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Delayed gamma emission from metastable nuclear de-excitation levels using MARLEY for electron neutrino interactions in the CCM experiment

Content

Charged current (CC) electron neutrino interactions on ^{40}Ar at tens of MeV energies produce excited ^{40}K nuclei that de-excite through gamma ray cascades and particle emission. These de-excitation products contribute to the visible energy and timing structure of events in liquid argon neutrino detectors. This is especially relevant for the Coherent CAPTAIN Mills (CCM) experiment, a 10 ton liquid argon detector at LANL that relies on fast timing and prompt-light observables to study electron neutrino interactions in the $E_\nu \leq 50$ MeV regime.

The MARLEY event generator predicts final states for neutrino interactions with argon using measured gamma-ray decay schemes and statistical nuclear emission models. In most cases, nuclear de-excitation levels have picosecond or femtosecond lifetimes, and the emitted gamma rays are effectively prompt on CCM timescales. However, metastable states can produce delayed gamma emission on a nanosecond timescale, providing a characteristic signature that may be observable with CCM's fast timing capabilities.

In this work, we present a time resolved extension of MARLEY focused on gamma emission from metastable de-excitation levels. We apply this extension to simulated electron-neutrino events and study metastable level populations. These observables connect nuclear structure information to detector-level timing quantities and provide a means to test the prompt gamma approximation for CC neutrino interactions.

Summary

Primary author(s) : Ms. CHAVEZ ESTRADA, Marisol (ICN-UNAM)

Presenter(s) : Ms. CHAVEZ ESTRADA, Marisol (ICN-UNAM)