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Gamma Hadron Separation using Machine Learning Techniques in SWGO D8 Array

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This work presents a study of gamma–hadron separation for the SWGO experiment using machine learning techniques applied to the D8 baseline array design considered in this first performance optimization study. Using the SWGO D8 simulation dataset, we select events with reconstructed zenith angles between 0 and 30° and logarithmic energy bins spanning log10(E/GeV)=2.5–5.0, and partition the array into three, later five, core-distance zones to investigate the radial dependence of classifier performance. From the reconstructed air-shower observables we construct a set of discrimination variables, including compactness, PINC, R_max, the total number of photoelectrons, and several timing quantiles, and systematically compare different subsets. Gradient-boosted decision-tree algorithms (CatBoost, XGBoost, LightGBM) and a VotingClassifier ensemble are trained and validated with a 60/20/20 split, with dedicated checks to control robustness and overfitting. The best-performing boosted models yield an improved true positive rate for gamma-ray events at high energies relative to the current SWGO reference analysis, while the level of hadronic background rejection indicates further room for optimization. The performance obtained in the outer core-distance zones is comparable to that of the original three-zone configuration, suggesting that including these regions in future analyses could increase the effective area of the observatory.

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