FNAL Experimental Proposal 407

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$\pi^+ p$ Interactions at 250 Gev/c in Improved FNAL 30" Hybrid System

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7 May 1975

ABSTRACT

We propose to utilize the excellent momentum resolution, increased angular acceptance, and neutral particle detection capabilities of the improved FNAL 30" hybrid bubble chamber system to study interaction of 250 Gev/c π^+ mesons in an enriched $\pi^{+(1)}$ beam. We will examine leading particle effects and diffraction dissociation, long and short range correlations, inclusive single particle and resonance production, strange particle production, and systematics of events with forward π^0 and η^0.

Comparison with Experiment 299 results and a proposed experiment at 75 Gev/c will permit determination of general energy dependence of these effects, particularly leading particle cross section where good resolution near $x = 1$ is essential to test carefully model dependent predictions of leading particle cross sections.

I. Improved 30" Hybrid System

Current improvements now underway of the FNAL 30" hybrid PWC system involve the rearrangement of the present 12" x 12" downstream PWC chambers and the replacement of the extreme downstream chamber by a 1.2m x 1.2m drift chamber, resulting in marked improvement of the angular acceptance of the full downstream system.

Additionally, a combination of vertex detector and lead glass total absorption counter for energy and angle measurements on forward γ rays is being constructed. This counter will subtend an angle of $\sim 3°$, will have an energy resolution of $\frac{\Delta E}{E} \approx \frac{0.05}{\sqrt{E}}$, and will localize vertices to $\pm$ 3mm.

The improved configuration will have a duty cycle similar to the present PWC system, thereby permitting the system to record information on all incident tracks without necessity for triggering. The system will give good momentum ($\frac{\Delta p}{p} \approx 0.04p$) and angular resolution (0.1 mrad) for charged tracks in PWC-drift chambers and 1 mrad for γ's in the lead glass detector. These features combine to form a powerful system for study of $\pi^+ p$ interactions at FNAL energies.

Removal of material from the downstream portion of the bubble chamber magnet has materially improved the utility of the chamber for use with a downstream system of greater acceptance, the magnet face now permitting exit of particles within 7.5° of the beam direction. Flanges on the bubble chamber body nevertheless, still limit the unobstructed opening to about 3°. For all experiments using the new system it would be desirable, although not essential, to remove much of this material. Such removal appears to be technically feasible.

II. Scope

We request a 100,000 picture equivalent exposure, i.e., 100,000/F pictures, where F is the fractional π^+ content of the beam. We estimate 20,000 π^+ events and 40,000 (1-F)/F proton events in the data sample. The experiment will be of sufficient statistics to permit detailed comparison with Exp. 154 (π^-p at 150 Gev/c), Exp: 299 (π^+p and pp at 150) and other proposed $\pi^\pm$, $K^\pm$ experiments at 75, 150, 300 Gev/c using the improved hybrid system.

III. Participants

The groups involved in this proposal have contributed substantially to the construction of the present PWC hybrid system and to the development of the analysis system required for combined analysis of bubble chamber and PWC data.

The present downstream 12" x 12" PWC system was constructed entirely by the group, 4 chambers (13 planes) at ORNL for charged track measurement and the present γ detector (3 planes) at JHU. The 1.2m x 1.2m drift chamber for the improved system is being designed and built at ORNL.

Rutgers University is primarily responsible for PWGP (Proportional Wire Geometry Program) which reconstructs multiple tracks in PWC system from wire firing data and combines them with bubble chamber vertex information to determine momentum and angle for fast shower tracks. The University of Tennessee originated the Survey programs which utilize non-interacting beam tracks to locate the PWC planes with respect to one another and with respect to the bubble chamber coordinate system, prepares scan lists, and checks PWC wire firing efficiencies.

IV. Physics

A. Leading Particle Effects and Diffraction Dissociation

The excellent momentum resolution and 4π angular acceptance of the improved system will permit complete studies of diffraction dissociation of both the beam pion as well as the target proton. The present hybrid system has demonstrated its capability to measure accurately both longitudinal and transverse momentum over the full dynamic range of these variables.[2] The complex overlap of diffractive and leading particle effects requires full knowledge of kinematic variables for all tracks to effect separation of diffraction effects. Tests of factorization without such separation yield little useful information.

This situation is even more intractable for double diffraction dissociation process where multidimensional cluster techniques are required to separate the process from production processes involving the central region.

B. Inclusive Single Particle and Resonance Production[3]

The power of the PWC hybrid system to measure momentum of all charged particles produced has been well established in Exp. 154 and other experiments. This permits complete measurements of $\frac{d\sigma}{d\vec{p}}$ not accessible to bare chamber experiments while proving complete topological information not available from single arm spectrometer techniques.

Perhaps the most interesting single feature for $\pi^- p$ interactions

at 150-200 Gev/c is ρ° production.[4] Production is copious and present in all rapidity regions although it is most important in high multiplicity events in the central region. Figure 1 shows the $\pi^+\pi^-$ mass spectrum at 150 Gev/c along with fits in the ρ region. Figure 2 shows similar information for $p\pi^+$ combination. Hints of abnormalities in the ρ°/π^+ and ρ°/π^- ratio as a function of P_T are also present. Similar studies with π^+p collisions should prove most interesting as will the energy dependence of these effects. The possibility of direct detection of forward $\rho^\pm$ mesons utilizing the gamma detector is most intriguing although fraught with difficulty. A direct measure of the ρ° contribution to diffraction dissociation is also possible with the gamma detector yielding results on the $\rho^+\pi^0$ final state.

C. Long and Short Range Correlations

Evidence for clustering is present in high energy data although it is far from conclusive. Hybrid system measurements with complete measurements on all charged particles permit detailed study of both long and short range two particle correlations between particles of both like and unlike charge. Correlations in both P_T and P_L are also available and may provide new insight into production mechanisms at these energies.

Two particle correlations have failed to provide complete information. It is clear that more sophisticated techniques using many particle correlations will become important particularly in the study of the central region. For such studies complete kinematic information is necessary requiring the combined solid angle acceptance of the bubble

chamber with the momentum precision on fast tracks furnished by the wire counters. Thus, charged correlations can be studied as a function of invariant mass, x, and P_T of the multiparticle system. Information from the gamma detector will give partial information on neutral particle correlations.

D. Exclusive Reactions and Semi-inclusive Neutral Production

The capability of the hybrid system for uniquely determing 4 constraint fits to final states

$$\pi^+ p \to \pi^+ p$$
$$\to \pi^+ p \pi^+ \pi^- $$
$$- \pi^+ p \pi^+ \pi^+ \pi^- \pi^-$$

is well established.

The improved hybrid system will, in addition, make possible isolation of final states with forward π^0 or η^0 and possible ω.

The semi-inclusive reaction

$$\pi^+ p \to \pi^0 + x$$
$$\pi^+ p \to \eta^0 + x$$

can be studied. Considerable discrimination between η^0 and π^0 production is possible with the forward γ detector. Charge multiplicity distributions for these forward neutral events provide information not easily accessible with other techniques.

REFERENCES

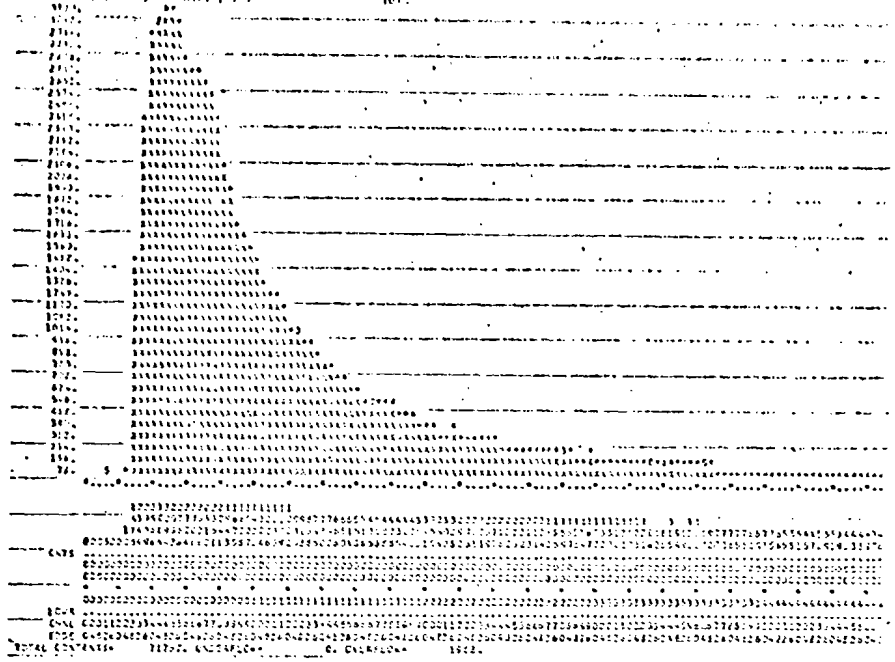
(1) Enriched Particle Beams for the Bubble Chambers at the Fermi National Accelerator Laboratory: W. W. Neale, FN-259, 2200 (1975).

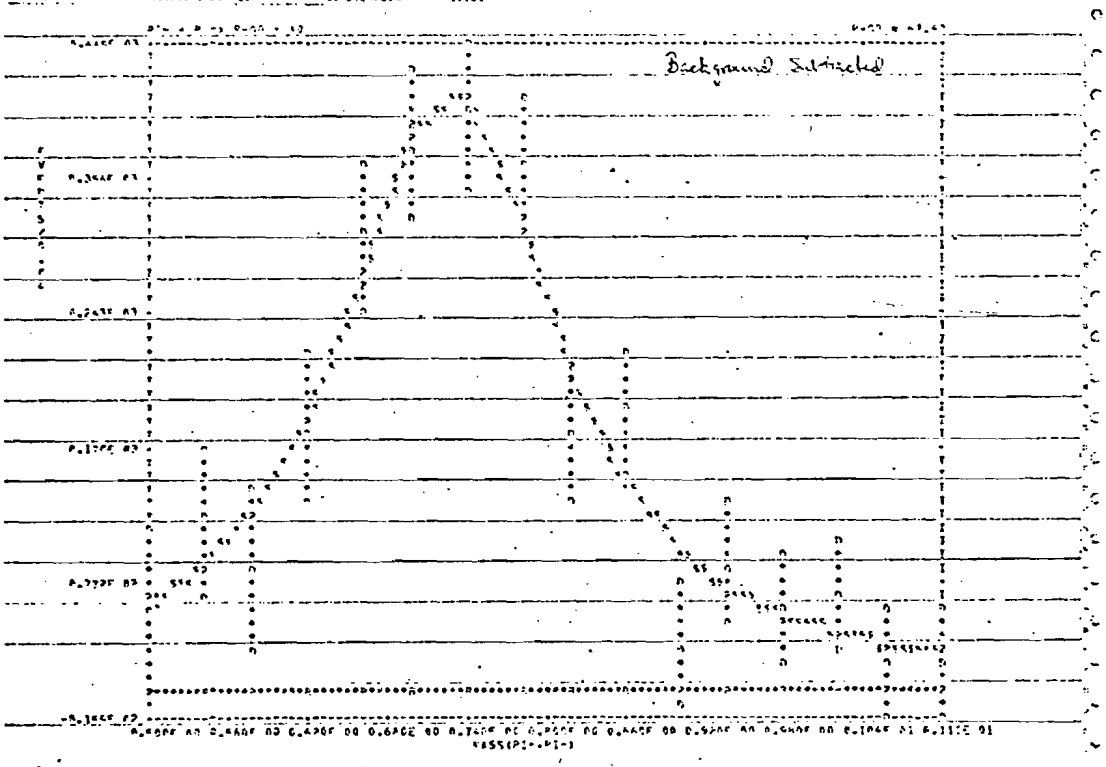
(2) Fong et al., Phys. Letters 53B (1974) 290.

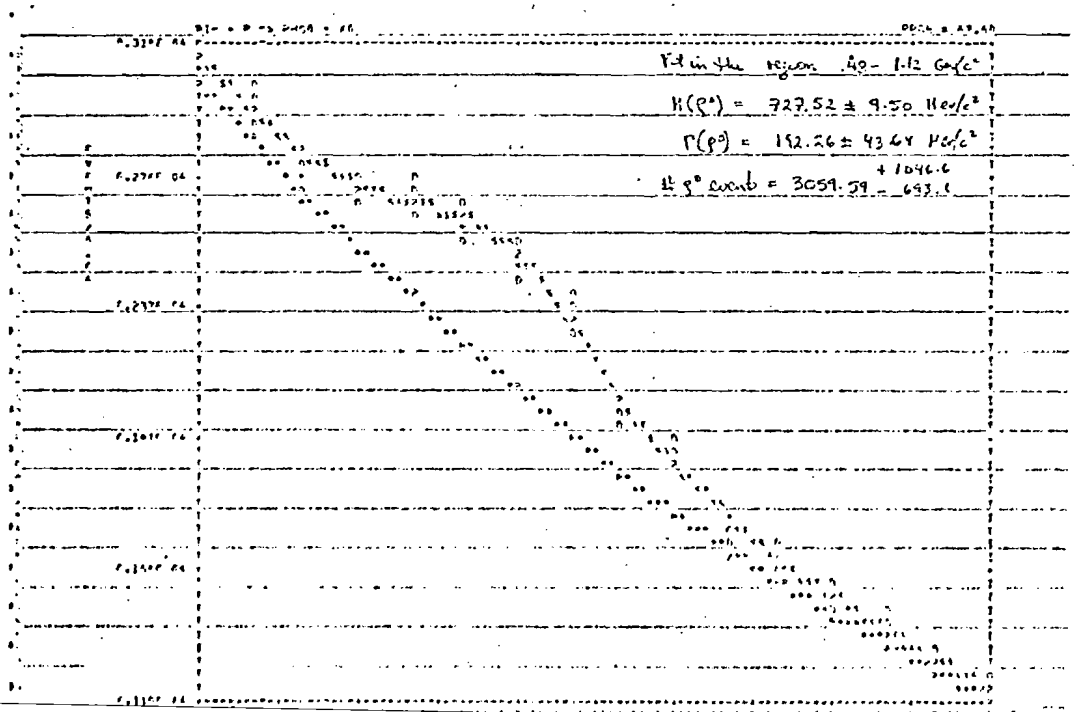
(3) See, for example, F.C. Winkelmann, Proceedings of IV International Conference on Meson Spectroscopy (1974).

(4) Inclusive ρ° Production on $\pi^{-}p$ Interactions at 205 Gev/c, Winkelmann et al., LBL-3390, Jan. 15, 1975.

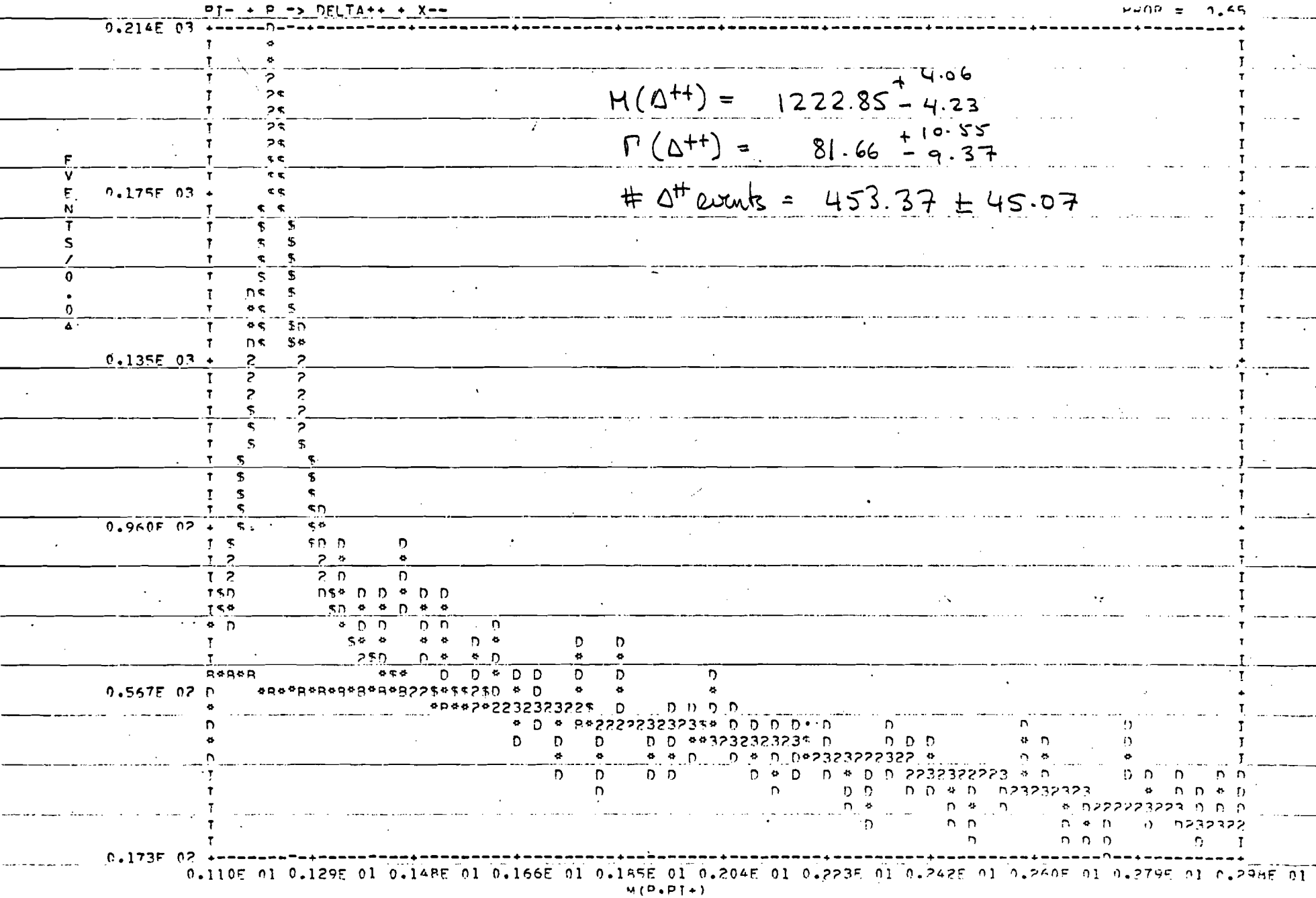
Fig 1




Background Subtracted


Fit in the region .40 - 1.12 Gev/c²
M(ρ°) = 727.52 ± 9.50 Mev/c²
Γ(ρ°) = 152.26 ± 43.64 Mev/c²
ρ° comb = 3059.59 +1046.6 -693.1

4/10/75



$M(\Delta^{++}) = 1222.85^{+4.06}_{-4.23}$

$\Gamma(\Delta^{++}) = 81.66^{+10.55}_{-9.37}$

Δ^{++} events = 453.37 ± 45.07

Figure 4