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IceTop gamma-hadron separation and angular error estimation using machine learning techniques

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The IceCube Neutrino Observatory, located at the South Pole, combines two detector systems to study high-energy cosmic-ray events. The surface array, called IceTop, indirectly detects cosmic rays within the 100 TeV to EeV range through ice-Cherenkov tanks, providing reconstructed observables such as primary energy and direction. The in-ice optical array detects high-energy muonic components of air showers. Together, these detectors could enhance particle-type discrimination, though at the cost of a narrower field of view for source searches. This work in progress aims to differentiate between photon- and cosmic-ray-induced air showers detected by IceTop. This is done using a Convolutional Neural Network (CNN) that processes time, charge, and lateral distance distributions. The resulting classification results are then compared against previous methods incorporating data from both detectors. Furthermore, to support gamma-ray source searches, we apply a boosted decision tree for estimating directional reconstruction errors. These tree-based models excel in regression and classification tasks, where we use numerous reconstruction fit parameters as inputs to obtain the angular error on an event-by-event basis.

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Primary author: VERGARA CARRASCO, Sebastian

Presenter: VERGARA CARRASCO, Sebastian

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