Study of charging up effect in GEM detector

K. Nivedita G[1],* A. Paul[2], S. Chatterjee[3],
S. Roy[3], A. Sen[3], S. Biswas[3], and S. Das[3]
[1] *IISER, Maruthamala PO, Vithura, Thiruvananthapuram, Kerala, India.*
[2] *University of Calcutta, Acharya Prafulla Chandra Road Kolkata- 700009 and*
[3] *Bose Institute, Department of Physics CAPSS, EN-80, Sector V, Kolkata-700091, India*

Introduction

Gas Electron Multiplier (GEM) is a micro-pattern gaseous detector widely used in high energy physics experiments (HEP) for tracking because of its good position resolution and rate handling capability[1]. GEM is made up of 50 μm Kapton foil with 5 μm copper cladding on both sides. A large number of holes are chemically etched using photolithography technique on the Kapton foil which acts as the multiplication region for the incoming charged particles. The presence of the dielectric medium inside the active volume of the detector changes its behavior when they are exposed to the external radiation. Due to the polarisation of the dielectric medium, charges are captured on the surface of the dielectric. The collection of a substantial number of charges on the dielectric surface induces a modification of the field in the GEM holes. As a result, the gain increases after the initial application of the high voltage across the foil and eventually it gets stabilized and follow the usuall T/p variation [2]. It is very important to understand how much time is required to start stable operation and how it will vary with the external irradiation. Such studies have been performed and reported earlier [3][4][5]. In this article, we are reporting the charging up effect observed in a double mask triple GEM detector with different irradiation rates.

*Electronic address: niveditakrishna16@iisertvm.ac.in

Experimental set up

A double mask triple GEM detector having dimension 10 cm×10 cm with 3 mm drift gap, 2 mm transfer and 2 mm induction gap have been used for this study. A premixed gas of Ar/CO_2 in 70/30 volume ratio has been used in flow mode at a rate of 3.5 lt/h. The negative high voltage (HV) is applied to one end of the resistance chain and the divider chain is used to bias the individual GEM foils. The output signal from the GEM is fed to a charge sensitive pre-amplifier and the output of the pre-amplifier is put to a Multi-Channel Analyser (MCA) for obtaining energy spectra of the detector. To study the effect of charging up process, the collimated source is placed on the detector and continuous monitoring of the energy spectra with the same source has been carried out. Different particle rates have been set using the collimator to see the effect of rate on the charging up process. ORTEC MCA has been used to store spectra automatically at a regular interval of time. A data logger made in house has been used to record ambient temperature and pressure online using CuteCom software package.

Results

The gain of the detector and ambient T/p (T is the absolute temperature and p is the pressure) variation as a function of time is shown in fig 1 and fig 2. The gain is calculated by fitting the Fe^{55} X-ray energy spectrum using a gaussian distribution and from the ADC calibration. Long term stability study in terms of gain, energy resolution and count rate of the chamber is reported earlier [6]. For radiation rates of 10 kHz and 90 kHz respectively, the HV is switched on and data taking

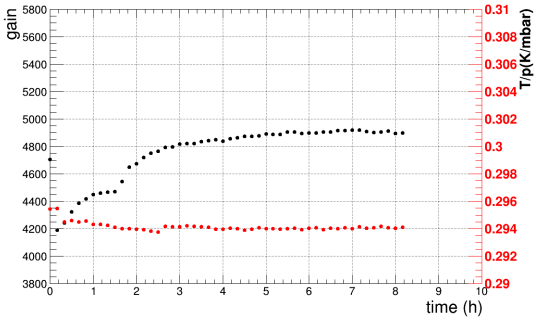

FIG. 1: Gain and T/p vs. time for the particle rate of 10 kHz

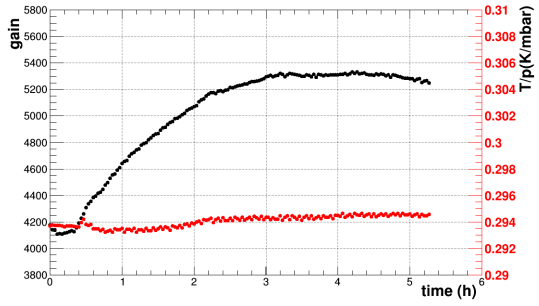

FIG. 2: Gain and T/p vs. time for the particle rate of 90 kHz

has been started simultaneously. The time required to achieve a stable gain is found to be more or less similar in both cases. The values of the gain are not similar in fig 1 & 2 because for both the measurements the positions of the source were not the same. It has been reported earlier that the characteristics of the prototype are not uniform throughout the active volume of the chamber [7]. From the fig 1 & 2, it is clear that atleast four to five hours is required to get a stable performance from the detector.

Summary

We have carried out R&D with 10 cm×10 cm triple GEM detector prototype. The main motivation of this work is to study the charging up effect and to understand how does it change with different irradiation rates. The gain of the detector has been measurement with premixed gas of Ar/CO_2 in 70/30 volume ratio. Fe^{55} X-ray source has been used to irradiate the chamber. It is found that, because of the charging up effect the gain increases with time and reached steady state in a time $\sim$ 4-5 hours.

Acknowledgement

We would like to thank the following person for their sincere help to develop this work:S. Jaiswal, Dr. S. K. Prasad, Prof. S. K. Ghosh.

References

[1] F. Sauli, Nuclear Instruments and Methods in Physics Research A 805 (2016) 2
[2] M. C. Altunbas et al., Nuclear Instruments and Methods in Physics Research Section A515(2003) 249
[3] M. Alfonsi et al., Nuclear Instruments and Methods in Physics Research A 671 (2012) 6
[4] B. Azmoun et al., IEEE Nuclear Science Symposium Conference Record, San Diego, CA, 2006, doi: 10.1109/NSSMIC.2006.353830
[5] P.M.M. Correia et. al., arXiv:1401.4009v2
[6] S. Roy et al., Nuclear Instruments and Methods in Physics Research A 936 (2019) 485
[7] S. Chatterjee et al., Nuclear Instruments and Methods in Physics Research A 936 (2019) 491