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Feature selection techniques for CR isotope identification with the AMS-02 experiment in space

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Isotopic composition measurements of singly-charged Cosmic Rays (CR) provide essential insights into CR transport in the Galaxy. The Alpha Magnetic Spectrometer (AMS-02) can identify singly-charged isotopes up to about 10 GeV/n. However, their identification presents challenges due to the small abundance of CR deuterons compared to the proton background. In particular, a high accuracy for the velocity measured by the Ring Imaging Cherenkov Detector (RICH) is needed to achieve a good isotopic mass separation over a wide range of energies.
The velocity measurement with the RICH is particularly challenging for Z=1 isotopes due to the low number of photons produced in the Cherenkov rings. This faint signal is easily disrupted by noisy hits leading to a misrecostruction of the particles' ring. Hence, an efficient background reduction process is needed to ensure the quality of the reconstructed Cherenkov rings and provide a correct measurement of the particles' velocity. Machine Learning methods, particularly Boosted Decision Trees, are well suited for this task, but their performance relies on the choice of the features needed for their training phase. While physics-driven feature selection methods based on the knowledge of the detector are often used, Machine Learning algorithms for automated feature selection can provide a helpful alternative that optimises the classification method's performance. We compare five algorithms for selecting the feature samples for RICH background reduction, achieving the best results with the Random Forest method. We also test its performance against the physics-driven selection method, obtaining better results.

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