OAK RIDGE National Laboratory

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Impact of cross sections and fission yields uncertainties on fuel inventory for a molten salt fast reactor model

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Goal: Compare the effect of ENDF/B-VII.1 and ENDF/B-VIII.1 libraries on uncertainty determination for nuclides inventories in an MCFR model

Quantify the effect of the nuclear data library on the uncertainty in calculated nuclides concentrations for selected actinides and fission products

Basis for nuclear data impact analysis is a representative molten chloride fast reactor (MCFR) model, developed using simplified, publicly available specifications for TerraPower's molten chloride fast reactor-demonstration (MCFR-D) plant.

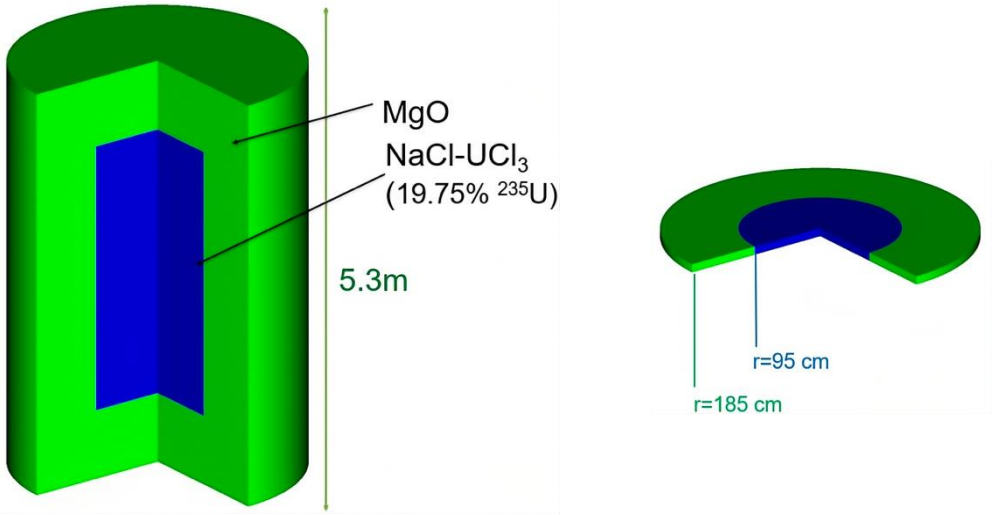
Cross section libraries considered:

ENDF/B-VII.1, ENDF/B-VIII.1

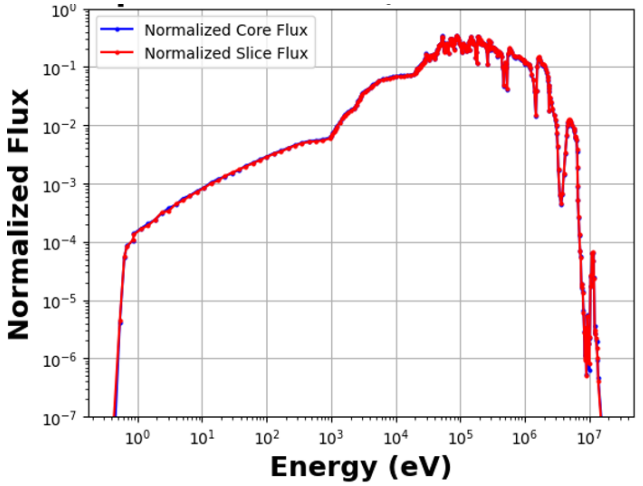
1) Reference for MCFR model used here: Rakim Hirji, Germina Procop, Rike Bostelmann, Rabab Elzohery (2025). Development of a Representative Molten Chloride Fast Reactor Model to Assess the Impact of Nuclear Data. In Proc. of Int. Conf. on Mathematics and Computational Methods Applied to Nuclear Science and Engineering (M&C2025), Denver, CO, USA.
2) Reference for uncertainties obtained with ENDF/B-VII.1: Germina Procop, Rike Bostelmann, Rabab Elzohery (2026). Nuclear Data Impact on Key Metrics for a Representative Molten Chloride Fast Reactor Model. Proc. of Int. Conf. on the Physics of Reactors (PHYSOR 2026), Turin, Italy, April 19-23.

Computational tools and associated nuclear data (SCALE 7.0)

Fuel depletion and decay simulations	**TRITON 1D** **(XSDRN + ORIGEN)** **302-gr cross sections**
Uncertainty quantification (random sampling approach)	**Sampler uncertainty quantification tool** 1,000 depletion runs for each perturbed ND set
Cases considered	**1) XS data only** **2) FPY data only** **3) XS + FPY**



SCALE 3D full core and axial slice models [Ref. 1].
Axial slice model used for depletion simulations here.



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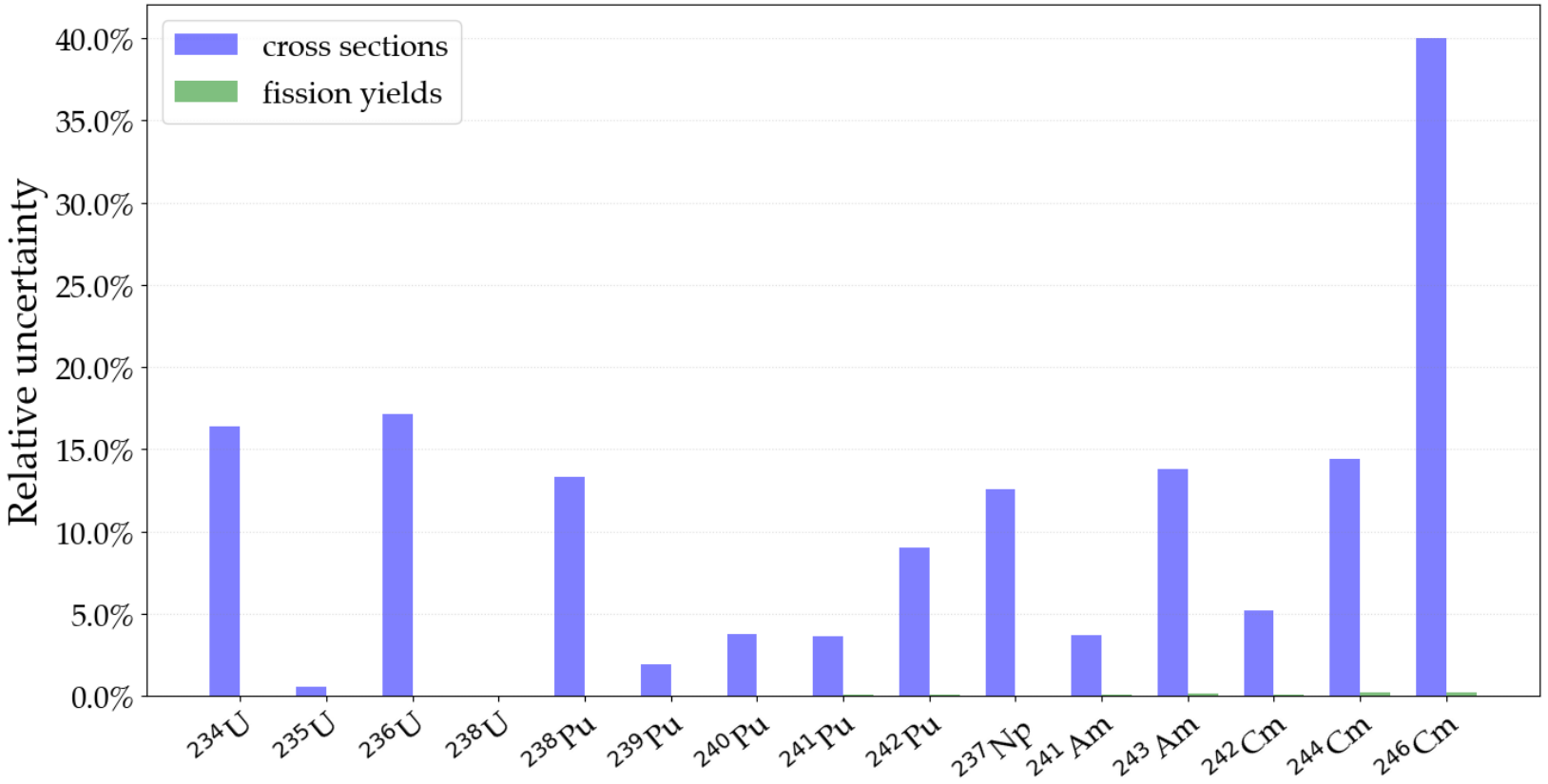
Uncertainties in calculated nuclide inventories for 5-yr irradiated fuel that result from uncertainties in cross section (XS) and fission product yield (FPY) data

ENDF/B-VII.1 results

ENDF/B-VII.1 : Effect of uncertainty in XS and FPY data on calculated actinides inventories



XS-induced uncertainty results:

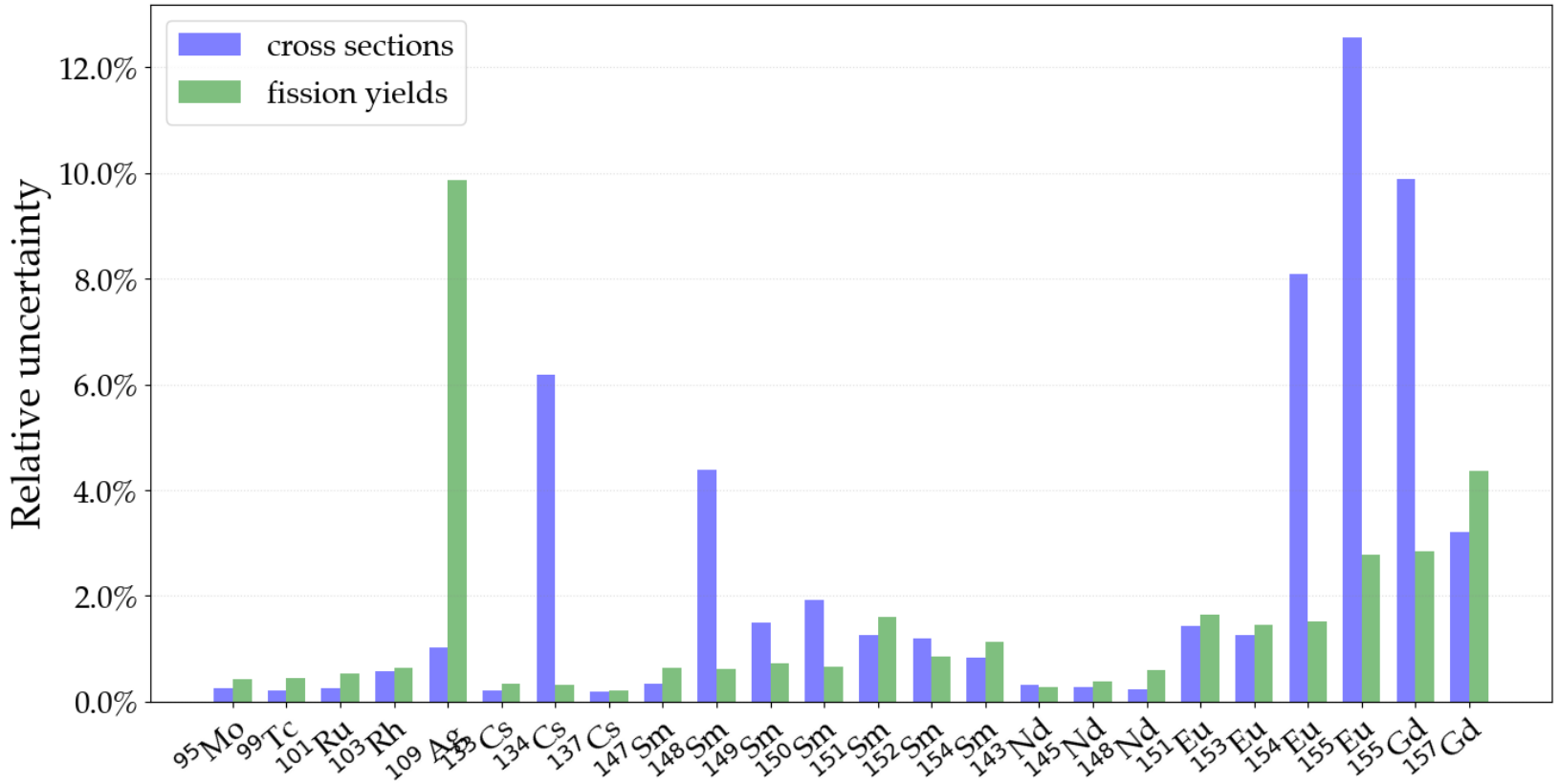
40% for **^{246}Cm**
13-17% for **^{234}U, ^{236}U, ^{237}Np, ^{238}Pu, ^{243}Am, ^{244}Cm**
5 – 9% for **^{244}Cm, ^{242}Pu**
1 - 5% for **^{239,240,241}Pu, ^{241}Am**
< 1% for **^{235,238}U**

FPY-induced uncertainty results:

< 0.2% for all considered actinides

Cross section uncertainties are major drivers for uncertainties of calculated actinide concentrations. No significant impact of fission yield uncertainties (< 0.2%).

ENDF/B-VII.1 : Effect of uncertainty in XS and FPY data on calculated FP inventories



XS-induced uncertainty results:

12.5% for ^{155}**Eu**
5 – 10% for ^{155}**Gd,** ^{154}**Eu,** ^{134}**Cs**
1 - 5% for ^{148,149,150,151,152}**Sm,** ^{109}**Ag,** ^{151,153}**Eu,** ^{157}**Gd**
< 1% for the other shown nuclides

FPY-induced uncertainty results:

~10% for ^{109}**Ag**
1-5% for $^{151, 153,154,155}$**Eu,**^{155,157}**Gd,** ^{151}**Sm**
< 1% for the other shown nuclides

Cross section uncertainties are major drivers for uncertainties of calculated FP concentrations for most of shown nuclides; notable exception ^{109}Ag

FPY-induced uncertainty >2% for ^{109}Ag,^{155}Eu,^{155,157}Gd

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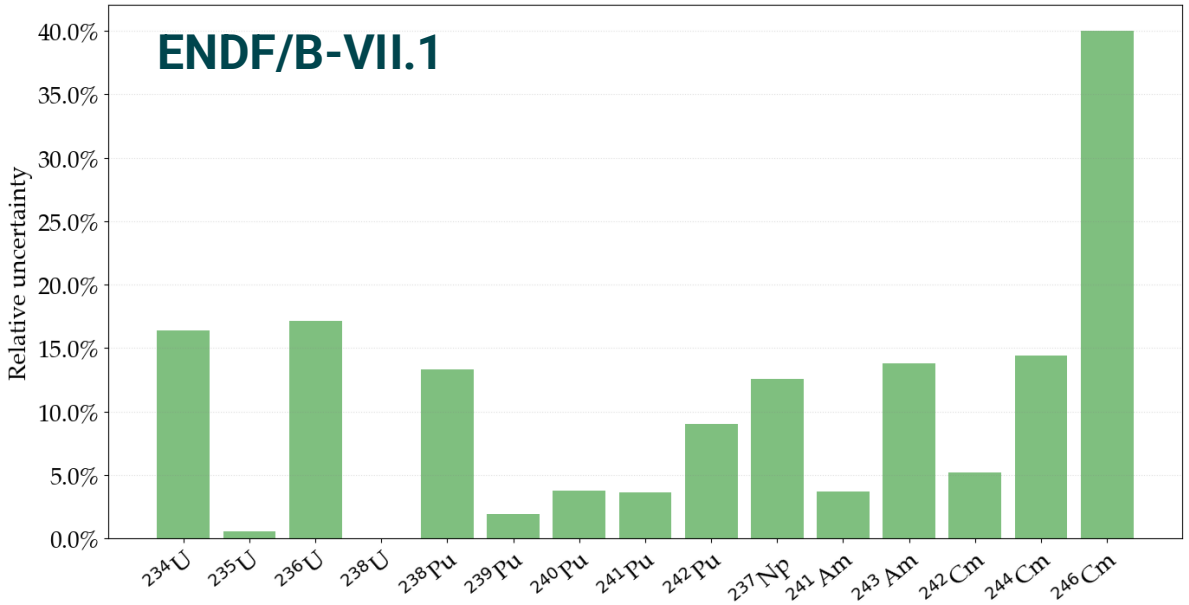
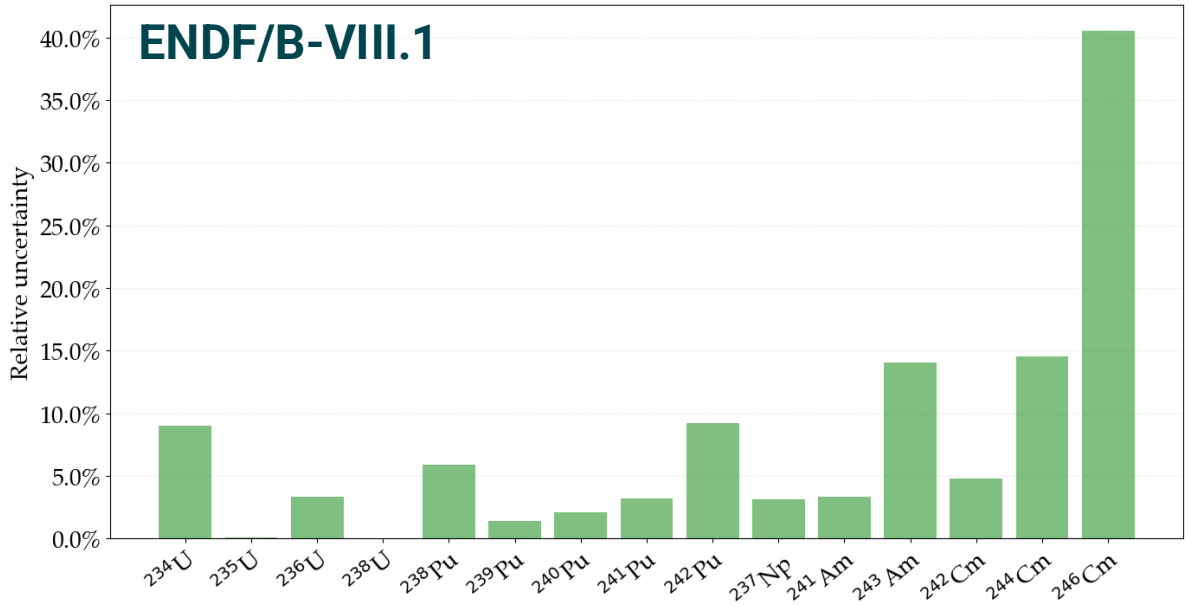
Uncertainties in calculated nuclide inventories for 5-yr irradiated fuel that result from uncertainties in cross section (XS) data

ENDF/B-VII.1 vs ENDF/B-VIII.1

ENDF/B-VII.1 vs ENDF/B-VIII.1: Effect of XS data uncertainty on uncertainties in calculated actinides inventories

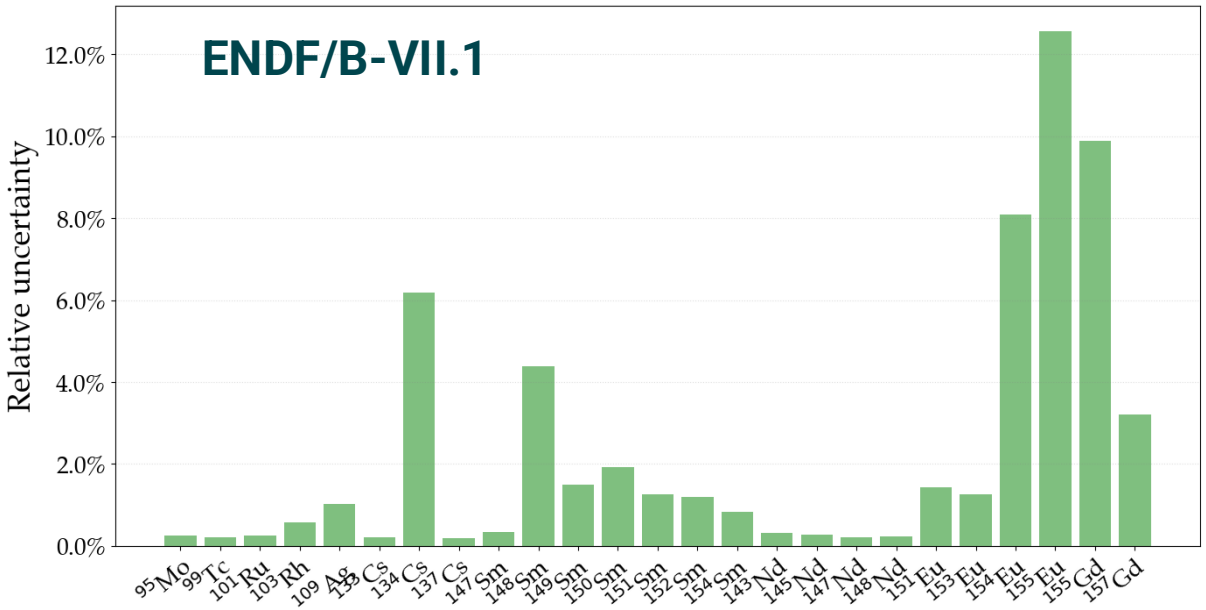


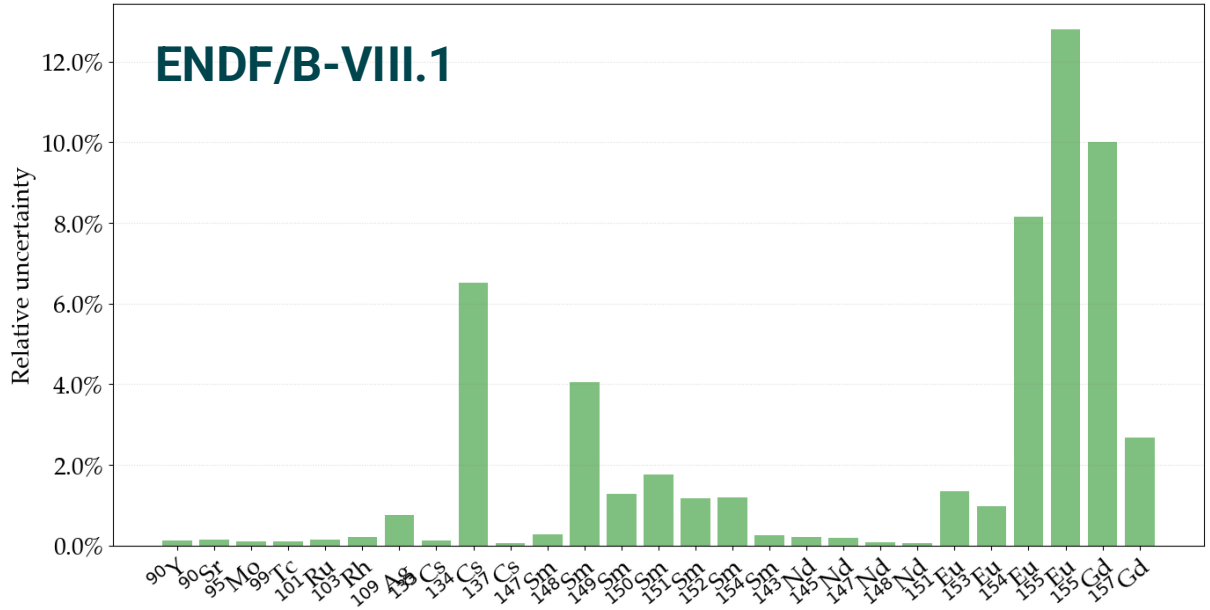


Significant improvement in uncertainty estimates with ENDF/B-VIII.1 compared to ENDF/B-VII.1: **-14%** for **^{236}U**, **-7%** for **^{234}U**, **-9%** for **^{237}Np**, **-8%** for **^{238}Pu**

Differences in uncertainty estimates are < 1% for the other shown actinides

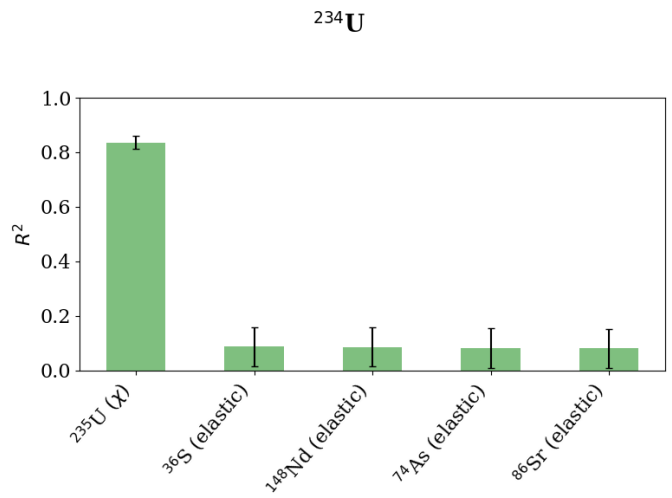
ENDF/B-VII.1 vs ENDF/B-VIII.1: Effect of XS data uncertainty on uncertainties in calculated fission products inventories

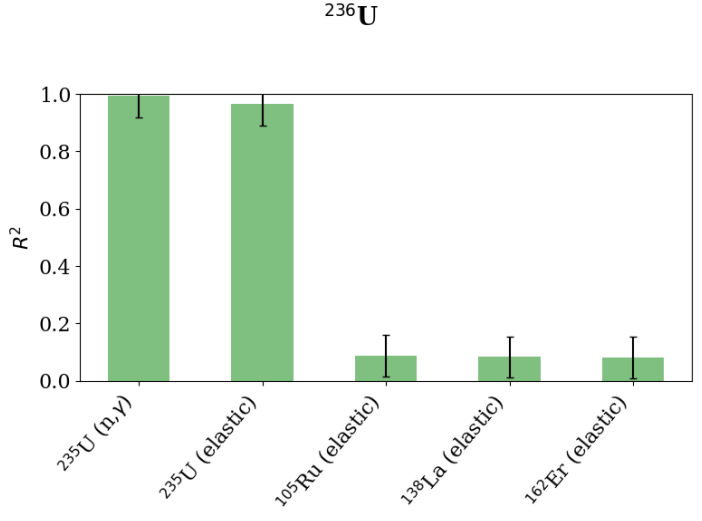


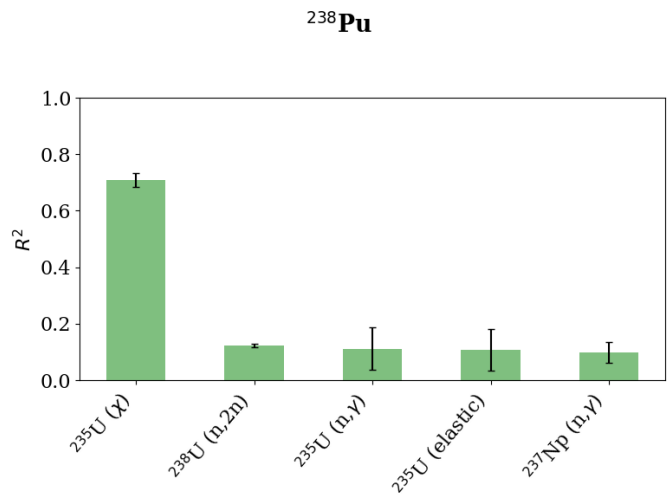


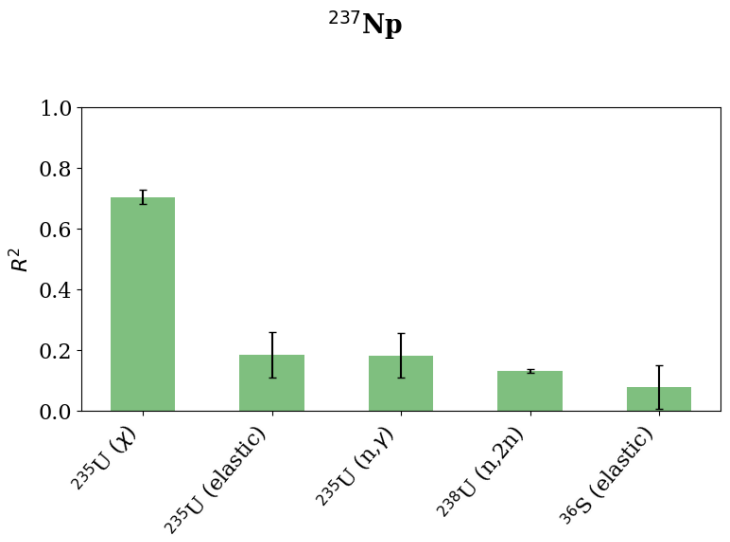
No significant differences in uncertainty estimates between ENDF/B-VIII.1 and ENDF/B-VII.1. Differences in estimates are < 0.6%.

Top contributors to XS-induced uncertainties in calculated inventories for the nuclides with significant differences observed (ENDF/B-VII.1 vs ENDF/B-VIII.1)









Top contributors to uncertainty estimated using the R^2 correlation index in SCALE/Sampler with ENDF/B-VII.1 XS are:

^{235}U (n,γ) for ^{236}U

^{235}U (χ) for ^{237}Np, ^{238}Pu and ^{234}U

Summary of observations

Change in the cross-section library can have an important effect on the XS-induced uncertainty for calculated nuclides inventories

ENDF/B-VIII.1 vs ENDF/B-VII.1

uncertainty reduction

-14% for ^{236}U, -9% for ^{237}Np

-7% for ^{234}U and ^{238}Pu

The XS-induced uncertainties for these nuclides are driven by ^{235}U(n,γ) and ^{235}U (χ) uncertainties for ENDF/B-VII.1

Uncertainties in actinides and FP inventories are driven by XS uncertainties. No significant impact of FY uncertainties on actinides, important effect on selected FPs inventories.

Top XS-induced uncertainties for actinides inventories*

40% for ^{246}Cm

14% for ^{243}Am, ^{244}Cm

5-10% for ^{238,242}Pu

1-5% for ^{236}U, ^{239,240,241}Pu, ^{237}Np, ^{241}Am

Top XS-induced uncertainties for fission products inventories*

13% for ^{155}Eu, 10% for ^{155}Gd

8% for ^{154}Eu, 6% for ^{134}Cs

*Results shown correspond to ENDF/B-VIII.1.

Acknowledgments

Work presented here was supported by funding from the US Department of Energy, Office of Science, Nuclear Data Program.

Questions ?

Middle TN state parks house spectacular caves and rock houses. Honey Creek Loop Trail.