EmCal Cooling

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November 8th, 2017
EmCal Cooling System

Purpose

1. Remove the heat produced by the electronic
2. Stabilize the temperature of the SiPMs

- Overview of heat produced
- Outline of Current Cooling Plan
- Overview of Electronics Loop
  - PreAmp and Interface loops
- Overview of SiPM Loop
- Some results for prototype testing
Power
SiPM Board  ~280Watts each MAX
Pre-Amp  ~ 5.5 watts each
Interface Board  ~5 watts each

Per Sector
SiPM – 96 boards
Pre-Amps - 24 boards
Interface - 6 boards

Total per Sector
SiPM– 27 watts (max from supply)
Pre-Amps— ~140 watts
Interface–  ~ 30Watts

**Total Calculated**– 197 Watts per sector → 12.6Kwatts total

**V3.0 Prototype (1/6)**  ~ 34 Watts measured (x6→204Watts)
The PreAmp, Interface and SiPM loops were separated because of final detector assembly concerns and for independent temperature control of the SiPMs (lower operating temp if needed). Tubing is continuous in the sector with no connections.
v2.1 Prototype

- Interface Board Loop
- PreAmp Loop
- SiPM Loop
  Straps not Shown
PreAmp and Interface Loop

- **Purpose:** Remove heat generated by electronics
- **Total heat removed:** 11k Watt
- **Operate at:** 15C to 20C +/-1.5C
- **Flow rate:** ~8-10 gpm
- **Based on:** PHENIX cooling system
- **Modified for:** flow rate, load and segmentation
- **Coolant:** Water based coolant
- **Loop:** Closed loop
- **Purifier loops:** built in
- **Monitored and alarmed:**
- **System:** 32 channel system for North and South
- **Redundancy:** built into the system.
Pre-Amp Cooling Plate

Cooling Plate
• Combines mechanical and cooling for electronics
• Double loop for PreAmp Plate
• Single loop for Interface
• Gap pad to thermally connect to Pre-amp
• Electrically isolated cooling from outside
• 1/6 shown
• Each sector plate will remove 170 watts from each sector

Bottom view
Interface Loop

• Needs to remove 5 watts per board
  30 per sector
• In series with PreAmp Loop
Few Prototype tests

Cooling water at 23C
0.25 lpm flow

First prototype made of brass to test concept
Better contact between preAmp and cooling plate is needed.

Prototype

Channel Map
Odd are PreAmps

Start 18.5C

17.0C @9am
15.5C @ 11am
14.0C @3pm
15C @ 3:30pm

1/1
2/3
4/5
6/7
8/9
10/11
12/13
14/15
16/17
18/19
20/21
22/23
24/25
26/27
28/29
30/31

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SiPM Loop

- Purpose: stabilize temperature of the SiPMs
- Total heat removed: 1.7k Watt Max
- Operation range: 10°C to 20°C
- Temp: +/- 0.1°C
- Flow: 5-6gpm
- Based on the PHENIX cooling system
- Modified for flow rate and load, and segmentation
- Water based coolant
- Closed loop
- Purifier loops built in
- Monitored and Alarmed
- 32 channel system for North and South
- Redundancy built into the system.
Testing of Prototype

Water is at 23C
0.25 lpm flow
Uninsulated loop
SiPM straps connected to Pre-Amp Plate

SiPM affected by change in room Temperature
Cooling Loop for SiPM’s

After testing the first prototype, it was determined to have 2 independent loops. This allows independent control of temperatures and also helps with detector assembly.

- Independent loop for PreAmps and SiPMs
- Thermally bonded to SiPM board.
- Insulated legs and lines.
SiPM Test with Leakage Current

Temperature in °C

Increase total current to 8300 microAmps @ 18.5°C

- Drop to 17.0°C @ 9am
- Drop to 15.5°C @ 11am
- Drop to 14.0°C @ 3pm
- Set to 15°C @ 3:30pm and turn off light

Current at each tower

Light Source
(i.e. Neutron damage simulator)
Conclusion

- Progress has been made to optimize the system’s design
- Separation of SiPM, PreAmp and Interface loop will aid in detector assembly and the stabilization of SiPM temps.
- Current designs will be tested on the v2.1 Prototype in the lab and at the Fermi Lab test beam test over the next few months.
- We will keep learning from our prototype testing and will continue to improve the design.
Backup