INL/CON-24-76339-Revision-1

CCTE Irradiation Plan - PBNC 2024

October 2024

Michael Jason Worrall, Christopher Glen Turner, Ian D Stites, Matthew Phillip Mihelish, Kyle R Gagnon, Paul Chan

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PBNC 2024

Irradiation Plan for a Mixed Thorium-Uranium Oxide Drop-in Experiment in the Advanced Test Reactor

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ANS® American Nuclear Society

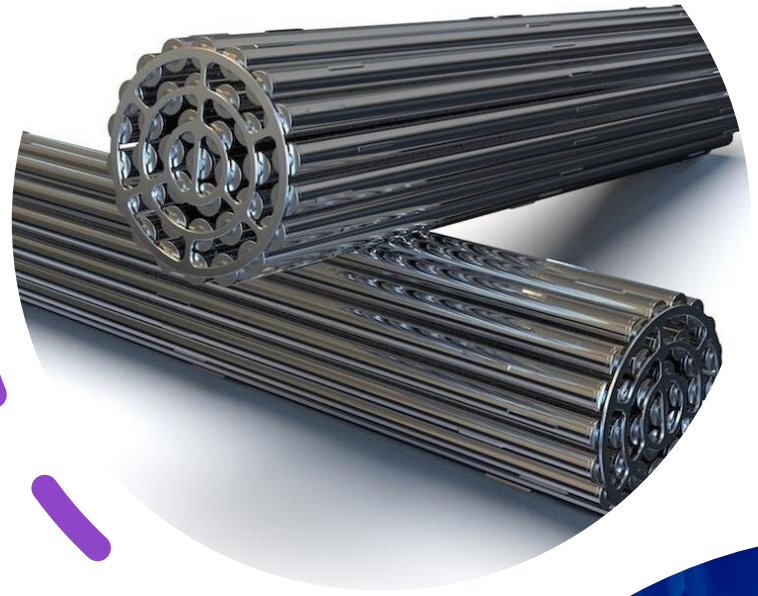
INL Idaho National Laboratory

CLEAN CORE THORIUM ENERGY

Outline

- Project Motivation
- Test Description
- Irradiation Plan
- Design Predictions
- Current Status
- Summary

Project Motivation



- Clean Core Thorium Energy (CCTE), Inc. is developing a novel thorium/uranium fuel form to be used in CANDU/PHWRs
- Once qualified, Advanced Nuclear Energy for Enhanced Life (ANEEL™) fuel will be capable of going to 6-8x the burnup of traditional natural uranium fuel
- There is very little literature on high-burnup thorium-based fuel. CCTE is performing an accelerated burnup test at the Advanced Test Reactor (ATR) at INL

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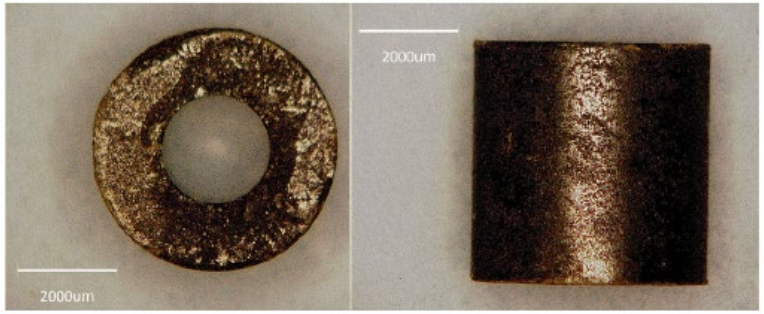
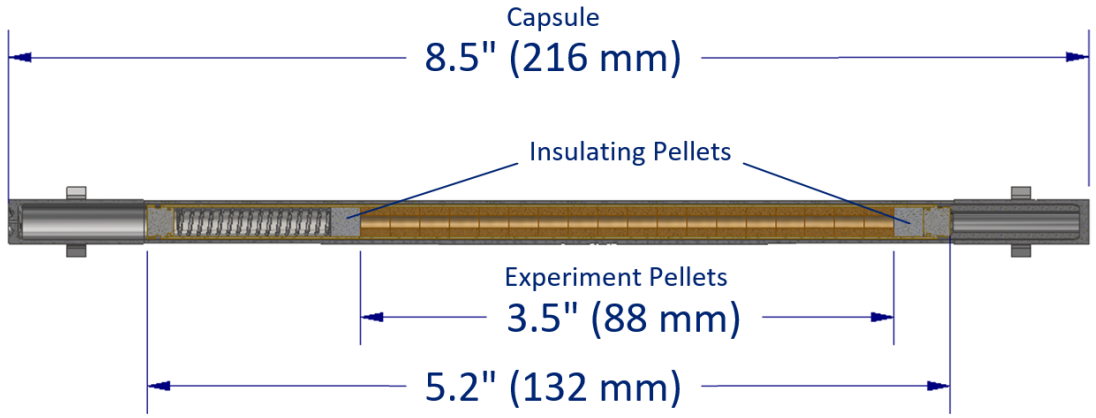
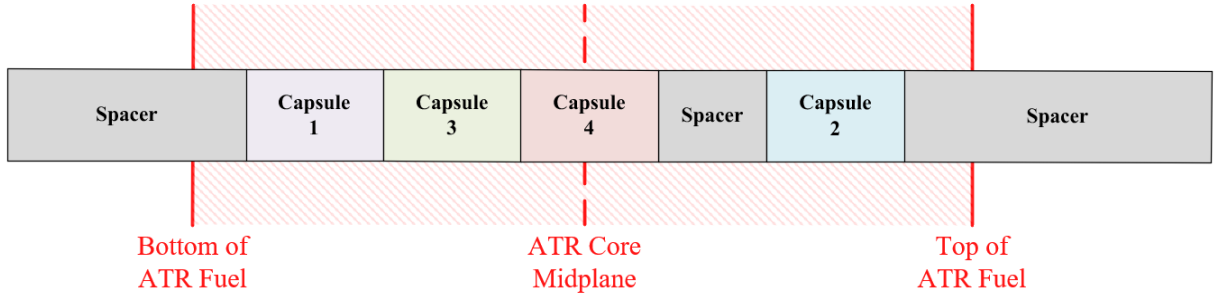
Test Description



- Fuel pellets fabricated by Texas A&M University
  - >300 pellets shipped to INL
  - 5 different material compositions
- 18 fuel pellets per rodlet
- 1 rodlet per capsule
- 4 capsules per test train





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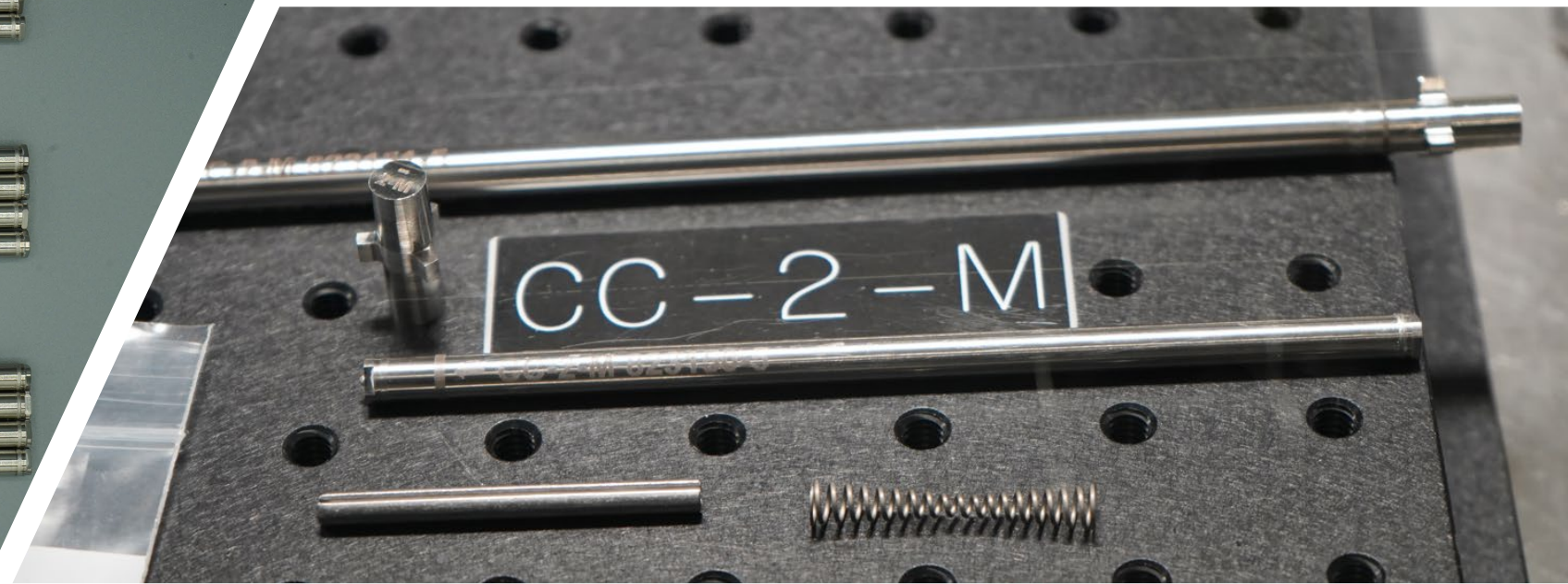
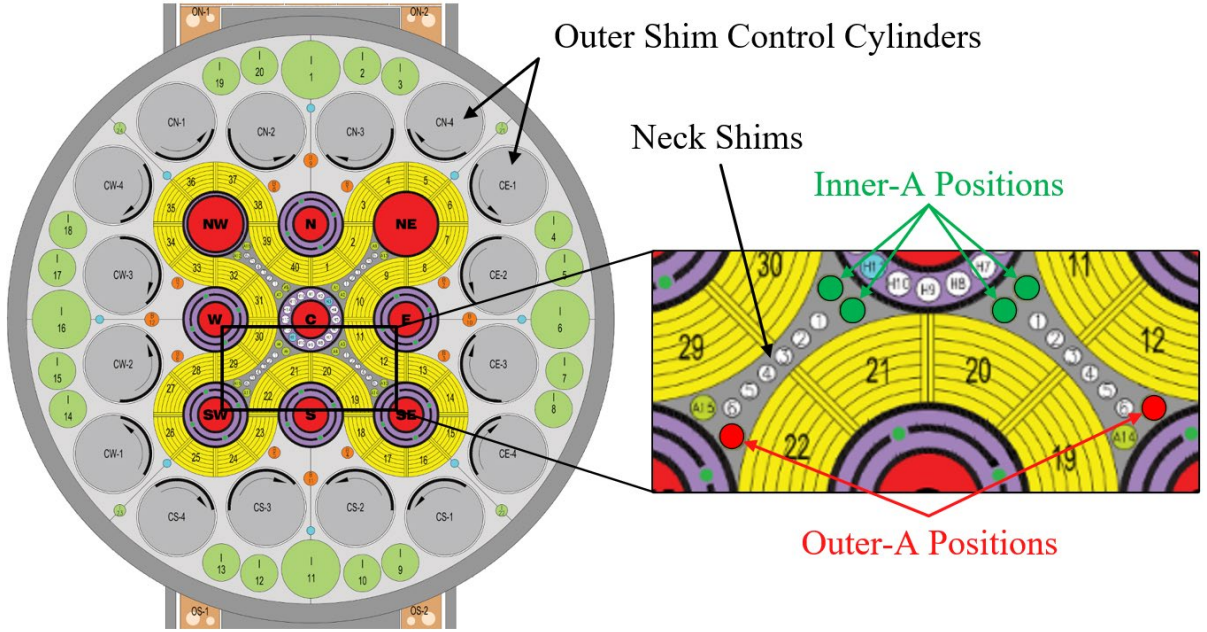
CAPSULES
LOW BURNUP
MEDIUM BURNUP
HIGH BURNUP


HIGH BURNUP
MEDIUM BURNUP
LOW BURNUP
RODLETS


CC-2-M

Irradiation Plan

- 3 test trains (12 capsules)
- 3 burnup targets
  - CCTE-L: 20 GWd/MTU
  - CCTE-M: 40 GWd/MTU
  - CCTE-H: 60 GWd/MTU
- Start in ATR Inner-A positions, move to Outer-A positions
- Remove from ATR as burnup targets are reached



	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 6	Cycle 7
CCTE-L	Inner-A	Inner-A					
CCTE-M	Inner-A	Inner-A	Inner-A	Outer-A			
CCTE-H	Inner-A	Inner-A	Inner-A	Outer-A	Outer-A	Outer-A	Outer-A

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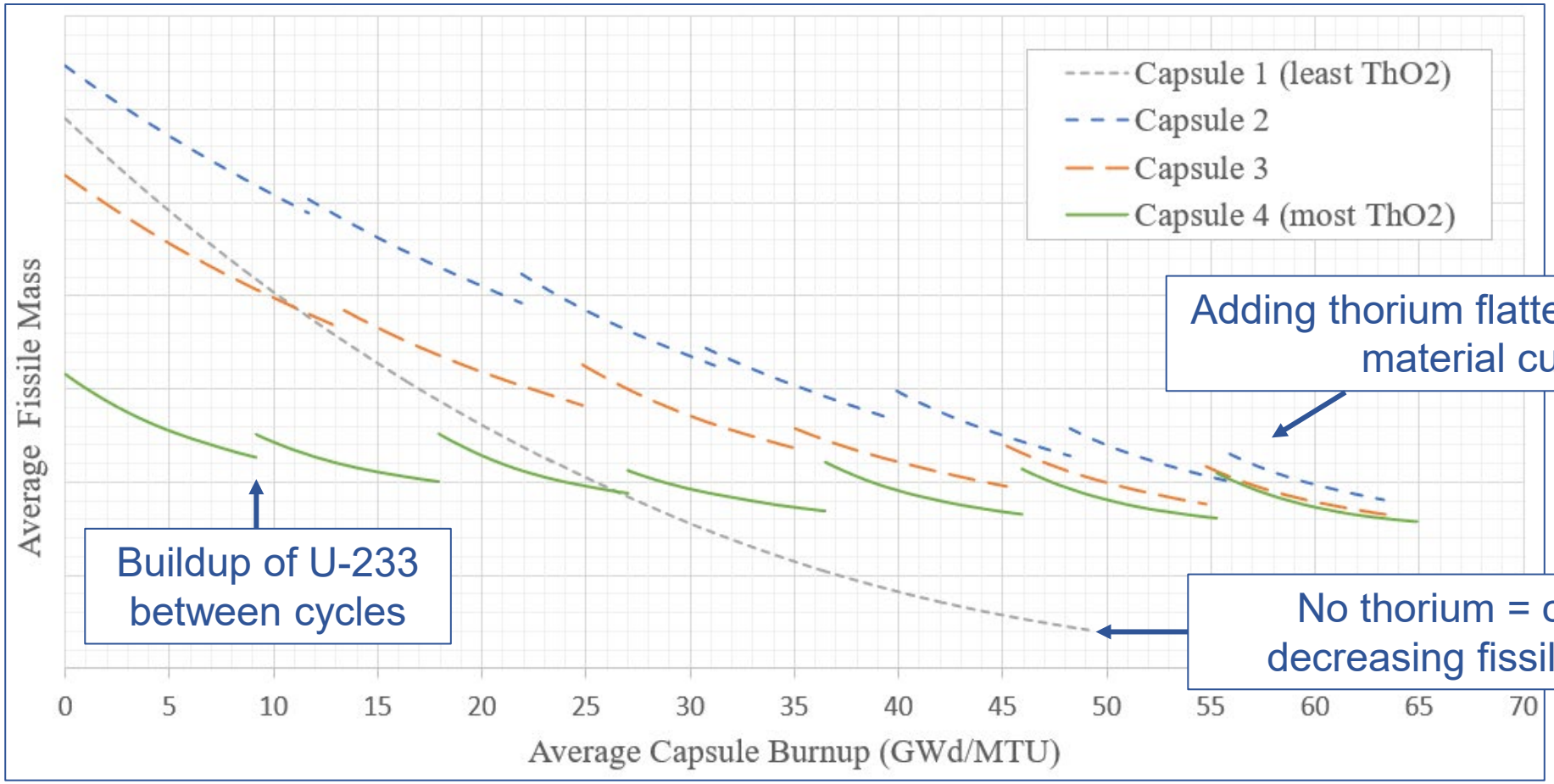
Design Predictions – Fissile Mass



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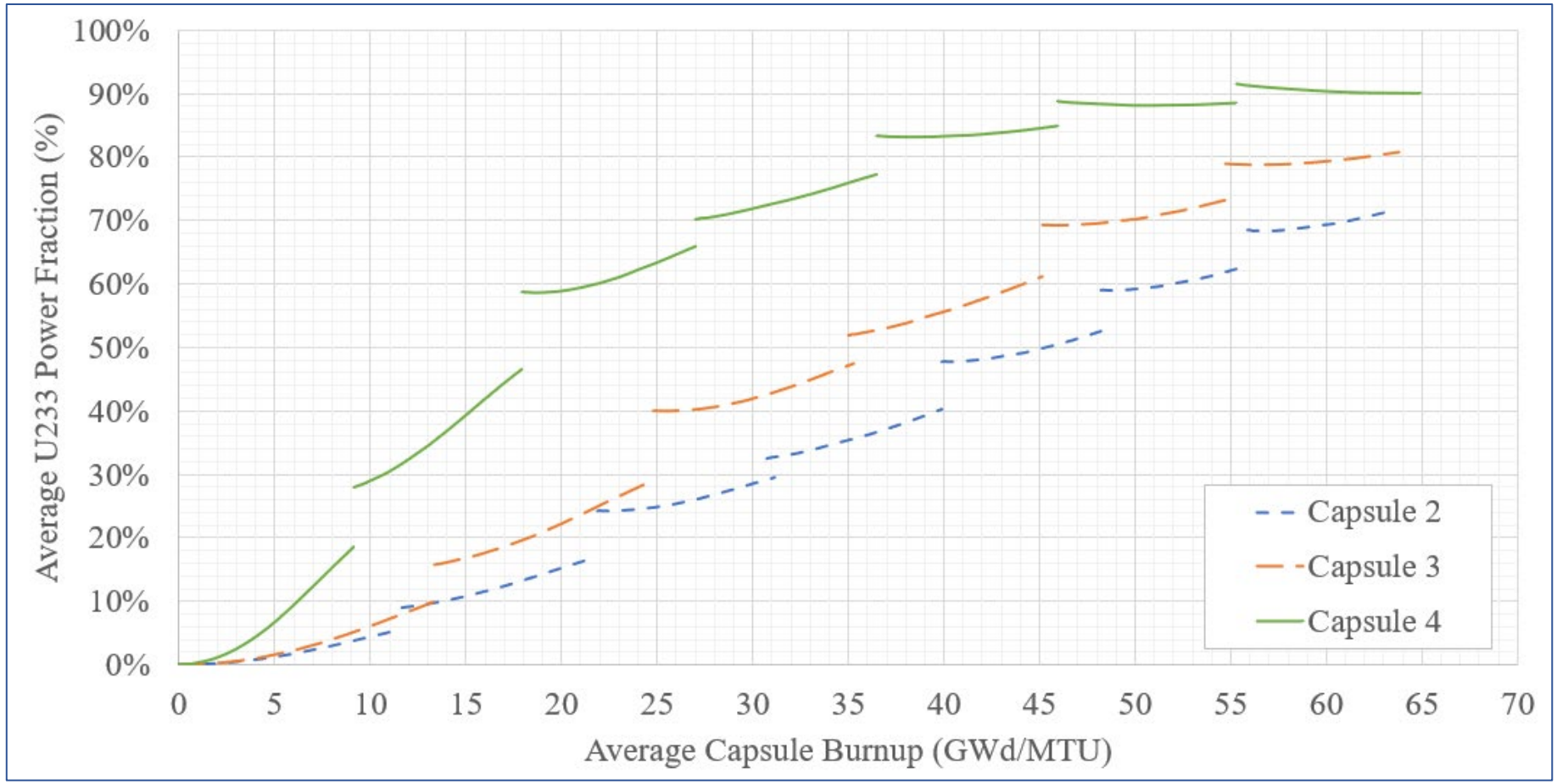
Design Predictions – U233 Power Fraction



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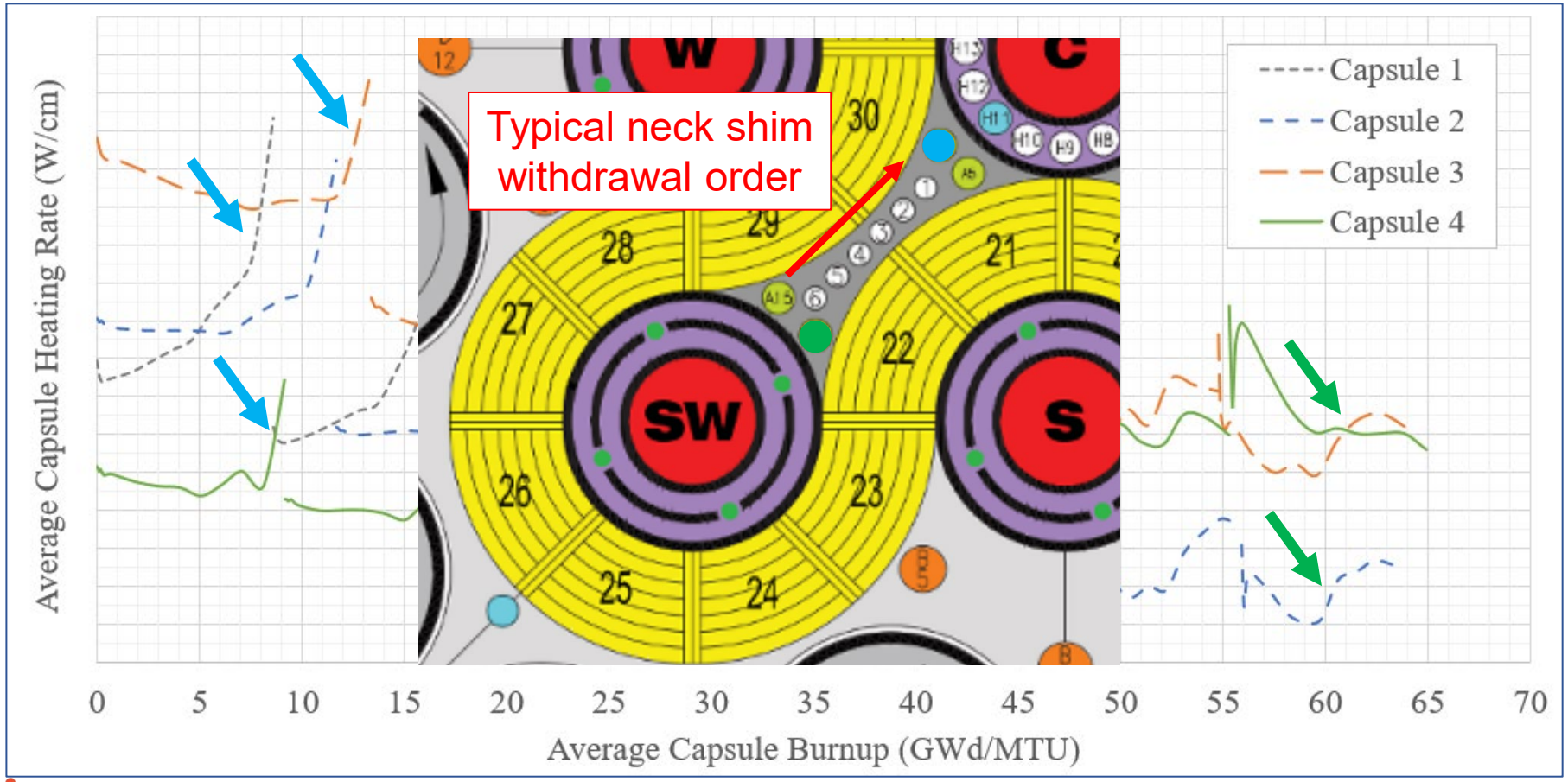
Design Predictions – Heat Generation Rate



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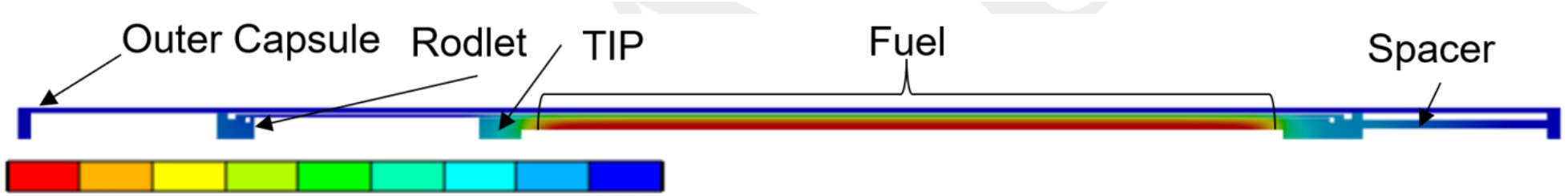
Design Predictions - Temperature

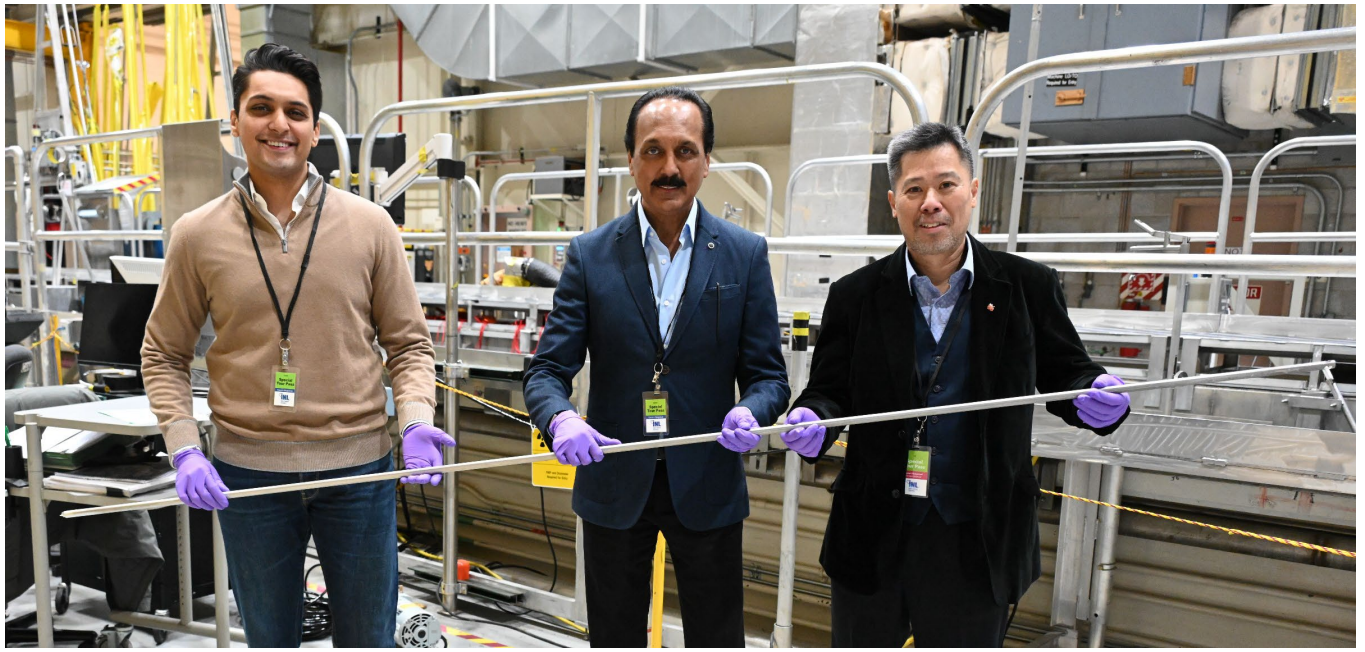


Capsule Number	Peak Internal Fuel Temperature (°C)	Peak Rodlet Temperature (°C)	Peak Capsule Temperature (°C)
1	1352	383	137
2	1167	530	125
3	1201	545	131
4	1173	532	127

- Temperature profile semi-prototypic for a CANDU/PHWR
- However, the radial thickness for the fuel pellets for this experiment is ~1.5 mm so radial temperature profiles are more extreme than a typical fuel pellet.

Current Status

	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 6	Cycle 7
CCTE-L	Inner-A	Inner-A					
CCTE-M	Inner-A	Inner-A	Inner-A	Outer-A			
CCTE-H	Inner-A	Inner-A	Inner-A	Outer-A	Outer-A	Outer-A	Outer-A



- All three test trains began irradiation in May 2024 (Cycle 173A)
- Low burnup capsules just finished irradiation with no abnormalities observed
- Shipment is being prepared for post-irradiation examination, such as fission gas release and grain size measurements
- Medium burnup capsules have two cycles remaining (ECD mid 2025)
- High burnup capsules have five cycles remaining (ECD early 2026)

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Summary

- An experiment campaign was designed, fabricated, and assembled by INL to assess the fuel performance of CCTE's ANEEL™ fuel
- Irradiation in ATR is ~1/3 of the way complete
- Results obtained from this experiment will help qualify ANEEL™ fuel for use in commercial reactors
- Once deployed, ANEEL™ fuel will dramatically decrease spent fuel volume and allow for extended operation for CANDUs/PHWRs

Questions?

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