

## Neutrino Oscillation Analysis with New Event Samples at T2K

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Neutral current  $\pi^0$  (NC $\pi^0$ ) events are a major background for  $\nu_e$  signal events in T2K neutrino oscillation measurements. These events, characterised by two photons from  $\pi^0$  decay, can mimic the detector response of electrons in Super-Kamiokande (Super-K). Previously, there were no dedicated samples to effectively constrain this NC $\pi^0$  background. To address this, events reconstructed with two Cherenkov rings (the 2-ring  $\pi^0$  sample) have been selected, improving the modeling of 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  $\pi^0$  sample). This adjustment recovers a portion of the  $\nu_e$  signal events that were previously misidentified and rejected during selection.

The inclusion of these NC $\pi^0$  samples offers a model-independent constraint on NC $\pi^0$  backgrounds directly from Super-K data and increases the total  $\nu_e$  ( $\bar{\nu}_e$ ) 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, 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.

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