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Advanced Tracking Analysis in Space Experiments with Graph Neural Networks

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The integration of advanced artificial intelligence techniques into astroparticle experiments marks a transformative step in data analysis and experimental design. As space missions grow increasingly complex, the adoption of AI technologies becomes critical to optimizing performance and achieving robust scientific outcomes.

This study focuses on the development of innovative AI-driven algorithms for tracking purposes, leveraging the power of Graph Neural Networks (GNNs). GNNs, a subset of geometric deep learning, are well-suited for exploiting the inherent graph structure of tracking systems, where nodes correspond to energy deposits (hits) and edges represent their interconnections. These networks enable a range of tasks, including node classification, link prediction, and graph classification, tailored to the specific challenges of space-based experiments.

A key obstacle in tracking systems for space experiments is the high-noise environment, characterized by backscattering tracks from calorimeter, which complicate the accurate identification of the primary particle trajectory. To overcome this, we propose a novel GNN-based approach for node-level classification, designed to distinguish noise hits, which include backscattering hits and electronic noise, from signal hits and accurately reconstruct particle tracks

The algorithm recognizes the primary hits among the noises one and allows to easily retrieve the track parameters. We will present the algorithm's architecture and the training strategy, which includes parallelization across multiple GPUs to reduce both time and memory consumption and the preliminary results achieved.

By addressing these challenges, our work aims to improve the accuracy and reliability of data interpretation in astroparticle physics, paving the way for more precise and insightful discoveries through the application of cutting-edge AI methodologies.

Primary author: Dr CUNA, Federica (Istituto Nazionale di Fisica Nucleare- Sezione di Bari)

Co-authors: Dr GARGANO, Fabio (INFN-Bari); BOSSA, Maria (Istituto Nazionale di Fisica Nucleare); MAZZIOTTA, Mario Nicola (Istituto Nazionale di Fisica Nucleare)

Presenter: Dr CUNA, Federica (Istituto Nazionale di Fisica Nucleare- Sezione di Bari)

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