Design of Large Size Segmented GEM foils and Drift PCB for CBM MUCH

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Introduction

Triple GEM (Gas Electron Multiplier), sector shaped detectors will be used for Muon tracking [1] in the Compressed Baryonic Matter (CBM) experiment at Anti-proton Ion Research (FAIR) facility at Darmstadt, Germany. The sizes of the detectors modules in the Muon Chambers (MUCH) are of the order of 1 meter with active area of about 75cms as schematically shown in Fig.1. Progressive pad geometry is chosen for the readout from these detectors. In construction of these chambers, three GEM foils are stacked on top of each other in a 3/2/2/2 gap configuration. The GEM foils are double layered copper clad 50µm thin Kapton foil. Each GEM foil has millions of holes on it. Foils of Large surface area are prone to damages due to discharges owing to the high capacitance of the foil. Hence, these foils have their top surfaces divided into segments of about 100 sq. cm. Further segmentation may be necessary when there are high rate requirements, as in the case of CBM. For the GEM foils of CBM MUCH, a 24 segment layout has been adopted as reported earlier [2]. Short-circuit in any of the GEM-holes will make entire foil un-usable. To reduce such occurrences, segment to segment isolation using opto-coupler in series with the GEM-foil segments has been introduced. Hence, a novel design for GEM chamber drift-PCB and foils has been made. In this scheme, each segment is powered and controlled individually. At the same time, the design takes into account, the space constraints, not only in x-y plane, but also in the z, due to compact assembly of MUCH detector layers.

GEM foil segmentation

The GEM module in CBM-MUCH is trapezoidal in shape and so are the GEM foils. The large size GEM foil is segmented into small divisions. The inner 4 segments are of 25sq. cms each, while the remaining ones have 100sq.cms each. As compared to the foils designed for first real-size prototype [2], a major modification was done to accommodate the independent HV input.

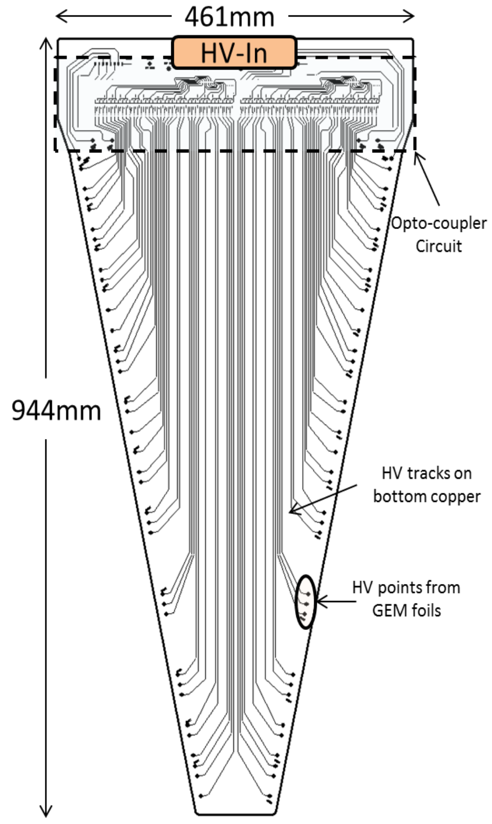

Fig. 1 Drift PCB schematic representation taken from GERBER of the design

Since each foil segment would now need to be controlled, this leads to having 3 HV spring-contacts for each set of top-foil, middle-foil and bottom-foil of a segment. Protection resisters were earlier placed on each foil, but now its position has been shifted to the drift PCB's along with the opto-coupler circuit section as shown in

Fig.1. The inner frames which clamp the foils are of thicknesses corresponding to the transfer gaps. These frames were redesigned to incorporate large number of spring contacts. The segment-design on the foils was modified to accommodate excess spring-contact holes as shown in Fig.2.

With 24 segments in each foil, there would be a total of 72 segments within one large sized CBM-MUCH GEM chamber. All the lines carrying HV to these segments and their proper insulation has been a big concern in laying out these tracks. The tracks are connected to the respective segments through the spring contacts as explained earlier [2]. Each segment is connected in series with an externally controlled opto-coupler. All these segments will be grouped in to two halves. Each half will be powered parallely by a resistive chain. As per the present design, the plan is to use one HV channel to supply both the resistive chains.

Drift PCB design modification

In earlier design all the segments are powered through the same power line and hence numbers of tracks were less and were accommodated on the top side of the drift PCB. However, with inclusion of this new HV distribution, number of HV tracks has increased manifold and hence these cannot be accommodated on the top copper due to limited space. In this new design all the tracks are now routed through the bottom copper. Top copper on this PCB is inside the chamber sealing and thus the tracks on the top side has no HV isolation issues but bottom copper is outside the chamber and special precaution needs to be taken while drawing HV tracks. A single layered thin PCB will be pasted on the bottom side of the drift PCB during fabrication process. The copper layer of the thin PCB will be connected to GND plane, for insulating the HV tracks and EMI-shielding. Each HV track requires one opto-coupler hence the circuit is required to handle 72 such components. These devices are in general not radiation hard, hence they are positioned at the outer extremity of the trapezoidal module. Under this optimized layout, the opto-couplers are placed radially at about 1 m distance from the beam-axis. At this position, they will have to withstand an estimated neutron radiation dose of ~10^{12} n.eq./cm^2 along with a total ionizing dose of ~30 krad for the entire running of CBM MUCH. The dose rate has been calculated using FLUKA and is reported in the CBM-MUCH TDR [1]. The layout of the drift PCB with opto-coupler circuit block and HV tracks are shown in Fig. 1. A prototype based on this new layout is under fabrication in Indian industry and will be available for tests by fall 2016.

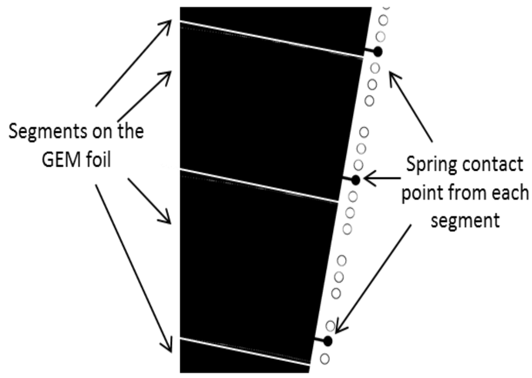

Fig. 2 GEM foil section showing segmentation and spring contact locations.

Acknowledgement

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References

[1] CBM-MUCH Technical Design Report 2014 (TDR)
[2] Building and testing of the first real size prototype chamber of CBM MUCH, DAE Symp. On Nucl. Phys. 60, 1078-1079 (2015).