The γ-ray emission process in highly-excited nuclei is typically described within the statistical model of nucleus using the two main ingredients - the level density (LD) and the photon strength functions (PSFs). The knowledge of LD and PSFs is essential in the modeling of nuclear reactions with applications in astrophysics or advanced nuclear reactors. In this work, we studied the multi-step γ-ray cascade spectra following the radiative neutron capture $^{167}\mathrm{Er}(n,\gamma)^{168}\mathrm{Er}$ measured with the Detector for Advanced Neutron Capture Experiments in Los Alamos National Laboratory. The experimental γ-ray spectra were compared with the simulated spectra exploiting the DICEBOX Monte Carlo code for simulation of radiative decay to test different models of LD and PSFs.

Furthermore, the measured spectra allowed us to determine the population of the isomeric state in $^{168}\mathrm{Er}$ with 109 ns half-life and compare it with the simulated isomeric population, which provides an important test of the applicability of the statistical model. The simulated isomeric population was found to be significantly lower than the experimental one if no structure effects are assumed above the excitation energy of the isomer. If we adopt the decay scheme up to excitation energy well above 2 MeV, we obtain the simulated isomeric ratio comparable to the experimental one.

This result indicates that the structural effects might still play a role in $^{168}\mathrm{Er}$ in the region of higher excitation energies (likely up to 2.0-2.4 MeV), where the statistical model was successfully used to describe the γ-ray spectra in other rare-earth nuclei.

In addition, from the $^{167}\mathrm{Er}(n,\gamma)^{168}\mathrm{Er}$ data, we were able to assign spins to individual neutron resonances up to energies of several hundred eV. We studied the fluctuation properties of these neutron resonances and compared them with the predictions of the random matrix theory. The Gaussian orthogonal ensemble version of the random matrix theory predicts a very precise determination of the nuclear level spacing if a sequence of neutron resonances is complete. However, we found that the determination of the completeness is problematic and the completeness cannot be guaranteed even for short sequences with tens of resonances.