A lab setup for efficiency measurement of triple GEM detector using beta source

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Introduction

Triple GEM (Gas Electron Multiplier) detectors are now a days widely used in many experiments[1][2]. We will use GEM based tracking detectors for the CBM (Compressed Baryonic Matter) experiment[3]. Detector characteristics like efficiency, gain uniformity and time resolution etc. are important parameters to study. These parameters should be uniform over the full active region of the detector. To measure these characteristics we have to make an efficient and flexible setup such that we can test full active area of the detector. Efficiency of the GEM detector with particle beams has been studied[4]. We measure the efficiency of detector in the lab using cosmic particles. But for testing it with comics we have to acquire data for a longer period of time for good statistics. Readout in CBM is self triggered, data volume will be high in case of cosmic test. To overcome this difficulty, FPGA based β-source test setup has been desined to measure these quantity. In this paper, we report time resolution and efficiency measurement of triple GEM detector with beta source.

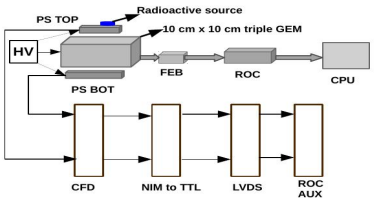

FIG. 1: Block diagram of experimental setup.

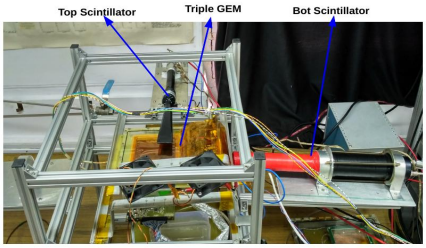

FIG. 2: Picture of experimental setup.

Experimental Setup

Block diagram of the experimental setup is shown in the FIG. 1. A 10 cm x 10 cm triple GEM detector (3 mm / 1 mm / 1 mm / 1.5 mm gap configuration) with strip readout were used for the testing. The readout consists of 128 strips of width 0.5 mm and pitch 0.2 mm. Two scintillator detectors, one (having dimension of 3 cm x 3 cm) on the top of GEM detector and another one (having dimension 6 cm x 6 cm) on bottom of the GEM detector were used for triggering. To bias the GEM detector we used a resistive chain scheme. One FEB (front-end-board), n-XYTER chip (self triggered electronics) having 128 channel, were used for reading out the signal from GEM detector. The analog signal from the scintillators is first discriminated from noise by Constant Fraction Discriminator (Canberra QUAD CFD 454). CFD delivers a fast negative NIM digital signal. Since the LVDS (Low Voltage Differential Signal), which we used, accepts TTL signal a NIM-to-TTL converter were

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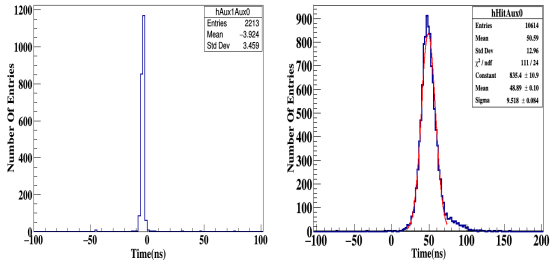

FIG. 3: Left: Distribution of time difference between two trigger scintillators. Right: Distribution of time difference between trigger and GEM hits.

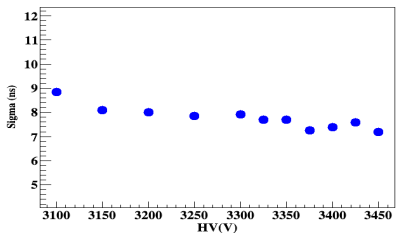

FIG. 4: Variation of sigma with high voltage.

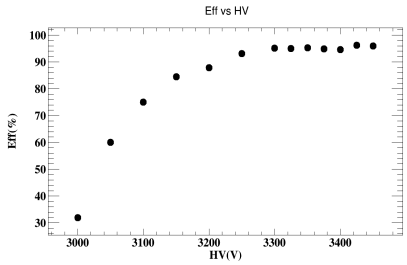

FIG. 5: Variation of efficiency with high voltage.

used in between them. The signal from LVDS was then given to auxiliary channels of ROC (Read Out Controller), which stores the time stamps of the scintillators signal. We put Sr^{90} (β-source) on the top scintillator and acquire data for different HV settings. The picture of the setup along with the detectors (GEM and scintillators) is shown in FIG. 2. System has been made flexible enough to carry out measurement in any part of the detector. In this way we will be able to test the GEM detector over full area.

Results and discussion

The distribution of time difference between two trigger scintillator is shown in the FIG. 3(left panel) and the distribution of time difference between GEM and trigger is shown in FIG. 3(right panel) at HV=3400V. The peak position in the time correlation spectra is due to the delays in the cable used as well as the electronics delay. The sigma of the time correlation spectra is the measure of time resolution of the GEM detector. Sigma for different high voltage settings is shown in the FIG. 4. A minimum of ˜ 7.8 ns sigma was obtained for HV=3400V. Efficiency of the GEM detector is calculated using formula

$$\text{Efficiency} = \frac{Three-Fold-Count}{Two-Fold-Count}$$

where Two-Fold-Count is the number particle which pass through bot scintillator and Three-Fold-Count is the number of particle which pass through two scintillator as well as GEM detector. Events in which both (top and bottom) scintillator has been hit were selected for the total number of triggers (Two-Fold-Count). For each trigger if there is hit in GEM detector, we count that as a total number of particle pass through the three detectors (Three-Fold-Count). The efficiency of GEM detector for varying high voltage is shown in FIG. 5. We obtained a plateau in efficiency curve at 96% for HV>3150V. Variation of efficiency and time resolution with varying thresholds are being studied. Efficiency uniformity for the entire area of the GEM detector is under progress. All these results will be presented in details.

References

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