Contribution ID: **14** Type: **Poster**

Cosmic ray mass composition at the knee using azimuthal fluctuations of air shower particles detected at ground

Tuesday, 18 June 2024 17:21 (3 minutes)

The presence of hadronic sub-showers in vertical extensive air showers produces non-uniformities in the azimuthal distribution of secondary particle densities at ground.
At a fixed distance from the shower axis, these non-uniformities are more pronounced in the case of showers induced by protons compared to those induced by iron nuclei, primarily due to larger fluctuations in the heights of primary interaction points.
In this study, we will demonstrate that these non-uniformities, quantified by the LCm parameter, can be successfully used as a mass discriminator of primary cosmic rays in experiments employing a relatively compact grid of detectors.
Based on the experimental data recorded by the KASCADE experiment, we reconstructed the mass composition of primary cosmic rays in the energy range lg(E/eV) = [15.0 - 16.0] using the LCm discriminator.
The results obtained through this method are in excellent agreement with the results previously obtained by the KASCADE and IceTop experiments based on different observables and techniques.
Considering that this reconstruction method is minimally dependent on the hadronic interaction model considered in the simulation process, we believe that this LCm parameter could be a valuable tool for forthcoming measurements of the LHAASO experiment to enhance our knowledge about the origin and acceleration mechanisms of cosmic rays.
Additionally, we will present various approaches aimed at maximizing the information provided by the non-uniformities of secondary particle densities for the purpose of mass composition studies.

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Session Classification: Flash Talks-2

Track Classification: Galactic and Solar Cosmic Rays