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Event reconstruction with the Radio detector of the Pierre Auger Observatory

The surface detector of the Pierre Auger Observatory has recently been upgraded with the addition of radio antennas, forming the Radio Detector (RD). This
contribution outlines the standard methods for reconstructing extensive air showers using the RD, along with recent developments.

The reconstruction pipeline is based on a robust understanding of the detector itself. The entire instrument, including the antenna pattern and analog chain, has been meticulously characterized within the “Offline” software framework, based on measurements in the laboratory as well as in the field.
To ensure data integrity, stations identified as unreliable through monitoring are excluded before event reconstruction. Absolute calibration is achieved at the 5% level by analysing the diffuse galactic radio emission. Next, the electric field that induced voltages in the antenna is calculated by “unfolding” the antenna response pattern. Key observables, such as the energy fluence (the energy deposited in the ground per unit area) and the arrival time of the pulse, are then determined. With these quantities, shower parameters can be reconstructed with very good accuracy in two χ^2-minimization fits: one to determine the shower’s arrival direction via a spherical wavefront fit (predicted within 0.2°), and the other to estimate the distance to the shower maximum and the electromagnetic cascade energy using a lateral density function (predicted within 6%).

Recently, it has become evident that the current method for signal estimation can be improved to better handle stations with a low signal-to-noise ratio, particularly in constraining measurement uncertainty. Consequently, a new approach, grounded in a robust and rigorous statistical framework using the appropriate Rice distribution, was developed and is currently being evaluated.

Collaboration(s)

Pierre Auger Collaboration

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