Installation and commissioning of pre-production series MuCh-GEM modules in mini-CBM, June 2024 beamtime at GSI, Germany

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Introduction

As a part of FAIR Phase-0 program, the mini-CBM (mCBM) experiment is designed to test all the detector sub systems, DAQ and the data transport chain. During the mCBM June, 2024 beamtime, 2 final version of MuCh GEM modules has been installed. As the CBM (Compressed Baryonic Matter) is designed to be a fixed target experiment, so the generated particles will be forward focussed. For 25 AGeV energy and 10 MHz interaction rate, the maximum hit density at the inner region of MuCh will reach upto 0.4 MHz/cm^2[1]. This rate will gradually decrease as we go radially outwards from beam pipe.

FIG. 1: MuCh setup in mCBM

The CBM MuCh detector readout planes are designed according to a progressive geometry, i.e the inner region pad sizes are of smaller size (0.1 cm^2) and the pad size increases upto 2.89 cm^2 as we go outwards for station-1 chambers [2] . So to test the rate capability of the inner zone of the detector, we oriented the narrow zone towards beampipe (30 cm away), such that this region faces the highest particle intensity as shown in Fig. 1.

During the beamtime due to some sudden accelerator constraint in GSI, SIS18, we got only fast extracted beam, which contained a spills of 10^6 Uranium (U^{73+}) particles coming in 1 micro sec duration and the time gap between 2 spills was around 3.5 sec. Fig. 2 shows the spill structure of MuCh GEM-1 module in 100 ns time bin, the inset shows the zoomed view of 1 spill and the beam is observed to have nano structures.

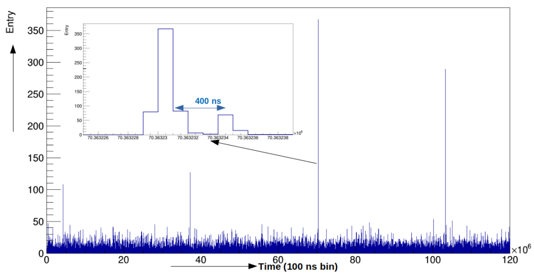

FIG. 2: Spill Structure of GEM-1, Inset: Zoomed view of 1 Spill

Data sets were acquired for around 6 runs, each of 1 hour duration, at GEM summed

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voltage of 1122 V for GEM-1 and 1130 V for GEM-2. GEM-1 was entirely populated with 18 Front End Boards (FEB) whereas GEM-2 was populated with 14 FEBs. A MFC based gas mixing unit was calibrated and was used to get Argon:CO_2 (70:30) gas mixture for MuCh GEMs. Both the modules were connected in daisy gas chain with gas entering through GEM2 and exiting through GEM1. GEM2 is the prototype that was tested at CERN, GIF++[3].

Data Analysis

The number of digis (fired pads) per time slice (1 TS = 128 ms) comparison is shown in Fig. 3. A noise cut of 1.5 KHz per channel is applied to remove the hot channels. As GEM-1 is more noisy so it shows higher digis compared to GEM-2.

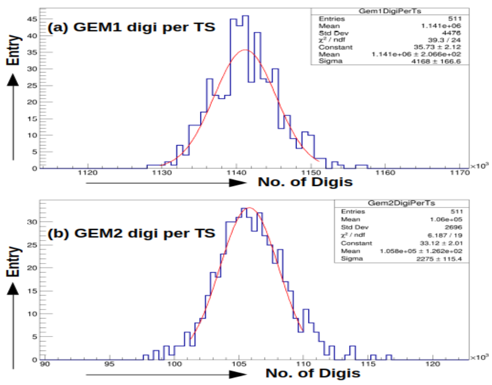

FIG. 3: Digis per TS: (a) GEM1, (b) GEM2

A clear time correlation peak with a sigma of 34 ns is observed between GEM-1 and GEM-2, as shown in Fig. 4.

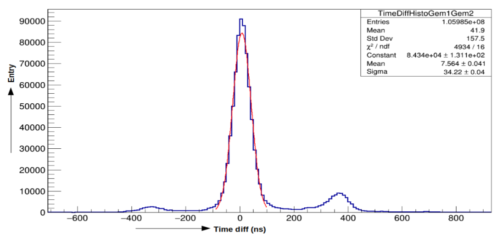

FIG. 4: Time correlation of GEM-1 and GEM-2

The extra 2 peaks in the figure arise due to nano structure in the beam. As the spill in Fig. 2 shows 2 structures, 400 ns apart (same has been observed for GEM-2 also), so from the time difference combinations of those structures result in the extra 2 peaks.

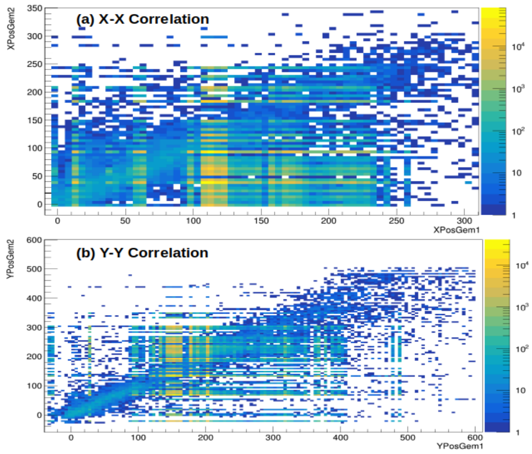

FIG. 5: X-X Correlation, (b) Y-Y Correlation

Fig. 5 shows the spatial correlation of GEM-1 and GEM-2. This has been calculated within a time window of -50 ns to 50 ns. The X and Y used here are local coordinates w.r.t the readout PCB. The X is along the narrow side and Y is along the broad size of the trapezoid. The GEM-2 readout has missing 4 FEBs in the outer region of the trapezoid, so one can see the unfilled portion in the Y-axis of Fig. 5. (b). The spatial correlation confirms that both the GEM modules are well alligned.

Further analysis on event building are ongoing for efficiency calculations.

Acknowledgments

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References

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