Fermilab Proposal No. 429

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Proposal to Study Interactions of 100 GeV/c Negative Pions in the 15-foot FNAL Hydrogen Bubble Chamber

Aachen-Bonn-CERN-Cracow-London-Warsaw Collaboration

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PROPOSAL TO STUDY INTERACTIONS OF 100 GeV/c NEGATIVE PIONS IN THE 15-FOOT FNAL HYDROGEN BUBBLE CHAMBER

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SUMMARY

A request is made for 50.000 photographs of 100 GeV/c negative particles in the 15 foot FNAL hydrogen bubble chamber. One of the main aims of the experiment is to study exclusive reactions. This would greatly extend our experimental knowledge of reaction mechanisms, in particular of diffraction dissociation. Strange particle production would also be expecially studied.

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1. PHYSICS MOTIVATION

Recently our knowledge of the reaction mechanism of inelastic high energy collisions has been greatly extended by the study of inclusive reactions. However, very few exclusive reactions have been or are being studied above 40 GeV/c. We feel that the next major advance will come from a systematic study of exclusive reactions and this is the main purpose of the experiment we propose.

A large bubble chamber is an excellent instrument to study exclusive reactions since the vertex region of the interaction can be clearly seen and accurate measurements can be made on the charged secondaries and on a substantial fraction of the neutral secondaries (e.g. neutrons, π^o's, K^o, Λ). With the FNAL 15 foot chamber, 4-constraint reactions should be easily identified kinematically, but such reactions are few in number and, from isospin considerations, have small cross sections at high multiplicities. One-constraint reactions are however more numerous and in general tend to have higher cross sections. Our aim is to obtain good samples of both 4C and 1C reactions - this will alow us to cover all multiplicities. Results from FNAL and ISR have shown that diffraction dissociation does not occur only in 3 and 4-body reactions, but also in higher multiplicities up to $\sim$ 10. Thus we would like to study diffraction dissociation in the reactions:

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

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

where we would study not only the pion dissociating into 3π, 5π, 7π, ... but also the proton dissociating into $p\pi^o$, $n\pi^+$, $p\pi^+\pi^-$, $p\pi^+\pi^-\pi^o$, $n\pi^+\pi^-\pi^+$, ...

Our choice of 100 GeV/c is motivated by the fact that this is an energy at which one can still identify a substantial fraction of one constraint reactions in the "bare" 15-foot chamber.

The choice of a negative beam (mainly π^-, some K^- and $\bar{p}$) as projectiles is made to study the interactions of non-identical hadrons. This provides considerable additional information to what is learnt from proton-proton interactions (e.g. a forward lambda particle would suggest baryon exchange in meson-proton reactions, but in pp reactions it would be difficult to determine whether the lambda came from the projectile or target proton).

While exclusive reactions are the most exciting subject, we would measure all charged secondaries and decays of neutral secondaries of all events to study also inclusive reactions, correlations, events of large transverse momentum.

We are very interested in the energy variation of the various exclusive and inclusive processes. Our Collaboration has already made extensive measurements of meson-proton reactions at lower energies (π^+p at 8,16 and 23 GeV/c, π^-p at 16 GeV/c, K^-p at 10 and 16 GeV/c) which would be immediately available for the new types of analysis that we expect to make with 100 GeV/c film. Also, the CERN group is at present working on photographs of 100 GeV/c π^-p interactions in the FNAL 30-inch chamber.

A more detailed description of the physics analysis is given in Proposal 267 which requested a somewhat larger number of photographs. However, we would like to emphasize that we believe that significant results can be obtained with 50,000 photographs. Assuming 10 beam particles per photograph, then using the cross section estimates of V. Karimäki, we would expect 2000 events of the $p\pi^+\pi^-\pi^-$ channel, 400 events of $p\pi^+\pi^-\pi^-\pi^o$, 300 events of $\pi^-p\pi^o$, 300 events of $\pi^-n\pi^+$ and 250 events of $\pi^-n\pi^+\pi^+\pi^-$.

2. BEAM

If accelerated protons of $\sim$ 400 GeV are used to produce the 100 GeV/c beam, then in addition to π^-, there will be a few percent of K^- mesons and about ½ to 1% of antiprotons. If the system of Cerenkov counters and beam hodoscopes being constructed, were available at the time of picture taking, it would be of considerable interest to study also K^-p and possibly $\bar{p}p$ interactions.

3. SCANNING AND MEASURING

The Collaboration has a large scanning and measuring capacity which is being prepared for the measurement of films from a chamber with a very similar optical system (BEBC). In particular CERN has the ERASME system working which was designed specially for large bubble chambers with fish-eye optics and which has made measurements on the fiducial marks of the 15-foot chamber film.

A special advantage of the ERASME system is that the geometry is calculated on-line. We propose to use this facility to calculate the direction and momentum of the missing mass. The operator will then be instructed to scan carefully along, and near, this direction. If the missing mass was a single particle, e.g. a neutron or K^o, then the measurement of any observed interaction, e.g. a proton recoil, could be instantly added and calculated. The effect of this would be to convert a possible 1-constraint fit into a relatively sure 4-constraint fit.

4. FUTURE

It is intended to continue measuring $\pi^- p$ film in the 15-foot chamber: (a) at 100 GeV/c (Proposal 267) to obtain higher statistics; (b) with π^- of the highest available energy ($\sim$ 390 GeV/c) to search for new short-lived particles and to study energy dependent effects by conbining the data with results obtained at 100 GeV/c and lower energy.