NAL PROPOSAL No. 293

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30-Inch Bubble Chamber Proposal
π^-d Interactions at 200 or 300 GeV/c
(50K Photographs)

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INTRODUCTION

πd interactions have been extensively studied at lower energies. For example FSU, in collaboration with Oak Ridge and University of Tennessee, is currently engaged in analyzing the results of an experiment involving 850K pictures of $\pi^+ d$ at 15 GeV/c from the SLAC 82-inch bubble chamber. An isospin-zero target is very useful for the study of production and exchange processes where Pomeron exchange dominates. At NAL energies, interactions with neutrons and deuterons is still virgin territory. Results from a neutron target should complement proton target data.

Our experimental study will include the following topics:

1) $\pi^- d$ and $\pi^- n$ total cross sections.

2) Cross sections of various final state charge multiplicities.

3) Coherent production: $\pi d \to 3\pi d$; $\pi d \to 5\pi d$.

4) Some exclusive $\pi^- n$ reactions, e.g., $\pi^- n \to p\pi^-\pi^-$.

5) Various inclusive particle distributions, e.g., $\pi^- n \to p$+anything.

6) Strange particle production, where a V is visible, from $\pi^- n$ reactions.

ABSTRACT

We request 50,000 photographs in the 30-inch bubble chamber filled with deuterium. This request is a bare bubble chamber experiment, although the tagging system for the beam will be used if operational during the exposure. The beam is about 10 π^- per photograph at 200 or 300 GeV/c.

We propose to double scan these photographs and determine partial and total cross sections for various π^-d and π^-n interactions. We also propose to measure those events which will yield information on inclusive reactions, such as π^-n → p+anything. We also propose to measure those exclusive events that could be analysed. Examples of this latter category are 4- and 6-prong 4-constraint events.

π^-d and π^-n total cross sections

This part is essentially a scanning experiment. Since no tracks need to be measured, a large fiducial volume can be used. We estimate that a final cross section value for π^-d interactions can be determined to better than 0.5%. At Serpukov (Denisov et al., PL 36B 415, 1971) π^-d cross sections have been measured up to 60 GeV/c. By subtracting the π^-p cross section and using the Glauber correction for screening, they have obtained the π^-n cross section. They find that the π^-n cross section is 4% lower than π^+p cross section at Serpukov energies. It will be very interesting to compare the π^-n total cross sections to π^+p cross sections at NAL energies. If the energy dependence of the total π^-n cross section is different from π^+p cross section, this in itself will be very important. Also a SLAC experiment (Bodek et al., PRL 30, 1087, 1973) studying ep and en deep inelastic cross sections have found unexplainable differences between p and n targets. All this points to the importance of extracting the π^-n cross section.

We will use two methods to determine $\sigma(\pi^-n)$. The first is $\sigma(\pi^-n) = \sigma(\pi^-d) - \sigma(\pi^-p) + \delta$ where δ is the screening correction which might be subject to some uncertainty. The second method is to count directly the events which have a visible or non-visible spectator. This so-called spectator can be either a proton (which, if above ~75 MeV/c, will be visible) or a deuteron. The deuteron events are a small

correction and we hope we can estimate the number of d "spectators" by studying the t distributions of these visible "spectators". We are confident that we can complete this part of the experiment in two months after obtaining the photographs.

Cross sections of various final state charge multiplicities

Another result of the scanning will be the partial cross sections for $\pi^- d$ and $\pi^- n$ into various charge states (i.e., prongs). Similar studies have already been performed for pp and πp interactions which showed some important differences. (See Erwin, et al., PRL 32, 254, 1974). Comparison of the πn topological cross sections and average multiplicities with πp and pp will be of great interest. For example, the determinations of $\langle n \rangle$, $\langle n \rangle / d$, f_2 (Bogart, et al., PRL 31, 1271, 1973). These studies could reveal possible differences in the behaviour of protons and neutrons as targets.

Coherent Production

Previous experiments in the bare 30-inch bubble chamber have already shown that 4-constraint 4-prong events can be analyzed at 200 to 300 GeV (Derrick, et al., PRL 32, 80, 1974). We plan to measure the 4- and 6-prong events in a more restricted fiducial volume (~25cm) and study the 4-constraint events. We hope to be able to isolate the

events where the deuteron does not break up. The cross section of $\pi d \to 3\pi d$ is dominated by Pomeron exchange and as such should be energy independent. The surprising results from low energies (8 to 15 GeV/c) is that this $\pi d \to 3\pi d$ cross section increases from 300μb to 450μb. It will be extremely important to know whether this cross section still grows with energy. A 450μb cross section should yield about 150 events with a visible deuteron. The study of these events should be sufficient to observe major variations in cross sections.

The t distribution below 20 GeV/c for $3\pi d$ events is proportional to e^{30t}. Any appreciable deviation from this steep slope will suggest that the deuteron behaves differently at high energies compared to lower energies.

The other coherent reaction $\pi d \to 5\pi d$ will also be studied if sufficient events can be identified.

Some exclusive $\pi^- n$ reactions

From 4- and 6-prong measurements we expect to identify some exclusive final states, such as $\pi^- d \to \pi^- \pi^- pp$. Most of these types of events are expected to come from diffractive dissociation of the target neutron. Our 15 GeV/c data has a 3mb cross section for the reaction $\pi d \to \pi\pi pp$. The cross section at 200 GeV/c will probably be smaller. The actual number of such events is very hard to estimate but our guess is that several hundred events of this reaction might be identified. The study of these

exclusive events should yield useful information on target fragmentation.

Various inclusive particle distributions

We propose to measure the momenta of some of the outgoing tracks to study inclusive distributions in rapidity, x and p_T^2. It is expected that the various inclusive distributions for $\pi^- n$ reactions are similar to $\pi^+ p$ distributions, but an actual measurement would still be very useful.

Inclusive study of $\pi^- n \rightarrow p$+anything where the p can be positively identified, i.e., momentum less than 1.2 GeV/c should yield information on target fragmentation. Other inclusive studies to be performed are $\pi^- n \rightarrow \pi^+$+(anything) and $\pi^- n \rightarrow \pi^-$+(anything). The study of this section will be similar to those already performed with the proton target.

Strange particle production

From the hydrogen photographs inclusive studies of K_s^0 and Λ^0 productions have been made at NAL energies (Dao et al., PRL, 30, 1151, 1973). We propose a similar study from the visible V^0 events in this experiment. In deuterium it is almost impossible to study Σ events since frequently particles scattering from neutrons are hard to distinguish from Σ decays. We expect to measure about 1000 V^0 events which can be associated with a primary vertex having the neutron as the target. From these events we will determine

partial cross sections and study the inclusive reactions $\pi^- n \rightarrow \Lambda^0 + (\text{anything})$ and $\pi^- n \rightarrow K^0 + (\text{anything})$.

Data processing plans

It is fully intended that when the film from this experiment has been received, its processing in each of our laboratories will receive top priority in order that we be able to complete the study in less than six months. This will include double scanning and measurements.

Measuring and scanning equipment

At FSU we have two film-plane digitizers with a least count of 1μ and three image plane digitizers (IPD) with a least count of 2μ at highest magnification. (The IPD's will increase to four by Fall 1974). The IPD's are on-line to a UNIVAC Series 60 computer.

At ORNL we have three film plane digitizers with a least count of 1μ and a spiral reader automatic measuring device.

Staff

This experiment is to be performed as a collaboration between the Florida State University (FSU), the Oak Ridge National Laboratory (ORNL), and the University of Tennessee (UT). In addition to the eleven Ph.D.-level physicists listed on the cover page of this proposal, there

are five experimental graduate students at FSU of whom two or three will probably devote a considerable amount of time to this experiment. In addition, we wish to add that at FSU there are three theoretical physicists who are greatly interested in helping with the interpretation and analysis of the data.

At FSU there are five full-time equivalent (FTE) scanner-measurers, one full time electronics engineer, and 1.2 FTE electronics technicians. The ORNL-UT group also has approximately 5 FTE scanner-measurers and a staff of engineers and programmers.

Computers

Most of the computer processing will probably be done at FSU. FSU has a CDC 6500 with a 132K word memory and, although we already have working processing systems for our other experiments, we have been offered consulting assistance and programs by members of the Bingham-Fretter group at Berkeley since they have made special improvements in TVGP, SQUAW and WEASEL for use with the NAL 30" chamber at high energies.