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GEM upgrade of the ALICE TPC

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The ALICE (A Large Ion Collider Experiment at CERN) collaboration plans an upgrade of the detector during the second long shutdown of the LHC, where the interaction rate will be increased to 50 kHz for Pb-Pb collisions. This demands an operation in an ungated continuous mode of the Time Projection Chamber (TPC). Therefore, a gating grid can not be used to block the ion back-flow (IBF) to the drift volume. Gas Electron Multipliers (GEM) offer an intrinsic suppression of ions although not on the same level as a gating grid. In order to keep the distortions due to space charge on a manageable level, an IBF of 5 to 10 back drifting ions per incoming electron is required. To measure the IBF several gas detectors with a GEM amplication system have been built and set up. In order to arrive at the target IBF, different TPC gases such as Ar/CO2 (90/10), Ne/CO2 (90/10) and Ne/CO2/N2 (90/10/5) are compared. In our studies a high impact of the incident X-ray rate as well as the direction on the IBF has been observed suggesting a large influence of space charge on the IBF. To clarify this, systematic measurements over a wide range of different charge densities has been measured. In parallel detailed simulations using ANSYS and Garfield have been performed to complement the measurements and find the optimal set of parameters. Different hole geometries leading to different optical transparencies and their impact on the ion collection as well as the usage of a fourth GEM has been simulated to further reduce the ion backflow. A first prototype of an ALICE Inner Read-Out Chamber (IROC) was equipped with three large GEM foils as an amplication stage to demonstrate that the requirements both in detector performance as well as the stability of operation can be reached. The dE/dx resolution of the prototype was measured at the CERN PS and compared to the resolution of the MWPC IROC. Stability under LHC conditions has been evaluated during the ALICE p-Pb beamtime with the prototype mounted close to the interaction point. Preliminary results as well as the further R&D program will be presented.

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