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A Monte Carlo Tool for Estimating Synchrotron Fluxes from EAS

In recent years, the development of orbital and sub-orbital missions aiming to the use the Earth's atmosphere as the target mass to detect extensive air showers (EAS) induced by ultra-high energy (UHE) CRs and neutrinos through their EM counterparts –such as EUSO-SPB2, the Terzina Payload onboard the NUSES missions, and the planned POEMMA mission –has driven interest in modeling the expected Cherenkov, fluorescence, and radio fluxes in atmosphere from these EAS.

In order to compute the expected fluxes reaching the plane of detector at a high altitude, Monte Carlo simulations are required that can: compute the intensity and spectra of EM emissions of EAS electrons during the shower development, and incorporate these fluxes in a framework that takes into account the candidate generation, propagation, and modeling of the instrument response. While well-established simulation tools exist for Cherenkov emission and radio emission from geomagnetic and Askaryan effects, less attention has been given to synchrotron emissions from EAS, spanning from X-rays down to radio wavelengths.

In this work, we present preliminary results from a novel Monte Carlo simulation tool to compute the expected fluxes of X-ray and radio emissions from EAS electrons gyrating in the Earth's magnetic field. Our approach builds upon analytic expressions for the spectra of synchrotron radiation found in literature, which are combined with parameterized electron population distributions (in energy and phase) and longitudinal shower profile templates to calculate the expected synchrotron emission from the EAS. After accounting for possible coherent emission effects, and propagation through the atmosphere, we then estimate the resulting photon fluxes at the detector plane.

These preliminary results, wherever applicable, are compared to existing alternative methods for flux estimation. Our framework aims to provide a first-order estimate of expected photon fluxes at the detector, serving as a valuable reference for the design and planning of future orbital and sub-orbital cosmic ray and neutrino observatories.

Collaboration(s)

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