FNAL Experimental Proposal
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A Proposal to Study $pp$ Interactions at 150 GeV/c

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SUMMARY

We propose an exposure of 0.6 events/µb for antiprotons as close as possible to 150 GeV/c in the FNAL 30-inch Bubble Chamber-Proportional Wire Chamber Hybrid Spectrometer System. We request these exposures as soon as suitably enriched beams of antiprotons are available to the spectrometer system. For a beam with antiprotons consisting of a fraction f of the total beam and eight beam tracks per picture, an exposure of $62,500/f$ pictures will yield 25,000 events for the study.

An integral part of the proposal is an effort to seek improved methods of obtaining antiproton-enriched beams, and to complete the forward gamma detector now under construction.

The purpose of this study is to gain some insight into the consequences of the difference between the valence quark makeup of protons and antiprotons. This will be accomplished by comparing the interactions proposed here with the p-p interactions being studied at the same energy in E-299. In particular, the availability of the forward gamma detector will enable us to compare the $\rho^+, \rho^-$, and $\rho^0$ production in the central region in the two processes.
We propose an exposure of 500,000 antiprotons at 150 GeV/c in the 30'' hydrogen bubble chamber at Fermilab using the upstream and downstream proportional wire chamber hybrid spectrometer system. The various experimental problems and features are outlined as well as the physics questions that are to be resolved by this study.

I. Beam

The studies of Neale at Fermilab* indicate that a mixed beam of $\bar{p}$ and $\pi^-$ at 100 GeV/c can be delivered to the 30'' HBC with a ratio of one to one. The preliminary studies indicate that this flux can be extended to 150 GeV/c with tolerable degradation. The upstream Čerenkov chamber and PWC's will enable the $\bar{p}$ beam tracks in the bubble chamber to be identified. With 10 beam particles per picture, 50% being $\bar{p}$'s, a total of 100,000 pictures will be needed for the experiment. One responsibility assumed by the proponents of this experiment will be to work with the staff of the Fermilab to obtain, improve, and test a $\bar{p}$ beam at 150 GeV/c.

II. Particle Detection System

In addition to the hybrid spectrometer system installed and used for experiments 154 and 299, we expect to participate in the installation and testing of some of the features proposed to Fermilab by the PHSC on September 27, 1974 to improve the system. Of particular value for this experiment will be the forward gamma

*W. W. Neale, FN-259, June 1974
detector planned to be installed after Chamber F of experiment 299. Design and
collection are already underway of a vertex locator and a lead glass total energy
hodoscope for this measurement. With this detector in place, most of the $\pi^0$'s
produced with $X > 0.1$ in the center of mass will be detected and their momenta
measured to an accuracy of about 1%. The bubble chamber magnet aperture has
already been enlarged by the Fermilab. Work is proceeding on the design of drift
chambers to be used to increase the acceptance of the downstream spectrometer.

III. Physics Goals

A. From data of experiment 154 already published or submitted for publica-
tion*, and from data of experiment 299 now in process, data will be available
on cross sections and recoiling mass distributions for leading particle effects for
$\pi^+p$, and $\pi^-p$, and pp reactions at 150 GeV/c. We will therefore be able to compare
pp leading particle effects with those.

B. Elastic $\bar{p}p$ cross sections will be measured at 150 GeV/c.

C. Since leading particle reactions can be separated out, the nonleading
particle reactions of $\bar{p}p$ can be compared with those of $p-p$ to get information on
annihilation cross sections at this energy.

D. Inclusive $\pi^0$ production in $\bar{p}p$ reactions can be studied for $\pi^0$'s with
$X > 0.1$, using the shower detector. Also identifiable will be the reaction
$\bar{p}p \rightarrow p$ ($p\pi^0$) as a component of the diffraction dissociation process. This can be
compared directly with $pp \rightarrow p$ ($p\pi^0$).

E. Multiplicity distributions and two particle correlation functions can
be determined.

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D. Fong et al., "Cross Sections and Multiplicity Distributions for $\pi^-p$ and
K$^-p$ Interactions at 147 GeV/c," submitted to Nuclear Physics B.
D. Fong et al., "Inelastic 2-prong Events in 147 GeV/c $\pi^-p$ Collisions," submitted to Nuclear Physics B.
F. Preliminary work at 150 GeV/c indicates that we can identify the reactions \( pp \rightarrow pp \pi^+ \pi^- \) and \( \bar{p}p \rightarrow pp \pi^+ \pi^- \) by kinematical fitting procedures. Therefore, these two processes can be compared as a result of this experiment.

G. According to the theory of Jacob and Nussinov\(^*\), the annihilation process occurs by the slowing down of the nucleon and antinucleon by pion emission until they have a rapidity difference of less than 1.4. Products of annihilation then are produced near zero on the rapidity scale. Since we will be able to measure the rapidities of all charged pions and of neutral pions for \( X > 0.1 \), we will be able to compare the pion, \( \rho^\pm \) and \( \rho^0 \) production in the central region for \( \bar{p}p \) and \( pp \). This comparison should give evidence on whether the difference between \( pp \) and \( \bar{p}p \) interactions of high energies is solely due to annihilation.

\(^*\) Jacob and Nussinov, N. L. 14A, 335(1973).