Nuclear Instruments and Methods 216 (1983) 393–397
North-Holland Publishing Company

A SYSTEM OF LARGE MULTIWIRE PROPORTIONAL CHAMBERS FOR A HIGH INTENSITY EXPERIMENT

M. DE PALMA, C. FAVUZZI, G. MAGGI, A. RANIERI, G. SELVAGGI and P. SPINELLI
Dipartimento di Fisica dell'Universita' di Bari, e Istituto Nazionale di Fisica Nucleare, Sezione di Bari, Italy

H.J. GEBAUER, J. FENT, P. FREUND, J. SEYBOTH and J. SEYERLEIN
Max-Planck-Institut für Physik und Astrophysik, München, Germany

Received 14 February 1983

We describe a system of three multiwire proportional chambers used in the experiment NA24 at CERN. Each chamber consists of four wire places (2×2 m^2 sensitive area), packed together in the same mechanical frame with only five cathode foils. All planes are electrically independent and can be operated individually although each of the three inner cathode foils is used for two adjacent wire planes. Another feature of the chamber is that an area around the beam can be desensitized to allow operation in a high intensity beam.

1. Introduction

Three 2×2 m^2 multiwire proportional chambers (MWPCs), described below, are part of the charged particle telescope of the experiment NA24 at CERN [1], together with five smaller chambers (1×1 m^2) already used in the experimental NA6 [2].

The experiment NA24 is intended to measure direct photon production in hard hadron–hadron collisions at 300 GeV incident energy, triggering with calorimeters on high P_T photons in the final state. The high particle flux used in the experiment (typically 2×10^7 particles/spill) requires the use of MPRCs because of their small dead time.

The MWPC telescope consists of 22 wire planes, and covers the acceptance of the triggering calorimeters [1,3]. It provides the reconstruction of charged tracks with good spatial resolution and high multitrack recognition efficiency.

The chamber telescope is primarily used for vertex reconstruction to reduce background and to measure the charged particle multiplicity.

The features of the large chambers are:

a) The cathode planes, made of plastic foils [4], are coated with graphite on both sides. Thus the cathodes can be used for two subsequent wire planes, obtaining a more compact chamber.

b) The two sides of the cathode planes are electrically independent and can be set to HV separately. In this way each wire plane can be operated independently. This feature is very useful when a damaged wire causes a breakdown in a plane. In this case the plane can be turned off, while the rest of the chamber can be used normally.

c) An area of variable size in the center of the chamber ("beam killer") can be desensitized to allow the operation in a high intensity beam without losses of efficiency outside the beam region.

2. General description of the chamber

Each chamber consists of 11 machined Stesalit frames [5], of the dimension 2390×2390 mm^2 external size and 2000×2000 mm^2 internal size and 6 ± 0.05 mm thickness, packed together and stiffened by two external iron frames (fig. 1a and b).

The gas volume of each chamber is enclosed by plastic foils, glued to the first and to the last Stesalit frame. They are coated with graphite on the inside and grounded in order to screen the chamber electrically and to balance approximately the electrostatic forces on the outer cathode foils. No further barrier is needed to prevent humidity from penetrating the chamber because of the adequate thickness of the foils used and the presence of gas filled gaps on both sides which separate the multiplication region from the air.

The cathodes are made of plastic foils which are glued to the Stesalit frames. The foils are coated on both sides with graphite. The conductive external sides of the first and the last cathode foils remove electrostatic charges on the surface.

As shown in fig. 2, each cathode plane contains a central area of 60 mm diameter and a ring shaped area

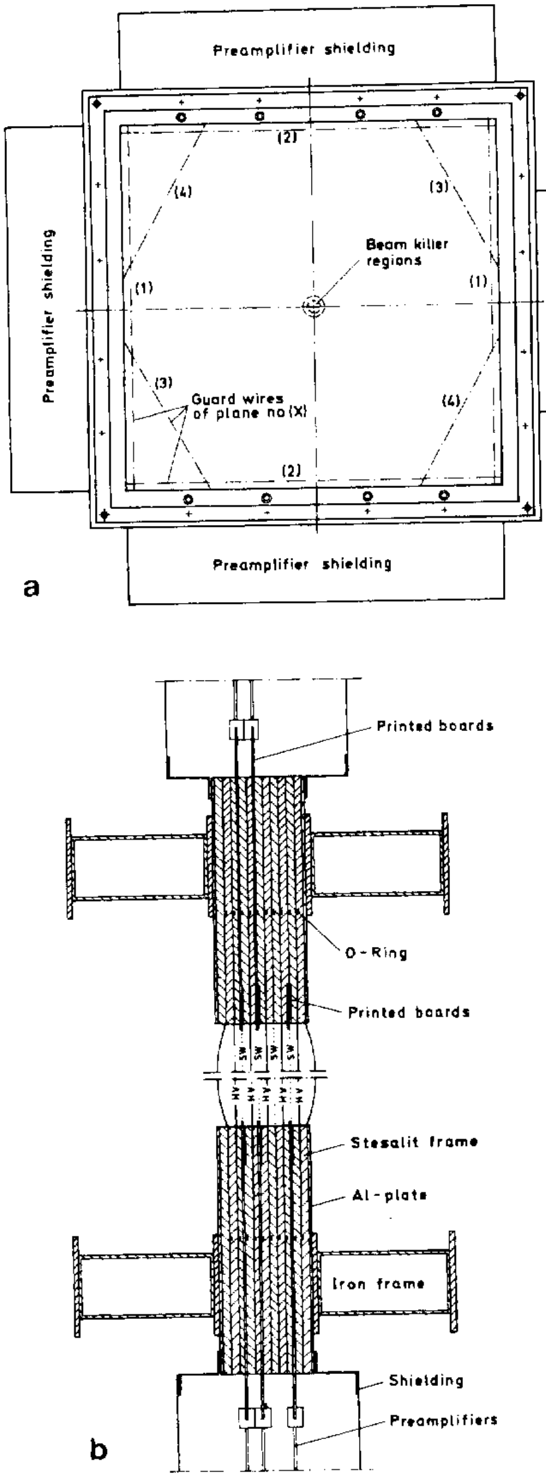

Fig. 1. a) Front view of a chamber. b) Cross section of a chamber.

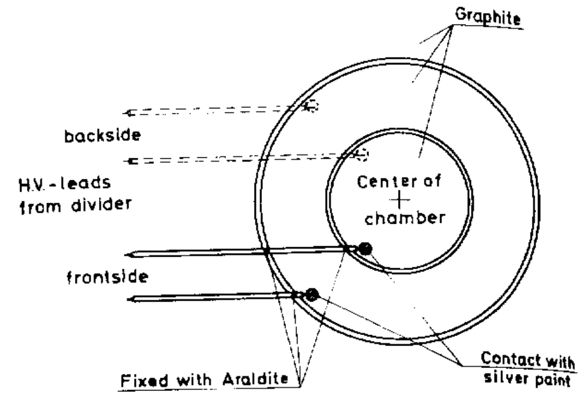

Fig. 2. Beam killer regions on the cathode plane.

of 120 mm external diameter connected to the HV separately ("beam killers").

The anode planes are made of 640 gold plated tungsten wires, spaced 3 mm apart, giving a sensitive area of about 2×2 m^2 (fig. 1a). The planes have four different orientations: vertical, horizontal and $\pm 28.07°$ with respect to the vertical. These angles were chosen because their sine and cosine are rational numbers (8/17 and 15/17). As a result of this, on-line space point reconstruction is possible without floating point calculations.

With a gap of 6 mm between anode and cathode a distance from the first to the fourth anode plane of only 36 mm is achieved (fig. 1b). This compactness simplifies the space point reconstruction of large angle tracks.

The 25 μm thick wires are soldered on printed boards with a precision of 0.1 mm and a tension of 70 ± 5 g. At the edges we use three guard wires with diameters of 50, 75 and 100 μm.

Two zig-zag shaped Mylar strips ("garlands"), 5 mm wide, in each gap between cathode foils and wires act as spacers and reduce the free wire length to a third. The free wire length (75 cm for inclined wires, 66 cm for the other ones) is shorter than the calculate critical length of 1.5 m. This prevent wire oscillations caused by electrostatic forces. The garlands also suppress the bending of the cathode foils if unbalanced electrostatic forces are present.

The garlands are glued at three points to a supporting nylon wire, 0.3 mm thick, which crosses them at their center as shown in fig. 3. The nylon wires are fixed at both ends to the Stesalit frames with a tension of 1 kg. As shown in fig. 3 insulated field wires of 0.9 mm diameter are stretched along the garlands in the 1 mm space between the garland and the anode wires. These field wires, set to a proper voltage, are used to restore the local chamber efficiency reduced by the garlands.

To aid in positioning the chambers, four fiducial

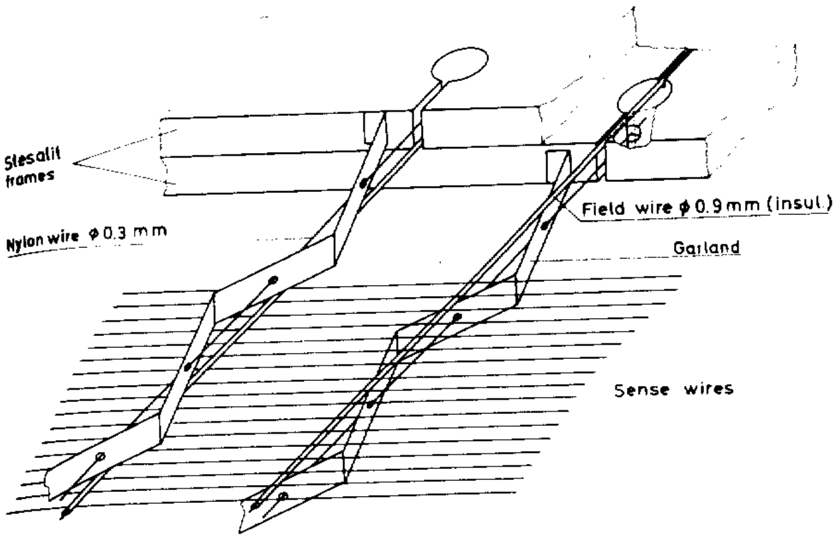

Fig. 3. Detail of the spacer arrangement.

marks are put on precision bolts (described below) in the corners of the chambers.

The gas tightness is ensured by soft O-rings placed in grooves in the chamber frames (fig. 1b). Four gas inlets and outlets were distributed along two opposite sides of the frame to provide a uniform gas flow.

3. Details of the chamber construction

3.1. Support frames

Iron frames stiffen the chamber and hold it up to its support. Iron was chosen because it has nearly the same thermal expansion coefficient as the Stesalit. Special care was taken in building these frames. Four rectangular extruded profiles were first welded at their corners to form a square structure. To obtain a good planarity four iron slabs of 4 mm thickness were placed on a flat assembling table and the iron support structure was glued on them with Araldite. In this way deviations from planarity of less than 0.1 mm were achieved on the surface facing the chamber.

Using a templet, machined bronze rings were positioned and glued with Araldite inside large corner holes of the Stesalit frame and of the iron frame. Then the 11 Stesalit frames of each chamber were assembled between the iron frames. Precision bolts of 20 mm diameter inserted into the holes give a position accuracy of 50 μm.

The position of the wires and the center of the beam killer region were referred to the center of these holes.

3.2. Cathode planes

The cathode planes were made by gluing plastic foils on the Stesalit frames. In order to stretch the foil uniformly and to prevent deformation of the finished plane, we used the following procedure: The Stesalit frame was first elastically deformed pushing its four sides towards the inner region with an expandable frame. Then the foil, stretched and fixed over the same expendable frame, was glued with Araldite to the Stesalit frame, which was kept under stress until polymerization had occurred. When the cathode plane was then released, it resumed its initial shape, without any significant deformation. The tension of the foil was set to about 50 kg/m, by using a dynanometric key when prestressing the expandable frame.

The graphite coating of the planes was applied by spraying twice the planes with Acheson 502 paint [6] diluted with 50% methy-butyl ketone. The surfaces were polished with a soft paper.

The beam killer regions were separated with two concentric tape rings 2.5 mm wide attached to the foils before the graphite spraying. The beam killers are connected via two insulated copper wires to the HV power supply distributor. These wires (0.9 mm diameter), were laid on the graphited plane and fixed to it with drops of rapid Araldite as shown in fig. 2; the electrical contact was provided by a drop of silver paint.

4. Read out electronics

The R.M.H. system developed at CERN was chosen to read out the chambers. A description of this system is given in ref. 7.

To facilitate checks on the electronics, signals can be induced on all the wires of a plane. For this purpose we stretched a brass strip, 1 cm wide, 50 μm thick, across the pads of the printed boards, insulated with a Mylar tape 75 μm thick. These strips are terminated with 50 Ω and fed with a fast pulse, a few volts high, which induces capacitively a signal on the pads.

5. Voltage supply

The voltage supply (5.2 V) for the preamplifier cards, is provided by a copper bar, which feeds all of them. The common is provided by an aluminium bar, insulated from the chamber support frame, to avoid ground loops.

The HV (one supply for each chamber) is distributed by four identical resistor dividers, one for each cathode plane pair (fig. 4). Those relays which are connected in parallel to the divider allow the beam killers to be switched on or off. When only the center is switched off its voltage is reduced to 2/3 of the full potential of the cathode. If the ring is switched off too, the voltage decreases to 1/2 at the center and 3/4 at the ring. This reduction is sufficient to lower the efficiency to nearly 0% (see below), and safe enough to avoid discharges across the "ring gaps" between the cathode regions. The remote control for switching the relays is placed in the counting room and their setting is displayed by LEDs.

A fast switch, sensitive to current bursts, protects the chamber against breakdowns. A Crytron KN 22 EGeG connects the HV to ground and lowers the chamber voltage to less than 10% within 0.5 μs after the current burst starts [8].

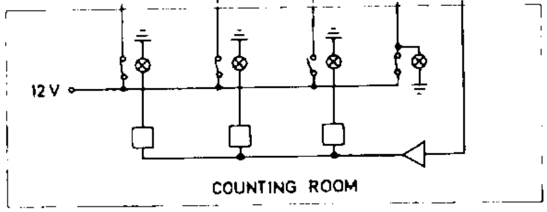

Fig. 4. High voltage distribution scheme.

6. Monitor chambers

In order to control the gas composition continuously we inserted six small monitor chambers in the gas circuit, one before and one after each large chamber. Each monitor chamber consists of a circular single plane MWPC of 6 cm sensitive diameter, inserted in an aluminium cylinder of 13 cm inner diameter and 3.5 cm height. In order to get the same dependence of the gas amplification on variations in gas composition, the important chamber parameters such as gap size, wire diameter, wire spacings, are identical to those of the large size chambers. Each monitor MWPC is irradiated through its transparent cathode (made of CU–Be wires) by a 100 μCi Ni 63 (β-emitter) source. Any variation of the gas mixture is immediately indicated by a change in the monitoring current.

7. Performance of the chambers

The chambers were operated with an argon (80%), carbon-dioxide (20%), freon (0.15%) mixture, for safety reasons and low cost operation.

Efficiency and dark current measurements are shown in fig. 5. The efficiency measurements were performed with 100 ns strobe width, 80 m twisted pair cable, and minimum R.M.H. threshold (5 mV). A plateau of 150 V is reached around a voltage of 2.97 kV.

The efficiency in the garland region was scanned with a beam spot of 2×15 mm^2. The results are shown in fig. 6, for various voltage settings on the field wire. The efficiency does not increase any more above 1750 V.

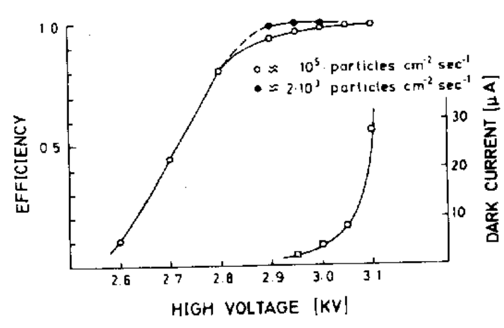

Fig. 5. Chamber efficiency (circles and dots) and dark current (squares) versus high voltage, for gas mixture of 80% argon, 20% carbon-dioxide, 0.15% freon.

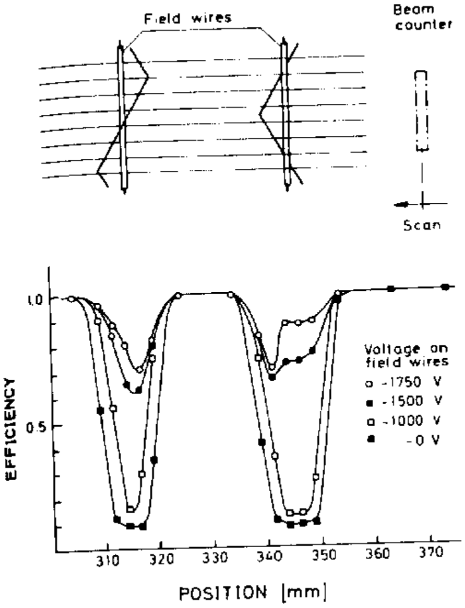

Fig. 6. Efficiency near the "garlands" for various high voltages settings of the field wire.

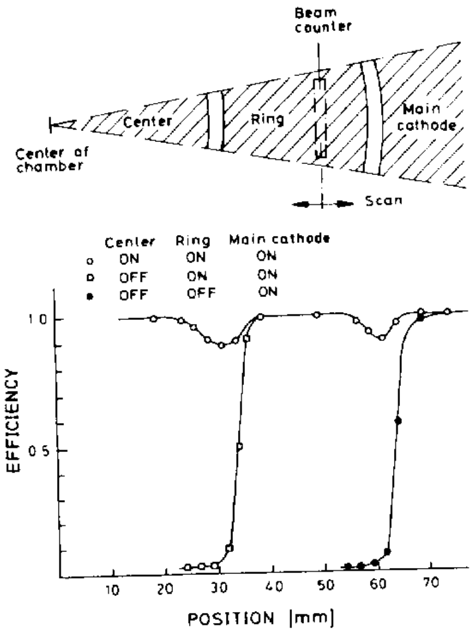

Fig. 7. Efficiency near the center of the chamber with the "beam killer" on and off.

We also measured the beam killer performance scanning with the same beam spot (fig. 7). The efficiency behaviour, in the beam killer regions set at full potential (2.97 kV), exhibits a slight decrease at the position of the 'ring gaps'. Fig. 7 also shows the efficiency when the center or the ring are set at the reduced potential. The inefficiency regions are seen to be sharply confined to the regions of reduced HV.

No efficiency losses were detected near the wires connecting the beam killers to the HV.

All the chambers have been successfully operated in the NA24 experiment.

We are grateful to Dr. K.P. Pretzl and Dr. P. Seyboth for many useful discussions. We wish to thank especially M. Lindenmayer for designing and making the construction drawings of the chambers. We thank our technical staff in Bari and Munich for their skillful work in building and operating the chambers. In particular we are grateful to R. Ferorelli for his help in designing the support equipment and to M. Perchiazzi, H. Fessler and A. Sacchetti for their contribution in assembling and testing the chambers. We thank G. Perchiazzi for her care in typing this paper.

References

[1] A. Bamberger et al., CERN Proposal CERN/SPSC/80-83, SPSC/p. 151.
[2] A. Babavev et al., CERN Proposal CERN/SPSC/76-74, SPSC/P76.
[3] C. De Marzo et al., Phys. Lett. 112B (1982) 173.
[4] Bari used foils 75 μm thick of Hostaphan type RV75, KALLE AG, Wiesbaden Bieberich, FRG, whole the Max Planck Institut, München used Myler foils 50 μm thick.
[5] A.G. Stesalit, Zullwill, Switzerland.
[6] DAG 502, Acheson cooloiden NV, Scheemda, Holland.
[7] J.B. Lindsay et al., Nucl. Instr. and Meth. 156 (1978) 329.
[8] M. Bozzo et al., Nucl. Instr. and Meth. 178 (1980) 77.