Testing of Track Point Resolution of Gas electron Multiplier with Pion Beam at CERN SPS

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Introduction

The future Compressed Baryonic Matter (CBM) Experiment at FAIR, Germany will measure charmonium and low mass vector mesons by their muonic decay channel with a Muon Chamber (MUCH) detector. Operation of CBM-MUCH at high interaction rate requires a detector with large acceptance, high granularity and high rate capability. First few detector stations at MUCH will use Gas Electron Multiplier (GEM) technology [1, 2] . We have conducted a test experiment with prototype detectors using triple GEM at CERN-SPS with 150 GeV/c Pion beam. In CBM experiment, tracks are reconstructed using the hits recorded in a number of Silicon Tracking Stations (STS) placed inside a dipole magnet. Later those tracks are projected onto muon chambers for further reconstruction required for muon detection. The beam undergoes multiple scattering inside the absorbers so tracking may be effected. We report here the estimate of the track-point resolution of the GEM detector using a self-trigger read out ASIC.

Experimental Setup

The layout of the setup is shown in Fig.1. In this test experiment, four prototype GEM detectors were used. One of them, is assembled at VECC and it is 10cm x 10cm in size and consists of 512 readout pads of dimension 3mm X 3mm. The drift gap, transfer gap1, transfer gap2 and induction gap were 3mm, 1mm, 1mm, 1.5mm respectively [3] and the gas mixture used was Ar:CO_2 in the ratio 70:30. The resistances are so chosen that the voltage across all the GEM foils are same for the GEM0. The signal corresponding to a hit, is read out by four Front End Boards(FEB), each of which houses one nXYTER chip. Data acquisition and control were done by Read Out Controllers(ROC). For data acquisition two types of triggering have been used. First one is the Aux1 triggering where 4 scintillators along with a finger scintillator was used. In Aux2 type triggering, only 4 scintillators were used. Here in this analysis we used Aux2 as trigger.

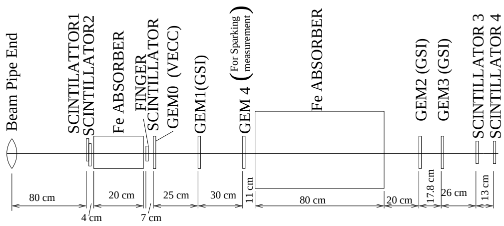

FIG. 1: Experimental Setup at CERN H4 beam line

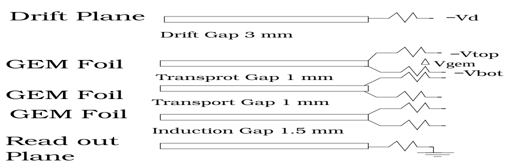

FIG. 2: Schematic layout of the triple GEM chamber

Another three detectors were built at GSI, Germany. The drift gap, transfer gap1, transfer gap2 and induction gap of GSI GEMs were 3mm, 2mm, 2mm, 2mm respectively. Each

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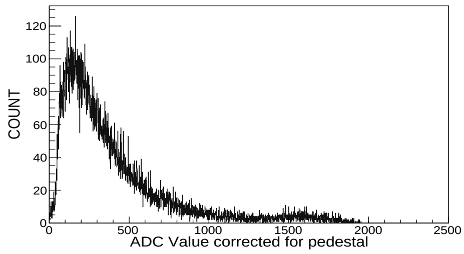

FIG. 3: ADC distribution of VECC GEM for V_d = 3000 Volt and Δ_{GEM} = 334 Volt

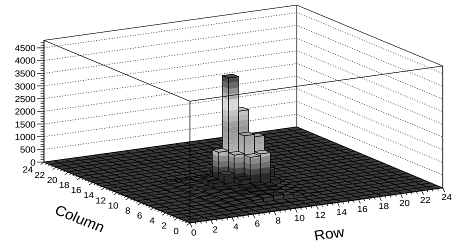

FIG. 4: Lego plot of the hits distribution for GEM0 for Δ_{GEM} = 334 Volt

chamber consists of 256 readout pads, each of which 6mm X 6mm in size and readout by 2 FEBs connected to one ROC. For this self triggering system, all the hits above a predefined threshold are readout by the nXYTER. The signals are digitized and stored. Only hits with the time-correlation with the trigger window are taken for analysis.

Result

In this analysis, first the alignment of the 3 GEMs(GEM0, GEM1 and GEM3) were tested. Noise in the experiment is measured by taking data in a no-beam-spill situation. The ADC values are then subtracted for each channel to obtain corrected ADC spectra. The ADC distribution is shown in Fig.2.

A readout pad with maximum ADC in an event is chosen at GEM0. The ADC weighted mean X, Y positions are determined from distribution of the hits from a large numbers of events (Fig.3).

This mean value is subtracted from each hit in an event. This is done for all the GEMs. The events that has hit on the chosen pad at GEM0, GEM1 and GEM3 are taken for tracking.

A straight line is drawn connecting the hits at GEM0 and GEM3. Then the corresponding x, y positions are calculated from the fit. The differences between the measured position and the fitted position are plotted for all the hits. The mean of this distribution gives the mis-alignment of the GEM1. The mis-alignment is negligible ($\sim 10^{-5}$cm) compared to the pad

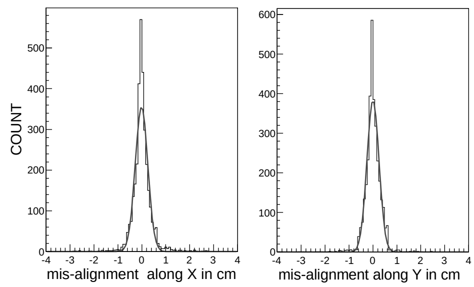

FIG. 5: mis-alignment along X and Y direction

size of the GSI GEM(6mm x 6mm) (Fig.4). Next, we have checked the track point resolution of the GEMs.

As per Fig.4 and considering the nominal resolution of the pads, the calculated position resolution follows $\sigma_{GEM1} = \sqrt{\sigma_{GEM0} + \sigma_{GEM3}}$ cm = 0.19 cm. In this analysis, we get a track point resolution 0.18 cm both along X and Y direction for the GEM1. The extracted resolution is as per expectation from the pad size of the chamber.

References

[1] www.gsi.de/en/work/research/cbmnqm/cbm.htm
[2] A.K. Dubey, S. Chattopadhyay et al., Nucl. Inst. and Meth. A 781 (2013) 418.
[3] A.K. Dubey, S. Chattopadhyay et al., Testing of Triple-GEM chambers for CBM Experiment at FAIR using self-triggered readout electronics (in press).