

PERFORMANCES OF A 3D MONTE-CARLO CALCULATION ROUTE IN THE CASE OF COMPLEX SYSTEMS (WHOLE SLAB REACTOR CORES) - APPLICATION TO NUCLEAR DATA VALIDATION

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Within the framework of the numerical validation of french neutronic codes (APOLLO2 /CRONOS2), Monte-Carlo calculations play the central role of reference and allow the analysis of model deterministic assumptions to propose new developments. Nevertheless those calculations are usually performed by considering simplified geometries (1D or 2D lattices) and cross-sections (i.e. multigroup) description to save computation time and reduce the statistical accuracy. This involves intricate transposition problems of results to the real (as-built) core configuration. This paper presents whole core calculations (based on JEFF, ENDF/B and JENDL datafiles) in the case of 3D complex systems (32 PWR assemblies made of several kind of heterogeneous UO₂ plates).

By using an appropriate GUI (Genuine User Interface) pre-processing software and the French polycinetic transport Monte-Carlo code TRIPOLI4 it is shown that satisfactory accurate results (same standard deviation than experimental measurements accuracy) can be obtained for both keff (around 10pcm, 1sigma) and local power distribution (less than 2 %, 1sigma) calculations. For each kind of calculation the statistical convergence has been studied and a maximum of 24 parallelized CPUs used.

The paper underlines the ability of the calculation route (GUI and TRIPOLI4 code) to investigate both deterministic model biases (self-shielding effects are identified by comparing multigroup and polycinetic TRIPOLI4 calculations) and nuclear data coming from different international sources (JEF2.2/JEFF3/ENDFB6.4/JENDL3.2 nuclear data libraries results compared to integral measurements). The dedicated GUI pre-processing software is used to describe the 3D PWR benchmarks (0.5 million of elementary volumes are need to represent the whole core) and calculations are performed with TRIPOLI4. By comparison with the integral core measurements it is shown that calculated Gd and Hf reactivity worths are systematically overestimated (by 5% to 9%) using both international datafiles. In particular, these results are consistent with previous Hf (reactivity worths) Monte-Carlo calculations performed in the case of simplified benchmarks (which gave rise to new JEFF3 recommended data for the first high resonances of ¹⁷⁷Hf isotope). Furthermore the analysis of ²³⁵U nuclear data (crossed comparisons of evaluated files) stressed the sensitivity of the benchmarks reactivity to capture cross-sections in the epithermal range and a systematic under-prediction (by 600 pcm) with the last JEFF3.0 european file.

Using the same calculation route, biases of assembly and core deterministic models are also quantified and separated. In particular, although the assembly reactivity worths may exceed 500 pcm, it is highlighted that counterbalancing self-shielding effects between the poisoned (Hf and Gd) and standard UO₂ assemblies, give rise to small differences between the deterministic (APOLLO2/CRONOS2) and probabilistic calculation routes (less than 100 pcm).

The development of an advanced Monte-Carlo calculation route is under way to cover a wide range of reactor applications (PWR and all the French experimental facility including the new Material Testing Reactor RJH) and help deterministic code users for error analysis. In particular, the same GUI software could be advantageously adapted to the validation of depletion calculations (by an iterative process which consists in getting for each step the cross-sections and performing Monte-Carlo flux calculation).