Shift Verification and Validation Efforts

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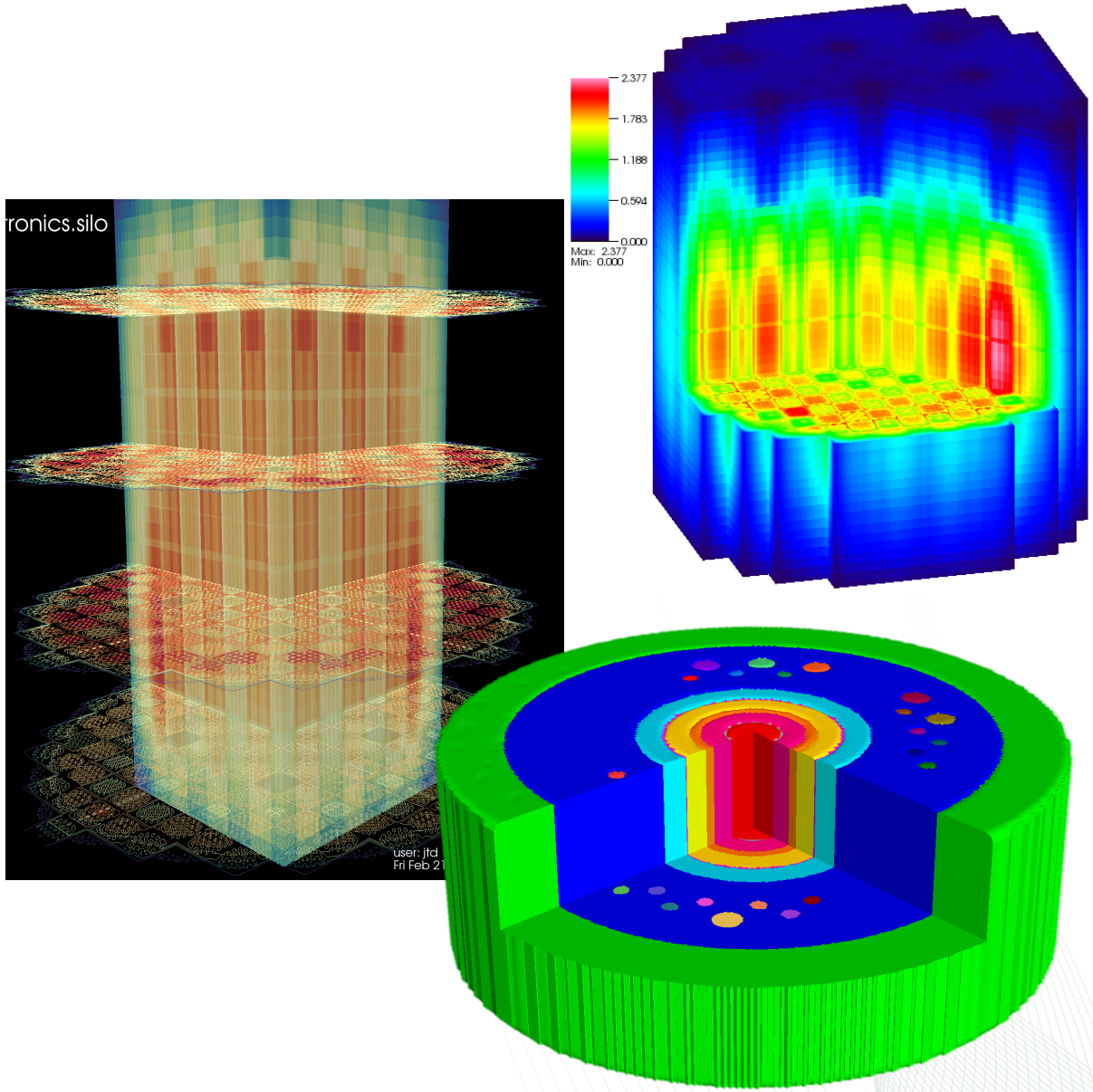
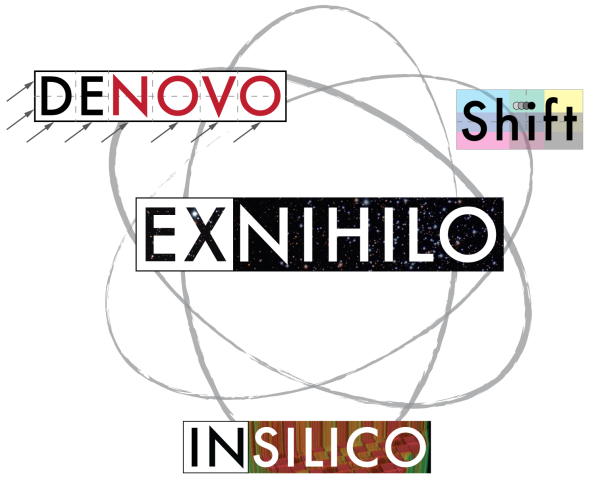
Outline

- What is Shift?
- Criticality Safety Benchmarks
- LWR Benchmarking
- Depletion Validation
- Detection Benchmarking
- Ongoing/Future Work

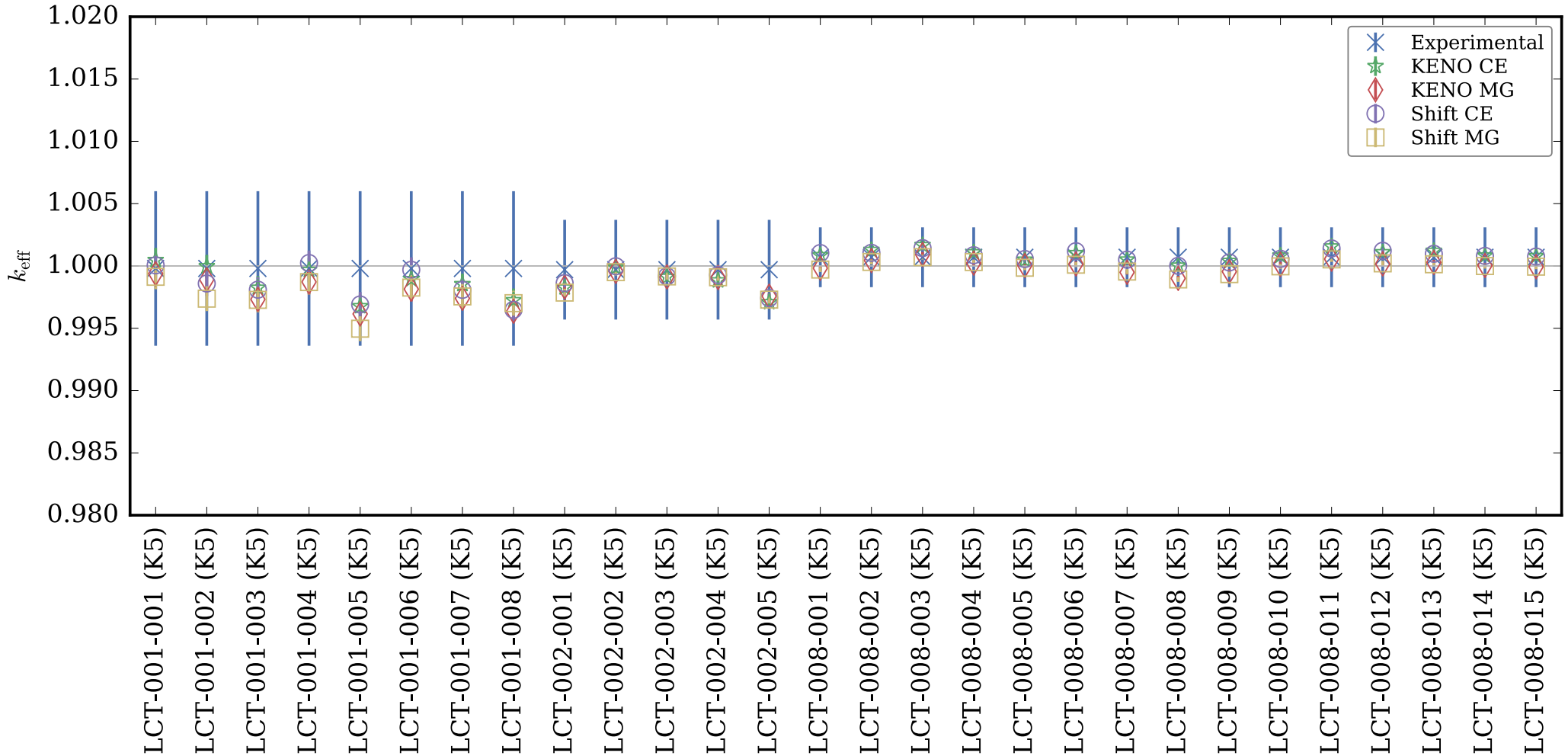


What is Shift?

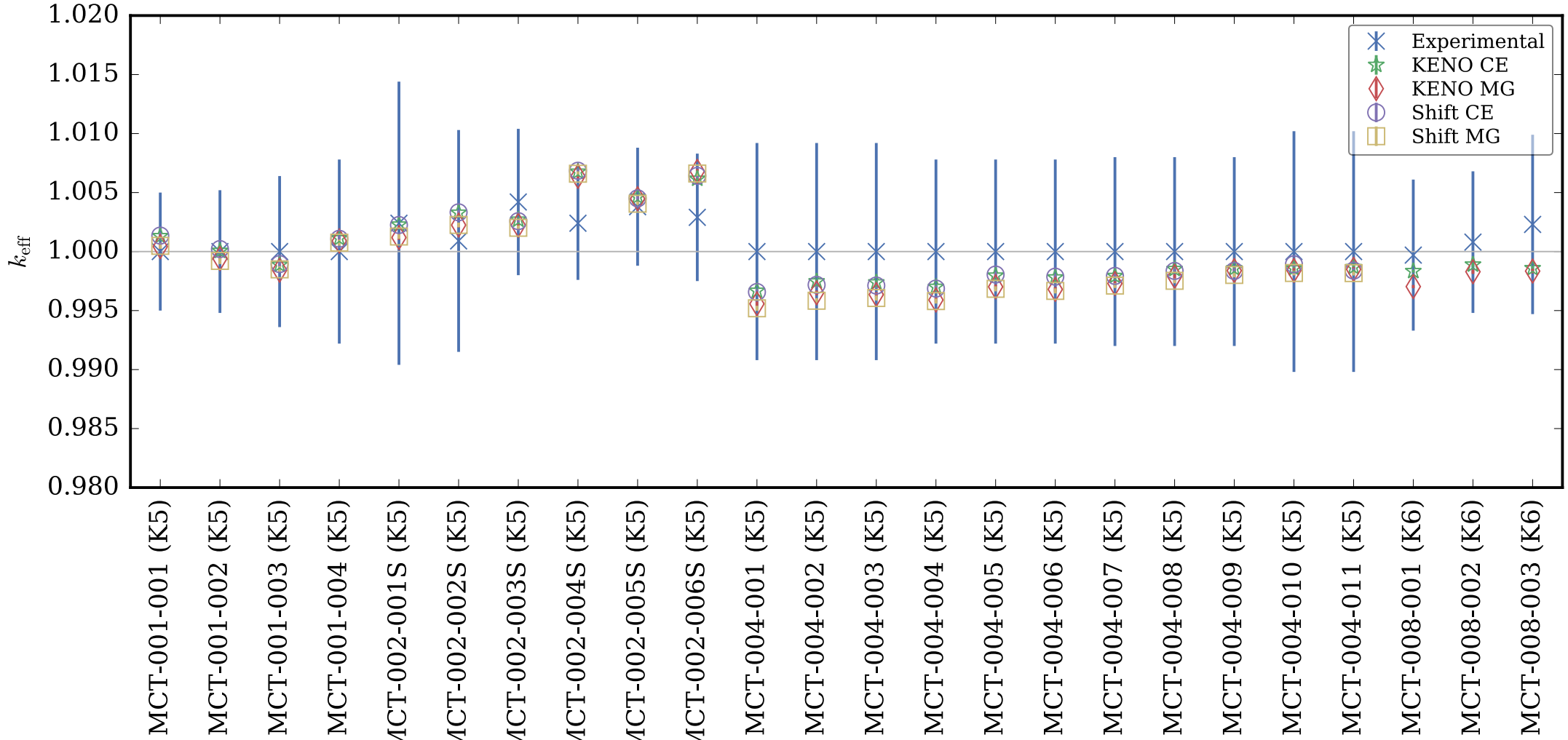
- Massively Parallel Monte Carlo Radiation Transport Code
- Part of the Exnihilo radiation transport code suite
- Integrated into SCALE and VERA
- Internal GitLab code repository and issue tracking: https://code-int.ornl.gov/exnihilo/Exnihilo



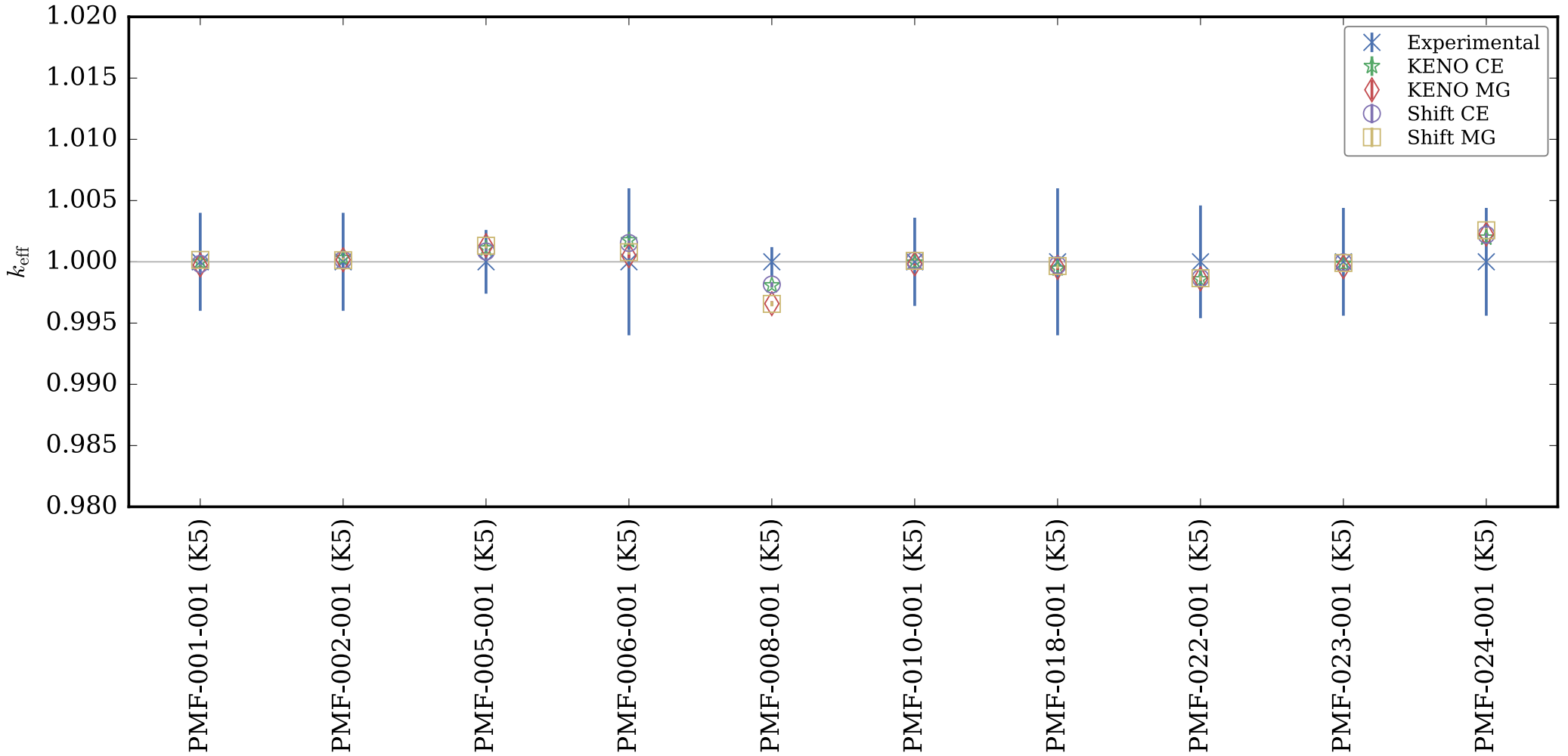
Criticality Safety – ICSBEP VALID test suite: LEU-COMP-THERM



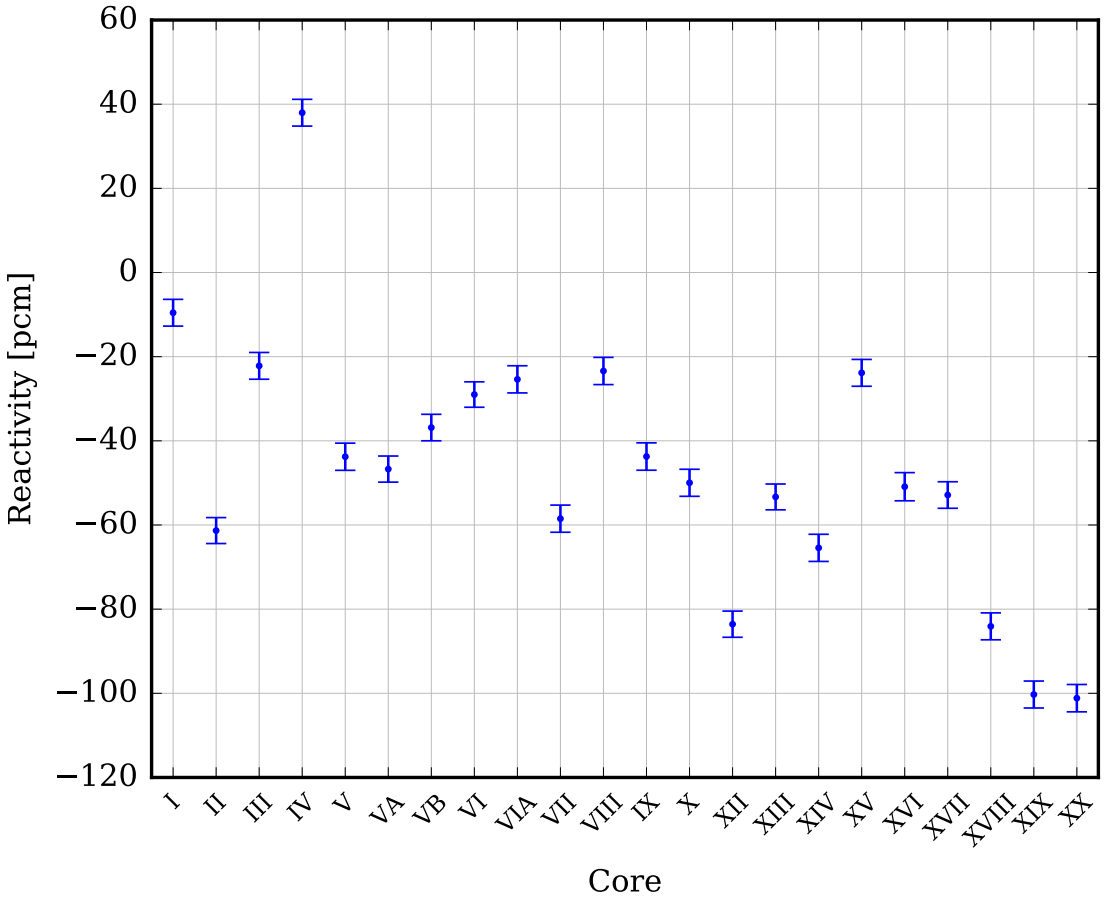
Criticality Safety – ICSBEP VALID test suite: MIX-COMP-THERM



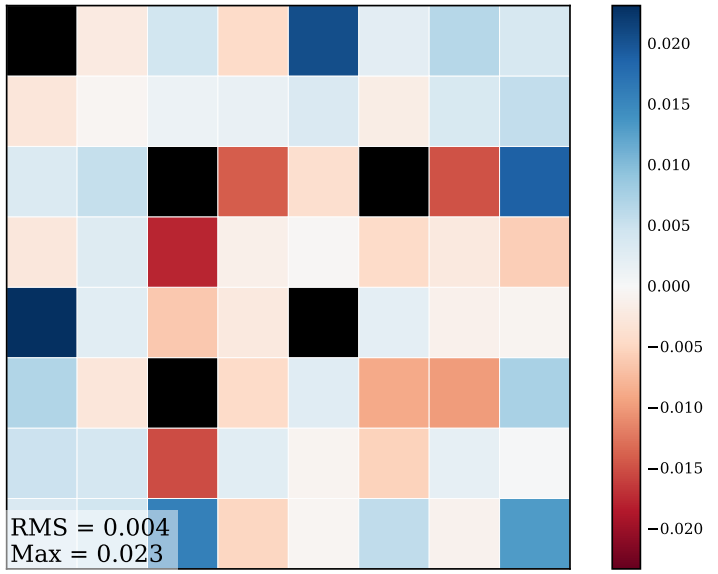
Criticality Safety – ICSBEP VALID test suite: PU-MET-FAST



LWR – Babcock and Wilcox 1810 experiments comparison

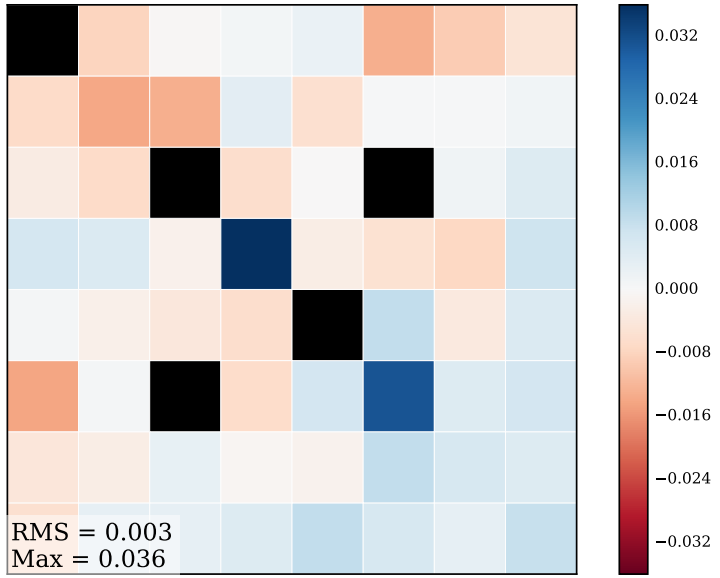


Reactivity over all cores:
Max: 38 pcm
Min: -101 pcm
Mean: -47 pcm



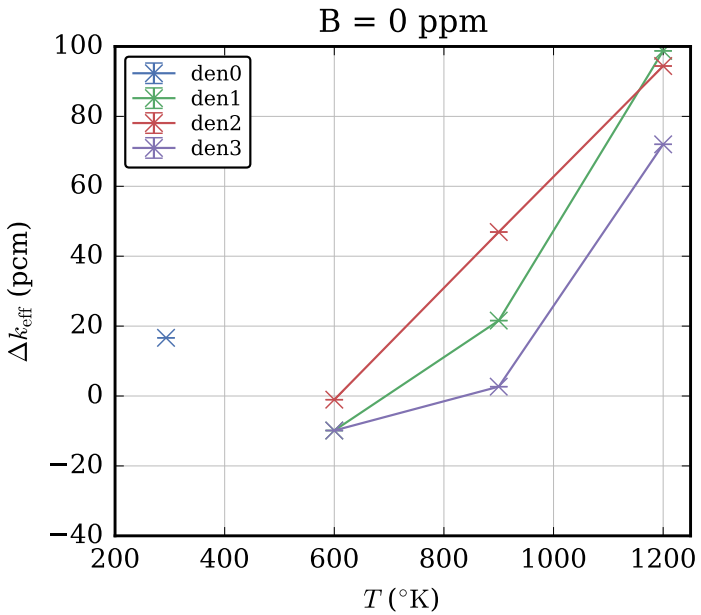
Core XII

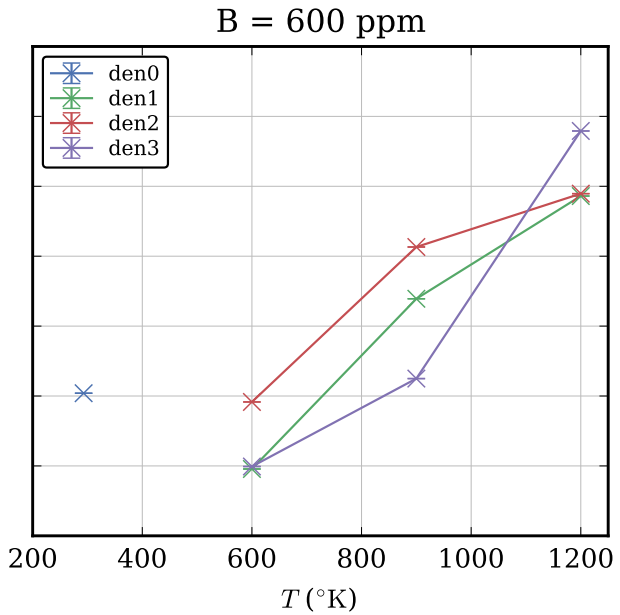
Midplane center assembly pin power relative difference

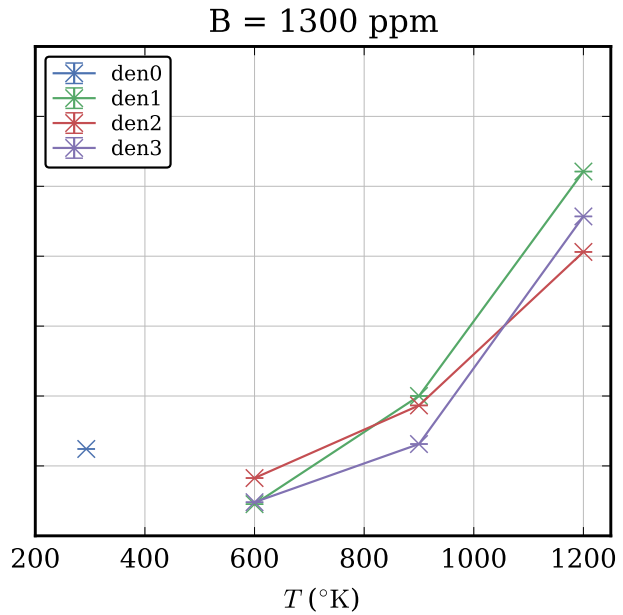


Core V

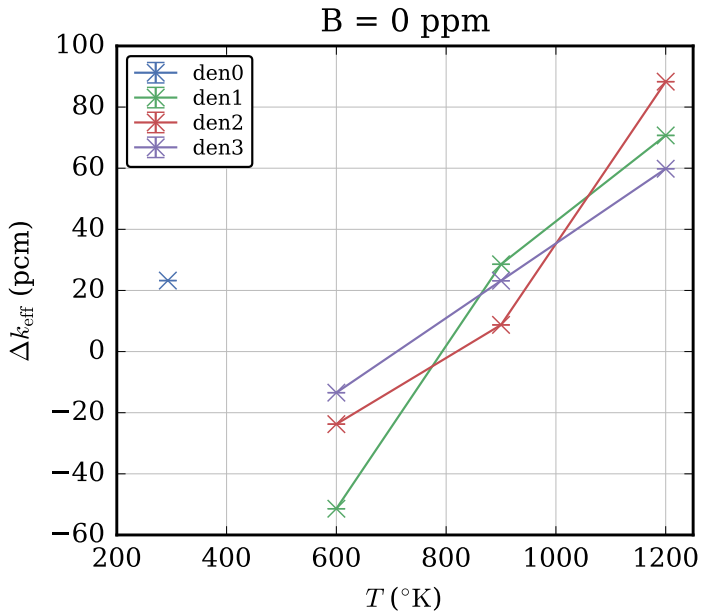
LWR – Pincells comparison with MCNP6

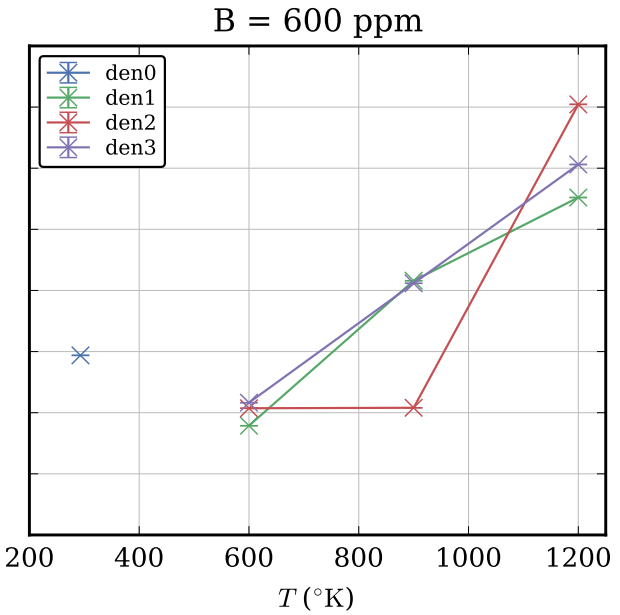


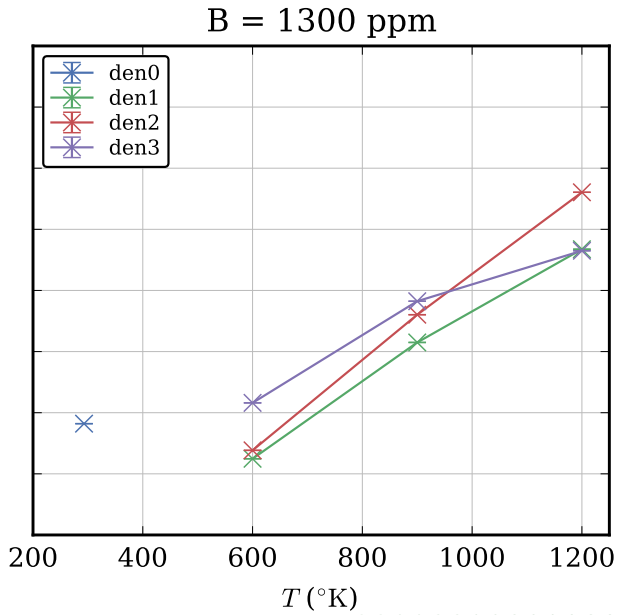




k_{eff} difference for BEAVRS pincell







k_{eff} difference for Surry pincell

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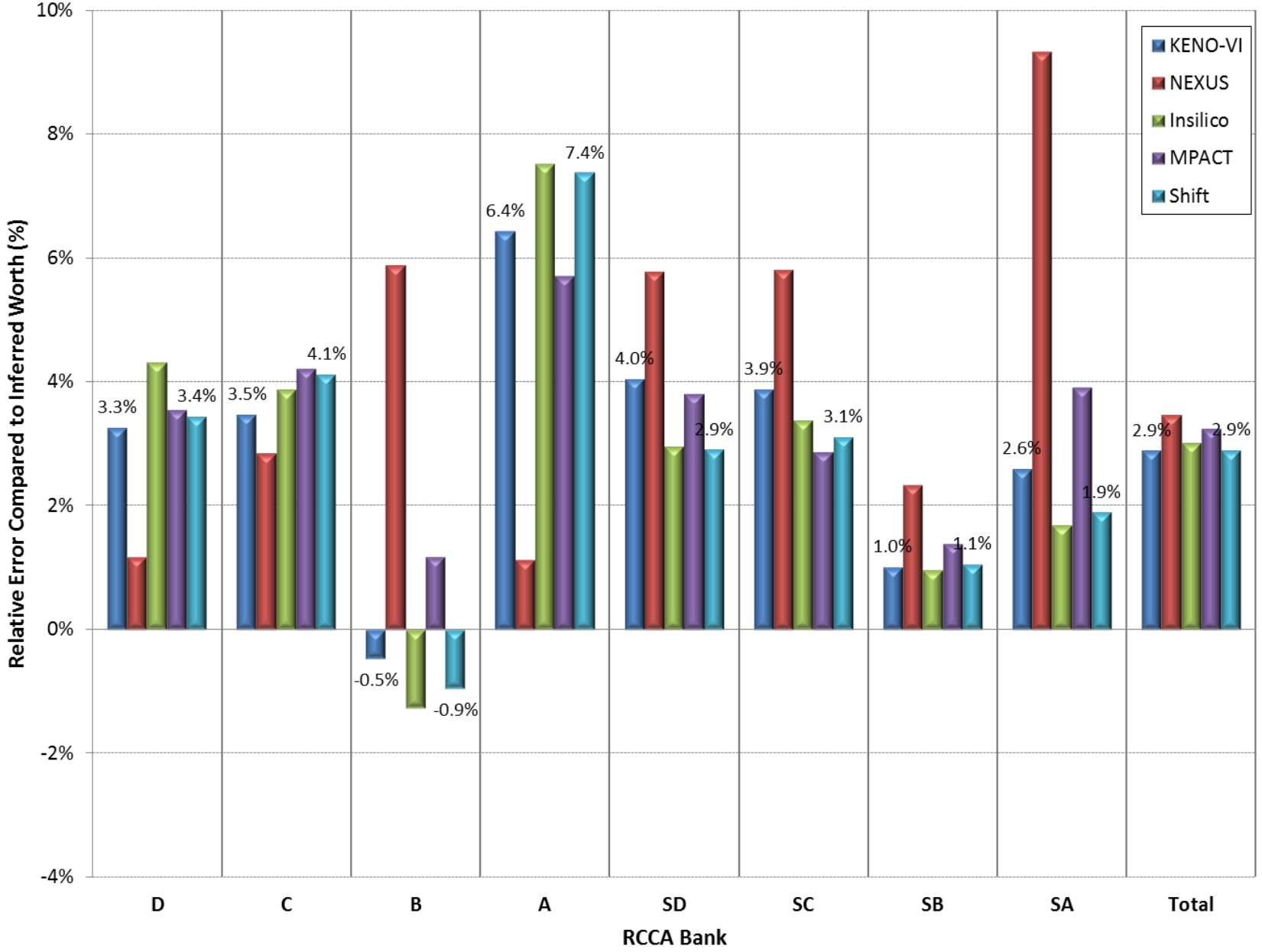
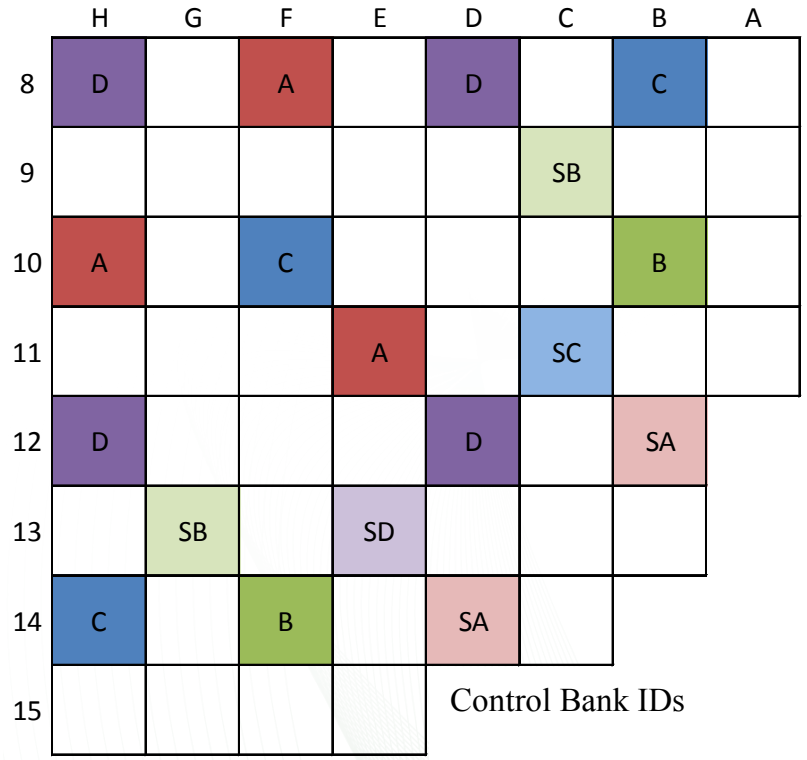
LWR – Watts Bar Unit 1 initial startup





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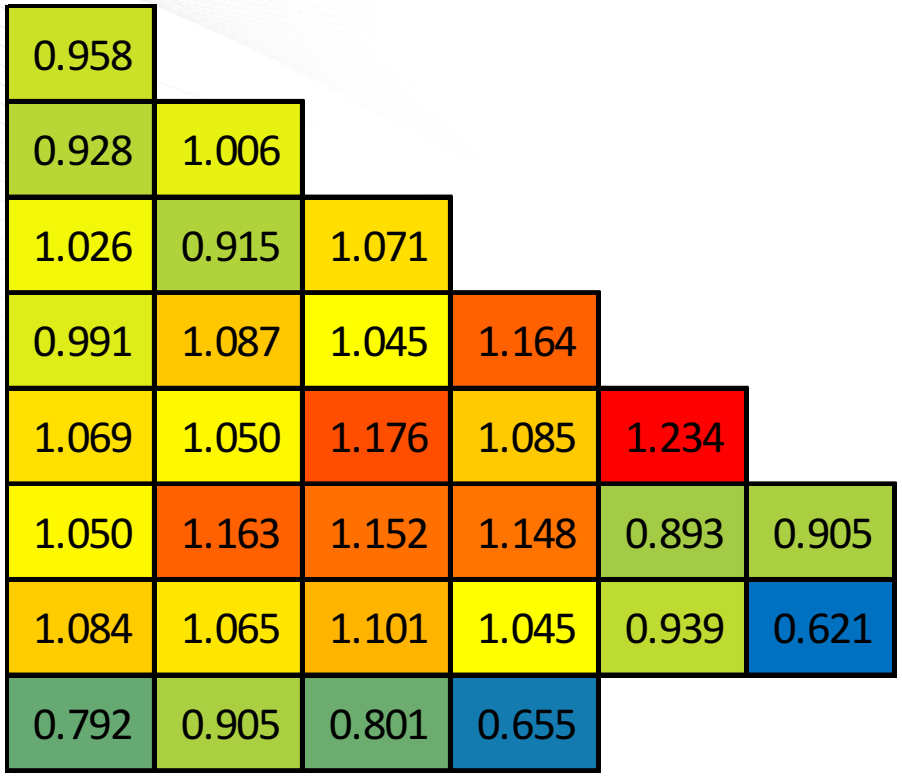
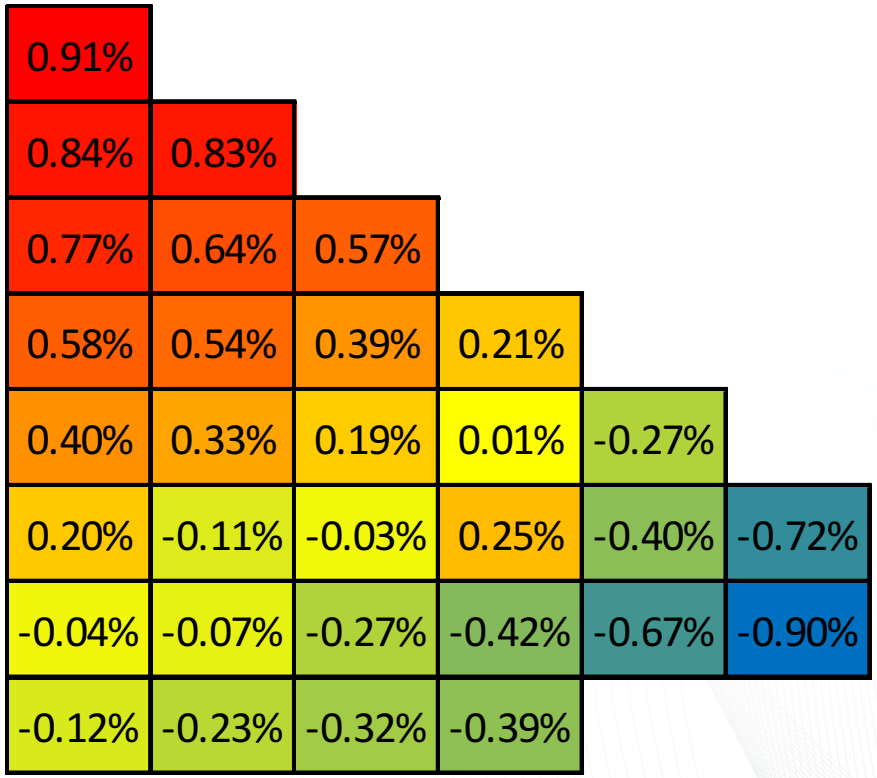
LWR – Watts Bar Unit 1 initial startup

Radial Pin Power Distribution



Max: 1.234 **Avg: 1.000**

Shift normalized power



Max: 0.84% **Min: -0.90%** **RMS: 0.45%**

Differences with KENO-VI

LWR - KRSKO

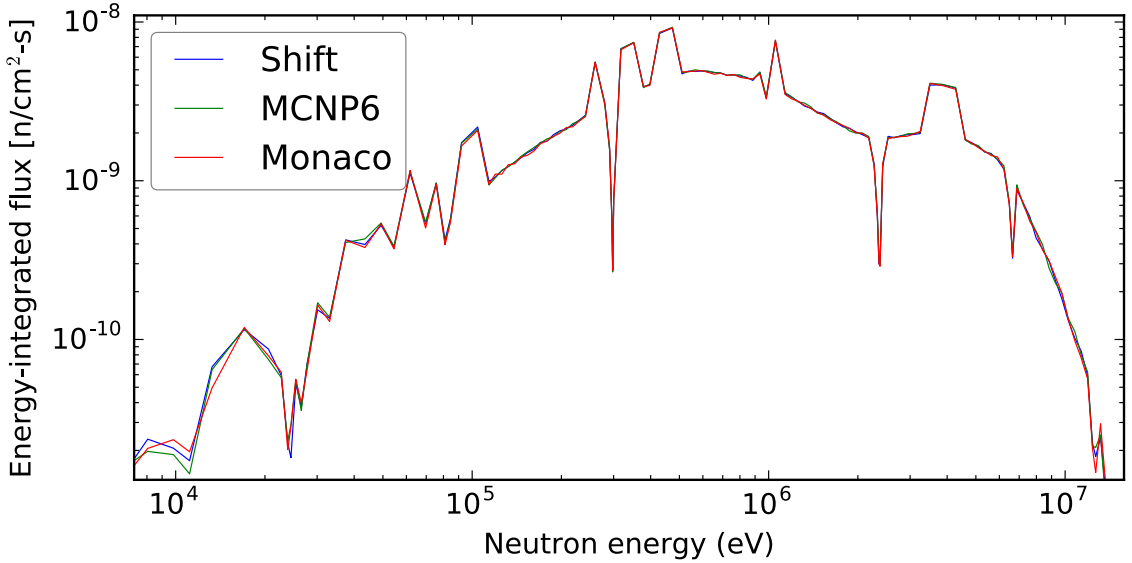
ZPPT control bank reactivity worth

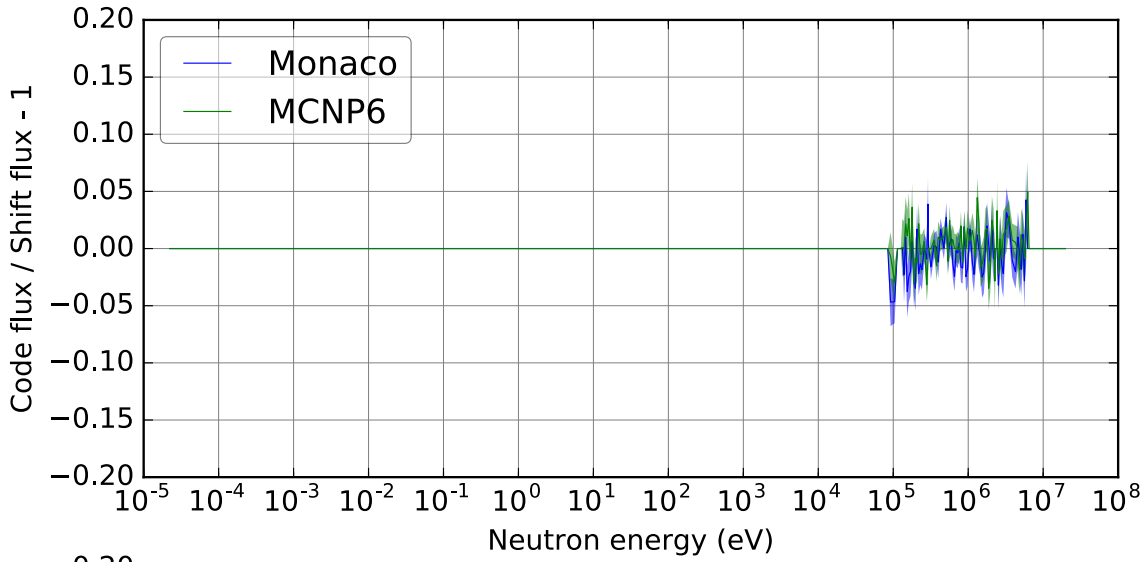
RCCA Position	Measured Worth (pcm)	Shift Relative Error (%)
D	949	-0.3
C with D Inserted	1367	3.4
B with CD Inserted	872	-0.6
A with BCD Inserted	2091	2.1
Total	5279	-0.1 +/- 2.4

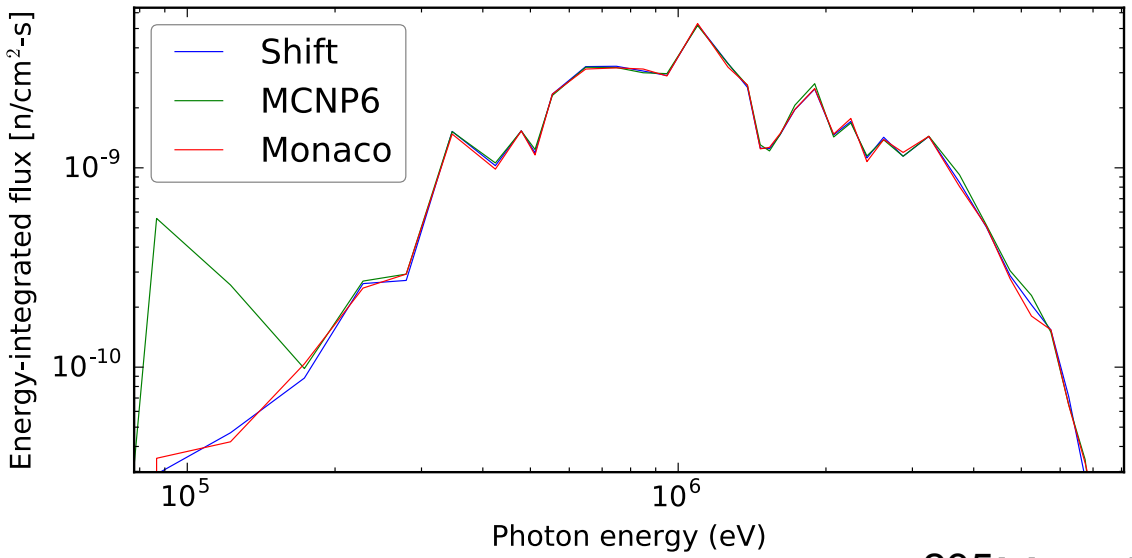
ZPPT boron endpoint criticality

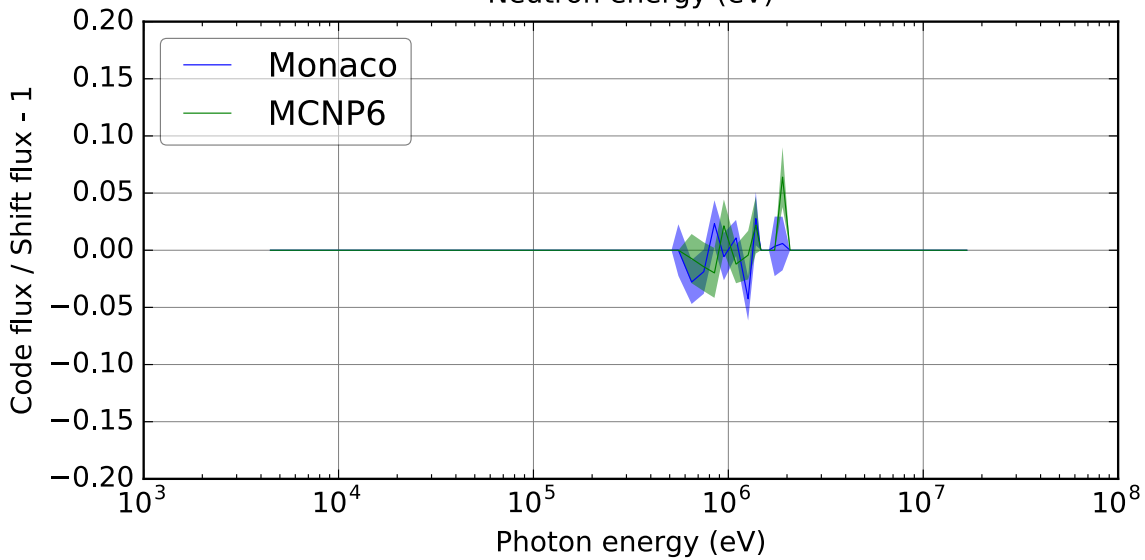
RCCA Position	Measured Boron (ppm)	Shift Difference (ppm)
ARO	1445	58
D Inserted	1343	95
CD Inserted	1192	147
BCD Inserted	1108	96
ABCD Inserted	905	41
Average		88 +/- 41

LWR – Coupled (n, γ) leakage spectra comparison



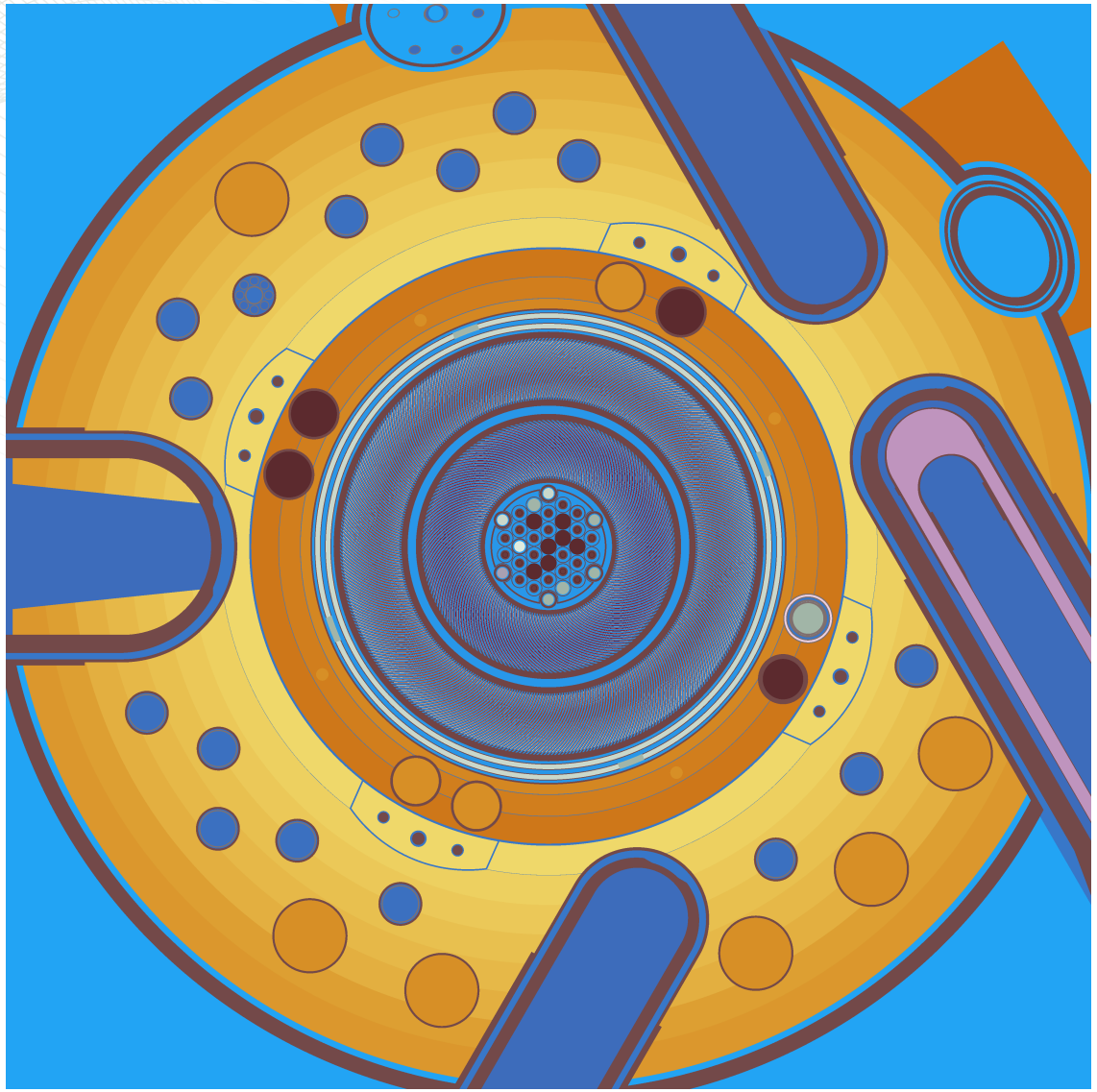


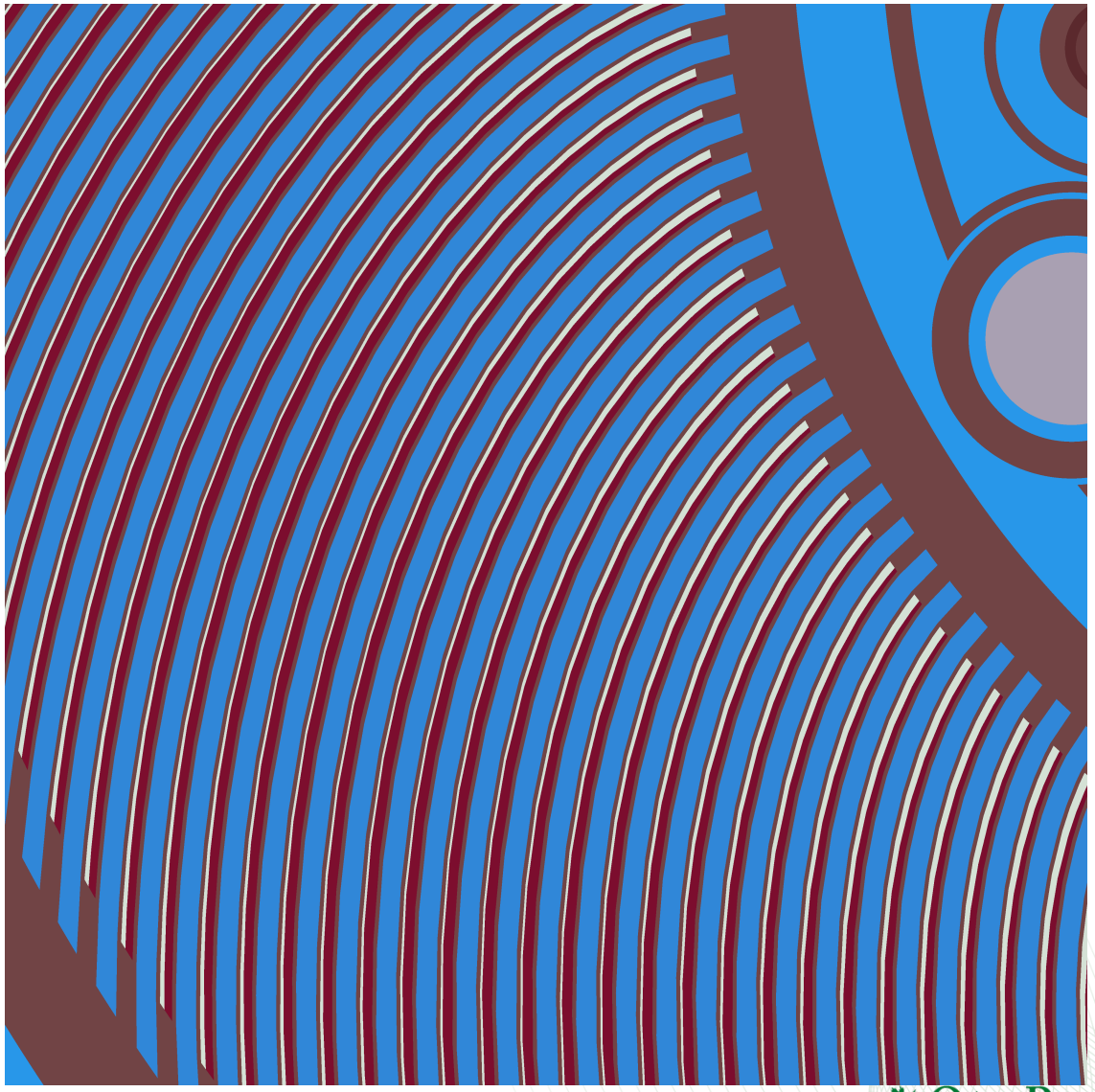




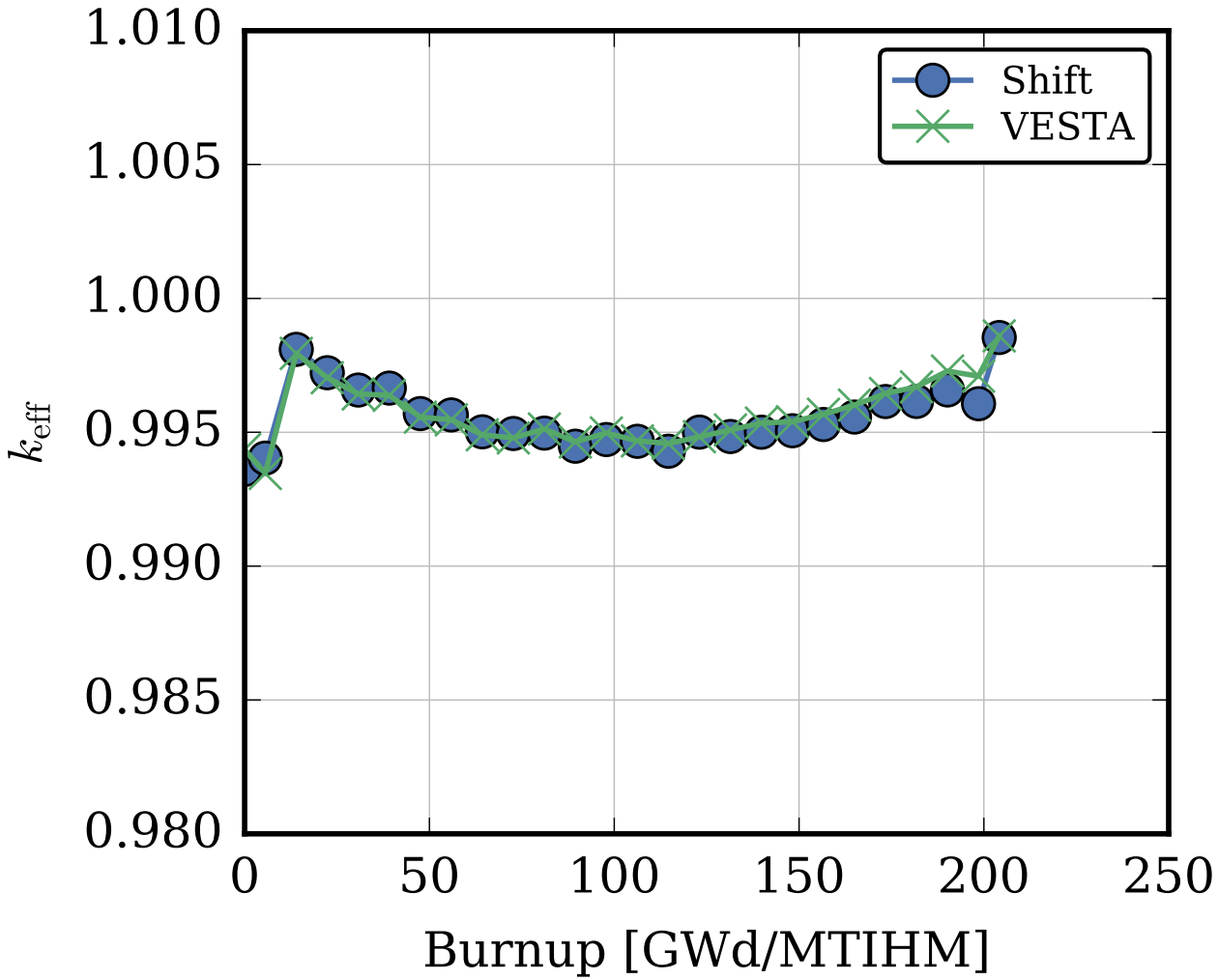
^{235}U spherical shell

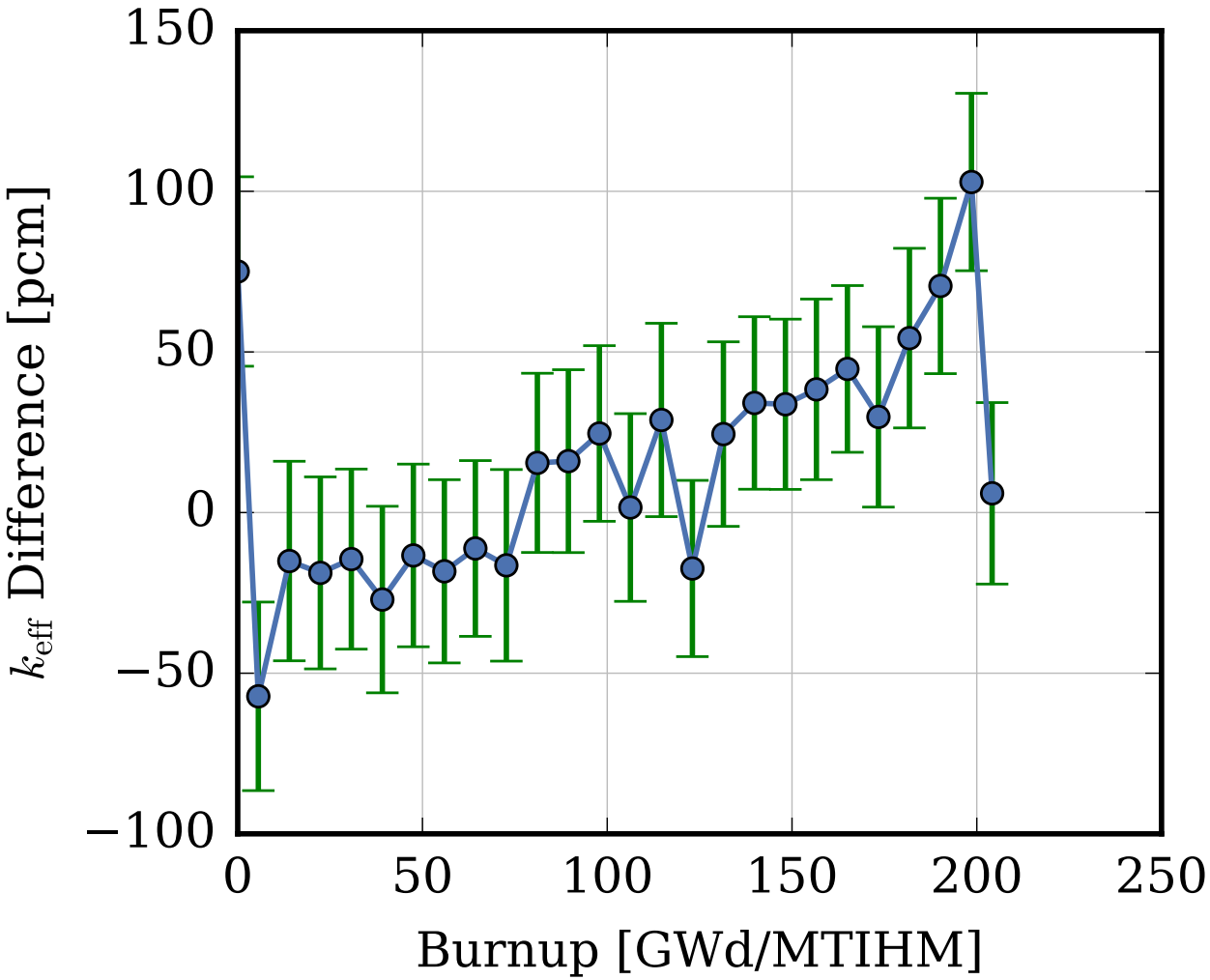
Depletion – HFIR Cycle 400 with explicit fuel plates





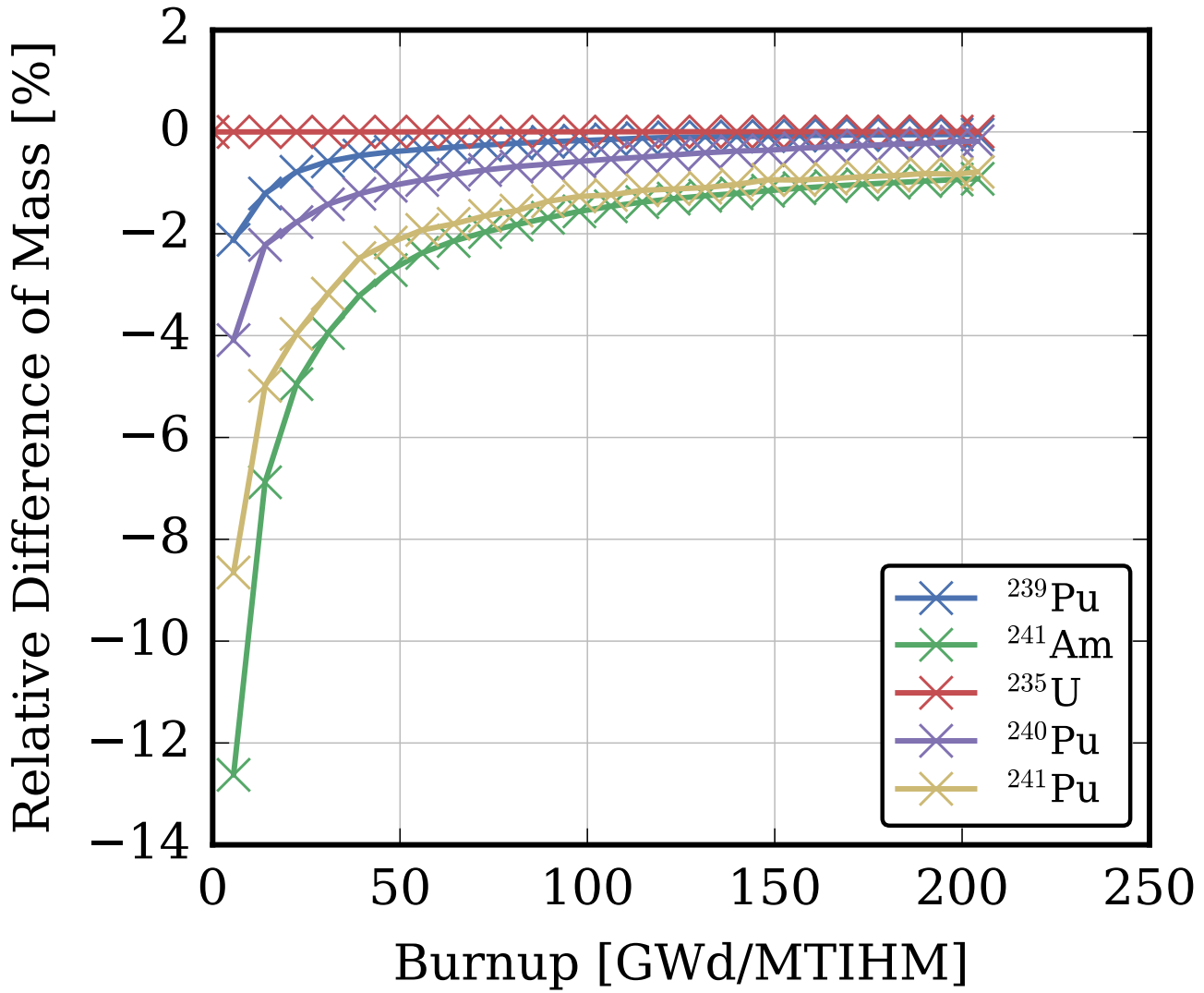
Depletion – HFIR Cycle 400 explicit: k_{eff}





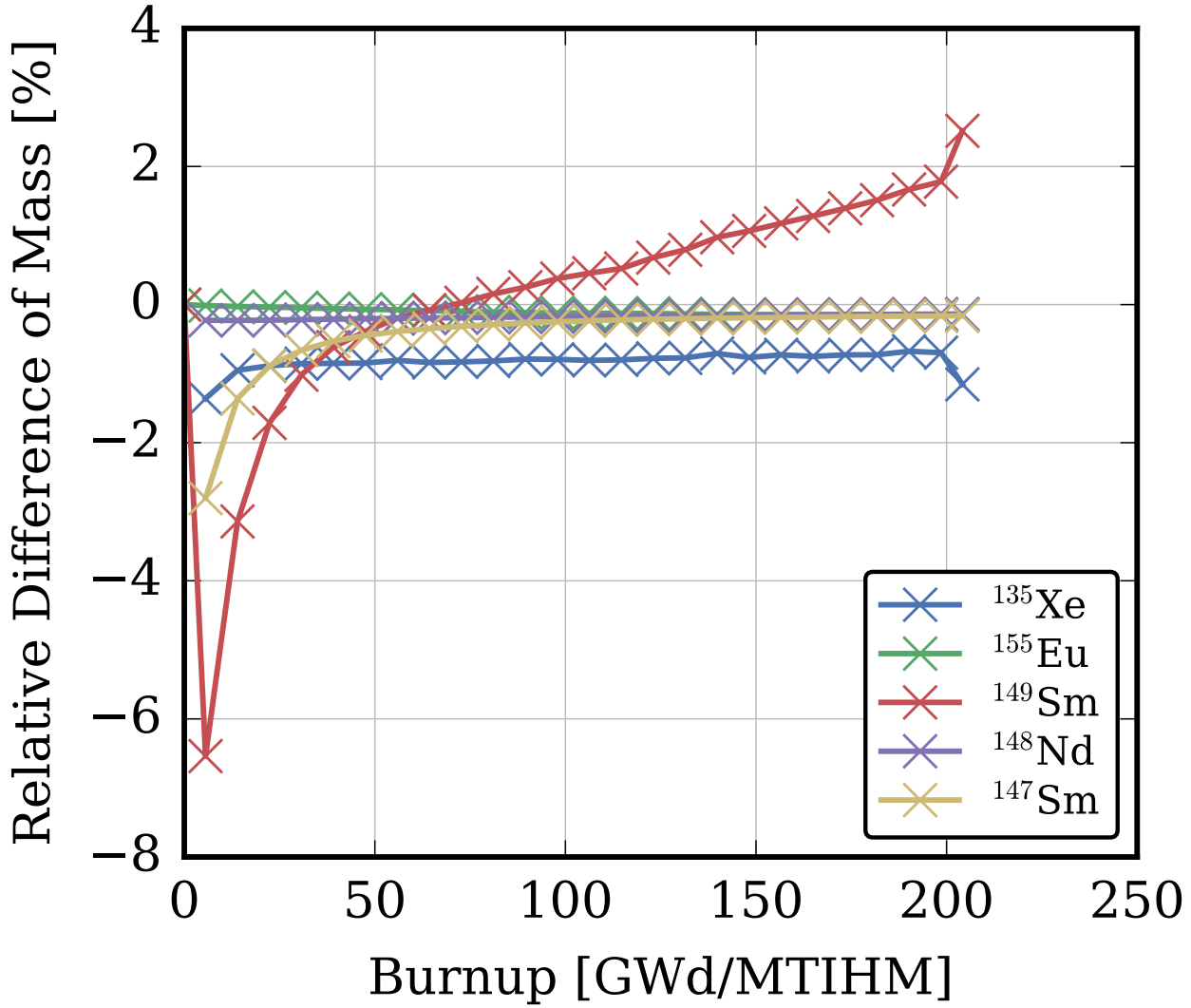
Depletion – HFIR Cycle 400 explicit: Actinides

Relative Difference in Atom Density for Actinides between Shift and VESTA

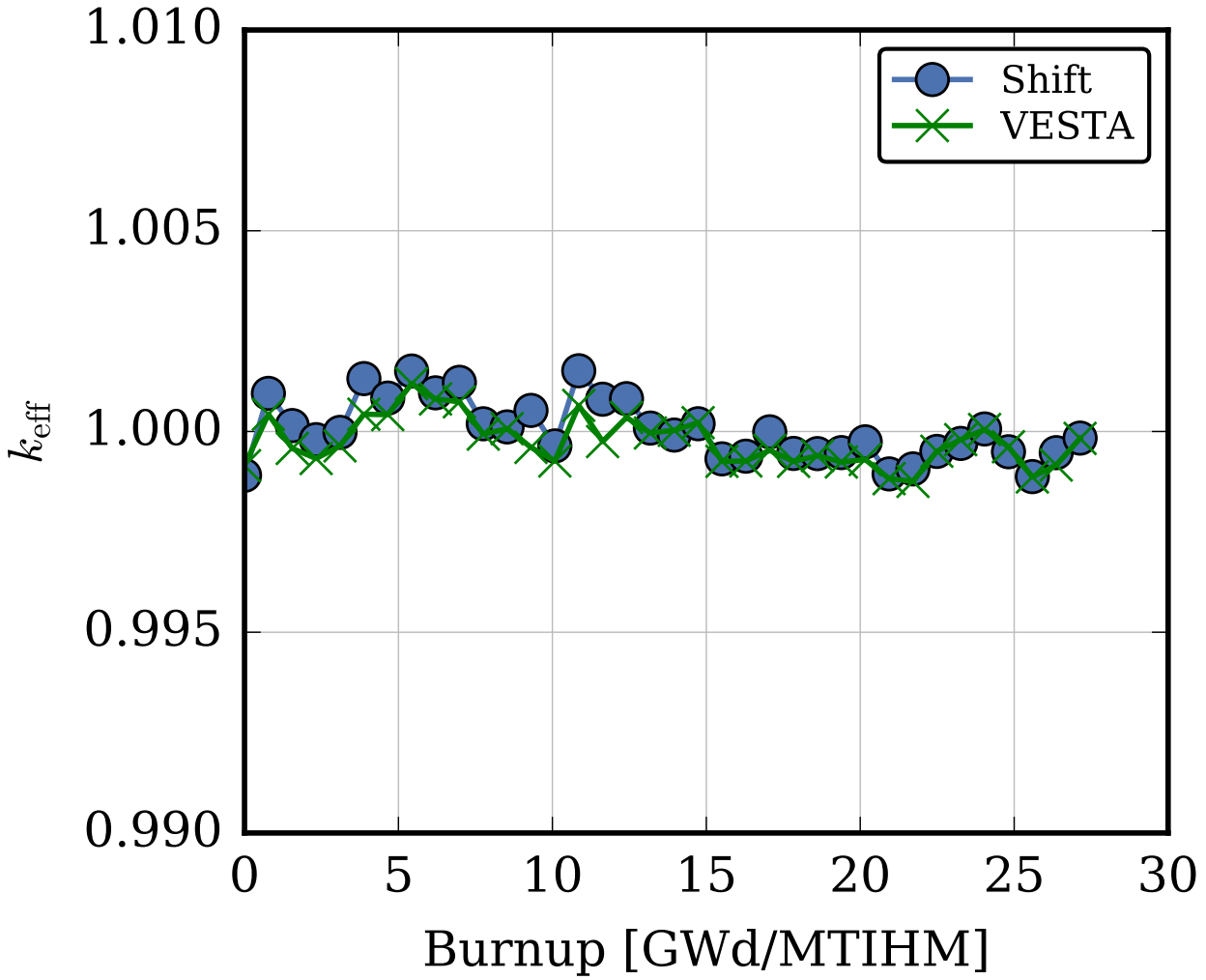


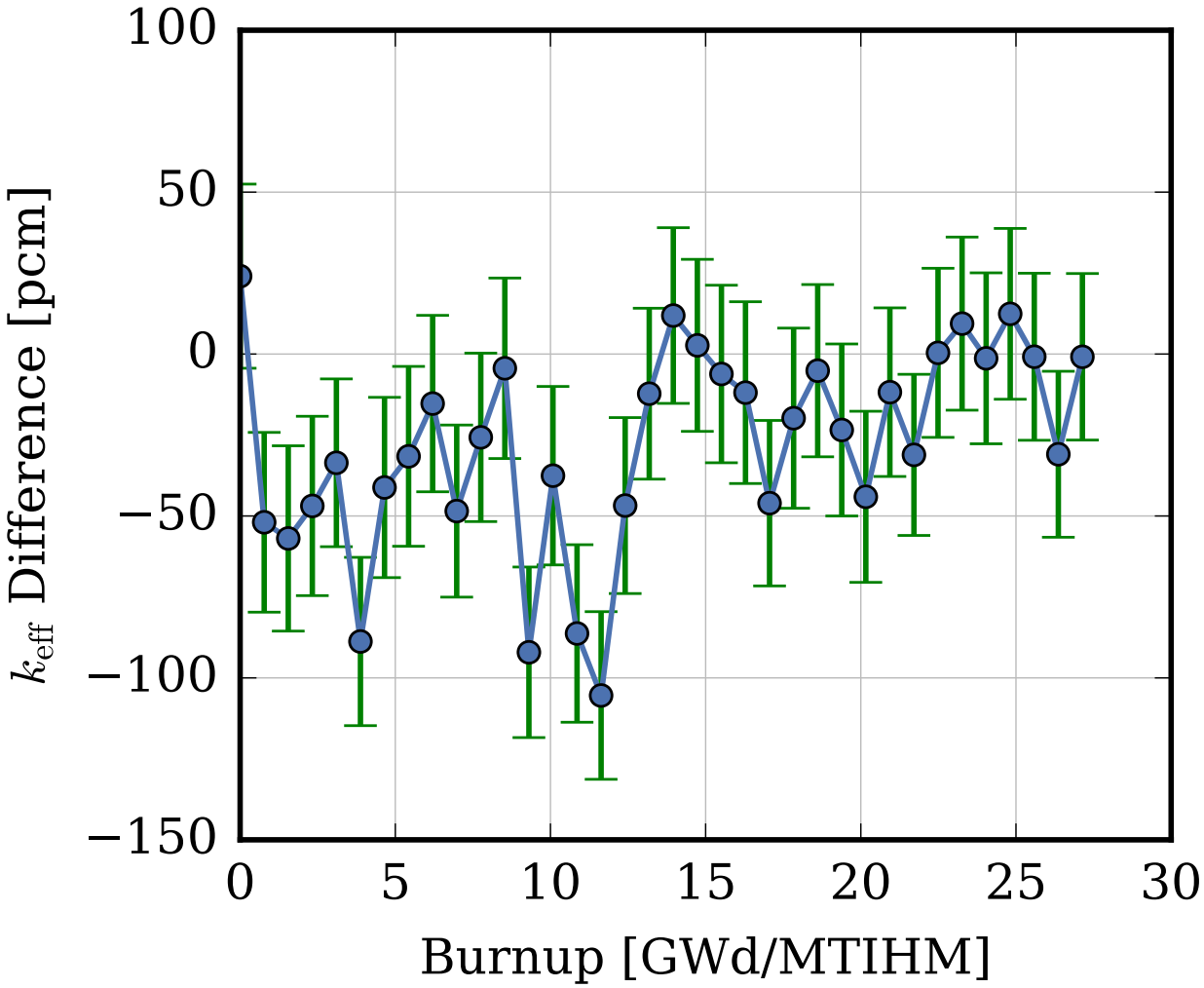
Depletion – HFIR Cycle 400 explicit: Fission Products

Relative Difference in Atom Density for Fission Products between Shift and VESTA



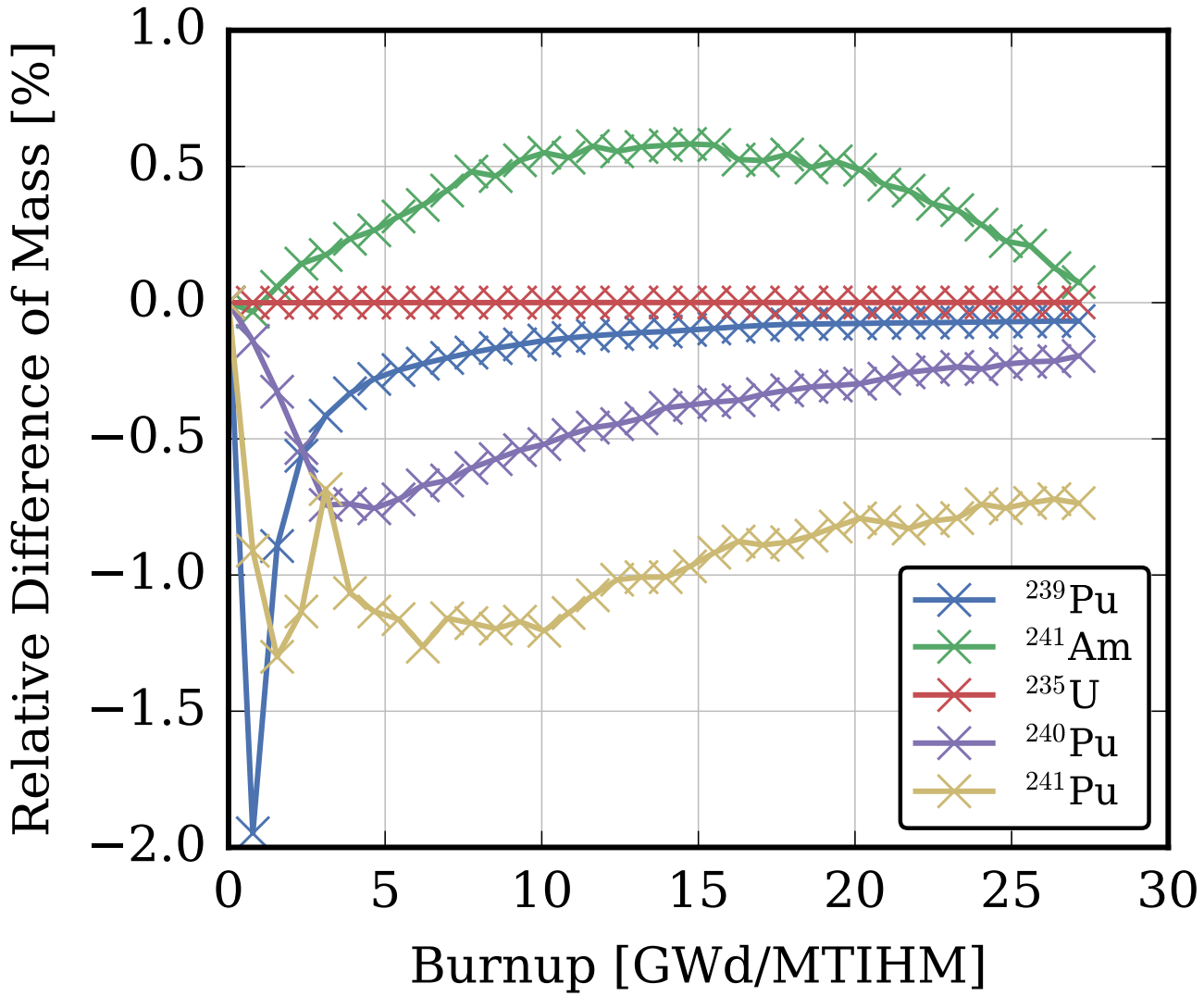
Depletion – HFIR LEU explicit: k_{eff}





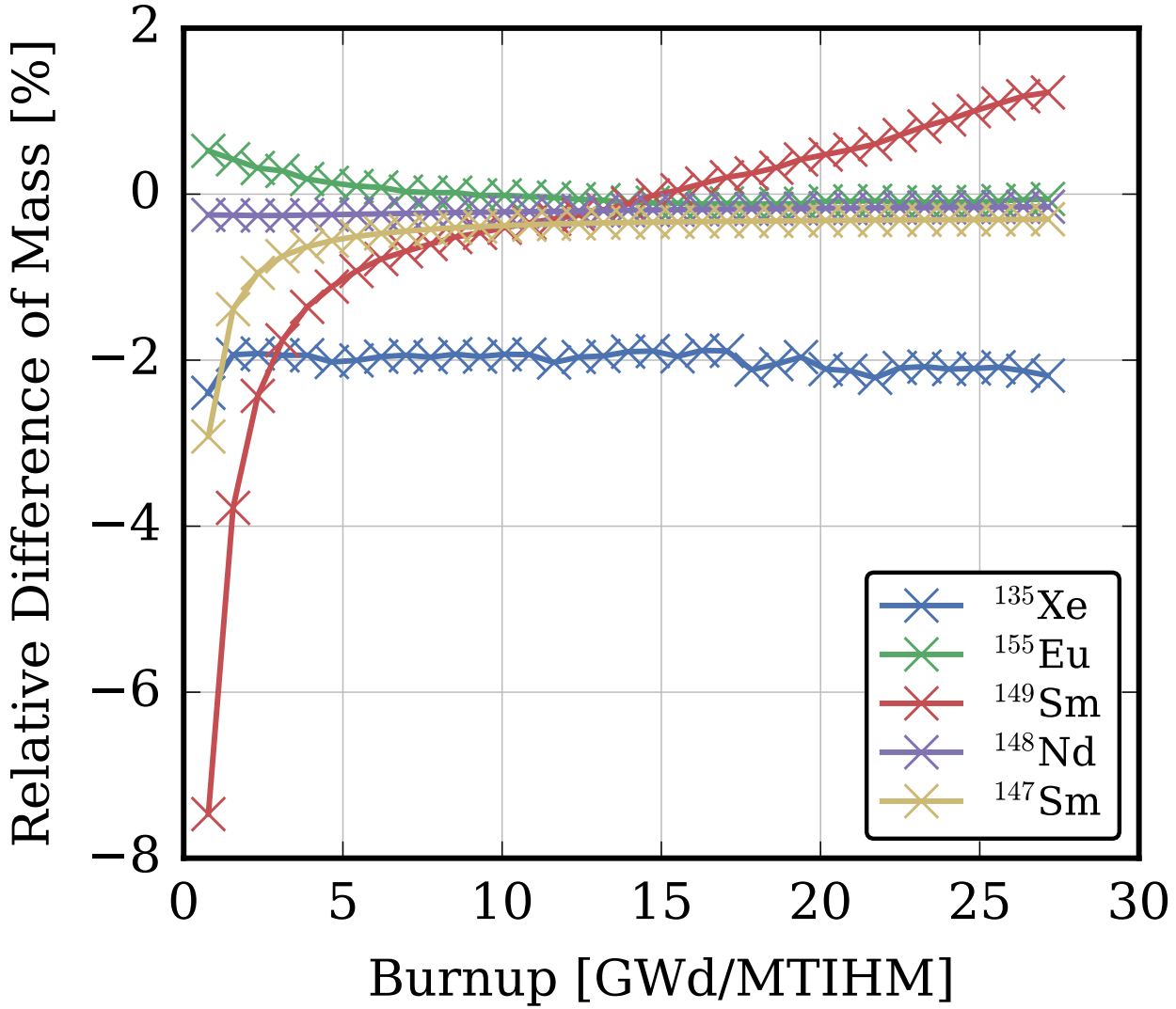
Depletion – HFIR LEU explicit: Actinides

Relative Difference in Atom Density for Actinides between Shift and VESTA



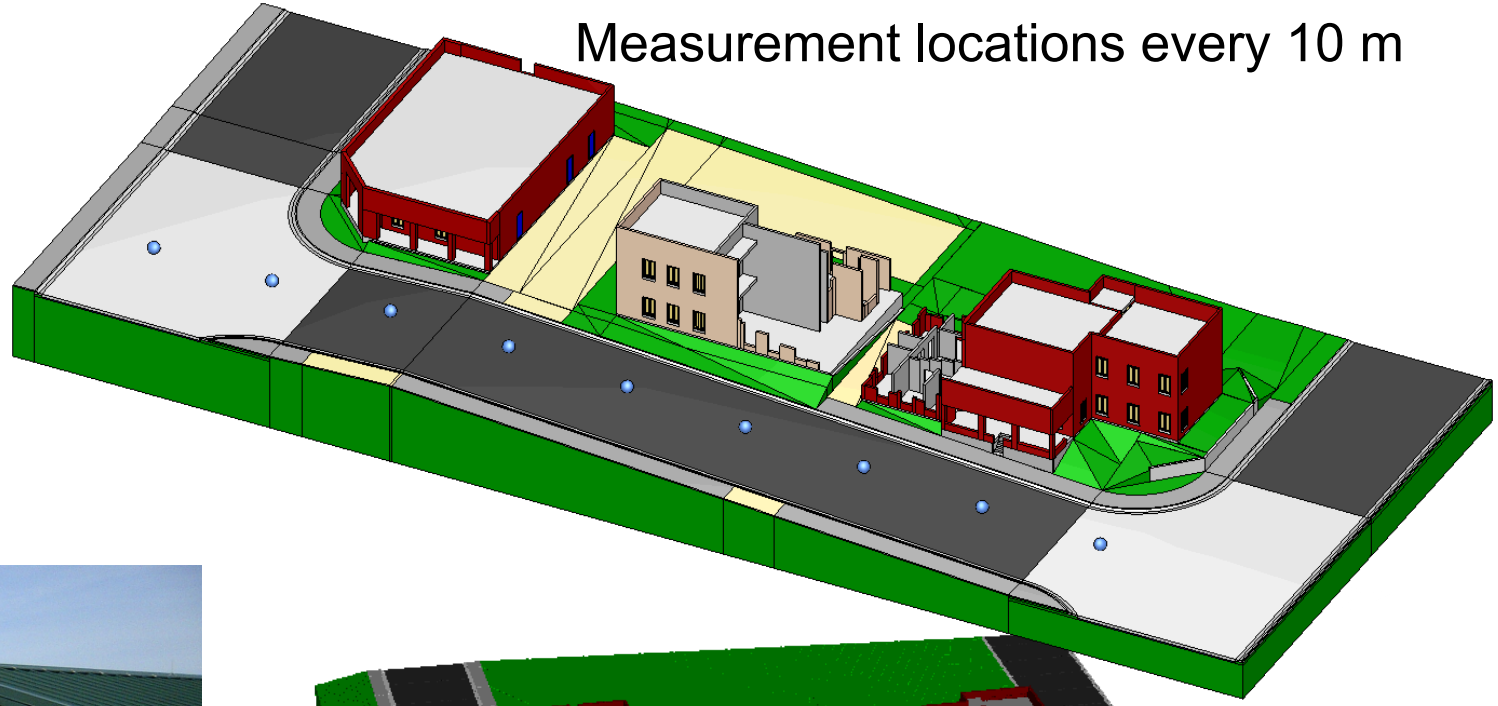
Depletion- HFIR LEU explicit: Fission Products

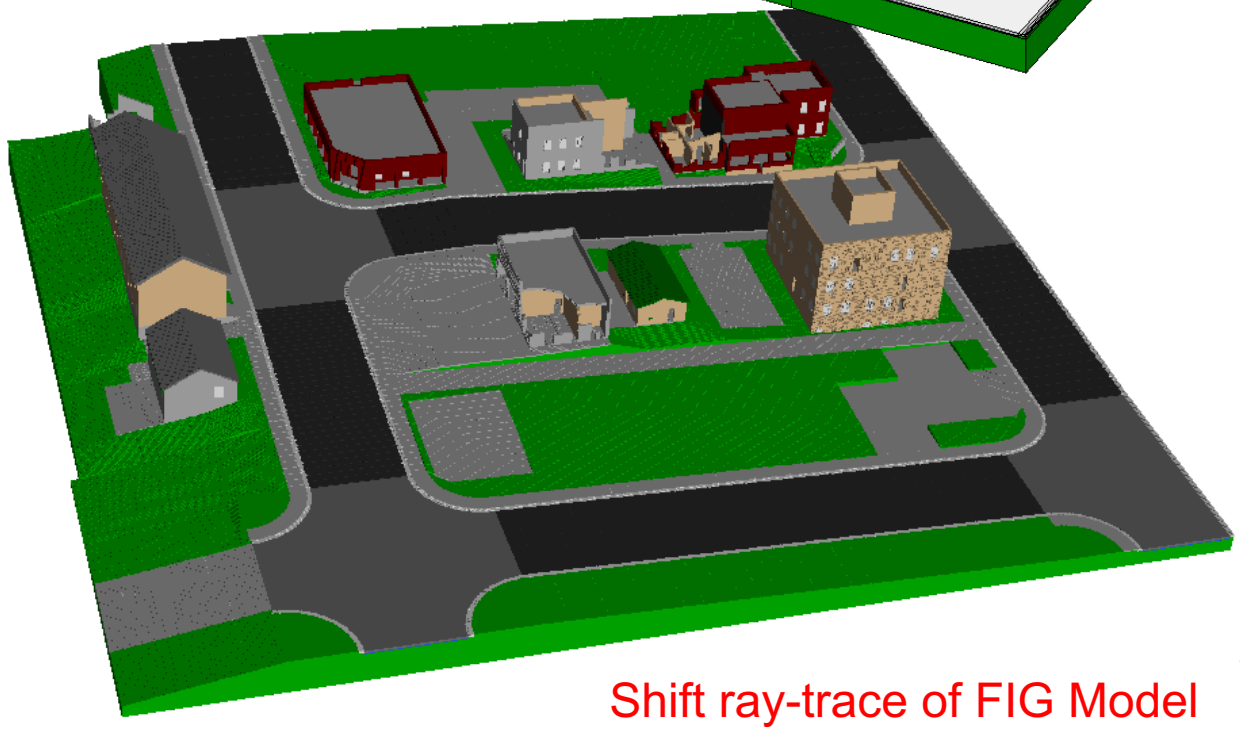
Relative Difference in Atom Density for Fission Products between Shift and VESTA



Detection – OPTUS-3

OPTUS-3 Measurements (Nov 2015): Along centerline of main street, used standard issue 2”×4”×16” NaI detector, measured background and Cs source at four locations

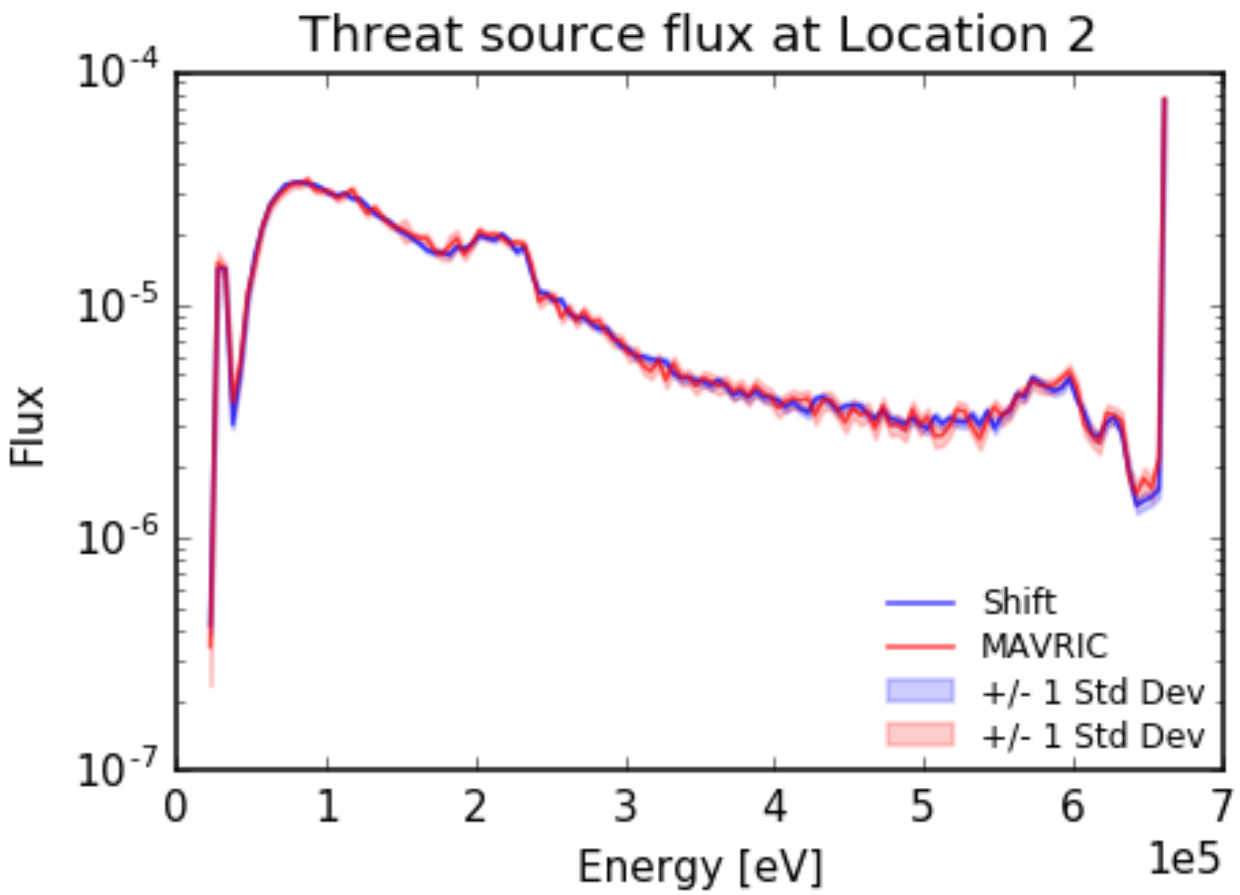


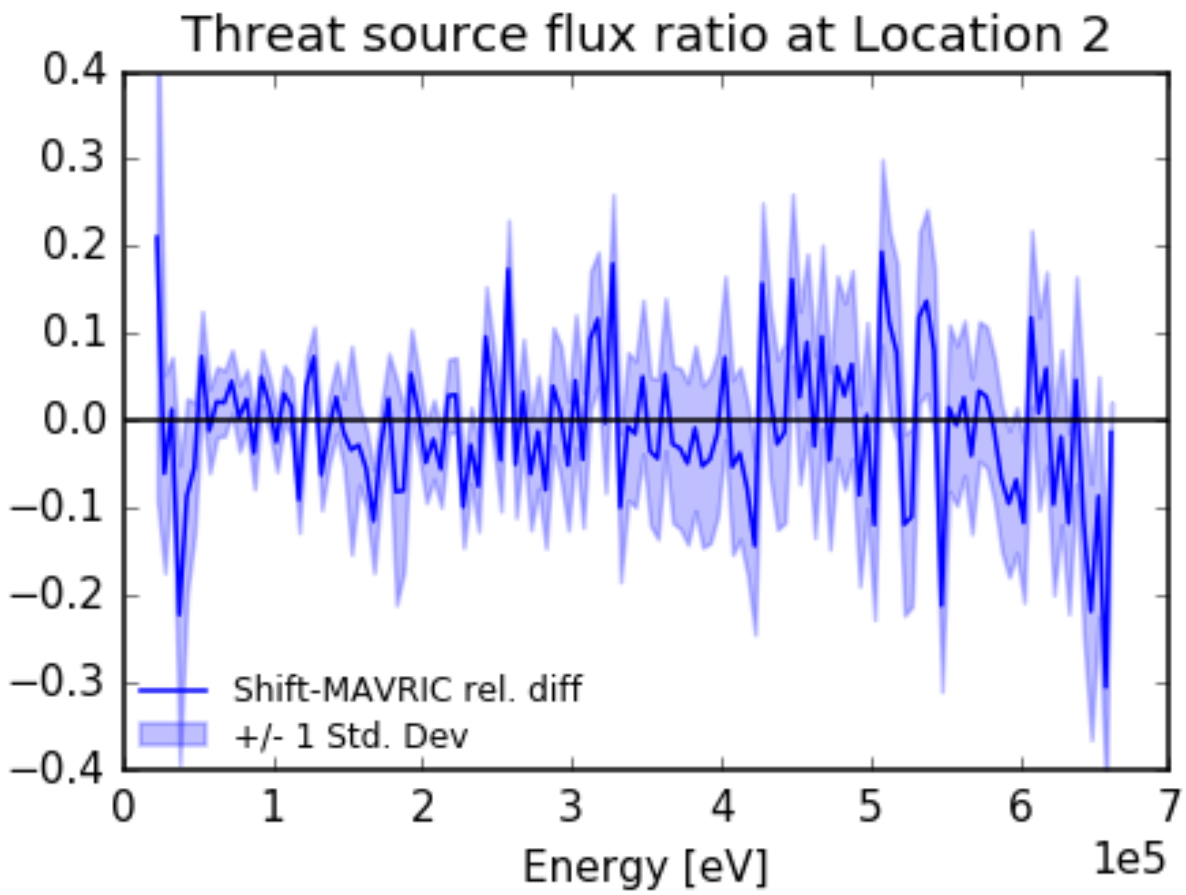


Shift ray-trace of FIG Model

Detection - Photon flux MAVRIC comparison

Photon flux distribution at location 2 due to threat source at position (2800,1650,764) cm

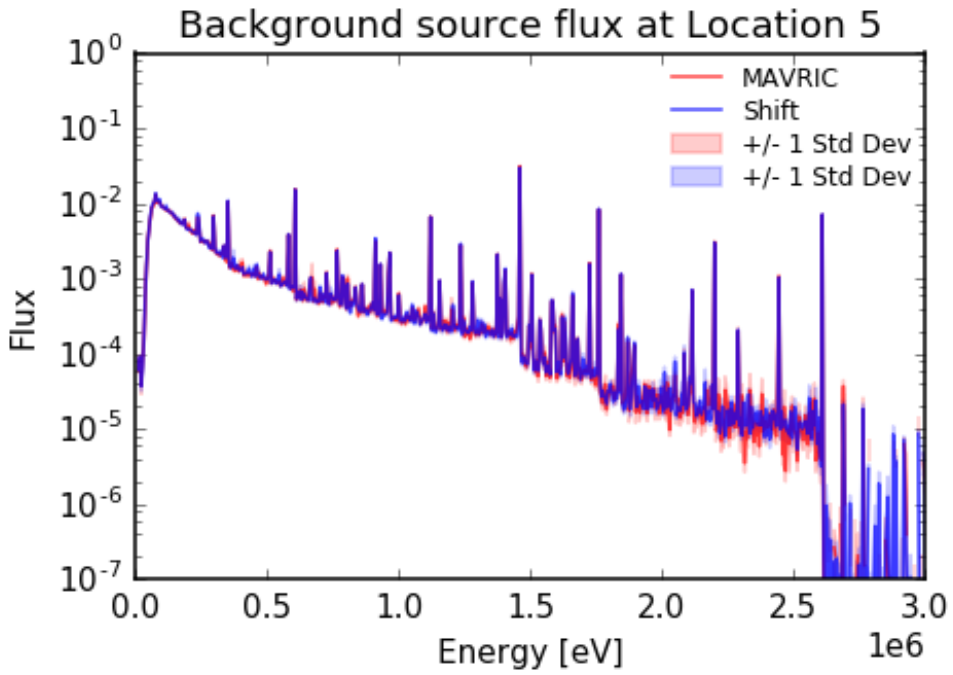


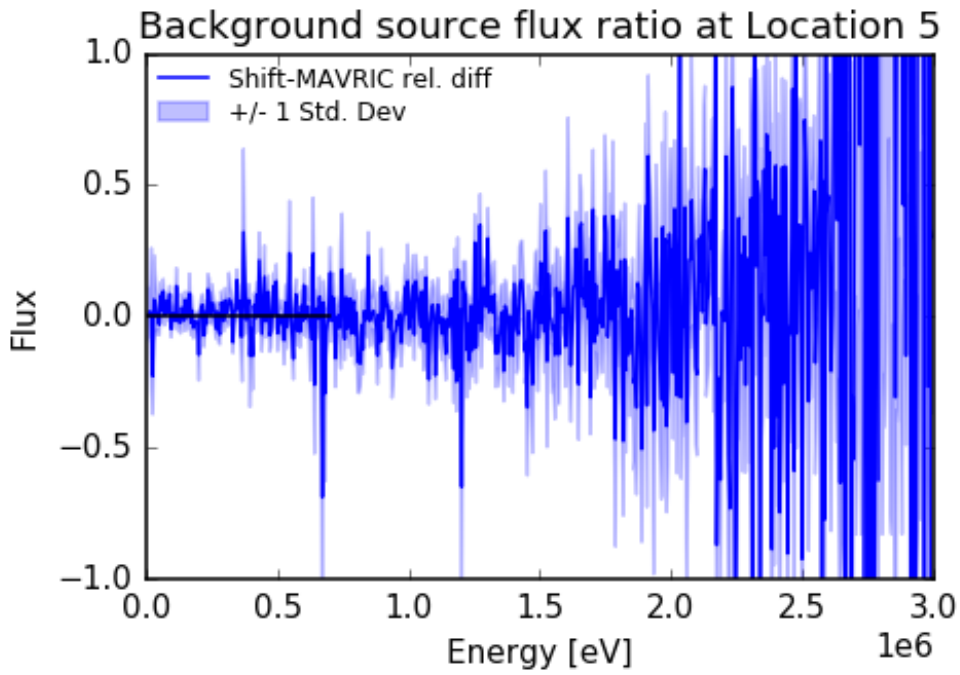


Detection – Background flux MAVRIC comparison

If fluxes match, then detector count rate spectra should match, if the same post-processing is used.

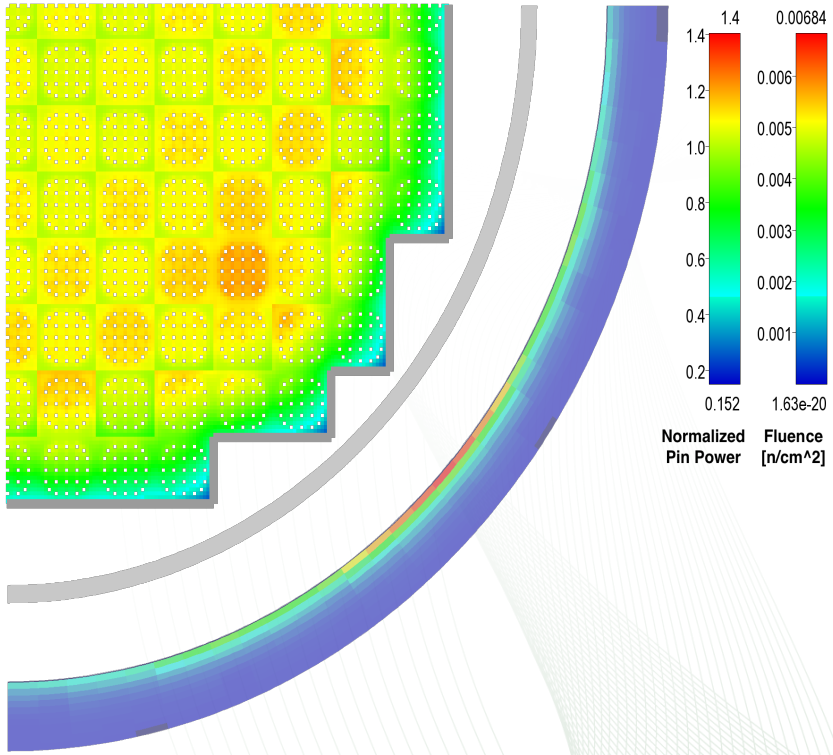
Photon flux distribution at location 5 due to all background sources





Ongoing and future Shift V&V work

- CASL vessel fluence and excore detectors through VERA
- Photon physics through Modeling Urban Scenarios & Experiments
- Lattice physics with TRITON
- Performance optimization



Thank You and Questions

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Slack channel: https://exnihilo-ornl.slack.com

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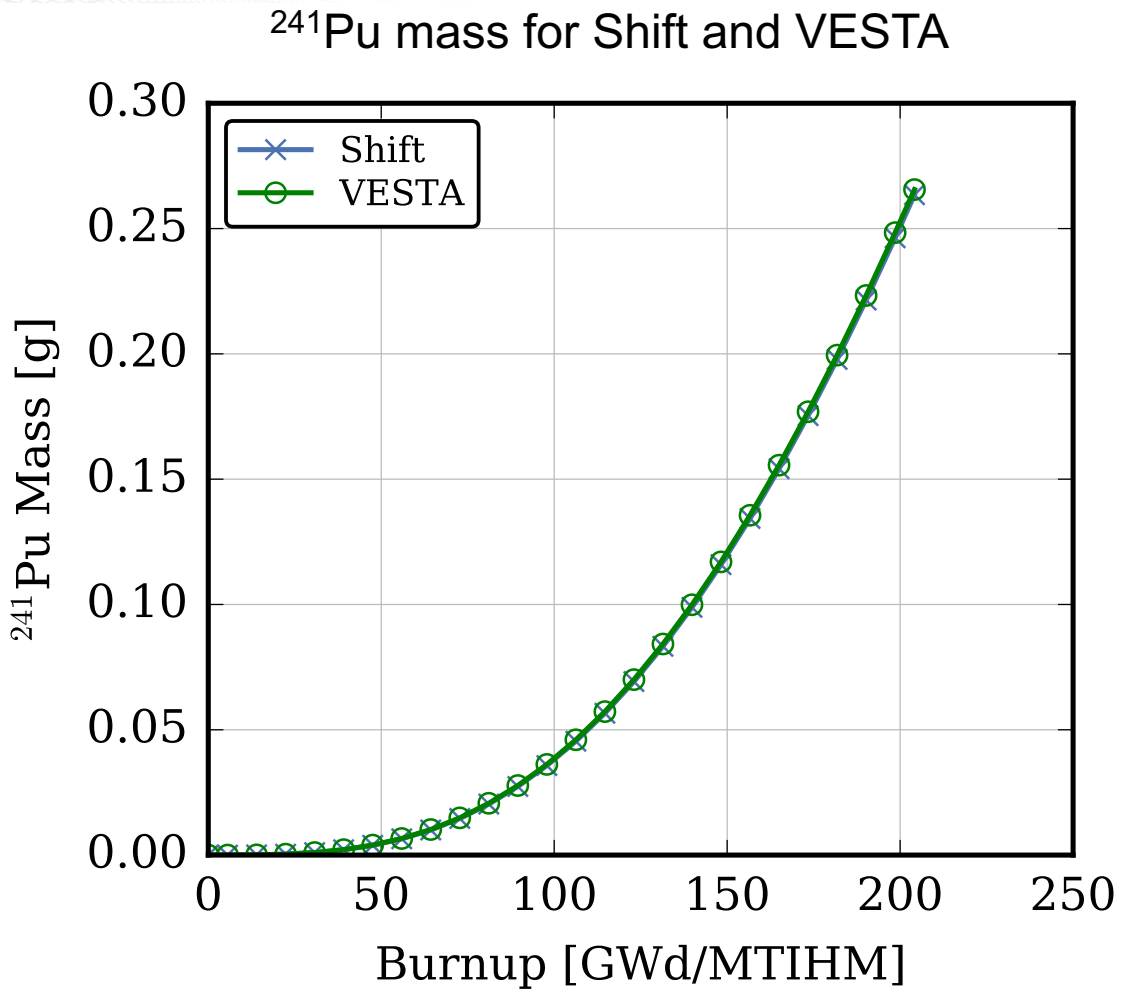
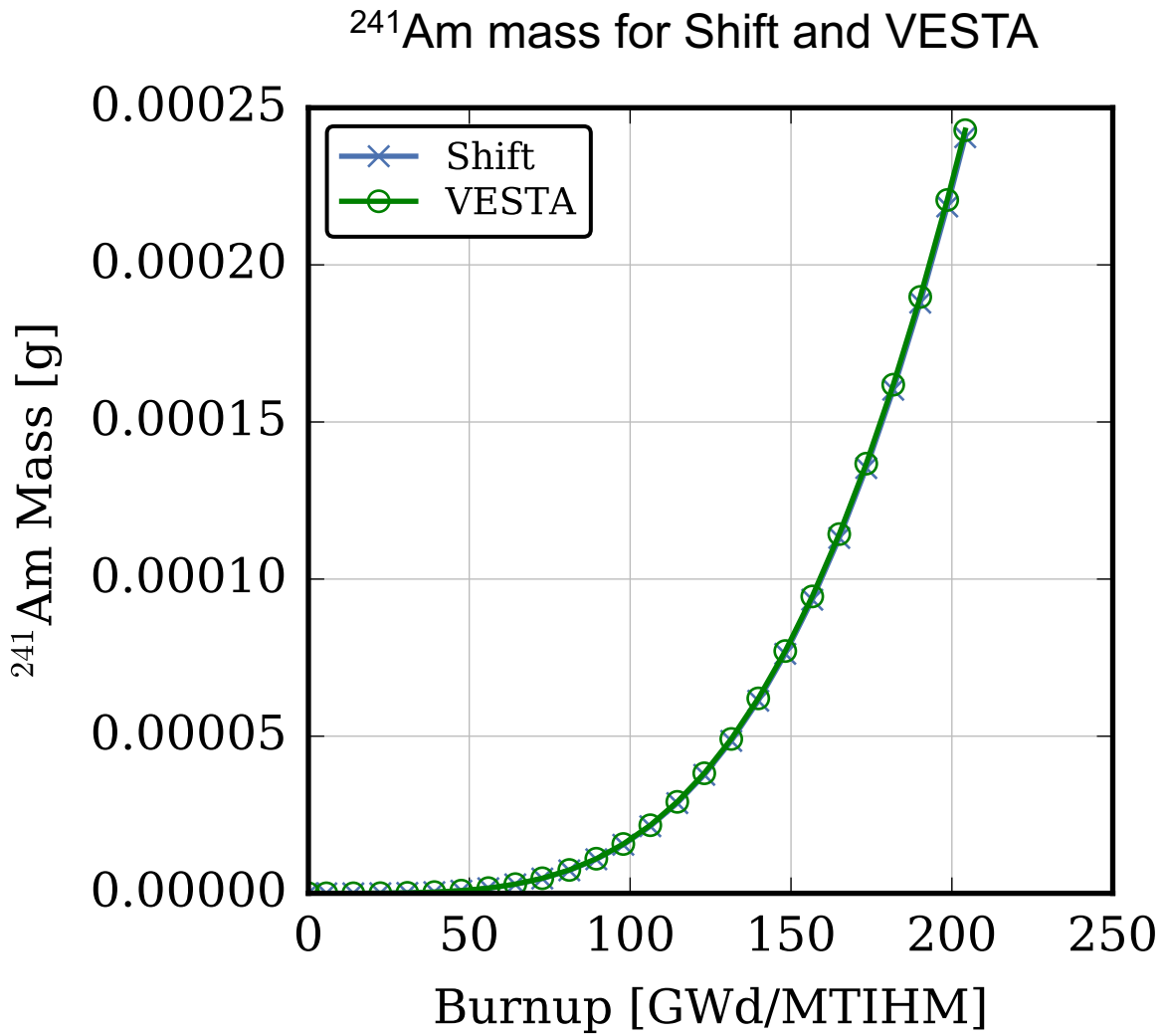
Depletion – HFIR Cycle 400 explicit: ^{241}Pu and ^{241}Am





Depletion – HFIR LEU explicit: ^{135}Xe