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Hadron Identification Prospects With Granular Calorimeters

In this work we consider the problem of determining the identity of hadrons at high energies based on the topology of their energy depositions in dense matter, along with the time of the interactions. Using GEANT4 simulations of a homogeneous lead tungstate calorimeter with high transverse and longitudinal segmentation, we investigated the discrimination of protons, positive pions, and positive kaons at 100 GeV. The analysis focuses on the impact of calorimeter granularity by progressively merging detector cells and extracting features like energy deposition patterns andtiming information. Two machine learning approaches, XGBoost and fully connected deep neural networks, were employed to assess the classification performance across particle pairs. The results indicate that fine segmentation improves particle discrimination, with higher granularity yielding more detailed characterization of energy showers. Additionally, the results highlight the importance of shower radius, energy fractions, and timing variables in distinguishing particle types. The XGBoost model demonstrated computational efficiency and interpretability advantages over deep learning for tabular data structures, while achieving similar classification performance. This motivates further work required to combine high- and low-level feature analysis, e.g., using convolutional and graph-based neural networks, and extending the study to a broader range of particle energies and types.

AI keywords

XGBoost, Boosted Decision Trees, Deep Neural Network, Classification Task

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Track Classification: Simulations & Generative Models