Contribution ID: **301** Type: **Poster**

Cherenkov Light in Liquid Scintillator at the NOvA Experiment: A Cautionary Tale

Tuesday, 10 July 2018 16:40 (20 minutes)

The observation of neutrino oscillations provides evidence of physics beyond the Standard Model, and the precise measurement of those oscillations remains an essential goal for the field of particle physics. The NOvA experiment is a long-baseline neutrino experiment composed of two finely-segmented liquid-scintillator detectors located off-axis from the NuMI muon-neutrino beam having as its primary goals to perform precision measurements of the atmospheric mass splitting, determine the mass hierarchy, and probe CP violation in the leptonic sector.

In early NOvA analyses, the systematic uncertainty on the non-linear scintillator response to the hadronic recoil component of neutrino interactions was one of the largest uncertainties considered. The initial scintillator model used second-order Birks-Chou suppression optimized to improve the data/Monte Carlo agreement for energy loss along proton and muon tracks; however, the optimal values were unrealistic and overestimated the brightness of untracked low-energy protons produced by neutron scattering. Subsequently, we determined that Cherenkov light produced at short wavelengths and absorbed and reemitted by the scintillator at experimentally useful wavelengths can almost entirely account for this mismodeling. This dramatically improved data/Monte Carlo agreement and reduced uncertainties due to scintillator response to nearly negligible levels. We will discuss the implementation and data-driven tuning of the Cherenkov absorption-reemission model and the impact of the new scintillator model on recent results.

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Session Classification: Posters

Track Classification: Track 2 – Offline computing