NAL PROPOSAL No. 40

Correspondent: R. B. Willmann
Department of Physics
Purdue University
Lafayette, Indiana 47907

Phone Lafayette 317

DIFFRACTIVE PROCESS IN π^-p Interactions at 100 GeV/c

V. E. Barnes, D. D. Carmony, R. S. Christian, J. A. Gaidos,
A. F. Garfinkel, L. J. Gutay, S. Lichtman, F. J. Loeffler,
R. L. McIlwain, D. H. Miller, T. R. Palfrey, R. B. Willmann,
D. Cords, J. Lamsa, K. Paler, K. Rangan, J. H. Scharenguivel
Purdue University

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Abstract

A study of diffractively produced hadron systems from 100 GeV/c π^- interactions in a 15 foot hydrogen bubble chamber is proposed. Primary interest is in the 4C reactions

$$\pi^- p \rightarrow p\pi^-\pi^-\pi^+$$

and

$$\pi^- p \rightarrow p\pi^-\pi^-\pi^-\pi^+\pi^+ .$$

Use of the chamber as a missing mass spectrometer for other four and six pronged interactions is proposed, also. A total 500,000 photographs is requested.

Experimenters

V. E. Barnes, D. D. Carmony, R. S. Christian, J. A. Gaidos, A. F. Garfinkel, L. J. Gütay, S. Lichtman, F. J. Loeffler, R. L. McIlwain, D. H. Miller, T. R. Palfrey, R. B. Willmann, D. Cords, J. Lamsa, K. Paler, K. Rangan, J. H. Scharenguivel.

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I. Physics Justification

The purpose of this experiment is to study diffractively produced hadron systems from $\pi^- p$ interactions at 100 GeV/c. The high energy is advantageous for this project because it allows access to kinematic regions which are excluded at lower energy. For example, a boson of mass 3 GeV/c^2 may be produced with a four momentum transfer of as little as $^-$.045 GeV/c^2. In addition, if diffractive cross sections remain constant with energy, background from competing processes should be reduced.

The most useful events for this study are those which fit the 4C hypotheses

$$\pi^- p \rightarrow p\pi^-\pi^-\pi^+ \qquad (1)$$

$$\pi^- p \rightarrow p\pi^-\pi^-\pi^-\pi^+\pi^+ \qquad (2)$$

These will be used to investigate:

A. Diffraction dissociation of the beam pion

$$\pi^- p \rightarrow p\pi^* \qquad \pi^* \rightarrow 3 \text{ or } 5\ \pi\text{'s} \qquad (3)$$

B. Diffraction dissociation of the target nucleon

$$\pi^- p \rightarrow \pi^- N^* \qquad N^* \rightarrow p2\pi \text{ or } 4\ \pi\text{'s} \qquad (4)$$

C. Possible "Double Diffraction Dissociation"

$$\pi^- p \rightarrow \pi^* N^* \qquad \pi^* \rightarrow 3\ \pi\text{'s}, \quad N^* \rightarrow p\ 2\ \pi\text{'s} \qquad (5)$$

D. In addition, the 4 and 6 pronged events, which will all be measured, will be used for a missing mass spectrometer type study when the proton is identifiable by ionization.

E. If this is the first high energy π^- exposure at NAL, a survey of the general characteristics of high energy πp interactions will be made

A. Diffraction Dissociation of the Beam Pion

Primary interest in this experiment will be focused on the comparison of the production amplitude for diffractive dissociation to experimental results at lower energy, and to the many theortical models of the process. For example, there are predictions of selection rules,[1-4] models of the spin-parity composition as a function of πp mass[5-6] and a discussion of the possibility of the conservation of s-channel helicity.[7] Because of the theoretical interest in this process, there will probably be many more papers on this subject by the time the experiment is done. Furthermore, the possibility of discovering high mass boson resonances of odd G parity is always exciting.

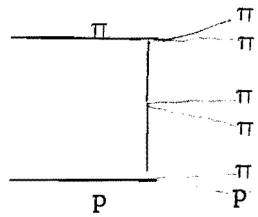
B. Diffraction Dissociation of the Target Nucleon

From the data in the 10 GeV/c region it appears that diffraction dissociation of nucleons off pions is approximately half that for diffraction of pions off nucleons. It will be especially interesting to look for rare decay modes of high mass isobars, i.e. $N_{\frac{1}{2}}^{*+} \rightarrow \Lambda^o K^+, \Sigma^+ K^{-o}$, $Y^{*+} K^o$, and $Y^{*o} K^+$. In addition, it is hoped that decay rates of $N_{\frac{1}{2}}^* \rightarrow \Delta^{++} \pi^-$ can be better determined because of reduced background.[8-9]

C. Double Diffraction Dissociation

Our interesting question which can be investigated is whether reactions such as (5) occur at high energy. No evidence for $pp \rightarrow N_{\frac{1}{2}}^* N_{\frac{1}{2}}^*$ was observed at 28.5 GeV/c,[10] but it is important to search for this type process in other reactions.

A related problem is whether reactions occur which can be represented by diagrams such as the one below:



At pre-NAL energies it has been very difficult to distinguish cluster formations because of their kinematic overlap. However, at the higher energy, the energy of the individual clusters should be small compared to the total energy, and the validity of multi-peripheral models can be investigated.[11-12]

D. Missing Mass Spectrometer Studies

The use of a large bubble chamber for missing mass spectrometer studies at NAL has been discussed by C. M. Rose.[13] The Purdue group has recently used this technique on π^+p interactions at 13 GeV/c.

E. Survey of High Energy πp Interactions

The determination of charged particle multiplicities, and transverse and longitudinal momentum distributions should provide information useful for understanding pion-nucleon interactions at cosmic ray energies. The apparent increase in the Kaon production cross section with increasing energy can be easily studied by counting K^o and $\bar{K}^o$ decays.

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II. Experimental Arrangement

This proposal is being made under the assumption that a hydrogen bubble chamber with a 15 foot diameter, setting error of 250μ, and magnetic field of 35 kG will be available. It is also assumed that the fractional error in the beam momentum will be .001 and $\Delta\theta \sim .3$ mrad. If these conditions cannot be met, a more thorough study of the possibility of selecting the 4C events must be done.

For the purpose of estimating the number of events to be measured, the cross sections given in the table below were assumed.

	Total	4-C
4-prongs	3mb	400μb
6-prongs	4mb	200μb

In order to obtain suffieient track length for the secondary particles, only events in the first half of the chamber will be measured. With an average of 20 tracks per picture, the yield should be 10 events /μb - 10^5 pictures. In order to obtain 10,000 events of reaction (1), it appears that 250,000 pictures are necessary. However, approximately 20% will have a proton with momentum less than 150 MeV/c, and will be lost. Of those remaining, only 60% will have 3 pions which do not interact within 200 cm, so the number of useful events is only one half of those produced. Therefore, it is requested that 500,000 pictures be allocated for this experiment.

In addition to the 10,000 events of reaction (1) 3,500 events of reaction (2) should be obtained (The probability that none of the 5 pions interact in 200 cm is only 0.4). It appears that 150,000 four pronged and 200,000 six pronged events must be measured to obtain these samples, but elimination of those events whose secondaries interact within 200 cm, those with a proton less than 150 MeV/c, and those with a visible pair should reduce the number of about 45,000 four pronged and 45,000 six pronged events.

The remaining 75,000 four pronged and 115,000 six pronged interactions are useful for the missing mass spectrometer study. However, only the proton must be measured in an exploratory survey, so these events can be measured at a more rapid rate than the full events. Assuming the rate is doubled, this corresponds to 95,000 event equivalents.

It is anticipated that a Polly measuring system will be operational at Purdue by the time this film is exposed. Measuring capability is estimated at 500,000 events/year, so this experiment should take approximately one half year to measure. The Purdue group is currently submitting proposals to NAL for a neutrino experiment, a $\bar{p}p$ experiment, and a triggered hybrid spectrometer/visual system experiment, but we feel these commitments are well within the capability of the group over the anticipated time scale.

II. Apparatus

The bubble chamber and beam specifications have been given in Section II.