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Expected performance of interferometric air-shower measurements with radio antennas

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Interferometric measurements of the radio emission of extensive air showers allow reconstructing cosmic-ray properties. A recent simulation study with an idealised detector promised measurements of the depth of the shower maximum X_{max} with an accuracy better than 10 g cm^{-2}.
In this contribution, we evaluate the potential of interferometric X_{max} measurements of (simulated) inclined air showers with realistically dimensioned, sparse antenna arrays. We account for imperfect time synchronisation between individual antennas and study its inter-dependency with the antenna density in detail. We find a strong correlation between the antenna multiplicity (per event) and the maximum acceptable inaccuracy in the time synchronisation of individual antennas. From this result, prerequisites for the design of antenna arrays for the application of interferometric measurements can be concluded. For data recorded with a time synchronisation accurate to 1 ns within the commonly used frequency band of 30 to 80 MHz, an antenna multiplicity of ≥ 50 is needed to achieve an X_{max} reconstruction with an accuracy of 20 g cm^{-2}. This multiplicity is achieved measuring inclined air showers with zenith angles $\theta \geq 77.5^{\circ}$ with 1 km spaced antenna arrays, while vertical air showers with zenith angles $\theta \leq 40^{\circ}$ require an antenna spacing below 100 m. Furthermore, we find no improvement in X_{max} resolution applying the interferometric reconstruction to measurements at higher frequencies, i.e., up to several hundred MHz.

Keywords

Radio Detection, Interferometry, Extensive Air Showers, Ultra-high-energy cosmic rays, Reconstruction

Collaboration

other Collaboration

Subcategory

Experimental Methods & Instrumentation

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