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Bevalac Extraction and External Beamline Optics

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Prepared for the U.S. Department of Energy under Contract No. DE-AC03-76SF00098

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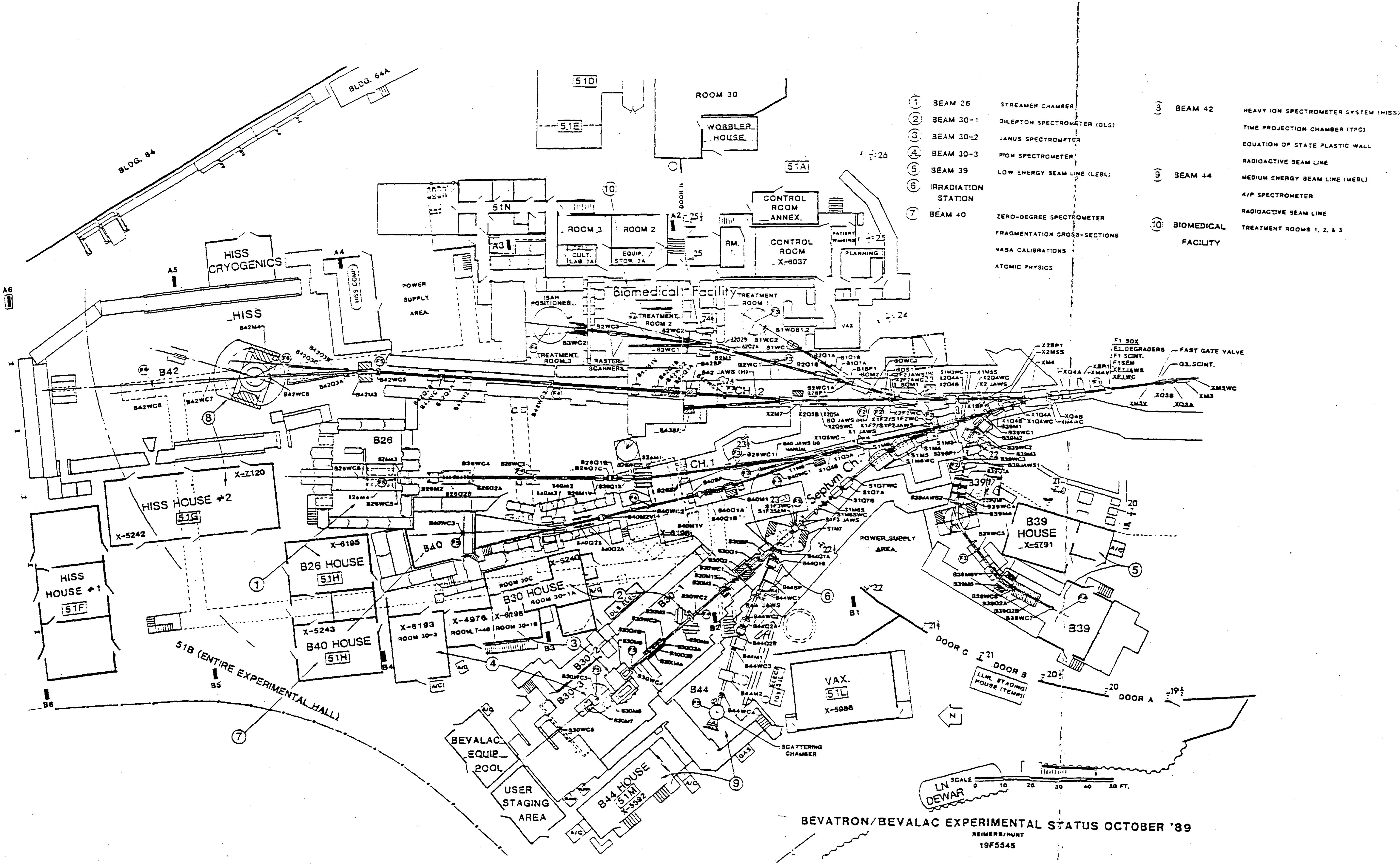
INTRODUCTION

This handbook is an update of the previous handbook Bevalac External Beamline Optics, LBL-23240. Some transport magnets have changed; most notably "XM4, XM5" were replaced by one magnet, called XM4.

A section on beamlines transverse acceptance has been added as well as a section for each beamline magnet that gives the average current vs. Bevalac field.

This handbook is intended as an aid for tuning the external particle beam (EPB) lines at the Lawrence Berkeley Laboratory's Bevalac. We hope the information obtained within will be useful to the Bevalac's Main Control Room and experimenters alike. First, some general information is given concerning the EPB lines and beam optics. Next, each beam line is described in detail: schematics of the beam line components are shown, all the variables required to run a beam transport program are presented, beam envelopes are given with wire chamber pictures and magnet currents, also the beam line focal points with magnifications and dispersion. The extraction system beam positions and magnet currents are then presented as a function of the Bevalac field. Finally, some tuning hints are suggested for multiple magnet bends.



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2.1 Some Bevalac Ions and Intensities

Bevalac Particle Inventory** September 1989					
Ion	Atomic Weight A	Atomic Number Z	Accelerator Charge	Maximum Energy MeV/amu	Intensity Particles/ Pulse @ F1
Hydrogen	1	1	1	4900	2×10^{9}
	2	1	1	2100	1×10^{9}
Deuteron	2	1	1	2100	$1 \times 10^{5*}$
Helium	3	2	2	3010	3×10^{8}
	4	2	2	2100	1×11^{10}
Boron	11	5	5	1840	1×10^{9}
Carbon	12	6	6	2100	5×10^{9}
Nitrogen	14	7	7	2100	$1 \times 10^{5*}$
Oxygen	16	8	8	2100	6×10^{9}
Fluorine	19	9	9	1950	1×10^{8}
Neon	20	12	10	2100	1×10^{10}
Magnesium	24	12	12	2100	$1 \times 10^{7*}$
Aluminum	27	13	13	2000	5×10^{8}
Silicon	28	14	14	2100	8×10^{8}
Argon	40	18	18	1815	1×10^{9}
Calcium	40	20	20	2100	4×10^{7}
	48	20	20	1640	1×10^{7}
Manganese	55	25	25	1840	$1 \times 10^{6*}$
Iron	56	26	24	1700	2×10^{8}
			16	1050	$5 \times 10^{7*}$
Nickel	58	28	26	1810	1×10^{6}
Krypton	84	36	33	1510	$1 \times 10^{7**}$
Niobium	93	41	35	1420	1×10^{8}
			23	770	8×10^{7}
Xenox	129	54	45	1280	5×10^{5}
	132	54	45	1240	1×10^{5}
	136	54	45	1180	3×10^{6}
Lanthanum	139	57	52	1410	1×10^{5}
			48	1260	4×10^{7}
			32	690	8×10^{7}
			29	587	6×10^{7}
Holmium	165	67	54	1170	2×10^{5}
Gold	197	97	61	1080	1×10^{5}
			37	490	1×10^{7}
			35	450	5×10^{6}
			11	50	1×10^{5}
Uranium	238	92	68	960	1×10^{6}
			40	410	1×10^{7}

* Low intensities are at experimenters' requests; no maximization has been done.
** (Reference 1)

2.2 Beam Line Rigidity Limits

The Bevalac has a rigidity limit of 192 kG-m. Depending on the magnet, current and angular bend, each beam line has an upper limit in rigidity which it can transport. The rigidity is given by:

$$R = \frac{R_o \gamma\beta}{(Q/A)} = p/q = \rho_{eff} B_{ev}$$

where $R_o = 31.07155$ kG-m $\equiv m_o c/e$

$$\gamma\beta = [\eta\ (2+\eta)]^{1/2}$$

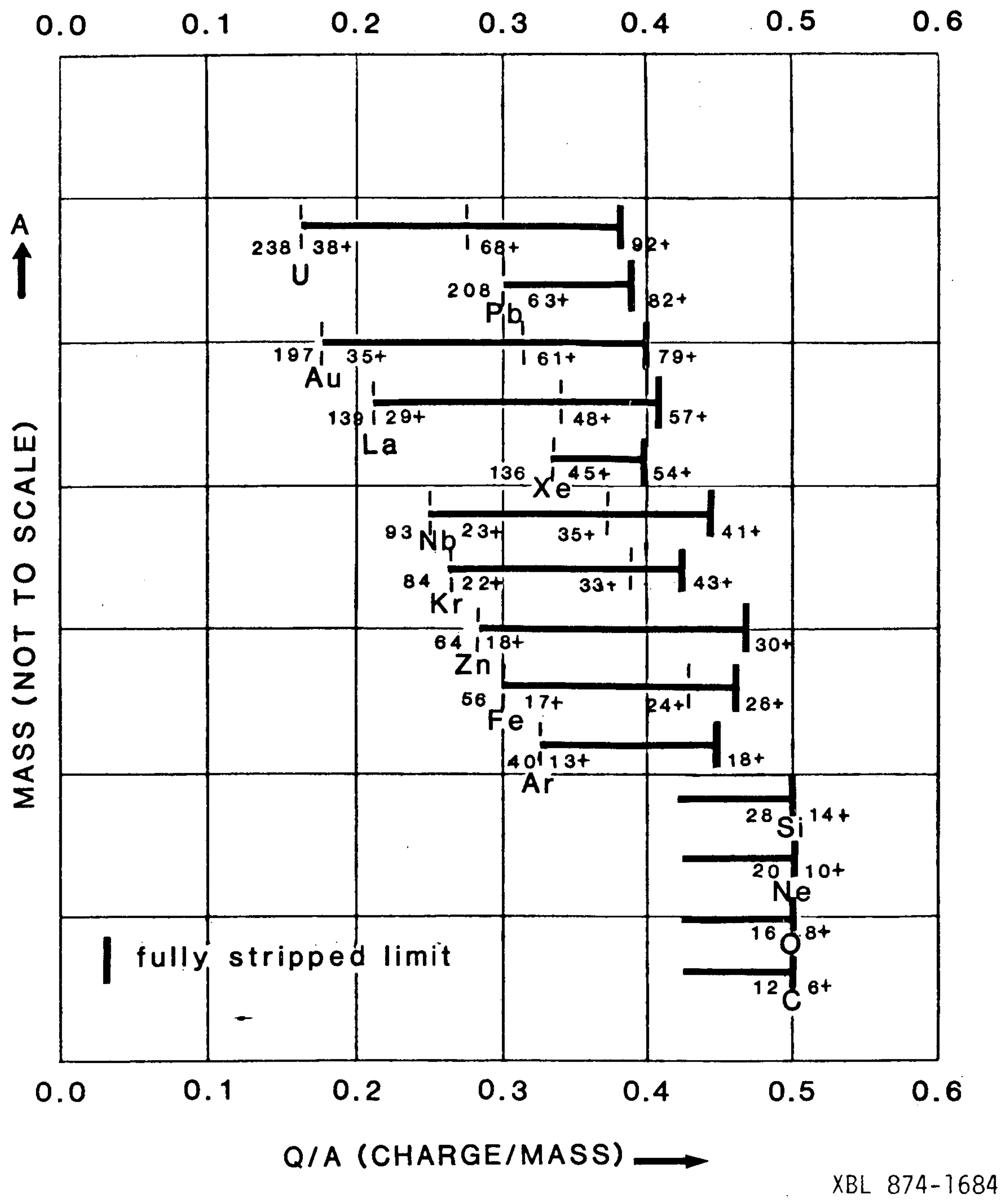
$$\eta = \frac{(T/A)}{W_o}$$

and

W_o	=	931.5016 MeV/amu $\equiv m_o c^2$
q	=	charge state of the ion $\equiv Qe$
m	=	atomic mass $\equiv Am_o$
T	=	kinetic energy
p	=	momentum = mc $\gamma\beta$
B_{ev}	=	Bevatron field (1500 to 12575G)
ρ_{eff}	=	The effective extraction radius (nominal is 600" = 15.24 m)

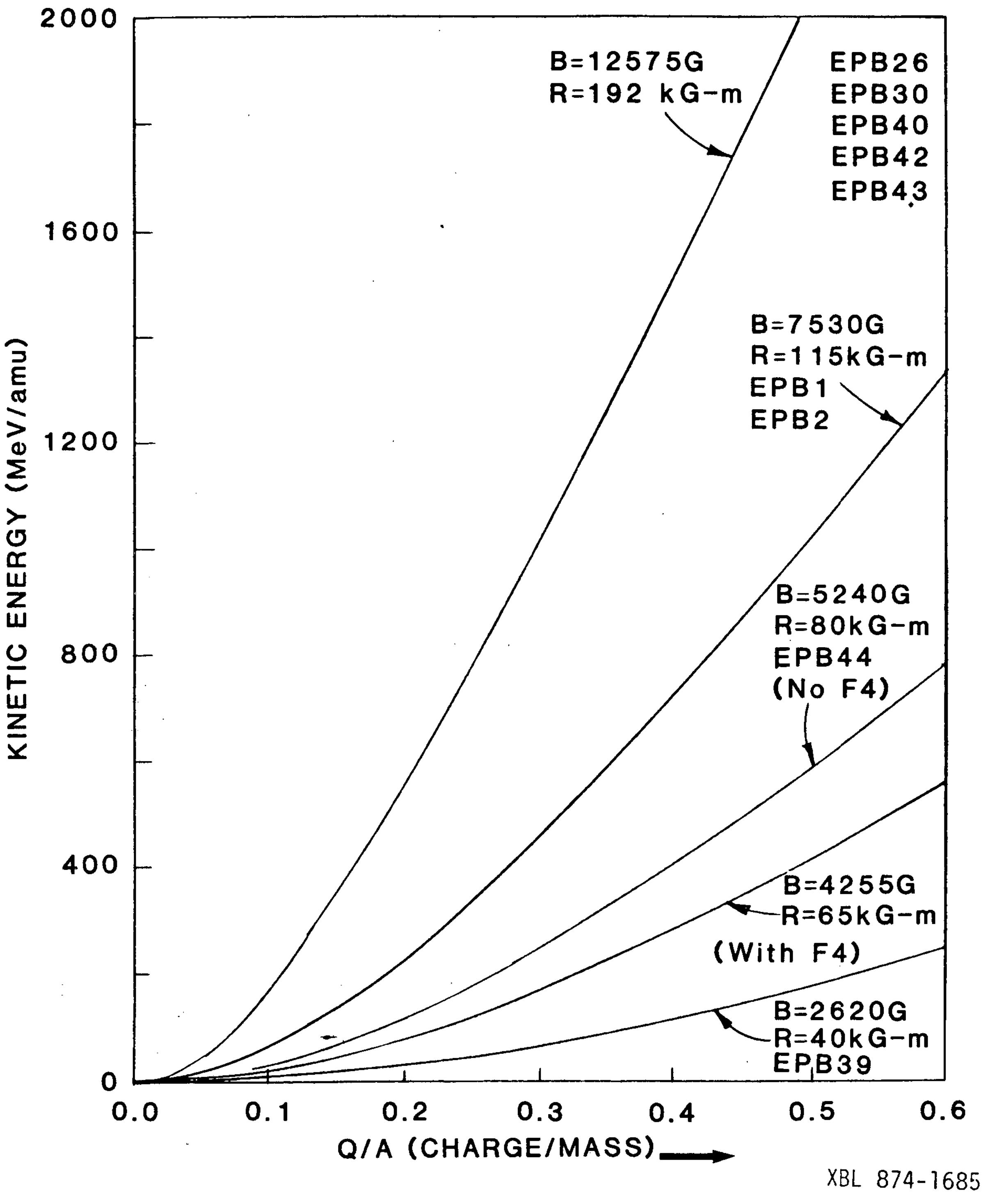
The importance of the beam rigidity is that for a given beam tune the magnet field strengths (and currents) scale linearly with rigidity (where there is no magnet saturation). The figures on the following two pages allow one to determine the maximum energy for a given charge/mass ratio that a particular beam line can deliver.

For an ion of mass A, Fig. 1A shows the charge/mass (Q/A) ratio for the various charge states that are typically run at the Bevatron. Then the maximum kinetic energy/amu that can be transported in a particular beam line is given in Fig. 1B for that particular (Q/A) (e.g. ^{136}Xe in the +45 charge state must have a kinetic energy below 295 MeV/amu to be transported down Beam Line 44, which has a rigidity limit of 80 kG-m). Note that Beam Line 44 has a rigidity limit of 65 kG-m when the beam is tuned to a focal point F4 at wire chamber B44WC1. A table of rigidities (2.2.1) is included for ions of different energies (the last column is for Q/A = 0.5).



SOME HEAVY IONS ACCELERATED AT THE BEVALAC AND THEIR Q/A

Fig.1A



KINETIC ENERGY VS Q/A FOR CONSTANT RIGIDITY

Fig. 1B

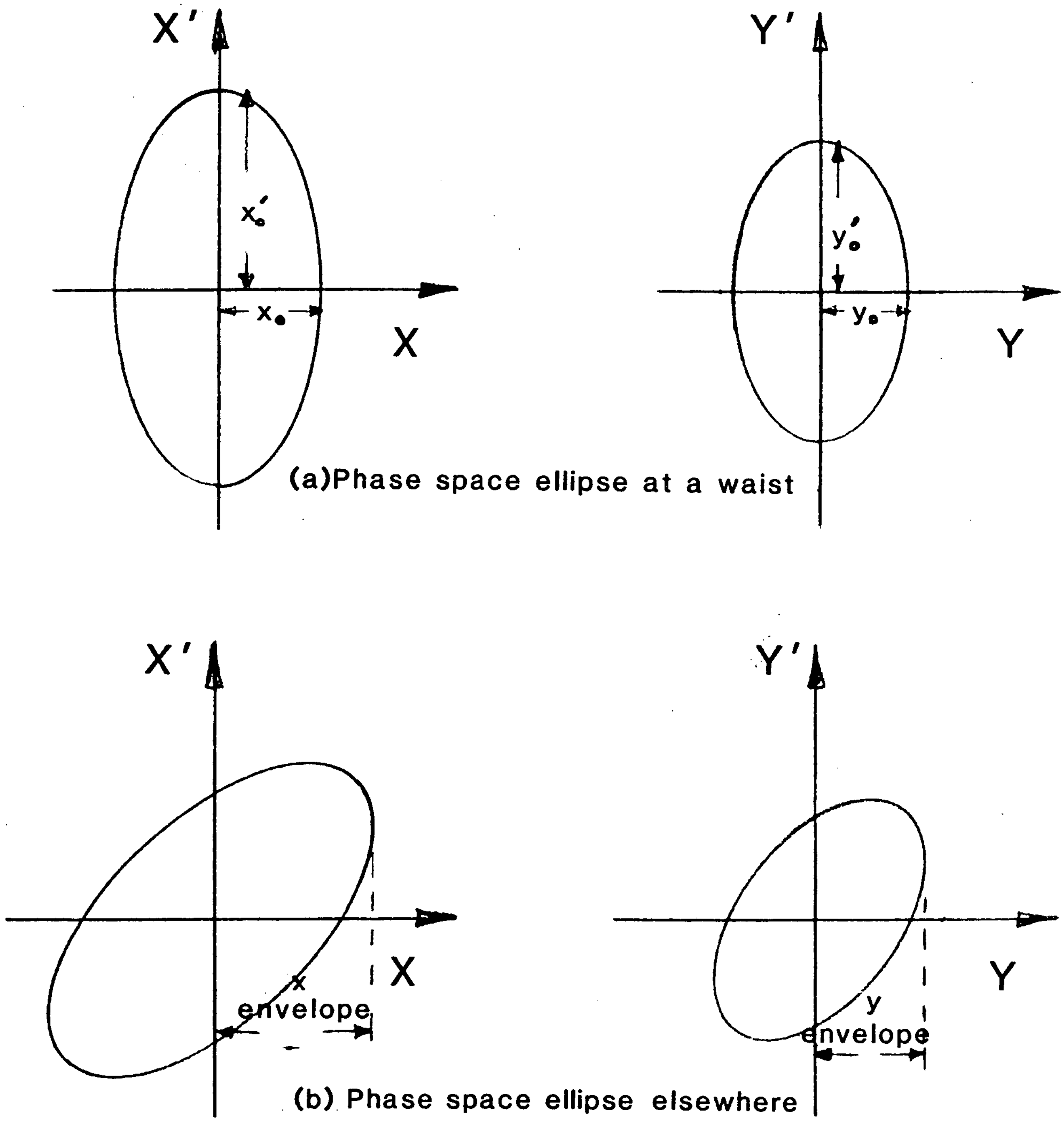
Table 2.2.1			
Rigidity for Ions with Charge/Mass of 0.5			
T/A (MeV/amu)	$\gamma\beta$	**R/(Q/A) (kG-m)**	**Q/A = 0.5 R (kG-m)**
10	0.146921	4.56506	9.13013
20	0.208332	6.47320	12.94640
30	0.255830	7.94905	15.89810
40	0.296187	9.20299	18.40598
50	0.332016	10.31625	20.63250
60	0.364655	11.33039	22.66078
70	0.394895	12.27000	24.54000
100	0.475638	14.77882	29.55764
150	0.589908	18.32935	36.65870
200	0.689575	21.42615	42.85230
250	0.780255	24.24372	48.48744
300	0.864780	26.87005	53.74010
400	1.021384	31.73597	63.47194
500	1.166900	36.25738	72.51476
600	1.305042	40.54967	81.09934
800	1.566921	48.68667	97.37334
1000	1.816466	56.44041	112.88082
1200	2.058168	63.95045	127.90090
1400	2.294506	71.29385	142.58770
1600	2.526986	78.51737	157.03474
1800	2.756584	85.65135	171.30270
2000	2.983966	92.71646	185.43292
2100	3.096979	96.22793	192.45586

2.3 Optics, beam envelope definitions.

A charged particle moving down a beam line may be represented by a six dimensional vector (x, x', y, y', z, Δp/p). The components of the vector are the horizontal and vertical displacement (x and y) from the central trajectory (optic axis), the horizontal and vertical divergence (x' and y'), the difference in length (z) between the longitudinal position of the particle and that of one at the central momentum, and the fractional momentum deviation (Δp/p) from the central momentum. The divergence x' is defined as the ratio of transverse to longitudinal velocities. That is:

$$x' = \frac{dx}{dz} = \frac{v_x}{v_z}$$

with a similar definition for vertical divergence. The particles in a given beam will form some distribution in the horizontal (x, x') phase space. For most beams a plot of the equidensity contour in the x - x' plane can be approximated by an ellipse as shown in Fig. 2. Most optics programs (matrix type) use the K-V distribution, for which the beam particle distribution is a uniform density ellipse in any of the phase space planes (x, x'), (y, y') and (z, Δp/p). The area of the ellipse (at waist Fig. 2(a)) is given by $E_x = \pi x_0 x_0'$ and is called the horizontal emittance: the vertical emittance is just $E_y = \pi y_0 y_0'$. To completely specify the emittance we also have to give the percentage of the beam that lies inside the ellipse boundary. A single particle can be traced through the transport system by matrix multiplication, and an extension of the matrix algebra provides a means for defining and tracking a beam of particles through a series of magnets and drift spaces. Computer programs such as TRANSPORT or LATTICE represent the beam of particles as lying on the surface of an ellipsoid in the six dimensional phase space coordinate system. The input to such

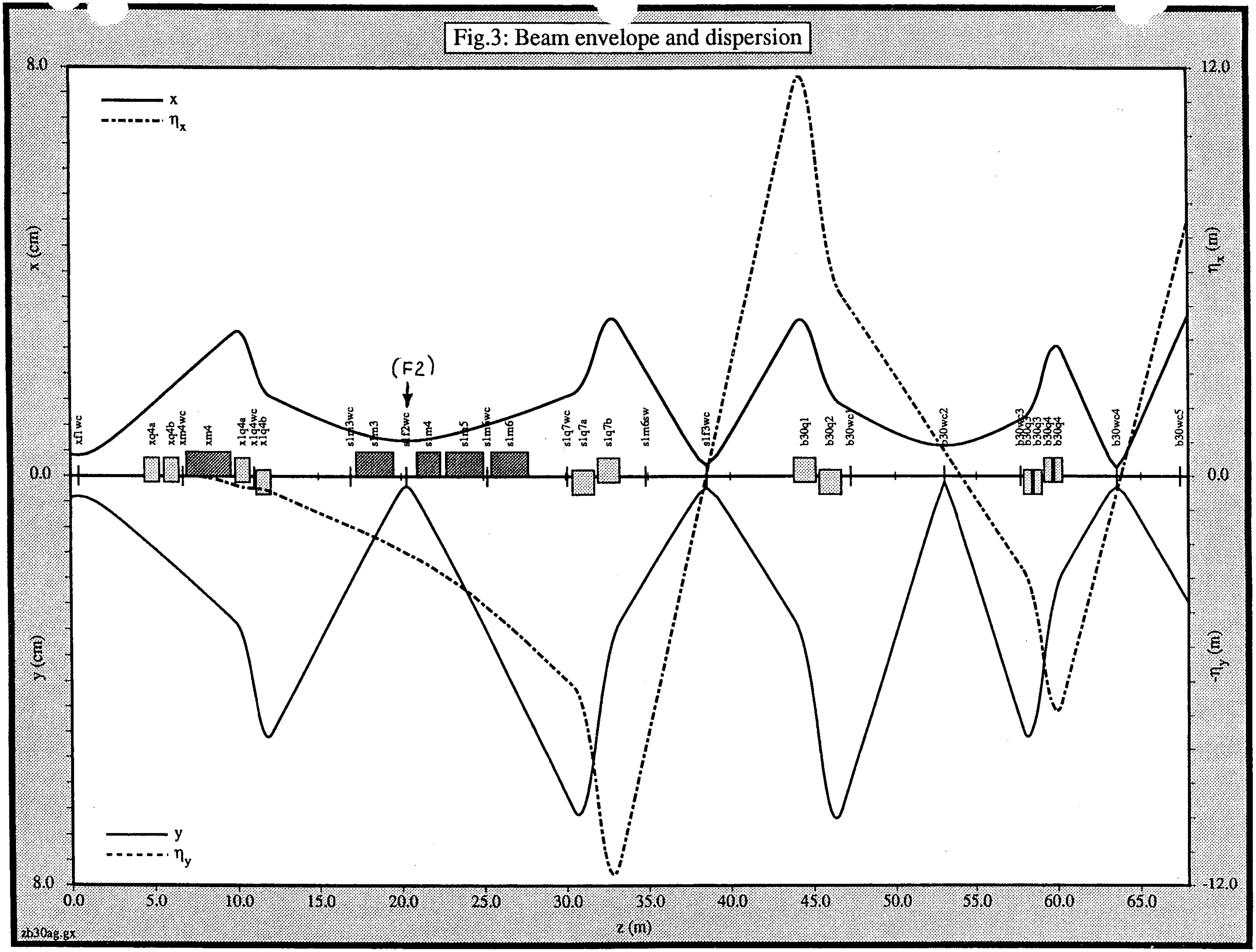


XBL 874-1686

Fig. 2

The phase space ellipse (divergence horizontally or vertically vs beam width horizontally or vertically)

Fig.3: Beam envelope and dispersion



programs is the initial values of the beam in the six coordinates of the ellipsoid (x_0, x_0', y_0 y_0', z_0, $\Delta p/p$) and their correlations (waist positions) when emerging from the accelerator, together with the beam line magnet positions and field strengths. In Table 2.3.1 we list the maximum transportable single particle angular divergencies (x_0', y_0') and momentum spread ($\Delta p/p$) specified at the initial F1 focal point, for the Bevalac beam lines.

Table 2.3.1			
Bevalac Beam Line Acceptances			
	Angular Divergence at F1		**Momentum Spread at F1**
Beam Line	**Horizontal $\pm X'_0$**	**Vertical $\pm Y'_0$**	**$\pm \Delta p/p$**
26	9.2 mr	4.7 mr	0.80%
30	9.2	3.4	0.81
39	6.5	5.0	0.59
40	9.2	5.0	1.41
42	3.9	5.0	5.90
44 (I)	9.2	3.4	0.81
44 (II)	9.4	15.0	0.78
Biomed I	3.9	5.0	4.22
Biomed II	3.9	5.0	0.87
Biomed III	10.4	7.3	1.00

Typically, the output from such computer programs is a tracing down the beam line of the extreme trajectories (both horizontally and vertically) of a group of particles. The emittance we will use, will be one which contains an estimated 98% of the beam within the extreme trajectories, called the beam envelopes. On wire chamber pictures, where the beam profile is approximately Gaussian, the beam envelope's horizontal half-width is then x(envelope) $\simeq 2.355\, x_{rms} \simeq$ FWHM with the same relation for the vertical envelope. The horizontal and vertical beam envelopes (for $\Delta p/p=0$) are shown as solid lines in Fig. 3 above and below the optic axis (center line), respectively. At the F1 focal point, the beam was taken to have a size $x_0 = y_0 = 0.4$ cm and an emittance $E_x = E_y = 1.2\,\pi$ cm - mr, which is typical for beams extracted from the Bevatron. The distance down the beam line (or optic axis) is given in meters, the half-widths of the horizontal and vertical envelopes are given in cm. Obstructions for a given beam line are generally not shown. The magnet names for a given beam line are listed along the center line. Quadrupoles that are shown projecting above the center line are horizontally focusing, while those projecting below are vertically focusing. Note the following aspects of the envelope pictures.

A. At the first focal point, F1, outside of the accelerator, the beam is assumed to have a certain horizontal and vertical size and divergence which will determine the initial emittance. The emittance of a beam of particles emerging from the Bevalac varies mainly according to energy; low energy beams can have emittances as high as $3.0\,\pi$ cm-mr while high energy beams can have emittances as low as $0.5\,\pi$ cm-mr. (This is a consequence of adiabatic damping in the Bevalac). As the group of particles travels down the beam line the emittance ellipse changes shape, but the area remains constant (if there are no obstructions). This is a statement of Liouville's Theorem.

B. The dispersion η_x for a given beam line tune gives the horizontal displacement d_x of a particle, with a rigidity (R + ΔR) differing from the central rigidity R (optics nomenclature often equates $\Delta R/R \equiv \Delta p/p$). The displacement is proportional to ΔR/R, that is $d_x = \eta_x \Delta R/R$ where η_x is a function of the longitudinal position along the beam line. In the beam envelope pictures the dispersion is given in meters, by the dotted line.

Dispersion is produced when a group of particles is bent by a dipole magnet. Particles of low rigidity are bent more than particles with higher rigidity. Once off-axis, the dispersion vector will be focused or defocused by the subsequent quadrupole and dipole magnets. From the equation for beam rigidity given in Sec. 2.2, we see that a beam can have different rigidity components due to beam energy spread (ΔT), different isotopes (ΔA) or different charge states (ΔQ). The dispersion has two primary effects on beam optics:

(i) An energy spread in the beam produces an increase in beam size at a place where the dispersion is large. For example, at a focal point such as F2 in Fig. 3, and with Guassian distributions in both coordinate and momentum space, the horizontal half-width becomes:

$$x = \sqrt{x^2\ (envelope) + d_x^2}$$

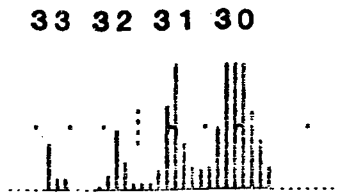
Where x(envelope) is the monoenergetic ($\Delta p/p = 0$) half-width of the beam particles. The momentum spread of the beam at the exit of the Bevalac is expected to be $\Delta p/p \leq 0.1\%$, with no material in the beam.

Usually, beam line optics are designed to give zero dispersion at the target focal point. A beam line of this design is called momentum recombining. This is a desirable quality for experiments whose results may be biased by a dependency on target interaction point with momentum. Beams of this type also have a minimum variation in beam size with respect to beam energy changes. Those positions along the beam line where the dispersion is non-zero will show greater beam movement. For maximum beam stability at the target, it is important to have beam optics such that:

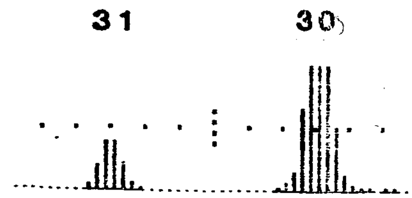
(a) The beam is centered going through all the beam line quadrupoles, so there is no quadrupole steering.

(b) The dispersion $\eta_x \approx 0$ at the target focus (i.e. an achromatic tune), with minimal slope ($\Delta\eta_x/\Delta Z \approx 0$, such as in B42)

(ii) A second effect of dispersion is to separate beams of different charge state or isotopic mass. As an example, 50 MeV/amu ^{139}La in the +30 charge state traveling through a poor vacuum (8×10^{-5} Torr) in the F1 area produced, by electron loss, the charge state distributions shown below at the S1M3 wire chamber and the F2 wire chamber. At the S1M3 wire chamber the dispersion is 1.5 cm for each % change in rigidity. At the F2 wire chamber the dispersion is 2.3 cm/% and some of the charge states have been bent out of the detection area of the wire chamber.

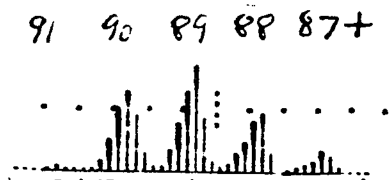


S1M3 Wire Chamber



S1F2 Wire Chamber

Another example is shown below. The charge state distribution on wire chamber S1F2 is that of a 450 MeV/amu U (+68) beam stripped with 2 mil Aluminum at F1 (wires have a 3 mm spacing).



S1F2 WIRE ChambeR

With the use of collimators, at a focal point with a large dispersion, we can select the desired charge state or isotopic mass to be transmitted. The Bevalac beam lines contain a number of collimators. A list is given in Sec. 2.7. Collimators placed near a focal point (waist) are effective in reducing the beam spot size at the subsequent focal points. Collimators located near quadrupoles do not change the spot size, but reduce the beam divergence at the subsequent focal points.

2.4 Explanation of the Contents of Each Beam Line Section.

A. Beam Line Schematic (See Sec. 3.1.1 etc.)

This is a schematic drawing showing all the active elements in each beam line.

B. Magnet Parameter Lists (See Sec. 3.1.2 etc.)

(a) The magnet parameter lists give the optic elements for input into a beam transport computer program. The names of the magnets are given in column one. Included also are wire chambers and other devices of interest, such as scatter chambers, etc. Starting at the first focal point (F1) of the Bevalac in the external particle beam region (wire chamber XF1WC), the effective magnet lengths and drift spaces are listed in column two. In columns three and four the quadrupole maximum magnetic field gradients and pole tip radii are given respectively. The following five columns give information about the dipoles in a given beam line. First the maximum magnetic field of the dipole magnet is given, followed by the dipole's bend radius, bend angle and finally edge angles. The edge angles are the angles that the pole tips make with respect to the incoming and outgoing beam, the sign convention can be obtained by examining the Bevalac map and the magnet list. Finally, the magnet type is given. The dipole dimensions in inches are listed in the order of gap height, horizontal aperture width and pole tip length. Some of the magnet parameters may be found in the Bevalac Users' Handbook. For wire chambers, we give the wire spacing and type. Additional information on wire chambers may also be found in the Bevalac Users' Handbook.

(b) The next table gives the magnet strengths (column 5), in LATTICE format [8], for a 19.2 Tesla-m rigid beam and the optics shown in the envelope plots (Sec. 3.1.3 etc.). For bend magnets the magnetic field (b) is in Tesla, while for quadrupoles the magnetic field gradient (b') is in Tesla/m.

C. Beam Envelope (See Sec. 3.1.3 etc.)

This is a described in Section 2.3.

D. Transverse Acceptance (See Sec. 3.1.4 etc.)

We show the horizontal (x - x') and vertical (y - y') acceptance polygons at the first focal point F1 out of the Bevalac. Any beam particle whose transverse phase space coordinates lie inside the acceptance polygon will be transported to the end of the beam line. The beam emittance used for the envelope calculation is shown by the ellipse (inside the polygon).

E. Focal Points (See Sec. 3.1.5 etc.)

This table gives the standard locations of the focal points (if used) in the beam line, together with the beam size magnification and dispersion.

F. Wire Chamber Pictures (See Sec. 3.1.6 etc.)

The name of each wire chamber along a given beam line is located on the right of the wire chamber pictures. After the name the voltage applied to that chamber is listed. Higher voltages are required when the particle flux is low. (The 6mm wire chambers are more sensitive for detection of low particle fluxes). On the next line the auto-ranging information is given. A0 with a black background auto-ranges the amplitude of the wire chamber distributions the most, while A7 changes the amplitude the least. Following the raging information, the wire spacing distance is given. The horizontal display of each wire chamber is shown on the left followed by the vertical display on the right. Given next to each wire chamber beam profile are the mean and the full-width at half-maximum (FWHM) for the distribution in units of wire number. In most cases beam center is physically located between wires 16 and 17. The four vertical dots indicate the central position. Looking downstream, if the horizontal and vertical wire chamber distributions are to the left of center then the beam is to the left and above the surveyed central (or optic) axis of the beam line. It is important to realize that the mean and standard deviation derived from the distribution on the wire chamber is often distorted and in error due to noise on the chamber. The distribution can also be intensity dependent.

G. <u>Current Values of the Magnet</u> <u>(See Sec. 3.1.6 etc.)</u>

The magnet current values associated with the wire chamber pictures are given on the following page. The name of each magnet for a given beam line is listed on the left side of the page. The current in Amperes for each magnet is then given in the column with the heading AM. The two exceptions are XM4 and B0M1 for which the bend field in Gauss is listed.

Also listed on the current value page are the ion species, the main Bevalac field, the beam radius (FT RAD), the position of the extraction magnets (MICE) and information about the type of 'spill' used.

H. <u>Optic Axis and Magnet Currents</u> (See Sec. 3.1.7 etc.)

(a) This table gives the standard wire chamber beam positions defining the optic axis, together with the active magnets used in tuning.

(b) This table gives the magnet currents (averaged over previous tunes) per Bevalac field for the standard tune.

2.5 Emittance at F1

Using known distances between wire chambers and the beam sizes at these wire chambers, one can estimate the emittance at F1, the first external focal point of the Bevalac. The distances between the initial wire chambers are:

XF1 wire chamber to XM4 wire chamber: 6.251 meters

XF1 wire chamber to X1Q4 wire chamber: 10.569 meters

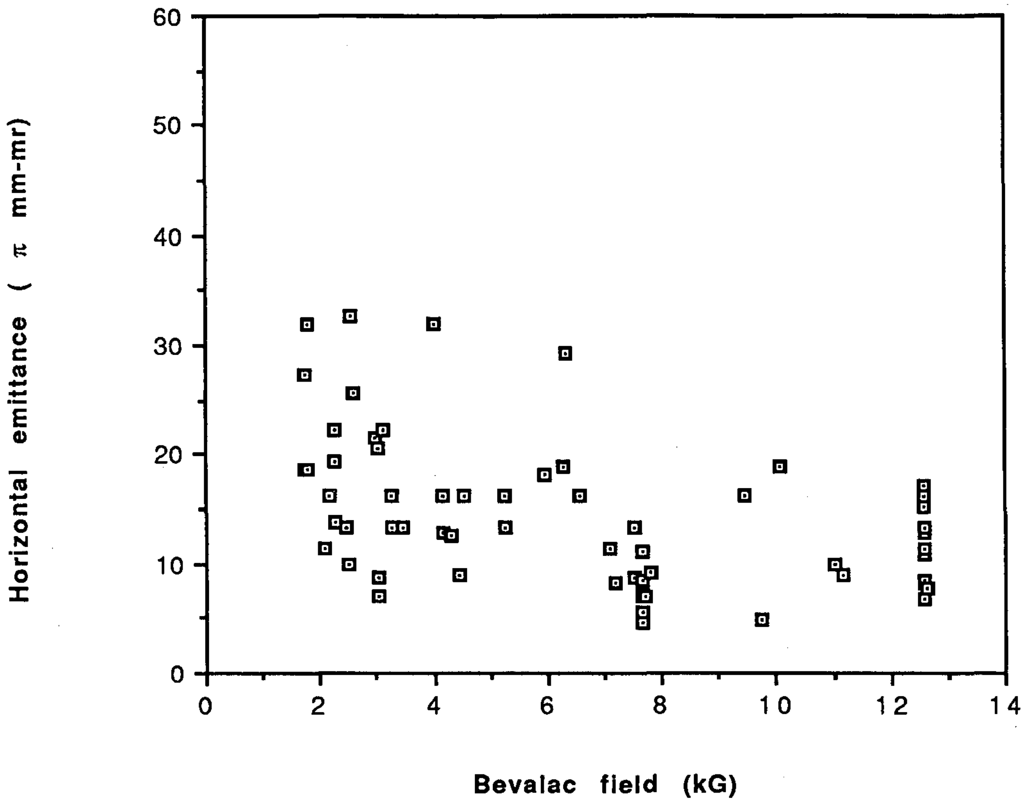
XF1 wire chamber to X2Q4 wire chamber: 14.439 meters

If the beam is tuned to a focal point (waist) at the F1 wire chamber (called XF1WC), then any of the downstream wire chambers may be used to determine the beam's divergence. If r_0 is the full-width at half-maximum beam waist size at the F1 wire chamber, L is the distance to the downstream wire chamber where the beam size is r, then the divergence is

$$r_0' \simeq \frac{\sqrt{r^2 - r_0^2}}{L}$$

The beam emittance (unnormalized) is then given by $E_r = \pi r_0 r_0'$, and the beta-function at F1 by $\beta_r = r_0 / r_0'$.

If we plot the horizontal and vertical emittances as a function of increasing Bevalac field (Fig. 4), we see that they decrease due to adiabatic damping. This is observed as a decrease in beam size at F1 (Fig. 5), the beam divergences remaining about the same (Fig. 6). The scatter in the data is due, not only to the uncertainty in the measurements (typically ± 25%) but also the type of beam particle (protons to Uranium) and the extraction parameters. Another significant parameter for the external beam line optics is the beta-function at F1, which like the emittance, also exhibits a decrease with increasing Bevalac field (Fig. 7) in both the horizontal and vertical planes.



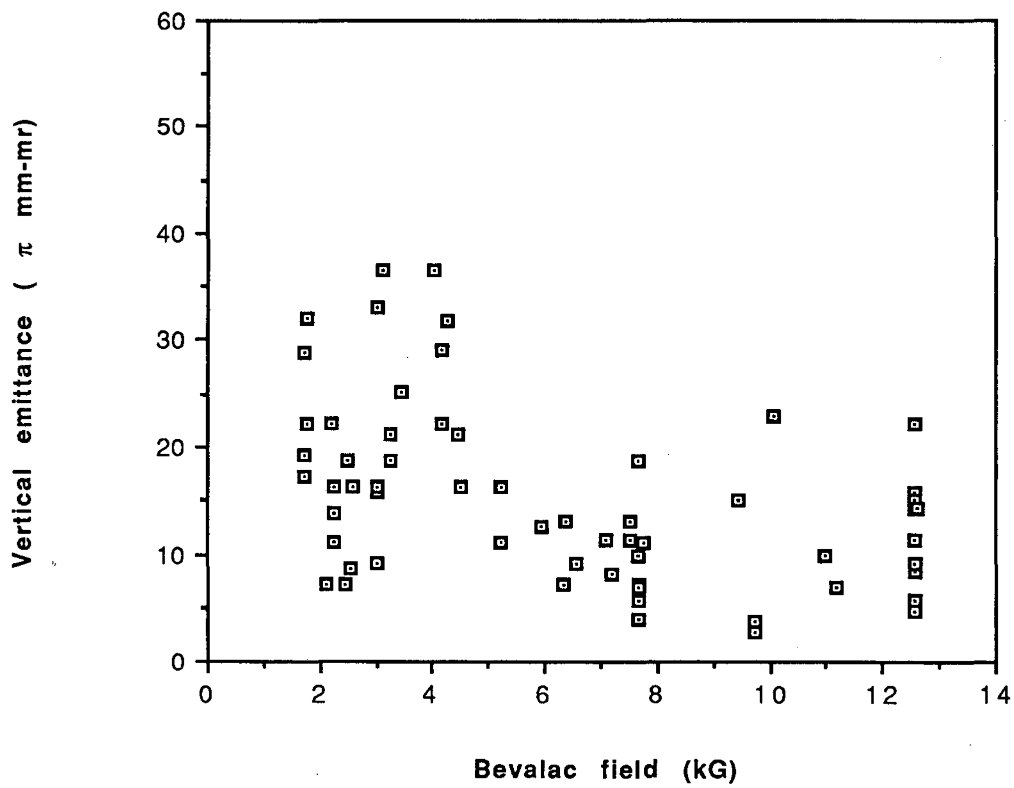
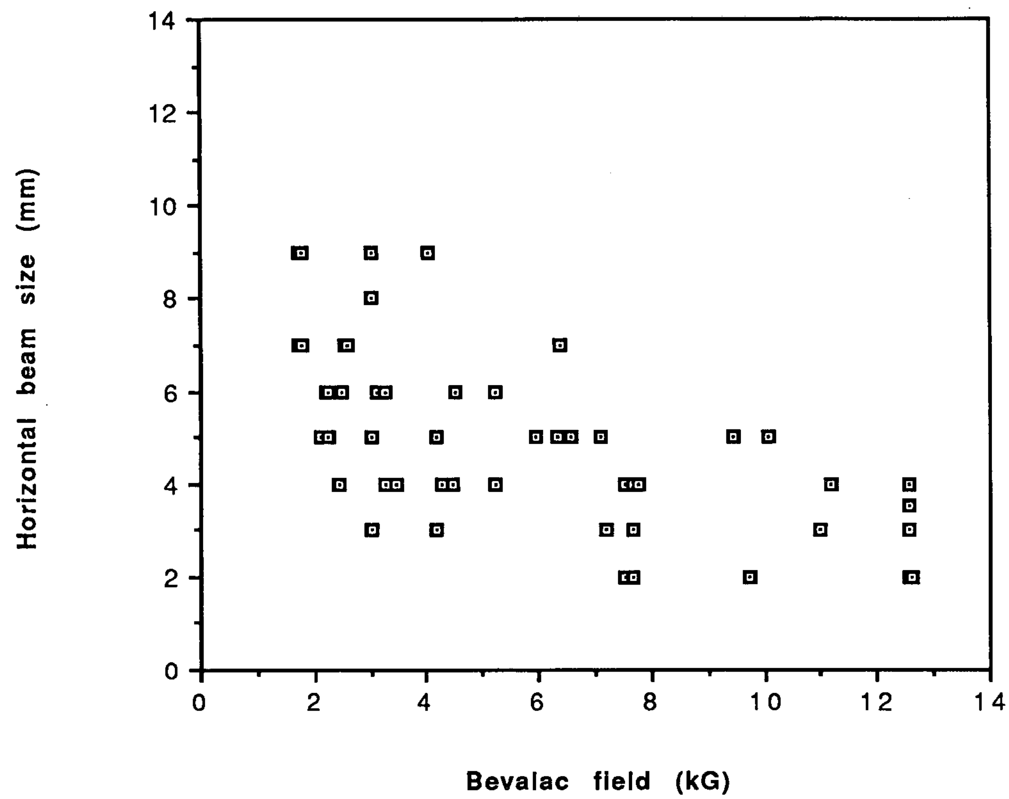


Fig.4 : The beam emittance as a function of the Bevalac field.



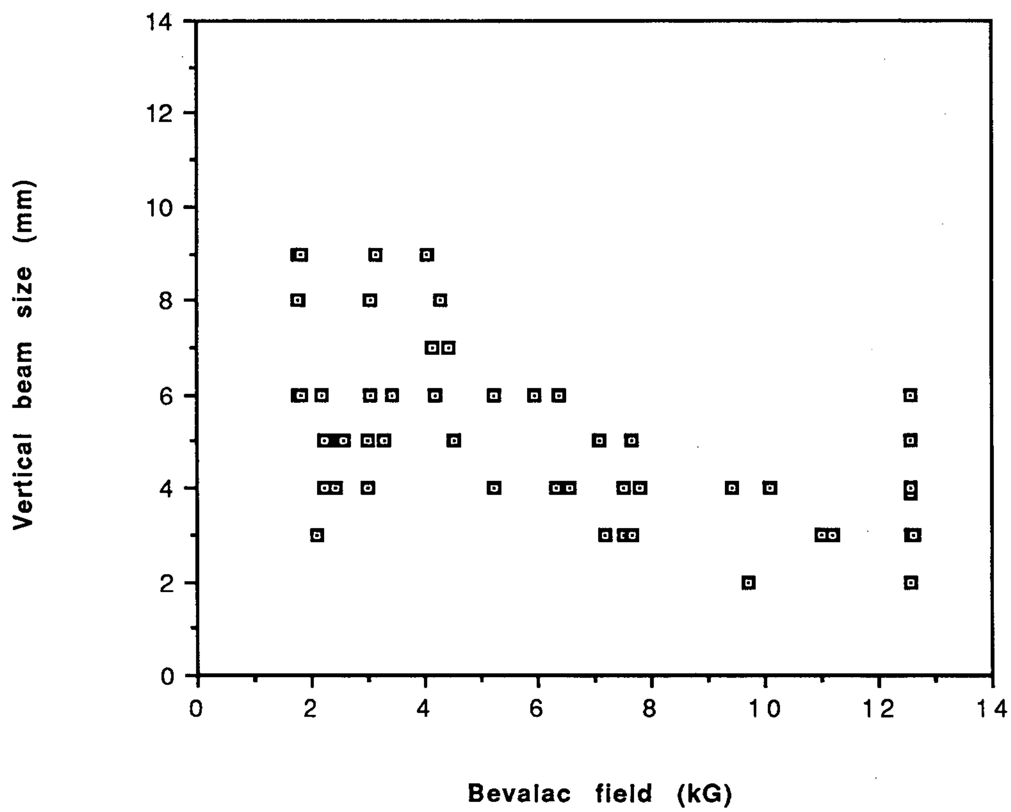


Fig.5 : Beam size at F1 as a function of the Bevalac field.

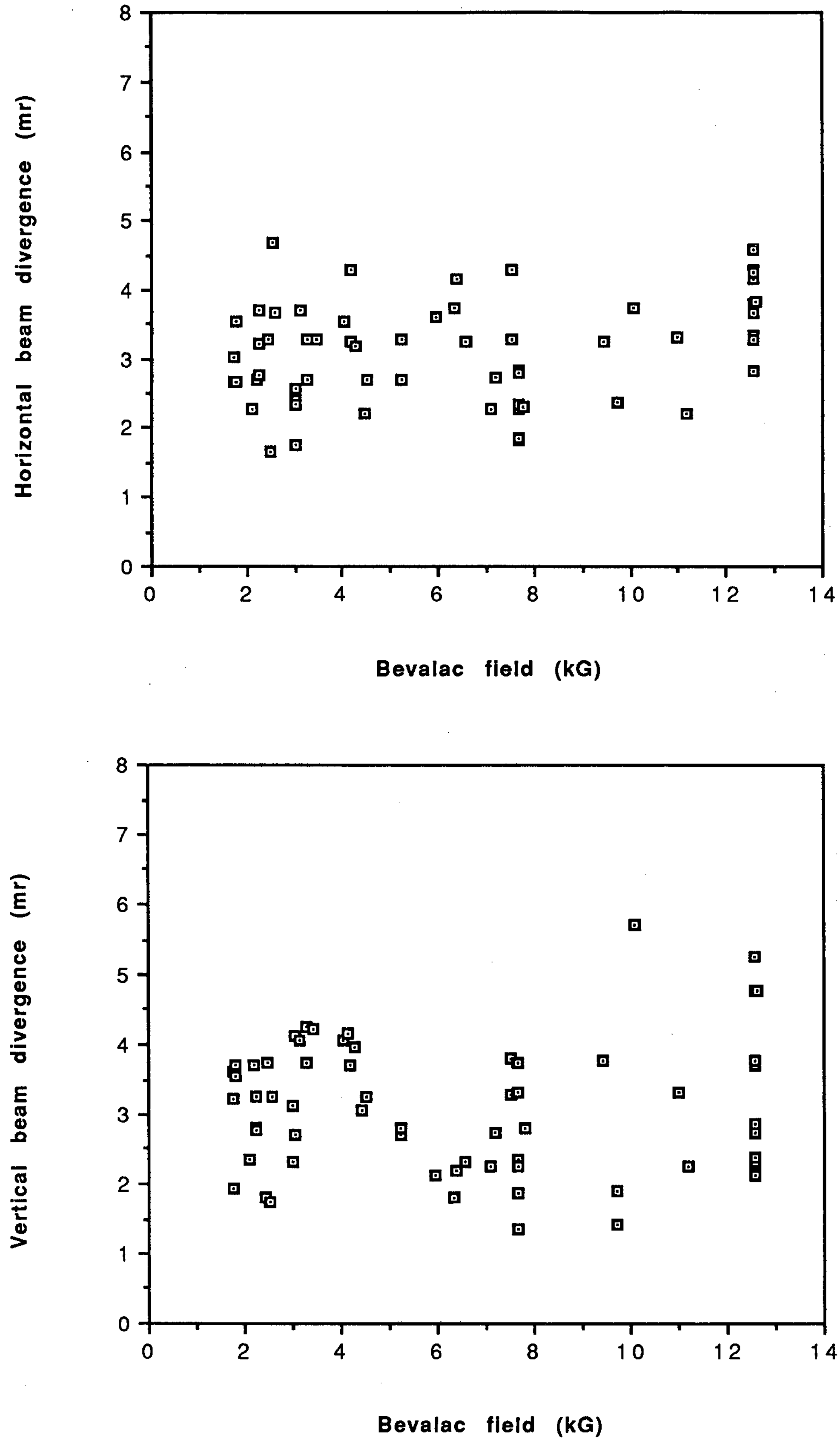
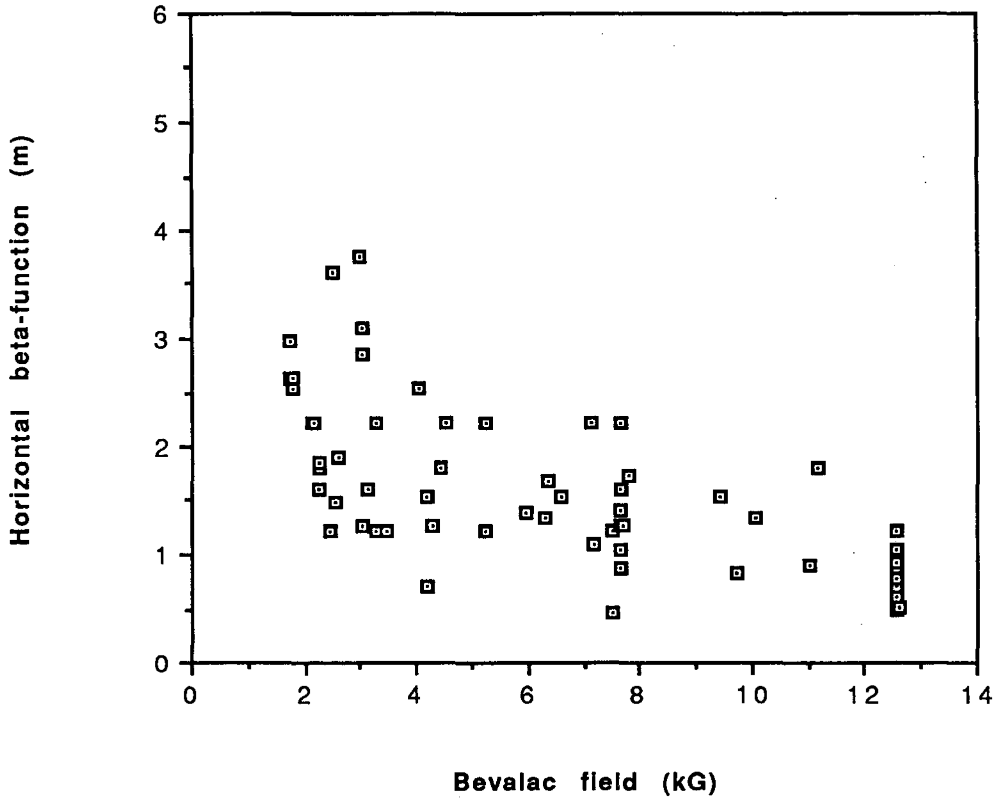


Fig.6 : Beam divergence at F1 as a function of the Bevalac field.



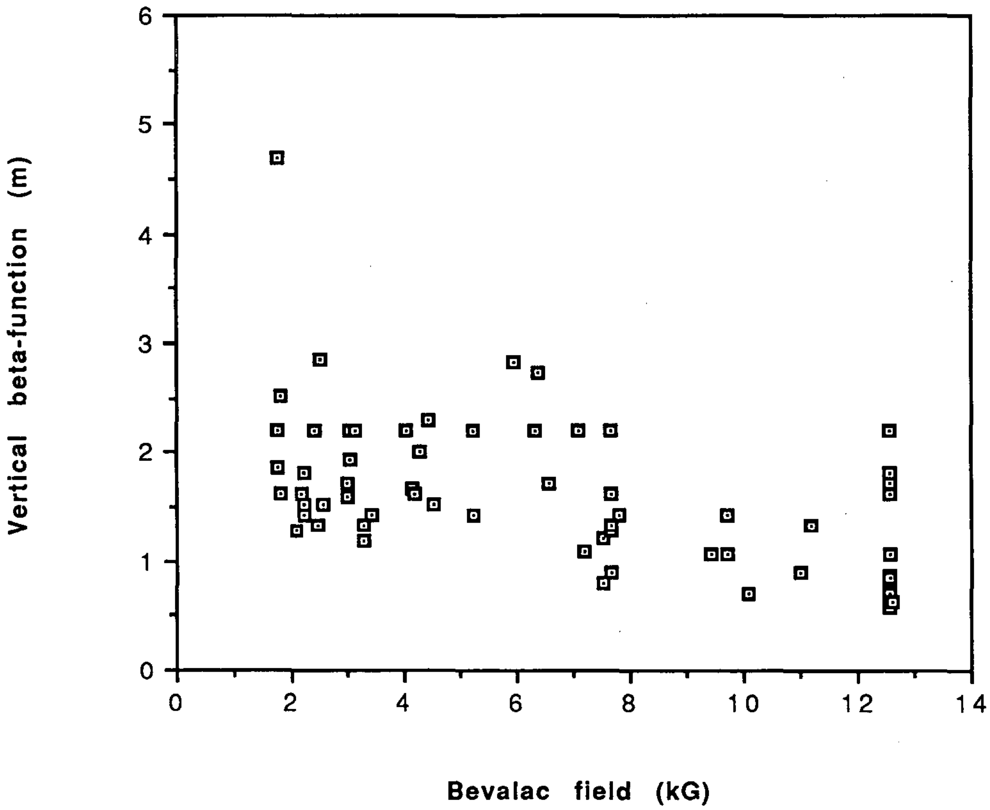
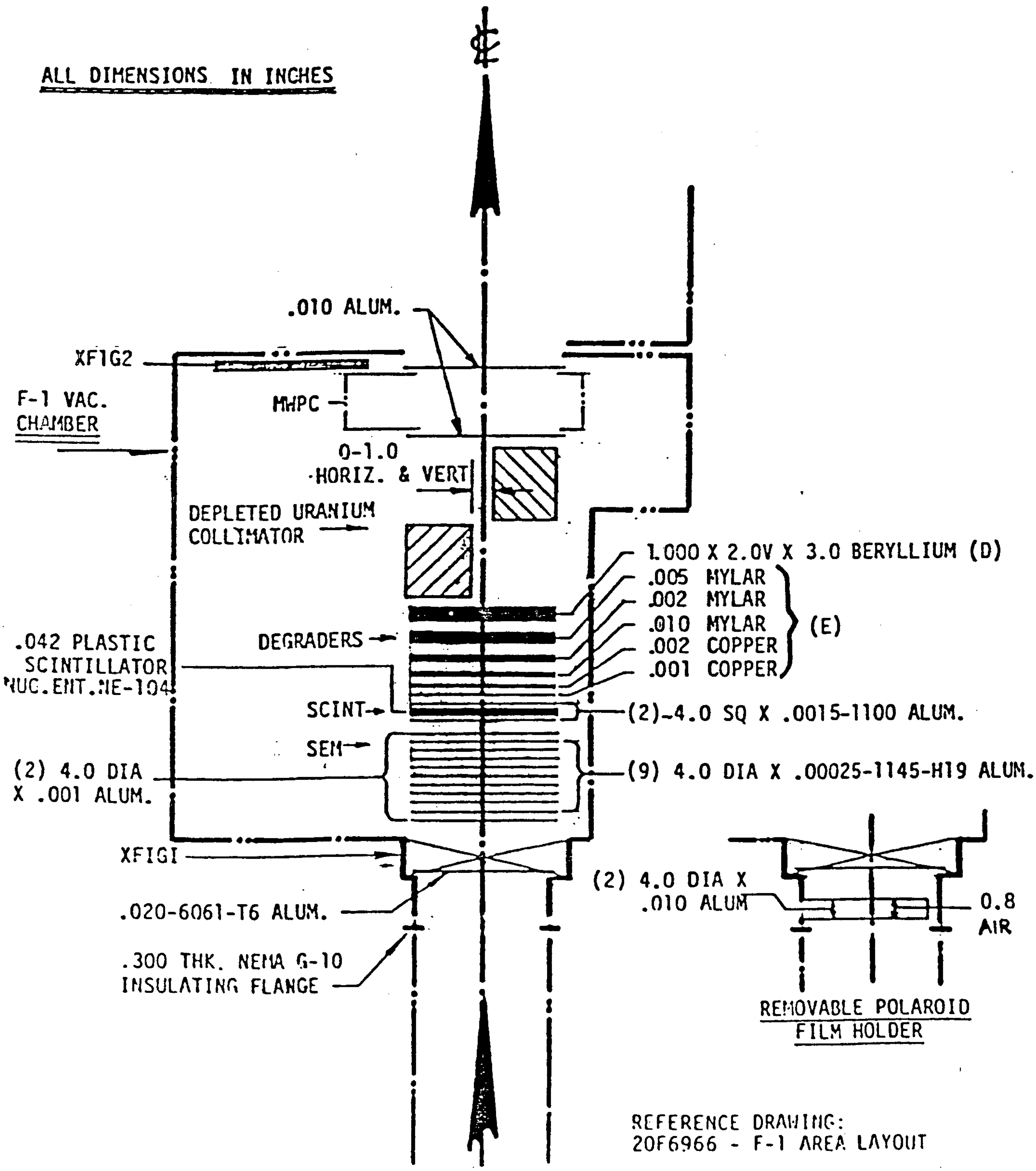


Fig.7 : The beam beta-function at F1 as a function of the Bevalac field.

2.6 CONTENTS OF THE F1 BOX



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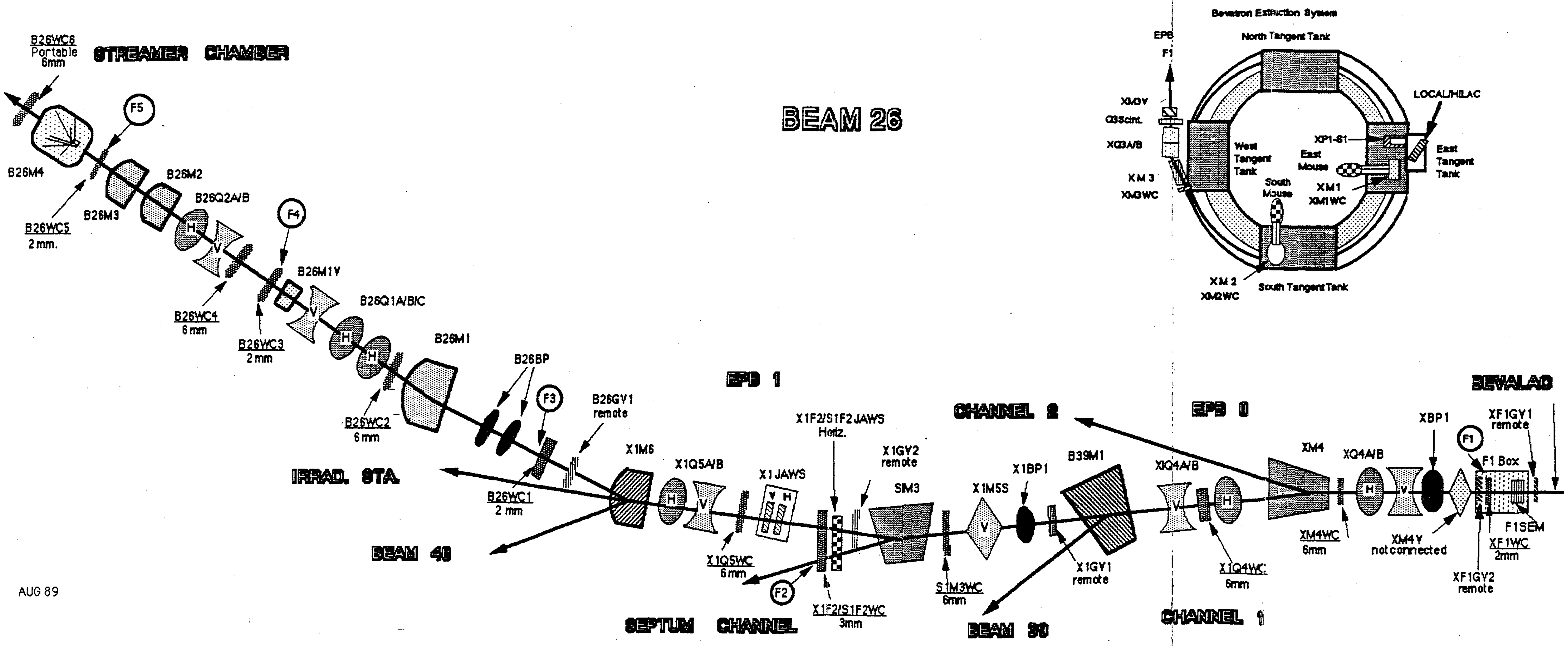
NOTE: THE FOILS AND THE DEGRADERS MAY BE CHANGED.

2.7 Collimators (Jaws) Index*

Name	Assembly Print	Location	Position of Jaws	Size of Jaws (Inches)	Material	Type
XF1JAWS	20E6116 (Area)	F-1 Box	Vertical/Horizontal	4H x 4W x 4L	Depleted Uranium	Spot size
X1F2/S1F2JAWS	1844106	Downstair S1M3	Horizontal	3-5/8 x 5-1/2 x 6-3/4	Lead	Spot size
X1JAWS	17J1536	Upstair X1Q5WC	Vertical/Horizontal	3 x 8-5/8 x 24	Lead	Divergence
	17J3096					
	17J4733					
X2JAWS	20P4066	Downstair X2M5S	Vertical		Lead	Divergence
	16P9376	Downstair X2M5S	Horizontal (Anderson)	4-1/8 x 8-1/4 x 12	Lead	
X2F2JAWS	16P9376	Upstair X2F2WC	Vertical (Anderson)	4-1/8 x 8-1/4 x 12	Lead	Spot size
B40JAWS	Not Applicable	Downstair B40WC1	Horizontal (Manual)	2" x 4" x 19"	Lead	Spot size
B42JAWS	Not Applicable	Downstair B42WC1	Horizontal	4" x 8" x 19"	Cooper	Spot size
	Drive Unit					Divergence
	17G0016					
B39JAWS1	Not Applicable	Downstair B39WC3	Vertical/Horizontal	2-3/4 x 4 x 1.4 CM	Carbon	Spot size
	From Brookhaven			2-3/4 x 4 x 1/2	Lead	
				3-1/2 x 4 x 2	Lead	
B39JAWS2	Same as #1	Downstair B39WC4	Vertical/Horizontal	3-1/2 x 4 x 2	Lead	Divergence
B0JAWS	Not Applicable	Downstair B0S1	Horizontal	4" x 8" x 10"	Lead	Spot size
S1F3JAWS	20E4066	Upstair S1M7	Horizontal/Vertical	3-3/4 x 7-1/4 x 9-1/2	Lead	Spot size
						Divergence
B44SL1	20E4066	Downstair B44	Horizontal/Vertical	3-3/4 x 7-1/4 x 9-1/2	Lead	Spot size
		Beam plug				

*Reference 2

3.1 BEAM 26


BEAM 26
STREAMER CHAMBER
B26WC6
Portable
6mm
F5
B26M4
B26M2
B26M3
B26Q2A/B
B26WC5
2 mm.
F4
B26M1Y
B26WC4
6 mm
B26WC3
2 mm
B26Q1A/B/C
B26M1
B26WC2
6 mm
B26BP
F3
B26GY1
remote
B26WC1
2 mm
IRRAD. STA.
BEAM 40
X1M6
X1Q5A/B
X1Q5WC
6mm
X1 JAWS
X1F2/S1F2 JAWS
Horiz.
F2
X1F2/S1F2WC
3mm
SEPTUM CHANNEL
X1GY2
remote
SM3
S1M3WC
6mm
X1M5S
X1BP1
X1GY1
remote
B39M1
BEAM 30
EPB 1
CHANNEL 2
XQ4A/B
X1Q4WC
6mm
CHANNEL 1
EPB 0
XM4
XM4WC
6mm
XQ4A/B
XBP1
XM4Y
not connected
F1
F1 Box
XF1GY1
remote
F1SEM
XF1WC
2mm
XF1GY2
remote
BEVALAC
Bevatron Extraction System
EPB
F1
North Tangent Tank
XM3V
Q3Scint.
XQ3A/B
XM 3
XM3WC
West Tangent Tank
South Mouse
East Mouse
XP1-S1
XM1
XM1WC
LOCAL/HILAC
East Tangent Tank
XM 2
XM2WC
South Tangent Tank
AUG 89

3.1.2 (a) Beam 26 - Magnet Parameters									
		Quadropole Magnet		Dipole Magnet					
Beam Line Element	Effective Length (m)	Max Gradient (kG/m)	Pole Tip Radius (m)	Max Field (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	Magnet or Wire Chamber Type (in)
(F1)-XF1WC	0.000								2mm Special
	3.969								
XQ4A	0.884	-147	0.1046						8QB32
	0.284								
XQ4B	0.884	+147	0.1046						8QB32
	0.230								
---XM4WC	0.000								6mm Perm. Gas
	0.233								
XM4	2.668			-17.86	15.972	9.572	0.00	9.572	4.1x22x100H
	0.269								
X1Q4A	0.884	+144	0.1046						8QN32
	0.264								
---X1Q4WC	0.000								6mm Perm. Gas
	0.140								
X1Q4B	0.884	-147	0.1046						8QB32
	4.862								
---S1M3WC	0.000								6mm Perm. Gas
	0.340								
S1M3	2.250			20.0	42.58	3.028	0.0	3.028	4.38x15x84H
	0.770								
(F2)-X1F2WC	0.000								3mm Perm. Gas
	9.480								
---X1Q5WC	0.000								6mm Perm. Gas
	0.240								
X1Q5A	0.884	-144	0.1046						8QN32
	0.306								
X1Q5B	0.884	+144	0.1046						8QN32
	0.361								
X1M6	1.036			22.0	9.577	6.2	0.0	6.2	6x16x36C
	8.600								
(F3)-B26WC1	0.000								2mm Crawford
	9.500								
B26M1	1.542			19.2	11.47	7.7	3.85	3.85	6x18x60H
	0.435								
---B26WC2	0.000								6mm Crawford
	0.308								
B26Q1A	0.884	+147	0.1046						8QB32
	0.177								
B26Q1B	0.490	-146	0.1046						8QB16
	0.120								
B26Q1C	0.490	-146	0.1046						8QB16
	8.214								
(F4)-B26WC3	0.000								2mm Crawford
	7.055								
---B26WC4	0.000								6mm Crawford
	0.484								
B26Q2A	1.308	-128	0.1048						8/12QB48
	0.181								
B26Q2B	1.308	+128	0.1048						8/12QB48
	5.140								
(F5)-B26WC5	0.000								2mm Crawford
	4.060								
---B26WC6	0.000								6mm Perm. Gas

b
Beam rigidity =   19.2000 t-m
x,y emittance =   1.2000   1.2000 cm-mrad
dp/p = 0.000%
t
Transport mode

betax	=	1.3333	alphax	=	0.0000
betay	=	1.3333	alphay	=	0.0000
etax	=	0.0000	eta'x	=	0.0000
etay	=	0.0000	eta'y	=	0.0000

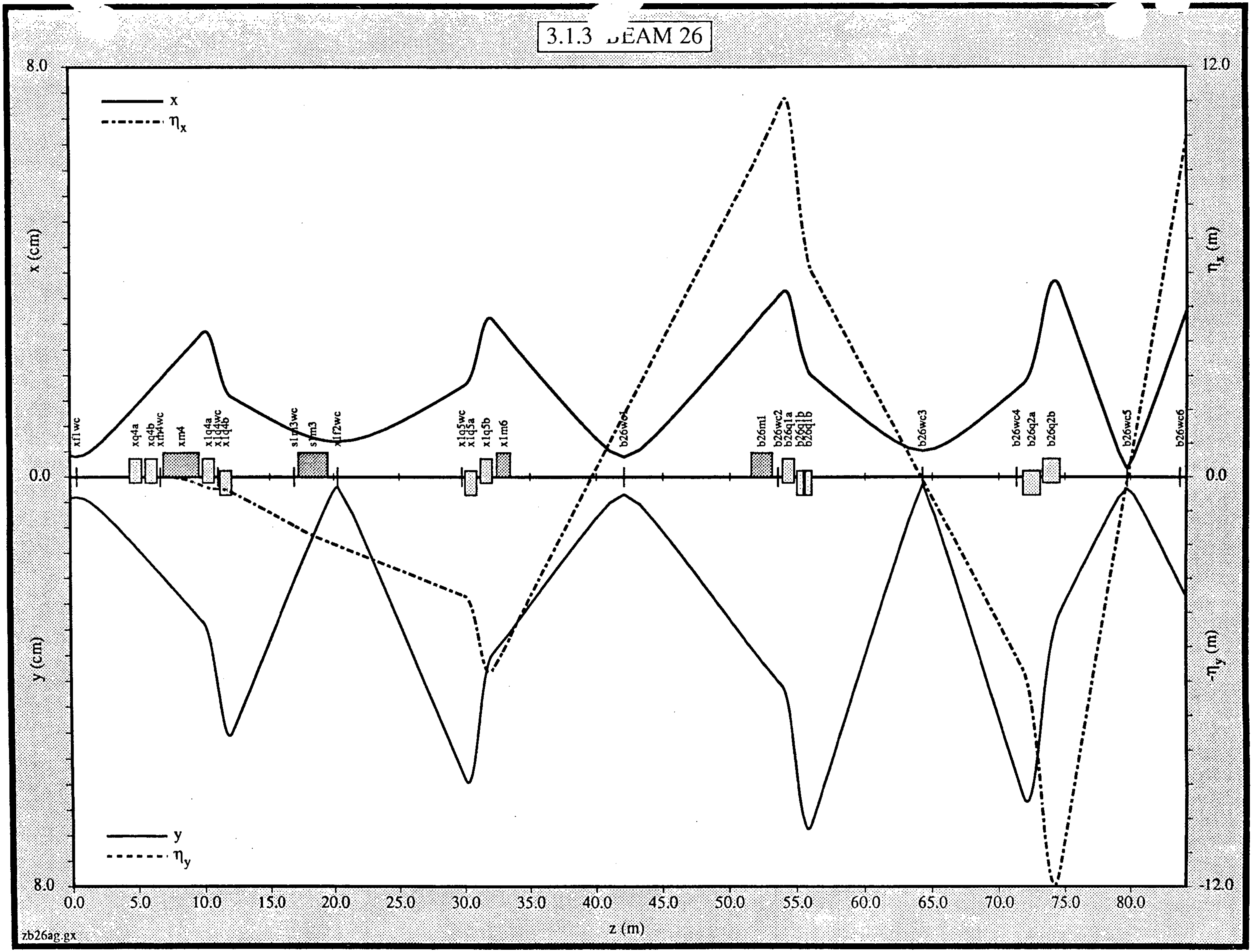
d

	name	type	vcode	lth,angle	b,b',s	n,gap	xaper	yaper
1	xflwc	lens	0.0	0.000000	0.000000	0.0000		
2	l1	drift	0.0	3.969000	0.000000	0.0000		
3	xq4a	quad	0.0	0.884000	0.000000	0.0000	0.1000	0.1000
4	s1	drift	0.0	0.284000	0.000000	0.0000		
5	xq4b	quad	0.0	0.884000	0.000000	0.0000	0.1000	0.1000
6	l2	drift	0.0	0.231000	0.000000	0.0000		
7	xm4wc	lens	0.0	0.000000	0.000000	0.0000		
8	l3	drift	0.0	0.232000	0.000000	0.0000		
9	xm4	bend	0.0	2.668000	-1.202100	0.0000	0.0836	0.0457
10	xm4o	edge	0.0	9.572000	1.202100	0.0000		
11	l4	drift	0.0	0.269000	0.000000	0.0000		
12	xlq4a	quad	0.0	0.884000	10.430752	0.0000	0.1000	0.1000
13	s2a	drift	0.0	0.264000	0.000000	0.0000		
14	xlq4wc	lens	0.0	0.000000	0.000000	0.0000		
15	s2b	drift	0.0	0.140000	0.000000	0.0000		
16	xlq4b	quad	0.0	0.884000	-10.634363	0.0000	0.1000	0.1000
17	l5	drift	0.0	4.862000	0.000000	0.0000		
18	slm3wc	lens	0.0	0.000000	0.000000	0.0000		
19	l6	drift	0.0	0.340000	0.000000	0.0000		
20	slm3	bend	0.0	2.250000	0.451000	0.0000	0.1000	0.0525
21	slm3o	edge	0.0	3.028000	0.451000	0.0000		
22	l7	drift	0.0	0.770000	0.000000	0.0000		
23	xlf2wc	lens	0.0	0.000000	0.000000	0.0000		
24	l8	drift	0.0	9.480000	0.000000	0.0000		
25	xlq5wc	lens	0.0	0.000000	0.000000	0.0000		
26	l9	drift	0.0	0.240000	0.000000	0.0000		
27	xlq5a	quad	0.0	0.884000	-10.437841	0.0000	0.1000	0.1000
28	s3	drift	0.0	0.306000	0.000000	0.0000		
29	xlq5b	quad	0.0	0.884000	10.345813	0.0000	0.1000	0.1000
30	l10	drift	0.0	0.361000	0.000000	0.0000		
31	xlm6	bend	0.0	1.036000	2.005000	0.0000	0.1000	0.0730
32	xlm6o	edge	0.0	6.200000	2.005000	0.0000		
33	l11	drift	0.0	8.600000	0.000000	0.0000		
34	b26wcl	lens	0.0	0.000000	0.000000	0.0000		
35	l12	drift	0.0	9.500000	0.000000	0.0000		
36	b26mle	edge	0.0	3.850000	1.674000	0.0000		
37	b26ml	bend	0.0	1.542000	1.674000	0.0000	0.1000	0.0730
38	b26mle	edge	0.0	3.850000	1.674000	0.0000		
39	l13	drift	0.0	0.435000	0.000000	0.0000		
40	b26wc2	lens	0.0	0.000000	0.000000	0.0000		
41	l14	drift	0.0	0.308000	0.000000	0.0000		
42	b26qla	quad	0.0	0.884000	10.770590	0.0000	0.1000	0.1000
43	s4a	drift	0.0	0.177000	0.000000	0.0000		
44	b26qlb	quad	0.0	0.490000	-10.119318	0.0000	0.1000	0.1000
45	s4b	drift	0.0	0.120000	0.000000	0.0000		
46	b26qlb	quad	0.0	0.490000	-10.119318	0.0000	0.1000	0.1000
47	l15	drift	0.0	8.214000	0.000000	0.0000		

3.1.2 (b) BEAM 26 - TRANSPORT LIST

```
 48 b26wc3      lens   0.0     0.000000    0.000000   0.0000
 49 l16         drift  0.0     7.055000    0.000000   0.0000
 50 b26wc4      lens   0.0     0.000000    0.000000   0.0000
 51 l17         drift  0.0     0.484000    0.000000   0.0000
 52 b26q2a      quad   1.2     1.308000   -8.270994   0.0000  0.1000  0.1000
 53 s5          drift  0.0     0.181000    0.000000   0.0000
 54 b26q2b      quad   2.2     1.308000    8.800716   0.0000  0.1000  0.1000
 55 l18         drift  0.0     5.140000    0.000000   0.0000
 56 b26wc5      lens   0.0     0.000000    0.000000   0.0000
 57 l19         drift  0.0     4.060000    0.000000   0.0000
 58 b26wc6      lens   0.0     0.000000    0.000000   0.0000
quit
End of program
```

3.1.2 (b) <u>BEAM 26 - TRANSPORT LIST</u>


3.1.3 BEAM 26
x
η_x
y
η_y
x (cm)
y (cm)
η_x (m)
$-\eta_y$ (m)
z (m)
8.0
0.0
8.0
12.0
0.0
-12.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
65.0
70.0
75.0
80.0
xf1wc
xq4a
xq4b
xm4wc
xm4
x1q4a
x1q4wc
x1q4b
s1m3wc
s1m3
x1f2wc
x1q5wc
x1q5a
x1q5b
x1m6
b26wc1
b26m1
b26wc2
b26q1a
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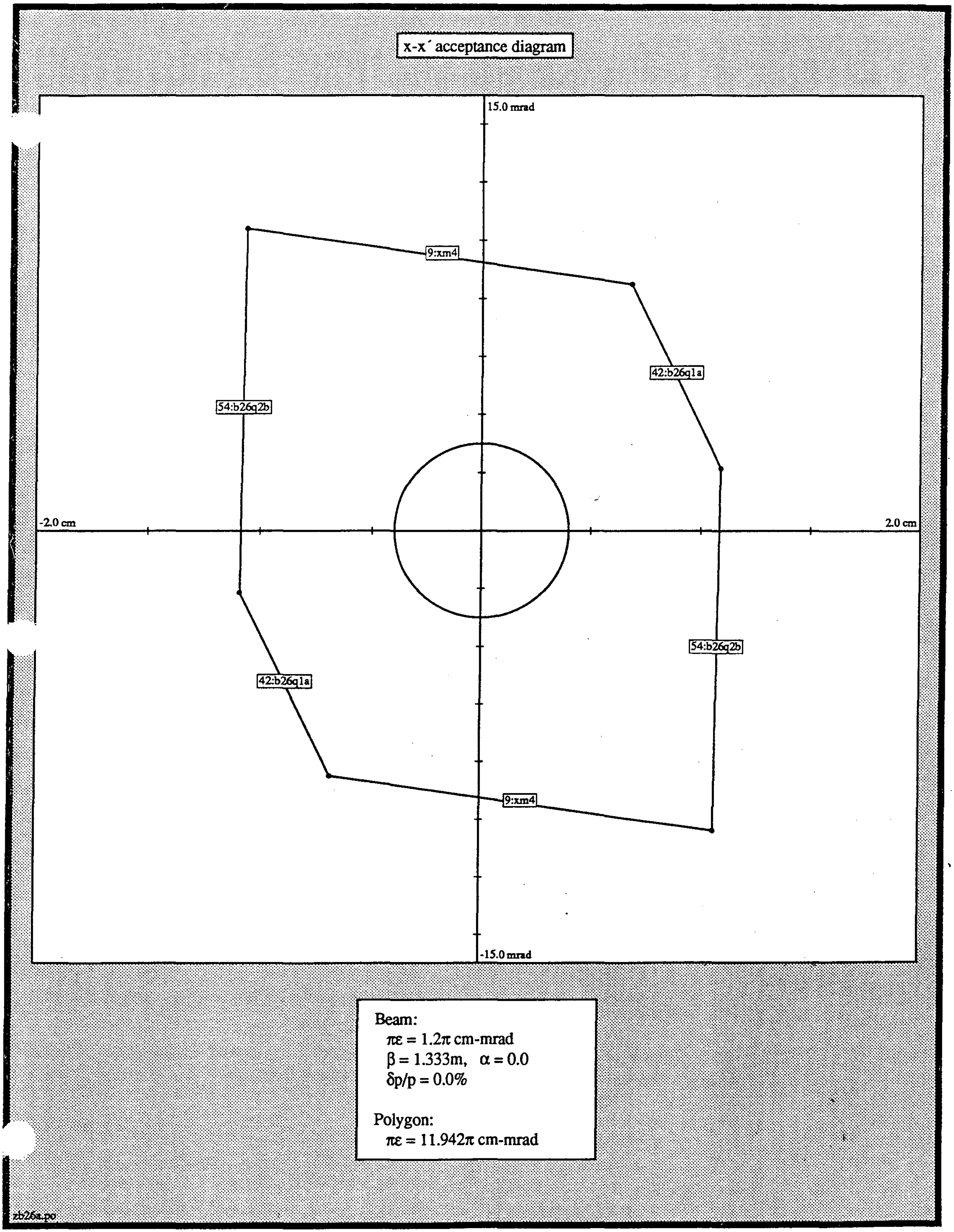
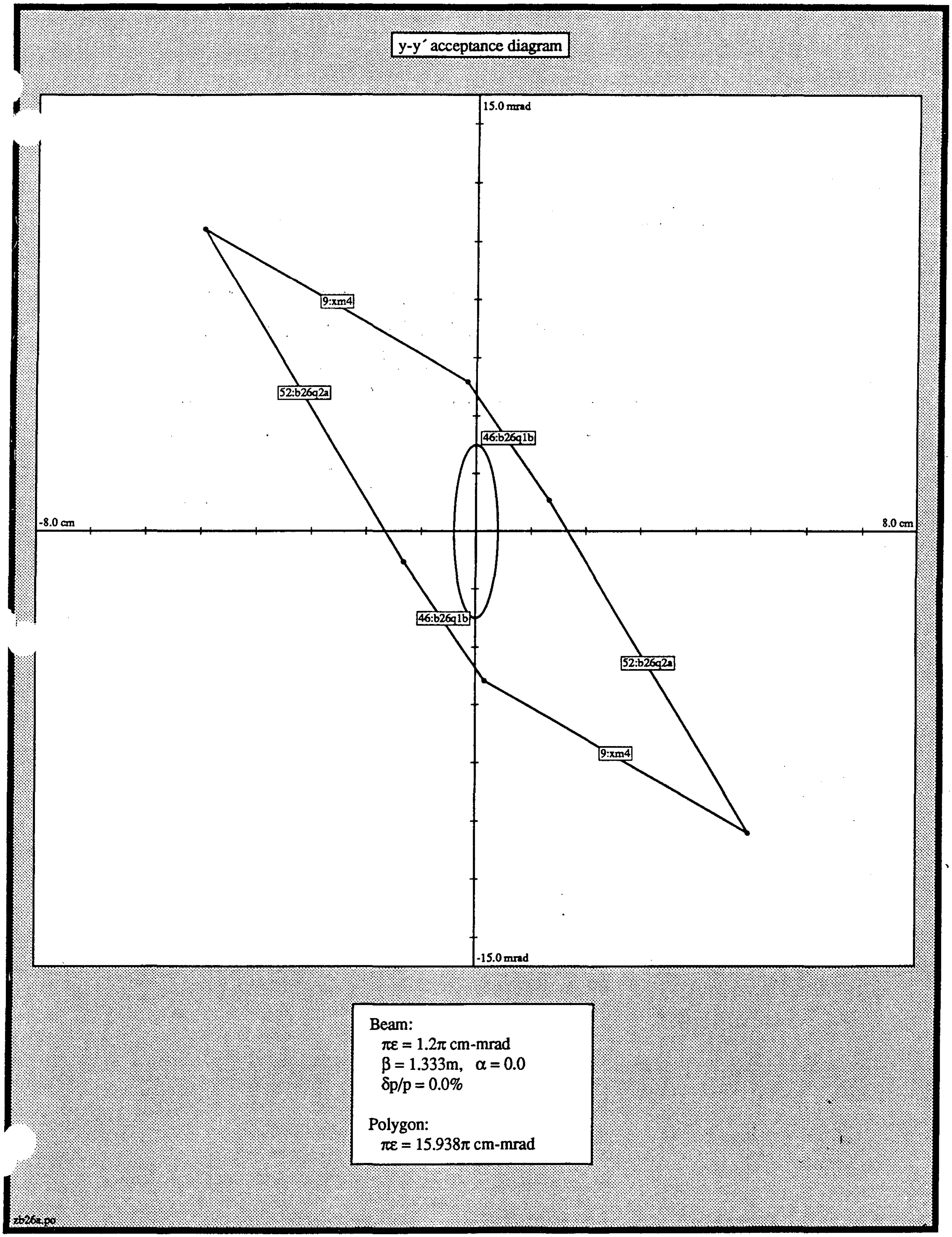
b26wc6
zb26ag.gx



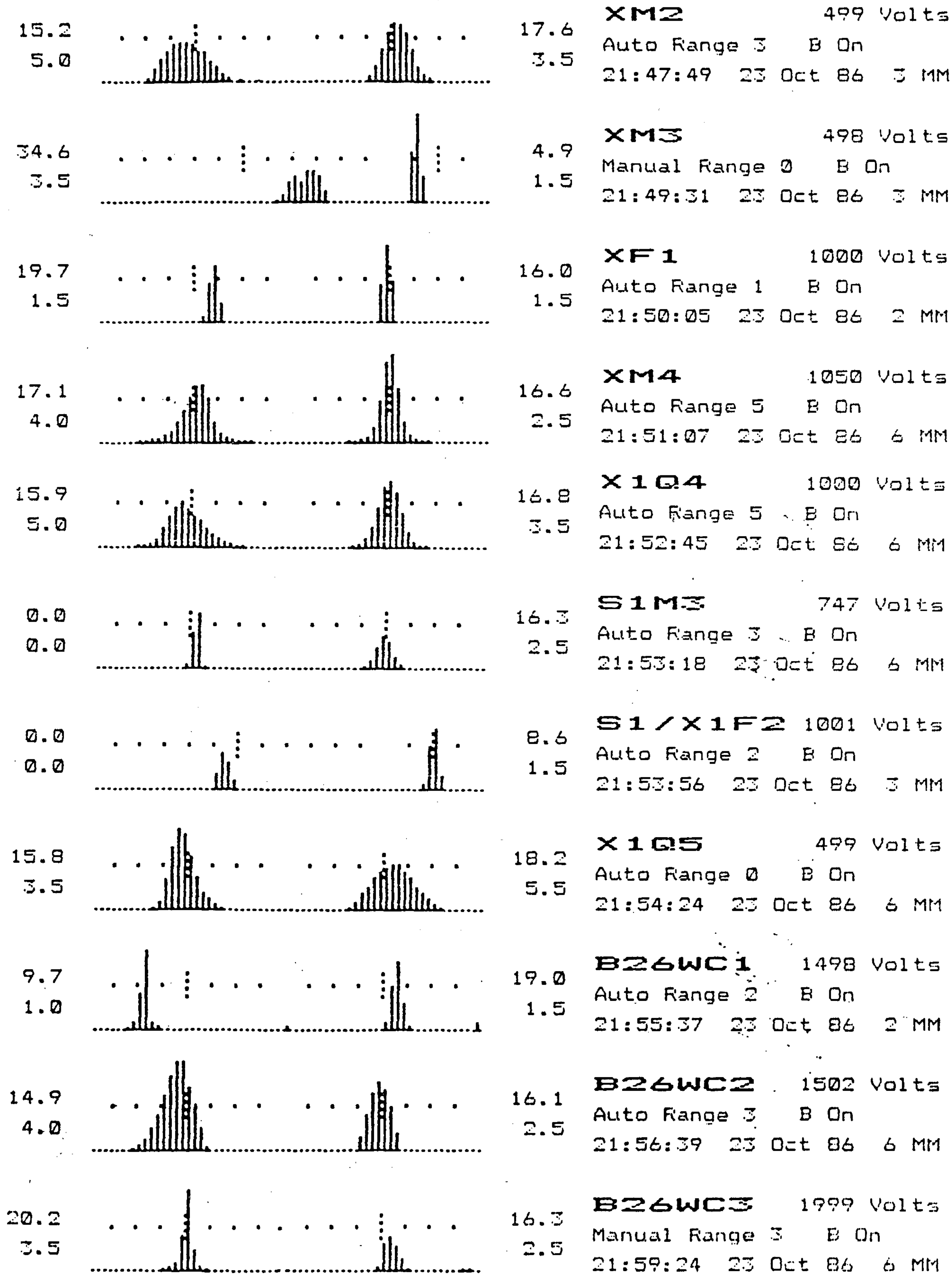
3.1.4 BEAM 26 HORIZONTAL ACCEPTANCE AT F1



3.1.4 BEAM 26 VERTICAL ACCEPTANCE AT F1

3.1.5 Beam 26 Focal Points

Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (cm/%)
F1	XF1WC	1.0	1.0	0.00
F2	X1F2WC	1.74	0.49	-2.04
F3	B26WC1	0.98	0.85	1.85
F4	B26WC3	1.28	0.36	-0.09
F5	B26WC5	0.42	0.58	0.12



3.1.6 (a) Wire Chamber Pictures

NAME	DATE	TIME	ENTRY	BEAM LINE
NE7284 B26	23OCT86	22:16:138308		BEAM26

COMMENTS

NE7284 B26
BEAM TUNED TO B26WC5
UNABLE TO GET A NO QUAD STEETING TUNE
E 594.0 S 586.58
RADIUS 600.1
XS1 FEEDBACK SPILL
EXT PFW ACL 6390 EXT

PERTURBATION UNIT DATA

NAME		FLAGS	AMPLITUDE	DELAY	GATE
X	P1	P+	79.33	400	1680
X	P2	P+	-3.20	400	1510
X	S2	S+	291.31	470	1300
X	S1	S+	51.28	440	1420
X	S2	P+	30.84	450	1100
X	M3	S+	-9.77	400	1400
X	S1	P+	36.71	400	1500
X	M2	S+	-32.08	400	1450

NAME		SP	AM	DI	OFFSET
X	P1	0.00	0.66	5	0.00
X	P2	0.00	0.29	5	0.00
X	S1	-1.68	1.32	5	0.00
X	S2	-0.06	2.08	5	0.00
X	M1	503.05	545.77	5	0.00
X	M2	1466.60	1504.49	2005	0.00
X	M3	1201.82	1218.76	5	0.00
X	Q3A	766.76	760.38	5	0.00
X	Q3B	750.92	817.05	5	0.00
X	M3V	10.00	9.40	2001	10.00
X	M4V	0.00	1.47	1	0.00
X	M4	617.84	617.59	2001	617.84
X	M5	301.42	304.45	2001	301.42
X1	Q4A	1135.91	1135.04	2005	0.00
X1	Q4B	1150.88	1201.56	2005	0.00
X1	M5S	54.53	54.11	2001	54.53
S1	M3	183.31	183.89	2003	183.31
X1	Q5A	1040.04	1035.61	2001	1040.04
X1	Q5B	1020.21	1018.61	2001	1020.21
X1	M6	764.29	756.08	2001	764.29
X	Q4A	0.00	0.00	5	0.00
X	Q4B	0.00	0.00	5	0.00
B26	M1	684.66	724.96	1	684.66
B26	Q1A	1119.87	1129.95	1	1119.87
B26	Q1B	1044.94	1056.67	1	1044.94
B26	Q2A	595.48	592.45	1	595.48
B26	Q2B	607.90	619.32	1	607.90
B40	M2+3	800.68	4.89	1	800.68

3.1.6 (b) **Magnet Currents**

3.1.7 (a) Beam 26 Optic-Axis Beam Positions on the Wire Chambers

Active Dipole Magnets	Wire Chamber	Beam Center on Wire Chamber (Wire Number)	
		Horizontal	Vertical
XM3V	X1Q4WC	---	16.5
XM4	S1M3WC	16.5	---
S1M3	X1Q5WC	16.5	---
X1M5S	B26WC2	---	16.5
X1M6*	B26WC2	16.5	---
B26M1*	B26WC4	16.5	---
B26M1V	B26WC4	---	16.5

* See Section 5.1

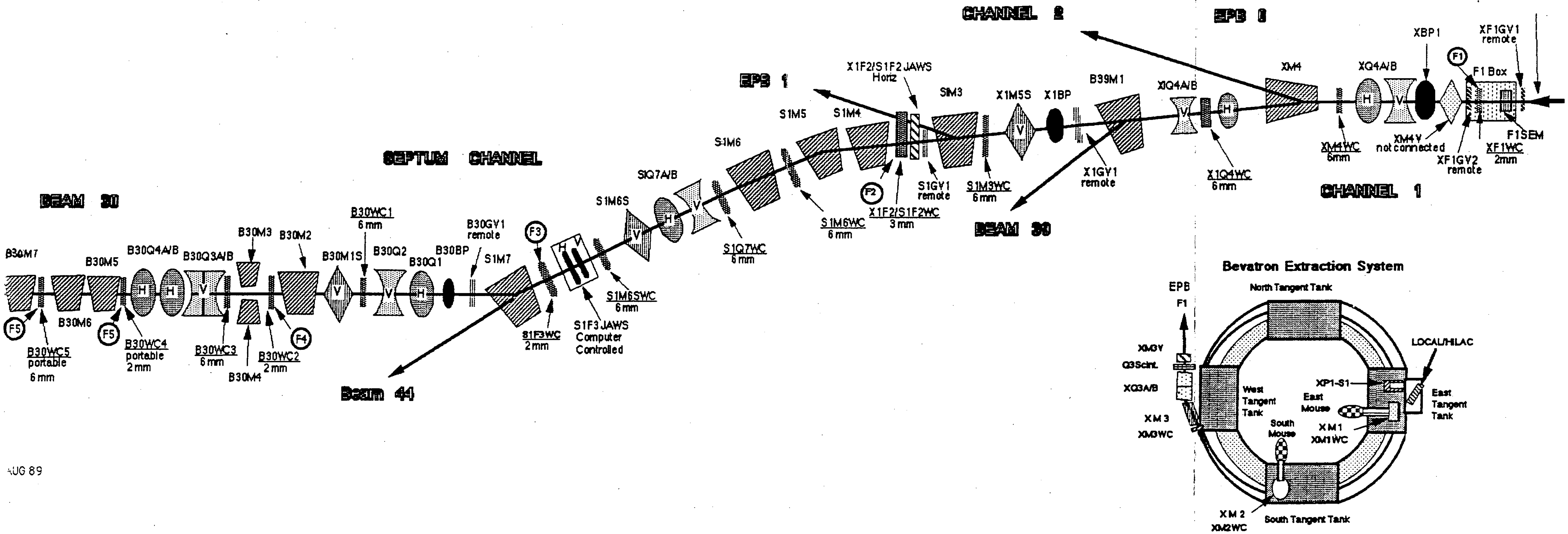
3.1.7 (b) Beam 26 Average Magnet Currents per Bevalac Field

Beam Line Magnet	Magnet Current per Bevalac Field (Ampere/kG)
XM4	952.3*
X1Q4A	153.2
X1Q4B	160.0
S1M3	25.2
X1Q5A	149.4
X1Q5B	143.3
X1M6	105.9
B26M1	93.8
B26Q1A	152.5
B26Q1B/C	140.4
B26Q2A	79.3
B26Q2B	81.5

* Magnet field per Bevalac field (gauss/kG)

3.2 BEAM 30

BEAM 30



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3.2.2 (a) Beam 30 - Magnet Parameters									
		Quadropole Magnet		Dipole Magnet					
Beam Line Element	Effective Length (m)	Max Gradient (kG/m)	Pole Tip Radius (m)	Max Field (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	Magnet or Wire Chamber Type (in)
(F1)-XF1WC	0.000								2mm Special
	3.969								
XQ4A	0.884	-147	0.1046						8QB32
	0.284								
XQ4B	0.884	+147	0.1046						8QB32
	0.230								
---XM4WC	0.000								6mm Perm. Gas
	0.233								
XM4	2.668			-17.86	15.972	9.572	0.00	9.572	4.1x22x100H
	0.269								
X1Q4A	0.884	+144	0.1046						8QN32
	0.264								
---X1Q4WC	0.000								6mm Perm. Gas
	0.140								
X1Q4B	0.884	-147	0.1046						8QB32
	4.862								
---S1M3WC	0.000								6mm Perm. Gas
	0.340								
S1M3	2.250			-20.0	43.44	2.968	0.0	2.968	4.38x15x84H
	0.770								
(F2)-S1F2WC	0.000								3mm Perm. Gas
	0.645								
S1M4	1.405			-20.3	13.41	6.0	0.0	6.0	2.25x7.5x48H
	0.370								
S1M5	2.250			-20.0	11.72	11.0	5.5	5.5	4.38x15x84H
	0.247								
---S1M6WC	0.000								6mm Cantilever
	0.247								
S1M6	2.250			-20.0	31.07	4.15	4.15	0.0	4.38x15x84H
	2.350								
---S1Q7WC	0.000								6mm Perm. Gas
	0.336								
S1Q7A	1.308	-140	0.1046						8QB48
	0.216								
S1Q7B	1.308	+140	0.1046						8QB48
	1.608								
---S1M6SWC	0.000								6mm Crawford
	3.700								
(F3)-S1F3WC	0.000								2mm Perm. Gas
	5.280								
B30Q1	1.308	+128	0.1048						8/12QB48
	0.218								
B30Q2	1.308	-128	0.1048						8/12QB48
	0.594								
---B30WC1	0.000								6mm Cantilever
	5.760								
(F4)-B30WC2	0.000								2mm Crawford
	4.660								
---B30WC3	0.000								6mm Perm. Gas
	0.185								
B30Q3A	0.490	-146	0.1046						8QB16
	0.120								
B30Q3B	0.490	-146	0.1046						8QB16

3.2.2 (a) Beam 30 - Magnet Parameters									
		Quadropole Magnet		Dipole Magnet					
Beam Line Element	Effective Length (m)	Max Gradient (kG/m)	Pole Tip Radius (m)	Max Field (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	Magnet or Wire Chamber Type (in)
	0.145								
B30Q4A	0.490	+146	0.1046						8QB16
	0.120								
B30Q4B	0.490	+146	0.1046						8QB16
	3.315								
(F5A)-B30WC4	0.000								2 or 6mm WC
	3.830								
(F5B)-B30WC5	0.000								2 or 6mm WC

```
b
Beam rigidity =   19.2000 t-m
x,y emittance =    1.2000   1.2000 cm-mrad
dp/p =  0.000%
t
Transport mode
        betax =   1.3333   alphax =    0.0000
        betay =   1.3333   alphay =    0.0000
        etax  =   0.0000   eta'x  =    0.0000
        etay  =   0.0000   eta'y  =    0.0000
d
```

	name	type	vcode	lth,angle	b,b',s	n,gap	xaper	yaper
	----	----	-----	---------	------	-----	-----	-----
1	xflwc	lens	0.0	0.000000	0.000000	0.0000		
2	l1	drift	0.0	3.969000	0.000000	0.0000		
3	xq4a	quad	0.0	0.884000	0.000000	0.0000	0.1000	0.1000
4	s1	drift	0.0	0.284000	0.000000	0.0000		
5	xq4b	quad	0.0	0.884000	0.000000	0.0000	0.1000	0.1000
6	l2	drift	0.0	0.230000	0.000000	0.0000		
7	xm4wc	lens	0.0	0.000000	0.000000	0.0000		
8	l3	drift	0.0	0.233000	0.000000	0.0000		
9	xm4	bend	0.0	2.668000	-1.202100	0.0000	0.0836	0.0457
10	xm4o	edge	0.0	9.572000	-1.202100	0.0000		
11	l4	drift	0.0	0.269000	0.000000	0.0000		
12	xlq4a	quad	0.0	0.884000	9.944050	0.0000	0.1000	0.1000
13	s2a	drift	0.0	0.264000	0.000000	0.0000		
14	xlq4wc	lens	0.0	0.000000	0.000000	0.0000		
15	s2b	drift	0.0	0.140000	0.000000	0.0000		
16	xlq4b	quad	0.0	0.884000	-10.574643	0.0000	0.1000	0.1000
17	l5	drift	0.0	4.862000	0.000000	0.0000		
18	slm3wc	lens	0.0	0.000000	0.000000	0.0000		
19	l6	drift	0.0	0.340000	0.000000	0.0000		
20	slm3	bend	0.0	2.250000	-0.442000	0.0000	0.1000	0.0525
21	slm3o	edge	0.0	2.968000	-0.442000	0.0000		
22	l7	drift	0.0	0.770000	0.000000	0.0000		
23	slf2wc	lens	0.0	0.000000	0.000000	0.0000		
24	l8	drift	0.0	0.645000	0.000000	0.0000		
25	slm4	bend	0.0	1.405000	-1.431000	0.0000	0.0953	0.0286
26	slm4o	edge	0.0	6.000000	-1.431000	0.0000		
27	l9	drift	0.0	0.370000	0.000000	0.0000		
28	slm5i	edge	0.0	5.500000	-1.638000	0.0000		
29	slm5	bend	0.0	2.250000	-1.638000	0.0000	0.1000	0.0525
30	slm5o	edge	0.0	5.500000	-1.638000	0.0000		
31	l10	drift	0.0	0.247000	0.000000	0.0000		
32	slm6wc	lens	0.0	0.000000	0.000000	0.0000		
33	l11	drift	0.0	0.247000	0.000000	0.0000		
34	slm6i	edge	0.0	4.150000	-0.618000	0.0000		
35	slm6	bend	0.0	2.250000	-0.618000	0.0000	0.1000	0.0525
36	l12	drift	0.0	2.350000	0.000000	0.0000		
37	slq7wc	lens	0.0	0.000000	0.000000	0.0000		
38	l13	drift	0.0	0.336000	0.000000	0.0000		
39	slq7a	quad	0.0	1.308000	-7.462412	0.0000	0.1000	0.1000
40	s3	drift	0.0	0.216000	0.000000	0.0000		
41	slq7b	quad	0.0	1.308000	8.141792	0.0000	0.1000	0.1000
42	l14	drift	0.0	1.608000	0.000000	0.0000		
43	slm6sw	lens	0.0	0.000000	0.000000	0.0000		
44	l15	drift	0.0	3.700000	0.000000	0.0000		
45	slf3wc	lens	0.0	0.000000	0.000000	0.0000		
46	l16	drift	0.0	5.280000	0.000000	0.0000		
47	b30ql	quad	0.0	1.308000	8.755249	0.0000	0.1000	0.1000

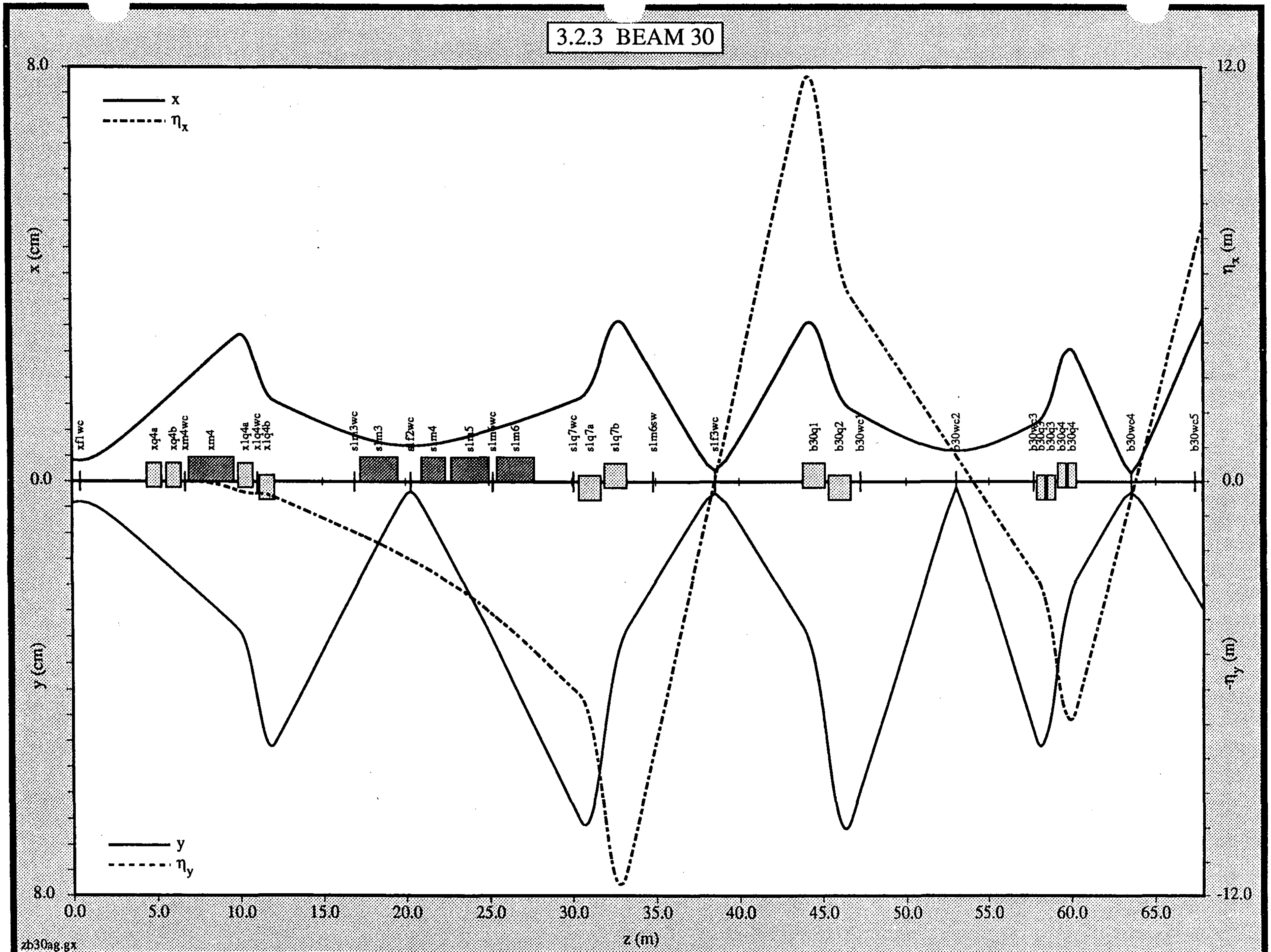
3.2.2 (b) BEAM 30 - TRANSPORT LIST

48	s4	drift	0.0	0.218000	0.000000	0.0000		
49	b30q2	quad	0.0	1.308000	-8.530792	0.0000	0.1000	0.1000
50	l17	drift	0.0	0.594000	0.000000	0.0000		
51	b30wcl	lens	0.0	0.000000	0.000000	0.0000		
52	l18	drift	0.0	5.760000	0.000000	0.0000		
53	b30wc2	lens	0.0	0.000000	0.000000	0.0000		
54	l19	drift	0.0	4.660000	0.000000	0.0000		
55	b30wc3	lens	0.0	0.000000	0.000000	0.0000		
56	l20	drift	0.0	0.185000	0.000000	0.0000		
57	b30q3	quad	1.2	0.490000	-15.338230	0.0000	0.1000	0.1000
58	s5a	drift	0.0	0.120000	0.000000	0.0000		
59	b30q3	quad	1.2	0.490000	-15.338230	0.0000	0.1000	0.1000
60	s5b	drift	0.0	0.145000	0.000000	0.0000		
61	b30q4	quad	2.2	0.490000	16.394558	0.0000	0.1000	0.1000
62	s5c	drift	0.0	0.120000	0.000000	0.0000		
63	b30q4	quad	2.2	0.490000	16.394558	0.0000	0.1000	0.1000
64	l21	drift	0.0	3.315000	0.000000	0.0000		
65	b30wc4	lens	0.0	0.000000	0.000000	0.0000		
66	l22	drift	0.0	3.830000	0.000000	0.0000		
67	b30wc5	lens	0.0	0.000000	0.000000	0.0000		

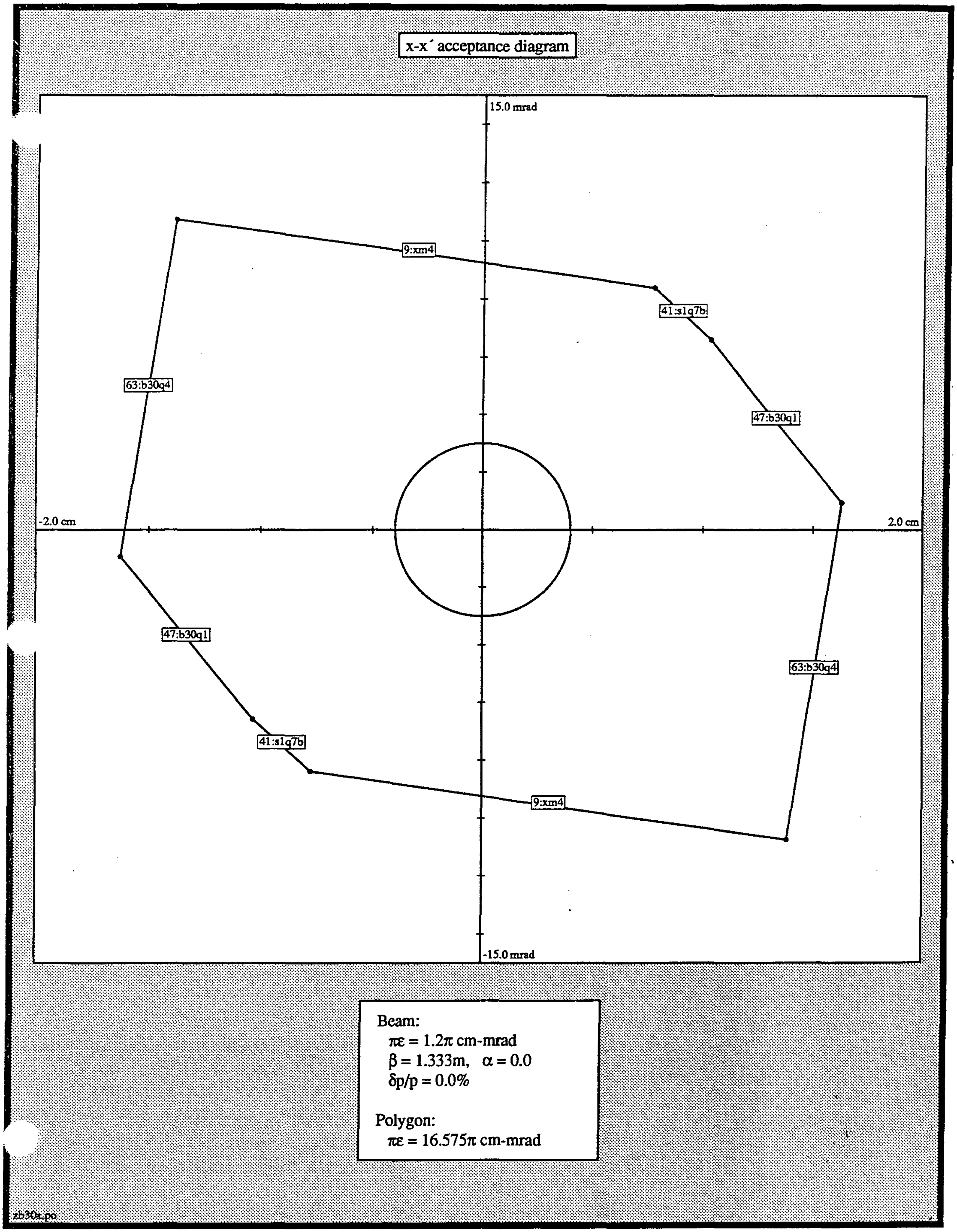
quit
End of program

3.2.2 (b) BEAM 30 - TRANSPORT LIST

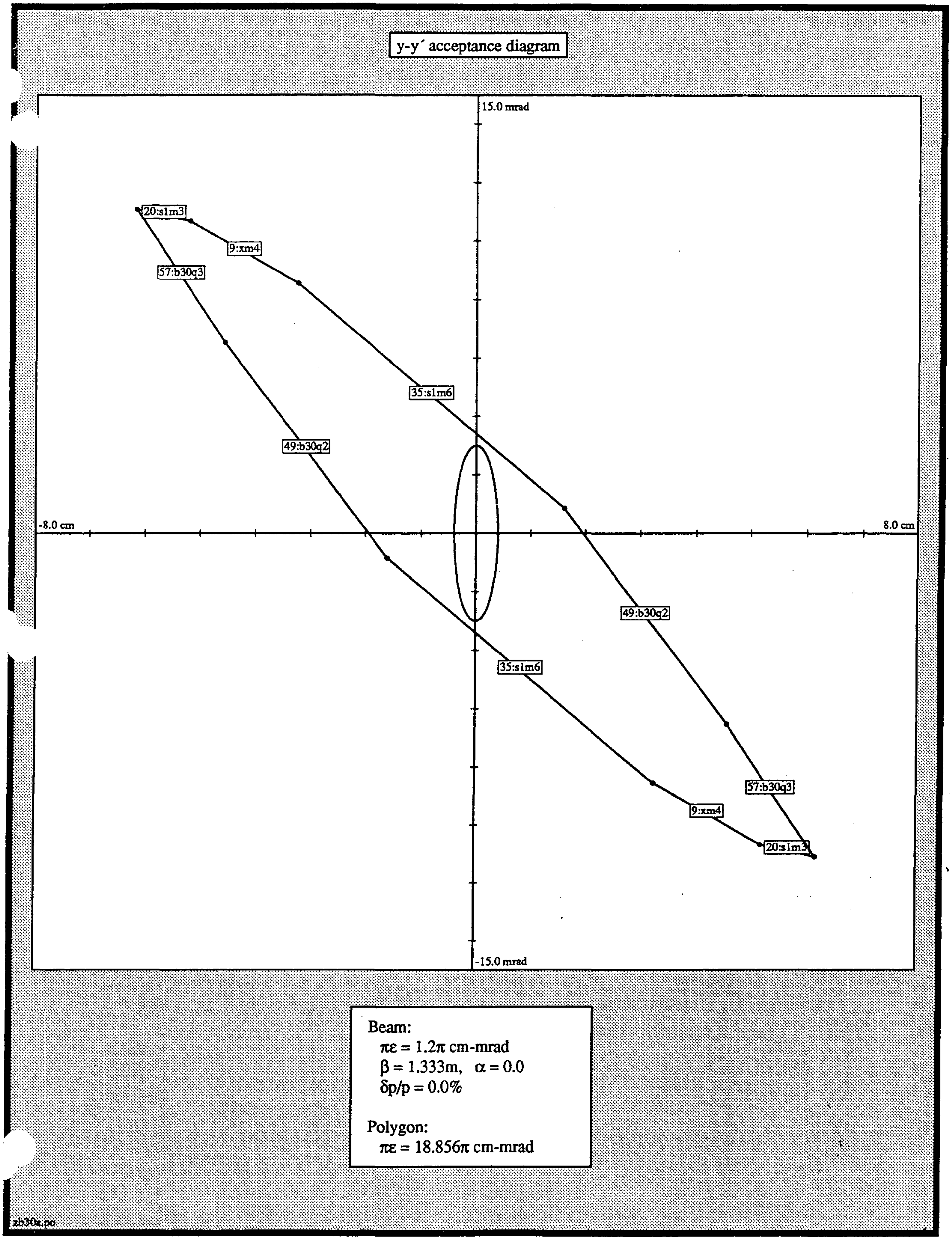
3.2.3 BEAM 30



x
ηx
y
ηy
x (cm)
y (cm)
ηx (m)
-ηy (m)
z (m)
8.0
0.0
8.0
12.0
0.0
-12.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
65.0
xf1wc
xq4a
xq4b
xm4wc
xm4
x1q4a
x1q4wc
x1q4b
s1m3wc
s1m3
s1f2wc
s1m4
s1m5
s1m6wc
s1m6
s1q7wc
s1q7a
s1q7b
s1m6sw
s1f3wc
b30q1
b30q2
b30wc1
b30wc2
b30wc3
b30q3
b30q3
b30q4
b30q4
b30wc4
b30wc5
zb30ag.gx



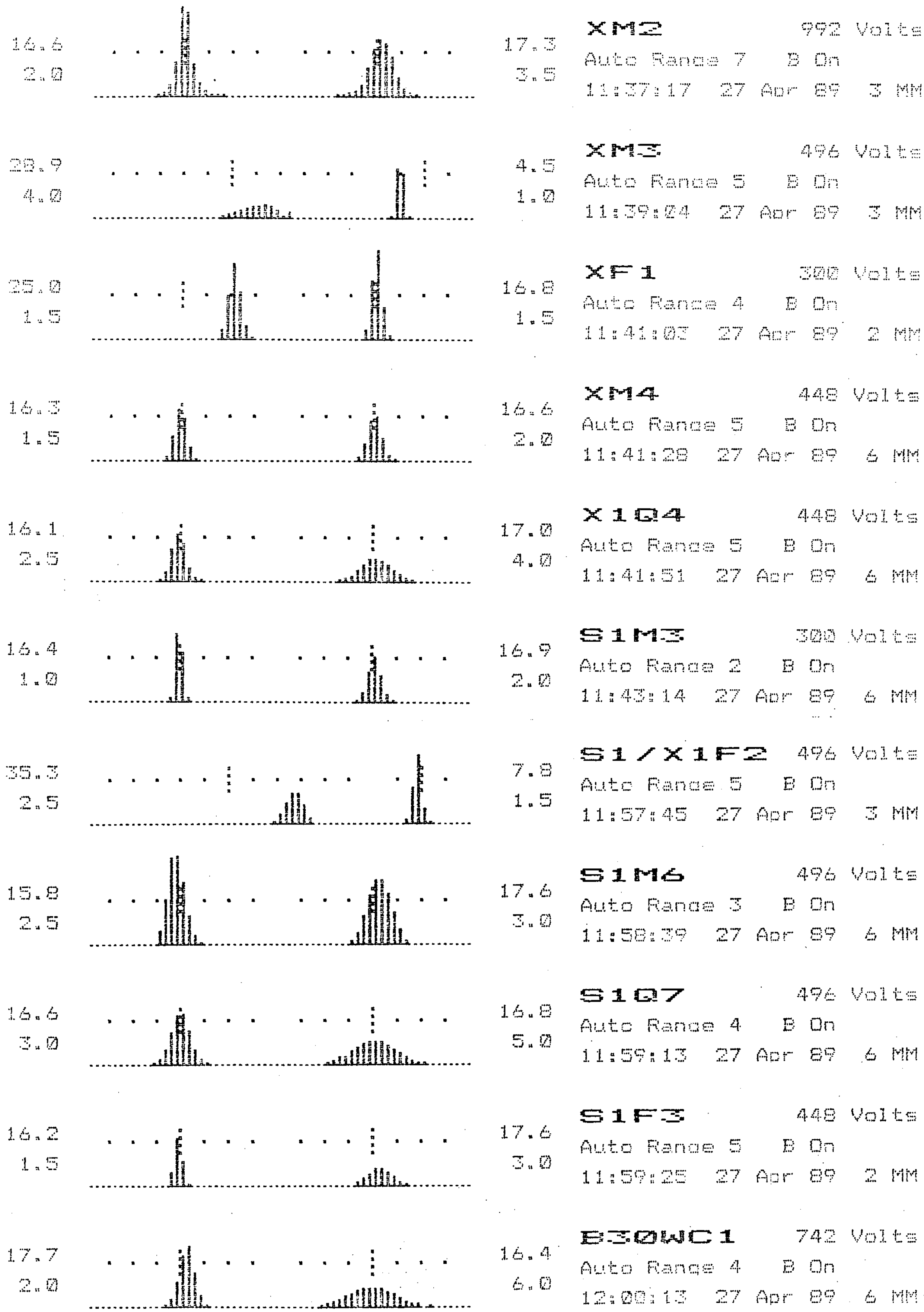
3.2.4 BEAM 30 HORIZONTAL ACCEPTANCE AT F1



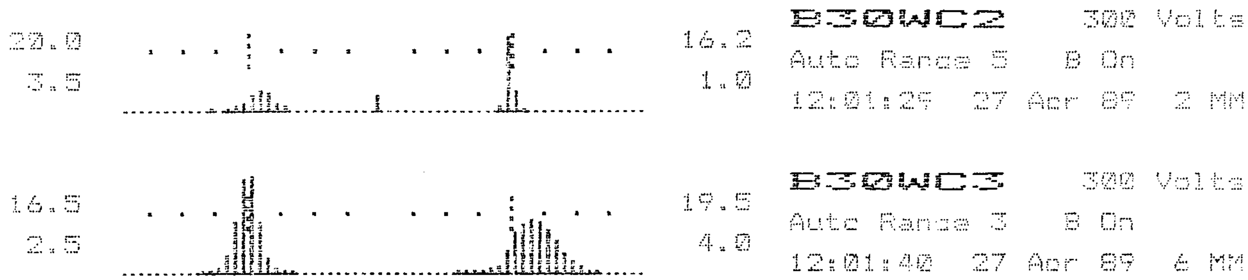
3.2.4 BEAM 30 VERTICAL ACCEPTANCE AT F1

3.2.5 Beam 30 Focal Points

Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (cm/%)
F1	XF1WC	1.0	1.0	0.00
F2	X1F2WC	1.76	0.49	-2.26
F3	B30WC1	0.54	0.56	0.08
F4	B30WC2	1.49	0.29	0.74
F5	B30WC4	0.41	0.53	-0.48



3.2.6 (a) Wire Chamber Pictures



3.2.6 (a) Wire Chamber Pictures

27APR89 EPB ACL PRINT 12:29:33 PAGE 1

NAME	DATE	TIME	ENTRY	BEAM LINE
PRENT B30	27APR99	12:29:33	0	BEAM30

PERTURBATION UNIT DATA

NAME		FLAGS	AMPLITUDE	DELAY	GATE
X	P1	P+	79.83	400	1680
X	P2	P+	42.56	400	1510
X	S2	S+	291.31	470	1300
X	S1	S+	93.29	440	1300
X	S2	P+	30.84	450	1100
X	M3	S+	7.42	360	1400
X	S1	P+	3.27	400	1300
X	M2	S+	0.94	400	1450

NAME		SP	AM	DI	OFFSET
X	P1	0.00	0.88	5	0.00
X	P2	0.00	0.49	5	0.00
X	S1	-1.51	0.00	5	0.00
X	S2	0.00	2.20	5	0.00
X	M1	620.61	691.96	5	0.00
X	M2	1712.84	1591.29	2005	0.00
X	M3	1240.28	1266.24	5	0.00
X	Q3A	800.18	784.56	5	0.00
X	Q3B	847.37	835.20	5	0.00
	M3V	37.26	36.39	2001	37.26
	M4	7255.20	7382.32	3001	7255.20
	Q4A	0.00	0.00	5	0.00
	Q4B	0.00	3.48	5	0.00
	Q4A	1148.69	1147.48	2005	0.00
	Q4B	1181.48	1178.46	2005	0.00
X1	MSS	25.00	22.69	2001	25.00
S1	M3	190.82	189.28	2001	190.82
S1	M4	1709.92	1714.12	2005	1650.05
S1	M5	681.70	677.86	2005	599.95
S1	M6	255.93	257.76	2001	255.93
S1	Q7A	841.43	857.09	2005	0.20
S1	Q7B	936.03	938.20	2005	0.00
S1	M6S	3.58	5.83	1	3.58
S1	M7	32.94	34.00	2001	32.94
B30	Q1	645.13	644.60	2001	645.13
B30	Q2	652.04	636.10	2001	652.04
B30	M2	0.00	0.39	2001	0.00
[illegible]	M3	0.00	0.03	1	0.00
B30	Q4A	0.00	0.00	1	0.00
B30	Q4B	0.00	0.00	1	0.00

DATA FOR ENERGY CALCULATION

INJECTION: HILAC LOCAL

PARTICLE: Ne^{10+} 2S FREQ : 246.2 KH

MASS NUM: 20 2S FIELD: 404

CHARGE : 10^+ K.ENERGY: 1048 MEV

INFLECTOR H.V: 17.0

EXTRACTION: PFW: ON; OFF;

FIELD: 7650 P1 CUR:

FREQ: 2.20 MHz P2 CUR:

BEAM RAD: 599.2

	RADIUS	CURRENT	TAIL WAG	
M1;		;	RISE;	GAUSS
M2:		;	TIME;	mSECS
M3;	-------;		S1 ON;	OFF;
			S2 ON:	OFF:

STD MATERIAL AT F1: IN; ✓ OUT;

3.2.6 (b) Magnet Currents

3.2.7 (a) Beam 30 Optic-Axis Beam Positions on the Wire Chambers

Active Dipole Magnets	Wire Chamber	Beam Center on Wire Chamber (Wire Number)	
		Horizontal	Vertical
XM3V	X1Q4WC	---	16.5
XM4	S1M3WC	16.5	---
S1M3	S1F2WC	35.0	---
S1M4*	S1M6WC	16.5	---
S1M5*	S1Q7WC	16.5	---
S1M6*	S1F3WC	16.5	---
X1M5S	S1Q7WC	---	16.5
S1M6S	B30WC1	---	16.0
S1M7	B30WC3	16.5	---
B30M1S	B30WC3	---	16.5

*See Section 5.2

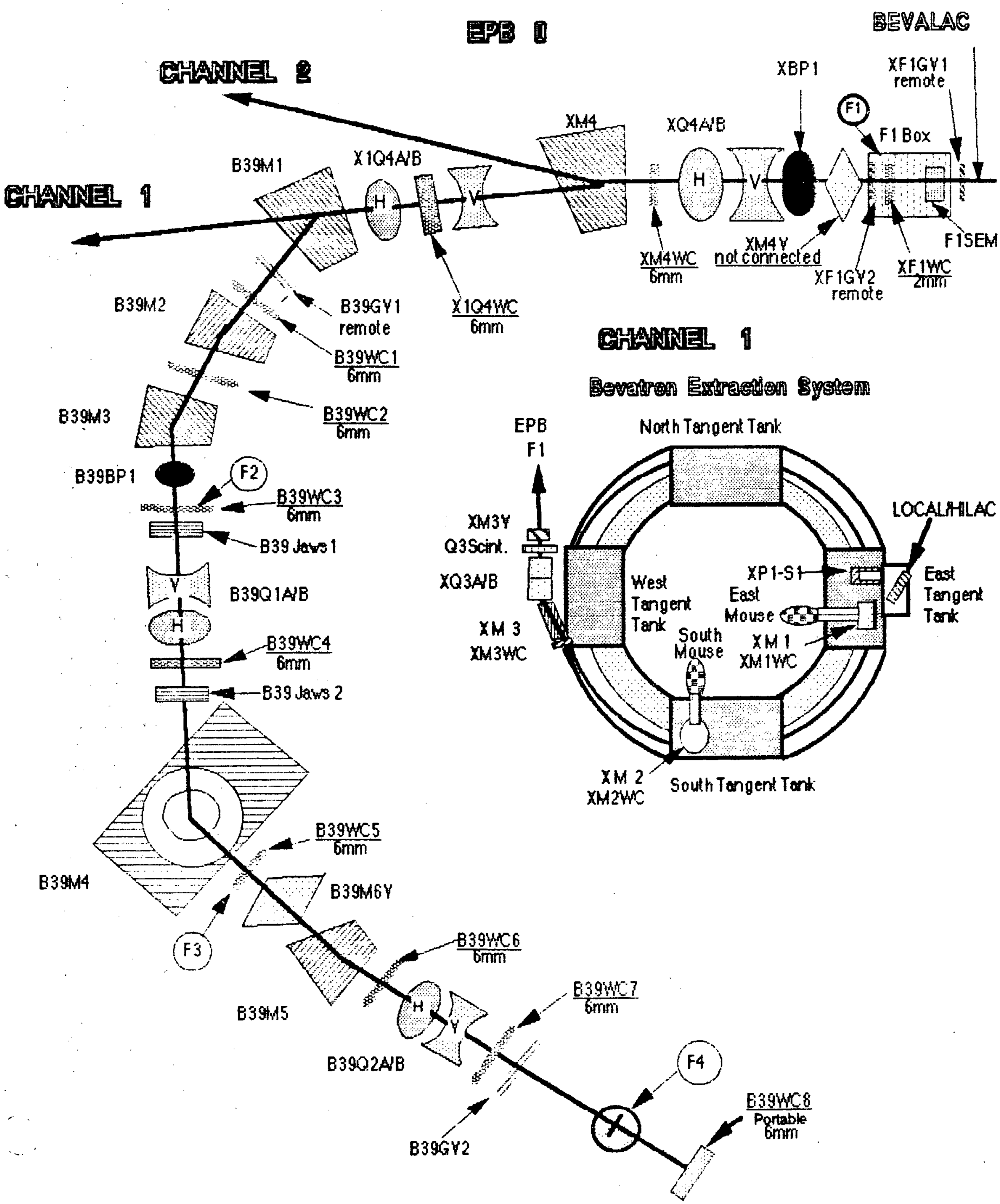
3.2.7 (b) <u>Beam 30 Average Magnet Currents per Bevalac Field</u>

Beam Line Magnet	Magnet Current per Bevalac Field (Ampere/kG)
XM4	952.3*
X1Q4A	153.3
X1Q4B	160.0
S1M3	24.6
S1M4	226.6
S1M5	87.7
S1M6	35.3
S1Q7A	115.3
S1Q7B	125.9
S1M7	4.0
B30Q1	85.8
B30Q2	82.0
B30Q3	220.0
B30Q4	212.0

* Magnet field per Bevalac field (gauss/kG)

3.3 BEAM 39

BEAM 39


EPB 0
BEVALAC
CHANNEL 2
CHANNEL 1
XBP1
XF1GV1
remote
F1
F1 Box
XM4
XQ4A/B
B39M1
X1Q4A/B
H
V
XM4WC
6mm
XM4V
not connected
XF1GV2
remote
XF1WC
2mm
F1SEM
B39M2
B39GV1
remote
X1Q4WC
6mm
B39WC1
6mm
B39M3
B39WC2
6mm
CHANNEL 1
Bevatron Extraction System
EPB
F1
North Tangent Tank
B39BP1
F2
B39WC3
6mm
B39 Jaws 1
B39Q1A/B
XM3V
Q3Scint.
XQ3A/B
XM 3
XM3WC
West
Tangent
Tank
XP1-S1
East
Mouse
South
Mouse
XM 1
XM1WC
LOCAL/HILAC
East
Tangent
Tank
B39WC4
6mm
B39 Jaws 2
XM 2
XM2WC
South Tangent Tank
B39WC5
6mm
B39M4
B39M6V
F3
B39WC6
6mm
B39M5
B39WC7
6mm
B39Q2A/B
F4
B39WC8
Portable
6mm
B39GV2

3.3.2 (a) Beam 39 - Magnet Parameters

		Quadropole Magnet		Dipole Magnet					
Beam Line Element	Effective Length (m)	Max Gradient (kG/m)	Pole Tip Radius (m)	Max Field (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	Magnet or Wire Chamber Type (in)
(F1)-XF1WC	0.000								2mm Special
	3.969								
XQ4A	0.884	-147	0.1046						8QB32
	0.284								
XQ4B	0.884	+147	0.1046						8QB32
	0.230								
---XM4WC	0.000								6mm Perm. Gas
	0.233								
XM4	2.668			-17.86	15.972	9.572	0.00	9.572	4.1x22x100H
	0.269								
X1Q4A	0.884	-144	0.1046						8QN32
	0.264								
---X1Q4WC	0.000								6mm Perm. Gas
	0.140								
X1Q4B	0.884	+147	0.1046						8QB32
	0.259								
B39M1	1.036			-19.7	2.969	20.0	10.00	10.00	8x16x36C
	0.774								
---B39WC1	0.000								6mm Perm. Gas
	0.394								
B39M2	1.036			-19.7	2.969	20.0	10.00	10.00	8x16x36C
	0.274								
---B39WC2	0.000								6mm Perm. Gas
	0.540								
339M3	1.080			-21.1	2.807	22.036	11.018	11.018	8x18x36HPH
	1.958								
(F2)-B39WC3	0.000								6mm Crawford
	2.428								
B39Q1A	0.734	-128	0.1048						8/12QB24
	0.142								
B39Q1B	0.734	+128	0.1048						8/12QB24
	0.220								
---B39WC4	0.000								6mm Cantilever
	1.753								
B39M4	1.872			-20.7	2.145	50.0	25.0	25.0	7.25x63H
	3.115								
(F3)-B39WC5	0.000								6mm Crawford
	4.372								
B39M5	1.093			-20.8	2.554	24.5	12.25	12.25	6x18x36LPH
	0.440								
---B39WC6	0.000								6mm Crawford
	0.200								
B39Q2A	1.321	+128	0.1048						8/12QB48
	0.165								
B39Q2B	1.321	-128	0.1048						8/12QB48
	1.835								
---B39WC7	0.000								6mm Crawford
	1.670								
(F4)-B39CSC	0.000								Center Scatt. Chamber

```
b
Beam rigidity =    19.2000 t-m
x,y emittance =     1.2000   1.2000 cm-mrad
dp/p =  0.000%
t
Transport mode
        betax =    1.3333   alphax =   0.0000
        betay =    1.3333   alphay =   0.0000
        etax  =    0.0000   eta'x  =   0.0000
        etay  =    0.0000   eta'y  =   0.0000
d
```

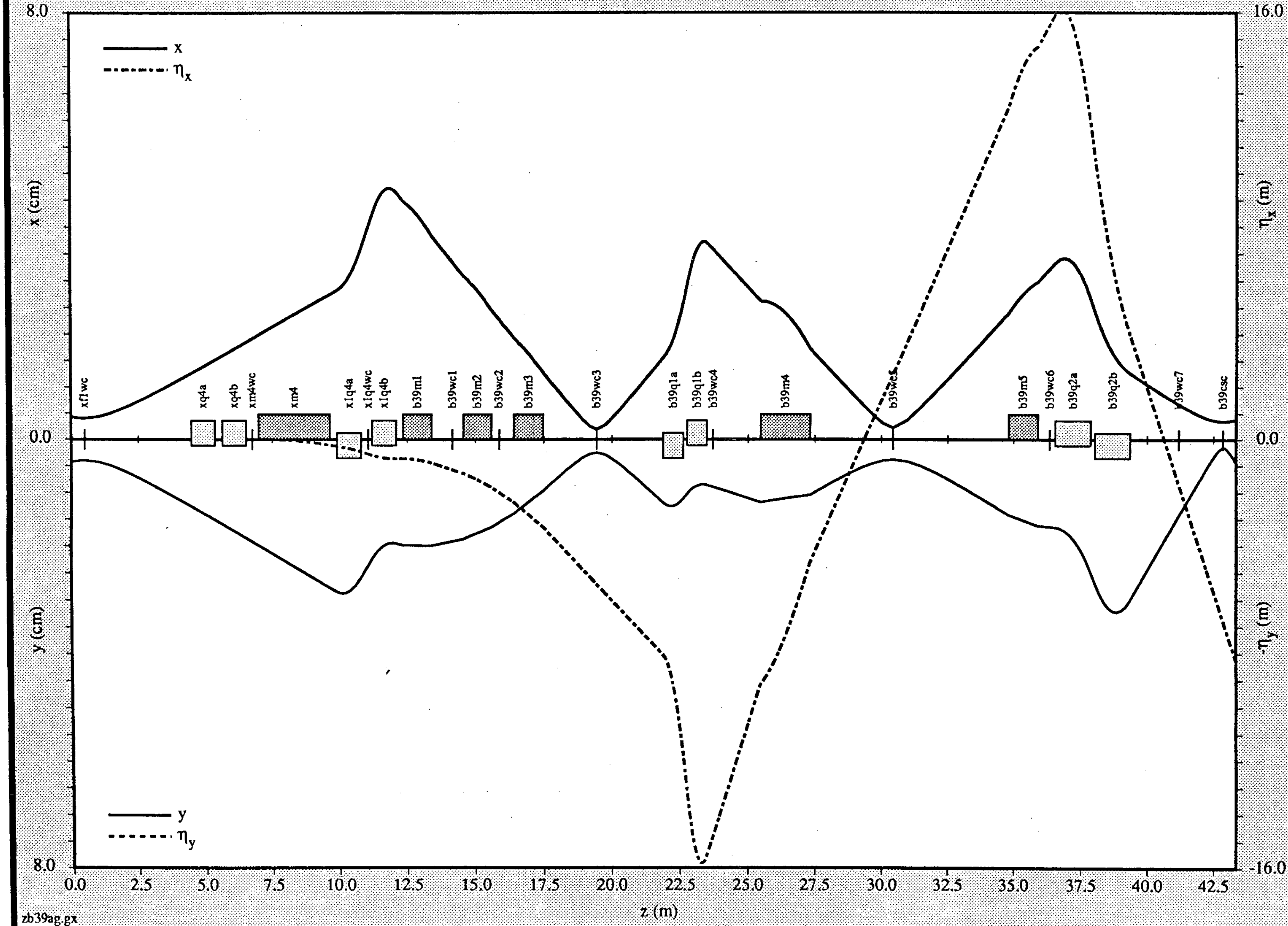
	name	type	vcode	lth,angle	b,b',s	n,gap	xaper	yaper
	----	----	-----	---------	------	-----	-----	-----
1	xflwc	lens	0.0	0.000000	0.000000	0.0000		
2	l1	drift	0.0	3.969000	0.000000	0.0000		
3	xq4a	quad	0.0	0.884000	0.000000	0.0000	0.1000	0.1000
4	s1	drift	0.0	0.284000	0.000000	0.0000		
5	xq4b	quad	0.0	0.884000	0.000000	0.0000	0.1000	0.1000
6	l2	drift	0.0	0.230000	0.000000	0.0000		
7	xm4wc	lens	0.0	0.000000	0.000000	0.0000		
8	l3	drift	0.0	0.233000	0.000000	0.0000		
9	xm4	bend	0.0	2.668000	-1.202100	0.0000	0.0836	0.0457
10	xm4o	edge	0.0	9.572000	1.202100	0.0000		
11	l4	drift	0.0	0.269000	0.000000	0.0000		
12	xlq4a	quad	0.0	0.884000	-8.541968	0.0000	0.1000	0.1000
13	s2a	drift	0.0	0.264000	0.000000	0.0000		
14	xlq4wc	lens	0.0	0.000000	0.000000	0.0000		
15	s2b	drift	0.0	0.140000	0.000000	0.0000		
16	xlq4b	quad	0.0	0.884000	10.246016	0.0000	0.1000	0.1000
17	l5	drift	0.0	0.259000	0.000000	0.0000		
18	b39m1e	edge	0.0	10.000000	6.467000	0.0000		
19	b39m1	bend	0.0	1.036000	-6.467000	0.0000	0.1000	0.1000
20	b39m1e	edge	0.0	10.000000	6.467000	0.0000		
21	l6	drift	0.0	0.774000	0.000000	0.0000		
22	b39wc1	lens	0.0	0.000000	0.000000	0.0000		
23	l7	drift	0.0	0.394000	0.000000	0.0000		
24	b39m2e	edge	0.0	10.000000	6.467000	0.0000		
25	b39m2	bend	0.0	1.036000	-6.467000	0.0000	0.1000	0.1000
26	b39m2e	edge	0.0	10.000000	6.467000	0.0000		
27	l8	drift	0.0	0.274000	0.000000	0.0000		
28	b39wc2	lens	0.0	0.000000	0.000000	0.0000		
29	l9	drift	0.0	0.540000	0.000000	0.0000		
30	b39m3e	edge	0.0	11.018003	6.841000	0.0000		
31	b39m3	bend	0.0	1.080000	-6.841000	0.0000	0.1000	0.1000
32	b39m3e	edge	0.0	11.018003	6.841000	0.0000		
33	l10	drift	0.0	1.958000	0.000000	0.0000		
34	b39wc3	lens	0.0	0.000000	0.000000	0.0000		
35	l11	drift	0.0	2.428000	0.000000	0.0000		
36	b39q1a	quad	0.0	0.734000	-23.639643	0.0000	0.1000	0.1000
37	s3	drift	0.0	0.142000	0.000000	0.0000		
38	b39q1b	quad	0.0	0.734000	22.124842	0.0000	0.1000	0.1000
39	l12	drift	0.0	0.220000	0.000000	0.0000		
40	b39wc4	lens	0.0	0.000000	0.000000	0.0000		
41	l13	drift	0.0	1.753000	0.000000	0.0000		
42	b39m4e	edge	0.0	25.000000	8.950000	0.0000		
43	b39m4	bend	0.0	1.872000	-8.950000	0.0000	0.1000	0.0920
44	b39m4e	edge	0.0	25.000000	8.950000	0.0000		
45	l14	drift	0.0	3.115000	0.000000	0.0000		
46	b39wc5	lens	0.0	0.000000	0.000000	0.0000		
47	l15	drift	0.0	4.372000	0.000000	0.0000		

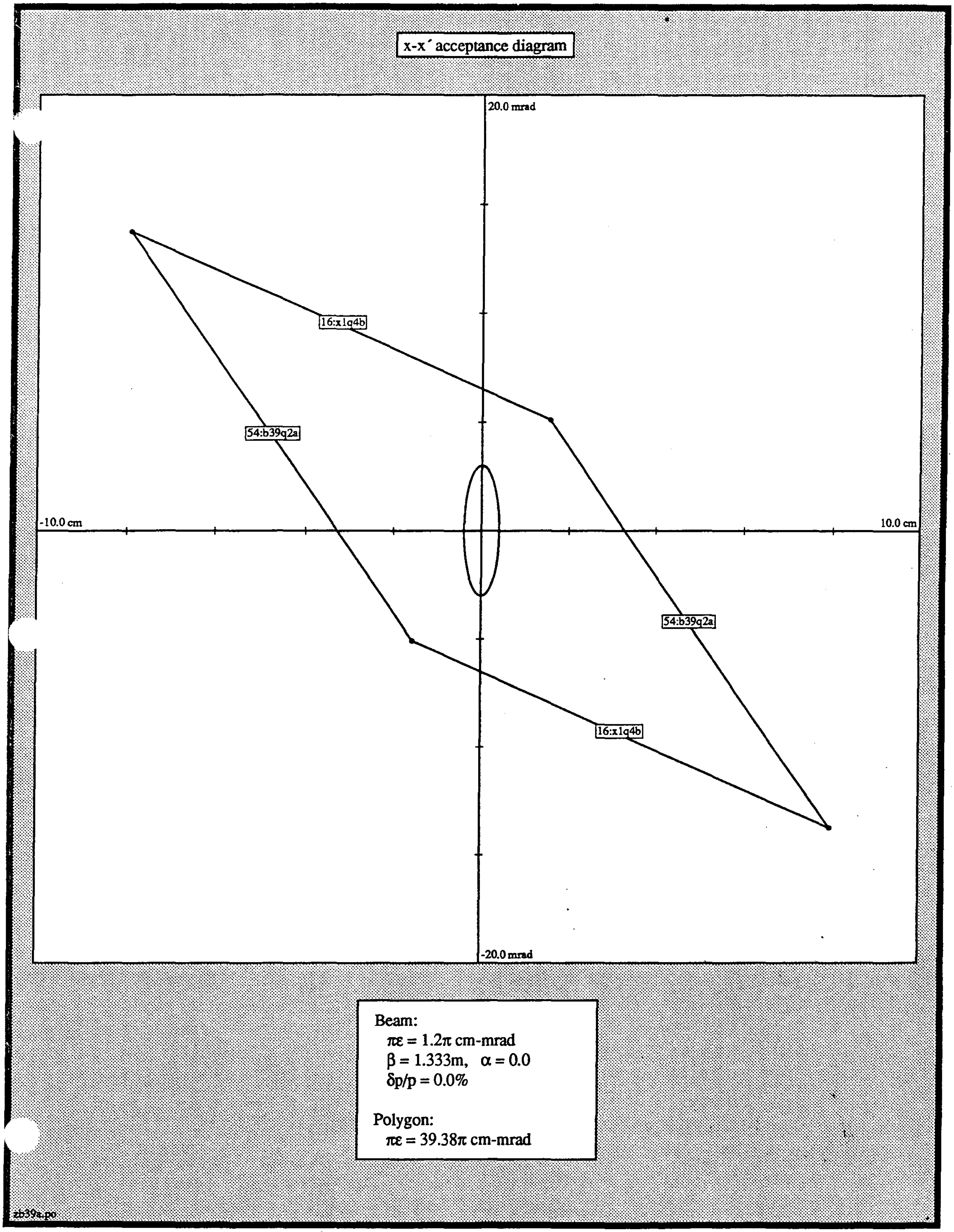
3.3.2 (b) <u>BEAM 39 - TRANSPORT LIST</u>

```
  48 b39m5e     edge   0.0    12.250000    7.517000   0.0000
  49 b39m5      bend   0.0     1.093000   -7.517000   0.0000  0.1000   0.0760
  50 b39m5e     edge   0.0    12.250000    7.517000   0.0000
  51 l16        drift  0.0     0.440000    0.000000   0.0000
  52 b39wc6     lens   0.0     0.000000    0.000000   0.0000
  53 l17        drift  0.0     0.200000    0.000000   0.0000
  54 b39q2a     quad   0.0     1.321000    9.314491   0.0000  0.1000   0.1000
  55 s4         drift  0.0     0.165000    0.000000   0.0000
  56 b39q2b     quad   0.0     1.321000  -10.099849   0.0000  0.1000   0.1000
  57 l18        drift  0.0     1.835000    0.000000   0.0000
  58 b39wc7     lens   0.0     0.000000    0.000000   0.0000
  59 l19        drift  0.0     1.670000    0.000000   0.0000
  60 b39csc     lens   0.0     0.000000    0.000000   0.0000
quit
End of program
```

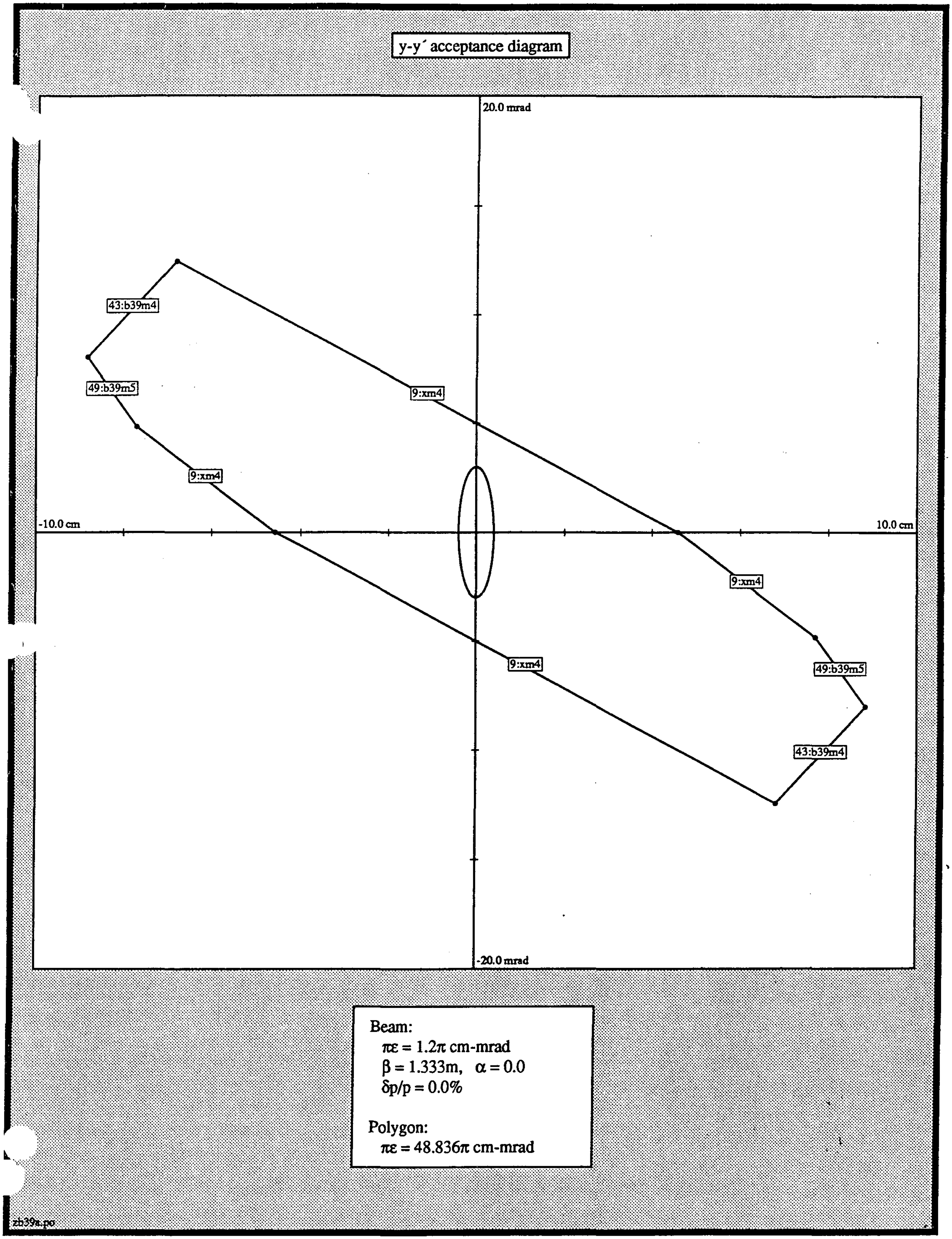
3.3.2 (b) BEAM 39 - TRANSPORT LIST

3.3.3 BEAM 39


x
η_x
y
η_y
x (cm)
y (cm)
η_x (m)
$-\eta_y$ (m)
z (m)
8.0
0.0
8.0
16.0
0.0
-16.0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0
32.5
35.0
37.5
40.0
42.5
xf1wc
xq4a
xq4b
xm4wc
xm4
x1q4a
x1q4wc
x1q4b
b39m1
b39wc1
b39m2
b39wc2
b39m3
b39wc3
b39q1a
b39q1b
b39wc4
b39m4
b39wc5
b39m5
b39wc6
b39q2a
b39q2b
b39wc7
b39csc
zb39ag.gx



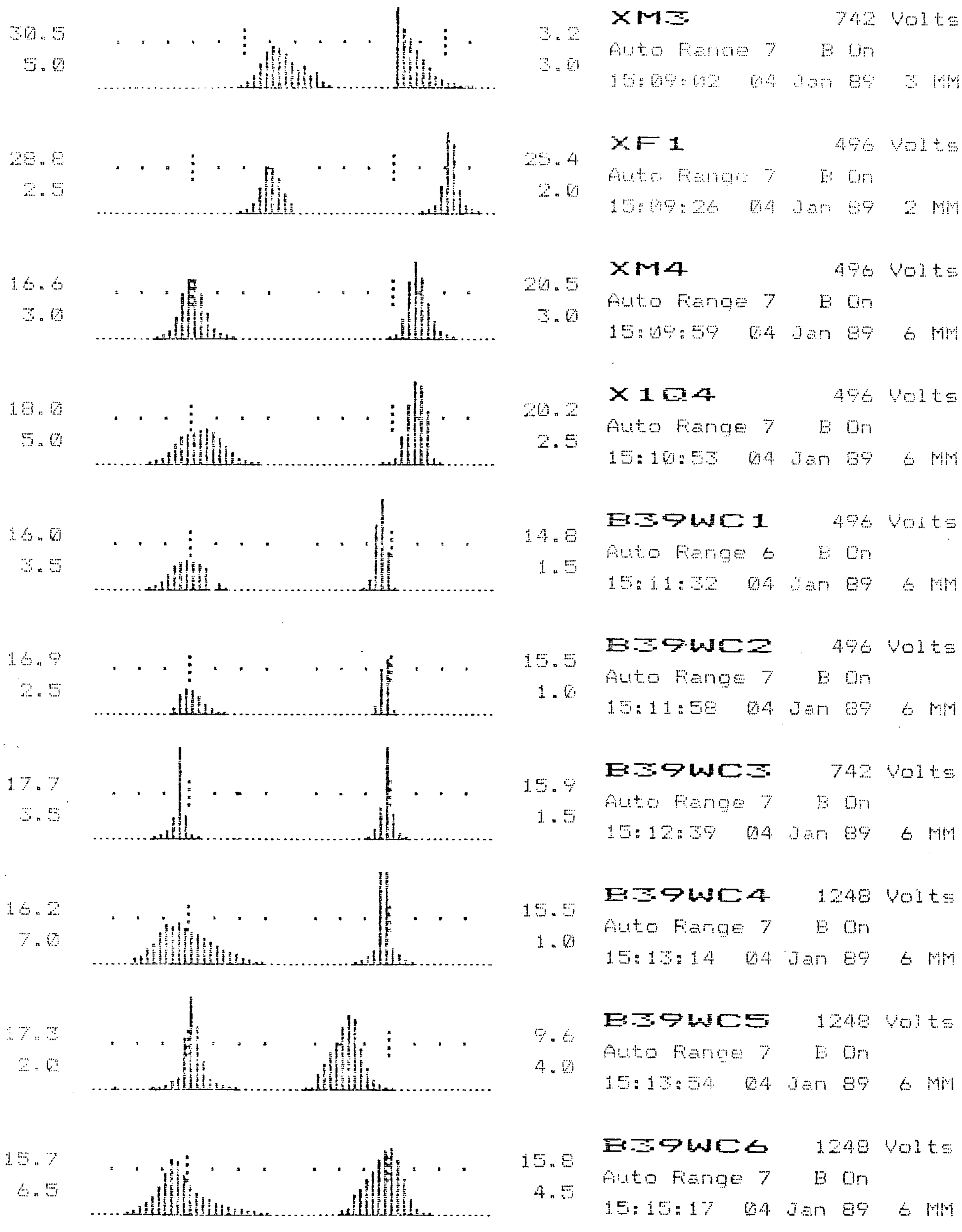
3.3.4 BEAM 39 HORIZONTAL ACCEPTANCE AT F1



3.3.4 BEAM 39 VERTICAL ACCEPTANCE AT F1

3.3.5 Beam 39 Focal Points

Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (cm/%)
F1	XF1WC	1.0	1.0	0.00
F2	B39WC3	0.47	0.63	-5.42
F3	B39WC5	0.55	0.96	2.50
F4	Center Scatter Chamber (CSC)	0.87	0.35	-6.80



3.3.6 (a) Wire Chamber Pictures

4JAN89 EPB ACL PRINT 15:07:13 PAGE 1

NAME	DATE	TIME	ENTRY	BEAM LINE
CURRENT WOBD	4JAN89	15:07:13	0	BEAM39

PERTURBATION UNIT DATA

NAME		FLAGS	AMPLITUDE	DELAY	GATE
X	P1	P+	36.00	400	1680
X	P2	P+	32.00	400	1510
X	S2	S+	291.31	470	1300
X	S1	S+	125.66	440	1150
X	S2	P+	30.84	450	1100
X	M3	S	0.12	400	910
X	S1	P+	15.50	400	1240
X	M2	S+	27.36	380	1120

NAME		SP	AM	DI	OFFSET
X	P1	0.00	0.66	5	0.00
X	P2	0.00	0.10	5	0.00
X	S1	0.00	0.00	5	0.00
X	S2	0.00	2.20	5	0.00
X	M1	144.19	153.15	5	0.00
X	M2	547.52	538.40	2005	0.00
X	M3	462.48	479.79	5	0.00
X	Q3A	199.84	183.38	5	0.00
X	Q3B	173.49	183.93	5	0.00
X	M3V	74.22	73.77	2001	74.22
X	M4	2207.32	2209.67	3003	2207.32
	Q4A	0.00	0.00	5	0.00
	Q4B	0.00	4.64	5	0.00
	Q4A	306.57	306.92	2007	0.00
X1	Q4B	361.18	358.16	2005	0.00
X1	M58	0.00	0.41	2001	0.00
S1	M6	1069.49	1073.34	2001	1069.49
S1	M5	0.00	961.00	2005	960.52
B39	Q3A+B	1010.41	1001.71	2001	1010.41
B39	Q1A	0.00	0.00	1	0.00
B39	Q2A	0.00	2700.66	1	0.00
B39	Q2B	0.00	2700.66	1	0.00

B39 M1 35.23 mV
B39 M2 24.32
B39 M3 16.72
B39 Q1A 15.86
B39 Q1B 17.88
B39 M4 13.63
B39 M5 22.03
B39 Q2A 6.45
B39 Q2B 7.16
B39 M1V 1.49

^{20}NE+9

22C1g B39

DATA FOR ENERGY CALCULATION

INJECTION: HILAC LOCAL ✓

PARTICLE; Ne 28 FREQ : 246.6

MASS NUM; 20 28 FIELD; 348

CHARGE ; +9 K.ENERGY; 109.5 MEV

INFLECTOR H.V; -18.9

EXTRACTION: PFW: ON; (OFF;)

FIELD; 2261 gauss P1 CUR;

FREQ; 1.115 P2 CUR;

BEAM RAD; 600.4"

	RADIUS	CURRENT	TAIL WAG	
M1;		;	RISE:	12 GAUSS
M2:		;	TIME;	mSECS
M3;	--------	;	S1 ON;	OFF;
			S2 ON;	OFF;

STD MATERIAL AT F1: IN; (OUT;)

3.3.6 (b) Magnet Currents

3.3.7 (a) Beam 39 Optic-Axis Beam Positions on the Wire Chambers

Active Dipole Magnets	Wire Chamber	Beam Center on Wire Chamber (Wire Number)	
		Horizontal	Vertical
XM4	X1Q4WC	16.5	---
B39M1	B39WC1	16.5	---
B39M2	B39WC2	16.5	---
B39M3	B39WC4	16.5	---
XM3V	B39WC6	---	16.5
B39M4	B39WC5	16.5	---
B39M5	B39WC7	16.5	---
B39M6V	B39WC7	---	16.5

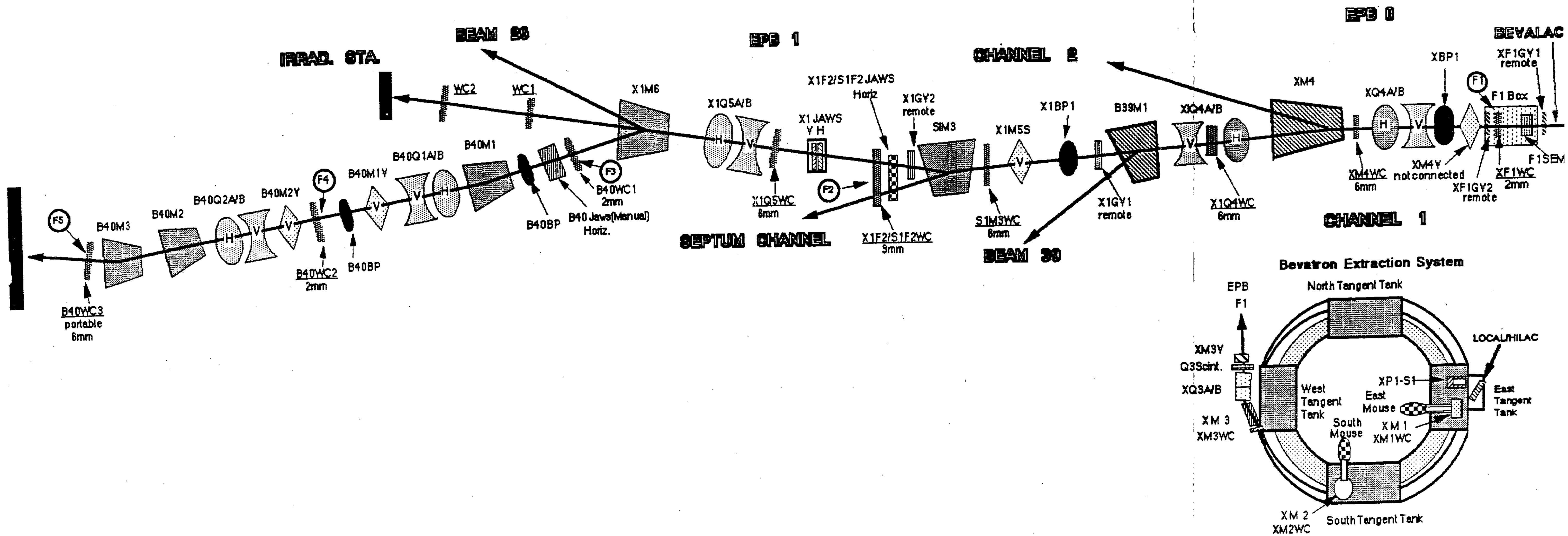
3.3.7 (b) Beam 39 Average Magnet Currents per Bevalac Field

Beam Line Magnet	Magnet Current per Bevalac Field (Ampere/kG)
XM4	952.3*
X1Q4A	134.1
X1Q4B	158.3
B39M1	456.2
B39M2	431.6
B39M3	436.7
B39Q1A	264.2
B39Q1B	229.8
B39M4	373.9
B39M5	193.8
B39Q2A	79.7
B39Q2B	79.6

* Magnet field per Bevalac field (gauss/kG)

3.4 BEAM 40

BEAM 40



AUG 89

3.4.2 (a) Beam 40 - Magnet Parameters									
		Quadropole Magnet		Dipole Magnet					
Beam Line Element	Effective Length (m)	Max Gradient (kG/m)	Pole Tip Radius (m)	Max Field (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	Magnet Type (in)
(F1)-XF1WC	0.000								2mm Special
	3.969								
XQ4A	0.884	-147	0.1046						8QB32
	0.284								
XQ4B	0.884	+147	0.1046						8QB32
	0.230								
---XM4WC	0.000								6mm Perm. Gas
	0.233								
XM4	2.668			-17.86	15.972	9.572	0.00	9.572	4.1x22x100H
	0.269								
X1Q4A	0.884	+144	0.1046						8QN32
	0.264								
---X1Q4WC	0.000								6mm Perm. Gas
	0.140								
X1Q4B	0.884	-147	0.1046						8QB32
	4.862								
---S1M3WC	0.000								6mm Perm. Gas
	0.340								
S1M3	2.250			20.0	42.58	3.028	0.0	3.028	4.38x15x84H
	0.770								
(F2)-X1F2WC	0.000								3mm Perm. Gas
	9.480								
---X1Q5WC	0.000								6mm Perm. Gas
	0.240								
X1Q5A	0.884	-144	0.1046						8QN32
	0.306								
X1Q5B	0.884	+144	0.1046						8QN32
	0.361								
X1M6	1.036			-22.0	9.577	6.2	0.0	6.2	6x16x36C
	4.318								
(F3)-B40WC1	0.000								2mm Cantilever
	4.940								
B40M1	1.036			22.0	9.577	6.2	3.1	3.1	6x16x36C
	0.335								
B40Q1A	0.884	+144	0.1046						8QN32
	0.082								
B40Q1B	0.884	-144	0.1046						8QN32
	6.453								
(F4A)	0.000								Target Box
	1.817								
(F4B)-B40WC2	0.000								2mm Crawford
	4.625								
B40Q2A	0.884	-147	0.1046						8QB32
	0.132								
B40Q2B	0.884	+147	0.1046						8QB32
	1.087								
B40M2	1.036			19.7	10.80	5.5	2.75	2.75	8x16x36C
	0.173								
B40M3	1.056			21.4	11.01	5.5	-2.75	8.25	8.12x40x36H
	9.264								
(F5)-B40WC3	0.000								2 or 6mm WC

```
b
Beam rigidity =    19.2000 t-m
x,y emittance =     1.2000   1.2000 cm-mrad
dp/p =  0.000%
t
Transport mode
        betax =    1.3333   alphax =    0.0000
        betay =    1.3333   alphay =    0.0000
        etax  =    0.0000   eta'x  =    0.0000
        etay  =    0.0000   eta'y  =    0.0000
d
```

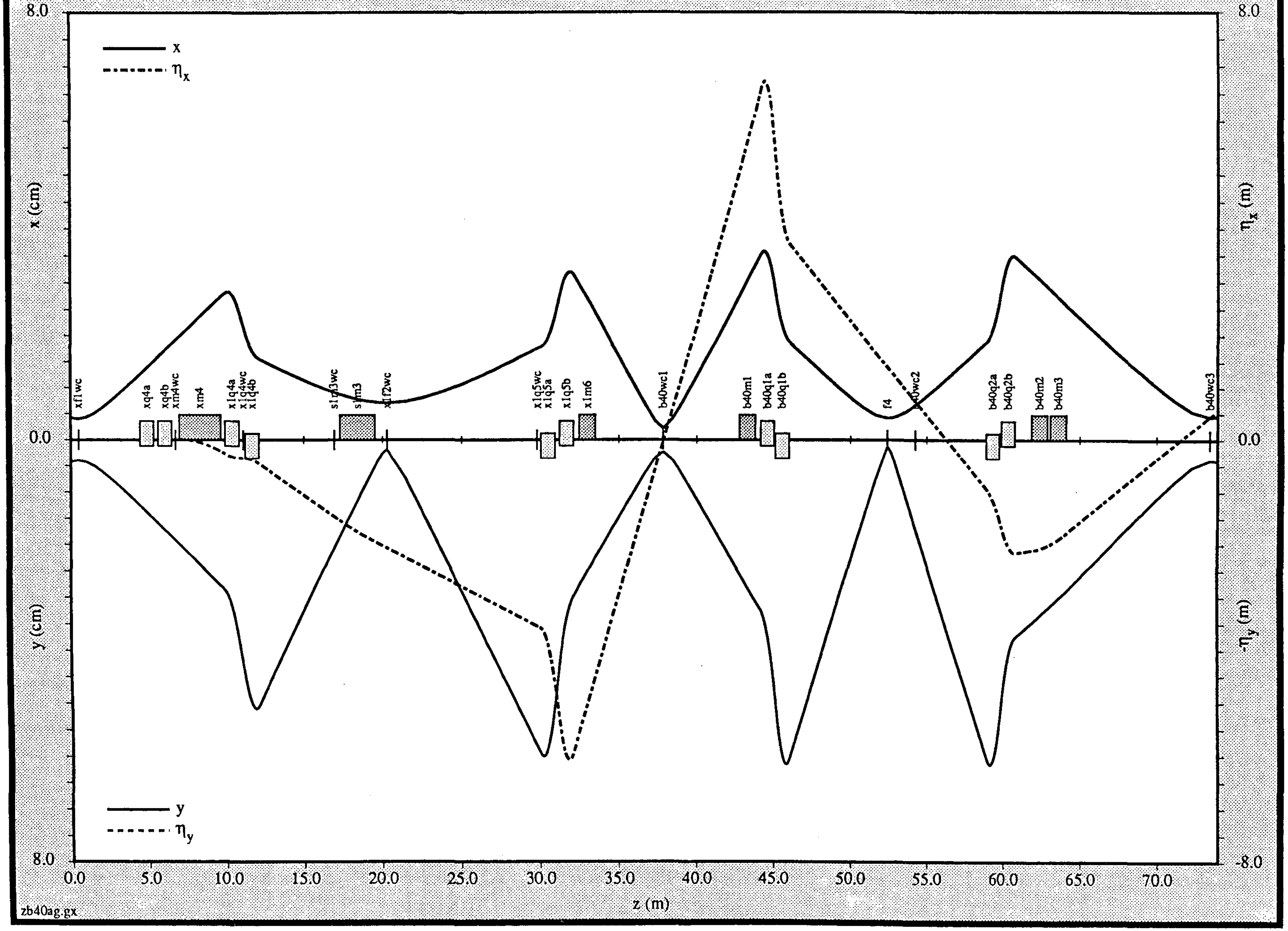
	name	type	vcode	lth,angle	b,b',s	n,gap	xaper	yaper
1	xflwc	lens	0.0	0.000000	0.000000	0.0000		
2	l1	drift	0.0	3.969000	0.000000	0.0000		
3	xq4a	quad	0.0	0.884000	0.000000	0.0000	0.1000	0.1000
4	s1	drift	0.0	0.284000	0.000000	0.0000		
5	xq4b	quad	0.0	0.884000	0.000000	0.0000	0.1000	0.1000
6	l2	drift	0.0	0.230000	0.000000	0.0000		
7	xm4wc	lens	0.0	0.000000	0.000000	0.0000		
8	l3	drift	0.0	0.233000	0.000000	0.0000		
9	xm4	bend	0.0	2.668000	-1.202100	0.0000	0.0836	0.0457
10	xm4o	edge	0.0	9.572000	-1.202100	0.0000		
11	l4	drift	0.0	0.269000	0.000000	0.0000		
12	xlq4a	quad	0.0	0.884000	9.937967	0.0000	0.1000	0.1000
13	s2a	drift	0.0	0.264000	0.000000	0.0000		
14	xlq4wc	lens	0.0	0.000000	0.000000	0.0000		
15	s2b	drift	0.0	0.140000	0.000000	0.0000		
16	xlq4b	quad	0.0	0.884000	-10.571670	0.0000	0.1000	0.1000
17	l5	drift	0.0	4.862000	0.000000	0.0000		
18	slm3wc	lens	0.0	0.000000	0.000000	0.0000		
19	l6	drift	0.0	0.340000	0.000000	0.0000		
20	slm3	bend	0.0	2.250000	0.451000	0.0000	0.1000	0.0525
21	slm3o	edge	0.0	3.028000	0.451000	0.0000		
22	l7	drift	0.0	0.770000	0.000000	0.0000		
23	xlf2wc	lens	0.0	0.000000	0.000000	0.0000		
24	l8	drift	0.0	9.480000	0.000000	0.0000		
25	xlq5wc	lens	0.0	0.000000	0.000000	0.0000		
26	l9	drift	0.0	0.240000	0.000000	0.0000		
27	xlq5a	quad	0.0	0.884000	-11.887638	0.0000	0.1000	0.1000
28	s3	drift	0.0	0.306000	0.000000	0.0000		
29	xlq5b	quad	0.0	0.884000	12.377823	0.0000	0.1000	0.1000
30	l10	drift	0.0	0.361000	0.000000	0.0000		
31	xlm6	bend	0.0	1.036000	-2.005000	0.0000	0.1000	0.0730
32	xlm6o	edge	0.0	6.200000	-2.005000	0.0000		
33	l11	drift	0.0	4.318000	0.000000	0.0000		
34	b40wcl	lens	0.0	0.000000	0.000000	0.0000		
35	l12	drift	0.0	4.940000	0.000000	0.0000		
36	b40mli	edge	0.0	3.100000	2.005000	0.0000		
37	b40ml	bend	0.0	1.036000	2.005000	0.0000	0.1000	0.0730
38	b40mlo	edge	0.0	3.100000	2.005000	0.0000		
39	l13	drift	0.0	0.335000	0.000000	0.0000		
40	b40qla	quad	0.0	0.884000	15.257069	0.0000	0.1000	0.1000
41	s4	drift	0.0	0.082000	0.000000	0.0000		
42	b40qlb	quad	0.0	0.884000	-15.211581	0.0000	0.1000	0.1000
43	l14	drift	0.0	6.453000	0.000000	0.0000		
44	f4	lens	0.0	0.000000	0.000000	0.0000		
45	l15	drift	0.0	1.817000	0.000000	0.0000		
46	b40wc2	lens	0.0	0.000000	0.000000	0.0000		
47	l16	drift	0.0	4.625000	0.000000	0.0000		

3.4.2 (b) BEAM 40 - TRANSPORT LIST

```
  48 b40q2a     quad   1.2     0.884000  -12.862744   0.0000  0.1000  0.1000
  49 s5         drift  0.0     0.132000    0.000000   0.0000
  50 b40q2b     quad   2.2     0.884000   12.058373   0.0000  0.1000  0.1000
  51 l17        drift  0.0     1.087000    0.000000   0.0000
  52 b40m2i     edge   0.0     2.750000    1.778000   0.0000
  53 b40m2      bend   0.0     1.036000    1.778000   0.0000  0.2000  0.1000
  54 b40m2o     edge   0.0     2.750000    1.778000   0.0000
  55 l18        drift  0.0     0.173000    0.000000   0.0000
  56 b40m3i     edge   0.0    -2.750000    1.744000   0.0000
  57 b40m3      bend   0.0     1.056000    1.744000   0.0000  0.5000  0.1000
  58 b40m3o     edge   0.0     8.250000    1.744000   0.0000
  59 l19        drift  0.0     9.264000    0.000000   0.0000
  60 b40wc3     lens   0.0     0.000000    0.000000   0.0000
quit
End of program
```

3.4.2 (b) BEAM 40 - TRANSPORT LIST

3.4.5 BEAM 40


x
η_x
y
η_y
x (cm)
y (cm)
η_x (m)
$-\eta_y$ (m)
z (m)
8.0
0.0
-8.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
65.0
70.0
xf1wc
xq4a
xq4b
xm4wc
xm4
x1q4a
x1q4wc
x1q4b
s1m3wc
s1m3
x1f2wc
x1q5wc
x1q5a
x1q5b
x1m6
b40wc1
b40m1
b40q1a
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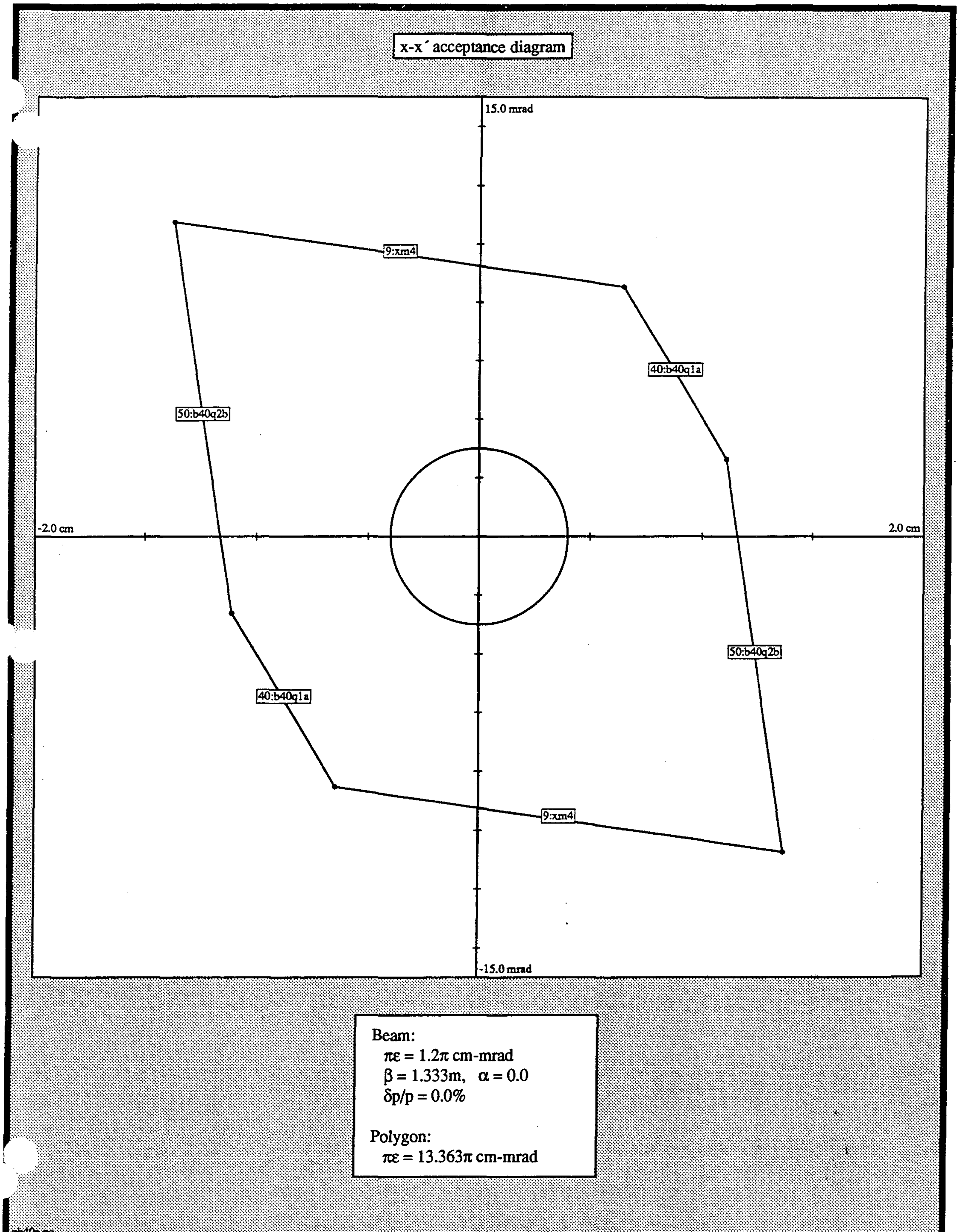
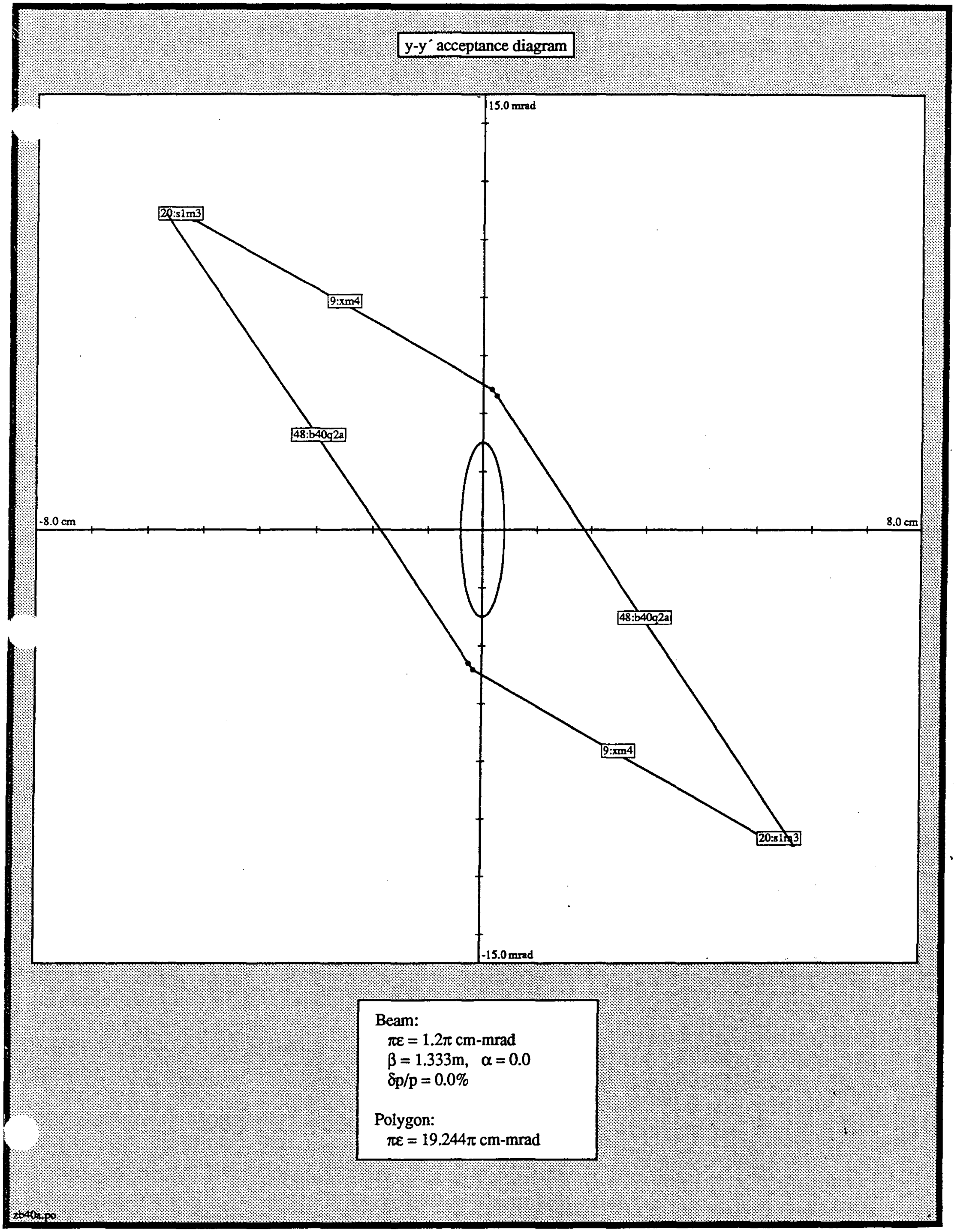
b40wc3
zb40ag.gx



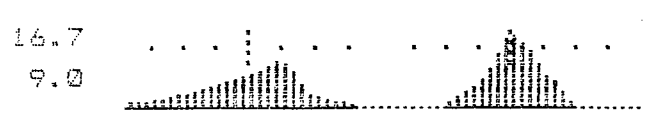
3.4.4. BEAM 40 HORIZONTAL ACCEPTANCE AT F1



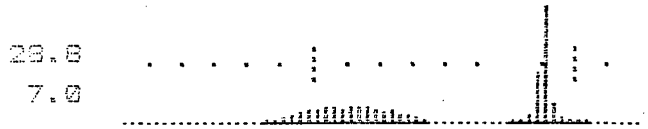
3.4.4 BEAM 40 VERTICAL ACCEPTANCE AT F1

3.4.5 Beam 40 Focal Points

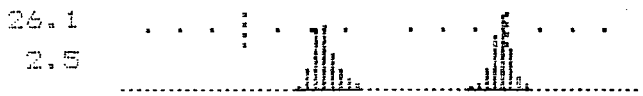
Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (cm/%)
F1	XF1WC	1.0	1.0	0.00
F2	X1F2WC	1.77	0.49	-2.06
F3	B40WC1	0.54	0.58	-0.03
F4	71-1/2" upstream B40WC2	1.05	0.32	1.39
F5	B40WC3	1.10	0.98	0.45



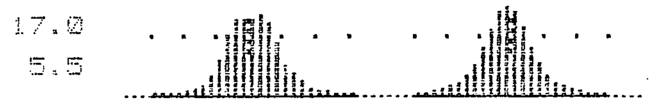
XM2 1984 Volts
Auto Range 7 B On
21:18:02 09 Feb 90 3 MM



XM3 742 Volts
Auto Range 5 B On
21:19:12 09 Feb 90 3 MM

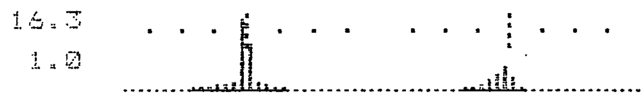


XF1 496 Volts
Auto Range 4 B On
21:30:38 09 Feb 90 2 MM

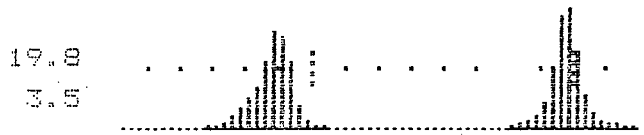


X1Q4 992 Volts
Auto Range 6 B On
21:32:06 09 Feb 90 6 MM

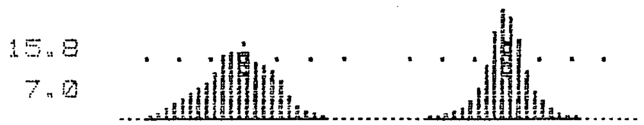
→ X M 4wc Centered on 16 Horz.



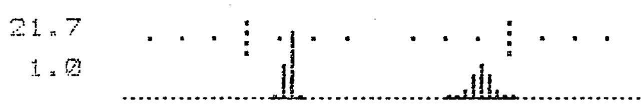
S1M3 992 Volts
Auto Range 6 B On
21:32:27 09 Feb 90 6 MM



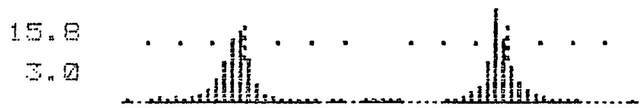
S1/X1F2 992 Volts
Auto Range 4 B On
21:32:51 09 Feb 90 3 MM



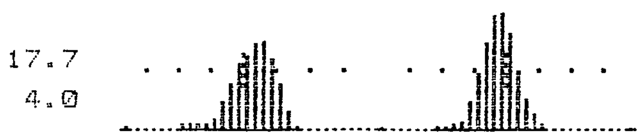
X1Q5 900 Volts
Auto Range 4 B On
21:33:15 09 Feb 90 6 MM



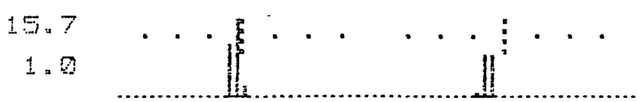
B40WC1 992 Volts
Auto Range 6 B On
23:36:24 09 Feb 90 2 MM



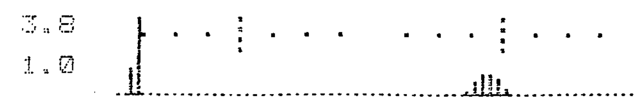
B40WC2 992 Volts
Auto Range 3 B On
23:37:26 09 Feb 90 2 MM



B26WC3 1248 Volts
Auto Range 2 B On
23:40:41 09 Feb 90 6 MM



B26WC4 1900 Volts
Auto Range 0 B On
23:41:32 09 Feb 90 2 MM



B26WC5 1984 Volts
Auto Range 2 B On
23:55:56 09 Feb 90 2 MM

3.4.6 (a) Wire Chamber Pictures

9FEB90 EPS ACL PRINT 23:49:08 PAGE 1

NAME	DATE	TIME	ENTRY	BEAM LINE
CURRENT B30	9FEB90	23:49:08	0	BEAM40

PERTURBATION UNIT DATA

NAME		FLAGS	AMPLITUDE	DELAY	GATE
X	P1	P+	100.00	400	190
X	P2	P+	0.10	400	1510
X	S2	S	291.31	470	1300
X	S1	S+	125.00	440	1060
X	S2	P	31.01	450	1100
X	M3	S	14.22	400	930

B40

$^{197}Au^{+52}$

NAME		SP	AM	DI	OFFSET
X	P1	0.00	0.66	5	0.00
X	P2	0.00	0.20	5	0.00
X	S1	0.00	0.00	5	0.00
X	S2	0.00	6.35	5	0.00
X	M1	619.04	675.95	5	0.00
X	M2	1639.57	1651.67	2005	0.00
X	M3	1220.86	1267.23	5	0.00
X	Q3A	799.84	796.65	5	0.00
X	Q3B	767.13	850.02	5	0.00
X	M3V	0.00	0.12	2001	0.00
XF1	PM	1999.94	2051.78	1	1999.94
X	M4	7504.73	7419.98	3001	7504.73
X	M4V	0.03	0.37	1	0.03
	Q4A	0.00	0.00	5	0.00
	Q4B	0.29	3.48	5	0.00
1	Q4A	1134.70	1135.04	2005	0.00
X1	Q4B	1100.08	1095.48	2005	0.00
X1	M5S	30.54	30.78	2001	30.54
S1	M3	197.93	196.97	2001	197.93
X1	Q5A	1370.49	1368.54	2001	1370.49
X1	Q5B	1402.54	1402.54	2001	1402.54
X1	M6	770.96	778.65	2001	770.96
B40	M1	802.52	819.74	2001	802.52
B40	Q1A	1679.53	1700.05	2001	1679.53
B40	Q1B	1646.56	1651.69	2001	1646.56
B40	M1V	6.46	5.50	2001	6.46
B40	M2V	0.00	2.64	2001	0.00
B40	Q2A	1467.86	1484.49	2021	1467.86
B40	Q2B	1335.54	1370.30	2001	1335.54
B40	M2+3	0.00	708.35	1	0.00

DATA FOR ENERGY CALCULATION

INJECTION: HILAC ✓ LOCAL

PARTICLE; Au   2S FREQ : 237.3

MASS NUM; 197   2S FIELD: 736.

CHARGE ; 52   K.ENERGY; 4.26 ME STANK

INFLECTOR H.V; 30.3

EXTRACTION: PFW: ON; (OFF;)

FIELD; 7650   P1 CUR;

FREQ; 176058   P2 CUR;

BEAM RAD: 598.4

	RADIUS	CURRENT	TAIL WAG
M1;		;	RISE; 70 GAUSS
M2:		;	TIME; mSECS
M3;	--------	;	S1 ON; (OFF;)
			S2 ON: OFF;

STD MATERIAL AT F1: IN; (OUT;)

ALL OUT

3.4.6 (b) Magnet Currents

3.4.7 (a) Beam 40 Optic-Axis Beam Positions on the Wire Chambers

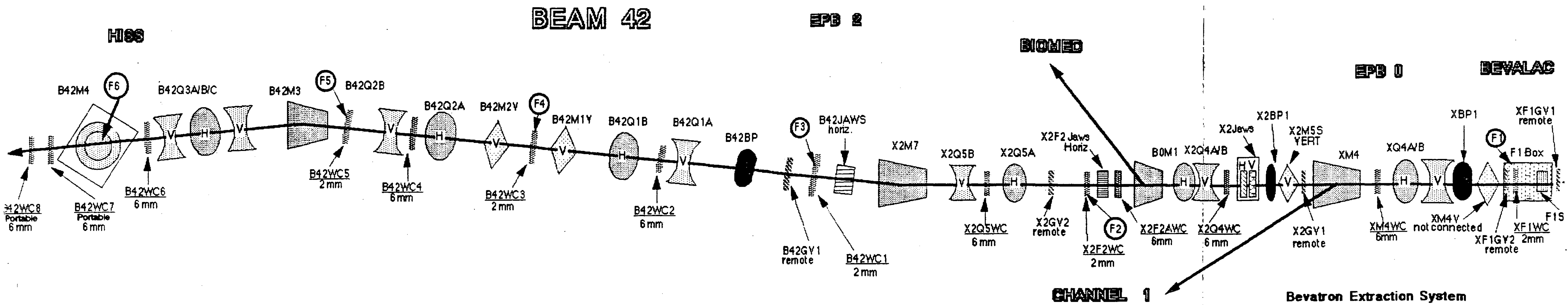
Active Dipole Magnets	Wire Chamber	Beam Center on Wire Chamber (Wire Number)	
		Horizontal	Vertical
XM3V	X1Q4WC	---	16.5
XM4	S1M3WC	16.5	---
S1M3	X1Q5WC	16.5	---
X1M5S	X1Q5WC	---	16.5
X1M6	B40WC1	16.5	---
B40M1	B40WC2	16.5	---
B40M1V	B40WC2	---	16.5

3.4.7 (b) Beam 40 Average Magnet Currents per Bevalac Field

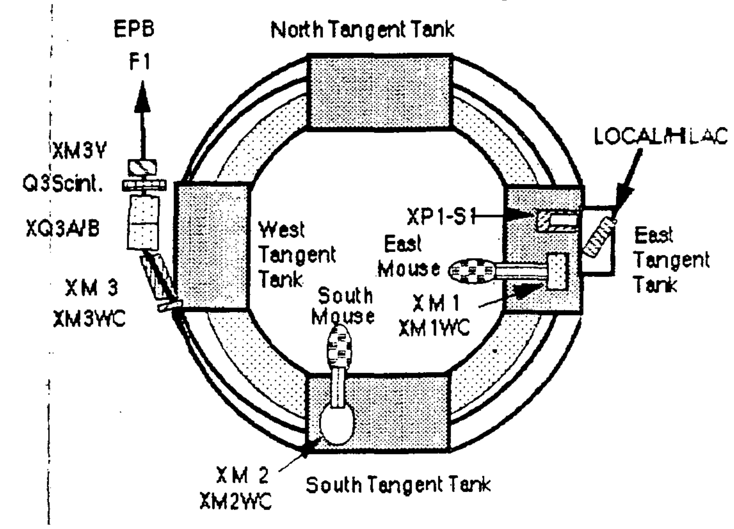
Beam Line Magnet	Magnet Current per Bevalac Field (Ampere/kG)
XM4	952.3*
X1Q4A	153.3
X1Q4B	160.0
S1M3	25.2
X1Q5A	168.0
X1Q5B	178.0
X1M6	102.9
B40M1	105.8
B40Q1A	205.8
B40Q1B	199.8
B40Q2A	215.8
B40Q2B	195.7
B40M2+3	132.6

* Magnet field per Bevalac field (gauss/kG)

3.5 BEAM 42



Bevatron Extraction System



AUG 89

3.5.2 (a) Beam 42 Magnet Parameters									
		Quadropole Magnet		Dipole Magnet					
Beam line Element	Effective Length (m)	Max Gradient (kG/m)	Pole Tip Radius (m)	Max Field (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	Magnet or Wire Chamber Type (in)
(F1)-XF1WC	0.000								2mm Special
	3.969								
XQ4A	0.884	-147	0.1046						8QB32
	0.284								
XQ4B	0.884	+147	0.1046						8QB32
	0.230								
---XM4WC	0.000								6mm Perm. Gas
	0.233								
XM4	2.668			17.86	23.413	6.529	0.0	6.529	4.1x22x100 H
	5.286								
---X2Q4WC	0.000								6mm Perm. Gas
	0.495								
X2Q4A	1.308	-138	0.1046						8QB48
	0.216								
X2Q4B	1.308	+138	0.1046						8QB48
	5.675								
(F2)-X2F2WC	0.000								2mm Crawford
	5.566								
X2Q5A	0.882	+117	0.1016						LP8Q32
	0.504								
---X2Q5WC	0.000								6mm Perm. Gas
	0.504								
X2Q5B	0.882	-117	0.1016						LP8Q32
	0.504								
X2M7	1.036			19.7	12.904	4.6	6.0	-1.4	8x16x36C
	7.420								
(F3)-B42WC1	0.000								2mm Crawford
	4.956								
B42Q1A	1.308	-138	0.1046						8QB48
	0.260								
---B42WC2	0.000								6mm Crawford
	0.260								
B42Q1B	1.308	+138	0.1046						8QB48
	10.992								
(F4)-B42WC3	0.000								2mm Crawford
	10.602								
B42Q2A	1.308	+138	0.1046						8QB48
	0.260								
---B42WC4	0.000								6mm Crawford
	0.260								
B42Q2B	1.308	-138	0.1046						8QB48
	5.452								
(F5)-B42WC5	0.000								2mm Crawford
	0.429								
B42M3	1.542			-20.8	11.780	7.5	3.75	3.75	8x18x60H
	1.689								
B42Q3A	0.490	-146	0.1046						8QB16
	0.939								
B42Q3B	0.884	+147	0.1046						8QB32
	0.939								
B42Q3C	0.490	-146	0.1046						8QB16
	5.943								

3.5.2 (a) Beam 42 Magnet Parameters									
		Quadropole Magnet		Dipole Magnet					
Beam line Element	Effective Length (m)	Max Gradient (kG/m)	Pole Tip Radius (m)	Max Field (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	Magnet or Wire Chamber Type (in)
(F6)-B42CM4	0.000								Center M4
	11.280								
---B42PTG	0.000								Plastic Wall Target
	4.000								
----B42PWL	0.000								Plastic Wall

b
Beam rigidity = 19.2000 t-m
x,y emittance = 1.2000 1.2000 cm-mrad
dp/p = 0.000%
t
Transport mode

betax	=	1.3333	alphax	=	0.0000
betay	=	1.3333	alphay	=	0.0000
etax	=	0.0000	eta'x	=	0.0000
etay	=	0.0000	eta'y	=	0.0000

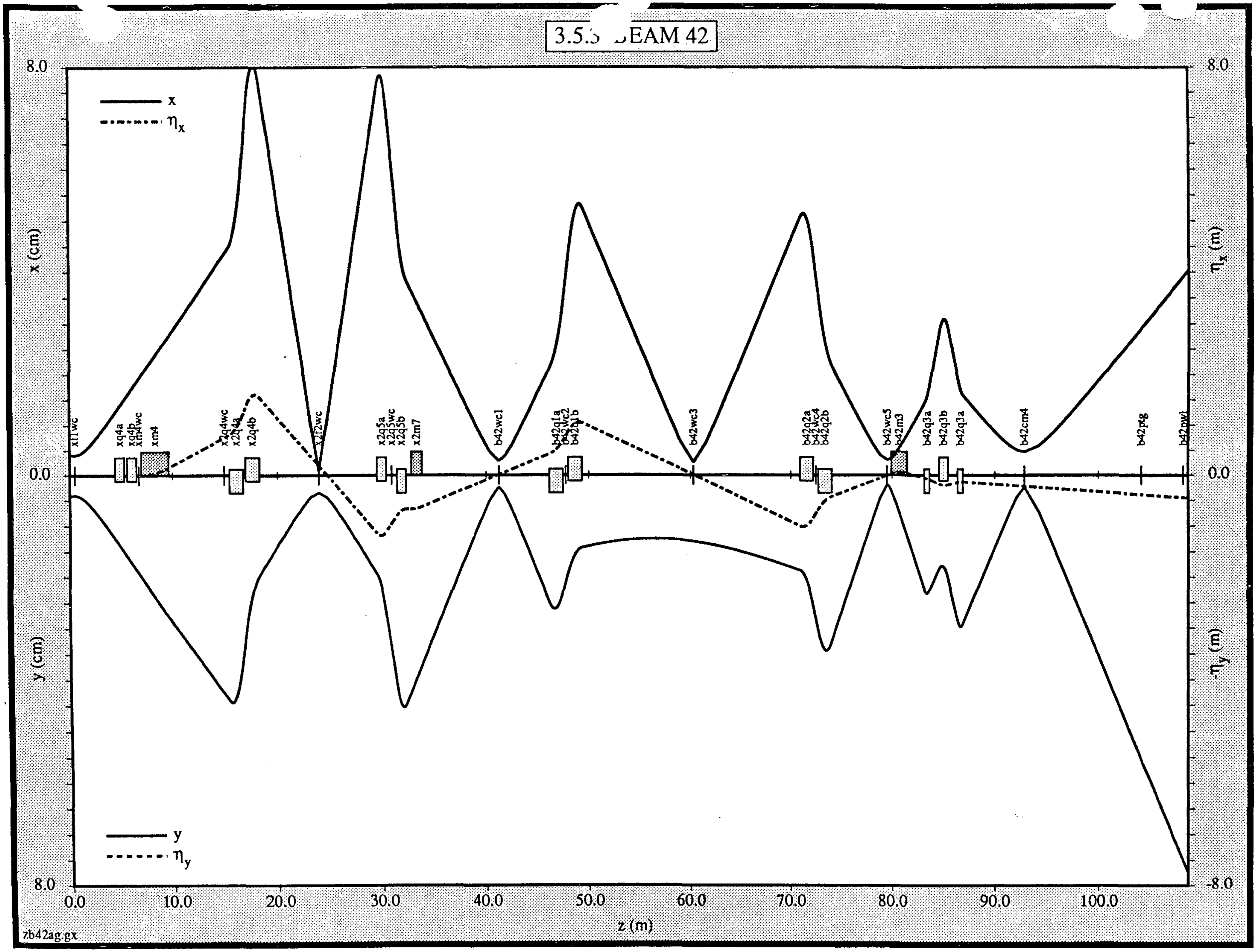
d

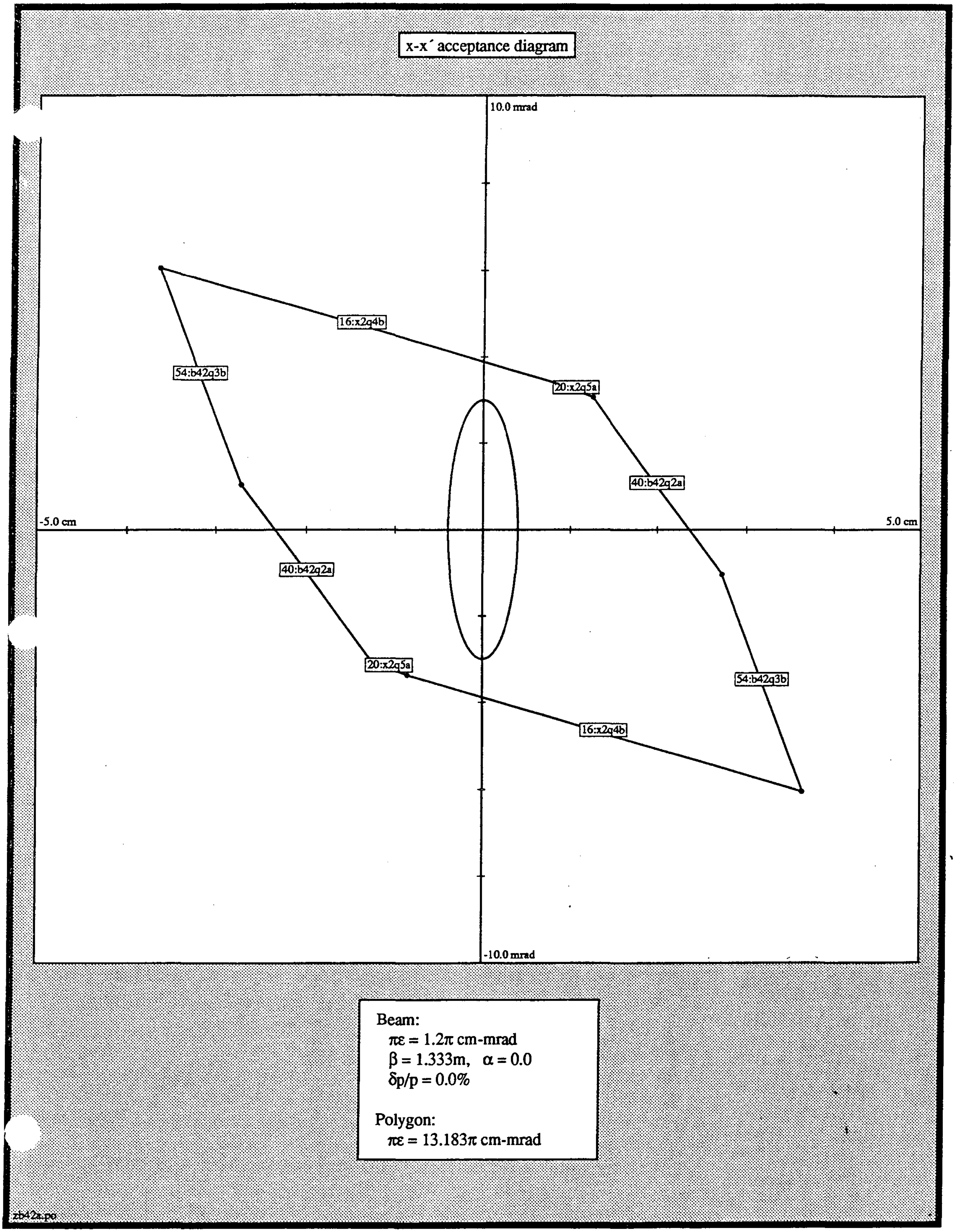
	name	type	vcode	lth,angle	b,b',s	n,gap	xaper	yaper
1	xf1wc	lens	0.0	0.000000	0.000000	0.0000		
2	l1	drift	0.0	3.969000	0.000000	0.0000		
3	xq4a	quad	0.0	0.884000	0.000000	0.0000	0.1000	0.1000
4	s1	drift	0.0	0.284000	0.000000	0.0000		
5	xq4b	quad	0.0	0.884000	0.000000	0.0000	0.1000	0.1000
6	l2	drift	0.0	0.230000	0.000000	0.0000		
7	xm4wc	lens	0.0	0.000000	0.000000	0.0000		
8	l3	drift	0.0	0.233000	0.000000	0.0000		
9	xm4	bend	0.0	2.668000	0.820000	0.0000	0.0836	0.0457
10	xm4o	edge	0.0	6.529000	0.820000	0.0000		
11	l4a	drift	0.0	5.286000	0.000000	0.0000		
12	x2q4wc	lens	0.0	0.000000	0.000000	0.0000		
13	l4b	drift	0.0	0.495000	0.000000	0.0000		
14	x2q4a	quad	0.0	1.308000	-6.605544	0.0000	0.1000	0.1000
15	s2	drift	0.0	0.216000	0.000000	0.0000		
16	x2q4b	quad	0.0	1.308000	7.544062	0.0000	0.1000	0.1000
17	l5	drift	0.0	5.675000	0.000000	0.0000		
18	x2f2wc	lens	0.0	0.000000	0.000000	0.0000		
19	l6	drift	0.0	5.566000	0.000000	0.0000		
20	x2q5a	quad	0.0	0.882000	10.187062	0.0000	0.1016	0.1016
21	s3a	drift	0.0	0.504000	0.000000	0.0000		
22	x2q5wc	lens	0.0	0.000000	0.000000	0.0000		
23	s3b	drift	0.0	0.504000	0.000000	0.0000		
24	x2q5b	quad	0.0	0.882000	-9.152547	0.0000	0.1016	0.1016
25	l7	drift	0.0	0.504000	0.000000	0.0000		
26	x2m7i	edge	0.0	6.000000	1.488000	0.0000		
27	x2m7	bend	0.0	1.036000	1.488000	0.0000	0.1000	0.1000
28	x2m7o	edge	0.0	-1.400000	1.488000	0.0000		
29	l8	drift	0.0	7.420000	0.000000	0.0000		
30	b42wc1	lens	0.0	0.000000	0.000000	0.0000		
31	l9	drift	0.0	4.956000	0.000000	0.0000		
32	b42q1a	quad	0.0	1.308000	-7.225722	0.0000	0.1046	0.1046
33	s4a	drift	0.0	0.260000	0.000000	0.0000		
34	b42wc2	lens	0.0	0.000000	0.000000	0.0000		
35	s4b	drift	0.0	0.260000	0.000000	0.0000		
36	b42q1b	quad	0.0	1.308000	6.423696	0.0000	0.1046	0.1046
37	l10	drift	0.0	10.992000	0.000000	0.0000		
38	b42wc3	lens	0.0	0.000000	0.000000	0.0000		
39	l11	drift	0.0	10.602000	0.000000	0.0000		
40	b42q2a	quad	0.0	1.308000	6.348887	0.0000	0.1046	0.1046
41	s5a	drift	0.0	0.260000	0.000000	0.0000		
42	b42wc4	lens	0.0	0.000000	0.000000	0.0000		
43	s5b	drift	0.0	0.260000	0.000000	0.0000		
44	b42q2b	quad	0.0	1.308000	-6.961214	0.0000	0.1046	0.1046
45	l12	drift	0.0	5.452000	0.000000	0.0000		
46	b42wc5	lens	0.0	0.000000	0.000000	0.0000		
47	l13	drift	0.0	0.429000	0.000000	0.0000		

3.5.2 (b) BEAM 42 - TRANSPORT LIST

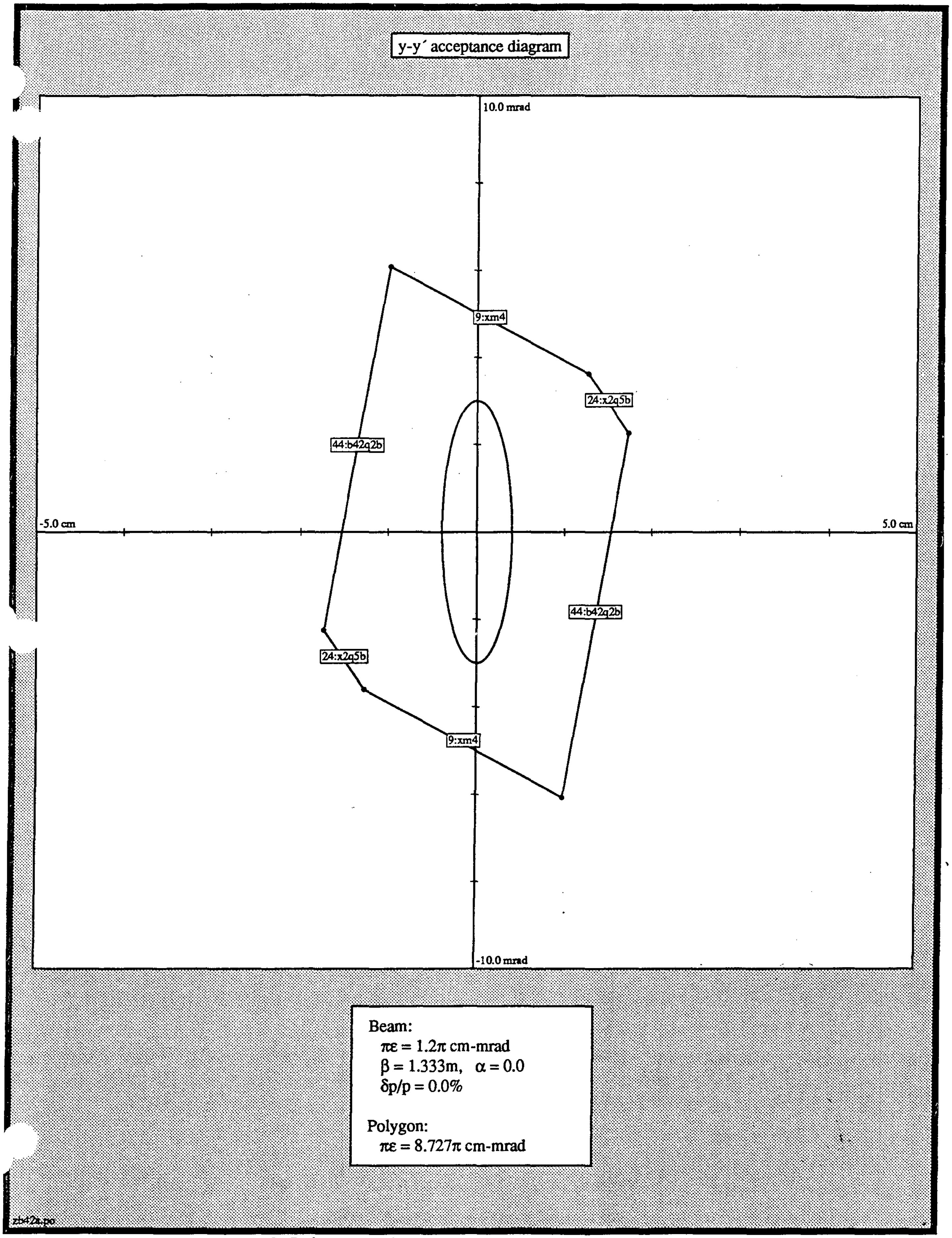
```
  48 b42m3e     edge   0.0    3.750000   -1.630000   0.0000
  49 b42m3      bend   0.0    1.542000   -1.630000   0.0000  0.1000  0.1000
  50 b42m3e     edge   0.0    3.750000   -1.630000   0.0000
  51 114        drift  0.0    1.689000    0.000000   0.0000
  52 b42q3a     quad   1.2    0.490000  -18.073729   0.0000  0.1046  0.1046
  53 s6         drift  0.0    0.939000    0.000000   0.0000
  54 b42q3b     quad   2.2    0.884000   15.459094   0.0000  0.1046  0.1046
  55 s6         drift  0.0    0.939000    0.000000   0.0000
  56 b42q3a     quad   1.2    0.490000  -18.073729   0.0000  0.1046  0.1046
  57 115        drift  0.0    5.943000    0.000000   0.0000
  58 b42cm4     lens   0.0    0.000000    0.000000   0.0000
  59 116        drift  0.0   11.280000    0.000000   0.0000
  60 b42ptg     lens   0.0    0.000000    0.000000   0.0000
  61 117        drift  0.0    4.000000    0.000000   0.0000
  62 b42pwl     lens   0.0    0.000000    0.000000   0.0000
quit
End of program
```

3.5.2 (b) BEAM 42 - TRANSPORT LIST


3.5.3 BEAM 42
x
η_x
y
η_y
x (cm)
y (cm)
η_x (m)
$-\eta_y$ (m)
z (m)
8.0
0.0
8.0
-8.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
xl1wc
xq4a
xq4b
xm4wc
xm4
x2q4wc
x2q4a
x2q4b
x2f2wc
x2q5a
x2q5wc
x2q5b
x2m7
b42wc1
b42q1a
b42wc2
b42q1b
b42wc3
b42q2a
b42wc4
b42q2b
b42wc5
b42m3
b42q3a
b42q3b
b42q3a
b42cm4
b42ptg
b42pwl
zb42ag.gx



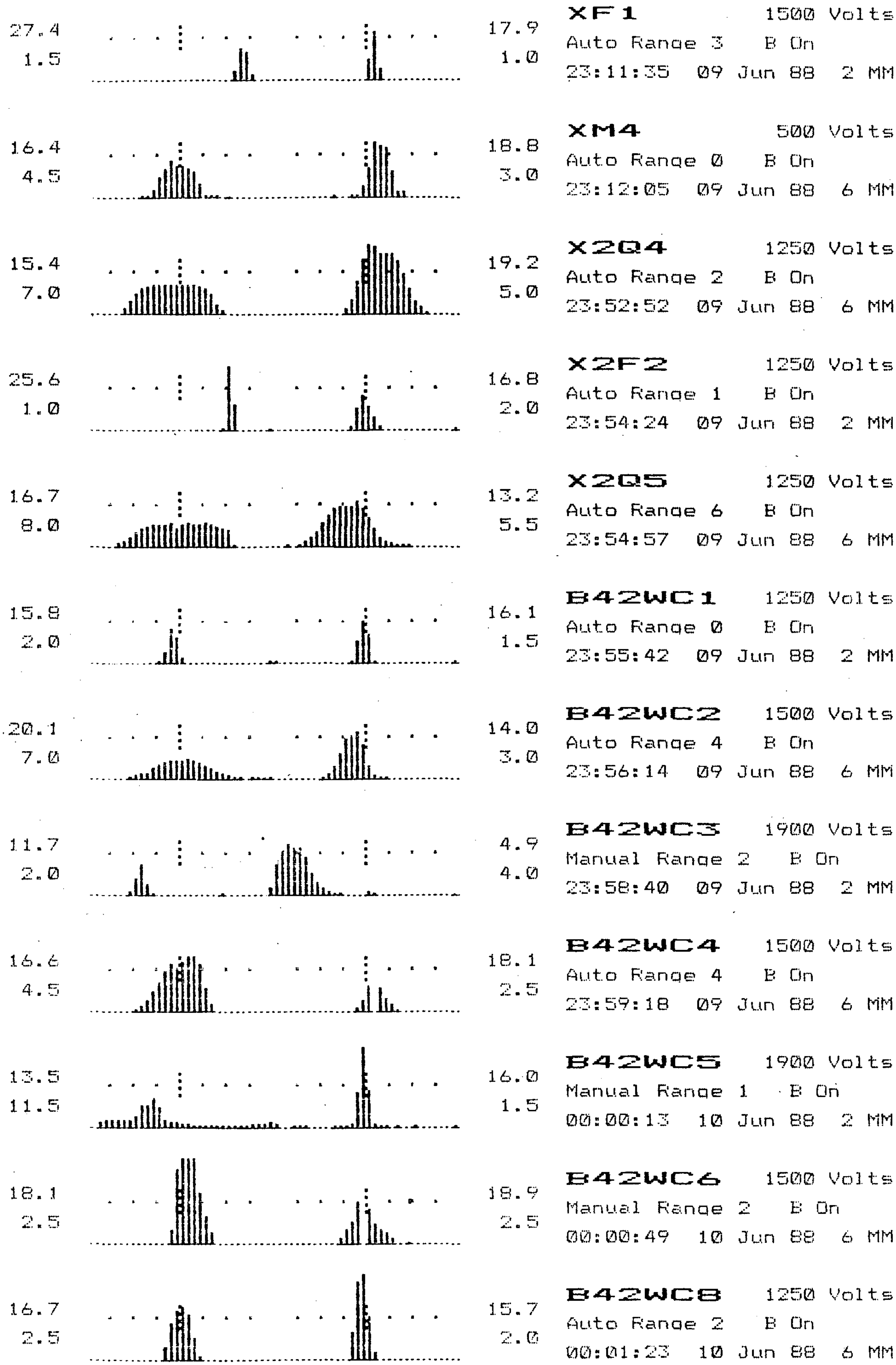
3.5.4 BEAM 42 HORIZONTAL ACCEPTANCE AT F1



3.5.4 BEAM 42 VERTICAL ACCEPTANCE AT F1

3.5.5 Beam 42 Focal Points

Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (cm/%)
F1	XF1WC	1.0	1.0	0.00
F2	X2F2WC	0.22	0.87	0.20
F3	B42WC1	0.70	0.60	0.005
F4	B42WC3	0.63	3.26	0.003
F5	B42WC5	0.77	0.50	-0.013
F6	Center M4	1.18	0.61	-0.23



3.5.6 (a) Wire Chamber Pictures

10JUN88 EPB ACL PRINT 0:19:22 PAGE 1

NAME	DATE	TIME	ENTRY	BEAM LINE
CURRENT B42	10JUN88	0:19:22	0	BEAM42

PERTURBATION UNIT DATA

NAME		FLAGS	AMPLITUDE	DELAY	GATE
X	P1	P+	189.00	410	1200
X	P2	P+	-0.71	410	1210
X	S2	S+	7.71	400	1030
X	M2	S	-30.66	400	1190
X	S1	S+	170.29	400	1450
X	M3	S+	-15.21	400	1220
X	S1	P+	281.88	460	1690

NAME		SP	AM	DI	OFFSET
X	P1	0.00	0.66	5	0.00
X	P2	0.00	0.00	5	0.00
X	S1	-2.89	0.00	5	0.00
X	S2	-0.12	2.81	5	0.00
X	M1	885.84	962.76	5	0.00
X	M2	2356.12	2356.12	5	0.00
X	M3	1938.44	1916.18	5	0.00
X	Q3A	1342.09	1348.80	5	0.00
X	Q3B	1358.39	1427.45	5	0.00
X	M3V	0.00	0.24	2001	0.00
X	M4V	0.00	0.12	2001	0.00
X	M4	-777.97	-789.94	2001	-777.97
	M5	-360.14	-341.57	2001	-360.14
	Q4A	0.00	0.00	5	0.00
	Q4B	0.00	3.48	5	0.00
X2	M5S	45.66	45.90	2001	45.66
X2	Q4A	1251.59	1283.83	2005	0.00
X2	Q4B	1374.42	1363.70	2005	0.00
B0	M1	0.00	0.00	1001	0.00
B3	M1	0.00	260.06	1	0.00
X2	Q5A	1182.25	1184.90	2001	1182.25
X2	Q5B	968.09	980.46	2001	968.09
X2	M7	1297.94	1297.75	2001	1297.94
B42	Q1A	1493.15	1486.52	2001	1493.15
B42	Q1B	1238.96	1245.69	1	1238.96
B42	M1V	84.16	95.41	2001	84.16
B42	Q2A	1284.83	1284.93	2001	1284.83
B42	Q2B	1498.25	1499.60	2001	1498.25
B42	M2V	53.54	56.42	2001	53.54
B42	M3	1428.68	1445.48	2001	1428.68
B42	Q3A+C	2779.86	2776.21	2001	2779.86
B42	Q3B	2361.43	2375.96	2001	2361.43

DATA FOR ENERGY CALCULATION

INJECTION: HILAC LOCAL

PARTICLE: He   2S FREQ : 246KHz

MASS NUM: 4   2S FIELD: 403.28

CHARGE : 2   K.ENERGY: 2085

INFLECTOR H.V: 16.57

EXTRACTION: PFW: ON: OFF:

FIELD: 12.575   P1 CUR:

FREQ: 2.37MHz   P2 CUR:

BEAM RAD: 599.7

	RADIUS	CURRENT	TAIL WAG	
M1:		:	RISE:	GAUSS
M2:		:	TIME:	mSECS
M3:	------	:	S1 ON:	OFF:
			S2 ON:	OFF:

STD MATERIAL AT F1: IN: OUT:

3.5.6 (b) Magnet Currents

3.5.7 (a) Beam 42 Optic-Axis Beam Positions on the Wire Chambers

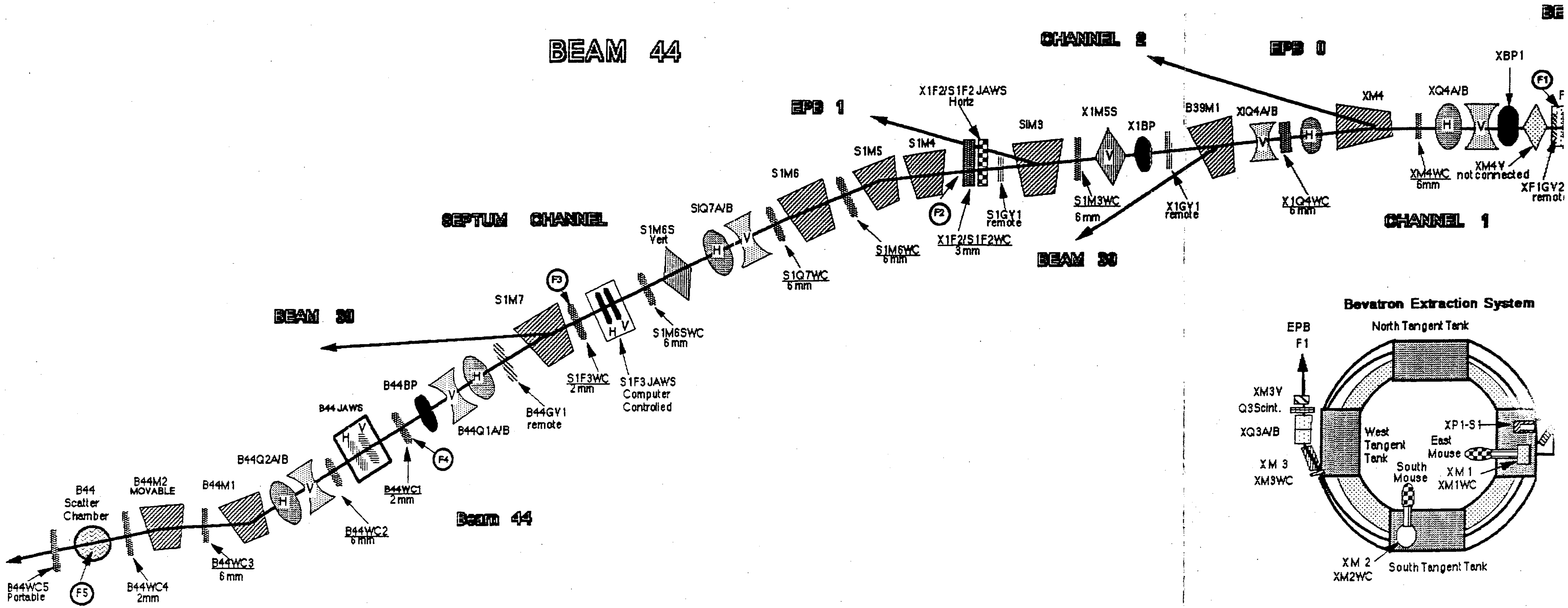
Active Dipole Magnets	Wire Chamber	Beam Center on Wire Chamber (Wire Number)	
		Horizontal	Vertical
XM3V	X2Q4WC	---	16.5
XM4	X2Q5WC	16.5	---
X2M5S	B42WC2	---	16.5
X2M7	B42WC4	16.5	---
B42M1V	B42WC4	---	16.5
B42M2V	B42WC6	---	16.5

3.5.7 (b) Beam 42 Average Magnet Currents per Bevalac Field

Beam Line Magnet	Magnet Current per Bevalac Field (Ampere/kG)
XM4	-649.6*
X2Q4A	100.6
X2Q4B	110.9
X2Q5A	84.6
X2Q5B	75.7
X2M7	102.4
B42Q1A	115.7
B42Q1B	100.6
B42Q2A	102.2
B42Q2B	116.3
B42M3	118.0
B42Q3A/C	218.4
B42Q3B	198.2

* Magnet field per Bevalac field (gauss/kG)

3.6 BEAM 44


BEAM 44
CHANNEL 2
EPB 0
EPB 1
SEPTUM CHANNEL
CHANNEL 1
BEAM 30
BEAM 30
Beam 44
Bevatron Extraction System
North Tangent Tank
West Tangent Tank
South Tangent Tank
East Mouse
South Mouse
XBP1
XQ4A/B
XM4
XM4WC 6mm
XM4V not connected
XF1GV2 remote
B39M1
XQ4A/B
X1Q4WC 6mm
X1GY1 remote
X1M5S
X1BP
S1M3WC 6mm
SIM3
X1F2/S1F2 JAWS Horiz
X1F2/S1F2WC 3mm
S1GY1 remote
S1M4
S1M5
S1M6
S1M6WC 6mm
SIQ7A/B
S1Q7WC 6mm
S1M6S Vert
S1M6SWC 6mm
S1F3 JAWS Computer Controlled
S1F3WC 2mm
S1M7
B44GY1 remote
B44BP
B44Q1A/B
B44 JAWS
B44WC1 2mm
B44Q2A/B
B44WC2 6mm
B44M1
B44WC3 6mm
B44M2 MOVABLE
B44WC4 2mm
B44 Scatter Chamber
B44WC5 Portable
EPB F1
XM3V
Q3Scint.
XQ3A/B
XM 3
XM3WC
XP1-S1
XM 1
XM1WC
XM 2
XM2WC

3.6.2 (a) Beam 44 - Magnet Parameters

Beam Line Element	Effective Length (m)	Quadropole Magnet: Max Gradient (kG/m)	Quadropole Magnet: Pole Tip Radius (m)	Dipole Magnet: Max Field (kG)	Dipole Magnet: Bend Radius (m)	Dipole Magnet: Bend Angle (deg.)	Dipole Magnet: Incoming Edge Angle (deg.)	Dipole Magnet: Outgoing Edge Angle (deg.)	Magnet or Wire Chamber Type (in)
(F1)-XF1WC	0.000								2mm Special
	3.969								
XQ4A	0.884	-147	0.1046						8QB32
	0.284								
XQ4B	0.884	+147	0.1046						8QB32
	0.230								
---XM4WC	0.000								6mm Perm. Gas
	0.233								
XM4	2.668			-17.86	15.972	9.572	0.0	9.572	4.1x22x100H
	0.269								
X1Q4A	0.884	+144	0.1046						8QN32
	0.264								
---X1Q4WC	0.000								6mm Perm. Gas
	0.140								
X1Q4B	0.884	-147	0.1046						8QB32
	4.862								
---S1M3WC	0.000								6mm Perm. Gas
	0.340								
S1M3	2.250			-20.0	43.44	2.968	0.0	2.968	4.38x15x84H
	0.770								
(F2)-S1F2WC	0.000								3mm Perm. Gas
	0.645								
S1M4	1.405			-20.3	13.41	6.0	0.0	6.0	2.25x7.5x48H
	0.370								
S1M5	2.250			-20.0	11.72	11.0	5.5	5.5	4.38x15x84H
	0.247								
---S1M6WC	0.000								6mm Cantilever
	0.247								
S1M6	2.250			-20.0	31.07	4.15	4.15	0.0	4.38x15x84H
	2.350								
---S1Q7WC	0.000								6mm Perm. Gas
	0.336								
S1Q7A	1.308	-138	0.1046						8QB48
	0.216								
S1Q7B	1.308	+138	0.1046						8QB48
	1.608								
---S1M6SWC	0.000								6mm Crawford
	3.700								
(F3)-S1F3WC	0.000								2mm Perm. Gas
	0.665								
S1M7	1.840			-18.6	4.217	25.0	12.0	12.0	7.25x63H
	0.773								
B44Q1A	0.726	+93	0.1571						12QN24
	0.265								
B44Q1B	0.726	-93	0.1571						12QN24
	2.686								
(F4)-B44WC1	0.000								2mm Crawford
	3.405								
---B44WC2	0.000								6mm Crawford
	0.295								
B44Q2A	0.726	-93	0.1571						12QN24
	0.265								
B44Q2B	0.726	+93	0.1571						12QN24

3.6.2 (a) Beam 44 - Magnet Parameters									
		Quadropole Magnet		Dipole Magnet					
Beam Line Element	Effective Length (m)	Max Gradient (kG/m)	Pole Tip Radius (m)	Max Field (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	Magnet or Wire Chamber Type (in)
	0.460								
B44M1	1.036			-19.7	5.938	10.0	5.0	5.0	8x16x36C
	1.094								
--B44WC3	0.000								6mm Crawford
	3.570								
--B44CM2	0.000								Center M2
	1.142								
--B44WC4	0.000								2mm Crawford
	1.524								
(F5)-B44CSC	0.000								Center Scatt. Chamber

```
b
Beam rigidity =    19.2000 t-m
x,y emittance =     1.2000   1.2000 cm-mrad
dp/p =  0.000%
t
Transport mode
        betax =    1.3333   alphax =    0.0000
        betay =    1.3333   alphay =    0.0000
        etax  =    0.0000   eta'x  =    0.0000
        etay  =    0.0000   eta'y  =    0.0000
d
```

	name	type	vcode	lth,angle	b,b',s	n,gap	xaper	yaper
1	xflwc	lens	0.0	0.000000	0.000000	0.0000		
2	l1	drift	0.0	3.969000	0.000000	0.0000		
3	xq4a	quad	0.0	0.884000	0.000000	0.0000	0.1000	0.1000
4	s1	drift	0.0	0.284000	0.000000	0.0000		
5	xq4b	quad	0.0	0.884000	0.000000	0.0000	0.1000	0.1000
6	l2	drift	0.0	0.230000	0.000000	0.0000		
7	xm4wc	lens	0.0	0.000000	0.000000	0.0000		
8	l3	drift	0.0	0.233000	0.000000	0.0000		
9	xm4	bend	0.0	2.668000	-1.202100	0.0000	0.0836	0.0457
10	xm4o	edge	0.0	9.572000	-1.202100	0.0000		
11	l4	drift	0.0	0.269000	0.000000	0.0000		
12	xlq4a	quad	0.0	0.884000	9.944050	0.0000	0.1000	0.1000
13	s2a	drift	0.0	0.264000	0.000000	0.0000		
14	xlq4wc	lens	0.0	0.000000	0.000000	0.0000		
15	s2b	drift	0.0	0.140000	0.000000	0.0000		
16	xlq4b	quad	0.0	0.884000	-10.574643	0.0000	0.1000	0.1000
17	l5	drift	0.0	4.862000	0.000000	0.0000		
18	slm3wc	lens	0.0	0.000000	0.000000	0.0000		
19	l6	drift	0.0	0.340000	0.000000	0.0000		
20	slm3	bend	0.0	2.250000	-0.442000	0.0000	0.1000	0.0525
21	slm3o	edge	0.0	2.968000	-0.442000	0.0000		
22	l7	drift	0.0	0.770000	0.000000	0.0000		
23	slf2wc	lens	0.0	0.000000	0.000000	0.0000		
24	l8	drift	0.0	0.645000	0.000000	0.0000		
25	slm4	bend	0.0	1.405000	-1.431000	0.0000	0.0953	0.0286
26	slm4o	edge	0.0	6.000000	-1.431000	0.0000		
27	l9	drift	0.0	0.370000	0.000000	0.0000		
28	slm5i	edge	0.0	5.500000	-1.638000	0.0000		
29	slm5	bend	0.0	2.250000	-1.638000	0.0000	0.1000	0.0525
30	slm5o	edge	0.0	5.500000	-1.638000	0.0000		
31	l10	drift	0.0	0.247000	0.000000	0.0000		
32	slm6wc	lens	0.0	0.000000	0.000000	0.0000		
33	l11	drift	0.0	0.247000	0.000000	0.0000		
34	slm6i	edge	0.0	4.150000	-0.618000	0.0000		
35	slm6	bend	0.0	2.250000	-0.618000	0.0000	0.1000	0.0525
36	l12	drift	0.0	2.350000	0.000000	0.0000		
37	slq7wc	lens	0.0	0.000000	0.000000	0.0000		
38	l13	drift	0.0	0.336000	0.000000	0.0000		
39	slq7a	quad	0.0	1.308000	-7.462412	0.0000	0.1000	0.1000
40	s3	drift	0.0	0.216000	0.000000	0.0000		
41	slq7b	quad	0.0	1.308000	8.141792	0.0000	0.1000	0.1000
42	l14	drift	0.0	1.608000	0.000000	0.0000		
43	slm6sw	lens	0.0	0.000000	0.000000	0.0000		
44	l15	drift	0.0	3.700000	0.000000	0.0000		
45	slf3wc	lens	0.0	0.000000	0.000000	0.0000		
46	l16	drift	0.0	0.665000	0.000000	0.0000		
47	slm7i	edge	0.0	12.000000	-4.553000	0.0000		

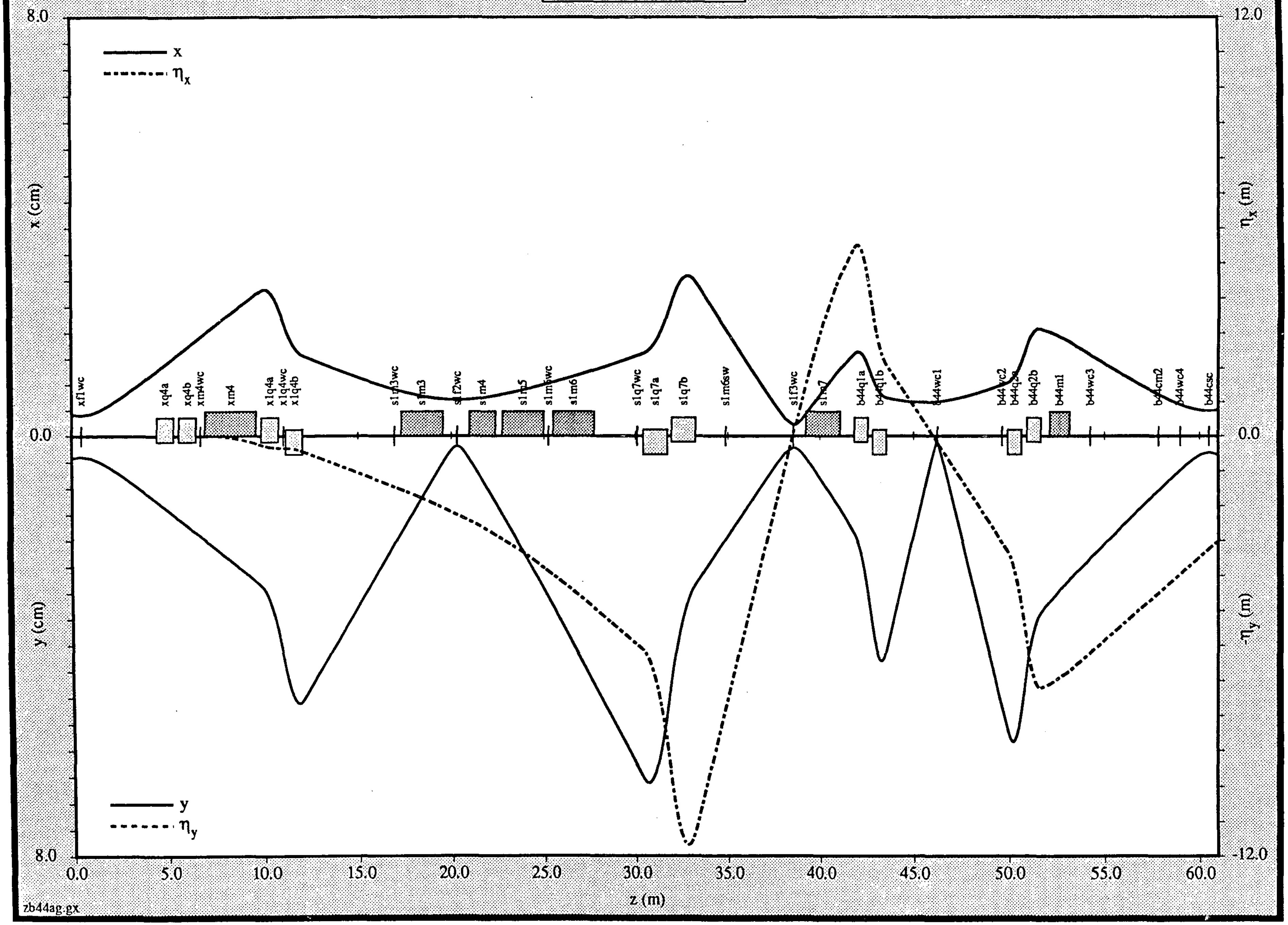
3.6.2 (b) BEAM 44(I) - TRANSPORT LIST

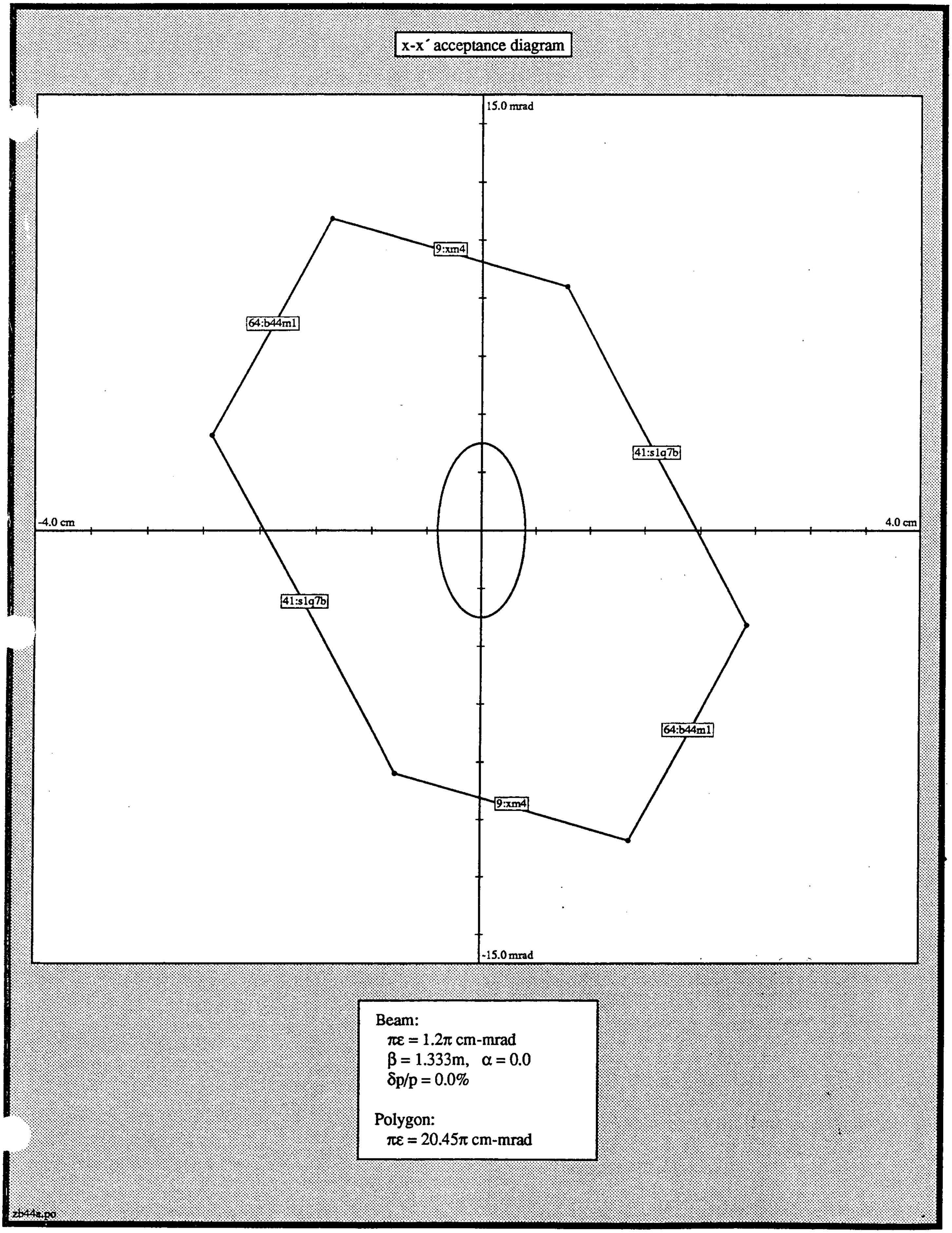
48	slm7	bend	0.0	1.840000	-4.553000	0.0000	0.1000	0.0920
49	slm7o	edge	0.0	12.000000	-4.553000	0.0000		
50	l17	drift	0.0	0.773000	0.000000	0.0000		
51	b44q1a	quad	0.0	0.726000	22.999573	0.0000	0.1500	0.1500
52	s4	drift	0.0	0.265000	0.000000	0.0000		
53	b44q1b	quad	0.0	0.726000	-26.476065	0.0000	0.1500	0.1500
54	l18	drift	0.0	2.686000	0.000000	0.0000		
55	b44wc1	lens	0.0	0.000000	0.000000	0.0000		
56	l19	drift	0.0	3.405000	0.000000	0.0000		
57	b44wc2	lens	0.0	0.000000	0.000000	0.0000		
58	l20	drift	0.0	0.295000	0.000000	0.0000		
59	b44q2a	quad	1.2	0.726000	-19.641693	0.0000	0.1500	0.1500
60	s5	drift	0.0	0.265000	0.000000	0.0000		
61	b44q2b	quad	2.2	0.726000	15.557851	0.0000	0.1500	0.1500
62	l21	drift	0.0	0.460000	0.000000	0.0000		
63	b44m1i	edge	0.0	5.000000	-3.234000	0.0000		
64	b44m1	bend	0.0	1.036000	-3.234000	0.0000	0.1000	0.1000
65	b44m1o	edge	0.0	5.000000	-3.234000	0.0000		
66	l22	drift	0.0	1.094000	0.000000	0.0000		
67	b44wc3	lens	0.0	0.000000	0.000000	0.0000		
68	l23	drift	0.0	3.570000	0.000000	0.0000		
69	b44cm2	lens	0.0	0.000000	0.000000	0.0000		
70	l24	drift	0.0	1.142000	0.000000	0.0000		
71	b44wc4	lens	0.0	0.000000	0.000000	0.0000		
72	l25	drift	0.0	1.524000	0.000000	0.0000		
73	b44csc	lens	0.0	0.000000	0.000000	0.0000		

quit
End of program

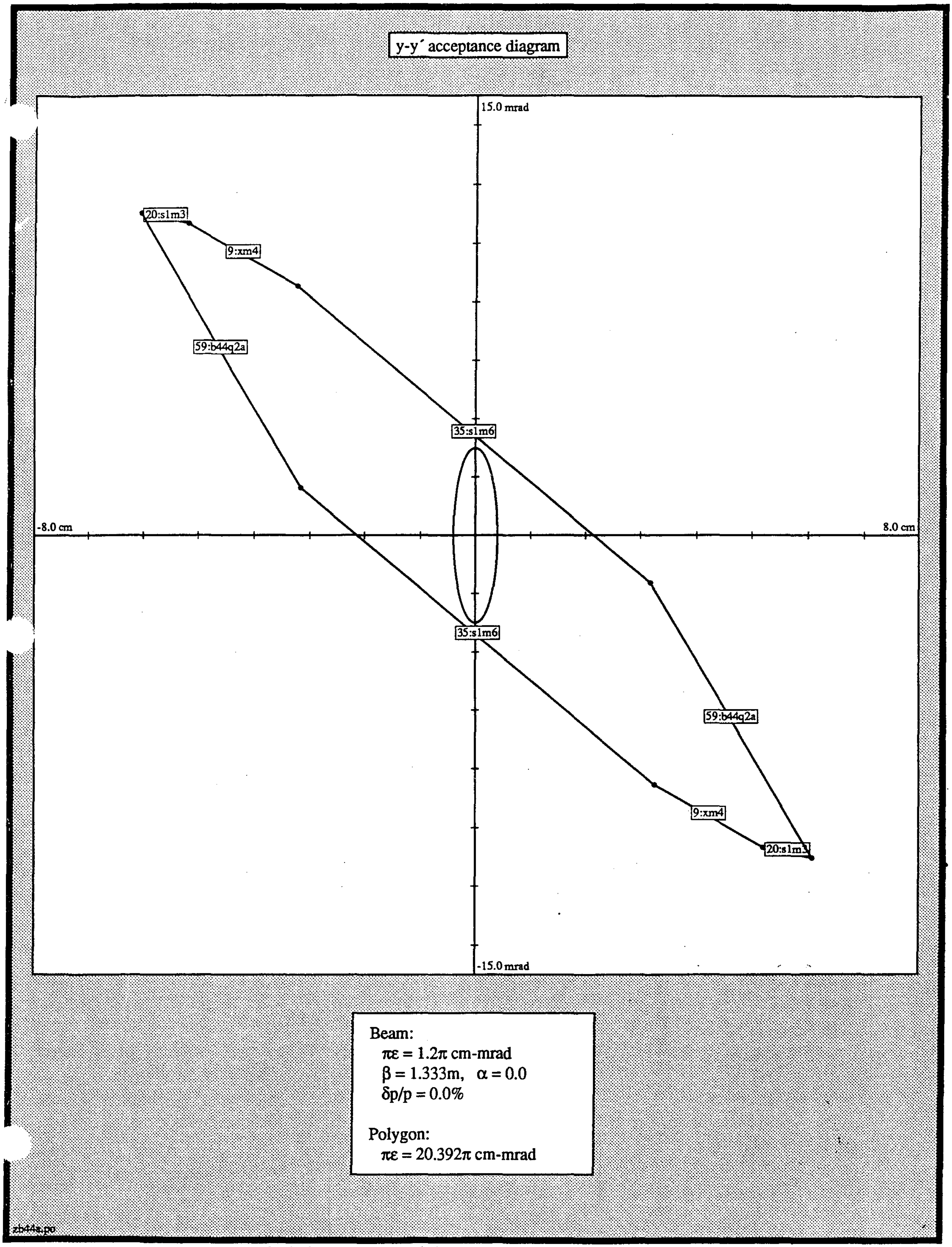
3.6.2 (b) BEAM 44(I) - TRANSPORT LIST

3.6.3 BEAM 44 (I)


x
η_x
y
η_y
x (cm)
y (cm)
η_x (m)
$-\eta_y$ (m)
z (m)
8.0
0.0
8.0
12.0
0.0
-12.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
xf1wc
xq4a
xq4b
xm4wc
xm4
x1q4a
x1q4wc
x1q4b
s1m3wc
s1m3
s1f2wc
s1m4
s1m5
s1m6wc
s1m6
s1q7wc
s1q7a
s1q7b
s1m6sw
s1f3wc
s1m7
b44q1a
b44q1b
b44wc1
b44wc2
b44q2a
b44q2b
b44m1
b44wc3
b44cm2
b44wc4
b44csc
zb44ag.gx



3.6.4 BEAM 44(I) HORIZONTAL ACCEPTANCE AT F1



3.6.4 BEAM 44 (I) VERTICAL ACCEPTANCE AT F1

b
Beam rigidity = 19.2000 t-m
x,y emittance = 4.7000 8.0000 cm-mrad
dp/p = 0.000%
t
Transport mode
betax = 0.5319 alphax = 0.0000
betay = 0.3125 alphay = 0.0000
etax = 0.0000 eta'x = 0.0000
etay = 0.0000 eta'y = 0.0000
d

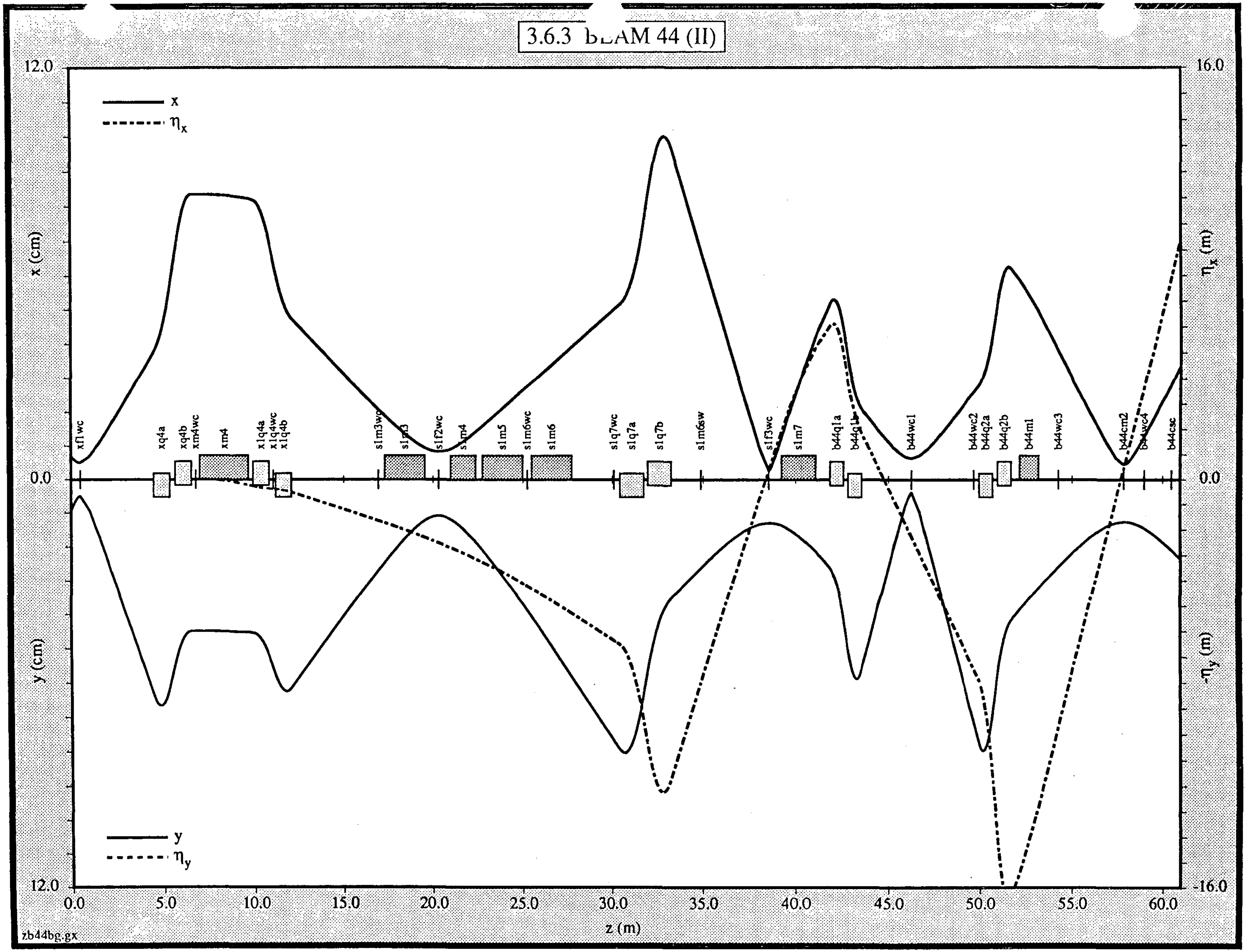
	name	type	vcode	lth,angle	b,b',s	n,gap	xaper	yaper
1	xflwc	lens	0.0	0.000000	0.000000	0.0000		
2	l1	drift	0.0	3.969000	0.000000	0.0000		
3	xq4a	quad	0.0	0.884000	-12.759374	0.0000	0.1000	0.1000
4	s1	drift	0.0	0.284000	0.000000	0.0000		
5	xq4b	quad	0.0	0.884000	10.025495	0.0000	0.1000	0.1000
6	l2	drift	0.0	0.230000	0.000000	0.0000		
7	xm4wc	lens	0.0	0.000000	0.000000	0.0000		
8	l3	drift	0.0	0.233000	0.000000	0.0000		
9	xm4	bend	0.0	2.668000	-1.202100	0.0000	0.0836	0.0457
10	xm4o	edge	0.0	9.572000	-1.202100	0.0000		
11	l4	drift	0.0	0.269000	0.000000	0.0000		
12	xlq4a	quad	0.0	0.884000	6.197357	0.0000	0.1000	0.1000
13	s2a	drift	0.0	0.264000	0.000000	0.0000		
14	xlq4wc	lens	0.0	0.000000	0.000000	0.0000		
15	s2b	drift	0.0	0.140000	0.000000	0.0000		
16	xlq4b	quad	0.0	0.884000	-7.489434	0.0000	0.1000	0.1000
17	l5	drift	0.0	4.862000	0.000000	0.0000		
18	slm3wc	lens	0.0	0.000000	0.000000	0.0000		
19	l6	drift	0.0	0.340000	0.000000	0.0000		
20	slm3	bend	0.0	2.250000	-0.442000	0.0000	0.1000	0.0525
21	slm3o	edge	0.0	2.968000	-0.442000	0.0000		
22	l7	drift	0.0	0.770000	0.000000	0.0000		
23	slf2wc	lens	0.0	0.000000	0.000000	0.0000		
24	l8	drift	0.0	0.645000	0.000000	0.0000		
25	slm4	bend	0.0	1.405000	-1.431000	0.0000	0.0953	0.0286
26	slm4o	edge	0.0	6.000000	-1.431000	0.0000		
27	l9	drift	0.0	0.370000	0.000000	0.0000		
28	slm5i	edge	0.0	5.500000	-1.638000	0.0000		
29	slm5	bend	0.0	2.250000	-1.638000	0.0000	0.1000	0.0525
30	slm5o	edge	0.0	5.500000	-1.638000	0.0000		
31	l10	drift	0.0	0.247000	0.000000	0.0000		
32	slm6wc	lens	0.0	0.000000	0.000000	0.0000		
33	l11	drift	0.0	0.247000	0.000000	0.0000		
34	slm6i	edge	0.0	4.150000	-0.618000	0.0000		
35	slm6	bend	0.0	2.250000	-0.618000	0.0000	0.1000	0.0525
36	l12	drift	0.0	2.350000	0.000000	0.0000		
37	slq7wc	lens	0.0	0.000000	0.000000	0.0000		
38	l13	drift	0.0	0.336000	0.000000	0.0000		
39	slq7a	quad	0.0	1.308000	-7.392178	0.0000	0.1000	0.1000
40	s3	drift	0.0	0.216000	0.000000	0.0000		
41	slq7b	quad	0.0	1.308000	8.164789	0.0000	0.1000	0.1000
42	l14	drift	0.0	1.608000	0.000000	0.0000		
43	slm6sw	lens	0.0	0.000000	0.000000	0.0000		
44	l15	drift	0.0	3.700000	0.000000	0.0000		
45	slf3wc	lens	0.0	0.000000	0.000000	0.0000		
46	l16	drift	0.0	0.665000	0.000000	0.0000		
47	slm7i	edge	0.0	12.000000	-4.553000	0.0000		

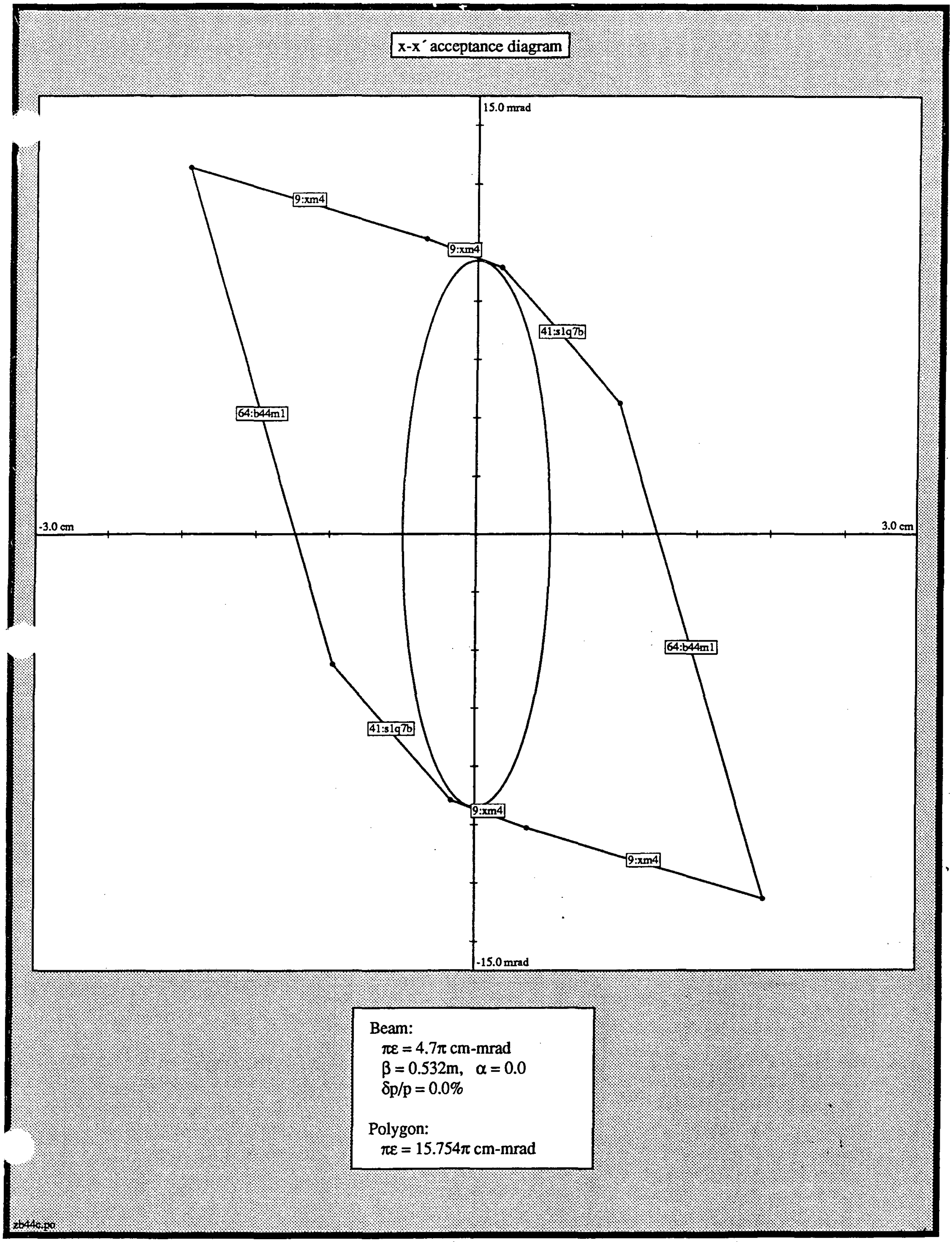
3.6.2 (b) BEAM 44 (II) - TRANSPORT LIST

48	slm7	bend	0.0	1.840000	-4.553000	0.0000	0.1000	0.0920
49	slm7o	edge	0.0	12.000000	-4.553000	0.0000		
50	l17	drift	0.0	0.773000	0.000000	0.0000		
51	b44q1a	quad	0.0	0.726000	23.979511	0.0000	0.1500	0.1500
52	s4	drift	0.0	0.265000	0.000000	0.0000		
53	b44q1b	quad	0.0	0.726000	-26.099379	0.0000	0.1500	0.1500
54	l18	drift	0.0	2.686000	0.000000	0.0000		
55	b44wc1	lens	0.0	0.000000	0.000000	0.0000		
56	l19	drift	0.0	3.405000	0.000000	0.0000		
57	b44wc2	lens	0.0	0.000000	0.000000	0.0000		
58	l20	drift	0.0	0.295000	0.000000	0.0000		
59	b44q2a	quad	1.2	0.726000	-21.150202	0.0000	0.1500	0.1500
60	s5	drift	0.0	0.265000	0.000000	0.0000		
61	b44q2b	quad	2.2	0.726000	18.558195	0.0000	0.1500	0.1500
62	l21	drift	0.0	0.460000	0.000000	0.0000		
63	b44m1i	edge	0.0	5.000000	-3.234000	0.0000		
64	b44m1	bend	0.0	1.036000	-3.234000	0.0000	0.1000	0.1000
65	b44m1o	edge	0.0	5.000000	-3.234000	0.0000		
66	l22	drift	0.0	1.094000	0.000000	0.0000		
67	b44wc3	lens	0.0	0.000000	0.000000	0.0000		
68	l23	drift	0.0	3.570000	0.000000	0.0000		
69	b44cm2	lens	0.0	0.000000	0.000000	0.0000		
70	l24	drift	0.0	1.142000	0.000000	0.0000		
71	b44wc4	lens	0.0	0.000000	0.000000	0.0000		
72	l25	drift	0.0	1.524000	0.000000	0.0000		
73	b44csc	lens	0.0	0.000000	0.000000	0.0000		

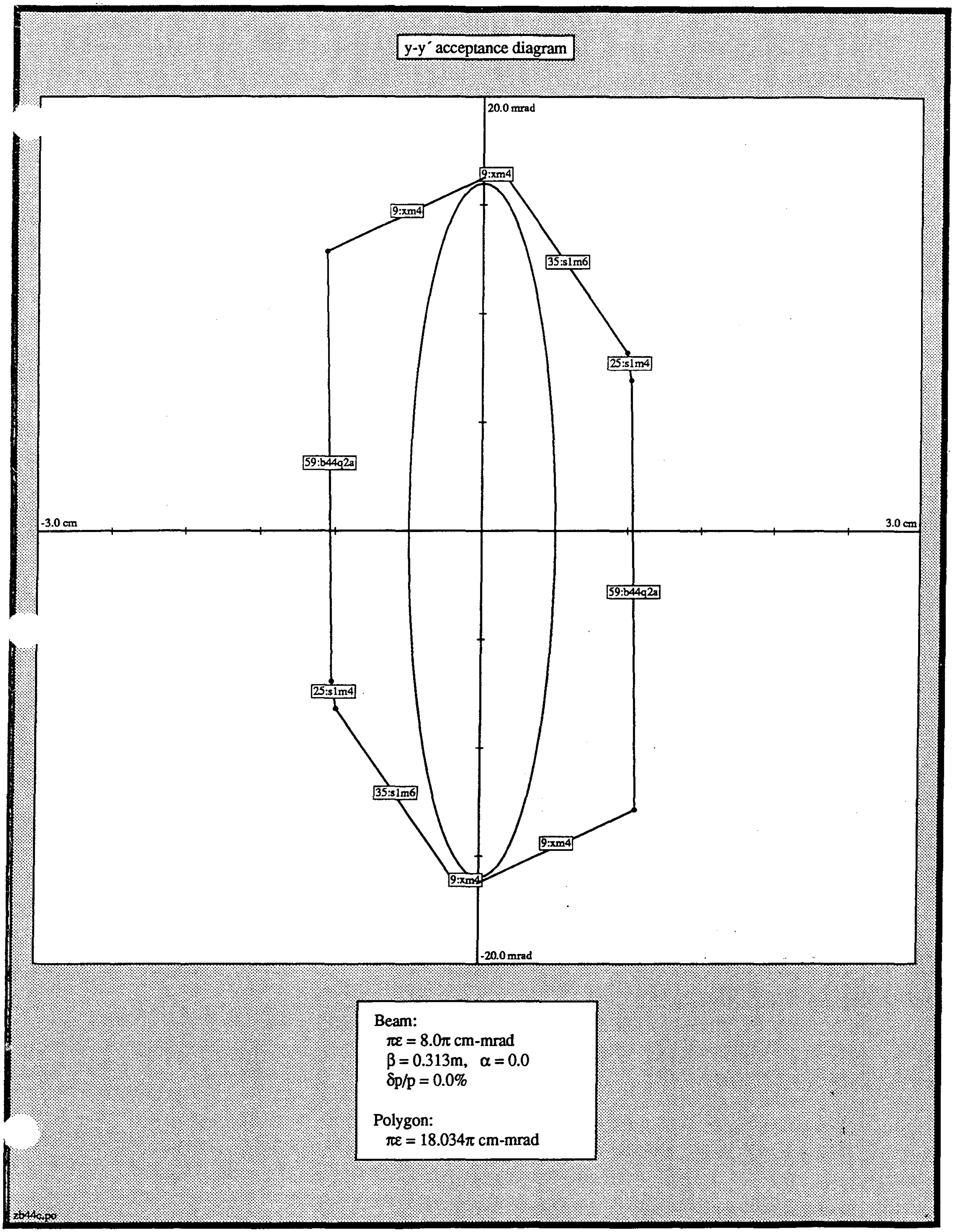
quit
End of program

3.6.2 (b) BEAM 44 (II) - TRANSPORT LIST


3.6.3 BEAM 44 (II)
x
η_x
y
η_y
x (cm)
y (cm)
η_x (m)
$-\eta_y$ (m)
z (m)
12.0
0.0
12.0
16.0
0.0
-16.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
xf1wc
xq4a
xq4b
xm4wc
xm4
x1q4a
x1q4wc
x1q4b
s1m3wc
s1f2wc
s1m5
s1m6wc
s1m6
s1q7wc
s1q7a
s1q7b
s1m6sw
s1f3wc
s1m7
b44q1a
b44wc1
b44wc2
b44q2a
b44q2b
b44m1
b44wc3
b44cm2
b44csc
zb44bg.gx



3.6.4 BEAM 44 (II) HORIZONTAL ACCEPTANCE AT F1



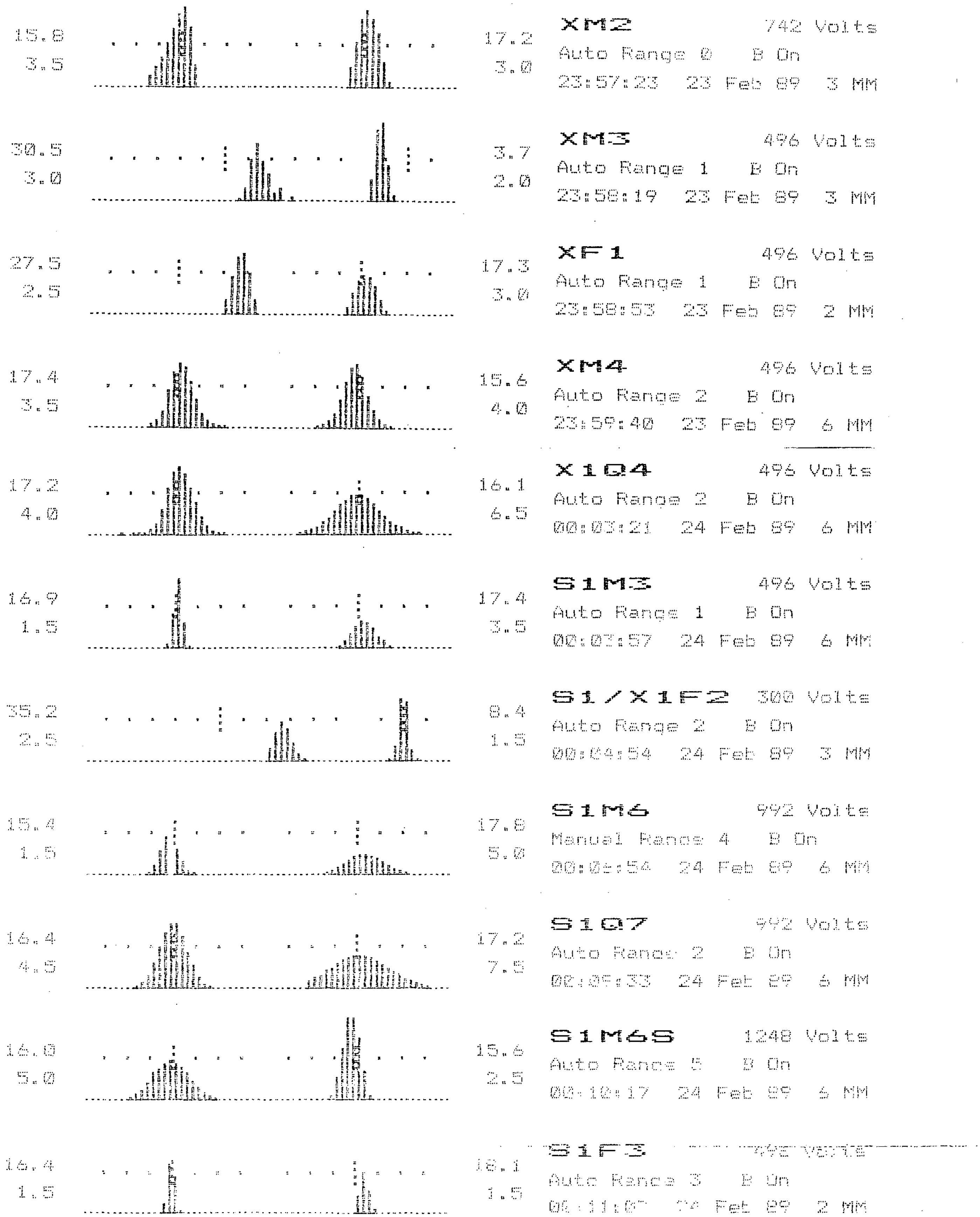
3.6.4 BEAM 44(II) VERTICAL ACCEPTANCE AT F1

3.6.5 Beam 44 Focal Points (I): Standard Optics

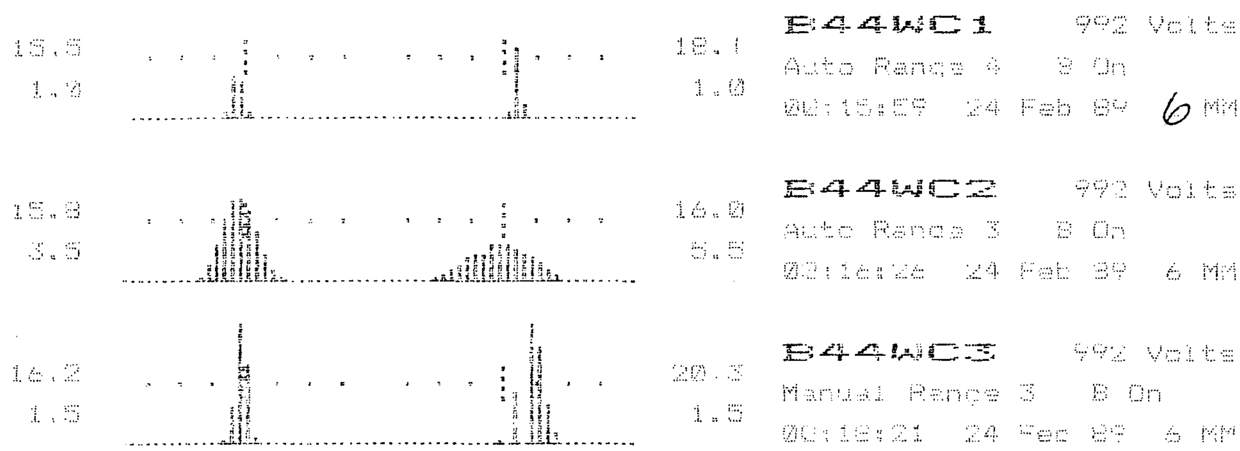
Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (cm/%)
F1	XF1WC	1.0	1.0	0.00
F2	S1F2WC	1.76	0.49	-2.26
F3	S1F3WC	0.54	0.56	0.08
F4	B44WC1	1.68	0.20	-0.19
F5	Center Scatter Chamber (CSC)	1.24	0.81	-3.24

Beam 44 Focal Points (II): Secondary Beam Optics

Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (cm/%)
F1	XF1WC	1.0	1.0	0.00
F2	S1F2WC	1.65	2.18	-2.52
F3	S1F3WC	0.52	2.60	0.37
F4	B44WC1	1.26	0.77	-2.26
F5	Center Isotope Magnet (CIM)	0.89	2.53	0.43



3.6.6 (a) Wire Chamber Pictures for Optics (I)



3.6.6 (a) Wire Chamber Pictures for Optics (I)

24FEB89 EPB ACL PRINT 0:39:17 PAGE 1

NAME	DATE	TIME	ENTRY	BEAM LINE
PRENT	16[illegible]24FEB89	0:39:17	0	BEAM44

PERTURBATION UNIT DATA

NAME		FLAGS	AMPLITUDE	DELAY	GATE
X	P1	P+	67.19	420	1660
X	P2	P+	100.00	400	1510
X	S2	S	306.09	400	1420
X	S1	S+	170.18	530	1790
X	S2	P	99.99	400	1330
X	M3	S+	0.25	670	1020
X	S1	P+	193.76	500	1300

NAME		SP	AM	DI	OFFSET
X	P1	0.00	0.66	5	0.00
X	P2	0.00	0.20	5	0.00
X	S1	0.00	0.22	5	0.00
X	S2	0.00	2.44	5	0.00
X	M1	349.38	379.40	5	0.00
X	M2	973.33	961.06	5	0.00
X	M3	750.60	785.47	5	0.00
X	Q3A	358.36	351.98	5	235.60
X	Q3B	317.02	340.01	5	207.10
X	M3V	33.71	32.49	2001	33.71
	M4	3844.17	4080.36	3001	3844.17
..	Q4A	0.00	4.64	5	0.00
	Q4B	0.00	0.00	5	0.00
X1	Q4A	607.27	590.33	2005	0.00
X1	Q4B	604.33	603.93	2007	0.00
X1	M5S	20.23	17.98	2001	20.23
S1	M3	98.97	98.49	2003	98.97
S1	M4	963.93	941.08	2005	900.12
S1	M5	355.09	356.24	2005	329.98
S1	M6	150.81	152.34	2001	150.81
S1	Q7A	490.05	486.18	2005	0.00
S1	Q7B	526.99	534.42	2005	0.00
S1	M6S	0.00	7.27	3	0.00
S1	M7	832.14	831.61	2001	832.14
B44	Q1A	2546.88	2554.32	2001	2546.88
B44	Q1B	2601.96	2538.74	2001	2601.96
B44	Q2A	2479.59	2474.99	2001	2479.59
B44	Q2B	2561.41	2574.16	2001	2561.41
B44	M1	908.17	910.99	2001	908.17

DATA FOR ENERGY CALCULATION

INJECTION: HILAC LOCAL

PARTICLE; $^4He^{+2}$ 2S FREQ ;

MASS NUM; 2S FIELD;

CHARGE ; K.ENERGY; 400 MeV

INFLECTOR H.V;

EXTRACTION: PFW: ON; OFF;

FIELD; 4169 gauss P1 CUR;

FREQ; P2 CUR;

BEAM RAD; ~~∅~~ 599.28

RADIUS	CURRENT	TAIL WAG	
M1;	;	RISE;	GAUSS
M2;	;	TIME:	mSECS
M3;	------;	S1 ON;	OFF;
		S2 ON;	OFF;

3.6.6 (b) Magnet Currents for Optics (I)

3.6.7 (a) Beam 44 Optic-Axis Beam Positions on the Wire Chambers

Active Dipole Magnets	Wire Chamber	Beam Center on Wire Chamber (Wire Number)	
		Horizontal	Vertical
XM3V	X1Q4WC	---	16.5
XM4	S1M3WC	16.5	---
S1M3	S1F2WC	35.0	---
S1M4*	S1M6WC	16.5	---
S1M5*	S1Q7WC	16.5	---
S1M6*	S1F3WC	16.5	---
X1M5S	S1Q7WC	---	16.5
S1M7	B44WC2	16.5	---
S1M6S	B44WC4	---	16.5

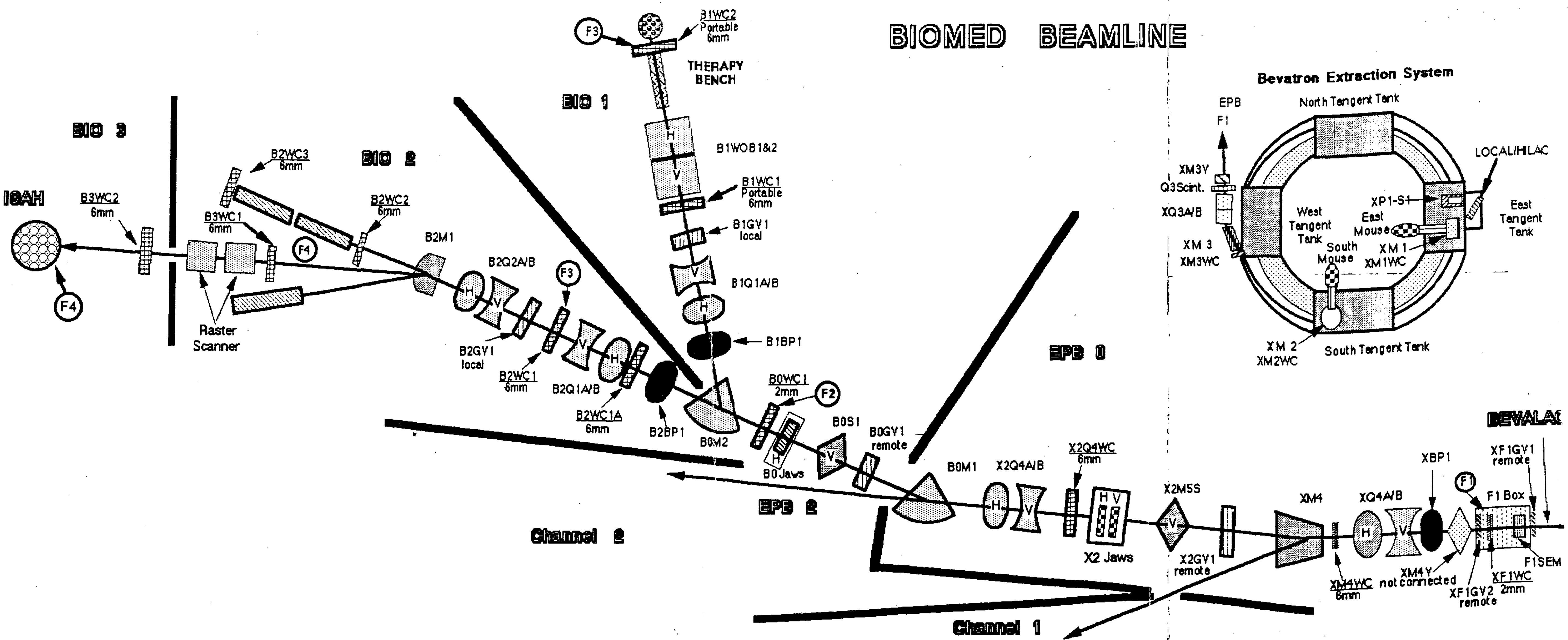
* See Section 5.2

3.6.7 (b) Beam 44 Average Magnet Currents per Bevalac Field

Beam Line Magnet	Magnet Current per Bevalac Field (Ampere/kG)
XM4	952.3*
X1Q4A	149.1
X1Q4B	159.3
S1M3	24.6
S1M4	223.2
S1M5	87.7
S1M6	35.9
S1Q7A	114.8
S1Q7B	125.3
S1M7	182.8
B44Q1A	566.3
B44Q1B	563.7
B44Q2A	451.0
B44Q2B	379.7
B44M1	213.0

* Magnet field per Bevalac field (gauss/kG)

3.7 BIOMED I



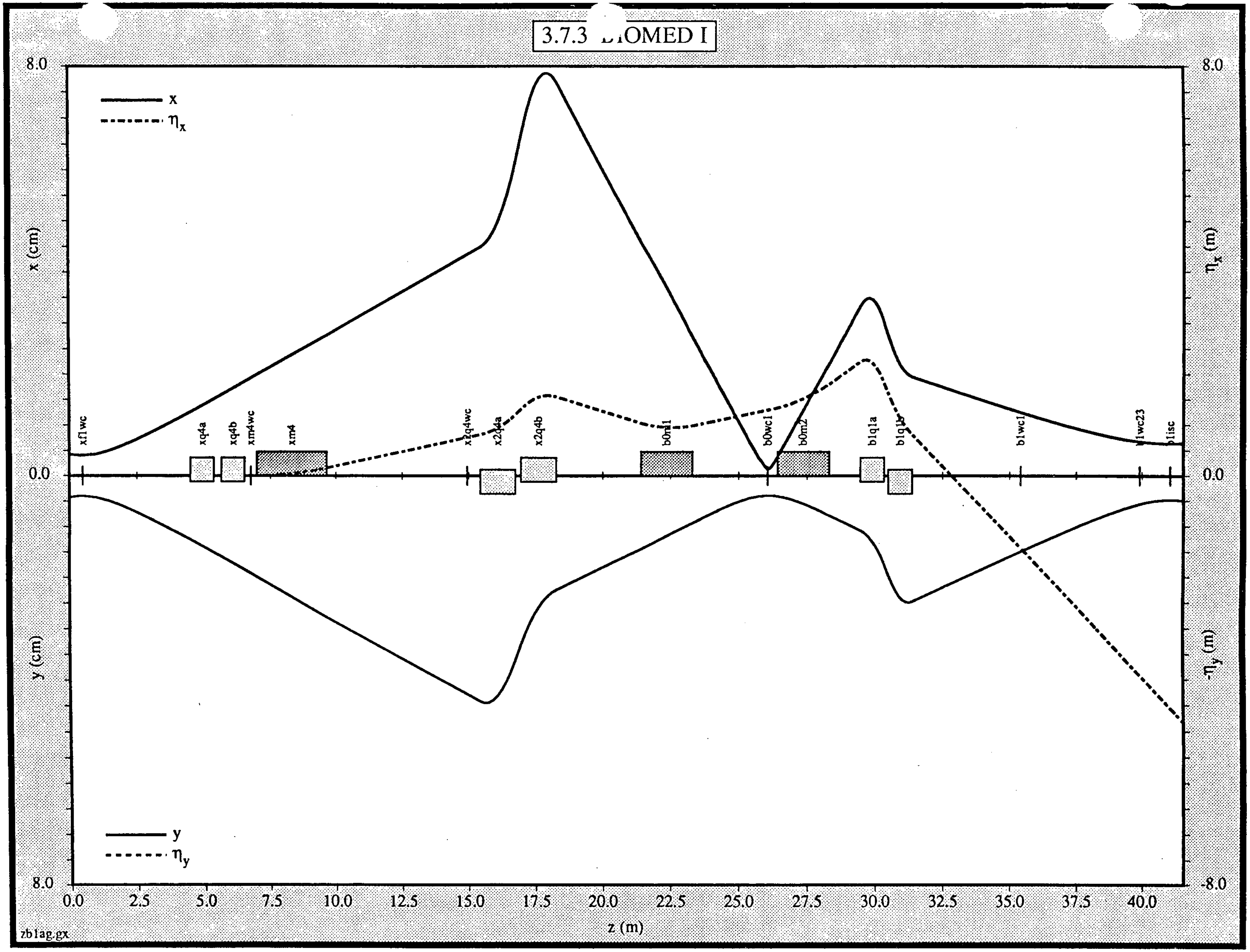
BIOMED BEAMLINE
Bevatron Extraction System
North Tangent Tank
EPB
F1
XM3Y
Q3Scint.
XQ3A/B
XM 3
XM3WC
West Tangent Tank
East Mouse
South Mouse
XP1-S1
XM 1
XM1WC
LOCAL/HILAC
East Tangent Tank
XM 2
XM2WC
South Tangent Tank
BIO 1
BIO 2
BIO 3
ISAH
THERAPY BENCH
B1WC2 Portable 6mm
B1WOB1&2
B1WC1 Portable 6mm
B1GV1 local
B1Q1A/B
B1BP1
B2WC3 6mm
B2WC2 6mm
B3WC2 6mm
B3WC1 6mm
B2M1
B2Q2A/B
Raster Scanner
B2GV1 local
B2WC1 6mm
B2Q1A/B
B2WC1A 6mm
B2BP1
B0M2
B0WC1 2mm
B0 Jaws
B0S1
B0GV1 remote
EPB 0
EPB 2
Channel 2
Channel 1
B0M1
X2Q4A/B
X2Q4WC 6mm
X2 Jaws
X2M5S
X2GV1 remote
XM4
XM4WC 6mm
XQ4A/B
XBP1
XM4Y not connected
XF1GV2 remote
XF1WC 2mm
F1 Box
XF1GV1 remote
F1SEM
BEVALAC

AUG 89

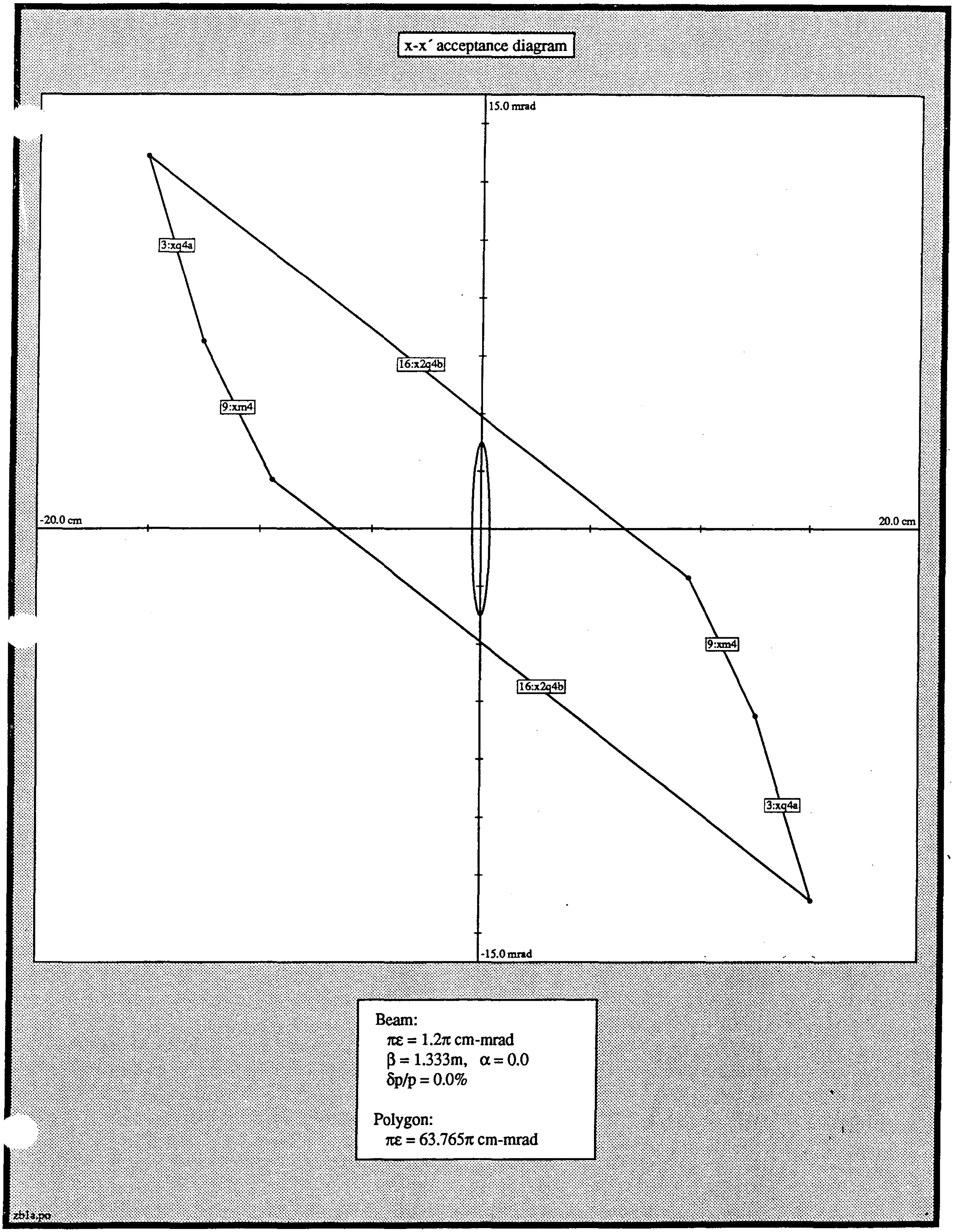
3.7.2 (a) Biomed I - Magnet Parameters									
		Quadropole Magnet		Dipole Magnet					
Beam line Element	Effective Length (m)	Max Gradient (kG/m)	Pole Tip Radius (m)	Max Field (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	Magnet or Wire Chamber Type (in)
(F1)-XF1WC	0.000								2mm Special
	3.969								
XQ4A	0.884	-147	0.1046						8QB32
	0.284								
XQ4B	0.884	+147	0.1046						8QB32
	0.230								
---XM4WC	0.000								6mm Perm. Gas
	0.233								
XM4	2.668			17.86	23.413	6.529	0.0	6.529	4.1x22x100 H
	5.286								
---X2Q4WC	0.000								6mm Perm. Gas
	0.495								
X2Q4A	1.308	-138	0.1046						8QB48
	0.216								
X2Q4B	1.308	+138	0.1046						8QB48
	3.142								
B0M1	1.898			17.3	6.905	15.75	7.875	7.875	5.4x16x72H
	2.756								
(F2)-B0WC1	0.000								2mm Crawford
	0.350								
B0M2	1.898			17.3	6.905	15.75	7.875	7.875	5.4x16x72H
	1.138								
B1Q1A	0.882	+117	0.1016						LP8Q32
	0.160								
B1Q1B	0.882	-117	0.1016						LP8Q32
	4.040								
---B1WC1	0.000								6mm Portable
	4.510								
---B1WC2/3	0.000								Biomed WC
	1.154								
(F3)-B1ISC	0.000								Isocenter

```
b
Beam rigidity =    19.2000 t-m
x,y emittance =     1.2000   1.2000 cm-mrad
dp/p =  0.000%
t
Transport mode
        betax =   1.3333   alphax =   0.0000
        betay =   1.3333   alphay =   0.0000
        etax  =   0.0000   eta'x  =   0.0000
        etay  =   0.0000   eta'y  =   0.0000
d
      name      type  vcode   lth,angle    b,b',s      n,gap   xaper   yaper
      ----      ----  -----   ---------    ------      -----   -----   -----
   1 xf1wc      lens   0.0     0.000000    0.000000   0.0000
   2 l1         drift  0.0     3.969000    0.000000   0.0000
   3 xq4a       quad   0.0     0.884000    0.000000   0.0000  0.1000  0.1000
   4 s1         drift  0.0     0.284000    0.000000   0.0000
   5 xq4b       quad   0.0     0.884000    0.000000   0.0000  0.1000  0.1000
   6 l2         drift  0.0     0.230000    0.000000   0.0000
   7 xm4wc      lens   0.0     0.000000    0.000000   0.0000
   8 l3         drift  0.0     0.233000    0.000000   0.0000
   9 xm4        bend   0.0     2.668000    0.820000   0.0000  0.0836  0.0457
  10 xm4o       edge   0.0     6.529000    0.820000   0.0000
  11 l4a        drift  0.0     5.286000    0.000000   0.0000
  12 x2q4wc     lens   0.0     0.000000    0.000000   0.0000
  13 l4b        drift  0.0     0.495000    0.000000   0.0000
  14 x2q4a      quad   0.0     1.308000   -6.037931   0.0000  0.1000  0.1000
  15 s2         drift  0.0     0.216000    0.000000   0.0000
  16 x2q4b      quad   0.0     1.308000    6.580145   0.0000  0.1000  0.1000
  17 l5         drift  0.0     3.142000    0.000000   0.0000
  18 b0m1e      edge   0.0     7.875000    2.782000   0.0000
  19 b0m1       bend   0.0     1.898000    2.782000   0.0000  0.1000  0.0686
  20 b0m1e      edge   0.0     7.875000    2.782000   0.0000
  21 l6         drift  0.0     2.756000    0.000000   0.0000
  22 b0wc1      lens   0.0     0.000000    0.000000   0.0000
  23 l7         drift  0.0     0.350000    0.000000   0.0000
  24 b0m2e      edge   0.0     7.875000    2.782000   0.0000
  25 b0m2       bend   0.0     1.898000    2.782000   0.0000  0.1000  0.0686
  26 b0m2e      edge   0.0     7.875000    2.782000   0.0000
  27 l8         drift  0.0     1.138000    0.000000   0.0000
  28 b1q1a      quad   1.2     0.882000   17.351295   0.0000  0.1000  0.1000
  29 s3         drift  0.0     0.160000    0.000000   0.0000
  30 b1q1b      quad   2.2     0.882000  -14.787666   0.0000  0.1000  0.1000
  31 l9         drift  0.0     4.040000    0.000000   0.0000
  32 b1wc1      lens   0.0     0.000000    0.000000   0.0000
  33 l10        drift  0.0     4.510000    0.000000   0.0000
  34 b1wc23     lens   0.0     0.000000    0.000000   0.0000
  35 l11        drift  0.0     1.154000    0.000000   0.0000
  36 b1isc      lens   0.0     0.000000    0.000000   0.0000
quit
End of program
```

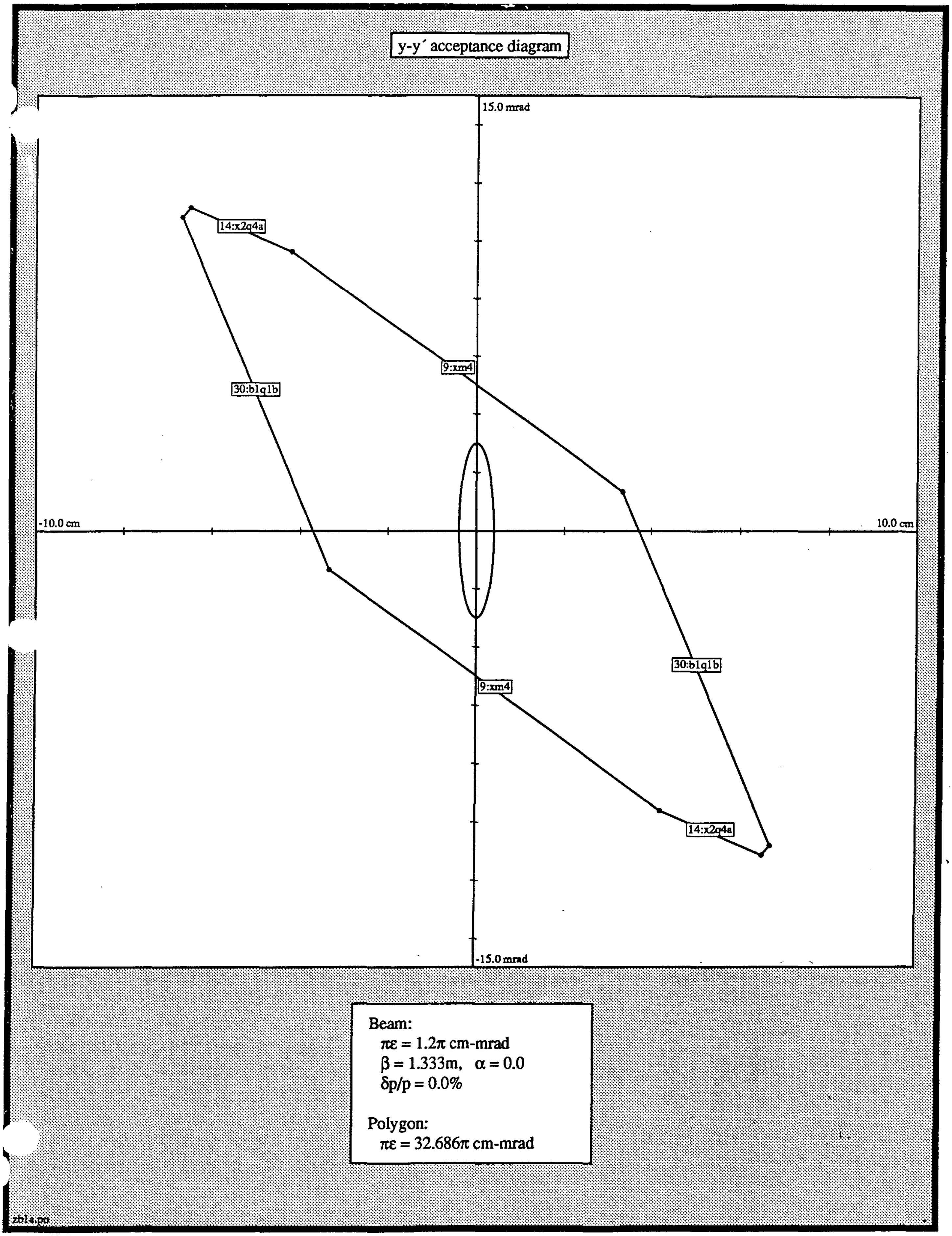
3.7.2 (b) **BIOMED I - TRANSPORT LIST**



3.7.3 OMED I
x
η_x
y
η_y
x (cm)
η_x (m)
y (cm)
$-\eta_y$ (m)
z (m)
8.0
0.0
8.0
-8.0
0.0 2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0 22.5 25.0 27.5 30.0 32.5 35.0 37.5 40.0
xf1wc
xq4a
xq4b
xm4wc
xm4
x2q4wc
x2q4b
b0wc1
b0m2
b1q1a
b1wc1
zb1ag.gx



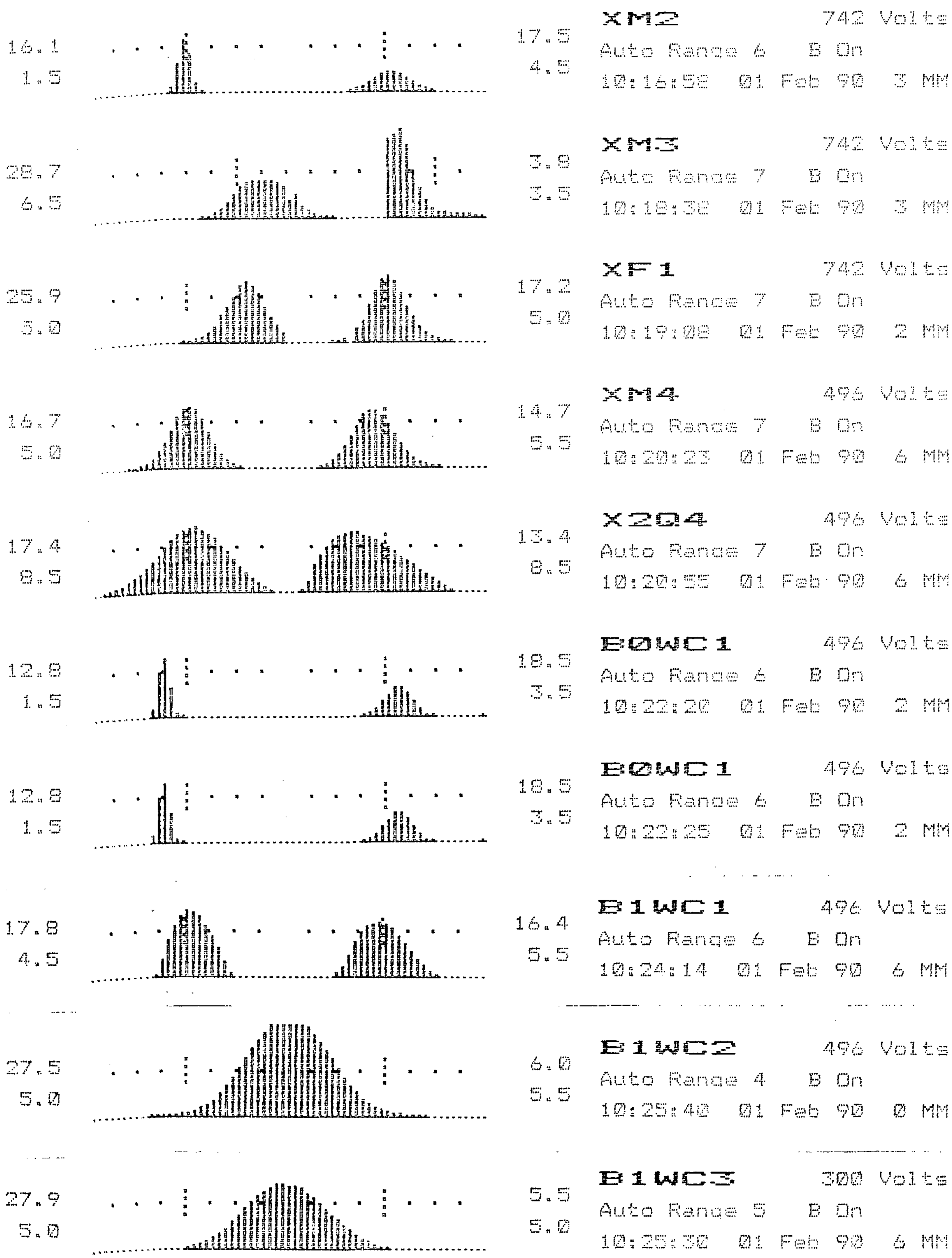
3.7.4 BIOMED I HORIZONTAL ACCEPTANCE AT F1



3.7.4 BIOMED I VERTICAL ACCEPTANCE AT F1

3.7.5 Biomed I Focal Points

Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (cm/%)
F1	XF1WC	1.0	1.0	0.00
F2	B0WC1	0.30	0.98	1.30
F3	Isocenter (ISC)	1.59	1.20	-4.55



3.7.6 (a) Wire Chamber Pictures

1FEB90 EPS ACL PRINT 10:38:38 PAGE 1

NAME	DATE	TIME	ENTRY	BEAM LINE
CURRENT WOBB	1FEB90	10:38:38	0	BIOM1

PERTURBATION UNIT DATA

NAME		FLAGS	AMPLITUDE	DELAY	GATE
X	P1	P+	30.64	420	1680
X	P2	P+	15.44	400	1510
X	S2	S	306.09	400	1420
X	S1	S+	170.18	500	1790
X	S2	P	99.99	400	1330
X	M3	S	0.25	670	1020
X	S1	P+	2.42	500	1300

NAME		SP	AM	DI	OFFSET
X	P1	0.00	0.66	5	0.00
X	P2	0.00	0.20	5	0.00
X	S1	0.00	0.00	5	0.00
X	S2	0.00	5.86	5	0.00
X	M1	193.27	219.28	5	0.00
X	M2	748.47	684.32	5	0.00
X	M3	552.25	596.52	5	0.00
X	Q3A	241.65	229.05	5	0.00
X	Q3B	216.72	246.95	5	0.00
X	M3V	11.01	9.89	2001	11.01
XF1	PM	1247.56	1327.80	1	1247.56
X	M4	-1876.19	-1876.97	3001	-1876.18
	M4V	0.00	0.00	1	0.00
	Q4A	0.00	0.00	5	0.00
	Q4B	0.00	3.48	5	0.00
B0	M2	6005.13	6077.18	2001	6005.13
X2	M5S	11.90	10.73	2001	11.90
X2	Q4A	274.70	270.40	2005	0.00
X2	Q4B	306.67	293.84	2005	0.00
B0	M1	5958.40	5959.77	3001	5958.40
B0	S1	0.00	0.00	2001	0.00
B1	Q1A	362.78	358.55	2001	362.78
B1	Q1B	273.91	275.45	1	273.91

DATA FOR ENERGY CALCULATION

INJECTION: HILAC LOCAL

PARTICLE: He 2S FREQ: 247128 Hz

MASS NUM: 4 2S FIELD: 406.28

CHARGE: +2 K.ENERGY:

INFLECTOR H.V: 16.80

EXTRACTION: PFW: (ON) OFF;

FIELD: 2926 P1 CUR: 30.64

FREQ: 1.45476 MHz P2 CUR: 15.44

BEAM RAD: 598.4

	RADIUS	CURRENT	TAIL WAG	
M1;		;	RISE;	GAUSS
M2;		;	TIME;	mSECS
M3;	--------	;	S1 (ON)	OFF;
			S2 ON;	OFF;

STD MATERIAL AT F1: (IN) OUT;

Q3 scint in

3.7.6 (b) Magnet Currents

3.7.7 (a) Biomed I Optic-Axis Beam Positions on the Wire Chambers

Active Dipole Magnets	Wire Chamber	Beam Center on Wire Chamber (Wire Number)	
		Horizontal	Vertical
XM3V	X2Q4WC	---	16.5
XM4	X2Q4WC	16.5	---
B0M1	B0WC1*	16.5	---
B0M2	B1WC1*	16.5	---
X2M5S	B0WC1*	---	16.5
B0S1	B1WC1*	---	16.5

*The final position is determined by ion chambers IC1, IC2, and IC3.

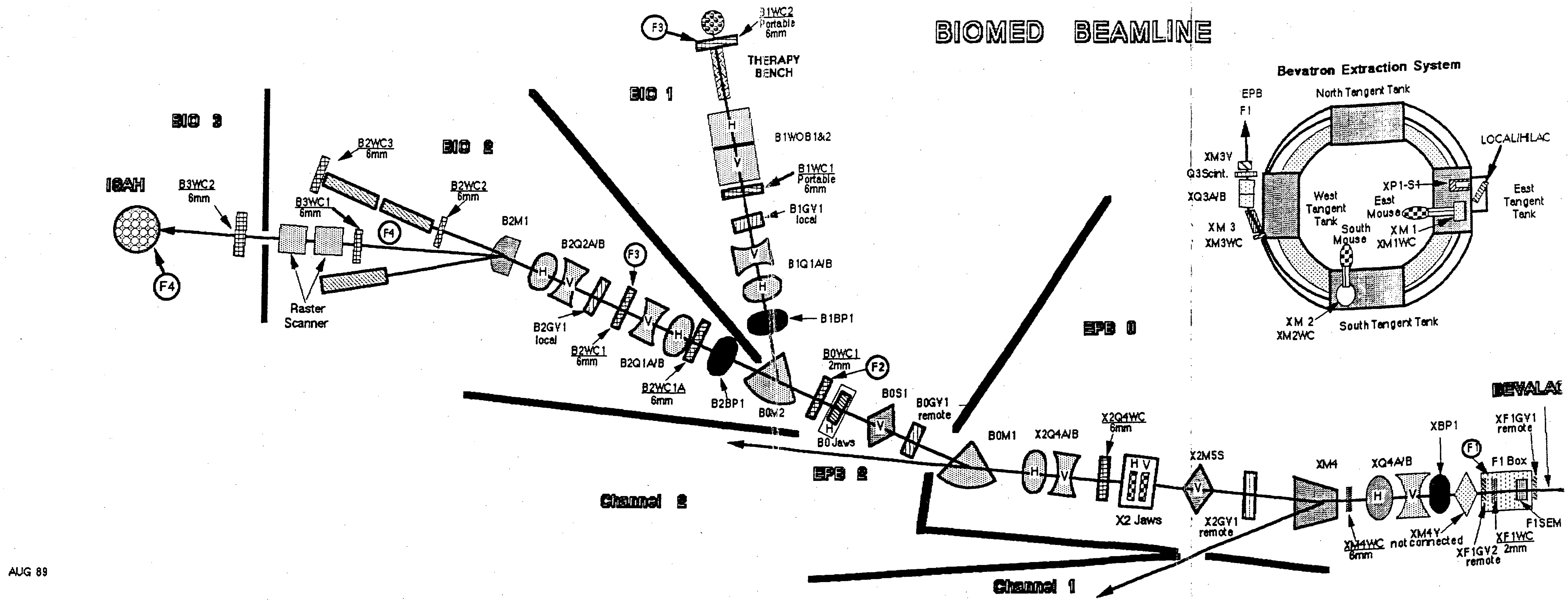
3.7.7 (b) Biomed I Average Magnet Currents per Bevalac Field

Beam Line Magnet	Magnet Current per Bevalac Field (Ampere/kG)
XM4	-649.6*
X2Q4A	91.9
X2Q4B	101.0
B0M1	2015.4*
B0M2	2056.6*
B1Q1A	95.6
B1Q1B	70.2

* Magnet field per Bevalac field (gauss/kG)

3.8 BIOMED II

BIOMED BEAMLINE

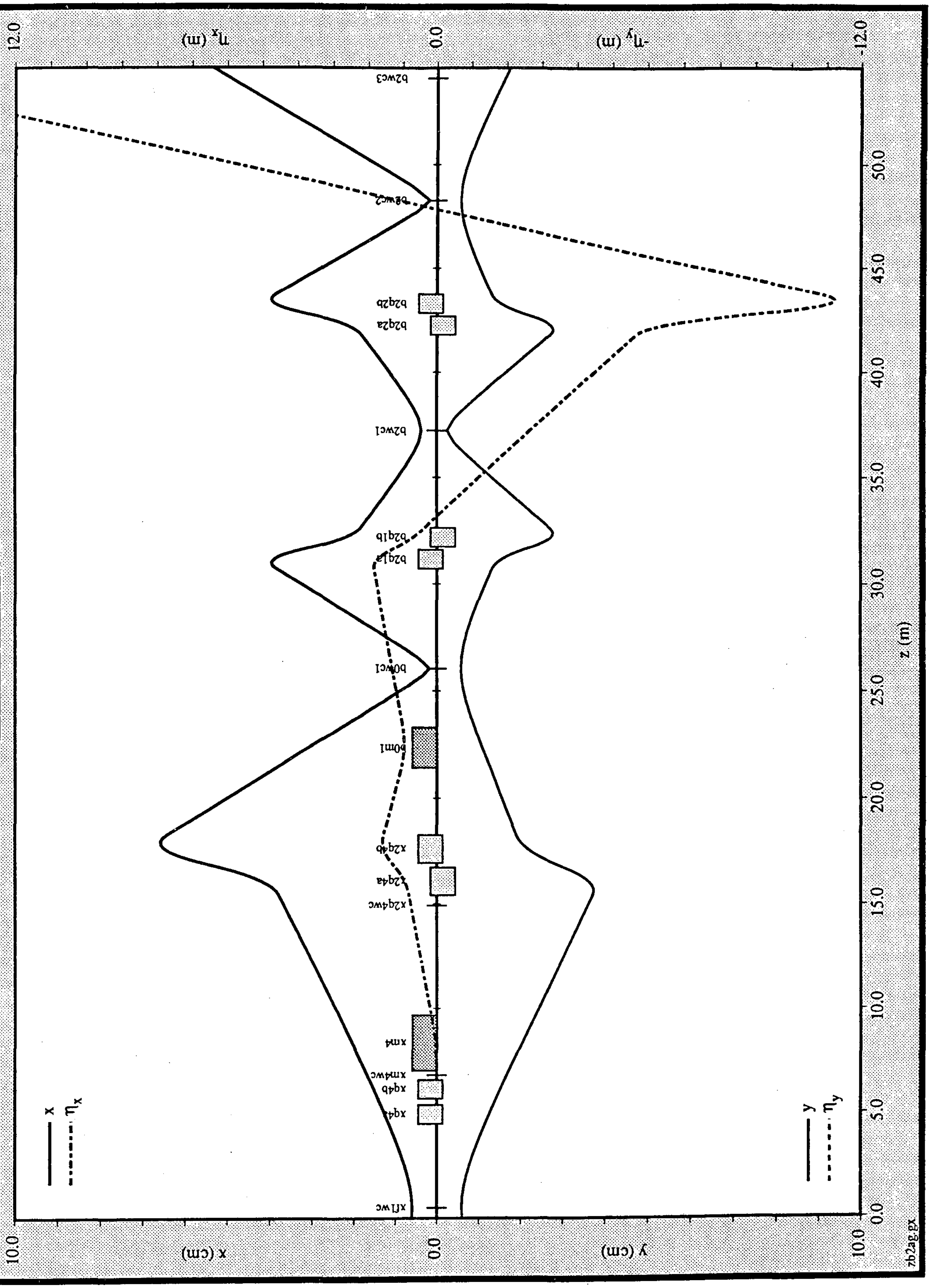


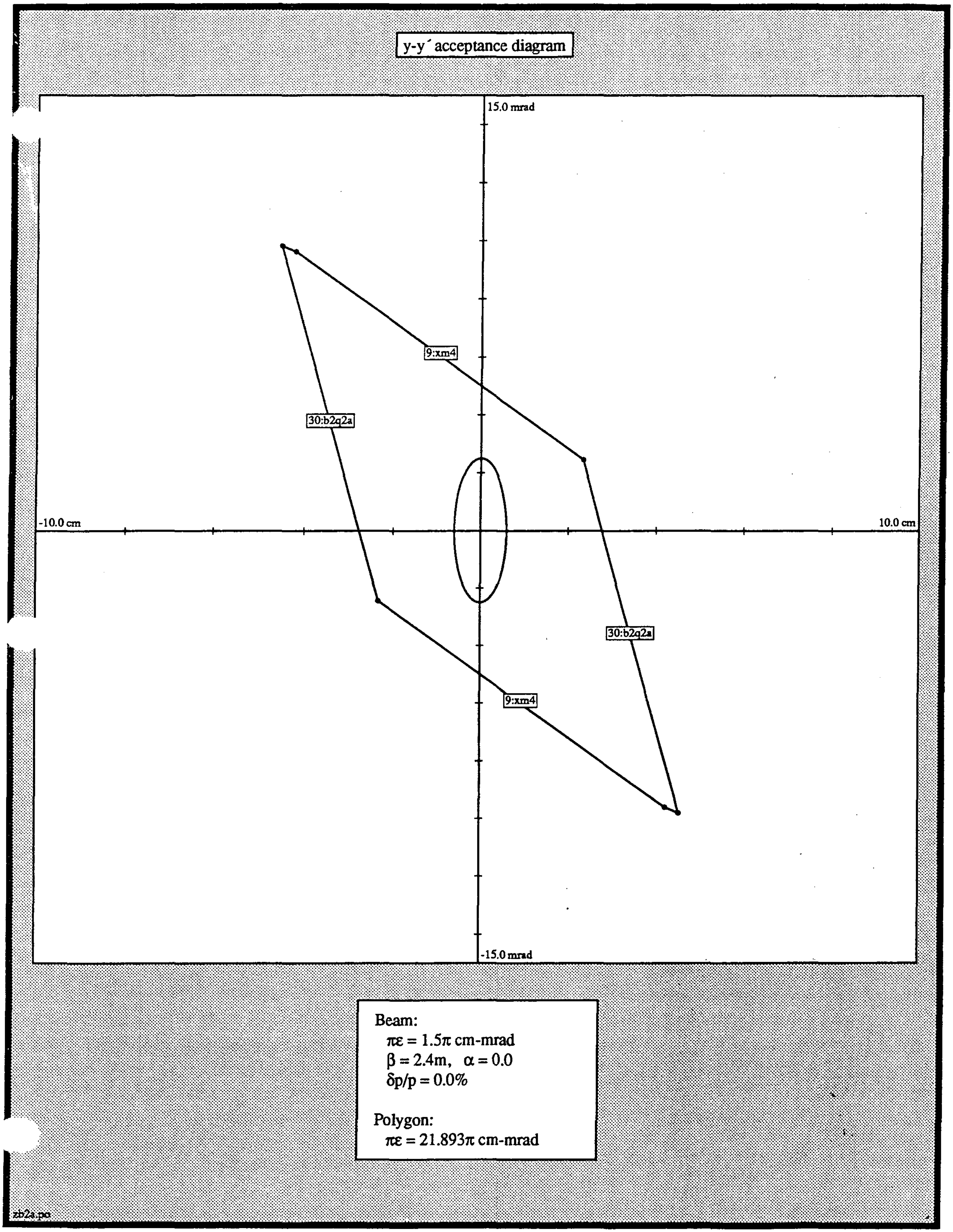
3.8.2 (a) Biomed II Magnet Parameters									
		Quadropole Magnet		Dipole Magnet					
Beam Line Element	Effective Length (m)	Max Gradient (kG/m)	Pole Tip Radius (m)	Max Field (kG)	Bend Radius (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	Magnet or Wire Chamber Type (in)
(F1)-XF1WC	0.000								2mm Special
	3.969								
XQ4A	0.884	-147	0.1046						8QB32
	0.284								
XQ4B	0.884	+147	0.1046						8QB32
	0.230								
--XM4WC	0.000								6mm Perm. Gas
	0.233								
XM4	2.668			17.86	23.413	6.529	0.0	6.529	4.1x22x100 H
	5.286								
--X2Q4WC	0.000								6mm Perm. Gas
	0.495								
X2Q4A	1.308	-138	0.1046						8QB48
	0.216								
X2Q4B	1.308	+138	0.1046						8QB48
	3.142								
B0M1	1.898			17.3	6.905	15.75	7.875	7.875	5.4x16x72H
	2.756								
(F2)-B0WC1	0.000								2mm Crawford
	4.651								
B2Q1A	0.882	+117	0.1016						LP8Q32
	0.160								
B2Q1B	0.882	-117	0.1016						LP8Q32
	4.578								
(F3)- B2WC1	0.000								6mm Crawford
	4.581								
B2Q2A	0.882	-117	0.1016						LP8Q32
	0.160								
B2Q2B	0.882	+117	0.1016						LP8Q32
	4.560								
(F4)-B2WC2	0.000								6mm Portable
	5.860								
--B2WC3	0.000								6mm Portable

```
b
Beam rigidity =    19.2000 t-m
x,y emittance =     1.5000   1.5000 cm-mrad
dp/p =  0.000%
t
Transport mode
        betax =    2.4000   alphax =    0.0000
        betay =    2.4000   alphay =    0.0000
        etax  =    0.0000   eta'x  =    0.0000
        etay  =    0.0000   eta'y  =    0.0000
d
      name        type  vcode    lth,angle     b,b',s       n,gap    xaper    yaper
      ----        ----  -----    ---------     ------       -----    -----    -----
   1 xflwc        lens   0.0      0.000000     0.000000     0.0000
   2 l1           drift  0.0      3.969000     0.000000     0.0000
   3 xq4a         quad   0.0      0.884000     0.000000     0.0000   0.1000   0.1000
   4 s1           drift  0.0      0.284000     0.000000     0.0000
   5 xq4b         quad   0.0      0.884000     0.000000     0.0000   0.1000   0.1000
   6 l2           drift  0.0      0.230000     0.000000     0.0000
   7 xm4wc        lens   0.0      0.000000     0.000000     0.0000
   8 l3           drift  0.0      0.233000     0.000000     0.0000
   9 xm4          bend   0.0      2.668000     0.820000     0.0000   0.0836   0.0457
  10 xm4o         edge   0.0      6.529000     0.820000     0.0000
  11 l4a          drift  0.0      5.286000     0.000000     0.0000
  12 x2q4wc       lens   0.0      0.000000     0.000000     0.0000
  13 l4b          drift  0.0      0.495000     0.000000     0.0000
  14 x2q4a        quad   0.0      1.308000    -5.981143     0.0000   0.1000   0.1000
  15 s2           drift  0.0      0.216000     0.000000     0.0000
  16 x2q4b        quad   0.0      1.308000     6.547521     0.0000   0.1000   0.1000
  17 l5           drift  0.0      3.142000     0.000000     0.0000
  18 b0mle        edge   0.0      7.875000     2.782000     0.0000
  19 b0ml         bend   0.0      1.898000     2.782000     0.0000   0.1000   0.0686
  20 b0mle        edge   0.0      7.875000     2.782000     0.0000
  21 l6           drift  0.0      2.756000     0.000000     0.0000
  22 b0wc1        lens   0.0      0.000000     0.000000     0.0000
  23 l7           drift  0.0      4.651000     0.000000     0.0000
  24 b2q1a        quad   0.0      0.882000    17.167797     0.0000   0.1000   0.1000
  25 s3           drift  0.0      0.160000     0.000000     0.0000
  26 b2q1b        quad   0.0      0.882000   -17.078485     0.0000   0.1000   0.1000
  27 l8           drift  0.0      4.578000     0.000000     0.0000
  28 b2wc1        lens   0.0      0.000000     0.000000     0.0000
  29 l9           drift  0.0      4.581000     0.000000     0.0000
  30 b2q2a        quad   1.2      0.882000   -17.142586     0.0000   0.1000   0.1000
  31 s4           drift  0.0      0.160000     0.000000     0.0000
  32 b2q2b        quad   2.2      0.882000    17.287745     0.0000   0.1000   0.1000
  33 l10          drift  0.0      4.560000     0.000000     0.0000
  34 b2wc2        lens   0.0      0.000000     0.000000     0.0000
  35 l11          drift  0.0      5.860000     0.000000     0.0000
  36 b2wc3        lens   0.0      0.000000     0.000000     0.0000
quit
End of program
```

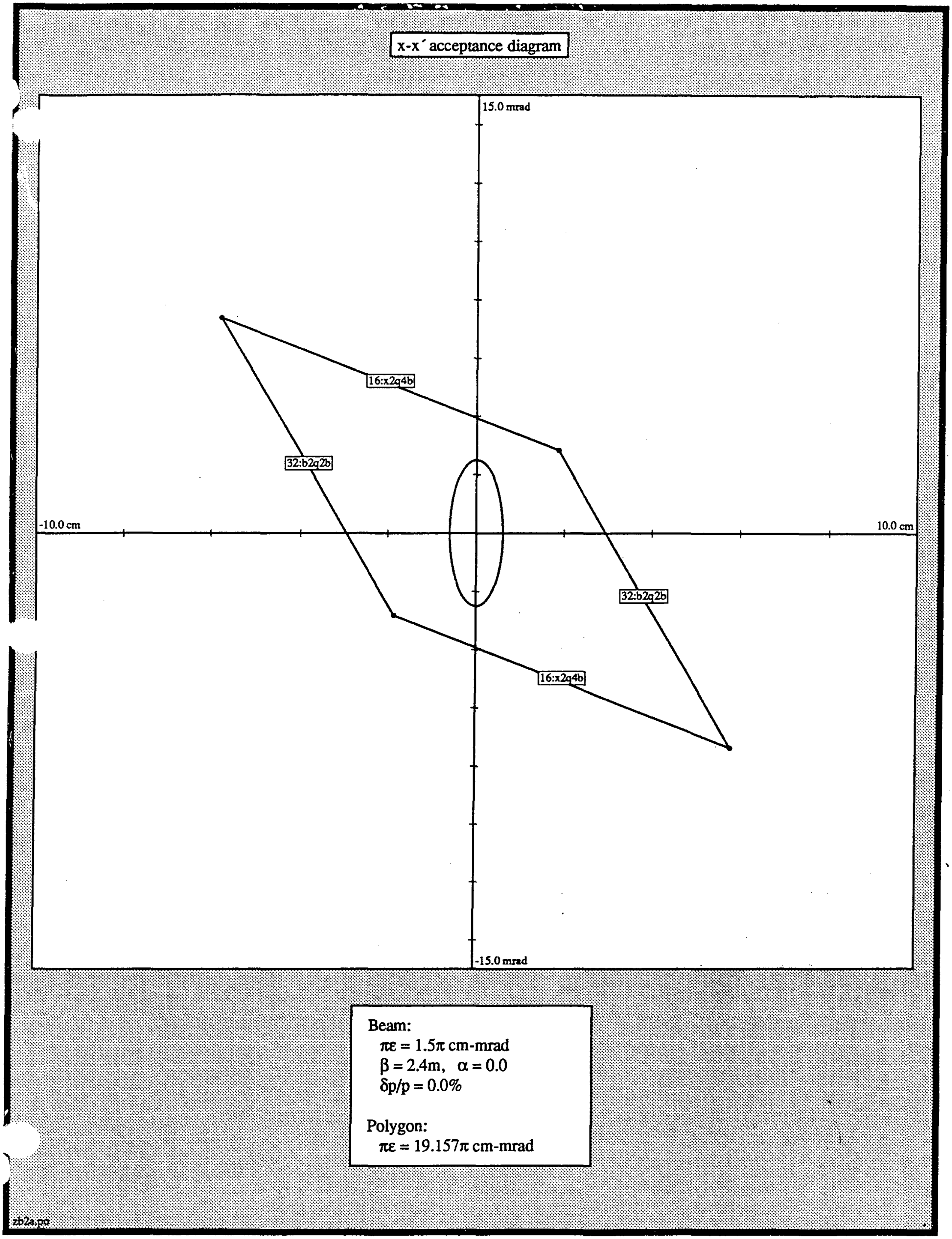
3.8.2 (b) BIOMED II – TRANSPORT LIST

3.8.3 DIOMED II





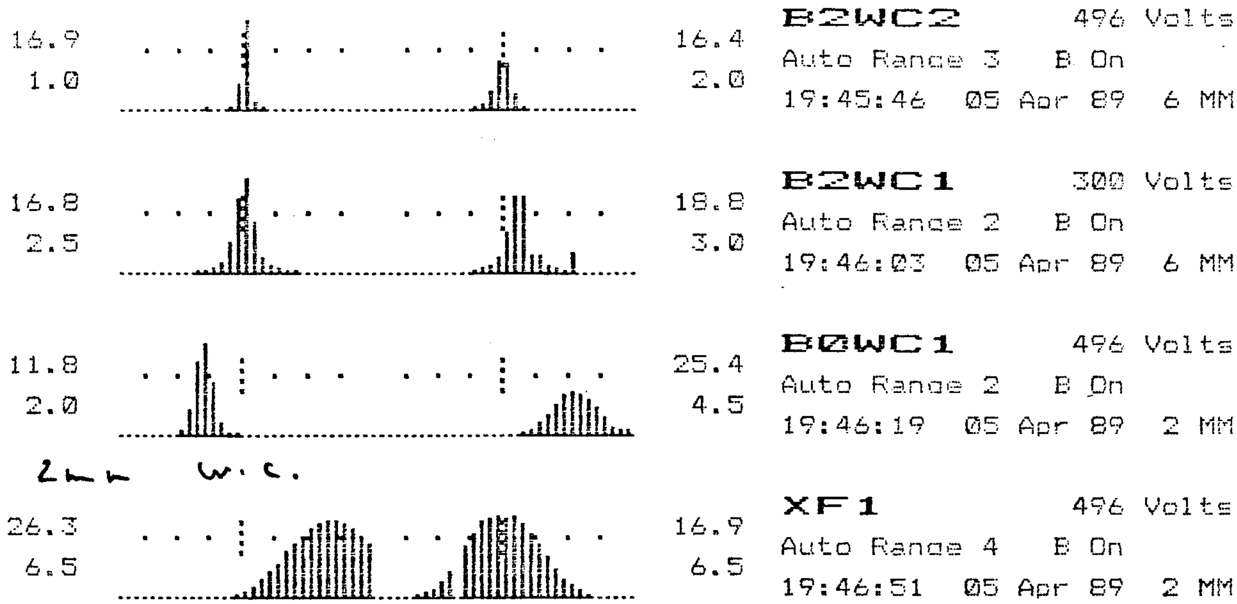
3.8.4 BIOMED II VERTICAL ACCEPTANCE AT F1



3.8.4 BIOMED II HORIZONTAL ACCEPTANCE AT F1

3.8.5 Biomed II Focal Points

Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (cm/%)
F1	XF1WC	1.0	1.0	0.00
F2	B0WC1	0.30	0.98	1.30
F3	B2WC1	0.64	0.43	-2.66
F4	B2WC2	0.30	0.97	1.15



3.8.6 (a) Wire Chamber Pictures

5APR89 EPB ACL PRINT 19:40:27 PAGE 1

NAME	DATE	TIME	ENTRY	BEAM LINE
CURRENT B2	5APR89	19:40:27	0	BIOM2

HE 2535 B2

SAVED ON F.S. " 6 "

PERTURBATION UNIT DATA

NAME		FLAGS	AMPLITUDE	DELAY	GATE
X	P1	P+	40.01	430	1680
X	P2	P+	20.00	400	1510
X	S2	S	306.09	400	1420
X	S1	S+	481.46	400	1790
X	S2	P	114.07	400	1330
X	M3	S+	13.11	670	1020
X	S1	P+	19.89	400	1260

NAME		SP	AM	DI	OFFSET
X	P1	0.00	0.66	5	0.00
X	P2	0.00	0.68	5	0.00
X	S1	0.00	0.00	5	0.00
X	S2	0.00	2.56	5	0.00
X	M1	103.20	132.27	5	0.00
X	M2	630.70	589.97	5	0.00
X	M3	485.97	530.24	5	0.00
X	Q3A	229.22	214.28	5	0.00
X	Q3B	229.82	241.08	5	0.00
X	M3V	15.01	13.92	2001	15.01
X	M4	-1384.18	-1657.25	3001	-1384.18
X	Q4A	0.00	0.00	5	0.00
	Q4B	0.00	3.48	5	0.00
	M2	5147.78	29.31	1	5147.78
	M5S	22.37	22.75	2001	22.37
X2	Q4A	236.23	232.29	2005	0.00
X2	Q4B	270.95	257.21	2005	0.00
B0	M1	5128.09	5139.08	3001	5128.09
B0	S1	66.17	66.17	2001	66.17
B2	M1	33.47	26.16	3001	33.47
B2	Q1A	367.01	367.78	2001	367.01
B2	Q1B	394.04	397.02	1	394.04
B2	Q2A	334.02	333.93	2001	334.02
B2	Q2B	332.97	330.08	1	332.97

DATA FOR ENERGY CALCULATION

INJECTION: HILAC (LOCAL)

PARTICLE: He 2S FREQ: 246.6

MASS NUM: 4 2S FIELD: 404.6

CHARGE: 2 K.ENERGY:

INFLECTOR H.V: -15.6

EXTRACTION: PFW: (ON) OFF: YMODE ON

FIELD: 2535 P1 CUR:

FREQ: P2 CUR:

BEAM RAD: 596.6

	RADIUS	CURRENT	TAIL WAG	
M1:		:	RISE:	GAUSS
M2:		:	TIME:	mSECS
M3:	------	:	S1 ON:	OFF:
			S2 ON:	OFF:

STD MATERIAL AT F1: (IN) OUT:

P3 SCINT

3.8.6 (b) Magnet Currents

3.8.7 (a) Biomed II Optic-Axis Beam Positions on the Wire Chambers

Active Dipole Magnets	Wire Chamber	Beam Center on Wire Chamber (Wire Number)	
		Horizontal	Vertical
XM3V	X2Q4WC	---	16.5
XM4	X2Q4WC	16.5	---
B0M1	B2WC1*	16.5	---
B2M1	B2WC2*	16.5	---
X2M5S	B2WC1*	---	16.5
B0S1	B2WC2*	---	16.5

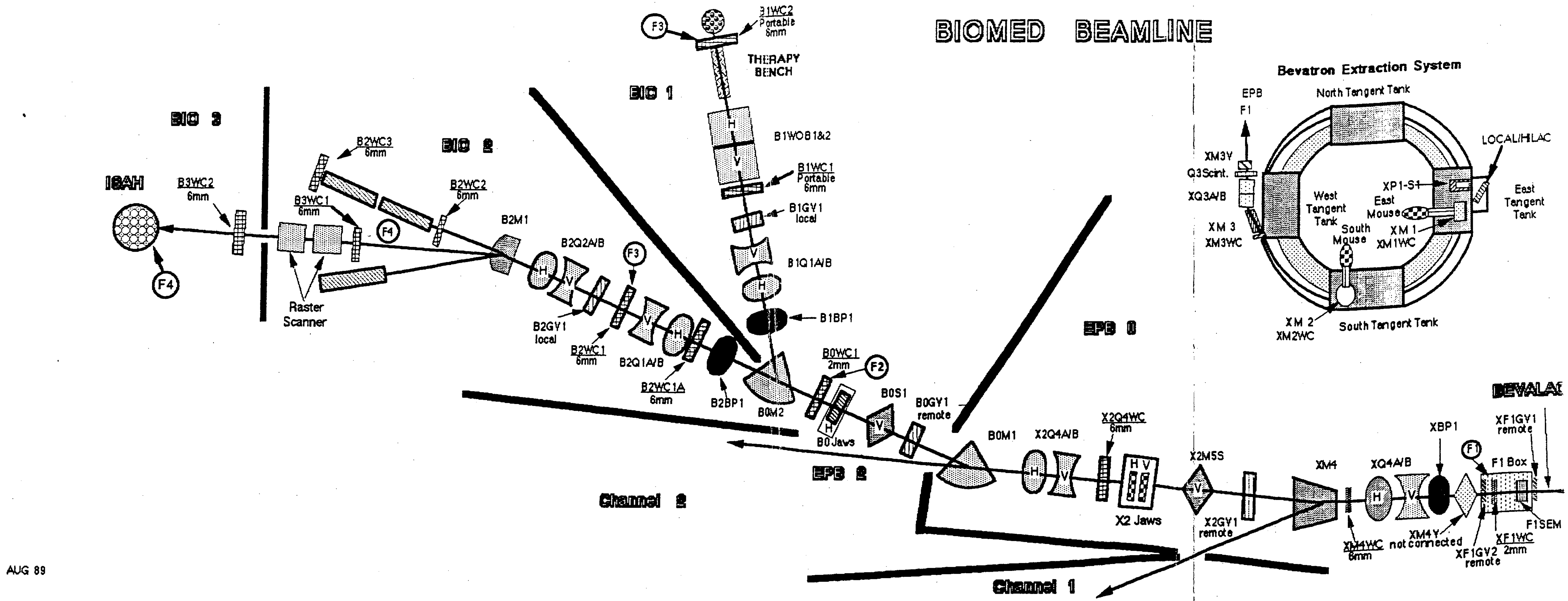
* The final position is determined by ion chambers IC1, IC2, and IC3.

3.8.7 (b) Biomed II Average Magnet Currents per Bevalac Field

Beam Line Magnet	Magnet Current per Bevalac Field (Ampere/kG)
XM4	-649.6*
X2Q4A	91.9
X2Q4B	101.0
B0M1	2020.0*
B2M1	10.5
B2Q1A	140.1
B2Q1B	138.7
B2Q2A	139.5
B2Q2B	129.4

* Magnet field per Bevalac field (gauss/kG)

3.9 BIOMED III



BIOMED BEAMLINE
Bevatron Extraction System
EPB
F1
North Tangent Tank
LOCAL/HILAC
XM3Y
Q3Scint.
XQ3A/B
XM 3
XM3WC
West Tangent Tank
XP1-S1
East Mouse
XM 1
XM1WC
South Mouse
East Tangent Tank
XM 2
XM2WC
South Tangent Tank
B1WC2 Portable 6mm
F3
THERAPY BENCH
BIO 1
B1WOB1&2
B1WC1 Portable 6mm
B1GV1 local
B1Q1A/B
B1BP1
BIO 3
BIO 2
ISAH
B3WC2 6mm
B2WC3 6mm
B3WC1 6mm
B2WC2 6mm
F4
B2M1
B2Q2A/B
Raster Scanner
B2GV1 local
B2WC1 6mm
B2Q1A/B
B2WC1A 6mm
B2BP1
B0M2
B0WC1 2mm
F2
B0S1
B0GY1 remote
B0 Jaws
EPB 0
EPB 2
Channel 2
B0M1
X2Q4A/B
X2Q4WC 6mm
X2 Jaws
X2M5S
X2GV1 remote
Channel 1
XM4
XQ4A/B
XBP1
F1
F1 Box
XF1GV1 remote
BEVALAC
XM4WC 6mm
XM4Y not connected
XF1GV2 remote
XF1WC 2mm
F1SEM
AUG 89

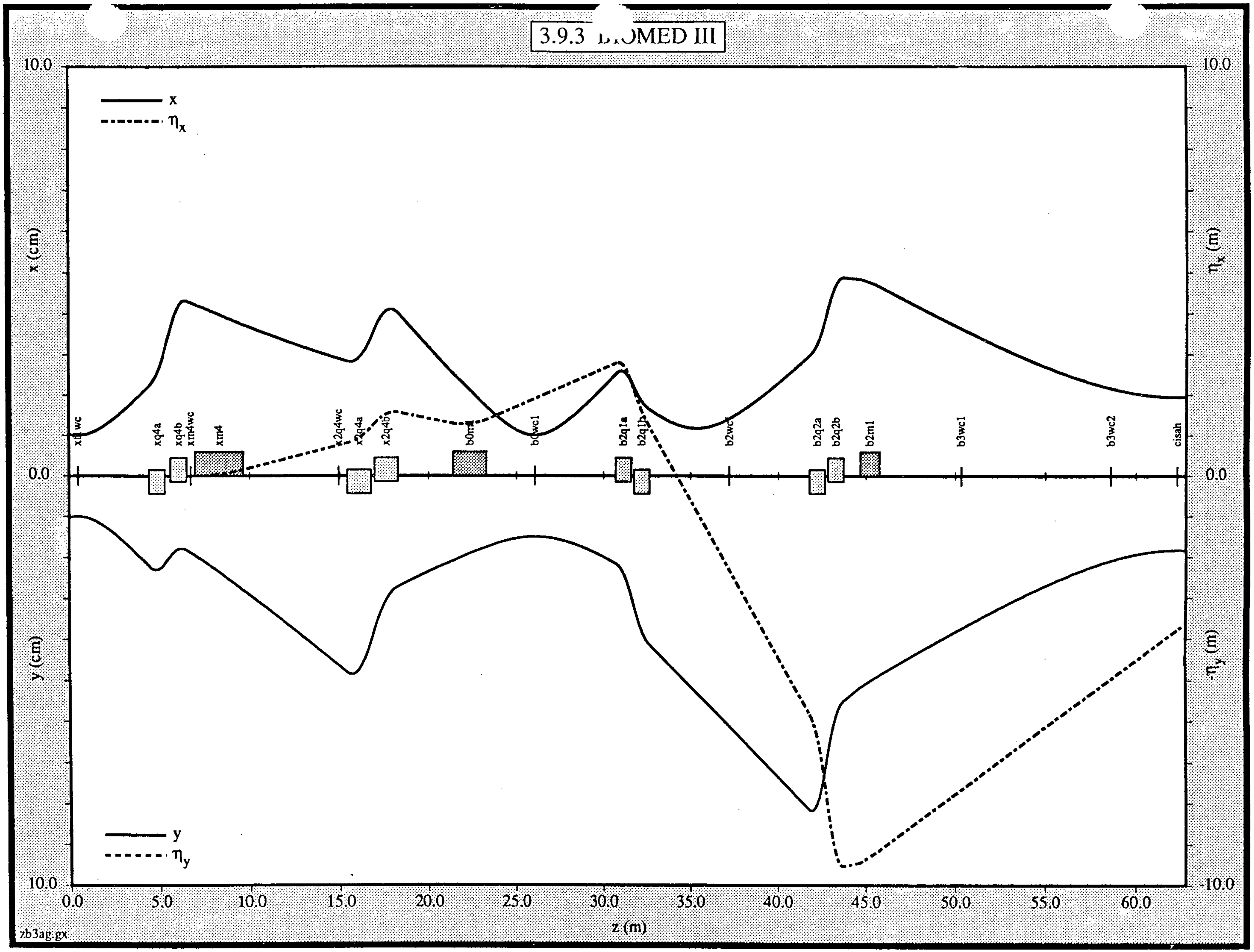
3.9.2. (a) Biomed III - Magnet Parameters									
		Quadropole Magnet		Dipole Magnet					
Beam Line Element	Effective Length (m)	Max Gradient (kG/m)	Pole Tip Radius (m)	Max Field (kG)	Bend Angle (m)	Bend Angle (deg.)	Incoming Edge Angle (deg.)	Outgoing Edge Angle (deg.)	Magnet or Wire Chamber Type (in)
(F1)-XF1WC	0.000								2mm Special
	3.969								
XQ4A	0.884	-147	0.1046						8QB32
	0.284								
XQ4B	0.884	+147	0.1046						8QB32
	0.230								
---XM4WC	0.000								6mm Perm. Gas
	0.233								
XM4	2.668			17.86	23.413	6.529	0.0	6.529	4.1x22x100 H
	5.286								
---X2Q4WC	0.000								6mm Perm. Gas
	0.495								
X2Q4A	1.308	-138	0.1046						8QB48
	0.216								
X2Q4B	1.308	+138	0.1046						8QB48
	3.142								
B0M1	1.898			17.3	6.905	15.75	7.875	7.875	5.4x16x72H
	2.756								
(F2)-B0WC1	0.000								2mm Crawford
	4.651								
B2Q1A	0.882	+117	0.1016						LP8Q32
	0.160								
B2Q1B	0.882	-117	0.1016						LP8Q32
	4.578								
(F3)-B2WC1	0.000								6mm Crawford
	4.581								
B2Q2A	0.882	-117	0.1016						LP8Q32
	0.160								
B2Q2B	0.882	+117	0.1016						LP8Q32
	0.947								
B2M1	1.085			-24.4	7.314	8.5	7.0	1.5	8x18x36 LPH
	4.558								
---B3WC1	0.000								6mm Crawford
	8.300								
---B3WC2	0.000								6mm Portable
	3.669								
(F4)-CISAH	0.000								Center ISAH

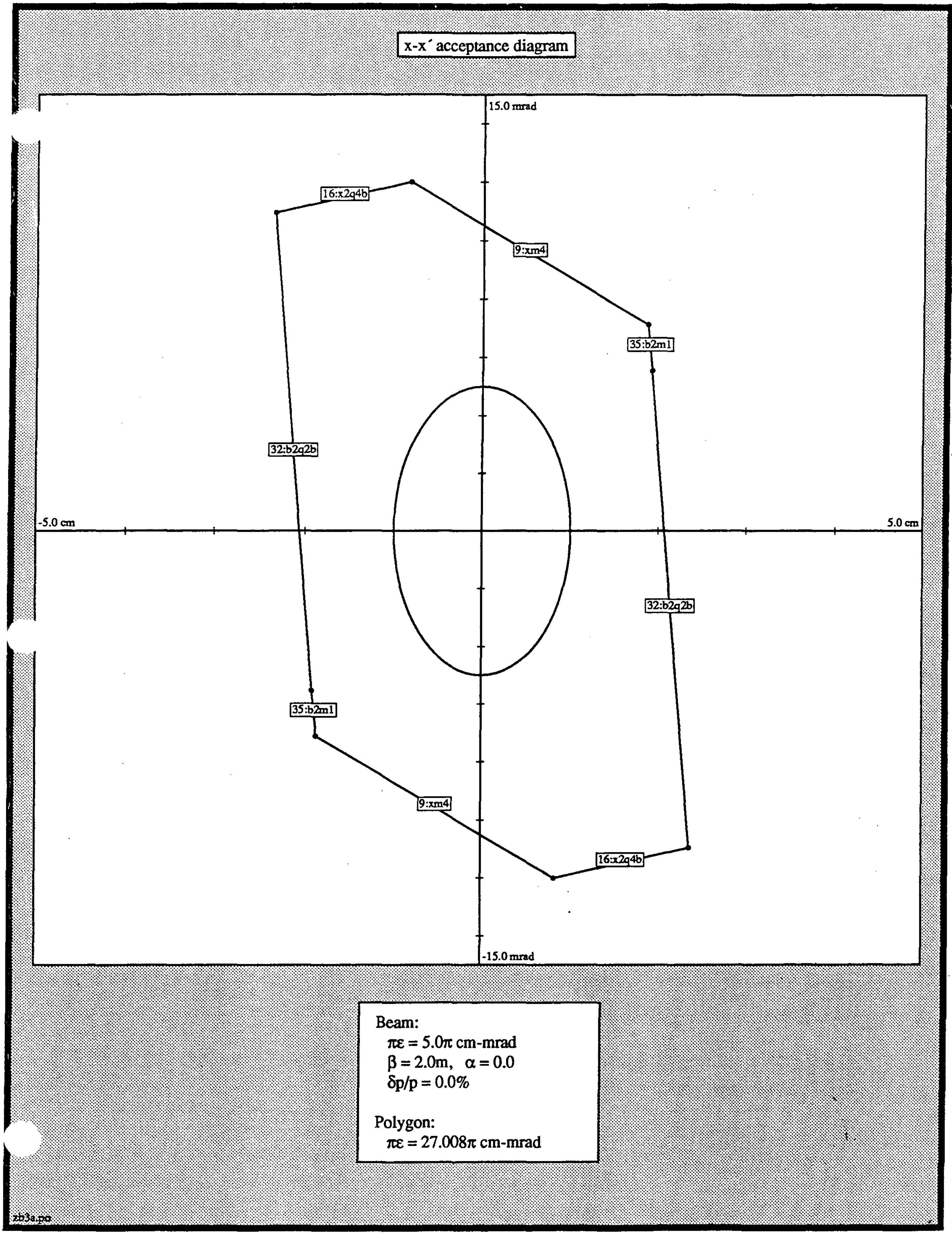
```
b
Beam rigidity =    19.2000 t-m
x,y emittance =     5.0000   5.0000 cm-mrad
dp/p =  0.000%
t
Transport mode
        betax =    2.0000   alphax =    0.0000
        betay =    2.0000   alphay =    0.0000
        etax  =    0.0000   eta'x  =    0.0000
        etay  =    0.0000   eta'y  =    0.0000
d
```

	name	type	vcode	lth,angle	b,b',s	n,gap	xaper	yaper
1	xflwc	lens	0.0	0.000000	0.000000	0.0000		
2	l1	drift	0.0	3.969000	0.000000	0.0000		
3	xq4a	quad	0.0	0.884000	-10.401003	0.0000	0.1000	0.1000
4	s1	drift	0.0	0.284000	0.000000	0.0000		
5	xq4b	quad	0.0	0.884000	9.985703	0.0000	0.1000	0.1000
6	l2	drift	0.0	0.230000	0.000000	0.0000		
7	xm4wc	lens	0.0	0.000000	0.000000	0.0000		
8	l3	drift	0.0	0.233000	0.000000	0.0000		
9	xm4	bend	0.0	2.668000	0.820000	0.0000	0.0836	0.0457
10	xm4o	edge	0.0	6.529000	0.820000	0.0000		
11	l4a	drift	0.0	5.286000	0.000000	0.0000		
12	x2q4wc	lens	0.0	0.000000	0.000000	0.0000		
13	l4b	drift	0.0	0.495000	0.000000	0.0000		
14	x2q4a	quad	0.0	1.308000	-5.676363	0.0000	0.1000	0.1000
15	s2	drift	0.0	0.216000	0.000000	0.0000		
16	x2q4b	quad	0.0	1.308000	5.631526	0.0000	0.1000	0.1000
17	l5	drift	0.0	3.142000	0.000000	0.0000		
18	b0mle	edge	0.0	7.875000	2.782000	0.0000		
19	b0ml	bend	0.0	1.898000	2.782000	0.0000	0.1000	0.0686
20	b0mle	edge	0.0	7.875000	2.782000	0.0000		
21	l6	drift	0.0	2.756000	0.000000	0.0000		
22	b0wcl	lens	0.0	0.000000	0.000000	0.0000		
23	l7	drift	0.0	4.651000	0.000000	0.0000		
24	b2qla	quad	0.0	0.882000	12.039852	0.0000	0.1000	0.1000
25	s3	drift	0.0	0.160000	0.000000	0.0000		
26	b2qlb	quad	0.0	0.882000	-6.883937	0.0000	0.1000	0.1000
27	l8	drift	0.0	4.578000	0.000000	0.0000		
28	b2wcl	lens	0.0	0.000000	0.000000	0.0000		
29	l9	drift	0.0	4.581000	0.000000	0.0000		
30	b2q2a	quad	1.2	0.882000	-8.339232	0.0000	0.1000	0.1000
31	s4	drift	0.0	0.160000	0.000000	0.0000		
32	b2q2b	quad	2.2	0.882000	8.073055	0.0000	0.1000	0.1000
33	l10	drift	0.0	0.947000	0.000000	0.0000		
34	b2mli	edge	0.0	7.000000	-2.626000	0.0000		
35	b2ml	bend	0.0	1.085000	-2.626000	0.0000	0.1000	0.1000
36	b2mlo	edge	0.0	1.500000	-2.626000	0.0000		
37	l11	drift	0.0	4.558000	0.000000	0.0000		
38	b3wcl	lens	0.0	0.000000	0.000000	0.0000		
39	l12	drift	0.0	8.300000	0.000000	0.0000		
40	b3wc2	lens	0.0	0.000000	0.000000	0.0000		
41	l13	drift	0.0	3.669000	0.000000	0.0000		
42	cisah	lens	0.0	0.000000	0.000000	0.0000		

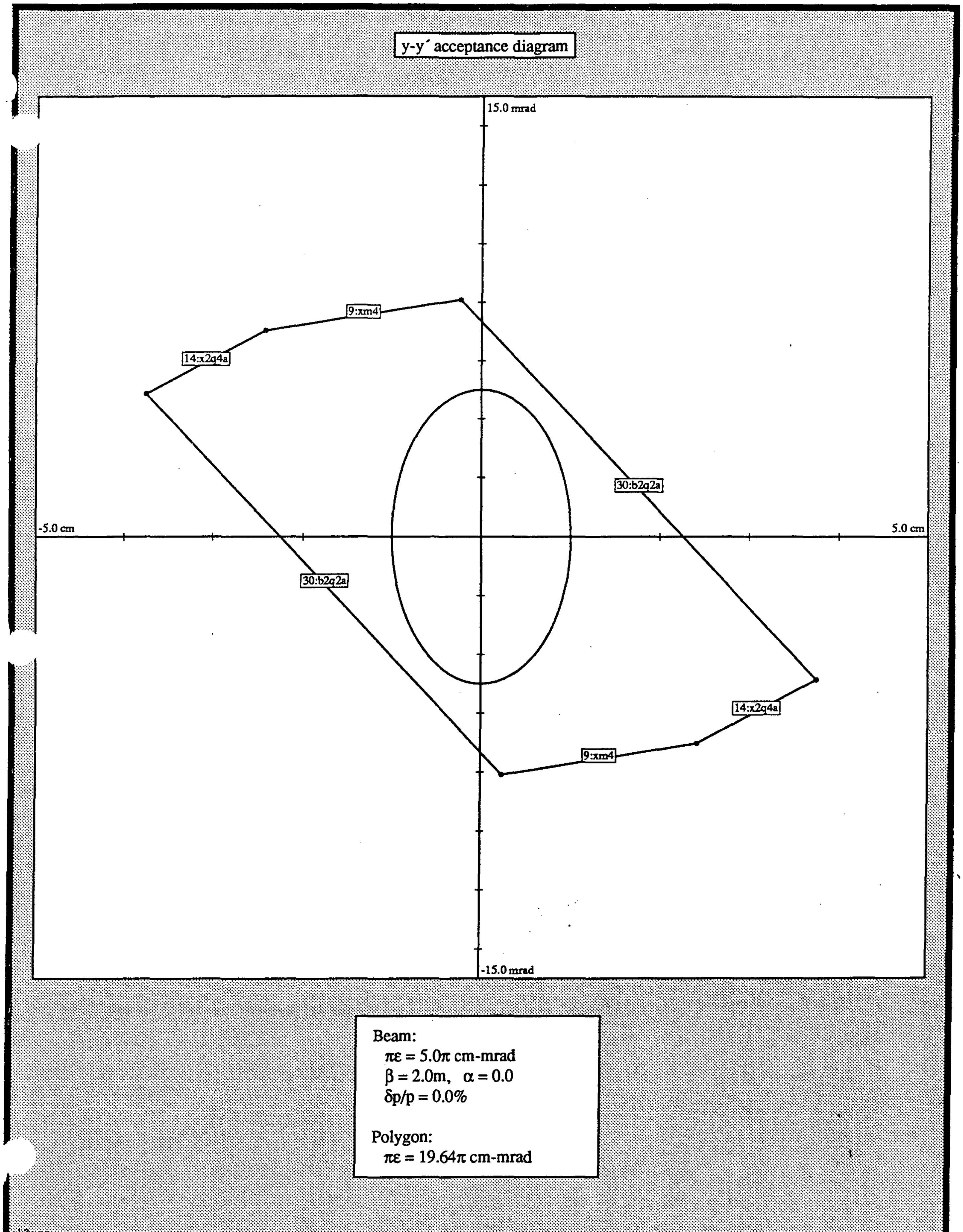
```
quit
End of program
```

3.9.2 (b) BIOMED III - TRANSPORT LIST


3.9.3 BIOMED III
x (cm)
y (cm)
η_x (m)
$-\eta_y$ (m)
z (m)
x
η_x
y
η_y
xf1wc
xq4a
xq4b
xm4wc
xm4
x2q4wc
x2q4a
x2q4b
b0m1
b0wc1
b2q1a
b2q1b
b2wc1
b2q2a
b2q2b
b2m1
b3wc1
b3wc2
cisah
10.0
0.0
-10.0
5.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
zb3ag.gx



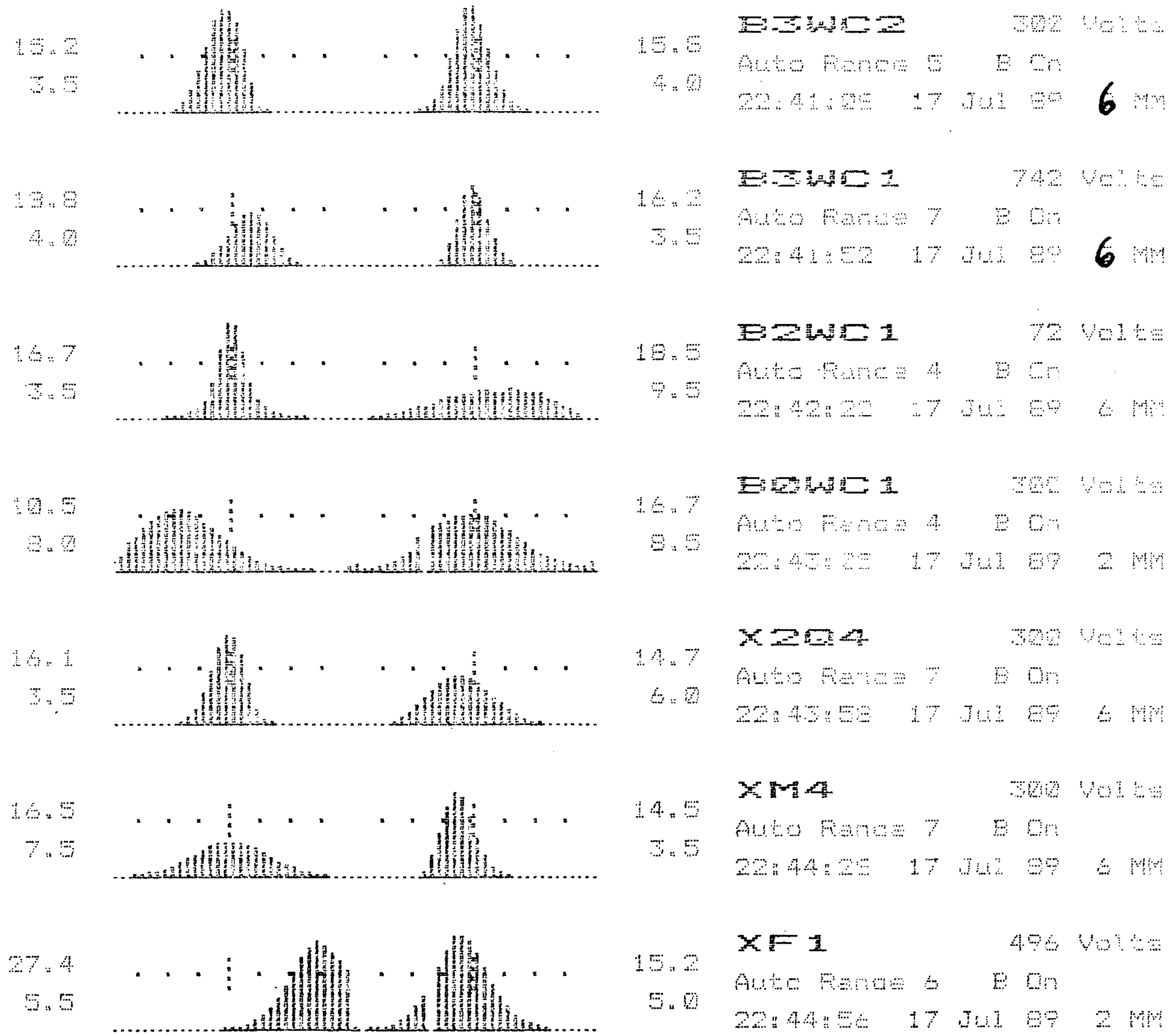
3.9.4 BIOMED III HORIZONTAL ACCEPTANCE AT F1



3.9.4 BIOMED III VERTICAL ACCEPTANCE AT F1

3.9.5 Biomed III Focal Points

Focal Point	Location	Horizontal Magnification	Vertical Magnification	Dispersion (cm/%)
F1	XF1WC	1.0	1.00	0.00
F2	B0WC1	1.00	1.50	1.91
F3	B2WC1	1.42	6.12	-2.31
F4	Center ISAH	1.95	1.83	-3.79



3.9.6 (a) Wire Chamber Pictures

17JUL89 SPB ?OL PRINT 22:12:26 PAGE 1

NAME	DATE	TIME	ENTRY	BEAM LINE
CURRENT 1544	17JUL89	22:32:26	0	SIDM3

PERTURBATION UNIT DATA

NAME		FLAGS	AMPLITUDE	DELAY	GATE
X	P1	P+	40.01	400	1480
X	P2	P+	20.00	400	1510
X	S2	S	306.09	400	1420
X	S1	S+	481.46	400	1790
X	S2	P	114.07	400	1330
X	M3	S+	2.25	470	1020
X	S1	P+	19.89	400	1260

NAME		SP	AM	DI	OFFSET
X	P1	0.02	0.66	5	0.00
X	P2	2.00	0.20	5	0.00
X	S1	0.02	0.00	5	0.02
X	S2	0.00	2.56	5	0.00
X	M1	120.52	146.19	5	0.02
X	M2	613.72	597.52	5	0.00
X	M3	482.79	525.26	5	0.00
X	Q3A	228.97	216.96	5	0.00
X	Q3B	215.99	241.02	5	0.02
X	M3V	0.00	0.12	2001	0.00
X	M4	-1494.04	-1600.76	3001	-1494.04
	M4V	0.00	1.22	1	0.00
	Q4A	400.43	392.16	2005	0.00
	Q4B	114.14	396.36	2005	0.00
B0	M2	5147.78	29.31	1	5147.78
X2	M5S	4.98	5.33	2003	4.98
X2	Q4A	230.23	225.70	2005	0.00
X2	Q4B	243.29	226.43	2005	0.00
B0	M1	5067.03	5139.08	3001	5067.03
B0	S1	0.00	0.00	2001	0.00
B2	M1	230.63	220.05	3001	230.63
B2	Q1A	248.33	249.29	2001	248.33
B2	Q1B	209.47	214.67	1	209.47
B42	Q1A	136.86	137.73	2001	136.86
B42	Q1B	176.20	173.12	1	176.20

Weak Focus Tune

$^4He^{2+}$ 165 MeV/A

2535 gauss

Return to be closer to ZB3C3 optics

Transmission is 68%

XQ3 quads on.

DATA FOR ENERGY CALCULATION

INJECTION: HILAC LOCAL

PARTICLE: He 2S FREQ :

MASS NUM: 4 2S FIELD:

CHARGE : 2 K.ENERGY:

INFLECTOR H.V:

EXTRACTION: PFW: ON: OFF:

FIELD: 2535 P1 CUR:

FREQ: P2 CUR:

BEAM RAD: 597.4

	RADIUS	CURRENT	TAIL WAG	
M1:		:	RISE:	GAUSS
M2:		:	TIME:	mSECS
M3:	--------	:	S1 ON:	OFF:
			S2 ON:	OFF:

STD MATERIAL AT F1: (IN) OUT:

3.9.6 (b) Magnet Currents

3.9.7 (a) **Biomed III Optic-Axis Beam Positions on the Wire Chambers**

Active Dipole Magnets	Wire Chamber	Beam Center on Wire Chamber (Wire Number)	
		Horizontal	Vertical
XM3V	X2Q4WC	---	16.5
XM4	X2Q4WC	16.5	---
B0M1	B2WC1*	16.5	---
B2M1	B3WC2*	16.5	---
X2M5S	B2WC1*	---	16.5
B0S1	B3WC2*	---	16.5

*The final position is determined by ion chambers IC1, IC2, and IC3.

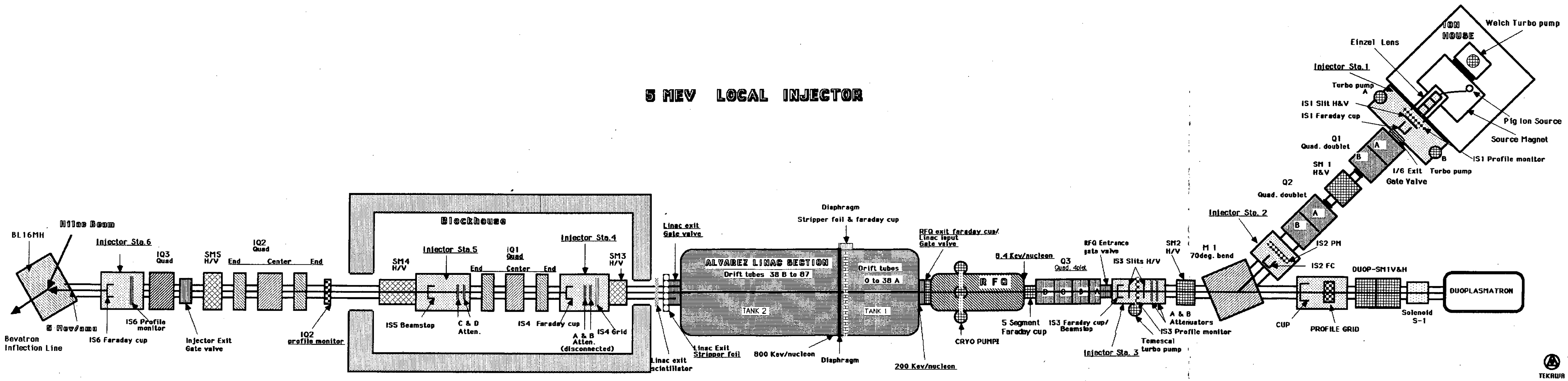
3.9.7 (b) Biomed III Average Magnet Currents per Bevalac Field

Beam Line Magnet	Magnet Current per Bevalac Field (Ampere/kG)
XQ4A	166.3
XQ4B	156.5
XM4	-643.6*
X2Q4A	93.6
X2Q4B	88.1
B0M1	2032.0*
B2M1	86.6
B2Q1A	81.0
B2Q1B	70.5
B2Q2A	59.4
B2Q2B	70.4

* Magnet field per Bevalac field (gauss/kG)

3.10 LOCAL INJECTOR

5 MEV LOCAL INJECTOR



3.10.2 Local Injector Tuning Parameters

The following tables lists some of the important parameters for tuning the local injector. The first table 'Local Tune' lists the typical tune for the local injector from the source to exit of Linac for several different ions which are used most often for the Bevatron. The next set of tables are actual tuning parameters saved on the computer for setting up the Local Injector for the different ions. As with EPB current computer readouts, column one is the setpoint and column two is the actual current in a particular magnet or source device. Source parameters are listed first followed by the low energy beam transport (LEBT). Finally, currents for the drift tube quads are listed up to the 'blockhouse' or the exit of the Linac (see Fig. 3.10.1) and are saved on the computer. Drift tubes labeled 0 - 38A are located in Tank #1 of the Linac and drift tubes labeled 38B - GR6 are located in Tank #2 of the Linac. The table called 'Linac Tank Gradient Settings" gives the local linacs tank gradients read from an RF pickup coil.

The following are typical ion intensities from the local injector at various stations along the injector line.

Station 3	600 Microamps	20 Ne^{+3}
Diaphragm exit foil	550 Microamps	20 Ne^{+7}
Linac exit foil	400 Microamps	20 Ne^{+10}
Linac exit cup (Station 4)	350 Microamps	20 Ne^{+10}
EOS Cup (entrance to Bevatron)	150 Microamps	20 Ne^{+10}
Accelerated beam	550 Microamps	20 Ne^{+7}
Linac exit foil	10^{10} particles/pulse	20 Ne^{+10}

Linac Tank Gradient Settings

ION SOURCE	RFQ	Tank 1	Tank 2	Foils Diaphragm	Foils Exit	Linac Exit Cup
$_{20}Ne^{+3}$	7 V	7.8 V	7.6 V	IN	IN	$_{20}Ne^{+10}$
$_{20}Ne^{+4}$	5.2 V	6.2 V	7.6 V	IN	IN	$_{20}Ne^{+10}$
$_{22}Ne^{+4}$	6.2 V	6.4 V	8.3 V	IN	IN	$_{22}Ne^{+10}$
$_{4}He^{+1}$	4.2 V	4.7 V	5.2 V	IN	OUT	$_{4}He^{+2}$
$_{12}C^{+2}$	6.5 V	7.0 V	6.0V	IN	IN	$_{12}C^{+6}$
$_{2}H^{+1}$	2.1 V	3.4 V	6.7 V	OUT	OUT	$_{2}H^{+1}$
$_{28}Si^{+4}$	6.8 V	8.0 V	8.0 V	IN	IN	$_{28}Si^{+14}$

ION	NEON 3+	NEON 4+	NEON 4+	NEON 4+	CARBON 2	CARBON 2	H2 1+	HE 1+	OXYGEN 3	OXYGEN 3	SI 4+
MASS	20	20	22	22	12	12	2	4	16	16	28
T1 CHARGE	3	4	4	4	2	2	1	1	3	3	4
T1 Q/A	0.15	0.2	0.182	0.182	0.167	0.167	0.5	0.25	0.188	0.188	0.143
T2 CHARGE	7	7	7	8	4	5	1	2	5	6	9
T2 Q/A	0.35	0.35	0.318	0.364	0.334	0.417	0.5	0.5	0.313	0.375	0.321
RFQ GRADIENT	7	5.25	5.8	5.8	6.3	6.3	2.1	4.2	5.6	5.6	7.3
T1 GRADIENT	7.8	5.8	6.4	6.4	7	7	2.3	4.7	6.2	6.2	8.2
T2 GRADIENT	7.6	5.7	8.4	7.3	7.9	6.4	5.3	5.3	8.5	7.1	8.3
DIAPHRAM FOIL	IN	IN	IN	IN	IN	IN	OUT	IN	IN	IN	IN
LINAC EXIT FOIL	IN	IN	IN	IN	IN	IN	OUT	OUT	IN	IN	IN
ARC (AMPS)	2.2	2.6	2.6	2.6	2	2	0.8	0.6		2.5	2.5
SARC (VOLTS)	0	0	0	0				0			2500
GAS PULSE (DELAY)	27	11	16				4	5		28	32
GAS PULSE (WIDTH)	5	2	5				4	4		1	1
EXTRACT (KV)	17.5	19.7	19.5	19.5	17	17	18.4	15.3		19.4	19.2
EINZEL (KV)	16.5	16.6	16.8	16.8	15.1	15.1	8.7	10.5		13.6	14.5
MAGNET (AMPS)	235	210	222	222	230	230	135	165		220	250
DECK (KV)	56	43	46	46	51	51	17	34		45	59
LEBT Q1A (AMPS)	3	6.2	9.9	9.9	2.7	2.7	9	18.9		42	180
LEBT Q1B (AMPS)	49	38	41.1	41.1	34.9	34.9	20	34.1		63.9	145
LEBT Q2A (AMPS)	114	92.2	111.3	111.3	101.2	101.2	35	69.4		87.3	123
LEBT Q2B (AMPS)	95	74.5	87.7	87.7	83.5	83.5	30.3	57.5		65.4	88
LEBT M1 (AMPS)	101.4	78.5	84.6	84.6	91.5	91.5	31.05	62.05		82.3	107.7
LEBT Q3A (AMPS)	106.9	60.7	94.9	94.9	112	112	26.1	53		62.4	113.5
LEBT Q3B (AMPS)	182.9	151.1	179.4	179.4	115	115	63.2	122.7		165.7	195
LEBT Q3C (AMPS)	195.2	191.7	189.8	189.8	156	156	71.7	136		194.5	199.6
LEBT Q3D (AMPS)	146.1	136.1	149.2	149.2	124.5	124.5	42.8	93.5		115.6	170.8
LEBT SM1H (AMPS)	0	0	0	0	0	0	0	0			
LEBT SM1V (AMPS)	0	0	0	0	0	0	0	0			
LEBT SM2H (AMPS)	0	0	0	0	0	0	0	0			
LEBT SM2V (AMPS)	0	0	0	0	0	0	0	0			
T1 DRIFT TUBES											
0	33.0	24.7	27.2	27.2	29.6	29.6	9.9	19.8	26.3	26.3	34.6
1	17.0	12.7	14.0	14.0	15.3	15.3	5.1	10.2	13.6	13.6	17.8
2	16.0	12.0	13.2	13.2	14.4	14.4	4.8	9.6	12.8	12.8	16.8
3	15.0	11.2	12.4	12.4	13.5	13.5	4.5	9.0	12.0	12.0	15.7
4	15.0	64.0	12.4	12.4	13.5	13.5	4.5	9.0	12.0	12.0	15.7
5	15.0	11.2	12.4	12.4	13.5	13.5	4.5	9.0	12.0	12.0	15.7
6	15.0	11.2	12.4	12.4	13.5	13.5	4.5	9.0	12.0	12.0	15.7
7	15.0	11.2	12.4	12.4	13.5	13.5	4.5	9.0	12.0	12.0	15.7
8	15.0	11.2	12.4	12.4	13.5	13.5	4.5	9.0	12.0	12.0	15.7
9	15.0	11.2	12.4	12.4	13.5	13.5	4.5	9.0	12.0	12.0	15.7
10	18.0	13.5	14.8	14.8	16.2	16.2	5.4	10.8	14.4	14.4	18.9
11	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
12	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0

ION	NEON 3+	NEON 4+	NEON 4+	NEON 4+	CARBON 2	CARBON 2	H2 1+	HE 1+	OXYGEN 3	OXYGEN 3	SI 4+
13	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
14	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
15	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
16	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
17	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
18	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
19	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
20	22.0	16.5	18.1	18.1	19.8	19.8	6.6	13.2	17.6	17.6	23.1
21	23.0	17.3	19.0	19.0	20.7	20.7	6.9	13.8	18.4	18.4	24.1
22	23.0	17.3	19.0	19.0	20.7	20.7	6.9	13.8	18.4	18.4	24.1
23	23.0	17.3	19.0	19.0	20.7	20.7	6.9	13.8	18.4	18.4	24.1
24	23.0	17.3	19.0	19.0	20.7	20.7	6.9	13.8	18.4	18.4	24.1
25	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
26	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
27	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
28	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
29	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
30	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
31	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
32	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
33	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
34	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
35	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
36	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
37	21.0	15.8	17.3	17.3	18.9	18.9	6.3	12.6	16.8	16.8	22.0
HALF QUAD 38A	26.2	19.7	21.6	21.6	23.5	23.5	7.9	15.7	20.9	20.9	27.5
HALF QUAD 38B	21.4	21.4	23.6	20.6	22.4	18.0	15.0	15.0	23.9	20.0	23.3
GRP 4 (25-38)	592.0	592.0	651.6	569.2	620.4	496.9	414.4	414.4	662.0	552.5	645.5
25	592.0	592.0	651.6	569.2	620.4	496.9	414.4	414.4	662.0	552.5	645.5
26	599.0	599.0	659.3	576.0	627.7	502.8	419.3	419.3	669.8	559.1	653.1
27	605.0	605.0	665.9	581.7	634.0	507.8	423.5	423.5	676.5	564.7	659.7
28	612.0	612.0	673.6	588.5	641.3	513.7	428.4	428.4	684.3	571.2	667.3
29	619.0	619.0	681.3	595.2	648.7	519.5	433.3	433.3	692.2	577.7	674.9
30	626.0	626.0	689.0	601.9	656.0	525.4	438.2	438.2	700.0	584.3	682.6
31	633.0	633.0	696.7	608.7	663.3	531.3	443.1	443.1	707.8	590.8	690.2
32	639.0	639.0	703.3	614.4	669.6	536.3	447.3	447.3	714.5	596.4	696.7
33	646.0	646.0	711.0	621.2	676.9	542.2	452.2	452.2	722.4	602.9	704.4
34	653.0	653.0	718.7	627.9	684.3	548.1	457.1	457.1	730.2	609.5	712.0
35	660.0	660.0	726.4	634.6	691.6	554.0	462.0	462.0	738.0	616.0	719.6
36	667.0	667.0	734.1	641.3	699.0	559.8	466.9	466.9	745.8	622.5	727.3
37	674.0	674.0	741.8	648.1	706.3	565.7	471.8	471.8	753.7	629.1	734.9
38	680.0	680.0	748.4	653.8	712.6	570.7	476.0	476.0	760.4	634.7	741.4
GRP 5A (39-50)	680.0	680.0	748.4	653.8	712.6	570.7	476.0	476.0	760.4	634.7	741.4
GRP 5B (51-62)	~~680.0~~	~~680.0~~	~~748.4~~	~~653.8~~	~~712.6~~	~~570.7~~	~~476.0~~	~~476.0~~	~~760.4~~	~~634.7~~	~~741.4~~
GRP 6 (63-74)	490.0	490.0	539.3	471.2	513.5	411.3	343.0	343.0	547.9	457.3	534.3
HALF QUAD 75	490.0	490.0	539.3	471.2	513.5	411.3	343.0	343.0	547.9	457.3	534.3

SAVE1 Ø7:42 Ø5/21/86 22 NEON 4+

STATIONS

ARC I	Ø.ØØØ	Ø.ØØØ	O
ARC E LIM	Ø.ØØØ	Ø.ØØØ	O
SPUT ARC E	Ø.ØØØ	Ø.ØØØ	O
SPUT ARC E L	Ø.ØØØ	Ø.ØØØ	C
EXTRACT E	19.578	Ø.359	O
EINZEL E	16.475	Ø.Ø39	O
MAGNET I	222.8Ø2	Ø.672	O
DECK E	47.ØØØ	Ø.ØØØ	C
LEBT Q1A	Ø.122	1.563	O
LEBT Q1B	39.335	39.463	O
LEBT Q2A	1Ø3.791	1Ø4.127	O
LEBT Q2B	76.88Ø	76.777	C
LEBT M1	84.829	84.786	O
DECK E	47.ØØØ	Ø.ØØØ	C
LEBT Q3A	82.68Ø	84.1Ø3	O
LEBT Q3B	164.7Ø1	166.935	O
LEBT Q3C	195.354	197.411	O
LEBT Q3D	143.773	155.Ø18	C
LEBT SM1H	Ø.ØØØ	Ø.ØØ1	O
LEBT SM1V	Ø.ØØØ	-Ø.ØØ2	O
LEBT SM2H	Ø.ØØØ	Ø.ØØ3	O
LEBT SM2V	Ø.3ØØ	Ø.ØØ5	O

DRIFT TUBES

Ø	3Ø.ØØØ	3Ø.37	O	15	19.ØØØ	19.Ø1	O	3Ø	22.192	22.33	O
1	18.ØØØ	17.9Ø	O	16	19.ØØØ	18.99	O	31	24.832	24.Ø5	O
2	15.369	15.26	O	17	19.ØØØ	18.96	O	32	24.3Ø1	24.93	O
3	16.217	16.Ø6	O	18	19.ØØØ	19.Ø2	O	33	24.417	24.92	O
4	15.997	15.87	O	19	19.ØØØ	19.21	O	34	24.965	24.4Ø	O
5	15.997	15.82	O	2Ø	23.ØØØ	23.Ø4	O	35	24.Ø82	24.31	O
6	17.ØØØ	17.78	O	21	23.ØØØ	22.98	O	36	24.237	23.82	O
7	17.ØØØ	17.Ø5	O ←	22	23.ØØØ	23.15	O	37	25.796	26.28	O
8	17.ØØØ	17.41	O	23	23.ØØØ	23.Ø8	O	38A	27.355	27.41	O
9	19.ØØØ	18.88	O	24	23.ØØØ	23.Ø7	O	38B	2Ø.ØØØ	19.82	O
1Ø	19.ØØØ	16.27	O	25	23.ØØØ	23.Ø6	O	GR4	64Ø.ØØØ	635.12	O
11	19.ØØØ	18.96	O	26	23.ØØØ	23.Ø7	O	GR5A	66Ø.ØØØ	642.15	O
12	19.ØØØ	18.78	O	27	23.ØØØ	23.12	O	GR5B	683.492	671.45	O
13	19.ØØØ	19.15	O	28	23.ØØØ	23.Ø8	O	GR6	42Ø.ØØØ	411.82	O
14	19.ØØØ	18.79	O	29	24.262	24.27	O				

TIMING

23 3 2Ø 1ØØØ 2Ø 1ØØØ 2ØØ 1ØØØ 6ØØ 4ØØ 2

SAVE2 07:57 03/04/87 CARBON 2+

STATIONS

[illegible] I	2.198	2.083	O
[illegible]C E LIM	0.000	0.000	O
SPUT ARC E	0.000	0.000	O
SPUT ARC E L	0.000	0.000	C
EXTRACT E	17.552	18.291	O
EINZEL E	17.542	18.217	O
MAGNET I	229.999	230.464	O
DECK E	51.000	51.016	C
LEBT Q1A	2.601	3.028	O
LEBT Q1B	33.663	33.797	O
LEBT Q2A	102.802	103.346	O
LEBT Q2B	87.216	86.935	C
LEBT M1	92.198	92.015	O
DECK E	51.000	50.952	C
LEBT Q3A	87.411	88.889	O
LEBT Q3B	168.578	170.843	O
LEBT Q3C	197.808	199.365	O
LEBT Q3D	156.099	170.256	C
LEBT SM1H	0.000	0.003	O
LEBT SM1V	0.000	-0.001	O
L[illegible]T SM2H	0.000	0.005	O
L[illegible]T SM2V	0.000	0.005	C

DRIFT TUBES

0	32.103	32.23	O	15	20.000	20.02	O	30	23.000	23.16	O
1	18.879	18.70	O	16	20.000	20.04	O	31	23.000	22.26	O
2	18.505	18.42	O	17	20.000	19.98	O	32	23.000	23.57	O
3	16.403	16.21	O	18	20.000	20.07	O	33	23.000	23.46	O
4	15.994	15.81	O	19	20.000	20.25	O	34	23.000	22.52	O
5	15.994	15.68	O	20	23.000	23.09	O	35	23.000	23.24	O
6	15.994	16.64	O	21	23.000	22.97	O	36	23.000	22.62	O
7	15.994	16.38	O	22	23.000	23.13	O	37	23.000	23.05	C
8	15.994	16.24	O	23	23.000	23.04	O	38A	33.005	32.59	C
9	15.994	15.74	O	24	23.000	23.05	O	38B	22.501	22.13	O
10	20.000	19.74	O	25	23.000	23.08	O	GR4	460.000	455.19	O
11	20.000	19.88	O	26	23.000	23.04	O	GR5A	460.635	461.44	O
12	20.000	19.65	O	27	23.000	23.11	O	GR5B	316.874	316.68	O
13	20.000	20.05	O	28	23.000	23.13	O	GR6	448.767	436.24	O
14	20.000	19.84	O	29	23.000	22.93	O				

TIMING

22	4	40	1000	80	1000	120	1000	600	400	2

SAVE3 14:08 12/03/85 HYDROGEN (H2 1+)

STATIONS

ARC I	0.826	0.652	O
ARC E LIM	2.137	0.000	O
SPUT ARC E	3.053	0.000	O
SPUT ARC E L	0.000	0.000	C
EXTRACT E	18.356	19.103	O
EINZEL E	8.740	9.143	O
MAGNET I	134.997	134.860	O
DECK E	17.000	17.333	O
LEBT Q1A	8.999	8.987	O
LEBT Q1B	20.000	19.634	O
LEBT Q2A	35.000	34.286	O
LEBT Q2B	30.293	30.379	C
LEBT M1	31.050	30.867	O
DECK E	17.000	17.302	O
LEBT Q3A	26.105	26.569	O
LEBT Q3B	63.211	63.980	O
LEBT Q3C	71.752	71.893	O
LEBT Q3D	42.796	42.686	C
LEBT SM1H	0.000	0.002	O
LEBT SM1V	0.000	-0.002	O
LEBT SM2H	0.083	0.004	O
LEBT SM2V	0.102	0.003	O

DRIFT TUBES

0	12.067	12.05	O	15	9.459	9.25	O	30	10.351	10.19	O
1	8.108	7.68	O	16	9.532	9.32	O	31	10.246	9.59	O
2	8.976	8.65	O	17	9.283	9.06	O	32	10.264	10.28	O
3	8.778	8.36	O	18	11.504	11.31	O	33	10.268	10.18	O
4	8.669	8.32	O	19	11.209	11.14	O	34	11.505	11.04	O
5	8.094	7.71	O	20	10.996	10.82	O	35	10.362	10.25	O
6	8.076	8.17	O	21	11.331	11.09	O	36	10.205	9.76	O
7	7.569	7.34	O	22	11.227	11.10	O	37	10.824	10.85	C
8	8.653	8.54	O	23	11.246	11.07	O	38A	10.863	10.85	C
9	9.768	9.50	O	24	11.074	10.84	O	38B	9.658	9.34	O
10	8.623	7.95	O	25	11.153	10.98	O	GR4	538.633	527.67	O
11	9.137	8.88	O	26	11.256	11.07	O	GR5A	618.999	594.48	O
12	9.026	8.69	O	27	11.199	11.02	O	GR5B	503.614	489.38	O
13	9.572	9.43	O	28	11.458	11.26	O	GR6	373.895	362.00	O
14	8.817	8.30	O	29	11.453	11.31	O				

TIMING

4 4 20 1000 80 1000 120 800 400 400 2

SAVE4 15:09 02/02/87 HELIUM 1+

STATIONS

[illegible] I	1.200	1.060	O
ARC E LIM	0.000	0.000	O
SPUT ARC E	0.000	0.000	O
SPUT ARC E L	0.000	0.000	C
EXTRACT E	15.139	15.795	O
EINZEL E	13.269	13.802	O
MAGNET I	164.995	165.446	O
DECK E	34.268	34.254	C
LEBT Q1A	18.895	19.243	O
LEBT Q1B	34.170	34.286	O
LEBT Q2A	69.438	69.451	O
LEBT Q2B	57.460	57.436	C
LEBT M1	62.051	61.929	O
DECK E	34.268	34.190	C
LEBT Q3A	53.004	54.115	O
LEBT Q3B	122.698	124.737	O
LEBT Q3C	136.001	136.459	O
LEBT Q3D	93.584	93.578	C
LEBT SM1H	0.000	0.001	O
LEBT SM1V	0.000	-0.002	O
LEBT SM2H	0.000	0.005	O
LEBT SM2V	0.000	0.003	C

DRIFT TUBES

0	22.794	22.98	O	15	15.692	15.65	O	30	18.000	18.13	O
1	12.836	12.49	O	16	15.692	15.69	O	31	18.000	17.36	O
2	13.708	13.49	O	17	15.692	15.63	O	32	18.000	18.39	O
3	14.517	14.27	O	18	15.692	15.68	O	33	18.000	18.28	O
4	13.471	13.22	O	19	15.692	15.79	O	34	18.000	17.59	O
5	13.444	13.10	O	20	19.660	19.71	O	35	18.000	18.18	O
6	12.982	13.42	O	21	19.013	18.96	O	36	20.000	19.66	O
7	12.188	12.39	O	22	19.059	19.16	O	37	20.000	19.99	C
8	12.595	12.69	O	23	18.942	18.94	O	38A	21.612	21.62	C
9	15.885	15.65	O	24	18.000	17.99	O	38B	21.738	21.42	O
10	15.660	15.26	O	25	18.000	18.02	O	GR4	432.332	427.64	O
11	15.954	15.76	O	26	18.000	18.03	O	GR5A	512.796	508.72	O
12	17.215	16.88	O	27	18.000	18.06	O	GR5B	374.994	368.45	O
13	15.692	15.69	O	28	18.000	18.06	O	GR6	356.703	349.89	O
14	14.994	14.71	O	29	18.000	17.93	O				

TIMING

4 2 20 1000 80 1000 120 1000 600 400 2

SAVE5 15:14 11/Ø7/86 OXYGEN 3+

STATIONS

ARC I	2.2ØØ	2.1Ø3	O
ARC E LIM	Ø.ØØØ	Ø.ØØØ	O
SPUT ARC E	Ø.ØØØ	Ø.ØØØ	O
SPUT ARC E L	Ø.ØØØ	Ø.ØØØ	C
EXTRACT E	17.7ØØ	18.41Ø	O
EINZEL E	17.ØØØ	17.592	O
MAGNET I	2Ø7.173	2Ø8.181	O
DECK E	45.ØØØ	44.984	C
LEBT Q1A	42.Ø27	41.9Ø5	O
LEBT Q1B	63.895	64.Ø78	O
LEBT Q2A	87.344	87.521	O
LEBT Q2B	65.4Ø3	65.446	C
LEBT M1	82.3Ø2	82.344	O
DECK E	45.ØØØ	45.Ø16	C
LEBT Q3A	62.393	63.ØØ4	O
LEBT Q3B	165.678	167.717	O
LEBT Q3C	194.475	196.63Ø	O
LEBT Q3D	115.513	118.Ø95	C
LEBT SM1H	Ø.ØØØ	Ø.ØØ3	O
LEBT SM1V	Ø.ØØØ	Ø.ØØØ	O
LEBT SM2H	Ø.ØØØ	Ø.ØØ6	O
LEBT SM2V	Ø.ØØØ	Ø.ØØ5	C

DRIFT TUBES

Ø	29.699	29.89	O	15	19.ØØØ	18.98	O	3Ø	23.ØØØ	23.11	O
1	17.5ØØ	17.32	O	16	19.ØØØ	18.97	O	31	2Ø.8ØØ	2Ø.Ø8	O
2	15.999	15.85	O	17	19.ØØØ	18.94	O	32	19.ØØØ	19.44	O
3	15.119	14.89	O	18	19.ØØØ	19.Ø2	O	33	19.ØØØ	19.34	O
4	15.Ø99	14.9Ø	O	19	19.ØØØ	19.2Ø	O	34	19.8ØØ	19.35	O
5	14.999	14.77	O	2Ø	23.4ØØ	23.45	O	35	19.8ØØ	19.9Ø	O
6	14.999	15.6Ø	O	21	23.4ØØ	23.36	O	36	18.4ØØ	18.Ø2	O
7	14.999	15.33	O	22	23.4ØØ	23.51	O	37	17.5ØØ	17.74	O
8	14.999	15.25	O	23	23.4ØØ	23.42	O	38A	26.8ØØ	26.75	O
9	19.ØØØ	18.82	O	24	23.4ØØ	23.42	O	38B	26.ØØØ	25.59	O
1Ø	19.ØØØ	18.7Ø	O	25	23.4ØØ	23.38	O	GR4	6ØØ.ØØØ	595.Ø7	O
11	19.ØØØ	18.91	O	26	23.4ØØ	23.41	O	GR5A	625.ØØ6	629.26	O
12	19.ØØØ	18.69	O	27	23.4ØØ	23.46	O	GR5B	425.ØØ6	416.12	O
13	19.ØØØ	19.Ø5	O	28	23.ØØØ	23.Ø7	O	GR6	532.576	523.96	O
14	19.ØØØ	18.82	O	29	23.ØØØ	22.96	O				

TIMING

22 4 2Ø 1ØØØ 8Ø 1ØØØ 13Ø 1ØØØ 6ØØ 4ØØ 2

SAVE7 13:26 03/23/87 SI+4 STA#3= 275uA

STATIONS

ARC I	2.547	2.447	O
ARC E LIM	1.526	0.000	O
SPUT ARC E	2699.940	2691.088	O
SPUT ARC E L	37.851	36.630	C
EXTRACT E	19.293	19.983	O
EINZEL E	15.756	16.088	O
MAGNET I	240.308	240.843	O
DECK E	59.000	58.889	C
LEBT Q1A	16.245	16.508	O
LEBT Q1B	60.232	60.562	O
LEBT Q2A	115.220	116.044	O
LEBT Q2B	86.117	85.958	C
LEBT M1	107.692	107.643	O
DECK E	59.000	59.016	C
LEBT Q3A	113.516	114.969	O
LEBT Q3B	195.049	197.607	O
LEBT Q3C	199.676	199.951	O
LEBT Q3D	170.800	188.327	C
LEBT SM1H	0.000	0.003	O
LEBT SM1V	0.000	-0.001	O
LEBT SM2H	0.000	0.005	O
LEBT SM2V	0.000	0.003	C

DRIFT TUBES

0	39.572	34.56	O	15	28.000	27.98	O	30	31.500	31.47	O
1	22.000	21.90	O	16	28.000	28.07	O	31	31.500	30.49	O
2	22.000	21.96	O	17	28.000	27.97	O	32	31.500	32.21	O
3	22.000	21.92	O	18	28.000	28.19	O	33	31.500	32.05	O
4	22.000	21.96	O	19	28.000	28.39	O	34	31.500	30.78	O
5	22.000	21.72	O	20	31.500	31.58	O	35	31.500	31.75	O
6	22.000	23.04	O	21	31.500	31.44	O	36	31.500	30.83	O
7	22.000	22.69	O	22	31.500	31.60	O	37	31.500	31.50	C
8	22.000	22.50	O	23	31.500	31.48	O	38A	26.718	26.72	C
9	28.300	27.94	O	24	31.500	31.50	O	38B	19.810	19.50	O
10	28.300	28.18	O	25	31.500	31.48	O	GR4	628.01[illegible]	615.78	O
11	28.300	28.12	O	26	31.500	31.38	O	GR5A	523.004	0.00	O
12	28.000	27.53	O	27	31.500	31.54	O	GR5B	425.006	426.28	O
13	28.000	28.09	O	28	31.500	31.64	O	GR6	549.988	544.86	O
14	28.000	27.92	O	29	31.500	31.26	O				

TIMING

13 2 40 1000 200 900 120 1000 600 400 2

SAVEB 07:32 03/10/87 neon 3+

STATIONS

I	2.600	2.447	O
ARC E LIM	2.747	2.442	O
SPUT ARC E	0.000	0.000	O
SPUT ARC E L	1.526	0.000	C
EXTRACT E	16.470	17.111	O
EINZEL E	17.073	17.661	O
MAGNET I	235.073	235.470	O
DECK E	56.500	55.968	C
LEBT Q1A	1.850	2.442	O
LEBT Q1B	46.856	46.789	O
LEBT Q2A	121.026	121.026	O
LEBT Q2B	101.905	101.587	C
LEBT M1	101.453	101.587	O
DECK E	56.500	56.190	C
LEBT Q3A	98.706	99.731	O
LEBT Q3B	176.551	178.657	O
LEBT Q3C	198.761	199.756	O
LEBT Q3D	166.954	183.150	C
LEBT SM1H	0.000	0.003	O
.EBT SM1V	0.000	0.000	O
T SM2H	0.000	0.006	O
L. .T SM2V	0.200	0.005	C

DRIFT TUBES

0	32.995	33.11	O	15	21.000	20.99	O	30	21.000	21.15	O
1	17.000	16.80	O	16	21.000	21.01	O	31	21.000	20.30	O
2	16.800	16.66	O	17	21.000	20.96	O	32	21.000	21.53	O
3	14.994	14.75	O	18	21.000	21.06	O	33	21.000	21.43	O
4	14.994	14.77	O	19	21.000	21.25	O	34	21.000	20.53	O
5	13.996	13.66	O	20	22.000	22.05	O	35	21.000	21.19	O
6	14.994	15.55	O	21	23.000	22.98	O	36	23.000	22.61	O
7	14.994	15.32	O	22	23.000	23.14	O	37	23.000	23.47	O
8	13.994	14.15	O	23	23.000	23.04	O	38A	35.996	32.49	O
9	14.994	14.73	O	24	23.000	23.05	O	38B	28.000	27.51	O
10	18.000	17.66	O	25	20.000	20.04	O	GR4	600.000	593.31	O
11	22.000	21.88	O	26	20.000	20.05	O	GR5A	500.000	502.47	O
12	21.000	20.64	O	27	20.000	20.09	O	GR5B	424.957	427.64	O
13	21.000	21.03	O	28	20.000	20.08	O	GR6	500.342	487.23	O
14	21.000	20.83	O	29	20.000	19.95	O				

TIMING

18 2 10 1000 80 1000 200 700 500 400 2

SAVE9 14:25 09/11/86 NEON 4+

STATIONS

ARC I	2.500	2.132	O
ARC E LIM	0.000	0.000	O
SPUT ARC E	0.000	0.000	O
SPUT ARC E L	1.526	0.000	C
EXTRACT E	19.494	20.145	O
EINZEL E	16.000	16.527	O
MAGNET I	210.073	210.623	O
DECK E	43.000	43.238	C
LEBT Q1A	6.227	6.447	O
LEBT Q1B	37.967	37.998	O
LEBT Q2A	92.204	92.405	O
LEBT Q2B	74.585	74.725	C
LEBT M1	75.147	74.921	O
DECK E	43.000	43.397	C
LEBT Q3A	60.769	1.074	O
LEBT Q3B	151.117	1.563	O
LEBT Q3C	191.740	2.247	O
LEBT Q3D	136.050	1.954	C
LEBT SM1H	0.078	0.002	O
LEBT SM1V	0.071	-0.002	O
LEBT SM2H	0.074	0.005	O
LEBT SM2V	0.222	0.003	C

DRIFT TUBES

0	26.000	0.00	O	15	18.000	0.00	O	30	23.000	0.00	O
1	15.995	0.00	O	16	18.000	0.01	O	31	23.000	0.00	O
2	15.995	0.00	O	17	18.000	0.04	O	32	23.000	0.00	O
3	16.629	0.00	O	18	18.000	0.00	O	33	23.000	1.12	O
4	16.122	0.00	O	19	18.000	0.00	O	34	24.000	0.02	O
5	16.715	0.00	O	20	22.000	0.00	O	35	24.000	0.04	O
6	16.888	0.00	O	21	22.000	0.00	O	36	24.000	0.00	O
7	16.826	0.00	O ←	22	22.000	0.04	O	37	24.000	0.00	O
8	16.278	0.00	O	23	22.000	0.01	O	38A	23.000	0.00	O
9	18.000	0.00	O	24	22.000	0.00	O	38B	25.000	0.00	O
10	18.000	0.00	O	25	22.000	0.02	O	GR4	605.226	0.00	O
11	18.000	0.00	O	26	22.000	0.00	O	GR5A	679.365	0.00	O
12	18.000	0.00	O	27	22.000	0.02	O	GR5B	669.499	0.00	O
13	18.000	0.00	O	28	22.000	0.00	O	GR6	437.827	0.00	O
14	18.000	0.00	O	29	22.000	0.00	O				

TIMING

30 1 20 1100 80 1000 220 1000 600 400 2

The Duoplasmatron ion source was commissioned in July of 1988 and is used mainly to provide an adequate supply of ions of hydrogen, deuterium and helium as well as providing a local fast switching capability from PIG source neon ions to Duoplasmatron source helium ions.

The Duoplasmatron source uses a hot filament of the tantalum hairpin variety or the newer LaB-6. The tantalum filament is easy to fabricate, inexpensive but with a lifetime of only 5 days. The LaB-6 is more costly to fabricate; however, it runs cooler and gives a lifetime of 3 weeks. The source uses a single gap extraction system and a tape wound solenoid to provide ion acceleration and focussing.

The following tables list the actual operating parameters that are stored in the computer. The enclosed tables titled "Local Tunes Duo-P" are scaled values using the HE 1+ ion as the monument particle.

SAVE1 Ø8:13 Ø7/13/88 Helium 1+... (Raise filament)

STATIONS

FILAMENT I	29.998	Ø.ØØØ	O
FIL ARC I	4.999	Ø.Ø1Ø	O
ELEC ARC I	3.9ØØ	Ø.ØØØ	O
LO MAGNET I	2.5ØØ	Ø.Ø92	O
DUOP DECK E	35.ØØØ	Ø.ØØØ	C
BIAS E	8ØØ.Ø61	Ø.ØØØ	O
DUOP SM1H	-1.124	-Ø.234	O
DUOP SM1V	Ø.2Ø7	-Ø.Ø15	O
SOL MAGNET I	Ø.575	Ø.ØØØ	O
HI MAGNET I	Ø.ØØØ	Ø.ØØØ	O
LEBT M1	62.ØØ2	Ø.684	O
DECK E	34.863	34.254	O
DUOP DECK E	35.ØØØ	Ø.ØØØ	C
LEBT Q3A	53.ØØ4	52.845	C
LEBT Q3B	122.698	122.198	C
LEBT Q3C	136.ØØ1	135.775	C
LEBT Q3D	93.584	93.382	C
LEBT SM1H	Ø.ØØØ	Ø.ØØ3	O
LEBT SM1V	Ø.ØØØ	-Ø.ØØ1	O
LEBT SM2H	Ø.ØØØ	Ø.ØØ4	C
LEBT SM2V	Ø.ØØØ	Ø.ØØ5	C

DRIFT TUBES

Ø	22.794	22.77	O	15	15.692	15.64	O	3Ø	18.ØØØ	18.Ø9	O
1	12.836	12.42	O	16	15.692	15.63	O	31	18.ØØØ	17.3Ø	O
2	13.7Ø8	13.38	O	17	15.692	15.62	O	32	18.ØØØ	18.37	O
3	14.517	14.14	O	18	15.692	15.66	O	33	18.ØØØ	18.32	O
4	13.471	13.Ø9	O	19	15.692	15.81	O	34	18.ØØØ	17.62	O
5	13.444	13.Ø1	O	2Ø	19.66Ø	19.7Ø	O	35	18.ØØØ	18.18	O
6	12.982	13.28	O	21	19.Ø13	18.92	O	36	2Ø.ØØØ	19.6Ø	O
7	12.188	12.32	O	22	19.Ø59	19.16	O	37	2Ø.ØØØ	2Ø.32	O
8	12.595	12.59	O	23	18.942	18.98	O	38A	21.612	21.35	O
9	15.885	15.51	O	24	18.ØØØ	17.94	O	38B	21.738	21.14	O
1Ø	15.66Ø	15.11	O	25	18.ØØØ	18.ØØ	O	GR4	527.18Ø	51Ø.28	O
11	15.954	15.63	O	26	18.ØØØ	17.92	O	GR5A	526.716	519.85	O
12	17.215	16.71	O	27	18.ØØØ	18.Ø1	O	GR5B	349.3Ø4	338.36	O
13	15.692	15.53	O	28	18.ØØØ	18.Ø3	O	GR6	452.943	441.71	O
14	14.994	14.64	O	29	18.ØØØ	17.93	O				

TIMING

5	1	2Ø	1	1ØØØ	1Ø	1ØØØ	3ØØ	Ø	Ø

SAVE2 17:12 Ø7/28/89 helium 1+, lab 6 filament, pv 1

STATIONS

FILAMENT I	51.ØØ1	48.298	O
FIL ARC I	9.459	8.132	O
ELEC ARC I	2.5ØØ	2.498	C
LO MAGNET I	3.8ØØ	3.795	C
DUOP DECK E	34.256	33.952	O
BIAS E	8ØØ.Ø61	675.214	O
DUOP SM1H	-1.124	Ø.ØØØ	O
DUOP SM1V	Ø.2Ø7	Ø.ØØØ	O
SOL MAGNET I	Ø.575	Ø.ØØØ	O
HI MAGNET I	Ø.ØØØ	Ø.ØØØ	O
LEBT M1	Ø.ØØØ	Ø.684	C
DECK E	56.ØØØ	55.937	C
DUOP DECK E	34.256	34.Ø32	O
LEBT Q3A	51.386	51.282	C
LEBT Q3B	119.982	119.853	C
LEBT Q3C	133.999	134.115	C
LEBT Q3D	9Ø.995	9Ø.745	C
LEBT SM1H	Ø.ØØØ	Ø.ØØ3	C
LEBT SM1V	Ø.ØØØ	-Ø.ØØ1	C
LEBT SM2H	Ø.ØØØ	Ø.ØØ6	C
LEBT SM2V	Ø.ØØØ	Ø.ØØ5	C

DRIFT TUBES

Ø	22.794	22.59	O	15	15.692	15.65	O	3Ø	18.ØØØ	18.1Ø	O
1	12.836	12.36	O	16	15.692	15.64	O	31	18.ØØØ	17.34	O
2	13.7Ø8	13.34	O	17	15.692	15.6Ø	O	32	18.ØØØ	18.39	O
3	14.517	14.Ø7	O	18	15.692	15.66	O	33	18.ØØØ	18.28	O
4	13.471	13.Ø3	O	19	15.692	15.82	O	34	18.ØØØ	17.67	O
5	13.444	12.93	O	2Ø	19.66Ø	19.72	O	35	18.ØØØ	18.13	O
6	12.982	13.22	O	21	19.Ø13	18.99	O	36	2Ø.ØØØ	19.62	O
7	12.188	12.26	O	22	19.Ø59	19.18	O	37	2Ø.ØØØ	2Ø.36	O
8	12.595	12.55	O	23	18.942	18.99	O	38A	21.612	21.23	O
9	15.885	15.41	O	24	18.ØØØ	17.96	O	38B	21.738	21.Ø2	O
1Ø	15.66Ø	14.98	O	25	18.ØØØ	18.Ø2	O	GR4	527.18Ø	5Ø5.98	O
11	15.954	15.57	O	26	18.ØØØ	18.Ø2	O	GR5A	526.716	5Ø3.83	O
12	17.215	16.61	O	27	18.ØØØ	18.Ø3	O	GR5B	349.3Ø4	334.85	O
13	15.692	15.41	O	28	18.ØØØ	18.Ø4	O	GR6	444.518	43Ø.38	O
14	14.994	14.68	O	29	18.ØØØ	18.Ø3	O				

TIMING

1Ø	3	2Ø	1	1ØØØ	1Ø	1ØØØ	3ØØ	Ø	Ø

SAVE3 20:04 06/23/89 2 H +1 LaB-6 FILAMENT

STATIONS

FILAMENT I	67.501	62.186	O
FIL ARC I	8.042	8.039	C
ELEC ARC I	3.290	3.297	C
LO MAGNET I	3.758	3.752	C
DUOP DECK E	17.433	16.540	O
BIAS E	800.061	673.993	O
DUOP SM1H	-1.227	-0.112	O
DUOP SM1V	0.296	-0.009	O
SOL MAGNET I	0.575	0.000	O
HI MAGNET I	0.022	0.000	O
LEBT M1	0.000	0.391	C
DECK E	17.847	17.825	C
DUOP DECK E	17.433	16.556	O
LEBT Q3A	25.012	25.592	O
LEBT Q3B	63.565	64.567	O
LEBT Q3C	69.689	69.451	O
LEBT Q3D	36.966	37.802	O
LEBT SM1H	0.000	0.002	C
LEBT SM1V	0.000	-0.002	C
LEBT SM2H	-0.011	0.006	C
LEBT SM2V	0.001	0.006	C

DRIFT TUBES

0	13.112	12.84	O	15	9.459	9.26	O	30	10.412	10.29	O
1	7.703	7.12	O	16	9.532	9.34	O	31	10.244	9.60	O
2	8.736	8.26	O	17	9.283	9.07	O	32	10.264	10.28	O
3	8.776	8.27	O	18	10.555	10.38	O	33	10.268	10.22	O
4	8.995	8.50	O	19	10.572	10.50	O	34	11.505	11.15	O
5	8.436	7.90	O	20	10.385	10.27	O	35	10.362	10.28	O
6	8.073	8.02	O	21	10.708	10.50	O	36	10.365	9.93	O
7	8.190	8.06	O	22	11.221	11.14	O	37	10.690	10.68	C
8	8.646	8.40	O	23	11.244	11.14	O	38A	9.190	9.20	C
9	9.109	8.63	O	24	11.072	10.85	O	38B	4.813	4.23	O
10	8.897	8.03	O	25	11.146	11.05	O	GR4	440.293	424.91	O
11	8.967	8.52	O	26	11.255	11.10	O	GR5A	460.147	443.47	O
12	9.369	8.80	O	27	10.513	10.33	O	GR5B	289.377	283.08	O
13	9.638	9.27	O	28	10.646	10.51	O	GR6	435.702	425.10	O
14	8.814	8.34	O	29	10.138	10.02	O				

TIMING

12 1 10 1 1000 10 1000 300 0 0

SAVE4 11:36 Ø7/Ø7/89 Tantalum Filament--Helium 1+

STATIONS

FILAMENT I	37.6ØØ	36.Ø49	O
FIL ARC I	5.6ØØ	5.6Ø2	C
ELEC ARC I	3.4ØØ	3.426	C
LO MAGNET I	3.ØØØ	2.983	C
DUOP DECK E	34.536	34.127	O
BIAS E	8ØØ.Ø61	671.551	O
DUOP SM1H	-1.124	-Ø.ØØ3	O
DUOP SM1V	Ø.2Ø7	-Ø.ØØ5	O
SOL MAGNET I	Ø.575	Ø.ØØØ	O
HI MAGNET I	Ø.ØØØ	Ø.ØØØ	O
LEBT M1	62.ØØ2	Ø.488	C
DECK E	34.863	Ø.ØØØ	C
DUOP DECK E	34.536	33.667	O
LEBT Q3A	53.95Ø	53.822	C
LEBT Q3B	122.173	122.ØØ2	C
LEBT Q3C	136.Ø81	136.Ø68	C
LEBT Q3D	94.585	94.652	C
LEBT SM1H	Ø.ØØØ	Ø.ØØ3	C
LEBT SM1V	Ø.ØØØ	Ø.ØØØ	C
LEBT SM2H	Ø.ØØØ	Ø.ØØ5	C
LEBT SM2V	Ø.ØØØ	Ø.ØØ7	C

DRIFT TUBES

Ø	22.794	22.58	O	15	15.692	15.64	O	3Ø	18.ØØØ	18.Ø9	O
1	12.836	12.36	O	16	15.692	15.65	O	31	18.ØØØ	17.31	O
2	13.7Ø8	13.33	O	17	15.692	15.6Ø	O	32	18.ØØØ	18.37	O
3	14.517	14.Ø9	O	18	15.692	15.68	O	33	18.ØØØ	18.26	O
4	13.471	13.Ø3	O	19	15.692	15.82	O	34	18.ØØØ	17.64	O
5	13.444	12.94	O	2Ø	19.66Ø	19.73	O	35	18.ØØØ	18.Ø7	O
6	12.982	13.22	O	21	19.Ø13	18.97	O	36	2Ø.ØØØ	19.54	O
7	12.188	12.25	O	22	19.Ø59	19.17	O	37	2Ø.ØØØ	2Ø.33	O
8	12.595	12.53	O	23	18.942	18.99	O	38A	21.612	21.22	O
9	15.885	15.41	O	24	18.ØØØ	17.95	O	38B	21.738	21.Ø1	O
1Ø	15.66Ø	14.99	O	25	18.ØØØ	18.Ø3	O	GR4	518.633	5Ø1.88	O
11	15.954	15.56	O	26	18.ØØØ	17.99	O	GR5A	523.541	5Ø5.79	O
12	17.215	16.59	O	27	18.ØØØ	18.Ø1	O	GR5B	336.85Ø	328.6Ø	O
13	15.692	15.41	O	28	18.ØØØ	18.Ø3	O	GR6	448.913	435.26	O
14	14.994	14.7Ø	O	29	18.ØØØ	18.Ø2	O				

TIMING

1Ø 3 2Ø 1 1ØØØ 1Ø 1ØØØ 3ØØ Ø Ø

SAVE7 20:55 07/30/89 helium-3, ta filament

STATIONS

FILAMENT I	29.659	0.000	O
FIL ARC I	5.556	0.000	O
ELEC ARC I	3.343	0.000	C
LO MAGNET I	1.667	0.138	C
DUOP DECK E	25.899	0.000	O
BIAS E	800.061	0.000	O
DUOP SM1H	-1.124	-0.013	O
DUOP SM1V	0.207	-0.101	O
SOL MAGNET I	0.575	0.000	O
HI MAGNET I	0.000	0.000	O
LEBT M1	0.000	0.684	C
DECK E	56.000	56.079	C
DUOP DECK E	25.899	0.000	O
LEBT Q3A	38.400	38.388	C
LEBT Q3B	89.902	90.061	C
LEBT Q3C	100.495	100.806	C
LEBT Q3D	68.193	68.278	C
LEBT SM1H	0.000	0.003	C
LEBT SM1V	0.000	-0.001	C
LEBT SM2H	0.000	0.006	C
LEBT SM2V	0.000	0.007	C

DRIFT TUBES

0	17.099	16.85	O	15	11.799	11.66	O	30	13.499	13.49	O
1	9.600	9.07	O	16	11.799	11.67	O	31	13.499	12.88	O
2	10.299	9.86	O	17	11.799	11.63	O	32	13.499	13.69	O
3	10.899	10.43	O	18	11.799	11.66	O	33	13.499	13.61	O
4	10.100	9.61	O	19	11.799	11.76	O	34	13.499	13.18	O
5	10.100	9.57	O	20	14.799	14.77	O	35	13.499	13.54	O
6	9.699	9.73	O	21	14.299	14.17	O	36	14.999	14.63	O
7	9.199	9.12	O	22	14.299	14.30	O	37	14.999	15.16	O
8	9.499	9.31	O	23	14.199	14.15	O	38A	16.200	15.77	O
9	11.899	11.42	O	24	13.499	13.34	O	38B	14.729	14.13	O
10	11.799	11.03	O	25	13.499	13.44	O	GR4	365.055	349.89	O
11	11.999	11.58	O	26	13.499	13.42	O	GR5A	412.308	396.00	O
12	12.899	12.30	O	27	13.499	13.43	O	GR5B	255.409	245.37	O
13	11.799	11.46	O	28	13.499	13.44	O	GR6	332.991	322.74	O
14	11.299	10.87	O	29	13.499	13.47	O				

TIMING

10	4	20	1	1000	10	1000	300	0	0

SAVE9 21:58 07/06/89 2 H +1 ..tantalum filament

STATIONS

FILAMENT I	35.344	34.303	O
FIL ARC I	5.054	4.996	C
ELEC ARC I	2.631	2.635	C
LO MAGNET I	3.904	3.900	C
DUOP DECK E	17.655	16.810	O
BIAS E	800.061	678.877	O
DUOP SM1H	-1.227	-0.108	O
DUOP SM1V	0.296	-0.007	O
SOL MAGNET I	0.575	0.000	O
HI MAGNET I	0.021	0.000	O
LEBT M1	0.000	0.586	C
DECK E	17.847	0.000	C
DUOP DECK E	17.655	16.667	O
LEBT Q3A	25.012	25.201	C
LEBT Q3B	63.565	63.394	C
LEBT Q3C	69.689	69.158	C
LEBT Q3D	36.966	36.728	C
LEBT SM1H	0.000	0.003	C
LEBT SM1V	0.000	-0.001	C
LEBT SM2H	-0.011	0.005	C
LEBT SM2V	0.001	0.008	C

DRIFT TUBES

0	13.112	12.81	O	15	9.459	9.25	O	30	10.412	10.28	O
1	7.701	7.10	O	16	9.532	9.32	O	31	10.244	9.60	O
2	8.736	8.25	O	17	9.283	9.05	O	32	10.264	10.27	O
3	8.776	8.27	O	18	10.555	10.37	O	33	10.268	10.21	O
4	8.995	8.48	O	19	10.572	10.50	O	34	11.505	11.14	O
5	8.436	7.90	O	20	10.385	10.27	O	35	10.362	10.26	O
6	8.073	8.01	O	21	10.708	10.50	O	36	10.365	9.88	O
7	8.190	8.07	O	22	11.221	11.12	O	37	10.690	10.67	C
8	8.646	8.39	O	23	11.244	11.15	O	38A	9.190	9.20	C
9	9.109	8.62	O	24	11.072	10.83	O	38B	4.813	4.23	O
10	8.896	8.03	O	25	11.146	11.04	O	GR4	440.293	425.49	O
11	8.967	8.51	O	26	11.255	11.08	O	GR5A	460.147	444.44	O
12	9.369	8.77	O	27	10.513	10.32	O	GR5B	289.377	283.86	O
13	9.638	9.24	O	28	10.646	10.50	O	GR6	435.702	423.54	O
14	8.814	8.32	O	29	10.138	10.02	O				

TIMING

12 2 10 1 1000 10 1000 300 0 0

LOCAL TUNES-DUO-P 8/30/89

SOURCE ION	H 1+	D 1+	3HE 1+	HE1+	HE 2+
Q	1	1	1	1	2
M	2	4	3	4	4
Q/M	0.50	0.25	0.33	0.25	0.5
RFQ RF	2.10	4.20	3.15	4.20	2.10
TANK 1 RF	2.34	4.68	3.51	4.68	2.34
TANK 2 Q	1	2	2	2	2
TANK 2 Q/M	0.50	0.50	0.67	0.50	0.50
TANK 2 RF	5.3	5.3	4.0	5.3	5.3
STATIONS		DUOPLASMATRON SOURCE			
FILAMENT (Amps) LaB-6	80	80	80	80	80
FILAMENT ARC (Amps)	9	9	9	9	9
ELECTRODE ARC (Amps)	3.5	3.5	3.5	3.5	3.5
SOURCE MAGNET (Amps)	3.5	3.5	3.5	3.5	3.5
FILAMENT (Amps) Ta	42	42	42	42	42
FILAMENT ARC (Amps)	5.5	5.5	5.5	5.5	5.5
ELECTRODE ARC (Amps)	3.3	3.3	3.3	3.3	3.3
SOURCE MAGNET (Amps)	3	3	3	3	3
DECK KV	17	25.5	25.5	34.0	17.0
BIAS V	800	800	800	800	800
LEBT M1	0	0.0	0.0	0.0	0.0
LEBT Q3A (Amps)	26.6	39.9	39.9	53.2	26.6
LEBT Q3B (Amps)	61	91.5	91.5	122.0	61.0
LEBT Q3C (Amps)	68	102.0	102.0	136.0	68.0
LEBT Q23D (Amps)	46.6	69.9	69.9	93.2	46.6

SOURCE ION	H 1+	D 1+	3HE 1+	HE1+	HE 2+
DRIFT TUBE (Amps) TANK # 1 (SCALED FROM HE 1+ TUNE)					
Drift tube number 0	11	22.0	16.5	22.0	11.0
1	6	12.0	9.0	12.0	6.0
2	7	14.0	10.5	14.0	7.0
3	7	14.0	10.5	14.0	7.0
4	6.5	13.0	9.8	13.0	6.5
5	6.5	13.0	9.8	13.0	6.5
6	6.5	13.0	9.8	13.0	6.5
7	6.5	13.0	9.8	13.0	6.5
8	6.5	13.0	9.8	13.0	6.5
9	7.7	15.4	11.6	15.4	7.7
10	7.8	15.6	11.7	15.6	7.8
11	8	16.0	12.0	16.0	8.0
12	8.5	17.0	12.8	17.0	8.5
13	7.8	15.6	11.7	15.6	7.8
14	7.5	15.0	11.3	15.0	7.5
15	7.8	15.6	11.7	15.6	7.8
16	7.8	15.6	11.7	15.6	7.8
17	7.8	15.6	11.7	15.6	7.8
18	7.8	15.6	11.7	15.6	7.8
19	7.8	15.6	11.7	15.6	7.8
20	9.8	19.6	14.7	19.6	9.8
21	9.6	19.2	14.4	19.2	9.6
22	9.5	19.0	14.3	19.0	9.5
23	9.5	19.0	14.3	19.0	9.5
24	9	18.0	13.5	18.0	9.0
25	9	18.0	13.5	18.0	9.0
26	9	18.0	13.5	18.0	9.0
27	9	18.0	13.5	18.0	9.0
28	9	18.0	13.5	18.0	9.0
29	9	18.0	13.5	18.0	9.0
30	9	18.0	13.5	18.0	9.0
31	9	18.0	13.5	18.0	9.0
32	9	18.0	13.5	18.0	9.0
33	9	18.0	13.5	18.0	9.0
34	9	18.0	13.5	18.0	9.0
35	9	18.0	13.5	18.0	9.0
36	10	20.0	15.0	20.0	10.0
37	10	20.0	15.0	20.0	10.0
38A	10.8	21.6	16.2	21.6	10.8
DRIFT TUBE VALUES - TANK # 2 (SCALED FROM HE 1+ TUNE)					
38B	21.7	21.7	16.3	21.7	21.7
GR4(25-38)	527	527.0	395.3	527.0	527.0
GR5A(39-50)	526	526.0	394.5	526.0	526.0
GR5B(51-62)	349	349.0	261.8	349.0	349.0
GR6(63-75)	452	452.0	339.0	452.0	452.0

SOURCE ION	H 1+	D 1+	3HE 1+	HE1+	HE 2+
LINAC EXIT TRANSPORT VALUES FOR IONS OF VARIOUS (Q/M)					
EXIT ION	H 1+	D 2	HE	HE	HE
Q	1	2	2	2	2
M	2	4	3	4	4
Q/M	0.50	0.50	0.67	0.50	0.50
IQ1 E	13.3	13.3	10.0	13.3	13.3
IQ1 C	16.2	16.2	12.2	16.2	16.2
IQ2 E	17.7	17.7	13.3	17.7	17.7
IQ2 C	17.2	17.2	12.9	17.2	17.2
Q3	18.0	18.0	13.5	18.0	18.0
BLM 16 MH	-661	-661	-495.8	-661	-661
BLM 17 MH	570	570	427.5	570	570
BLM 18 MH	557	557	417.75	557	557
ESI	17	17	12.75	17	17
BL 17 SV	-0.029	-0.029	-0.022	-0.029	-0.03
BL 17 Qv	-3.9	-3.9	-2.925	-3.9	-3.9

4.0 Extraction Optics and Magnet Currents vs. Bevalac Field[9]

The standard extraction tune out of the Bevalac is specified horizontally as follows:

(1) Magnet XM1 is used to center the beam at wire 16.5 on wire chamber XM2WC

(2) Magnet XM2 is used to center the beam at wire 29 on wire chamber XM3WC

(3) Magnet XM3 is used to center the beam at wire 16.5 on wire chamber XM4WC.

In Fig. 8 we present a plot of the XP1, XP2, XM1, XM2 and XM3 magnet currents per Bevalac field, as a function of the Bevalac field.

The XQ3A (horizontally focusing) and XQ3B (vertically focusing) quadrupoles are normally tuned for a focus at wire chamber XF1WC. In Fig. 9, we plot the quadrupole current per Bevalac field, as a function of the Bevalac field.

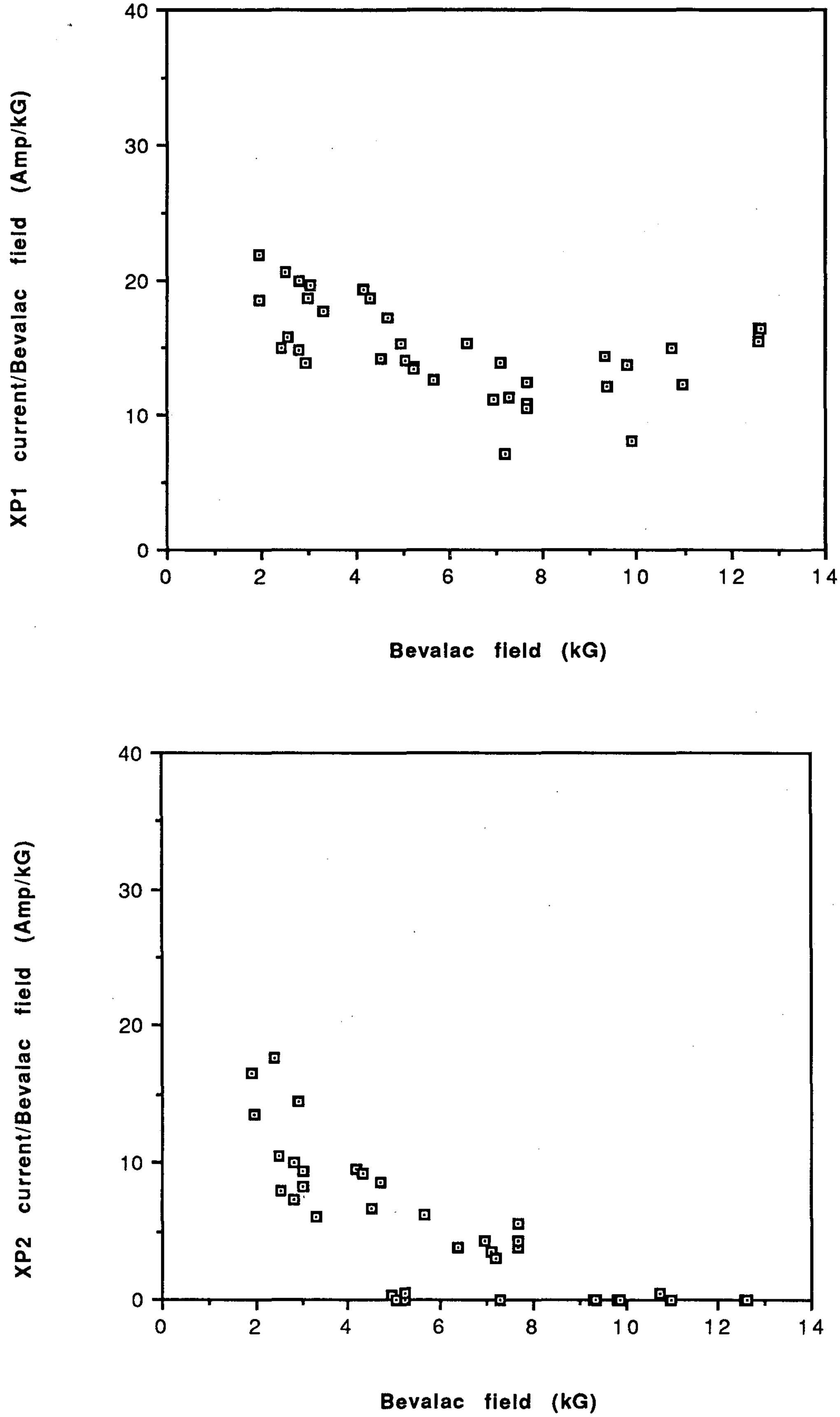


Fig.8(a) : XP1 and XP2 magnet currents as a function of the Bevalac field.

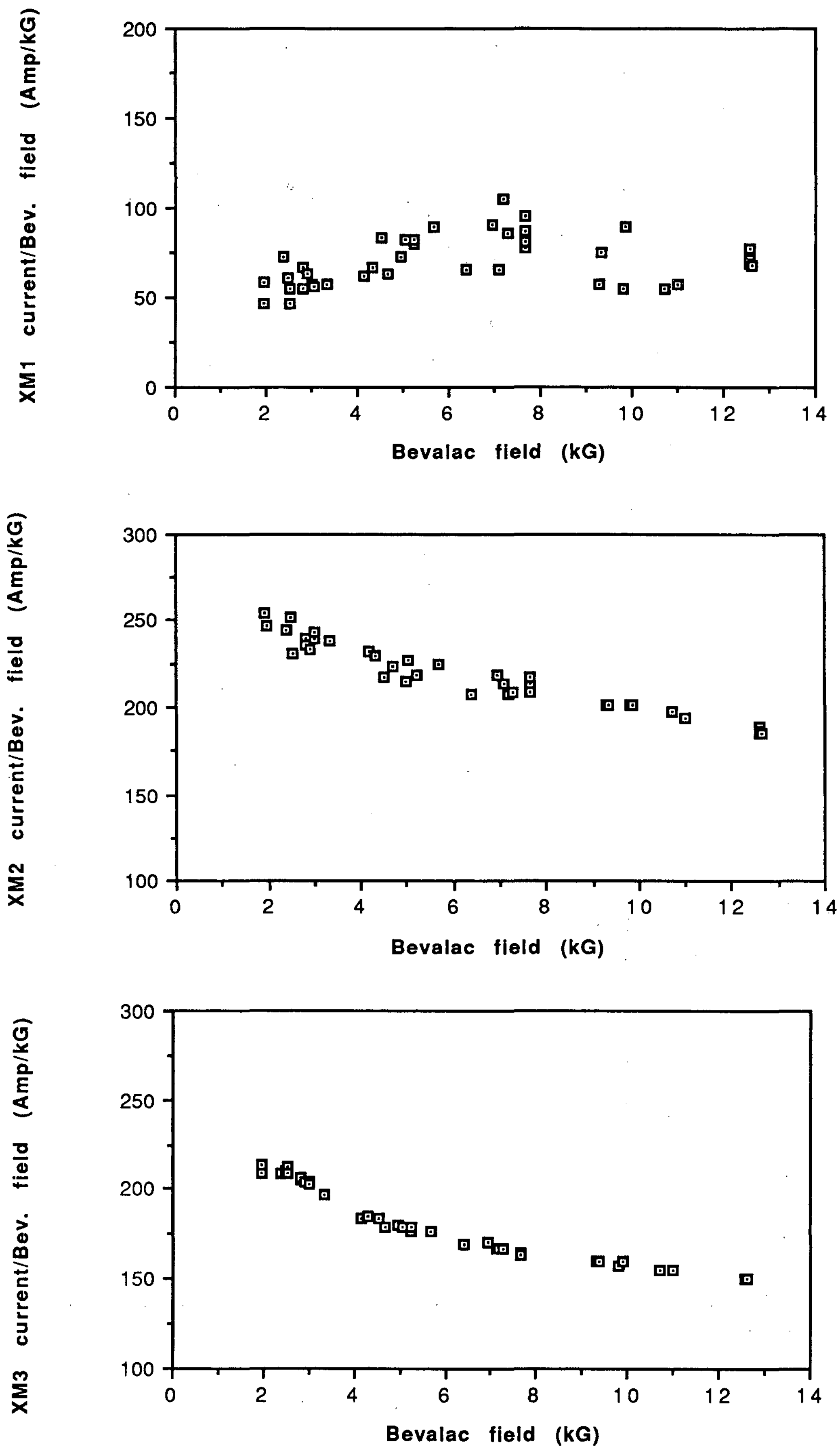
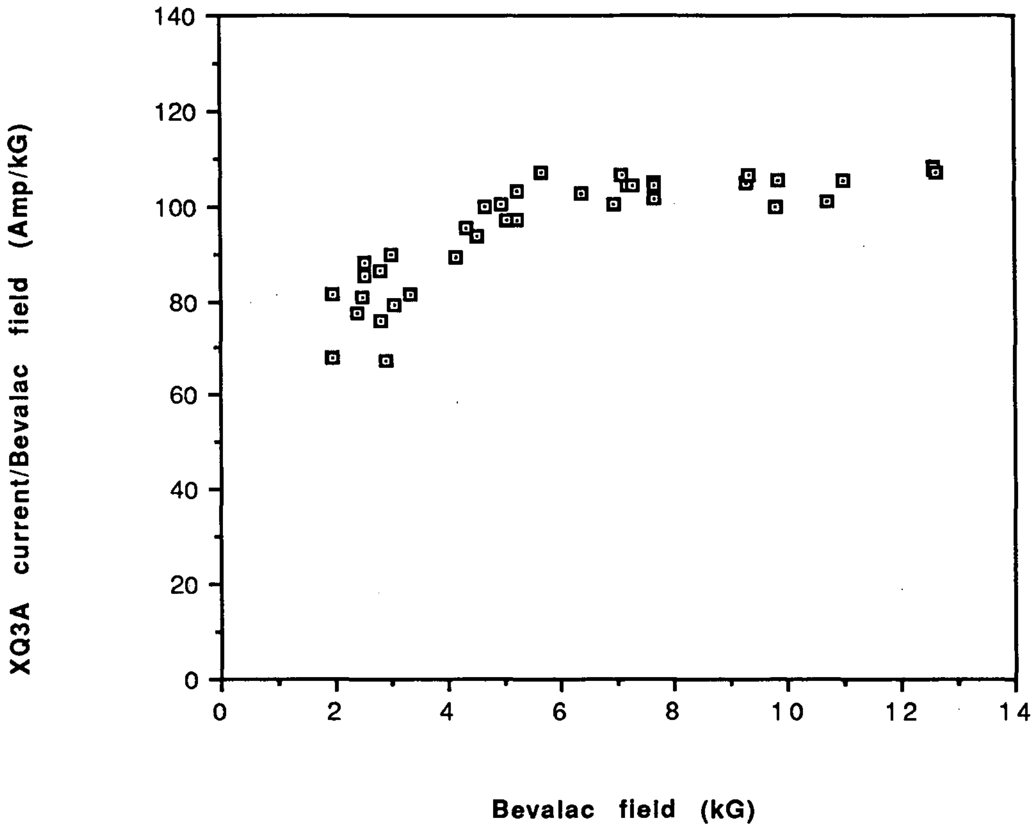


Fig.8(b) : XM1,XM2 and XM3 magnet currents as a function of the Bevalac field.



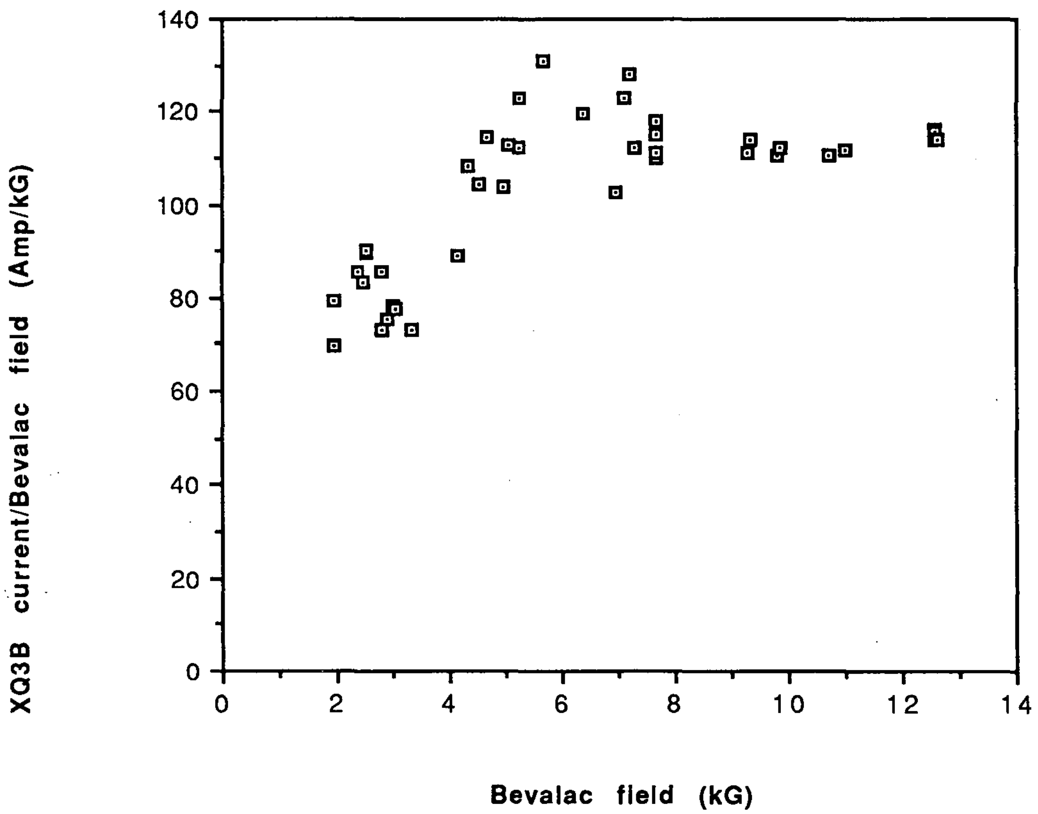


Fig.9 : Extraction quadrupole currents as a function of the Bevalac field.

5.0 Some Dipole Tuning Hints.

5.1 Beam 26: Magnets X1M6 and B26M1

Horizontally, do not center the beam on B26WC1 (wire = 16.5). This wire chamber is badly misaligned (due to hardware constraints, it is difficult to reorient). Note the wire chamber pictures of B26WC1 in Sec. 3.1.6. Set X1M6 and B26M1 at nominal values calculated from Table 3.1.7.

1. Use X1M6 to center the beam at wire 16.5 on B26WC2.
2. Use B26M1 to center the beam at wire 16.5 on B26WC4.
3. Repeat step 1 and then 2, etc., until the beam is centered on both wire chambers.

5.2 Beam 30 and 44 Magnets S1M4, S1M5 and S1M6.

Horizontally, the beam should be centered on wire chamber:

S1M6WC at wire = 16.5

S1Q7WC at wire = 16.5

S1F3WC at wire = 16.5

The procedure is as follows:

1. Put in the nominal current for magnets S1M4, S1M5 and S1M6. They can be obtained from Table 3.2.7 for Beam 30 and Table 3.6.7 for Beam 44.
2. Adjust the S1M6 current to center the beam on S1F3WC at wire = 16.5.
3. Adjust the S1M5 current to center the beam on S1Q7WC at wire = 16.5.
4. Repeat Step 2 and then Step 3 until wire position conditions are satisfied.

5. Adjust the S1M4 current to center the beam on S1M6WC at wire = 16.5.

6. Now repeat Step 2 and Step 3.

7. Repeat Step 5. Stop when all conditions are met.

<u>**References:**</u>

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3. <u>Transport: A Computer Program for Designing Charged Particle Beam Transport Systems,</u> K. L. Brown, et al: SLAC - 91 Feb. 1974.
4. <u>Transport: An Ion Optic Program LBL Version</u>, A. C. Paul, LBL 2697 (UC-32), Feb. 1975.
5. <u>Principles of Cyclic Particle Accelerators</u>, J. J. Livingood, pub by D. Van Nostron 1961, AC786, L45.
6. <u>Introduction to the Physics Involved in the Operation of the Bevatron</u>, K. Crebbin, BEV-3049, 1973.
7. Drawing and compilation by B. Caylor.
8. <u>LATTICE...A Beam Transport Program</u>, John Staples, LBL June 1987 LBL-23939
9. Magnet data compiled by Terry Byrne, for Section 4.0 and the Tables of Average Magnet Currents per Bevalac Field

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