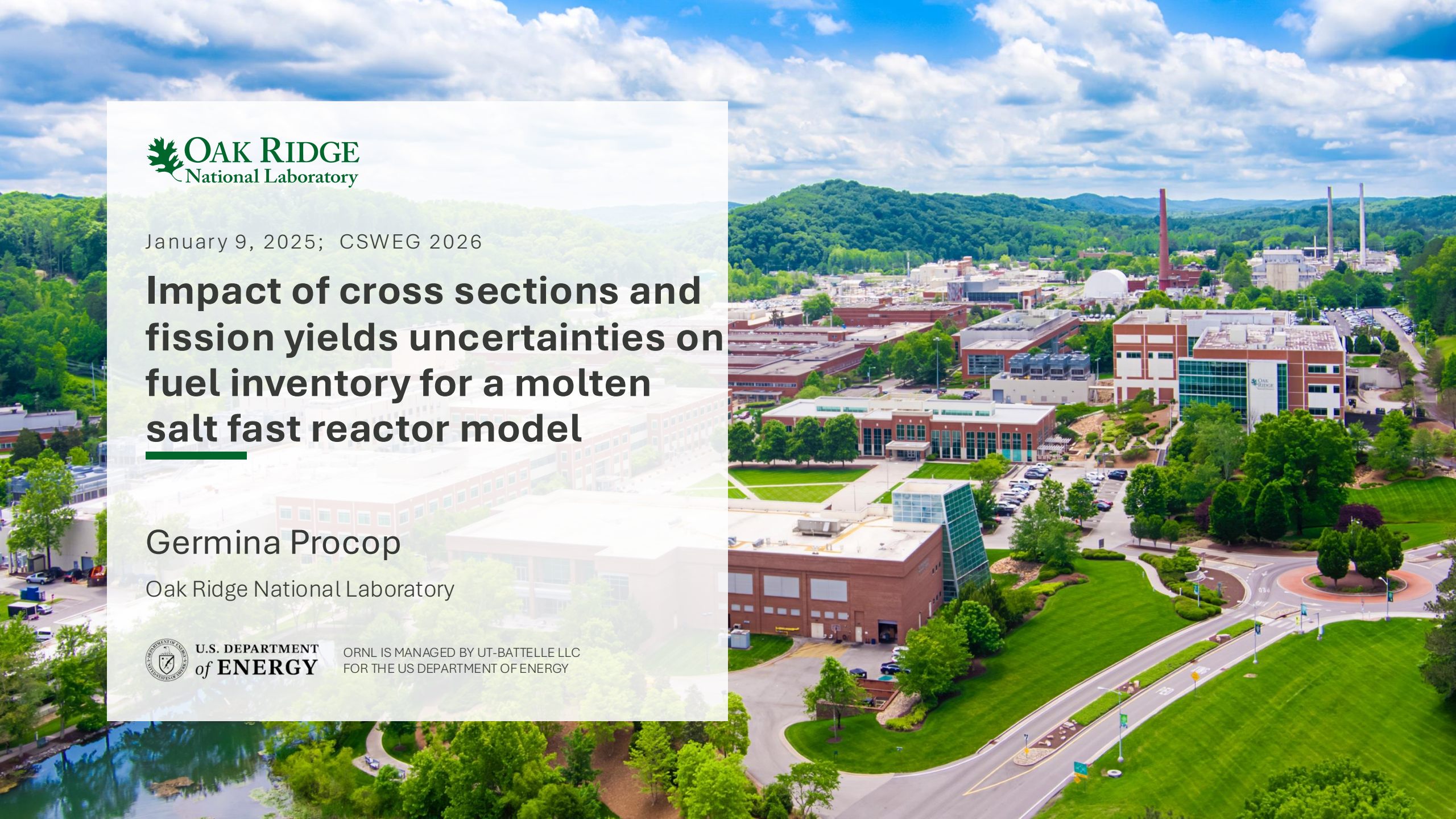

OAK RIDGE National Laboratory

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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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U.S. DEPARTMENT of ENERGY

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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.

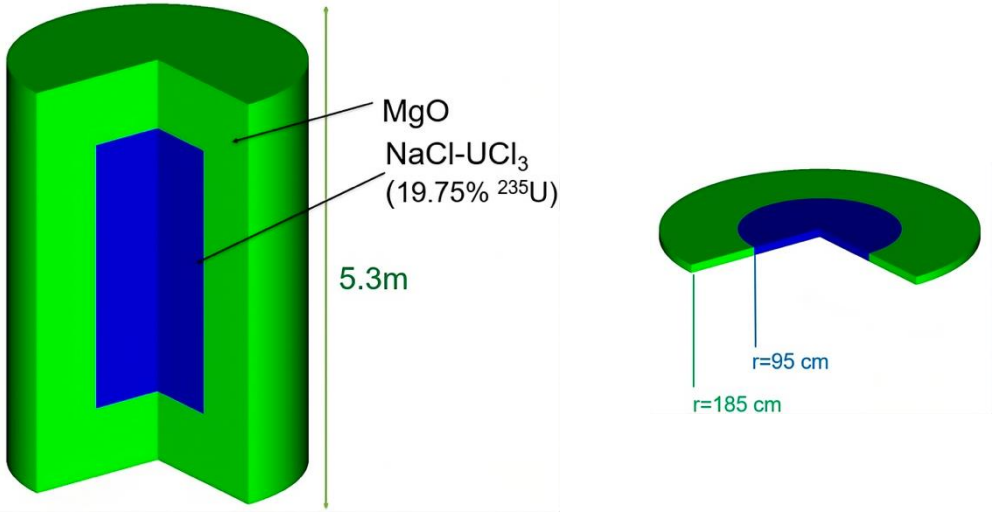
Cross section libraries considered:

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

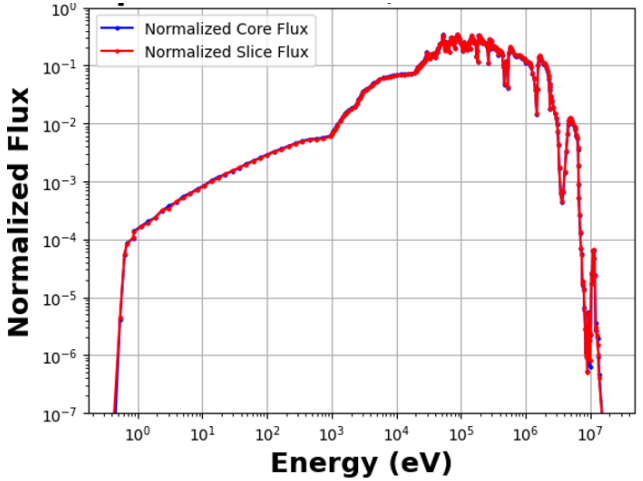
1) Reference for MCFR model used here: Rakim Hirji, Germina Procop, Rike Bostelmann, Rabab Elzohery (2025). Development of a Representative Molten Chloride Fast Reactor Model to Assess the Impact of Nuclear Data. In Proc. of Int. Conf. on Mathematics and Computational Methods Applied to Nuclear Science and Engineering (M&C 2025), 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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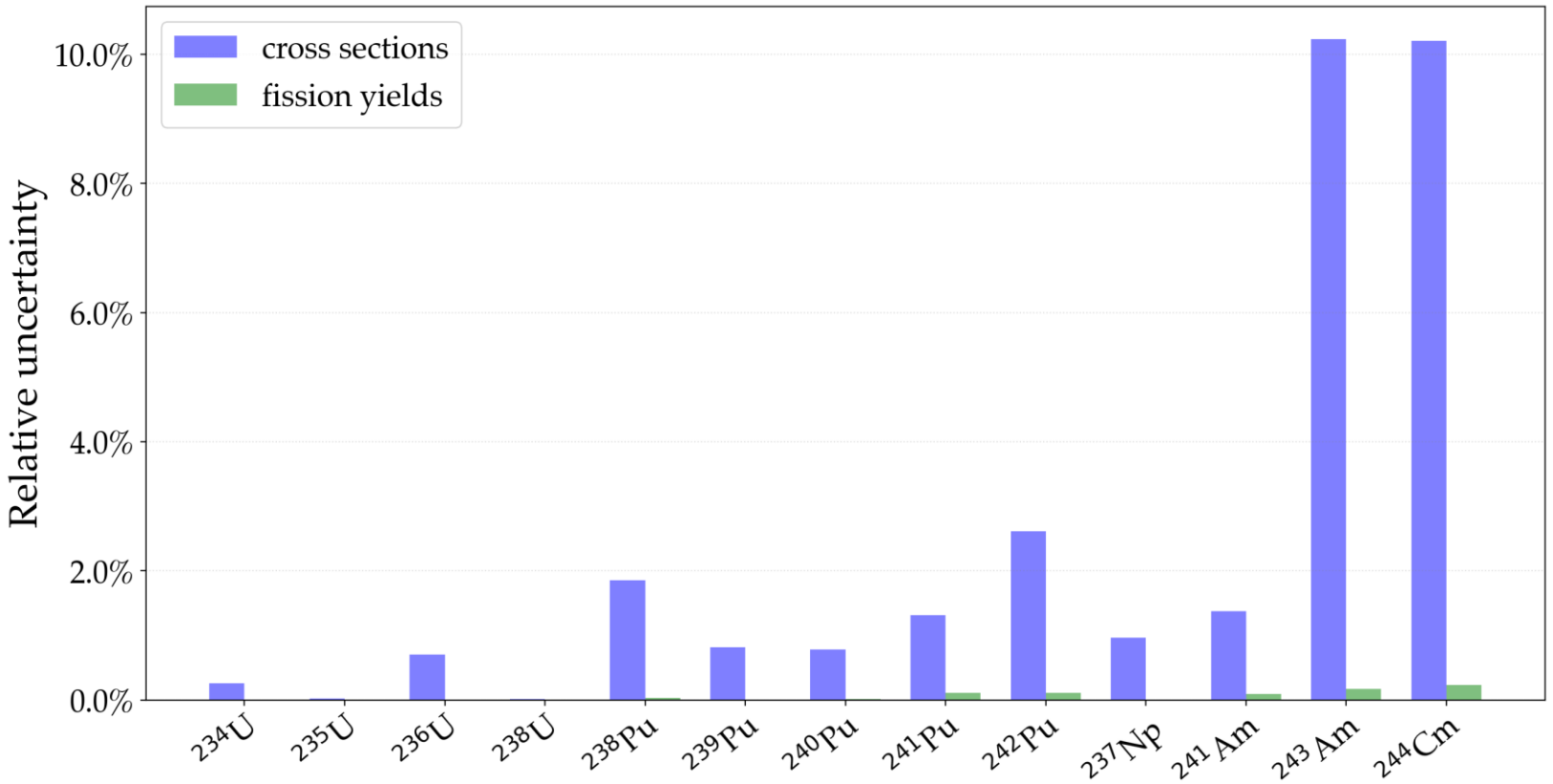
Uncertainties in calculated nuclide inventories for 5-yr irradiated fuel that result from uncertainties in cross section (XS) and fission product yield (FPY) data

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:

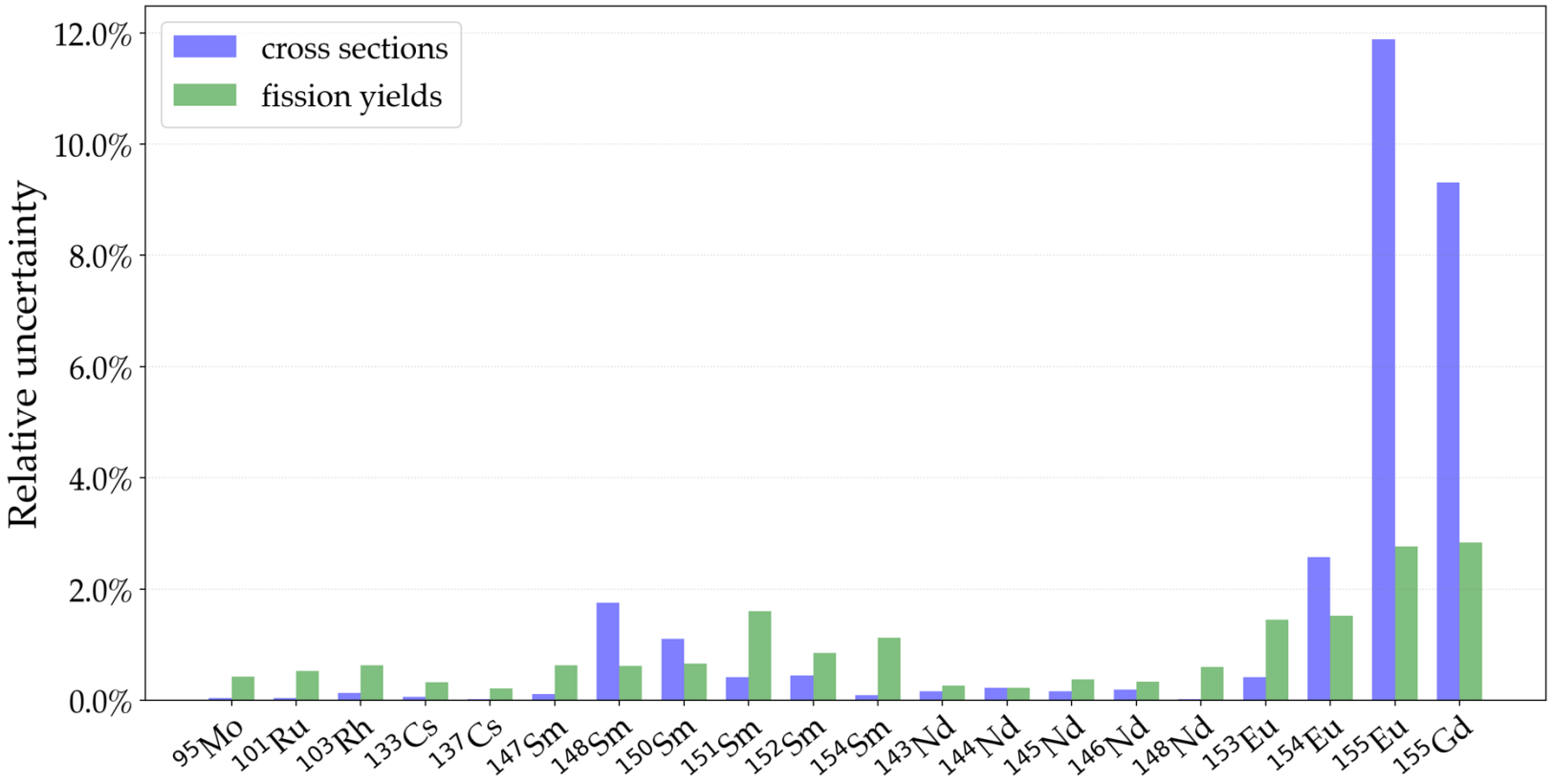
~ 10% for ^{243}**Am,** ^{244}**Cm**
1 - 3% for ^{238,241,242}**Pu,** ^{241}**Am**
0.7 - 1% for ^{236}**U,** ^{239,240}**Pu,** ^{237}**Np**
< 0.3% for ^{234,235,238}**U**

FPY-induced uncertainty results:

< 0.2% for all actinides shown

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% for ^{155}**Eu**
9% for ^{155}**Gd**
1 - 3% for ^{148,150}**Sm**, ^{154}**Eu**
0.4 - 1% for ^{151,153}**Sm**, ^{153}**Eu**
< 0.2% for the other shown nuclides

FPY-induced uncertainty results:

~2% for ^{155}**Eu** and ^{155}**Gd**
1 - 3% for ^{154}**Sm**, ^{153,154}**Eu**
0.5 - 1% for ^{101}**Ru**, ^{103}**Rh**, ^{148}**Nd**, ^{147,148,150,152}**Sm**
< 0.4% for the other shown nuclides

Cross section uncertainties are major drivers for uncertainties of calculated FP concentrations.
FPY- induced uncertainties in 1-3% range for ^{155}Eu, ^{153,154,1555}Gd, ^{154}Sm.

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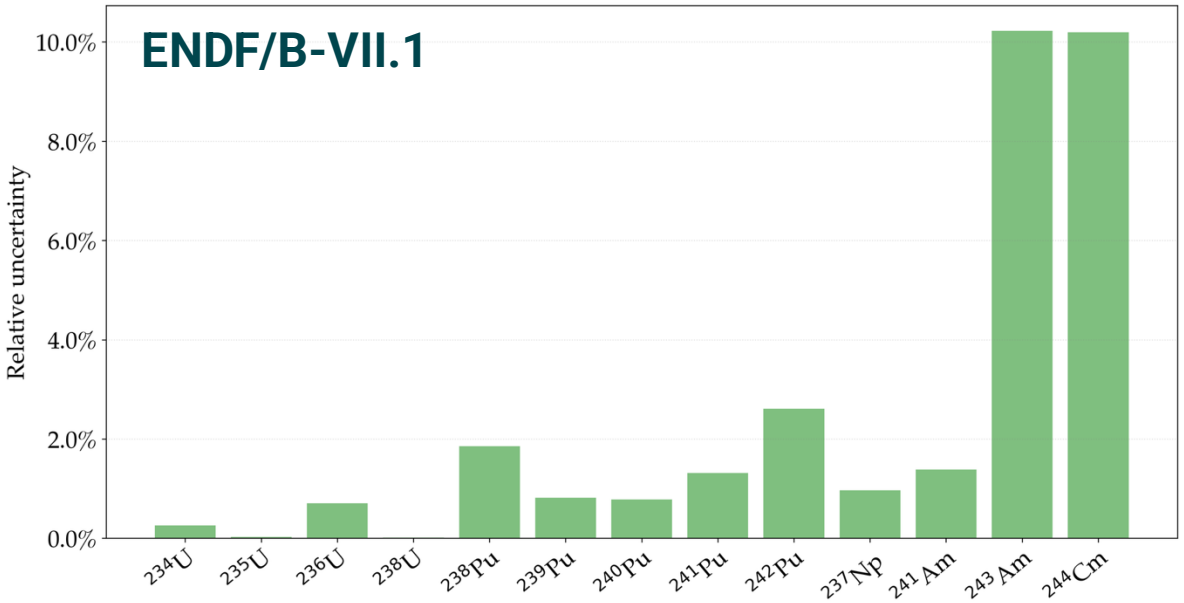
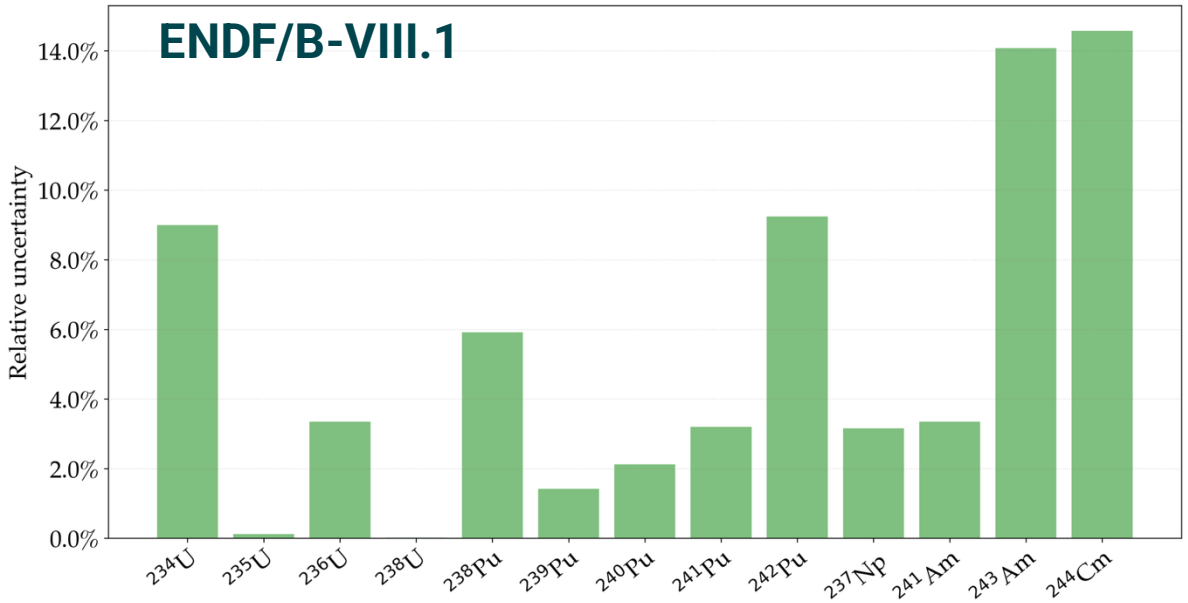
Uncertainties in calculated nuclide inventories for 5-yr irradiated fuel that result from uncertainties in cross section (XS) data

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

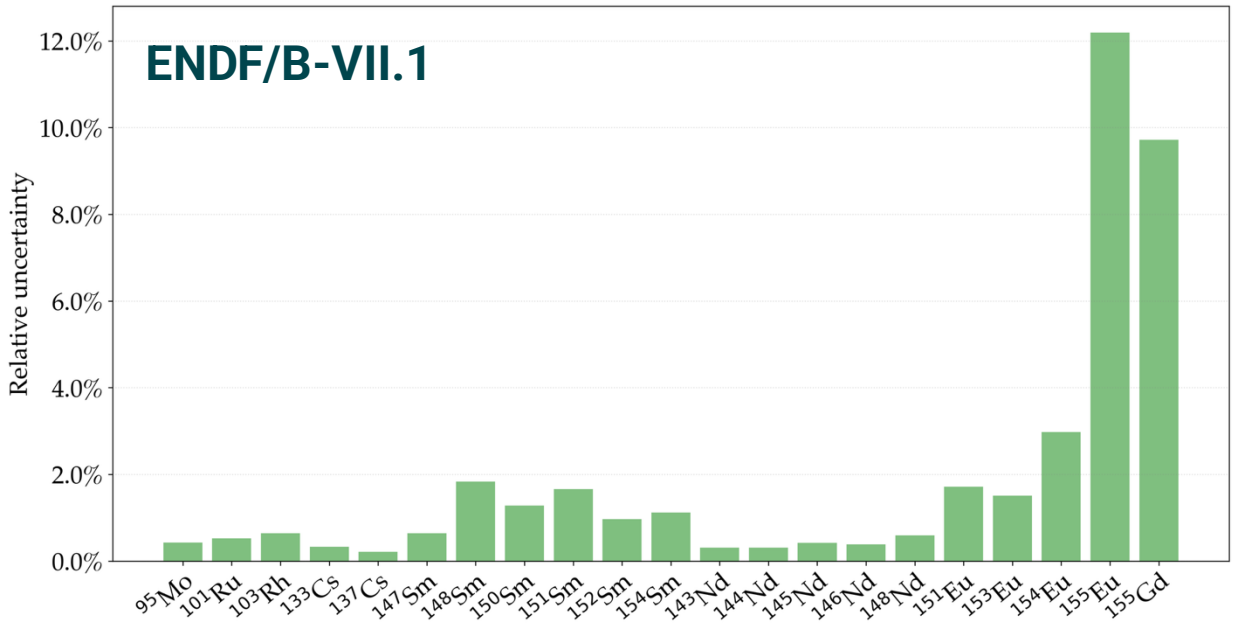


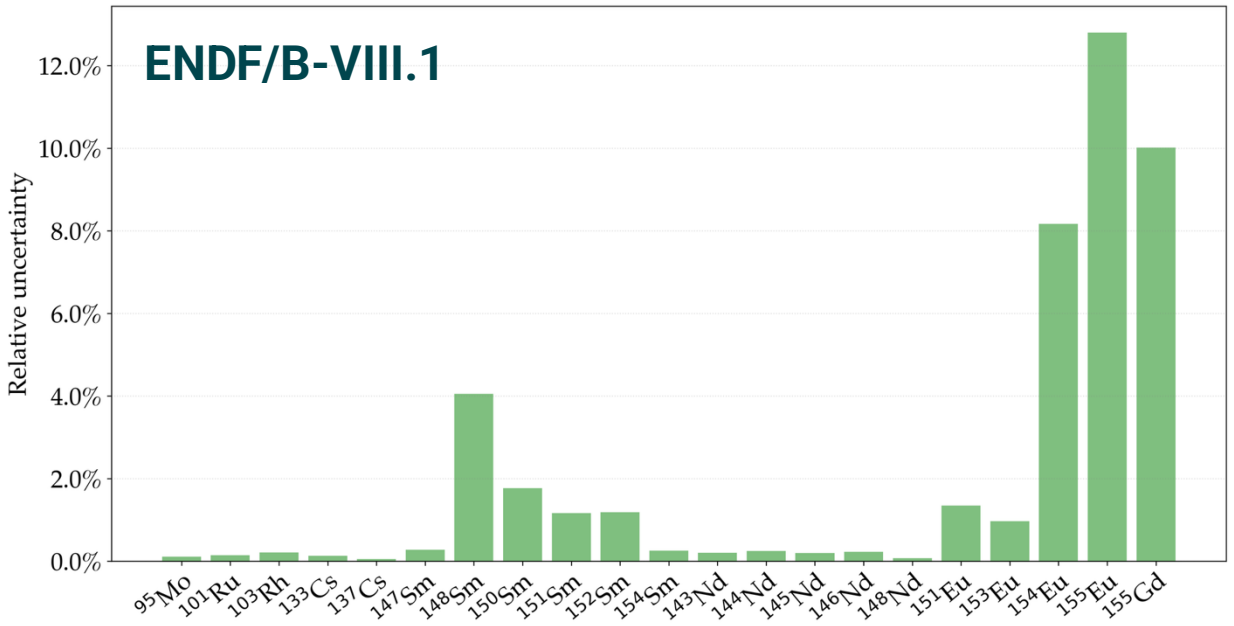


Significant differences in uncertainty estimates between ENDF/B-VIII.1 and ENDF/B-VII.1:

- **+9%** for **^{234}U**, **+3%** for **^{236}U**
- **+6%** for **^{242}Pu**, **+4%** for **^{238}Pu**

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

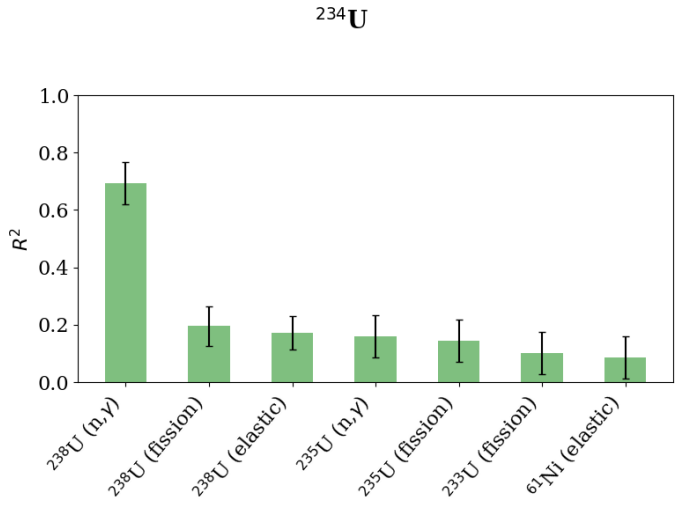


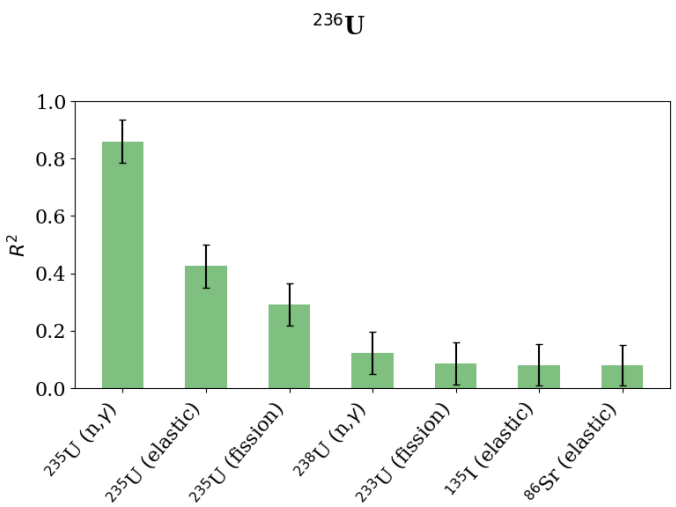


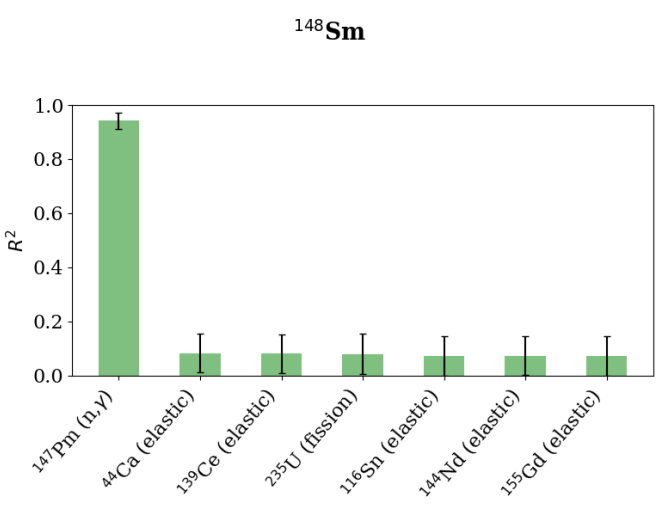
Significant differences in uncertainty estimates between ENDF/B-VIII.1 and ENDF/B-VII.1:

- **+2%** for **^{148}Sm**
- **+5%** for **^{154}Eu**

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



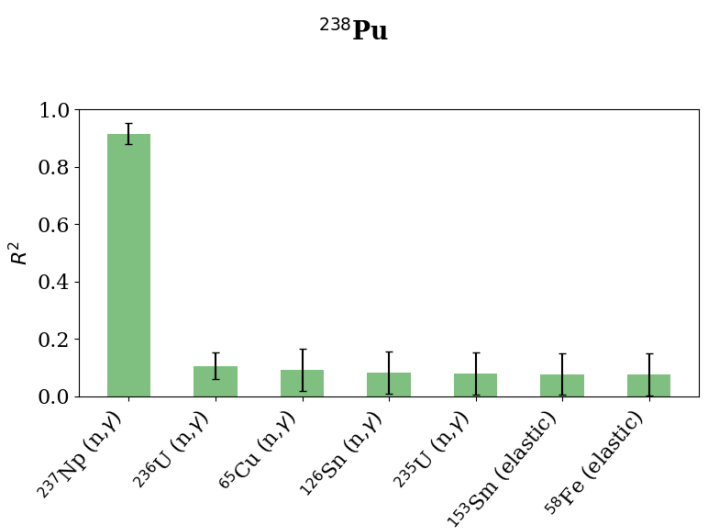


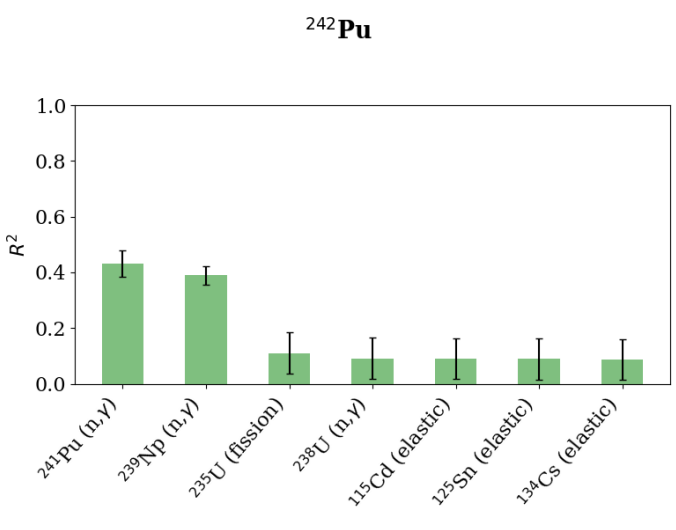


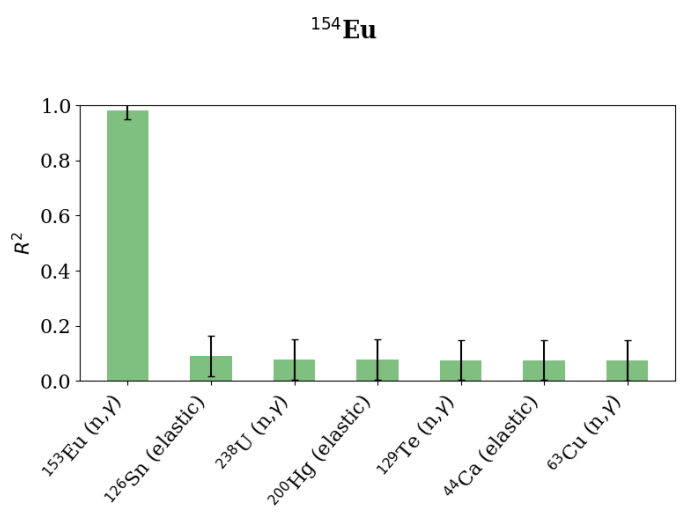
^{238}U (n,γ) for ^{234}U

^{235}U (n,γ) for ^{236}U

^{147}Pm (n,γ) for ^{148}Sm







^{237}Np (n,γ) for ^{238}Pu

^{241}Pu (n,γ) for ^{242}Pu

^{153}Eu (n,γ) for ^{154}Eu

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 VII.1

+9% for ^{234}U, +6% for ^{242}Pu
+4% for ^{238}Pu, +3% for ^{236}U

+5% for ^{154}Eu, +2% for ^{148}Sm

These XS-induced uncertainties are driven by (n,γ) for a precursor nuclide

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*

10% for ^{243}Am, ^{244}Cm

1 - 3% for ^{238,241,242}Pu, ^{241}Am

12% for ^{155}Eu, 9% for ^{155}Gd

1 - 3% for ^{148,150}Sm, ^{154}Eu

Top FY-induced uncertainties *

2% for ^{155}Eu, ^{155}Gd

1 - 3% for ^{154}Sm, ^{153,154}Eu

*Results shown correspond to ENDF/B-VII.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.