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Reconstruction of Complex Particle Trajectories in the SuperNEMO Detector

The SuperNEMO experiment is designed to search for neutrinoless double beta decay, a rare process whose discovery would confirm the Majorana nature of neutrinos and provide insight into their absolute mass scale. Unlike most detectors focused only on calorimetry, SuperNEMO uniquely combines energy measurement with a tracking system composed of 2034 Geiger-mode drift cells, enabling detailed topological reconstruction of charged particle trajectories. This dual approach enhances background rejection and allows for the study of decay kinematics, such as angular distributions and single-electron energy spectra.

This work presents a novel algorithm for particle track reconstruction tailored to SuperNEMO's tracking detector. Building on a previously developed method based on the Legendre transform, we introduce an improved reconstruction approach based on a maximum likelihood method that incorporates a tunable model of the detector's response to identify the most probable particle trajectories. This method evaluates how well candidate tracks explain the observed data, allowing for precise 3D reconstruction even with limited information.

What sets this approach apart is the unique nature of the tracking data in SuperNEMO's low-activity environment, where events typically contain only one or two tracks. Each Geiger cell provides a ring-shaped constraint on the particle's position, rather than a precise point, making trajectory reconstruction a non-trivial task. With only a few such measurements per track, the algorithm must combine this limited information as effectively as possible to accurately recover the full 3D path. To handle complex trajectories affected by scattering, the algorithm employs a polyline trajectory model, reconstructing paths as sequences of linear segments. These are identified using recursive clustering, ordered and refined through geometrical criteria, and assembled into complete trajectories. The result is a robust and accurate reconstruction method, capable of resolving both simple and complex topologies. These improvements represent a step toward achieving the experiment's ultra-low background goals and will contribute to the sensitivity of the upcoming physics run.

Secondary track

T09 - Beyond the Standard Model

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