Quality Control Testing of GEM Detector

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Introduction

The Compact Muon Solenoid (CMS) collaboration is planning to install the Gas Electron Multiplier (GEM) detectors (referred to as GE1/1 detectors) in the 1^{st} ring in 1^{st} muon station in both end-caps of the CMS detector as already available detection technologies i.e. Resistive Plate Chamber (RPC), Cathode Strip Chamber (CSC), Drift Tube (DT) etc. are approaching their limits due to increased luminosity [1]. The triple-GEM detector has high rate capability, can withstand in high radiations and has spatial resolution $\sim$ 100 µm, time resolution $\sim$ ns, an average efficiency $\sim$ 97 % [2]. 144 triple-GEM detectors will be installed in both end-caps of the CMS detector. There are several production sites across the whole world for GE1/1 detectors's assembly and testing. In India, there are total 4 production lines i.e. Panjab University (Chandigarh), Delhi University (Delhi), Bhabha Atomic Research Centre (Mumbai) and Saha Institute of Nuclear Physics (Kolkata). In the present studies, the required stringent as well as dedicated quality control (QC) set-ups at PU site and corresponding results of the triple-GEM detector testing are reported.

The Triple-GEM Detector

The GEM structure is introduced in 1996 by F. Sauli. The GEM foil is a thin ($\sim$ 50 µm thick) polyimide layer and coated on both sides with $\sim$ 5 µm thick copper layers. The triple-GEM detector consists of three GEM foils embedded between a drift plane (acting as the cathode) and the readout plane (acting as the anode) [2]. By chemical etching, GEM foil is perforated with microscopic holes (acting as amplification centres). For GE1/1 detectors, the part of the detector production is expected to take place at above mentioned Indian sites. A class 100 clean room is ready at PU site for the triple-GEM assembly. Besides triple-GEM assembly, also QCs (explained in next sections) will be performed at PU site. All QCs results shown in next sections are obtained from a 5th generation GEM detector (received from CERN) bearing ID GE1/1-V-PANJAB-0001 shown in Fig. 1.

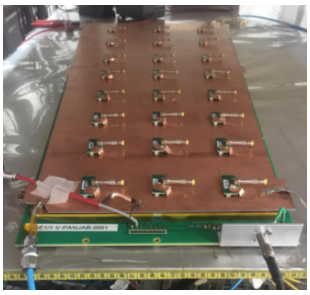

FIG. 1: The Triple-GEM Detector.

QC2 Fast Test

QC2 fast test is performed to determine the quality of GEM foils by measuring the maximum leakage current flowing on the surface of GEM holes. It is performed using Megger MIT 420 by applying voltage up to 550 Volt to the GEM foils, due to which dust particles trapped in the GEM holes are burnt. If impedance of all the three GEM foils is above 10 GΩ, then that triple-GEM detector can be accepted. Observations are shown in Table I.

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TABLE I: Measured Impedance of The Three GEM Foils.

Region	Impedance	Current
GEM Foil1	>120 GΩ	4.58 nA
GEM Foil2	>120 GΩ	4.58 nA
GEM Foil3	>120 GΩ	4.58 nA

QC3 Gas Leak Test

QC3 gas leak test is performed to calculate GEM detector's gas leak rate or to check gas tightness. QC3 gas leak test set-up has 2 flowmeters, micro-controller based arduino chip having 3 sensors for atmospheric pressure, internal gas pressure and temperature measurements. QC3 gas leak test is performed using CO_2 gas. Initial pressure is kept 25.13 millibar, final pressure after 1 hour is found to be 23.63 millibar. Calculated leak rate (of both, set-up as well as GEM detector) is $\sim$ 1.5 millibar/hour. QC3 gas leak test plot is shown in Fig. 2.

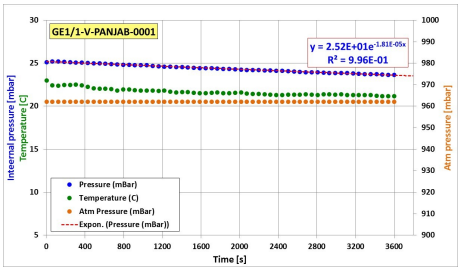

FIG. 2: QC3 Gas Leak Test Plot.

QC4 Test

QC4 test is performed to study VI (applied voltage vs. current) characteristics and spurious signal rate (due to internal leakage current, defects in electrical circuit) of GEM detector. For QC4 test, CO_2 gas is used keeping flowrate 5 litre/hour. High voltage is applied using CAEN SY5527 power supply. Observed current is $\sim$ 1000 µA and noise rate is $\sim$ 6-7 Hz/cm^2 shown in Fig. 3.

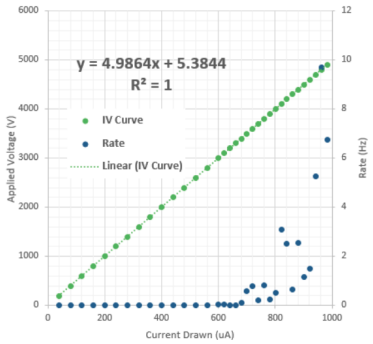

FIG. 3: VI and Spurious Signal Rate Characteristics.

Conclusions

PU site is ready for GE1/1 detectors assembly as well as QC2-QC4 testing, final approval by CMS GEM community is expected this year.

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References

[1] The CMS collaboration et al., CMS TECHNICAL DESIGN REPORT FOR THE MUON ENDCAP GEM UPGRADECERN-LHCC-2015-012/CMS-TDR-013.

[2] Jeremie A. Merlin, CERN-THESIS-2016-041.