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Advanced Tracking Analysis in Space Experiments with Graph Neural Networks

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The integration of advanced Artificial Intelligence (AI) techniques into astroparticle experiments represents a transformative step for data analysis and experimental design. With the increasing complexity of space missions, the adoption of AI technologies becomes crucial for optimizing performance and achieving robust scientific outcomes.

This study focuses on the development of innovative AI-driven algorithms for track reconstruction, leveraging the potential of Graph Neural Networks (GNNs). GNNs, as a branch of geometric deep learning, are particularly well-suited for modeling the intrinsic structure of tracking detectors, where nodes correspond to energy deposits ('hits') and edges to their potential connections. These networks enable the development of targeted approaches for tasks such as node classification, link prediction, and graph classification, addressing the specific challenges of space-based experiments.

A critical obstacle in tracking systems for space experiments is the high-noise environment. This noise, characterized by hits originating from backscattering particles from the calorimeter and by electronic noise, significantly complicates the accurate identification of the primary particle trajectory.

To overcome this challenge, we propose an innovative GNN-based approach for node-level classification, specifically designed to distinguish signal hits (belonging to the primary particle track) from noise hits (including backscattering and electronic noise).

This algorithm effectively identifies the hits constituting the primary track within a noisy environment, thus facilitating the subsequent accurate retrieval of the particle's track parameters.

We will present updates on our work, aimed at demonstrating the potential of this GNN-based tracking algorithm applied to simulated HERD data.

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