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# Impact of cross section and fission yield uncertainties on reactor fuel inventories

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U.S. DEPARTMENT  
of **ENERGY**

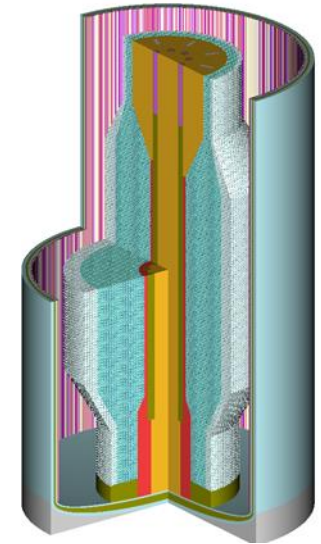
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# Objective: provide examples for the impact of nuclear data uncertainties on reactor fuel inventories for different reactor/fuel types

LWR/ $\text{UO}_2$  inventory for a fuel sample with available destructive assay (RCA) data

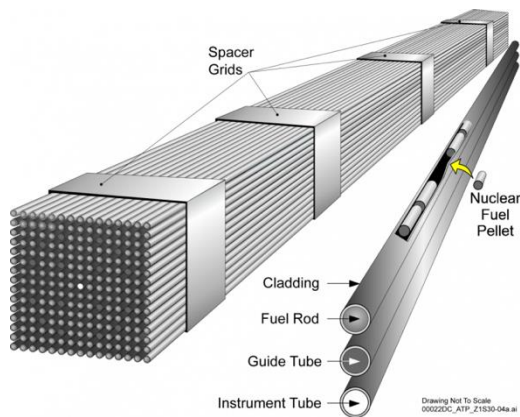
Calculated fuel inventory for a representative molten chloride fast reactor (MCFR-D) model



SCALE model of FHR

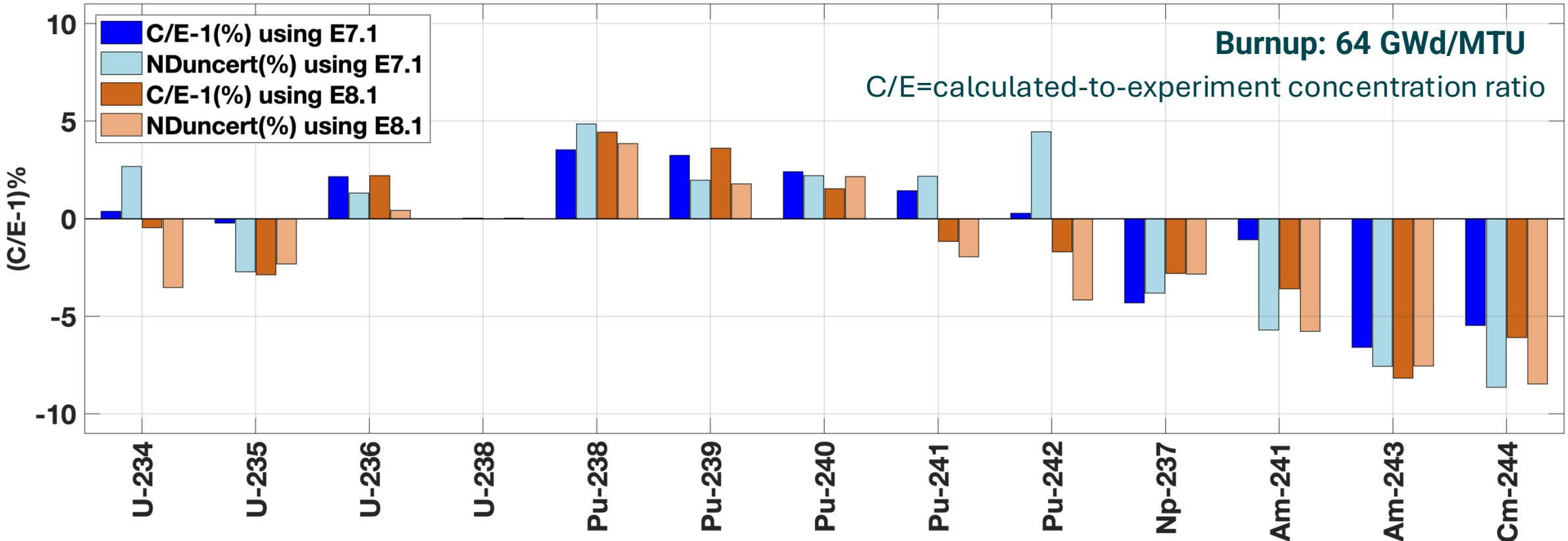
Calculated fuel inventory for a HALEU-fueled sodium-cooled fast reactor (SFR) model, based on the ABTR design

Calculated fuel inventory for a TRISO-fueled high temperature fluoride salt-cooled reactor (FHR) - UCB Mark 1



PWR fuel assembly

# LWR/UO<sub>2</sub>: computational bias in actinide prediction can be smaller than the nuclear-data induced uncertainty



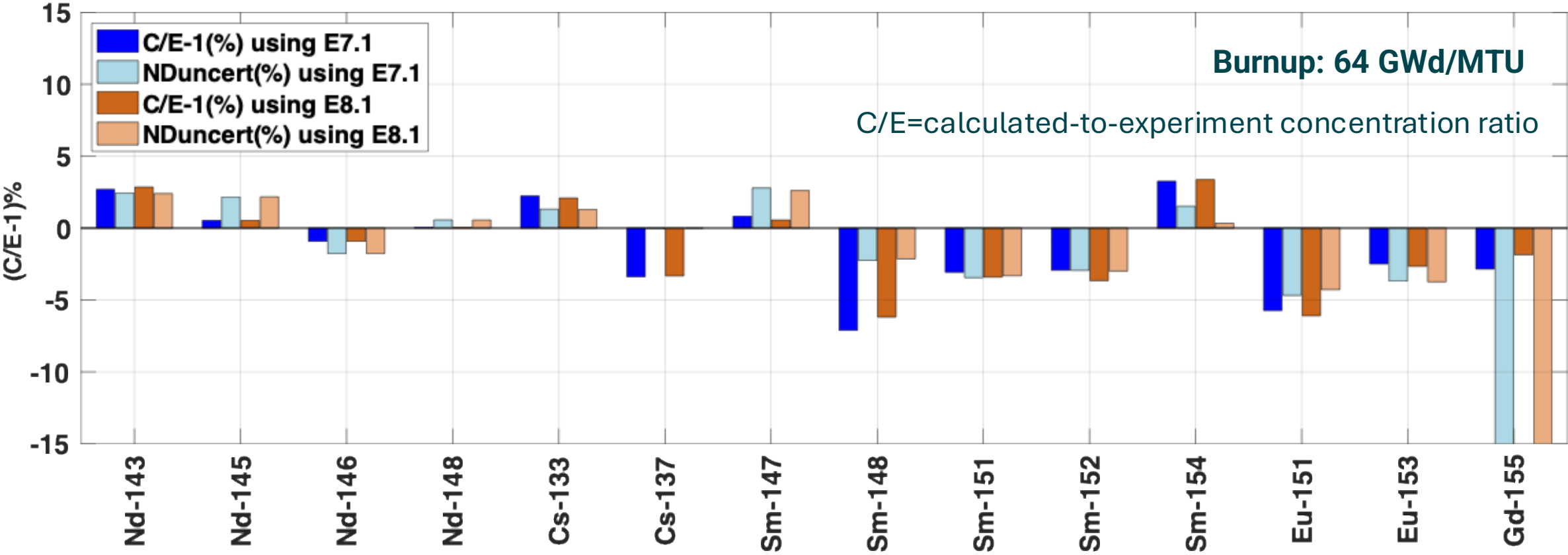
Most of these actinides are important for reactivity (crit safety with burnup-credit)

Key long-term contributors to decay heat

Largest contributor to neutron source for LWR spent fuel

Refs. G.Procop, J. Brown, Nuclide inventory validation: effect of nuclear data libraries, CSEWG 2025; <https://doi.org/10.1080/00295639.2025.2527491>

# LWR/EO<sub>2</sub>: computational bias in fission products prediction can be smaller than the nuclear-data induced uncertainty

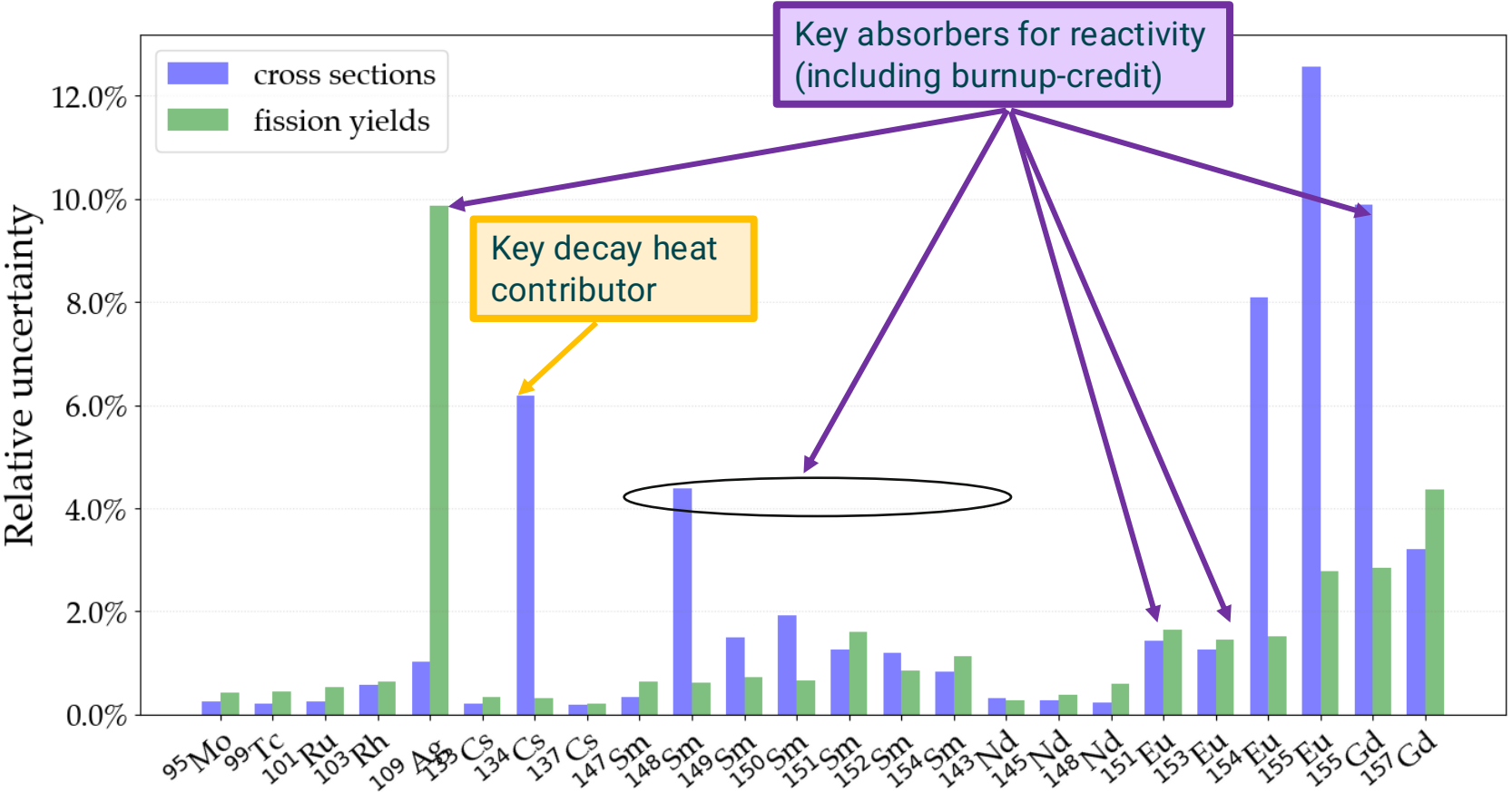


Most of these are key absorbers relevant to reactivity (crit safety with burnup-credit)

<sup>137</sup>Cs is key nuclide for decay heat and shielding applications, burnup monitor

Important for reactor operation: strong neutron absorbers such as <sup>155</sup>Gd and Sm isotopes

# MCFR: effect of uncertainty in cross section and fission yield data on fission product inventory



XS-induced uncertainty:  
**12.5%** for <sup>155</sup>Eu  
**5 – 10%** for <sup>155</sup>Gd, <sup>154</sup>Eu, <sup>134</sup>Cs

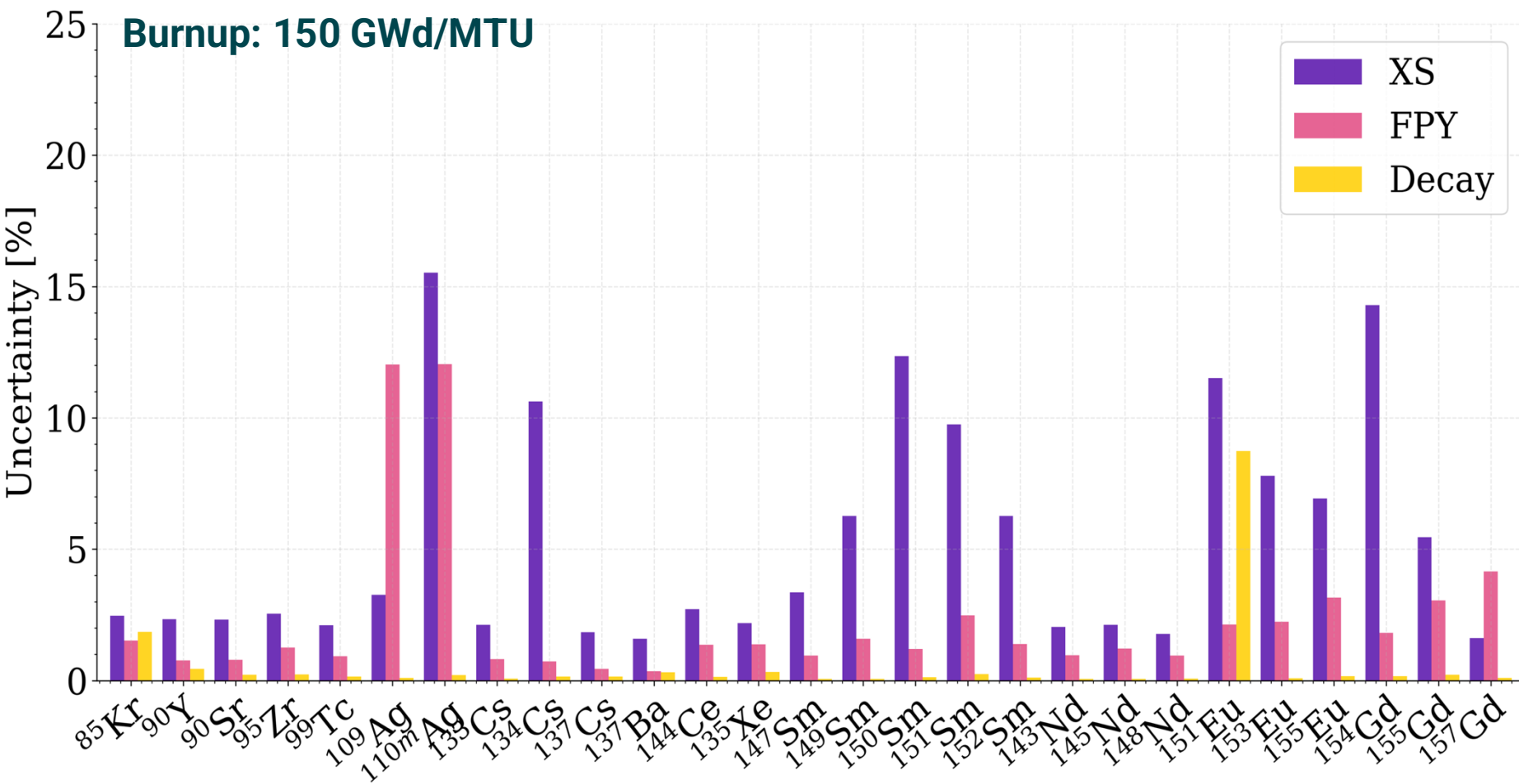
FPY-induced uncertainty:  
**10%** for <sup>109</sup>Ag  
**2-5%** for <sup>155</sup>Eu, <sup>155,157</sup>Gd

Inventory results at 5-yr irradiation, using SCALE and ENDF/B-VII.1 data. XS covariance data: ENDF/B-VII.1 supplemented by LoFi BLO data

**Cross section uncertainties are major drivers for FP inventory uncertainties; exception <sup>109</sup>Ag**  
**FPY-induced uncertainty important for relevant nuclides <sup>109</sup>Ag, <sup>151,153</sup>Eu, <sup>155,157</sup>Gd**

Refs. for SCALE covariance data: W. Wieselquist et. al, NUREG\_CR\_7249\_2017 (2017); M. Pigni et.al, Nuclear Data Sheets 123 (2015)

# SFR/HALEU: effect of nuclear data uncertainties on fission product inventory

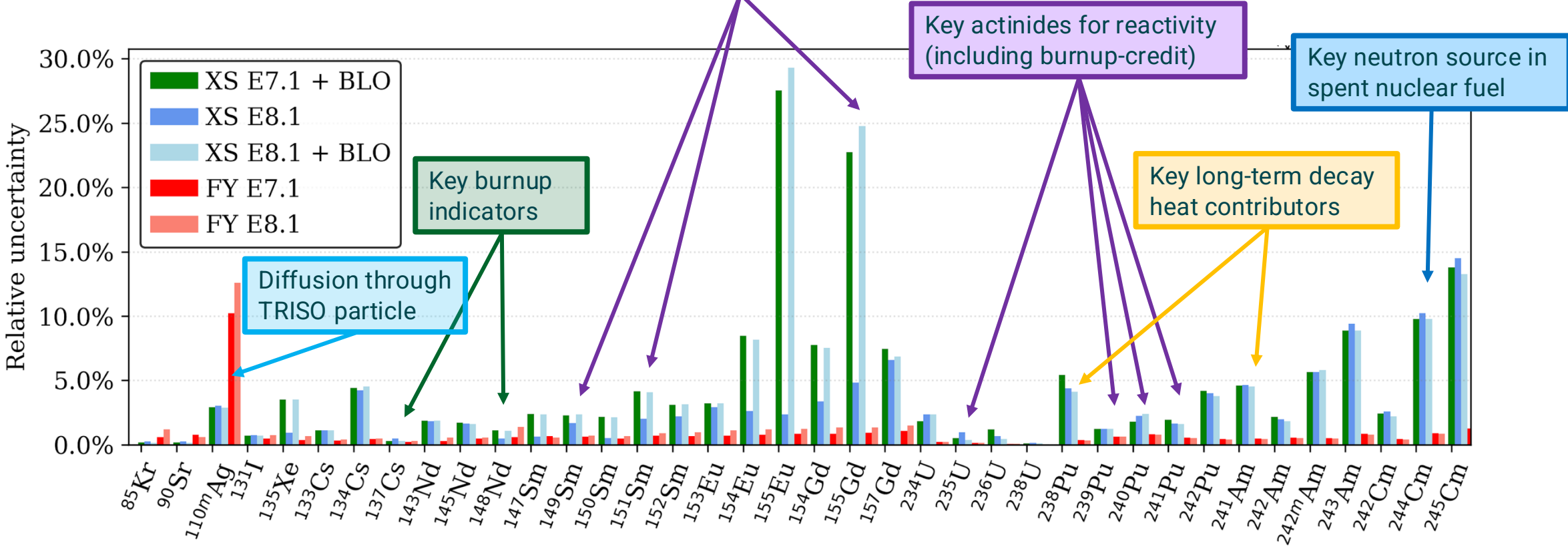


Inventory at discharge, using SCALE and ENDF/B-VII.1 data. XS covariance data: ENDF/B-VII.1 supplemented by BLO data

**Effects of fission product yields and decay data uncertainties are not always negligible.**  
 Decay data induced uncertainty is **9%** for  $^{151}\text{Eu}$  resulting from uncertainty in beta-decay of its parent  $^{151}\text{Sm}$

# FHR: effect of uncertainty in cross section and fission yield data on calculated inventories

Burnup: 180 GWd/tU



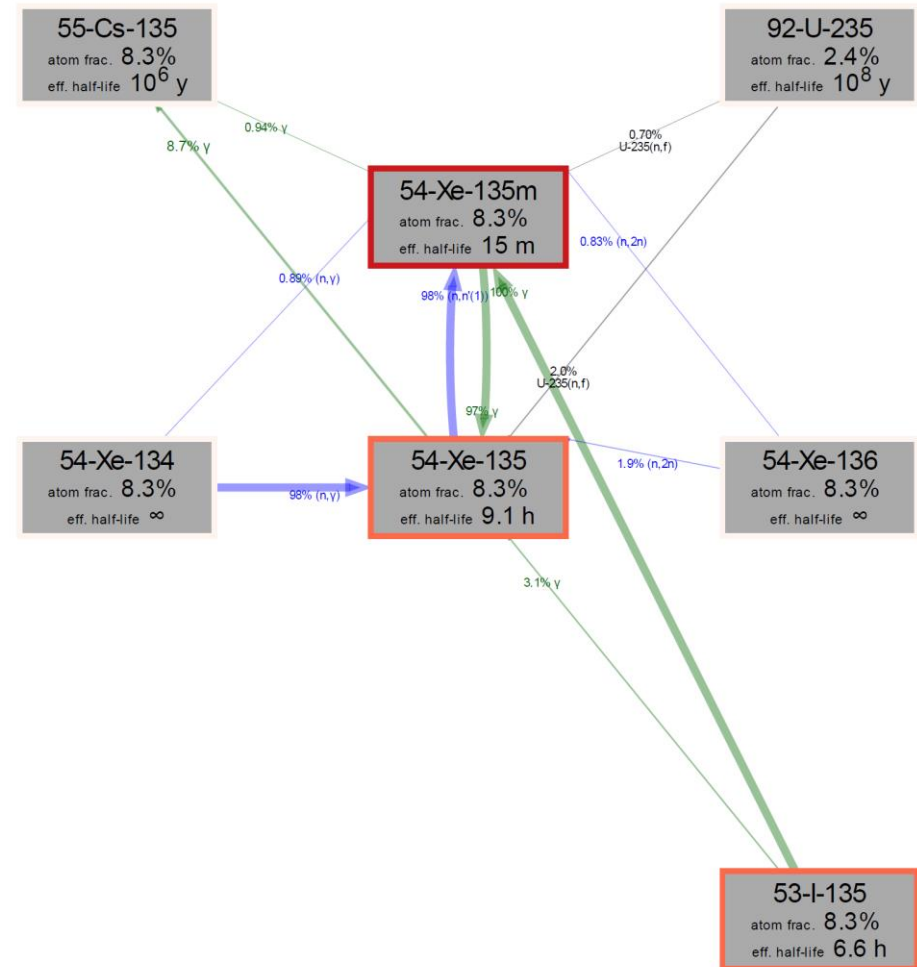
Cross section uncertainties are major drivers for inventory uncertainties; exceptions  $^{110m}\text{Ag}$ ,  $^{85}\text{Kr}$ ,  $^{90}\text{Sr}$   
 Impact of BLO uncertainties for key fission products Sm, Eu, Gd points to missing covariance data

# ENDF/B is missing nuclear data for important metastable nuclides

Metastables data are important for fuel inventory simulations

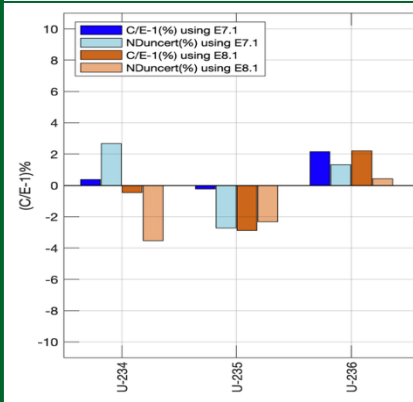
Data notably important for both reactor and inventory simulations, which are not in ENDF/B, include  $U^{235m}$  and  $Xe^{135m}$

$Xe^{135}$  is a strong neutron poison (absorber) that is critical for safe reactor operation (shutdown, transients, reactor control)

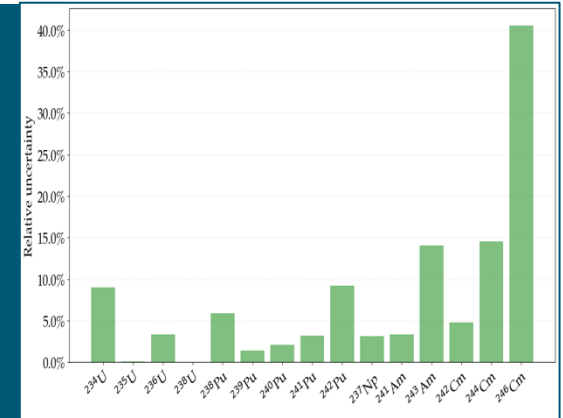


# Validated nuclear data with well-understood uncertainty are important for LWRs and non-LWRs reactor safety and back-end of fuel cycle

ND improvements could lead to reduction of bias and uncertainty in nuclide inventories prediction for spent fuel transportation and storage.

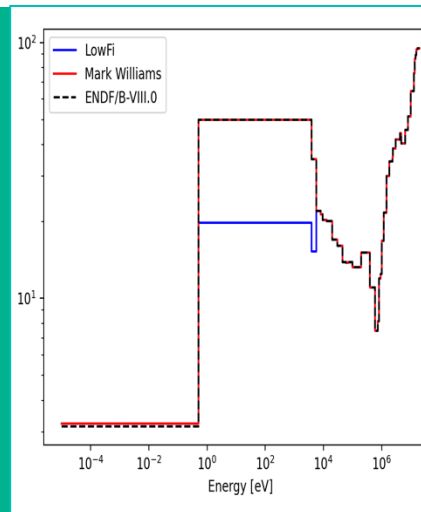


ND-induced uncertainty in calculated nuclide inventory is generally greater than that resulting from uncertainty in modeling data.



Important nuclear data are provided with either larger or no uncertainties in ENDF/B.

Ex: data impacting <sup>155</sup>Gd and <sup>157</sup>Gd, relevant for reactor operation and back-end of fuel cycle.



Small differences in ND and uncertainties might seem non-impactful. For nuclear energy applications and regulatory purposes, the ultimate effect may be consequential.

How could we better embed the user experience and results in ND generation, evaluation, and validation?

# References

1. F. Bostelmann et. al., **Impact of cross section and fission yield uncertainties on the fuel inventory in a high temperature fluoride salt-cooled reactor**, Proc. of 16<sup>th</sup> Nuclear Data For Science and Technology conference, Madrid, Spain, June 2025 (pending publication)
2. R. Elzohery et. al, **Impact of nuclear data on fuel inventory for HALEU-fueled sodium-cooled fast reactors**, American Nuclear Society Meeting, Denver, CO, June 2026 (submitted)
3. G. Procop et. al, **Impact of cross sections and fission yields uncertainties on fuel inventory for a molten salt fast reactor model**, CSWEG 2025 (Jan 2026). <https://indico.bnl.gov/event/29405/timetable/#20260109.detailed>
4. F. Bostelmann et. al, **Impact of cross section and fission yield uncertainties on the fuel inventory in a high temperature fluoride salt -cooled reactor**, CSWEG 2025 (Jan 2026). <https://indico.bnl.gov/event/29405/timetable/#20260108.detailed>
5. G. Procop and J. Brown, **Nuclide inventory validation: effect of nuclear data libraries**, CSWEG 2025 (Jan 2026). <https://indico.bnl.gov/event/29405/timetable/#20260109.detailed>
6. G. Procop et. al, **Extending the nuclide inventory validation basis for high-burnup fuel with new radiochemical assay data**, Nuclear Science and Engineering (2025). <https://doi.org/10.1080/00295639.2025.2527491>

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# Questions ?



Indian Summer in Smoky Mtns, Dec 2025, Mount LeConte