Testing a triple-GEM detector with cosmic rays using a self-triggered Front End Electronics (FEE)

A. K. Dubey,* J. Saini, R.N. Singaraju, S. Chattopadhyay, G. S. N. Murthy, S. A. Khan, Y.P. Viyogi
VECC, Kolkata

* **email: anand@vecc.gov.in**

Introduction

A high rate, high granularity gas detector system is being developed for its use as Muon Tracker in the Compressed Baryonic Matter (CBM)[1] experiment at the upcoming FAIR facility at GSI, Darmstadt. We, at VECC are involved in developing Gas Electron Multiplier (GEM)-based muon detectors for the first two stations of Muon Chambers(MUCH) from the target. This large acceptance detector is required to have high position resolution and should be able to cope with the high rate (10 MHz/cm^2) of particle flux in the CBM experiment. High detection efficiency for the Minimum Ionizing Particles (MIP) is one of the necessary criteria for the MUCH detectors. One of the unique features of the CBM detectors is the use of self -triggered readout electronics to avoid trigger processing time which otherwise will be the reason to miss events at high interaction rates. The philosophy is to collect all hits on the detector and group them offline based on the time stamp of the fired cells. In this paper, we report the setting up of such a data acquisition and testing system at VECC lab, using cosmics as the trigger and nXYTER as the Front End Electronics(FEE) for readout. We also report the response of the detector based on this self triggered approach. The advantage in having such a system in the lab locally is that it would facilitate us to carry out several basic studies of the detector in lab with actual FEE/DAQ and would also allow us to do a detailed parameter study of the electronics, which is still in a developing phase. This study thus would help in understanding the readout characteristics and in optimizing the operating conditions of the triple GEM chamber.

Prototype Chamber and Test Setup

A triple GEM prototype chamber based on 10 cm x 10 cm CERN-made-and-framed GEM foils was placed in between a set of three scintillator pads arranged one over the other with appropriate gaps between them(Fig.1). A coincidence between the three scintillators provided the cosmic muon trigger. The middle scintillator with an area of 5 cm x 1 cm which was kept very close to the prototype chamber, provided the actual geometrical overlap with the active area of the detector. The signal from detector was readout using 512 square pads, each having a dimension of 3 mm, via four Front End Boards (FEBs) consisting of nXYTER chips. Each FEB reads 128 channels. The four FEBs were connected to two ReadOut Controllers(ROC) from where the data was transferred to a PC. The three GEMs and the drift mesh were biased via a single resistive chain. A premixed gas mixture of Ar/CO2 in the ratio 70/30 was used for all our tests.

In order to register the time of the trigger, this signal was fed to the Auxiliary channel(AUX) input of the ROC. The way it was carried out is schematically shown in Fig.2. CBM DAQ was installed on a Linux PC and the two ROCs were synchronized in a master-slave format. The time difference when the detector sees the correlated signal with respect to AUX, was noted. If this time difference between the GEM chamber hit and the AUX is below 200 ns, then it was considered to be a valid cosmic muon track hit. Efficiency of the detector was then estimated as the ratio of valid tracks hit to the total number of triggers(AUX).

Results

The 2-D picture of the pads hit by the cosmic muons accumulated over several triggers and occurring in a time window of 200ns is shown in Fig.3. It is rather wide as compared to the actual size of the finger scintillator placed in the middle. The reason could be that the trigger

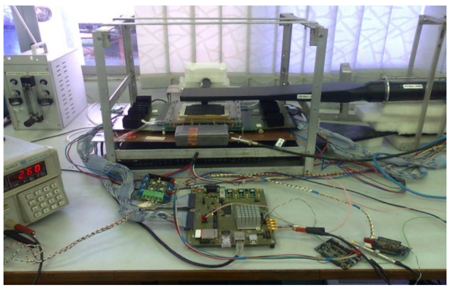

Fig.1 Picture of the detector under test in VECC lab

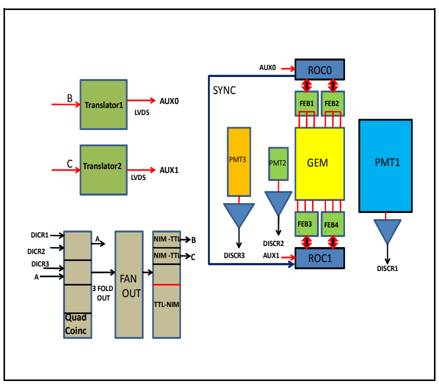

Fig.2 Schematic of the trigger arrangement

scintillators were too wide and being very close to each other, may have included several slant tracks in the trigger thus covering somewhat larger area. The other reason could that the noise is still very large. Noise subtractions using nXYTER is a non-trivial process since baseline for each 512 pads has to be determined by running data acquisition in a special mode and the ADC for each channel is then individually subtracted offline owing to the typical inverted ADC spectra of nXYTER[3]. Implementation of a proper ADC subtraction algorithm is under progress and final data will be presented after considering these parameters. Fig. 4 shows the timing distribution of the difference in the arrival times of the GEM signal and the AUX. There is an inherent delay of 750 ns in the trigger chain and this compounded with the delays due to drift

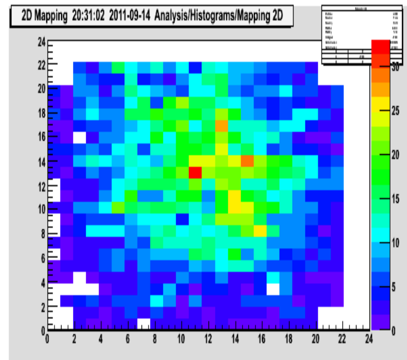

Fig. 3. 2-D picture of the pads hit due to cosmics

times of the arriving primary ionization electrons, a peak around 900 ns is seen. The average efficiency of charged particle detection in a time window of 200ns, is found to saturate around 94%. More rigorous tests and analysis of data at different voltages is underway. The detailed response of the triple GEM chamber would be presented and discussed.

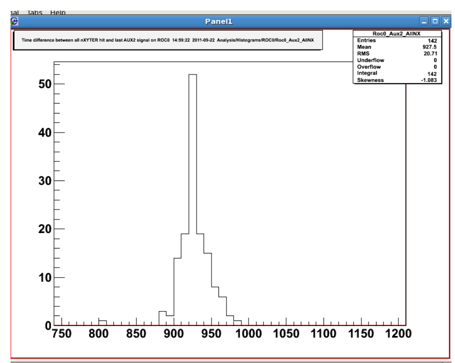

Fig. 4. Timing difference spectra for ROC1

References

[1] Conceptual Design Report (CDR) at www.gsi.de/fair/reports/index.html.

[2] NIM A (568) (2006) 301-308

[3] DAE Symp. On Nucl.Phys. **53**, 677 (2008)