



MARVEL Reactivity Control: Central Insurance Absorber Rod

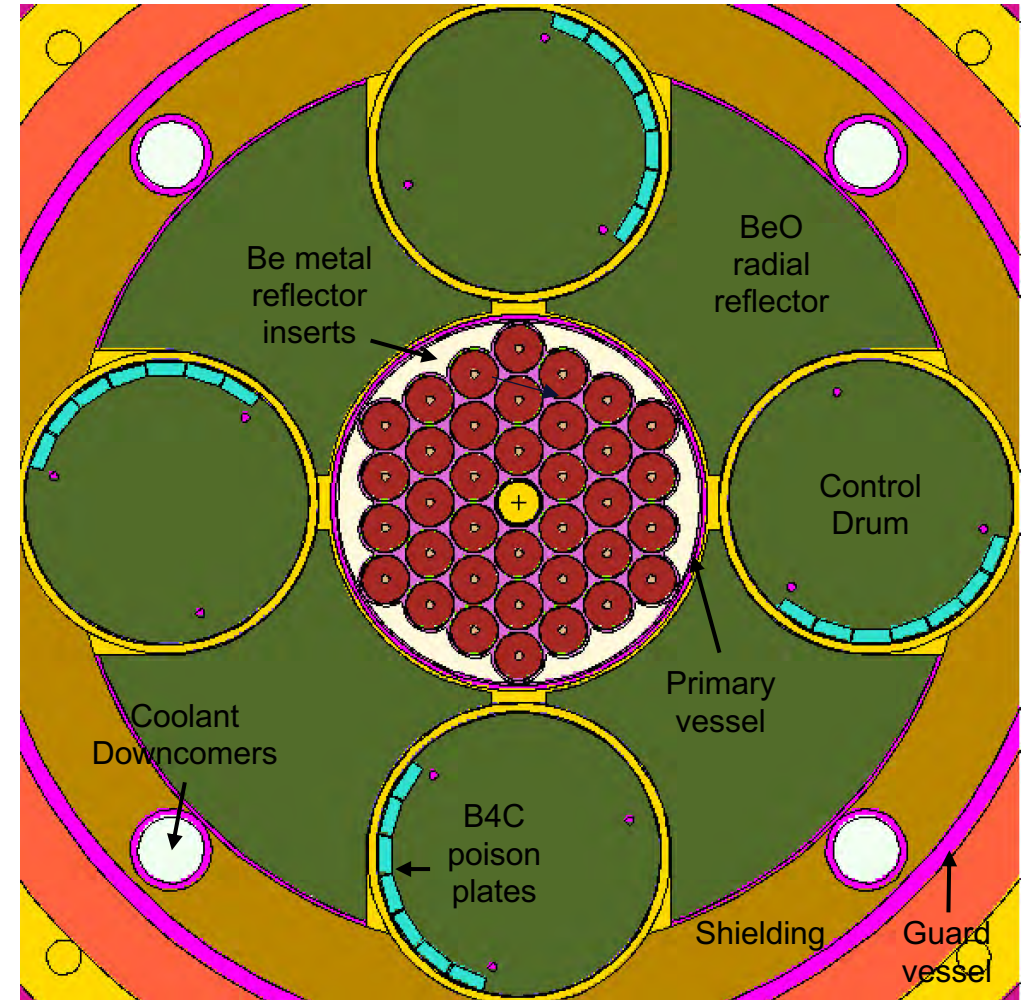
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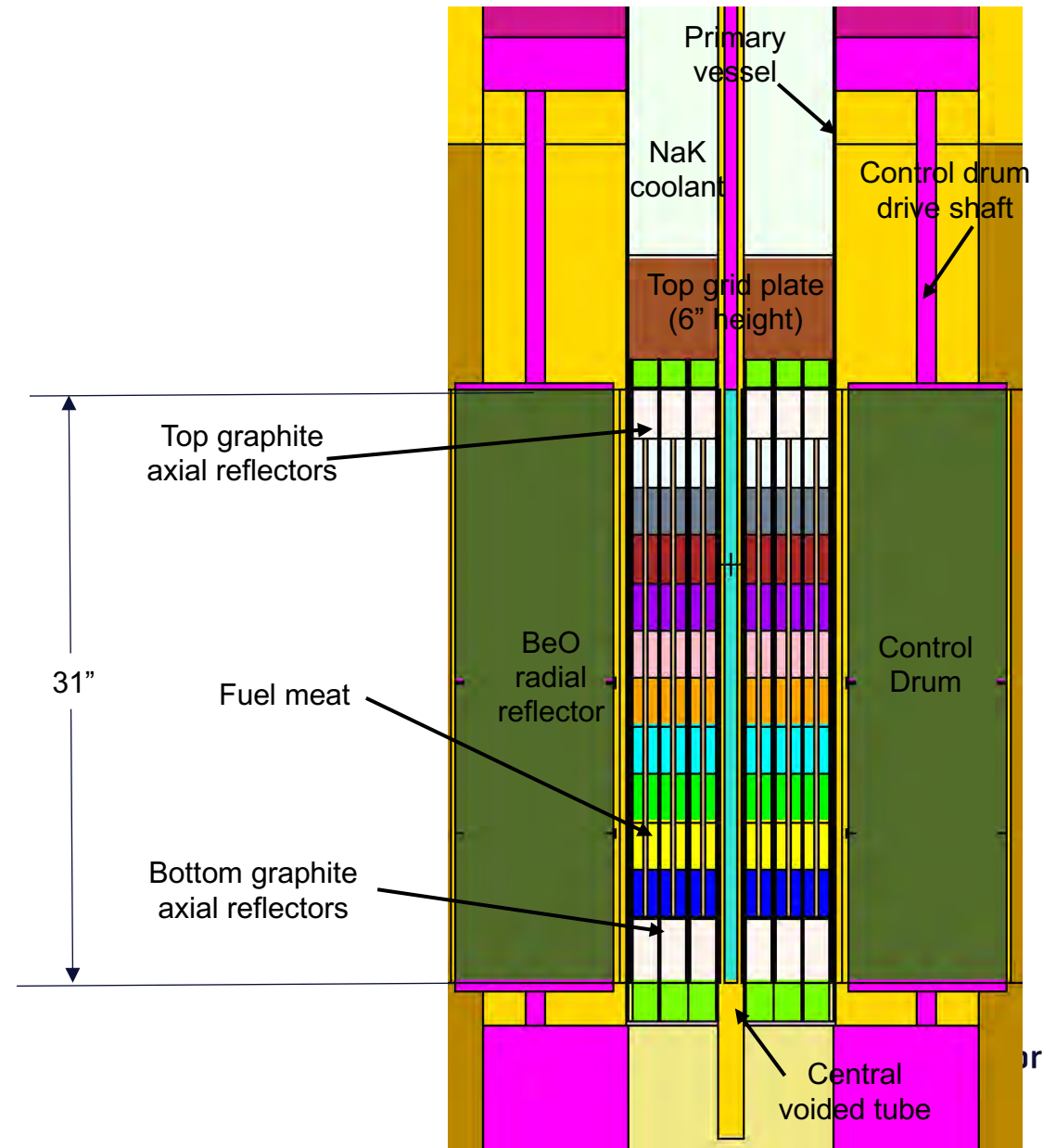
MARVEL Core Overview: Radial

- 36 fuel rod design
- U-ZrH_{1.6} TRIGA fuel
- Be and BeO neutron reflectors
- 4 control drums
- 1 central absorber rod



MARVEL Core Overview: Axial

- 25 inch active fuel region
- Graphite axial reflectors
- 40 inch overall fuel rod length
- Eutectic NaK coolant
- Natural convection primary and secondary coolant loops

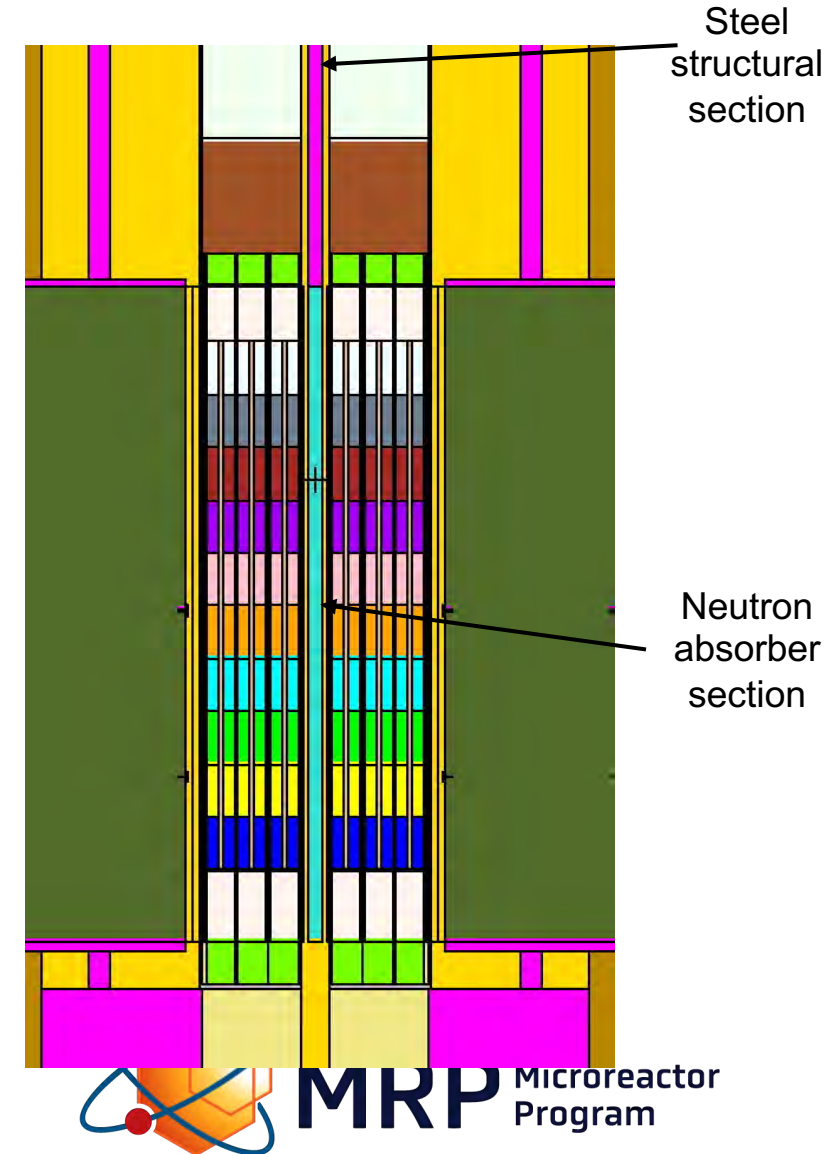
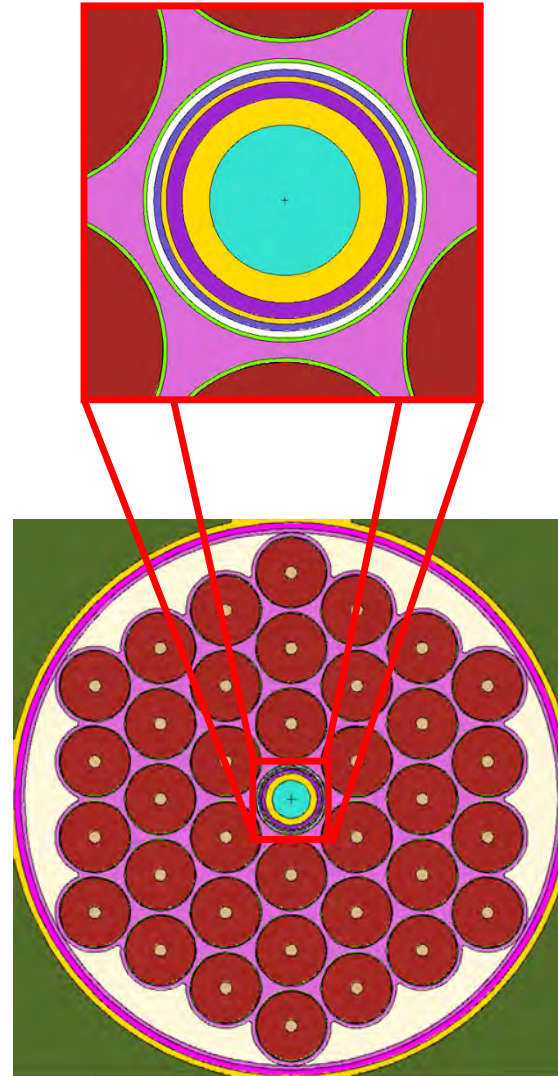


Central Insurance Absorber (CIA) Rod

- Due to export control, we cannot share full details
- Added in response to technical review feedback
- Defense-in-depth reactivity control/shutdown capability
 - Not a safety-related system
- Designed to:
 - Shutdown the reactor by itself at hot full power conditions
 - Hold the reactor shutdown with CIA rod + 1 control drum in most reactive state (cold zero power conditions)

CIA Rod Design Overview

- B4C absorber rod
- Center rod location in core
- Fully withdrawn during operations
- Fully inserted during shutdown



Shutdown Worth of CIA Rod

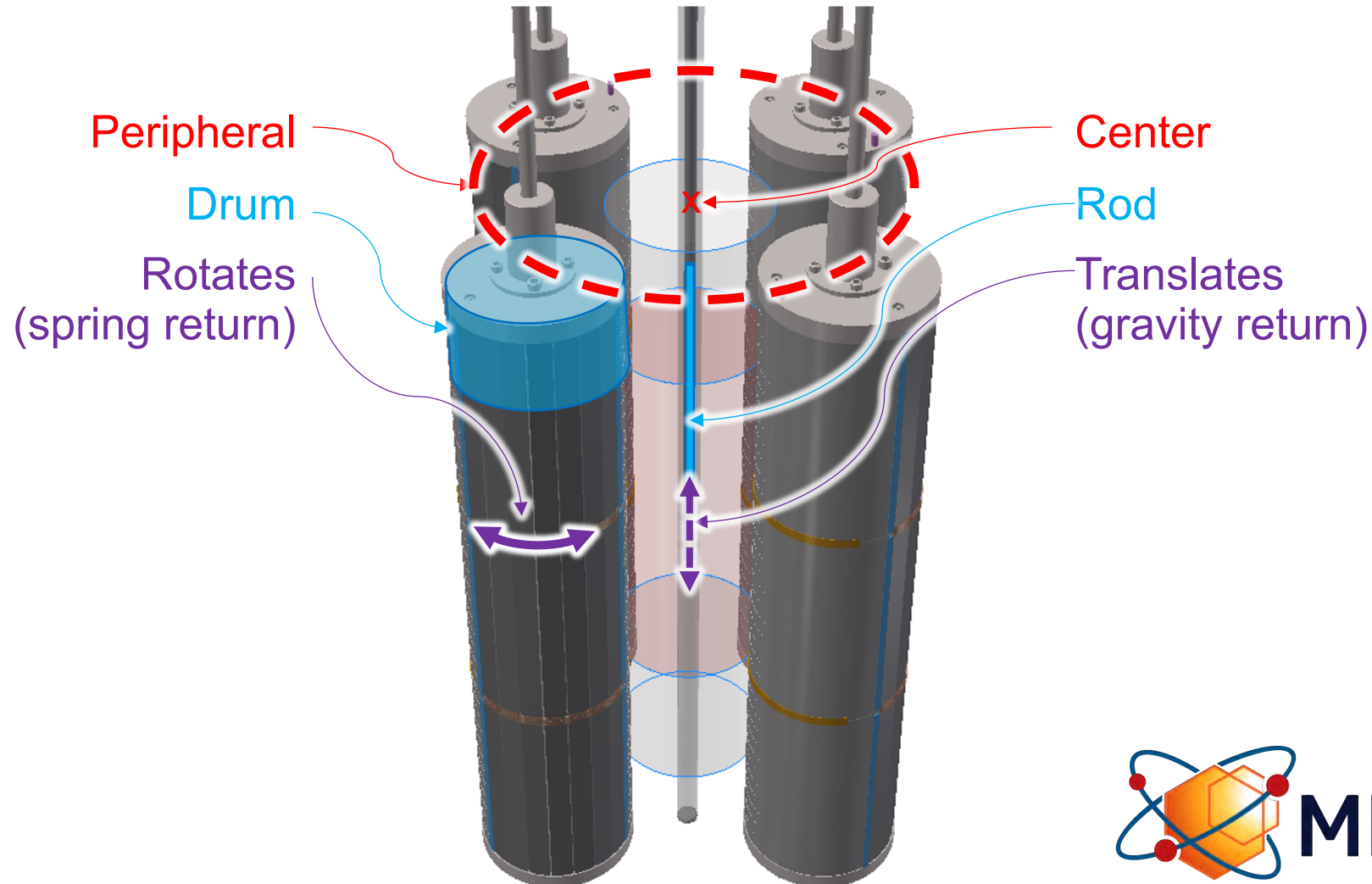
- CIA rod shutdown worth – alone
 - -3079 pcm
- CIA rod shutdown worth – w/ 1 control drum inserted
 - -5544 pcm
- CIA rod alone can shutdown the reactor in hot conditions
- CIA rod alone could possible shutdown and hold down the reactor at cold conditions
 - Improvements in design may enable this

Case	k-effective
All control out HFP	1.00467
CIA in HFP	0.97388
CIA + 1 CD in HFP	0.94923
CIA in CZP	0.99556
CIA + 1 CD in CZP	0.97043
*HFP = hot full power	
*CZP = cold zero power	

Diversity Enhancement

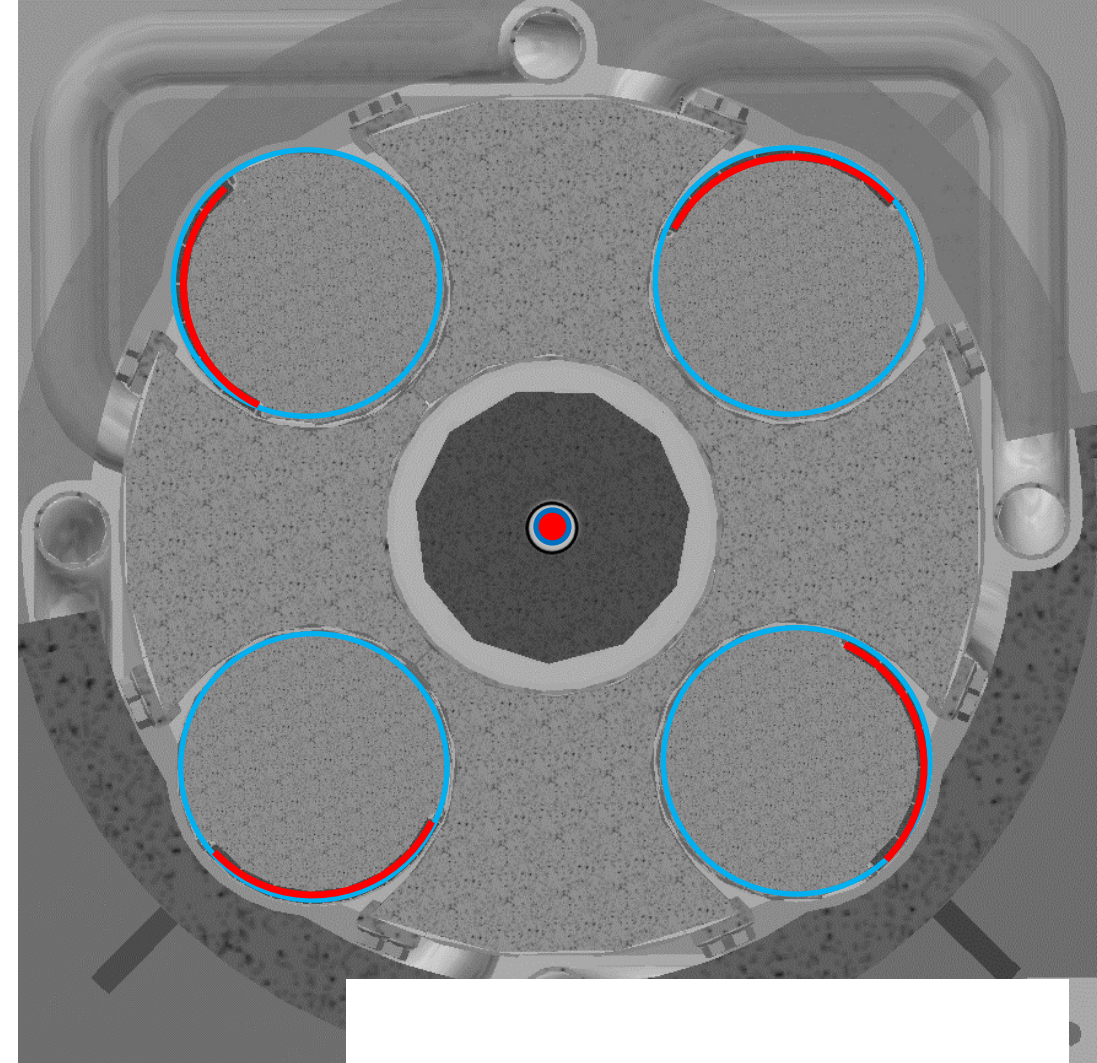
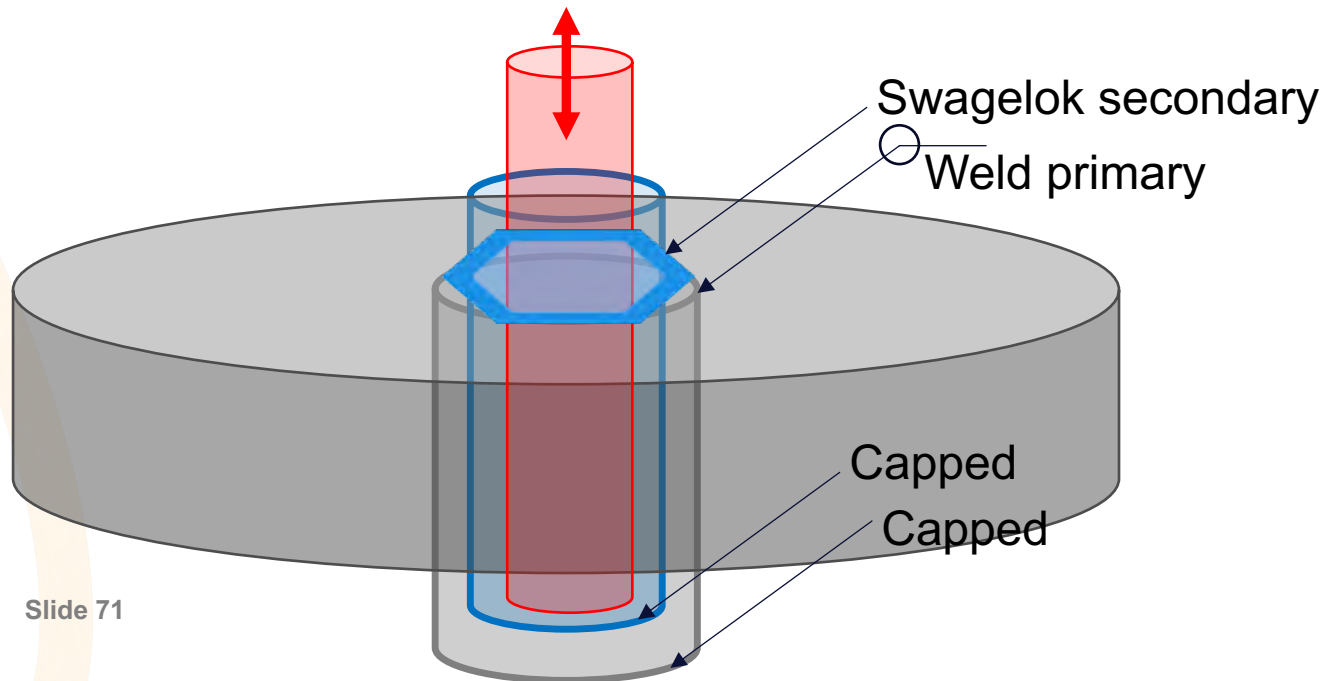
- Issue: Duplicate Control Drums may be subject to common failure mode
 - Solution: Incorporate a significantly different method

Control Drum (CD) *Complemented by* Central Insurance Absorber (CIA)



Diversity Enhancement CIA Core Interaction Description

- Central Insurance Absorber (CIA)
 - Absorber in core's center position
 - Double wall tube as primary and secondary NaK coolant boundary
 - Primary boundary tube
 - Welded to head
 - Secondary boundary tube
 - Swagelok fitted to primary boundary tube

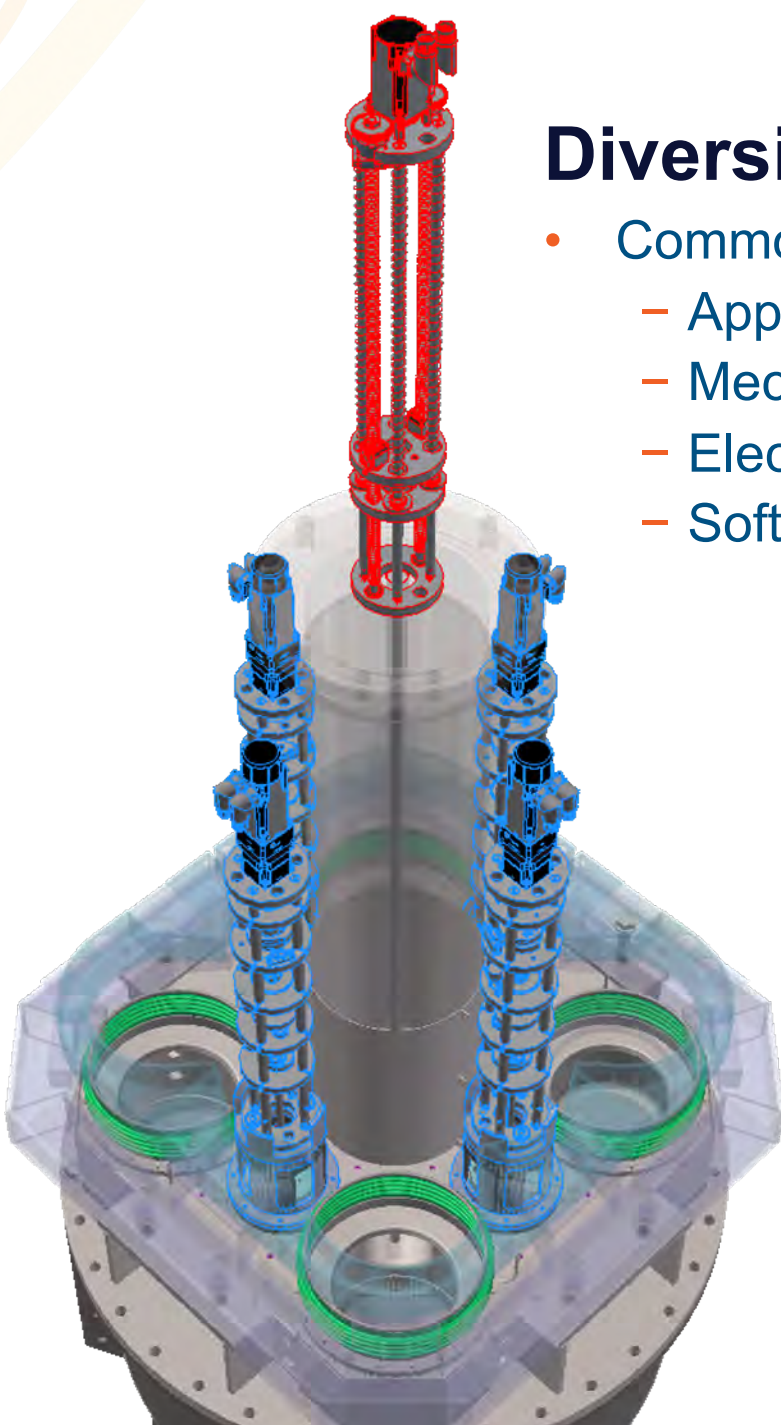


Methods

- Leverage Control Drum System

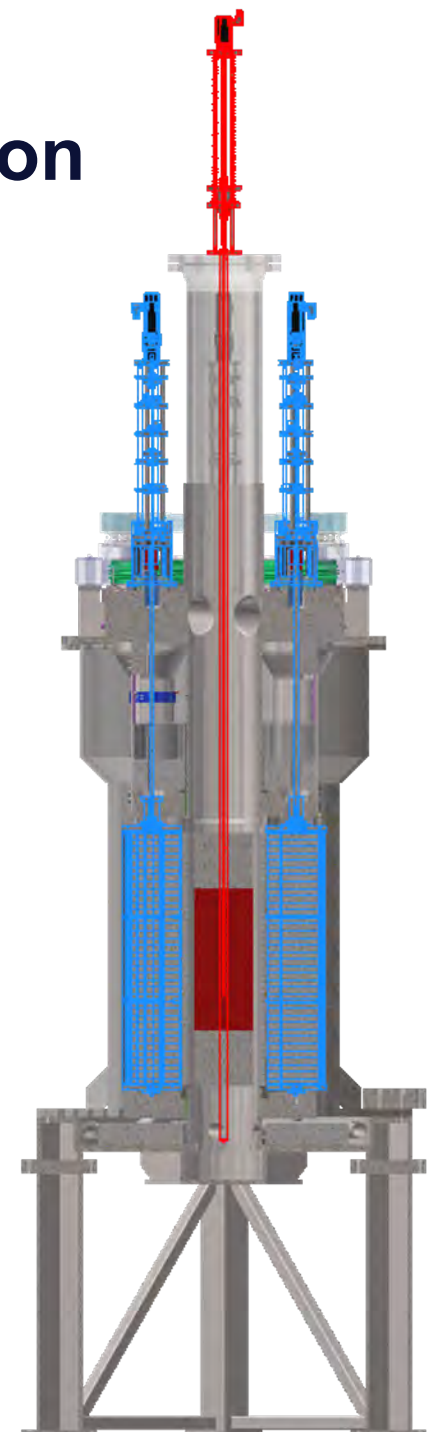
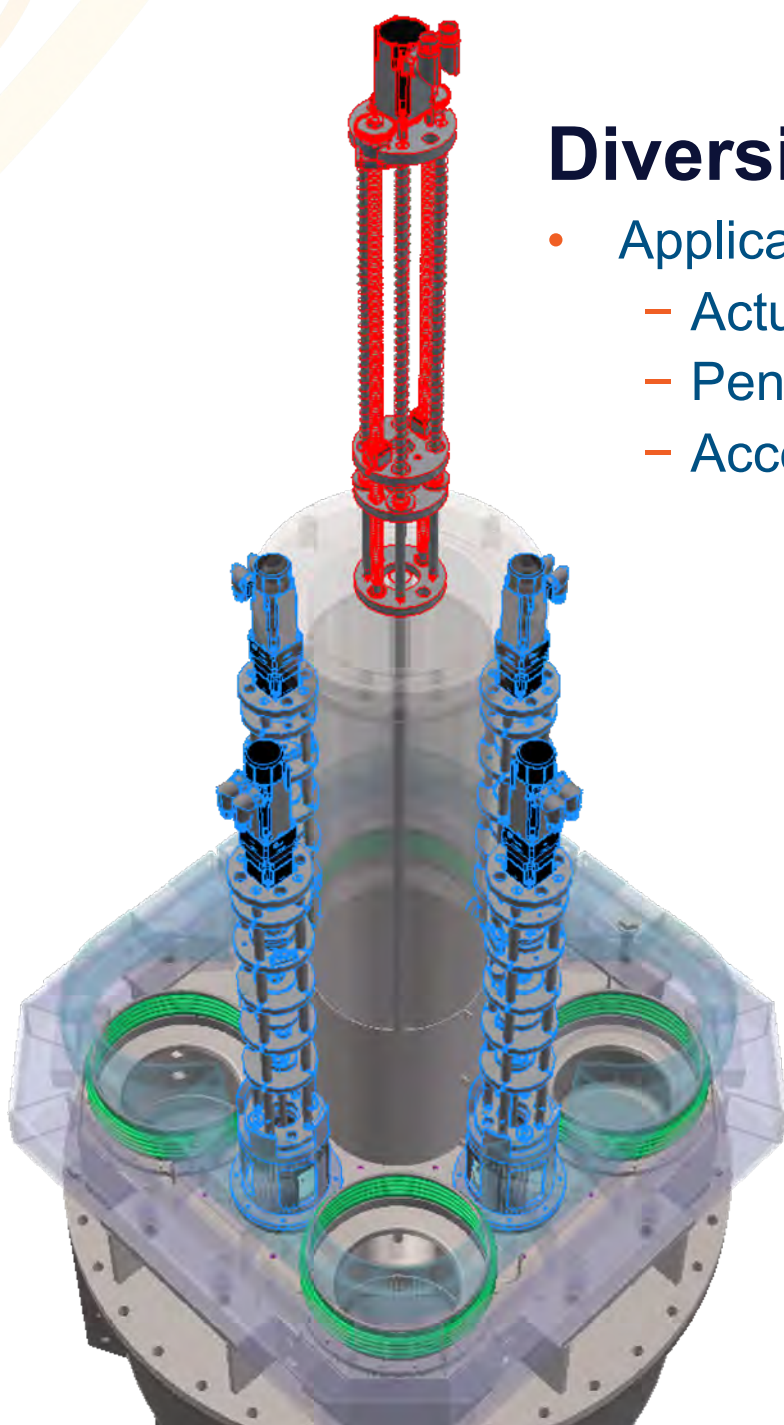
Diversity Enhancement Description

- Commonalities which will accelerate development
 - Application
 - Mechanical
 - Electrical
 - Software



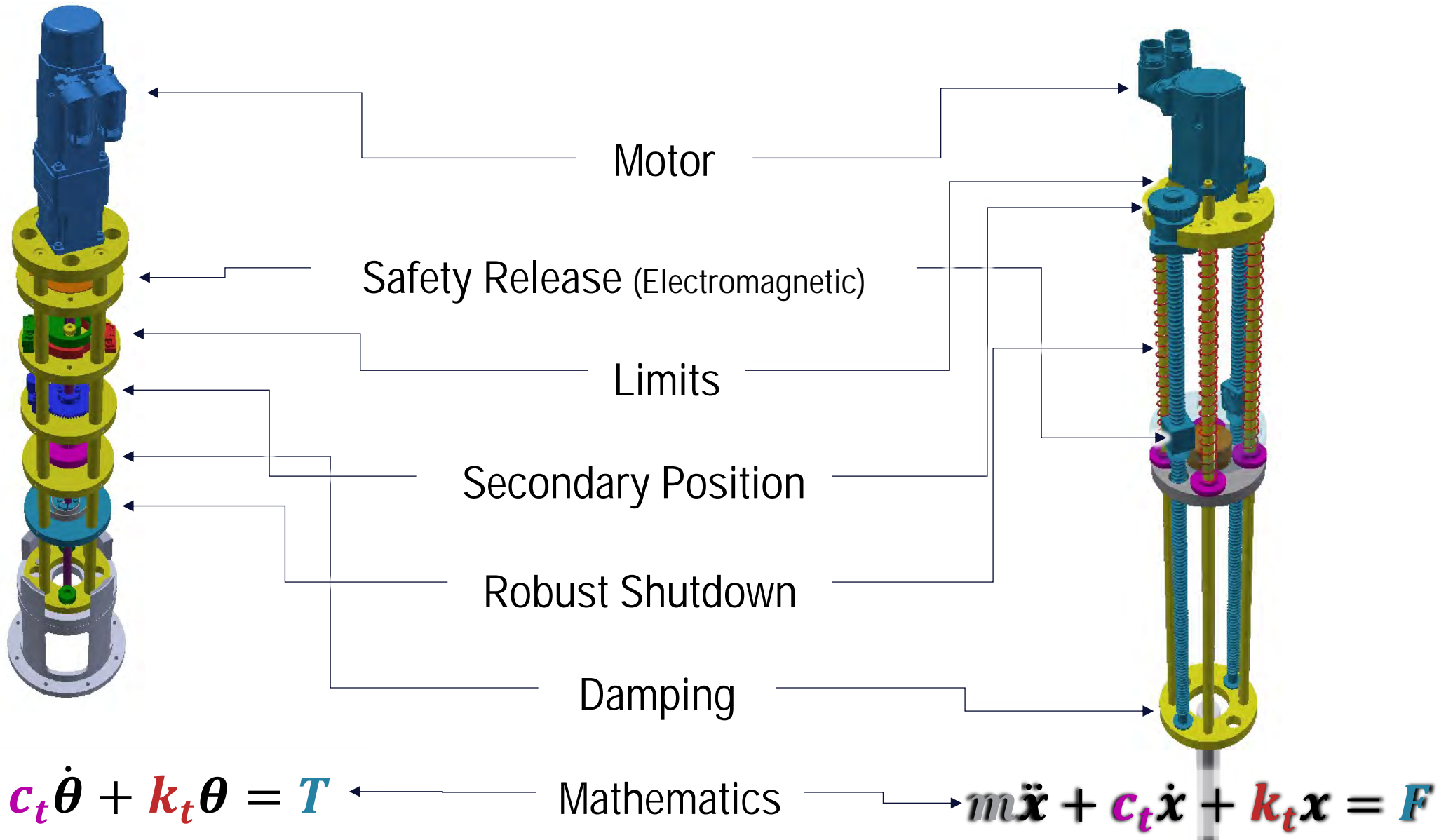
Diversity Enhancement Description

- Application commonalities
 - Actuated at top of reactor
 - Penetrations are minimal
 - Accessible



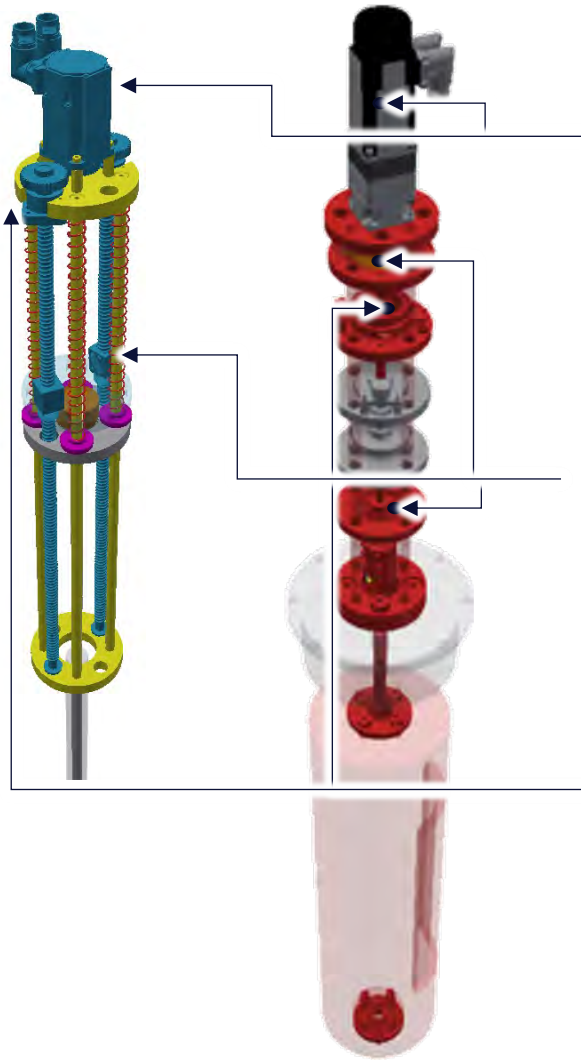
Diversity Enhancement Description

- Mechanical hardware commonalities



Diversity Enhancement Description

- Electrical hardware commonalities



CIA and CD System (NSR):

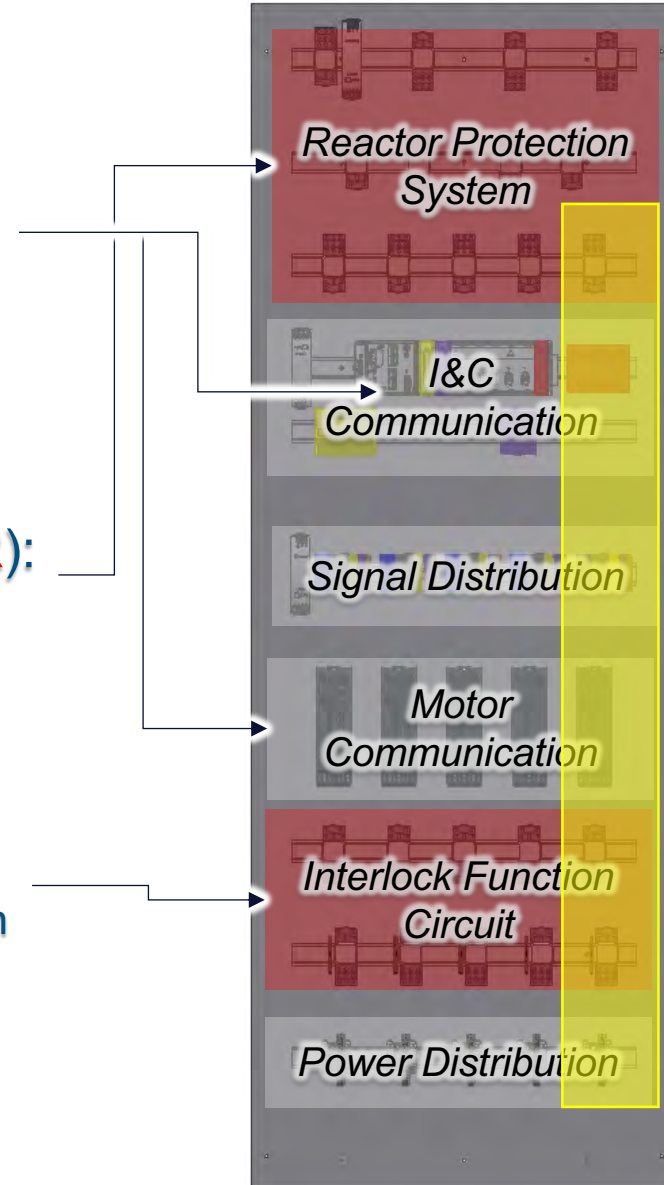
- Read parameters
- Control reactivity via position
- Provided controlled shutdown

Reactor Protection System (SR):

- Passively Shutdown System

Interlocks (SR):

- Prevent excess reactivity insertion



5th Driver, Interlock, I&C ports, and RPS
output already incorporated!

Diversity Enhancement Description

- Software commonalities

Identical algorithms required for motion control, interlock, RPS, and I&C inputs (already incorporated!)

The image displays a control interface for a reactor protection system, organized into several functional panels:

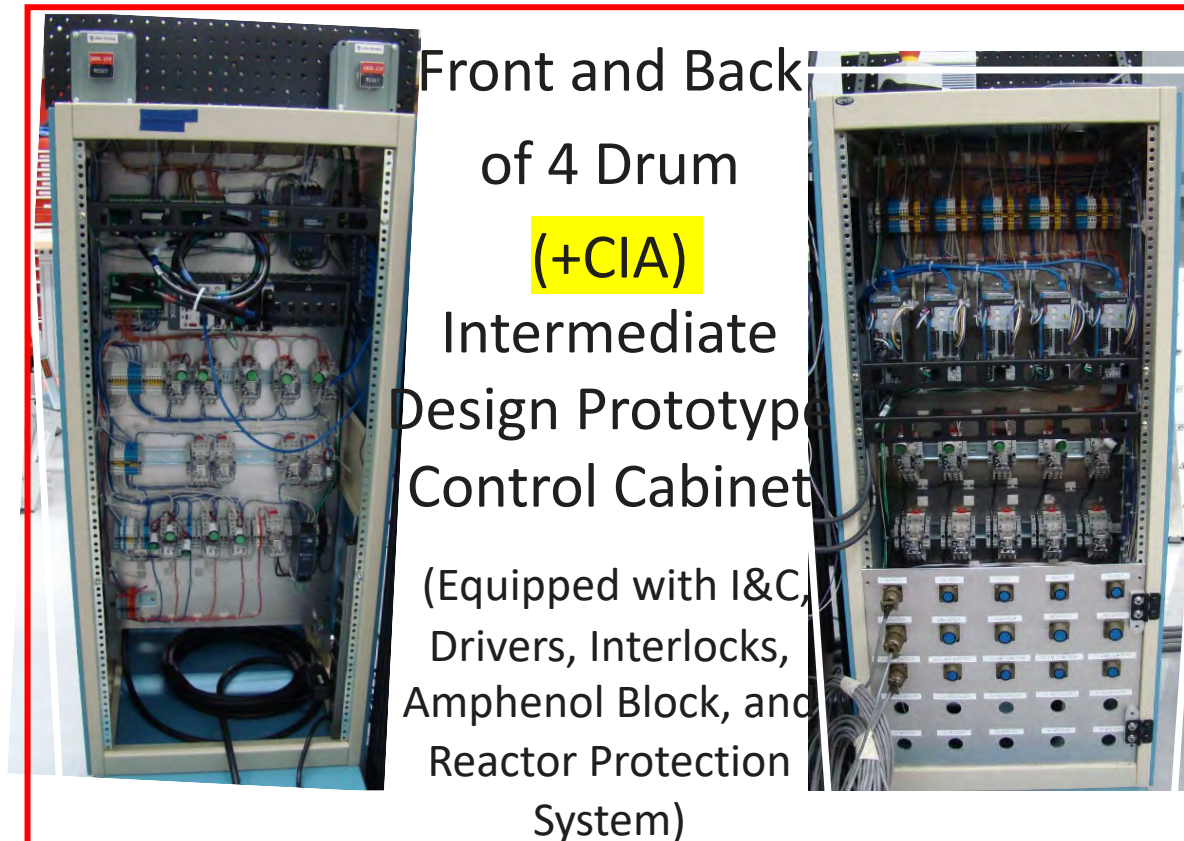
- REACTOR PROTECTION SYSTEM (RPS):**
 - RPS: INPUTS:** Includes 'OTHER' and 'COMPUTER' status indicators.
 - RPS: STATUS:** Features several status buttons: 'Power (AC or DC) or Manual (AC) or Seismic A (AC)', 'Other (DC)', 'Seismic B (DC)', 'Computer (DC)', 'Manual Local', and 'Manual B (DC)'. A 'Reset' button is also present.
- INTERLOCK: DRUM SELECTOR:** A row of five drum selector buttons labeled 0 through 5. Below them are 'RPS: INDEP. INPUTS' for SCRAM Drum 1 through 4, and 'SCRAM CIA' for drum 5.
- RCS: GENERAL STATUS:** A grid of five motor status panels (Motor Status 1 to 5). Each panel includes 'Enable/Disable' controls, 'Motor Torque (1)' (Measured/Predicted), 'Resolver', 'Potentiometer (1-5)' with AKD and I&C settings, and 'Limit OUT'/'Limit IN' (AKD and I&C) buttons. A red vertical label 'bool array for motion status?' is positioned to the left of this grid.
- RCS: SETUP AND CONTROL:** A grid of five control panels (IP 1 to IP 5). Each panel has a 'Setup' section with 'Vel/Acc (1-5) (Write/Read)' and 'Gains (Write/Read) (1-5)' tables. The 'Vel/Acc' table contains values for Vel and Acc. The 'Gains' table contains values for KP, KD, and KI. Below each panel are 'Set Home' and 'Complete' buttons.

The rightmost column (drum 5, motor status 5, and IP 5) is highlighted in yellow, indicating the active or selected configuration.

Diversity Enhancement Description

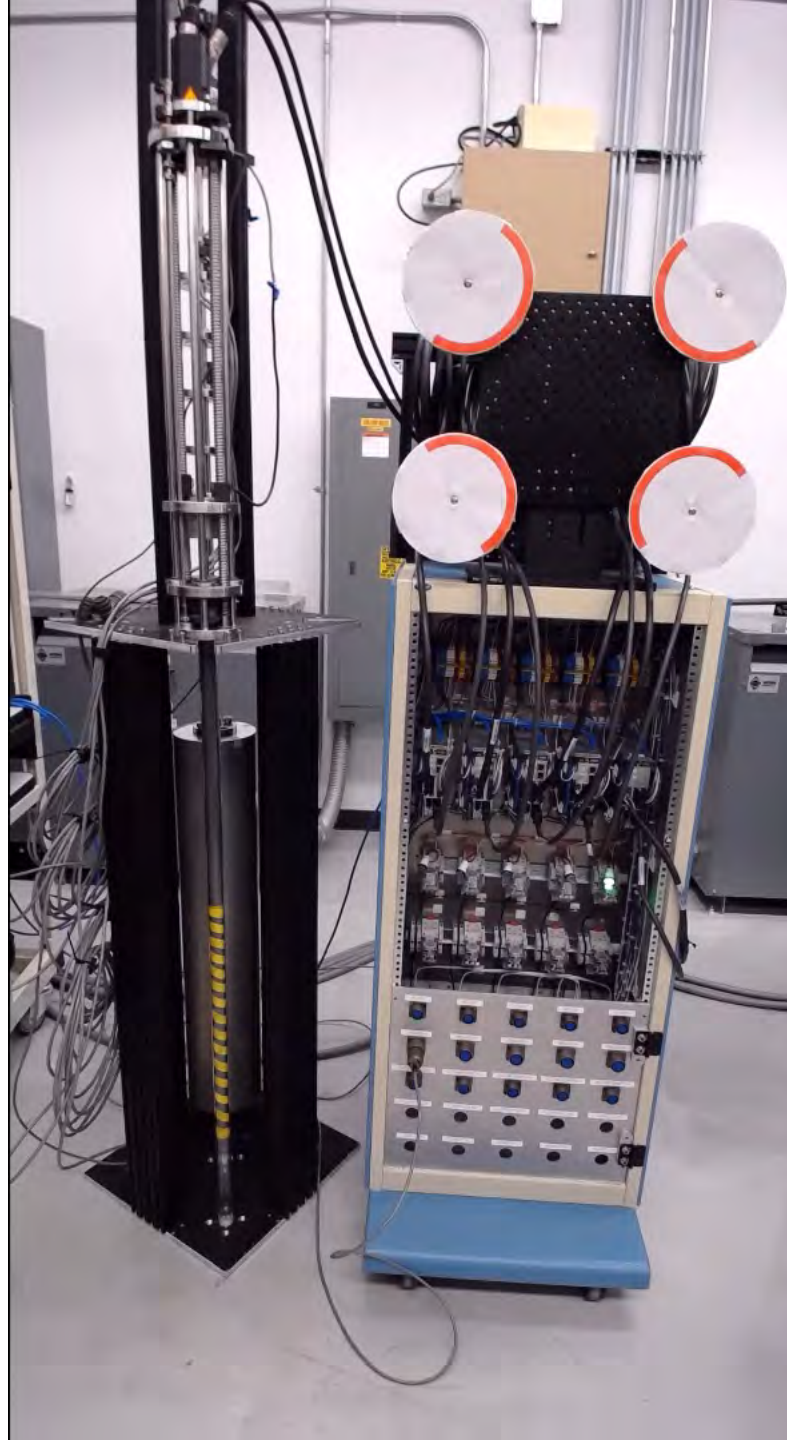
- Hands-on experience/assurance

Prototype mechanical, electrical, and software developed and being tested



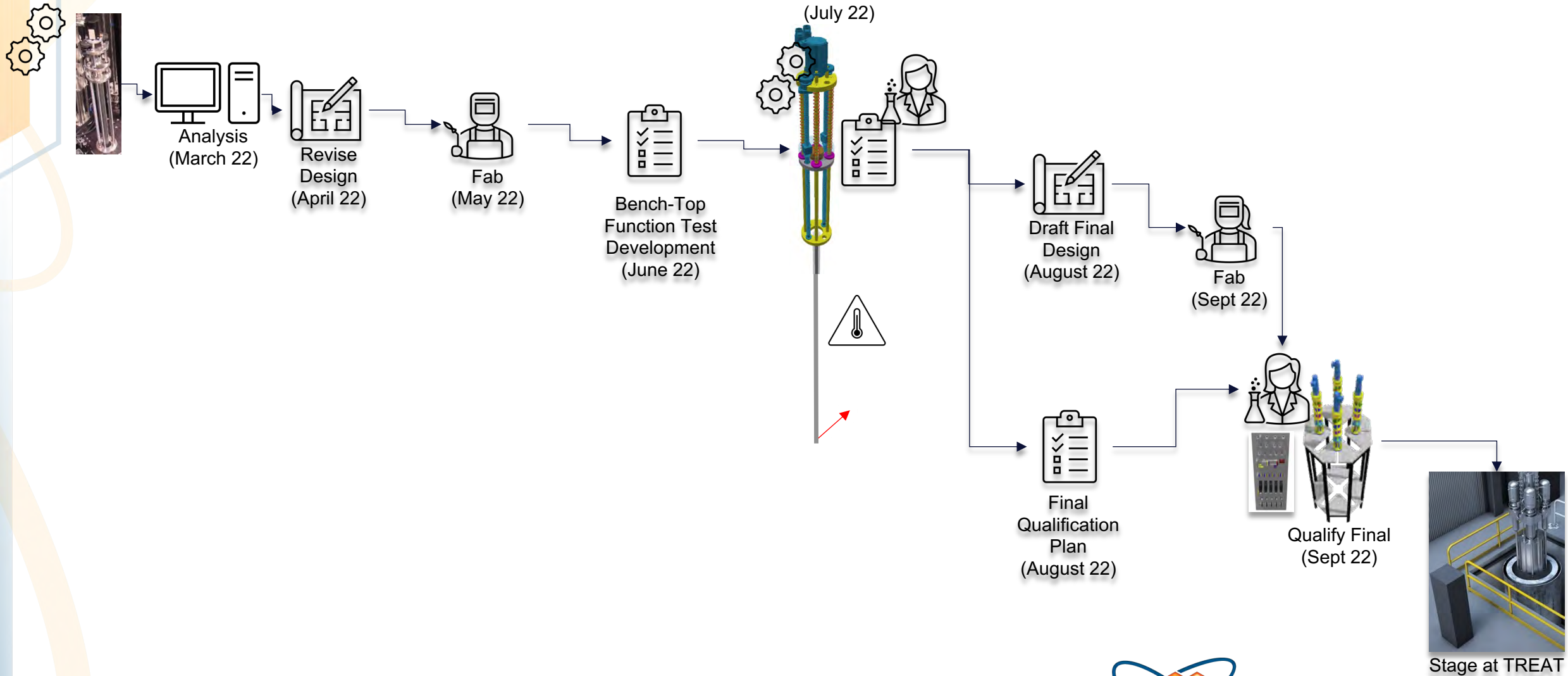
Tests

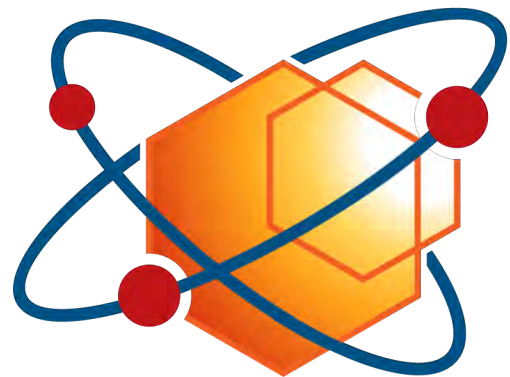
- Prototype
 - Benchtop
 - Assimilated environment



CIA Roadmap

- Parallel CD Plan





MRP Microreactor
Program