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Cascade Reconstruction in Pacific Ocean Neutrino Experiment (P-ONE)

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The Pacific Ocean Neutrino Experiment (P-ONE) is a proposed multi-cubic kilometer neutrino telescope off the coast of Canada. It aims to probe physics at previously inaccessible regimes, and builds on the discoveries made by the IceCube Experiment, located at the South Pole. Some goals of a full-scale P-ONE are to confirm the relative flux for different neutrino flavors and their possible cosmic origins.

I have explored the problem of analysing a single neutrino that enters the P-ONE detector and classifying that as either a muon-type neutrino or an electron-type/tau-type neutrino. If this is accurately accomplished, we will be able to solve the problem of determining neutrino fluxes.

Neutrino flavors can be distinguished by how they interact with the medium inside the detector while producing its corresponding charged lepton. A muon neutrino gives a track-like signature while electron/tau neutrinos produce secondary hadronic showers called "cascades". To combat an inherent risk of misclassification of track-like events as cascade-like events due to large stochastic energy losses, I proposed, designed and benchmarked a cascade-fitter algorithm that uses the maximum likelihood reconstruction approach.

I used a three-step process for the cascade-fitter. First, the neutrino-nucleon interaction vertex is approximated by taking a weighted average of the charges collected by the detectors with a definite geometry. Second, I improved on the assumption that the Cerenkov emissions are isotropic, by incorporating a carefully-chosen anisotropy factor that depends on the relativistic velocity of the primary daughter particle. Finally, the parameters of the anisotropy function were obtained by fitting to data representing the angular distribution of DOM hits with respect to the primary lepton direction.

For this aforementioned reconstruction approach, we find that the peak of the likelihood curve shifts towards the origin, in comparison to the isotropic case. This indicates that the fit is a lot better than the existing approach, and the high likelihood value also provides a strong confirmation of the fit. There is also an improvement in the resolution of the azimuthal and zenith angle estimations of the incoming electron or tau neutrino. We hope to improve the analysis and fit further to improve our understanding of neutrino physics.

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