Contribution ID: **334** Type: **Poster**

Neutron Capture Information in Improving IBD Angular Resolution

Wednesday 27 August 2025 18:00 (2 hours)

One of the most important neutrino interactions is the Inverse Beta Decay (IBD). However, the IBD events typically carry no directional information in water Cherenkov detectors as the positrons direction is mostly isotropic at low energies, such as those in supernova studies. As Gadolinium is being added to Super Kamiokande, the improved neutron capture efficiency not only allows better background rejection, but the neutron capture information could potentially provide additional information that allows better event reconstruction. Due to neutron diffusion in water, event by event reconstruction is difficult. However, if the final neutron capture position is correlated with the initial neutrino momentum, it may be possible that neutrino directionality could be reconstructed statistically, with or without using the positron information. In this work, we use Geant4 to simulate neutron propagation in water. We show that in a wide range of neutrino energy from about 10 MeV to several hundred MeV, neutron capture information could statistically enhance the neutrino directionality, compared to positron-only inference, even with neutron diffusion in water. However, practical application of this technique depends crucially on detection effects, particularly the vertex reconstruction resolutions. Our work therefore motivates developments of better reconstruction algorithms and techniques, as well as detector upgrades.

Collaboration you are representing

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Session Classification: Poster session

Track Classification: Neutrino Physics and Astrophysics