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COMPARISON OF STREAMER CHAMBER AND BUBBLE CHAMBER

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ABSTRACT

Some features of a large streamer chamber for NAL are examined, and the capabilities of streamer chamber and bubble chamber are compared. While the streamer chamber will not completely replace the large bubble chamber, it appears that for many purposes a large streamer chamber would be a superior instrument.

I. INTRODUCTION

The streamer chamber is a triggerable 4π detector which records photographically the trajectories of charged particles. Since bubble-chamber groups are equipped to scan and measure pictures, it is pertinent to examine what advantage, if any, this device offers relative to the bubble chamber for strong-interaction studies at NAL.[1]

The streamer chamber currently operating at SLAC is $2 \times 1.5 \times 0.8$ meters[3] with a 12-kG field. The filling is neon gas at 1 atmosphere and interactions occur in a gaseous hydrogen target contained in a 12-mm diameter tube with 50μ thick walls. The tube can be filled with a variety of gases up to 10 atmospheres pressure. Interactions are recorded by three cameras on 35-mm film. The chamber is limited by modulator power supply to a pulse rate of 16 per second.

The streamer chamber at DESY has been operated with a liquid hydrogen target.

II. DIMENSIONS OF A STREAMER CHAMBER FOR NAL

In the SLAC chamber 3c physics has been successfully done at 18 GeV/c with a setting error of 560μ and 12-kG field. This setting error has since been reduced to

320μ. Extrapolating to 100 GeV/c and assuming a setting error of 300μ suggests that a chamber $5 \times 2 \times 1$ meters^3 with 24-kG field would be adequate.

Clearly the question of how the setting error scales with volume is a crucial one which we cannot answer. However, it is likely that the scaling factor will be considerably less than for a bubble chamber, since the streamer chamber has a low density gas filling and no moving parts.

Furthermore, the improved accuracy achievable for very high momentum by adding wire chambers downstream has not been considered in scaling the chamber and magnet dimensions. FAKE studies of the type described in NAL C. 4-68-57 are needed to determine the parameters for a 100 GeV/c streamer chamber.[2]

III. STREAMER CHAMBER RATES FOR UNSELECTED INTERACTIONS

For survey experiments the chamber will be triggered when an anticoincidence between downstream and upstream scintillation counters indicates that a beam particle has interacted in the target. For a beam averaging 10^4 particles/sec and a 1-meter long hydrogen gas target at 10 atmospheres there will be 5.4 interactions/sec for a cross section of 20 mb. Assuming that the chamber is down 25% of the time there are 360,000 pictures and interactions per day.

The corresponding rate for the 25-foot bubble chamber is 32,400 pictures per day assuming 1 picture every 2 seconds (realistic rate according to W. Fowler).

IV. OPERATION WITH SELECTIVE TRIGGERS

As pointed out by Hulsizer, one can achieve rates of 10/sec for events with cross sections $\geq 2\ \mu b$ for a beam particle flux of 10^8/sec.[3] This rate presupposes a highly selective trigger. In order to design a trigger, detailed Monte Carlo studies based on survey information are required. Here we can only indicate some of the triggering capabilities:

1. π^0 emission can be signaled by shower counters outside the chamber.
2. One can select events in the "deep inelastic" region, say maximum outgoing track momentum $< 0.9\ p_{beam}$.
3. One can trigger on low momentum transfer to the target particle.
4. One can trigger on the multiplicity of charged outgoing particles, setting a threshold or accepting only a fixed number of outgoing tracks.
5. The chamber can be operated in non-separated beams (e.g. hyperon beams) by making a mass selection with a DISC Cerenkov counter upstream.
6. Combinations of the above may be used.

V. ADVANTAGES OF STREAMER CHAMBER

1. Data acquisition in the unselective mode is an order of magnitude faster than bubble chamber.

2. In intense beams, the rate is about 1 event/sec for a 1 μb cross section.

3. There is one beam particle and one interaction per picture. The interactions are located in the target which facilitates scanning and automatic measurement.

4. There are no secondary interactions which reduce measurement accuracy in the bubble chamber for high multiplicity events.

5. Target material is easily changed. This may prove to be a considerable advantage if one considers the cost of filling a large volume bubble chamber with deuterium.

6. The chamber is well suited for study of neutral decays, because the decay length is much less than the interaction length.

7. Cosmic-ray background is down by a factor of 10^3 from bubble chamber of same volume because of the shorter sensitive time.

8. The chamber can operate in unseparated beams, e.g., hyperon beams.

VI. DISADVANTAGES OF STREAMER CHAMBER

1. The interaction vertex is not seen.

2. Less ionization information than in bubble chamber.

VII. CONCLUSIONS

While the streamer chamber will not completely replace the bubble chamber for work at NAL (e.g., for the study of interactions of secondary particles or for the study of new extremely short-lived particles), the streamer chamber in its present state of performance is already a powerful and very promising technique. A streamer chamber facility at NAL would considerably enlarge the area of physics accessible to bubble-chamber groups and for many purposes would probably be superior to the bubble chamber.

REFERENCES

[1] This question has also been studied by 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] I. Derado, A. Odian, and F. Villa, Proposal for 12 Meter Streamer Chamber, National Accelerator Laboratory 1968 Summer Study Report C. 4-68-57, Vol. III, p. 167.

[3]R. Hulsizer, Comments on Substituting a Streamer Chamber for the Bubble Chamber in the Hybrid Bubble-Chamber-Spark Chamber Detector Proposed by Fields et al., National Accelerator Laboratory 1968 Summer Study Report A. 3-68-95, Vol. III. p. 271.