Thermal Analysis of BIC(Barrel Imaging Calorimeter)

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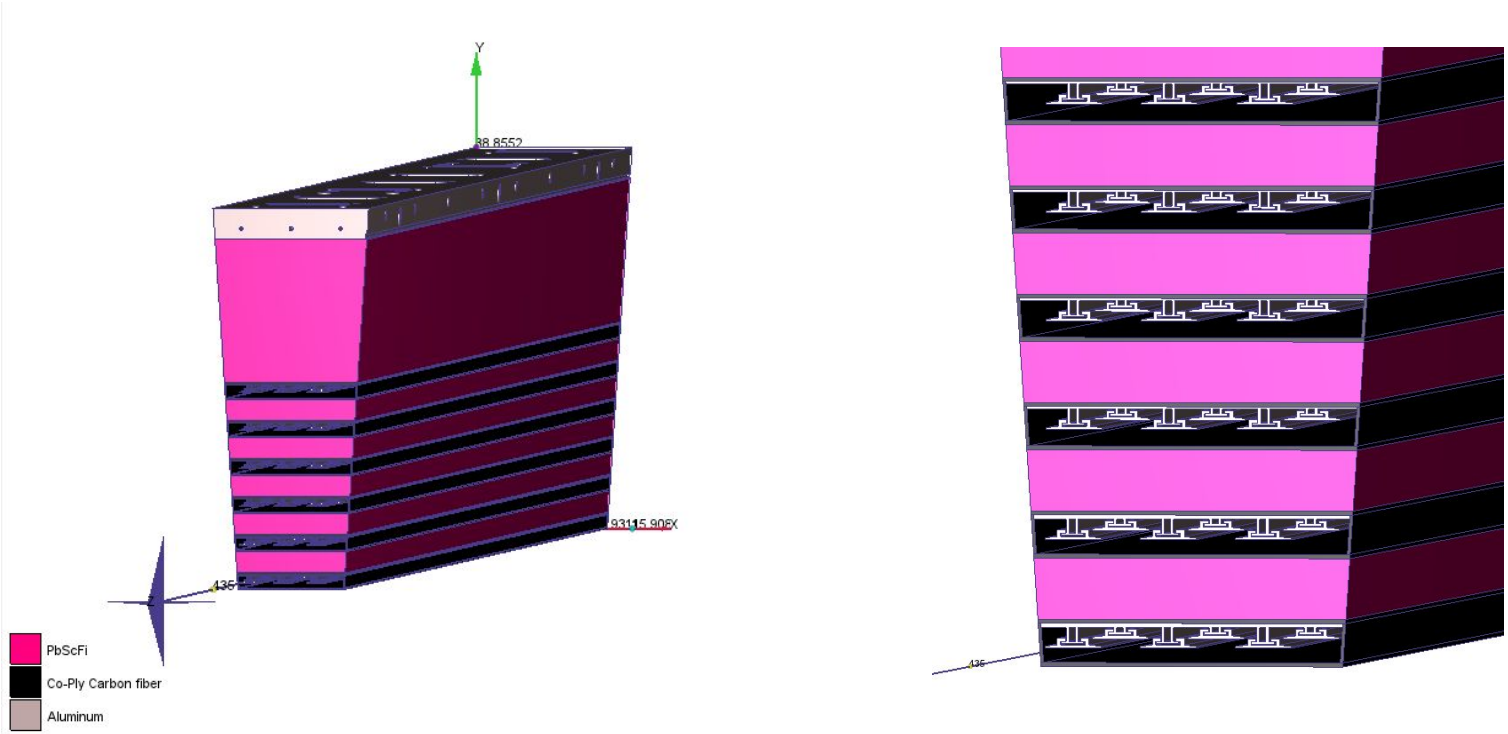
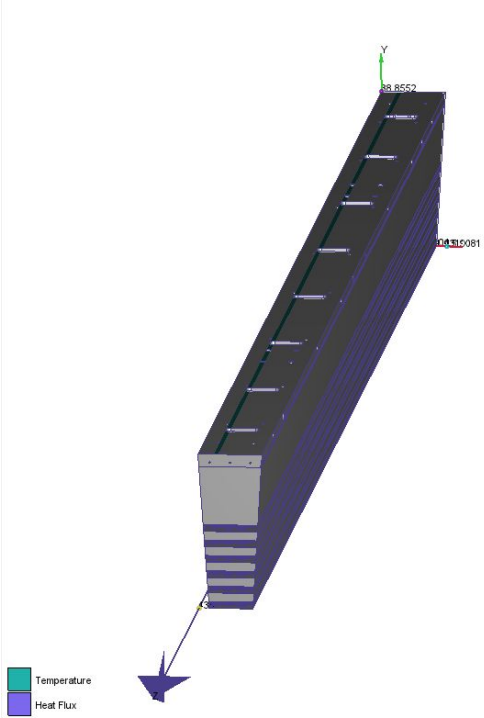
Single Sector with Sliding Trays for Astropix Sensors with new Carbon Fiber Material

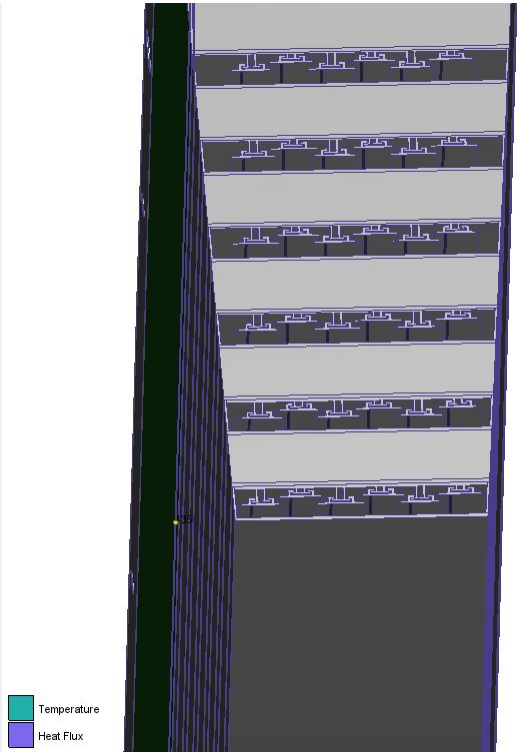


Thermal Conductivity of Carbon Fiber
Source: https://www.physics.purdue.edu/jung/tc-data/index.html

Boundary Conditions

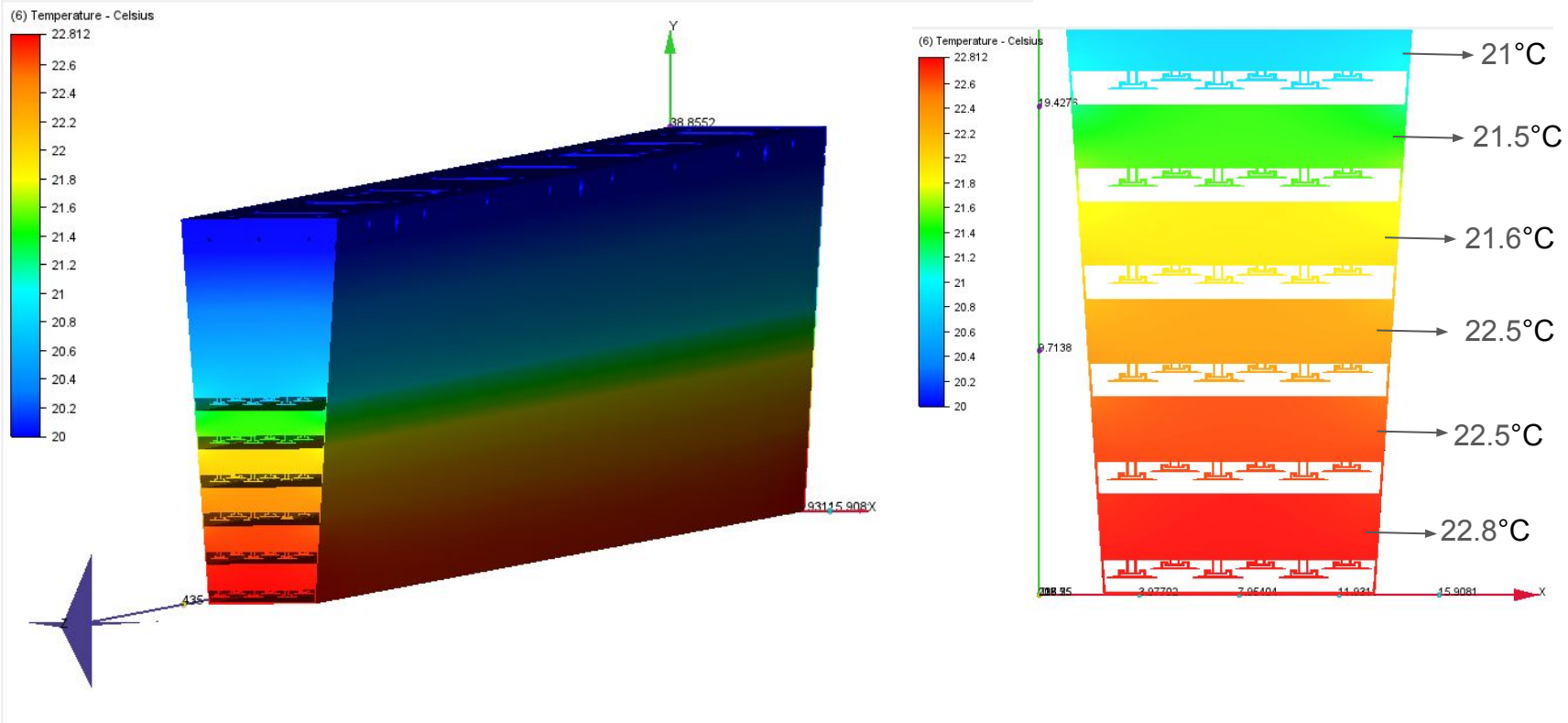


Boundary condition: Temperature as 20°C



Boundary condition: Heat flux as 0.002 W/cm² on the Astropix sensor trays.

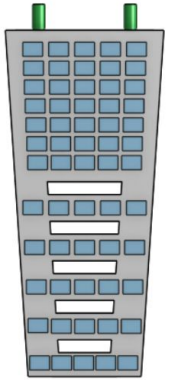
Simulation results

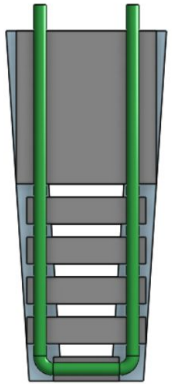


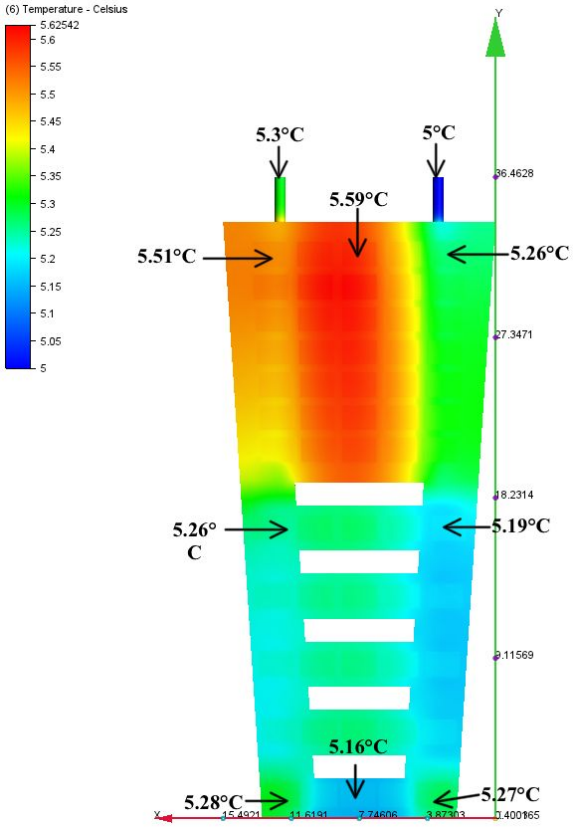
End of Sector Box

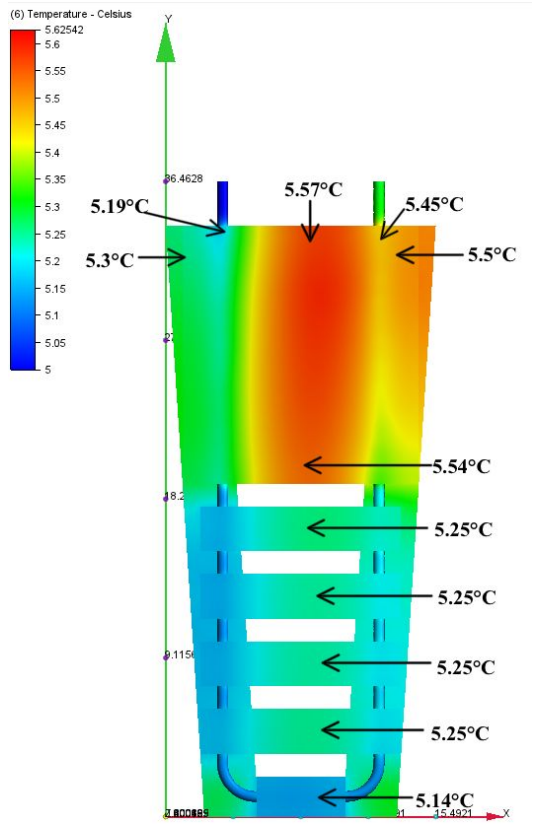
Boundary Conditions

- **Temperature of water at the inlet:** 5 °C
- **Inlet volumetric flow rate:** 0.3 gal/min
- **Outlet pressure:** 0 Pa
- **Heat flux at each SiPM:** 0.0464 W/cm²





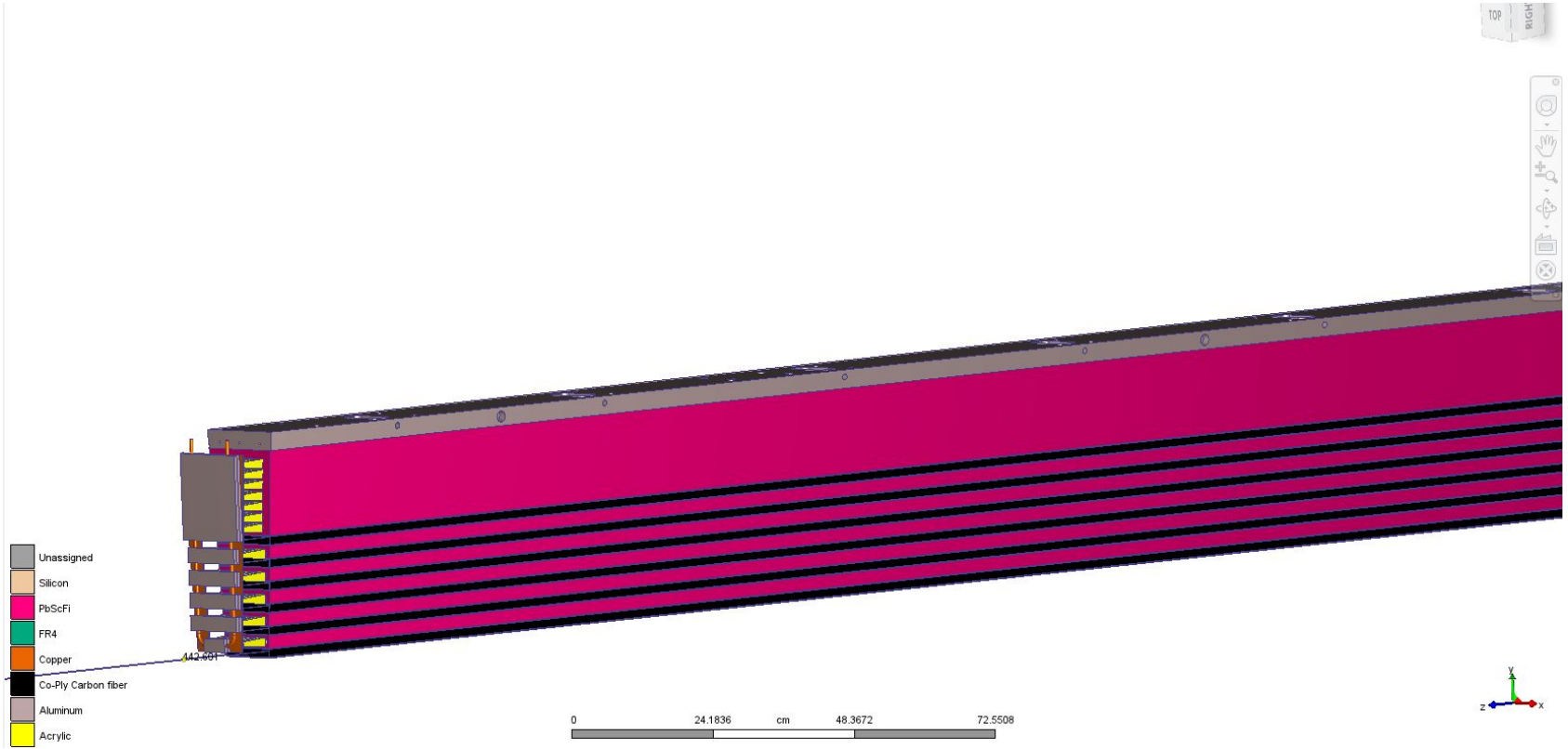




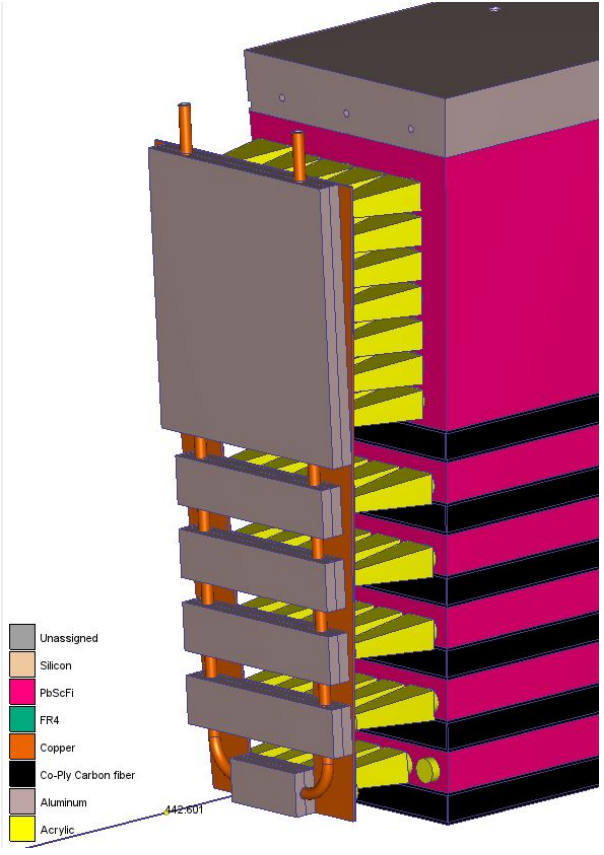
Current Status & Next Steps

- Cooling provided to the sector: **20 °C**
- Future integration: **ESB will be connected to the system**
- **SiPM temperature requirement:**
  - Must be maintained at **~7 °C**
- **Simulation results (standalone SiPM model):**
  - With water at **5 °C**, SiPMs remain within the required temperature range
- **Key concern during integration:**
  - Will heat from **Astropix** propagate to SiPMs?
  - Potential risk of **SiPM temperature increase**
- **Next step would be to produce results for the integrated model.**

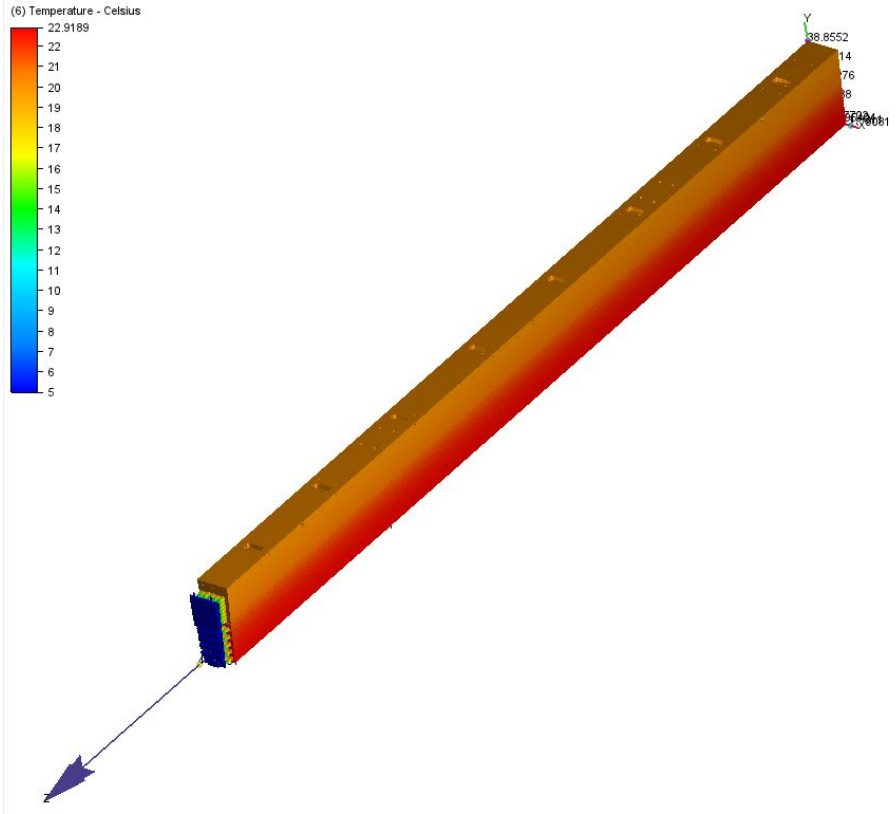
Integrated Model



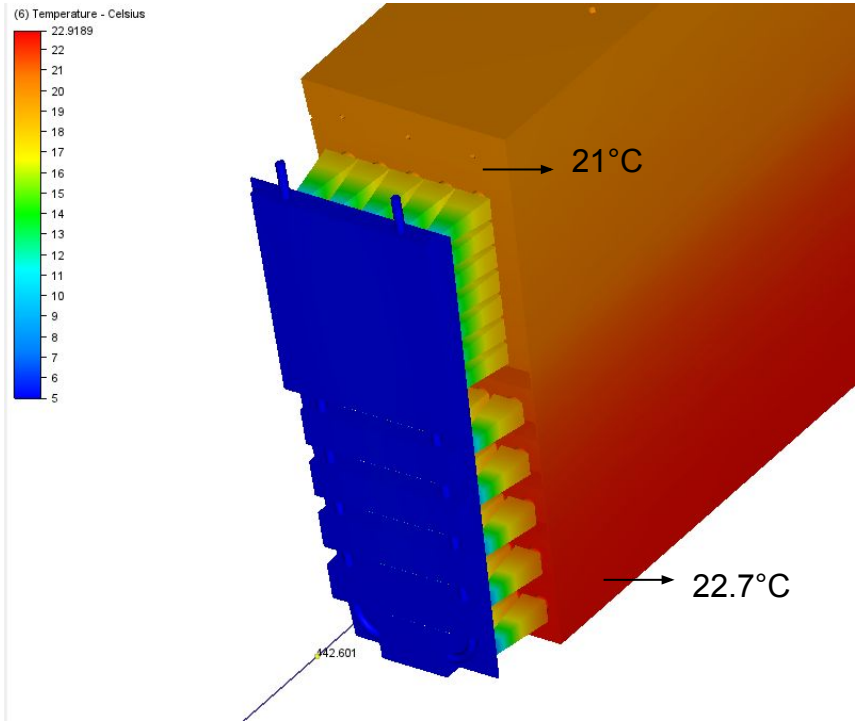
Integrated Model

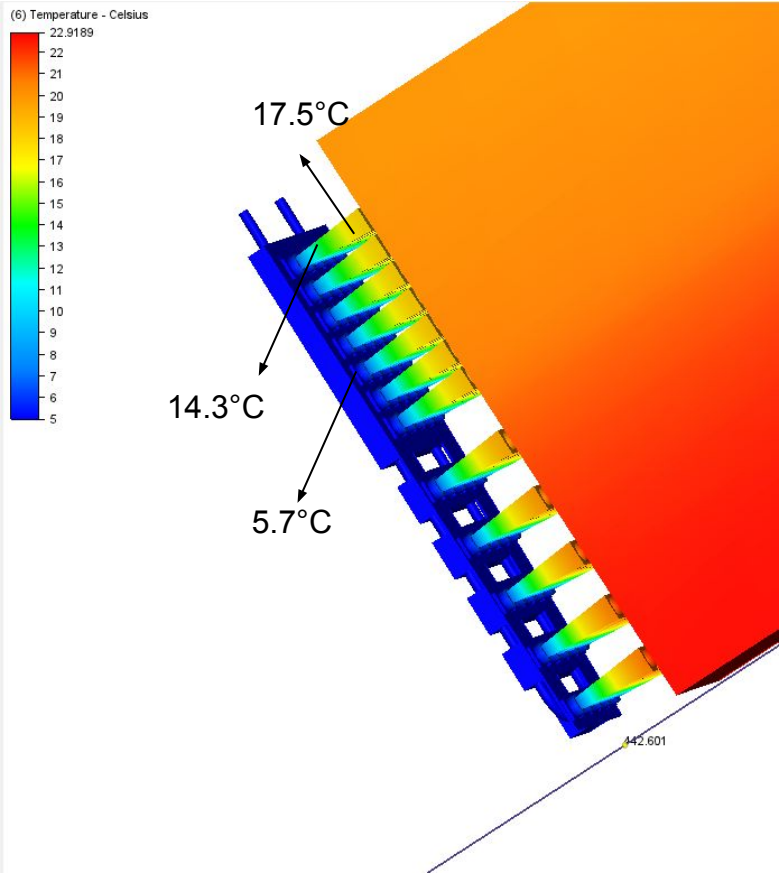


Simulation Results for the Integrated Model

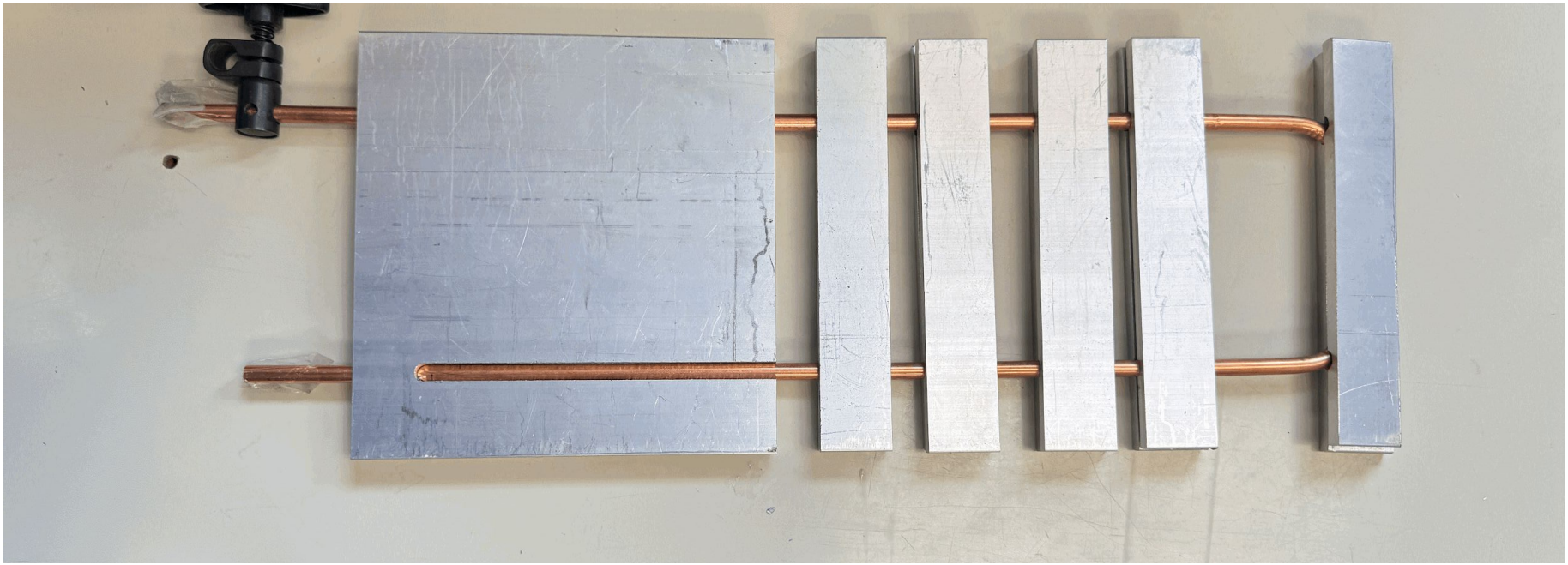


Simulation Results for the Integrated Model





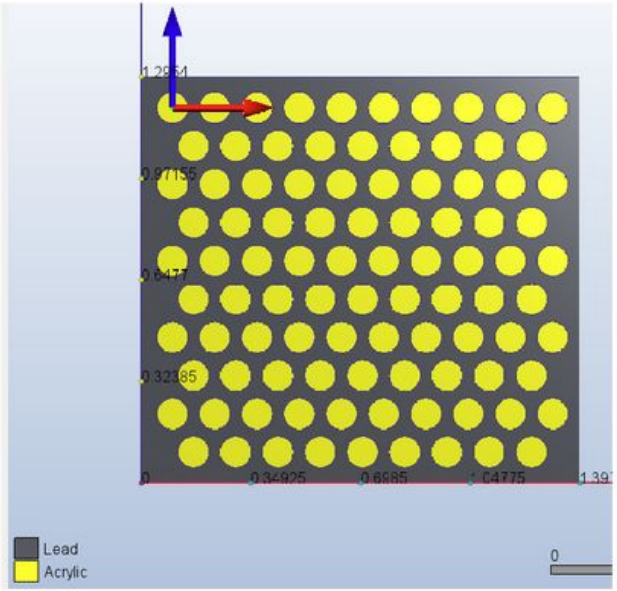
ESB Test Article (Work in Progress)



Backup Slides

Pb/Scintillating Fibre's thermal conductivity in different directions

The property that tells how well the heat is transferred through a material due to a temperature gradient is called the thermal conductivity. It can be described by Fourier's law in 1-D as: **q = −k (dT/dx)**.

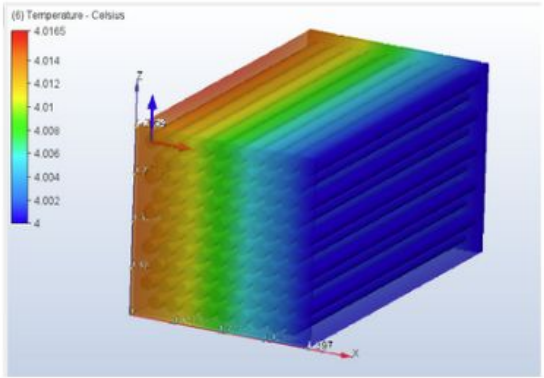


CAD model for the Pb scintillating fibres (glue layers ignored, probably similar k as acrylic).

ScFi Radial (y) separation: **1.22 mm**

ScFi Azimuthal (x) separation:**1.35 mm**

Thermal conductivities in x,y,z direction



Thermal conductivity (k) (x-axis): **15.7 W/(m-K)**.

Boundary conditions: Heat flux: **0.002 W/cm²**.
Temperature: **4°C**.

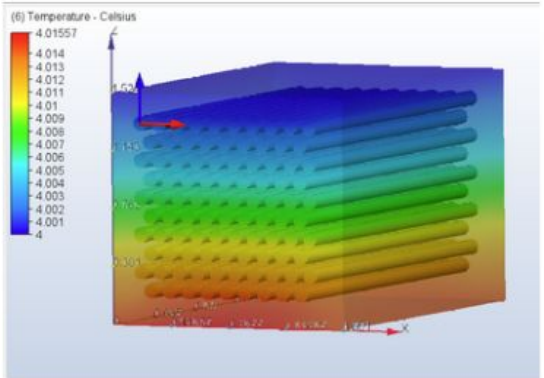
Length along x axis = 1.3 cm

k_{Pb} = 35 W/(m-K)

k_{Ac} = 0.19 W/(m-K)

k_x = **0.44** k_{Pb}

k_x = **82.6** k_{Ac}



Thermal conductivity (k) (y-axis): **18.4 W/(m-K)**.

Boundary conditions: Heat flux: **0.002 W/cm²**.
Temperature: **4°C**.

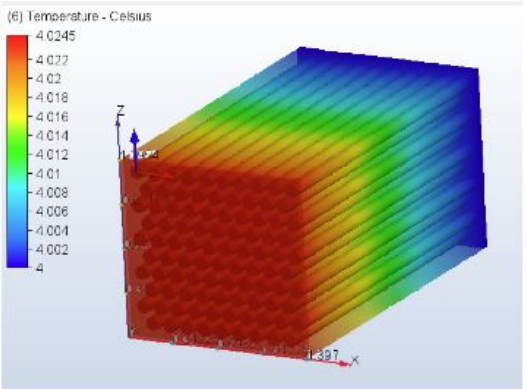
Length along y axis = 1.4 cm

k_{Pb} = 35 W/(m-K)

k_{Ac} = 0.19 W/(m-K)

k_y = **0.53** k_{Pb}

k_y = **96.8** k_{Ac}



Thermal conductivity (k) (z-axis): **21.55 W/(m-K)**.

Boundary conditions: Heat flux: **0.002 W/cm²**.
Temperature: **4°C**.

Length along z axis = 2.6 cm

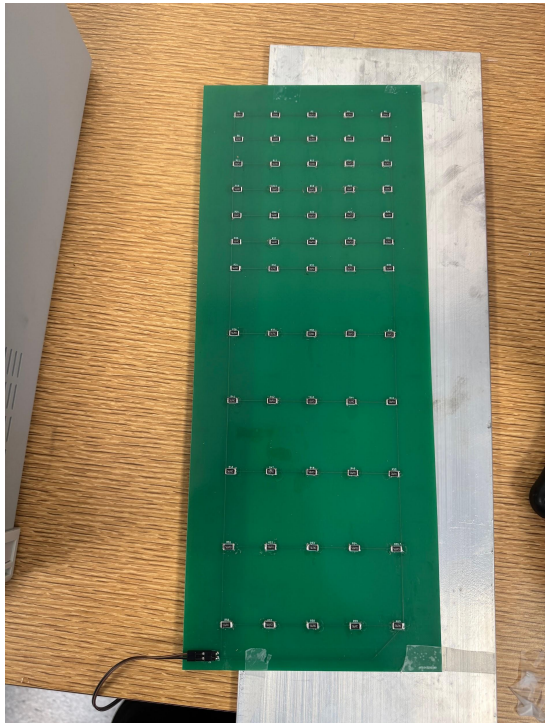
k_{Pb} = 35 W/(m-K)

k_{Ac} = 0.19 W/(m-K)

k_z = **0.62** k_{Pb}

k_z = **113.4** k_{Ac}

Dummy SiPm Board



- Size of the Resistors = (6.3 X 3.15) mm (smd__6332_2512).
- PCB has one layer, FR4 = 1.6 mm.
- Resistance measured = 26.1 Ohm.
- We will deposit 8.4 W of power.