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[7]The importance of Bose-statistics effects in analysis of the $\pi\rho$ enhancement was exploited first by R. L. Lander, M. Abolins, D. D. Carmony, T. Hendricks, N. Xuong, and P. Yager (to be published). Since they assumed that the 1.0- to 1.4-BeV $\pi\rho$ enhancement is a single peak, their conclusions are markedly different from those presented here.

[8]It must be emphasized that these statements are valid only (a) for pure states, and (b) if the crucial regions of the Dalitz plot are not preferentially populated with background from $\rho^0 N^{*0}$ for nonresonant $\pi^-\rho^0 p$ events. Additional information is available from correlations in production and decay. However, more extensive data are required before these correlations can be studied in adequate detail.

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Λ-p ELASTIC SCATTERING*

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This Letter is a report of the Λ-p elastic cross section in the laboratory momentum range of 150 to 400 MeV/c. At present four measurements of the Λ-p elastic cross section have been reported in the literature.[1-4] Wide momentum ranges and low statistics have made it difficult to discriminate between several theoretical potentials. The data presented in this paper enable us to draw some conclusions regarding these potentials.

The experiment was carried out in the Berkeley-Powell 30-in. heavy liquid bubble chamber filled with a mixture of 76% CF_3Br and 24% C_3H_8 by weight. The Λ's were produced in the interaction K^- + nucleus → Λ + fragments. A total of 45 000 frames was double scanned to give 15 000 Λ's with an average path length of 1.66 cm. A random sample of 250 nonscattered Λ's was measured to provide the momentum distribution, plotted in Fig. 1, and the scanner efficiency. The sample events were then analyzed using the FOG-CLOUDY-FAIR data reduction programs developed by White and his group at Lawrence Radiation Laboratory.

The scanning criteria required that the proton and pion from the decay of the Λ remain in the chamber. From range-momentum curves the scanners could construct a vector diagram to determine the direction of the Λ. They could then decide if any possible recoil protons lay along the flight path of the Λ. The total number of events found by the scanners was reduced by 30%, since this percentage of the measured sample did not meet the required chi-squared criteria.

It was necessary to investigate what biases would be induced from the requirement that both the proton and pion from the decay of the Λ stop in the chamber. This correction was accomplished by the use of a Monte-Carlo program which generated events corresponding to the two configurations observed, i.e., one where the Λ scatters and one where it does not. The program generated Λ's which obeyed distributions obtained from the sample events. These distributions were the coordinates of the K interaction, the azimuthal and dip angles of the Λ, the lifetime of the Λ, and its momemtum. A sample of 1000 events for each configuration (scattered and unscattered) was generated by the program. The end points of the proton and pion were calculated and then checked to determine if they remained in the chamber. The ratio of observed nonscatters to observed scat-

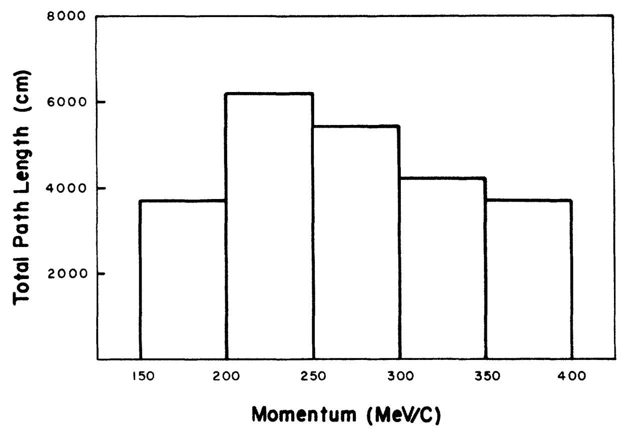

FIG. 1. Momentum plotted vs total path length. This distribution was obtained from the sample events and normalized to the total number of events.

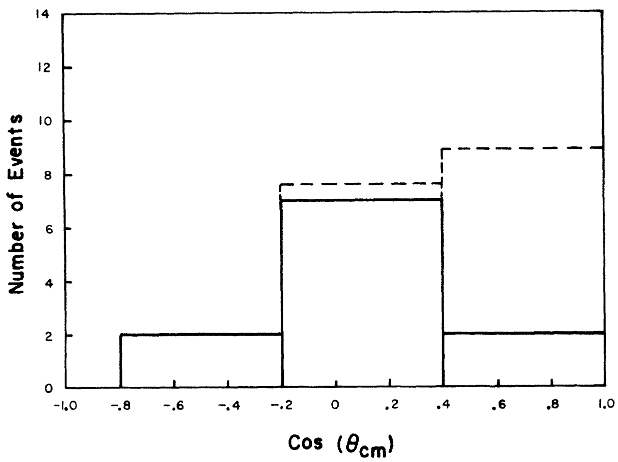

FIG. 2. Number of events plotted vs cosine of the scattering angle in the center of mass. Events enclosed by the solid line were observed, the others are due to the short-recoil correction.

ters was found to be 0.97 ± 0.04. As the statistical error is on the order of 25%, no correction for this 3% effect was made.

The average energy of the Λ before it scatters is about 30 MeV. Its maximum energy is 85 MeV. The binding energy of a proton is about 8 MeV in fluorine and bromine and 15 MeV in carbon. The requirement that all particles stop in the chamber enabled us to measure energy with an accuracy of 3% or better. On this basis, and as the chi-squared for acceptable elastic events was less than 9.3, it was estimated that there is negligible contamination of the recoil events by interactions similar to $\Lambda + {}^{12}C \rightarrow \Lambda + p + {}^{11}B$.

It was also necessary to make a kinematical correction due to our inability to observe recoil protons shorter than 2 mm. This correction was made with the assumption that the cross section in each of the intervals in Fig. 2 is constant over the momentum range 150-400 MeV/c. The amount of this correction can be observed in Fig. 2 where the number of events is plotted vs the cosine of the scattering angle in the center-of-mass system. The area enclosed by the solid line represents the observed events. The rest are due to the correction for short recoils.

In a total path length of 24 600 cm, we observed 11 Λ-p scatters with a maximum chi-squared of 9.3. To calculate the cross section we included the 7.5 events due to the short-recoil correction. The value arrived at for the elastic cross section was 34 ± 10 mb. The error is due to the statistical error from the 11 observed events. The experimental result with appropriate error bars is plotted in Fig. 3.

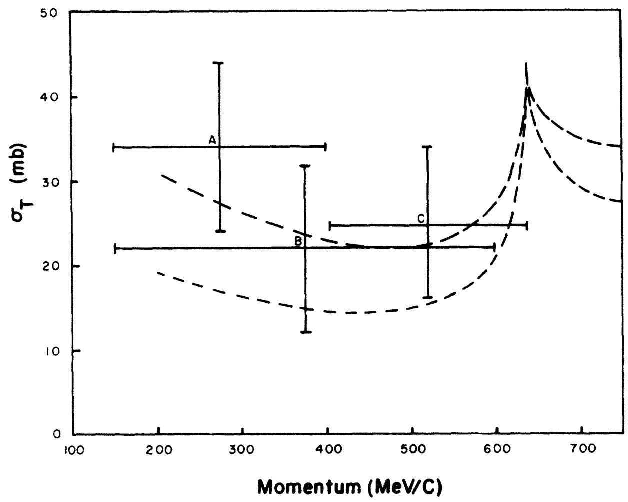

FIG. 3. Comparison of experimental results with theoretical predictions. Upper curve calculated with BGSM potential, lower curve with the Hamada potential by Dullemond and de Swart. Point A is the result of this experiment. Point B and point C are the experimental results of Groves and of Alexander et al., respectively.

On Fig. 3 we have plotted the experimental results of Alexander et al.[2] and those of Groves.[4] These results were based on six and seven events, respectively, in momentum ranges comparable with ours. On Fig. 3 is plotted the theoretical cross section from the Hamada and BGSM potentials calculated by Dullemond and de Swart[5] on the basis of global symmetry. Two other theoretical points at 416 MeV/c have been obtained by Kovacs and Lichtenberg.[6] These points were calculated from a phenomenological potential with a hard core assuming angular momentum ≤ 2. With a spin-orbit term in the potential they obtained 34 mb. Without a spin-orbit term they obtained 26 mb. The experimental results seem to indicate that, within the experimental error, the BGSM potential gives results consistent with the experimental points.

Also of interest is the observed lack of backward scattering in Fig. 1. This would indicate that K exchange does not play an important role in the low energy Λ-p interaction.

We greatly appreciate Dr. Wilson Powell's generous loan of the film. We are indebted to Ward Schultz for his help with the data reduction programs. We thank Henriette de Nardini, John Tremaine, and all our scanners and measurers for their diligent work.

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UNITARITY AND FORM FACTORS IN THE PRODUCTION PROCESS $\pi + N \rightarrow \rho + N$

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The peripheral model has provided a relatively successful interpretation of many high-energy reactions. In this paper we consider one of the most thoroughly examined reactions,

$$\pi + N \rightarrow \rho + N, \tag{1}$$

in order to better understand the peripheral model and to elucidate the nature of the ρ resonance.

There are three important related problems that are raised in connection with the peripheral model for this and similar reactions:

(i) The lowest partial waves exceed the unitarity limit[1] of

$$\sigma_j \leq \pi(j+\tfrac{1}{2})\lambda\!\!\!^{-2}.$$

(ii) Quite aside from this, elastic πN diffraction scattering reveals that ρ production (1) must be suppressed, particularly in the low partial waves because of competing absorption processes[2] (i.e., the initial- and final-state absorption must be taken into account in a manner analogous to distorted-wave Born approximation calculations of low-energy physics).

(iii) The "form factor"

$$F^2(t) = [(m_\pi^{\ 2} - \Lambda^2)/(t - \Lambda^2)]^2 \tag{2}$$

now introduced phenomenologically[3] into the cross section requires a quite unphysically small Λ to fit the data.[4] The form factor at either vertex or associated with the propagator in pion exchange will be governed by the lowest mass intermediate state to which a pion can couple. Up to energies over one BeV, no significant intermediate state of the correct properties is known. Thus qualitatively we expect $\Lambda^2 \gtrsim 50 m_\pi^{\ 2}$, whereas the phenomenological value which has been used is $\approx 6 m_\pi^{\ 2}$.[4] Using the form

$$F^2 = [(m_\pi^{\ 2} - \Lambda^2)/(t - \Lambda^2)]^n \tag{3}$$

with $n = 4$ or 6 instead of (2) yields a higher Λ^2 but does not change the qualitative situation.[5]

We will calculate the effects (ii) of absorption on the peripheral process (1). We find below that these absorption effects are quite sizable at all production angles, although, of course, largest away from the forward direction. This immediately suggests an entirely different attitude toward the peripheral process as observed in the physical region from that suggested by a "form factor." Qualitatively, no ρ remains unscathed, even in the forward direction, as it leaves the nucleon. This means that the width and position of the ρ will vary significantly with momentum transfer[6] and also with total energy. As others have suggested, we strongly emphasize that one should observe that the ρ is broader at large momentum transfer and that it approaches the free ρ for high total energy.[7] The polarization of the ρ may also be modified from the predictions of the peripheral model, increasingly with increasing momentum transfer. (We are talking about the decay angular distribution in $\cos\theta_{\pi\pi}$ and the Treiman-Yang angle.) In order to discover the true properties of the ρ, one needs first to examine experimentally the momentum transfer dependence of these quantities.[6]

The cross section for

$$\pi^- + p \rightarrow \rho^0 + n \tag{4}$$

in the peripheral or one-pion exchange model can