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A LARGE POLYGON DRIFT CHAMBER FOR THE JADE EXPERIMENT AT PETRA

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A large cylindrical shell drift chamber is described. The chamber is 2.4 m long and 1.75 m diameter with a shell thickness of 45 mm. The sense wires are strung in the form of a polygon over rigid supports. This allows a measurement of the z-coordinate in the direction of the cylinder axis with an accuracy of approximately 250 μ. Results of tests on a representative prototype are presented.

1. Introduction

In the JADE detector at the PETRA storage ring, the coordinates of charged tracks are determined with an accuracy of 180 μ in the $r-\phi$-plane from the drift-time measurement [1]. The z-coordinates along the sense wires are determined by charge division, but only with an accuracy of 16 mm. However, good z-resolution is of special importance for the calculation of invariant masses of particles with higher momentum, where the opening angle of the decay particles is small. Therefore a drift chamber of cylindrical shape has been developed for the JADE experiment as shown in fig. 1. The sense wires are stretched over supports in a polygon around the cylindrical surface, so that the z-coordinate can be determined with good accuracy from the drift-time measurement. The drift chamber consists of two half cylinders of 2.4 m length and 1.75 m diameter. The total thickness is only 45 mm in order to fit into the gap in the JADE detector between the pressure tank of the JET-chamber and the TOF-counters.

The actual chamber is at present under construction at the Rutherford Appleton Laboratory. The expected properties and the results obtained with a smaller representative prototype chamber are presented here.

2. Description of drift cell

The cross section of the basic drift cell is shown in fig. 2a. Two sense wires of 20 μ thickness are strung between two printed circuit boards. The top and bottom

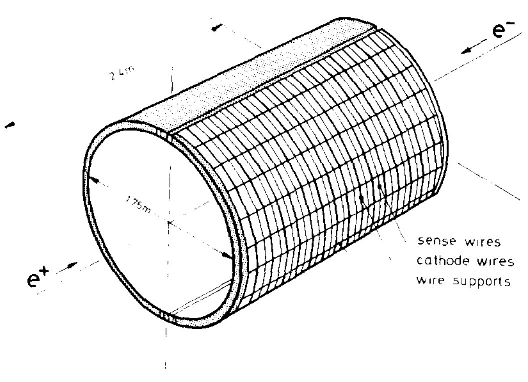

Fig. 1. General view, showing the complete polygonal chamber.

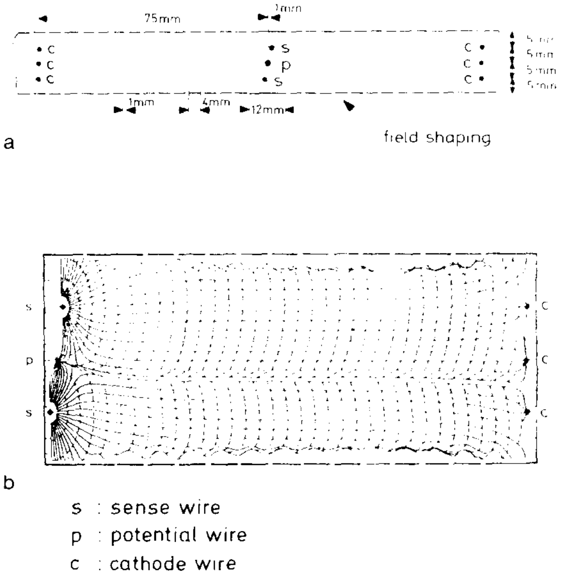

Fig. 2. Basic drift cell: cross section (a) and field calculations (b) showing field lines (full lines) and lines of constant drift time (dashed lines).

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boards are 20 mm apart. A voltage is applied via a resistor chain to the copper strips on the boards in order to obtain a constant drift field of about 280 V/cm. The drift space on each side of the sense wires is ±75 mm giving a cell width of 150 mm. The ends of the drift spaces are defined by a triplet of cathode wires. The two sense wires are staggered by ±1 mm in order to resolve the left/right ambiguity. A potential wire of 120 μ thickness is stretched between the two sense wires. Separate voltages on the potential wire and the centre strips allow the gas gain to be regulated independently of the drift field. The calculated field lines and lines of constant drift-time for this cell are shown in fig. 2b. The rather large wire staggering of ±1 mm results in a different track length and therefore different amplitudes measured on the two sense wires. The many strip for field shaping reduce the inhomogeneity of the field at the top and bottom boards, where the drift-time is longer than in the middle of the cell.

Sixteen of these cells adjacent to one another form a 2.4 m long drift chamber. In the direction along the wire the chamber is angled every 23 cm by 15° and the wires are supported at this point by another printed circuit board with feedthroughs for the wires. It also serves as a spacer between the top and bottom drift field circuit boards. Twelve of these segments form a half cylinder of 1.75 m diameter. At both ends, the sense wires are connected via amplifiers to the standard JADE JET-chamber electronics [2] which measure the drift-times and the amplitudes for up to 8 tracks. The z-coordinate is then determined with good accuracy from the drift-time measurement and the ϕ-coordinate can be determined from charge division. The space coordinates from the two sense wires will provide information for matching with the tracks in the inner detector.

The whole z-chamber consists of two of these half cylinders with 32 sense wires in each. Where the two halves are bolted together there will be a dead space of approximately 20 cm, due to end wire supports and amplifier mountings.

3. Properties of the chamber

The prototype chamber, on which all measurements have been made so far, consists of three adjacent drift cells. The chamber has two 15° bends and there are two rigid supports to keep the wires at fixed positions. The chamber was tested in an electron test beam at DESY using a gas mixture of 90% argon and 10% ethane. The efficiency is more than 99%. The space resolution obtained ranges from 180 μ close to the sense wire up to 400 μ for 75 mm drift distance, with an average value of about 250 μ.

In the JADE detector, tracks can pass the z-chamber at angles of up to 40° with respect to the drift direction. This may result in more than one hit on a sense wire due to fluctuations in the ionization loss of the tracks and a wider range of drift-times for the different ionization electrons. Therefore the fraction of double hits has been measured in the test beam and found to be 5% independent of the angle. This is consistent with the number of double tracks in the test beam. So we conclude that the fraction of double hits is negligible. Furthermore, although the space resolution could be affected for inclined tracks, no effect has been found for angles up to 40°.

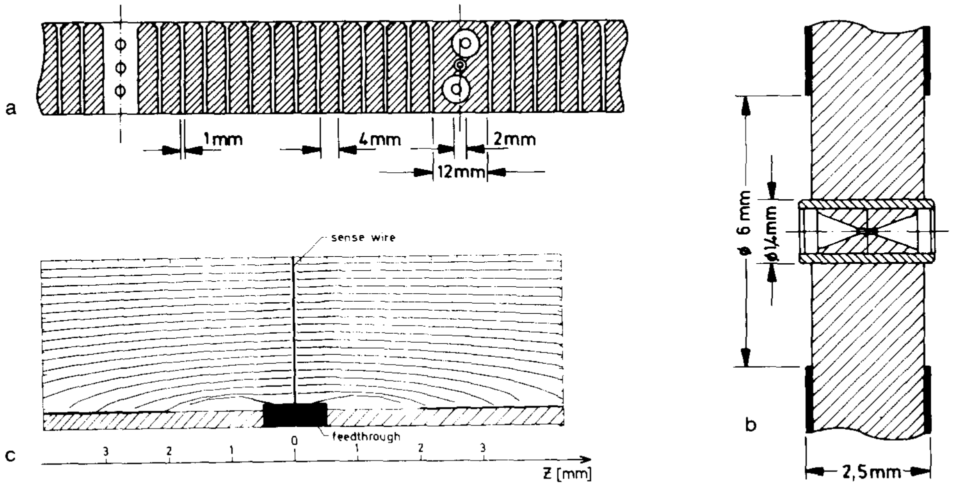

Fig. 3. Rigid wire support: layout of strips for field shaping (a), cross section at the wire feedthrough (b) and field lines in the region of the wire feedthrough (c).

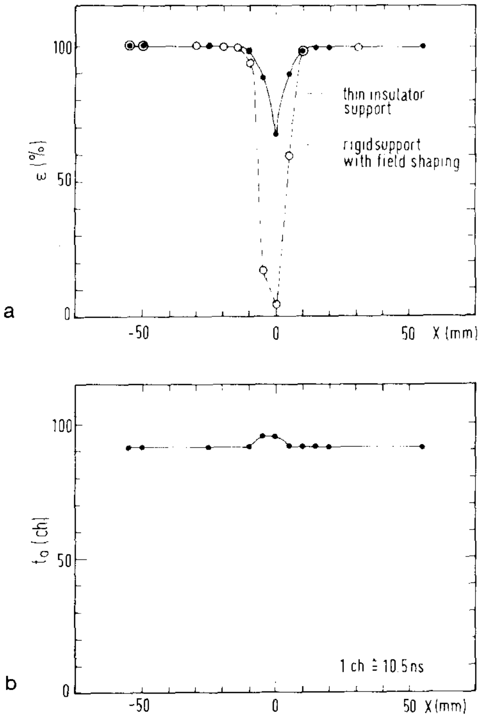

Fig. 4. Efficiency (a) and drift-time (b) in the support region.

4. Properties of the wire support

The support is a 2.5 mm thick and 20 mm wide printed circuit board (see fig. 3a), with strips of copper connected to and having the same pattern as the field shaping electrodes on the top and bottom boards. This method of wire support causes only a small field disturbance. The only irregularity occurs at the feedthrough of the wires. Here one has circular areas without copper of 6 and 4 mm diameter around the signal wires and the potential wire, respectively. The feedthrough itself (fig. 3b) is a brass tube which protrudes about 0.3 mm from the fibre glass material of the board. Inside the tube is a cylindrical cone which allows wire positioning to an accuracy of about 50 μ, and an easy feedthrough when stretching the wire.

The efficiency as measured across the rigid support is shown in fig. 4a. Because of the beam size of 5×5 mm^2 the measured inefficient region is wider but less pronounced than the real one. The total inefficient area amounts to a width of 2.5 mm which is exactly the width of the support. For comparison we show in fig. 4a the much larger inefficient region obtained with a thin insulating support, a method which was tried but rejected.

In addition the drift-time of electrons from tracks has been analyzed as a function of the distance from the support (see fig. 4b). At the support a longer drift-time is measured. This can be understood from the field calculations in the drift cell of fig. 2b showing longer drift lines close to the boards, where the lines wiggle around the gaps between the copper field shaping strips. Similar behaviour is expected and also measured close to the support.

Field calculations for the support itself close to the wire feedthrough are shown in fig. 3c. Electrons, which drift along the field lines, bend away from the feedthrough. Only a small inefficiency is expected for tracks close to the feedthrough, where the electrons produce no gas amplification and therefore no signal. It is essential for the feedthrough to protrude in order to prevent gas amplification close to the support. As we understand it, this would otherwise result in a high density of positive ions which would attach themselves to the insulator and attract subsequent drifting electrons, resulting in a high inefficiency as measured for a pure insulating support (fig. 4a).

5. Conclusions

Technical development has been carried out on the construction of a large cylindrical shell drift chamber. The sense wires, which are strung in a polygon over rigid supports allow a measurement of the z-coordinate in the direction of the cylinder axis with an accuracy of about 250 μ. An efficiency of more than 99% and an average spatial resolution of 250 μ in a 75 mm wide drift space reproduce properties of conventional drift chambers. The central problem – the development of a support, which results in a small inefficiency only and which is also rigid enough to serve as a mechanical support for the construction – has been solved. A measured inefficient region of only 2.5 mm corresponds to an average efficiency of 98.5%. At present a 2.4 m long chamber with a diameter of 1.75 m is under construction and is expected to be installed in the JADE experiment in the summer of 1983.

References

[1] H. Drumm et al., Nucl. Instr. and Meth. 176 (1980) 333.
[2] W. Farr and J. Heintze, Nucl. Instr. and Meth. 156 (1978) 301.