Design Modifications for ESB cooling

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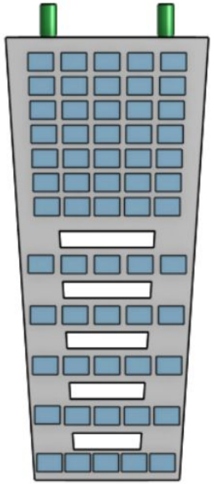
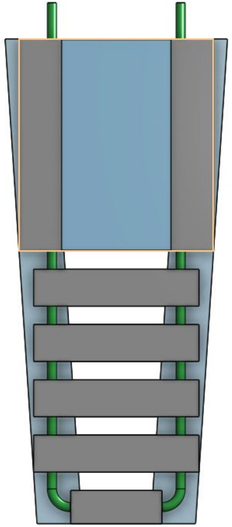
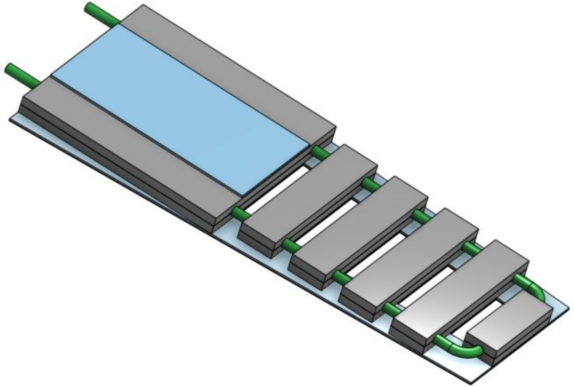
Design with the CalRoc board

- **The diameter of the cooling pipeline has been changed.** The new pipeline has an outer diameter of one-quarter inch with wall thickness of 0.03 inches, which helps ensure better integration with the modified cold plates.
- **The thickness of the cold plates has been decreased.** Each individual cold plate now has a thickness of one-quarter inch, providing improved thermal conduction and structural support to cooling pipeline.
- **The cooling pipeline is now fully enclosed between the two cold plates.** In the previous design, half of the pipe was exposed to air, which reduced cooling efficiency due to heat loss through air. In the current design, the pipe is completely embedded in the cold plates along its full diameter, which significantly improves heat conduction by increasing the contact area and allowing better heat removal from the system.







Thermal Simulation results

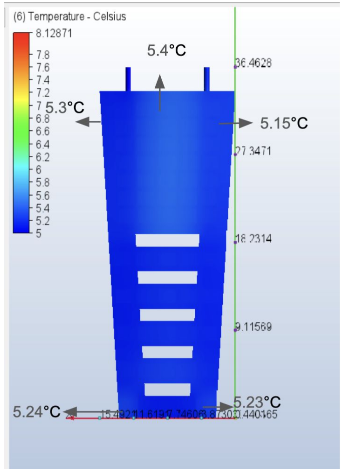
Boundary Conditions Used:

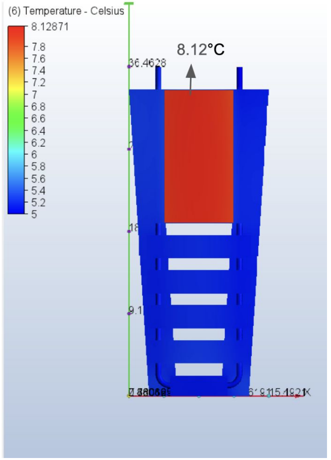
- Water inlet temperature: 5°C
- Volumetric flow rate: 0.3 gal/min
- Outlet pressure: 0 Pa
- Heat flux from each SiPM: 0.046 W/cm²
- Total power from Calroc: 5 W

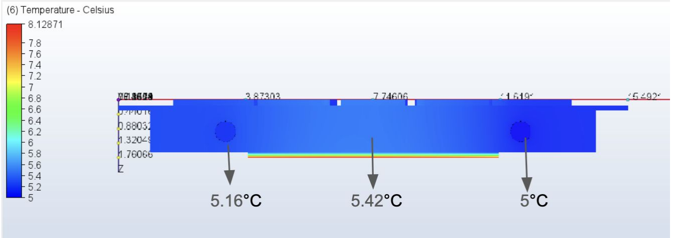
Material:
Calroc was modeled as FR4, which has poor thermal conductivity, causing localized heat buildup.

Simulation Outcome:

- Temperature rises from 5°C to a peak of 8.12°C.
- Localized heating observed near the Calroc region (center of the middle image)







Discussion Summary from last BIC Sector meeting

- The current simulation assumed only the Calroc contributes 5 W of power, with localized heat due to its placement and FR4 material.

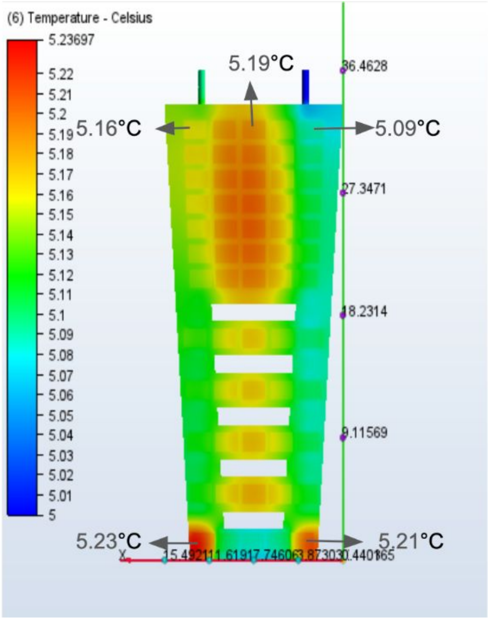
- However, it was pointed out that **Calroc is not the sole heat source**. Other components can also dissipate heat like the ones from card tray, to incorporate heat from such sources, we have run simulations increasing power input on the Calroc as 10 W, 15 W and 20W, and the maximum temperature located on the system (which is on Calroc board is shown in the table below).

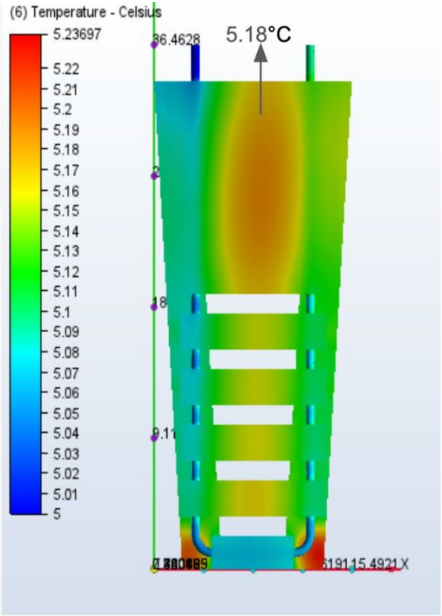
Heat flux on the CalRoc	Max. Temperature
5W (0.045 W/cm^{2})	8.13°C
10W (0.089 W/cm^{2})	11°C
15W (0.134 W/cm^{2})	13.9°C
20W (0.178 W/cm^{2})	16.78°C

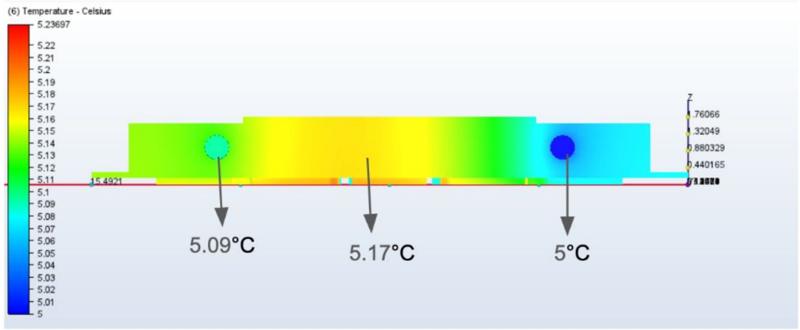
- It was also discussed that using a metal-core Calroc could improve heat spreading and conduction.The next slide presents simulation results with 5 watts of power applied to the metal-core Calroc.

Thermal Simulation results with metal-core Calroc board

- Switching from **FR4 to metal-core Calroc** greatly enhances thermal performance by improving uniform heat dissipation.



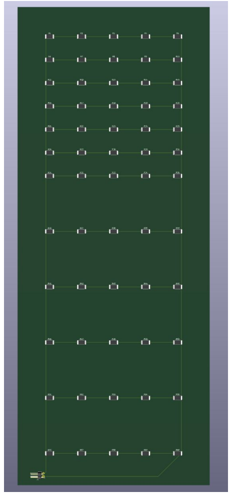




Next Steps

- Next steps involve fabricating a test article based on this design and conducting experiments (without Calroc board for now) in the local lab to validate the simulation results.

PCB Design



Design of the PCB

- Resistance of each resistor = 56 Ohm.
- I_h = 0.05 A
- V_h= 2.6 V
- P_h ≈ 0.14 W, P_t ≈8.4 W
- Dimensions of PCB: Length = 381 mm (15 in), Width = 152.40 mm (6 in), Thickness= 1.6mm (FR4 = 0.3 mm, Cu base: 1.3 mm).