Development of GEM Based Detector for ALICE TPC

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Introduction:

The goal of A Large Ion Collider Experiment (ALICE) at Large Hadron Collider (LHC) is to study matter at highly extreme condition. The main detector of ALICE experiment is Time Projection Chamber (TPC), which is used for charged particle tracking and identification. The present ALICE TPC readout is based on Multi Wire Proportional Chamber (MWPC). The readout chambers are operated with an active bipolar Gating Grid (GG), which, in the presence of a trigger, switches to transparent mode to allow the ionization electrons to pass into the amplification region. However, Operation of the TPC at high interaction rate (50kHz) cannot be accomplished with an active ion-gating scheme. The back-drifting ions from the amplification region of a MWPC without gate will lead to excessive ion charge densities and drift distortions that render precise space-point measurements impossible. Therefore there is a proposal to replace existing MWPC-based readout chambers by a multi-stage GEM system [1].

VECC along with other collaborating institute of ALICE Collaboration in India, are taking part in the R&D of GEM based readout in the upgrade of the experiment. For this purpose, a GEM based prototype detector has been built. Details of the prototype will be presented here.

Specifications and Characterisation of the GEM Foils:

The size of the GEM foils is 10 cm X 10cm. These were built on double mask technique. The thickness of the foils is 0.5 mm having pitch of 140 μm. Foils with higher pitch (180 μm) have also been tested though they have not been used in the present detector system. We have tested all the procured GEM foils before building the detector. The test includes the measurement of number of discharges found for each foil and leakage current measurement.
We found single discharge in two foils and rest of the foils had (total nine foils were tested) no discharge. The measured capacitance of the foils varied between 5.64 nF to 5.79 nF.

Building the GEM Detector:

We have used 3 standard GEM foils to build the triple GEM.
The gas gaps are 3-2-2-2 mm. We have also built High Voltage divider to apply voltage to the detector. The measured voltages are $\Delta v1$= 397 Volts, $\Delta V2$= 364 Volts and $\Delta V3$= 323 Volts.

The photograph of the built detector along with divider is shown in Fig.1.

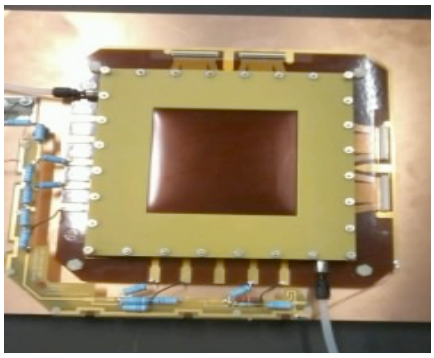

Fig 1.

Tests and Results:

We have used Ar+Co_2 gas mixture in the ratio of 70:30 to test the detector.
Fe-55 source is used to test the detector's sensitivity and other parameters. The charge spectrum has been shown at 4200 volts in Fig.2 and 5.9 KeV peak of Fe-55 has been fitted with Gaussian to extract width of the distribution.

The applied threshold for removing noise is 75 ADC channel. Data are also collected without source to get the peak position of noise.

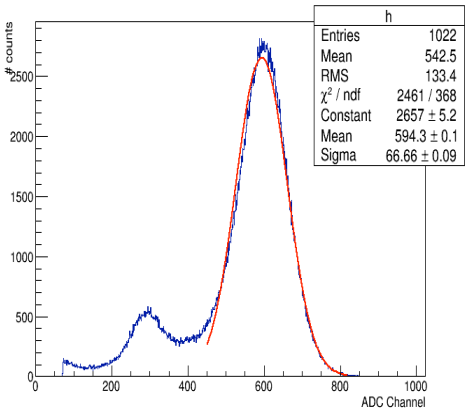

Fig.2. Fe spectra at 4200 volts. Fitted line corresponds to Gaussian fitting.

Energy Resolution:

The measured energy resolution (σ_E/<E>) is shown in Fig. 3 w.r.t. applied voltage. We observe that the measured energy resolution is ~12%.

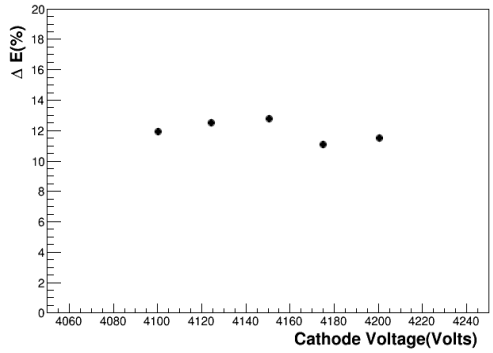

Fig 3. Measured Energy Resolution as function of applied voltage.

Gain Measurement:

The gain of the detector is defined as

$$G = \frac{I}{f * n * e}$$

Where, I = measured Anode current,
f* =interaction rate
n* = number of primary electrons coming from the source
e = electron charge

To measure the current, we have used Keithley Pico Ammeter.
The measured gain as a function of applied voltage has been shown in Figure 4. We observe that the gain is ~ 10^4 at 4150 Volts.

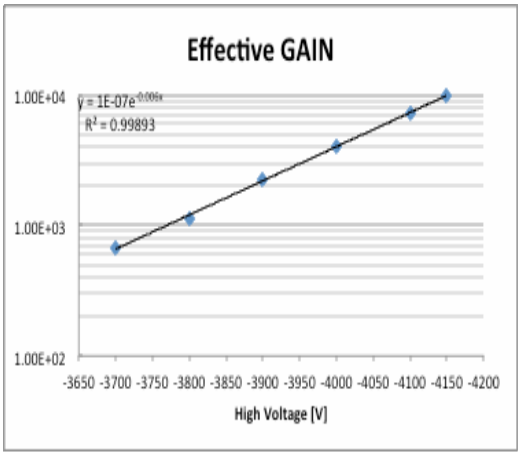

Fig. 4: Gain as a function of applied voltage.

Summary and Future Outlook:

In a first attempt, we have built one triple GEM based detector using standard foils after characterization of the GEM foils. The measured energy resolution is about ~ 12% and the measured gain is about 10^4. The measurement of efficiency and other parameters like ion back flow and rate capability are in progress.

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References

{1} A Time Projection Chamber for High-Rate Experiments: Towards an Upgrade of the ALICE TPC. Nucl.Instrum.Meth. A732 (2013) 237-240.