN=ATAN(ZYY/ZXX)
      ARC=RFAN*ARCTAN
      K=ARC+AXIS+.5
      BETAU=(FLOAT(K)-AXIS+.5)*ANGLE
      BETAL=BETAU-ANGLE
      BETAP=ARCTAN
      THETAU=BETAU-BETAP
      THETAL=BETAP-BETAL
      DU=DH*BWID*THETAU
      DL=DH*BWID*THETAL
      ISUB=LANG+M-1
      ALPHAU=BETAU+ANG(ISUB)
      AREA1=SQINT(DU,ALPHAU)
      ALPHAL=BETAL+ANG(ISUB)
      AREA2=SQINT(DL,ALPHAL)
      AREA=AREA1+AREA2
      MK=K
      MK1=MK
      MK2=MK
      P(MK)=P(MK)+B(IJ)*AREA*RFP/DH
      AREAX=AREA1
      AREAY=AREA2
      IF (AREA1.GT.Z) GO TO 12
   10 THETAU=THETAU+ANGLE
      DU=DH*BWID*THETAU
      ALPHAU=ALPHAU+ANGLE
      AREAU1=SQINT(DU,ALPHAU)
      AREAU=AREAU1-AREAX
      AREAX=AREAU1
      MK2=MK2+1
      P(MK2)=P(MK2)+B(IJ)*AREAU*RFP/DH
      IF (AREAU1.LE.Z) GO TO 10
   12 IF (AREA2.GT.Z) GO TO 16
   14 THETAL=THETAL+ANGLE
      DL=DH*BWID*THETAL
      ALPHAL=ALPHAL+ANGLE
      AREAL1=SQINT(DL,ALPHAL)
      AREAL=AREAL1-AREAY
      AREAY=AREAL1
      MK1=MK1-1
      P(MK1)=P(MK1)+B(IJ)*AREAL*RFP/DH
      IF (AREAL1.LE.Z) GO TO 14
   16 CONTINUE
   18 IJL=IJL+NN
      RETURN
C
   20 DO 30 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
```

```
      DO 28 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      ARCTAN=ATAN(ZYY/ZXX)
      YCENTR=ZYY/ZXX*RFAN
      K=YCENTR+AXIS+.5
      BETAU=ATAN((FLOAT(K)-AXIS+.5)/RFAN)
      BETAL=ATAN((FLOAT(K-1)-AXIS+.5)/RFAN)
      BETAP=ARCTAN
      THETAU=BETAU-BETAP
      THETAL=BETAP-BETAL
      DU=DH*BWID*THETAU
      DL=DH*BWID*THETAL
      ISUB=LANG+M-1
      ALPHAU=BETAU+ANG(ISUB)
      AREA1=SQINT(DU,ALPHAU)
      ALPHAL=BETAL+ANG(ISUB)
      AREA2=SQINT(DL,ALPHAL)
      AREA=AREA1+AREA2
      MK=K
      MK1=MK
      MK2=MK
      P(MK)=P(MK)+B(IJ)*AREA*RFP/ZXX
      AREAX=AREA1
      AREAY=AREA2
      IF (AREA1.GT.Z) GO TO 24
   22 MK2=MK2+1
      ANGLE=ATAN(RFAN/(RFAN**2+(FLOAT(MK2)-AXIS)**2-.25))
      THETAU=THETAU+ANGLE
      DU=DH*BWID*THETAU
      ALPHAU=ALPHAU+ANGLE
      AREAU1=SQINT(DU,ALPHAU)
      AREAU=AREAU1-AREAX
      AREAX=AREAU1
      P(MK2)=P(MK2)+B(IJ)*AREAU*RFP/ZXX
      IF (AREAU1.LE.Z) GO TO 22
   24 IF (AREA2.GT.Z) GO TO 28
   26 MK1=MK1-1
      ANGLE=ATAN(RFAN/(RFAN**2+(FLOAT(MK1)-AXIS)**2-.25))
      THETAL=THETAL+ANGLE
      DL=DH*BWID*THETAL
      ALPHAL=ALPHAL+ANGLE
      AREAL1=SQINT(DL,ALPHAL)
      AREAL=AREAL1-AREAY
      AREAY=AREAL1
      P(MK1)=P(MK1)+B(IJ)*AREAL*RFP/ZXX
      IF (AREAL1.LE.Z) GO TO 26
   28 CONTINUE
   30 IJL=IJL+NN
C
      RETURN
C
   32 M=-M
      IF (M.NE.1) GO TO 34
      CALL ZERO (B,NMAT)
      ANGLE=1./RFAN
C
   34 CONTINUE
C
      ISUB=LSINE+M-1
      S=SINE(ISUB)*PWID
      ISUB=LCOSIN+M-1
      C=COSINE(ISUB)*PWID
      HS=.5*S
      HC=.5*C
      ZN=.5*FLOAT(NDIM+1)
      ZX=RFAN-ZN*(C+S)
      ZY=ZN*(S-C)
      RFP=RFAN*PWID
      IJL=1
C
      IF (TFANF) GO TO 46
C
      DO 44 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 42 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      ARCTAN=ATAN(ZYY/ZXX)
      ARC=RFAN*ARCTAN
      K=ARC+AXIS+.5
      BETAU=(FLOAT(K)-AXIS+.5)*ANGLE
      BETAL=BETAU-ANGLE
      BETAP=ARCTAN
      THETAU=BETAU-BETAP
      THETAL=BETAP-BETAL
      DU=DH*BWID*THETAU
      DL=DH*BWID*THETAL
      ISUB=LANG+M-1
      ALPHAU=BETAU+ANG(ISUB)
      AREA1=SQINT(DU,ALPHAU)
      ALPHAL=BETAL+ANG(ISUB)
      AREA2=SQINT(DL,ALPHAL)
      AREA=AREA1+AREA2
      MK=K
      MK1=MK
      MK2=MK
      B(IJ)=B(IJ)+P(MK)*(AREA*RFP/DH)**2
      AREAX=AREA1
      AREAY=AREA2
      IF (AREA1.GT.Z) GO TO 38
   36 THETAU=THETAU+ANGLE
      DU=DH*BWID*THETAU
      ALPHAU=ALPHAU+ANGLE
      AREAU1=SQINT(DU,ALPHAU)
      AREAU=AREAU1-AREAX
      AREAX=AREAU1
      MK2=MK2+1
      B(IJ)=B(IJ)+P(MK2)*(AREAU*RFP/DH)**2
      IF (AREAU1.LE.Z) GO TO 36
   38 IF (AREA2.GT.Z) GO TO 42
   40 THETAL=THETAL+ANGLE
      DL=DH*BWID*THETAL
      ALPHAL=ALPHAL+ANGLE
      AREAL1=SQINT(DL,ALPHAL)
      AREAL=AREAL1-AREAY
      AREAY=AREAL1
      MK1=MK1-1
      B(IJ)=B(IJ)+P(MK1)*(AREAL*RFP/DH)**2
      IF (AREAL1.LE.Z) GO TO 40
   42 CONTINUE
   44 IJL=IJL+NN
      M=-M
      RETURN
C
   46 DO 56 J=1,NDIM
      ZX=ZX+S
      ZY=ZY+C
      ISUB=LNI+J-1
      NN=NI(ISUB)
      ZXX=ZX+FLOAT(NDIM-NN)*HC
      ZYY=ZY-FLOAT(NDIM-NN)*HS
      IJU=IJL+NN-1
      DO 54 IJ=IJL,IJU
      ZXX=ZXX+C
      ZYY=ZYY-S
      DH=SQRT(ZXX**2+ZYY**2)
      ARCTAN=ATAN(ZYY/ZXX)
      YCENTR=ZYY/ZXX*RFAN
      K=YCENTR+AXIS+.5
      BETAU=ATAN((FLOAT(K)-AXIS+.5)/RFAN)
      BETAL=ATAN((FLOAT(K-1)-AXIS+.5)/RFAN)
      BETAP=ARCTAN
      THETAU=BETAU-BETAP
      THETAL=BETAP-BETAL
      DU=DH*BWID*THETAU
      DL=DH*BWID*THETAL
      ISUB=LANG+M-1
      ALPHAU=BETAU+ANG(ISUB)
      AREA1=SQINT(DU,ALPHAU)
      ALPHAL=BETAL+ANG(ISUB)
      AREA2=SQINT(DL,ALPHAL)
      AREA=AREA1+AREA2
      MK=K
      MK1=MK
      MK2=MK
      B(IJ)=B(IJ)+P(MK)*(AREA*RFP/ZXX)**2
      AREAX=AREA1
      AREAY=AREA2
      IF (AREA1.GT.Z) GO TO 50
   48 MK2=MK2+1
      ANGLE=ATAN(RFAN/(RFAN**2+(FLOAT(MK2)-AXIS)**2-.25))
      THETAU=THETAU+ANGLE
      DU=DH*BWID*THETAU
      ALPHAU=ALPHAU+ANGLE
      AREAU1=SQINT(DU,ALPHAU)
      AREAU=AREAU1-AREAX
      AREAX=AREAU1
      B(IJ)=B(IJ)+P(MK2)*(AREAU*RFP/ZXX)**2
      IF (AREAU1.LE.Z) GO TO 48
   50 IF (AREA2.GT.Z) GO TO 54
   52 MK1=MK1-1
      ANGLE=ATAN(RFAN/(RFAN**2+(FLOAT(MK1)-AXIS)**2-.25))
      THETAL=THETAL+ANGLE
      DL=DH*BWID*THETAL
      ALPHAL=ALPHAL+ANGLE
      AREAL1=SQINT(DL,ALPHAL)
      AREAL=AREAL1-AREAY
      AREAY=AREAL1
      B(IJ)=B(IJ)+P(MK1)*(AREAL*RFP/ZXX)**2
      IF (AREAL1.LE.Z) GO TO 52
   54 CONTINUE
   56 IJL=IJL+NN
      M=-M
      RETURN
C
   58 IF (M.LT.0) GO TO 32
      DO 60 I=1,4
   60 B(I)=FLAGS(I)
      RETURN
      END
```

RADAL

```
      SUBROUTINE RADAL (Z,M,NXTAL,BBZ)
C
C     ****************************************************************
C     *       RECLBL    --          VERSION 1.0    --         17OCT77  *
C     ****************************************************************
C
C          THE SUBROUTINE RADAL IS USED BY THE SUBROUTINE MARR.  IT
C       COMPUTES AND LEAVES IN COMMON STORAGE THE QUANTITIES
C
C       (AAMR(N),BBMR(N))=SUMMATION,K=0,KMAX(N),(ALPHA(N,K),BETA(N,K))
C                        *Q(N,K,Z)     .... N=1,2,...,M
C
C       AND
C
C         BBZ=SUMMATION,K=0,KMX,BETA(0,K)*Q(N,K,Z)
C
C       WHERE KMX=(N/2), KMAX(N)=((M-N)/2), AND THE Q(N,K,Z) DENOTES
C       ((-1)**K) TIMES THE JACOBI POLYNOMIAL OF DEGREE K AND INDICES
C       (N,0), AS FUNCTION OF THE ARGUMENT, 1-2 AND WHERE ALPHA AND
C       BETA ARE OBTAINED FROM THE COMMON ARRAY GAM IN PACKED FORMAT
C       ACCORDING TO THE CONVENTIONS --
C         ALPHA(N,K) = GAM(32-N,16-K)
C         BETA(N,K) = GAM(N+1,K+1)
C
C           THE SUBROUTINE IS A MODIFICATION OF THE SUBROUTINE RADAL
C       (*** VERSION 2.0 -- 12/10/71) SUPPLIED TO US BY P. MARR.
C
C         Z        - RADIAL DISTANCE
C         M        - DEGREE OF THE POLYNOMIAL
C         NXTAL    - NUMBER OF CRYSTALS
C         BBZ      - SUMMATION FROM K=0 TO KMX (KMX=N/2) OF
C                        BETA(0,K)*Q(N,K,Z)
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - MARR, SETUP
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                        COMMON
C         IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                        SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                        FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                        EXECUTING.
C         WORK     - BLANK COMMON WORKING ARRAY
C
C
```

```
      COMMON/MARCOM/LGAM,LGPRJ,LBBMR,LAAMR,LAMAR,LBMAR
      DIMENSION GAM(1),GPRJ(1),BBMR(1),AAMR(1),AMAR(1),BMAR(1)
      EQUIVALENCE (WORK(1),GAM(1),GPRJ(1),BBMR(1),AAMR(1),AMAR(1),
     1           BMAR(1))
C
      DIMENSION P(31)
C
      NXTL2=NXTAL/2
      IF (M.GT.30) M=30
      X=Z+Z
      P(1)=1.
      BBZ=GAM(LGAM)
      DO 10 N=1,M
      P(N+1)=1.
C
C     **      Q(N,0,Z)=1, ALL N,Z.
C
      ISUB1=LBBMR+N-1
      ISUB2=LGAM+N
      BBMR(ISUB1)=GAM(ISUB2)
      ISUB=(NXTAL-1)*(NXTL2-1)+NXTAL-N
      ISUB1=LAAMR+N-1
      ISUB2=ISUB+LGAM-1
   10 AAMR(ISUB1)=GAM(ISUB2)
C
      KMX=M/2
      DO 16 K=1,KMX
C
C     ** USE RECURSION FORMULA-- Q(0,K,Z)=2*Z*Q(1,K-1,Z)-Q(0,K-1,Z), K.G
C
      P(1)=X*P(2)-P(1)
C
C     ** P(1) NOW CONTAINS Q(0,K,Z)
C
      ISUB=LGAM+(NXTAL-1)*K
      BBZ=BBZ+GAM(ISUB)*P(1)
      NMX=M-K-K
      IF (NMX) 16,16,12
   12 DO 14 N=1,NMX
C
C     **  USE RECURSION FORMULA--
C     ** Q(N,K,Z) =((N+2*K)*Q(N-1,K,Z) -K*Q(N,K-1,Z))/(N+K),  FOR N,K PO
C
      T=P(N)+(P(N)-P(N+1))*FLOAT(K)/FLOAT(N+K)
      P(N+1)=T
C
C     **  P(N+1) NOW CONTAINS Q(N,K,Z)
C
      ISUB=(NXTAL-1)*K+N+1
      ISUB1=LBBMR+N-1
      ISUB2=ISUB+LGAM-1
      BBMR(ISUB1)=BBMR(ISUB1)+T*GAM(ISUB2)
      ISUB=(NXTAL-1)*(NXTL2-K-1)+NXTAL-N
      ISUB1=LAAMR+N-1
      ISUB2=ISUB+LGAM-1
   14 AAMR(ISUB1)=AAMR(ISUB1)+T*GAM(ISUB2)
   16 CONTINUE
C
      RETURN
C
      END
```

RALA

```
      SUBROUTINE RALA (X,RA,M)
C
C     ******************************************************************
C     *       RECLBL    --         VERSION 1.0     --          17OCT77    *
C     ******************************************************************
C
C          SUBROUTINE RALA GENERATES THE CONVOLUTION FUNCTION FOR
C       CONVOLUTION RECONSTRUCTION OF PARALLEL BEAM DATA.  THIS
C       FUNCTION IS TAKEN FROM THE ARTICLE BY RAMACHANDRAN AND
C       LAKSHMINARAYANAN, PROC. NATL. ACAD. SCI., VOL. 68, P. 2236,
C       (1971).
C
C         X        - ARRAY IN WHICH THE CONVOLUTION FUNCTION IS RETURNED
C         RA       - DUMMY ARGUEMENT
C         M        - IF M IS LESS THAN OR EQUAL TO ZERO THEN FLAGS ARE
C                       RETURNED IN THE ARRAY X.  OTHERWISE THE
C                       CONVOLUTION FUNCTION (LENGTH=2*M-1) IS RETURNED
C
C       LANGUAGE - FORTRAN
C
      DIMENSION X(1),RA(2)
      DIMENSION FLAGS(4)
      DATA FLAGS/2.,-1.,0.,0./
C
      IF (M.LE.0) GO TO 14
C
      PI=4.*ATAN(1.)
      M1=M-1
      M2=M+1
C
      X(M)=.25*PI
C
      ISUB1=M1
      ISUB2=M2
      DO 10 K=1,M1,2
      X(ISUB1)=-1./(PI*FLOAT(K)**2)
      X(ISUB2)=X(ISUB1)
      ISUB1=ISUB1-2
   10 ISUB2=ISUB2+2
C
      ISUB1=M1-1
      ISUB2=M2+1
      DO 12 K=2,M1,2
      X(ISUB1)=0.
      X(ISUB2)=0.
      ISUB1=ISUB1-2
   12 ISUB2=ISUB2+2
      RETURN
C
   14 DO 16 I=1,4
   16 X(I)=FLAGS(I)
      RETURN
      END
```

RAMP

```
      SUBROUTINE RAMP (R,XI,M)
C
C     ******************************************************************
C     *       RECLBL    --         VERSION 1.0     --          17OCT77    *
C     ******************************************************************
C
C          THE SUBROUTINE RAMP EVALUATES THE VALUE OF THE RAMP
C       FILTER AT THE POINT XI.
C
C         R        - THE FUNCTIONAL VALUE
C         XI       - THE INDEPENDENT VARIABLE
C         M        - HAS THE FOLLOWING VALUES
C                    .LE. THE FLAGS ARE RETURNED IN R
C                    .GT. 0 THE FUNCTIONAL VALUE IS RETURNED IN R
C
C       THE FILTER PARAMETER FREQ IS PASSED IN THE COMMON BLOCK FILCOM.
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                       COMMON
C         IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                       SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                       FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                       EXECUTING.
C         WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/FILCOM/ORDER,FREQ,LBCKA,LPRJA,LFILT
      DIMENSION BCKA(1),PRJA(1),FILT(1)
      EQUIVALENCE (WORK(1),BCKA(1),PRJA(1),FILT(1))
C
C         ORDER    - FILTER PARAMETER USED ONLY BY THE FILTER BUTER
C         FREQ     - FILTER PARAMETER
C         LBCKA    - POINTER TO THE ARRAY BCKA IN BLANK COMMON
C                       BACK-PROJECTION ARRAY WHICH HAS THE DIMENSION
C                       NDIM X NDIM
C         LPRJA    - POINTER TO THE ARRAY PRJA IN BLANK COMMON
C                       A PROJECTION ARRAY FOR ONE ANGLE
C         LFILT    - POINTER TO THE ARRAY FILT IN BLANK COMMON
C                       ARRAY OF FILTER VALUES
C
      DIMENSION R(1)
C
C       BCK/PRJ/CNV/2DF,WT,ATEN,FAN ARE THE J FLAGS RETURNED IN R
C          IF M .LE. 0
C
      DIMENSION FLAGS(4)
      DATA FLAGS/3.,-1.,0.,-1./
C
      IF (M.LE.0) GO TO 12
C
      RAM=XI
      IF (RAM.LE.FREQ) GO TO 10
      RAM=0.
   10 R(1)=RAM
      RETURN
C
   12 DO 14 I=1,4
   14 R(I)=FLAGS(I)
C
      RETURN
      END
```

RAYST

```
      SUBROUTINE RAYST
C
C     ******************************************************************
C     *       RECLBL    --         VERSION 1.0     --          17OCT77    *
C     ******************************************************************
C
C          THE SUBROUTINE RAYST SETS UP THE COMMON BLOCK /RAYCOM/
C       THE SIZE OF A CELL IN THE TRANSVERSE SECTION IS ASSUMED TO BE
C       THE SAME AS THE WIDTH OF A RAY AND THE ARRAY RFAC CONTAINS THE
C       FRACTIONS OF A CELL WHICH LIE WITHIN A GIVEN RAY.  THE
C       FRACTIONS ARE COMPUTED FOR DISCRETE DISTANCES OF THE CENTER OF
C       THE CELL TO THE CENTER OF THE RAY.  THESE DISTANCES ARE
C       MULTIPLES OF 1/20.
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINES - MEMST. SQINT
C
C       RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                       COMMON
C         IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                       SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                       FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                       EXECUTING.
C         WORK     - BLANK COMMON WORKING ARRAY
C
```

```
      COMMON/CUTCOM/LUNOUT,I80132
C
C           LUNOUT  - LOGICAL UNIT NUMBER FOR OUTPUT
C           I80132  - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                        OUTPUT ON LUNOUT
C                 0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      COMMON/PRTCOM/TPRINT(8)
      LOGICAL TPRINT
C
C           TPRINT  - LOGICAL PRINT FLAGS
C                  1 - PRINT REQUIRED FLOATING POINT BLANK COMMON
C                        WHENEVER CHANGED
C                  2 - PRINT PROJECTION DATA AND UNCERTAINTIES
C                  3 - PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
C                  4 - PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER
C                        ROUTINES
C                  5 - PRINT VALUES FOR THE LAGRANGE MULTIPILERS AND
C                        THE GRADIENT FOR THE FUNCTION OF LAGRANGE MULTI-
C                        PILERS FOR THE ENTROPY RECONSTRUCTION
C                  6 - PRINT POINTERS IN BLANK COMMON WHENEVER CHANGED
C                        (DEBUG)
C
      COMMON/RAYCOM/NLEV,LMRFAC,KMRFAC,LRFAC
      DIMENSION MRFAC(1),RFAC(1)
      EQUIVALENCE(WORK(1),MRFAC(1),RFAC(1))
C
C           NLEV    - NUMBER OF FRACTION LEVELS
C           LMRFAC  - POINTER TO THE ARRAY MRFAC IN BLANK COMMON
C                        MRFAC(MANGLE) POINTS TO THE LOCATION IN BLANK
C                        COMMON WHERE RFAC(MRFAC(MANGLE)) IS STORED.
C                        RFAC(MRFAC(MANGLE)) IS THE FRACTION OF THE CELL
C                        WITHIN THE RAY WHEN THE CENTER OF THE CELL IS IN
C                        THE CENTER OF THE RAY AT THE ANGLE MANGLE.
C           KMRFAC  - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE MRFAC
C                        IS AN INTEGER VARIABLE
C           LRFAC   - POINTER TO THE ARRAY RFAC IN BLANK COMMON
C                        FRACTIONAL AREAS OF A CELL WHICH INTERSECT
C                        A RAY AND THIS FRACTION IS MEASURED AS A FUNCTION
C                        OF THE DISTANCE THE CENTER OF THE CELL IS FROM
C                        THE CENTER OF THE RAY.  THE TOTAL DIMENSION OF
C                        THE ARRAY RFAC IS NRFAC=LL*EQANG, WHERE
C                              3*NLEV+2  IF NLEV IS EVEN
C                        LL =
C                              3*NLEV+1  IF NLEV IS ODD
C                        AND EQANG IS THE SIZE OF THE SET OF ANGLES FORMED
C                        FROM THE SET OF TOTAL ANGLES WITH MOD OPERATION
C                        OF PHI/2 THEN REFLECTION ABOUT PHI/4.
C
      COMMON/STRCOM/TSTORE
      LOGICAL TSTORE
C
C           TSTORE  - LOGICAL VARIABLE SET TRUE WHEN TESTING STORAGE SIZE
C                        SETS TPRINT(1) = .TRUE.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C           IGEOM   - GEOMETRY FLAG
C                 0 = PARALLEL BEAM GEOMETRY
C                 1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                 2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                 3 = RING DETECTOR GEOMETRY
C           KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                        BY THE USER
C           AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                        AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                        IN THE CENTER OF A PROJECTION BIN.)
C           BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C           KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                        ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                        ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C           KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C           KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE LAST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C           KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                        TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                        KDIM=KDIMU.
C           AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY, USUALLY AXIS=AXISU.
C           LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                        INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                        VECTOR
C           NANG    - NUMBER OF PROJECTIONS
C           MODANG  - MODE FOR PROJECTION ANGLE INPUT
C           LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                        PROJECTION ANGLES IN RADIANS
C           LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                        SINE OF THE PROJECTION ANGLES
C           LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                        COSINE OF THE PROJECTION ANGLES
C           LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                        USER PROJECTION DATA AND UNCERTAINTIES
C           TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                        FALSE FOR TRANSMISSION DATA
C
      DIMENSION ANGL(1)
      LOGICAL TPSAVE
      DATA EPS/1.E-6/
C
      CALL MEMST (KMRFAC,NANG)
C
      DX=1./FLOAT(NLEV)
      HDX=.5*DX
C
      NN=NLEV/2
      MM=NLEV+(NLEV+1)/2
      LL=2*MM+1
C
      QPI=ATAN(1.)
      HPI=2.*QPI
C
      IF (TSTORE) GO TO 24
C
      TPSAVE=TPRINT(1)
      TPRINT(1)=.FALSE.
      CALL MEMST (LRFAC,1)
      NANGI=0
      DO 20 IANG=1,NANG
      ISUB=LANG+IANG-1
      THETA=QPI-ABS(AMOD(ABS(ANG(ISUB)),HPI)-QPI)
C
      LO=LRFAC+MM
      IF (NANGI.LT.1) GO TO 12
      DO 10 I=1,NANGI
      ISUB=LO-MM
      IF (ABS(THETA-RFAC(ISUB)).LT.EPS) GO TO 18
   10 LO=LO+LL
C
   12 NANGI=NANGI+1
      CALL MEMST (LRFAC,LL*NANGI)
      IF (TSTORE) GO TO 24
C
      S=THETA
      T=SQINT(.5,S)
      RFAC(LO)=2.*T
      ISUB=LO+NLEV
      RFAC(ISUB)=SQINT(1.5,S)-T
C
      X=0.
      DO 14 I=1,NN
      X=X+DX
      T1=SQINT(.5-X,S)
      T2=SQINT(.5+X,S)
      ISUB=LO+I
      RFAC(ISUB)=T1+T2
      ISUB=LO+NLEV-I
      RFAC(ISUB)=SQINT(1.5-X,S)-T1
      ISUB=LO+NLEV+I
   14 RFAC(ISUB)=SQINT(1.5+X,S)-T2
      ISUB=LO+MM
      RFAC(ISUB)=0.
C
      DO 16 I=1,MM
      ISUB1=LO-I
      ISUB2=LO+I
   16 RFAC(ISUB1)=RFAC(ISUB2)
C
      ISUB=LO-MM
      RFAC(ISUB)=THETA
   18 ISUB=LMRFAC+IANG-1
   20 MRFAC(ISUB)=LO-LRFAC
C
      LO=LRFAC+MM
      DO 22 I=1,NANGI
      ISUB=LO-MM
      RFAC(ISUB)=0.
   22 LO=LO+LL
C
      TPRINT(1)=TPSAVE
      IF (TPRINT(1)) CALL MEMST (LRFAC,LL*NANGI)
      RETURN
C
   24 CALL MEMST (LRFAC,LL*NANG)
      NOVF=1.+7.*FLOAT(LL*NANG)/8.
      NOCT=IOCTL(NOVF)
      WRITE (LUNOUT,26) NOVF,NOCT
      RETURN
C
   26 FORMAT(  //26H BLANK COMMON REQUIRED      /
     1           26H MAY BE OVERESTIMATED       /
     2           26H BY AS MUCH AS              ,I6,1H(,I6,1H))
      END
```

RCHEK

```
      SUBROUTINE RCHEK (BCK,PRJ,IIROU)
C
C     ******************************************************************
C     *      RECLBL    --         VERSION 1.0    --          17OCT77   *
C     ******************************************************************
C
C          THE SUBROUTINE RCHEK CHECKS IF BCK AND PRJ ARE COMPATIBLE.
C       IT ALSO SETS INT, IATEN AND IFAN AND CHECKS NLEV.
C
C         BCK     - THE BACK-PROJECTION SUBROUTINE
C         PRJ     - THE PROJECTION SUBROUTINE
C         IIROU   - SET TO A VALUE ACCORDING TO WHICH SUBROUTINE CALLS
C                        RCHEK -
C                             BKFIL   - 3
C                             CONGR   - 1
C                             CONVO   - 2
C                             ENTPY   - 5
C                             FILBK   - 4
C                             GRADY   - 1
C                             GVERS   - 1
C
C       THIS SUBROUTINE CALLS RECLBL ROUTINE - EMESG
C
C
C       EXTERNAL RECLBL SUBROUTINES - BCK, PRJ
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C         NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                        COMMON
C         IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C         NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C         ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                        SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                        FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                        EXECUTING.
C         WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/ATNCOM/LATEN,LBMAP,TATEN,LUNATN
      LOGICAL TATEN
      DIMENSION ATEN(1),BMAP(1)
      EQUIVALENCE (WORK(1),ATEN(1),BMAP(1))
C
C         LATEN   - POINTER TO THE ARRAY ATEN IN BLANK COMMON
C                        STORES ATTENUATION FACTORS FOR ONE ANGLE
C         LBMAP   - POINTER TO THE ARRAY BMAP IN BLANK COMMON
C                        A MATRIX USED TO STORE THE CONSTANT ATTENUATION
C                        COEFFICIENTS
C         TATEN   - LOGICAL VARIABLE SET TRUE FOR ATTENUATION
C                        RECONSTRUCTION
C         LUNATN  - LOGICAL UNIT NUMBER FOR ATTENUATION FACTOR STORAGE
C
```

```
      COMMON/FANCOM/RFAN,TFANC,TFANF
      LOGICAL TFANC,TFANF
C
C         RFAN    - FOR FAN BEAM GEOMETRY RFAN IS THE DISTANCE FROM
C                   THE SOURCE TO THE CENTER OF ROTATION.  RFAN
C                   IS MEASURED IN UNITS OF PROJECTION BIN WIDTHS AT
C                   THE CENTER OF ROTATION.
C         TFANC   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                   CURVED DETECTOR
C         TFANF   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                   FLAT DETECTOR
C
      COMMON/ITRCOM/NSTP,TRLX,TERR,TZER,LWGT,LDEL,LTEMP,LCDEL,LTRAN
      LOGICAL TRLX,TERR,TZER
      DIMENSION WGT(1),DEL(1),TEMP(1),CDEL(1),TRAN(1)
      EQUIVALENCE (WORK(1),WGT(1),DEL(1),TEMP(1),CDEL(1),TRAN(1))
C
C         NSTP    - NUMBER OF ITERATION STEPS
C         TRLX    - LOGICAL VARIABLE SET TRUE FOR RELAXATION
C         TERR    - LOGICAL VARIABLE SET TRUE FOR WEIGHTED LEAST SQUARE
C         TZER    - LOGICAL VARIABLE SET TRUE TO ZERO INITIAL SOLUTION
C         LWGT    - POINTER TO THE ARRAY WGT IN BLANK COMMON
C                   WEIGHTS FOR WEIGHTED LEAST SQUARES (SEE TERR)
C         LDEL    - POINTER TO THE ARRAY DEL IN BLANK COMMON
C                   GRADIENT VECTOR
C         LTEMP   - POINTER TO THE ARRAY TEMP IN BLANK COMMON
C                   TEMPORARY STORAGE TO INCREASE SPEED
C         LCDEL   - POINTER TO THE ARRAY CDEL IN BLANK COMMON
C                   STEP DIRECTION FOR CONJUGATE GRADIENTS
C         LTRAN   - POINTER TO THE ARRAY TRAN IN BLANK COMMON
C                   TRANSFORMATION MATRIX FOR RELAXATION (SEE TRLX)
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C         LUNOUT  - LOGICAL UNIT NUMBER FOR OUTPUT
C         I80132  - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                   OUTPUT ON LUNOUT
C               0 = 80 CHARACTERS   (132 CHARACTERS OTHERWISE)
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C         NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C         NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C         PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C         TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C         NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C         LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                   NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                   THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C         KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                   IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C         IGEOM   - GEOMETRY FLAG
C               0 = PARALLEL BEAM GEOMETRY
C               1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C               2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C               3 = RING DETECTOR GEOMETRY
C         KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                   BY THE USER
C         AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                   PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                   AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                   IN THE CENTER OF A PROJECTION BIN.)
C         BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                   ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                   ARRAY (AXISU).   AXIS = AXISU+FLOAT(KMOV)
C         KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                   THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                   IS GOING TO BE USED.
C         KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                   THE DATA OF THE LAST USER PROJECTION BIN THAT
C                   IS GOING TO BE USED.
C         KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                   TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                   KDIM=KDIMU.
C         AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                   PROJECTION ARRAY, USUALLY AXIS=AXISU.
C         LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                   INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                   VECTOR
C         NANG    - NUMBER OF PROJECTIONS
C         MODANG  - MODE FOR PROJECTION ANGLE INPUT
C         LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                   PROJECTION ANGLES IN RADIANS
C         LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                   SINE OF THE PROJECTION ANGLES
C         LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                   COSINE OF THE PROJECTION ANGLES
C         LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                   USER PROJECTION DATA AND UNCERTAINTIES
C         TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                   FALSE FOR TRANSMISSION DATA
C
      EXTERNAL BCK,PRJ
      DIMENSION BFLG(4),PFLG(4),IHOL(120),KROU(2,3)
      DIMENSION NAMER(5)
      LOGICAL TFANN,TATENN
      LOGICAL TFAN,TANGP,TANGF
      DATA IHOL/
     1   2HBA,2HCK,2HPR,2HOJ,2HEC,      2HTI,2HON,2H  ,2H  ,2H  ,
     2   2HPR,2HOJ,2HEC,2HTI,2HON,      2H  ,2H  ,2H  ,2H  ,2H  ,
     3   2HCO,2HNV,2HOL,2HUT,2HIO,      2HN ,2H  ,2H  ,2H  ,2H  ,
     4   2HFI,2HLT,2HER,2H  ,2H  ,      2H  ,2H  ,2H  ,2H  ,2H  ,
     5   2H  ,2H  ,2H N,2H/A,2H  ,      2H  ,2H  ,2H  ,2H  ,2H  ,
     6   2HDE,2HLT,2HA ,2HFU,2HNC,      2HTI,2HON,2H  ,2H  ,2H  ,
     7   2HCO,2HNC,2HAV,2HE ,2HDI,      2HSK,2H  ,2H  ,2H  ,2H  ,
     8   2HUN,2HIF,2HOR,2HM ,2HSQ,      2HUA,2HRE,2H  ,2H  ,2H  ,
     9   2HLI,2HNE,2H L,2HEN,2HGT,      2HH ,2H  ,2H  ,2H  ,2H  ,
     $   2HIN,2HTE,2HRP,2HOL,2HAT,      2HIO,2HN ,2H  ,2H  ,2H  ,
     $   2H  ,2H  ,2H  ,2H  ,2H  ,      2H  ,2H  ,2H N,2H/A,2H  ,
     $   2H  ,2H  ,2H N,2HO ,2H  ,      2H  ,2H  ,2H Y,2HES,2H  /
      DATA KROU/2HPR,1HJ, 2HCN,1HV, 2HFI,1HL/
      DATA EPS/1.E-6/
      DATA NAMER/1HR,1HC,1HH,1HE,1HK/
C
      IROU=IIROU
      IF (IIROU.EQ.5) IROU=1
      IF (IIROU.NE.5.OR..NOT.TATEN) GO TO 10
      WRITE (LUNOUT,68)
      CALL EMESG (46,NAMER,3)
   10 CONTINUE
      IF (IGEOM.EQ.3) GO TO 40
      JERR=0
      TFAN=TFANC.OR.TFANF
      IF (.NOT.(TFAN.AND.IROU.EQ.3)) GO TO 12
      WRITE (LUNOUT,42)
      CALL EMESG (37,NAMER,3)
   12 CALL BCK (BFLG,DIM,0)
      IF (IROU.NE.4) GO TO 14
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      IF (.NOT.TFAN) GO TO 18
      IF (BFLG(2).GE.20.) GO TO 16
      WRITE (LUNOUT,44)
      CALL EMESG (21,NAMER,3)
   14 IF (.NOT.BFLG(2).GE.20.) GO TO 20
      WRITE (LUNOUT,46)
      CALL EMESG (15,NAMER,3)
   16 BFLG(2)=BFLG(2)-20.+EPS
   18 IROU=3
   20 CALL PRJ (PFLG,DUM,0)
      IF (ABS(BFLG(1)).GT.EPS) JERR=1
      IF (ABS(PFLG(1)-FLOAT(IROU)).GT.EPS) JERR=1
      DO 22 I=2,4
      IF (ABS(BFLG(I)-PFLG(I)).LT.EPS) GO TO 22
      IF (ABS(BFLG(I)+1.).LT.EPS) GO TO 22
      IF (ABS(PFLG(I)+1.).LT.EPS) GO TO 22
      JERR=1
   22 CONTINUE
C
      WRITE (LUNOUT,48)
C
      I=BFLG(1)
      IWT=BFLG(2)
      IATEN=BFLG(3)
      IFAN=BFLG(4)
C
      J1L=10*I+1
      J1U=J1L+5
      J2L=10*IWT+51
      J2U=J2L+9
      J3L=5*IATEN+111
      J3U=J3L+4
      J4L=5*IFAN+111
      J4U=J4L+4
      WRITE (LUNOUT,50) (IHOL(J),J=J1L,J1U),(IHOL(J),J=J2L,J2U),(IHOL(J)
     1,J=J3L,J3U),(IHOL(J),J=J4L,J4U)
C
      I=PFLG(1)
      IWT=PFLG(2)
      IATEN=PFLG(3)
      IFAN=PFLG(4)
      J1L=10*I+1
      J1U=J1L+9
      J2L=10*IWT+51
      J2U=J2L+9
      J3L=5*IATEN+111
      J3U=J3L+4
      J4L=5*IFAN+111
      J4U=J4L+4
      WRITE (LUNOUT,52) KROU(1,IROU),KROU(2,IROU),(IHOL(J),J=J1L,J1U),(I
     1HOL(J),J=J2L,J2U),(IHOL(J),J=J3L,J3U),(IHOL(J),J=J4L,J4U)
C
      IF (JERR.EQ.0) GO TO 24
      WRITE (LUNOUT,54)
      CALL EMESG (16,NAMER,3)
C
   24 IWT=BFLG(2)
      IATEN=BFLG(3)
      IFAN=BFLG(4)
      TFANN=IFAN.EQ.1
      TATENN=IATEN.EQ.1
C
      IF (IROU.NE.2.OR.IWT.EQ.4.OR..NOT.TERR) GO TO 26
      WRITE (LUNOUT,56)
      CALL EMESG (17,NAMER,3)
   26 CONTINUE
C
      IF (IWT.NE.1.AND.IWT.NE.2) GO TO 28
      IF (ABS(PWID-1.).LT.EPS.OR.TFANN) GO TO 28
      WRITE (LUNOUT,58)
      CALL EMESG (18,NAMER,3)
C
   28 IF (TFAN.AND.TFANN.OR..NOT.(TFAN.OR.TFANN)) GO TO 30
      WRITE (LUNOUT,60)
      CALL EMESG (19,NAMER,3)
C
   30 IF (TATEN.AND.TATENN.OR..NOT.(TATEN.OR.TATENN)) GO TO 32
      WRITE (LUNOUT,62)
      CALL EMESG (20,NAMER,3)
C
   32 IF (IIROU.EQ.5) GO TO 34
      IF (IROU.LT.2) GO TO 38
   34 TANGP=IABS(MODANG).GE.2.AND.IABS(MODANG).LE.5
      TANGF=IABS(MODANG).EQ.3.OR.IABS(MODANG).EQ.5
      IF (TFAN.AND..NOT.TANGF) GO TO 36
      IF (TFAN.OR.TANGP) GO TO 38
      WRITE (LUNOUT,64)
      CALL EMESG (32,NAMER,3)
   36 WRITE (LUNOUT,66)
      CALL EMESG (33,NAMER,3)
C
   38 IF (IROU.NE.2.OR..NOT.TFAN.OR.IWT.EQ.4) RETURN
      WRITE (LUNOUT,70)
      CALL EMESG (42,NAMER,3)
C
   40 WRITE (LUNOUT,72)
      CALL EMESG (36,NAMER,3)
      STOP
C
C
C
   42 FORMAT(//10X,60HDUE TO LACK OF APPPOPRIATE FILTERS, BKFIL CANNOT E
     1XECUTE/15X,45HFAN BEAM RECONSTRUCTIONS AT THE PRESENT TIME.)
   44 FORMAT(/1X,65HWHEN USING FAN BEAM GEOMETRY AND THE SUBROUTINE FILB
     1K, ONE OF THE/1X,63HBACK-PROJECTION SUBROUTINES BCDF2, BPTF2, BRFF
     22 SHOULD BE USED.)
   46 FORMAT(/1X,64HSHOULD USE BCDF2, BPTF2 AND BRFFZ ONLY WITH THE SUBR
     1OUTINE FILBK)
   48 FORMAT(  //58H BACKPROJECTION AND PROJECTION/CONVOLUTION/FILTER RO
     1UTINES/32H PERFORM THE FOLLOWING FUNCTIONS//4H ARG,5X,8HFUNCTION,
     212X,13HRAY WEIGHTING,7X,12HATTENUATION ,8X,9HFAN BEAM )
   50 FORMAT(9H BCK      ,25A2,10X,5A2)
   52 FORMAT(1X,2A2,4X,25A2,10X,5A2)
   54 FORMAT(37H THESE ARE INCONSISTENT.    ...STOP...)
   56 FORMAT(/1X,50HTHE REQUESTED BACK-PPOJECTION SUBROUTINE WILL NOT
     1/3X,48HCALCULATE ERRORS FOR CONVOLUTION RECONSTRUCTIONS)
   58 FORMAT(/1X,46HFOR THIS WEIGHTING MODEL PIXELS AND PROJECTION /
     13X,44HBINS MUST BE THE SAME SIZE (PWID=PAR(3)=1.0))
   60 FORMAT(/1X,77HTHESE SUBROUTINES ARE INCONSISTENT WITH THE FAN BEAM
     1 PARAMETERS SEEN BY SETUP)
   62 FORMAT(/1X,66HATTEMPTED CALL OF A PROJECTION OR BACK PROJECTION SU
     1BROUTINE WHICH
     2/3X,59HUSES ATTENUATION FACTORS BEFORE THE FACTORS WERE EVALUATED.
     3)
   64 FORMAT(/10X,50HFOR CONVOLUTION AND FOURIER RECONSTRUCTION METHODS/
     110X,48HPROJECTION ANGLES MUST BE EQUALLY SPACED OVER AT/10X,  46HL
     2EAST PI RADIANS FOR PARALLEL BEAM.  TO INSURE/10X,60HTHIS MODANG=I
     3PAR(4) MUST NOT BE 0 OR 1 IN THE CALL TO SETUP.)
   66 FORMAT(/10X,52HFOR CONVOLUTION, FOURIER, AND ENTROPY RECONSTRUCTIO
     1N/10X,53HMETHODS PROJECTION ANGLES MUST BE EQUALLY SPACED OVER/10X
     2,57H2*PI RADIANS FOR FAN BEAM.  TO INSURE THIS MODANG=IPAR(4)/10X,
     344HMUST BE 3, -3, 5 OR -5 IN THE CALL TO SETUP.)
   68 FORMAT(/10X,65HCANNOT USE ATTENUATION PROJECTION AND BACK-PROJECTI
     1ON SUBROUTINES/10X,26HWITH THE SUBROUTINE ENTRY.)
   70 FORMAT(/10X,59HMUST USE BINF WHEN PERFORMING CONVOLUTION ON FAN BE
     1AM DATA.)
   72 FORMAT(/10X,65HMUST USE THE MARR RECONSTRUCTION ALGORITHM ON RING
     1GEOMETRY DATA.)
      END
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SETIT

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      SUBROUTINE SETIT (X,CHI,PRJ,BCK)
C
C     ******************************************************************
C     *       RECLBL      --         VERSION 1.0      --        17OCT77    *
C     ******************************************************************
C
C        SETIT SETS UP THE INITIAL CHISQ AND GRADIENT FOR THE ITERATIVE
C        ROUTINES GRADY AND CONGR.
C
C          X        - THE INITIAL SOLUTION FOR THE RECONSTRUCTION ARRAY.
C                       IF IZER=0 THEN THE INITIAL SOLUTION IS ZERO.
C          CHI      - ARRAY WHICH GIVES THE CHI-SQUARE FOR EACH ITERATION
C                       STEP
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - CISQ, DOT, GETDE, ZERO
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        EXTERNAL RECLBL SUBROUTINES - BCK, PRJ
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C           NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                        COMMON
C           IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C           NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C           ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                        SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                        FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                        EXECUTING.
C           WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/ITRCOM/NSTP,TRLX,TERR,TZER,LWGT,LDEL,LTEMP,LCDEL,LTRAN
      LOGICAL TRLX,TERR,TZER
      DIMENSION WGT(1),DEL(1),TEMP(1),CDEL(1),TRAN(1)
      EQUIVALENCE (WORK(1),WGT(1),DEL(1),TEMP(1),CDEL(1),TRAN(1))
C
C           NSTP     - NUMBER OF ITERATION STEPS
C           TRLX     - LOGICAL VARIABLE SET TRUE FOR RELAXATION
C           TERR     - LOGICAL VARIABLE SET TRUE FOR WEIGHTED LEAST SQUARE
C           TZER     - LOGICAL VARIABLE SET TRUE TO ZERO INITIAL SOLUTION
C           LWGT     - POINTER TO THE ARRAY WGT IN BLANK COMMON
C                        WEIGHTS FOR WEIGHTED LEAST SQUARES (SEE TERR)
C           LDEL     - POINTER TO THE ARRAY DEL IN BLANK COMMON
C                        GRADIENT VECTOR
C           LTEMP    - POINTER TO THE ARRAY TEMP IN BLANK COMMON
C                        TEMPORARY STORAGE TO INCREASE SPEED
C           LCDEL    - POINTER TO THE ARRAY CDEL IN BLANK COMMON
C                        STEP DIRECTION FOR CONJUGATE GRADIENTS
C           LTRAN    - POINTER TO THE ARRAY TRAN IN BLANK COMMON
C                        TRANSFORMATION MATRIX FOR RELAXATION (SEE TRLX)
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C           NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C           NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C           PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C           TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C           NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C           LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                        NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                        THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C           KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                        IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C           IGEOM    - GEOMETRY FLAG
C                  0 = PARALLEL BEAM GEOMETRY
C                  1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C                  2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C                  3 = RING DETECTOR GEOMETRY
C           KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                        BY THE USER
C           AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                        AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                        IN THE CENTER OF A PROJECTION BIN.)
C           BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C           KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                        ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                        ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C           KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C           KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                        THE DATA OF THE LAST USER PROJECTION BIN THAT
C                        IS GOING TO BE USED.
C           KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                        TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                        KDIM=KDIMU.
C           AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                        PROJECTION ARRAY, USUALLY AXIS=AXISU.
C           LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                        INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                        VECTOR
C           NANG     - NUMBER OF PROJECTIONS
C           MODANG   - MODE FOR PROJECTION ANGLE INPUT
C           LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                        PROJECTION ANGLES IN RADIANS
C           LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                        SINE OF THE PROJECTION ANGLES
C           LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                        COSINE OF THE PROJECTION ANGLES
C           LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                        USER PROJECTION DATA AND UNCERTAINTIES
C           TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                        FALSE FOR TRANSMISSION DATA
C
      EXTERNAL PRJ,BCK
      DIMENSION X(1)
C
C        *INITIAL CHI-SQUARE
C        *INITIAL GRADIENT
C
      CHI=0.
      DO 24 M=1,NANG
C
      ISUB1=LPROJ
      ISUB2=LPROJ+KDIM
      CALL GETDE (M,PROJ(ISUB1),PROJ(ISUB2))
C
      IF (.NOT.TERR) GO TO 12
      DO 10 I=1,KDIM
      ISUB1=LPROJ+KDIM+I-1
      ISUB2=LWGT+(M-1)*KDIM+I-1
   10 WGT(ISUB2)=1./PROJ(ISUB1)**2
C
   12 IF (TZER) GO TO 16
      ISUB=LPROJ+KDIM
      CALL PRJ (X,PROJ(ISUB),M)
      DO 14 I=1,KDIM
      ISUB1=LPROJ+I-1
      ISUB2=LPROJ+KDIM+I-1
   14 PROJ(ISUB1)=PROJ(ISUB2)-PROJ(ISUB2)
      GO TO 18
C
   16 CALL ZERO (X,NMAT)
   18 IF (.NOT.TERR) GO TO 22
      DO 20 I=1,KDIM
      ISUB1=LPROJ+I-1
      ISUB2=LWGT+(M-1)*KDIM+I-1
      CHI=CHI+PROJ(ISUB1)**2*WGT(ISUB2)
   20 PROJ(ISUB1)=PROJ(ISUB1)*WGT(ISUB2)
      GO TO 24
C
   22 CHI=CHI+DOT(PROJ(LPROJ),1,PROJ(LPROJ),1,KDIM)
C
   24 CALL BCK (TEMP(LTEMP),PROJ(LPROJ),M)
C
C
      DO 26 I=1,NMAT
      ISUB1=LDEL+I-1
      ISUB2=LTEMP+I-1
   26 DEL(ISUB1)=TEMP(ISUB2)
C
C        *TRANSFORMATION OF THE INITIAL GRADIENT
C        *EVALUATE THE TRANSFORMATION MATRIX TRAN AND STORE IT IN WORK
C             STARTING WITH LOCATION LTRAN
C
      IF (.NOT.TRLX) RETURN
      IF (TERR) GO TO 32
      DO 28 I=1,KDIM
      ISUB=LPROJ+I-1
   28 PROJ(ISUB)=1.
      DO 30 M=1,NANG
   30 CALL PRJ (TEMP(LTEMP),PROJ(LPROJ),-M)
      GO TO 36
   32 K=LWGT
      DO 34 M=1,NANG
      CALL PRJ (TEMP(LTEMP),WGT(K),-M)
   34 K=K+KDIM
   36 DO 38 I=1,NMAT
      ISUB1=LTRAN+I-1
      ISUB2=LTEMP+I-1
      TRAN(ISUB1)=1./SQRT(TEMP(ISUB2))
      ISUB3=LDEL+I-1
   38 DEL(ISUB3)=DEL(ISUB3)*TRAN(ISUB1)
      RETURN
C
      END
```

SETUP

```
      SUBROUTINE SETUP (IPAR,PAR,ANGL)
C
C     ******************************************************************
C     *       RECLBL      --         VERSION 1.0      --        17OCT77    *
C     ******************************************************************
C
C          THE SUBROUTINE SETUP SETS UP THE COMMON BLOCKS FANCOM,
C       PTRCOM, RAYCOM, AND TRGCOM.
C
C         IPAR     - INTEGER ARRAY WHICH DESCRIBES THE FOLLOWING OPTIONS
C                      AND VARIABLES
C
C              IPAR(1)  = LINEAR DIMENSION OF THE RECONSTRUCTION ARRAY
C
C              IPAR(2)  = 0 TO RECONSTRUCT A CIRCULAR ARRAY
C                           OTHERWISE RECONSTRUCT A SQUARE ARRAY
C
C              IPAR(3)  = 0 PARALLEL BEAM GEOMETRY
C                         1 FAN BEAM GEOMETRY (CURVED DETECTOR)
C                         2 FAN BEAM GEOMETRY (FLAT DETECTOR)
C                         3 RING DETECTOR GEOMETRY
C
C              IPAR(4)  = NUMBER OF PROJECTION ANGLES
C
C              IPAR(5)  = 0 USER SUPPLIES PROJECTION ANGLES IN DEGREES
C                         1 USER SUPPLIES PROJECTION ANGLES IN RADIANS
C                         2 PROJECTION ANGLES GENERATED BETWEEN ZERO
C                           AND PI STARTING AT THE HALF ANGLE
C                         3 PROJECTION ANGLES GENERATED BETWEEN ZERO
C                           AND 2*PI STARTING AT THE HALF ANGLE
C                         4 PROJECTION ANGLES GENERATED BETWEEN ZERO
C                           AND PI STARTING AT ZERO
C                         5 PROJECTION ANGLES GENERATED BETWEEN ZERO
C                           AND 2*PI STARTING AT ZERO
C                        -I WHERE I IS BETWEEN 2 AND 5 DOES THE SAME
C                           AS ABOVE WITH THE ORDER OF ANGLES REVERSED
C
C
C              IPAR(6)  = NUMBER OF BINS FOR EACH PROJECTION ANGLE
C
C              IPAR(7)  = 0 TO RECONSTRUCT EMMISION DATA
C                           OTHERWISE RECONSTRUCT TRANSMISSION DATA
C
```

```
C             IPAR(8)  = DIMENSION OF BLANK COMMON SET BY THE USER
C
C             IPAR(9)  = NUMBER OF WORDS FOR A FLOATING POINT
C                        VARIABLE
C
C             IPAR(10) = 0 TO PERFORM A RECONSTRUCTION
C                        OTHERWISE ONLY DO A STORAGE SIZE TEST
C
C             IPAR(11) = PRINT FLAGS  (BIT 0 = LEAST SIGNIFICANT BIT)
C                        BIT 0  PRINT REQUIRED FLOATING POINT BLANK
C                               COMMON WHENEVER CHANGED
C                        BIT 1  PRINT PROJECTION DATA AND
C                               UNCERTAINTIES
C                        BIT 2  PRINT SETUP VALUES FROM IPAR AND
C                               PAR ARRAYS
C                        BIT 3  PRINT FILTER FUNCTION FOR
C                               CONVOLUTION AND FILTER ROUTINES
C                        BIT 4  PRINT VALUES FOR THE LAGRANGE MUL-
C                               TIPILERS AND THE GRADIENT FOR THE
C                               FUNCTION OF LAGRANGE MULTIPILERS
C                               FOR THE ENTROPY RECONSTRUCTION
C                        BIT 5  PRINT POINTERS IN BLANK COMMON
C                               WHENEVER CHANGED  (DEBUG)
C
C             IPAR(12) = LOGICAL UNIT NUMBER FOR ATTENUATION FACTOR
C                        STORAGE (DEF. STATN AND FTATN)
C
C       PAR     - REAL ARRAY WHICH HAS THE FOLLOWING PARAMETERS
C
C             PAR(1)   = PIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH
C
C             PAR(2)   = LOCATION OF THE ROTATION AXIS IN THE PROJECT-
C                        ION ARRAY
C
C             PAR(3)   = THE DISTANCE FROM THE SOURCE TO THE CENTER
C                        OF ROTATION FOR FAN BEAM GEOMETRY (MEASURED
C                        IN UNITS OF PROJECTION BIN WIDTHS AT THE
C                        CENTER OF ROTATION).  IF NOT USING FAN
C                        BEAM GEOMETRY THEN PAR(3) MUST BE EQUAL
C                        TO ZERO.
C
C       ANGL    - THE PROJECTION ANGLES
C
C     THIS SUBROUTINE CALLS RECLBL ROUTINES - EMESG, LGTXT, MEMST,
C       RAYST, STPTR
C
C     LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C       NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                 COMMON
C       IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C       NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C       ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                 SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                 FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                 EXECUTING.
C       WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/ATNCOM/LATEN,LBMAP,TATEN,LUNATN
      LOGICAL TATEN
      DIMENSION ATEN(1),BMAP(1)
      EQUIVALENCE (WORK(1),ATEN(1),BMAP(1))
C
C       LATEN   - POINTER TO THE ARRAY ATEN IN BLANK COMMON
C                 STORES ATTENUATION FACTORS FOR ONE ANGLE
C       LBMAP   - POINTER TO THE ARRAY BMAP IN BLANK COMMON
C                 A MATRIX USED TO STORE THE CONSTANT ATTENUATION
C                 COEFFICIENTS
C       TATEN   - LOGICAL VARIABLE SET TRUE FOR ATTENUATION
C                 RECONSTRUCTION
C       LUNATN  - LOGICAL UNIT NUMBER FOR ATTENUATION FACTOR STORAGE
C
      COMMON/FANCOM/RFAN,TFANC,TFANF
      LOGICAL TFANC,TFANF
C
C       RFAN    - FOR FAN BEAM GEOMETRY RFAN IS THE DISTANCE FROM
C                 THE SOURCE TO THE CENTER OF ROTATION.  RFAN
C                 IS MEASURED IN UNITS OF PROJECTION BIN WIDTHS AT
C                 THE CENTER OF ROTATION.
C       TFANC   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                 CURVED DETECTOR
C       TFANF   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                 FLAT DETECTOR
C
      COMMON/ITRCOM/NSTP,TRLX,TERR,TZER,LWGT,LDEL,LTEMP,LCDEL,LTRAN
      LOGICAL TRLX,TERR,TZER
      DIMENSION WGT(1),DEL(1),TEMP(1),CDEL(1),TRAN(1)
      EQUIVALENCE (WORK(1),WGT(1),DEL(1),TEMP(1),CDEL(1),TRAN(1))
C
C       NSTP    - NUMBER OF ITERATION STEPS
C       TRLX    - LOGICAL VARIABLE SET TRUE FOR RELAXATION
C       TERR    - LOGICAL VARIABLE SET TRUE FOR WEIGHTED LEAST SQUARE
C       TZER    - LOGICAL VARIABLE SET TRUE TO ZERO INITIAL SOLUTION
C       LWGT    - POINTER TO THE ARRAY WGT IN BLANK COMMON
C                 WEIGHTS FOR WEIGHTED LEAST SQUARES (SEE TERR)
C       LDEL    - POINTER TO THE ARRAY DEL IN BLANK COMMON
C                 GRADIENT VECTOR
C       LTEMP   - POINTER TO THE ARRAY TEMP IN BLANK COMMON
C                 TEMPORARY STORAGE TO INCREASE SPEED
C       LCDEL   - POINTER TO THE ARRAY CDEL IN BLANK COMMON
C                 STEP DIRECTION FOR CONJUGATE GRADIENTS
C       LTRAN   - POINTER TO THE ARRAY TRAN IN BLANK COMMON
C                 TRANSFORMATION MATRIX FOR RELAXATION (SEE TRLX)
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C       LUNOUT  - LOGICAL UNIT NUMBER FOR OUTPUT
C       I80132  - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                 OUTPUT ON LUNOUT
C               0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      COMMON/PRTCOM/TPRINT(8)
      LOGICAL TPRINT
C
C       TPRINT  - LOGICAL PRINT FLAGS
C               1 - PRINT REQUIRED FLOATING POINT BLANK COMMON
C                   WHENEVER CHANGED
C               2 - PRINT PROJECTION DATA AND UNCERTAINTIES
C               3 - PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
C               4 - PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER
C                   ROUTINES
C               5 - PRINT VALUES FOR THE LAGRANGE MULTIPILERS AND
C                   THE GRADIENT FOR THE FUNCTION OF LAGRANGE MULTI-
C                   PILERS FOR THE ENTROPY RECONSTRUCTION
C               6 - PRINT POINTERS IN BLANK COMMON WHENEVER CHANGED
C                   (DEBUG)
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C       NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C       NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C       PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C       TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C       NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C       LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                 NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                 THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C       KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                 IS AN INTEGER VARIABLE
C
      COMMON/RAYCOM/NLEV,LMRFAC,KMRFAC,LRFAC
      DIMENSION MRFAC(1),RFAC(1)
      EQUIVALENCE(WORK(1),MRFAC(1),RFAC(1))
C
C       NLEV    - NUMBER OF FRACTION LEVELS
C       LMRFAC  - POINTER TO THE ARRAY MRFAC IN BLANK COMMON
C                 MRFAC(MANGLE) POINTS TO THE LOCATION IN BLANK
C                 COMMON WHERE RFAC(MRFAC(MANGLE)) IS STORED.
C                 RFAC(MRFAC(MANGLE)) IS THE FRACTION OF THE CELL
C                 WITHIN THE RAY WHEN THE CENTER OF THE CELL IS IN
C                 THE CENTER OF THE RAY AT THE ANGLE MANGLE.
C       KMRFAC  - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE MRFAC
C                 IS AN INTEGER VARIABLE
C       LRFAC   - POINTER TO THE ARRAY RFAC IN BLANK COMMON
C                 FRACTIONAL AREAS OF A CELL WHICH INTERSECT
C                 A RAY AND THIS FRACTION IS MEASURED AS A FUNCTION
C                 OF THE DISTANCE THE CENTER OF THE CELL IS FROM
C                 THE CENTER OF THE RAY.  THE TOTAL DIMENSION OF
C                 THE ARRAY RFAC IS NRFAC=LL*EQANG, WHERE
C                           3*NLEV+2  IF NLEV IS EVEN
C                      LL =
C                           3*NLEV+1  IF NLEV IS ODD
C                 AND EQANG IS THE SIZE OF THE SET OF ANGLES FORMED
C                 FROM THE SET OF TOTAL ANGLES WITH MOD OPERATION
C                 OF PHI/2 THEN REFLECTION ABOUT PHI/4.
C
      COMMON/STRCOM/TSTORE
      LOGICAL TSTORE
C
C       TSTORE  - LOGICAL VARIABLE SET TRUE WHEN TESTING STORAGE SIZE
C                 SETS TPRINT(1) = .TRUE.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1          LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LOATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C       IGEOM   - GEOMETRY FLAG
C               0 = PARALLEL BEAM GEOMETRY
C               1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C               2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C               3 = RING DETECTOR GEOMETRY
C       KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                 BY THE USER
C       AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                 PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                 AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                 IN THE CENTER OF A PROJECTION BIN.)
C       BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C       KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                 ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                 ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C       KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                 THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                 IS GOING TO BE USED.
C       KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                 THE DATA OF THE LAST USER PROJECTION BIN THAT
C                 IS GOING TO BE USED.
C       KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                 TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                 KDIM=KDIMU.
C       AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                 PROJECTION ARRAY, USUALLY AXIS=AXISU.
C       LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                 INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                 VECTOR
C       NANG    - NUMBER OF PROJECTIONS
C       MODANG  - MODE FOR PROJECTION ANGLE INPUT
C       LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                 PROJECTION ANGLES IN RADIANS
C       LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                 SINE OF THE PROJECTION ANGLES
C       LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                 COSINE OF THE PROJECTION ANGLES
C       LOATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                 USER PROJECTION DATA AND UNCERTAINTIES
C       TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                 FALSE FOR TRANSMISSION DATA
C
      DIMENSION ANGL(1),IPAR(20),PAR(6)
      DIMENSION KERR(3)
      DIMENSION NAMER(9)
      LOGICAL TRING
      DATA NAMER/1HE,1HN,1HD,1H ,1HS,1HE,1HT,1HU,1HP/
      DATA IOK,KERR/2HOK,2H  ,2HER,2HNA/
      DATA JNDIM,JCIR,JANG,JODANG,JGEOM,JKDIM,JEMIT,JWORK,JFLOAT,JSTORE,
     1    JPPRINT,JUNATN,JXIS,JFAN,JWID/
     2 1,2,4,5,3,6,7,8,9,10,11,12,2,3,1/
C
      WRITE (LUNOUT,54)
      CALL LGTXT (NAMER(5),5)
      ISETUP=IOK
      TATEN=.FALSE.
      TERR=.FALSE.
      JERR=0
      NDIMU=IPAR(JNDIM)
      NDIM=NDIMU
      IF (NDIM.LE.0) JERR=JERR+1
      TCIR=IPAR(JCIR).EQ.0
      NANG=IPAR(JANG)
      IF (NANG.LE.0) JERR=JERR+1
      MODANG=IPAR(JODANG)
      IGEOM=IPAR(JGEOM)
      IF (IGEOM.LT.0.OR.IGEOM.GT.3) JERR=JERR+1
      TFANC=IGEOM.EQ.1
      TFANF=IGEOM.EQ.2
      TRING=IGEOM.EQ.3
      IF ((MODANG.EQ.-1.OR.IABS(MODANG).GT.5).AND..NOT.TRING) JERR=JERR+
     11
      KDIMU=IPAR(JKDIM)
      IF (KDIMU.LE.0) JERR=JERR+1
      TEMIT=IPAR(JEMIT).EQ.0
      NWORK=IPAR(JWORK)
      IF (NWORK.LE.0) JERR=JERR+1
      IWUSED=0
```

```
      NFLOAT=IPAR(JFLOAT)
      TSTORE=IPAR(JSTORE).NE.0
      J=IPAR(JPRINT)
      DO 10 I=1,8
   10 TPRINT(I)=(J/2**(I-1)-2*(J/2**I)).EQ.1
      TPRINT(1)=TPRINT(1).OR.TPRINT(6)
      IF (NFLOAT.LE.0) JERR=JERR+1
      LUNATN=IPAR(JUNATN)
      AXISU=PAR(JXIS)
      RFAN=PAR(JFAN)
      IF (.NOT.(TFANC.OR.TFANF)) RFAN=0.
      IF ((TFANC.OR.TFANF).AND.RFAN.LE.0.) JERR=JERR+1
      PWID=PAR(JWID)
      IF (PWID.LE.0.) GO TO 12
      BWID=1./PWID
      GO TO 14
   12 JERR=JERR+1
   14 CONTINUE
C
      IF ((JERR.EQ.0).AND..NOT.TPRINT(3)) GO TO 38
C
      WRITE (LUNOUT,56)
      KER=KERR(1)
C
      IF (NDIM.LE.0) KER=KERR(2)
      WRITE (LUNOUT,58) JNDIM,IPAR(JNDIM),KER
      KER=KERR(1)
C
      IF (TRING) WRITE (LUNOUT,60) JCIR,IPAR(JCIR),KERR(3)
      IF (TRING) GO TO 26
      IF (TCIR) WRITE (LUNOUT,62) JCIR,IPAR(JCIR),KER
      IF (.NOT.TCIR) WRITE (LUNOUT,64) JCIR,IPAR(JCIR),KER
C
   26 KER=KERR(1)
      IF (IGEOM.LT.0.OR.IGEOM.GT.3) KER=KERR(2)
      WRITE (LUNOUT,66) JGEOM,IPAR(JGEOM),KER
      IPCFR=IGEOM+1
      IF (KER.EQ.KERR(1)) GO TO (16,18,20,22),IPCFP
      WRITE (LUNOUT,68)
      GO TO 24
   16 WRITE (LUNOUT,70)
      GO TO 24
   18 WRITE (LUNOUT,72)
      GO TO 24
   20 WRITE (LUNOUT,74)
      GO TO 24
   22 WRITE (LUNOUT,76)
   24 KER=KERR(1)
C
      IF (NANG.LE.0) KER=KERR(2)
      WRITE (LUNOUT,78) JANG,IPAR(JANG),KER
      IF (TRING) WRITE (LUNOUT,80)
      KER=KERR(1)
C
      IF (MODANG.EQ.-1) KER=KERR(2)
      IF (IABS(MODANG).GT.5) KER=KERR(2)
      IF (TRING) GO TO 30
      WRITE (LUNOUT,82) JODANG,IPAR(JODANG),KER
      IF (KER.EQ.KERR(2)) GO TO 28
      IF (IABS(MODANG).LE.1) GO TO 32
      NPI=1+MOD(IABS(MODANG),2)
      IF (NPI.EQ.1) WRITE (LUNOUT,84)
      IF (NPI.EQ.2) WRITE (LUNOUT,86)
      IF (IABS(MODANG).LE.3) WRITE (LUNOUT,88)
      IF (IABS(MODANG).GT.3) WRITE (LUNOUT,90)
      IF (MODANG.LT.0) WRITE (LUNOUT,92)
      GO TO 34
   28 WRITE (LUNOUT,94)
      GO TO 34
   30 WRITE (LUNOUT,60) JODANG,IPAR(JODANG),KERR(3)
      GO TO 34
   32 IF (MODANG.EQ.0) WRITE (LUNOUT,96)
      IF (MODANG.EQ.1) WRITE (LUNOUT,98)
   34 KER=KERR(1)
C
      IF (KDIMU.LE.0) KER=KERR(2)
      IF (TRING) WRITE (LUNOUT,60) JKDIM,IPAR(JKDIM),KERR(3)
      IF (.NOT.TRING) WRITE (LUNOUT,100) JKDIM,IPAR(JKDIM),KER
      KER=KERR(1)
C
      IF (TEMIT) WRITE (LUNOUT,102) JEMIT,IPAR(JEMIT),KER
      IF (.NOT.TEMIT) WRITE (LUNOUT,104) JEMIT,IPAR(JEMIT),KER
C
      IF (NWORK.LE.0) KER=KERR(2)
      WRITE (LUNOUT,106) JWORK,IPAR(JWORK),KER
      KER=KERR(1)
C
      IF (NFLOAT.LE.0) KER=KERR(2)
      WRITE (LUNOUT,108) JFLOAT,IPAR(JFLOAT),KER
      KER=KERR(1)
C
      IF (TSTORE) WRITE (LUNOUT,110) JSTORE,IPAR(JSTORE),KER
      IF (.NOT.TSTORE) WRITE (LUNOUT,112) JSTORE,IPAR(JSTORE),KER
C
      WRITE (LUNOUT,114) JPRINT,IPAR(JPRINT),KER
      IF (TPRINT(1)) WRITE (LUNOUT,116)
      IF (TPRINT(2)) WRITE (LUNOUT,118)
      IF (TPRINT(3)) WRITE (LUNOUT,120)
      IF (TPRINT(4)) WRITE (LUNOUT,122)
      IF (TPRINT(5)) WRITE (LUNOUT,124)
      IF (TPRINT(6)) WRITE (LUNOUT,126)
      IF (TSTORE) TPRINT(1)=.TRUE.
C
      IF (.NOT.TRING) WRITE (LUNOUT,128) JUNATN,IPAR(JUNATN),KER
      IF (TRING) WRITE (LUNOUT,60) JUNATN,IPAR(JUNATN),KERR(3)
C
      WRITE (LUNOUT,130)
C
      IF (PWID.LE.0.) KER=KERR(2)
      IF (.NOT.(TFANC.OR.TFANF)) WRITE (LUNOUT,132) JWID,PAR(JWID),KER
      IF (TFANC.OR.TFANF) WRITE (LUNOUT,134) JWID,PAR(JWID),KER
      KER=KERR(1)
C
      IF (.NOT.TRING) WRITE (LUNOUT,136) JXIS,PAR(JXIS),KER
      IF (TRING) WRITE (LUNOUT,138) JXIS,PAR(JXIS),KERR(3)
C
      IF (TRING) WRITE (LUNOUT,138) JFAN,PAR(JFAN),KERR(3)
      IF (TRING) GO TO 36
      IF ((TFANC.OR.TFANF).AND.RFAN.LE.0.) KER=KERR(2)
      IF (TFANC.OR.TFANF) WRITE (LUNOUT,140) JFAN,PAR(JFAN),KEP
      IF (.NOT.(TFANC.OR.TFANF)) WRITE (LUNOUT,142) JFAN,PAR(JFAN),KERR(
     13)
      KER=KERR(1)
C
   36 IF (JERR.EQ.0) GO TO 38
      WRITE (LUNOUT,144) JERR
      CALL EMESG (22,NAMER(5),1)
   38 CONTINUE
C
C
      CALL MEMST (IDUM,-2)
      PI=4.*ATAN(1.)
      N2ANG=NANG
C
      IF (TRING) N2ANG=2*NANG
      CALL MEMST (LANG,N2ANG)
      CALL MEMST (LSINE,N2ANG)
      CALL MEMST (LCOSIN,N2ANG)
      IF (.NOT.TRING) GO TO 40
      CALL MEMST (LDATER,N2ANG)
      DANG=PI/FLOAT(NANG)
      ZANG=DANG
      IF (TSTORE) GO TO 52
      GO TO 42
C
   40 CALL MEMST (LOATER,2*KDIMU)
      IF (TSTORE) GO TO 50
      IF (IABS(MODANG).LE.1) GO TO 46
      IF (MODANG.LT.0) NPI=-NPI
      DANG=PI*FLOAT(NPI)/FLOAT(NANG)
      ZANG=0.
      IF (MODANG.LT.0) ZANG=ABS(PI*FLOAT(NPI))
      IF (IABS(MODANG).LE.3) ZANG=ZANG+.5*DANG
C
   42 DO 44 IANG=1,N2ANG
      ISUB=LSINE+IANG-1
      SINE(ISUB)=SIN(ZANG)
      ISUB=LCOSIN+IANG-1
      COSINE(ISUB)=COS(ZANG)
      ISUB=LANG+IANG-1
      ANG(ISUB)=ZANG
   44 ZANG=ZANG+DANG
      IF (TRING) GO TO 52
      GO TO 50
C
   46 TWOPI=8.*ATAN(1.)
      DTOR=1.
      IF (MODANG.EQ.0) DTOR=TWOPI/360.
      DO 48 IANG=1,NANG
      ANGR=AMOD(ANGL(IANG)*DTOR,TWOPI)
      IF (ANGR.LT.0.) ANGR=ANGR+TWOPI
      ISUB=LSINE+IANG-1
      SINE(ISUB)=SIN(ANGR)
      ISUB=LCOSIN+IANG-1
      COSINE(ISUB)=COS(ANGR)
      ISUB=LANG+IANG-1
   48 ANG(ISUB)=ANGR
C
   50 CALL STPTR
      NLEV=20
C
   52 CALL MEMST (MAXFW,-1)
      WRITE (LUNOUT,146) MAXFW
      CALL LGTXT (NAMER,9)
      RETURN
C
C
   54 FORMAT(1H1)
   56 FORMAT(  ////11X,31HINTEGER PARAMETER ARRAY  (IPAR)//
     12X,1HI,3X,7HIPAR(I),6X,11HDESCRIPTION/1X)
   58 FORMAT(1X,I2,I10,2X,A2,2X,
     1 44HLINEAR DIMENSION OF THE RECONSTRUCTION ARRAY)
   60 FORMAT(1X,I2,I10,2X,A2,2X,30HNOT APPLICABLE (RING GEOMETRY))
   62 FORMAT(1X,I2,I10,2X,A2,2X,
     1 31HRECONSTRUCT IN A CIRCULAR ARRAY)
   64 FORMAT(1X,I2,I10,2X,A2,2X,
     1 29HRECONSTRUCT IN A SQUARE ARRAY)
   66 FORMAT(1X,I2,I10,2X,A2,2X,
     1 13HGEOMETRY FLAG)
   68 FORMAT(19X,
     1 22HTHIS FLAG IS UNDEFINED)
   70 FORMAT(19X,
     1 22HPARALLEL BEAM GEOMETRY)
   72 FORMAT(19X,
     1 35HFAN BEAM GEOMETRY (CURVED DETECTOR))
   74 FORMAT(19X,
     1 33HFAN BEAM GEOMETRY (FLAT DETECTOR))
   76 FORMAT(19X,
     1 22HRING DETECTOR GEOMETRY)
   78 FORMAT(1X,I2,I10,2X,A2,2X,
     1 27HNUMBER OF PROJECTION ANGLES)
   60 FORMAT(19X,29H(EQUAL TO NUMBER OF CRYSTALS))
   82 FORMAT(1X,I2,I10,2X,A2,2X,
     1 54HMODE FOR PROJECTION ANGLE INPUT  (SEE FOLLOWING LINES))
   84 FORMAT(19X,
     1 36HANGLES GENERATED BETWEEN ZERO AND PI)
   86 FORMAT(19X,
     1 38HANGLES GENERATED BETWEEN ZERO AND 2*PI)
   88 FORMAT(19X,
     1 26HSTARTING AT THE HALF ANGLE)
   90 FORMAT(19X,
     1 16HSTARTING AT ZERO)
   92 FORMAT(19X,
     1 23HWITH THE ORDER REVERSED)
   94 FORMAT(19X,
     1 22HTHIS MODE IS UNDEFINED)
   56 FORMAT(19X,
     1 42HUSER SUPPLIED PROJECTION ANGLES IN DEGREES)
   98 FORMAT(19X,
     1 42HUSER SUPPLIED PROJECTION ANGLES IN RADIANS)
  100 FORMAT(1X,I2,I10,2X,A2,2X,
     1 34HNUMBER OF RAYS FOR EACH PROJECTION)
  102 FORMAT(1X,I2,I10,2X,A2,2X,
     1 13HEMISSION DATA)
  104 FORMAT(1X,I2,I10,2X,A2,2X,
     1 17HTRANSMISSION DATA)
  106 FORMAT(1X,I2,I10,2X,A2,2X,
     1 56HDIMENSION OF THE FLOATING POINT USERS BLANK COMMON BLOCK)
  108 FORMAT(1X,I2,I10,2X,A2,2X,
     1 45HNUMBER OF WORDS FOR A FLOATING POINT VARIABLE)
  110 FORMAT(1X,I2,I10,2X,A2,2X,
     1 47HTHIS IS A STORAGE SIZE TEST (NO RECONSTRUCTION))
  112 FORMAT(1X,I2,I10,2X,A2,2X,
     1 55HEXECUTE THE RECONSTRUCTION (NOT JUST STORAGE SIZE TEST))
  114 FORMAT(1X,I2,I10,2X,A2,2X,
     1 57HPRINT FLAGS (OPTIONS SELECTED ARE ON THE FOLLOWING LINES))
  116 FORMAT(19X,
     1 59HPRINT REQUIRED FLOATING POINT BLANK COMMON WHENEVER CHANGED)
  118 FORMAT(19X,
     1 39HPRINT PROJECTION DATA AND UNCERTAINTIES)
  120 FORMAT(19X,
     1 43HPRINT SETUP VALUES FROM IPAR AND PAR ARRAYS)
  122 FORMAT(19X,
     1 57HPRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER ROUTINES)
  124 FORMAT(19X,
     1 58HPRINT VALUES FOR THE LAGRANGE MULTIPLIERS AND THE GRADIENT/
     2 19X,
     3 58H  FOR THE FUNCTION OF LAGRANGE MULTIPLIERS FOR THE ENTROPY/
     4 19X,
     5 16H  RECONSTRUCTION)
  126 FORMAT(19X,
     1 56HPRINT POINTERS IN BLANK COMMON WHENEVER CHANGED  (DEBUG))
  128 FORMAT(1X,I2,I10,2X,A2,2X,
     1 47HLOGICAL UNIT NO. FOR ATTENUATION FACTOR STORAGE)
  130 FORMAT(////11X,37HFLOATING POINT PARAMETER ARRAY  (PAR)//
     12X,1HI,3X,7H PAR(I),6X,11HDESCRIPTION/1X)
  132 FORMAT(1X,I2,F10.3,2X,A2,2X,
     1 44HPIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH)
```

```
  134 FORMAT(1X,I2,F10.3,2X,A2,2X,
     1 57HPIXEL WIDTH IN UNITS OF PROJECTION BIN WIDTH AT CENTER OF
     2 /19X,8HROTATION)
  136 FORMAT(1X,I2,F10.3,2X,A2,2X,
     1 53HLOCATION OF THE ROTATION AXIS IN THE PROJECTION ARRAY)
  138 FORMAT(1X,I2,F10.3,2X,A2,2X,30HNOT APPLICABLE (RING GEOMETRY))
  140 FORMAT(1X,I2,F10.3,2X,A2,2X,
     1 58HDISTANCE FROM SOURCE TO CENTER OF ROTATION FOR FAN BEAM IN
     2 /19X,
     3 51HUNITS OF PROJECTION BIN WIDTH AT CENTER OF ROTATION)
  142 FORMAT(1X,I2,F10.3,2X,A2,2X,
     1 39HNOT APPLICABLE  (NOT FAN BEAM GEOMETRY))
  144 FORMAT(///1X,I6,43H ERRORS IN IPAR AND PAR ARRAYS   ...STOP...)
  146 FORMAT(//10X,38HMAXIMUM SIZE OF BLANK COMMON THUS FAR=,I7,
     122H FLOATING POINT WORDS.)
      END
```

SHLO

```
      SUBROUTINE SHLO (X,RA,M)
C
C     ****************************************************************
C     *      RECLBL     --        VERSION 1.0     --        17OCT77     *
C     ****************************************************************
C
C          SUBROUTINE SHLO GENERATES THE CONVOLUTION FUNCTION FOR
C       CONVOLUTION RECONSTRUCTION OF PARALLEL BEAM DATA.  THIS
C       FUNCTION IS TAKEN FROM THE ARTICLE BY SHEPP AND LOGAN, IEEE
C       TRANS. NUCL. SCI., VOL. NS-21, (3), (1974).
C
C        X        - ARRAY IN WHICH CONVOLUTION FUNCTION IS RETURNED
C        RA       - DUMMY ARGUEMENT
C        M        - IF M IS LESS THAN OR EQUAL TO ZERO THEN FLAGS ARE
C                     RETURNED IN THE ARRAY P.  OTHERWISE THE
C                     CONVOLUTION FUNCTION (LENGTH=2*M-1) IS RETURNED
C
C       LANGUAGE - FORTRAN
C
      DIMENSION X(1),RA(2)
      DIMENSION FLAGS(4)
      DATA FLAGS/2.,-1.,0.,0./
C
      IF (M.LE.0) GO TO 12
C
      KK=2*M-1
      PI=4.*ATAN(1.)
      DO 10 K=1,KK
   10 X(K)=-2./(PI*(4.*FLOAT(M-K)**2-1.))
      RETURN
C
   12 DO 14 I=1,4
   14 X(I)=FLAGS(I)
      RETURN
      END
```

SQINT

```
      FUNCTION SQINT (X,THETA)
C
C     ****************************************************************
C     *      RECLBL     --        VERSION 1.0     --        17OCT77     *
C     ****************************************************************
C
C
C          THE FUNCTION SQINT RETURNS THE AREA WITHIN A UNIT SQUARE
C       WHICH LIES BETWEEN TWO PARALLEL STRAIGHT LINES.  ONE OF THE
C       LINES PASSES THROUGH THE CENTER OF THE SQUARE, AND THE OTHER IS
C       A DISTANCE ABS(X) FROM THE FIRST.  THE LINES MAKE AN ANGLE
C       THETA WITH ONE OF THE BOUNDARIES OF THE SQUARE.
C
C        X        - THE DISTANT BETWEEN THE FIRST LINE OF THE RAY AND
C                     A LINE PARALLEL PASSING THROUGH THE CENTER OF THE
C                     SQUARE.
C        THETA    - THE ANGLE WHICH THE RAY INTERSECTS ONE OF THE SIDES
C                     OF THE SQUARE
C
C       LANGUAGE - FORTRAN
C
C
      DATA SAVE,A,B,EPS/0.,.5,.5,1.E-6/
C
      IF (ABS(THETA-SAVE).LT.EPS) GO TO 10
      SAVE=THETA
      AB=ABS(SIN(THETA))
      BA=SQRT(1.-AB**2)
      B=.5*(AB+BA)
      A=.5*ABS(AB-BA)
   10 XX=ABS(X)
      IF (XX.GE.B) GO TO 14
      IF (XX.GT.A) GO TO 12
C         TAKE IN NO CORNERS
      SQINT=XX/(B+A)
      RETURN
C         TAKE IN ONE CORNER
   12 SQINT=.5*(1.-(B-XX)**2/((B+A)*(B-A)))
      RETURN
C         TAKE IN BOTH CORNERS
   14 SQINT=.5
      RETURN
      END
```

SRCH

```
      SUBROUTINE SRCH (B,BMAP,ATENL,XLEVAL)
C
C     ****************************************************************
C     *      RECLBL     --        VERSION 1.0     --        17OCT77     *
C     ****************************************************************
C
C          THE SUBROUTINE SRCH DETERMINES THE SMALLEST CONVEX
C       BOUNDARY ENCLOSING ALL PIXELS OF B WHOSE VALUES ARE GREATER
C       THAN BMAX/XLEVAL, WHERE BMAX IS THE LARGEST PIXEL VALUE.
C       SRCH USES THE USERS ANGLES TO DETERMINE CONVEXITY.  ALL
C       PIXELS OF BMAP OUTSIDE THE BOUNDARY ARE SET TO ZERO AND
C       THOSE INSIDE ARE SET TO ATENL.
C
C        B        - THE RECONSTRUCTED ARRAY
C        BMAP     - A MATRIX WITH THE VALUE ATENL INSIDE THE OBJECT
C                     AND ZERO OUTSIDE THE OBJECT
C                 - BMAP(1) IS RETURNED -1 IF B HAS ZERO RANGE
C                 - BMAP(1) IS RETURNED -2 IF XLEVAL .LE. 1
C        ATENL    - THE CONSTANT ATTENUATION COEFFICIENT
C        XLEVAL   - TARGET-TO-NONTARGET RATIO
C
C       LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C        NWORK    - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                     COMMON
C        IWUSED   - THE NUMBER OF WORDS USED IN BLANK COMMON
C        NFLOAT   - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C        ISETUP   - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                     SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                     FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                     EXECUTING.
C        WORK     - BLANK COMMON WORKING ARRAY
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C        NDIMU    - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C        NDIM     - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C        PWID     - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C        TCIR     - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C        NMAT     - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C        LNI      - POINTER TO THE ARRAY NI IN BLANK COMMON
C                     NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                     THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C        KNI      - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                     IS AN INTEGER VARIABLE
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
C
C        IGEOM    - GEOMETRY FLAG
C               0 = PARALLEL BEAM GEOMETRY
C               1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C               2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C               3 = RING DETECTOR GEOMETRY
C        KDIMU    - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                     BY THE USER
C        AXISU    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                     PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                     AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                     IN THE CENTER OF A PROJECTION BIN.)
C        BWID     - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C        KMOV     - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                     ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                     ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C        KMIN     - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                     THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                     IS GOING TO BE USED.
C        KMAX     - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                     THE DATA OF THE LAST USER PROJECTION BIN THAT
C                     IS GOING TO BE USED.
C        KDIM     - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                     TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                     KDIM=KDIMU.
C        AXIS     - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                     PROJECTION ARRAY, USUALLY AXIS=AXISU.
C        LPROJ    - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                     INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                     VECTOR
C        NANG     - NUMBER OF PROJECTIONS
C        MODANG   - MODE FOR PROJECTION ANGLE INPUT
C        LANG     - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                     PROJECTION ANGLES IN RADIANS
C        LSINE    - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                     SINE OF THE PROJECTION ANGLES
C        LCOSIN   - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                     COSINE OF THE PROJECTION ANGLES
C        LDATER   - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                     USER PROJECTION DATA AND UNCERTAINTIES
C        TEMIT    - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                     FALSE FOR TRANSMISSION DATA
C
      DIMENSION B(1),BMAP(1)
C
      NSQ=NDIM**2
      ZN=.5*FLOAT(NDIM+1)
C
C        *FIND LARGEST ELEMENT OF B
C
      BMAX=0.
      DO 10 I=1,NSQ
   10 IF (B(I).GT.BMAX) BMAX=B(I)
      IF (BMAX.GT.0.) GO TO 12
      BMAP(1)=-1.
```

```
      RETURN
C
C         *SET THRESHOLD
C
   12 IF (XLEVAL.GT.1.) GO TO 14
      BMAP(1)=-2.
      RETURN
   14 THRESH=BMAX/XLEVAL
C
C         *SET ALL VALUES GREATER THAN THE THRESHOLD POSITIVE
C
      DO 20 I=1,NSQ
      IF (B(I)-THRESH) 16,16,18
   16 BMAP(I)=0.
      GO TO 20
   18 BMAP(I)=1.
   20 CONTINUE
C
C         *LOOP OVER ANGLES
C
      PI=4.*ATAN(1.)
      NNG=.5*PI*FLOAT(NDIM)
      DANG=PI/FLOAT(NNG)
      SS=SIN(DANG)
      CC=COS(DANG)
      S=0.
      C=1.
C
      DO 30 M=1,NNG
      T=S
      S=S*CC+C*SS
      C=C*CC-T*SS
C
C         *FIND THE LOWER AND UPPER PROJECTION BINS WHICH A PIXEL
C         *HIGHER THAN THE THRESHOLD PROJECTS INTO
C
      ZZ=ZN*(S-C)+AXIS+.5
      IJL=1
      KL=KDIM
      KU=1
      DO 24 J=1,NDIM
      ZZ=ZZ+C
      Z=ZZ
      IJU=IJL+NDIM-1
      DO 22 IJ=IJL,IJU
      Z=Z-S
      K=Z
      IF (BMAP(IJ).LE.0.) GO TO 22
      IF (K.LT.KL) KL=K
      IF (K.GT.KU) KU=K
   22 CONTINUE
   24 IJL=IJL+NDIM
C
C         *SET ALL PIXELS WHICH PROJECT OUTSIDE LOWER AND UPPER
C         *PROJECTION BINS NEGATIVE
C
      ZZ=ZN*(S-C)+AXIS+.5
      IJL=1
      DO 28 J=1,NDIM
      ZZ=ZZ+C
      Z=ZZ
      IJU=IJL+NDIM-1
      DO 26 IJ=IJL,IJU
      Z=Z-S
      K=Z
      IF (K.LT.KL) BMAP(IJ)=-1.
   26 IF (K.GT.KU) BMAP(IJ)=-1.
   28 IJL=IJL+NDIM
   30 CONTINUE
C
C         *SET ALL NON-NEGATIVE VALUES TO ATENL AND ALL NEGATIVE
C         *VALUES TO ZERO
C
      DO 36 I=1,NSQ
      IF (BMAP(I)) 32,34,34
   32 BMAP(I)=0.
      GO TO 36
   34 BMAP(I)=ATENL
   36 CONTINUE
C
      RETURN
      END
```

STATN

```
      SUBROUTINE STATN (M,A,N)
C
C     ****************************************************************
C     *       RECLBL    --         VERSION 1.0    --          17OCT77   *
C     ****************************************************************
C
C           THE SUBROUTINE STATN STORES THE ARRAY OF ATTENUATION
C        FACTORS A ON THE FILE LUNATN.
C
C          M        - ANGLE INDEX
C          A        - ARRAY OF ATTENUATION FACTORS
C          N        - NUMBER OF FACTORS FOR THE M-TH ANGLE
C
C        LANGUAGE - FORTRAN
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - EMESG
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                      COMMON
C          IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT  - NUMBER OF WORDS FOR A FLOATING POINT VARIABLE
C          ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                      SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                      FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                      EXECUTING.
C          WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/ATNCOM/LATEN,LBMAP,TATEN,LUNATN
      LOGICAL TATEN
      DIMENSION ATEN(1),BMAP(1)
      EQUIVALENCE (WORK(1),ATEN(1),BMAP(1))
C
C          LATEN   - POINTER TO THE ARRAY ATEN IN BLANK COMMON
C                      STORES ATTENUATION FACTORS FOR ONE ANGLE
C          LBMAP   - POINTER TO THE ARRAY BMAP IN BLANK COMMON
C                      A MATRIX USED TO STORE THE CONSTANT ATTENUATION
C                      COEFFICIENTS
C          TATEN   - LOGICAL VARIABLE SET TRUE FOR ATTENUATION
C                      RECONSTRUCTION
C          LUNATN  - LOGICAL UNIT NUMBER FOR ATTENUATION FACTOR STORAGE
C
      DIMENSION A(1)
      DIMENSION NAMER(5)
      DATA NAMER/1HS,1HT,1HA,1HT,1HN/
      DATA MEQ/-1/
C
      IF (M.NE.1) GO TO 10
      REWIND LUNATN
      GO TO 12
   10 IF (M.NE.MEQ+1) CALL EMESG (31,NAMER,2)
   12 MEQ=M
      WRITE (LUNATN) (A(K),K=1,N)
      RETURN
      END
```

STPTR

```
      SUBROUTINE STPTR
C
C     ****************************************************************
C     *       RECLBL    --         VERSION 1.0    --          17OCT77   *
C     ****************************************************************
C
C           THE SUBROUTINE STPTR SETS UP THE COMMON BLOCK /PTRCOM/
C        FOR A DISK SHAPED ARRAY.  NDIM IS THE DIMENSION OF THE SQUARE
C        ARRAY, NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF THE
C        CIRCULAR ARRAY, AND NMAT IS THE TOTAL NUMBER OF CELLS IN THE
C        CIRCULAR ARRAY.  THE STARTING I VALUE FOR THE J-TH ROW IS
C        GIVEN BY (1 + NDIM - NI(J)).
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINES - EMESG, MEMST
C
C        RECLBL ROUTINES WHICH MUST BE CALLED FIRST - SETUP
C
C        LANGUAGE - FORTRAN
C
C
      COMMON/WRKCOM/NWORK,IWUSED,NFLOAT,ISETUP
      COMMON WORK(1)
C
C          NWORK   - DIMENSION OF THE USER S COMMON BLOCK IN BLANK
C                      COMMON
C          IWUSED  - THE NUMBER OF WORDS USED IN BLANK COMMON
C          NFLOAT  - NUMBER OF WOPDS FOR A FLOATING POINT VARIABLE
C          ISETUP  - THE SUBROUTINE SETUP SETS ISETUP = 2HOK.
C                      SUBROUTINES WHICH REQUIRE THAT SETUP IS CALLED
C                      FIRST TEST TO SEE IF ISETUP = 2HOK BEFORE
C                      EXECUTING.
C          WORK    - BLANK COMMON WORKING ARRAY
C
      COMMON/FANCOM/RFAN,TFANC,TFANF
      LOGICAL TFANC,TFANF
C
C          RFAN    - FOR FAN BEAM GEOMETRY RFAN IS THE DISTANCE FROM
C                      THE SOURCE TO THE CENTER OF ROTATION.  RFAN
C                      IS MEASURED IN UNITS OF PROJECTION BIN WIDTHS AT
C                      THE CENTER OF ROTATION.
C          TFANC   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                      CURVED DETECTOR
C          TFANF   - LOGICAL VARIABLE SET TRUE FOR FAN BEAM WITH A
C                      FLAT DETECTOR
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT  - LOGICAL UNIT NUMBER FOR OUTPUT
C          I80132  - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                      OUTPUT ON LUNOUT
C                0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      COMMON/PRTCOM/TPRINT(8)
      LOGICAL TPRINT
C
C          TPRINT  - LOGICAL PRINT FLAGS
C                1 - PRINT REQUIRED FLOATING POINT BLANK COMMON
C                      WHENEVER CHANGED
C                2 - PRINT PROJECTION DATA AND UNCERTAINTIES
C                3 - PRINT SETUP VALUES FROM IPAR AND PAR ARRAYS
C                4 - PRINT FILTER FUNCTION FOR CONVOLUTION AND FILTER
C                      ROUTINES
C                5 - PRINT VALUES FOR THE LAGRANGE MULTIPILERS AND
C                      THE GRADIENT FOR THE FUNCTION OF LAGRANGE MULTI-
C                      PILERS FOR THE ENTROPY RECONSTRUCTION
C                6 - PRINT POINTERS IN BLANK COMMON WHENEVER CHANGED
C                      (DEBUG)
C
      COMMON/PTRCOM/NDIMU,NDIM,PWID,TCIR,NMAT,LNI,KNI
      LOGICAL TCIR
      DIMENSION NI(1)
      EQUIVALENCE(WORK(1),NI(1))
C
C          NDIMU   - THE LINEAR DIMENSION OF THE TRANSVERSE SECTION
C          NDIM    - THE CURRENT LINEAR DIMENSION USED BY THE PROGRAM
C          PWID    - PIXEL WIDTH (IN UNITS OF PROJECTION BIN WIDTH)
C          TCIR    - LOGICAL VARIABLE SET TRUE FOR CIRCULAR RECON.
C          NMAT    - THE NUMBER OF CELLS IN THE TRANSVERSE SECTION
C          LNI     - POINTER TO THE ARRAY NI IN BLANK COMMON
C                      NI(J) IS THE NUMBER OF CELLS IN THE J-TH ROW OF
C                      THE SQUARE OR CIRCULAR FORM OF THE ARRAY
C          KNI     - SPECIAL FLAG FOR MEMST CALLS NEEDED BECAUSE NI
C                      IS AN INTEGER VARIABLE
C
      COMMON/STRCOM/TSTORE
      LOGICAL TSTORE
C
C          TSTORE  - LOGICAL VARIABLE SET TRUE WHEN TESTING STORAGE SIZE
C                      SETS TPRINT(1) = .TRUE.
C
      COMMON/TRGCOM/IGEOM,KDIMU,AXISU,BWID,KMOV,KMIN,KMAX,KDIM,AXIS,
     1              LPROJ,NANG,MODANG,LANG,LSINE,LCOSIN,LDATER,TEMIT
      LOGICAL TEMIT
      DIMENSION PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1)
      EQUIVALENCE (WORK(1),PROJ(1),ANG(1),SINE(1),COSINE(1),DATER(1))
```

```
C
C         IGEOM   - GEOMETRY FLAG
C               0 = PARALLEL BEAM GEOMETRY
C               1 = FAN BEAM GEOMETRY  (CURVED DETECTOR)
C               2 = FAN BEAM GEOMETRY  (FLAT DETECTOR)
C               3 = RING DETECTOR GEOMETRY
C         KDIMU   - NUMBER OF BINS IN THE PROJECTION ARRAY SUPPLIED
C                     BY THE USER
C         AXISU   - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                     PROJECTION ARRAY (THIS IS SUPPLIED BY THE USER
C                     AND IF AXISU IS INTEGER, THEN ROTATION AXIS FALLS
C                     IN THE CENTER OF A PROJECTION BIN.)
C         BWID    - PROJECTION BIN WIDTH (IN UNITS OF PIXEL WIDTH)
C         KMOV    - THE DISTANCE BETWEEN THE AXIS FOR THE SYSTEM DATA
C                     ARRAY (AXIS) AND THE AXIS FOR THE USER DATA
C                     ARRAY (AXISU).  AXIS = AXISU+FLOAT(KMOV)
C         KMIN    - FIRST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                     THE DATA OF THE FIRST USER PROJECTION BIN THAT
C                     IS GOING TO BE USED.
C         KMAX    - LAST LOCATION IN SYSTEM DATA ARRAY THAT STORES
C                     THE DATA OF THE LAST USER PROJECTION BIN THAT
C                     IS GOING TO BE USED.
C         KDIM    - NUMBER OF BINS IN THE PROJECTION ARRAY SUFFICIENT
C                     TO RECONSTRUCT AN NDIM X NDIM ARRAY, USUALLY
C                     KDIM=KDIMU.
C         AXIS    - THE PROJECTED LOCATION OF THE ROTATION AXIS IN THE
C                     PROJECTION ARRAY, USUALLY AXIS=AXISU.
C         LPROJ   - POINTER TO THE ARRAY PROJ IN BLANK COMMON
C                     INTERMEDIATE PROJECTION AND PROJECTION ERROR
C                     VECTOR
C         NANG    - NUMBER OF PROJECTIONS
C         MODANG  - MODE FOR PROJECTION ANGLE INPUT
C         LANG    - POINTER TO THE ARRAY ANG IN BLANK COMMON
C                     PROJECTION ANGLES IN RADIANS
C         LSINE   - POINTER TO THE ARRAY SINE IN BLANK COMMON
C                     SINE OF THE PROJECTION ANGLES
C         LCOSIN  - POINTER TO THE ARRAY COSINE IN BLANK COMMON
C                     COSINE OF THE PROJECTION ANGLES
C         LDATER  - POINTER TO THE ARRAY DATER IN BLANK COMMON
C                     USER PROJECTION DATA AND UNCERTAINTIES
C         TEMIT   - LOGICAL VARIABLE SET TRUE FOR EMISSION DATA AND
C                     FALSE FOR TRANSMISSION DATA
C
      DIMENSION NAMER(5)
      DATA EPS/1.E-6/
      DATA NAMER/1HS,1HT,1HP,1HT,1HR/
C
      CALL MEMST (KNI,2*NDIM)
C
C        MAKE SURE THAT ROTATION AXIUS PROJECTS INTO PROJECTION ARRAY
C
      IF (AXISU.LT..5) GO TO 10
      IF (AXISU.GT.FLOAT(KDIMU)+.5) GO TO 10
      GO TO 12
   10 WRITE (LUNOUT,26) AXISU,KDIMU
      CALL EMESG (23,NAMER,3)
   12 CONTINUE
C
C        R IS THE DISTANCE FROM THE ROTATION AXIS TO THE CENTER OF THE
C          FURTHEST CELL
C
      R=SQRT(.5)*FLOAT(NDIM-1)
      IF (TCIR) R=.5*FLOAT(NDIM)
      R=PWID*R+EPS
      IF (.NOT.(TFANC.OR.TFANF)) GO TO 16
      RARC=FLOAT(NDIM)*PWID*SQRT(.5)
      IF (TCIR.AND.(TFANC.OR.TFANF)) RARC=FLOAT(NDIM)*PWID*.5
      IF (RARC.LE.RFAN) GO TO 14
      WRITE (LUNOUT,28) RFAN,RARC,NDIM
      CALL EMESG (24,NAMER,3)
   14 IF (TFANC) R=RFAN*ASIN(RARC/RFAN)+EPS
      IF (TFANF) R=RFAN*TAN(ASIN(RARC/RFAN))+EPS
   16 CONTINUE
C
C        KMIN AND KMAX ARE THE SMALLEST AND LARGEST BIN INDECIES THAT
C          THE CENTER OF ANY CELL CAN PROJECT INTO
C
      BMIN=AXISU+.5-R
      BMAX=AXISU+.5+R
C
C        BE SURE TO ROUND DOWN EVEN IF NEGATIVE
C
      KMIN=IFIX(BMIN+AINT(1.+ABS(BMIN)))-IFIX(1.+ABS(BMIN))
      KMAX=IFIX(BMAX+AINT(1.+ABS(BMAX)))-IFIX(1.+ABS(BMAX))
C
C        GO ONE FURTHER TO ACCOUNT FOR FINITE CELL SIZE
C
      KMIN=KMIN-1
      KMAX=KMAX+1
C
C        NEW KDIM AND AXIS
C
      KDIM=KMAX-KMIN+1
      KMOV=1-KMIN
      AXIS=AXISU+FLOAT(KMOV)
C
C        NU IS THE NUMBER OF ORIGINAL BINS USED
C
      IF (KMIN.LT.1) KMIN=1
      IF (KMAX.GT.KDIMU) KMAX=KDIMU
      NU=KMAX-KMIN+1
      IF (NU.GE.1) GO TO 18
      WRITE (LUNOUT,30)
      CALL EMESG (25,NAMER,3)
C
   18 WRITE (LUNOUT,32) NU,KMIN,KMAX,KDIMU
      NZ=MAX0(KMIN+KMOV-1,0)+MAX0(KDIM-KMAX-KMOV,0)
      WRITE (LUNOUT,34) KDIM,NZ
C
C        CHANGE KMIN AND KMAX TO REPRESENT THE MINIMUM AND MAXIMUM OF
C          SYSTEM ARRAY
C
      KMIN=KMOV+KMIN
      KMAX=KMOV+KMAX
C
      IF (.NOT.TCIR) GO TO 22
C
      ZN=.5*FLOAT(NDIM+1)
      RSQ=.25*FLOAT(NDIM)**2
      NMAT=0
      DO 20 J=1,NDIM
      Y2=(FLOAT(J)-ZN)**2
      X2=RSQ-Y2
      I=SQRT(X2)+ZN
      NIJ=2*I-NDIM
      IF (TSTORE) GO TO 20
      ISUB=LNI+J-1
      NI(ISUB)=NIJ
      ISUB=ISUB+NDIM
      NI(ISUB)=NMAT-(NDIM-NIJ)/2
   20 NMAT=NMAT+NIJ
      RETURN
C
   22 NMAT=NDIM**2
      IF (TSTORE) RETURN
      DO 24 J=1,NDIM
      ISUB=LNI+J-1
      NI(ISUB)=NDIM
      ISUB=ISUB+NDIM
   24 NI(ISUB)=(J-1)*NDIM
      RETURN
C
C
C
   26 FORMAT(  //1X,27HTHE ROTATION AXIS (AXISU = ,F8.2,
     142H) DOES NOT PROJECT INTO THE RECONSTRUCTION/
     227H ARRAY.  THE PROJECTION IS ,I5,11H BINS LONG.)
   28 FORMAT(  //33H THE FAN SOURCE AT A DISTANCE OF ,E10.3,
     136H IS INSIDE THE RECONSTRUCTION ARRAY./3X,
     276H THE DISTANCE FROM THE FAN SOURCE TO THE CENTER OF ROTATION MUS
     3T BE AT LEAST /3X,E10.3,
     453H IN ORDER TO RECONSTRUCT A SQUARE ARRAY OF DIMENSION ,I3)
   30 FORMAT(  //73H THE RECONSTRUCTION REGION DOES NOT PROJECT INTO ANY
     1 USER PROJECTION BINS)
   32 FORMAT(  //12H A TOTAL OF ,I3,2H (,I3,6H THRU ,I3,9H) OF THE ,I3,
     1 34H USER PROJECTION BINS WILL BE USED)
   34 FORMAT(  //1X,I3,39H PROJECTION BINS WILL BE USED OF WHICH ,I3,
     1 32H HAVE BEEN ZEROED BY THE PROGRAM)
      END
```

USER

```
      SUBROUTINE USER (ITER,X,FCN)
C
C     ****************************************************************
C     *       RECLBL     --          VERSION 1.0     --         17OCT77     *
C     ****************************************************************
C
C           THE SUBROUTINE USER GIVES THE USER THE OPPORTUNITY TO
C        INVESTIGATE THE PARTIAL RECONSTRUCTION BETWEEN ITERATIONS.
C        ITER IS THE ITERATION NUMBER JUST COMPLETED, X IS THE ARRAY OF
C        FITTED PARAMETERS AND FCN IS THE FUNCTIONAL VALUE OF THE
C        FUNCTION BEING OPTIMIZED.
C
C          ITER     - ITERATION NUMBER
C          X        - ARRAY OF FITTED PARAMETERS
C                       FOR CONGR AND GRADY - RECONSTRUCTION ARRAY
C                       FOR ENTPY - LAGRANGE MULTIPILERS
C          FCN      - VALUE OF FUNCTION BEING OPTIMIZED
C                       FOR CONGR AND GRADY - CHI-SQUARE
C                       FOR ENTPY - OBJECTIVE FUNCTION FOR THE DUAL
C                       PROGRAM (SEE SUBROUTINE DULFC)
C
C        LANGUAGE - FORTRAN
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT   - LOGICAL UNIT NUMBER FOR OUTPUT
C          I80132   - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                       OUTPUT ON LUNOUT
C                 0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
      DIMENSION X(1)
      IF (ITER.EQ.0) WRITE (LUNOUT,10)
      WRITE (LUNOUT,12) ITER,FCN
      RETURN
C
C
   10 FORMAT(/55H FOR CONGR AND GRADY FCN IS THE VALUE OF THE CHI-SQUARE
     1/51H FOR ENTPY FCN IS EVALUATED BY THE SUBROUTINE DULFC)
   12 FORMAT(5H ITER,I3,8H      FCN,E12.3)
      END
```

XYGRF

```
      SUBROUTINE XYGRF (B,N,NP,BMAX,BMIN,IXY,ICOR,IL,IU)
C
C     ****************************************************************
C     *       RECLBL     --          VERSION 1.0     --         17OCT77     *
C     ****************************************************************
C
C           THE SUBROUTINE XYGRF DISPLAYS NP PLOTS OF INTENSITIES FOR
C        CROSS-SECTIONS OF THE N X N ARRAY B.  TEN IS THE MAXIMUM
C        NUMBER OF PLOTS THAT CAN BE DISPLAYED AT ONE TIME.
C
C          B        - SQUARE ARRAY FROM WHICH PLOTS ARE GENERATED
C          N        - DIMENSION OF B IS N X N
C          NP       - NUMBER OF CROSS-SECTIONAL PLOTS
C          BMAX     - MAXIMUM VALUE FOR THE PLOT.  IF BMAX = 999999. THE
C                       MAXIMUM WILL BE DETERMINED.
C          BMIN     - MINIMUM VALUE FOR THE PLOT.  IF BMIN = 999999. THE
C                       MINIMUM WILL BE DETERMINED.
C          IXY      - EQUALS 0 IF THE CROSS-SECTION IS PARALLEL TO THE
C                       X-AXIS
C                     EQUALS 1 IF THE CROSS-SECTION IS PARALLEL TO THE
C                       Y-AXIS
C          ICOR     - ARRAY OF X OR Y INTERCEPTS WHICH DETERMINE THE
C                       LOCATION OF THE CROSS-SECTION
C          IL       - LOWER COORDINATE FOR THE PLOT
C          IU       - UPPER COORDINATE FOR THE PLOT
C
C        THIS SUBROUTINE CALLS RECLBL ROUTINE - EMESG
C
C        LANGUAGE - FORTRAN
C
      COMMON/OUTCOM/LUNOUT,I80132
C
C          LUNOUT   - LOGICAL UNIT NUMBER FOR OUTPUT
C          I80132   - FLAG INDICATING NUMBER OF CHARACTERS IN A LINE OF
C                       OUTPUT ON LUNOUT
C                 0 = 80 CHARACTERS  (132 CHARACTERS OTHERWISE)
C
```

```
      DIMENSION B(1),ICOR(1)
      DIMENSION LINE(120),ISYM(10)
      DIMENSION NAMER(5)
      LOGICAL T80,T132
      DATA NAMER/1HX,1HY,1HG,1HR,1HF/
      DATA LINE/120*1H /
      DATA ISYM/1H*,1H+,1H.,1H-,1HO,1H=,1HX,1H/,1HA,1HH/
      DATA IBLNK/1H /
C
      T80=I80132.EQ.0
      T132=I80132.NE.0
C
C
      IF (IXY.EQ.0.OR.IXY.EQ.1) GO TO 10
      WRITE (LUNOUT,34) IXY
      CALL EMESG (26,NAMER,1)
C
   10 NFUN=NP
      IF (NP.GT.10) WRITE (LUNOUT,36) NP
      IF (NP.GT.10) NFUN=10
C
      IF (T80) WRITE (LUNOUT,38)
      IF (T132) WRITE (LUNOUT,40)
      WRITE (LUNOUT,42)
C
      IF (IXY.EQ.1) ISUB=N*(IL-1)+ICOR(1)
      IF (IXY.EQ.0) ISUB=N*(ICOR(1)-1)+IL
      BMINN=B(ISUB)
      BMAXX=B(ISUB)
      DO 16 J=1,NFUN
      IF (IXY.EQ.1) ISUB1=N*(IL-1)+ICOR(J)
      IF (IXY.EQ.0) ISUB1=N*(ICOR(J)-1)+IL
      ISUB=ISUB1
      BMINJ=B(ISUB)
      DO 12 I=IL,IU
      IF (B(ISUB).LT.BMINJ) BMINJ=B(ISUB)
      IF (IXY.EQ.1) ISUB=ISUB+N
   12 IF (IXY.EQ.0) ISUB=ISUB+1
C
      ISUB=ISUB1
      BMAXJ=B(ISUB)
      DO 14 I=IL,IU
      IF (B(ISUB).GT.BMAXJ) BMAXJ=B(ISUB)
      IF (IXY.EQ.1) ISUB=ISUB+N
   14 IF (IXY.EQ.0) ISUB=ISUB+1
C
      IF (BMINJ.LT.BMINN) BMINN=BMINJ
      IF (BMAXJ.GT.BMAXX) BMAXX=BMAXJ
C
      IF (IXY.EQ.0) WRITE (LUNOUT,44) ISYM(J),BMINJ,BMAXJ,ICOR(J)
      IF (IXY.EQ.1) WRITE (LUNOUT,46) ISYM(J),BMINJ,BMAXJ,ICOR(J)
   16 CONTINUE
C
      IF (ABS(BMIN-999999.).LT..5) GO TO 18
      BMINN=BMIN
   18 IF (ABS(BMAX-999999.).LT..5) GO TO 20
      BMAXX=BMAX
   20 WRITE (LUNOUT,48) BMINN,BMAXX
C
      IF (BMAXX.GT.BMINN) GO TO 22
      WRITE (LUNOUT,50)
      RETURN
   22 WRITE (LUNOUT,52)
C
      DO 32 I=IL,IU
      DO 28 J=1,NFUN
      IF (IXY.EQ.1) ISUB=N*(N-I)+ICOR(J)
      IF (IXY.EQ.0) ISUB=N*(ICOR(J)-1)+I
      IF (T80) L=1.+(B(ISUB)-BMINN)/(BMAXX-BMINN)*72.
      IF (T132) L=1.+(B(ISUB)-BMINN)/(BMAXX-BMINN)*120.
      IF (L.LT.1) L=1
      IF (L.GT.120.AND.T132) L=120
      IF (L.GT.72.AND.T80) L=72
      LINE(L)=ISYM(J)
      IF (NFUN.NE.1) GO TO 26
      DO 24 K=1,L
      LINE(K)=ISYM(7)
   24 CONTINUE
   26 IF (T80) WRITE (LUNOUT,54) LINE
      IF (T132) WRITE (LUNOUT,56) LINE
      LINE(L)=IBLNK
   28 CONTINUE
      IF (NFUN.NE.1) GO TO 32
      DO 30 K=1,L
      LINE(K)=IBLNK
   30 CONTINUE
      IF (T80) WRITE (LUNOUT,58) I
      IF (T132) WRITE (LUNOUT,60) I
   32 CONTINUE
      IF (T132) WRITE (LUNOUT,62)
      IF (T80) WRITE (LUNOUT,38)
      RETURN
C
C
C
   34 FORMAT (7H IXY = ,I10,36H IS NOT SET PROPERLY.      ...STOP...)
   36 FORMAT(46H THE FIRST TEN PLOTS ARE DISPLAYED SINCE NP = ,I3,21H IS
     1 GREATER THAN TEN.)
   38 FORMAT(/)
   40 FORMAT(6H1*OVF*)
   42 FORMAT(//15H XYGRF PRINTOUT//7H SYMBOL,11X,7HMINIMUM,8X,7HMAXIMUM,
     112X,9HINTERCEPT)
   44 FORMAT(5X,A1,5X,2E15.3,5X,18HTHE Y-INTERCEPT = ,I3,1H.)
   46 FORMAT(5X,A1,5X,2E15.3,5X,18HTHE X-INTERCEPT = ,I3,1H.)
   48 FORMAT(11H PLOT RANGE,2E15.3//)
   50 FORMAT(5X,30HZERO RANGE  -  PLOT SUPPRESSED/)
   52 FORMAT(1X)
   54 FORMAT(1H+,6X,72A1)
   56 FORMAT(1H+,6X,120A1)
   58 FORMAT(1X,I3,2X,1HI,72X,1HI)
   60 FORMAT(1X,I3,2X,1HI,120X,1HI)
   62 FORMAT(6H1*OVN*)
      END
```

ZERO

```
      SUBROUTINE ZERO (X,N)
C
C     ******************************************************************
C     *       RECLBL     --       VERSION 1.0     --       17OCT77      *
C     ******************************************************************
C
C          THE SUBROUTINE ZERO SETS N ELEMENTS OF THE ARRAY X TO 0.0
C       STARTING AT X(1).
C
C         X        - ARRAY TO BE ZEROED
C         N        - NUMBER OF ELEMENTS TO ZERO
C
C       LANGUAGE - FORTRAN
C
      DIMENSION X(1)
C
      DO 10 I=1,N
   10 X(I)=0.0
C
      RETURN
      END
```

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