# TOF mechanics and cooling updates

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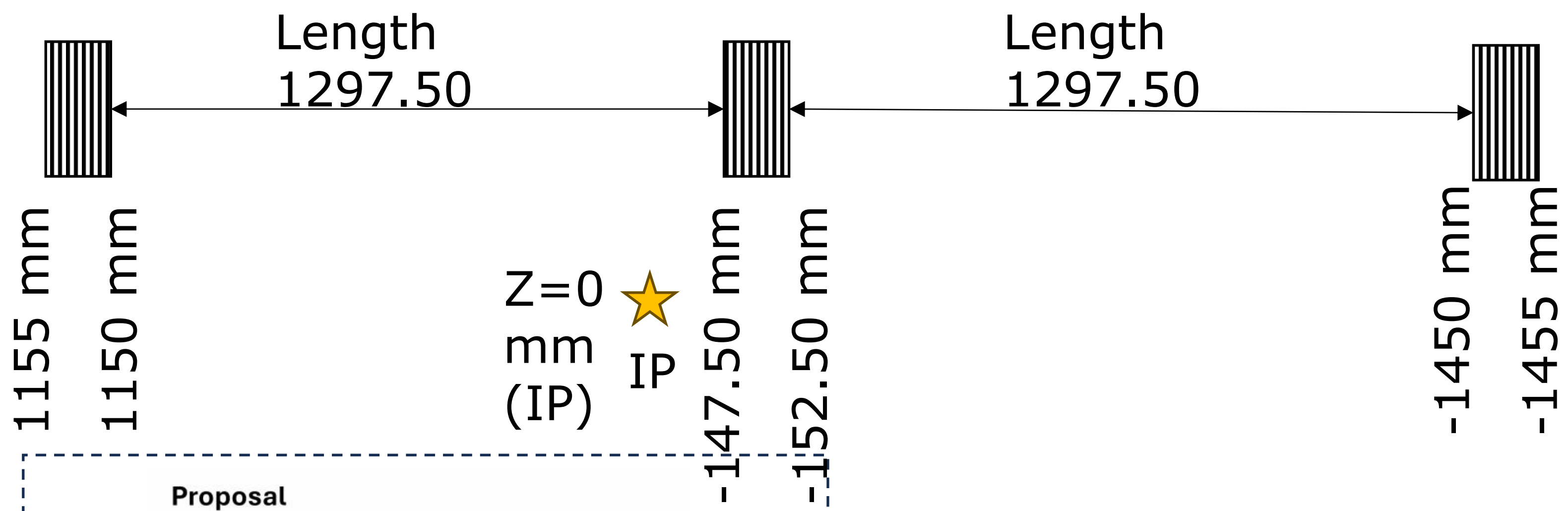
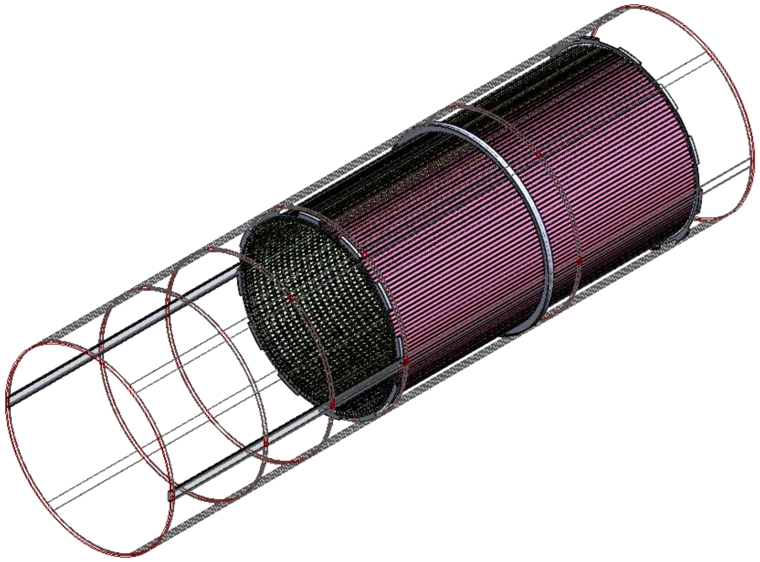
1. bTOF mechanics updates
2. Updated bTOF heat transfer analysis
3. Mounting Mechanism re-design (forced by re-design of engagement rings in GST – See GST presentation from the afternoon slot)
4. fTOF Mechanics updates and heat transfer analysis

# bTOF staves updated geometry

- The staves are now symmetric (1.3 m) on either side of the center engagement ring.

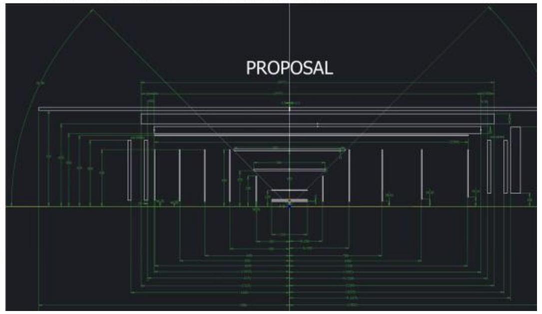
Z coordinates for Engagement Ring



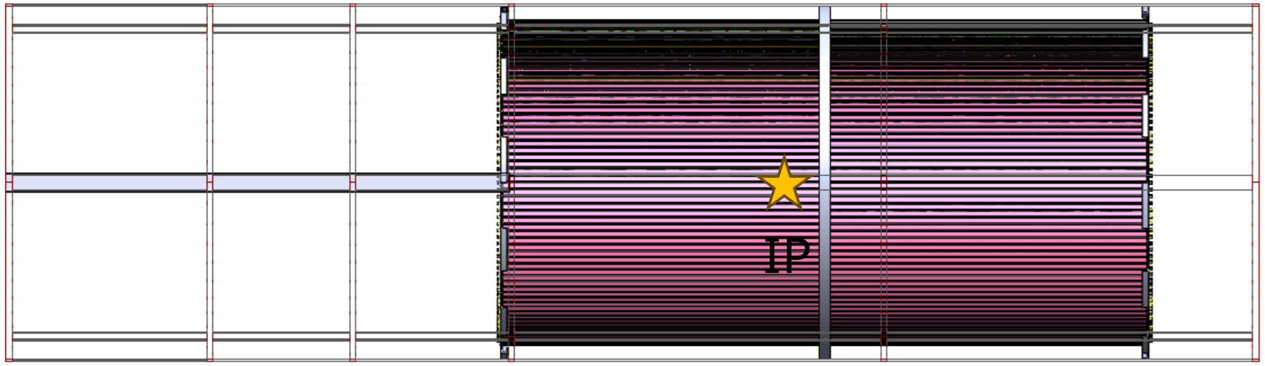



**Proposal**

- TOF and MPGD Centers line up for engagement ring
- TOF Flex cables are limited to 1.3m
- MPGD Disks spaced better for FEB



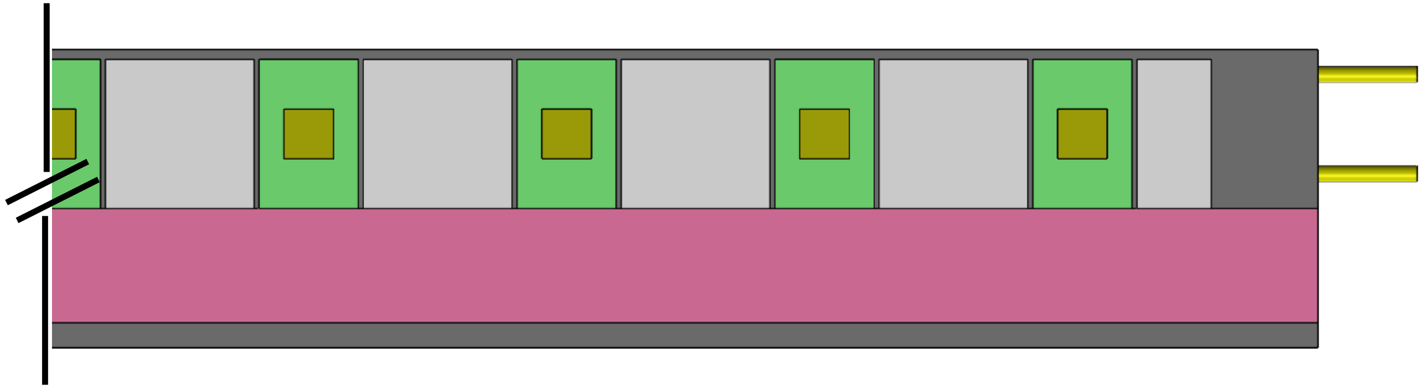

Comes from Dan’s proposal from Jan 2025

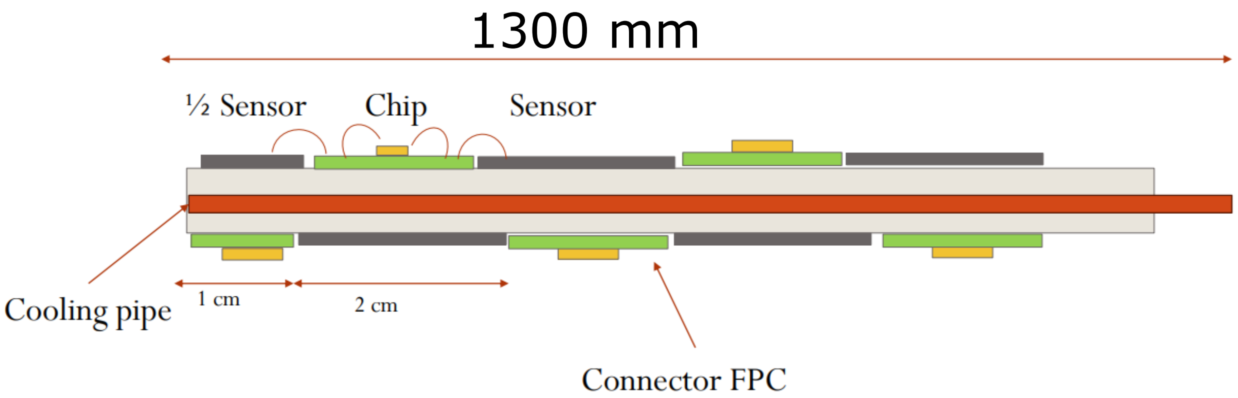


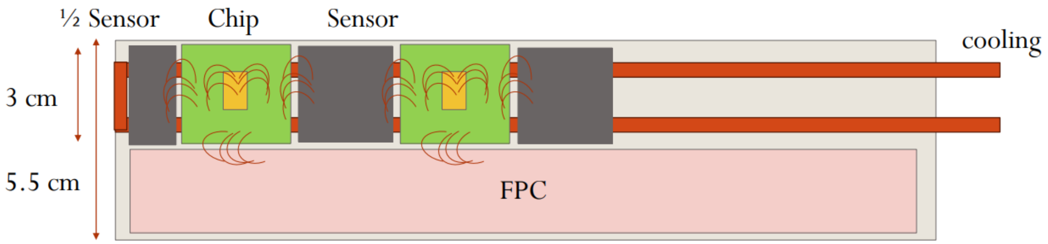
# Updated bTOF stave design / modules and mounting



- Module and mounting scheme has been updated to reduce mass as well as significantly increase the available services space in the inner detector
- Updated stave geometry is used to do the thermal simulation for cooling performance estimation.





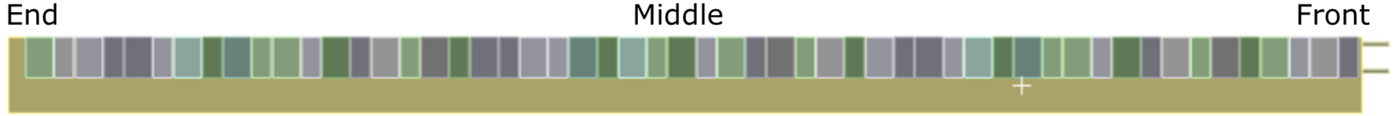

Slides from Simone Mazza (UCSC)

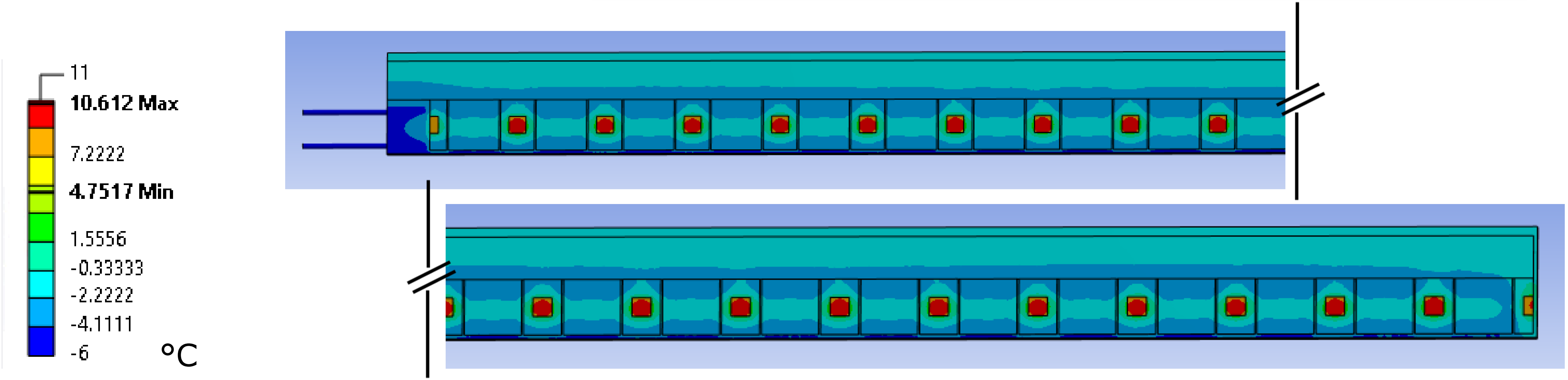
# Glycol cooling (+5°C) results for bTOF stave (1.3 m long)

| Part Name | Thermal Conductivity (W/mK) | Thickness (µm) |
|---|---|---|
| ROC and ASIC (Kapton properties) | 0.97 | 400 and 300 |
| Silicon Module | 148 | 200 |
| Carbon Face Sheet | Kxx - 180<br>Kyy - 150<br>Kzz – 0.70-2.01(Shown in graph) | 200 |
| Carbon Foam | 25 | 6420 |
| Loctite Epoxy | 1.28 | 120 |
| Stainless Steel Pipe | 16 | 716 |

| Working Fluid | ASIC End | ASIC Middle | ASIC Front | Silicon End | Silicon Middle | Silicon Front |
|---|---|---|---|---|---|---|
| -5 C Glycol | -0.001 | -0.018 | 0.101 | -3.297 | -3.464 | -3.500 |
| +5 C Glycol | 9.919 | 9.904 | 10.020 | 6.576 | 6.462 | 6.426 |

Average temperature for each sensor/ASIC along the length of half stave in °C

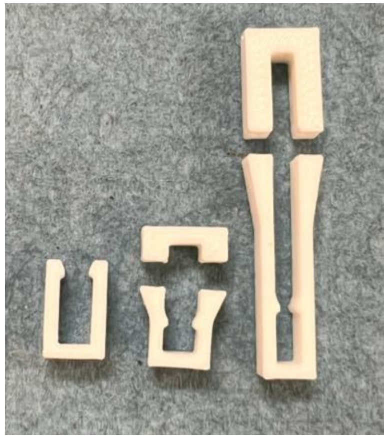


# Mechanical Update – Concept #2 for stave mounting

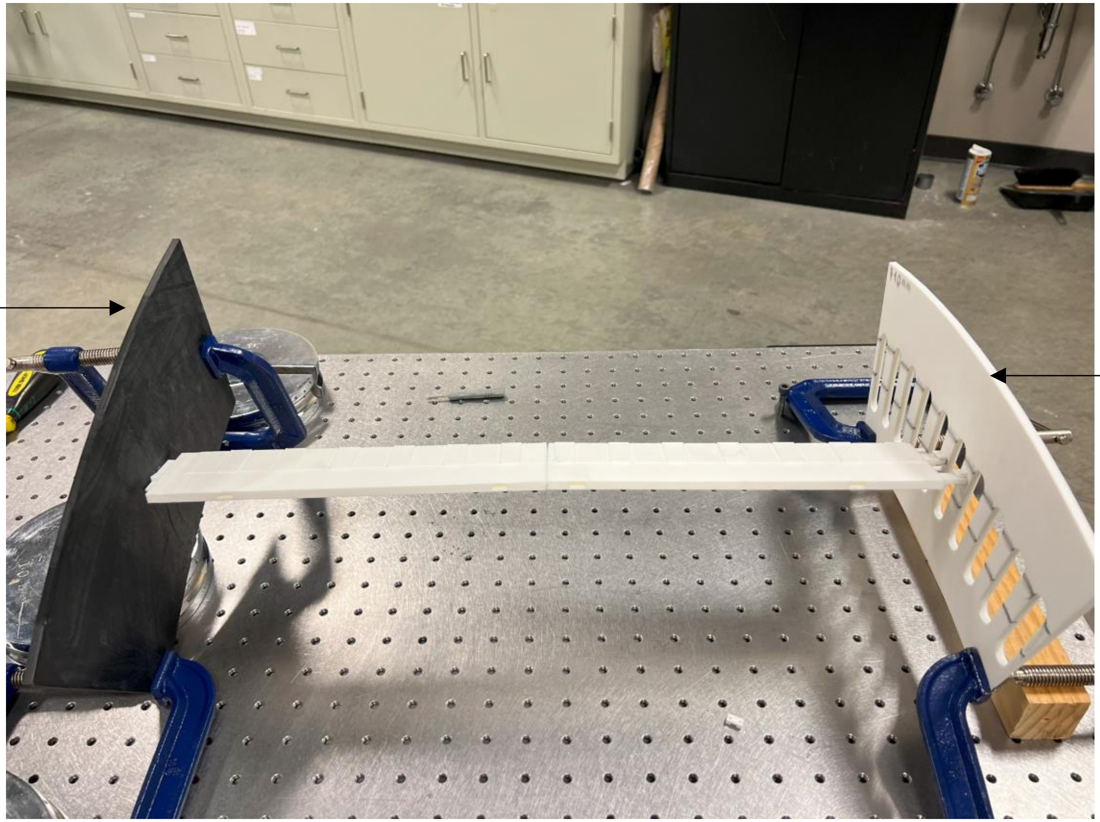


- The TOF staves are mounted at 18° angle to the normal on the engagement rings.
- The clip mechanism to hold the stave stable and allow for services and cooling to pass through the engagement rings is crucial for the TOF sub-detector
- This is first attempt at design and prototyping of the clip mechanism for the TOF stave mounts



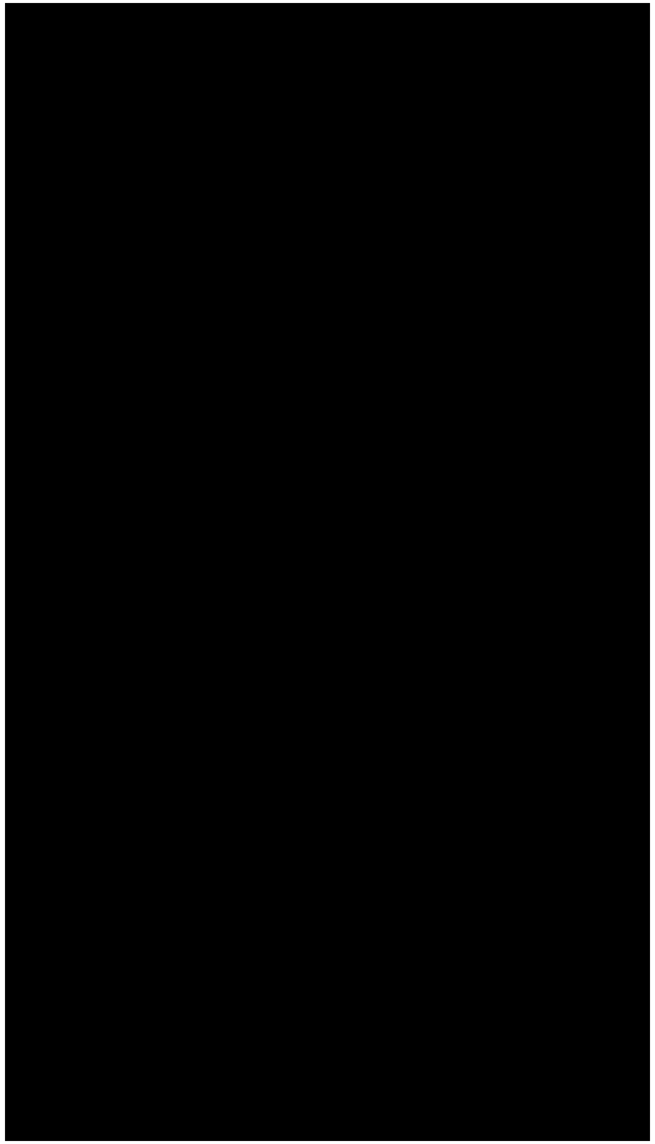
Clip and locking mechanism

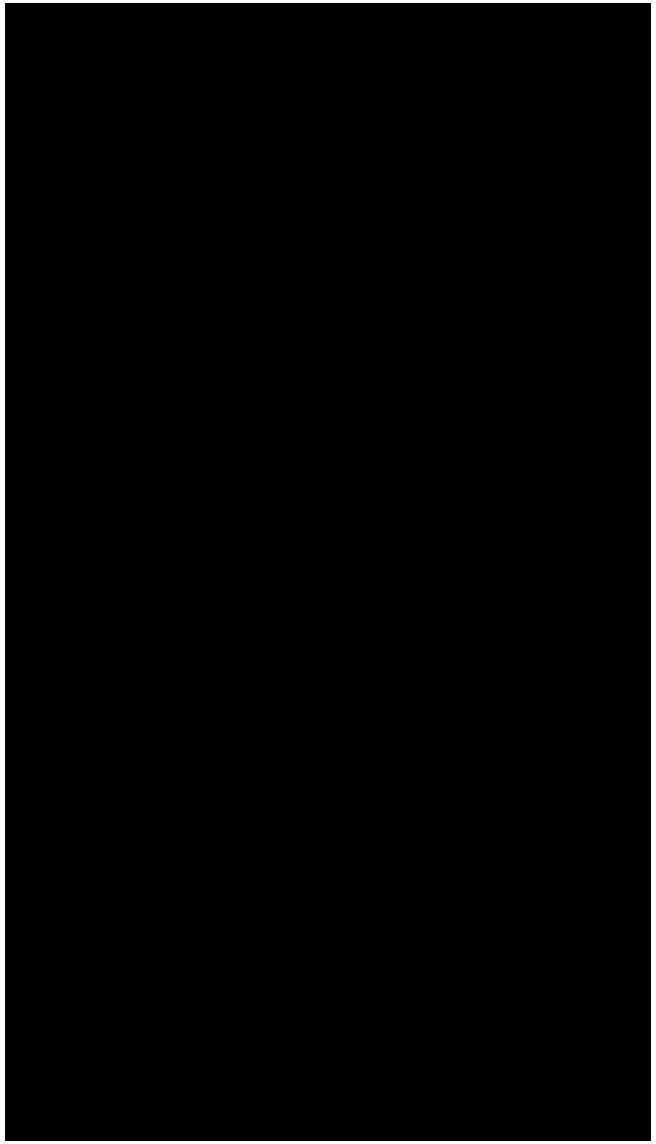
Center engagement ring



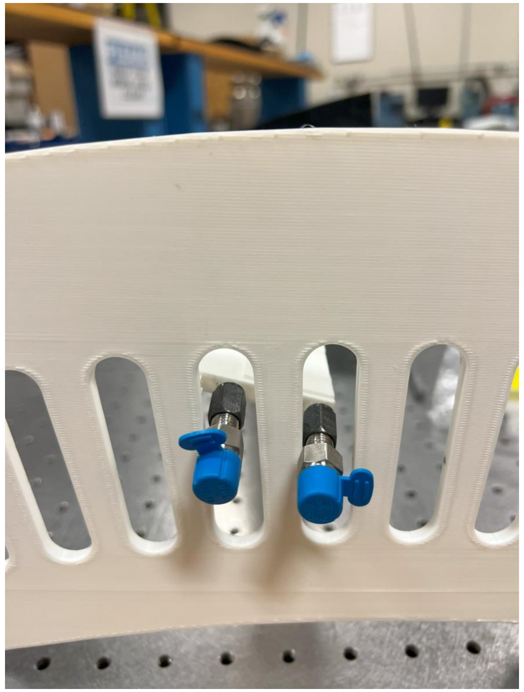
(e-/p) End engagement ring

# Clip mounting mechanism to assemble the staves





← 2 videos →



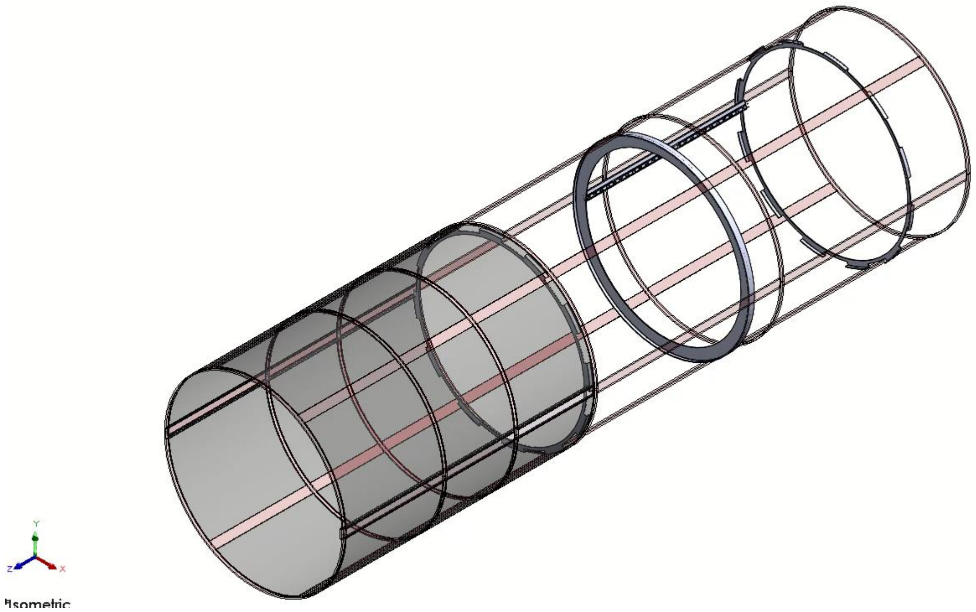
This mechanism was prototyped and tested in Nov 2024 to Jan 2025

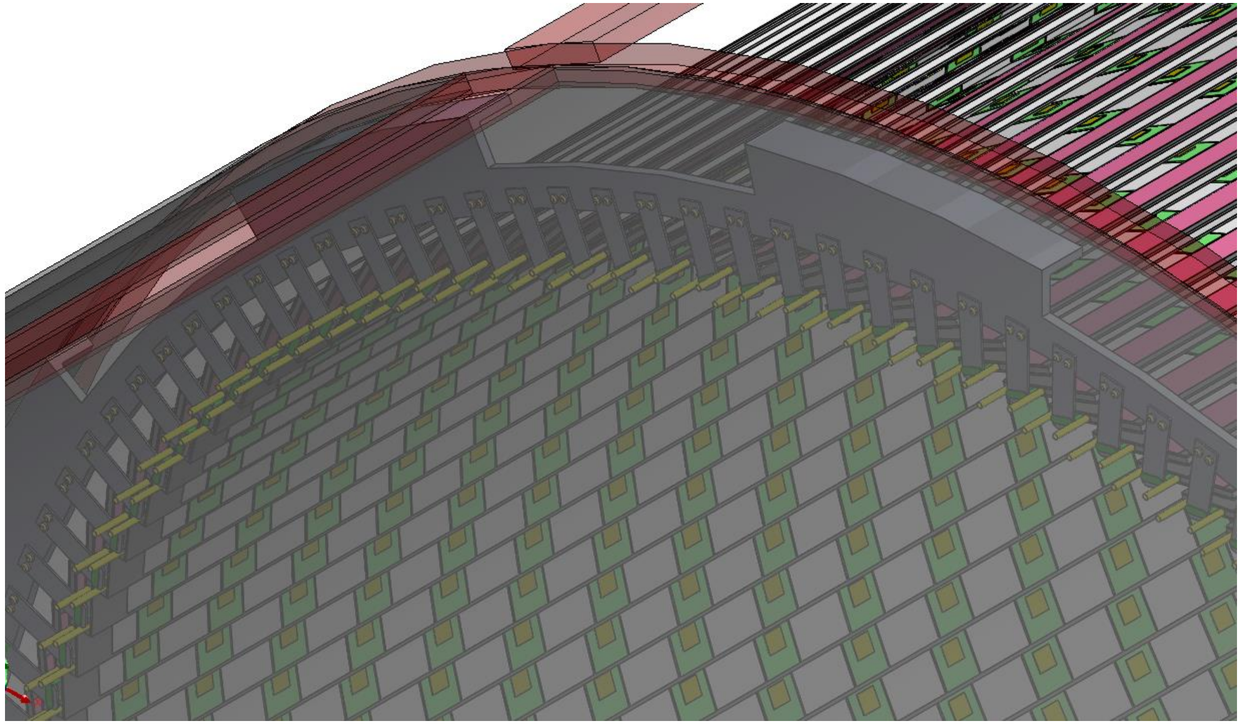
Changed needed as the mounting for tubes was not very service friendly and the engagement rings take too much service space (optimized further)

# Mechanical Update – Concept #3 for stave mounting



- The TOF staves are mounted at 18° angle from the center engagement ring using two dowel pins.
- The outer engagement rings have a mounting "patch" that attaches to the end of the stave to help support the tubes and the manifold for the bTOF cooling system.

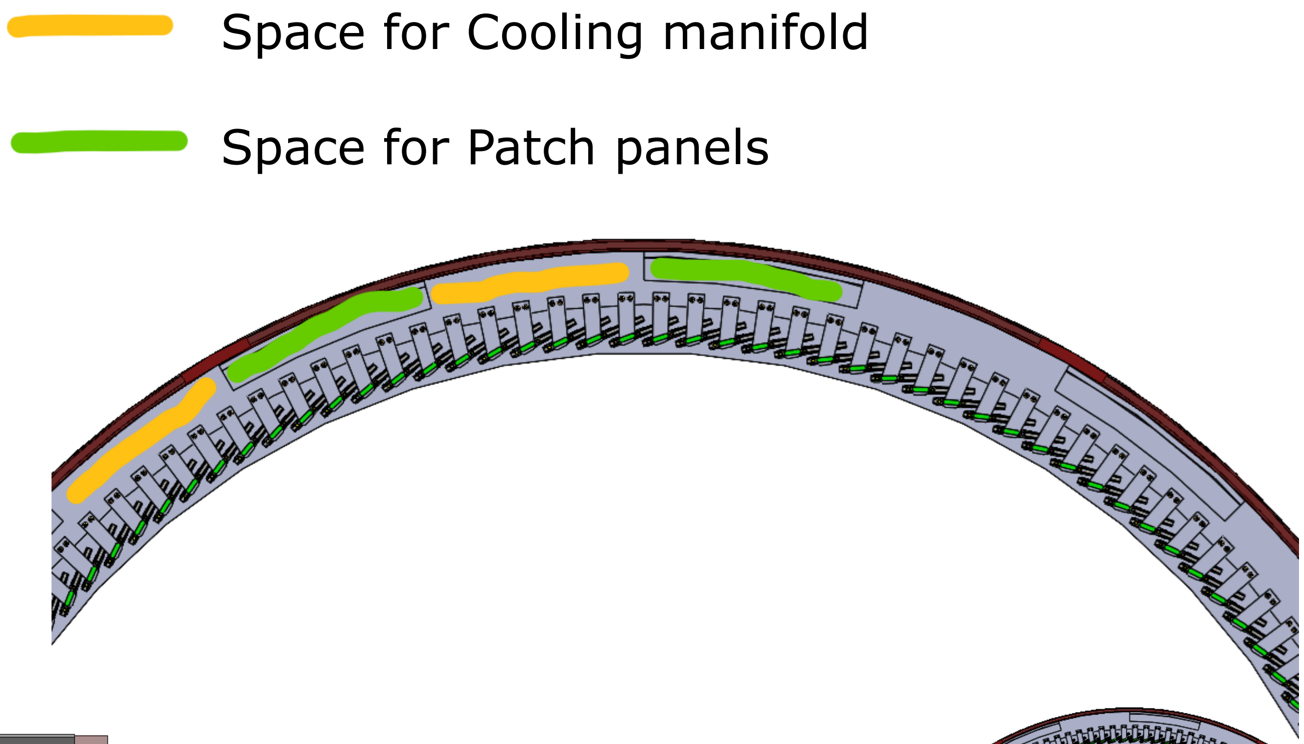


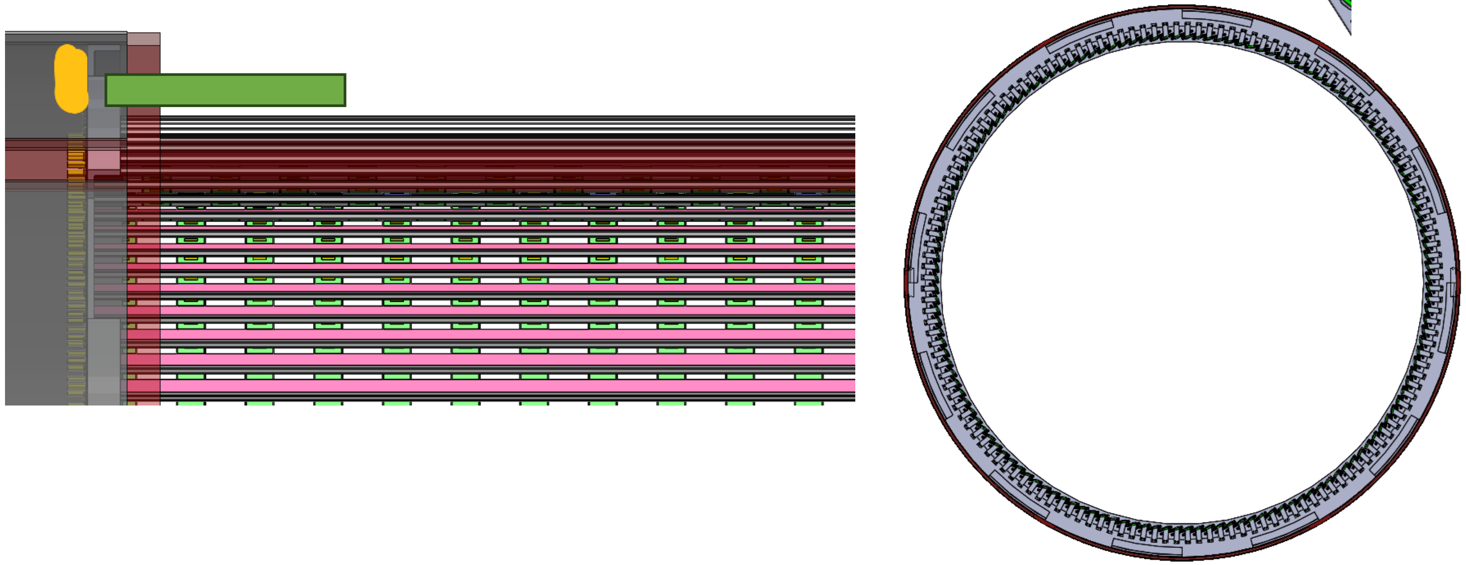


See detailed view in CAD models / at GST discussion in the afternoon

# Advantages of the new engagement rings + mounts

- Simplified mounting allows for the easy removal of single staves during service/maintenance
- Flat planner parts that can be easily trimmed from flat sheets and PEEK stock screws and dowel pins for ease of manufacturing and procurement
- Frees up a lot of services space for the SVT/inner detector services
- Cons –
  - Multiple (144 x 4 x 2 ) small parts to be integrated / assembled
  - Can explore assembling in segments of 4 or 6 staves to reduce work inside the GST.

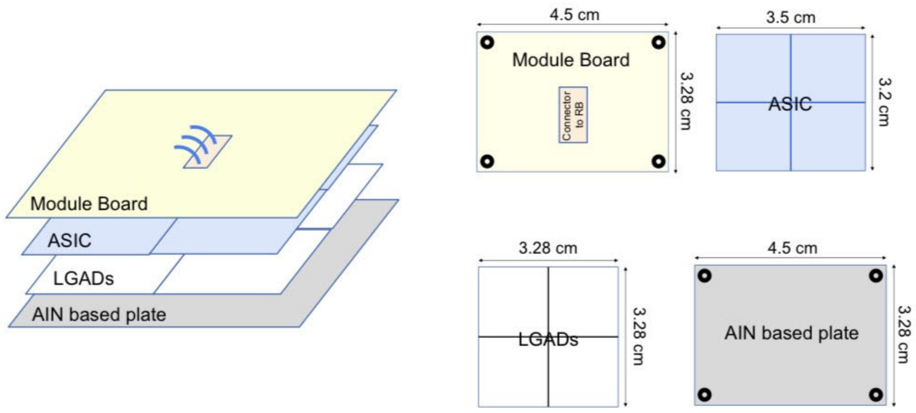


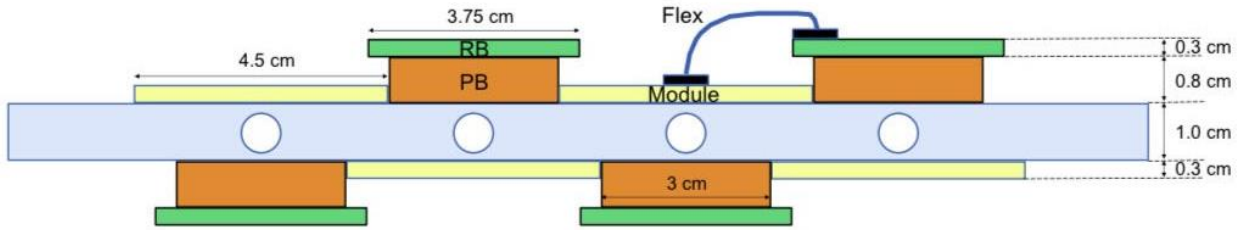



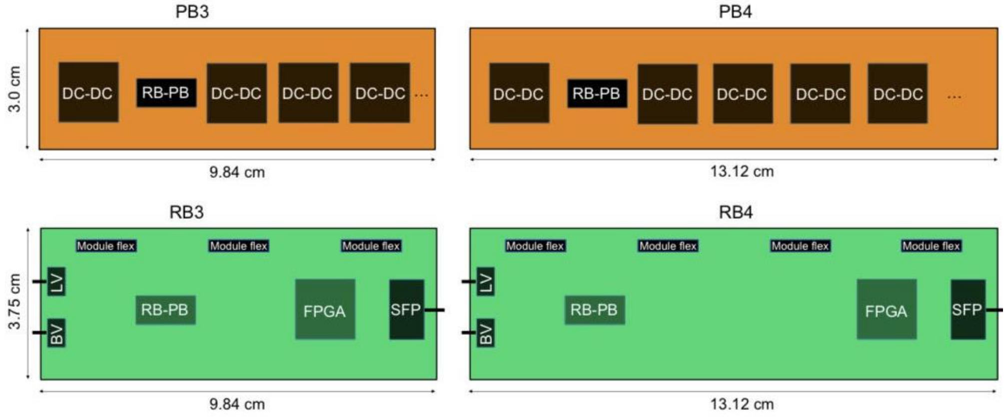
# fTOF mechanics updates

# Dimensions and Boundary Conditions

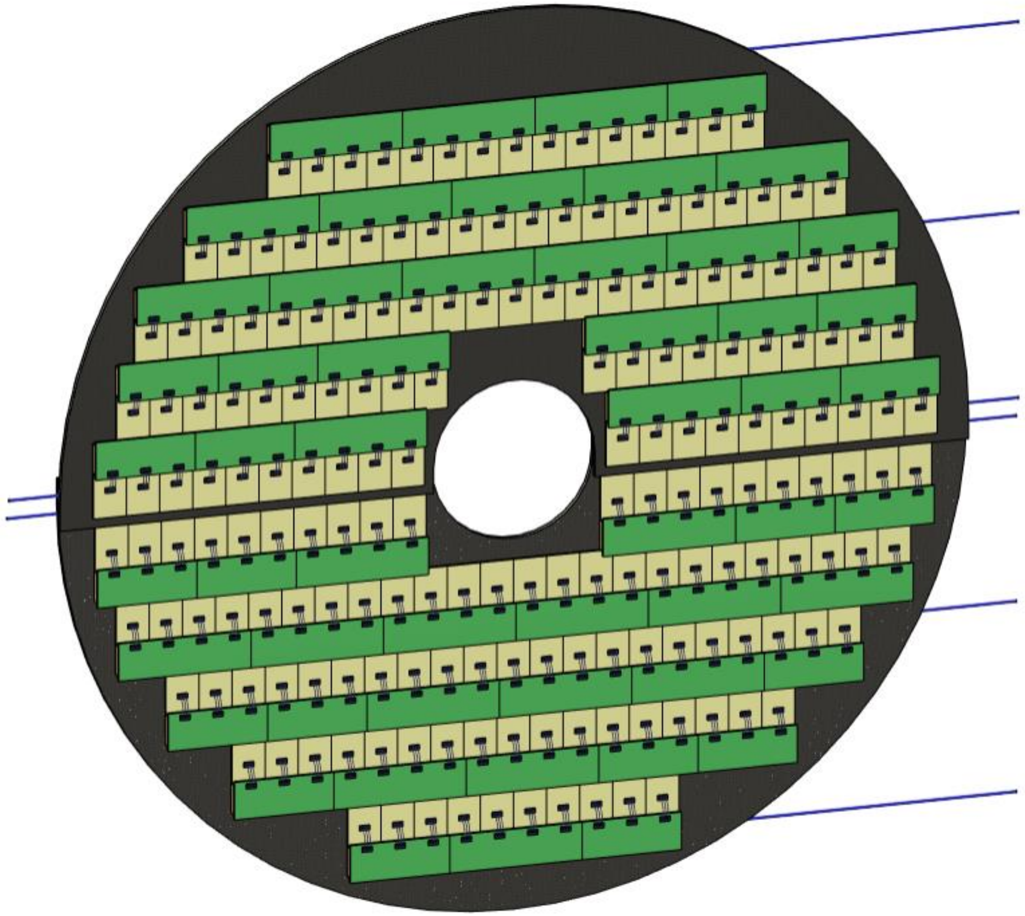
- 1.4 W/cm^2 on ASIC surface
- 5 C pipe cooling – water glycol 70/30
- 22 C ambient air with 5 W/m^2 Film Coefficient
- 30 C impinging air from R500-R600 with 10 W/m^2 Film Co

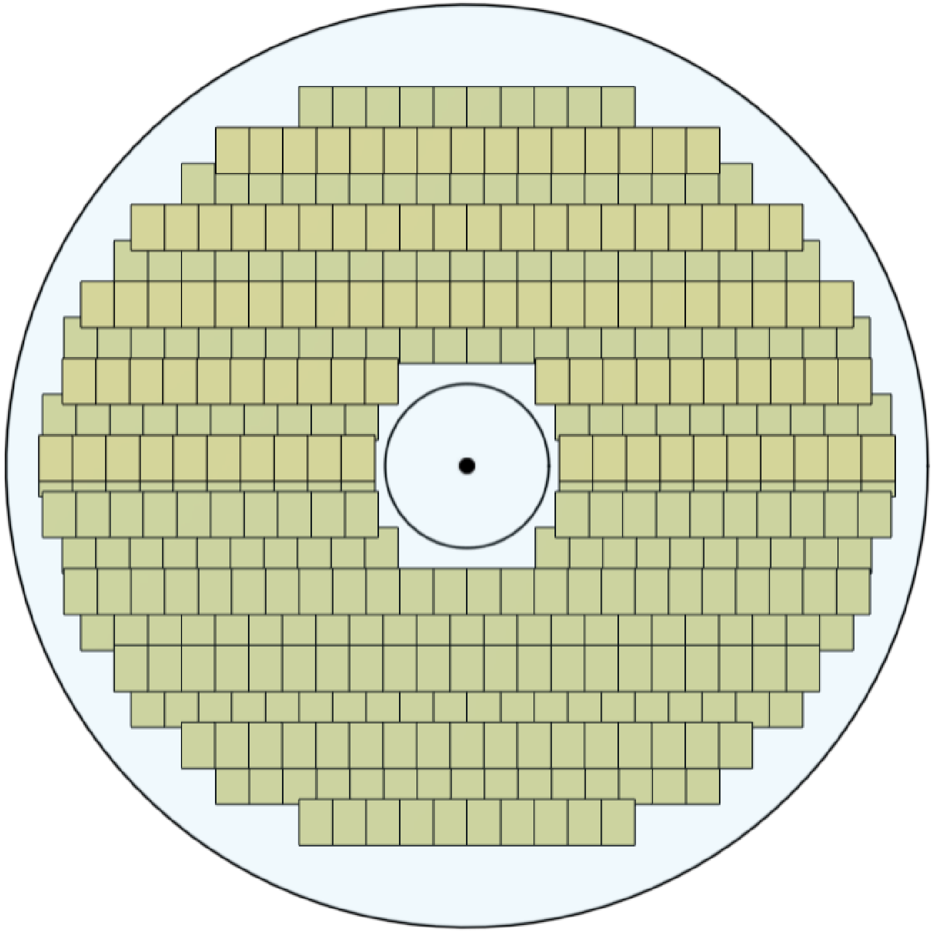


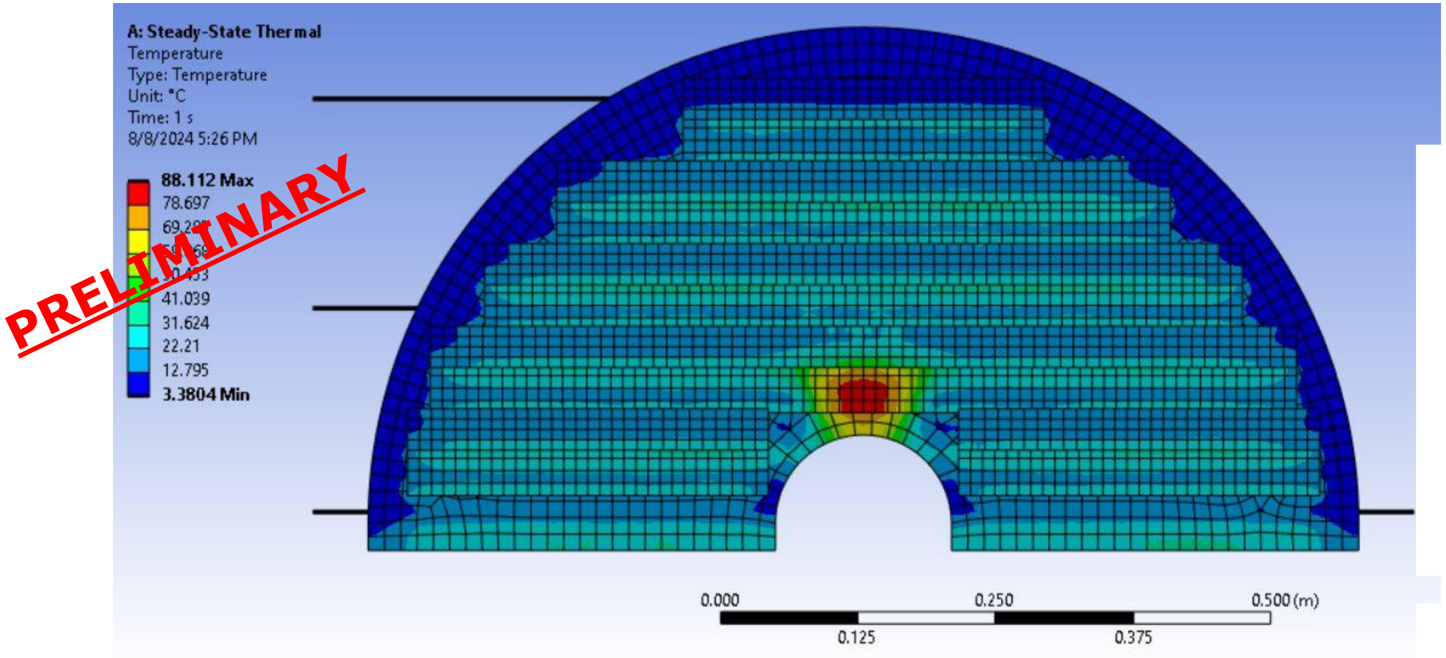



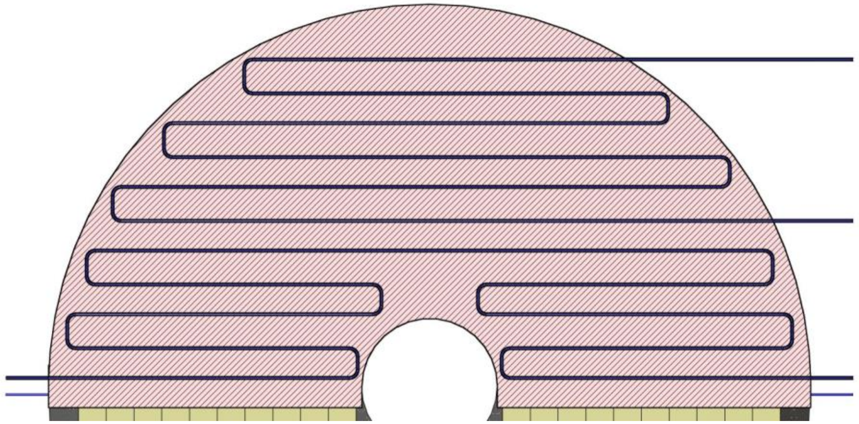
# Sensor Tiling CAD

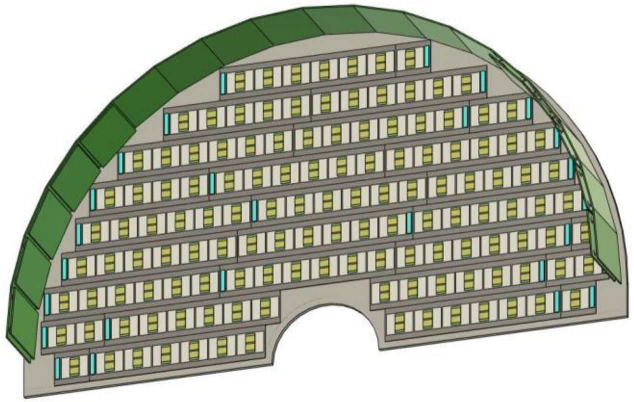


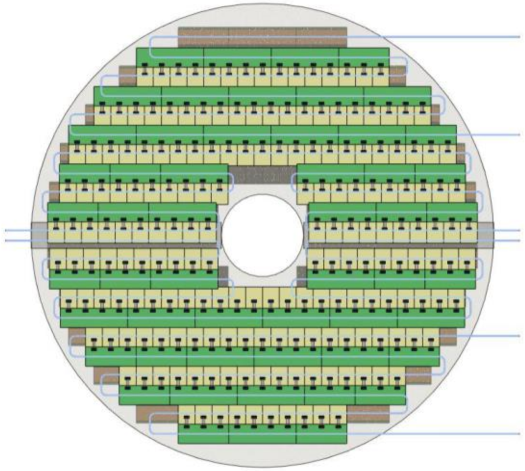


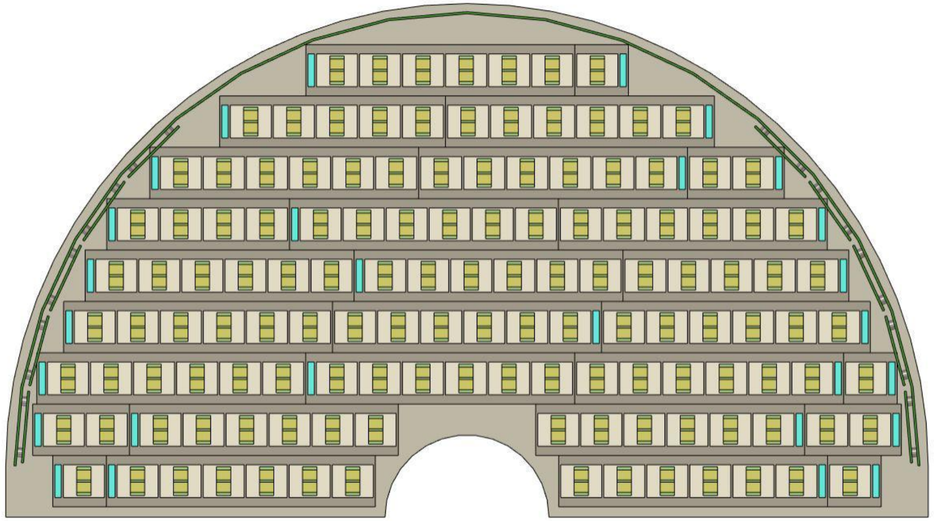
# First iteration of piping layout and heat transfer FEA



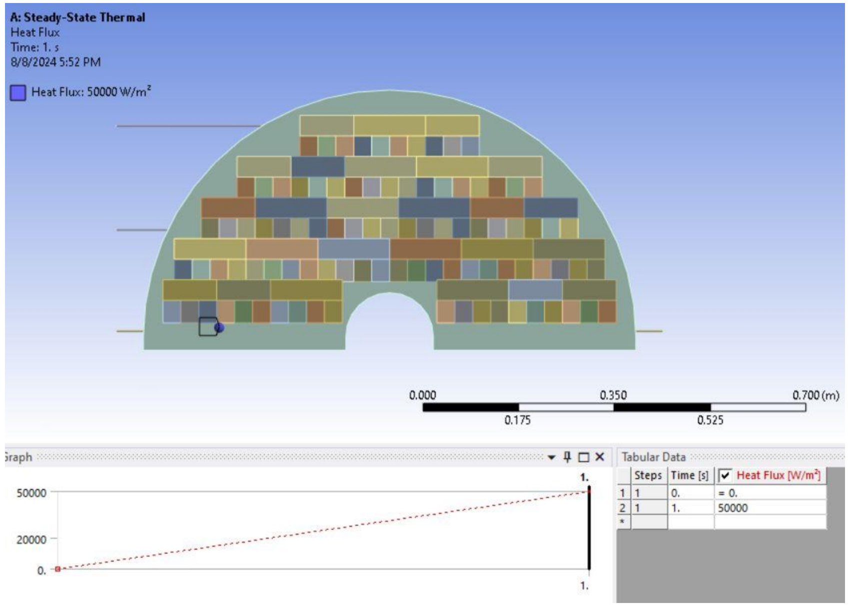



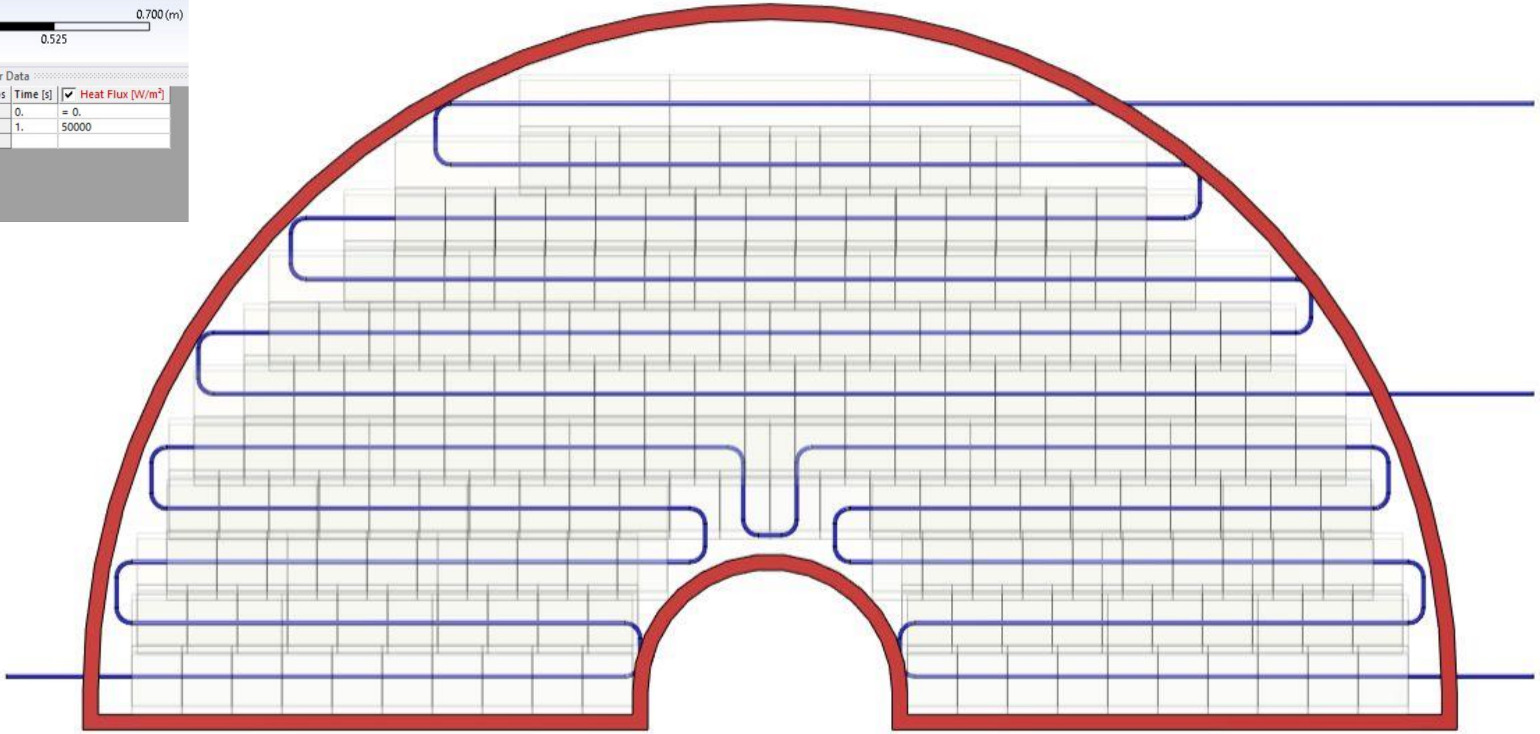






# Pipe – rerouting and repeat on FEA



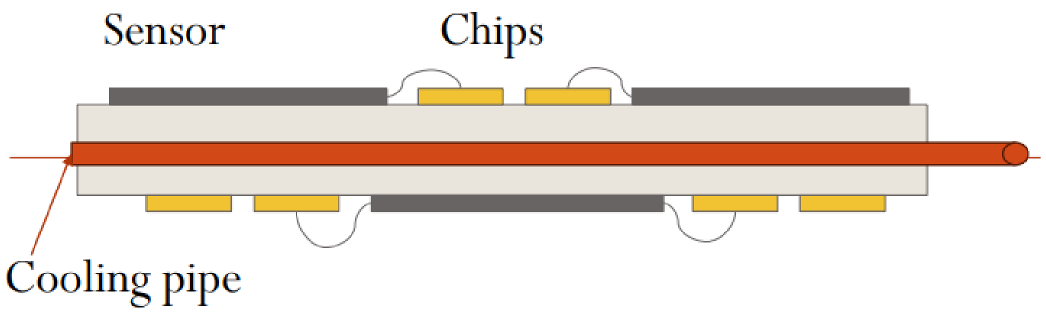
# Summary

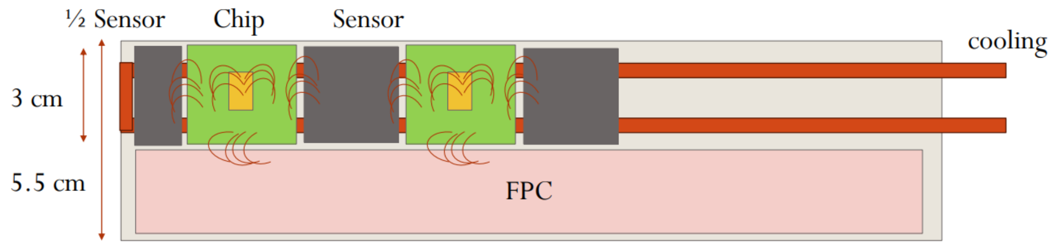


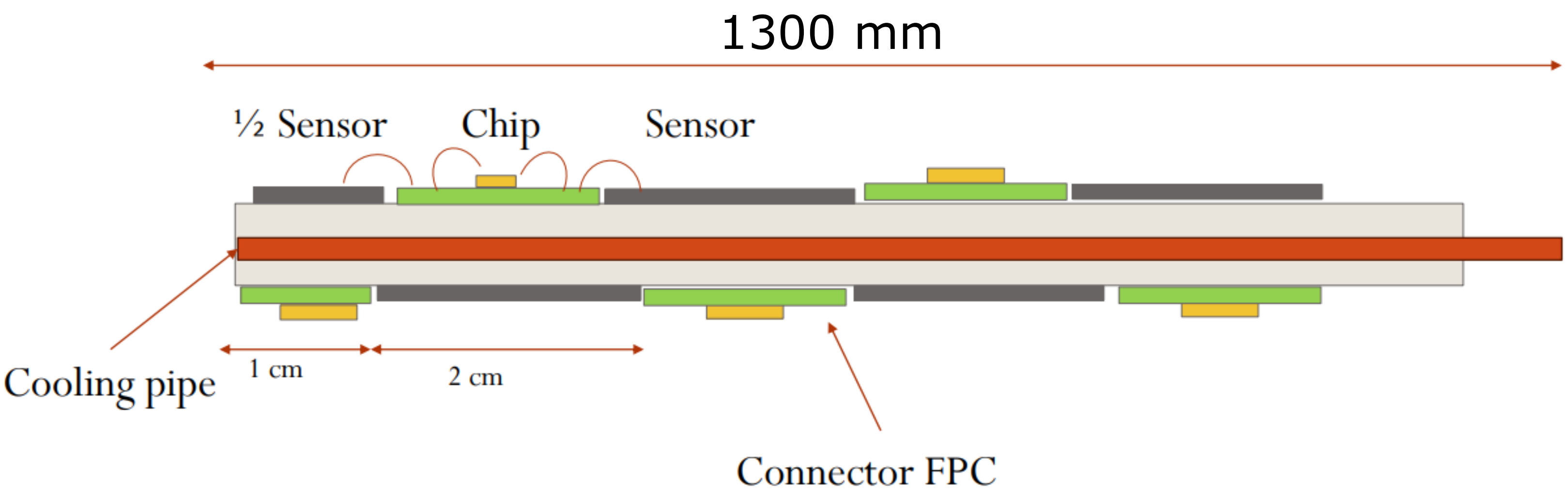
- fTOF –
  1. CAD geometry for the latest tiling scheme (with updated diameter) under going thermal FEAs
  2. Fits within the new envelope created for services access to outside GST
- bTOF –
  1. Finished implementing proposal from Dan on symmetric bTOF, structural simulation underway
  2. Thermal simulation completed for the updated module assembly scheme and heat generation estimated to inform the cooling requirements
  3. Mounting mechanism iteration #3 reduces need for service space while still being able to disassemble and work on individual staves
  4. Allows for mounts and space for cooling manifold as well as portcards / patch panels (internal to bTOF)

# Back up slides

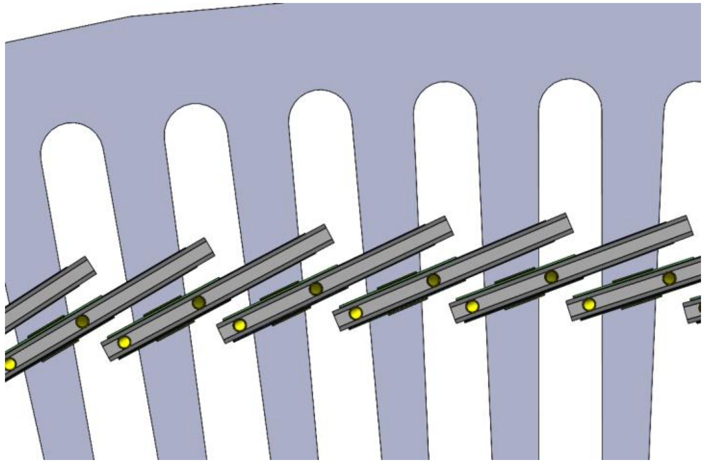
# To do – change the stave CAD with the updated dimensions as shown on this slide

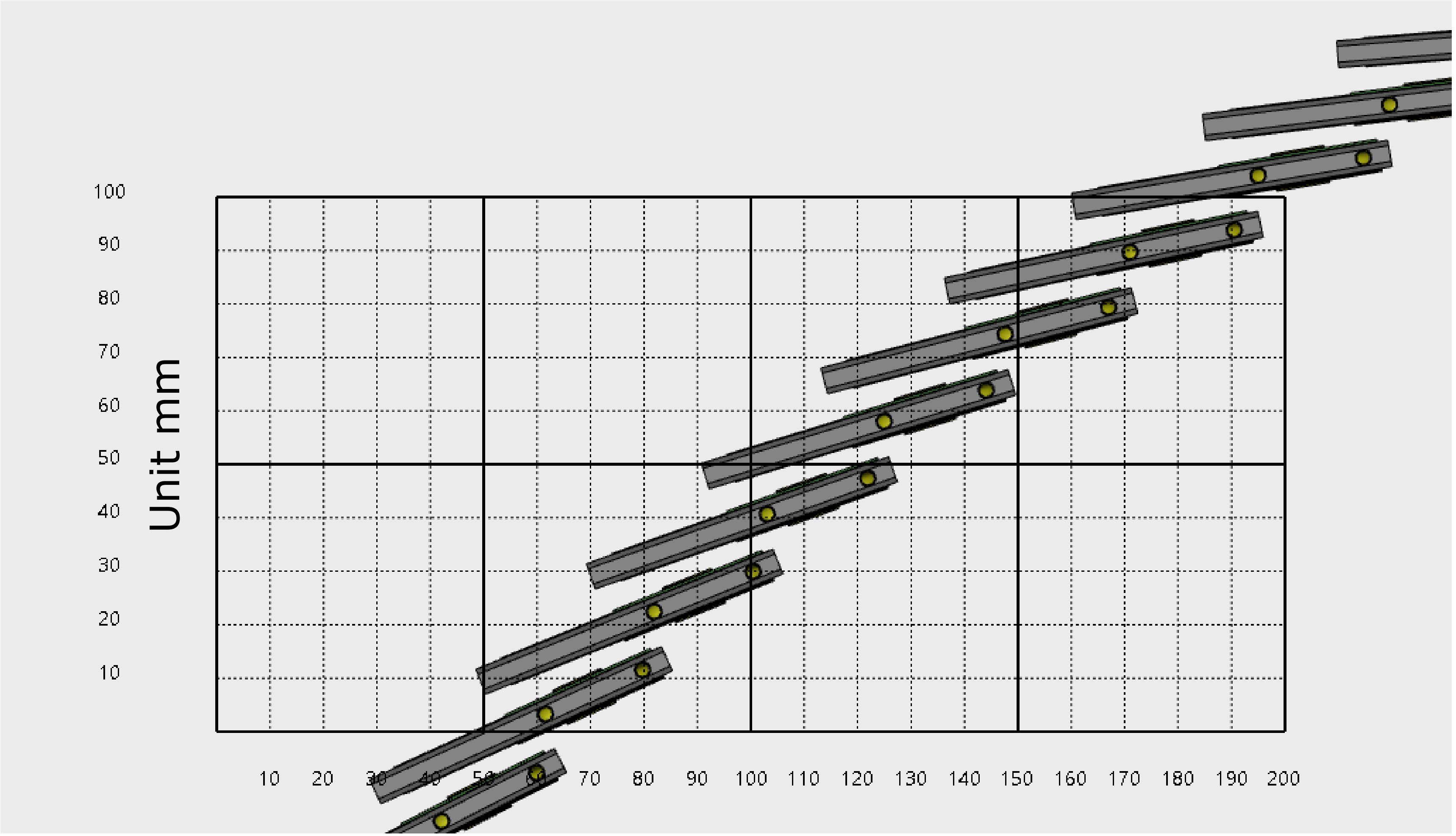


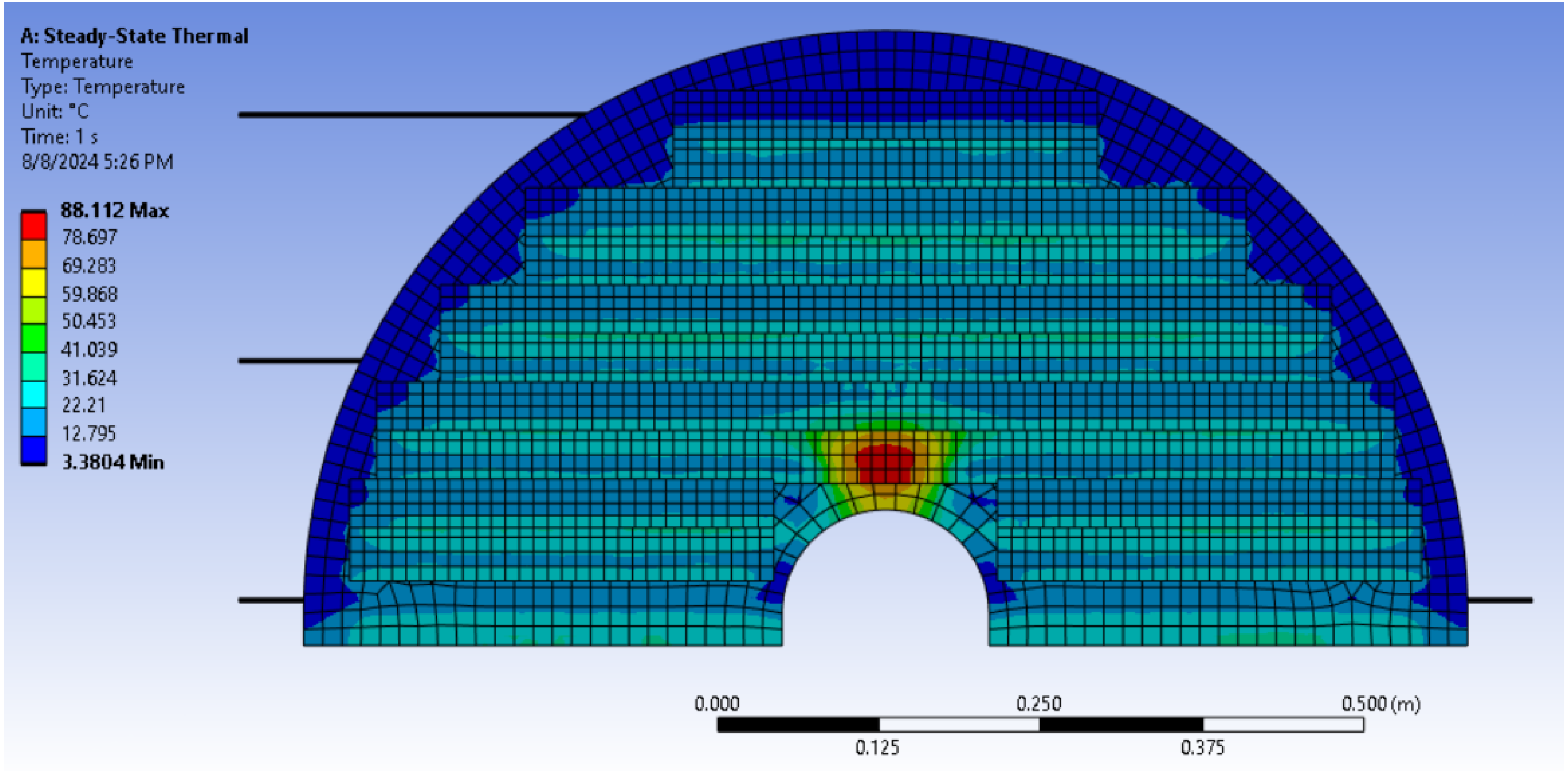
# Modified stave width to 6cm





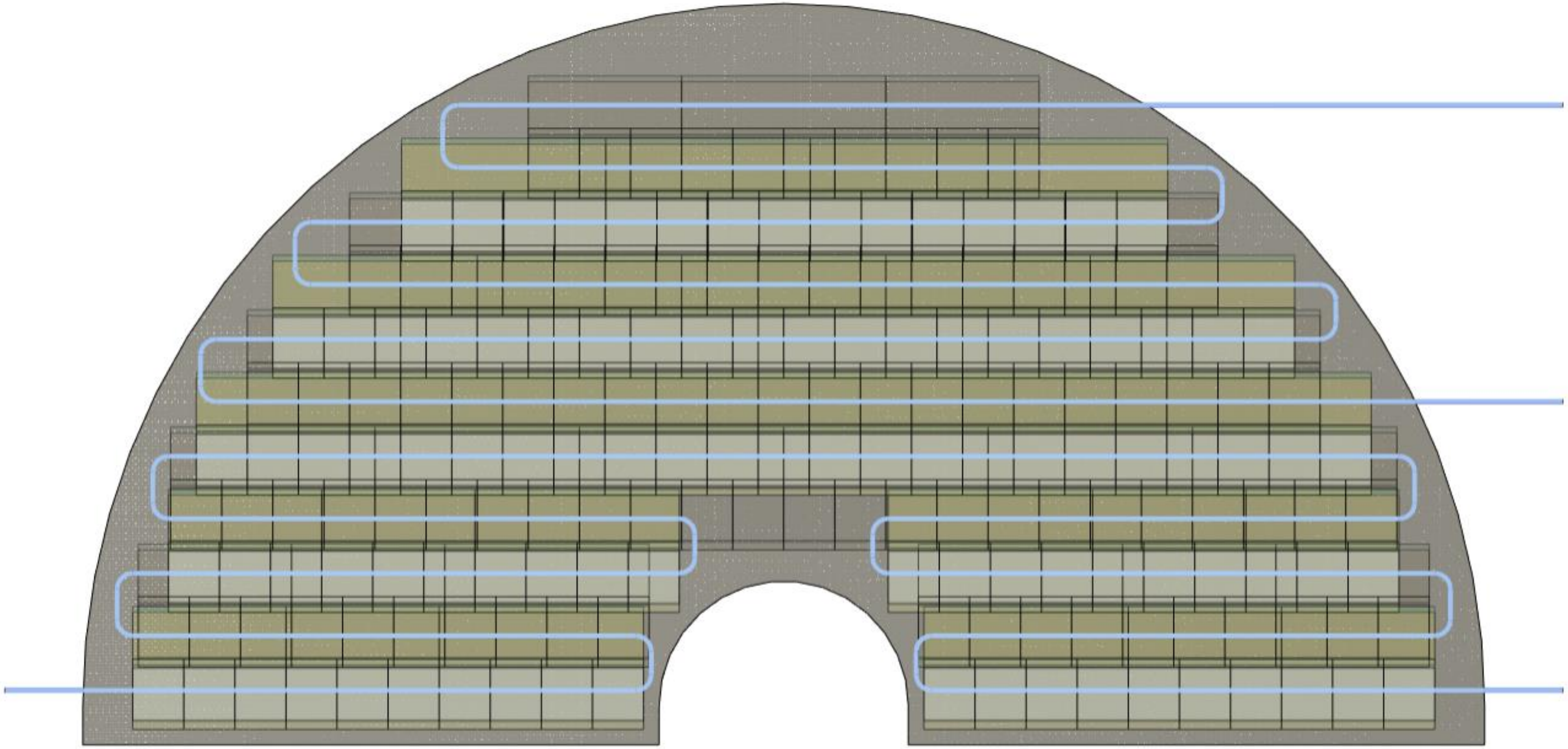
# Results




A: Steady-State Thermal
Temperature
Type: Temperature
Unit: °C
Time: 1 s
8/8/2024 5:26 PM
88.112 Max
78.697
69.283
59.868
50.453
41.039
31.624
22.21
12.795
3.3804 Min
0.000
0.250
0.500 (m)
0.125
0.375

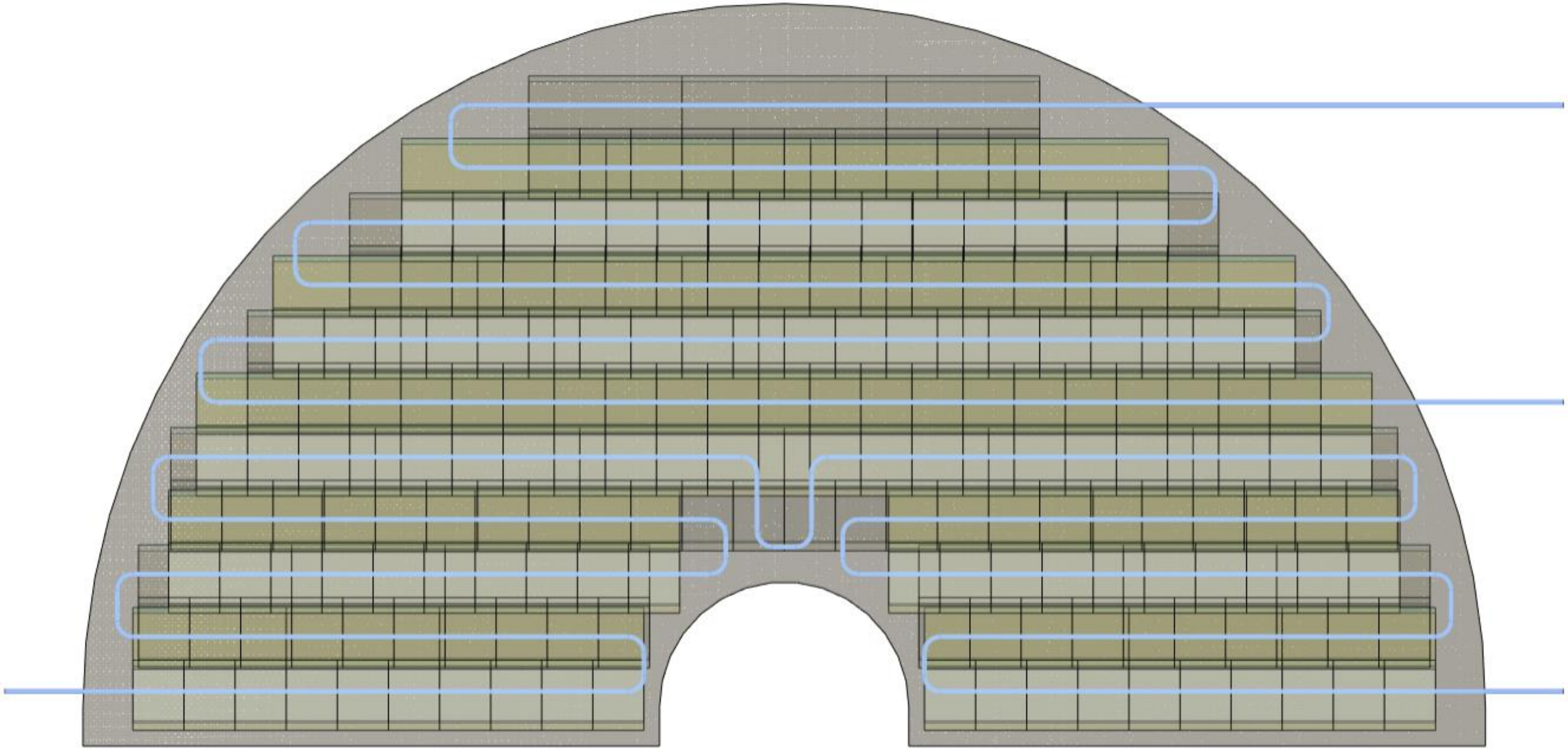
| Part Name | Thermal Conductivity (W/mK) | Thickness (mm) |
|---|---|---|
| ASIC | 0.97 | 0.75 |
| LGAD | 0.97 | 0.75 |
| AlN | 160 | 0.75 |
| Silicon Module | 148 | 0.75 |
| Carbon Face Sheet | Kxx - 200<br>Kyy - 200<br>Kzz - 2 | 0.5 |
| Carbon Foam | 17 | 5 |
| Stainless Steel Pipe | 15 | 0.1 |

# Pipe Routing

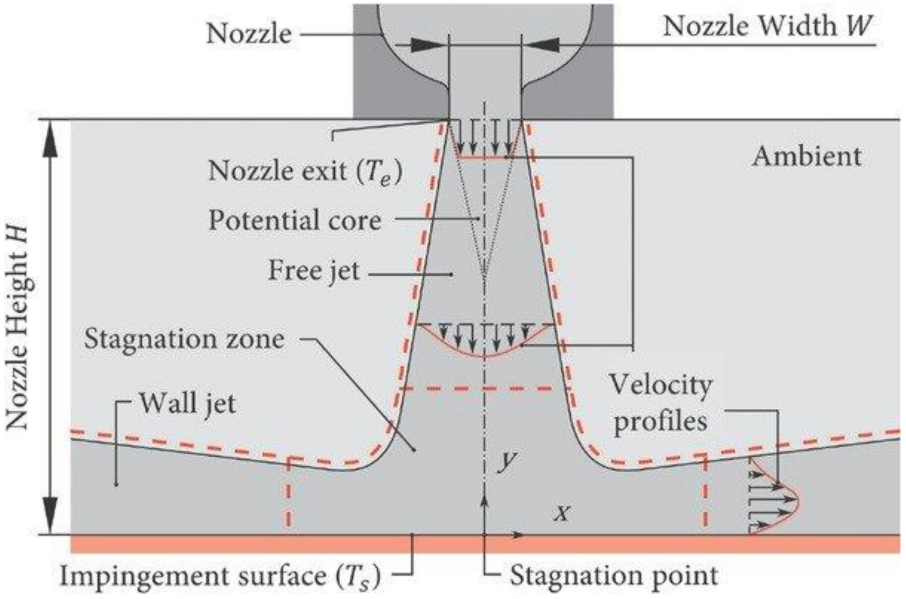


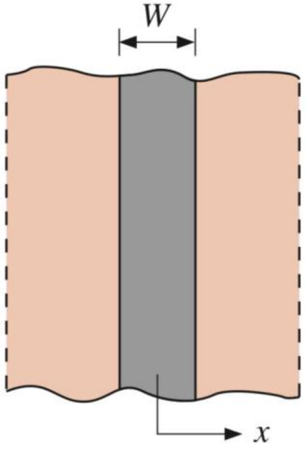
# Pipe Re-routing





# Heat Transfer Coefficient Calculation for Impinging Air




$A_r = W/2x$

(d)

**Slot Nozzles** For a *single slot nozzle* ($A_r = W/2x$), the recommended correlation is

$$\frac{\overline{Nu}}{Pr^{0.42}} = \frac{3.06}{0.5/A_r + H/W + 2.78} Re^m \qquad (7.75)$$

where

$$m = 0.695 - \left[\left(\frac{1}{4A_r}\right) + \left(\frac{H}{2W}\right)^{1.33} + 3.06\right]^{-1} \qquad (7.76)$$

and the ranges of validity are

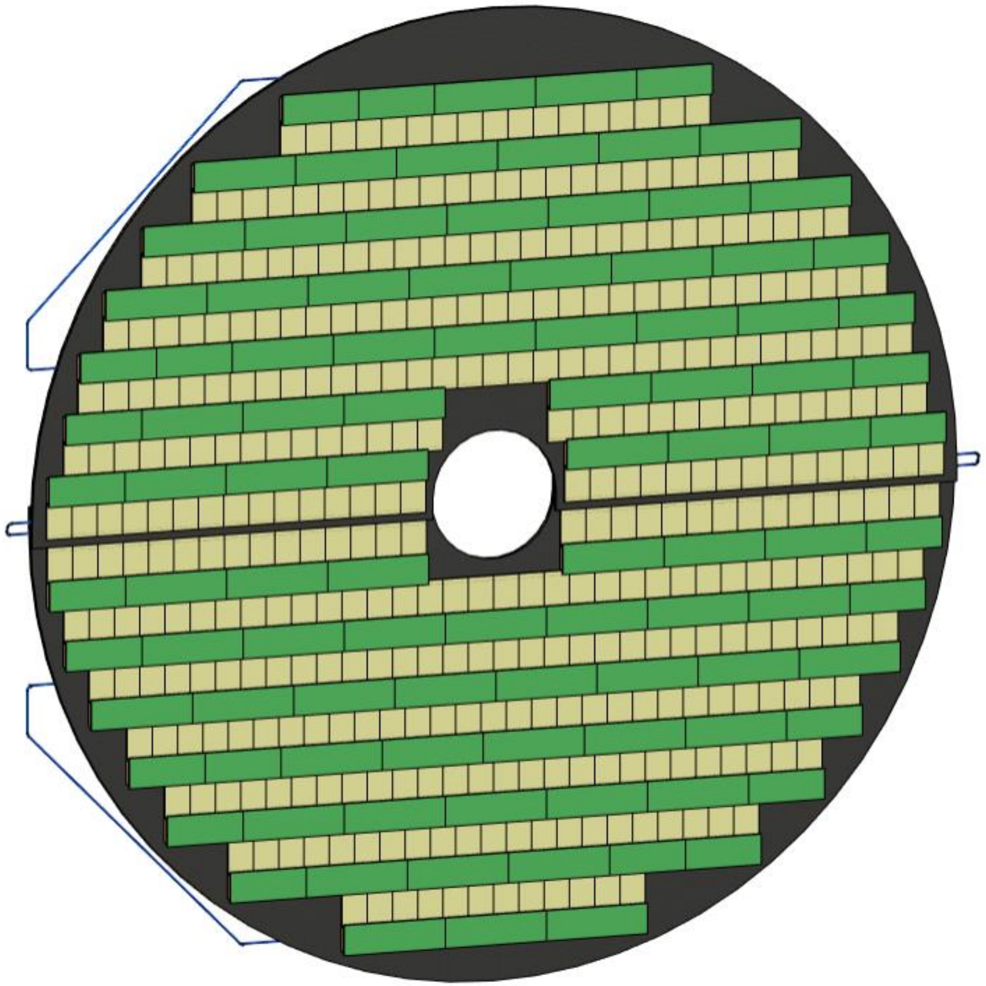
$$\begin{bmatrix} 3000 \lesssim Re \lesssim 90{,}000 \\ 2 \lesssim H/W \lesssim 10 \\ 0.025 \lesssim A_r \lesssim 0.125 \end{bmatrix}$$

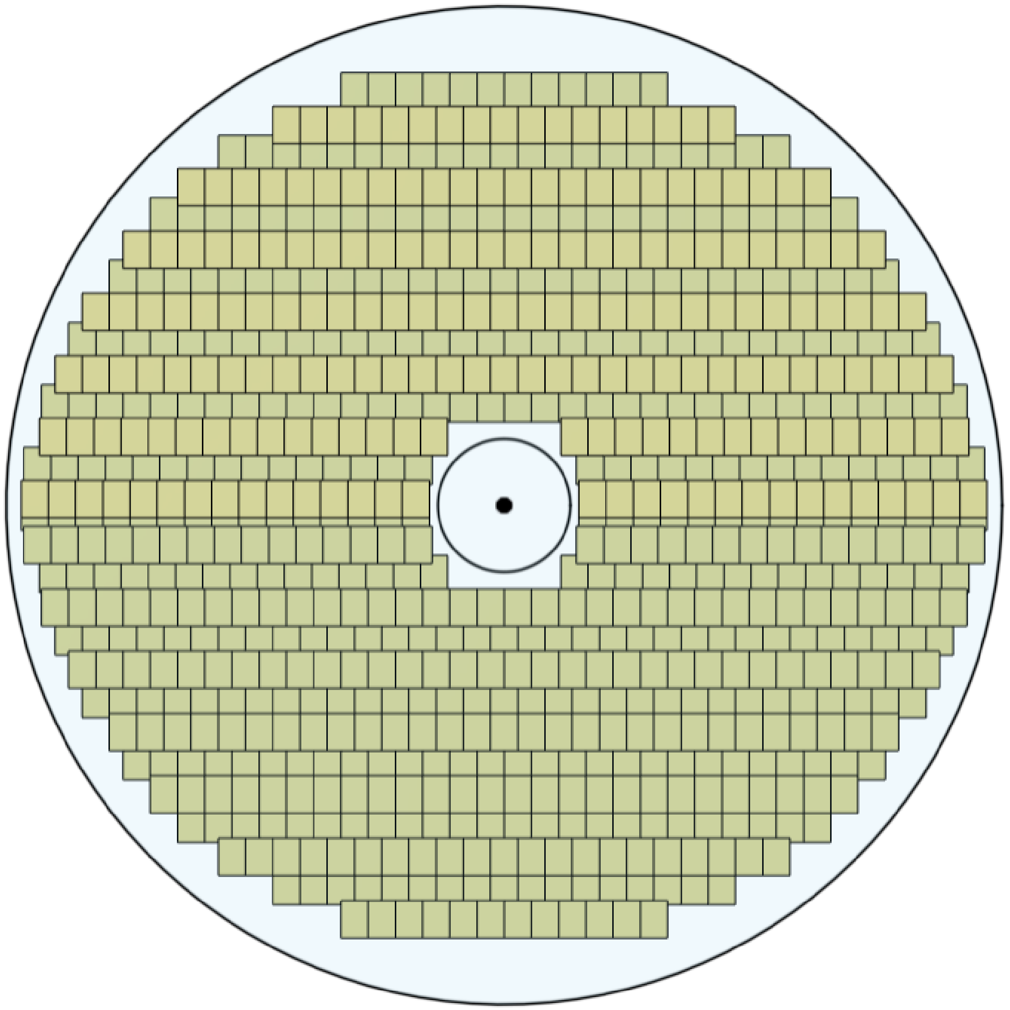
As a *rst approximation* , Equation 7.75 may be used for $A_r \gtrsim 0.125$, yielding predictions for the stagnation point ($x = 0$, $A_r \rightarrow \infty$) that are within 40% of measured values.

- H = 370 mm, W = 100 mm
- 100 cfm -> 0.268 m/s
- h = ~7.5 W/m^2

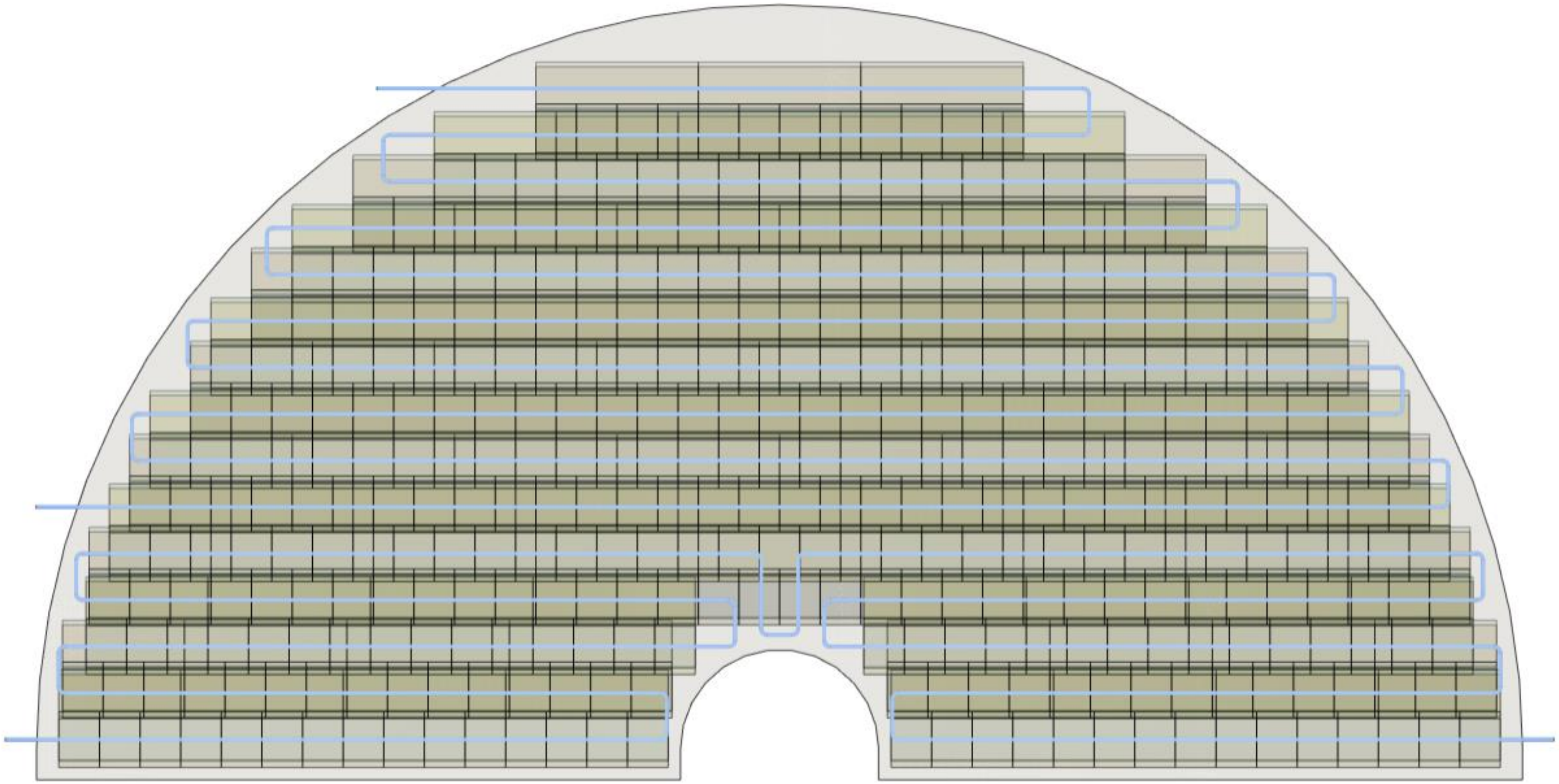
# Updated Sensor Tiling CAD – 9/20/2024







# Updated Pipe Routing – 9/20/2024



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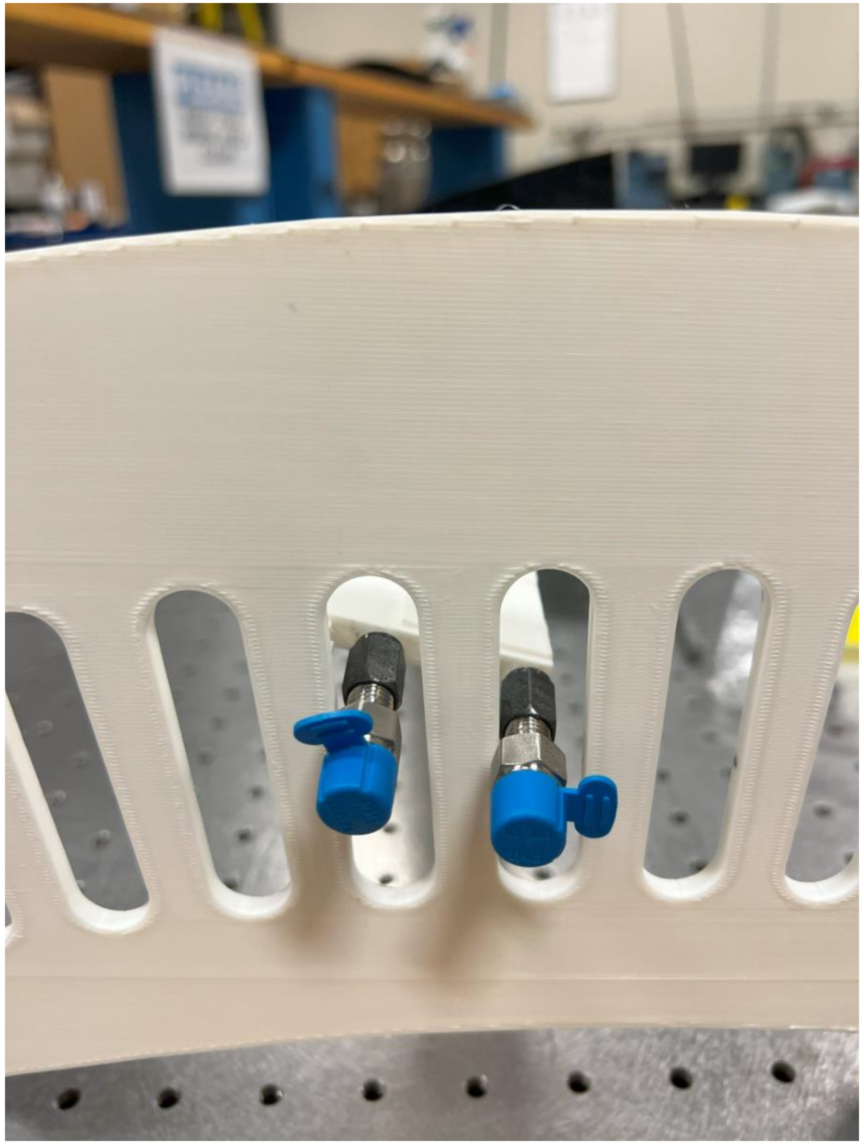
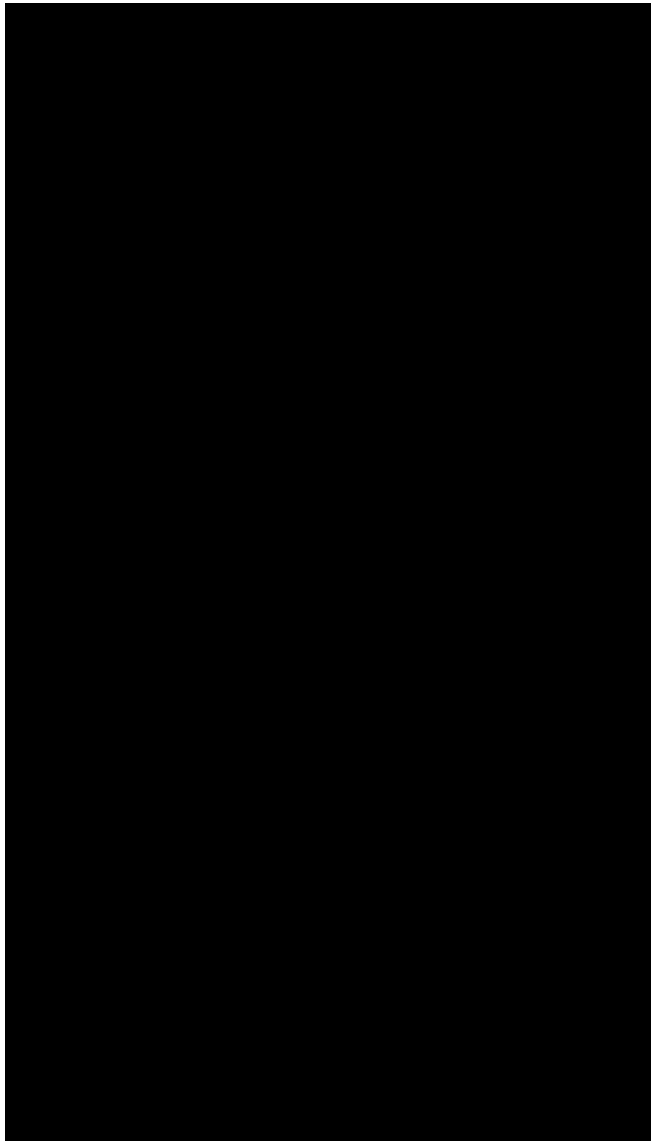
# Addition of cooling connectors for the pipes

CMSC Composites Manufacturing & Simulation Center



# Clip mounting mechanism to assemble the staves





← Video

- Clamp / lock mechanism to hold the staves in place
- The assembly is well suited to remove a single stave during maintenance as needed
- There are design iterations in progress to refine the mounting mechanism
- This is the second working mounting prototype for stave mounting mechanism