

Proposal

VT³G-SNFP (Spent Nuclear Fuel Pool) benchmark, a loosely coupled system

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Purpose

- Recent public and regulatory concerns about safety and security of spent nuclear fuel pools (SNFP) has resulted in the need for utilization and/or development of best estimate techniques that have to be benchmarked
- Determination of accuracy and efficiency of different methodologies, e.g., Monte Carlo criticality calculation vs. Fission Matrix (FM) approach

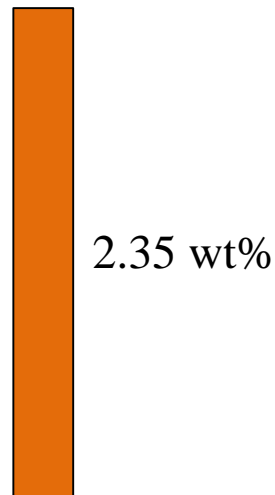
Background

- Since 2006, VT³G (Virginia Tech Transport Theory Group) has been engaged in the development and testing of accurate and fast methodologies for simulation and analysis of SNFP with applications to criticality safety and nuclear safeguards. two software tools have been developed based on the Multi-stage Response-function Transport (MRT) methodology :
 - INSPCT-s (Inspection of Nuclear Spent fuel-Pool Calculation Tool ver. Spreadsheet) uses pre-calculated databases for identification of fuel diversion and/or placement mishaps.
 - RAPID (Real-time Analysis for spent fuel Pool *in situ* Detection) is developed for the determination of detailed fission density throughout a SNFP in addition to the pool eigenvalue and subcritical multiplication
- Based on above experience, we are:
 - Organizing a workshop entitled *1st Workshop on Spent Nuclear Fuel Pool Simulation, Safety and Security*, **June 23-25, 2015**, at the Virginia Tech Research Center (VTRC) in Arlington, VA, USA.
 - **Proposing the VT³G-SNFP benchmark problem** (identify tools, their accuracy and efficiency, and obtain information on the range of variations of different parameters and their sensitivity to problem detail and complexity)

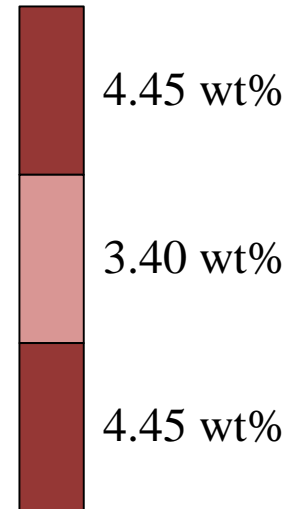
Proposed Problems

- Two problems, made of two types of assemblies, which are made of the following fuel pin types:

Type 1 (T1)



Type 2 (T2)



Problem 1

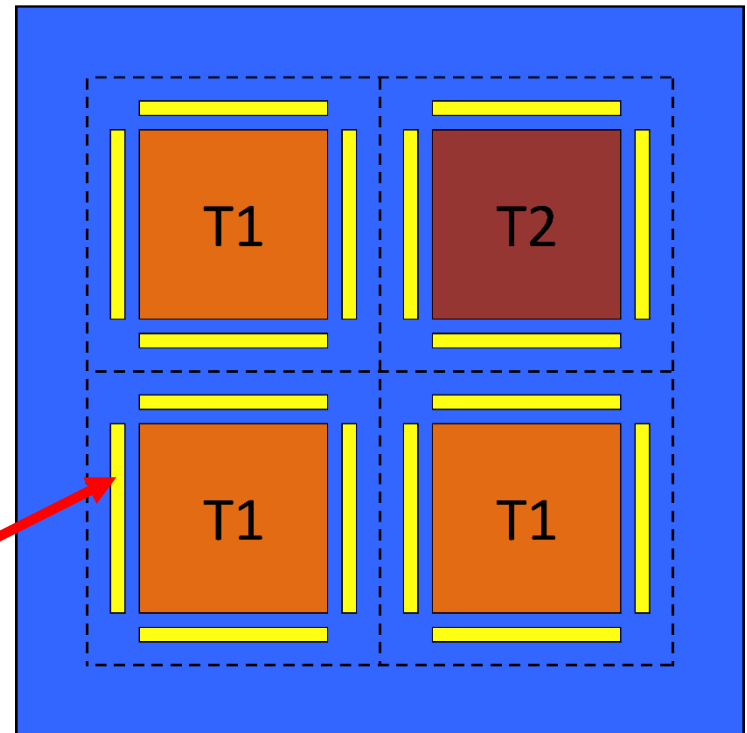
4-Assembly with axial variable enrichment (4A-AVE);

The four assemblies are placed in a pool of water and separated by *Metamic* neutron absorbers.

Two types of *Metamic*:

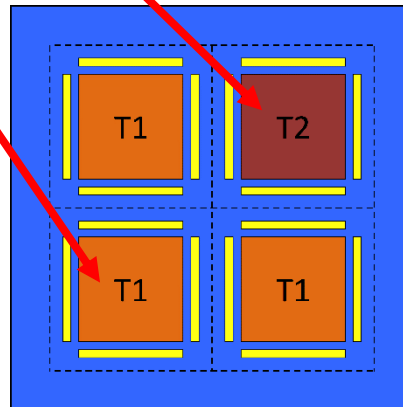
18.92 wt% B_4C

43.30 wt% B_4C



Benchmark Results

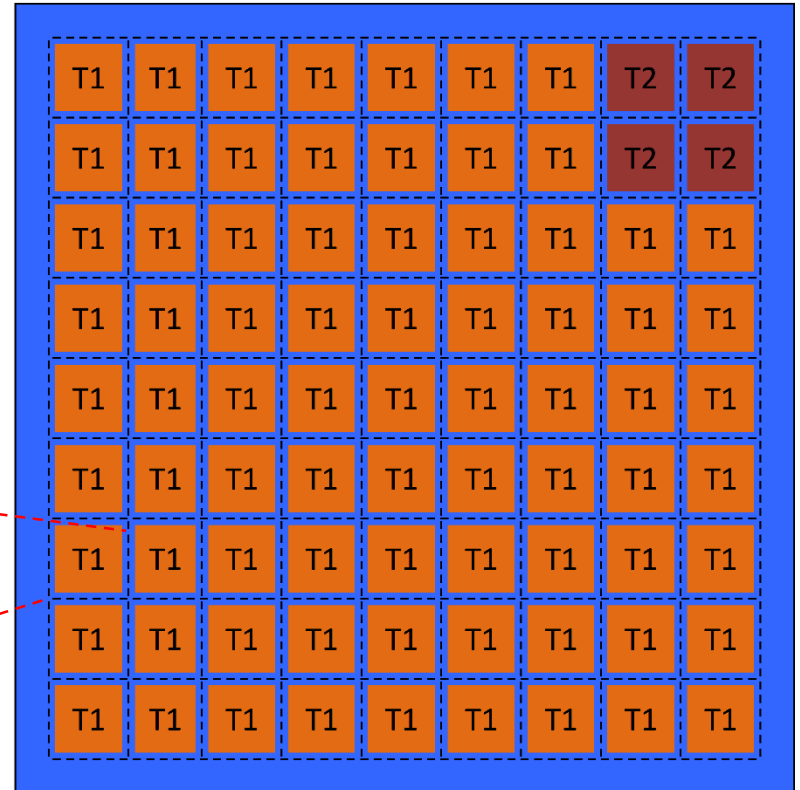
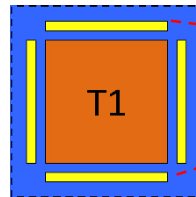
- Pin-wise fission density for all four assemblies
- K_{eff} value for the system
- Pin-wise, **axially-dependent** fission density for assembly *T1* and *T2* using Table A.1



Problem 2

81-Assembly Pool with Different Enrichments (81A-PDE).

All assemblies are separated by *Metamic* neutron absorbers.



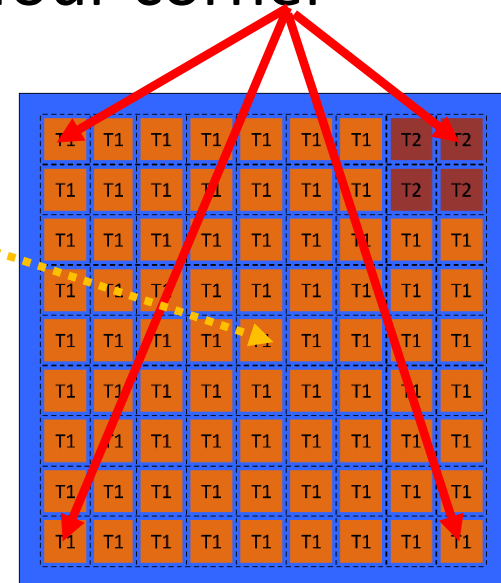
Two types of *Metamic*:

18.92 wt% B_4C

43.30 wt% B_4C

Benchmark Results

- Pin-wise fission density for all assemblies
- K_{eff} value for the pool
- Using Table A.1, provide pin-wise, axially-dependent fission density for the four corner assemblies, the center assembly



Sample Data & Tools

Table 1 - Assembly structure and dimensions

Item	Data	Comment
Assembly lattice size	17x17	
Rods per Assembly	264	
Guide Tubes per Assembly	25	
Rod pitch	0.4960 in	
Fuel pellet OD	0.3225 in	
Height (active)	168" (144")	12" of water is placed at top and bottom of active fuel
Clad OD	0.3740 in	
Clad Thickness	0.0225 in	
Guide Tube OD	0.4820 in	
Guide Tube Thickness	0.0200 in	
Neutron Absorber Length	168 in	
Neutron Absorber Width	7.5 in	
Neutron Absorber Thickness	0.106 in	

Table 2 - Materials information

Mixture	Materials	Density	Weight Fraction	Mixture	Materials	Density	Weight Fraction	
Fuel	UO ₂	10.74 g/cm ³ (97.5% theoretical density)	<u>2.25 wt% 235U</u> U-235 – 0.8608 U238 – 0.0207 O – 0.1185	Stainless steel, 316		7.94 g/cm ³	C - 0.000410 Si - 0.005070 P - 0.000230 S - 0.000150 Cr - 0.170000 Mn - 0.010140 Fe - 0.669000 Ni - 0.120000 Mo - 0.025000	
			<u>3.4 wt% 235U</u> U-238 – 0.8515 U-235 – 0.0300 O – 0.1185					
			<u>4.45 wt% 235U</u> 238U – 0.8422 235U – 0.0392 O – 0.1185					
Gap	void			Metamic absorber	B ₄ C	2.664 g/cm ³	<u>18.92 wt% B₄C</u> Al – 0.8108 11B – 0.1209 10B – 0.0271 C – 0.0411	
Cladding	Zircaloy	6.58 g/cm ³	Zr – 0.9824 Sn – 0.0145 Fe – 0.0021 Cr – 0.0010				2.619 g/cm ³	<u>43.30 wt% B₄C</u> Al – 0.5670 11B – 0.2768 10B – 0.0621 C – 0.0941
Water		1.0 g/cm ³	H – 0.1119 O – 0.8881					

Processing Tools

- Provide a software for normalization of data
- Provide a software for processing the outputs
- Provide a software for preparing 2-D and 3-D graphs

Thanks!

Questions?



Completed June 2011