Discs: prototyping, FEA, & next steps

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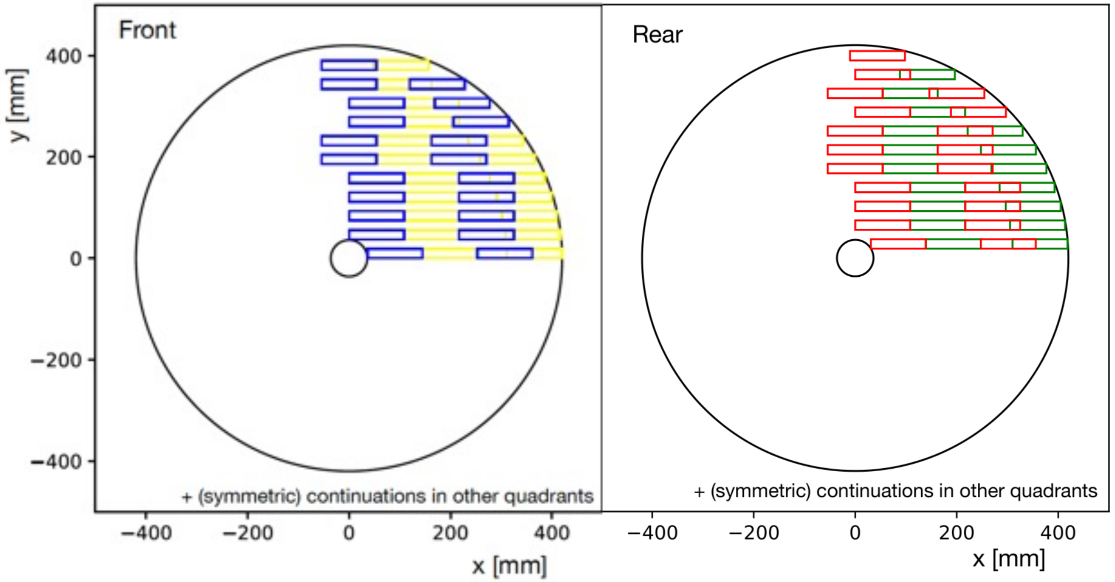
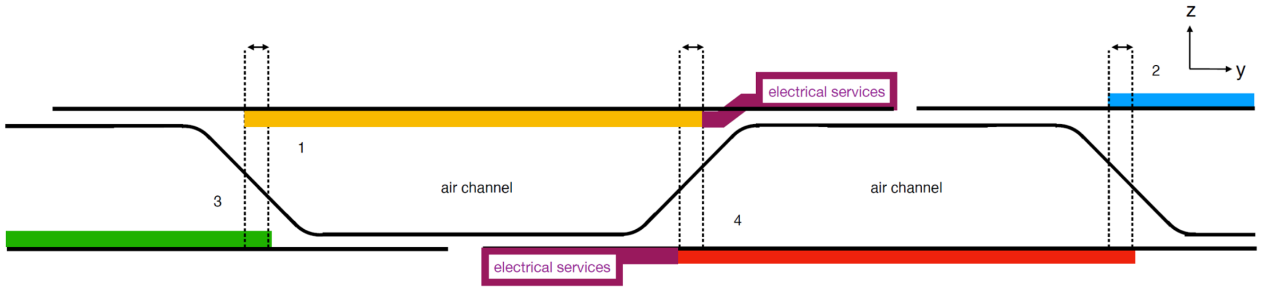
ePIC Collaboration Meeting

January 23, 2025

Corrugated disc design

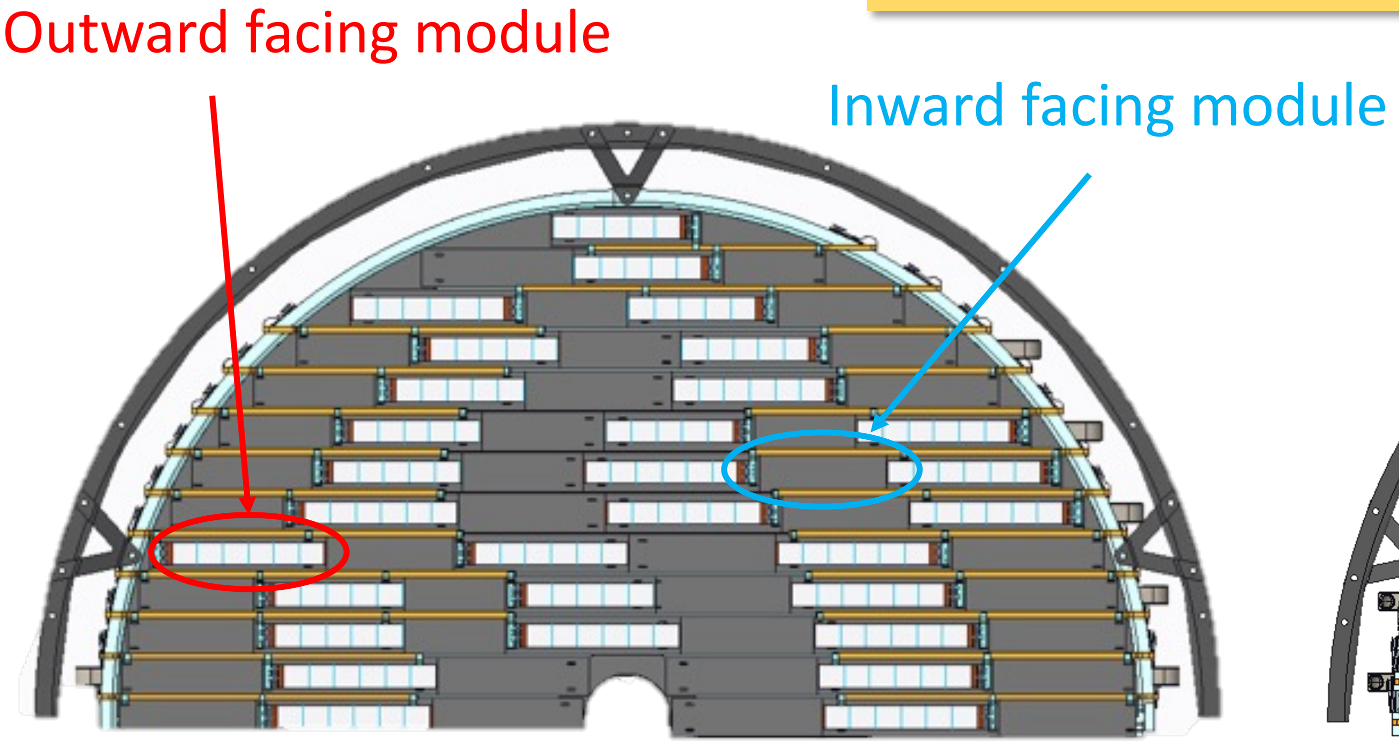
- Front and rear facing constructed from modules
- Two module types:
  - **Outward facing** (sensor facing outward from corrugation)
  - **Inward facing** (sensor facing inward to corrugation)



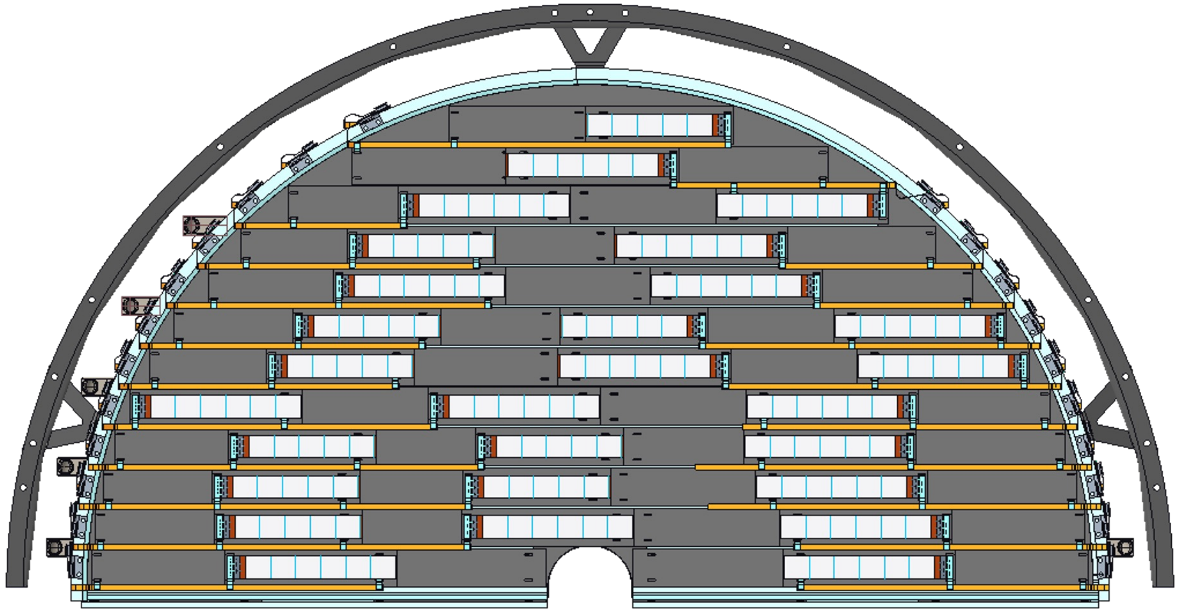


Sensor layout

Sensor layout changes disc to disc with changing inner radius
→ New beam pipe changes means re-doing the sensor layout



"Front" face of disc (facing in to IP)



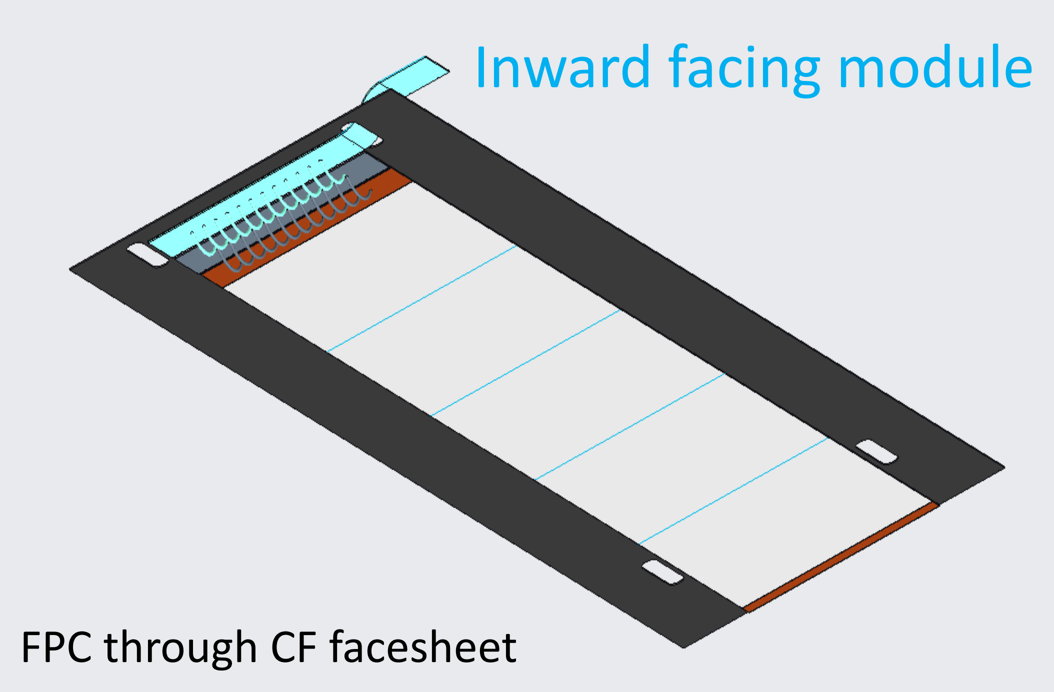
"Back" face of disc (facing away from IP)

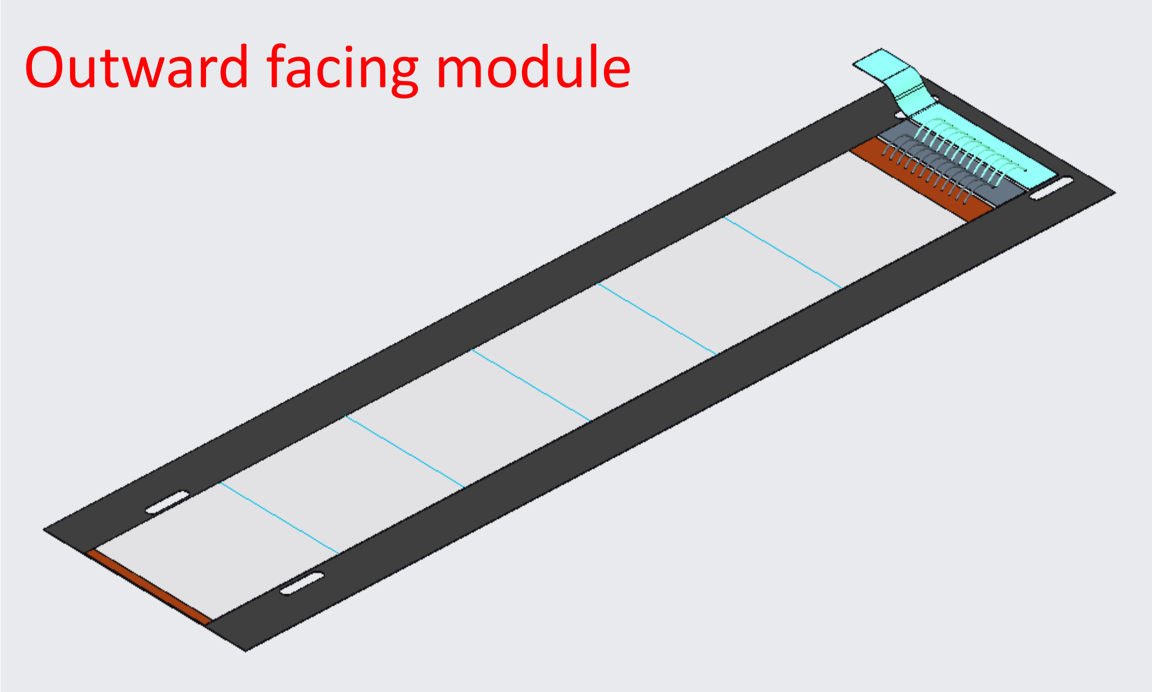
****This will change to ensure we aren't mixing 5 & 6 RSUs on same FPC**

Credit: Jim Curtis

Modules

- One sensor glued to a carbon fiber sheet & bonded to an Ancillary ASIC (AncASIC) and Flexible Printed Circuit (FPC)
- New information about AncASIC to be incorporated

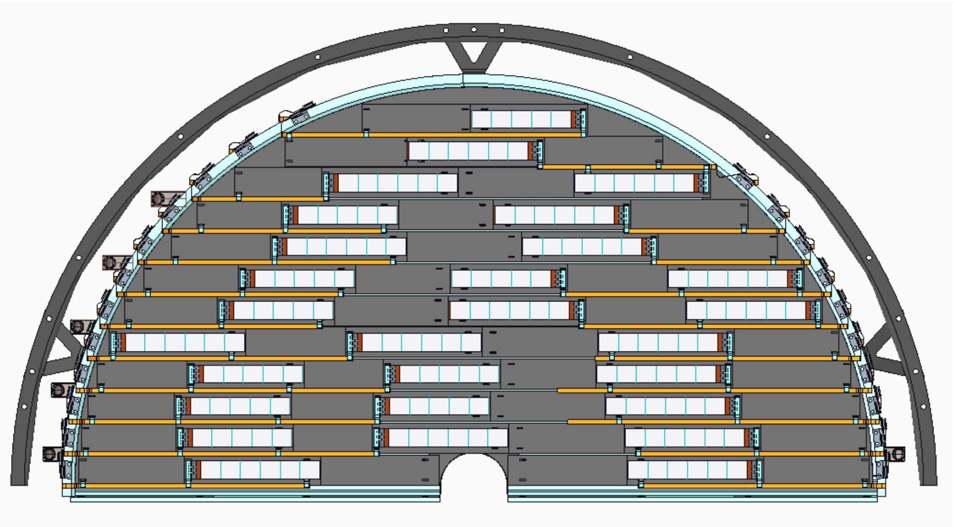




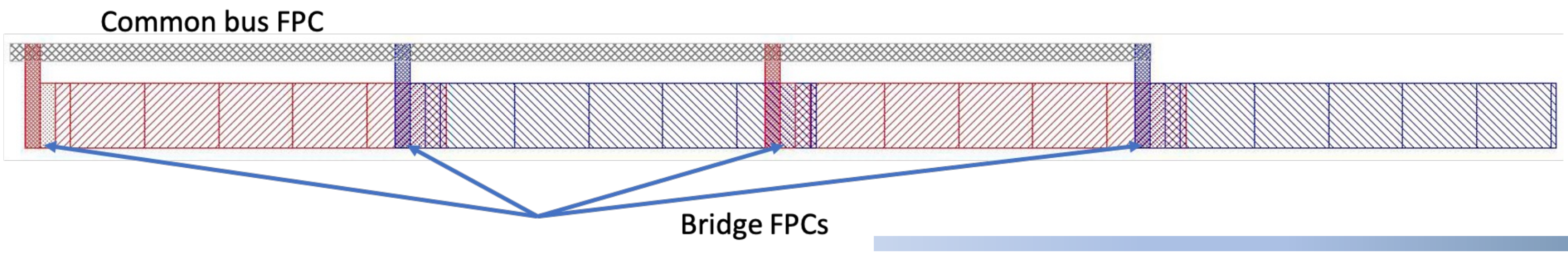
Credit: Jim Curtis

*design from before we had information about the AncASIC size & placement

Module grouping & FPC

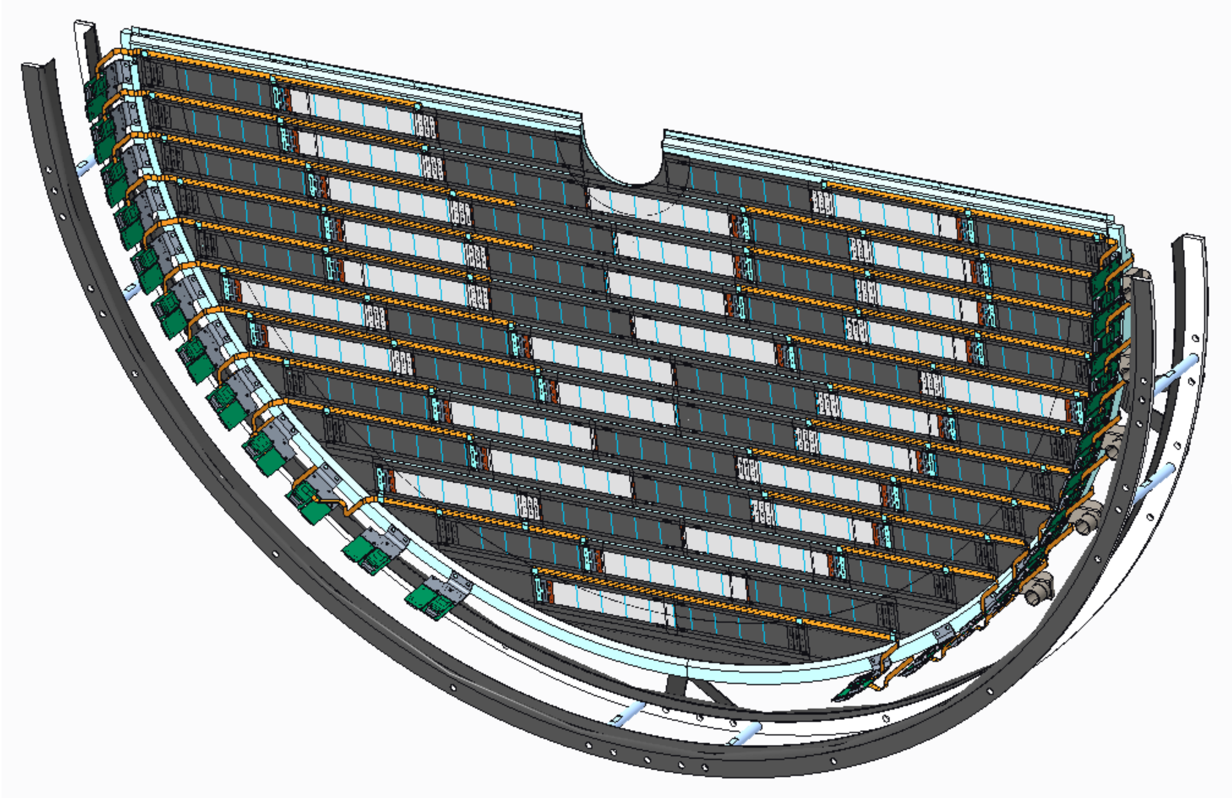


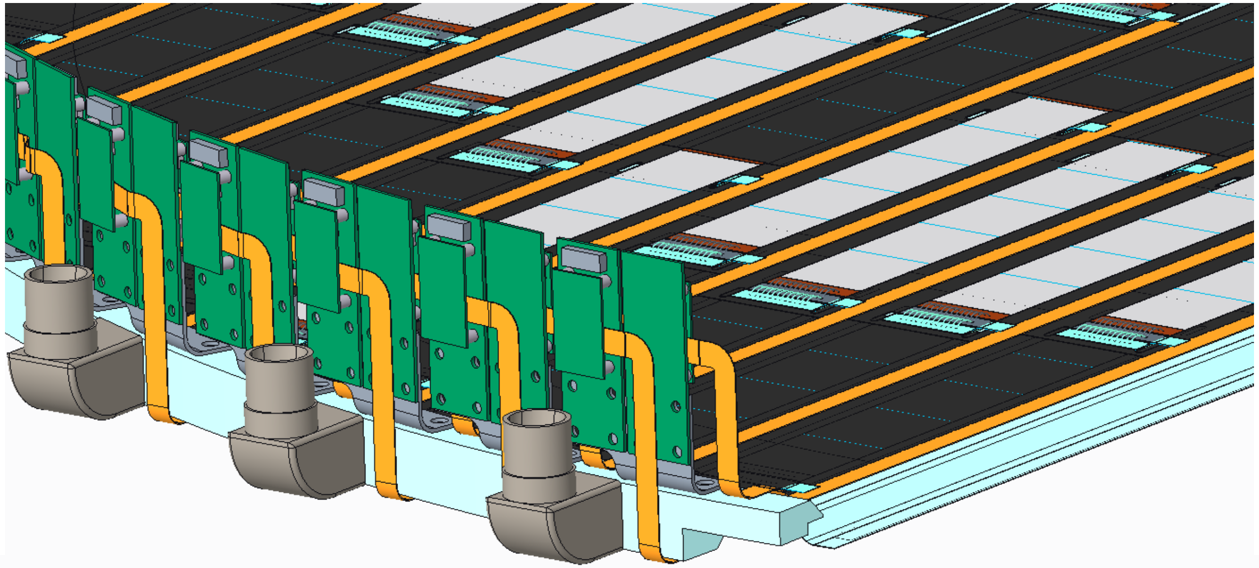
- 1 bridge FPC per module → up to 4 modules per common FPC
- Unlike OB, Discs need varying distances between bridge FPCs
- Bridge FPC & (likely) AncASIC will be bonded during module assembly
- Bridge FPCs need to connect to common FPC after gluing to corrugation
  - Bridge to common connection needs to happen on the disc → prefer to solder, otherwise disc needs to be moved to wire bonding machine

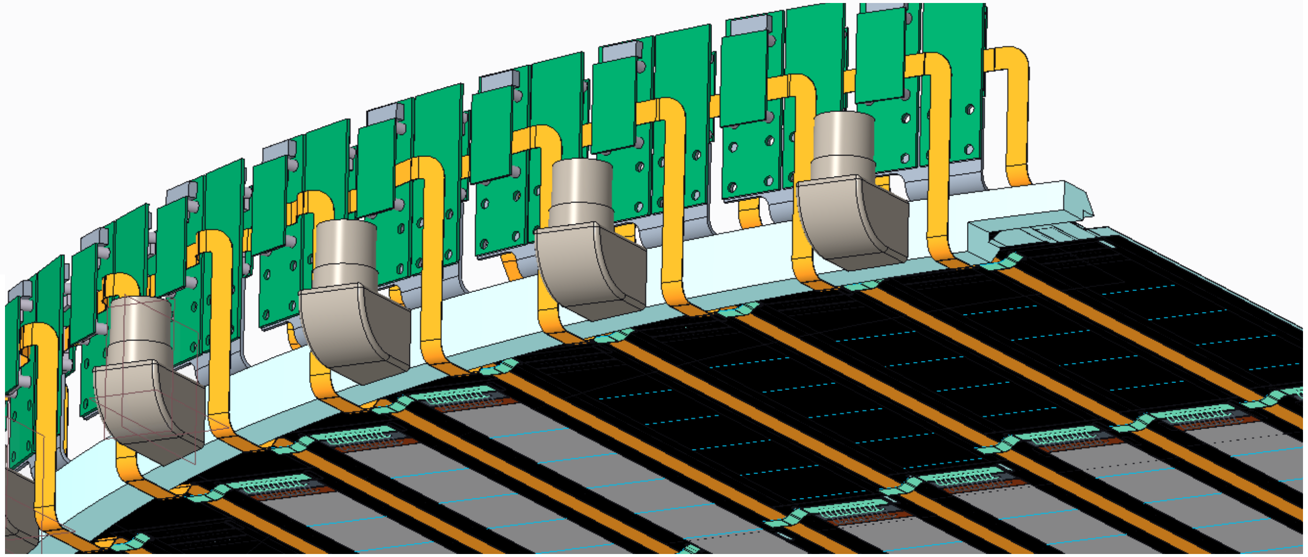


Credit: Jim Curtis

Readout boards

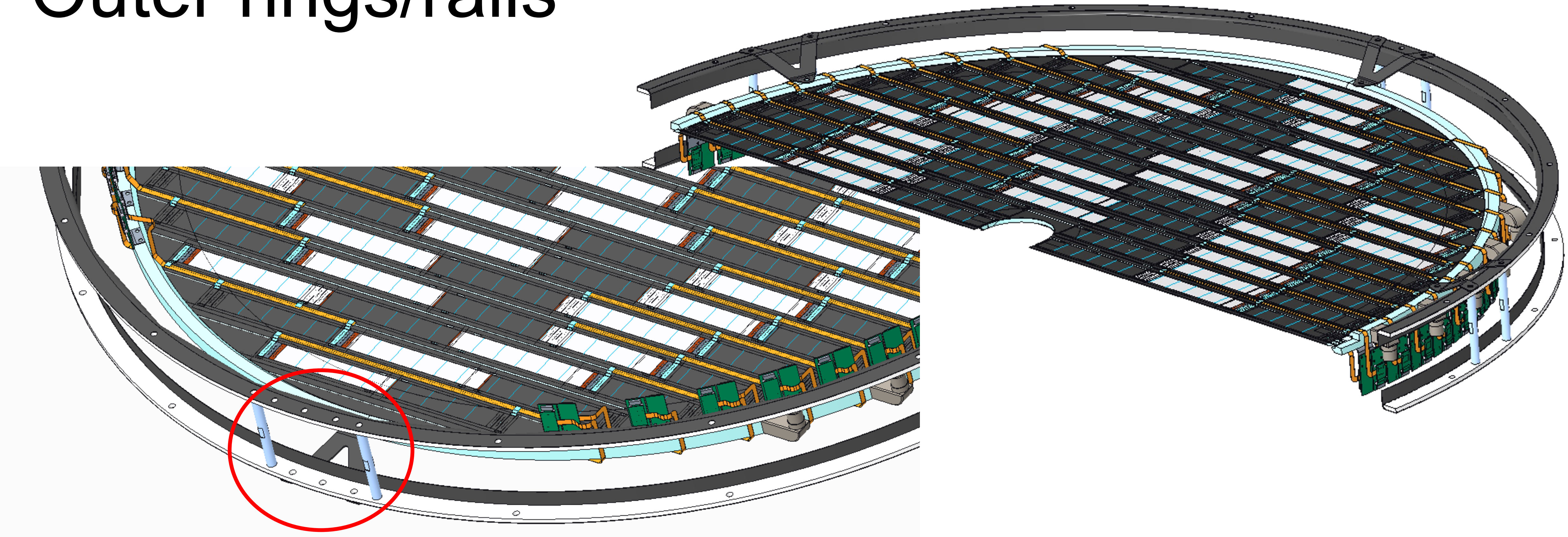






- Arranged around outer radius of disc
- Point away from IP
- Size and shape a first estimate
  - Needs refinement with new information

Outer rings/rails



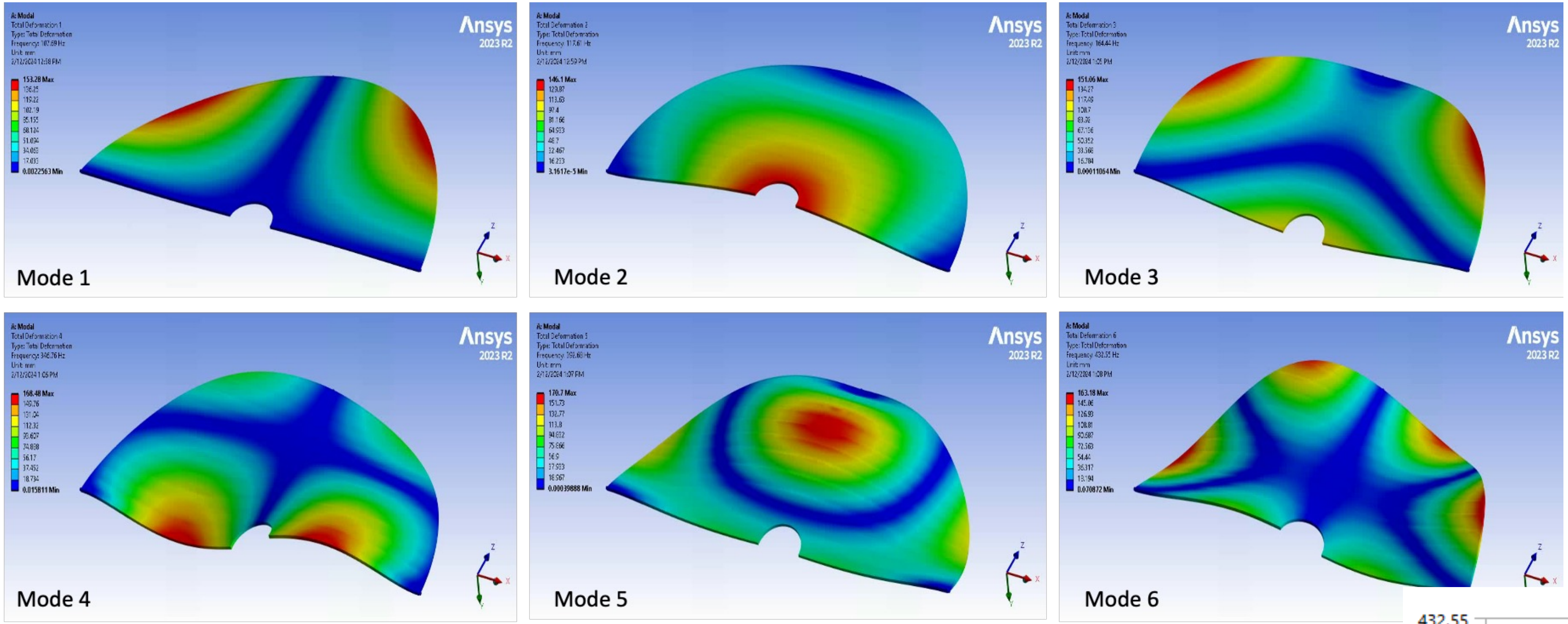
Outer rails allow for resting points for the discs during construction

- Outer ring provides structural support and sandwiches both sides of the disc
- Need for outer rail TBD depending on connection to support tube (IST)

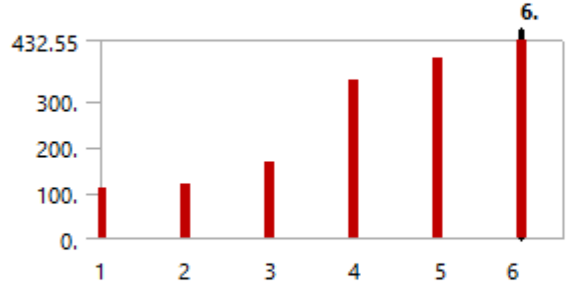
Credit: Jim Curtis

Natural frequency

Corrugated Disc of 6 mm Height – Rev 2 (Mesh size = 2 mm)



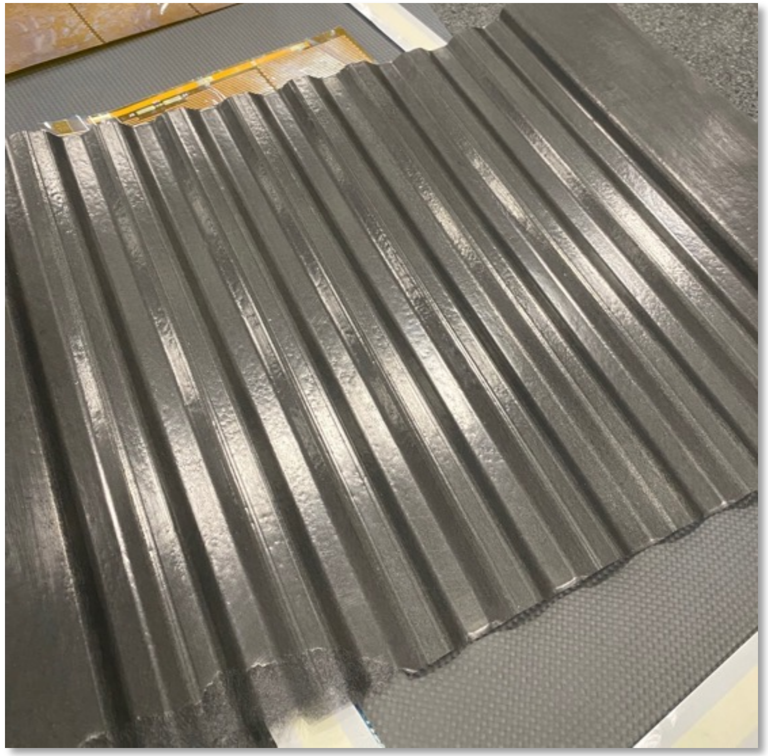
Mode	Frequency [Hz
1.	107.69
2.	117.61
3.	164.44
4.	346.76
5.	392.68
6.	432.55

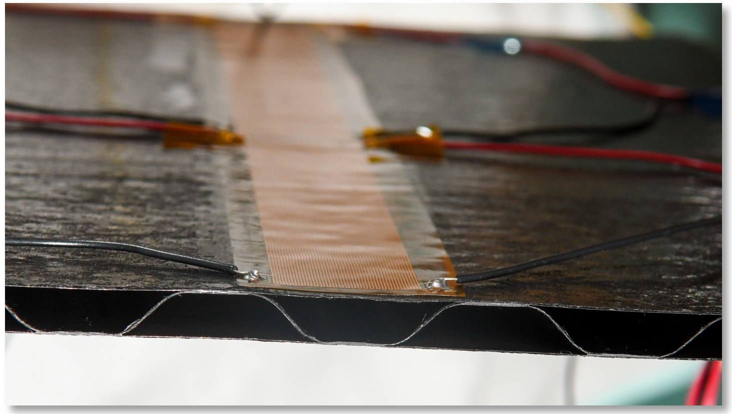


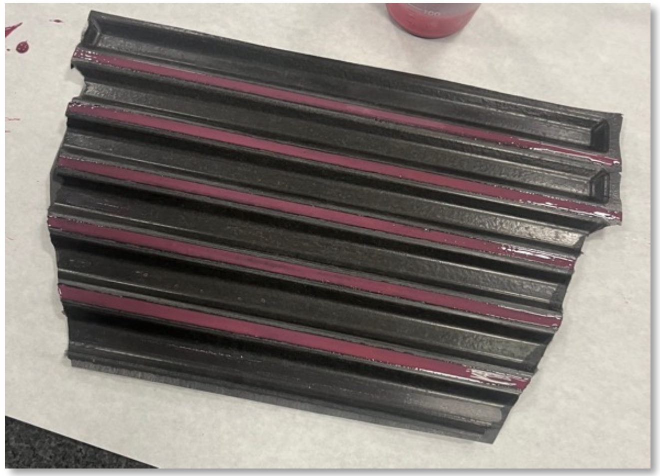
First mode > 100 Hz
Promising first result

First prototype test piece

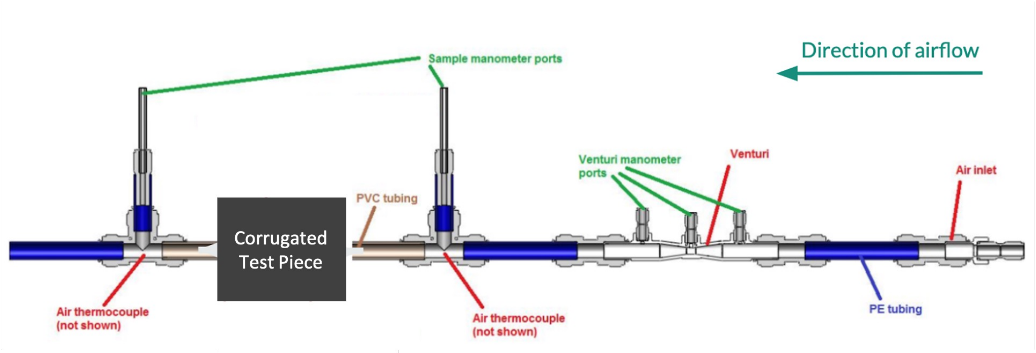
- 2 layers 34 gsm veil & 5 layers 10 gsm resin
- Face sheet glued with 9309 adhesive in 5 mm strips
- Density = 497 gsm → ~0.12% X/X_0



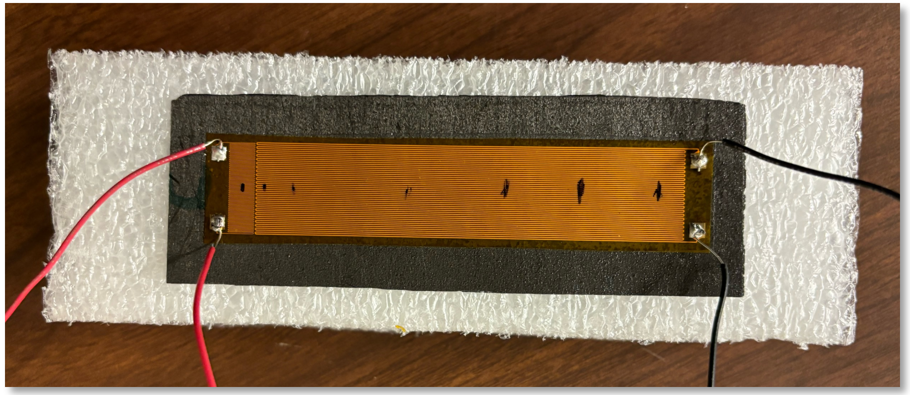


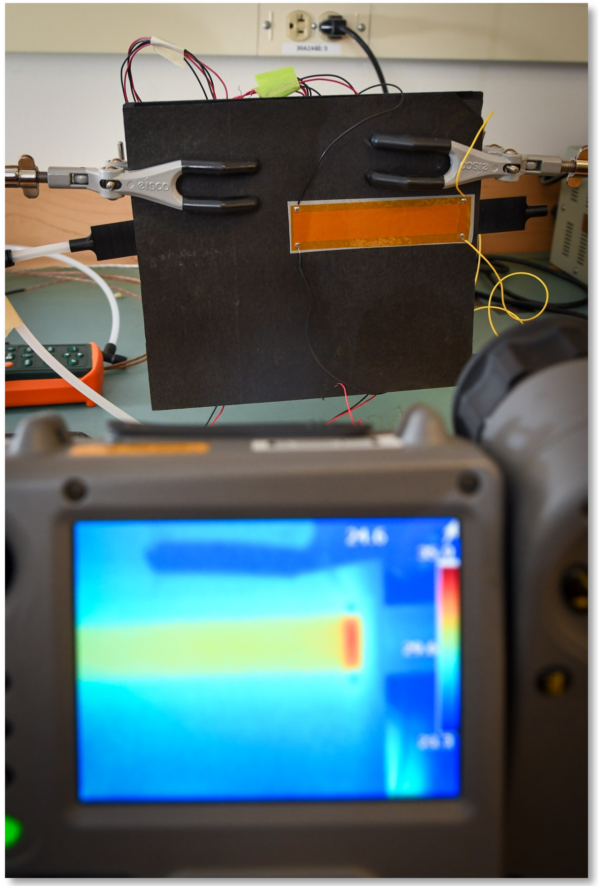


Discs: previous results

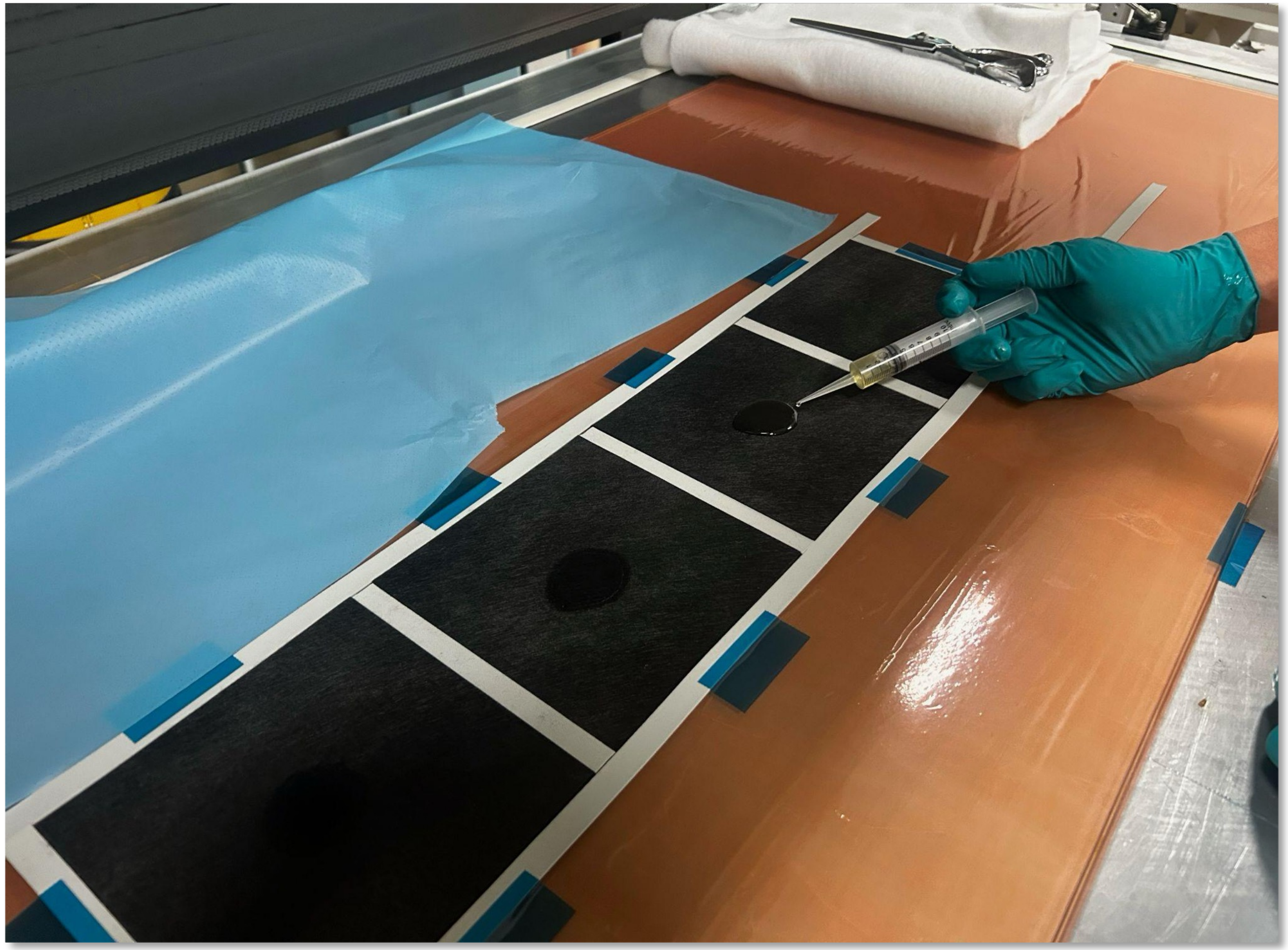


- [Cooling through corrugated carbon veil (first prototype)]
- [Thermal studies using PGS (graphite) & unidirectional carbon fiber (K13C2U)]



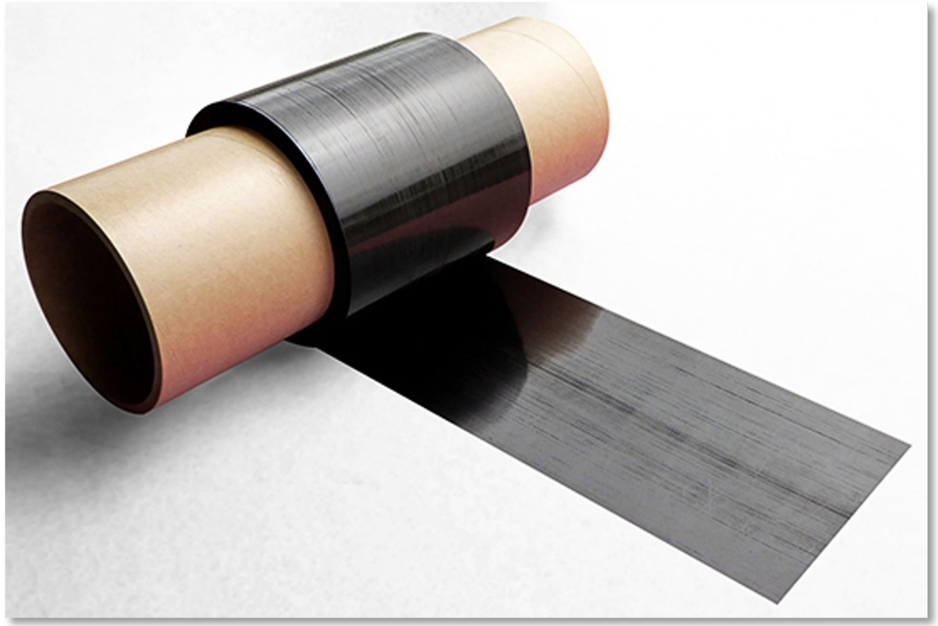


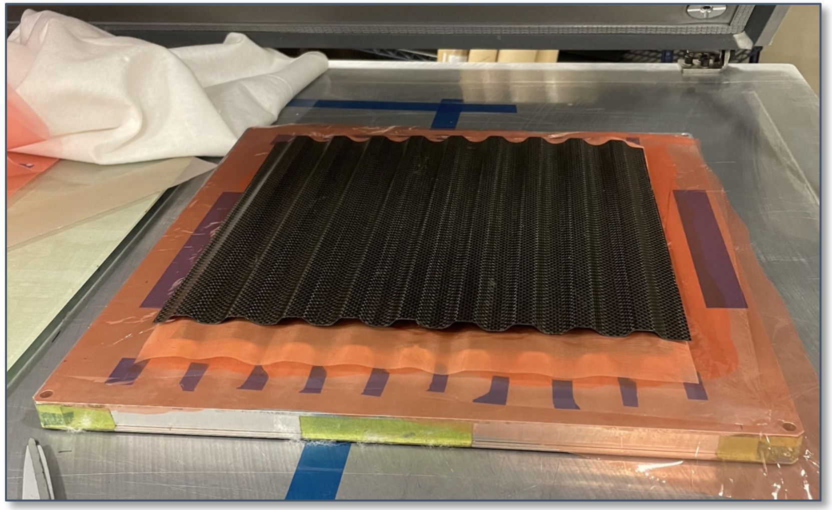
Carbon composite layup



- First prototype: Used carbon veil and 10 gsm resin
  - Veil was difficult to get on and off tooling and get fully wetted
  - Tried wet layup (liquid resin) → didn't spread evenly through the layers, mass is difficult to control
- Moved on to unidirectional fiber for next prototypes

New prototypes





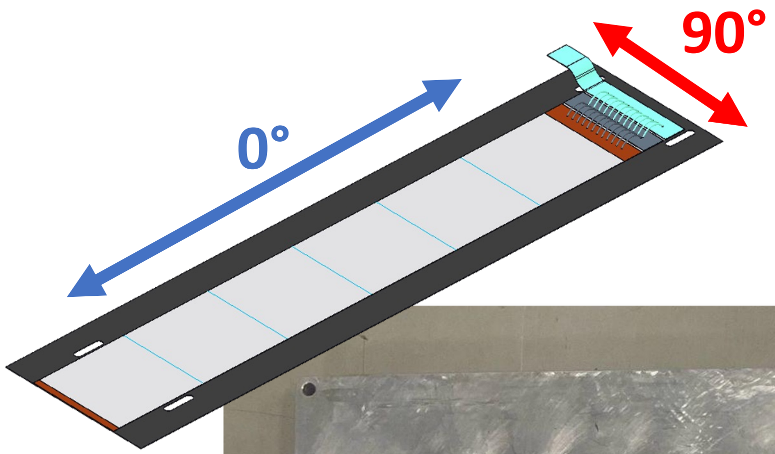
K13C2U Carbon Fiber
- unidirectional
- high thermal conductivity

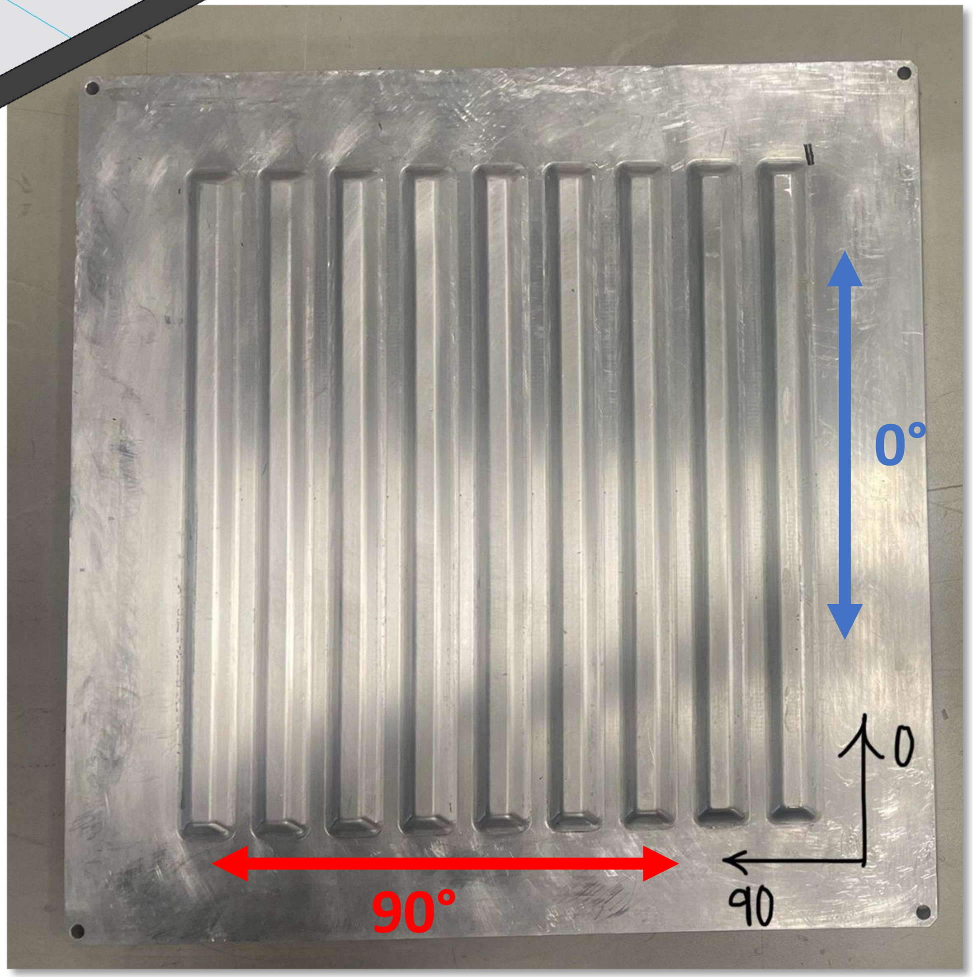
Caul plate created out of a heavy weave (CN80) to hold K13 in place and distribute vacuum pressure equally

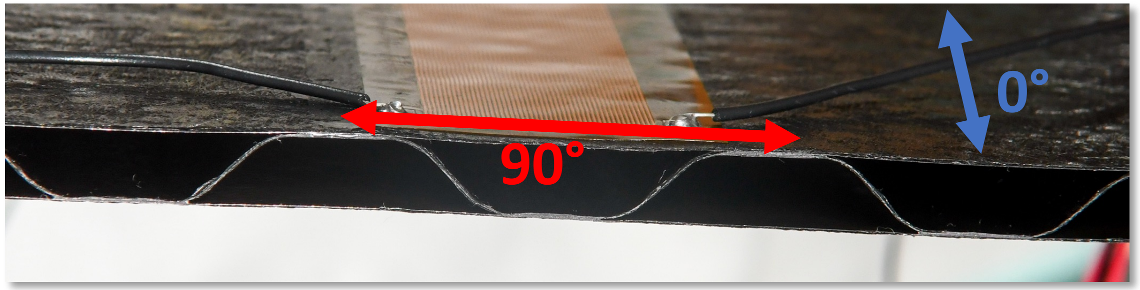
Credit: Skye Heiles

Layup orientation

- 0°: along the corrugation
- 90°: against the corrugation
- Tested two different configurations
  - 0/90/0 → thermal & mechanical advantage on module flat sheet
  - 90/0/90 → mechanical advantage for corrugation

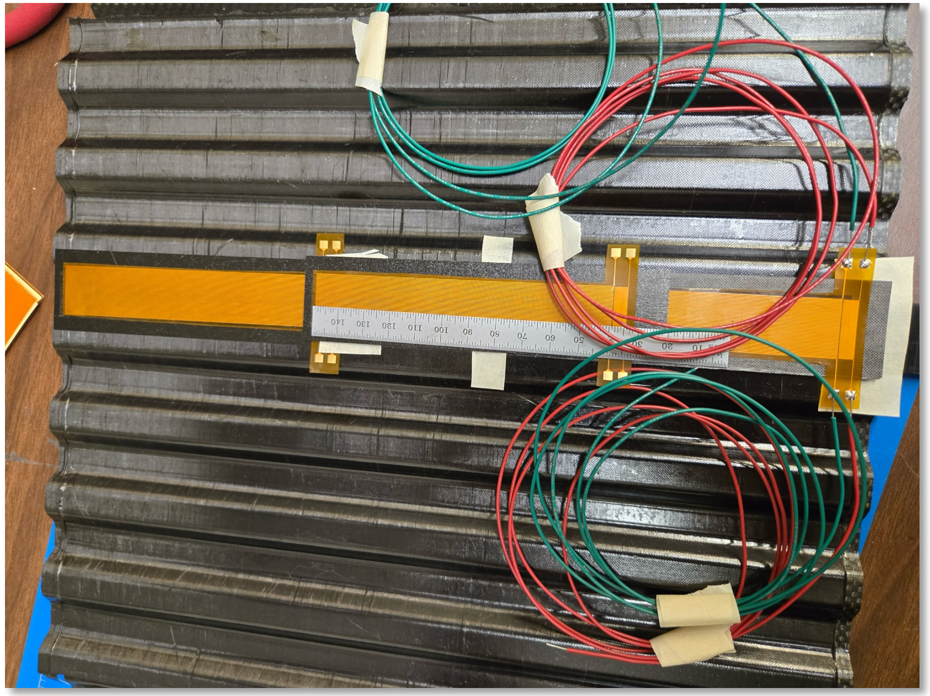






Credit: Skye Heiles

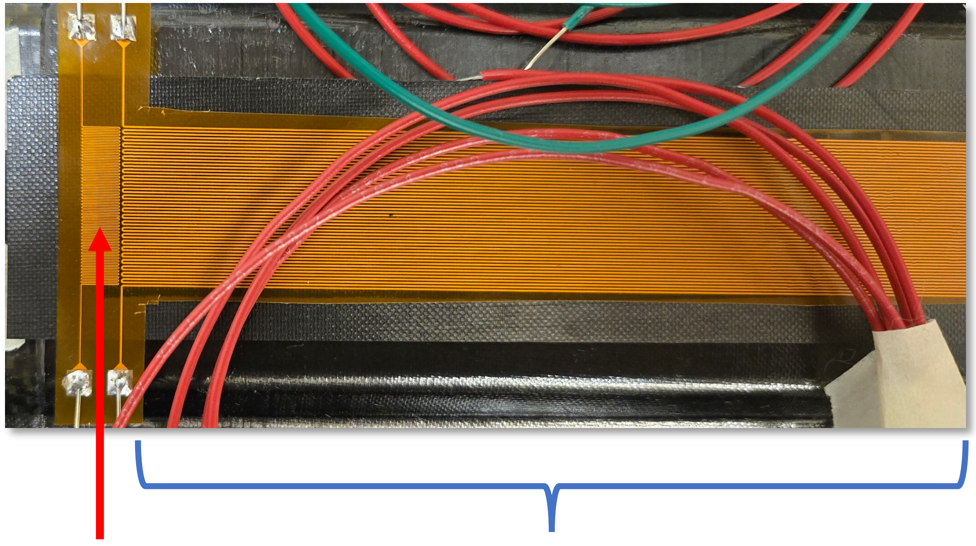
Second test piece

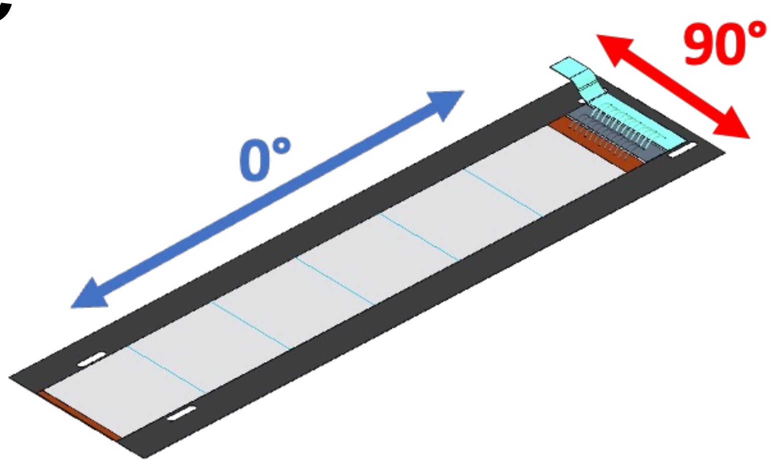


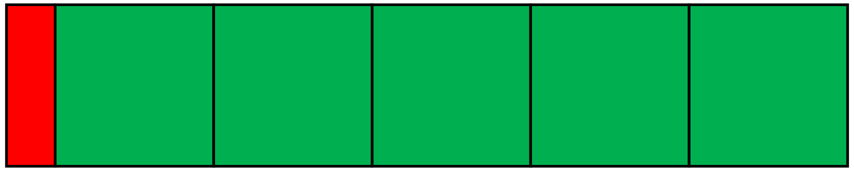
- Modules → size and shape close to expected
  - Width: 1.5 mm < pitch. Length: 1.5 cm > EIC-LAS
  - Refined carbon fiber cutting technique for straighter edges & better precision
- Attaching modules to corrugation
  - Using caul plate as support for the corrugation during module attachment
  - Lining up modules using tape and straight edges
- All adhesion done using 3M 467MP double-sided tape, 60 μm thick (used for STAR HFT)
  - Other glues to be tested (e.g. hysol 9309 for module to corrugation)

Modules: thermal performance

Heaters: 2 power regions

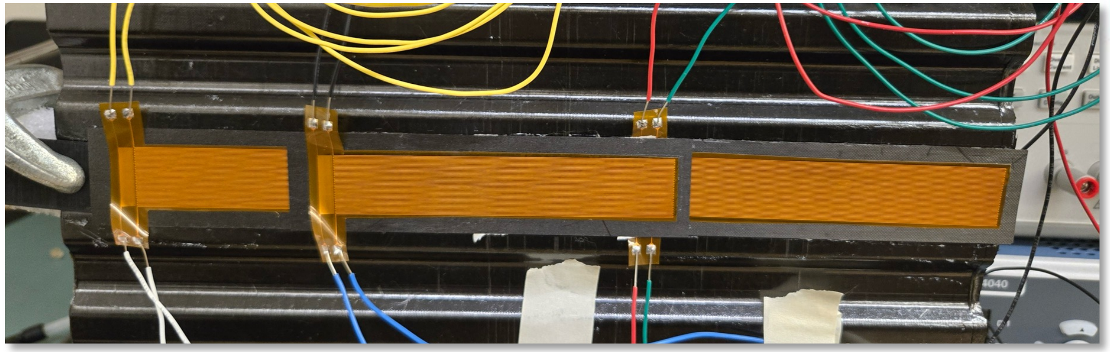






Each power region powered separately
Capable of a range of power densities

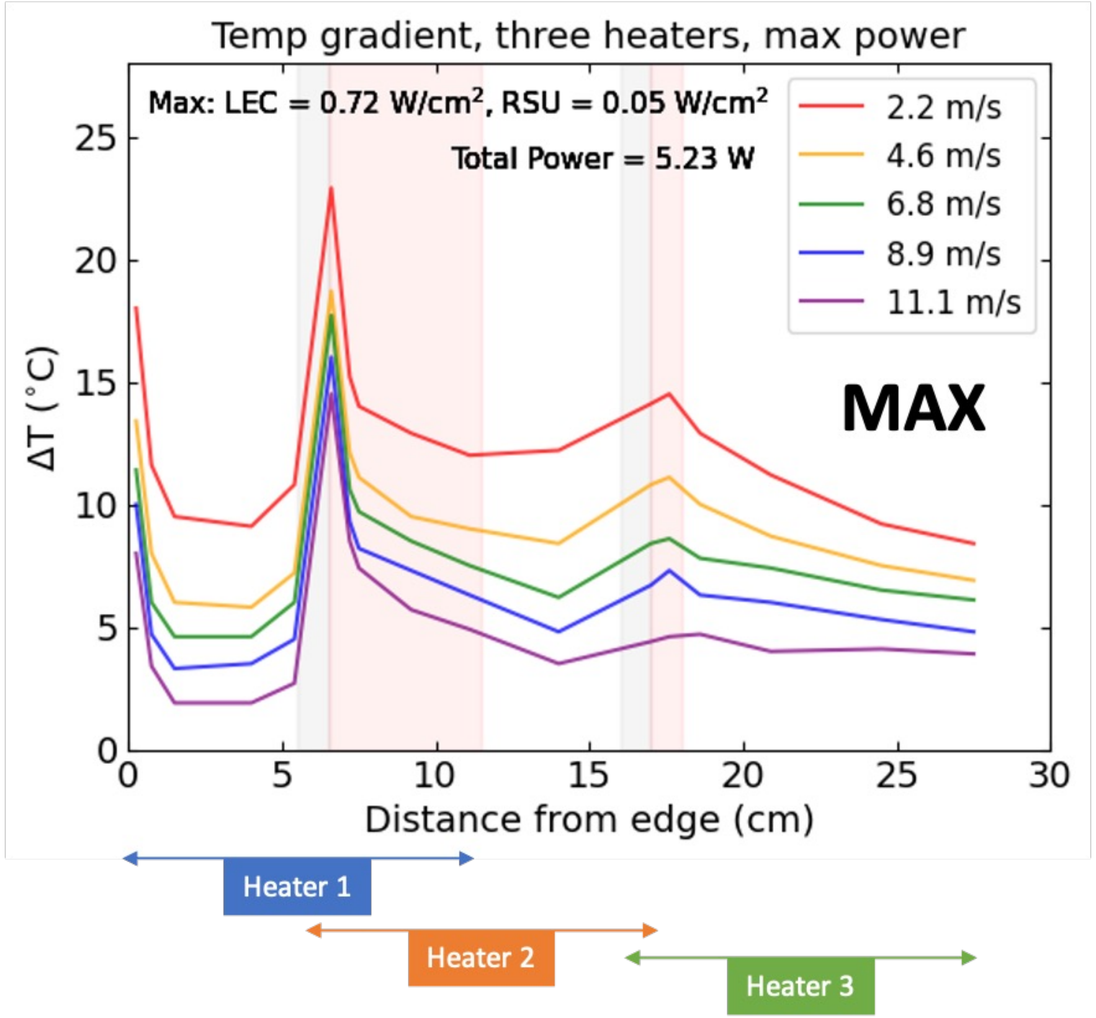
New thermal prototype

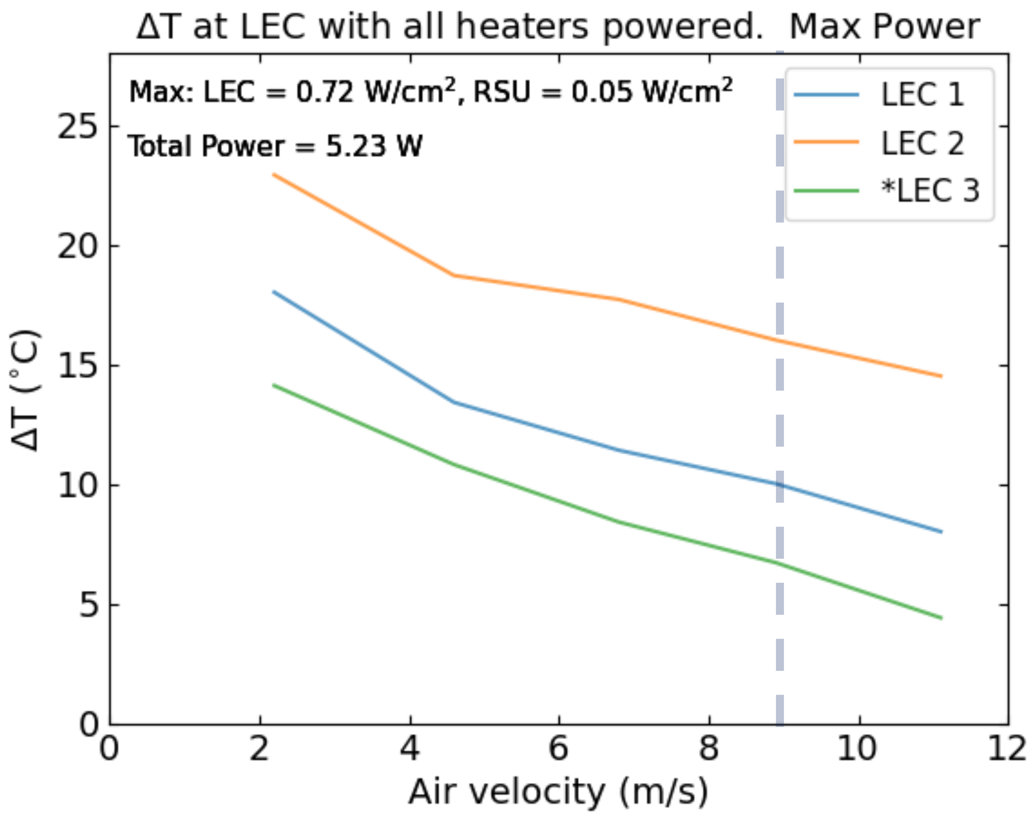


- Three heaters placed on one corrugated channel
- Two overlap regions
  - Large (~1/2 the heater length)
  - Minimal (~LEC length)
- Configuration: outward facing only
- Tested at two different powers, MAX and MIN (in this case, MIN is the nominal value given by the sensor designers)
- Held in same orientation as planned in ePIC

New thermal results

[Tuesday's presentation on cooling]



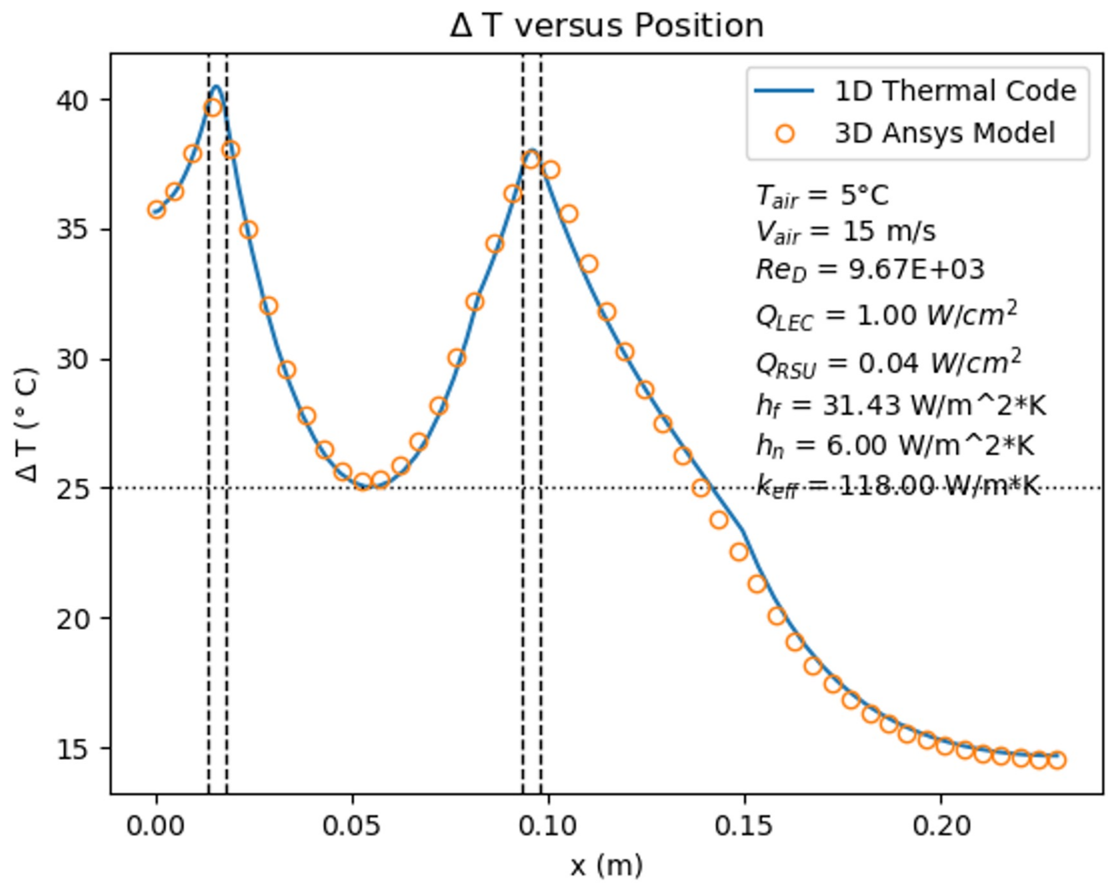


At 9 m/s:

RSU ΔT < 10°C for MAX and < 5°C for MIN

LEC ΔT < 20°C for MAX and < 15°C for MIN

Thermal FEA



One example: Air velocity and temp to be further explored

- 1D thermal code for quick changes and system wide calculations
- Comparison to 3D Ansys model shows good agreement
- Working on comparing to test bench results
  - Shape matches well to overlap test bench data

Credit: Nick Payne

Next steps/plans

- Continuation of thermal studies → add AncASIC thermal dummy. ***1 month***
- Develop tooling for module prototyping → sensor handling and alignment
  - First set needs to be ready for dummy sensors. ***2-3 months***
- Develop tooling for disc prototyping → module handling and alignment
  - Develop in parallel to module tooling. ***3-4 months***
- Vibration study of corrugation in wind tunnel ***2-3 months***
- Mechanical model and FEA ***Continuous***
- Thermal model and FEA. ***Continuous***
- Module prototypes
  - With dummy silicon for handling, alignment, tooling, mechanical tests. First pieces ready before thermomechanical dummies arrive. ***Late spring '25***
  - With thermomechanical dummies for thermal studies → intent to be ready as soon as thermomechanical dummies are available. ***Late summer '25***
- Disc prototypes (after module prototypes)
  - With dummy mechanical modules for handling, alignment, tooling, mechanical tests ***Late spring, early summer***
  - With thermomechanical dummies for thermal studies ***Late summer, early fall***
  - Tooling checks for gluing on both sides of the disc ***Over the course of the year. Finalization towards end '25***

Backups

Sensor Power Regions

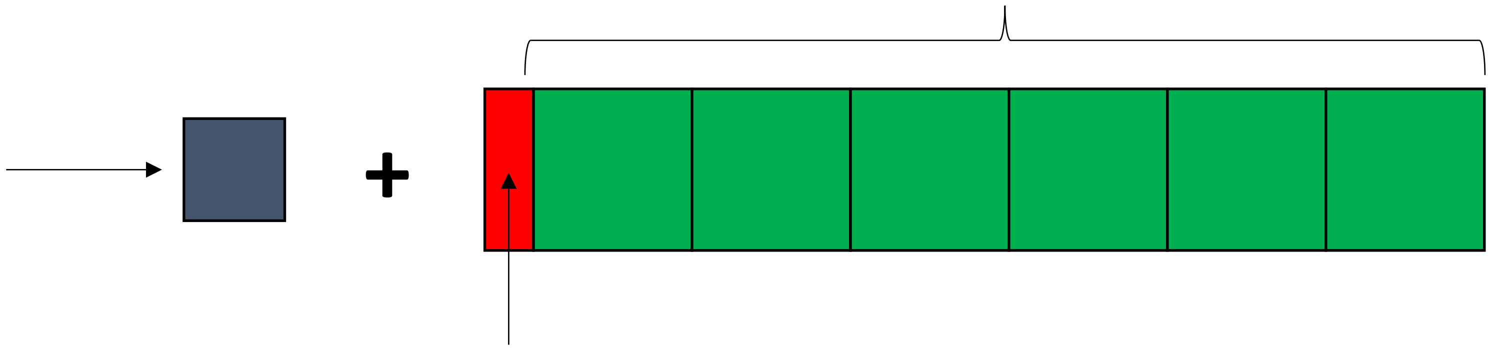
*Snapshot → new numbers shown today

Information from Iain and Georg's presentations at previous SVT meetings*

EIC-LAS

5-6 RSUs
Max: 0.05 W/cm2
Min: 0.03 W/cm2

AncASIC:
Max: 45% of LAS
Min: 35% of LAS



LEC
Max: 0.72 W/cm2
Min: 0.48 W/cm2

Total power (6 RSUs)
Max: 1.89 W
Min: 1.21 W

MOSAIX: same power densities as EIC-LAS