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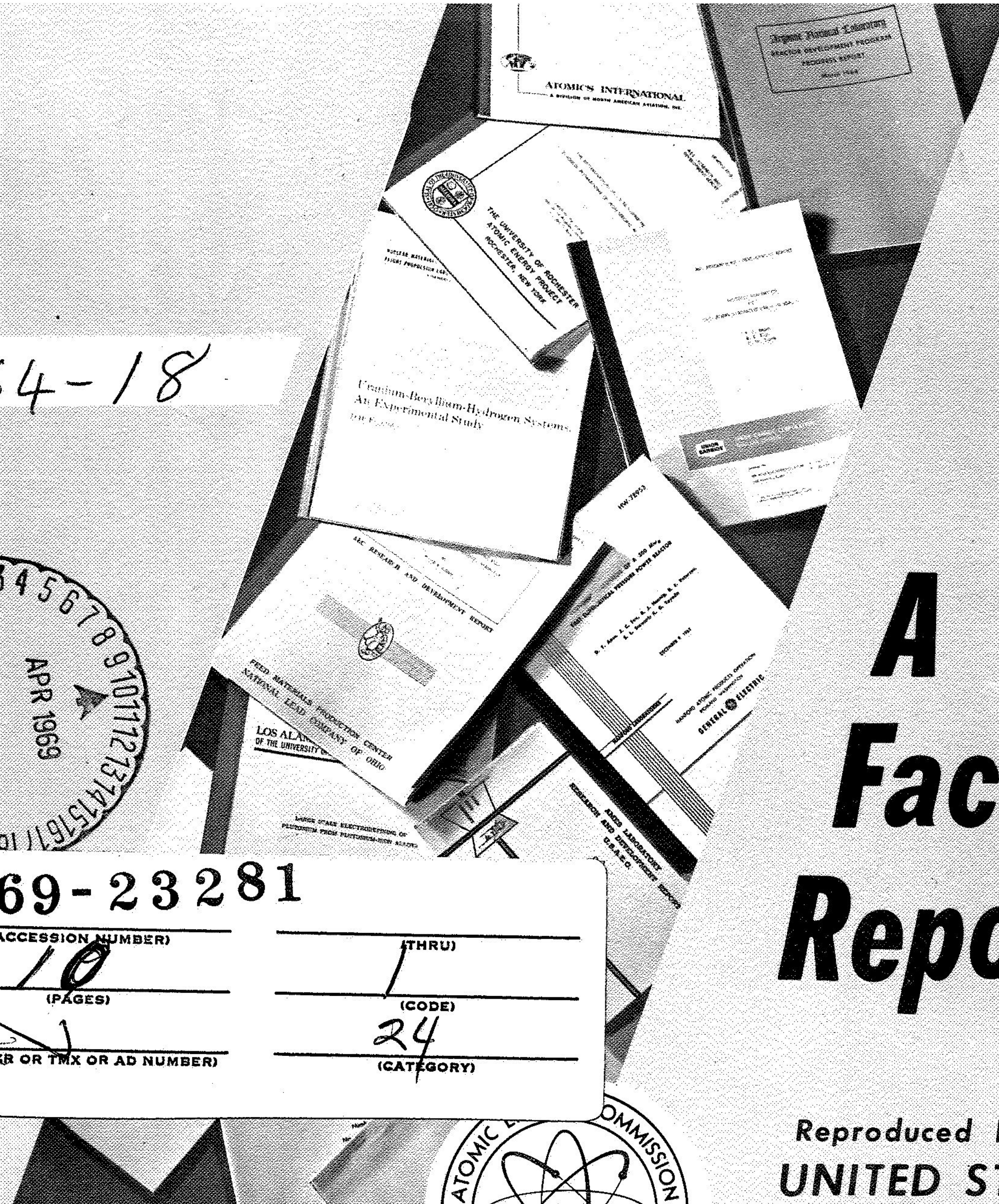

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High Energy Pion-Deuteron Elastic Scattering*

R. C. Chase, E. Coleman, and T. G. Rhoades
University of Minnesota, Minneapolis, Minnesota 55455

and

M. Fellinger, E. Gutman, R. C. Lamb and L. S. Schroeder
Iowa State University and Ames Laboratory
Ames, Iowa 50010

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ABSTRACT

Measurements of π^- D elastic scattering at 3.75 GeV/c are presented, covering the range of four-momentum transfer $0.2 \leq |t| \leq 0.9\ (\mathrm{GeV/c})^2$. The results of the Glauber high energy approximation including double charge exchange and the deuteron D state are compared with the data.

Introduction

We have measured the elastic scattering of 3.75 GeV/c negative pions from deuterium in the four-momentum transfer region $0.2 \leq |t| \leq 0.9$ $(GeV/c)^2$.

The study of π D elastic scattering offers a source of data to test various multiple scattering theories such as the Glauber formalism[1] or Regge pole models[2]. Our measurements were performed in the four-momentum transfer region which is sensitive to both single and double scattering in the deuteron.

Experimental Procedure

The experiment was performed in the 17^{o} beam of the Zero Gradient Synchrotron (ZGS) of the Argonne National Laboratory. The beam transport system determined the momentum of the pions to ± 3/4%, and brought the beam to a final focus on a 2.3 - inch long liquid deuterium target. The target and the experimental apparatus used to detect the elastic events are shown in Figure 1. Counters S1 and S2 defined the incident beam position. Elastic events were detected in a double-arm spectrometer consisting of two bending magnets, M1 and M2, and scintillation counter arrays, A, B and D. Each of the A and B arrays consisted of 16 elements; the D array consisted of 30 elements. Negative particles traversed M1 and were detected by corresponding pairs of the A and B arrays. A single scintillation counter, G, behind the A array determined the azimuthal angular acceptance. The associated deuterons traversed M2 and were detected by the D array. The Z1 and Z2 counters were used to veto particles which did not satisfy the angular restrictions of the elastic deuteron kinematics. The Z3 counter was used as an additional anticoincidence counter to veto beam pions that did not interact in the target. Events satisfying the $S_1 S_2 G \overline{Z}_1 \overline{Z}_2 \overline{Z}_3$ coincidence requirement and which triggered corresponding A and B counters

in coincidence with any of the D counters were stored in a multichannel analyzer. These double-arm events were sorted into 16 different groups corresponding to the 16 AB pairs. For each pair the distribution of events along the D array was obtained. The elastic deuteron events appeared as a peak in each of the 16 distributions, and an inelastic background was observed as well. This background, due to deuteron breakup and other processes, was greatly diminished by requiring the D counter signals to have the timing appropriate to elastically scattered deuterons. The background was determined to be almost exclusively protons. To simulate this background, we inserted a carbon target into the beam and found the residual background to be less than 5% for each of the 16 channels. There was no significant target empty background. The positions of the deuteron peaks agreed with the predictions of a Monte Carlo program. In this manner 16 differential cross sections were measured simultaneously.

The system was further checked by filling the target with liquid hydrogen and measuring the π^- p elastic differential cross section at 3.5 GeV/c. These measurements are in excellent agreement with the results of Coffin et al[3] and are presented in Figure 2.

The data have been corrected for nuclear absorption of the scattered pions and deuterons, beam attenuation in the target, decay of the scattered pion, background events, electron and muon contamination of the beam, and multiple Coulomb scattering. The effect of these corrections is less than 10%.

Results and Interpretation

The preliminary results for elastic differential cross section as a function of four-momentum transfer (t) are shown in 3. At present the absolute normalization of our data is known to within 10%. As has been observed in nucleon-deuteron elastic scattering[4], a shoulder like departure from the diffraction peak is displayed. These data are not in disagreement with the π^+ D bubble chamber results at 3.65 GeV/c[5].

The solid curve shown in figure 3 is the result of a calculation based on the Glauber high energy approximation[6] including double charge exchange[7] with the Hamada-Johnston[8] wave function for the deuteron. In this calculation we included both S and D states of the deuteron.

We have used pion nucleon amplitudes of the form:

$$f_N = (i + \alpha_N) \quad k \sqrt{d\sigma_N(t)/\pi \, (1 + \alpha_N^2)}$$

with N = n, p and k is the laboratory pion momentum, α_N is the ratio of the real to imaginary part of the pion-nucleon scattering amplitudes at t = 0, and $d\sigma_N(t)$ is $\frac{d\sigma}{dt}$ of the free π N cross sections which were fit to $d\sigma_N(t) = C(k) \exp A_N t$. We performed the calculation shown with $\alpha_n(t) = \alpha(0) = -0.304$ and $\alpha_p(t) = \alpha_p(0) = -0.170$. These values of $\alpha(0)$ were taken from Barashenkov.[9]

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FIGURES

1. Plan view of experiment.
2. Comparison of π^- p elastic scattering at 3.50 GeV/c data obtained in this experiment with the data of reference 3.
3. Preliminary results for π^- D elastic scattering at 3.75 GeV/c. The solid curve is the result of a theoretical calculation described in the text. The error bars on the data points are the standard deviations of counting statistics and do not include an overall normalization uncertainty of less than 10%.

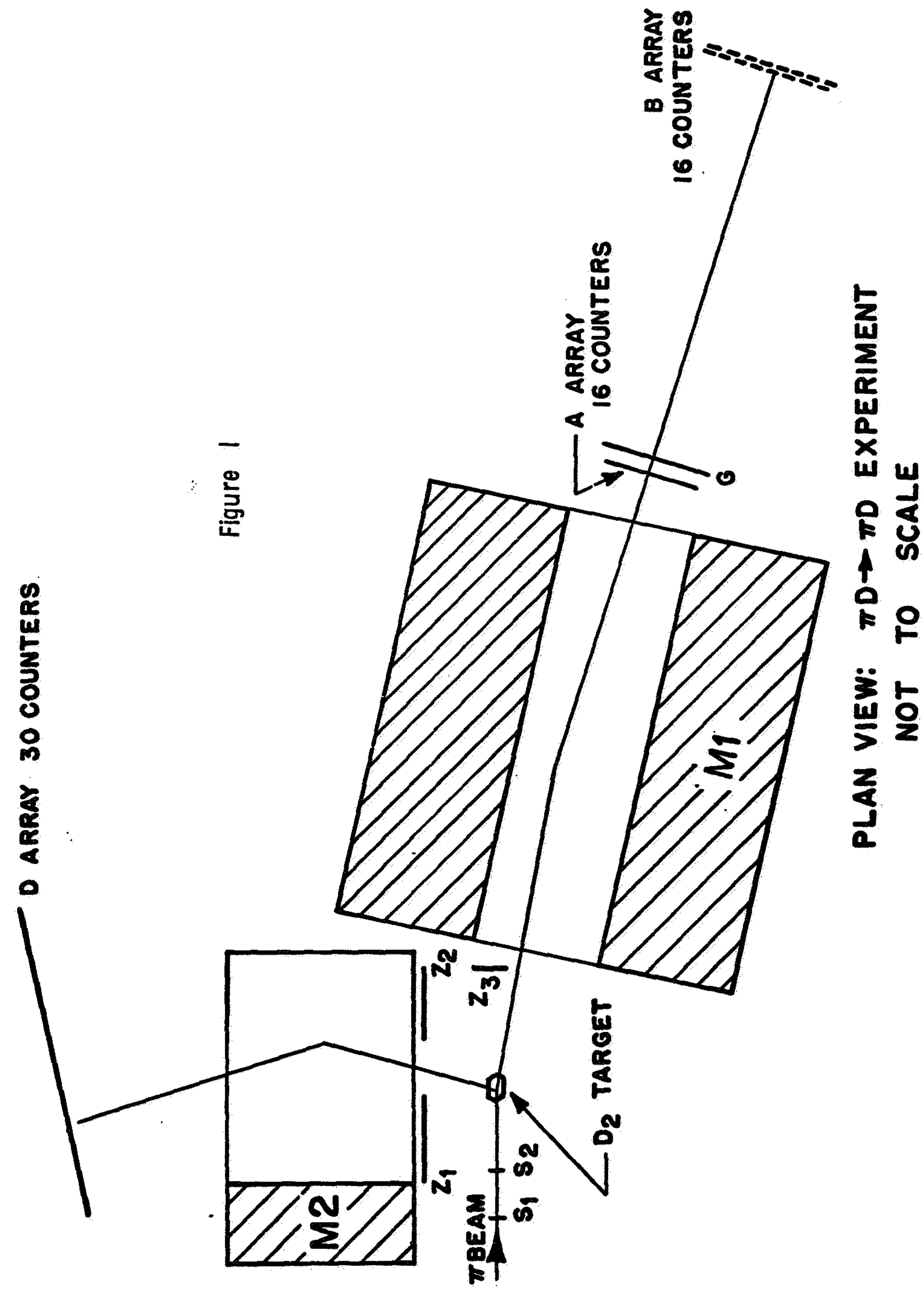

Figure 1

Figure 2

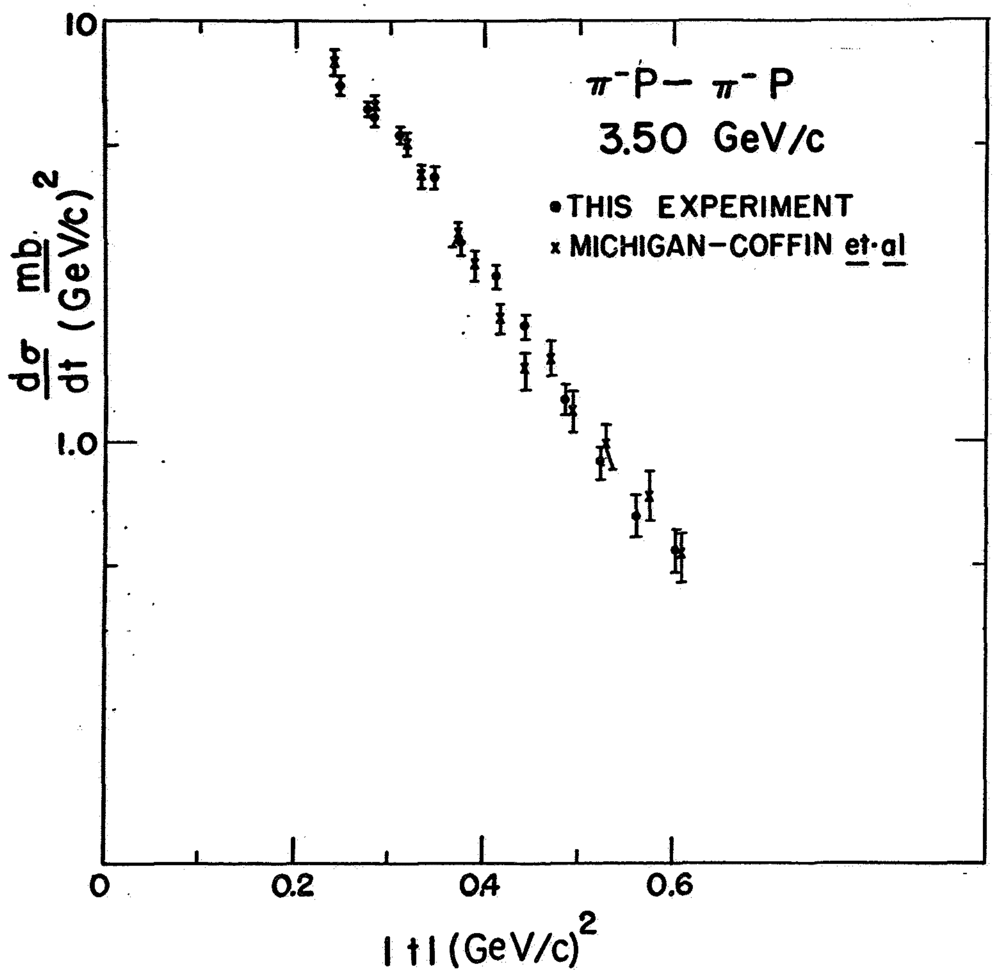

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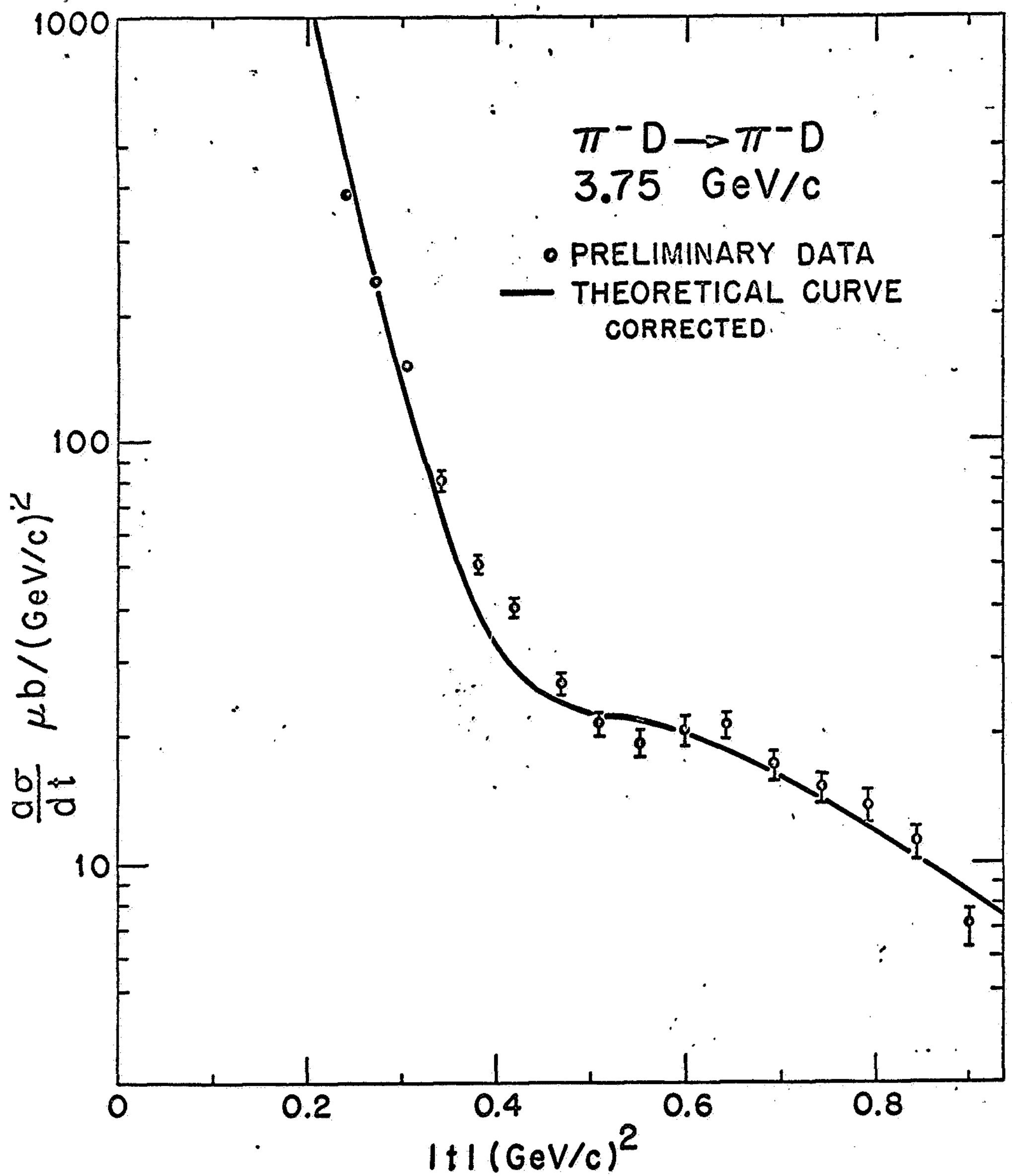
FIGURE 3



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