

A decorative graphic on the left side of the slide consists of a 4x3 grid of shapes. The first and third columns contain solid blue circles. The second column contains green four-pointed stars with concave sides, positioned between the circles of the first and third columns. The top-right corner of the grid is missing a shape.

# Afternoon Session – RAPID Demonstration

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*One-day Workshop on the RAPID Code System for presentation at the  
Nuclear Regulatory Commission*

*November 9<sup>th</sup>, 2017*

# Overview VRS-RAPID web Application

**SPENT FUEL POOL**

*Build Model*  
*Prebuilt Cases:*

- 5x5 Fresh
- 5x5 Checkerboard
- 9x9 Burned Center
- 9x9 Burned Regions
- 3x3 Reference

**SPENT FUEL CASKS**

*Build Model*  
*Prebuilt Cases*

- GBC-32 Uniform
- GBC-32 Checkerboard

**REACTOR CORES**

*Build Model*  
*Reactor Types*

- PWR Uniform
- PWR Mixed
- MSR (coming soon...)

Connected users:  
amrit  
nate

\* amrit created a new 2x2 input table.

Intro | How to build a model | Outputs | Other options

VRS-RAPID allows multi-user input generation, running and output visualization for RAPID. Different nuclear systems can be simulated:

1. Run a **pre-made case** by clicking one of the links on the left taskbar.
2. Manually build your input by selecting *Build Model* on the left taskbar, choosing the system of interest (see the "How to build a model" pane of these instructions).

Refer to the "Outputs" pane for a description of the data output. Check the "Misc" pane for a description of other options.

**Ready!**

Est. time:	# of axial levels:
RAPID run-time:	# of pins per assembly:
X3D preparation:	# of computational cells:

Show Pool Environment | Download 3D fission source file | Show 2D plot | Activate Detector Response | Show Antineutrino Fluxes

Assembly (17, 10)
Burnup: 0 MWd/t
Cooling: 0 yrs
Type: 1

n Neutron Source (n/s)

- 7.9984e-3
- 5.9550e-3
- 4.4336e-3
- 3.3009e-3
- 2.4576e-3
- 1.8298e-3



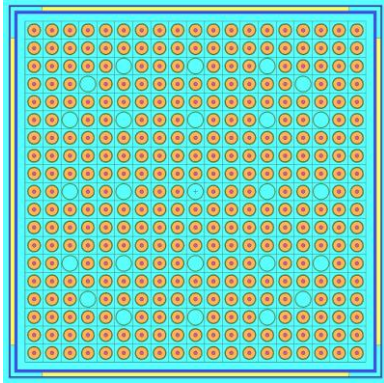
# Spent Fuel Pool

I2S-LWR Model

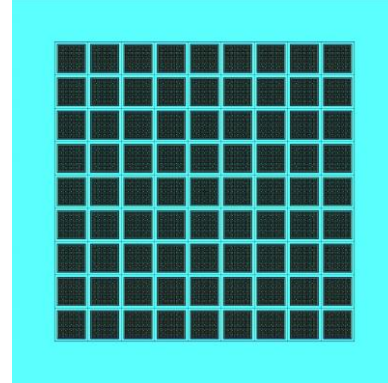
# Background: I2S-LWR

- **Assembly Size** – 19x19
- **Fuel type** –  $U_3Si_2$ , enriched to 4.45 wt%  $^{235}U$
- **Database Range:**
  - Burnup: 15340 – 59169 MWd/MTHM
  - Cooling Time: 0-9 years

Can be expanded as necessary



I2S-LWR Fuel Assembly



9x9 Segment of SFP

# Test Case 1

- MODEL: 5x5 Segment of I2S-LWR Spent Fuel Pool
  - Uniform material distribution (all fresh assemblies)
- GOALS:
  - Perform an eigenvalue calculation
  - Analyze outputs (k, fission source)
  - Perform subcritical multiplication calculation
  - Analyze outputs (M, total source)
  - Become familiar with the RAPID's inspection capability

# Test Case 2



- MODEL: 5x5 Segment of I2S-LWR Spent Fuel Pool
  - Checkerboard Material layout, low/high burnups (15/50 GWd/MTHM)
- GOALS:
  - Perform an eigenvalue calculation
  - Using RAPID's inspection capability, provide detector measurements based on the normalized values
  - Reduce the measured response by a factor 20 for the (5, 5) corner assembly.
  - What should be the burnup of this assembly to match the new detector response?

# Test Case 3

- MODEL: 9x9 segment of I2S-LWR Spent Fuel Pool
  - Prebuilt 9x9 burned regions
- GOALS:
  - Perform an eigenvalue calculation
  - Using RAPID's inspection capability, provide a few detector measurements based on the normalized value detector responses
  - Examine the results (measurements vs. predictions)



# Spent Fuel Storage Cask

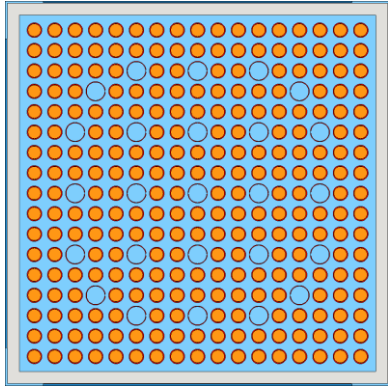
GBC-32 Benchmark Model



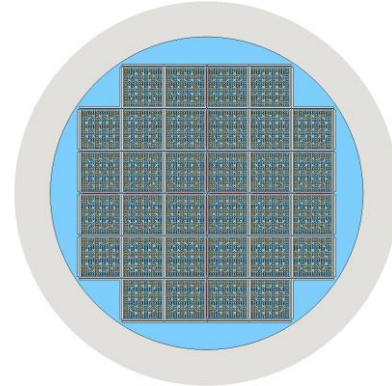
# Background: GBC-32 Cask

- **Assembly Size** – 17x17
- **Fuel type** – UO<sub>2</sub>, enriched to 4.5 wt% <sup>235</sup>U
- **Database Range:**
  - Burnup: 5000 – 50000 MWd/MTHM
  - Cooling Time: 0 years

Can be expanded as necessary



GBC-32 Fuel Assembly

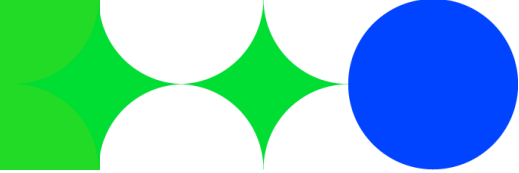


GBC-32 Full Cask

# Test Case 4a

- MODEL: A fully loaded GBC-32 Cask (*prebuilt*)
  - Uniformly loaded with highly burned fuel (40 GWd/MTHM)
- GOALS:
  - Perform an eigenvalue calculation
  - Analyze outputs (k, fission source)
  - Compare results to Serpent Reference Solution

# Test Case 4a



- Comparison with the Serpent predictions:

Code	# Core	$K_{\text{eff}}$	Time (s)	Diff. (pcm)	Speedup
Serpent	16	$0.75113 \pm 11$ pcm	27,000	-	-
<b>RAPID</b>	<b>1</b>	<b>0.75120</b>	<b>59</b>	<b>9.3</b>	<b>458</b>

# Test Case 4b

- MODEL: A fully loaded GBC-32 Cask
  - Loaded as a checkerboard with, fresh/burned fuel (40 GWd/MTHM)
- GOALS:
  - Perform an eigenvalue calculation
  - Analyze outputs (k, fission source)
  - Compare results to Case 4a
  - Compare results to Serpent Reference Solution

# Test Case 4b

- Comparison with the Serpent predictions:

Code	# Core	$K_{\text{eff}}$	Time (s)	Diff. (pcm)	Speedup
Serpent	16	0.98679±12 pcm	25,200	-	-
<b>RAPID</b>	<b>1</b>	<b>0.98693</b>	<b>54</b>	<b>14.2</b>	<b>467</b>



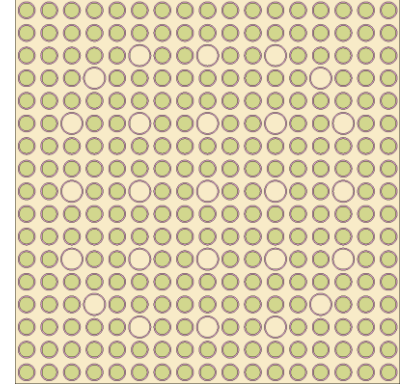
# Reactor Core

NEA/OECD Monte Carlo Performance Benchmark (Gen-PWR)

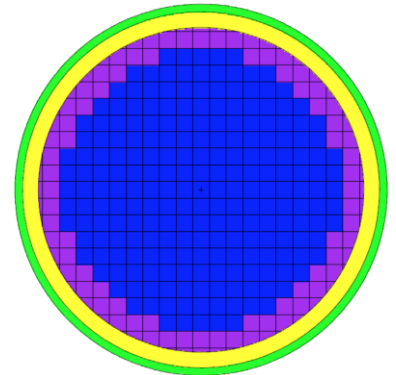
# Background: Gen-PWR Core

- **Assembly Size** – 17x17
- **Fuel type** –  $\text{UO}_2$
- **Database Range:**
  - Burnup: 0
  - Cooling Time: 0 years
  - Enrichment : 3.0,4.0, and 5.0 wt%  $^{235}\text{U}$

Gen-PWR  
Assembly

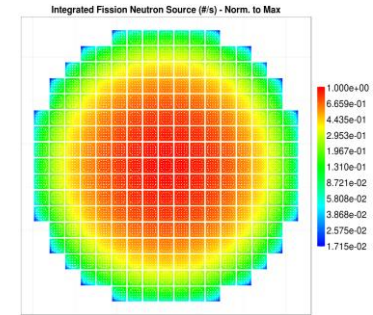


Gen-PWR  
Core



# Test Case 5a

- MODEL: A Gen-PWR Core
  - Uniformly loaded with 3.0 wt%  $^{235}\text{U}$  fuel
- GOALS:
  - Perform an eigenvalue calculation (*prebuilt*)
  - Analyze outputs (k, fission source)
  - Copy 2-D fission density
  - Compare with Serpent Reference Calculation





# Test Case 5a

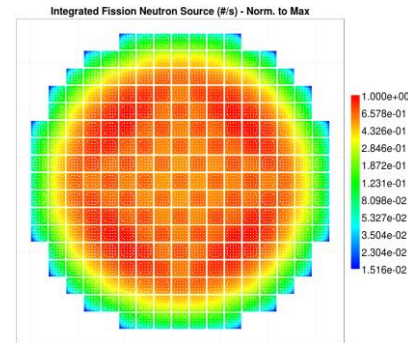
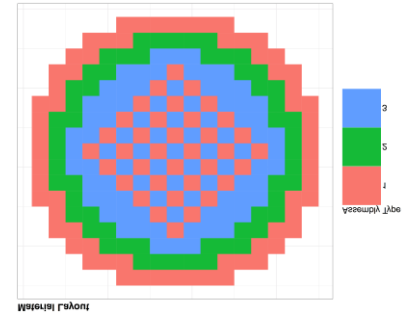
- Comparison with the Serpent predictions:

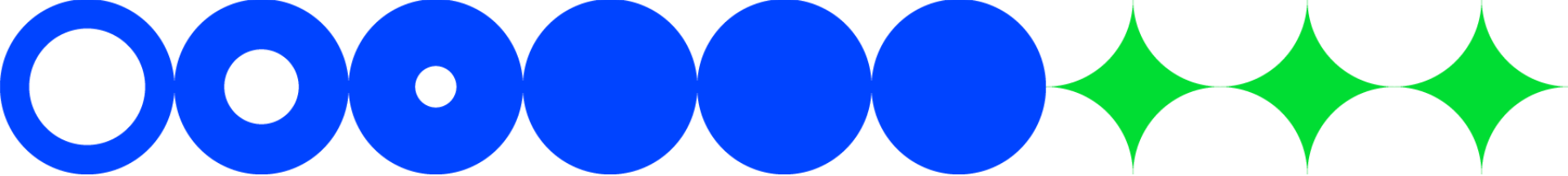
Code	# Core	$K_{\text{eff}}$	Time (s)	Diff. (pcm)	Speedup
Serpent*	32	1.17573±0.0000064	80,940	-	-
<b>RAPID</b>	<b>1</b>	<b>1.17560</b>	<b>503</b>	<b>-11</b>	<b>161</b>

\*Note that only pin-wise fission source was tallied in Serpent Reference calculation

# Test Case 5b

- MODEL: A Gen-PWR Core
  - Mixed Core Loading
- GOALS:
  - Perform an eigenvalue calculation (***prebuilt, mixed***)
  - Analyze outputs (k, fission source)
  - Copy 2-D fission density
  - Compare results Case 5a





Questions?

Thanks

