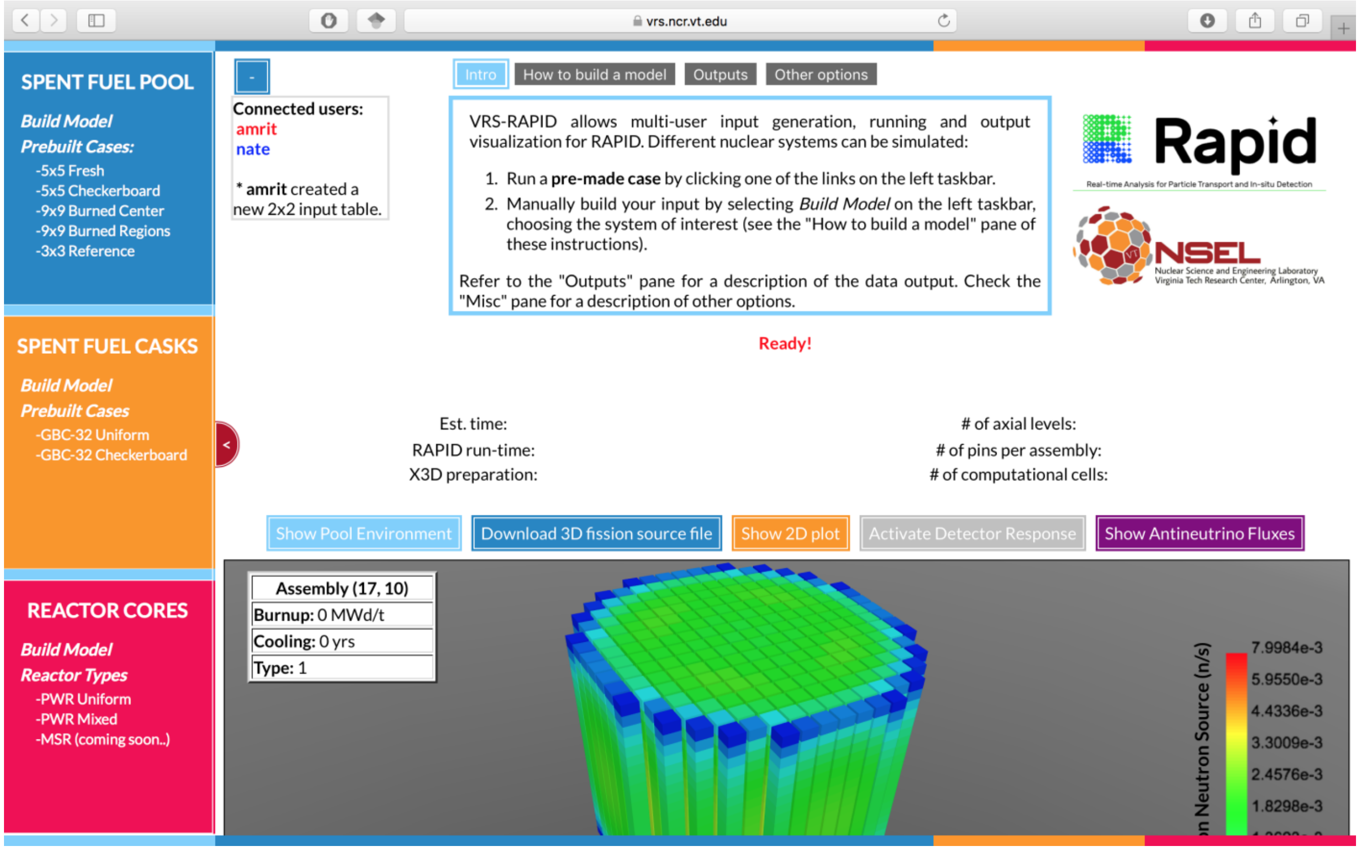
Afternoon Session – RAPID Demonstration

Nathan Roskoff, Valerio Mascolino, and Alireza Haghighat

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

November 9th, 2017

Overview VRS-RAPID web Application



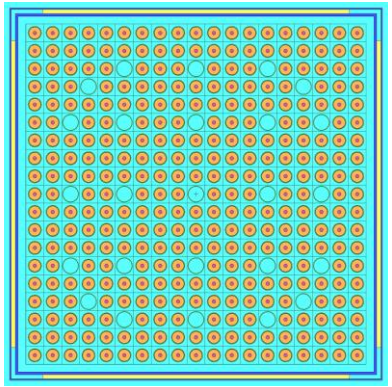
Spent Fuel Pool

I2S-LWR Model

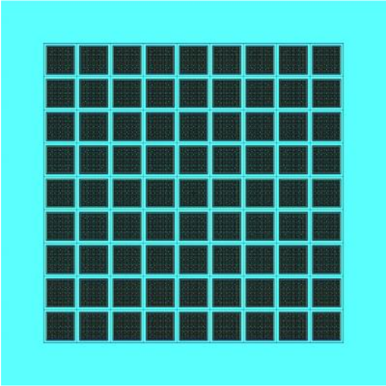
Background: I2S-LWR

- **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)

Rapid

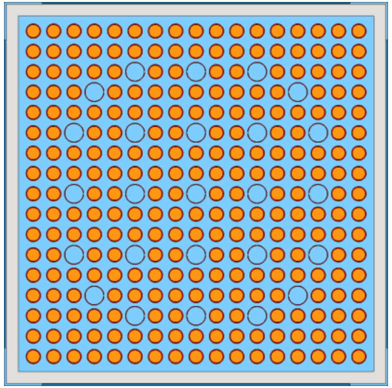
Spent Fuel Storage Cask

GBC-32 Benchmark Model

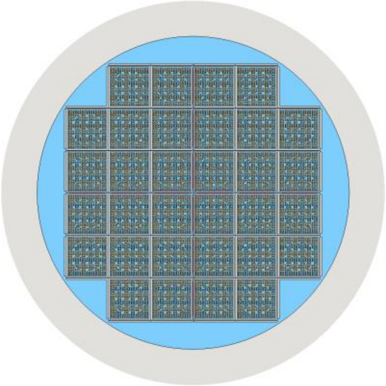
Background: GBC-32 Cask

- **Assembly Size** – 17x17
- **Fuel type** – $U0_2$, enriched to 4.5 wt% ^{235}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_{eff}	Time (s)	Diff. (pcm)	Speedup
Serpent	16	0.75113 ± 11 pcm	27,000	-	-
RAPID	1	0.75120	59	9.3	458

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_{eff}	Time (s)	Diff. (pcm)	Speedup
Serpent	16	0.98679±12 pcm	25,200	-	-
RAPID	1	0.98693	54	14.2	467

Rapid

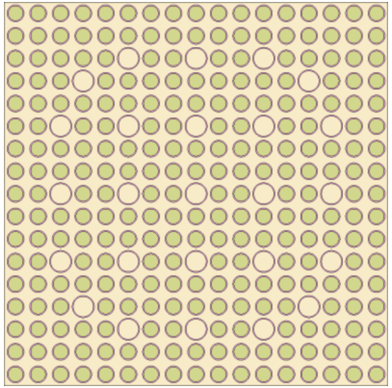
Reactor Core

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

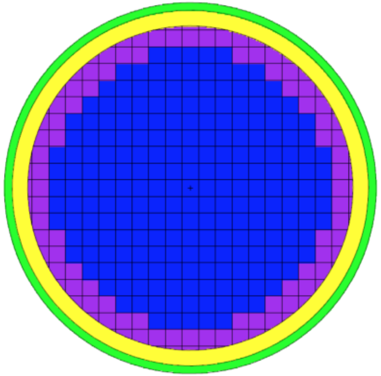
Background: Gen-PWR Core

- **Assembly Size** – 17x17
- **Fuel type** – UO_2
- **Database Range**:
  - Burnup: 0
  - Cooling Time: 0 years
  - Enrichment : 3.0,4.0, and 5.0 wt% ^{235}U

Gen-PWR Assembly



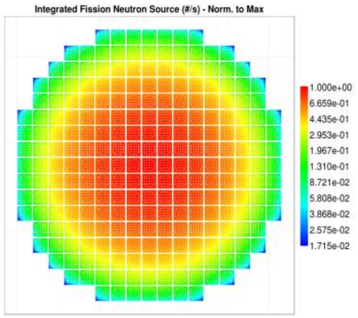
Gen-PWR Core



Test Case 5a

- MODEL: A Gen-PWR Core
  - Uniformly loaded with 3.0 wt% ^{235}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:

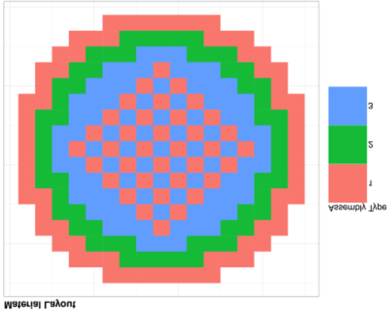
Code	# Core	K_{eff}	Time (s)	Diff. (pcm)	Speedup
Serpent*	32	1.17573±0.0000064	80,940	-	-
RAPID	1	1.17560	503	-11	161

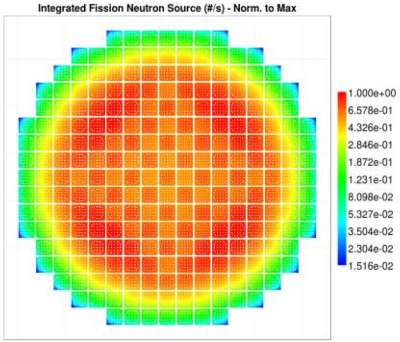
*Note that only pin-wise fission source was tallied in Serpent Reference calculation

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