Testing of Large Real-Size GEM Detector for CBM Experiment

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Introduction

Gas Electron Multiplier (GEM) detector has been extensively used in many experiments for its excellent performance as a traking detector. In CBM experiment, Muon Chamber detector (MUCH) for tracking muon, will be built using GEM based detector technology [1]. In this direction several R & D has been performed with small to medium size triple GEM chambers [2]. A real-size triple GEM detector proto-type, suitable for 1st detector station of MUCH detector, has been tested using high intensity proton beam of momentum 2.36 GeV/c at COSY, Germany. We get efficiency of detector > 95 % at $\Delta V_{GEM} = 371.85\ V$. The variation of efficiency of the detector with rate of incoming particle is within 1%. The detector shows a gain of 3509 at $\Delta V_{gem} = 375.18\ Volt$. The gain is stable with high rate of incoming particles with a small variation ($\sim$ 9%).

Experimental Setup

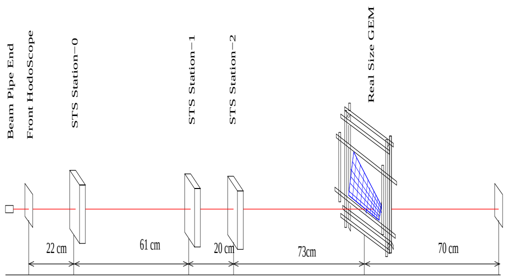

FIG. 1: Experimental Setup at COSY

The schematic layout of the test setup is shown in Fig. 1. A proto-type triple GEM of trapezoidal shape is used. The active region of the detector is 708 mm along radial direction and width of the innermost and outermost rings are 100.25 mm and 381 mm respectively. The drift gap, transfer gap and the induction gap of the chamber are 3 mm, 1 mm, 1.5 mm respectively. The readout pads are 1° progressing size pads [3] of area 3.96 $mm \times$ 3.96 mm to maximum 16.6 $mm \times 16.6\ mm$. A premixed gas mixture of Ar and CO_2 in mass ratio of 70:30, was used. Data are taken in self-triggered mode.

Results

In this nXYTER based self-triggered readout system, all hits above a predefined threshold are digitized and stored. Only hits produced by the beam particles are correlated with the trigger. We get clear beam spot at GEM detector as shown in Fig. 2.

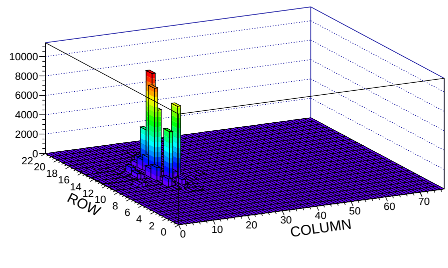

FIG. 2: Proton beam profile of GEM for $\Delta V_{GEM} = 366.67\ V$

The pedestal subtracted event by event ADC distribution fitted with Landau func-

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tion is shown for the region where pad size is 5.46 $mm \times 5.46$ mm shown in Fig 3.

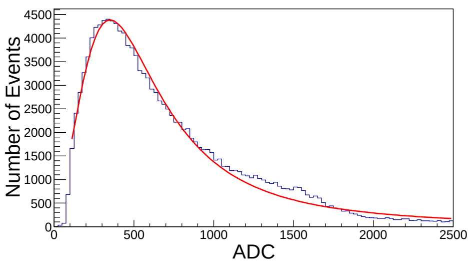

FIG. 3: Event by event ADC spectra at $\Delta V_{GEM} = 366.67$ V

The particles pass through the two scintillators are taken as input to the detector while calculating efficiency. Efficiency reaches above 95% at $\Delta V_{GEM} = 371.85$ V. The variation of efficiency with ΔV_{GEM} is shown in Fig. 4.

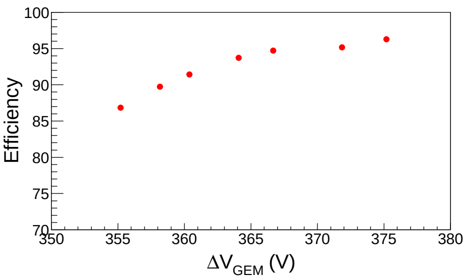

FIG. 4: Efficiency vs. ΔV_{GEM}

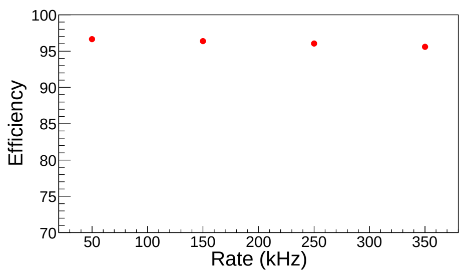

FIG. 5: Uniformity of Efficiency with respect to rate

One of the challenges in CBM is to handle extremely high rate of particle. The variation of efficiency of the detector with the rate of particle is $\sim$ 1% as seen from Fig. 5.

The MPV value of the cluster ADC distribution are used to calculate the gain. The

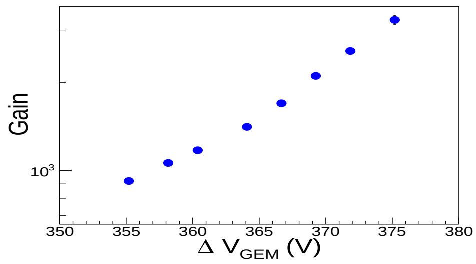

FIG. 6: Variation of Gain with ΔV_{GEM}

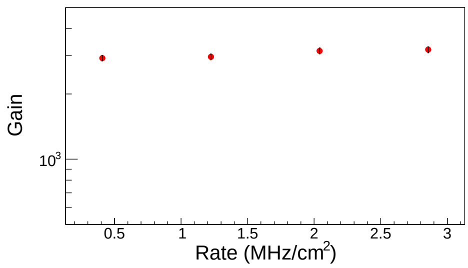

FIG. 7: Stability of gain against rate of particles

variation of gain with ΔV_{GEM} is shown in 6.

The gain uniformity with the rate of particles is shown in 7 . We observe a variation of $\sim$ 9% as the particle rate increases to 350 kHz. The corresponding rate is 2.85 MHz/cm^2 which is comparable to the rate, the first detector of MUCH will have to face.

References

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[3] S. Ahmed et al., Nucl. Inst. and Meth. A 775(2015) 139