FNAL Experimental Proposal 409

Spokesman: Terence L. Watts
Physics Department
Rutgers University
New Brunswick, N. J. 08903
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$\pi^+ p$ Collisions at 75 GeV/c in the 30in Hybrid Chambers.

Rutgers/Stevens - Tennessee/ORNL - Johns Hopkins

Abstract

We propose to take a more detailed look at $\pi^+ p$ collisions at an energy intermediate between AGS energies and current high energies at FNAL. We would initially concentrate on the quasi-elastic diffraction processes to understand their energy dependence by comparison to the data at 150 GeV/c (FNAL experiments E154 and E299). The exposure is for the pure beam equivalent of 100k pictures.

$\pi^+ p$ Collisions at 75 GeV/c in the 30in Hybrid Chambers

M. D. Jones, P. Jacques, R. J. Plano, T. L. Watts -
E. B. Brucker, E. L. Koller, S. Taylor, P. Stamer

Rutgers University - Stevens Institute

W. M. Bugg, G. T. Condo, E. L. Hart, T. Handler —
H. O. Cohn, R. O. McCulloch
University of Tennessee - Oak Ridge National Lab.

L. Bachman, C.-Y. Chien, P. Lucas, A. Pevsner

Johns Hopkins University

I Physics

Leading particle effects have long been reported in cosmic ray literature and have been observed in pp collisions at ISR and NAL. Recently[1], we[2] have demonstrated the ability of the hybrid 30 in. bubble (BC) and proportional wire chambers (PWC) to isolate fast leading particles, and have measured the overall leading cross-sections for $\pi^- p$ collisions at 150 GeV/c.

These leading particle effects are associated with the diffraction contribution to multi-particle collisions and we wish to exploit the 4π geometry of the bubble chamber and good momentum resolution of the chambers to investigate the details of the diffraction mechanism. In particular, we propose to study $\pi^+ p$ leading particle collisions and investigate whether their energy dependence is constant as expected for diffraction processes. In addition, comparison among several types of collision will be necessary to understand some features of diffraction, e.g. factorization of amplitudes and dependence on quark content. We will make comparisons to the published pp and $\pi^- p$ data. We expect that by the time our study is completed further comparisons to detailed data from $\pi^+ p$ collisions at 150 GeV/c (E-299) will be possible.

We expect to examine the following features of leading particle interactions especially concentrating on their energy and beam particle dependences:

(a) leading particle cross-sections

(b) associated multiplicity

(c) Comparative π^+, π^- and p inclusive distributions. Correlation among particles, i.e. invariant masses, azimuthal angles, longitudinal and transverse momentum distributions. We expect to look for resonances and sub-clustering effects.

(d) Exclusive final states determined by 4C fits

(e) π^o production using conversions in the bubble chamber or in a lead glass hodoscope which we plan to help make available.

(f) strange particle production

Past experiments in the AGS energy range have studied diffractive multibody processes in exclusive channels such as $p \to p\pi\pi$, $\pi \to 3\pi$, $\gamma \to \rho$ etc. At high energy, we have available an inclusive outline of diffractive processes, namely interactions producing a leading particle, either projectile or target-like. In these reactions the system recoiling against the leading particle forms a well defined cluster whose properties it would be of interest to compare to those of the clusters expected to occur in multi-peripheral collisions. This experiment will be able to do this for π^+p collisions and, will be compared to experiments with other beams and at other energies.

Experiment E154 (π^-p collisions at 150 GeV/c) has established the leading particle cross-sections.[1] Some preliminary results[3] have established that K, Λ, and $\bar{\Lambda}$ production in leading particle collisions are in the approximate ratios 1/2, 1, 1 compared to all collisions. Continuing work should establish ratios for π^o production, and should establish other properties of the diffraction dissociation of the target.[3] We wish to extend these studies to an energy intermediate between the AGS and NAL ranges, and to another beam particle.

II Feasibility

(a) Resolution

Fig. 1 shows inclusive distributions in the Feynman-x variable for π^-p collisions at 150 GeV/c resulting in low multiplicity events. Leading particle peaks for π^- and p near x = +1 and -1 respectively can be seen, most prominently in the 2 and 4 prongs. The resolution on leading π^- is sufficient to separate events with a leading π^- by making a cut in the Feynman x variable giving a good signal to background ratio. The resolution for leading protons is better and separation easier.

These results are for 150 GeV/c π^-p collisions. The resolution on momentum measurement of fast tracks is proportional to momentum so should be better by a factor of 2 for the 75 GeV/c collisions proposed here; the extraction of leading particle events should be cleaner.

The acceptance of the proportional planes in the overall c.m. frame of reference will be less at 75 GeV/c compared to that at 150 GeV/c. This will reduce the number of tracks which have an improved momentum measurement but not enough to affect the measurement of leading π^+.

(b) Event Yield

Pictures should be taken with an average of 5 entering beam particles per picture. At an assumed π^+/p ratio of 1:1 (Fermilab report FN259) to obtain 100K of pure beam equivalent pictures

would require 200K of pictures. This would give approximately 1200 events each of leading π^+ and p among π^+p collisions, roughly 15-20% of all π^+p collisions. These could be located in the film using scan lists generated from $\hat{C}$ tag information on the nature of the beam particle and from the existence of a fast forward track in the downstream PWC.

(d) Manpower Considerations etc:

The main burden of the experiment lies in scanner time. All events in the film could be processed by 8 scanners in 1 year; with selection obtained from PWC upstream and downstream information, this could be reduced by roughly a factor of 5. This scan load is easily within the power of this collaboration.

References

1. D. Fong et al., Physics Letters B53 290 (1974)
2. E154 Consortium consisted of Brown University, Illinois Institute of Technology, University of Illinois, Indiana University, Johns Hopkins University, Massachusetts Institute of Technology, Rutgers University/Stevens Institute of Technology, University of Tennessee/ORNL, Yale University/FNAL.
3. Bull. Am. Phys. Soc. 20, 546 (Washington Meeting 1975) papers AF7 through AF15.

Figure 1:

π^- meson and proton x distribution. a) - c) give the π^- meson data while d) - f) give the proton data. The shaded areas are those tracks for which the downstream PWC equipment determined the momentum.

a) Two prong π^- sample. The insert is the inelastic sample.
b) Four prong π^- data
c) Six prong π^- data
d) Two prong proton sample. The insert is the inelastic sample.
e) Four prong proton sample
f) Six prong proton sample

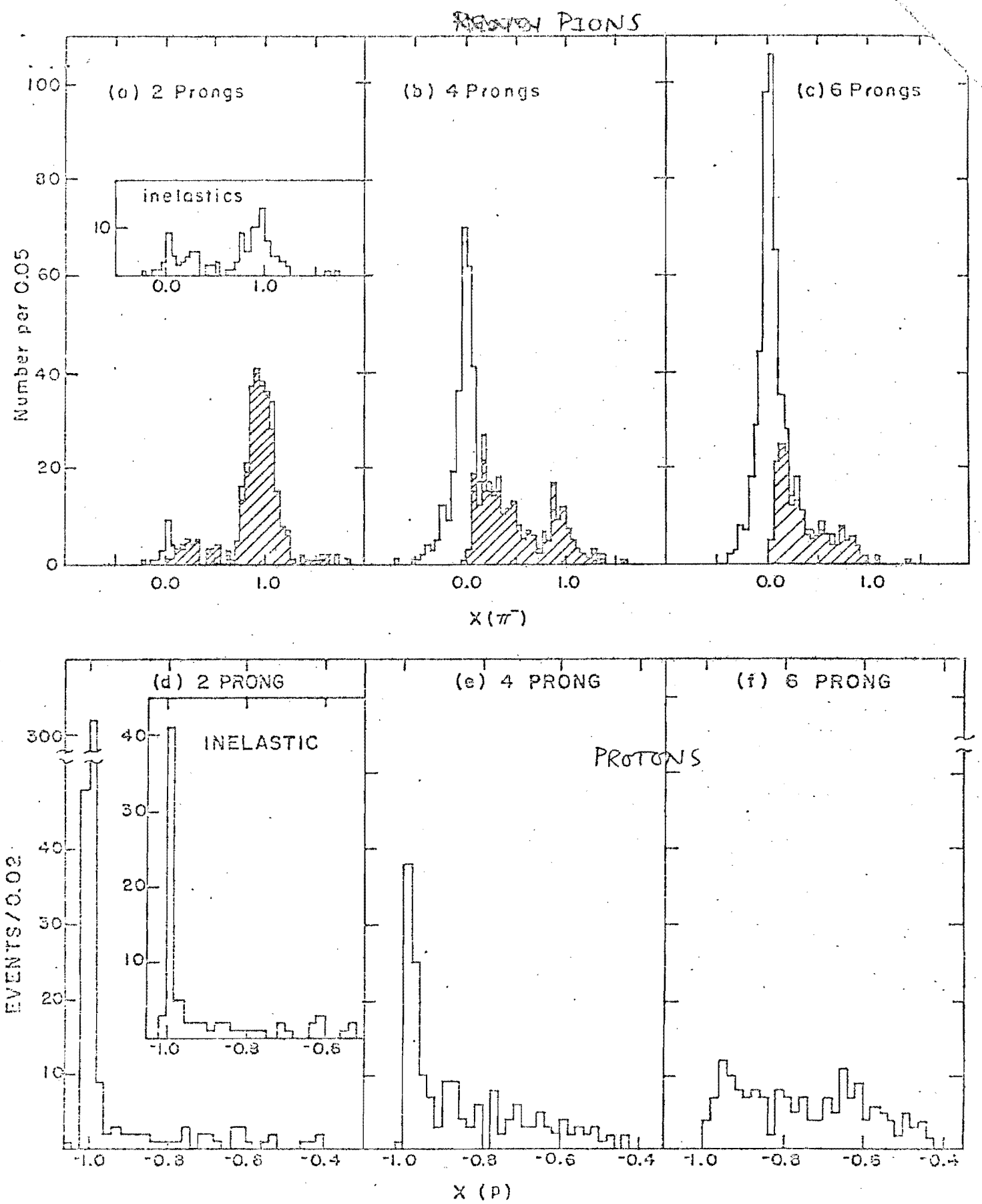
NEGATIVE PIONS
(a) 2 Prongs
(b) 4 Prongs
(c) 6 Prongs
inelastics
Number per 0.05
X(π⁻)
(d) 2 PRONG
(e) 4 PRONG
(f) 6 PRONG
INELASTIC
PROTONS
EVENTS/0.02
X (p)

FIGURE 1