Testing of Triple-GEM chambers at High Intensity Beam for CBM Experiment

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Introduction

The future Compressed Baryonic Matter (CBM) Experiment at FAIR, will measure charmonia and low mass vector mesons by their muon decay channel with a Muon Chamber (MUCH) detector [1]. We have conducted a beam test of triple GEM MUCH prototype detectors at COSY using proton beam of momentum 2.36 GeV/c. Our goal was to study the response of the detector with high intensity beam using nXYTER based self-triggered readout electronics and also to test for the first time the performance of a intermediate size $31cm \times 31cm$ triple GEM detector. Here we present first results with high intensity beam. At $\Delta V_{GEM} = 360.01\ V$, we get efficiency of our detectors $> 95\%$ that satisfies the basic design criteria.

Experimental Setup

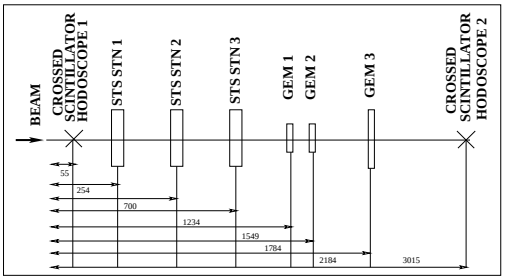

FIG. 1: Experimental Setup at COSY

The schematic layout of the test setup is shown in Fig. 1. Three proto-type triple GEM detectors were used. One of the $10cm \times 10cm$ detector (GEM2) was tested earlier and reported in [2]. Here we report the results of intermediate size detector (GEM3). It has trapezoidal readout pads of radially increasing size from $2.97mm \times 2.97mm$ to $11.21mm \times 11.21mm$. The drift, transfer and induction gap of the chamber are $3mm, 1mm, 1.5mm$ respectively. A premixed gas mixture of Ar and CO_2 in mass ratio of 70:30, was used for all the GEMs. Data were acquired by DABC based DAQ sysytem.

Results

In this nXYTER based self-triggered readout system, all hits above a predefined threshold are digitised and stored. Only hits produced by the beam particles are correlated with the trigger. The time-correlation spectra is shown in Fig. 2.

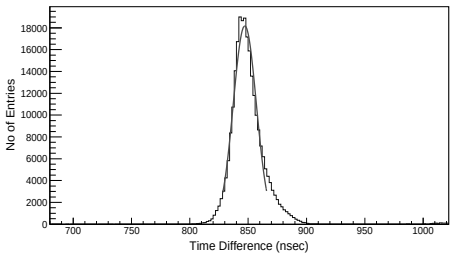

FIG. 2: Spectra of the time correlation between GEM hits and the coincidence trigger.

We get clear beamspot at GEM2 and GEM3 detector shown in Fig. 3 for high particle rate upto 1.2 $MHz/(6mm \times 6mm)$ as obtained from the spill structure of the beam. The pedestal subtracted event by event adc distribution for the pad with highest hits and fitted with Landau distribution function is shown in Fig. 4 for GEM3 for $\Delta V_{GEM} = 366.30\ V$.

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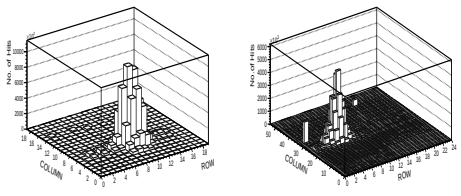

FIG. 3: Proton beam profile of GEM2 (left) and GEM3 (right) for $\Delta V_{GEM3} = 381.64\ V$ at 1.2 MHz particle rate

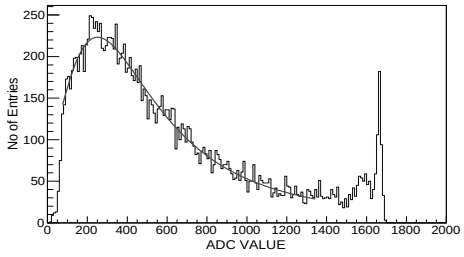

FIG. 4: Event by event Adc spectra on the readout pad with highest hits for GEM3 at $\Delta V_{GEM} = 366.20\ V$

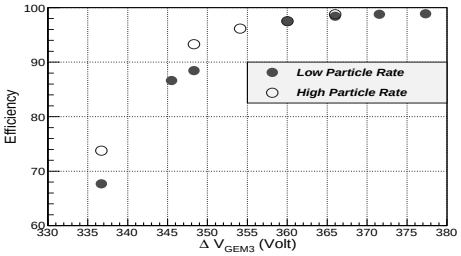

FIG. 5: Efficiency Vs. ΔV_{GEM3} for GEM3

We take the coincidence of the signal from scintillators with the signal from GEM2 as the trigger for GEM3. Efficiency reaches 95% at $\Delta V_{GEM} = 360.01\ V$. The variation of efficiency with ΔV_{GEM3} is shown in Fig. 5. Due to narrow profile of the electron avalanche in GEM, the beamspot is expected to cover an area $\sim 600\ \mu m$ width. So, for the readout pad used in GEM3, we expect the beam profile to be within one pad.

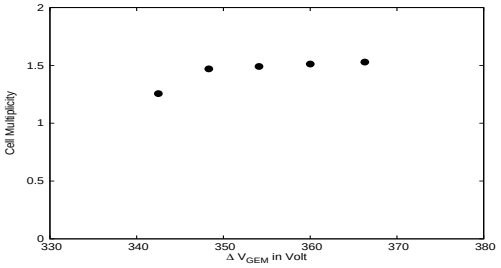

FIG. 6: Variation of Cell Multiplicity with ΔV_{GEM}

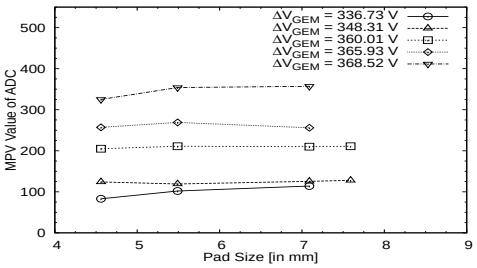

FIG. 7: Uniformity of MPV value of ADC spectra for GEM3

In Fig. 6, variation of cell multiplicity is shown with ΔV_{GEM} of GEM3 for the pad of area $5.36mm \times 5.36mm$. From the plot it is clear that cell multiplicity increases with ΔV_{GEM} because increase in gain results in large transverse area on the GEM. The variation of the MPV values of ADC spectra at different zones on GEM3 is shown in Fig. 7, the MPV values remain almost uniform for a particular ΔV_{GEM} of GEM3 irrespective of the pad size as expected.

References

[1] A.K.Dubey et al., Nucl. Inst. and Meth. A 718(2013) 418.
[2] A.K.Dubey et al., Nucl. Inst. and Meth. A 755(2014) 62.