A HYBRID SPECTROMETER FOR ANALYZING INELASTIC REACTIONS WITH A SINGLE HIGH-MOMENTUM SECONDARY

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ABSTRACT

A streamer chamber with an internal hydrogen target along with a single-armed spectrometer downstream should be a very good way to analyze inelastic reactions with only one high-momentum charged secondary. The remaining particles will have low momentum, by momentum conservation, and only a moderate-sized streamer chamber (~ 1 meter) will be required to measure the secondaries at the target vertex.

A number of experiments have been proposed[1] which involve a single-armed missing-mass spectrometer to measure reactions of the type

A	+	B	→	A'	+	M. . .	(1)
(beam)		(target)		(high-momentum forward-peaked secondary)		("missing mass")	

A specific reaction of this type is backward inelastic $\pi^- p$ scattering where A' is a forward-peaked proton. The spectrometer yields measurements relating to three variables: the mass M, the momentum transfer, the incident beam momentum. However, much is to be gained by also detecting the particles that constitute M. To achieve the latter objective, we propose a hybrid system that combines the single-armed spectrometer with a streamer chamber surrounding the target to measure low-momentum secondaries.

The class of reactions most suitable to study with the proposed hybrid spectrometer has the properties:

1. The secondary, A', is in general a different particle than the beam particle A, and the cross sections for reactions of this type are small and decrease with increasing beam momentum.[2] An example of this type of reaction was reported by the Brookhaven and Carnegie-Mellon University collaboration.[3] Their experiment gave results on A_1^-, A_2^- and higher-mass bosons produced near 180° in $\pi^- p \rightarrow p\,(\text{missing mass})^-$ at 16 GeV/c. They collected less than 100,000 events in 45 hours of running at the AGS with a beam of 10^6 pions per burst incident on a 30-in. liquid H_2 target.

2. The particles constituting M have low laboratory momentum since A' carries off most of the incident momentum.

The combination of low cross section, (1), and low-momentum secondaries, (2), makes the streamer-chamber and spectrometer combination ideal for the class of reactions (1). Moreover, the total number of events is small, and the data-taking rate is not limited by the streamer-chamber dead time. The streamer-chamber memory can be reduced to a few μsec by adding a proper amount of impurity to the chamber gas mixture. By achieving this small memory time, there will not be more than one interaction per picture for $\sim 10^6$ particles/sec in ~10 cm liquid H_2 target. The secondaries in M having low momentum makes it possible to obtain accurate measurements with a moderate-sized streamer chamber (~1 meter in length).

In addition to backward inelastic $\pi^- p$ scattering, there are many other interesting reactions of type (1). With high-energy and high-intensity beams at NAL, exploratory studies can be made with all possible combinations of incident (A) and outgoing (A') particles. A typical experiment may have less than 10^5 pictures to analyze which could be handled by a relatively small university group with bubble-chamber measuring equipment. On the other hand, to be competitive in bubble-chamber analysis, it is becoming necessary to be able to analyze $\sim 10^6$ events/year which rules out many of the smaller bubble-chamber groups.

The combination streamer chamber and spectrometer we propose has features that make it superior to other techniques for the detection and measurement of reactions of type (1). An excessive amount of scanning with enormous number ($>> 10^6$) of pictures would be required with a bubble chamber to do the same experiments. Rapid-cycling bubble chambers with triggering of lights are an alternative for some experiments, but it is not likely that such systems will be able to probe the small cross sections or have the flexibility of a streamer-chamber hybrid system. The downstream spectrometer is important to accurately momentum analyze and identify the secondary A'. Techniques that use only wire spark chambers have not yet been successfully operated for multiparticle final states, whereas a streamer chamber, like a bubble chamber, gives good solid-angle coverage for an essentially unlimited number of secondaries. The streamer chamber required would be a state-of-the-art device.[4] A group at DESY has been able to successfully operate a streamer chamber with an internal liquid-hydrogen target, and the SLAC streamer-chamber group is working on very high pressure H_2 gas targets.[5] With either the liquid or high-pressure H_2 target inside the streamer chamber, the number of events obtainable is about the same as one gets with a spectrometer alone.

The most expensive elements of the proposed system either exist or will be constructed as standard items. The single-armed spectrometer part of the apparatus is the same as would be needed for a variety of other missing-mass experiments.[1] It will not be necessary to design a very high resolution spectrometer since there is the added information in the streamer chamber. A large bubble-chamber magnet or any good existing spectrometer magnet together with bubble-chamber cameras should be adequate for the streamer chamber. The remaining accessories including the streamer chamber itself, the Marx generator, the Blumlein, the gas purification system, all together should amount to less than $100,000.

REFERENCES

[1] Experiments of this type are included among those discussed in other reports of this summer study, in particular the report on inclusive reactions (SS-182) by Chien et al.

[2] The variation of cross sections with energy as related to the exchange of quantum numbers has been reviewed by D. R. O. Morrison on several occasions, for example, Proceedings of the Conference on High Energy Two-Body Reactions, State University of New York, Stony Brook, 1966, p. 192. Although the reactions we refer to are not necessarily two body as such, cross sections are expected to drop whenever the final state is in two groups, beam-like and target-like, which do not have the same internal quantum numbers as the incident particles from which they were formed. See also R. P. Feynman, High Energy Collisions (Gordon and Breach, New York, 1969), p. 251.

[3] E. W. Anderson et al., Phys. Rev. Letters 22, 1390 (1969).

[4] F. Villa, What is New in Streamer Chambers, National Accelerator Laboratory 1969 Summer Study Report SS-60, Vol. III, p. 129.

[5] A liquid hydrogen or high pressure (~10,000 psi) gas target is being constructed for an approved experiment with the SLAC streamer chamber (Proposal E-60, Hyperon Production in K_p^- Interactions, SLAC, U.C. Riverside, and LRL Berkeley collaboration).