Effect of bias current variation on the gain of a single mask triple GEM chamber

S. Sahai[1], R. Paul[2], P. Barik[2], A. Dandapat[3],
S. Chatterjee[4],* A. Sen[4], S. Das[4], and S. Biswas[4]
[1]Amity Institute of Nuclear Science and Technology,
Amity University Uttar Pradesh, Noida, INDIA
[2]Department of Physics, Savitribai Phule Pune University, Pune, INDIA
[3]Department of Physics, Indian Institute of Technology Ropar, Punjab, INDIA and
[4]Department of Physics, Bose Institute, Kolkata, INDIA

Introduction

The Gas Electron Multiplier (GEM) detector, one of the advanced members of the Micro Pattern Gaseous Detector (MPGD) family, is widely used in High Energy Physics (HEP) experiments due to its high rate handling capability and good position resolution [1]. GEM foil is basically a 60 μm thick Copper cladded Kapton foil. The thickness of the Copper cladding is 5 μm on both sides of the 50 μm thick Kapton foil. A large number of holes are etched on the Copper cladded Kapton film using the photolithographic technique. A potential difference ($\sim$ 400 V) is applied across the GEM foils to create an electric field ($\sim$ 80 kV/cm) inside the GEM holes. Due to the very high electric field, the holes act as the multiplication region for the incoming primary electrons created by the external radiation. The gain of the detector is thus defined as the ratio of the total output charge accumulated after the multiplication of the primary electrons inside the GEM holes to the input charge created due to the energy deposition by the external radiation.

In this article, the variation of gain as a function of time of a Single Mask (SM) [2] triple GEM chamber prototype, irradiated with Fe^{55} X-ray source and operated with Ar/CO_2 gas mixture in 70/30 volume ratio, is presented.

*Electronic address: sayakchatterjee@jcbose.ac.in,sayakchatterjee896@gmail.com

Experimental setup

The drift gap, transfer gaps and induction gap of the chamber are kept fixed at 3 mm, 2 mm and 2 mm respectively [3]. The applied negative High Voltage (HV) is distributed across the GEM foils and different gaps using a resistor chain network as shown in Fig. 1. The output signal from the readout plane is fed to a charge sensitive pre-amplifier. The output of the pre-amplifier is put to a linear Fan In Fan Out (FIFO) module to create identical copies of the input signal. One output from the FIFO is fed to a Multi Channel Analyzer (MCA) to store the X-ray spectra in the computer. Another output from FIFO is fed to a Single Channel Analyzer (SCA), the output of which above the noise threshold is counted using a NIM scaler. The ambient

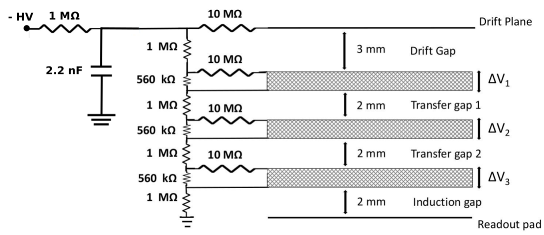

FIG. 1: Schematic of the HV distribution through the resistive chain to different planes of the SM triple GEM detector. A low pass HV filter is used between the input HV line and resistive chain to block the ripple.

temperature, pressure and relative humidity are monitored continuously using a data logger. The divider current is monitored contin-

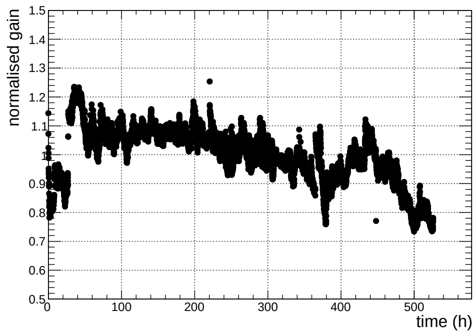

FIG. 2: Variation of normalised gain as a function of time at an applied HV of - 5100 V. The error bars are smaller than the marker size.

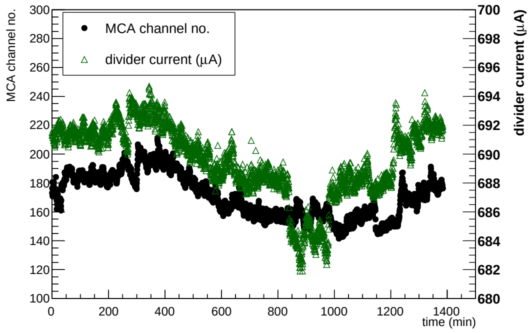

FIG. 3: Variation of MCA channel no. and divider current as a function of time at an applied HV of - 5100 V. The error bars are smaller than the marker size.

uously using the GEneral COntrol (GECO) software [4].

Results and discussion

The gain of the chamber is calculated from 5.9 keV main peak of the X-ray coming from the Fe^{55} source having activity $\sim$ 20 mCi. The details of the gain calculation are discussed in Ref. [5]. As it is well known that the gain of any gaseous detector depends on the temperature (T) and pressure (p) variation, therefore, the gain of the chamber is parameterized as a function of T/p using an exponential form [$A\ exp(B\ T/p)$, where A and B are the free parameters] [6]. In order to nullify the effect of temperature and pressure variations, the gain is normalized using the following relation;

$$normalized\,gain \;=\; gain/A\,exp(B\,T/p) \quad (1)$$

The details of the normalization of gain is reported in Ref. [7]. After normalising the gain to eliminate the temperature and pressure effects, the normalized gain is found to be decreased with time. The variation of normalised gain as a function of time is shown in Fig. 2.

In order to investigate the probable reason behind the decreasing trend of the normalised gain of the chamber, it is found that the divider current which is also monitored continuously using the GECO software [4], is positively correlated with the MCA channel no. The MCA channel no. of the 5.9 keV Fe^{55} X-ray peak and the divider current is plotted as a function of time in Fig. 3. As the mean MCA channel no. of the 5.9 keV peak represents the gain of the chamber, therefore, with change in divider current the ΔV across the GEM foil as well as the gain of the chamber changes proportionally.

Acknowledgments

Mr. Shreesh Sahai would like to thank Prof. Alpana Goel for her support in course of the study.

References

[1] F. Sauli, Nucl. Instrum. Methods Phys. Res. A 386 (1997) 531

[2] R. De Oliveira et al., United States Patent, Patent No.: US 8,597,490 B2, December 3, 2013

[3] S. Chatterjee et al., Nucl. Instrum. Methods Phys. Res. A 1014 (2021) 165749

[4] https://www.caen.it/products/geco2020/

[5] S. Chatterjee et al., J. Instrum. 15 (2020) T09011

[6] M. C. Altunbas et al., Nucl. Instrum. Methods Phys. Res. A 515 (2003) 249

[7] S. Chatterjee *et* al., arXiv:2206.04051