

# Transverse Kinematic Imbalance Analysis and Pion Trackless Reconstruction at the upgraded T2K near detector

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The upgrade of the T2K magnetised near detector (ND280) is near completion in J-PARC. After detecting the first neutrinos in Fall 2023, ND280 is collecting new data in 2024 with a beam intensity above 700 kW. The new active target, the Super Fine-Grained Detector (SFGD) is made up of about 2 million  $1\text{ cm}^3$  scintillation cubes, thereby offering excellent timing resolution and isotropic tracking.

In this work, we present the preliminary Transverse Kinematic Imbalance (TKI) reconstruction with and without pion at the T2K near detector upgrade. The Elastically Scattered Contained protons technique is used to select a high-quality proton sample for  $\nu_\mu CC0\pi^+1p$  TKI analysis. The reconstruction shows promising resolution. The pion trackless reconstruction exploits the unique time signal of its decay chain to reconstruct the primary pion in a neutrino nucleus interaction without requiring the presence of a reconstructed track. Hence, it transcends the tracking threshold and further lower the pion reconstruction limit. Additionally, the reconstruction quality of the trackless technique is also excellent. Moreover, a  $\nu_\mu CC1\pi^+1p$  selection, based on the trackless technique and, has been produced for a preliminary study of the TKI variables. Furthermore, owing to the excellent resolution of the hadronic kinematic variables, a new set of variables, the Centre-of-Momentum (COM) variables, are devised and serve as excellent Final State Interactions (FSI) probes independent of the initial nucleon state. As the COM variables are sensitive to FSI differently from the TKI variables, it shows potential results that the two are used together to select a Hydrogen sample with high purity.

## Poster prize

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T2K

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