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NuLeptonSim: A practical use of a neutrino propagation code as an event generator

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To calculate the sensitivity of current and future telescopes to astrophysical neutrinos, it is necessary to understand the key properties (energy, flavor, and probability weight) of both these primary neutrinos and their secondary particles after propagation through the Earth. The properties of these particles are strongly influenced by the various interactions that both neutrinos and their secondaries are subject to, and a full treatment of the propagation is required. Many different computation schemes exist to treat this problem (NuTauSim, TauRunner, and NuPyProp being just a few examples).

In this work, we detail NuLeptonSim, an update to the NuTauSim Monte Carlo neutrino propagation code for high energy tau neutrinos. The improvements included in NuLeptonSim include i) all flavor neutrino modeling ii) Glashow Resonance interactions and iii) compatibility with detector frameworks (arbitrary definitions of detector geometry and particle trajectory, including downwards trajectories). We demonstrate the results from including these effects on the Earth emergence probability of various charged leptons and their corresponding energy distributions. Using NuLeptonSim to model propagation, we calculate the sensitivity of the Askaryan Radio Array (ARA) experiment to cosmic neutrinos. Following this calculation, we also include secondary particle interactions (radiative losses from muons and τ-leptons) to improve the estimate of the sensitivity.

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