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A mass-sensitive criterion for SPHERE-3: dependence on atmospheric and hadronic interaction models

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The SPHERE-3 experiment is being developed to study the mass composition of primary cosmic rays using Cherenkov light from extensive air showers reflected from the snow surface. The lateral distribution of this light carries information about the primary mass, but its interpretation depends on the atmospheric profile and the hadronic interaction model used in shower simulations.

We present a physically interpretable mass-sensitive criterion based on ratios of Cherenkov light integrated over radial regions of the reconstructed lateral distribution. A Fisher discriminant combines several radial ratios while retaining their connection to the spatial distribution of light. The approach is studied using simulated proton, nitrogen, and iron showers, with the telescope response included, and evaluated through pairwise mass separation.

Building on this analysis, we outline a comparative study of atmospheric and hadronic interaction models. The planned comparison will examine shifts in the criterion distributions and changes in mass-separation performance under different simulation assumptions. Applying a criterion calibrated with one model to samples generated with another will allow its transferability to be assessed. This study aims to quantify the sensitivity of the criterion to modelling choices and to identify the systematic effects that must be considered when using reflected Cherenkov light to infer cosmic-ray mass composition.

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