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Influence of boundary thermal fluctuations on event coordinate determination in a Time-projection chamber

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We performed numerical simulations to assess the impact of thermal fluctuations on coordinate determination accuracy in a Time Projection Chamber (TPC) detector filled with an Ar (90%) and CH_4 (10%) gas mixture. Utilizing the Navier-Stokes and heat transfer equations, we modeled convective heat exchange and its effect on electron drift. Our methodology included simulating the temperature field, calculating local electron drift velocities in response to thermal fluctuations, and numerically integrating electron trajectories. The results indicate that thermal fluctuations with an amplitude of 1 K can cause coordinate errors on the order of tens of microns, while fluctuations of 2.5 K can lead to errors of hundreds of microns. Although switching to a non-flammable Ar (80%) and CO_2 (20%) gas mixture addresses safety concerns, it increases coordinate determination errors. Our simulations, covering thermal fluctuations from 0.1 to 2.5 K, establish threshold values for temperature stability necessary to minimize measurement inaccuracies.

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