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TWO-DIMENSIONAL DRIFT CHAMBERS

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Drift chambers have often been envisaged for many applications requiring large surfaces of detection, at a minimum cost. In most applications three planes with three different drift directions are necessary to determine a point in space, in order to solve two distinct types of ambiguities:

i) the right-left ambiguity. The measurement of the time of drift does not tell us on which side of the wire the particle passed;

ii) the ambiguity arising when several particles cross the chambers.

A Heidelberg Group has developed different methods of solving the ambiguities. The right-left ambiguity is lifted by using, instead of one single sense wire, a triplet of wires, namely two sense wires separated by a shielding wire[1)].

The multiparticle ambiguity is lifted by using the strict time correlation between the pulses on the sense wires and the pulses induced on cathode wires orthogonal to the sense wires[2)].

This last method is inadequate in chambers with a structure leading to a uniform drift field, which require cathode wires or strips parallel to the sense wires. This structure presents, however, considerable advantages since it leads to a total freedom in the sense wire spacing in drift chambers and can be adapted to magnetic fields[3)]. Thin chambers, of 1 cm total thickness, with wire spacings of 5 cm or 10 cm, can be constructed, with an accuracy of better than a fraction of a millimetre.

We have investigated several methods of measuring the position of the avalanches along the sense wire. Since the two coordinates of an avalanche are simultaneously determined, no ambiguity is introduced by the passage of several particles in the chamber, provided they do not cross the drift space around the same wire. The current division method has been tested, and preliminary results by us and Rubbia's group have shown that accuracies of the order of a fraction of a centimetre could be envisaged for chambets of the order of 1 m long but at a rather considerable cost per wire. We have then proposed "delay line" methods for measuring the coordinate along the wires.

A strip line, of 4 mm width and 0.1 mm thickness, is placed on the cathode, parallel to the sense wire. The induced pulse propagates to each end of the line. By measuring the differences in the times of arrival at the two ends of the line, the position of the avalanche along the wire can be obtained. The first results, presented at the 1973 Frascati Conference on Instrumentation for High-Energy Physics, showed that an accuracy of $\sigma = 2$ mm could easily be obtained in a 20 cm chamber. It appeared to us that this method was much easier to implement than the current division method.

Figure 1 shows the delay line, made of a printed circuit with 9 lines per mm on one face of the plastic strip, and a continuous copper layer on the other face.

Figure 2 shows the resolution and linearity obtained with this chamber, using a collimated ^{55}Fe X-ray source.

However, it appeared that it was difficult to extend this method for large dimensions. The resistance of the line was 150 Ω, twice the impedance of the line. We had thus a non-negligible attenuation.

We then found another construction method which gives much better results. The line is made simply with a thin wire wound around an insulated wire. We found it very easy to build delay lines with characteristic impedances varying from 100 Ω to 1000 Ω with delays varying from 1 nsec per cm to 4 nsec per cm. We have tried such a delay line, 20 cm long, in a chamber and the result is illustrated in Fig. 4. The accuracy was varying from $\sigma = 2$ mm to $\sigma = 4$ mm depending on the position along the wire, as seen from Fig. 4.

The considerable advantage of such a line is that it should permit a synthesis of the best features of the different drift chambers so far used, with a construction illustrated in Fig. 5:

1. The Heidelberg method of removing the right-left ambiguity by using the thin delay line as the shielding wire between the sense wires.
2. The structure of cathode wires at rising potentials to give a constant drift field.
3. The two-dimensional read-out for each sense wire, thus removing the need for three coordinate measurements to cure the multiparticle ambiguity.

Such a chamber should be suitable for two important applications:

i) Structures of a large size. The resistance of our line of 20 cm was 3 Ω, for an intrinsic impedance of 200 Ω; the attenuation is thus negligible even for metre-long lines.

ii) Cylindrical chambers. The accuracy along the line is indeed worse than the accuracy in the drift direction. However, we believe that we are far from having optimized this measurement.

There is indeed a loss of accuracy in the vicinity of the delay line; either because of the scattering in the line or because of the ambiguous region between the sense wire and the delay line. However, since our construction is compatible with large drift spaces, the ambiguous regions can represent only a negligible fraction of the total surface of the chambers.

It seems to us that such a method should lead to the cheapest and simplest automatic detector per unit surface so far realized, and it is worth serious effort to develop it.

We are indebted to Mr. R.E. Benoit for the construction of the first type of printed delay line and for his constant help in developing prototypes.

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REFERENCES

1) A.H. Walenta, J. Heintze and B. Schülein, Nuclear Instrum. Methods 92, 373 (1971).

2) A.H. Walenta, Two-dimensional read-out of drift chambers, Proc. Int. Conf. on High-Energy Physics, Batavia, 1972 (Chicago, August 1972).

3) G. Charpak and F. Sauli, Nuclear Instrum. Methods 108, 413 (1973).

Figure captions

Fig. 1 : Strip line 4 mm width, 1/10 mm thick, one side is 10 μm of Cu, the other is a zig-zag of copper with nine lines/mm in the cathode plane, facing the sense wire of a drift chamber, at a distance of 3 mm.

Fig. 2 : The response of the strip line. The time interval between the pulses arriving at the two ends of the line is measured.

a) The two peaks correspond to a source of ^{55}Fe displaced by 1 cm along the wire of a drift chamber. The accuracy corresponds to σ = 2 mm.

b) Variation of the time as a function of position.

Fig. 3 : Properties of some thin helicoidal lines. Transmission of pulses:

a) Line length 25 cm, diameter 2 mm. Impedance 1.1 kΩ, total ohmic resistance 30 Ω. One horizontal division = 10 nsec.

b) Line length 30 cm, diameter 2 mm. Impedance 390 Ω, total ohmic resistance 3.3 Ω. One horizontal division = 5 nsec.

Fig. 4 : Localization of an avalanche along a wire:

Chamber length 25 cm.

Distance between delay line and sense wire = 3 mm.

Collimated ^{55}Fe X-ray beam.

Measurement of the time difference between the arrival at the two ends of the line.

a) Peaks corresponding to two source positives separated by 2 cm.

b) Variation of the time difference as a function of position.

c) Accuracy as a function of position.

Fig. 5 : Construction of a two-dimensional drift chamber free of right-left ambiguity.

- The delay line is placed between two sense wires.
- The position of an avalanche on the sense wires is measured by the time difference of the pulses arriving at the two ends of a line.
- The cathode wires are placed at potentials rising from the sense wire to the middle potential wire and provide a uniform field drift space.

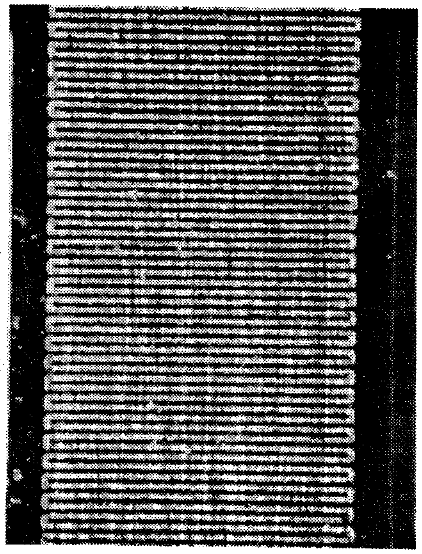
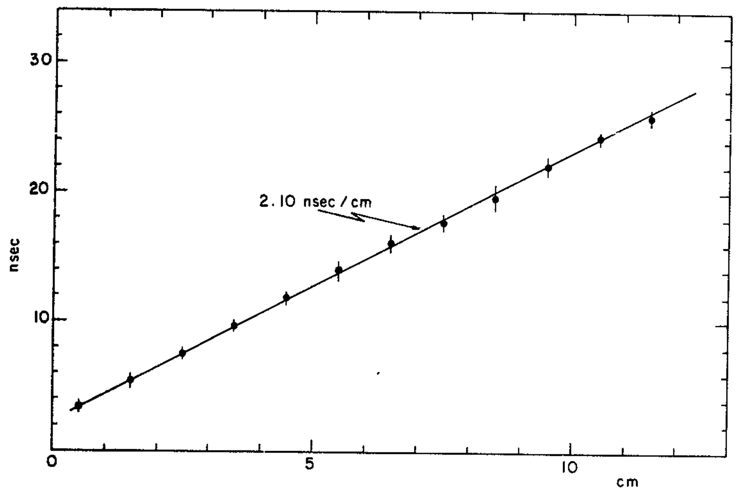


Fig. 1



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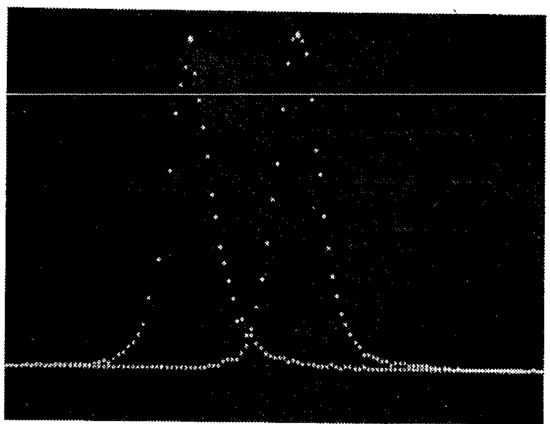

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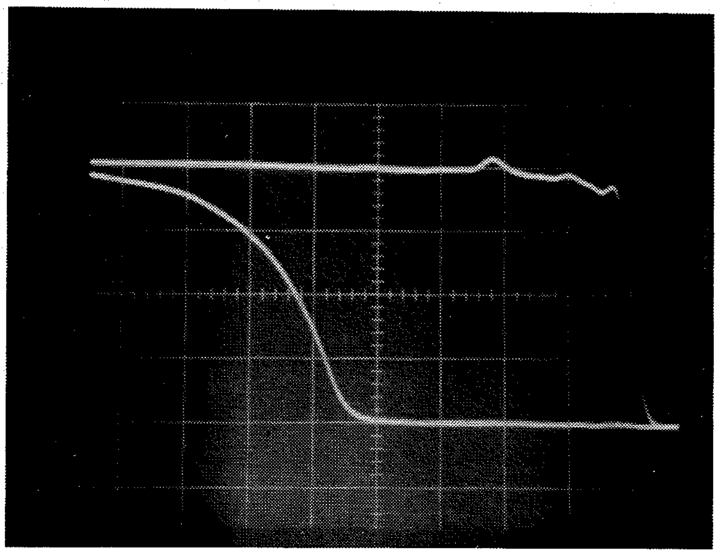
Fig. 2



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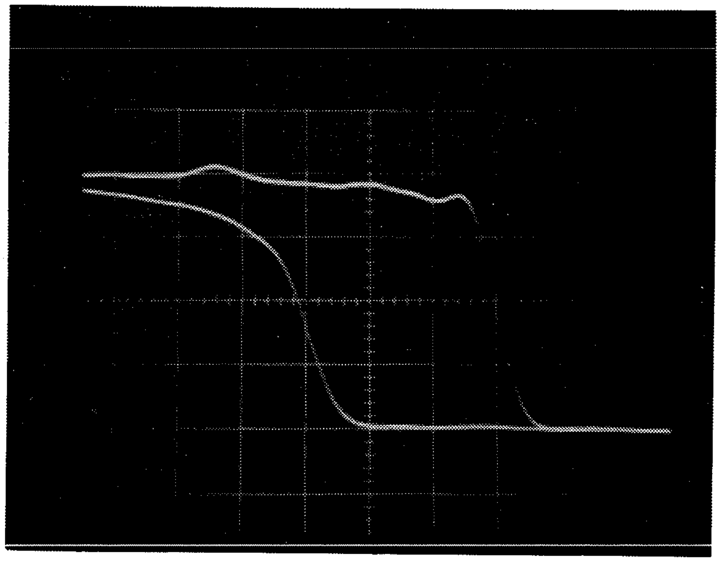

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Fig. 3

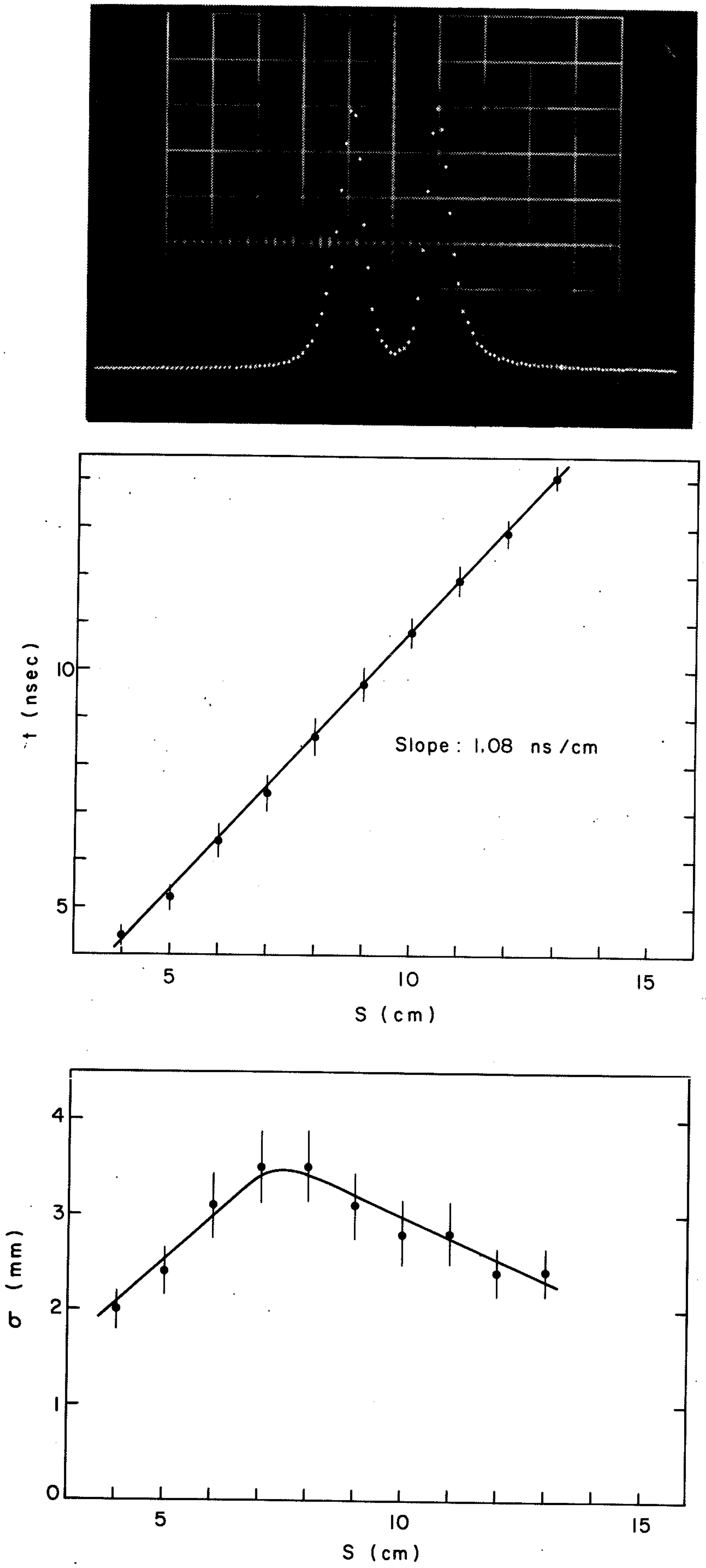

Fig. 4

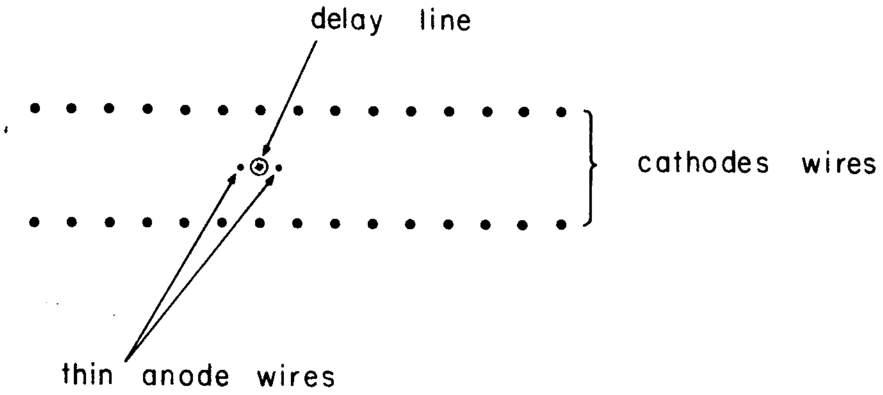

Fig. 5