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Machine Learning Pipeline for Particle Classification for the LAGO Water Cherenkov Detectors

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One of LAGO's primary objectives is to measure the secondary particle flux generated by Galactic Cosmic Rays (GCRs) as they impinge the Earth's atmosphere, using its extensive network of Water Cherenkov Detectors (WCDs). We know that this flux predominantly includes electromagnetic, muonic, and hadronic components. While the resulting charge histograms provide valuable insights into the flux of primary cosmic rays and their key characteristics, they fall short in effectively differentiating the contributions from the various secondary particles.

In this work, we present a Machine Learning (ML) pipeline designed to process WCD data—both real and simulated—and classify these secondary particles, in a High Performance Computing (HPC) environment. This pipeline involves preprocessing, feature engineering and selection, a machine learning stage, and a final stage to aggregate the results. The primary algorithm used is an unsupervised hierarchical density-based clustering method called OPTICS (Ordering Points to Identify the Clustering Structure), which finds similarity patterns within the data to group and effectively classify the secondary particles. Here, OPTICS is run many times in parallel in the HPC environment to produce a set of results that are aggregated in the final stage to show the algorithm's robustness in terms of accuracy and precision.

Our results demonstrate that this enhanced methodology accurately identifies originating particles with a high degree of confidence on a single-pulse basis. These promising outcomes suggest the potential for implementing ML-based models across LAGO's distributed detection network and in other astroparticle observatories, enabling semi-automated, onboard, and real-time data analysis.

Charla presencial o virtual

Virtual

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