

Research Result Report**ICRR Inter-University Research Program 2025***Research Subject:*

Data Taking, Calibrations, Measurements and Analysis with Super-Kamiokande I - VIII

Principal Investigator:

Luis Labarga (University Autonoma Madrid)

Participating Researchers:

Pablo Fernández (also University Santiago Compostela, USC, Santiago de Compostela, Spain)

Felipe Garay (PhD student, University Autonoma Madrid)

Dustin Samudio (PhD student, University Autonoma Madrid)

Summary of Research Result:

The aim of the project is to get the scientific outmost of the Super-K (SK) experiment in general and of its SK-Gd phase and to acquire further know-how for the design and construction of the next generation Hyper-Kamiokande (HK).

Currently the UAM is the only Spanish institution belonging to SK. It is fundamental for SK to continue with the works by the UAM and our close collaboration with ICRR colleagues (see below in this proposal). This project has been granted by the Inter-University Research Program during FY2019, FY2020, FY2021, FY2022 and FY2023 lead by Luis Labarga, FY2024 by Nataly Ospina and this FY2025 by L. Labarga.

The main scientific activities that have been carried out by the UAM group during FY2025 are detailed below. They are continuation of those carried out during the previous years and always fundamental for the SK operation and its data analyses.

a) Monitoring Performance of SK: Calibration & related works (mainly L. Labarga):

- Analysis of the SK water properties evolution with time with auto-Xenon and the so-called “Nickel” data. Also, their correlations with ID temperatures, behavior of Korean Injectors data and evolution of Dark-Rate
- Further study the behavior of the gains of SK inner detector (ID) photo-multiplier-tubes (PMT)
 - Evolution of mean gain with time for both, every individual ID-PMT and ID-PMT grouped in “Production Year”, “HK” and “Top/ Barrel/ Bottom”
- Study of “Nickel” calibration events at SK-VII: relationship between Nickel and Gd gamma Neutron multiplicities; spatial and time dependencies.
- Studies of impact on SK performance from the failures and repairs of coils in SK’s

geomagnetic system, occurred during October – December 2023; and their main fix at the summer 2024:

- Participate in the main fix during the summer 2024
- Use auto-Xenon data for studying collection efficiencies
- Used Nickel data: for changes in ID-PMT gains from the above changes in the geomagnetic system.

b) Performance of SKG4 & comparisons with SK (mainly D. Samudio):

- As regular check of the correctness of the program chain we have compared most important variables like multiplicities, energy distributions etc. for two “SK-VI” & “SK-VII” samples of events generated with SKG4, in SK-VI and SK-VII conditions, using the NEUT v5.6.4 physics simulations code.
- Thorough study of NiCf event generation with SKG4
 - Generated “true” values of relevant variables
 - Comparison of Data and NiCf Simulations Using SKG4 in SK-VII: Shift in vertex reconstruction: Dependence on the position along the detector
 - Study of vertex Reconstruction using Nickel-Cf Data and SKG4 simulated Nickel-Cf Data from SK-IV to SK-VIII

c) Physics Analyses (all)

The UAM group is actively involved in the search for the Diffuse Supernova Neutrino Background (DSNB) since its beginning in SK: first with the immense R&D for dissolving a Gd salt in the SK water, with the implementation of the project in SK and the loading of the salt itself, and now, after so many years, with the observation.

Therefore, our current main objective and works, as it is that of the whole SK Collaboration is all related to the discovery of the DSNB with SuperK-Gd (mainly D. Samudio, F. de Gary, L. Labarga). Particularly this year, our efforts went to the measurement of one of the most important backgrounds for the DSNB search: the atmospheric neutrino NCQE cross section in water in the SK-Gd VII and SK-GdVIII data (mainly D. Samudio).

On the other hand, we continue with our improvements on the neutrino oscillation analyses (mainly P. Fernández) by A) emphasizing the presence of neutrons tagged with the Gd for better neutrino/antineutrino separation (hybrid analysis), and B) the SK-T2K joint oscillation analysis also emphasizing the neutron tagging by Gd

FINAL NOTE: all our related publications during this FY2025 are collaborative ones, i.e. from the Super-Kamiokande, T2K and Hyper-Kamiokande Collaborations.

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No. 2025i-A-003