Testing of a triple-GEM chamber with muon beams at CERN SPS

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Introduction

As part of the ongoing R&D activity at VECC, for developing a Muon tracking system for the CBM experiment[1,2], we conducted a test experiment of a triple GEM chamber at H4 beamline of CERN SPS with 150 GeV/c muon beams. Using a self triggered readout system the goal was to optimize the detector geometry parameters and readout characteristics and arrive at an appropriate operating voltage of a triple GEM chamber. A high detection efficiency for the Minimum Ionizing Particles (MIP) is one of the necessary criteria for the Muon chambers (MUCH). In addition to this, owing to the requirements of high interaction rates for detecting rare probes at CBM, all detectors therein would have to take data in a self triggered mode. The philosophy is to collect all hits on the detector as and when they arrive and group them into events offline based on the time stamp of the fired pads. In this paper, we report the first measurement of the efficiency of the detector using a self-triggered readout ASIC[3].

Prototype Chamber and Test Setup

A triple GEM prototype chamber based on 10 cm x 10 cm CERN-made-and-framed GEM foils and consisting of 512 readout pads each of 3 mm x 3 mm dimension was assembled at VECC. The signal from the pads were read out via four Front End Boards(FEBs), each consisting of one nXYTER chip. The four FEBs were connected to two ReadOut Controllers(ROC) which helps to to transfer data to a PC. High voltage was applied to the three GEMs and the drift plane via a resistive divider. A premixed gas mixture of Ar/CO2 in the ratio 70/30 was used for all our tests.

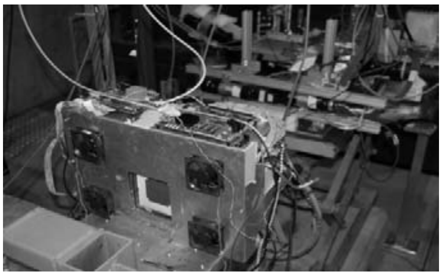

Fig.1 Picture of the GEM prototype chamber under test at H4 beamline of CERN SPS

Fig. 1 shows the picture of the chamber under test at H4 beamline at CERN SPS. A set of three scintillators including a tiny 3 mm x 3mm scintillator provided the muon trigger. This “finger” scintillator placed very close to the detector facilitated the positioning of the beam at the centre of desired pad.

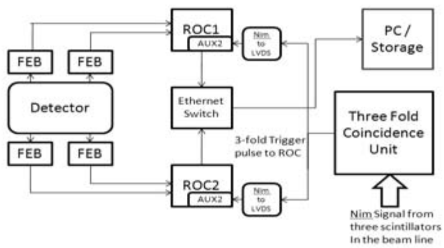

Fig.2 Schematic of the readout and DAQ setup

The arrival time of the three fold coincidence signal was fed to the Auxiliary channel(AUX) input of the ROC and the corresponding timestamp of the trigger was registered. Total number of AUX hits thus provided the total number of triggers in a given time period. CBM DAQ was installed on a Linux PC and the two

ROCs were synchronized in a master-slave format. The schematic of the readout and data acquisition is shown in Fig.2.

Results

The distribution of the timing difference when the detector sees the correlated signal with respect to AUX is shown in Fig.3. The time resolution(σ) is observed to be about 15 ns. A lego plot of the beam spot as obtained from the chamber, by applying a timing window of 200 ns accumulated over several triggers is shown in Fig.4. It clearly shows that the number of pads hit due to beam is close to unity.

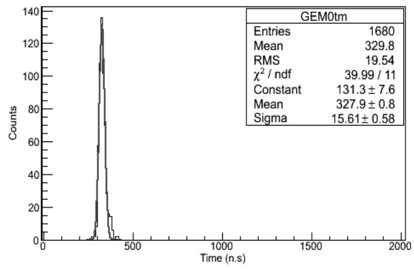

Fig.3 Distribution of the time difference between GEM hits and triggers.

All detector hits occurring within this time window was considered to be a valid cosmic muon track hit. Efficiency of the detector was then estimated as the ratio of trigger having valid tracks hit to the total number of triggers(AUX).

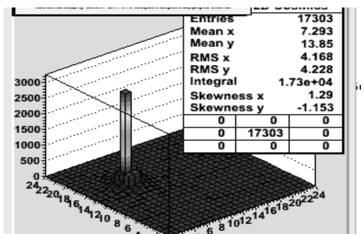

Fig.4 Lego plot of the distribution of pads hit corresponding to trigger muons.

Noise determination for each of 512 channels was carried out by running data acquisition in a no-beam-spill condition and the ADC from such data for each channel is then individually subtracted. The pulse height corresponding to the muon beam and fitted to a Landau distribution function is shown in Fig. 5.

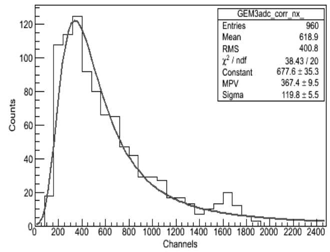

Fig.5. Pulse height spectra for 150 GeV/c muon beam.

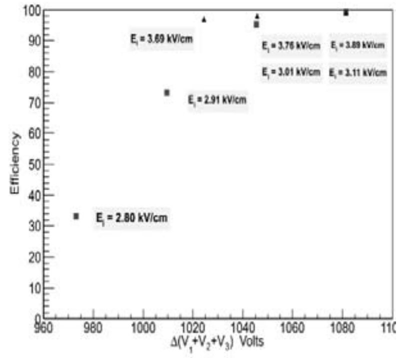

Fig.6 Variation of Efficiency with GEM voltage.

Data at varying GEM voltages were taken at two different HV bias resistive divider configuration. The efficiency of charged particle detection for the two cases obtained in a time window of 200ns, is found to reach a value >95%. The detailed response of the triple GEM chamber would be presented and discussed.

References

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[3] A.S. Brogna, et.al., NIM A568 301(2006)