# Numerical Study of beam induced space charge effect in a small TPC with hydrodynamic model

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**Abstract:**

In the realm of low-energy nuclear physics experiments, Active Target Time Projection Chambers (AT-TPC) proves advantageous for studying nuclear reaction kinematics. Specifically, it allows investigation into phenomena like the alpha cluster decay of $^{12}C$ by precisely tracking the reaction products produced within the active gas medium of the TPC. The tracking capability of the TPC critically depends on the homogeneity of the electric field applied across its drift medium. However, this homogeneity is significantly influenced by the space charge generated by low-energy projectiles and reaction products within the active gas medium through the ionization process. In our research, we developed a mathematical model based on a hydrodynamic approach to simulate the space charge effect caused by the alpha beam on the TPC's performance. We achieved this using a commercial Finite Element Method (FEM) package available in COMSOL Multiphysics. The primary ionization resulting from alpha particles was simulated using Geant4, while the electron transport parameters for the active gas were obtained from MAGBOLTZ. Our findings include the impact of space charge on the applied electric field of the TPC and the angular and spatial resolution of scattered tracks. These results were obtained for beam currents ranging from 2.5 pA to 25 pA. Additionally, we employed the same model to simulate the temporal evolution of scattered tracks for $^{4}He$ and $^{12}C$ in active gas mediums, specifically $Ar+CO_2$ with volumetric ratios of 90:10. We also explored various readout geometries for the TPC to determine the optimal pad dimensions and the number of pixels at the TPC end cap necessary for resolving scattered particle tracks accurately. Furthermore, we developed a tracking algorithm capable of distinguishing between multiple tracks associated with scattered events and the $^{12}C$ breakup. Based on our simulation results, we are currently in the process of designing a 64-channel Micromegas-based prototype TPC.