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Seasonal Variation of Polar Ice as a Medium for Ultra-High Energy Neutrino Detectors

Numerous experiments search for Ultra-High Energy Neutrinos by instrumenting the upper 200 meters of the polar ice sheet with antennas to detect neutrino-induced radio emission, including Askaryan radiation and radar reflections off the ionization trail left in the wake of the particle cascade. This places them within or immediately below the region of compacted snow, known as firn, which is subject to seasonal changes in temperature, snow accumulation, and periodic surface melting. These processes lead to time-dependent variations in the firn density (ρ) and refractive index (n). We present a radio frequency simulation study of an in-ice radio source observed by an in-ice receiver array, showing that density anomalies alter the amplitude and arrival time of signals propagation in the firn. Seasonal density variations cause up to $\sim 20\%$ fluctuations in received power for reflected and refracted signals and observable shifts in reflected pulse arrival times. These fluctuations introduce an inherent background uncertainty in neutrino energy and direction reconstruction. Accounting for these effects is essential for on-going Ultra-High Energy Neutrino searches.

Collaboration(s)

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