Characterization of a prototype single ThGEM detector

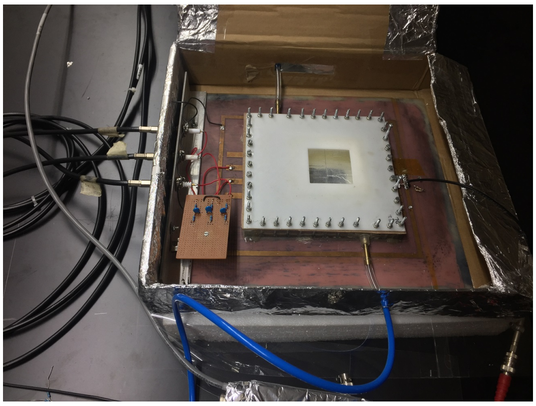
D. Shekar[1,3], A. Kumar[1,3], V. K. S. Kashyap[1,3],* S. S. Dasgupta[2,3], and B. Mohanty[1,2,3]
[1]*School of Physical Sciences, National Institute of Science Education and Research, Jatni 752050, Odisha, INDIA*
[2]*Centre for Medical and Radiation Physics,*
National Institute of Science Education and Research, Jatni 752050, Odisha, INDIA and
[3]*Homi Bhabha National Institute, Training School Complex,*
Anushaktinagar, Mumbai 400094, Maharashtra, INDIA

Introduction

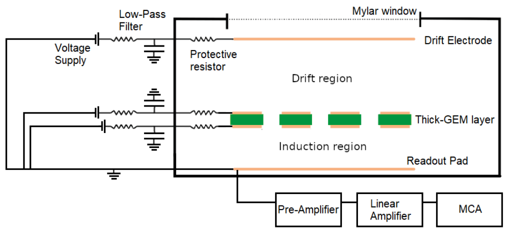
Thick Gas Electron Multiplier (ThGEM) is a modification of the Gas Electron Multiplier detector that have foils of thicker and larger hole sizes. ThGEMs were first introduced by several groups in the early 2000 [1]. ThGEMs have a few 100 micron to millimeter level position resolution, making them very good candidates for tracking detectors. They are also radiation hard and can handle particle fluxes of a few MHz mm^{-2} [2]. In this contribution, we report the characterization results of a protoype ThGEM detector that - except for the ThGEM foil - has been fully built and assembled at NISER. The ThGEM foil was manufactured by Micropack Pvt. Ltd., Bengaluru, India.

Fabrication of ThGEM detector

The detector consists of three main elements: (i) The drift electrode (ii) the ThGEM foil and (iii) the readout pad. The drift electrode was made by pasting aluminium tape on a mylar sheet stuck on a 3D printed frame of dimension 10 cm × 10 cm. The ThGEM foil procured from Micropack India Pvt. Ltd. has a working area of 10 cm × 10 cm. Its thickness is 0.25 mm, and inner and outer hole diameters are 0.2 mm and 0.3 mm respectively. The pitch between the holes is 0.45 mm. There are ~500 holes/cm^2. The readout PCB is made at NISER by etching a double layered copper PCB of 30 cm × 30 cm dimension. Readout strip pattern is designed and printed on a photographic paper. The pattern is transferred on to the PCB using the heat of a cloth press. The copper layer not masked by the ink pattern is etched using $FeCl_3$ solution. Holes are drilled in the PCB to fasten plastic screws as standoffs so that different elements like the drift and the ThGEM foil can be held and gap maintained. The readout PCB forms the bottom layer, the drift electrode forms the top layer and the ThGEM foil is in the middle. The etched readout strips on the readout are 1 cm wide and 15 cm long so that it is in line with the layers of ThGEM and the drift electrode.



(a)

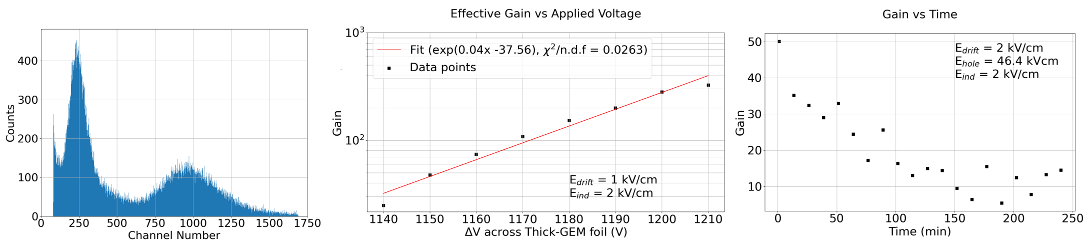


(b)

FIG. 1: (a) Picture of the detector. (b) Schematic of the detector.

A picture of the detector and the schematic is shown in Fig. 1(a) and (b) respectively. A Thick acrylic frame with gas nozzles is glued on the PCB

*Electronic address: `vkashyap@niser.ac.in`



(a) (b) (c)

FIG. 2: (a) Raw energy spectrum of the ^{55}Fe source. (b) Variation of gain as a function of voltage. (c) Variation of gain as a function of time.

that surrounds the various detector layers. On the top a 3D printed flange with a Mylar window is fastened using screws as shown in the figure to form a chamber and make it leak tight. Ar-CO_2 (80:20) mixture was flown through the detector.

Characterization using an ^{55}Fe source

A ^{55}Fe source placed on the window is used to characterize the detector. One of the strips is connected to an ORTEC 142IH preamplifier using a LEMO cable. The output of the preamplifier was shaped using the ORTEC 672 Spectroscopy Amplifier and fed to an ORTEC ASPEC-927 MCA. By theoretical estimates, the number of primary electrons generated by the interaction of 5.9 keV in the gas mixture corresponds to 0.033 fC. With the help of a pulser, the relation between the charge Q and Channel No. of the MCA is determined to be Q = 0.022×Channel No. The raw energy spectrum of ^{55}Fe is shown in Fig. 2(a). The 5.9 keV peak is observed in the energy spectrum. Due to poor resolution, we are not able to see the escape peak. We see a second peak like structure after the 5.9 keV peak which is not understood yet. We feel it may be due to a bend in the foil.

We studied the variation of gain as a function of voltage by looking at the shift in the mean position of the 5.9 keV peak. Fig. 2(b) shows the variation as a function of voltage. We see that the gain increases linearly with voltage. We also studied the variation of gain as a function of time in a similar way but at a fixed voltage and fixed intervals of time. Gain reduces with time due to space charge effects which is expected. The variation is shown in Fig. 2(c).

Conclusion

We have characterized the prototype ThGEM detector using X-rays from an ^{55}Fe source. Initial results show that the detector is able to detect the X-rays with scope to have better energy resolution. A second peak like structure has also been observed in the energy spectrum. This could be because of a slight bend in the foil (standoff screws were not precisely positioned) causing distortion in the electric field. The electric field in the holes in some regions of the foil might have been higher. The variation of the detector gain as a function of time and applied voltage has been studied. The gain increases linearly with voltage and it reduces over time due to space charge effects. We will improve the resolution of the detector by rectifying the design limitations and do a thorough characterization of the detector. We also plan to design and develop multigap ThGEM detectors with single photon detection efficiency.

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References

[1] F. Tessarotto, NIM A, 912, 2018, pp. 278-286.
[2] C. Shalem et al, NIM A, 558(2), 2006, pp. 475-489.