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Machine Learning for Enhanced $0\nu\beta\beta$ Searches in LEGEND

The LEGEND experiment aims to push the sensitivity of neutrinoless double beta decay ($0\nu\beta\beta$) searches by minimizing backgrounds while leveraging the exceptional energy resolution of high-purity germanium (HPGe) detectors. A key challenge is improving background rejection, particularly through pulse shape discrimination (PSD). Machine learning provides powerful tools to enhance this effort.
We present a transformer-based waveform classification framework designed to distinguish signal-like from background-like events with high accuracy. While simulations play a crucial role in training such models, they inevitably differ from real experimental data, as no simulation can capture every subtle detail of a detector's response. To mitigate potential biases arising from these differences, we integrate Domain Adversarial Neural Networks (DANN), which improve generalization by aligning simulated and real waveforms in a shared feature space.
Beyond waveform classification, we employ semi-supervised data cleaning with Affinity Propagation to cluster waveform structures and train an SVM-based classifier, adapting to evolving detector conditions. These techniques not only strengthen LEGEND's $0\nu\beta\beta$ search but also have broad applications in dark matter detection, neutrino oscillation experiments, and rare event searches at colliders, where precise event classification and background suppression are critical.
This talk will provide insight into how AI-driven methods are reshaping event selection in fundamental physics, offering a pathway toward next-generation discovery.

AI keywords

Transformers; Domain Adaptation; Simulation-Based Inference; Semi-Supervised Learning

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Track Classification: Patterns & Anomalies