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Numerical study of electrostatic field distortion on LPTPC end-plates based on bulk Micromegas modules

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A time projection chamber (TPC) is envisaged just beyond the vertex detector of the proposed linear collider. Because of the high flux environment, micro-pattern gaseous detectors (MPGD) have been proposed to build the end-plates of the TPC. Because of the large area coverage and their geometry, the end-plates are expected to be made of a number of MPGD modules. During experiments using the large prototype TPC (LPTPC), reduced signal sensitivity have been observed at the boundary of these modules. Electrostatic field distortion near the module boundaries has been considered to be the major reason behind these observations. In the present work, we will explore this hypothesis for endplates based on bulk Micromegas modules.

3D electrostatic field calculations have been carried out for two geometries representing the end-plates and distortion of the electrostatic field near the module boundaries has been analyzed. The simpler geometry has only two modules, while the more representative geometry has three staggered modules as in a real end-plate. The effect of application of 1T magnetic field has been simulated, in addition to the cases where there is no magnetic field. The drift and diffusion of electrons originating from tracks at different locations in the drift volume have been followed. Estimates of the residuals have been made by computing the difference among the starting and ending points of the electrons. Intrinsic position resolution of the device has been estimated without taking into account a pad structure and anode resistivity.

Significant electrostatic field distortion has been observed at the boundaries which is consistent with the module geometry. The resulting drift lines clearly show that areas close to the edge of the modules will have less number of electrons than those away from the edges. Residuals estimated close to the boundary are found to increase substantially and follow the "S"pattern observed in the experiments. Significant reduction in residuals is observed in general, when magnetic field is applied. The E×B effect is found to play an important role close to the boundaries since the directions of these two fields are no longer parallel due to the distortion in the electric field.

The simulated estimates follow trends very similar to the experimental results obtained using bulk Micromegas modules. Similar estimates for GEM-based TPC end-plates were made earlier. Although overall features of the electrostatic field, electron drift and diffusion are the same, no direct comparison can be made since the geometries of the modules and the approximations involved are of a different nature.

In future, the simulations will be made more realistic by making the end-plate geometry closer to the real one and making the anode resistive. In addition, possible suitable design modifications will be investigated, use of which may lead to less edge effects than that in the present scheme of things.

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