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Effective gas gain and uniformity measurement test for Triple-GEM detectors for the GE1/1 muon upgrade of the CMS experiment at CERN

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The Gas Electron Multiplier (GEM), an ionizing radiation detector, contains chemically pierced thin copper-coated polyimide layers sandwiched between a drift cathode and a charge collective readout anode immersed in a closed gas mixture. An optimized electric potential is applied between the electrodes to achieve amplified signals in the readout when ionized electrons are released from the drift. This technology is utilized in the muon system upgrade of the Compact Muon Solenoid (CMS) experiment at the Large Hadron Collider (LHC) to achieve high performance, precision tracking, fast triggering, and the missing redundancy in the high-η region. Altogether, there are 144 triple-GEM chambers installed in both endcaps of the CMS experiment during the second long shutdown (LS2) of the LHC. To validate the chambers for the proposed upgrade, detectors are undergoing several levels of pre- and post-assembly quality control (QC) tests. The effective gas gain measurement test (QC5) is crucial in indicating the chamber's overall uniformity of gas gain. By irradiating the gas-filled GEM chamber using X-rays, secondary electrons are generated, which are then collected as an electronic signal on the readout board. All tested chambers clearly manifest gain variations of less than 30% which is well below the threshold of 37%. Consequently, all the detectors passed the QC5 phase. Depending on the QC5 test results, two chambers with nearly equal gas gain and high uniformity in all sectors are coupled to form a "Superchamber" and are grouped for high-voltage power supply.

Keywords: Gas Electron Multiplier; Muon System; CMS Upgrade; Gas Gain Uniformity

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