Quality Control Testing of GEM Detectors to be Installed in CMS

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Abstract

GEM detectors are to be added to the Forward Muon Endcap Region of the CMS experiment during the phase II upgrade of CMS for the High-Luminosity LHC. To that end, Florida Tech is one of the sites for the assembly and testing of these detectors. Upon receiving the latest version of the detectors from CERN, they undergo rigorous quality control testing both during and after assembly to ensure proper quality, performance, and readiness for installation in the LHC.

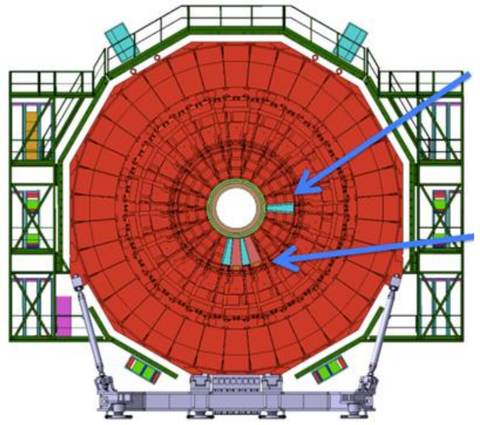

Figure 1: GEM Detector placement in CMS

Background

The upcoming addition of GEM (Gas Electron Multiplier) detectors to the forward muon endcap region of the CMS detector will allow for more precise tracking and improved muon momentum resolution. To that end, 160 1-meter long detectors will be assembled at various sites around the world, to be installed in the CMS of the LHC in 2019.

References

[1] M., Rahmani. (n.d.). *Quality Control of the Large area GEM detectors at Production Sites for the CMS Muon Endcap Upgrade* (Tech.).

[2] GE1/1 Quality Control : instructions
Michele Bianco, Brian Dorney, Jeremie A. Merlin
CERN
On behalf of the CMS GEM Collaboration September 28, 2016

Quality Control Tests

QC 2: GEM Foil Acceptance

QC 2 is split into two parts: QC2: Long and QC 2: Fast. QC 2: Fast measures the current leakage across the top and bottom electrodes of the foils, as well as counts the number of sparks observed on the foils. If the impedance is greater than 10 GΩ with the number of sparks per minute less than 2/3 the amount in the last three minutes, then the foil is accepted. For QC 2: Long, the current leakage and sparks are measured over 30 minutes to 1 hour period from within a plexiglass box filled with nitrogen, being accepted if the mean current is below 5 nA.

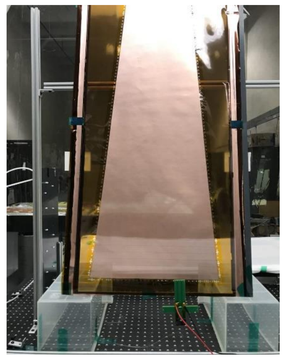

Figure 2: GEM Foil ready to undergo QC 2: Fast

QC 3: Gas Leak Test

QC 3 involves an assembled chamber which is filled with gas to 25 mbar and is monitored over time for internal pressure, along with environmental conditions including atmospheric pressure and temperature. For the chamber to be considered leak-tight, the internal pressure within the chamber should not drop by more than 1 mbar per hour.

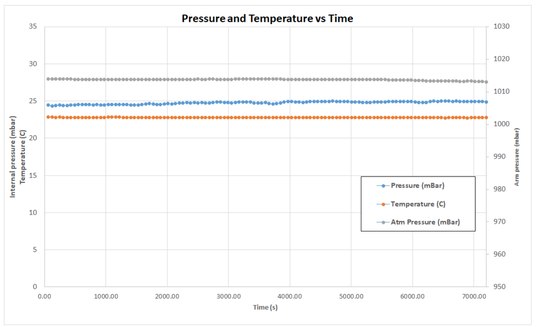

Figure 3: Graph of the internal pressure of the detector, atmospheric pressure, and the temperature over time

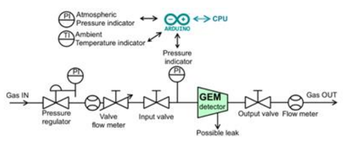

Figure 4: The outline schematic that shows the hardware and gas flow for QC 3.

QC 4: High Voltage Test

The goal of the QC 4 test is to find the voltage and rate vs current graph for the detector and to identify any issues with the HV circuit as well as any spurious signals.

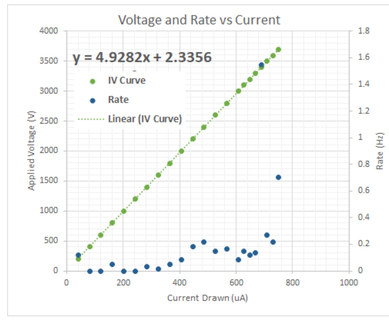

Figure 5: Graph of the results of QC 4.

QC 5: Gain Calibration

QC 5 is split into two parts. One is measurement of the effective gain. This is to confirm the detector's high-rate functionality. Gain vs Incident Rate using an X-Ray source is measured. The other test is to determine that the response across the detector is uniform, being accepted if the pulse height information is within 15% of the average, and has greater than 97% efficiency.

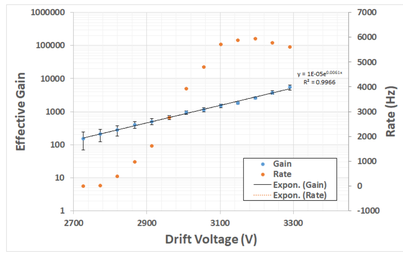

Fig. 6: Effective Gain

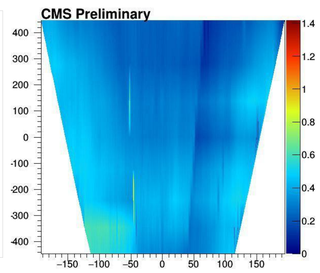

Fig. 7: Gain Uniformity

Conclusion

The Florida Tech site, having completed all of the tasks related to the production and testing of the detectors, have shown to be a successful site for contribution to mass production, and have received continual shipments to that end. As detectors continue to be assembled and tested, they will shipped back to CERN to be installed in the LHC.