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Fermilab Proposal

Neutron-Deuteron Elastic Scattering

by

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SUMMARY

We propose to measure the neutron-deuteron differential elastic cross-section in the region $0.25 \leq t \leq 1.5 (\text{GeV}/c)^2$ for $100 \leq P_{\text{lab}} \leq 400 \text{ GeV}/c$. The equipment required is identical to that currently in use by E-248, with deuterium replacing hydrogen in the target. Three hundred hours of beam (in the M-3 beam line) are requested. This experiment would not be undertaken until E-248 is completed.

In recent years there has been considerable interest in the high-energy interaction of hadrons with nuclei, and their relationship to Glauber's interaction theory [1,2,3]. In these discussions, interactions with deuterium are of special interest because the wave function of the target nucleus is essentially known and the multiple scattering (within the nucleus) can be explicitly calculated term-by-term. Also, because the recoil nucleus can be detected, there is no difficulty in separating elastic scattering off deuterium from quasi-elastic, a major problem in experiments with larger nuclei. Thus deuterium is unique in allowing a straightforward comparison between Glauber theory (including whatever improvements may be desirable) and experiment throughout the range of momentum transfer accessible experimentally.

For lab momenta above approximately 50 GeV/c, Glauber's original formulation has been found to be in disagreement with the data [2,3,4] in several ways, and the requisite modifications in the theory are of significant interest. We feel that a good measurement of n-d elastic scattering can help further our knowledge of these distinctly high-energy effects.

Another interest of n-d elastic scattering is the possibility of combining these data with that from p-d scattering in order to make a test of charge symmetry at high energies and moderate momentum transfers. Most tests of this important symmetry have been performed in the sub-GeV

energy range at low momentum transfer. The major exception to this is our own group's n-d measurement at the Argonne ZGS [5]. With the very real possibility that new and startling effects (e.g. charm, heavy leptons, and the whole gamut of contemporary speculation) appear in this energy range, we feel that a new test of this symmetry is justified at these higher energies.

At present there are no data on p-d elastic scattering at Fermilab energies for comparable four-momentum transfers. Thus the test of isospin invariance (charge symmetry) would await a p-d measurement. It is interesting to note that our n-d data from the ZGS experiment are significantly better than the existing p-d data in that energy range. (See Figure 1.)

The existing apparatus of E-248 in the M-3 beam line is ideally suited for this experiment — essentially no modification from its present form is required. The only things requested from Fermilab are:

- 1) A deuterium filling of the hydrogen target
- 2) Sufficient running time (in the M-3 beam) for good statistics.

Experimental personnel will be supplied by the University of Michigan.

From cross sections at 12.4 GeV/c [5], and our experience in this beam during E-248, we estimate that 300 hours of beam will yield approximately 60,000 elastic events in the region $0.25 \leq t \leq 1.5$ (GeV/c)², $100 \leq P_{lab} \leq 400$ GeV/c, and would provide reasonable statistics to investigate the physics. One week of parasitic beam before the run would be useful, but not absolutely necessary for testing.

References

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- [3] K. Gottfried, Acta Phys. Pol. B 3, 769(1972).
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Figure Caption

Fig. 1. Neutron-Deuteron elastic scattering, an experiment at the Argonne ZGS (•) exhibiting proton-deuteron scattering (+,x) and Glauber theory calculations, for various incident neutron momenta.

