A PROPOSAL TO STUDY DIFFRACTION DISSOCIATION USING A HYBRID SPECTROMETER AND RAPID-CYCLING NEON BUBBLE CHAMBER

D. D. Reeder
University of Wisconsin

ABSTRACT

An experiment is proposed to study diffraction dissociation using a hybrid detector consisting of a rapid-cycling Ne bubble chamber with a hydrogen target and a wire-chamber spectrometer. The system uniquely provides information on some aspects of diffraction dissociation and particle spectroscopy.

I. DIFFRACTION DISSOCIATION

The most intriguing aspect of diffraction dissociation (DD) is that the cross sections are expected to remain roughly constant as the bombarding energy is increased. Evidence supporting this observation was presented in Strauch's article in the 1968 Summer Study.[1] For example the cross section for the reaction

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

has been measured at 13 and 20 GeV/c and found to be nearly constant. The diffraction dissociative interpretation of this result is to say that the incident π^- turned into 3π's with a minimum of fuss--i.e., at small t with no change in quantum numbers except angular momentum. Although not as clearly seen in πp interactions a similar dissociation of the target proton is expected. The cross sections are large. For the reaction 1 it is about 1 mb. Cross sections for individual resonance production may be 50-100 μb. I suggest that a form of the hybrid detector similar to that of Fields et al.,[2] can uniquely provide information on some aspects of diffraction dissociation.

Consider the reaction diagrammed in Fig. 1. If the reaction proceeds by DD then any baryon resonances produced have natural spin parity $p = (-1)^{J-1/2}$. Furthermore, the observed angular correlations between the 3π vertex and the lower vertex can provide tests of the assumptions and details of specific models. The measurement of cross sections and decay branching ratios for such events is a good match to the broad spectrum capabilities of a rapid-cycling bubble chamber.

II. DESCRIPTION OF THE APPARATUS

A separated beam of K^+, π^+, or p (or unseparated π^-) is incident on a cryogenic rapid-cycling bubble chamber of ~ 1 m diameter (see Fig. 2). The chamber is filled with neon and has a liquid hydrogen snout of 10 cm diameter passing through the chamber.[3] The interactions take place in the hydrogen and the very energetic forward particles leave the chamber, pass through a radiator (~ 3 radiation lengths of Pb) and enter a spark-chamber spectrometer.

An "event" is defined by a scintillator hodoscope which detects 3 outgoing charged particles. The radiator acts to "anti" gammas resulting from fast π^0's. After the trigger a beam "shutter" is activated which deflects the subsequent beam particles onto a collimator. This is to reduce the background of γ's and neutron stars in the bubble chamber.

THE SPECTROMETER

Nothing special is required for the downstream spectrometer. In fact the device proposed by Carrigan et al., should be quite satisfactory.[4]

THE BUBBLE CHAMBER

A chamber 1 m in diameter, 70 cm in depth with a 40 kG superconducting magnet and capable of cycling 5-10 times during the flat top seems very feasible. Other chambers have operated with track-sensitive hydrogen snouts and this seems also possible. However, the success of the experiment does not depend on the observation of tracks in the hydrogen.

The neon chamber is a nearly 4π γ detector (misses only 0.5% in directly forward and backward direction). The probability of conversion based on 40 cm average gamma track length is 75%. Thus the chamber is ~ 92% efficient in vetoing a slow π^0 and is 50% efficient in detecting both γ's of a π^0. Futhermore, a neutron will interact visibly about 40-50% of the time.

Another advantage of the bubble chamber is that γ energies can be measured to about 15%. Of course, the relative ionization measurement will also contribute to slow particle identification. Protons of ~ 700 MeV/c or less will be stopped in the neon, and the momentum measured by range to an accuracy of 2 to 3%. Other tracks will be measured to 4 to 4-1/2% in the bubble chamber. Momentum of π^0's can be reconstructed to 7% using measured γ energies. The resultant errors on $p_\perp$ and $p_\parallel$ are comparable to the accuracy required in the Strauch work.

RATES

We assume 20 tracks per expansion so there will be on the average 2 interactions in the hydrogen per expansion. More tracks could be used if the backgrounds were manageable. If a fiducial volume of 70 cm is assumed and 10 expansions per burst, one trigger per burst will be observed for a cross section of 2 mb. Thus 12,000 pictures per day should be possible.

III. ANALYSIS

The experience at 20 GeV/c reported by Strauch[1] indicates that the following parameters permit a clean separation of 4c fits:

1. Nominal point accuracy in xy plane in space = 90μ
2. Average error in transverse momentum 40 MeV/c
3. Average error in longitudinal momentum 400 MeV/c

If we restrict ourselves to events in which all final state particles are observed, it is possible to equal the parameters quoted above, even for 100 GeV/c incident momentum. The following partial list of decay modes of isobars produced by DD will be observed with ≥ 3-constraint fits and with ≥ 50% efficiency:

$$
\begin{aligned}
N^* &\rightarrow p\,\pi^o \\
&\rightarrow n\,\pi^+ \\
&\rightarrow \Lambda K^+ \\
&\rightarrow \Sigma^+ K^o \\
&\rightarrow \Sigma^o K^+ \\
&\rightarrow p\,\pi^+\pi^- \\
&\rightarrow p\,\pi^+\pi^-\pi^o \\
&\rightarrow p\,\eta^o \\
&\rightarrow p\,K^+K^- \\
&\rightarrow n\,\pi^+\pi^-\pi^+
\end{aligned}
$$

Other modes will be detected with less efficiency. Although the multi-π^o events suffer in γ conversion efficiency, the good γ energy measurement solves the pairing ambiguity which plagues other techniques.

IV. CONCLUSIONS

1. The experiment proposed can measure branching ratios of isobars produced by diffraction dissociation independent of the final state.
2. Cross sections can be measured.
3. Some information on the dynamics of DD can be obtained from the angular correlations of the upper and lower vertices.
4. The large items to be provided by NAL are the bubble chamber and the spectrometer magnet.

REFERENCES

[1] K. Strauch, Remarks on Doing Strong-Interaction Physics Involving Multiparticle Final States in the 100-BeV Region, National Accelerator Laboratory 1968 Summer Study Report C.3-68-98, Vol. III, p. 281.

[2]T. Fields et al., A Hybrid Detector System for 100-GeV Strong Interactions, National Accelerator Laboratory 1968 Summer Study Report A.3-68-12 (Revision), Vol. III, p. 227.

[3]See, for example, the report by Florent et al., Nucl. Instr. and Methods 56, 160 (1967). I also acknowledge discussions with Dr. P. Kenny of Notre Dame on the feasibility of this technique.

[4]R. A. Carrigan et al., A Study of the Reaction $\pi p \rightarrow \Delta \rho$, National Accelerator Laboratory 1969 Summer Study Report SS-45, Vol. IV.

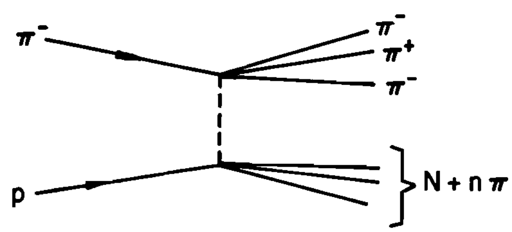

Fig. 1. Diffraction dissociation of a pion into three pions, accompanying resonance production.

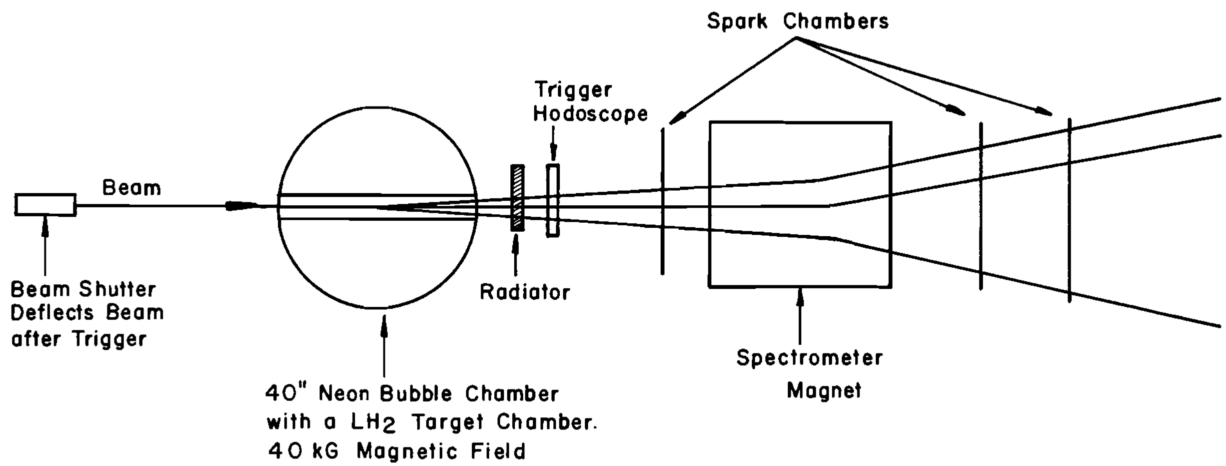

Fig. 2. Hybrid spectrometer for study of diffraction dissociation.