OAK RIDGE National Laboratory

Second Target Station (STS) Project

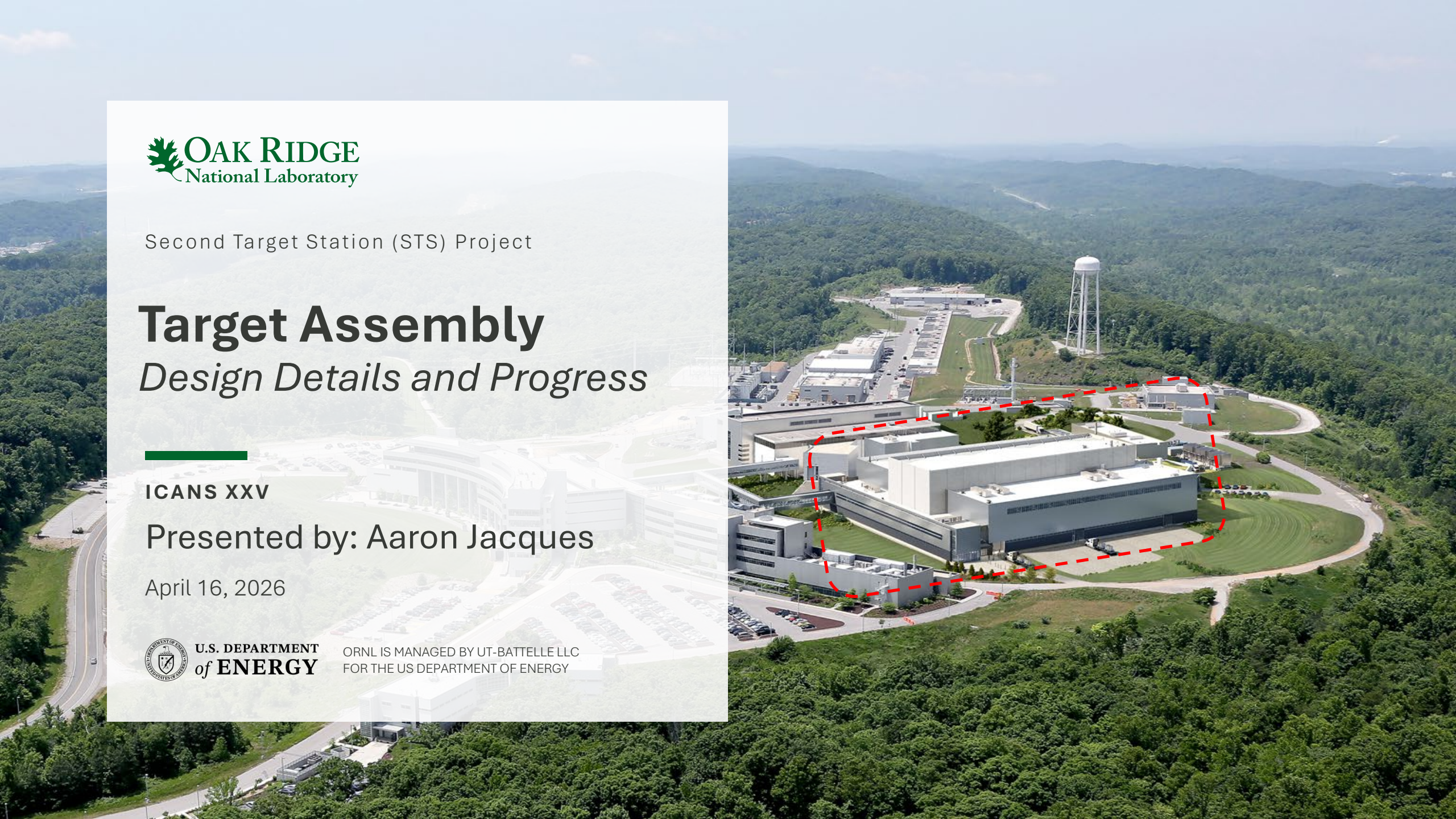
Target Assembly

Design Details and Progress

ICANS XXV

Presented by: Aaron Jacques

April 16, 2026



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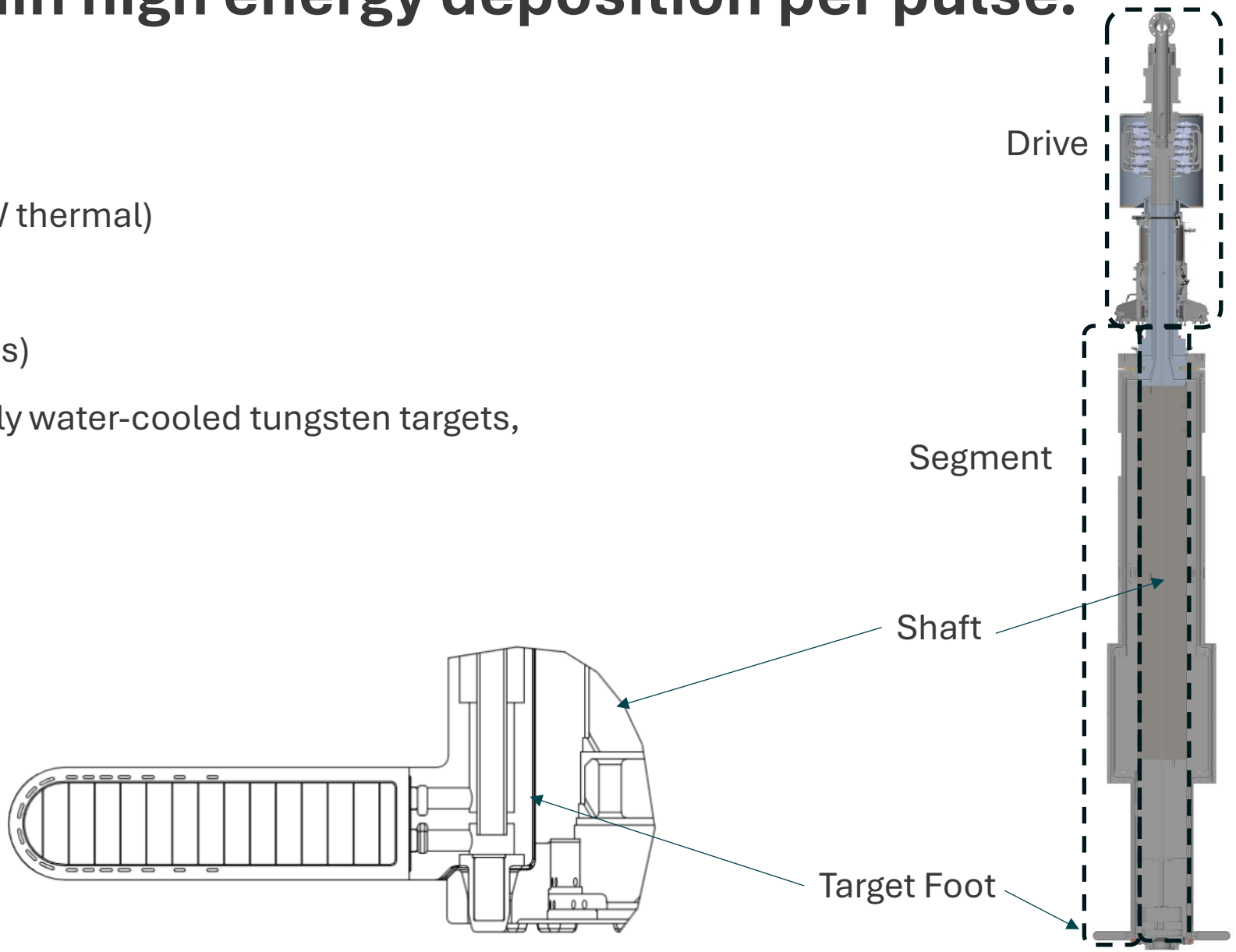
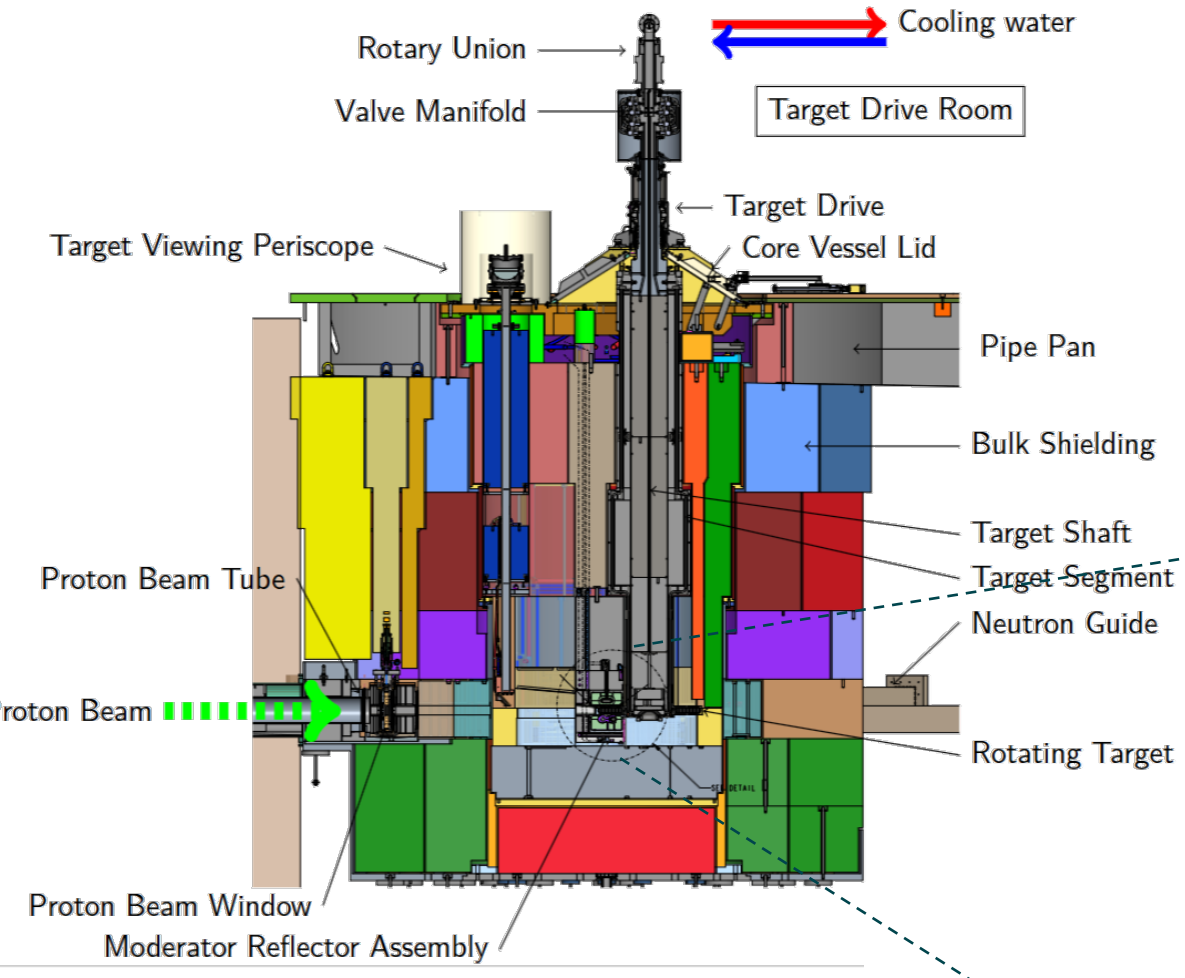
STS has chosen a rotating tungsten target to provide peak brightness and sustain high energy deposition per pulse.

- Beam parameters:
  - Beam size: 60 cm^2-90cm^2
  - Beam power: 700kW (400kW thermal)
  - Beam energy: 1.3 GeV
  - Energy per pulse: 19kJ (700ns)
- Number of segments: 20 individually water-cooled tungsten targets,
- Rotational speed: 45 rpm (0.75Hz)
- Wheel diameter: 1.2m
- System weight: 17,400kg
- Total Height: 8m
- Natural frequency: 2.5Hz

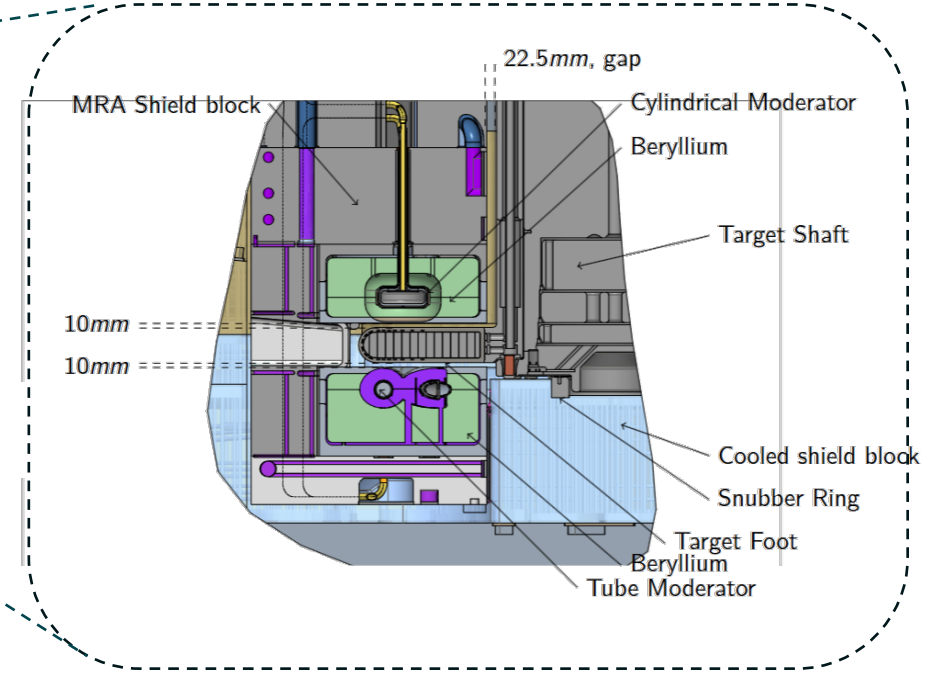


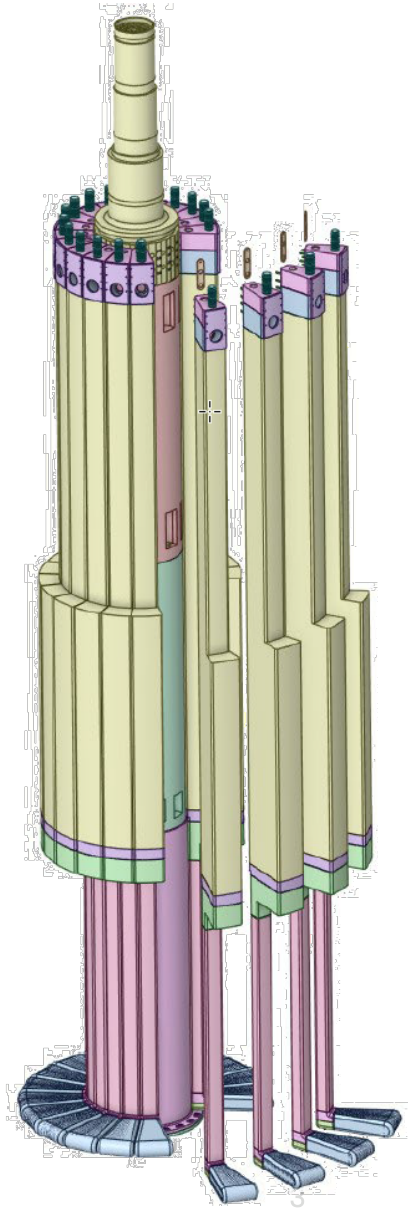
The target assembly is pre-segmented for fast removal of targets and moderator reflector assembly



Requirements:

- Fast Removal (tungsten!)
- No chips during downsizing
- Minimize radiation exposure





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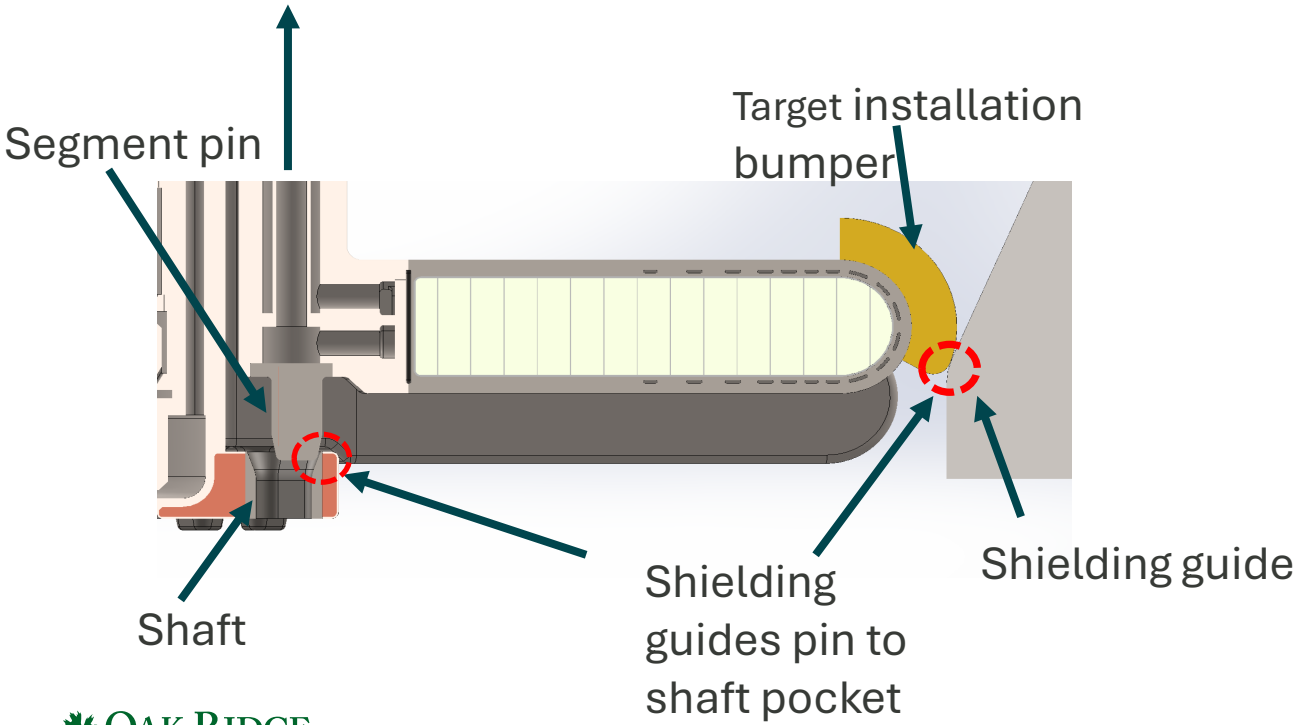
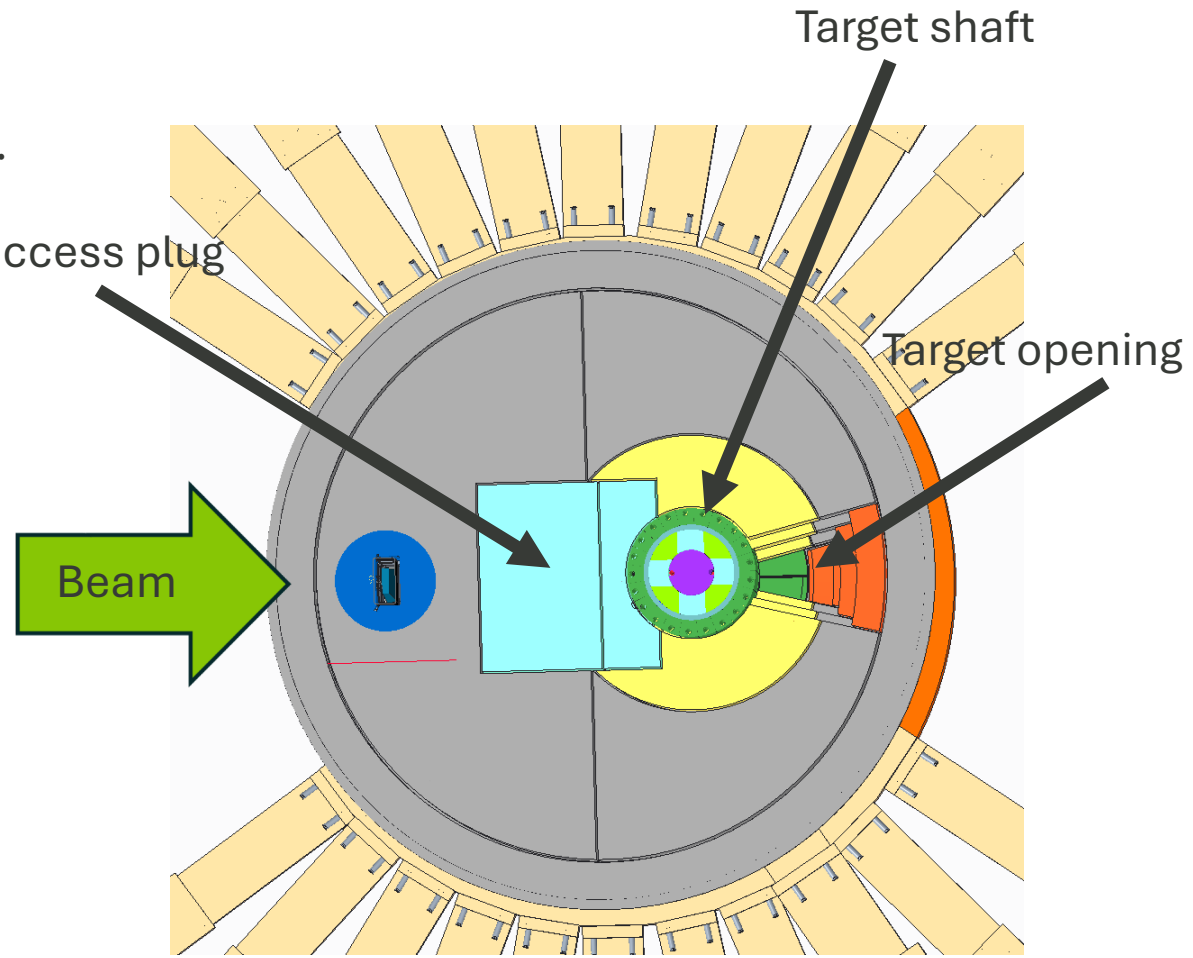
The segmented concept enables fast removal of targets

- Remove & replace segment through vertical "plug"
- MRA vertical replacement after 3 segments removed.
- Downstream opening minimizes exposure
- Shielding provides coarse alignment; shaft pocket and segment pin provide final alignment

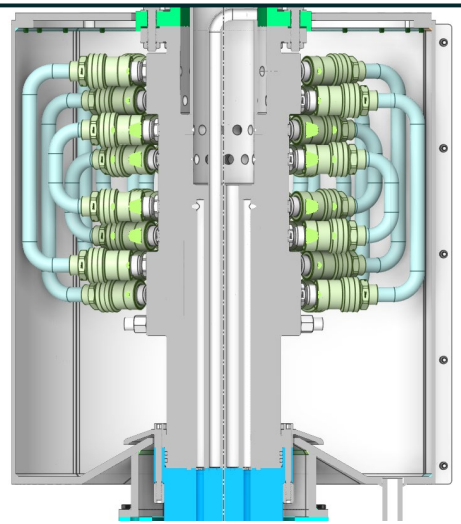


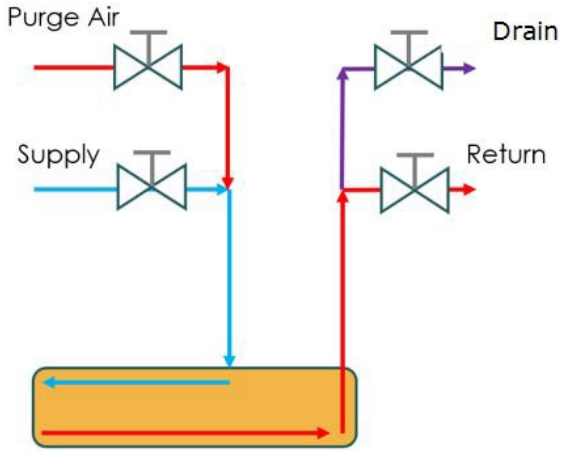


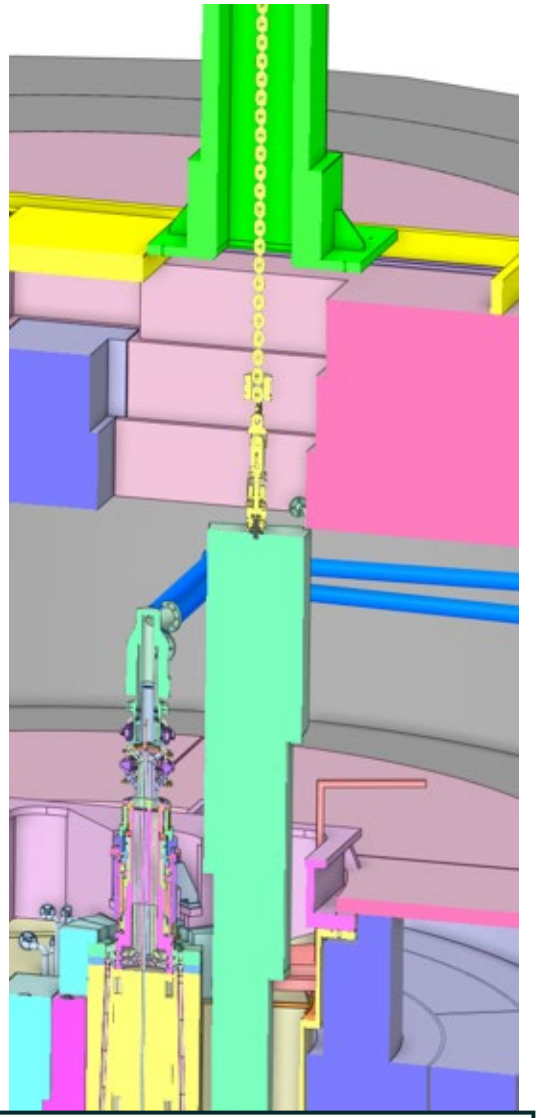
Estimated target replacement: **<10 days**

Segment removal & installation sequence is coordinated within the core vessel and target design

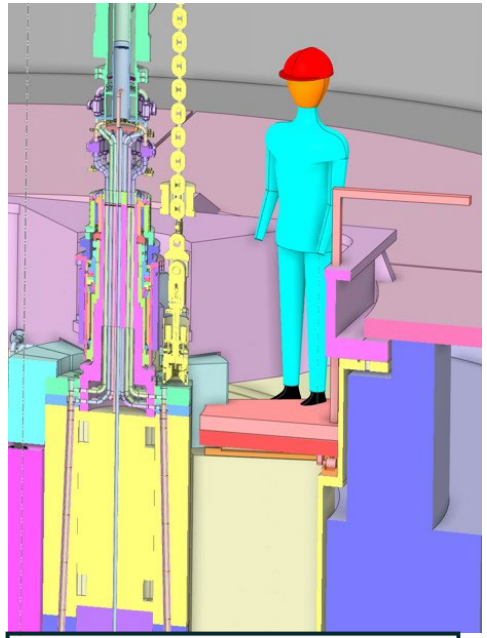
Requires knowledge of which segment has failed





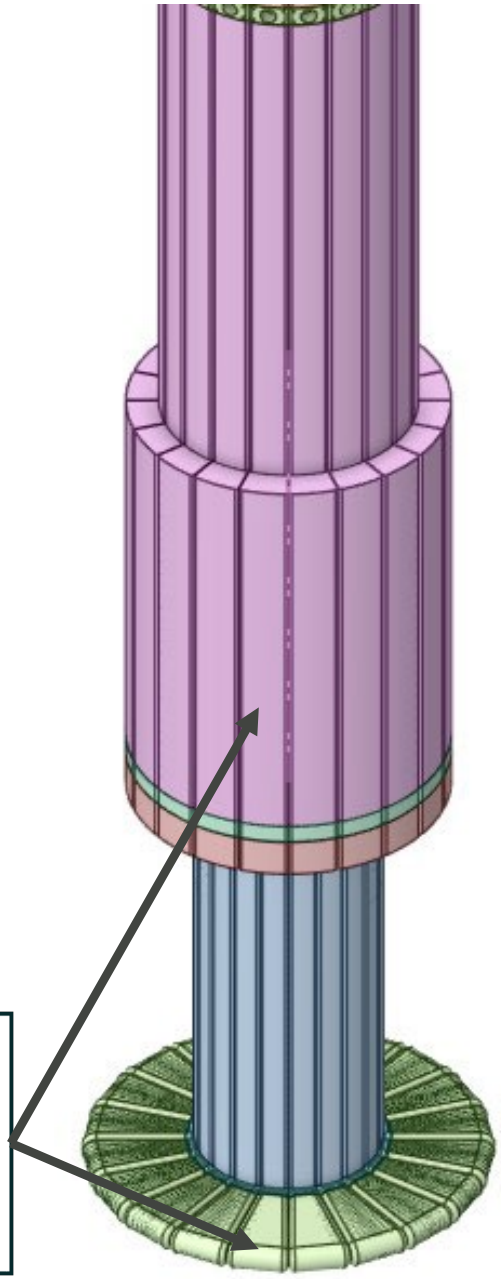


Shield block removal



Target removal

Independent target segments (top – bottom)



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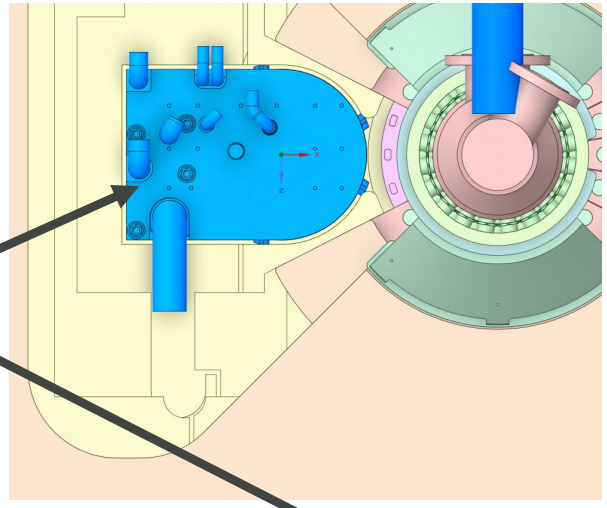
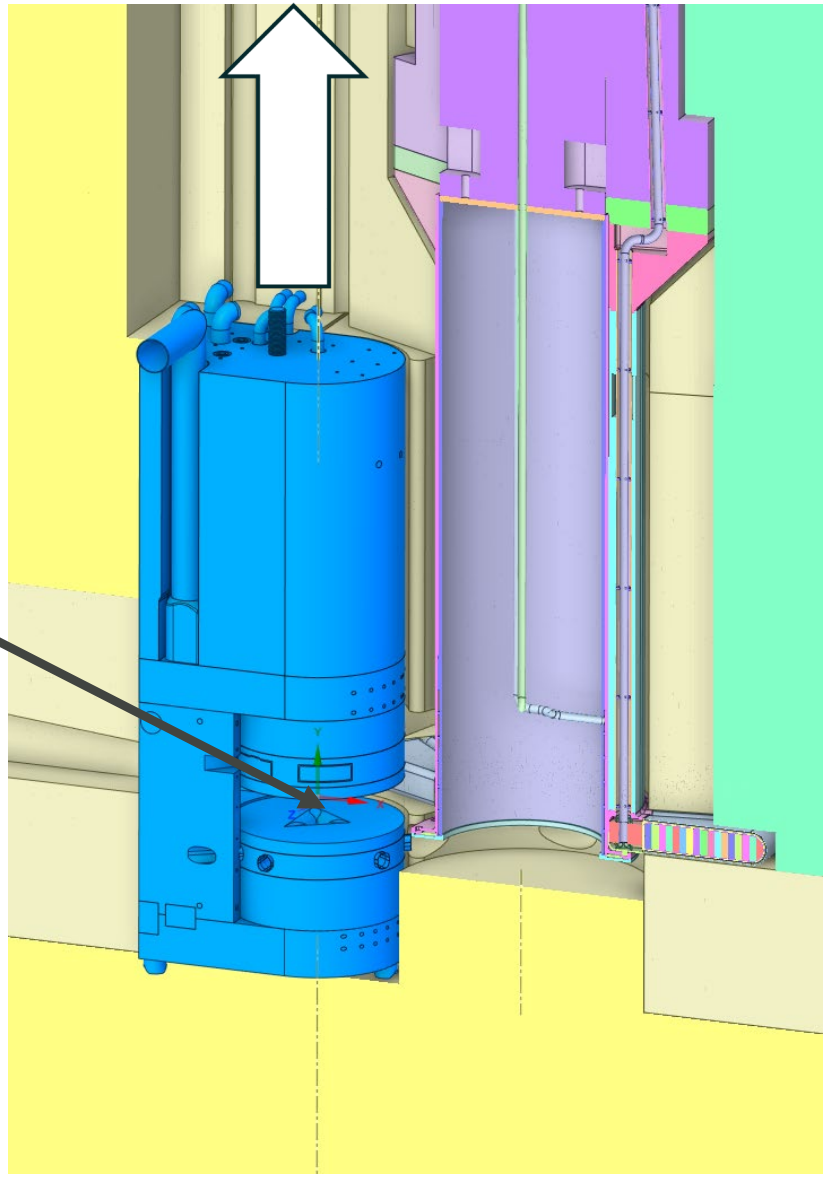
The segmented target enables vertical removal of the moderator and reflector assembly

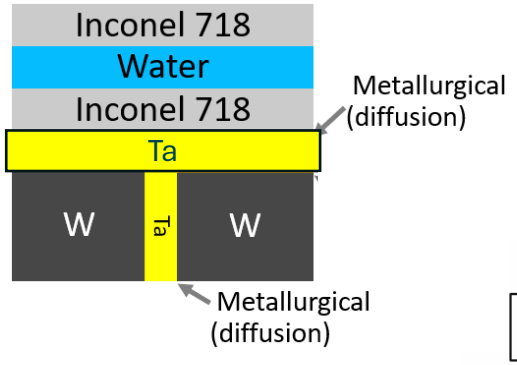
- 3 Segments removed
- Gap rotated under MRA
- Vertical MRA removal
- 3 segment replacements aligns with planned segment replacement cadence
- Vertical installation onto alignment features



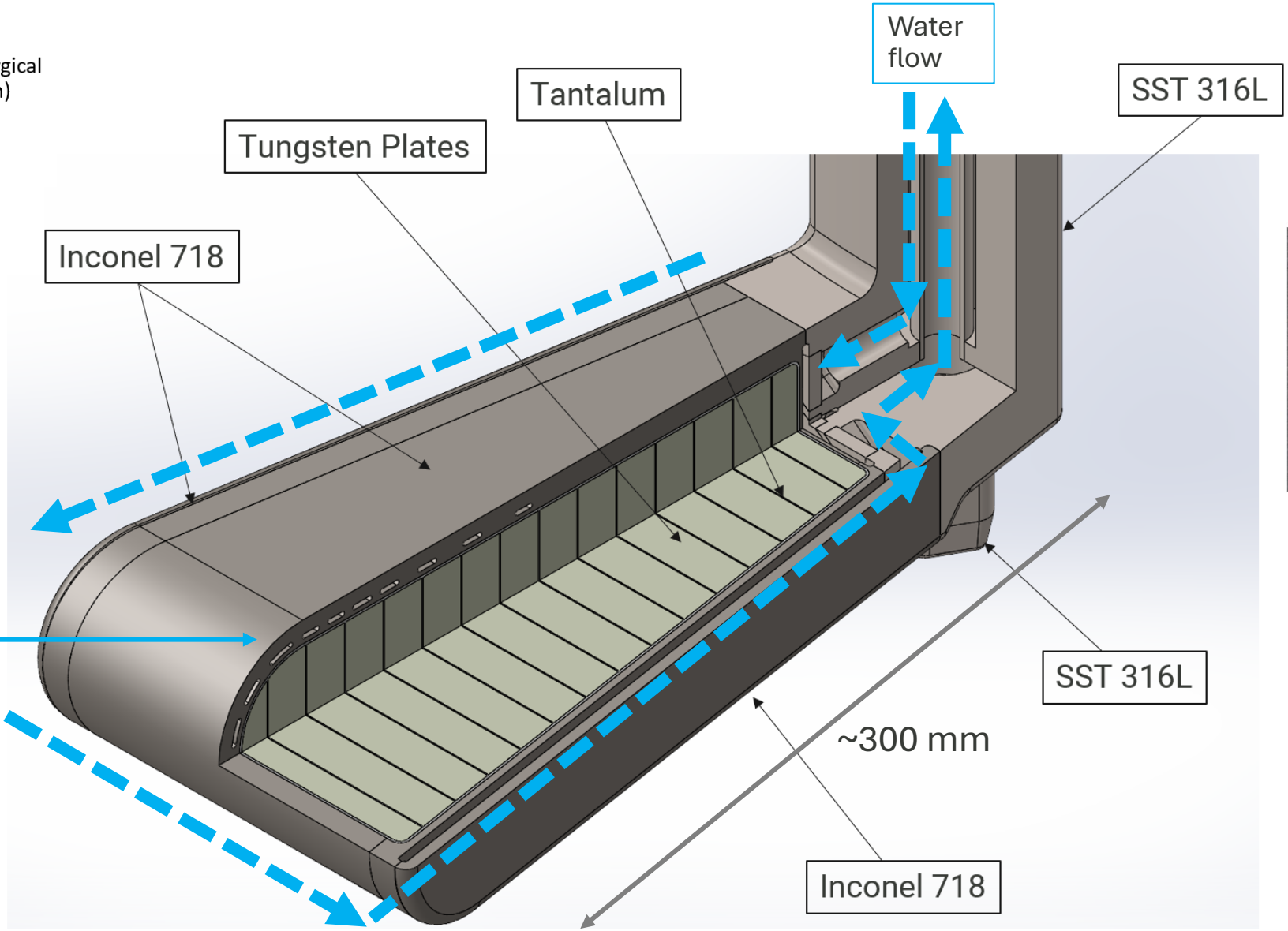


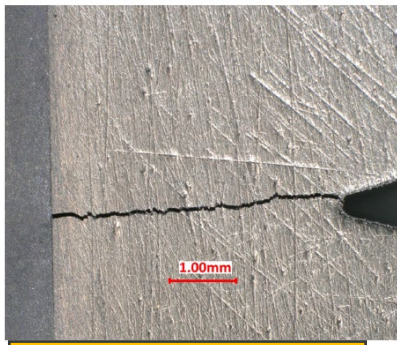
Target Design

The target design is a robust package for handling the challenges of Tungsten



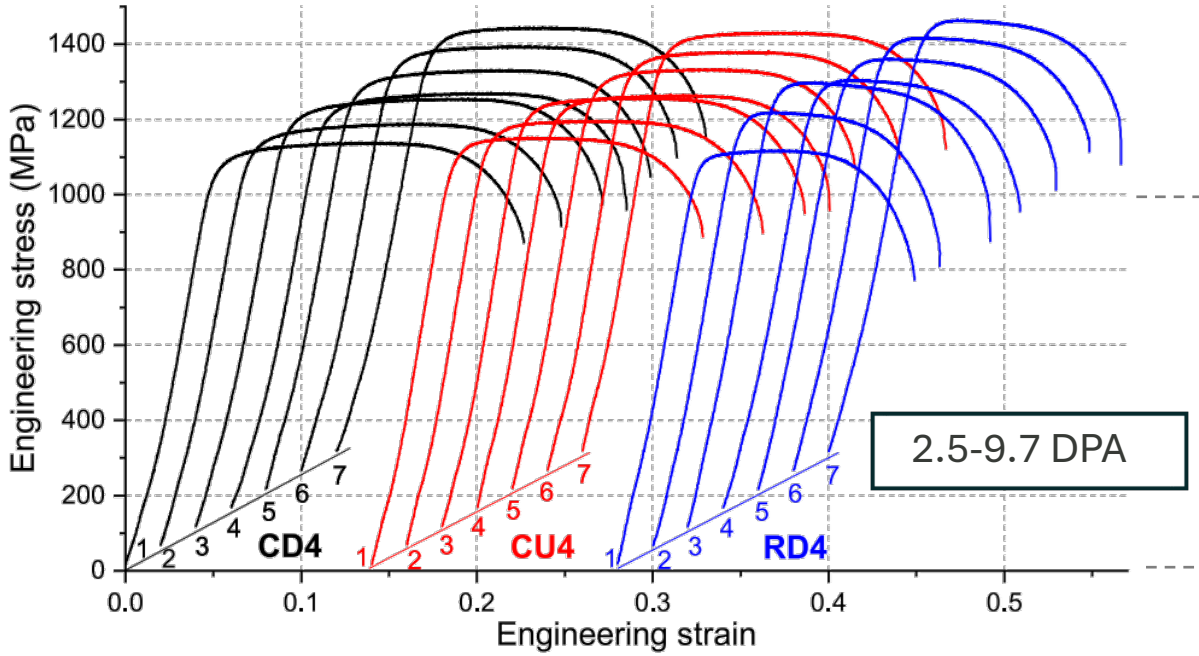
~3x CTE mismatch from 718 to W



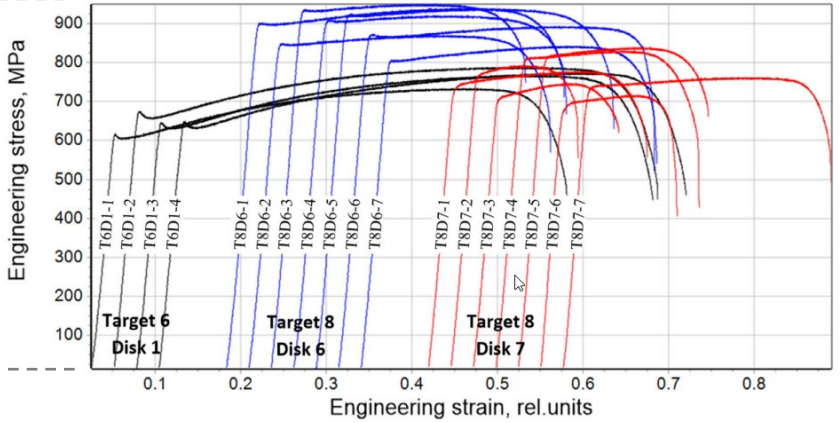


Crack deflection

Solution annealed Inconel has superior strength, maintains ductility and provides a higher compressive initial state than 316L



0-7.6 DPA

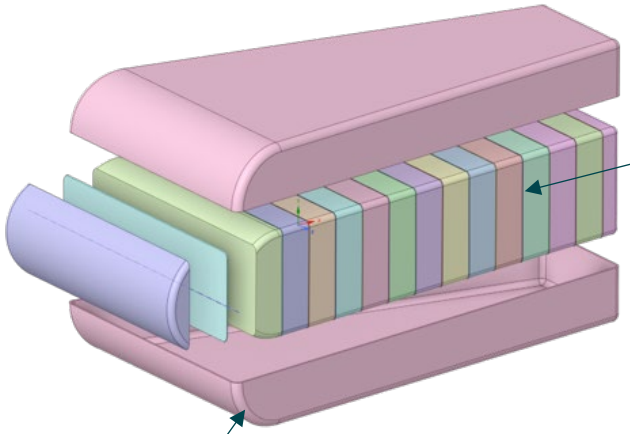


McClintock et. Al. *"Observations of radiation-enhanced ductility in irradiated Inconel 718: Tensile properties, deformation behavior, and microstructure" Acta Materialia 231 (2022)*

McClintock et. Al. "Characterization of mechanical properties and deformation behavior of highly irradiated 316L stainless steel from target modules at the Spallation Neutron Source using digital image correlation analysis*" J. Nuclear Materials, 545 (2021)*

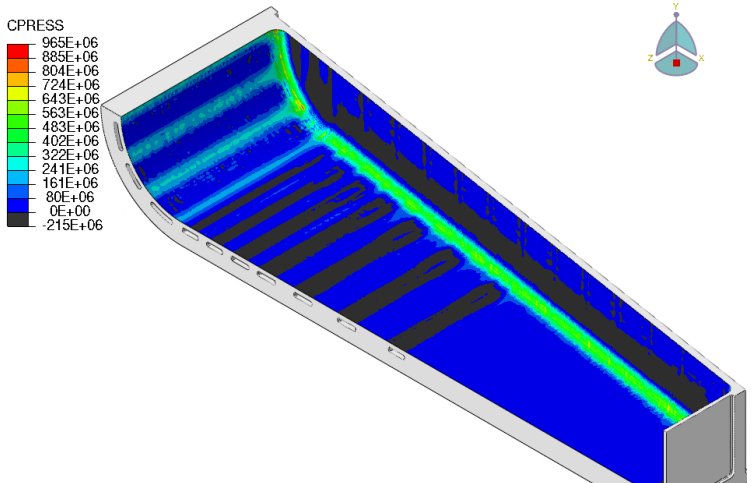
The tungsten target is a sequence of nested metallurgical bonds and machining operations between tungsten, tantalum and Inconel and results in high residual stresses

Spallation Package (VHP → HIP)

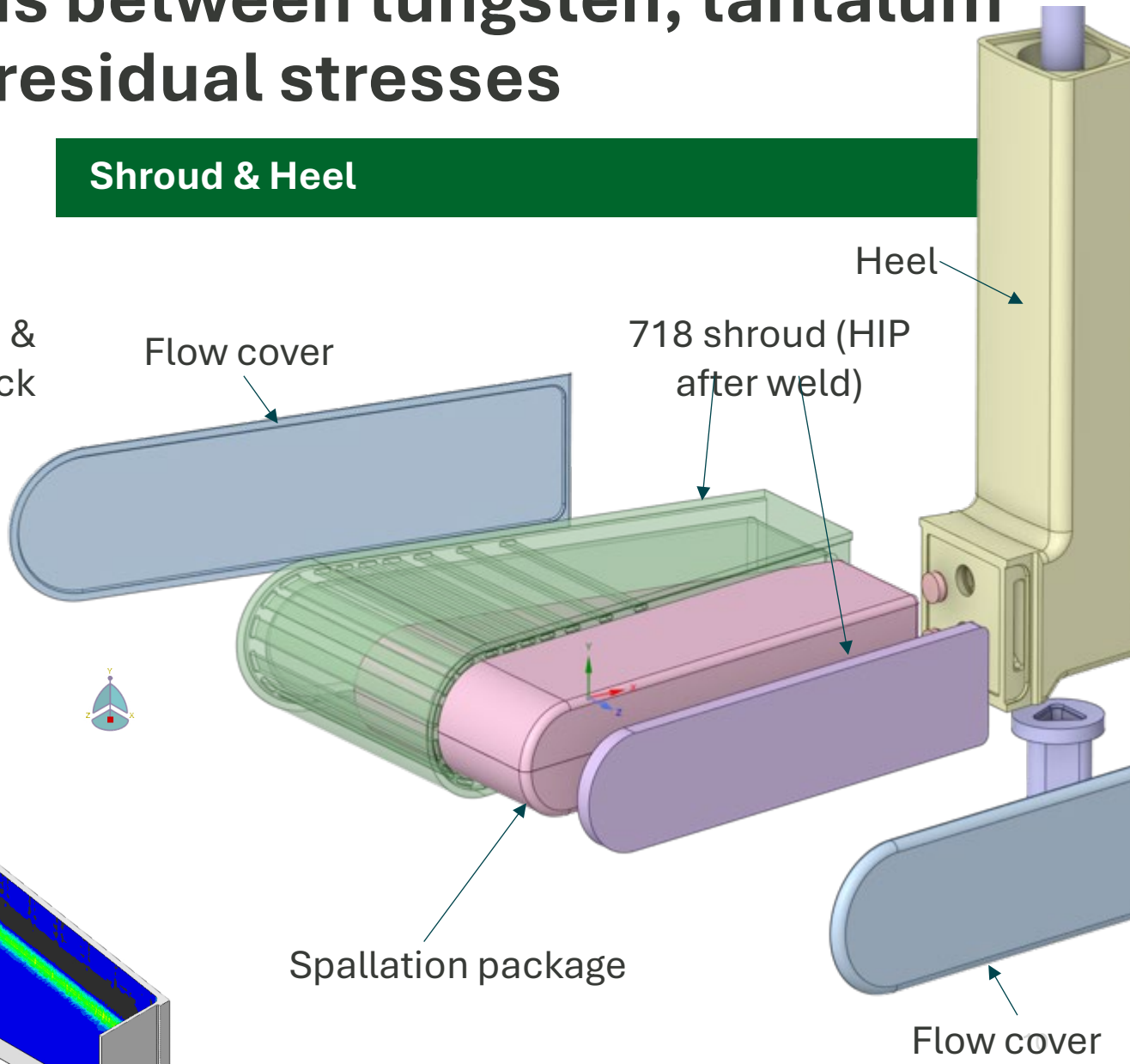


VHP W(18mm) & (0.5mm)Ta stack

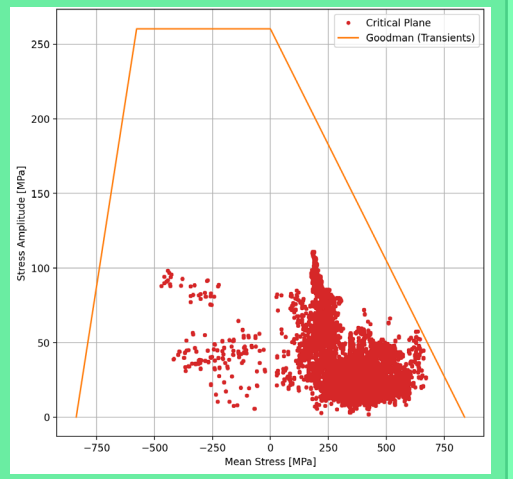
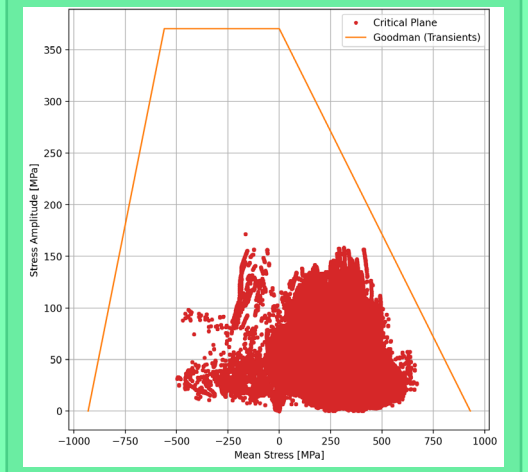
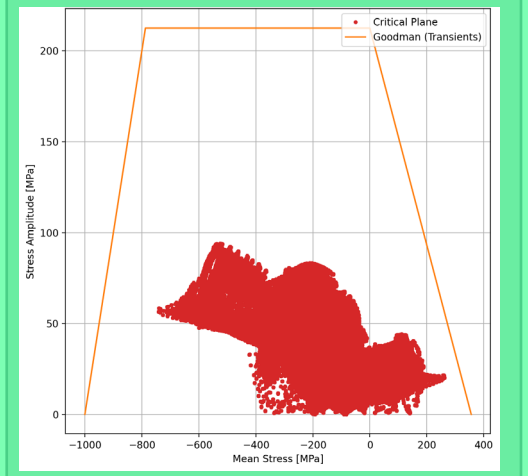
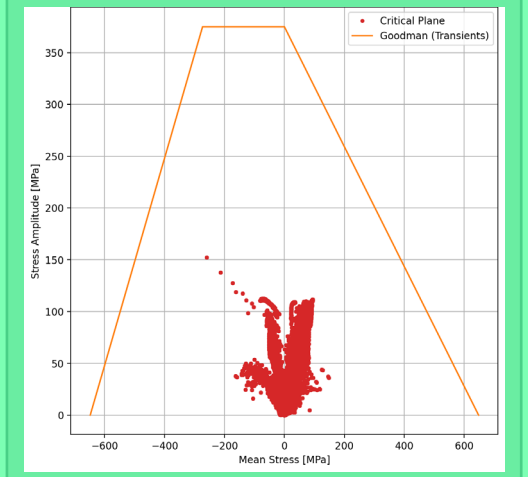
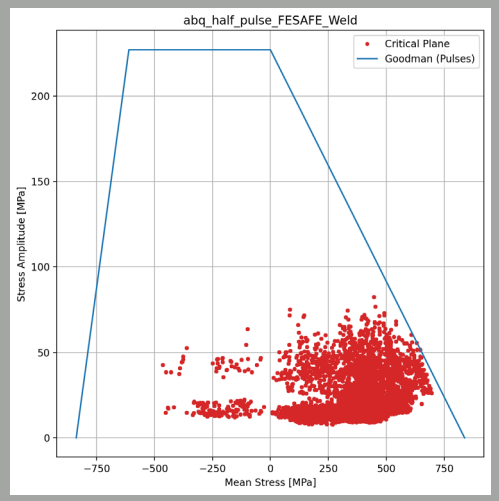
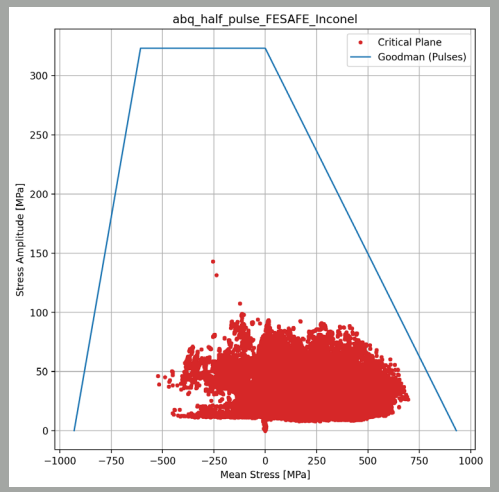
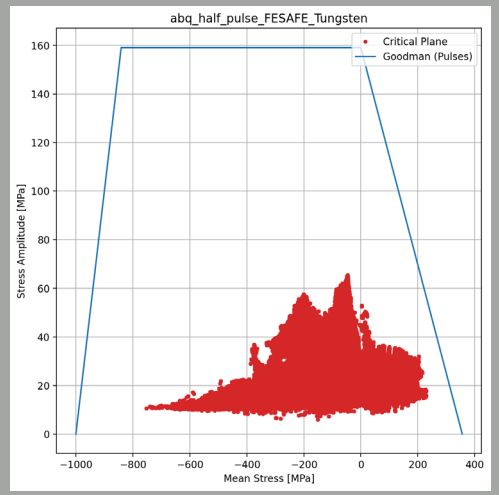
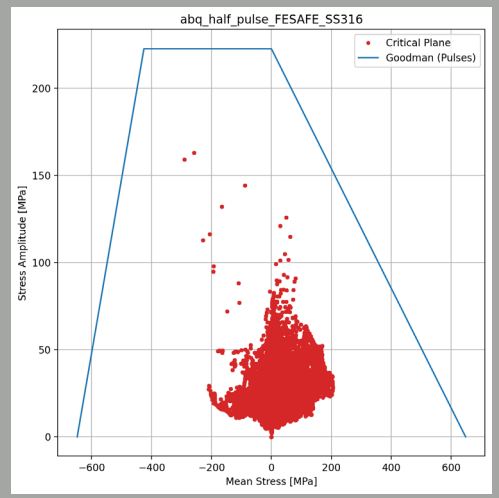
1mm Ta shell



Shroud & Heel

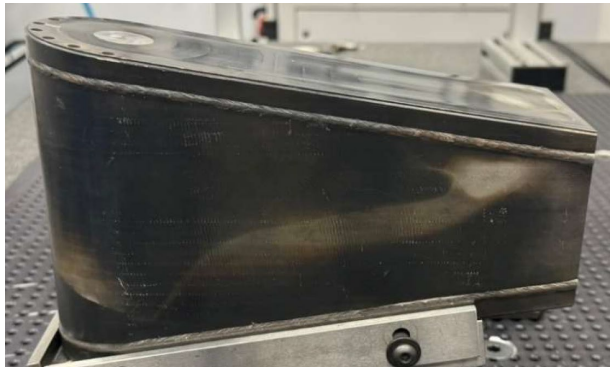


High fidelity analyses for residual stress, beam pulses, and beam trips show acceptable fatigue margins over 10 years of operation

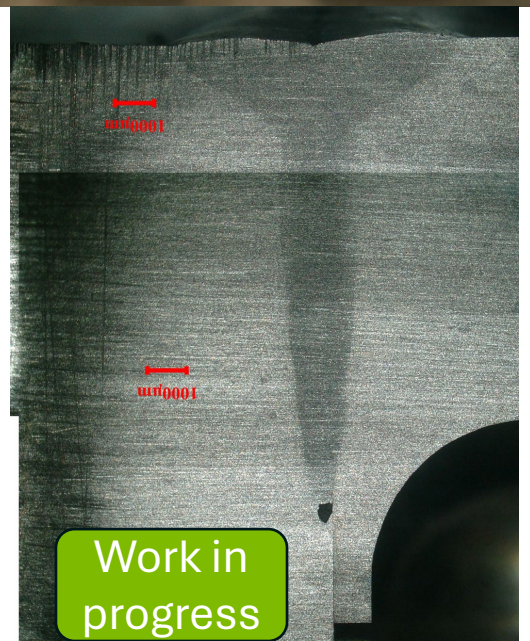
	Inconel Side Weld	Inconel 718 (SA)	Tungsten	SS316L
Beam Trips				
Beam Pulses				

Verification of key processes, geometry, and specifications give high confidence in methods and will be validated in a vendor qualification article

Water passages & HIP

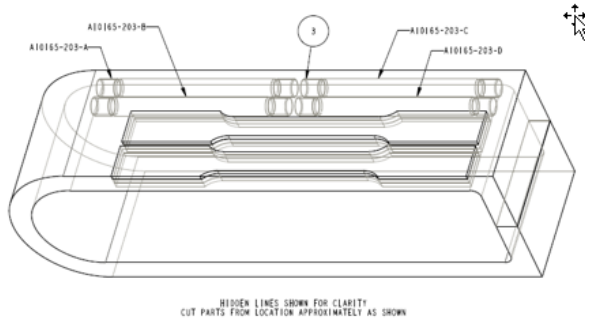


Weld joint

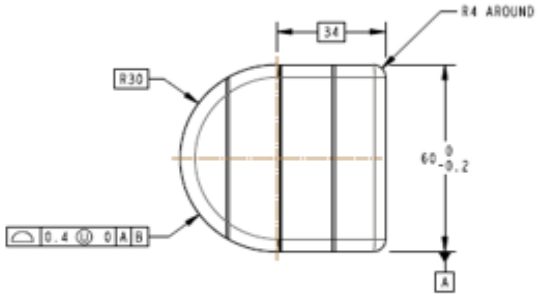


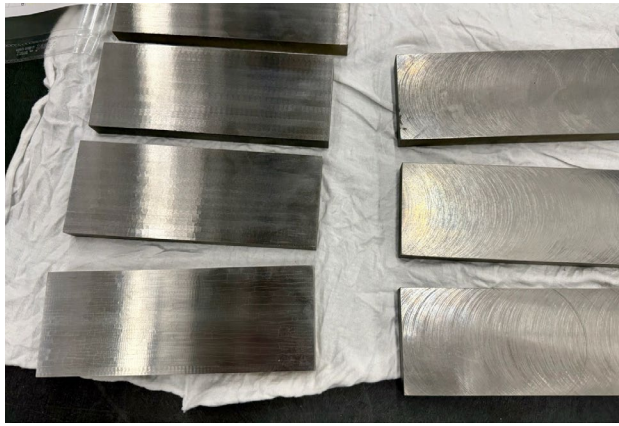
Work in progress

Inconel grain size



VHP Stack & machining





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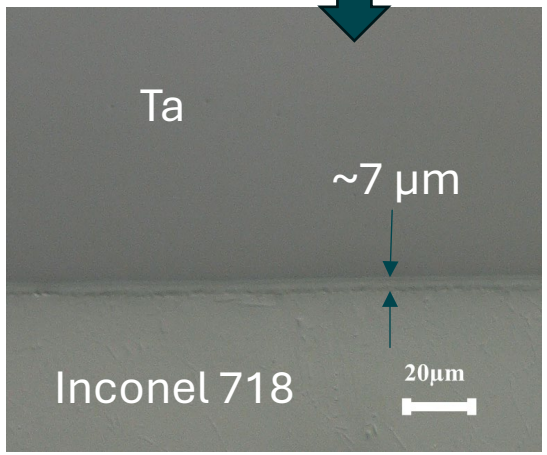
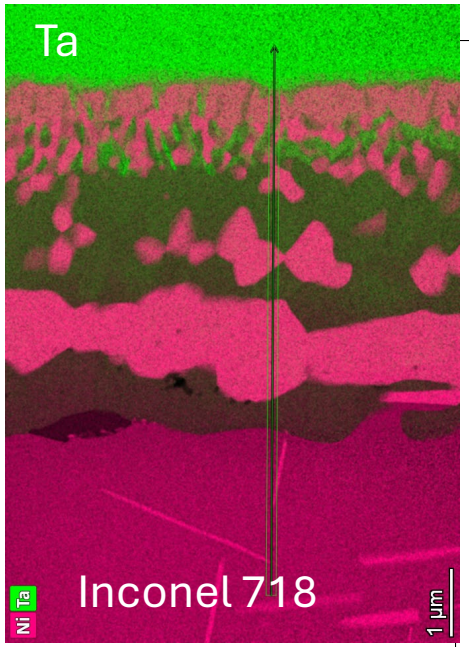
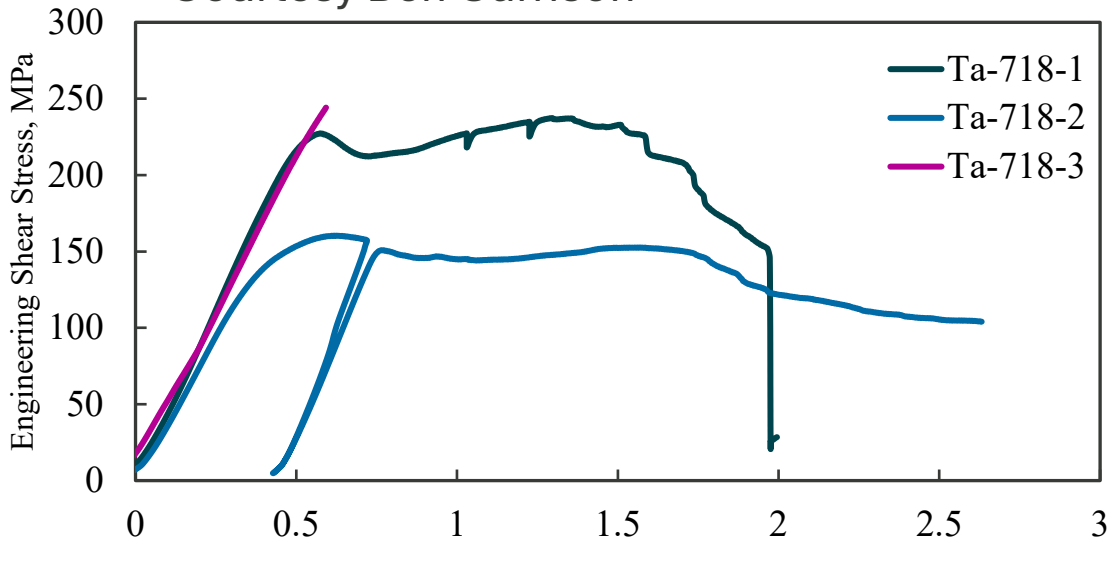
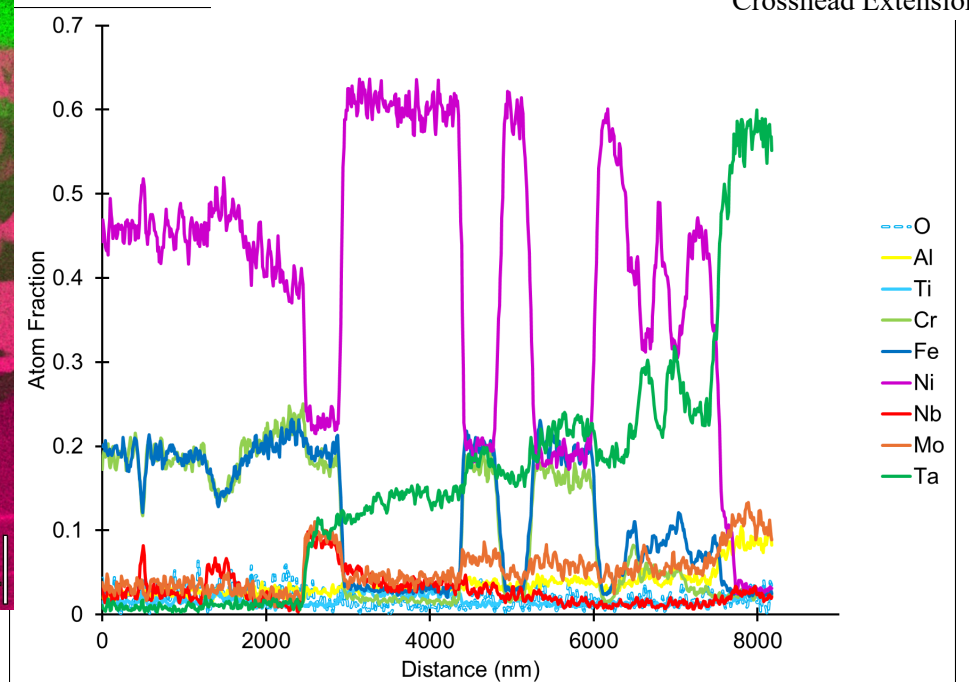
Inconel-Tantalum and W-Ta bonds have been established by the STS project





Courtesy Ben Garrison





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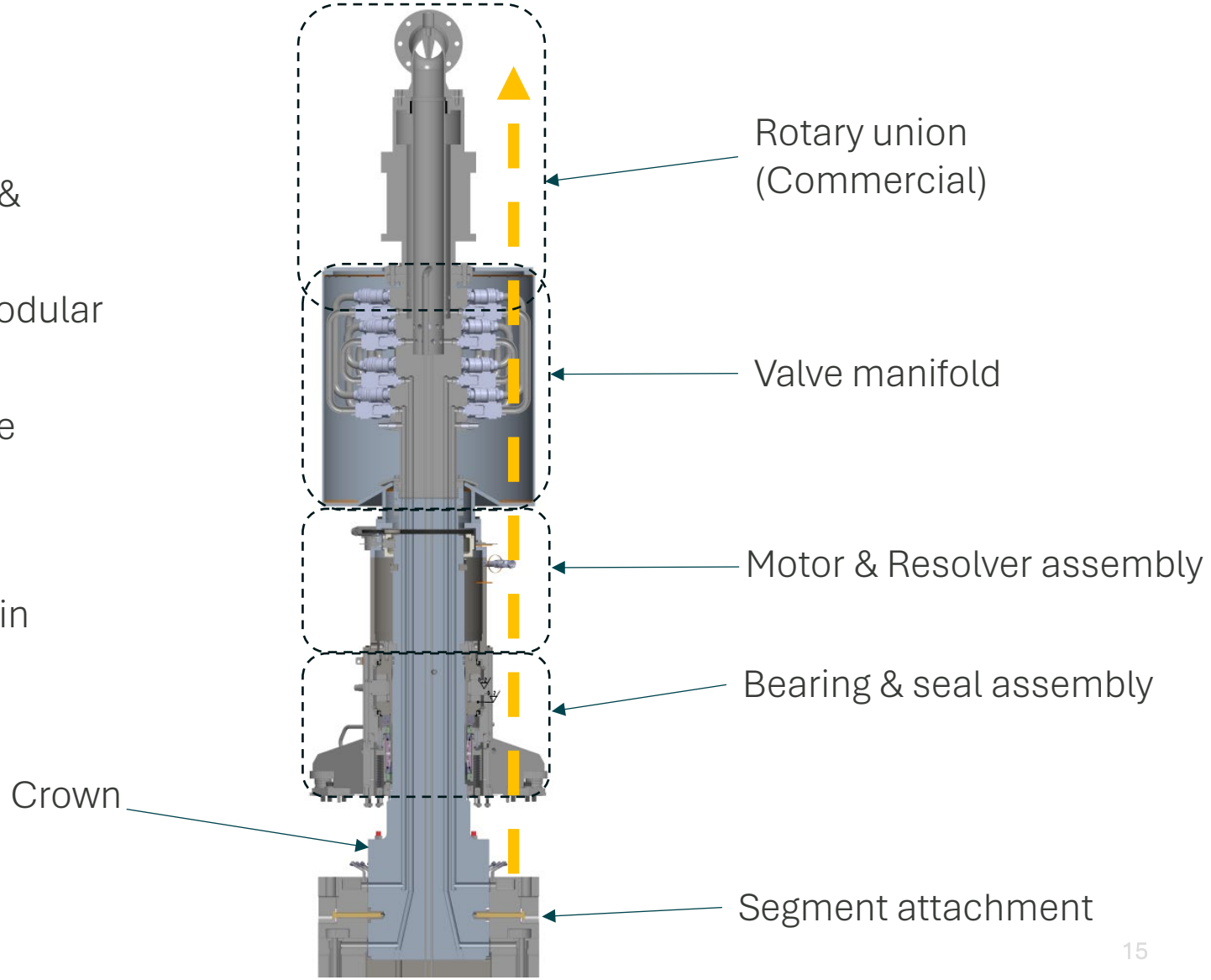
Drive and Shaft Design

Design Overview

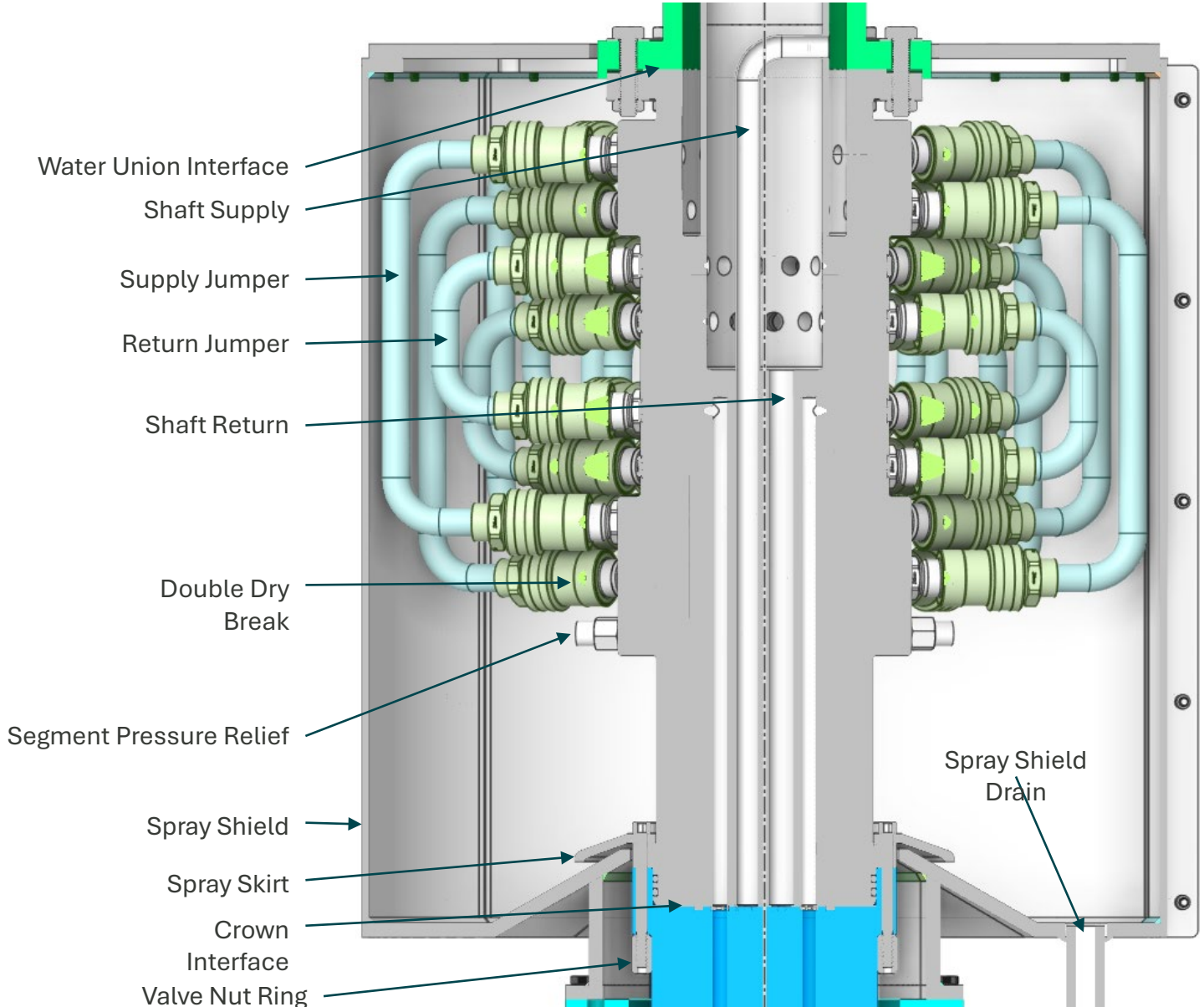
Target Assembly drive is located outside the vacuum for vertical segment installation and hands on access

- Regular access items are easily accessible
- Independent water circuits for segment removal & decay heat
- Motor, resolver, bearings accessed in order as modular units
- Modular units built off-line to minimize time in the radiation environment
- Crown is life of the facility
- Core Vessel attachment point remains to maintain alignment

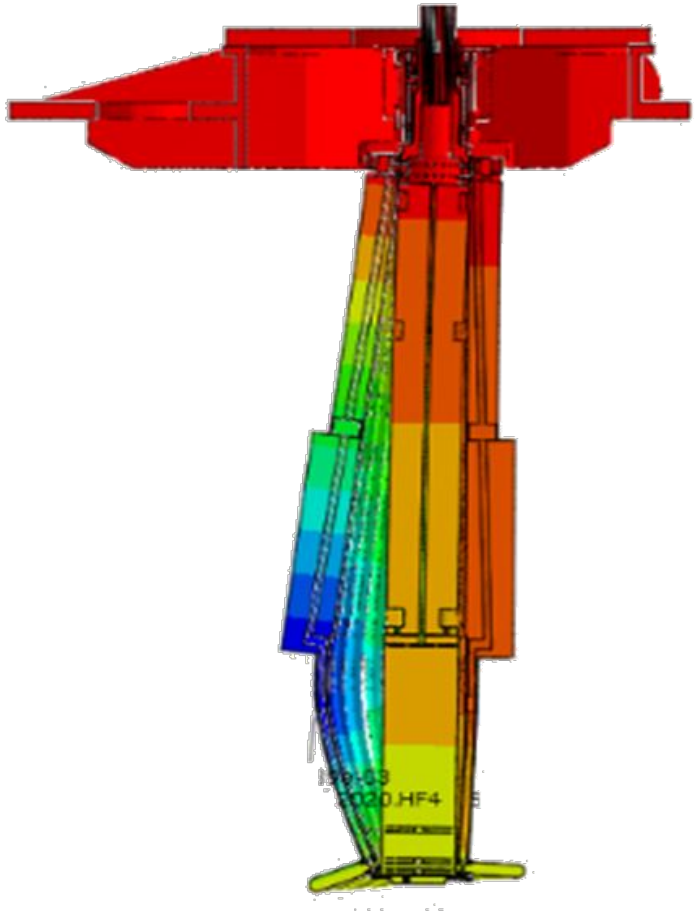


The valve manifold provides control and diagnostics for 20 segments without segment damage

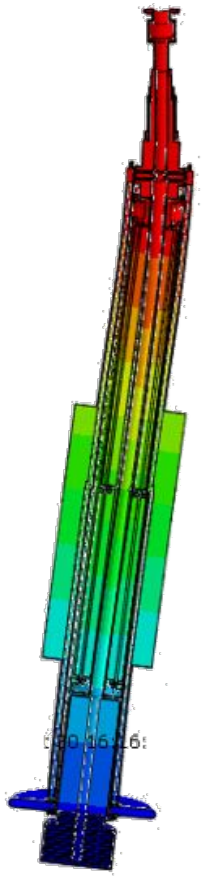
- Field Replaceable Unit is easily swapped and bench assembled
- Individual segments can be replaced without interrupting flow to remaining segments (remove jumpers)
- Double-dry break connections for leak prevention and isolation during maintenance.
- Provides diagnostic interface and blowdown interface
- Clear indication of valve status



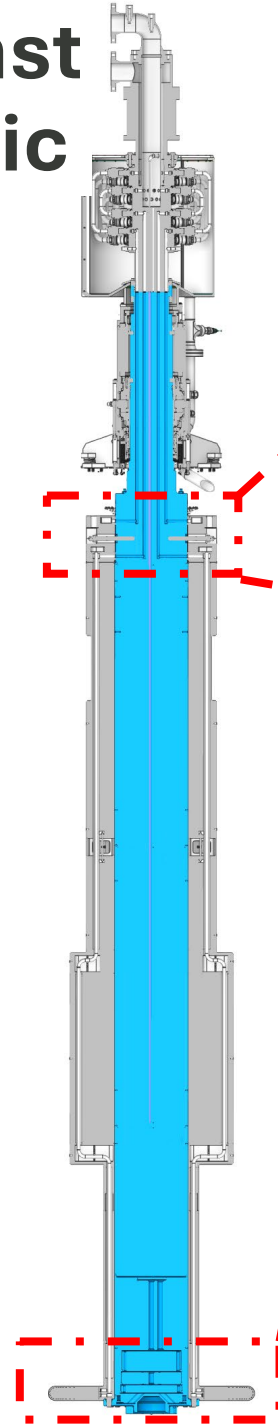
The shaft provides restraint against centrifugal, seismic, and eccentric motion.

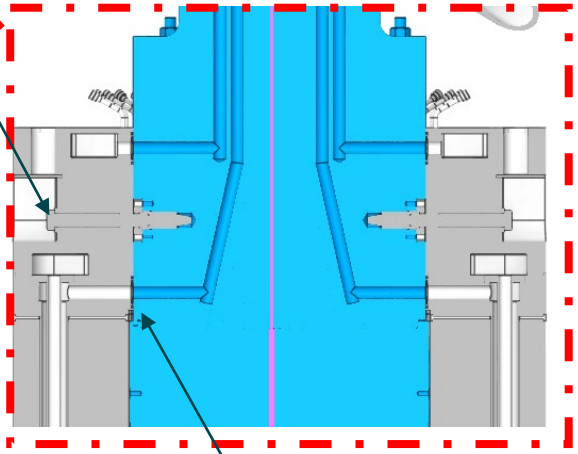


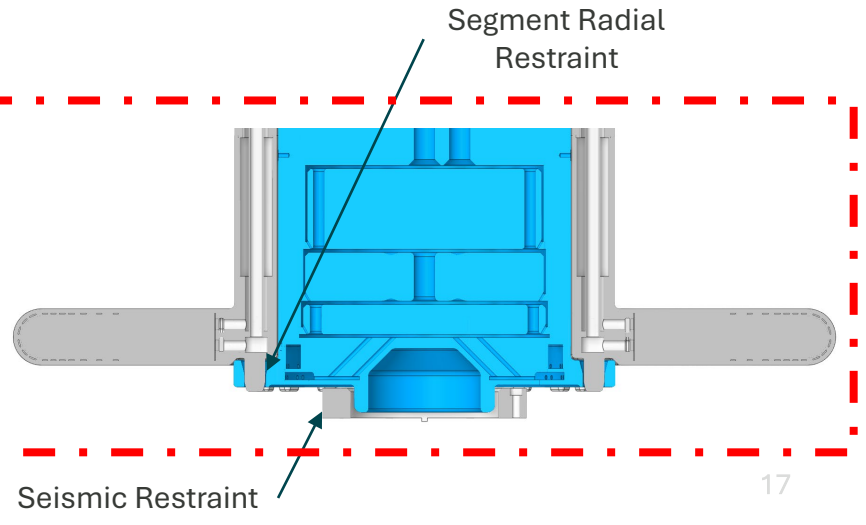
Restrained Deflection: 8mm



Cantilever Deflection: 25mm







The target assembly work presented is the product of a world-class team

Joseph Tipton Jr. Min-Tsung Kao Tucker McClanahan Lukas Zavorka	Analysis
Lukas Bearden Joel Montross Yong Joong Lee Tom McManamy	Engineering
Thomas Muth Ben Garrison Tim Lach Sabrina Calzada	Material Science

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