OAK RIDGE National Laboratory

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MRA Manufacturing Plan

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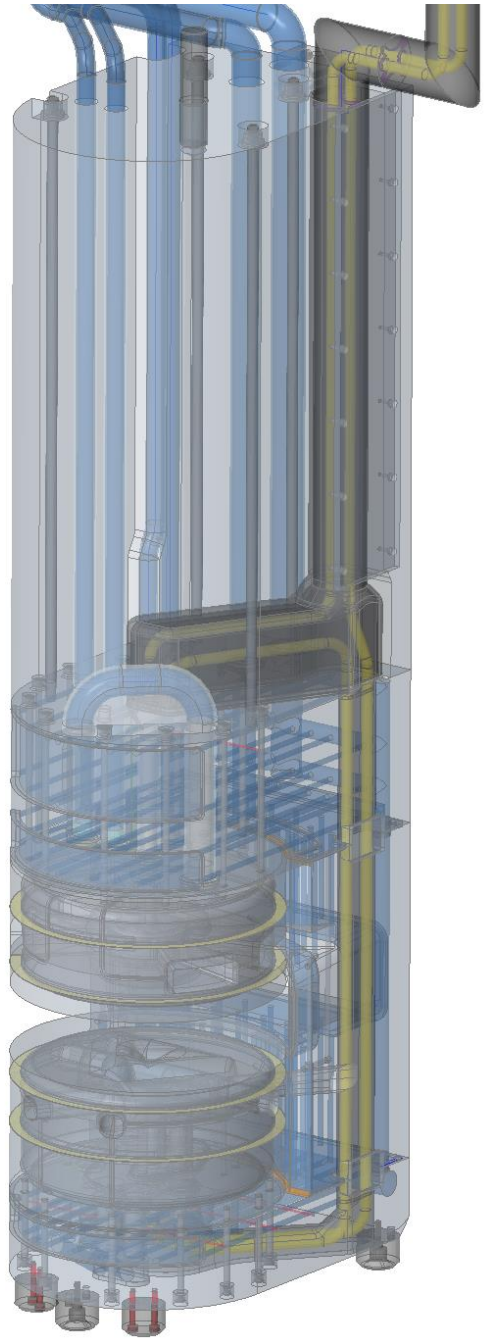
U.S. DEPARTMENT of ENERGY

ORNL IS MANAGED BY UT-BATTELLE LLC
FOR THE US DEPARTMENT OF ENERGY

MRA Manufacturing Overall Strategy

- Minimize the quantity and complexity of welding by simplifying design
    - Goal is to have no GTAW touch up on aluminum welds, which was achieved on the moderator prototypes
    - No post weld smoothing of aluminum welds
- Choose machining complexity and volume in order to reduce welding complexity and volume



MRA Aluminum Welding Strategy

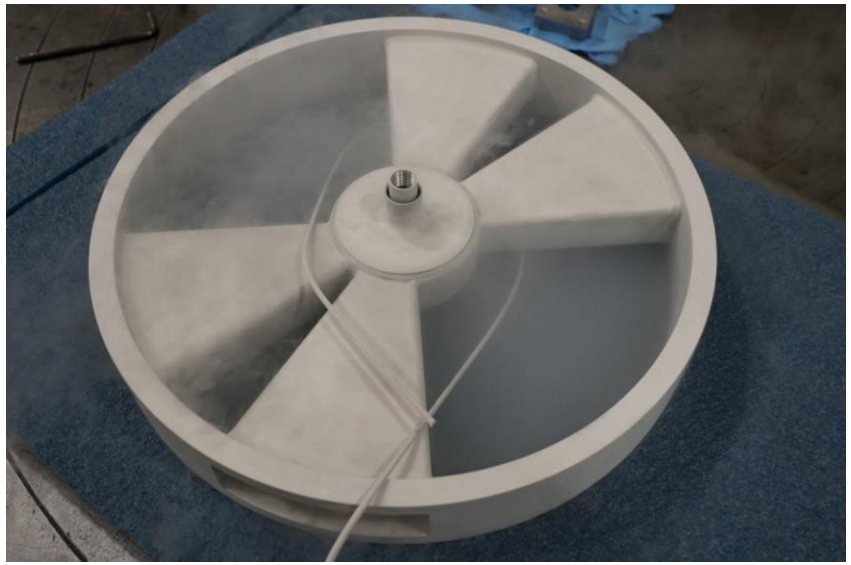
- Electron beam welding for reduced deformation and repeatability
- MRA aluminum is Al 6061-T6
    - Al 4047 shim stock used for filler
    - Shims cut using microwaterjet
- Moderator parts and shims cut to close fit up tolerance
    - Gaps less than 0.1 mm
- All parts pickled and then nitrogen bagged to prepare for welding
- Bags opened immediately prior to welding
- Process proved successful in both prototypes

Moderator Prototype Experience

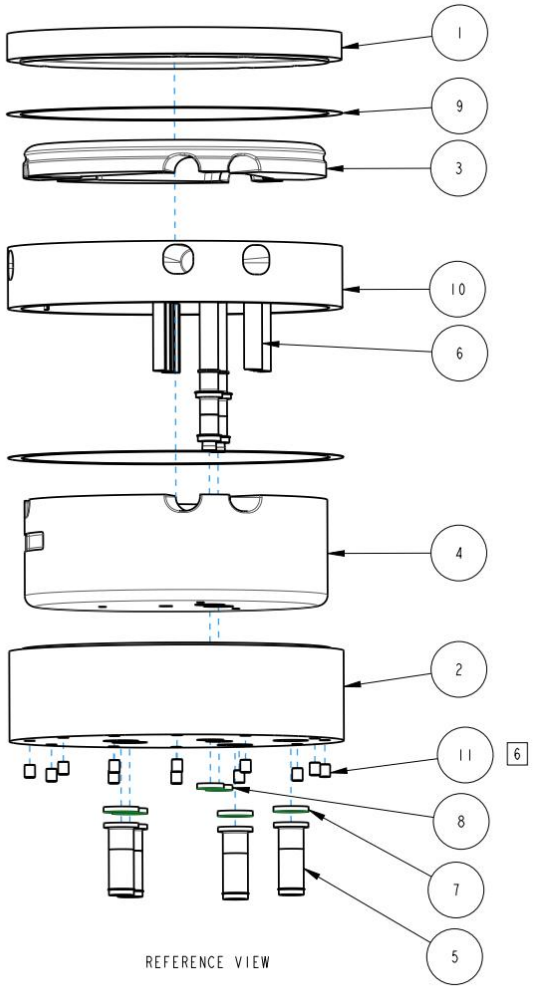
- Strategy to increase machining complexity to reduce number and complexity of welds was very successful
- Tube moderator is more difficult than cylinder moderator, but still manufacturable
- Careful attention must be paid to weld shrinkage and post weld machining strategies to achieve tolerance requirements
- Domestic supply chain developed to successfully build moderators

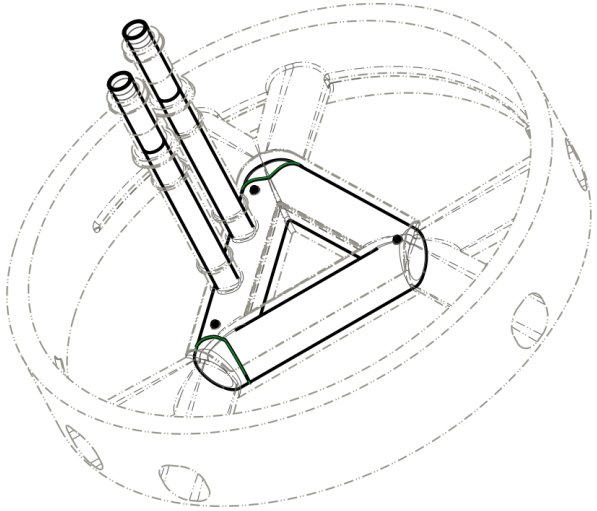
In Process Testing Critical to Successful MRA Fabrication

- In process cold shocking, leak checking, and pressure testing to ensure pressure boundaries are tested while they are still accessible
- To be noted on drawings for clarity

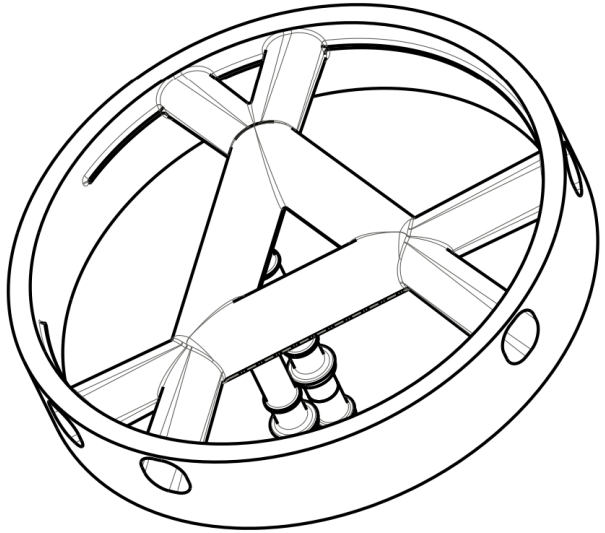


MRA Lower Reflector Vessel Drawing Package Walkthrough





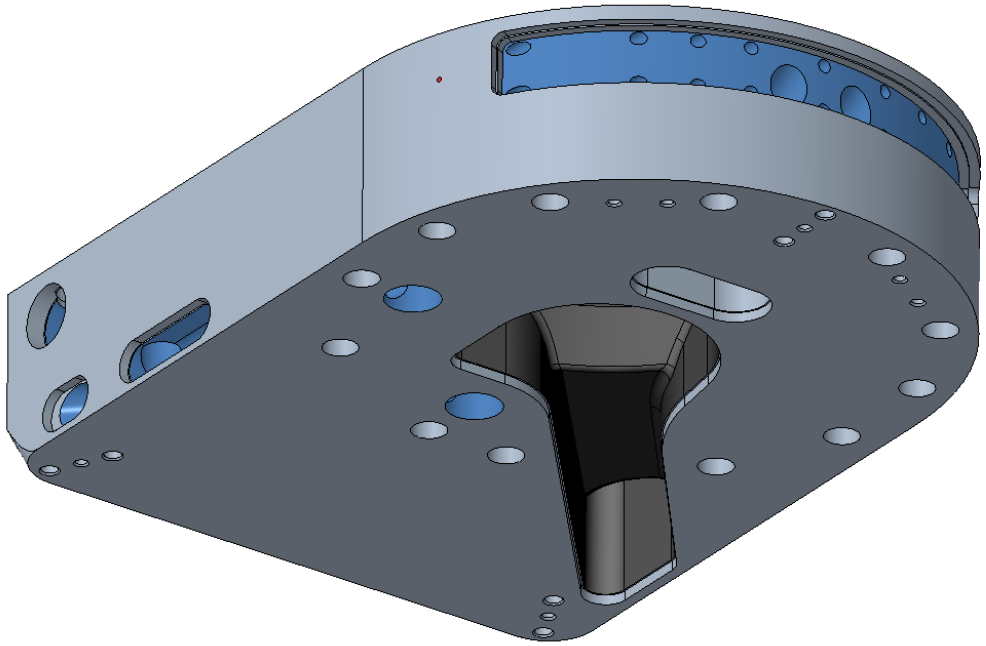
SCALE 1:4
REFERENCE VIEW

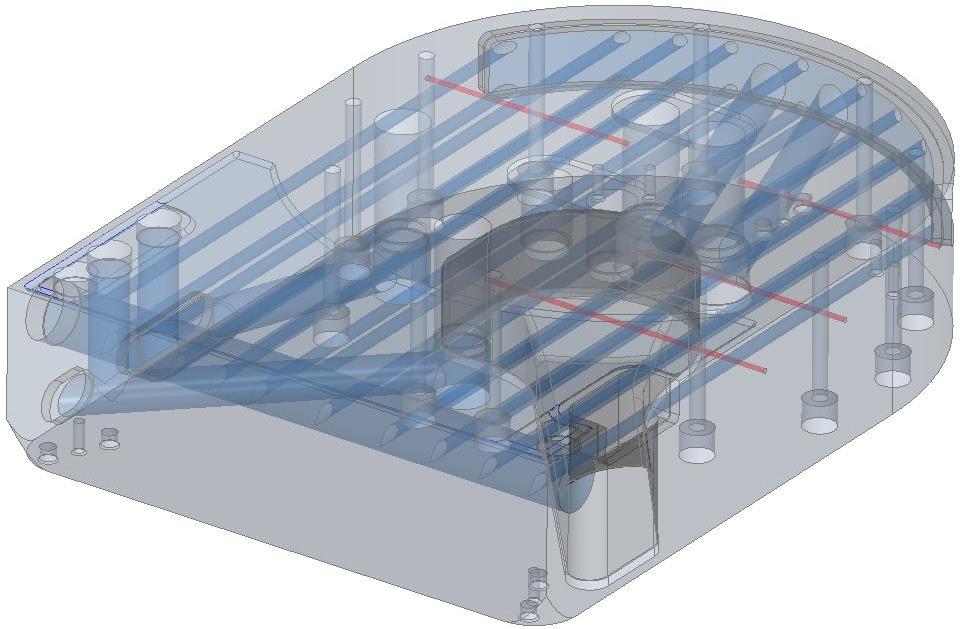


SCALE 1:4
REFERENCE VIEW

MRA Lower Backbone

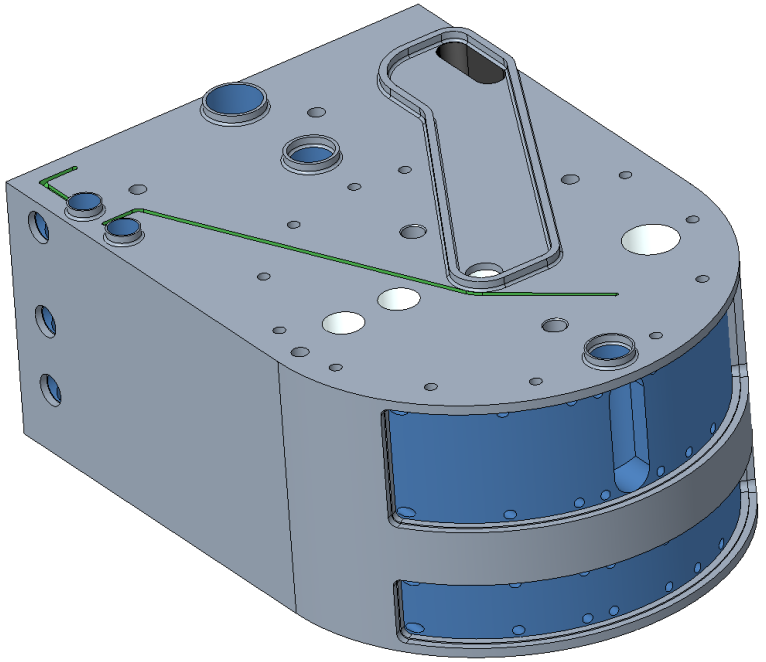
- 316L Plate Material
- Lots of deep hole drilling for cooling channels
- Vacuum boundary internal surfaces to be polished
- 4 water passage cover plates which can be welded prior to reflector vessel assembly
- Stock left on reflector vessel side to allow machining to final dimension after backbone welding

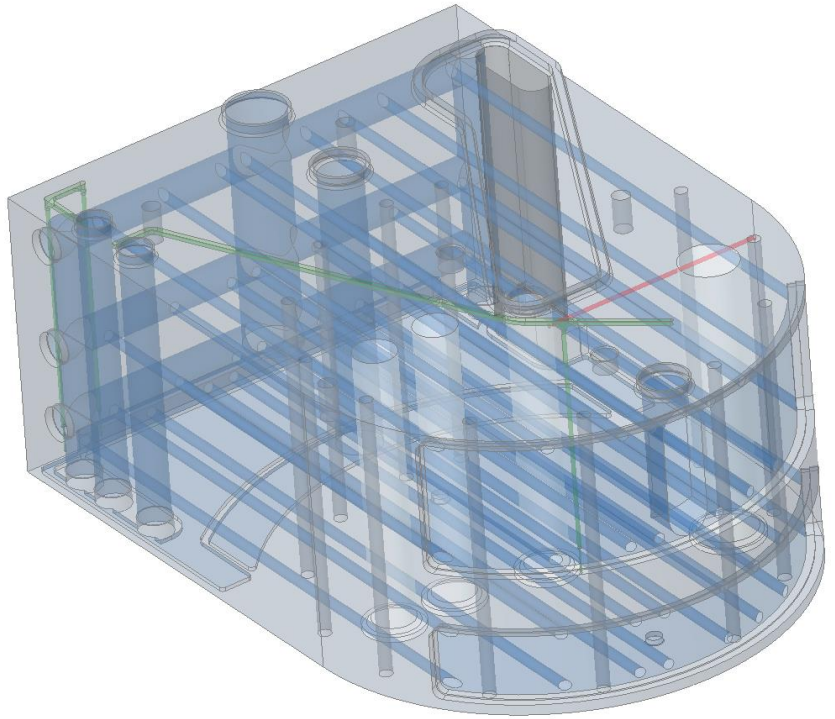




MRA Upper Backbone

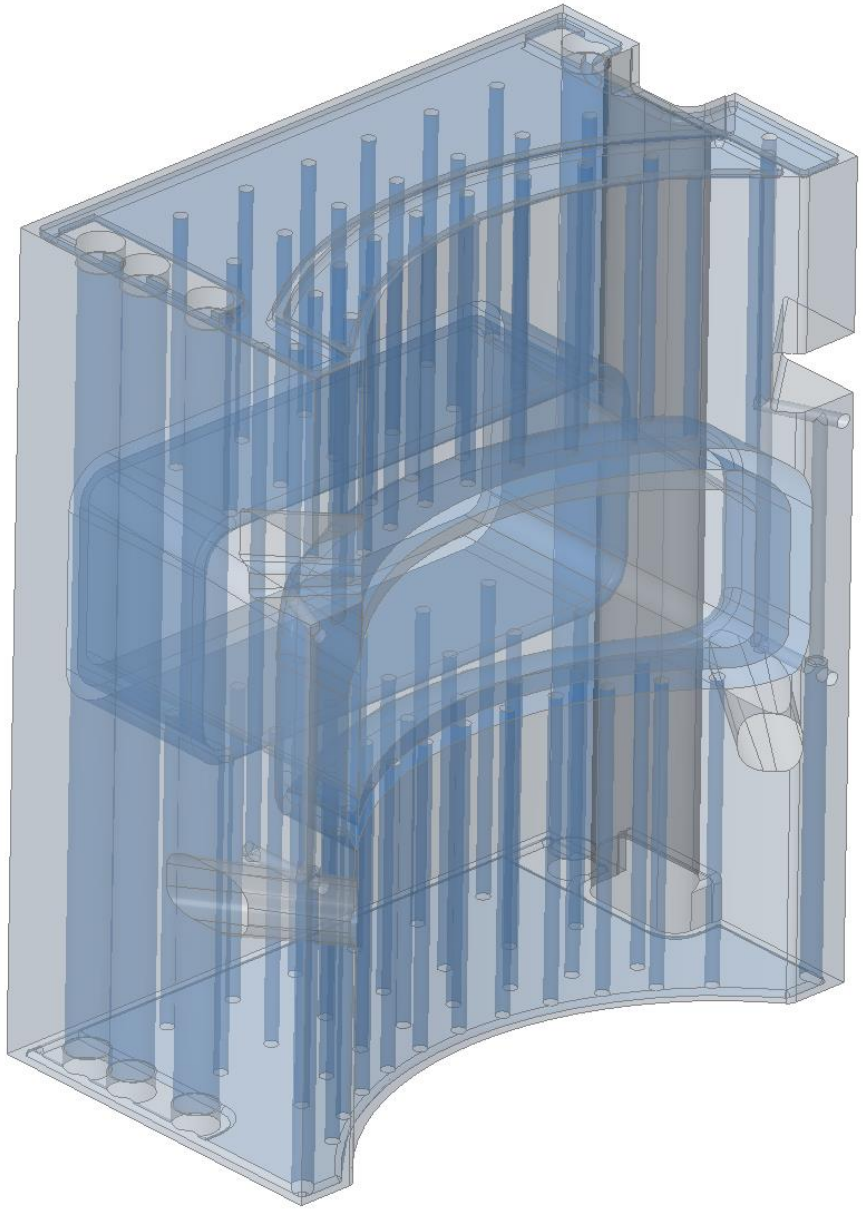
- 316L Plate Material
- Lots (even more) of deep hole drilling for cooling channels
- Vacuum boundary internal surfaces to be polished
- 5 water passage cover plates which can be welded prior to reflector vessel assembly
- Stock left on both top and bottom to allow machining to final dimension after backbone welding
- Butt weld extensions on top surface to reduce required heat input for vacuum cover and piping welding





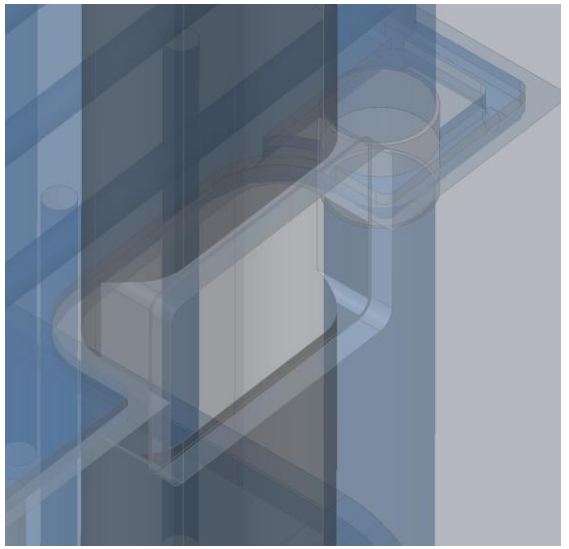
MRA Middle Backbone

- 316L Plate Material
- Lots of deep hole drilling for cooling channels
- Vacuum passage will require wire EDM
- Cooling channels around proton beam port will require slot cutting and plunge EDM
- Vacuum boundary internal surfaces to be polished
- 2 water passage cover plates and 4 plug welds required to close water channels

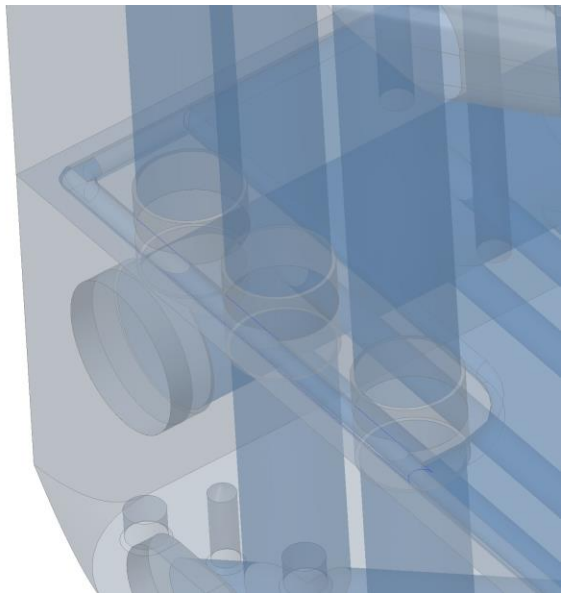


Backbone Weldment

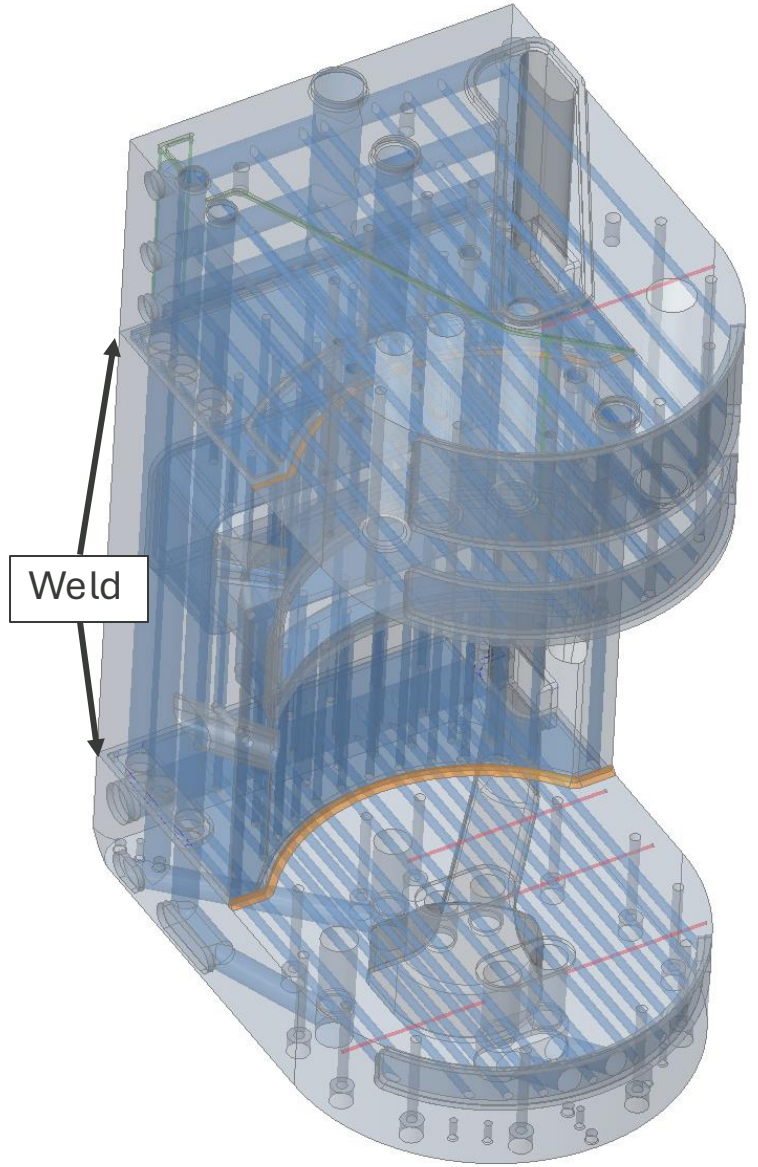
- GTAW welds connecting upper and lower backbone to middle backbone
  - Full penetration 6 mm deep structural welds which also close middle backbone cooling manifolds
  - Fillet weld reinforcement machined to improve fatigue resistance
- Recesses and cover plates allow welding behind and subsequent sealing of vacuum passages
- Sleeves prevent leakage from lower reflector water pass throughs to middle backbone manifolds
- Mating surfaces to reflector vessels and shield block finished after welding



Vacuum Cover Detail



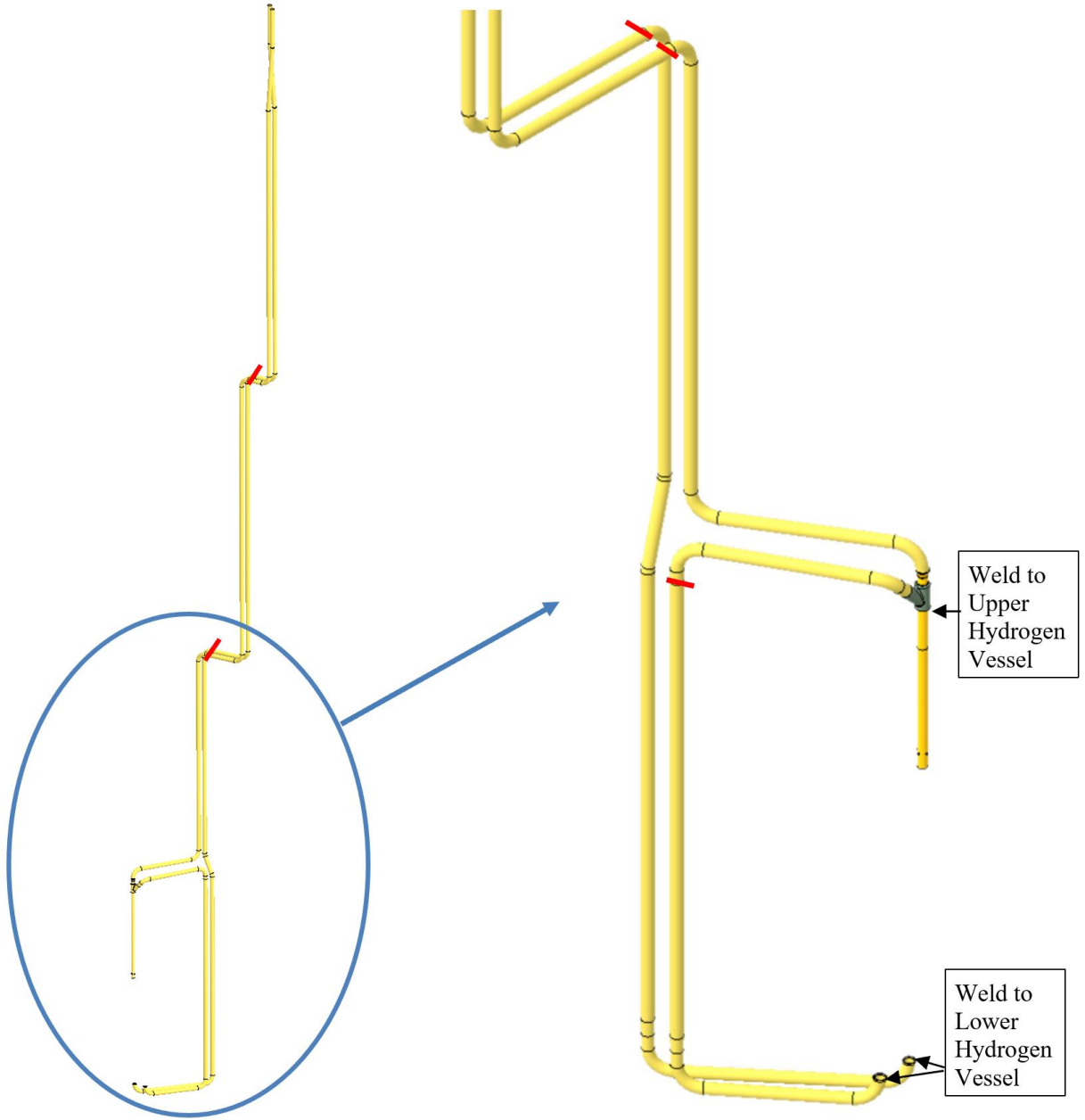
Sleeve Detail



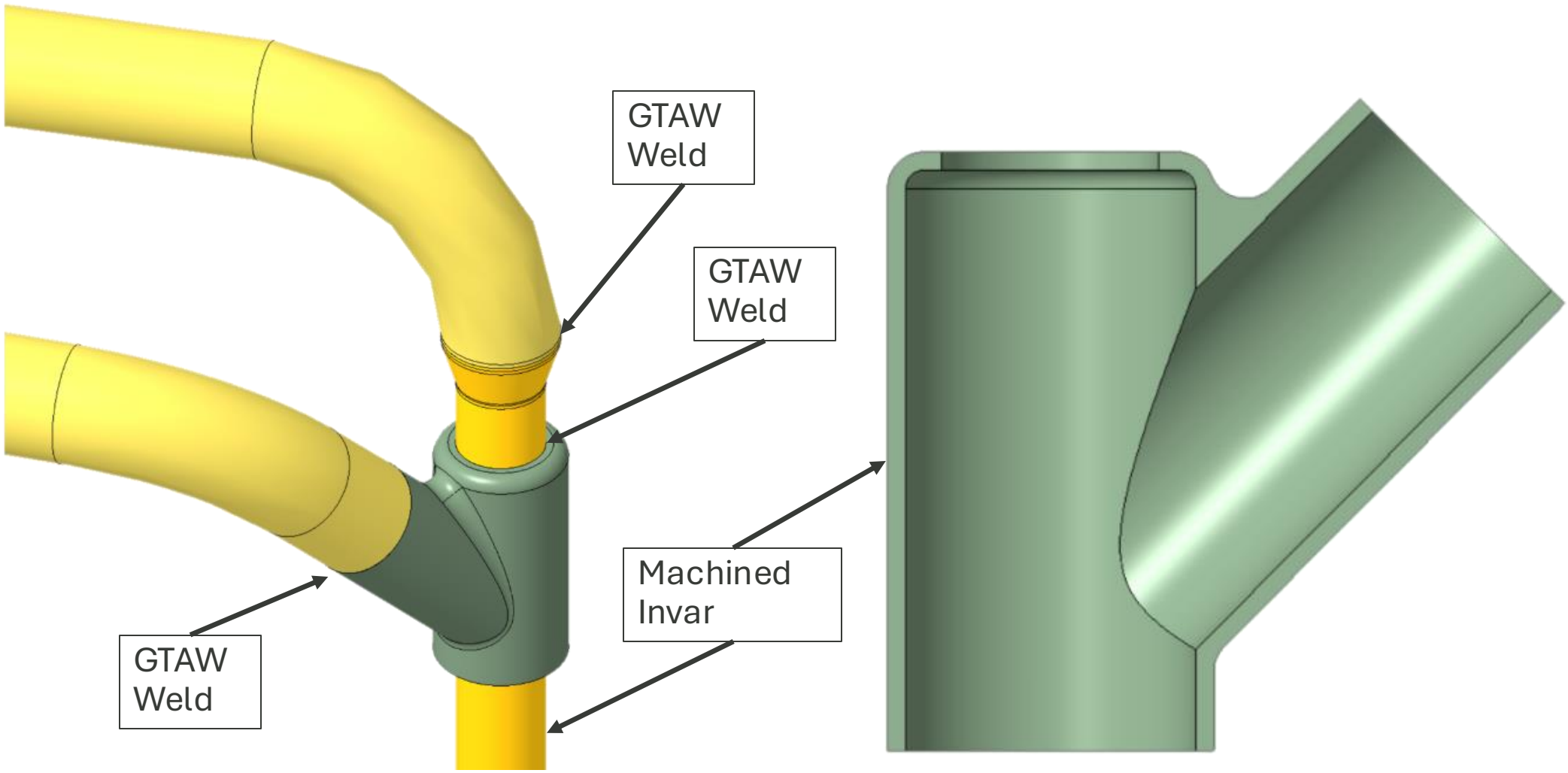
Backbone Weldment

MRA Hydrogen Tubing

- Invar 36 5/8” OD, 0.035” wall tubing
  - Custom tubing
  - To be ordered along with CMS Transfer Line tubing
- 8 sections of bent tubing required for MRA hydrogen piping
- All welding aside from upper hydrogen performed at assembly on MRA

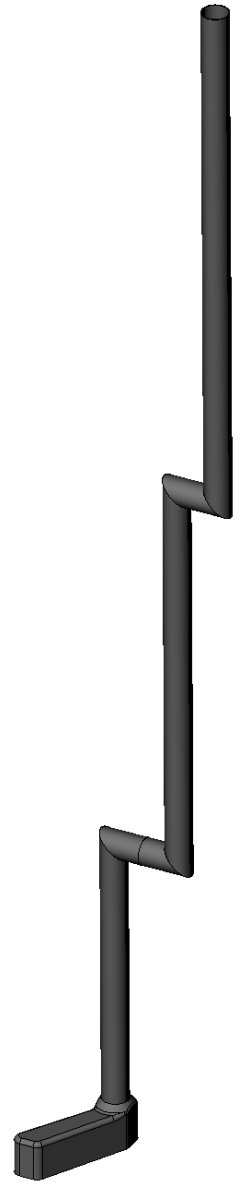


Upper Hydrogen Supply Stinger



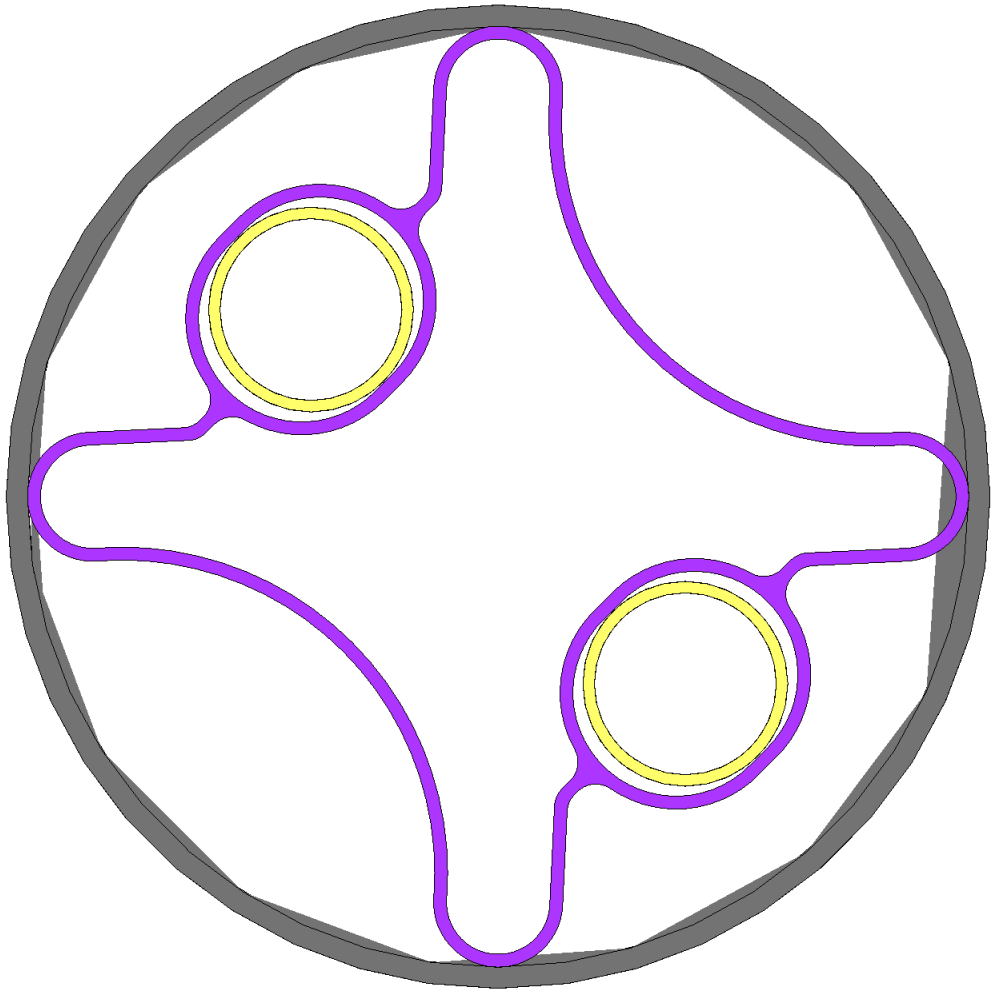
MRA Vacuum Line

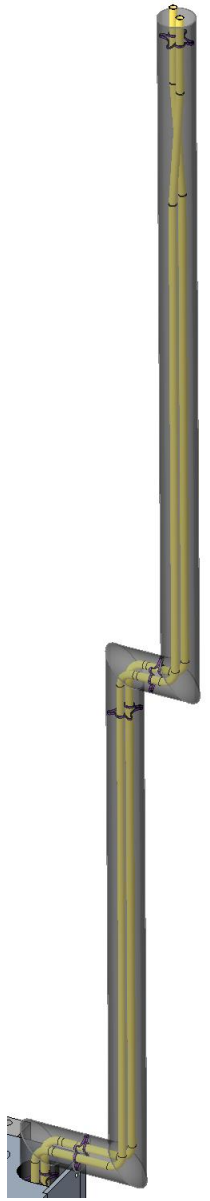
- 316L 3” OD, 0.065” wall tube
  - Specified polished and cleaned
  - Large enough for 2 hydrogen tubes
  - Large enough for bent hydrogen lines to fit through mitered bends
- 6 straight sections with mitered ends
- All welding performed at MRA integration



MRA Transfer Line Spacers

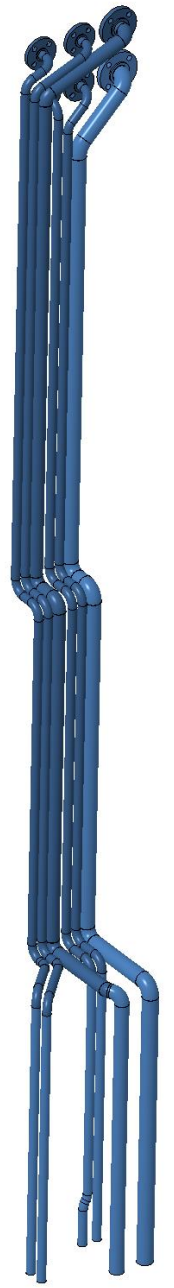
- Ti-15-3-3 6 mm deep spacers
  - Material availability may be problematic
  - Can substitute Grade 5 Ti if not available
- Wall thickness of 1 mm





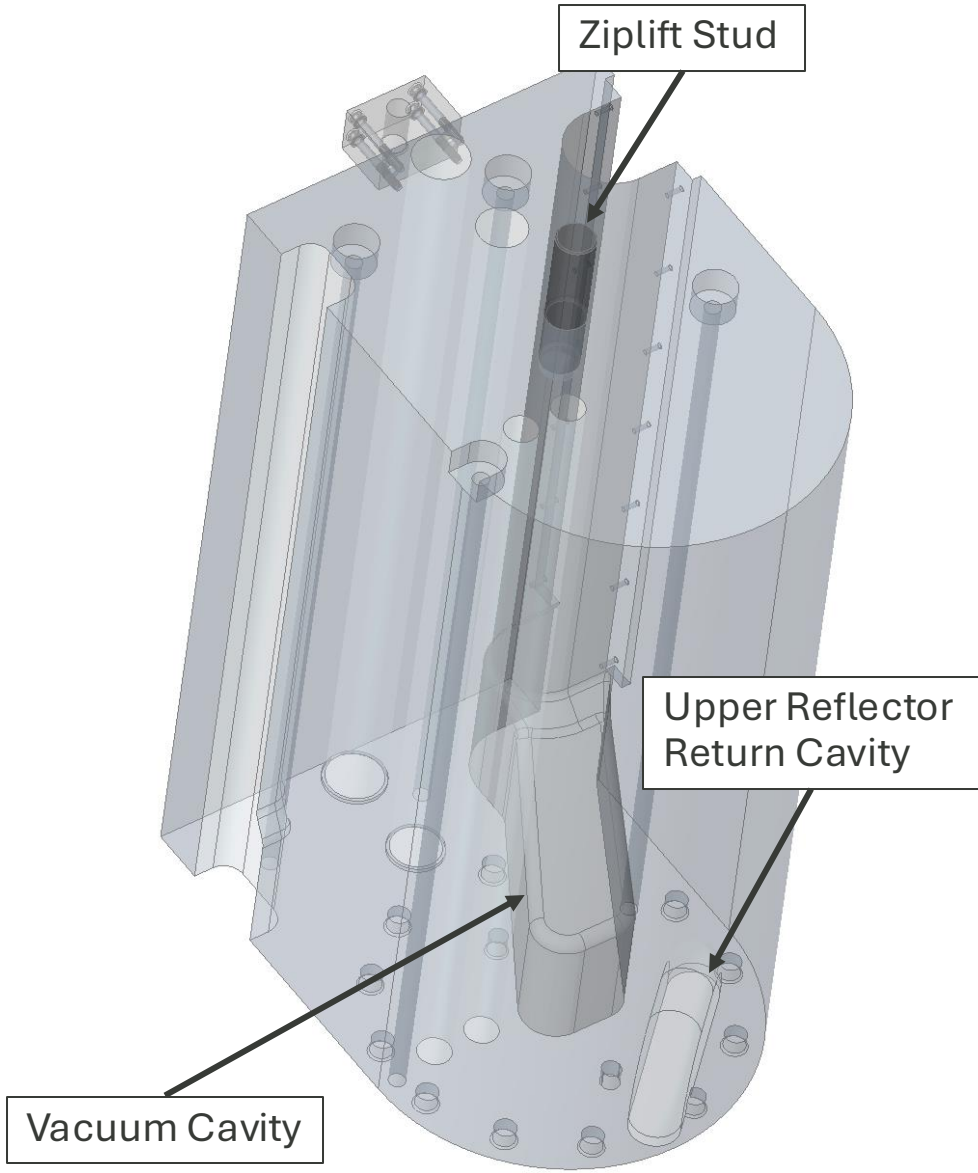
MRA Water Piping

- 6 316L water lines with raised face flanges
  - 4 ¾” sch 10
  - 1 1.25” sch 10
  - 1 1.5” sch 10
- 4 lines delivered in sections for completion during MRA integration
- 2 lines fully completed prior to MRA integration



MRA Shield Block

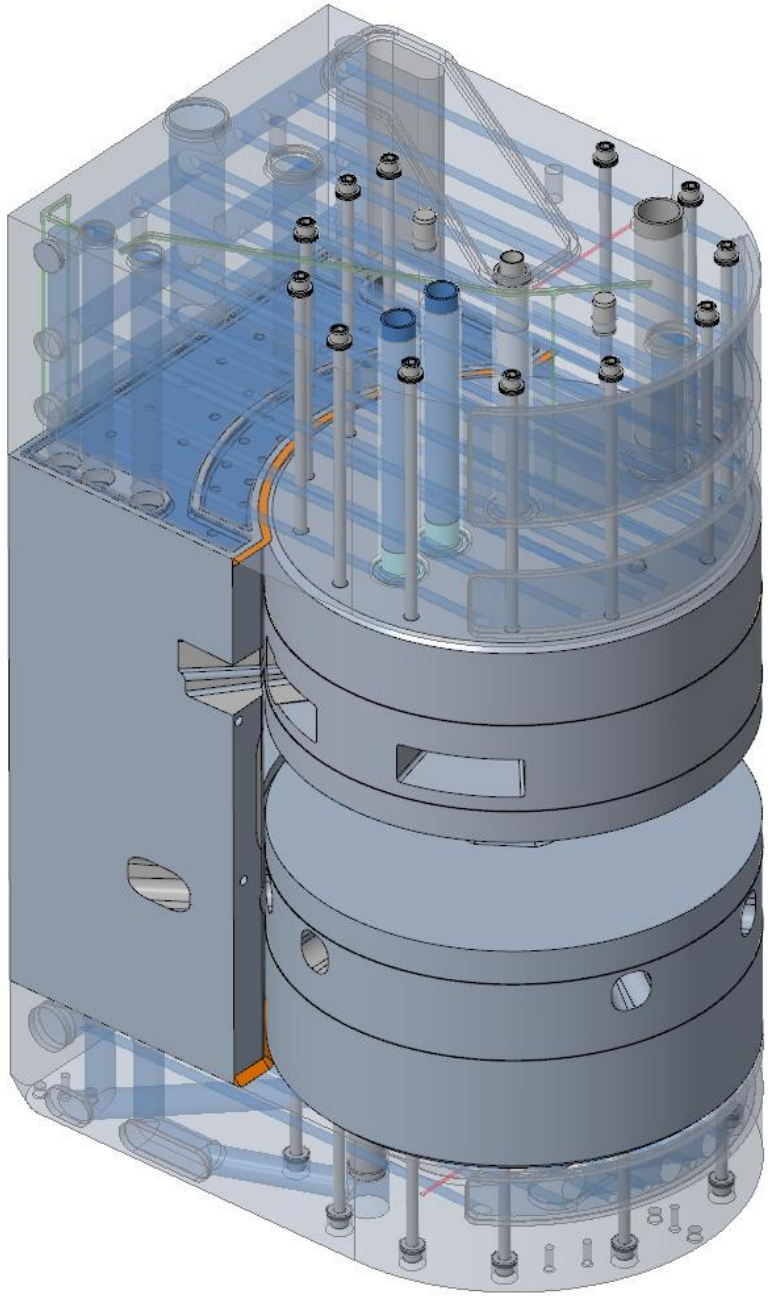
- A36 Steel Plate
- Cavities to provide clearance to upper vacuum cover, Upper Reflector outlet, and Upper Reflector bolt heads
- Passages/chases for all MRA utilities
- Still requires precise machining to meet MRA outside profile tolerances
- Nickel coating for some corrosion resistance



MRA Shield Block

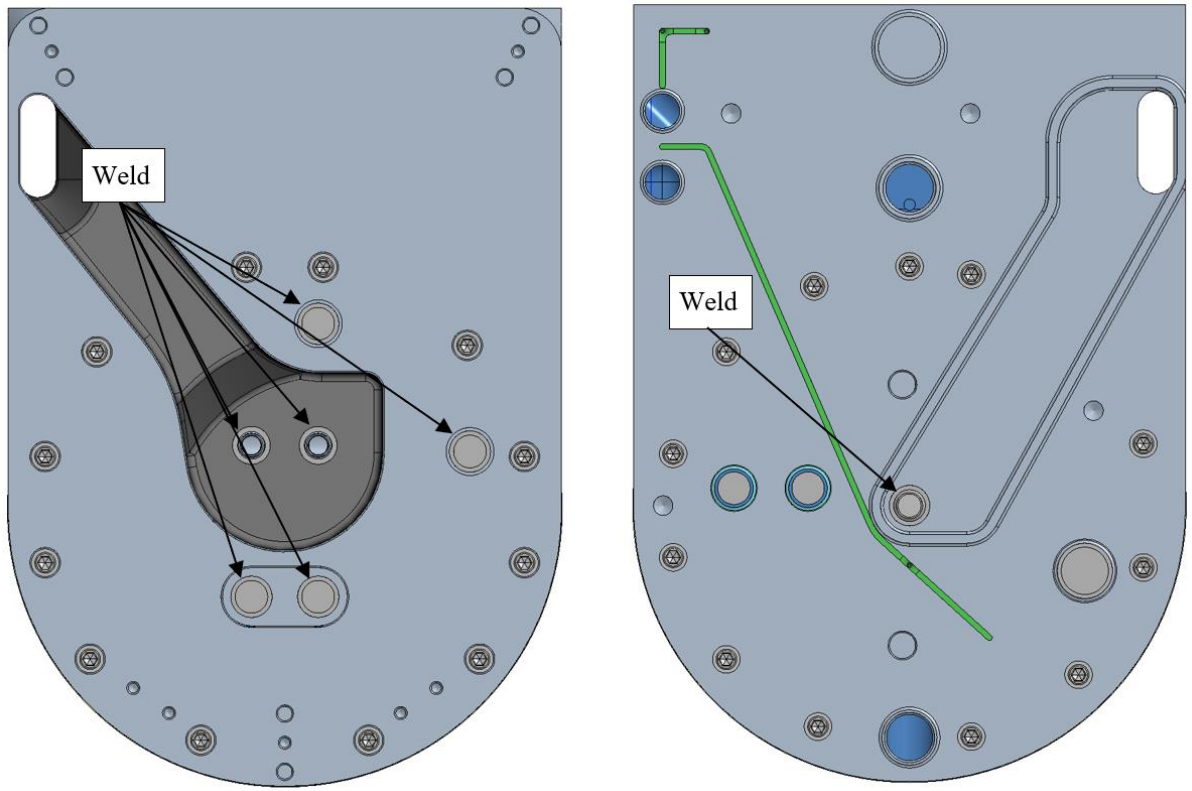
Reflector Vessel Attachment

- 12 3/8”-16 SS316 SHCS provide structural connection between each reflector vessel and backbone
- Preload applied by flattening Belleville washers
- Lower reflector vessel aligned to backbone by 6 utility connections
- Upper reflector vessel is aligned to backbone with dowel pins as there is only 1 utility connection with a long thin tube
- Reflector vessel assembly mass of ~40 kg each makes assembly within backbone C space will be feasible

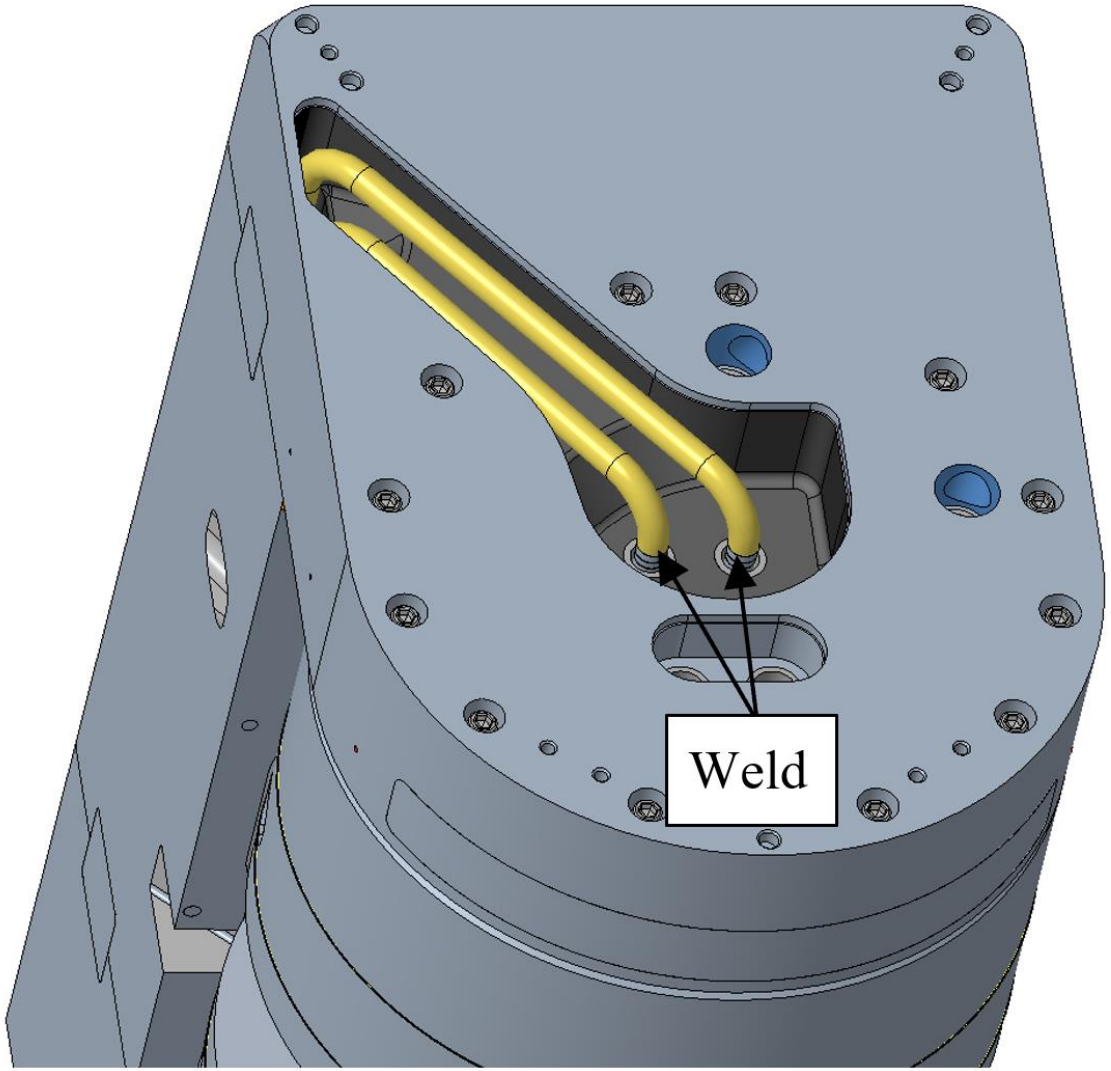


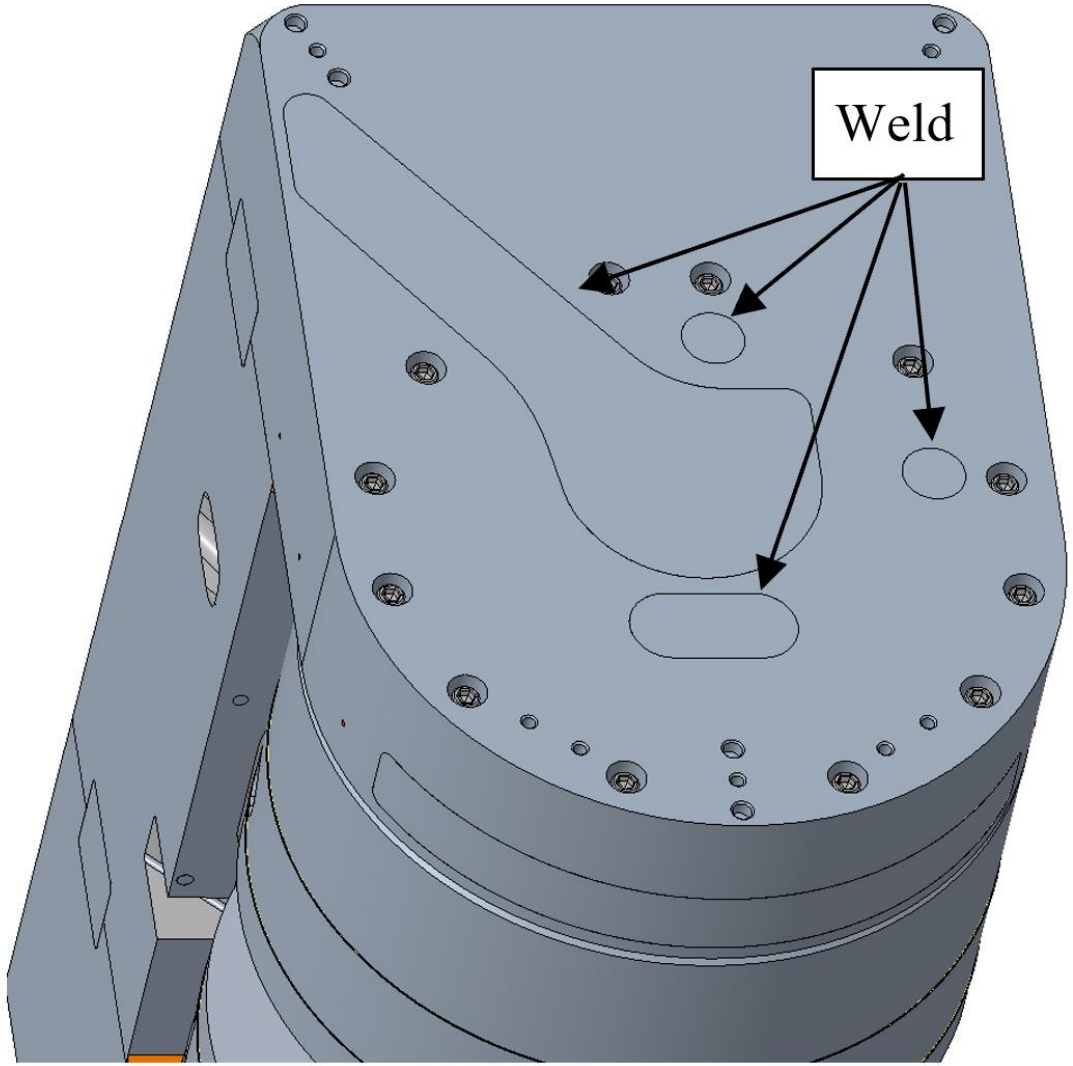
Reflector Vessel Assembly Utility Welds

- All lower reflector utilities (2 vacuum, 4 water tubes) weld to backbone
  - 6 mm deep 316L EB welds
  - All welds recessed below backbone surface
- Upper reflector vacuum tube seals to backbone
  - 6 mm deep 316L EB weld
  - All water utilities pass through backbone
- Weld fitups finished by machining backbone to match location of reflector vessel utility weld connections

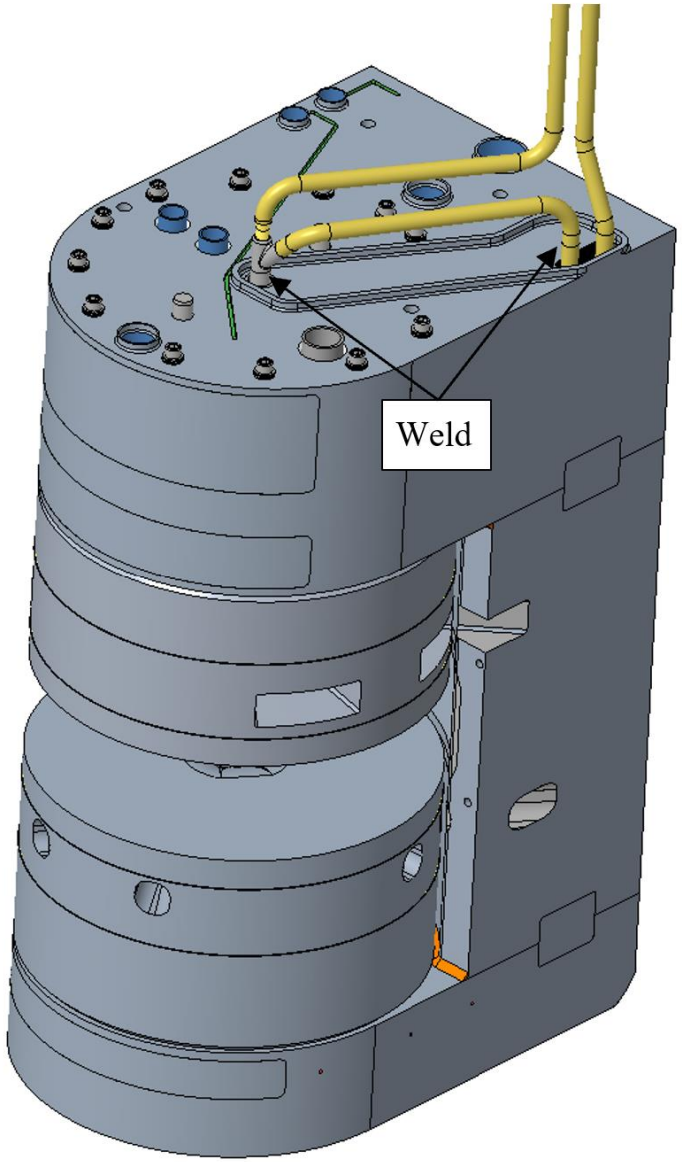


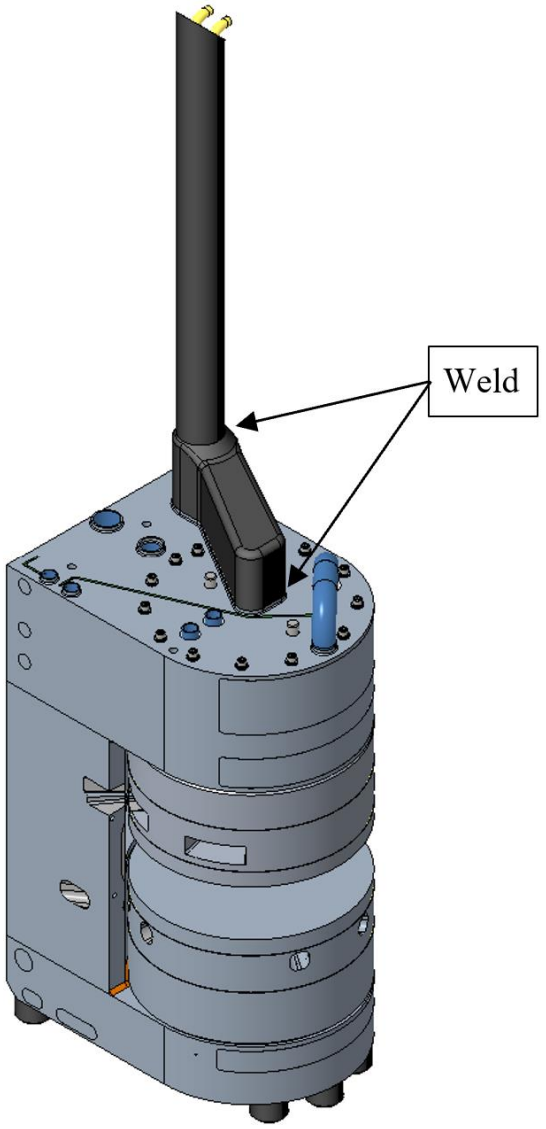
Lower Hydrogen Line and Subsequent Cover Plate Welding

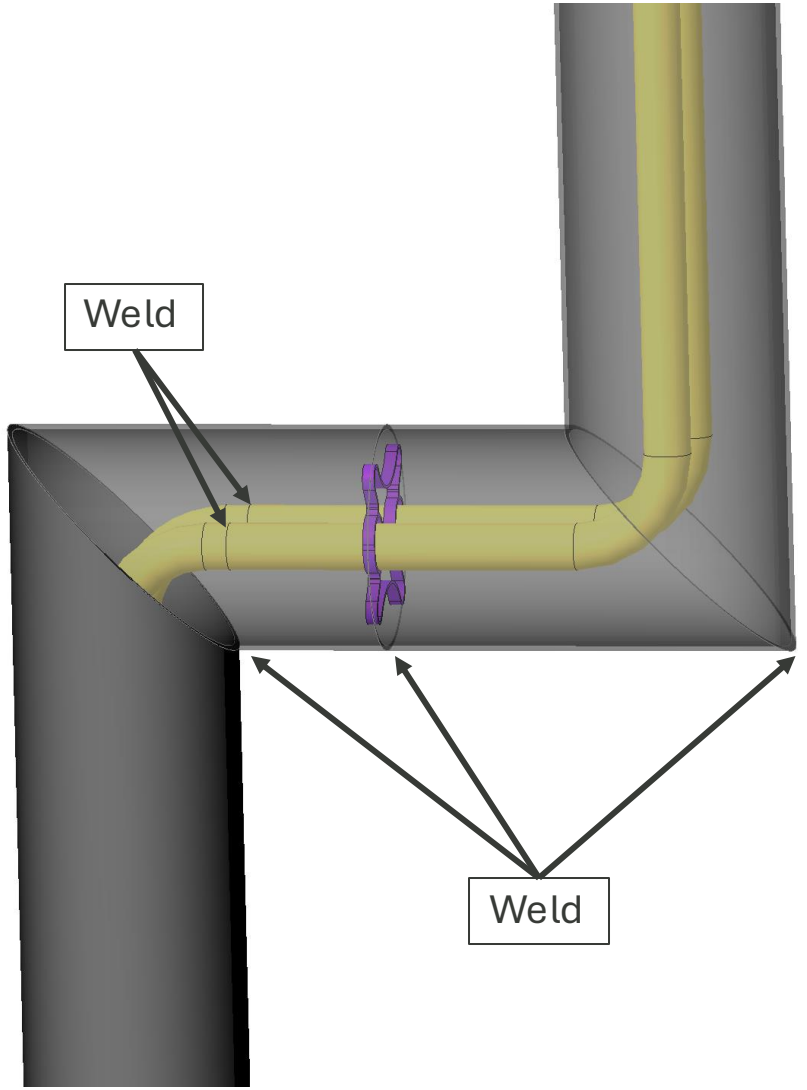




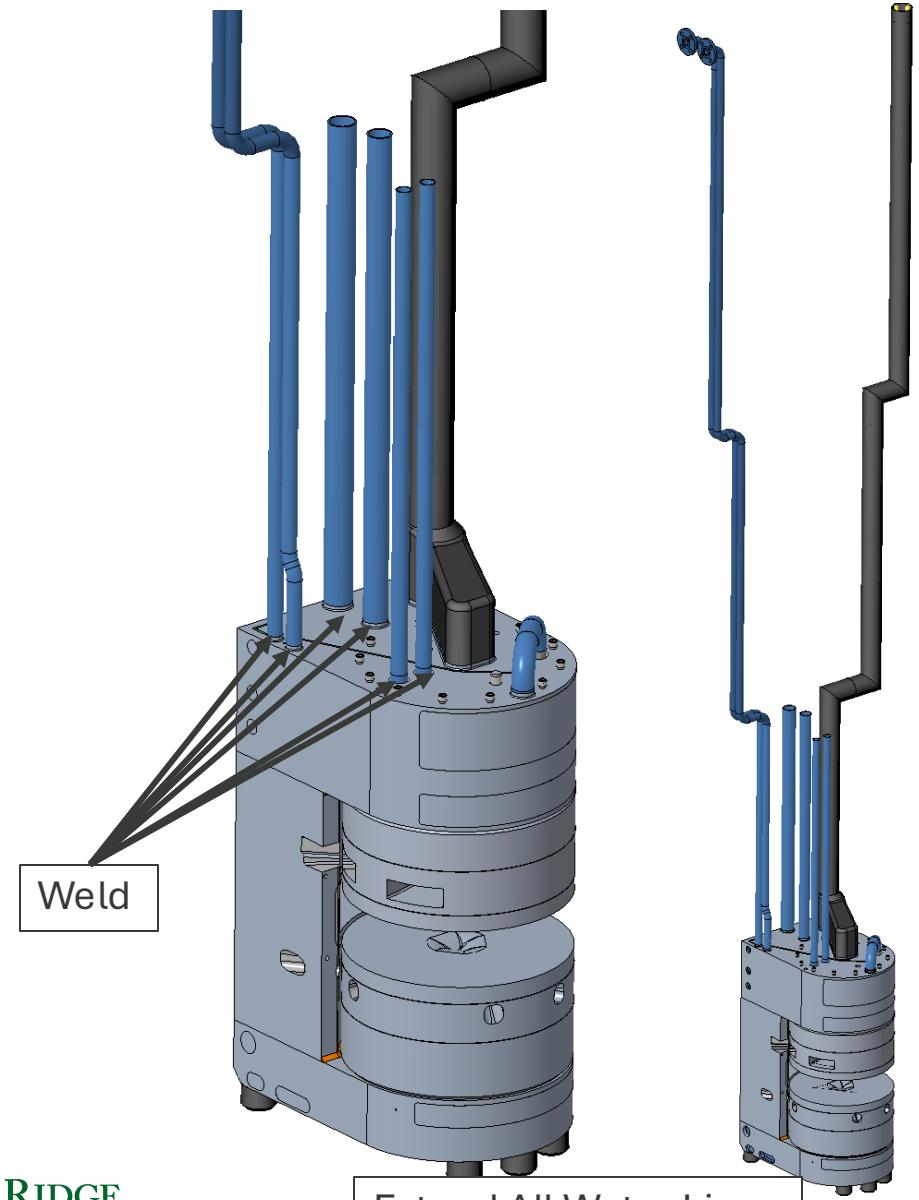
Upper Hydrogen Line and Vacuum Cover Welding



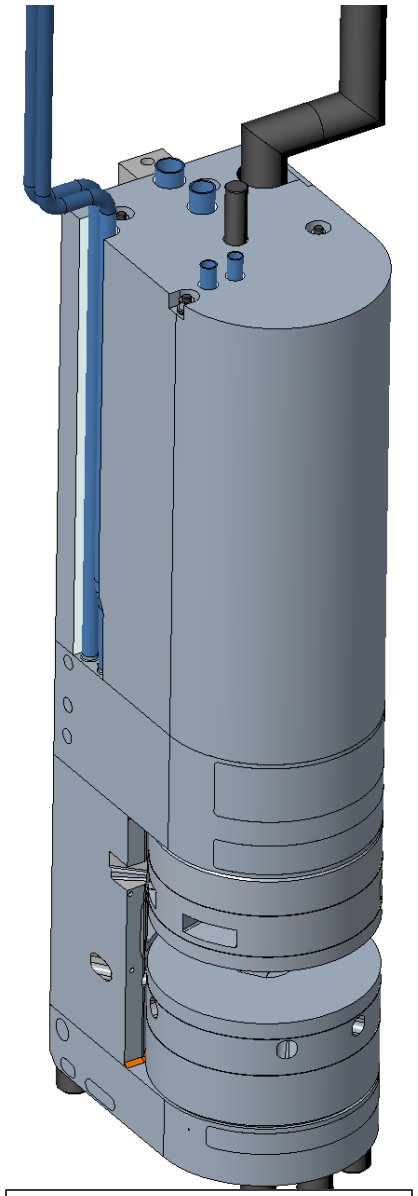




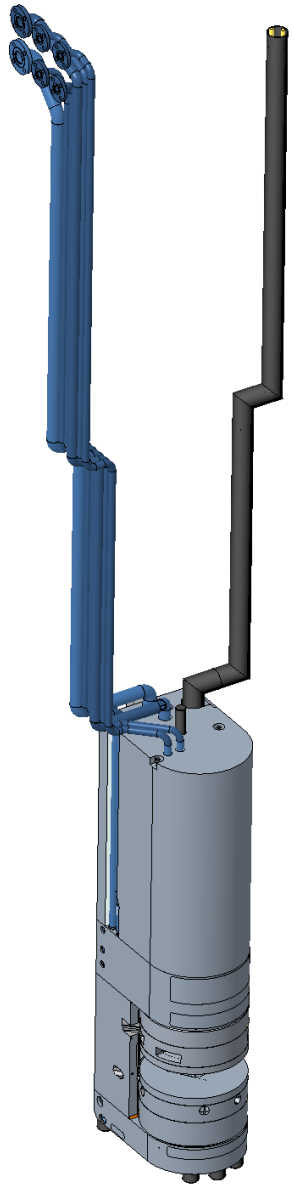
Water Piping Extended Above Shield Block Elevation



Extend All Water Lines

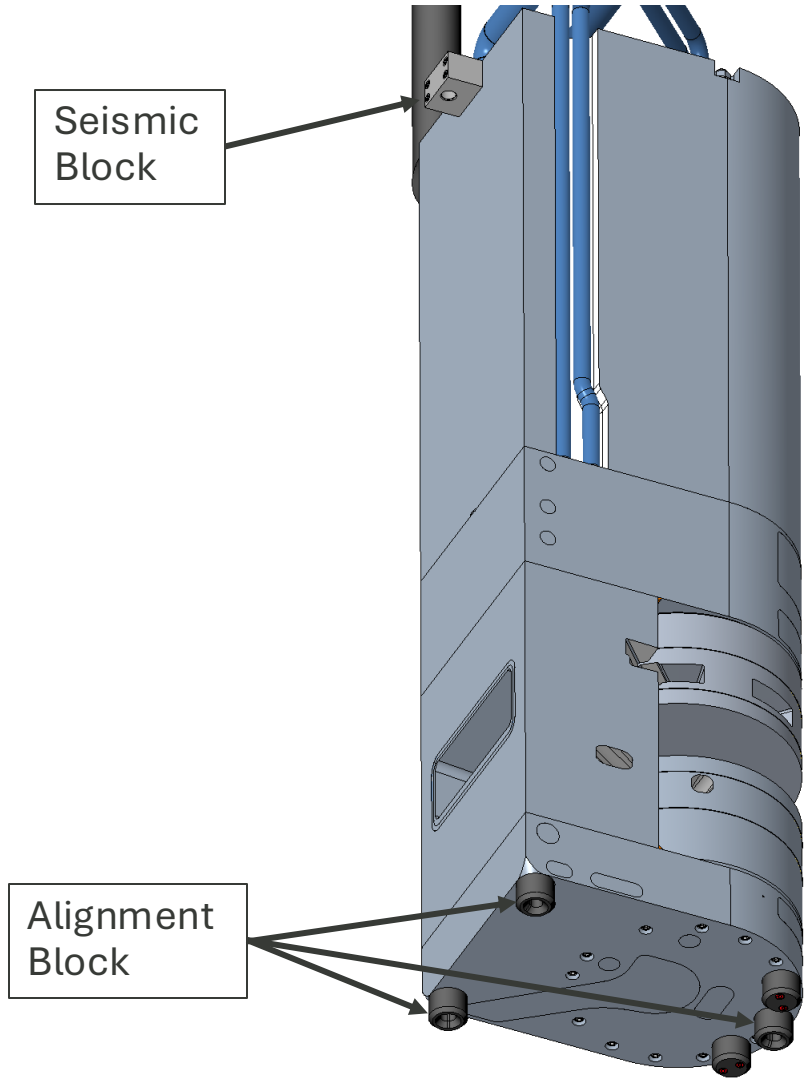


Install Shield Block

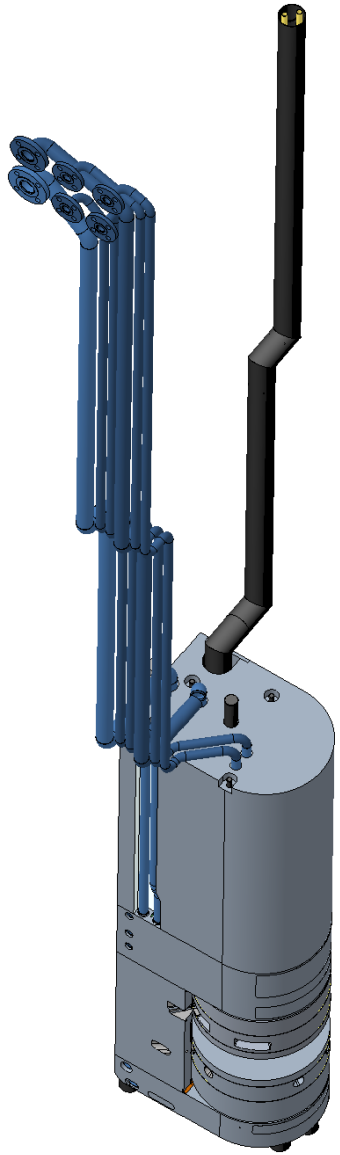


Complete Piping

Complete MRA!

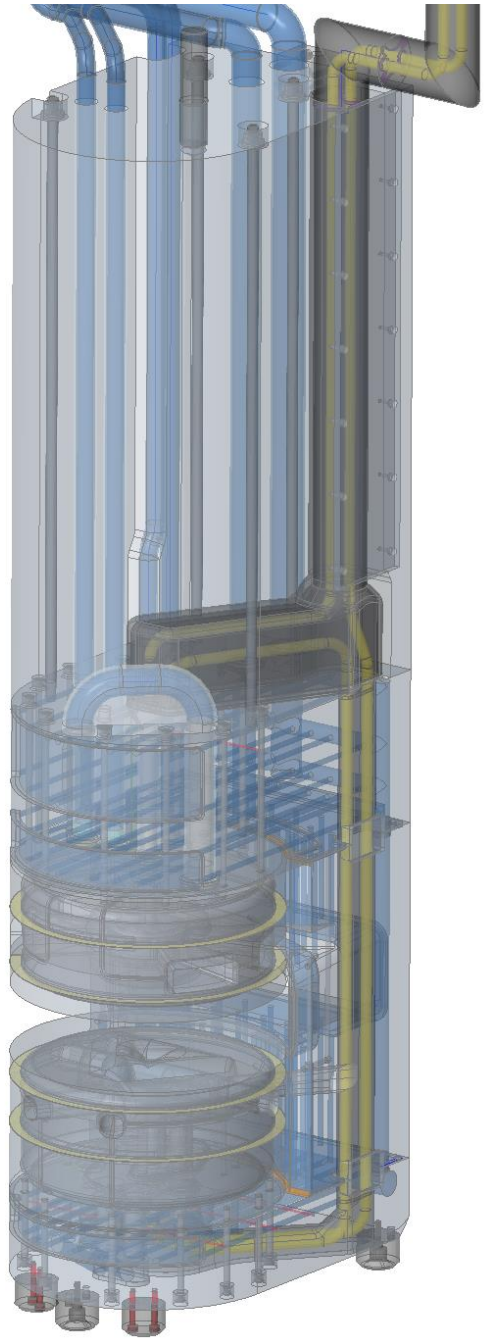


- Alignment blocks and seismic block will be machined based on installed CV mating feature survey to meet MRA alignment requirements
  - Subsequent MRAs will not require last minute adjustments



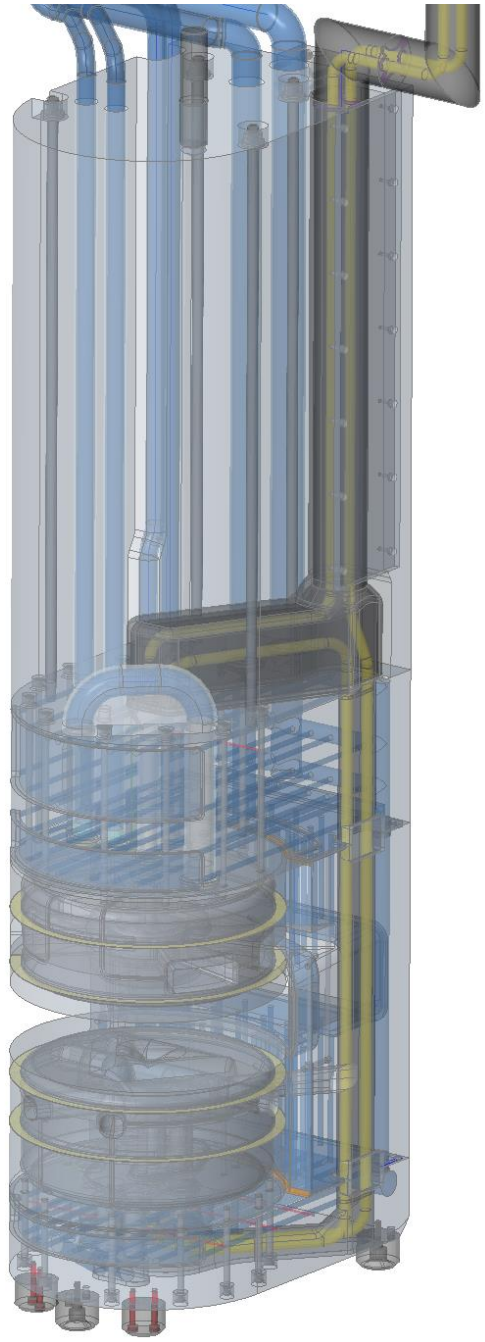
Fabrication Specifications

- MRA procurement is modeling fabrication specification structure off SNS PPU Target structure
  - Specs broken down by task type for improved clarity for vendors
    - General
    - Welding
    - Weld Inspection
    - Testing
    - Pickling
- Specifications have been drafted and are being refined now



Conclusions

- MRA design has been built from the beginning with manufacturability in mind
- The final MRA design attempts to make manufacturing as straightforward and low risk as possible, but there are still many difficult processes required
- The MRA team will continue to work with vendors to implement improvements and troubleshoot problems as necessary



Thank You