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Numerical Studies on Primary Ionization in TPC

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The Active-Target Time Project Chamber (AT-TPC) is used in the field of low-energy nuclear physics to study nuclear reactions by tracking the reaction products. The primary ionization produced by charged products along their track in the active gas volume of the TPC can be utilized for track reconstruction. The primary electrons are multiplied in the applied electric field and collected over a 2D array of electrode elements placed at one end of the device for producing 2D position information. The third co-ordinate information can be obtained from the measurement of time of flight of the electrons to reach the collecting electrode. The use of the TPC gas volume simultaneously as a reaction target as well as a tracking medium of ions emitted from the reaction turns out advantageous to conventional detector arrays, especially in probing inverse kinematics where a heavy-ion beam collides with a light-ion target. One of the important factors that govern the tracking capability of the TPC is the homogeneity of the electric field prevailing in the drift volume of the device which is crucially dependent upon the design of the field cage and electrode configuration used in the device. The other factor which can distort the field is space charge effect. It can be substantial in case of low-energy particles which deposit their full energy in the medium and produce a large amount of ionization. Here, we report the spatial information of the primary space charges produced by alpha particles in a TPC filled with Ar:CO2 (70:30) at different gas pressures using Geant4 [1] and Heed [2] simulation packages. We have used Photoabsorption and Ionization Physics Lists in Geant4 for the simulation and compared the results with that of the Heed. The same simulation has been carried out using cosmic muons at atmospheric pressure for validation. These results can be used for finding the distortion of the electric field due to the space charge in the drift region of the TPC which can be helpful for designing an AT-TPC for low-energy nuclear reaction experiments.

Reference

[1] S. Agostinelli et al. [GEANT4], GEANT4–a simulation toolkit, Nucl. Instrum. Meth. A 506, 250-303 (2003). https://geant4.web.cern.ch/
[2] I.B. Smirnov; “Interactions of particles with gases”; online at http://cern.ch/heed

What is your experiment?

Particle Tracking

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