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Multi-purpose Time Projection Chamber (MTPC) Signal Simulation Method and Experimental Verification

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The Multi-purpose Time Projection Chamber (MTPC) prototype has been successfully developed and commissioned at the CSNS Back-n white neutron beamline. As a novel detection system, its primary design objective focuses on precise measurement of light charged particle emissions in nuclear reactions, while maintaining versatile capabilities for multiple applications including fission cross-section determination, beam profile characterization, and neutron imaging experiments. Our research team has conducted a series of beam tests with the MTPC prototype, obtaining preliminary yet significant experimental results. These initial findings demonstrate the detector's feasibility for conducting neutron-induced nuclear reaction measurements with satisfactory resolution. To support the development of advanced data analysis algorithms, we have established a comprehensive simulation and analysis framework that integrates the operational principles of MTPC with established open-source tools including Geant4 for particle transport simulations, Garfield++ for drift field calculations, and ROOT for data processing. This integrated framework enables parametric studies through systematic variation of experimental conditions, generating simulation predictions that show strong agreement with actual measurement data. The synergy between experimental validation and computational modeling provides valuable insights for detector optimization and experimental design refinement, particularly in understanding complex signal formation processes within the time projection chamber.

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