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THE CONSTRUCTION OF THE CENTRAL DETECTOR
FOR AN EXPERIMENT AT THE CERN $\bar{p}$ -p COLLIDER

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ABSTRACT

The construction of a large (25 m^3 , 23,000 wires) drift chamber assembly with image read-out to be used at the CERN $\bar{p}$ -p collider facility is reported. In this contribution the accent is placed mainly on the mechanical and electrostatic design and on the implementation of the various control procedures.

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1. INTRODUCTION

The UA1 Collaboration is engaged in the very advanced project of the $\bar{p}$ -p collider at the CERN Super Proton Synchrotron (SPS) ¹⁾. An artist's view of the experimental set-up under construction is shown in Fig. 1. The complete detector is about 10 m long and 5 m wide. The magnet, which is of a dipole type with a nominal field value of 0.7 T, has an internal magnetic volume of $\sim 80 \text{ m}^3$, of which 25 m^3 , around the beam pipe, are occupied by the central detector used for tracking and momentum measurement. The central detector is designed for the measurement of events which have rather complex topologies, since at the collider energy ($2 \times 270 \text{ GeV}$) a clustering (jets) and a multiplicity of ~ 50 secondaries per event are predicted. Therefore the chambers of the central detector will provide full three-dimensional space points. They are of drift type with image read-out; the third coordinate is obtained by current division. Furthermore, the large number of points measured on each track makes it possible to determine the ionization of particles down to $\pm 6\%$. The most relevant properties of the detector are summarized in Table 1.

This paper describes the technique used to construct the chambers; it will mainly concern the rather new technological solutions imposed by the unusually large dimensions associated with the requirements of a very light structure.

2. THE CHAMBER SYSTEM

The central detector is a self-supporting cylinder having a diameter of 2.2 m and a length of about 6 m. As shown in Fig. 2, this cylinder is split into six half-moon sections, which can easily be removed and replaced by another standard element in case of failure. The central modules are referred to as the central chambers and the outer sections as the forward chambers; they differ mainly for the orientation of the wire planes, vertical for the central chambers and horizontal for the forward ones. In both cases the wires are parallel to the direction of the magnetic field.

The arrangement of the wire planes has been chosen such as to maximize the number of points for track reconstruction and to have the drift direction more or less normal to the track directions.

The cylindrical outer shell of a chamber consists of a honeycomb structure sandwiched between two layers of Vetronite; this structure is strengthened by means of Stesalit^{*)} bars (inserts), which also hold the wires, as shown in Fig. 3. This design combines a maximum of rigidity with a minimum of radiation length of material. Each half-cylinder is prestressed, and closed by means of a cover consisting of two side walls and a central plane connected together. This cover, made of Plexiglas foam, has its inside covered with copper strips and planes which define rather precisely the electric field at the boundaries of each half-cylinder. The shell construction, on the other hand, presents the most original technological solutions. The structure is different from those realized for most of similar detectors, in that it is rather elastic and can be deformed. In other words the shell, before wiring, has a form very different from the final shape, which is circular. A prestressing, which has to balance exactly the tension of the wires, is needed in order to bring the chamber to its final form. Typically, for a forward chamber, the contraction of the shell in the median plane is 80 mm for a load of about 700 kg, which represents the tension of all wires.

As the wire tension is determined by requirements of minimum sag and their mechanical strength, delicate calculations were needed in order to determine the initial geometry of the shell and its mould. These calculations have been carried out using both the finite elements method and a more classical analytical approach. The procedure for building the shell follows a technique commonly used for aircraft components^{**)}. The supporting bars (inserts) are first positioned in a precisely machined mould; the honeycomb sandwiched between two resin layers is then laid down. The soldering of the inserts to the honeycomb wall is finally obtained through polymerization of the resin layers under pressure and at 120 °C.

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^{**)} The shells are made by Aérospatiale, Nantes (France).

The approximations assumed in the calculations have been shown to be rather good, since a maximum difference of 15% between the calculated and measured rigidity of the structure has been found. This difference, on the other hand, is easily compensated by the tension given to the wires, since they are stretched rather far beyond the elasticity limit. Before the wiring operation, a set of accurate controls is needed for each module. Schematically their logic sequence is the following:

- i) Deformation of the structure to its nominal circular form (to an accuracy of ± 2 mm) with a network of strings which produces a load equivalent to the assembly of the wires. This operation gives knowledge of the effective rigidity of the unit and therefore determines the amount of tension to be given to the wires.
- ii) Transfer of the deformed shell in a rigid frame where it will be held during the wiring (Fig. 4).
- iii) Removal of the strings and transfer of the prestressing force to the frame through a network of pressure screws equipped with strain gauges (Fig. 5).

The over-all precision aimed at in all these operations is of the order of 0.5 mm, this figure reflecting the need to know the position in space of the wires with a precision equivalent to the drift-time measurement (~ 300 μ m).

The delicate equilibrium between the tension given to the wires and the stresses in the supporting structure requires a precise control of the tension during the wiring and afterwards. For this purpose a new method, described in a preceding paper²⁾, has been developed. The basic principle consists in sending an alternating current to one wire at a time, and measuring the wire resonance frequency and hence its mechanical tension with a rather good precision ($< 1\%$).

It is only after there has been a final control of the evolution of the stress in the gauges that the chamber, together with its cover, is removed from the frame.

3. WIRE STRUCTURE AND FIELD SHAPING

The basic unit in the structure of the drift chamber consists of a cell with a station of sense wires and a drift-field region as shown in Fig. 6. A uniform electric field is generated by cathode wires (gold-plated Cu-Be, $\varnothing = 100 \mu\text{m}$) set at the potential V_D . At the boundaries of the detector, the drift field is defined by an array of conductive strips on printed circuits (racetracks) (1.5 mm apart and 1 mm wide) set at uniformly graded potential by means of a resistive voltage divider.

The sense wires configuration consists of three planes. The two outer planes are made alternatively of sense (35 μm Ni-Cr) and field wires, whereas the intermediate plane is made of cathode wires. This multiwire configuration has several advantages over previous designs:

- i) the electrostatic forces are almost exactly balanced by compensating the effect of V_D with V_C ;
- ii) the wires are protected against accidental switch-off of the various voltages;
- iii) the transparency for positive ions is quite high.

The field wires are in a region of low field, and trap positive ions; for this the addition of the intermediate plane contributes towards a firm linking of the ground on both sides of the sense wires, this property being of help for the charge division method.

The mechanical sag and the electrostatic deflection of the wires are not mechanically compensated, even for the longest wires (2.2 m). The effect of gravity is only to add a sag of $\sim 70 \mu\text{m}$ to the displacement, which can be made quite small in the region around the chosen voltage even if cathode and field wires sag by $\sim 300 \mu\text{m}$. The high voltage is distributed to the racetracks with a low-current resistor chain (30 μA /drift space). To compensate for space charge and dark current (leaks, corona, etc.) effects, the voltage is boosted in nine intermediate points along each drift space. The required precision and the stability of the electric field are $< 1\%$, a distortion of this magnitude meaning in some cases an error of 300 μm in the drift measurement.

4. CONCLUSIONS

Various prototypes and three final chambers have already been built. Most technological and electrical problems have been solved and are under control. A long program of tests, to fully understand the behaviour of the chamber, is now under way.

REFERENCES

- 1) A. Astbury et al., A 4π solid angle detector for the SPS used as a $\bar{p}p$ collider at c.m. energy of 540 GeV, CERN/SPSC/78-06, SPSC/P 92, 30 January 1978.
- 2) M. Calvetti, G. Piano Mortari, A. Placci and M. Rijssenbeek, A computed-aided system for MWPC wire tension control, CERN-EP/80-21 (submitted to Nuclear Instruments and Methods).

Table 1

General characteristics of the central detector

Type	Drift, image read-out
Gas	Argon (40%) + ethane (60%)
Drift length and field	18 cm, 1.5 kV/cm
Drift velocity and angle	5 cm/ μ m, 23° at 0.7 T
Collecting electrodes:	
a) wire spacing	5 mm
b) wire length	2.2 m max.
c) wire diameter, sense	35 μ m Ni-Cr
d) wire diameter, field	100 μ m gold-plated Cu-Be
Total number of wires	22800
Total number of sense wires	6110

Figure captions

- Fig. 1 : Over-all schematic view of the experimental set-up, showing the access to the central detector.
- Fig. 2 : Cut-away diagram of the central detector showing the orientation of the wire planes in the central and forward chambers.
- Fig. 3 : Schematic drawing of the mechanical assembly of a chamber.
- Fig. 4 : A forward chamber submitted to the first deformation.
- Fig. 5 : A forward chamber after the wiring operation.
- Fig. 6 : Typical drift cell of a forward chamber.

Fig. 1

Fig. 2

FORWARD CHAMBER

COVER

Fig. 3

Fig. 4

Fig. 5

- FIELD WIRES (Cu-Be) $\varnothing = 100 \mu\text{m}$
- * SENSE WIRES (Ni-Cr) $\varnothing = 35 \mu\text{m}$

TYPICAL HV SETTING

$V_D = 28 \text{ kV}$
 $V_F = 1.5 \text{ kV}$
 $V_C = 2.5 \text{ kV}$

Fig. 6