Contribution ID: **898** Type: **Poster**

Investigating double bump air showers with the SKA

Double-bump showers are a rare class of extensive air showers (EAS) predicted by Monte Carlo simulations. They occur when a high-energy secondary particle, the leading particle, travels significantly farther than the rest, creating a distinct double-peaked longitudinal profile. So far, no experiment has been able to directly detect these showers. The unique radio footprint of double-bump showers, characterized by multiple Cherenkov rings, provides a way to reconstruct longitudinal profiles from radio observations. With its dense antenna array and broad frequency range, the Square Kilometer Array (SKA) will be the first experiment capable of detecting these features, offering a new opportunity to probe hadronic interactions and constrain particle cross sections at ultra-high energies.

In our analysis, we simulate the EAS using CORSIKA with the CoREAS plugin for radio.
We developed a new method based on the Akaike information criterion to identify double bump showers in simulations by analyzing their longitudinal profiles.
Then we investigate the prevalence of these double bump showers across different cosmic ray primary particles and various hadronic interaction models.
We create a skeleton of the EAS which consists of all the particles with at least 1% of the primary energy, allowing us to confirm the leading particle hypophysis and and track shower development following these particles. This will enable us to relate the attributes of the leading particle to measurable parameters.
Depending on the exact shower properties, the radio footprint of a double bump shower can create a complex interference pattern, consisting of multiple rings. From this information, the longitudinal profiles can be extracted.
SKA due to its dense antenna array and frequency range will be the first experiment able to observe these double bump showers in detail.

Collaboration(s)

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Session Classification: PO-1

Track Classification: Cosmic-Ray Indirect