Propagation of $^{235,236,238}$U and $^{239}$Pu nuclear data uncertainties for a typical PWR assembly

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We need to assess the impact of realistic nuclear data uncertainties on different reactor and fuel parameters. Fission yields and decay data need to be considered together with transport data. As an example, a simple system is selected for the propagation of:

① Transport data covariances,

② Fission yield uncertainties and

③ Decay data uncertainties.

Method:

☞ Monte Carlo transport and depletion code SERPENT,

☞ Uncertainty propagation with the Total Monte Carlo (TMC) method,

☞ Reactivity swing, inventory and radiotoxicity studied.
Advantages of the method

😊 SERPENT has using a unique source of nuclear data for the whole chain of calculations,
(no hidden link, no separation between ”transport data” and ”decay data”...)

😊 TMC becomes straightforward,
(a single line to change to randomize the nuclear data)

😊 A single processing tool is required: NJOY/ACE.

✌ No complicated processing

✌ No covariance files needed

✌ Fast, reproducible, but need computer time (cheap compared to human time)
PWR fuel assembly model

Based on a Westinghouse 3-loop PWR-design, 4.8 % enrichment in $^{235}$U, rods of zirconium alloy, 17x17, 4 m in length and 21.5 cm in width, fuel temperature of 930 Kelvin, cladding and moderator at 590 Kelvin, constant boric acid concentration of 500 ppm.

Beginning of irradiation

Coolant in blue, depletion in the lattice is indicated by a darker color or rods

End of irradiation
Total Monte Carlo (TMC): based on the TALYS system

- **AutoTalys Tasman**
  - $n$ TANES input files
  - $n$ TALYS input files
  - $n$ TARES input files
  - $n$ TAFIS input files

- **TANES**
  - $n$ Fission Neutron Spect. output files

- **TALYS**
  - $n$ TALYS output files

- **TARES**
  - $n$ Resonance Parameters output files

- **TAFIS**
  - $n$ $\nu$-bar output files

- **TEFAL**

- **1 ENDF file + covariances**

- **$n \times$ ENDF random files**
Total Monte Carlo (TMC)

The TALYS system

- Optimum Search and find
- Original nuclear data library TENDL
- Library cloning
- Full covariances for perturbation methods
- Uncertainty propagation
- Total Monte Carlo

5000 random Talys parameter sets
5000 random resonance parameter sets

Average to get full covariance matrix MF-32,33,34

5000 random ENDF-6 files
NJOY → 5000 ACE files
5000 SERPENT calcs for the same case
In this work, nominal fission yields and uncertainties are taken from ENDF/B-VII.0 if they exist.

If not, nominal fission yields and uncertainties are taken from the Wahl systematics.
Results for the reactivity swing
Results for the inventory (at 50 GWd/tHM)

236U

238U

235U

239Pu
Results for the radiotoxicity

Uncertainties due to transport files
(random nuclear data before and after irradiation)

Uncertainties due to fission yields
(random nuclear data before and after irradiation)

Uncertainties due to decay data
(random nuclear data before and after irradiation)
Conclusions and Future improvements

- SERPENT model for a typical PWR fuel element + TMC method,
- Random transport data, fission yields and decay data for $^{235,236,238}\text{U}$ and $^{239}\text{Pu}$,
- Reactivity swing, inventory and radiotoxicity calculated,
- Decay data: no impact,
- Transport data and fission yields and significant impact,
- Fission yields should not be neglected and can contribute to a large extend some characteristics of the fuel cycle.