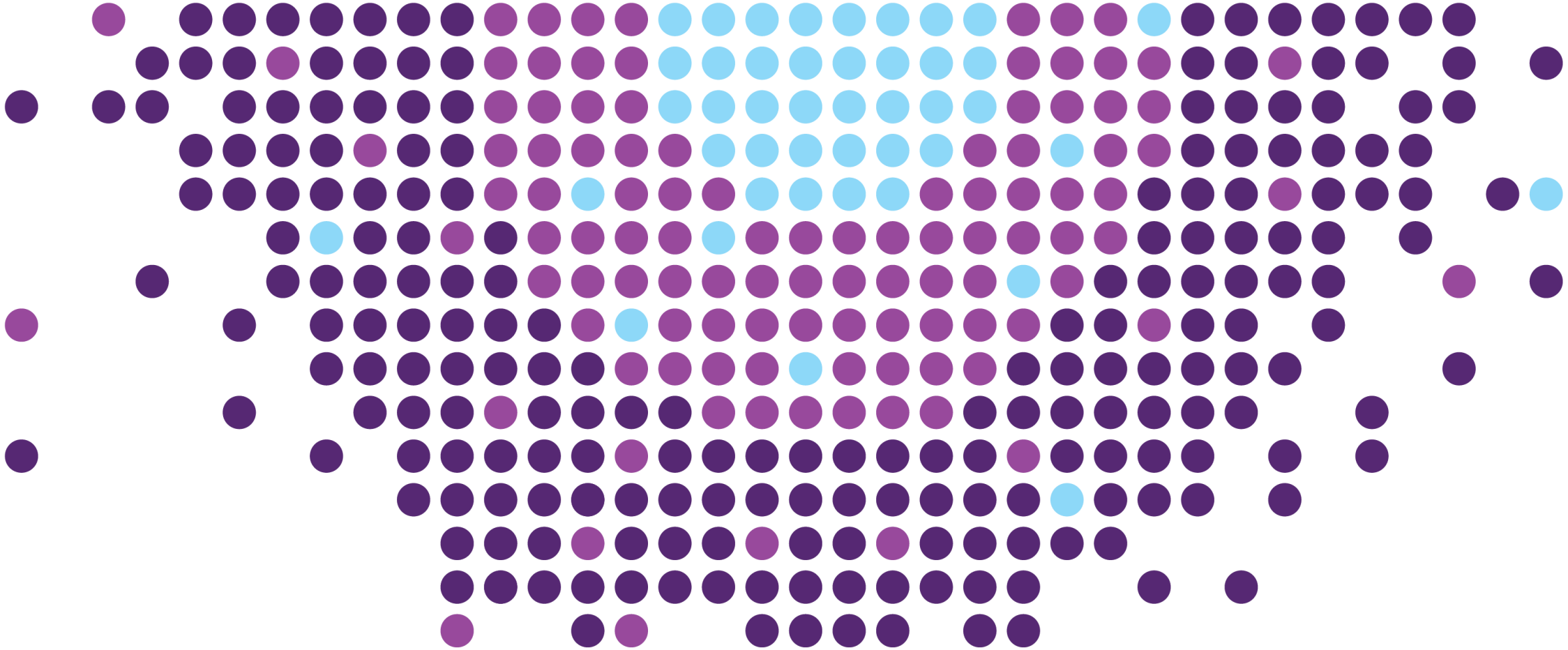

sck cen
Belgian Nuclear Research Centre

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Benchmarking of JENDL-5 and JEFF-4T2 in depletion calculations against isotopic inventories

1. Introduction

Validation of ALEPH Code by using experiments from MALIBU Program

ALEPH2

Burn-up code (Monte Carlo + Depletion module RADAU5)

Performs time evolution calculations

Developed in SCK CEN since 2004

Create reference models of the irradiated samples in ALEPH to simulate experiments conducted in MALIBU Program.

Compare isotopic inventory

Computational values (ALEPH) | Experimental values (PSI)

Validation of ALEPH for LWR cases

Variation of parameters and NDL to assess their impact on the model's performance

JENDL-5 | JEFF-4T2

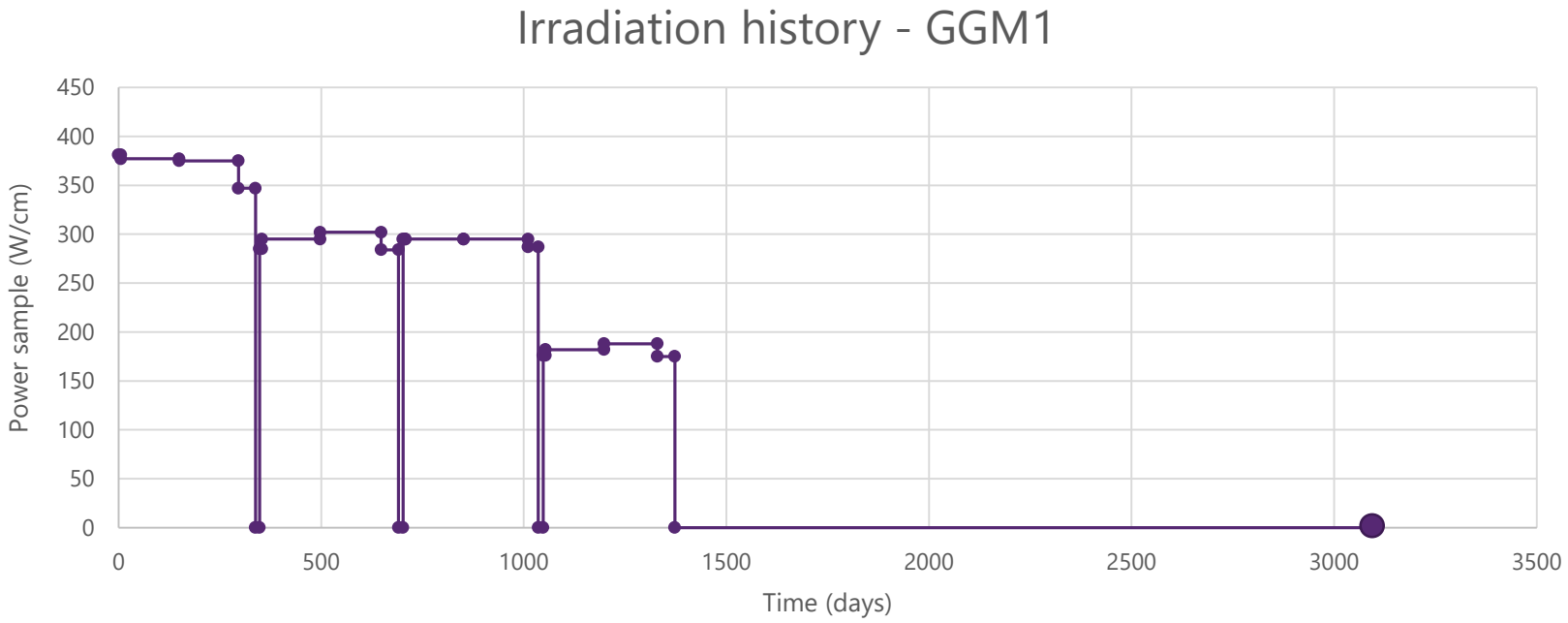
2. Evaluated model

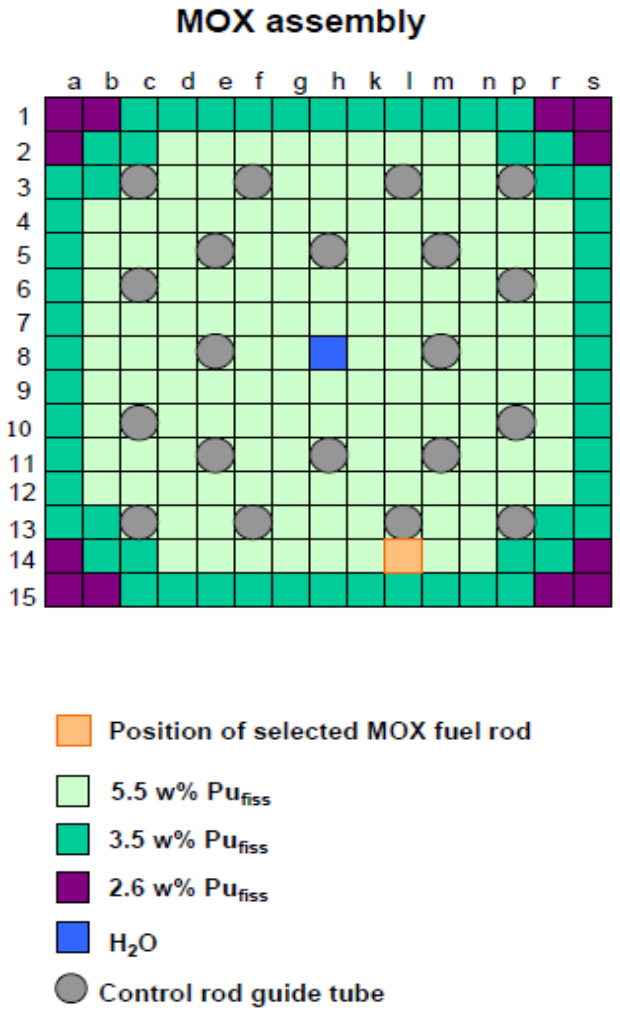
Sample selected for validation

GGM1 from Gösgen Reactor (PWR), measured by PSI Laboratory

GGM1: MOX sample

Burnup: 66.8 MWd/kgHM



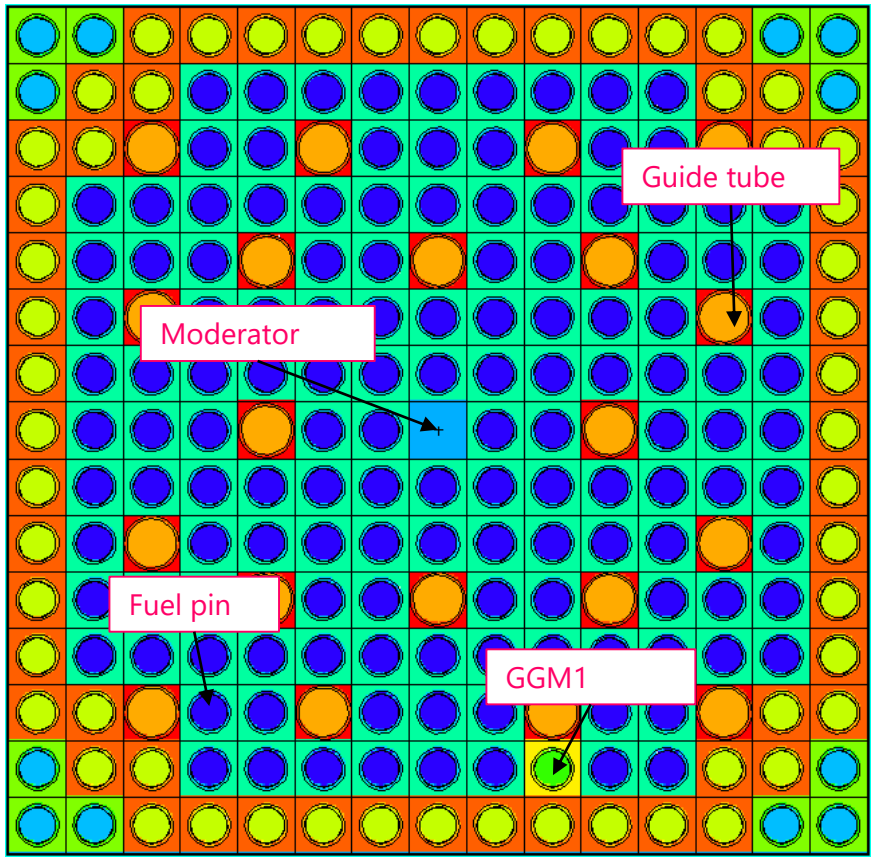


2. Evaluated model

Modelling a PWR fuel assembly

- 1 fuel assembly
- Variation of B with time
- Pu vector (%wt):
  - ^{238}Pu: 1.49
  - ^{239}Pu: 60.34
  - ^{240}Pu: 25.56
  - ^{241}Pu: 7.35
  - ^{242}Pu: 5.25
- $T_{mod}=T_{clad}=582K$
- $T_{fuel}=900K$
- Height = 1 cm
- Provided irradiation history
- Fuel pins depleted as 3 single materials
- NDL: JEFF-3.3, ENDF/B-VIII.0, JENDL-5, JEFF-4T2

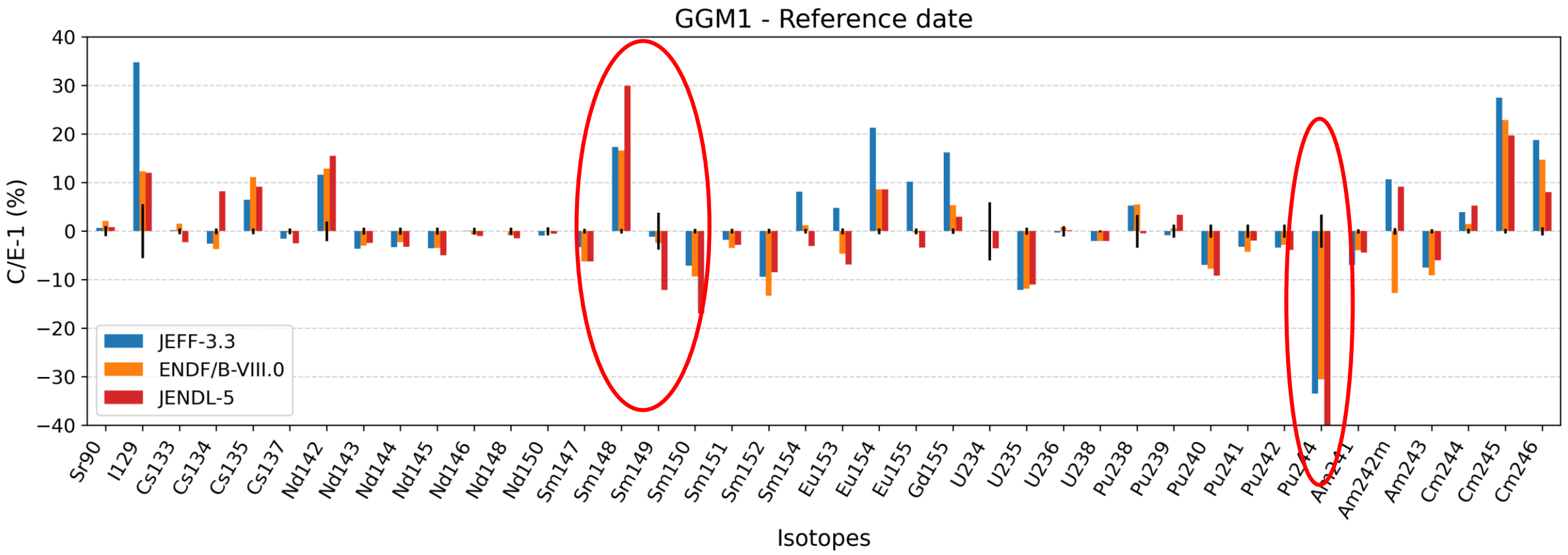
GGM1



3. Evaluation of JENDL-5 library

>0 → Overestimation of the nuclide concentration by ALEPH

Analyze the source of discrepancies for **^{244}Pu** and **Sm** isotopes



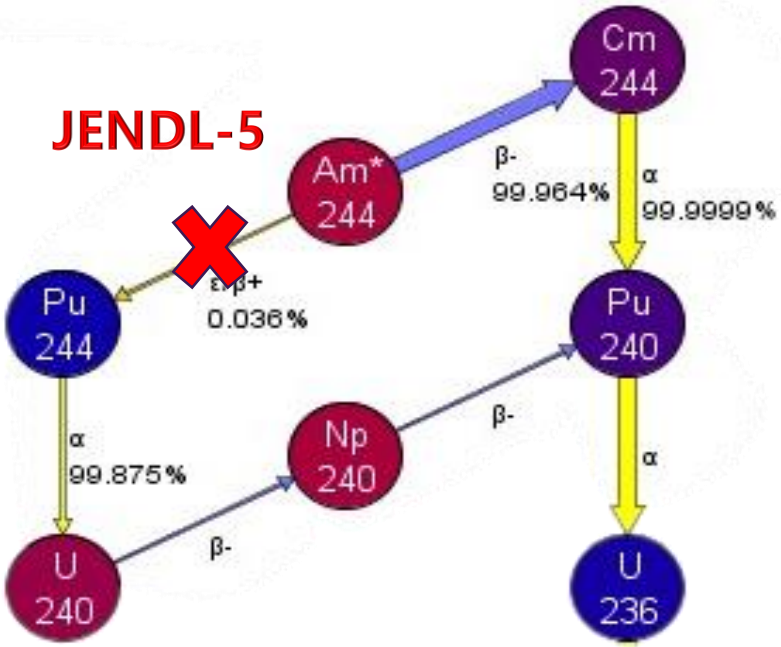
3. Evaluation of JENDL-5 library

^{244}Pu

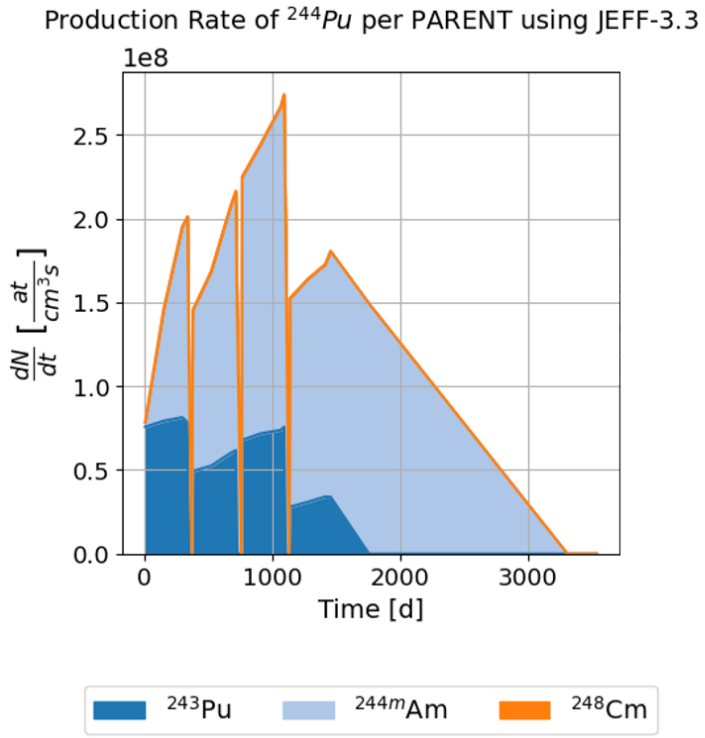
Production paths

$$^{243}\text{Pu} \xrightarrow{(n,\gamma)} {}^{244}\text{Pu}$$

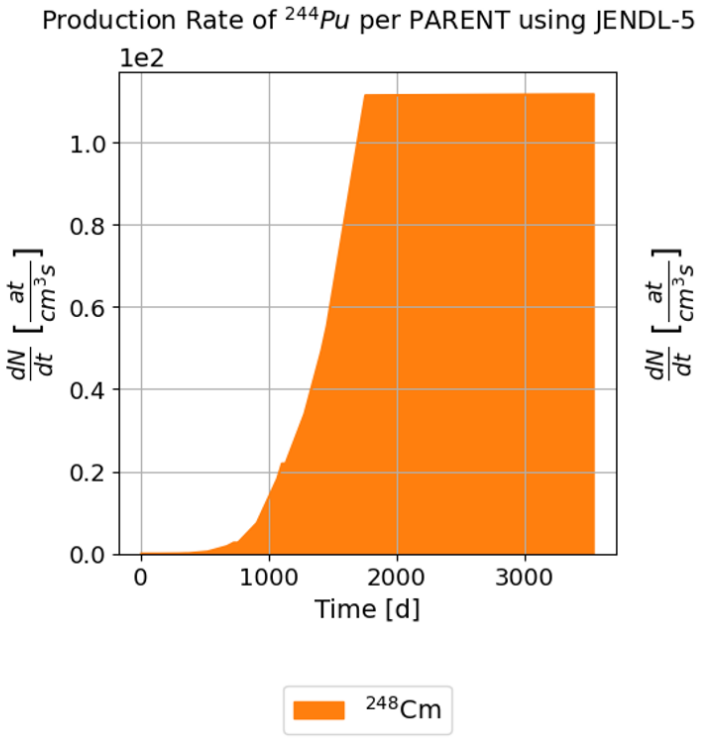
JEFF-3.3 Am244m decay path



JEFF-3.3



JENDL-5



Observations

- Main contributors to ^{244}Pu production (^{243}Pu and ^{244m}Am) not present in JENDL-5.
- 6 orders of magnitude of difference (negligible contribution of ^{248}Cm).
- Path of ^{244m}Am decay through β+/EC not contemplated in JENDL-5 (all decay path drives to ^{244}Cm).

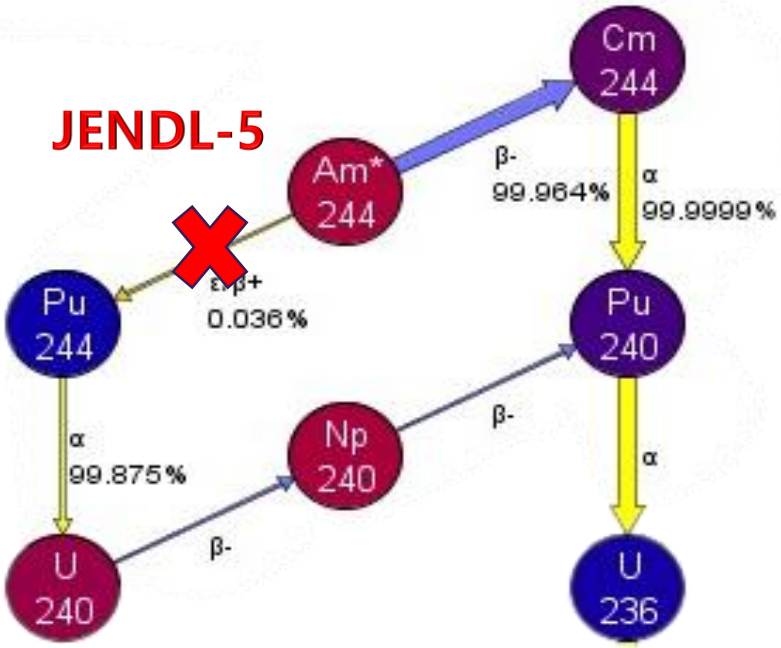
3. Evaluation of JENDL-5 library

^{244}Pu

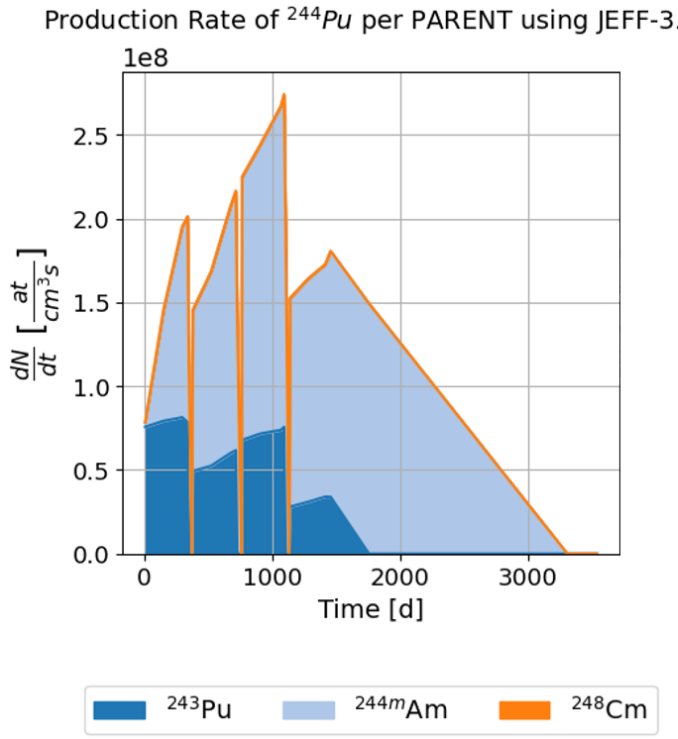
Production paths

$$^{243}\text{Pu} \xrightarrow{(n,\gamma)} {}^{244}\text{Pu}$$

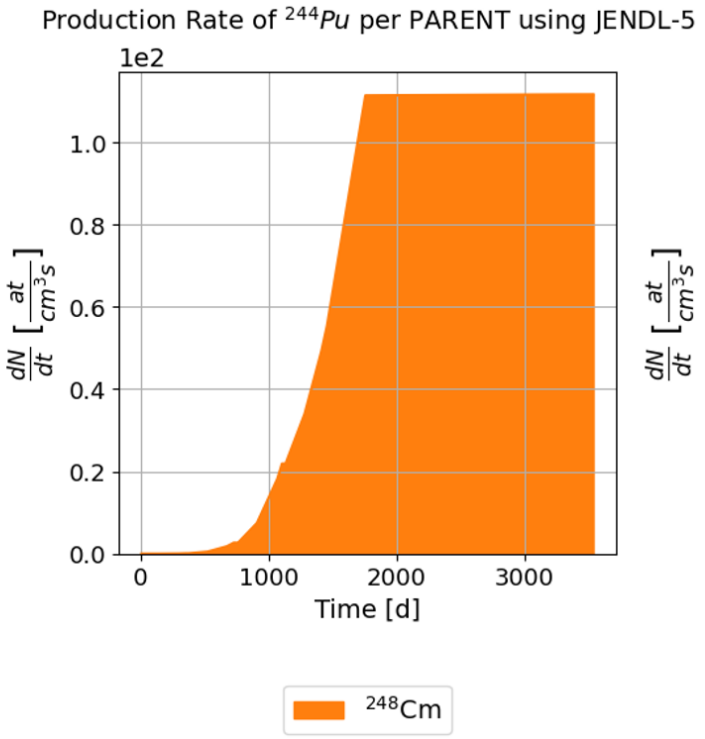
JEFF-3.3 Am244m decay path



JEFF-3.3



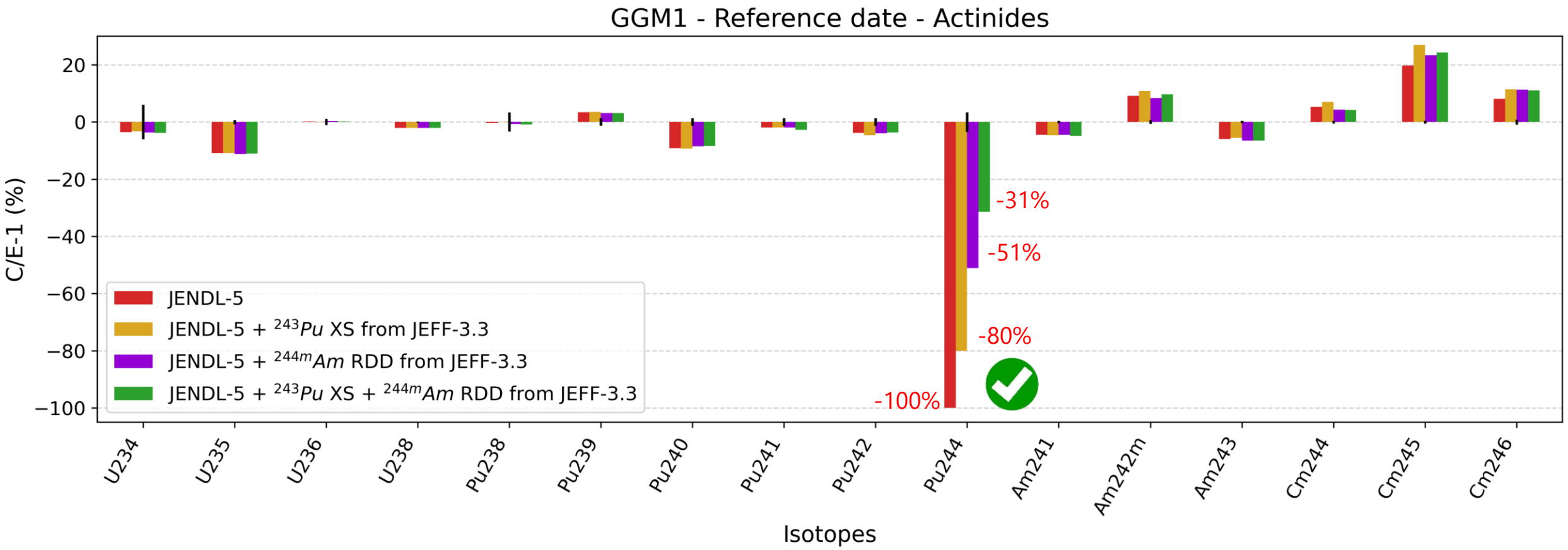
JENDL-5



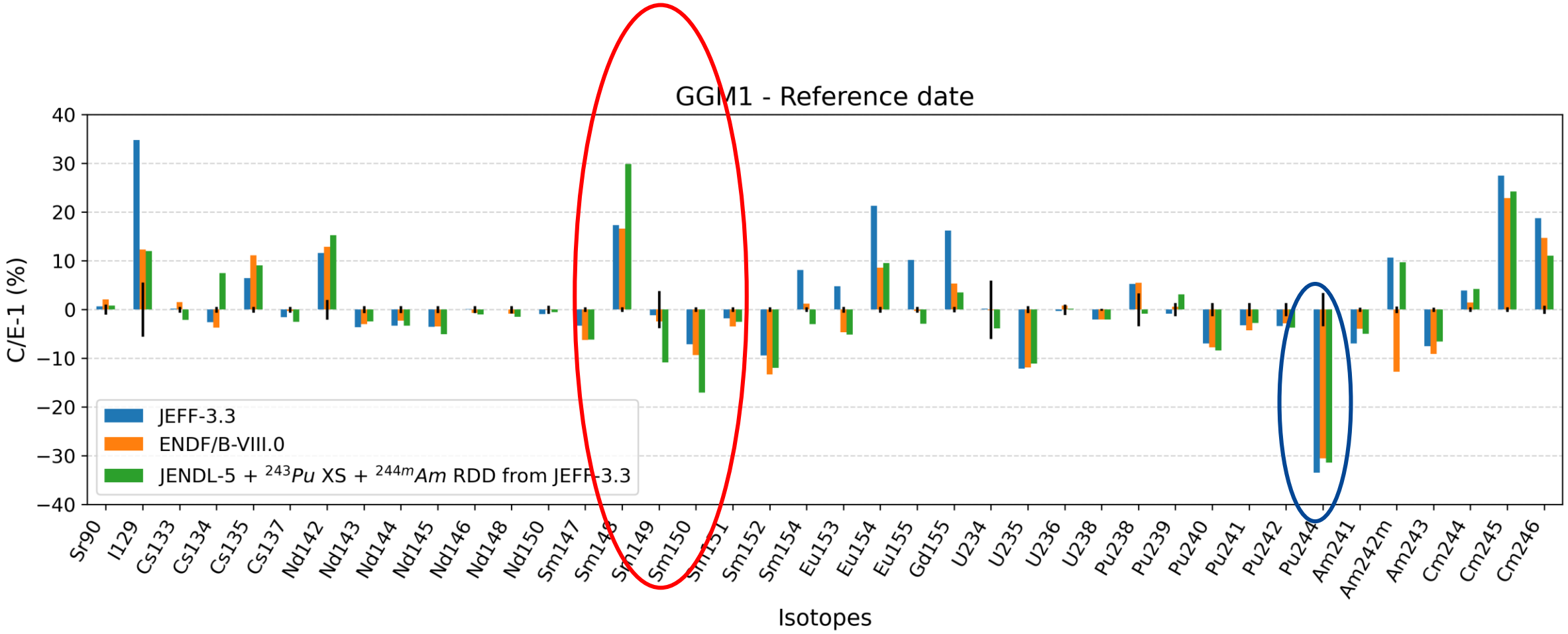
Origin of discrepancies

- Missing ^{243}Pu XS files in JENDL-5
- Missing ^{244m}Am RDD

Optimization of JENDL-5 for ^{244}Pu



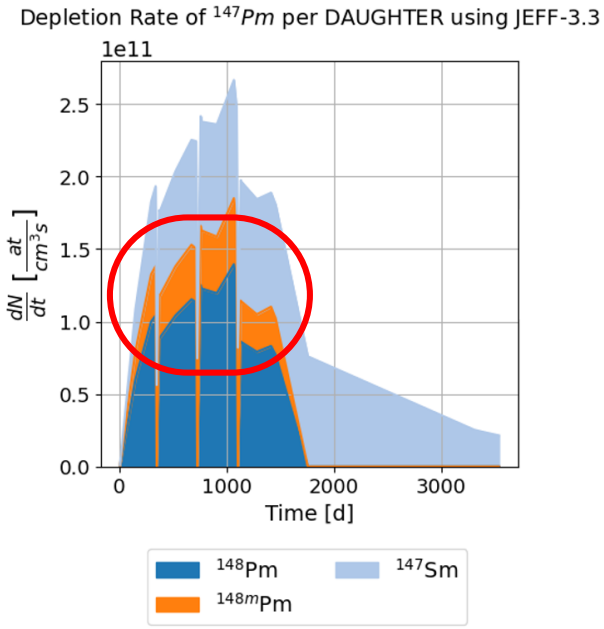
Optimization of JENDL-5 for ^{244}Pu



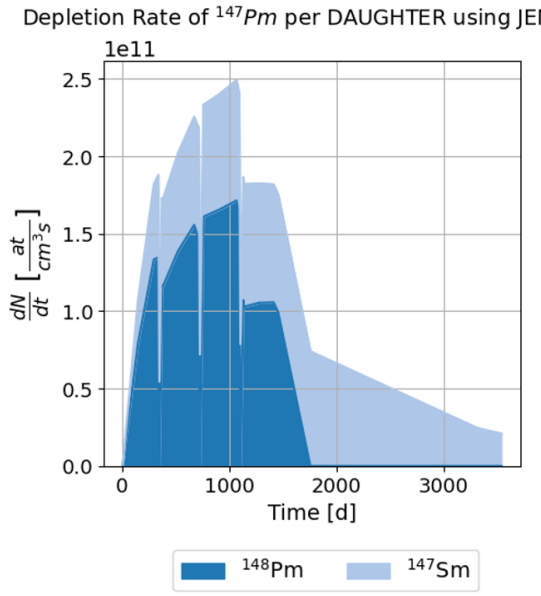
3. Evaluation of JENDL-5 library

Sm isotopes

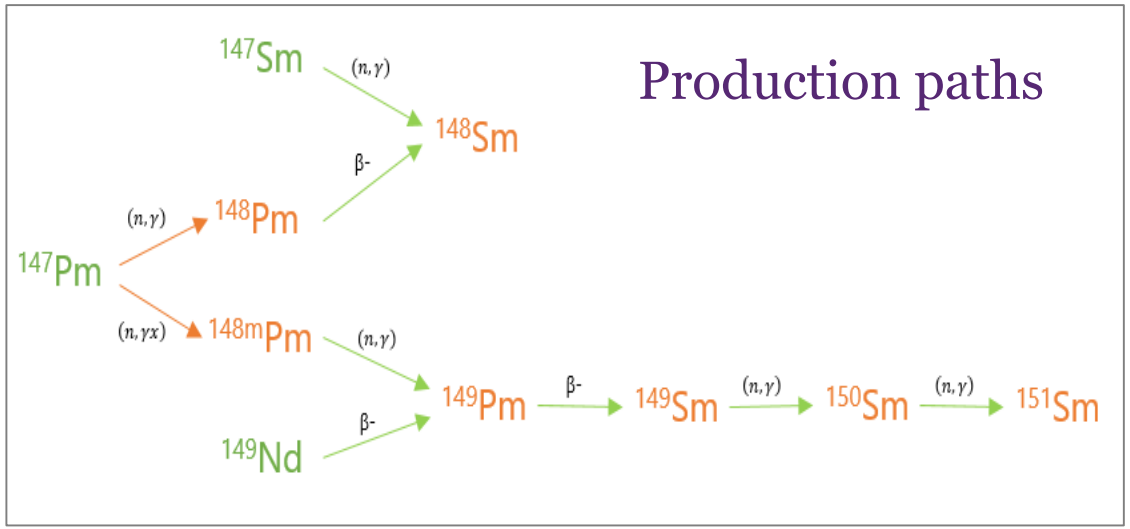
JEFF-3.3



JENDL-5



	n,g	n,gx	n,el	n,f	n,tot
JEFF33	3.02121e+01	9.86012e+00	2.93064e+01	0.00000e+00	7.07180e+01
JENDL5	4.08035e+01	0.00000e+00	3.46087e+01	0.00000e+00	7.64603e+01

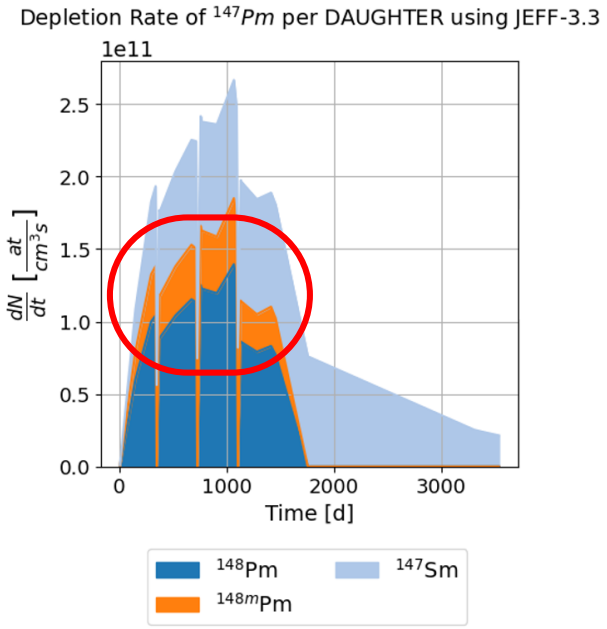


- Problems with ^{148}Sm,^{149}Sm and ^{150}Sm estimation with JENDL-5
- ^{148}Pm and ^{148m}Pm are mainly produced by captures of ^{147}Pm → Check ^{147}Pm one-group XS from ALEPH
- ^{147}Pm (n,gx) one-group XS is zero in JENDL-5

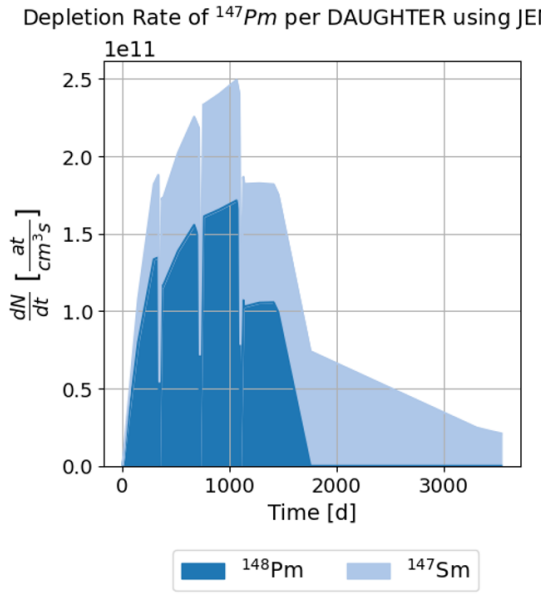
3. Evaluation of JENDL-5 library

Sm isotopes

JEFF-3.3



JENDL-5



	n,g	n,gx	n,el	n,f	n,tot
JEFF33	3.02121e+01	9.86012e+00	2.93064e+01	0.00000e+00	7.07180e+01
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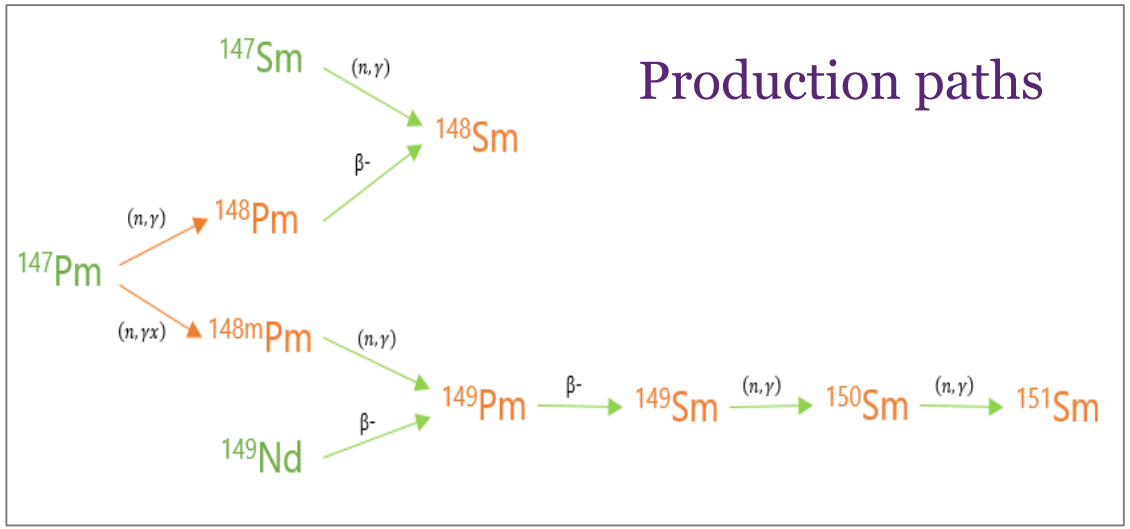

- Problems with ^{148}Sm,^{149}Sm and ^{150}Sm estimation with JENDL-5
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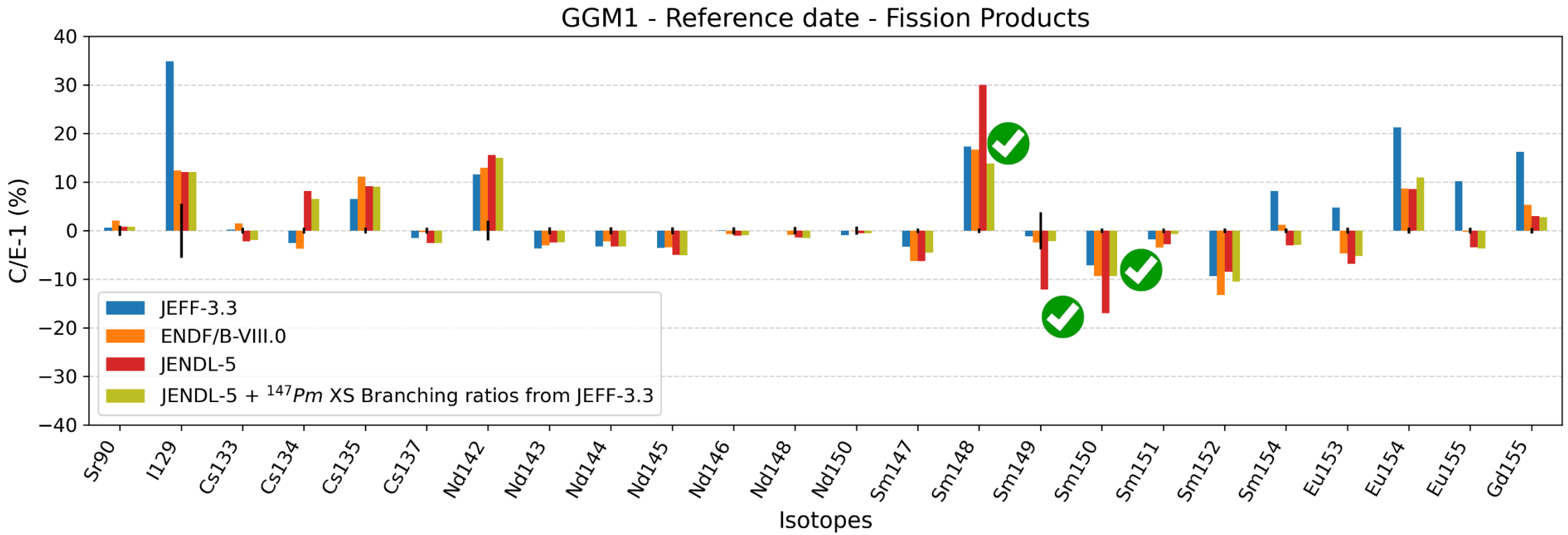
- ^{147}Pm (n,gx) one-group XS is zero in JENDL-5

Daughter	Parent	Reaction rates (at/cm³·s)	
		JEFF-3.3	JENDL-5
^{148}Pm	^{147}Pm	7.7129E+10	9.9259E+10
^{148m}Pm	^{147}Pm	2.5171E+10	0.0000E+0

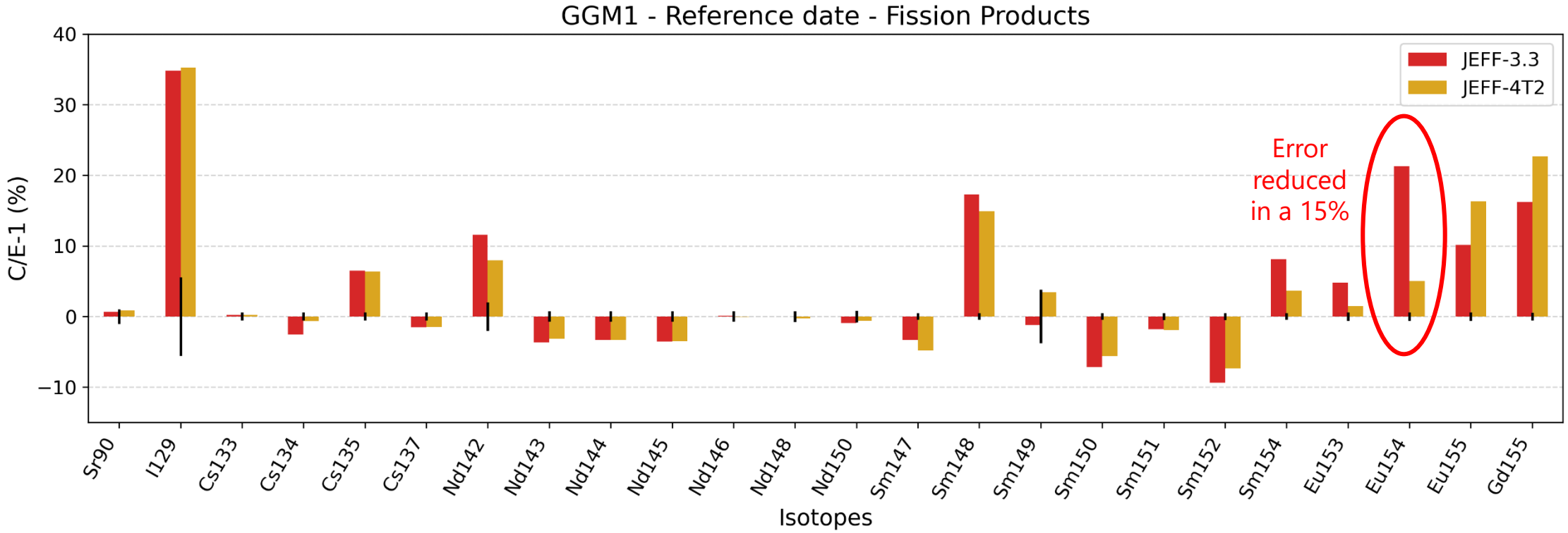
- Missing branching ratio for the production of meta-stable state of ^{148}Pm through radiative captures in ^{147}Pm

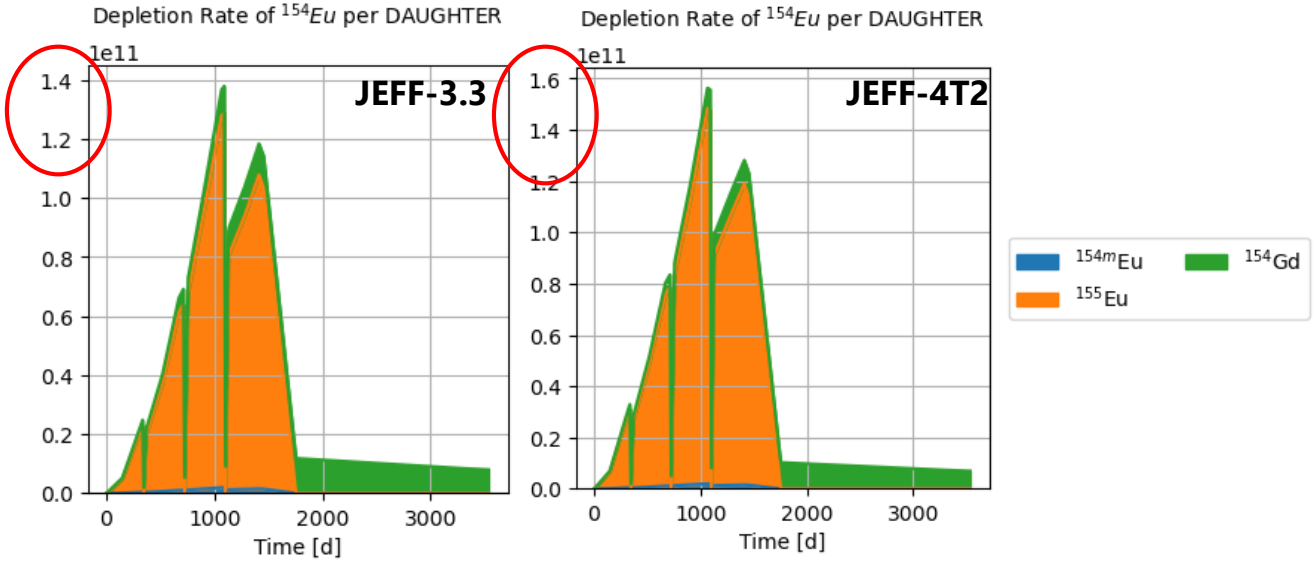
Optimization of JENDL-5 for Sm isotopes



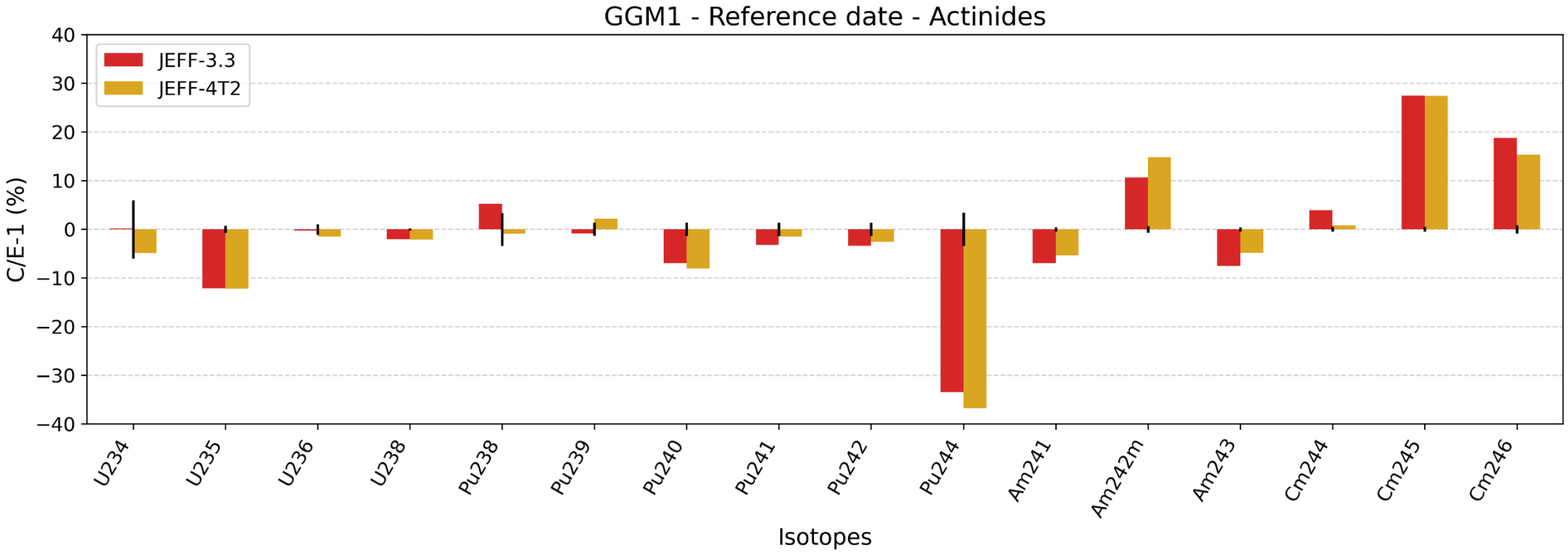
Isotopes	Relative error between PSI and ALEPH models (%)			
	JEFF-3.3	ENDF/B-VIII.0	JENDL-5	JENDL-5 with missing files from JEFF-3.3
Sm-148	+17.293	+16.643	+29.95	+13.827
Sm-149	-1.182	-2.479	-12.1235	-2.1735
Sm-150	-7.135	-9.358	-16.978	-9.362

4. Evaluation of JEFF-4T2 library



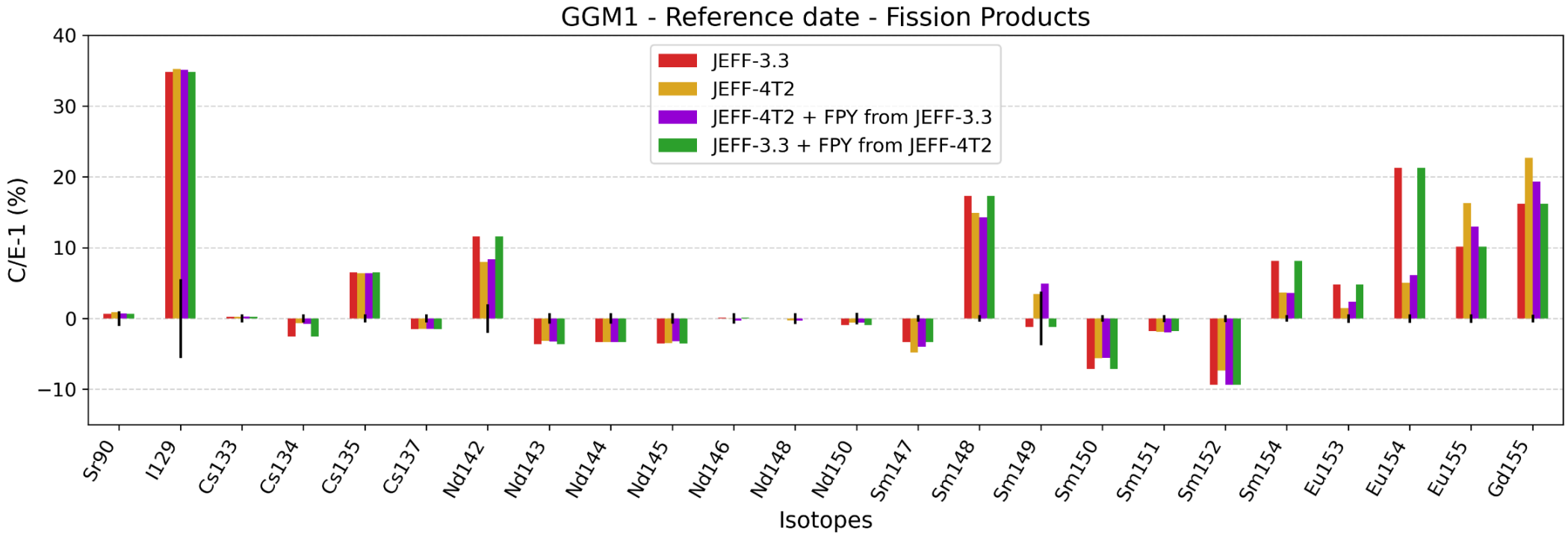


4. Evaluation of JEFF-4T2 library



Currently working on it

Impact of XS and FPY files



- Evolution of JEFF-4T2 (yellow) and JEFF-4T2 with FPY from JEFF-3.3 (purple) is very similar and the responsible of the biggest discrepancies among models → Differences come from XS files
- FPY does not have a real impact

3 Sources of discrepancies in JENDL-5

- The ^{244}Pu prediction by JENDL-5 can be improved by including files corresponding to:
  - ^{243}Pu neutron transport;
  - ^{244m}Am radioactive decay data.
- Discrepancies for Sm isotopes will be reduced with the inclusion of:
  - ^{147}Pm branching ratio for radiative capture.

Performance of JEFF-4T2

- Improvement on the results for MOX sample.
- Main effect by using XS from JEFF-4T2.

Evaluation exercises → ensure the accuracy and reliability of the information used in research and nuclear safety.