Cooling Studies 4/15

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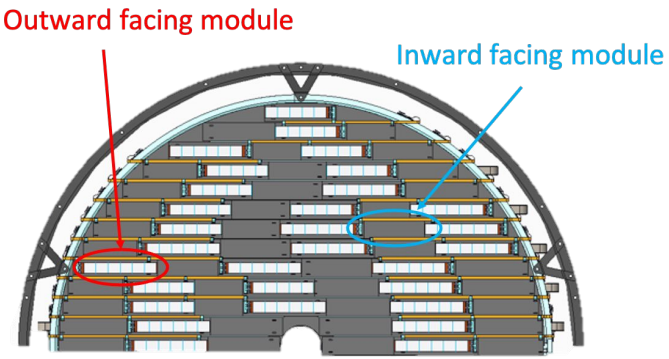
Goals

Simulate thermal performance of full disks

We want to extract several parameters from our heater measurements:

- Thermal transfer coefficient - h
  - $h = q/\Delta T$
  - q = power density
  - ΔT= difference between surface and fluid
- Natural convection coefficient



Single Row Corrugation Measurement - Setup

Copper trace heaters (1.9 cm x 10.833 cm) -> corresponds to 5 RSU EIC-LAS

K13C2U corrugated carbon fiber backing

Heaters connected to PSU and room air

Using a thermal camera, these are measured at two power densities:

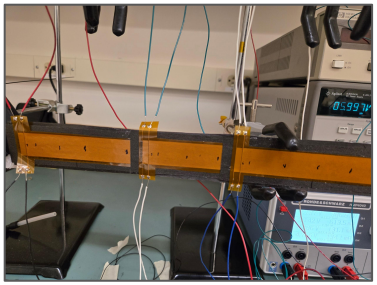
Nom: LEC 0.48 W/cm^2 RSU 0.03 W/cm^2

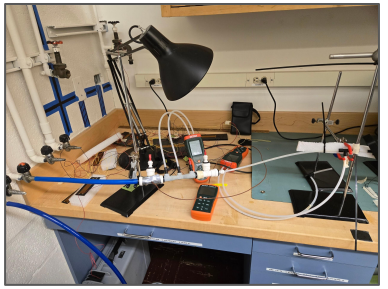
Max: LEC 0.72 W/cm^2 RSU 0.05 W/cm^2

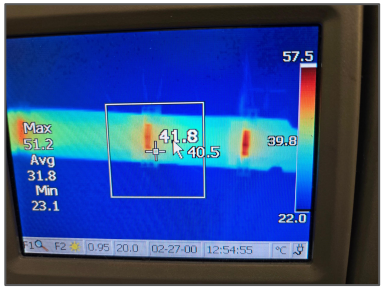
Three different air speeds:

4.6 m/s, 6.8 m/s, 8.9 m/s

Air speed measured with manometer



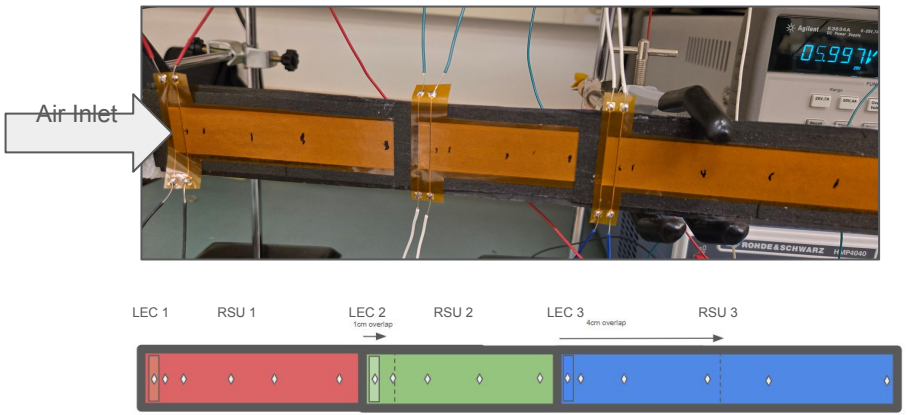




Measurement Setup - Measurement Points and Overlap

Measurement points chosen at LEC, start and end of RSU, start and end of overlap, and center points of RSU

Measurement taken as ΔT - difference between temperature of heaters with power off and with power on

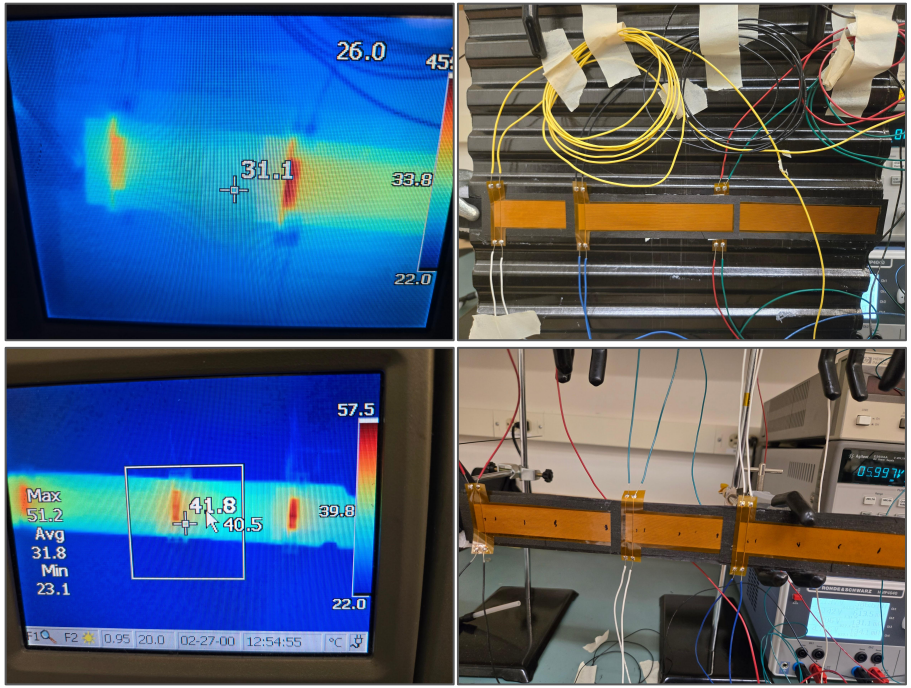


Single Row Corrugation Measurement

To provide input to the simulation, we needed to create single row of corrugation.

Minimizes heat conduction through the corrugated carbon

Helps to isolate the natural convection and forced convection components



Top: Large corrugation and thermal measurement
Bottom: Single row of corrugation and thermal measurement

Measurement vs Simulation

Simulations of single row provided by Nick Payne

In simulation and measurement:

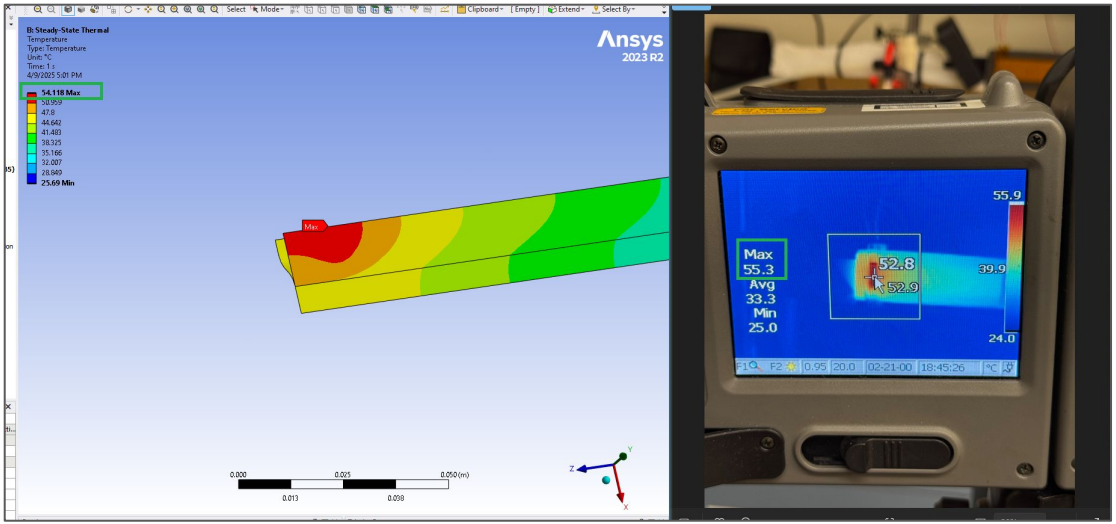
No forced convection, only natural convection. This is to attempt to isolate natural convection coefficient.

Coefficient simulated to be 10 W/m^2*C

Simulation and measurement are in close agreement (54.118 C vs 55.3 C)

Assumed room temperature is slightly different

Heating pattern is similar

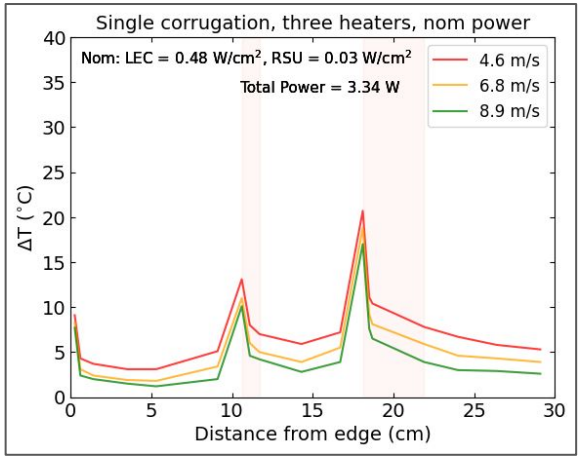


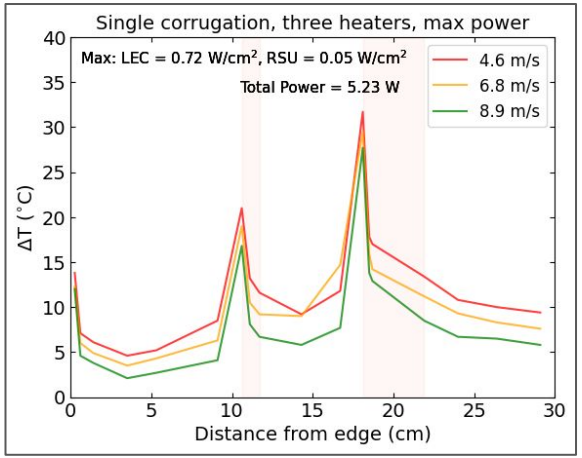
Temperature along the corrugated channel

First time directly measuring LEC 3

deltaT of LEC3 is significantly higher than other LECs. This could be from the air being heated as it travels down the corrugation

This data, and follow up measurements, are still being analyzed

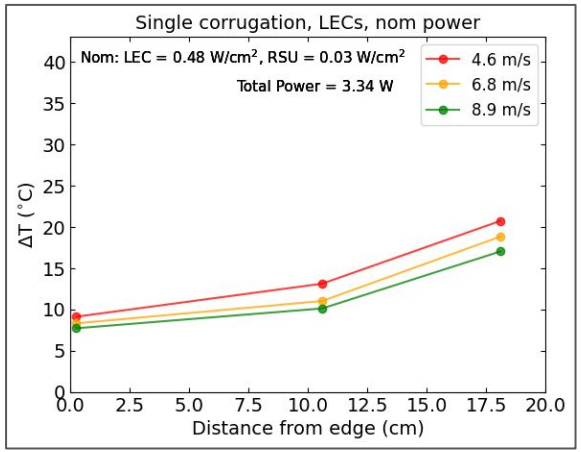


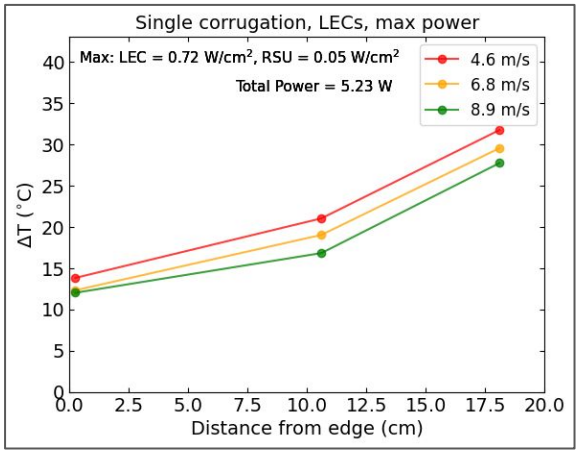


LEC Temperatures vs Distance for Varying Air Speeds

Air cooling has greater effect on LEC 3 at higher air speeds

Particularly at max power

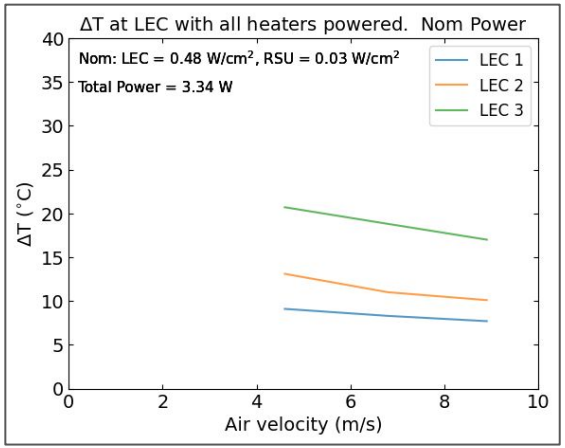


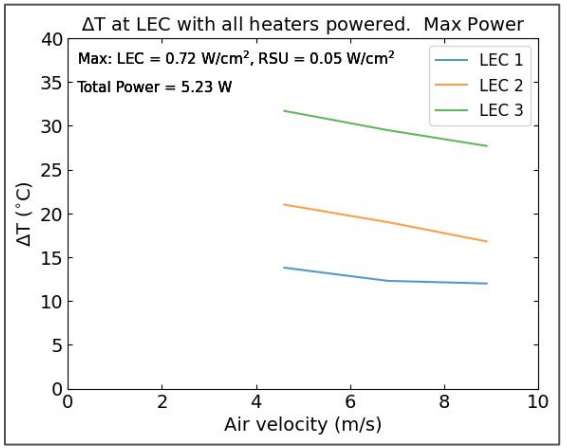


LEC only Measurements at Varying Air Temperatures

Each LEC is isolated for each air speed to see the effect on just the LEC temperature

LEC 1, the closest to the inlet, is the least affected by the change in air speed

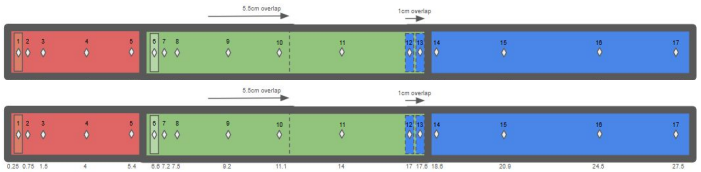




Three Rows - Under construction

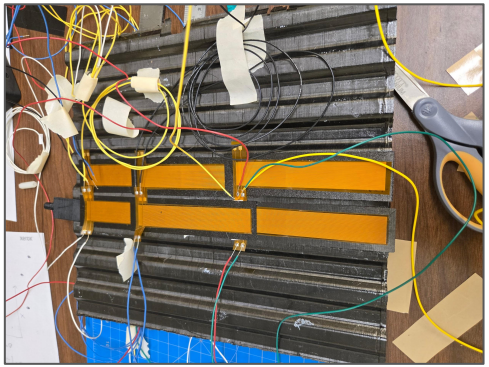
Create three adjacent rows of heaters

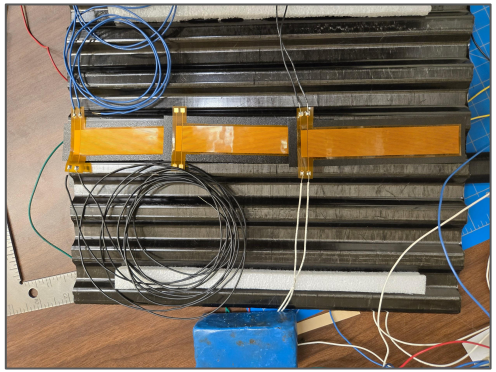
LECs of each row are aligned



Heaters are tiled so that LECs are visible and measurable

On reverse side (bottom image), alignment and tiling is the same



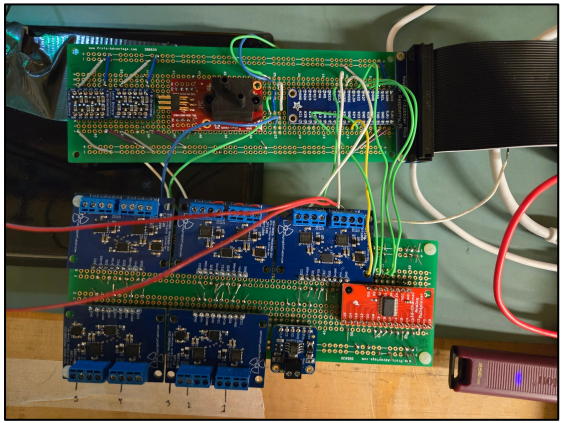


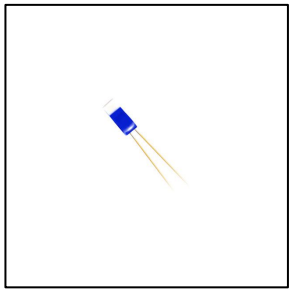
PT100 Measurements

We plan on using PT100 Resistance Temperature Detectors to measure temperatures inaccessible to thermal cameras. Especially important for measuring inward facing modules.

2-wire sensors chosen for minimal profile -> does not disrupt airflow

Using Raspberry Pi 4 as readout of sensors





Pt100 Progress

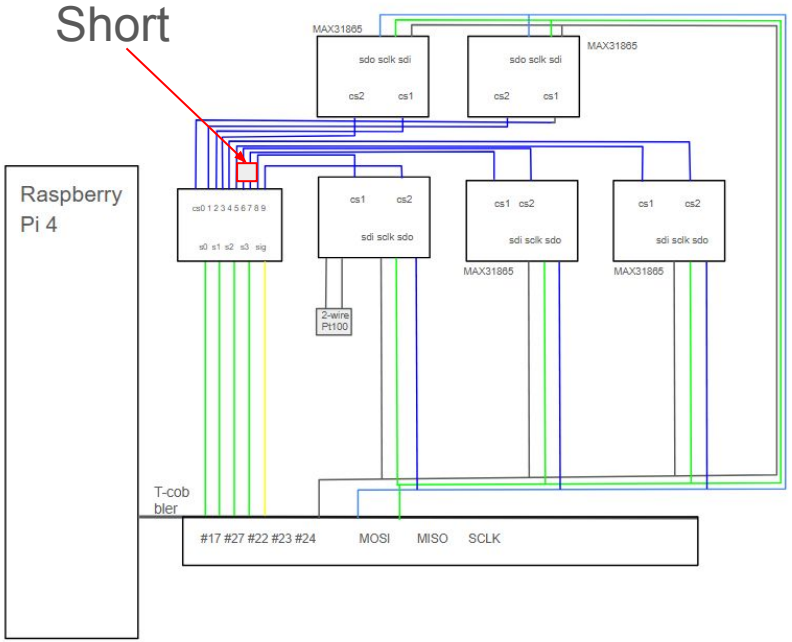
Short discovered in setup -> desoldered ADCs and are resoldering in a new topology

Pt100s are intermittently working

Spencer Klein is providing guidance

Clock speed of chip may be inaccurate compared to documentation

Current strategy is to test the chips with oscilloscope

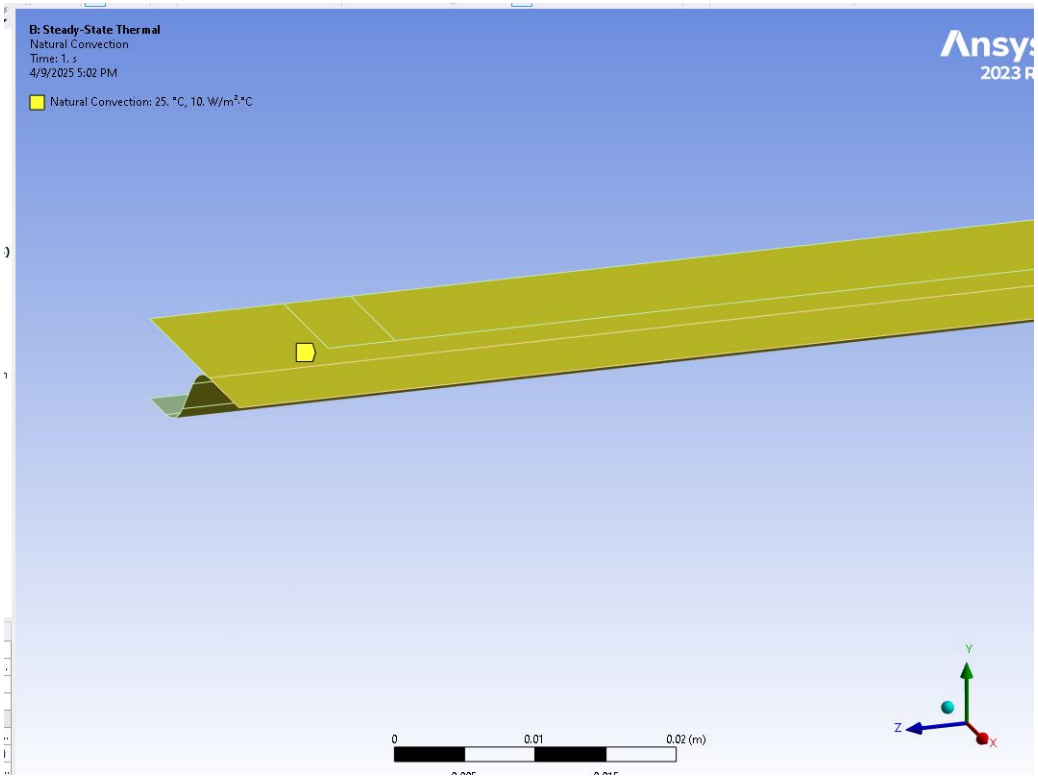


Future Work

Measure air temperature emerging from outlet of corrugation

Create inward facing modules and attach Pt100s

Create and measure 2 more rows of modules on carbon fiber sheet


B: Steady-State Thermal
Natural Convection
Time: 1. s
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Natural Convection: 25. °C, 10. W/m²·°C
Ansys
2023 R
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