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USE OF STREAMER TUBES IN A LARGE
CALORIMETRIC NEUTRINO DETECTOR

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ABSTRACT

The spatial resolution of the fine grained neutrino calorimeter of the CHARM Collaboration is being improved by adding a new system of aluminium tubes, working in the limited streamer mode, to the existing detector planes of proportional tubes and scintillators.

One third of the whole system of 20 000 wires is already in operation. The characteristics and performance of the streamer tubes are described.

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1. INTRODUCTION

This paper reports on improvements of the fine-grained calorimetric detector of the CHARM neutrino collaboration aimed at obtaining a better spatial resolution in the measurement of hadronic and electromagnetic showers.

The target calorimeter of the CHARM detector¹⁾ is composed of 78 modules, each one consists, in the beam direction, of a 3 m x 3 m x 8 cm marble plate followed by a plane of 128 proportional drift tubes, each tube with a cross-section of 29 x 29 mm² and 4 m in length and a plane of 20 scintillators each of 3 cm thickness and 15 x 300 cm² surface area. The proportional drift tubes and the scintillators are oriented at 90° to each other. Both together measure the energy and the direction of particle showers produced in the interaction of neutrinos.

A plane of 256 aluminium tubes, working in the limited streamer mode, will be added to each of the 78 modules, oriented at 90° with respect to the proportional drift tubes. In this way crossed tubes will sample the shower every target plate giving both coordinates.

Streamer tubes are very well suited for application in a calorimeter because:

- i) The tubes have a cross section of only 9 x 9 mm thus ensuring a good spatial resolution and giving the possibility of constructing a detector plane of only 12 mm thickness.
- ii) The response is uniform on large transverse dimensions (the surface of each of the 78 planes is 285 x 265 cm).
- iii) The working conditions are uncritical (the length of the HV plateau is 500 V and the gas mixture can be varied by about 20% without affecting the efficiency).
- iv) The output pulses are large, thus the electronics can be very simple.

At present the detector has been equipped with 24 planes making a total of 6144 sensitive wires. The experience of running this large streamer tube system is very satisfactory.

2. THE STREAMER REGIME

High current discharges have been observed in wire chambers by several authors in the last few years. A discussion of these regimes and an almost complete list of references can be found in ²⁾. The experimental possibilities for detectors working in the streamer mode have been widely investigated by the

authors of ref. 3) and two experiments have already used this technique⁴⁾⁵⁾. The characteristic features of the streamer mode are the thick sense wire ($50 \div 100 \mu\text{m}$) and the high percentage of the organic quenching gas ($25 \div 75\%$); hence large wire signals ($> 10 \text{ mV}$ on 50Ω load, width $30\text{--}50 \text{ nsec}$) and a wide high voltage operation range (several hundred volts) are obtained. The dead time in the region of the discharge ($\sim 1 \text{ cm}$) is of the order of $100 \mu\text{s}$. For the application in the CHARM detector we have chosen aluminium as cathode material, stainless steel wire $50 \mu\text{m}$ in diameter and a gas mixture 1 : 3 of argon-isobutane; with these conditions and taking into account the transverse dimensions of the tubes, the high voltage has to be set at about 3.8 kV and the mean output pulse is 15 mV on 50Ω load, in parallel with a 100 pF load.

CONSTRUCTION OF THE STREAMER TUBES

One plane of streamer tubes is made of 16 chambers with 16 channels each (see fig. 1). It covers an area of $285 \times 265 \text{ cm}^2$. The chamber itself is built of 2 extruded Al-profiles (Pandolfo, UNI 3569) of 8 channels, glued together with epoxy to form one unit. The square channels have $9 \times 9 \text{ mm}^2$ inside dimensions and a wall thickness of 1 mm inbetween adjacent channels.

Before the assembling of a chamber the extruded profiles were degreased and cleaned in a bath of perchlorethylene. The $50 \mu\text{m}$ stainless steel wire is stretched with a force of 1 N and blocked at the ends by conical pins. Its position in the tube is determined by 6 Mylar spacers equidistant along the wire.

The ends of each chamber are sealed by plastic caps which are glued on with epoxy and which also locate the blocking pieces of the wires. One of the end-caps is used for the gas inlet and outlet and to house 16 resistors of $1 \text{ k}\Omega$ to apply the HV to each tube. For reasons of mechanical constraints of the existing detector elements each channel is connected via a 125 cm long coaxial cable (RG 58 C/U) to a printed circuit board. This card is accessible from outside the detector and is used to apply the HV to all 16 channels and to decouple the signals from it (coupling capacitor $C = 1000 \text{ pF}$, 6 kV). The gas is supplied via 85 cm long copper tubes (2 mm inside diameter) to each chamber from a gas distribution, common for each plane.

The construction of a plane of streamer tubes had to be as flat as possible and flexible enough to allow the mounting in the restricted space available, $\approx 15 \text{ mm}$ gap. Consequently the 16 chambers, forming one plane, were glued together with an elastomer and constrained by two stainless steel bands, each 40 mm wide and 0.3 mm thick and glued on with epoxy. Each plane is suspended in the detector on 80 cm long steel bands of the same kind.

4. ELECTRONICS

The electronics were designed to perform within the following constraints:

- mean number of tubes hit per event 660
- max number of tubes hit per plane per event 210
- to accept a maximum of 40 events before a CAMAC transfer
- to accept a second event 10 μ s after first event
- to reject an event by a slow trigger (second generation decision).

The logic was arranged as in diagram 2a. The data originates on the card (daughter card) plugged directly on the printed circuit board at the end of the coaxial cables, 16 channels wide. These cards accept any streamer pulse above the threshold set to 20 mV on 1.8 k Ω , in parallel with 100 pF of cable capacity and generate a TTL pulse $\approx$ 2.5 μ s wide, with a total dead time of $\approx$ 6 μ s to overcome after pulsing problems. This pulse is then latched by the trigger and writes the FIFO buffer 5 μ s later if there has been no slow trigger.

After the machine burst the FIFOs are read in parallel and then their outputs are scanned by the readout box suppressing zeros and buffering 1 event $\approx$ 1K 32 bit words, before a CAMAC block transfer.

The readout box generates the control bus signals, initialize, fast trigger, FIFO write, FIFO read, and data select. The data selected depends on the address, which is decoded by the data routing system. This system is based (diagram 2b) on two other cards, a "mother" card routes the data from 16 daughter cards, and a "grandmother" card routes the data from 12 "mother" cards. The address bus from the readout box drives 7 "grandmother" cards.

5. TESTS AND PERFORMANCES

For each tube an HV plateau using a cosmic ray telescope was made. The typical efficiency curve for a chamber of 16 tubes is shown in fig. 3; the spread indicated in the rising part is the total spread over 160 chambers and includes: the individual response of the chamber due to its constructional details, the uncertainty in the gas mixture setting^{*)} and the differences between the electronic cards. Over the plateau region the mean amplitude of the pulses, the width of the pulse height spectrum and the probability of giving secondary streamers increase, giving some cross talk. With the threshold used, the cross talk

^{*)} A variation of 20% in the isobutane fraction shifts the plateau of 100 $\div$ 150 volts.

level is about 1% at 4.0 kV. The single's rate of each tube is 14 Hz when the tube is completely unscreened and is reduced by about a factor two when it is installed in the set-up. For the whole plateau region there is no change in that rate. In the set up, without the beam, each plane absorbs an average current of .7 μ A, that corresponds for one tube to the standard figure of $\sim .4$ nA/Hz, characteristic of the streamer regime. With the first prototype possible deteriorations of the inner aluminium surfaces, due to isobutane degradation and to high rate discharges, were also studied. About 6×10^9 pulses were induced on a small region (~ 1 cm) of a tube without any change in its behaviour; the total charge collected on that region was ~ 2.5 C.

The good performance of the first 24 streamer tube planes installed in the set up can be summarized as follows:

- i) it is demonstrated that aluminium streamer tubes operate stably and reliably; about 6000 tubes (more than 16 km total length) operating for ~ 1000 hours have manifested no faults;
- ii) the detection efficiency of a plane for traversing μ 's $\sim 94\%$;
- iii) the spurious hit probability is less than 10^{-4} per tube.

The improvements in track and shower reconstruction are currently under study.

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- FIGURE CAPTIONS -

Fig. 1 - Schematic of a streamer tube plane

Fig. 2a - The daughter card logic

Fig. 2b - The data routing system

Fig. 3 - Chamber efficiencies

fig.1

(THE COMPARATOR WORKS
AS A MONOSTABLE)

fig.2a

fig.2 b

fig. 3