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Effect of geometrical inhomogeneity on electron and ion transmission of GEM-based detectors: A numerical study

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A Time Projection Chamber (TPC) is an ideal device for three—dimensional tracking, momentum measurement and identification of charged particles. They are being used in many on—going experiments, including ALICE. Owing to the enormous particle multiplicity per event, very specific requirements are made on the performance of the detectors in harsh radiation environments. Different R&D activities are currently concentrated on the adoption of the Gas Electron Multiplier (GEM) as the gas amplification stage of the upgraded version of the ALICE-TPC. For example, to keep distortions due to space-charge at a manageable level, a lower ion feedback in the drift volume is required. Again, for a substantial detector gain, it is important that a large fraction of primary electrons participate in the avalanche process and contribute to the signal generation. Thus, a proper optimization of the detector geometry, field configuration and gas mixtures are required to have a higher electron transparency and lower ion backflow. The manufacturing tolerances, defects, asperities on the material surface, normally arising out of machining and handling processes, are likely to cause distortions in the local field. For example, the results of scanning electron microscope (SEM) analysis give the evidence of the widening of GEM holes, as well as the formation of the non—conductive layer on the copper near the hole edge. Depending on their shape and size amplitude, these imperfections can be responsible for generating local discharges and related fluctuations, which can ultimately affect the performance of the detector. Detailed studies on the effects of such structural inhomogeneity on the performance of GEMs is crucial. In the present work, a numerical study simulation work has been carried out to investigate the role of geometrical inhomogeneity and surface asperities on the electron transmission and ion backflow of GEM-based detectors. Ideally perfect, as well as single GEM detector with such imperfections have been considered here in order to achieve a comprehensive understanding. Here, we plan to present demonstrate and discuss our detailed numerical results in detail and will try to make an attempt to relate the above studies in the context of the high luminosity experiments, in particular, the ALICE upgrade scenario.

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