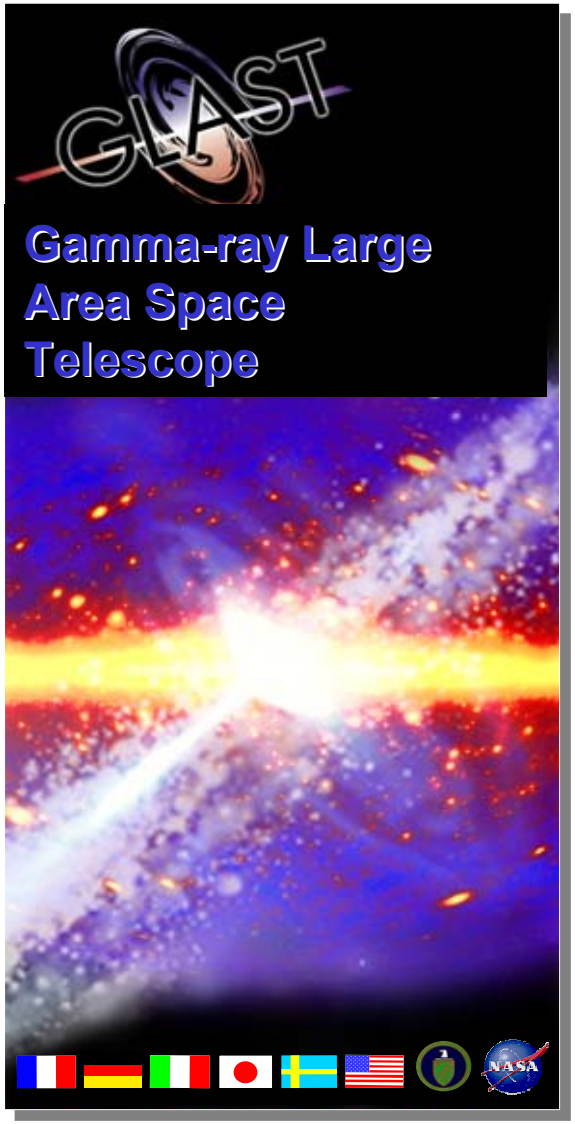

GLAST Thermal Model Overview

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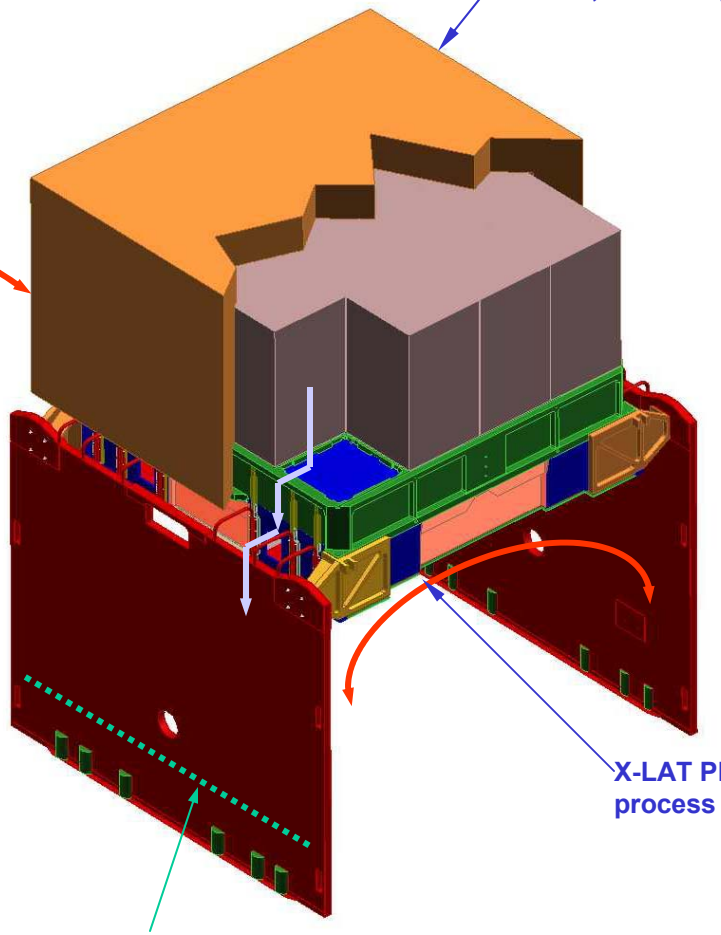
LAT Thermal Systems Overview

On-Orbit Thermal Environment and LAT Process Power				
	Survival	Cold	Hot	Units
Earth IR	208	208	265	W/m^2
Earth Albedo	0.25	0.25	0.40	
Solar Flux	1286	1286	1419	W/m^2
LAT Process Power	0	523	602	W

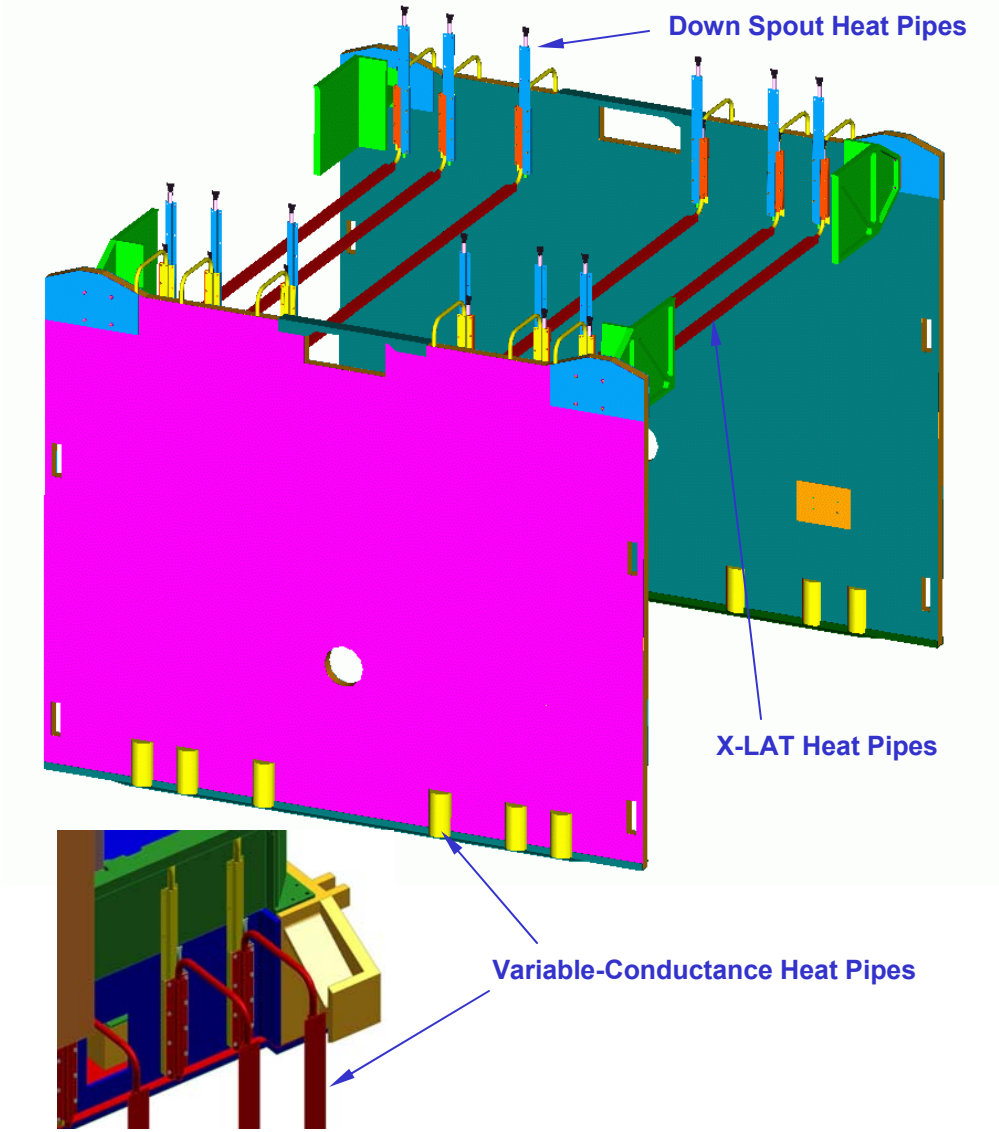
Total Max Power = 602 + 48 = 650 W



LAT Thermal Overview

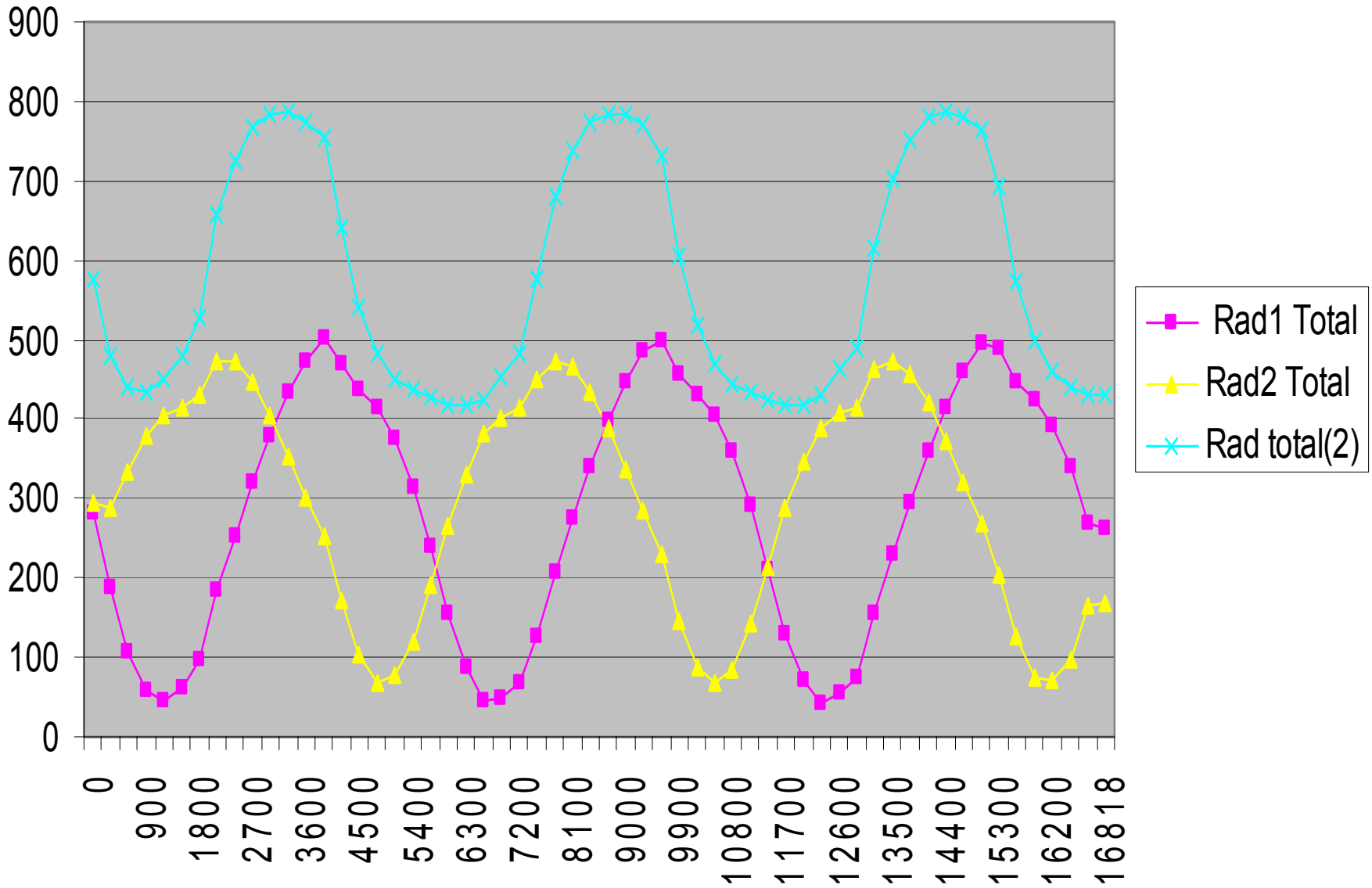
Thermal System Detailed Design

- **Radiators**
  - Two panels, parallel to the LAT XZ-plane
  - Size per panel: 1.85 m x 1.46 m = 2.7 m^2
  - Construction
    - Aluminum honeycomb structure
- **6 variable-conductance heat pipes on each Radiator panel**
  - Provide active feedback control of grid temperature through VCHP's
- **Heat Pipes**
  - Design
    - Constant-conductance heat pipes on the Grid Box
    - Ammonia working fluid
    - Extruded aluminum
    - Multiple axial groove casings
  - Top Flange Heat Pipes (not shown)
    - Isothermalize grid structure
  - X-LAT Heat Pipes
    - Remove waste heat from electronics
    - Connect radiators for load-sharing
  - Downspout Heat Pipes
    - Transport waste heat from grid to radiator VCHPs



Radiator and Heat Pipe Details

Radiator Hot Design Case Heat Loads

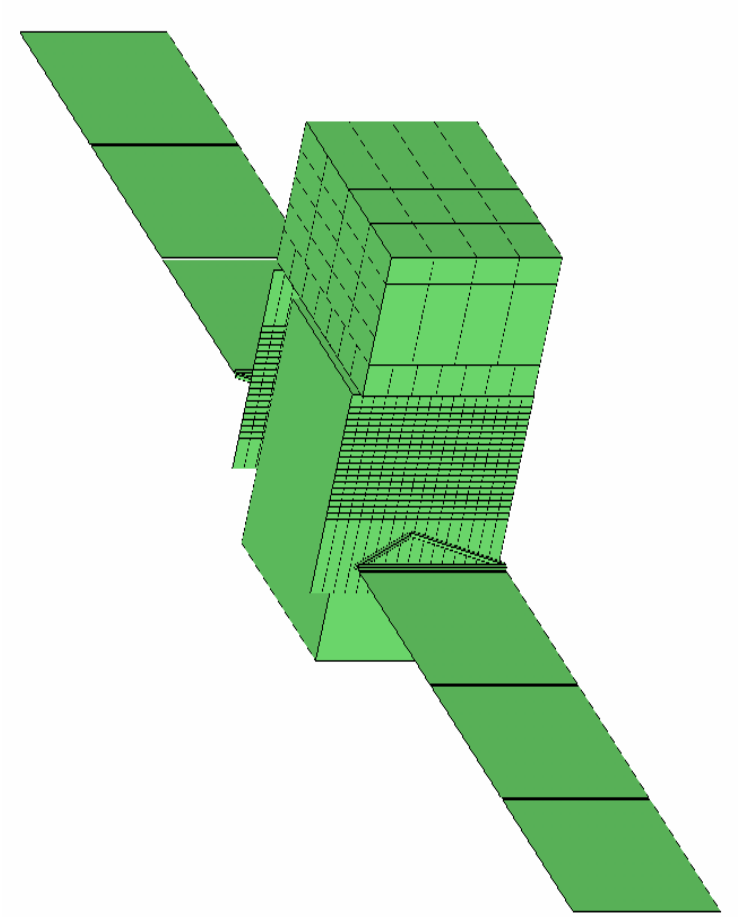


Thermal Design Changes Since DPDR

- **Radiators**
  - Moved Radiators closer to Grid to accommodate spacecraft concerns
  - Increased radiator area from 2.7 sq meters to 2.73 sq meters but added area in inefficient locations(far from VCHPs)
  - Provide individual control of each VCHP reservoir-lessons learned from on orbit experience
  - Due to lack of definition of minimum solar array view factor, asked for greater survival heater power budget-affects cost, schedule of TCS components
- **Tracker**
  - Add high emissivity black paint to aluminum EMI shield on tracker composite walls
    - Increases heat transfer to ACD and increases tile detector assembly temperatures
    - Increase heat transfer among tracker towers and reduces the maximum tracker temperature
- **ACD**
  - Change outside layer of LAT MLI blanket from FOSR to germanium black kapton
    - Increases tile detector assembly temperatures
    - Increases maximum tracker temperature

LAT Instrument and Radiator Assembly Thermal Model

- Combined TSS/SINDA Model consists of
  - External TSS from ACD TSS Model
    - (64 surfaces, 2440/2752 active nodes)
  - Internal TSS includes internals from ACD and LAT Grid and TKR's
  - TSS radiators, XLAT, solar arrays and vehicle
- SINDA Model
  - Consists of 11,617 nodes
  - ACD model from GSFC with Grid and TKR's removed (516 nodes)
  - LAT SINDA model generated from SLAC ANSYS model (7969 nodes)
  - Radiator, X-LAT and solar array SINDA nodes and conductors generated by LMMS



LAT Thermal Model TSS External Geometry

Tracker Thermal Model

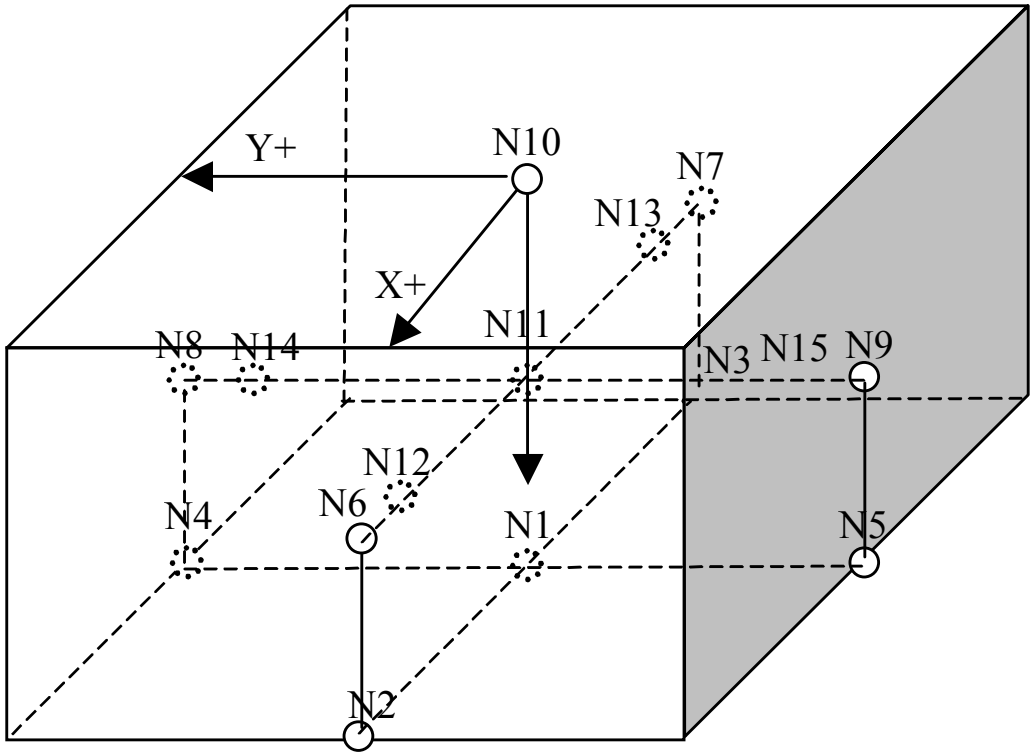
- **Current tracker thermal model not adequate**
  - **Does not account for radiation heat transfer**
  - **Current Thermal Model doesn't converge during steady state calculations**
    - **Can lead to error in temperature predictions if not understood**
    - **Very high conductors indicate some nodes should be lumped together**
    - **Some zero conductors**

- **Developing new thermal model of tracker**
  - **Will include radiation heat transfer between tracker with high emissivity coating(black paint) on tracker walls**
  - **Model expected 1/15/03**

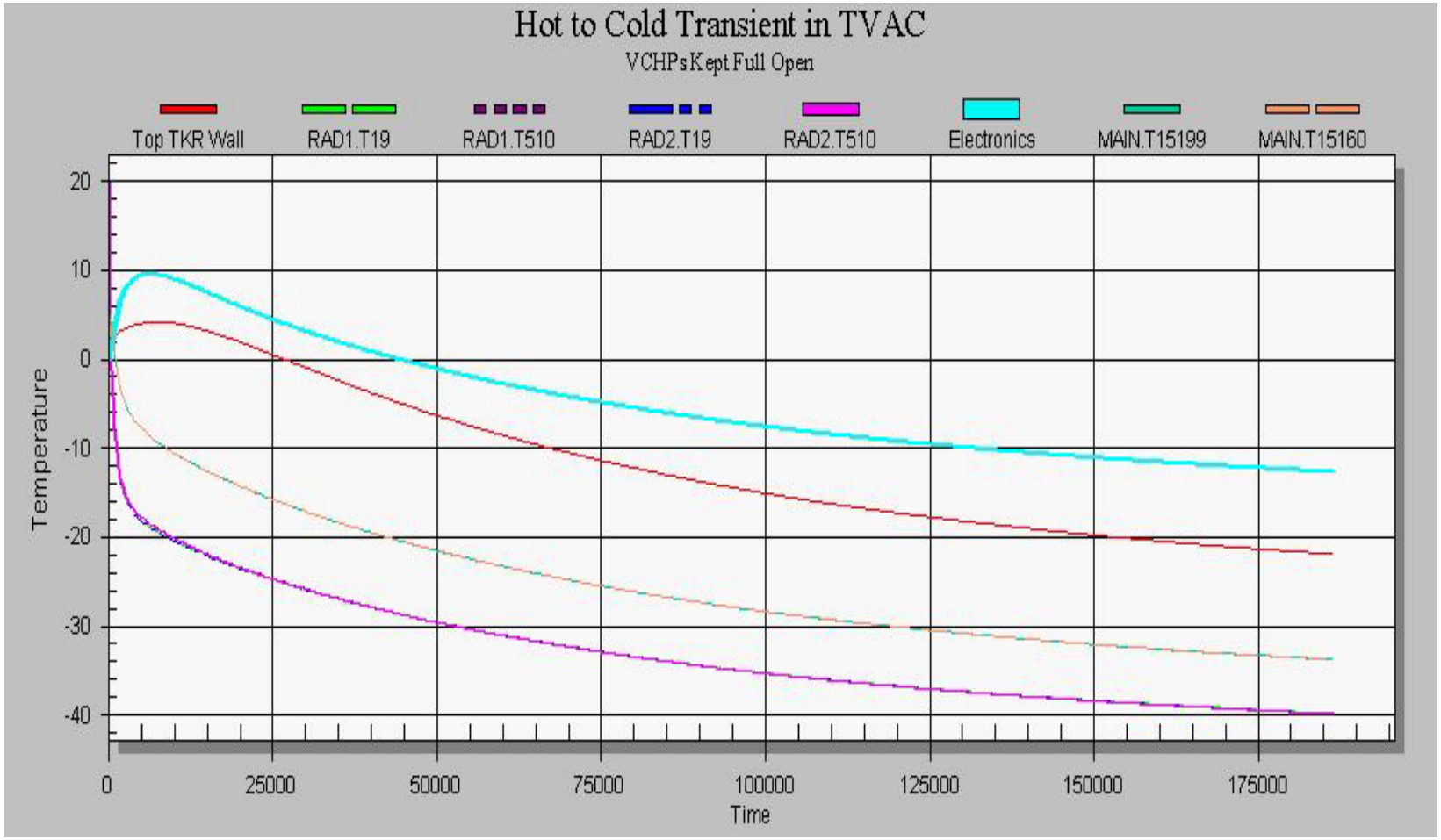
- **Confirmed thermal conductivity of tracker composite walls**
  297 w/m-K in the Z-direction; 147 w/m-K in plane perpendicular to Z

Calorimeter Thermal Model

- **Detailed Calorimeter model developed to replace current ~200 node model in LAT**
  - **Will be correlated to upcoming component level test**
  - **Reduced model (15 nodes) developed for LAT thermal model**
    - **Will be correlated with detailed model**
    - **Model due 11/15-currently scheduled for 11/22**
    - **Will use to confirm TV cycle time**

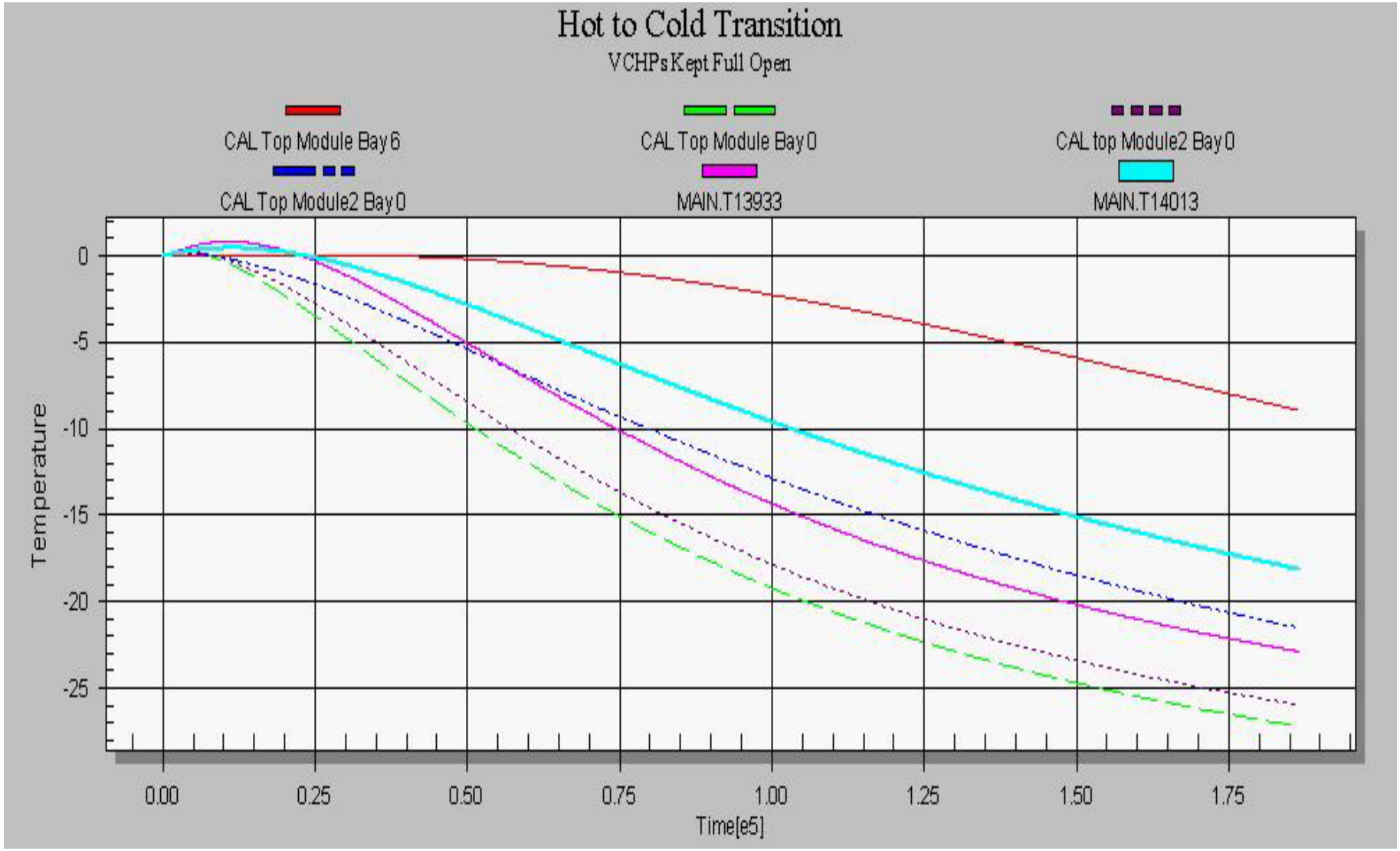


Cooldown of LAT in Thermal Vacuum Test



With VCHPs kept full open, it takes about 36 hours for the Tracker to reach its lower ATP limit. This also assumes the LAT is in flight configuration, i.e. MLI blankets, Radiators, etc. as designed for flight.

Calorimeter Cooldown-Current Model Predicts



Electronics Modeling

- **Current definition, used for Delta-PDR**

Cold Case Power Dissipation

LAT +Y
+Y Side
LAT Radiator

Bay 12 SIU-A 27.97	Bay 13 Empty 0	Bay 14 Empty 0	Bay 15 EPU-A 13.61
Bay 8 SIU-B 0	Bay 9 GASU 7.08	Bay 10 GASU 7.08	Bay 11 EPU-A 13.61
Bay 4 Pwr Dist-B 0	Bay 5 GASU 7.08	Bay 6 GASU 7.08	Bay 7 EPU-A 13.61
Bay 0 Pwr Dist-A 24.00	Bay 1 Empty 0	Bay 2 EPU-B 0	Bay 3 EPU-A 13.61

-X Side
LAT +X
+X Side
Sun Side
-Y Side
LAT Radiator

Ptot: 134.75
TEM/TPS: 9.23
P(tot): 282.43

LAT Top View

Hot Case Power Dissipation

LAT +Y
+Y Side
LAT Radiator

Bay 12 SIU-A 33.78	Bay 13 Empty 0	Bay 14 Empty 0	Bay 15 EPU-A 16.44
Bay 8 SIU-B 0	Bay 9 GASU 8.64	Bay 10 GASU 8.64	Bay 11 EPU-A 16.44
Bay 4 Pwr Dist-B 0	Bay 5 GASU 8.64	Bay 6 GASU 8.64	Bay 7 EPU-A 16.44
Bay 0 Pwr Dist-A 36.00	Bay 1 Empty 0	Bay 2 EPU-B 0	Bay 3 EPU-A 16.44

-X Side
LAT +X
+X Side
Sun Side
-Y Side
LAT Radiator

Ptot: 170.08
TEM/TPS: 13.02
P(tot): 378.38

LAT Top View

Legend:

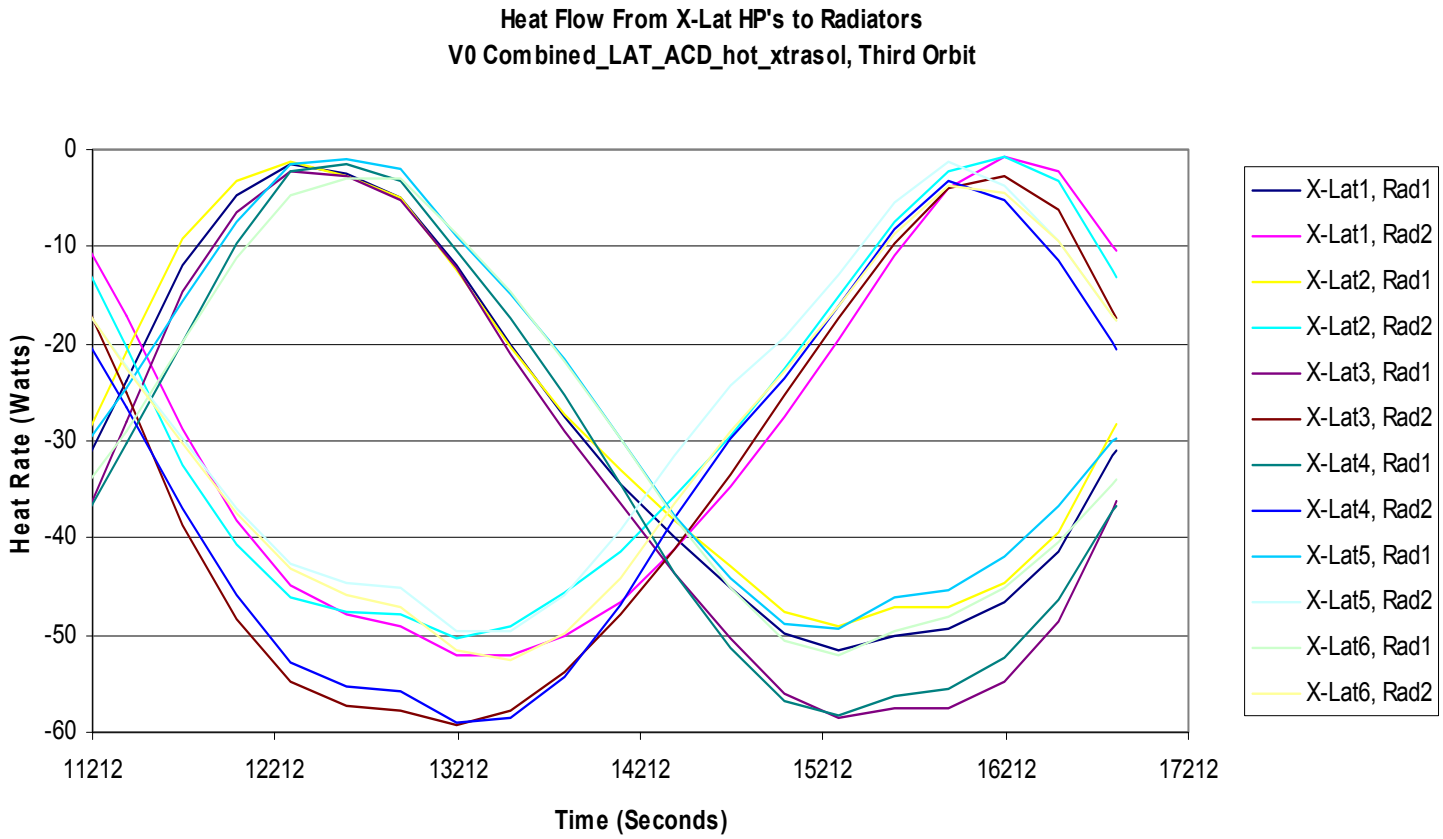
GASU	Global trigger, ACD, and Switching Unit
SIU	Spacecraft Interface Unit
Pwr Dist	Power Distribution Box
EPU	LAT Event Processor
-A	A-side, powered box
-B	B-side, unpowered cold box

Notes:

1. All power is in watts

Electronics Modeling

- No detailed definition
  - Only preliminary mechanical layouts
  - Only preliminary footprints of specific electronics on X-LAT plate
  - Mechanical lead recently hired to work interface details
- Current definition will define X-LAT heat pipes
  - Need detailed definition of electronics box design by 12/20



VCHP Modeling

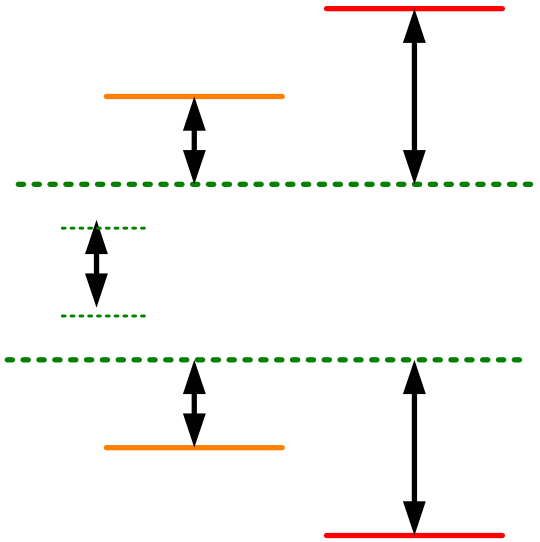
- **Lockheed Martin Software**
  - Converted from heritage to Sinda format
  - Providing results consistent with Cullimore & Ring routine; will allow use of commercial software for model delivery
  - Currently working VCHP control logic; expected by 12/20

- **VCHP Modeling**
  - Added reservoirs to TSS model; required for feedback control
  - Can evaluate hot design case; cold case evaluation difficult without minimum solar array view factor

- **VCHP Control**
  - For normal operations, each heatpipe will be individually controlled
    - Requires more heater zones and thermistors
    - Complicates control logic
    - necessary for control during all possible orientations(flight experience)

Verification Test Temperatures

- **Test temperatures set to exercise subsystem design limits**



Environmental Temperature Limits

- Shooting for "Desired" temperature limits
- Any deviations from desired limits requires a technical note justifying the change

Component	Low Temp Limits (degC)			High Temp Limits (degC)			Survival (degC)	
	Qual	AT	Operating	Operating	AT	Qual	Low	High
Desired	**-40**	**-35**	**-30**	**+50**	**+55**	**+60**	**-40**	**+60**
Tracker	-30	-20	-15	25	30	50	-30	50
Calorimeter	-30	-20	-15	25	30	50	-30	50
TEM*	-40	-35	-30	50	55	60	-40	60
EPU*	-40	-35	-30	50	55	60	-40	60
SIU*	-40	-35	-30	50	55	60	-40	60
Pwr Dist*	-40	-35	-30	50	55	60	-40	60
GASU*	-40	-35	-30	50	55	60	-40	60
BEA	-25	-20	-15	30	35	40	-40	45
TDA	-50	-45	-40	35	40	45	-60	45
Grid	-40	-35	-30	30	35	40	-40	40
CCHP's	-40	-35	-30	30	35	40	-40	40
VCHP's	-35	-30	-25	30	35	40	-67	40
Radiator Panels	-72	-67	-62	50	55	60	-72	60