Response of triple GEM chamber with high intensity Xray source

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A large area, high rate and high granularity detector system has been envisaged for the Muon Chambers (MUCH) for the future Compressed Baryonic Matter (CBM) Experiment at upcoming future facility of FAIR at GSI, Darmstadt[1][2]. The MUCH detector system consists of alternate layers of absorber and detector stations. For the first few stations the detectors have to cope up with a high particle flux of about 1 MHz/cm^2. For such stations, micropattern detectors based on Gas Electron Multipliers (GEM) have been proposed. In this regard, we have tested several prototype detectors having an active area of 10 cm x 10 cm using self triggered readout electronics, as would be the case in the actual experiment.

Fig. 1 Picture of the X-ray test setup at RD51 lab at CERN

One of the key issues in studying the prototype chamber characteristics is the efficiency of charged particle detection and its dependence on varying incident particle flux. In the beamtests that have been performed so far, one could reach rates upto about several hundred kHz/cm^2. We have used the self triggered nXYTER[3] ASIC, for reading out the signal from the pads for all our beamtests. Preliminary investigations of these data have revealed stable performance of the detectors at low frequencies. However, at high rates, the data could not be understood properly as considerable crosstalks along with drop in efficiency were observed, and it was not clear what was the source of this problem. Hence, no inference about rate capability of the chamber could be made as the readout electronics also needed an in depth investigation. nXYTER electronics is still under development. Hence, in order to independently ascertain the rate capability of triple GEM chamber it was decided to decouple the electronics investigation with the study of triple GEM chamber characteristics. Hence, to study the response of the detector at higher rates, we tested the chambers using conventional NIM electronics, which consisted of Ortec 142-IH preamp coupled to Ortec 572 amplifier. The chambers were tested with a high intensity Xray source facility at RD51 laboratory at CERN. The Cu target based Xray source with a characteristic energy of 8 keV was incident from a narrow tube having an aperture of 2 mm diameter.

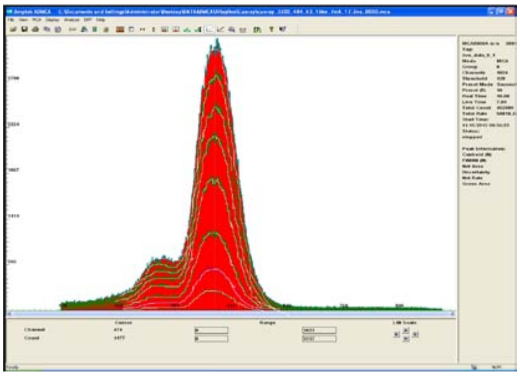

Fig. 2 Cu-Xray pulse height spectra for varying incident intensities.

A triple GEM chamber made from single mask GEMs and having an active area of 10 cm x 10 cm was used for this purpose. The chamber had 512 readout pads, divided into 8 zones as it was originally built for beamtests using nXYTYER. For the Xray test, each of the 8 zones of the readout plane was individually shorted using 8 different connectors and the signal was readout from one such zone, which was illuminated with Xrays. The drift gap, transfer gap and induction gap of the triple GEM chamber was 3 mm, 1 mm and 1.5 mm respectively. The biasing chain consisted of a protection resistor of 12 MΩ across the top surface of each GEM foil. The chamber was tested at HV=3200 V. The GEMs were biased in a symmetric configuration i.e. ΔVgem across each GEM was about 358 V. Ar/CO2 mixed in the ratio 70:30 was the gas mixture used.

Fig.1 shows the picture of the prototype chamber under test. The Xray tube is placed about 2 cm away from the chamber. The chamber had an opening of 1 mm diameter for the Xrays to pass through. The intensity of the Copper Xray was varied by changing the filament current of Xray tube. Fig.2 shows the pulse height spectra corresponding to seven different intensities overlayed on top of each other. The spectrum with highest intensity (of about 1.37 MHz/cm^2) is shown by the topmost overlay curve, while the one with lowest peak-counts corresponds to a frequency of ~93 kHz/cm^2. The different white curves drawn are for eye guidance and better visibility of the histograms. It is seen from these pulse height spectra that the mean of the major peak is quite stable inspite of about 12 times change in rate of incident particles. The intensity of the incident Xray was calculated based on the frequency of signal collected from the bottom of the last GEM. The anode pads from the zone being readout was coupled to a picoammeter to have an independent and quantitative estimate of the change in gain.

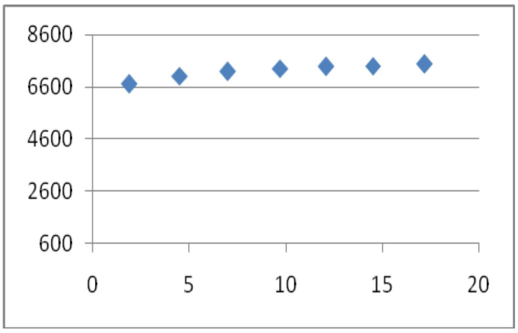

Fig. 3 Variation of detector gain(Y-axis) with anode current (in micro amperes).

As shown in Fig. 3, the detector was operated at an average gain of ~7x10^3 and the observed change in gain based on the anode current measurement was found to be around 10 % for the range of intensities studied. This value is close to what can be gathered from the mean positions of the major peak of the pulse height spectra shown in Fig.1. Further investigations of this data are underway. The study of the gain stability at high particle intensities for varying GEM voltages and for different protection resistors is under progress.

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References

[1] Conceptual Design Report (CDR) Announcement Poster and Website, DAE Symp. on Nucl. Physics.
[2] A.K. Dubey, et. al, DAE Symp. On Nucl.Phys. **vv**, ppp (2010), Anna Kiseleva, P.P. Bhaduri, et.al. 85, 211-216 (2011)
[3] NIM A 568 (2006) 301–308