MULTIBODY PHOTOPRODUCTION AT NAL

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ABSTRACT

The possibility of performing multibody photoproduction experiments at NAL is reviewed.

Many of the experiments traditionally carried out only at electron accelerators can be extended to energies above 100 GeV at NAL. Among these, multibody photoproduction is an outstanding example. Either streamer-chamber or bubble-chamber detectors could be used with incident tagged photons, and either technique would yield event rates comparable to, or superior to, those obtained previously at energies an order of magnitude lower.

It is important to stress that the absence of a specific proposal at this early date does not reflect a lack of interest in this important subject; rather, it derives mainly from realistic considerations of the availability of a suitable detector and a high-resolution tagged-photon beam soon after NAL beams are first produced. It seems appropriate, therefore, to view multibody photoproduction as a likely second, or third, generation experiment that might occur after, for example, a photoproduction total cross-section experiment or a ρ-production experiment requiring less expensive detectors and a rudimentary tagged-photon beam.

The feasibility of studying multibody photoproduction in a bubble chamber has been discussed in a previous summer study by Ballam and Baltay.[1] Their rate estimates for a 25-foot bubble chamber are reproduced in Table I and assume 10^4 150-GeV/c electrons per pulse and a 0.02-radiation-length radiator yielding 150 photons per pulse. The rate is limited in the case of the bubble chamber by background e^+e^- pairs: These authors have assumed 10 pairs per meter giving 60 pairs and 120 tracks per picture in the 25-foot chamber. The event rates in a 15-foot bubble chamber would be scaled down by perhaps 15/25 = 0.6 but are, nevertheless, quite substantial. While it is doubtful that one would tag photons down to 0.5 GeV, it is clear from the table that a million-picture exposure could yield 50,000 to 100,000 useful events in the 15-foot chamber of which perhaps 10,000 would have incident photon energies above 100 GeV.

In a streamer-chamber experiment with tagged photons, it is possible to design a trigger for which nearly every picture contains a hadronic event. Conceptually, the trigger logic is equivalent to that used in the photoproduction total cross-section experiment at SLAC:[2] The tagging counters signal an incident photon with precision exceeding 99%, a shower-counter veto downstream of the streamer chamber indicates the absorption of a photon in the target, a scintillator surrounding the target verifies that an interaction has occurred, and narrow counters perpendicular to the beam in horizontal plane veto pairs bent out of the target by the magnetic field. The acceptance of such a trigger is virtually 4π, as in the bubble chamber.

The streamer chamber has important advantages over the bubble chamber at NAL where annihilation-photon or laser-photon beams are not practical and where the duty cycle is long. The fact that nearly every picture contains an event has already been mentioned. Second, since the sensitive time of the streamer chamber is short compared to the 1-sec beam spill, high interaction rates are possible with less than 1 e^+e^- pair per picture. Third, the cycling rate for large streamer chambers can be much higher (e.g., 10 per sec) than is presently planned for the 15-foot chamber at NAL. This permits a substantial increase in the total number of events or decrease in running time for a given number.

One option available to a streamer chamber at NAL is to tag only the upper portion (e.g., a 30% band) of the bremsstrahlung spectrum, as in total cross-section experiments using counters. Lower energies are easily obtained by lowering the incident electron energy. This option would greatly reduce the cost and complexity of the tagging system, particularly since high-energy photons are associated with low-energy final electrons, which are much easier to momentum-analyze and tag efficiently. The running time to cover the energy range above 20 GeV would still be less than that required by a bubble-chamber exposure with comparable statistics.

Table II suggests possible interaction rates in a multibody-photoproduction experiment using a large streamer chamber at NAL (typical dimensions: 2-m width, 1-m gap, 4-m length). A 1-m liquid hydrogen target is assumed, while the tagging rates are taken from NAL Proposal 25[3] for a 0.002-radiation-length radiator and the electron beam intensities estimated by Diebold and Hand.[4] A pressurized hydrogen-gas target could be used with somewhat higher tagging rates to yield the same number of events per unit time. The electron intensity increases rapidly with decreasing energy; thus, intensity is not a problem, although the peak energy for the experiment may vary somewhat.

REFERENCES

[1]J. Ballam and C. Baltay, Photoproduction Experiments in the 25-Foot Hydrogen Bubble Chamber, National Accelerator Laboratory 1969 Summer Study Report SS-135 Vol. II, p. 83.

[2]D. O. Caldwell, V. B. Elings, W. P. Hesse, G. E. Jahn, R. J. Morrison, F. V. Murphy, and D. E. Yount, Phys. Rev. Letters 23, 1256 (1969).

[3]D. Caldwell, V. Elings, A. Greenberg, B. Kendall, R. Morrison, and F. Murphy, Measurement of the Total Photoabsorption Cross Section on H, D, C, Cu, and Pb for Photon Energies from 26 to 125 GeV, National Accelerator Laboratory Proposal 25, 1970.

[4]R. Diebold and L. Hand, Electron-Photon Beam at NAL, National Accelerator Laboratory 1969 Summer Study Report SS-49, Vol. I, p. 153.

Table I. Numbers of Events Expected in a 10^6-Picture Exposure of the 25-Foot Hydrogen Bubble Chamber to Photons at NAL.

E_ν (GeV)	Events/μb	γp-hadrons	γp-ρp	γp-ωp
0.5-10	1250	150,000	18,750	1875
10-50	625	75,000	9,400	940
5	250	30,000	3,750	375
100-150	150	18,000	2,800	280
Total	2275	270,000	35,000	3500

Table II. Typical parameters for a Streamer-Chamber Photoproduction Experiment at NAL (1-m Liquid-Hydrogen Target).

E_{e^-} (GeV)	132	104
E_ν (GeV) (30% of spectrum)	86-125	69-98
Hours	54	13
Events (10,000/5-GeV bin) (100 μb)	80,000	60,000
Events/Pulse (1 sec spill/3 sec)	1.2	3.9
Pairs/Pulse	500	1600
Pairs/Picture (0.1 msec sensitivity)	0.05	0.16
Triggers/Pulse	< 2	< 6
Events/Picture	> 1/2	> 1/2