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## A combined likelihood to reconstruct the muon lateral distribution function using integrator and binary modes of underground muon detectors

The origin of ultra-high energy cosmic rays remains a significant unsolved question in high-energy astrophysics. One of the key observables for determining their origin is the evolution of mass composition with primary energy. A crucial parameter for inferring mass composition is the muon content of extensive air showers, which are generated when these high-energy particles interact with atmospheric molecules. Dedicated muon detectors have been developed and deployed in cosmic-ray observatories, some operate with two acquisition modes: binary and ADC. In binary mode, the detector functions as a counter, while in ADC mode, the total number of muons is estimated from the total signal using a given calibration. In this study, we develop a likelihood function incorporating measurements from both acquisition modes to reconstruct the muon lateral distribution function. We use the Underground Muon Detectors at the Pierre Auger Observatory as a case study. We compare the new method's performance with that of the ADC and binary mode-based methods.

## Collaboration(s)

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