

Neutrino Oscillation Analysis with New Event Samples at T2K

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Neutral current π^0 ($\text{NC}\pi^0$) events are a major background for ν_e signal events in T2K neutrino oscillation measurements. These events, characterised by two photons from π^0 decay, can mimic the detector response of electrons in Super-Kamiokande (Super-K). Previously, there were no dedicated samples to effectively constrain this $\text{NC}\pi^0$ background. To address this, events reconstructed with two Cherenkov rings (the 2-ring π^0 sample) have been selected, improving the modeling of $\text{NC}\pi^0$ interaction cross-sections. In addition, events reconstructed as single-ring, which were previously rejected from the 1-ring e-like selection, are now included (referred to as the 1-ring π^0 sample). This adjustment recovers a portion of the ν_e signal events that were previously misidentified and rejected during selection.

The inclusion of these $\text{NC}\pi^0$ samples offers a model-independent constraint on $\text{NC}\pi^0$ backgrounds directly from Super-K data and increases the total ν_e ($\bar{\nu}_e$) signal events by 7% (11%) at T2K. Since NC interactions are flavor-independent, these samples provide a large event sample to serve as a cross-check of the total neutrino flux at Super-K, in comparison with the unoscillated flux measured near the neutrino beam production point. Furthermore, $\text{NC}\pi^0$ samples offer unique advantages for sterile neutrino searches. A deficit in charged-current (CC) events without a corresponding deficit in NC events would be a strong signature of sterile neutrino oscillations.

Primary author: ZHU, Tailin (TDLI)

Presenter: ZHU, Tailin (TDLI)

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