Comparing the Steady State System Modeling Results of the Conceptual NIST Reactor with ANL-PARET and RELAP5-3D

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Present at ANS Student Conference, Richmond, VA, April 6th, 2019

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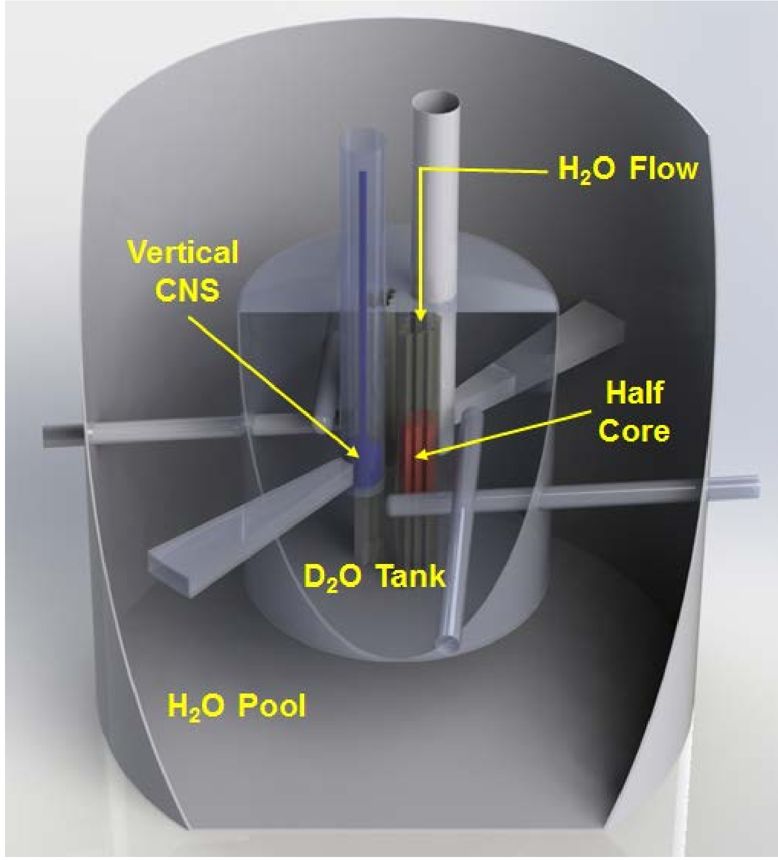
3-D Cutaway View of the Proposed NIST Reactor



- Tank in pool reactor
- 20MW thermal power and 30-day operating cycle
- Low enriched uranium (LEU) – U_3Si_2-Al
- Cooled by forced downward circulation
- Moderated by heavy water

Research background and Purpose

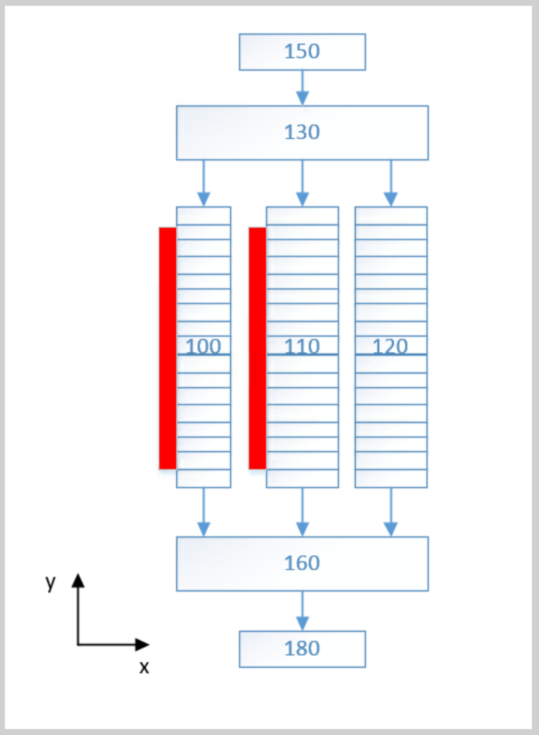
Preliminary neutronics and T/H safety analyses have been performed.

- Neutornics: Monte Carlo code MCNP.
- Safety analyses: Modular channel code PARET.

To overcome computational modeling limits, RELAP5-3D will be used.

- Nodalization of the core and other important components of PCS.
- Comparison study of the system behavior predicted by both T/H codes.

Reactor Core Model in the Relap5-3D



Boundary Conditions

- Time-dependent control volumes and junctions

Upper and bottom plenum

- Branch

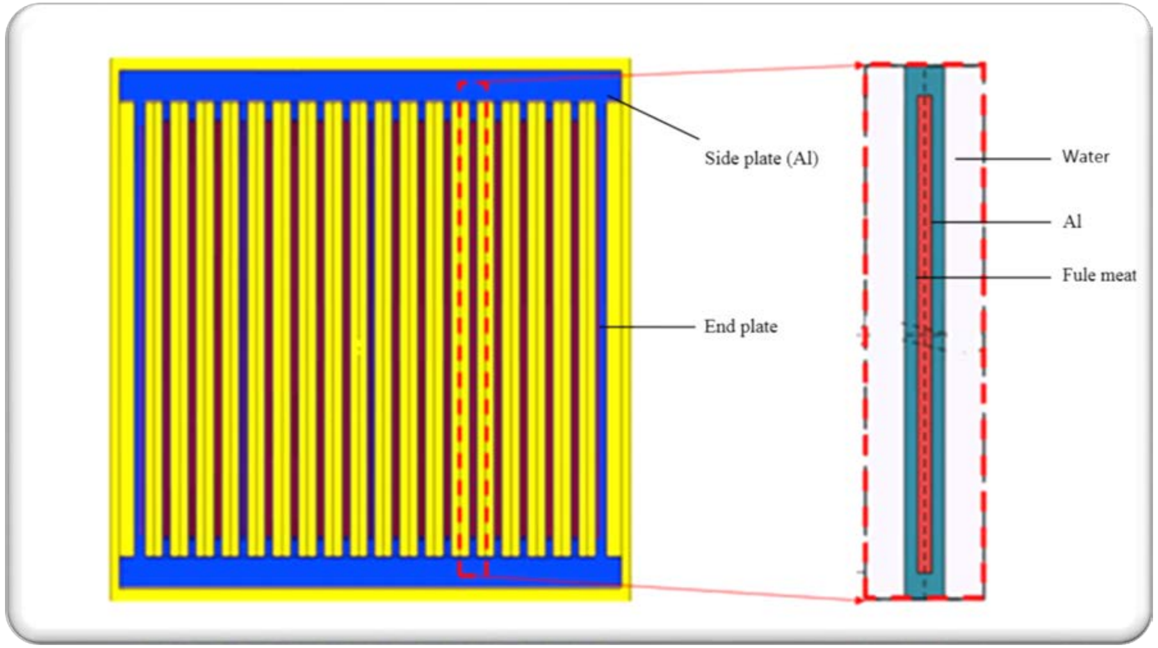
Hydrodynamic channels

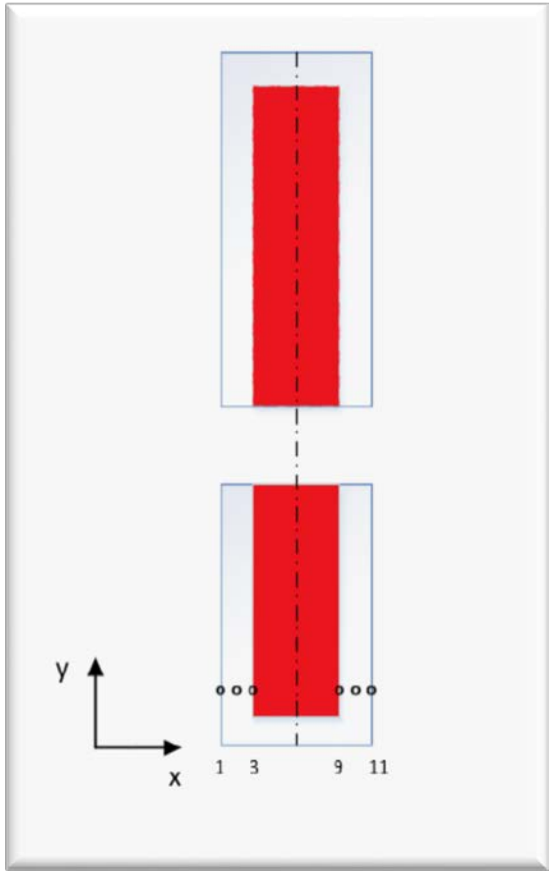
- Hot channel, average channel and bypass channel
- Divided into 17 control volumes

Fuel element

- Heat structures

MTR Fuel Element and Flow Channel Modeling



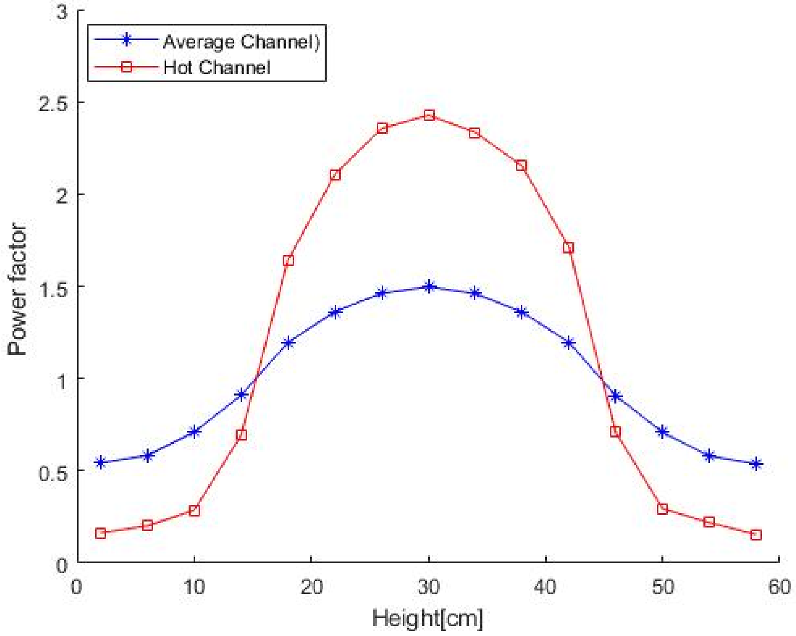


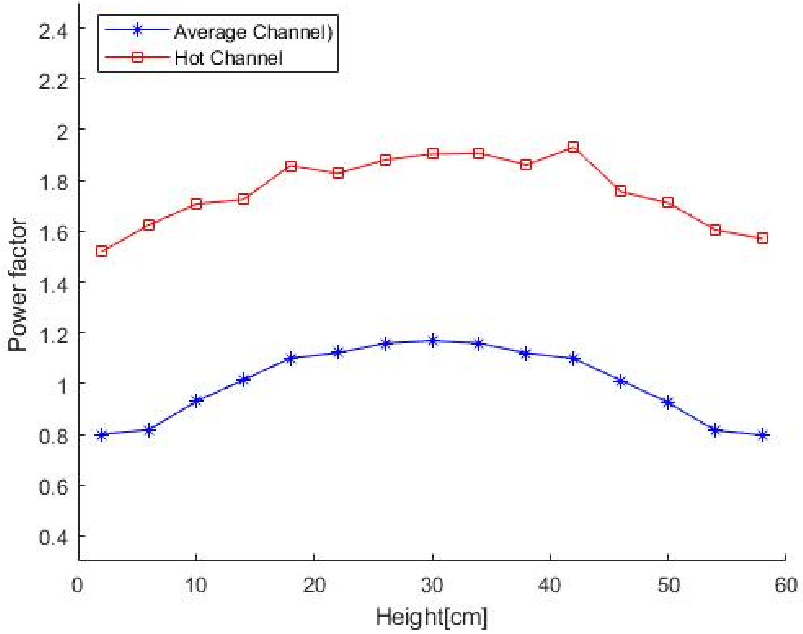
Key Parameters for RELAP5-3D Model

Materials	Values
Fuel meat material	U_3Si_2-Al
Fuel type	Plate type
Fuel density (g/cc)	6.53
Enrichment (wt%)	19.75
U-235 loading (g/plate)	391.47
Fuel assembly geometry	Values
Fuel assembly	18
Fuel plates per assembly	17
Aluminum plates	2
Fuel plate width (cm)	6.665
Fuel meat width (cm)	6.134
Fuel plate thickness (cm)	0.127
Fuel meat thickness (cm)	0.066
Cladding thickness (cm)	0.0305
Fuel plate length (cm)	60
Fuel meat length (cm)	67.28

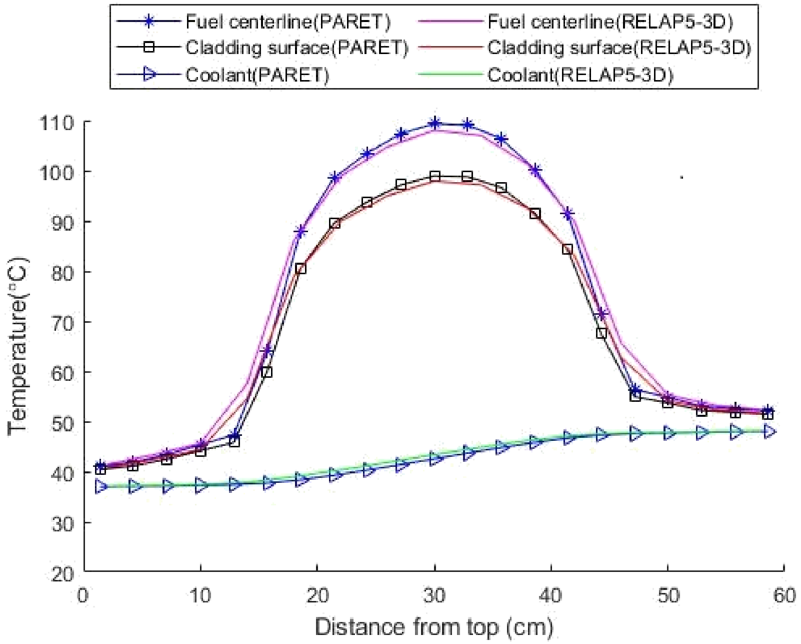
Thermal-hydraulics	Values
Fuel thermal conductivity (W/m·K)	48
Cladding thermal conductivity (W/m·K)	180
Fuel volumetric heat capacity (J/m^3·K)	2.225E+6
Cladding volumetric heat capacity (J/m^3·K)	2.419E+6
Inlet coolant temperature (°C)	37
Core outlet pressure (kPa)	200
Total power (MW)	20
Inlet volumetric flow rate (gpm)	8000
Hydraulic diameter (cm)	0.56
Reactor kinetics	Values
Prompt neutron generation time (µs)	252.63
Effective delayed neutron fraction (β_{eff})	0.00718

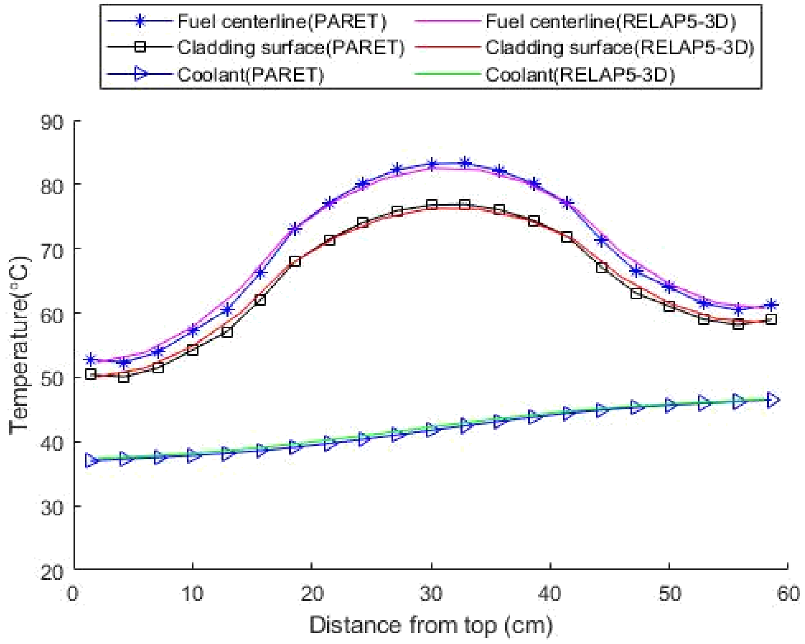
Power Distribution in Start-up (SU) and End of Cycle (EOC)





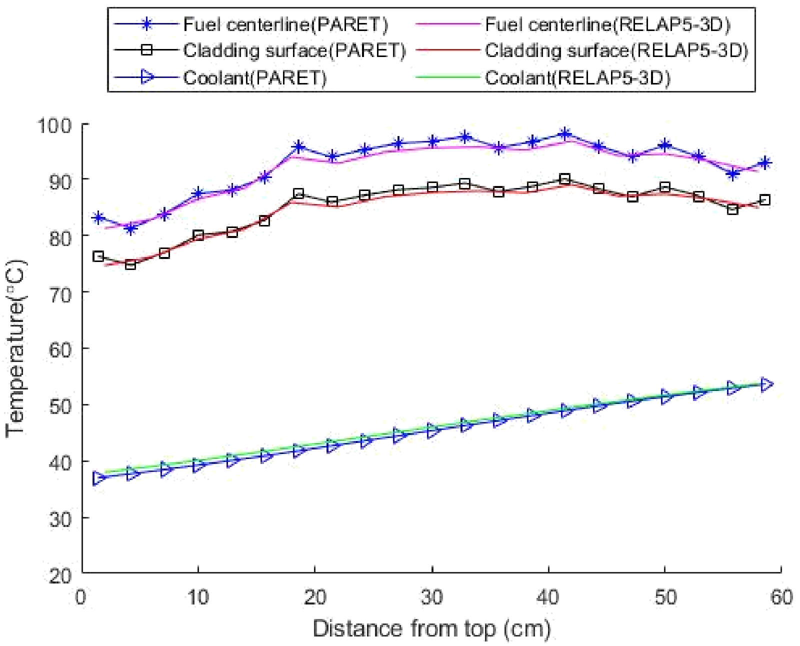
Temperature distribution in Start-up (SU) Core

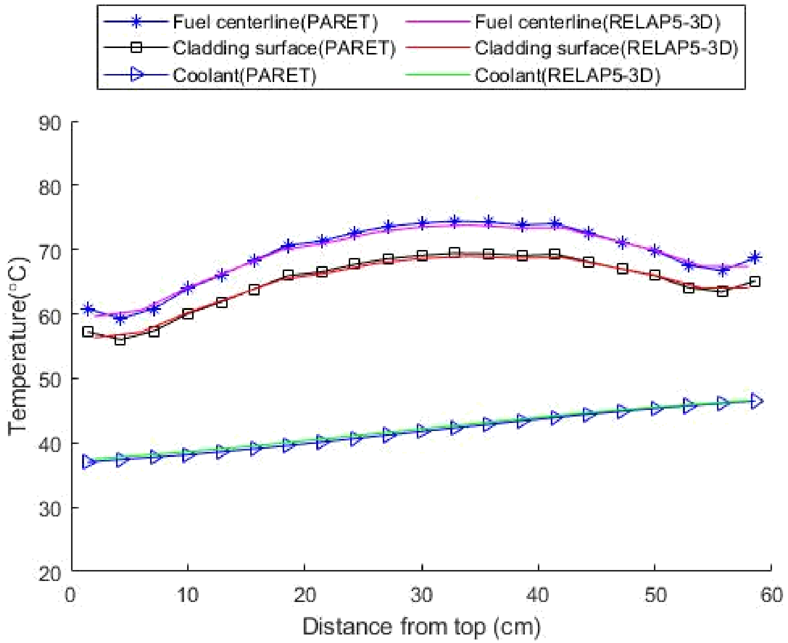




°C	Hot Channel			Average Channel		
	RELAP5	PARET	Deviation	RELAP5	PARET	Deviation
T (Fuel)	108.05	109.38	1.22%	82.52	83.27	0.90%
T(Cladding)	97.91	98.95	1.05%	76.25	76.90	0.85%
T(Outlet)	48.11	48.01	0.21%	46.56	46.49	0.15%

Temperature distribution in End of Cycle (EOC) Core





°C	Hot Channel			Average Channel		
	RELAP5	PARET	Deviation	RELAP5	PARET	Deviation
T (Fuel)	96.94	98.14	1.22%	73.80	74.44	0.86%
T(Cladding)	89.20	90.10	1.00%	68.96	69.43	0.68%
T(Outlet)	53.74	53.66	0.15%	46.54	46.50	0.09%

Conclusions and Future Work

- The thermal hydraulics properties of the conceptual NIST research reactor core was established and the steady state calculations were performed using RELAP5-3D model.
- Preliminary results produced by the RELAP5-3D have a good agreement with the ones from the PARET code, which verifies the validity of the current model in a certain degree.
- In the next stage, some additional components in the primary cooling system of the reactor, such as heat exchanger and primary loop pump, will be developed using RELAP5-3D model, and design basis accidental transient analyses will be performed using the RELAP5-3D models.

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Thank you!

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