Heat Study

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February 1, 2023

1 Introduction

Just some general notes on the thermodynamics of the system and using this document as a point of reference for moving forwards.

2 Technical Design - Cooling System

2.1 General

2.1.1 Water Cooling

This should not be too important to look at. The water cooling focuses on the periphery electronics (outside the active volume of the detector). This includes the front-end ASICs of the timing systems, the front-end FPGA boards, DC-DC converters, voltage converters etc. The estimated load that the water cooling system accounts for is $\approx 5kW$. To assure there is no ice buildup the water inlet is required to be $> 2°C$. This is not a concern anyway as the dew point is $< -40°C$. This water is pumped through the experiment using pipes to the heat sinks. Any further details of the water cooling can be found at the technical design report [AAB+]. Figure 1 shows a schematic of the water cooling system.

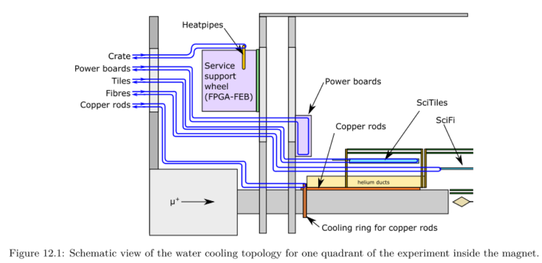
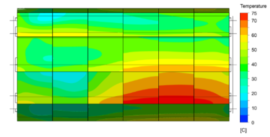


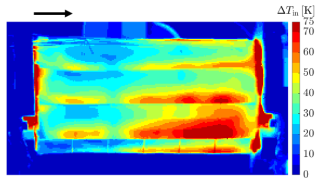
Figure 1: Schematic of one quadrant of the water cooling system.

2.1.2 Helium Cooling

The MuPix chips are cooled by gaseous helium at an inlet temperature $\gtrsim 0°C$ at approximately ambient pressure. The report assumes a maximum power consumption of the pixel sensors at $400mW/cm^2$, the helium gas system us designed for a total heat transfer of $5.2kW$ which increases the average gas temperature by $\approx 18°C$. For this requirement, the helium cooling system has to provide a flow of $\approx 20m^3/min = 56g/s$. This is under controlled conditions split between several cooling systems. The specific heat capacity of gaseous helium is $= 5.2kJ/kgK$.



(a) Simulated temperature on the outer layer of the mock-up.



(b) Measured temperature on the outer layer of the mock-up using an infrared camera.

Figure 2: Simulation and measurement of the heat distribution on the pixel tracker.

2.2 Pixel Tracker

References

[AAB+] K Arndt, H Augustin, P Baesso, N Berger, F Berg, C Betancourt, D Bortoletto, A Bravar, K Briggl, D Vom Bruch, A Buonaura, F Cadoux, C Chavez Barajas, H Chen, K Clark, P Cooke, S Corrodi, A Damyanova, Y Demets, S Dittmeier, P Eckert, F Ehrler, D Fahrni, S Gagneur, L Gerritzen, J Goldstein, D Gottschalk, C Grab, R Gredig, A Groves, J Hammerich, U Hartenstein, U Hartmann, H Hayward, A Herkert, G Hesketh, S Hetzel, M Hildebrandt, Z Hodge, A Hofer, Q H Huang, S Hughes, L Huth, D M Immig, T Jones, M Jones, H.-C Kästli, M Köppel, P.-R Kettle, M Kiehn, S Kilani, H Klingenmeyer, A Knecht, A Knight, B Kotlinski, A Kozlinskiy, R Leys, G Lockwood, A Loreti, D La Marra, M Müller, B Meier, F Meier Aeschbacher, A Meneses, K Metodiev, A Mtchedlishvili, S Muley, Y Munwes, L O S Noehte, P Owen, A Papa, I Paraskevas, I Perić, A.-K Perrevoort, R Plackett, M Pohl, S Ritt, P Robmann, N Rompotis, T Rudzki, G Rutar, A Schöning, R Schimassek, H.-C Schultz-Coulon, N Serra, W Shen, I Shipsey, S Shrestha, O Steinkamp, A Stoykov, U Straumann, S Streuli, K Stumpf, N Tata, J Velthuis, L Vigani, E Vilella-Figueras, J Vossebeld, R Wallny, A Wasili, F Wauters, A Weber Bj, D Wiedner, B Windelband, and T Zhong. Technical design of the phase I Mu3e experiment. Technical report.