High-Precision Tracking and Calibration with a Novel Triple-GEM Detector for the Moller Experiment

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The MOLLER experiment seeks to break new ground in sensitivity for electroweak interactions beyond the Standard Model. It will achieve this by measuring the parity-violating asymmetry (A_{PV}) in electron-electron scattering with unprecedented precision using 11 GeV polarized electron beam at Jefferson Laboratory made possible by funding from the National Science Foundation (NSF) and the Department of Energy (DOE). This abstract focuses on the crucial role of the MOLLER tracking system, specifically its innovative use of Triple-GEM detectors. The Triple-GEM detectors will play a vital role in measuring scattered electron distributions and verifying spectrometer and quartz detector acceptance. The tracking system features 28 Triple-GEM detectors, strategically placed in four layers within each of the seven experiment sectors. These detectors offer high-precision tracking in a high flux environment for scattered electrons, enabling detailed analysis of their trajectories. The system's design incorporates a rotation mechanism for comprehensive azimuthal coverage which requires a novel detector design and its readout system. We describe the layout, detailed mechanical analysis, and the overall assembly technique of such GEM chambers along with the overall performance of the GEM detector under different test conditions.