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Reconstruction of inclined cosmic ray properties with GRAND data

Radio-detection is now an established technique for studying ultra-high-energy (UHE) cosmic rays with energies exceeding $\sim 10^{17}$ eV. The next generation of radio experiments, such as the Giant Radio Array for Neutrino Detection (GRAND), aims to expand this technique to the observation of Earth-skimming UHE neutrinos, which requires the detection of very inclined extensive air showers (EAS). Currently, GRAND is validating its detection principle—autonomous radio detection—through the prototype array GRANDProto300, deployed in the Gobi Desert. In this phase, the array is limited to detecting inclined EAS only from cosmic rays, not neutrinos, due to its restricted size and antenna multiplicity. We present a novel method for reconstructing the arrival direction and energy of EAS with zenith angles above 60° as well as for upward-going trajectories. This method combines a point-source-like description of the radio wavefront with the angular distribution function (ADF), a phenomenological model that describes the angular distribution of the radio signal amplitude in the 50–200 MHz frequency range. Particular attention is given to the Cherenkov angle, a key feature of the radio amplitude pattern. The proposed reconstruction method has been tested on cosmic ray air-showers simulations, achieving an angular resolution on the shower arrival direction better than 4 arcminutes, an electromagnetic energy resolution of 4%, and a primary energy resolution of approximately 15% under realistic conditions. In the near future, the method will be tested on real candidate EAS events detected by GRANDProto300.

Collaboration(s)

GRAND

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