

TOF mechanics and cooling updates

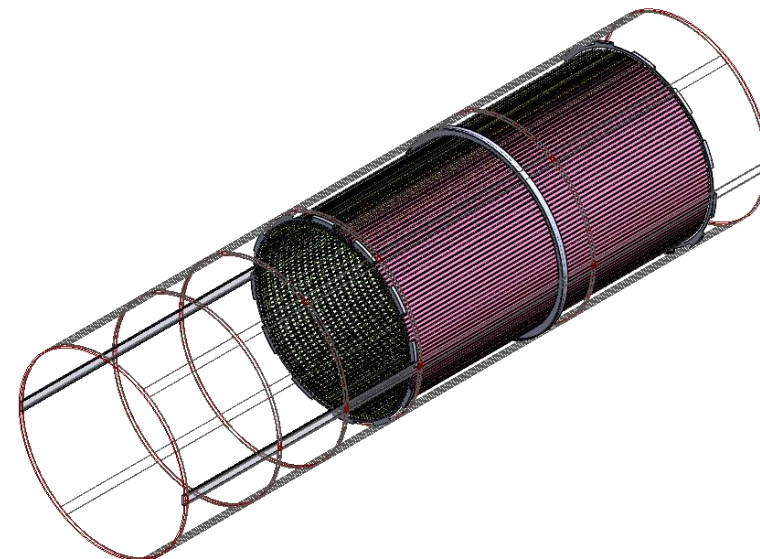
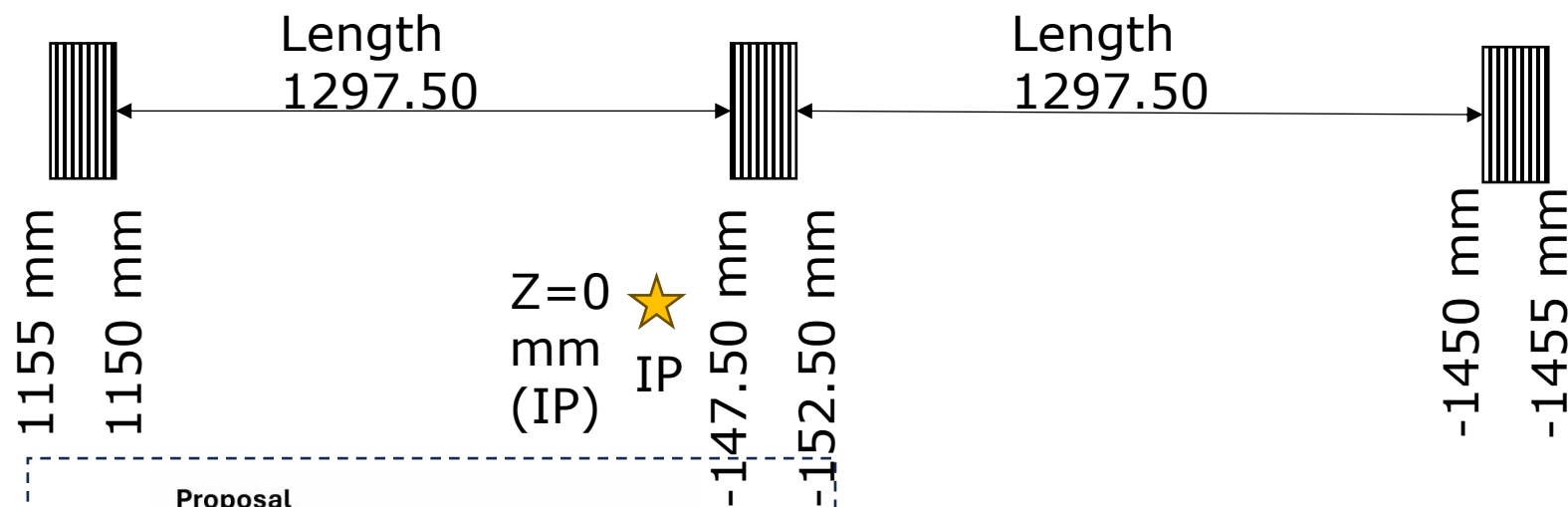
Sushrut Karmarkar, Ben Denos,
Andy Jung

24 March 2025

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

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

Z coordinates for Engagement Ring

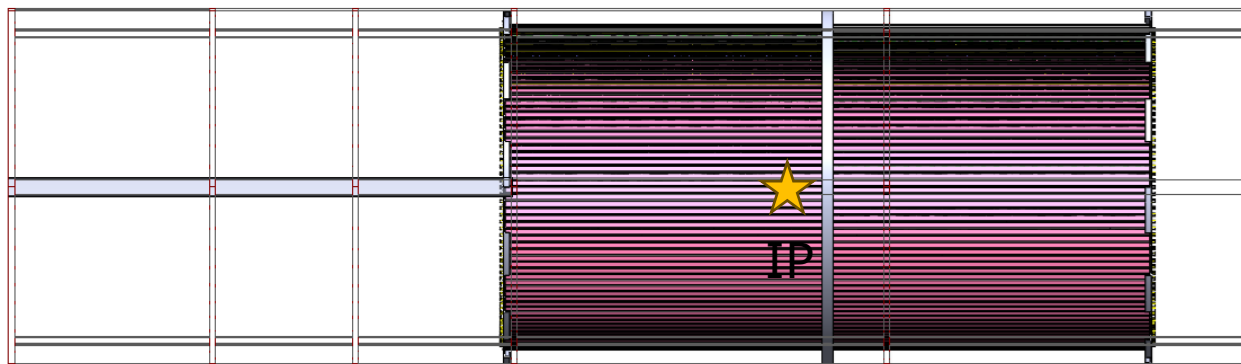


Proposal

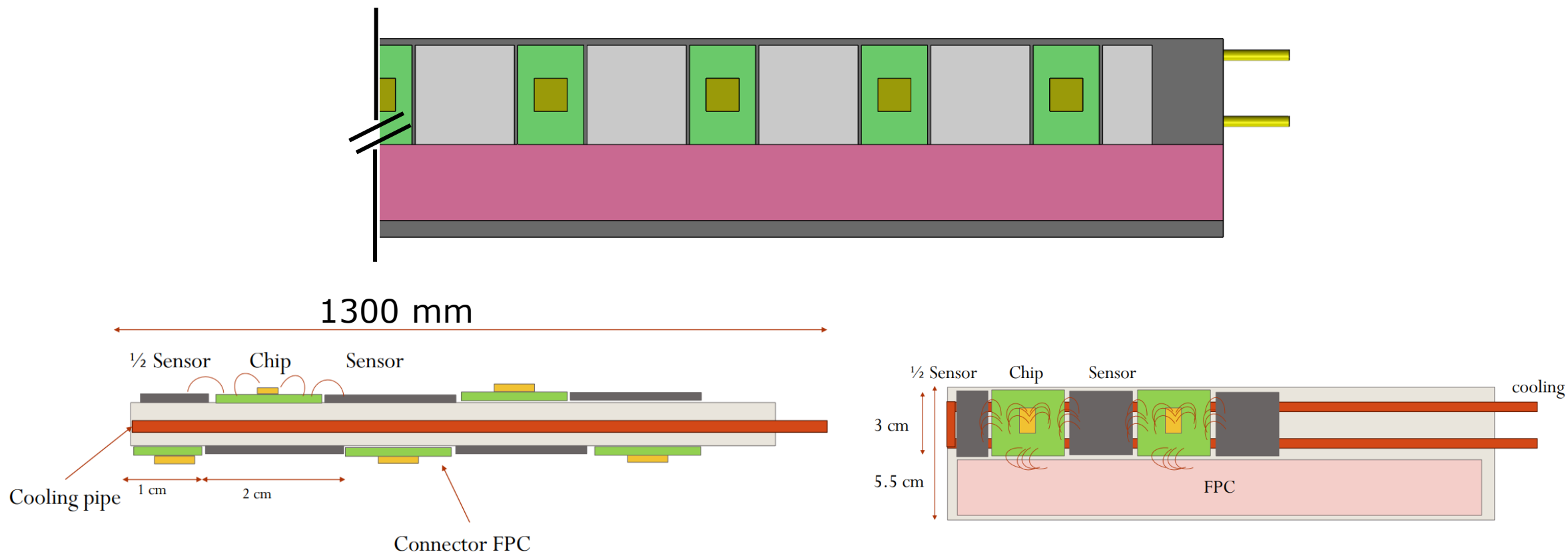
- TOF and MPGD Centers line up for engagement ring
- TOF Flex cables are limited to 1.3m
- MPGD Disks spaced better for FEB



Comes from Dan's proposal from Jan 2025

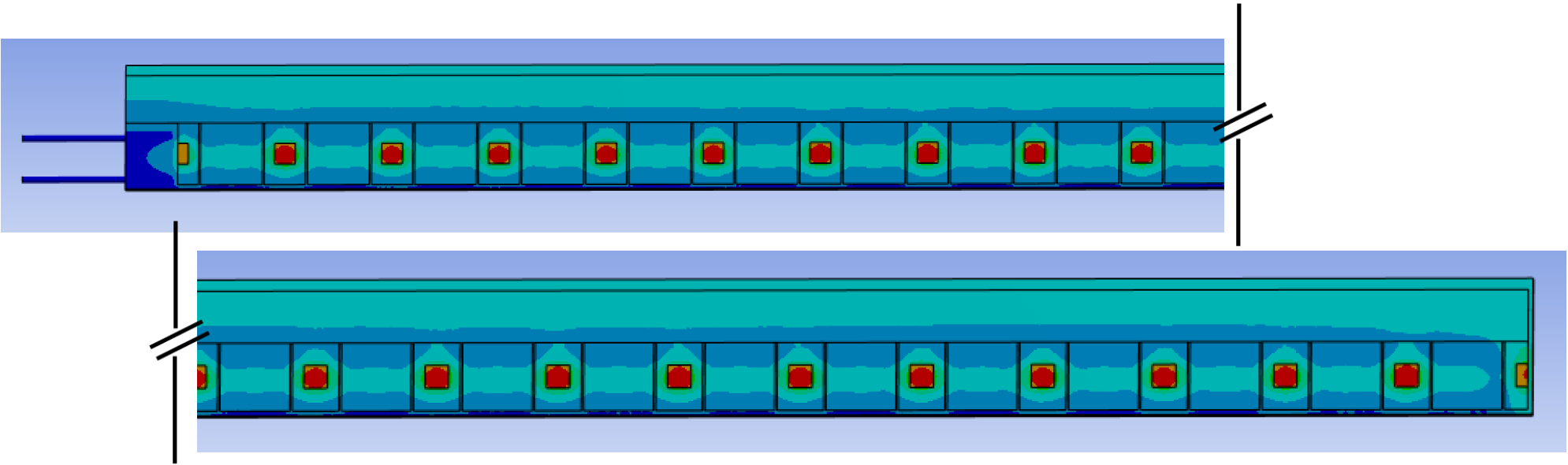
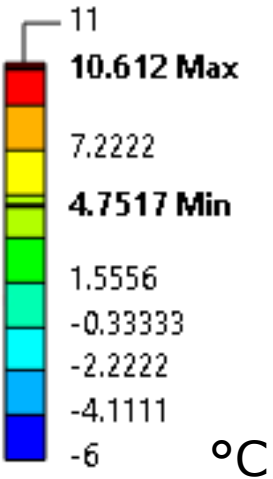
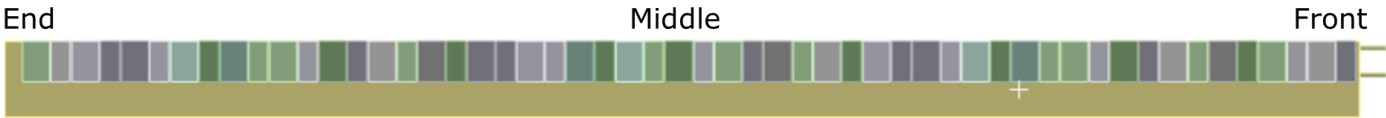


- Module and mounting scheme has been updated to reduce mass as well as significantly increase the available services space in the inner detector
- Updated stave geometry is used to do the thermal simulation for cooling performance estimation.



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 Kyy - 150 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						

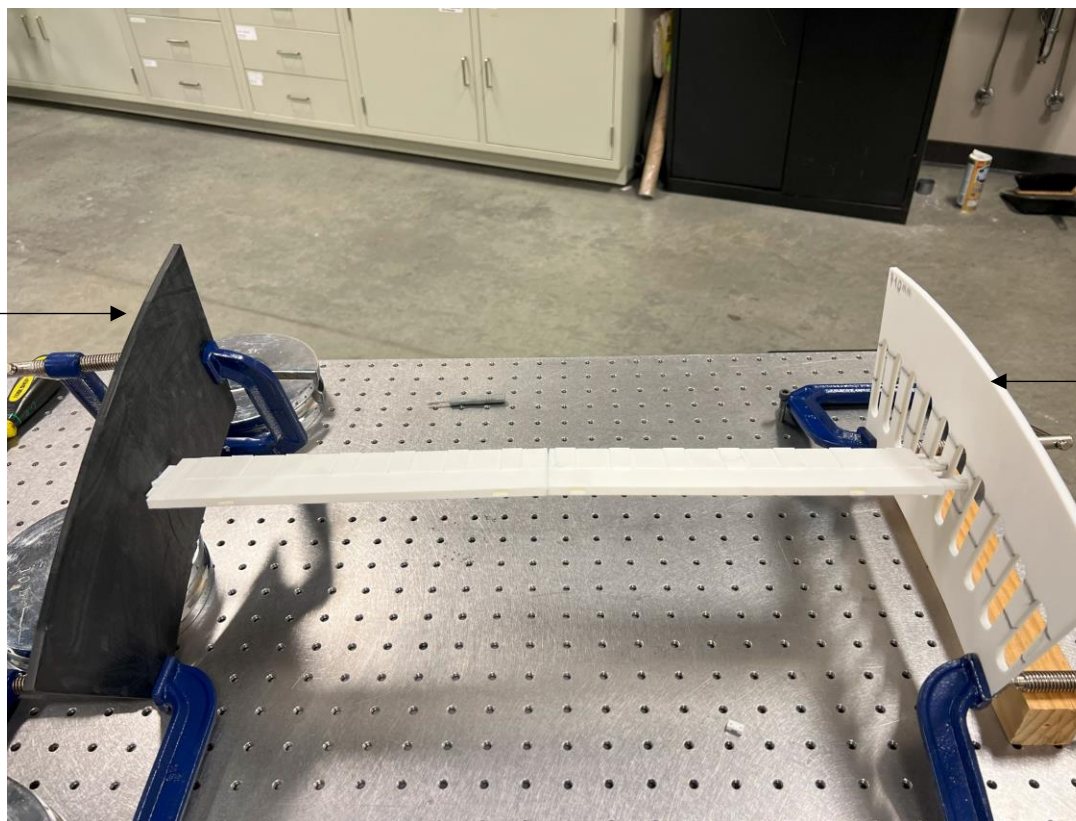


- ⬡ The TOF staves are mounted at 18° angle to the normal on the engagement rings.
- ⬡ The clip mechanism to hold the stave stable and allow for services and cooling to pass through the engagement rings is crucial for the TOF sub-detector
- ⬡ This is first attempt at design and prototyping of the clip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

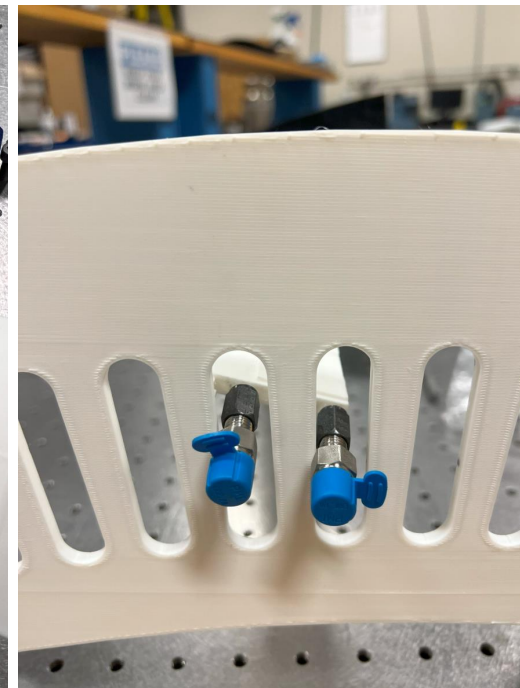
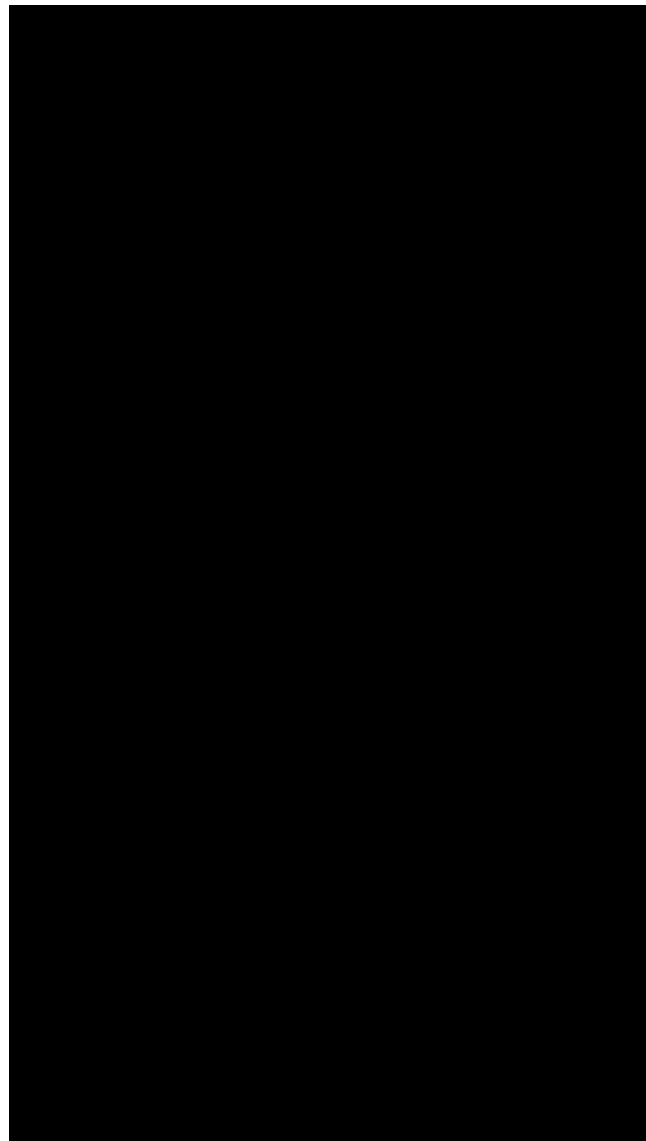
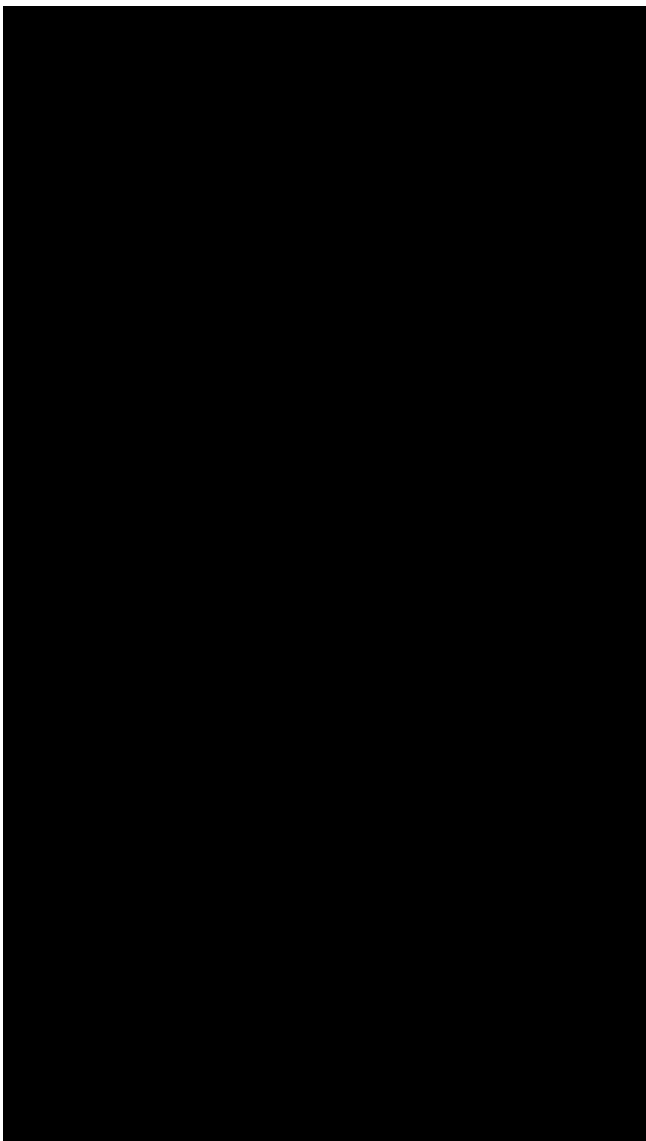


Clip and locking
mechanism

Center
engagement ring



(e-/p) End
engagement ring

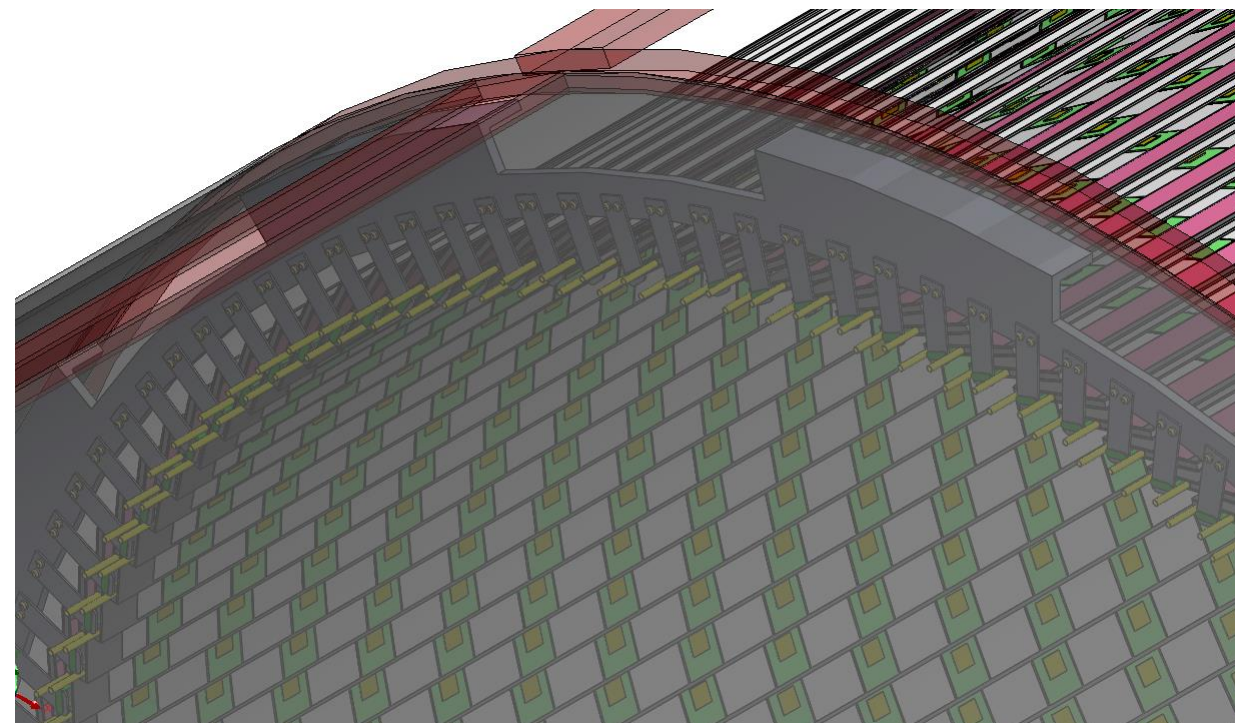
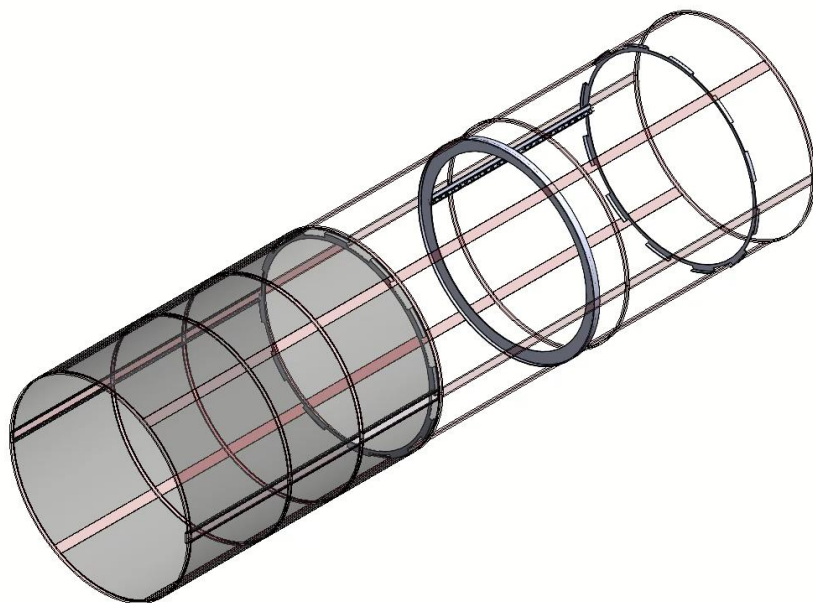


This mechanism was prototyped and tested in Nov 2024 to Jan 2025

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

← 2 videos →

- ⬠ 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.

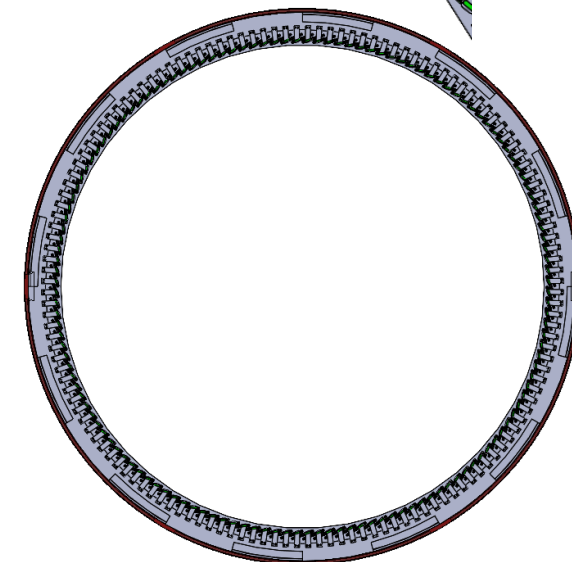
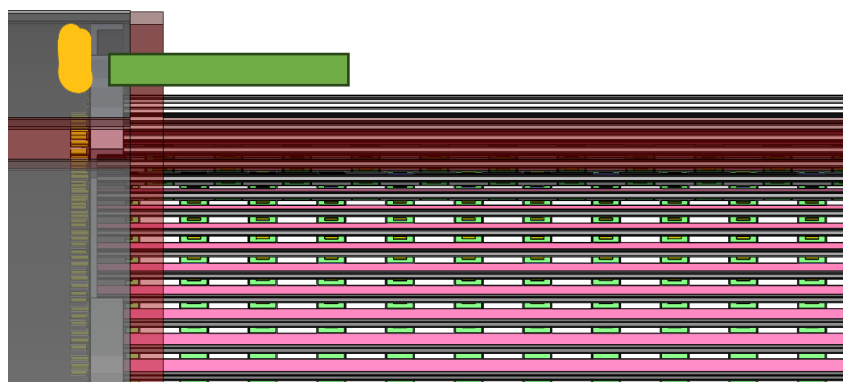
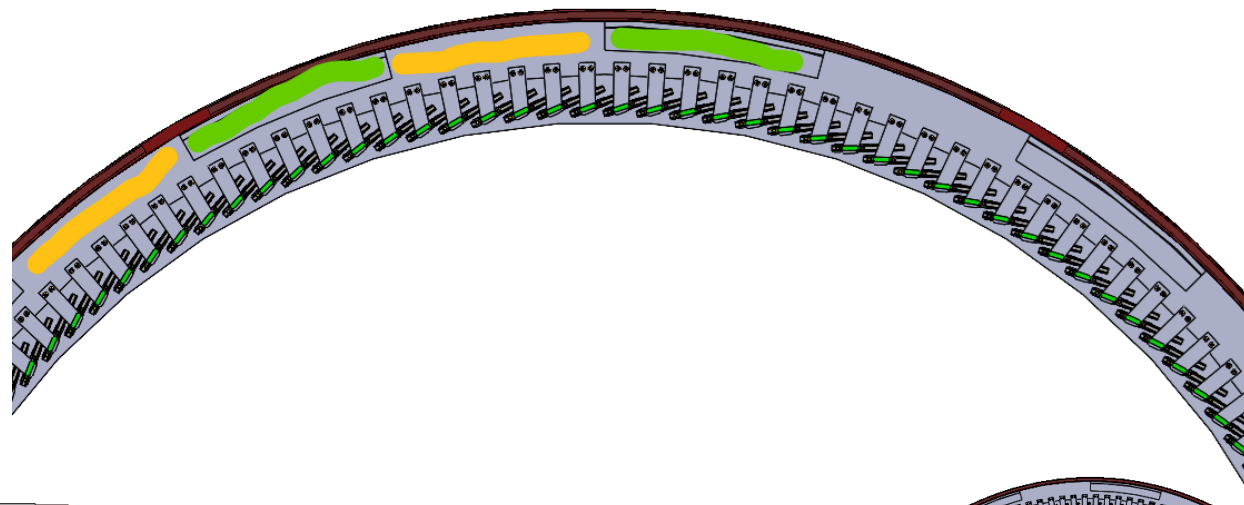


See detailed view in CAD models / at GST discussion
in the afternoon

- ⬢ Simplified mounting allows for the easy removal of single staves during service/maintenance
- ⬢ Flat planar 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.

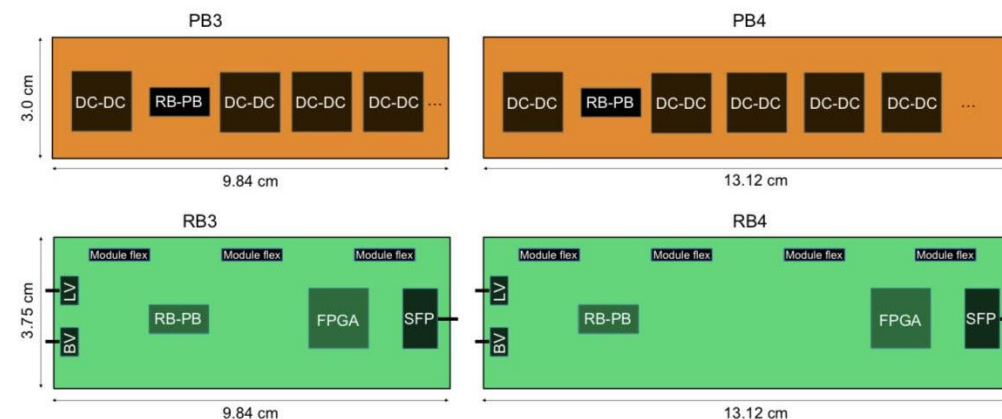
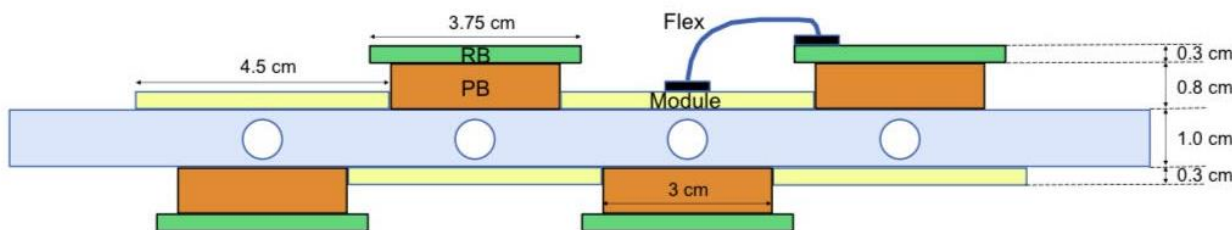
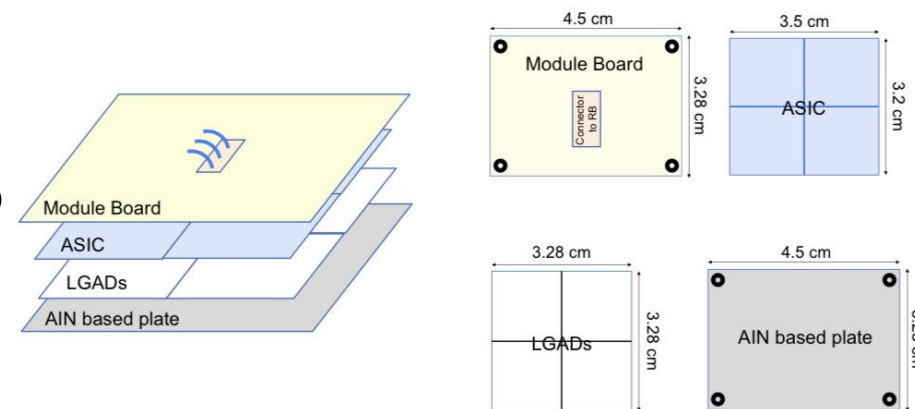
 Space for Cooling manifold

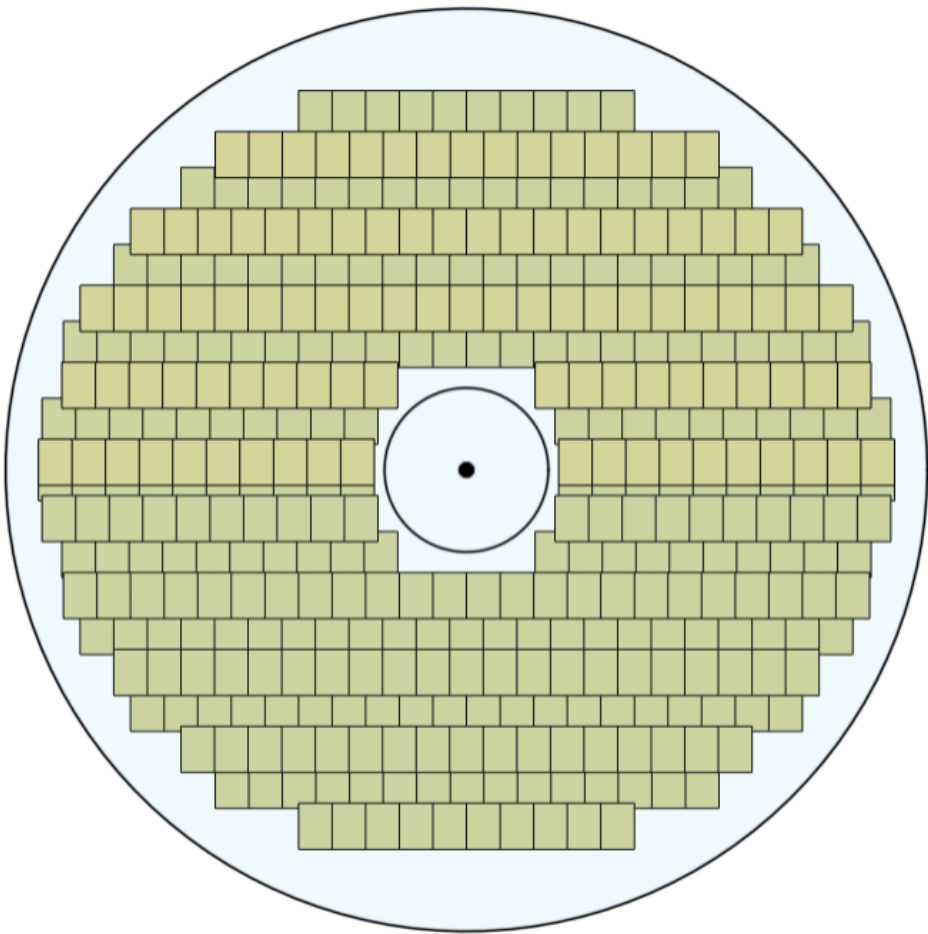
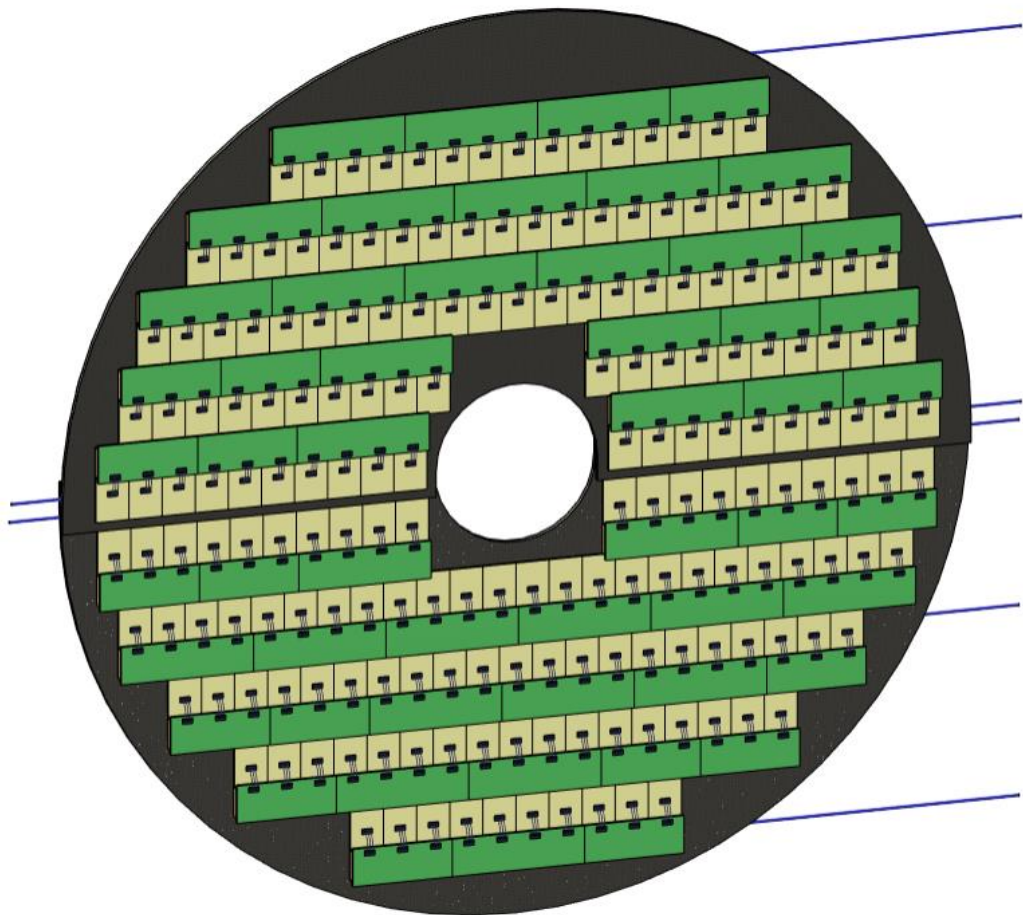
 Space for Patch panels



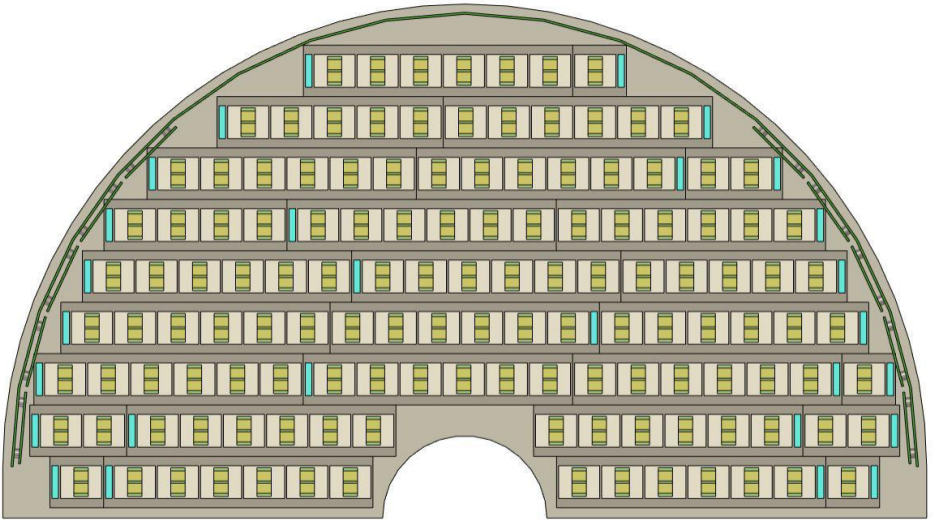
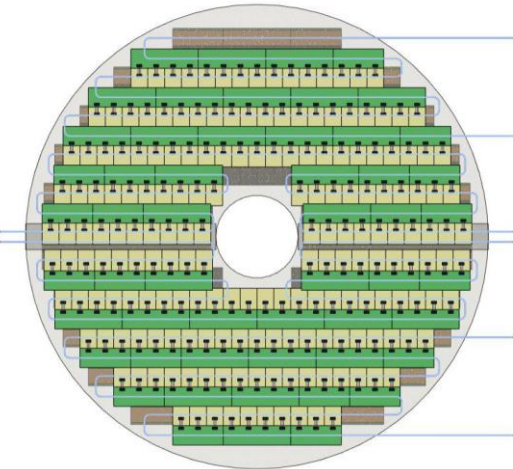
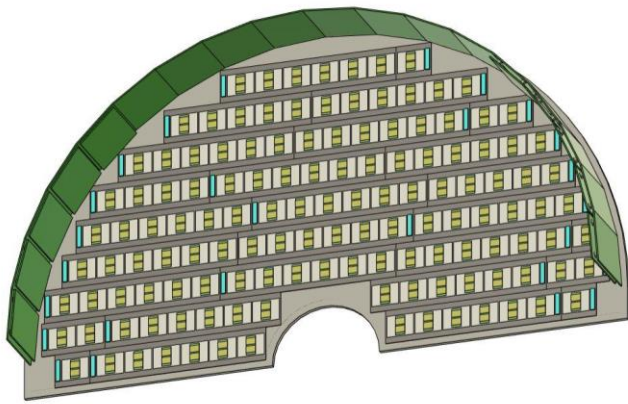
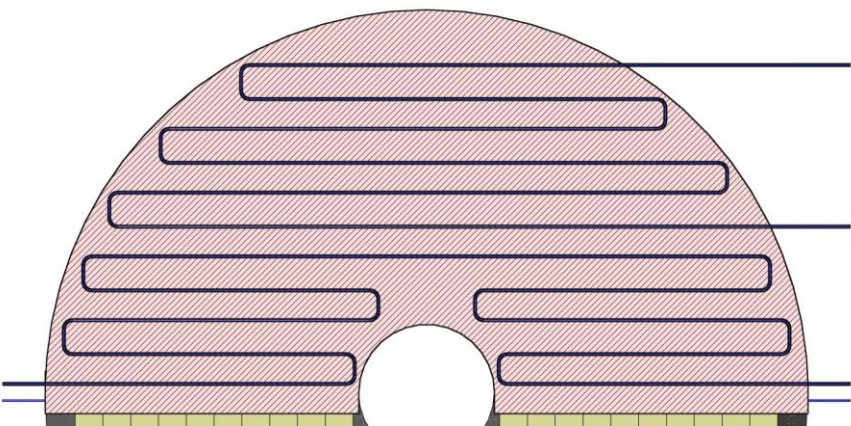
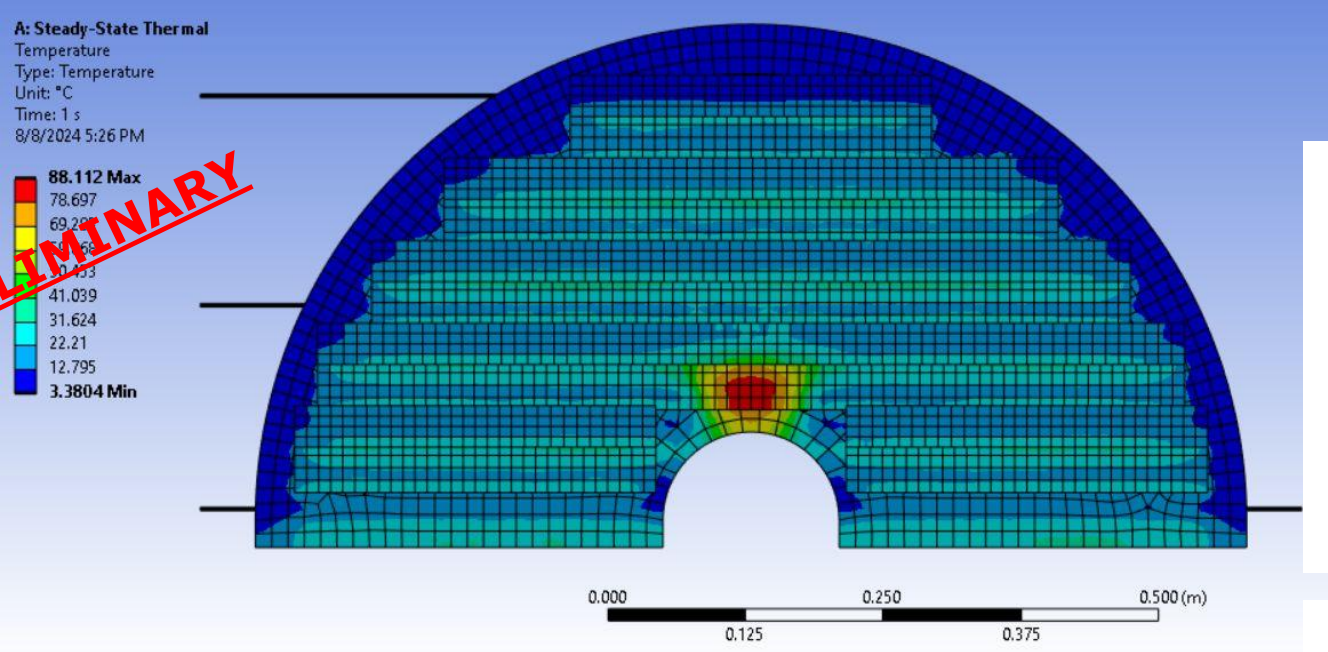
fTOF mechanics updates

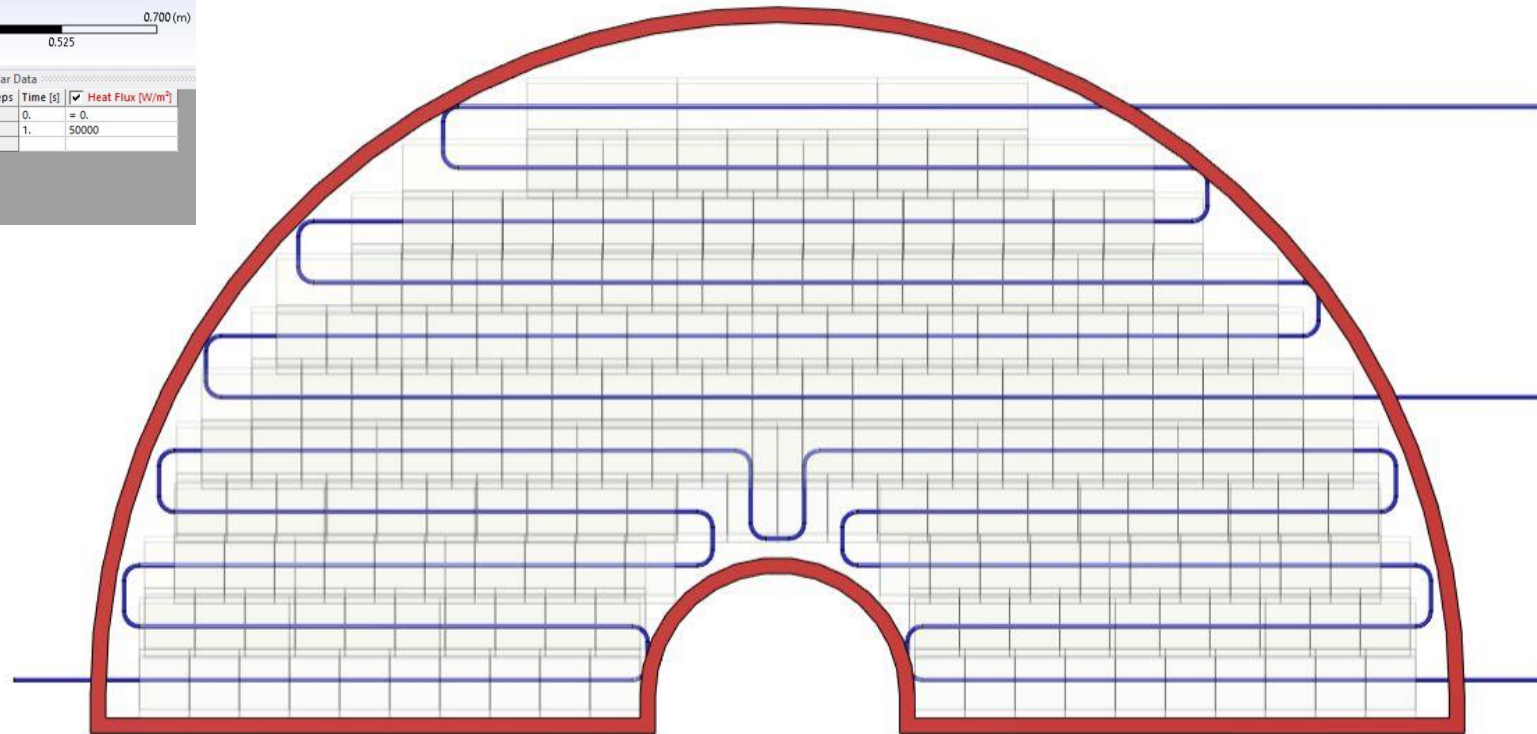
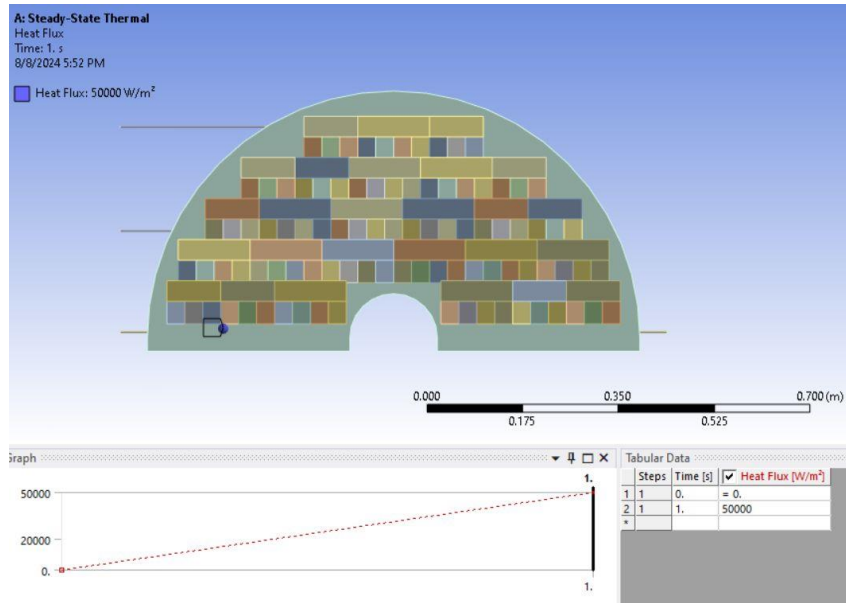
- 1.4 W/cm² on ASIC surface
- 5 C pipe cooling – water glycol 70/30
- 22 C ambient air with 5 W/m² Film Coefficient
- 30 C impinging air from R500-R600 with 10 W/m² Film Co





PRELIMINARY





⬡ fTOF –

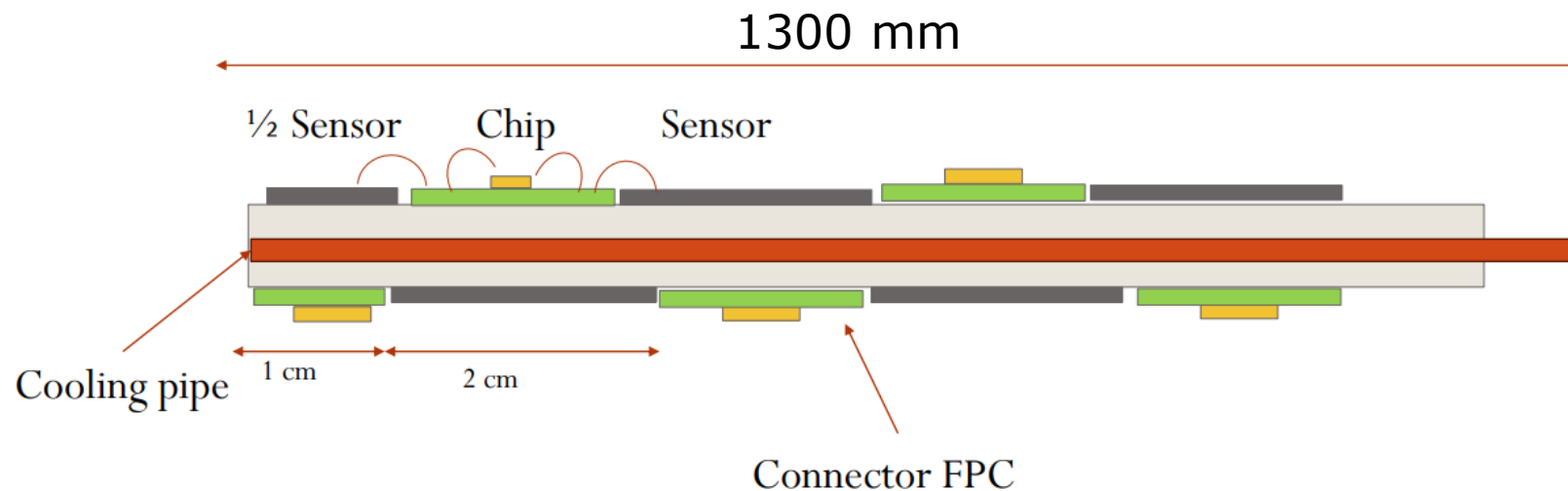
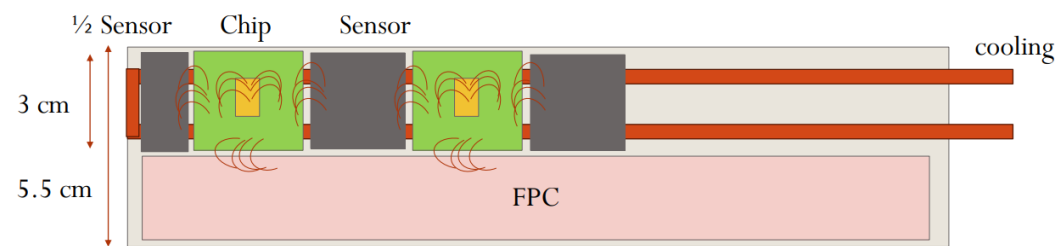
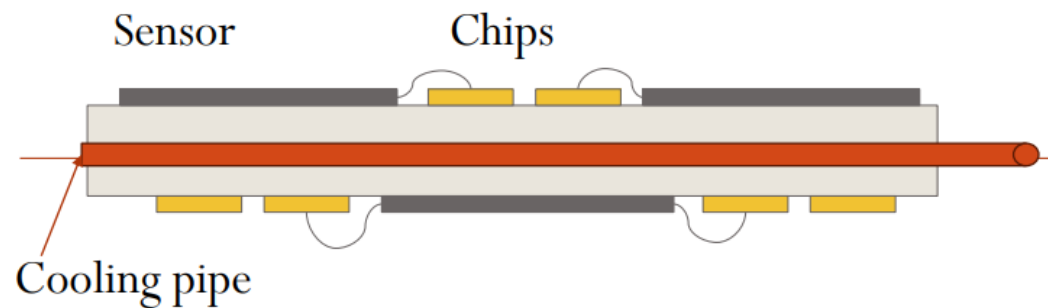
1. CAD geometry for the latest tiling scheme (with updated diameter) under going thermal FEAs
2. Fits within the new envelope created for services access to outside GST

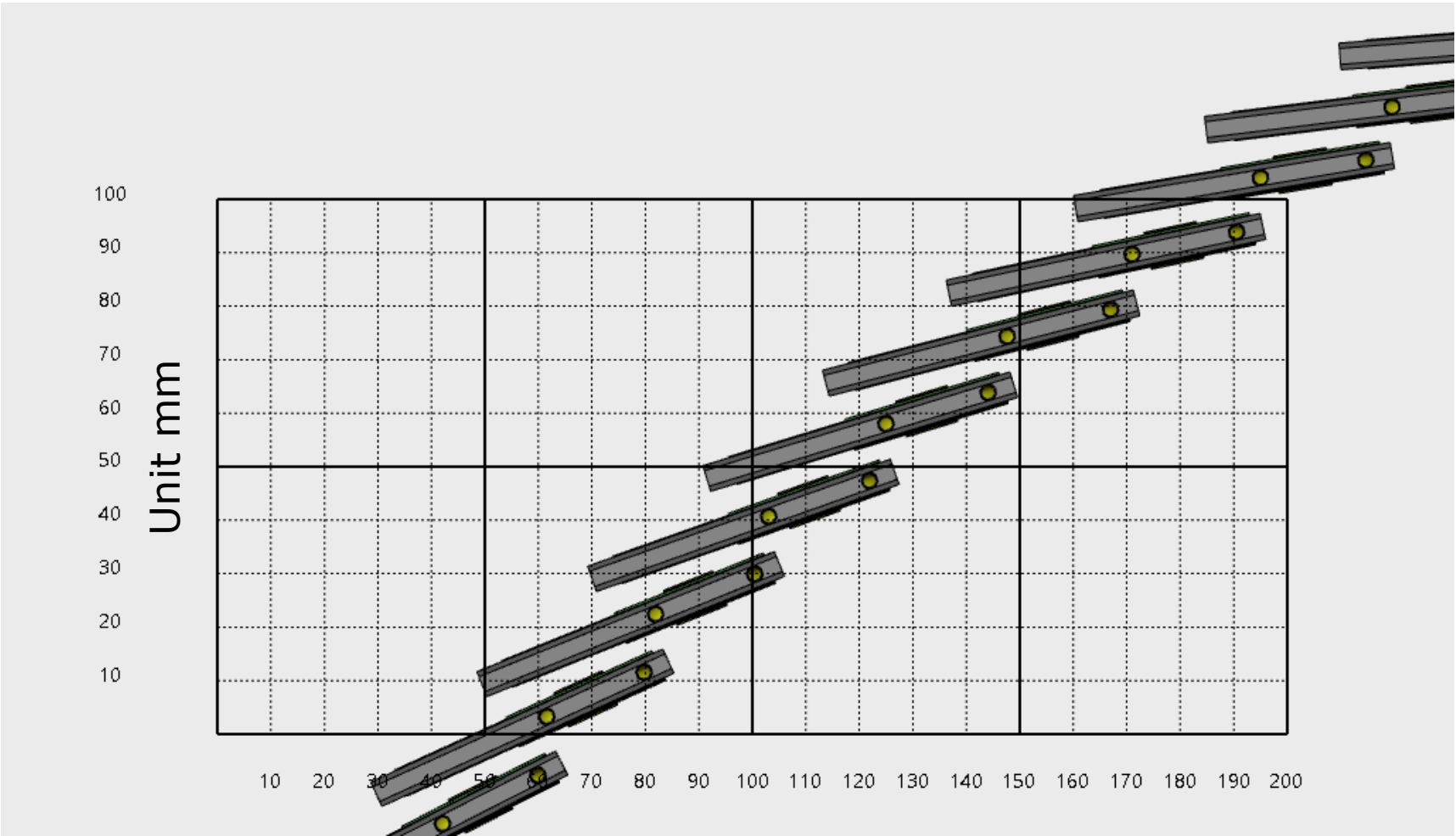
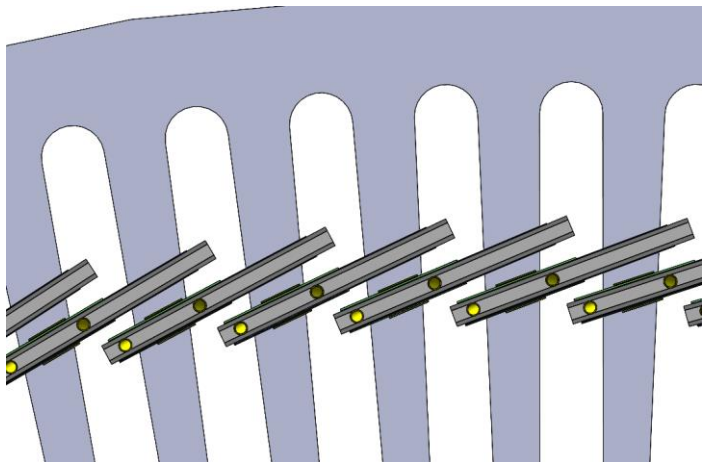
⬡ bTOF –

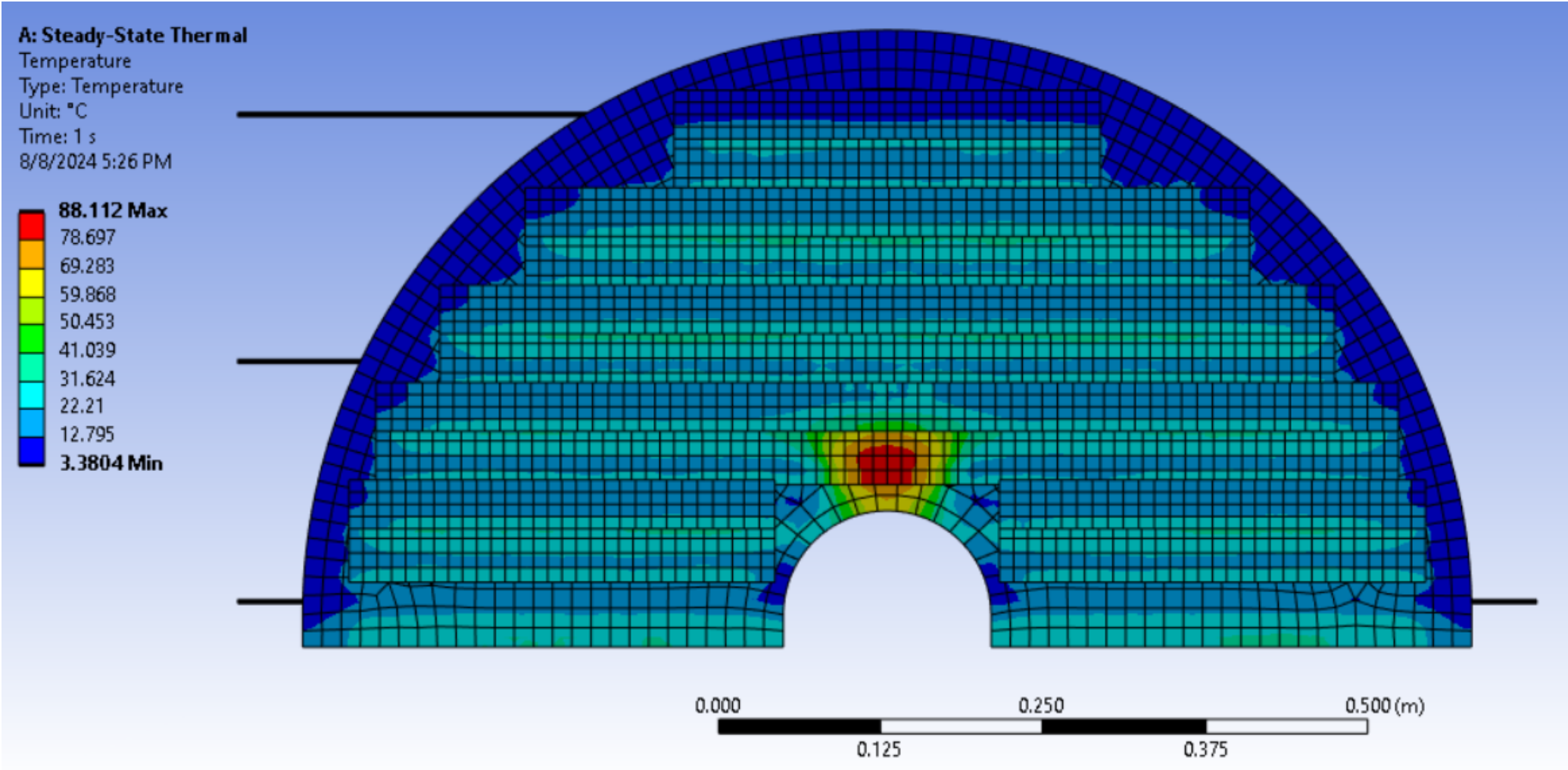
1. Finished implementing proposal from Dan on symmetric bTOF, structural simulation underway
2. Thermal simulation completed for the updated module assembly scheme and heat generation estimated to inform the cooling requirements
3. Mounting mechanism iteration #3 reduces need for service space while 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

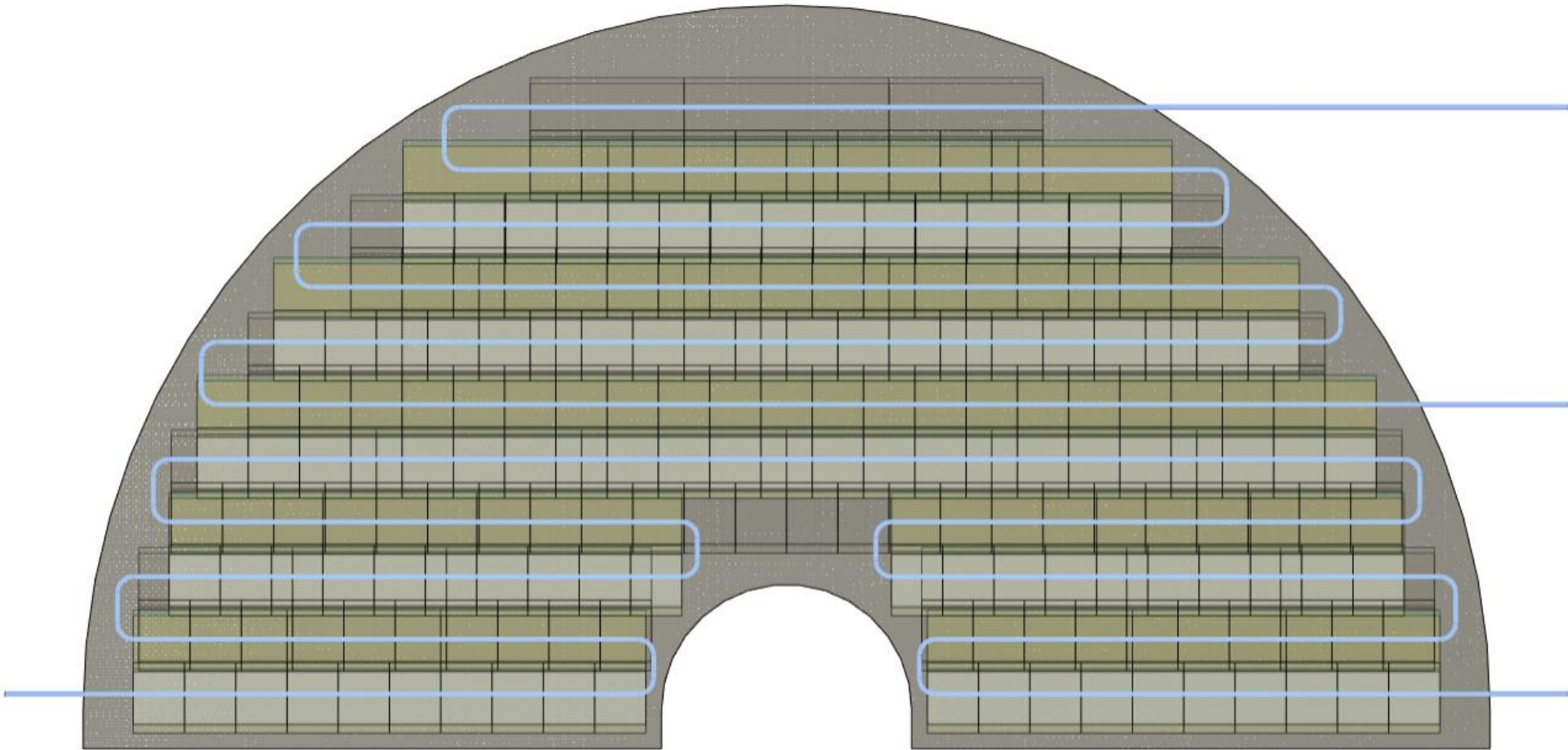
To do – change the stave CAD with the updated dimensions as shown on this slide

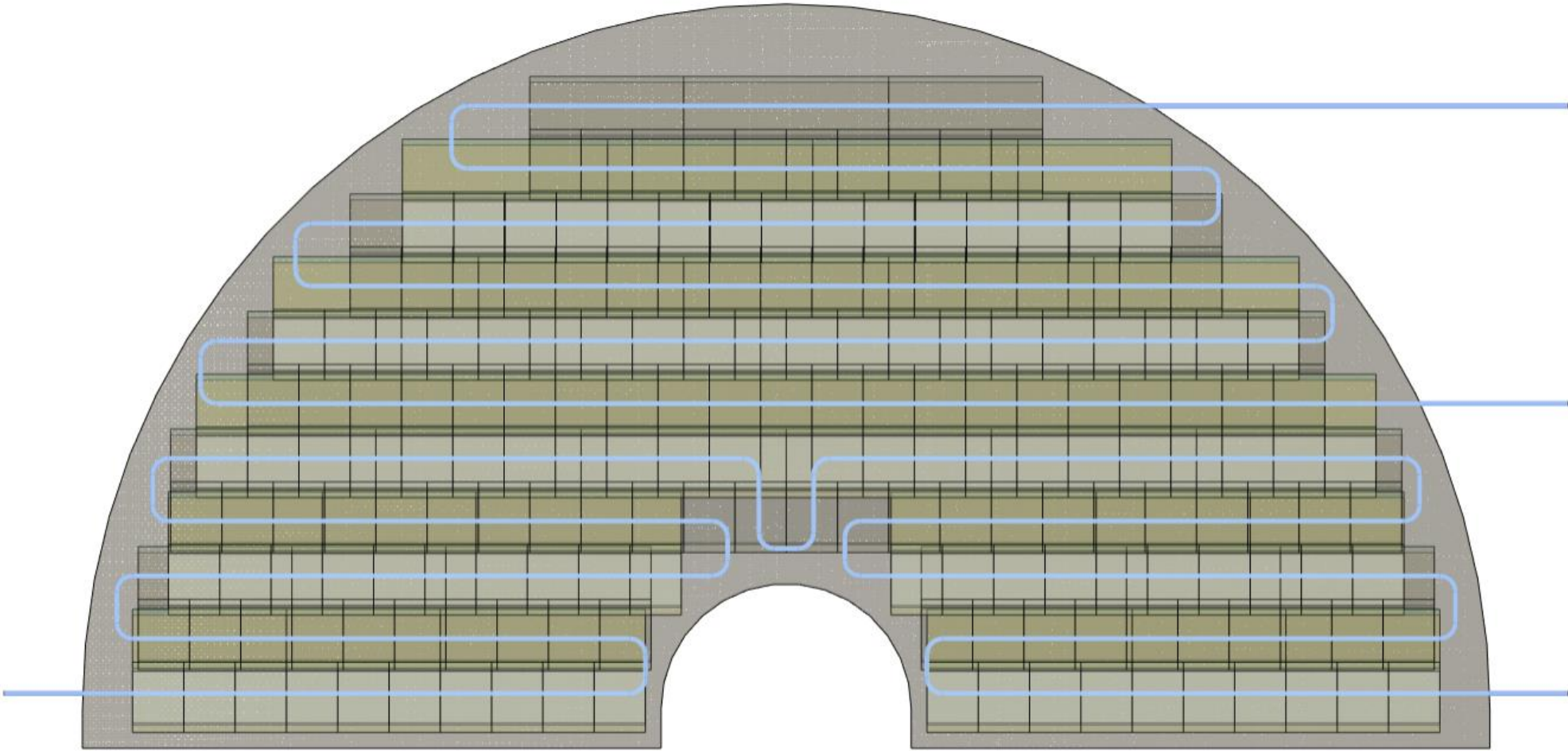


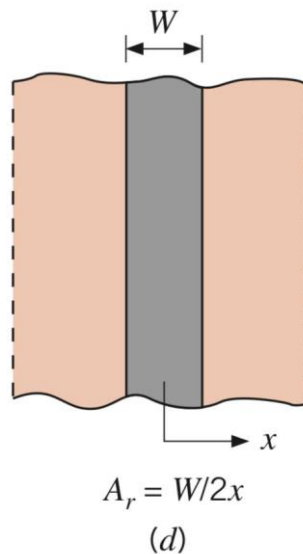
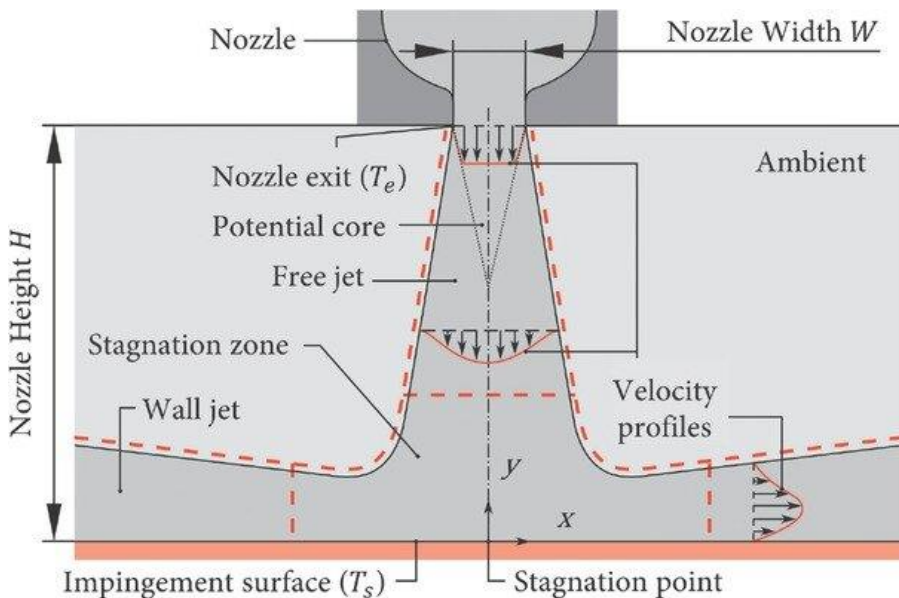




<u>Part Name</u>	<u>Thermal Conductivity (W/mK)</u>	<u>Thickness (mm)</u>
ASIC	0.97	0.75
LGAD	0.97	0.75
AlN	160	0.75
Silicon Module	148	0.75
Carbon Face Sheet	Kxx - 200 Kyy - 200 Kzz - 2	0.5
Carbon Foam	17	5
Stainless Steel Pipe	15	0.1







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

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

where

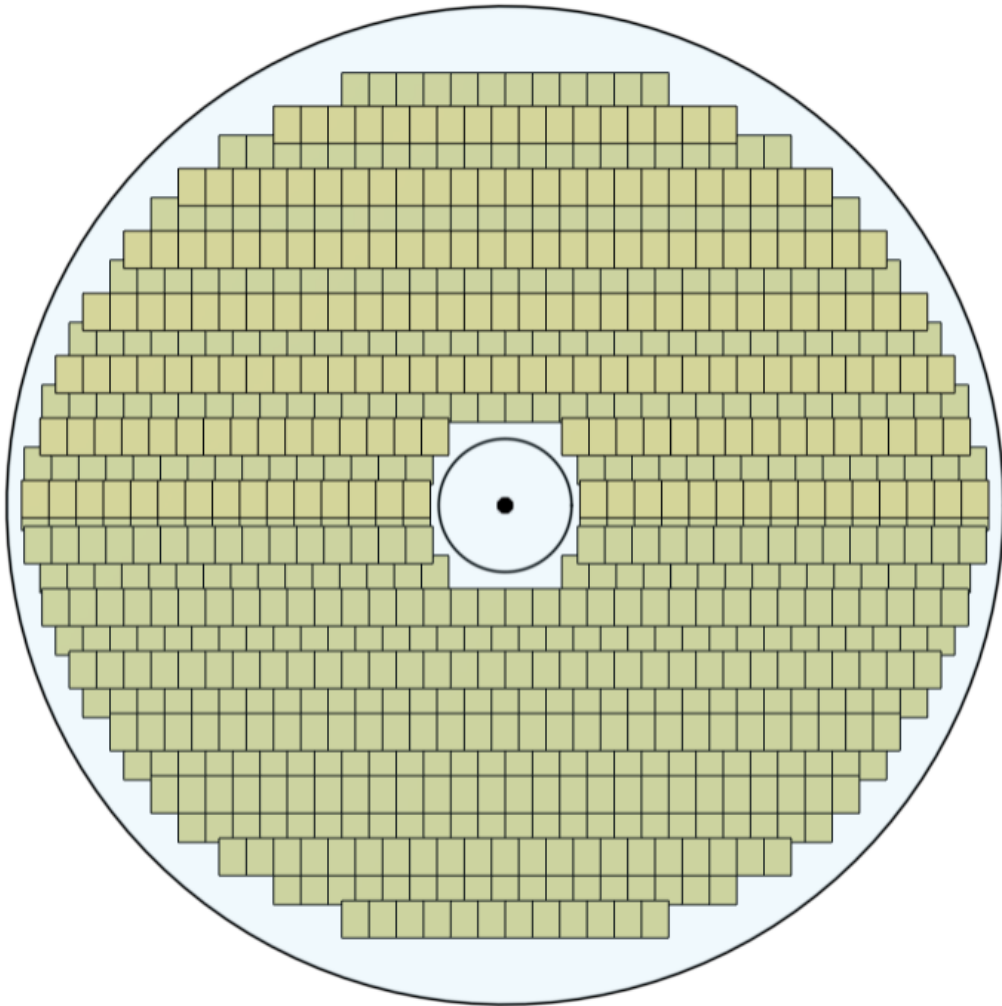
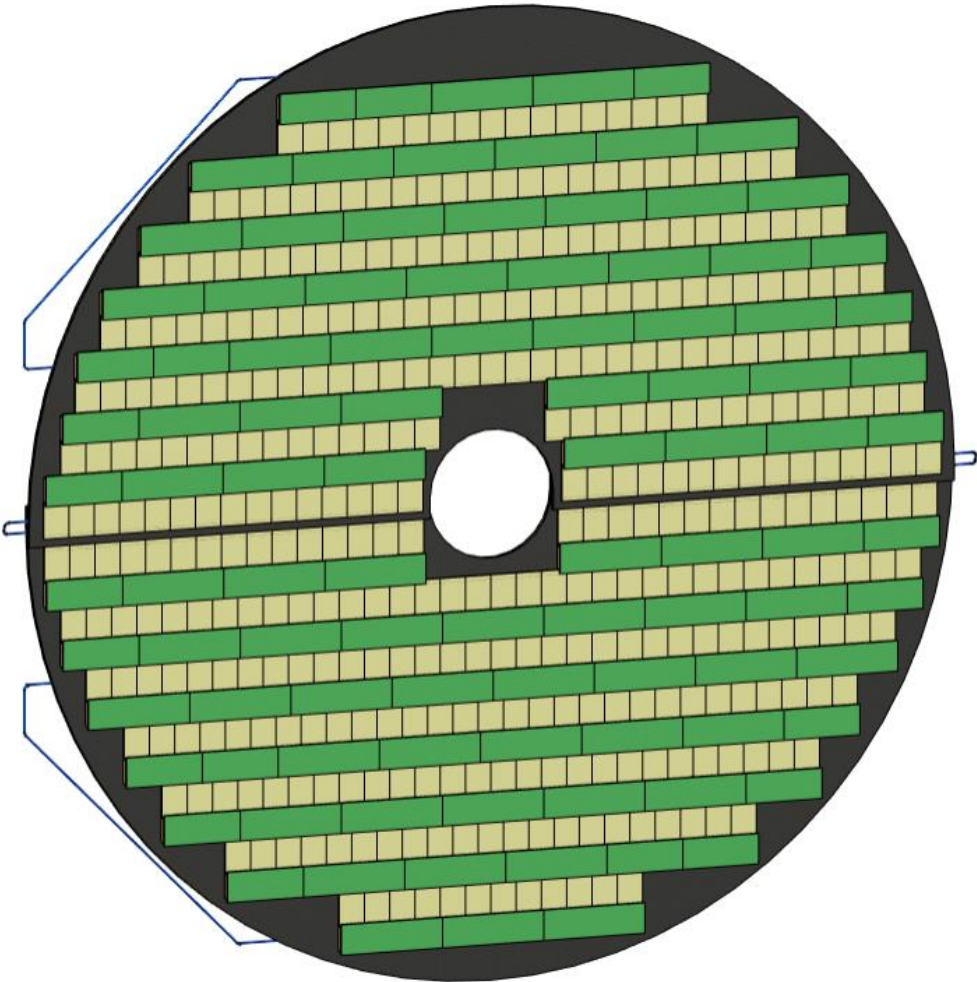
$$m = 0.695 - \left[\left(\frac{1}{4A_r} \right) + \left(\frac{H}{2W} \right)^{1.33} + 3.06 \right]^{-1} \quad (7.76)$$

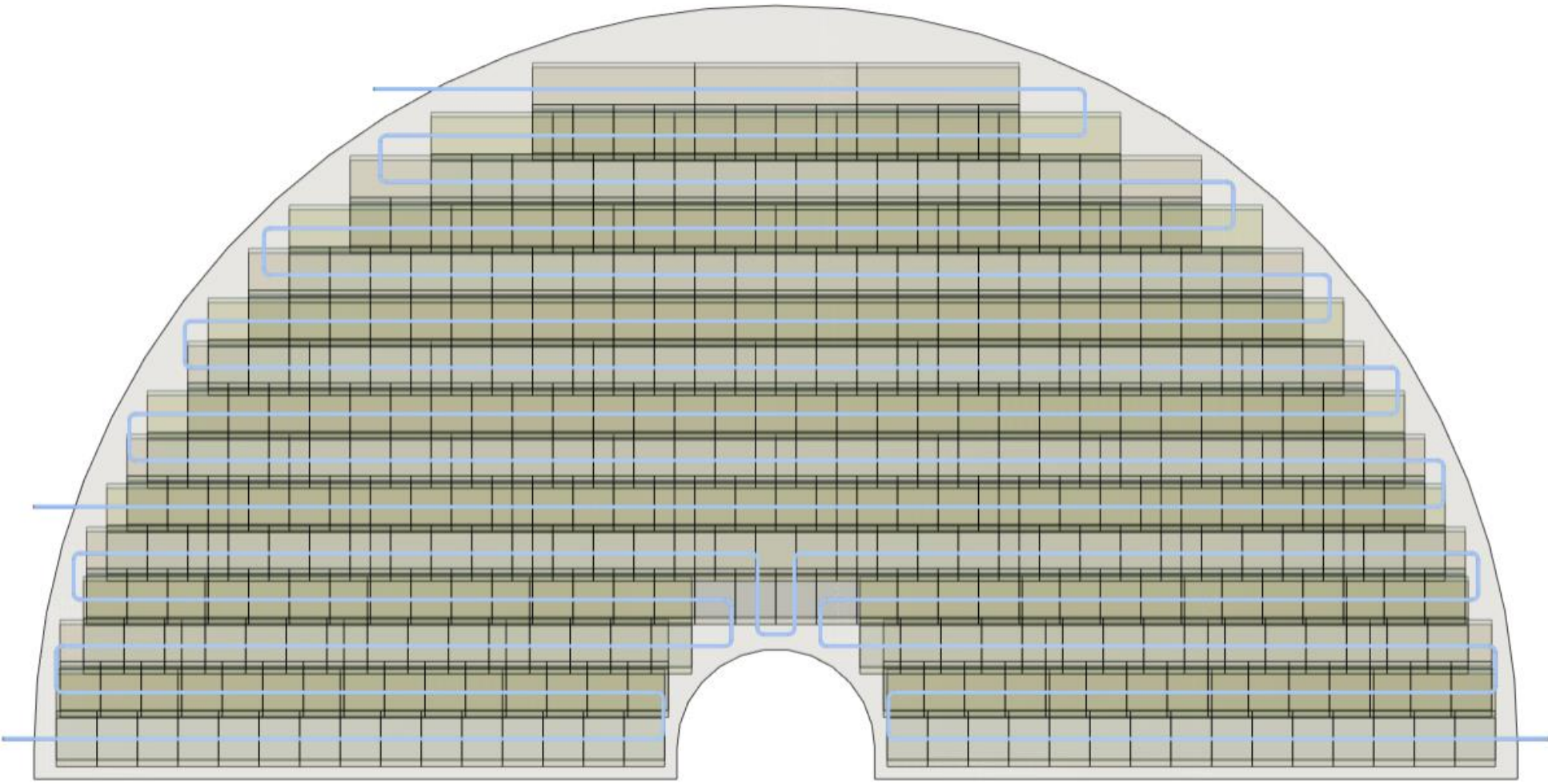
and the ranges of validity are

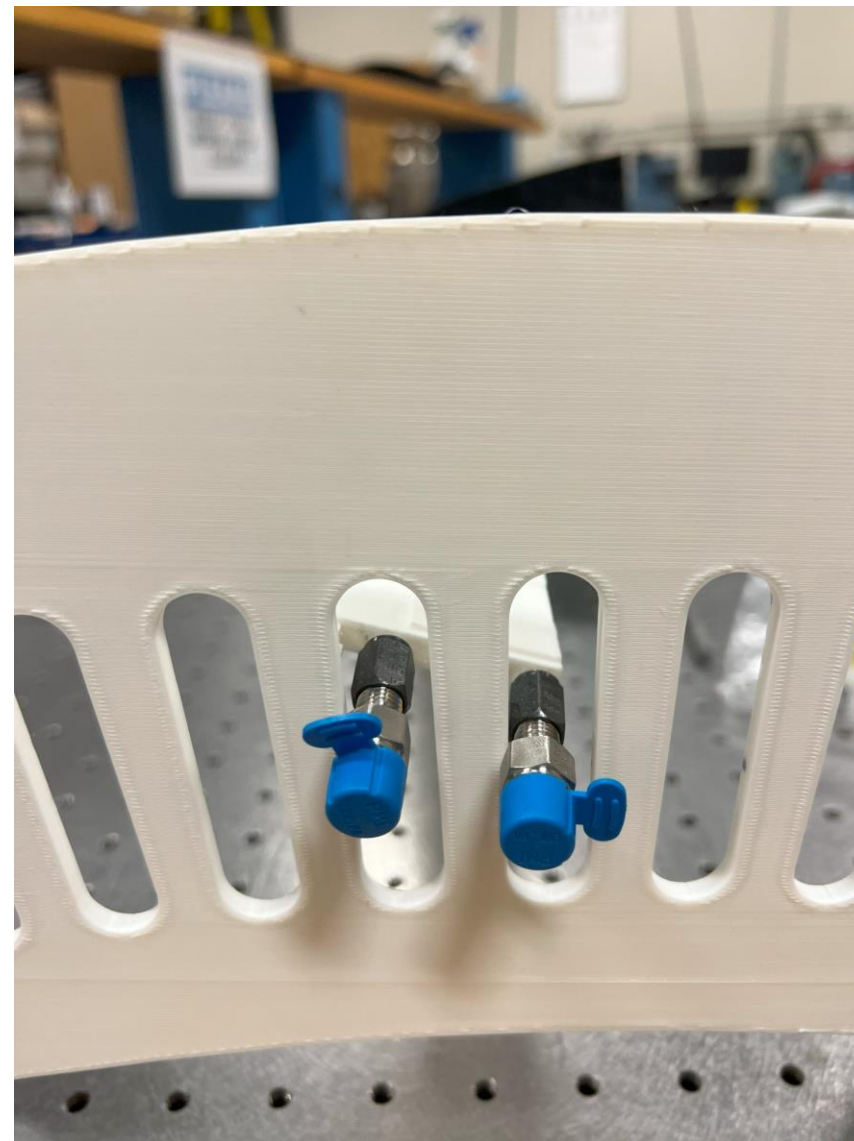
$$\begin{bmatrix} 3000 \leq Re \leq 90,000 \\ 2 \leq H/W \leq 10 \\ 0.025 \leq A_r \leq 0.125 \end{bmatrix}$$

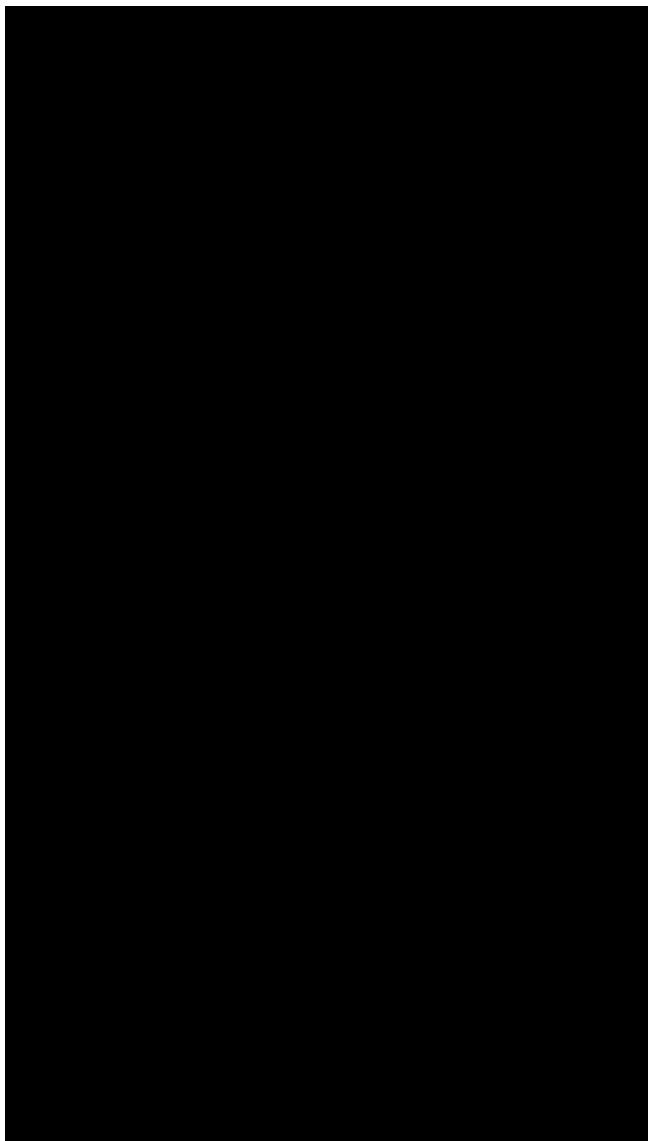
As a *rst approximation*, Equation 7.75 may be used for $A_r \geq 0.125$, yielding predictions for the stagnation point ($x = 0, A_r \rightarrow \infty$) that are within 40% of measured values.

- $H = 370 \text{ mm}, W = 100 \text{ mm}$
- $100 \text{ cfm} \rightarrow 0.268 \text{ m/s}$
- $h = \sim 7.5 \text{ W/m}^2$









← 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