Letters to the Editor

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Production of a π^+ Meson Beam Using the Deflected Proton Beam of the 184-Inch Synchro-Cyclotron*

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SOME progress has been made toward the production of an approximately monochromatic meson beam with the 340-Mev protons from the Berkeley 184-inch synchro-cyclotron.

Owing to the large peak at about 70 Mev in the spectrum of π^+ mesons produced at 0° by protons on protons,[1] hydrogen is peculiarly suited for use in a meson production target. Many more mesons are produced per *nucleon* in an 8- or 10-Mev interval from hydrogen than from any other material that has been studied.[2]

A convenient target, rich in hydrogen and easy to handle, is polyethylene $(CH_2)_n$. Because of the hydrogen, the production from CH_2 for a thin target is strongly peaked[3] at about 69 Mev. (See curve I, Fig. 1.) A 5-cm thick piece of CH_2 was used as a meson production target. One would expect that such a thick target would broaden the peak considerably. This, however, is not the case. With a 5-cm CH_2 target, a 69-Mev meson created at the front of the target by a 340-Mev proton loses 15 Mev in the target and emerges with 54 Mev, whereas at the back of the target the protons have an energy of 323 Mev and produce mesons with a peak energy of 54 Mev.

The experimental arrangement was designed with a meson scattering experiment in mind. For this purpose it was desirable to use the external proton beam of the 184-inch cyclotron. This beam emerges from a 2-inch diameter collimator and has at present a maximum intensity of about 6×10^{-10} amp.

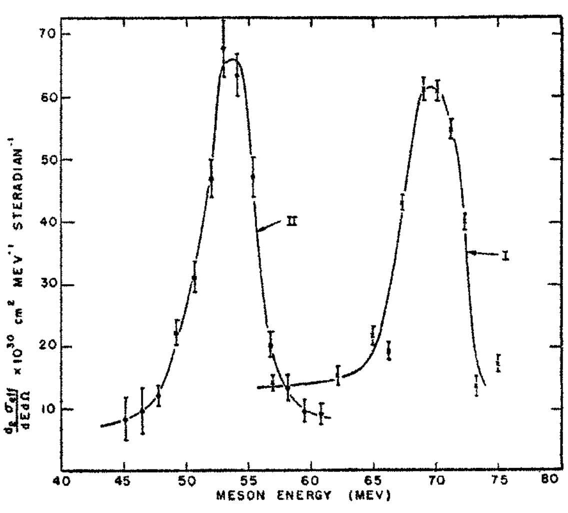

FIG. 1. The effective differential cross section per Mev per CH_2 molecule per incident proton for the production of mesons in the forward direction by 340-Mev protons. Curve I: thin ($\frac{3}{32}$-in.) CH_2 target. Curve II: 5-cm CH_2 target.

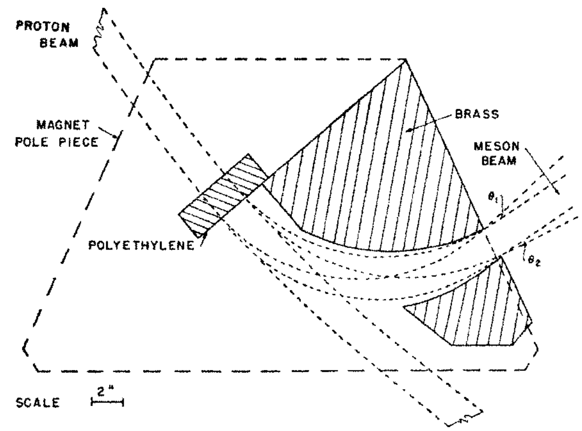

FIG. 2. Arrangement of the apparatus in the magnetic field.

Since the mesons come off from the CH_2 target predominantly in the forward direction, they must be separated from the proton beam. This is achieved with a magnetic field of 14,300 gauss across a gap of 3.4 inches, which gives a 54-Mev meson and a 340-Mev proton radii of curvature of 12.4 inches and 80 inches, respectively.

In order to collimate the meson beam, and also to eliminate all particles other than mesons in the desired energy interval, a channel for the mesons was cut in the brass shielding (Fig. 2). The channel accepts mesons with energies between 48 and 60 Mev. A 54-Mev meson produced at 0° in the center of the target is turned through 85° before emerging from the center of the channel. The exit area of the channel is 2 inches wide by 2.5 inches high, subtending a solid angle of about 2.2×10^{-2} steradian at the CH_2 target. With this arrangement the meson beam collimation was such that $\theta_1\cong\theta_2\cong9°$.

The meson energy spectrum was measured by means of nuclear emulsions embedded in absorbers.[2] Curve II of Fig. 1 shows the spectrum of the mesons leaving the 5-cm CH_2 target in the forward direction. To obtain this curve, the meson density in the emulsions was corrected for (a) the loss of about 9 percent of the mesons due to decay in flight and (b) the loss of about 16 percent of the mesons due to nuclear scattering and absorption in the aluminum absorber holding the emulsions, assuming nuclear area for the total nuclear cross section. The errors indicated are probable errors due to the statistics.

The peak of the spectrum occurs at 53.5 Mev, and the half-width of the peak is 5 Mev. Comparison of the thin and thick target spectra shows that a thick target does not indeed spread the peak.

Integrating curve II of Fig. 1 over the 12-Mev meson energy interval from 48 to 60 Mev, one obtains 4.0×10^{-28} cm² per steradian per CH_2 molecule per incident proton. This is the effective differential cross section for the production of mesons from a thick CH_2 target. The thin target spectrum integrated from 62 to 74 Mev gives 4.4×10^{-28} cm² per steradian. Apparently, the excitation does not fall off rapidly over the proton energy interval from 340 to 323 Mev.

With a proton beam of 5×10^{-10} amp. there are about 5000 mesons per second with energies between 48 and 60 Mev issuing from the channel.

It is a pleasure to acknowledge the encouragement we have received from Professor R. L. Thornton. We would also like to think Mr. J. Vale and the cyclotron crew for making the bombardments.

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[1] Cartwright, Richman, Whitehead, and Wilcox, Phys. Rev. 78, 823 (1950). V. Z. Peterson, Phys. Rev. 79, 407 (1950).
[2] C. Richman and H. A. Wilcox, Phys. Rev. 78, 496 (1950). M. Weissbluth, Ph.D. thesis, University of California (1950) (UCRL-568).
[3] Cartwright, Richman, Whitehead, and Wilcox (to be published).