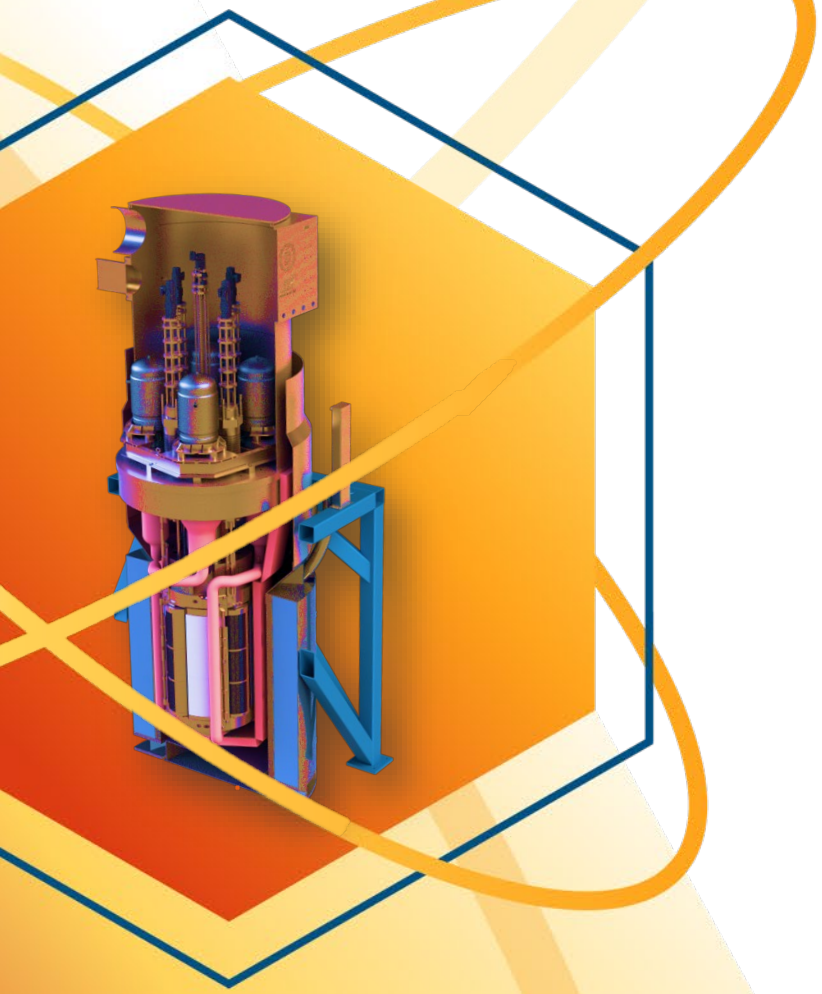
(Microreactor Applications Research, Validation & EvaLuation),



MARVEL Dry Critical: Fuel Loading and Initial Startup Neutronics Analysis

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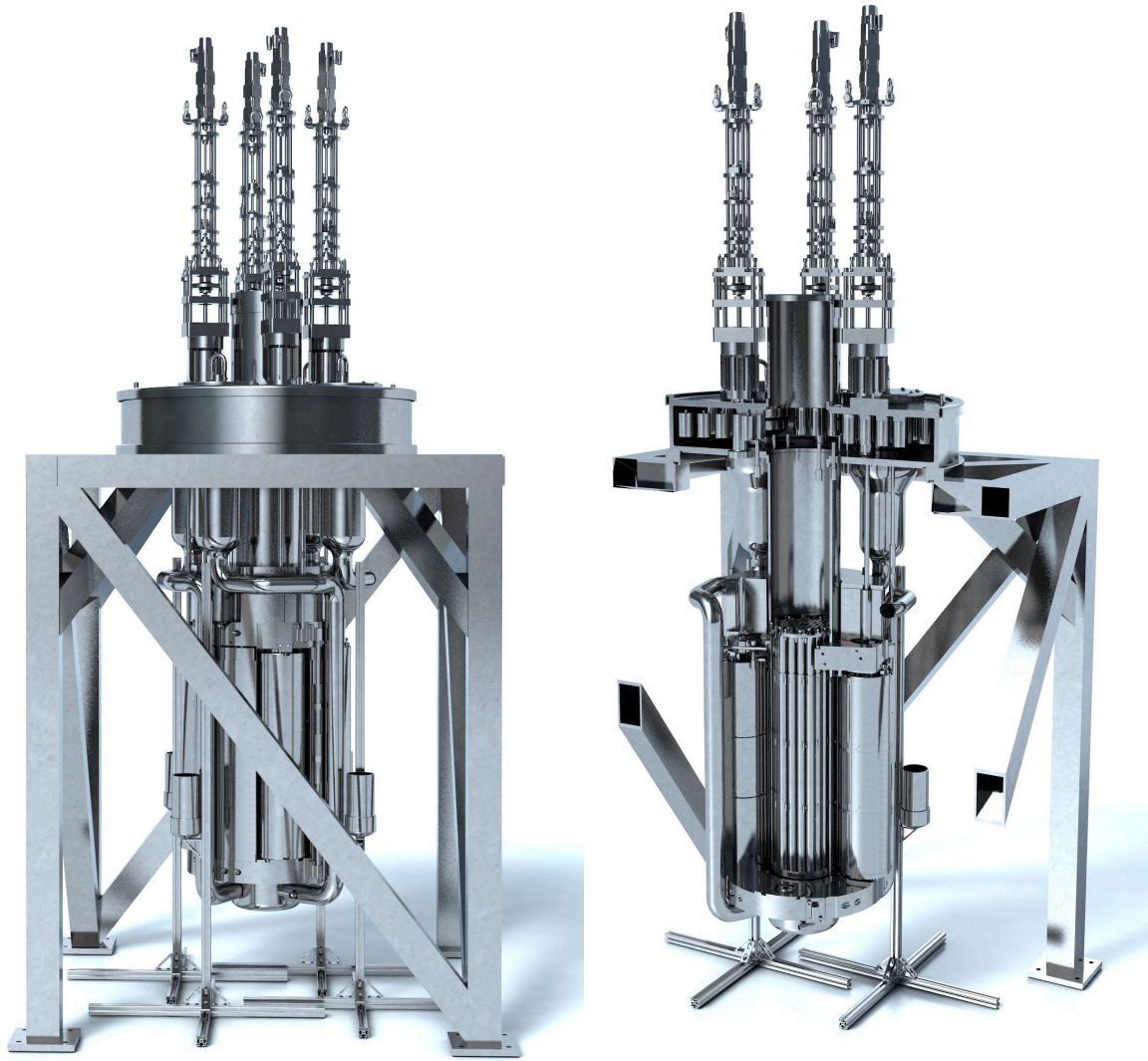
INL/MIS-26-90673

MARVEL Dry Crit Overview

- **MOTIVATION**
  - Provide de-risking of key characteristics of MARVEL design
  - Validation of reactor physics models for excess reactivity and shutdown margin
  - Create a neutronic benchmark for industry, researchers, academia
- **CHARACTERISTICS**:
  - Ability to decouple from other project efforts (e.g., TREXC pit)
  - Ability to make adjustments/repairs as needed (Guard Vessel welding is irreversible)
  - Ability to validate neutronics sooner (similar to PCAT goals)
- **SCOPE**:
  - **Included**: PCS, Fuel, Reflector, RCS, NI
  - **Not included**: Insulation, TCs (installed but not connected), GVS installation, T-REXC pit completion (experiment can be conducted on TREAT floor), HES, PGS



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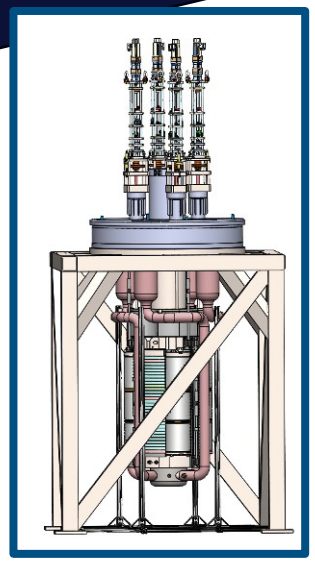
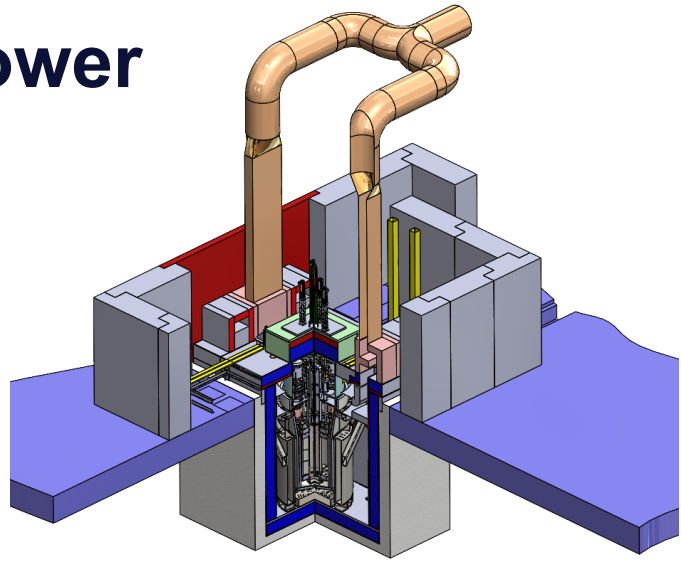
Key Hardware Tests Along The Path To Full Power

PCAT Hydraulic Validation Testing
Complete: *Summer 2025*

MARVEL Reactivity Control Qualification
Target: *Fall 2025*





1. **Reactor install in pit**
2. **HES install**
3. **T-REXC completion**
4. **NaK Loading**
5. **Zero Power Physics Test**
6. **Full Power Test**
7. **Turnover to Ops**

Target: *Summer 2028*

MACS Startup Procedure Testing
Complete: *Summer 2025*

Proposed modified configuration:

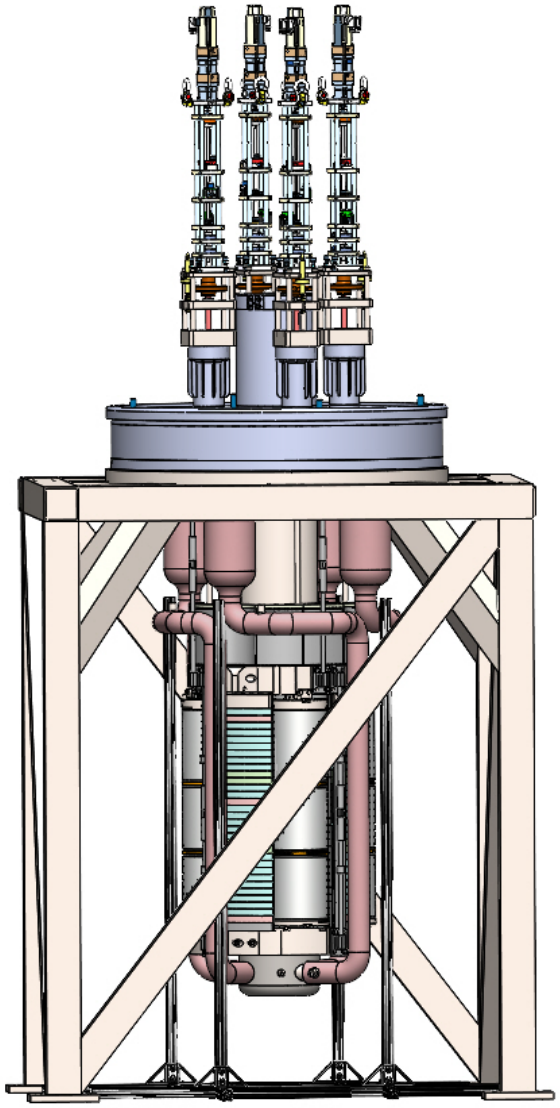
MARVEL Dry Criticality Test
Target: *Winter 2026 – Spring 2027*

MRP Microreactor Program

MARVEL Initial Criticality – Dry

PLN-25056

- No Shielding
- No Guard Vessel
- No CIA Assembly
- On TREAT floor (not in pit)
- From T-REXC:
  - I&C
  - Radiation Area Monitors
  - AC Power Distribution
- 30-34 Fuel Pins depending on as-built
  - Load to $k_{eff} \leq 0.9$ (ANS/ANSI-1)
- Operate from TREAT Control Room
  - Incremental Drum Withdrawal to criticality
  - Use of control drum hardstops, if necessary



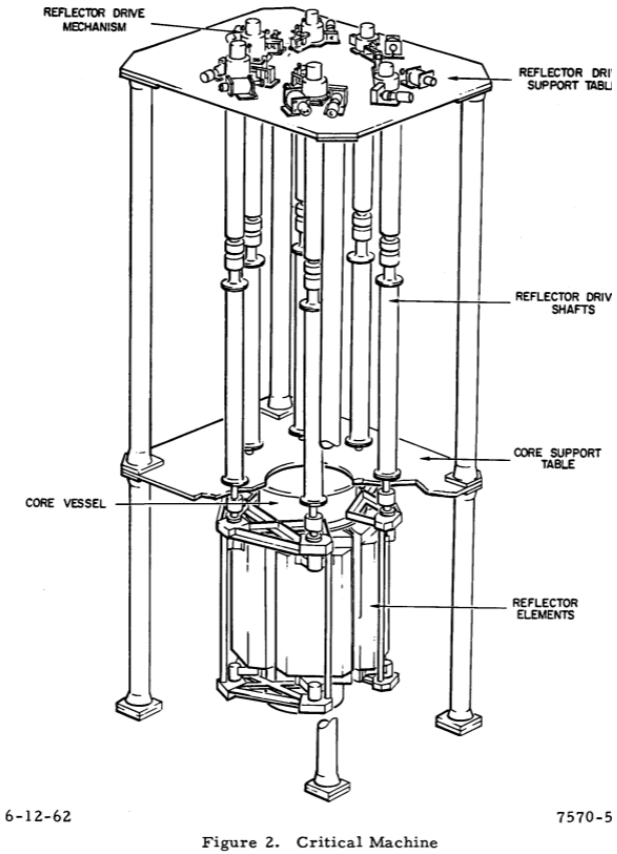


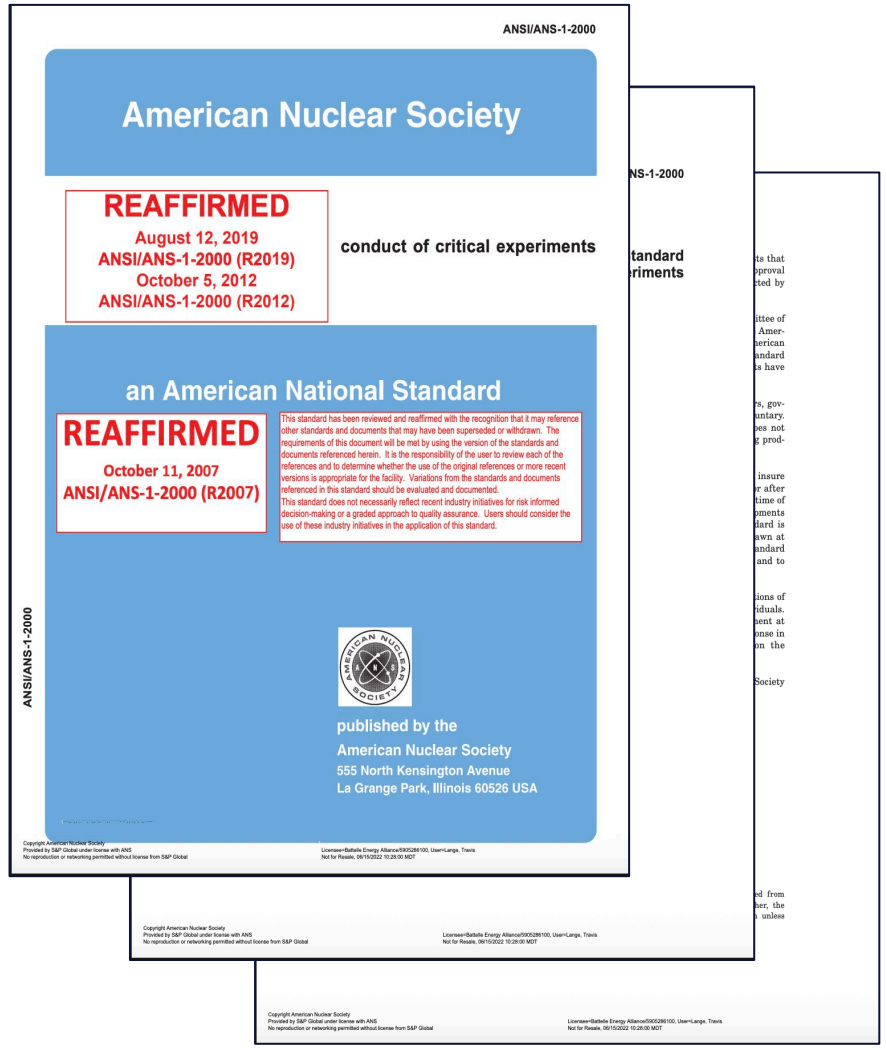
Figure 2. Critical Machine

SNAP 8 Critical Experiment

MRP Microreactor Program

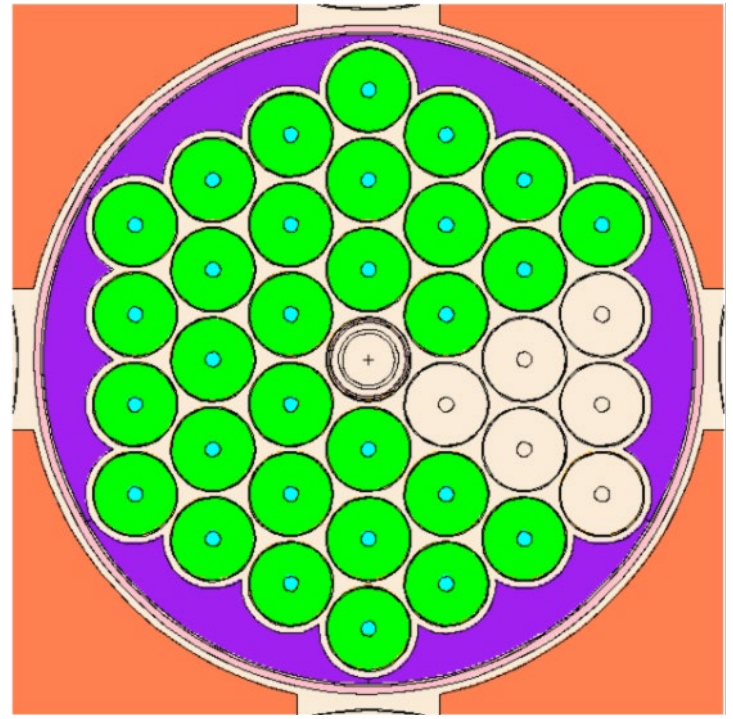
Conduct of Critical Experiments as Guidance

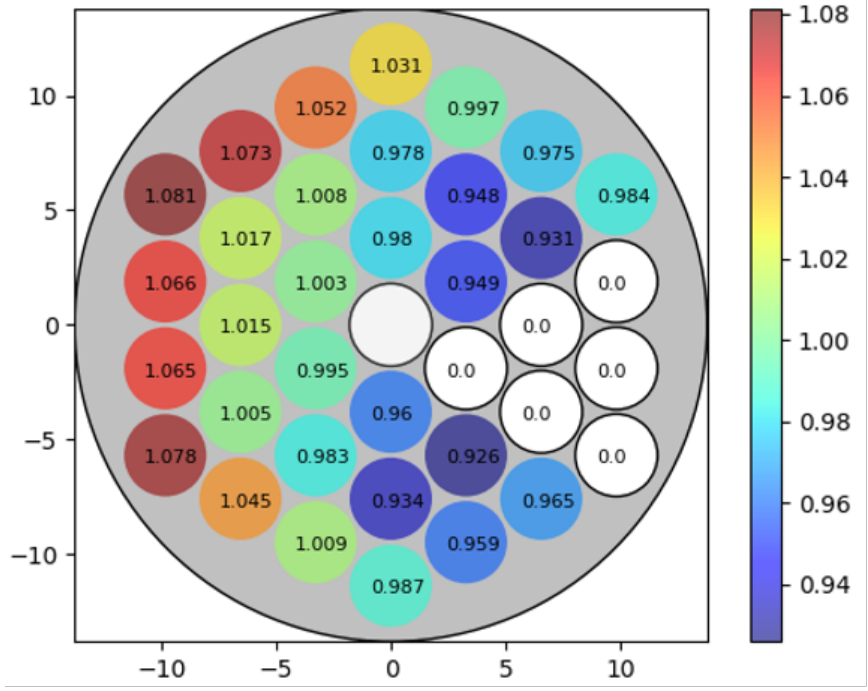
- ANSI/ANS-1-2000 being used for guidance on fuel loading and initial startup:
  - Program of experiments documented, independently reviewed, and approved (sec. 3.3)
  - Predicted k_{eff} < 0.9 for manual loading of “unknown configurations” (sec. 3.9)
  - Predicted k_{eff} < 0.95 for manual loading of “known configurations” (sec. 3.9)
  - Use of startup neutron source (sec. 4.4)
  - Nuclear instrumentation (sec. 4.9)



Neutronics Analysis for Partial Fuel Loading

- Calculated that 30 fuel rods (5 six-packs of fuel) meet conditions
  - $k_{eff} \leq 0.9$ for fuel loading with drums fully inserted
  - Worth of control drums > 10%
  - Can be made critical ($k_{eff}=1.0$) with control drums operated remotely
- Safety basis analyses completed
  - 2D power peaking factors
  - Integral control drum worth curves
  - Kinetics parameters

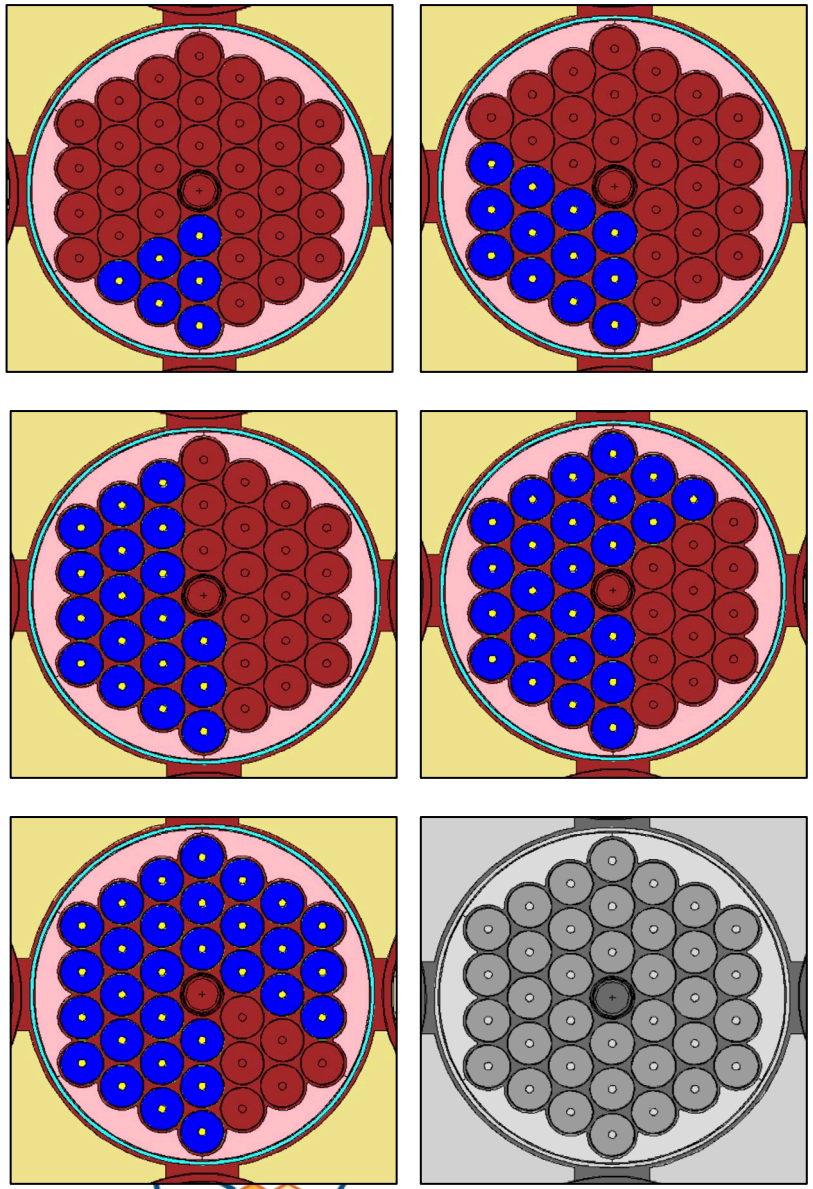




Fuel Loading Sequence Neutronics Analysis

NUMBER OF SUBASSEMBLIES	THERMAL FLUX AT DETECTOR [N/CM2/S]	K-EFFECTIVE	CALCULATED COUNTS PER SECOND AT DETECTOR
0	14.1	0.00000	56.4
1	13.2	0.30832	52.8
2	13.5	0.53343	54.0
3	14.5	0.65979	58.0
4	16.0	0.75186	64.0
5	19.2	0.84106	76.8
6*	29.4	0.92859	117.6

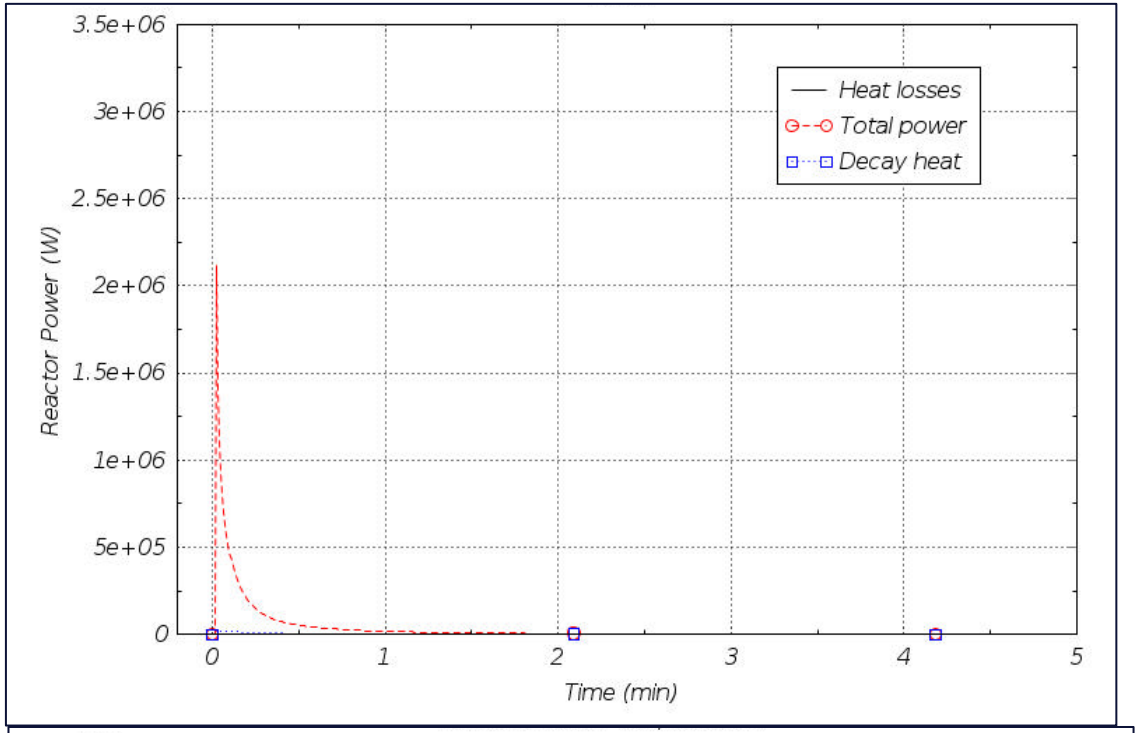
* Full core loading not used for initial approach to criticality. Available as additional experimental configuration after initial criticality with partial fuel loading.

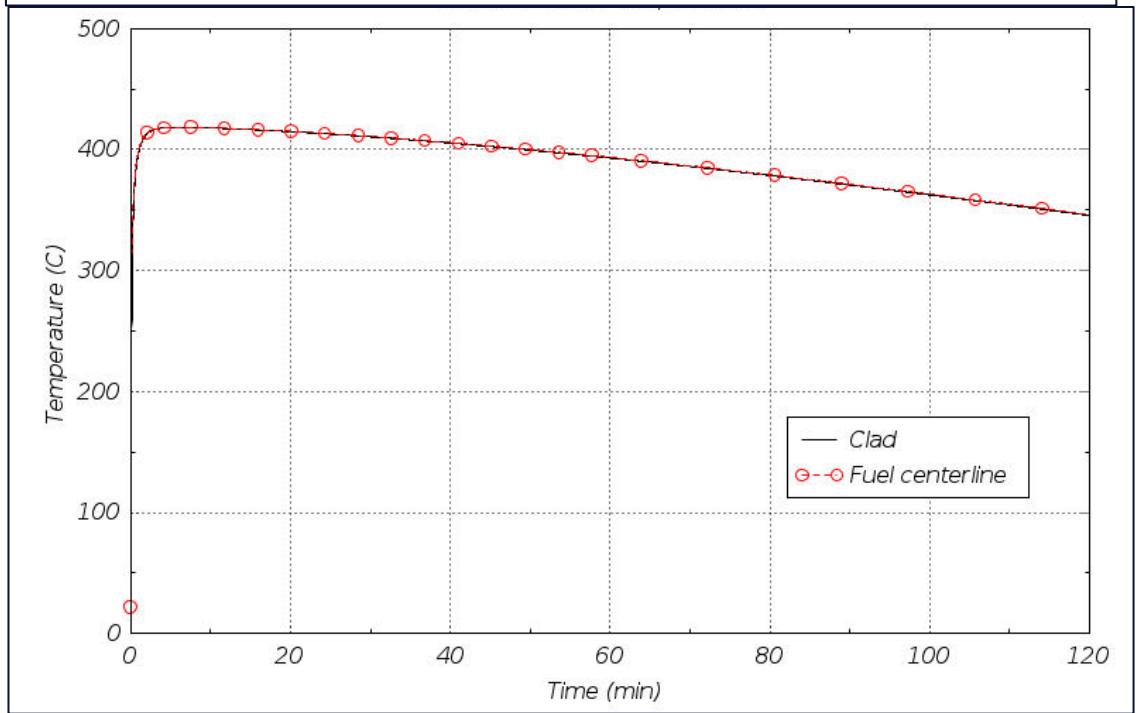


MRP Microreactor Program

Updating RELAP Dry RIA Transient

- Unprotected Transient Overpower (UTOP) at DRY-CRIT conditions simulated
- Update of the MARVEL RELAP5-3D model
  - Hot Channel Factor (HCF)
  - Core flow area
  - Neutronic parameters
- Simulation of 1.33$ prompt reactivity insertion
- Fuel and clad temperature peaking at ~410 °C
- Safety margins OK for clad and fuel
  - Conservative hot channel factor, conservative clad safety limit





Questions?

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