

GE1/1 upgrade of CMS detector at LHC facility at CERN

S. T. Sehgal¹, D. Mulmule^{1,2}, P. K. Netrakanti¹, V. Jha¹,
D. K. Mishra¹, R. Sehgal¹ and L. M. Pant^{1,2}

¹Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA,

²Homi Bhabha National Institute, Mumbai, 400094

Introduction : The goal of the CMS muon upgrade is to maintain the L1 trigger rate with maximum selection efficiency in order to fully exploit the High Luminosity LHC. The CMS GEM Collaboration has proposed to instrument the vacant high-eta region of the muon end-caps with Gas Electron Multiplier (GEM) detectors, called GE1/1 chambers [1]. One of the major phase I upgrade is the introduction of the GEM-based technology in the first station of the forward end-caps of the muon system at $1.55 < \eta < 2.18$ (GE1/1). These detectors are scheduled for installation during the Long Shutdown-II (early 2019). The GE1/1 upgrade involves building of 144 detectors at nine assembly centres around the world, three of which are in India : at BARC-Mumbai, Panjab University-Chandigarh and Delhi University. These three centres will contribute 10 GE1/1 detectors each, totaling to 30 GE1/1 detectors for the upgrade from India.

Assembly and Quality Control tests of GE1/1 detectors (QC3 to QC5) : This paper highlights various quality control procedures and facilities built for the same in the laboratory connected with impedance test, leak test, spurious pulse test and finally the gain uniformity test, before dispatch of GE1/1 detectors to CERN. Since the surface conductivity of the GEM foil depends on the relative humidity of the environment, a weather station with temperature and humidity sensors is setup near the QC2 (impedance measurement) test stand. In order to obtain comparable results, the

relative humidity in the clean room must be equal or less than 40 %. To perform the QC2 test, we place the stretched foil in a clean environment (class 1000) and connect the Megger to the GEM HV pads with the custom clip. The HV needs to be set at 550 V on the Megger and the impedance of the foil is to be measured. Also, the number of sparks after 30 s are to be counted, every minute for a period of 10 minutes. The GEM foil is accepted if its impedance is above 10 G Ω and the spark rate lower than 2 Hz during the last two/three minutes of test. A typical impedance measurement of 10 cm x 10 cm GEM foil developed at Micropack, Bangalore is shown in Fig.1.

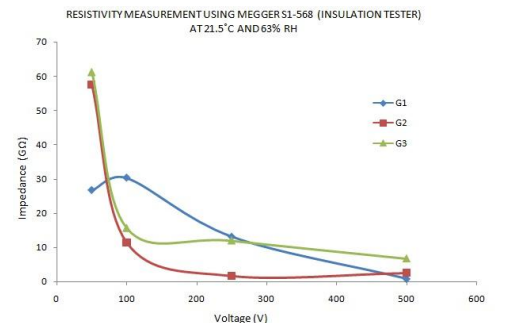


Fig. 1 : GEM foil impedance w.r.t. HV from Micropack, Bangalore.

Micropack at Bangalore, is involved in making large area, Single Mask Thin GEM foils for the CMS upgrade (GE2/1), but for the GE1/1 upgrade the GEM foils ($\sim 0.5 \text{ m}^2$ in area) will be build at South Korea. Micropack has qualified the building of GEM foils in terms of the optimum hole diameter/pitch ($70\mu\text{m}/140\mu\text{m}$) and is

building large area foils in steps, currently having made a 30 cm x 30 cm GEM foil, too. The next test, after the assembly of the triple GEM detector with three GEM foils, Read Out Boards (ROB) and Drift Cathode Boards (DCB) is the QC3, gas leak test which aims to identify the gas leak rate of a GE1/1 detector by monitoring the drop of the internal over-pressure as a function of the time. The acceptable leak rate is 1 mbar/hour. The QC4 test aims to determine the V vs. I curve of a GE1/1 detector and identify possible malfunctions, defects in the HV circuit and spurious signals. Fig. 2, shows a typical set up in the lab for QC3 and QC4, both of which are performed with CO₂ gas. Fig. 3 shows a leaking detector and the leak is to be rectified in it.

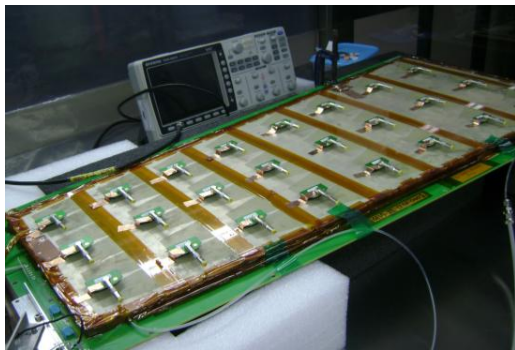


Fig. 2 : A typical GE1/1 assembled detector ready for QC3 and QC4 at NPD-BARC

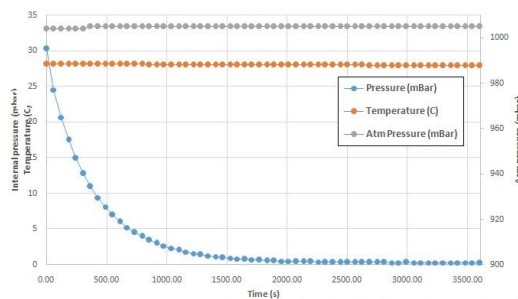


Fig. 3 : QC3, of a GE1/1 detector over pressurized at 30 mbar

QC4 is performed with CO₂ gas to look for spurious pulses with all the 24 Panasonic

connectors on the ROB terminated in 50 Ω. The last of the tests is QC5 for gain uniformity with an x-ray source for which an SRS (Scalable Readout System) has been procured from CERN under the aegis of RD51 collaboration and is under shipment at the moment. The related software for handling QC5 is under implementation at NPD-BARC. The QC5 response uniformity test consists of measuring the pulse height distribution all over the active surface of a GE1/1 detectors.

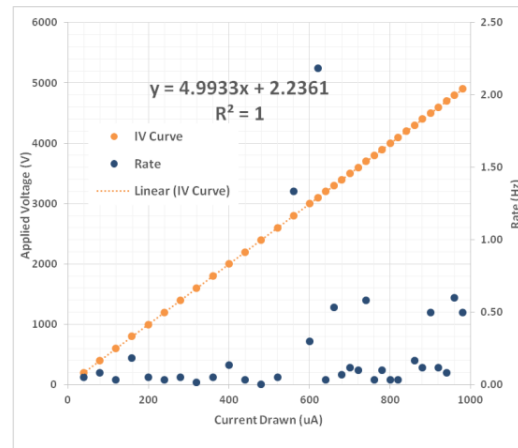


Fig. 4 : QC4 of a typical GE1/1 for spurious pulses with CO₂ gas

NPD-BARC is also responsible for QA/QC of the ROB and DCBs for all the GE1/1 detectors being fabricated at Micropack, Bangalore, before their dispatch to CERN. These are double layered PCBs and the average track width varies from 4 mil to 6 mil for the ROB. The ROB is segmented into eight η sections with each η section having 384 segmentations in φ.

References :

[1] CMS GEM Collaboration, URL <https://twiki.cern.ch/twiki/bin/view/MPGD/CmsGEMConferences>