Design validation of the CMS Phase-2 Triple-GEM Detectors

Abstract

The High-Luminosity LHC (HL-LHC, or \textit{Phase-2} LHC) will deliver proton-proton collisions at 5-7.5 times the nominal LHC luminosity, with an expected number of 140-200 pp-interactions per bunch crossing (Pile-up or PU). To maintain the performance of muon triggering and reconstruction under high background, the forward part of the Muon spectrometer of the CMS experiment will be upgraded with Gas Electron Multipliers (GEM) and improved Resistive Plate Chambers (\textit{i}RPC) detectors. Particularly challenging is the extension of the pseudo-rapidity of the muon system up to $|\eta < 2.8|$ with a 6-layer station, named ME0, that will be installed at the back of the new high-granular calorimeter (HGCAL) and that will see particle rates up to 150kHz/cm2 and integrate a dose of 250krad by the end of HL-LHC. The challenging radiation environment, together with the necessity to design the system for nearly-zero access for repairs because of its location behind HGCAL. In this contribution we will present the major design changes of the Triple-GEM detectors to adapt them for the harsh radiation environment and the high particle rate. We will summarize the performance of prototype Triple-GEM detectors measured with beams at CERN SPS and under irradiation at the CERN GIF++ irradiation facility. We will present also preliminary results of a 4-layer ME0 stack prototype tested with beams in May 2023 and results of the irradiation campaign at GIF++ in July 2023, with the aim to demonstrate segment reconstruction under an intense background rate up to 150kHz/cm2. We will demonstrate that the ME0 design meets or exceeds all requirements and that the project is ready to start construction in 2024.