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A LARGE-FIELD MEDICAL BEAM AT THE 184-INCH SYNCHROCYCLOTRON

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The 184-Inch Synchrocyclotron at the Lawrence Laboratory in Berkeley has, for many years, provided a highly reliable 930-MeV helium-ion beam of relatively high intensity for pituitary irradiation and treatment of lung lesions, etc. A plan view of the medical cave area is shown in Fig. 1. For irradiations, a typical beam-spot size of ~5 cm with an intensity on the order of 2,000 rads/min has been commonly available. With the recent advent of a new method of programming the "Dee" voltage, dose-rates have been increased to slightly more than 4,000 rads/min.

In order to enlarge upon the possible therapeutic, diagnositc, and radiobiological research capabilities of the 184-Inch Synchrocyclotron, we have recently developed a large-area helium-ion beam of approx. 30-cm diam with a uniform intensity of about 165 rads/min ± 2%. over 86% of the diameter. (Fig. 2).

The method used to obtain this large-field beam is a modification of that used at Harvard University Medical Center and was suggested by Dr. Andy Koehler.[1,2] The method consists of passing the full-energy emergent beam of 3.8-cm diam, through a 7.7-mm-thick lead scatterer, which produces a gaussian intensity distribution at the treatment plane (Fig. 3). Collimater #1, 14 cm in diam, simply trims the edges of the beam. It is evident that the number of helium ions in the central area must be reduced to obtain the desired uniform intensity. A cylinder and annular ring assembly made of brass, and thick enough to stop the helium ions, is placed 2.6 m downstream from the first scatterer. The particles emerging from the two resulting annular sources are additionally scattered by a 3-mm-thick brass sheet. Approximately 55% of the beam survives, with a horizontal and vertical distribution as shown in Fig. 4. In addition, to enhance the biological usefulness, a "spiral ridge filter" may be incorporated as part of collimater #1 to modify the depth distribution of the high-dose region.

Figure 5 indicates the depth-dose variation in water when the spiral ridge filters and 12 cm of lucite degrader are inserted in the beam line to bring the Bragg peak within the limits required for typical theraputic use. Both curves were obtained from a calibrated EGG Ionization Chamber with a volume of 1.0 cm^3, whose output was presented to an X-Y recorder.

To minimize extraneous off-axis radiation, the beam passes through a thick-walled iron cylindrical collimator about 2.3 m long, with an entrance diam of about 20 cm and a 25-cm exit diam. Heavy-metal collimators of appropriate thickness may be inserted into the downstream end of this collimator to more exactly define the beam shape and size.

At the present time, two concentric lead collimators of 7.6 cm thickness with internal diams of 17 and 12 cm are provided to roughly confine the treatment field to 20 cm and 14 cm, respectively. A final collimator, made to precisely outline the treatment area is place approximately 1.5 m downstream, adjacent to the patient.

It has been suggested that Cerrobend collimators are easy to make and use for the final collimation. It should be remembered, though, that in the case of high-energy particle accelerators, the material becomes radioactive and special procedures must be followed to permit its reuse.

A light source and mirror given an immediate visual check of beam size and location. The mirror is very thin (0.013 mm aluminized mylar) and may be permanently installed in the beam line near the second scatterer.

The high reliability of this system is due to its relative simplicity. The reproducibility of the beam profile is limited by the spatial stability of the cyclotron beam and by the mechanical reproducibility of the scatterer and collimating system. Both scatterers and any of the collimators may be quickly and easily removed or replaced with a resulting error of less than 1% in the beam profile. It is therefor possible to change from the small diameter (pituitary irradiation) beam to the large area treatment field in a few minutes.

References:

1. Personal communication.
2. R. Schneider, R. A. Schmidt, and A.M. Koehler, Physical Preparations for Cancer Therapy at the Harvard Cyclotron, Bull. Amer. Pys. Soc. <u>19</u>, 31 (1974).

Figure Captions:

1. Plan view of the medical cave area.

2. The salient features are shown for the treatment area with the large-area helium-ion beam.

3. Beam line in the medical cave at the 184-Inch Synchrocyclotron showing collimators and scatterers.

4. The horizontal and vertical distributions across a diameter of the beam measured in air at the treatment field. The distributions are identical, within the tolerance limits.

5. Depth dose as measured in water by an EGG ionization chamber with a volume of 1.0 cm^3.

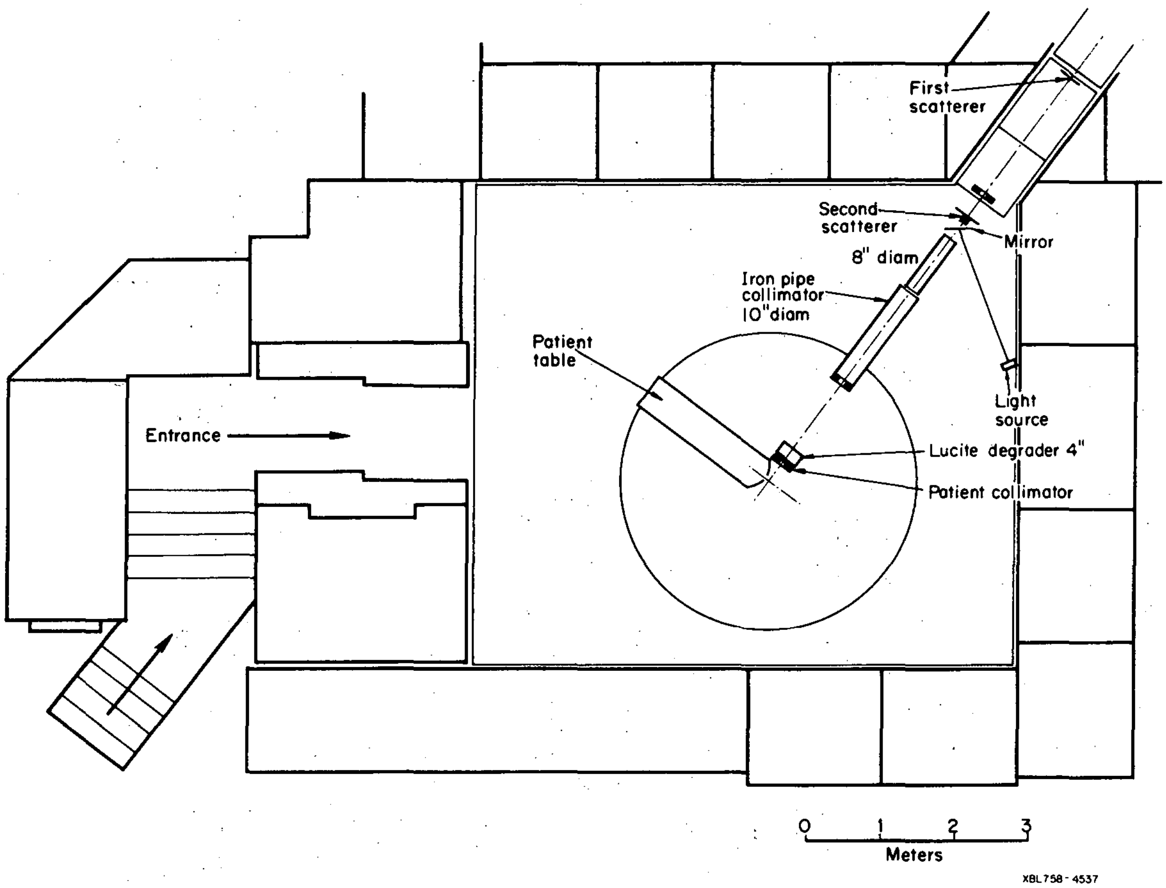
First scatterer
Second scatterer
Mirror
8" diam
Iron pipe collimator 10"diam
Patient table
Light source
Lucite degrader 4"
Patient collimator
Entrance
0
1
2
3
Meters
XBL758-4537

Fig. 1

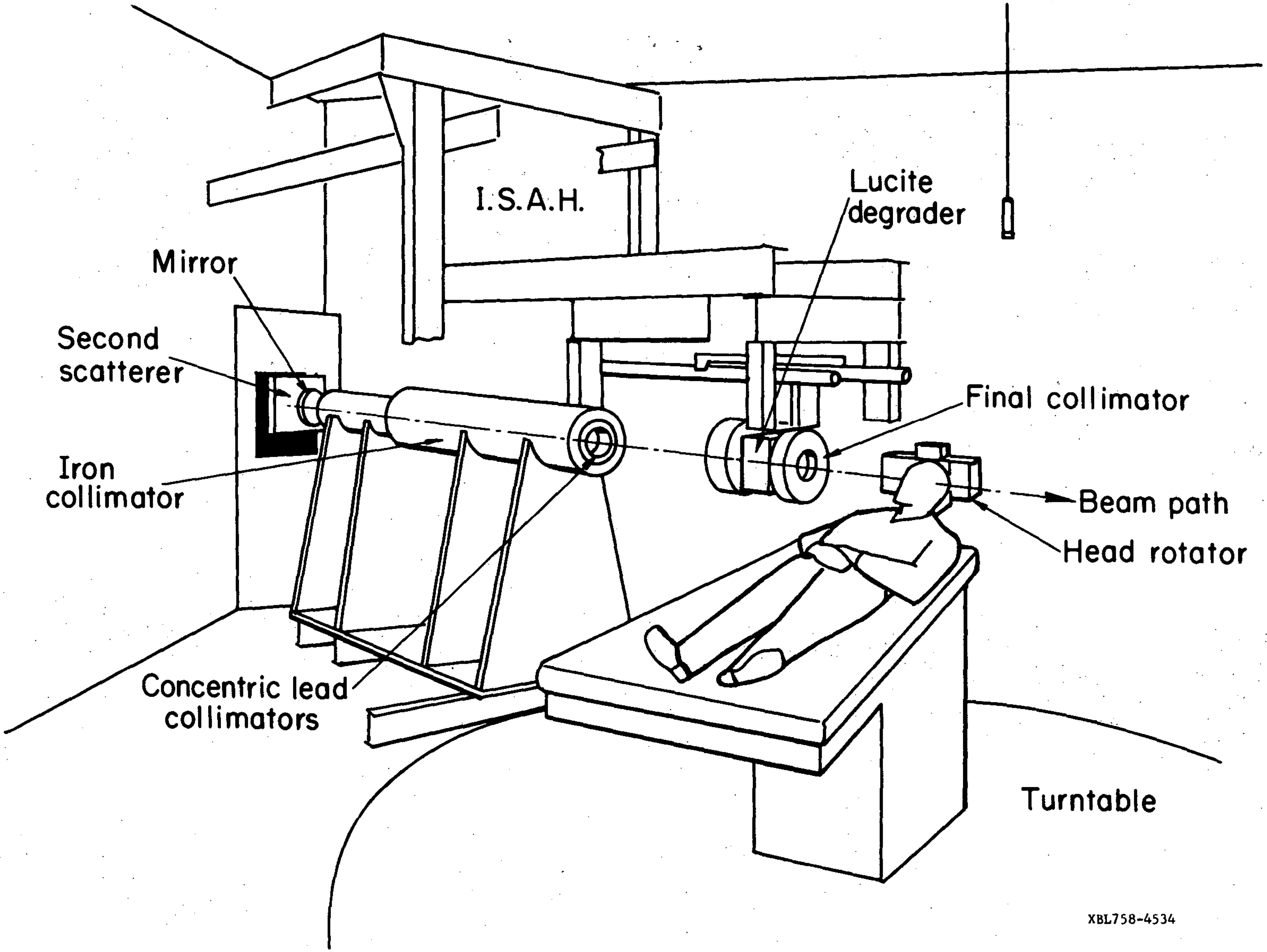

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Fig. 2

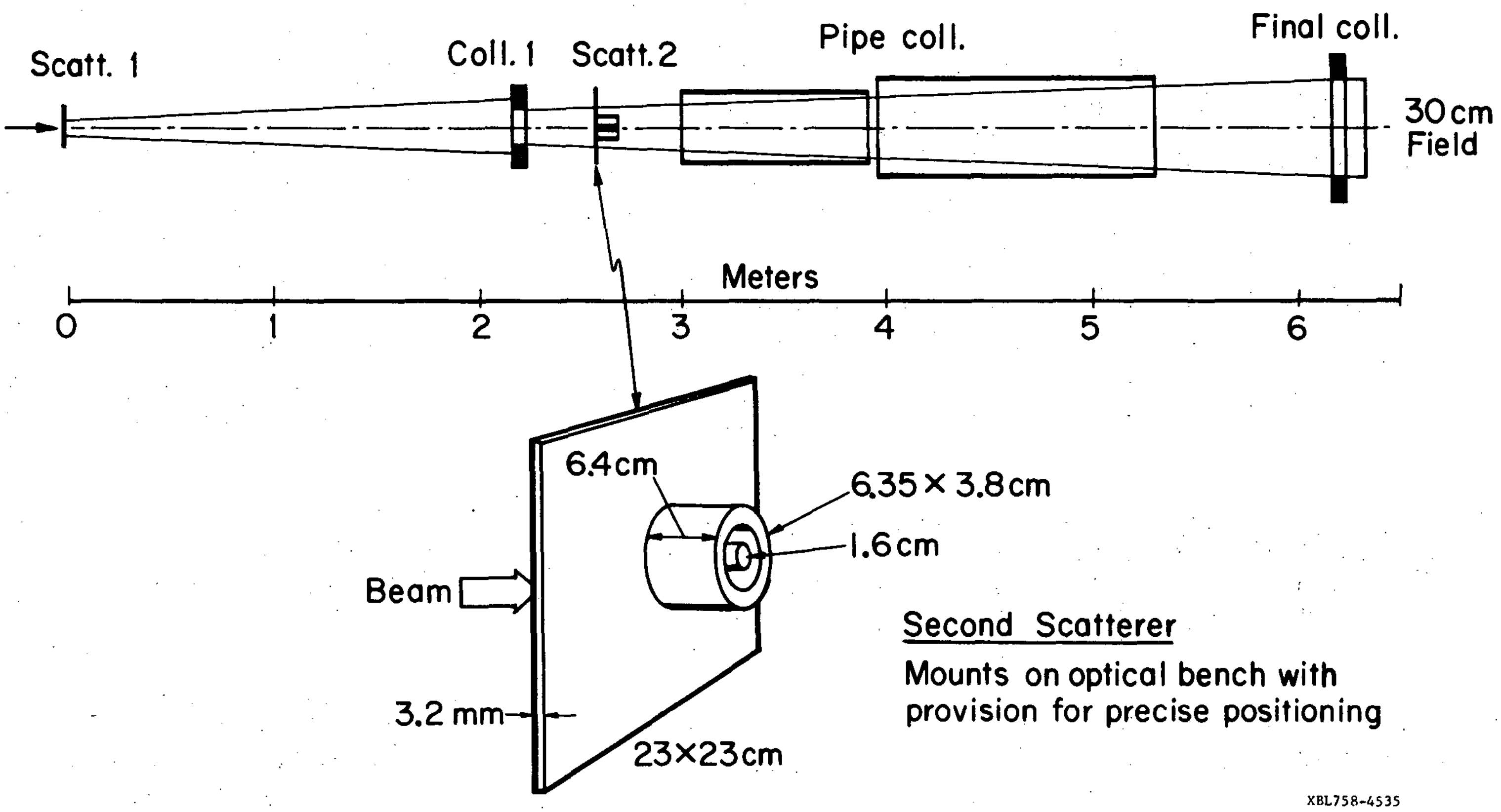

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Fig. 3

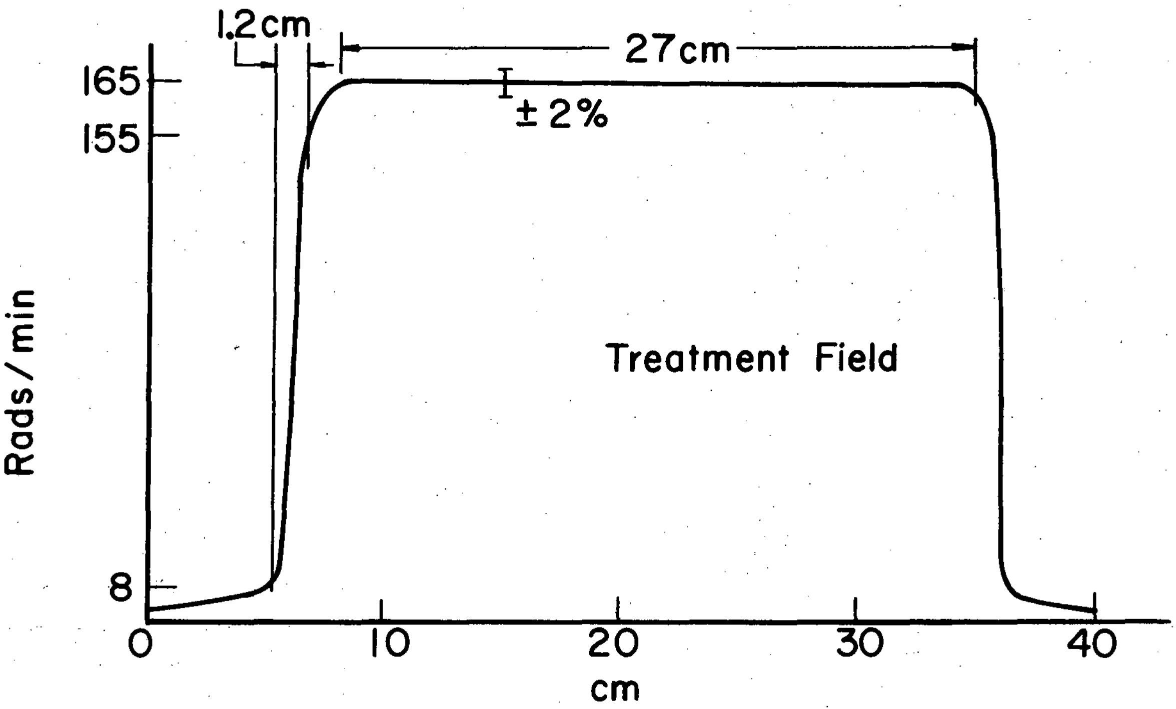

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Fig. 4

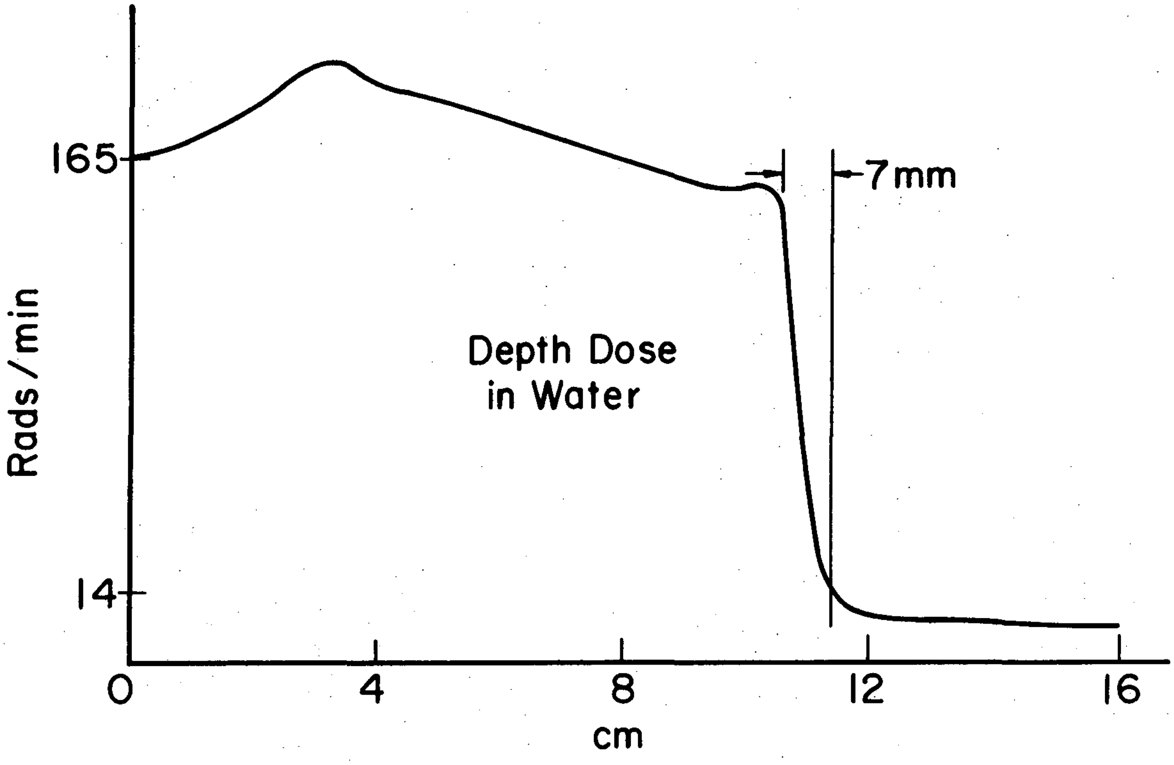

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Fig. 5

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