ID de la contribución : **47** Tipo : **no especificado**

Detector calibration studies for the e-Shape experiment

martes, 5 de mayo de 2026 15:50 (40)

Forbidden β decays are of particular interest for both nuclear physics and astrophysics.
In the context of the astrophysical r-process, they govern the matter flow along neutron-rich nuclei and strongly impact the final abundance distribution of heavy elements. In nuclear reactors, an incomplete description of forbidden transitions has been identified as one of the leading hypotheses behind the reactor antineutrino shape anomaly, which complements the global reactor antineutrino anomaly. Despite their importance, forbidden β decays remain poorly understood due to the complexity of their spectra and the challenges in modeling their shape factors.
This contribution focuses on the detector calibration work carried out after the 2023 e-Shape experimental campaign at the IGISOL facility of Jyväskylä, Finland. A detailed detector geometry has been implemented in Geant4 in order to reproduce the experimental setup as accurately as possible. Energy calibration has been performed using several radioactive sources and nuclei, together with a dedicated study of the detector energy resolution.
The resulting calibrated simulations are compared with experimental data in order to assess the level of agreement between measurement and Monte Carlo spectra. A good agreement has already been obtained for the 114Ag beta decay energy spectrum, providing a first validation of both the detector calibration and the resolution convolution procedure. These developments constitute an essential step toward future precision analyses of forbidden β spectra and the extraction of reliable shape factors. Future efforts will focus on the analysis of β spectra of selected nuclei in order to extract shape factors, and on the benchmarking of these results against theoretical predictions. Ultimately, this work will contribute to more reliable modeling of forbidden transitions, with applications to both r-process nucleosynthesis simulations and reactor antineutrino spectrum predictions.

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