NAL PROPOSAL No. 282

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Proposal to Study Central Collisions in the Reaction $\bar{p} + p \rightarrow$ Mesons at 40 GeV/c in the 15-foot N.A.L. Hydrogen Bubble Chamber

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Submitted by:

The Purdue High Energy Physics Group

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Date: January 8, 1974

ABSTRACT

We propose to investigate close collisions in hadron-hadron interactions by examining annihilation spectra from $\bar{p}$ + p reactions in the 15-foot hydrogen bubble chamber. Current information on central collisions derives from large momentum transfer inelastic scattering data of very limited statistics; most high energy data are dominated by peripheral interactions.

Recent data from p + p scattering at 28.5 GeV/c with $p_\perp >$ 1 GeV/c indicate that resonance production in central collisions occurs in a manner that is at variance with expectations based upon meson exchange models.

Names of Experimenters

Members of the Purdue High Energy Group who will participate in this experiment consist of the following:

Professors: D. D. Carmony
R. S. Christian
J. A. Gaidos
L. J. Gutay
R. L. McIlwain
D. H. Miller
T. R. Palfrey
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This proposal is submitted by the above listed physicists.

Date: January 8, 1974

Proposal to Study Central Collisions

in the Reaction $\bar{p} + p \rightarrow$ Mesons at 40 GeV/c

in the 15-foot N.A.L. Hydrogen Bubble Chamber

Beam requirements:

We request a separated $\bar{p}$ beam. The beam momentum is not crucial as long as it is between 30 and 40 GeV/c. We request 15 beam tracks per picture.

Bubble chamber requirement:

Hydrogen filled chamber.

Film format requirement:

We will measure the film on the Purdue Polly system.

Number of pictures:

We request $0.6 \cdot 10^{+6}$ pictures.

States to be analyzed:

$$\bar{p} + p \rightarrow \text{mesons} \qquad (1)$$

$$\bar{p} + p \rightarrow \bar{\Delta}^{++} + \Delta^{++} \qquad (2)$$

$$\bar{p} + p \rightarrow \bar{d} + d \qquad (3)$$

$$\bar{p} + p \rightarrow \bar{p} + N^{*}(1700) \qquad (4)$$

$$\hookrightarrow \Delta^{++} + \pi^{-}$$

$$\bar{p} + p \rightarrow \bar{p} + p + \pi^{+} + \pi^{-} \qquad (5)$$

$$\bar{p} + p \rightarrow \bar{p} + p + \bar{p} + p \qquad (6)$$

$$\bar{p} + p \rightarrow \bar{p} + p + n(\pi^{+} + \pi^{-}) \qquad (7)$$

The cross section for reaction 1 at 40 GeV/c is 10 mb.

Physics Justification

In order to gain information of the strong interactions structure of the proton one has to study close collision. Since at small momentum transfers multipheripheral diagrams dominate one has to look for certain types of (rare) events to which no multipheripheral diagram contributes. They are the reactions 1 and possibly 2 and 3. The incentive to study high momentum transfer reaction comes from our recent counter experiment and the SLAC $e^+ + e^-$ storage ring results.

In studying p + p inelastic interactions at 28.5 GeV/c we succeeded in isolating a small sample of four constraint reactions of the type

$$p + p \rightarrow p + p + \pi^+ + \pi^- \qquad (7)$$

for $p_\perp \geq 1$ GeV. We found a very clean Δ^{++} signal and a modest enhancement at the ρ^o mass in the $\pi^+ p$ and the $\pi^+\pi^-$ effective mass distributions, respectively. In other words, the reaction

$$p + p \rightarrow p + p + \pi^+ + \pi^- \qquad (8)$$

at high momentum transfer shows quasi three body structure like

$$p + p \rightarrow \Delta^{++} + \pi^- + p \qquad (9)$$

$$p + p \rightarrow \rho^o + p + p \qquad (10)$$

but the angular distribution is completely different from that of the known ρ^o meson or Δ^{++} observed at small t in the same reactions. This indicates that the processes 8, 9 and 10 go via a new kind of production mechanism. It could be strong interaction Bremsstrahlung, fireball or spin ½ parton-parton scattering. Since a fermion-antifermion annihilation into ρ^o can result in isotropic angular distribution we inquired about the SLAC annihilation result. We did not get definite answers, but it is cle

their results for the process

$$e^+ + e^- \rightarrow \text{hadrons}$$

is also unexpected.

Both our p + p and the SLAC results have the common factor that large amount of energy is compressed into a small volume.

The above facts lead us to the following conclusions. If our results are due to the creation of a virtual pair (of fermion-antifermion off mass shell system) which annihilate into pions, we might see its effects in $\bar{p}$ + p annihilations, and in the production and decay of the $\overline{\Delta^{++}}$ - Δ^{++} pair.

We intend to analyze reactions 4-7 in terms of peripheral models, and any events which we are unable to fit we will analyze in terms of the thermodynamic models.

As soon as we have further information on NAL's plans for the 15-foot chamber we will expand this proposal.