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Hybrid Bubble Chamber Study of $\bar{p}p$

Interactions at 75 GeV/c

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Abstract

We propose a careful study of antiproton-proton interactions at 75 GeV/c in the Fermilab 30" hybrid bubble chamber. An exposure of 300K pictures is requested to provide 50K interactions of which approximately 7K are annihilation events. Using the properties of this system which is very well matched to the often complex topologies associated with annihilations and to this beam momentum, we plan to study all experimentally accessible features. In particular, single and multi-particle inclusive distributions for charged and neutrals will be measured, exclusive fits will be made where possible, new particles will be searched for, and comparisons made to other energies and to other beam particles.

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I. Introduction.

We propose a careful study of antiproton-proton interactions at a beam momentum of 75 GeV/c in the Fermilab 30" bubble chamber enhanced by the downstream proportional wire chamber system and a shower detector to measure forward fast gammas with good efficiency and energy resolution. 300K pictures are requested to provide 50,000 interactions of which perhaps 7,000 are annihilation events.

We propose to study all aspects of these interactions which are accessible to this technique with a major emphasis on annihilation events. In particular, we will determine the total cross section (to 3%), the elastic differential cross section in the forward direction, single and multi-particle inclusive distributions for both annihilation and non-annihilation events to the considerable extent that this separation is possible, and neutral particle distributions for K^0 , Λ^0 , and gammas. Leading particle effects will be studied. Exclusive fits will be done to those channels with no missing neutrals for which such fits are reliable. The fraction of energy given to neutral particles will be determined. New particles, which could be produced in pairs and have complex decay modes will be searched for. Comparisons will be made both to $\bar{p}p$ and pp characteristics at higher and lower energies.

This hybrid bubble chamber is well suited for a fairly detailed survey experiment of this type due to its 4π sensitivity, good accuracy on both slow and fast forward particles -- especially at 75 GeV/c, and ability to detect gammas with good angle and energy resolution. We presume that the downstream shower detector, at least one large (1 meter) drift chamber, and a cut out bubble chamber

vacuum chamber (7.5° aperture) will be available for this run. We are now working on the shower detector and large drift chamber and plan to help develop the antiproton beam, which should be almost optimum at this energy.

II. Physics Justification.

This exposure will provide an opportunity to make a reasonably detailed and complete study of antiproton-proton interactions at an energy intermediate between the lower energies (below 15 GeV/c) at which careful studies have been made and somewhat higher energies at which studies are proposed. By some measure, such as $\langle n \rangle / D$,¹ $\bar{p}p$ interactions have already reached an asymptotic value by 10 GeV/c whereas other incident particles are only approaching this value by 75 GeV/c. In this sense, very high energy effects can be studied at much lower energies where the experimental problems are much simpler by using antiproton beams.

The 30" hybrid system is extremely well suited for this study due to the relatively large cross section (40 mb total and perhaps 10 mb annihilation cross sections), and the relative complexity of the annihilation events. The 4π sensitivity of the bubble chamber permits all charged prongs to be observed with excellent efficiency and, at this energy, to be measured with good accuracy. The downstream system allows measurement of the fastest tracks with a momentum accuracy no worse than 3%. Fast forward gammas will be detected with excellent efficiency in the shower detector currently being developed by the PHS consortium² and measured with good energy and angle accuracy. Neutral strange particles will be

observed in the bubble chamber as well as in the downstream chambers.

Using the high efficiency and good accuracy of this system for this study, we plan to concentrate on the following features:

1. Total cross section.

We plan to measure the total cross section with an accuracy of a few percent. Note that the upstream and downstream PWC chambers permit us to select on all interactions while the visible target permits the use of a well defined fiducial region. Thus, even zero-prong events will be found with high efficiency and wall effects can be minimized:

2. Elastic scattering cross section.

As we have shown in π^-p interactions at $150 \text{ GeV}/c^3$, elastic scattering events can be reliably isolated using the bubble chamber in connection with the PWC chambers in the t range from 0.04 to $0.4 \text{ (GeV}/c)^2$. At $75 \text{ GeV}/c$ the separation will be even cleaner.

3. Multiplicity.

We plan to measure charged particle multiplicities as well as Λ^0 's, K^0 's, and gammas. Insofar as possible -- by excluding events with clear protons, antiprotons, Λ^0 's, and probably events with a fast forward negative, we hope to estimate multiplicities for annihilation events. The results will be compared with $\bar{p}$ multiplicities at lower and higher energies as well as with results from other beam particles.

4. Inclusive Distributions.

We will measure transverse and longitudinal variables for all measureable tracks. Insofar as possible, we will extend these measurements to resonance production for those resonances which

may be copiously produced and readily isolated. Two particle correlations will also be studied. The partial symmetry of the $\bar{p}p$ system will be useful for studying possible biases in these studies.

5. Exclusive channels.

With the good accuracy available with this system, it should be possible to isolate channels without missing neutrals with small background. In particular, the $\bar{p}p\pi^+\pi^-$ should be of interest to compare with the reaction $pp\rightarrow pp\pi^+\pi^-$ to test factorization and other properties. The downstream shower detector may make it possible to isolate channels with a fast forward π^0 as well.

6. Leading Particle Effects.

Leading particle effects have been shown to be important in 2, 4, and -- to a lesser extent -- 6-prong events in 150 GeV/c π^-p interactions³. It will be interesting to compare these results with $\bar{p}$ initiated reactions. The downstream system is important here to isolate events in which the $\bar{p}$ is the leading particle whereas the bare chamber can easily determine those events in which the proton is leading.

7. New Particle Search.

Since annihilations at lower energies exhibit copious resonance production (even 7 pion annihilations at 1.3 GeV/c proceed through omega production 2/3 of the time), we might expect similar effects at these energies. Annihilations presumably probe hadrons at the smallest distances and therefore might be expected to show most clearly new and surprising effects. Since most outgoing particles will be accurately measured in even the most complex events, we

would be sensitive to many of these effects at the one event / microbarn level.

III. Technical Details.

We propose to use the "target halo" technique⁵ to produce an antiproton beam. This technique, which uses antiprotons from antilambdas should produce a beam of adequate intensity with a $\bar{p}$ component of approximately 1/3. We propose to help with the development and testing of this beam.

The upstream and downstream PWC system has been by now thoroughly tested and shown to be reliable and useful. Having participated in its development as well as in the analysis of the first experiments using it, we are fully prepared and foresee no difficulty in its use.

We are now participating in efforts to further improve this system by the installation of a shower detector and by gradual replacement of the 0.3 meter PWC chambers by 1 meter drift chambers⁶. The larger chambers are important for this experiment since the lower momentum and somewhat larger transverse momenta associated with annihilations make increased acceptance important. It is also of critical importance that the vacuum tank of the bubble chamber be revised to permit this increased acceptance to be usefully employed.

IV. References

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