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Berkeley, California

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Studies of the production of π^+-mesons by 341 Mev protons on protons[1,2] have shown a continuous spectrum of mesons with a pronounced peak at the high energy end. It was suggested[3] that besides the reaction $P + P \rightarrow N + P + \pi^+$, a second reaction takes place, namely $P + P \rightarrow D + \pi^+$, which could be expected to give a considerable yield of mesons in a line spectrum separated from the continuous spectrum produced by the first reaction by 2.2 Mev as measured in the center of mass system. Recently it was shown by F. Crawford et al.[4] that deuterons do come off in coincidence with the π^+-mesons around the peak energy. They did not measure the absolute yield. The reaction $P + P \rightarrow D + \pi^+$ is of great interest since, as has been pointed out by R. Marshak and W. Cheston[5] and independently by M. H. Johnson, a measurement of the inverse process will by means of detailed balancing determine the spin of the π^+-meson.

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1 W. F. Cartwright, C. Richman, M. N. Whitehead and H. A. Wilcox, Phys. Rev. 78, 823 (1950) and Phys. Rev. 81, 652 (1951).

2 V. Z. Peterson, Phys. Rev. 79, 407 (1950) and V. Peterson, E. Iloff and Dora Sherman, Phys. Rev. 81, 647 (1951).

3 G. Chew and E. Hart, private communication. See also Morand, Cüer, and Moucharafyeh, Compt. rend. 226, 1974 (1948).

4 F. S. Crawford, K. M. Crowe and M. L. Stevenson, Phys. Rev. 82, 97 (1951).

5 R. E. Marshak, Rochester High Energy Conference, December 1950. W. Cheston, Phys. Rev. (in press).

It is very important for the sake of the complete detailed balancing arguments as well as for the theory of this process[6] to find the angular distribution of the mesons. The measurements of the meson yield at 0°,[1] and at 18° and 30° [2] show a non-isotropic distribution when transformed to the center of mass system and suggest that the total meson yield goes something like $\cos^2 \theta$, where θ is the angle in the center of mass of the mesons with respect to the line of the protons. To determine the angular distribution more precisely we have measured the yield in the laboratory at 60°. The method we used is the same as was used to measure the yield at 0°, that is to take a polyethylene-carbon difference. As before the mesons are detected by means of nuclear emulsions. The spectrum obtained is shown in Figure 1. The errors shown are the statistical probable errors. Because of the low yield from hydrogen the subtraction method becomes more difficult here, and no data was obtained at the low energy end of the spectrum. The spectrum shows the characteristic peak to be around 25 Mev. The energy of the beam was 341 ± 3 Mev. The angle at which the mesons were observed was determined to be $58^{\circ} \pm 5^{\circ}$. From energy and momentum conservation, the energy of the meson peak if it is produced by the formation of a deuteron would be 25 ± 2 Mev at 60°, using a meson mass equal to $(276.2 \pm 2.3)m_e$. We believe that the energy of the peak is the best measure of the angle at which the mesons emerge with respect to the beam. The dotted curve is the spectrum corrected for nuclear interaction of the mesons in the absorber, assuming nuclear area for this interaction. The total cross section for the production of mesons in the peak at this angle is $(8.0 \pm 2)10^{-30}$ cm^2 ster.$^{-1}$

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[6] K. Brueckner, Phys. Rev. 82, 598 (1951). K. M. Watson and K. A. Brueckner, Phys. Rev. (in press).

The measurements of the yield of mesons at the various angle which have so far been made do not tell us whether a deuteron comes off in coincidence with every meson observed at the peak. However, the phenomenological calculations of Watson and Brueckner,[6] when compared to the meson spectrum at 0°, lead one to believe that most of the mesons in the peak come from the reaction in which a deuteron is formed. Because of the experimental uncertainties in our spectrum at 60° it is more difficult to make comparisons with the theory at this angle. We will assume that here too the peak is primarily due to the reaction $P + P \rightarrow D + \pi^{+}$ and calculate the angular distribution in the center of mass on this basis. The integrated cross section due to the peak at 0° is $(1.3 \pm 0.26)10^{-28}$ cm^2 $ster.^{-1}$ in the laboratory frame. Comparing this cross section with the cross section at 60°, we obtain the following formula for the differential cross section is the center of mass as a function of Θ, the angle in the center of mass:

$$\left(\frac{d\sigma}{d\Omega}\right)_{cm} = (3.20 \pm 0.78)(0.071 \pm 0.068 + \cos^2 \Theta)10^{-29} \text{ cm}^2 \text{ ster.}^{-1}$$

The total cross section for the mesons in the peak is therefore $(1.62 \pm 0.49)10^{-28}$ cm^2. This suggests that the meson comes off almost entirely in a P-wave, and since the majority of the mesons of the entire spectrum are in the peak, it would follow that the total spectrum is approximately in a P-wave.

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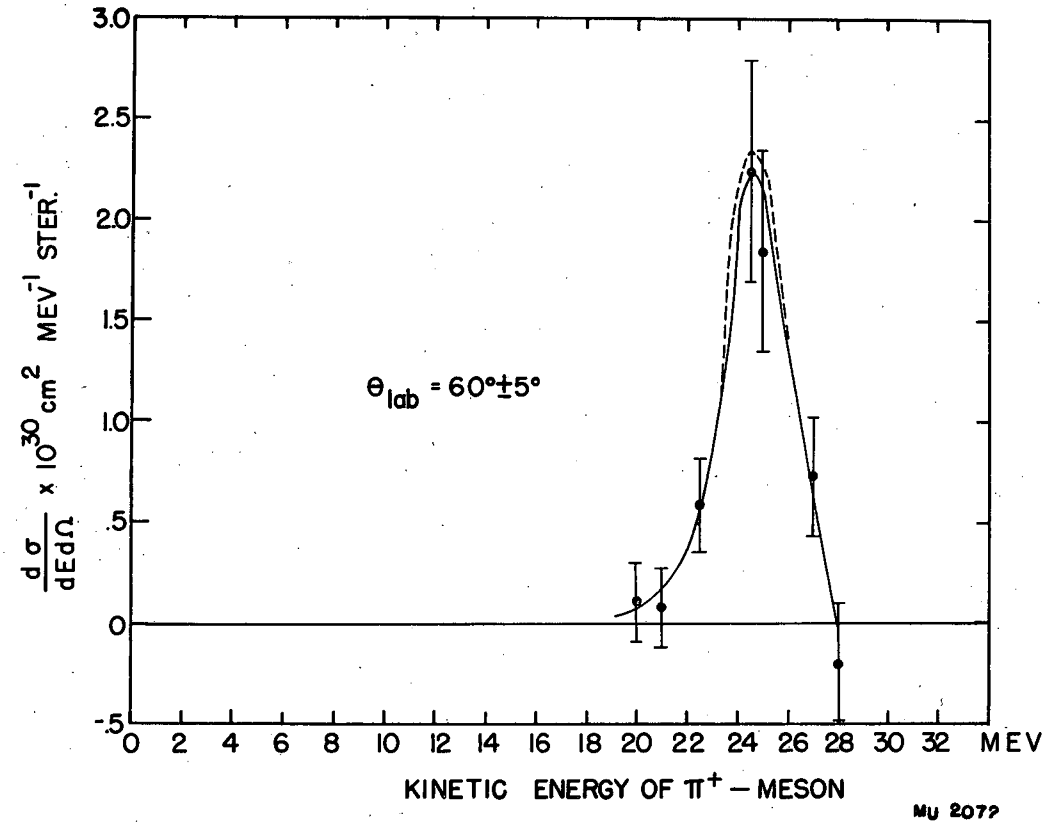

Fig. 1

Spectrum of π^+-Mesons at $\theta = 60^{\circ} \pm 5^{\circ}$
to the Proton Beam