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ELECTRODELESS PLASTIC STREAMER TUBES

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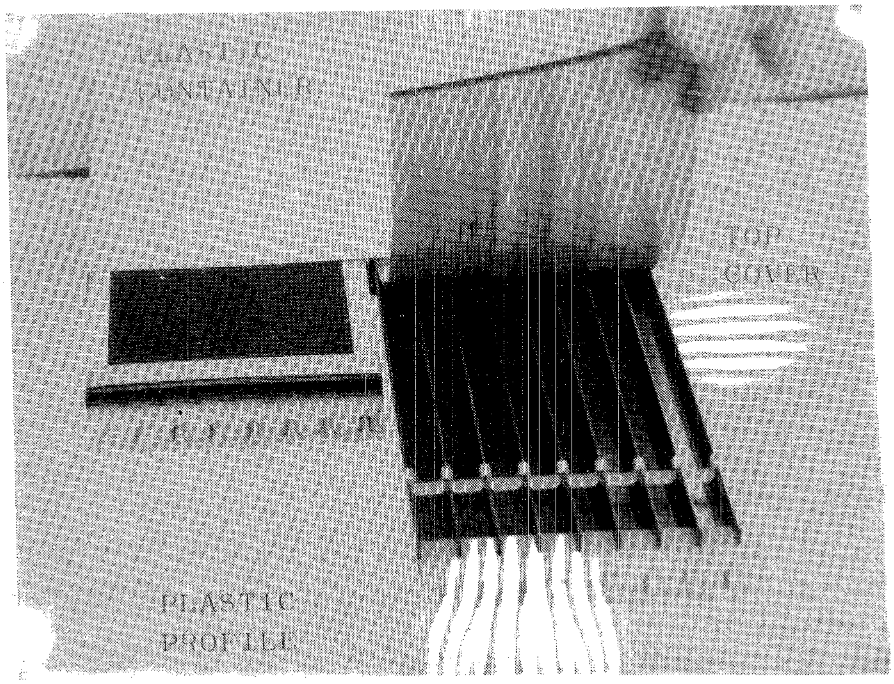
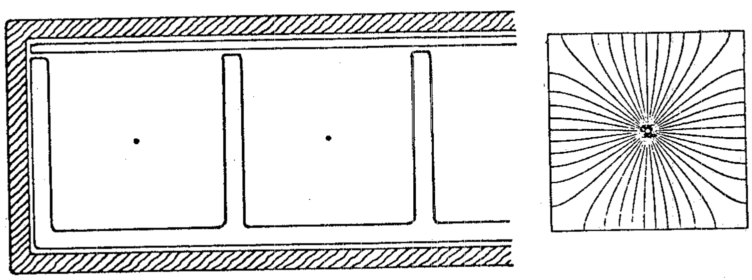
Making use of the electrodeless drift chamber idea(1), we have tested plastic streamer tubes with three sides of the square cross section coated with graphite, and the fourth side being left electrodeless. This simplifies the structure and the construction of plastic streamer tubes of the type developed for the Mont Blanc proton decay detector(2). The basic structure of this device together with a picture to show the essential details, is in Fig. 1a. It consists of an extruded PVC profile, shaped as an open 8-cell element where the 100 μm anode wires are stretched along. A PVC cover is placed on top of it to close the 8-tube element. Both the top cover and the open profile are coated with graphite, on the side facing the wires, acting as the resistive cathode of the device. The 8-tube element is inserted inside an extructed PVC container. External pick-up electrodes are used to detect induced pulses, transmitted through the resistive cathode.

The simplified structure we have tested is shown in Fig. 1b: we have simply got rid of the top cover, the top face of each tube element now being the inner surface of the plastic container, which is not coated with graphite. We have tested the cover-less tubes, with external pick-up strip elements, and compared their operation features with those of standard tubes. When the anode wire voltage is turned on, the positive ions produced in the gas by the streamer process, drift toward the insulated top side, and deposit there,



(a)



(b)

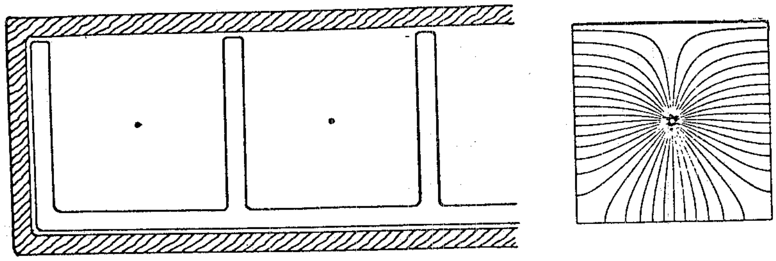


FIG. 1 - (a) The basic structure of the Plastic Streamer Tubes, together with the field lines for the tube element; (b) The geometry and the electric field lines for the cover-less Plastic Tube.

reshaping the electric field, until all lines of force from the wire will eventually end only on the graphite cathode. The electric field shape calculated for the square-cathode, together with that for the cover-less one, are also shown in Figg. 1a, 1b.

The singles counting rate vs. H. V. curves for the standard and cover-less tubes are shown in Fig. 2. The gas mixture is A + Isobutane (1 + 3) and the discriminator threshold is set below the minimum streamer pulse height. The only difference appears to be a 150 V shift to higher voltage of the cover-less tube plateau curve. Those curves are obtained with a non collimated ^{90}Sr source spreading over about 100 cm^2 of tube surface. They do not change when the tubes count only local radioactivity and cosmic rays.

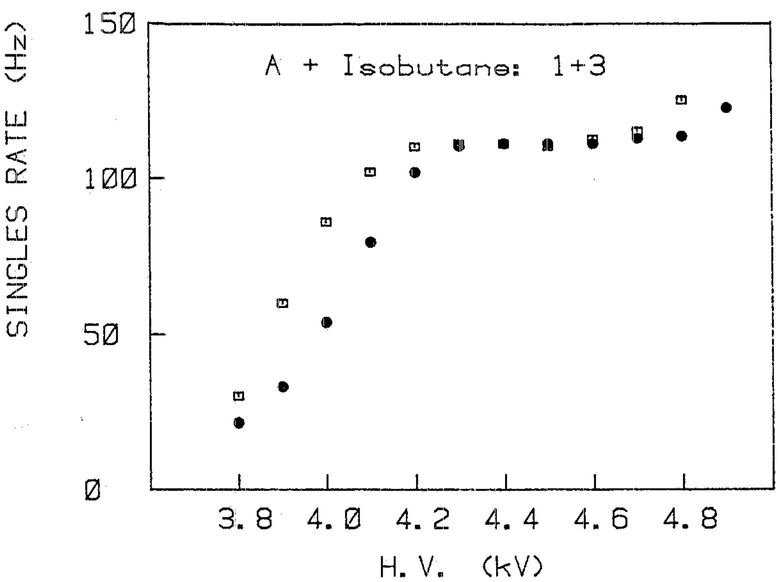


FIG. 2 - Singles counting rate vs. H. V. curves for standard tubes (squares) and cover-less tubes (dots): 9 x 9 mm^2 cell, 100 μm wire.

The pulse height distribution of the wire pulses from the cover-less tubes is shown in Fig. 3a, as measured at the beginning of the efficiency plateau (4.45 KV), with the non collimated ^{90}Sr source. Due to the practically isotropic track distribution, the single and double streamer peaks are clearly visible in the spectrum, followed by the tail of higher streamer multiplicity. The spectrum does not show any substantial difference with respect to the distribution obtained with the standard tubes (Fig. 3b), at 4.3 kV, which is the corresponding voltage with respect to the plateau curve.

The authors of the papers on electrodeless drift devices have pointed out the long charge-up time (several minutes), and the very long discharge-out time (few days), which

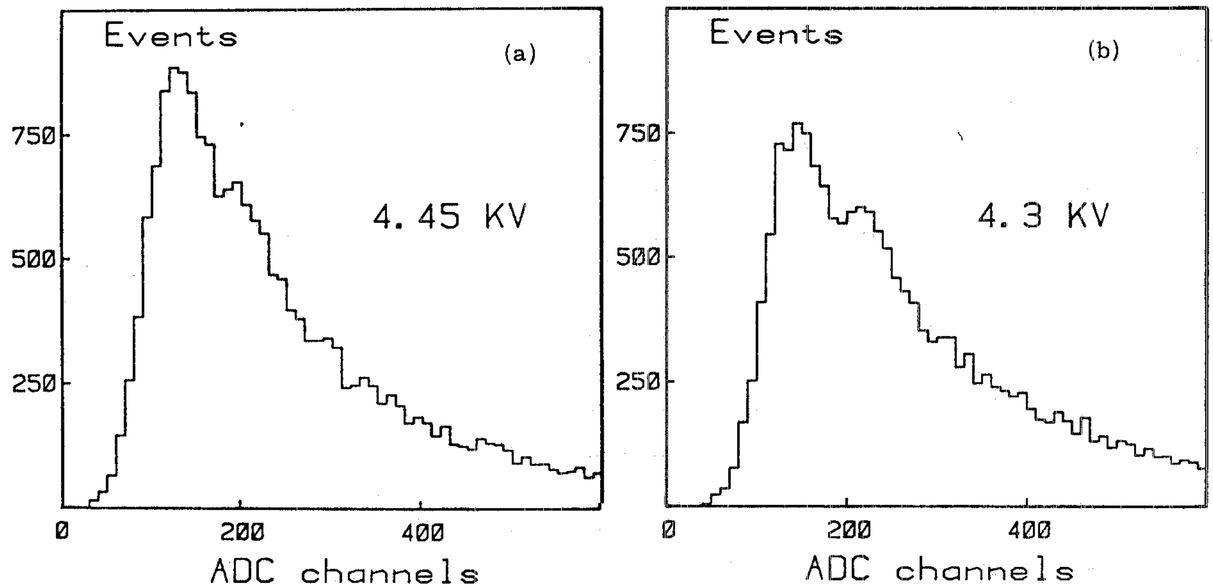


FIG. 3 - Pulse height distribution of the wire pulses for the cover-less tube (a) and for the standard tube of Fig. 2 (b).

characterize this kind of devices and make tedious their testing. In our case due to the very small extension of the drift space and the large amount of ionic charge produced in the streamer process, the charge-up time is negligible, even at the lowest counting rate condition. Due to the small drift distance involved, also the discharge time is shorter, but in any case non negligible for simple testing procedures. However we have worked out two rather simple methods to measure counting rate plateaux In one case, the positive charge accumulated on the insulated tube side is neutralized by electrons produced in a low current discharge, obtained by applying a reverse voltage (~ 1000 V) with pure Argon in the tubes. In the other case, the high voltage is kept at a constant predetermined value, coincident with the operation H. V. with the standard gas mixture, while the gas mixture is varied: curves are obtained which have the same shape and meaning of the standard voltage curves.

The rigidity of the tube container and the small extension of the electrodeless surface, make the device uncritical as far as mechanical deformations are concerned, which can affect the electric field shape for a long time, if the new equilibrium requires a decrease of the positive charge deposited on the insulating surface. We have verified that changes of few torr in the differential gas pressure, which in practice are the only cause of change of geometry, do not induce appreciable change in the streamer charge response.

Two standard tube modules (32 tubes, 3.5 m long) in the Mont Blanc detector have been substituted with two cover-less modules, for a long term test of the new structure, in extreme low rate condition (~ 30 Hz/m^2).

It is clear that in the cover-less tube structure in Fig. 1b, the multicell plastic profile can be substituted with a metal profile. This would avoid the graphite coating, which is a simple operation, while, on the other hand, the metal cathode would exhibit several problems. The first one concerns streamer operation, which is less comfortable with metal cathodes, which require more quenching gas mixtures to avoid afterpulse generation, due to electron extraction from the cathode by U. V.[3]. Induced pulse detection is affected both in flexibility of application, only one side being left for external pick-ups, and in the pulse height available, which is only 1/4 the total streamer charge for the metal profile instead of 1/2 for the resistive cathode. Furthermore one would loose most of the constructive simplicity of the plastic tube device, which relies essentially in the use of thermoplastic materials and their technology. In the limits, should one not care about the loss concerning induced pulse detection, in our opinion it is convenient in any case to use plastics coated with graphite, without any care on resistivity, which makes the coating a trivial operation.

The electrodeless plastic tube device looks to be open to further developments. We are testing plastic tubes with only the side walls coated with graphite, and top and bottom sides uncoated. This configuration opens the possibility of making rectangular cells with narrow gaps, while maintaining the wire spacing around 1 cm. In this case the structure is exactly the same of the long electrodeless drift device, but on a small scale, and not to measure drift but in view of compact digital calorimeters.

In conclusion we want to point out that the cover-less plastic tubes exhibit a noticeably simplified construction ($\sim 30\%$ manpower reduction), while do not exhibit appreciable difference in performance. On the other hand its specific limitation in operation condition, that is the long time needed to readjust the surface charge distribution if the working H. V. is lowered, appears to be not relevant in an experiment.

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(3) - G. Battistoni et al., Influence of Gas Mixture and Cathode Material on Limited Streamer Operation, Frascati report LNF-83/1 (1983).