Research Result Report
ICRR Inter-University Research Program 2022

Research Subject:

Constraining systematics at T2K and SuperKamiokande oscillation analyses using neutrino-nucleus interaction models

Principal Investigator:

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Summary of Research Result：

Progresses on the development and optimization of neutrino interaction models (SuSAv2-MEC and RMF models) for the analysis of data from T2K and other experiments have been published in FY2022 together with other T2K papers in common with ICRR members:

- J. Gonzalez-Rosa, G. D. Megias, J. A. Caballero, M. B. Barbaro. *SuSAv2 model for inelastic neutrino-nucleus scattering*. Phys. Rev. D 105, 093009 (2022).

- J.M. Franco-Patino *et al.*. F*inal state interactions in semi-inclusive neutrino-nucleus scattering: Applications to the T2K and MINERνA experiments*. Phys. Rev. D 106, 113005 (2022).

- J. M. Franco-Patino, *et al.*. *Study of semi-inclusive CC electron and muon neutrino scattering from 40Ar in the energy range of the MicroBooNE experiment*. arXiv:2304.01916 [hep-ex] (2023). Submitted to PRD.

- K. Abe et al. (T2K Collaboration), *Scintillator ageing of the T2K near detectors from 2010 to 2021*. Journal of Instrumentation, 17, P10028 (2022).

- K. Abe et al. (T2K Collaboration), *First measurement of \mu_\nu CC interactions on hydrocarbon without pions in the FS using multiple detectors with correlated energy spectra at T2K.* arXiv:2303.14228 [hep-ex] (2023).

- K. Abe et al. (T2K Collaboration), *Measurements of neutrino oscillation*

parameters from the T2K experiment using 3.6×1021 protons on target. arXiv:2303.03222 [hep-ex] (2023).

Work is in progress with Prof. Hayato-san (ICRR) to include the DCC model from the Osaka group in the SuSAv2 model and subsequently implement it in the NEUT event generator used in T2K and SuperKamiokande. This will allow to use different approaches to analyze the resonant regime in neutrino-nucleus reactions. Also, in collaboration with Hayato-san and other T2K members, a first implementation of the inclusive and semi-inclusive SuSAv2 and RMF-1p1h models in NEUT is also in progress. 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. The outcomes of this research are expected to be published in coming months, and have been also presented at several conferences and meetings:

- T2K Collaboration Meeting (Tokai, Japan): - Study of inelastic neutrino-nucleus scattering using the SuSAv2 model, J. Gonzalez-Rosa. - Modelling of semi-inclusive nu-A scattering, J. M. Franco-Patino. - Summary of NIWG theory talks, G. D. Megias. February 2023

- XXXVIII Biennial of Physics (Valencia, Spanish Royal Physics Society RSEF). "The relevance of neutrino-nucleus interaction models in neutrino oscillations". G. D. Megias. July 2022

- 23rd International Workshop on Neutrinos from Accelerators (NUFACT2022). "Final state interactions in semi-inclusive nu-A scattering: application to T2K and MINERvA experiments". J. M. Franco-Patino. August 2022

- CERN EP-NU Meeting (Switzerland). "Modelling neutrino-nucleus interactions for long-baseline neutrino oscillation experiments". G. D. Megias. Nov 2022

- 43rd International school of nuclear physics (Erice, Italy). "Modelling semi-inclusive neutrino-nucleus interactions". J. M. Franco-Patino. September 2022

With regard to the ICRR Research Program, the Univ. of Seville group has obtained a 3-year R&D project of the Spanish Ministry of Science in which Prof. Hayato-san (ICRR) participates as collaborator. The Univ. of Seville consider these projects a research line of strategic interest, having approved a special allocation to support the participation of their researchers in T2K.

We will also continue these projects on FY2023 under the ICRR Inter-University Research Program 2023.