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E8R1 BETA1 TESTING IN STUDSVIK'S CASMO5 LATTICE PHYSICS CODE

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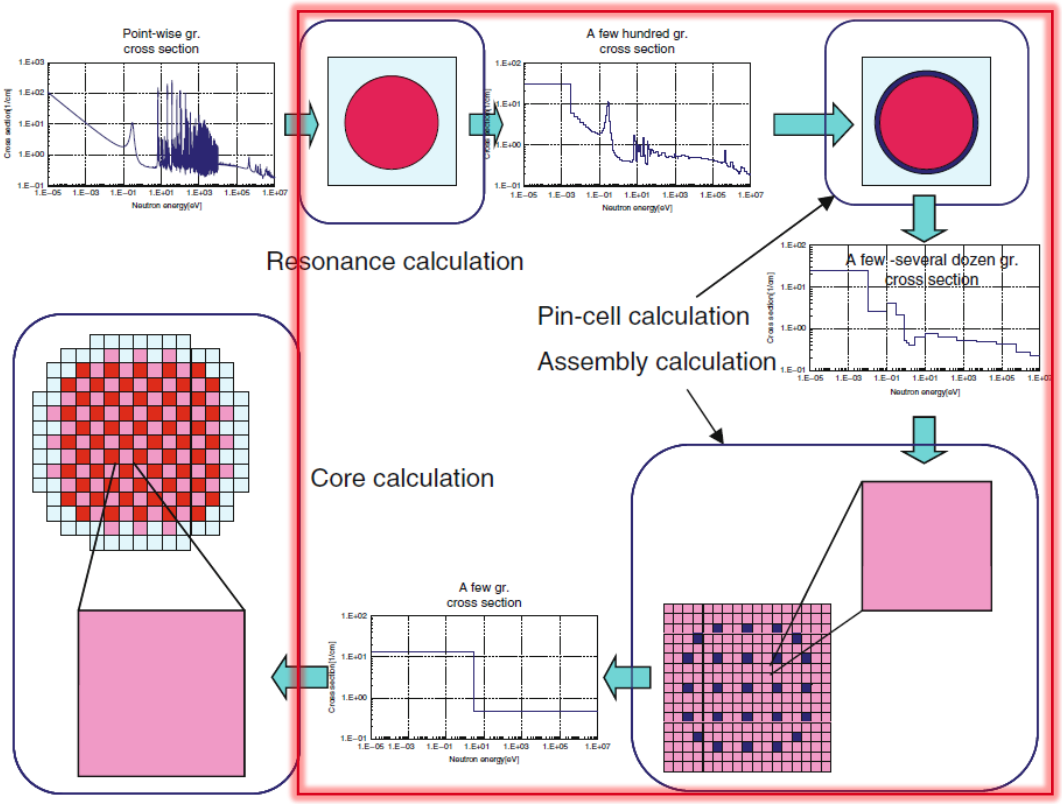
INTRODUCTION

- As “end users” of nuclear data evaluations, we are very interested in development and performance of ENDF/B releases.
- Always look forward to the release of the latest evaluations, hope that improvements in nuclear data manifest in improvements in predictions.
  - Relative to measured plant data such as boron letdown, flux maps, detector responses, etc.
  - “A rising tide lifts all boats.”
- Adjustments are not applied in the process of generating multi-group data.
- We are also early adopters of nuclear data as it is released by the community, including JENDL and JEFF.
  - E7R0 (2006)
  - **E7R1 (2012) – the default library**
  - JENDL-4 (2012)
  - JEFF-3.1.1 (2012)
  - JEFF-3.2 (2015)
  - E8R0 (2019)
  - JENDL-5 (2022)

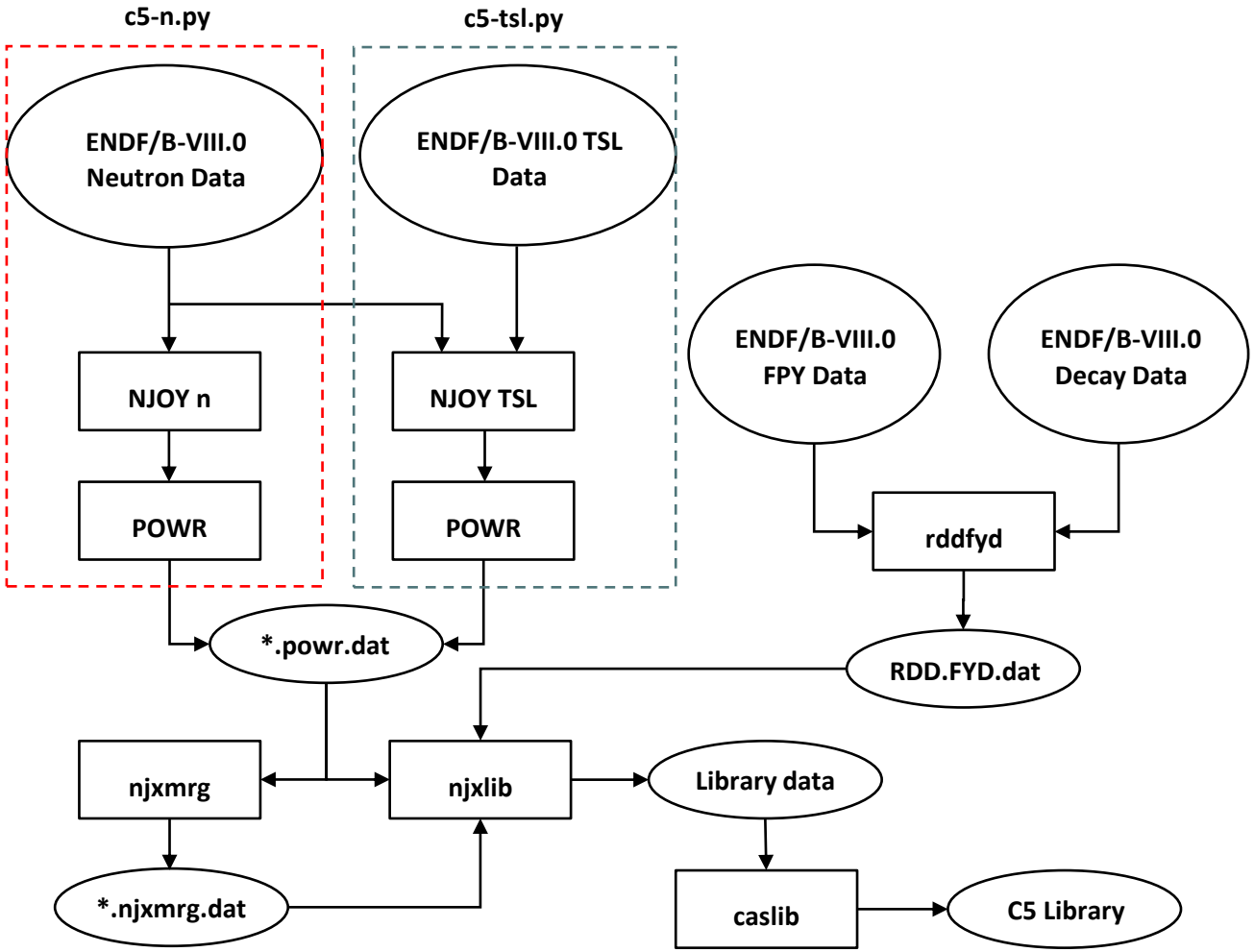
REACTOR ANALYSIS METHODS

- Current Light Water Reactor (LWR) analysis methods rely on two-step scheme.
- CASMO5 – advanced lattice physics analysis.
- SIMULATE5 – nodal core simulator for BWRs, PWRs, and VVERs.
- CASMO5 generates homogenized data for downstream full-core analysis.
- Preliminary results use CASMO5 to study impact of libraries on eigenvalue versus depletion.



**Courtesy of Dave Knott, from Handbook of Nuclear Engineering, Springer (2010).*

PYTHON-BASED LIBRARY GENERATION



CASMO5 NUCLEAR DATA LIBRARY

- Nuclear data library incorporates 586 energy group structure for incident neutron cross sections and encompasses 1095 nuclide/material IDs.

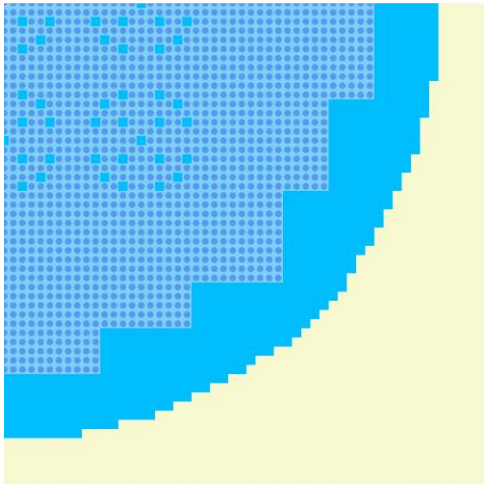
	CASMO-4 **L-Library**	**CASMO5** **E7R1, E8R0, E8R1**
Evaluation	ENDF/B-IV	ENDF/B-VII.1, VIII.0, VIII.1
# Neutron Grps	70	586
# Reso. Grps.	13	41
# Thermal Grps.	43 (below 4 eV)	42 (below 0.625 eV)
# Gamma Grps	18	18
#IDs	103	1095 [+992, +758]
# Actinides	20	118 [+98, +82]
# Fission Products	29 + 2 Lumped	490
# IDs with resonance data	21	443 [+422, +411]
# IDs with Pn-data	3	114 [+111, +94]

B&W-1810 CRITICAL EXPERIMENTS

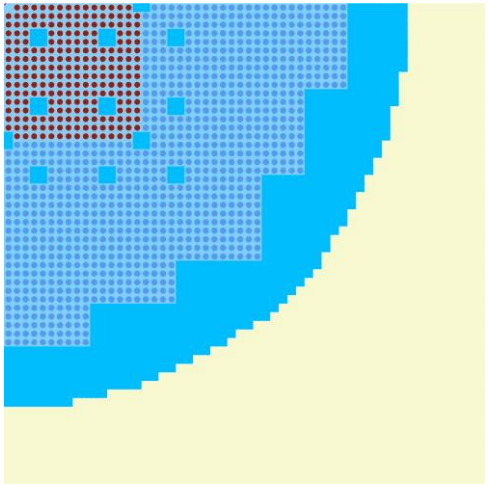
- Core consists of 5x5 array of either PWR 15x15 type or 16x16 type assemblies.
- Some cores contained gadolinium fuel pins, Ag-In-Cd (AIC), or B4C control rods, or hollow rods.

Core	Boron (ppm)	Lattice	Central Region	4w/o Gd Pins	AIC Rods
1	1,337.90	15x15	Uniform	-	-
2	1,250.00	15x15	Uniform	-	16
3	1,239.30	15x15	Uniform	20	-
4	1,171.70	15x15	Uniform	20	16
5	1,208.00	15x15	Uniform	28	-
5A	1,191.30	15x15	Uniform	32	-
5B	1,207.10	15x15	Uniform	28	-
6	1,155.80	15x15	Uniform	28	16
6A	1,135.60	15x15	Uniform	32	16
7	1,208.80	15x15	Uniform	28 (annular)	-
8	1,170.70	15x15	Uniform	36	-
9	1,130.50	15x15	Uniform	36	16
10	1,177.10	15x15	Uniform	36	16
12	1,899.30	15x15	2-Region	-	-
13	1,635.40	15x15	2-Region	-	16
14	1,653.80	15x15	2-Region	28	16
15	1,479.70	15x15	2-Region	28	16
16	1,579.40	15x15	2-Region	36	-
17	1,432.10	15x15	2-Region	36	16
18	1,776.80	16x16	2-Region	-	-
19	1,628.30	16x16	2-Region	16	-
20	1,499.00	16x16	2-Region	32	-

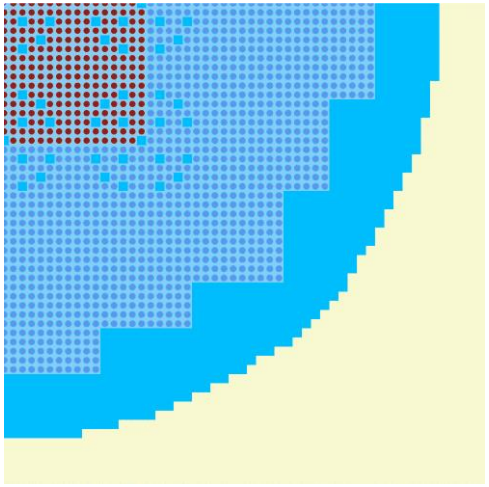
B&W-1810 CRITICAL EXPERIMENTS



Core 1
(15x15 Uniform)

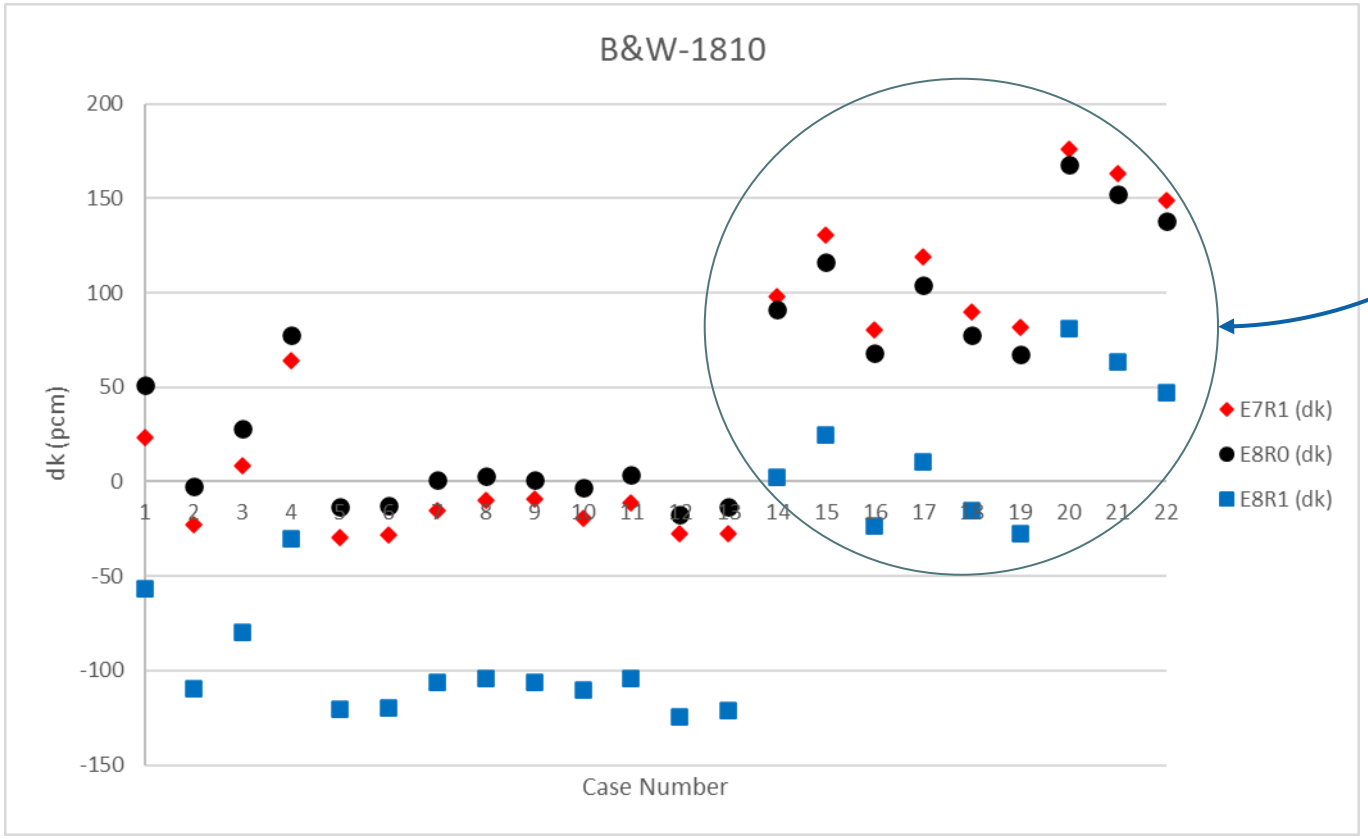


Core 12
(15x15 2-Reg.)



Core 18
(16x16 2-Reg.)

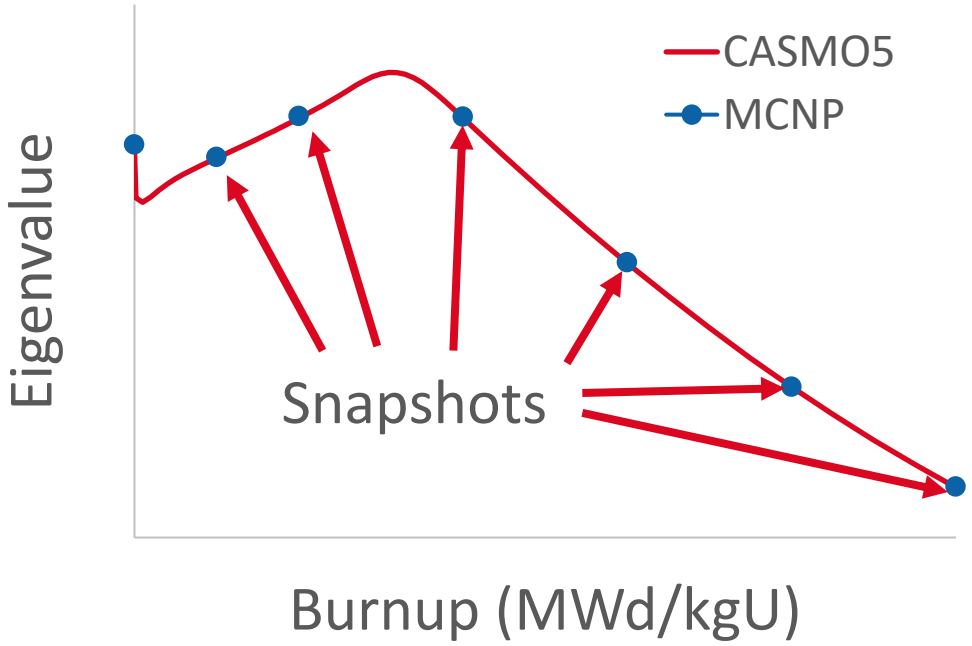
B&W-1810 RESULTS



dk (pcm)	E7R1	E8R0	E8R1
AVE	45	49	-51
SD	70	58	66

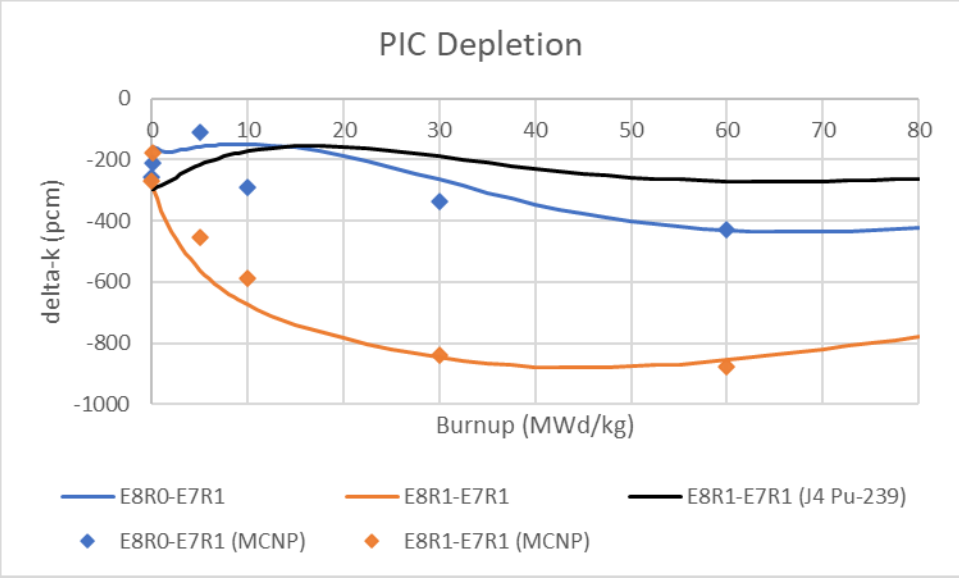
COMPARISONS TO MCNP6

- Processed ENDF/B-VIII.1 files with NJOY-2016 and generated ACE files.
- Use CASMO5 option to automatically “snapshot” generate MCNP input files.
  - Depletion is performed by CASMO5.
  - Identical geometry, composition and temperatures at “snapshot” points.



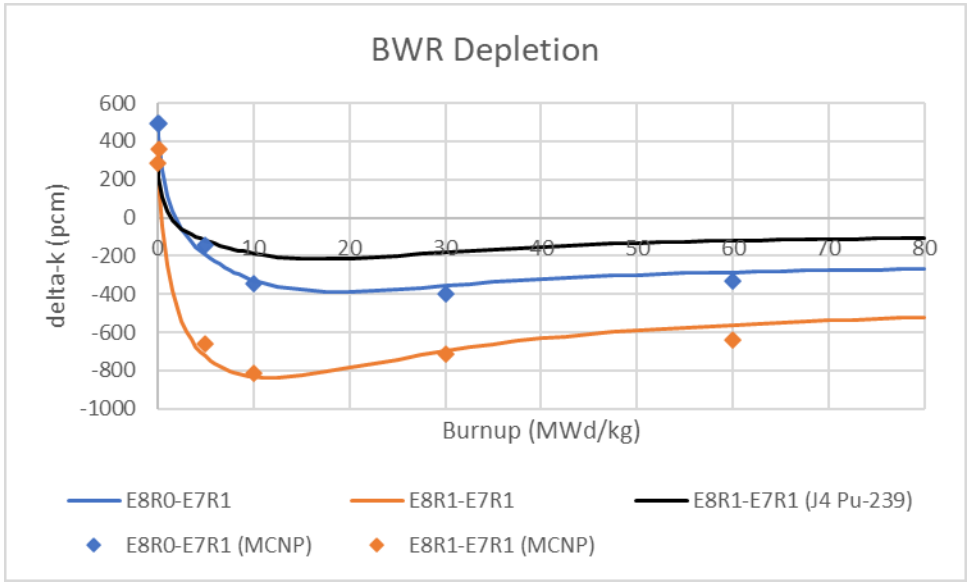
PIN-CELL RESULTS

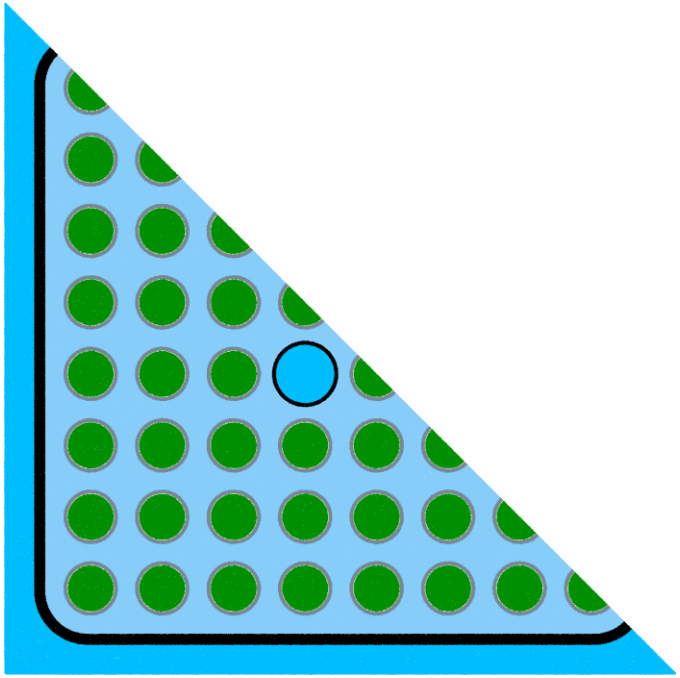
- Single pin-cell depletion assuming typical PWR nominal conditions and geometry.
- Replacing Pu-239 with JENDL-4 evaluation yields better agreement (E8R1 vs E7R1.)



BOILING WATER REACTOR (BWR) RESULTS

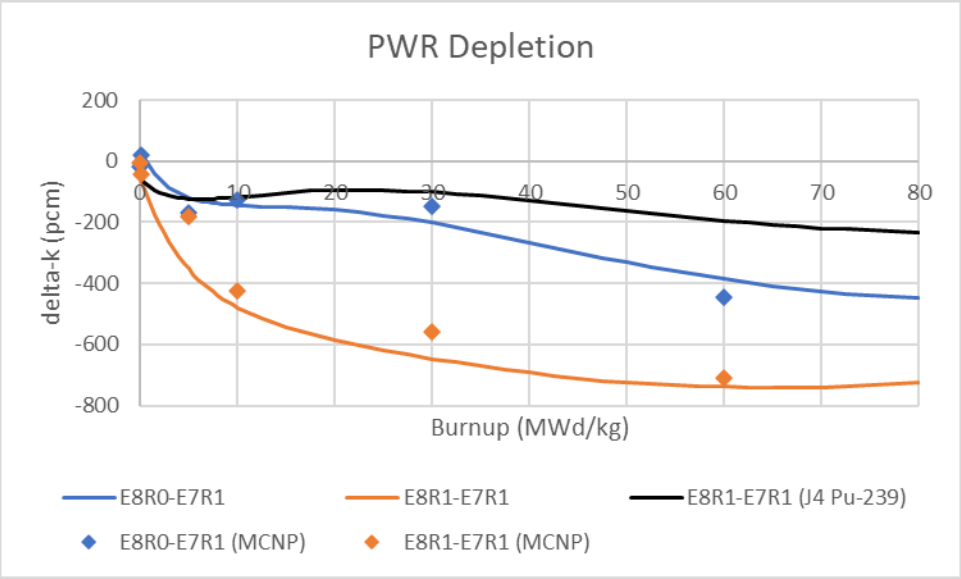
- BWR depletion assuming typical nominal conditions and geometry.
- Replacing Pu-239 with JENDL-4 evaluation yields better agreement (E8R1 vs E7R1.)

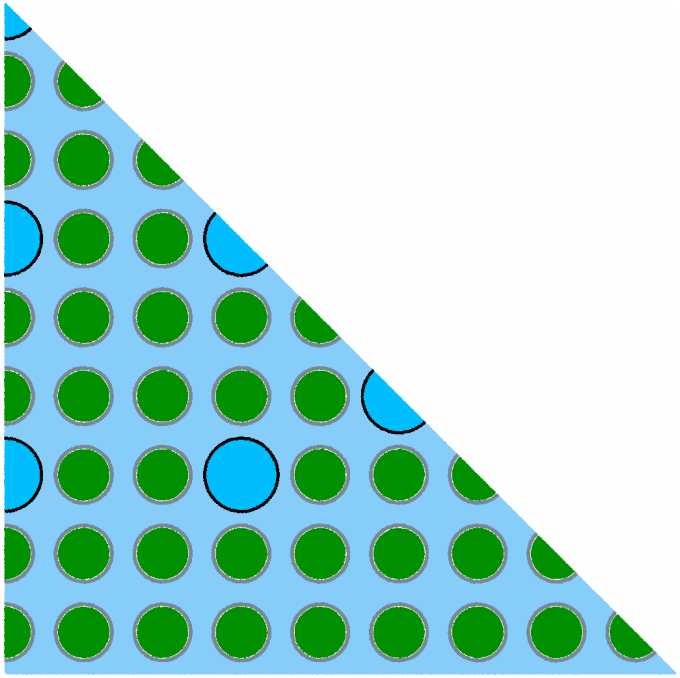




PRESSURIZED WATER REACTOR (PWR) RESULTS

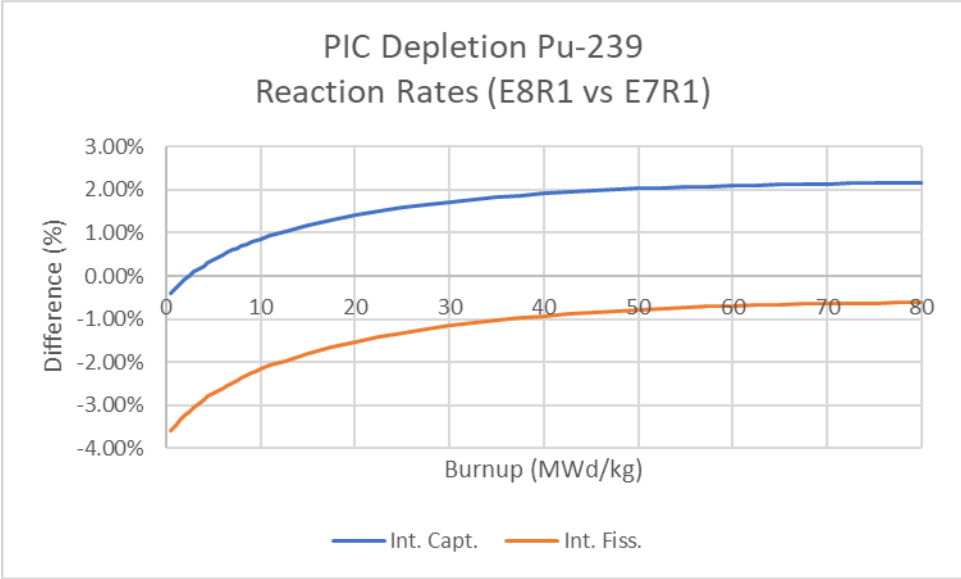
- PWR depletion assuming typical nominal conditions and geometry.
- Replacing Pu-239 with JENDL-4 evaluation yields better agreement (E8R1 vs E7R1.)





OBSERVATIONS FROM COMPARISON OF PU-239 DATA

- Compared integrated capture and fission reaction rates for pin-cell depletion.
- Reaction rate comparison indicates integrated capture is **higher** in E8R1 relative to E7R1.
- Reaction rate comparison indicates integrated fission is **lower** in E8R1 relative to E7R1.



CONCLUSION & FUTURE WORK

- Further testing is necessary to quantify downstream impact relative to core measurements.
  - Experience from previous libraries suggests that using the E8R1 data will result in a large decrease in reactivity at the full-core level.
- B&W-1810 results indicate slight decrease in reactivity, likely due to updated U-235 and U-238.
- Early feedback is that ENDF/B-VIII.1 Pu-239 evaluation is quite different in terms of reactivity from ENDF/B-VII.1 and ENDF/B-VIII.0.
  - In general, ENDF/B-VIII tends to underestimate k-infinity, as well as full-core k-effective, for actual reactors.
  - ENDF/B-VIII.1 was successfully processed.
- Comparison to data shows that ENDF/B-VII.1 yields best predictions.
  - Switching to JENDL-4.0 Pu-239 evaluation helps improve agreements.
  - Recommend using JENDL-4.0 Pu-239 evaluation in guiding new Pu-239 evaluations.
  - JENDL-5.0 Pu-239 gives similar results to E8R0.
- **Results are preliminary**, and hence, subject to changes and/or updates.

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THANKS
FOR LISTENING!