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Operation of 1/4 Scale Model Bevatron

Author
Lofgren, E.J.

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E. J. Lofgren

June 13, 1949

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INFORMATION DIVISION
Radiation Laboratory
University of California
Berkeley, California

OPERATION OF 1/4 SCALE MODEL BEVATRON

E. J. Lofgren

Accelerated protons were first observed in the 1/4 Scale Bevatron on April 30, 1949. This is an account of some of the things learned since then. No attempt is made to give a description of the machine except that which is essential to describe operation. The basic parameters are given by W. M. Brobeck in Bevatron Brief Specifications M62a. Figure 1 is a general view of the apparatus.

The results are still meager and must be considered provisional since the larger fraction of time has been spent in modifications and repairs.

Injected Beam

Three quarter Mev protons are supplied for injection into the bevatron by a small pulsed cyclotron. An electrostatic deflector and a magnetic shield bring the beam out to a focusing magnetic field. Of a circulating beam 10 to 18 ma., 200 to 350 μa are focused at the entrance to the bevatron on a probe 1 in. wide and 2 in. high. The beam here is bent into the bevatron tank by a 90°, 25 inch radius electrostatic deflector (usually called the inflector to distinguish from the cyclotron deflector). It is shown in Figure 2. At the exit of this deflector the beam is reduced to 100 to 180 μa. for a pulse length of about .6 milliseconds. We have shown (see last section) that only about .2 ms are effective.

Beam Detection and Magnitude.

The accelerated beam was first detected on a probe which consisted of a 1-1/4 in. diameter lucite rod, 4 ft. long with activated zinc sulphide on the inner end and a 1P21 photomultiplier and preamp on the outer end. The probe is inserted into the straight sections of the tank from the inside. The beam is observed as it spirals in due to increasing magnetic field after the accelerating r.f. is turned off.

Later the beam was detected on an ionization chamber and finally after it had been increased by several orders of magnitude it was measured on an electrical probe covered with 1 mil aluminum by using a cathode follower and preamp. The largest measured beam has been $3.5 \cdot 10^{-9}$ amp in a pulse about 2-1/2 milliseconds long.

We found by comparison with direct electrical measurement at beams greater than 10^{-10} amp that the scintillation probe preamp was non-linear. This has been corrected but direct measurement is preferred for quantitative experiments.

Vacuum

The tank is evacuated by 8 20 in. diffusion pumps with Freon cooled oil baffles. There are 1-1/2 in. dia. liquid Nitrogen traps running through the length of each of the quadrants. With this it has been possible to reach pressures of $2.7 \cdot 10^{-6}$ mm. as measured on Western Electric ionization gages in the manifold above the oil baffle. When the pressure is increased by closing some of the pumps the beam as measured on an ionization chamber follows an exponential curve fairly well in which the $\frac{1}{e}$ pressure is 1.8×10^{-6} mm. This experiment was done with the beam accelerated for about 100 ms, corresponding to about 3 Mev.

On a warm afternoon, about 90° F, the tank pressure is 2 to 3 times as high as on a cool evening, about 65° F.

Tank Aperture

In normal running the unobstructed vertical aperture is the full tank height, 9-3/4 inches. The horizontal aperture is set by the inflector on the outside and the probe on the inside. That distance is usually 27 in. There are horizontal and vertical clippers to restrict the aperture to any value. With the beam accelerated to 100 ms they have been used only with the zinc sulphide detector under non-linear conditions. Hence we can only say from those experiments that a detectable amount of beam survives at an aperture as small as 4-3/4 inches high by 14-1/2 inches wide.

Accelerating the beam to only 12 ms we have varied the aperture and made direct quantitative measurements. As far as these measurements have been carried it shows that as the horizontal aperture is decreased there is no change in beam down to 20 in. Decreasing to 14 in. the beam is halved. The beam is constant when the vertical aperture is decreased down to 6 inches. From there it drops to one-half at 4-3/4 inches and to one-tenth at 4 inches.

Beam Distribution on First Turn

If the bevatron is tuned up to give a maximum accelerated beam and then completely blocked off by a vane at the 360° azimuthal angle from the point of injection the distribution of beam at 90°, 270°, and 360° is as shown in Figure 4. The 360° curve shows that about 10 μa survive the first turn and clear the inside of the inflector.

Beam Striking the Inflector

We have shown that the accelerated beam is not a steep function of small changes in inflector obstruction. This was done by placing a 3/8 in. wide obstruction on the lip of the inner inflector electrode which was equivalent to increasing the thickness of the tip of that electrode from 1/32 inch to 13/32 inch. No change in beam was observed when it was put on or taken off. Since the change in each case requires the bevatron to be let down to air during which time something else might change, the observation is good only to about ± 50 percent.

Efficiency

By pulsing the inflector off at a variable time after the cyclotron comes on we have measured the beam as a function of injected pulse length. To an accuracy of ± 20 percent there is no decrease for pulse lengths down to .2 ms. If from

Fig. 4 we take 10 μa as the injected beam of proper direction and of the right energy to miss the inflector and if we take .2 ms as the effective pulse length we have $2 \cdot 10^{-9}$ coulombs injected. Our best beam accelerated to 100 ms has been $3.5 \cdot 10^{-9}$ amp for 2-1/2 ms or $8.8 \cdot 10^{-12}$ coulombs. This gives $4.4 \cdot 10^{-3}$ for an efficiency figure after the first turn.

The Operating Group consists of: W. Chupp, R. Clack, N. Knable, E. Lofgren D. Nielsen, R. Richter, D. Sewell and W. Stephan.

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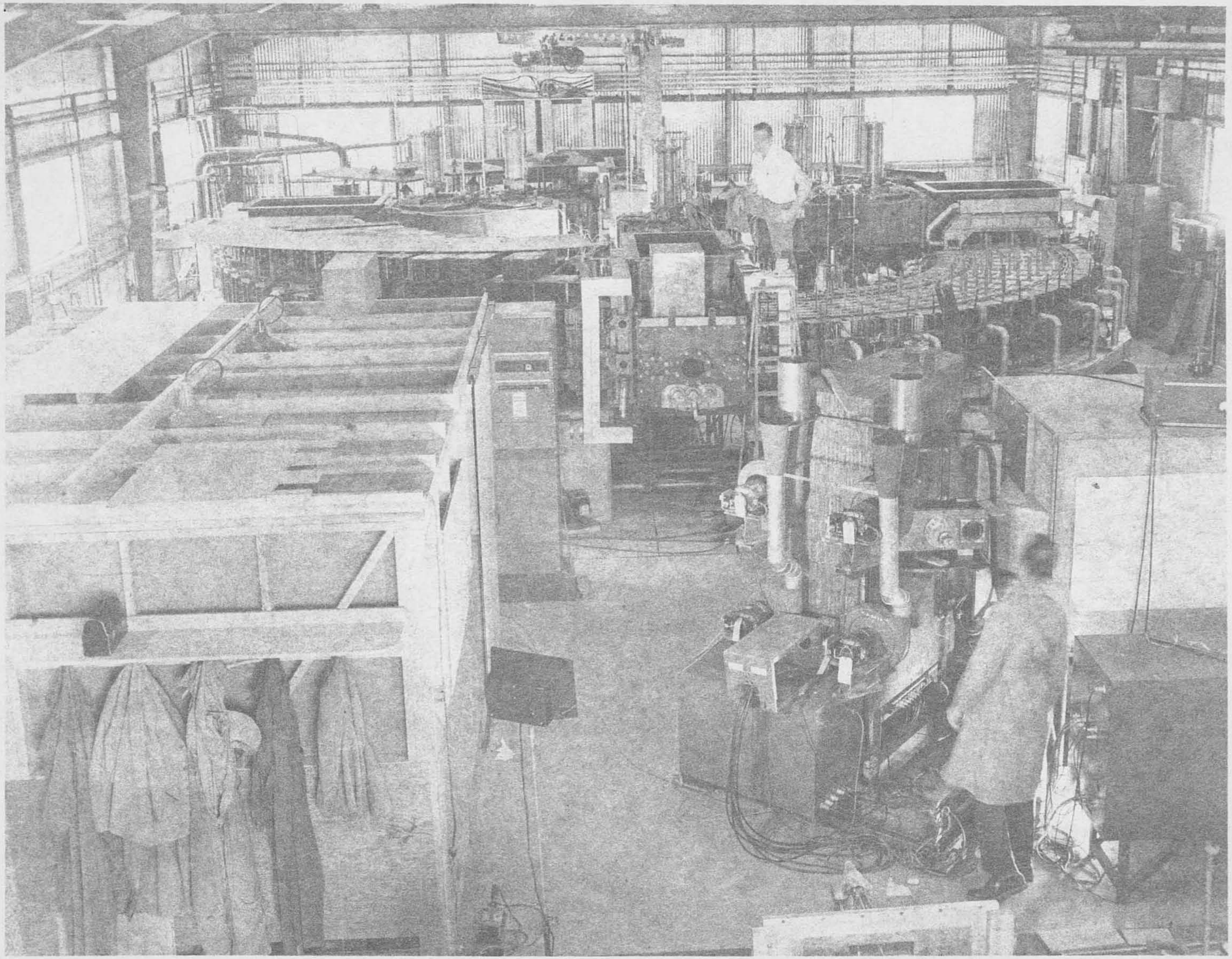

FIG. 1

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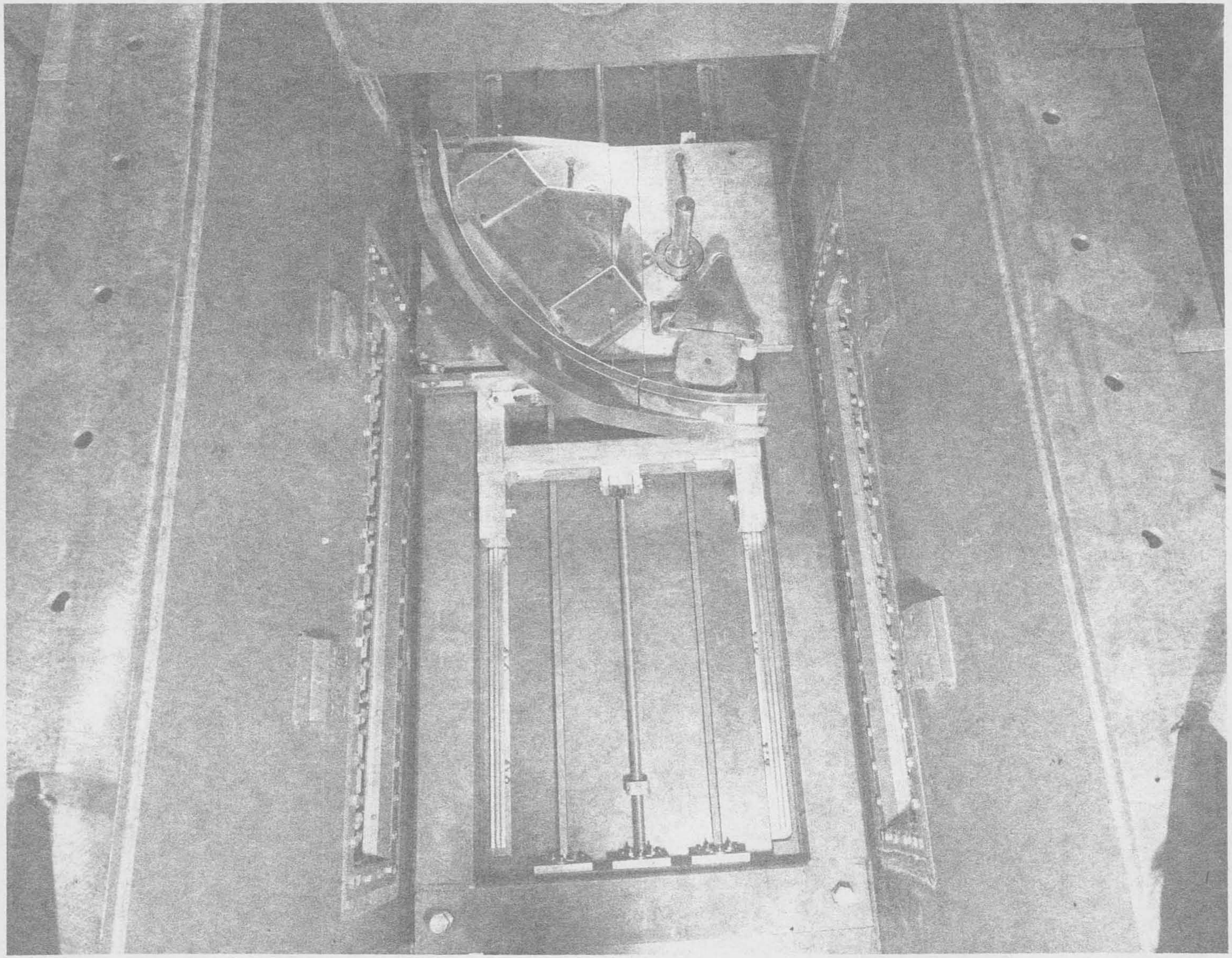
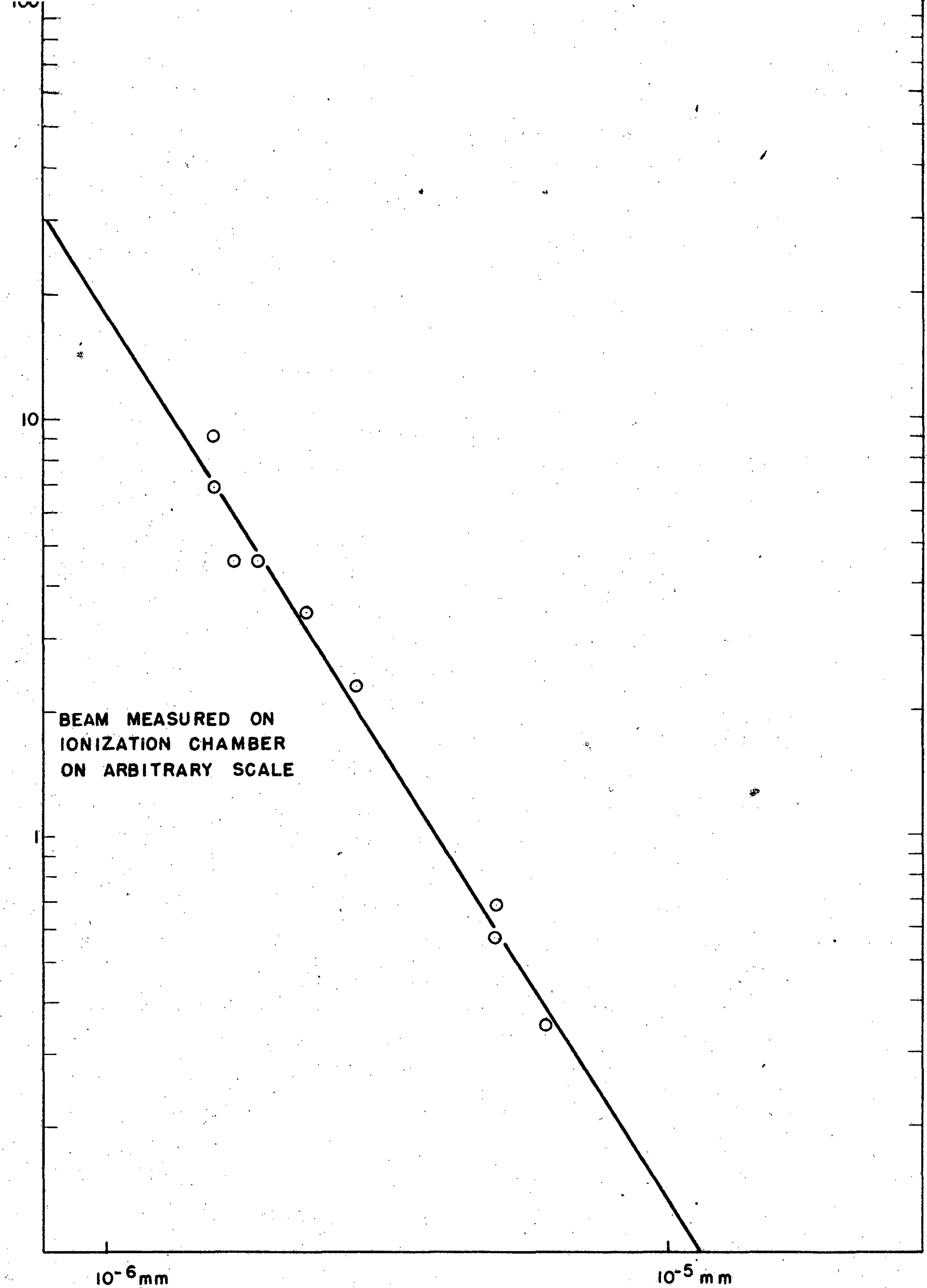


FIG. 2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BEAM MEASURED ON
IONIZATION CHAMBER
ON ARBITRARY SCALE
10^-6 mm
10^-5 mm
PRESSURE, AVERAGE OF ION GAGES ON THE FOUR PUMP MANIFOLDS

FIG. 3

13802-1

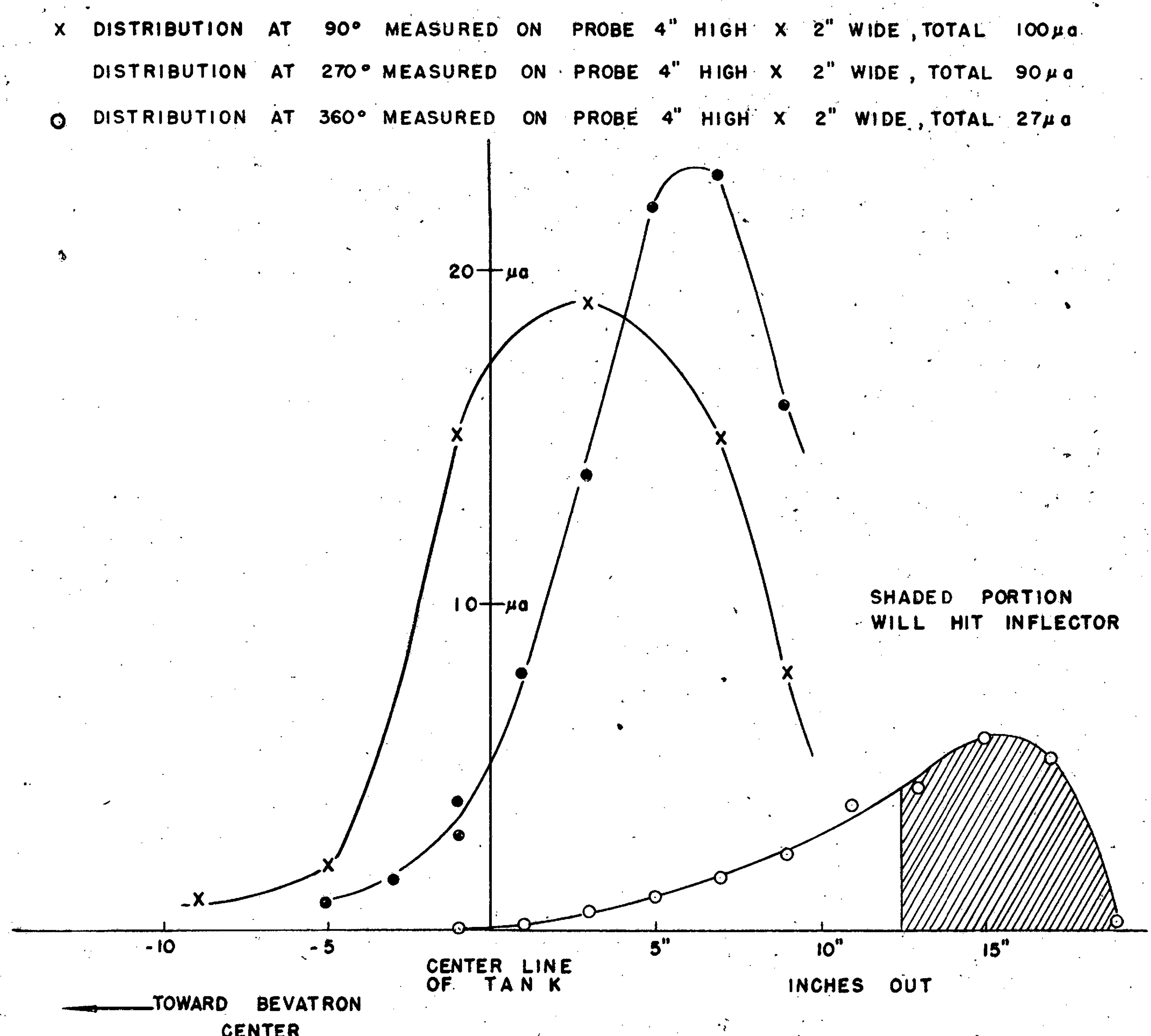
X DISTRIBUTION AT 90° MEASURED ON PROBE 4" HIGH X 2" WIDE, TOTAL 100μa
DISTRIBUTION AT 270° MEASURED ON PROBE 4" HIGH X 2" WIDE, TOTAL 90μa
O DISTRIBUTION AT 360° MEASURED ON PROBE 4" HIGH X 2" WIDE, TOTAL 27μa
20 μa
10 μa
SHADED PORTION WILL HIT INFLECTOR
-10
-5
5"
10"
15"
CENTER LINE OF TANK
INCHES OUT
TOWARD BEVATRON CENTER

FIG. 4

13803-1