DSG NPS Status Update

Aaron Brown and the
Detector Support Group
May 12, 2022

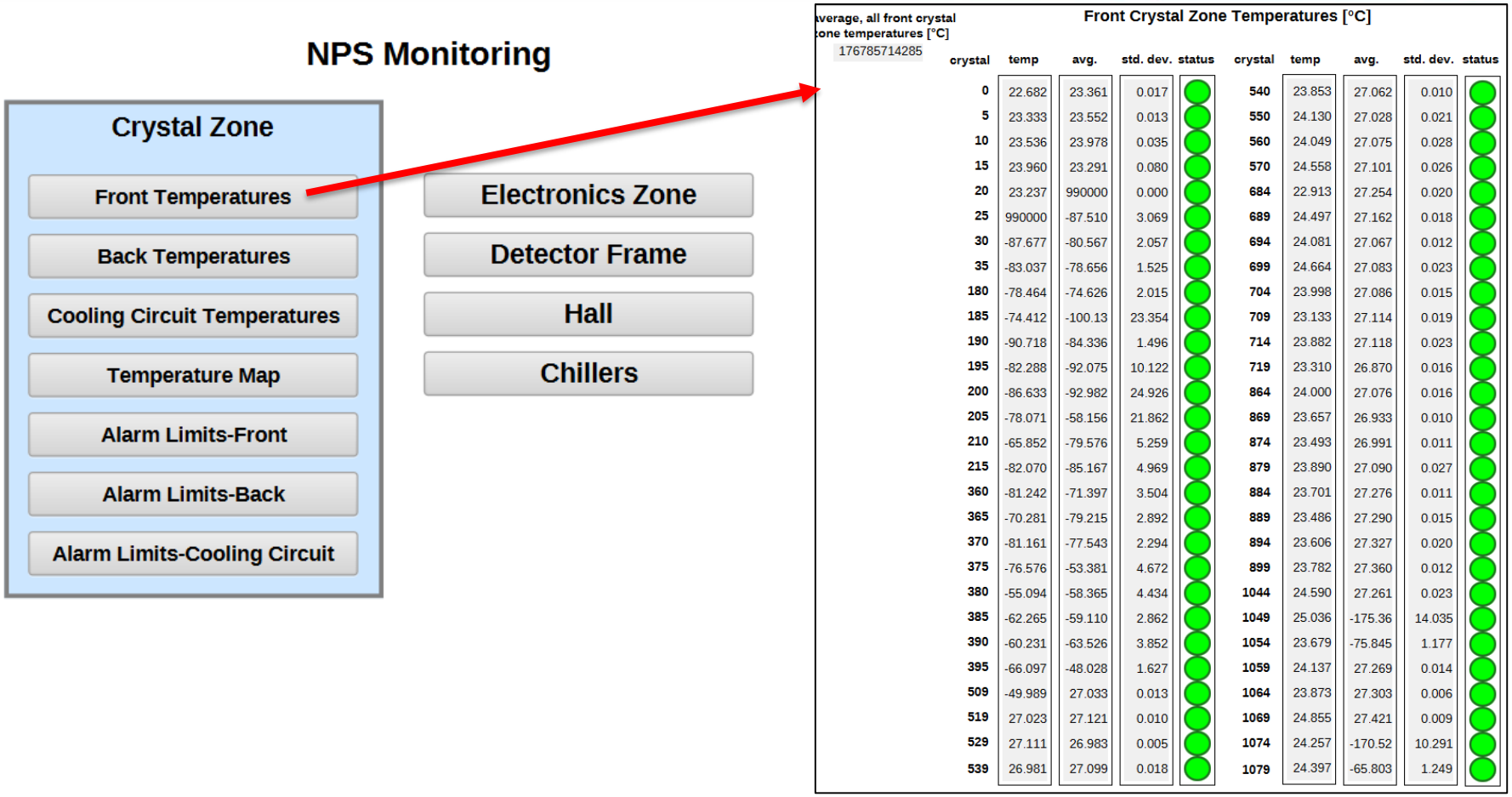
Contents

Gantt Chart for Controls & Monitoring System

- Completed items highlighted in yellow
- DSG plans to complete Controls & Monitoring System by end of July

Controls & Monitoring System	Staff	FY 22																							
		April				May					June				July										
		4	11	18	25	2	9	16	23	30	6	13	20	27	4	11	18	25							
Keysight Measurement Unit Scanner																									
Modifiy device drivers for Keysight GPIB-RS232 control	Aaron/Tyler																								
LabVIEW Interlock Control																									
Temperature and humidity interlocks	Mary Ann																								
Cooling system interlocks	Mary Ann																								
Coolant leak interlocks	Mary Ann																								
Dew point interlocks	Mary Ann																								
Humidity sensor conversion	Aaron																								
Door safety switch interlocks	Mary Ann																								
HV interlock enable/disable logic	Mary Ann																								
LV interlock enable/disable logic	Mary Ann																								
Time over threshold (trip delay) & averaging for interlocks	Mary Ann																								
EPICS Hardware Monitoring																									
CZ Front Temperatures	Mary Ann																								
CZ Back Temperatures	Mary Ann																								
CZ Cooling Circuit Temperatures	Mary Ann																								
CZ Temperature Map	Mary Ann																								
CZ Alarm Limits-Front	Mary Ann																								
CZ Alarm Limits-Back	Mary Ann																								
CZ Alarm Limits-Cooling Circuit	Mary Ann																								
Electronics Zone	Mary Ann																								
Detector Frame	Mary Ann																								
Hall	Mary Ann																								
Chillers	Mary Ann																								
Test/debug Hardware Monitoring Code	Mary Ann /Aaron																								
Chiller Control & Monitoring																									
Device Driver Library	Mary Ann																								
Read Chiller Status	Mary Ann																								
Set Chiller Control Temp	Mary Ann																								
Read Setpoint Temp	Mary Ann																								
Read Plant Temp	Mary Ann																								
Read User Menu Configuration	Mary Ann																								
Set Over Temp Limit	Mary Ann																								
Set Low Temp Alarm Limit	Mary Ann																								
Set Offset Calibration	Mary Ann																								
Set User Control Flags	Mary Ann																								
Test / debug chiller code	Mary Ann /Aaron																								

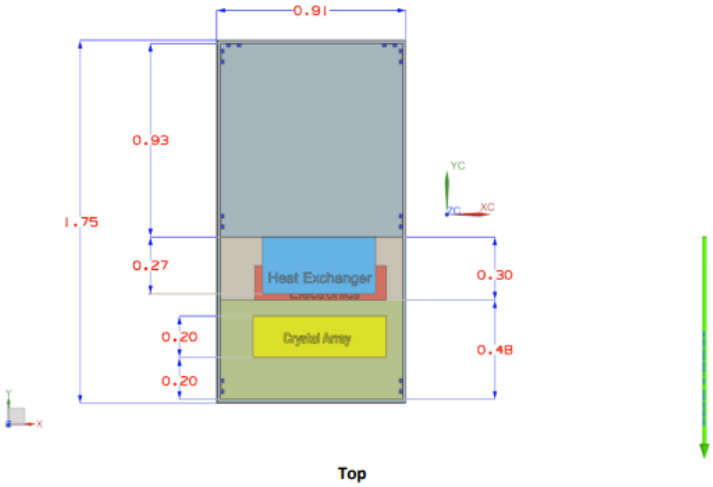
EPICS Phoebus Screens

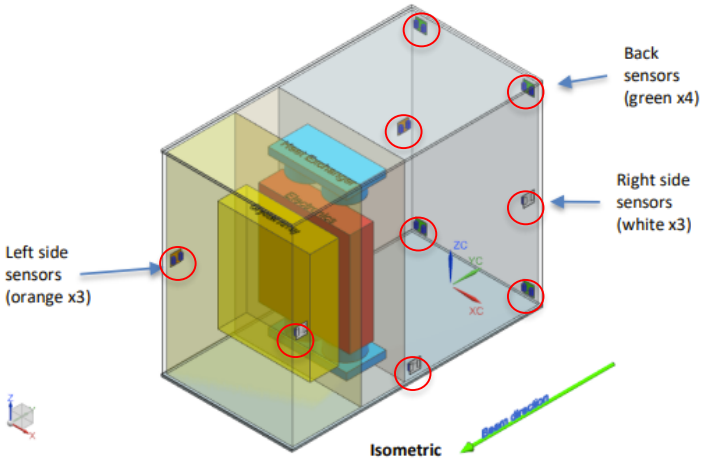


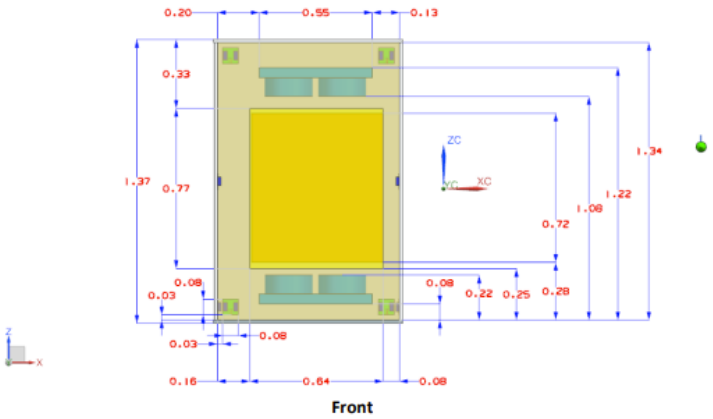
crystal	temp	avg.	std. dev.	status	crystal	temp	avg.	std. dev.	status
0	22.682	23.361	0.017		540	23.853	27.062	0.010	
5	23.333	23.552	0.013		550	24.130	27.028	0.021	
10	23.536	23.978	0.035		560	24.049	27.075	0.028	
15	23.960	23.291	0.080		570	24.558	27.101	0.026	
20	23.237	990000	0.000		684	22.913	27.254	0.020	
25	990000	-87.510	3.069		689	24.497	27.162	0.018	
30	-87.677	-80.567	2.057		694	24.081	27.067	0.012	
35	-83.037	-78.656	1.525		699	24.664	27.083	0.023	
180	-78.464	-74.626	2.015		704	23.998	27.086	0.015	
185	-74.412	-100.13	23.354		709	23.133	27.114	0.019	
190	-90.718	-84.336	1.496		714	23.882	27.118	0.023	
195	-82.288	-92.075	10.122		719	23.310	26.870	0.016	
200	-86.633	-92.982	24.926		864	24.000	27.076	0.016	
205	-78.071	-58.156	21.862		869	23.657	26.933	0.010	
210	-65.852	-79.576	5.259		874	23.493	26.991	0.011	
215	-82.070	-85.167	4.969		879	23.890	27.090	0.027	
360	-81.242	-71.397	3.504		884	23.701	27.276	0.011	
365	-70.281	-79.215	2.892		889	23.486	27.290	0.015	
370	-81.161	-77.543	2.294		894	23.606	27.327	0.020	
375	-76.576	-53.381	4.672		899	23.782	27.360	0.012	
380	-55.094	-58.365	4.434		1044	24.590	27.261	0.023	
385	-62.265	-59.110	2.862		1049	25.036	-175.36	14.035	
390	-60.231	-63.526	3.852		1054	23.679	-75.845	1.177	
395	-66.097	-48.028	1.627		1059	24.137	27.269	0.014	
509	-49.989	27.033	0.013		1064	23.873	27.303	0.006	
519	27.023	27.121	0.010		1069	24.855	27.421	0.009	
529	27.111	26.983	0.005		1074	24.257	-170.52	10.291	
539	26.981	27.099	0.018		1079	24.397	-65.803	1.249	

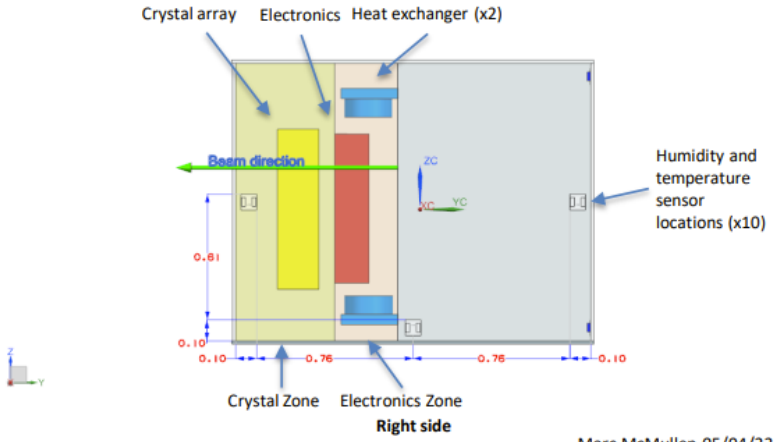
- Clicking “Front Temperatures” button opens the “Front Crystal Zone Temperatures” screen in a new window
  - Displays temperature, average temperature, standard deviation, and status
- Developed by Mary Ann Antonioli

Detector Frame Sensor Locations





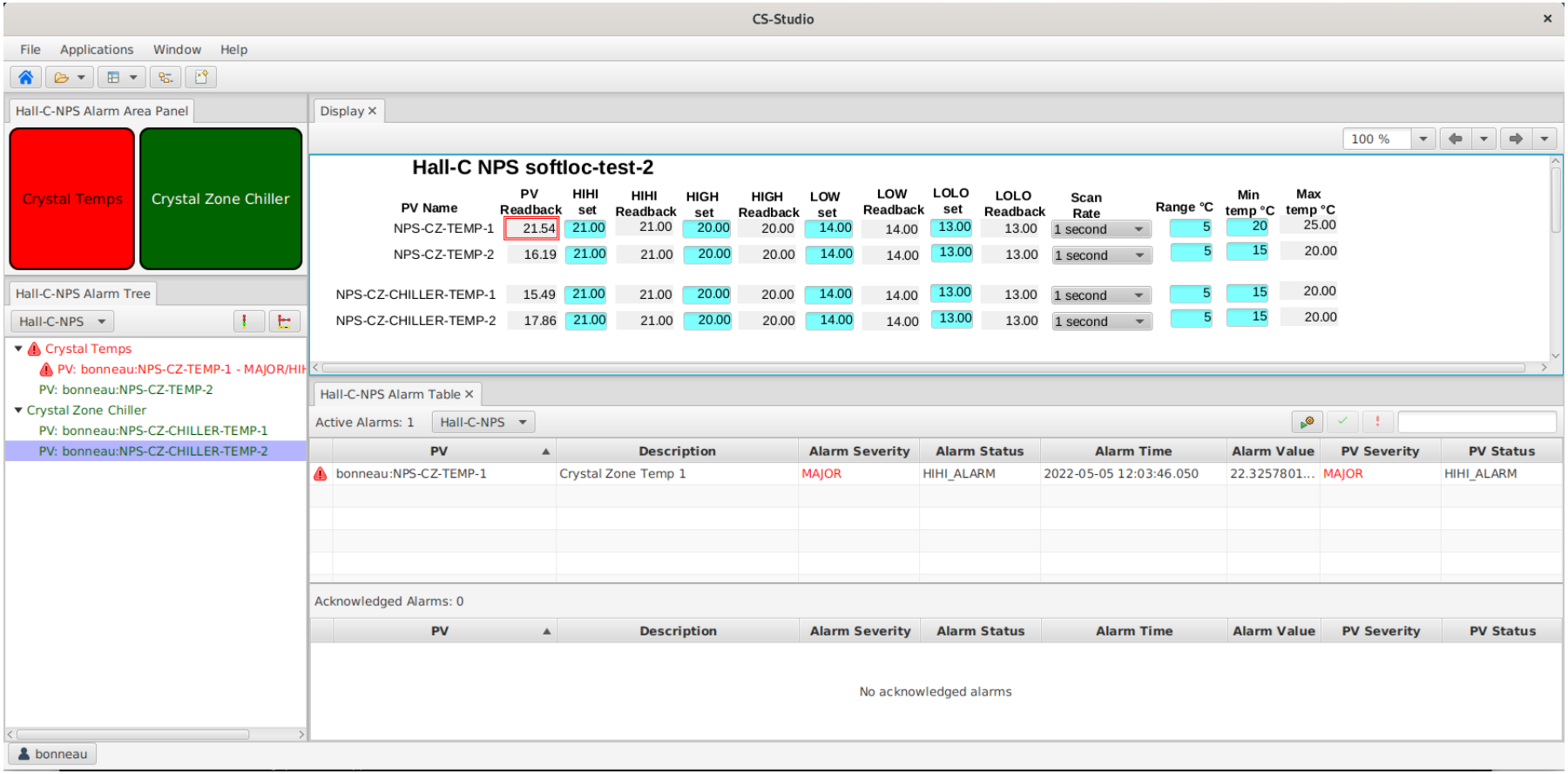




Marc McMullen 05/04/22
All dimensions in meters

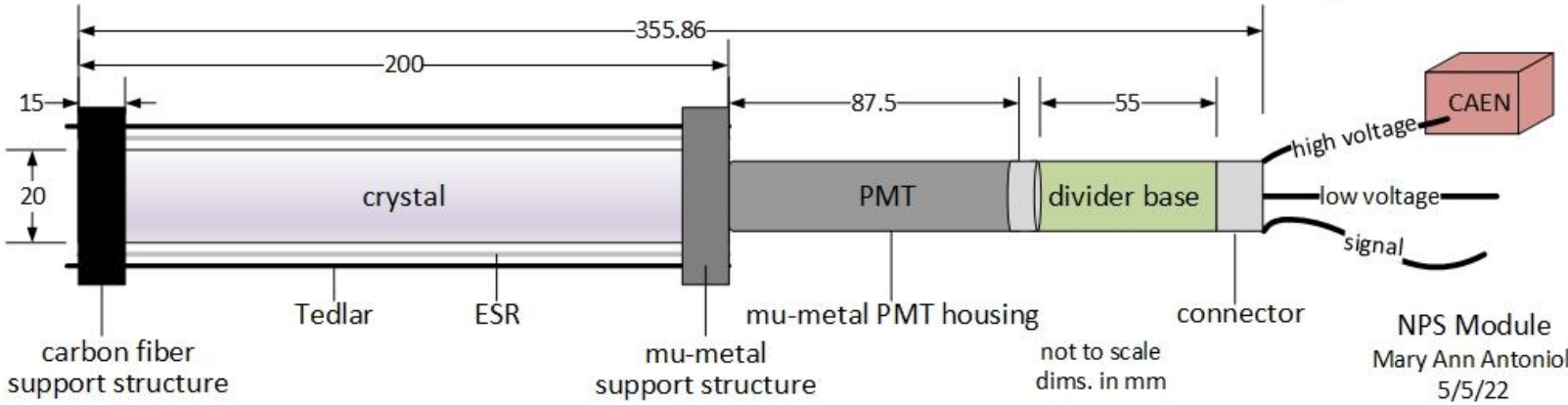
- Proposed temperature and humidity sensor locations (red circles)
  - Ten locations in all; four sensors per location
  - Electronics zone volume = 0.37 m^3 (13 cf)
- 3D rendering by Marc McMullen

EPICS Phoebus Alarm System

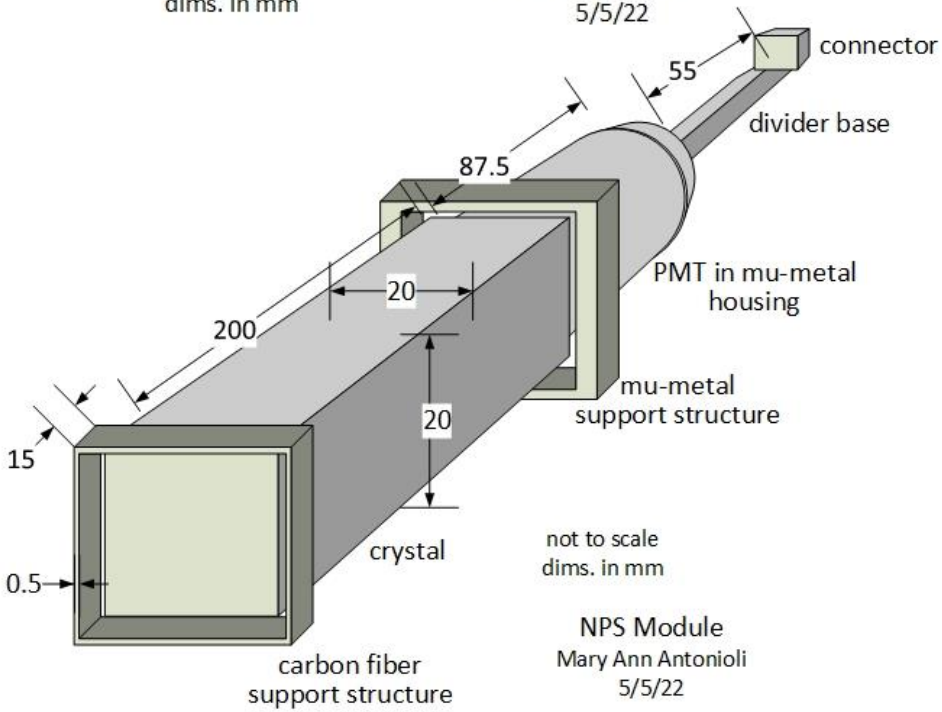


- Testing the Phoebus-based alarm system using test PVs
  - Uses randomly generated test PV values
- Being developed by Peter Bonneau

NPS Module Dimensions



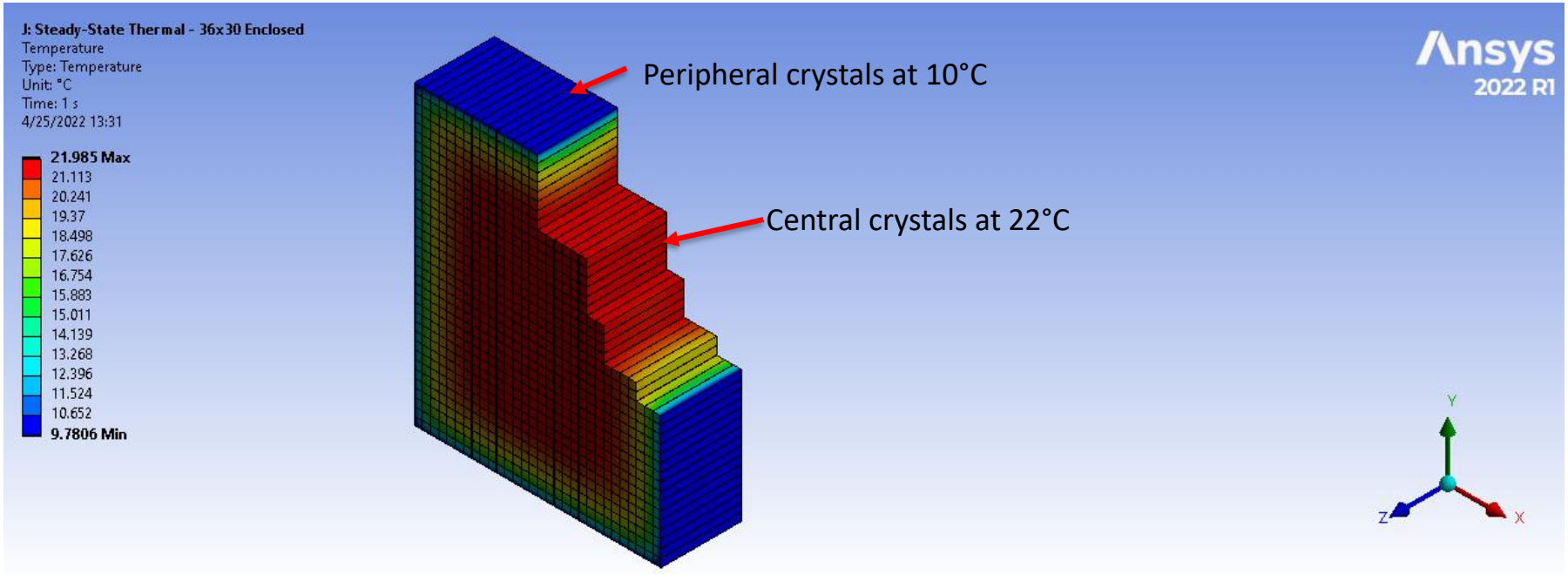
- Dimensions of $PbWO_4$ crystal, PMT, and divider base
  - Model developed to be used in Ansys



Ansys Thermal Simulation Parameters

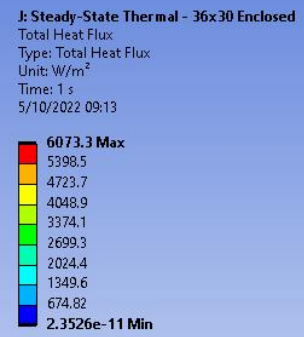
Component	Property	Value
$PbWO_4$ crystal	Size	20x2x2 cm
$PbWO_4$ crystal	Thermal conductivity *x*- and *y*-axis	2.4 W/m·K (*x*- and *y*-axis)
$PbWO_4$ crystal	Thermal conductivity *z*-axis	2.0 W/m·K (*z*-axis)
Carbon fiber dividers	Thermal conductivity	0.5523 W/m·°C
Mu-metal dividers	Thermal conductivity	19 W/m·K
Copper cooling shell	Temperature	10°C
Ambient air	Temperature	20°C

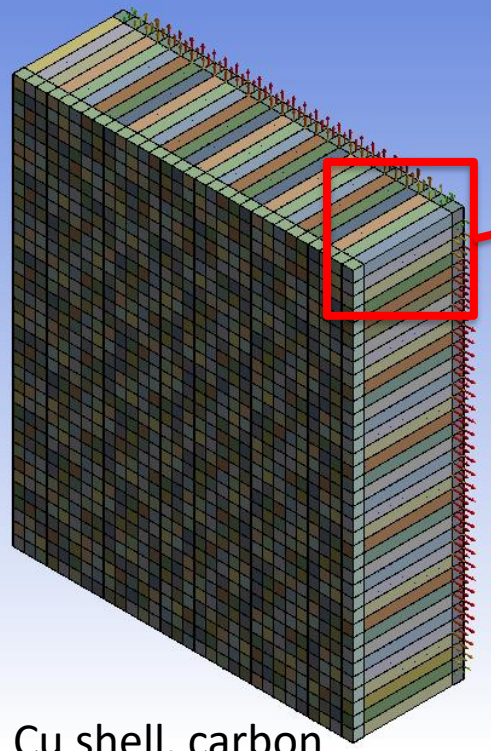
Ansys Steady-State Thermal Analysis

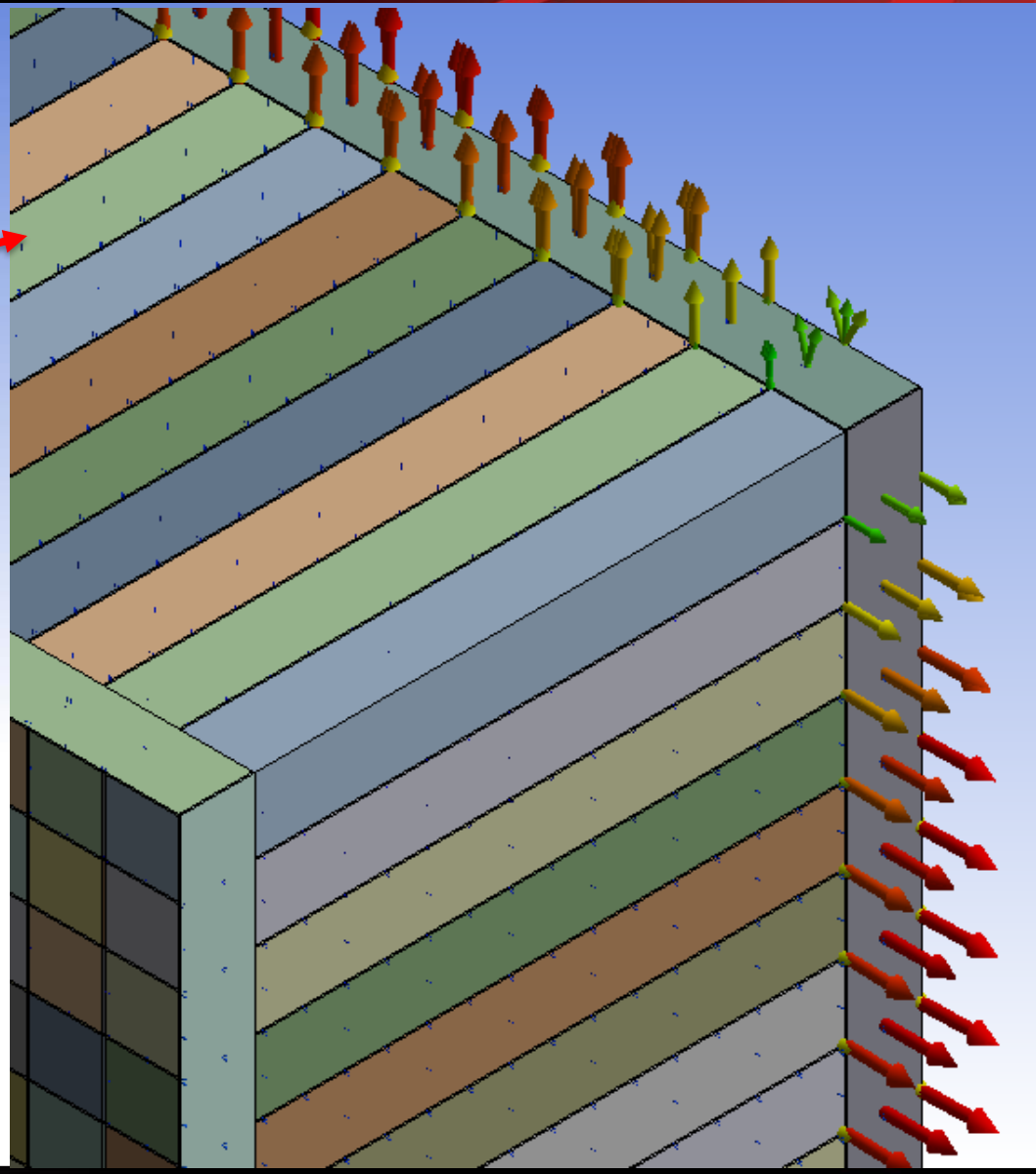


- Slices of crystal array
- Cu cooling shell, carbon fiber and mu-metal dividers
- Ambient temperature = 20°C
- Q = 0.5 W per crystal

Ansys Steady-State Thermal Analysis

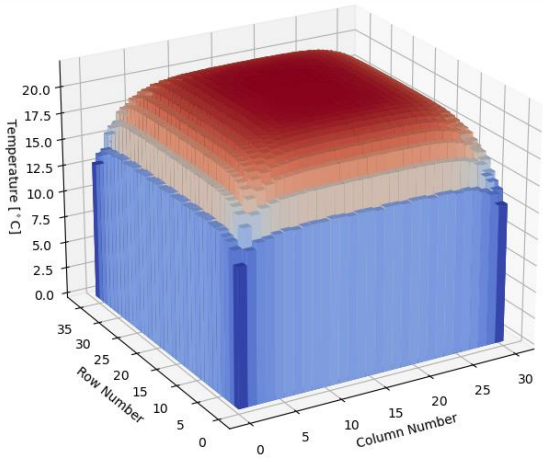


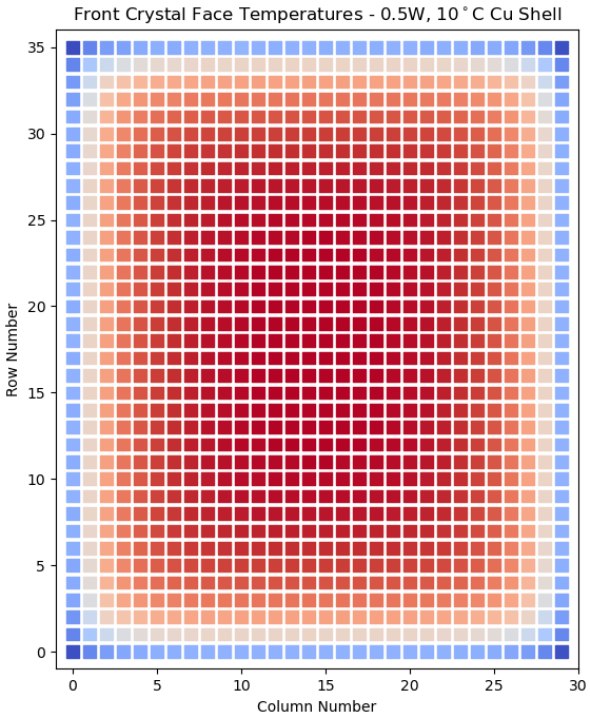


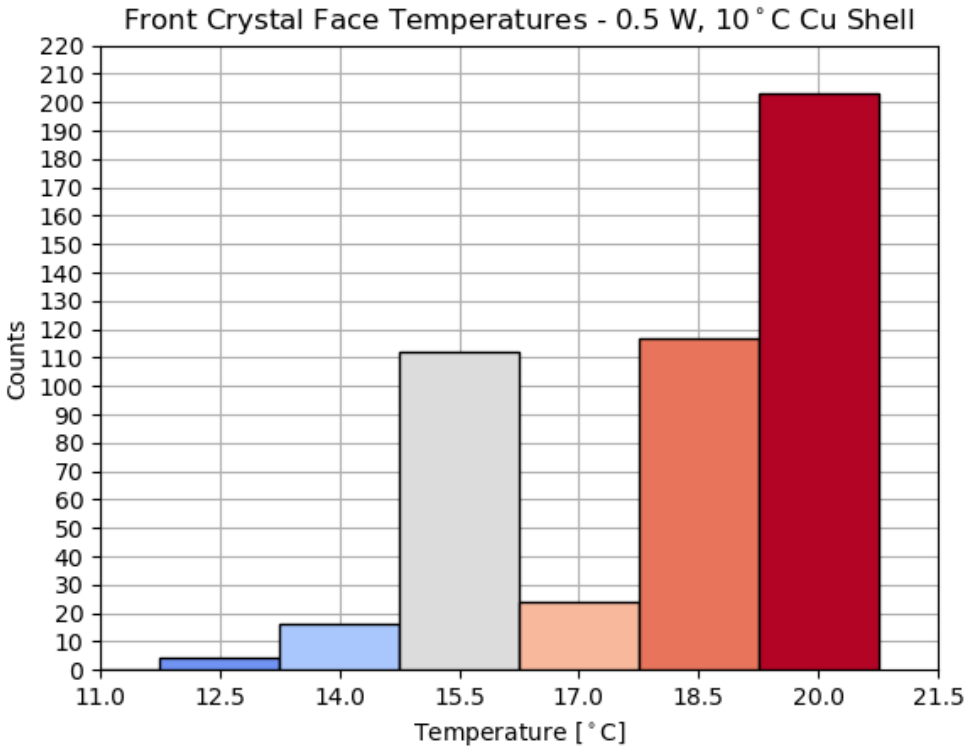


- Model with Cu shell, carbon fiber and mu-metal dividers
- Ambient temperature = 20°C
- Q = 0.5 W per crystal
- Heat flux full scale model
  - ≥ 240 W dissipated in mu-metal

Ansys Steady-State Thermal Analysis





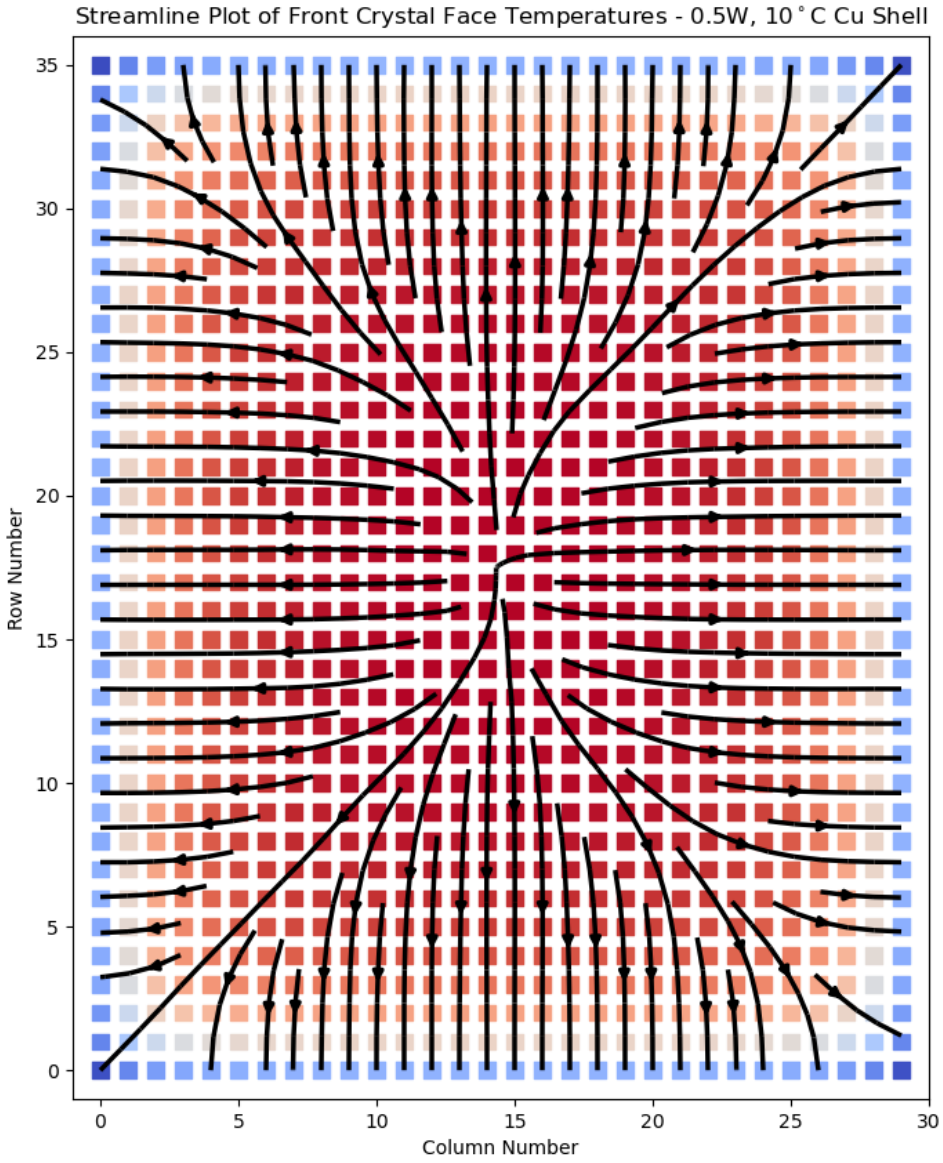


- ~210 crystals in the central zone are at ~22°C

Ansys Steady-State Thermal Analysis

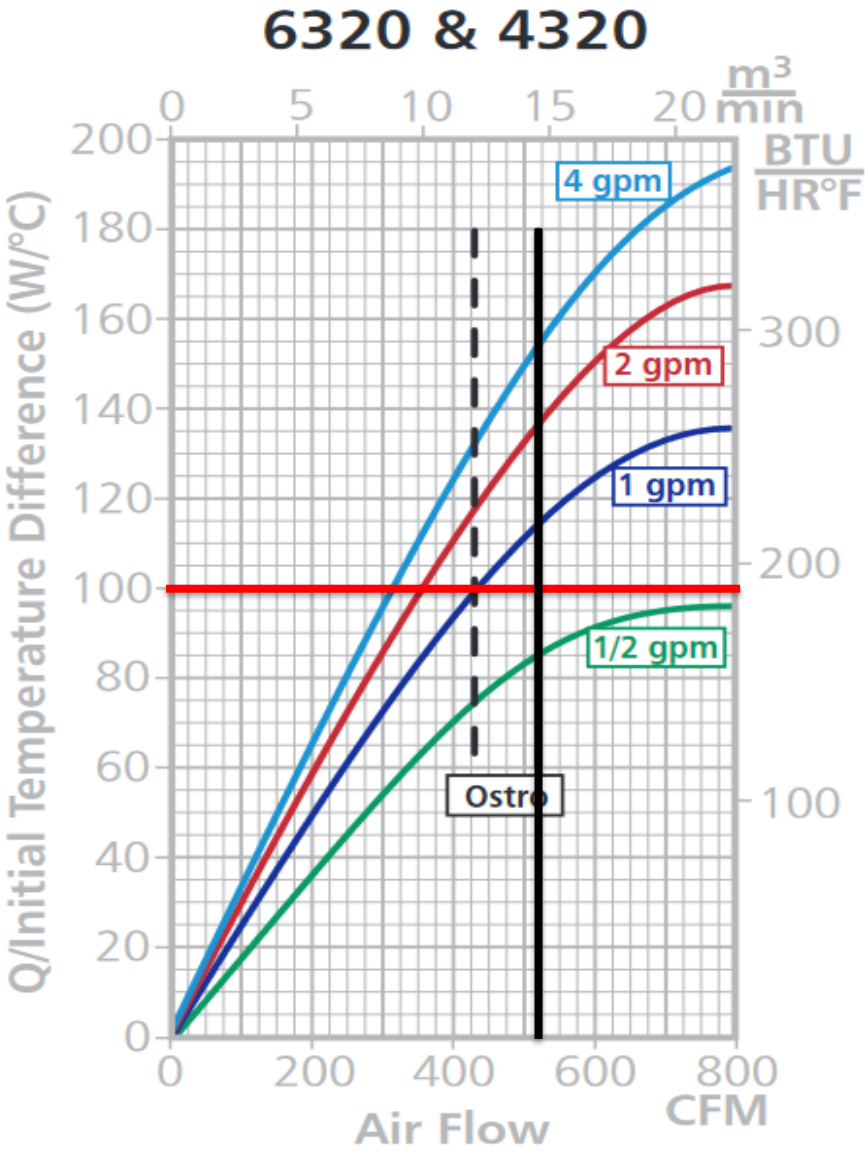
- Streamline plot generated using temperature probe data extracted from Ansys steady-state thermal simulation

- Plot shows heat flow on the front crystal faces
  - Central zone is warmest (~22°C)
  - Peripheral zone is at coolant temperature (~10°C)

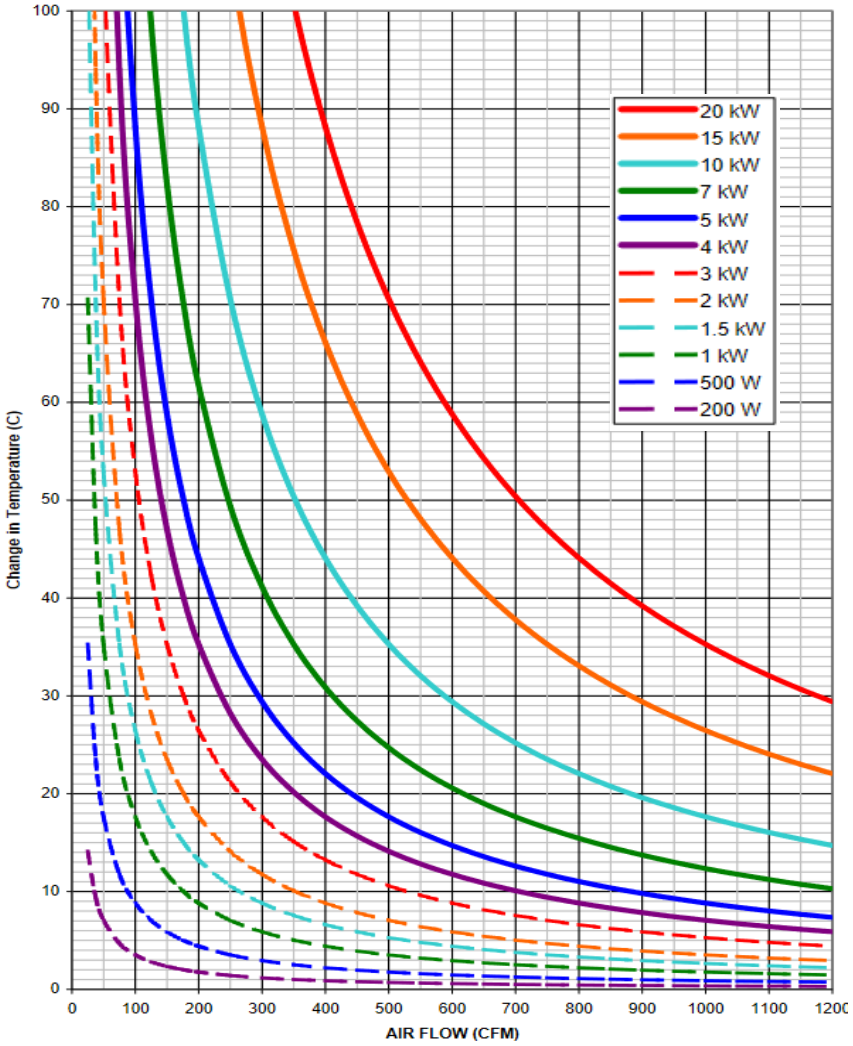


Thermal Calculations

- Based on Lytron 6320 heat exchanger data
  - Assume generated heat Q = 1000 W
  - Assume maximum allowed temperature in electronics zone 20°C
  - Coolant temperature 10°C
  - Initial Temperature Difference (ITD) = 10°C
  - Required performance = Q/ITD = 100 W/°C
  - Four Ostro fans at ~525 CFM
  - ~160 volume (13 cf) exchanges per minute
- Because of the volume exchanges, estimated temperature in the electronics zone is close to ambient temperature

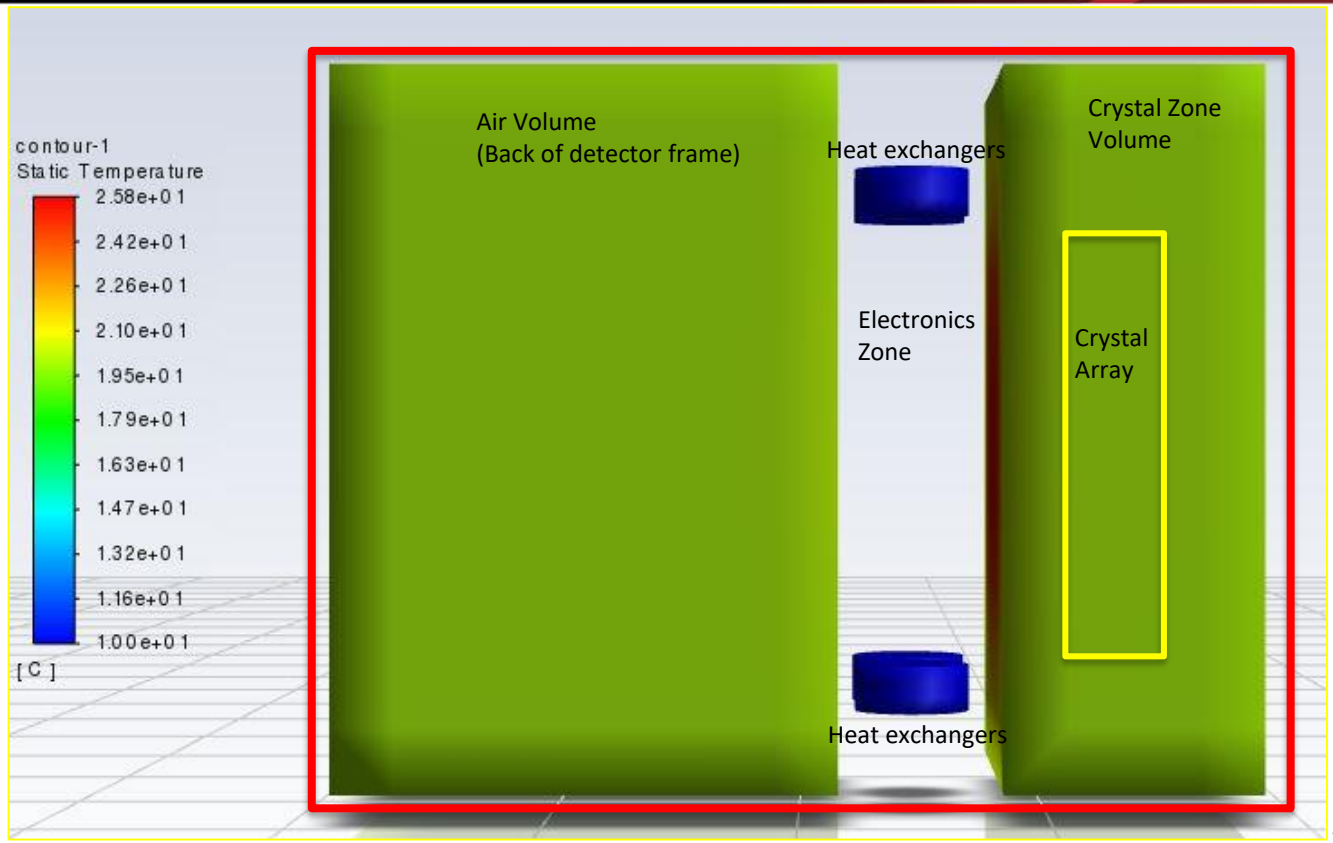


Thermal Calculations



- Air entering the electronics zone will be ~20°C (if zone is in a cabinet)
- Assuming RH is ~40% and temperature in electronics zone is ~20°C, dew point is ~6°C
- No condensation issues

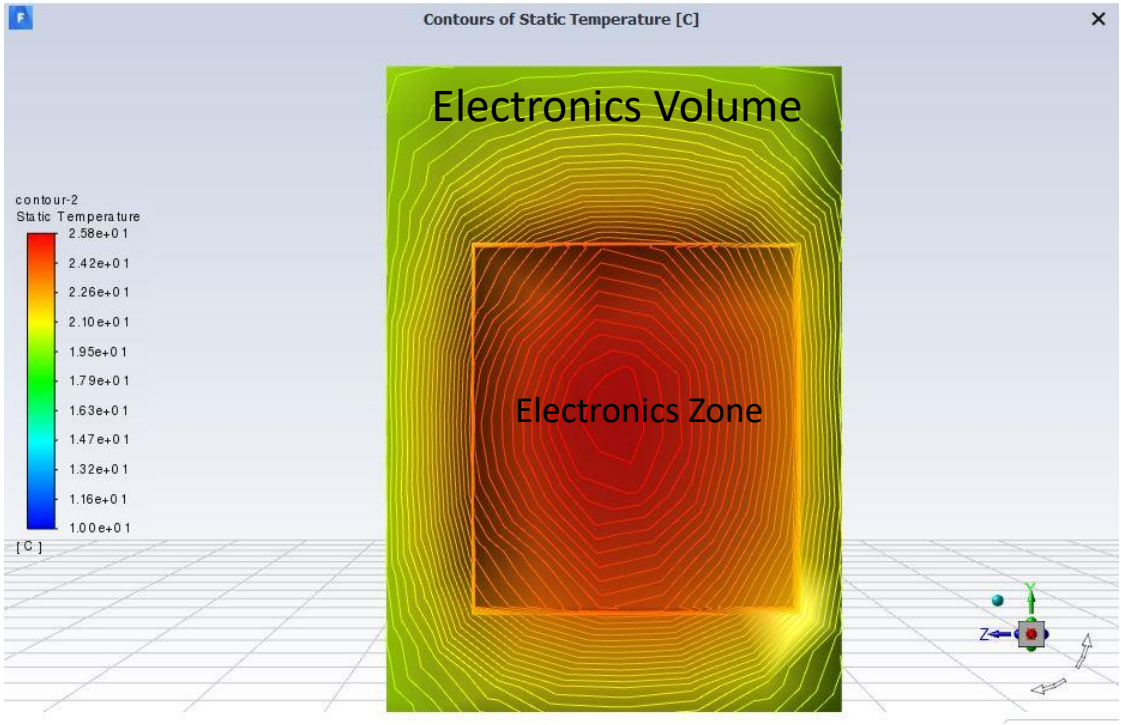
Ansys Fluent Fluid Thermal Analysis

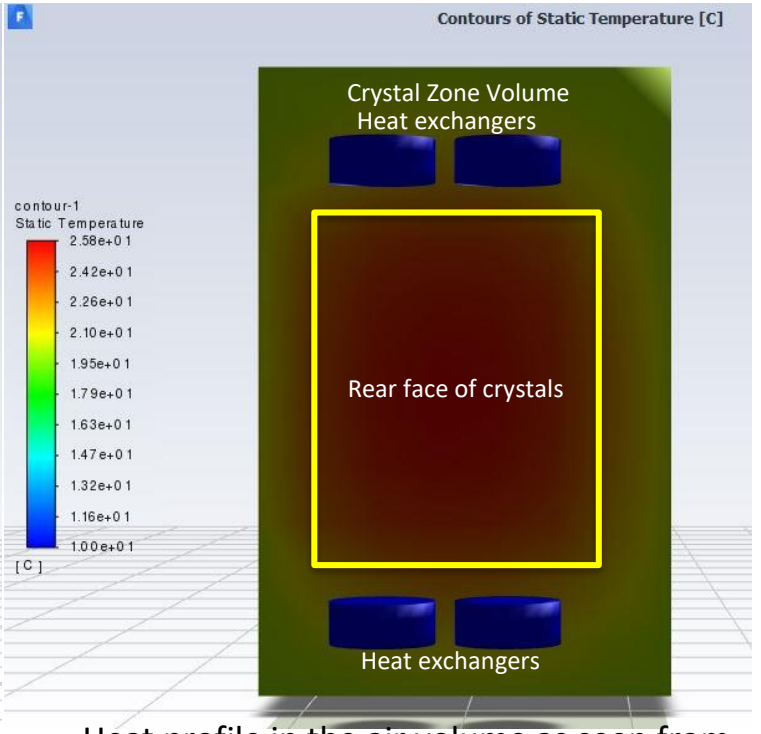


Ansys model for simulation

- Fluent thermal simulation includes heat removal effects from heat exchangers
- Maximum temperature of ~26°C
- Developed by Pablo Campero

Ansys Fluent Fluid Thermal Analysis

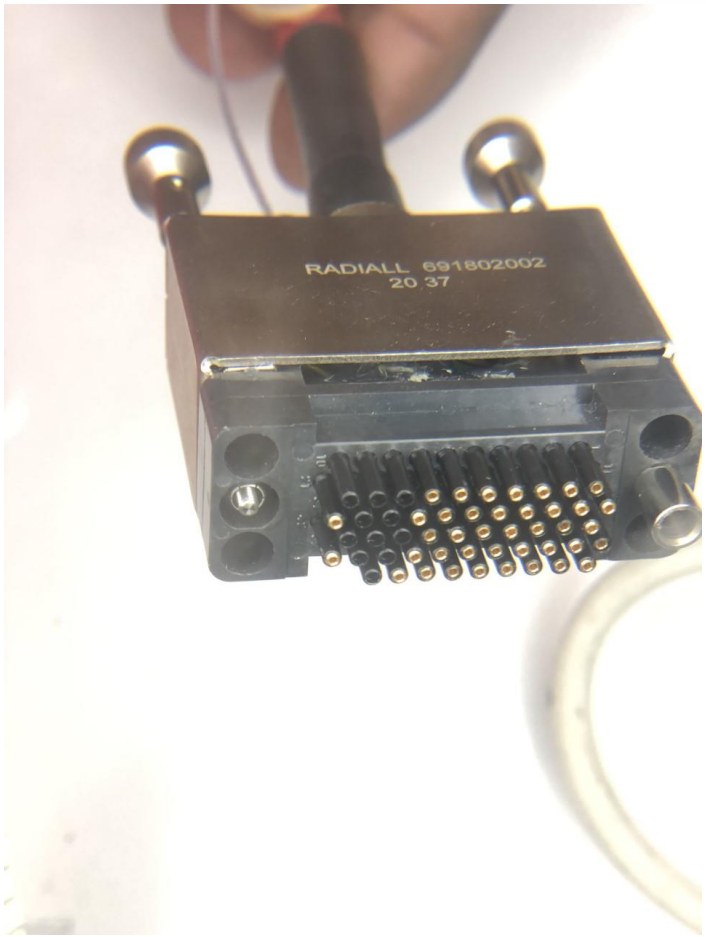


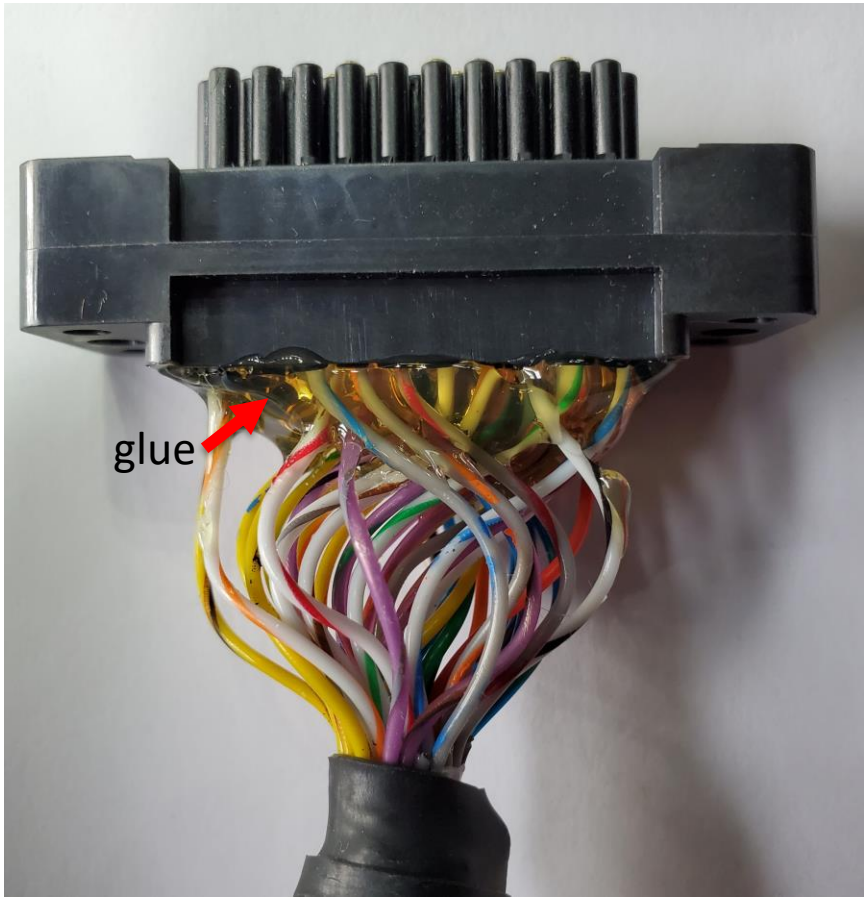


Heat profile in the air volume as seen from the rear

- Electronics volume includes the air surrounding the electronics zone
  - ~26°C

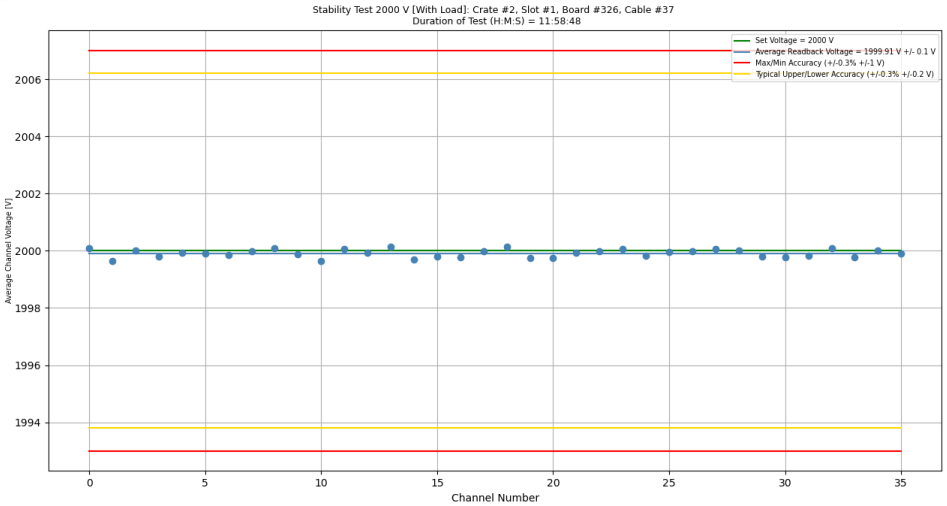
Radiall Connector Back-potting

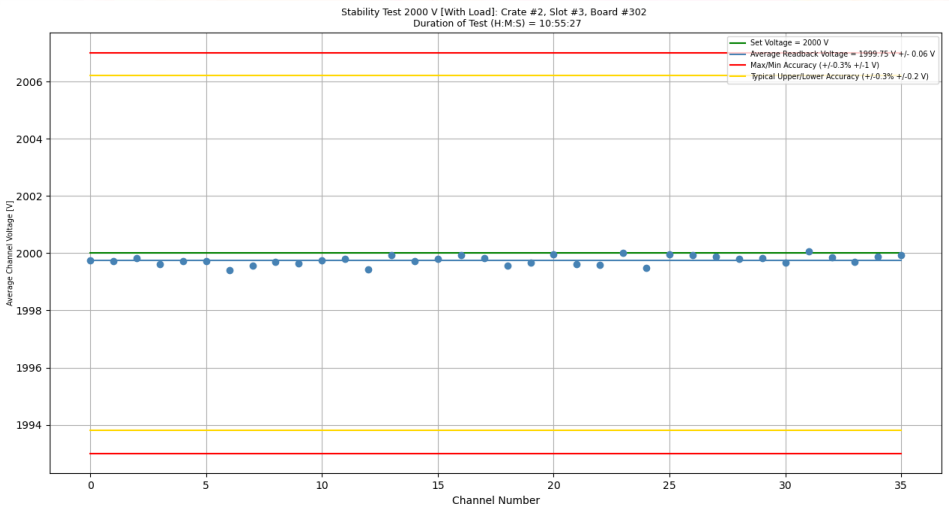


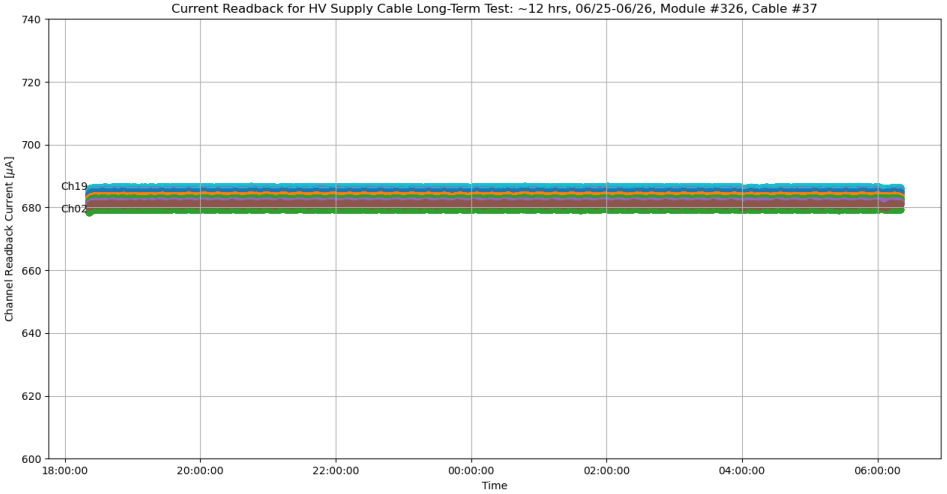


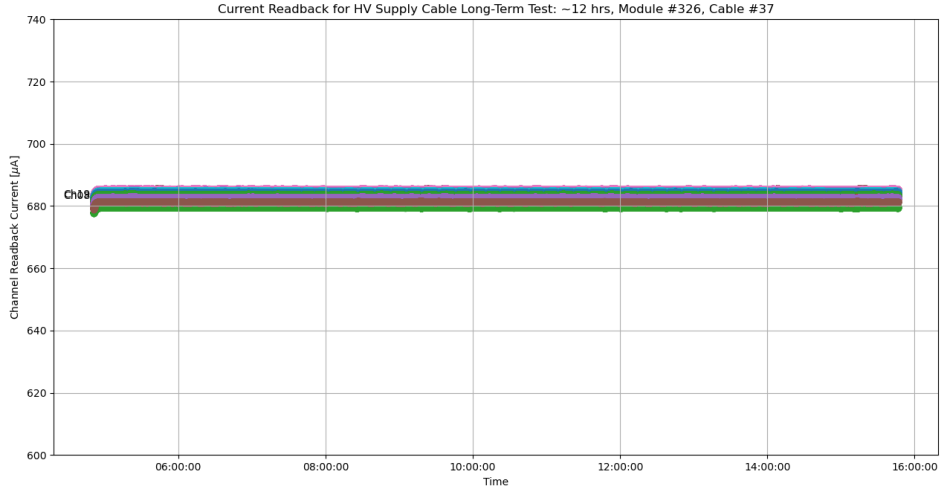
- Mindy Leffel has potted the Radiall connectors of 20 high voltage supply cables

High Voltage Supply Cable Testing









- Testing results for cable #37 before back-potting (left) and after (right)
  - No difference between before and after
- Cables back-potted by Mindy Leffel and tested by George Jacobs

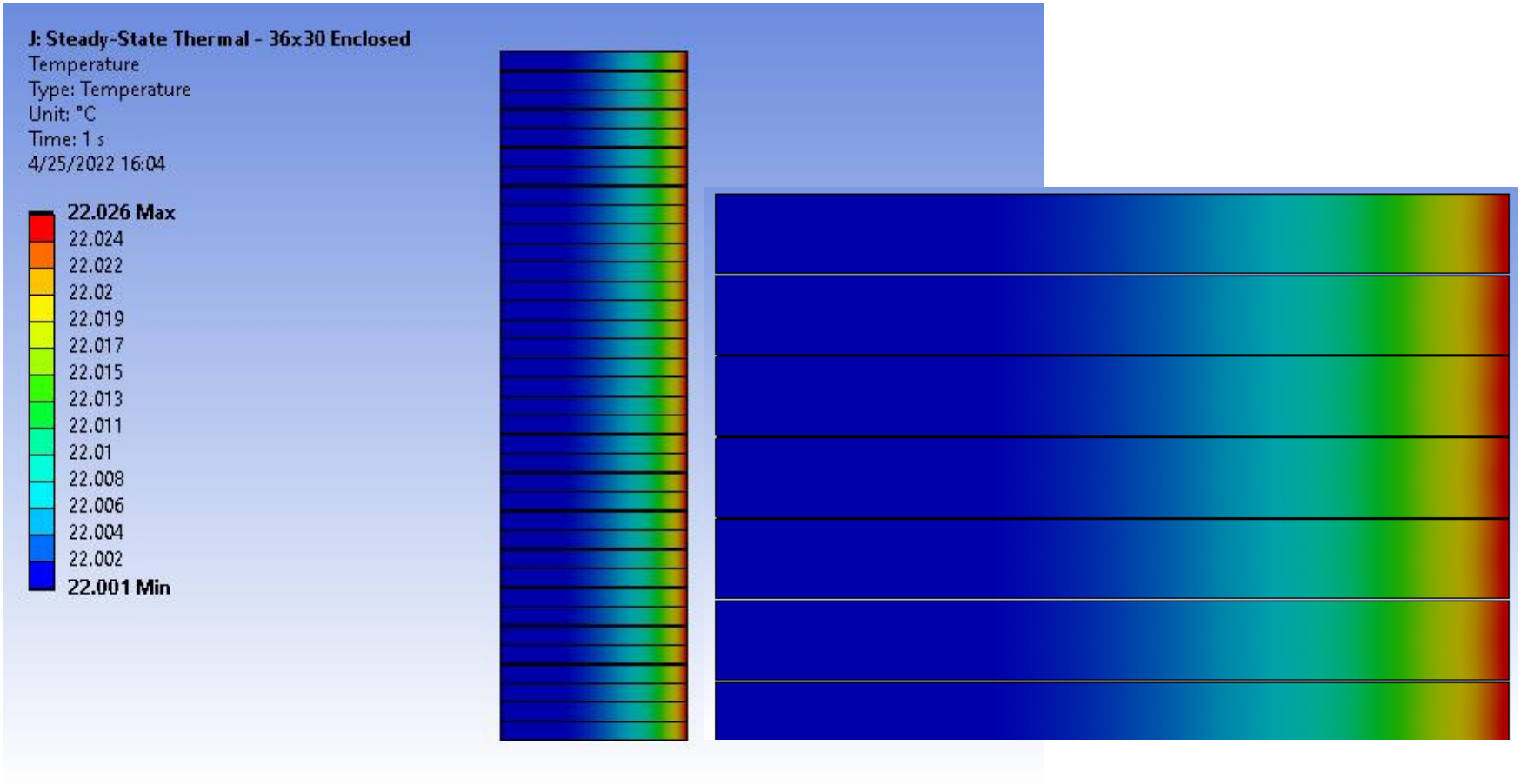
Conclusion

- Controls & Monitoring System progressing well
  - Developing EPICS Phoebus monitoring and alarm system
  - Developing engineered interlocks system
- Ansys Thermal Analysis
  - Steady-state analysis indicates central zone crystal temperature of ~22°C
  - Fluent analysis in progress for electronics, PMTs, and crystals; indicates temperature in electronics zone and rear face of crystals to be ~26°C
- High Voltage Supply Cables
  - Back-potting of Radiall connectors has no effect on cable performance

THANK YOU!

Backups

Ansys Steady-State Thermal Analysis



- 20°C ambient temperature
- No dividers or perimeter cooling
- Q = 0.5 W per crystal