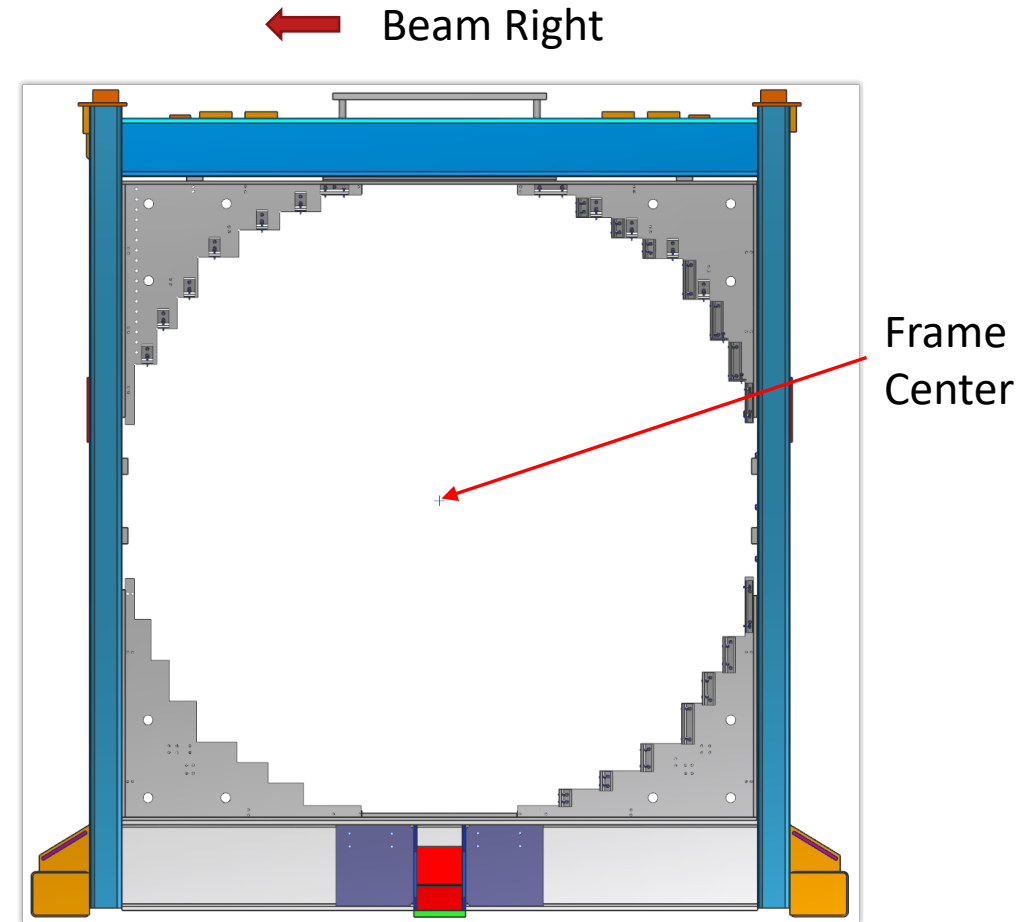


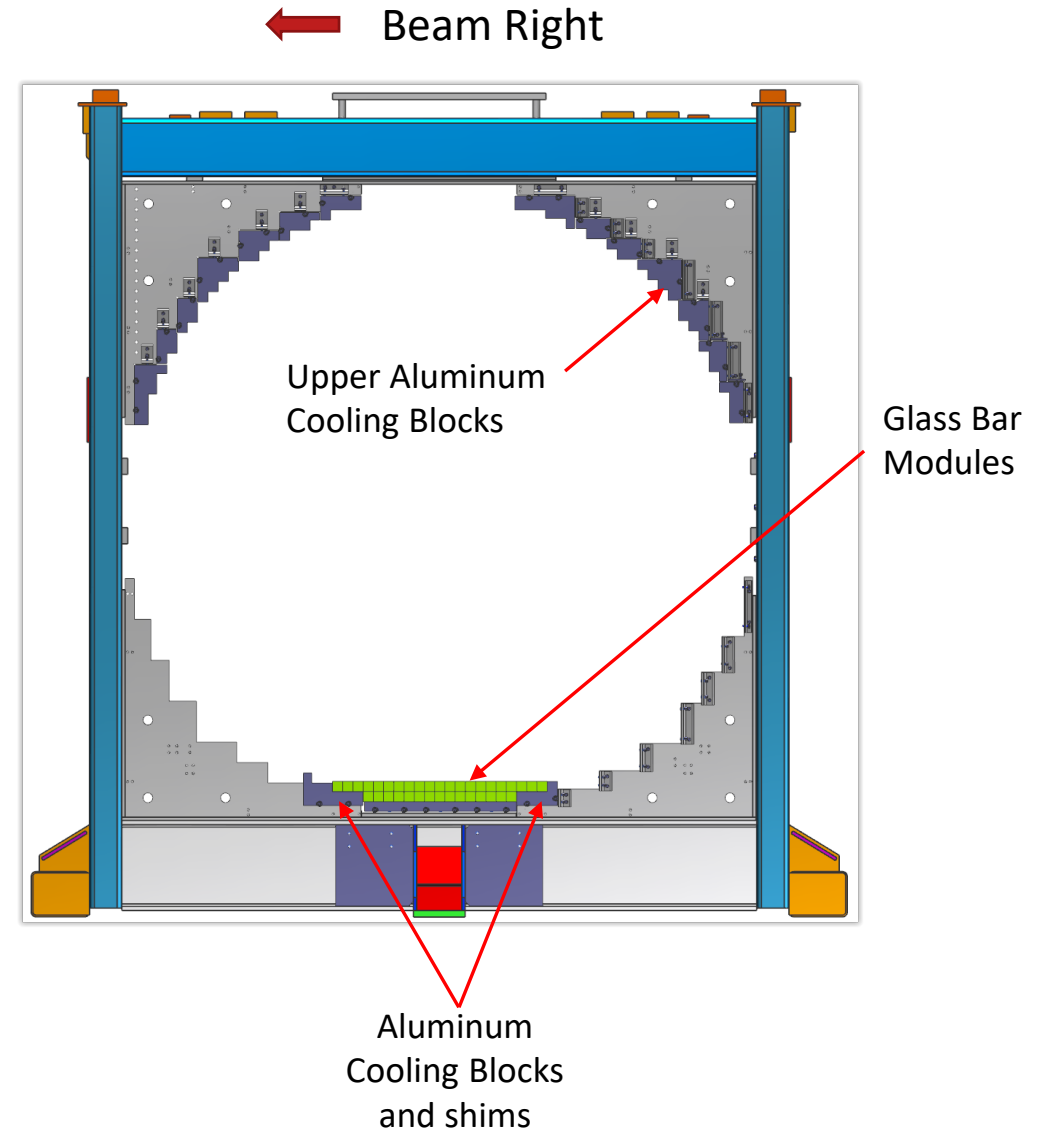
## Initial Preparations

- 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.
- Create large printout of the layout to assist in tracking and calculating shims.
- Fiducialize frame to center on beamline, making allowance for deviations in frame geometry
- Mark the centerline on the frame for horizontal and vertical
- Determine best plane on “Z” for Up-Beam face of Glass Bar Modules



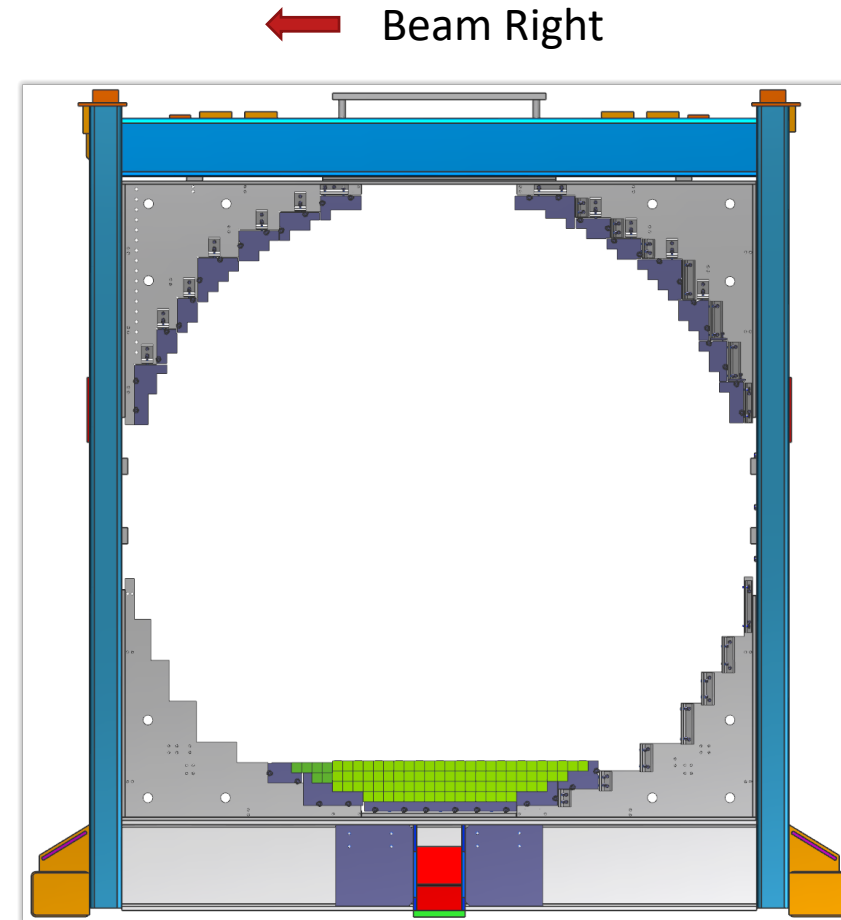
## STAGE 1

- Install ALL upper Aluminum Cooling Blocks and secure – fully retracted position
- 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
- Lay in the first 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
- Re-shim on beam right for horizontal alignment if needed
- Release pressure (Do NOT allow Modules to move)



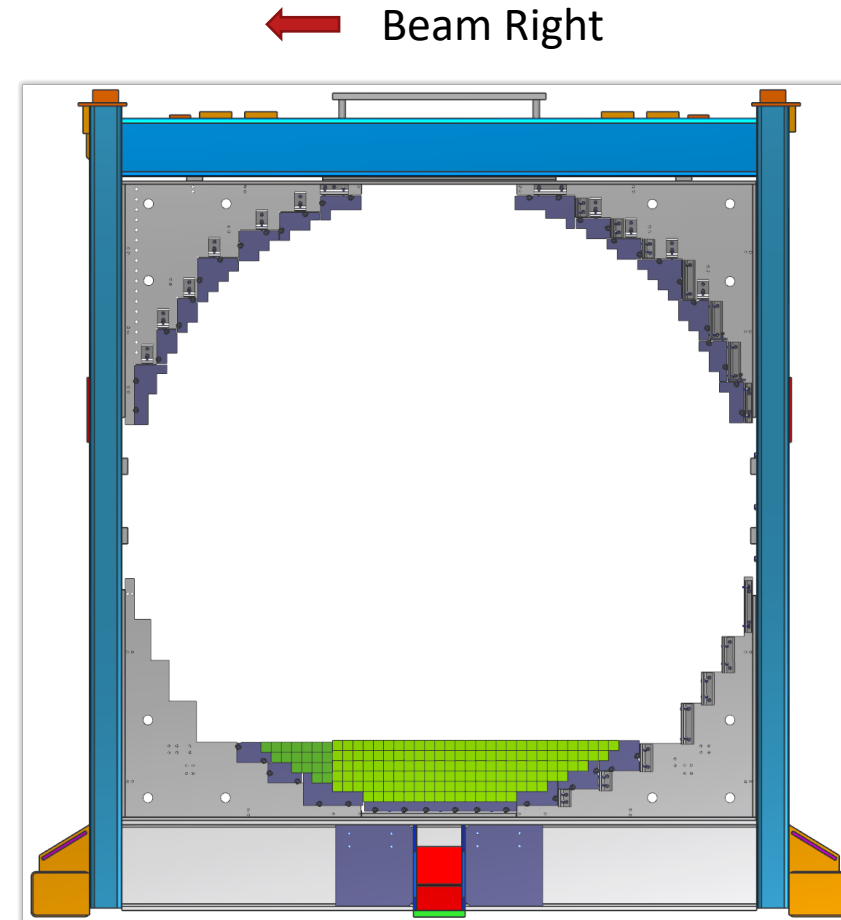
## STAGE 2

- Install 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
- Release pressure (Do NOT allow Modules to move)
- Retighten Stage 1 Cooling Blocks



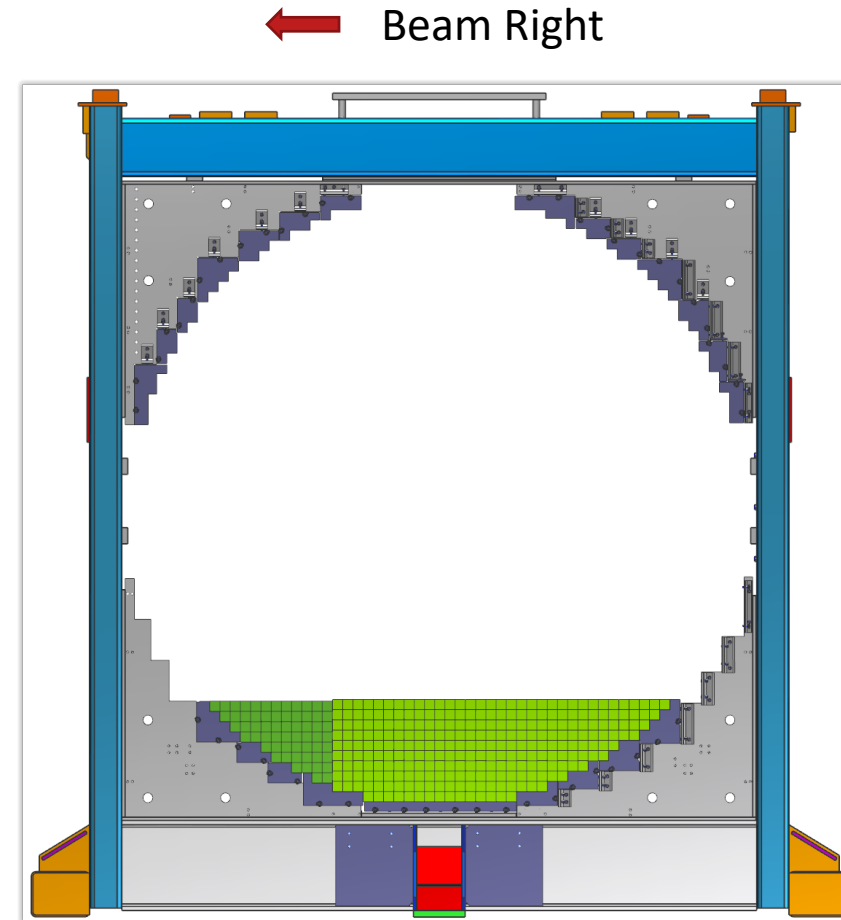
### STAGE 3

- Install 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
- Release pressure (Do NOT allow Modules to move)
- Retighten Stage 2 Cooling Blocks



## STAGE 4

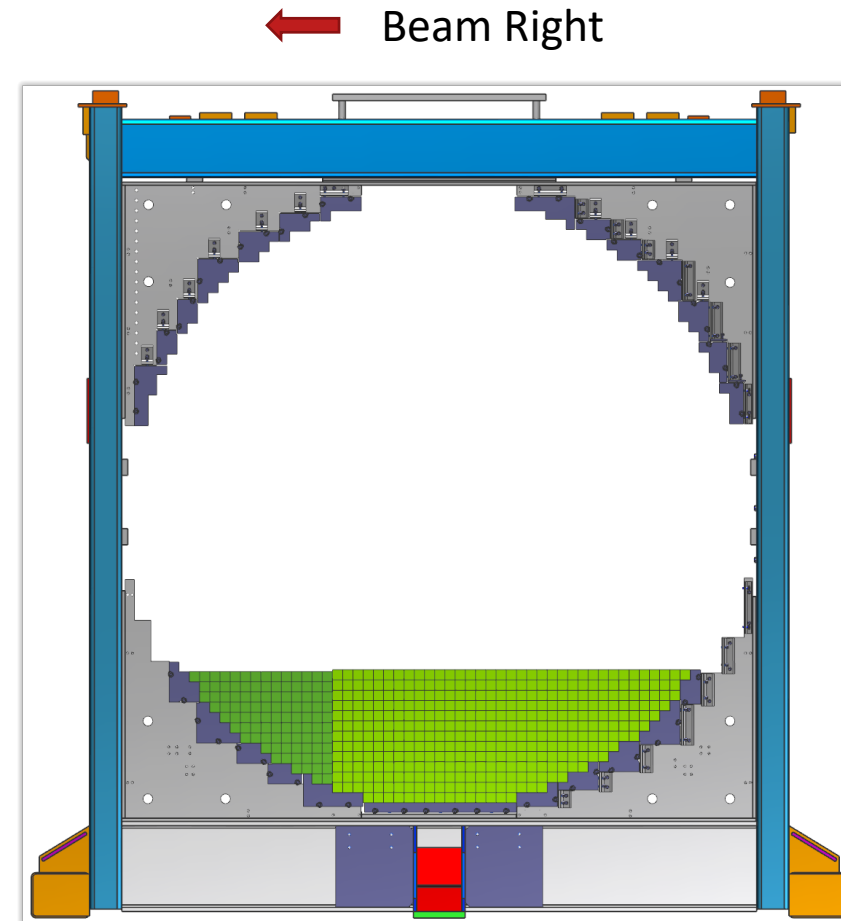
- Install Cooling Blocks with Blocks fully retracted
- Lay in the next four rows of Glass Bar Modules using calculated shims (alternating each 90° along BL axis)
- Tighten these rows to Beam Right (Think Pre-Loading)
- Check the position of the Glass Bar Modules to verify correct positioning
- Release pressure (Do NOT allow Modules to move)
- Retighten Stage 3 Cooling Blocks





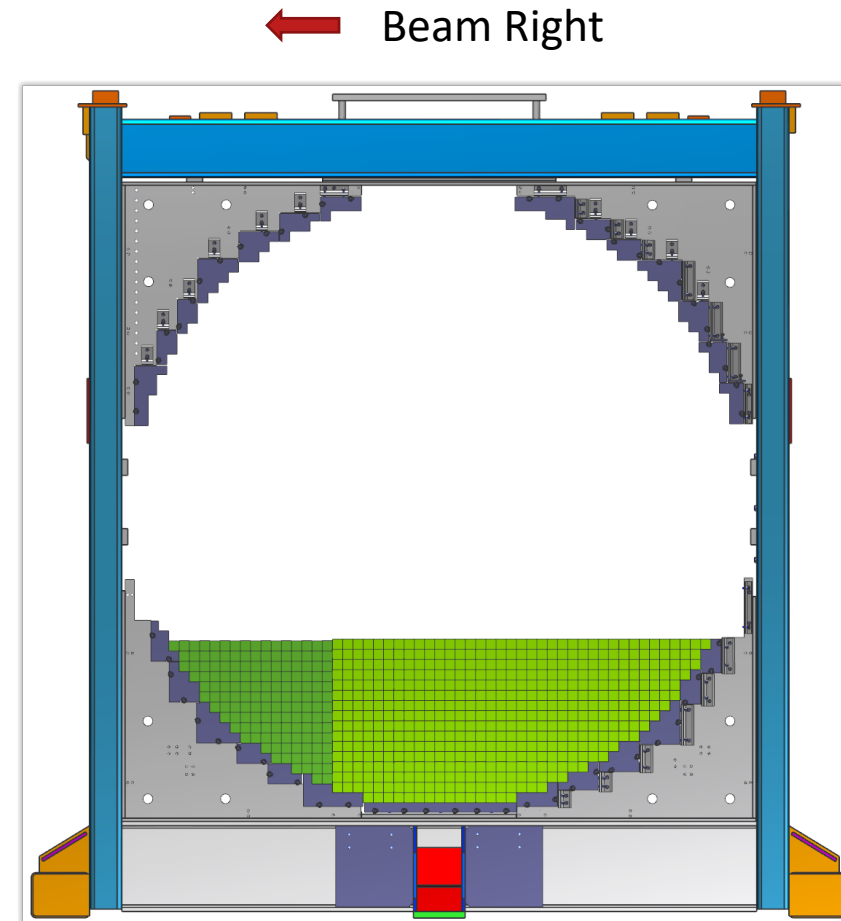
## STAGE 5

- 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



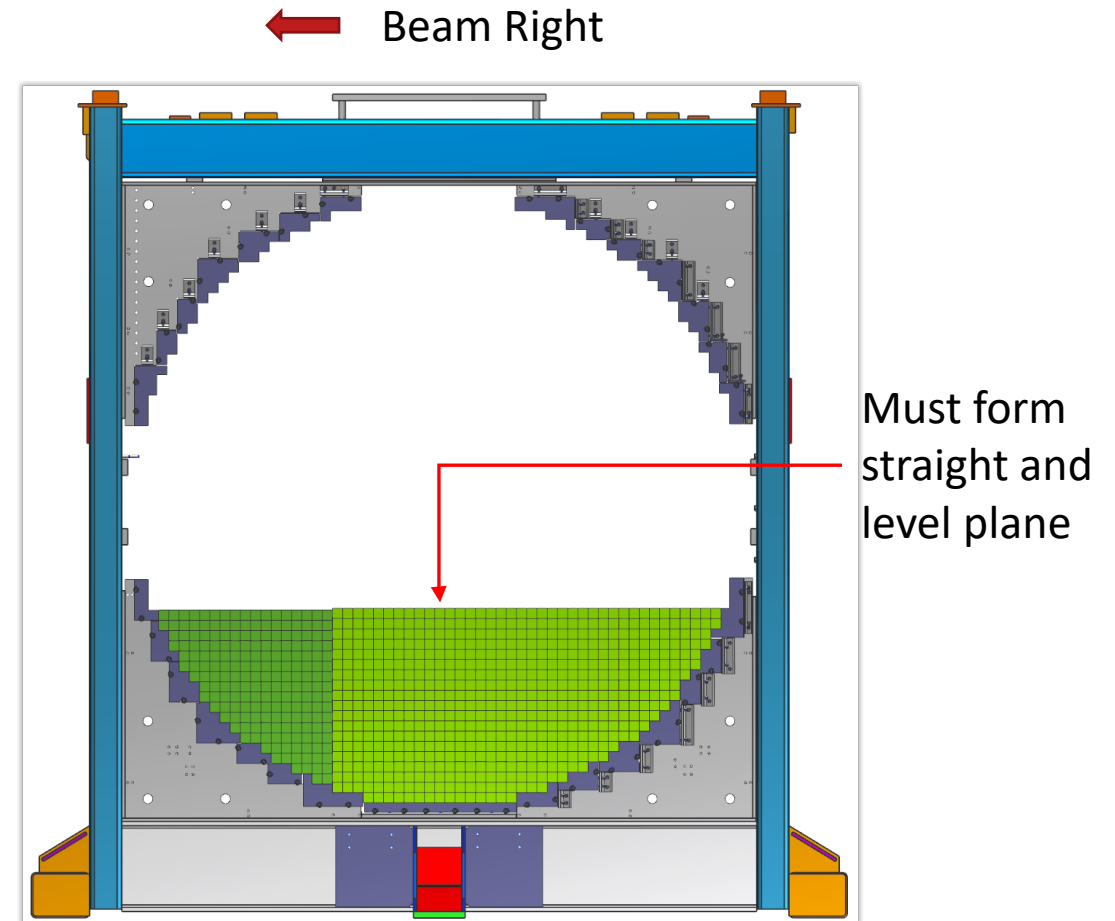
## STAGE 6

- 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



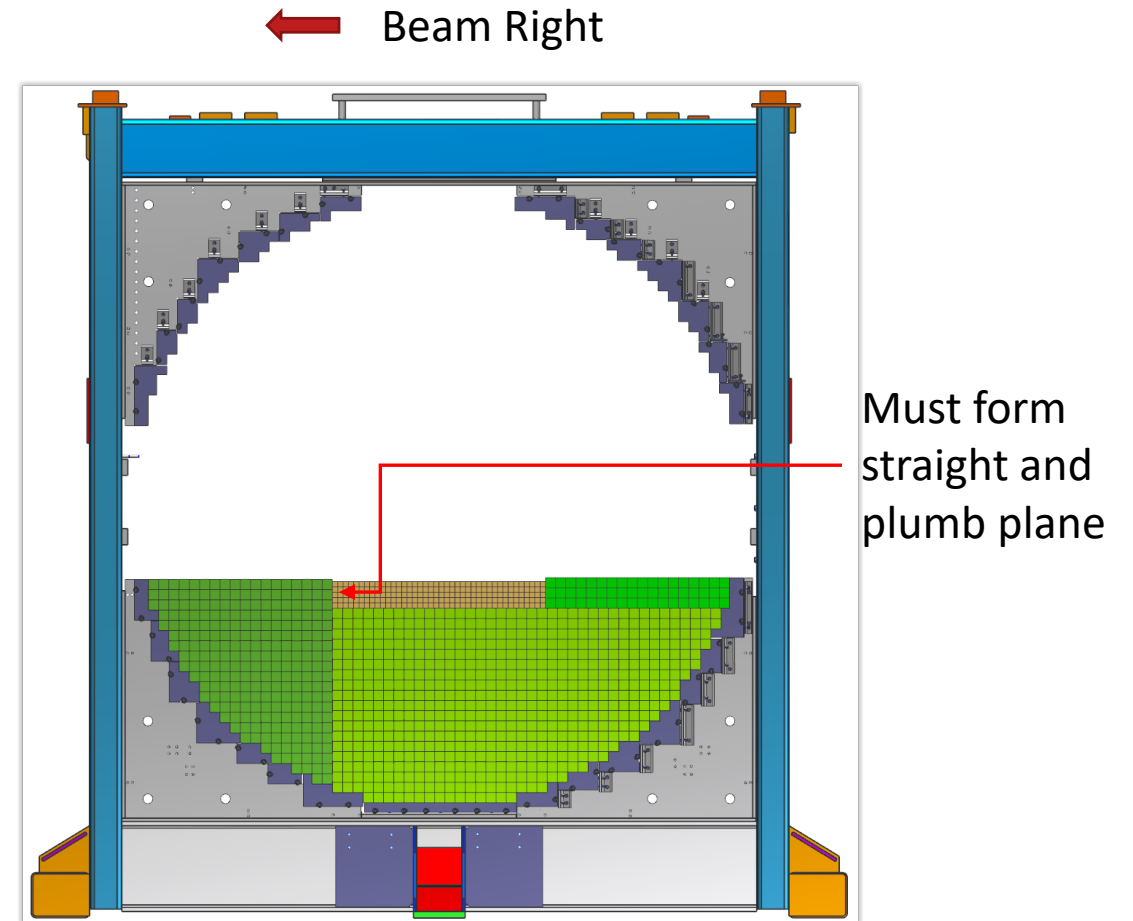
## STAGE 7A

- 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)
- Re-tighten stage 6
- Release pressure (Do NOT allow Modules to move)



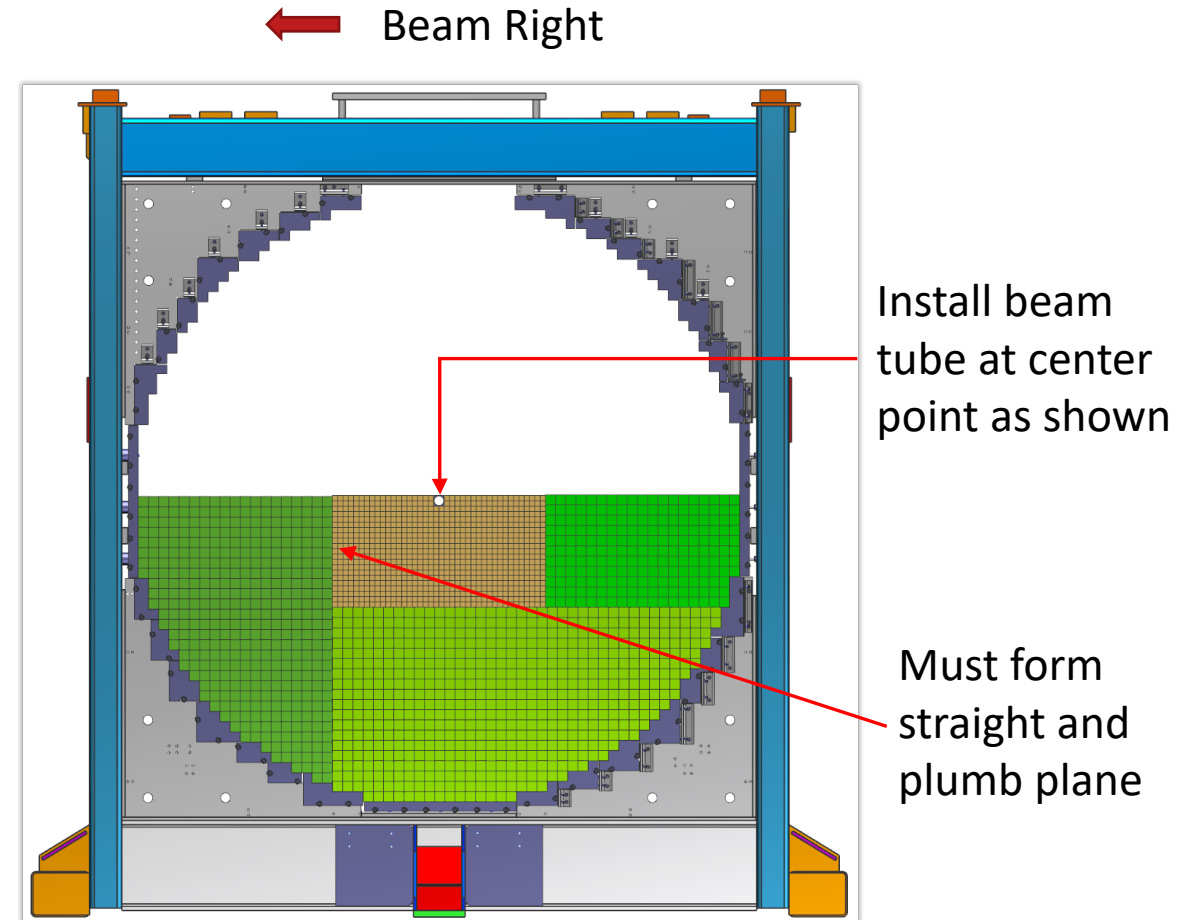
## STAGE 7B

- Lay in the next three rows of 18 Glass Bar Modules using calculated shims starting from Beam Right (alternating each 90° along BL axis)
- Validate these rows form a straight and plumb plane (Shim Beam Right as necessary)
- 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
- 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)
- Release pressure (Do NOT allow Modules to move)



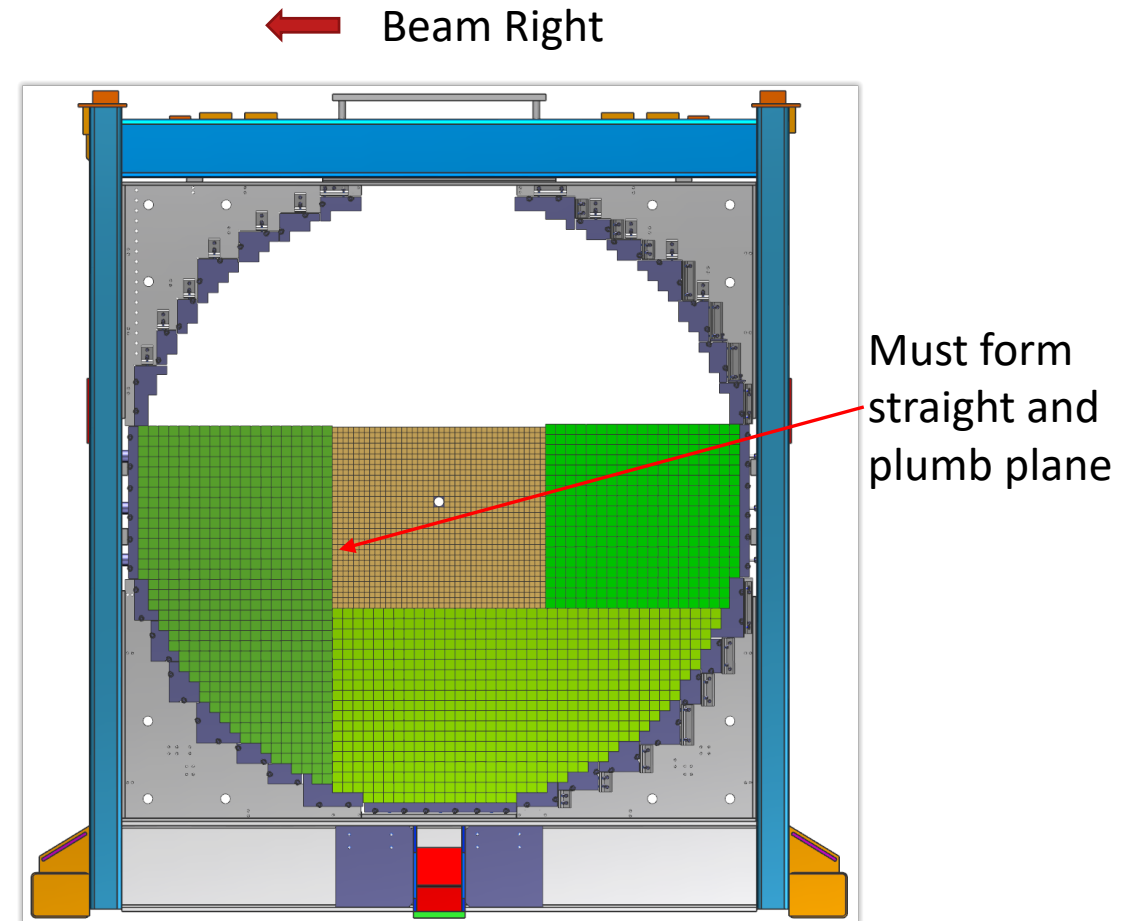
## STAGE 8

- 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)
- Release pressure (Do NOT allow Modules to move)
- Retighten Stage 7 Cooling Blocks



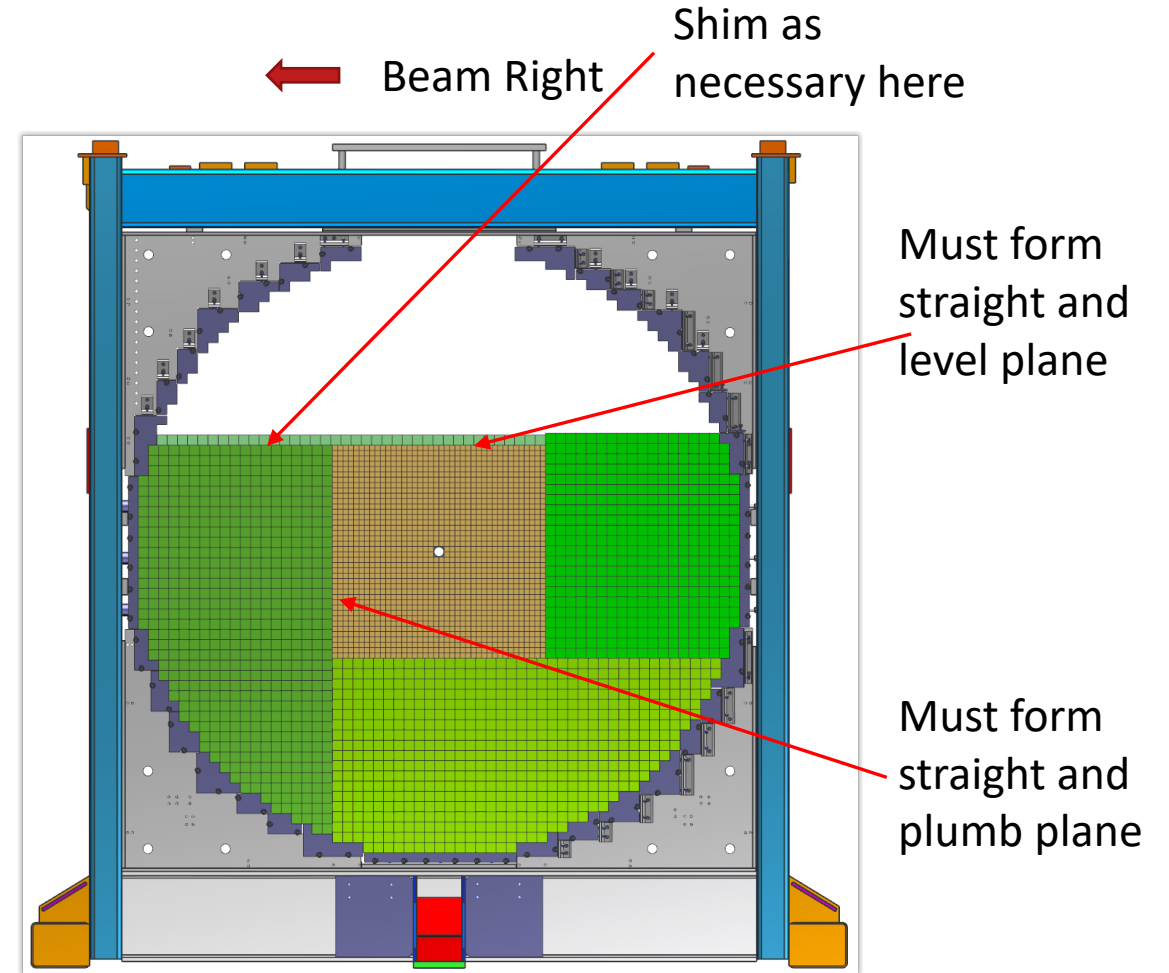
## STAGE 9

- 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

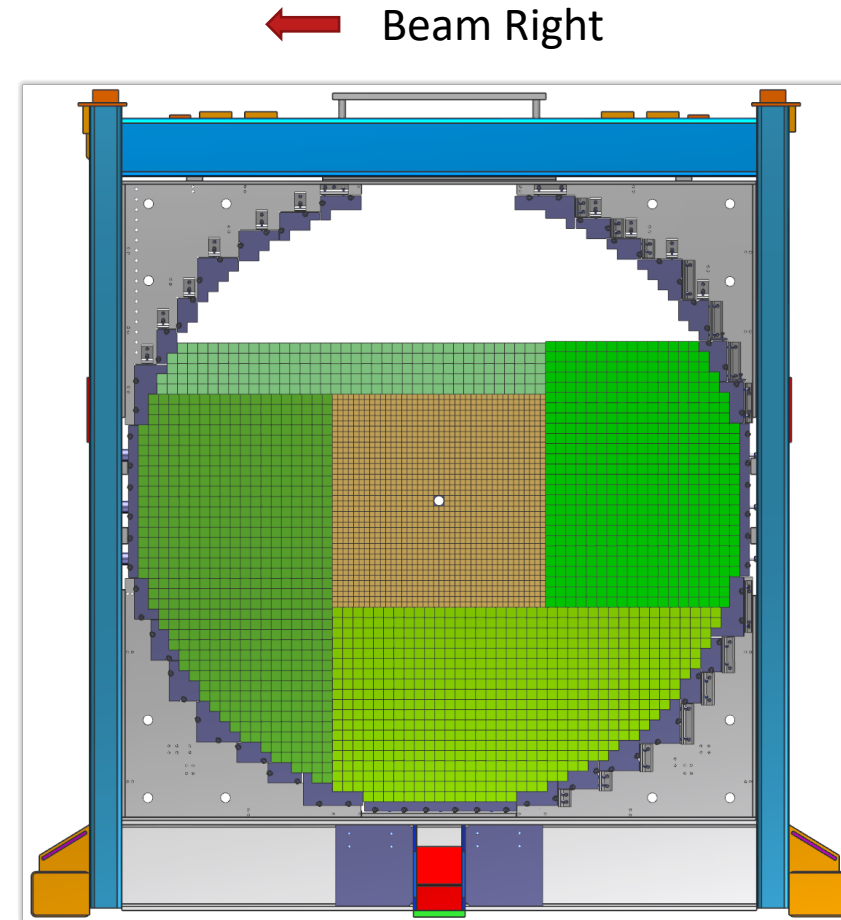
- Ensure Cooling Blocks are fully retracted both vertically and horizontally
- Lay in the next 3 rows of 19 Glass Bar Modules using calculated shims starting from Beam Right (alternating each 90° along BL axis)
- Validate these rows form a straight and plumb plane (Shim Beam Right as necessary)
- Install 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 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

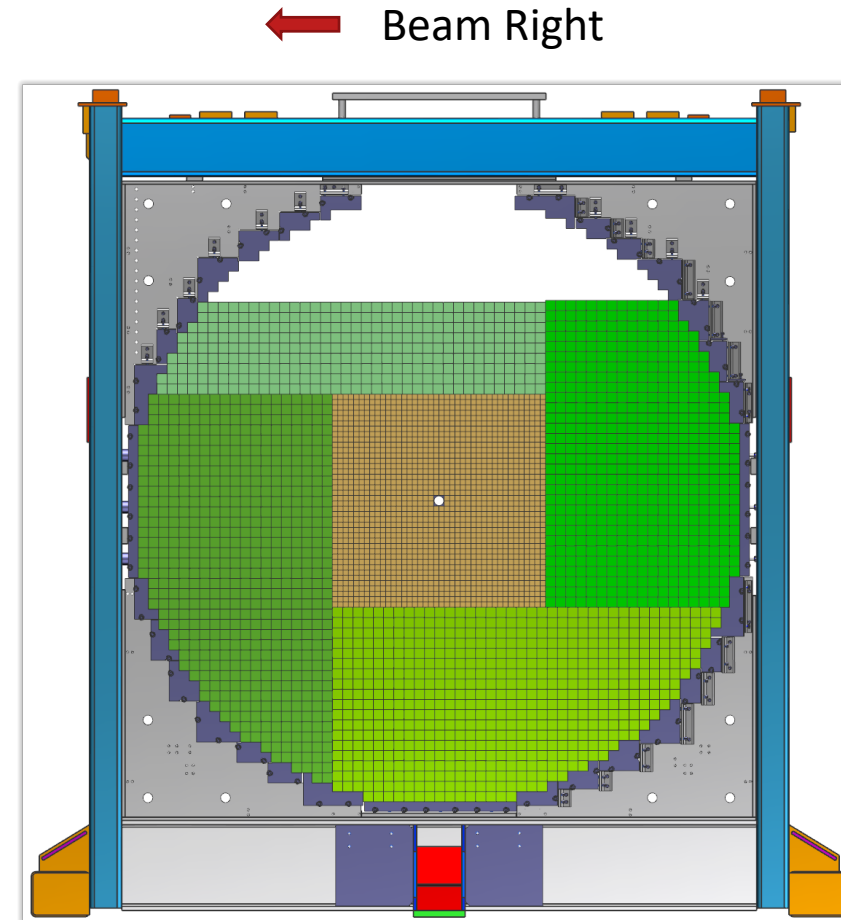
- Ensure Cooling Blocks are fully retracted both vertically and horizontally
- Lay in the next four rows of Glass Bar Modules using calculated shims (alternating each 90° along BL axis)
- Tighten these rows to Beam Right (Think Pre-Loading)
- Check the position of the Glass Bar Modules to verify correct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





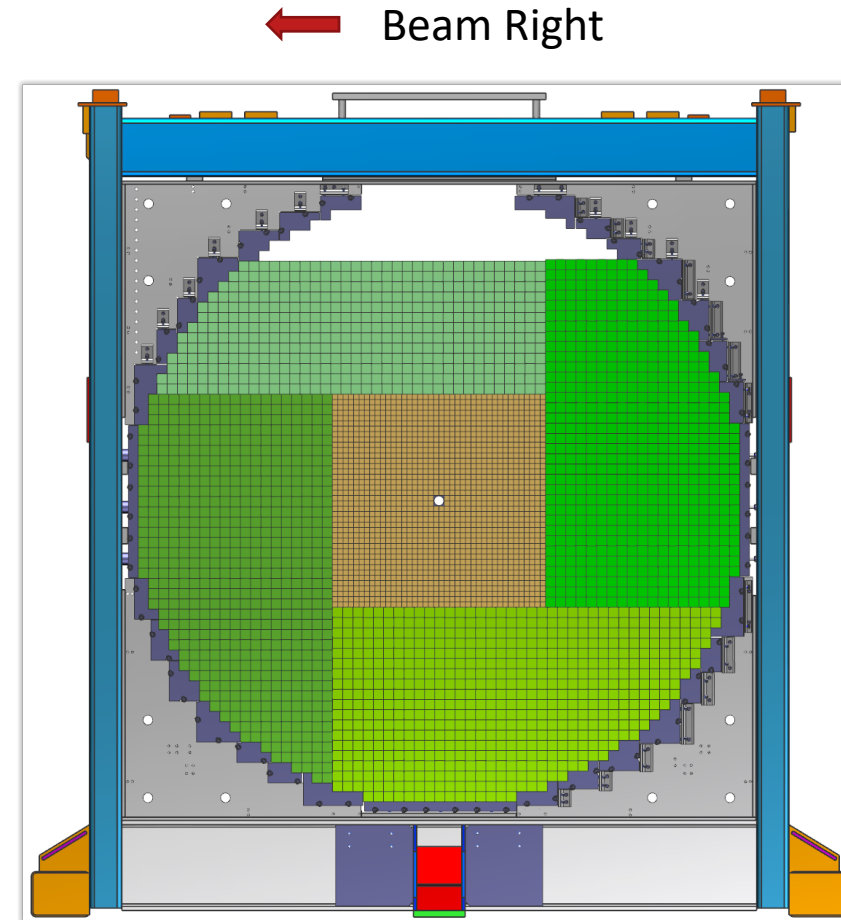
## STAGE 12

- 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



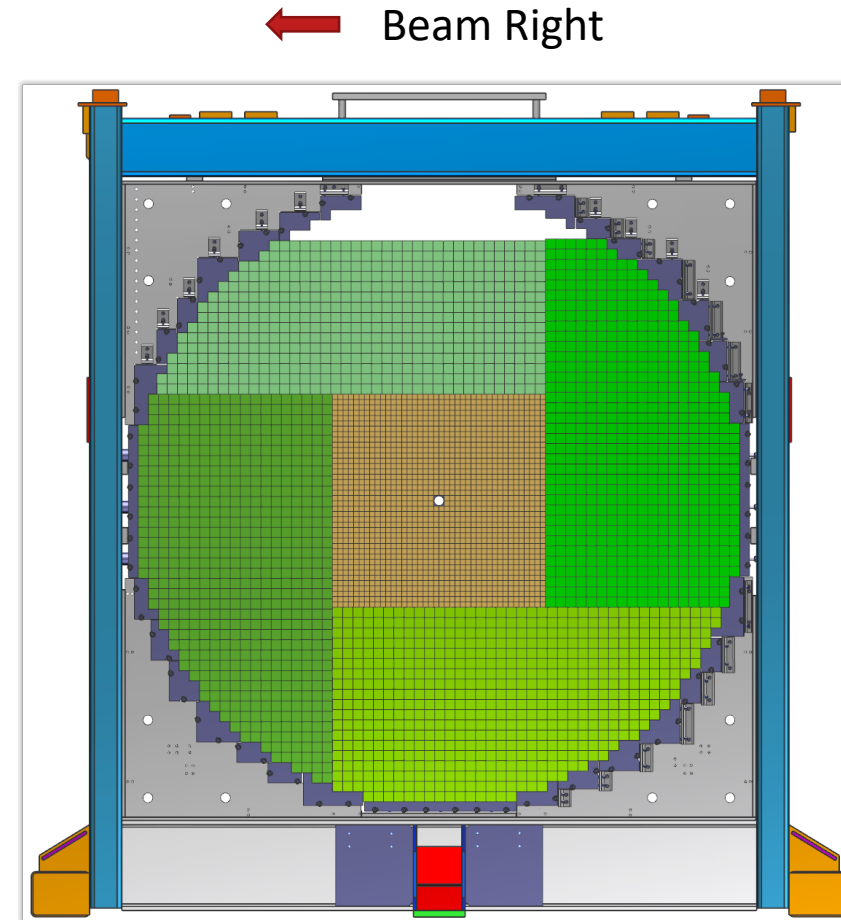
### STAGE 13

- 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



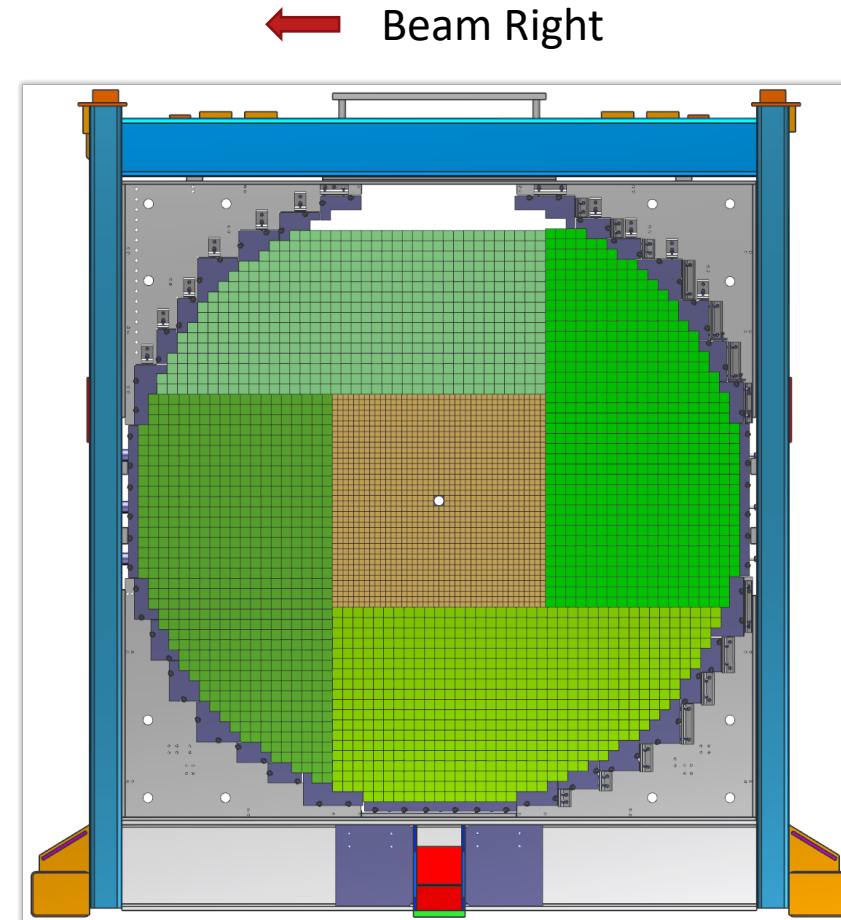
## STAGE 14

- 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



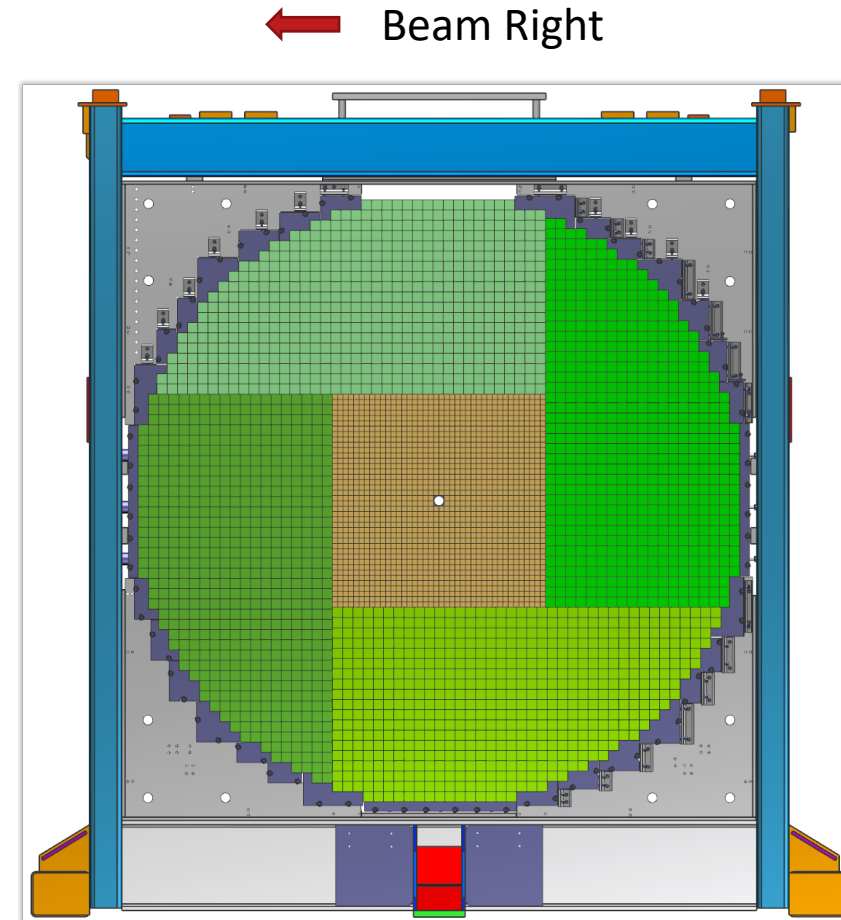
## STAGE 15

- 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

- Install Top Compression Cooling Plate
- 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.

