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A Novel Technique to Study Diffractive Baryon Resonances

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In a recent experiment at BNL we studied p-p interactions using the diffracted proton beam of 28.5 GeV/c momentum. Our Multiparticle Argo Spectrometer System (MASS) consisted of a high momentum spectrometer (HMS), a low momentum spectrometer (LMS) and a magnetic vertex spectrometer (VS). See Table 1. Its layout is described in Ref. 1. The system was designed to study all charged particles in the final states

$$p + p \rightarrow p_T + p_T + \text{charged particles} \quad (1)$$

$$p + p \rightarrow \pi_T^+ + p_T + \text{charged particles} \quad (2)$$

$$p + p \rightarrow \pi_T^+ + \pi_T^+ + \text{charged particles} \quad (3)$$

$$p + p \rightarrow p_T + \text{charged particles} \quad (4)$$

$$p + p \rightarrow \pi_T^+ + \text{charged particles} \quad (5)$$

The particles triggered upon are labeled with a subscript T and were mass identified. To measure the charges and momenta of the "charged particles" the vertex spectrometer (VS) was used¹. The detector consisted of 9 digitized cylindrical wire spark chambers immersed in a 10 KG magnetic field. The solid angle of the detector was about 4π and the momentum resolution was between 2% and 10% for a 1 GeV/c particle.

Let us now look at the simplest events among the over 3 million triggers:

Two prong events stem mainly from the reactions:

$$p + p \rightarrow p_T + p \quad (6)$$

$$p + p \rightarrow p_T + \pi^+ + n \quad (7)$$

$$p + p \rightarrow p_T + \pi^+ + n + \pi\pi^0 \quad (8)$$

$$p + p \rightarrow p_T + p + \pi\pi^0 \quad (9)$$

Elastic events can be readily identified by requiring coplanarity and satisfying the elastic scattering angle criterium. They are shown in Fig. 1. From the width of the elastic peak we conclude that the missing mass resolution is about $\pm 120 \text{ MeV}/c^2$. In Fig. 2 we display the MM distribution from the projectile proton averaged over the t region from $0.15 < -t < 1.0 \text{ (GeV}/c^2\text{)}^2$ for two prongs, after the elastic events were removed.

To isolate reaction 7 from the rest we calculated the missing mass to the high momentum proton and the positive particle in the vertex spectrometer assuming it to be a π^+ . We obtain a broad neutron peak sitting on a large background. Since we have not completed the kinematic fit to these events we do not plot

Table I - Spectrometer Characteristics

<u>Spectrometer</u>	<u>HMS</u>	<u>LMS</u>	<u>TS</u>
Solid Angle (mr^2)	33 x 10	180 x 47	almost 4π
Momentum Acceptance Δp (GeV/c)	5 - 28.5 ($p = 20$ GeV/c)	.6 - 10 ($p = 2$ GeV/c)	--
Resolution $\Delta\theta$ (mr)	$\pm .2$ ($p = 20$ GeV/c)	± 1.0 ($p = 2$ GeV/c)	± 4 (forward) ± 11 (side)
Resolution $\Delta p/p$ (%)	$\pm \frac{1}{2}$ ($p = 20$ GeV/c)	$\pm \frac{1}{2}$ ($p = 2$ GeV/c)	± 2 (forward) ± 10 (side) ($p = 1$ GeV/c)
Mass Identification	Yes	Yes	No
Data Rate (events/s)	100	40	20
CDC-660 Track Reconstruction Time (s)	.015	.025	1.5
Movement Time (hrs)	4	1	-

Fig. 1. Missing mass distribution from the HMS protons for elastic events.

Fig. 2. Missing mass distribution from the HMS proton for two prong events in the vertex detector. Elastic events were removed and the t cut $0.15 < -t < 1.0$ (GeV/c)² was imposed.

the π^+n effective mass distribution. The four prong events are more complicated since they can not be classified without a kinematic fit. The missing mass distribution from the projectile proton requiring four prong events in the vertex detector are plotted in Fig. 3.

Finally in Fig. 4 the missing mass distribution from the projectile proton is plotted for all multiplicities. The data suggest that the two prong final state strongly couples to a low mass baryon resonance or a series of resonance states in the 1.3-1.7 GeV region. It is also important to note that in contrast to the purely missing mass spectrum the enhancement is sitting on almost no background. The width of the enhancement is 500 MeV/c² suggesting that we observed both the $N^*(1400)$ and $N^*(1700)$ and that our mass resolution is not adequate to resolve them into two distinct peaks. Since the data presented were taken at a single HMS position $0.15 < -t < 1.0$ (GeV/c)², we have integrated over a region of momentum transfer where the $N^*(1400)$, which dominates the low t distribution, is still comparable in strength to the $N^*(1700)$.

The four prong data at the present level of statistics do not reveal any obvious structure in this t region.

It has to be emphasized that all the above two and four prong events were obtained by automatic pattern recognition programs without human intervention.

In conclusion we remark that we have demonstrated the practical feasibility of studying diffractive N^* -production with automatic spark chamber techniques. A more sophisticated analysis is in progress.

References

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Fig. 3. Missing mass distribution from the HMS proton for four prong events in the vertex detector.

Fig. 4. Missing mass distribution from the HMS proton for all multiplicities.