Using the Fission Source Mesh Tally to Validation KENO for Pin Power Calculations

Justin Clarity

R&D Staff

Nuclear Data and Criticality Safety

Oak Ridge National Laboratory

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Overview

- Half scientific work half informercial
- Need for pin power calculation validation
- BAW-1810 Experiments
  - Description
  - Methods
- Modification of Inputs to generate fission density information
- Getting fission density information out
- Results

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Need to validate KENO for pin power calculations

- KENO primarily used for criticality safety, infrequently but not never used for reactor physics
  - Used in SFP criticality license applications as depletion code as well as criticality
- Flexible geometry allows for easier comparison to experiment than standard lattice codes
- Can then be used as a reference for comparing lattice codes against
  - KENO vs. Experiment → Lattice code vs. KENO
  - Continuous energy treatment available in KENO

BAW-1810 Experiments - Description

- Babcock and Wilcox experiments
  - Developed in early 1980s
  - Lynchburg facility used for multiple critical experiments
  - Validation of B&W 15x15 and CE 16x16 fuel assemblies with
    - Soluble Boron
    - Gd_2O_3 burnable absorbers
    - B_4C absorber rodlets
  - Not in the ICSBEP handbook
- Used fuel enrichments of 4.02 and 2.46 wt. % for UO_2 rods, 1.944 wt. % enriched UO_2 with 4.02 wt. % Gd_2O_3
- 23 total configurations measured, 6 for Pin powers

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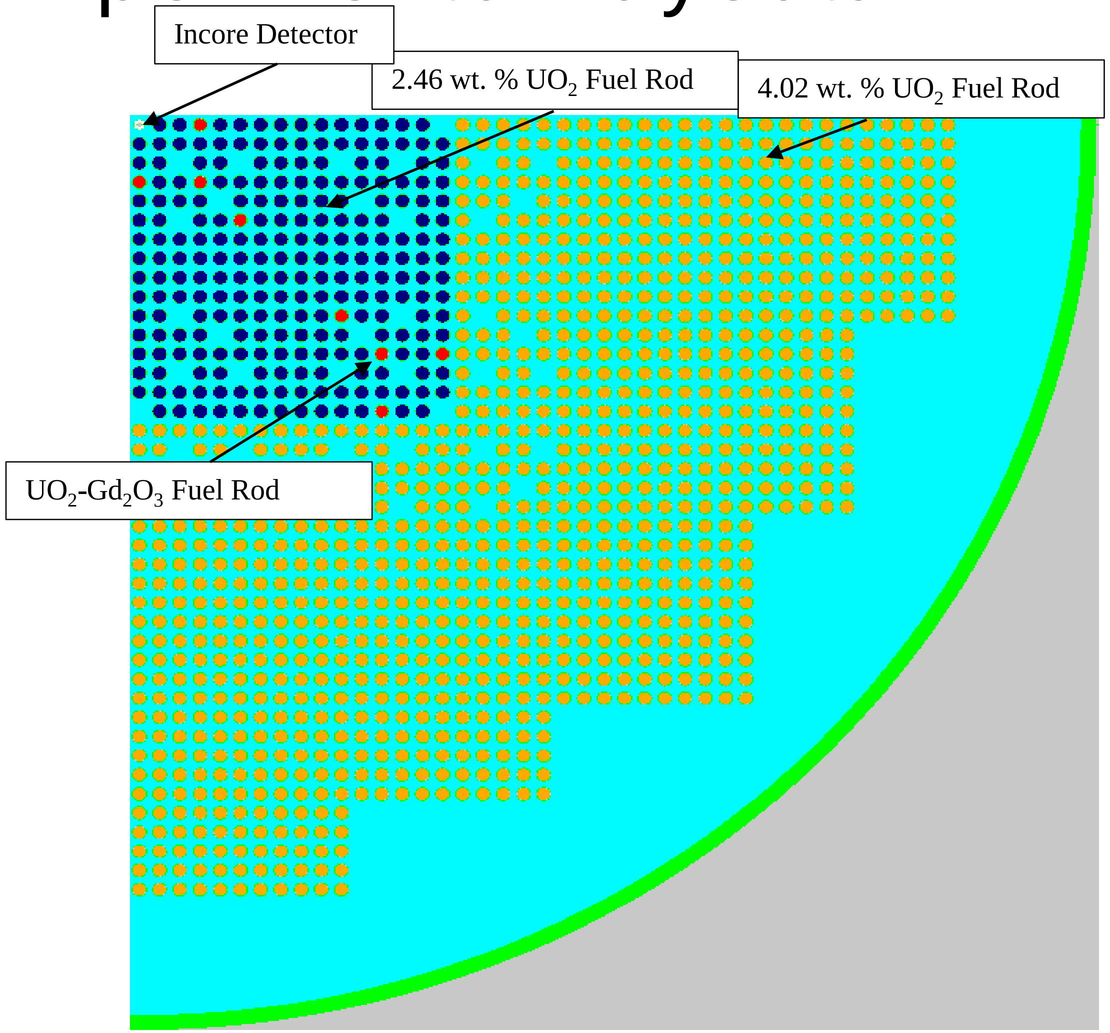
BAW-1810 Experiments – Methods

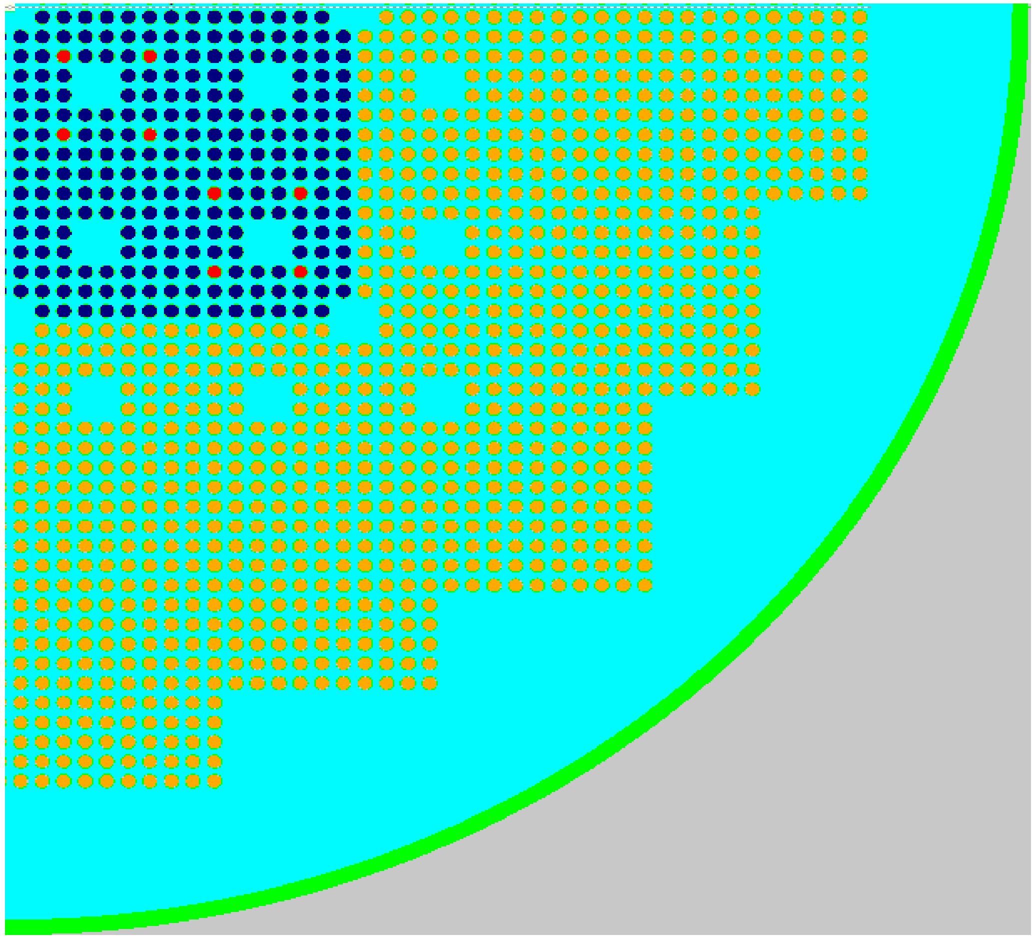
- Pin powers measured for Cores 1, 5, 12, 14, 18, and 20
  - Reactor was placed on a positive period and exposed to 1kw-minute of burnup
  - Fuel rods were removed and fission product gammas were counted along the midplane (1”) using a collimated NaI detector
  - One rod was simultaneously counted with the others to control for radioactive decay during sequential counting
  - Results normalized to central region.

Core	2.46 wt. % Rods	4.02 wt. % Rods	UO_2-Gd_2O_3 Rods	Similar Fuel Design	Soluble boron concentration (ppm)
I	4808	0	0	B&W 15 × 15	1337.9
V	4780	0	20	B&W 15 × 15	1208.0
XII	3920	888	0	B&W 15 × 15	1899.3
XIV	3920	860	20	B&W 15 × 15	1653.8
XVIII	3676	944	0	CE 16 × 16	1776.8
XX	3676	912	20	CE 16 × 16	1499.8

Experimental Layouts



Core 14



Core 20

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Calculations

- Base inputs taken from NUREG-6361
  - Validation of LWR shipping packages for 10 CFR 71
- Reflected boundary conditions on top and bottom to simulate planar slice
- Added incore detector model
- 200,000 particles per generation for 10,000 active generations and 500 skipped generations
- **Add cds=yes to parameter block**
- **Provided a mesh corresponding to the pitch of the fuel rods using the grid block**

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Getting results out

- Generates a .3dmap file
  - Originally used to pass information to MAVRIC for CAAS simulation
- Can be plotted over a 2-D Fulcrum visualization of the model
- Tools available to pull information out of the .3dmap file
  - mtpull – allows individual voxels to pulled out of file
- Results normalized to the measured pins to match the values published

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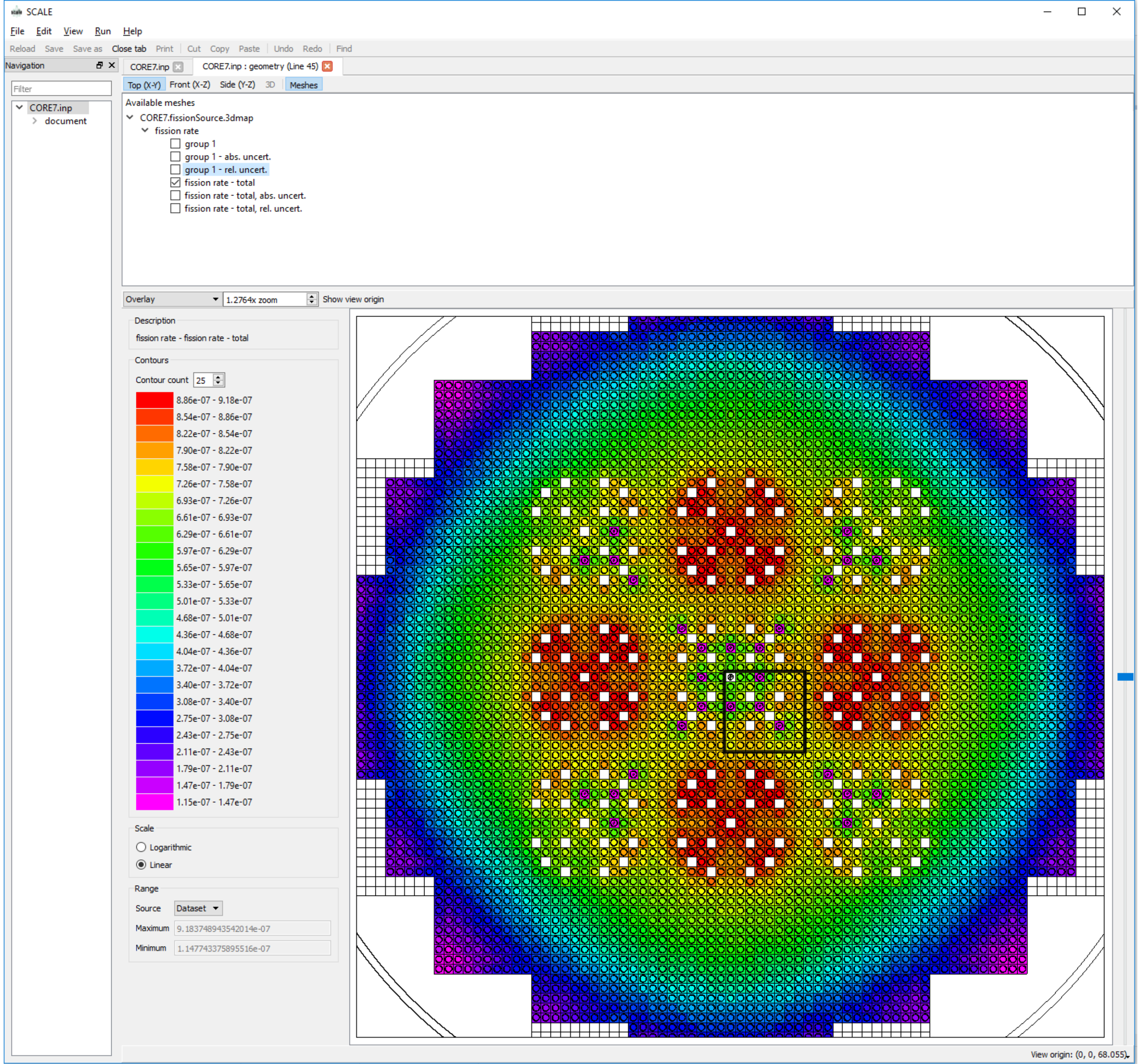
SCALE
File Edit View Run Help
Reload Save Save as Close tab Print Cut Copy Paste Undo Redo Find
Navigation
Filter
CORE7.inp
document
CORE7.inp
CORE7.inp : geometry (Line 45)
Top (X-Y) Front (X-Z) Side (Y-Z) 3D Meshes
Available meshes
CORE7.fissionSource.3dmap
fission rate
group 1
group 1 - abs. uncert.
group 1 - rel. uncert.
fission rate - total
fission rate - total, abs. uncert.
fission rate - total, rel. uncert.
Overlay
1.2764x zoom
Show view origin
Description
fission rate - fission rate - total
Contours
Contour count 25
8.86e-07 - 9.18e-07
8.54e-07 - 8.86e-07
8.22e-07 - 8.54e-07
7.90e-07 - 8.22e-07
7.58e-07 - 7.90e-07
7.26e-07 - 7.58e-07
6.93e-07 - 7.26e-07
6.61e-07 - 6.93e-07
6.29e-07 - 6.61e-07
5.97e-07 - 6.29e-07
5.65e-07 - 5.97e-07
5.33e-07 - 5.65e-07
5.01e-07 - 5.33e-07
4.68e-07 - 5.01e-07
4.36e-07 - 4.68e-07
4.04e-07 - 4.36e-07
3.72e-07 - 4.04e-07
3.40e-07 - 3.72e-07
3.08e-07 - 3.40e-07
2.75e-07 - 3.08e-07
2.43e-07 - 2.75e-07
2.11e-07 - 2.43e-07
1.79e-07 - 2.11e-07
1.47e-07 - 1.79e-07
1.15e-07 - 1.47e-07
Scale
Logarithmic
Linear
Range
Source Dataset
Maximum 9.183748943542014e-07
Minimum 1.147743375895516e-07
View origin: (0, 0, 68.055)

Results

N/A							
-0.40%	-0.02%						
-0.56%	-0.45%	N/A					
0.24%	0.44%	0.42%	0.86%				
0.43%	0.51%	-0.23%	0.03%	N/A			
-0.84%	-0.84%	N/A	-0.10%	-0.08%	-0.23%		
-0.21%	-1.37%	0.54%	0.23%	0.11%	0.49%	0.08%	
-0.21%	0.17%	0.27%	0.14%	0.08%	0.00%	-0.07%	0.18%

Core 1

N/A							
-1.17%	-0.71%						
-0.47%	-0.95%	N/A					
-0.05%	-0.53%	0.79%	-0.05%				
-0.12%	-0.53%	0.88%	0.87%	N/A			
-0.64%	-1.17%	N/A	2.12%	0.11%	-0.01%		
0.47%	-1.81%	0.84%	0.90%	-0.26%	-0.40%	-0.36%	
-0.19%	0.27%	0.02%	0.88%	-0.24%	0.36%	-0.72%	0.17%

Core 12

N/A							
0.51%	0.43%						
0.21%	1.05%	1.36%					
0.19%	1.65%	-1.19%	N/A				
-1.60%	0.50%	-0.02%	N/A	N/A			
0.37%	-0.38%	-0.41%	-0.31%	-0.23%	1.02%		
0.07%	-0.08%	-0.08%	-0.38%	-1.18%	-0.25%	0.47%	
1.03%	0.58%	-1.34%	-1.16%	-0.71%	-0.26%	-0.38%	0.77%

Core 18

N/A							
-0.42%	0.59%						
0.18%	0.35%	N/A					
1.05%	-0.83%	-0.10%	0.35%				
-0.16%	0.34%	0.05%	-0.28%	N/A			
1.28%	-0.30%	N/A	0.49%	-0.96%	0.60%		
0.67%	0.24%	-0.32%	0.44%	0.02%	-0.47%	-0.15%	
1.01%	-0.14%	-0.32%	-0.23%	-0.38%	-0.38%	-0.06%	-0.23%

Core 5

N/A							
0.51%	0.43%						
0.21%	1.05%	1.36%					
0.19%	1.65%	-1.19%	N/A				
-1.60%	0.50%	-0.02%	N/A	N/A			
0.37%	-0.38%	-0.41%	-0.31%	-0.23%	1.02%		
0.07%	-0.08%	-0.08%	-0.38%	-1.18%	-0.25%	0.47%	
1.03%	0.58%	-1.34%	-1.16%	-0.71%	-0.26%	-0.38%	0.77%

Core 14

N/A							
0.34%	0.15%						
-0.05%	0.11%	-0.15%					
-0.45%	0.49%	-1.00%	N/A				
0.56%	0.25%	1.22%	N/A	N/A			
-0.81%	-0.39%	-1.38%	-1.85%	-0.26%	0.56%		
0.39%	-0.72%	-0.09%	2.58%	-0.49%	-0.39%	-0.06%	
0.93%	1.64%	1.63%	-0.77%	0.15%	-1.05%	1.02%	0.13%

Core 20

3.0%
2.6%
2.2%
1.8%
1.4%
1.0%
0.6%
0.2%
-0.2%
-0.6%
-1.0%
-1.4%
-1.8%
-2.2%
-2.6%
-3.0%

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Aggregate Results

Core	RMS Error	Max Error
1	0.46%	-1.37%
5	0.53%	1.28%
12	0.75%	-2.08%
14	0.80%	2.12%
18	0.78%	1.65%
20	0.95%	2.58%

Questions?