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Bayesian Monte Carlo for FY evaluation with GEF: example and plan

CRP on FY, videoconference, August 31-September 4, 2020

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Summary

- Background/recall
- Bayesian Monte Carlo with GEF
- Example for ^{235}U
- Plans for the CRP

- Acknowledgment: to K.H. Schmidt for the availability of the full GEF version

Background/recall

- No covariances in libraries, only uncertainties

- Users need covariances
- A few evaluation methods exists, leading to various results (see next slide with 2 examples)

- In the following, a Bayesian Monte Carlo method is proposed

- Original idea was presented in JEF/DOC-1681, and at the PND2 2014 conference at Bruyères-le-Châtel (A.J. Koning)

- Applied in NDS 139 (2017) 1, EPJ Web Conf. 146 (2017) 09023, PNE 101(2017) 486, ANE 95 (2016) 125

Background/recall

Table 3. Comparisons with the uncertainties presented in reference [26] for a PWR case, 4.1 wt.% enrichment, UO fuel, exposure of 40 MWd/tHM without cooling (case 1), and with reference [11] for a PWR case, 3.4% enrichment, UO fuel, exposure of 54 MWd/kgU, with 10 years cooling (case 2).

Isotope	Uncertainty (%)			
	Case 1		Case 2	
	[26]	This work	[11]	This work
^{234}U	–	1.8	2.4	2.1
^{235}U	1.0	1.4	3.3	2.7
^{236}U	1.5	1.6	1.5	1.6
^{239}Pu	2.0	2.3	2.9	2.6
^{240}Pu	1.9	2.3	2.5	2.2
^{241}Pu	2.7	1.7	2.7	2.1
^{242}Cm	2.2	2.7	–	3.6
^{244}Cm	8.5	9.7	9.6	9.1
^{90}Sr	5.0	0.7	1.5	0.7
^{99}Tc	9.5	1.3	10	1.5
^{129}I	13	2.5	–	2.9
^{137}Cs	1.7	7	4.0	6.2
^{148}Nd	14	0.4	0.4	0.4

EPJ Nuclear Sci. Technol. 4, 6 (2018)

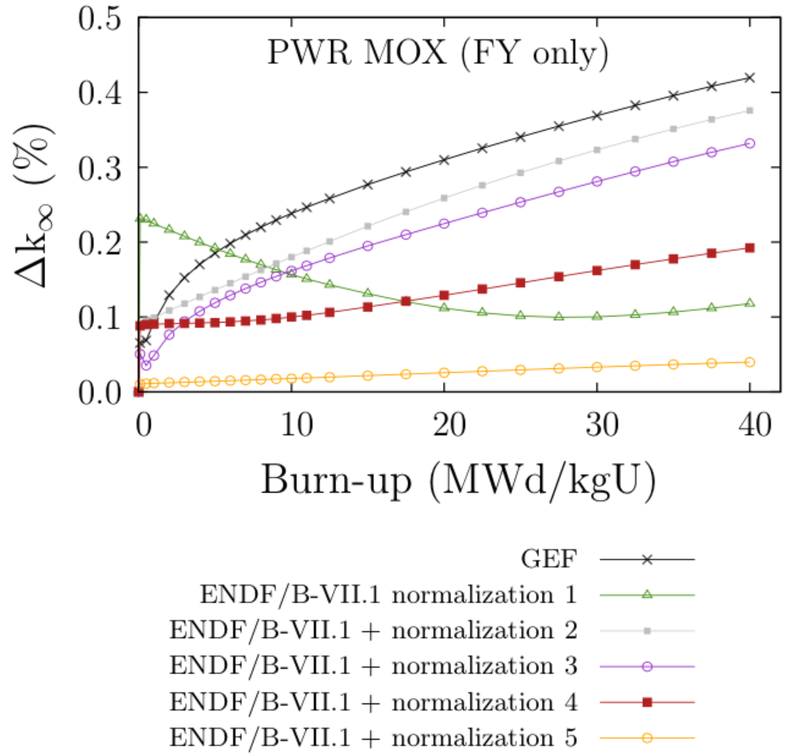


FIG. 25. (Color online) Uncertainty on k_∞ for the PWR MOX assembly due to the fission yields of ^{239,241}Pu and ^{235,238}U for different types of correlations and normalizations (see text). The number of groups for the CASMO-5 transport is 19.

Nucl. Data Sheets 139 (2017) 1

Bayesian Monte Carlo with GEF

- GEF can produce good quality fission yields (with covariances), bases on physical models and a limited set of parameters (as TALYS for cross sections)
- It is well suited for a Bayesian Monte Carlo (BMC) method defined as

BMC = TMC + feedback on parameter distributions

- The method is applied as follows:
  1. Select parameter distributions
  2. Produce random FY by sampling parameters
  3. Compare C and E
  4. Use weights (from C and E) to update parameters
  5. Repeat 2. to 4. until convergence

Example for ^{235}U

- BMC is applied here to the independent FY of ^{235}U at thermal energy
- Latest GEF (2020 V. 1.1 from K.H. Schmidt) is used

- Random FY are compared to 75 evaluated FY from ENDF/B-8.0
- 22 GEF parameters are used (Table 7 in the JEFF-Report 24)

- Normal and independent distributions, χ^2 defined as

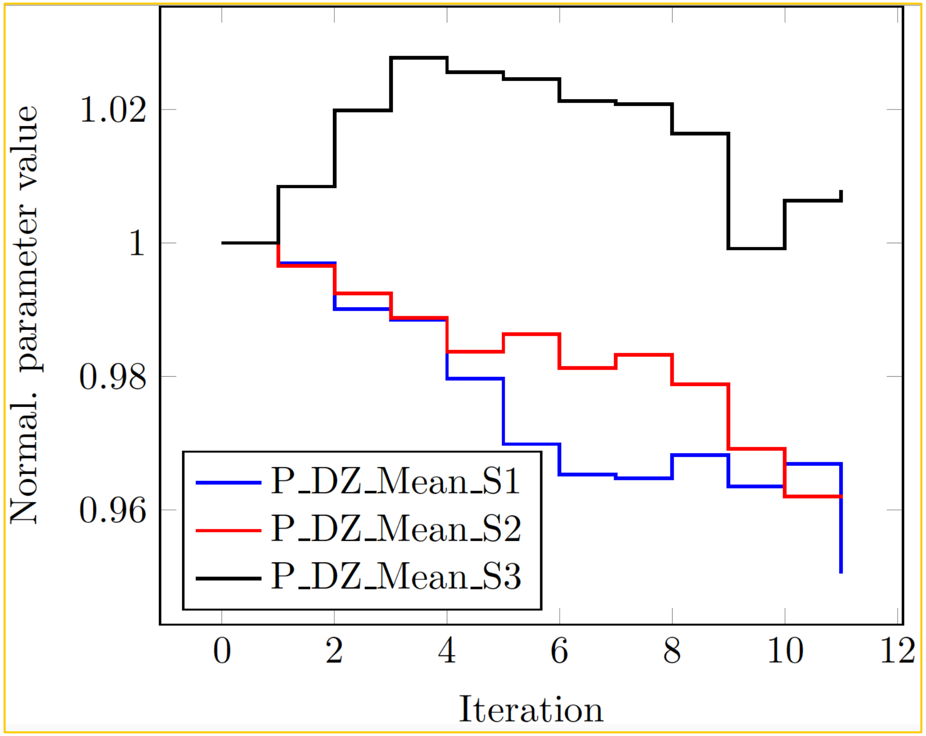
$$\chi^2 = \frac{1}{n_{FY}} \sum_{j=1}^{n_{FY}} \left(\frac{C_j^{(i)} - E_j}{\sqrt{\left(\Delta E_j{}^2 + \Delta C_j{}^2\right)}} \right)^2, \ i \text{ random calculation}$$

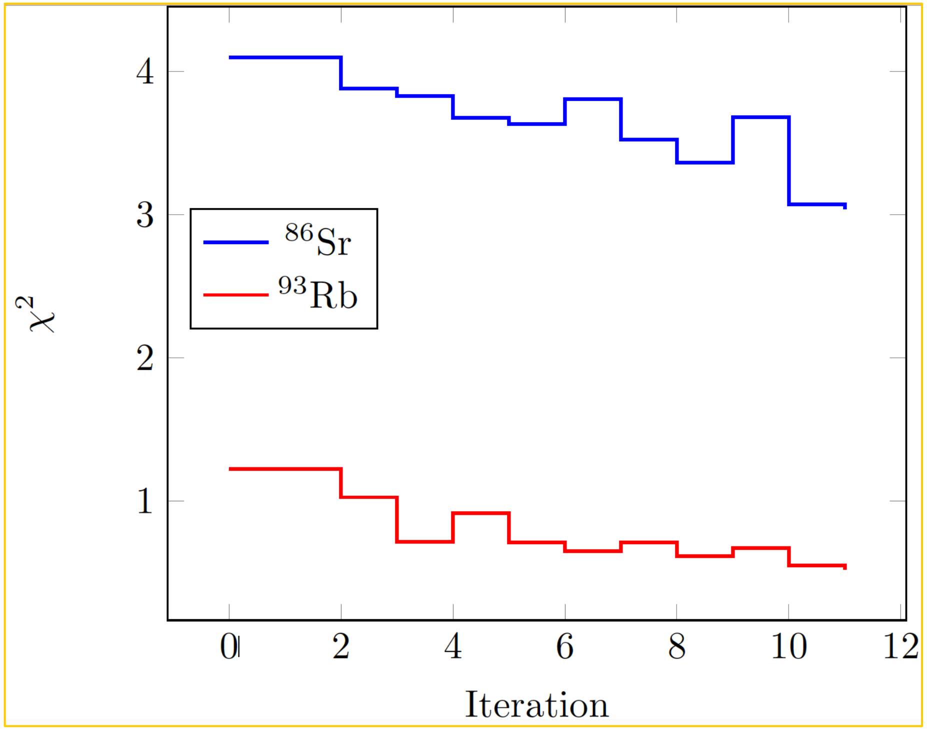
- Weights defined as

$$w_i = e^{-\chi^2/2}$$

Example for ^{235}U

- 11 iterations performed, 1500 random files / iteration
- 22 parameters updated





Plans for the CRP

- Apply the BMC approach to minor actinides

- Which actinides: to be decided during the CRP

- Which fission yields (measured, evaluated, independent, cumulative, all): to be decided during the CRP

- First possibility: targeting major actinides,
- Second possibility: targeting minor actinides (possibly a chain of actinides all together, e.g. all Cm) ?

- Which incident energy ?

Wir schaffen Wissen – heute für morgen