**Abstract**

The Large Hadron Collider (LHC) upgrade will increase the instantaneous luminosity and deliver it in the range of $5 \times 10^{34} \text{cm}^{-2} \text{s}^{-1}$ to $7 \times 10^{34} \text{cm}^{-2} \text{s}^{-1}$, up to 7 times higher than the nominal rate. The forward regions of the Compact Muon Solenoid (CMS) detector will face significant challenges due to this high luminosity. The muon system of the CMS experiment sets forth enhancement of the forward muon system by introducing the new GEM stations (GE1/1, GE2/1, ME0) in order to improve the tracking and trigger capabilities in this challenging forward region in the presence of high particle fluxes. The pseudorapidity range covered by the GE2/1 detector is $1.6 < \eta < 2.4$. The successful experience of GE1/1 served as the foundation for the basic design and the production plan for the GE2/1 station. A number of significant improvements have been made to the detector to extend its life span, reduce the spread of discharge, and stop crosstalk when heavy ions are present. We need to ensure optimal coverage and avoid having gaps, GE2/1 chambers are split up into 8 distinct types of modules. Modules M.1 to M.8 form one back chamber, whereas chambers M.5 to M.8 build the front chamber. There are 18 GE2/1 super chambers per endcap, each of which is made up of two chambers that contain four modules each. Prior to being built as chambers and deployed in the YETS 2023 and (E)YETS 2024, a few of the triplex-GEM detector modules have been fabricated, qualified, and validated for optimal detector performance. We present an overview of the GEM GE2/1 detector’s status in this poster.

**Status of GE2/1 Module Assembly**

- A total of 98 modules out of 288 are already produced at various production sites.
- A critical problem of the PCBs (readout and drift boards), lack of passivation was found. Therefore, all 98 of these modules need retrofitting.
- The PCBs are being cleaned and passivated at the CERN MPT workshop. New PCBs are being fabricated and passivated by the MicroPack company.
- The full retrofitting process of all these modules and further QC will last between 2.1-3 years.
- The front chambers are now in place and 22 out of 28 modules have been passivated.

**Status of GE2/1 Foils, PCBs & Electronics**

- The two best validated GE2/1 chambers will be installed in January 2024 in the CMS endcap stations.
- Two GE2/1 Foil Producers
  - MPT workshop (CERN)
  - KCM/Macefic (W) produced 296 foils of different module types, including M.2, M.3, M.6, and M.7. At this site, GE2/1 production has now stopped.
  - Production Scheme of GE2/1
    - GEM (GE2/1 Electronics Board)
      - The GEM is a printed circuit board (PCB) designed to host VFA Ts connected to the 12 sectors of the GEM ROB. It routes signals to the Opto-Hybrid (OH), distributes power to the chips, and provides electrical shielding to the detector.
    - VFA T plug-in card
      - VFA T 3 ASIC is a binary front end chip optimized for gaseous detectors whose function is to digitize the analog signals coming from the detector and provide fast trigger and tracking data.
    - OH (Opto-Hybrid) board
      - The Opto-hybrid (OH) is located in the middle of the GEM chamber and ROB and is connected to the GEM. The OH acts as the concentrator board and communication relay for the 12 VFA T ASIC.
    - VTR & VTX
      - These are attached with the OH board
    - FEAST
      - It distributed the low voltage to the electronics as per their operating voltage.

**Quality Control Status & Plan at CMS P5**

- QC3 (Gas Leakage Test): This test is performed in the presence of Ar/CO2, in a range of 70-30 to measure the effective gain of the detector.
- QC5 (Gain Uniformity Measurement): This test is performed to measure the gain response uniformly throughout the entire module using the SRS-AVPV2 system.
- QC4a (High Voltage Test): This test ensures the stability of the detector with high voltage applied for 10 min. A total of 21 GE2/1 modules have passed QC4 test.
- QC5 (High Voltage Stability Test): This test ensures the stability of the high voltage and prepares these GE2/1 modules for further electronics connectivity tests (QC7).
- QC6 (Gain Measurement Test): This test is performed to calibrate and validate the front-end electronics.
- QC7 (Electronics Test): This test is performed to identify broken components, fix communication failures, and ensure that the number of bad (dead/disconnected/noisy) channels/strips per ETA partition is ≤ 3.

**Summary**

- Two GE2/1 chambers will be installed in January 2024 in the negative endcap of the CMS experiment.
- ME0 R&D is completed and its mass production will begin in 2022.
- M6 installation is priority, hence GE2/1 project will be delayed until 2027.

**Bibliography**