CMS Conference Report

March 10, 1998

Report on the CMS Forward-Backward MSGC milestone

Oliver Pooth for the CMS Forward MSGC Collaboration

*IIHE ULB/VUB Brussels, UCL Louvain la Neuve, UIA Antwerp, UMH Mons
IPN Lyon, UHA Mulhouse, IReS Strasbourg
RWTH Aachen I & III, IEKP Universität Karlsruhe
Budker Institute for Nuclear Physics, Novosibirsk*

Abstract

The CMS MF1 milestone was set in order to evaluate system aspects of the CMS forward-backward MSGC tracker, to check the design and feasibility of mass production and to set up all assembly and test procedures. We describe the construction and the experiences gained with the operation of a complete system of 38 MSGC detectors assembled in 6 multi-substrate detector modules corresponding to the geometry of the forward-backward MSGC tracker in CMS. Corresponding to various possible designs, the detector modules were equipped with MSGCs mounted side by side without dead space (wall less φ crack) forming a continuous detector surface of about 0.2 m^2 . Operation conditions for these 38 MSGCs are reported from an exposure to a muon beam at the CERN SPS. Gain uniformity along the wedge shaped strip pattern and across the detector modules will be shown.

Presented at *Vienna Wire Chamber Conference*, Vienna, February 24, 1998

Submitted to *Nucl. Instrum. Methods A*

1 Introduction

The MF1 Milestone experiment: The CMS [1] forward MSGC group performed a milestone experiment to study system aspects of a complete system of multi-substrate Micro Strip Gas Chambers (MSGC).

Detector modules with 4 to 8 substrates with wedge shaped strip patterns were tested in a beam test experiment. The substrates in each module are aligned with respect to each other and mounted in a wall less φ crack manner, i.e. without any mechanics between them to build a continuous detector surface.

Such six detector modules were built and tested with a total of 38 substrates, i.e. 19456 strips, and operated for two weeks. The detectors are equipped with 152 front end chips on 4-chip hybrids connected to service board modules providing all driving signals. The readout was done by a common data acquisition system.

The CMS environment: The Large Hadron Collider (LHC) will be built to study proton-proton interactions at a centre of mass energy of 14 TeV at a 40 MHz rate, i.e. 25 ns between the beam crossings. CMS is one of the experiments that will be installed at LHC (see fig. 1). The outer shell of its central tracker will be equipped with MSGCs and will cover an area of about 200 m² with approximately 15500 substrates leading to $6.6 \cdot 10^6$ readout channels. The forward-backward disk structure for the CMS detector is shown in figure 2. On these disks wedge shaped counters are arranged in rings, one ring being made of several detector modules.

Figure 1: The CMS detector.

Figure 2: Forward-Backward disk structure.

2 Detector modules in the milestone

Six detector modules were built by different groups with two different designs. They differ essentially by their gas flow system, their alignment procedure and the fact, that the front end electronics in either outside or inside the gas volume. Referring to their design, they are labelled C1, C2, O1 to O4. Figure 4 shows a picture of two adjacent multi-substrate modules with 4 trapezoidal MSGCs in the same gas volume.

As it is convenient for pattern recognition the strips are arranged radially on the substrates. The length of the central strip is 18.6 cm. The width of the substrate is 12.8 cm on the long side and 10.7 cm on the short side. Therefore the anode-anode pitch varies from 250 μm to 212 μm along the strips. The substrate's dimensions can be seen in figure 3. In order to keep a constant gain over the full length of the MSGC substrate the anode width is kept constant at about 10 μm , while the anode-cathode gap and the cathode width follow a homothetic rule, the so-called NIKHEF rule [1]:

$$G = P/8 + 20\mu\text{m}. \quad (1)$$

G represents the anode-cathode gap, P the pitch, both depending on the radial position of the detector module. For the present milestone, aiming only to test the system aspects, cheaper substrates than the final ones were used. Either Al or Au were printed on bare D-263 glass of 300 μm thickness. Different producers were tried by different groups.

All 512 anodes of each substrate were read out by four PreMux128 chips [2]. A 128 channel front end chip containing 128 charge sensitive preamplifiers, 128 CR-RC shaper ($\tau \approx 40$ ns), 128 sampling circuits and a multiplexer at the output realized in CMOS. The PreMux128 were operated in the peak-mode, i.e. one sampling point per event at the maximum of the signal.

Figure 3: A wedge shaped MSGC substrate.

Figure 4: Two multi-substrate modules, 4 substrates each.

3 Results from the milestone

CERN's X5 area provides 100 GeV muons in spill mode penetrating the six modules standing one behind the other on a common support. In total 19456 MSGC channels were operated for two weeks with Ne/DME (1:2) as counting gas. The results obtained by the different detectors were very similar. Therefore only some selected examples are shown here.

Figures 5 and 6 show typical distributions of the signal-to-noise ratio (S/N) and the number of strips with signal over threshold within the cluster of charge deposited by a particle. The S/N ratio is defined as the total cluster charge divided by the cluster noise, taking into account all strips in the cluster.

Figure 5: S/N distribution calculated by $Q_{\text{cluster}} / \sqrt{\sum \sigma_i^2}$.

Figure 6: Cluster size distribution.

Figure 7 shows the detector efficiency, corrected for dead strips, as a function of the average S/N. Figure 8 shows the average S/N with varying drift voltage for a cathode voltage of -530 V. A single measurement with a cathode voltage of -510 V is also displayed. A decrease of cathode voltage by 20 V can be compensated by an increase of the drift voltage by 800 V. This results in more safe operation conditions.

To proof the validity of formula 1 we investigated the uniformity of the gain along the wedge shaped strip pattern. Results for various detectors are given in figure 9. For the detector modules C1 and O2 the variations are less than 8%. Larger variations are observed for C2 and O2, made with the same mask, are attributed to the procedure used by the producer, being the same in both cases. Figure 10 shows that it's possible in the wall less φ crack mounting to get uniform response from the detector module.

Figure 7: Efficiency vs. S/N (max. probable value of the Landau distribution).

Figure 8: S/N vs. drift voltage.

Figure 9: S/N vs. anode pitch.

Figure 10: S/N vs. position in the module.

4 Conclusion

The MF1 milestone experiment shows that the CMS forward MSGC collaboration is able to build multi-substrate modules with trapezoidal strip pattern. During the MF1 test we operated 19456 strips grouped in six multi-substrate detector modules.

Uniform gain across the entire detector surface was found and the wall less φ crack mounting of aligned substrates has been shown to work.

References

- [1] CMS Technical Proposal, CERN/LHCC 94-38
- [2] L. L. Jones, PreMux specification, version 2.3, January 1995