# Study of uniformity of characteristics over the surface for triple GEM detector

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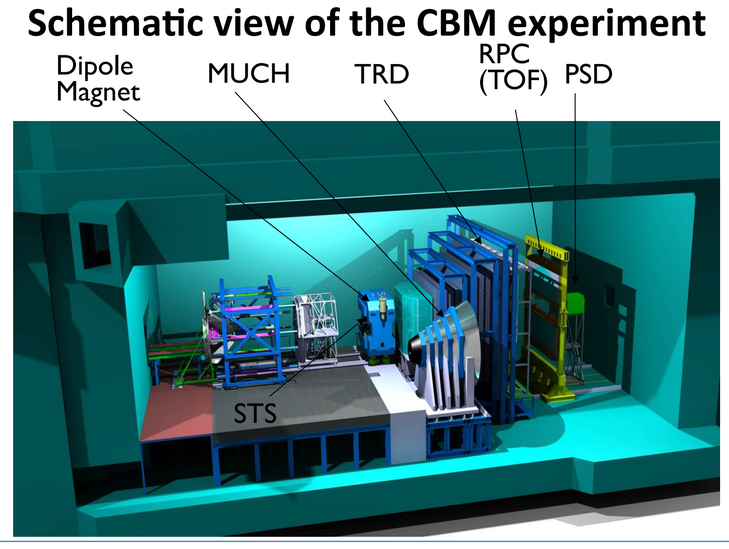
## Introduction

At the Compressed Baryonic Matter (CBM) experiment of Facility for Antiproton and Ion Research (FAIR), Germany, we will explore the QCD phase diagram. In CBM experiment one of the biggest challenges is to detect J/Ψ (charmonium) at a high interaction rate. One of the largest components of CBM experiment is the MUON chamber (MUCH). The muon chamber will use several hadron absorbers made of graphite and iron and sophisticated gaseous detectors. Triple Gas Electron Multiplier (GEM) detectors will be used in the first two stations of the CBM MUCH. It is found in simulation that the incident particle rate in the 1st station of CBM MUCH will be about 1 MHz/cm$^2$ and CBM will run for several years. So one of the major goals is the stable operation of the detectors for long period and also the uniformity of the detectors characteristics over its active area. In this poster the systematic study of uniformity of a triple GEM detector prototype over its active area is presented.

## Schematic view of the CBM experiment




## Why Gas Electron Multiplier (GEM)

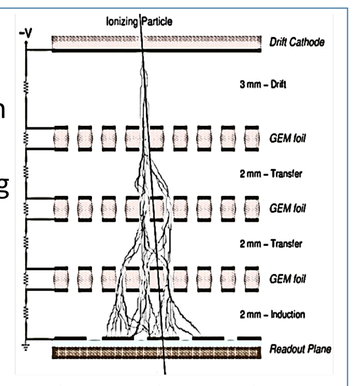
- High rate capability
- Radiation hardness
- Good spatial resolution
- High efficiency
- Can be used in cascaded mode to increase the overall gain of the detector

## Main goal of the study

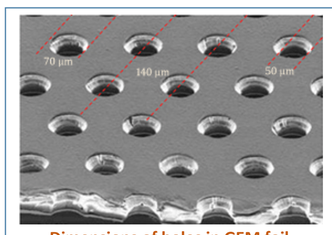
- Long term stability test of GEM detector.
- Study of uniformity of gain, energy resolution and count rate of Fe$^{55}$ X-ray over the active area of a GEM detector.

## GEM detector

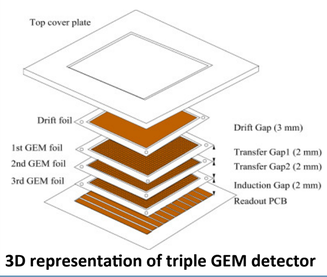
- GEM foils are 50 micron thick Kapton sheets sandwiched between two 5 micron thick copper cladding.
- Holes of diameter 70 micron are etched into the combination using photolithography technique.
- With the application of high voltage across the copper layers, primary electrons passing through the holes create avalanche.
- The resulting signal is collected in the anode plane, which is a number of pads or strips, giving the accurate position of the incoming particle.
- Three or more foils are stacked on top of one another to achieve sufficient gain at a lower applied voltage, also reducing the probability of spark.



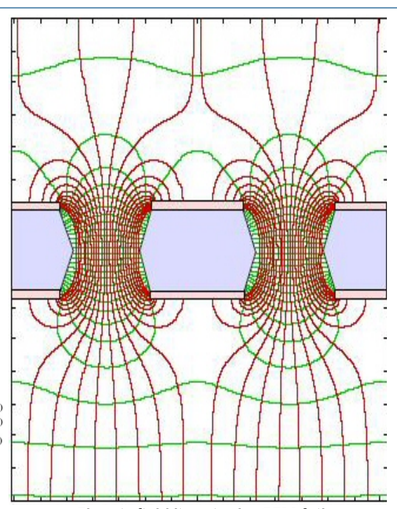

Schematic diagram showing the working principle of GEM



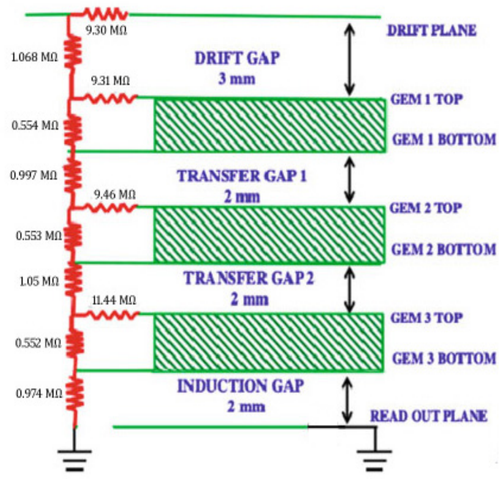

Dimensions of holes in GEM foil




3D representation of triple GEM detector

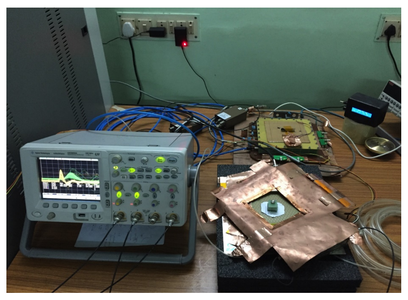


Electric field lines in the GEM foil



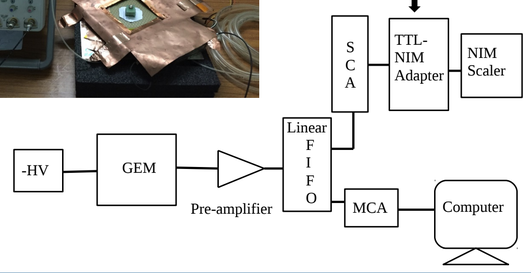

Voltage divider network of Triple GEM detector

## Experimental setup



Detector setup

electronic setup

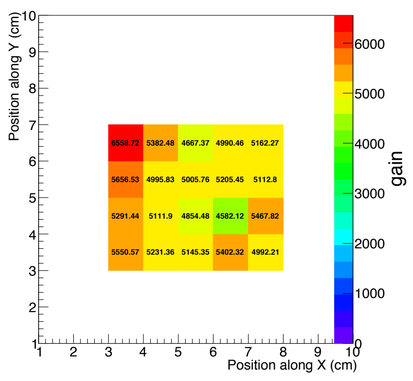



## Details of uniformity study

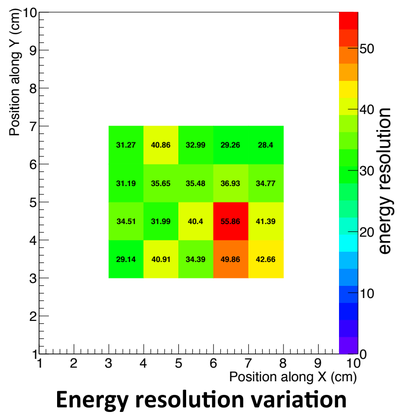
The characteristics of the GEM detector will not be the same over all of it's active area. It is to be mentioned here that because of intrinsic inhomogeneity in their characteristics due to GEM geometry variations and also for the inhomogeneity in the gap between individual GEM foils a gain variation up to few percentage is possible. The central part of the active area of the triple GEM detector prototype was divided into 20 equal segments and the Fe$^{55}$ X-ray source was placed on each of them and from the respective data we have studied the uniformity in the gain, energy resolution, and rate.

- Detector used: 10 cm × 10 cm triple GEM detector with double mask foil
- Read-out pad: 9 mm × 9 mm, 9 Nos.
- Source used: Fe$^{55}$ (5.9 keV X-ray); Collimator: Made of G-10 material area ~ 50 mm$^2$.
- Gas: Ar/$CO_2$ in the ratio 70/30 ; Gas flow rate: 3.4 litre/hour
- Applied voltage to the divider: - 4150 V
- Temperature, pressure and relative humidity are monitored continuously with time stamp

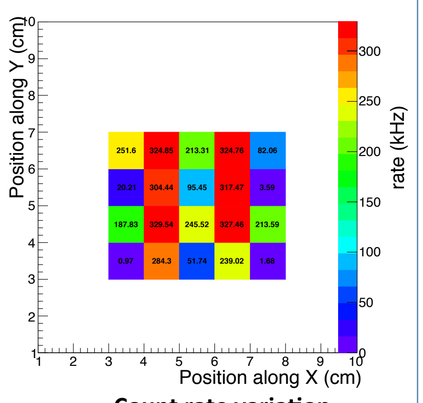
## Results



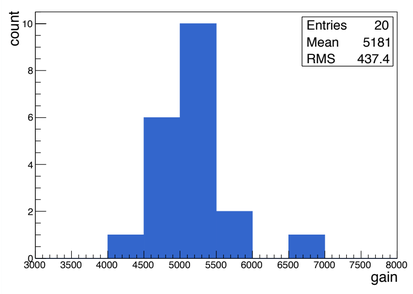

Gain variation



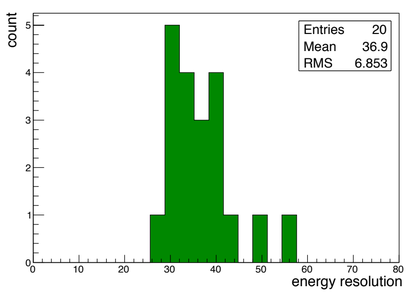

Energy resolution variation



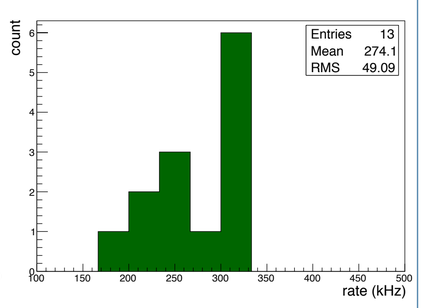

Count rate variation




Fluctuation : 8.4 %




Fluctuation : 18.6%




Fluctuation : 17.9%

## Summary and Outlook

- The uniformity of gain, energy resolution and count rate is studied for a 10 cm × 10 cm triple GEM detector over its central active area
- Gain fluctuation is found to be ~ 10% while the fluctuation of energy resolution and count rate is ~ 20%
- Similar studies are to be performed with different gas mixtures and flow rate

## Acknowledgements

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