Post-doctoral position

IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Monte-Carlo propagation of nuclear data uncertainties in depletion calculations using Random sampling methods

Location:	IRSN Fontenay-aux-Roses, France
Unit:	Laboratoire de Neutronique (LN) - Service de Neutronique et des risques de Criticité (SNC)
Duration:	1 year
Starting date:	June 2023

About IRSN:
IRSN, a public industrial and commercial establishment - whose missions are defined by Law n° 2015-992 of August 17th, 2015, is the national public expert on nuclear and radiological risks. IRSN contributes to public policies on nuclear safety and on the protection of health and environment from ionizing radiations. As a research and expert organization, it acts in consultation with all the partners concerned by these policies, while ensuring its independence of judgment.

About the team:
The Neutronics Laboratory (LN), within the Neutronics and Criticality Risks Department (SNC), is made up of a team of about twenty researchers. You will be joining a young and dynamic team, which operates in a very good atmosphere.

Missions:
The LN works on the optimization and improvement of calculation tools and methods relating to neutron simulations for safety assessment studies of nuclear installations and transport. In this respect, the laboratory is also involved in the processing of nuclear data and the quantification of the uncertainty due to nuclear data, in particular for criticality and reactor safety studies. In order to validate neutronics calculation schemes associated to a nuclear data library, it is necessary to quantify one of the major sources of uncertainties, i.e. the uncertainties on nuclear data. Nevertheless, they are still rarely taken into account in the results of burn-up calculations performed for reactor applications and burn-up credit, i.e. when the fuel nuclear materials change under irradiation. Indeed, if tools exist to propagate nuclear data uncertainty for static criticality applications, the complexity increases as soon as one wishes to evaluate it during irradiation. The LN is also involved in the NEEDS *program (Nucléaire : Énergie, Environnement, Déchets, Société)*, together with the CNRS and the CEA, and co-pilots the structuring project SUDEC (Sensitivity Uncertainty comparison for DEpletion Calculations). Axis 1 concerns the calculation of the uncertainty due to nuclear data on the infinite multiplication factor, or k_{inf}, of a depleted fuel rod, as well as on depleted fuel inventories. The results of the various participants show discrepancies that must be investigated. They have been obtained on a common calculational benchmark using different types of calculation codes and nuclear data uncertainty propagation methods (Monte-Carlo or perturbation theory). At IRSN, Monte-Carlo methodologies for uncertainty propagation (random sampling) are currently being studied, with a reference depletion Monte-Carlo code, VESTA 2.2, but they must be consolidated and validated. CEA is developing the neutron transport Monte-Carlo code TRIPOLI-4® coupled with the evolution solver MENDEL which makes it possible to obtain reference solutions for inventory calculations. Nevertheless, if errors induced by the classical approximations of depletion calculations are being studied in TRIPOLI-4®, the propagation of nuclear data uncertainties within depletion calculations has not been explored via this tool. It therefore appears interesting for IRSN and CEA to compare their results of uncertainties due to nuclear data, via the VESTA and TRIPOLI-4® depletion codes, by exploring the so-called “random sampling" propagation path.

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Description:
The objective of this work is to carry out a comparative study, between VESTA and TRIPOLI-4®, of the nuclear data uncertainty obtained on quantities of interest in depletion calculations, after a first comparative study between the two codes on these same quantities of interest (k_{inf} and isotopic compositions of criticality-safety nuclides)

The work consist of 3 axes:

1/ The first axis consists in comparing the outputs between VESTA and TRIPOLI-4® depletion calculations, for simple PWR configurations (fuel pin and fuel assembly). The discrepancies will be analyzed with regard to the multiple options used by the two codes.

2/ The second axis consists in comparing the impact of the use of different nuclear data evaluations in the depletion calculations. Depending on the evaluations available in the two institutes, five or six evaluations could be used, including the two latest one: JEFF-3.3 and ENDF/B-VIII.0. The comparison, for each isotope, between the "discrepancies between evaluation" approach and the "propagation of nuclear data uncertainties" approach, performed in the third axis, appears indeed interesting.

3/ The third axis consists in the uncertainty propagation within VESTA and TRIPOLI-4® calculations. The uncertainties due to the nuclear data (cross sections, nu-bar and fission yields) will be propagate using the random sampling method in the ranges of uncertainties given by the nuclear data covariance matrices. The propagation will be performed on the PWR fuel rod configuration used in the previous steps 1 and 2, on the integral parameters of interest: k_{inf} and isotopic compositions of criticality-safety nuclides. The work will be carried out using the same nuclear data evaluation and the same covariance matrix. A global sampling of all data will be performed, with the aim of having an estimate of the maximal uncertainty on the k_{inf}, as well as on the selected isotopes, in both codes.

Candidate requirements:
Knowledge in Monte-Carlo codes and depletion calculations as well as in nuclear data will be appreciated. Skills in computer tools, numerical simulations, and Python programming, are essential.

The post-doctoral fellow will develop an in-depth knowledge of the depletion Monte Carlo modelling, the approximations performed in both codes, and the ways to progress towards reference solutions. He will also develop important knowledge in the field of uncertainties in nuclear data. This subject will lead to scientific publications.

The post-doctoral fellow will be supervised by a specialist in Monte-Carlo calculations and nuclear data from the IRSN's Neutronics and Criticality Risk Department (SNC, IRSN Fontenay-aux-roses) and a support will be provided by a specialist of fuel cycle quantities and nuclear data calculations from the CEA's Reactor and Cycle Study Department (SPRC, CEA Cadarache).

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