Study of the characteristics of Gas Electron Multipliers for the FAIR experiment CBM

S. Biswas[1],* A. Abuhoza[1], U. Frankenfeld[1], J. Hehner[1], C. J. Schmidt[1], H.R. Schmidt[2], M. Träger[1], S. Colafranceschi[3], A. Marinov[3], and A.Sharma[3]
[1] *GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, GERMANY*
[2] *University of Tübingen, GERMANY and*
[3] *CERN, SWITZERLAND*

The Compressed Baryonic Matter (CBM) experiment at the future Facility for Antiproton and Ion Research (FAIR) in Darmstadt, Germany will use proton and heavy ion beams to study matter at extreme conditions [1, 2]. The CBM experiment at FAIR is designed to explore the QCD phase diagram in the region of high baryon densities. With CBM we will enter a new era of nuclear matter research by measuring rare diagnostic probes never observed before at FAIR energies, and thus CBM has a unique discovery potential. This will only be possible with the application of advanced instrumentation, including highly segmented and fast gaseous detectors.

Gas Electron multipliers (GEM) will be used in CBM Muon Chamber (MUCH) located downstream of the Silicon Tracking System (STS) of the CBM experiment along with other sophisticated detectors. The microstructured gas detectors GEMs, invented by Sauli in 1997 was a 5 cm × 5 cm square foil with a 25 μm thick polymer sandwiched between 18 μm thick copper electrodes; the etching pattern has parallel rows of 70 μm wide holes 100 μm apart [3]. Upon application of a suitable difference of potential between the electrodes, the electric field in a channel of the GEM hole develops. With the application of 400 V, the electric field strength along the central field line reaches 40 kV/cm. Electrons released by the ionisation in the upper gas volume drift into the channels, avalanche in the high field region and leave towards the electrode in the lower volume: ions generated in the avalanche drift along the central field lines in the other direction. Nowadays GEMs with areas of 10 cm × 10 cm or 30 cm × 30 cm are available by default. Recent investigations at CERN on the single-mask technology have shown that the fabrication of large-area GEMs is feasible [4, 5]. The maximum gain achievable with the GEM electrode depends on the thickness of the polymeric support, the diameter of the holes, the gas mixture, and the applied voltages. As reported in Ref. [6] the optimum performance is obtained with 50 μm-thick polymer foils, hole diameters of 50-100 μm, and a pitch of 100-200 μm.

In GSI detector laboratory an R&D effort is launched to study the characteristics of GEM detectors for the CBM experiment. The primary goals of this R&D program are: (a) to verify the stability and integrity of the GEM detectors over a period of time, during which a charge density of the order of several Coulomb/cm^2 is accumulated in the detector; (b) to establish the functioning of a triple GEM as a precise tracking detector under the extreme condition of the CBM experiment; (c) to study usual parameters e.g., efficiency, rate capability, long term stability, spark probability by varying conditions like temperature, gas composition or radiation dose.

One triple double mask GEM detector obtained from CERN with 3 mm drift gap, 2 mm transfer gap and 2 mm induction gap has been studied systematically. The voltage to the drift plane and individual GEM plates has been applied through a voltage divider chain. Although there is a segmented readout pad the signal in this study was obtained from all the pads summed by a add up board and a single input is fed to a charge sensitive pream-

*Electronic address: S.Biswas@gsi.de

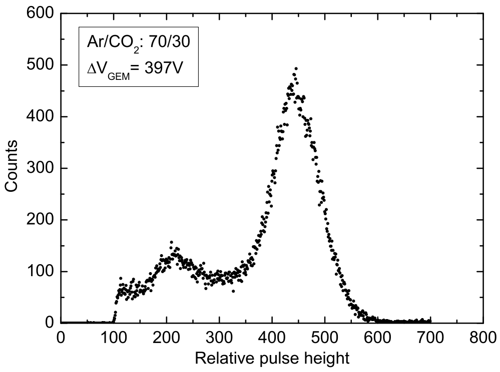

FIG. 1: (Pulse height distribution for 5.9 keV Fe^{55} source obtained with triple GEM detector.

plifier. After that a Lab-View based data acquisition system is used. The variation of the effective gain, resolution of this detector with variation of the applied high voltage has been measured with Fe^{55} X-ray source for different gas mixtures and with different gas flow rates etc. The fraction of large signal (probable spark) relative to average signal has also been measured by setting different threshold values.

The detector has been operated with Argon and CO_2 with different ratios such as 70/30, 80/20 and also with different flow rates e.g. 50 ml/min, 100 ml/min and 200 ml/min. FIG. 1 gives an example of pulse height distribution for a Fe^{55} X-ray source with Argon and CO_2 in 70/30 ratio at $\Delta V_{GEM} = 397$V. The variation of effective gain and energy resolution (FWHM) with that of ΔV_{GEM} are shown in FIG. 2 (a) and FIG. 2 (b) respectively. It is clear that the gain increases exponentially and the energy resolution improves with the increase of ΔV_{GEM}.

Currently fabrication of new 10 cm × 10 cm GEM detector with newly designed box and their characterisation is under progress. Testing of GEM without voltage divider chain and

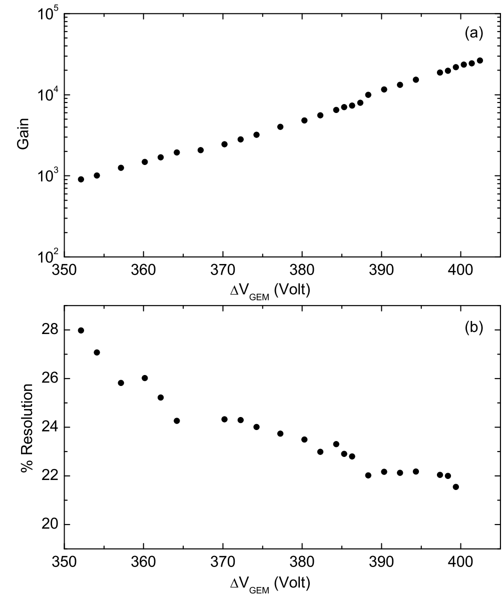

FIG. 2: (a) Effective gain curve of the triple GEM, operated in argon/CO_2 70/30. (b) Energy resolution as a function of ΔV_{GEM}.

using a seven channel high voltage module, dedicated for triple GEM has also been performed. Building of large area single mask GEM is also a future plan. The test results and details of the fabrication will be presented.

References

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