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Neutron detection to improve the neutrino energy resolution in oscillation experiments

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After the recent discovery of the massive nature of neutrinos, through the observation of their oscillations, we now enter an era of precision measurement of the oscillation parameters. The next long-baseline neutrino accelerator experiments will be crucial for these precision measurements and will need to feature innovative detector technologies that offer high target mass (to acquire large data samples) while reducing the various systematic uncertainties.

In addition, as the oscillation probability of the neutrinos depends on their energy, a precise measurement of their energy is key to the determination of the neutrino oscillation parameters.

In order to fulfill the needs for both a high-target mass and improved neutrino energy resolution, a new design recently arose for highly granular scintillating detectors, such as superFGD that will be part of the T2K Near Detector upgrade. These detectors are composed of scintillating cubes of centimetric-size readout by wavelength-shifting fibers in three directions. They allow the reconstruction of the charged particle tracks, thus giving access to the interaction vertex and neutrino energy. However, a share of the interaction energy goes into neutral particles such as neutrons that are typically not reconstructed in such tracking detectors, thus degrading the neutrino energy resolution.

In this presentation, the neutron detection capabilities of state-of-the-art highly granular scintillating detectors and their usefulness in order to better estimate the neutrino energy will be shown. The detection of the neutrons allows one to directly access their energy by “time of flight” measurements, but also gives access to kinematic variables that can be leveraged to better constrain the event selection and marginalize nuclear effects.

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