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P3 — THE FULL-SCALE PROTOTYPE OF THE ME1/1 CSC

1999

1 Introduction

The overall view of the CMS Endcap muon system, ME, is shown in Fig. 1 [1]. The innermost first forward muon station ME1/1 is placed in a slot between the Endcap hadron calorimeter HE and the return yoke disk YN1. There are 36 ME1/1 6-layer cathode strip chambers, CSCs [2], in each Endcap.

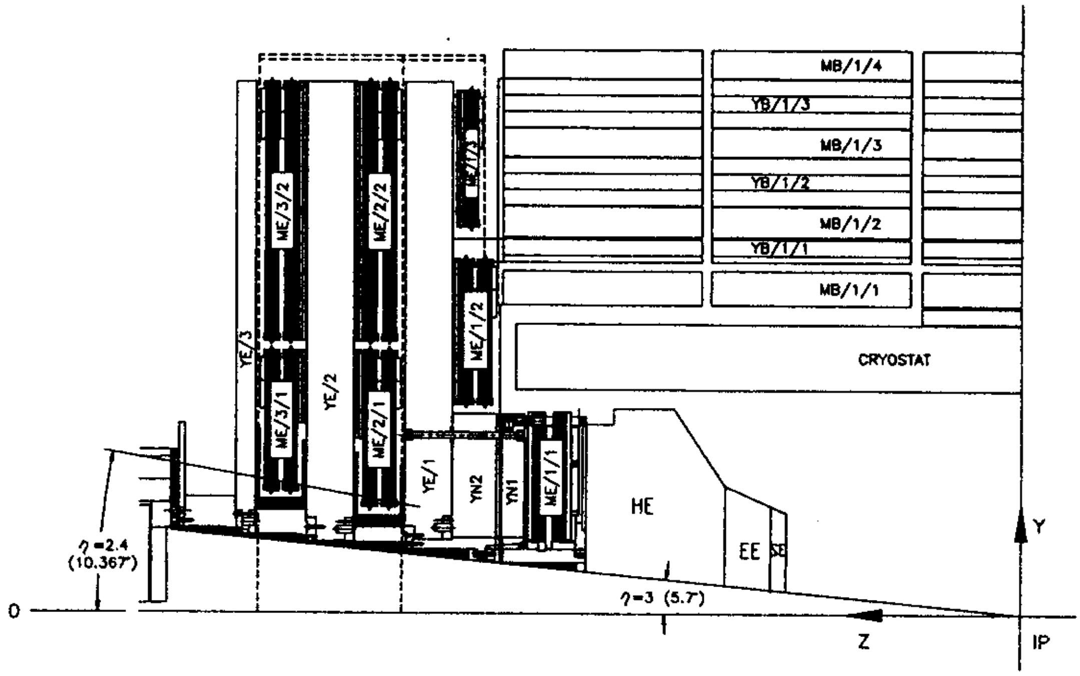

Fig. 1: Longitudinal view of the CMS detector.

CSCs are arranged to form a disk (see Fig. 2) with the angular acceptance η=1.6-2.4. Each CSC overlaps with the neighbouring chambers in 5 strips. The chambers are situated inside the CMS solenoid and operate at high magnetic field of about 3 Tesla. The overall sensitive area covered by the chambers is more than 34 m^2.

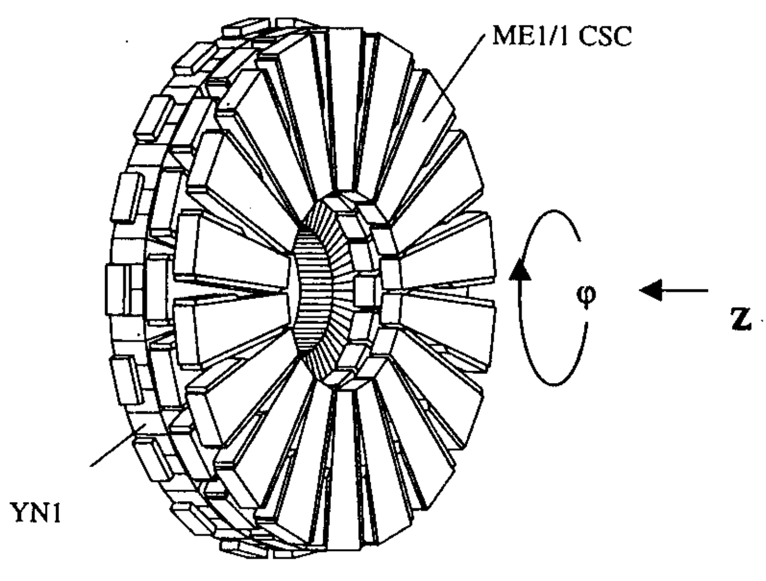

Fig. 2: ME1/1 muon station (one Endcap).

2 P3 layout and main parameters

The layout of the P3 prototype is shown in Fig. 3. It was designed and fabricated at JINR Particle Physics Laboratory. P3 represents a full-scale 10° sector of the CMS ME1/1 Endcap muon station [3]. It is a unit of six trapezoidal proportional chambers, layers, with cathode strip readout. Each layer is formed by two cathode electrodes with the gap of 5.6 mm and anode wire electrode in the middle.

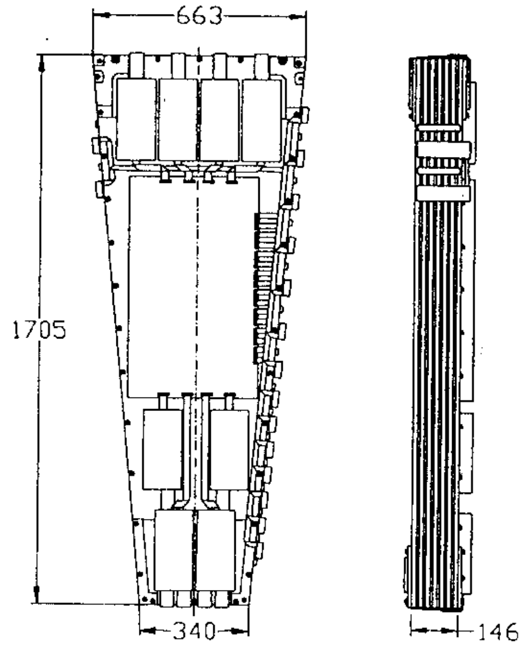

Fig. 3: Overall dimensions of the full-scale prototype P3 (in mm).

To compensate the effect of the avalanche shift in the magnetic field of 3 Tesla the anode wires are positioned at the inclination angle of 22° with respect to perpendicular to the cathode electrode axis as shown in Fig. 4.

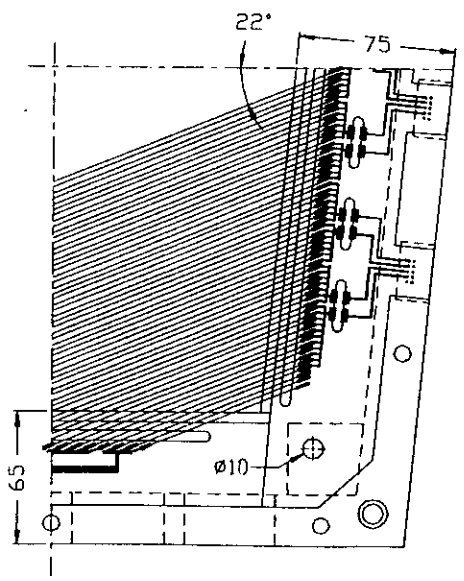

Fig. 4: The fragment of the bottom part of the anode wire electrode.

Wire tension is 80±5 gram. The anode wire readout channel corresponds to the group of 7–12 wires. In each layer one cathode is continuous while another one represents a system of strips. This radial strip structure covers the φ–angle range of ±5.42° to provide the overlapping with the neighbouring CSCs. The strip electrode is segmented by a transversal cut in 2 groups: the top part - η=1.6-2.0 and the bottom one - η=2.0-2.4. The main P3 parameters are presented in Table 1.

Table 1

The main parameters of the P3 ME1/1 prototype.

ME1/1	Number of φ-segments (CSCs)		72
	η-segmentation		2
	Total number of strip channels		55,296
	Total number of anode channels		27,648
CSC	Number of layers per CSC		6
	Inner radius	m	0.995
	Outer radius	m	2.700
	Height	m	1.705
	Inner width	m	0.340
	Outer width	m	0.663
	Area	m^2	0.85
	Sensitive area	m^2	0.55
	Number of strip channels		768
	Number of anode channels		384
CSC Layer	Anode-Cathode distance	mm	2.8
	Wire spacing	mm	2.5
	Cathode strips:		
	Number of channels		64+64
	Strip length: top	mm	1135
	Strip length: bottom	mm	440
	Readout pitch width: top	mm	7.8
	Readout pitch width: bottom	mm	3.15
	Shape		radial
	Anode wires:		
	Diameter	μm	30
	Number of wires		625
	Number of channels		64
	Number of wires per group		7–12
	Inclination angle	degree	22

3 Panel design and production technology

For strip electrode production a milling machine has been designed and assembled. The radial shape of strips is made by a 0.35 mm thick rotating diamond disk. A transversal cut of the strips provides a radial separation in two groups of the strips (see Fig. 5). The length of the strips for the bottom group is 0.440 m and 1.135 m for the top one. Each strip covers the φ-angle of 2.96 mrad. After the milling the strip electrode is polished. Flat cables are soldered to the strips for connection to the readout electronics. There are 64 (top) + 64 (bottom) readout channels in each layer.

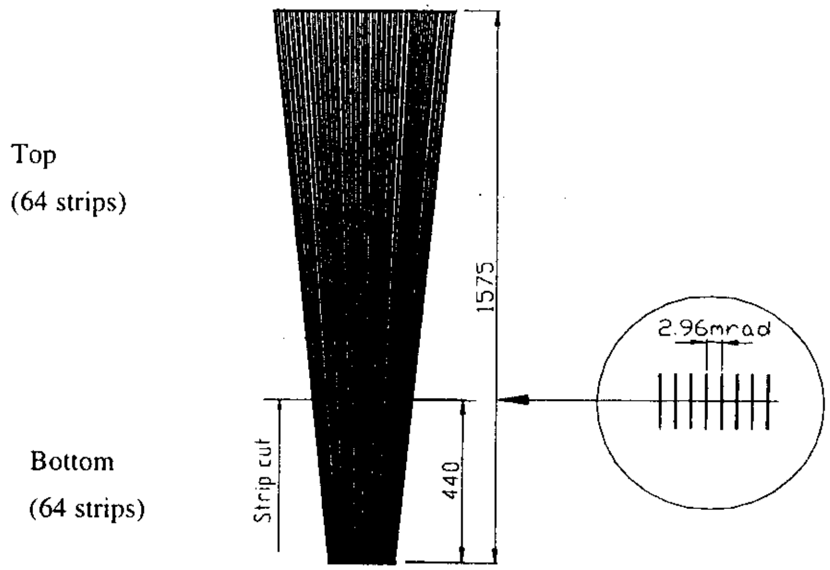

Fig. 5: P3 strip electrode.

The main constructive element of the P3, a "honeycomb" self-supporting panel, is shown in Fig. 6.

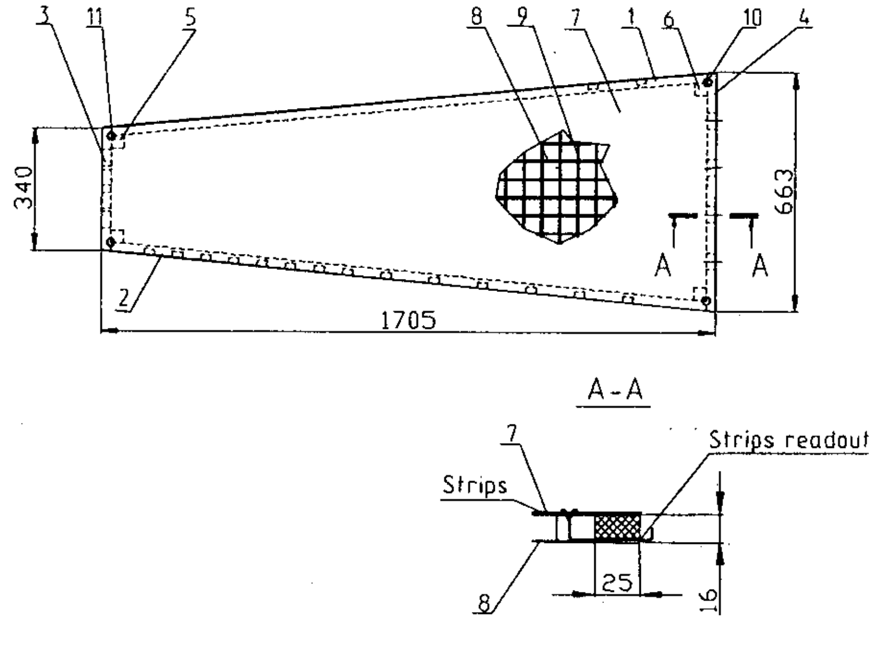

Fig. 6: Self–supporting "honeycomb"–like panel.

The main requirements for the panel are: unflatness not worse than ±50 μm, rigidity, and low weight. The P3 panel consists of 25 mm width edge bars, pos. 1–4, insets for gas channels, pos. 5-6, strip electrode, pos. 7, continuous electrode, pos. 8, and "honeycomb"-like structure, pos. 9. Strip and continuous electrodes are made of 0.8 mm single sided metallized FR4. The thickness of the Cu lamination is 18 μm. The "honeycomb"-like filler of the rectangular shape is made of 0.5 mm FR4 strips. The size of the cell is 20×20 mm^2.

4 P3 assembly

The P3 cross-section is shown in Fig. 7. The chamber construction is symmetrical with respect to the central panel # 4 in order to compensate the rest tensions in the panels. The anode-strip electrode gap is determined with the accuracy of ± 25 μm by anode bars with PCBs. The bars are glued to the panel. The anode wire electrode is made by a wire-stretching machine. The wires are transferred to the PCBs by the transfer frames. Special combs ensure 2.5 mm wire spacing with the accuracy of ± 25 μm. The wires are soldered to the PCB pads (see Fig. 4) and glued. The rubber seal is used to isolate the gas volume from the atmosphere.

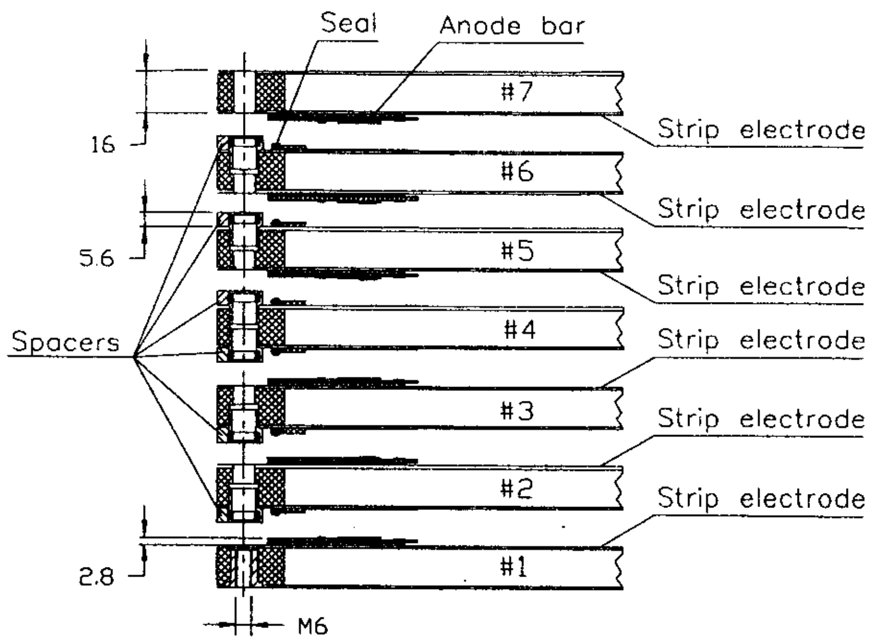

Fig. 7: P3 cross-section

The precision of the cathode–cathode gap is determined by 32 brass spacers with the accuracy of ±25 μm. The spacer design also provides an electrical connection between the two cathodes of each layer and at the same time isolates the outer CSC electromagnetic screen from reference ground of the analog signal.

The assembly procedure is the following. The two alignment pins are inserted into the reference bushings (pos. 10-11, Fig. 6) of the first panel. The second panel is put on the first one. Pins are inserted into the reference bushings of the second panel and so on. Finally P3 is screwed by 32 M6 bolts.

6 Acknowledgements

The authors would like to thank E.Zubarev and Dubna CMS group for their kind attention to our activity.

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Ершов Ю.В. и др. E13-99-296
Р3 — полномасштабный прототип КСК ME1/1

Сконструирована и изготовлена шестислойная катодно-стриповая камера Р3. Эта камера является полномасштабным прототипом 10° сектора мюонной станции ME1/1 детектора CMS (ЦЕРН). Описаны конструкция, основные параметры и технология производства Р3.

Работа выполнена в Лаборатории физики частиц ОИЯИ.

Сообщение Объединенного института ядерных исследований. Дубна, 1999

Erchov Yu.V. et al. E13-99-296
P3 — the Full-Scale Prototype of the ME1/1 CSC

P3, the 6-layer cathode strip chamber has been designed and produced. This chamber is a full-scale prototype of 10° sector of the ME1/1 Endcap muon station of CMS detector (CERN). Design, basic parameters and fabrication technology of P3 are described.

The investigation has been performed at the Laboratory of Particle Physics, JINR.

Communication of the Joint Institute for Nuclear Research. Dubna, 1999