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# Propagating Air Shower Radio Signals to In-ice Antennas

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Cosmic ray showers provide essential background signals for in-ice Askaryan neutrino radio detectors in the polar regions as they emit neutrino-like radio signals. They can also serve as calibration sources for in-ice radio detectors due to their relatively large flux. Thus in this work, we present a novel way to upgrade CoREAS such that it takes into account curved ray paths caused by the exponential refractive index profiles of air and ice, which enables propagating signals from air to antennas located inside the polar ice sheets. Analytic raytracing expressions are used to calculate the relevant parameters for the curved ray paths between the air shower particles and the in-ice antennas. However, analytic raytracing takes around 0.05 to 0.1 ms per call and is too slow for all the particles in the air shower. Therefore we have developed an interpolation scheme that calculates ray parameters using pre-tabulated raytraced values and takes around 200 ns per parameter per call. In this work, we will show some simulations of air-shower signals as observed by in-ice antennas and discuss the implementation of analytic raytracing and interpolation schemes in the current and the future CORSIKA versions.

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