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A STUDY OF HIGH ENERGY π^- PROTON INTERACTIONS WITH THE NAL 14-FT BUBBLE CHAMBER

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Abstract: We propose to study the general properties of π^- proton interactions at an incident momentum of about 150 GeV/c or greater. In order to facilitate the detection of neutral particles we plan to install a hydrogen track sensitive target within the NAL 14-ft chamber and surround it with a mixture of hydrogen and neon. To aid in kinematical fitting we would like the incident beam to have a momentum resolution ($\Delta p/p$) of about 0.1% and an angular definition of about 0.1 mrad. We plan to investigate the use of a beam wire chamber to insure us of this resolution. An exposure of 250,000 pictures is requested.

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Physics Justification: The purpose of this experiment is to study the general properties of high energy meson induced interactions. We feel that a large hydrogen bubble chamber has a set of capabilities which make it a unique tool for the study of strong interactions at NAL. Although these capabilities have been widely discussed let us make explicit the most important of them.

1) It is a 4π detector with which one can study a wide variety of interactions and obtain precise and unbiased information on the direction and momentum of charged secondaries. Its ability to provide this information is not dependent on the number of the charged secondaries.

2) It has high spatial resolution and allows clear visibility of the interaction and decay vertices. This means that the decay of short lived charged hyperons will be identifiable as well as lambda and K_1 decays which occur within the chamber volume. The high three dimensional spatial resolution of the bubble chamber is worthy of emphasis since all of the existing hyperons (and the known anti-hyperons) have been discoverd in bubble chambers and for some (e.g. Ω^-) this is the only instrument with which they have been observed.

3) Bubble density and delta-ray information provide a means of particle identification over a wide range of momenta.

4) All stopping positive tracks can be positively identified by their characteristic decay products. In particular, range provides a very accurate method of determining the momenta of slow recoil protons if they stop within the chamber volume. This is of particular interest in the study of diffraction disassociation processes which are of great significance at high energies. The

ability to observe 'spectator' protons in reactions which occur in deuterium make this a unique instrument for observing reactions which involve the lightly bound neutron of the deuterium nucleus.

5) The chamber will be particularly useful in the configuration we propose; namely, the insertion of a track sensitive hydrogen target surrounded by a neon-hydrogen mixture. Using this technique, missing neutral particles can be determined with high efficiency at almost a 4π solid angle. This is especially useful at high energies where very probably production of neutrals would prevent analysis in pure hydrogen or deuterium or in smaller chambers. Typical of the interesting ways this neutral detector could be used is the reduction obtained in the number of events that would not have to be measured by using the neutral detector in the neon-hydrogen mixture as an anticoincidence at the scanning level. Furthermore, delta ray analysis in neon allows separation of protons and K-mesons up to several BeV.

The above qualitative properties are ones which make a large bubble chamber a distinctive and unique instrument for the study of strong interactions. These properties and in particular its high spatial resolution and extraordinary ability to provide us with an immense amount of reliable information about a single event make it an invaluable tool for studying the unexpected. It would be very short sighted to assume that physics at 200 GeV was fully contained in extrapolations from our knowledge at lower energies and hence provide only those tools which were capable of making high statistics measurements of these expected processes.

We propose to run with a beam intensity which would be sufficient to give us about two interactions per picture in the hydrogen volume. We feel that this is probably an upper limit since essentially all secondaries will have interactions in the hydrogen neon blanket and larger fluxes would make it very difficult to untangle events. Thus, an exposure of 250,000 pictures should provide about 500,000 events.

We see the analysis of these events divided into two parts. The first would be an analysis of properties which do not require a kinematic fit to be made of the production vertex. This would include a study of multiplicities - including neutrals which interact in the neon blanket - momentum distributions, analysis of vees, etc. In this phase we would also look carefully for unusual topologies such as tracks with multiple kinks or vees emerging from kinks which might be indicative of particles of high strongness. For this study all of the 500,000 events would be available.

The second phase of our analysis would involve the kinematic fitting of the primary interaction vertex. For this we would like as good a determination of the incident pion momentum ($\Delta p/p \sim 0.1\%$) and angle ($\Delta\theta \sim 0.1$ mrad) as possible. We plan to investigate the use of proportional wire chambers in the incident beam to accomplish this. A reasonable estimate is that between 5-10% of all events will be four constraint fits which we believe we can separate from other states. We then have a sample of 25,000 - 50,000 identified events which can be used to study production cross sections and detailed kinematical properties of these channels. Of particular interest is the study of diffraction channels such as $A_1 \rightarrow \pi\rho$, $A_3 \rightarrow \pi f$, 5 π's, etc. An exposure to an incident negative pion beam will help to minimize the effects of final state particle misidentification; namely, ambiguities of $K^{\pm}\,\pi^{\pm}$ identifications should occur less frequently than in a kaon exposure.

Experimental Arrangement and Apparatus: We propose to use the NAL 14-ft bubble chamber located in Area 1. This chamber as well as the track sensitive target and any necessary special beam instrumentation will be developed by members of this experiment.