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A MODULAR DRIFT-CHAMBER VERTEX DETECTOR AT THE CERN ISR

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ABSTRACT

The vertex detector built by the Pisa Group for the CERN Intersecting Storage Rings muon pair experiment R 209 is described.

A modular system of 136 small drift chambers, assembled around the ISR intersection region, measures the entrance directions of the muon pairs into the magnetized iron spectrometer, and the directions of the charged hadrons produced in association.

Each module contains two doublets of sense wires, each doublet being associated with one delay line to determine directly the space points without left-right ambiguities.

The mechanical structure is rather unconventional, having been designed with the aim of minimizing any dead space in the assembly of the modules.

Space resolution is $\sim \pm 0.2$ mm in the drift coordinate and $\sim \pm 2$ mm in the delay coordinate.

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1. INTRODUCTION

A drift chamber of rather unconventional design is presented in this report: 136 chambers of this kind have been assembled around the interaction region I-2 at the CERN Intersecting Storage Rings (ISR). This system of chambers is used as a vertex detector for the CERN-Harvard-Frascati-MIT-Napoli-Pisa experiment R 209, the aim of which is to search for high invariant mass muon pairs and to study the distributions of the associated hadrons.

The vertex detector is built in the core of the muon spectrometer -- an assembly of large magnetized iron toroids, interspaced with large drift chambers and counter hodoscopes -- which provides filtering and bending for the two muons produced off proton-proton collisions.

The vertex detector has been designed and it is being used to measure:

- i) the coordinates of the interaction vertex;
- ii) the directions of the two muons before they enter the magnetized iron spectrometer;
- iii) the directions of the other charged-hadron tracks produced in association down to $\theta \approx 10^\circ$ with respect to both beam lines.

The free space available around the beam pipes, before the spectrometer inner walls, was very limited (150 cm along the beam lines, $70 \times 70 \text{ cm}^2$ cross-section) and it was already filled, in part, by the ISR vacuum pipes.

The choice of a drift chamber system was forced because of the excellent space-resolution of these detectors.

For the sake of minimizing the number of wire planes, the drift coordinate had to be determined without left-right ambiguity, and the coordinate along the wire had to be measured simultaneously inside the same chamber. Wire staggering was compulsory: the ISR event-rate reaches 10^6 events/second with an average multiplicity of ~ 10 tracks/event.

A modular system appeared to be the best solution to the problem. Furthermore, obvious advantages offered by modularity are the ease with which repairs can be carried out and parts replaced, and malfunctioning during data-taking can

be isolated. Major disadvantages are the unavoidable increase of material along the particle paths and the dead spaces at the boundaries of the modules. The module of chamber which has been adopted is described in the next section.

2. STRUCTURE OF THE DRIFT CHAMBER MODULE

A schematic cross-sectional view of the module is shown in Fig. 1. Five different types of modules have been used in the realization of the project; they have different lengths along the wires, but the cross-sectional structure is the same as in Fig. 1 *).

The limiting surfaces are provided by fibre-glass boards, 0.2 mm thick, stiffened by fibre-glass rods. The parallel strips perpendicular to the plane of the figure, which are printed on the same board, provide the shaping of the field.

The sensitive elements of the chamber are two pairs of sense wires, each pair consisting of two (20 μ m in diameter) gold-plated tungsten wires 1.8 mm apart. One single cylindrical delay line (3.24 mm external diameter) faces the two wires.

Each module contains therefore four drift cells, 11 mm thick, 41 mm wide, each one being read by one single sense wire (without left-right ambiguity) and the other coordinate being read by the delay line.

The mechanical structure is such that a plane of wires can be built up by a series of adjacent similar modules, the dead space between each module and the nearby one being negligible.

Figures 2a and 2b show two views of one assembled module. The two fibre-glass end caps which seal the chamber at both ends are 8 mm thick (this is the only dead space inside the chamber). They support the wires and the delay lines, and they guarantee the rigidity of the whole structure.

*) Only half of the module is shown in the figure, the other half being symmetrical with respect to the field wire.

Two additional, lozenge-shaped printed boards sandwich the chamber: they distribute to the field strips the appropriate potentials as they are generated by the voltage divider, also visible in the figure.

The signals from the four sense wires are sensed through a capacitive coupling which matches the wire impedance to a $50\ \Omega$ coaxial cable. The four capacitors are visible in Fig. 2b.

The delay line is first terminated to its characteristic impedance ($Z_0 \approx 1200\ \Omega$) and then it is matched to a $50\ \Omega$ cable via an emitter follower. The four transistors and their associated protecting diodes are seen in Fig. 2a.

The coaxial, $50\ \Omega$ cables are welded to the chamber boards and they carry the pulses ~ 10 m outside the spectrometer. Here the signals are amplified ($\times 80$) and then they are sent to the counting room through RG-58 cables, 60 m long. Details about the data-acquisition system will not be given in this report.

3. THE VERTEX DETECTOR

From inspection of Fig. 3 the reader can easily understand the solution which has been envisaged for assembling the planes of wires and providing the gas-flow to the chambers at the same time^{*)}. The 136 drift chambers are assembled inside 10 plexiglas containers, as shown in Fig. 4 which is a picture of half of the detector. The missing part is a symmetrical c-shaped structure. The different boxes can slide into position inside the muon spectrometer along well-machined rails to enclose the ISR intersection region inside their double-c aperture.

Prior to insertion inside the spectrometer, the geometry of the different boxes is determined in the laboratory: the relative position of the wires inside each single box is known to an accuracy of ~ 0.1 mm.

The positions of the plexiglas containers inside the ISR is known to an accuracy of ~ 1 mm.

*) Two of the four copper plugs which are visible at the ends of the module shown in Fig. 2 are the inlet and the outlet for the gas, the other couple of plugs being used for support.

4. CHAMBER PERFORMANCES

Test runs performed at the CERN Proton Synchrotron (PS) have shown the chambers to be fully efficient. For perpendicular incident particles the cells are rather sharply separated with no dead space and very little cross-talk. Only in between the two sense wires of each pair may the separation of cells be ambiguous -- which corresponds to a loss of resolution in these small regions -- but there is no dead space.

The graph in Fig. 5 shows the time-space response of the chamber for three different angles of incidence of the beam^{*)}. For normal incidence ($\theta = 0^\circ$) the dependence is linear, showing that no major disturbances on the drift field are introduced by the asymmetric position of the delay line. The resulting drift velocity is 5.2 cm/ μ sec, and it appears to be only slightly smaller at the end of the cell. The same diagram for non-perpendicular incidence shows a linear relation over most of the drift space: the drift velocity changes only at the end of the cell and close to the sense wire.

Efficiency and time-space relation for the delay-line have also been measured. The line is 100% efficient, it is uniform, and its specific delay is 7.43 nsec/cm. This figure corresponds to a resolution of few millimetres if times are digitized in bins of 1.5 nsec, as is the case for our experiment.

In order to emphasize the excellent performances of the delay-line that we have adopted, we quote the average value $\delta = \pm 1.6$ mm for the deviation between the actual coordinate as measured by the delay-line and the coordinate determined by the fit to the tracks belonging to a sample of ISR events reconstructed by the off-line program. A typical reconstructed event is shown in Fig. 6.

*) The gas mixture is 27% isobutane, 72% argon, 1% methylal.

Figure captions

- Fig. 1 : Schematic cross-section of the drift-chamber module.
- Fig. 2 : Pictures of one assembled module.
- Fig. 3 : Housing of the modules inside the vertex-detector containers.
- Fig. 4 : The detector assembled in the laboratory. Only half of it is shown in the picture.
- Fig. 5 : Time-space diagram for three different angles of incidence, $\theta = 0^\circ$ meaning that incidence is perpendicular to the chamber; x is the distance between the beam and the sense wire.
- Fig. 6 : Two projections of the same ISR event. Full squares are the projection of space points as determined by the chambers. Full lines are the best fit reconstructed tracks.

Fig. 1

Fig. 2 a)

Fig. 2 b)

Fig. 3

Fig. 4

Fig. 5

RUN NO. 432 EVENT 7361

RUN NO. 432 EVENT 7361

Fig. 6