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A MODULAR MULTIDRIFT VERTEX DETECTOR

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ABSTRACT

We have built an 80 cm long multiwire drift tube with 128 independent anodes, mounted within a light hexagonal carbon-fibre envelope 3 cm in diameter. Several modules can be assembled together to build a vertex detector suitable for collider experiments. Measurements on prototypes and simulations have provided a single-hit accuracy below 100 μm and a two-track resolution around 300 μm .

An obvious way to improve the rate capability and two-track resolution of a multiwire proportional chamber, given its intrinsic limitations, is to increase the density of sense wires in order to reduce the flux of radiation on each element [1,2]. We are building a multidrift vertex detector composed of many independent modules each with the following characteristics (see Fig. 1): 128 independent drift cells are packed within a carbon-fibre supporting tube, also of hexagonal shape, that constitutes the gas envelope. Each sensitive cell consists of an anode wire, 30 μm in diameter, centred in a hexagonal structure 1 mm in radius with 70 μm cathode wires at the corners. The wires are strung between two fibre-glass hexagonal end plates with an outer dimension of 30 mm, and perforated on a numeric drilling machine. Each wire is soldered in the groove of a high-precision metal pin inserted in the holes of the supporting plate (Fig. 2); all cathode wires are connected together, and operate at a negative high voltage, while the anodes are individually wired to the amplifier and discriminator circuits. Although for the first prototype we are using conventional, thick-film hybrid electronics elements, a large-scale integration is envisaged to reduce the volume and cost of the hardware. We intend to profit from the effort already invested for the needs of the microstrip silicon detectors, where similar problems of packaging density are met. A simplified delay line readout serializing large groups of wires is also being tried.

The prototype drift tube is 80 cm long, adapted to use as a vertex detector around a collider; many tubes can indeed be closely packed in a

Fig. 1 Schematic of the multidrift detector module. 128 independent drift cells, each realized with an anode wire centred on a hexagonal pattern of cathodes, are packed in a carbon-fibre hexagonal envelope, 30 mm in width.

cylindrical geometry. A contact with the anode wires is available at both ends of the detector, to allow a longitudinal coordinate determination through current division; in this case the wires should be of the resistive type. We have also developed a cheap multi-connector using soft conducting pads inset in a printed-circuit board drilled with a hole matrix that repeats the layout of the anode pins. Figures 3 and 4 show the wiring and assembly of the multidrift module. Wires are first pulled through the

Fig. 2 Detailed cross-section of the end plate and connector assembly.

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Fig. 3 Final phase of assembly of a multidrift module. All wires are stretched and fastened to the end plates; the carbon-fibre tube is ready to be slid over the wires, after removal of the plate's support.

Fig. 4 Detail of the temporary support of the end plate during wiring.

end plates, which are fixed to the bench; the supporting cylinders are inserted and the wires soldered under tension. Once all wires have been strung, the end plates are fixed to central rods, one of which holds the hexagonal carbon-fibre supporting tube, and freed from their supports; the tube is then slid in and epoxied at the two ends on the plates. The gas inlet and high-voltage connection are provided through a central pin on each side.

The first measurements realized with a 32-wire prototype in a minimum ionizing test beam confirm the relative ease of operating the counter in many gas mixtures, although to avoid edge discharge we prefer to use small fractions of quenchers in argon so as to limit the absolute working voltage. Detection efficiencies close to 100% and localization accuracies of $100\ \mu\text{m}$ r.m.s. on each wire have been recorded.

A typical reconstructed event is represented in Fig. 5; the display shows also the coordinate of the track measured with a conventional high-accuracy drift chamber used as reference. The space-time relationship of a single wire for a uniformly spread beam, measured by comparison with the drift chamber, is shown in Fig. 6. The pattern exhibits the typical right-left symmetry of a drift cell around the anode wire; the linearity of the response is rather good, and the width of the distribution of the scattered points provides the localization accuracy of the cell, having an r.m.s. of around $100\ \mu\text{m}$ (the maximum drift length is 1 mm on each side).

One interesting way of operating the counter is to use an electronegative gas mixture, such as a large proportion of freon in a

Fig. 5 Computer display on one track, recorded with a 32 wire prototype multidrift detector. The coordinate of the track provided by a reference high-accuracy drift chamber is also shown.

Fig. 6 Space-time relationship in a single wire of the multidrift detector, obtained in comparison with the coordinate provided by the reference drift chamber (horizontal coordinate). The good linearity of response and the localization accuracy (about $100\ \mu\text{m}$ r.m.s.) are apparent. Gas filling: argon-isobutane-methylal (70-25-5).

normal gas. In this case the efficient region of detection can be restricted to a narrow cylinder around each anode; for 20% freon in argon-isobutane the sensitive region has about $200\ \mu\text{m}$ FWHM. A space-time correlation measured on a wire in these conditions, always with reference to an external drift chamber, is shown in Fig. 7; all points cluster within a small region around the anode wire, as expected. The counter can then be used as a purely digital one, each wire providing a signal only for

Fig. 7 Space-time relationship for a single wire of the detector filled with an electronegative gas mixture, argon-isobutane-freon (70-10-20). The FWHM of the efficient region around the wire is 200 μm .

tracks within the quoted region. This mode of operation allows the highest flux capability (because of the reduced efficiency) and the use of a simpler pattern electronics; the number of measured points on each track is of course reduced.

To analyse the resolution properties of the device and optimize the pattern recognition, we have developed a rather detailed generation program for Monte Carlo events that takes into account the primary and total ionization statistics and the drift and diffusion of the electrons in the cells of the detector. The simulation indicates that an average reconstruction accuracy of 70 μm r.m.s. should be achievable on each cell; in the complete tube, a single track is measured on an average a dozen times with the quoted accuracy. The time resolution of the counter is about 30 ns, corresponding to the maximum drift time.

For two near tracks of course only the coordinate closest to each wire is measured; the geometry is such, however, that on an average each track will still be recorded on alternate wires and can be reconstructed, although on a reduced number of wires (see the example in Fig. 8 generated and reconstructed with the described program). We expect indeed a two-track resolution of two or three hundred microns, somewhat depending on the sophistication of the software reconstruction

Fig. 8 Monte Carlo simulation of two tracks detected by a multidrift module. Circles indicate the measured drift times, and the straight lines the reconstructed tracks.

algorithm. For dense concentrations of tracks, as in jets or for calorimetry applications, the envelope of the cluster of tracks should still be well determined.

The success of this approach to the realization of a high-rate, high-resolution detector will depend, of course, on the finding of cheap and reliable construction techniques, as well as on the development of a high-density electronics.

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