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Title
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Authors
Birge, Robert W.
Ely, Robert P.
Schumann, Thomas
et al.

Publication Date
1964-07-07
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Berkeley, California
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π⁻ p INTERACTIONS AT 3.9 GeV/c

Robert W. Birge, Robert P. Ely, Jr., Thomas Schumann
Zaven G. T. Guiragossian, and Marian N. Whitehead

July 7, 1964
π⁻p INTERACTIONS AT 3.9 GeV/c

Robert W. Birge, Robert P. Ely, Jr., and Thomas Schumann
Lawrence Radiation Laboratory
University of California
Berkeley, California

and

Zaven G. T. Guiragossian and Marian N. Whitehead
Stanford Linear Accelerator Center
Stanford University
Stanford, California

(Presented by Robert W. Birge)
July 7, 1964

This report covers the first phase of a careful study of two- and four-prong reactions from π⁻ + 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 π⁺ + π⁻ + n and π⁻ + π⁰ + 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 π⁺π⁻n events, 855 π⁻π⁰p, and 2,440 π⁻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 π⁺π⁻ and π⁻π⁰, respectively, showing clearly the ρ⁰, f⁰, and ρ⁻. The width of the ρ⁰ in our data is about 120 to 150 MeV, in agreement with that of Lee and considerably less than that of Bondar et al. We have plotted unconstrained quantities to

*Work done under the auspices of the U.S. Atomic Energy Commission.
obtain this value and believe that slight shifts in beam momentum during
the run can cause broadening of the \( \rho \) 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 turbulence in the down-stream end of
the chamber. The turbulence 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 \( \rho^0 \) 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 \( \pi^- \pi^- \) 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 \( \rho^0 \), 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 \( \rho^0 \) 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 \( \pi^- \pi^+ \) scattering angular distribution. This result is contrary to the predictions of Eberhard and Pripstein, who suggested that a final-state interaction between the \( \pi^+ \) and \( n \) could lead to an asymmetric \( \pi^- \pi^+ \) scattering distribution, causing the \( \pi^+ \) 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 \( \rho^0 \).
REFERENCES


5. W. Selove, University of Pennsylvania, private communication.


8. P. Eberhard, Lawrence Radiation Laboratory private communication.
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 $\rho^0$.

Fig. 4. Forward-backward asymmetry in $\pi^-\pi$ scattering as a function of $\pi^+\pi^-$ invariant mass. The dashed line is the theoretical curve from reference 4.
Fig. 1
Fig. 3
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