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G. Corradi, L. Daniello, M. Enorini, F. L. Fabbri, M. Giardoni, P. Laurelli, L. Passamonti, L. Satta, P. Spillantini, V. Russc and A. Zallo: A NEW SET OF MULTIGAP PLANE PROPORTIONAL CHAMBER FOR THE NA1 VERTEX DETECTOR

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A NEW SET OF MULTIGAP PLANE PROPORTIONAL CHAMBER FOR THE NA1 VERTEX DETECTOR.

ABSTRACT

The construction and performance of multigap plane MWPC's 64 x 64 cm^2 are described. Relevant details on the construction procedure and on triggering use are reported. These chambers are operating in the NA1 experiment at SPS, CERN.

1. - INTRODUCTION

We describe a set of MWPC built up for the modified version of the vertex detector of NA1 experiment$^{(1,2)}$ which intends to measure the lifetimes of photoproduced charmed mesons (D^o, $D^\pm$).

The main goal of this new vertex detector was to get a better resolution in vertex reconstruction, leading to an increase of the acceptance of the apparatus towards shorter lifetimes, and to improve the reconstruction of tracks coming out from the target. This was achieved by the substitution of the old silicon target with a new one consisting in a germanium crystal plus a set of silicon layers, and a complete re-design of the vertex chambers.

In the vertex detector design we had to solve the problem of setting the maximum number of information preserving the physical dimensions of the whole detector to a reasonable size. In a volume of less than 1 m^3 we installed ~200 drift cells, ~3000 proportional wires and ~500 pm's (Fig. 1), ensuring the complete coverage for charged particles up to 120° and the detection and energy measurement of photons up to 70°.

The MWPC's were used for triggering purposes and off-line analysis. The main requirements on the MWPC's were that, independently from the drift chambers information, the interaction point should be reconstructed with a precision better than 2 mm in the direction perpendicular to the beam, and that the secondary vertices due to K and Λ decays should be identified.

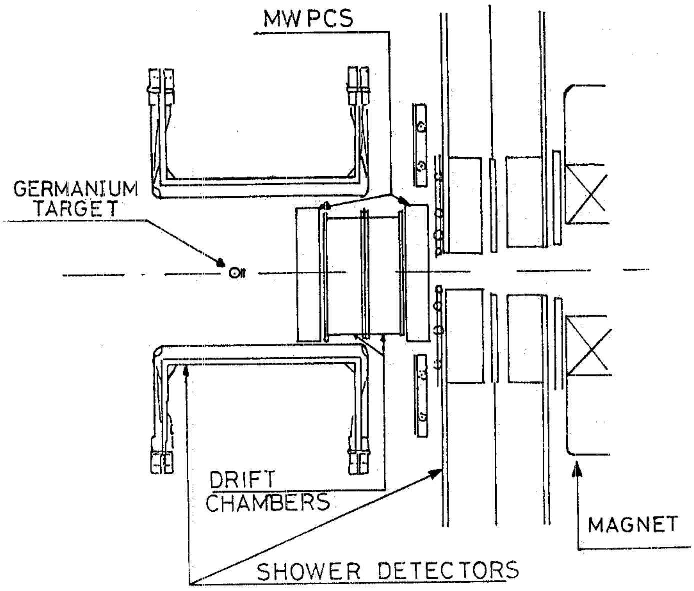

FIG. 1

In the present paper we describe the characteristics of the MWPC design and the construction procedure.

2. - DESIGN AND CONSTRUCTION

The design was mainly influenced by the request of having the minimum depth in the beam direction. Accordingly, we decided to build the chambers with four sense wires planes (instead of two, as usual) to reduce the total number of external support frames. In order to decouple optically the gaps, we used for the cathode planes aluminium foils 30 micron thick. Because of this choice we were forced to maintain the overall mechanical tolerance at the 1% level to prevent high voltage breakdown in the chambers.

The main mechanical characteristics of the chambers are: a) 64×64 cm^2 internal dimension, b) 20 micron wires, c) 2 mm pitch, d) 8 mm gap. Each chamber is composed of twelve vetronite frames ($\varrho = 3 \times 10^{15}$ Ω/cm), held together by two 12 mm thick aluminium frames, ensuring the necessary mechanical rigidity. On the frames are glued two aclar foils 50 micron thick for gas enclosure (Fig. 2).

2. 1. - Cathode planes

To limit to 0.1 mm the dishing-in of the cathode due to the electrostatic force, the aluminium foils have to be streched before being glued on the frames. To this purpose the foils are laid out on a specially designed table where they can be heated to

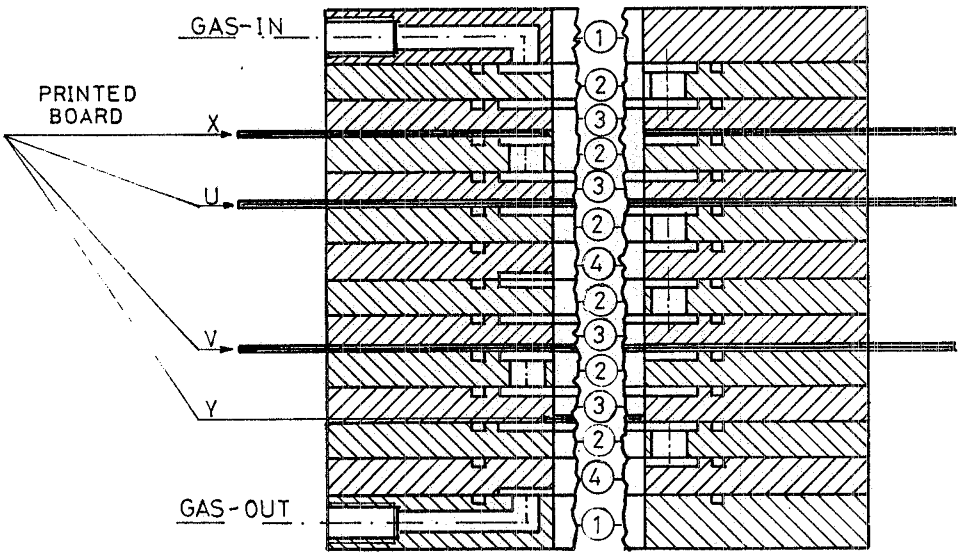

FIG. 2

40°C and streched by means of the atmospheric pressure, making a moderate vacuum in a grove milled along the rim of the table. The foils are heated mainly to speed up the glue polymerization. The size of the grove is determined from the solution of the differential equation describing a membrane deformed by a distributed force. In our case, at the center of the cathode plane, the solution is of the form:

$$U(0,0) - 7.37\times10^{-2}\,\frac{p}{T}\,L^2$$

where p is the electrostatic pressure, L^2 the surface of the aluminium foil and T the mechanical stress.

By imposing that the maximum vertical displacement be less than 0.1 mm, one can calculate the corresponding mechanical stress that must be applied to the aluminium foil. Since the stress due to the heating is insufficient, the size of the grove has to be such that the total force per meter equals the computed mechanical stress. Finally, to provide additional path length for surface discharges, mylar strips 10mm wide and 250 micron thick are inserted over and under the cathode in a slot, cut in the inner perimeter of the vetronite frames.

2. 2. - Wire planes

The four sense planes are oriented in different directions, two of them scan the horizontal and vertical coordinates, while the other two are oriented at 45° and 135° respectively.

Special care was put in the choice of the wire and in their soldering: the thickness was 20 micron W-Ru (3%), the rupture limit was of 130 g instead of the usual 90 g. This allowed a stretching of 70 ± 0.5 g for the two x-y planes, up to 90 g for the u-v ones. Due to the stretching capability of the wires and to medium dimensions of the chambers no supporting wire was needed. The wires are positioned with a precision of 0.01 mm by means of a special comb.

A special machine was built to solder the wires on the printed boards. It consisted in a table 2×2 m^2 on which a chariot holding a head which emitted a flow of hot Nitrogen (400°C) could be automatically moved in two orthogonal directions. Chariot speed as well as temperature and duration of the Nitrogen jet were regulated according to the dimension of the soldering to be made. In that way one could fix all the wires of a plane with a unique operation getting a better and cleaner result.

2. 3. - Gas Flow

For space reasons, the gas inlet and outlet are drilled in the aluminium frame in the direction of the wire planes. Since the four gaps do not communicate due to the cathode foils, the gas is brought to the gap through holes in the vetronite frames. The entrance to each gap is obtained by milling several rectangular openings in the vetronite: particular care has been devoted to the design of these holes to insure a gas flow as uniform as possible.

3. - ELECTRONICS AND TESTS

The readout we used was originally designed by Lindsay et al.$^{(3)}$. We had to redesign the preamplifiers to have the possibility of stacking them on the chambers and to have a capacitive input for testing purposes (Fig. 3). Besides our preamplifiers

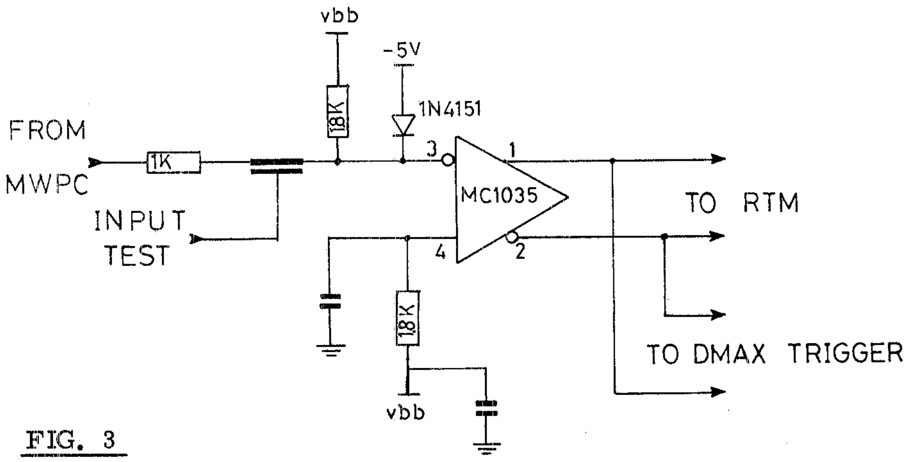

FIG. 3

provide an extra output that we have used to design a special fast trigger (see par. 4).

The high voltage generator has been especially designed for the NA1 vertex detector chambers and was described elsewhere$^{(4)}$. Its main features are that it is located near the chambers and is remotely controlled by the on-line computer. The maximum current it can draw is hardware prefixed to a value depending on the beam intensity. If a voltage breakdown occurs in the chamber, the generator automatically drops the high voltage in nearly one millisecond to a point where the current falls below the fixed value. In that way the chambers are protected against multiple sparking.

During tests and data taking we always used the so called magic-gas mixture (isobutane 25%, freon 13B1 0.1%, methylal 5% in argon). In nearly one year of operation we did not observe any deterioration of chamber performances.

The chambers were tested in laboratory with a ^{106}Ru source and with an electron beam at the CERN SPS. Fig. 4 shows the efficiency curve of the four wire planes in the central region, obtained with 100GeV electrons. The point of the inflection of the curves lies in a $\sim$100 V range, and the plateau extends for a few hundreds volts. Inside the plateau zone the mean multiplicity for normal incidence varies between 1.1 and 1.2 for the four planes. Similar results were obtained with the ^{106}Ru source. After a careful conditioning of the chambers, carried out by increasing the high voltage in such a way that the dark current is limited to $5\ \mu A$, and waiting for it to return to zero before a new voltage increment, the final noise rate, 100 V after the highest plateau knee was a few Hz per wire.

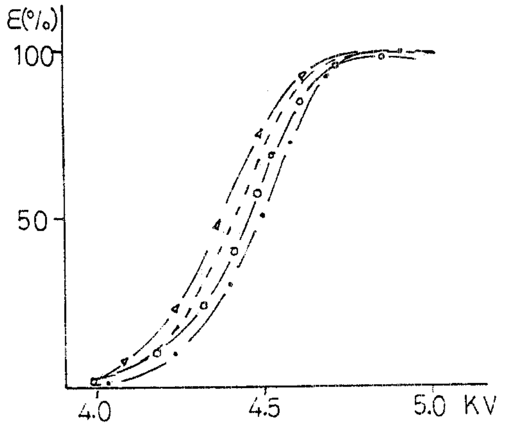

FIG. 4

The efficiency of the chamber in the control region is better than 99.6%, the efficiency uniformity over the whole chamber surface is within 3% of the value of the central region.

4. - TRIGGERING CAPABILITIES

The very good performances of these chambers (low noise, high efficiency), allowed to their use as triggering devices.

The physical requirement was to allow a fast rejection of interactions in which only e^+e^- pairs were produced.

Due to the high energy of the beam, these events were characterized by a very small opening angle between the tracks. The problem was thus to find a parameter which should allow a selection of events with a sufficiently large maximum opening angle. Signals from the central 64 wires both in x and y planes (corresponding to 128 mm) were sent to a special built electronics, which computed in each direction the maximum opening of the event. This information, sent to the trigger, allowed a reduction in the trigger rate of 2.5.

5. - CONCLUDING REMARKS

We built MWPC's with four sense planes, such that a single module can give a point in space without ambiguities, and where the ratio of useful surface to total surface is maximized. The chambers proved to be very reliable over a period of nearly half a year of running. We did not observe any degradation of their operative characteristics. By the same period we had only one wire failure in about 3000 wires simultaneously working.

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