Study of basic characteristics of triple GEM detector

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Introduction

Triple GEM (Gas Electron Multiplier) detectors will be used for MUCH (Muon Chamber) system at CBM (Compressed Baryonic Experiment). It consists of drift (active volume), GEM (amplification region), transfer and induction region. Symbols for different regions are Vd(drift voltage), Vi(induction voltage), Vt(transfer voltage), Vg1(Top GEM voltage), Vg2(middle GEM voltage), Vg3(bottom GEM voltage) and Vg(for all GEM voltage). We use two schemes to power the triple GEM detector: (1) Through resistive chain. (2) Through independent power supply to each electrode. Advantage of first method is that we need only one voltage supply for powering the different electrodes. But in a high rate the latter configuration may be more suited. This apart the systematic effect of individual voltage(like drift, transfer, induction and GEM) on detector gain, energy resolution and time resolution etc. can be studied using independent power supply. In this paper, we studied the effect of drift, transfer, induction and GEM voltages on detector gain and energy resolution using independent power supply for a triple GEM detector.

Experimental Setup

The block diagram of experimental setup is shown in the FIG. 1 (left panel). We tested a 31 cm x 31 cm triple GEM detector (3 mm / 1 mm / 1 mm / 1.5 mm gap configuration), having pad readout of varying size from 3 mm x 3 mm to 10 mm x 10 mm, using Fe^{55} (X-Ray source). Signal from detector were first given to the charge sensitive pre-amplifier (Ortec 142 IH) and then to the main amplifier (Gain 20). Amplified signal then digitized using Analog-To-Digital converter (ADC) and pulse height spectra for different voltage settings were stored in computer. The picture of the setup in lab is shown in the FIG. 1 (right panel). A CAEN made[1] independent power supply was used for biasing the GEM detector.

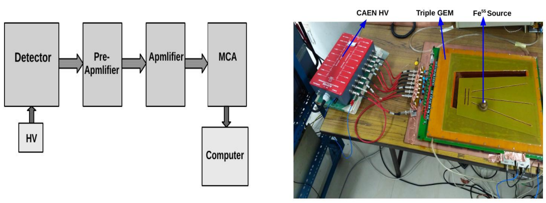

FIG. 1: Block diagram of experimental setup (left) and picture of experimental setup (right)

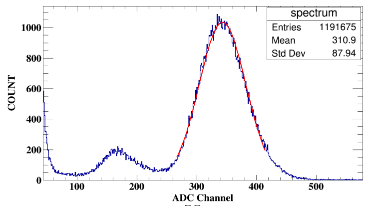

FIG. 2: Typical Fe^{55} pulse height spectra

Results and Discussion

How the gain (ADC channel) and energy resolution of triple GEM detector varies with different voltages (drift, induction, transfer and GEM) are discussed here. We studied the effect of one voltage setting by keeping the other voltages fixed. A typical Fe^{55} (5.9 keV X-ray) spectra is shown in the FIG. 2. Energy resolution is given by

$$R = \frac{FWHM}{PeakADCChannel}$$

where is FWHM is Full Width at Half Maximum and Peak ADC channel is mean of Gaussian.

Effect of GEM voltage

FIG. 3 shows the variation of gain and energy resolution with GEM voltage by keeping other voltages fixed (Vd=680V, Vt=280V, Vi=660V) Here we increase three GEM voltages equally and simultaneously (Vg1=Vg2=Vg3) and plotted the combined effect of GEM voltage on gain and energy resolution. Gain increases exponentially by increasing GEM voltage as expected.

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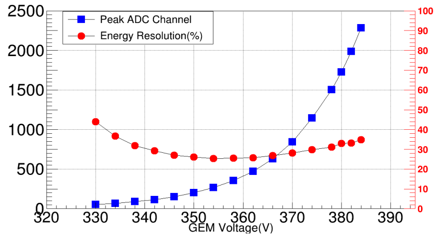

FIG. 3: Variation of Peak ADC channel and energy resolution with GEM voltage(GEM1=GEM2=GEM3)

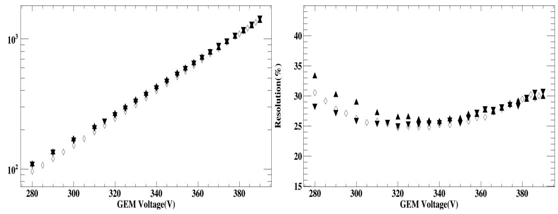

FIG. 4: Variation of peak ADC channel(left) and energy resolution(right) with GEM voltage(individually)

But the resolution first decrease and then increase. First decrease of resolution is due to the the increase in number of multiplication but the increase is due to the UV emission which leads to the more fluctuations in charges. The effect of individual GEM voltage was also studied by keeping other voltage (Vd,Vi,Vt) fixed. Here we plotted the effect of individual GEM voltage on gain (FIG. 4 (left) and energy resolution (FIG. 4(right). Upper tingle is for top GEM, lower triangle is for middle GEM and star is for the bottom GEM.

Effect of drift voltage

Effect of drift voltage on detector gain and energy resolution is shown in the FIG. 5 keeping other voltages fixed(Vi=660V, Vt=280V, Vg1=Vg2=Vg3=370V). By increasing the GEM voltage first gain increases and then decrease as expected. First increase is due to less recombination and decrease is due to loss of primary electrons. Similarly the resolution is larger at lower drift voltage and decreases at higher drift voltage.

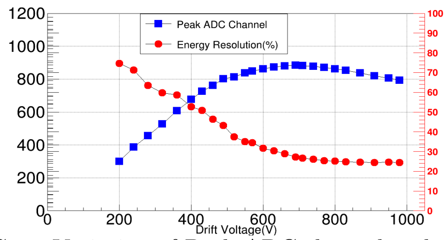

FIG. 5: Variation of Peak ADC channel and energy resolution with drift voltage

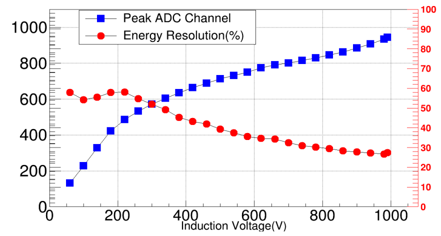

FIG. 6: Variation of Peak ADC channel and energy resolution with induction voltage

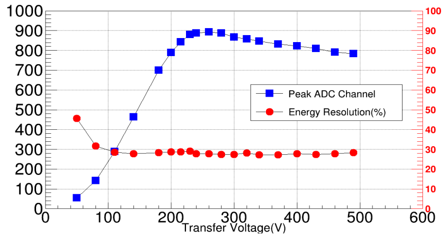

FIG. 7: Variation of Peak ADC channel and energy resolution with transfer voltage

Effect of induction voltage

Effect of induction voltage on gain and energy resolution of detector is shown in FIG. 6. keeping other voltages fixed (Vd=680V, Vt=280V, Vg1=Vg2=Vg3=370V). If we increase the induction voltage we collect more and more charges so gain increases. Resolution is large at lower induction and decreases as we increase induction.

Effect of transfer voltage

The effect of transfer (Vt1=Vt2) on gain and resolution is shown in the FIG. 7 keeping Vd=680V, Vi=660V and Vg=370 fixed. Gain increases with Vt as can be expected. The decrease in gain at higher Vt is because of the losses of avalanche in transfer region. Resolution at lower transfer is larger and decreases for high transfer.

The systematic effect of Vd, Vi, Vt and Vg on gain and energy resolution is under progress. All these results will be presented in details.

References

[1] http://www.caen.it/csite/CaenFlyer.jsp?parent=342