OAK RIDGE National Laboratory | SECOND TARGET STATION

Vessel Systems and Target Station Shielding Preliminary Design

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U.S. DEPARTMENT OF ENERGY

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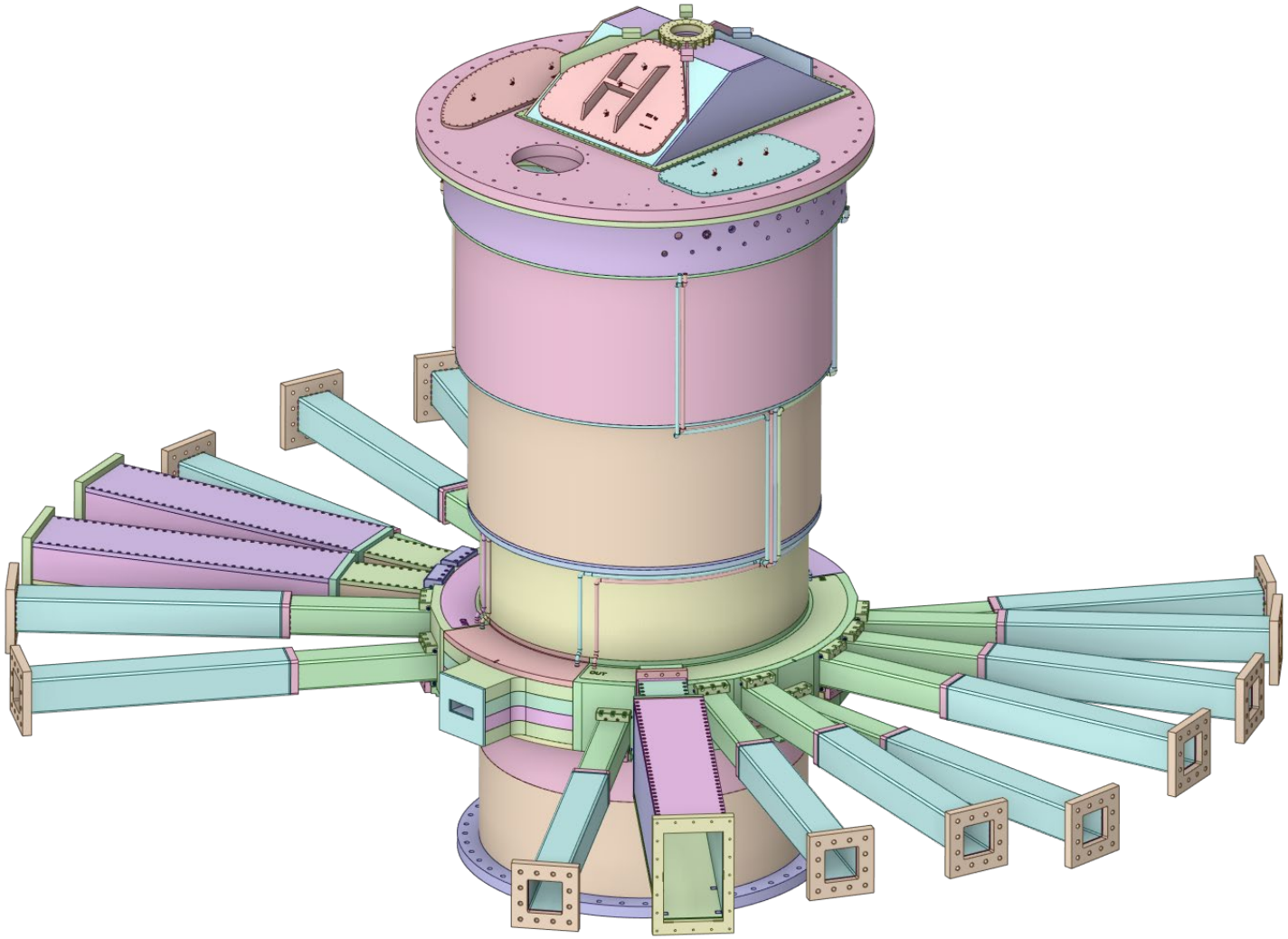
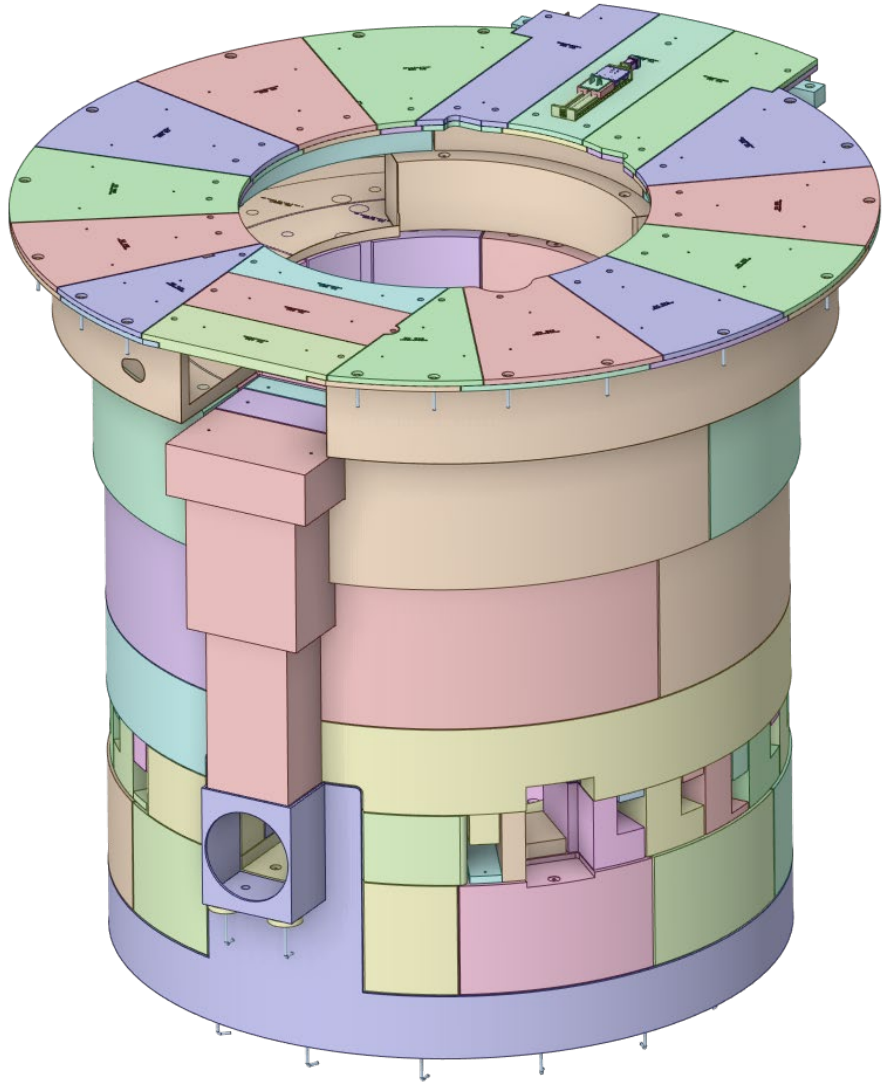
S.03.06 Vessel Systems and S.03.07 Target Station Shielding

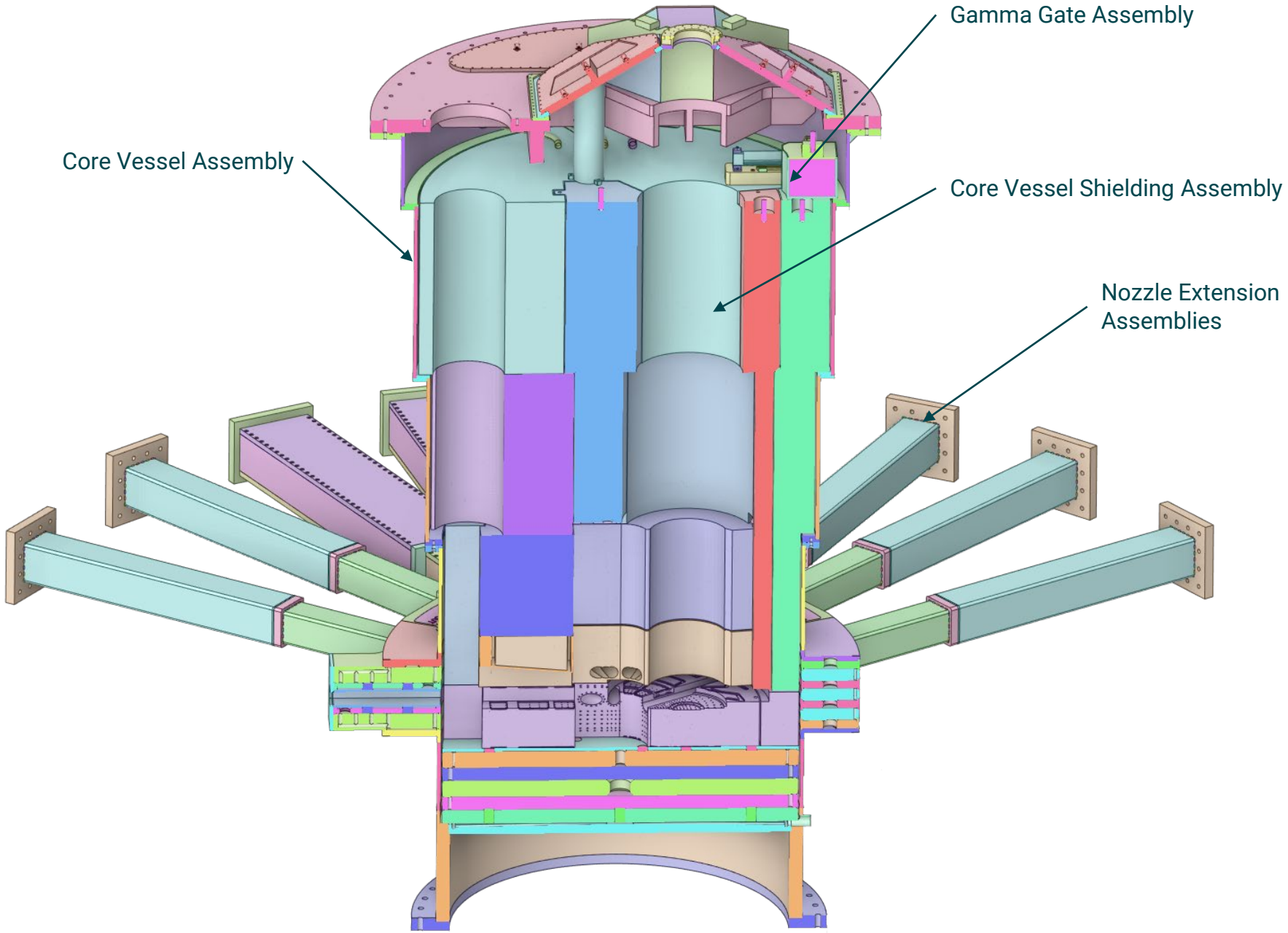
Vessel Systems



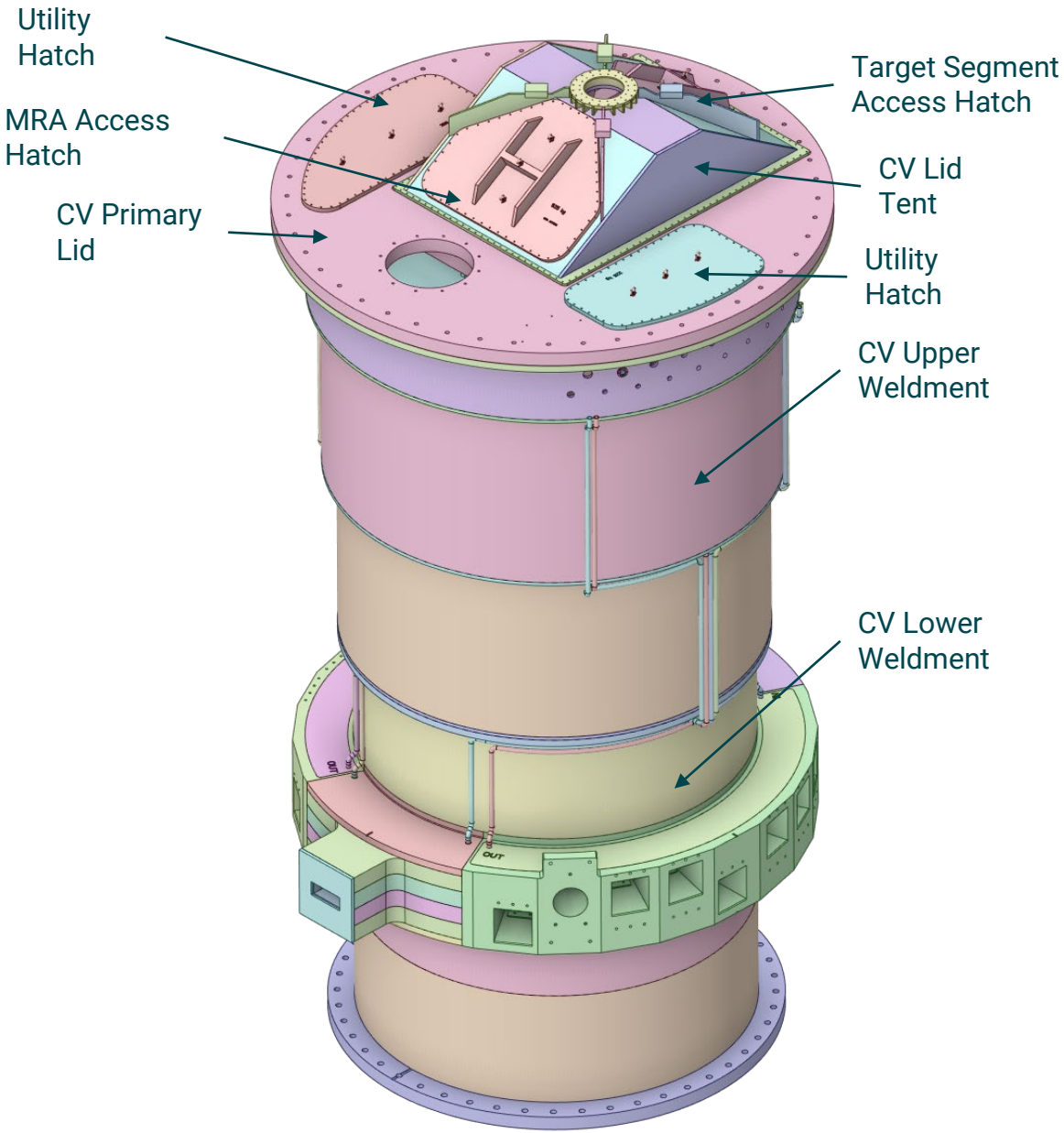
Target Station Shielding



Vessel Systems Scope



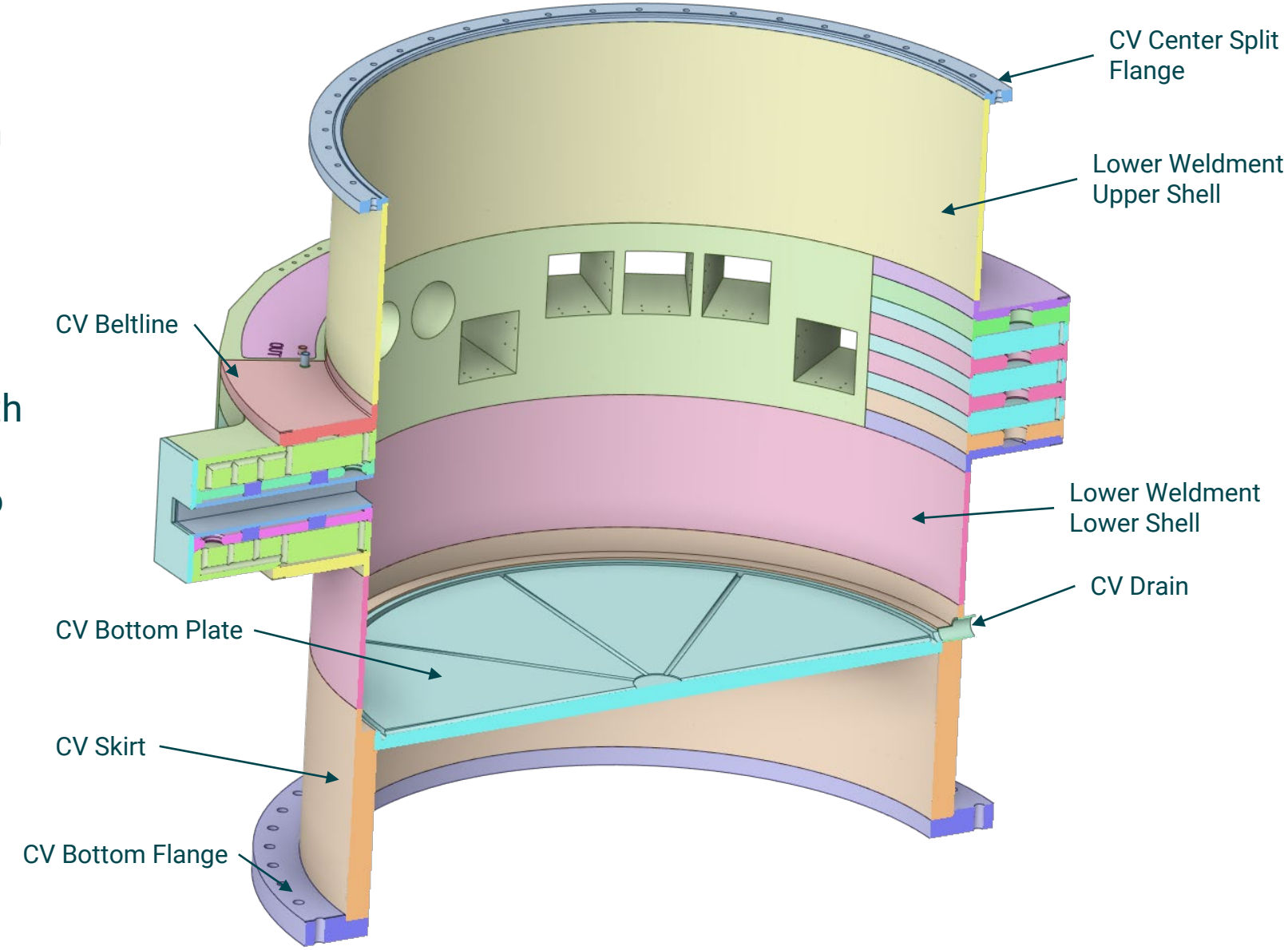
Core Vessel Assembly



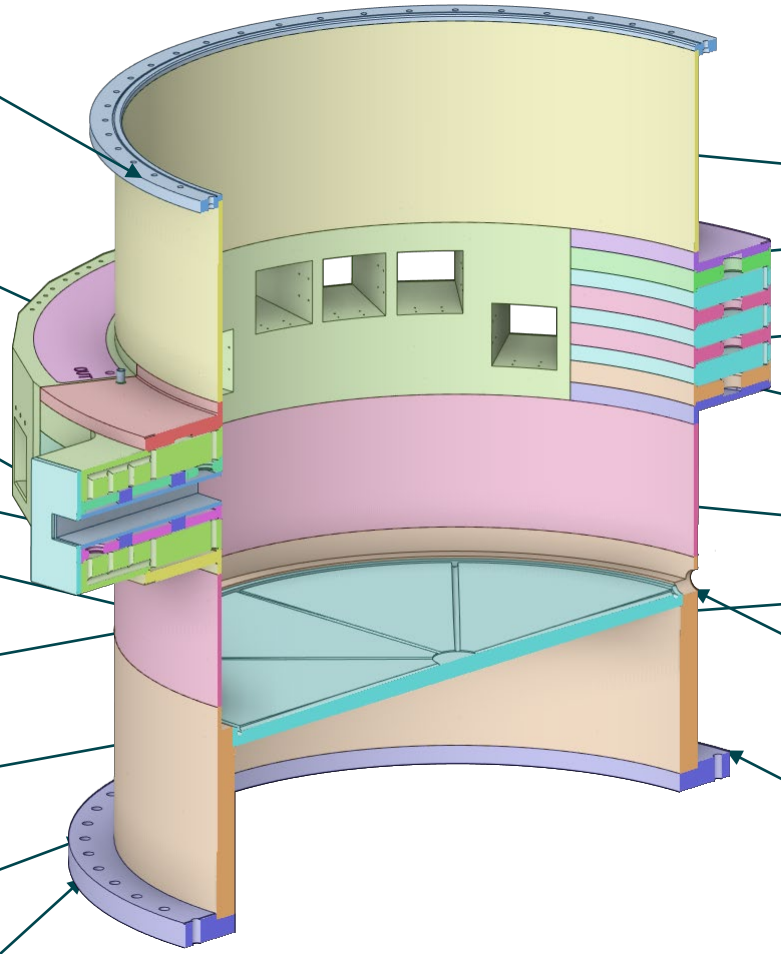
Core Vessel Lower Weldment Details

Key Features:

- Contain CV environment (vacuum or helium)
- Support internal shielding and technical components
- Leak collection and draining
- Allow passing of proton beam
- Support and alignment of monolith inserts containing guide optics
- Minimal thermal deflection due to beam operation required to maintain guide optic alignment
- Design for manufacturability to reduce procurement cost and schedule



Core Vessel Lower Weldment Details



CV Split Flange with weld prep and o-ring groove

Dual Channel and QIKR nozzle extensions weld to ID of beltline

PBW Sealing Interface

Proton Beam Clearance Opening

Sits below tan skirt shelf

Weight of internal shielding supported here

100 mm thick rolled and welded shell

Clearance holes allow for CV fine alignment

100 mm thick flange bolts to CV Baseplate

25 mm rolled and welded vacuum shell

Flood cooled north and south beltline quadrants

Monolith insert alignment shim mounting holes

Laminated east and west beltline quadrants

25 mm rolled and welded vacuum shell

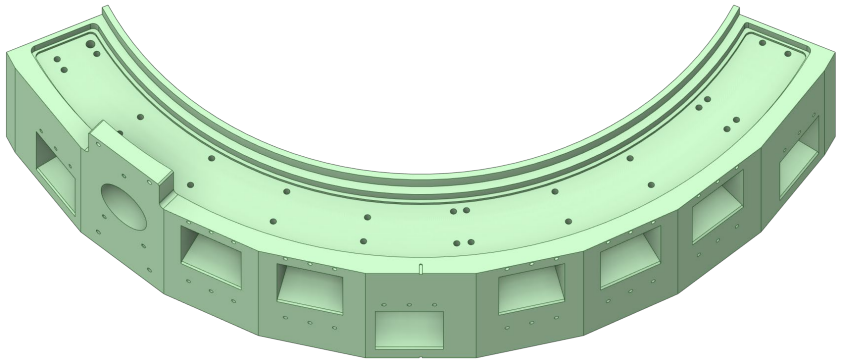
Drainage grooves

Core Vessel drain hole

Alignment Notches set orientation of CV in monolith

Core Vessel Beltline Details

Forged cooling block design



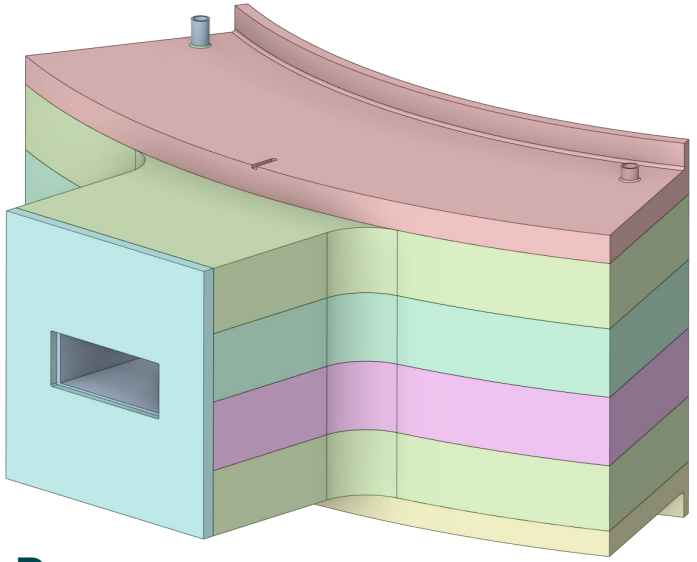
Pros

- Much less welding
  - Less weld distortion
  - Less post-weld machining
  - Greater reliability
- Greater flexibility in cooling designs

Cons

- Raw material cost is higher
- Limited suppliers for large forgings

Laminated cooling block design

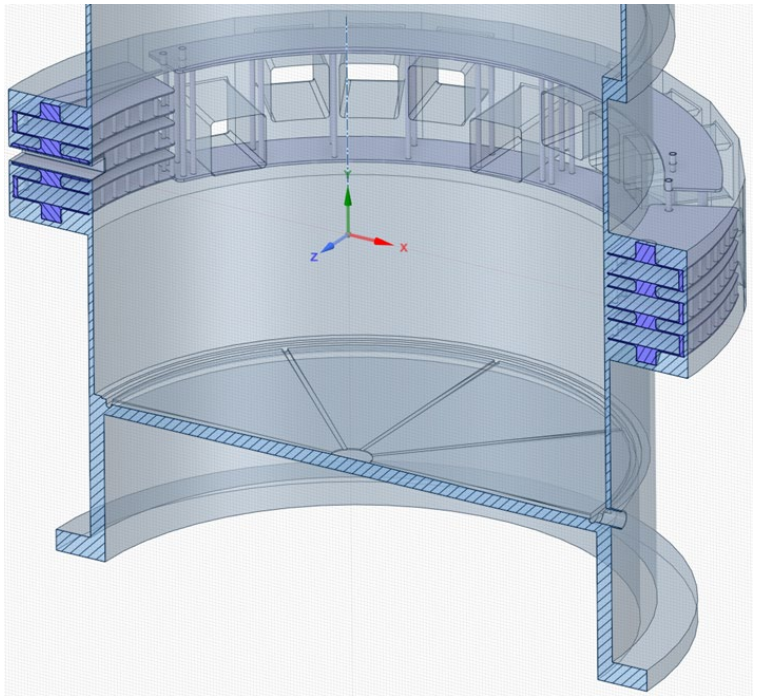


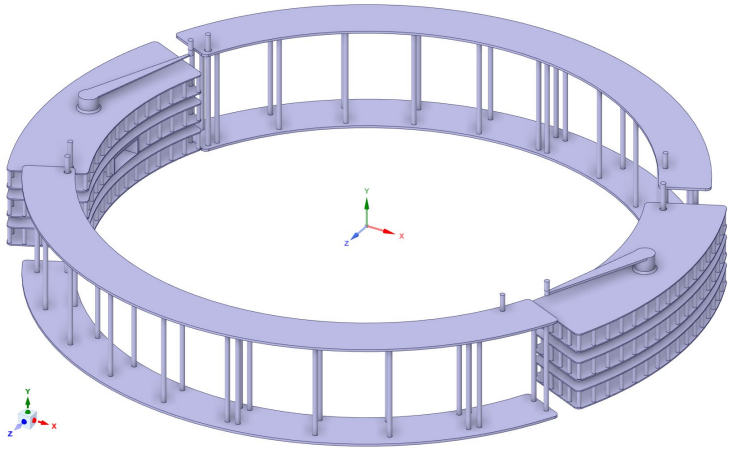
Pros

- 316 plates are easy to source

Cons

- Complex welding required
- Extensive post-weld machining
- Reduced reliability



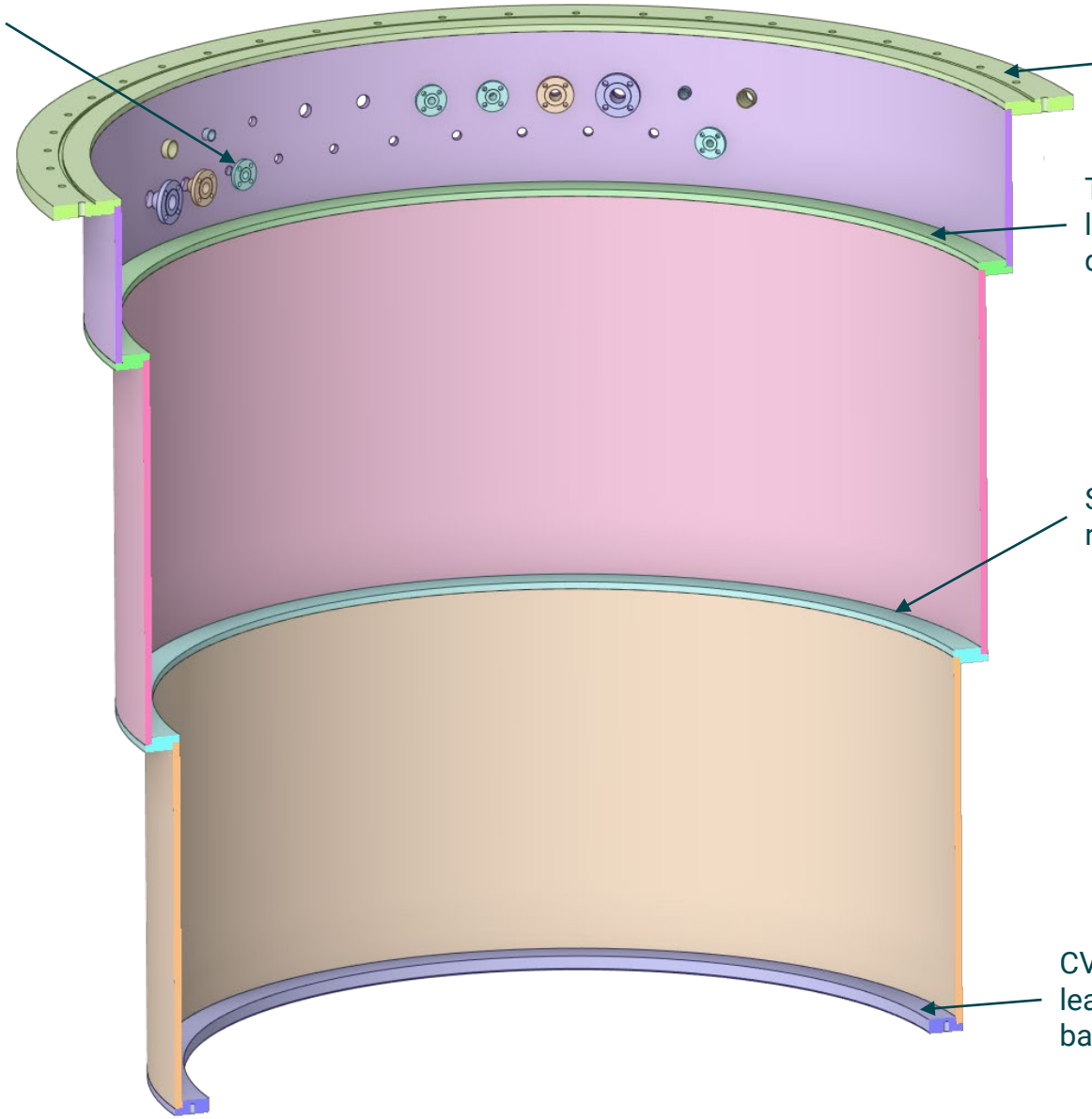


Core Vessel Upper Weldment Details

Utility nozzles accommodate water cooling, helium filling and sensor passthroughs

Key Characteristics:

- Contain CV environment (vacuum or helium)
- Minimize radiation shine up CV side walls
- Leak collection and draining
- Minimal thermal deflection due to beam operation required to maintain target alignment
- Design for manufacturability to reduce procurement cost and schedule
- Accommodate all utility feedthroughs with spares for flexibility during operational life



Thick top flange to reduce vacuum induced deflections

Top step allows for utility lines to clear shield blocks during vertical removal

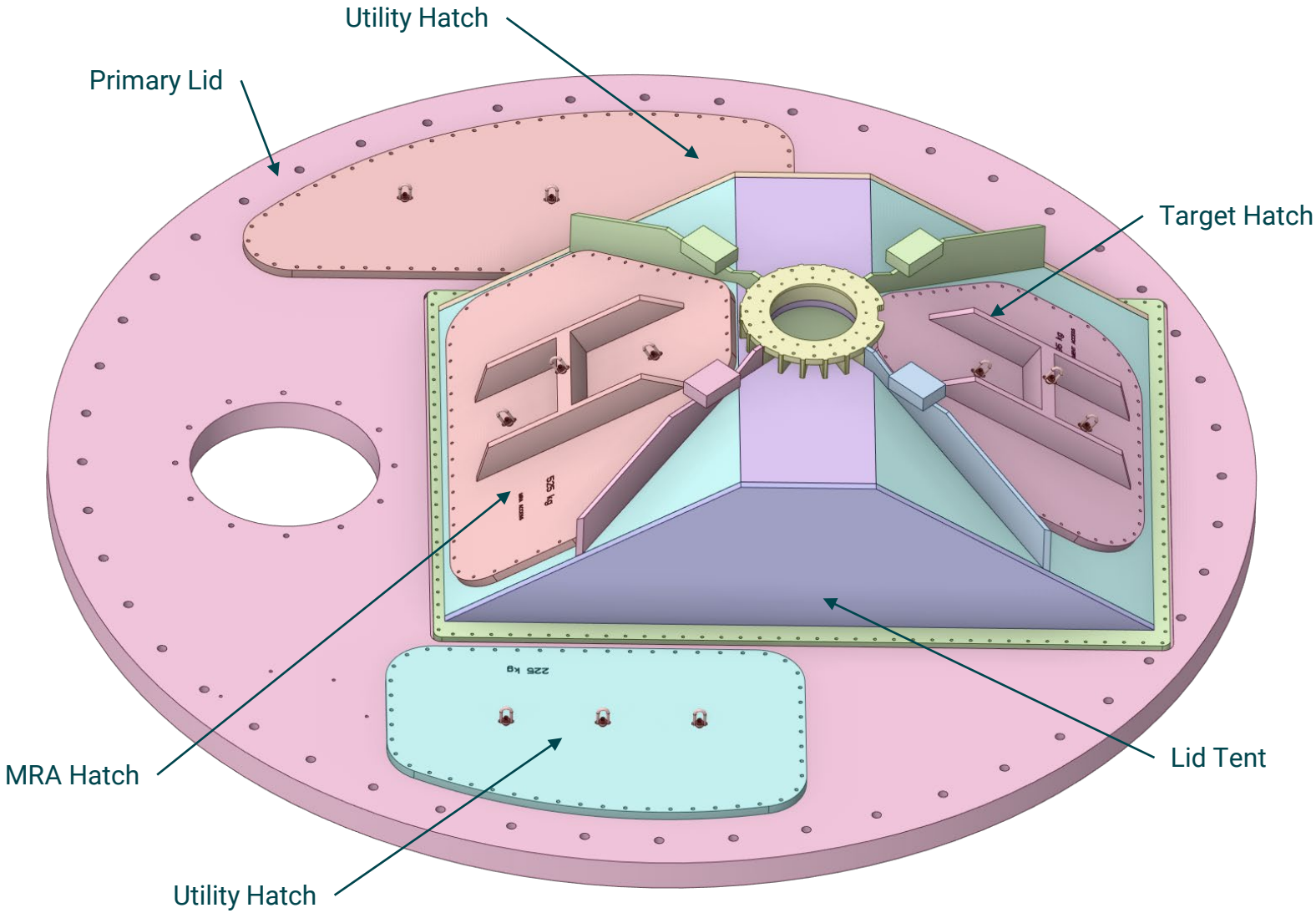
Steps in sidewall to reduce radiation shine

CV Split Flange allows for factory leak testing, installation via high bay crane, and welded final seal

Core Vessel Lid Assembly Details

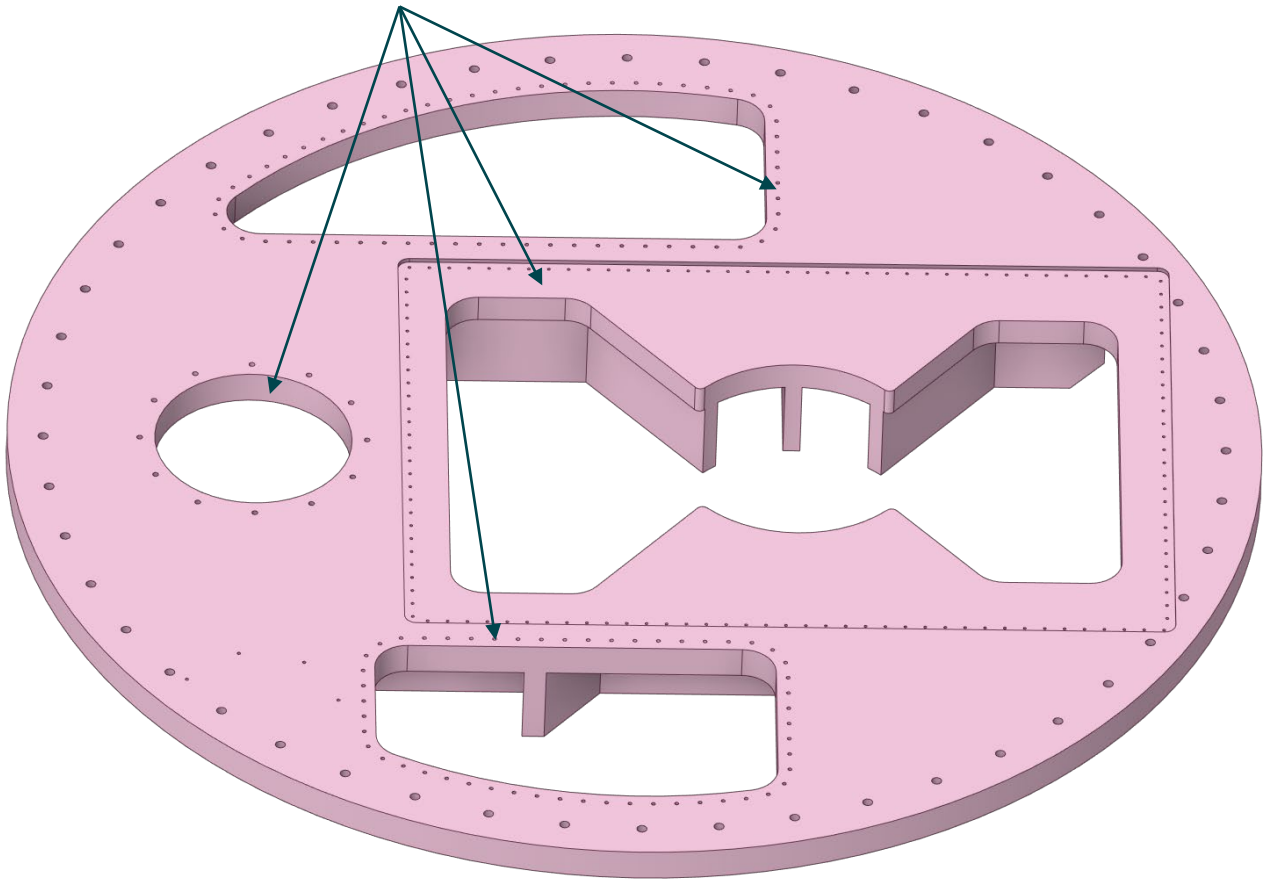
Key Characteristics:

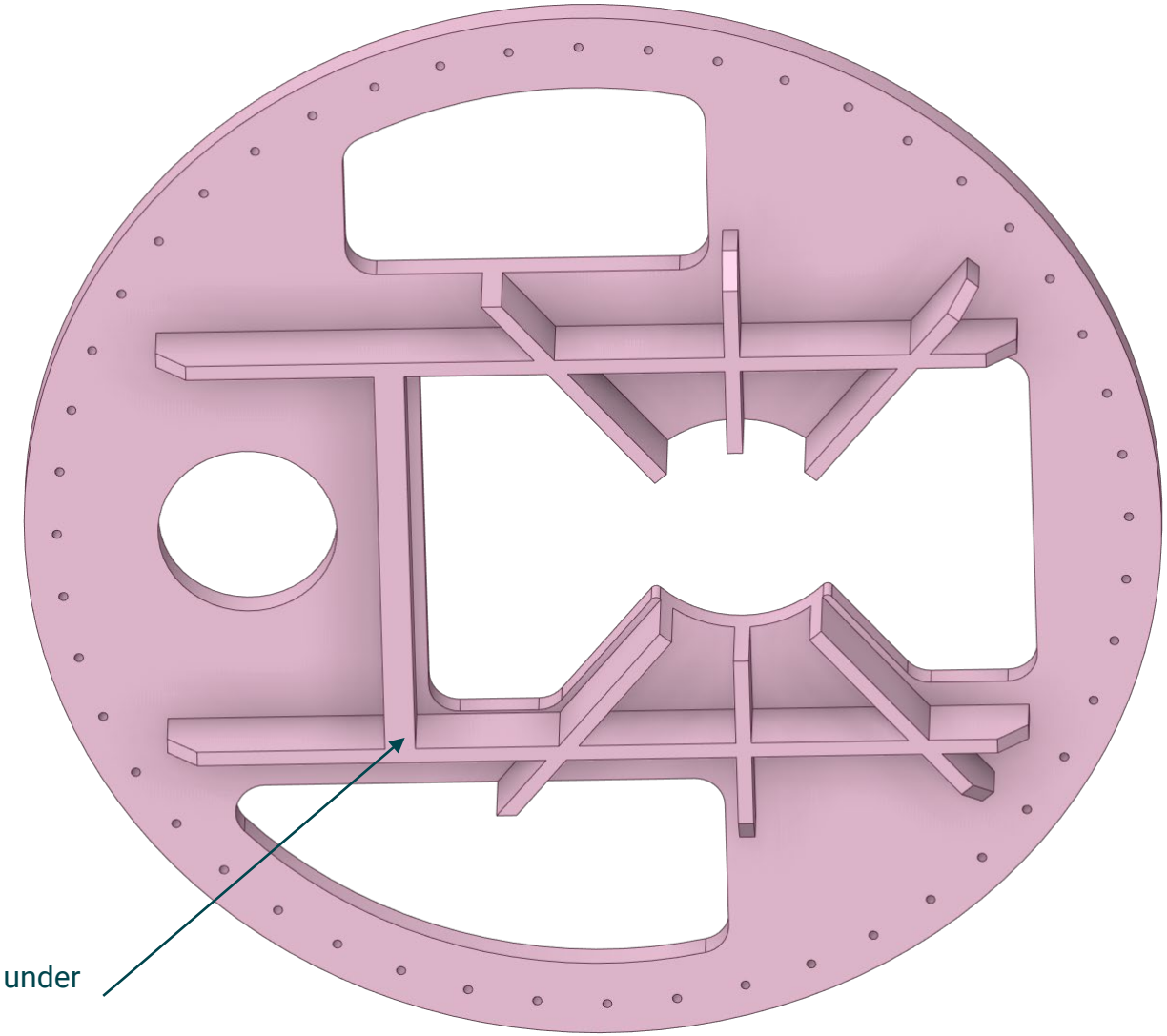
- Contain CV environment (vacuum or helium)
- Support target assembly mass
- Minimize all target flange deflections
- Design for manufacturability to reduce procurement cost and schedule
- Enable MRA, Target segment and TVP removal
- Provide access to CV interior utility connections



Core Vessel Primary Lid Details

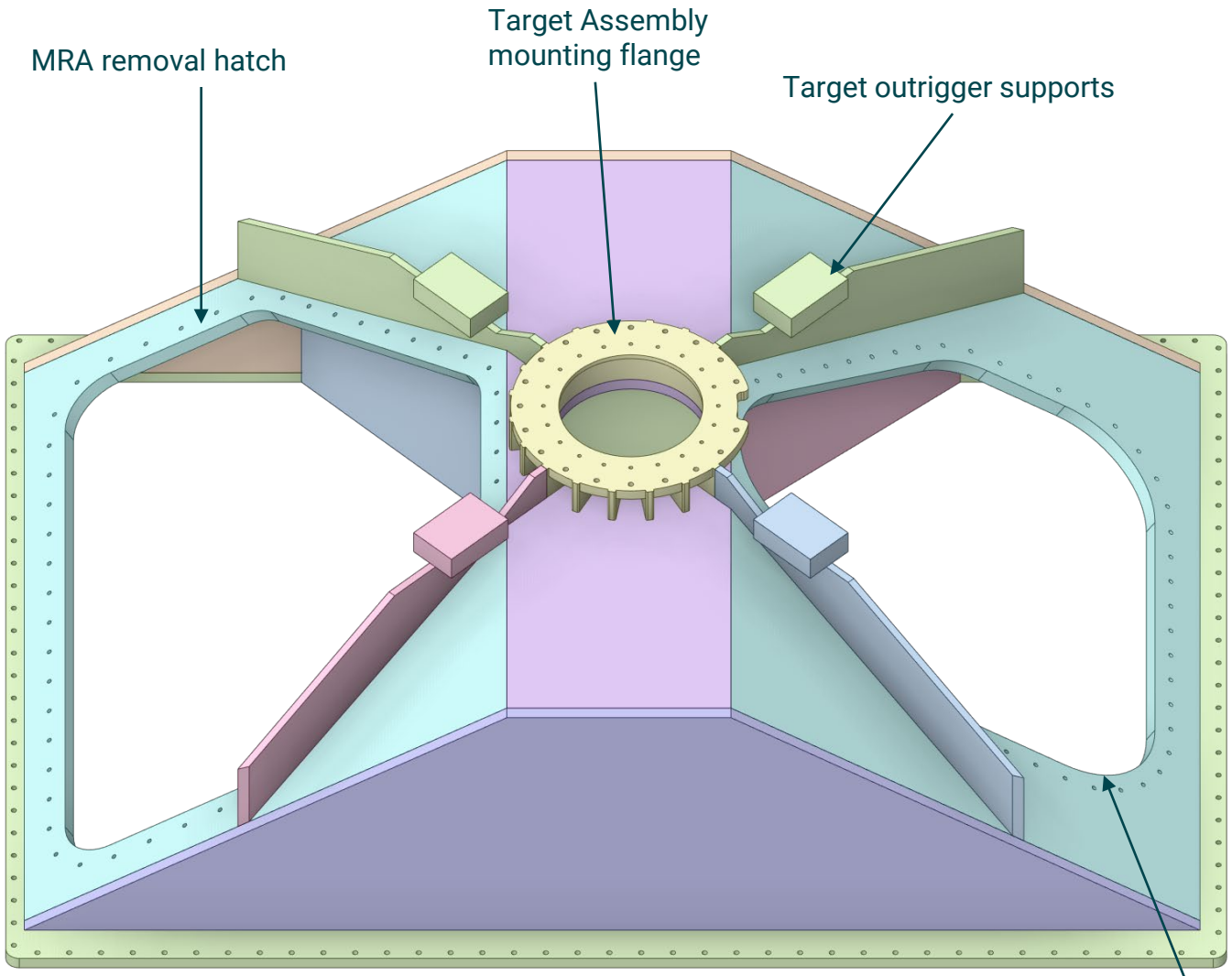
TVP, tent and hatch covers with bolt patterns and sealing surfaces

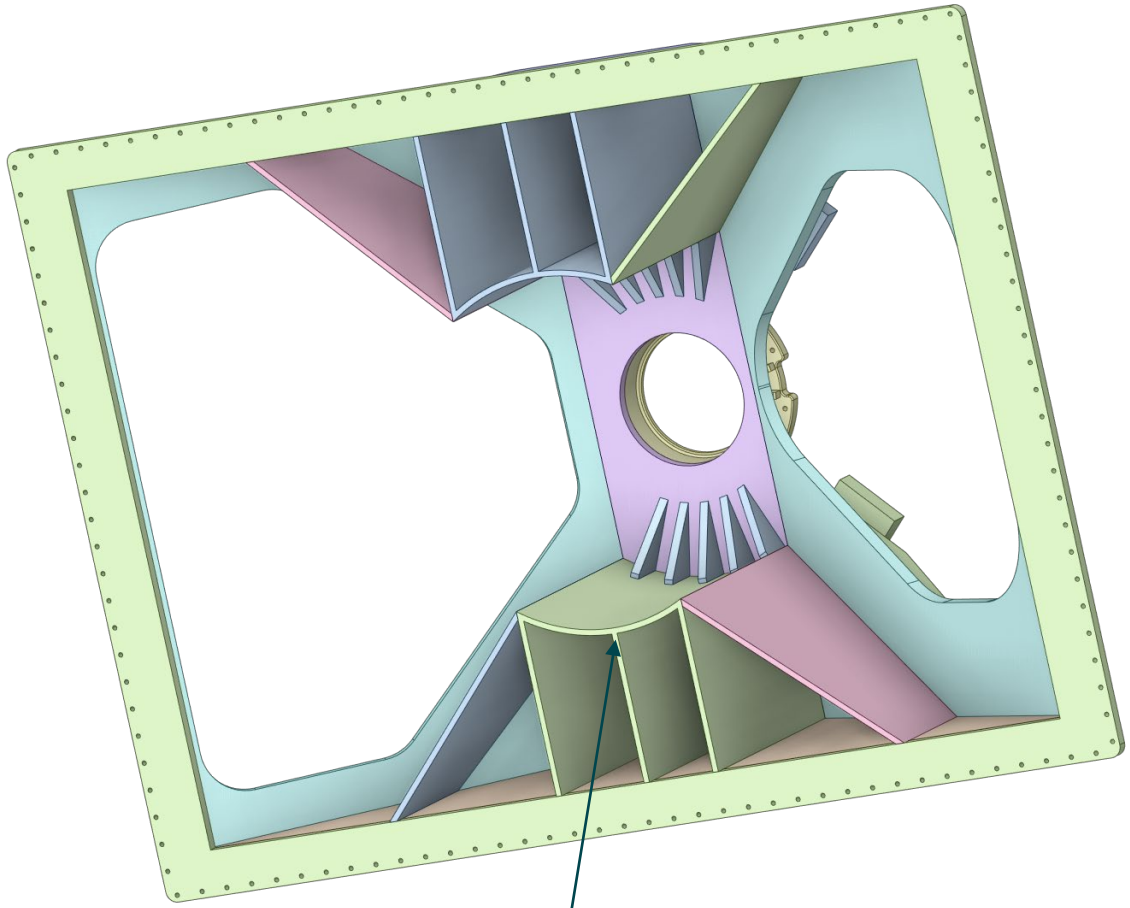




Stiffening ribs to reduce lid deflections under gravitational and vacuum loading

Core Vessel Lid Tent Details



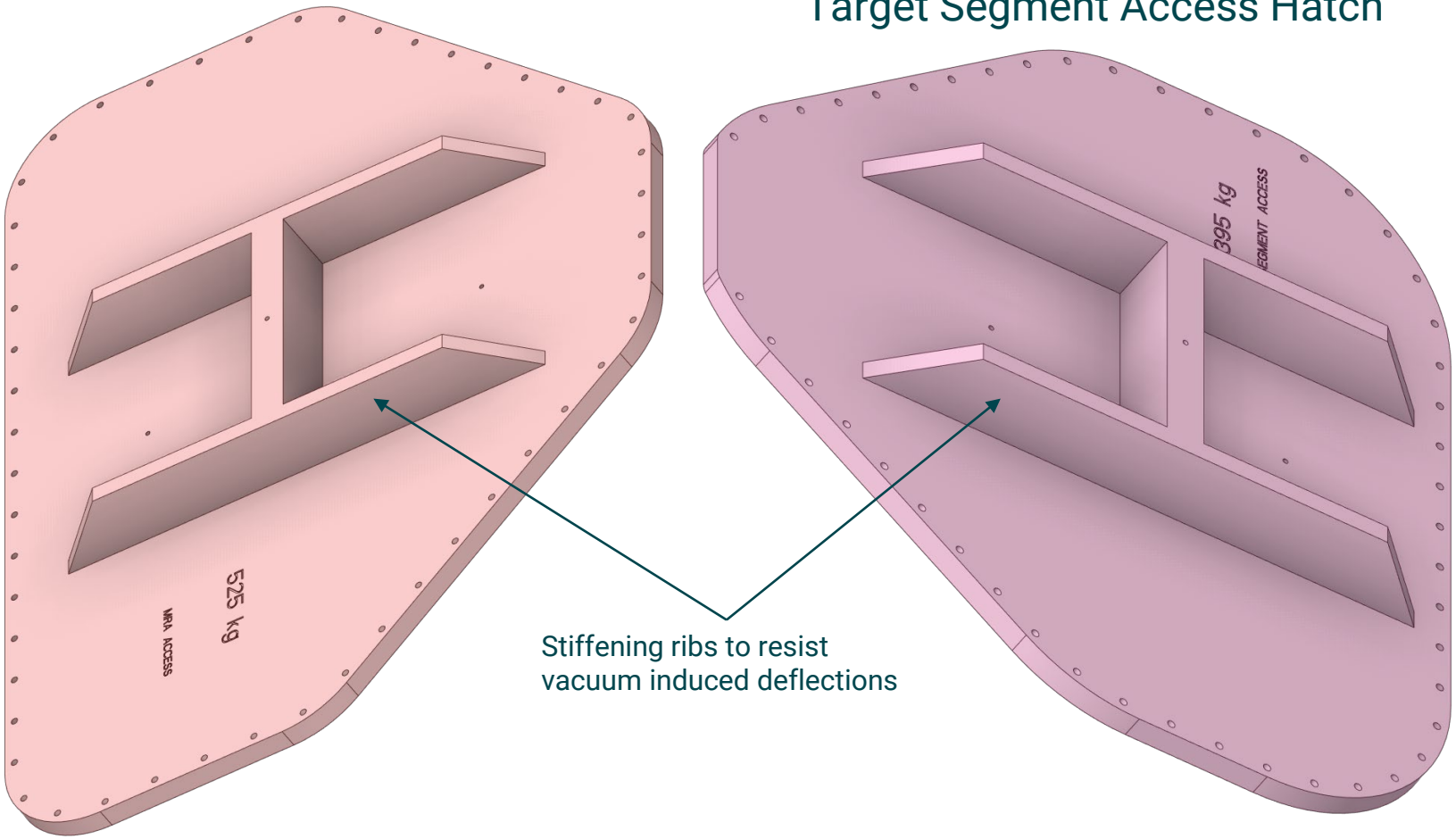


***Tent is captured by the target shaft

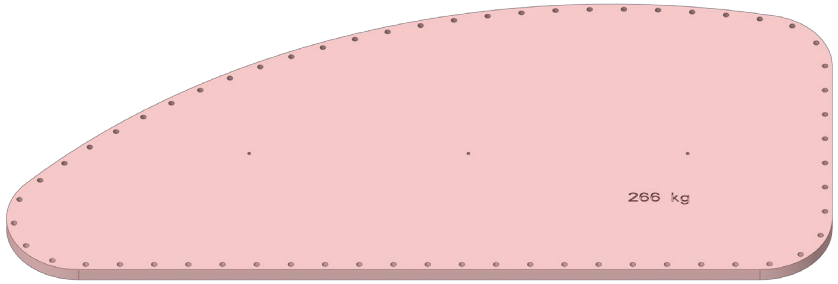
Core Vessel Lid Hatch Details

MRA Access Hatch

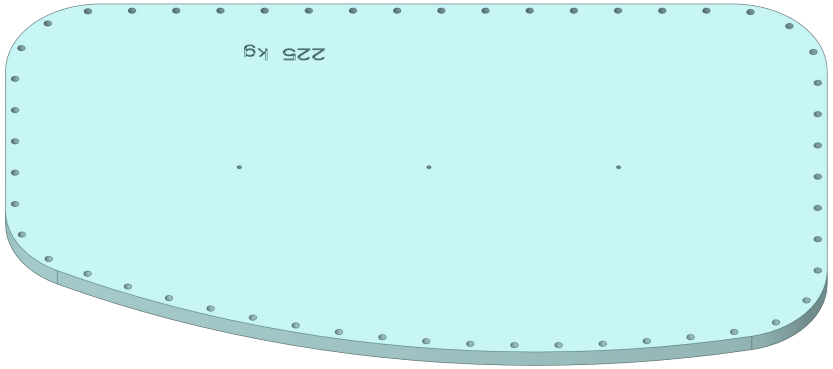
Target Segment Access Hatch



Stiffening ribs to resist vacuum induced deflections



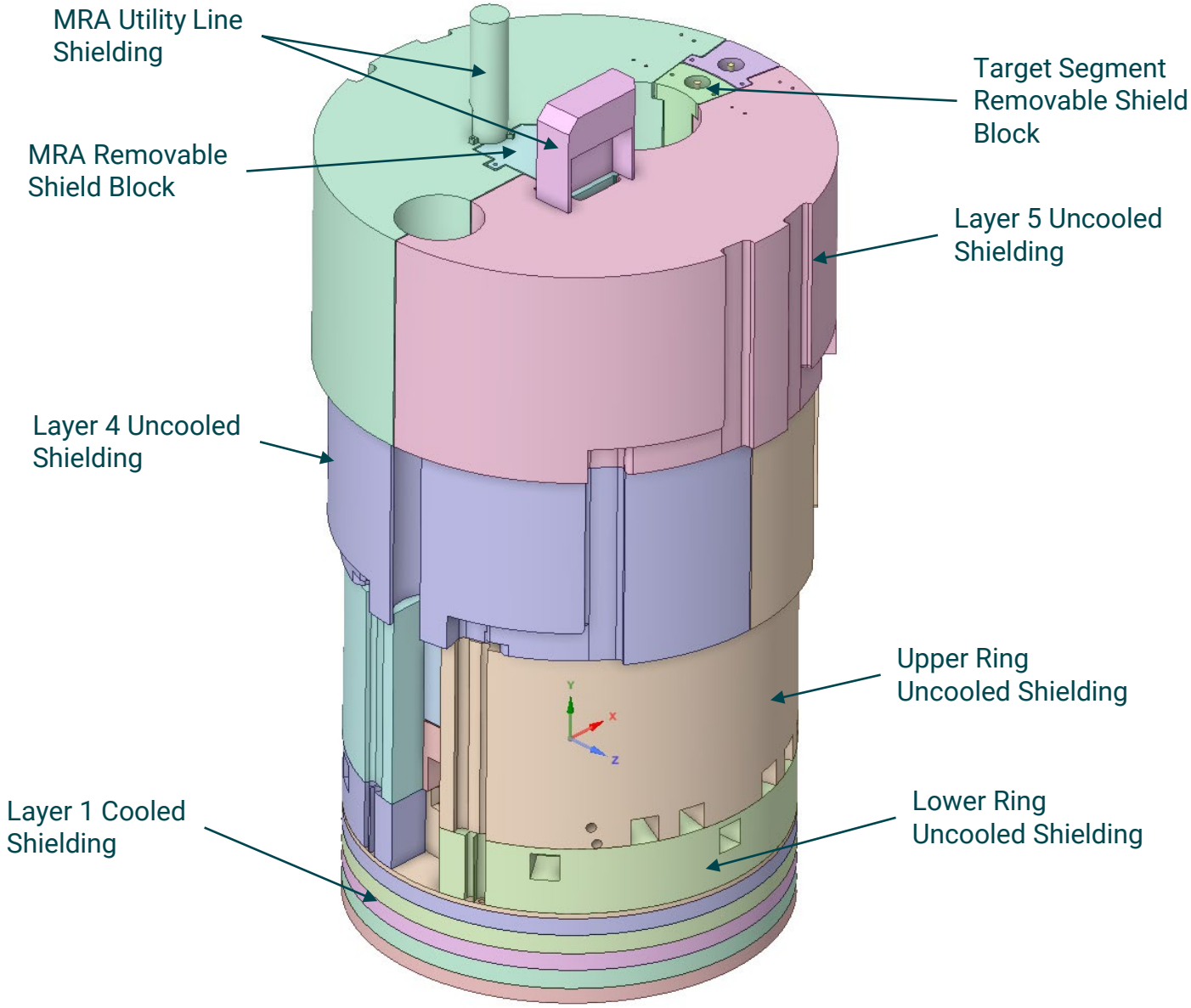
Utility Hatches



Core Vessel Shielding

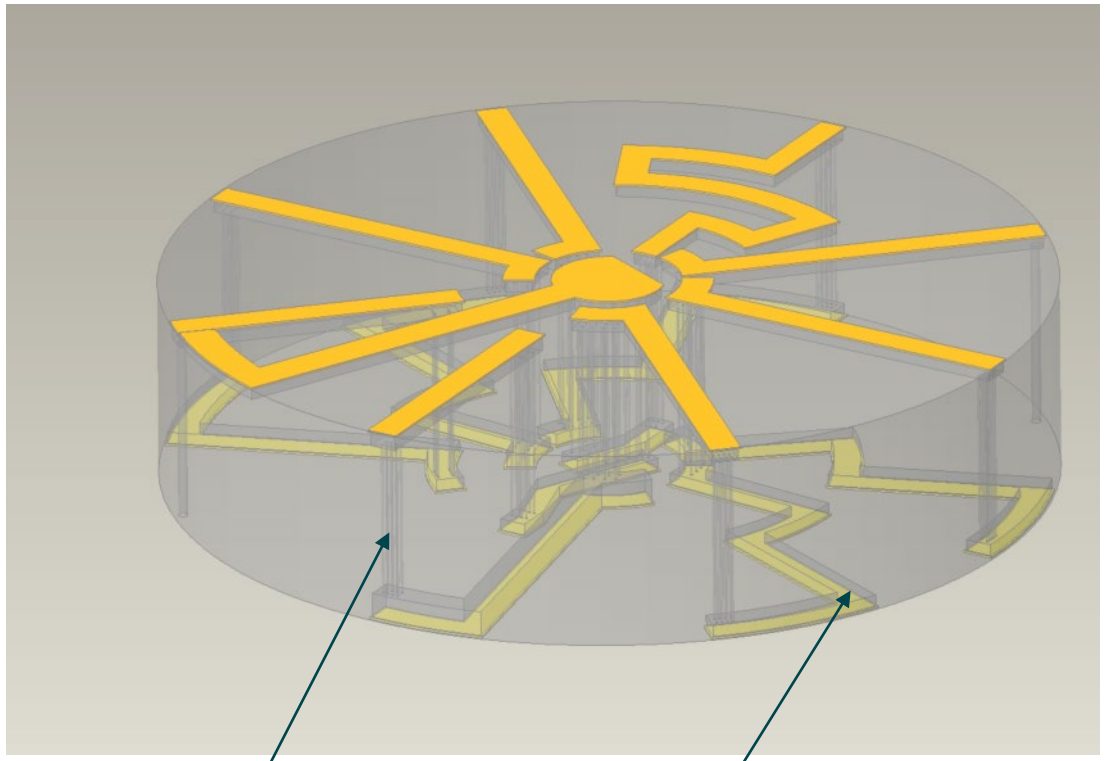
Key Characteristics:

- Provide radiation shielding
- Minimize thermal deflection of surfaces interfacing with technical components
- Allow for vertical extraction of the target segments, MRA and TVP
- Allow for vertical extraction of target shaft
- Minimize radiation streaming
- Protect the MRA hydrogen lines from physical damage
- Provide clear neutron flight paths between MRA and guide optics
- Provide clear proton flight path
- Restrain target during seismic event
- Support and align MRA

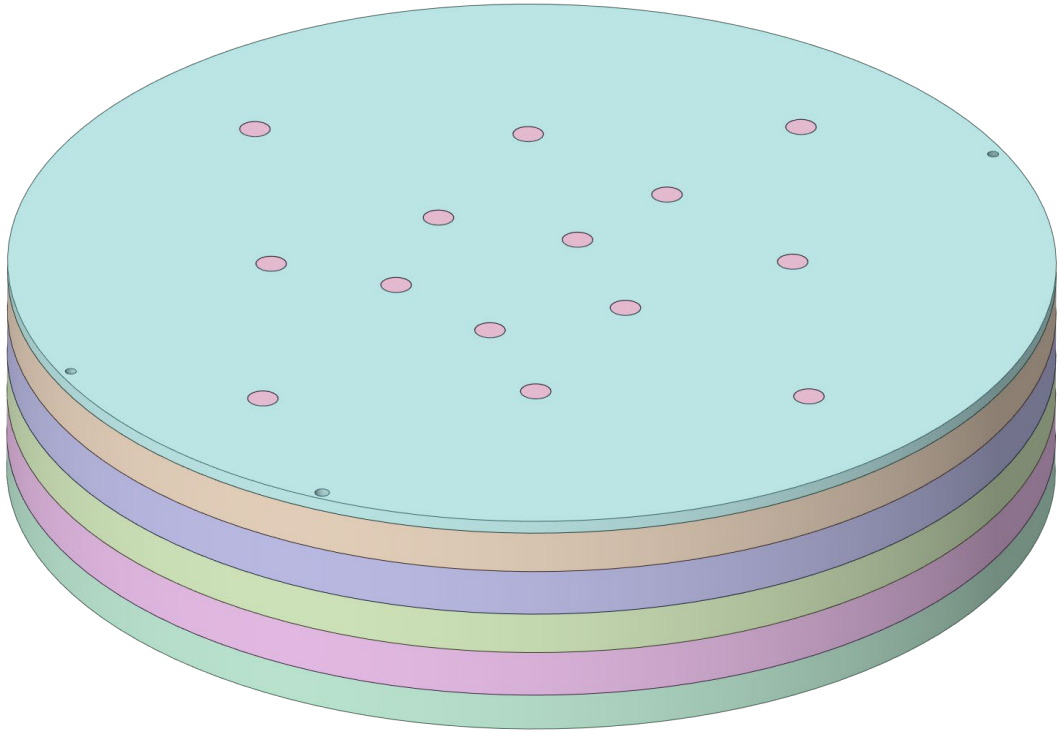


CV Shield Block #1 Details

Current gun drilled forged design

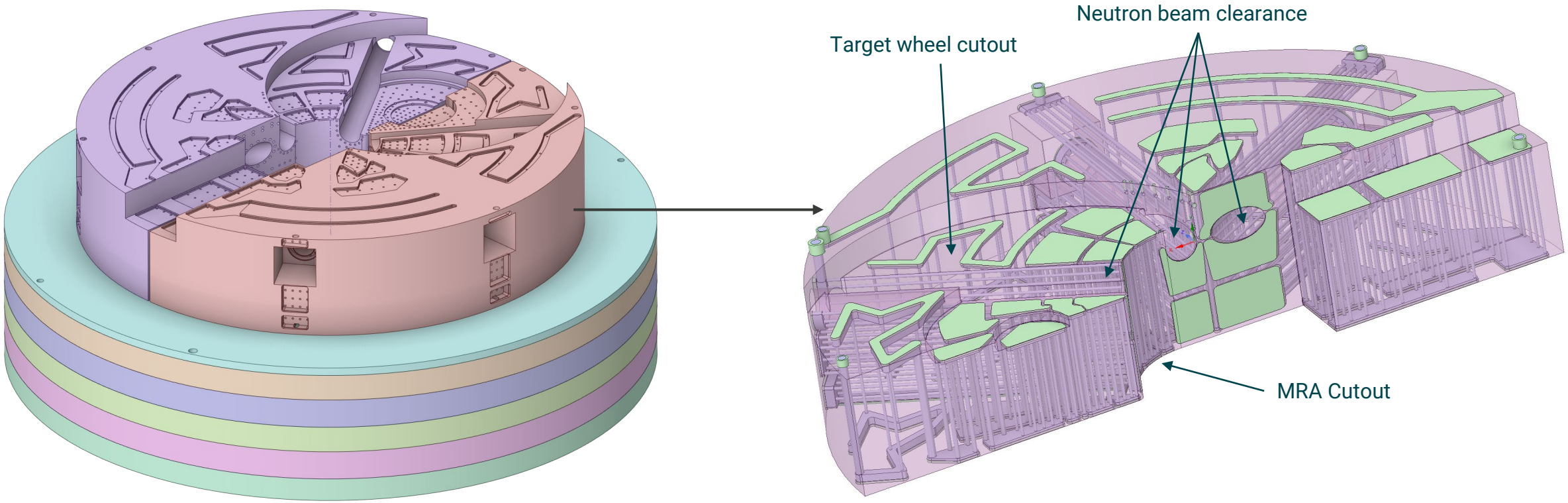


Previous laminated plate design



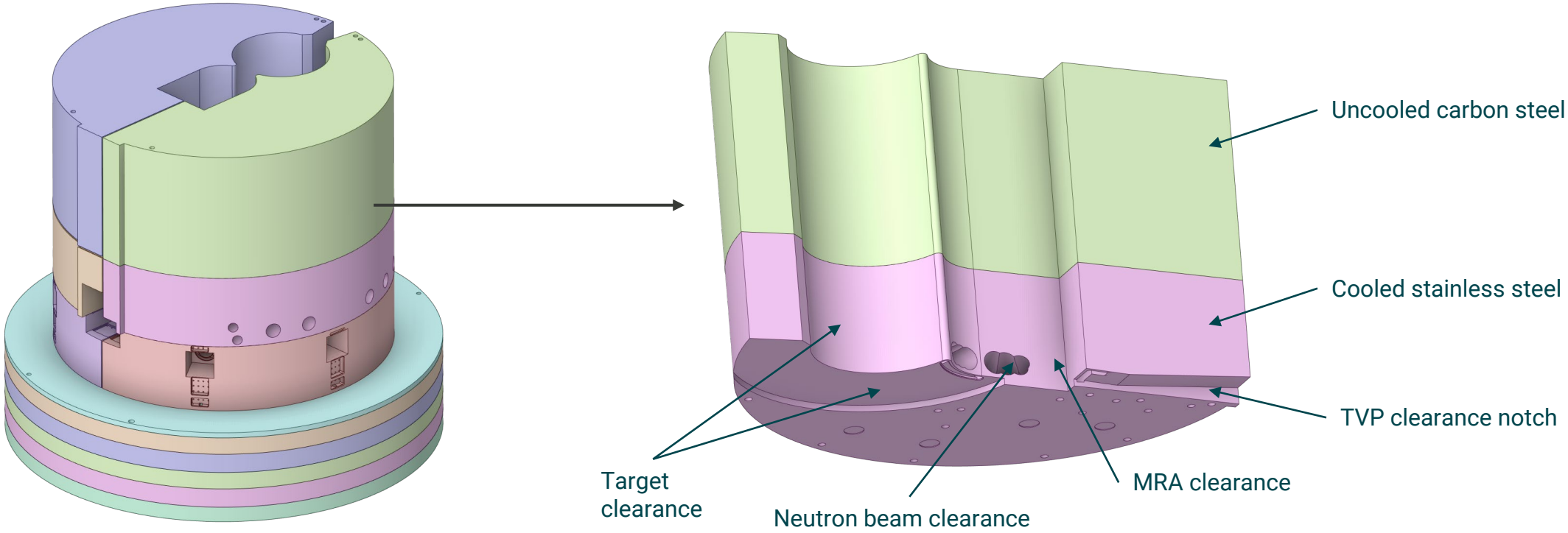
- Current design is transitioning from stacked plate design to machine forging design
  - Superior pressure-bearing performance
  - Significantly less welding
- MRA supported off of this shield block

CV Cooled Shield Block Layer 2 Details



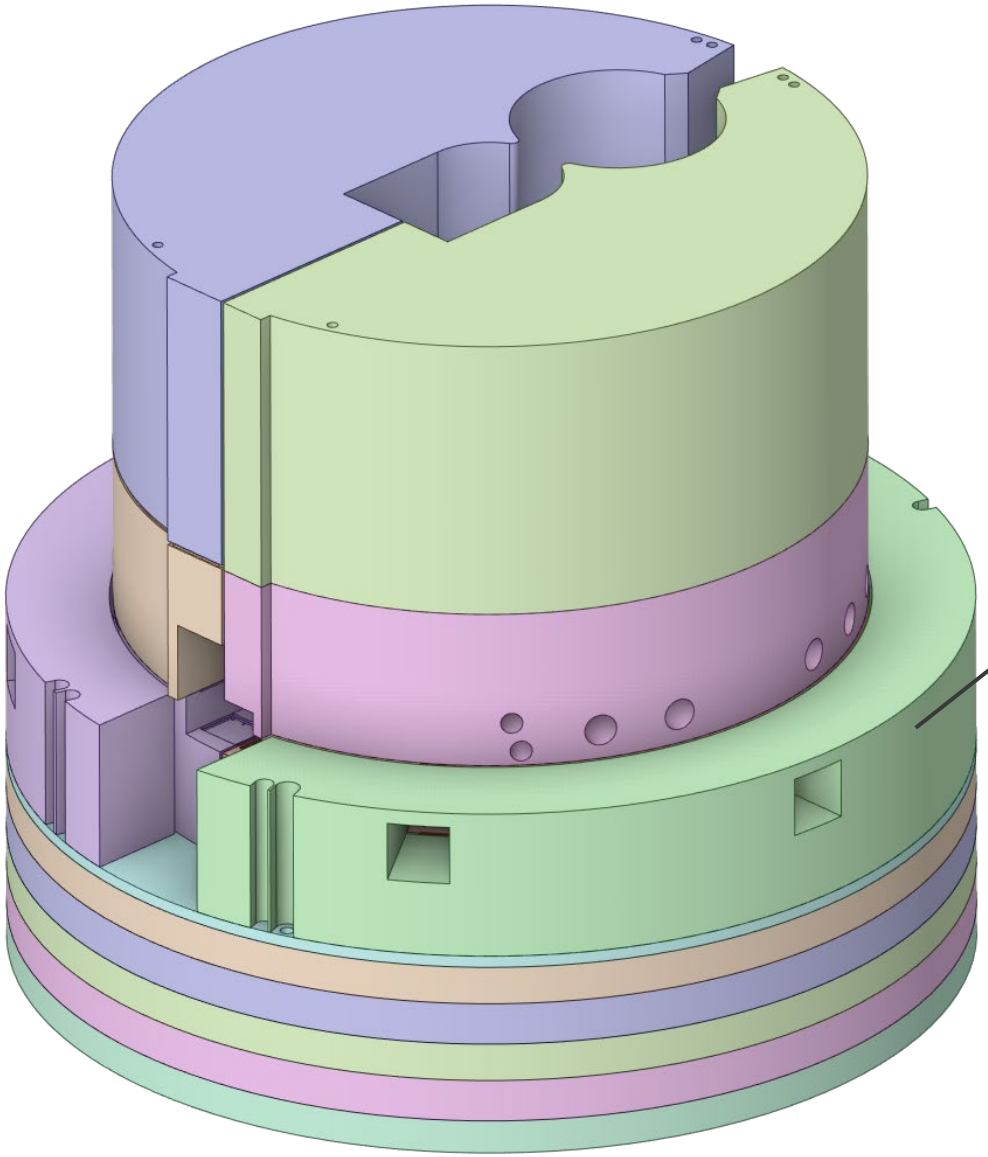
- Current design is transitioning from stacked plate design to machine forging design
  - Superior pressure-bearing performance
  - Significantly less welding
- Target snubber ring mounted to these shield blocks
- Lower neutron beams (6x total) pass through these shield blocks
- High heat loads require complex cooling scheme

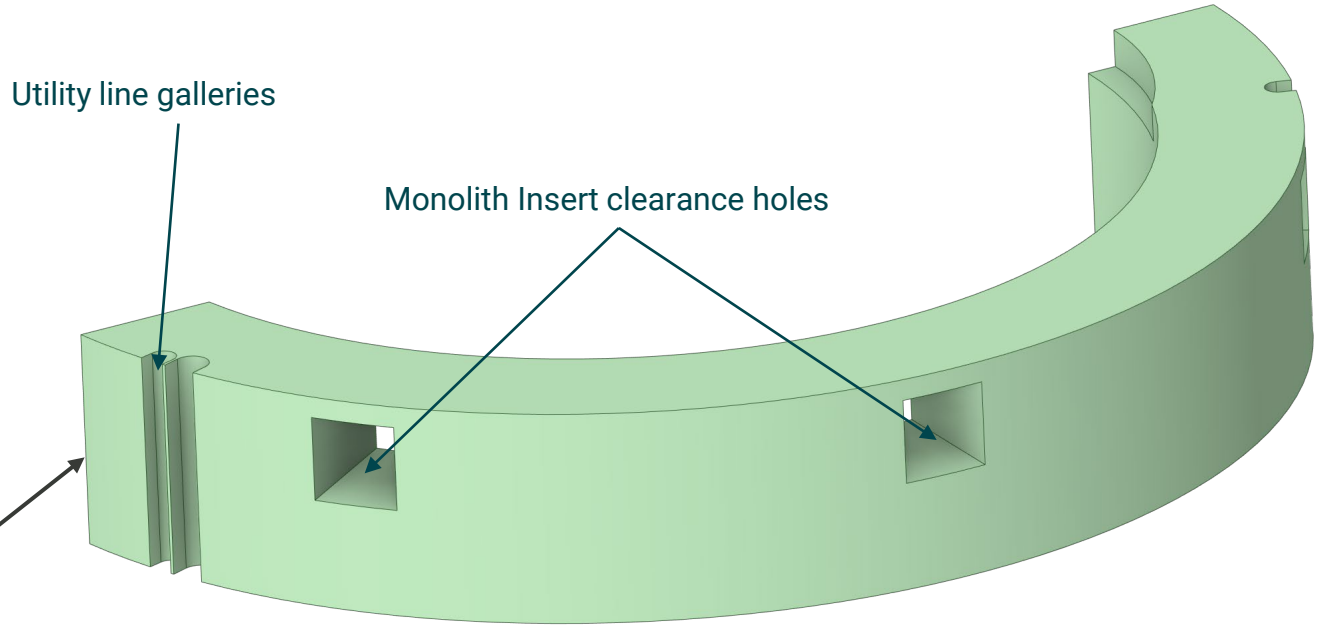
CV Cooled Shield Block Layer 3 Details



- Current design is transitioning from stacked plate design to machine forging design
- Development of layer 3 shielding has intentionally lagged behind layer 2 due to their similar thermal profiles
- Target and MRA are surrounded by these shield blocks
- Upper neutron beams (12x total) pass through these shield blocks
- High heat loads require complex cooling scheme

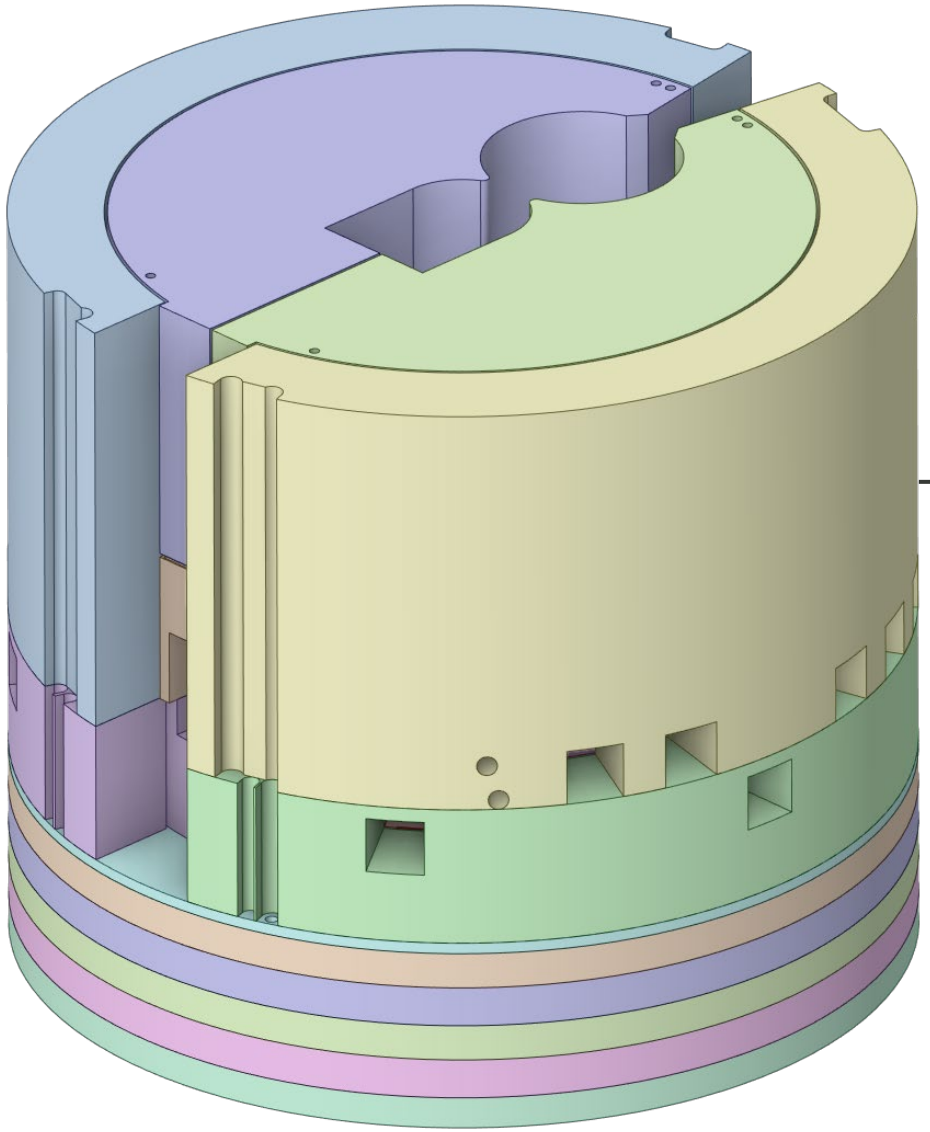
CV Lower Ring Shielding Details

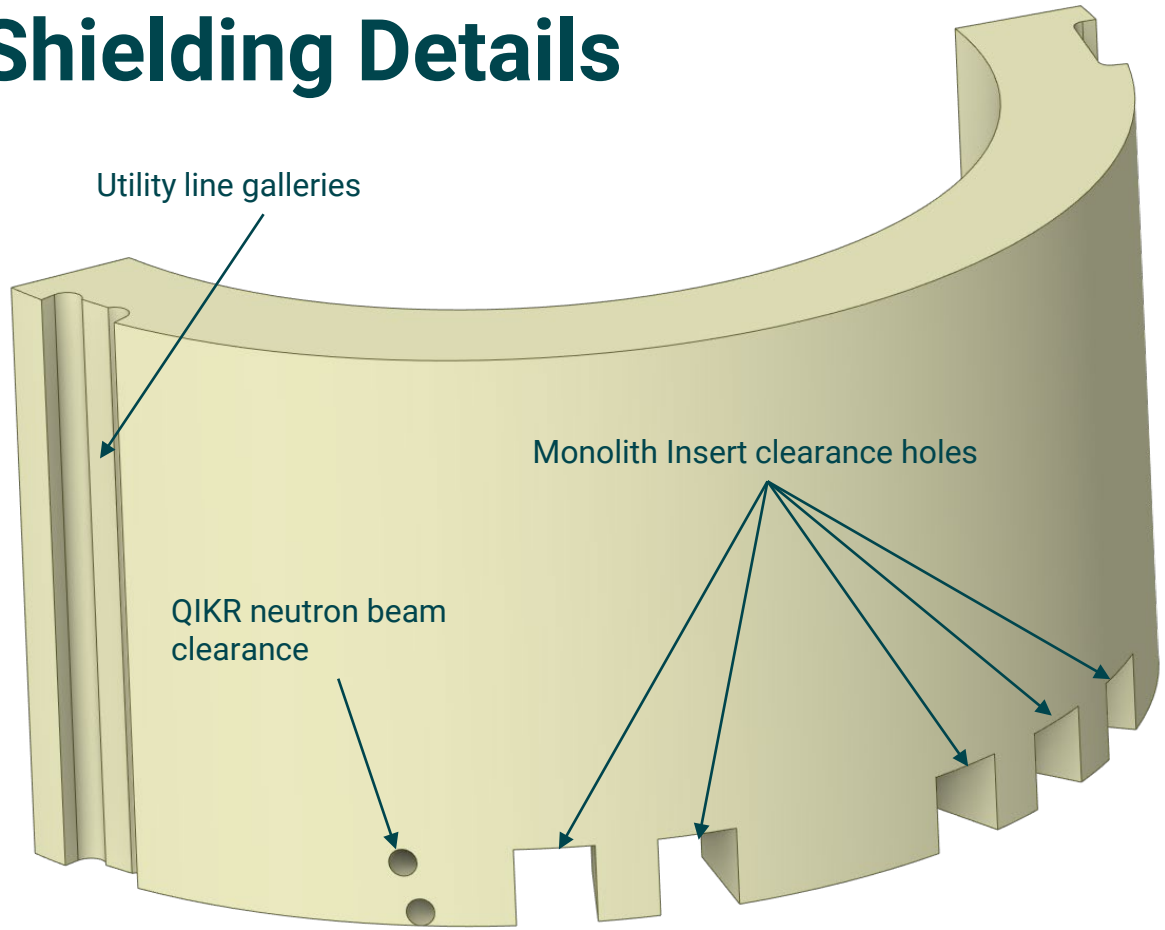




- Carbon steel ring shields serve two primary purposes:
  - Facilitate extraction of a fully populated target assembly that is unable to rotate
  - Reduce the volume of cooled shielding, reducing CV shielding costs

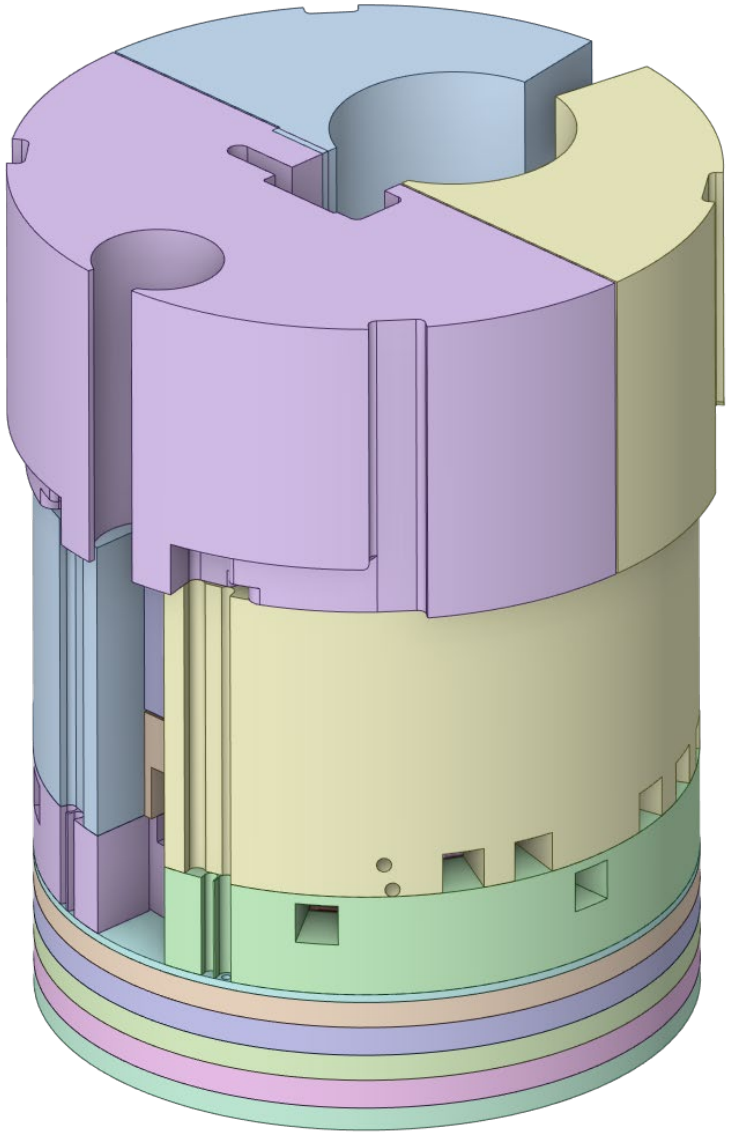
CV Upper Ring Shielding Details

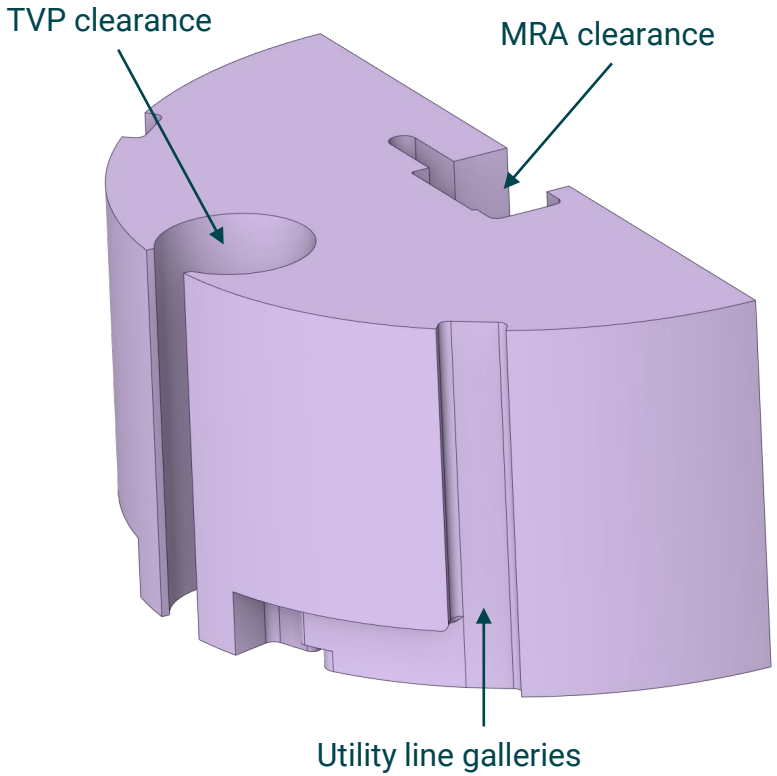


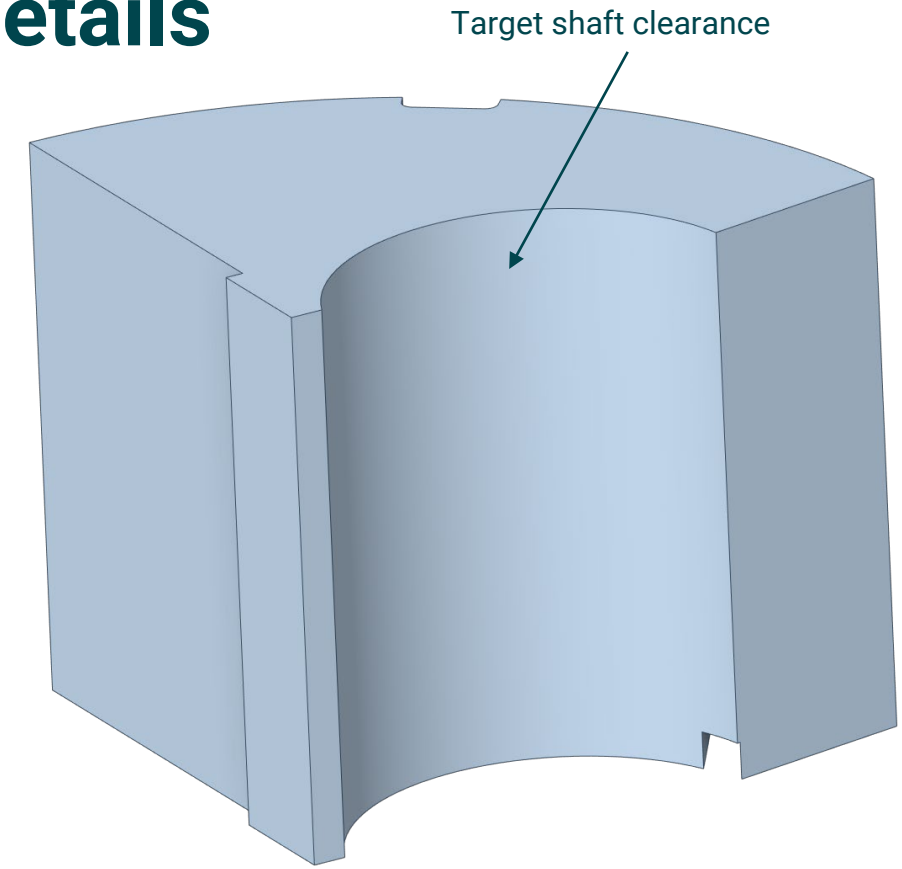


- Carbon steel ring shields serve two primary purposes:
  - Facilitate extraction of a fully populated target assembly that is unable to rotate
  - Reduce the volume of cooled shielding, reducing CV shielding costs

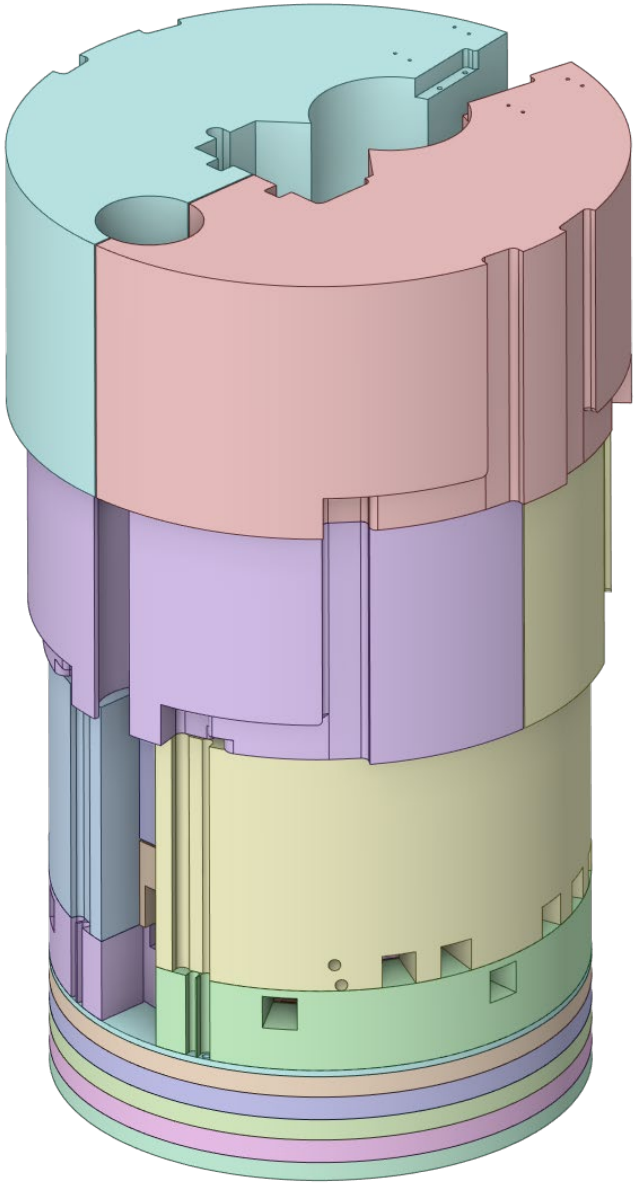
CV Layer 4 Shielding Details

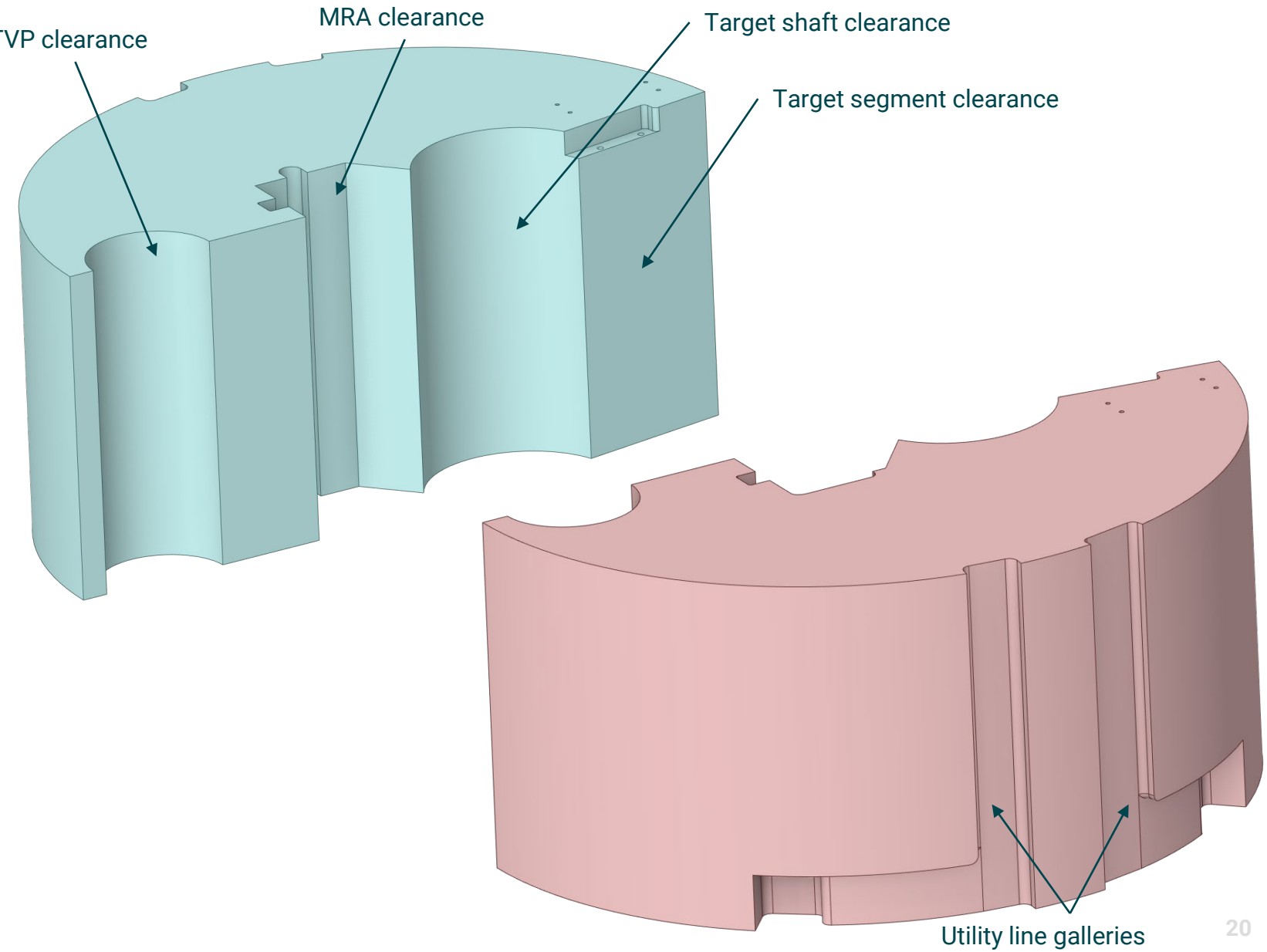




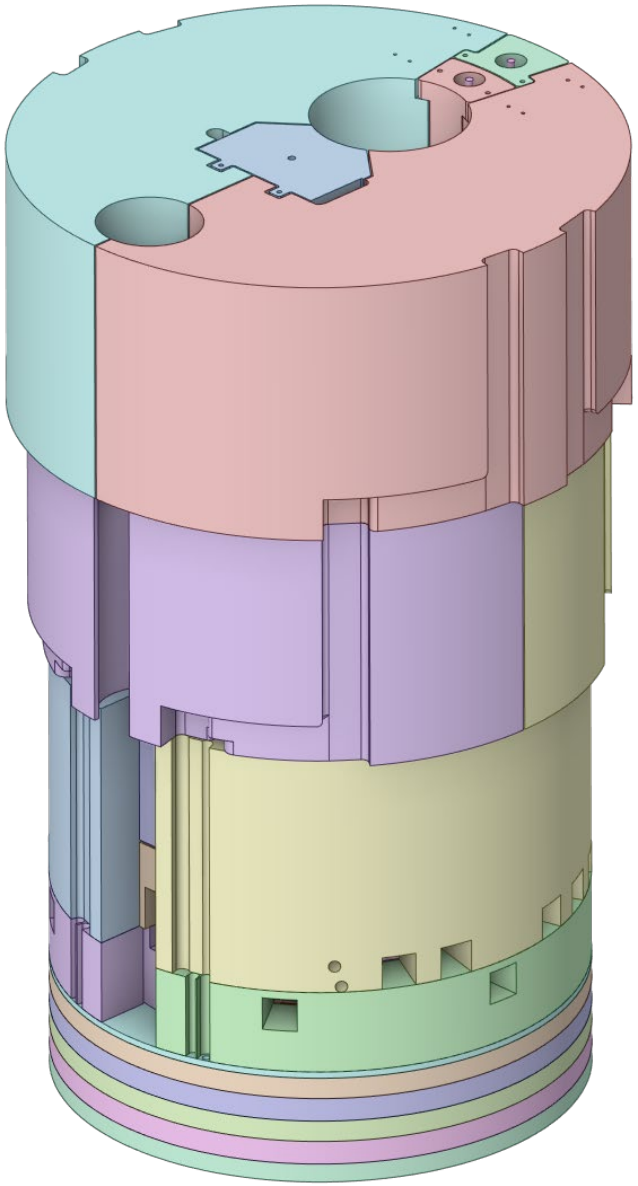


CV Layer 5 Shielding Details

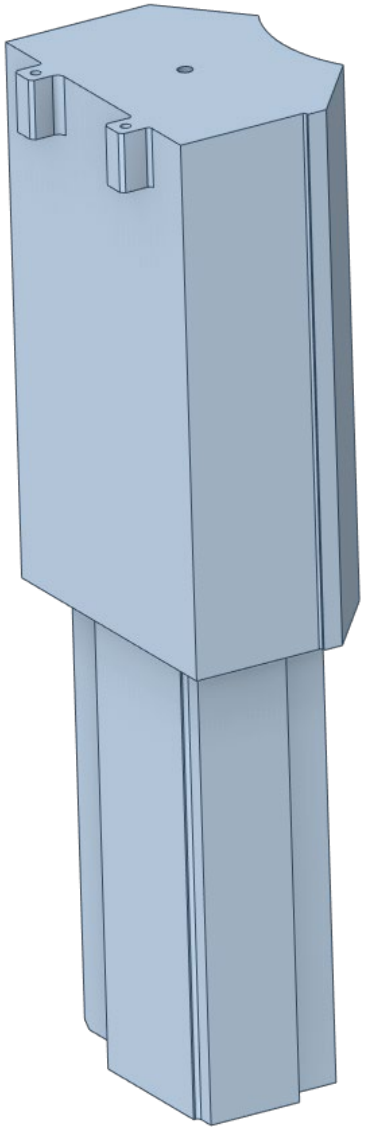




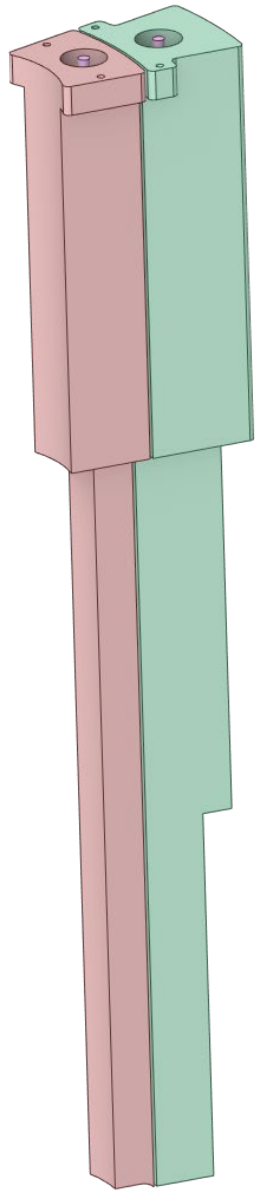
CV Removable Shielding Details



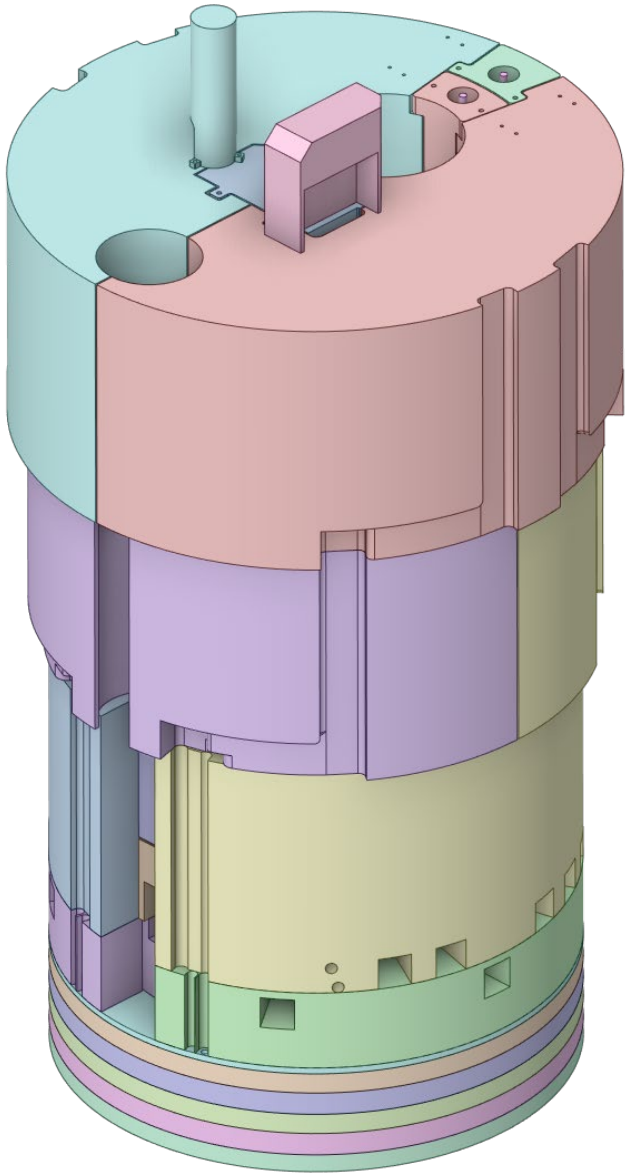
MRA removable shield block



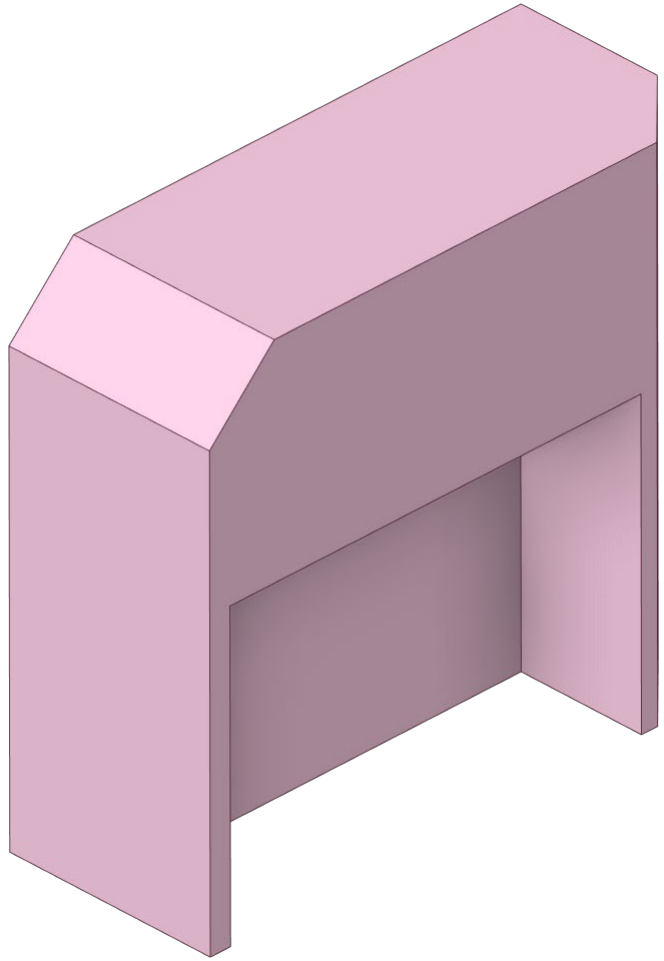
Target segment removable shield block



CV MRA Utility Shielding Details

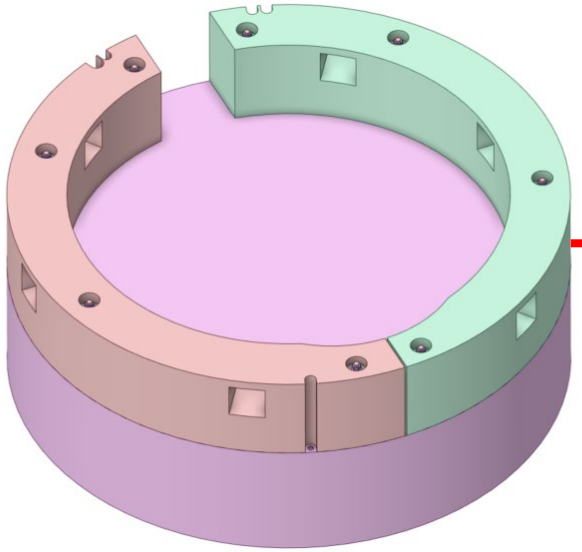


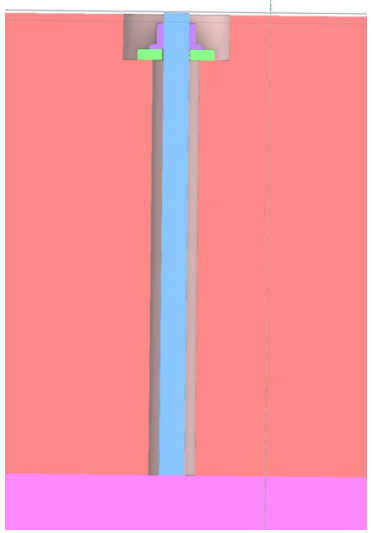
MRA utility line shine shield

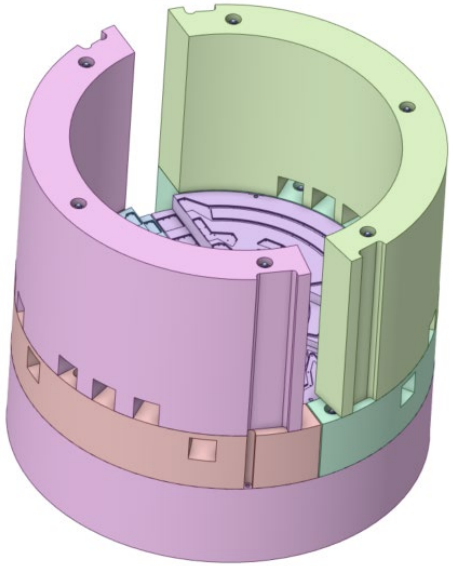


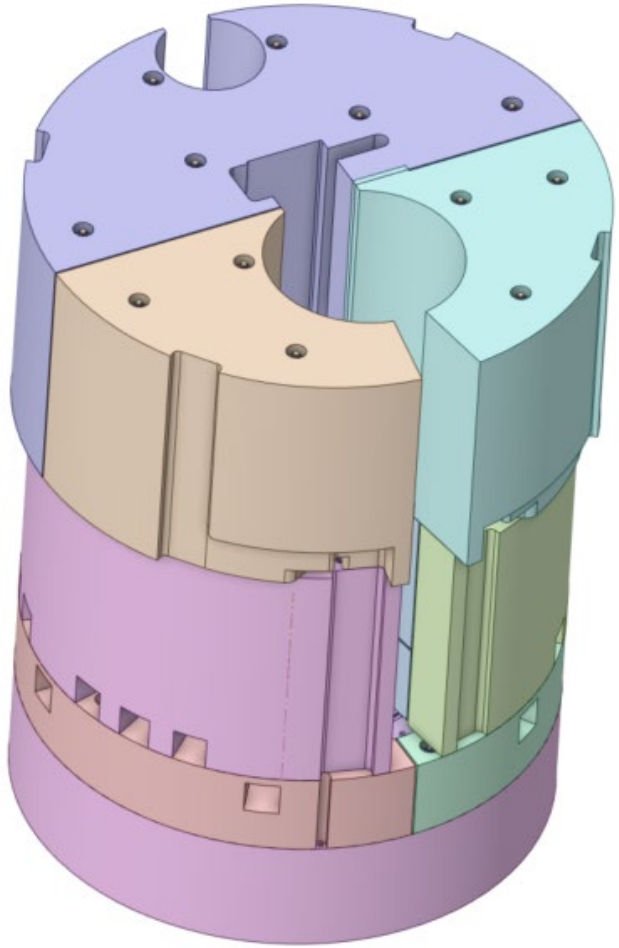
Hydrogen transfer line shine shield

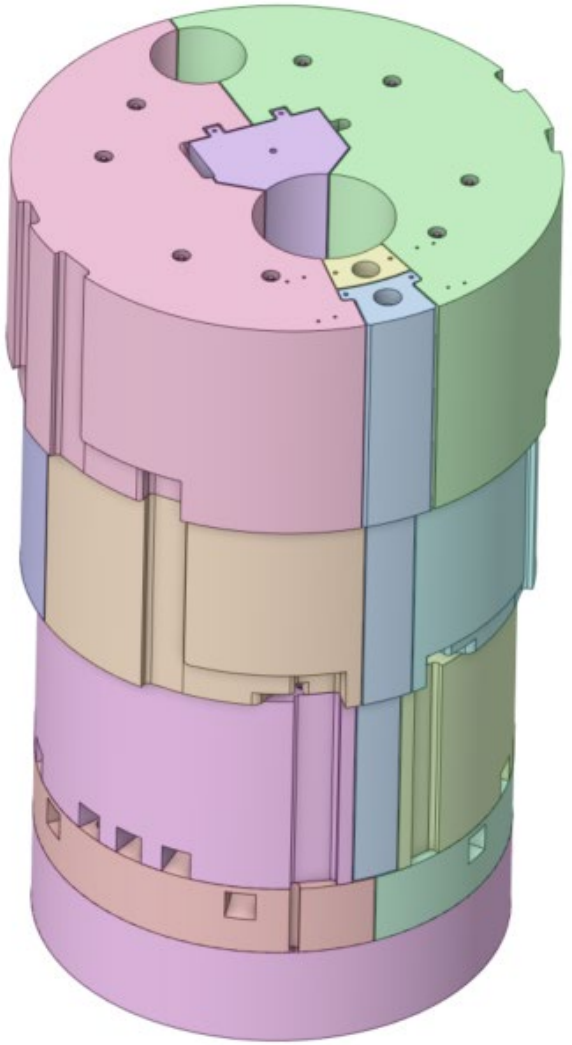
Core Vessel Shielding Restraint System



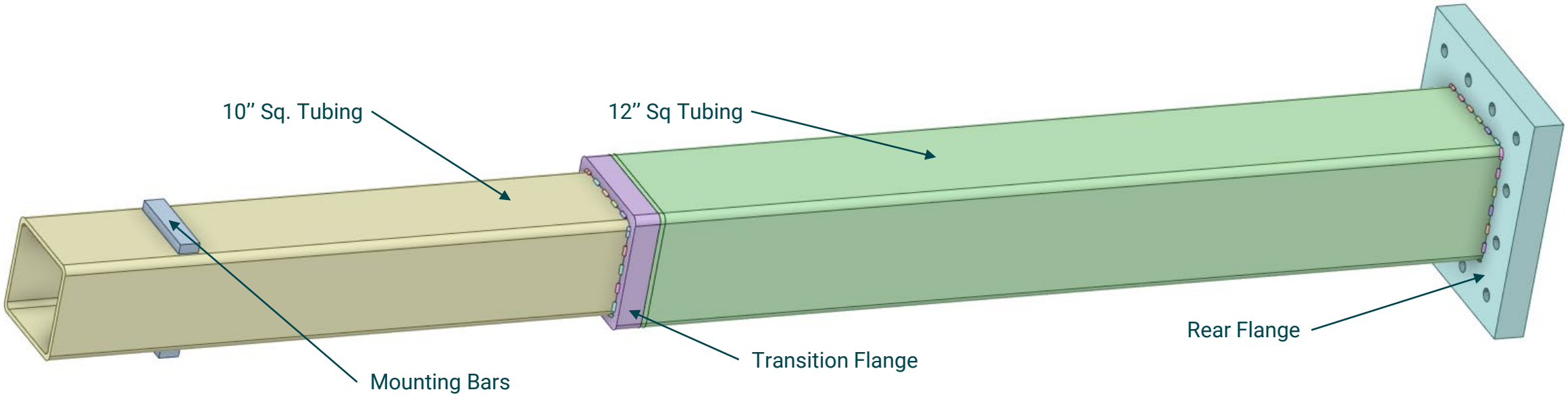




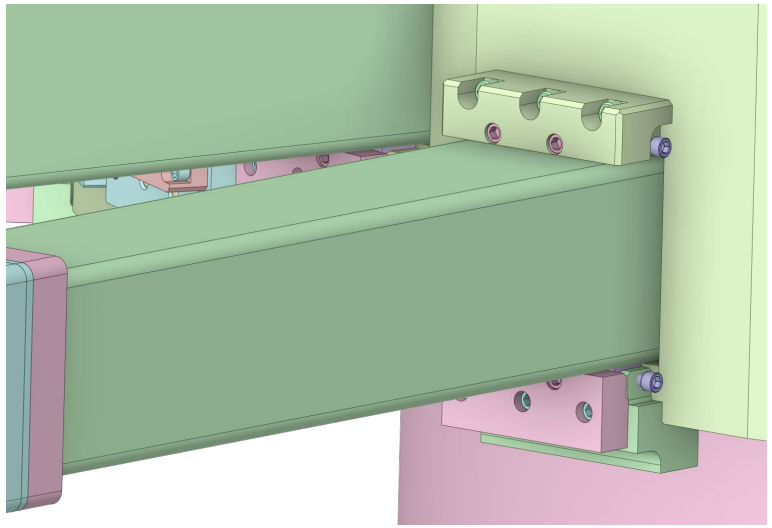




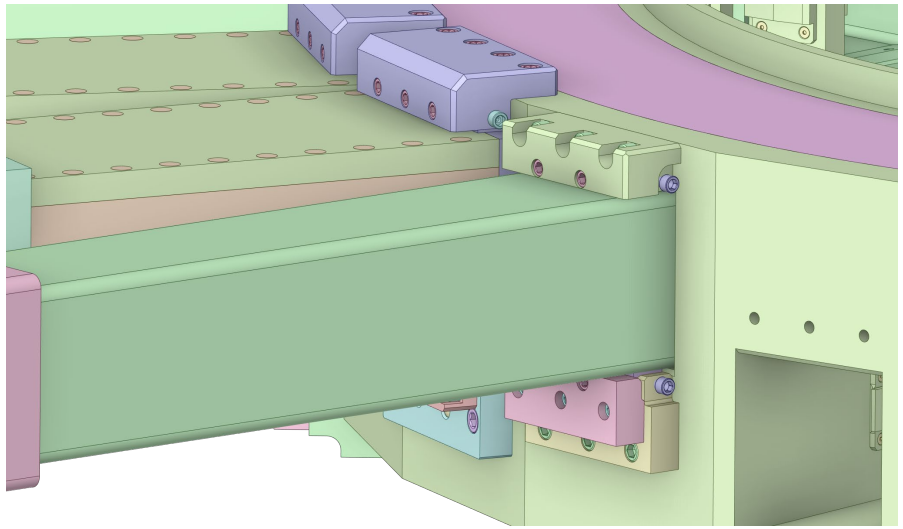
Standard Nozzle Extension Assembly Details



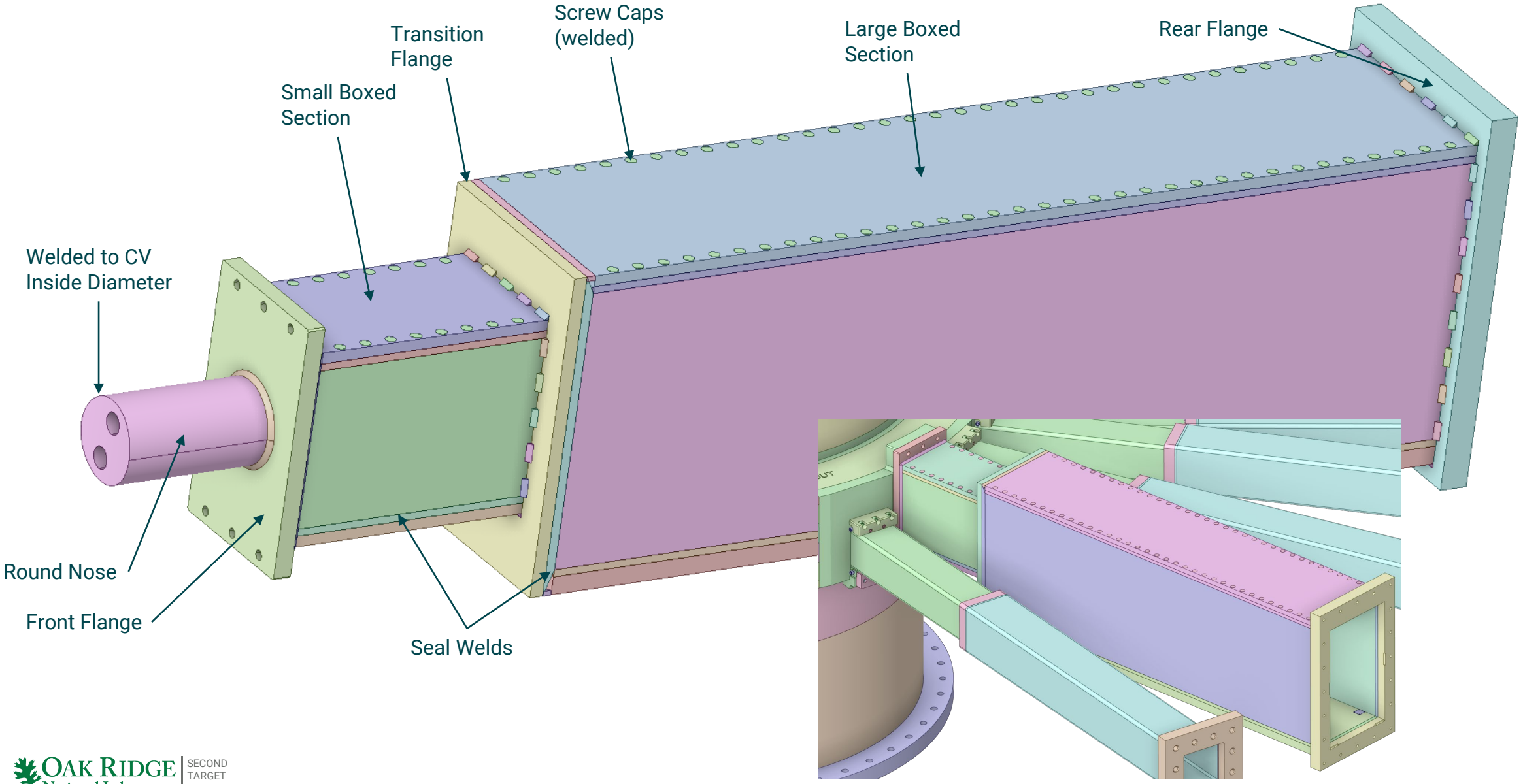
Lower Bracket Assembly



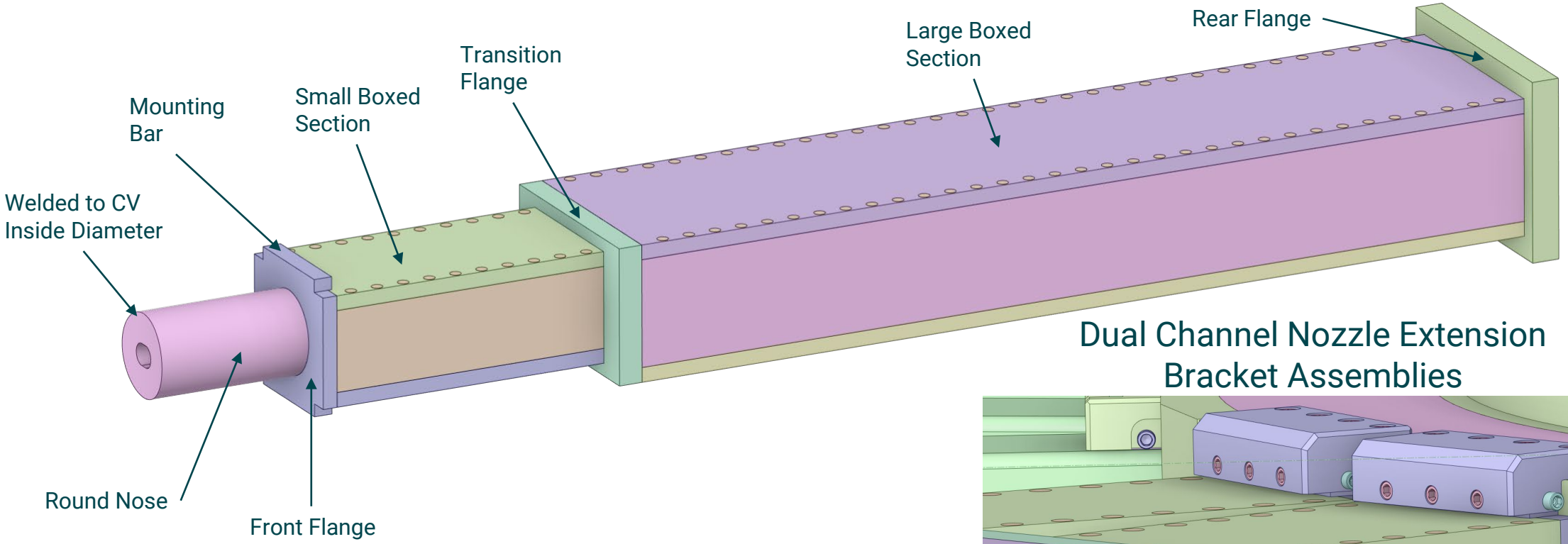
Upper Bracket Assembly



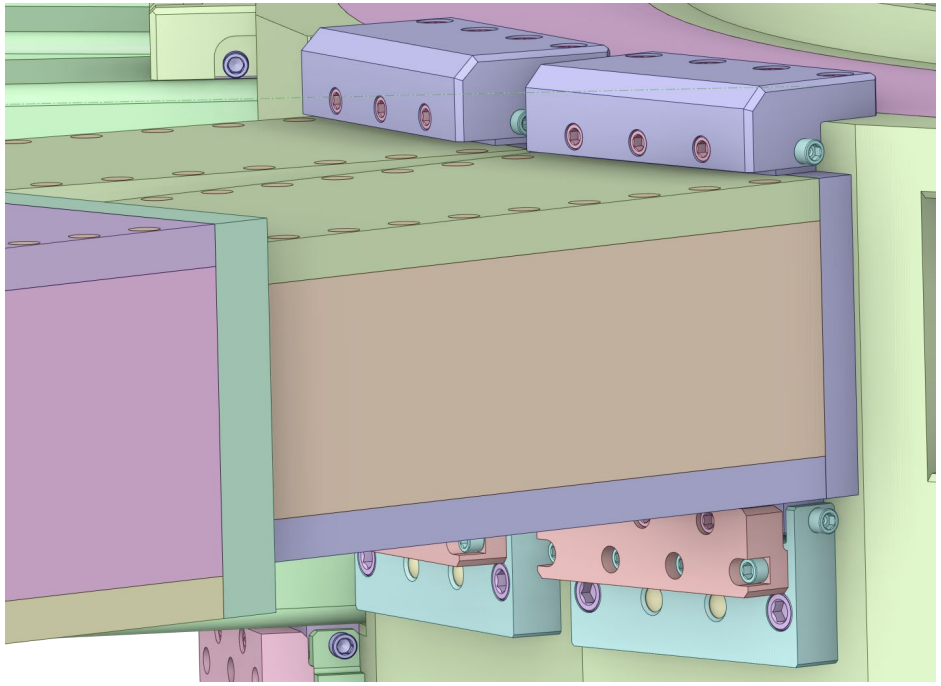
QIKR Nozzle Extension Assembly Details



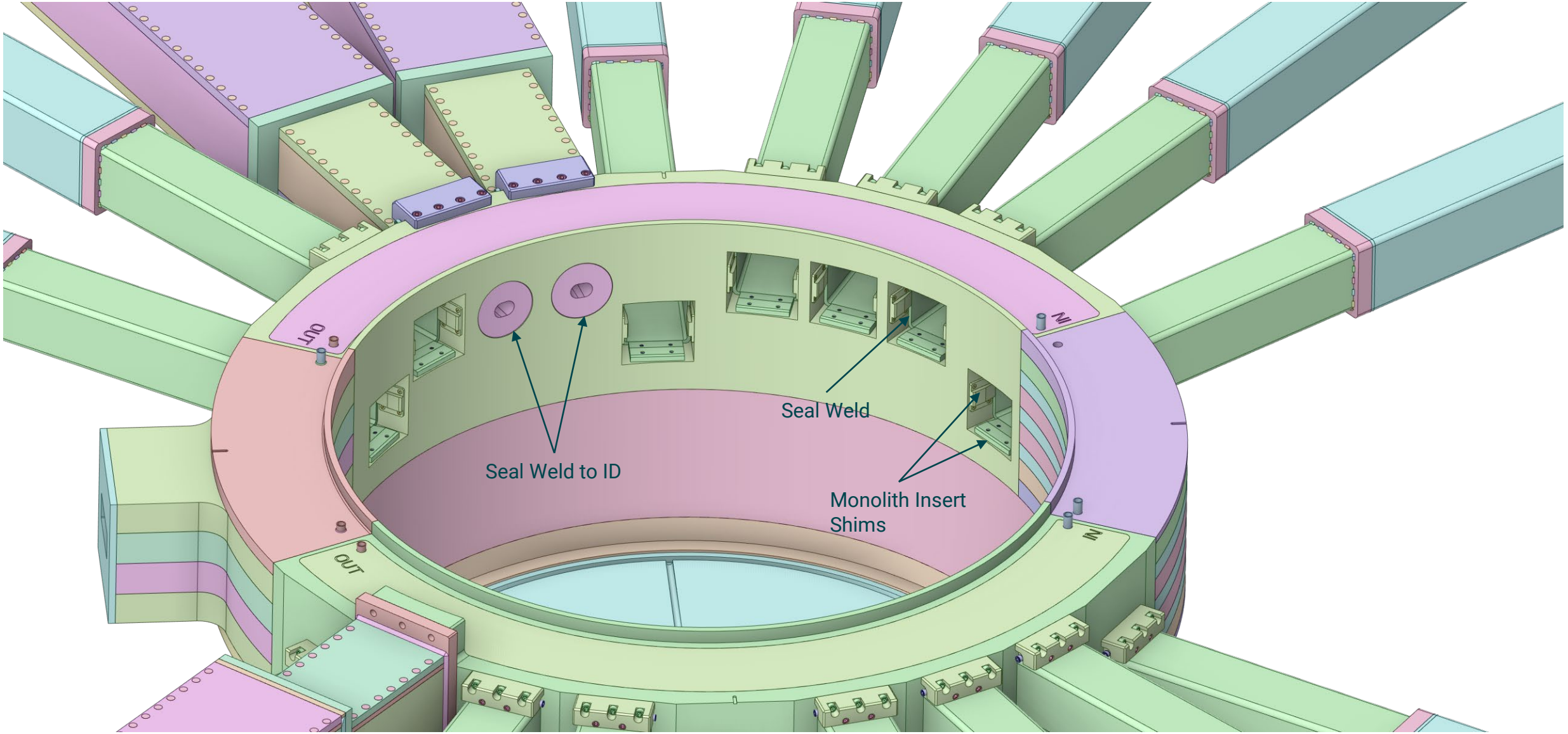
Dual Channel Nozzle Extension Assembly Details



Dual Channel Nozzle Extension Bracket Assemblies

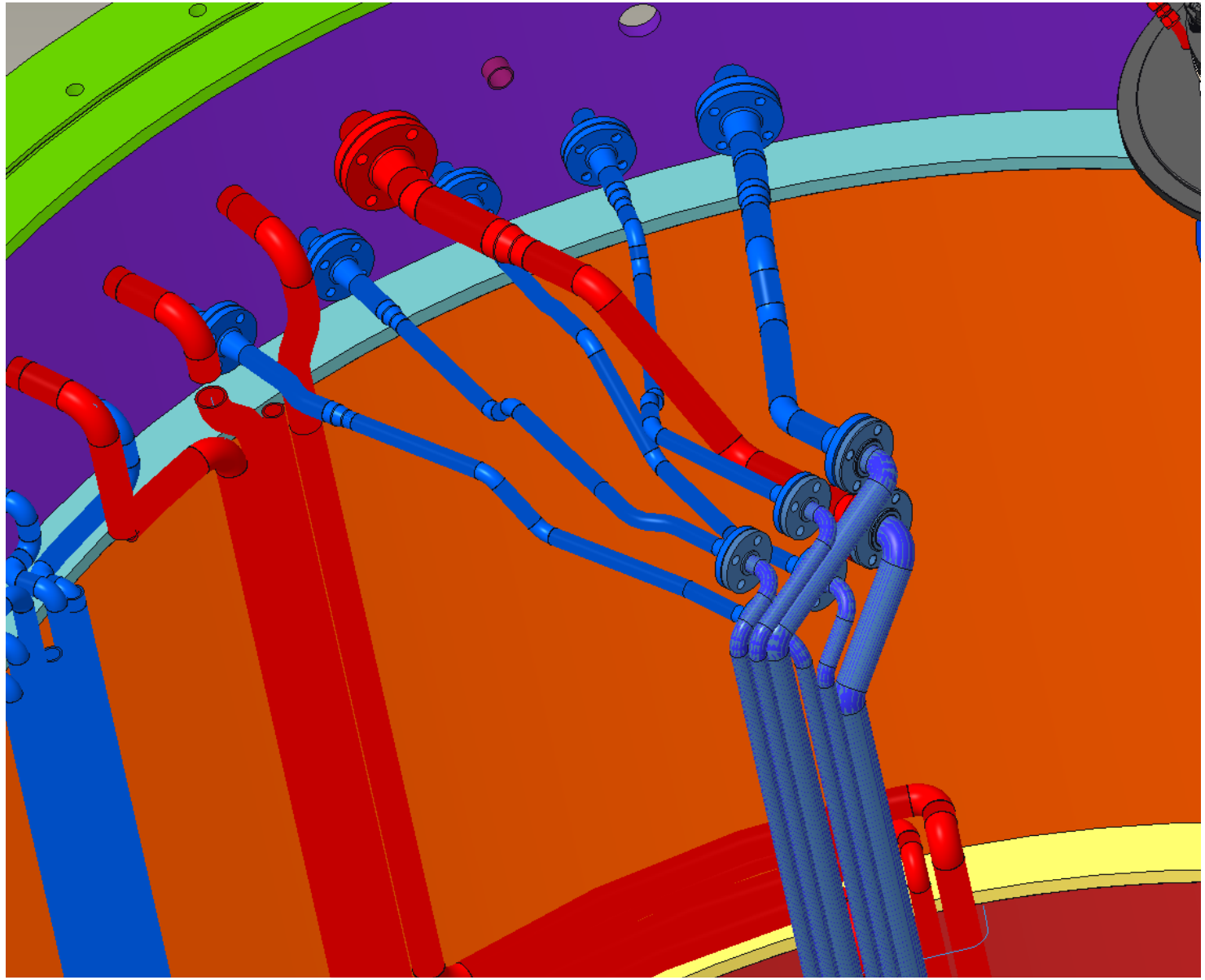


Nozzle Extension Seal Welds and Monolith Insert shims



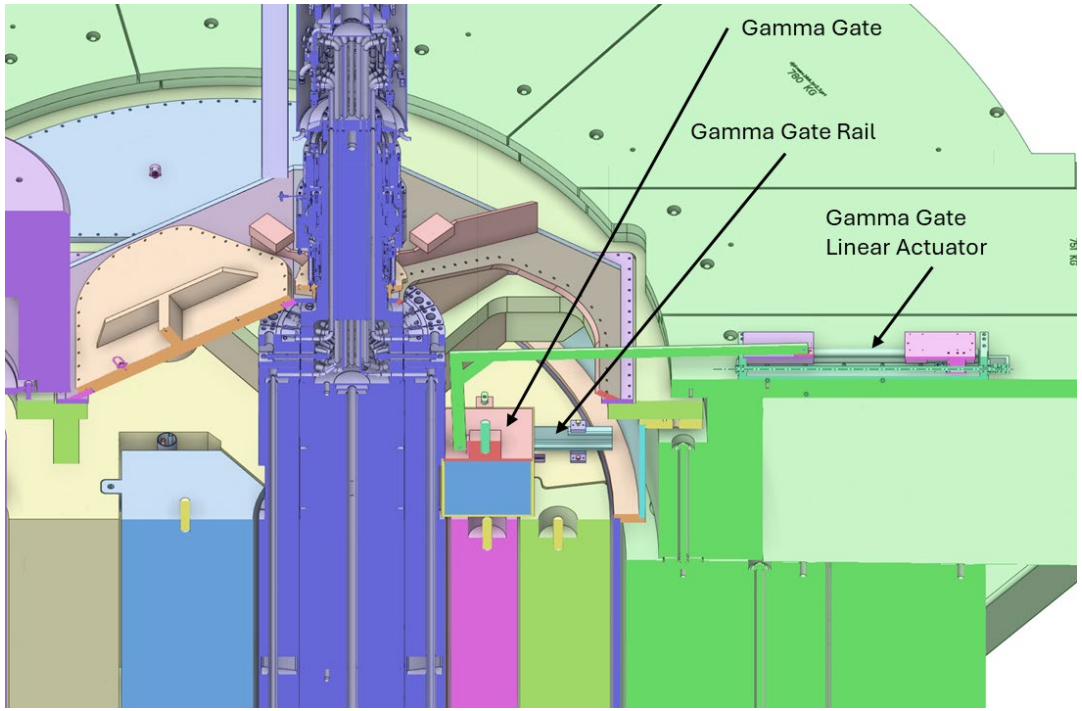
MRA Utility Jumpers

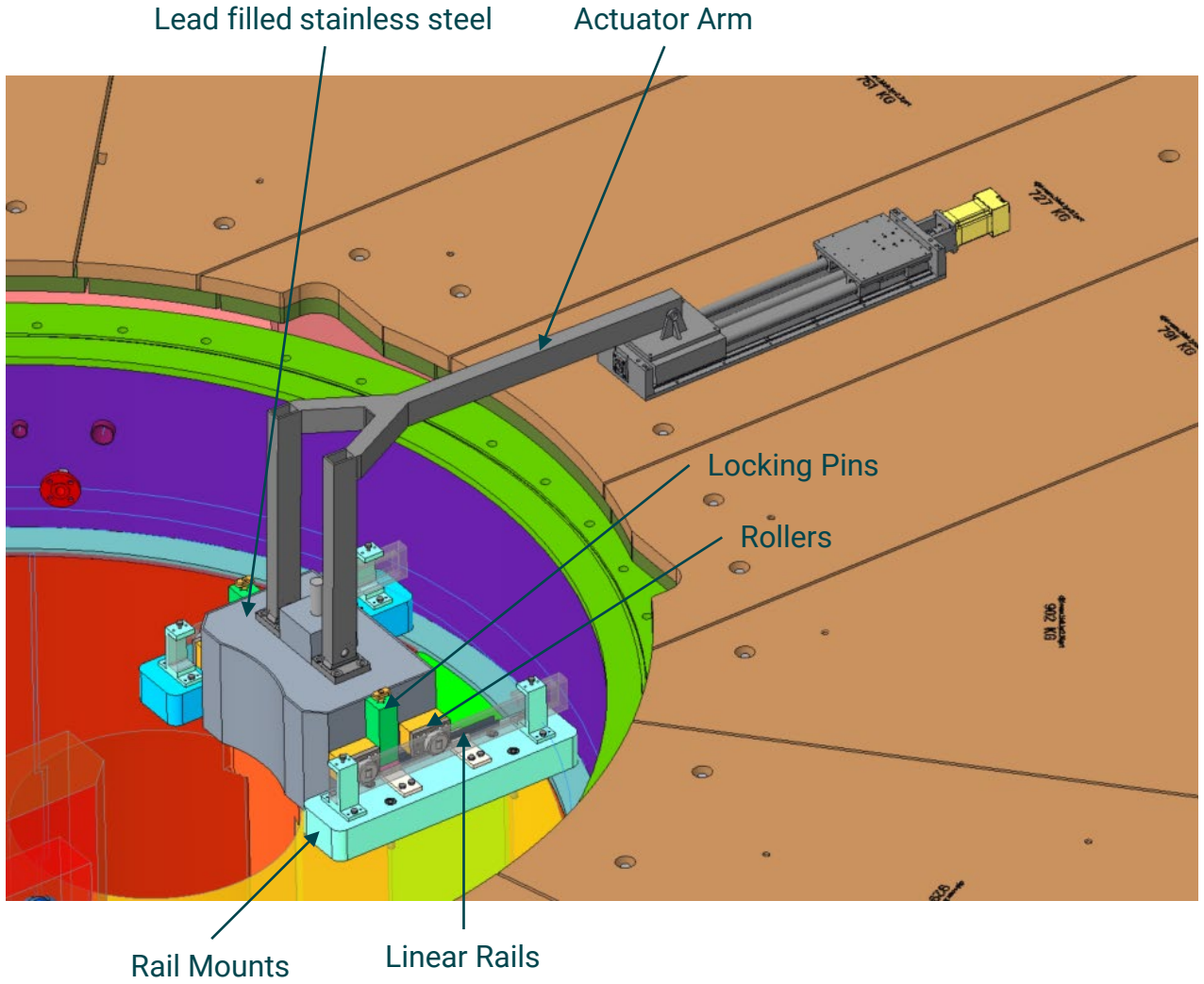
- Connect MRA flanged connections to corresponding flanged connections on CV side walls
- Each line will include a flex line portion
- Flex lines allow for MRA connections to be broken and the jumper lines moved during MRA removal and installation



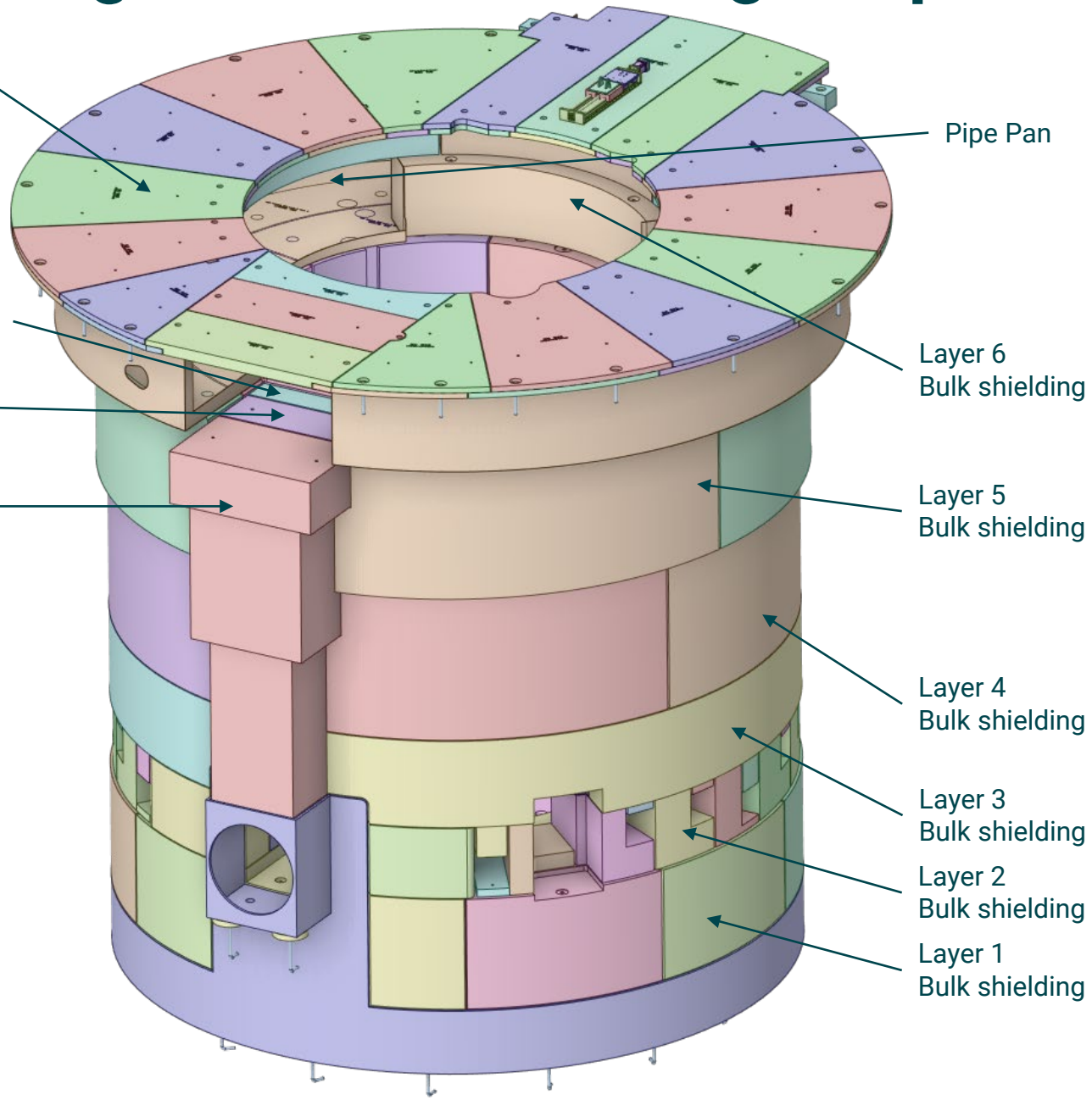
Gamma Gate Assembly

- The gamma gate provides radiation protection during target maintenance activities
- Remote actuation is required
- Facilitates hands-on target maintenance

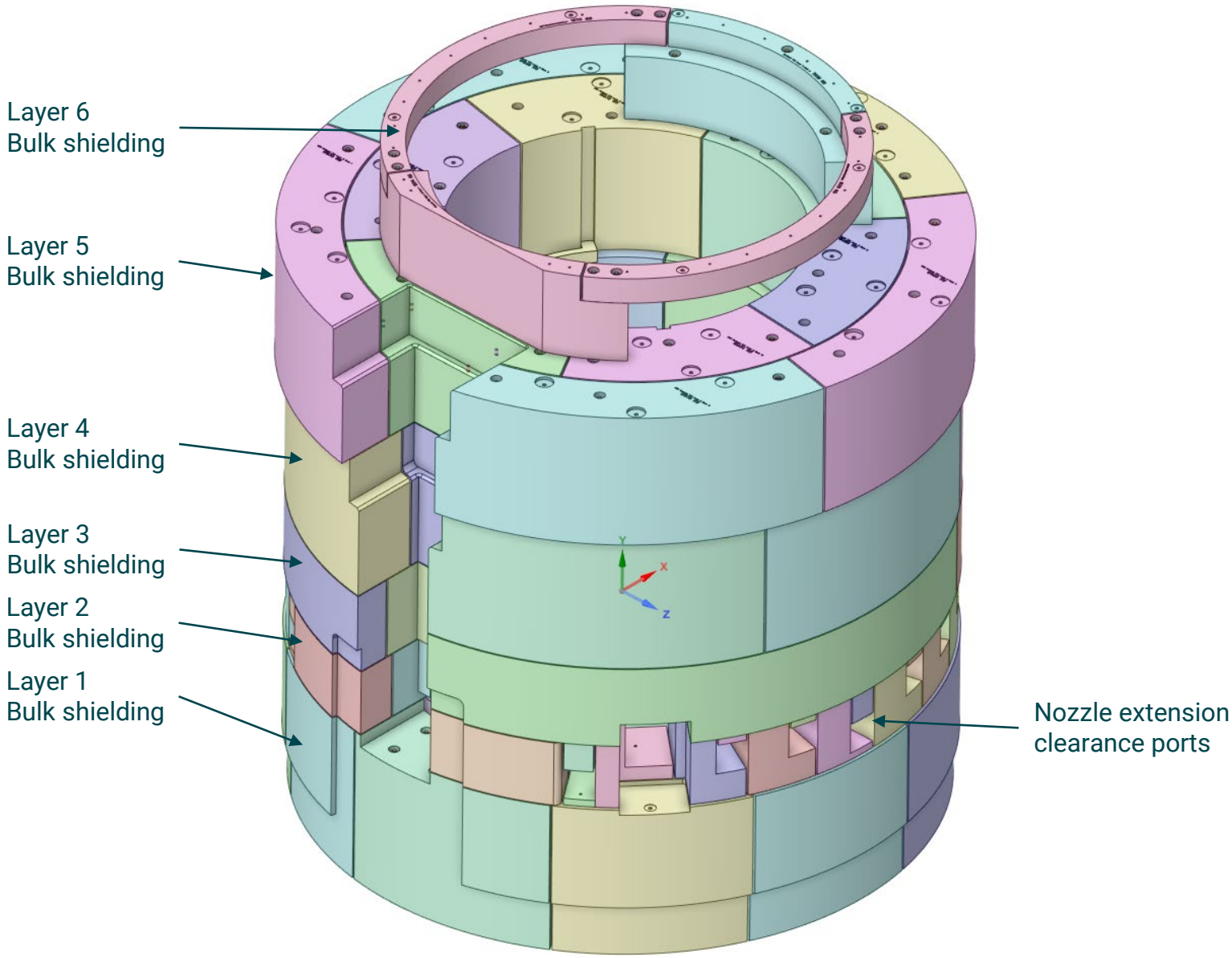




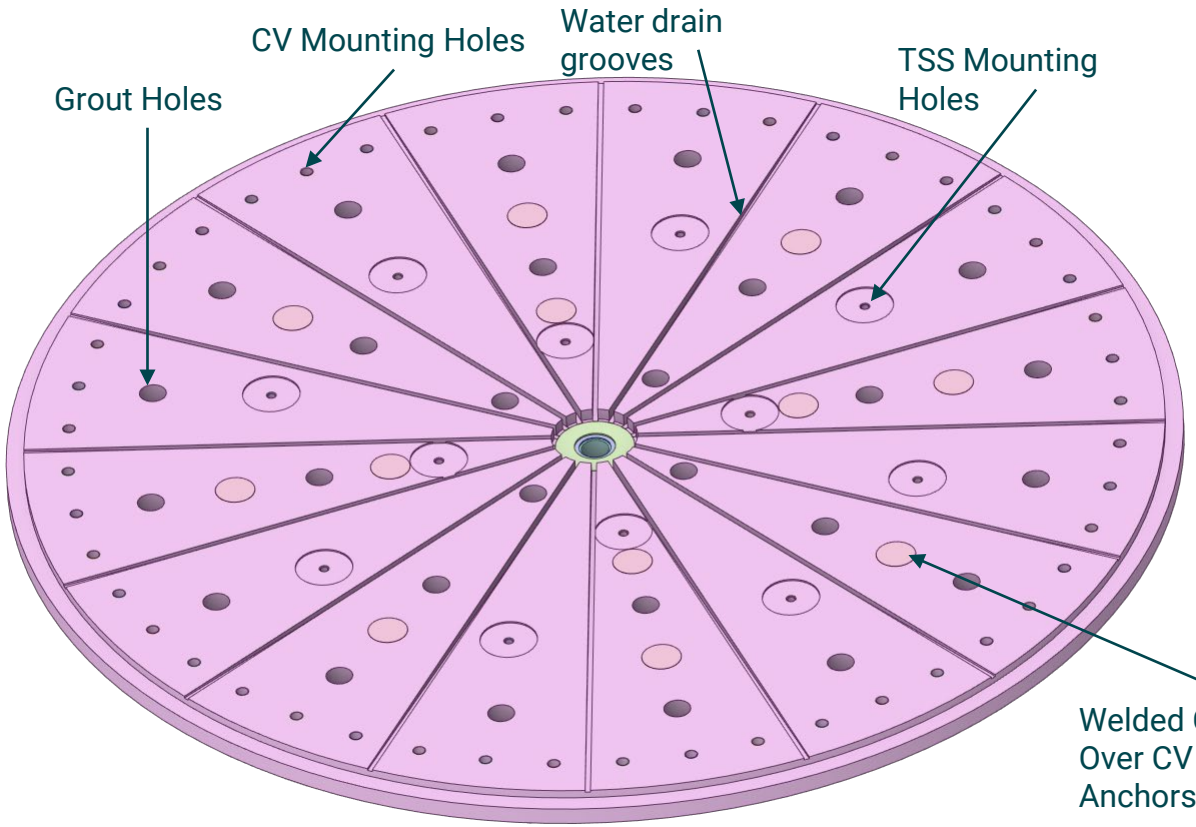
Target Station Shielding Scope

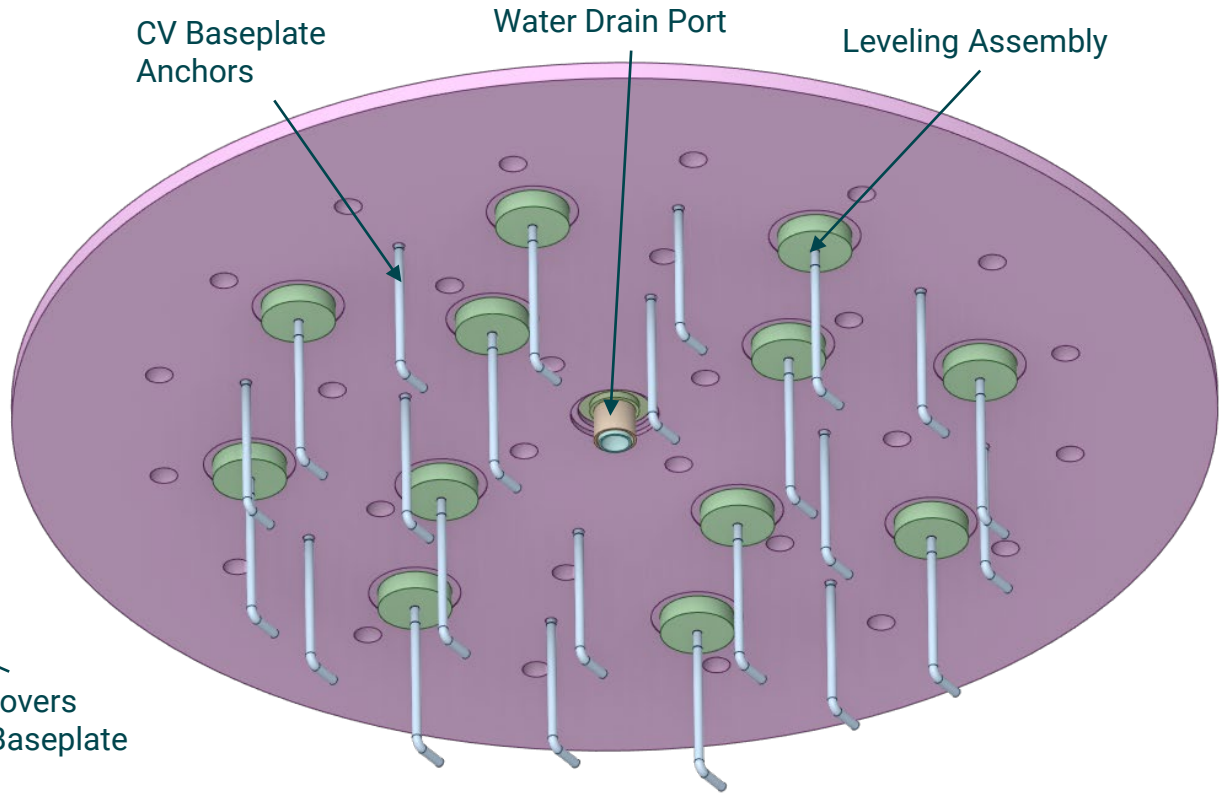


Bulk Shielding Scope

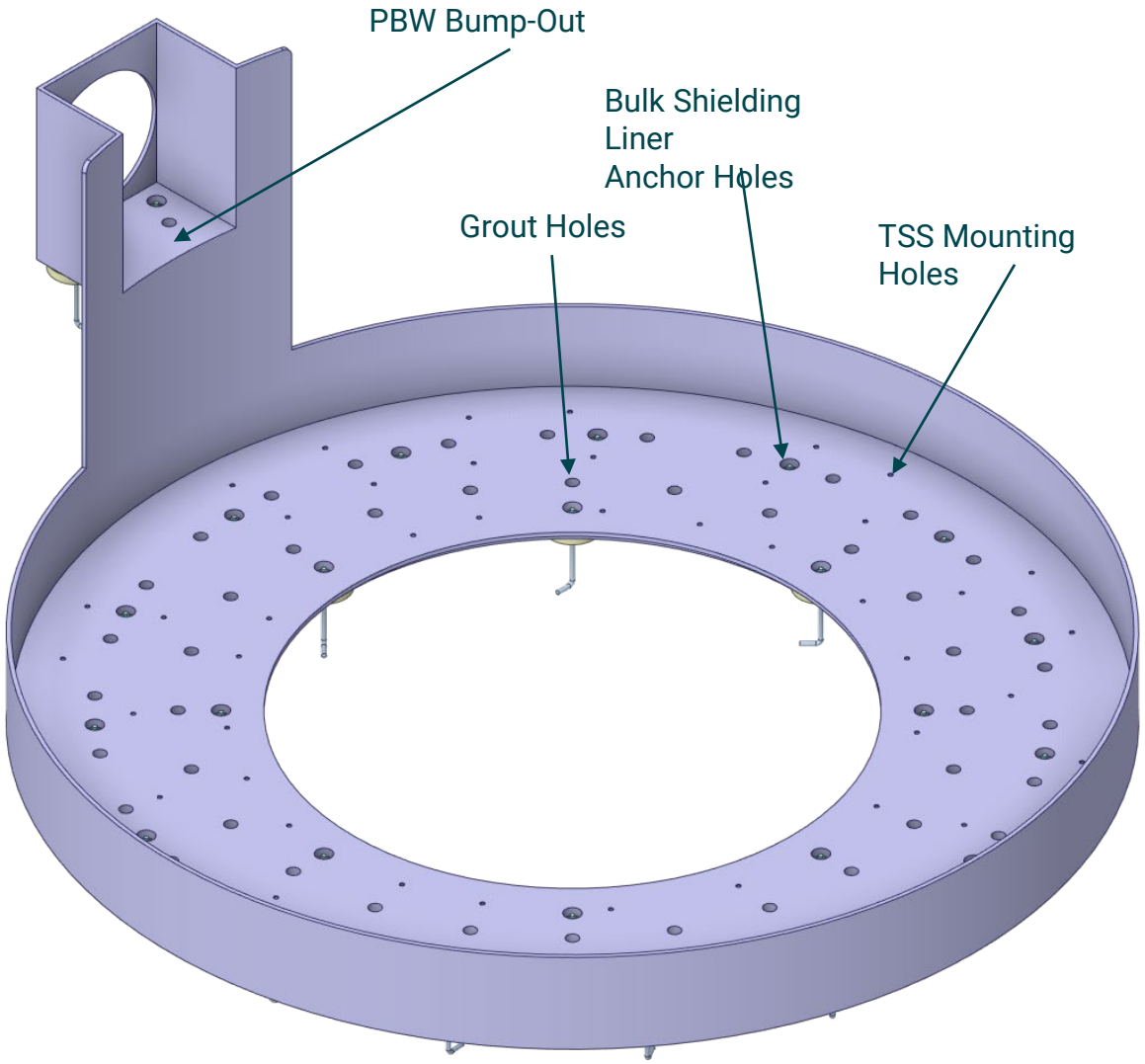


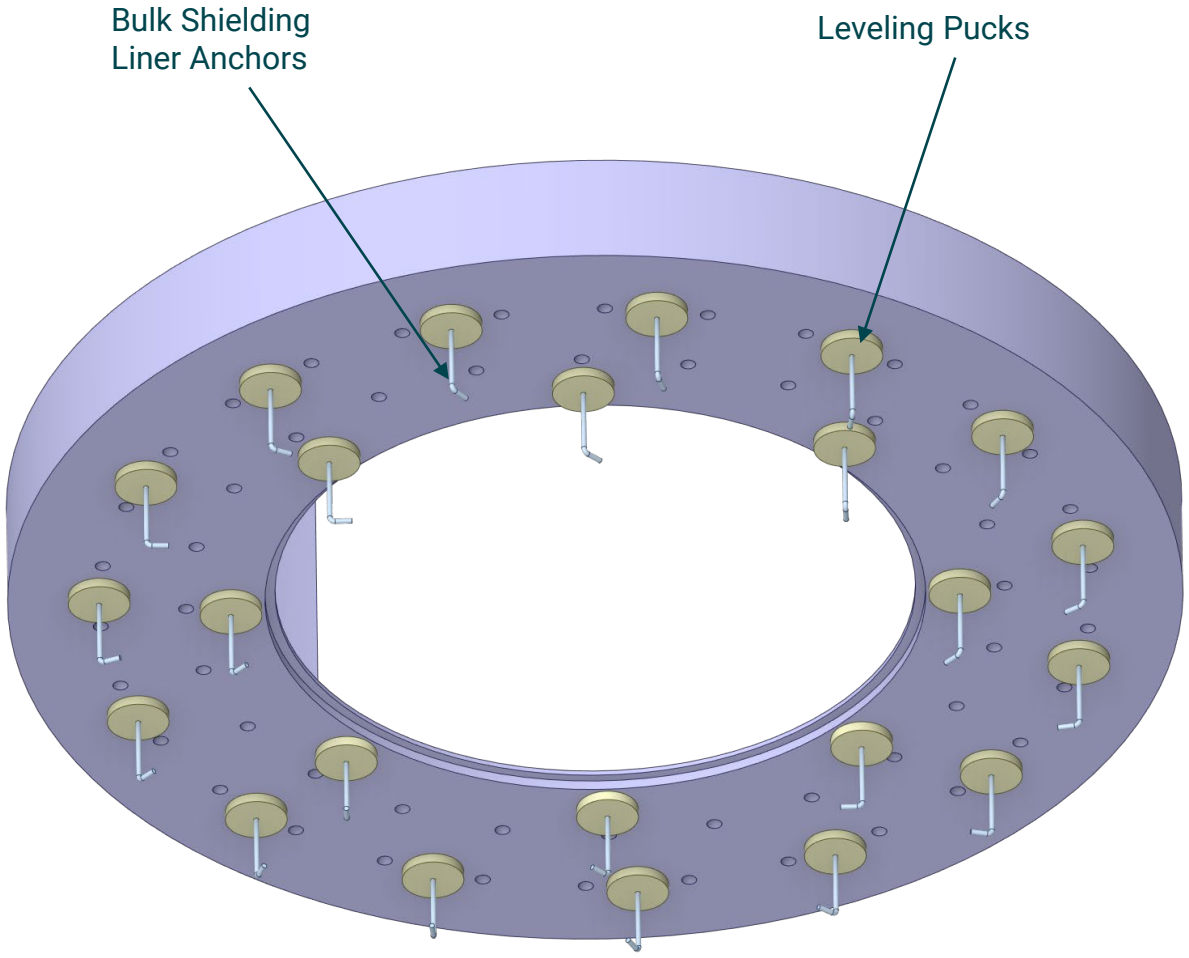
Core Vessel Baseplate Details



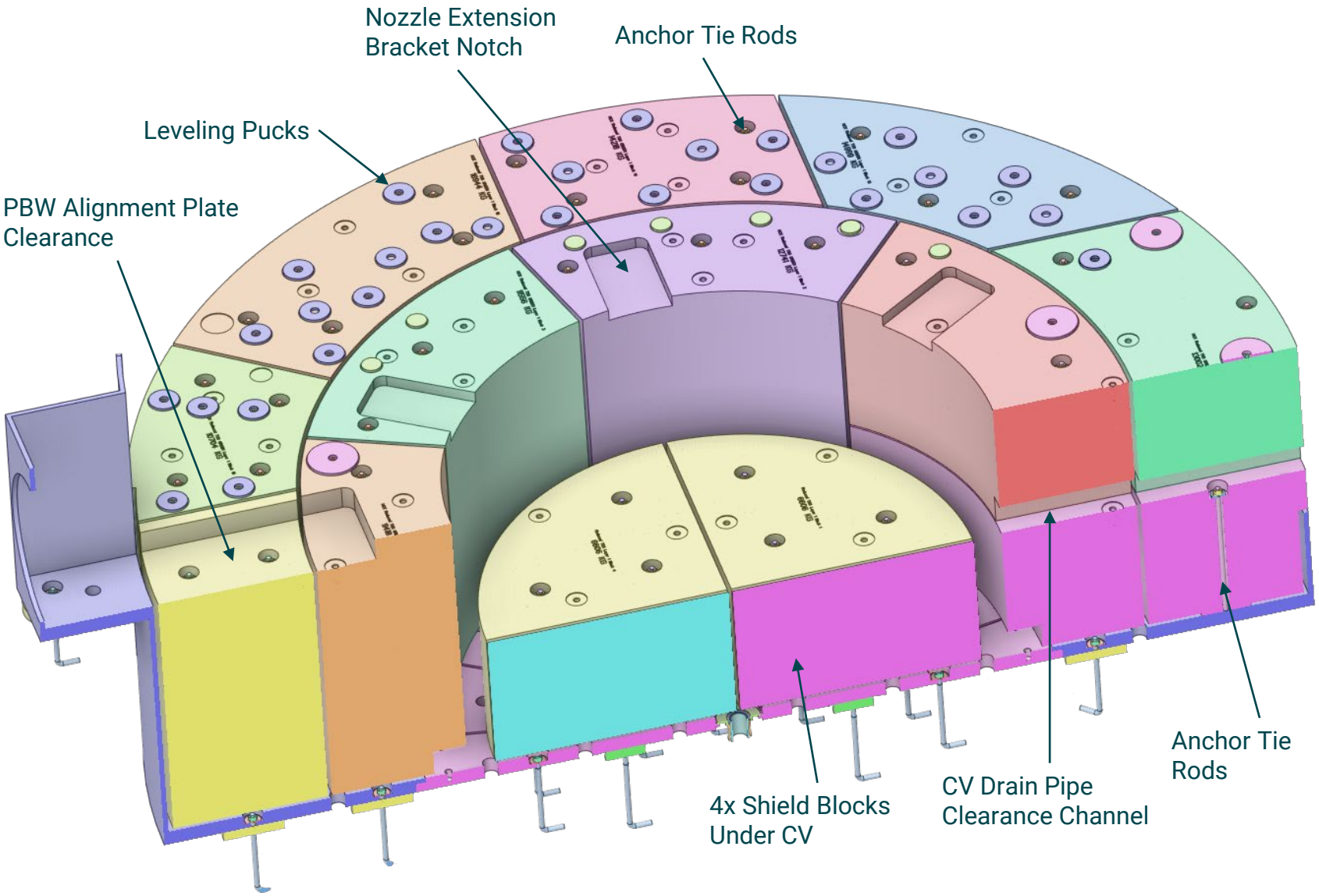


Bulk Shielding Liner Details

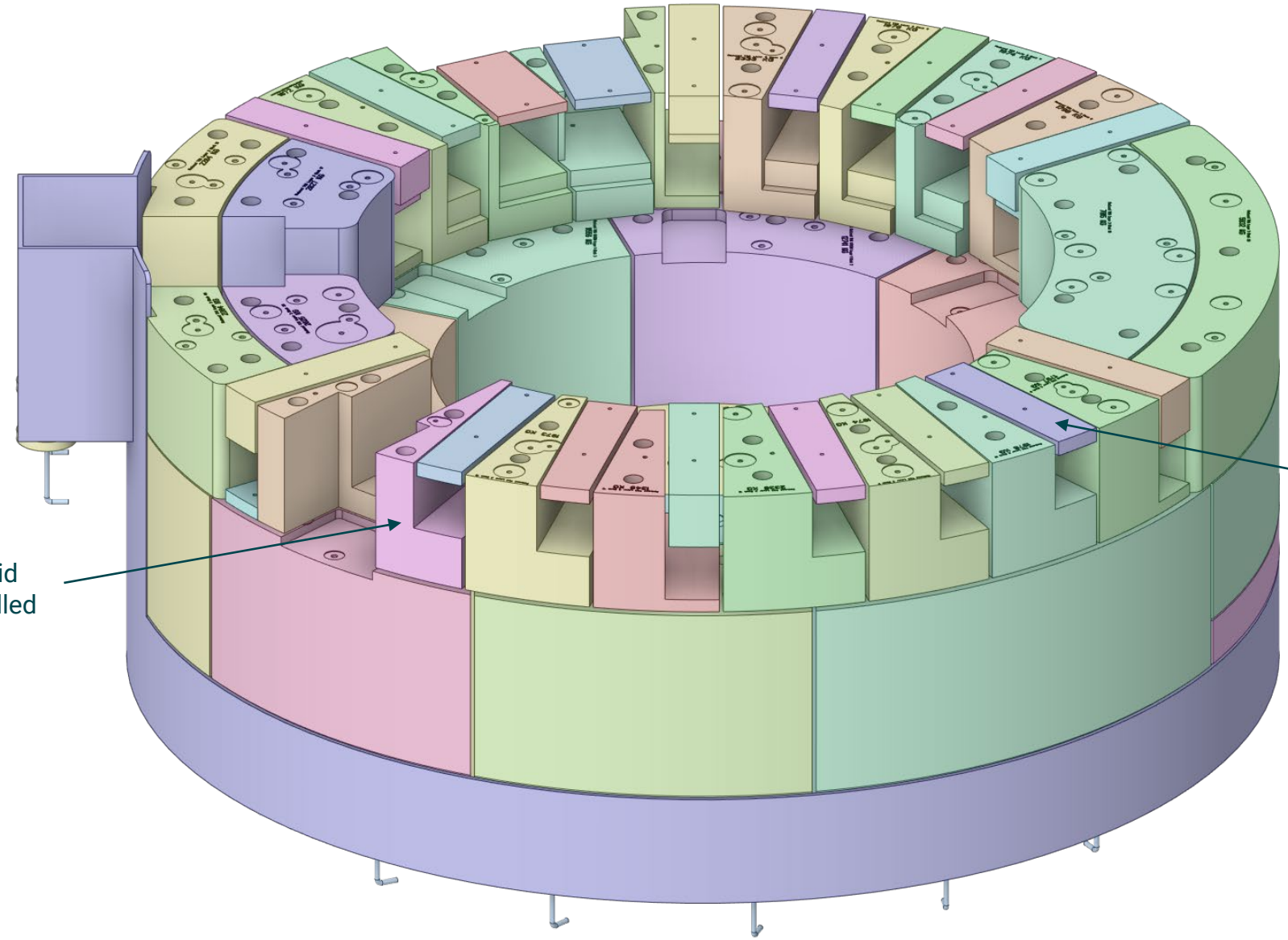




Bulk Shielding Layer 1 Details



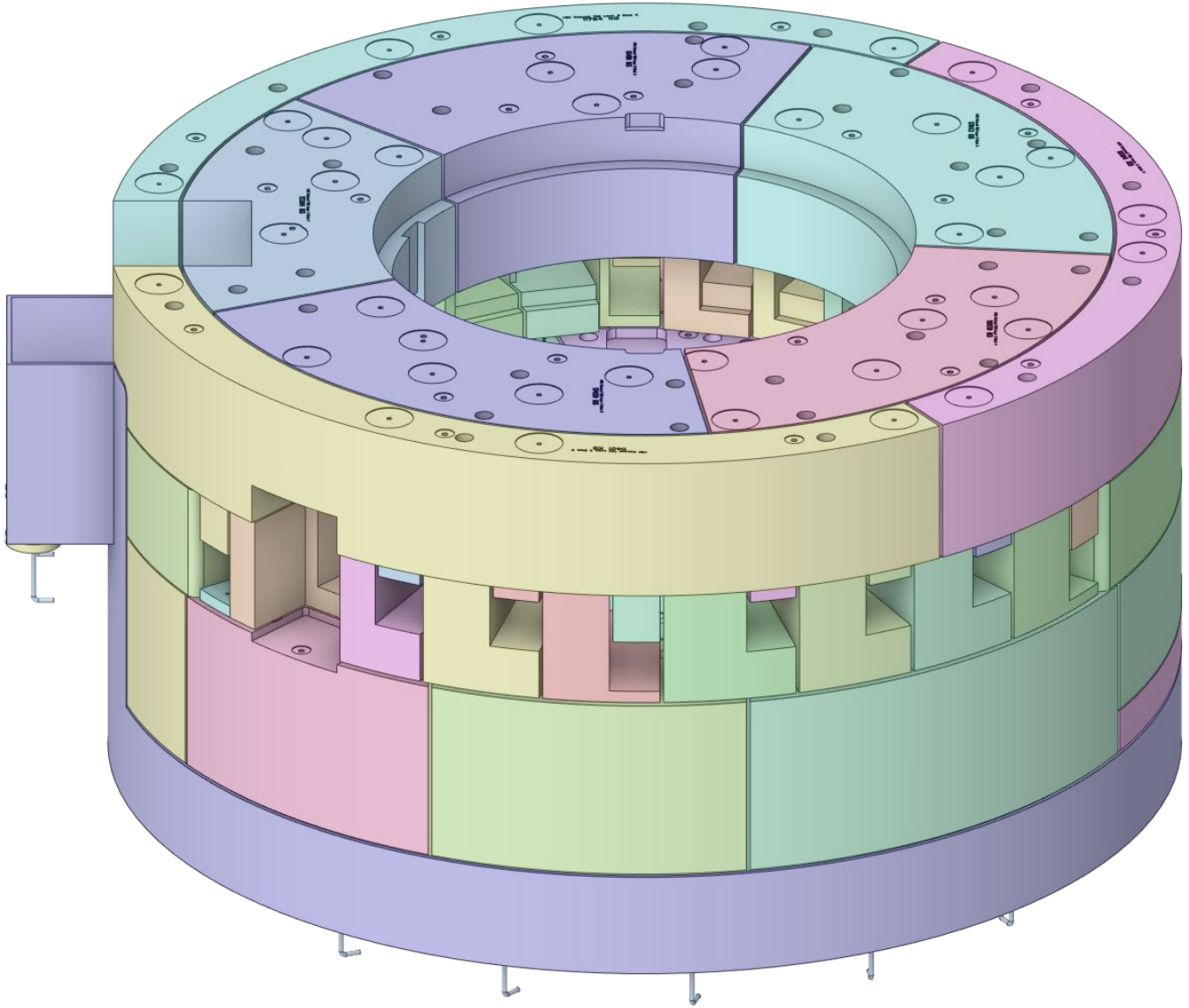
Bulk Shielding Layer 2 Details



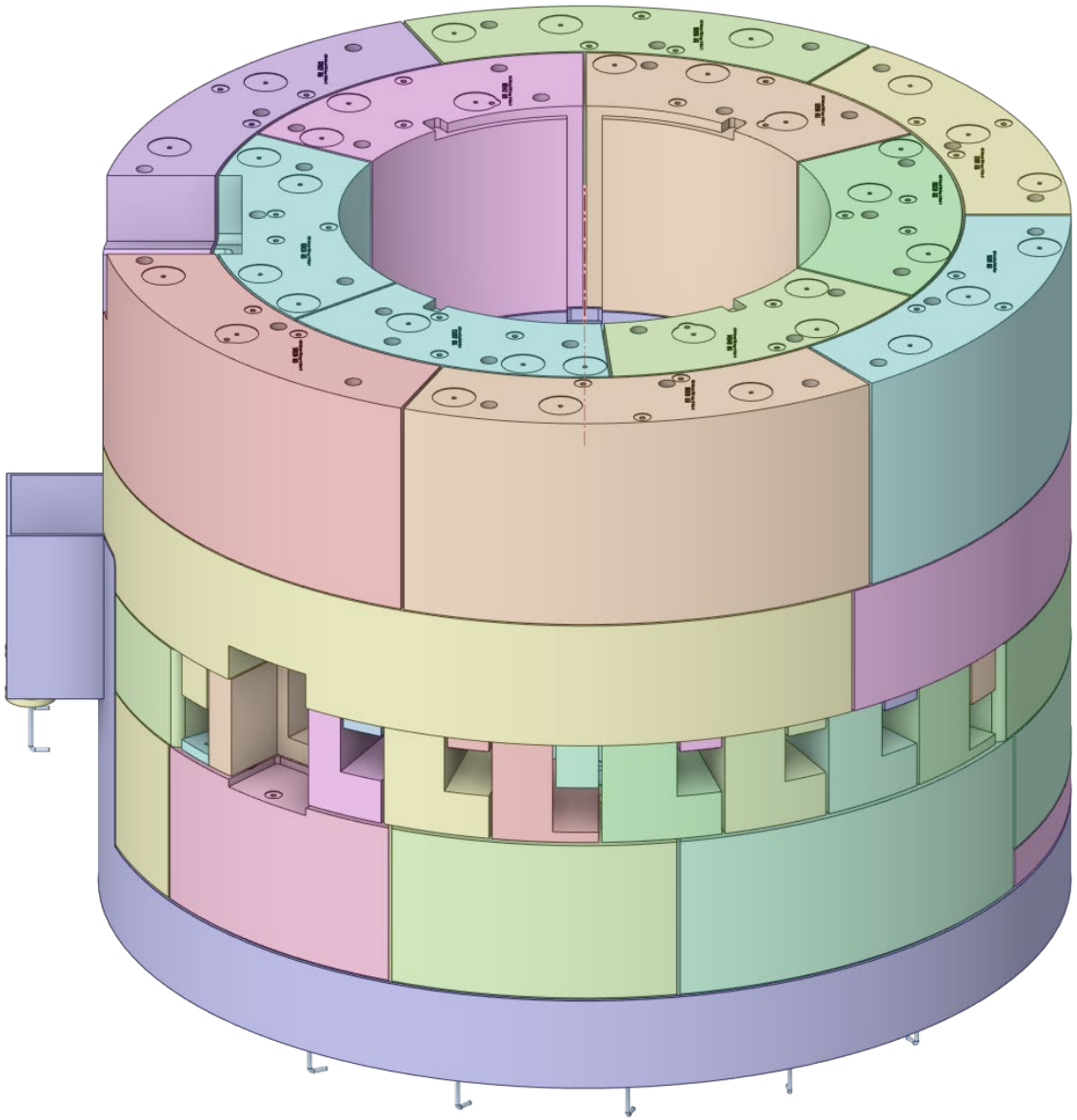
Bolt to the next layer of shield block

L shaped blocks are slid underneath each installed nozzle extension

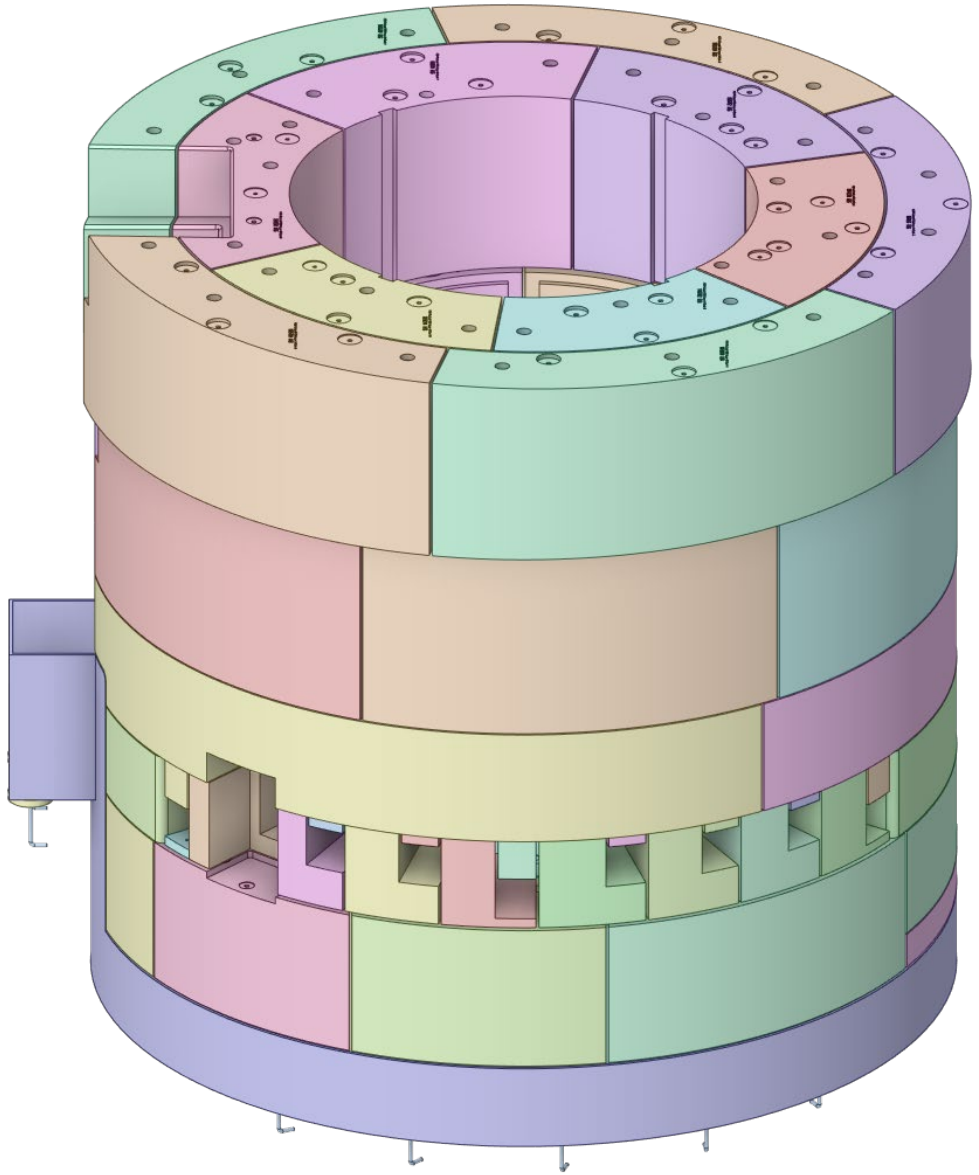
Bulk Shielding Layer 3 Details



Bulk Shielding Layer 4 Details

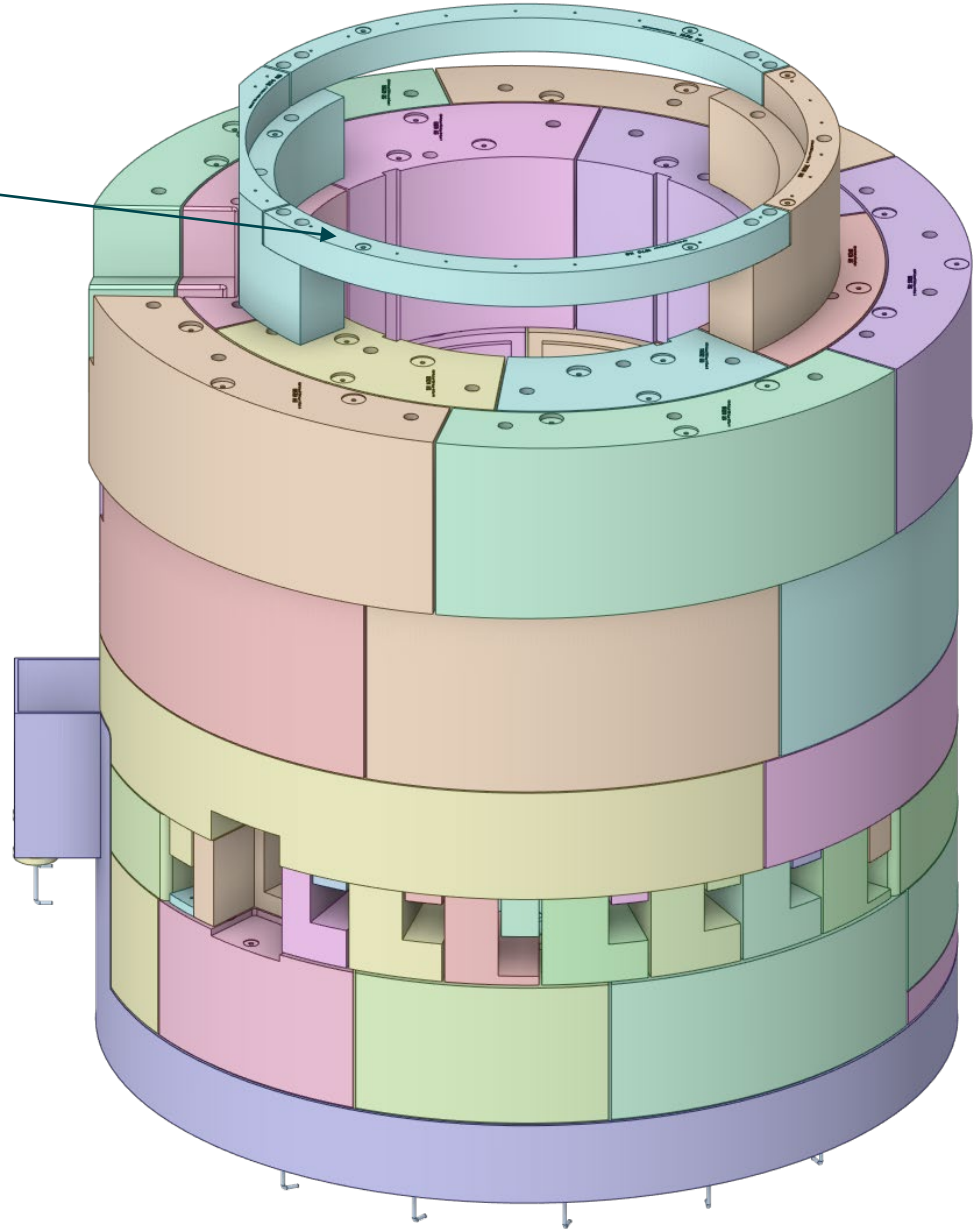


Bulk Shielding Layer 5 Details

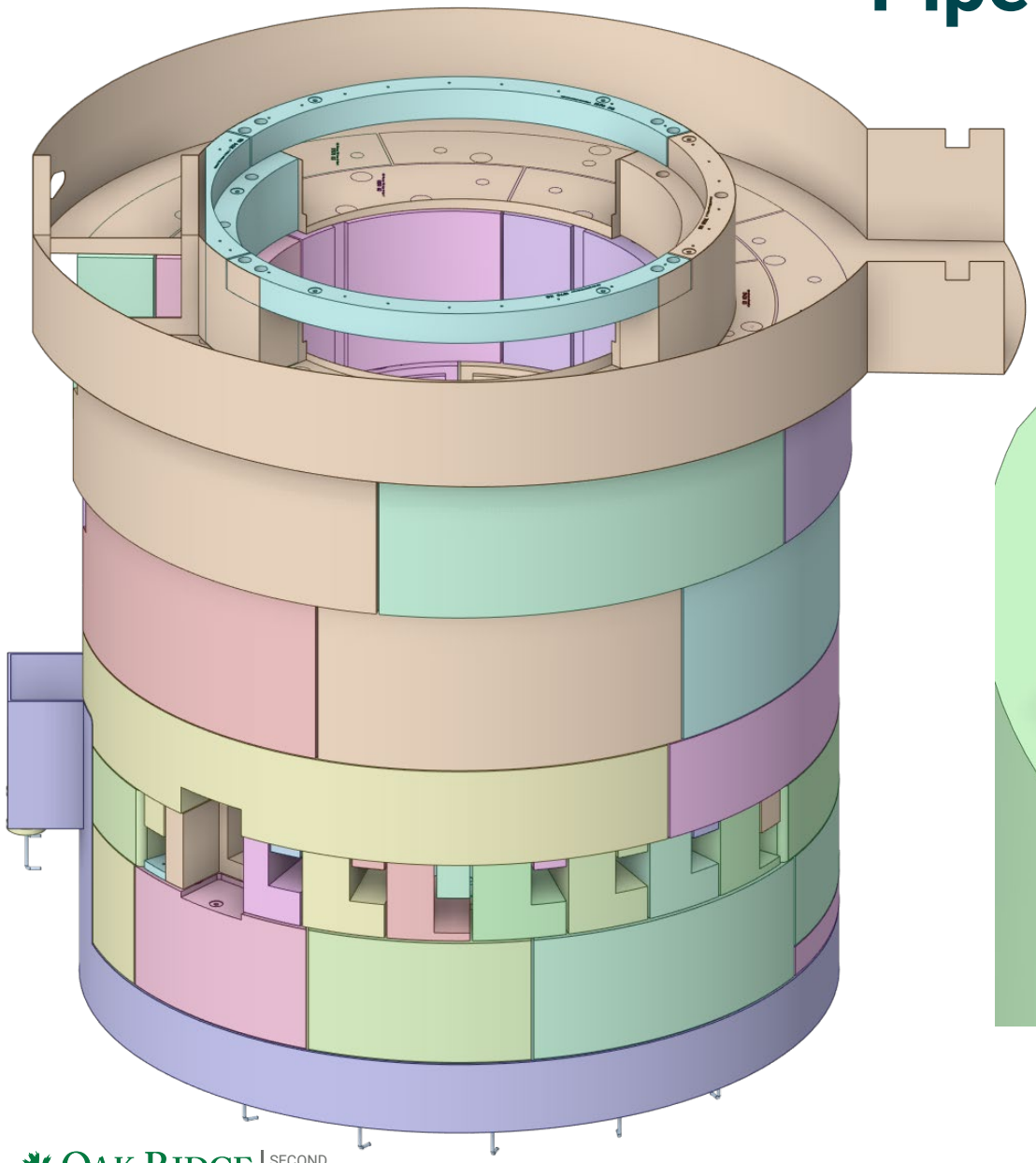


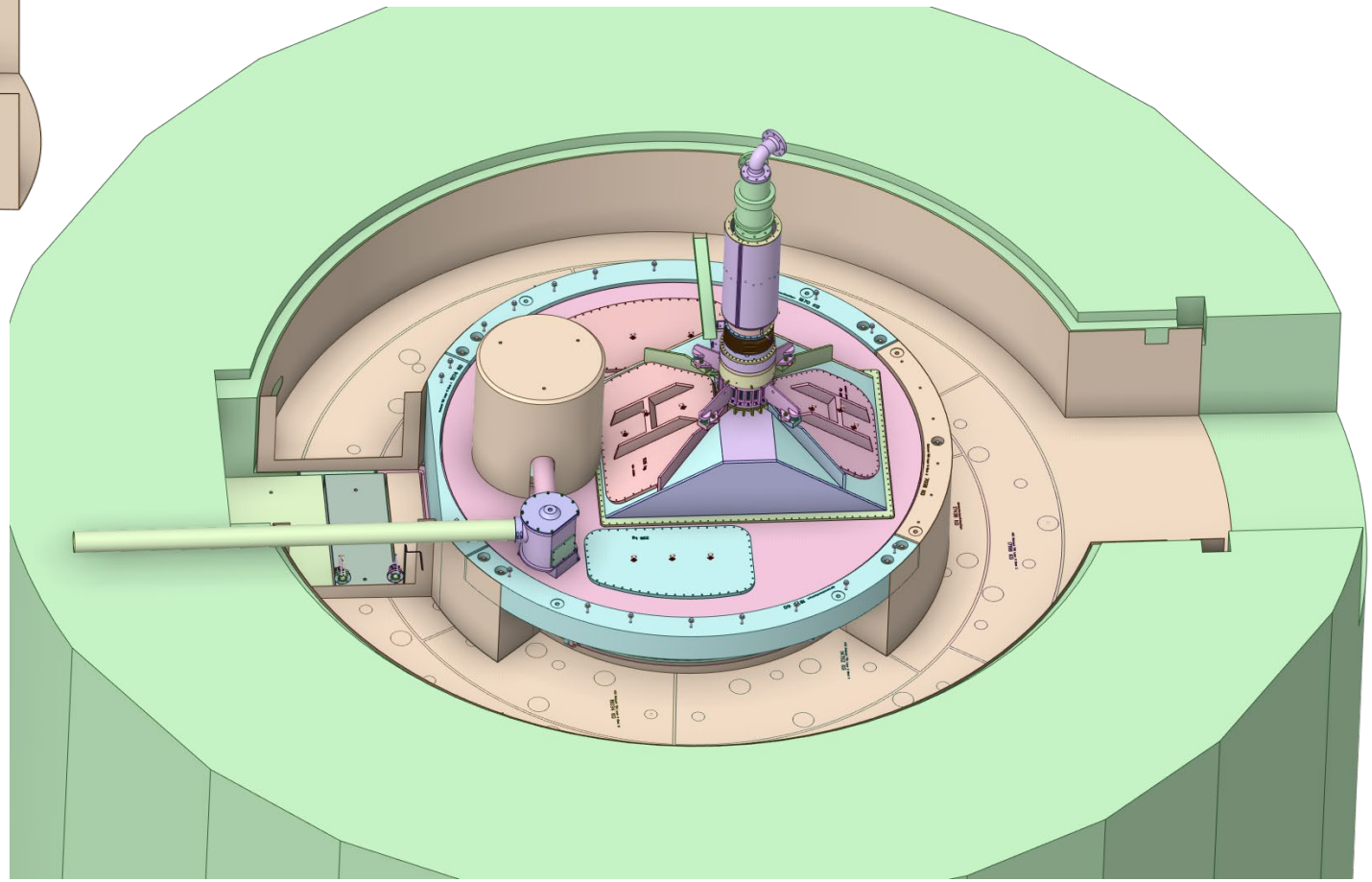
Bulk Shielding Layer 6 Details

Forms support for removable shield plates above pipe pans

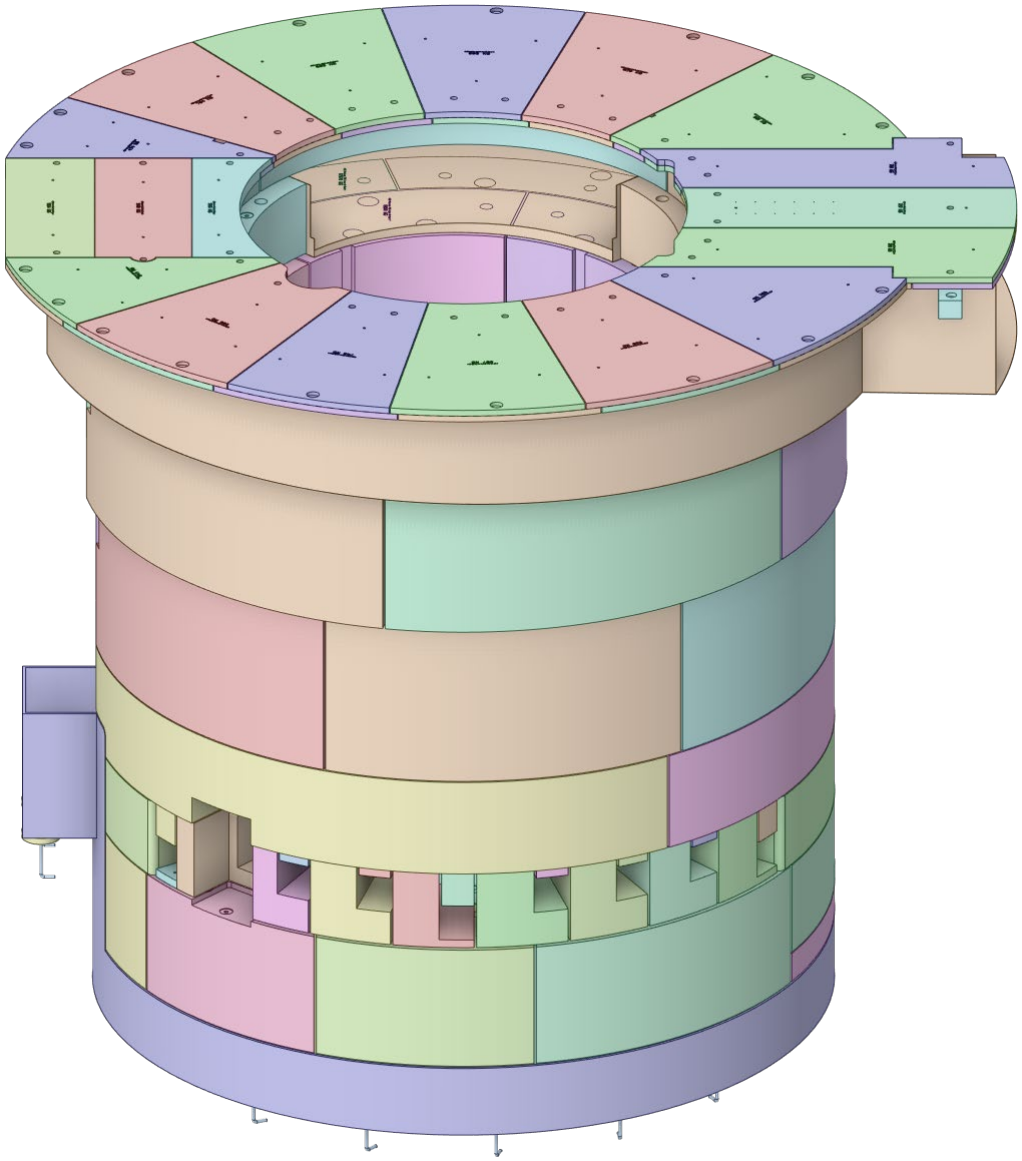


Pipe Pan Details

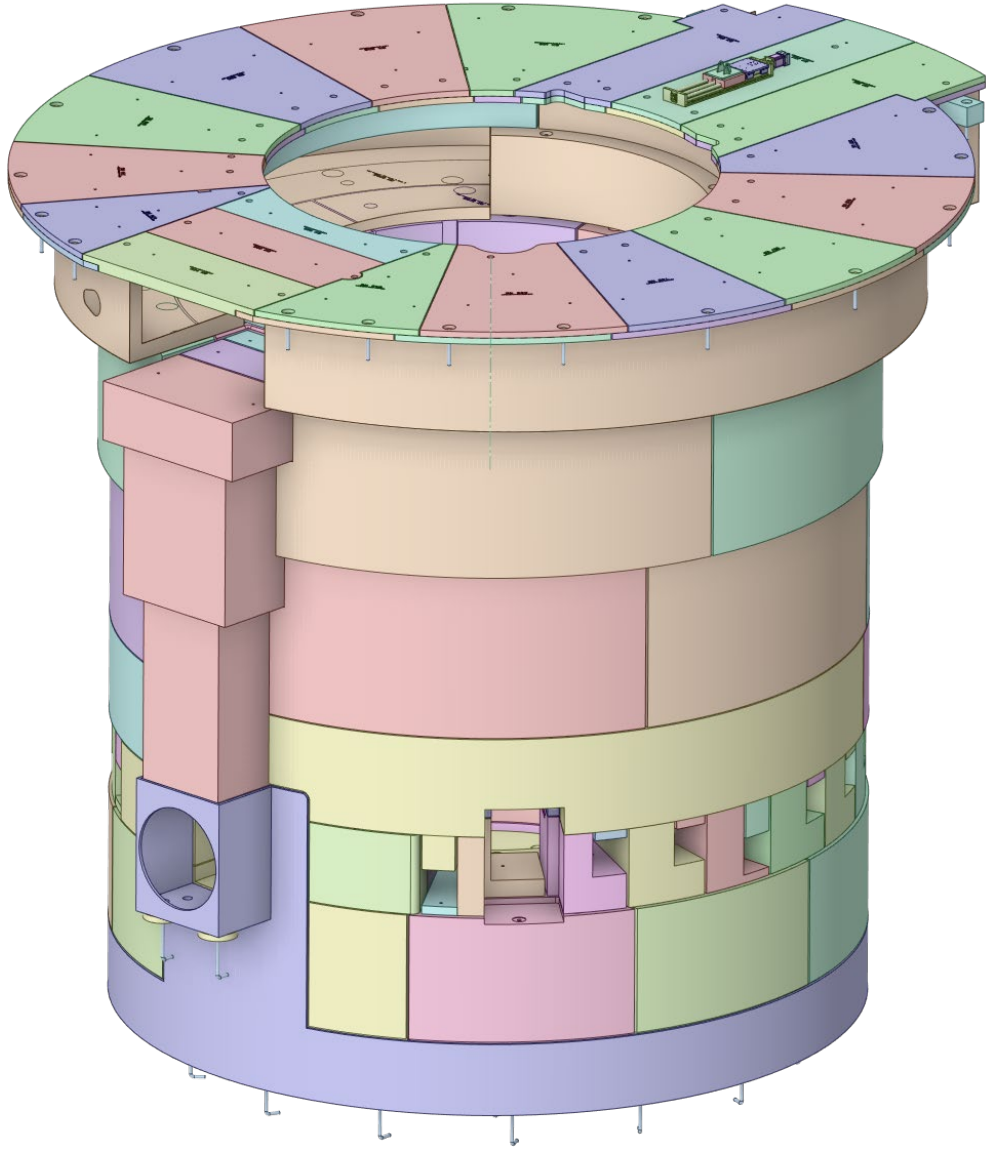


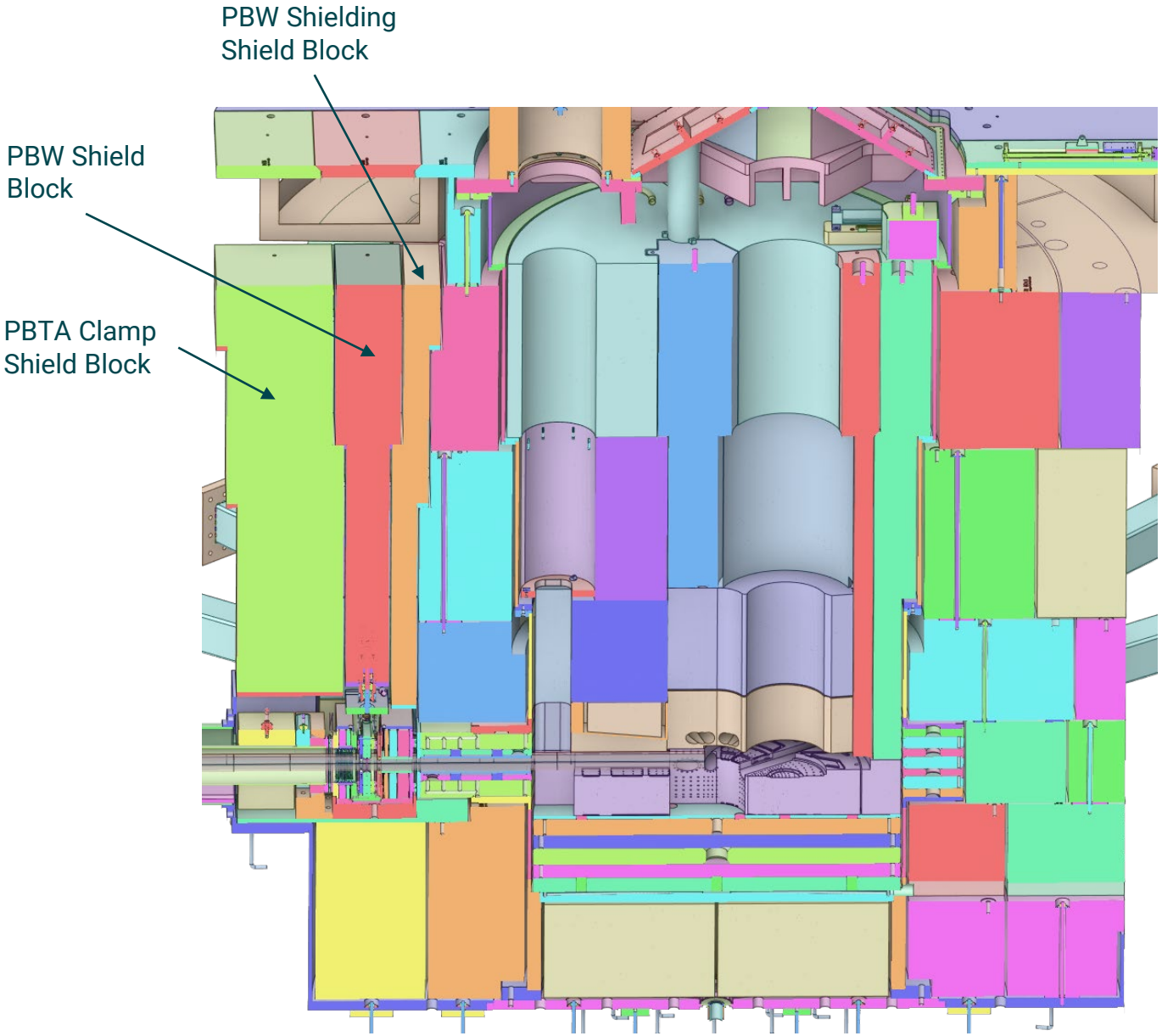


Pipe Pan Removable Shielding Details



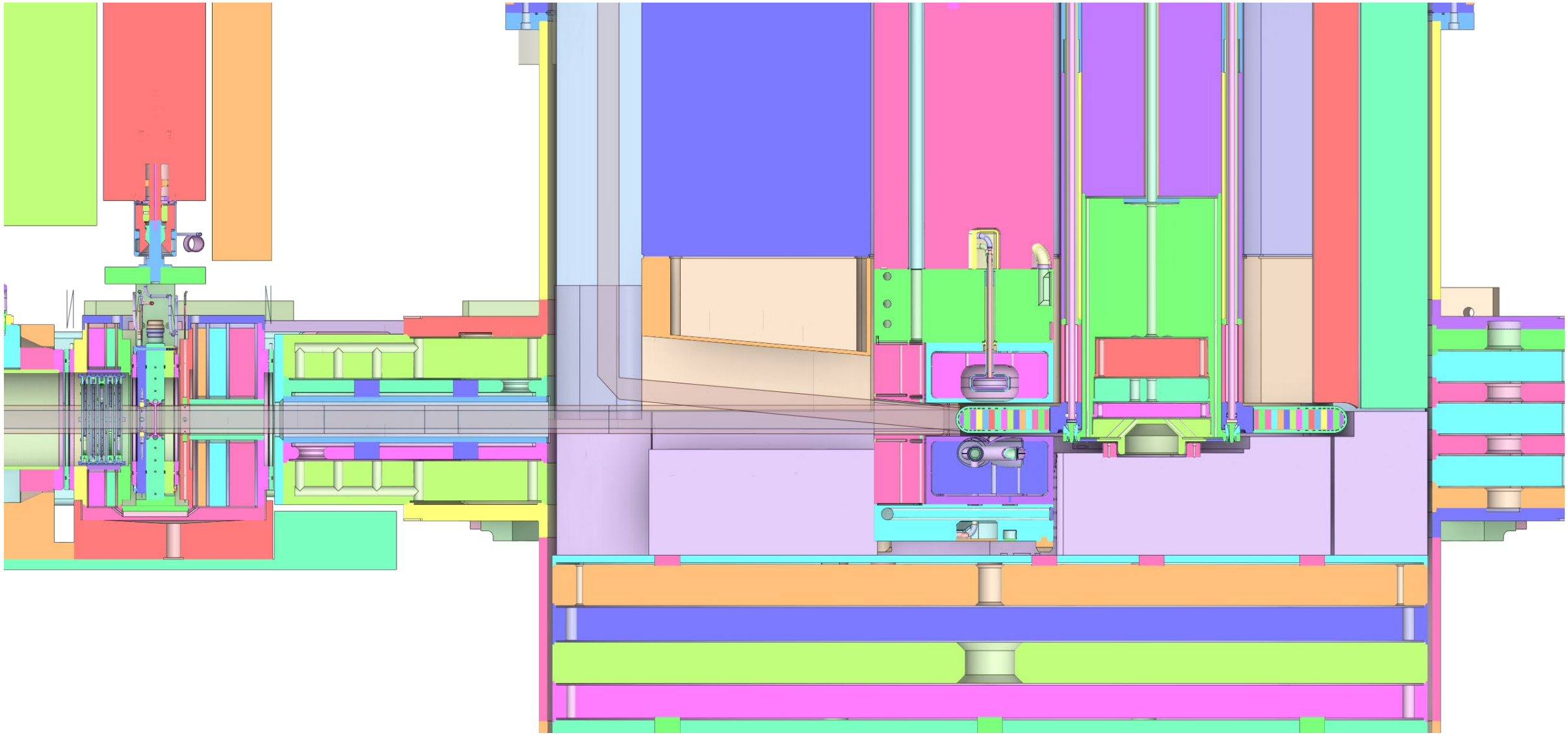
AIC Removable Shielding Details



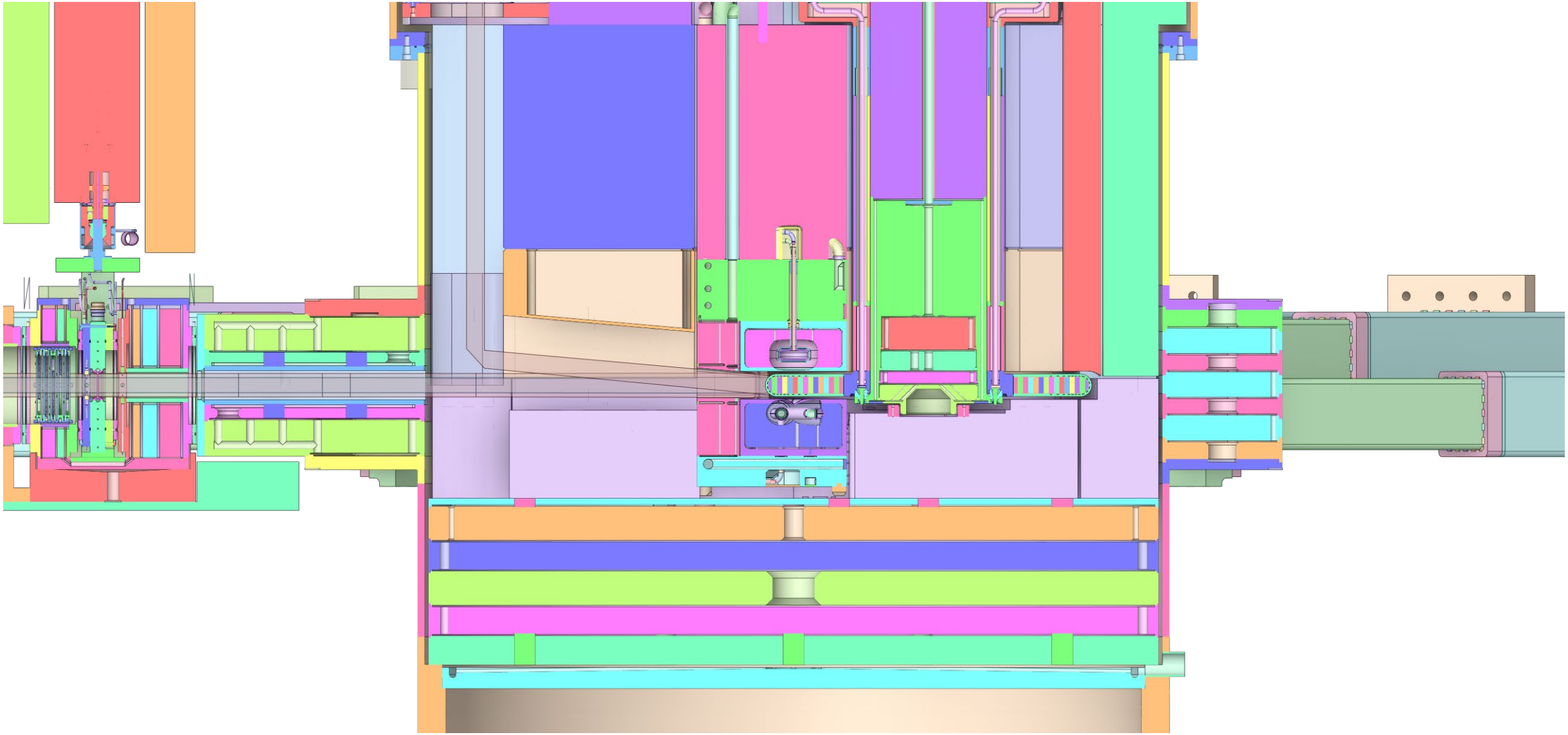


BACKUP SLIDES

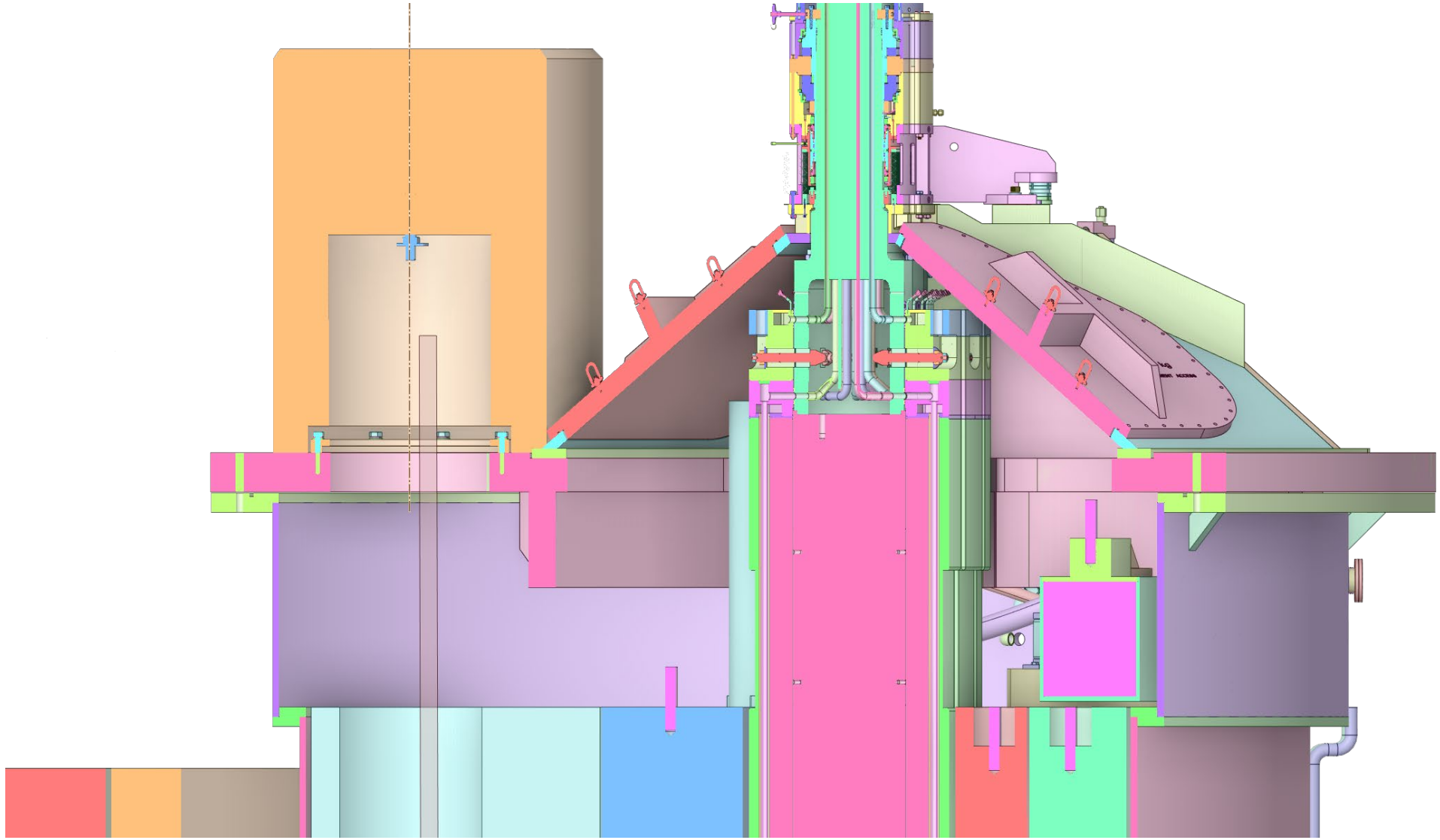
BACKUP SLIDES



BACKUP SLIDES



BACKUP SLIDES



BACKUP SLIDES