NAL PROPOSAL NO. 161

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PROPOSAL TO SURVEY HIGH ENERGY PROTON COLLISIONS IN NEON AND TO SEARCH FOR ANOMALOUS PHOTON BUNDLES AT NAL

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ABSTRACT

Using the 30" bubble chamber filled with a neon-H_2 mixture we wish to (1) Search for anomalous interactions of high energy protons producing multiple photon events, (2) Obtain information on the π^o production by high energy protons (3) Search for nuclear collisions between protons and Ne that involve large target masses. We request 50,000 pictures of the Ne bubble chamber at the highest available proton momentum with (2 - 5) protons per pulse.

1. Introduction

Several interesting events involving multiple photons have been recorded in cosmic ray studies during the past 20 years.[1,2,3] The characteristics of these events are listed in Table 1. In general, they are characterized by multiple photons at small angles and without accompanying charged particles.[1,2] In some cases the electromagnetic properties of the photon bundle appear anomalous.[3] Since these events were in fact observed in cosmic rays with the attendent low flux of particles it is possible that such events might be produced more copiously at NAL in the 30" bubble chamber using high energy protons. In order to detect the photons a short radiation length liquid would be needed and we propose a filling of nearly pure neon. We list below the main physics goals of the experiment and the experimental procedure.

2. Search for Anomalous Interactions with Photon Bundles

In the neon filled 30" bubble chamber, using interactions that occur near the front of the chamber there will be approximately 2 radiation lengths available for converting photons. If a photon bundle were formed in the initial collision having 20 photons it is expected that greater than 5 of the photons would convert in the chamber. If these photons were collimated as the Schein or Perkins-Fowler events then the event would be very spectacular since the e^+-e^- pairs would be spaced almost uniformily across the bubble chamber, all within one or two radiation lengths. The primary collision producing such a bundle would then be carefully studied. The combined analytic power of the 30" bubble filled with neon (even though it is

a very small chamber) should allow a definitive search for such phenomena if they can be produced in the NAL energy range.

While there will certainly be events produced with multiple π^o's it is very unlikely that the resulting photons will be as highly collimated as the cosmic ray events observed by Schein et al. We can anticipate that there would be other signatures for such events which are easier observed in the bubble chamber than the earlier emulsion experiments.

3. Test of Multiple Production Models

The piece of information most conspiciously missing in multiparticle studies so far has been data on neutral particle production. Without this one can only guess at the average multiplicity, the quantity predicted by most theories. Any information at all on the neutral spectra, however meager, seems to be a powerful constraint on current theories. This can be seen in Fig. 1 which shows how well the multiperipheral model can fit the observed charged multiplicities in 25 GeV/c $\pi^- p$ data.[4] However, the same model is almost orthogonal to the crude data on π^o production in Fig. 2.[4] A great improvement results if one assumes all π's are produced in resonant pairs (Fig. 2). The data in Fig. 2 can be obtained much more accurately and easily in a neon-filled bubble chamber.

In addition to the average number of π^o's for a given charge multiplicity, one can calculate the distribution about the average because of the high pair conversion efficiency of neon (eg. 8 prongs may have $[n_{\pi^o}] = 3$, with 25% $2\pi^o$, 50% $3\pi^o$, 25% $4\pi^o$ events.). This

information is completely unknown now. It would be another strong constraint on models. In addition it would allow one to calculate the true multiplicity at high energy for the first time.

A most interesting number to obtain would be the relative amount of η° and π° production. In most theories the η° is ignored although it belongs to the same SU(3) multiplet as the π°. No doubt this is unjustified. To obtain this ratio some measuring will be necessary. By using opening angles and shower length to get 15-20% energy determination (a technique used in the Russian Xenon chamber) it may be possible to get some crude information on the η°/π° ratio.

4. Search for Nuclear Collisions With Large Target Masses

In a previous proposal it was suggested that a search be made for collisions with incident protons and clusters of particles in the nucleus.[5] This search is entirely exploratory since there are no detailed theoretical expectations in present nuclear models although there is the hint of such phenomena from cosmic ray data.[5] We propose to carry out a preliminary feasibility study for this search using collisions with Ne nuclei in the present experiment. The details of the experiment would follow that in proposal 128. Briefly we propose to study events with net electric charge in the forward fast jet of particles that are greater than 2 as a signature of a interactions with several nucleons. We would then carefully study events with "apparent" high invariant mass in the high energy forward particles. The invariant mass of the charged particles will be measured. This represents the minimum mass of the high energy jet of particles (we neglect π°'s in this part of the

experiment). The distribution of this "visible" invariant mass would be studied. Hopefully structure might be observed at various discrete masses indicating collisions with clusters with a fixed number of nucleons.

5. Experimental Procedures

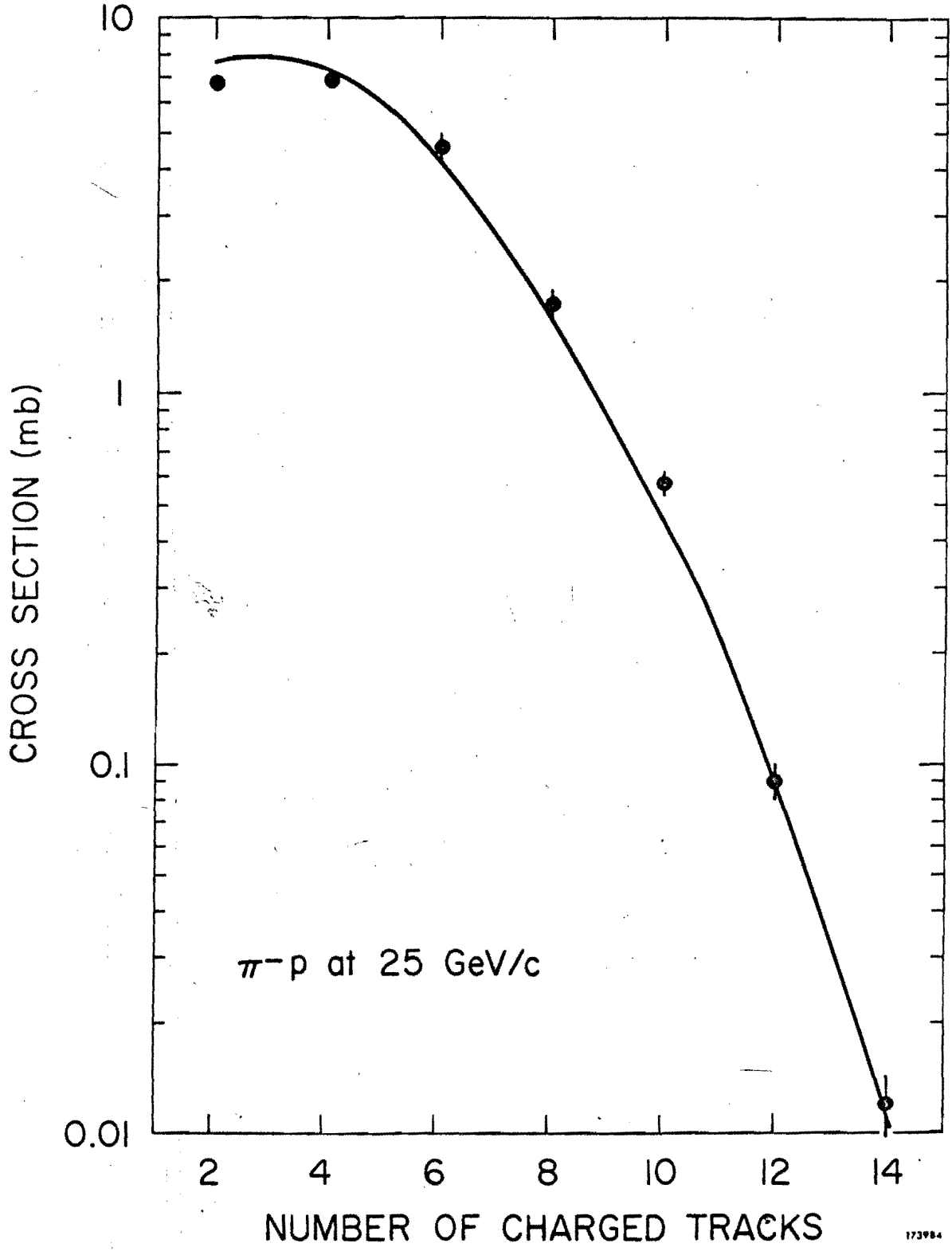
We have had considerable experience with the 30" bubble chamber and with heavy liquid bubble chambers. Our scanners are well trained to the subtleties of such film and we have working computer programs to analyze such film. We anticipate that the search for anomalous photon production can be carried out within three months after completion of the run.

TABLE 1

Characteristic of Events	Reference
Narrow Photon Shower - 16 pairs are produced within a pair conversion length - no accompanying charged particles - the angles between pairs are very small compared to the energies of the photons.	Schein et al. (Ref. 1).
Very similar to the Schein events.	Debenedetti et al. (Ref. 2).
Two anomalous events with photon bundles were observed - the events appeared to have ∿20 photons - several cores were observed in the shower. The development of the electromagnetic showers in these cores were anomalous with the shower apparently rejuvenating after about 8 radiation lengths - the maximum of the cascade shower development occurs at ∿18 radiation lengths - the late development of the shower is very colinear with the early development.	Perkins and Fowler (Ref. 3)

REFERENCES

1. M. Schein, et al., Phys. Rev. 95, 855 (1954).
2. A. Debenedetti, et al., Nuovo Cimento 12, 954 (1954).
3. P. H. Fowler and D. Perkins, International Conference on Theoretical Aspects of Very High Energy Phenomena, CERN 61-22, p. 125.
4. L. Caneschi and A. Schwimmer, Phys. Letters 33B, 577 (1970).
5. A. Benvenuti, D. Cline and D. D. Reeder, NAL Proposal #128.


10
1
0.1
0.01
CROSS SECTION (mb)
π⁻p at 25 GeV/c
2
4
6
8
10
12
14
NUMBER OF CHARGED TRACKS

173984 FIG 1

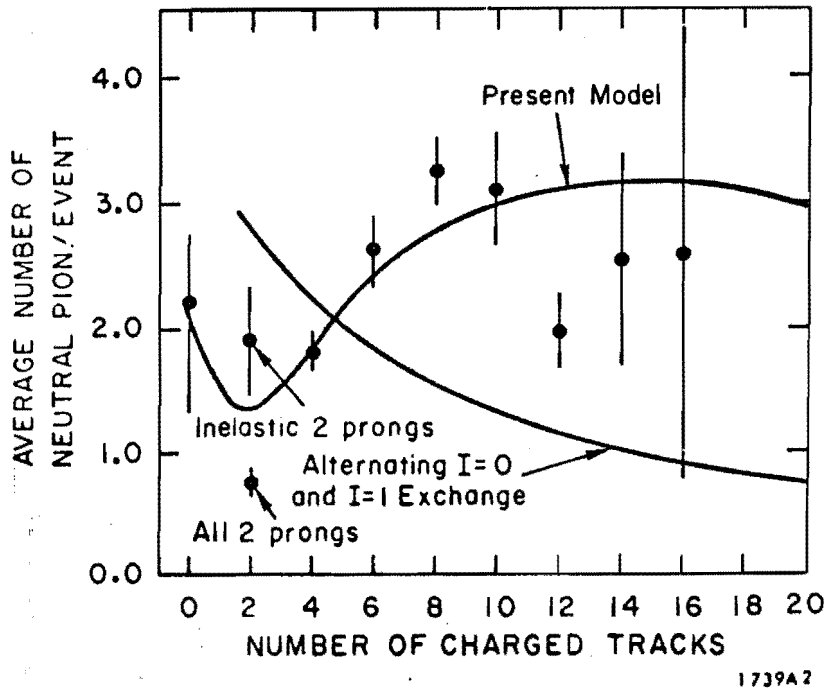

AVERAGE NUMBER OF NEUTRAL PION/EVENT
4.0
3.0
2.0
1.0
0.0
Present Model
Inelastic 2 prongs
Alternating I=0 and I=1 Exchange
All 2 prongs
0 2 4 6 8 10 12 14 16 18 20
NUMBER OF CHARGED TRACKS
1739A2

Fig 2