Contribution ID : **74** Type : **Talk**

Classification of Electrons-Positrons from Cosmic Proton Background with AMS-02 TRD using Deep Learning

AMS-02 has recorded over 250 billion cosmic-ray events aboard the ISS since 2011. Its Transition Radiation Detector (TRD) separates electrons and positrons from the far more abundant cosmic-ray proton background. The conventional likelihood estimator for this task does not fully capture layer-to-layer dependencies, nor the effect of secondary particles and transition-radiation absorption across consecutive TRD layers. We present a Transformer-based classifier that treats TRD hits as a sequence, using self-attention to learn inter-layer correlations and infer global context across all layers. Electron and proton samples were labeled using the AMS-02 ECAL likelihood estimator and log(|Reconstructed Energy/Rigidity|) cuts on positive and negative rigidity samples, with Tracker and Time-of-Flight charge cuts, then split 60/20/20 into training, validation, and test sets, with a TRD-based electron-helium likelihood cut removing helium contamination from the validation and test sets. We quantify performance with a background rejection metric, defined as total proton number over false proton number on the test data. At 90% electron efficiency, this rises from ~3000 to ~5300 (+77%) in the 10.32-20.04 GeV bin (2.9M protons / 249k electrons), ~2400 to ~3600 (+50%) in 20.04-30.21 GeV (1.0M / 94.6k), and ~1500 to ~2100 (+40%) in 30.21-49.33 GeV (590k / 70k). This improves cosmic-ray positron-fraction purity and shows the approach can be transferred to other layered detectors like the TRD.

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Session Classification : Machine Learning in Astrophysics

Track Classification : Machine Learning in Physics