Disks:

Modules
Mechanics & Integration
Prototyping

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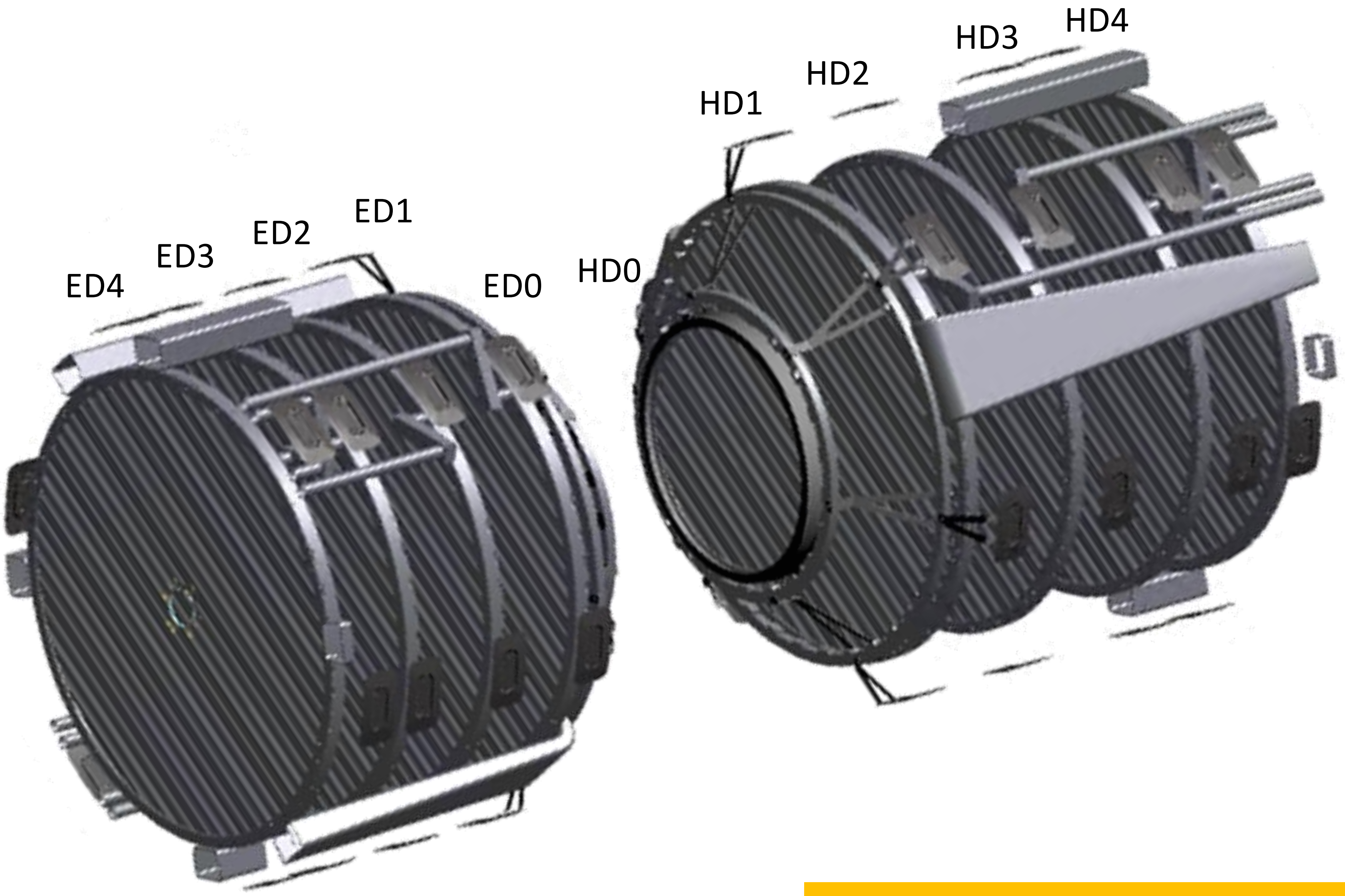
Last presentation at SVT meeting 11/11/25

Disks

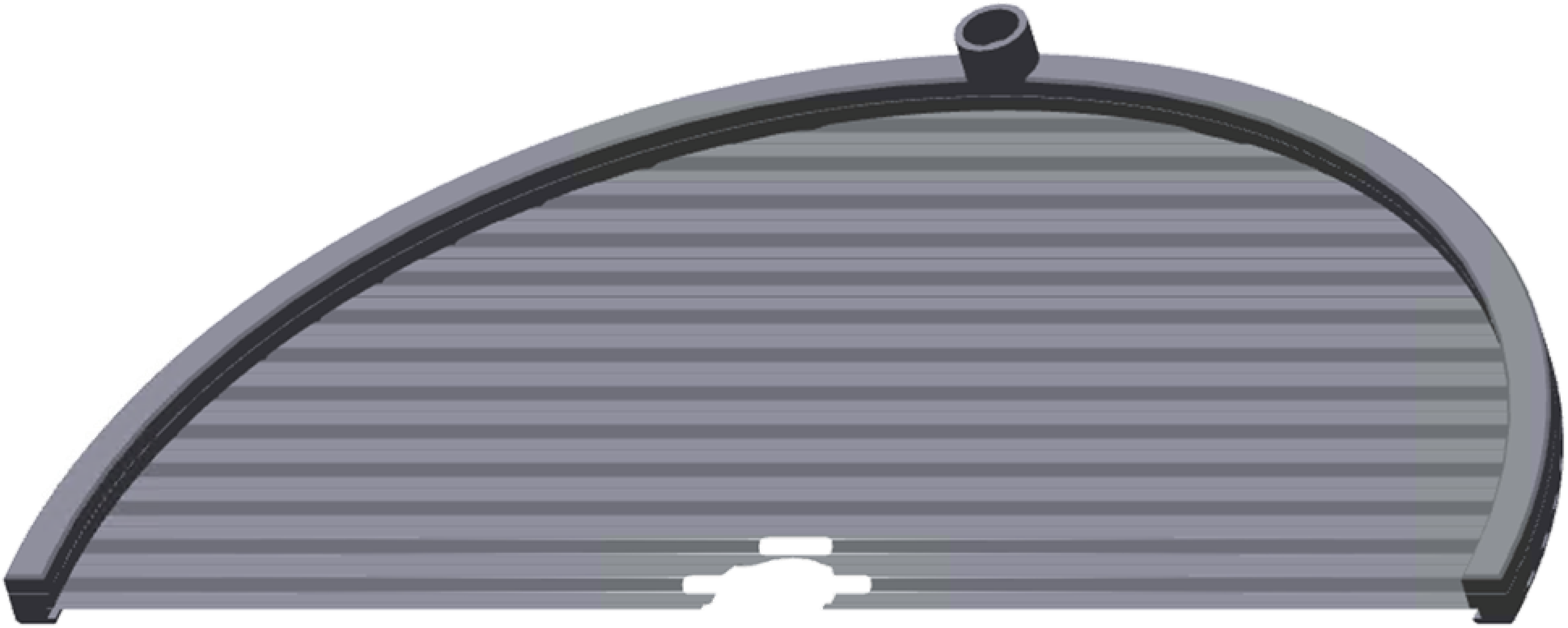


10 total disks → 8 “large” & 2 “small”

Work by Joe Silber & Elaine Buron

Disk design

Back side of disk (facing away from IP)

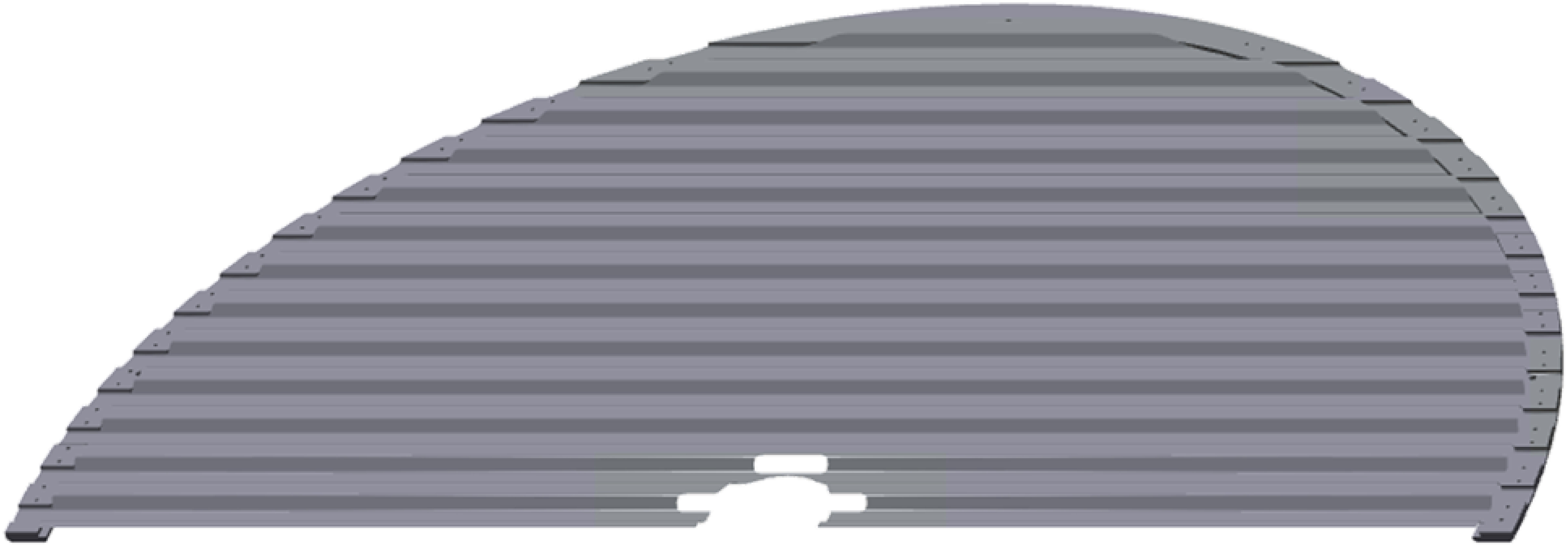


Air manifold integrated into rim design

Disk design

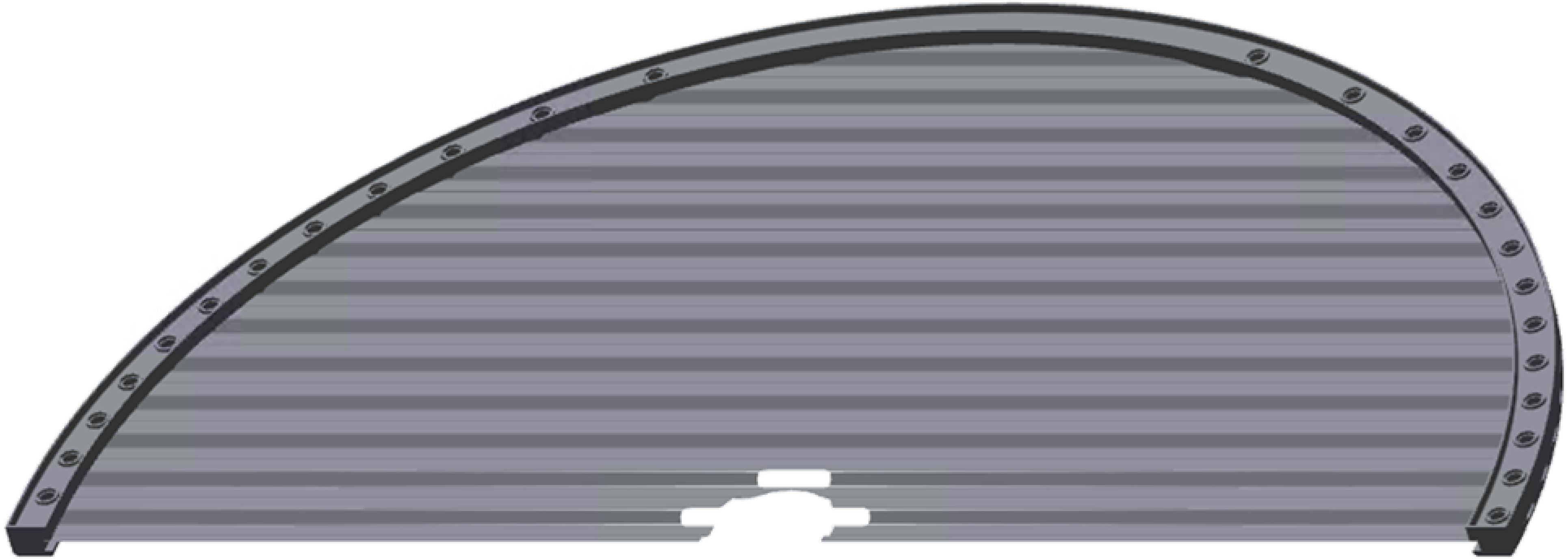
Front side of rim shaped to corrugation

Disk design



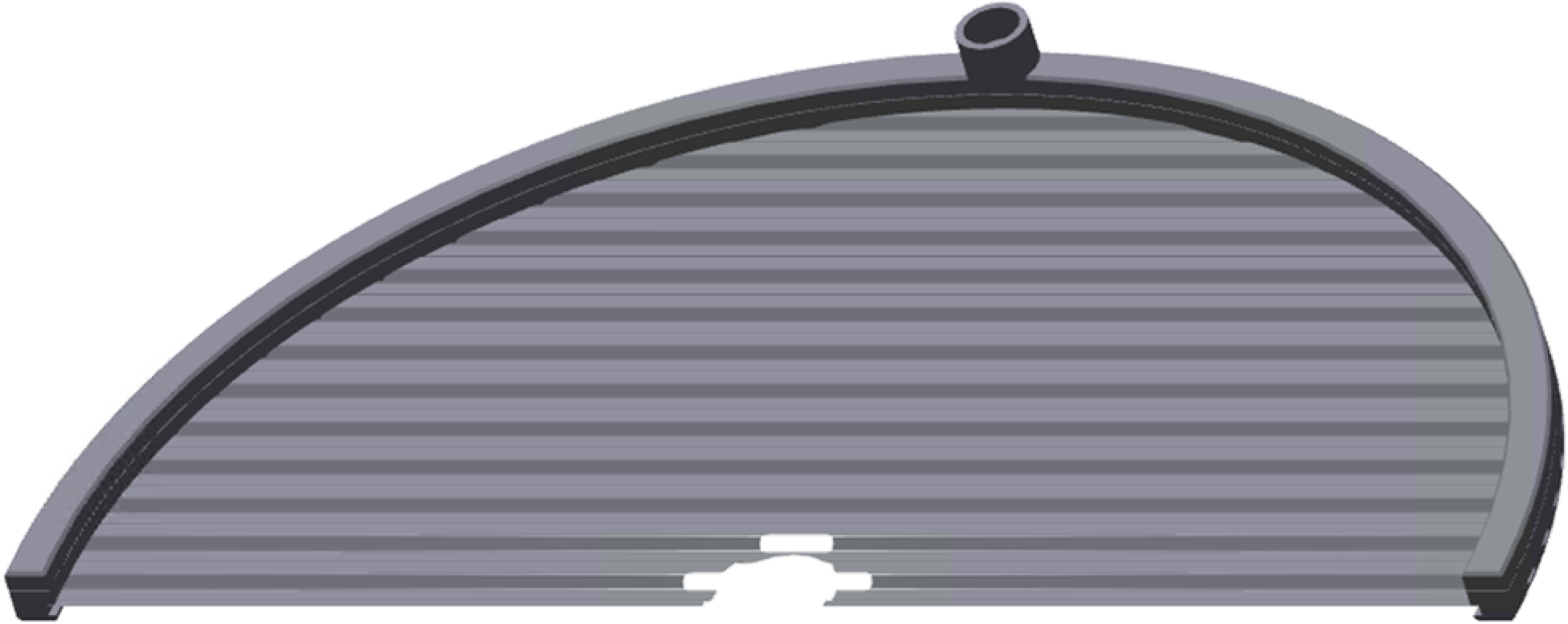
Corrugation glued onto shaped rim

Disk design



Holes for air flow through the corrugation

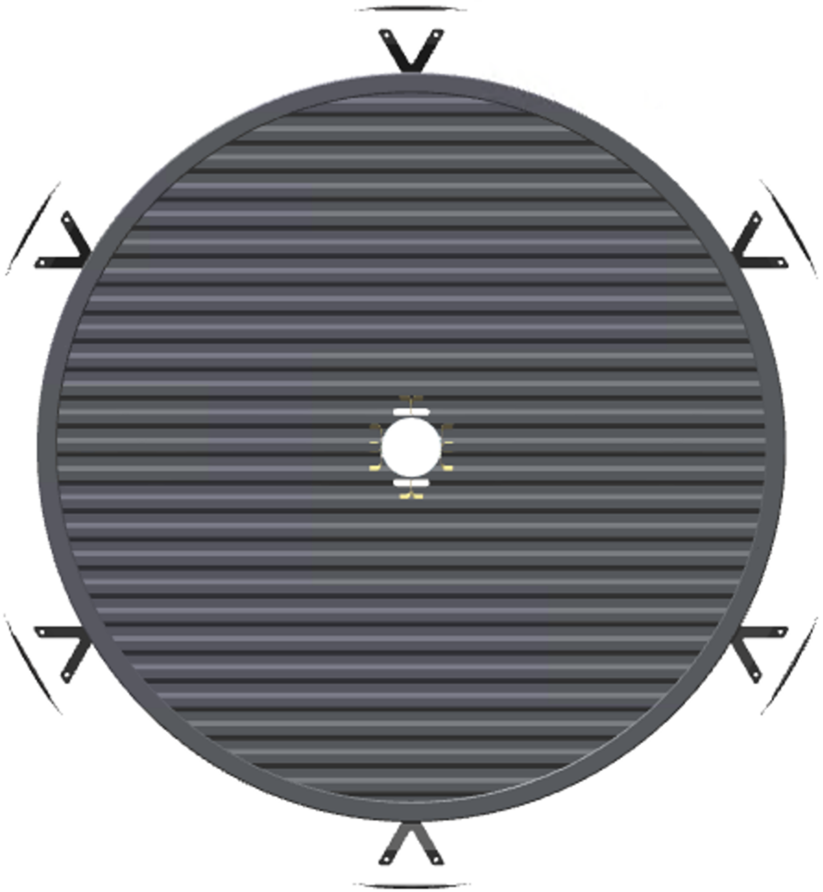
Disk design

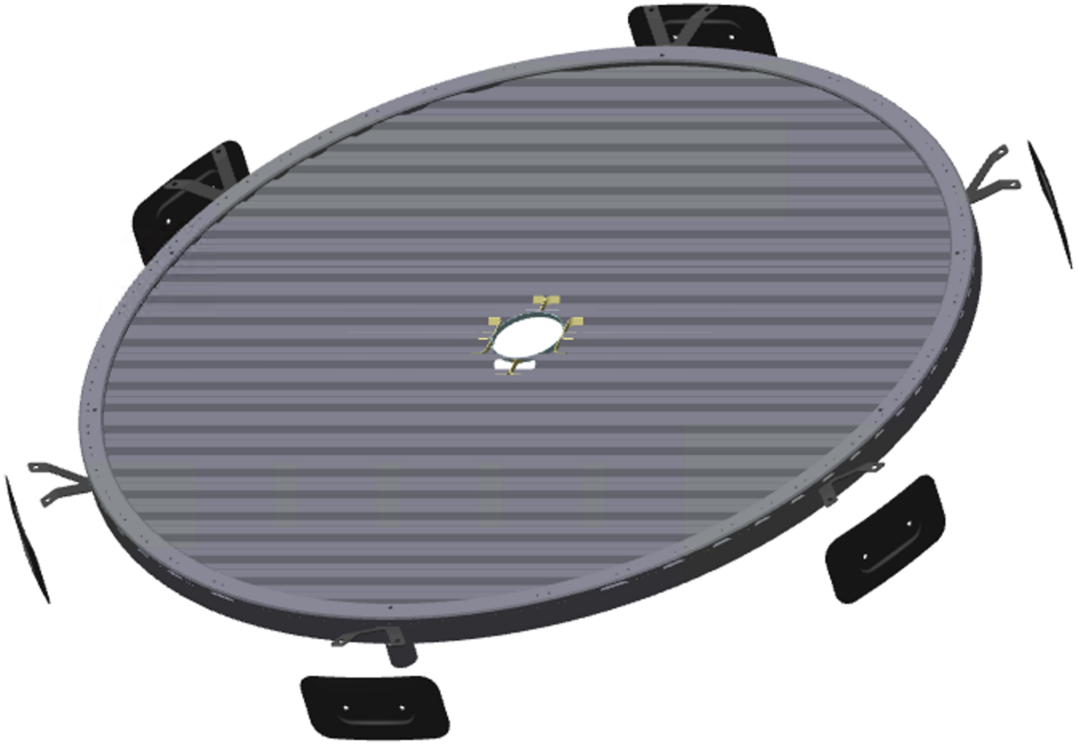


Top part of manifold with air tube

Disk design

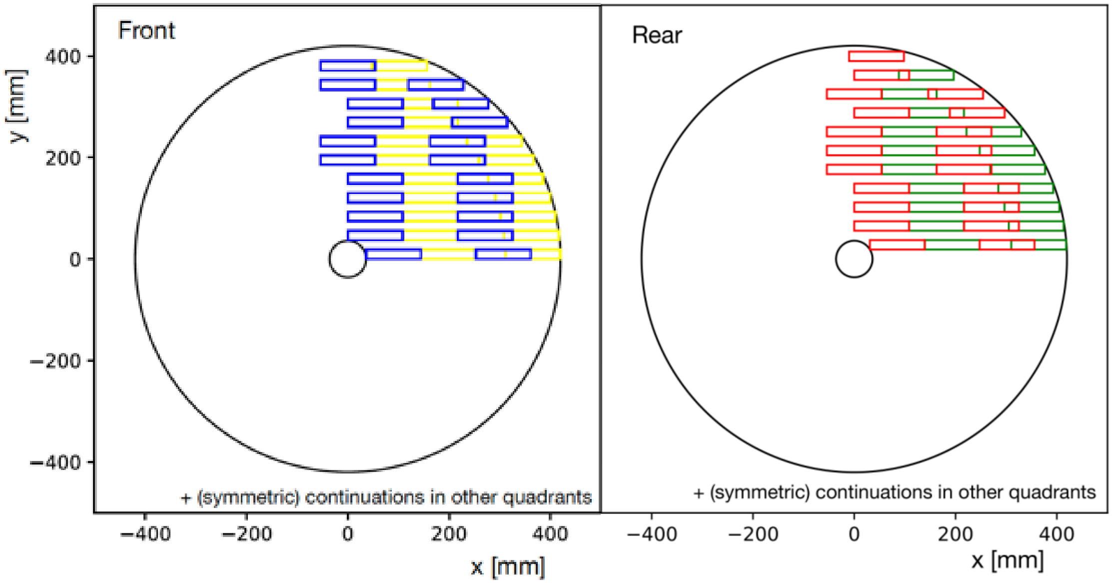
Bipod connections from disks to PST

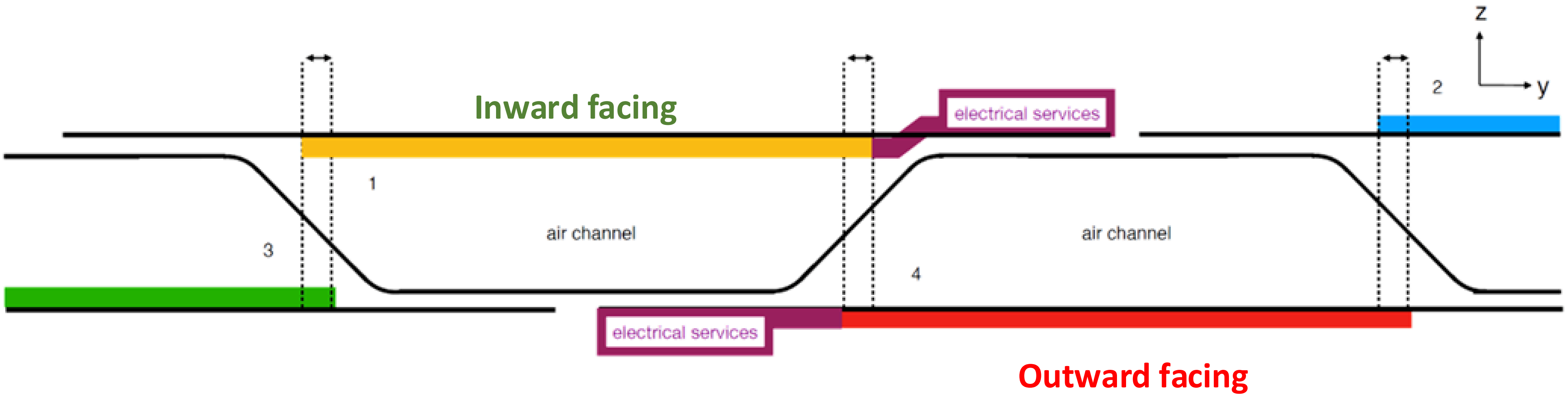




Module layout

Just a reminder: modules will be placed on front and back of disk and alternate between inward and outward facing

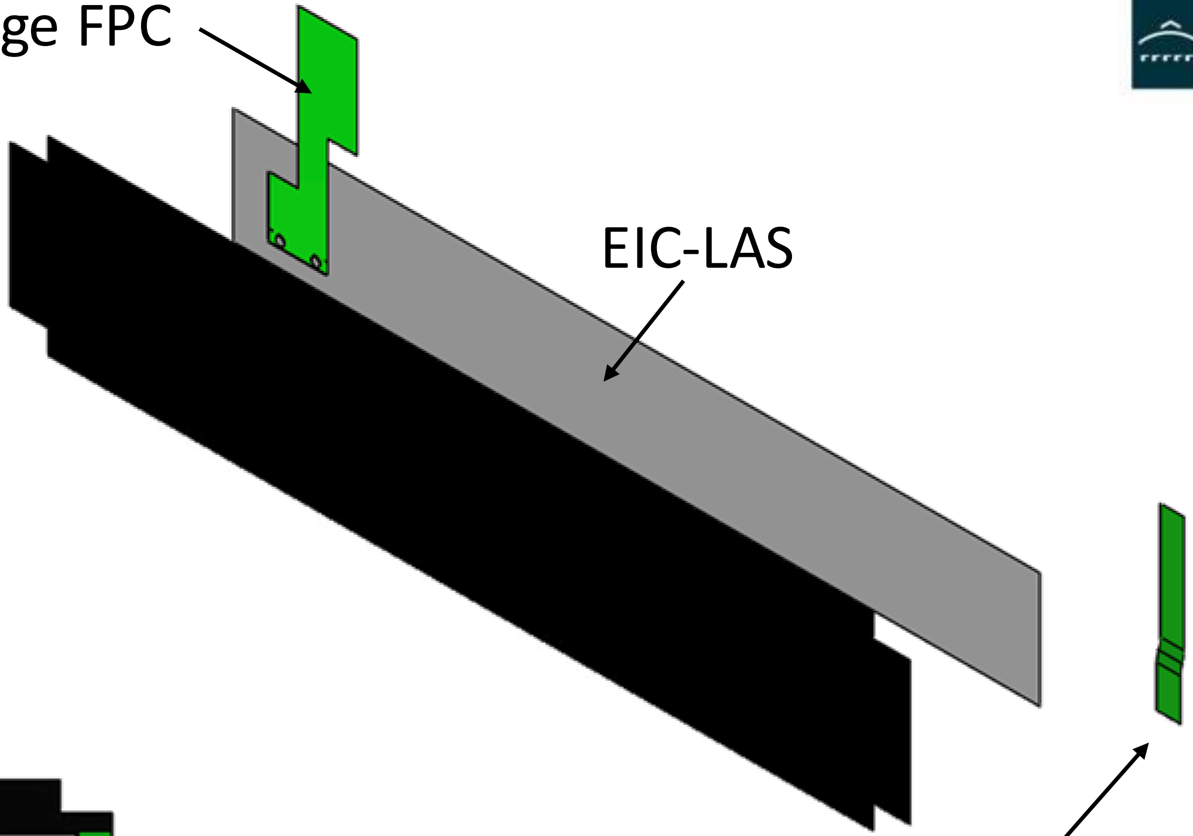




Module design

Carbon fiber flat sheet (CF FS)

- Cut outs to allow for inward facing bridge FPCs to come out (final sizes & placement TBD)



FPCs are not final – just a general representation. Holes are for alignment and will be cut off

Module Types

8 total variations

- 5 or 6 RSU
- Inward or Outward facing
- Left or Right handed
  - Direction of bridge FPCs

4 different bridge FPCs

- IN/Right
- IN/Left
- OUT/Right
- OUT/Left

Material budget (estimated)

- Based on current disk design. Averaged over one pitch (35° angle), two modules long (with minimum overlap)

Part	Thickness (μm)	Rel. width (%)	Rel. length (%)	% X/X0
Sensor (x4)	75 (relative)	56	47	0.08
Adhesive	60	60	52	0.03
Bridge FPC (x4)	100	78	10	0.02
Main FPC	100	23	50	0.01
CF FS (x4)	150	90	53	0.09
Corr flat	150	31	100	0.02
Corr angle	183	82	100	0.05
Total				**0.30**

Can save some material by making cut outs in the FS

Material measurements

Piece	Exp. Density [g/cm^2]	Meas. Density [g/cm^2]	% Difference (exp. to meas.)	Meas. % X/X_0
Corrugation	0.023	0.024	+4.3	0.06
Flat sheet	0.023	0.026	+13	0.06
Panel (fs + glue + corr + glue + fs)	0.072	0.078	+8	0.18

- Flat sheet not bleeding as much/enough resin? **Currently being checked**

Assembly

Module assembly

- Time estimate assumptions
  - AncASIC glued & wire bonded to LEC bridge FPC **before** attachment to module
  - All components inspected before assembly
  - Flat sheet (FS) cut and prepared
- EIC-LAS, LEC/REC bridge FPCs all glued at the same time
  - Can be done individually, but if glue is long cure time, it extends the # days to make a module & may require more tooling

Module assembly (One module)

~2300 modules needed for disks

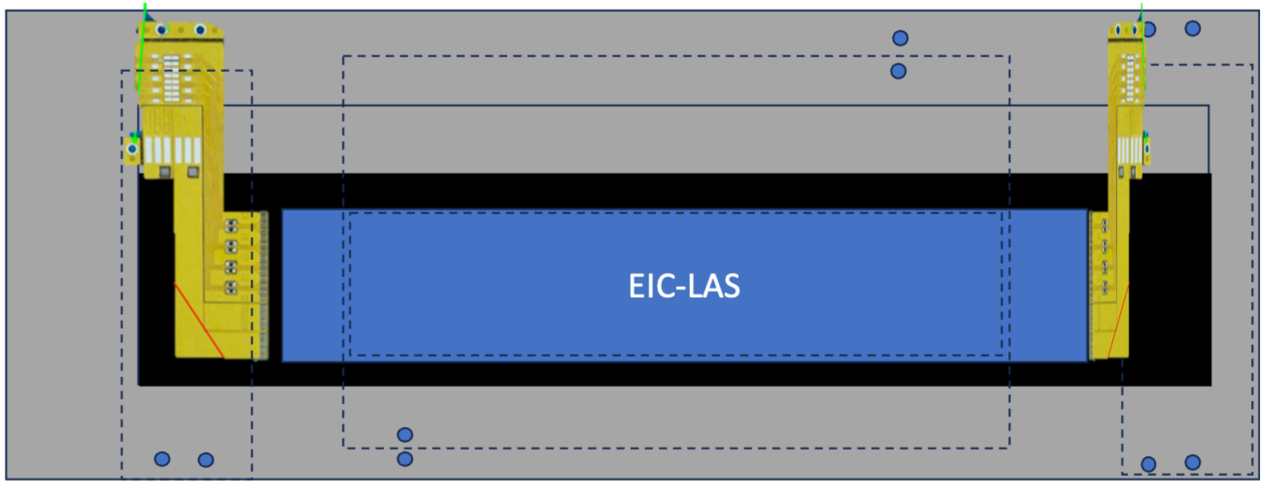
- Pre-alignment
  - CF FS, LEC bridge FPC, REC bridge FPC, EIC-LAS
- Glue preparation & application
- Alignment of EIC-LAS, LEC bridge FPC, REC bridge FPC
- Glue dry time
- Visual inspection
- Wire bonding: Alignment, bonding, visual inspection
- Testing
  - Quick test (powering, communication)
  - Overnight test? Longer?

Total time: 1 day for quick cure glue, 2 days for long cure

5/day/site → 1 year to complete modules

Module tooling

- Alignment/gluing/wire-bonding jig for AncASIC to LEC bridge FPC
- LEC & REC bridge FPC pre-alignment jig & vacuum pick up tools
- EIC-LAS pre-alignment jig & vacuum pick up tool
- Module gluing jig (also acts as FS pre-alignment)
- Module wire-bonding/carrier/testing board
- Cooling plate for testing?



(some) Open questions:

- how many sets of tooling to make? (glue choice is likely a factor)

- how many carrier boards? → how many modules do we want to stockpile before disk assembly?

- do we need a longevity test? How long? Will affect # of carrier boards

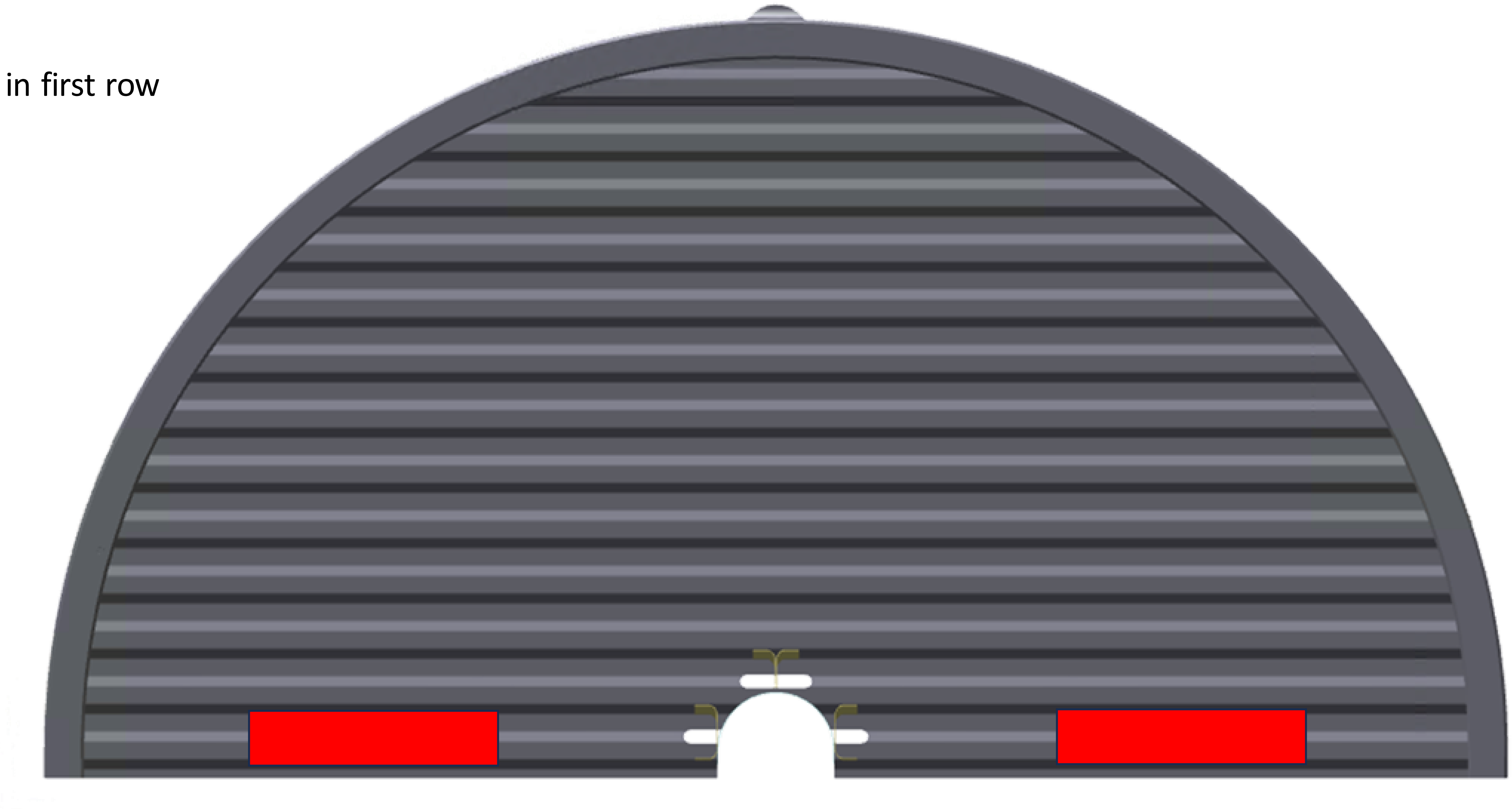
Disk assembly: One disk

- Time estimate assumptions:
  - One gluing station
  - One connection/testing station
  - Top & bottom half disks are done in parallel
    - Both stations are always in use (rotate top & bottom)
- Gluing & connecting ~one row at a time
- Complete one side before working on the opposite side

Disk assembly

Not to scale
Generalization only

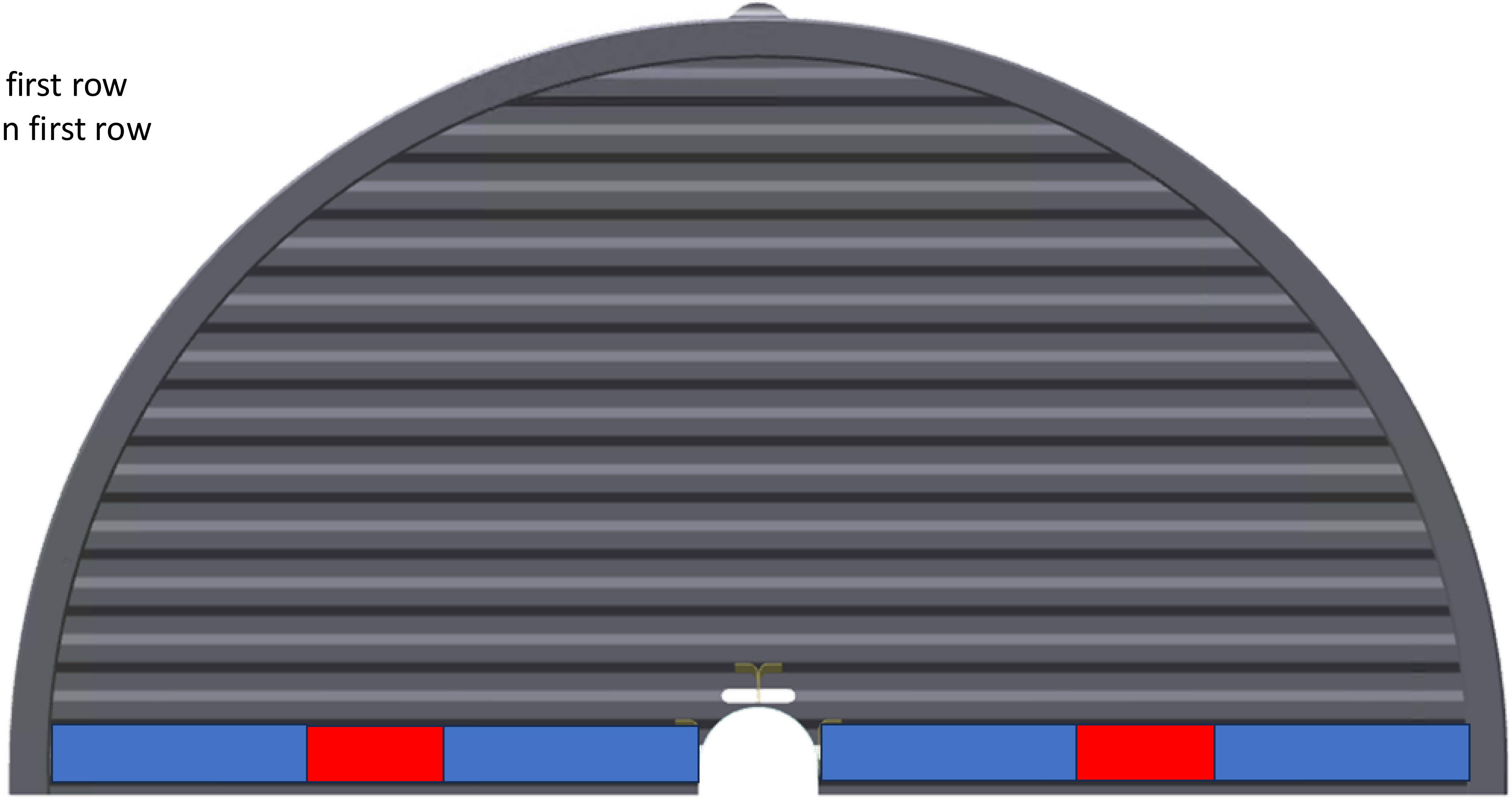
Glue inward modules in first row



Disk assembly

Not to scale
Generalization only

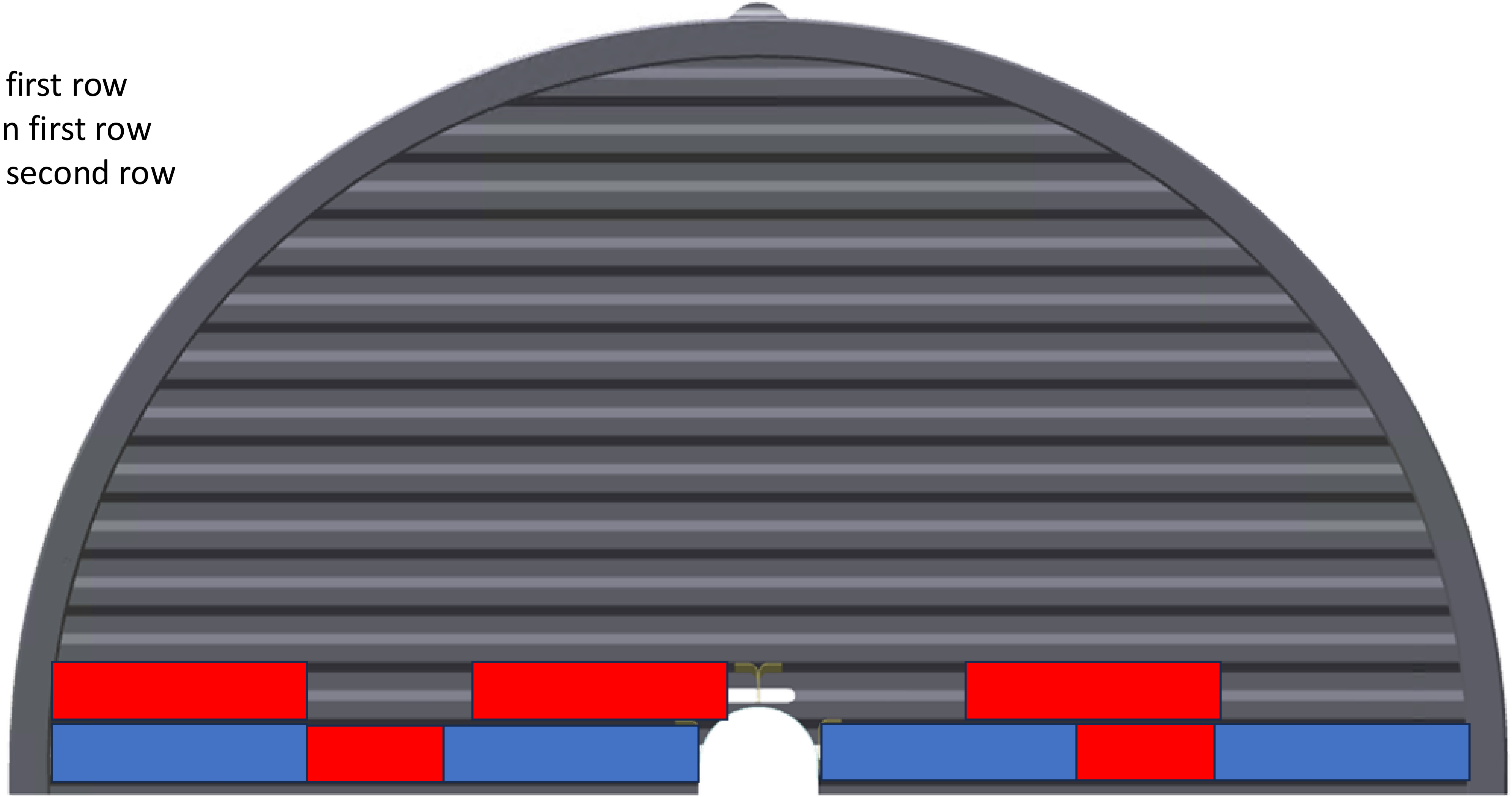
Glue inward modules in first row
Glue outward modules in first row



Disk assembly

Not to scale
Generalization only

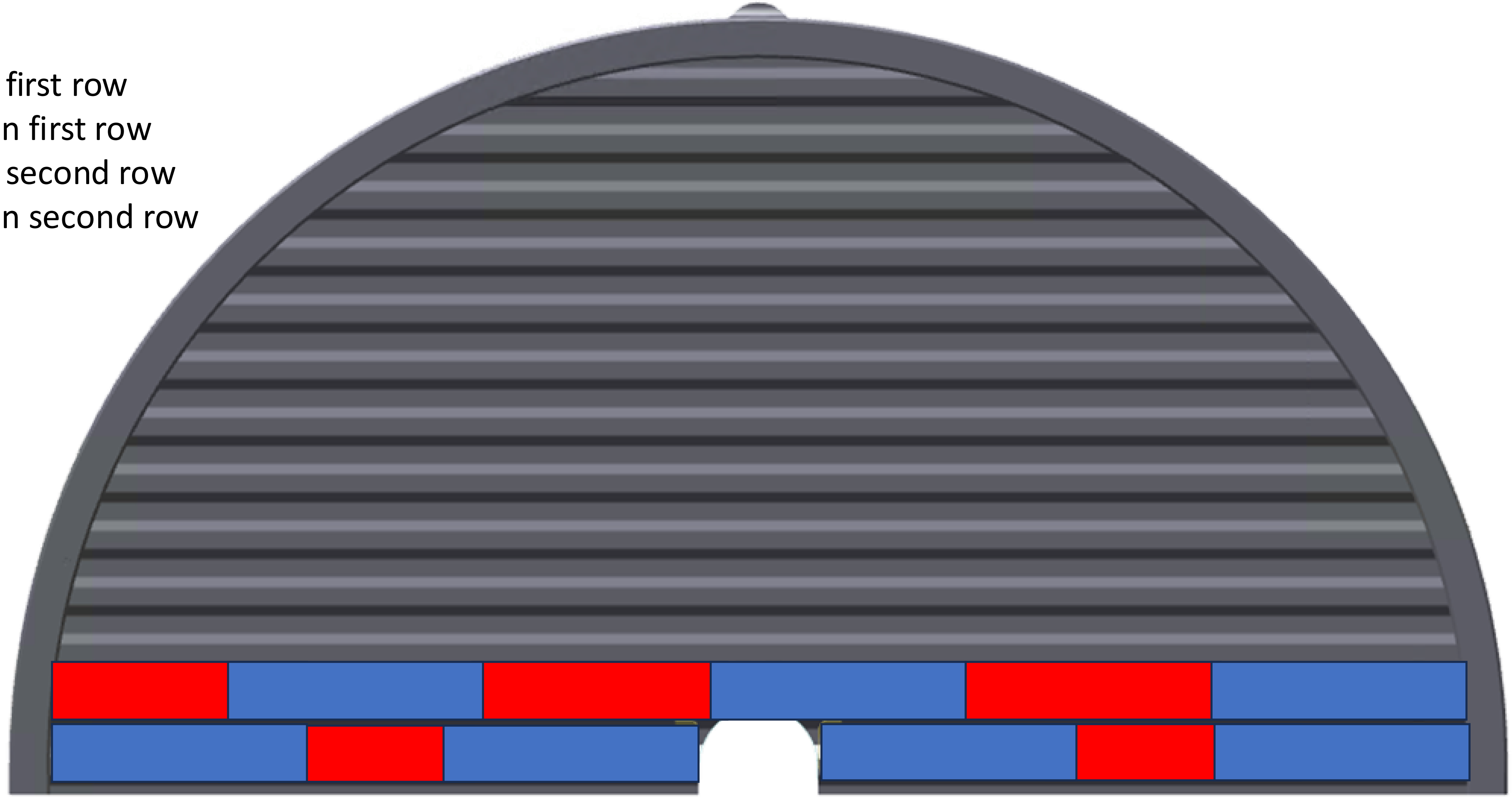
Glue inward modules in first row
Glue outward modules in first row
Glue inward modules in second row



Disk assembly

Not to scale
Generalization only

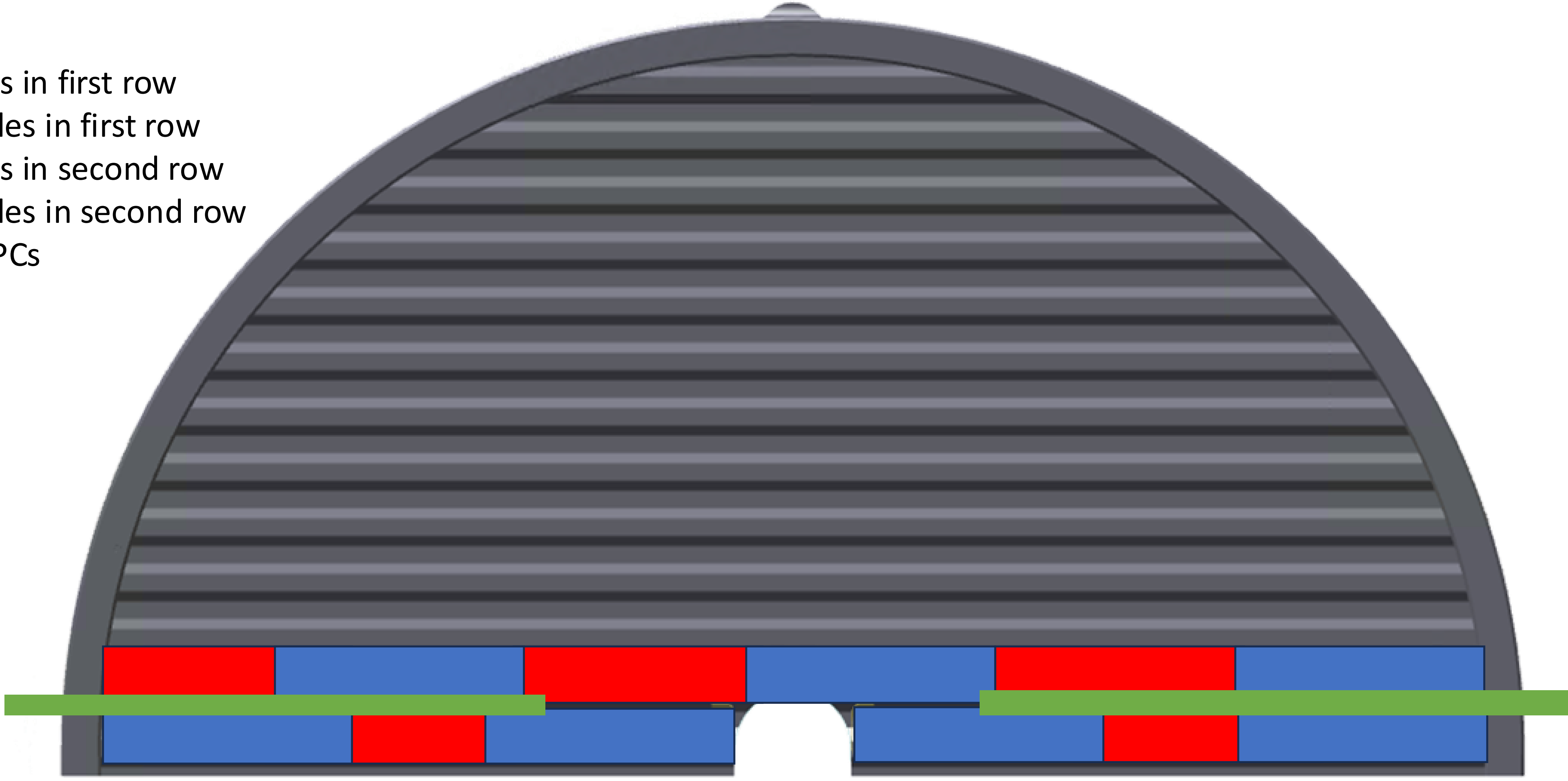
Glue inward modules in first row
Glue outward modules in first row
Glue inward modules in second row
Glue outward modules in second row



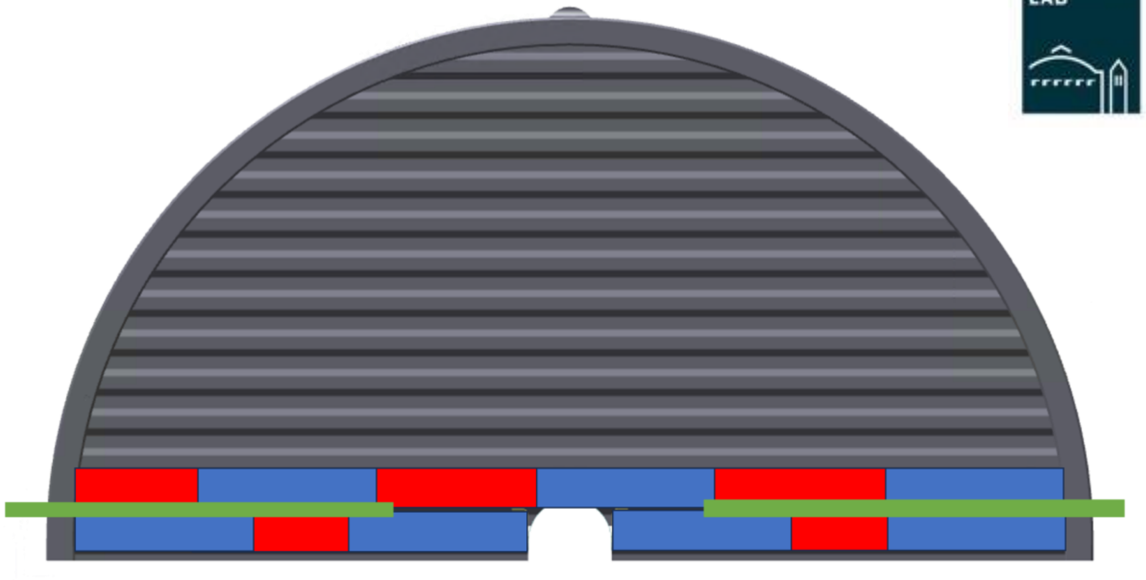
Disk assembly

Not to scale
Generalization only

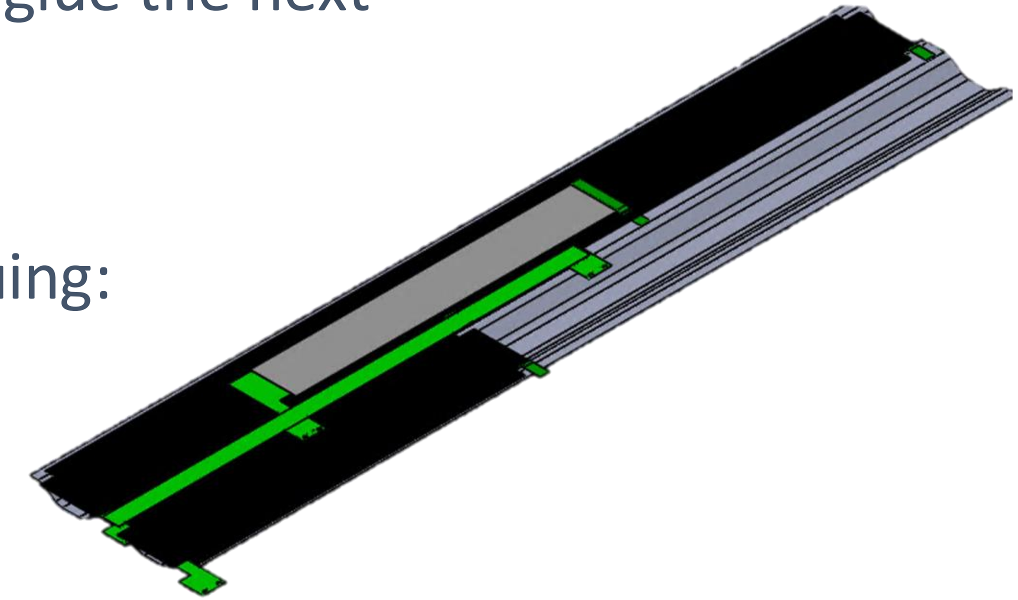
Glue inward modules in first row
Glue outward modules in first row
Glue inward modules in second row
Glue outward modules in second row
Glue main & edge FPCs



Disk assembly



- Make connections between bridge FPCs & main FPC
- Test the row
- Next day: Move half disk back to gluing table, glue the next row of modules & main FPC

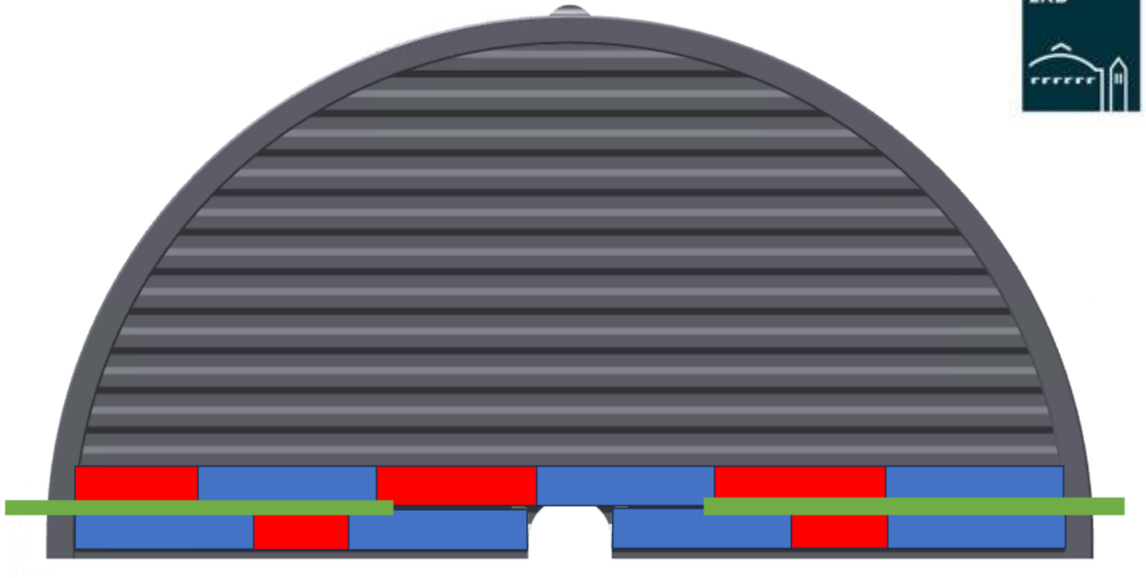


With two stations, alternating top & bottom gluing:

One (large) disk ~2-3 months

2 sites → 1-1.5 years to complete

Disk tooling



- Alignment & gluing jig
- Electrical connection jig
- Test stand
- Needs to be adaptable for both front and back side of disks

(some) Open questions

- Alignment all done mechanically?

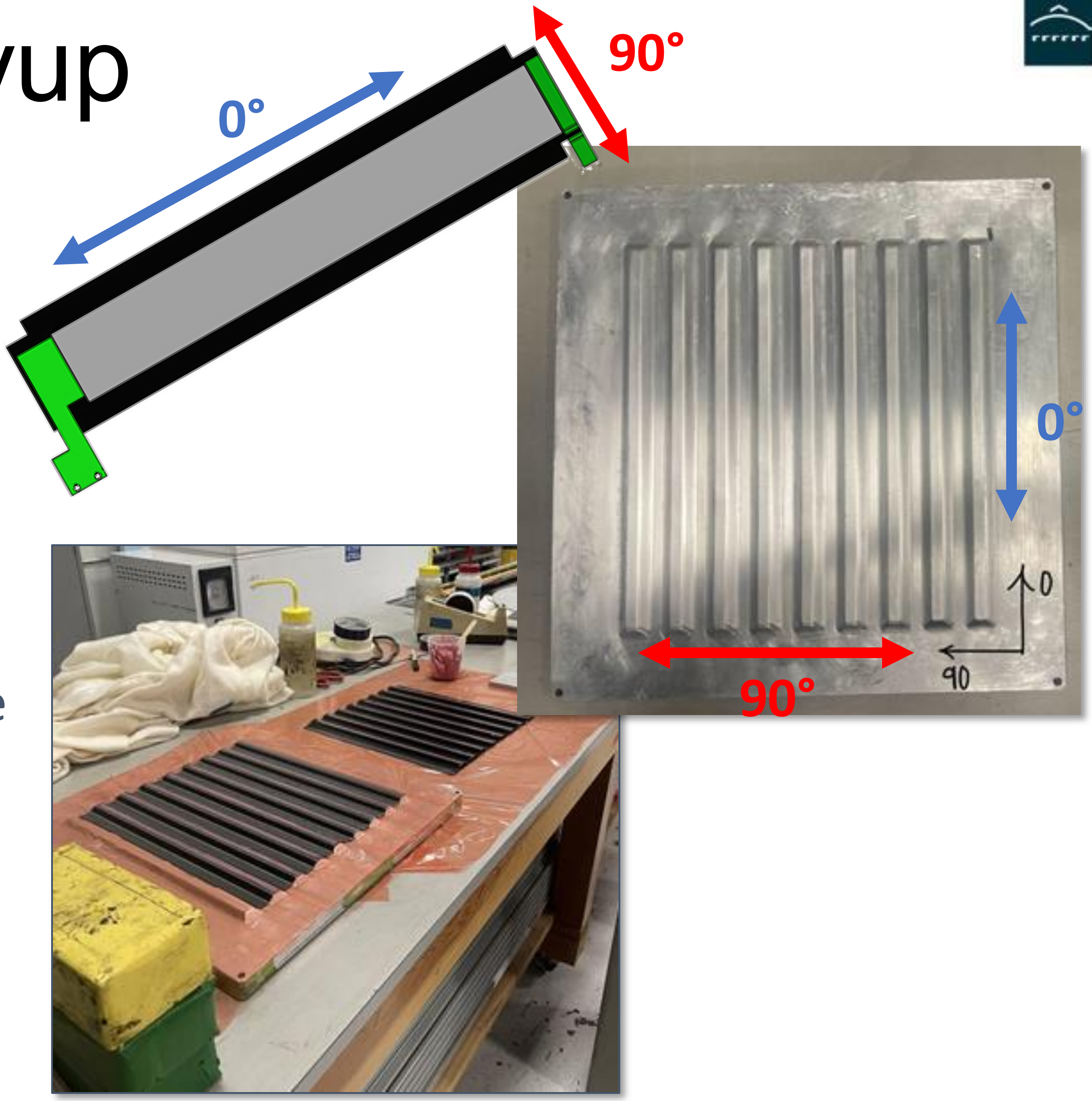
- Do we align optically at all or just use for metrology?

- How many EIC-LAS chains can we test at one time?

Prototyping

Carbon composite & layup

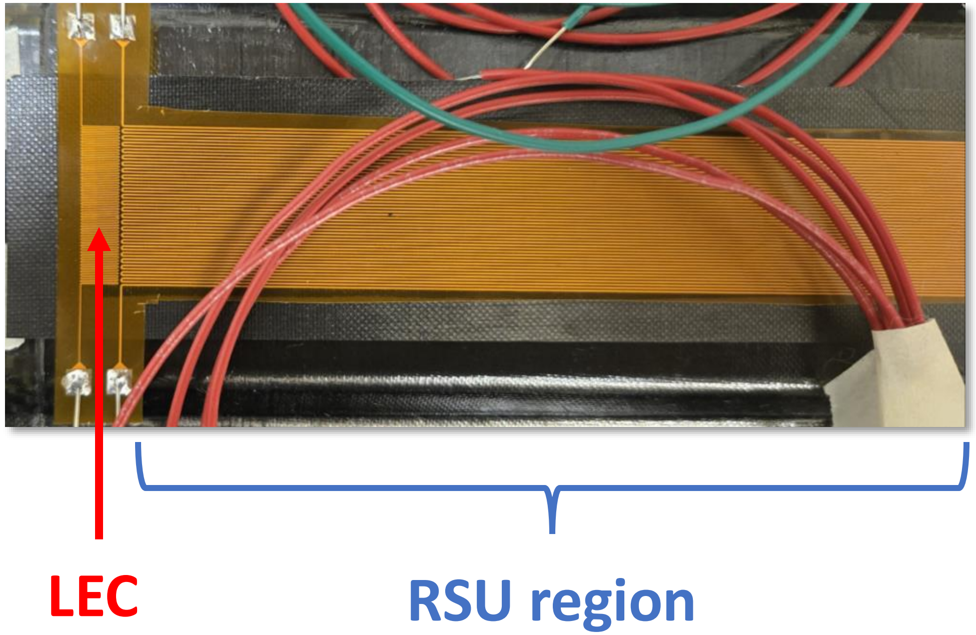
- **K13C2U** Carbon Fiber pre-preg
- **0°: along the corrugation**
- **90°: against the corrugation**
- Two different configurations
  - **Flat sheet: 0/90/0** → thermal advantage
  - **Corrugation: 90/0/90** → mechanical advantage for corrugation

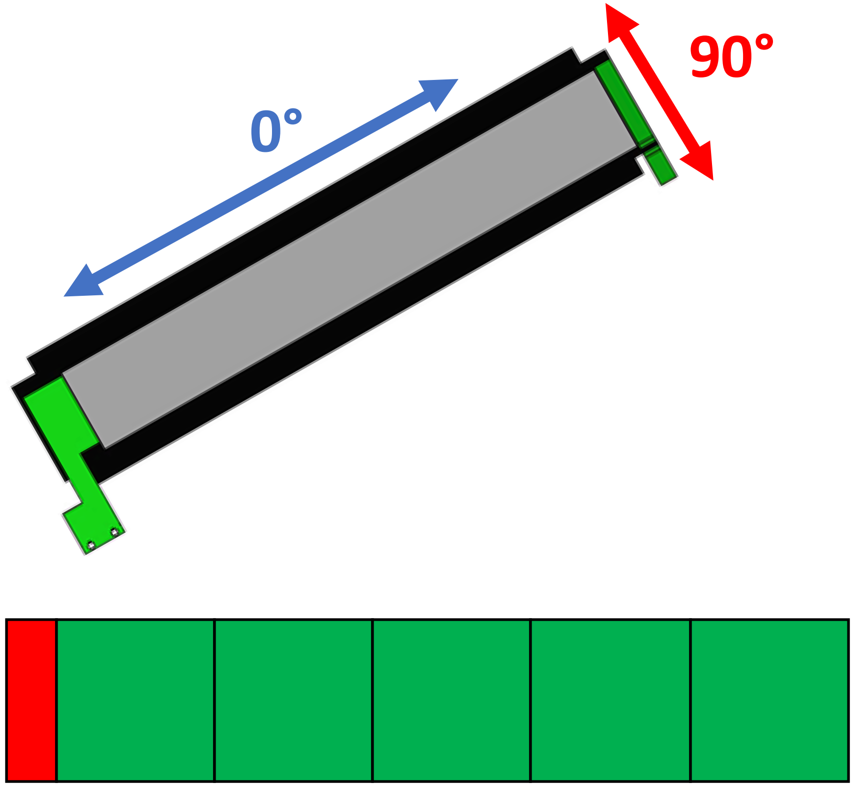


Credit: Skye Heiles

Module thermal test pieces

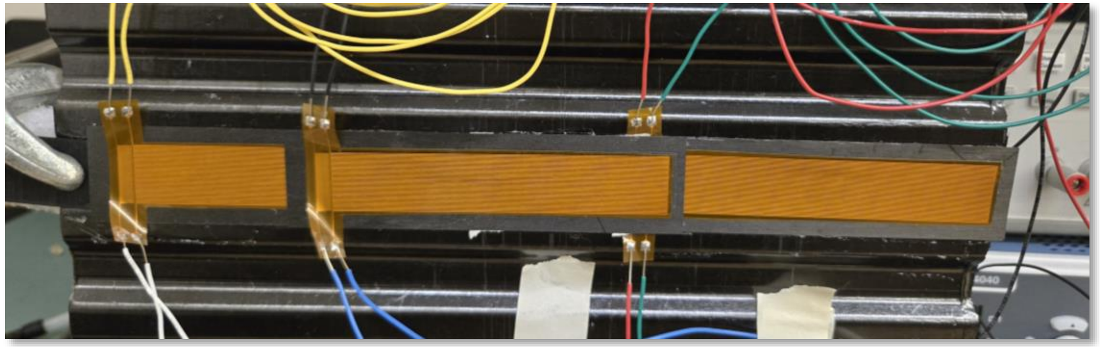
Heaters: 2 power regions





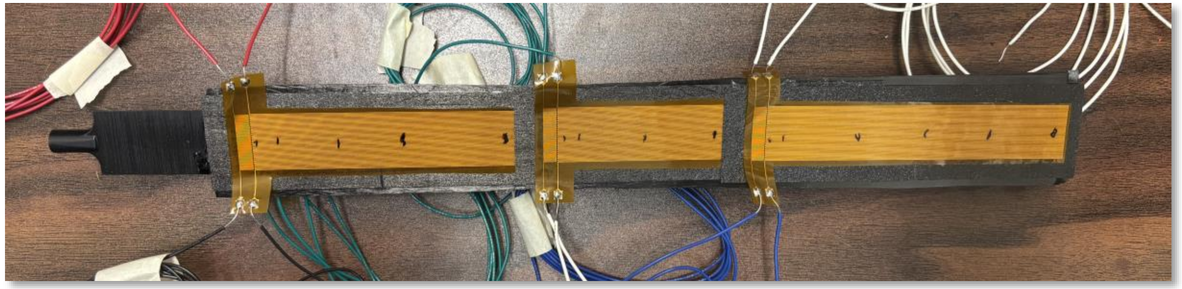
Each region powered separately
Capable of a range of power densities

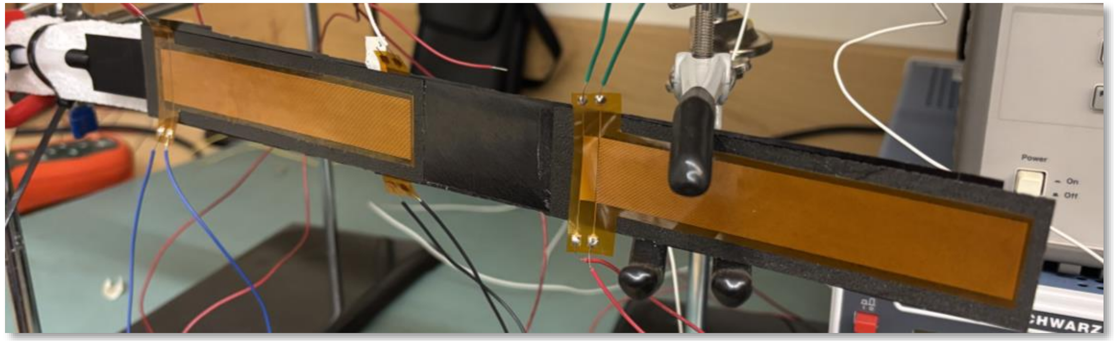
Disk thermal test pieces



Large corrugated piece with one channel used
All heaters outward facing
3rd LEC hidden

Single corrugation channel #1 & #2
All heaters facing outward
All LEC visible



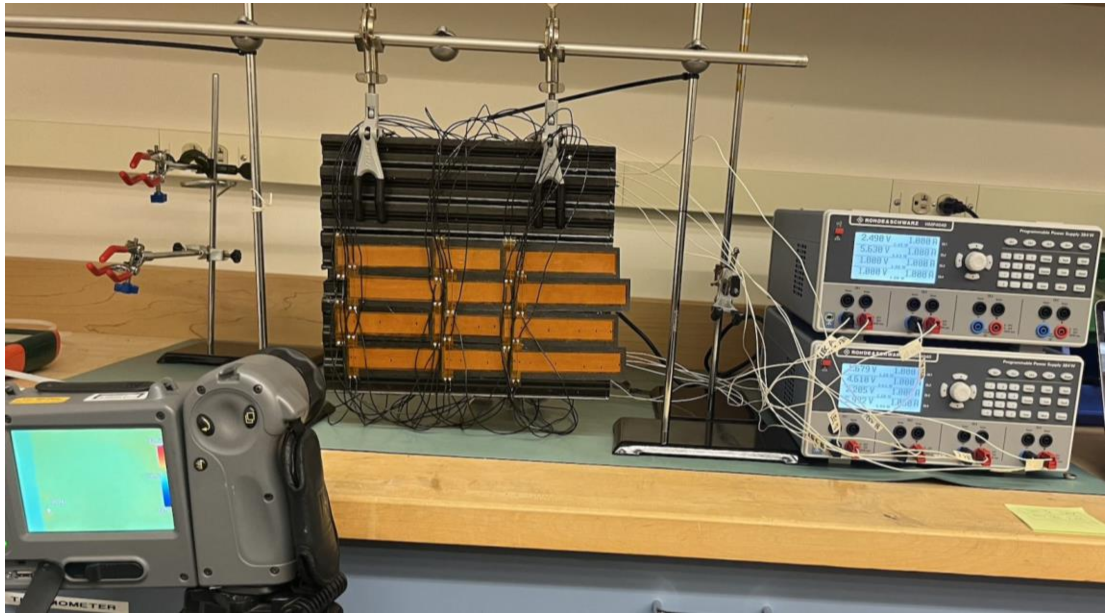


Single corrugation channel #3
One heater inward facing
2nd heater hidden

Large thermal test piece

- Held in same orientation as planned in ePIC
- Using thermal camera → ~0.5°C fluctuations
- $\Delta T = T_{BrightTemp} - T_{DarkTemp}$
  - Dark temp taken with air flowing, but no power
  - Bright temp taken with air flowing and power on
- Cannot measure ΔT of sections we cannot see, i.e. hidden behind overlap
- Air velocity limited by setup safety

4 rows in front



1 row in back

Work by Katie Gray

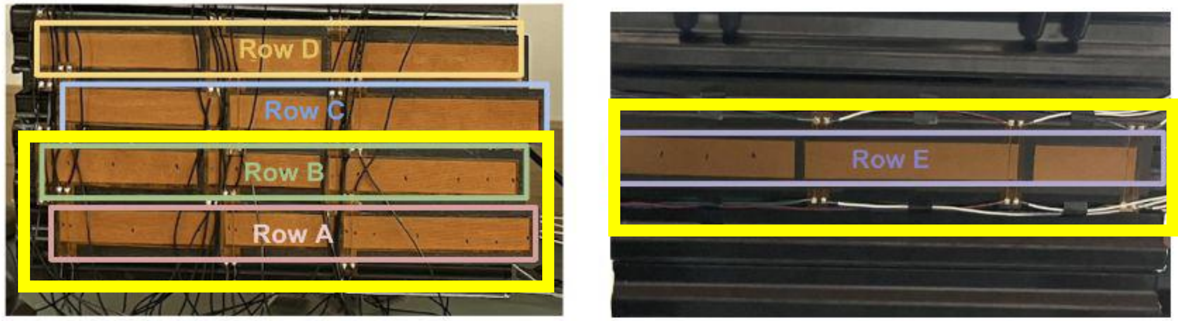
Thermal results

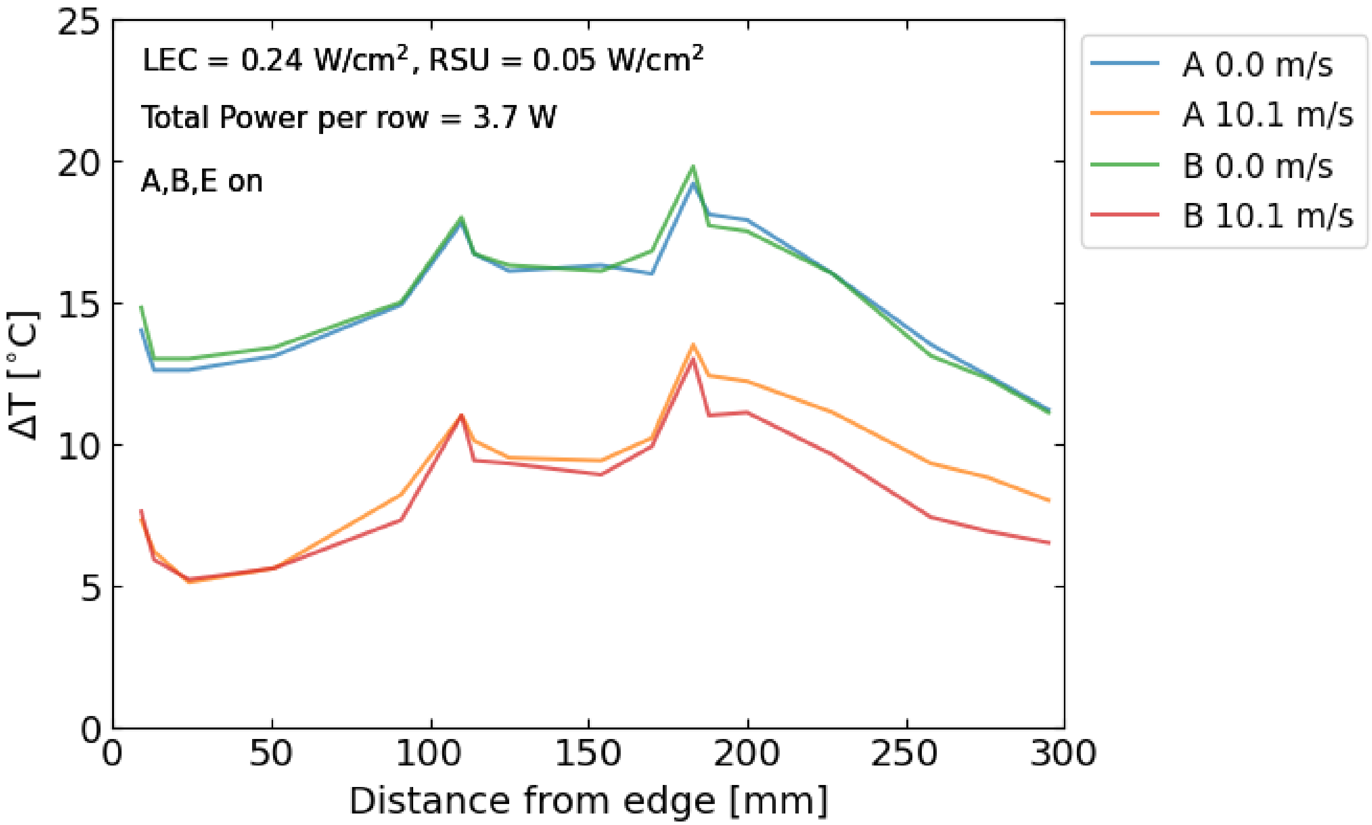
[”New” power numbers]

30% reduction in ΔT from previous power for LEC peaks

No major change in RSU temp → power density stayed the same

Caveat: No AncASIC





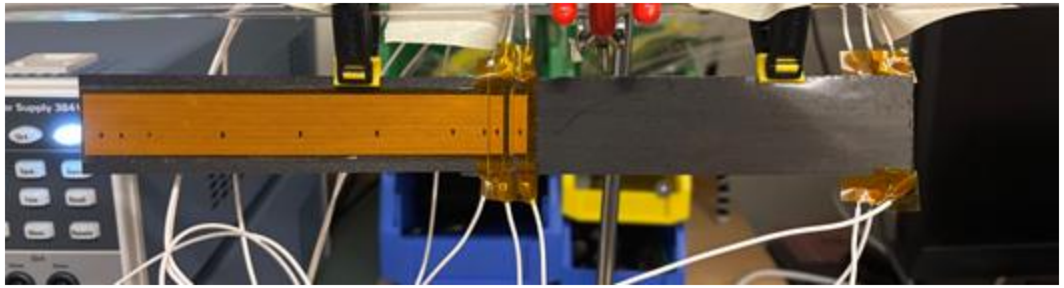
AncASIC placement: thermal performance

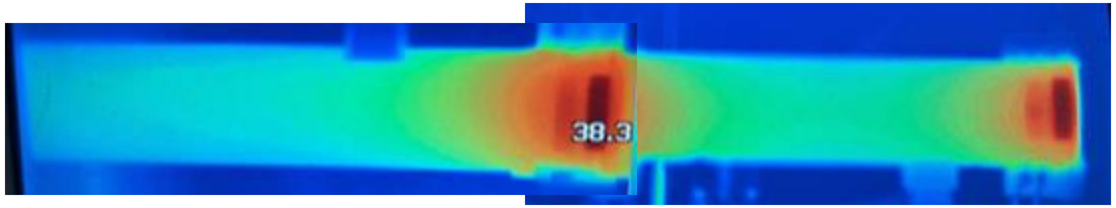
- Putting the AncASIC next to the EIC-LAS is preferred
- Comes with a complication for the disks, the AncASIC is **HOT** and sits right above RSUs in the overlap region
- Requires that we keep the AncASIC to the same temperature specifications as the RSUs
- Previous lab measurements did not have an AncASIC mockup
  - New results with mockup in the next slides

EIC-LAS & AncASIC thermal test piece

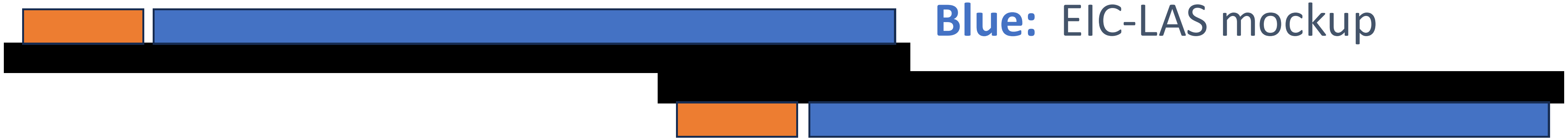
Caveats:

- AncASIC Not the right size → using LEC
  - Power = AncASIC power → lower power density than real life
- Simple structure, no corrugation
- No forced convection
- ”Double” natural convection

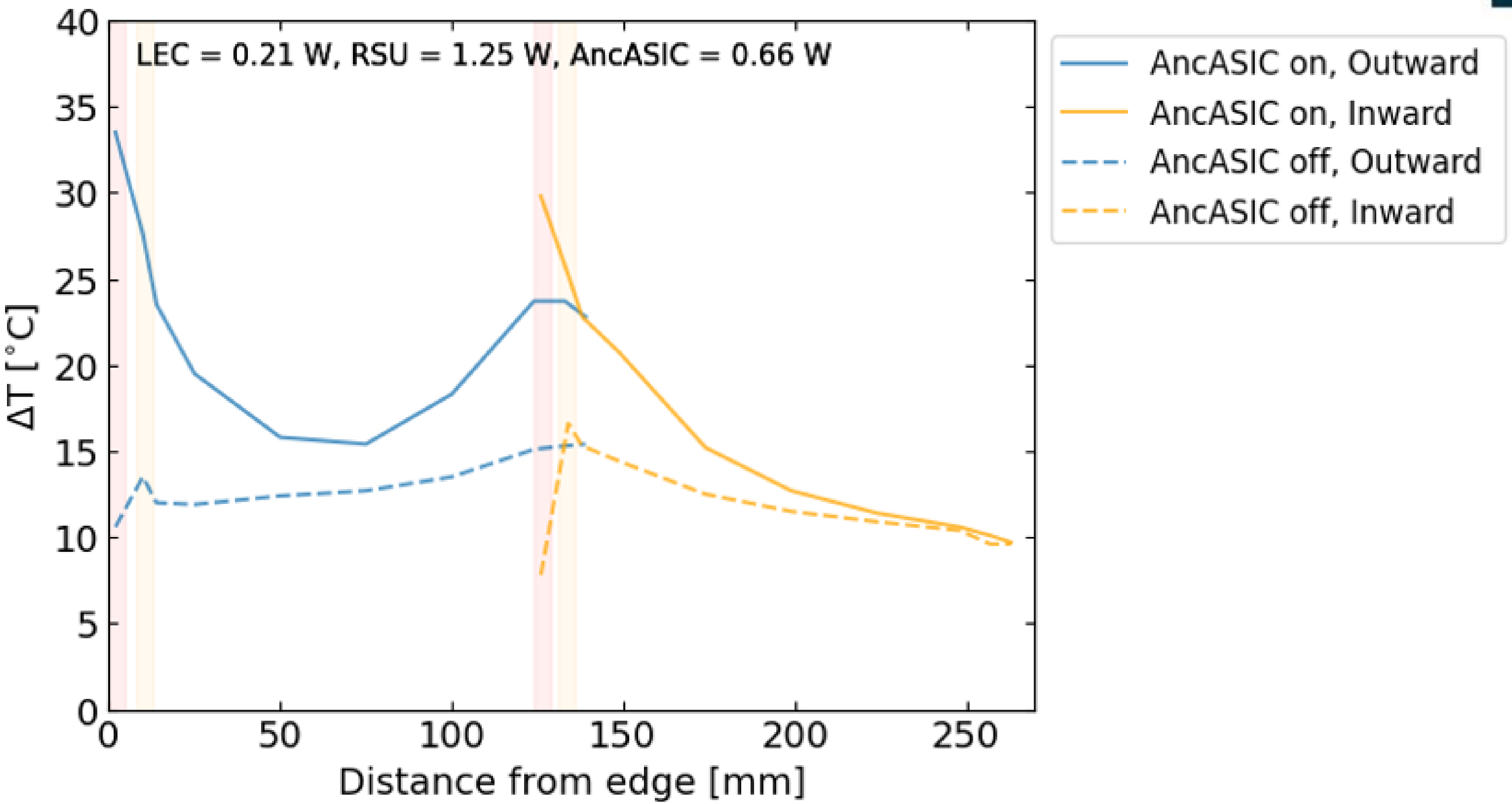




Side view of test piece.
Orange: AncASIC mockup
Blue: EIC-LAS mockup

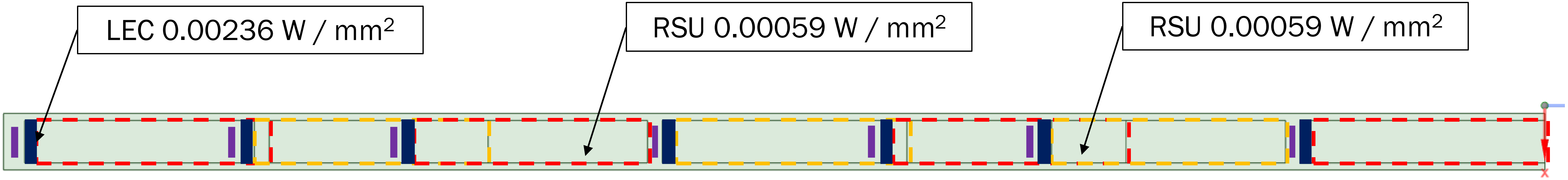


Results



- **AncASIC makes a significant difference to the temperature**

Thermal FEA



- Considered power 6 RSU in footprint 5 RSU
- RSU = 6 reticles * 0.208 W/ reticle = 1.248 W
- LEC = 0.208 W
- Total EIC-LAS (6 Reticles) = 1.456 W
- Overlapped loads due detectors configuration.

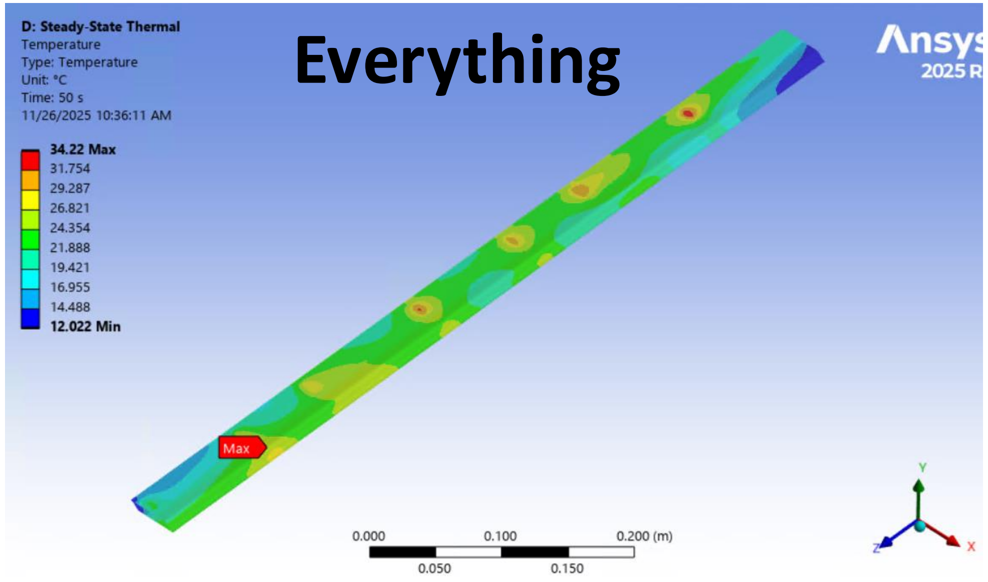
- Load in LEC and RSU defined as density power for analysis:

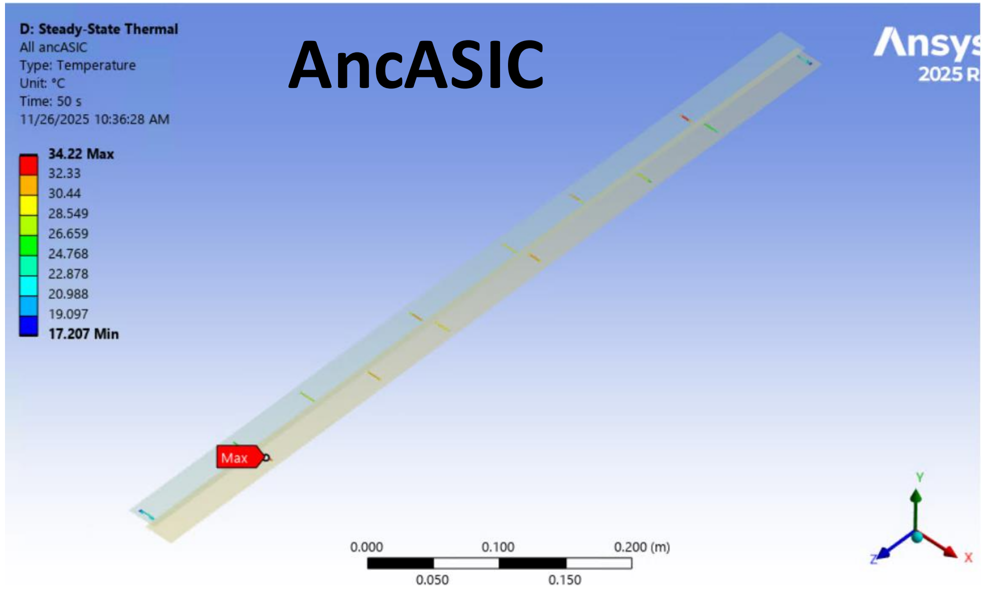
Thermal load	W	Units	Total Power (W)	Area (mm2) Ernest	Density Power (W/mm2) Ernst Area	Density Power (W/mm2) Nick Area
RSU. Reticle	0.208	6	1.248	2119.37	0.00059	
LEC. Unit	0.208	1	0.208	88.04	0.00236	
Total EIC-LAS (6 Reticles)			1.456			

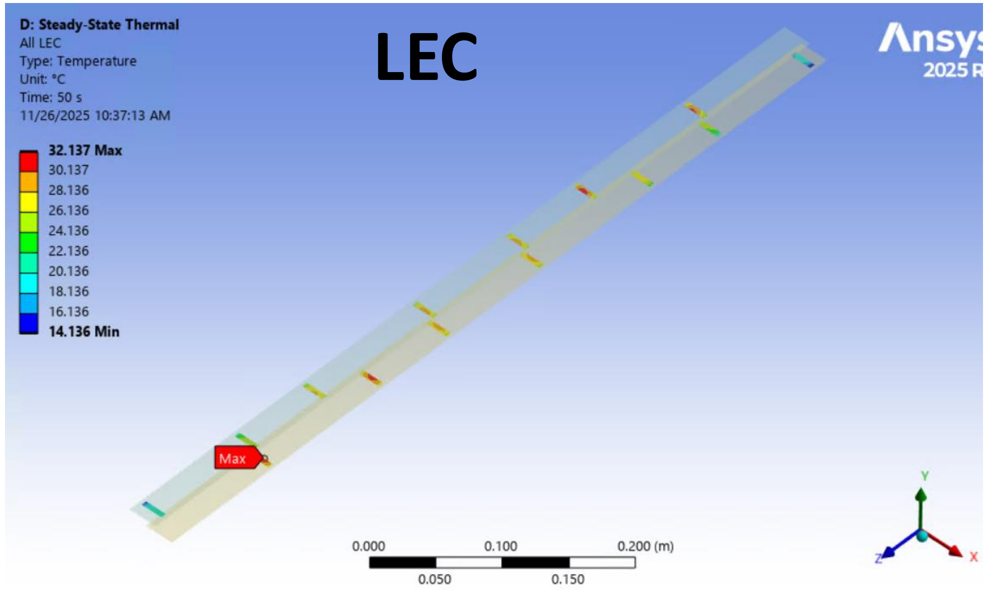
Work by Jaime Cruz Duran

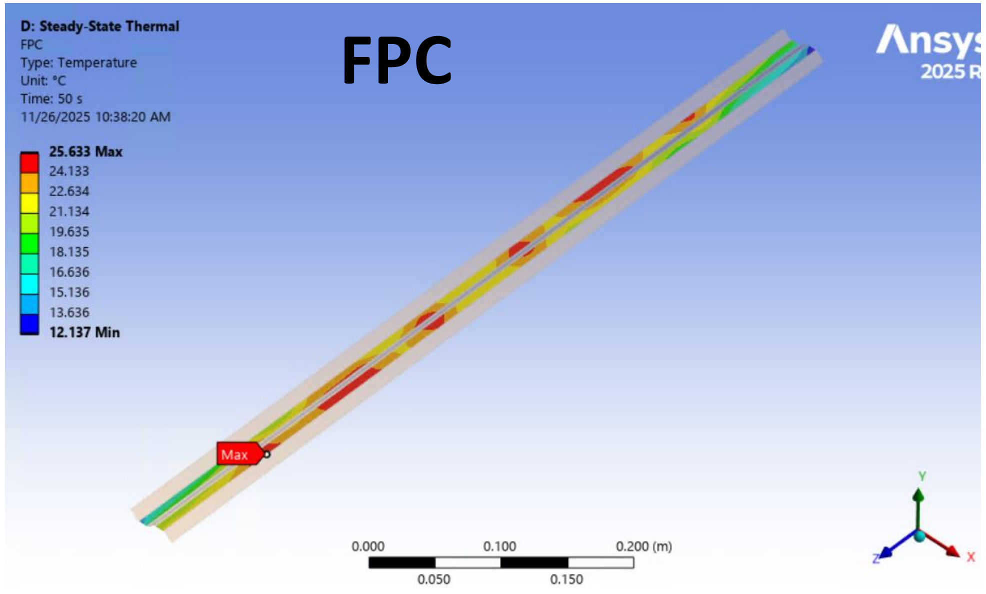
*Inlet temperature 5 Celsius

V = 10 m/s





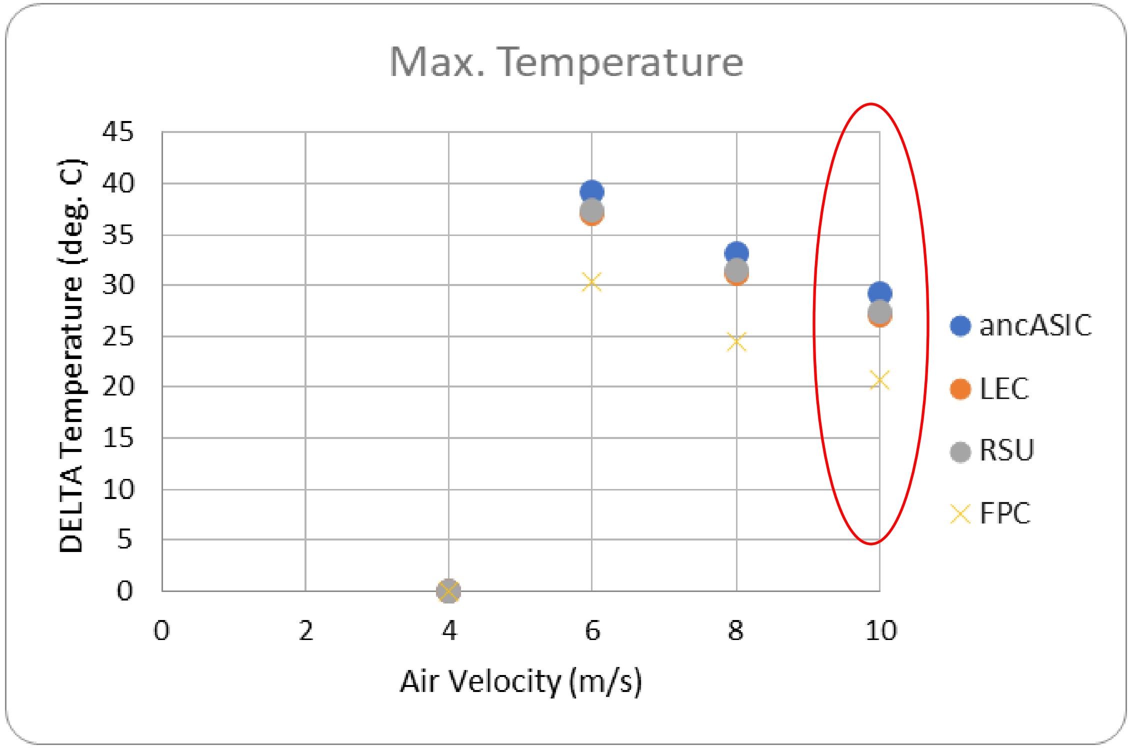


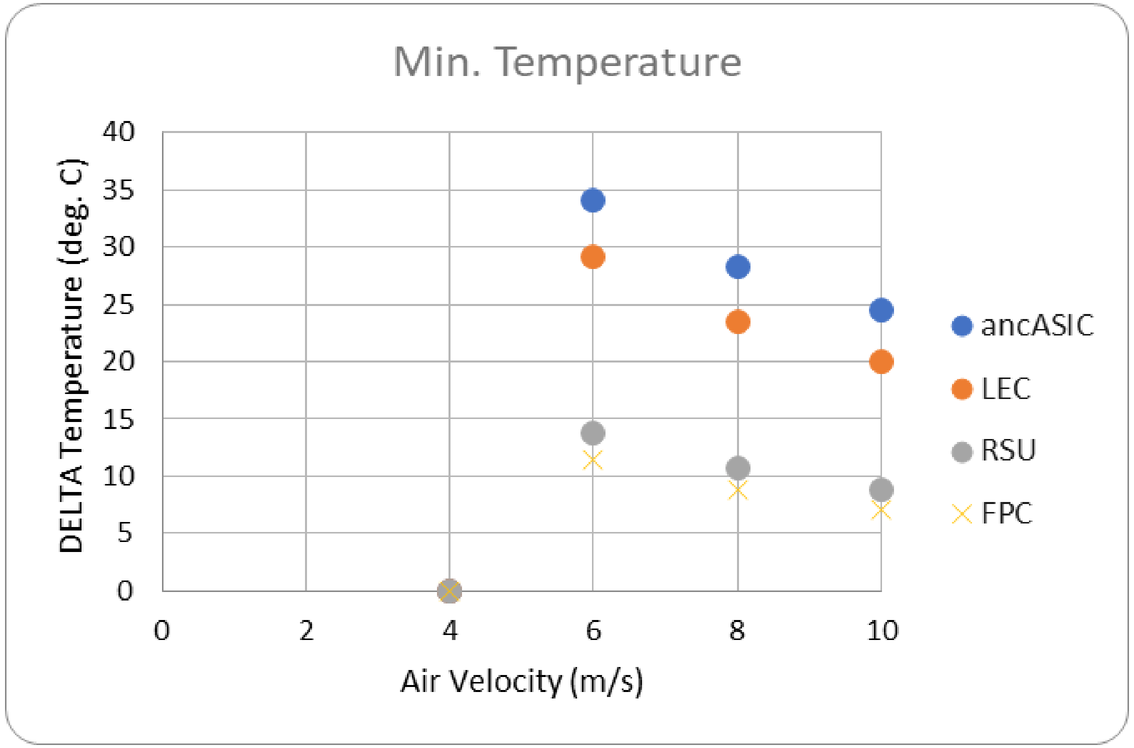


Work by Jaime Cruz Duran

Work by Jaime Cruz Duran

Thermal FEA results





Results: Component Temperatures. DELTA Temp

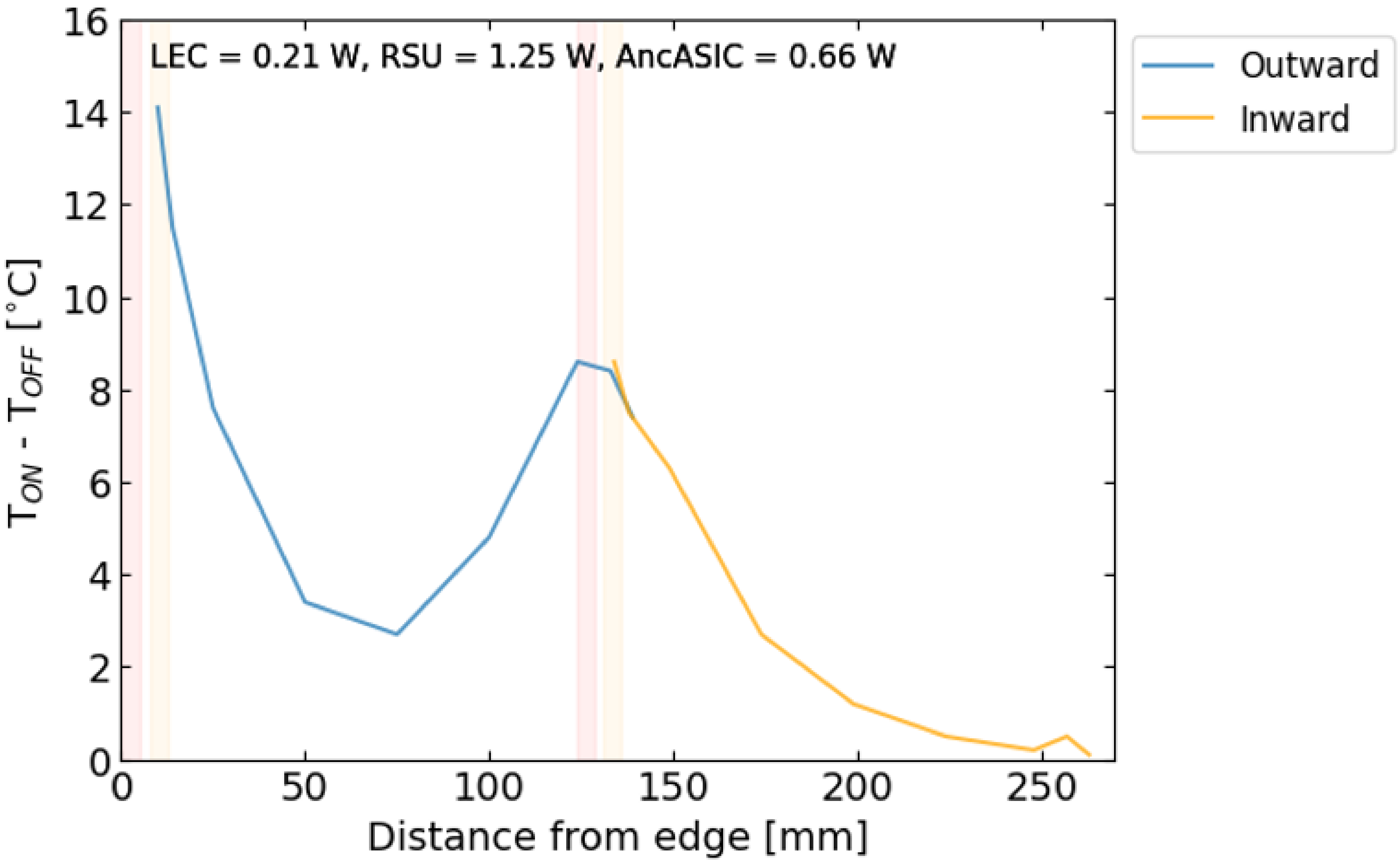
	ancASIC			LEC			RSU			FPC		
v (m/s)	T min.	T max.	T avg.	T min.	T max.	T avg.	T min.	T max.	T avg.	T min.	T max.	T avg.
4												
6	34.027	39.236	37.31	29.092	37.099	33.792	13.831	37.441	26.391	11.4	30.401	25.463
8	28.271	33.202	31.361	23.557	31.111	27.969	10.777	31.422	21.14	8.81	24.528	20.197
10	24.518	29.221	27.446	19.966	27.137	24.114	8.825	27.471	17.745	7.137	20.633	16.771

Summary/open points

- With new power numbers AncASIC can be placed next to LEC
  - Also dependent on max temperature allowed
- Module prototyping needs to happen next
  - Tooling design ongoing (slowly)
- Open points (not exhaustive)
  - Cut outs in FS: where? What does that do to the mechanical stability?
  - When to cut off the FPC alignment tabs?
  - Final sensor layout
  - # of FIBs → how different is the disk FIB to the OB FIB?
  - How do we electrically isolate the sensors from the CF?

Planned test pieces

- Module test pieces testing gluing & alignment
  - Using 1st iteration module tooling
- Half-disk engineering test article
  - Using some mechanical & thermomechanical test pieces
  - Needs disk half-ring engineering test article & 1st iteration disk tooling
- Combined thermal & flow test
  - Blow compressed air at planned pressure through all channels
  - Power heaters
  - Measure air pressure, flow rate, temperature
  - Measure thermal module temperatures



Temperature difference between AncASIC ON vs OFF. Temperature of AncASIC location not shown

OLD: LEC = 0.70 W, RSU = 1.25 W, AncASIC = 0.87 W

NEW: LEC = 0.21 W, RSU = 1.25 W, AncASIC = 0.66 W