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Electron and Proton Classification with AMS ECAL Using Convolutional Vision Transformers and Domain Adaptation - Poster

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Alpha Magnetic Spectrometer (AMS-02) is a precision high-energy cosmic-ray experiment on the ISS operating since 2011 and has collected more than 228 billion particles. Among them, positrons are important to understand the particle nature of dark matter. Separating the positrons from cosmic background protons is challenging above 1 TeV. Therefore, we use state-of-the-art convolutional and transformer models, CoAtNet and Convolutional Vision Transformer (CvT), that employ the shower signals from the ECAL to classify the electrons/positrons in the dominant cosmic proton background. We created sets of electrons, positrons, and protons events from the ISS data and Monte Carlo Simulation in the energy range between 0.2-2 TeV by applying various data quality cuts on reconstructed variables obtained from the subdetectors. Initially, since ECAL showers are not tunned in the AMS MC, our MC trained models show a lower proton rejection on the ISS data. To accommodate the difference between the training and test domain distributions, we implemented domain adaptation with the CoAtNet and CvT to mitigate this dataset bias/domain shift. We also trained domain adaptation with a set of well-reconstructed 1 electron charge ISS events without electron/proton labels at TeV energy order as the target dataset. We evaluated the models between 1-2 TeV energy using ISS and MC events with the proton rejection vs. electron efficiency and proton rejection vs. energy at near 90% electron efficiency plots. We performed experiments using various training and validation dataset combinations and other hyperparameters with the CvT and CoAtNet. Among them, the best models are obtained with the 1-2TeV MC events as training data and half of the labeled 1-2 TeV ISS events as validation data. Using domain adaptation with the CoAtNet, we obtained a maximum proton rejection at 88% electron efficiency on the ISS data. We also rejected all of the MC protons at higher than 99.8% electron efficiency with both CvT and CoAtNet. At 90% electron efficiency, the proton rejection power of the CvT and CoAtNet is 5 and 7 times higher than the proton rejection power of the AMS's Boosted Decision Tree and ECAL Likelihood Estimator for MC events in the 1-2 TeV range.

Would you like to be considered for an oral presentation?

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