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Template synthesis approach for radio emission from extensive air showers

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The study of high-energy cosmic-ray air showers relies on Monte-Carlo techniques to simulate the particles and corresponding radio emission. These microscopic simulations require a lot of computing time, which not only limits our analyses but also negatively impacts the environment. Other techniques exist, using macroscopic quantities instead, but these currently lack the required precision.

We therefore present a novel way to synthesise the radio emission from air showers. It is a hybrid approach which uses a single microscopic simulation to generate the radio emission from a shower with a different longitudinal evolution, primary particle type and energy. The method employs semi-analytical relations which only depend on the shower parameters to transform to radio signal in the simulated antennas.

The central idea of the template synthesis, is to slice up the atmosphere and consider the radio emission from each slice separately. In this way we only need to account for shower age effects when synthesising the required signal, as geometric effects are already taken care of. The former are handled by rescaling the frequency spectra in each slice, according to aforementioned semi-analytical relations.

As a first step we tested this approach for vertical air showers, using CORSIKA together with the CoREAS plugin for the radio emission. We generated a library of 600 showers, with primary energies ranging from 10^{17} eV to 10^{19} eV. From this library we extracted the necessary parameters for the semi-analytical expressions, after which we used randomly selected showers to gauge the reconstruction quality of the template synthesis. We achieve a reconstruction quality of 5 – 10 %.

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