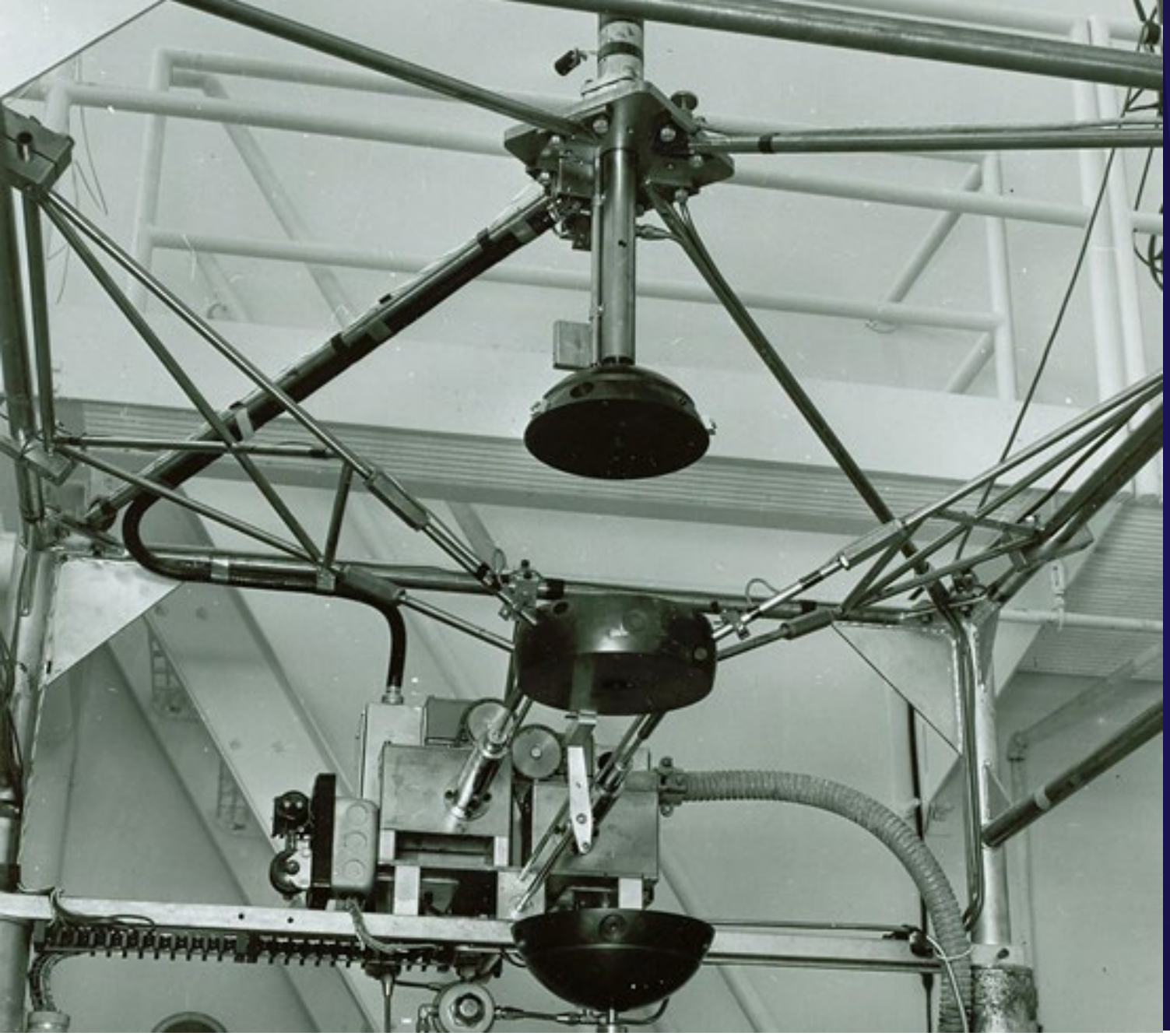

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National Nuclear Security Administration

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Design of a Critical Experiment to Validate Yttrium Hydride at Varying Temperatures

June 2020

ANS Annual Meeting

Theresa Cutler, Travis Grove, Kelsey Amundson, Holly Trellue

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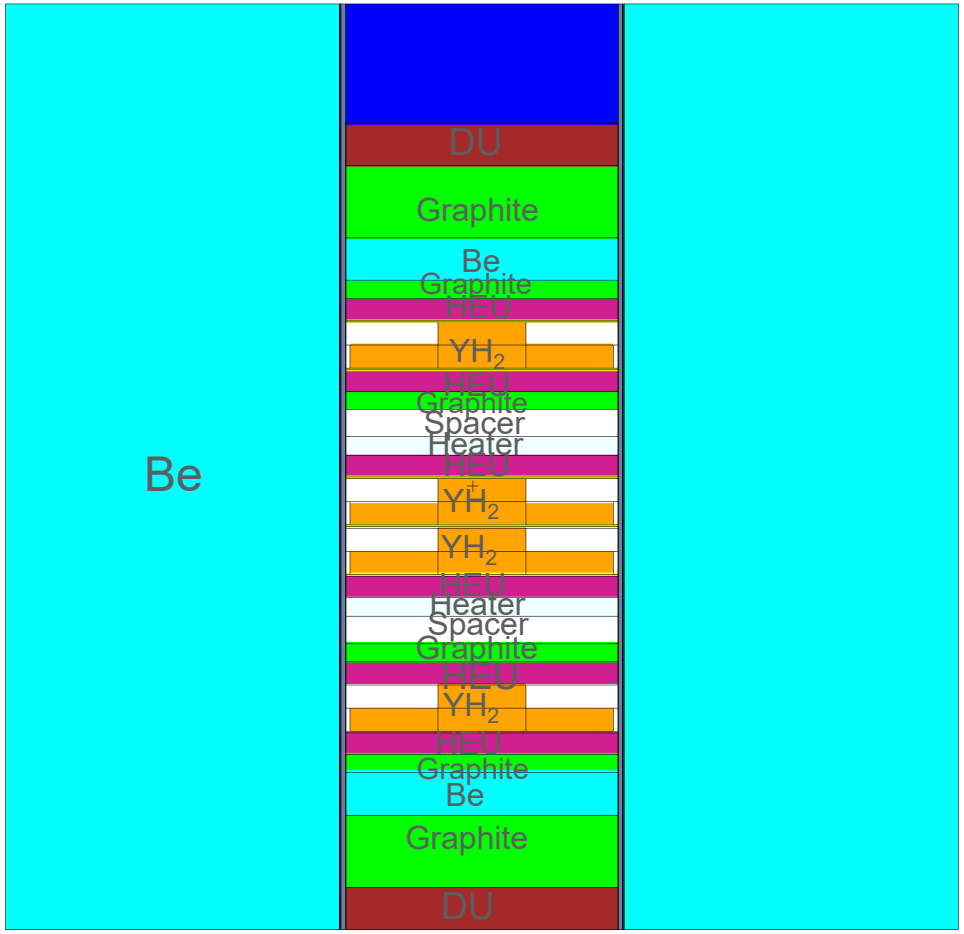
Overview

- **Microreactor Applications**
  - Attractive technology for kick starting nuclear innovation
  - Emerging nuclear energy source for microgrids, mining/industry, and remote applications
  - Expectations of moderator material
    - Reduces required fuel masses and/or enrichments
    - Research best moderator to achieve this goal
    - Low-Z and High-Z combined compound seems most promising
    - Yttrium hydride retains hydrogen to higher temperatures than other moderating material
  - Current Work
    - Many thermomechanical material properties of unirradiated material are known
    - Recent Thermal Scattering Law was developed for H-YH_2 in ENDF/B-VIII.0
    - Expected high performance at elevated temperatures
  - Need an integral experiment to validate neutronic and kinetic performance

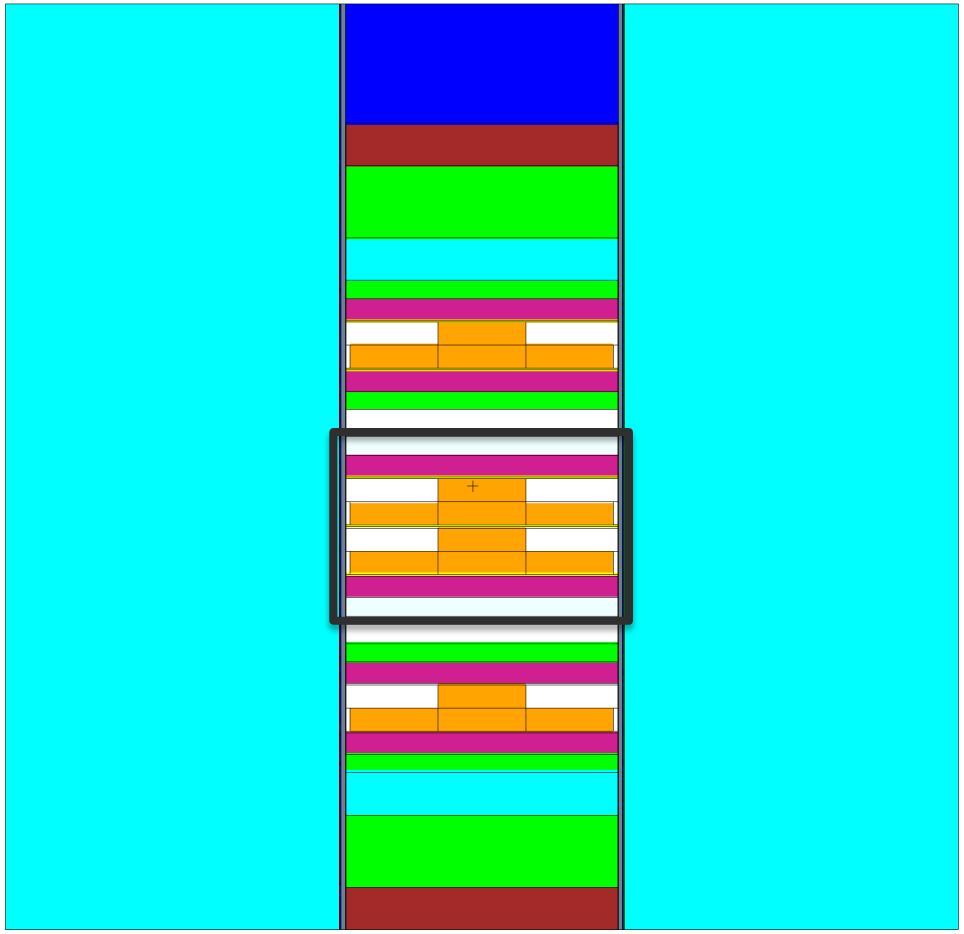
Motivation

- **Yttrium dihydride YH_2 is a promising candidate for moderator applications**
  - High thermal stability compared to other metal hydrides
  - Significantly reduces critical mass
- **Lots of material property measurements of unirradiated material have been made**
- **S(a,B) in ENDF/B-VIII.0 exists for YH_2**
- **Many differential measurements across DOE**
- **Integral experiment is required to verify cross section and behavior in a critical environment.**



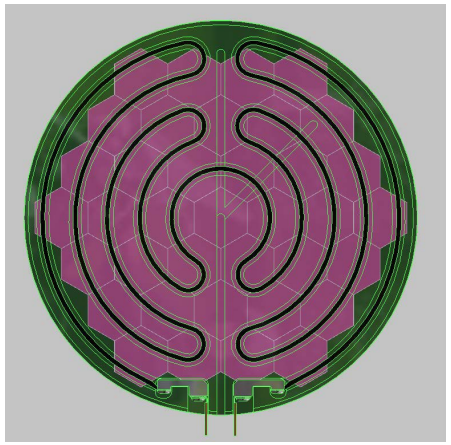
Experimental Objectives

- **Measure reactivity with central region heated**
  - Various points from 20 C to 330 C
  - Compare the change in reactivity at these points
  - Repeat without YH_2 in central region
- **Why not heat all?**
  - Decouple many competing effects
  - Reduce heating elements needed
  - Reduce time to heat the region
- **Why limit to 330 C?**
  - HEU metal used in not alloyed
  - Staying away from HEU phase transition

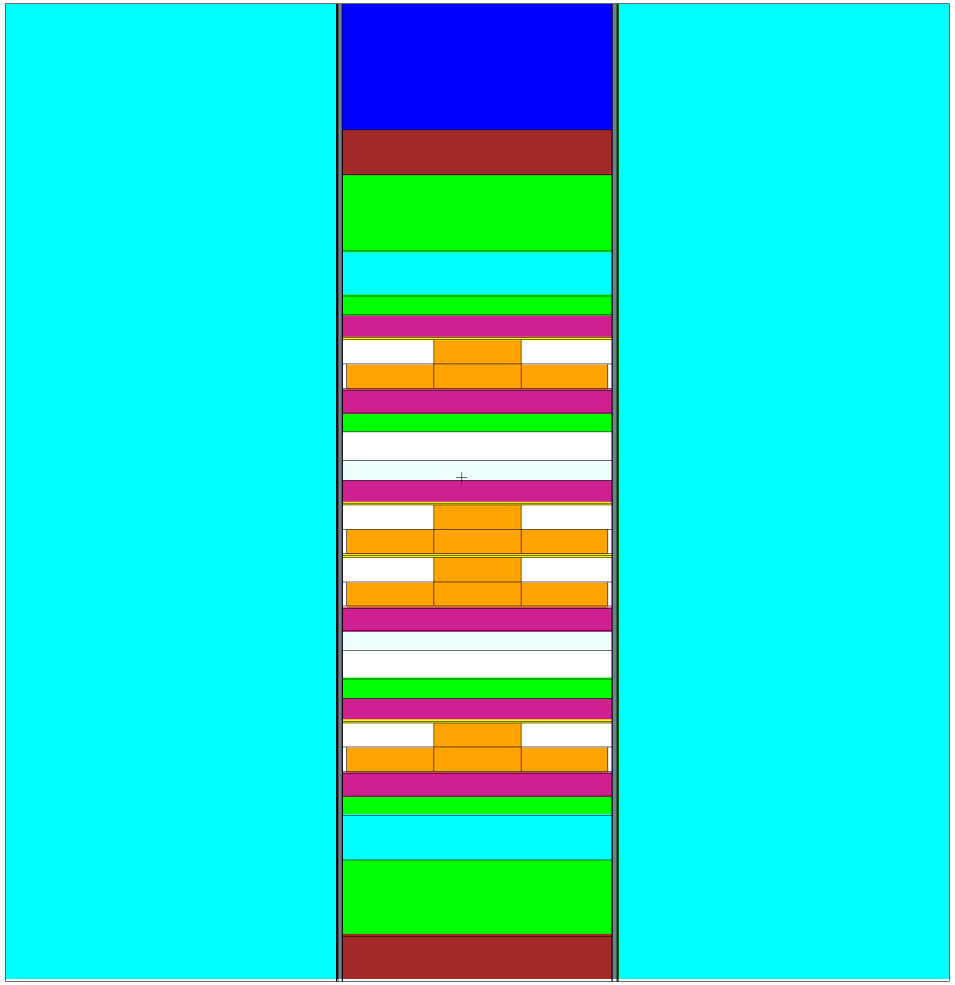


Experiment Design

- **Planet Critical Assembly Machine**
- **Stacking**
  - Series of 6” Nominal OD parts
  - YH_2, made at LANL
  - C-discs in Inventory
  - Be discs in Inventory
  - New graphite spacers
  - Heaters
- **Reflector**
  - Layers of Be blocks in NCERC Inventory



Heater



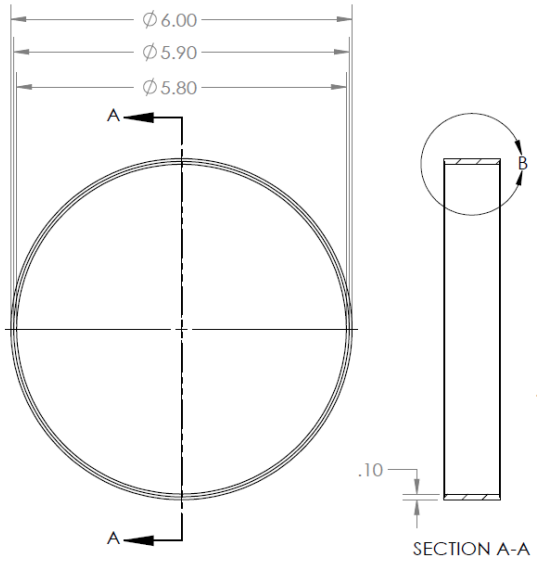
MCNP® Rendering of the YH_2 Experiment

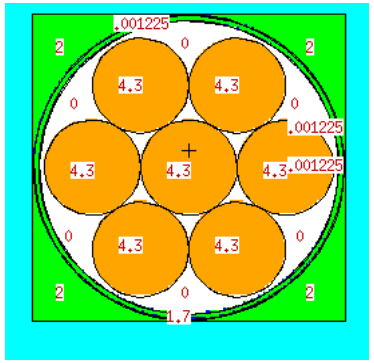
HEU Fuel

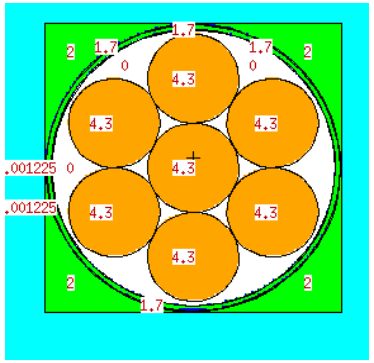
- **General information**
  - Commonly referred to as “C-discs”
  - 6 total
  - Bare/ unclad

Yttrium Hydride

- **Manufacturer**
  - LANL
  - 14 discs per can
  - 2 layers of discs per can
- **Canning**
  - Molybdenum
  - E-beam welded closed
  - vacuum
- **Can Dimensions**
  - OD: 6.00 inch
  - ID: 5.80 inch
  - Height: 1.00 inch
  - Top and Bottom Height: 0.02 inch
- **YH_2 Disc Dimensions**
  - OD: 1.930 inch
  - Height: 0.480 inch





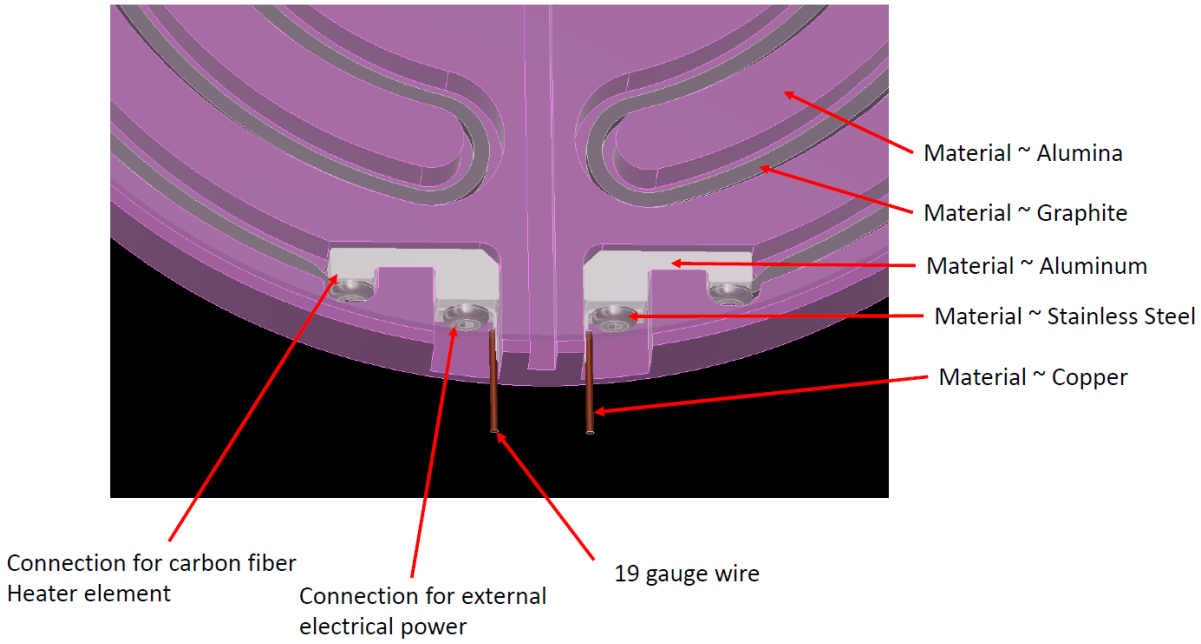


YH_2 plates in MCNP®

$YH_{1.9}$

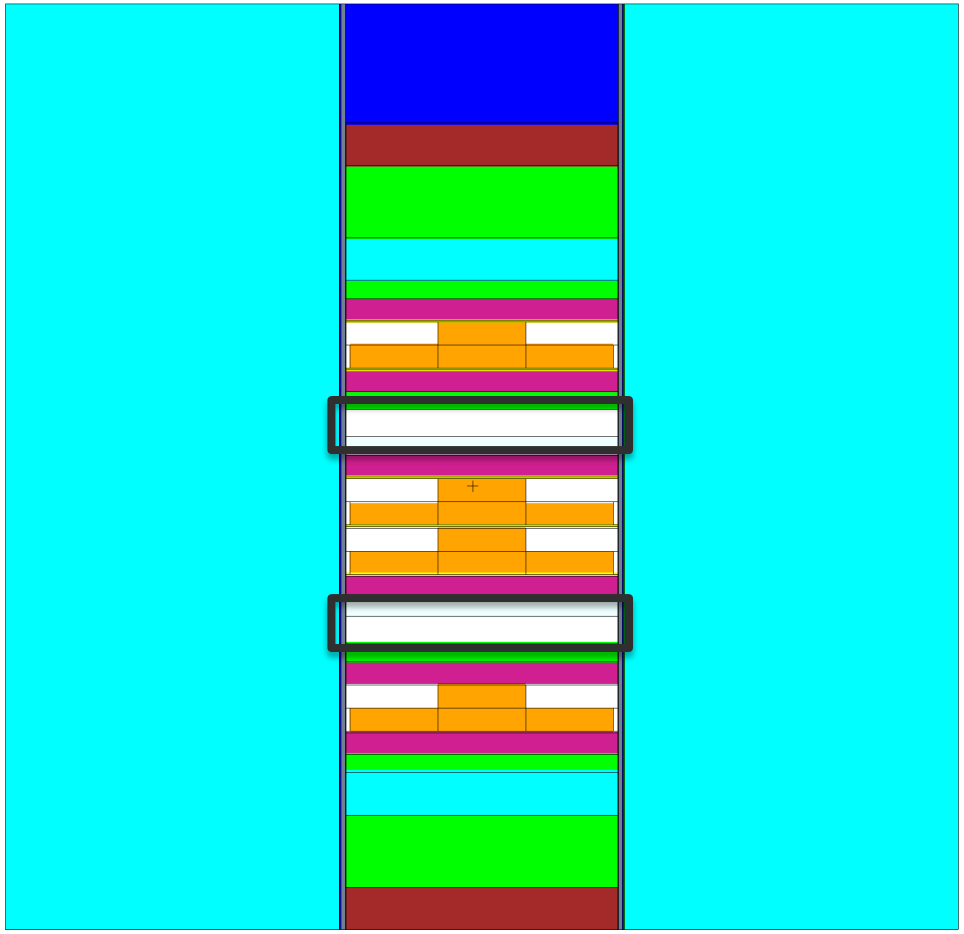
Heaters

- **Manufactured by NASA**
  - Alumina outer surfaces
  - Graphite inner heating element
- **Dimensions**
  - Height: 0.406 inches



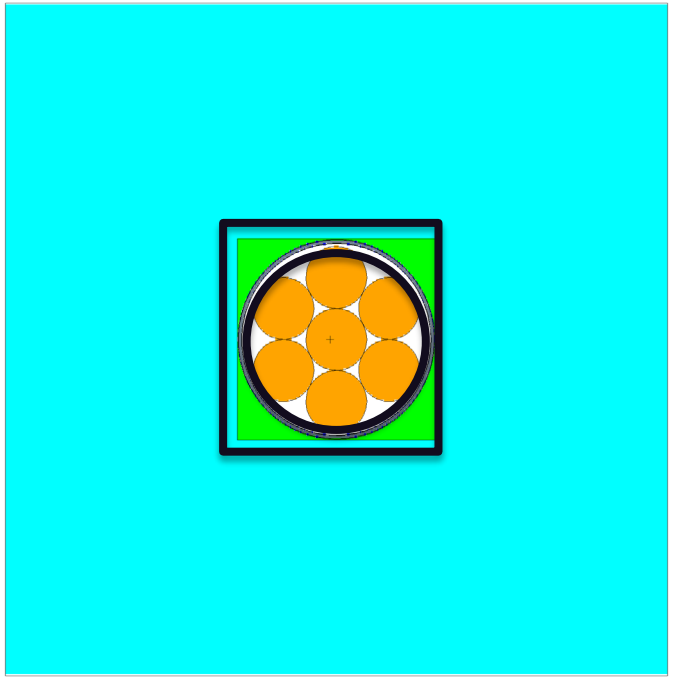
Spacers

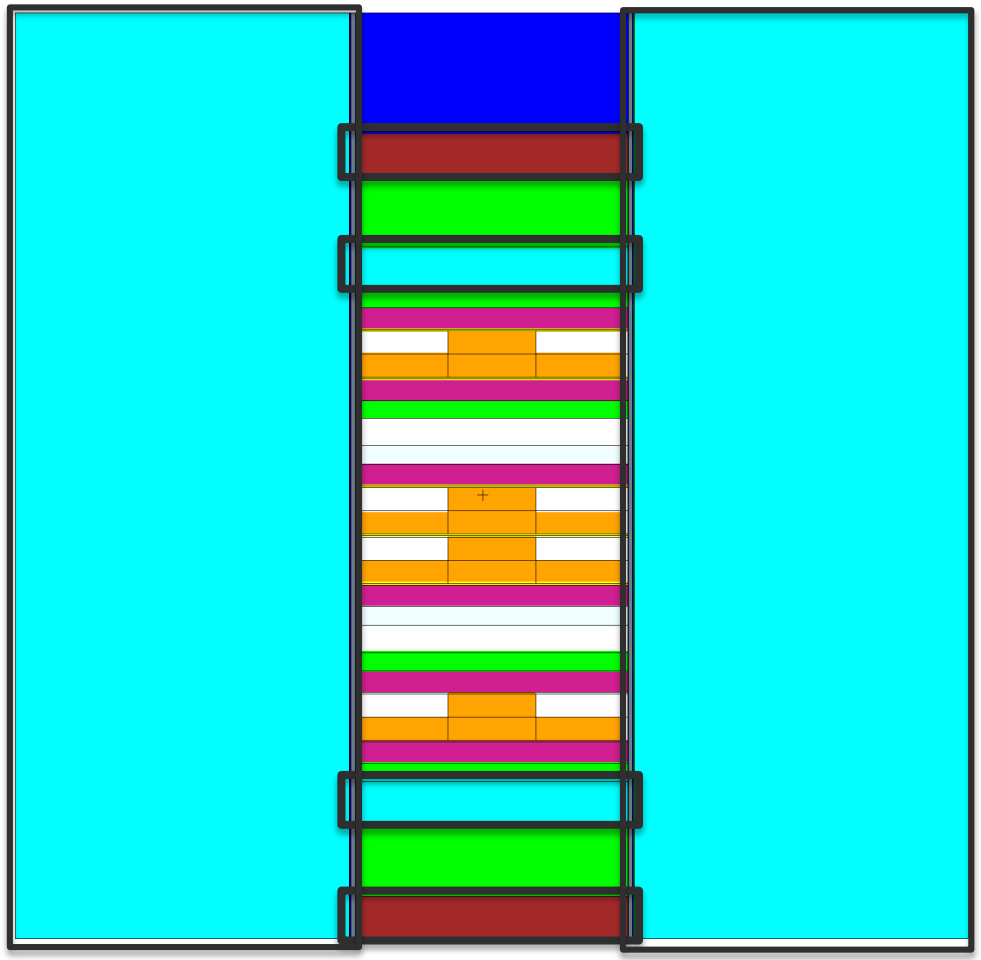
- **Purpose**
  - Control reactivity
  - Separate central heated region
- **Material**
  - Graphite
- **Planned Dimensions**
  - Height: 0.1 – 1 inch



Reflectors

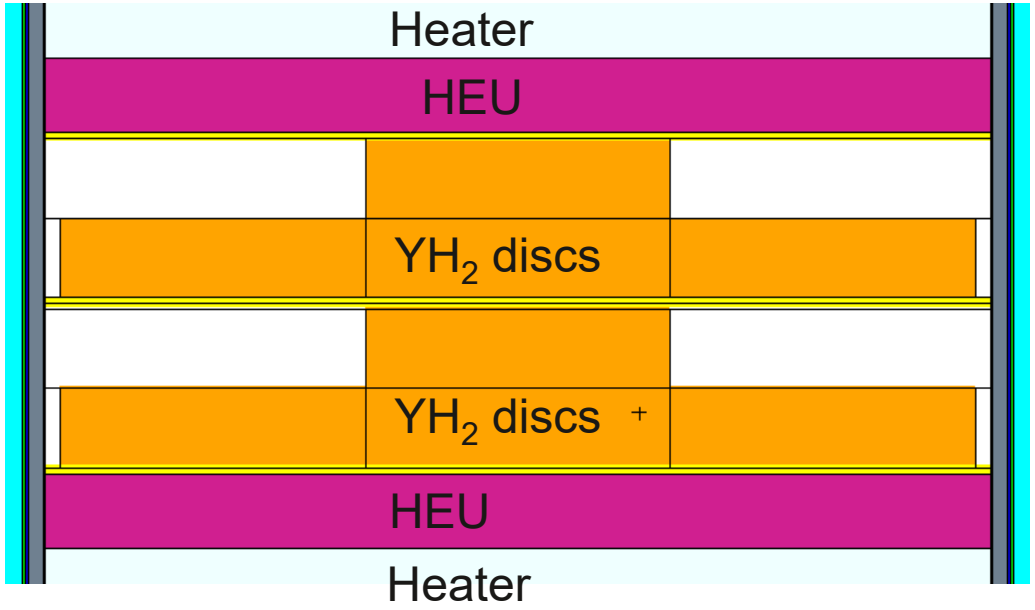
- **Axial Reflectors**
  - Depleted Uranium
  - Be
- **Radial Reflectors**
  - Be blocks from Honeycomb experimental series
- **Intermediate Radial Reflectors**
  - Graphite corner pieces





Experiment Design Summary

- **Planet Critical Assembly Machine**
- **Proof of Concept**
- **Execution**
  - Validate reactivity at room temperature
  - Heat central region to various points, up to 330 C
  - Repeat without YH_2 (i.e. only HEU) in central heated region
  - Compare reactivity effects at all temperatures
  - Compare to expected results
- **Possible Future Experiments**
  - Benchmark quality
    - Highly detailed characterization of all materials
    - Procurement of many new parts, such as Be
  - Effect of poison in the center



MCNP® Rendering of the Central Heated Region

Acknowledgments

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- The initial YH_2 discs were manufactured under LANL LDRD-DR “Multi-Scale Kinetics of Self-Regulating Nuclear Reactors”