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Determination of cosmic-ray primary mass on an event-by-event basis using radio detection

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Traditionally, the depth of maximum shower development $X_{\rm max}$ has been used as a surrogate observable for composition. Most current methods to reconstruct $X_{\rm max}$ from the information collected with arrays of antennas are based on a method developed in the context of the LOFAR experiment. These methods use comparisons between the measured electric fields with simulations of proton and iron initiated showers, allowing one to infer the $X_{\rm max}$ of the detected event. In this work we show that this type of $X_{\rm max}$ reconstructions lose accuracy in the case of showers with large zenith angles.

We also investigate the differences in the radio footprint that arise due to different primary compositions, leading to a new methodology to discriminate between light and heavy ultra-high energy cosmic-ray primaries on an event-by-event basis using information from the radio detection of extensive air showers at MHz frequencies. This method is also based on comparisons between detected radio signals and Monte Carlo simulations for multiple primary cosmic ray compositions. But, unlike other methods that first reconstruct $X_{\rm max}$ to relate it to the nature of the primaries, we instead try to infer the cosmic-ray composition directly. We show that a large discrimination efficiency could in principle be reached for zenith angles above $\theta \simeq 65^{\circ}$, even when some of the typical uncertainties in radio detection are taken into account.

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