Design and development of large size 8-layered sector shaped readout PCB for the GEM detector of CBM experiment

J. Saini,* A. K. Dubey, N. Mondal and S. Chattopadhyay
Variable Energy Cyclotron Center, 1/AF Bidhan Naga, Kolkata-700064, INDIA
** email: jsaini@vecc.gov.in*

Introduction

A GEM based detector system is being developed at VECC, Kolkata for use as muon tracker [1] in the Compressed Baryonic Matter (CBM) experiment. Due to high rate in the inner region near the beam pipe and relatively lower rate radially outwards, progressive pad geometry was chosen to optimize the rate versus number of channels per chamber, for the first two stations. Due to progressive pad geometry, there is relatively high density of pads in the inner ring and hence the design required an 8-layered PCB.

PCB design and constraints

GEM chambers of the first two stations are placed in the high intensity zone and hence to take care of the rate, the pad size was optimized to one degree through simulation.

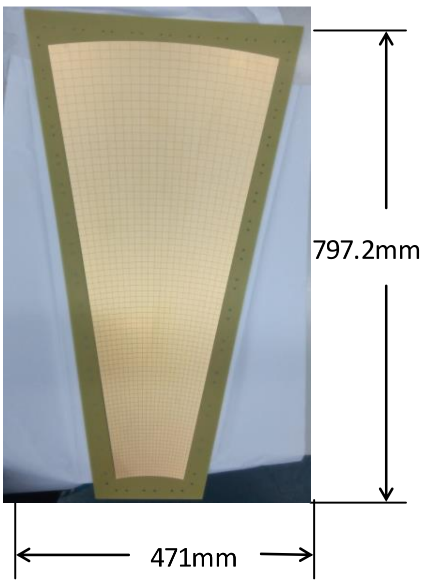

Fig. 1 Top copper view of the readout PCB showing progressive geometry of the pads

To fit in the sector geometry and have the lowest dead area, each pad is a trapezoid where two larger angles of the trapezoid are of 90.5 degree each. In the current design, minimum isosceles trapezoid with both base and height of 4mm, which are used as the pads in innermost ring while maximum isosceles trapezoid with both base and height of 16.6mm which are used as the pads in outermost ring. The GEM chambers are designed to have a coverage of 22.5º which makes 16 chambers to cover the entire layer of the 1st station. To cover the full region, alternate chambers are planned to be put in different planes to avoid dead area due to mechanical structure of the chamber. To further reduce the dead space, this design is made with 23º coverage so as to overlap half degree with the consecutive sectors. With 23º the PCB has 23 pads and in the annular ring and 79 pads in radial direction giving total number of pads to be 1817 for a detector module.

To cover these 1817 among the FEE boards of 128 channels each, this PCB is divided into 15 readout zones. Furthermore, this PCB is designed to meet the active area from 5.4º to 25º. Excluding the inner unavoidable mechanical structure, total active area is 708mm in radial direction and 381mm width at the outermost ring of this sector geometry. To accommodate the mechanical fittings, the final dimension of this PCB is 471mm X 798mm. Fig.1 shows the dimension of the PCB and the active area as the top copper progressive geometry pads.

As the radiation in the innermost region is very high, the connector closest to the beam pipe is located at radii of 396mm from the beam axis. This position corresponds to 146mm from the PCB edge. Fig.2 shows the connectors at the bottom PCB with connector mounted on it. As per FLUKA calculations, this distance reduces the radiation, 3-times (i.e. 10Krad instead of

30Krad for 10-years of operation) from the edge putting lesser constraint on the component selection. To reduce the noise, the tracks are drawn beneath the pads and bottom plane is used as a ground plane. Although this extra ground plane adds the capacitance but at the same time, additional shielding is not required to achieve the acceptable noise levels. The maximum track lengths are approximately 30cms at the outer zone where pads are more scattered.

Fabrication

As the proceedings print will be in mono-color due to multi-layered PCB, and minimum track width of 6mil, there are limitations with the PCB manufacturers. They have the jig of 800mm X 600mm but they ensure the quality in the area of 600mm X 400mm. For this PCB, they have used their fullest jig with some reduced accuracy at the edges. For this purpose, special care is taken at the edges in the layout design. There was further problem in the solder mask bath tub size used in the fabrication process.

Fig. 2 Bottom copper view of the readout PCB showing connectors for signal output from pads.

This was sorted out by making bath twice. This makes an overlap region on the PCB back which is visible on the bottom side of the PCB. This was not critical in this design as the sensitive region, which is pad side PCB didn't required the bath.

Performance

A GEM chamber was made using this PCB and was tested in the beam time at COSY in Dec-2014. The noise with the self-triggered nXYTER [1] based readout was under acceptable limits. Chamber also showed the efficiency of charge particle detection was more than 90% percent at all the zones showing that this is an acceptable design. Further studies on noise characteristics with respect to small v/s large track length are underway. The results of this tests and the detailed design will be presented.

Future design

The new design is ongoing which will have 6cms bigger active region than the current design. The work is ongoing in consultation with the manufacturer to meet the larger active area within their existing setup.

References

[1] CBM-MUCH Technical Design Report 2014 (TDR).