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Analysis of Muon Neutrino Interactions in the Upgraded Near Detector ND280 of the T2K Experiment

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The Tokai-to-Kamioka (T2K) experiment is a long-baseline neutrino oscillation experiment designed to precisely measure oscillation parameters and search for CP violation in lepton sector using an intense muon (anti)neutrino beam. The experimental setup consists of the J-PARC proton accelerator complex, the near detector ND280, and the far Super-Kamiokande water Cherenkov detector. Data from ND280 are essential for constraining neutrino interaction model parameters and the initial neutrino flux, which significantly reduce systematic uncertainties in the oscillation analysis. In 2024, ND280 was upgraded with a novel 3D-segmented SuperFGD detector at its core, surrounded by time projection chambers and time-of-flight detectors. The upgrade aims to expand the phase space acceptance for neutrino interaction studies, lower tracking threshold, and enhance timing precision. This work presents the first analysis of muon neutrino interactions in the SuperFGD detector. The results provide the foundation for integrating the upgraded ND280 into the T2K oscillation analysis, thereby improving the overall precision of T2K and laying the groundwork for the next-generation Hyper-Kamiokande experiment at the J-PARC beamline.

Primary author: FEDOROVA, Daria (INR RAS)

Presenter: FEDOROVA, Daria (INR RAS)

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