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Charge-exchange straggling and correlated A–E reconstruction for heavy-ion isotope identification in silicon detectors

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Isotope identification in multilayer silicon detectors requires joint reconstruction of mass number A and energy E . Different A – E pairs may yield nearly identical mean profiles, while deposited-energy fluctuations limit isotope separation. For partially stripped ions, stochastic electron capture and loss alter the charge state and add charge-exchange fluctuations, requiring explicit modeling.

We developed a Geant4 framework combining GLOBAL capture/loss cross sections, Mott-corrected δ -electron production, and secondary-electron transport in general geometries. To our knowledge, no existing code provides this combination at the level of detector energy deposition. MOCADI models charge-state evolution and projectile energy loss in beam lines, but not deposited energy. We also developed an N -dimensional likelihood reconstruction of A and E using total deposition and correlated layer profiles. Beyond xenon, simulations predict non-Gaussian, sometimes multi-peaked ΔE distributions in thin silicon, where charge-exchange mean free paths can match typical 300–1000 μm layer thicknesses while ions remain partially stripped.

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