Characteristics of triple GEM detector for the ALICE TPC upgrade at CERN

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Introduction

Gas Electron Multiplier (GEM) detector, introduced by F. Sauli [1] in 1997 and has been widely improved in last two decades for applications to high energy physics experiments and imaging. GEM detectors have several advantages, like good spatial resolution (~100 μm), high detection efficiency (>98%), high rate handling capability (~10^5 Hz/mm^2) and reasonable time response (~5 ns) [2]. The unique features of the GEM detector make it suitable for experiments at Large Hadron Collider (LHC) at CERN and FAIR at GSI. With the increase of beam luminosity of LHC for its next phase of running from the year 2020, the ALICE experiment is planning to take data for PbPb collisions at a rate of 50 kHz. The ALICE Time Projection Chamber (TPC) will be upgraded by GEM based read-out to fulfil this future goal. In this report, results of a thorough test in the laboratory using a newly developed online data monitoring system are discussed.

Detector Features

The detector setup contains a stack of three standard GEM foils above the read-out plane [3] as shown in Fig 1. The detector is operated with Ar/CO_2 (70/30) gas mixture in flow mode at atmospheric pressure. A resistor chain is used to apply voltage difference across the different sections of the detector. Detector is operated with negative high voltage (HV) of 3900-4400 V. Signals are summed-up from both up and down strips of the readout and processed with NIM electronics.

General Characteristics

The characteristics study of the detector was performed with different radioactive sources

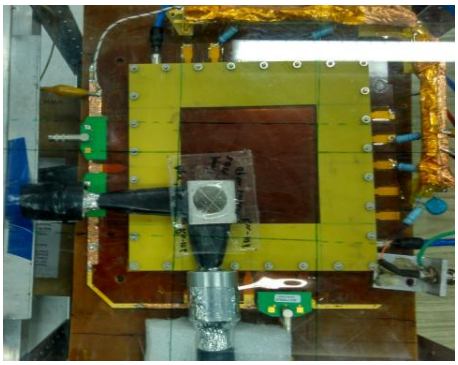

Fig. 1 Triple GEM detector lab setup.

and cosmic muons. The gas gain and energy resolution measurements are done using the ^{55}Fe X-ray source. Pulse height spectrum of the ^{55}Fe is shown in Fig. 2. The main peak is corresponds to 5.9 keV X-ray and the smaller peak corresponding to argon escape peak.

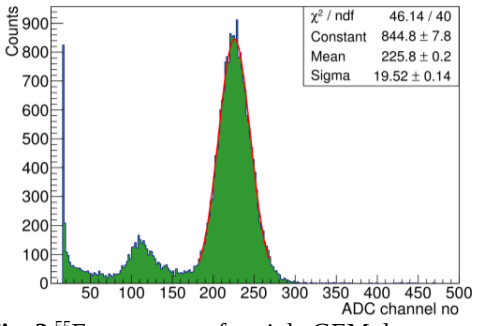

Fig. 2 ^{55}Fe spectrum of a triple GEM detector.

Gain is calculated from the mean value of the Gaussian peak with consideration of the electronics gain of the instruments. Gain of the detector is found to be of the order of 10^4 at the operational HV. Gain variation as a function of applied HV is shown in Fig. 2. The energy resolution of the detector is ~20% in terms of

FWHM for the 5.9 k eV X-ray. Energy resolution against HV is given in Fig. 4.

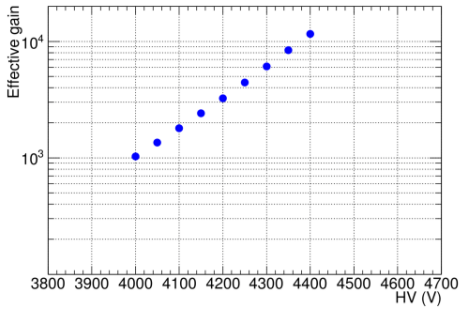

Fig. 3 Gain variation as a function of HV.

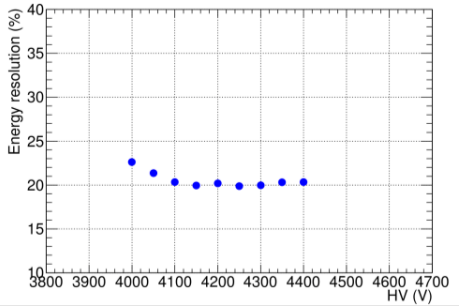

Fig. 4 Energy resolution as a function of HV.

Another important property of the detector is the detector efficiency. For this measurement we have used cosmic muons and ^{106}Ru-Rh β^- source. Trigger from coincidence signals of three scintillator detectors (two small scintillators on the top and one at bottom) are used for the true signal counts. Efficiency vs. HV plot is shown in Fig. 5, here it can be seen that the efficiency is ~96% at the plateau.

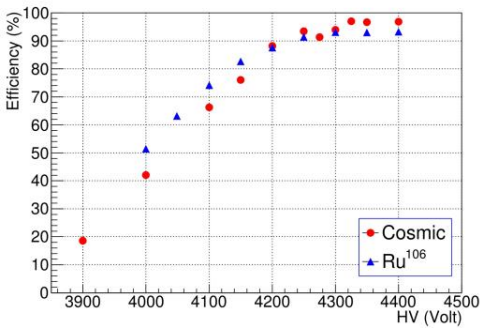

Fig. 5 Efficiency variation as a function of HV for cosmic muons and ^{106}Ru-Rh source.

In addition, a data logger system [4] has been used by interfacing it to a PC through by RS232 using. The CoolTerm software is used to monitor temperature, pressure and humidity. The Keithley pico-ammeter is also interfaced with the PC using Lab VIEW software. The measured current value of the GEM detector with ^{90}Sr source is shown in Fig. 6. Longtime continuous current measurement helps to understand the ageing of the detector.

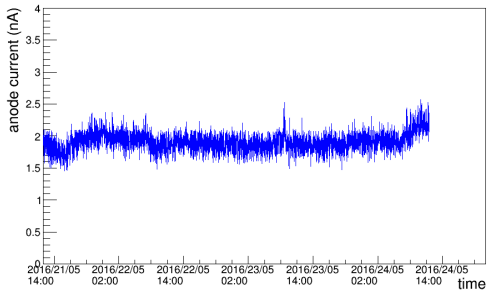

Fig. 6 Current variation as a function of time

Summary

A triple GEM detector is tested with standard gas mixture Ar/CO_2 (70:30). The gain at operational HV is of the order of 10^4 and the energy resolution is comparable with other test results. The measured efficiency is 96%, from both cosmic rays and radioactive source. Current monitoring as a function time helps to study the long-term stability of the detector.

References

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