Study of ion backflow with 2GEMs + MICROMEGAS for the ALICE-TPC upgrade

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ALICE is a dedicated experiment to study Quark Gluon Plasma (QGP), a hot and dense Quantum chromodynamics (QCD) medium, via heavy ion collisions at LHC. The ALICE Time Projection Chamber (ALICE-TPC),[1)] which is the main device in the central barrel for tracking and particle identification of charged particles, consists of a 90 m^3 cylinder filled with $Ne/CO_2/N_2$ (90/10/5).

Secondary ions generated in an electron-avalanche process in the TPC return to the drift space, known as "Ion Backflow (IBF)." Because IBF distorts the electric field in the drift space, its reduction is essential to achieve good performance of the TPC. A gating grid system is widely employed to reduce IBF; however, it limits the data acquisition rate to the order of kilohertz. The rate of heavy-ion collisions at the LHC will be 50 kHz from 2019. The ALICE-TPC will be upgraded to read out the data of Pb-Pb collisions continuously, which requires IBF and energy resolution for ^{55}Fe to be less than 1.0% and 12%, respectively, at a gain of 2000 for Ne-based gas mixtures.[2)]

The performance of quadruple GEM stacks as a readout chamber is being investigated for this upgrade. In addition, investigations with 2GEMs + MICROMEGAS are being carried out. The MICRO-MEsh-GAeous Structure (MICROMEGAS)[3)] has a micromesh $\sim$ 100 μm above a readout. Electrons are multiplied through application of a potential difference between the mesh and the readout (ΔV_{MM}). Secondary ions are absorbed efficiently on the mesh when the electric field above the mesh is considerably smaller (by a factor of 100) than that below the mesh.

A schematic of the measurement setup with 2GEMs + MICROMEGAS is shown in Fig. 1. Our MICROMEGAS has a 400 LPI (Lines Per Inch) mesh located 128 μm above 120 readout pads (8×10 mm^2) and the current from all the readout pads is summed up. Two 50 μm-thick GEMs are placed above MICROMEGAS. IBF is defined as I_c/I_a, where I_c and I_a are the current at the cathode plane and that at the anode pads, respectively. Gain is calculated as $I_a/(N_{\mathrm{seed}} \times R \times e)$, where N_{seed}, R, and e are the number of seed electrons for ^{55}Fe in Ne gas, the rate of X-ray from ^{55}Fe, and the charge of an electron, respectively.

The correlation between energy resolution and IBF for Ne/CO_2 (90/10) and $Ne/CO_2/N_2$ (90/10/5) with different voltage setups is shown in Fig. 2. Different measurements are indicated by different markers; for example, the GEM1-MM scan represents the points corresponding to variations of both ΔV_{GEM1} and ΔV_{MM} to maintain the gain of 2000. It shows that certain points meet the requirement for Ne/CO_2 (90/10) and IBF is less than 0.5% at an energy resolution of $\sim$ 12% for $Ne/CO_2/N_2$ (90/10/5). Additional nitrogen leads to better IBF because a larger potential difference is required to achieve the gain of 2000 and subsequently the field ratio of MICROMEGAS decreases. The evaluation for $Ne/CO_2/N_2$ (90/10/5) at a better energy resolution (and worse IBF) is in progress. Eventually, the performance of a MICROMEGAS that has a 780 LPI micromesh and 90 μm gap will be evaluated.

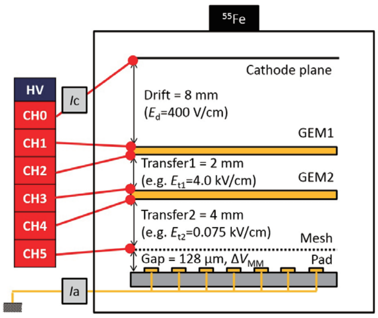

Fig. 1. A schematic of measurement setup with 2GEMs + MICROMEGAS.

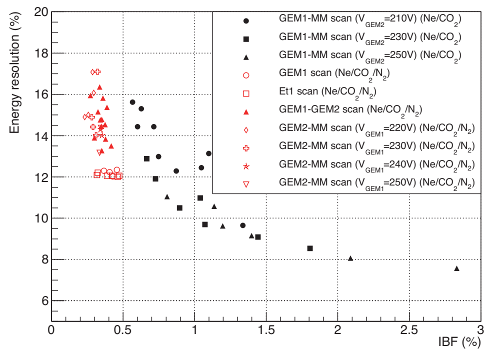

Fig. 2. Energy resolution as a function of IBF for Ne/CO_2 (black) and $Ne/CO_2/N_2$ (red).

References

1) CERN-LHCC-2000-001 (2000).
2) CERN-LHCC-2013-020 (2013).
3) Y. Giomataris et al.: Nucl. Instr. and Meth. **A 376**, 29 (1996).

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