

Research Result Report

ICRR Inter-University Research Program 2025

Research Subject: Constraining systematics at T2K and SuperKamiokande oscillation analyses using neutrino-nucleus interaction models
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Participating Researchers: J. A. Caballero, R. González Jiménez, J. González Rosa (University of Seville); J. M. Franco Patiño (IFIC-CSIC, Valencia); J. M. Udías Moinelo (Complutense University of Madrid); M. Benedetta Barbaro (University of Turin and INFN); T. William Donnelly (Massachusetts Institute of Technology (MIT)); Kimihiro Okumura, Yoshinari Hayato, Seisho Abe (University of Tokyo, ICRR); Laura Munteanu, Stephen Dolan (CERN).
Summary of Research Result : Publications in FY2025: Progresses on development and optimization of neutrino interaction models (SuSAv2 and RMF models) for the analysis of data from T2K and other experiments have been published in FY2025 together with other T2K papers in common with ICRR members: 1. The NOvA Collaboration & The T2K Collaboration. <i>Joint neutrino oscillation analysis from the T2K and NOvA experiments</i>. Nature 646, 818-824 (2025). DOI: https://doi.org/10.1038/s41586-025-09599-3 2. K. Abe et al. (T2K Collaboration). <i>First measurement of neutron capture multiplicity in neutrino-oxygen neutral-current quasielasticlike interactions using an accelerator neutrino beam</i>. Phys. Rev. D 112, 032003 (2025). DOI: https://doi.org/10.1103/gh28-4znk 3. J. Gonzalez-Rosa, G. D. Megias, J. A. Caballero, and M. B. Barbaro. <i>Analysis of NOvA and MicroBooNE charged-current inclusive neutrino measurements within the SuSAv2 framework</i>. Phys. Rev. D 111, 073002 (2025). DOI: https://doi.org/10.1103/PhysRevD.111.073002 4. K. Abe et al. (T2K Collaboration). <i>First Measurement of the Electron-Neutrino Charged-Current Pion Production Cross Section on Carbon with the T2K Near Detector</i>. Phys. Rev. Lett. 135, 151802 (2025). DOI: https://doi.org/10.1103/klhv-7t6h 5. K. Abe et al. (T2K Collaboration). <i>First Differential Measurement of the Single π^+ Production Cross Section in Neutrino Neutral-Current Scattering</i>. Phys. Rev. Lett. 135, 171803 (2025). DOI: https://doi.org/10.1103/6d32-1452 6. K. Abe et al. (T2K Collaboration). <i>Signal selection and model-independent extraction of the neutrino neutral-current single π^+ cross section with the T2K experiment</i>. Phys. Rev. D 112, 072008 (2025). DOI: https://doi.org/10.1103/wcn1-4tyl 7. K. Abe et al. (T2K Collaboration). <i>Testing T2K's Bayesian constraints with priors in alternate parameterisations</i>. Eur. Phys. J. C 85, 1414 (2025). DOI: https://doi.org/10.1140/epjc/s10052-025-14836-0 8. K. Abe et al. (T2K Collaboration). <i>Results from the T2K Experiment on Neutrino Mixing Including a New Far Detector μ-like Sample</i>. Phys. Rev. Lett. 135, 261801 (2025). DOI: https://doi.org/10.1103/gh5j-5cwv 9. Jesus Gonzalez-Rosa, Alexis Nikolakopoulos, Maria B. Barbaro, Juan A. Caballero, Raúl González-Jiménez, Guillermo D. Megias. <i>Charged-Current Neutrino-Induced Single-Pion Production in the Superscaling Approach and Relativistic Distorted-Wave Impulse Approximation</i>. Universe 2026, 12(5), 121. DOI: https://doi.org/10.3390/universe12050121. This article belongs to the Special

Issue “Neutrino Insights: Peering into the Subatomic Universe” (Guest Editor: G. D. Megias).

Work is in progress with Dr. Abe-san (UTokyo) and Prof. Hayato-san (ICRR) to compare the implementation of the DCC model from the Osaka group in the SuSAv2 framework and the results from the DCC approach implemented in the NEUT event generator used in T2K and SuperKamiokande. The different descriptions of the nuclear dynamics in the SuSAv2 and NEUT models are being analyzed in comparison with neutrino cross-section data to validate nuclear models in the resonance regime. Also, in collaboration with different T2K members, a first implementation of the inclusive and semi-inclusive SuSAv2 and RMF-1p1h models in NEUT is also in progress, having already finished the RFM-1p1h implementation in NEUT by R. Gonzalez-Jimenez et al. This will allow the reweight of several parameters for the oscillation analysis, the study of nuclear-medium effects, and a comparison between nuclear optical potentials and cascade models in generators, among other issues. Some outcomes of this research have been recently published and additional works are expected to be published in coming months. Also, we have explored in recent works [Universe 2026, 12(5), 121] different descriptions of the inelastic structure functions based on the Osaka-DCC approach and the Hybrid model in combination with SuSAv2 and RMF, and comparing with measurements from T2K and other experiments.

All these results and research projects have been also presented at several conferences and meetings, such as: T2K Collaboration Meeting 2025, NuSTEC Collaboration Meetings, GENIE Collaboration Meeting 2026, Neutrinos and Flavour: a stairway to New Physics (Pisa, Italy, 2025), etc.

Additionally, we are starting a collaboration with the NINJA experiment (Seungho Han, Kyoto University) for the analysis of nuclear effects in their experimental analyses.

With regard to the ICRR Research Program, the Univ. of Seville group has got on FY2024-FY2025 a 3-year R&D project of the Spanish Ministry of Science in which Profs. Hayato-san and Okumura-san (ICRR) participate as collaborators, and also a 4-year HORIZON-MSCA-SE project from the European Commission entitled “Japan and Europe Network for Neutrino and Intensity Frontier Experimental Research 3 (JENNIFER3)” to promote collaboration between European and Japanese institutions, being composed of 15 European institutions and 3 international partners (KEK, University of Tokyo and King’s College London). This year, we have also applied for a similar European HORIZON-MSCA-SE project entitled “SHOGUN (Super-Kamiokande and Hyper-Kamiokande Observatories for Grand unification, Universe and Neutrinos)” in which the University of Tokyo and KEK are also involved, being the University of Seville’s official adscription to HyperKamiokande expected in FY2026. Furthermore, we have also joined this year the JSPS core-to-core program in a project led by Prof. Yoshinari Hayato from ICRR.

The Univ. of Seville considers all these projects and our participation in Japanese neutrino experiments a research line of strategic interest, having approved special allocations to support the participation of their researchers in T2K. We will also continue these projects in FY2026 under the ICRR Inter-University Research Program 2026.

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