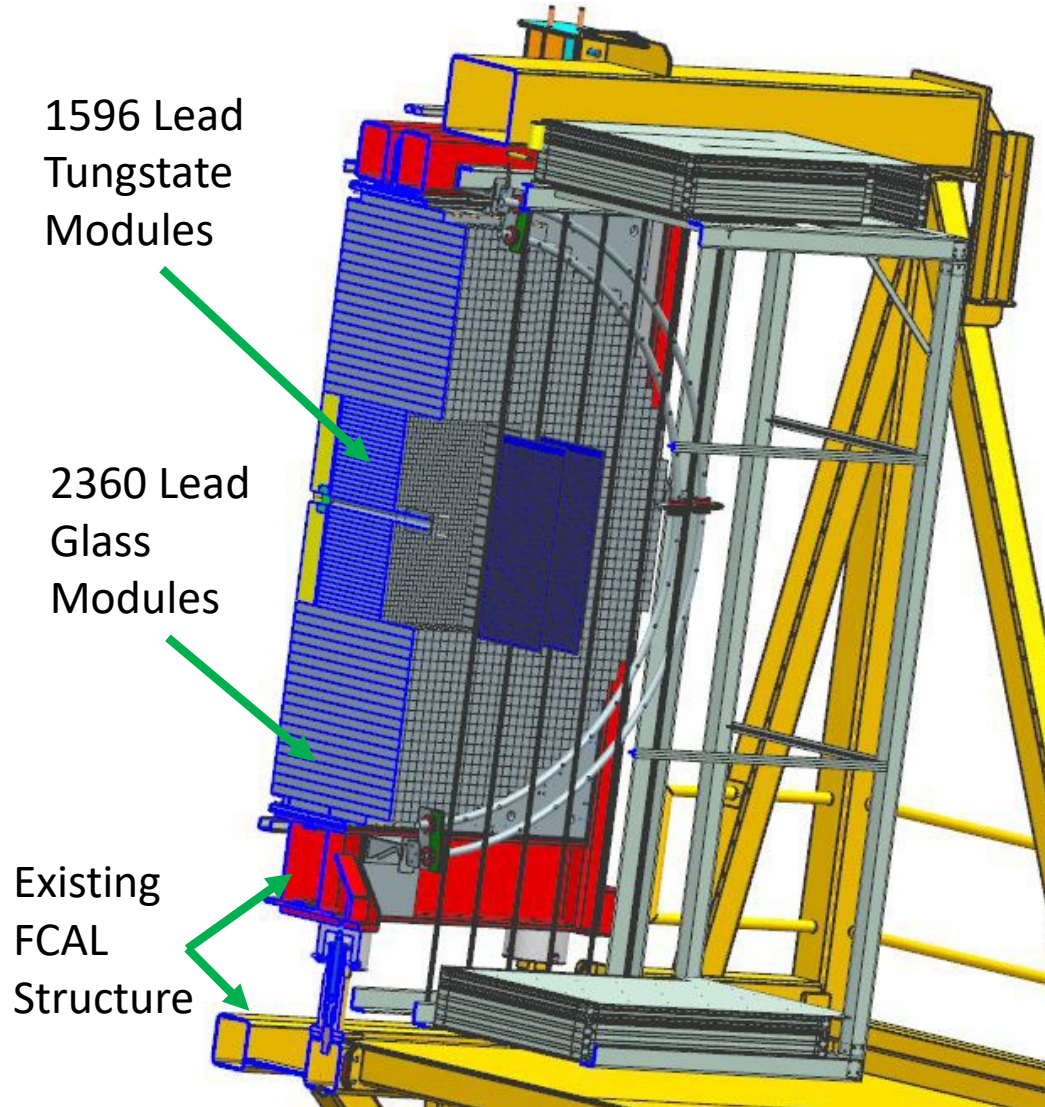


# FCAL 2 Upgrade Process

- This document outlines the steps to disassemble the existing FCAL and reassemble the new FCAL 2

# FCAL Insert Design

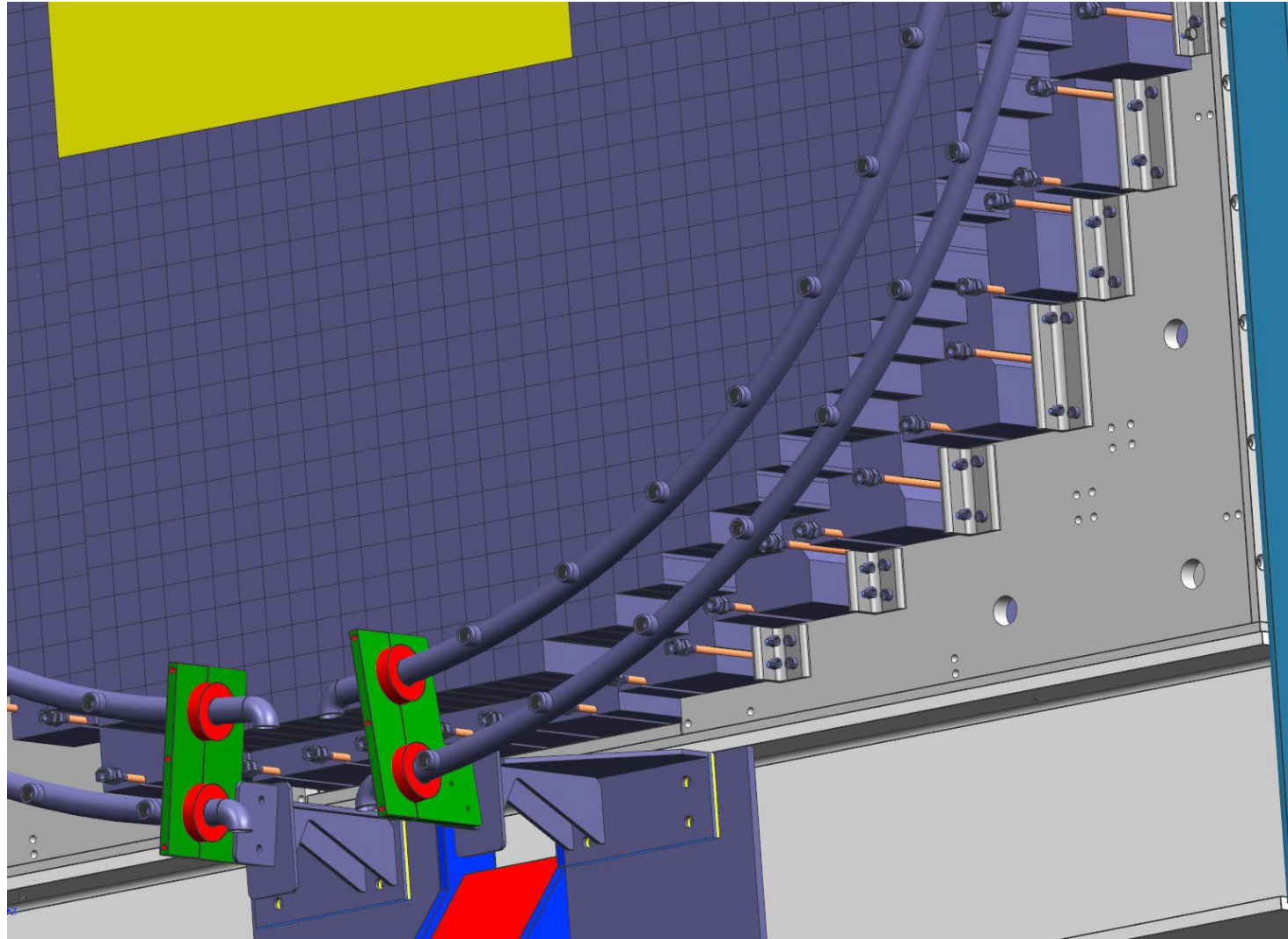


- Borrowed Designer from Engineering – Keith Harding
- 40x40 (2cm) Lead Tungstate Insert
- Design of infrastructure and Modules complete
- Complete set of preliminary drawings have been produced
- All crystal module components on order
- FCAL Darkroom becomes a Refrigerator

Items needing decisions;

- Tungsten absorber size
- Monitoring Panel config.
- PMT Bases – Heat load may be 4KW.

# FCAL Insert Cooling Design



# Required documents

- Aluminum Cooling Block Layout With Dimensions
- D00000-01-06-1201 Lifiable Frame Modifications
- D00000-01-06-0200 FCAL 2 Assembly
- Original Assembly Procedure for FCAL Frame
- D00000-05-00-1021 FCAL Platform assy
- D00000-00-00-1023 FCAL2 Installation

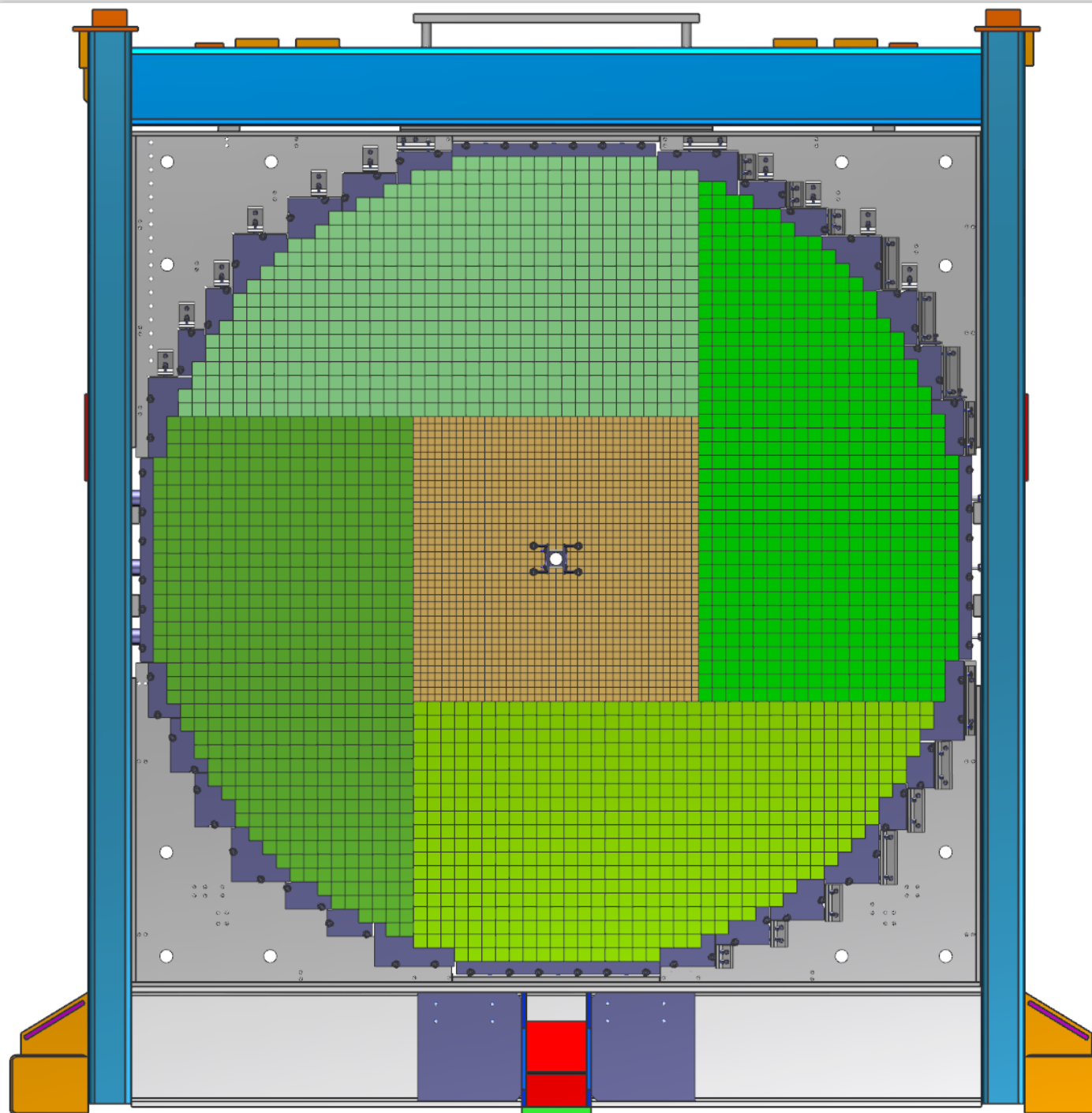
# Additional Information

- The glass modules are 40.2082mm X 40.0558mm or average of 40.132mm<sup>2</sup> They are stacked alternating larger side up vertical then horizontal. Based on IU info
- The crystal modules are 20.9mm<sup>2</sup> square
- Measured existing glass vertical height (59 modules) = (94 1/16" Tape measure – 4mm less than expected – compressed over time? -to be surveyed this week)
- Measured existing glass horizontal span (59 modules) = (94 1/4" Tape measure – 1mm more than expected – to be surveyed this week)

# Final Module Arrangement

2360 Lead-Glass Modules

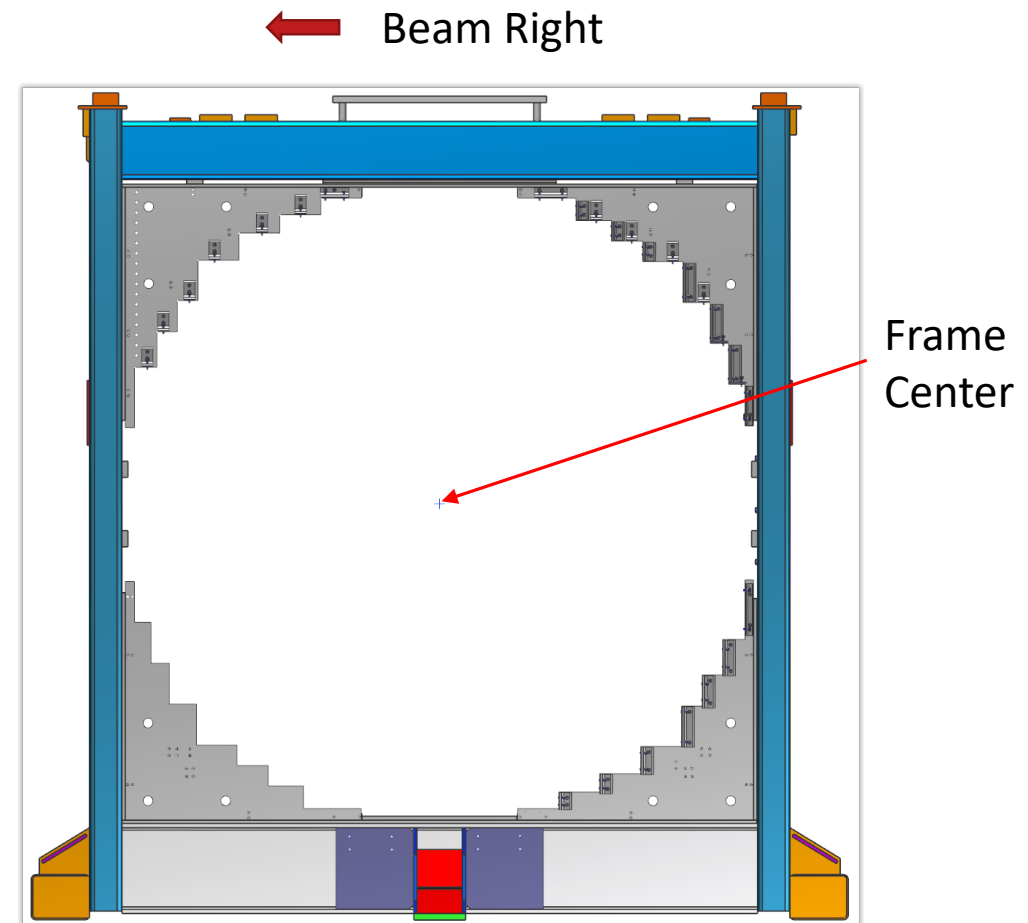
1596 Lead Tungstate Modules





## Initial Preparations

- Before moving the existing FCAL, Survey as found - **complete**
- Move platform as far down stream as possible
- Re-survey position for X and Y deltas - **complete**
- Remove VESDA piping from Darkroom - **complete**
- Remove DS panels, cable labyrinth and 8" side panels from Darkroom
- Remove all cabling
- Remove TOF and monitoring panels - **complete**
- Categorize all module assemblies
- Before disassembly of our current FCAL detector, we need to get the best average Vertical and Horizontal Glass Module dimensions.
  - From those dimensions, determine the best shim sizes (vertically and horizontally).
  - Create large printout of the layout to assist in tracking and calculating shims.

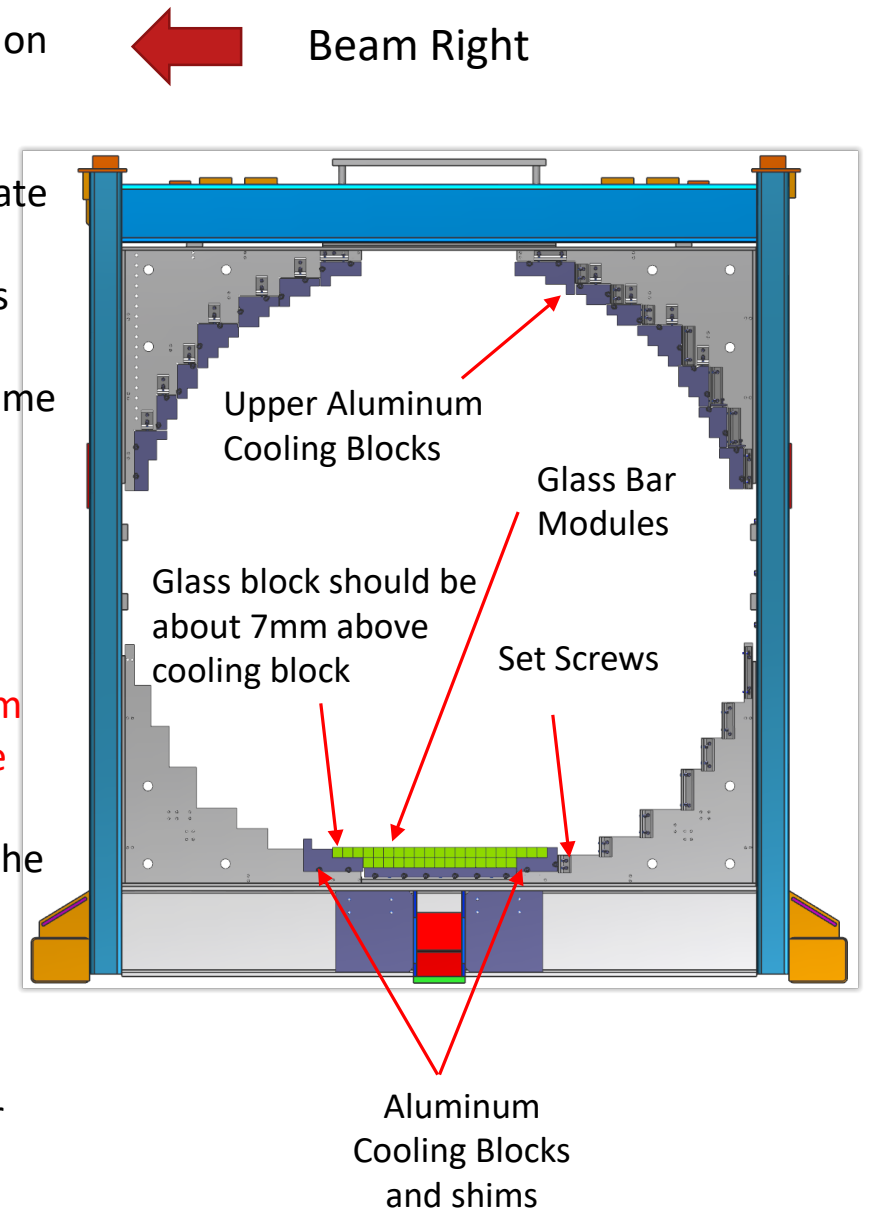


- Remove FCAL Acrylic Light Monitoring System (See dwg D00000-01-06-1214 Plexiglass light monitoring system)
- Unstack all modules and repair as needed
- Remove the liftable frame from the platform and place on floor (See dwg D00000-05-00-1021 FCAL Platform assy)
- Disassemble the frame components in reverse order per “Assembly Procedure for FCAL Frame”
- Modify frame per D00000-01-06-1201
- Assemble FCAL2 frame components per D000000106-0200 with the exception of the Lead glass and crystal modules. Beam right components should be pressed tight against support steps
- Survey the entire assembly and adjust/shim as required to get steps within 500 um (See layout for baseline dimensions)
- Fiducialize frame to center on beamline, making allowance for deviations in frame geometry
  - The base plate should be used as the datum defining the X-Z plane
  - The Beam right side plate should be used as the datum defining the Y-Z plane
  - Mark the centerline on the base plate for horizontal and side plates for vertical based on the fixed beam right side
  - Determine best plane on “Z” for Up-stream face of Glass Bar Modules – will be flush with cooling block supports
- Install the cooling manifold to ensure all components fit
- Remove bottom cooling blocks. All upper cooling blocks should be secured in fully retracted position
- Remove the cooling manifold if there will be interference during frame installation.
- Crane frame assy onto platform (D00000-05-00-1021 shows hardware)
- Survey to get the frame in nominal position taking the Z location into consideration and difference in X and Y when platform will be moved into position (delta X = 2mm, delta Y = 1mm)



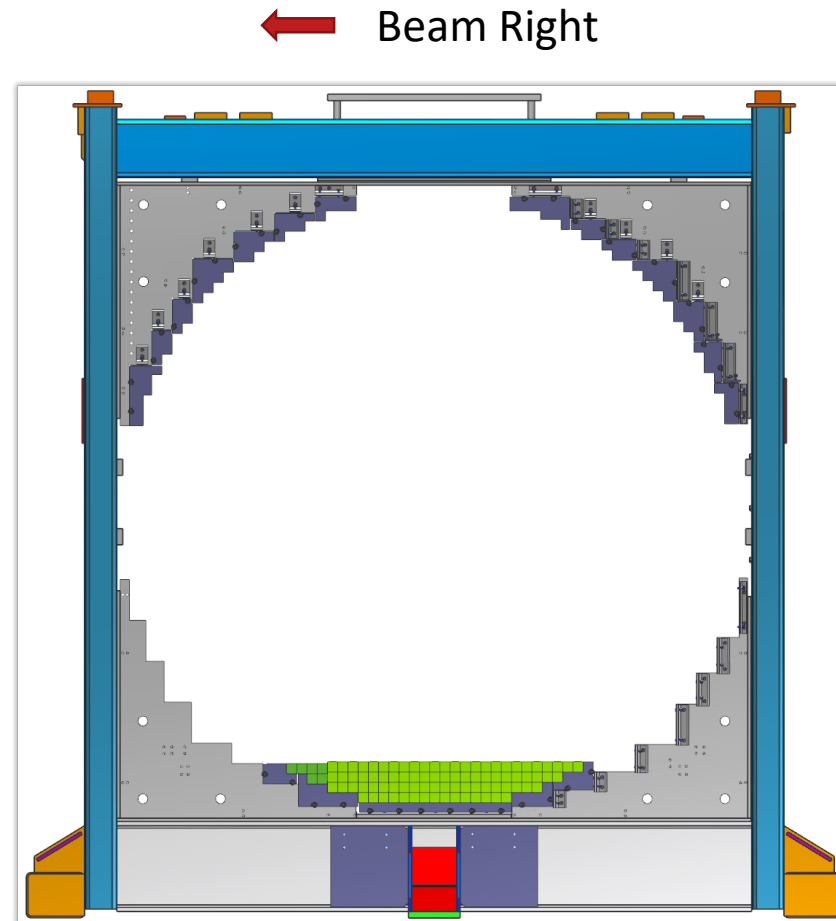
## STAGE 1 Stacking

- Install first Cooling Blocks with Blocks fully retracted and install shims for vertical alignment that will make top row of tungstate crystals level or above the glass modules on beam right – nominally 7mm offset
- Ensure the upstream edges are in the proper Z plane
- Lay the first row of glass bar modules starting tight against the beam right block. Alternate vertical and horizontal strap orientation.
- Using a straight edge across the top of the first row, Ensure the top of the glass modules are within 160 microns (.006 inch) of the next step on the cooling blocks.
- Use a straight edge across the upstream face of the module to ensure they are in the same Z plane and flush with the cooling blocks
- Carefully snug the set screws evenly on beam left to force the first row of modules to beam right. Record the screw torque and displacement of the row of modules
- Loosen the set screws to make enough room to be able to install the 2<sup>nd</sup> row
- Lay in the 2<sup>nd</sup> row of Glass Bar Modules using calculated shims if needed at beam right. (alternating each 90° along BL axis). **Always ensure the module above is rotated 90° from the one below. The PMT base should always be oriented the same regardless of module orientation.**
- Ensure the upstream face of the modules are aligned in the same Z position flush with the cooling blocks.
- The module will stick up over the beam right cooling block step. This is as designed
- Tighten these rows to Beam Right (Think Pre-Loading) **20 in-lbs (400 lbs)? They must be tightened evenly for all four screws – total 1600 lbs**
- Check the position of the Glass Bar Modules to verify correct positioning in X, ie. Center lines up with center mark
- Re-shim on beam right for horizontal alignment if needed
- Release pressure (Do NOT allow Modules to move)



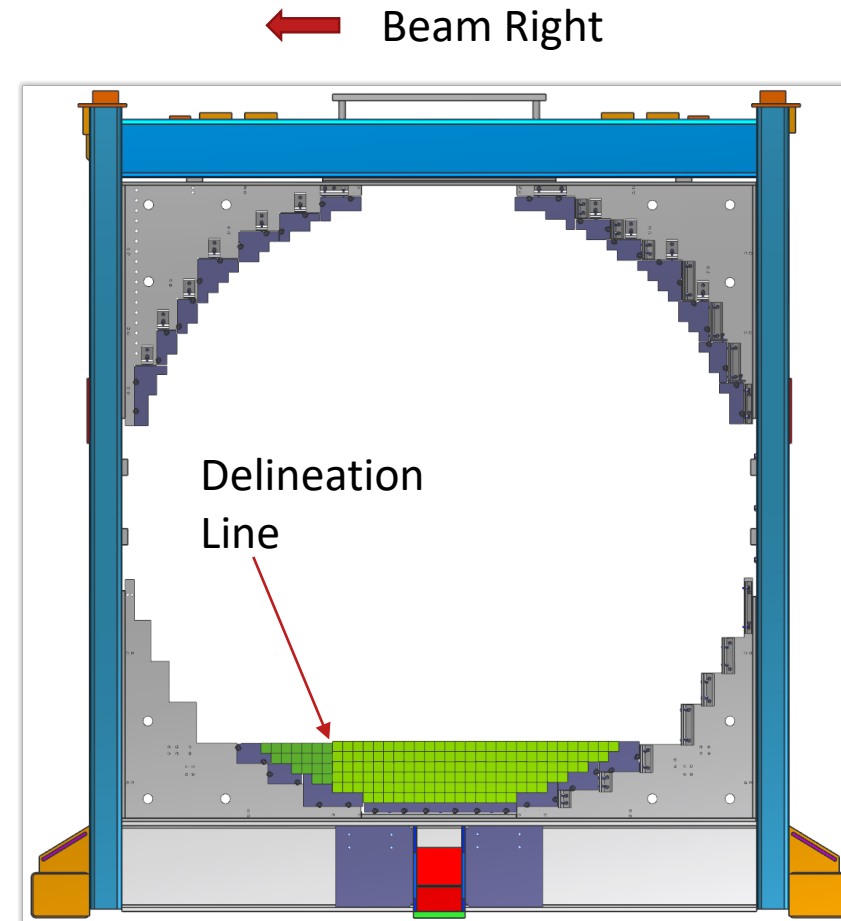
## STAGE 2

- Install next layer of Cooling Blocks with Blocks fully retracted
- Starting from beam right, Lay in the next two rows of Glass Bar Modules using calculated shims from beam right side (alternating each 90° along BL axis). If the 1<sup>st</sup> 2 blocks of the 3<sup>rd</sup> row do not fit, re-shim the 1<sup>st</sup> 2 rows on the beam right side to accommodate.
- Tighten these all rows to Beam Right (Think Pre-Loading)
- Check the position of the Glass Bar Modules to verify correct positioning. The beam right modules should be **7mm (.275 in)** below other blocks.
- Release pressure (Do NOT allow Modules to move)
- Retighten Stage 1 Cooling Blocks (**maybe spot epoxy in place to lock position?**)
- Verify that the modules, all rows are compressed on both BR and BL (ie no gaps)



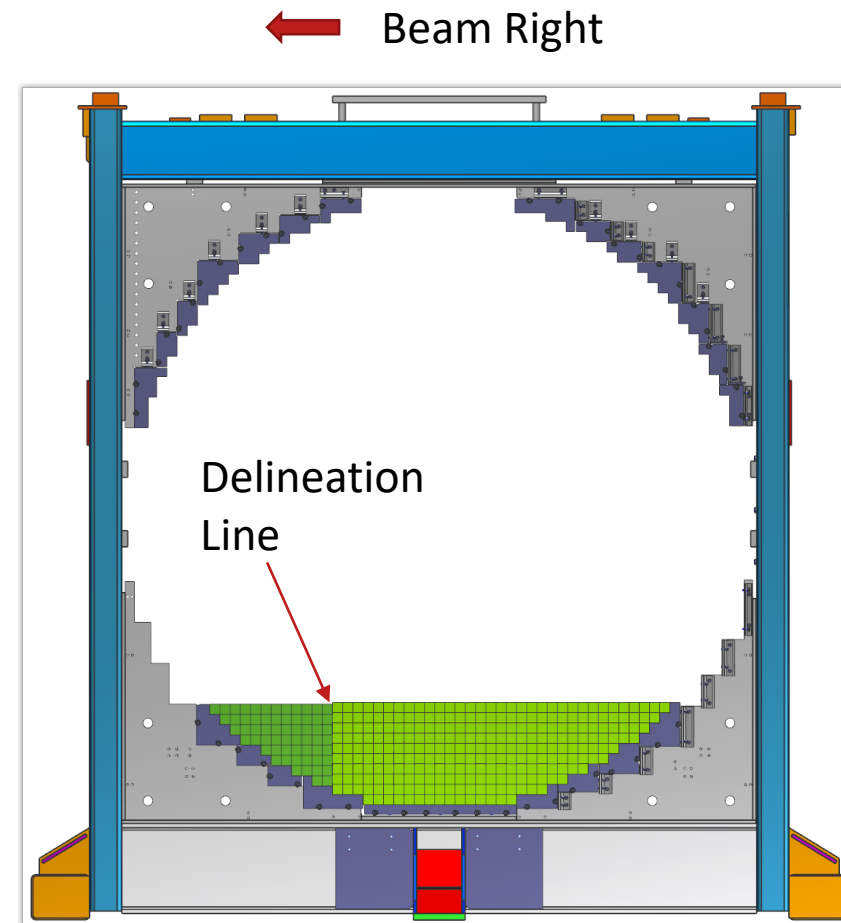
### STAGE 3

- Install next set of Cooling Blocks with Blocks fully retracted
- Lay in the next two rows of Glass Bar Modules using calculated shims (alternating each 90° along BL axis)
- Tighten these rows to Beam Right (Think Pre-Loading)
- Check the position of the Glass Bar Modules to verify correct positioning
- Ensure the vertical delineation line is straight and vertical and located properly in X. If too far out, the subsequent rows may need to be shifted)
- Release pressure (Do NOT allow Modules to move)
- Retighten Stage 2 Cooling Blocks
- Apply a straight edge to the top of the row and check to make sure there is no greater than a 200 um offset in any block
- Use Survey optical tool to verify
- Survey frame fiducials to ensure the assembly is still in proper position. Adjust if needed.



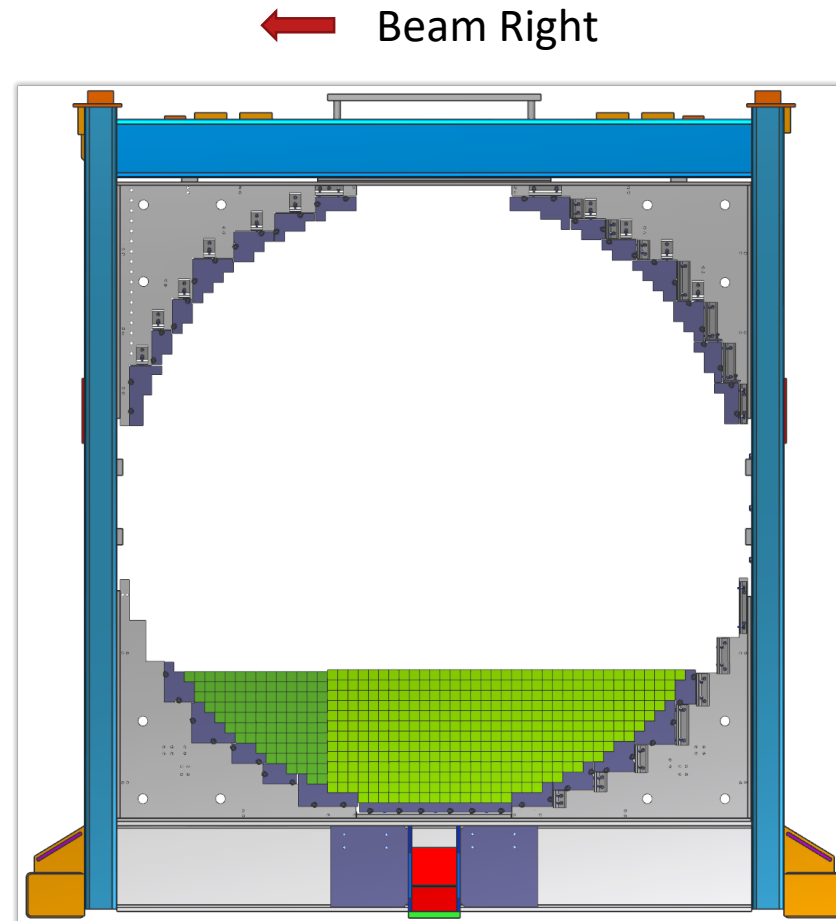
## STAGE 4

- Install Cooling Blocks with Blocks fully retracted
- Lay in the next four rows of Glass Bar Modules using calculated shims (alternating each 90° along BL axis)
- Tighten these rows to Beam Right (Think Pre-Loading)
- Check the position of the Glass Bar Modules to verify correct positioning
- Ensure the vertical delineation line is straight and located properly in X. If too far out, the subsequent rows may need to be shifted)
- Ensure all is straight and level
- Release pressure (Do NOT allow Modules to move)
- Retighten Stage 3 Cooling Blocks



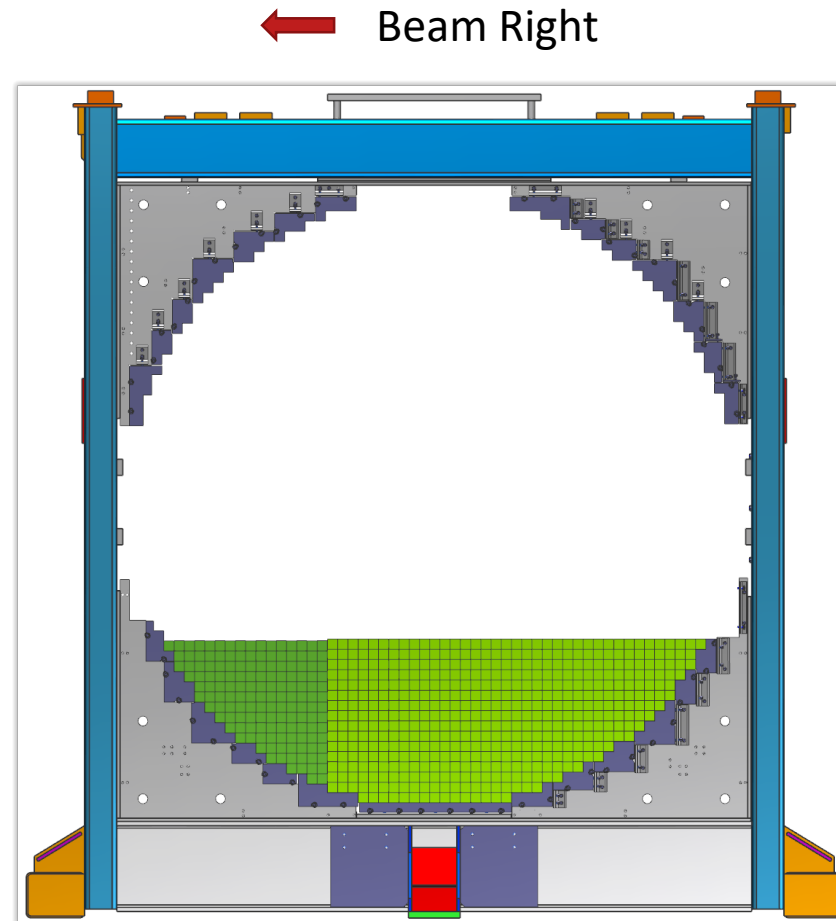
## STAGE 5

- Install Cooling Blocks with Blocks fully retracted
- Lay in the next three rows of Glass Bar Modules using calculated shims (alternating each 90° along BL axis)
- Tighten these rows to Beam Right (Think Pre-Loading)
- Check the position of the Glass Bar Modules to verify correct positioning
- Release pressure (Do NOT allow Modules to move)
- Retighten Stage 4 Cooling Blocks



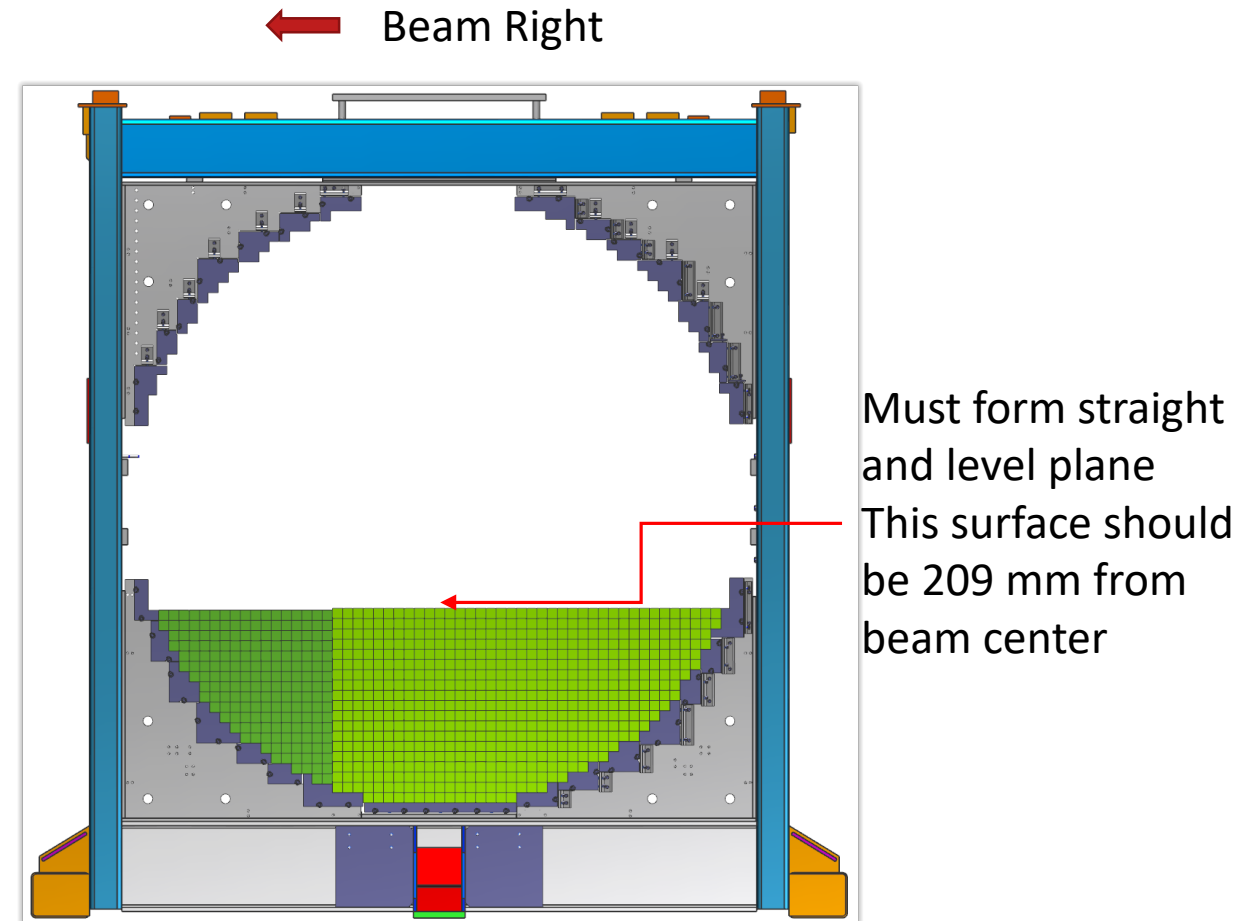
## STAGE 6

- Install Cooling Blocks with Blocks fully retracted
- Lay in the next three rows of Glass Bar Modules using calculated shims (alternating each 90° along BL axis)
- Tighten these rows to Beam Right (Think Pre-Loading)
- Check the position of the Glass Bar Modules to verify correct positioning
- Release pressure (Do NOT allow Modules to move)
- Retighten Stage 5 Cooling Blocks



## STAGE 7A

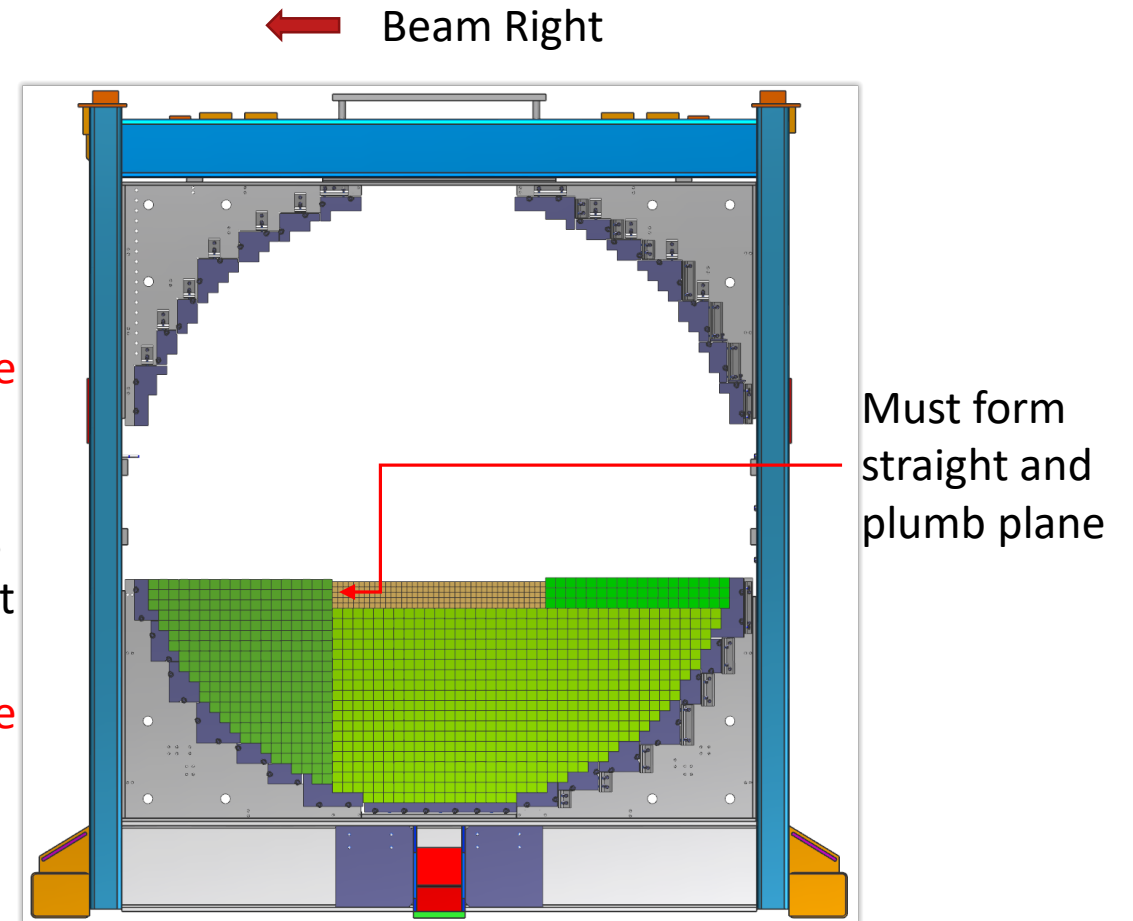
- Install Cooling Blocks with Blocks fully retracted
- Lay in the next three rows of Glass Bar Modules using calculated shims (alternating each 90° along BL axis)
- Tighten these rows to Beam Right (Think Pre-Loading)
- Check the position of the Glass Bar Modules to verify correct positioning (CRITICAL that the tops of Modules be level and straight for this stage) **Nominally we will need 160 um shims on every other glass block where crystals will go – maybe a thin aluminum sheet to cover all glass modules?**
- Get survey and Alignment group to shoot the top row and frame fiducials. Adjust as needed
- Re-tighten stage 6
- Release pressure (Do NOT allow Modules to move)





## STAGE 7B

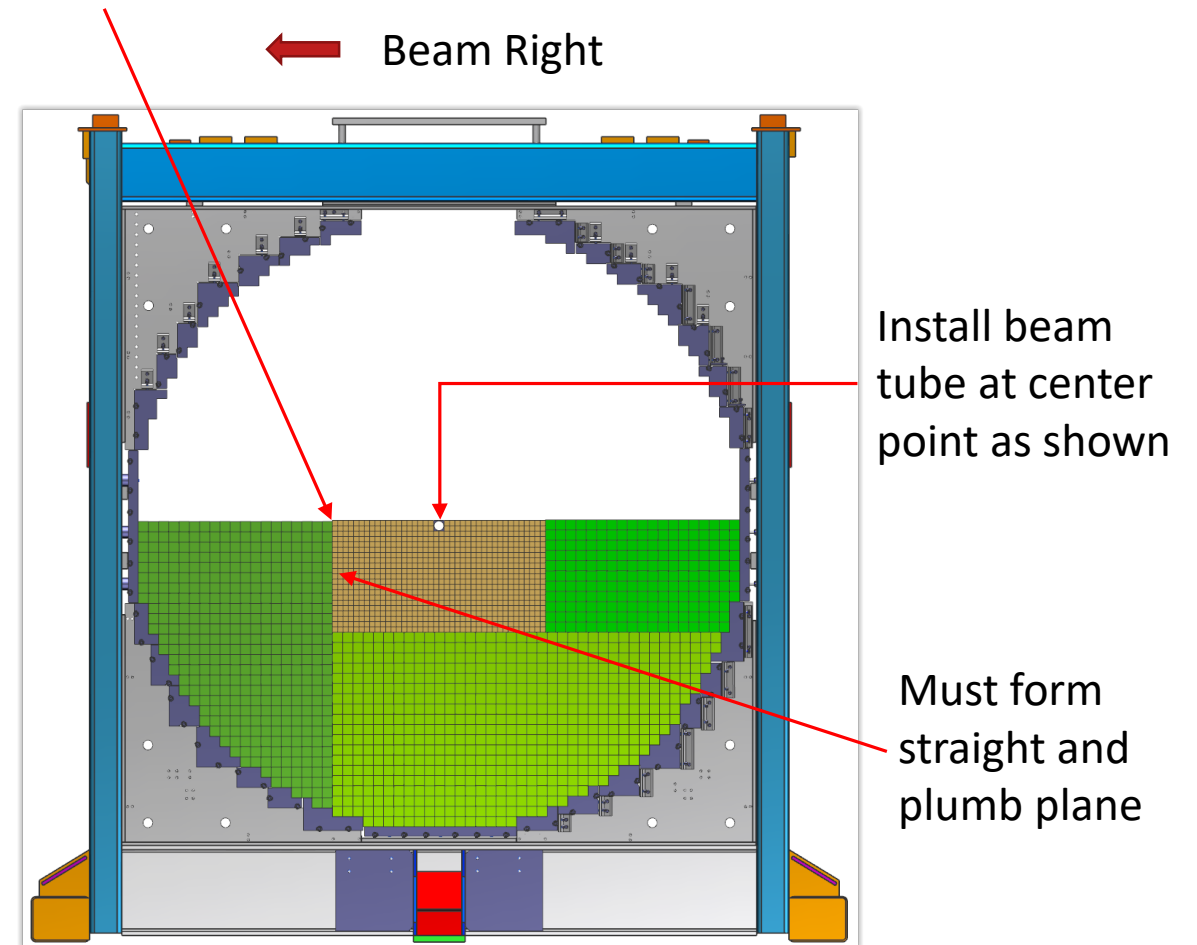
- Lay in the next three rows of 18 Glass Bar Modules using calculated shims starting from Beam Right (alternating each 90° along BL axis)
- **Install a thin SS or aluminum sheet on top of the glass modules?**
- Validate these rows form a straight and plumb plane (Shim Beam Right as necessary)
- **Install a thin SS or aluminum sheet and thermally conductive silicone pad against the edge of the glass modules**
- Install 5 rows of 40 Lead Tungstate Crystals with Up-Beam faces 125mm Down-beam of Glass Bar Module faces always pushing tight to beam right may wish to install fewer rows at first to determine how they react to squeezing.
- **Install a thin SS or aluminum sheet and thermally conductive silicone pad against the edge of the glass modules**
- Install remaining 3 rows of 18 glass Bar Modules
- Tighten these rows to Beam Right (Think Pre-Loading)
- Check the position of the Glass Bar Modules and Crystals to verify correct positioning (CRITICAL that the tops of Modules and Crystals be level and straight for this stage)
- The top of the crystals should be ? Below BR and ? Below BL modules
- Release pressure (Do NOT allow Modules to move)



## STAGE 8

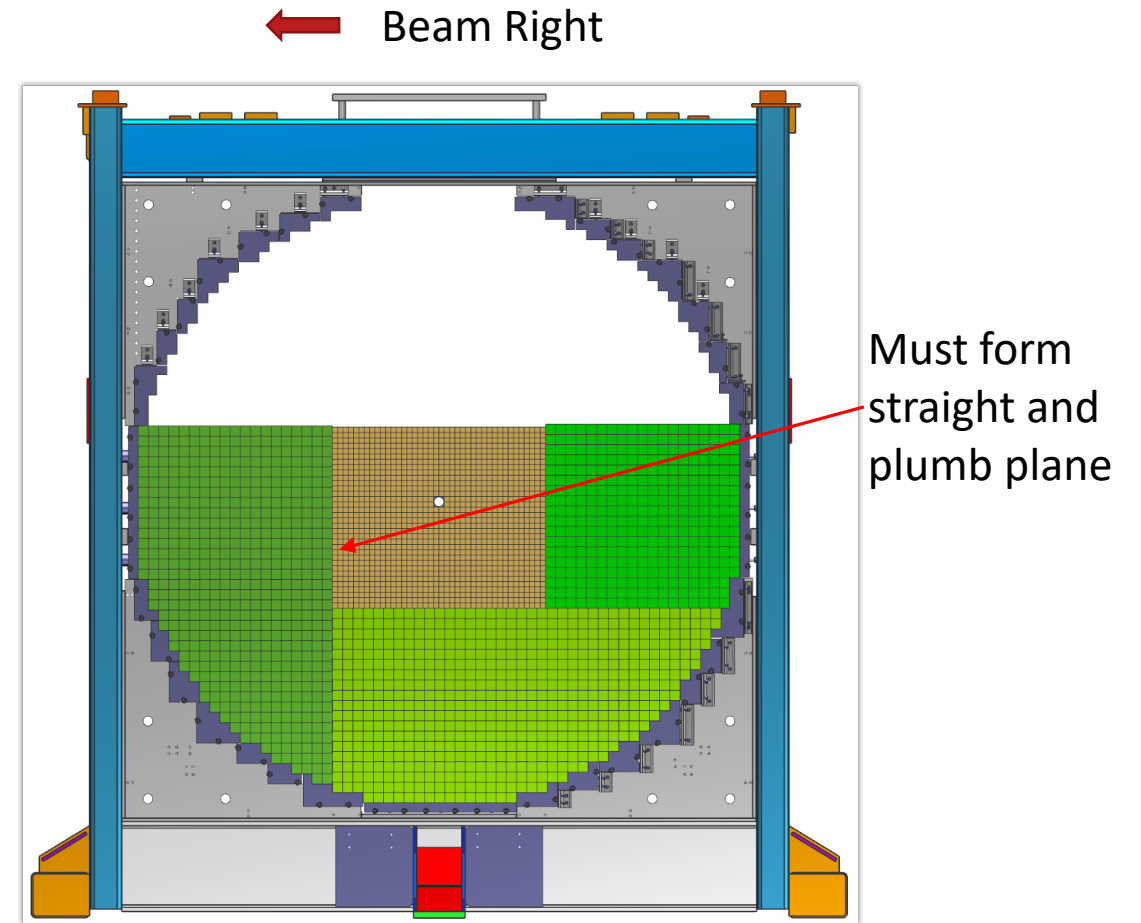
- Install Compression Cooling Plates on both Beam Right and Beam Left
- Lay in the next 8 rows of 19 Glass Bar Modules using calculated shims starting from Beam Right (alternating each 90° along BL axis)
- Validate these rows form a straight and plumb plane (Shim Beam Right as necessary)
- Install 14 rows of 40 Lead Tungstate Crystals with Up-Beam faces 125mm Down-beam of Glass Bar Module faces
- Install 2 rows of 19 Lead Tungstate Crystals then the Beam Tube then the remaining 2 rows of 19 Crystals.
- Install remaining 8 rows of 19 glass Bar Modules
- Tighten these rows to Beam Right (Think Pre-Loading)
- Check the position of the Glass Bar Modules and Crystals to verify correct positioning (CRITICAL that the tops of Modules and Crystals be level and straight for this stage)
- Ensure BR step height is ? To see if future rows may need to be shimmed.
- Release pressure (Do NOT allow Modules to move)
- Retighten Stage 7 Cooling Blocks

This step height should be ?mm



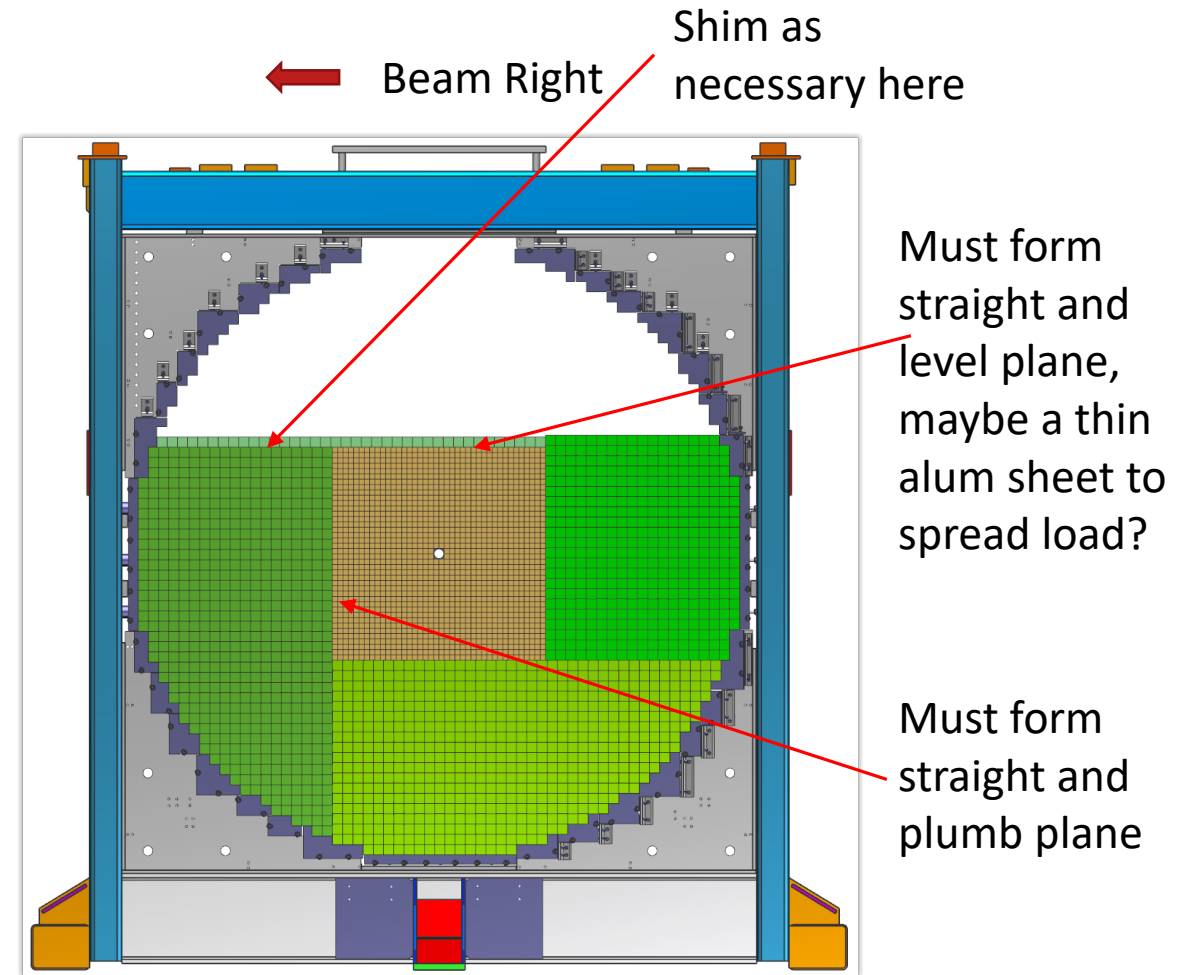
## STAGE 9

- Lay in the next 7 rows of 19 Glass Bar Modules using calculated shims starting from Beam Right (alternating each 90° along BL axis)
- Validate these rows form a straight and plumb plane (Shim Beam Right as necessary)
- Install 13 rows of 40 Lead Tungstate Crystals with Up-Beam faces 125mm Down-beam of Glass Bar Module faces
- Install remaining 7 rows of 19 glass Bar Modules
- Tighten these rows to Beam Right (Think Pre-Loading)
- Check the position of the Glass Bar Modules and Crystals to verify correct positioning (CRITICAL that the tops of Modules and Crystals be level and straight for this stage)
- Release pressure (Do NOT allow Modules to move)



## STAGE 10

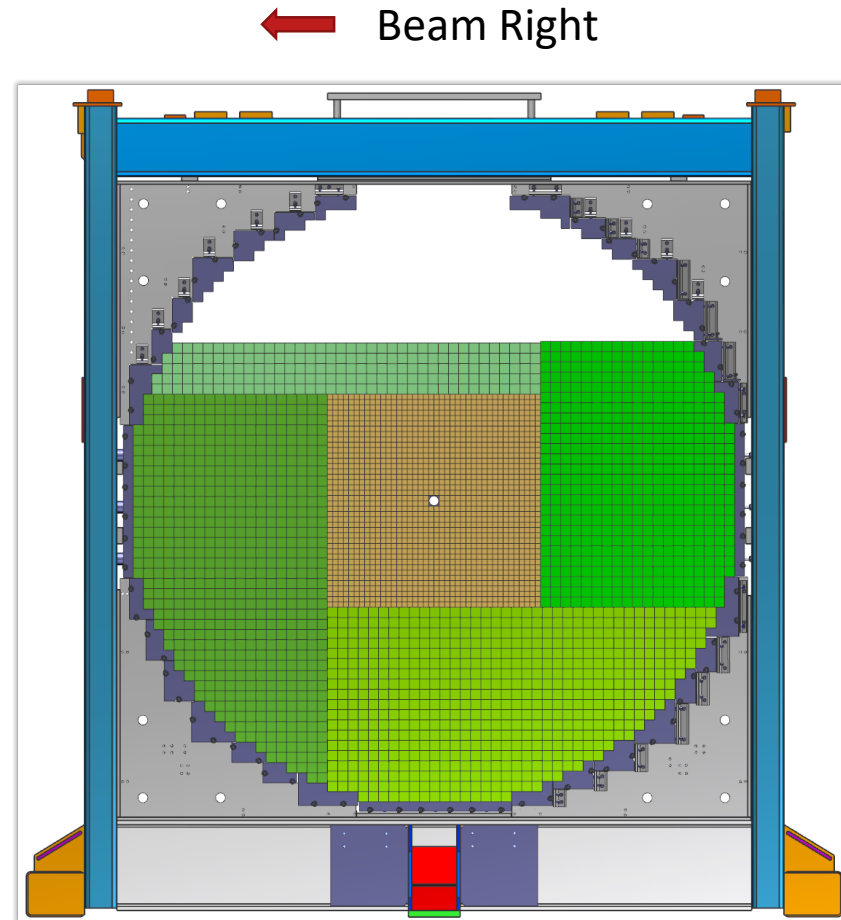
- Ensure Cooling Blocks are fully retracted both vertically and horizontally
- Lay in the next 3 rows of 19 Glass Bar Modules using calculated shims starting from Beam Right (alternating each 90° along BL axis)
- Validate these rows form a straight and plumb plane (Shim Beam Right as necessary)
- Install 6 rows of 40 Lead Tungstate Crystals with Up-Beam faces 125mm Down-beam of Glass Bar Module faces
- Install next 3 rows of 19 glass Bar Modules
- Tighten these rows to Beam Right (Think Pre-Loading)
- Check the position of the Glass Bar Modules and Lead Crystals to verify correct positioning (CRITICAL that the tops of Modules and Crystals be level and straight for this stage)
- If the beam right Lead Glass Modules do not align with the top of the Crystals, shim as required on top of Glass Modules to make these flush
- Release pressure (Do NOT allow Modules to move)
- **Install a thin SS or aluminum sheet on top of the glass modules?**
- Install next FULL row of Glass Bar Modules



- Tighten row again and recheck positions of Glass Bar Modules (Straight and level)
- Release pressure (Do NOT allow Modules to move)
- Retighten Stage 8 & 9 Cooling Blocks

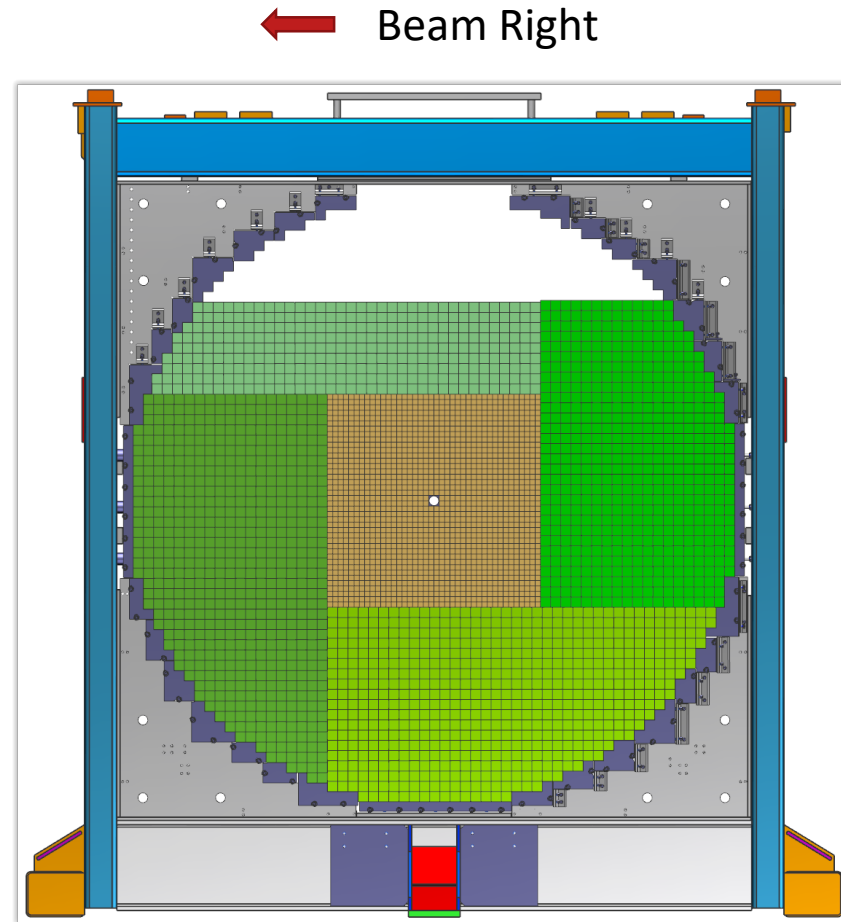
## STAGE 11

- Ensure Cooling Blocks are fully retracted both vertically and horizontally
- Lay in the next four rows of Glass Bar Modules using calculated shims (alternating each 90° along BL axis)
- Tighten these rows to Beam Right (Think Pre-Loading)
- Check the position of the Glass Bar Modules to verify correct positioning
- Release pressure (Do NOT allow Modules to move)
- Retighten Stage 10 Cooling Blocks



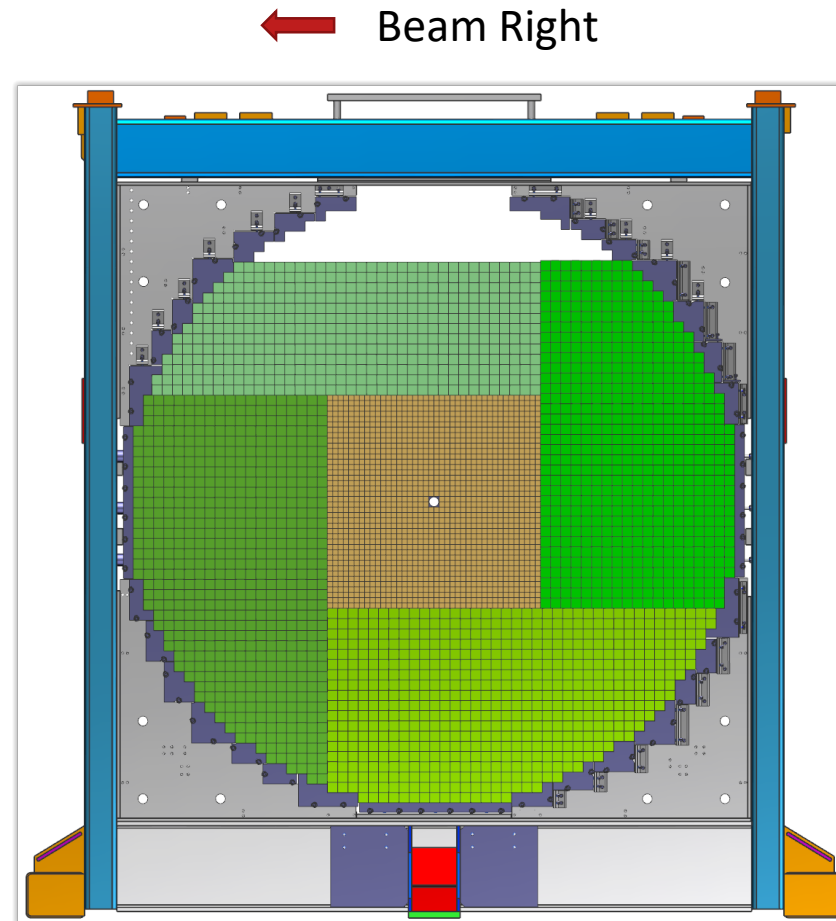
## STAGE 12

- Ensure Cooling Blocks are fully retracted both vertically and horizontally
- Lay in the next four rows of Glass Bar Modules using calculated shims (alternating each 90° along BL axis)
- Tighten these rows to Beam Right (Think Pre-Loading)
- Check the position of the Glass Bar Modules to verify correct positioning
- Release pressure (Do NOT allow Modules to move)
- Retighten Stage 11 Cooling Blocks



### STAGE 13

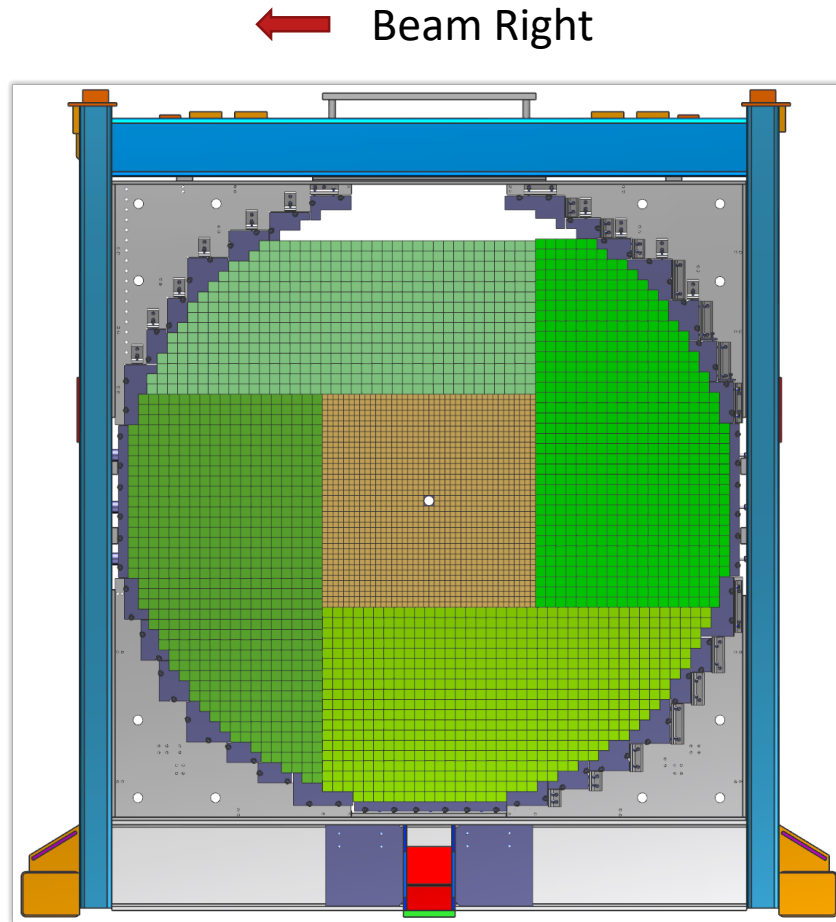
- Ensure Cooling Blocks are fully retracted both vertically and horizontally
- Lay in the next four rows of Glass Bar Modules using calculated shims (alternating each 90° along BL axis)
- Tighten these rows to Beam Right (Think Pre-Loading)
- Check the position of the Glass Bar Modules to verify correct positioning
- Release pressure (Do NOT allow Modules to move)
- Retighten Stage 12 Cooling Blocks





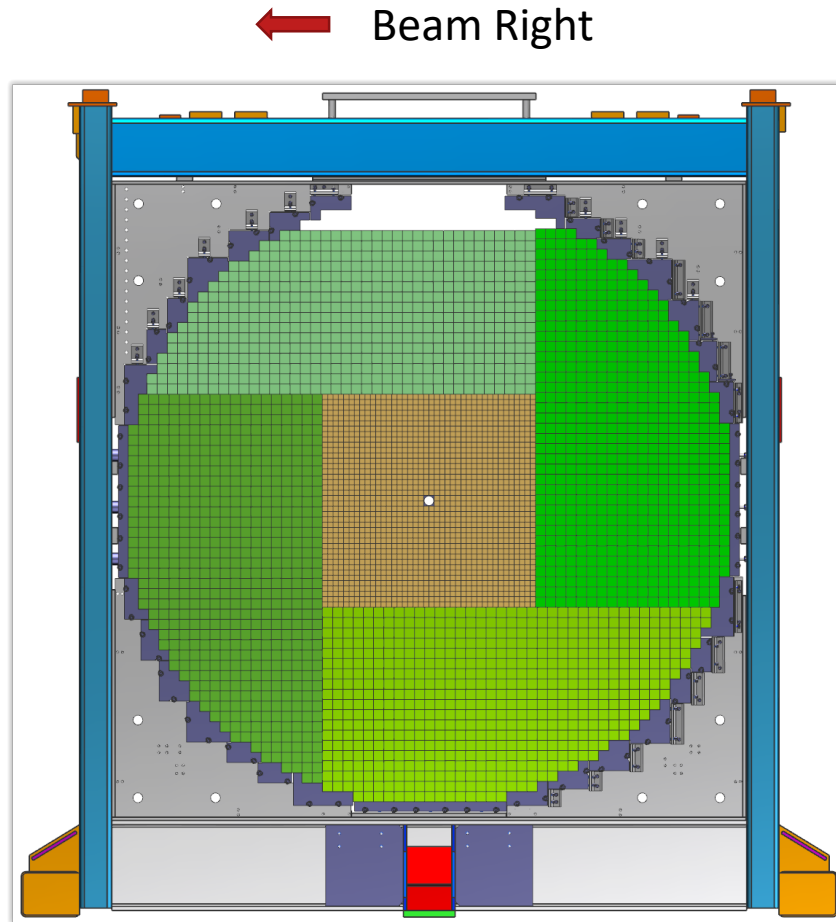
## STAGE 14

- Ensure Cooling Blocks are fully retracted both vertically and horizontally
- Lay in the next four rows of Glass Bar Modules using calculated shims (alternating each 90° along BL axis)
- Tighten these rows to Beam Right (Think Pre-Loading)
- Check the position of the Glass Bar Modules to verify correct positioning
- Release pressure (Do NOT allow Modules to move)
- Retighten Stage 13 Cooling Blocks



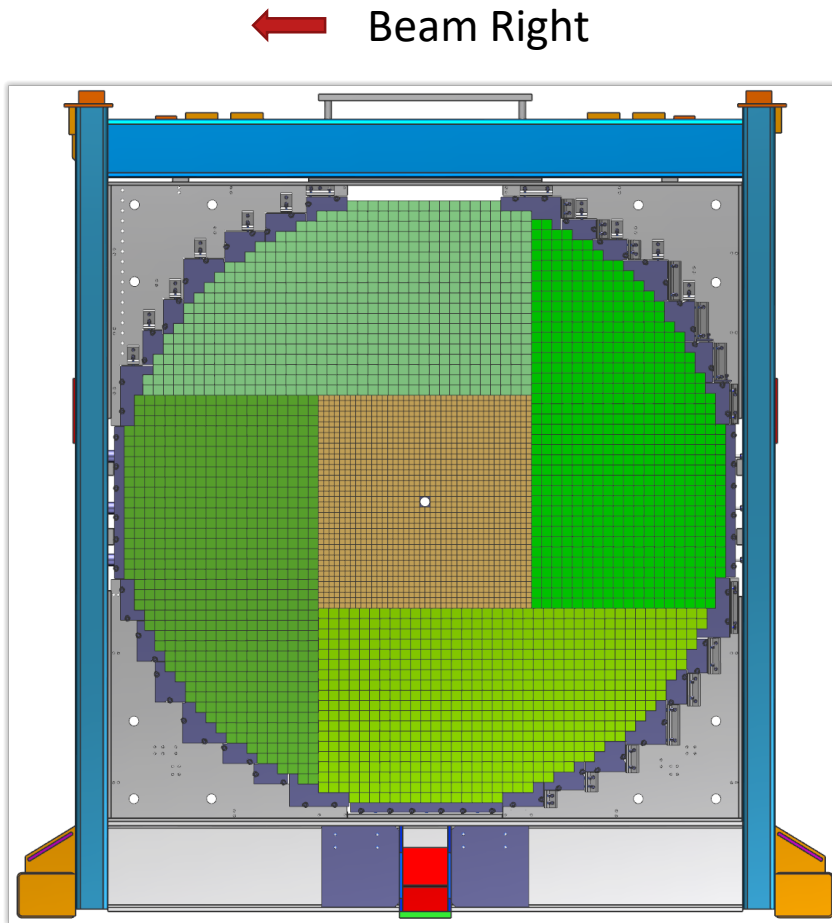
## STAGE 15

- Ensure Cooling Blocks are fully retracted both vertically and horizontally
- Lay in the next row of Glass Bar Modules using calculated shims (alternating each 90° along BL axis)
- Tighten this row to Beam Right (Think Pre-Loading)
- Check the position of the Glass Bar Modules to verify correct positioning
- Release pressure (Do NOT allow Modules to move)
- Retighten Stage 14 Cooling Blocks



## STAGE 16

- Ensure Cooling Blocks are fully retracted both vertically and horizontally
- Lay in the next row of Glass Bar Modules using calculated shims (alternating each 90° along BL axis)
- Tighten this row to Beam Right (Think Pre-Loading)
- Check the position of the Glass Bar Modules to verify correct positioning
- Retighten Stage 15 Cooling Blocks



## Completed Detector Assembly

- Install Top Compression Cooling Plate (if not already installed).
- Apply downward pressure to each Upper Cooling Blocks using provided screws
- Apply downward pressure to Top Compression Cooling Plate
- Survey beamline center to Frame center to verify position
- Install Monitoring System, Tungsten Absorber, and Rohacell foam supports
- Temporarily install Removable Inner Tube Cooling Assy.

