Solar Probe Plus

A NASA Mission to Touch the Sun

Integrated Science Investigation of the Sun
Energetic Particles

Preliminary Design Review

05 – 06 NOV 2013

ISIS Thermal

Gregory J Dirks

Outline

- Driving Instrument Thermal Requirements
- Thermal Design and Implementation
  - Thermal Management
  - Heaters and Sensors
  - MLI Design
  - Materials and Finishes
- Predicted Performance and Margins
  - Thermal Model Details
  - Design Cases
  - Optical Properties
  - Predictions and Margins
- Plans for Thermal Verification

Requirements

- Design Temperature Limits

EPI-Hi

Component	Hot Op. (°C)	Cold Op. (°C)	Cold Surv. (°C)
EPI-HI HET	40	-25	-40
EPI-Hi LET1	40	-25	-40
EPI-Hi LET2	40	-25	-40
EPI-Hi DPU	40	-25	-40
EPI-Hi Bias	40	-25	-40
EPI-Hi LVPS	40	-25	-40
EPI-Hi HET Tel	30	-25	-40
EPI-Hi LET 1 Tel	30	-25	-40
EPI-Hi LET 2 Tel	30	-25	-40

EPI-Lo

Component	Hot Op. (°C)	Cold Op. (°C)	Cold Surv. (°C)
Detector	35	-30	-45
Anode Board	55	-30	-45
Event Board	55	-30	-45
Power Board	55	-30	-45
Dome	35	-30	-45

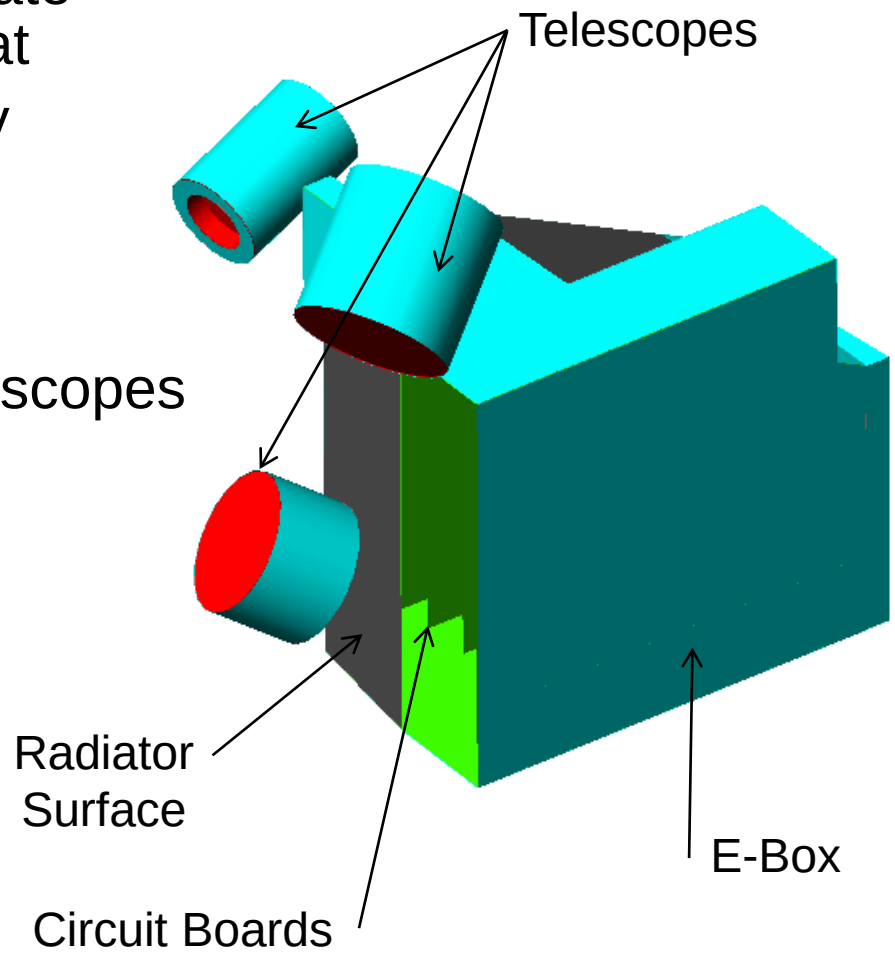
- Margin Guidelines – Includes Test and Model Uncertainty
  - Hot Limits 10 C and Cold Limits 5 C (Heater Controlled)

Requirements

- Interface Temperatures
  - Operational: -25 / +65 C
  - Non-Operational: -30 / +70 C
- Heaters
  - 75% Maximum Duty Cycle
  - Resistance Determined at 26 V

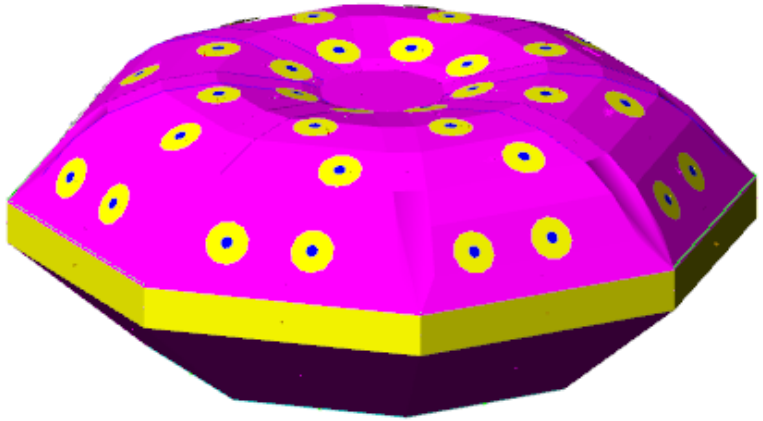
Design

- EPI-Hi
  - E-box Radiator to Dissipate Internally Generated Heat
  - Telescopes Conductively Isolated from E-box
  - Operational Heaters on Telescopes
  - Survival Heaters on Telescopes and E-box
  - MLI on Surfaces Except Apertures and Radiators



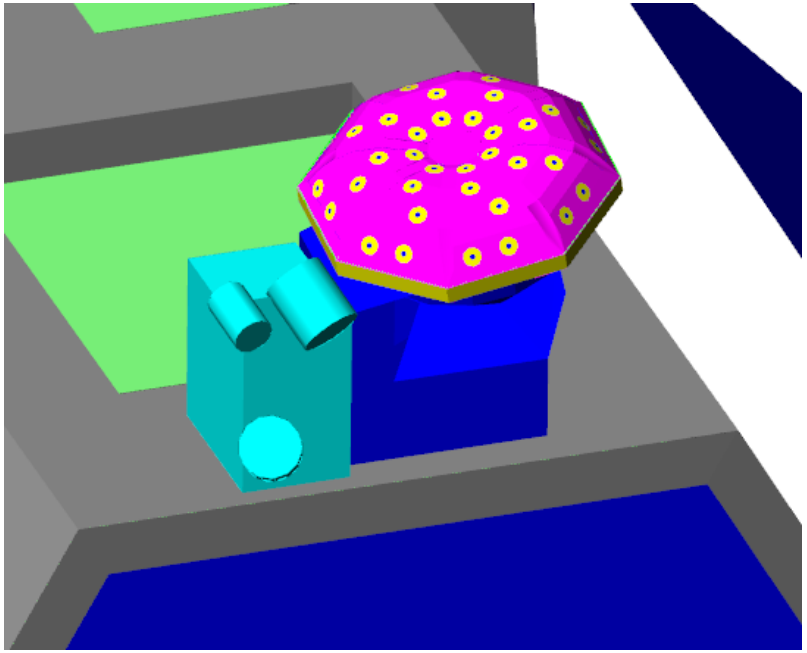
Design

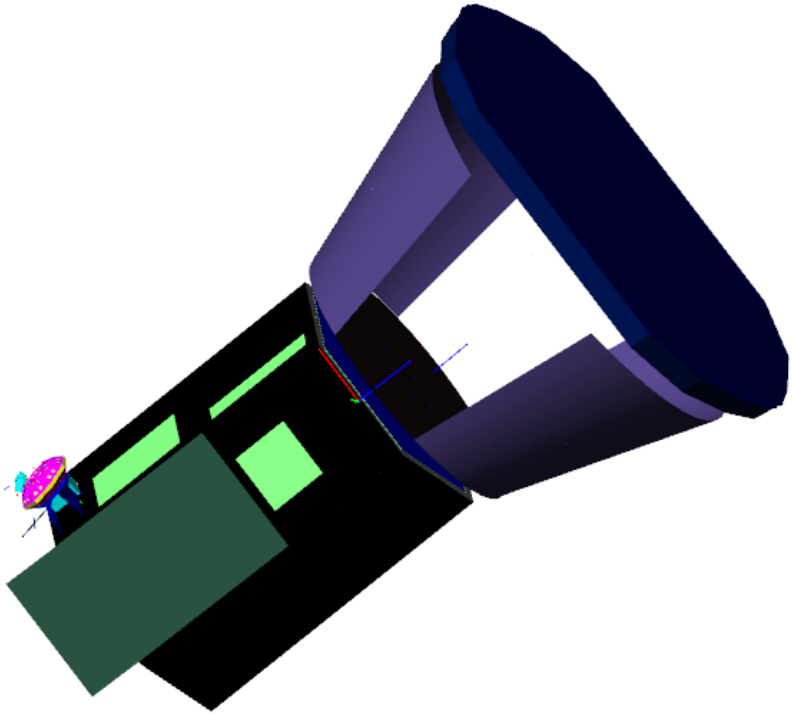
- EPI-Lo
  - Wedge Radiators (8) to Dissipate Internally Generated Heat
  - Eight Survival Heaters (One on Each Wedge)
  - MLI on Surfaces Except Apertures and Radiators



Design

- ISIS
  - EPI-Hi and EPI-Lo are Thermally Isolated from the Bracket
  - Bracket is Thermally Isolated from the S/C





Heaters and Sensors

- EPI-Hi Heater Operations
  - One S/C Thermistor on Each Telescope and Two S/C Thermistors on E-box (Primary and Redundant)
  - Operational Heaters on Each Telescope are on One S/C Service, but Controlled by E-box
  - Survival Heaters on Each Telescope and the E-Box are on One S/C Service and Controlled by S/C with Sense Location Currently Baselined as the E-box
  - Survival Heaters Also Used to Warm Instrument to Cold Operational Temperature for Cold Turn On by using Different Set Points

Heaters and Sensors

- EPI-Lo Heater Operations
  - Two (Primary and Redundant) S/C Thermistors on Dome for Heater Control and One More (To Be Positioned)
  - Survival Heaters on One S/C Service (Separate from EPI-Hi) Controlled by S/C with Sense Location Currently Baselined as One of the Wedges
  - Survival Heaters are Used to Warm Instrument to Cold Operational Temperature for Cold Turn On by Using Different Set Points
  - Survival Heaters are Also Used to Maintain Minimum Cold Operating Temperature During Low Power Operating Conditions
- Summary
  - One S/C Operational Heater Service (EPI-Hi)
  - Two S/C Survival Heater Services
  - Eight total (5 EPI-Hi and 3 EPI-Lo) S/C Thermistors

MLI

- Coverage
  - Entire Instrument (Including Underneath) Other than Apertures and Radiators
- Specifications

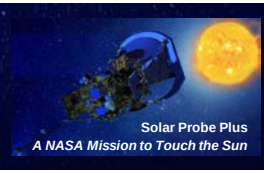
  i. Outer Layer #1: 1.6 Mil Germanium Black Kapton with Nomex Scrim (Germanium facing space and Black facing Spacecraft)- 1 Layer
  ii. Outer Layer #2: 2 Mil VDA1 Kapton (Aluminum facing space and Kapton facing Spacecraft)- 1 Layer
  iii. Internal Layers: 10 layers of .25 Mil VDA2 Mylar altered by 11 layer of Dacron B4A netting.

  - Each Separate Blanket Grounded with Wire to S/C
  - Vented Using Edge Mesh Screens Directed away from Apertures
  - Edges and Seams Sealed using GBK Tape
  - Blankets Secured using G-10 Buttons and SS Snap Rings

Materials and Finishes

- Radiators
  - Z-93Z55 Conductive White Coating
- MLI
  - Germanium Black Kapton (GBK)
- Apertures
  - EPI-Hi: TBD
  - EPI-Lo: TBD
- Thermal Isolators
  - G-10 Fiberglass

Thermal Model



- EPI-Hi Modeled by Vertex Aerospace
  - Rommel Zara and Santino Rosanova
- EPI-Lo Modeled by APL
  - Shawn Begley
- Bracket Modeled by Vertex Aerospace
- ISIS Model Integrated by Vertex Aerospace
- All Models Created using Thermal Desktop Software
- Pre-PDR Model Delivered to S/C in June
- Good Correlation between Instrument and S/C Results

Design Cases

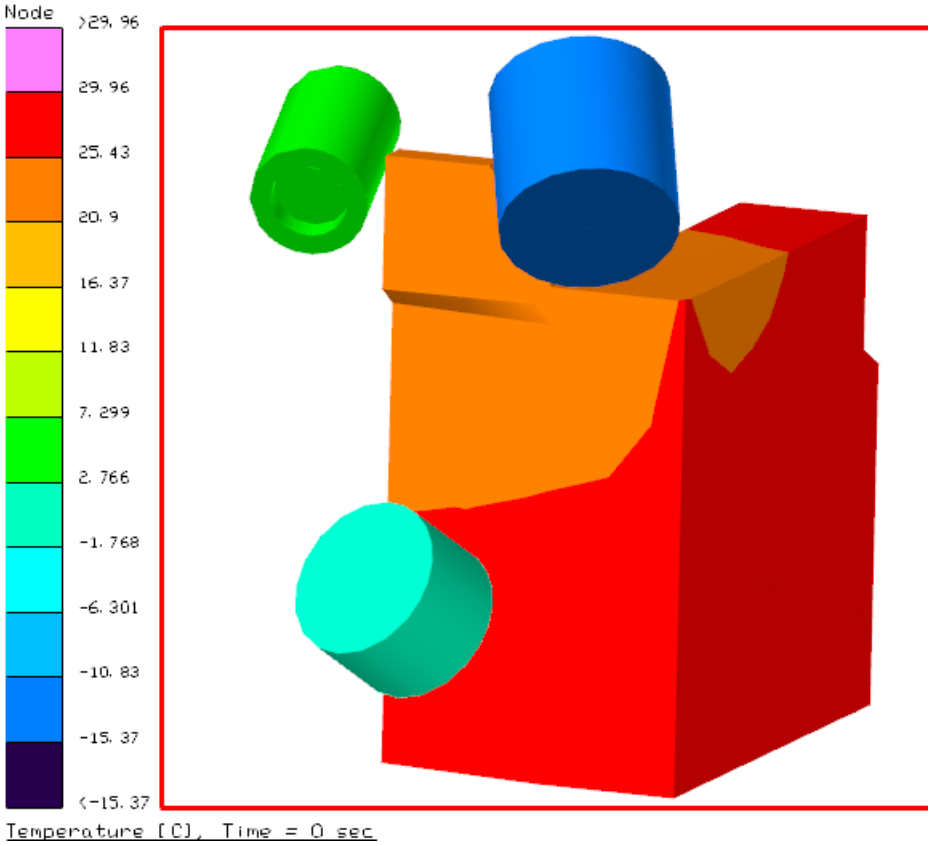
- Hot Operational
  - 0.TBD AU with +65 C I/F Temperature
  - EOL Power and Optical Properties
  - Low MLI e* = 0.03
- Cold Operational
  - 0.TBD AU with -25 C I/F Temperature
  - BOL Power and Optical Properties
  - High MLI e* = 0.05
- Cold Non-Operational
  - 0.TBD AU with -30 I/F Temperature
  - BOL Optical Properties and e* = 0.05
- Hot Non-Operational
  - 0.TBD AU with +70 I/F Temperature
  - EOL Optical Properties and e* = 0.03

Optical Properties

- Radiator: Z-93Z55 White Coating
  - BOL: a = 0.20, e = 0.90
  - EOL: a = 0.45, e = 0.90
- MLI Exterior: GBK
  - BOL: a = 0.49, e = 0.81
  - EOL: a = 0.55, e = 0.78

Predictions

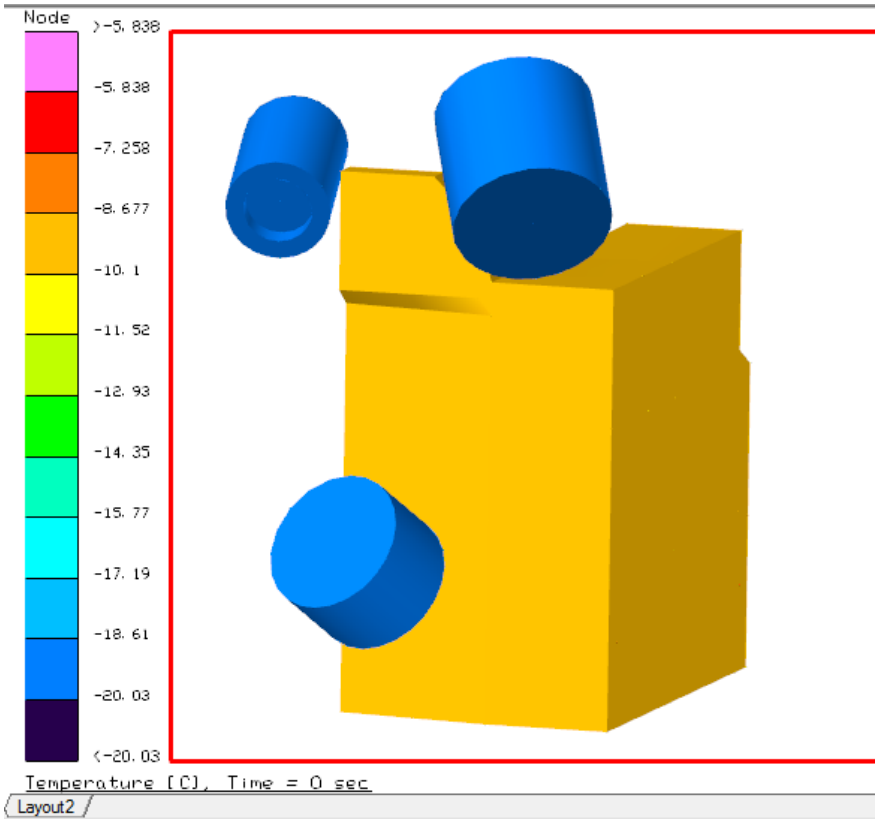
- EPI-Hi Hot Operational



Component	Limit (°C)	Predict (°C)	Margin (°C)
EPI-HI HET	40	29.2	10.8
EPI-Hi LET1	40	29.3	10.7
EPI-Hi LET2	40	27.9	12.0
EPI-Hi DPU	40	28.4	11.6
EPI-Hi Bias	40	28.4	11.6
EPI-Hi LVPS	40	29.9	10.0
EPI-Hi HET Tel	30	3.5	26.5
EPI-Hi LET 1 Tel	30	-15.3	45.3
EPI-Hi LET 2 Tel	30	-1.2	31.2

Predictions

- EPI-Hi Cold Operational

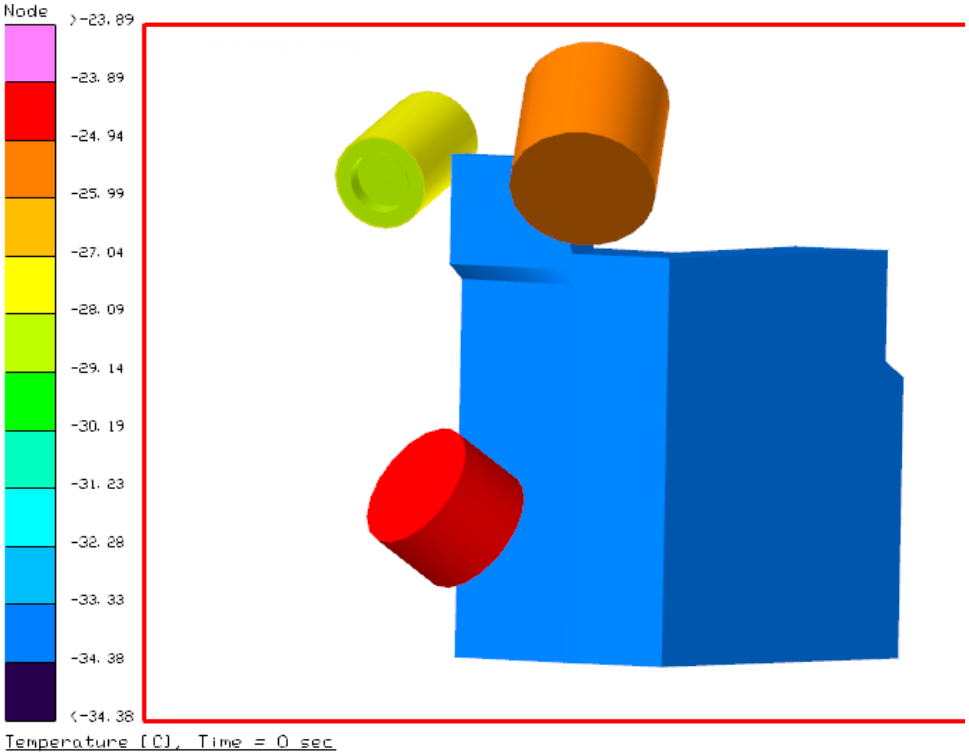


Component	Limit (°C)	Predict (°C)	Margin (°C)
EPI-HI HET	-25	-6.76	18.24
EPI-Hi LET1	-25	-6.73	18.27
EPI-Hi LET2	-25	-8.58	16.42
EPI-Hi DPU	-25	-7.99	17.01
EPI-Hi Bias	-25	-7.32	17.68
EPI-Hi LVPS	-25	-6.55	18.45
EPI-Hi HET Tel	-25	-20	5
EPI-Hi LET 1 Tel	-25	-20	5
EPI-Hi LET 2 Tel	-25	-20	5

Heater Location	Heater Power(W)
EPI-Hi HET TEL	0
EPI-Hi LET1 TEL	0.35
EPI-Hi LET2TEL	0.13
TOTAL	0.48

Predictions

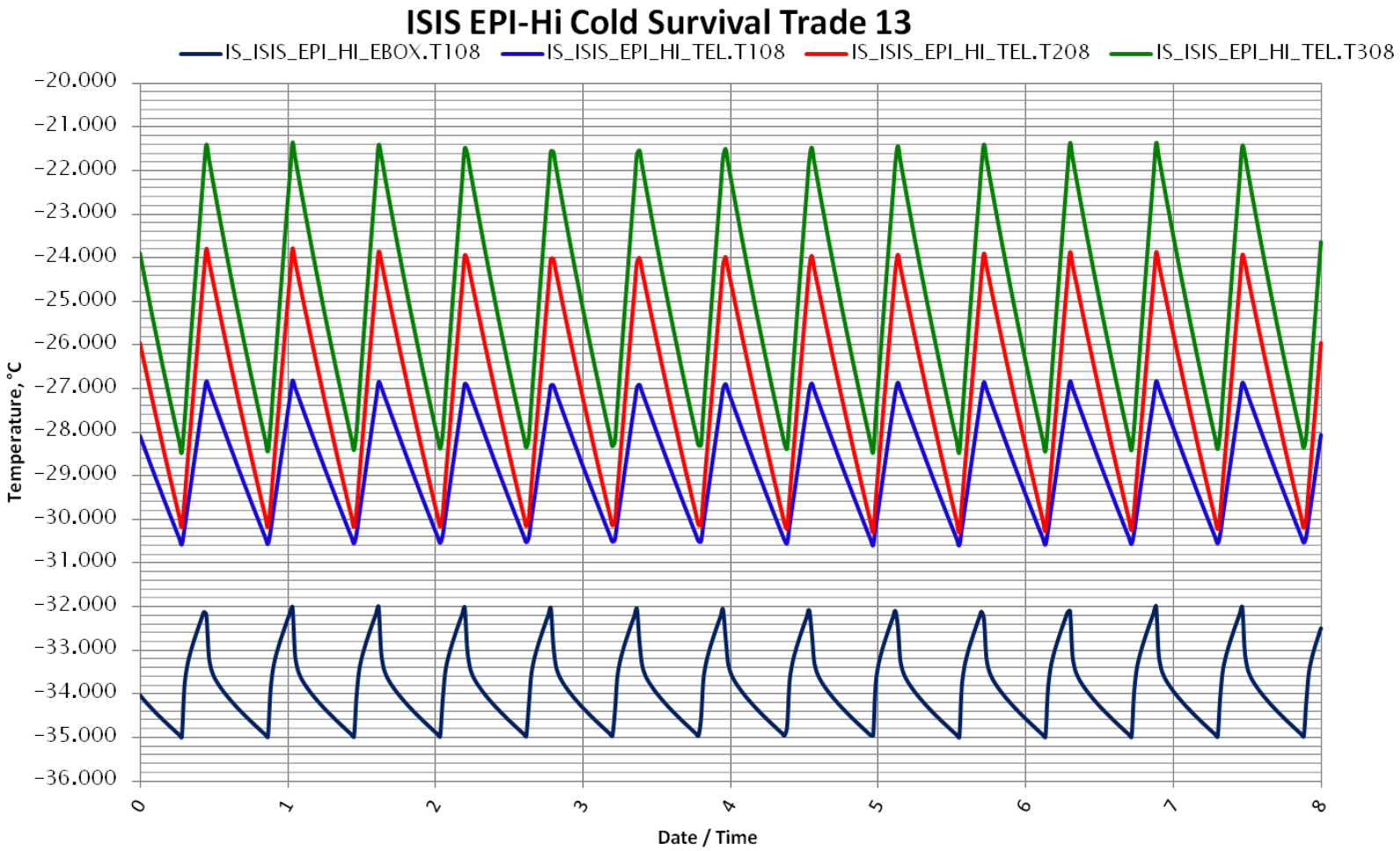
- EPI-Hi Cold Non-Operational



Heater Location	Heater Power (W)
EPI-Hi EBOX	2.78
LET 1 Telescope	0.47
LET 2 Telescope	0.35
HET Telescope	0.21
TOTAL	3.81

Predictions

- EPI-Hi Cold Non-Operational Temperatures

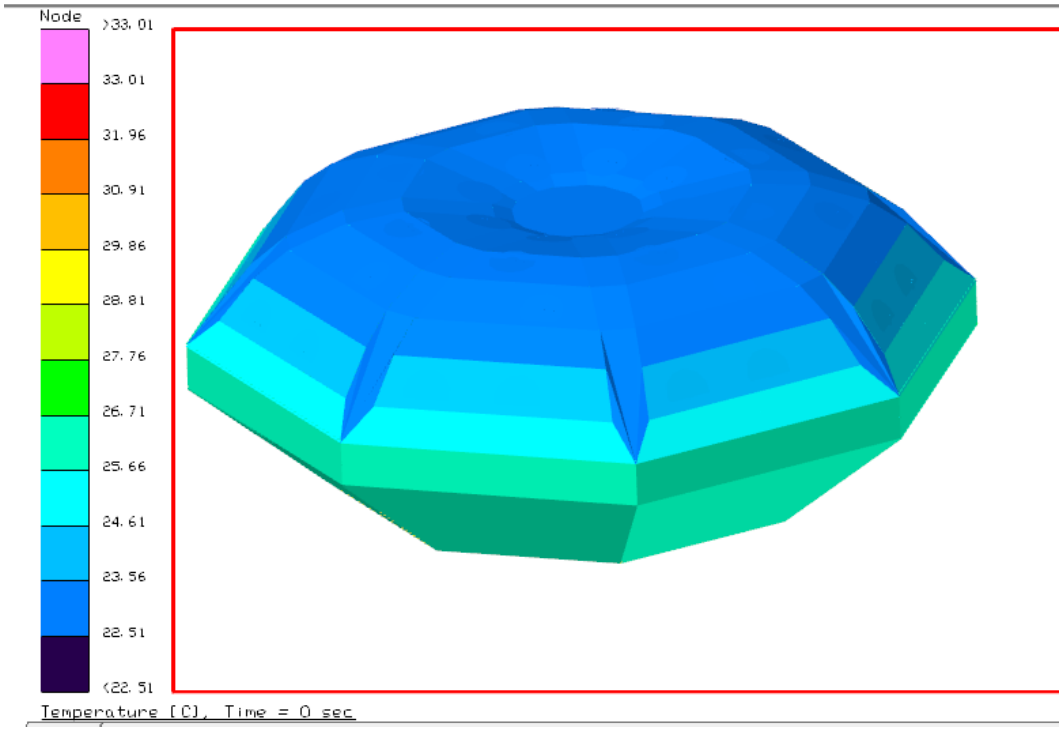


Predictions

- EPI-Hi Hot Non Operational

Predictions

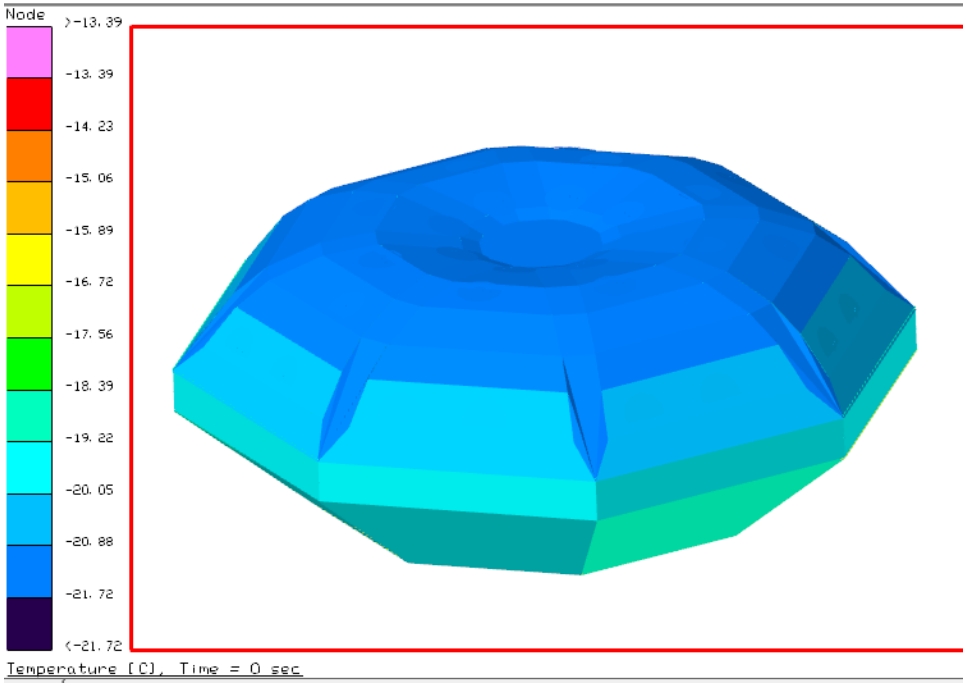
- EPI-Lo Hot Operational



Component	Limit (°C)	Predict (°C)	Margin (°C)
Detector	35	24.62	10.4
Electronics	55	33.01	21.99

Predictions

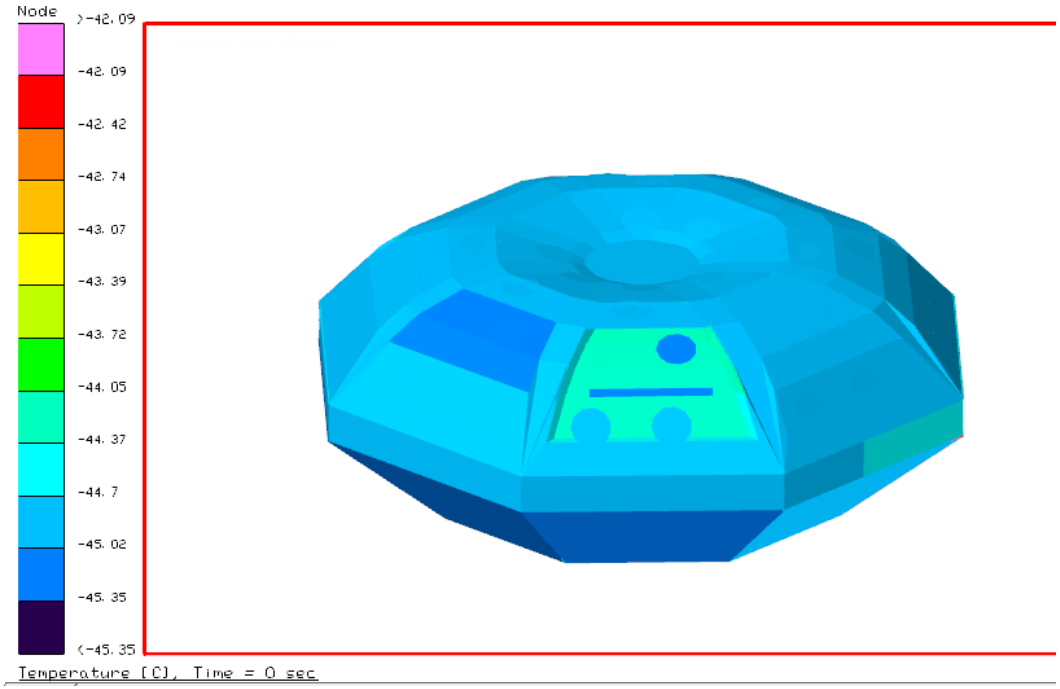
- EPI-Lo Cold Operational



Component	Limit (°C)	Predict (°C)	Margin (°C)
Detector	-30	-20.65	9.35
Electronics	-30	-13.39	16.61

Predictions

- EPI-Lo Cold Non Operational



Component	Limit (°C)	Predict (°C)	Margin (°C)
Detector	-45	-40.24	4.76
Anode Board	-45	-41.28	3.72
Event Board	-45	-41.17	3.83
Power Board	-45	-41.27	3.73
Dome	-45	-40	5

	Heater Power (W)
EPI-Lo Surv Heater	2.45

Predictions

- EPI-Lo Hot Non Operational