Assembly and Test Results of a 4-GEM Detector

Rajendra Nath Patra[1],* R. N. Singaraju[1], T. K. Nayak[1,2], and Y. P. Viyogi[1]
[1] *Variable Energy Cyclotron Centre, HBNI, Kolkata - 700064, INDIA and*
[2] *CERN, Geneva 23, SWITZERLAND*

Introduction

The development of Gas Electron Multiplier (GEM) detector at CERN has led to its extensive use in many present and planned future experiments in high energy physics [1]. The advantages of the GEM detectors, compared to other gas detectors, are high particle detection rate, good position and energy resolution, low ion back flow (IBF) and stable operation in long run experiments [2–4].

Triple GEM detectors with 3 GEM foils are commonly used in most of the experiments. We have reported a detailed test of a triple GEM detector recently [5]. 4-GEM detectors with 4 GEM foils have the advantage of low IBF and low discharge probability [6]. For this purpose, we have assembled a 4-GEM detector at VECC, Kolkata and tested. Here we report the assembly method and test results of the 4-GEM detector.

Detector setup

For the present detector setup with four GEM foils, the GEM foils of 10×10 cm^2 dimension along with other accessories are procured from CERN, Geneva. All the four GEM foils used in this detector are single mask standard GEM foil. The GEM foils have hole diameter of 70 μm with 140 μm pitch in a hexagonal pattern. The readout plane of the detector is divided into 120 pads of equal area. Above the readout plane all the four GEM foils are put one above the other followed by the drift (cathode) plane on the top. The drift gap, transfer gaps and the induction gap are 4.8-2-2-2-2 mm, respectively, as mentioned in the Fig. 1. The high voltage (HV) is applied through a resistor chain to produce required electric field across the GEM holes and within different gaps of the detector.

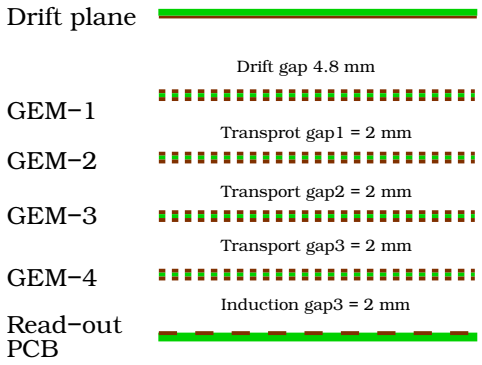

FIG. 1: Schematics design of a 4-GEM detector.

Test results

The 4-GEM detector has been operated using Ar/CO_2 90:10 gas mixture. The following tests have been performed.

The first test is the spectrometry study using ^{106}Ru-Rh β^-source and ^{55}Fe 5.9 keV X-ray source. Landau distribution kind of spectrum was obtained in case of β^-source. The ADC spectrum of ^{55}Fe 5.9 keV X-ray is shown in Fig. 2. The main peak at higher ADC corresponds to the photo peak of 5.9 keV X-ray, followed by the Argon escape peak. Gain variation of the detector as a function of total GEM voltage ($\Delta V_{GEM-tot}$) is shown in Fig. 3(top). It can be easily found out that the gain variation is exponential in nature. The energy resolution of the detector (in terms of FWHM) is shown in Fig. 3(bottom). The resolution obtained with this detector is somewhat worse than our previous study with a triple GEM detector [5]. The reason is that IBF and energy resolution vary inversely to each other [6]. The setup of measuring the efficiency was made

*Electronic address: rajendra.nath.patra@vecc.gov.in

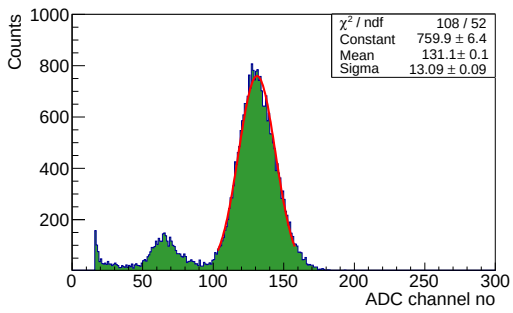

FIG. 2: ADC spectrum of ^{55}Fe 5.9 keV X-ray at $\Delta V_{GEM-tot}$ 1070 V

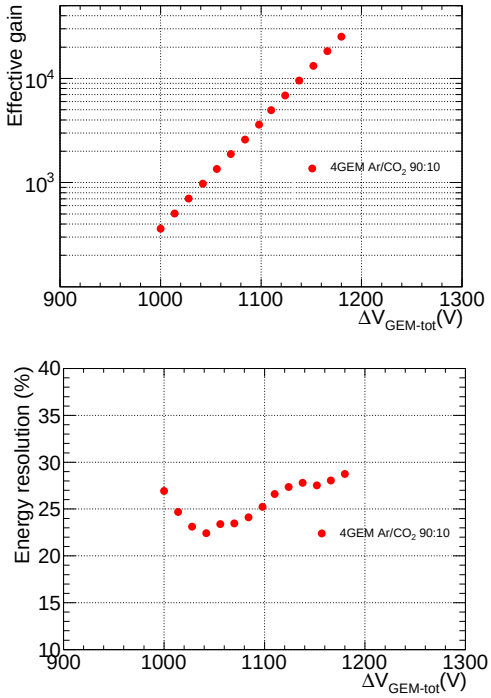

FIG. 3: (top) Gain and (bottom) resolution (FWHM) variation with $\Delta V_{GEM-tot}$.

using two small scintillator detectors on the top of the GEM detector and one scintillator detector at the bottom as described in [5]. ^{106}Ru-Rh β^-source is used for giving 3-Fold scintillator trigger. The efficiency is the ratio of the number of detector signal to the 3-Fold counts in percentage. The efficiency plot of

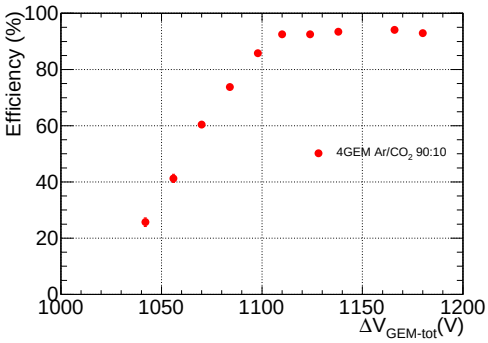

FIG. 4: Efficiency variation with $\Delta V_{GEM-tot}$.

the detector is shown in Fig. 4. The efficiency at the plateau region is ∼94% obtained.

Summary and discussions

A 4-GEM detector prototype is assembled with 10×10 cm^2 foils and tested with Ar/CO_2 90:10 gas mixture. Basic characteristics of the detector are studied in terms of energy spectrum, gain, energy resolution and efficiency measurements. The results are in good agreement with our previous test results of the triple GEM detector.

Acknowledgments

RNP acknowledges the receipt of UGC-NET Fellowship and YPV acknowledges the INSA senior scientist award. The authors would like to thank Dr. Saikat Biswas and Mr. Partha Bhaskar for their technical advices.

References

[1] F. Sauli, NIM A, **386** 531, (1997).
[2] G. Bencivenni, *et al.*, NIM A **488**, 493 (2002).
[3] M. Alfonsi, *et al.*, NIM A **525**, 17 (2004).
[4] M. Ball, *et al.*, JINST **9**, C04025 (2014).
[5] R. N. Patra, *et al.*, NIM A **862**, 25 (2017).
[6] ALICE-TPC Upgrade, ALICE-TDR-016, CERN-LHCC- 2013-020, March 3 2014.