A study of the radio frequency spectrum emitted by high energy air showers with LOFAR


Introduction

The detection of radio signal emitted by extensive air showers allows to reconstruct the cascade geometry. Thus, important properties of primary particles (e.g. arrival direction, mass composition) can be inferred. A study of several geometrical parameters of the radio signal emitted by extensive air showers, and their correlation with the observed radio frequency spectrum is presented here.

In view of extending these measurements to all data detected by LOFAR [1], a preliminary simulation study of the radio frequency spectrum has been conducted. Monte Carlo simulations of radio signals have been produced by using CoREAS, a plug-in of the CORSIKA particle simulation code. The final aim of this study is to improve the radio detection technique, thus contributing to affirm this technique as reliable method for the study of high energy cosmic rays.

Simulation study of the frequency spectrum

Main goal:

to measure cosmic ray energy and mass composition in the energy range $10^6$ – $10^9$ eV through the analysis of radio signal in the frequency–domain

Procedure:

➢ preliminary study on simulated shower induced by protons

➢ simulations have been produced considering 160 antennas, distributed on 8 arms at an angle 45$^\circ$ between each other in the shower plane (i.e. plane perpendicular to both the shower axis and the geomagnetic field) (see figure 2–left)

➢ the signal has been converted to the frequency–domain by applying a Fast Fourier Transform; the frequency spectrum has been studied as function of distance to the shower axis in the frequency range 30 – 80 MHz (see figure 2–right) [2]

➢ frequency spectrum has been studied as function of distance to the shower axis, and as function of $X_{\text{max}}$ through the 30$^\text{th}$, 50$^\text{th}$, and 70$^\text{th}$ percentile (see figures 3 and 4); the percentile indicates the frequency value, in the 30 – 80 MHz range, at which the integrated spectrum reaches the given percent of the total integral

Conclusions and outlook

➢ Simulation study of radio signals emitted by protons in the frequency–domain

➢ dependence of the frequency spectrum as function of distance to the shower axis, and as function of $X_{\text{max}}$ has been found

➢ the method presented here will be applied to all data detected by LOFAR since 2011

References


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