WHAT IS NEW IN STREAMER CHAMBERS

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ABSTRACT

The report is a brief summary of significant developments in streamer-chamber technology at SLAC and elsewhere.

I. INTRODUCTION

In the last two years the streamer chamber has shown the capability of performing large scale experiments (Refs. 1-5) with certain unique advantages and disadvantages with respect to more established techniques, like spark chambers and wire chambers. The first photoproduction survey was performed with the simplest possible configuration, a first generation device (see Figs. 1 and 2). Since then a fair amount of development has gone into the technique at SLAC and elsewhere. This is an attempt to condense relevant features of the SC in the case that some non-specialist wants to design an experiment. I assume the non-specialist to be familiar with the principle and some technical details of the SC (see Refs. 6 and 7).

II. CURE OF THE OLD PROBLEMS

Flares and track distortions have been eliminated by making the chamber electrodes out of a fine mesh immersed in the NeHe gas. The credit goes to the DESY SC group which originated the technique (Ref. 8). The brightness fluctuations were cured by DESY and SLAC stabilizing the high voltage pulse (to a few percent) with specially designed spark gaps in the Blumlein pulse forming network.

III. ACCURACY

Point accuracy for straight tracks (high-energy muons and no magnetic field) is 120μ in the plane perpendicular to the optical axis of the cameras. This accuracy is diffusion limited; i.e., in absence of magnetic field the primary ionization diffuses during the delay ($\sim$ 750 nsec in our case) between the passage of the particle and the application of the high voltage pulse.

After the analysis of $\sim$1,000 events ($\gamma p \rightarrow \pi^+\pi^- p$ or $\pi^+\pi^+\pi^+\pi^- p$) in the SLAC chamber we find the setting error in geometrical fits to be $\sim 300\mu$ in space.

This has to be compared with 560μ [used last year in the 12 m streamer-chamber proposal (4-68-57)] that we needed for geometrical fitting of similar events in the old (1967) experiment. Figure 3 shows the standard deviation distribution for geometry fits, with a setting error of 8μ on film, equivalent to 560μ in space (since the demagnification is 70). The distribution of Fig. 3 refers to the old data and peaks at 1, meaning that the choice of 8μ is correct. The distribution of Fig. 4 refers to the new data and peaks at ~0.55, meaning that the correct setting error is 0.55 × 8μ. The corresponding error in space is therefore 0.55 × 70μ = 308μ. This improvement comes from a better knowledge of the magnetic field, better optical constants, better lens distortion functions.

I believe that a reasonable ultimate setting error will be about 200-250μ*; a relevant number is the diffusion limited accuracy in magnetic field (20 kG) estimated at 90μ.

In Fig. 5 is the mass spectrum of the V events seen in the SLAC SC. There is a e^+e^- peak (low-energy photons converting in the NeHe gas), a K^0 and Λ peak. Figure 6 shows the K^0 mass region, with the mass value obtained (498.11 ± 0.40 MeV) and the resolution (8 MeV). The DESY SC is currently using a setting error of 380μ in space (Ref. 8).

IV. MEMORY

The memory of a SC filled with very pure NeHe is very long (~ 1,000 μsec). Very small amounts of impurities (like air, 0.1%) reduce the memory to a level of ~50 μsec. Some tests were made at SLAC in order to reduce the memory by adding controlled amounts of electronegative gases. Unfortunately the gas used reduced not only the memory time but also the light output. Recently the Russians (Dolgoshein, et al.) tried SF_6(sulfur hexaflouride) in very small amounts (10^{-7} Torr): the memory is reduced to 1 μsec without appreciable loss of light (Ref. 9). DESY's SC is presently running a photoproduction experiment with SF_6 poisoning.

V. TARGETS

A gaseous hydrogen target (maximum pressure 10 atm, 12 mm diameter tube, 50μ thick mylar walls) was used at SLAC. This target is approximately equivalent to 3 cm of liquid hydrogen. Very high pressure targets (like 100 atm) with 50μ thick walls (of glass or other super strong filaments) and about 1 cm diameter are under construction and testing at SLAC.

DESY has successfully operated a liquid H_2 target in the SC. The target is a

*It is also important to mention that our measuring machine (SPVB) has a least count of 2.5μ on film, and that the accuracy quoted (300μ in space) corresponds to less than 2 least counts.

cylinder 25-mm diameter, 40-mm long, and it is surrounded by a 4π scintillation counter (Ref. 8). A liquid hydrogen target is almost completed at SLAC and will be tested next year.

VI. IONIZATION MEASUREMENTS

Ionization information has been routinely used in our γp experiment. Protons with momenta less than 800 MeV/c can be distinguished from minimum ionizing π's if their trajectory is at an angle larger than $\sim 45^{\circ}$ with the electric field in the SC. Above this angle, the track goes from a streamer mode to a spark mode where the brightness does not depend upon the specific ionization but rather upon the angle between the track and the electric field. No attempt was made to measure the specific ionization. In other words, we can only say if a track is heavier than 1.2-1.3 times minimum and from the knowledge of the momentum we can decide if a track is a proton or not (or in some cases, if it is a $K^{\pm}$).

Another appealing feature of the SC is the ability to measure the relativistic rise of ionization, under particular conditions (in He, at 0.6 atm, and looking at tracks with an image intensifier, Ref. 10). After having measured the relativistic rise for electrons, the authors estimate track length necessary to distinguish p, π, K of a given momentum with 95% confidence. The results are in Fig. 7 (reprinted from Ref. 10).

VII. DATA RATE

In the last γp experiment we accumulated $\sim 10^5$ photoproduction events from a bremsstrahlung beam at 18 GeV peak in about two weeks. The ratio of number of pictures with a useful strong interaction to the total was 1:5. The pictures with no strong interactions are either blank, or show one or two e^+e^- pairs, which are easily rejected by a scanner. We kept our deadtime at 300 msec during the experiment; for the next experiment we are modifying the modulator power supply to reach a dead time of 100 msec, which is approximately the deadtime of our cameras. If faster cameras with larger magazines can be developed, I feel that a data rate of 50 pictures/sec is entirely feasible for the SC.

VIII. DATA ANALYSIS

Our geometrical reconstruction program SYBIL (Refs. 11 and 12) has been used with a special kinematical fitting program TEUTA to analyze the γp experiment. The two programs are tailored to our SC magnet system, but other bubble-chamber programs (like TVGP) could be used. So far we have measured our film with manual measuring machines (SPVB and NRI) but the inherently high data rate of the SC can be better utilized by automatic or semi-automatic measuring machines. Some progress has been made in this direction. At SLAC the HUMMINGBIRD flying spot digitizer is being modified to accept our SC format (3 views, 35 mm double frame). Some events on our old film have been successfully measured on SMP machines (Ref. 13).

IX. FUTURE PLANS

The SLAC chamber has been moved to the central beam area where a large variety of charged and neutral beams is available. The next experiment planned is a K^o_L decay (Ref. 14) scheduled to run in September of this year. We plan to accumulate 2×10^5 $\pi\mu\nu$ decays, 2.8×10^5 $\pi\mu\nu$ decays, and 0.9×10^5 $\pi^+\pi^-\pi^o$ decays. For this experiment we have modified the SC completely, adding counters and high-Z showering plates to distinguish π and μ from e in the sensitive volume. The SC gap has been increased from ±30 cm to ±40 cm, which is the maximum practical depth we can fit in our magnet.

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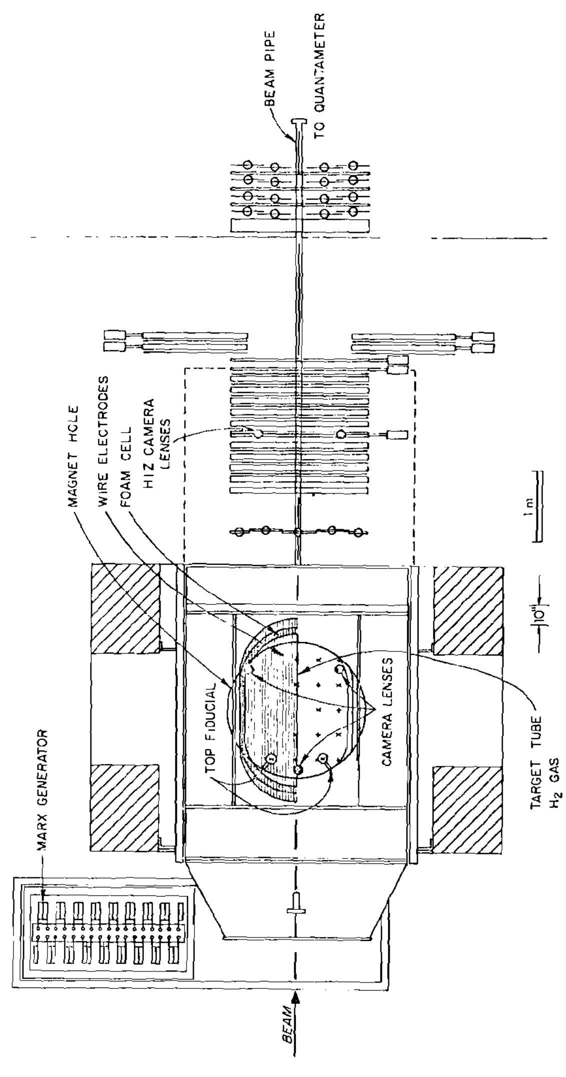

Fig. 1. Streamer-chamber system layout, plan view.

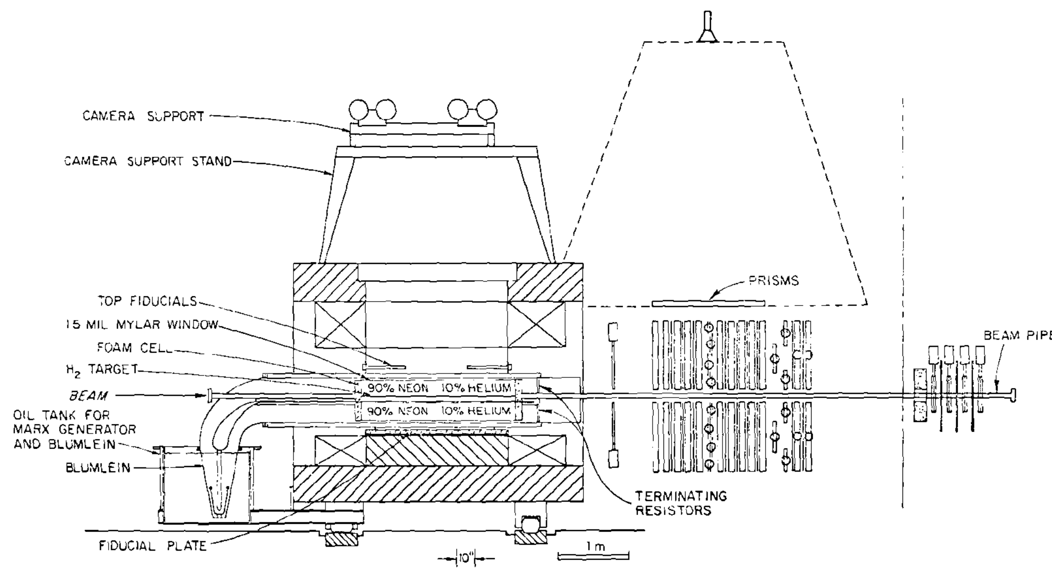

Fig. 2. Streamer-chamber system, elevation.

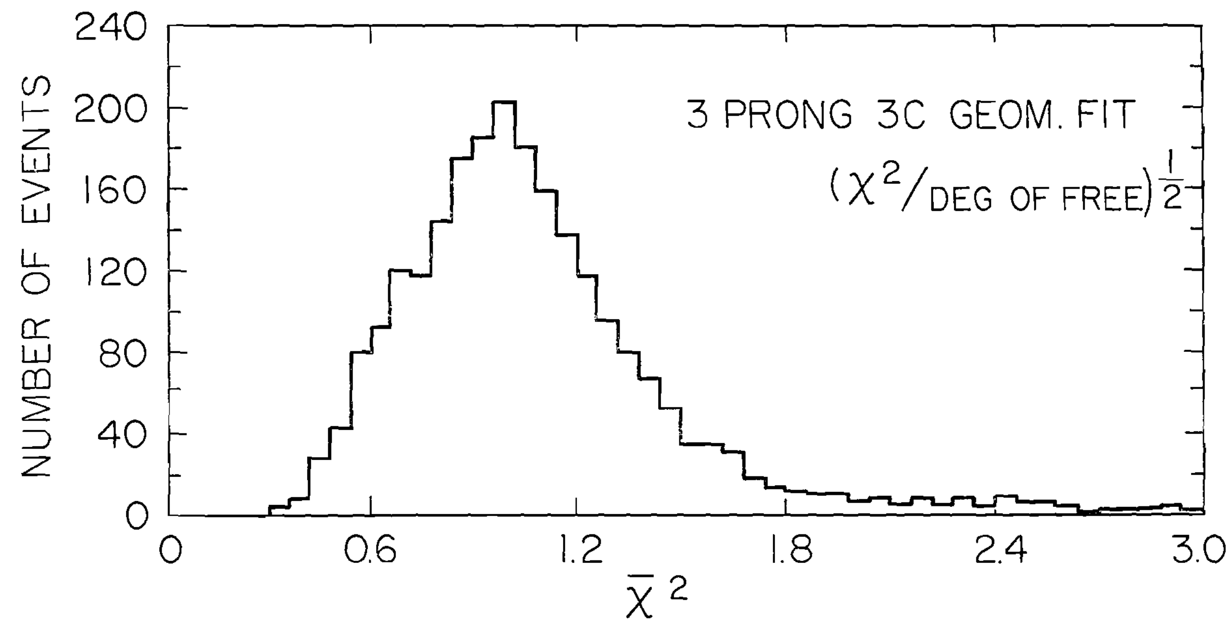

Fig. 3. Goodness-of-fit test for 3-prong 3c events.

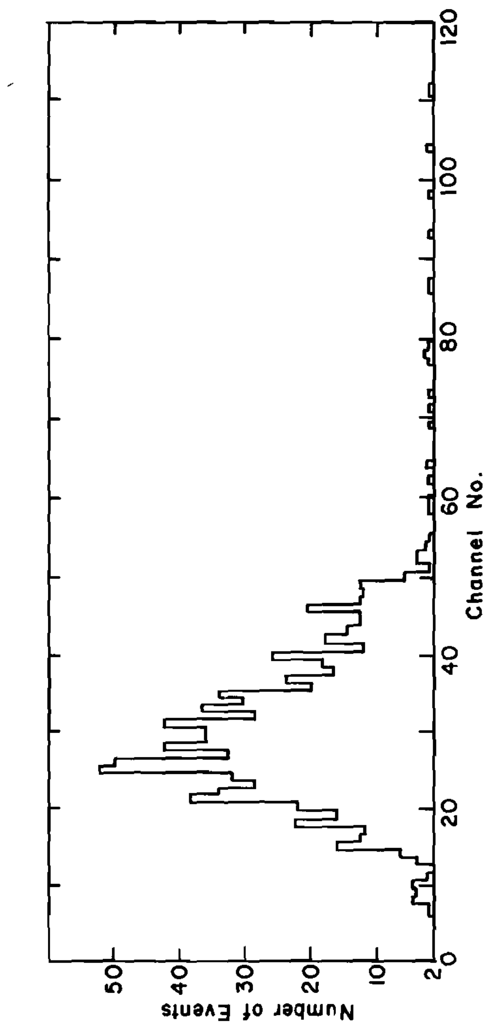

Fig. 4. Goodness-of-fit test for new data.

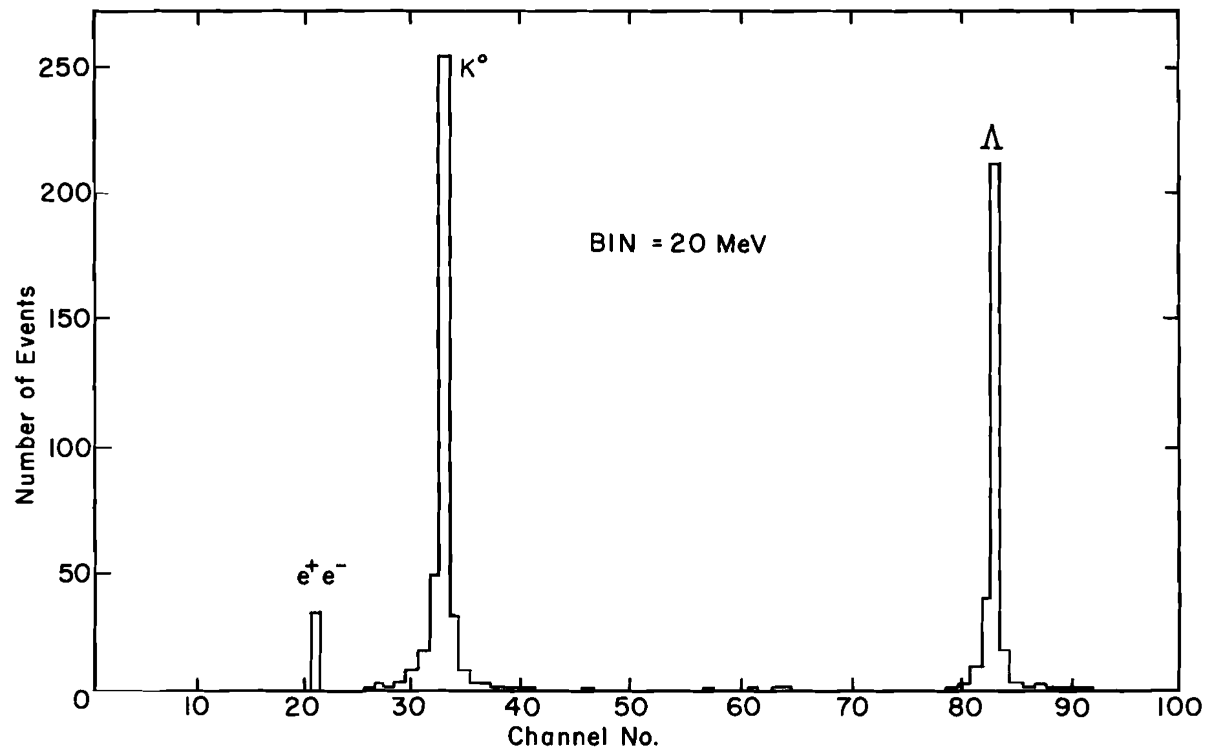

Fig. 5. Mass spectrum of V-events in streamer chamber.

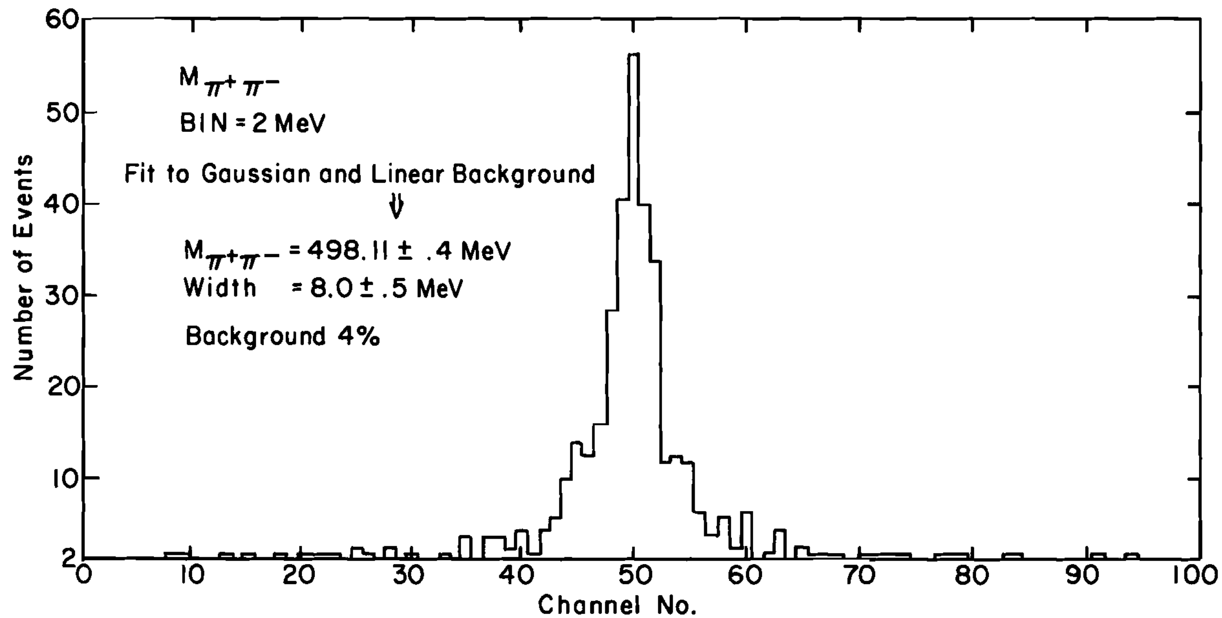

Fig. 6. Mass spectrum of K^o region, showing resolution obtained.

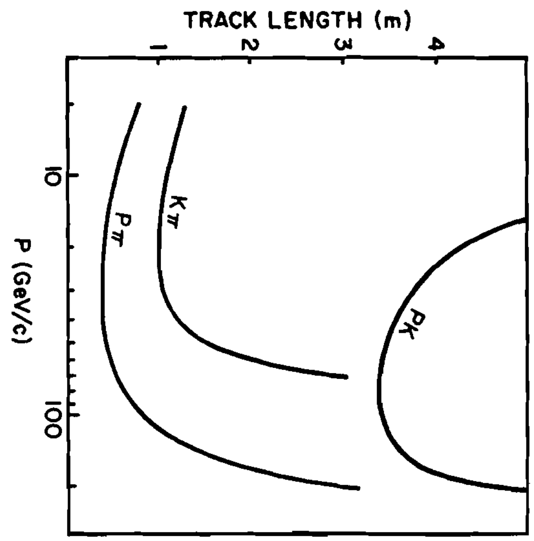

Fig. 7. Track length required to distinguish pairs of particles.