



Contribution ID: 43

Type: Oral

## Machine Learning techniques for Cosmic Rays Physics analysis and simulations

Friday 16 May 2025 12:40 (25 minutes)

The growing demand for GPUs has led to the rapid development of machine learning research techniques in all areas of science, including High Energy Physics.

We present a study focused on the classification task of simulated electrons and protons as they would be detected by the High Energy Cosmic-Radiation Detection (HERD) Facility. HERD is a high-energy cosmic-ray detector based on a deep three-dimensional electromagnetic calorimeter, proposed to be installed on the Chinese Space Station. The main scientific objectives of HERD include detecting dark matter particles, studying cosmic ray composition, and observing high-energy gamma rays. Our classification task is based on data from Monte Carlo simulations of proton and electron particle showers in the HERD electromagnetic calorimeter, with energies ranging from 100 GeV to 20 TeV. We tackle the classification task with a Deep Convolutional Neural Network that can reach a background rejection of the order of  $10^{-4}$ - $10^{-5}$ . Given the size of our dataset, a few million events, the Neural Network has reached the highest separation power available. A systematic study of performance vs. complexity of the network is presented.

Machine learning finds applications also in the anomaly detection field. Therefore, we can think of using it also to detect possible rare heavy-antimatter nuclei in CRs. In this spirit, we present an anomaly detection algorithm to search for anti-helium in the events collected by the Alpha Magnetic Spectrometer (AMS-02).

Machine learning can be used not only for data analysis in High Energy Physics but also to model complex physical processes, enhancing the precision and velocity of data simulations. In this view, we present a sketch idea of how Physics-Informed Neural Networks can be employed to study the diffusion process of Cosmic Rays.

### Eligibility for "Best presentation for young researcher" or "Best poster for young researcher" prize

Yes

**Author:** TABARRONI, Luca (INFN e Universita Roma Tor Vergata (IT))

**Co-authors:** BRUGNONI, Claudio (Universita e INFN, Perugia (IT)); FORMATO, Valerio (INFN)

**Presenter:** TABARRONI, Luca (INFN e Universita Roma Tor Vergata (IT))

**Session Classification:** R&D of novel approaches and instruments