MARVEL Reactivity Control: Central Insurance Absorber Rod

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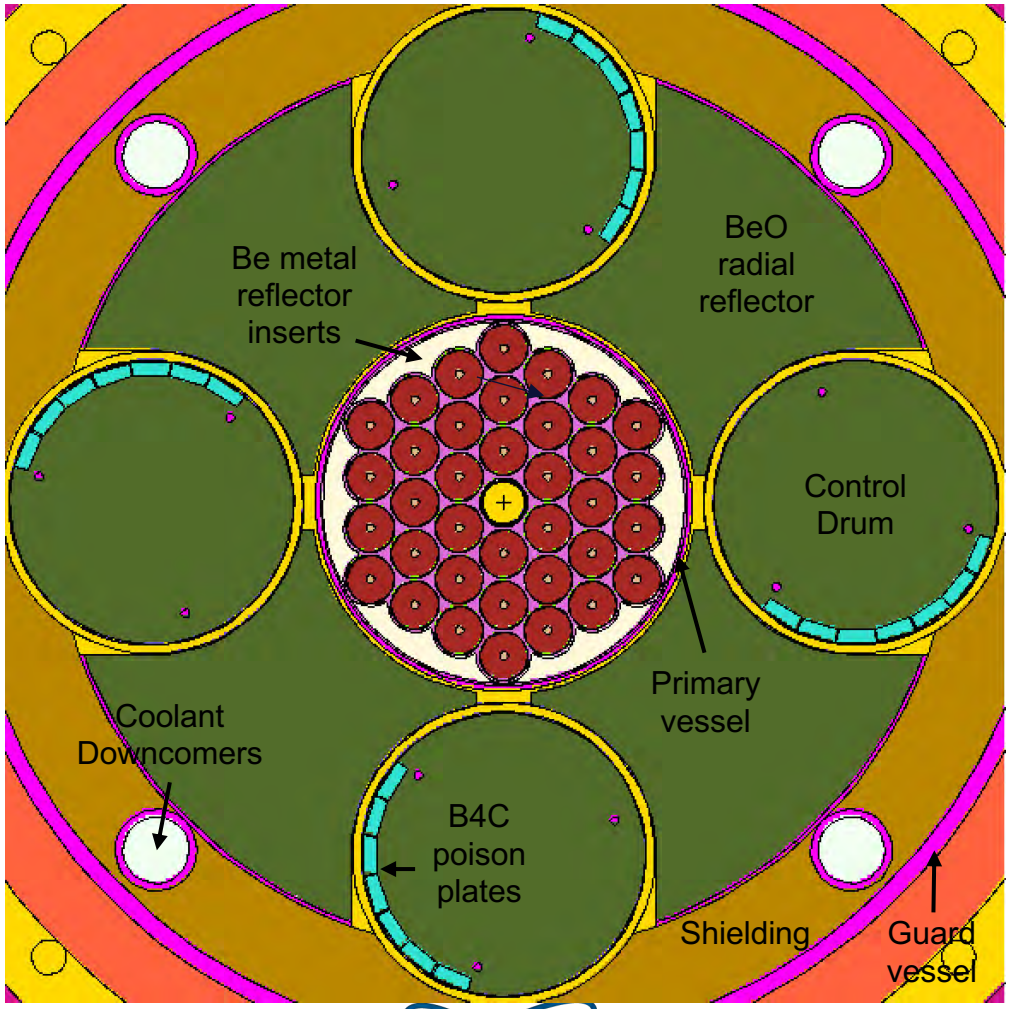
MARVEL Core Overview: Radial

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



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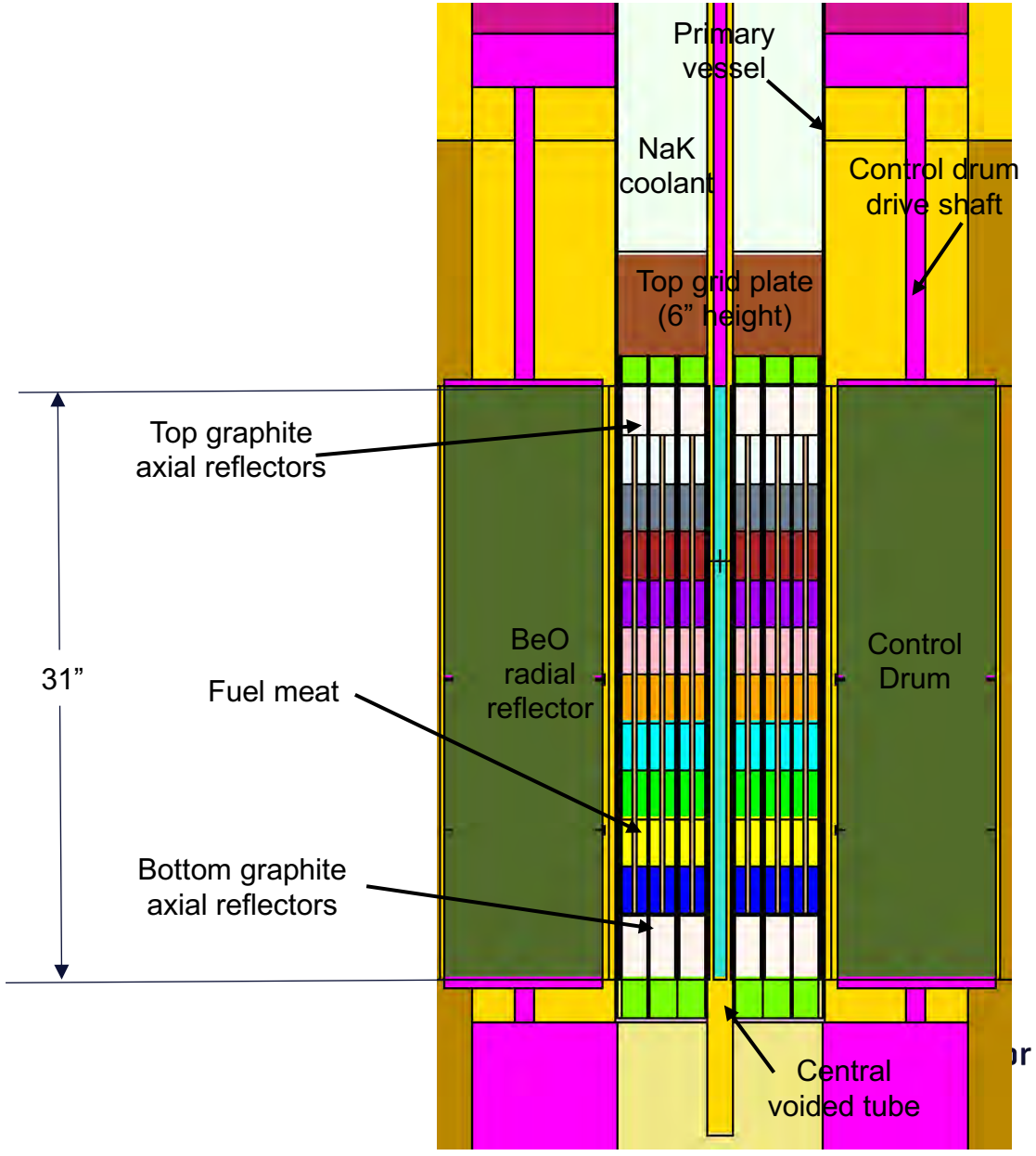
MARVEL Core Overview: Axial

- 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)

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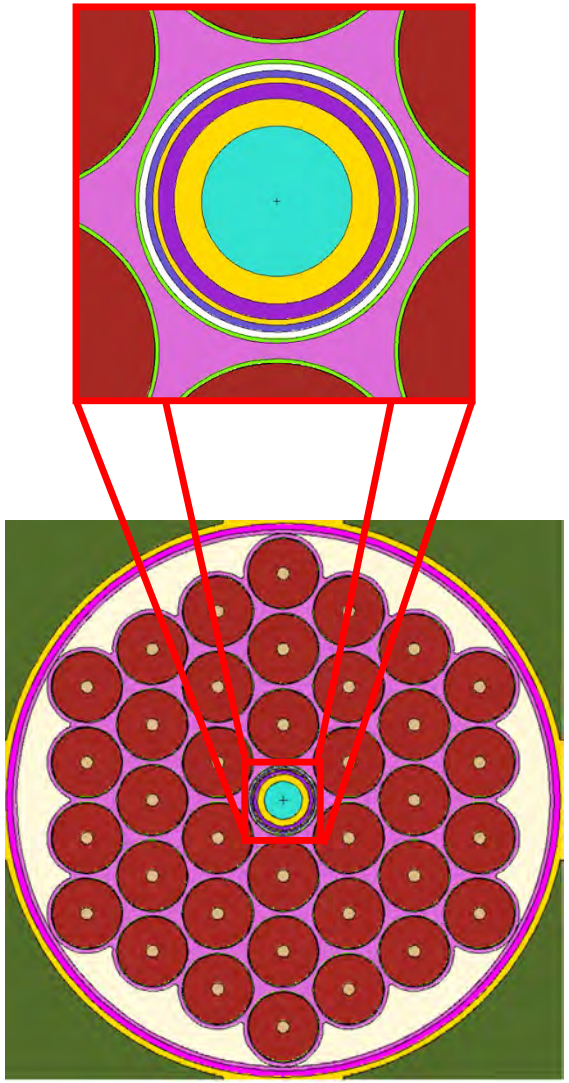
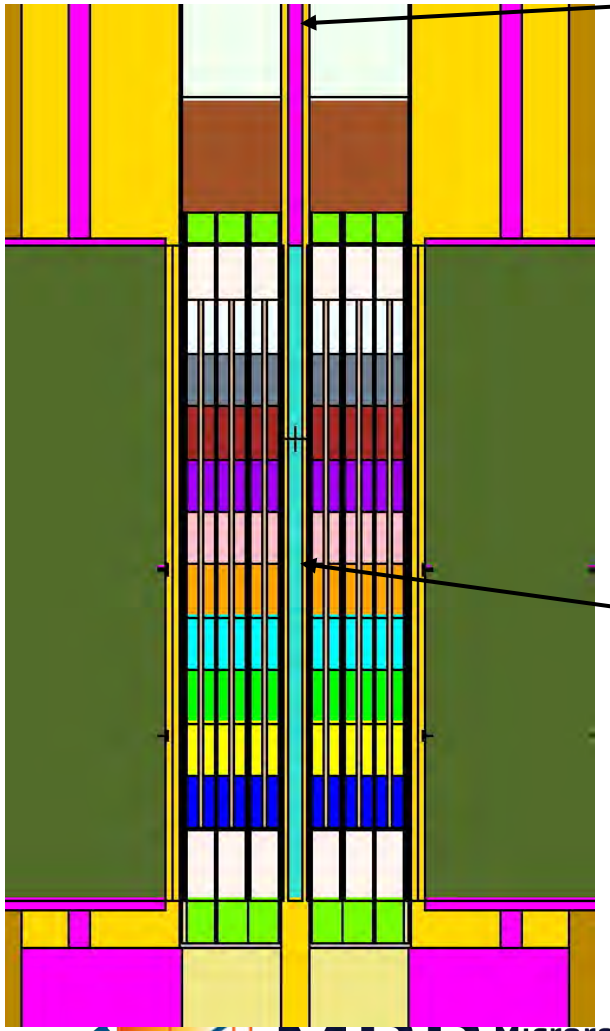
CIA Rod Design Overview

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- Fully withdrawn during operations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





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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	

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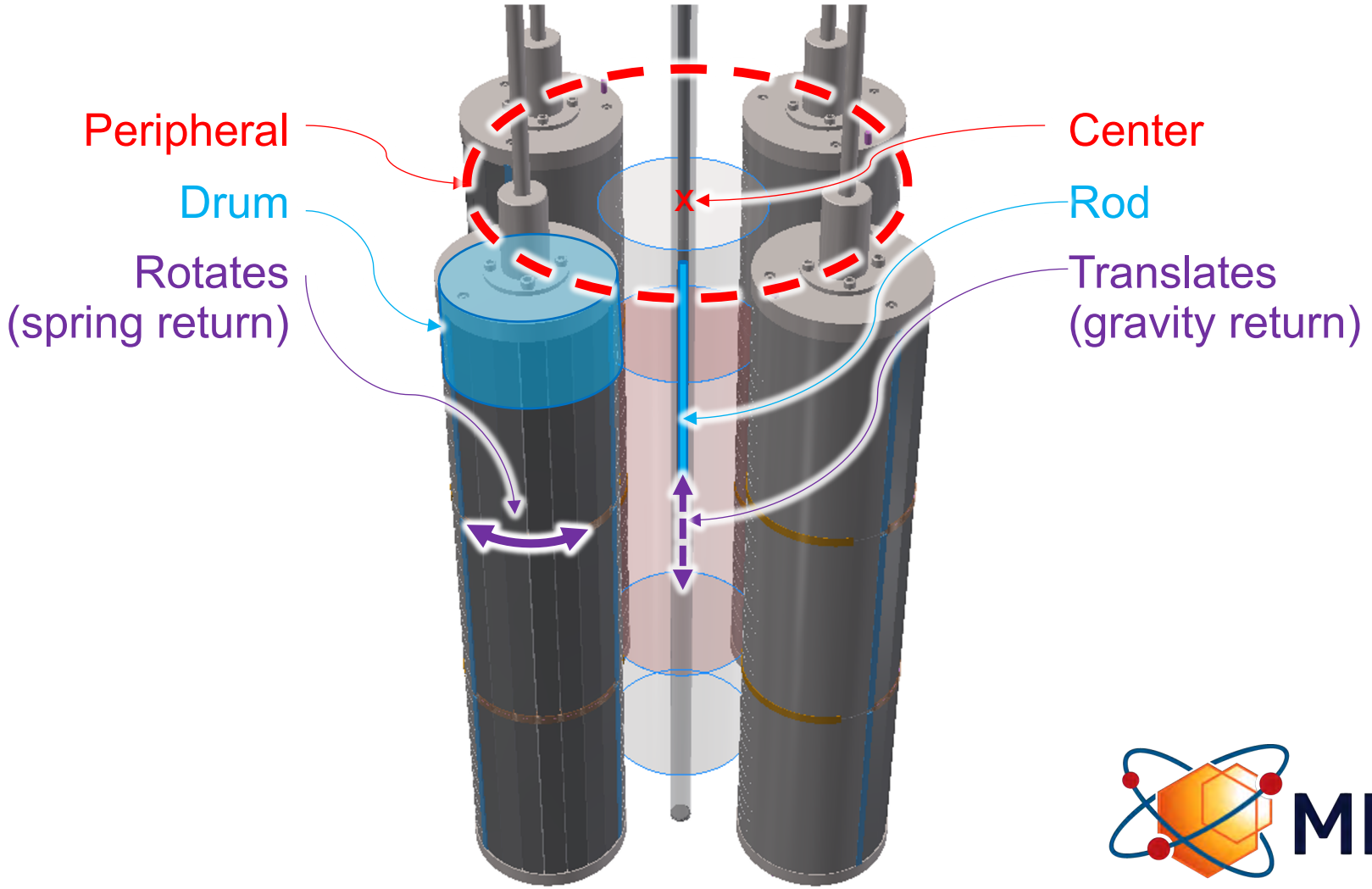
Diversity Enhancement

- 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)



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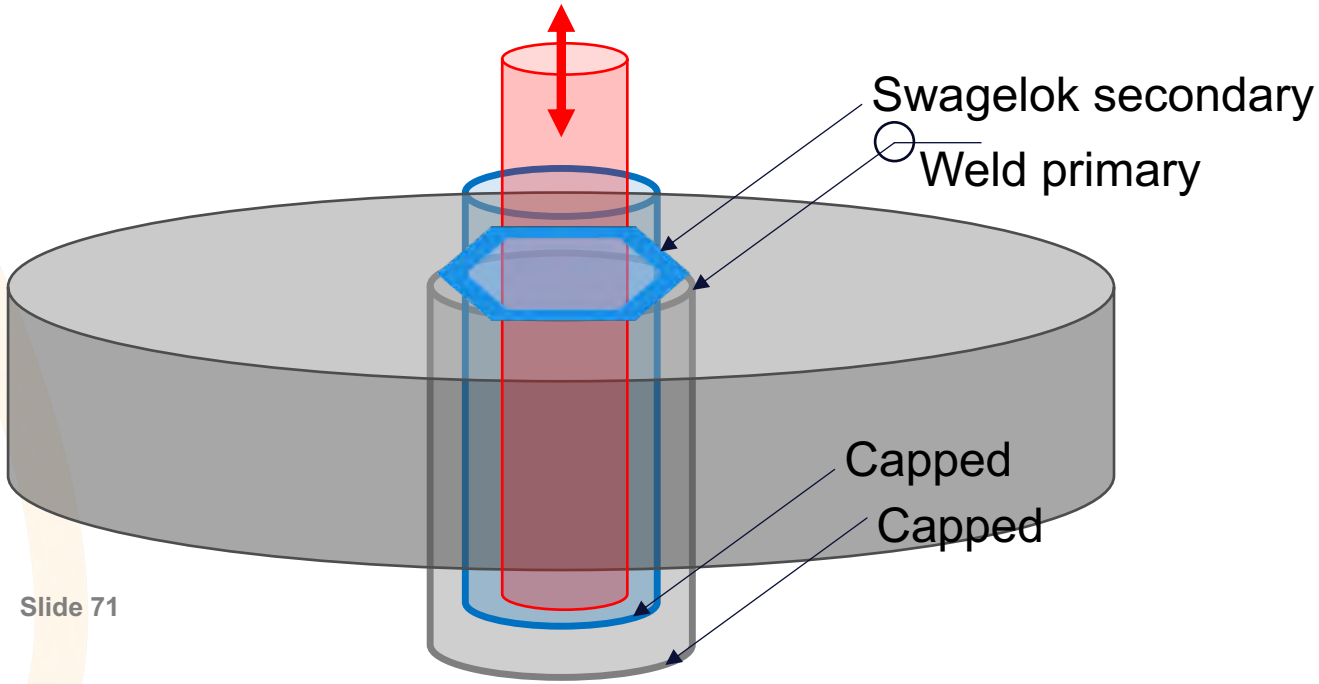
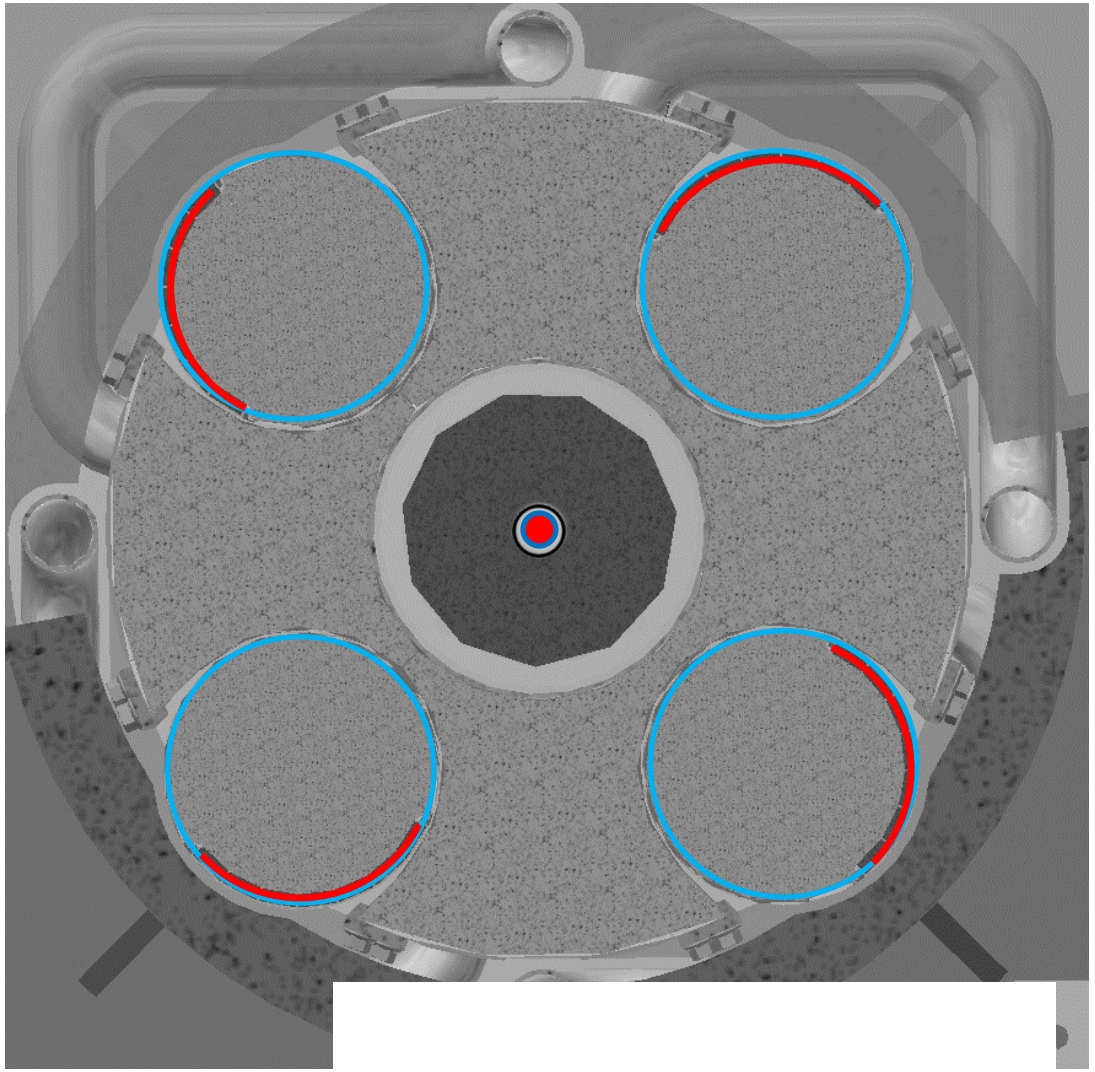
Diversity Enhancement CIA Core Interaction Description

- 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

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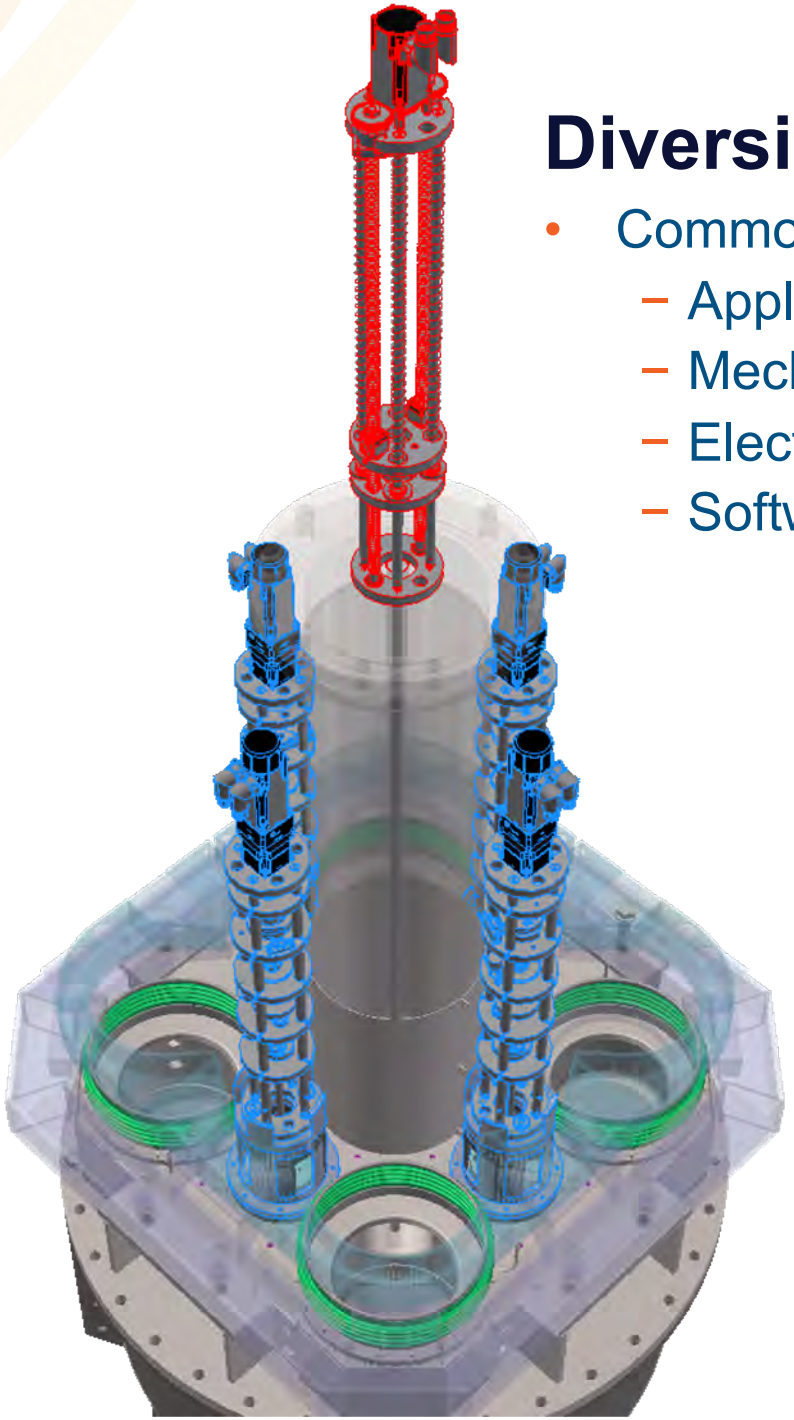
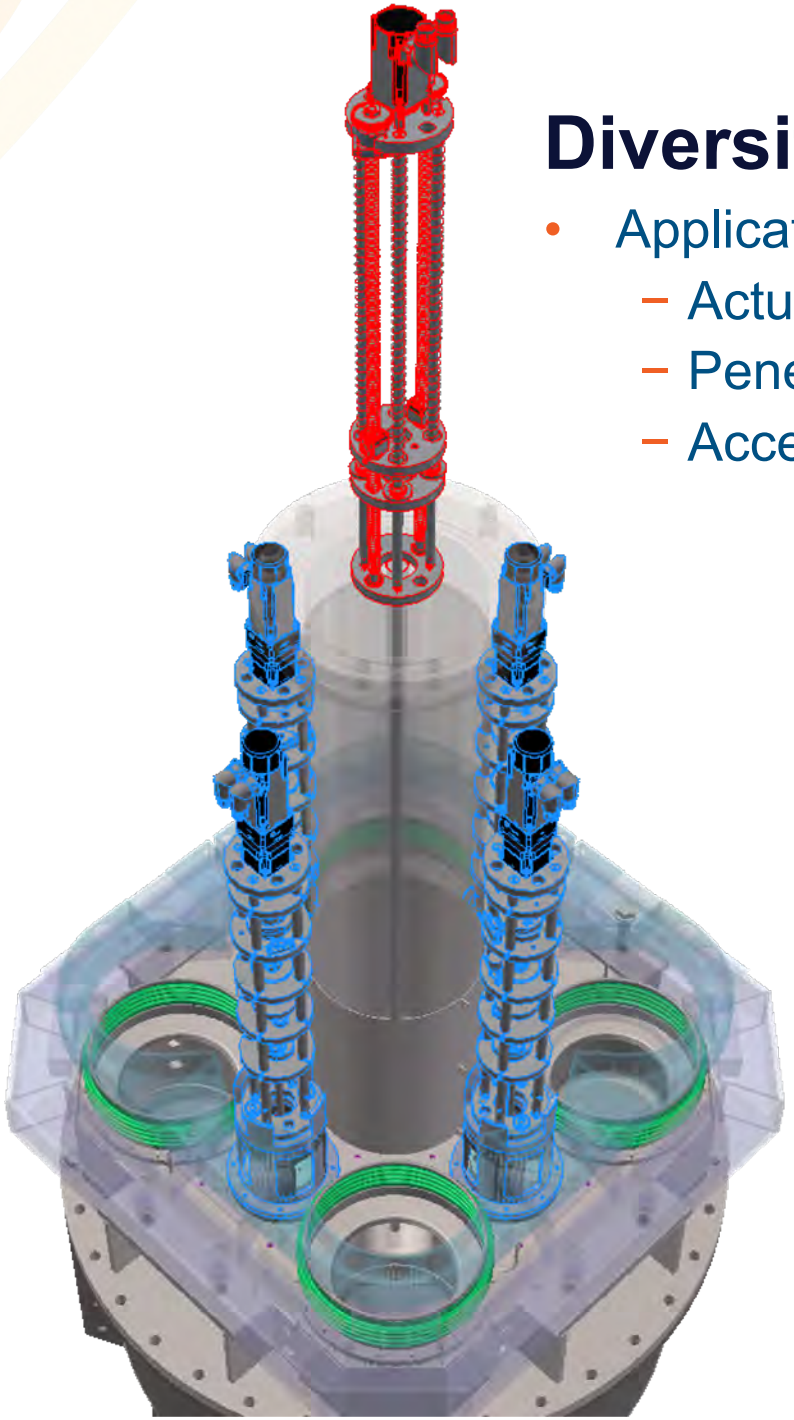


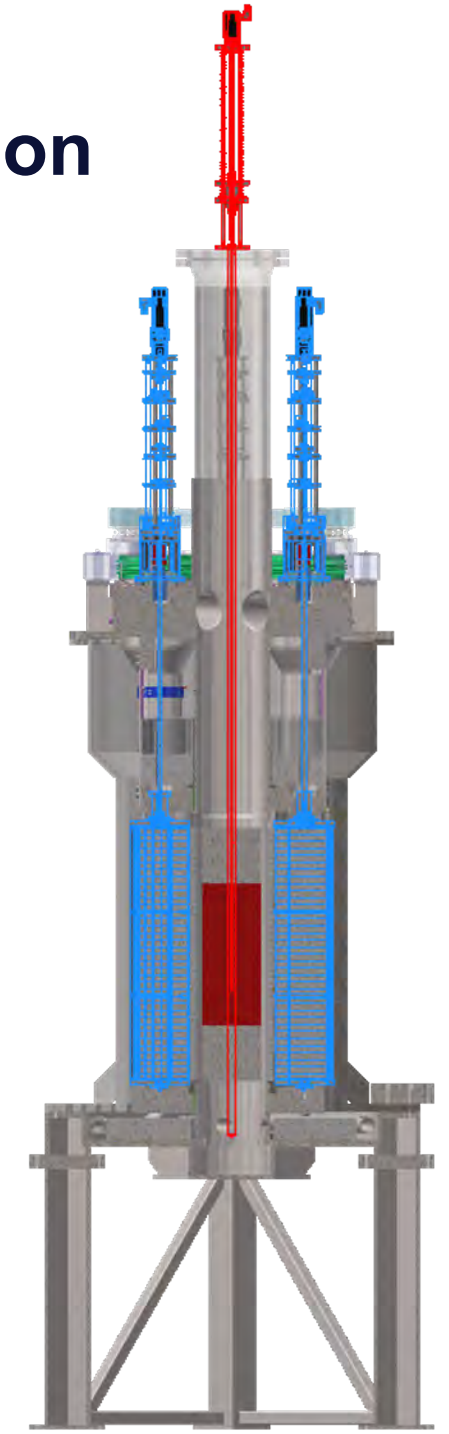
Diversity Enhancement Description

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

Diversity Enhancement Description

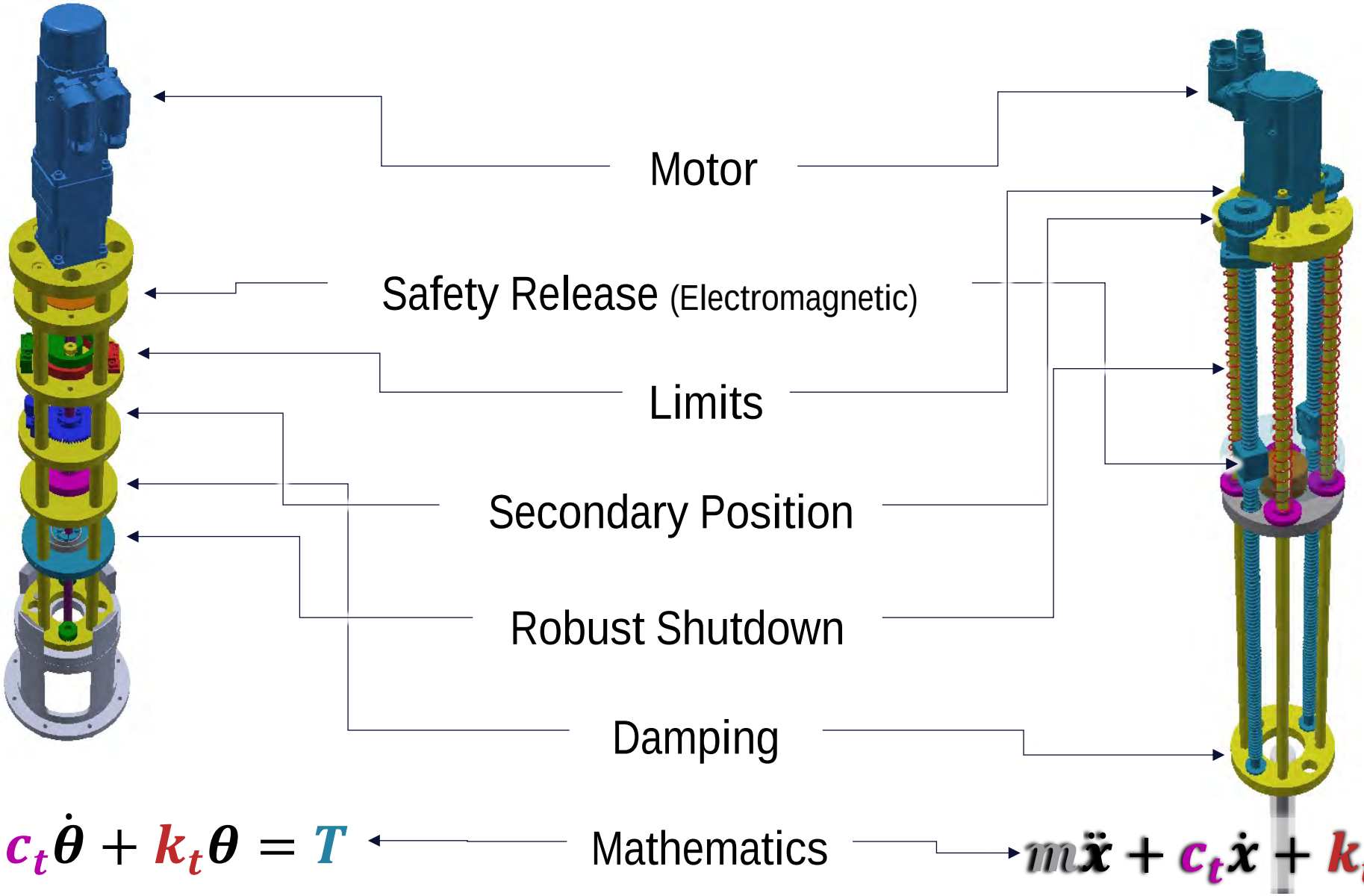
- Application commonalities
  - Actuated at top of reactor
  - Penetrations are minimal
  - Accessible





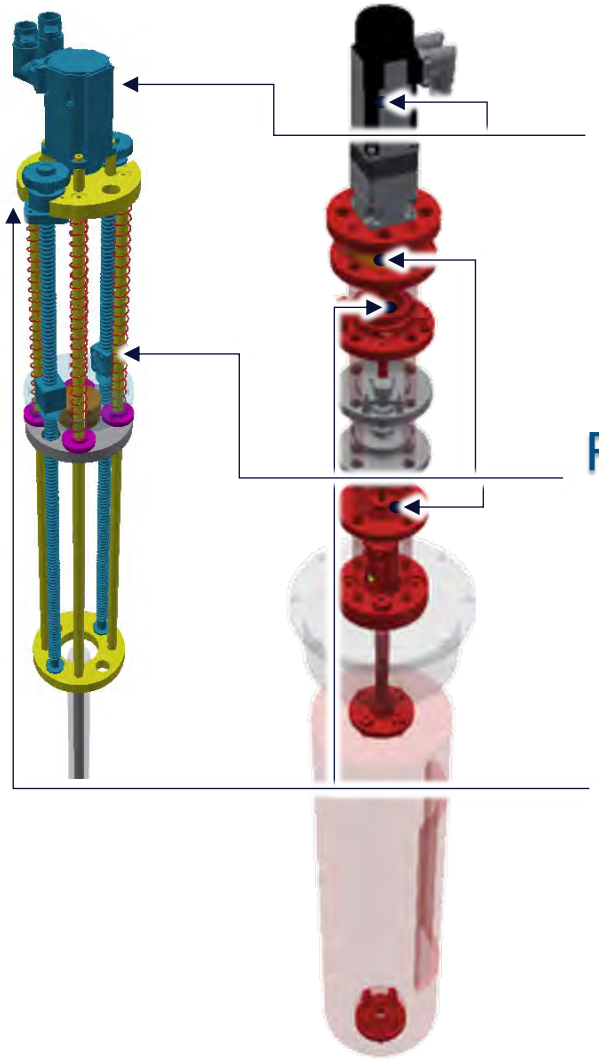
Diversity Enhancement Description

- Mechanical hardware commonalities



Diversity Enhancement Description

- Electrical hardware commonalities



CIA and CD System (NSR):

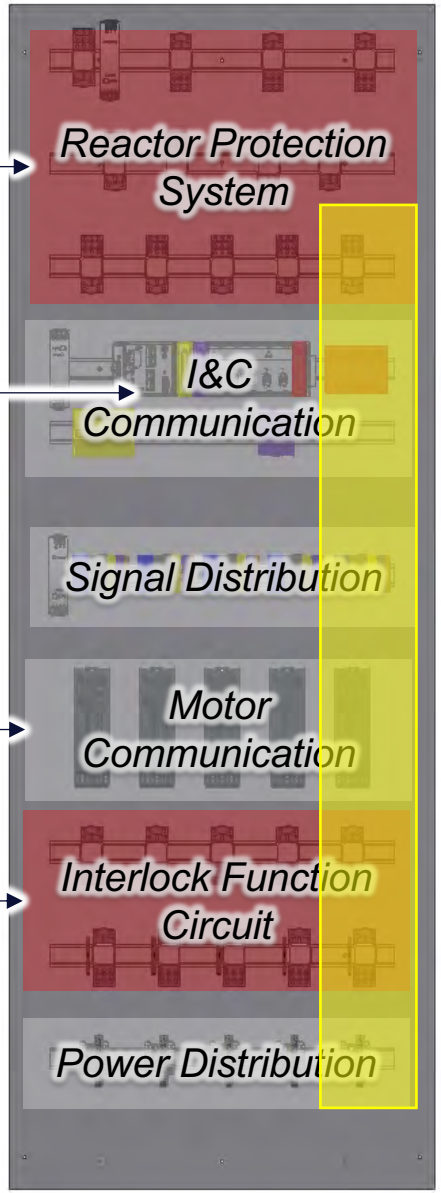
- Read parameters
- Control reactivity via position
- Provided controlled shutdown

Reactor Protection System (SR):

- Passively Shutdown System

Interlocks (SR):

- Prevent excess reactivity insertion

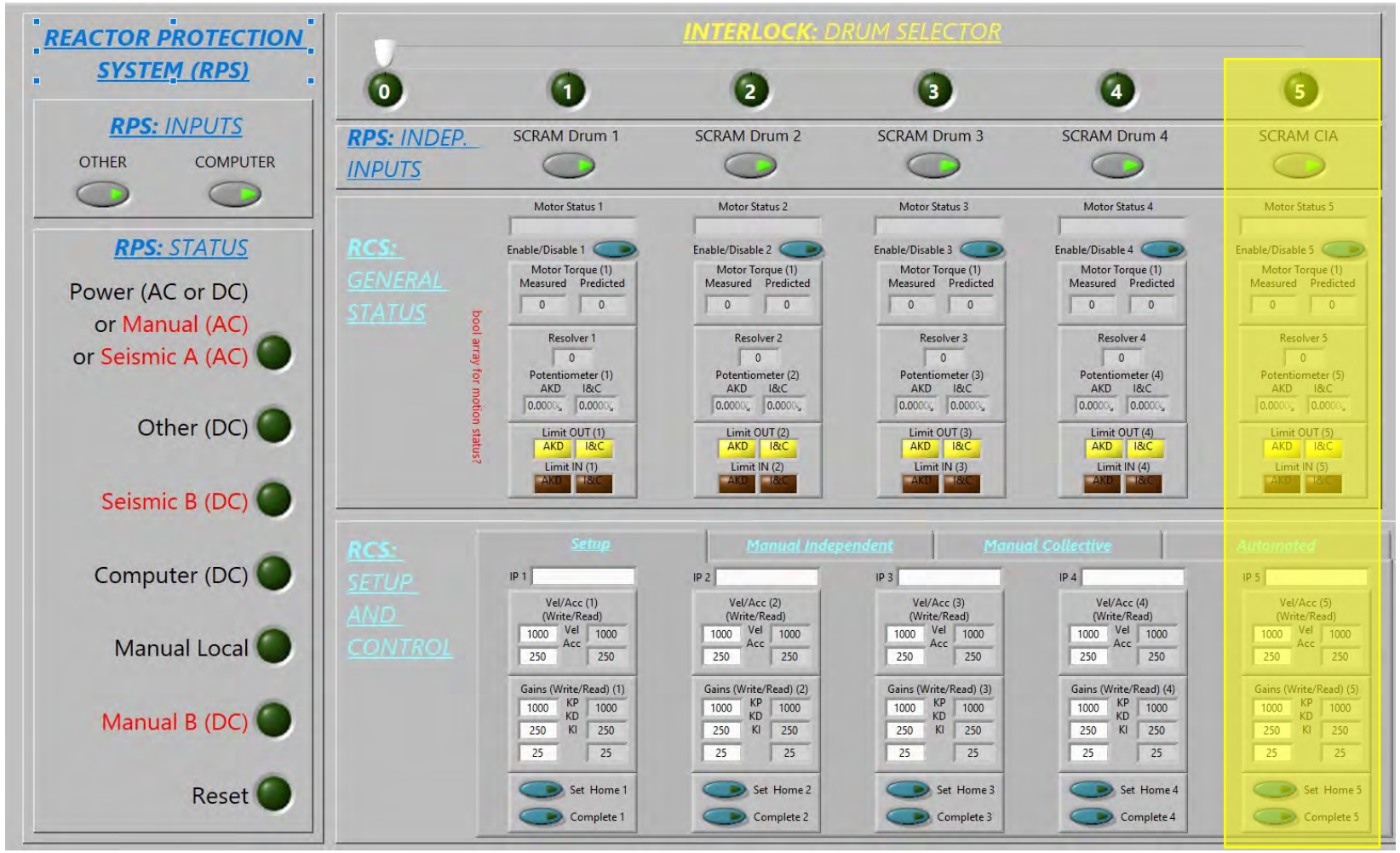


5th Driver, Interlock, I&C ports, and RPS output already incorporated!

Diversity Enhancement Description

- Software commonalities

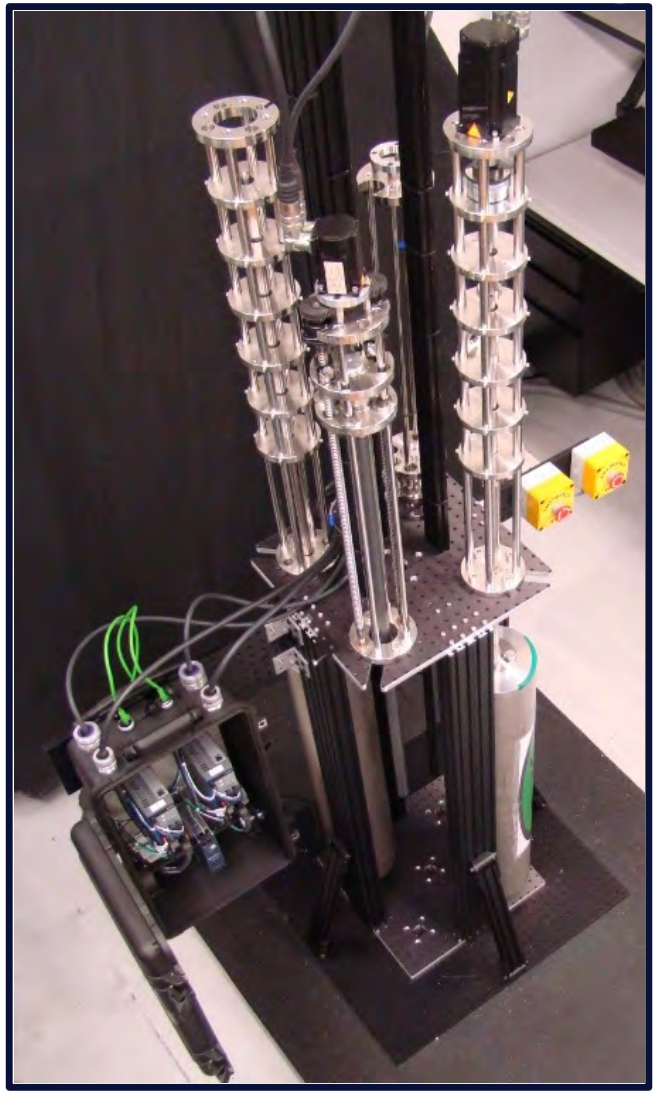
Identical algorithms required for motion control, interlock, RPS, and I&C inputs (already incorporated!)

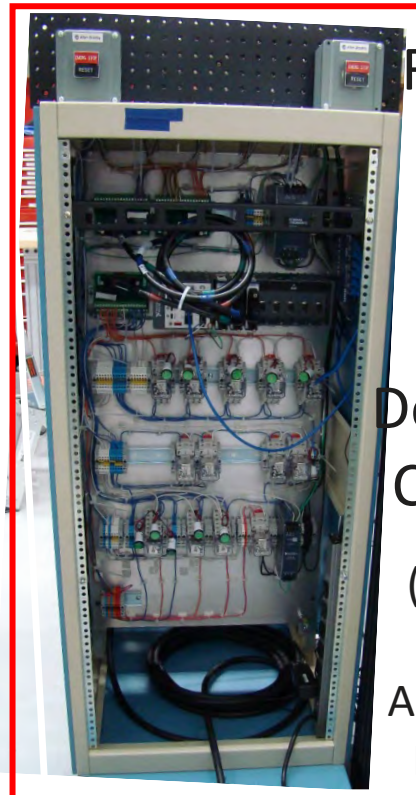


Diversity Enhancement Description

- Hands-on experience/assurance

Prototype mechanical, electrical, and software developed and being tested



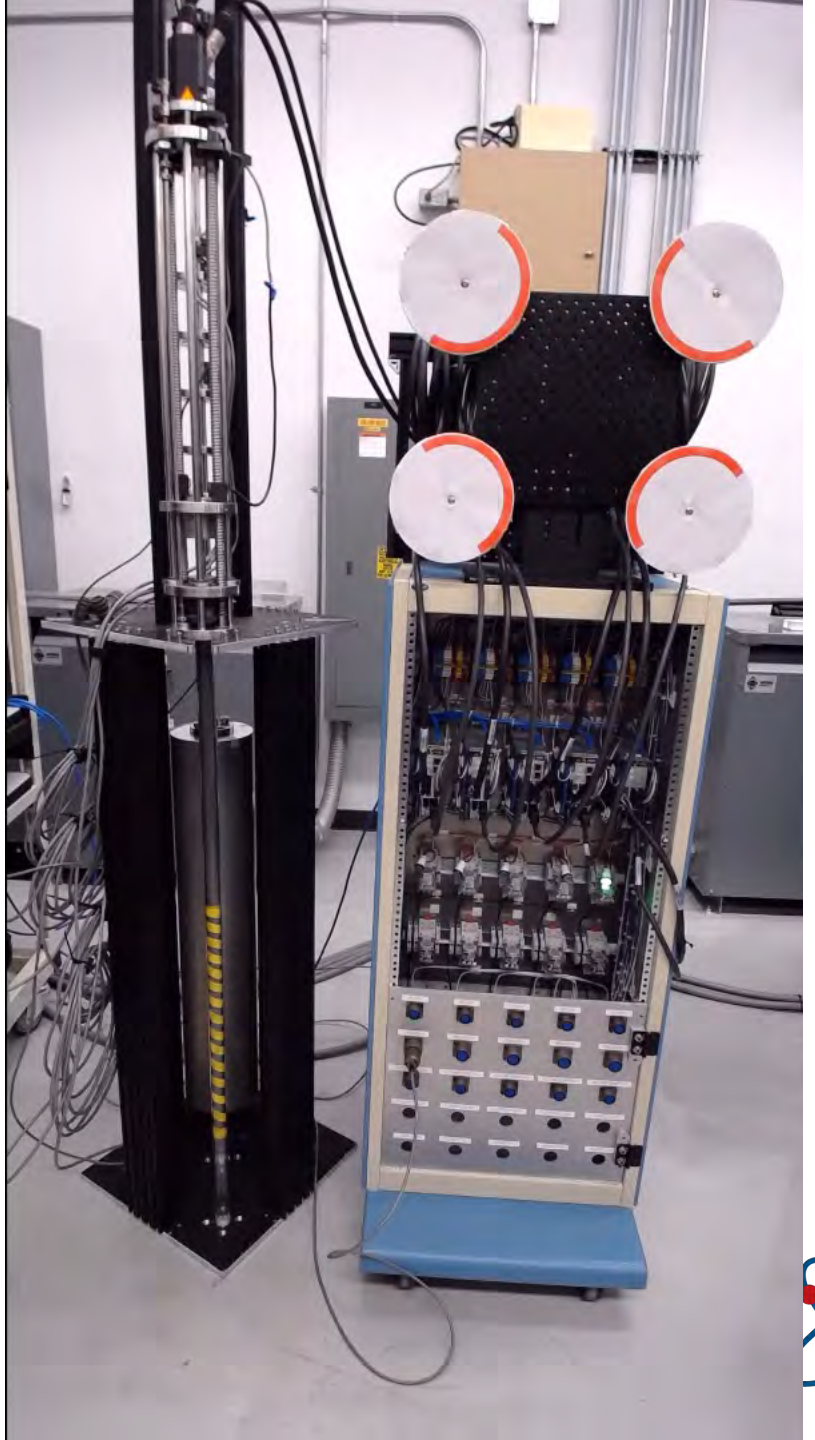


Front and Back of 4 Drum (+CIA) Intermediate Design Prototype Control Cabinet

(Equipped with I&C, Drivers, Interlocks, Amphenol Block, and Reactor Protection System)

Tests

- Prototype
  - Benchtop
  - Assimilated environment



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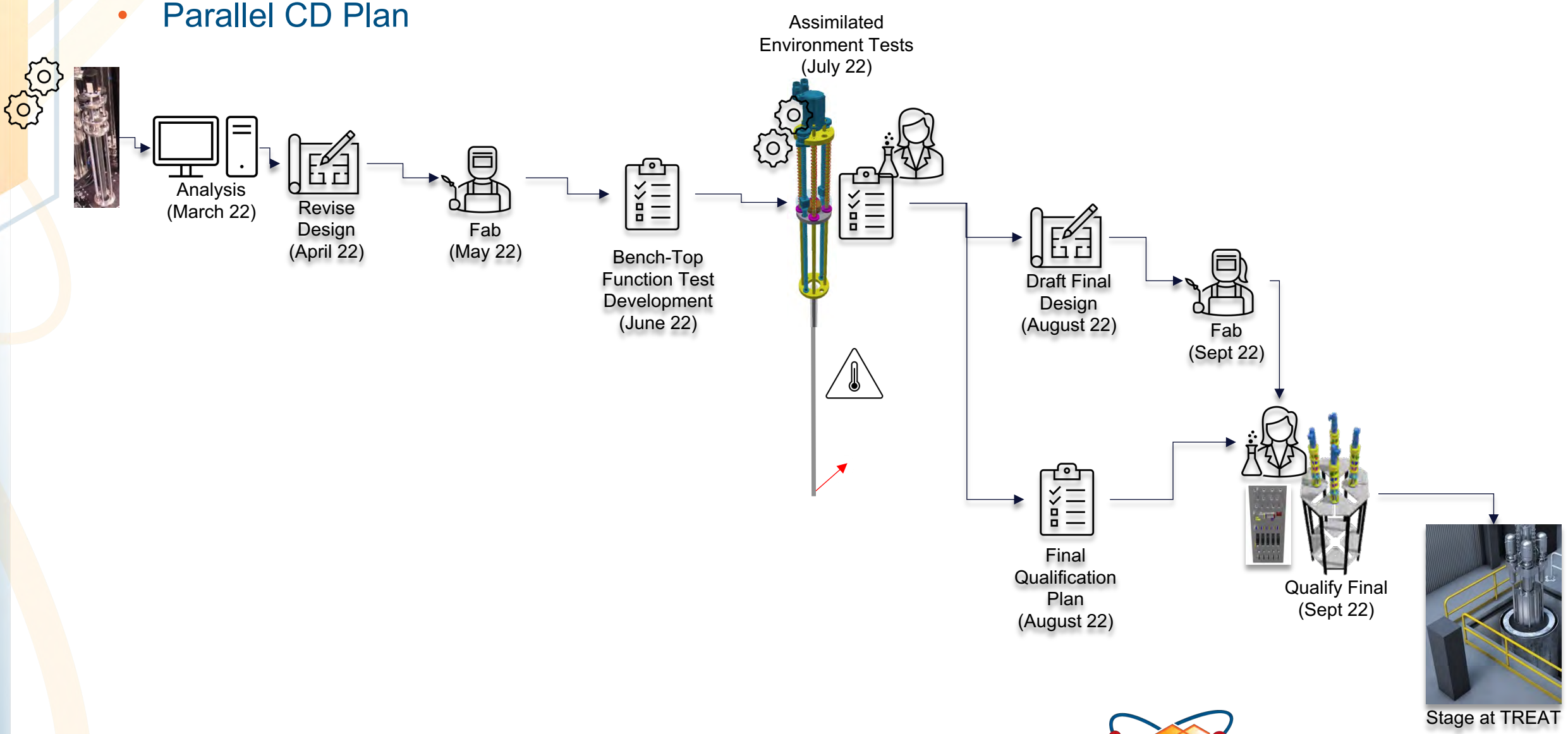
CIA Roadmap

- Parallel CD Plan



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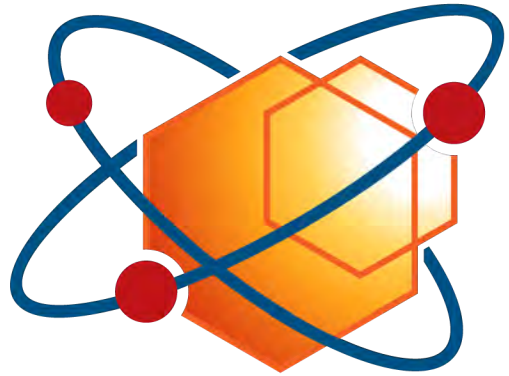

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