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π^--p INTERACTIONS AT 3.9 GeV/c

Berkeley, California

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July 7, 1964

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July 7, 1964

This report covers the first phase of a careful study of two- and four-prong reactions from $\pi^- + p$ at 3.9 ± 0.03 GeV/c. We took about 50,000 pictures in the Berkeley 72-inch hydrogen bubble chamber and have scanned and measured events on about 60% of the film. In this preliminary report, we discuss only the two-prong events leading to $\pi^+ + \pi^- + n$ and $\pi^- + \pi^0 + p$. The approximately 30,000 two- and four-prong events we found were measured on the FSD and processed through the FOG-CLOUDY-FAIR programs. About three-quarters or 22,500 are two-prong events. Severe cuts were made in the fiducial volume of the chamber and on parameters related to measurement quality, leaving a sample of 9,950 good two-prong events, giving about 1340 $\pi^+\pi^- n$ events, 855 $\pi^-\pi^0 p$, and 2,440 $\pi^- p$. The remainder do not fit a two- or three-body reaction. We are aware of a very severe cut-off on short proton tracks, hence relative cross sections cannot be deduced from these data.

In Figs. 1 and 2 are plotted the invariant masses of the $\pi^+\pi^-$ and $\pi^-\pi^0$, respectively, showing clearly the ρ^0, f^0, and ρ^-. The width of the ρ^0 in our data is about 120 to 150 MeV, in agreement with that of Lee[1] and considerably less than that of Bondar et al.[2] We have plotted unconstrained quantities to

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obtain this value and believe that slight shifts in beam momentum during the run can cause broadening of the ρ peak when one plots constrained quantities.

The above-mentioned chamber cuts were also done to improve the momentum resolution, because about halfway through the measurement program we detected a rather severe turbulance in the down-stream end of the chamber. The turbulance caused a change in the momentum of high-energy tracks measured in different parts of the chamber, and led to a longitudinal momentum unbalance of 70 MeV/c in elastic scatters prior to constraint, and a corresponding shift in the neutron missing mass for $\pi^+\pi^-n$ events.

The invariant mass plots have other peaks present in addition to these well-known resonances, none of which are statistically significant in our data alone. Some of them are similarly present in other experiments done in this energy region.[1,2,3] We hope to increase our statistics so we can investigate these peaks.

The ρ^0 in our data can be fitted by a p-wave Breit-Wigner distribution as has been done by other experimenters. Similarly, the forward-backward asymmetry in the π-π scattering for low-momentum transfer events can be fitted by an interference between a background s-wave and the p-wave resonance (see Fig. 3).[1,4] However, it is our feeling that the situation is more complicated than it appears. Firstly, if the interaction were due solely to one-pion exchange, the Treiman-Yang angular distribution would not be asymmetric, as recently seen by Selove,[5] and the changes in our forward-backward asymmetry with invariant mass (Fig. 4) would agree better with those calculated by Islam and Pinon.[4] However, our asymmetry drops sharply in the region of the ρ^0, without going through zero just as does that of the Saclay-Orsay-Bari-Bologna collaboration data.[6] Again, either set of data

by itself does not clearly indicate violent disagreement, but taken together they show a serious discrepancy with the theory. We have also analyzed the invariant-mass plots near the ρ^0 with various four-momentum transfer cuts, and find a shift to higher masses with increasing momentum transfer, as do Ross and Shaw[7] using the data of Lee et al.[1] However, although curves fitted to the data imply that the shift is as large, the data themselves do not show a convincing shift, due to the jagged nature of the peak.

Lastly we have cut out of our data those events lying in the band formed by the N^{*+} (1238), and find little or no change in the π-π scattering angular distribution. This result is contrary to the predictions of Eberhard and Pripstein, who suggested that a final-state interaction between the π^+ and n could lead to an asymmetric π-π scattering distribution, causing the π^+ to go predominantly backward.

In conclusion it does not seem as though any of the explanations thus far offered can explain the decay properties of the ρ^0.

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FIGURE LEGENDS

Fig. 1. Invariant mass of the $\pi^+\pi^-$ in GeV. Boxes are 40 MeV wide. The p-wave Breit-Wigner fit is shown by circled points.

Fig. 2. Invariant mass of the $\pi^-\pi^0$ in GeV. Boxes are 40-MeV wide.

Fig. 3. Angular distribution of $\pi\pi$ scattering in the region of the ρ^0.

Fig. 4. Forward-backward asymmetry in π-π scattering as a function of $\pi^+\pi^-$ invariant mass. The dashed line is the theoretical curve from reference 4.

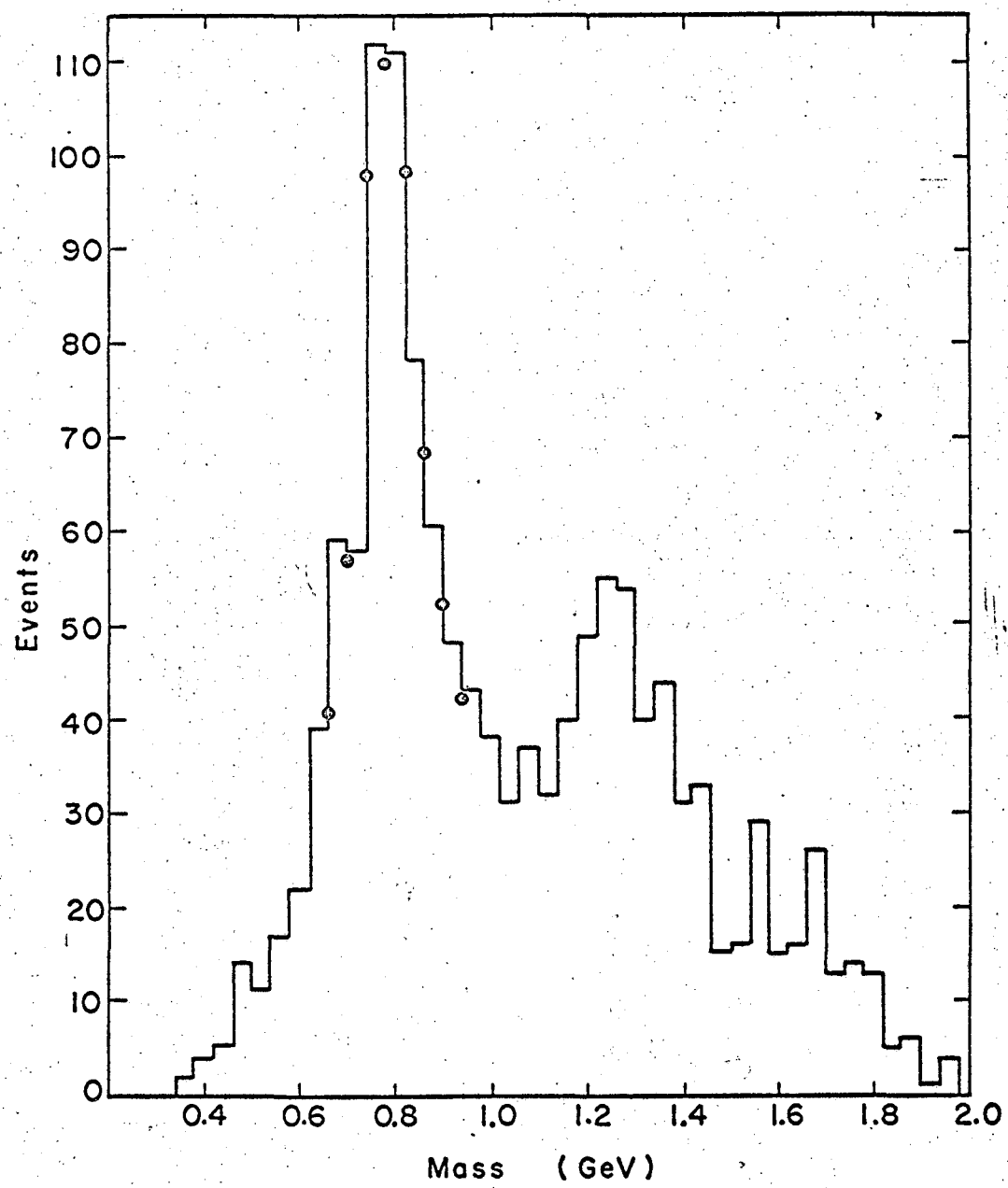

Fig. 1

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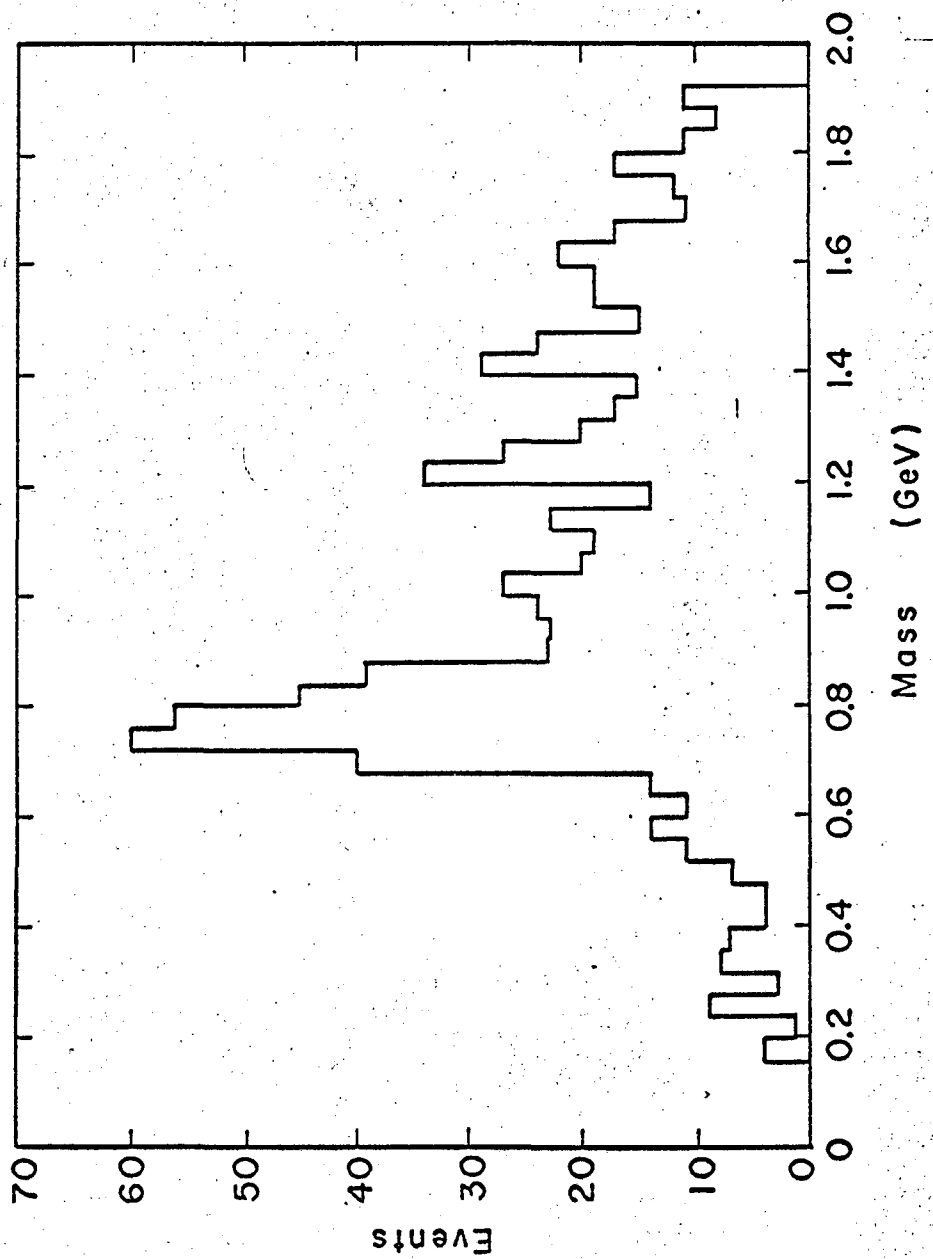

Fig. 2

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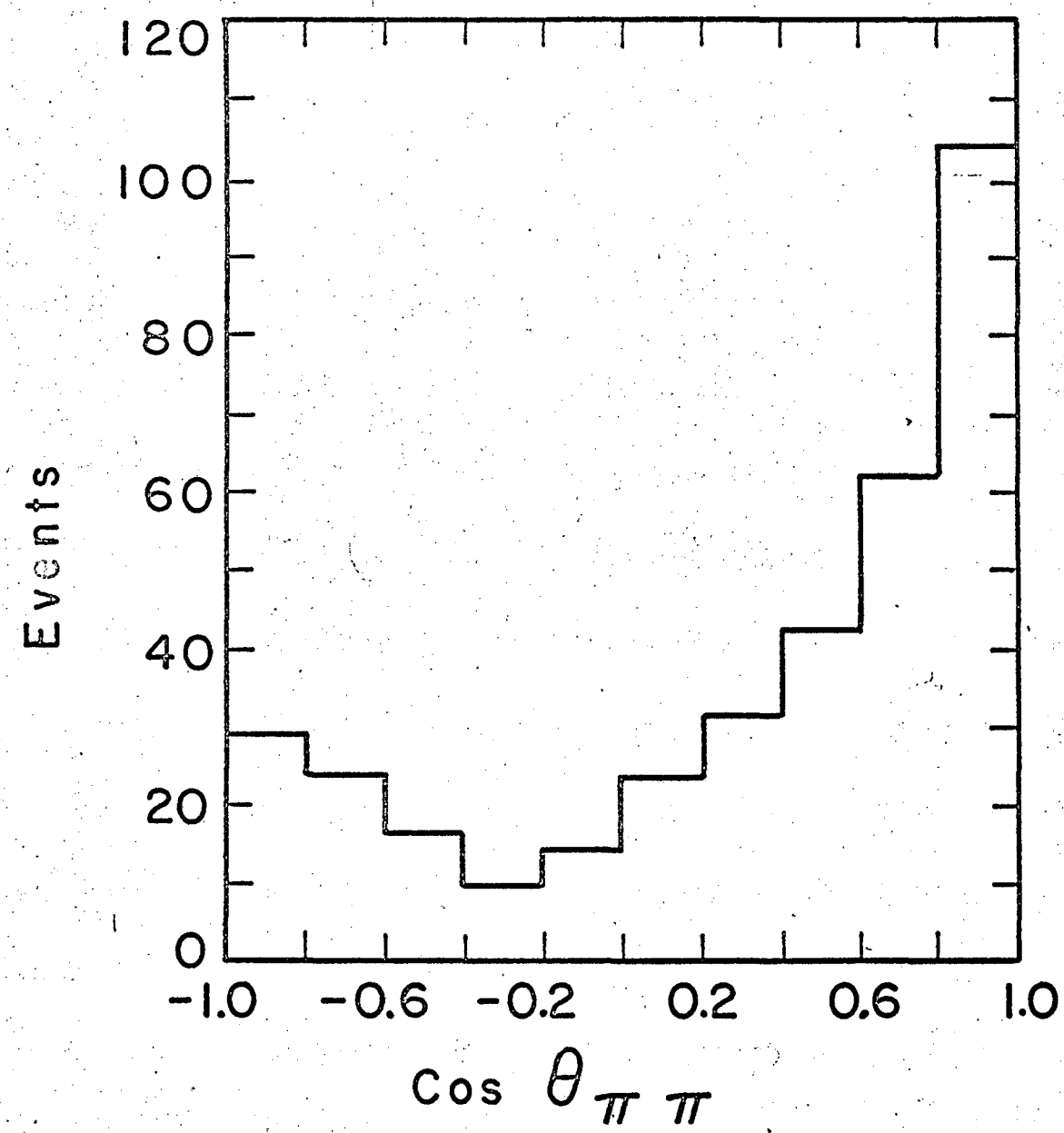

Fig. 3

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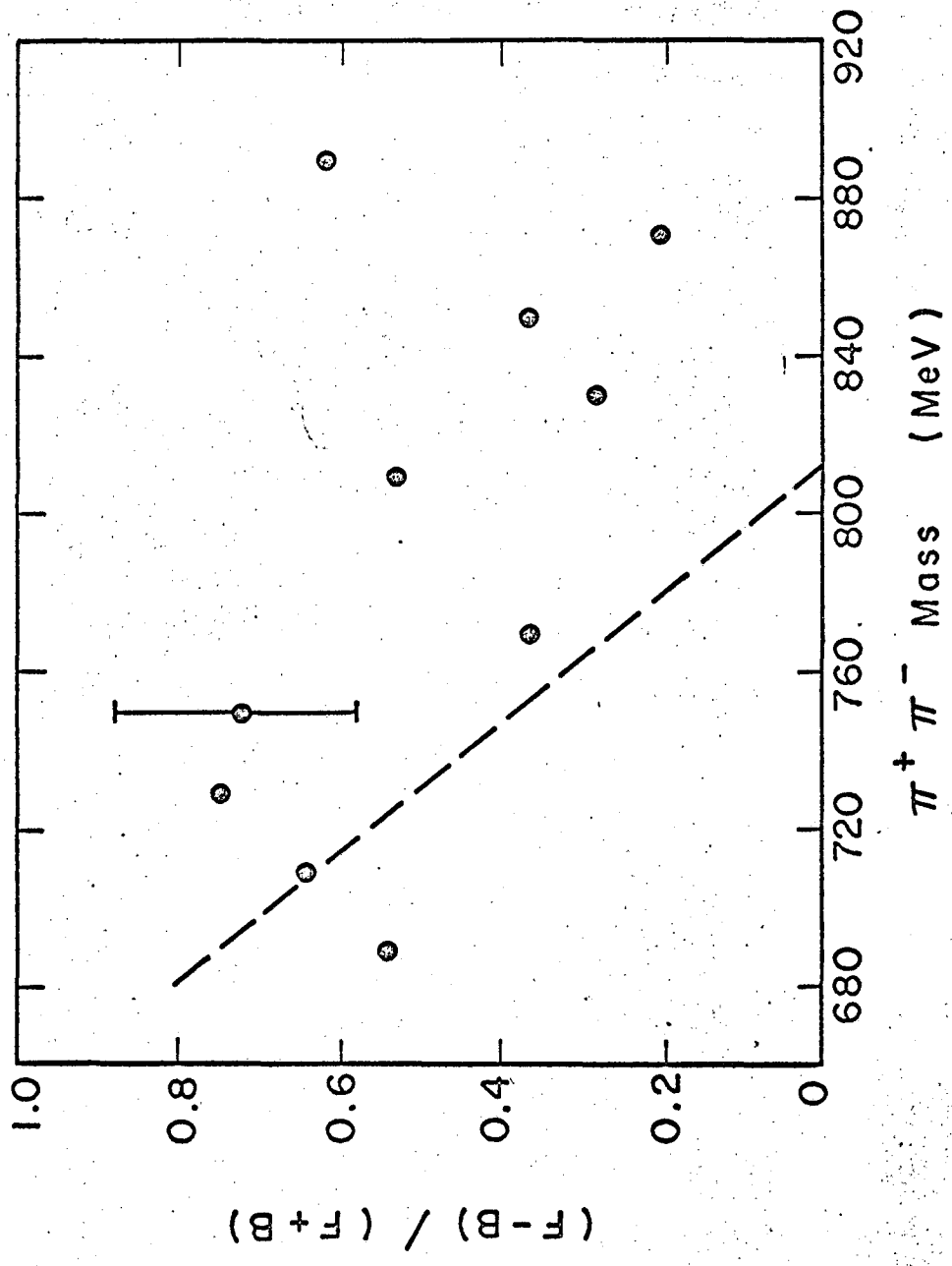

Fig. 4

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