Title: **H-EPLM Thermal Model and Analysis**

CI-No: 120 000

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Issue	Date	Page	Description of Change	Release
1	30.11.01	all	First Issue	
2Draft	11.06.02	all	Draft Issue for PDR Sect. 5.3: - HTT, HOT, TS1 and innermost tank suspension straps implemented in ESARAD Geometry Model, - Heat shield Beam entrance baffles merged to a common baffle with 0.8 emissivity and attached to TS2 only, - Cryostat Baffle Insert with 500 mm diameter introduced, - Telescope opening changed from 360 mm to 560 mm. Sect. 5.4: - +Y Radiator rotated by 14° towards Y axis (to avoid collision with filling port), - emissivity of CVV main radiator changed from 0.8 to 0.7, - emissivity of CVV ±Y and –Z Radiator changed from 0.9 to 0.8. Sect. 5.5: - Waveguides implemented in ESARAD Geometry Model, - LOU harness updated acc. to RD 02, - LOU radiator design updated acc. to ECP HP-2-ASED-CP-001, - Telescope mechanical fixation on CVV changed from GFRP struts to T300 CFRP struts, - BOLA direct mounted on CVV and covered with MLI Sect. 5.6: - Scientific harness updated acc. to RD 02, - Thermalization of SPIRE JFET harness shifted from TS 1 to TS 2. Sect. 5.7: - HSS update acc. to. Drawing Set Status "Begin 2002". Sect. 5.8: - SVM Thermal Shield modified (+Z half deleted), - SVM top MLI set to 230 K boundary acc. to AD 07, - Cross-section to length ratio of SVM/CVV struts changed from 18.42 mm to 13.05 mm. Sect. 6.1:	

Issue	Date	Page	Description of Change	Release
			- MLI performance data changed based on RD 08 and RD 09.	
2	17.06.02	all	PDR Issue of document	
2.1	10.12.02	30	Table 5.2-2 corrected (typo: JFET dissipation in wrong column)	
		35, 36	Table 5.3-1 corrected (typo: 9 LOU windows instead 7)	
		37	Explanation of CVV radiator model added as requested in PDR RID 8516	
		41	Table 5.4-1 corrected (typo: 9 LOU windows instead 7)	
		47	Table 5.6-2 corrected (typo: JFET harness length)	
		52	Complete data as requested in PDR RID 8517	
		53, 55	Correction of SVM shield skin data acc. to TMM assumptions	
		58-64	References for material data plots completed as requested in PDR RID 8517	
		74	Table 7.4-1 corrected and completed	
		79	Table 7.4-3 completed as requested in PDR RID 8519	
		80	Figure 7.4-5 exchanged (copy and paste error)	
		86	Table 7.4-6 corrected (typo: HOB temperature uncertainty)	
		90	Introduction of Section 7.4.5 to refer to transient analyses described in RD 06	
		91	Lifetime of PDR Collocation Status added	
		Annex 1	Temperature listings for in orbit hot and cold case as well as for ground case added as requested in PDR RID 8517	
		Annex 2	Input Traceability Matrix added	
3	09.09.03	all	Document entirely modified. Major changes: - Restructuring of H-EPLM GMM/TMM to allow Submodel structure - Refinement of CVV lower bulkhead MLI (HP-2-ASPI-TN-0366) - Increase of CVV radiator (upper bulk and Cryostat Baffle). - Refinement of Telescope Geometry based on ASEF catia model ICD-DT0018251-02-00-3D-TELESCOPE_28_05_02. - Refinement/update of ventline modelling. - Implementation of Cryo-Cooled Cover (low emissive cover shield). - Update LEOP Calculation (PPS Sample 5). - Implementation of HIFI coax cable: Precision Tube JS50141,	

Issue	Date	Page	Description of Change	Release
			JN50141. - Refinement/update of beam entrance baffles - Removal of BOLA - Implementation of H-RSVM submodel (ASPI delivery) - Introduction of L3 interfaces. - Update of SVM Thermal Shield material (CFRP panel instead of Al panel). - Removal of Instrument Shield MLI - Introduction of 100 mm EPLM enlargement - Implementation of HSS lower stiffening ribs - Introduction of Safe Mode - Introduction of On-Ground Test Mode (IMT) - Implementation of optimized tank suspension straps - ISO TMM conductance values between suspension bolts and heat shields replaced by physical values - Update/Refinement of LOU TS2 baffle and LOU windows in H-EPLM GMM - Refinement (nodal- break-down) of Cryostat Baffle and Cryostat Baffle MLI - Update of Al 5083 thermal conductivity data (CVV) acc. to NIST data base - Implementation of HSS/SVM closure MLI - Implementation of overall instrument timeline - Update of Lifetime calculation (HP-2-ASED-TN-0065) - Implementation of Instrument Submodels, see below - Integration of PACS RTMM update (delivery date 09.05.2003) - Integration of SPIRE RTMM Issue 2.3 - Integration of HIFI RTMM update (delivery date 28.03.2003)	
4	15.04.04	all	Major changes: - Integration of SPIRE RTMM Issue 2.5 - Refinement of nodal break down of Thermal Shields (in circumferential direction) incl. Ventline and SFW - Implementation of CDR Harness (HP-2-ASED-TN-0010, Issue 3.1) - Update of CVV internal MLI performance data (based on FZ Karlsruhe test results) - Implementation of GFRP and CFRP test data for TSS - Implementation of updated (enlarged) LOU Radiator & LOU - Implementation of Startracker heat load (200mW) - Replacement of L0 thermal link conductance requirements and L1/L3 link conductance by actual geometry and measured (temperature dependent) conductance data - Radiation in filling line - Gas conduction in cover flush line - Update of solar array thermo-optical properties - Merging of the two SPIRE L1 strap I/F points on VL to one I/F - Beam entrance: introduction of TS2 baffle aperture and IMT crown - Update of Pre-Launch/Early Orbit scenario - Update of Lifetime formula	

Issue	Date	Page	Description of Change	Release
			- Introduction of IMT transient timeline - Update of instrument interface temperature & heat flow requirements - Update of CVV radiator thermal properties	
5Draft	16.07.07		Draft issue 5 for H-EPLM MQR session B	
5	08.08.07	All	Major changes (all changes w.r.t. issue 4): Section 3: List of lifetime requirements refined/IID-B conditions introduced (RFD ASED-RD-0047) Instrument I/F requirement tables adapted according to updated requirements (RFDs) and instrument models Fig. 3.2-1 (Roll & Pitch angle evolution) updated L2 orbit conditions compiled in table 3.2-1 Section 4 (Thermal Model Description) entirely reworked, in particular: Software handling updated Section 4.2 (Lifetime calculation) updated and shifted to new section 6.5.1 Section 4.3 (H-EPLM Model with implemented Instrument Models) deleted Section 4.4 (Pressure Drop Model) updated and shifted to new section 4.4.2 Table 4.2-1 (modelling references) updated Section 4.3 (OBA, SF and Tanks) updated (figures and tables) Table 4.4-1 (Ventline tubing) refined Section 4.5.1 (PACS) updated w.r.t. L0 flexible links, dissipation profiles (Figure 4.5-3) and masses (table 4.5-1) Section 4.5.2 (SPIRE) updated w.r.t. dissipation profiles (Figure 4.5-6), masses and OBP supports (table 4.5-1) Section 4.5.3 (HIFI) updated w.r.t. add.dissipation profile (Figure 4.5-8) and L0 flexible Cu strap cross section (table 4.5-3) Section 4.6 (Thermal Shields and Tank Suspensions): figures and table 4.6-1 updated (CuBe blades added, LOU TS1 baffle added, case-dependend baffle emissivities introduced). Section 4.7 (CVV) updated w.r.t. external model refinements (radiators, ventline, plugs, harness etc.), LOU baffles, beam entrance in text, figures and tables Section 4.8 (LOU and Telescope): figures and tables refined; telescope RGMM/RTMM provided by ESA introduced Section 4.9 (Harness) updated, including harness chart (figure 4.9-1 and tables 4.9-2 to 4.9-3 (anchoring of JFET harness, refined modelling of coax, HOT depl. heater harness dissipation) Section 5 (Material Properties): CVV External MLI reworked Fig. 5.2-1 with updated data for GFRP struts conductivity Fig. 5.2-6 introduced	

Issue	Date	Page	Description of Change	Release
			Section 6 (Thermal Analysis Results) entirely reworked, in particular:	
			Section 6.1.1 (Operation On Ground) updated w.r.t. heat flow chart and sensitivity tables	
			Section 6.1.2 (On-Ground Autonomy) updated w.r.t. issue 5 TMM	
			Section 6.1.3 (On-ground testing IMT) deleted; to be analysed separately if required (IST)	
			Section 6.2 (Pre-Launch and LEOP) updated w.r.t issue 5 TMM; viewgraphs for launch phase added (figure 6.2-4)	
			Section 6.3 (Spacecraft Operation in L2 Orbit) updated: analysis results including heat flow charts & sensitivity tables	
			Section 6.3.3 (Transient S/C Operations) updated	
			Section 6.4 (Transient instrument operations) updated	
			Section 6.5.2 (Lifetime calculation) updated according to issue 5 TMM	
			Section 6.6 (Instrument I/F temperatures) updated according to issue 5 TMM; additional data sets for higher massflows included; description of calculation approach added	
			Annex 1 (Temperature listing) updated	
6	20.03.09	17	Scope updated	
		18-21	Appl. & Ref. Documents updated	
		22	Abbreviations updated	
		24	PACS/SPIRE I/F requ. L2 & L3 in section 3.1.2 updated	
		30-34	Sections 4.1 and 4.2 updated	
		39	Emissivities of spatial framework added and OBP mass updated in Table 4.3-1	
		44	Paragraph updated (pressure drop)	
		50, 53	SPIRE SMEC coils node 826 added	
		51	Update of Figure 4.5-5 and Figure 4.5-6 (dissip. temp. depend.)	
		56	Update of Figure 4.5-8 (HIFI TMM updated)	
		63-65, 69	Ext. VL elongation (“moustache”) and therm. straps implemented	
		70-72	Update of LOU emissivity & dissipation	
		73	Implementation of LWB/LOAACH	
		74	Update of Figure 4.8-5: Telescope GMM	
		75-76	Update of Table 4.8-1: Item List for LOU and Telescope	
		77	Update of Figure 4.9-1:	
		78	Telescope harness section added	
		81	Update of Table 4.9-5: CVV External CCH Data	
		82-84	Update of Sunshade vertical stiffener thermooptical properties, refinement of HSS contour	
		88	Grounding wires to SVM Shield implemented	
		102	Ground heat flow chart Figure 6.1-1 updated	
		103-104	Ground sensitivities updated	
		105-106	Section 6.1.2 On-Ground Autonomy deleted	
		105-112	Launch autonomy and LEOP completely reworked (no HOT)	
		113	Table 6.3-1 updated	
		114	Figure 6.3-1 updated	
		116-117	Orbit heat flow charts Figure 6.3-3 to Figure 6.3-5 updated	
		118-137	Section 6.3.2 Orbit Sensitivities updated	
		138-139	Figure 6.3-6 to Figure 6.3-9 updated (S/C rotation 30°)	
		140-159	Instrument transient timeline figures updated	
		161	Section 6.5.2 Lifetime Calculation updated	

Issue	Date	Page	Description of Change	Release
		162-164 165 166-198	Section 6.6 Instr. I/F temperatures updated Section 7 (Summary & Conclusions) updated ANNEX 1 updated	

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1 SCOPE

This document describes the HERSCHEL EPLM Detailed Thermal Mathematical Model (DTMM) and Detailed Geometrical Mathematical Model (DGMM). It represents the PFM configuration and is used for the final flight predictions. It incorporates the correlation activities performed in the framework of the STM, STM2 and PFM test campaigns [RD 45] [RD 46] [RD 59]. The nodal break down and the corresponding assumptions are described in detail. Following the issue numbering of this report, the thermal model is referenced as issue 6 and will be released with the next issue of [RD 47].

Material properties used in the DTMM/DGMM are also reported in this document. Finally, the flight prediction analyses performed with this thermal model are described in detail. The results are shown basically in form of temperature distribution and heat flow charts. A comprehensive sensitivity analysis is performed with respect to lifetime and EPLM temperatures. Instrument interface temperatures are calculated using a dedicated instrument timeline of 6 x 48h which includes transient operation of and switching between 5 different instrument modes. Finally, lifetime calculations are carried out based on the thermal analysis results including transient in-orbit cool down.

2 Applicable and Reference Documents

2.1 Applicable Documents

AD 01 HERSCHEL/PLANCK Instrument Interface Document IID Part A, Doc. No.: SCI-PT-IIDA-04624, Issue 4, 30.04.2006

AD 02 HERSCHEL/PLANCK Instrument Interface Document IID Part B for PACS, Doc. No.: SCI-PT-IIDB/PACS-02126, Issue 4, 02.06.2006

AD 03 HERSCHEL/PLANCK Instrument Interface Document IID Part B for SPIRE, Doc. No.: SCI-PT-IIDB/SPIRE-02124, Issue 4, 01.04.2006

AD 04 HERSCHEL/PLANCK Instrument Interface Document IID Part B for HIFI, Doc. No.: SCI-PT-IIDB/HIFI-02125, Issue 3.3, 21.10.2005

AD 05 H-EPLM Environment & Test Requirements Specification, Doc. No.: HP-2-ASED-SP-0004, Issue 3, 16.07.2004

AD 06 H-EPLM Requirement Specification, Doc. No.: HP-ASPI-SP-0250, Issue 3.3, 20.10.2004

AD 07 Herschel EPLM Interface Specification; HP-2-ASPI-IS-0039; Issue 6, 07.10.2004

AD 08 Herschel EPLM Thermal Interfaces; HP-1-ASP-TN-0413; Issue 1, 24.10.2002

AD 09 List of Acronyms, HP-1-ASPI-LI-0077, Issue 2, 12.07.2004

AD 10 General Design and Interface Requirements (GDIR), Doc. No.: HP-1-ASPI-SP-0027, Issue 5, 07.10.2004

AD 11 RFD for HIFI Instrument Interface Temperatures, Doc. No.: HP-2-ASED-RD-0040, Issue 2, 27.07.2006

AD 12 RFW for Change of cryogenic lifetime calculation, Doc. No.: HP-2-ASED-RW-0013, Issue 2, 19.01.2009

AD 13 Herschel Telescope Specification, Doc. No.: HP-2-ESA-SP-4671 / SCI-PT-RS-04671, Issue 7, 26.07.2004

AD 14 RFD for Instrument Interface Temperatures, Doc. No.: HP-2-ASED-RD-0020, Issue 1, 26.04.2004

AD 15 RFW for Photometer JFET dissipation, Doc. No.: HR-SP-RAL-RFW-005 v1

AD 16 RFD for PACS FPU Interface Temperatures, Doc. No.: HP-2-ASED-RD-0048, Issue 2, 12.11.2008

AD 17 RFD for SPIRE FPU Interface Temperatures, Doc. No.: HP-2-ASED-RD-0050, Issue 2, 11.11.2008

AD 18 Herschel Launch Sequence Test Specification, HP-2-ASP-TS-1646, Issue 1, 30.06.2008

AD 19 RFW for FPU I/F Gradients during launch autonomy and LEOP, Doc. No.: HP-2-ASED-RW-0011, issue 1, 12.11.2008

2.2 Reference Documents

RD 01 Hypothesis and Methods for Lifetime Calculations; Doc.No.: HP-2-ASED-TN-0065, Issue 2, dated 07.04.2004

RD 02 Harness Inputs for Thermal Analysis Doc.No.: HP-2-ASED-TN-0010, Issue 3.2, dated 21.01.05

RD 03 Reduced PACS Instrument Interface TMM, Issue 3.1, provided by ESA on 26.04.2007

RD 04 Reduced SPIRE Instrument Interface TMM, Issue 2.6, provided by SPIRE on 27.04.2007

RD 05 Reduced HIFI Instrument Interface TMM, Issue 4.1.3, e-mail ESA "Re: HIFI TMM status" on 21.07.2008

RD 06 He System Description, HP-2-ASED-RP-0034, Issue 3, dated 15.03.2004

RD 07 Thermal Mathematical Modelling Methods of HPLM Ventline on Optical Bench, HP-2-ASED-TN-0056, Draft Issue, dated 10.06.02

RD 08 Evaluation of LINDE/ESTEC-MLI Measurements and Transformation to the ISO Cryostat MLI Design, Doc.No.: ISO.TN-B1430.007, dated 12.07.88

RD 09 J. Doenecke: Survey and Evaluation of Multilayer Insulation Heat Transfer Measurement, ICES July 1993

RD 10 PACS FPU Drawing No. PACS-KT-ICD-0000W1.22, dated 04.09.01

RD 11 SPIRE Interface Drawing No. 5264 300, dated 30.07.01

RD 12 HIFI-FPU External Configuration Drawing No. 455-3-001-0, dated 29.05.01

RD 13 H-EPLM Pressure Drop Analysis, HP-2-ASED-TN-0071, Issue 1.1, dated 12.03.2004

RD 14 M. Sander: ISO Thermal Mathematical Model, Submodel VENT, Version 3.00, 24.02.1994

RD 15 Test Report of the Additional Pressure Drop Measurements of DASA Valve #990-11 at Different Mass Flows and Temperatures, ISO-TR-BCGI0.008, Issue 1, 02.11.1993

RD 16 SPIRE Cryogenic Interface Thermal Mathematical Model, SPIRE-RAL-PRJ-000728, Issue 2.5, dated 02.02.2004

RD 17 EPLM Thermal Analysis from Fairing Jettison to Launcher Separation, HP-2-ASED-TN-0096, Issue 1, dated 14.04.2004

RD 18 Electrical Power Analysis and Design Report, Doc.No.: HP-2-GAMI-AN-0014_F, dated 09.02.06

RD 19 Helium Content Determination in Orbit, HP-2-ASED-AN-0010, Issue 1.1,dated 06.12.04

RD 20 TSS Design Justification, HP-2-ASED-TN-0081, dated 12.05.2003

RD 21 Procurement Specification for Tank Support Suspensions, HP-2-ASED-PS-0017, Issue 2, dated 25.03.03

RD 22 Procurement Specification for Herschel Spatial Framework, HP-2-ASED-PS-0016, Issue 2.1, dated 14.02.03

RD 23 OBA Specification, HP-2-ASED-PS-0015, Issue 2.1, dated 15.03.04

RD 24 Procurement Specification for H-PLM Internal MLI, HP-2-ASED-PS-0028, Issue 2, dated 07.03.03

RD 25 Procurement Specification for Herschel Support Structures, HP-2-ASED-PS-0026, Issue 2, dated 19.11.03

RD 26 Procurement Specification for SVM Thermal Shield, HP-2-ASED-PS-0034, Issue 2, dated 01.12.03

RD 27 Procurement Specification for Herschel Telescope Mounting Structure, HP-2-ASED-PS-0037 Issue 3, dated 14.07.05

RD 28 Procurement Specification for Herschel External MLI, HP-2-ASED-PS-0029, Issue 1, dated 29.07.02

RD 29 Reduced Telescope TMM/GMM, Issue 4/Issue 3, provided by ESA on 31.01.2008

RD 30 Thermal Shields Procurement Specification PFM, HP-2-ASED-PS-0044, Issue 1, dated 04.11.02

RD 31 Procurement Specification for Herschel Cryostat Vacuum Vessel, HP-2-ASED-PS-0003, Issue 4, dated 09.10.02

RD 32 Procurement Specification for Cryostat Cover, Cryostat Baffle and Test Components, HP-2-ASED-PS-0018, Issue 3, dated 02.12.03

RD 33 HIFI LOU Cryoharness - Electrical/Thermal Performance, HP-2-ASED-FX-0553-03, dated 27.06.03

RD 34 RYMSA CDR Data Package

RD 35 Evaluation of Thermal Property Tests for the H-EPLM TMM, HP-2-ASED-RP-0095, Issue 2, dated 21.06.2006

RD 36 Evaluation of Calorimeter Tests for Herschel Internal MLI; HP-2-ASED-TN-0083, Issue 1, dated 01.03.2004

RD 37 HSS Thermal Analysis Report, HP-2-DSSA-AN-0013, Issue 6, 31.05.2007

RD 38 Strut Fitting Design Update, HP-ASED-FX-0037-04, dated 28.01.2004

RD 39 HP-2-AAE-AN-0004 Issue 2.1, dated 29.01.2004

RD 40 LEOP HTT Temperature Margins and Verification, HP-ASED-FX-0226-04, dated 31.03.2004

RD 41 LEOP after delayed launch without HOT, Doc. No.: HP-2-ASED-TN-0173, Issue 1, 09.07.2008

RD 42 E-mail TAS-F “H-P-ASP-LT-9388 H Tel FQR AI#50 1st part close-out - Harness dissipation during decontamination”, 20.07.2007

RD 43 Barbecue Thermal Analyses, Doc. No.: HP-2-ASED-TN-0112, Issue 1, 07.02.2005

RD 44 SVM Thermal Shield Thermal Analyses, Doc. No.: HP-2-ASED-TN-0119, Issue 1, 25.04.2005

RD 45 H-EPLM TMM Correlation of STM TB/TV Test, Doc. No.: HP-2-ASED-RP-0176, Issue 1, 23.03.2007

RD 46 H-PLM TMM Correlation of Delta STM TB/TV Test, Doc. No.: HP-2-ASED-RP-0230, Issue 1, 12.06.2007

RD 47 H-EPLM Thermal Model Release, Doc. No.: HP-2-ASED-RP-0207, Issue 6, 19.06.2008

RD 48 TMM Correlation for L0 Conductance Measurements, Doc. No.: HP-2-ASED-TN-0138, Issue 1.1, 27.07.2007

RD 49 TMM Correlation for L1 and L3 Performance Measurements, Doc. No.: HP-2-ASED-TN-0147, Issue 1, 27.07.2007

RD 50 Herschel PLM MLI, Design Report External MLI, Doc. No.: HP-2-AAEM-RP-0007, Issue 3, 29.08.2005

RD 51 HERSCHEL I/F DRAWING PLM/SVM INTERFACE STRUTS, Doc. No.: HP-2-ECAS-ID-0002, Issue 3, 31.01.2005

RD 52 LOU Heatable Window Baffle, Thermal Model & Analysis, Doc. No.: HP-2-ASED-TN-0174, Issue 1, 18.07.2008

RD 53 LOU Window Baffle Design Report, Doc. No.: HP-2-ASED-RP-0256, Issue 1, 31.07.2008

RD 54 Herschel Telescope Flight thermal predictions, Doc. No.: HER.NT.0750.T.ASTR, Issue 3, 19.06.2006

RD 55 Thermal analyses of baffles on Thermal shields one and two, Doc. No.: HP-2-ASP-TN-1161, Issue 1, 09.06.2006

RD 56 Herschel – HST, HTT Thermal Link, Doc. No.: HP-2-AIRT-TN-0002, Issue 1, 23.11.2004

RD 57 Assessment of Coax Cable Modelling Refinement and Thermal Anchoring, Doc. No.: HP-2-ASED-TN-0136, Issue 2, 12.07.2006

RD 58 STM TB/TV TMM Meeting, Doc. No.: HP-2-ASED-MN-0958, 12.05.2005

RD 59 Herschel PFM TB/TV Test: Verification of H-EPLM TMM, Doc. No.: HP-2-ASED-RP-0277, Issue 1.2, 13.02.2009

RD 60 HERSCHEL/HIFI – LO, Procedure for thermal equilibrium test, MPIfR/HIFI/PR/2008-571, iss. 1, 19.06.2008

RD 61 Reduced Instrument TMMs exclusively for LA & LEOP, e-mail ESA " FW: Updated Instruments TMM for LA and LEOP", 19.09.2008

RD 62 SPIRE TMM update exclusively for LA & LEOP, e-mail ESA “FW SPIRE Level 3 temperatures during commissioning.txt”, 04.02.2009

RD 63 DLCM OPERATION TO REDUCE LEVEL 2 TEMPERATURE IN ORBIT, Doc. No.: HP-2-ASED-PR-0141, Issue 1, 10.10.2008

RD 64 In Orbit Predictions _ Telescope Heating, e-mail from ESA, 03.02.2009

RD 65 HELIUM VENTING NOZZLES DW-0243-C AND DW-0244-B UNIT LEVEL PRESSURE DROP TEST REPORT, HP-2-ASED-TR-0269, Iss. 1, 17.07.2008

RD 66 HELIUM VENTING NOZZLES DW-0332 (2.0MM) AND DW-0347 (1.8MM) UNIT LEVEL PRESSURE DROP TEST REPORT, HP-2-ASED-TR-0292, Iss. 1, 22.10.2008

RD 67 Herschel FM TB/TV Test Evaluation Report – PLM, HP-2-ASED-RP-0271 Iss.1, 28.01.2009

Note: Further References concerning material properties are listed in section 5.6 separately.

2.3 Abbreviations

ASED	Astrium GmbH
ASP	Alcatel Space
CCH	Cryo Control Harness
GMM	Geometrical Mathematical Model
H-EPLM	Herschel Extended Payload Module
HSS	Herschel Solar Array & Sunshade
LEOP	Launch and Early Orbit Phase
LOAACH	Local Oscillator Attenuator Assembly Conductively Heated
LWB	LOU Window Baffle
OBA	Optical Bench Assembly
OBP	Optical Bench Plate
SIH	Scientific Harness
SS	Summer Solstice
SSD	Sunshade
TMM	Thermal Mathematical Model
TSS	Tank Support Suspensions
TAS-F	Thales Alenia Space France
WS	Winter Solstice

Further Abbreviations are listed in AD 09.

3 Requirements and Boundary Conditions

3.1 Thermal Requirements

3.1.1 Lifetime

The relevant requirements regarding the H-EPLM lifetime are as follows:

GDGE-210 [AD 10]:

For the Herschel mission, the spacecraft shall have a nominal lifetime of 3. 5 years. This duration is counted from the launch to end of mission. This duration includes an allocation of 6 months for the transfer to the L-2 Lissajous orbit. (SPER-005)

HERS-0530 [AD 06]:

A cryogenic lifetime of 3.5 years shall be achieved. This requirement shall be met including dispersions. Computation of the cryogenic lifetime shall be as defined in Annex 1 of [AD06].

HERS-0535 [AD 06]:

The lifetime computation shall take into account a total conductive heat load of 200 mW via the 6 interface points of the Star Tracker Assembly.

HERS-0540 [AD 06]:

The determination on a half-yearly basis (7 measurements over nominal lifetime) of the remaining mass of helium contained in the main tank over the nominal lifetime shall be included in the lifetime calculation and shall not shorten the lifetime by more than 1%.

HERS-2250 [AD 06]:

The cryostat shall allow for an on-ground autonomy period of 6 days with the helium tank filled and the helium temperature after 6 days below 2.1 K and instruments being non operational.

For the in-orbit lifetime prediction, it has been agreed between ESA, TAS-F and ASED to replace the formerly used IID-A allocations by IID-B conditions, i.e. to perform the calculations with implemented instrument TMMs [RD 03] [RD 04] [RD 05]. Instrument dissipations meanwhile have been verified in unit level tests, so the IID-B values are considered more realistic than the IID-A allocations. An RFD has been raised against HERS-0530 to formalise this approach [AD 12] and meanwhile has been (technically) accpeted by ESA. The instruments are operated in average dissipation mode, and an average thermal environment at L2 orbit is used to calculate the average massflow. The corresponding external heat loads are given in Table 3.2-1.

3.1.2 Temperature Requirements of Instruments within Cryostat

The temperature limits required at the instrument interfaces are specified in the instrument interface control documents IIDBs for PACS [AD 02], SPIRE [AD 03] and HIFI [AD 04] and are compiled in Table 3.1-1 to Table 3.1-3 together with the corresponding interface nodes.

Instrument Interface	Temp. Level	TMM Node	Operating		Heat Load	Non-operating	
PACS			Min. [K]	Max. [K]	[mW]	Min.	Max.
Red Detector	L0	724	1.6	1.75	1.0	NA	60°C *) 85°C **)
Blue Detector	L0	723	1.6	2.0	2.2	NA	60°C *) 85°C **)
Cooler Pump	L0	761	1.6	12.06 ***) 5	500 (peak) 2.2	NA	60°C *) 85°C **)
Cooler Evaporator	L0	762	1.6	1.85	15.1	NA	60°C *) 85°C **)
Optics/Structure assy.	L1	781 782 783	2.0	5.0	30	NA	60°C *) 85°C **)
OBA Interface	L2	371	NA	15 ****)	0	NA	NA

*) Continuous temperature limit

**) Short-duration temperature limit for bake-out during a maximum of 3 days at 80°C

***) Value acc. RFD [AD 14]; was 10 K before

****) Value acc. RFD [AD 16]; was 12 K before

Table 3.1-1: PACS Temperature Limits

Instrument Interface	Temp. Level	TMM Node	Operating		Heat Load	Non-operating	
SPIRE			Min. [K]	Max. [K]	[mW]	Min.	Max.
Detector Enclosure	L0	814	0	2.0 1.71 (goal)	4.0 1.0 (goal)	NA	60°C *
Cooler Pump	L0	815	0	10 2	500 (peak) 2	NA	
Cooler Evaporator	L0	816	0	1.85 1.75 (goal)	15 15 (goal)	NA	
SPIRE OBA units	L1	800 830	0	5.5 3.7 (goal)	15 13 (goal)	NA	
OBA Interface	L2	381		15.5 ***) 8 (goal)	0 0 (goal)	NA	80°C **
Instrument Shield	L2	315		16	0	NA	80°C **
PM-JFETs	L3	831	0	20 ***)	50	NA	80°C **
SM-JFET	L3	832	0	16.5 ***)	25	NA	

*) Continuous temperature limit, but compliant with bake-out temperature of 80°C for 72 h maximum

**) Bake-out temperature for 72 h maximum

***) Value acc. RFD [AD 17]; L2 was 12 K, PM-JFET was 15.6 K [AD 14], SM-JFET was 15 K before

Table 3.1-2: SPIRE Temperature Limits

Instrument Interface	Temp. Level	TMM Node	Operating		Heat Load	Non-operating	
HIFI			Min. [K]	Max. [K]	[mW]	Min.	Max.
L0 boundary	L0	949	0	2.1 **	6.8	0 K	60°C *
L1 boundary	L1	939	0	6.4 **	15.5	0 K	60°C *
FPU structure	L2	919	0	20	22	0 K	60°C *

*) Continuous temperature limit, but compliant with the bake-out of 3 days at 80°C

**) Value acc. RFD [AD 11]; L0 was 2.0 K, L1 was 6.0 K before

Table 3.1-3: HIFI Temperature Limits

Temperature Stability for HIFI as specified in AD 04

The following temperature changes shall not be exceeded during operation under the assumption of passive thermal control and with the exception of heat peaks caused by HIFI:

Level 2 parts: 0.015 K per 100 s

Level 1 parts: 0.006 K per 100 s

Level 0 parts: 0.006 K per 100 s

3.1.3 Temperature Requirements for LOU (outside Cryostat)

As specified in AD 04 the HIFI Local Oscillator Unit (LOU) shall not exceed the temperature limits at the mounting interfaces compiled in following Table 3.1-4.

Instrument Interface	Thermal node No.	Operating		Functional testing	Start-up	Switch-off	Non-operating	
		Min. [K]	Max. [K]	Max. [K]	[K]	[K]	Min. [K]	Max. [K]
LOU	4201	90	150	298	80	303	80	328

Table 3.1-4: LOU Temperature Limits

3.1.4 Temperature Requirements for Telescope

For the HERSCHEL Telescope, the following requirements exist [AD 13]:

	Thermal node No.	Operating		Contamination Release (3 weeks)		Non-operating	
		Min. [K]	Max. [K]	Min. [K]	Max. [K]	Min. [K]	Max. [K]
Telescope	8001	70	90	313	323	55	358

Table 3.1-5: Telescope Temperature Limits

3.1.5 Thermal Interface Requirements for SVM

According to HEIF-TH-225 a [AD 7], the maximum thermal flux from HSS to SVM shall be less than 15 W distributed as follows:

- maximum 5 W via HSS CFRP struts, uniformly distributed on each interface point,
- maximum 10 W via Sunshield brackets, uniformly distributed on each interface point.

3.2 Thermal Environment

3.2.1 Ground and Pre-Launch Phase

According to R-EVT-040 [AD 05], the He filled PLM is in a temperature controlled environment at 22±3°C during ground operation.

During transport and storage, different environments apply, ranging from 10°C to 30°C at ambient pressure ranging from 970 mbar to 1070 mbar.

3.2.2 Early Orbit Phase

The thermal loads to be applied for the H-EPLM during the launch and early orbit phase are defined in detail in [AD 05].

Solar constant:

The applicable values of the solar constant for the early orbit phase (BOL) are:

- 1425 W/m² during Winter Solstice (WS)
- 1325 W/m² during Summer Solstice (SS)

The solar aspect angle evolution during launch is shown in Figure 3.2-1 [AD 13] [RD 43] [RD 44].

Albedo is the fraction of incident solar radiation that is reflected from the earth back into space. A value of 0.3 ± 0.05 shall be used.

Earth Infrared Thermal Radiation

The Earth infrared radiation shall be assumed as a black body with a characteristic temperature of 288 K. The average infrared radiation emitted by Earth is 230 W/m^2, with variations between 150 W/m² and 350 W/m².

From the above mentioned data, following load cases can be derived:

Hot Case: WS solar constant, max. Earth IR radiation, 0.35 albedo
BOL thermo-optical properties, Solar power generator in shunt mode

Cold Case: SS solar constant, min. Earth IR radiation, 0.25 albedo
BOL thermo-optical properties, Solar power generator in operating mode

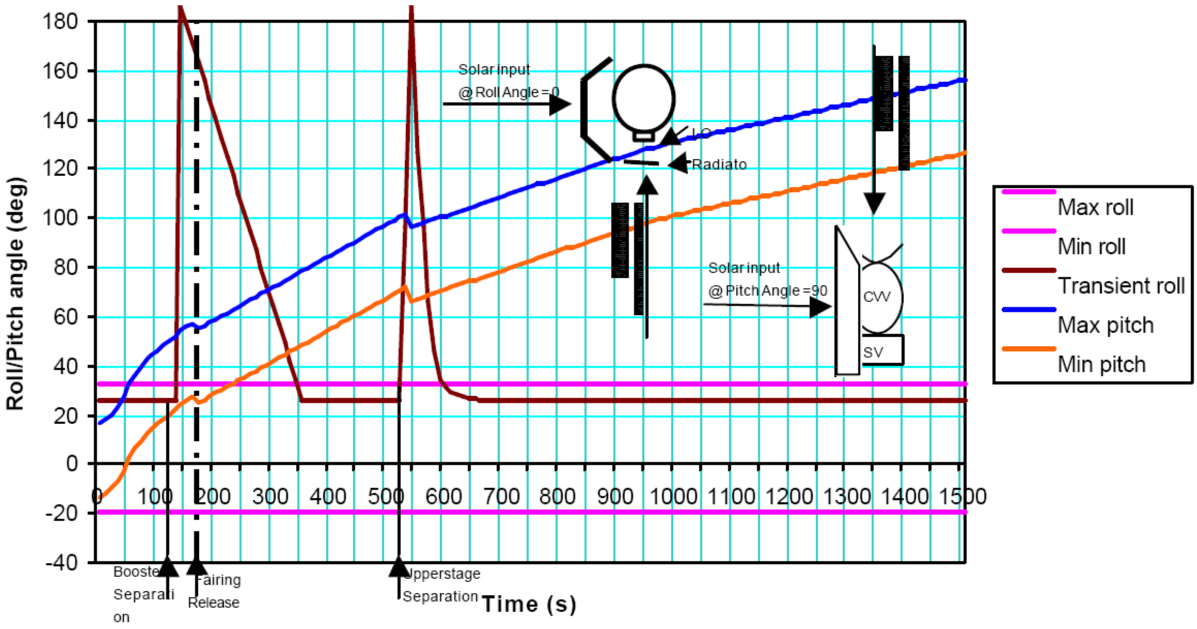


Figure 3.2-1: Roll and Pitch Angle Evolution During Launch

3.2.3 Operation Phase in L2 Orbit

During in-orbit operation at L2 the extremes of solar constant are (section 3.4.3 of [AD 05]):

- 1405 W/m² during Winter Solstice (WS)
- 1287 W/m² during Summer Solstice (SS)

During HERSCHEL mission phases and operational modes, the solar aspect angle will be maintained at ± 30 deg around the Y-axis and at ± 1 deg around the X-axis (HERS-0090 a [AD 06]).

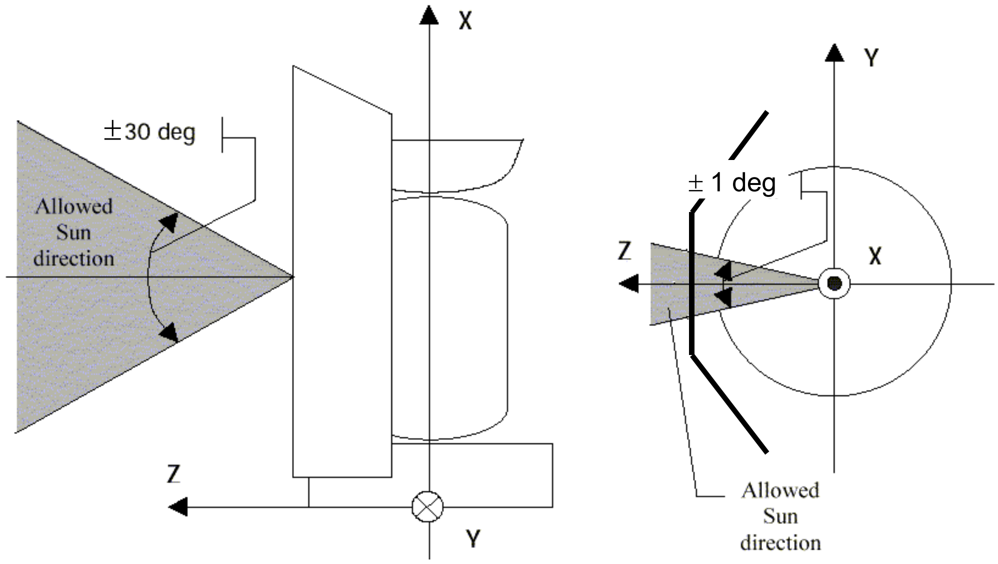


Figure 3.2-2: Solar Aspect Angels on H-EPLM at L2

From the above-mentioned data, the load cases compiled in Table 3.2-1 are derived (extracted from [RD 01]).

	Solar constant	Solar aspect angel SAA, around Y axis	OSR Solar absorptance	SVM I/F for CVV struts	SVM I/F for WG, SIH, CCH, HSS struts, SVM Thermal Shield struts
Cold case	1287 W/m² (SS)	30°	0.1 (BOL)	293 K	266 K
Hot case	1405 W/m² (WS)	0°	0.2 (EOL)	293 K	293 K
Average case	1352 W/m²	17.267°	0.15	293 K	280 K

Table 3.2-1: L2 orbit conditions

The temperatures of the H-EPLM structure attachment points on the SVM (conductive I/F, see also Table 3.2-1) and the temperatures of the SVM outer surfaces like top panel MLI (radiative I/F) are considered according to [AD 07] and [AD 08].

The average case is the basis for the lifetime calculation (see section 6.5), more details to that case are given in [RD 01].

4 Thermal Model Description

In this section the main control parameters for using the H-EPLM thermal model are described, followed by a detailed break-down of thermal nodes. The TMM in total consists of 1749 thermal nodes.

4.1 Software and Handling

Analyses have been performed with PC ESATAN V 8.9.2 for the TMM and PC ESARAD V 6.2 for the GMM.

4.1.1 TMM Control

The following main calculation modes can be operated from ESATAN (input file control.ctl, control variable GPLTO):

G Operation on Ground (steady state)

P Prelaunch: Launch Autonomy (SUBCASE=2), including pre-cooling activities (former On-Ground Autonomy operated via SUBCASE=1 considered to be covered by Launch Autonomy, therefore deleted)

L Launch until fairing jettisoning

T LEOP (“Transfer”), i.e. in-orbit transient cool down (SUBCASE=1 for nominal nozzle switching based on nominal launch, SUBCASE=2 for early nozzle switching based on launch delay)

O Operation at L2 orbit, including nominal steady state modes (hot, cold), transient orbit timeline, safe mode and a lifetime calculation mode (adjustable via control variables SUBCASE, IMODE, TRANS)

A dedicated set of uncertainty parameters (sensitivities) has been provided by ESA, to be used exclusively for launch autonomy and LEOP analyses [RD 61]:

- k_1 HTT MLI conductance: 1.7
- k_2a TS1 MLI conductance: 1.15
- k_2b TS2 MLI conductance: 1.4
- k_2c TS3 MLI conductance: 1.12
- k_8 CVV int. harness conductance (=k_9): 1.0
- k_50 artificial extra HTT heat load [mW]: 50

Above uncertainty parameters yielded in conservative results w. r. t. measurements in the framework of PFM TB/TV testing during early LEOP simulation (until HTT has passed its peak). For the LEOP flight prediction, the parameters are switched back to their “old” values used before PFM TB/TV test (issue 6 of [RD 47]) automatically 10 days after launch (read in from the file “sensitivity_LA&LEOP.ctl”). The reason for that is that it is not appropriate to maintain the values above when the spacecraft approaches the in-orbit temperature regime (which applies especially to the extra 50 mW on the HTT!). The switched values are listed below:

- k_1 HTT MLI conductance: 1.0
- k_2a TS1 MLI conductance: 1.5
- k_2b TS2 MLI conductance: 1.5
- k_2c TS3 MLI conductance: 1.5
- k_8 CVV int. harness conductance (=k_9): 1.15
- k_50 artificial extra HTT heat load [mW]: 0

A dedicated set of FPU models has been provided by ESA, also to be used exclusively for launch autonomy and LEOP analyses [RD 61]: PACS 3.1.1, SPIRE 2.6.1, HIFI 4.1.4. The related files are referenced with the suffix "_LA&LEOP". To use them for analysis, this suffix just has to be deleted from the file name.

In addition to the uncertainty parameters stated above, two additional sets exist for orbit/GPLTO = O and ground GPLTO = G conditions (outcome of [RD 46]). For orbit, the parameters k_1, k_2a, k_2b and k_2c are set to 1.6 (tanks and shields MLI). For ground, k_2b (TS2 MLI) is set to 1.1. All other parameters are equal 1.

4.1.2 GMM Control

ESARAD provides the following case dependent control (to be adjusted in input file CONTROL.CTL, control variable LCASE):

0 All orbit cases

1 All ground cases, including Launch Autonomy, Launch and LEOP

By calling one of these cases the corresponding thermooptical properties (BOL/EOL) and geometrical configurations (cover open/closed) are automatically loaded.

4.2 EPLM Configuration Breakdown for Thermal Modelling

Thermal Report	**TMM Issue 4** HP-2-ASED-RP-0011, Issue 4.0, dated April 04	**TMM Issue 5** HP-2-ASED-RP-0011, Issue 5.0, dated August 07	**TMM Issue 6** HP-2-ASED-RP-0011, Issue 6.0, dated March 09
Thermal Mathematical Model	TMM (ESATAN): herschel.d, Issue 4, dated 19.03.2004. GMM (ESARAD): HERSCHEL_EOL.erg, Issue 4, dated 19.03.04	TMM (ESATAN): herschel.d, Issue 5, dated 09.08.2007. GMM (ESARAD): HERSCHEL.erg, Issue 5, dated 09.08.2007	TMM (ESATAN): herschel.d, Issue 6, dated March 2009. GMM (ESARAD): HERSCHEL.erg, Issue 6, dated March 2009
HTT	Herschel HTT Interface Drawing: HP-2-ASED-ID-0001, Issue D, dated 08.08.03	Herschel HTT Interface Drawing: HP-2-ASED-ID-0001, Issue D, dated 08.08.03	Herschel HTT Interface Drawing: HP-2-ASED-ID-0001, Issue D, dated 08.08.03
HOT	Herschel HOT Interface Drawing: HP-2-ASED-ID-0002, Issue C, dated 06.08.03	Herschel HOT Interface Drawing: HP-2-ASED-ID-0002, Issue C, dated 06.08.03	Herschel HOT Interface Drawing: HP-2-ASED-ID-0002, Issue C, dated 06.08.03
OBP including Instrument Shield	Optical Bench Assembly Interface drawing HP-2-ASED-ID-0042, Issue A, dated 31.03.03	Optical Bench Assembly Interface drawing HP-2-ASED-ID-0042, Issue A, dated 31.03.03	Optical Bench Assembly Interface drawing HP-2-ASED-ID-0042, Issue A, dated 31.03.03
L0, L1, L3 Thermal Links and Ventline	AIRL Thermal Analysis HP-2-AIRL-AN-0003, Issue 4, dated 13.02.04 and HP-2-AIRL-HO-0010, dated 05.02.04	AIRL Thermal Analysis HP-2-AIRL-AN-0003, Issue 4, dated 13.02.04 and HP-2-AIRL-HO-0010, dated 05.02.04	AIRL Thermal Analysis HP-2-AIRL-AN-0003, Issue 4, dated 13.02.04 and HP-2-AIRL-HO-0010, dated 05.02.04
PACS	Reduced PACS Instrument TMM provided by PACS on 09.05.2003. ASED made GMM acc. to PACS FPU Drawing No. PACS-KT-ICD-0000W1.22, dated 04.09.01. (IR emissivity of FPU set to 0.26)	Reduced PACS Instrument TMM Iss. 3.1 provided by ESA on 26.04.2007. ASED made GMM acc. to PACS FPU Drawing No. PACS-KT-ICD-0000W1.22, dated 04.09.01. (IR emissivity of FPU set to 0.26)	Reduced PACS Instrument TMM Iss. 3.1 provided by ESA on 26.04.2007. ASED made GMM acc. to PACS FPU Drawing No. PACS-KT-ICD-0000W1.22, dated 04.09.01. (IR emissivity of FPU set to 0.26) Additional PACS TMM issue 3.1-1 to be used exclusively for LA/LEOP [RD 61]
SPIRE	Reduced SPIRE Instrument TMM, Issue 2.5 provided by SPIRE on 03.02.2004.	Reduced SPIRE Instrument TMM, Issue 2.6 provided by SPIRE on 28.04.2007. SPIRE RGMM provided by	Reduced SPIRE Instrument TMM, Issue 2.6 provided by SPIRE on 28.04.2007. SPIRE RGMM provided by

Thermal Report	**TMM Issue 4** HP-2-ASED-RP-0011, Issue 4.0, dated April 04	**TMM Issue 5** HP-2-ASED-RP-0011, Issue 5.0, dated August 07	**TMM Issue 6** HP-2-ASED-RP-0011, Issue 6.0, dated March 09
	SPIRE RGMM provided by SPIRE on 03.02.04, Issue 3 (IR emissivity of FPU: 0.2)	SPIRE on 03.02.04, Issue 3 (IR emissivity of FPU STM2 correlated value: 0.05)	SPIRE on 03.02.04, Issue 3 (IR emissivity of FPU STM2 correlated value: 0.05) Additional SPIRE TMM issue 2.6.1 to be used exclusively for LA/LEOP [RD 62]
HIFI	Reduced HIFI Instrument TMM provided by HIFI on 28.03.2003. ASED made GMM acc. to HIFI-FPU External Configuration Drawing No. 455-3-001-0, dated 29.05.01 (IR emissivity of FPU set to 0.26	Reduced HIFI Instrument TMM provided by HIFI on 28.03.2003. ASED made GMM acc. to HIFI-FPU External Configuration Drawing No. 455-3-001-0, dated 29.05.01 (IR emissivity of FPU set to 0.26	Reduced HIFI Instrument TMM, Issue 4.1.3 provided by ESA on 21.07.2008. ASED made GMM acc. to HIFI-FPU External Configuration Drawing No. 455-3-001-0, dated 29.05.01 (IR emissivity of FPU set to 0.26 Additional HIFI TMM issue 4.1.4 to be used exclusively for LA/LEOP [RD 61]
Thermal Shields with TS2 Baffle and LOU Baffle	Thermal Shield Geometry as Issue 2.1, Baffles acc. to. HP-2-ASED-ID-0065, dated Jan 04	Thermal Shield Geometry as Issue 4; TS2 Baffle acc. to. HP-2-ASED-ID-0065 Iss. B, 30.09.04; LOU int. Baffles acc. to HP-2-ASP-TN-1161, iss. 1, 09.06.06	Thermal Shield Geometry as Issue 4; TS2 Baffle acc. to. HP-2-ASED-ID-0065 Iss. B, 30.09.04; LOU int. Baffles acc. to HP-2-ASP-TN-1161, iss. 1, 09.06.06
TSS	Dimensions acc. to HP-2-ASED-TN-0081, dated 12.05.2003	Dimensions acc. to HP-2-ASED-TN-0081, dated 12.05.2003	Dimensions acc. to HP-2-ASED-TN-0081, dated 12.05.2003
Cryostat Baffle and Beam Entrance	Drawing No.: HP-2-ASED-ID-0063, dated 31.01.03 and HP-2-ASED-ID-0095, dated 25.07.03	Drawing No.: HP-2-ASED-ID-0063-0C, 30.09.04 and HP-2-ASED-ID-0095, dated 25.07.03	Drawing No.: HP-2-ASED-ID-0063-0C, 30.09.04 and HP-2-ASED-ID-0095, dated 25.07.03
Cryo Cover	HP-2-AAE-IC-0001, Issue 3, dated 18.10.03	HP-2-AAE-IC-0001, Issue 5, 20.01.05	HP-2-AAE-IC-0001, Issue 5, 20.01.05
CVV including Radiators	Herschel CVV Radiator Assembly, HP-2-APCO-DW-0015-01-0A	Herschel CVV Radiator Assembly, HP-2-APCO-DW-0015-01-0A	Herschel CVV Radiator Assembly, HP-2-APCO-DW-0015-01-0A
LOU	Thermal Analysis Handout from ABAQUS, dated 28.01.04	Thermal Analysis Handout from ABAQUS, dated 28.01.04	Thermal Analysis Handout from ABAQUS, dated 28.01.04
LOU External Window Baffle	-	-	HP-2-ASED-DW-0335/, -0336/-, -0337/, -0338, July 2008

Thermal Report	TMM Issue 4 HP-2-ASED-RP-0011, Issue 4.0, dated April 04	TMM Issue 5 HP-2-ASED-RP-0011, Issue 5.0, dated August 07	TMM Issue 6 HP-2-ASED-RP-0011, Issue 6.0, dated March 09
Telescope	ASED made GMM acc. to ASEF catia model DT0018251-02-00-3D-TELESCOPE-28-05-02.model. (IR emissivity of M1 set to 0.01, RD29)	Reduced TMM/GMM Iss. 2.1 provided by ESA on 15.05.07	Reduced TMM/GMM Iss. 4/ Iss. 3 provided by ESA on 31.01.08
Harness	Harness Inputs for Thermal Analysis Doc.No.: HP-2-ASED-TN-0010, Issue 3.1, dated 12.03.04	Harness Inputs for Thermal Analysis Doc.No.: HP-2-ASED-TN-0010, Issue 3.2, 21.01.05 HIFI Coax: HP-2-ASED-PS-0048 iss. 3, 18.10.06	Harness Inputs for Thermal Analysis Doc.No.: HP-2-ASED-TN-0010, Issue 3.2, 21.01.05 HIFI Coax: HP-2-ASED-PS-0048 iss. 3, 18.10.06
Sunshade Panels	Sunshade Panels I/F drawing HP-2-ASED-ID-0051, Issue B, dated 17.03.03	HP-2-DSSA-ID-0004_E, 13.01.06; HP-2-DSSA-DD-0002, iss. 1, Nov. 05	HP-2-DSSA-ID-0004_E, 13.01.06; HP-2-DSSA-DD-0002, iss. 1, Nov. 05
Solar Array Panels	Solar Array Panels I/F drawing HP-2-ASED-ID-0043, Issue B, dated 17.03.03		
EPLM Support Structures	HP-2-ECAS-AN-0004, Issue 2, dated 28.1103 and Fax HP-ASED-FX-0037-04, 28.01.04	HP-2-ECAS-AN-0004, Issue 6, 27.07.05 and HP-2-ECAS-ID-0002, Issue 3, 31.01.05	HP-2-ECAS-AN-0004, Issue 6, 27.07.05 and HP-2-ECAS-ID-0002, Issue 3, 31.01.05
SVM Thermal Shield	Drawing No.: HP-2-ASED-ID-0056, Issue A, dated 14.10.03	Drawing No.: HP-2-ECAS-DW-0006, 27.07.04	Drawing No.: HP-2-ECAS-DW-0006, 27.07.04
SVM	SVM Submodel provided by ASPI on 24.10.02, HP-2-ASP-TN-0413; Issue 1	SVM Submodel provided by ASPI on 24.10.02, HP-2-ASP-TN-0413; Issue 1	SVM Submodel provided by ASPI on 24.10.02, HP-2-ASP-TN-0413; Issue 1
Ext. ventline elongation ("moustache")	-	-	HP-2-ASED-DW-0180, HP-2-ASED-DW-0315/-0316/-0317/-0318/-0319/-0320/, 10.11.08

Table 4.2-1: Drawings and Submodels used for Thermal Modelling

4.3 Optical Bench Assembly, Spatial Framework and Tanks

The Optical Bench Assembly (OBA) is mounted on top of the HTT via the so-called Spatial Framework (SFW). The SFW consists of a frame made of aluminium and struts to the HTT made out of T300 CFRP. The OBA is connected to the aluminium frame by means of Titanium blades. The SFW itself is attached to the CVV structure by the tank suspension straps. The nodal break down of the SFW is shown in Figure 4.3-1 and Figure 4.3-2. Concerning the tank MLIs see also Figure 4.6-2.

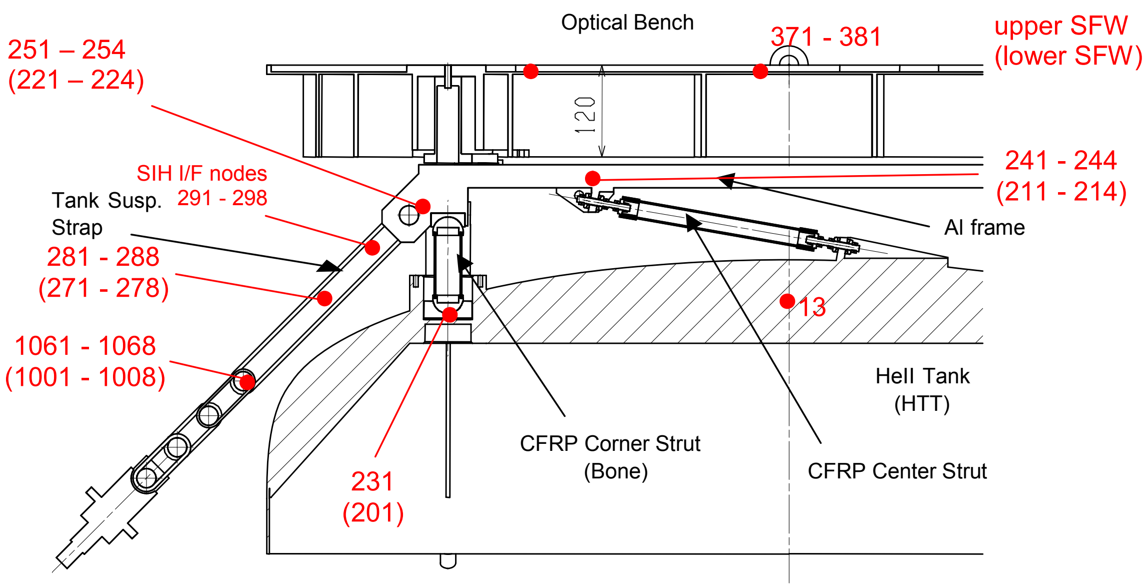


Figure 4.3-1: Nodal Breakdown of HTT and SFW

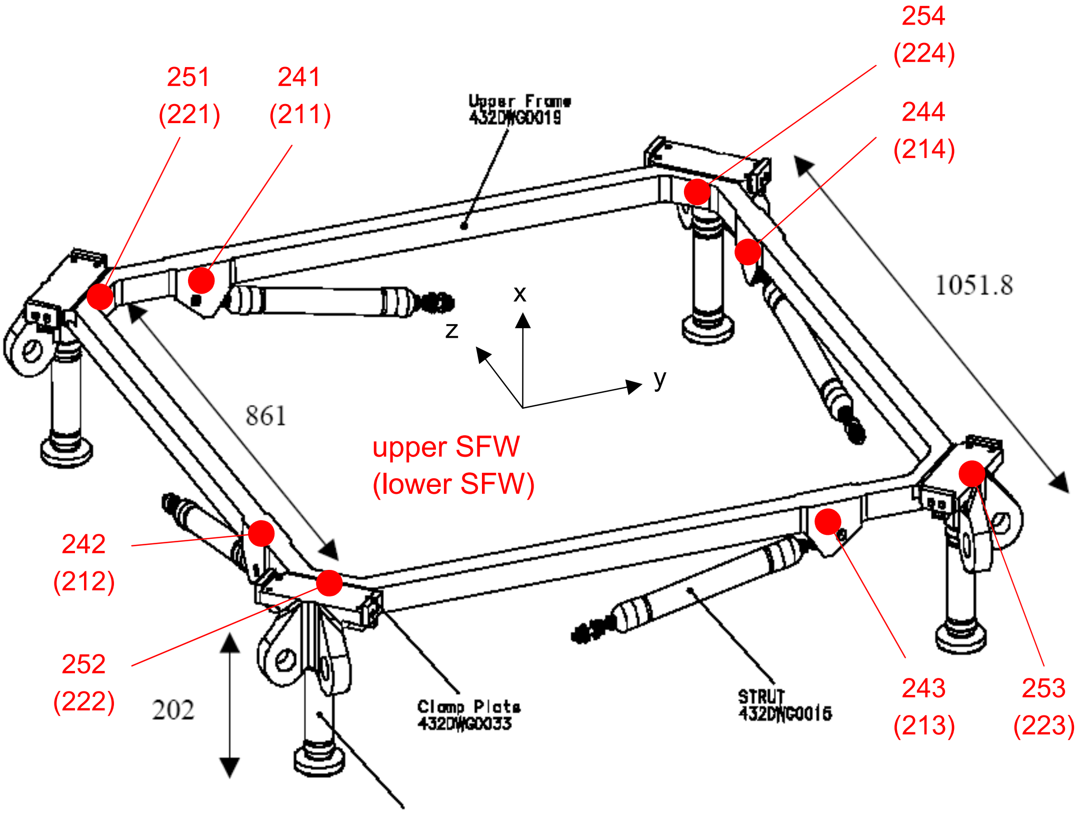


Figure 4.3-2: Nodal Breakdown of Spatial Framework (detailed)

The OBA with the instruments is covered with the Instrument Shield, see Figure 4.3-3. The opening for the beam entrance is modelled with cylindrical baffles, thermally (and mechanically) attached to the Thermal Shield 2 (node 2050) and to the Instrument Shield (node 315). The thermal and material properties are compiled in Table 4.3-1. The Instrument Shield baffle has rectangular cut-outs reflecting the beam pattern for the three instruments, see Figure 4.3-4.

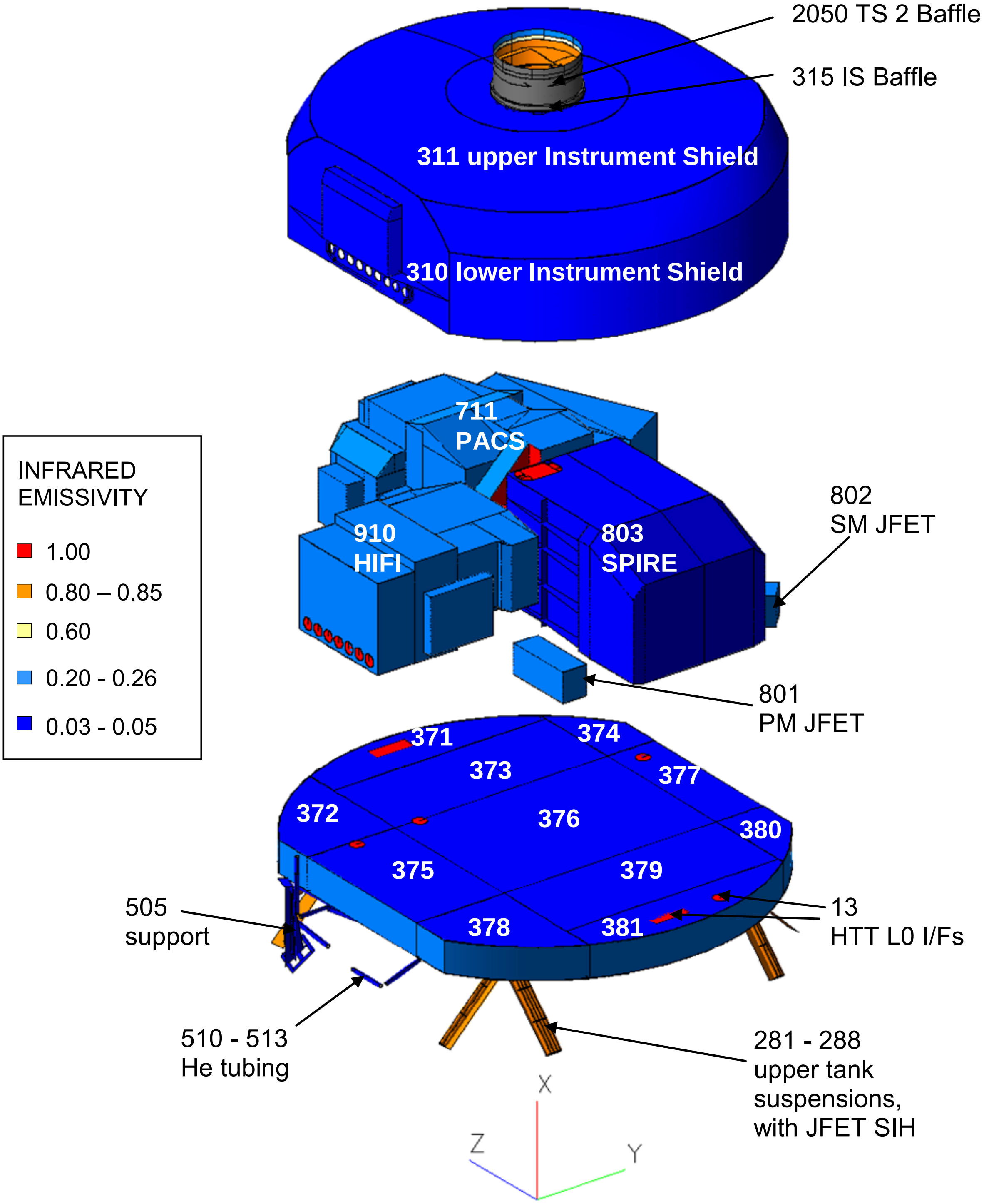
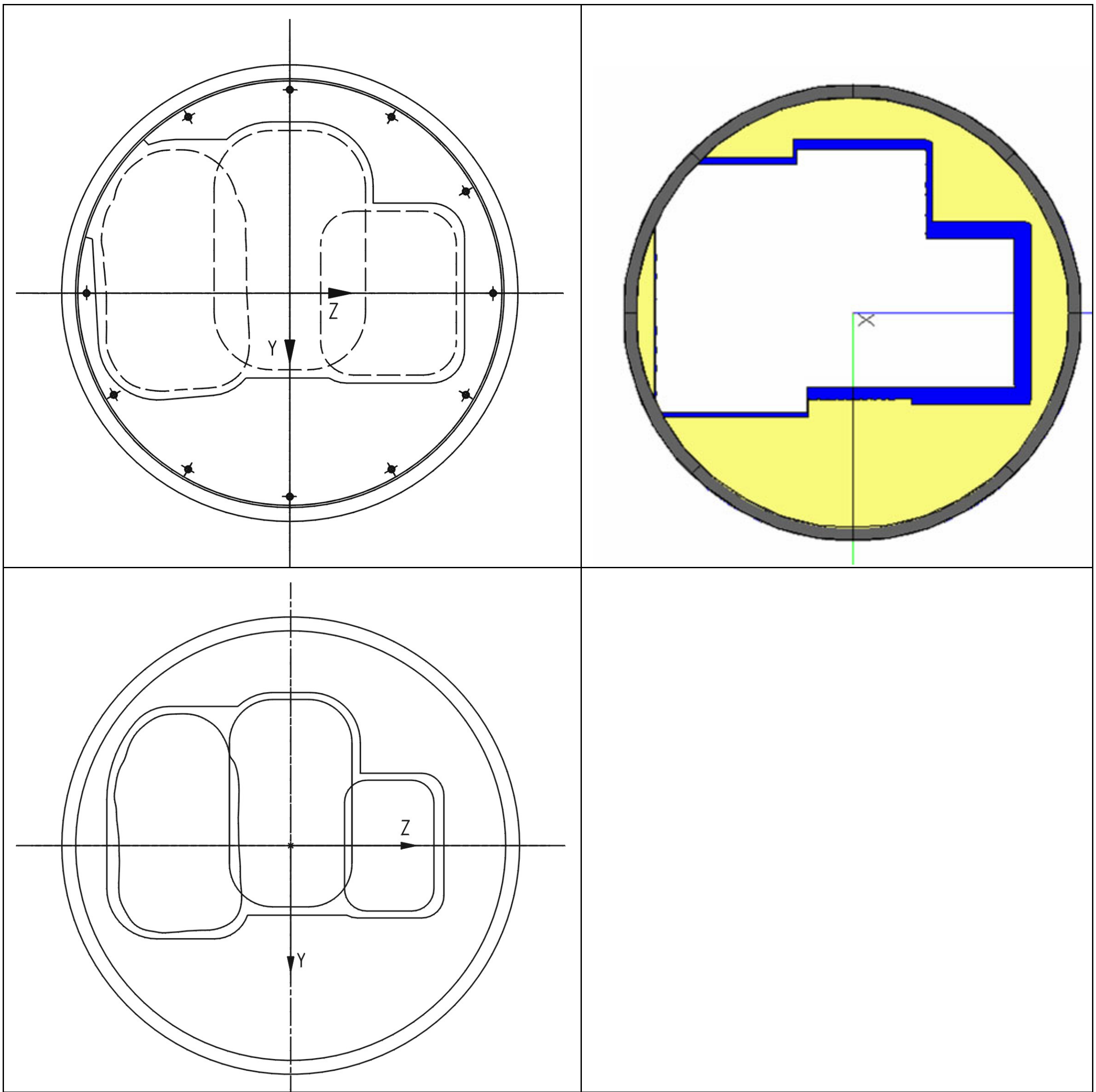


Figure 4.3-3: Nodal Breakdown of Optical Bench with Instruments



Apertures of Thermal Shield 2 Baffle (top) and Instrument Shield Baffle (bottom), view from + X	Instrument Shield Baffle (blue, node 315) and Thermal Shield 2 Baffle (yellow, node 2050) in TMM, view from +X

Figure 4.3-4: Beam Pattern for the Three Instruments

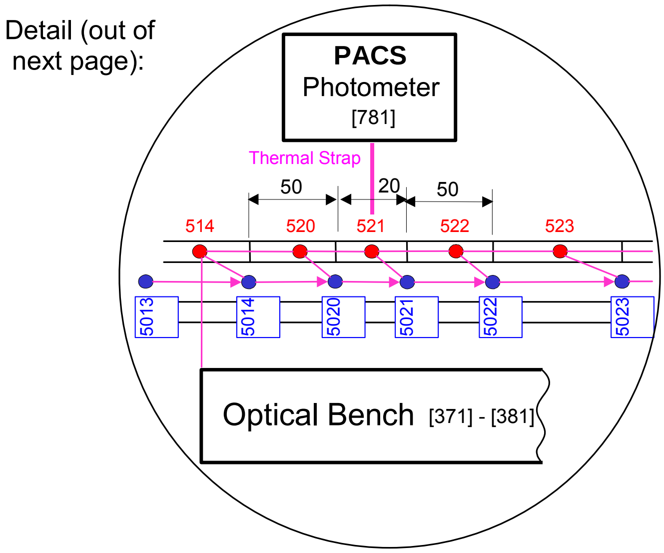
Item	Node	Material / Components	Mass	Size	IR Emiss.	Unit Level Requirement	Remark
He II Tank (HTT)	10, 13	superfluid Helium (He II) Al tank (Al 5083, 3.3547)	337 kg 141.8 kg	2367 l (cold volume) D = 1.63 m, h = 1.352 m			
MLI on He II Tank low cyl. upp.	111 112 113	10 layers	1.1 kg 3.2 kg 1.1 kg	A = 3.26 m² A = 2.91 m² (D=1.63 m, h=0.569 m) A = 2.94 m²	0.05	R-INM-0220 [RD 24] R-INM-0230 [RD 24]	
He I Tank (HOT)	20	90% He I (=~8.7 kg He on ground) ellipsoid shaped Al tank (Al 5083)	19 kg	78 l (cold volume) D = 0.88 m, h = 0.252 m			
MLI on He I Tank low upp.	121 122	10 layers	0.45 kg 0.45 kg	A = 0.66 m² A = 0.66 m²	0.05	R-INM-0320 [RD 24] R-INM-0330 [RD 24]	
Lower Spatial Framework (lSF)	211-214 221-224	Al frame (Al 5083) covered with SLI Center struts T300 to HTT SST blades to HOT Corner struts T300 to HTT	19.6 kg	 A/L = 4 x 0.736 mm A/L = 4 x 0.968 mm A/L = 4 x 2.825 mm	0.05	 R-SFW-300 [RD 22] R-SFW-290 [RD 22]	
Upper Spatial Framework (uSF)	241-244 251-254	Al frame (Al 5083) Center struts T300 Corner struts T300	16.3 kg	 A/L = 4 x 0.736 mm A/L = 4 x 2.825 mm	0.5	 R-SFW-300 [RD 22] R-SFW-290 [RD 22]	
Optical Bench Plate (OBP)	371-381	Aluminium structure 4 Titanium blades to Al frame of uSF	68 kg	D=1.63 m,H=70 mm, 2.5 mm skins Total A/L = 28.6 mm Ti6AlV4	0.1 +x side 0.2 others	R-OBA-330 [RD 23] R-OBA-145 [RD 23]	
Instrument Shield	310 311	Al 6061 (cylinder) Al 1100 (top)	3.7 kg 4.7 kg	A = 1.70 m², s = 0.8 mm A = 2.18 m², s = 0.8 mm	0.03 all faces	R-OBA-326 [RD 23] R-OBA-325 [RD 23]	
Instrument Shield Baffle	315	Al baffle with aperture; cut-out area 0.035 m², see Figure 4.3-4	0.23 kg	D = 307 mm, s = 0.8 mm	0.03 all faces	R-OBA-410 [RD 23]	

Table 4.3-1: Item List for Tanks, Spatial Framework and Optical Bench Assembly

4.4 Helium Ventline Subsystem

4.4.1 Modelling of Ventline

A schematic overview of the OBA and Thermal Shield ventline modelling is given in following Figure 4.4-1.



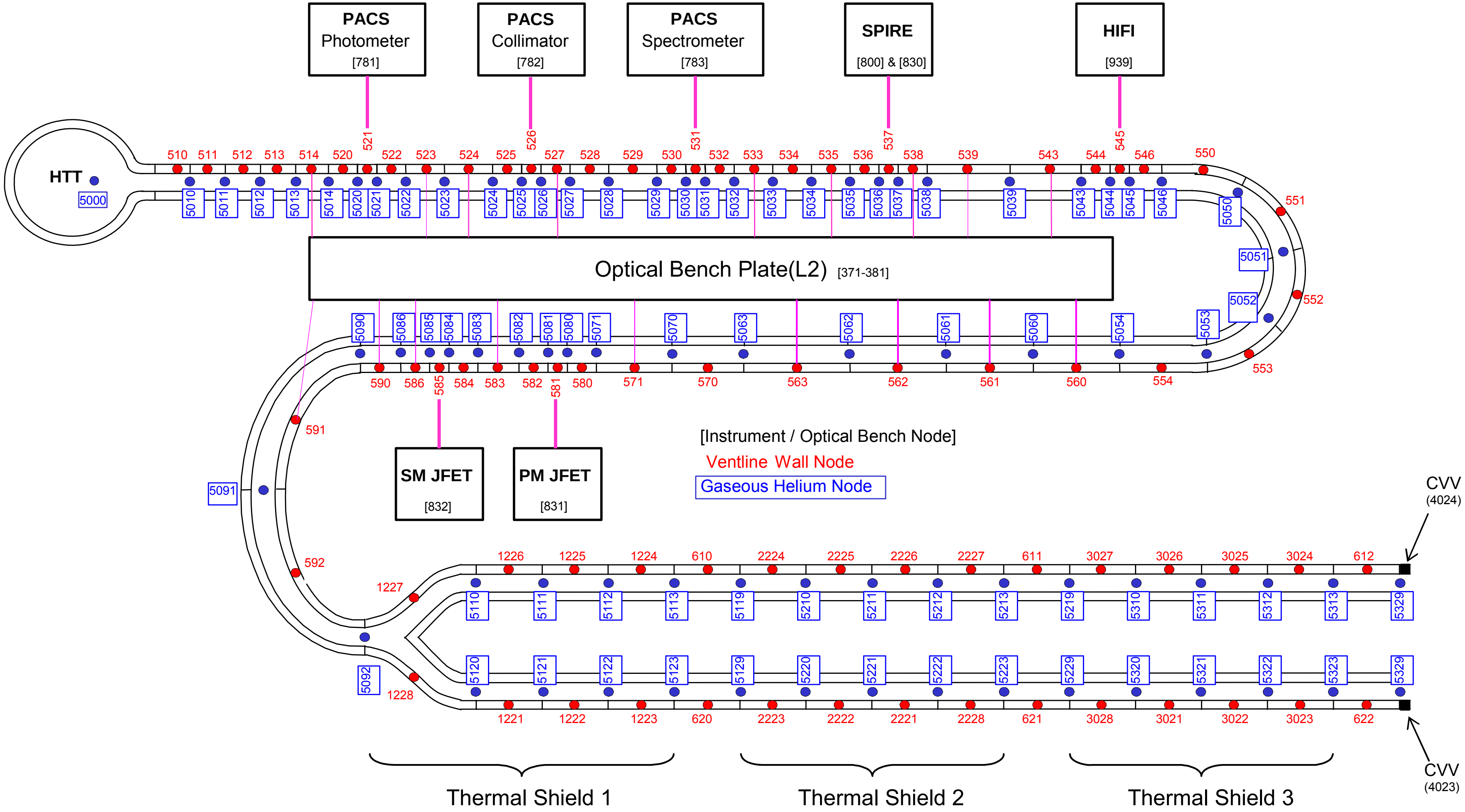


Figure 4.4-1: Nodal Break Down of OB Ventline and Thermal Shield Ventline

Item	Node	Material / Components	Mass	Size	IR Emiss.	Unit Level Requirement	Remark
GHe Ventline between HTT and Level 1	510-514 505	stainless steel tube Ventline support L1 inlet, stainless steel	0.41 kg 0.70 kg	A=19.6 mm^2; D=13 mm, d=12 mm	0.05 0.05		
GHe Ventline Level 1	520-546	Al6063 tube CFRP T300 brackets to OBP	0.67 kg	A = 112.3 mm^2; D=14.9 mm, d=12 mm, incl. fins Total A/l = 2.016 mm		R-OBA-360 [RD 23]	
GHe Ventline between Level 1 and Level 2	550-554	Al6061 tube (not coupled to OBP)	0.03 kg	A = 44.6 mm^2; D=12.7 mm, d=10.2 mm		R-OBA-365 [RD 23]	
GHe Ventline Level 2	560-563	Al tube on OBP strongly bolted to OBP	0.63 kg	A = 112.3 mm^2; D=14.9 mm, d=12 mm, incl. fins		R-OBA-370 [RD 23]	
GHe Ventline between Level 2 and Level 3	570-571	Al6061 tube (not coupled to OBP)	0.03 kg	A = 44.6 mm^2; D=12.7 mm, d=10.2 mm		R-OBA-365 [RD 23]	
GHe Ventline Level 3	580-586	Al6063 tube CFRP T300 brackets to OBP	0.12 kg	A=61.3 mm^2; D=14.9 mm, d=12 mm Total A/l = 9.90 mm			
GHe Ventline between Level 3 and TS1	590-592	stainless steel tube	0.15 kg	A=17.3 mm^2; D=12.7 mm, d=11.8 mm			
GHe Ventline between Thermal Shields/CVV	610-612 620-622	stainless steel tube	1.2 kg	A=17.3 mm^2; D=12.7 mm, d=11.8 mm			
Filling Port	440-445	stainless steel	2.08 kg	ISO design	0.1		
MLI on Filling Port	643-644	towards FP inner end, 10 layers			0.05	R-INM-0820 [RD 24]	
Safety line	451-459 455	SST; GHe conduction considered Cu strap thermal link to TS 1 (1036)	0.29 kg	A=27.5 mm^2; D=18 mm, d=17 mm A = 1.7 mm^2, l = 480 mm			RD 56
Filling line	471-499	SST; GHe conduction considered	0.48 kg	A=11.8 mm^2; D=8 mm, d=7 mm			
HTT tubing	431-435 461-463	SST; GHe conduction considered	0.68 kg	A=19.6 mm^2; D=13 mm, d=12 mm	0.1 0.05 in SLI		
HOT tubing	411-417 421-424 417	SST; GHe conduction considered V701 inlet: Cu strap to ISF	0.54 kg	A=15.7 mm^2; D=10 mm, d=9 mm A=11.8 mm^2; D=8 mm, d=7 mm A = 0.354 mm^2, l = 65 mm			
Valves	400-408	SST	15.0 kg				

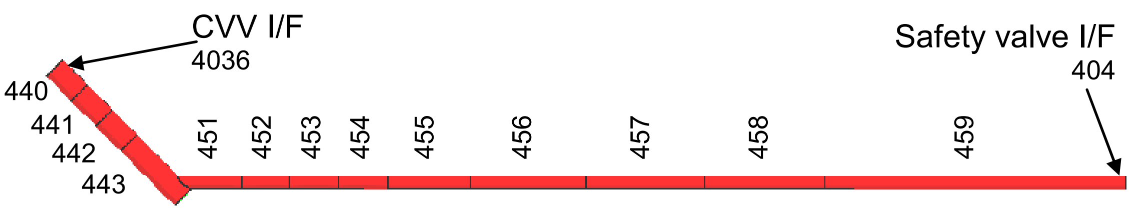
Table 4.4-1: Item List for Ventline tubing

Radiation within filling/safety lines:

To assess the impact of radiation from the CVV interface down the Filling Port and the safety line to the SV123 that is mounted on the HTT a separat small ESARAD model has been established with the following basic assumptions:

- The filling line is invisible from the CVV interface due to the filter and the Joule-Thompson valve in the Filling Port. The filling line is therefore neglected in this model. The FP is closed at the location of the JT valve.
- A straight safety line with the correct length is assumed (conservative wrt bent tube).
- The emissivity of the CVV interface is assumed to be 0.7, the emissivity of the SV123 internal parts is assumed to be 0.9. These assumptions are considered to be conservative.
- The end of the safety line is directly coupled to the HTT, i.e. the heat flow resistance through the SV123 is neglected.
- For the emissivity of the internal surface of the FP and the safety line, a value of 0.05 is assumed. The reflectivity is considered to be 100% specular.

The following picture shows modelling of the Filling Port and the Safety Line in the assessment model.



The calculated radiative couplings are implemented in the Herschel TMM.

4.4.2 Pressure Drop Model

The pressure drop calculation within the ESATAN model uses the detailed numerical pressure drop model as described in [RD 13].

The detailed pressure drop model is based on the pressure drop model used in the ISO TMM [RD 14] for the final flight predictions. In the detailed model, the pressure drop of the individual vent line components (e.g. PPS, straight pipes, bends, t-pieces, valves, heater, nozzles…) is calculated by dedicated subroutines. Most of these subroutines are directly inherited from the ISO model, with the exceptions being

1. PPS: The Herschel phase separator is different from the ISO PPS. A mini-model-type regression function is used to represent the flight model porous plug which was characterised as Sample 5 in the Herschel PPS Pre-Development test campaign. The regression formula is

$$p_{in}^2 - p_{out}^2 = a \cdot \dot{m}^b \cdot T^c$$

with pressure p [mbar], mass flow rate $\dot{m}$ [mg/s], temperature T [K], and fit parameters a=6.039899454, b=1.532479916, and c=0.439538736.

2. Electromagnetic valves: The original valve function from ISO results in unrealistically small pressure drop values (below 10^{-10} Pa per valve) for the Herschel conditions. The function has therefore been replaced by a mini-model type regression which represents the measurements of the external valves (without filters) carried out in the ISO programme [RD 15]. Filters in the external valves are implemented by calling a dedicated filter function. The impedance coefficient of this function is adjusted to the measurements performed with the Herschel TM valve and filters.

3. CVSE Pump: For the nominal ground steady-state case, a cryo vacuum pump is attached to the V502. The characteristic of this pump is represented by a newly introduced function which calculates the inlet pressure depending on the mass flow rate and the gas temperature. This feature is currently not being used within the TMM.

The pressure drop model is called from ESATAN with the following arguments:
CALL CALCMD (TIMEM, MDOT, T10, T546, T563, T586, T1031, T2031, T3031, T5344, IPPS, INOZZ, SUCCES)
This call calculates the mass flow rates depending on the tank temperature and the temperature distribution along the ventline. Input arguments are

TIMEM:	current time step, used for control output
MDOT:	initial value for mass flow rate calculation, new value after calcmd returns
T10-T5344:	temperatures of the individual elements
IPPS:	integer switch: =1 for flow through PPS, =0 for bypass via V104, <0 for closed HTT
INOZZ:	integer switch: =1 for flow through small nozzles, =2 flow through big and small nozzles, <= 0 for flow via V502
SUCCESS:	integer flag: =0 if iteration was successful (calcmd output)

To calculate the tank temperature depending on a given mass flow rate and temperature distribution along the vent line, the pressure drop model is called with the subroutine
CALL CALCTT (TIMEM, MDOT, T10, T546, T563, T586, T1031, T2031, T3031, T5344, IPPS, INOZZ, SUCCES). This subroutine uses the same arguments as for the mass flow calculation routine calcmd.

CALCMD and CALCTT both call the internal subroutine DPVENT and apply the Regula Falsi to iterate the mass flow rate until the pressure drop along the vent line, together with the nozzle inlet pressure calculated from the choked flow conditions, is equal to the pressure in the tank as defined by the tank temperature (or vice versa for CALCTT). The subroutine DPVENT calculates and sums up the respective pressure drop contributions of the individual vent line components one by one going upstream from the external nozzles to the phase separator. Bends in the pipe routing are modelled using equal or smaller bending radii than defined in the drawings. For the two pairs of parallel redundant valves V103/V106 and V501/V503, it is assumed that the respective valve with the shorter pipe routing does not open. Filling and safety lines as well as the filling port are not represented in the current version of the pressure drop model.

The Fortran code for CALCMD, CALCTT, and all functions and routines which are used internally by the pressure drop model is included in the file calcmd.f, which has to be compiled and transformed to an object library named USRLIB.a. The makefile delivered with the TMM automatically performs these tasks. The Esatan pre-processor requires that the calling names of the subroutines provided in the object library be listed in the file USRLIB.DAT.

The detailed pressure drop model is completely coded in Fortran 77. Thus it can be used either as a stand-alone program with the temperatures of the vent line sections being defined as input, or it can be called from the ESATAN Herschel TMM to perform transient analyses with variable mass flow rate.

The dominating contributions to the overall pressure drop in the orbit cool-down and operation phases are generated by the PPS and the external nozzles. The nozzle throat diameters are adjusted for the combination of desired tank temperature, temperature distribution along the vent line and mass flow rate, and are hard-coded in the pressure drop model. Changes with an impact on the mass flow rate or temperatures will therefore also have an impact on the average tank temperature.

The nozzle diameters are 1.46 mm for two small (HP-2-ASED-DW-0243_C) and 1.8 mm for one big nozzle (HP-2-ASED-DW-0347-01-0A). The flow factors have been determined from unit level test and have been implemented in the pressure drop model in order to be able to predict the vent line behaviour. To achieve good correlation to test results, the flow factor dependency on mass flow rate is included in the code. During the first part of LEOP, when the large nozzle is operated in parallel to the small nozzles, the mass flow split between large and small nozzles branches is determined in a second iteration loop.

Further details and comparison to measurement data can be found in [RD 65], [RD 66] and [RD 67].

4.5 Instruments

The latest issues of the Instrument Interface Thermal Mathematical Models (ITMMs) have been supplied by the instrument people [RD 04] resp. ESA [RD 03] [RD 05] in ESATAN format and are implemented as submodels in the overall H-EPLM TMM structure. SPIRE in addition has delivered an Interface Geometrical Mathematical Model (IGMM) in ESARAD format. Since no IGMMs of PACS and HIFI were available, they had to be established by ASED according to the corresponding FPU drawings in [RD 10] and [RD 12]. The IGMMs are implemented as submodels in the overall H-EPLM GMM.

4.5.1 PACS

The PACS instrument TMM thermal network is illustrated in Figure 4.5-1. The relevant data of each instrument node are compiled in Table 4.5-1 together with the design data of the thermal links to the Level 0 and Level 1 interfaces. The dissipation timeline during PACS operation and sorption cooler recycling is shown in Figure 4.5-2 and Figure 4.5-3.

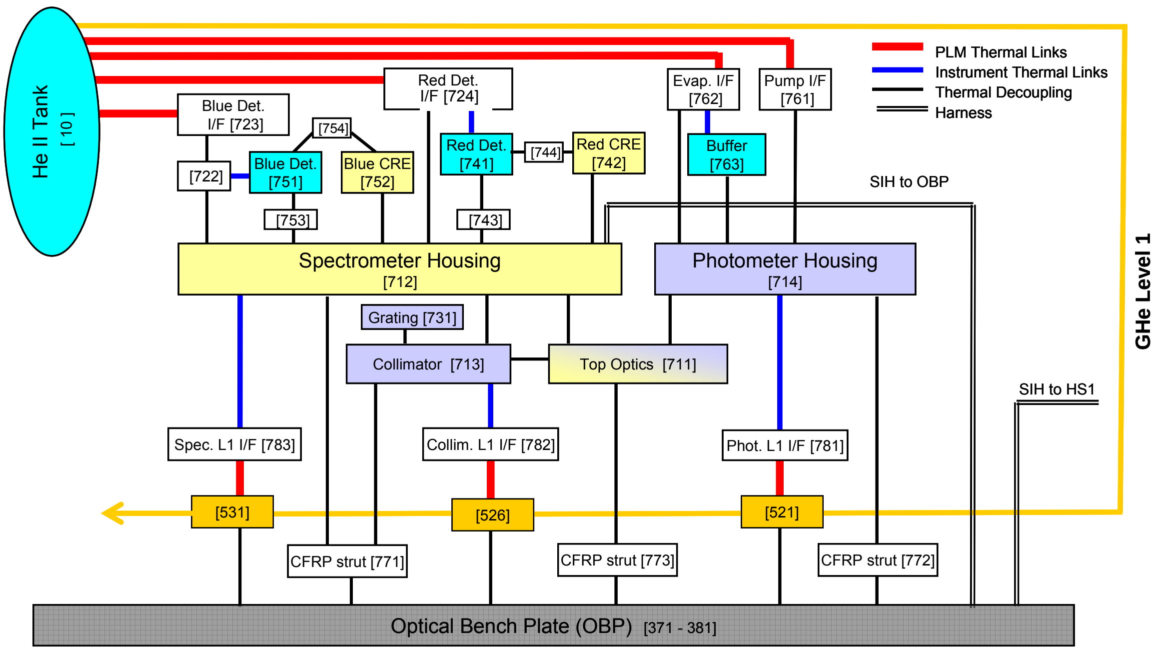


Figure 4.5-1: Reduced PACS Instrument TMM

Note that with this latest issue of the PACS TMM the PLM L0 Thermal Links are reduced to the Al pods (and related contact conductances), compare to Table 4.5-1. The flexible Cu links are provided by PACS and therefore form part of the PACS TMM.

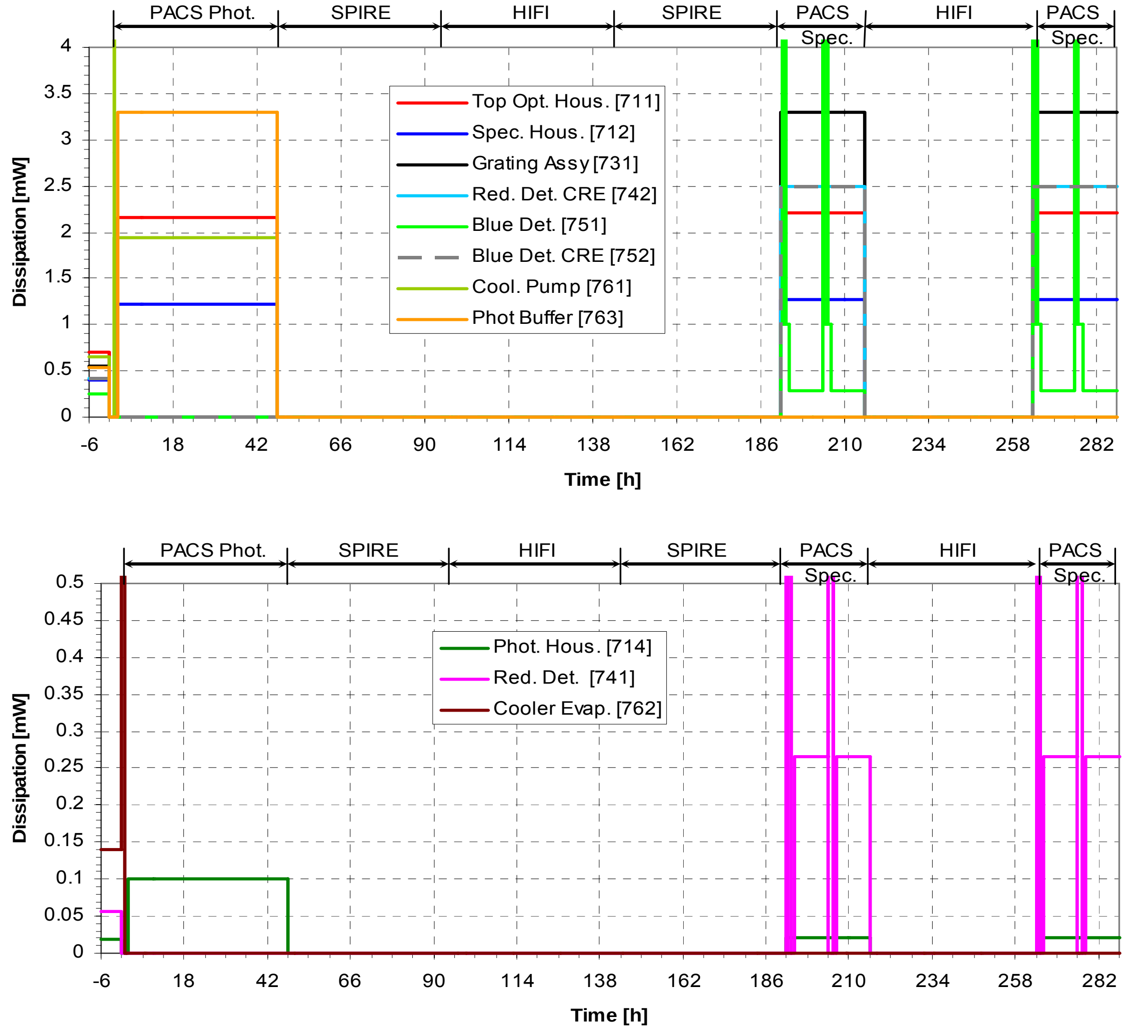


Figure 4.5-2: PACS Dissipation Profile during Operation

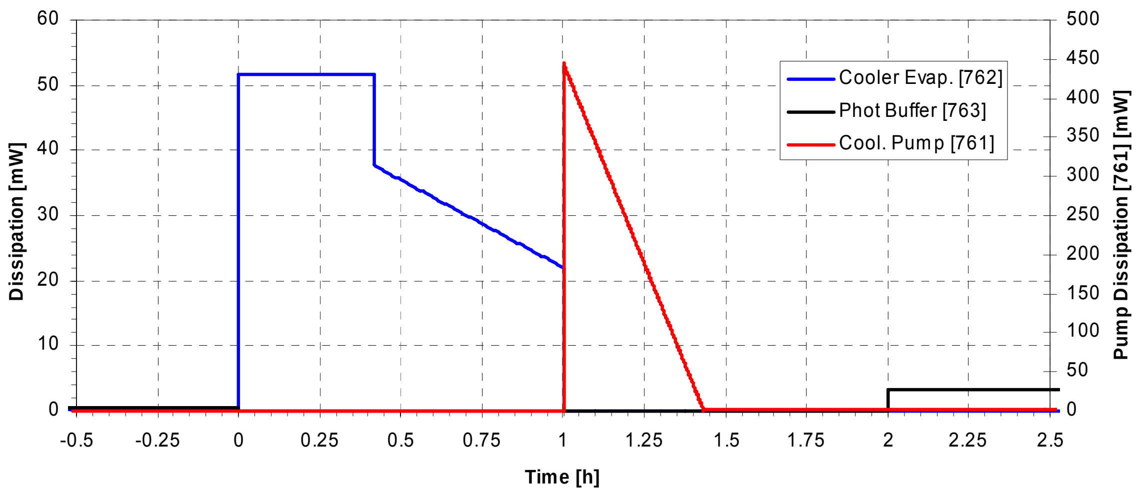


Figure 4.5-3: PACS Dissipation Profile during Recycling

Item	Node	Material / Components	Mass [kg]	Size / Performance	IR Emiss.	Unit Level Requirement	Remark
Red Detector I/F	724	Thermal link to HTT (L0) Al 1050 pod		4 x M4 cross sect.: 452 mm², l=0.284m 8 x M5 at HTT I/F		R-OBA-345 [RD 23]	
Feed Through Red Det.	721						
Feed Through Blue Det.	722						
Blue Detector I/F	723	Thermal link to HTT (L0) Al 1050 pod		4 x M4 cross sect.: 580 mm², l=0.235m 8 x M5 at HTT I/F		R-OBA-345 [RD 23]	
Cooler Pump I/F	761	Thermal link to HTT (L0) Al 1050 pod	0.15	4 x M4 cross sect.: 1130 mm², l=0.235m 8 x M5 at HTT I/F		R-OBA-345 [RD 23]	
Evaporator I/F	762	Thermal link to HTT (L0) Al 1050 pod	0.15	4 x M4 cross sect.: 1130 mm², l=0.235m 8 x M5 at HTT I/F		R-OBA-345 [RD 23]	
Buffer	763	Al, PACS cooling strap to Evaporator I/F	1.45				
Blue Detector	751	Al	2.9				
Red Detector	741	Al	2.25				
Blue Det. CRE	752	Al	0.4				
Red Det. CRE	742	Al	0.4				
CFRP strut Blue Det.	753						
CFRP strut Red Det.	743						
Harness Blue Det. Int.	754						
Harness Red Det. Int.	744						
Spectr. Housing	712	Al	14.9				harness I/F
Collimator Housing	713	Al	13.7				
Phot. Housing	714	Al, Ti	15.2				
Top Optics	711	Al	14.5	 Apertures with filters: 0.002 m²	0.26 1.0		

Item	Node	Material / Components	Mass [kg]	Size / Performance	IR Emiss.	Unit Level Requirement	Remark
Grating	731	Al, Cu	4.0				
Phot. L1 I/F	781	Cu Cooling strap to GHe ventline (L1) Cu flexible strap		2 x M4 at Instr. I/F cross sect.: (20x3)mm, l=0.217m 4 x M4 at ventline I/F		R-OBA-345 [RD 23]	
Collimator L1 I/F	782	Cu Cooling strap to GHe ventline (L1) Cu flexible strap		2 x M4 at Instr. I/F cross sect.: (20x2)mm, l=0.128m 4 x M4 at ventline I/F		R-OBA-345 [RD 23]	
Spec. L1 I/F	783	Cu Cooling strap to GHe ventline (L1) Cu flexible strap		2 x M4 at Instr. I/F cross sect.: (20x3)mm, l=0.227m 4 x M4 at ventline I/F		R-OBA-345 [RD 23]	
L2 I/F (Phot.)	772	CFRP bracket to OBP (L2)		A/L= 7.66 mm			
L2 I/F (Top Opt.)	773	CFRP bracket to OBP (L2)		A/L= 15.3 mm			
L2 I/F (Spec/Coll.)	771	CFRP bracket to OBP (L2)		A/L= 23.0 mm			

Table 4.5-1: Item List for PACS

4.5.2 SPIRE

The SPIRE instrument TMM thermal network is illustrated in Figure 4.5-4. The thermal nodes are represented in this sketch and are also compiled in Table 4.5-2, together with the design and performance data of the thermal links to the Level 0, Level 1 and Level 3 interfaces. The latest update of the SPIRE TMM additionally includes the “SMEC coils” node 826 which is coupled to the SMECm node 806 (not shown in Figure 4.5-4). The dissipation timeline during SPIRE operation and sorption cooler recycling is shown in Figure 4.5-5 and Figure 4.5-6, respectively. A more detailed description of the SPIRE instrument TMM is given in RD 16.

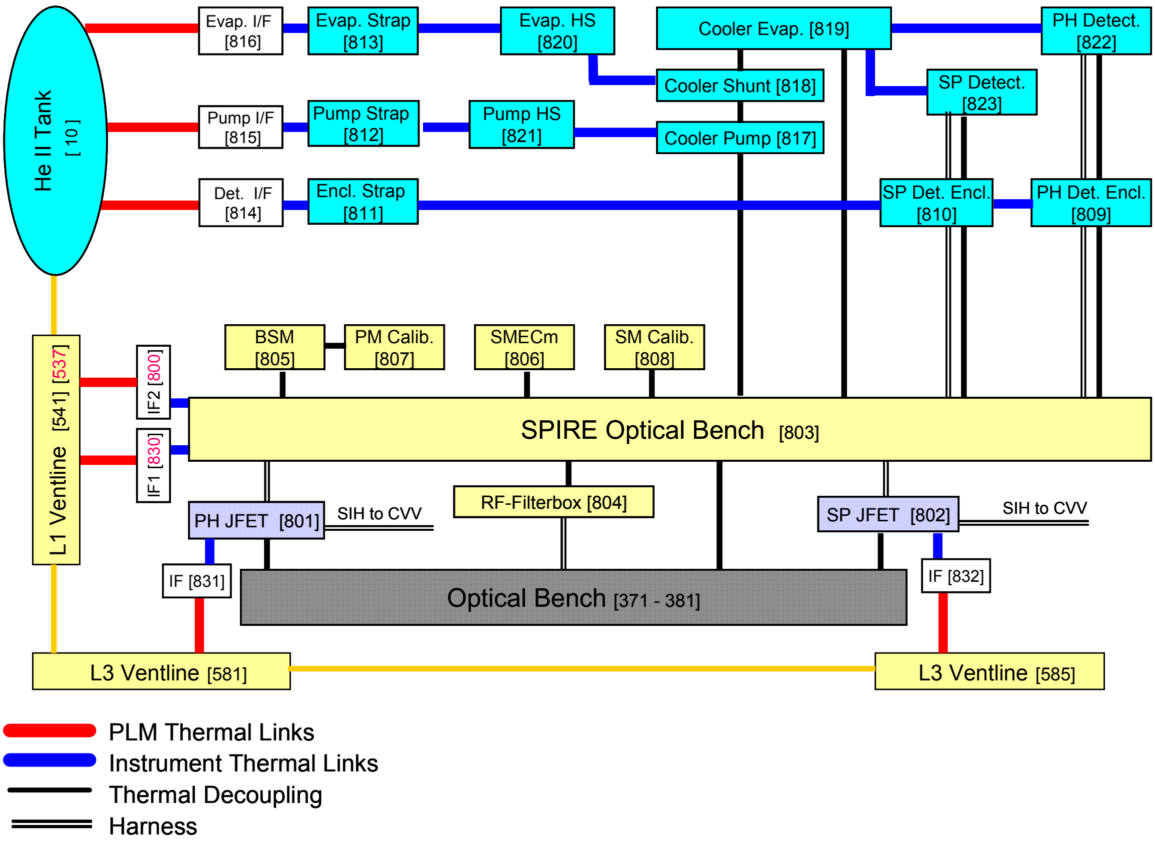


Figure 4.5-4: Reduced SPIRE Instrument TMM

The following radiative couplings (GR) inside the SPIRE TMM exist:

GR (819,820) = 6.619E-5 m²

GR (817,821) = 6.619E-5 m².

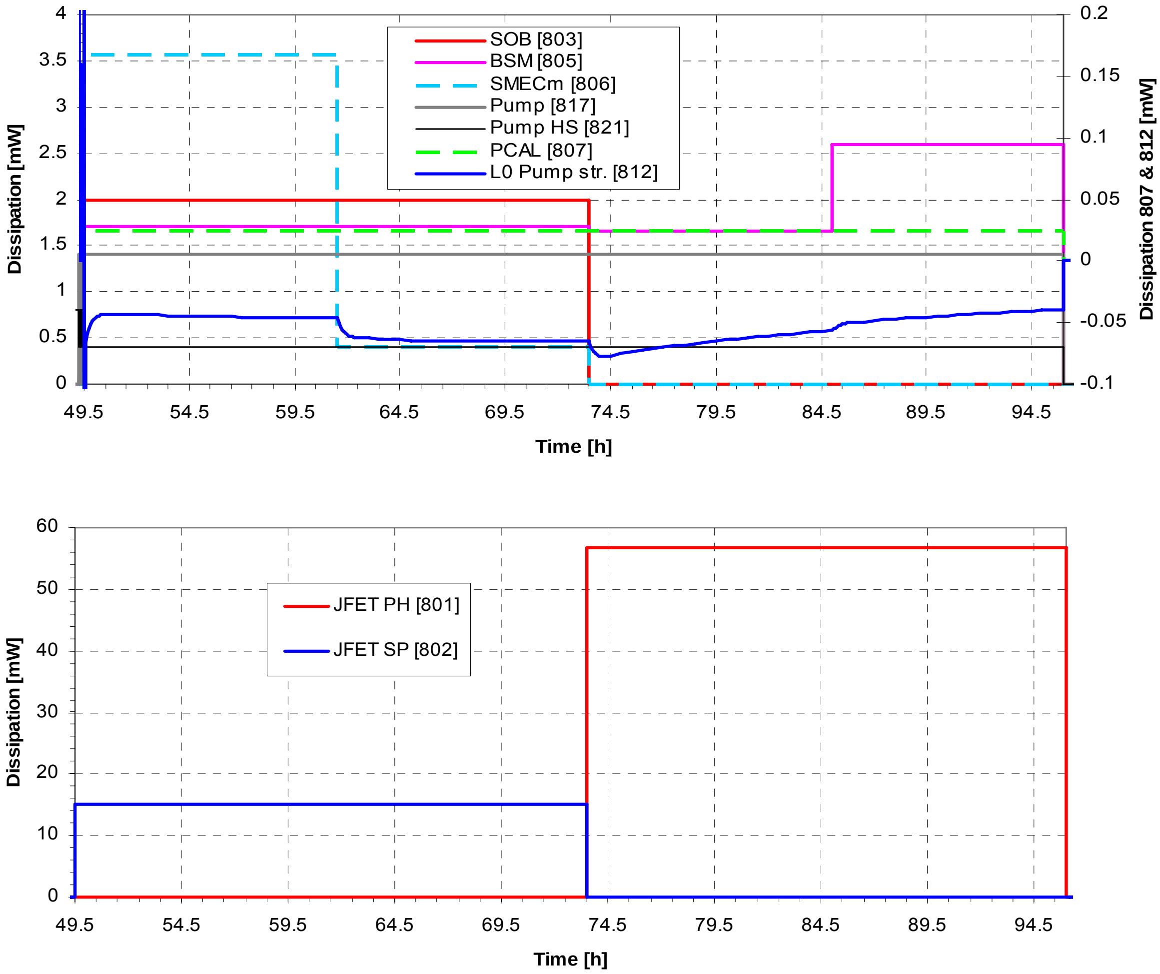


Figure 4.5-5: SPIRE Dissipation Profile during Operation

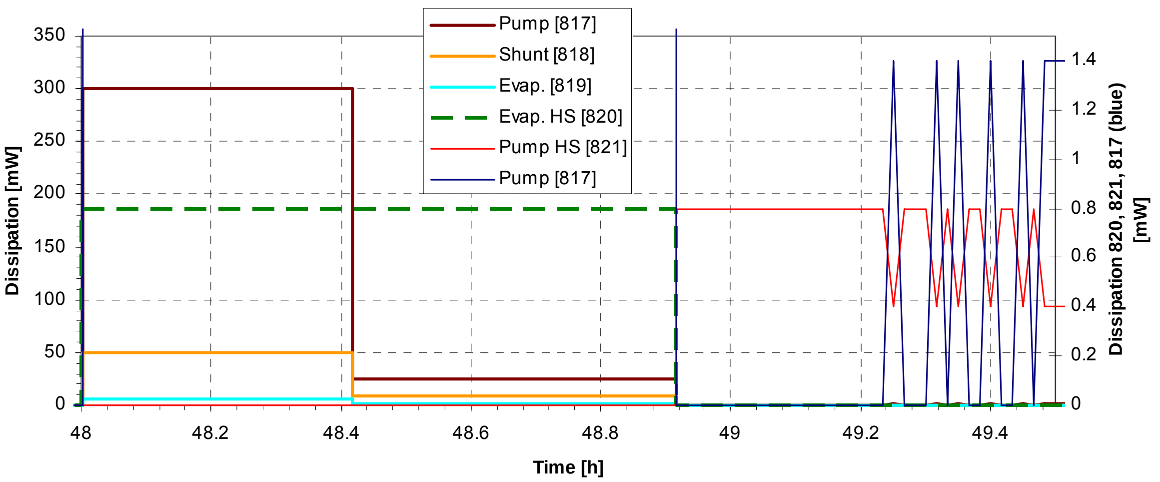


Figure 4.5-6: SPIRE Dissipation Profile during Recycling

Item	Node	Material / Components	Mass [kg]	Size / Performance	IR Emissivity	Unit Level Reqirement	Remark
PM Det. enclosure	809	Al, St. Steel, Invar, Silicon	3.91				
SM Det. enclosure	810	Al, St. Steel, Invar, Silicon	1.70				
Enclosure Strap	811		0.164				
Pump Strap	812		0.159				
Evap. Strap	813		0.152				
Enclosure Strap I/F	814	Thermal link to HTT (L0) Al1050 pod	0.462	4 x M4 at Instr. I/F cross sect.: 960 mm², l=0.340m 8 x M5 at HTT I/F		R-OBA-345 [RD 23]	
Pump Strap I/F	815	Thermal link to HTT (L0) Al1050 pod	0.516	4 x M4 at Instr. I/F cross sect.: 960 mm², l=0.340m 8 x M5 at HTT I/F		R-OBA-345 [RD 23]	
Evap. Strap I/F	816	Thermal link to HTT (L0) Al1050 pod	0.701	4 x M4 at Instr. I/F cross sect.: 960 mm², l=0.340m 8 x M5 at HTT I/F		R-OBA-345 [RD 23]	
Cooler Pump	817	Ti	0.15				
Cooler Shunt	818	Ti	0.01				
Cooler Evaporator	819	Ti	0.084				
Cooler Evapor. HS	820	Ti	0.074				
Cooler Pump HS	821	Ti	0.074				
PM Detector	822	Invar, Cu	1.144				
SM Detector	823	Invar, Cu	0.535				
L1 strap I/F1	800	Cooling strap to GHe ventline (L1) Cu flexible strap	0.001	0.5 x M8 + 1 x M4 at Instr. I/F cross sect.: (20x2)mm, l=0.173m 4 x M4 at ventline I/F		R-OBA-345 [RD 23]	
L1 strap I/F2	830	Cooling strap to GHe ventline (L1) Cu flexible strap		0.5 x M8 + 1 x M4 at Instr. I/F cross sect.: (20x2)mm, l=0.173m 4 x M4 at ventline I/F		R-OBA-345 [RD 23]	

Item	Node	Material / Components	Mass [kg]	Size / Performance	IR Emissivity	Unit Level Reqirement	Remark
SPIRE Optical Bench (SOB)	803	1 SST cone support to OBP 2 A-frame supports to OBP	26.75	aperture A/L= 1.530 mm various serials	0.05 1.0		
RF Filter box	804	Al casing/structure	1.465				harness I/F
BSM	805		1.10				
SMECm	806		1.043				
SMEC coils	826						used for SPIRE launch latch
PM Calibration	807		0.03				
SM Calibration	808		2.041E-4				
PM JFET Encl.	801	Al, 5 CFRP T300 brackets to OBP	2.348	Total A/L= 36.63 mm	0.20		harness I/F
PM JFET I/F	831	Cooling strap to Level 3 Cu flexible strap		2 x M4 at Instr. I/F cross sect.: (20x4)mm, l=0.252m 4 x M4 at ventline I/F			
SM JFET Encl.	802	Al, 4 CFRP T300 brackets to OBP	0.81342	Total A/L= 29.30 mm	0.20		harness I/F
SM JFET I/F	832	Cooling strap to Level 3 Cu flexible strap		2 x M4 at Instr. I/F cross sect.: (20x4)mm, l=0.308m 4 x M4 at ventline I/F			

Table 4.5-2: Item List for SPIRE

4.5.3 HIFI

The HIFI instrument TMM thermal network is illustrated in Figure 4.5-7. All thermal nodes are represented in this sketch and are also compiled in Table 4.5-3 together with the design and performance data of the thermal links to the Level 0 and Level 1 interfaces.

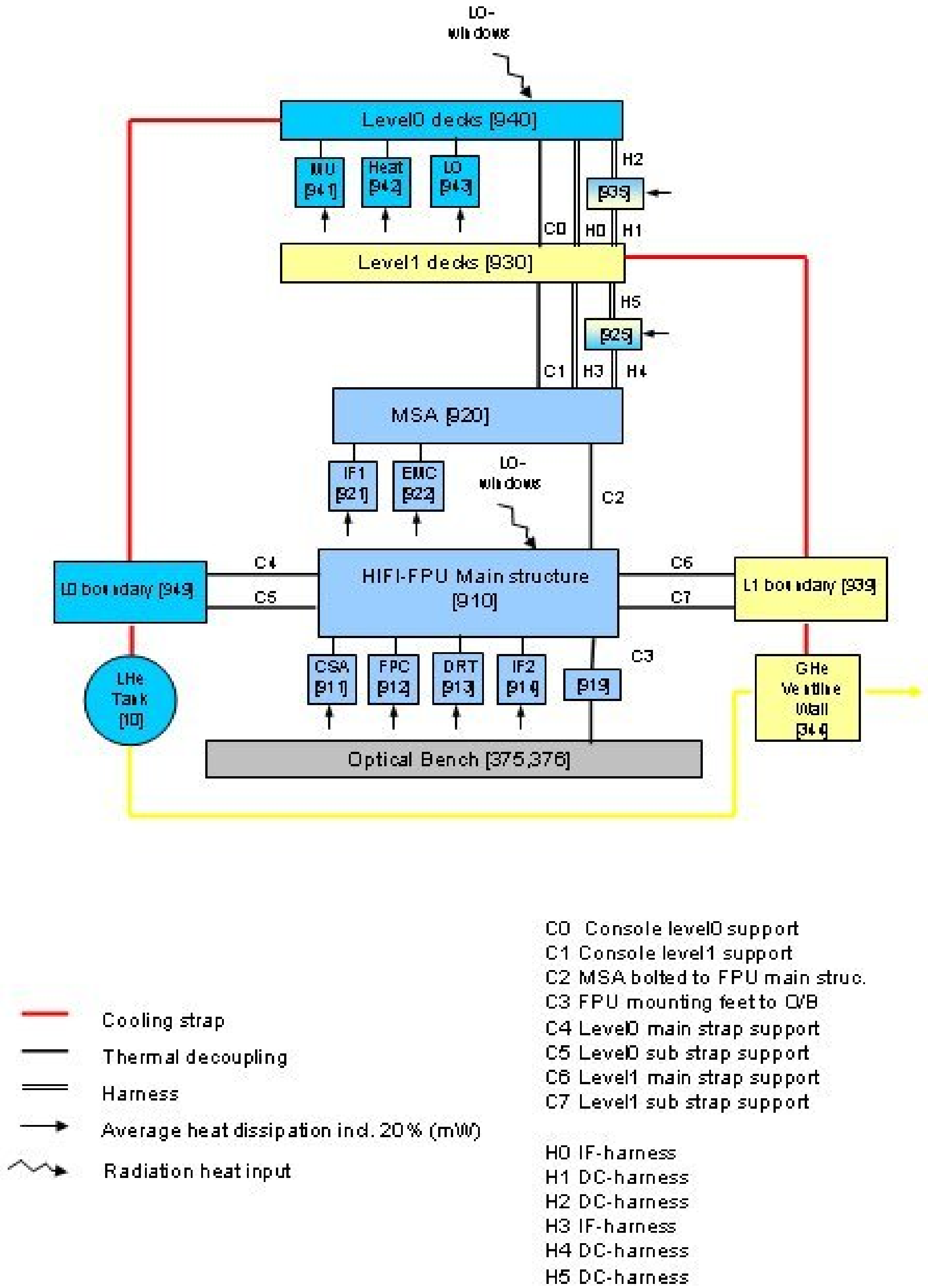


Figure 4.5-7: Reduced HIFI Instrument TMM

The dissipation timeline during HIFI operation is shown in Figure 4.5-8.

The following radiative couplings (GR) from the LOU windows (Node 4090 in H-EPLM TMM) to the HIFI Level 0 exist:
GR (4090 , 940) = 1.02E-5 m^2

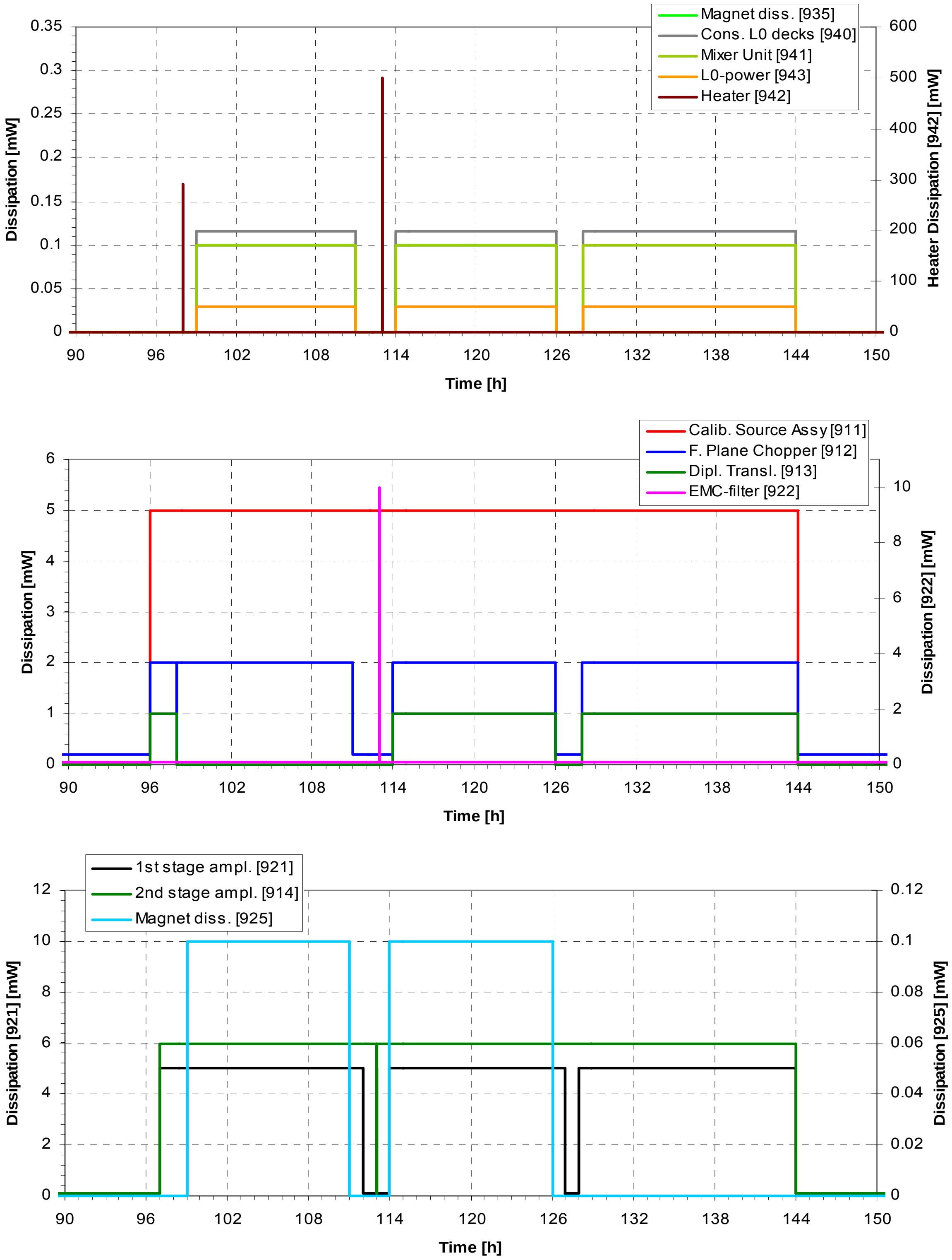


Figure 4.5-8: HIFI Dissipation Profile during Operation

Item	Node	Material / Components	Mass [kg]	Size / Performance	IR Emiss.	Unit Level Requirement	Remark
FPU Structure	910	Al	35.72	 Apertures	0.26 1.0		harness I/F
Calib. Source Assy	911	Al	1.5				
Focal Plane Chopper	912	Al	0.40				
Dipl. Rooftop transl.	913	Al	0.59				
2^{nd} stage amplifier	914	Al	2.30				
L2 boundary	919			thermal coupl. to OBP: 1.2 W/K			
Mixer Sub Assy	920	Al	2				
1^{st} stage amplifier	921						
EMC filtering	922						
Magnet current diss.	925						
Console L1 decks	930	Al	0.56				
Magnet current diss.	935						
L1 boundary	939	Al, Cu Cooling strap to GHe ventl. (L1)	0.40	4 x M4 at Instr. I/F cross sect.: (20x3.5)mm, l=0.172m 4 x M4 at ventline I/F		R-OBA-345 [RD 23]	
Console L0 decks	940	Al	1.68				
Mixer Unit	941	Al	1.05				
Heater	942						
LO-power	943						
L0 boundary	949	Al, Thermal link to HTT (L0) Cu flexible strap Al 1050 pod	0.40	 4 x M4 at Instr. I/F cross sect.: 75 mm², l=0.236m 4 x M4 cross sect.: 392 mm², l=0.404m 8 x M5 at HTT I/F		R-OBA-345 [RD 23]	

Table 4.5-3: Item List for HIFI

4.6 Thermal Shields and Tank Suspensions

The tank suspension consists of GFRP and T300 CFRP chains with heat interceptions at each Thermal Shield. The two innermost chains are made out of T300 CFRP; the other ones are made out of S-glass. The cross section and material selection of each chain has been optimized w.r.t. thermal and mechanical performance. The details are described in [RD 20]. The nodal breakdown of the chains is shown in Figure 4.6-1 and the relevant data are compiled in Table 4.6-1.

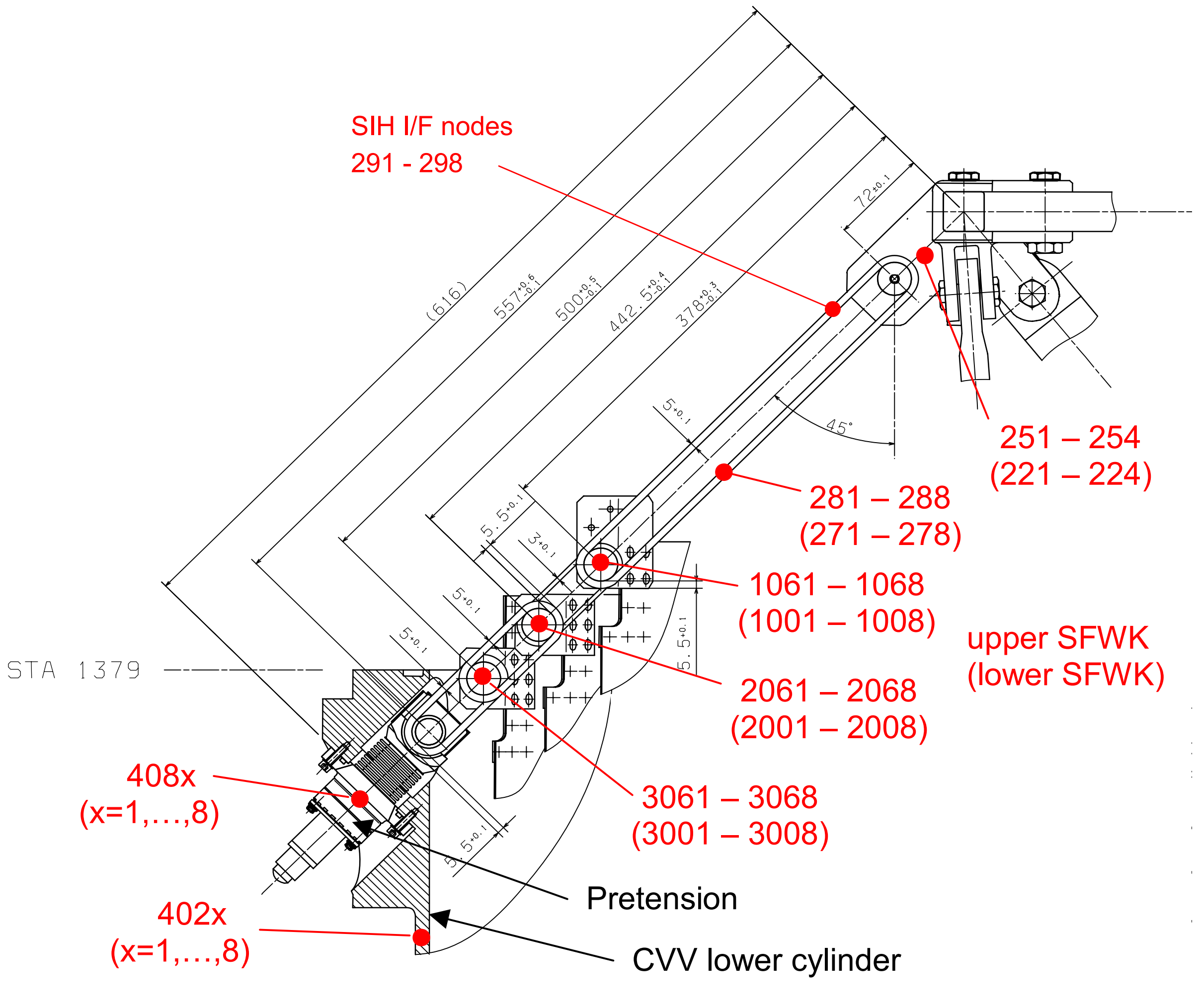


Figure 4.6-1: Nodal Breakdown of Tank Suspensions

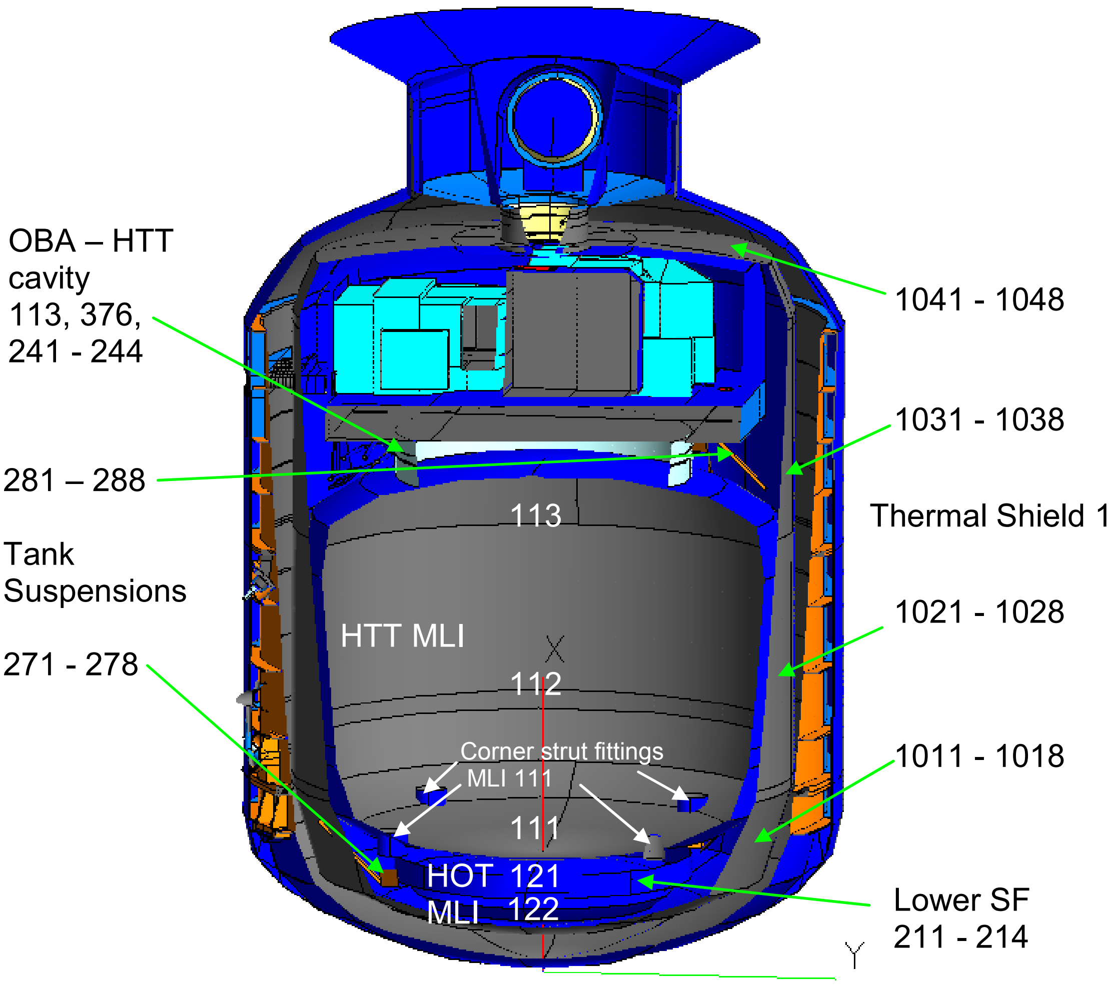


Figure 4.6-2: Nodal Breakdown of Tanks and Thermal Shield 1

Item	Node	Material / Components	Mass [kg]	Size	IR Emiss.	Unit Level Requirement	Remark
Susp. Bolt TS1 lo Susp. Bolt TS1 up	1001-1008 1061-1068	stainless steel stainless steel	0.15 0.15				
Susp. Straps lo Susp. Straps up	271-278 281-288	8 CFRP T300, between TS1 and SFW 8 CFRP T300, between TS1 and SFW		8x137 mm², l= 306 mm 8x137 mm², l= 306 mm	0.8	R-TSS-200 [RD 21]	A)
Thermal Shld 1 low bulk Thermal Shld 1 low cyl. Thermal Shld 1 upp cyl. Thermal Shld 1 upp bulk	1011-1018 1021-1028 1031-1038 1041-1048	Al 6061 CuBe blades to TSS	10.0 12.1 10.0 8.2	A= 3.708 m², s=0.8 mm D=1.69m, h=0.842m, s=0.8 mm D=1.69m, h=0.696m, s=0.8 mm A= 3.021 m², s=0.8 mm	0.05	R-FTS-170 [RD 30]	
TS 1 LOU Baffle	1090	Common Al baffle for all 7 HIFI chanels + 2 alignment apertures			0.7 int. C) 0.1 ext.		[RD 55]
Thermal Shield 1 MLI	1111-1118 1121-1128 1131-1138 1141-1148	2 x 5 layers	1.9 2.0 1.9 1.4	A= 3.708 m² D=1.69m, h=0.842m D=1.69m, h=0.696m A= 3.021 m²	0.05	R-INM-0510 [RD 24] R-INM-0530 [RD 24]	B)
Susp. Bolt TS2 lo Susp. Bolt TS2 up	2001-2008 2061-2068	stainless steel stainless steel 2x8 CFRP T300, susp. straps to TS1	0.15 0.15	 2x8x131 mm², l= 64.5 mm		 R-TSS-200 [RD 21]	 A)
Thermal Shld 2 low bulk Thermal Shld 2 low cyl . Thermal Shld 2 upp cyl. Thermal Shld 2 upp bulk	2011-2018 2021-2028 2031-2038 2041-2048	Al 6061 CuBe blades to TSS	11.1 12.6 10.4 9.0	A= 4.124 m², s=0.8 mm D=1.76m, h=0.842m, s=0.8 mm D=1.76m, h=0.696m, s=0.8 mm A= 3.319 m², s=0.8 mm	0.05	R-FTS-173 [RD 30]	
Thermal Shield 2 Baffle	2050	Al baffle with aperture; cut-out area 0.040 m², see Figure 4.3-4		290 mm diameter	0.7 cyl. C) 0.7 +x side C) 0.05-x side		
TS 2 LOU Baffle	2090	Al tubes (LOU/HIFI) Al tubes (Alignment)		7 x 42 mm inner diameter 2 x 35 mm inner diameter	0.7 int. C)		[RD 55]
Thermal Shield 2 MLI	2111-2118 2121-2128 2131-2138	4 x 5 layers	2.1 2.1 1.9	A= 4.124 m² D=1.76m, h=0.842m D=1.76m, h=0.696m	0.05	R-INM-0610 [RD 24] R-INM-0630 [RD 24]	B)

Item	Node	Material / Components	Mass [kg]	Size	IR Emiss.	Unit Level Requirement	Remark
	2141-2148		1.7	A= 3.319 m²			
Susp. Bolt TS3 lo Susp. Bolt TS3 up	3001-3008 3061-3068	stainless steel stainless steel 2x8 GFRP suspension straps to TS2 2x8 GFRP suspension straps to CVV	0.15 0.15	 2x8x168 mm², l= 57.5 mm 2x8x167 mm², l= 57 mm		R-TSS-200 [RD 21]	A)
Thermal Shld 3 low bulk Thermal Shld 3 low cyl. Thermal Shld 3 upp cyl. Thermal Shld 3 upp bulk	3011-3018 3021-3028 3031-3038 3041-3048	Al 6061 CuBe blades to TSS	12.2 kg 13.1 kg 10.8 kg 10.5 kg	A= 4.503 m², s=1mm D=1.83m, h=0.842m, s=1mm D=1.83m, h=0.696m, s=1mm A= 3.886 m², s=1mm	0.05	R-FTS-173 [RD 30]	
Thermal Shield 3 MLI	3111- 3148	4 x 5 layers	2.5 kg 4.6 kg 2.1 kg		0.05	R-INM-0710 [RD 24] R-INM-0730 [RD 24]	B)

A) Thermal conductivity of material confirmed by sample tests

B) MLI Performance test data of Forschungszentrum Karlsruhe included (details are reported in [RD 36])

C) 0.85 for ground cases, to account for higher temperatures

Table 4.6-1: Item List for Thermal Shields

The thermal property data of the cryostat internal MLI are described in Section 5.1.

4.7 Cryostat Vacuum Vessel and Radiators

The nodal break-down of the CVV is shown in Figure 4.7-1. About one half of the cylindrical part and a 90° section of the upper bulkhead of the CVV serve as radiator, this area is called the CVV main radiator. The remaining surface of the CVV is covered with MLI. Three additional radiators are located at the –Z, +Y and –Y sides.

The ±Y radiators shadow the CVV main radiator from the warm Solar Array MLI and increase further the CVV radiative area to space. The radiator (-Z) side of the ±Y radiators (as well as both sides of the –Z radiator) are black anodized. The rear (+Z) sides of the ±Y radiators are covered with MLI.

The –Z radiator is split in an upper and a lower part, with the nozzle assembly in between. The thermal / mechanical attachment of each radiator to the CVV is provided with M8 bolt connections as listed in Table 4.7-1. The contact conductances between radiators and CVV structure are calculated using the values shown in Figure 5.3-1.

The heat spreading effect on CVV and radiators has been taken into account in the TMM using appropriate formulas in the corresponding "GL" conductance calculations (serial conductance of contact conductance and linear conductance of the corresponding CVV radiator). On the CVV two arithmetic nodes are located at the –Z Radiator I/F on the lower (node 4051) and upper part (4052). Thus, node 4051 connects the radiator node 4050 with the CVV nodes 4024 and 4025. Node 4052 connects the radiator node 4053 with the CVV nodes 4034 and 4035.

Detailed modelling of CVV external items in the GMM like CVV ribs, connector plugs, pretension devices, external tubing/LHVs, nozzles etc. is shown in Figure 4.7-2 to Figure 4.7-4.

The cryostat baffle that is located between the telescope and the CVV upper bulk has an additional so-called "SLI I/F collar". This device ensures the light-tightness of the interface between telescope and cryostat baffle towards the external environment, see Figure 4.7-5. The external surface of this baffle is covered with MLI except a 90° section at the -Z side that serves as radiator area and is black anodized. The internal surface has a low IR emissivity. Inside the cryostat baffle there is an additional internal conical baffle with a low IR surface emissivity, providing minimum disturbance of the instruments main optical path (beam entrance).

The optical path between HIFI and LOU is visualised in Figure 4.7-6. Two dedicated baffles with integrated vanes are implemented on Thermal Shield 1 and 2 [RD 55].

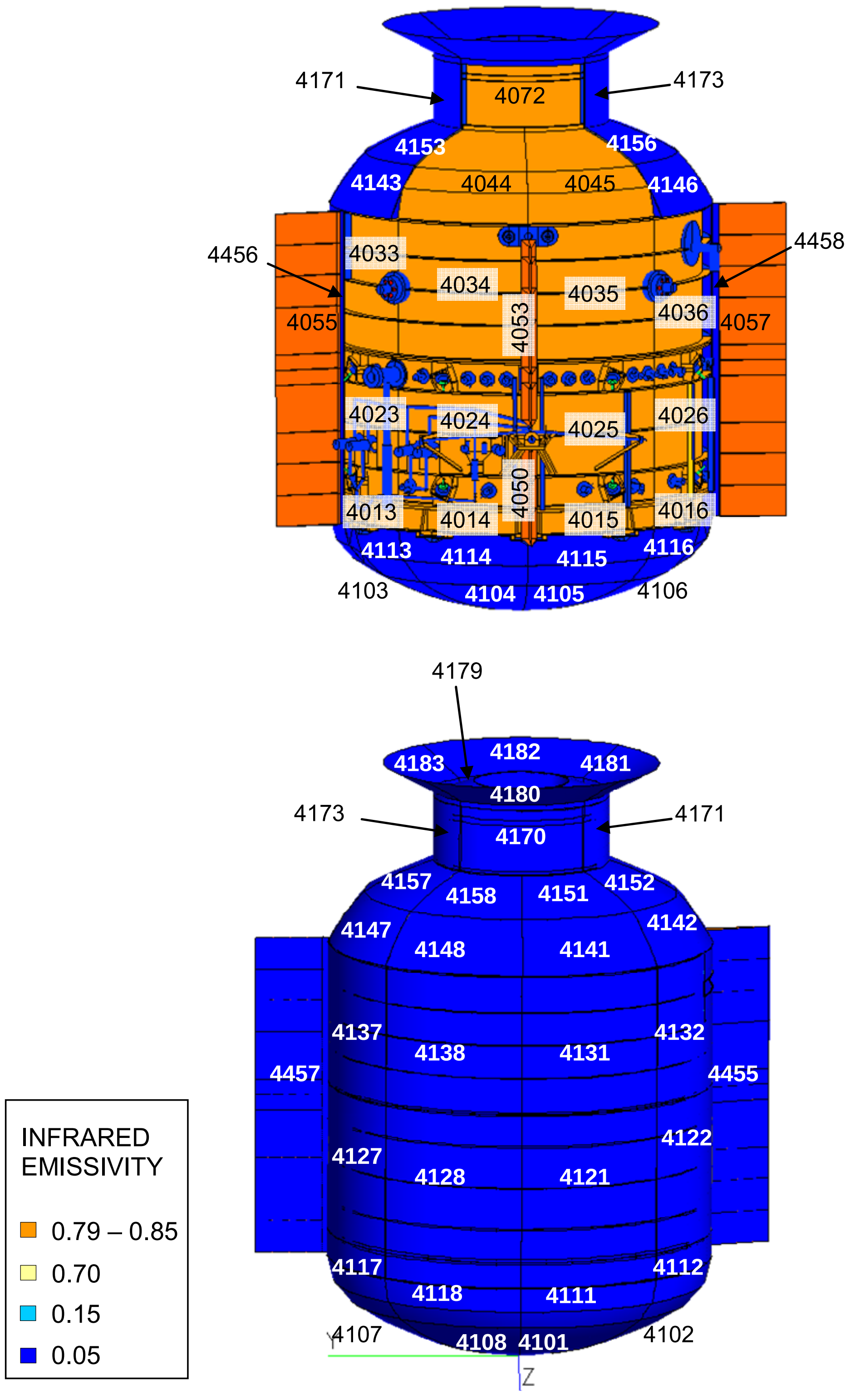


Figure 4.7-1: CVV Radiator and MLI Nodal Break-Down

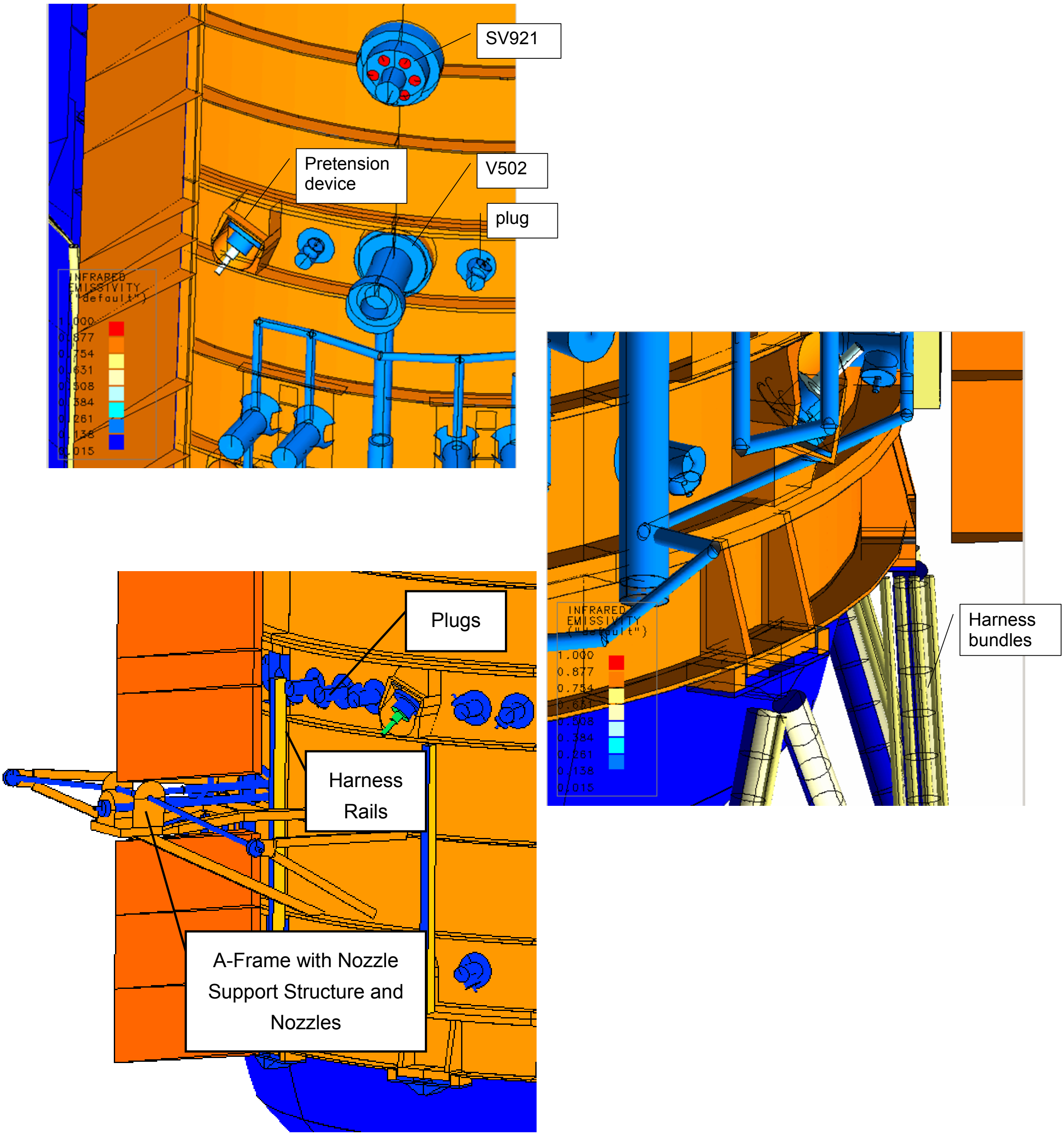


Figure 4.7-2: Detailed view on CVV external items (CVV ribs, connector plugs, pretension devices, external tubing with LHVs, A-frame with nozzles, harness bundles & rails)

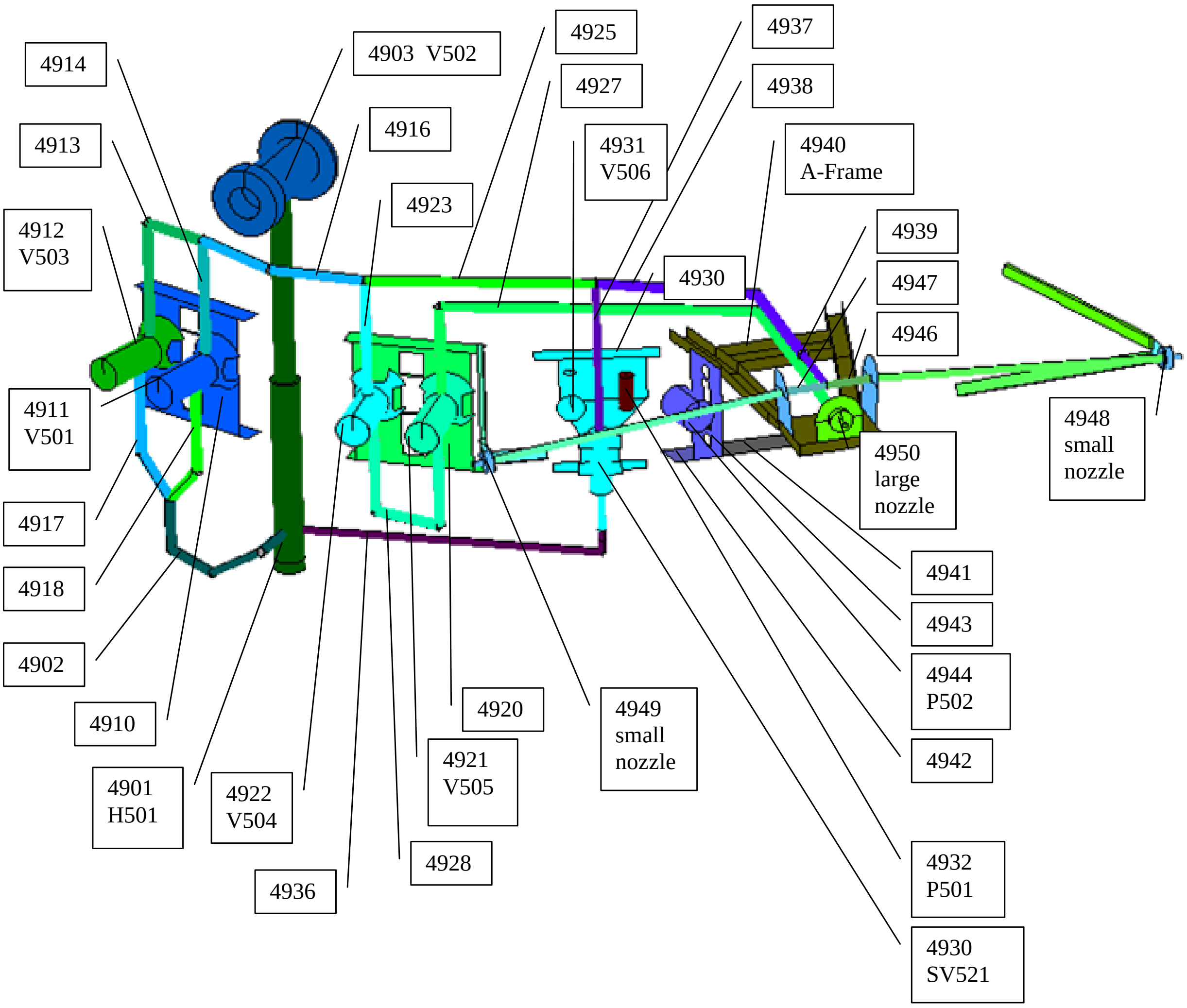


Figure 4.7-3: External tubing nodal breakdown

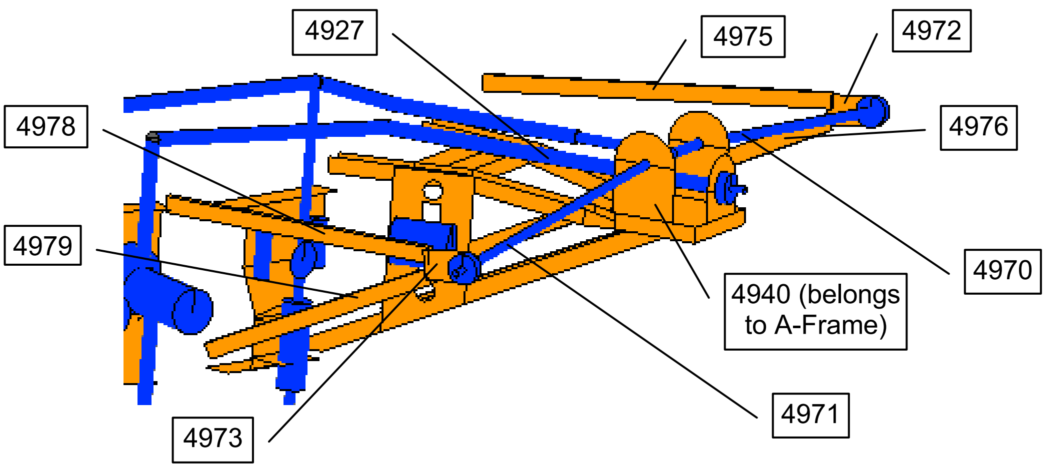


Figure 4.7-4: Nozzle elongation nodal breakdown

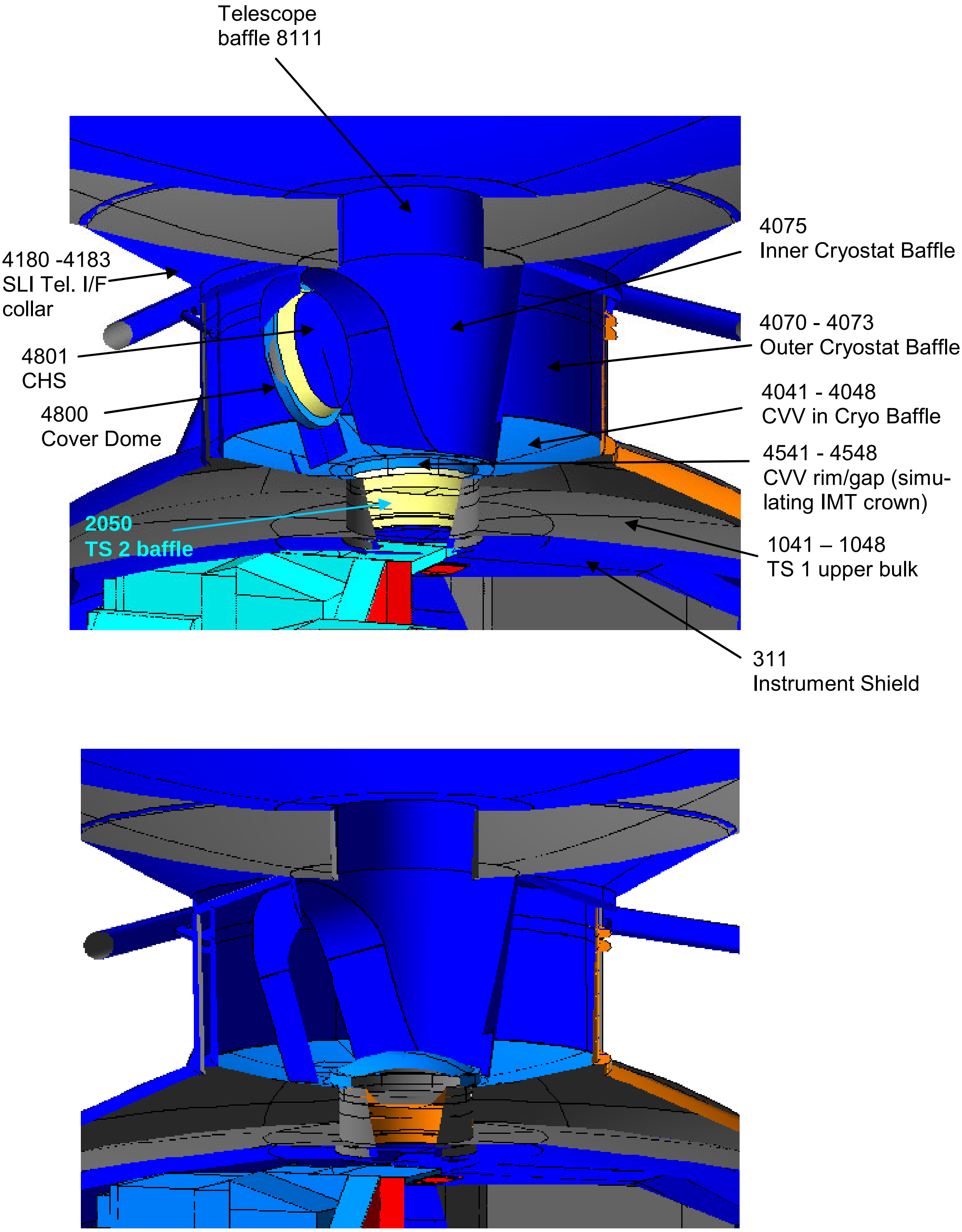


Figure 4.7-5: Cryostat Baffle and Cover Nodal Break-Down (Cover open & closed View)

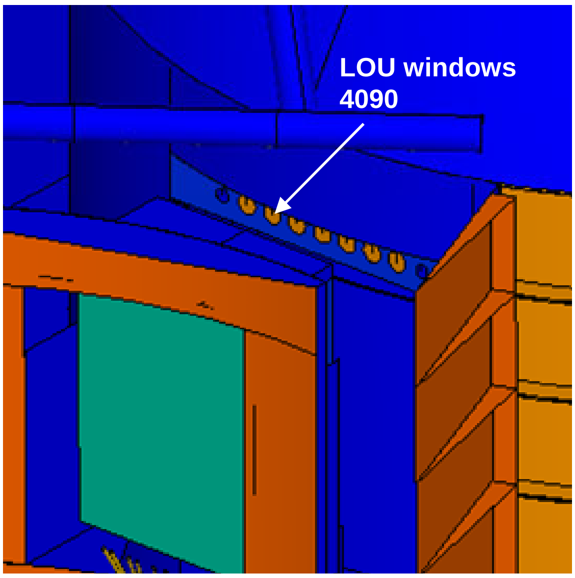
Thermal conductance due to gaseous Helium in the Cryo Cover flushing line

According to [RD 39], the total linear heat conductance between the Cover and the CHS is 0.00325 W/K. The cited value does not include the heat conduction through the gaseous Helium, which is left in the tube after cover flushing. To avoid leakage of air and water vapour into the flushing lines, the lines will be sealed off with a slight He overpressure inside during the ground hold time / launch autonomy.
For the current worst-case calculation, a Helium pressure of 1.5 bar (150kPa) is assumed. The thermal conductivity of He varies between 0.137 W/mK and 0.156 W/mK for temperatures between 250 K and 300 K according to NIST. Two parallel stainless steel (1.4404) lines, free effective length L = 60 mm, outer diameter da = 5.0 mm, inner diameter di = 4.6 mm [RD 39]. This leads to a pipe wall conductance of 0.0015 W/K.

Since the warm part (Johnston coupling) is above the cold part (CHS), convection will not take place. Conduction in the He gas is:

$$C = 2 \cdot \lambda \cdot \frac{\pi d_i^2}{4L} = 8.30951\text{E-05 W/K}$$

This linear conductor is also implemented in the TMM.



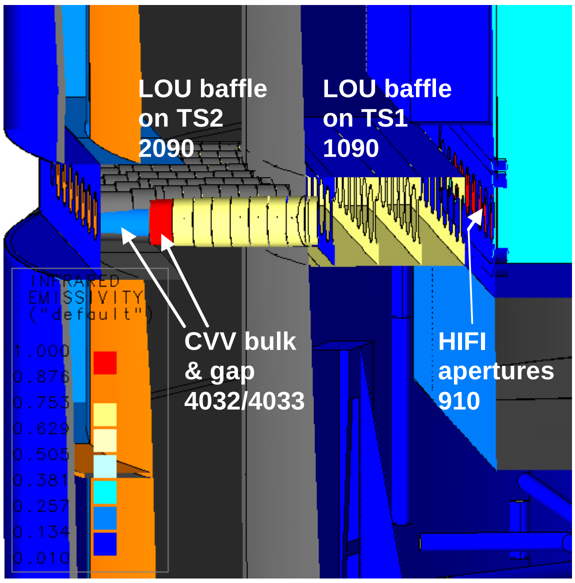


Figure 4.7-6: LOU Windows / Baffles (LOU Ext. Window Baffle and Attenuators not shown)

Item	Node	Material / Components	Mass [kg]	Size	Solar Absorpt.	IR Emiss.	Unit Level Requirement	Remark
CVV lower bulk	4011-4018	Al 5083, 3.3547 Radiator area outside: black anodized (78/60 µm thickn. upper/lower CVV); (1) = ε @ 65 K (in-orbit) (2) = ε @ 100 K (LSS) inner side: polished (3)	88.5	A= 8 x 0.585 m² 7 mm thickness (average)	0.95 (1)	0.79 (1) 0.81 (2) 0.05 (3)	R-CVV-F-640 [RD 31] R-CVV-F-645 [RD 31]	A)
CVV lower cylinder	4021-4028		95.0	D = 1.9 m, h=0.842 m 7 mm thickness (average)				
CVV upper cylinder	4031-4038		78.5	D = 1.9 m , h= 0.696 m 7 mm thickness (average)		0.80 (1) 0.82 (2) 0.05 (3)		
CVV upper bulk	4041-4048		78.1	A= 8 x 0.516 m² 7 mm thickness (average)				
CVV lower bulk MLI Inner side Inner side	4101-4108 4111-4118 4411-4412 4417-4418	41 layers (4 blankets: 3x9+1x14) IR specularity 0.80			0.13	0.05	R-EXM-530 [RD 28]	
CVV lower cyl. MLI Inner side Inner side	4121-4122 4127-4128 4421-4422 4427-4428							
CVV upper cyl. MLI Inner side Inner side	4131-4132 4137-4138 4431-4432 4437-4438							
CVV upper bulk MLI	4141-4148 4151-4158							
CVV –Z Radiator (+X)	4053	Al 6063, both sides with micro grooves and black anodized (72 µm thickness)	3.021	(0.35 x 0.968) m² 15 x M8	0.95	0.85 (1) 0.86 (2)	R-CVV-F-480 [RD 31]	A)
CVV –Z Radiator (-X)	4050	Al 6063, both sides with micro grooves and black anodized (72 µm thickness)	1.703	(0.35 x 0.506) m² 9 x M8	0.95	0.85 (1) 0.86 (2)	R-CVV-F-480 [RD 31]	A)
CVV -Y Radiator	4055	Al 6063, -Z side with micro grooves and black anodized (70 µm thickness)	4.534	(0.35 x 1.687) m² 24 x M8	0.95	0.84 (1) 0.85 (2)	R-CVV-F-485 [RD 31]	A)
CVV +Y Radiator	4057	Al 6063, -Z side with micro grooves and black anodized (71 µm thickness)	4.568	(0.35 x 1.687) m² 24 x M8	0.95	0.83 (1) 0.84 (2)	R-CVV-F-485 [RD 31]	A)
CVV -Y Radiat. MLI	4455, 4456	41 layers (4 blankets: 3x9+1x14) IR specularity 0.80			0.13	0.05	R-EXM-530 [RD 28]	
CVV +Y Radiat. MLI	4457, 4458							

Item	Node	Material / Components	Mass [kg]	Size	Solar Absorpt.	IR Emiss.	Unit Level Requirement	Remark
LOU Windows	4090	Quartz Glass windows (LOU), 5 mm thick Quartz Glass windows (Alignment) 5 mm thick	0.36	7 x ∅34 mm opening in CVV 2 x ∅24 mm opening in CVV	0.05	0.8		IR transm. 0.20
Cover	4800	If opened: -107° rotated around Y axis	7			0.15	R-CC-090 [RD32]	
Cover Heat Shield	4801	 Heat shield rim/short cone	0.46			0.1 0.7	R-CC-080 [RD32]	
Outer Cryostat Baffle	4070-4073, 4079 4072	Al 5083 90° radiator section	5	D=850mm 0.229 m²		0.1 0.80 (1) 0.82 (2)	R-CB-135 [RD32] R-CB-135 [RD32]	 A)
Inner Cryostat Baffle	4075	Al 5083 outer surface	1	Conical: D=500, d=300		0.05 0.1	R-CB-135 [RD32]	
Cryostat Baffle MLI	4170,4171, 4173,4179	41 layers (4 blankets: 3x9+1x14) IR specularity 0.80			0.13	0.05	R-EXM-830 [RD 28]	
SLI Tel. I/F collar	4180-4183	1 layer; IR specularity 0.80			0.13	0.05		
CVV gap	4541-4548	simulates IMT crown		D = 290mm, h = 14.5mm		0.6		
Pretension 1 - 8	4081-4088	Ti brackets	8x0.15		0.4	0.15		
Ext. Ventline & valves	4901-4979	Stainless steel nodes 4902 & 4938 coupled to CVV via 2 Cu straps small and large nozzles		 2 x 4 mm² cross-section, 80 mm length 1.46 and 1.8 mm throat diam.	0.4	0.15		[RD 41]
CVV plugs	4023-4026 4033-4036	Stainless steel			0.4	0.15		
CVV ext. harness	9011-9096				0.7	0.7		
Harness rails	22100-24344	Al			0.4 0.7	0.15 0.7		

A) Test results obtained from sample testing [RD 35]

Table 4.7-1: Item List for CVV and Cryostat Baffle

The thermal property data of the CVV MLI are described in Section 5.1.

4.8 LOU and Telescope

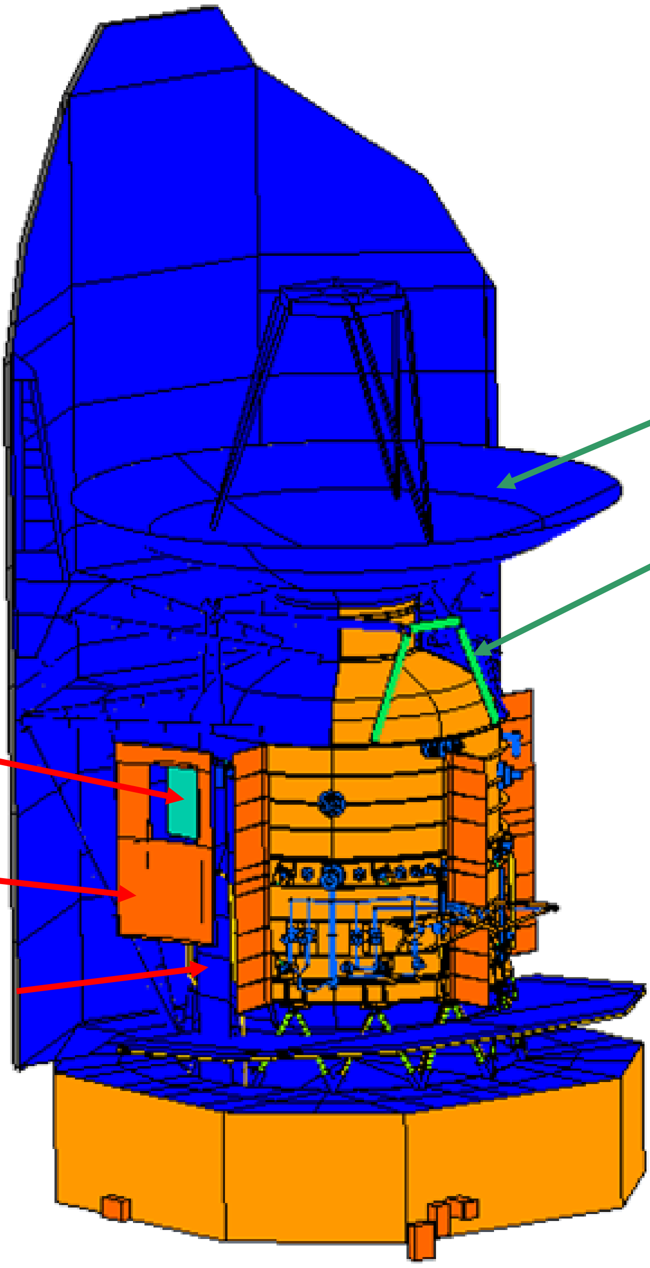


Figure 4.8-1: H-EPLM GMM External Overall View including H-SVM RGMM

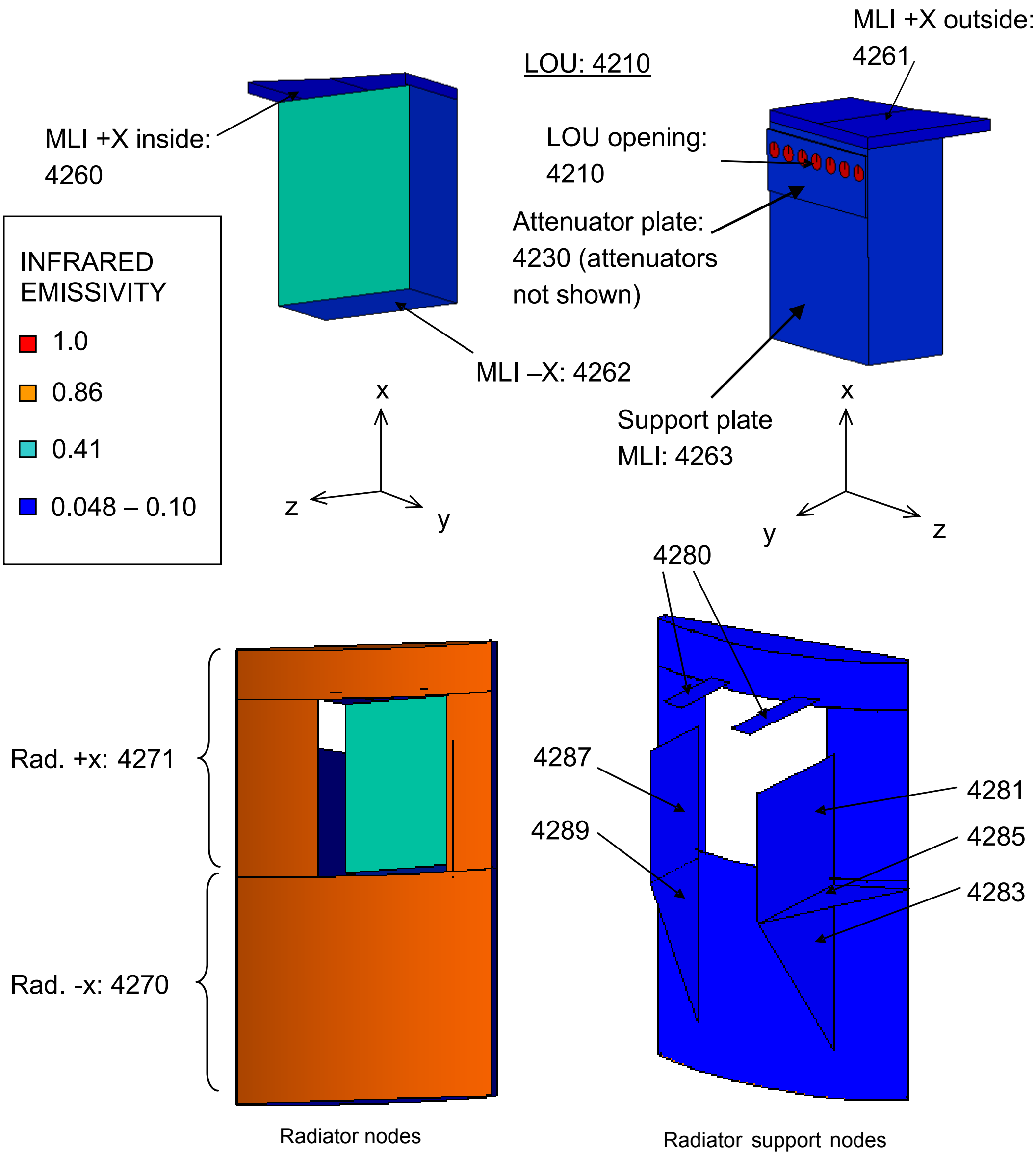


Figure 4.8-2: LOU & LOU Radiator GMM

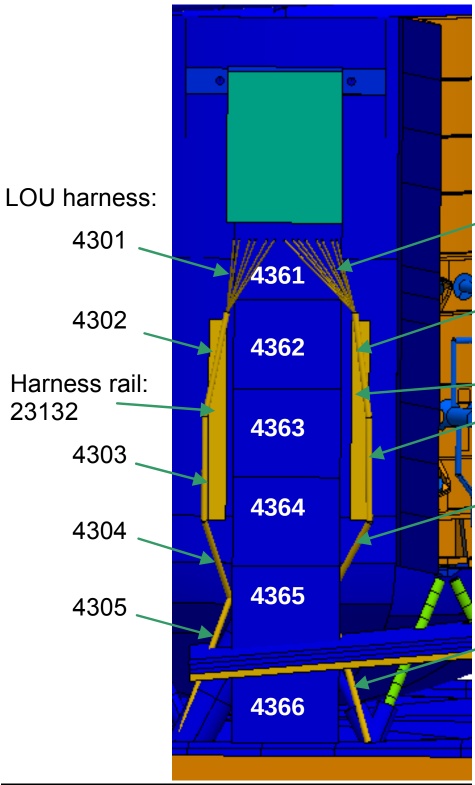
LOU:

The LOU is modelled as one common box, which is well-connected via the baseplate to the LOU support plate, and with a heat dissipation of 4.71 W [AD 01] [AD 04] [RD 60].

The LOU support plate is conductively isolated against the CVV via 8 GFRP struts, and is linked to the LOU radiator via the radiator supports. The LOU baseplate only has a poor direct link to the LOU radiator via the +x support straps.

In addition to the LOU radiator, the –Y side of the LOU serves as radiating area. i.e. that about half of the surface in sum is black (in the GMM this is modelled as a mean emissivity over the whole surface). The other sides of the box are bare aluminium or covered with MLI.

The LOU waveguides are subdivided in 6 nodes, similar to the LOU harness, see Figure 4.8-3.



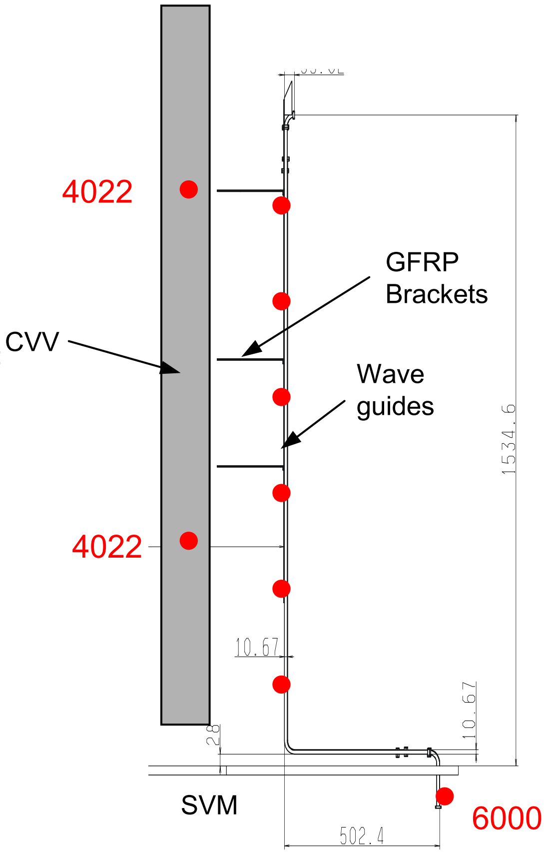


Figure 4.8-3: Nodal Breakdown of LOU Waveguides and Harness

LOU Window Baffle (LWB) and LO Attenuator Assembly (LOAACH):

The LWB/LOAACH represents the reduced version of the corresponding detailed thermal model which is described in [RD 52]. In short, the task of this assembly is the decontamination heating of the structural parts within the optical path between LOU and LOU windows on CVV side. For that reason both the LWB and the LOAACH are equipped with dedicated heaters (Dale resistors).

The LWB is mechanically mounted to the CVV structure and consists of the CVV I/F Cover (#4250), the Steel Baffle (#4242), the Flight Spare Windows (#4245) and the Window Bracket (#4240) on which the heaters are mounted. Thermal isolation towards the CVV is provided by the low conductance Steel Baffle.

The LOAACH is mechanically mounted to the LOU support plate and consists of 6 Attenuators with Attenuator holders (#4235) and the Attenuator Plate (#4230) on which the heaters are mounted.

More detailed information can be found in [RD 53].

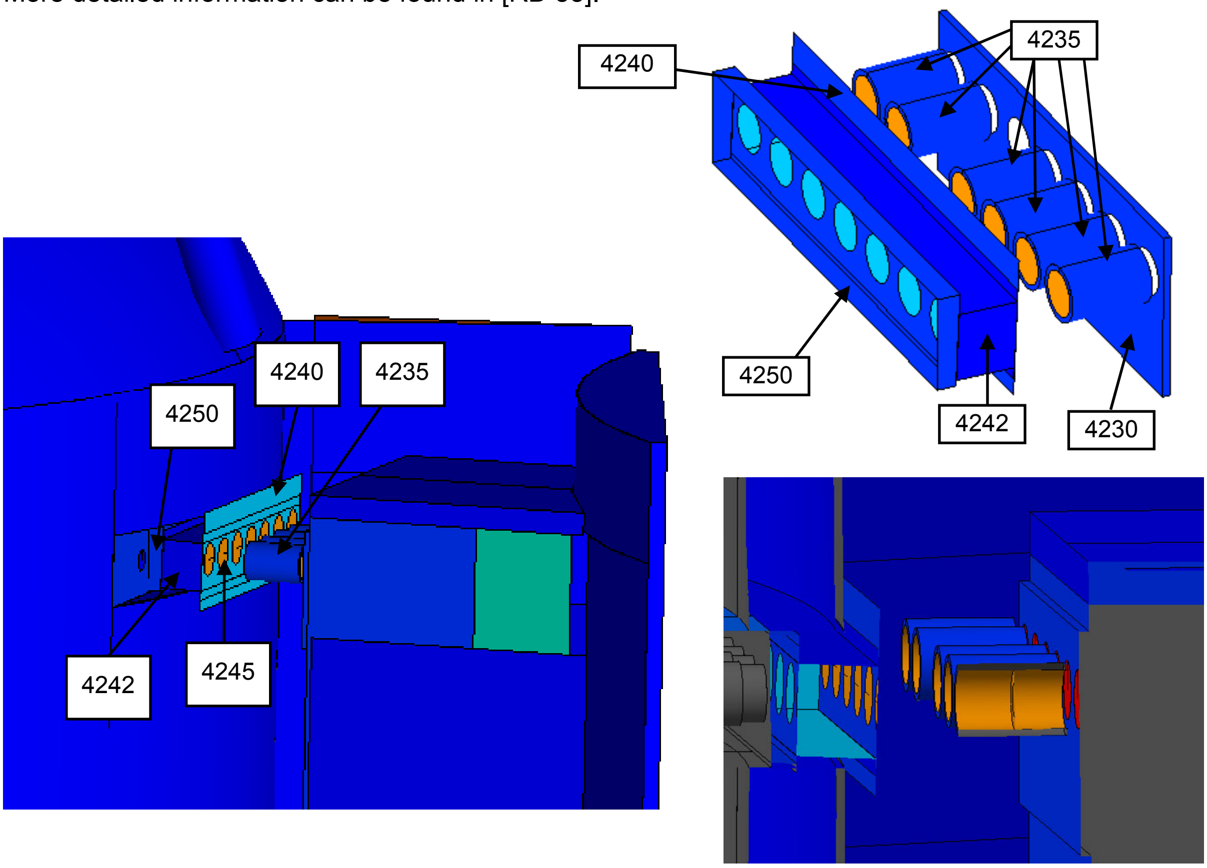


Figure 4.8-4: LWB and LOAACH Nodal Breakdown

Telescope/TMS:

The telescope GMM/TMM has been delivered by ESA [RD 29]. The node distribution and other thermal parameters are given hereafter, a cross-sectional view is given in Figure 4.7-5. A more detailed thermal design description (including also the SLI sceen concept) can be found in [RD 54].

The Telescope Mounting Structure is wrapped in MLI, except the struts on –z side that are left open towards space for radiating, see Figure 4.8-1. The nodal breakdown of the TMS is shown in Figure 4.8-6.

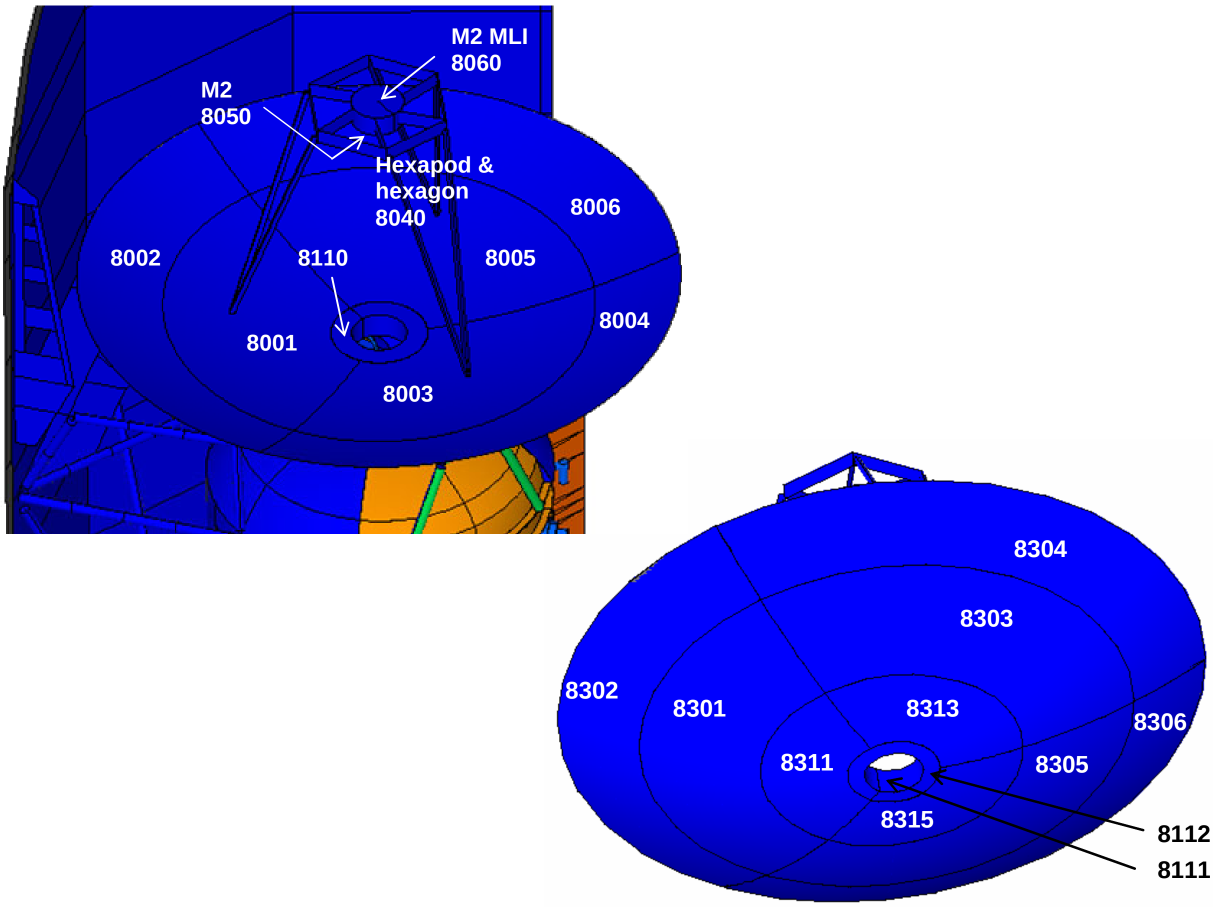


Figure 4.8-5: Telescope GMM

```
                   |                      |
           18411 x                      x 18416
                   |        18401         |
           18421 x--------x--------x 18426
                  /                         \
                 /          Z                \
        18402 x                               x 18406
               /            ^                   \
              /             |                    \
      --x--x 18422          |           18425 x--x--
    18412   \               +---> Y           /    18415
             \                               /
              \                             /
         18403 x                         x 18405
                \                       /
                 \                     /
                  \                   /
                   \     8404        /
            18423 x-----x-----x 18424
                   /                 \
             8413 x                   x 8414
                 /                     \
```

Figure 4.8-6: Scematic view of TMS

Item	Node	Material / Components	Mass [kg]	Size	Solar Abs.	Emissivity	Unit Level Requirement	Remark
LOU Support Structure	4201-4207, 4211-4217	Al 6061 8 GFRP E-glass struts to CVV 51xM5 to LOU baseplate (20+8)xM5 to LOU Radiator support	4	(507x439x10) mm Total A/L = 5.56 mm			R-SS-0330 [RD 25]	
LOU incl. baseplate radiative area (-Y)	4210	thermally equivalent to Al 6xM5 to Radiator support (+x straps) LOU openings	40	(466x352x170) mm ~0.08 m²	0.13 1.0 0.95	0.1 1.0 0.82		4.71 W dissipation
LOU MLI +/-X, +Y	4260-4263	41 layers (4 blankets: 3x9+1x14) IR specularity 0.75 to 0.80			0.13	0.05 – 0.1		
LOU Radiator	4270-4271	Front side: black painted Al	3.2	0.933 m²	0.95 0.95	0.86 front 0.048 rear		
LOU Rad. Support	4280-4289	Al, IR specularity 0.75	3.5		0.13	0.05		
LOU Waveguides	4361-4366	13x WR28 + 1xWR34 SST WG's to SVM	1.92		0.48	0.06		RD 34
		GFRP WG support brackets to CVV		Total A/l = 3.6 mm				
LOU harness	4301-4316	76 mm^2 Cu GFRP harness supports to CVV		 Total A/l = 1.07 mm	0.7	0.7		
LWB	4240-4250	CVV I/F Cover, Alodine Steel Baffle Flight Spare Windows Window Bracket with Dale resistors (3x48 W installed)	0.13 0.17 0.36 0.43	 (352 x 54 x 47) mm, t = 0.5 mm 7 x ∅36 mm (352 x 110) mm	1.0 1.0 0.05	0.1 0.05 ext., 0.3 int. 0.8 0.3 –y side 0.1 +y side		 IR transm. 0.2
LOAACH	4230-4235	Attenuator plate Al, Alodine, with Dale resistors (3x48 W installed) 6 Attenuator holders, Alodine ext., black Stycast with SiC grains int. 6 Attenuators Al2O3	 ~ 1	(351 x 131 x 6/avg.) mm D = 43 mm, d = 35 mm, l = 64 mm t= 0.254 mm, D = 40 mm	1.0	0.1 0.1 ext. 0.8 int. 0.08		

Item	Node	Material / Components	Mass [kg]	Size	Solar Abs.	Emissivity	Unit Level Requirement	Remark
TMS incl. MLI	8401-8416, 18401-18426	6 CFRP T300 struts to CVV 6 GFRP struts to Cryostat Baffle 14 layers MLI; IR specularity 0.80		Total A/L = 10.7 mm Total A/L = 2.0 mm	0.70 0.70 0.13	0.5 0.5 0.05	R-TMS-0330 [RD 27]	
Telescope **	8001-8006	M1 (SiC); IR specularity 0.92 / 0.90 * Cond. to TMS: 0.049 W/K Cu harness to TMS from M1 & M2	279	Outer ∅ 3.5 m see Table 4.9-5	0.11	0.01 / 0.02 *		* Nom. in orbit/ decontamin.
	8608-8620	Cu harness from TMS to SVM connec.		see Table 4.9-5				routed across CVV radiator
	8110-8112	Telescope Baffle	6	Inner ∅ 0.320 m	0.13	0.025		
	8050	M2 Mirror (SiC); IR specul. 0.92 / 0.90 *	17	D = 0.31 m	0.11	0.01 / 0.02 *		
	8040	Hexapod & hexagon (SiC)			0.13	0.025		
Telesc. M1 MLI **	8101-8106 8201-8315	”Two/three screen” concept IR specularity 0.80		D = 3.5 m, d = 0.320 m	0.13	0.025		
Telesc. M2 MLI **	8060	IR specularity 0.80		D = 0.31 m	0.13	0.025		

** Telescope submodel provided by ESA [RD 29]

Table 4.8-1: Item List for LOU and Telescope

4.9 Harness

The harness implementation principle in the H-EPLM TMM is shown in Figure 4.9-1. Depending on the harness dissipation, the different harness branches are modelled either by dedicated nodes or via a thermal conductance coupling using thermal conductivity integral functions. For the latter ones, the harness dissipation is distributed to the corresponding interface at the cold end. An overview for the CVV internal harness modelling is given in Table 4.9-1.

Instrument	Branches with dedicated nodes	Branches with (integral) thermal conductance	Remark
PACS FPU	3	12	
SPIRE FPU	1	3	
HIFI FPU	5 + 4 x coax	0	
SPIRE JFET Phot.	1	6	
SPIRE JFET Spec.	0	2	

Table 4.9-1: Modelling of the CVV Internal Harness Branches in the EPLM TMM

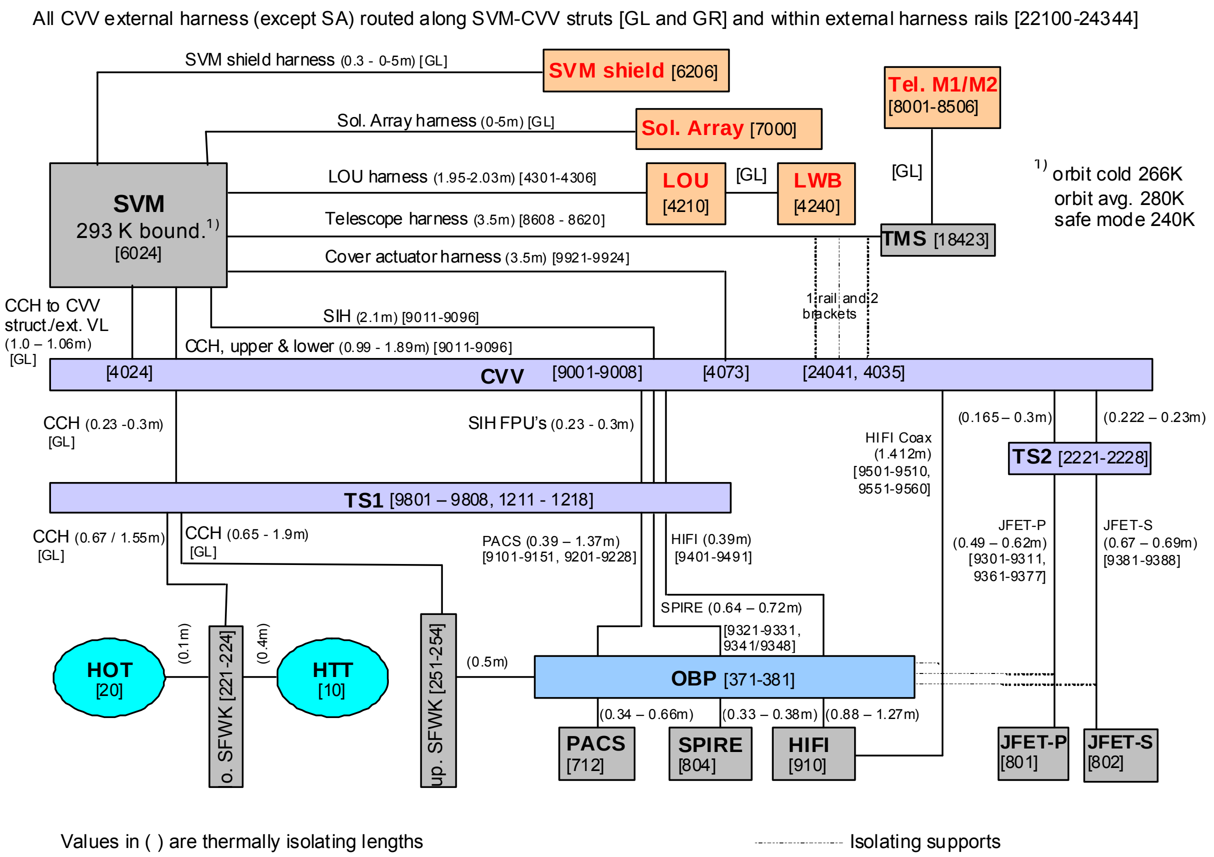


Figure 4.9-1: Harness Chart used in TMM

The LOU harness is routed in two bundles along the LOU waveguides on separate GFRP supports and is also modelled in the GMM, see Figure 4.8-3.

Harness bundles that are implemented by means of conductive couplings between the corresponding I/F nodes are indicated by “[GL]” in Figure 4.9-1, their dissipation is distributed to 100% to the corresponding cold end.

The cross-section and dissipation values of the scientific harness (SIH) and the cryostat control harness (CCH) have been evaluated based on the data listed in RD 02. The SIH data are summarized in Table 4.9-2 and Table 4.9-3; the CCH data are listed in Table 4.9-4 and Table 4.9-5.

The HIFI coax harness modelling has been refined with separate inner (silver coated CuBe) and outer (SST) conductors CVV internally. Due to different temperature shrinking the two conductors are considered to be conductively decoupled from each other, with a remaining radiative coupling. Detailed investigations have been performed in [RD 57].

The thermally isolating harness lengths are defined between the following I/F points, see Figure 4.9-1:

- at SVM: all harness assumed to have SVM temperature at SVM / CVV strut I/F
- at CVV: all harness assumed to have CVV temperature at the CVV / tank suspension strap I/F. Thermal connection via connector brackets, additional thermal connections at CVV internal wall (if necessary)
- at TS1: thermal connection of SIH (except SPIRE JFET and HIFI coax harness) and CCH by means of "Stycast brackets", similar as done on ISO
- at TS2: thermal connection of SPIRE JFET harness by means of separate copper wires
- at OBA: thermal connection of PACS FPU, SPIRE FPU and HIFI FPU harness by means of "Stycast brackets”.
- Furthermore, several other mechanical fixation points are necessary, like on the OBA (JFET and coax harness brackets), and generally on the tank suspension straps with lacing cords. Thermally, these interfaces are isolated by means of vespel washers or teflon/Goretex tape. Nevertheless, they are also considered in the TMM (see also Figure 4.3-1, nodes 291 – 298).

Thermal isolation length in general means the "free" length between the ends of harness thermal connection sections,e. g. between the CVV and the TS 1; the harness routing length between CVV connector brackets and the tank suspension straps is not taken as thermal isolating length, which is a conservative assumption.

The thermal contact conductance across a "Stycast bracket" is estimated to 0.05 W/K per branch.

The telescope harness (heater + sensor) is routed along the –Z side across the CVV radiator. The harness thus can dump its dissipation partly via radiation during telescope decontamination. The viewfactors of the harness to deep space and to the CVV have been estimated with 0.5, respectively.

Internal Harness (SIH)	Node	from	to	Length (1)	Average Dissip. at 77K	Spec Mode Dissip. at 77K	Phot Mode Dissip. at 77K	Stainl. St.	Brass	Silver	PTFE
				m	mW/m	mW/m	mW/m	mm^2	mm^2	mm^2	mm^2
PACS FPU	9101-9151, 9201-9228	CVV TS1 OBP	TS1 OB FPU	0.228-0.3 0.391-1.366 0.340-0.655	4.32	19.9	6.03	37.594	5.1	-	367
SPIRE FPU	9321-9331, 9341-9348	CVV TS1 OBP	TS1 OB FPU	0.3 0.636-0.723 0.327-0.378	1.186	7.116	1.217	11.068	6.216	-	103
SPIRE JFET-P (5)	9301-9311, 9361-9377	CVV TS2 (4)	TS2 (4) JFET-P	0.165-0.300 0.493-0.617	0.034	0	0.202	40.792	0.914	-	318
SPIRE JFET-S (5)	9381-9388	CVV TS2 (4)	TS2 (4) JFET-S	0.222-0.230 0.666-0.689	0.007	0.043	0	13.306	0.594	-	92
HIFI FPU	9401-9491	CVV TS1 OBP	TS1 OB FPU	0.236-0.3 0.383-0.394 0.385-1.272	4.55	HIFI on: 13.66		10.805	6.014		123
Coax (4x); ELSPEC type JS 50141	9501-9510, 9551-9560	CVV OBP	OBP FPU	0.788-1.227 (2) 0.185-0.414 (2)	-			4 x 3.08	CuBe: 4 x 0.653	4 x 0.034 (3)	4 x 6.34

(1) thermally isolating length

(2) Coax bundle mounted on CVV/OBP via 3 isolating vespel standoffs, resp.; A/l = 3 x 3.0 mm to CVV, A/l = 3 x 6.4 mm to OBP

(3) equal to 11.7 microns silver coating thickness, measured by ASED; for detailed information see [RD 57]

(4) JFET harness thermally linked to TS2 via copper wires; isolated mounting on OBP (vespel washers under stycast brackets)

(5) JFET harness partly modelled in GMM, see Figure 4.3-3

Table 4.9-2: CVV Internal SIH Data for PACS, SPIRE and HIFI

External Harness (SIH)	Node	from	to	Length (1)	Average Dissip. (2)	Spec Mode Dissip. (2)	Phot Mode Dissip. (2)	Stainl. St.	Brass	Cu	Silver	Manganin	PTFE
				m	mW/m	mW/m	mW/m	mm^2	mm^2	mm^2	mm^2	mm^2	mm^2
PACS FPU	9011-9096	SVM	CVV	1.5 - 2.0	2.9	8.21	9.17	37.536	5.132	-	-	17.517	367
SPIRE FPU		SVM	CVV	1.44-2.0	1.96	11.8	2.43	9.646	6.019	-	-	12.1	107
SPIRE JFET-P		SVM	CVV	1.44-2.0	0.0567	0	0.34	28.864	2.942	-	-	26.21	270
SPIRE JFET-S		SVM	CVV	1.44-2.0	0.0475	0.285	0	8.416	1.028	-	-	6.048	83
HIFI FPU		SVM	CVV	1.67-2.0	7	HIFI on: 21		30.73	6.014	-	21.02	8.64	121
Coax (4x) ELSPEC type JS 50141		SVM	CVV	2	-			4 x 3.08	-	CuBe: 4 x 0.653	4 x 0.034 (3)	-	4 x 6.34
HIFI LOU [RD 33] (4)	4301-4316	SVM	LOU	1.95-2.03	49.4	LOU on: 148.2		7.72	0.914	76.4	-	24.31	106

(1) thermally isolating length

(2) with the exception of LOU harness all dissipation values are valid for 293 K, dissipation at lower temperature expected to be lower

(3) equal to 11.7 microns silver coating thickness, measured by ASED; for detailed information see [RD 57]

(4) attached to CVV via GFRP support tubes, see also Figure 4.8-3

Table 4.9-3: CVV External SIH Data

Internal Harness (CCH)	from	to	Length (1)	Dissip.	Stainl. St.	Brass	PTFE
			m	mW	mm^2	mm^2	mm^2
CCH to HOT & HTT	CVV low. CB TS1	TS1 low. SFW	0.24-0.3 0.67-1.55	296 (2) 437 (2)	2.23 2.23	3.05 3.05	34.2 34.2
	low. SFW	HOT	0.1	547 (2)	0.55	0.91	9.1
	low. SFW	HTT	0.4	0	1.48	2.12	23.4
CCH to OBP	CVV upp. CB TS1 upp. SFW	TS1 upp. SFW OBP	0.23-0.3 0.65-1.9 0.5	0	1.98 1.62 1.62	-	18 14.7 14.7

(1) thermally isolating length

(2) only at the end of Launch Autonomy; dissipation of HOT depletion heater harness, providing depletion heater with 10 W (comp. to Figure 6.2-2)

Table 4.9-4: CVV Internal CCH Data

External Harness (CCH and Telescope)	Node	from	to	Length (1)	Dissip.	Stainl. St.	Brass	Cu	Manganin	PTFE
				m	mW	mm^2	mm^2	mm^2	mm^2	mm^2
CCH to CVV lower CB	9011- 9096	SVM	CVV low. CB	0.99-1.68	0	2.384	3.0	-	5.3	35.6
CCH to CVV upper CB		SVM	CVV upp. CB	1.46-1.89	0	2.352	-	-	1.992	21.3
CCH to CVV structure/VL		SVM	CVV	1.0-1.06	0	1.12	1.224	2.4	7.02	16.2
CCH to Cover	9921- 9924	SVM	Cryostat baffle conn. bracket	3.5		0.128	2.856	-	1.968	8.76
Telescope sensor & heater via CVV (3)	8608- 8620	SVM TMS	TMS conn. bracket Tel. M1/M2	3.5 2 – 6.5	9000 (2)	0.384	-	8.0 24.4	3.24	11.17
CCH to SVM Thermal Shield		SVM	SVM Shield	0.3 - 0.5	0	0.128	-	0.6	0.648	1.18
CCH to Solar Array		SVM	Solar Array	0.5			-	34.5	-	-
LOU Window Baffle		LOU	LWB	0.3		0.528	0.72	-	10.56	-

(1) thermally isolating length

(2) only during telescope decontamination

(3) fixed along CVV via 2 glass/epoxy brackets (clickbond), total A/l = 9.6 mm and a harness rail

Table 4.9-5: CVV External CCH Data

4.10 Herschel Solar Array and Sunshade with Struts

The Herschel Solar Array and Sunshade (HSS) is split in two parts, the upper part is the Sunshade (SSD), providing the shade mainly for the telescope and the lower part is the Solar Array (SA), which provides shading for the CVV and the electrical power. The SA +Z side therefore is covered with solar cells and the SSD +Z side is covered with OSRs. The rear side (-Z side) of the HSS is covered with high efficient MLI. The HSS nodal breakdown including struts is shown in Figure 4.10-1 and Figure 4.10-2 and the corresponding thermally relevant data are listed in Table 4.10-1.

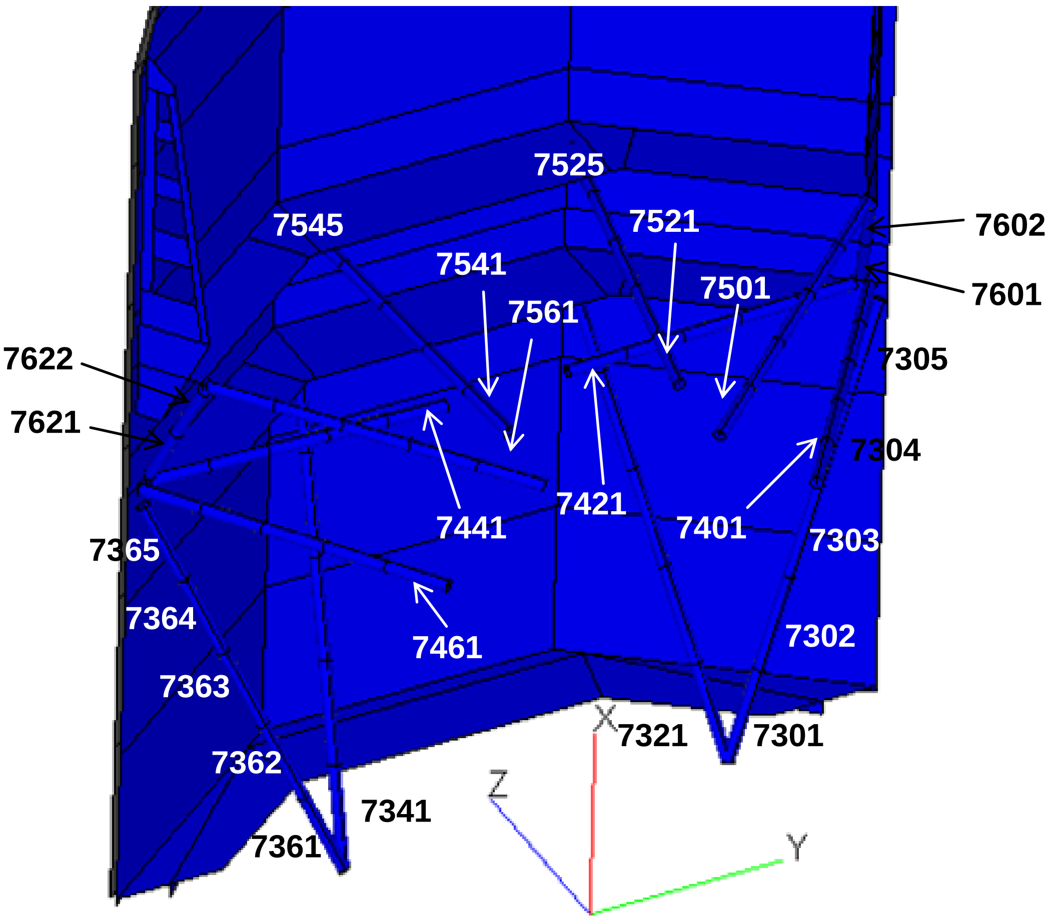


Figure 4.10-1: HSS Struts Nodal Breakdown

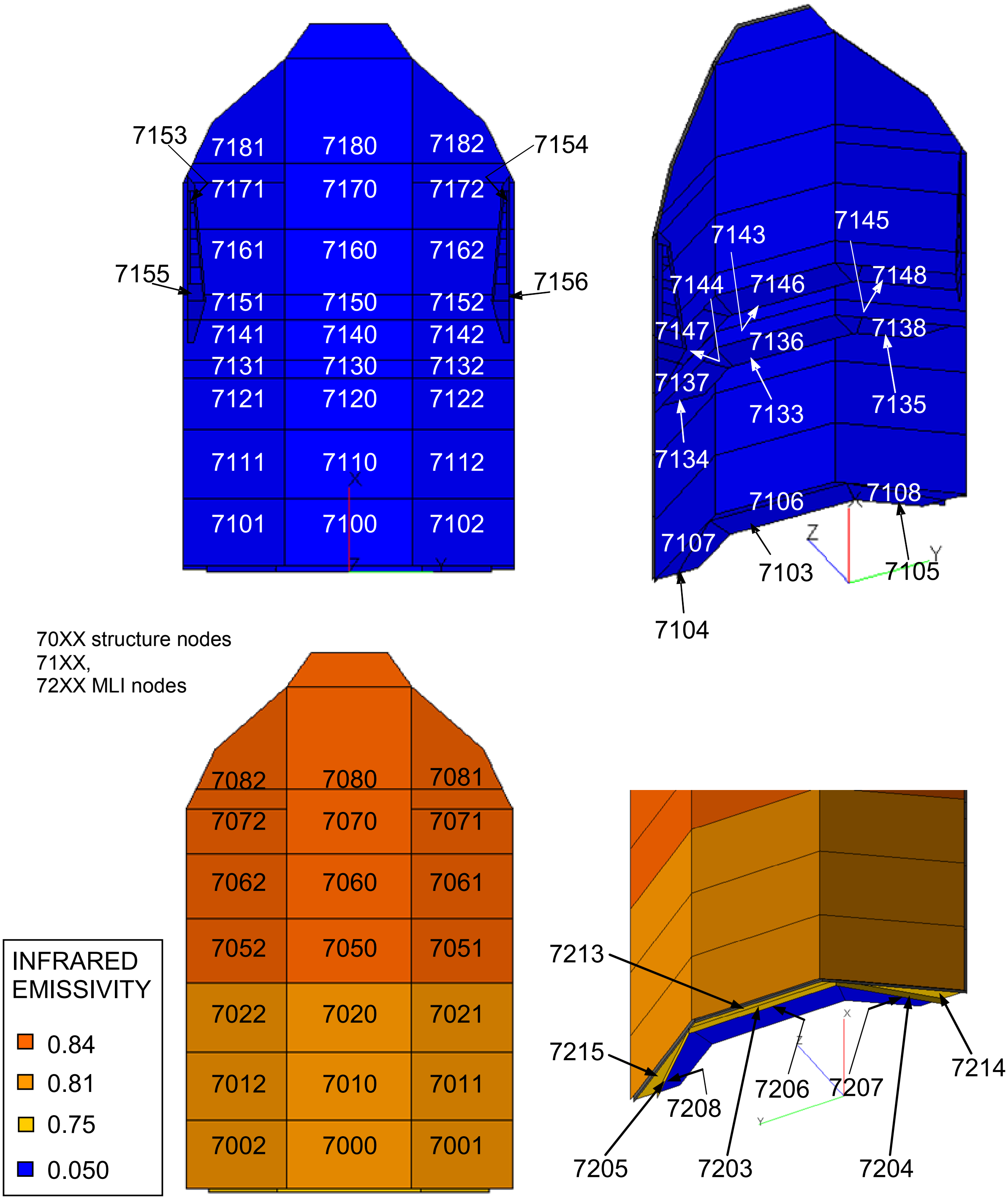


Figure 4.10-2: HSS Nodal Breakdown

Item	Node	Material / Components	Mass	Size	Unit Level Requirement	Solar Absorpt.	IR Emiss.	Remark
Solar Array Panels	7000-7022	Solar Cells with cover glass and harness CFRP skins (M55J) * Adhesive for HC Al Honeycomb (16 kg/m³)	1.6 kg/m² 0.83 kg/m² 0.3 kg/m² 0.8 kg/m²	 2 x 0.3 mm thick 50 mm thick		0.915 [RD 18] -1200 W during Operation	0.81 [RD 18]	
Solar Array-CVV struts Solar Array-SVM struts	7401-7465 7301-7365	GFRP struts incl. MLI to CVV M55J CFRP struts incl. MLI with Ti end fittings (Ti6AlV4) to SVM Ti tubes to SVM Power harness to SVM		A/L = 2.5 mm GFRP in total A/L = 1.4 mm M55J with A/L =12.9 mm Ti in serial 0.04 W/K 34.5 mm² Copper, 0.5 m length	R-SS-0330 [RD 25]	0.13 0.13	0.15 0.15	[RD 37], [RD 38] [RD 37]
Solar Array Panels MLI	7100-7132	27 layers (1+7+18+1); IR specularity 0.80	0.65 kg/m^2		R-EXM-430 [RD 28]	0.13	0.05	
Solar Array horizontal stiffener MLI upper	7133-7138							
Solar Array horizontal stiffener MLI lower	7103-7108							
Solar Array-SVM Closure MLI	7203-7208	27 layers (1+7+18+1); IR spec. 0.8 -x side: ITO FEP; IR spec. 0	0.65 kg/m^2		R-EXM-430 [RD 28]	0.13 0.14	0.05 0.75	+x side -x side
Sunshade Panels Sunshade-CVV struts	7050-7082 7501-7565	OSR inclusive Adhesive CFRP skins (M55J) Al Honeycomb (16 kg/m³) GFRP struts incl. MLI to CVV Ti brackets/vespel washers to SA	1.0 kg/m^2 0.83 kg/m² 0.8 kg/m²	 2 x 0.2 mm thick 50 mm thick A/L = 2.4 mm GFRP in total	 R-SS-0330 [RD 25]	0.20 0.10 0.13	0.84 0.84 0.15	EOL BOL
Sunsh. +Y vert. stiffener	7054					-	-	
Sunsh. -Y vert. stiffener	7053					-	-	
Sunshade Panels MLI	7140-7142, 7150-7182	25 layers (1+7+6+10+1) IR specularity 0.80	0.65 kg/m^2		R-EXM-330 [RD 28]	0.13	0.05	
Sunsh. +Y vert. stiff. MLI	7154, 7156							
Sunsh. -Y vert. stiff. MLI	7153, 7155							
Sunshade hor. Stiff. MLI	7143-7148							

Table 4.10-1: HSS related Items

4.11 SVM with Struts and SVM Thermal Shield

To calculate the radiative couplings of the HERSCHEL SVM/CVV GFRP struts to their environment all 24 struts have been modelled in the ESARAD geometry model, including the MLI around the struts.

Generally, struts covered in MLI are subdivided in 3 nodes, struts without MLI around are subdivided in 10 nodes (more refined due to "T^4-law") in longitudinal direction. The strut MLI is subdivided additionally around the perimeter. An overview is given in Figure 4.11-1. Detailed figures showing the node distribution both for the SVM/CVV struts and their MLI are given in [RD 45], p. 58 - 62. The thermal design for each strut is summarised in Table 4.11-1.

The relevant conductive length for the thermal analysis is the total GFRP strut length minus the length of the sections where GFRP tube and the titanium end fitting overlap. The thermally relevant dimensions of the struts are summarized in Table 4.11-2.

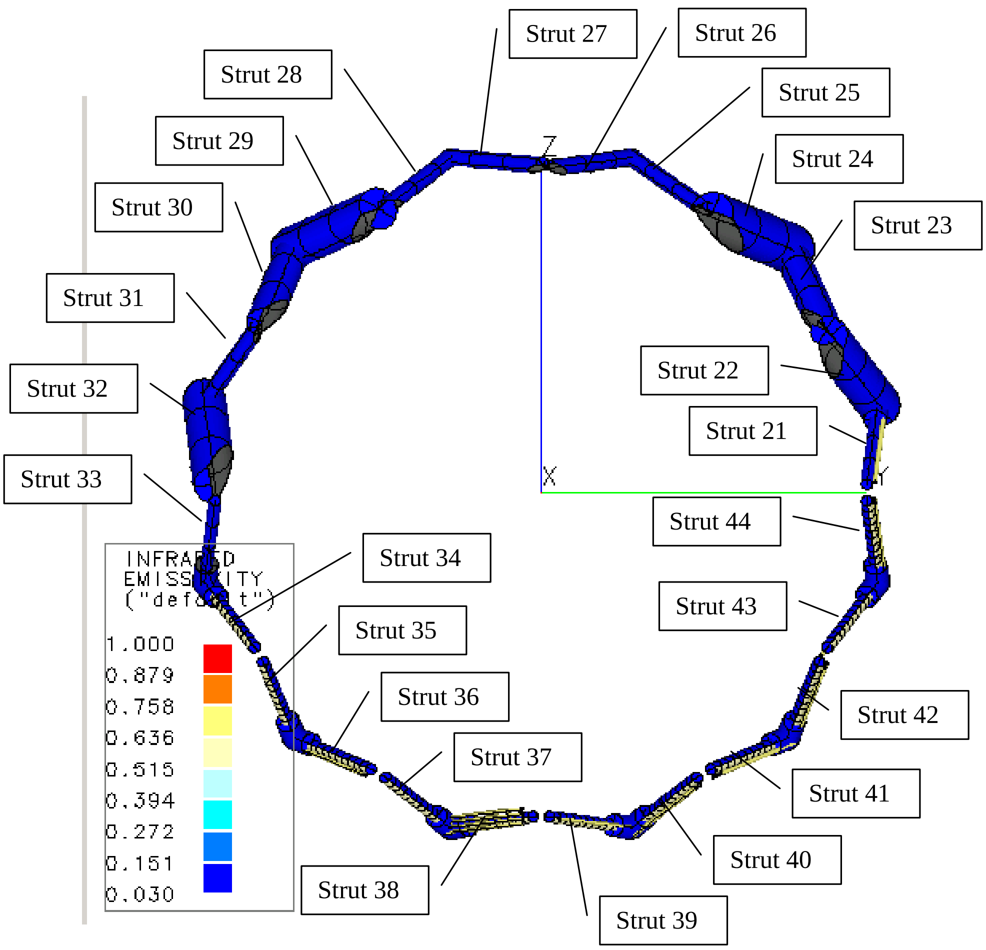


Figure 4.11-1: SVM/CVV Interface Struts (numbering as per CASA I/F drawings)

Strut No. as defined in CASA I/F drawings [RD 51]	Strut No. as used in TMM and GMM	Thermal Design
22 23 24 25 26 27 28 29 30 31 32	19 20 21 22 23 24 1 2 3 4 5	Completely wrapped in MLI; 9-layer VDA Kapton MLI, Type “STRUT_7e” as defined in [RD 50], p. 5
21 33	18 6	Struts completely taped with VDA/Kapton around the perimeter; Struts covered with MLI only at the SVM I/F (typically up to a height of 10 cm above the SVM I/F); MLI Type “STRUT_7e” as defined in [RD 50], iss. 3.0, p. 5
34 35 36 37 38 39 40 41 42 43 44	7 8 9 10 11 12 13 14 15 16 17	Half perimeter facing the S/C centre taped with VDA/Kapton; Half perimeter facing deep space left uncoated (glass-fibre/epoxy); Struts covered with MLI only at the SVM I/F (typically up to a height of 10 cm above the SVM I/F); MLI Type “STRUT_7e” as defined in [RD 50], iss. 3.0, p. 5

Table 4.11-1: SVM/CVV Interface Struts – Numbering and Thermal Design

The SVM Thermal Shield is subdivided into 5 nodes and the SLI screen on top of the SVM Shield is subdivided accordingly, see Figure 4.11-2. The whole SVM Shield has a high IR reflectivity (VDA Kapton), apart from the +/-Y tips of the SVM Shield panel that are coated with ITO VDA Kapton, which is an outcome of a detailed barbecue analyses [RD 17].

The struts supporting the SVM Thermal Shield are implemented by conductive couplings between SVM and SVM Thermal Shield.

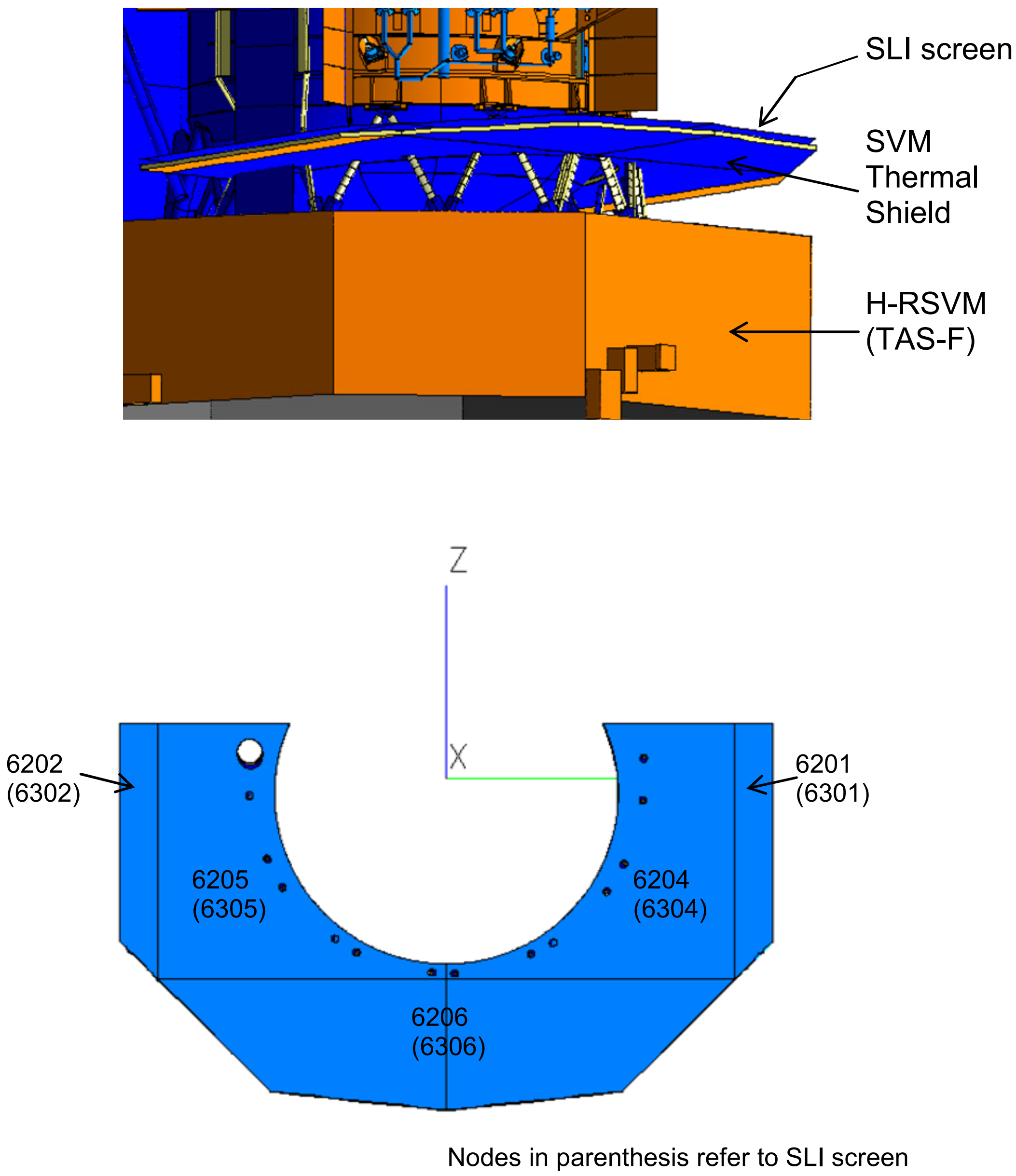


Figure 4.11-2: H-RSVM, SVM Thermal Shield and SVM/CVV Struts

Item	Node	Material / Components	Mass	Size	Unit Level Requirement	Solar Absor.	IR Emiss.	Remark
SVM Module	60XX,61XX 6020-6024 6051-6058, 6101-6108	H-RSVM model, provided by TAS-F Boundary Nodes (conductive) SVM top MLI				 0.15	 0.05	[AD 07], [AD 08]
SVM/CVV struts	6501-6733	GFRP strut tubes Ti fittings for GFRP tubes		A/L = 13.35 mm GFRP in total (24x D=35 x 2.1 mm, l=390 mm)	R-SS-0330 [RD 25]	0.7	0.6	[RD 37], [RD 38]
SVM/CVV struts MLI	65011-67322	9 layers VDA Kapton				0.13	0.03	[RD 50]
SVM Thermal Shield	6201-6206	CFRP T300 face sheets, VDA Kapton Foil on +/-X side (90% specularity) +/-Y tips on -X side ITO coated VDA Kapton Al Honeycomb (32 kg/m³) Panel rim Kapton taped 2 Cu grounding wires to SVM		2 x 0.5 mm thick 19 mm thick 2 x 0.24 mm², l = 0.5 m	R-STS-0180 [RD 26] R-STS-0190 [RD 26]	0.3 0.44 0.41	0.05 0.77 0.72	
		GFRP strut tubes to SVM structure Ti fittings for GFRP tubes		A/L = 3.679 mm GFRP in total	R-STS-0230 [RD 26]		0.05	[RD 37], [RD 38]
SVM Thermal Shield SLI screen	6301-6306	1 layer VDA/Kapton/VDA IR specularity 0.80 both sides		~ 30 mm distance to SVM Thermal Shield	R-EXM-630 [RD 28]	0.13	0.05	

Table 4.11-2: SVM and SVM Shield related Items

5 Material Properties

Note: All material properties tested on Herschel samples and components are compiled in [RD 35]. All other references used for material properties are listed in Section 5.6 of this chapter (i.e. not in Section 2).

5.1 MLI Thermo-Optical Properties and Performance Data

CVV Internal MLI

The heat flux approximations and the thermal performance parameters derived in [RD 36] are compiled in Table 5.1-1 for the "Herschel-type" MLI. This MLI is used for the Thermal Shields MLI. The corresponding values for the "ISO-type" MLI are taken from /1/ and are summarized in Table 5.1-2. The ISO MLI data are used for the HTT and HOT MLI.

The heat fluxes are calculated for different boundary temperatures T_H and T_C. Herewith T_H corresponds to the temperature of the outermost MLI blanket layer while T_C corresponds to the thermal shield temperature the MLI blanket is attached to.

	$q = (a\,(T_H + T_C)/2 + b)\,(T_H - T_C) + \varepsilon\,\sigma\,((T_H^4 - T_C^4)$		
	a	b	ε
10-layer MLI	8.720E-06	2.353E-05	0.00395
20-layer MLI	4.360E-06	1.177E-05	0.001975

Table 5.1-1: Derived MLI Performance Data for Herschel Type MLI

	$q = h\,(T_H - T_C) + \varepsilon\,\sigma\,((T_H^4 - T_C^4)$	
	h (W/m²K)	ε
10-layer "ISO-type" MLI	3.50E-04	0.0030

T_H = "hot" temperature of outermost blanket layer
T_C = "cold" temperature of innermost blanket layer = identical to thermal shield temperature

Table 5.1-2: Derived MLI Performance Data for ISO Type MLI /1/

Degradation factors of integrated MLI have been evaluated in detail for the different MLI sections. The derivation of those factors is also described in [RD 36]. It should be noted that worst-case assumptions have been used for the individual contributions to the total degradation factor, leading to a strictly conservative MLI performance presentation in the TMM. An overview of all CVV internal MLI performance data used in the TMM is compiled in Table 5.1-3.

MLI on	Layers	radiative emissivity (ε_{rad})	linear conductance H [W/m²K]	Integration Factor Orbit	Ground	emissivity of ext. layer (ε_{ext})	specul. of ext. layer (ρ_{ext})
HTT	10	0.003	3.5 E-4	2	2	0.05	0
HOT	10	0.003	3.5 E-4	1	1	0.05	0
TS 1 upper bulk	10	0.00395	H(T) *	1.86	2.57	0.05	0
TS 1 upper cylinder	10	0.00395	H(T) *	2.60	4.05	0.05	0
TS 1 lower cylinder	10	0.00395	H(T) *	1.50	1.99	0.05	0
TS 1 lower bulk	10	0.00395	H(T) *	2.43	2.75	0.05	0
TS 2 upper bulk	20	0.001975	H(T) *	1.66	1.66	0.05	0
TS 2 upper cylinder	20	0.001975	H(T) *	2.05	2.03	0.05	0
TS 2 lower cylinder	20	0.001975	H(T) *	1.42	1.43	0.05	0
TS 2 lower bulk	20	0.001975	H(T) *	1.83	1.80	0.05	0
TS 3 upper bulk	20	0.001975	H(T) *	1.64	1.63	0.05	0
TS 3 upper cylinder	20	0.001975	H(T) *	2.09	2.05	0.05	0
TS 3 lower cylinder	20	0.001975	H(T) *	1.55	1.53	0.05	0
TS 3 lower bulk	20	0.001975	H(T) *	1.60	1.58	0.05	0

*) see Table 5.1-1

Table 5.1-3: Overview on CVV Internal MLI Performance Data

CVV External MLI

The temperature-dependent performance of the external MLI is defined in table arrays within the file matdattab.d. These tables include overall heat transfer coefficients [W/(m²K)] dependent on the temperatures TEXT and TINT of the outermost and innermost blanket layer. These heat transfer coefficients were calculated with the help of dedicated ESATAN models prepared for each type of MLI. In these models each foil of the relevant MLI blanket is represented by a separate thermal node and the heat exchange between two adjacent foils is simulated by both, a temperature-dependent conductance GL(i, i+1) and a constant or temperature-dependent radiation heat exchange factor GR(i, i+1), depending on the type of the blanket.

GL(i, i+1) and GR(i, i+1) are based on mathematical approaches that have been correlated by calorimeter tests conducted at ESTEC for a Dacron-spacered XMM-type blanket (YCV/2248.BA) and a non-spacered embossed-Kapton type blanket (TOS-MCV/2438.BA). The calorimeter tests were conducted at five different temperature pairs T_innermost foil / T_outermost foil. The lowest temperature was 83 K which is very close to the Herschel in-orbit CVV temperature.

Detailed information on the various blanket/layer compositions of the different components, the corresponding thermal performances and the analytical background is given in [RD 43], [RD 46] and [RD 50].

Note that the SVM thermal shield now is equipped with a single Kapton foil (VDA on both sides), which is mounted on the +x side via standoffs in a distance of about 30 mm (see also Figure 4.11-2).

MLI on	Layers	Type	emissivity of external layer (ε_{ext})	IR specul. of external layer (ρ_{ext})	Remark
CVV, Cryostat Baffle	41	CVV_7embossed – CVV5 - CVV5 – CVV5; Kapton VDA, Mylar VDA	0.05	0.80	[RD 50]
LOU	41	CVV_7embossed – CVV5 - CVV5 – CVV5; Kapton VDA, Mylar VDA	0.05	0.80	[RD 50]
Sunshade	25	SSD_7embossed; Kapton VDA, Mylar VDA	0.05	0.80	[RD 50] (degr. Factor 1.8) *
Solar Array	27	SSH_7embossed; Kapton VDA	0.05	0.80	[RD 50] (degr. Factor 1.8) *
SVM Shield +X	1	SL4; VDA/Kapton/VDA	0.05	0.80	SLI screen [RD 50]
SVM Struts	9	STRUT_7embossed; Kapton VDA	0.03	0	[RD 50]
SVM Top	n.a.	n.a.	0.05	0	Provided by TAS-I [AD 07], [AD 08]
Telescope Mounting Structure	14	CVV_7embossed; Kapton VDA	0.05	0.80	[RD 50]
Telescope Orbit Decontamination	2-3	n.a.	 0.025 0.05	 0.80 0.80	2-screen concept; provided by ASEF [RD 29]

* given performance data reflect "realistic" MLI performance (correlates to sensitivity calculation "Updated HSS MLI def.", acc. to section 6.3.2). Nominal analyses are based on the previous conservative approach with an MLI effective emittance of 0.015 resp. 0.012 for the Sunshade resp. Solar Array.

Table 5.1-4: Overview on CVV External MLI Performance Data

5.2 Thermal Conductivity Data

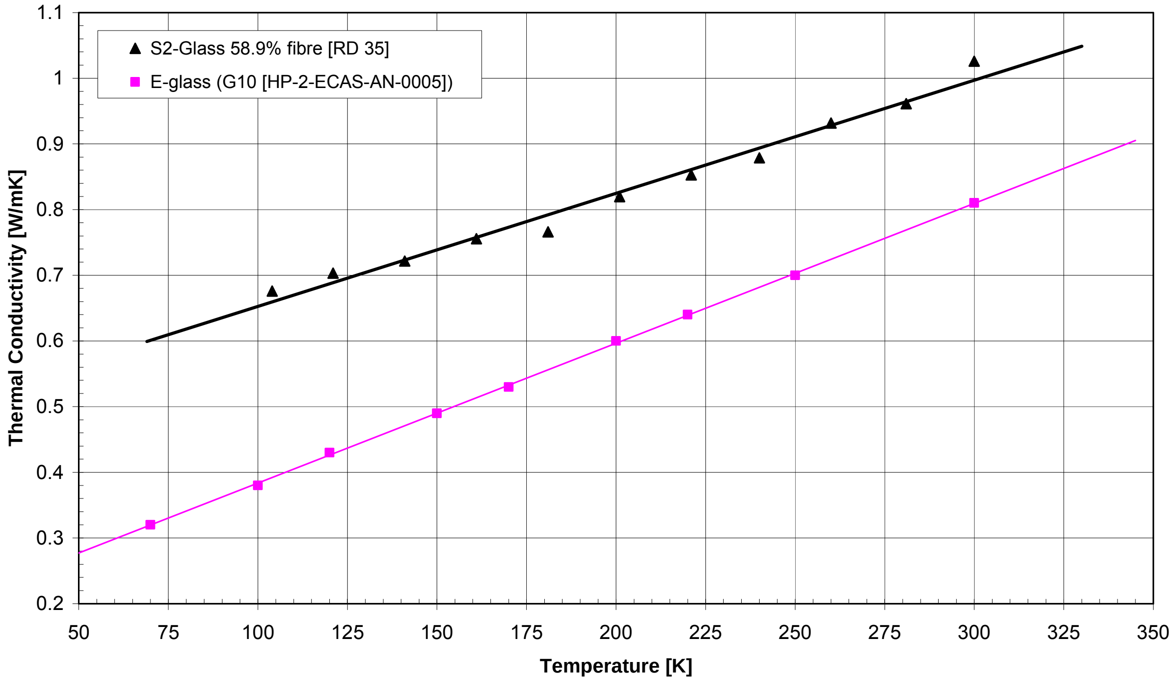


Figure 5.2-1: Thermal Conductivity of S2-Glass and E-Glass GFRP Struts

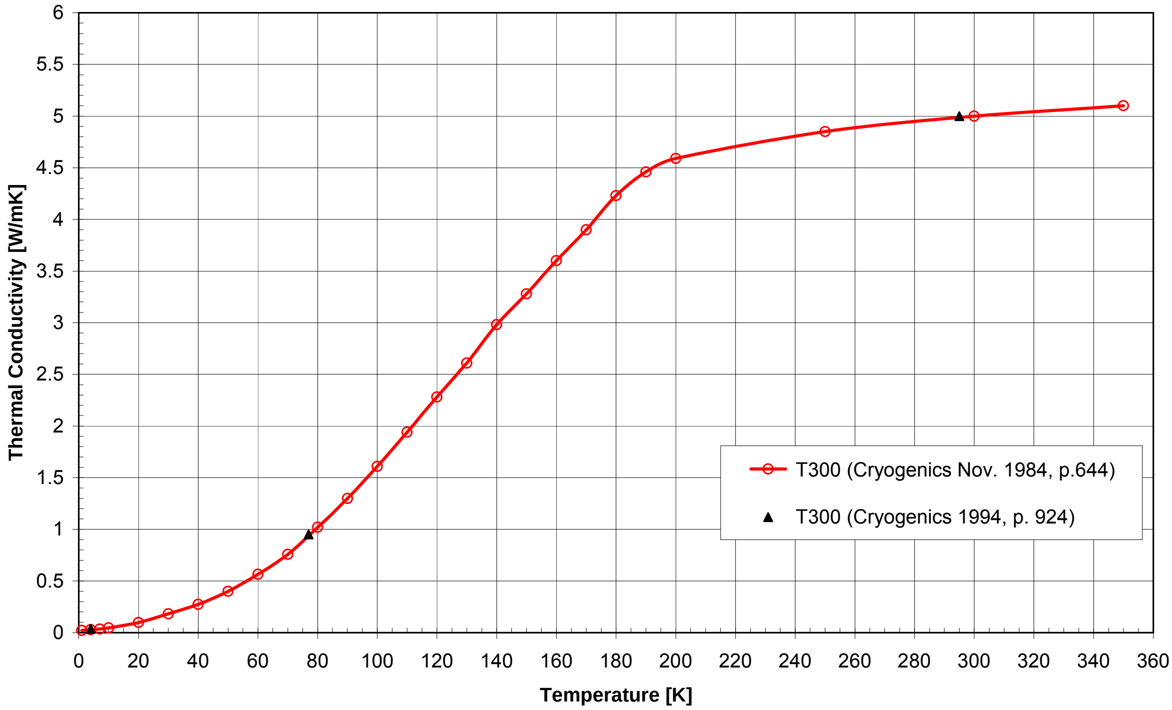


Figure 5.2-2: Thermal Conductivity of CFRP T300 Struts

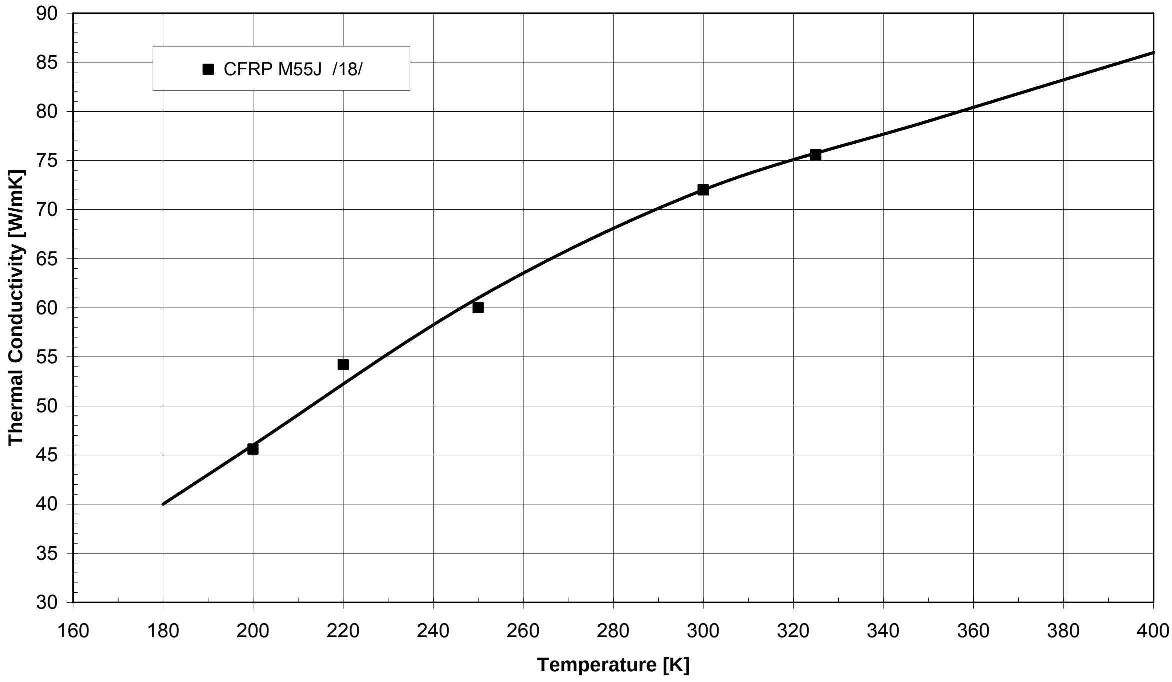


Figure 5.2-3: Thermal Conductivity of CFRP M55J Struts

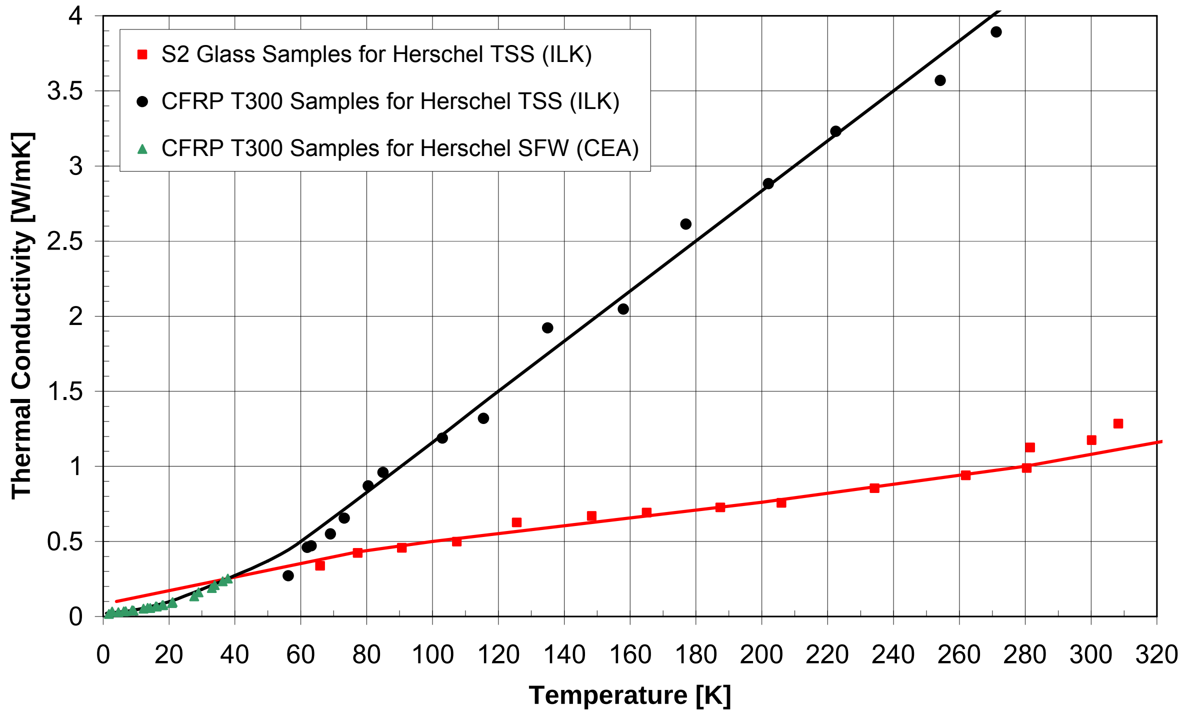


Figure 5.2-4: Thermal Conductivity of CFRP T300 and GFRP (S-glass) Tank Suspensions [RD 35]

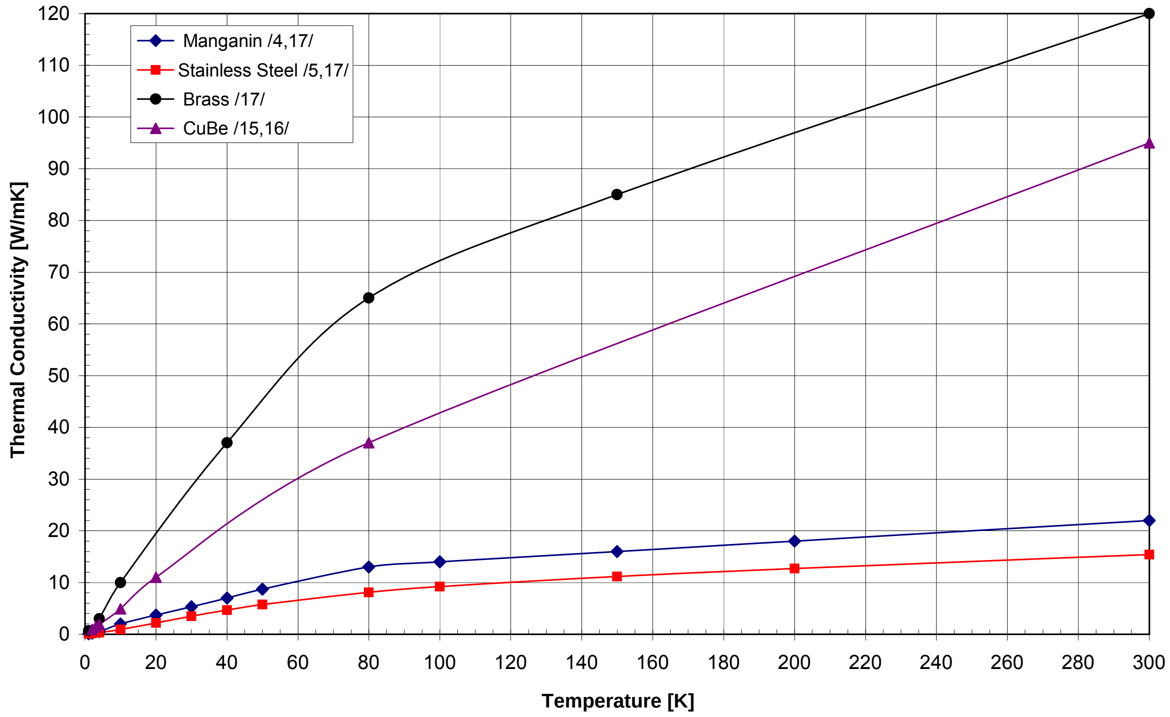


Figure 5.2-5: Thermal Conductivity of Harness Wires

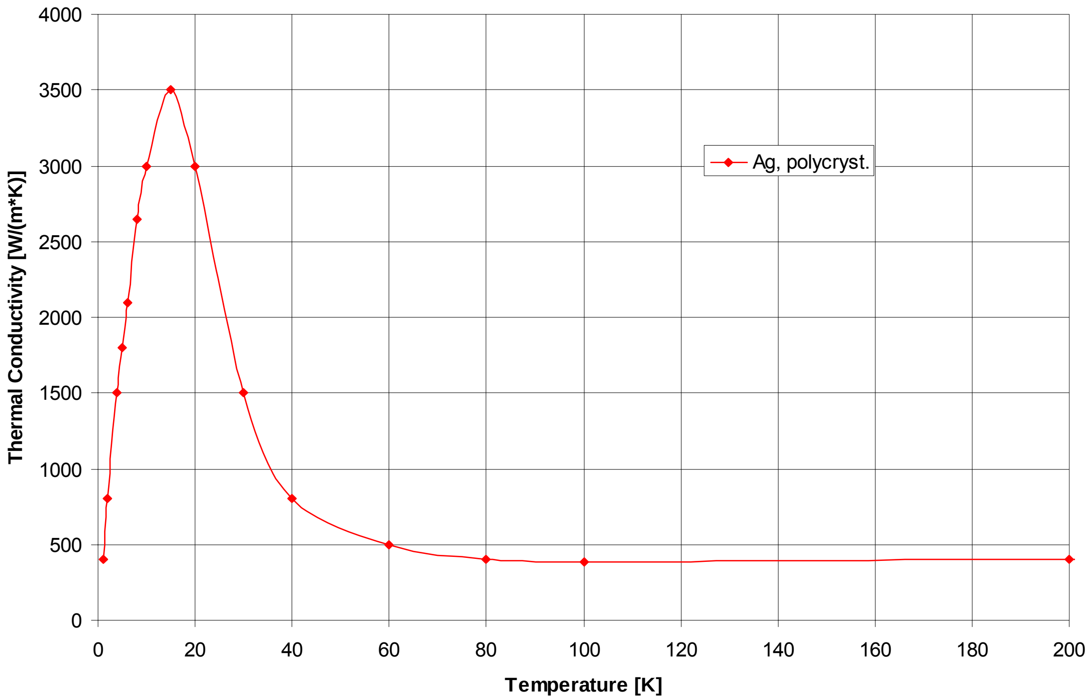


Figure 5.2-6: Thermal Conductivity of Coax Coating

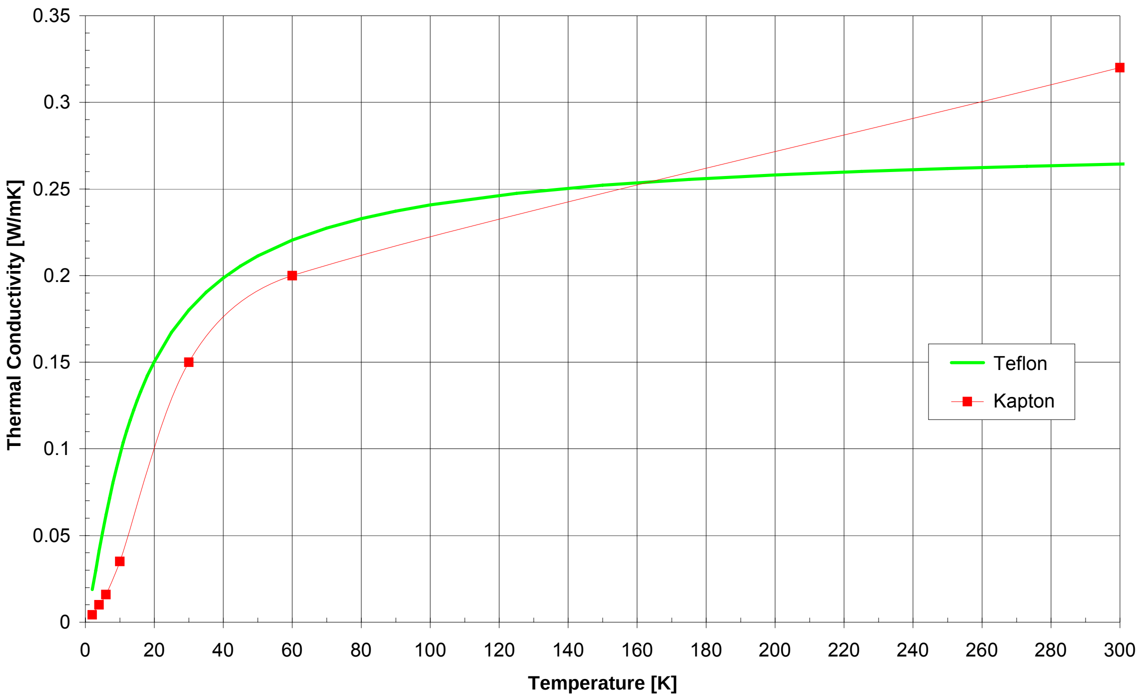


Figure 5.2-7: Thermal Conductivity of Harness Wire Insulation Materials /14/

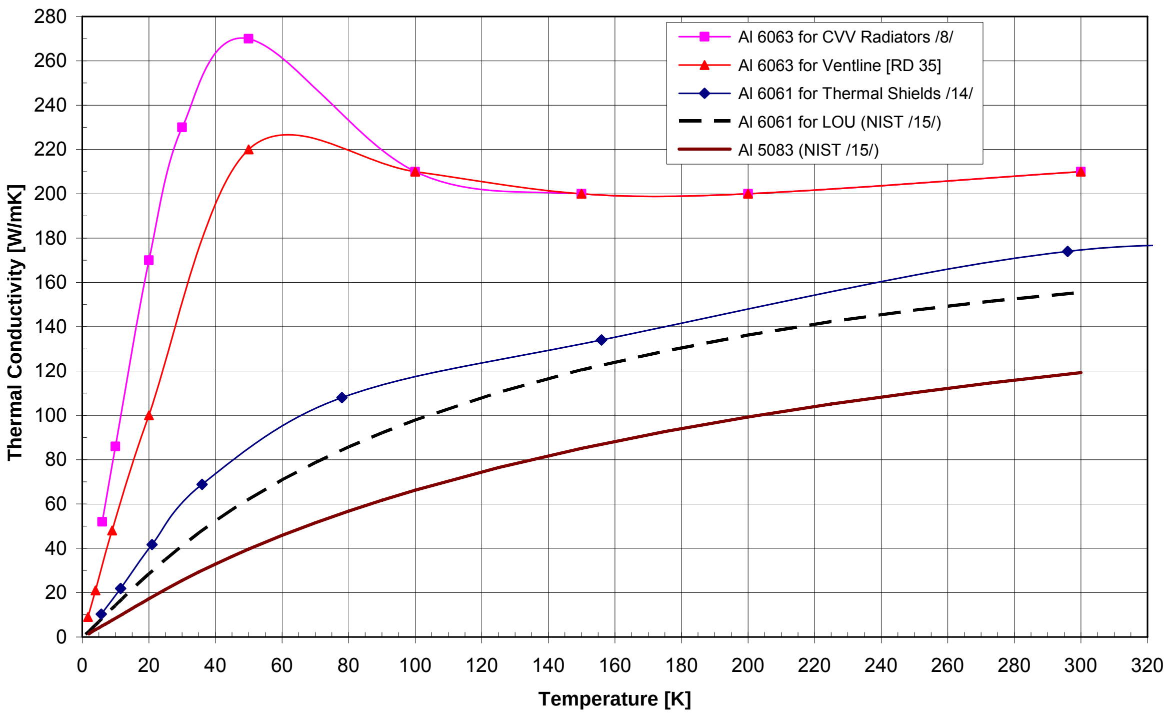


Figure 5.2-8: Thermal Conductivity of Aluminium Alloys

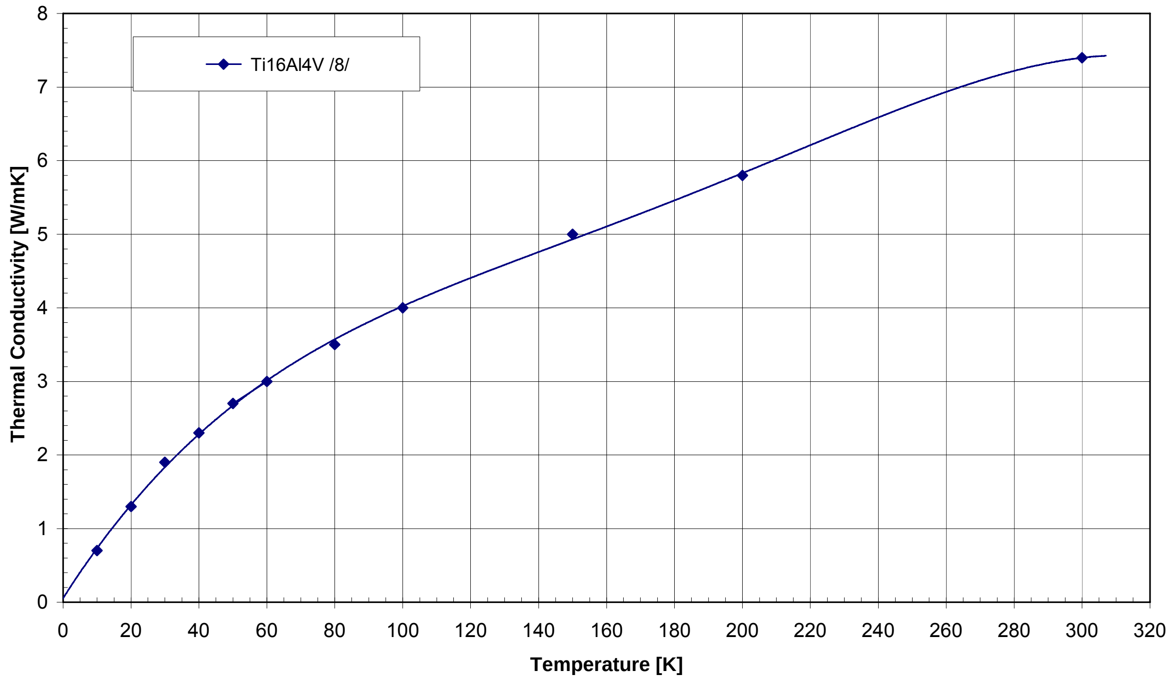


Figure 5.2-9: Thermal Conductivity of Titanium Alloy Ti6Al4V

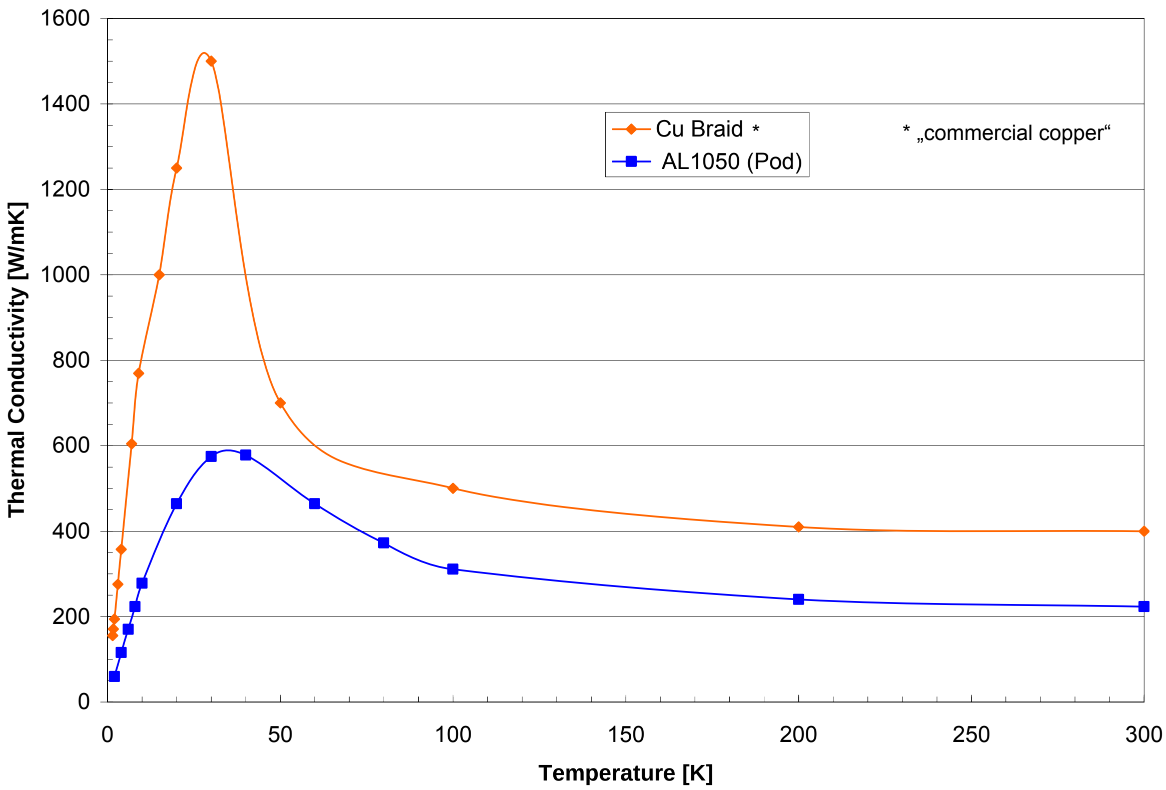


Figure 5.2-10: Thermal Conductivity of Thermal Link Materials [RD 35]

5.3 Thermal Contact Conductance Data

The thermal contact conductance data given in Figure 5.3-1 are related to 1 kN and 1 bolt. For calculating the total contact conductance of an interface the following contact forces are applied:

- 2000 N for each M4 bolt with Invar washer
- 3000 N for each M5 bolt with Invar washer
- 10000 N for each M8 bolt with Invar washer

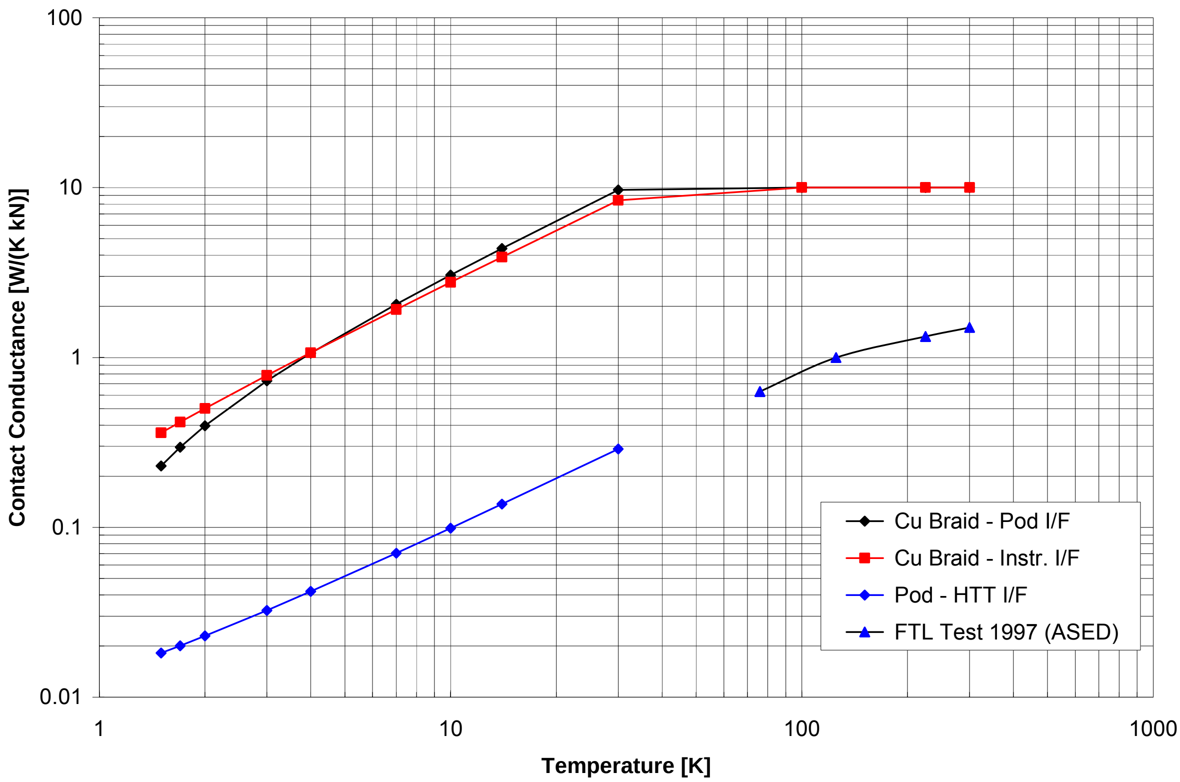


Figure 5.3-1: Thermal Contact Conductance of Thermal Link Interfaces [RD 35]

5.4 Specific Heat Capacity Data

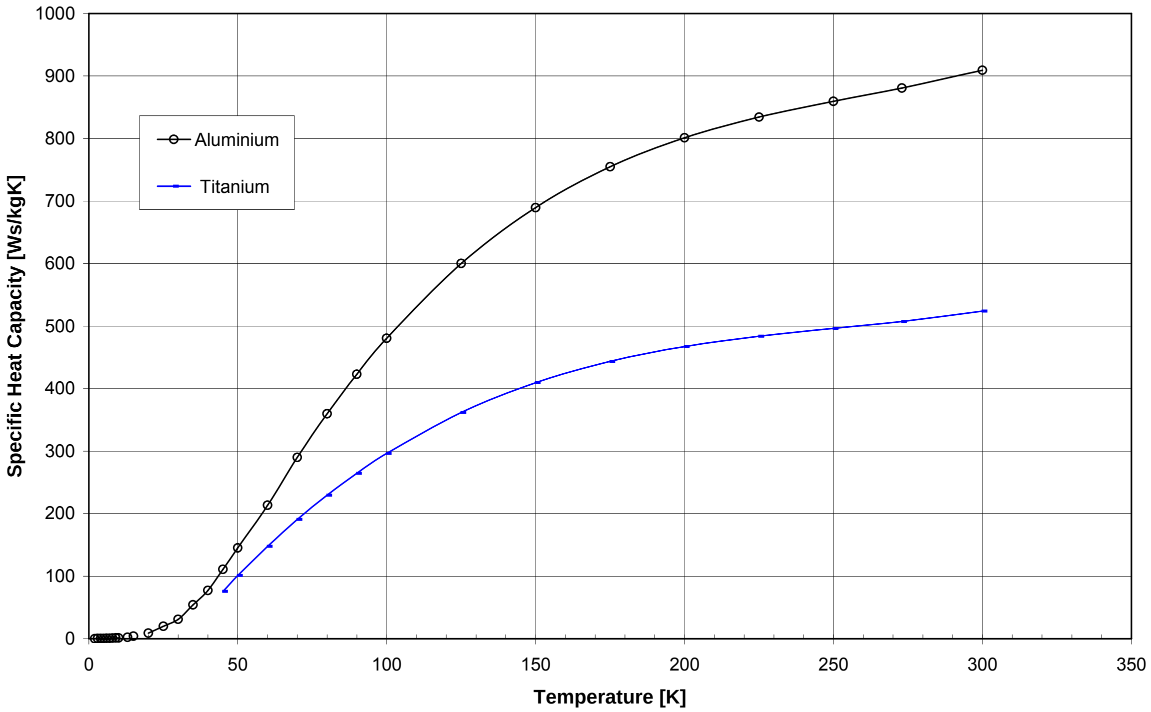


Figure 5.4-1: Specific Heat Capacity of Aluminium and Titanium /14/

5.5 Helium Properties

For the heat of vaporization of Helium different values are found in literature, see Figure 5.5-1. For the TMM calculations, the data reported in Ref. /2/ are used.

The specific heat of the gas is 5.1966 kJ/kg/K (almost constant versus temperature).

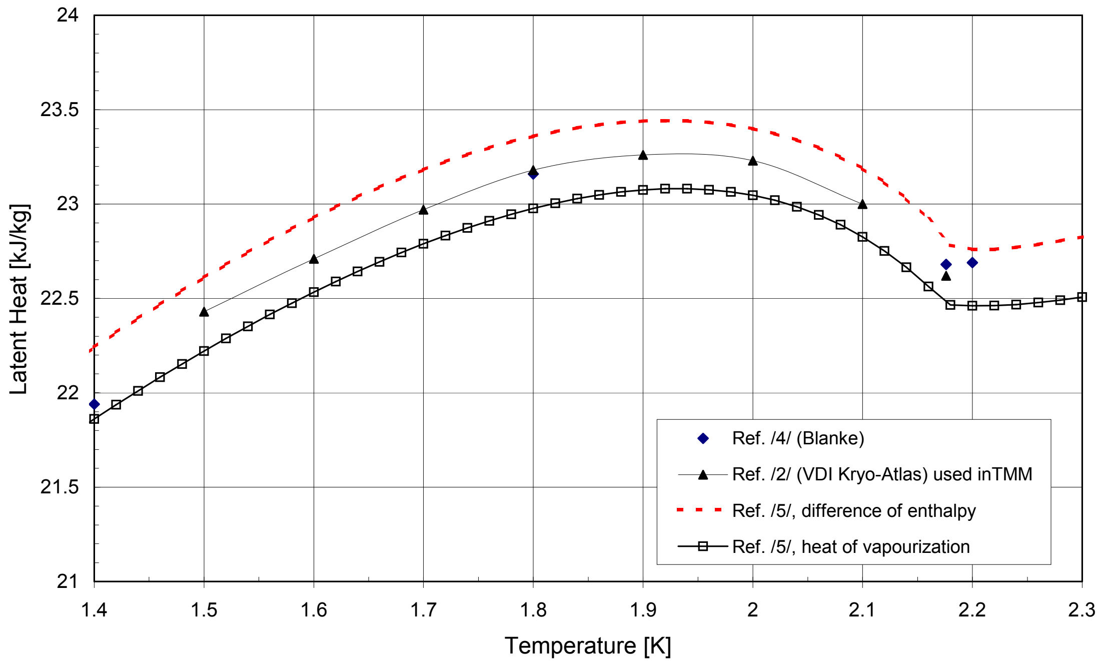


Figure 5.5-1: Heat of Vaporization of Helium 4

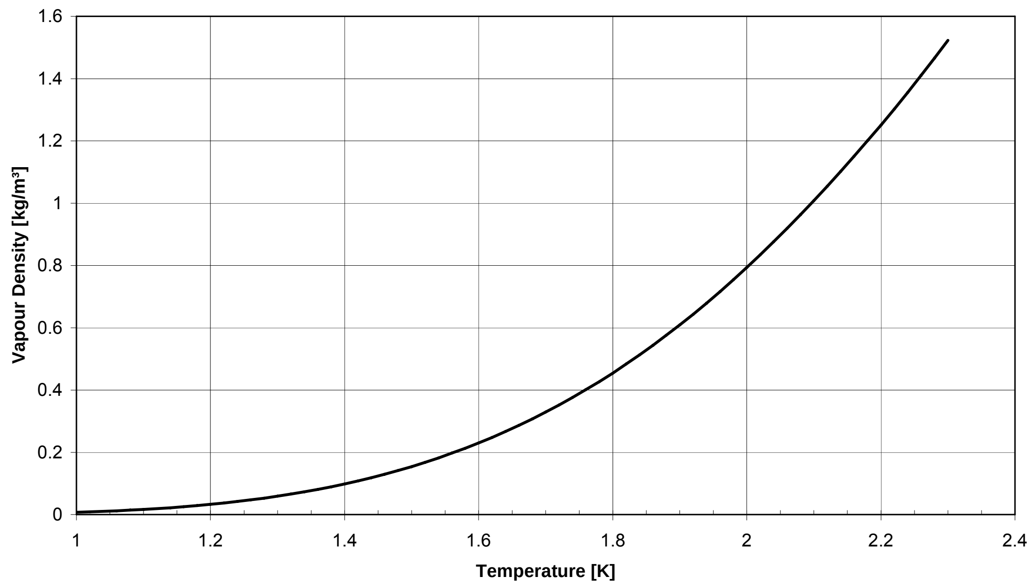


Figure 5.5-2: Vapour Density of Helium (Ref. /5/)

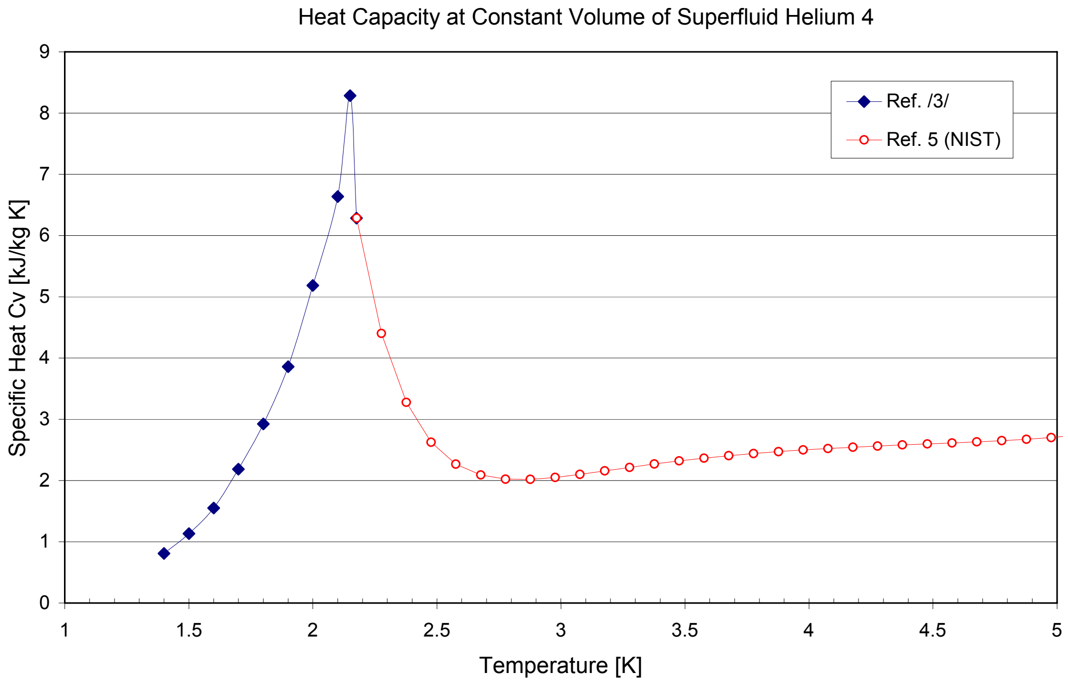


Figure 5.5-3: Volume Specific Heat Capacity of Liquid He on Saturation Line

5.6 References for Material Properties

/1/ Evaluation of LINDE/ESTEC-MLI Measurements and Transformation to the ISO Cryostat MLI Design, Doc.No.: ISO.TN-B1430.007, dated 12.07.88

/2/ VDI Kryoatlas BW 2407

/3/ Thermophysical Properties of Helium from 2 to 1500K with pressures to 1000 Atm (National Bureau of Standards TN 631)

/4/ W. Blanke: Thermophysikalische Stoffdaten, Springer 1989

/5/ NIST Standard Reference Database 12: NIST Thermophysical Properties of Pure Fluids, Version 3.0.

/6/ ASPI fax AS-FAX SE/SP/IS 2244/89, dated 30.01.89

/7/ Hartwig & Knaak, Cryogenics, Nov. 84, p.645

/8/ Touloukian: Thermophysical Properties of Matter, 1972

/9/ MLI Test Report – Linde, Doc.No.: ISO-TR-C130.001, dated 19.02.88

/10/ METOP Mechanical and Thermal Design Requirement Specification, Doc.No.; MO.RS.MMT.SY.0004, Issue 3, June 2000

/11/ Comparative Performance Measurements on MLI Test Samples with different Types of Foils and Studs, Test Report: YCV/BA/136, dated 07.03.88

/12/ Doenecke: Survey and Evaluation of Multilayer Insulation Heat Transfer Measurement, ICES July 1993

/13/ Reed and Golda: Cryogenic composite supports, Cryogenics 1997, p.233

/14/ ISO Thermal Mathematical Model, Version 7.12

/15/ NIST Data Base, http://cryogenics.nist.gov/NewFiles/material_properties.html

/16/ Data delivered by Th. Passvogel, ESA-FAX-PT-01750, dated 23.02.1996

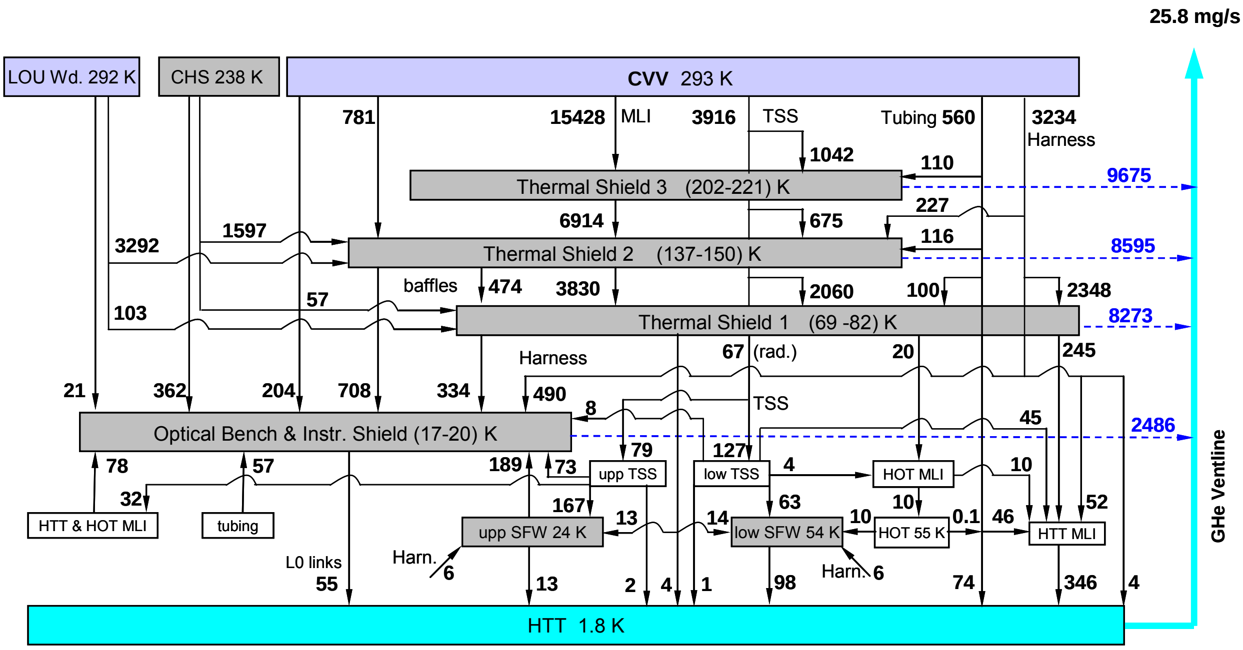
/17/ Guy K. White: Experimental Techniques in Low Temperature Physics, Handbook on Materials for Superconductivity Machinery, 3rd Edition

/18/ Thermomechanical Analysis, HP-2-ECAS-AN-0004, Issue 2, dated 28.11.03

6 Thermal Analysis Results

6.1 Operation On Ground

A heat flow chart based on ground case analysis is shown in Figure 6.1-1. Included are the CVV internal main heat paths, the temperatures of the different components and the GHe mass flow rate. The PPS in this configuration is bypassed, the different ventline path is also considered in the TMM.



Only main paths are shown. All values are in [mW]

Figure 6.1-1: CVV Heat Flow Chart for On-Ground Environment

The sensitivity analysis performed for ground case conditions is summarised in Table 6.1-1 and Table 6.1-2. Generally, the uncertainties for the different items are assumed to be between ±20% for mechanical support structures and ±50% for MLI conductance.

General remarks for sensitivity tables:

- ± 50% means 1.5 x nominal value for + 50%, 0.5 x nominal values for -50%
- Highlighting in color in the tables indicates the extreme values in the respective column
- Overall uncertainties are calculated as root square sum
- In the graphical representation tables, the number of bars per field indicates the relative magnitude (wrt the maximum value in the same column) of the respective sensitivity

	label	Varia-tion	HOT [K]	OBA [K]	TS1 [K]	TS2 [K]	TS3 [K]	mdot [mg/s]	HTT_Heat [mW]
Reference value			***54.74***	***19.77***	***78.00***	***145.05***	***215.61***	***25.79***	***597.8***
Overall uncertainty	**pos** **neg**		**8.50** **-5.94**	**4.65** **-2.05**	**9.05** **-6.08**	**10.63** **-11.73**	**14.69** **-21.86**	**1.97** **-2.97**	**45.9** **-69.0**
HTT MLI conductance	k_1	-0.5 50%	7.56 -3.60	4.49 -1.88	8.60 -4.18	6.28 -3.20	3.59 -1.87	-1.07 0.55	-24.8 12.8
TS1 MLI conductance	k_2a	-50% 50%	-1.47 0.75	0.85 -0.41	-2.16 1.07	5.00 -2.61	2.89 -1.54	-0.78 0.42	-18.0 9.6
TS2 MLI conductance	k_2b	-50% 50%	-1.92 1.18	-0.33 0.21	-2.13 1.31	-6.59 3.95	5.97 -3.72	-1.47 0.94	-34.1 21.7
TS3 MLI conductance	k_2c	-50% 50%	-2.86 1.86	-0.33 0.24	-2.98 1.94	-8.62 5.49	-21.31 12.46	-2.10 1.44	-48.6 33.3
HTT bones	k_3	-20% 20%	2.77 -2.37	0.26 -0.21	0.55 -0.45	0.42 -0.34	0.24 -0.20	-0.07 0.06	-1.6 1.4
inner tank suspension	k_4	-20% 20%	-1.30 1.13	0.12 -0.10	0.55 -0.50	0.43 -0.40	0.25 -0.23	-0.07 0.07	-1.7 1.6
TS 1/2 tank susp.	k_5	-20% 20%	-0.59 0.51	0.24 -0.21	-0.27 0.24	1.19 -1.06	0.82 -0.73	-0.22 0.20	-5.2 4.6
TS 2/3 tank susp.	k_6	-20% 20%	-0.40 0.36	0.02 -0.02	-0.33 0.30	-0.66 0.59	0.73 -0.66	-0.25 0.22	-5.7 5.2
outer tank suspension	k_7	-20% 20%	-0.30 0.28	-0.02 0.02	-0.30 0.27	-0.80 0.74	-1.49 1.36	-0.22 0.20	-5.0 4.7
CVV int. harness conductance	k_8	-15% 15%	-0.49 0.48	-0.40 0.40	-0.63 0.62	0.37 -0.36	0.62 -0.61	-0.58 0.57	-13.4 13.2
He vapourisation heat	k_11	-1% 1%	-0.25 0.25	-0.14 0.14	-0.32 0.31	-0.25 0.25	-0.15 0.15	0.05 -0.05	-4.9 4.8
Stycast comb at TS1	k_17	-90% 90%	-0.31 0.02	0.53 -0.03	-0.42 0.02	-0.13 0.01	0.03 0.00	-0.10 0.01	-2.4 0.1
Stycast comb at OBP	k_18	-90% 90%	0.00 0.00	-0.02 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.0 0.0

Table 6.1-1: Sensitivities for Operation on Ground

	label	HOT	OBA	TS1	TS2	TS3	mdot	HTT_Heat
Reference v.		***54.74***	***19.77***	***78.00***	***145.05***	***215.61***	***25.79***	***597.8***
Overall uncertainty	**pos** **neg**	**8.50** **-5.94**	**4.65** **-2.05**	**9.05** **-6.08**	**10.63** **-11.73**	**14.69** **-21.86**	**1.97** **-2.97**	**45.9** **-69.0**
HTT MLI conductance	-50% 50%																
TS1 MLI conductance	-50% 50%			
TS2 MLI conductance	-50% 50%				
TS3 MLI conductance	-50% 50%						
HTT bones	-20% 20%					
inner tank suspension	-20% 20%		
TS 1/2 tank susp.	-20% 20%	
TS 2/3 tank susp.	-20% 20%				
outer tank suspension	-20% 20%				
CVV int. harness conductance	-15% 15%	
He vapourisation heat	-1% 1%							
Stycast comb at TS1	-90% 90%								
Stycast comb at OBP	-90% 90%							

Note: The number of bars per field indicates the relative magnitude of the respective sensitivity

Table 6.1-2: Graphical representation of sensitivities for Operation on Ground

6.2 Pre-Launch and Early Orbit Phase

As a consequence of the helium leak in the auxiliary tank (HOT) detected during PFM preparation activities, the launch autonomy phase willl be performed without using the HOT. The new approach is based on Thermal Shields cooling from an external dewar until the latest possible moment, followed by a non-cooled phase which is significantly longer than in the original plans. (In original plans, the last hot filling was planned at D-2. The non cooled phase was starting after the HOT depletion, i. e. 4 hours before nominal launch. In that sense, the non cooled phase is longer now, but access to S/C for refilling or cooling is better in the new scenario.)

6.2.1 Launch Autonomy, Delay and Roll-back

For the launch autonomy/pre-launch and LEOP (Launch and Early Orbit Phase) two scenarios have been investigated in accordance with the POC operations as discussed with Arianespace and reflected in the launch sequence test spec [AD 18]:

1. Nominal scenario with no launch delay:
   - Helium II top up/pump-down completed at launch-102 h with a level of 96.8 %/333 kg and a temperature of 1.70 K
   - HOT starting temperature 30 K (derived from test experience)
   - Fairing installation until l-88 h, no He cooling
   - Thermal Shields cooling until l-34 h
   - Dewar disconnection at l-34 h, no more shields cooling
2. Scenario with 25 hours launch delay:
   - Same as 1., but additionally:
   - 1st launch attempt aborted
   - 25 hours hold time until 2nd launch attempt

The complete launch autonomy sequence has been calculated until l+4 days considering a possible roll-back scenario being applicable in case both launch attempts fail.

Both for launch autonomy and LEOP a dedicated set of sensitivity parameters and dedicated FPU submodels have been used (compare to section 4.1.1).

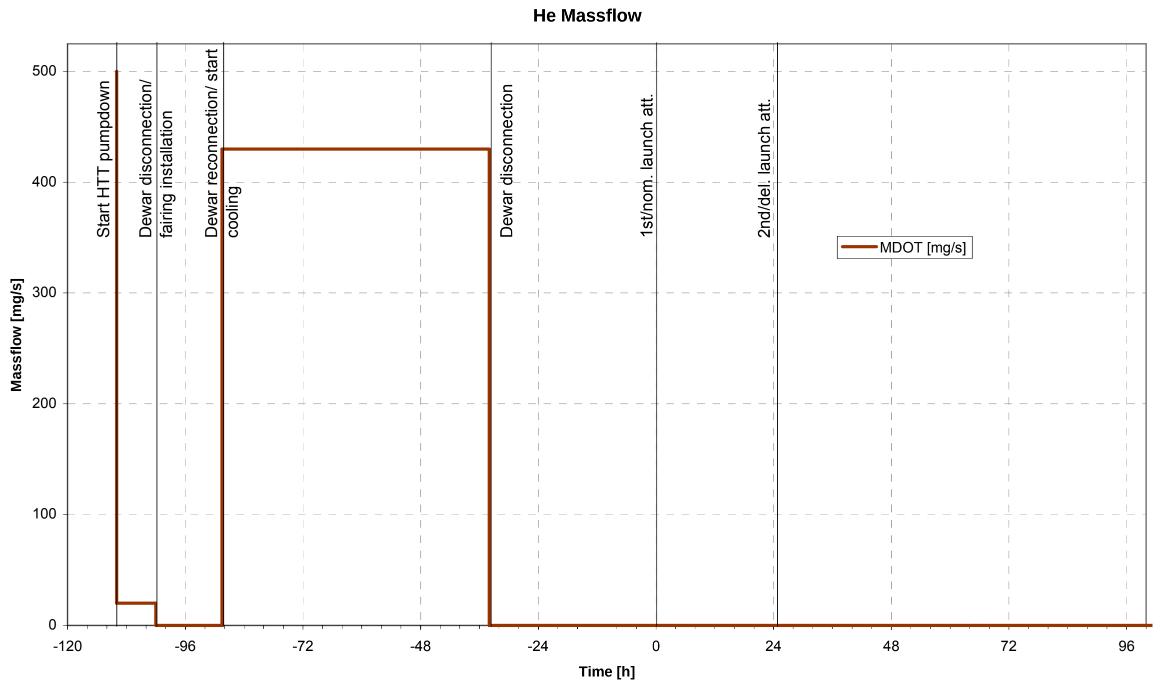


Figure 6.2-1: He Massflow during Pre-Launch Phase

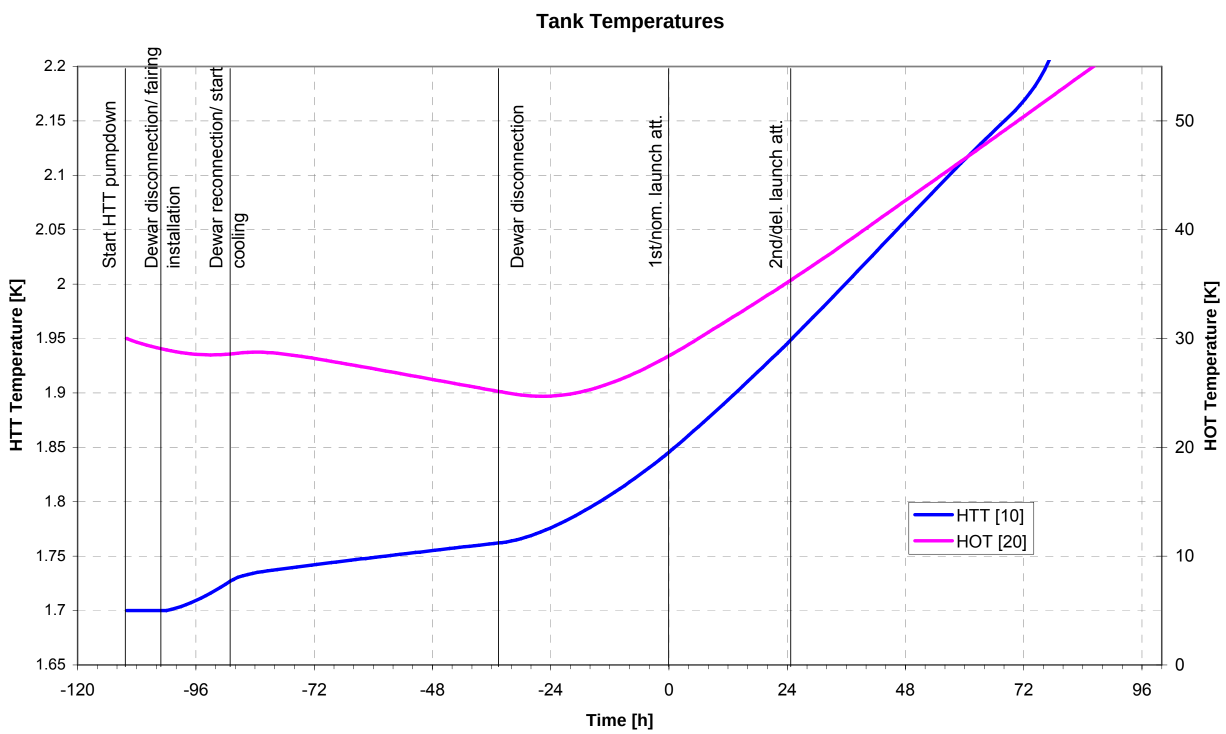


Figure 6.2-2: HTT and HOT Temperature Evolution during Pre-Launch Phase

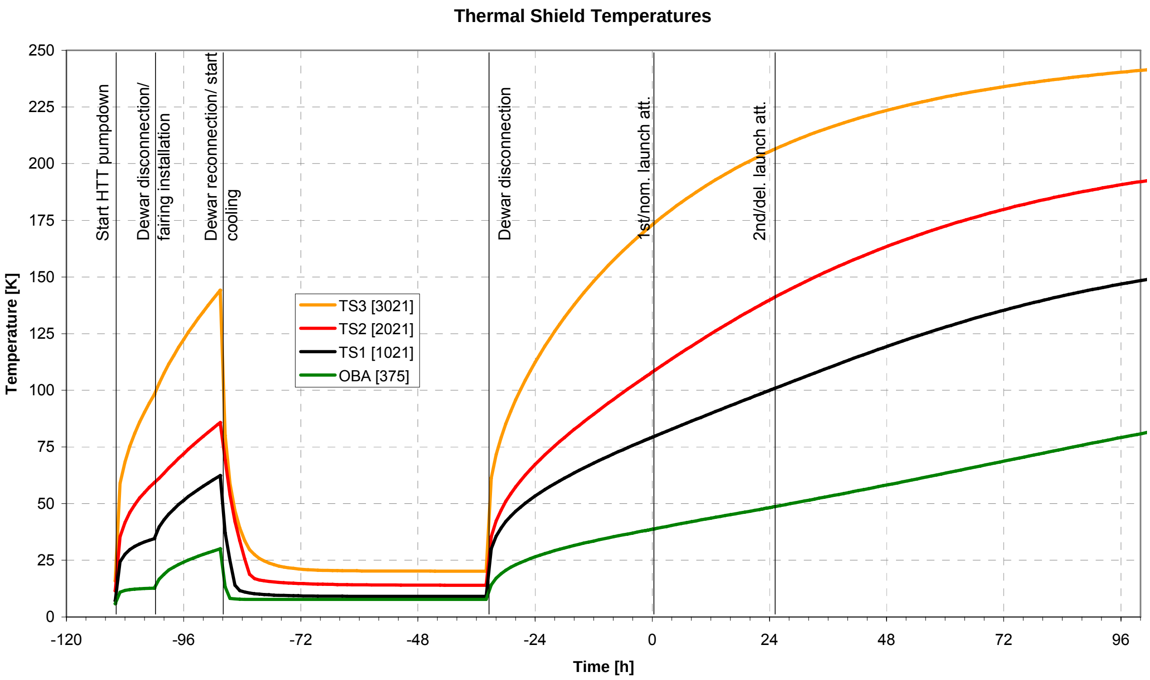


Figure 6.2-3: Thermal Shield Temperature Evolution during Pre-Launch Phase

Figure 6.2-4 shows the temperature profile of the SPIRE SMEC coils due to the SPIRE launch latch dissipation.

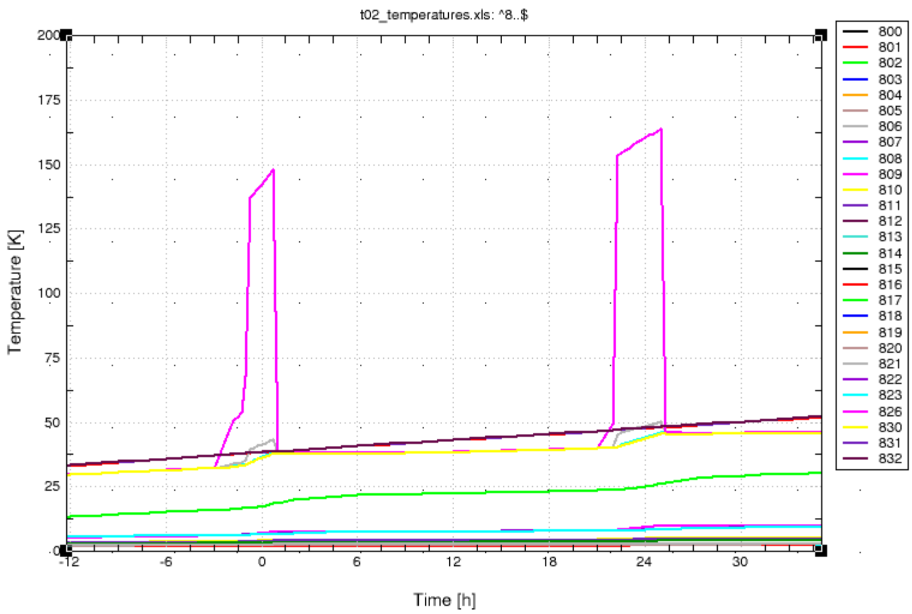


Figure 6.2-4: SPIRE Launch Latch during Pre-Launch Phase

6.2.2 Launch Phase

For the launch phase of 200 sec (launch until fairing jettison), a heat flux of 1000 W/m2 radiated by the fairing is assumed [AD 05]. The temperature evolution of some exposed external parts is shown in Figure 6.2-5.

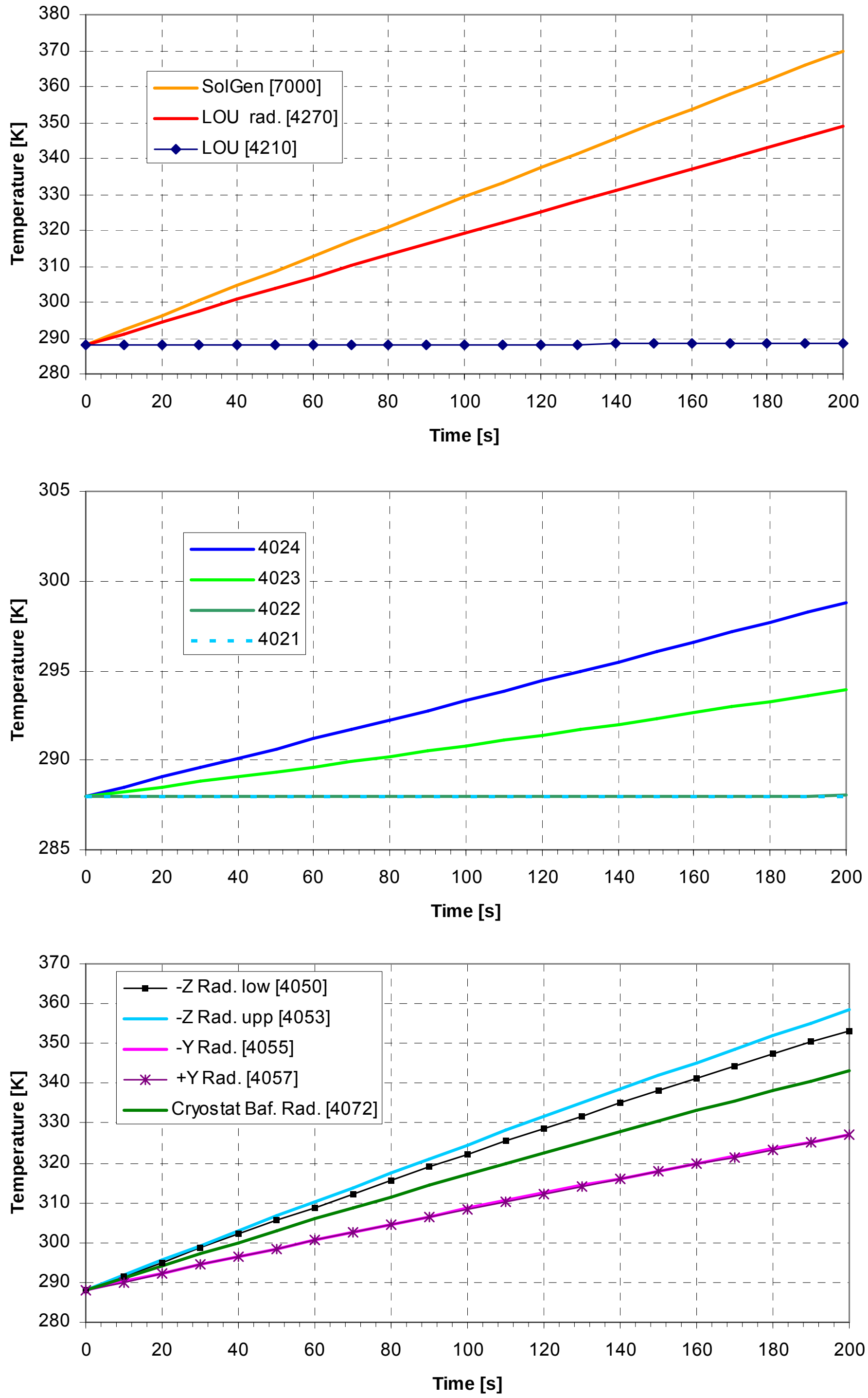


Figure 6.2-5: H-EPLM Temperatures during Launch Phase

6.2.3 *Early Orbit Phase*

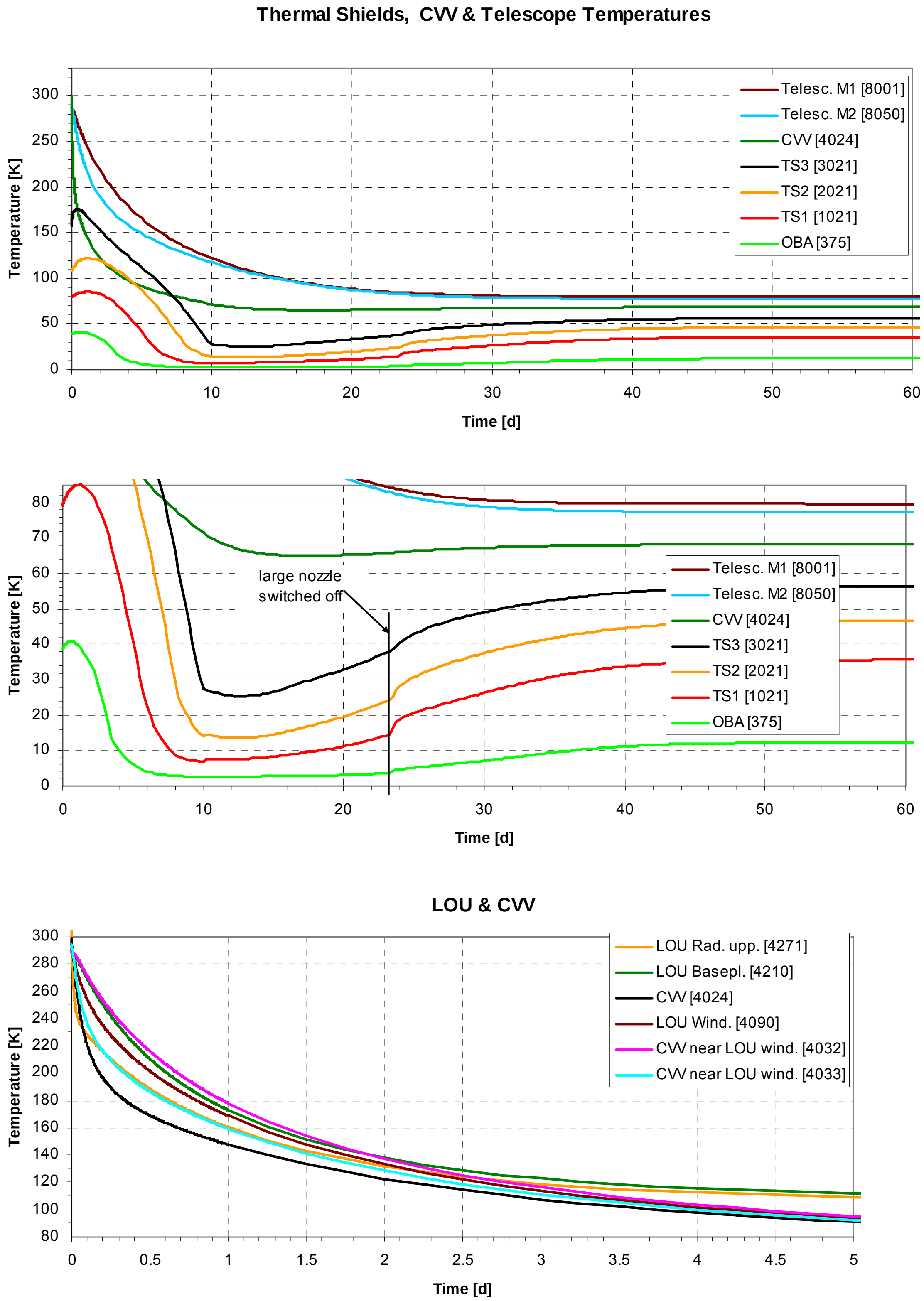


Figure 6.2-6: H-EPLM Temperatures during In-Orbit Cool-Down (nom. launch)

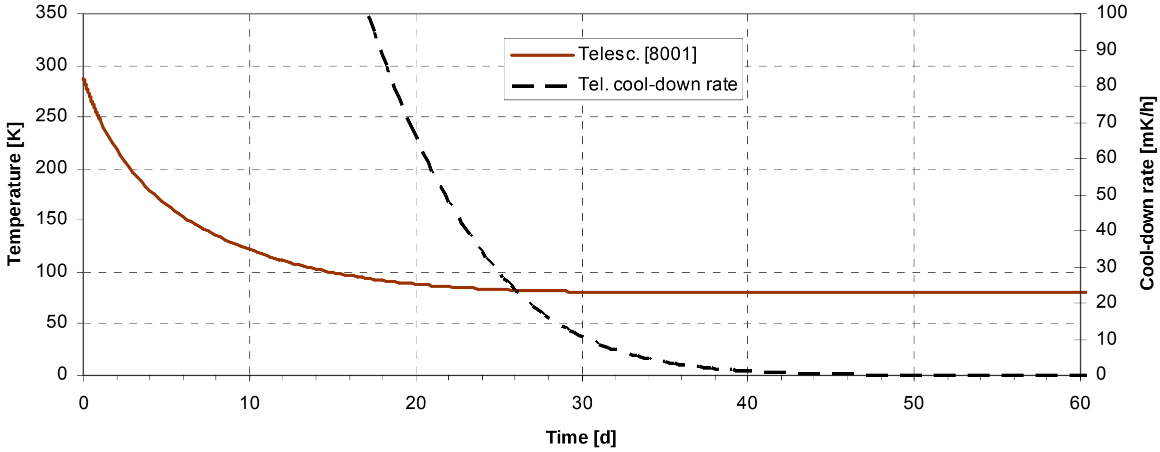


Figure 6.2-7: Telescope Cool-Down Rate (nom. launch, Cryo Cover still closed)

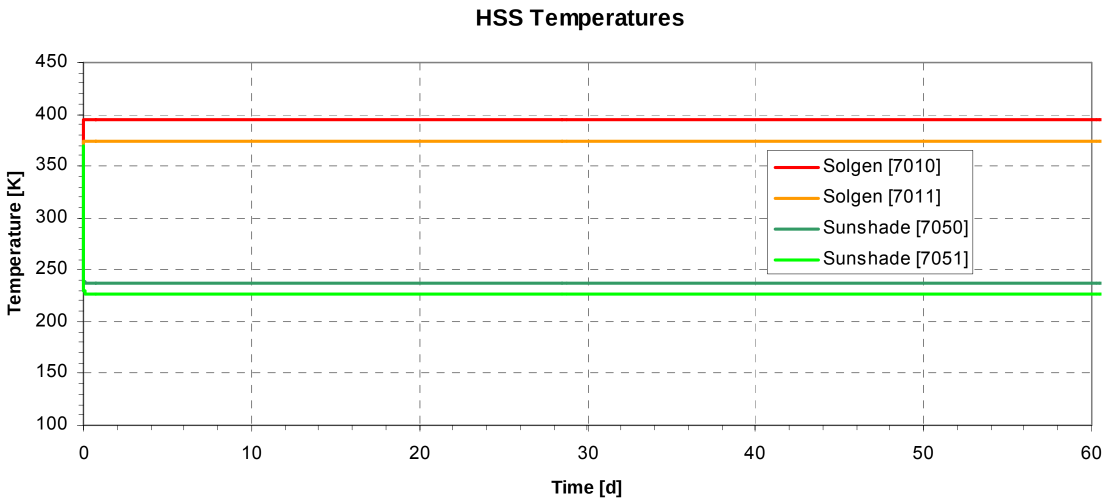


Figure 6.2-8: HSS Temperatures during In-Orbit Cool-Down (nom. launch)

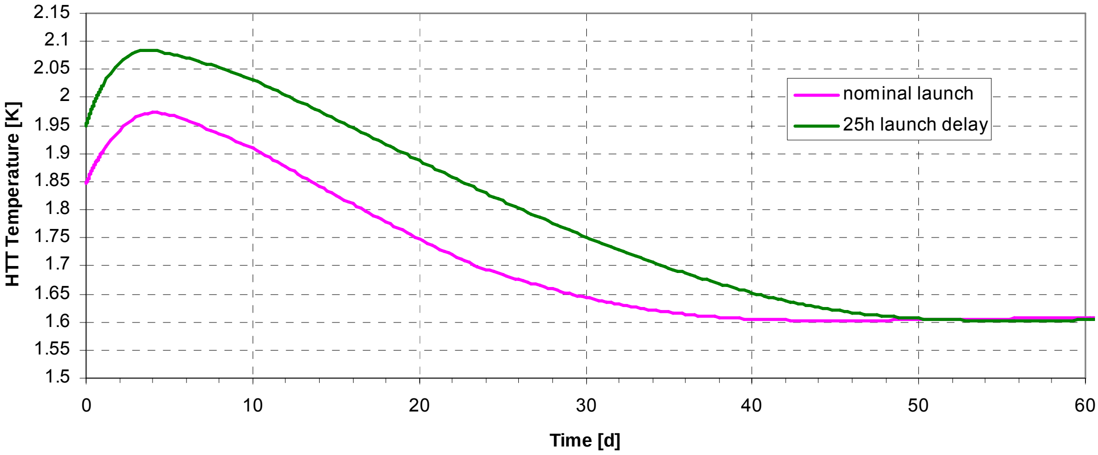


Figure 6.2-9: HTT Temperature during In-Orbit Cool-Down

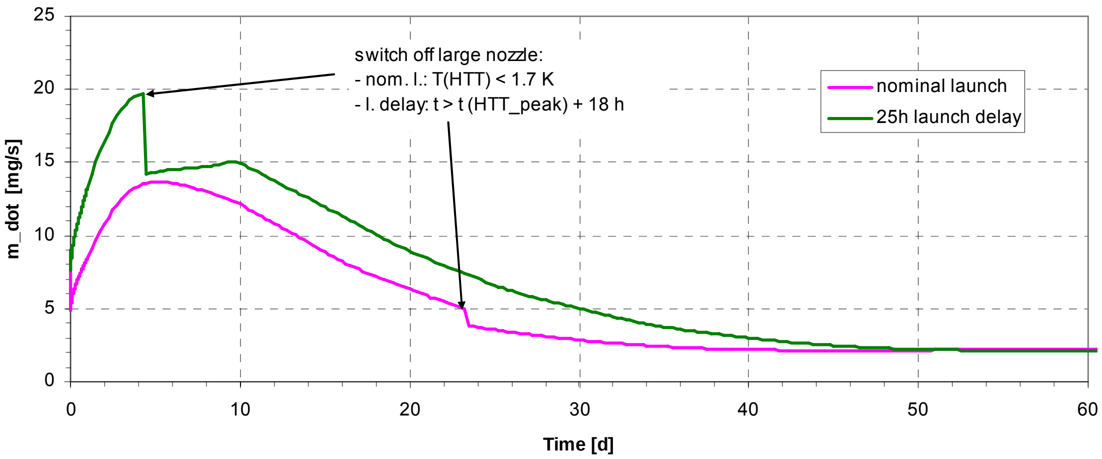


Figure 6.2-10: Helium Mass flow during In-Orbit Cool-Down

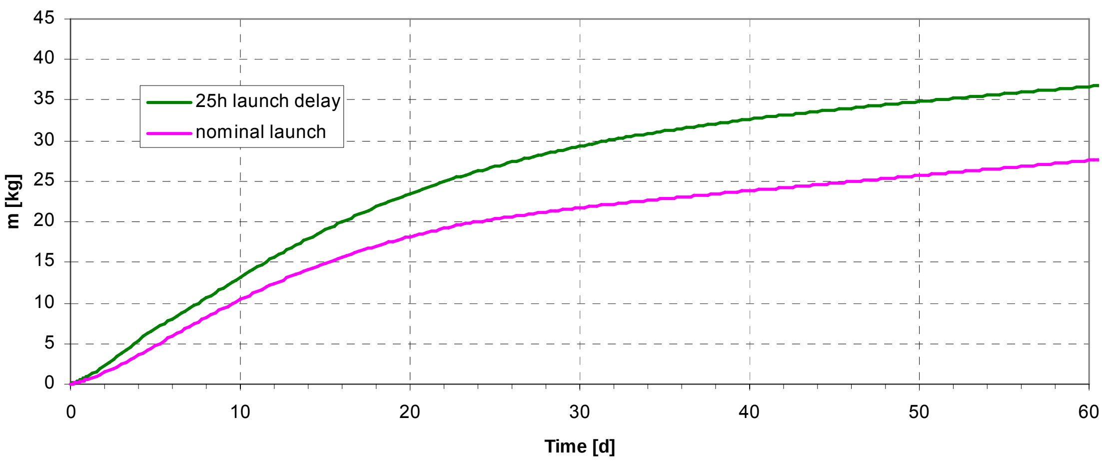


Figure 6.2-11: Helium Mass Loss during In-Orbit Cool-Down

Critical areas that are exposed to an intensive solar as well as aero-thermal flux until launcher separation are investigated in RD 17. The cool-down of the HSS after fairing jettison has been assessed for an extreme S/C attitude, see also RD 17.

According to [RD 64] the Telescope decontamination heating is no longer applicable for final flight predictions.

For the nominal launch scenario, the closing of the large nozzle is performed when the HTT temperature reaches 1.7 K (i.e. ~23 days after launch).

In case of a launch delay an early nozzle switching, i. e. closure of the large nozzle, is performed in LEOP, shortly (18 hours) after passing the HTT temperature peak. A second mass flow peak occurs due to the temperature drop of the external vent line and the related decrease in the vent line impedance. With the early nozzle switching this second mass flow peak can be clearly reduced (comp. to Figure 6.2-10). The nozzles are the dominating element in the ventline flow path during early orbit phase and have finally been designed with a nozzle throat diameter of 1.46 mm for the small nozzles respectively 1.8 mm for the large nozzle. Further information is given in [RD 41]

Although using conservative parameters (compare to section 4.1.1), the maximum values for the HTT temperature and the mass flow are always below the PPS qualification range of 2.1 K and 20 mg/s, see Table 6.2-1.

Acc. to [AD 06], the end of the transient cool down phase is reached after

- Telescope cool down until a rate of < 0.03 K/hour
- Cryo-cover opening (note that cover opening is not implemented in the LEOP transient thermal analysis)
- Large nozzle switched off
- HTT has reached 1.65 K

Table 6.2-1 summarises the helium losses and HTT temperatures for the above-described scenarios.

	Nominal launch	Launch delay	Reference
Duration of transient cool down	29 days (1)	40 days (2)	
He loss during cool down	21.5 kg (1)	32.6 kg (2)	Figure 6.2-11
T (HTT) at launch	1.846 K	1.950 K	Figure 6.2-2
T (HTT, max)	1.973 K @ I+4 d	2.085 K @ I+3.75 d	Figure 6.2-9
Max. mass flow	13.7 mg/s @ I+5 d	19.73 mg/s @ I+4.5 d	Figure 6.2-10

(1) used for lifetime analysis, see section 6.5
(2) used for lifetime uncertainty

Table 6.2-1: Helium loss and HTT temperatures during in-orbit cool down

6.3 Spacecraft Operation in L2 Orbit

6.3.1 Steady State Analysis for Hot and Cold Case Conditions

Thermal analyses with implemented instrument models have been performed both for the hot and cold case thermal environment at L2 (for definition see Table 3.2-1).

The main results are summarized in Table 6.3-1. The corresponding heat flow charts showing the CVV external main paths are shown in Figure 6.3-3 for the hot case environment and in Figure 6.3-4 for the cold case environment. The calculated temperatures of the relevant components are included. The internal heat flow chart for the hot case environment is shown in Figure 6.3-5. A detailed listing of all node temperatures is given in the annex.

	T (CVV)	T (TS3)	T (TS2)	T (TS1)	T (OBA)	T (HTT)	He Mass Flow
Hot case	67.0 K	54.6 K	45.2 K	34.1 K	12.8 K	1.609 K	2.283 mg/s
Cold case	63.8 K	52.2 K	43.4 K	33.1 K	12.6 K	1.593 K	2.123 mg/s
Safe Mode *	60.0 K	49.9 K	42.0 K	32.1 K	11.4 K	1.555 K	1.739 mg/s
Average (IID-B) **	65.5 K	53.5 K	44.4 K	33.6 K	12.7 K	1.603 K	2.207 mg/s

*) All dissipation set to zero + SVM in safe mode; thermal environment equal to cold case
**) Used for lifetime calculation

Table 6.3-1: Analysis Results for Hot and Cold Case Environment

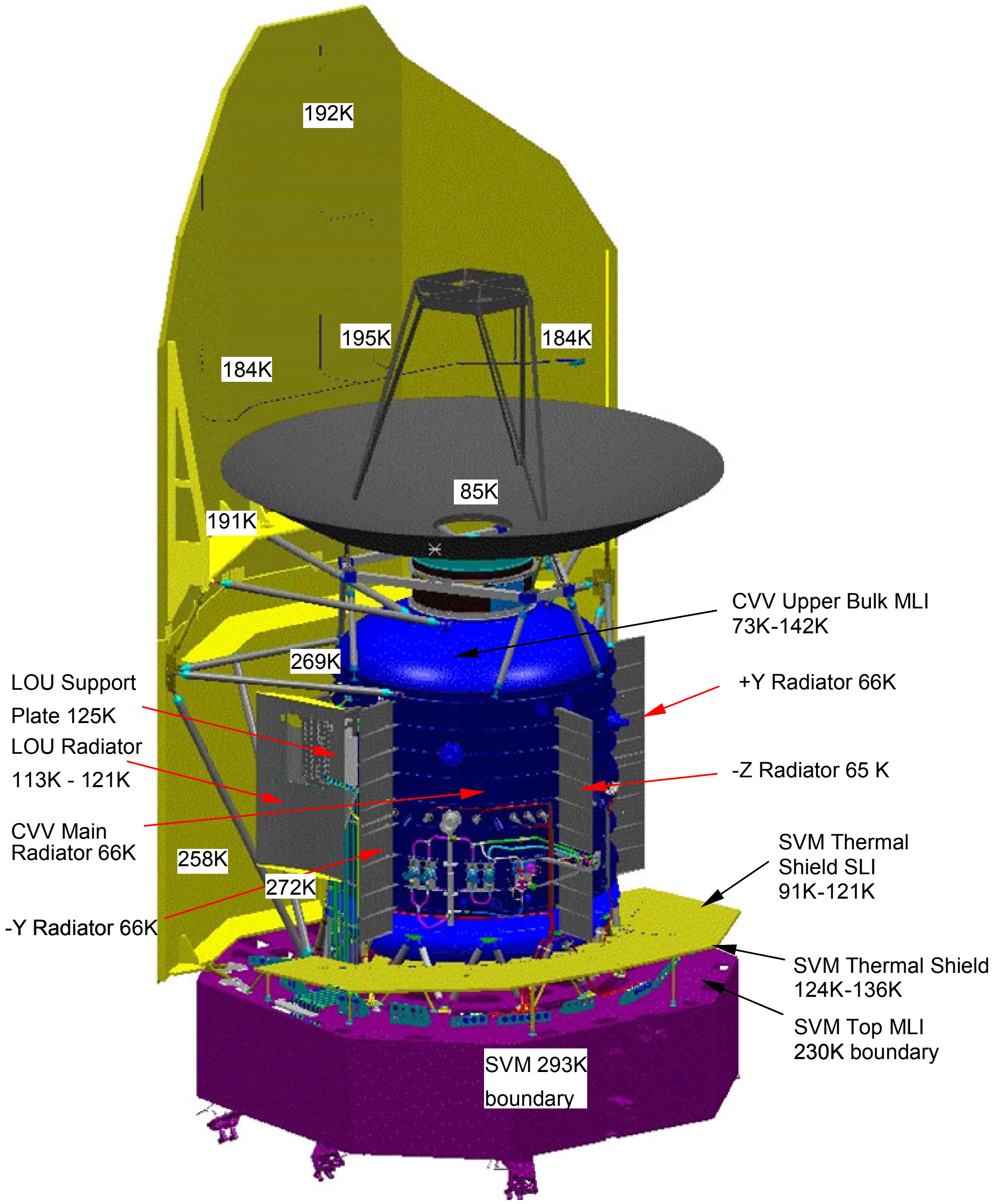


Figure 6.3-1: H-EPLM Temperature Distribution for Hot Case Environment at L2

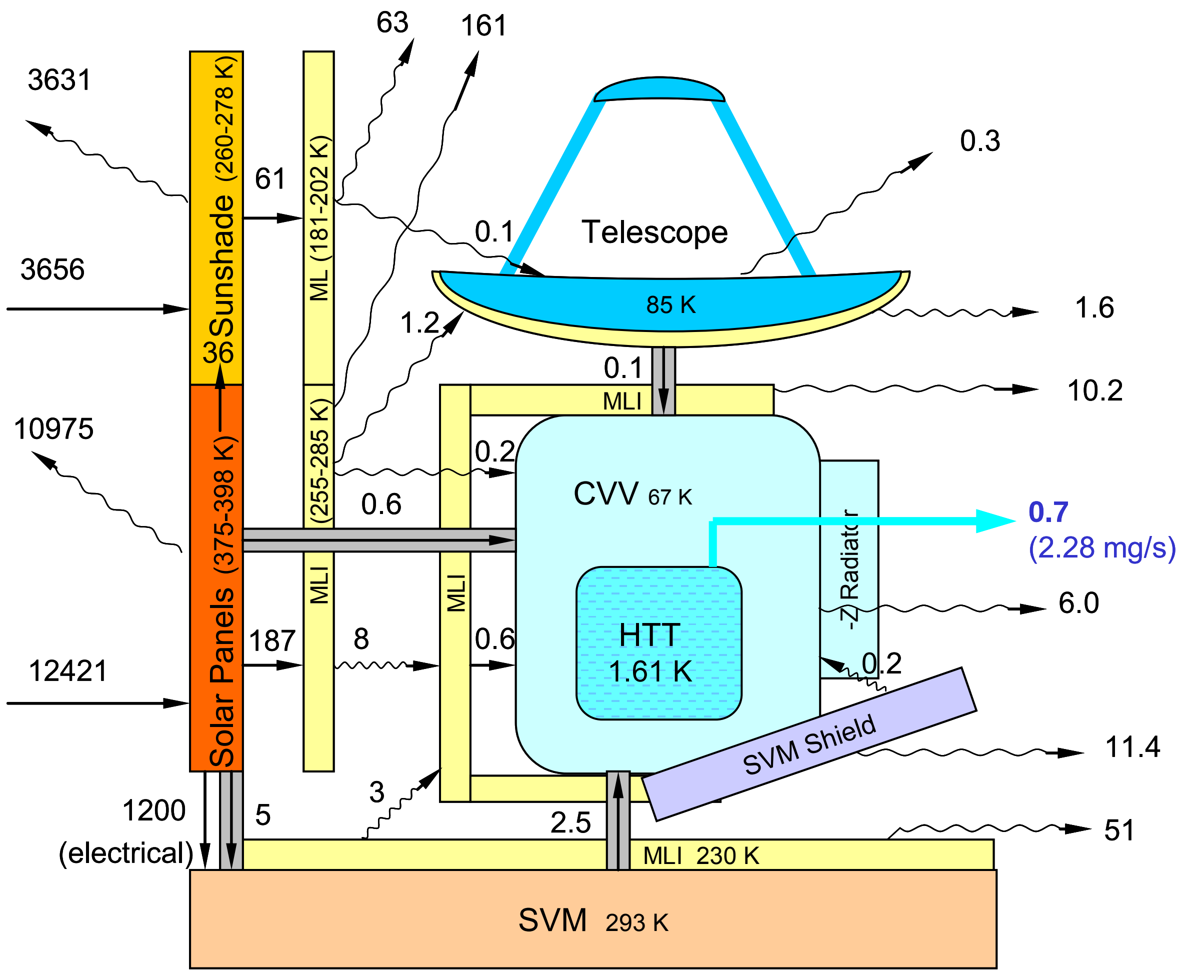
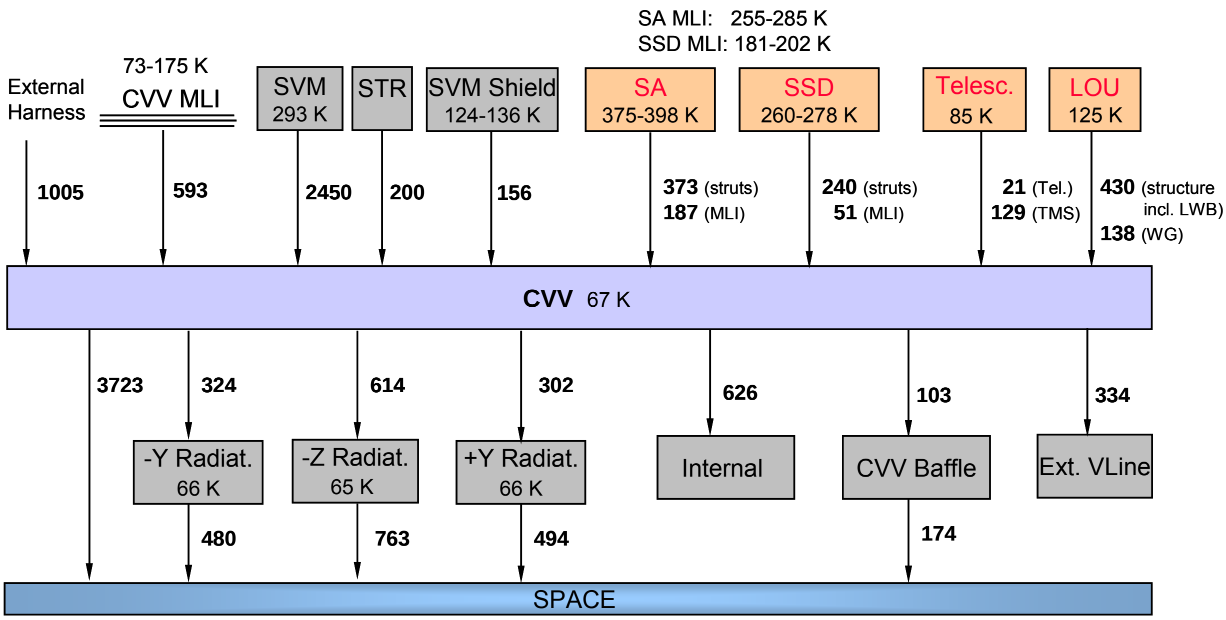


Figure 6.3-2: CVV External Heat Flow Chart in [W] (Hot Case)

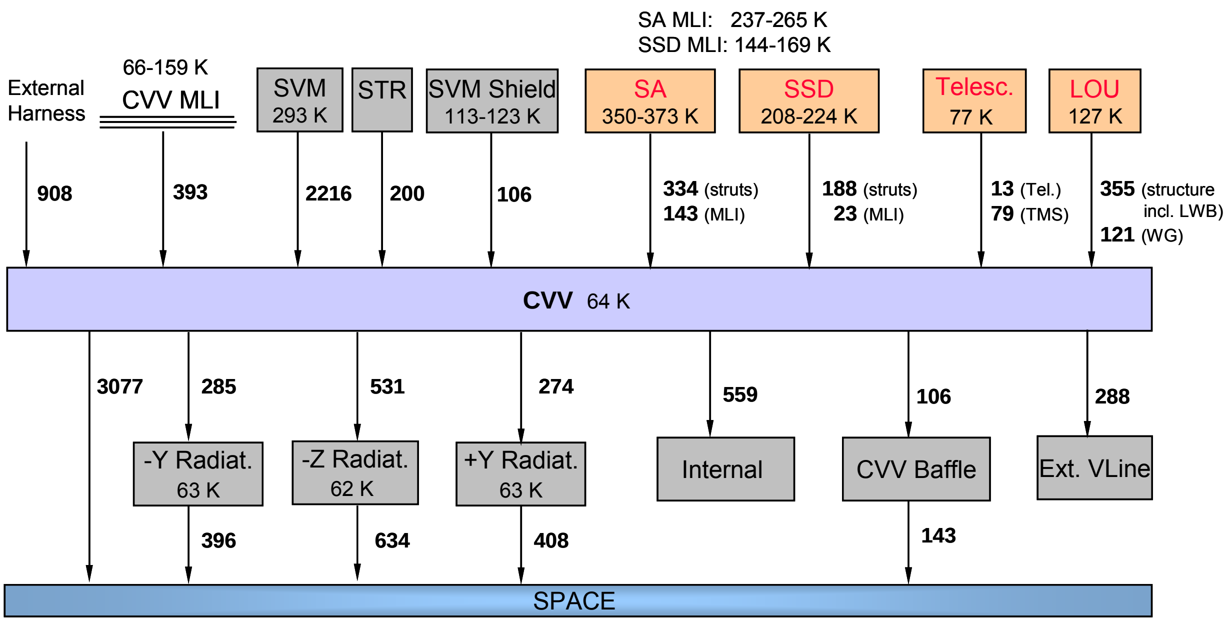
The maximum calculated thermal interface fluxes from Sunshield (=Solar Panels) to SVM are as follows. The max. allowed values as per [AD 07] are given in parenthesis:

Flux via CFRP struts:	-1.5 W (<5 W required)
Flux via Sunshield brackets:	3.3 W (<10 W required)
Flux via harness:	2.8 W



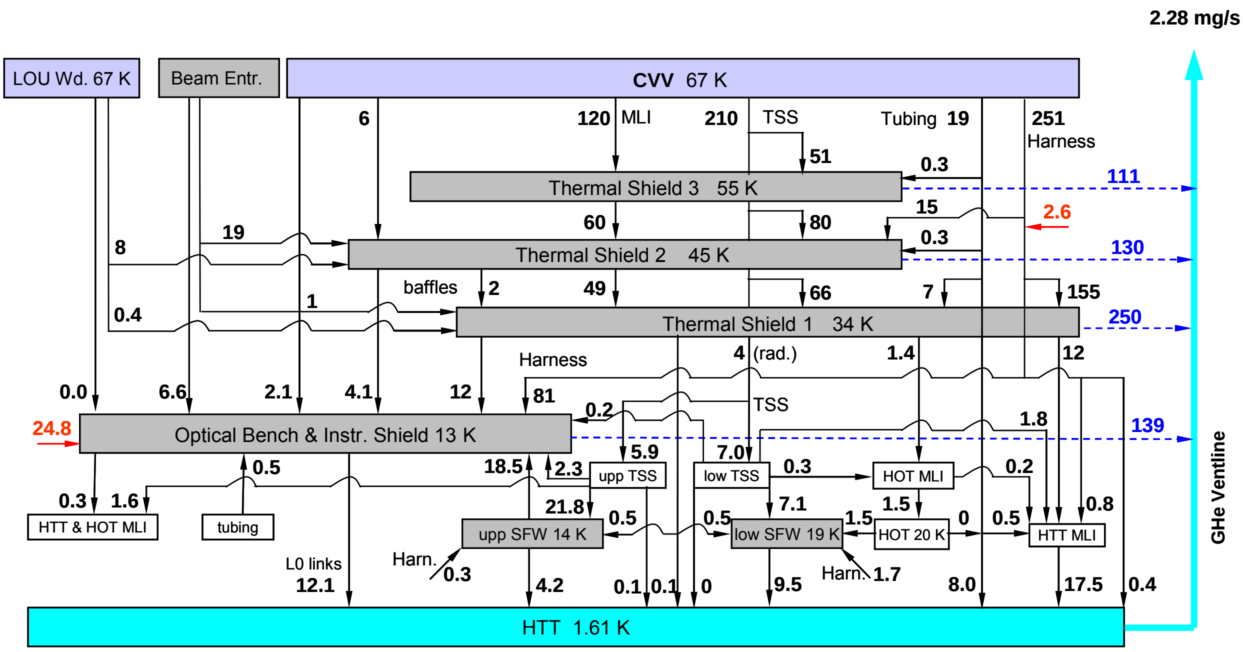
All values are in [mW]

Figure 6.3-3: CVV Heat Flow Chart for Hot Case Environment at L2



All values are in [mW]

Figure 6.3-4: CVV Heat Flow Chart for Cold Case Environment at L2



Only main paths are shown. All values are in [mW]

Figure 6.3-5: HPLM internal Heat Flow Chart for Average Instrument Dissipation and Hot Case Environment at L2

6.3.2 *Sensitivity Analysis for Lifetime and EPLM Temperatures*

A comprehensive sensitivity analysis has been performed for In-Orbit operations. The results are listed in the following tables.

General remarks for sensitivity tables:

- ± 50% means 1.5 x nominal value for + 50%, 0.5 x nominal values for -50%
- Highlighting in colour in the tables indicates the extreme values in the respective column
- Overall uncertainties are calculated as root square sum
- In the graphical representation tables, the number of bars per field indicates the relative magnitude (wrt. the maximum value in the same column) of the respective sensitivity
- "HTT temp (dp) uncertainty" indicates the uncertainty of the respective temperature for an error in the pressure drop model by ±1.5 mbar
- The "Updated HSS MLI definition" replaces the negative sensitivities of the HSS MLI conductances k_22/k_23 and represents the more realistic MLI performance formulation based on calorimeter test results. The HSS MLI definition in the reference TMM is based on the effective emissivity formulation which is considered to be very conservative.

	label	Varia-tion	HTT [K]	mdot [mg/s]	HOT [K]	OBA [K]	TS1 [K]	TS2 [K]	TS3 [K]
Reference value			***1.609***	***2.283***	***19.601***	***12.738***	***34.112***	***45.228***	***54.576***
Overall uncertainty	**pos** **neg**		**0.043** **-0.053**	**0.154** **-0.238**	**1.487** **-1.663**	**0.549** **-0.577**	**0.878** **-1.498**	**1.303** **-2.460**	**1.753** **-3.310**
HTT temp (dp) uncertainty	-	+1.5mbar -1.5mbar	0.0419 -0.0486						
HTT MLI conductance	k_1	-50% 50%	-0.0001 0.0000	-0.0010 0.0003	-0.1204 0.0436	0.010 -0.003	0.014 -0.004	0.010 -0.003	0.007 -0.002
TS1 MLI conductance	k_2a	-50% 50%	-0.0007 0.0003	-0.0112 0.0044	-0.0782 0.0305	0.022 -0.008	-0.122 0.047	0.182 -0.071	0.109 -0.042
TS2 MLI conductance	k_2b	-50% 50%	-0.0009 0.0005	-0.0139 0.0072	-0.0763 0.0393	-0.007 0.004	-0.100 0.052	-0.357 0.182	0.187 -0.096
TS3 MLI conductance	k_2c	-50% 50%	-0.0019 0.0011	-0.0235 0.0138	-0.1346 0.0781	-0.009 0.005	-0.173 0.100	-0.550 0.316	-1.124 0.642
HTT bones	k_3	-20% 20%	-0.0008 0.0007	-0.0140 0.0125	1.1991 -1.0328	0.182 -0.165	0.200 -0.179	0.145 -0.130	0.095 -0.085
inner tank suspension	k_4	-20% 20%	-0.0011 0.0010	-0.0173 0.0159	-0.6974 0.6086	-0.001 0.004	0.232 -0.212	0.182 -0.167	0.119 -0.109
TS 1/2 tank susp.	k_5	-20% 20%	-0.0015 0.0013	-0.0234 0.0209	-0.1950 0.1713	0.049 -0.043	-0.222 0.195	0.333 -0.296	0.224 -0.200
TS 2/3 tank susp.	k_6	-20% 20%	-0.0016 0.0013	-0.0238 0.0200	-0.1382 0.1151	-0.007 0.005	-0.175 0.146	-0.524 0.433	0.240 -0.201
outer tank suspension	k_7	-20% 20%	-0.0016 0.0013	-0.0206 0.0172	-0.1182 0.0981	-0.008 0.006	-0.151 0.125	-0.477 0.392	-0.837 0.686

	label	Varia-tion	HTT [K]	mdot [mg/s]	HOT [K]	OBA [K]	TS1 [K]	TS2 [K]	TS3 [K]
CVV int. harness conductance (=k_9)	k_8	-15%	-0.0077	-0.1160	-0.4067	-0.505	-0.505	-0.052	0.123
		15%	0.0073	0.1123	0.3727	0.471	0.460	0.049	-0.116
Int. harness dissipation	k_10	-20%	-0.0009	-0.0131	-0.0080	-0.118	-0.012	0.020	0.023
		20%	0.0009	0.0131	0.0081	0.117	0.012	-0.020	-0.023
He vapourisation heat	k_11	-1%	0.0004	0.0073	-0.0501	-0.054	-0.072	-0.057	-0.039
		1%	-0.0004	-0.0072	0.0501	0.054	0.072	0.057	0.039
Stycast comb at TS1	k_17	-90%	-0.0004	-0.0063	-0.1206	0.147	-0.178	-0.079	-0.034
		90%	0.0000	0.0004	0.0066	-0.008	0.010	0.004	0.002
Stycast comb at OBP	k_18	-90%	0.0000	-0.0002	0.0018	-0.014	0.003	0.002	0.001
		90%	0.0000	0.0000	-0.0003	0.000	0.000	0.000	0.000
CVV MLI conductance	k_21	-50%	-0.0029	-0.0335	-0.1640	-0.019	-0.225	-0.365	-0.522
		50%	0.0026	0.0309	0.1500	0.018	0.205	0.334	0.478
Sol. Gen. MLI conduct.	k_22	50%	0.0052	0.0606	0.2846	0.042	0.389	0.645	0.908
Sunshade MLI conduct.	k_23	50%	0.0013	0.0161	0.0609	0.025	0.082	0.176	0.182
Updated HSS MLI def.	-	n/a	-0.0182	-0.1839	-0.8760	-0.170	-1.201	-2.059	-2.722
SVM shield SLI emiss.	k_24	0.03	0.0003	0.0035	0.0188	0.000	0.026	0.041	0.060
CVV strut conductance	k_25	-20%	-0.0042	-0.0490	-0.2427	-0.029	-0.333	-0.538	-0.768
		20%	0.0040	0.0467	0.2265	0.026	0.310	0.503	0.722
HSS strut conductance	k_26	-20%	-0.0014	-0.0160	-0.0768	-0.010	-0.105	-0.174	-0.247
		20%	0.0014	0.0164	0.0786	0.011	0.107	0.178	0.253
CVV ext. harness conductance (=k_28)	k_27	-15%	-0.0018	-0.0204	-0.1003	-0.013	-0.138	-0.210	-0.289
		15%	0.0017	0.0199	0.0975	0.012	0.134	0.204	0.280
Ext. harness dissipation	k_29	-15%	0.0000	-0.0004	-0.0022	0.000	-0.003	-0.004	-0.006
		15%	0.0000	0.0004	0.0023	0.000	0.003	0.005	0.006
Sunshade emissivity	k_32	-0.03	0.0002	0.0020	0.0082	0.003	0.011	0.023	0.025
		0.03	-0.0002	-0.0020	-0.0073	-0.002	-0.010	-0.021	-0.023
Solar Generator emissivity	k_33	-0.03	0.0006	0.0071	0.0338	0.005	0.046	0.076	0.107
		0.03	-0.0006	-0.0066	-0.0316	-0.005	-0.043	-0.072	-0.100
Sunshade OSR absorptivity	k_34	-0.03	-0.0007	-0.0085	-0.0330	-0.012	-0.045	-0.092	-0.100
		0.03	0.0007	0.0083	0.0326	0.012	0.044	0.091	0.098
Solar Generator absorptivity	k_35	-0.03	-0.0006	-0.0069	-0.0329	-0.005	-0.045	-0.075	-0.105
		0.03	0.0006	0.0069	0.0327	0.005	0.045	0.074	0.104
LOU strut conductance	k_38	-20%	-0.0002	-0.0028	-0.0131	-0.001	-0.018	-0.030	-0.042
		20%	0.0002	0.0027	0.0133	0.002	0.018	0.030	0.042
MLI IR specularity	k_30	-20%	0.0026	0.0308	0.1289	0.033	0.178	0.305	0.419
		19%	-0.0027	-0.0320	-0.1436	-0.032	-0.194	-0.330	-0.453
Emissivity of CVV radiator surfaces	k_31	-0.03	0.0010	0.0112	0.0546	0.006	0.076	0.125	0.172
		0.03	-0.0027	-0.0309	-0.1441	-0.026	-0.196	-0.325	-0.456
Telescope M1/M2 emissivity	k_36	-0.005	0.0003	0.0035	0.0156	0.004	0.021	0.037	0.050
		0.005	-0.0002	-0.0026	-0.0115	-0.002	-0.016	-0.027	-0.037
Emissivity of radiating struts	-	-0.03	0.0000	0.0001	-0.0001	0.000	0.000	0.000	0.000
		0.03	0.0000	-0.0003	-0.0015	0.000	-0.002	-0.002	-0.005

Table 6.3-2: In-Orbit Sensitivities for CVV internal elements

	label	variation	CVV [K]	SVM-TS [K]	Telescope [K]	LOU_BP [K]	HTT_Heat [mW]	Lifetime [days]
Reference value			*67.020*	*130.488*	*85.086*	*125.413*	*51.909*	*1465.235*
Overall uncertainty	**pos** **neg**		**1.943** **-4.012**	**2.062** **-5.254**	**4.796** **-15.598**	**2.827** **-7.097**	**3.582** **-5.549**	**152.723** **-89.251**
HTT temp (dp) uncertainty	-	+1.5mbar -1.5mbar						
HTT MLI conductance	k_1	-50% 50%	0.001 0.000	0.000 0.000	0.000 0.000	0.000 0.000	-0.021 0.007	0.575 -0.174
TS1 MLI conductance	k_2a	-50% 50%	0.009 -0.004	0.000 0.000	0.001 -0.001	0.000 0.000	-0.259 0.102	6.781 -2.621
TS2 MLI conductance	k_2b	-50% 50%	0.012 -0.006	0.000 0.000	0.002 -0.001	0.000 0.000	-0.321 0.166	8.409 -4.282
TS3 MLI conductance	k_2c	-50% 50%	0.025 -0.015	0.000 0.000	0.004 -0.002	0.000 0.000	-0.546 0.320	14.282 -8.205
HTT bones	k_3	-20% 20%	0.012 -0.011	0.000 0.000	0.002 -0.002	0.000 0.000	-0.321 0.289	8.434 -7.481
inner tank suspension	k_4	-20% 20%	0.015 -0.013	0.000 0.000	0.002 -0.002	0.000 0.000	-0.400 0.368	10.487 -9.477
TS 1/2 tank susp.	k_5	-20% 20%	0.019 -0.017	0.000 0.000	0.003 -0.003	0.000 0.000	-0.537 0.484	14.164 -12.413
TS 2/3 tank susp.	k_6	-20% 20%	0.021 -0.017	0.000 0.000	0.003 -0.003	0.000 0.000	-0.550 0.463	14.417 -11.885
outer tank suspension	k_7	-20% 20%	0.020 -0.017	0.000 0.000	0.003 -0.002	0.000 0.000	-0.478 0.401	12.496 -10.268
CVV int. harness conductance (=k_9)	k_8	-15% 15%	0.100 -0.096	0.000 0.000	0.015 -0.014	0.001 -0.001	-2.682 2.599	73.374 -64.216
Int. harness dissipation	k_10	-20% 20%	0.002 -0.002	0.000 0.000	0.000 0.000	0.000 0.000	-0.303 0.304	7.912 -7.816
He vapourisation heat	k_11	-1% 1%	-0.005 0.005	0.000 0.000	-0.001 0.001	0.000 0.000	-0.350 0.353	-4.354 4.360
Stycast comb at TS1	k_17	-90% 90%	0.006 0.000	0.000 0.000	0.001 0.000	0.000 0.000	-0.144 0.008	3.800 -0.210
Stycast comb at OBP	k_18	-90% 90%	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	-0.004 0.001	0.115 -0.016
CVV MLI conductance	k_21	-50% 50%	-0.718 0.658	0.022 -0.021	-0.086 0.079	0.005 -0.005	-0.775 0.720	20.382 -18.287
Sol. Gen. MLI conduct.	k_22	50%	1.254	2.012	3.117	2.589	1.412	-35.452
Sunshade MLI conduct.	k_23	50%	0.213	0.094	1.991	0.185	0.374	-9.588
Updated HSS MLI def.	-	n/a	-3.653	-5.188	-15.404	-7.009	-4.289	120.056
SVM shield SLI emiss.	k_24	0.03	0.081	-0.550	0.006	0.008	0.083	-2.114
CVV strut conductance	k_25	-20% 20%	-1.058 0.995	-0.179 0.159	-0.158 0.150	-0.016 0.015	-1.139 1.088	30.075 -27.456

	label	variation	CVV [K]	SVM-TS [K]	Telescope [K]	LOU_BP [K]	HTT_Heat [mW]	Lifetime [days]
HSS strut conductance	k_26	-20% 20%	-0.349 0.358	-0.035 0.029	-0.109 0.102	-0.052 0.044	-0.370 0.383	9.663 -9.787
CVV ext. harness conductance (=k_28)	k_27	-15% 15%	-0.385 0.373	-0.140 0.133	-0.254 0.262	-1.031 1.031	-0.473 0.464	12.328 -11.858
Ext. harness dissipation	k_29	-15% 15%	-0.008 0.008	-0.001 0.001	-0.001 0.001	-0.014 0.014	-0.010 0.011	0.260 -0.254
Sunshade emissivity	k_32	-0.03 0.03	0.030 -0.028	0.012 -0.011	0.239 -0.224	0.023 -0.022	0.048 -0.043	-1.228 1.173
Solar Generator emissivity	k_33	-0.03 0.03	0.148 -0.139	0.230 -0.215	0.367 -0.345	0.298 -0.279	0.166 -0.154	-4.243 3.998
Sunshade OSR absorptivity	k_34	-0.03 0.03	-0.121 0.118	-0.048 0.048	-0.989 0.961	-0.094 0.093	-0.194 0.194	5.105 -4.966
Solar Generator absorptivity	k_35	-0.03 0.03	-0.145 0.144	-0.224 0.223	-0.361 0.356	-0.291 0.289	-0.161 0.161	4.166 -4.113
LOU strut conductance	k_38	-20% 20%	-0.060 0.060	0.000 0.000	-0.009 0.009	0.084 -0.084	-0.062 0.064	1.664 -1.627
MLI IR specularity	k_30	-20% 19%	0.572 -0.618	0.201 -0.424	0.367 -0.230	0.016 -0.008	0.717 -0.742	-18.217 19.461
Emissivity of CVV radiator surfaces	k_31	-0.03 0.03	0.232 -0.627	0.027 -0.234	0.033 -0.170	0.030 0.015	0.261 -0.718	-6.690 18.821
Telescope M1/M2 emissivity	k_36	-0.005 0.005	0.069 -0.051	-0.007 0.006	2.798 -2.135	0.002 0.007	0.083 -0.058	-2.124 1.561
Emissivity of radiating struts	-	-0.03 0.03	0.001 -0.009	-0.046 0.040	0.053 -0.031	0.017 0.000	0.001 -0.008	-0.031 0.206

Table 6.3-3: In-Orbit Sensitivities for CVV external elements (CVV, SVM TS, Tel., LOU)

The case of 25 hours launch delay has also to be taken into account for the lifetime uncertainty. As stated in Table 6.2-1 the launch delay leads to a Helium consumption of 32.6 kg in 40 days compared to 21.5 kg in 29 days for nominal launch. This leads to an additional helium loss of 11.1 kg and a corresponding lifetime loss of 11.1 kg / (2.207 mg/s) -11 days = 47 days.

The overall uncertainty of the lifetime is evaluated using the sum root square of the uncertainty of 47 days due to 25 hours launch delay and the uncertainties shown in Table 6.3-3, leading to

-101 days for the negative sensitivities

+153 days for the positive sensitivities.

	label	variation	SolGen [K]	Sunshade [K]	SolGen_MLI [K]	SSD_MLI [K]
Reference value			***382.464***	***266.074***	***260.710***	***189.326***
Overall uncertainty	**pos** **neg**		**5.083** **-4.920**	**9.626** **-10.610**	**19.759** **-77.320**	**14.868** **-52.195**
CVV MLI conductance	k_21	-50% 50%	0.000 0.000	0.0000 0.0000	0.0057 -0.0053	0.0022 -0.0020
Sol. Gen. MLI conduct.	k_22	50%	-0.579	0.0049	19.4891	0.5793
Sunshade MLI conduct.	k_23	50%	-0.001	-0.3493	0.0763	13.3345
Updated HSS MLI def.	-	n/a	1.238	1.0232	-77.2521	-51.6925
SVM shield SLI emiss.	k_24	0.03	0.000	-0.0001	-0.0666	0.0008
CVV strut conductance	k_25	-20% 20%	0.000 0.000	0.0000 0.0000	-0.0023 0.0020	-0.0007 0.0007
HSS strut conductance	k_26	-20% 20%	0.015 -0.014	-0.0043 0.0047	-0.0159 0.0122	-0.0129 0.0112
CVV ext. harness conductance (=k_28)	k_27	-15% 15%	0.003 -0.003	0.0000 0.0000	-0.0031 0.0028	-0.0017 0.0016
Ext. harness dissipation	k_29	-15% 15%	0.000 0.000	0.0000 0.0000	-0.0001 0.0001	0.0000 0.0000
Sunshade emissivity	k_32	-0.03 0.03	0.007 -0.006	2.3642 -2.2631	0.0139 -0.0131	1.6132 -1.5424
Solar Generator emissivity	k_33	-0.03 0.03	3.543 -3.386	0.0253 -0.0241	2.3316 -2.2262	0.0792 -0.0742
Sunshade OSR absorptivity	k_34	-0.03 0.03	-0.028 0.026	-10.3596 9.2751	-0.0572 0.0553	-7.0597 6.3472
Solar Generator absorptivity	k_35	-0.03 0.03	-3.522 3.427	-0.0253 0.0247	-2.3157 2.2557	-0.0776 0.0770
LOU strut conductance	k_38	-20% 20%	0.000 0.000	0.0000 0.0000	0.0001 -0.0001	0.0000 0.0000
MLI IR specularity	k_30	-20% 19%	0.002 -0.001	0.0010 -0.0004	0.2258 -0.2735	0.1400 -0.0980
Emissivity of CVV radiator surfaces	k_31	-0.03 0.03	0.000 -0.001	-0.0010 -0.0007	-0.0597 -0.1552	-0.0006 -0.0486
Telescope M1/M2 emissivity	k_36	-0.005 0.005	-0.001 0.000	-0.0001 -0.0001	-0.0002 -0.0008	-0.0027 -0.0039
Emissivity of radiating struts	-	-0.03 0.03	-0.001 0.000	-0.0005 -0.0001	-0.0041 -0.0023	-0.0024 -0.0036

Table 6.3-4: In-Orbit Sensitivities for CVV external elements (HSS)

<table>
<tr><th></th><th></th><th>HTT</th><th>mdot</th><th>HOT</th><th>OBA</th><th>TS1</th><th>TS2</th><th>TS3</th></tr>
<tr><td>Reference value</td><td></td><td>1.609</td><td>2.283</td><td>19.601</td><td>12.738</td><td>34.112</td><td>45.228</td><td>54.576</td></tr>
<tr><td>Overall uncertainty</td><td>pos
neg</td><td>0.043
-0.053</td><td>0.154
-0.238</td><td>1.487
-1.663</td><td>0.549
-0.577</td><td>0.878
-1.498</td><td>1.303
-2.460</td><td>1.753
-3.310</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>HTT temp (dp) uncertainty</td><td>+1.5mbar
-1.5mbar</td><td>|||||||||||||
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<tr><td>HTT MLI conductance</td><td>-50%
50%</td><td></td><td></td><td>|</td><td></td><td></td><td></td><td></td></tr>
<tr><td>TS1 MLI conductance</td><td>-50%
50%</td><td></td><td></td><td>|</td><td></td><td>|</td><td>|</td><td></td></tr>
<tr><td>TS2 MLI conductance</td><td>-50%
50%</td><td></td><td>|</td><td>|</td><td></td><td>|</td><td>||
|</td><td>|</td></tr>
<tr><td>TS3 MLI conductance</td><td>-50%
50%</td><td></td><td>||
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<tr><td>HTT bones</td><td>-20% 20%</td><td></td><td>
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<tr><td>inner tank suspension</td><td>-20% 20%</td><td></td><td>
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	</td><td>
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<tr><td>TS 1/2 tank susp.</td><td>-20% 20%</td><td></td><td>	
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<tr><td>TS 2/3 tank susp.</td><td>-20% 20%</td><td></td><td>	
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<tr><td>outer tank suspension</td><td>-20% 20%</td><td></td><td>
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		</td><td>			
			</td></tr>
<tr><td>CVV int. harness conductance (=k_9)</td><td>-15% 15%</td><td>	
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			</td><td>															
													</td><td>					
					</td><td></td><td></td></tr>
<tr><td>Int. harness dissipation</td><td>-20% 20%</td><td></td><td>
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	|</td><td></td><td></td><td></td></tr>
<tr><td>He vapourisation heat</td><td>-1% 1%</td><td></td><td></td><td></td><td>
</td><td></td><td></td><td></td></tr>
<tr><td>Stycast comb at TS1</td><td>-90% 90%</td><td></td><td></td><td>	</td><td>				</td><td>		</td><td></td><td></td></tr>
<tr><td>Stycast comb at OBP</td><td>-90% 90%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CVV MLI conductance</td><td>-50% 50%</td><td></td><td>	
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<tr><td>Sol. Gen. MLI conduct.</td><td>50%</td><td>	</td><td>					</td><td>			</td><td>	</td><td>					</td><td>					</td><td>					</td></tr>
<tr><td>Sunshade MLI conduct.</td><td>50%</td><td></td><td>	</td><td></td><td></td><td>	</td><td>	</td><td>	</td></tr>
<tr><td>Updated HSS MLI def.</td><td>n/a</td><td>|||||</td><td>||||||||||||||||</td><td>|||||||||||</td><td>|||||</td><td>||||||||||||||||</td><td>||||||||||||||||</td><td>||||||||||||||||</td></tr>
<tr><td>SVM shield SLI emiss.</td><td>0.03</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CVV strut conductance</td><td>-20% 20%</td><td>
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<tr><td>HSS strut conductance</td><td>-20%</td><td></td><td>|</td><td>|</td><td></td><td>|</td><td>|</td><td>|</td></tr>
</table>

<table>
<tr><th></th><th></th><th>HTT</th><th>mdot</th><th>HOT</th><th>OBA</th><th>TS1</th><th>TS2</th><th>TS3</th></tr>
<tr><td></td><td>20%</td><td></td><td>|</td><td>|</td><td></td><td>|</td><td>|</td><td>|</td></tr>
<tr><td>CVV ext. harness conductance (=k_28)</td><td>-15%
15%</td><td></td><td>|
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<tr><td>Ext. harness dissipation</td><td>-15%
15%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sunshade emissivity</td><td>-0.03
0.03</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Solar Generator emissivity</td><td>-0.03
0.03</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sunshade OSR absorptivity</td><td>-0.03
0.03</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Solar generator absorptivity</td><td>-0.03
0.03</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>LOU strut conductance</td><td>-20%
20%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>MLI IR specularity</td><td>-20%
19%</td><td></td><td>||
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<tr><td>Emissivity of CVV radiator surfaces</td><td>-0.03 0.03</td><td></td><td> 		</td><td> 	</td><td></td><td>
	</td><td> 		</td><td>
	</td></tr>
<tr><td>Telescope M1/M2 emissivity</td><td>-0.005
0.005</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Emissivity of radiating struts</td><td>-0.03
0.03</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Table 6.3-5: Graphical representation of In-Orbit Sensitivities for CVV internal elements

<table>
<tr><th></th><th></th><th>CVV</th><th>SVM-TS</th><th>Telescope</th><th>LOU_BP</th><th>HTT_Heat</th></tr>
<tr><td>Reference value</td><td></td><td>67.020</td><td>130.488</td><td>85.086</td><td>125.413</td><td>51.909</td></tr>
<tr><td>Overall uncertainty</td><td>pos
neg</td><td>1.943
-4.012</td><td>2.062
-5.254</td><td>4.796
-15.598</td><td>2.827
-7.097</td><td>3.582
-5.549</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>HTT temp (dp) uncertainty</td><td>+1.5mbar
-1.5mbar</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>HTT MLI conductance</td><td>-50%
50%</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>TS1 MLI conductance</td><td>-50%
50%</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>TS2 MLI conductance</td><td>-50%
50%</td><td></td><td></td><td></td><td></td><td>|</td></tr>
<tr><td>TS3 MLI conductance</td><td>-50%
50%</td><td></td><td></td><td></td><td></td><td>||
|</td></tr>
<tr><td>HTT bones</td><td>-20%
20%</td><td></td><td></td><td></td><td></td><td>|
|</td></tr>
</table>

<table>
<tr><th></th><th></th><th>CVV</th><th>SVM-TS</th><th>Telescope</th><th>LOU_BP</th><th>HTT_Heat</th></tr>
<tr><td>inner tank suspension</td><td>-20%
20%</td><td></td><td></td><td></td><td></td><td>|
|</td></tr>
<tr><td>TS 1/2 tank susp.</td><td>-20%
20%</td><td></td><td></td><td></td><td></td><td>||
|</td></tr>
<tr><td>TS 2/3 tank susp.</td><td>-20%
20%</td><td></td><td></td><td></td><td></td><td>||
|</td></tr>
<tr><td>outer tank suspension</td><td>-20%
20%</td><td></td><td></td><td></td><td></td><td>|
|</td></tr>
<tr><td>CVV int. harness conductance (=k_9)</td><td>-15%
15%</td><td></td><td></td><td></td><td></td><td>||||||||||
|||||||||</td></tr>
<tr><td>Int. harness dissipation</td><td>-20%
20%</td><td></td><td></td><td></td><td></td><td>|
|</td></tr>
<tr><td>He vapourisation heat</td><td>-1%
1%</td><td></td><td></td><td></td><td></td><td>|
|</td></tr>
<tr><td>Stycast comb at TS1</td><td>-90%
90%</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Stycast comb at OBP</td><td>-90%
90%</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CVV MLI conductance</td><td>-50%
50%</td><td>|||
||</td><td></td><td></td><td></td><td>||
||</td></tr>
<tr><td>Sol. Gen. MLI conduct.</td><td>50%</td><td>|||||</td><td>||||||</td><td>|||</td><td>|||||</td><td>|||||</td></tr>
<tr><td>Sunshade MLI conduct.</td><td>50%</td><td></td><td></td><td>||</td><td></td><td>|</td></tr>
<tr><td>Updated HSS MLI def.</td><td>n/a</td><td>||||||||||||||||</td><td>||||||||||||||||</td><td>||||||||||||||||</td><td>||||||||||||||||</td><td>||||||||||||||||</td></tr>
<tr><td>SVM shield SLI emiss.</td><td>0.03</td><td></td><td>|</td><td></td><td></td><td></td></tr>
<tr><td>CVV strut conductance</td><td>-20%
20%</td><td>||||
||||</td><td></td><td></td><td></td><td>||||
||||</td></tr>
<tr><td>HSS strut conductance</td><td>-20%
20%</td><td>|
|</td><td></td><td></td><td></td><td>|
|</td></tr>
<tr><td>CVV ext. harness conductance (=k_28)</td><td>-15%
15%</td><td>|
|</td><td></td><td></td><td>||
||</td><td>|
|</td></tr>
<tr><td>Ext. harness dissipation</td><td>-15%
15%</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sunshade emissivity</td><td>-0.03
0.03</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Solar Generator emissivity</td><td>-0.03
0.03</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sunshade OSR absorptivity</td><td>-0.03
0.03</td><td></td><td></td><td>|</td><td></td><td></td></tr>
<tr><td>Solar generator absorptivity</td><td>-0.03
0.03</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>LOU strut conductance</td><td>-20%
20%</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>MLI IR specularity</td><td>-20%
19%</td><td>||
||</td><td>|</td><td></td><td></td><td>||
||</td></tr>
</table>

		CVV	SVM-TS	Telescope	LOU_BP	HTT_Heat
Emissivity of CVV radiator surfaces	-0.03 0.03	| ||				 ||
Telescope M1/M2 emissivity	-0.005 0.005			|| ||		
Emissivity of radiating struts	-0.03 0.03					

Table 6.3-6: Graphical representation of In-Orbit Sensitivities for CVV external elements (CVV, SVM TS, Tel., LOU)

	label	Vari-ation	L0 724	723	761	762	814	815	816	949
Reference value			***1.630***	***1.635***	***1.634***	***1.616***	***1.629***	***1.653***	***1.613***	***1.896***
Overall uncertainty	**pos** **neg**		**0.043** **-0.053**	**0.043** **-0.053**	**0.043** **-0.053**	**0.043** **-0.053**	**0.044** **-0.053**	**0.043** **-0.053**	**0.043** **-0.053**	**0.052** **-0.061**
HTT temp (dp) uncertainty	-	+1.5mbar -1.5mbar	0.0419 -0.0486	0.0419 -0.0486	0.0419 -0.0486	0.0419 -0.0486	0.0419 -0.0486	0.0419 -0.0486	0.0419 -0.0486	0.0419 -0.0486
HTT MLI conductance	k_1	-50% 50%	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	-0.0001 0.0000	0.0000 0.0000	0.0000 0.0000	-0.0001 0.0000	0.0004 -0.0001
TS1 MLI conductance	k_2a	-50% 50%	-0.0006 0.0002	-0.0006 0.0002	-0.0006 0.0002	-0.0007 0.0003	-0.0005 0.0002	-0.0005 0.0002	-0.0007 0.0003	0.0009 -0.0003
TS2 MLI conductance	k_2b	-50% 50%	-0.0009 0.0004	-0.0009 0.0004	-0.0009 0.0005	-0.0009 0.0005	-0.0008 0.0004	-0.0009 0.0004	-0.0009 0.0005	-0.0008 0.0004
TS3 MLI conductance	k_2c	-50% 50%	-0.0017 0.0010	-0.0017 0.0010	-0.0018 0.0010	-0.0018 0.0011	-0.0017 0.0010	-0.0017 0.0010	-0.0018 0.0011	-0.0014 0.0008
HTT bones	k_3	-20% 20%	-0.0004 0.0004	-0.0004 0.0004	-0.0007 0.0006	-0.0007 0.0007	0.0000 0.0001	-0.0003 0.0003	-0.0007 0.0007	0.0087 -0.0077
inner tank suspension	k_4	-20% 20%	-0.0009 0.0008	-0.0009 0.0008	-0.0010 0.0009	-0.0010 0.0009	-0.0008 0.0008	-0.0009 0.0008	-0.0010 0.0009	-0.0004 0.0005
TS 1/2 tank susp.	k_5	-20% 20%	-0.0012 0.0010	-0.0012 0.0010	-0.0013 0.0012	-0.0014 0.0012	-0.0010 0.0009	-0.0011 0.0010	-0.0014 0.0012	0.0019 -0.0017
TS 2/3 tank susp.	k_6	-20% 20%	-0.0015 0.0012	-0.0015 0.0012	-0.0015 0.0013	-0.0016 0.0013	-0.0014 0.0012	-0.0014 0.0012	-0.0016 0.0013	-0.0011 0.0009
outer tank suspension	k_7	-20% 20%	-0.0015 0.0012	-0.0015 0.0012	-0.0015 0.0013	-0.0016 0.0013	-0.0014 0.0012	-0.0015 0.0012	-0.0016 0.0013	-0.0012 0.0010
CVV int. harness conductance (=k_9)	k_8	-15% 15%	-0.0079 0.0076	-0.0079 0.0076	-0.0076 0.0073	-0.0078 0.0074	-0.0084 0.0081	-0.0080 0.0076	-0.0078 0.0074	-0.0280 0.0270
Int. harness dissipation	k_10	-20% 20%	-0.0011 0.0011	-0.0011 0.0011	-0.0009 0.0009	-0.0009 0.0009	-0.0013 0.0013	-0.0011 0.0011	-0.0009 0.0009	-0.0064 0.0064
He vapourisation heat	k_11	-1% 1%	0.0003 -0.0003	0.0003 -0.0003	0.0004 -0.0004	0.0004 -0.0004	0.0002 -0.0002	0.0003 -0.0003	0.0004 -0.0004	-0.0025 0.0025
Stycast comb at	k_17	-90%	-0.0002	-0.0002	-0.0003	-0.0004	0.0001	-0.0001	-0.0004	0.0070

	label	Variation	L0							
			724	723	761	762	814	815	816	949
TS1		90%	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0004
Stycast comb at OBP	k_18	-90%	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0005
		90%	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
CVV MLI conductance	k_21	-50%	-0.0028	-0.0028	-0.0028	-0.0029	-0.0027	-0.0027	-0.0029	-0.0027
		50%	0.0026	0.0025	0.0026	0.0026	0.0025	0.0025	0.0026	0.0025
Sol. Gen. MLI conduct.	k_22	50%	0.0051	0.0051	0.0050	0.0052	0.0051	0.0050	0.0052	0.0055
Sunshade MLI conduct.	k_23	50%	0.0015	0.0014	0.0013	0.0013	0.0015	0.0014	0.0013	0.0025
Updated HSS MLI definition	-	n/a	-0.0183	-0.0181	-0.0177	-0.0182	-0.0183	-0.0178	-0.0182	-0.0214
SVM shld SLI emis.	k_24	0.03	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
CVV strut conductance	k_25	-20%	-0.0041	-0.0041	-0.0041	-0.0042	-0.0040	-0.0040	-0.0042	-0.0040
		20%	0.0039	0.0039	0.0039	0.0040	0.0038	0.0038	0.0040	0.0038
HSS strut conductance	k_26	-20%	-0.0013	-0.0013	-0.0013	-0.0014	-0.0013	-0.0013	-0.0014	-0.0014
		20%	0.0014	0.0014	0.0014	0.0014	0.0014	0.0013	0.0014	0.0014
CVV ext. harness conduct. (=k_28)	k_27	-15%	-0.0017	-0.0017	-0.0017	-0.0017	-0.0017	-0.0017	-0.0017	-0.0017
		15%	0.0017	0.0016	0.0016	0.0017	0.0016	0.0016	0.0017	0.0016
Ext. harness dissipation	k_29	-15%	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		15%	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sunshade emissivity	k_32	-0.03	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003
		0.03	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0003
Solar generator emissivity	k_33	-0.03	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
		0.03	-0.0006	-0.0006	-0.0006	-0.0006	-0.0006	-0.0005	-0.0006	-0.0006
Sunshade OSR absorptivity	k_34	-0.03	-0.0008	-0.0008	-0.0007	-0.0007	-0.0008	-0.0007	-0.0007	-0.0012
		0.03	0.0007	0.0007	0.0007	0.0007	0.0008	0.0007	0.0007	0.0012
Solar Generator absorptivity	k_35	-0.03	-0.0006	-0.0006	-0.0006	-0.0006	-0.0006	-0.0006	-0.0006	-0.0006
		0.03	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
LOU strut conductance	k_38	-20%	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002
		20%	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
MLI IR specularity	k_30	-20%	0.0027	0.0027	0.0026	0.0026	0.0028	0.0026	0.0026	0.0037
		19%	-0.0028	-0.0028	-0.0027	-0.0027	-0.0028	-0.0027	-0.0027	-0.0036
Emissivity of CVV radiator surfaces	k_31	-0.03	0.0010	0.0009	0.0010	0.0010	0.0009	0.0009	0.0010	0.0009
		0.03	-0.0027	-0.0027	-0.0026	-0.0027	-0.0027	-0.0026	-0.0027	-0.0031
Telescope M1/M2 emissivity	k_36	-0.005	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004
		0.005	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0002	-0.0003
Emissivity of radiating struts	-	-0.03	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		0.03	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 6.3-7: In-Orbit Sensitivities for Instrument Interface nodes – Level 0

	label	Vari- ation	L1					L2			
			781	782	783	800	939	371	381	315	919
Reference value			***2.654***	***2.988***	***3.143***	***4.663***	***5.530***	***12.729***	***12.769***	***12.749***	***12.730***
Overall uncertainty	**pos** **neg**		**0.066** **-0.071**	**0.078** **-0.082**	**0.084** **-0.090**	**0.162** **-0.155**	**0.216** **-0.193**	**0.551** **-0.579**	**0.552** **-0.581**	**0.551** **-0.580**	**0.548** **-0.577**
HTT temp (dp) uncertainty	-	+1.5mbar -1.5mbar	0.042 -0.049	0.042 -0.049	0.042 -0.049	0.042 -0.049	0.042 -0.049	0.042 -0.049	0.042 -0.049	0.042 -0.049	0.042 -0.049
HTT MLI conductance	k_1	-50% 50%	0.001 0.000	0.002 -0.001	0.002 -0.001	0.004 -0.001	0.006 -0.002	0.010 -0.003	0.010 -0.003	0.010 -0.003	0.010 -0.003
TS1 MLI conductance	k_2a	-50% 50%	0.007 -0.003	0.010 -0.004	0.010 -0.004	0.021 -0.008	0.027 -0.010	0.022 -0.008	0.022 -0.008	0.022 -0.008	0.022 -0.008
TS2 MLI conductance	k_2b	-50% 50%	0.002 -0.001	0.003 -0.001	0.003 -0.001	0.006 -0.003	0.009 -0.005	-0.007 0.004	-0.007 0.004	-0.007 0.004	-0.007 0.004
TS3 MLI conductance	k_2c	-50% 50%	0.004 -0.002	0.005 -0.003	0.005 -0.003	0.011 -0.006	0.018 -0.010	-0.009 0.005	-0.010 0.005	-0.009 0.005	-0.009 0.005
HTT bones	k_3	-20% 20%	0.025 -0.022	0.032 -0.028	0.034 -0.030	0.076 -0.067	0.107 -0.095	0.183 -0.165	0.182 -0.164	0.183 -0.165	0.181 -0.163
inner tank suspension	k_4	-20% 20%	0.008 -0.007	0.011 -0.009	0.011 -0.009	0.020 -0.017	0.024 -0.021	-0.002 0.004	-0.002 0.004	-0.001 0.004	-0.001 0.004
TS 1/2 tank susp.	k_5	-20% 20%	0.016 -0.013	0.021 -0.018	0.022 -0.019	0.043 -0.038	0.057 -0.050	0.048 -0.042	0.048 -0.042	0.048 -0.042	0.048 -0.042
TS 2/3 tank susp.	k_6	-20% 20%	0.005 -0.004	0.006 -0.005	0.006 -0.005	0.013 -0.010	0.020 -0.017	-0.007 0.005	-0.007 0.006	-0.007 0.006	-0.007 0.005
outer tank suspension	k_7	-20% 20%	0.003 -0.003	0.005 -0.004	0.005 -0.004	0.010 -0.008	0.016 -0.013	-0.008 0.006	-0.008 0.007	-0.008 0.006	-0.008 0.006
CVV int. harness conduct. (=k_9)	k_8	-15% 15%	-0.023 0.025	-0.028 0.031	-0.034 0.037	-0.092 0.094	-0.129 0.125	-0.504 0.471	-0.505 0.472	-0.505 0.472	-0.502 0.469
Int. harness dissipation	k_10	-20% 20%	-0.017 0.017	-0.022 0.022	-0.024 0.024	-0.041 0.040	-0.053 0.053	-0.119 0.118	-0.118 0.116	-0.118 0.117	-0.118 0.117
He vapourisation heat	k_11	-1% 1%	-0.009 0.009	-0.011 0.011	-0.012 0.012	-0.025 0.026	-0.036 0.036	-0.054 0.055	-0.054 0.054	-0.054 0.055	-0.054 0.054
Stycast comb at TS1	k_17	-90% 90%	0.016 -0.001	0.021 -0.001	0.022 -0.001	0.053 -0.003	0.077 -0.004	0.148 -0.008	0.147 -0.008	0.147 -0.008	0.146 -0.008
Stycast comb at OBP	k_18	-90% 90%	0.001 0.000	0.001 0.000	0.001 0.000	0.006 0.000	0.002 0.000	-0.003 -0.008	-0.013 0.000	-0.013 0.000	-0.015 0.001
CVV MLI conductance	k_21	-50% 50%	0.002 -0.002	0.003 -0.002	0.002 -0.002	0.007 -0.006	0.017 -0.015	-0.019 0.018	-0.020 0.019	-0.019 0.018	-0.019 0.018
Sol. Gen. MLI conduct.	k_22	50%	0.002	0.002	0.003	0.001	-0.017	0.041	0.043	0.042	0.042
Sunshade MLI conduct.	k_23	50%	0.012	0.016	0.018	0.029	0.023	0.025	0.025	0.025	0.025
Updated HSS	-	n/a	-0.030	-0.038	-0.047	-0.062	-0.006	-0.169	-0.174	-0.172	-0.171

	label	Variation	L1					L2			
			781	782	783	800	939	371	381	315	919
MLI definition											
SVM shld SLI emis.	k_24	0.03	0.000	-0.001	-0.001	-0.002	-0.003	0.000	0.000	0.000	0.000
CVV strut conductance	k_25	-20%	0.004	0.005	0.004	0.011	0.025	-0.028	-0.030	-0.029	-0.029
		20%	-0.003	-0.004	-0.003	-0.010	-0.023	0.026	0.027	0.027	0.027
HSS strut conductance	k_26	-20%	0.000	0.001	0.000	0.002	0.006	-0.010	-0.010	-0.010	-0.010
		20%	0.000	-0.001	0.000	-0.002	-0.006	0.010	0.011	0.011	0.011
CVV ext. harness conduct. (=k_28)	k_27	-15%	0.002	0.002	0.002	0.005	0.010	-0.012	-0.013	-0.013	-0.013
		15%	-0.001	-0.002	-0.002	-0.005	-0.010	0.012	0.013	0.012	0.012
Ext. harness dissipation	k_29	-15%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		15%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sunshade emissivity	k_32	-0.03	0.001	0.002	0.002	0.003	0.002	0.003	0.003	0.003	0.003
		0.03	-0.001	-0.002	-0.002	-0.003	-0.002	-0.002	-0.002	-0.002	-0.002
Solar generator emissivity	k_33	-0.03	0.000	0.000	0.000	0.000	-0.002	0.005	0.005	0.005	0.005
		0.03	0.000	0.000	0.000	0.000	0.002	-0.005	-0.005	-0.005	-0.005
Sunshade OSR absorptivity	k_34	-0.03	-0.005	-0.007	-0.008	-0.013	-0.010	-0.012	-0.012	-0.012	-0.012
		0.03	0.005	0.007	0.008	0.013	0.010	0.012	0.012	0.012	0.012
Solar Generator absorptivity	k_35	-0.03	0.000	0.000	0.000	0.000	0.002	-0.005	-0.005	-0.005	-0.005
		0.03	0.000	0.000	0.000	0.000	-0.002	0.005	0.005	0.005	0.005
LOU strut conductance	k_38	-20%	0.000	0.000	0.000	0.001	0.001	-0.001	-0.002	-0.001	-0.001
		20%	0.000	0.000	0.000	0.000	-0.001	0.002	0.002	0.002	0.002
MLI IR specularity	k_30	-20%	0.011	0.014	0.016	0.023	0.014	0.032	0.033	0.033	0.033
		19%	-0.008	-0.011	-0.012	-0.017	-0.007	-0.032	-0.032	-0.032	-0.032
Emissivity of CVV radiator surfaces	k_31	-0.03	0.000	-0.001	0.000	-0.001	-0.005	0.006	0.007	0.006	0.006
		0.03	-0.004	-0.005	-0.007	-0.005	0.003	-0.025	-0.026	-0.026	-0.026
Telescope M1/M2 emissivity	k_36	-0.005	0.001	0.001	0.001	0.002	0.001	0.004	0.004	0.004	0.004
		0.005	0.000	0.000	0.000	-0.001	0.000	-0.002	-0.002	-0.002	-0.002
Emissivity of radiating struts	-	-0.03	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		0.03	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 6.3-8: In-Orbit Sensitivities for Instrument Interface nodes – Level 1 & 2

	label	variation	L3 831	L3 832	LOU 4201	Telescope 8001	Telescope 8050	mdot 5900
Reference value			***13.366***	***13.412***	***125.362***	***85.094***	***82.494***	***2.283***
Overall uncertainty	**pos** **neg**		**0.536** **-0.554**	**0.536** **-0.553**	**2.825** **-7.096**	**4.796** **-15.603**	**4.204** **-14.428**	**0.154** **-0.238**
HTT temp (dp) uncertainty	-	+1.5mbar -1.5mbar	0.042 -0.049	0.042 -0.049	0 0	0 0	0 0	0 0
HTT MLI conductance	k_1	-50% 50%	0.009 -0.003	0.009 -0.003	0.0000 0.0000	0.0001 0.0000	0.0001 0.0000	-0.001 0.000
TS1 MLI conductance	k_2a	-50% 50%	0.023 -0.009	0.023 -0.009	0.0001 0.0000	0.0014 -0.0006	0.0012 -0.0005	-0.011 0.004
TS2 MLI conductance	k_2b	-50% 50%	-0.006 0.003	-0.006 0.003	0.0001 -0.0001	0.0018 -0.0009	0.0015 -0.0008	-0.014 0.007
TS3 MLI conductance	k_2c	-50% 50%	-0.007 0.004	-0.007 0.004	0.0003 -0.0002	0.0041 -0.0024	0.0034 -0.0020	-0.024 0.014
HTT bones	k_3	-20% 20%	0.179 -0.162	0.178 -0.161	0.0001 -0.0001	0.0018 -0.0016	0.0015 -0.0014	-0.014 0.013
inner tank suspension	k_4	-20% 20%	0.004 0.000	0.004 0.000	0.0002 -0.0002	0.0022 -0.0020	0.0019 -0.0017	-0.017 0.016
TS 1/2 tank susp.	k_5	-20% 20%	0.051 -0.045	0.051 -0.045	0.0002 -0.0002	0.0030 -0.0027	0.0025 -0.0023	-0.023 0.021
TS 2/3 tank susp.	k_6	-20% 20%	-0.004 0.003	-0.004 0.003	0.0002 -0.0002	0.0030 -0.0025	0.0025 -0.0021	-0.024 0.020
outer tank suspension	k_7	-20% 20%	-0.006 0.004	-0.006 0.004	0.0002 -0.0002	0.0029 -0.0025	0.0025 -0.0021	-0.021 0.017
CVV int. harness conductance (=k_9)	k_8	-15% 15%	-0.488 0.460	-0.487 0.460	0.0012 -0.0011	0.0150 -0.0145	0.0126 -0.0122	-0.116 0.112
Int. harness dissipation	k_10	-20% 20%	-0.112 0.110	-0.111 0.110	0.0000 0.0000	0.0003 -0.0003	0.0003 -0.0003	-0.013 0.013
He vapourisation heat	k_11	-1% 1%	-0.054 0.054	-0.053 0.054	-0.0001 0.0001	-0.0007 0.0007	-0.0006 0.0006	0.007 -0.007
Stycast comb at TS1	k_17	-90% 90%	0.143 -0.008	0.143 -0.008	0.0001 0.0000	0.0008 0.0000	0.0007 0.0000	-0.006 0.000
Stycast comb at OBP	k_18	-90% 90%	-0.013 0.000	-0.013 0.000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.000 0.000
CVV MLI conductance	k_21	-50% 50%	-0.015 0.014	-0.015 0.014	0.0050 -0.0047	-0.0859 0.0795	-0.0721 0.0667	-0.033 0.031
Sol. Gen. MLI conduct.	k_22	50%	0.034	0.034	2.5876	3.1178	2.6139	0.061
Sunshade MLI conduct.	k_23	50%	0.023	0.022	0.1845	1.9918	2.0076	0.016
Updated HSS MLI definition	-	n/a	-0.144	-0.144	-7.0076	-15.4088	-14.2672	-0.184

	label	variation	L3 831	L3 832	LOU 4201	Telescope 8001	Telescope 8050	mdot 5900
SVM shld SLI emis.	k_24	0.03	0.000	0.000	0.0079	0.0056	0.0084	0.004
CVV strut conductance	k_25	-20%	-0.023	-0.023	-0.0160	-0.1578	-0.1328	-0.049
		20%	0.021	0.021	0.0149	0.1503	0.1264	0.047
HSS strut conductance	k_26	-20%	-0.008	-0.008	-0.0525	-0.1090	-0.0919	-0.016
		20%	0.008	0.009	0.0442	0.1019	0.0858	0.016
CVV ext. harness conduct. (=k_28)	k_27	-15%	-0.010	-0.010	-1.0300	-0.2532	-0.2200	-0.020
		15%	0.010	0.010	1.0295	0.2610	0.2266	0.020
Ext. harness dissipation	k_29	-15%	0.000	0.000	-0.0142	-0.0014	-0.0012	0.000
		15%	0.000	0.000	0.0142	0.0014	0.0012	0.000
Sunshade emissivity	k_32	-0.03	0.003	0.003	0.0232	0.2390	0.2394	0.002
		0.03	-0.002	-0.002	-0.0217	-0.2245	-0.2249	-0.002
Solar generator emissivity	k_33	-0.03	0.004	0.004	0.2980	0.3670	0.3097	0.007
		0.03	-0.004	-0.004	-0.2792	-0.3455	-0.2920	-0.007
Sunshade OSR absorptivity	k_34	-0.03	-0.010	-0.010	-0.0938	-0.9898	-0.9934	-0.008
		0.03	0.011	0.011	0.0933	0.9615	0.9641	0.008
Solar Generator absorptivity	k_35	-0.03	-0.004	-0.004	-0.2907	-0.3606	-0.3048	-0.007
		0.03	0.004	0.004	0.2886	0.3563	0.3007	0.007
LOU strut conductance	k_38	-20%	-0.001	-0.001	0.0842	-0.0090	-0.0075	-0.003
		20%	0.002	0.002	-0.0838	0.0089	0.0075	0.003
MLI IR specularity	k_30	-20%	0.028	0.028	0.0163	0.3677	0.3672	0.031
		19%	-0.027	-0.027	-0.0080	-0.2298	-0.2311	-0.032
Emissivity of CVV radiator surfaces	k_31	-0.03	0.005	0.005	0.0302	0.0327	0.0284	0.011
		0.03	-0.022	-0.022	0.0153	-0.1703	-0.1602	-0.031
Telescope M1/M2 emissivity	k_36	-0.005	0.003	0.003	0.0017	2.7966	2.3282	0.004
		0.005	-0.002	-0.002	0.0074	-2.1343	-1.7998	-0.003
Emissivity of radiating struts	-	-0.03	0.000	0.000	0.0170	0.0524	0.0438	0.000
		0.03	0.000	0.000	0.0004	-0.0313	-0.0295	0.000

Table 6.3-9: In-Orbit Sensitivities for Level 3 Instrument Interface nodes, LOU and Telescope

<table>
<tr><th></th><th></th><th colspan="8">L0</th></tr>
<tr><th></th><th>label</th><th>724</th><th>723</th><th>761</th><th>762</th><th>814</th><th>815</th><th>816</th><th>949</th></tr>
<tr><td>Reference value</td><td></td><td>1.630</td><td>1.635</td><td>1.634</td><td>1.616</td><td>1.629</td><td>1.653</td><td>1.613</td><td>1.896</td></tr>
<tr><td>Overall uncertainty</td><td>pos
neg</td><td>0.043
-0.053</td><td>0.043
-0.053</td><td>0.043
-0.053</td><td>0.043
-0.053</td><td>0.044
-0.053</td><td>0.043
-0.053</td><td>0.043
-0.053</td><td>0.052
-0.061</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>HTT temp (dp) uncertainty</td><td>+1.5mbar
-1.5mbar</td><td>||||||||||||
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<tr><td>HTT MLI conductance</td><td>-50% 50%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>TS1 MLI conductance</td><td>-50% 50%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>TS2 MLI conductance</td><td>-50% 50%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>TS3 MLI conductance</td><td>-50% 50%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>HTT bones</td><td>-20% 20%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>	
	</td></tr>
<tr><td>inner tank suspension</td><td>-20% 20%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>TS 1/2 tank susp.</td><td>-20% 20%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>TS 2/3 tank susp.</td><td>-20% 20%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>outer tank suspension</td><td>-20% 20%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CVV int. harness conduct. (=k_9)</td><td>-15% 15%</td><td>	
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						</td></tr>
<tr><td>Int. harness dissipation</td><td>-20% 20%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>
</td></tr>
<tr><td>He vapourisation heat</td><td>-1%
1%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Stycast comb at TS1</td><td>-90%
90%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>||</td></tr>
<tr><td>Stycast comb at OBP</td><td>-90%
90%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CVV MLI conductance</td><td>-50%
50%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sol. Gen. MLI conduct.</td><td>50%</td><td>|</td><td>|</td><td>|</td><td>|</td><td>|</td><td>|</td><td>|</td><td>|</td></tr>
<tr><td>Sunshade MLI conduct.</td><td>50%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Updated HSS</td><td>n/a</td><td>|||||</td><td>|||||</td><td>|||||</td><td>|||||</td><td>|||||</td><td>|||||</td><td>|||||</td><td>||||||</td></tr>
</table>

		L0							
	label	724	723	761	762	814	815	816	949
MLI definition									
SVM shield SLI emiss.	0.03								
CVV strut conductance	-20% 20%	| |	| |	| |	| |	| |	| |	| |	| |
HSS strut conductance	-20% 20%								
CVV ext. harness conduct. (=k_28)	-15% 15%								
Ext. harness dissipation	-15% 15%								
Sunshade emissivity	-0.03 0.03								
Solar generator emissivity	-0.03 0.03								
Sunshade OSR absorptivity	-0.03 0.03								
Solar Generator absorptivity	-0.03 0.03								
LOU strut conductance	-20% 20%								
MLI IR specularity	-20% 19%								| |
Emissivity of CVV rad. surfaces	-0.03 0.03								
Telescope M1/M2 emissivity	-0.005 0.005								
Emissivity of radiating struts	-0.03 0.03								

Table 6.3-10: Graphical representation of In-Orbit Sensitivities for Instrument Interface nodes – Level 0

	label	L1 781	 782	 783	 800	 939	L2 371	 381	 315	 919
Reference value		***2.654***	***2.988***	***3.143***	***4.663***	***5.530***	***12.729***	***12.769***	***12.749***	***12.730***
Overall uncertainty	**pos** **neg**	**0.066** **-0.071**	**0.078** **-0.082**	**0.084** **-0.090**	**0.162** **-0.155**	**0.216** **-0.193**	**0.551** **-0.579**	**0.552** **-0.581**	**0.551** **-0.580**	**0.548** **-0.577**
HTT temp (dp) uncertainty	+1.5mbar -1.5mbar	¦¦¦¦¦¦¦¦¦¦¦¦ ¦¦¦¦¦¦¦¦¦¦¦¦¦¦	¦¦¦¦¦¦¦¦¦¦¦¦ ¦¦¦¦¦¦¦¦¦¦¦¦¦¦	¦¦¦¦¦¦¦¦¦¦¦¦ ¦¦¦¦¦¦¦¦¦¦¦¦¦¦	¦¦¦¦¦¦ ¦¦¦¦¦¦¦	¦¦¦¦ ¦¦¦¦¦	¦ ¦	¦ ¦	¦ ¦	¦ ¦
HTT MLI conductance	-50% 50%									
TS1 MLI conductance	-50% 50%	¦¦	¦¦ ¦	¦¦ ¦	¦¦¦ ¦	¦¦ ¦				
TS2 MLI conductance	-50% 50%					¦				
TS3 MLI conductance	-50% 50%	¦	¦	¦	¦	¦ ¦				
HTT bones	-20% 20%	¦¦¦¦¦¦¦ ¦¦¦¦¦¦	¦¦¦¦¦¦¦¦¦ ¦¦¦¦¦¦¦¦	¦¦¦¦¦¦¦¦¦ ¦¦¦¦¦¦¦¦	¦¦¦¦¦¦¦¦¦¦¦ ¦¦¦¦¦¦¦¦¦	¦¦¦¦¦¦¦¦¦¦¦ ¦¦¦¦¦¦¦¦¦¦	¦¦¦¦¦ ¦¦¦¦	¦¦¦¦¦ ¦¦¦¦	¦¦¦¦¦ ¦¦¦¦	¦¦¦¦¦ ¦¦¦¦
inner tank suspension	-20% 20%	¦¦ ¦¦	¦¦¦ ¦¦	¦¦¦ ¦¦	¦¦ ¦¦	¦¦ ¦¦				
TS 1/2 tank susp.	-20% 20%	¦¦¦¦ ¦¦¦	¦¦¦¦¦ ¦¦¦¦¦	¦¦¦¦¦¦ ¦¦¦¦¦	¦¦¦¦¦¦ ¦¦¦¦¦	¦¦¦¦¦¦ ¦¦¦¦¦	¦ ¦	¦ ¦	¦ ¦	¦ ¦
TS 2/3 tank susp.	-20% 20%	¦ ¦	¦ ¦	¦ ¦	¦ ¦	¦¦ ¦				
outer tank suspension	-20% 20%	¦	¦ ¦	¦ ¦	¦ ¦	¦ ¦				
CVV int. harness conduct. (=k_9)	-15% 15%	¦¦¦¦¦¦ ¦¦¦¦¦¦¦	¦¦¦¦¦¦¦¦ ¦¦¦¦¦¦¦¦	¦¦¦¦¦¦¦¦¦ ¦¦¦¦¦¦¦¦¦¦	¦¦¦¦¦¦¦¦¦¦¦¦¦ ¦¦¦¦¦¦¦¦¦¦¦¦¦¦	¦¦¦¦¦¦¦¦¦¦¦¦¦¦ ¦¦¦¦¦¦¦¦¦¦¦¦¦	¦¦¦¦¦¦¦¦¦¦¦¦¦¦ ¦¦¦¦¦¦¦¦¦¦¦¦¦	¦¦¦¦¦¦¦¦¦¦¦¦¦¦ ¦¦¦¦¦¦¦¦¦¦¦¦¦	¦¦¦¦¦¦¦¦¦¦¦¦¦¦ ¦¦¦¦¦¦¦¦¦¦¦¦¦	¦¦¦¦¦¦¦¦¦¦¦¦¦¦ ¦¦¦¦¦¦¦¦¦¦¦¦¦
Int. harness dissipation	-20% 20%	¦¦¦¦ ¦¦¦¦	¦¦¦¦¦¦ ¦¦¦¦¦¦	¦¦¦¦¦¦¦ ¦¦¦¦¦¦	¦¦¦¦¦¦ ¦¦¦¦¦¦	¦¦¦¦¦ ¦¦¦¦¦	¦¦¦ ¦¦¦	¦¦¦ ¦¦¦	¦¦¦ ¦¦¦	¦¦¦ ¦¦¦
He vapourisation heat	-1% 1%	¦¦ ¦¦	¦¦¦ ¦¦¦	¦¦¦ ¦¦¦	¦¦¦ ¦¦¦	¦¦¦ ¦¦¦	¦ ¦	¦ ¦	¦ ¦	¦ ¦
Stycast comb at TS1	-90% 90%	¦¦¦¦	¦¦¦¦¦	¦¦¦¦¦¦	¦¦¦¦¦¦¦	¦¦¦¦¦¦¦¦	¦¦¦¦	¦¦¦¦	¦¦¦¦	¦¦¦¦
Stycast comb at OBP	-90% 90%									
CVV MLI conductance	-50% 50%				¦	¦ ¦				
Sol. Gen. MLI conduct.	50%			¦		¦	¦	¦	¦	¦
Sunshade MLI conduct.	50%	¦¦¦	¦¦¦¦	¦¦¦¦¦	¦¦¦¦	¦¦				
Updated HSS	n/a	¦¦¦¦¦¦¦¦	¦¦¦¦¦¦¦¦¦¦¦	¦¦¦¦¦¦¦¦¦¦¦¦¦	¦¦¦¦¦¦¦¦¦		¦¦¦¦	¦¦¦¦	¦¦¦¦	¦¦¦¦

<table>
<tr><td></td><td></td><td colspan="5">L1</td><td colspan="4">L2</td></tr>
<tr><td></td><td>label</td><td>781</td><td>782</td><td>783</td><td>800</td><td>939</td><td>371</td><td>381</td><td>315</td><td>919</td></tr>
<tr><td>MLI definition</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>SVM shield SLI emiss.</td><td>0.03</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CVV strut conductance</td><td>-20%
20%</td><td>|
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<tr><td>HSS strut conductance</td><td>-20%
20%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CVV ext. harness conduct. (=k_28)</td><td>-15%
15%</td><td></td><td></td><td></td><td></td><td>|
|</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Ext. harness dissipation</td><td>-15%
15%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sunshade emissivity</td><td>-0.03
0.03</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Solar generator emissivity</td><td>-0.03
0.03</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sunshade OSR absorptivity</td><td>-0.03
0.03</td><td>|
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</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Solar Generator absorptivity</td><td>-0.03 0.03</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>LOU strut conductance</td><td>-20% 20%</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>MLI IR specularity</td><td>-20% 19%</td><td>|	
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		</td><td>			
		</td><td>		
	</td><td>	 </td><td></td><td></td><td></td><td></td></tr>
<tr><td>Emissivity of CVV radiator surfaces</td><td>-0.03
0.03</td><td>
|</td><td>
|</td><td>
|</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Telescope M1/M2 emissivity</td><td>-0.005
0.005</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Emissivity of radiating struts</td><td>-0.03
0.03</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Table 6.3-11: Graphical representation of In-Orbit Sensitivities for Instrument Interface nodes – Level 1 & 2

<table>
<tr><td></td><td>label</td><td colspan="2">L3
831   832</td><td>LOU
4201</td><td colspan="2">Telescope
8001   8050</td><td>mdot
5900</td></tr>
<tr><td>Reference value</td><td></td><td>13.366</td><td>13.412</td><td>125.362</td><td>85.094</td><td>82.494</td><td>2.283</td></tr>
<tr><td>Overall uncertainty</td><td>pos
neg</td><td>0.536
-0.554</td><td>0.536
-0.553</td><td>2.825
-7.096</td><td>4.796
-15.603</td><td>4.204
-14.428</td><td>0.154
-0.238</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td>HTT temp (dp) uncertainty</td><td>+1.5mbar
-1.5mbar</td><td>|
|</td><td>|
|</td><td></td><td></td><td></td><td></td></tr>
<tr><td>HTT MLI conductance</td><td>-50%
50%</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>TS1 MLI conductance</td><td>-50%
50%</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>TS2 MLI conductance</td><td>-50%
50%</td><td></td><td></td><td></td><td></td><td></td><td>|</td></tr>
<tr><td>TS3 MLI conductance</td><td>-50%
50%</td><td></td><td></td><td></td><td></td><td></td><td>|
|</td></tr>
<tr><td>HTT bones</td><td>-20%
20%</td><td>|||||
||||</td><td>|||||
||||</td><td></td><td></td><td></td><td>|</td></tr>
<tr><td>inner tank suspension</td><td>-20%
20%</td><td></td><td></td><td></td><td></td><td></td><td>|
|</td></tr>
<tr><td>TS 1/2 tank susp.</td><td>-20%
20%</td><td>|
|</td><td>|
|</td><td></td><td></td><td></td><td>|
|</td></tr>
<tr><td>TS 2/3 tank susp.</td><td>-20%
20%</td><td></td><td></td><td></td><td></td><td></td><td>|
|</td></tr>
<tr><td>outer tank suspension</td><td>-20%
20%</td><td></td><td></td><td></td><td></td><td></td><td>|
|</td></tr>
<tr><td>CVV int. harness conductance (=k_9)</td><td>-15%
15%</td><td>||||||||||||||
|||||||||||||</td><td>||||||||||||||
|||||||||||||</td><td></td><td></td><td></td><td>||||||||
||||||||</td></tr>
<tr><td>Int. harness dissipation</td><td>-20%
20%</td><td>|||
|||</td><td>|||
|||</td><td></td><td></td><td></td><td></td></tr>
<tr><td>He vapourisation heat</td><td>-1%
1%</td><td>|
|</td><td>|
|</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Stycast comb at TS1</td><td>-90%
90%</td><td>||||</td><td>||||</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Stycast comb at OBP</td><td>-90%
90%</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CVV MLI conductance</td><td>-50%
50%</td><td></td><td></td><td></td><td></td><td></td><td>||
||</td></tr>
<tr><td>Sol. Gen. MLI conduct.</td><td>50%</td><td></td><td></td><td>|||||</td><td>||</td><td>||</td><td>||||</td></tr>
<tr><td>Sunshade MLI conduct.</td><td>50%</td><td></td><td></td><td></td><td>|</td><td>|</td><td>|</td></tr>
<tr><td>Updated HSS MLI definition</td><td>n/a</td><td>||||</td><td>||||</td><td>||||||||||||||</td><td>||||||||||||||</td><td>||||||||||||||</td><td>||||||||||||||</td></tr>
<tr><td>SVM shield SLI emiss.</td><td>0.03</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CVV strut conductance</td><td>-20%</td><td></td><td></td><td></td><td></td><td></td><td>|||</td></tr>
</table>

<table>
<tr><th></th><th></th><th colspan="2">L3</th><th>LOU</th><th colspan="2">Telescope</th><th>mdot</th></tr>
<tr><th></th><th>label</th><th>831</th><th>832</th><th>4201</th><th>8001</th><th>8050</th><th>5900</th></tr>
<tr><td></td><td>20%</td><td></td><td></td><td></td><td></td><td></td><td>|||</td></tr>
<tr><td>HSS strut conductance</td><td>-20%
20%</td><td></td><td></td><td></td><td></td><td></td><td>|
|</td></tr>
<tr><td>CVV ext. harness conductance (=k_28)</td><td>-15%
15%</td><td></td><td></td><td>||
||</td><td></td><td></td><td>|
|</td></tr>
<tr><td>Ext. harness dissipation</td><td>-15%
15%</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sunshade emissivity</td><td>-0.03
0.03</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Solar generator emissivity</td><td>-0.03
0.03</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sunshade OSR absorptivity</td><td>-0.03
0.03</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Solar Generator absorptivity</td><td>-0.03
0.03</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>LOU strut conductance</td><td>-20%
20%</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>MLI IR specularity</td><td>-20%
19%</td><td></td><td></td><td></td><td></td><td></td><td>||
||</td></tr>
<tr><td>Emissivity of CVV radiator surfaces</td><td>-0.03
0.03</td><td></td><td></td><td></td><td></td><td></td><td>
||</td></tr>
<tr><td>Telescope M1/M2 emissivity</td><td>-0.005
0.005</td><td></td><td></td><td></td><td>||
|</td><td>||
|</td><td></td></tr>
<tr><td>Emissivity of radiating struts</td><td>-0.03
0.03</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Table 6.3-12: Graphical representation of In-Orbit Sensitivities for Level 3 Instrument Interface nodes, LOU and Telescope

In case the solar cells are in shunt mode and all absorbed solar energy is dumped in the Solar Array, the temperature of the center panel increases to 409 K (136°C). This has been calculated for LEOP and Winter Solstice.

6.3.3 Transient Spacecraft Operations

A transient analysis run has been performed simulating a spacecraft rotation from 0° to 30 ° (z-axis to sun pointing, step function at start) around the y-axis, based on orbit hot conditions. The transient cool-down curves of Telescope, LOU, CVV and HTT in this case are shown in the following figures.

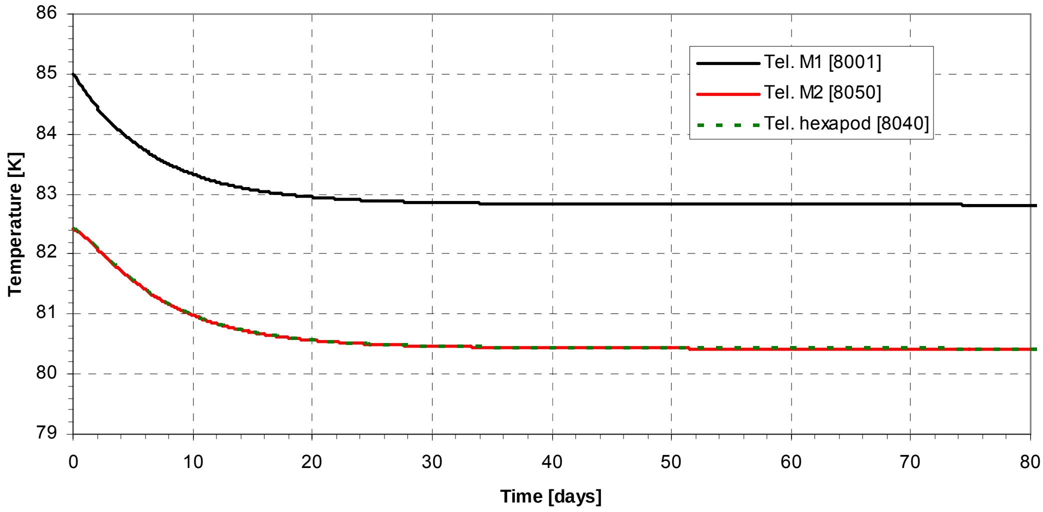


Figure 6.3-6: Transient Cool-Down of Telescope after S/C Rotation 30° around Y-Axis

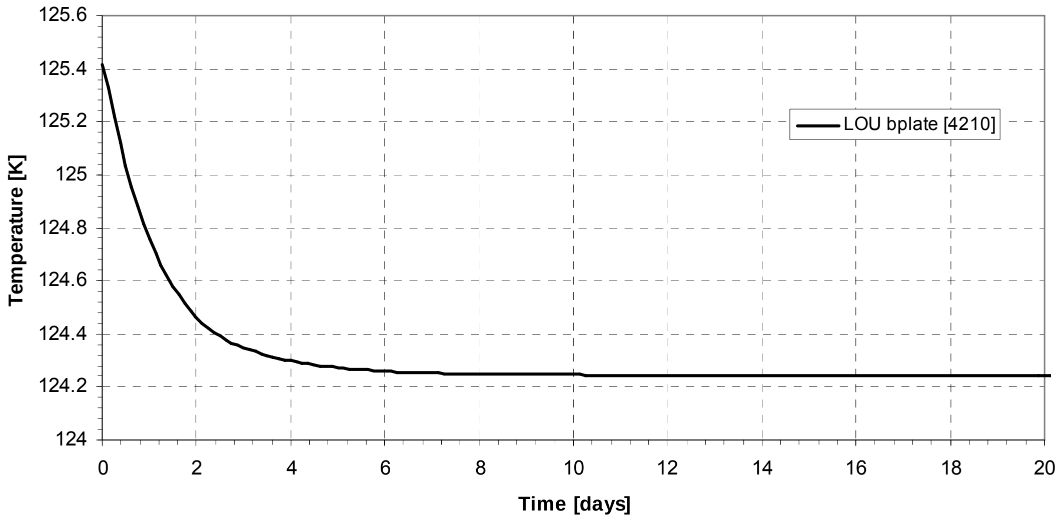


Figure 6.3-7: Transient Cool-Down of LOU Baseplate after S/C Rotation 30° around Y-Axis

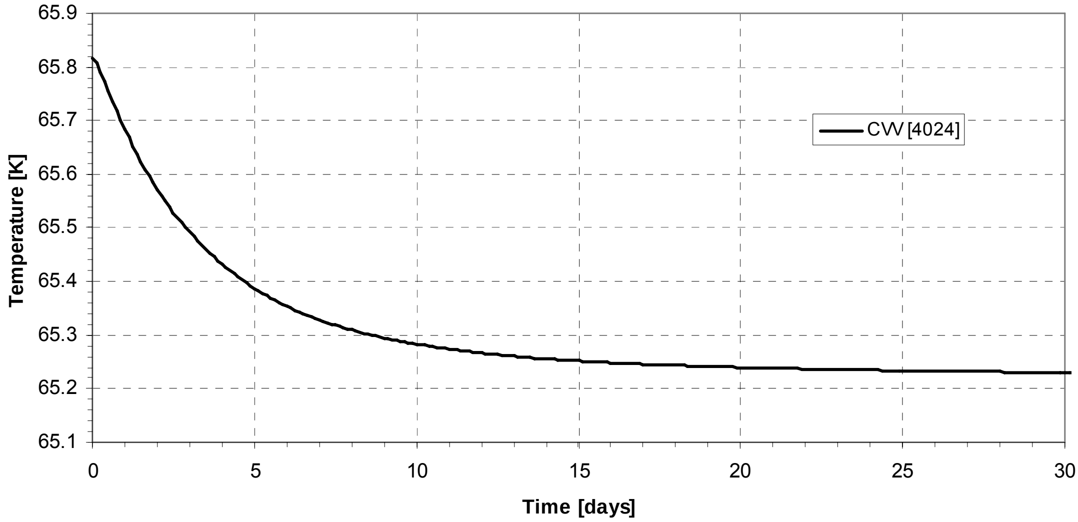


Figure 6.3-8: Transient Cool-Down of CVV after S/C Rotation 30° around Y-Axis

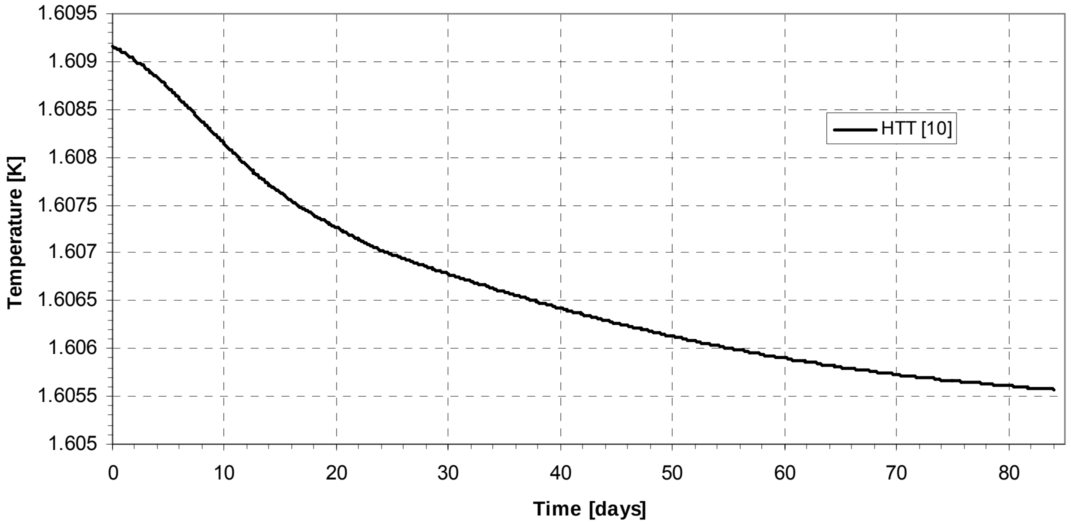


Figure 6.3-9: Transient Cool-Down of HTT after S/C Rotation 30° around Y-Axis

6.4 Instrument Operation in L2 Orbit

The transient temperature and heat flow results for the instrument thermal interface nodes shown in this section are based on the following instrument timeline:

- Start conditions (steady state): Instruments average dissipation
- PACS Photometer Mode (incl. sorption cooler cycle) 48 h
- SPIRE 48 h
- HIFI 48 h
- SPIRE 48 h
- PACS Spectrometer Mode (no sorption cooler cycle) 24 h
- HIFI 48 h
- PACS Spectrometer Mode (no sorption cooler cycle) 24 h

The related instrument dissipation profiles used as input for these calculations are compiled in section 4.5.

The analysis results shown in Section 6.4.1 to 6.4.4 are performed for hot case conditions (acc. to Table 3.2-1) with a remaining He II mass of 35 kg at the beginning of the simulation.

The uncertainties to be taken into account for the different temperature levels are given in Table 6.6-1.

Further analyses have been performed to investigate the effect of cold case conditions at L2 and to compare the results of an almost empty Helium tank (35 kg) with the performance of an almost full Helium tank (300 kg). Those results are shown in Section 6.4.5.

6.4.1 PACS Interface Temperatures and Heat Flows

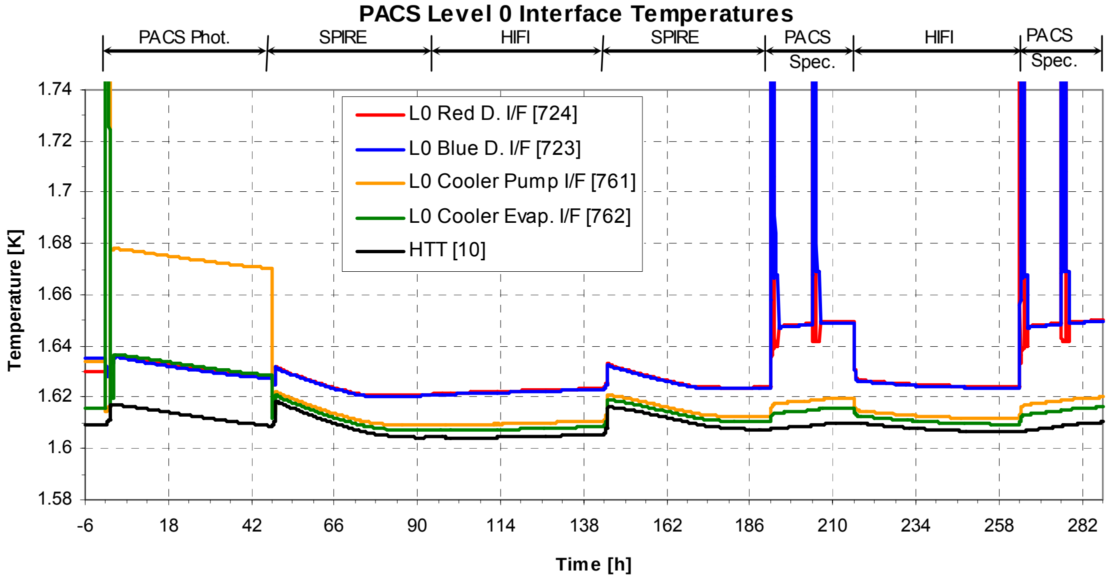


Figure 6.4-1: PACS L0 Interface Temperatures

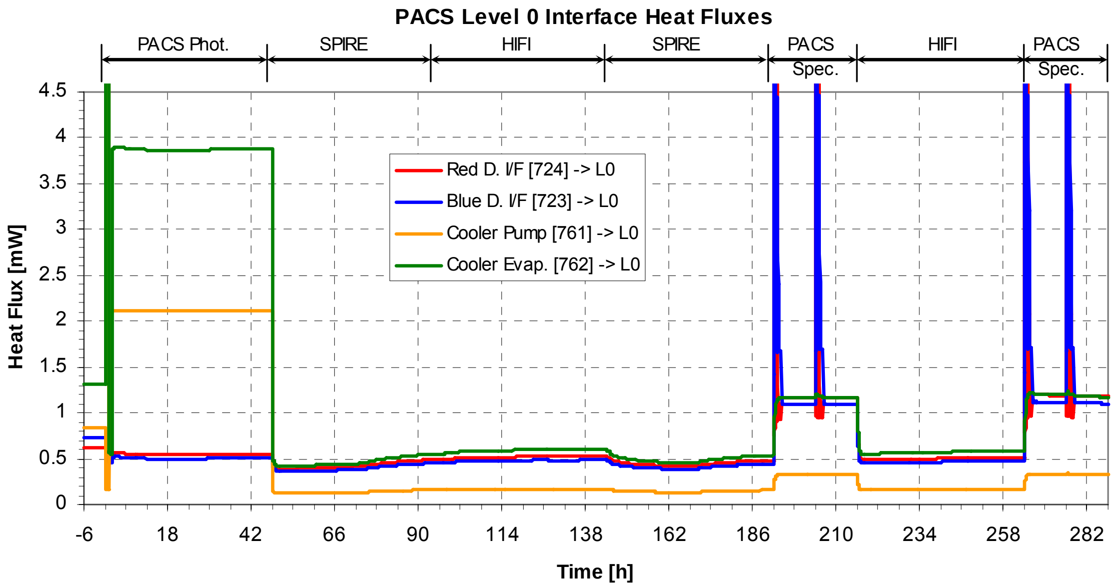


Figure 6.4-2: PACS L0 Interface Heat Flows

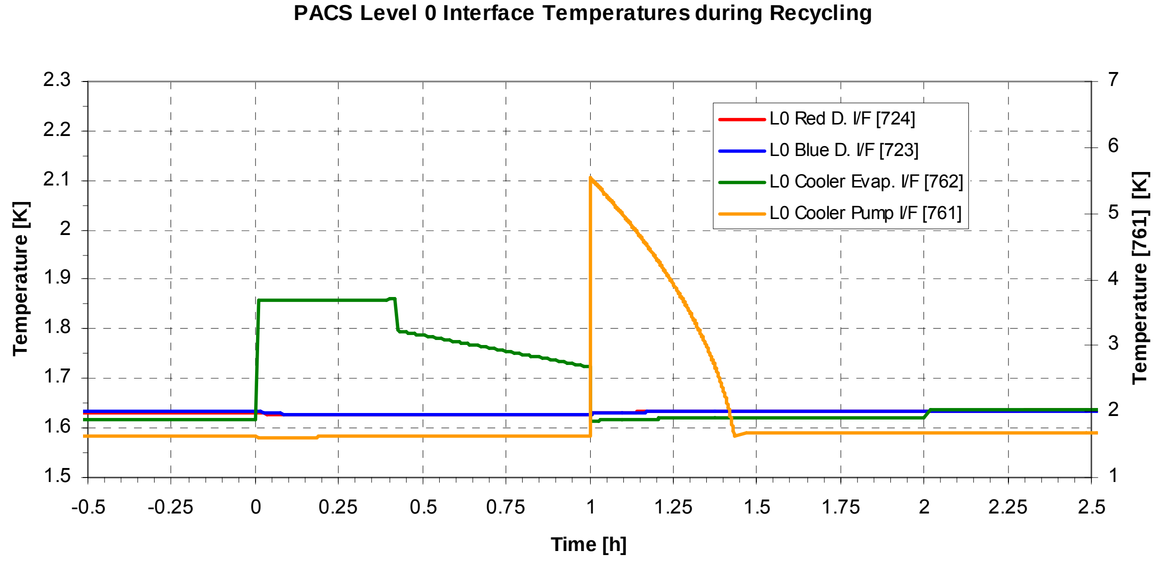


Figure 6.4-3: PACS L0 Interface Temperatures during Recycling

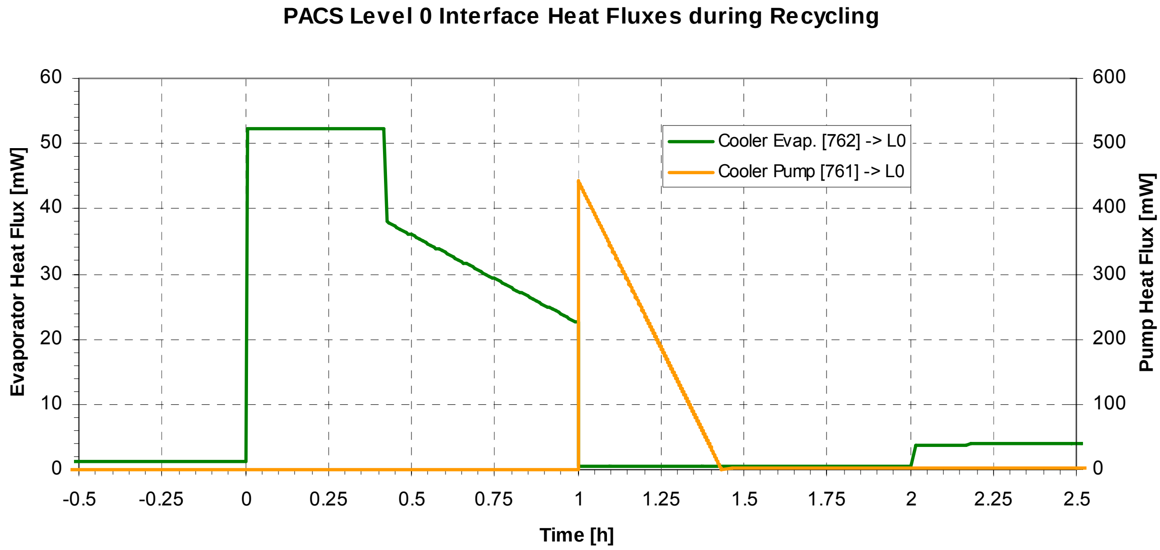


Figure 6.4-4: PACS L0 Interface Heat Flows during Recycling

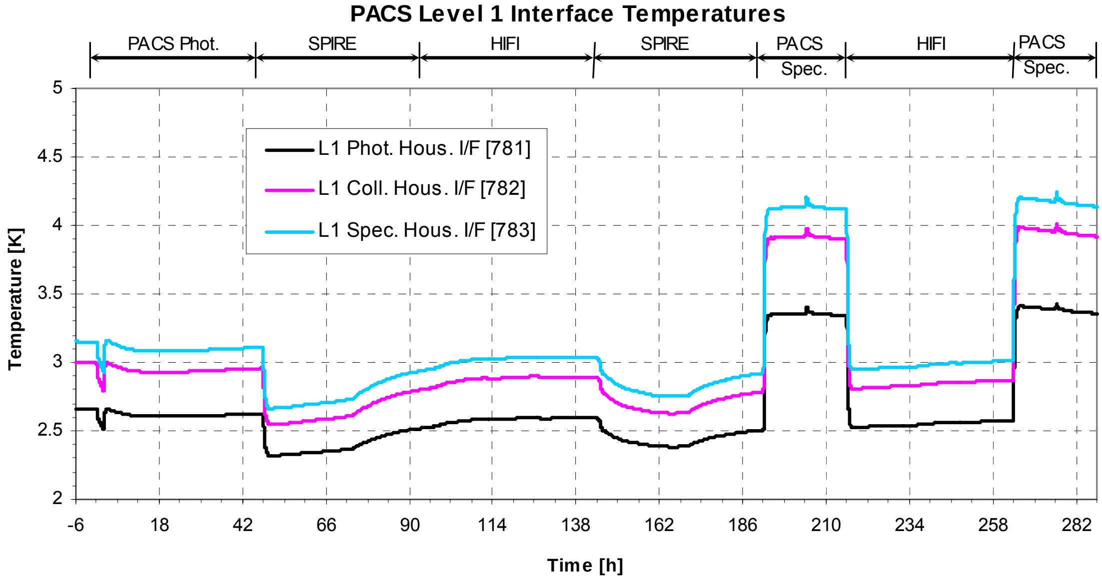


Figure 6.4-5: PACS L1 Interface Temperatures

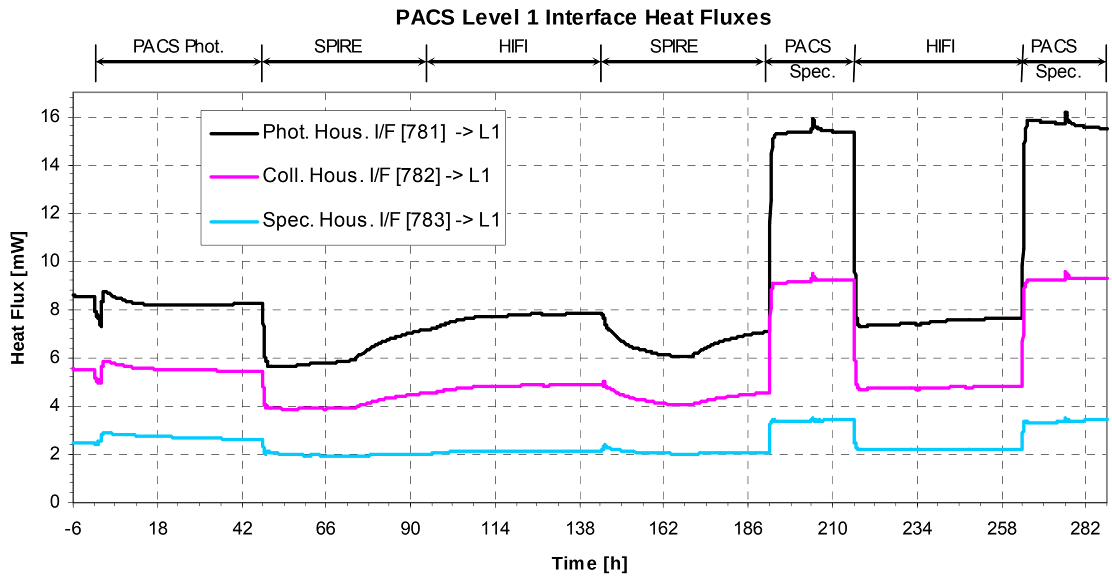


Figure 6.4-6: PACS L1 Interface Heat Flows

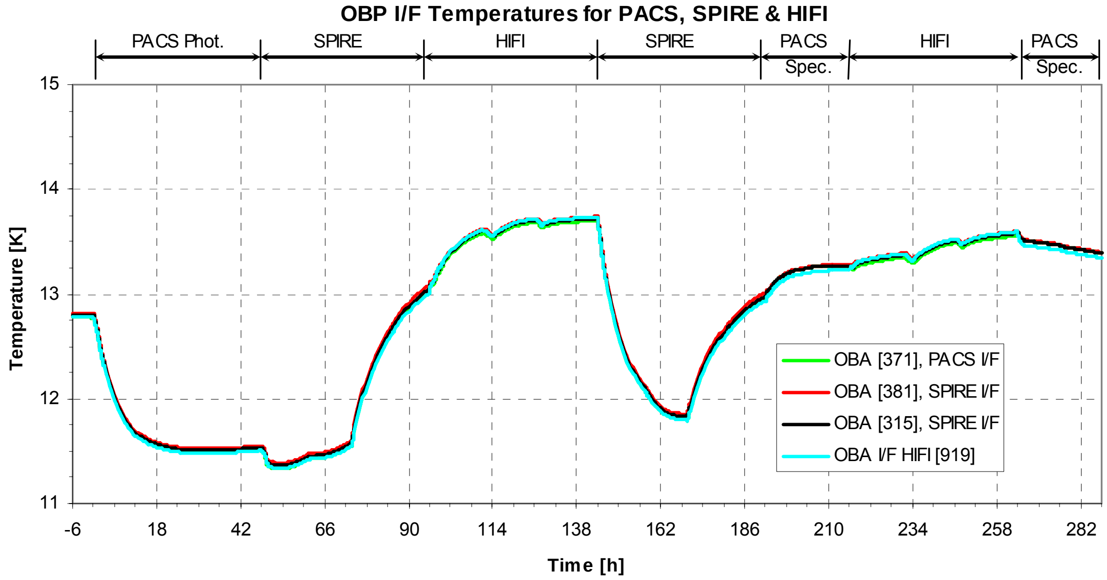


Figure 6.4-7: FPU L2 Interface Temperatures

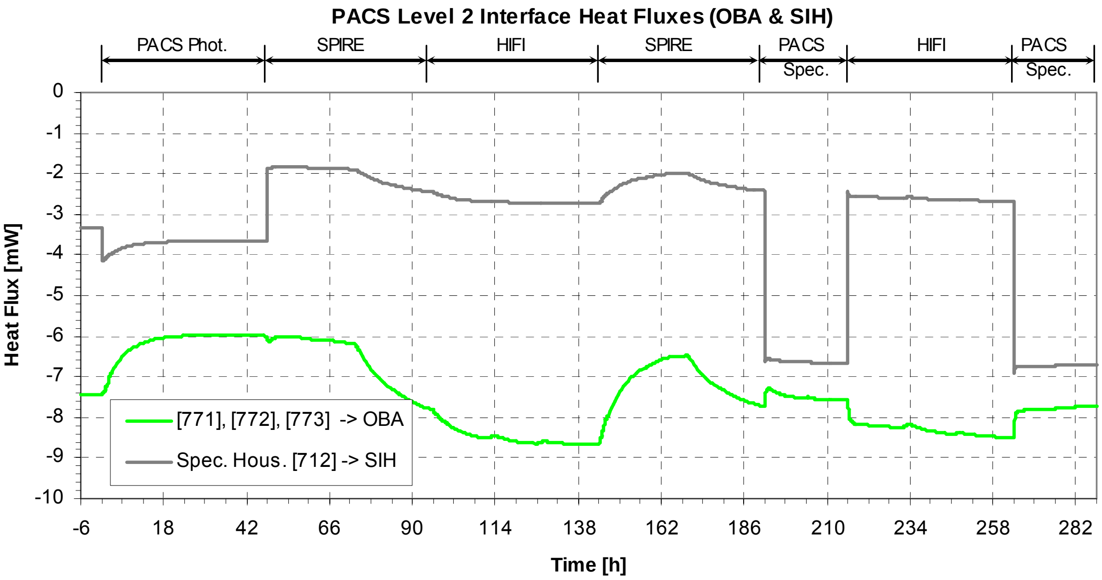


Figure 6.4-8: PACS L2 Interface Heat Flows

6.4.2 SPIRE Interface Temperatures and Heat Flows

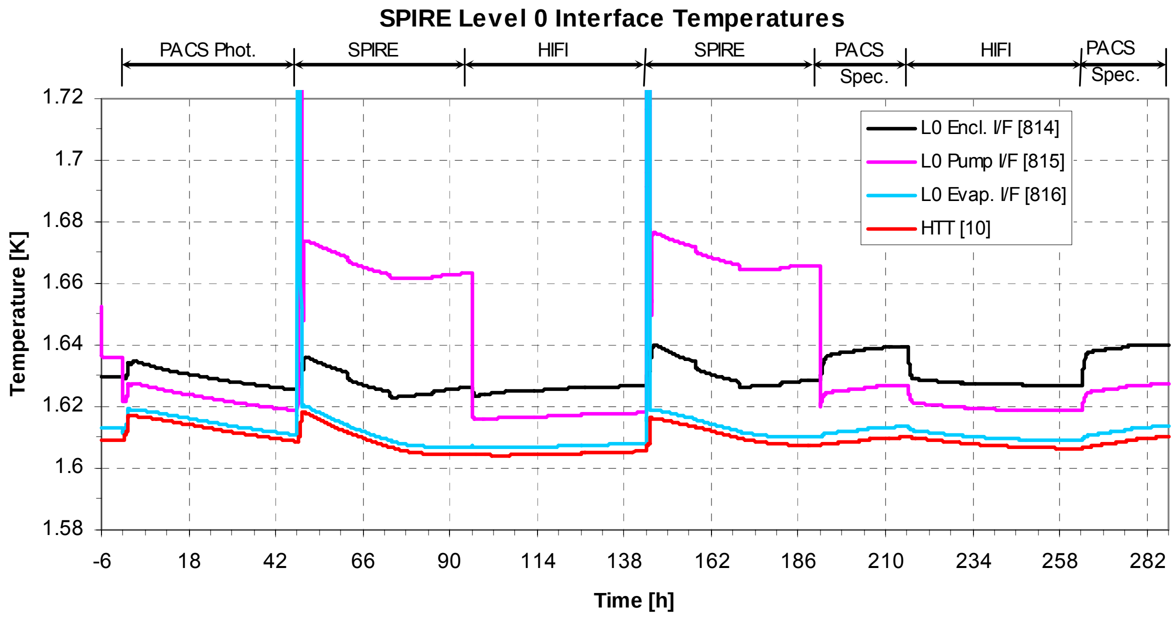


Figure 6.4-9: SPIRE L0 Interface Temperatures

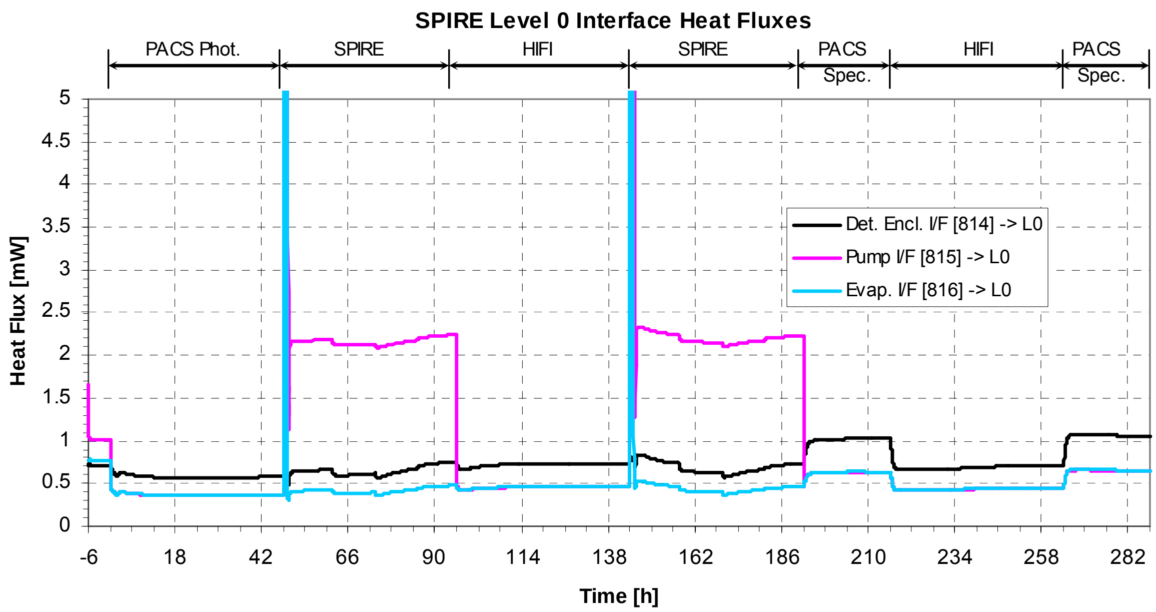


Figure 6.4-10: SPIRE L0 Interface Heat Flows

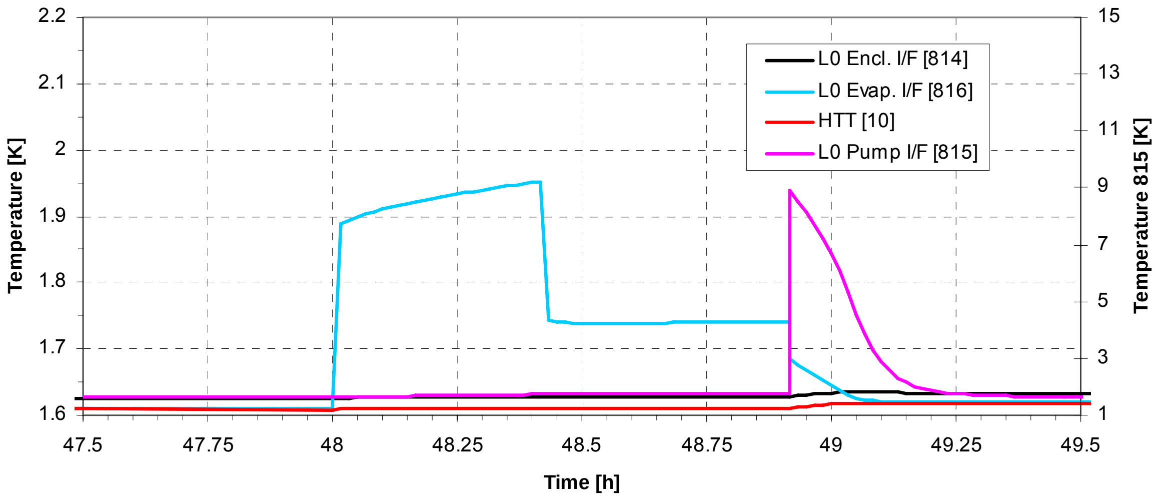


Figure 6.4-11: SPIRE L0 Interface Temperatures during Recycling

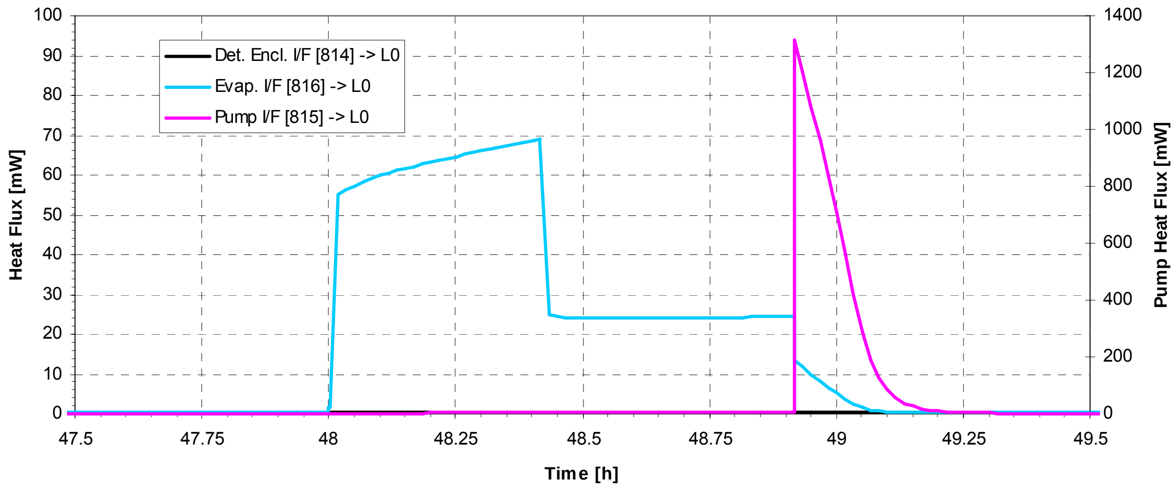


Figure 6.4-12: SPIRE L0 Interface Heat Flows during Recycling

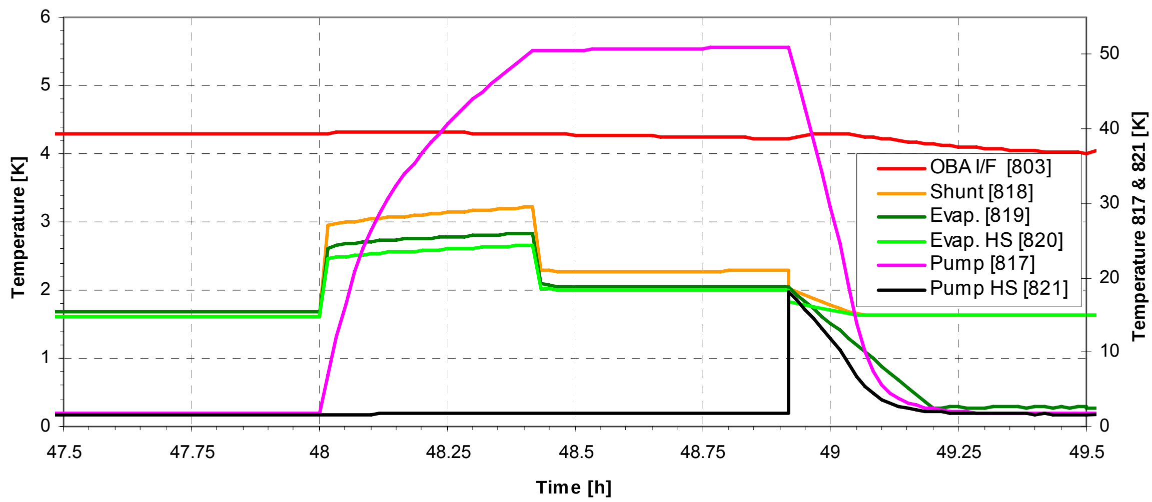


Figure 6.4-13: SPIRE Cooler Temperatures during Recycling (for information)

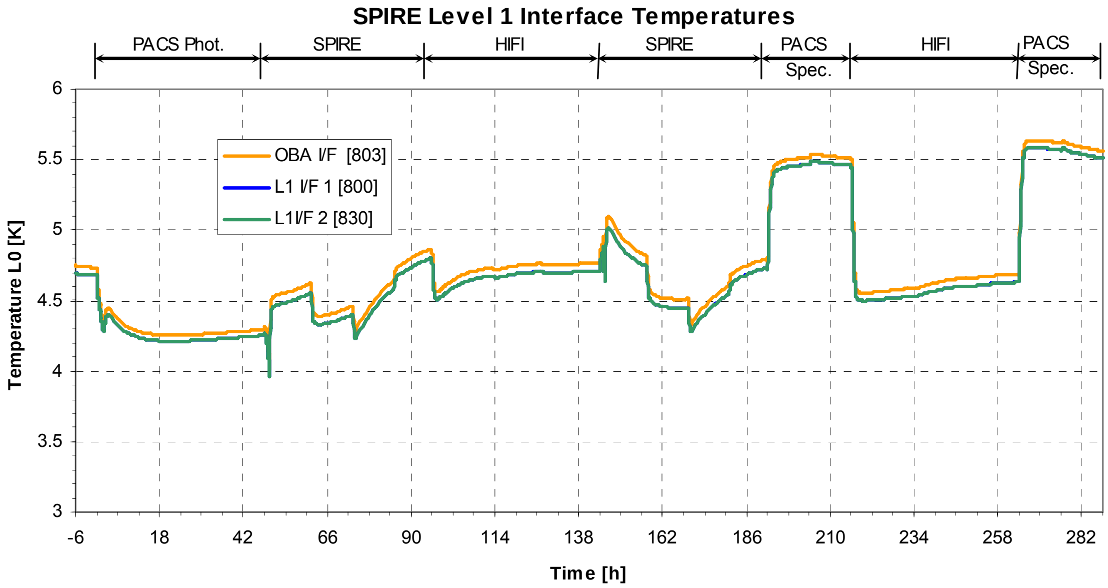


Figure 6.4-14: SPIRE L1 Interface Temperatures

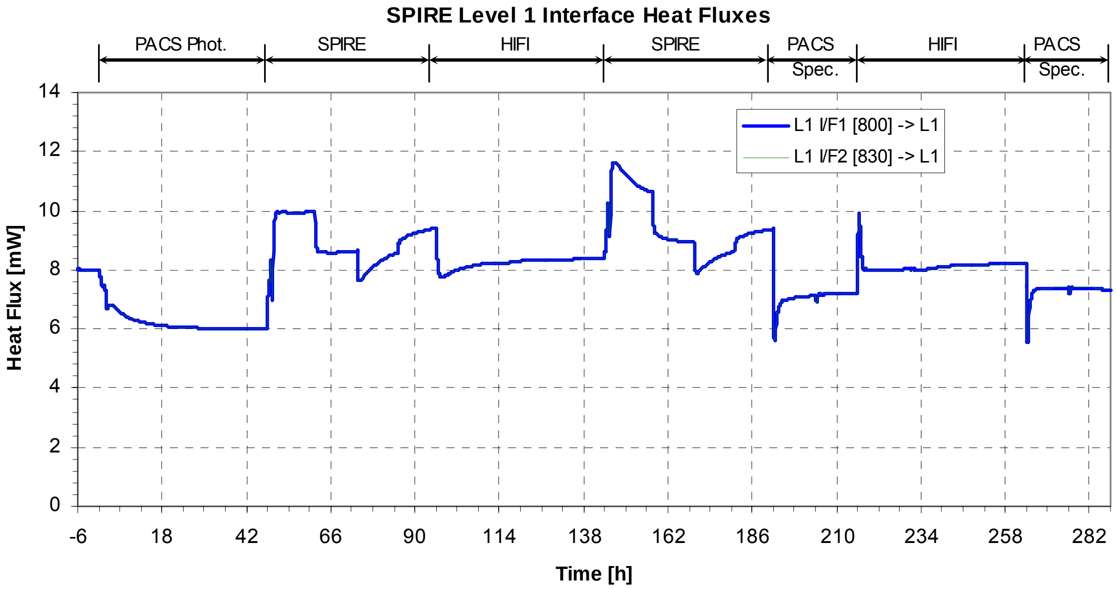


Figure 6.4-15: SPIRE L1 Interface Heat Flows

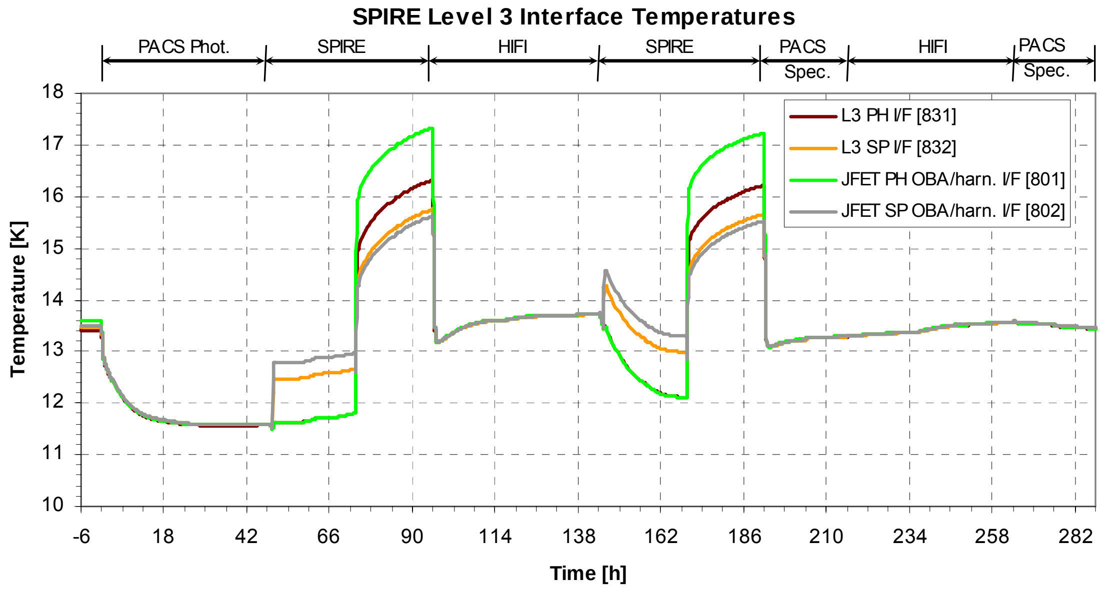


Figure 6.4-16: SPIRE L3 Interface Temperatures

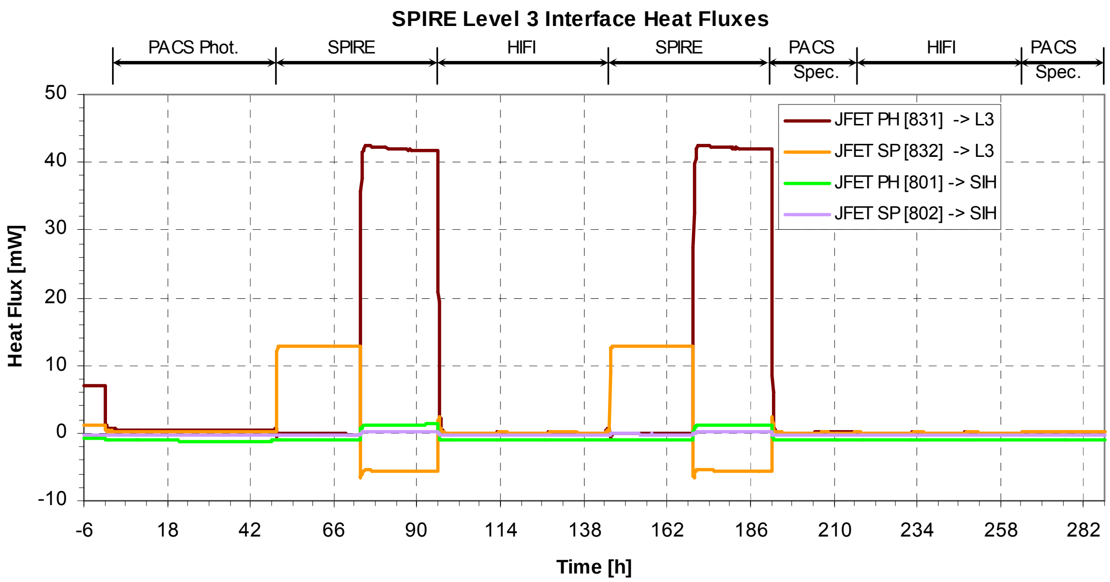


Figure 6.4-17: SPIRE L3 Interface Heat Flows

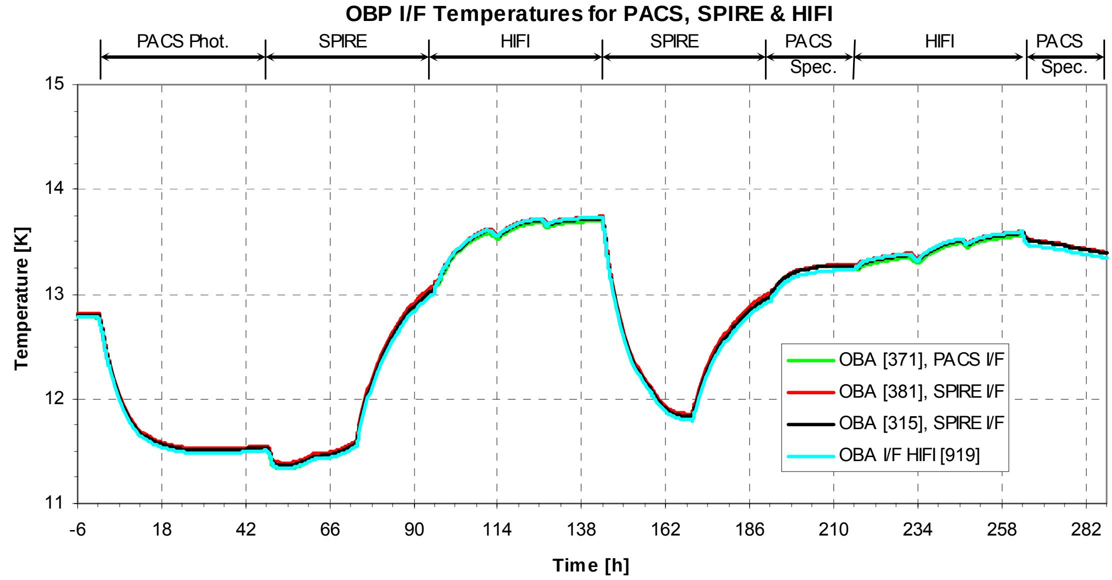


Figure 6.4-18: FPU L2 Interface Temperatures

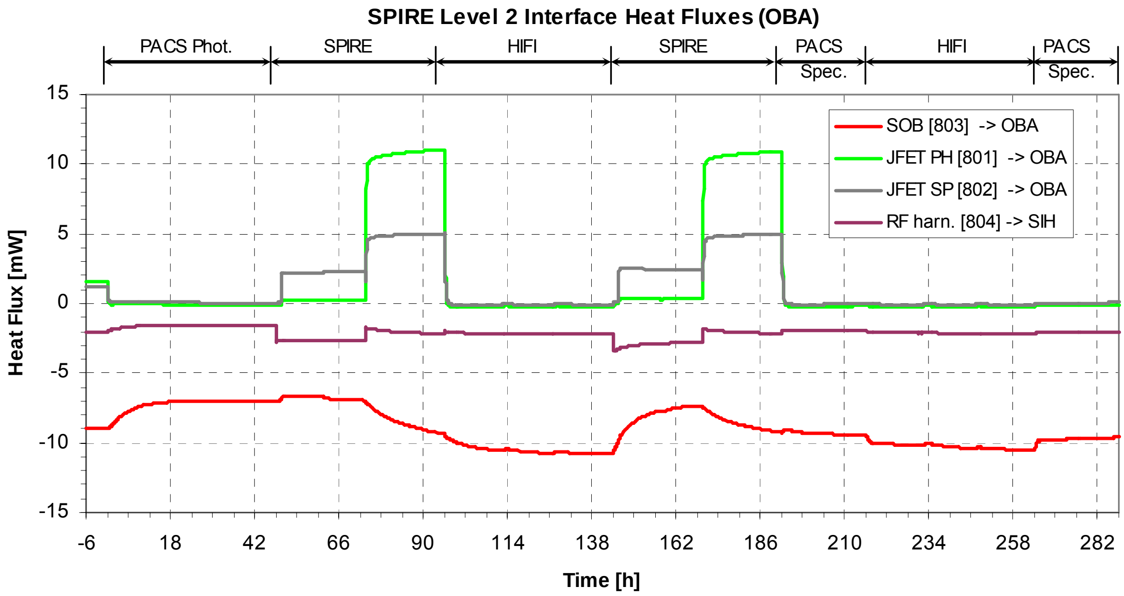


Figure 6.4-19: SPIRE L2 Interface Heat Flows

6.4.3 HIFI Interface Temperatures and Heat Flows

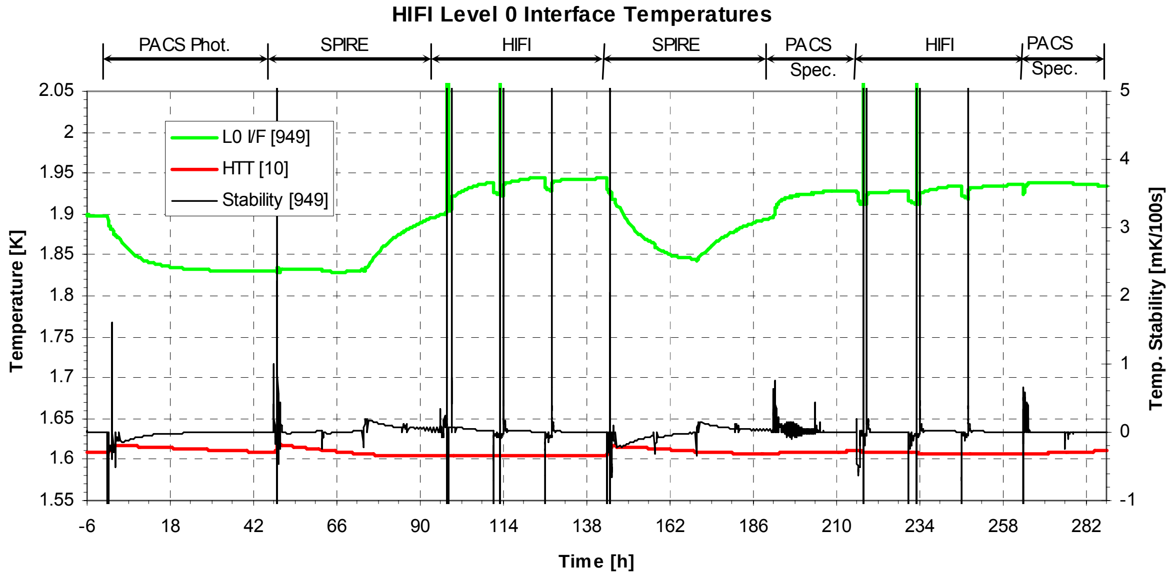


Figure 6.4-20: HIFI L0 Interface Temperature and Stability

Note that the temperature stability peaks of HIFI are caused by short heat peak phases due to dissipation switching.

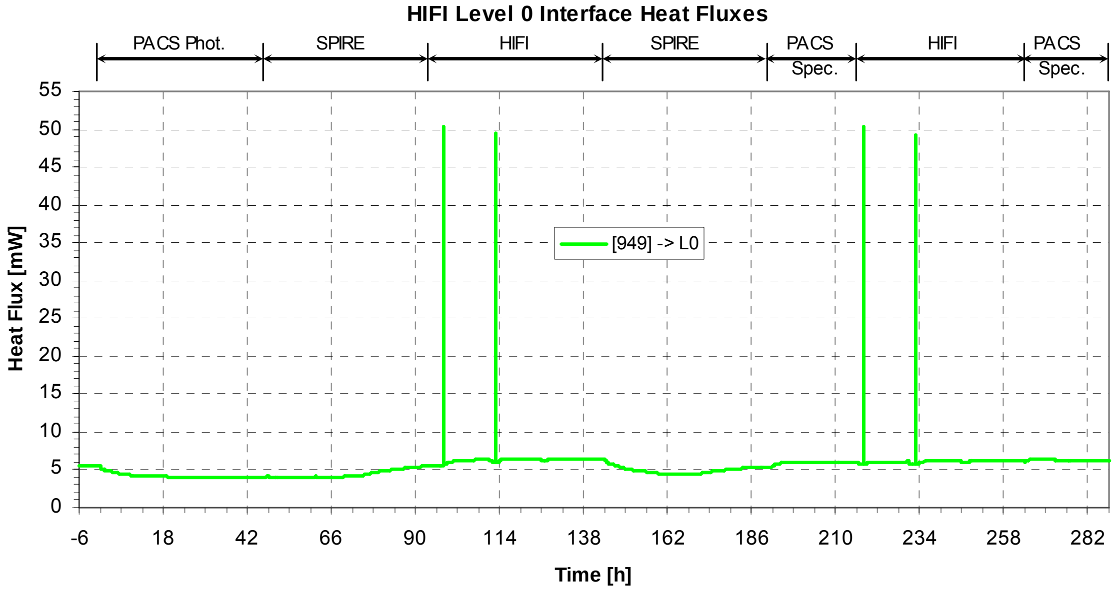


Figure 6.4-21: HIFI L0 Interface Heat Flow

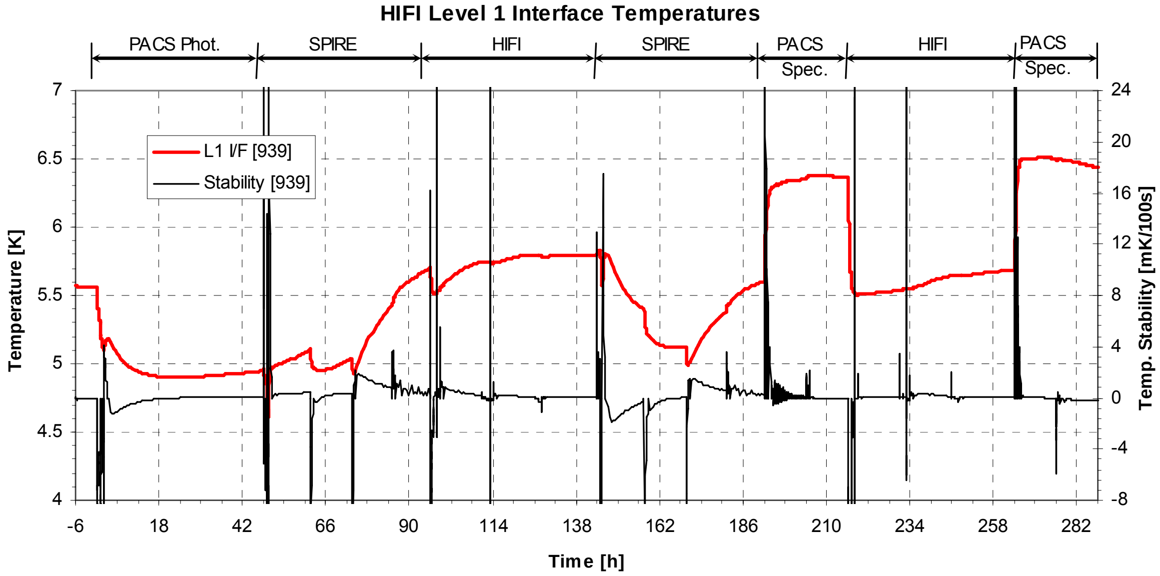


Figure 6.4-22: HIFI L1 Interface Temperature and Stability

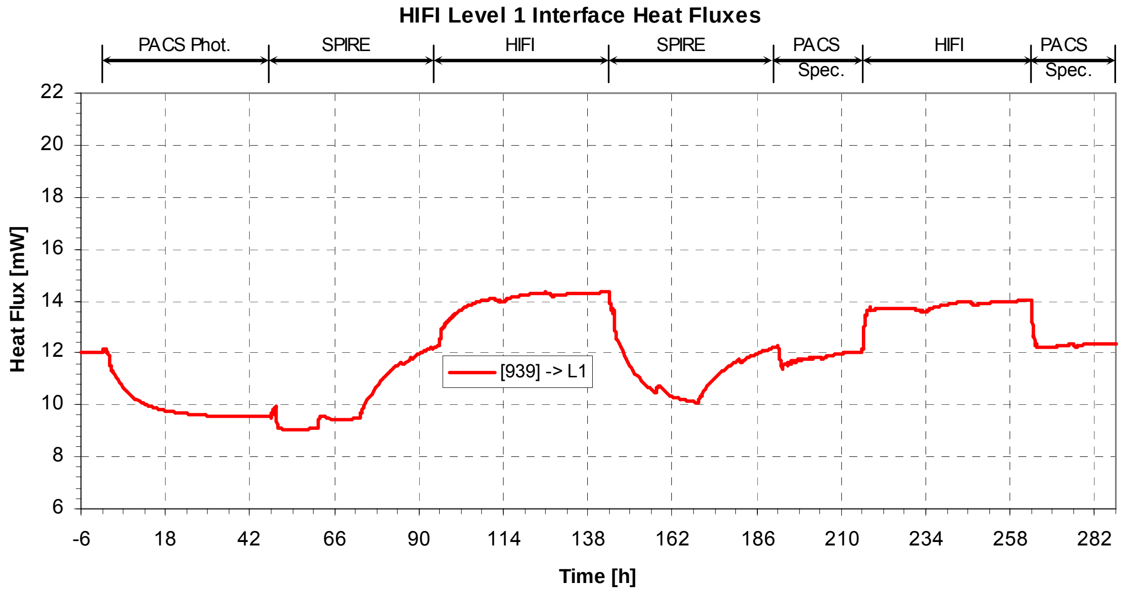


Figure 6.4-23: HIFI L1 Interface Heat Flow

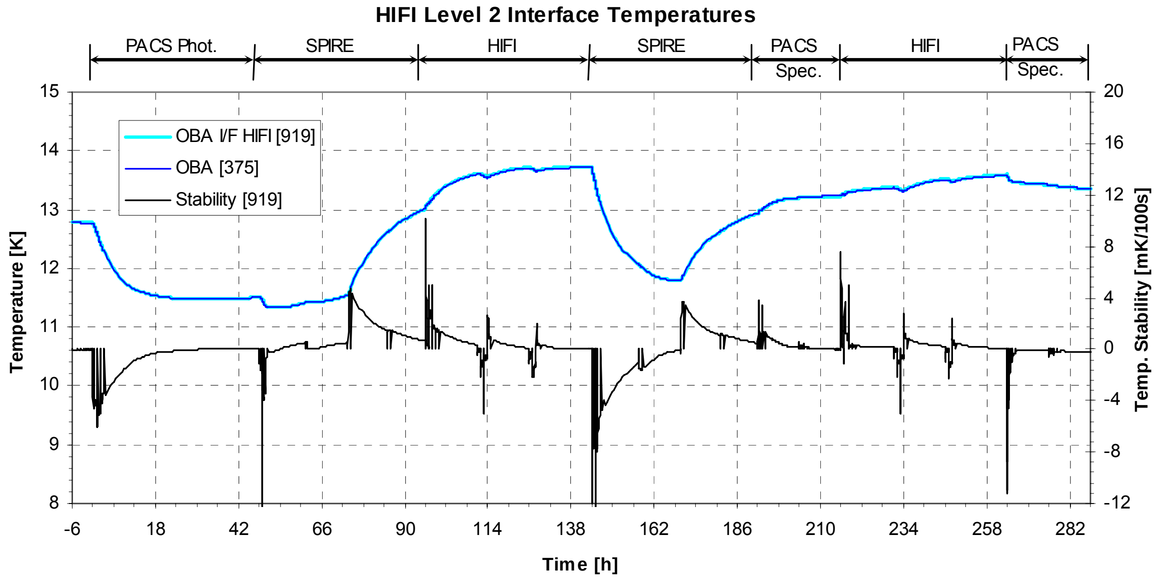


Figure 6.4-24: HIFI L2 Interface Temperature and Stability

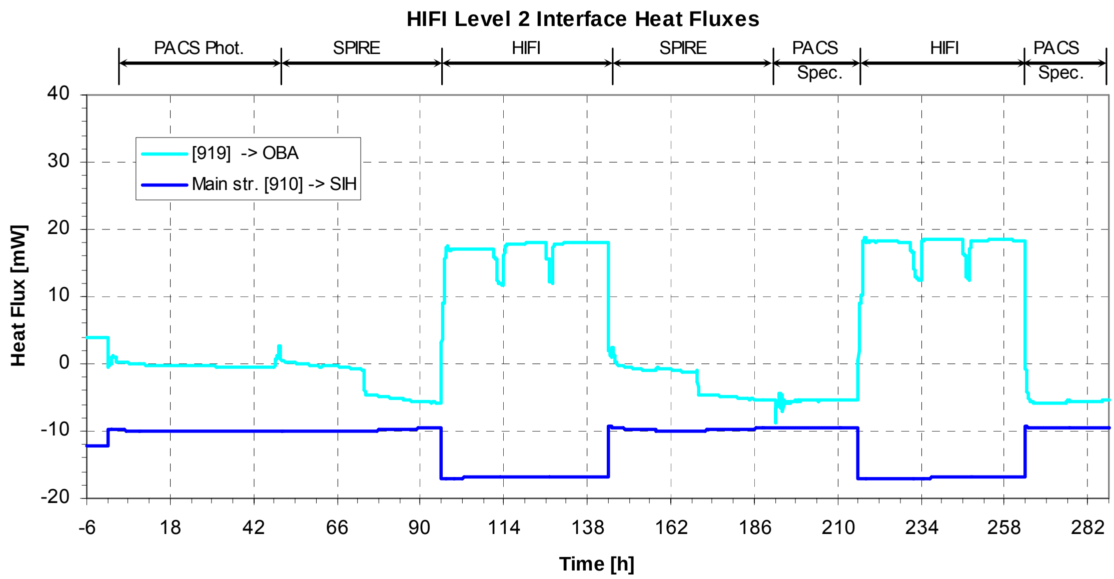
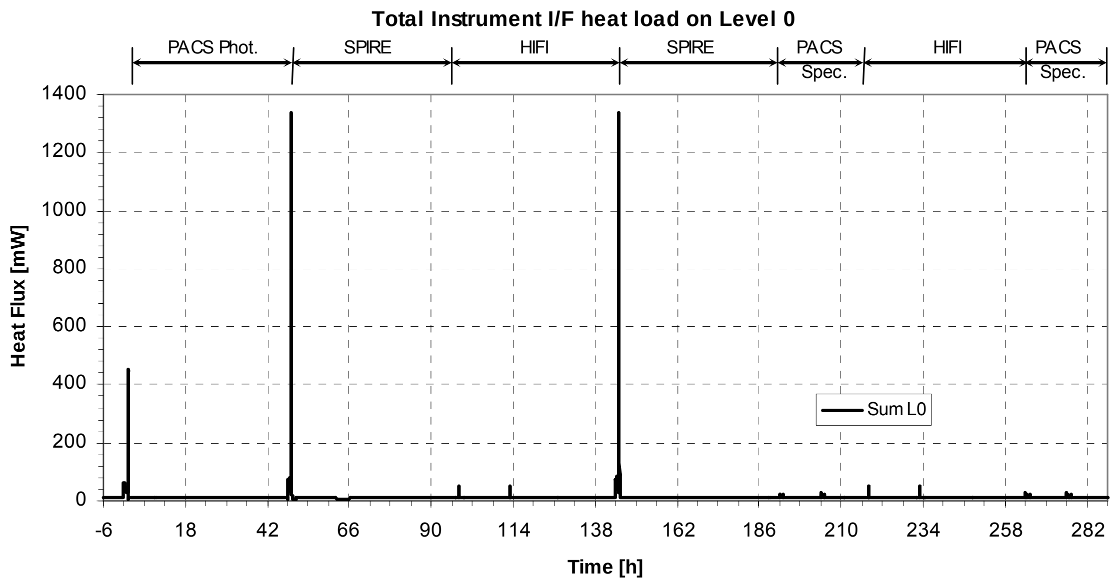


Figure 6.4-25: HIFI L2 Interface Heat Flow

6.4.4 Instrument Heat Load on HTT and He Mass Flow



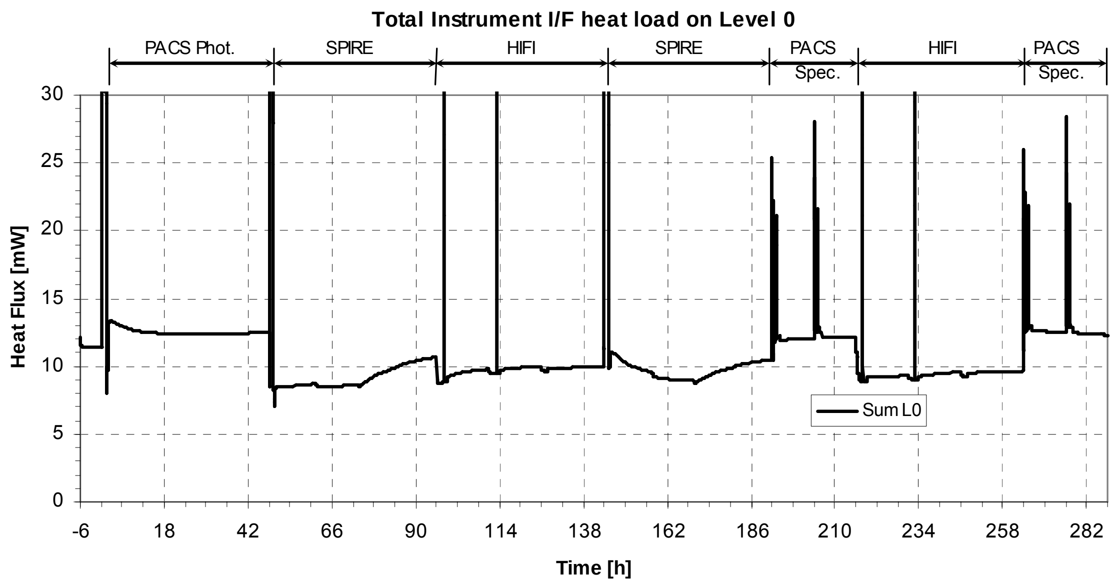


Figure 6.4-26: Total Instrument I/F Heat Load on HTT (different scales on Y-axis)

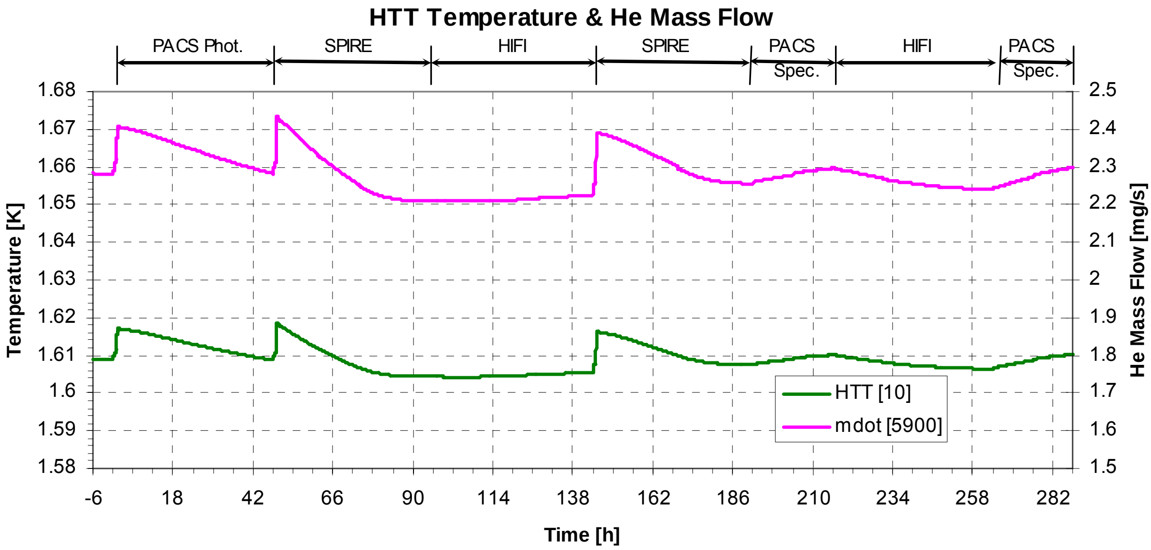


Figure 6.4-27: HTT Temperature and He Mass Flow Rate

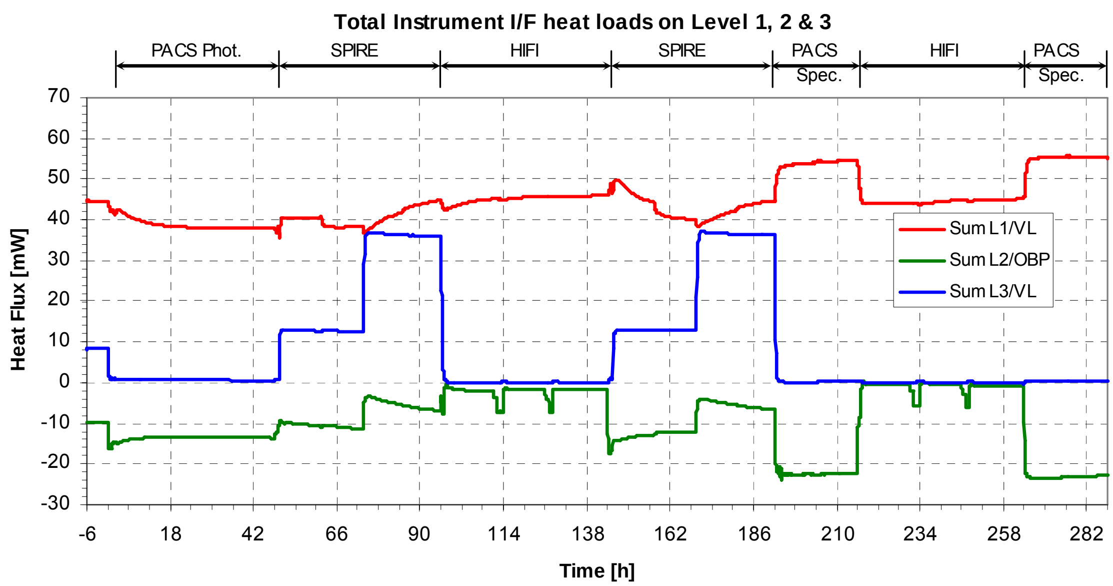


Figure 6.4-28: Total Instrument I/F Heat Load on L1, L2 and L3

6.4.5 Sensitivity Analysis

The following sensitivities have been performed:

- Hot Case with nearly empty HTT: hot case environment at L2 and 35 kg He in the tank (detailed results see sections 6.4.1 to 6.4.4)
- Cold Case with nearly empty HTT: cold case environment at L2 and 35 kg He in the tank
- Hot Case with nearly full HTT: hot case environment at L2 and 300 kg He in the tank

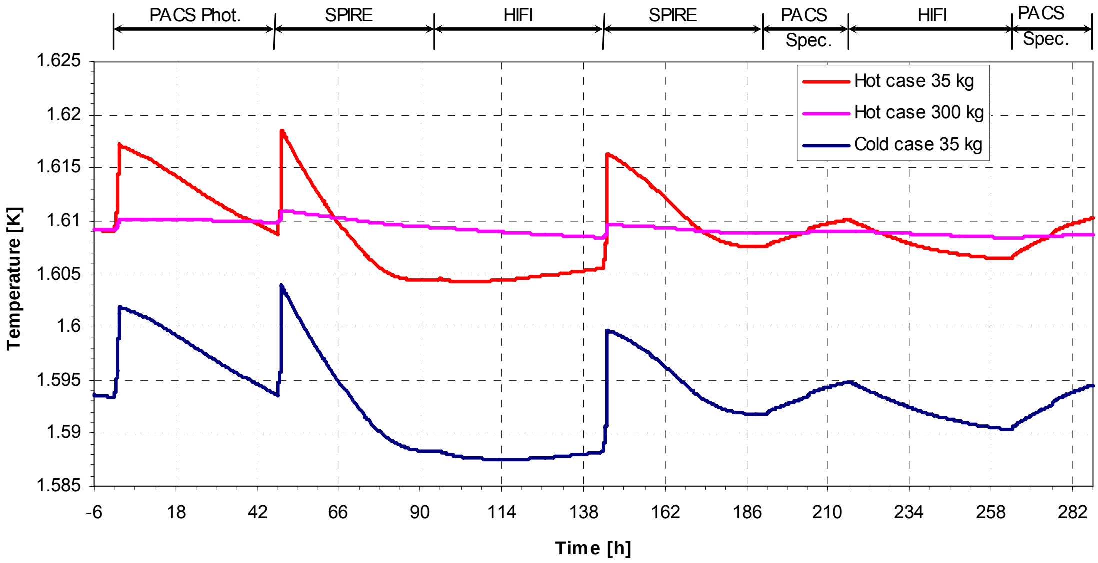


Figure 6.4-29: HTT Temperature for Different Conditions

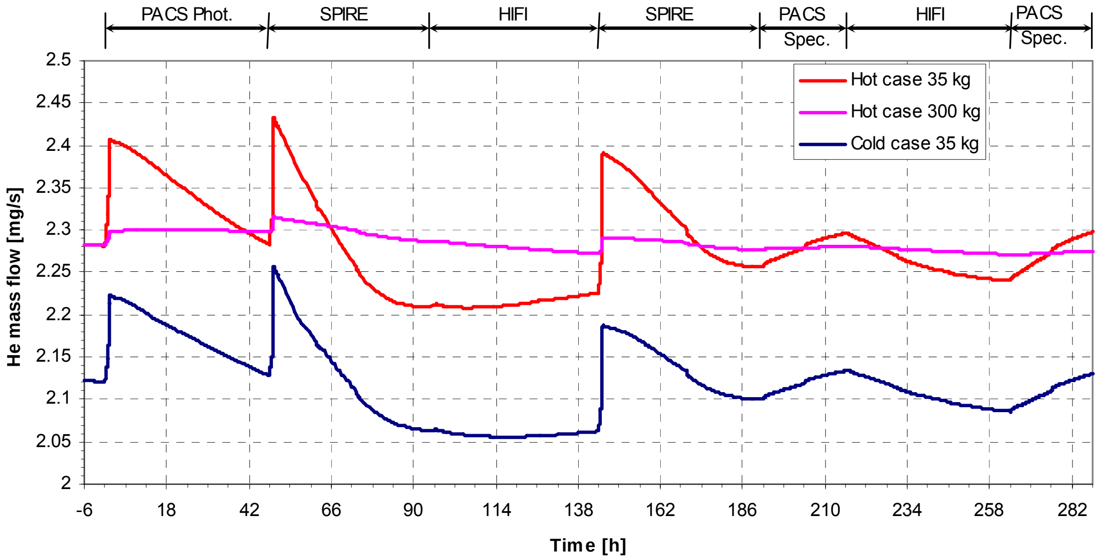


Figure 6.4-30: Helium Mass Flow for Different Conditions

In the following figures some representative temperatures curves are shown for the level 0, 1, 2 and 3 instrument interfaces.

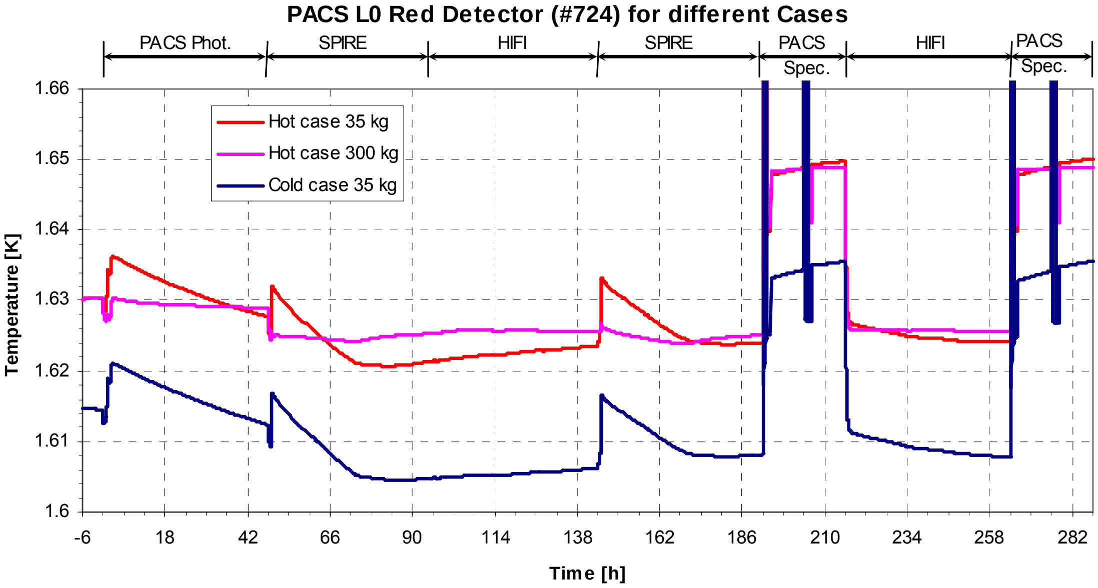


Figure 6.4-31: PACS L0 Temperature for Different Conditions

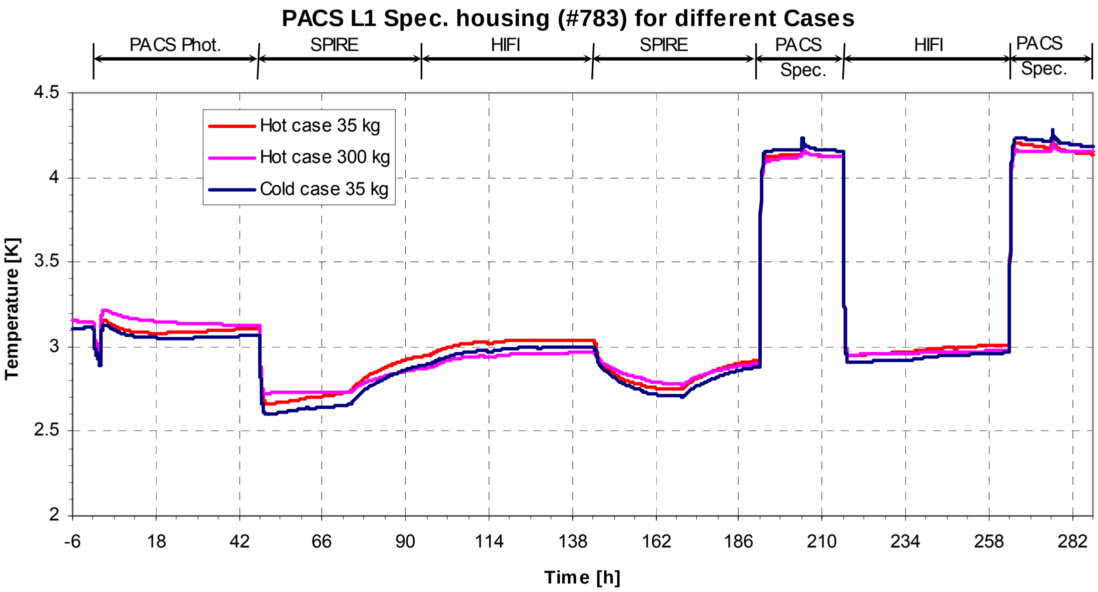


Figure 6.4-32: PACS L1 Temperature for Different Conditions

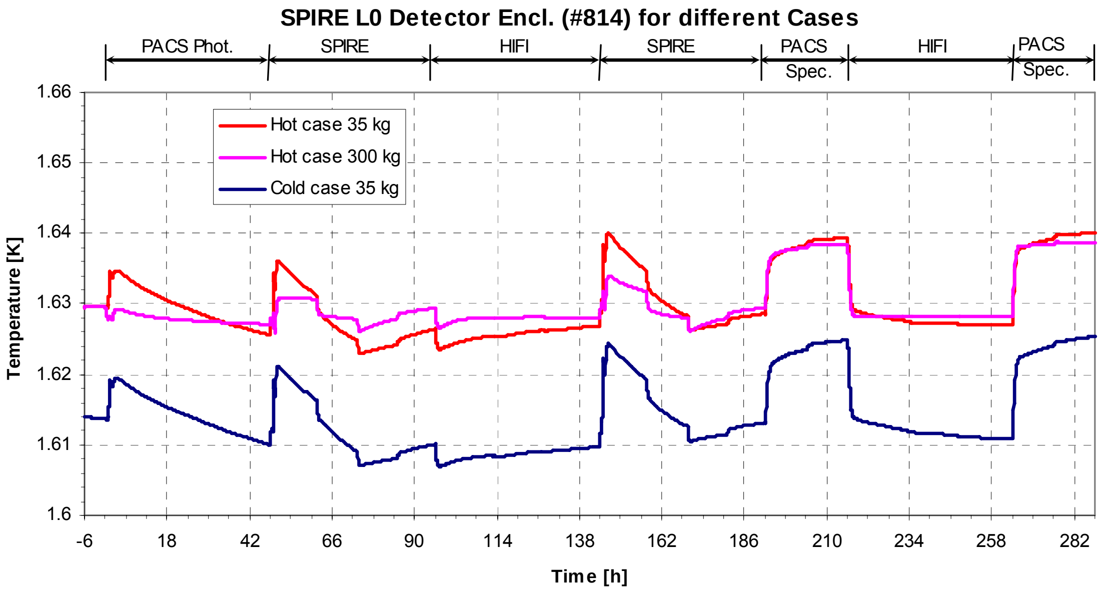


Figure 6.4-33: SPIRE L0 Temperature for Different Conditions

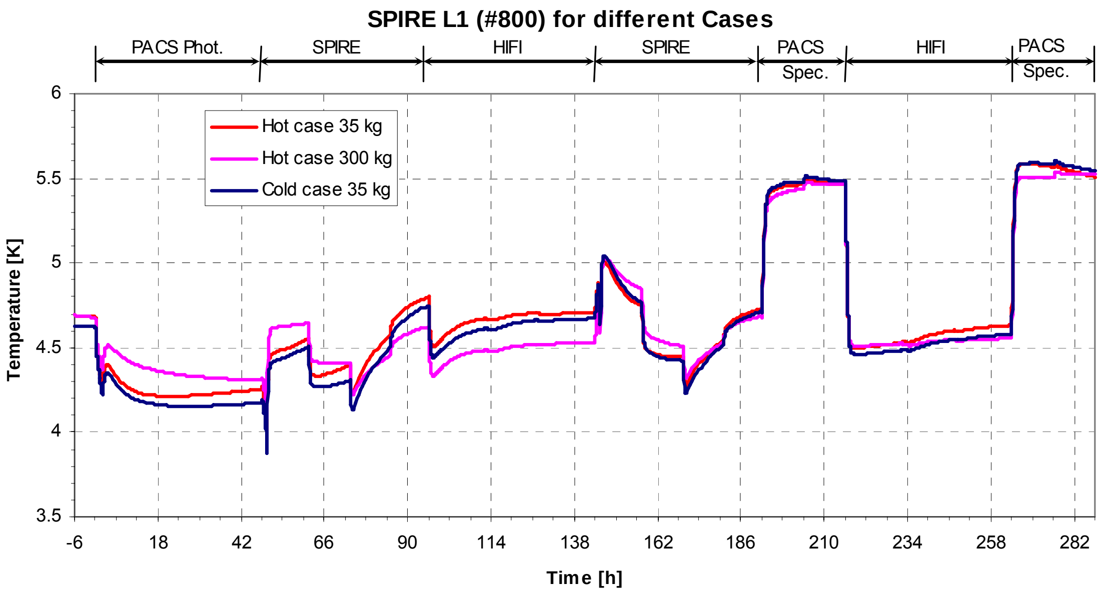


Figure 6.4-34: SPIRE L1 Temperature for Different Conditions

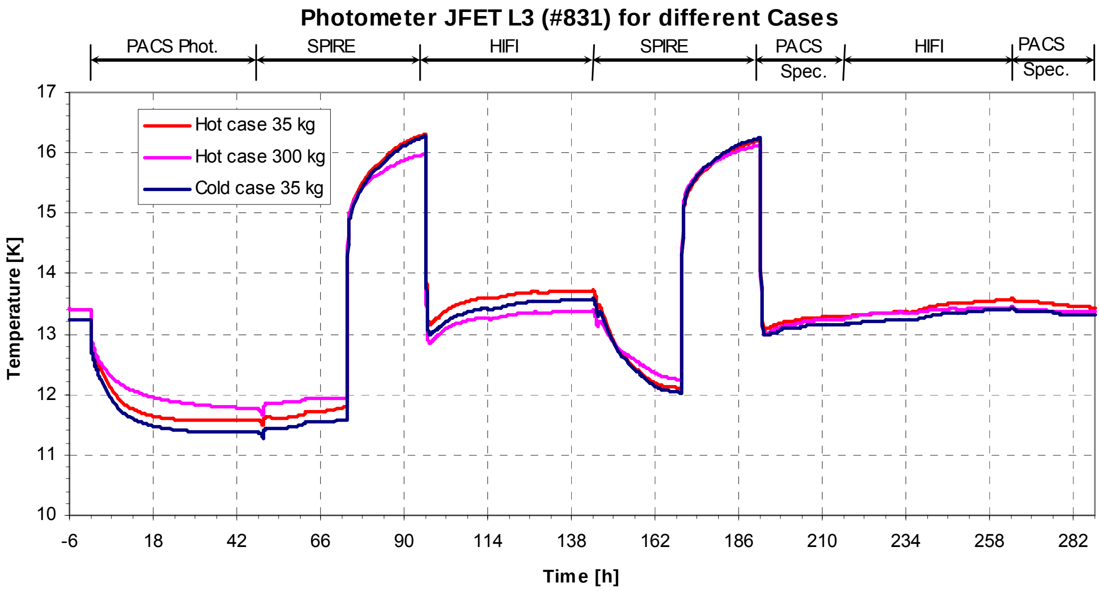


Figure 6.4-35: Photometer JFET L3 Temperature for Different Conditions

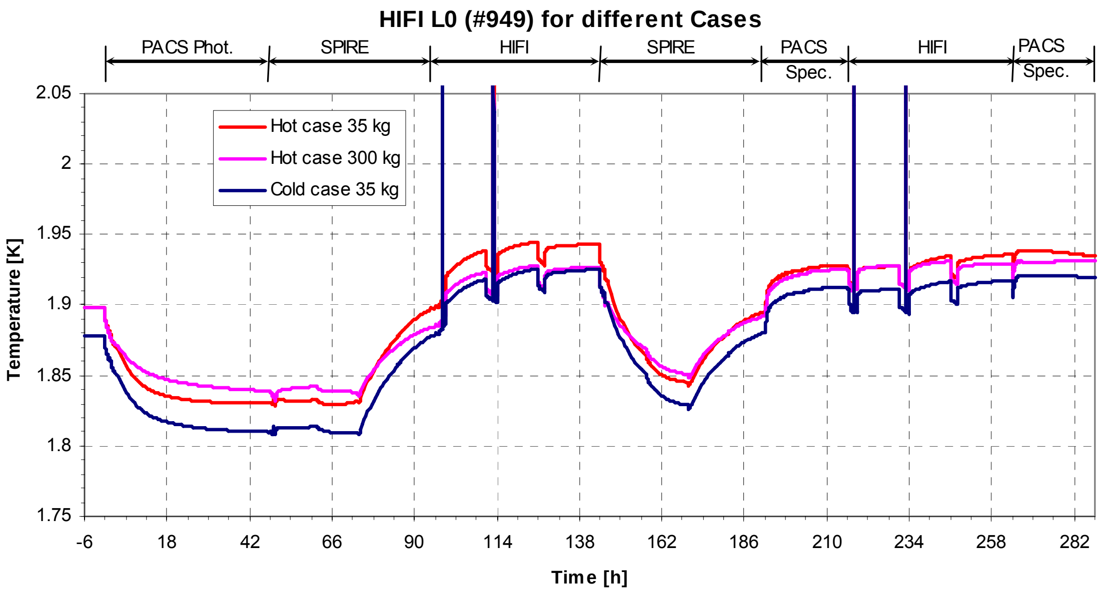


Figure 6.4-36: HIFI L0 Temperature for Different Conditions

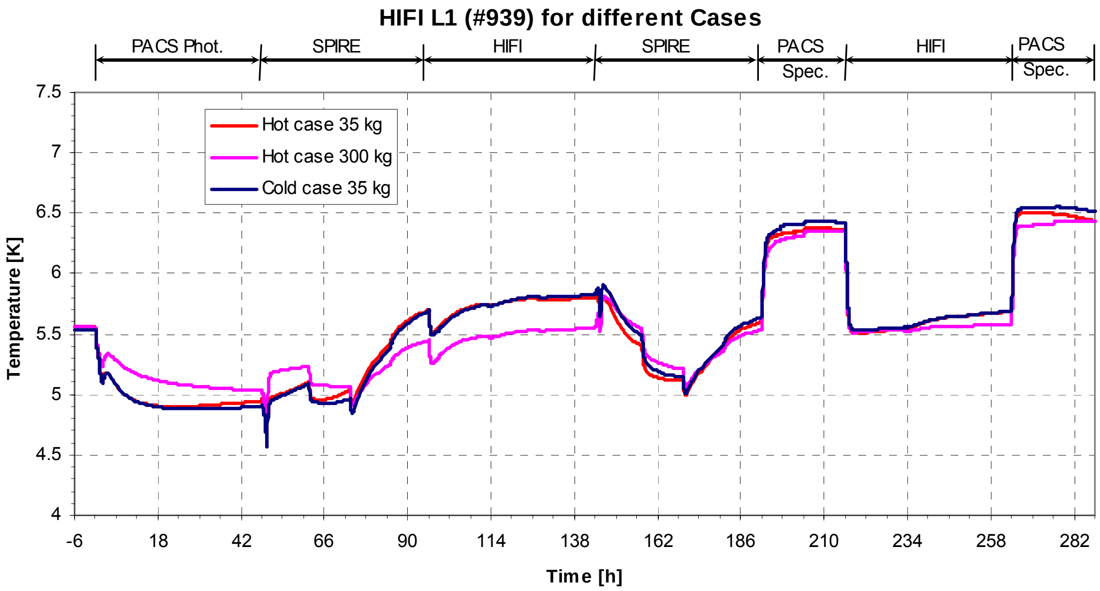


Figure 6.4-37: HIFI L1 Temperature for Different Conditions

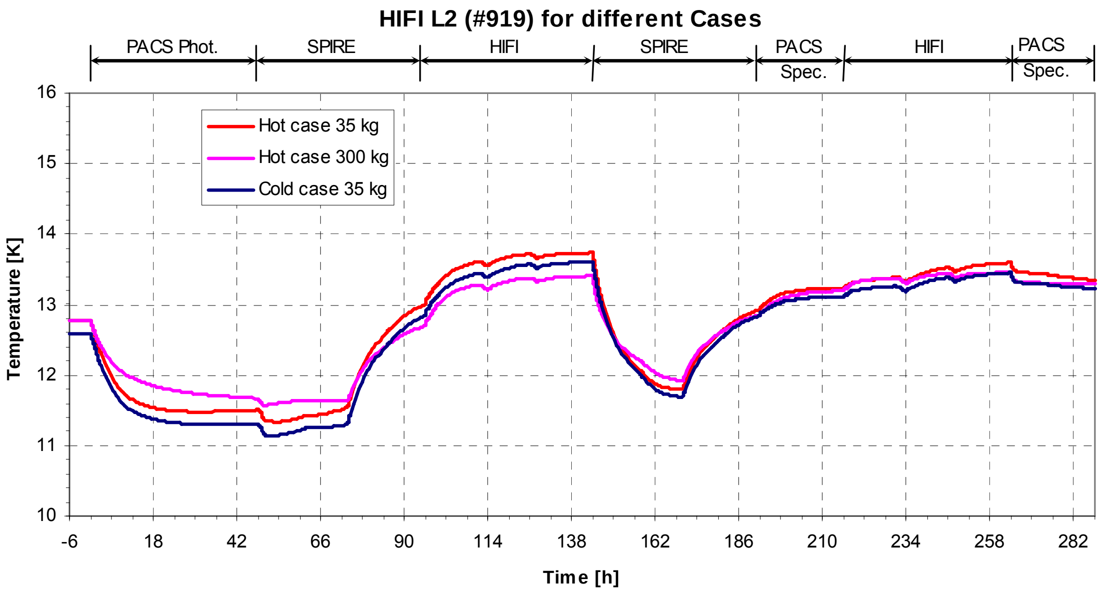


Figure 6.4-38: HIFI L2 Temperature for Different Conditions

6.5 Lifetime Performance

6.5.1 Lifetime Formula

Basically, the lifetime is defined by the total parasitic heat load into the HTT $\sum Q_{HTT}$ and the helium heat of vapourisation h_{vap} for the average environmental conditions at L2 (see Table 3.2-1), leading to an average He massflow $M_{He,\ avg}$.

Additional parameters determining the lifetime in detail are:

- The nominal initial helium mass m_0 is based on a filling level of 98 % and shall include a margin of 15%.(HERS-0530 [AD 06])
- The increased helium consumption m_{trans} during the in-orbit cooldown period t_{trans} (transfer orbit) is considered.
- The residual He gas $m_{residual}$ that cannot be used for vapour cooling at the end of the mission is included.
- A lifetime correction factor $t_{uncertainty}$ is applied reflecting parameter variations.
- DLCM in-orbit measurements for determination of the remaining helium mass are considered with a maximum lifetime loss of 0.36% [RD 19].
- The effect of the configuration changes introduced by ESA/ASPI (startracker attached to CVV, SPIRE harness overall shield, LOU radiator enlargement) on the lifetime is included in the TMM, but is compensated in the lifetime calculation by t_{others}.

Finally, the lifetime is calculated according to the following formula:

$$\mathbf{Lifetime = 0.9964*((m_0 - m_{trans} - m_{residual}) / M_{He,avg} + t_{trans} - t_{uncertainty} + t_{others})}$$

with

m_0	nominal amount of He at lift off; $m_0 = 0.968/1.15$ * HeII density * HTT volume
m_{trans}	He consumption during in-orbit cool down
$m_{residual}$	residual He gas in HTT at EOL; $m_{residual} = 0.94$ * GHe density * HTT volume
$M_{He,\ avg}$	mass flow at L2 (at conditions described in section 3.1.1); $M_{He} = \Sigma\ Q_{HTT} / hv$
t_{trans}	duration of transient cool down until HTT @ 1.65K
$t_{uncertainty}$	Lifetime correction due to RSS input variations
t_{others}	Lifetime compensation

6.5.2 Lifetime Calculation

According to the lifetime formula presented in section 6.5.1, the expected lifetime is calculated by thermal analysis as follows:

m_0 = 0.968 /1.15 * 145.338 kg/m³ * 2.367m³ = 333 kg/1.15 = 289.57 kg
m_{trans} = 21.5 kg (compare to section 6.2)
$m_{residual}$ = 0.94 * 0.33 kg/m³ * 2.367m³ = 0.73 kg
$M_{He, avg}$ = 2.207 mg/s
t_{trans} = 29 days (compare to section 6.2)
$t_{uncertainty}$ = -101 days (compare to section 6.3.2)
t_{others} = +48 days

The lifetime compensation t_{others} is composed of following:

- Enlarged LOU radiator: - 7 days (radiator area increased by about 100 %)
- Startracker on CVV: - 14 days (additional 200 mW heat load to CVV)
- SPIRE overall shield: - 16 days (20 mm² additional stainless steel cross-section for CVV internal harness and 24 mm² additional manganin cross-section for CVV external harness)
- Heatable LOU Baffle: - 11 days (additional heat load on CVV during operation of heaters)

Thus, the lifetime formula can be written:

Lifetime [days] =
= 0.9964 * ((289.57 kg – 21.5 kg – 0.73 kg) * 1E6 / ($M_{He, avg}$ [mg/s] * 3600 ***** 24) + 29 days + 48 days -101 days) =
= 0.9964 * (3094.2 / M_{He} [mg/s] + 77 days – 101 days) = 1373 days = **3.76 years**

With this result the requirement of 3.5 years is fulfilled.

Taking into account positive *and* negative uncertainties (compare to section 6.3.2), the lifetime is predicted in a range of 4.04 years -101 days /+153 days.

Considering a “realistic” lifetime performance, i. e. by neglecting the 15% ESA margin and the lifetime compensation factor “t_others”, the predictions end up with 4.53 years -101 days /+153 days.

Calculation with IID-A Instrument heat load allocations (used until issue 4 of this report as “contractual” lifetime) results in an average He mass flow of 2.383 mg/sec. Neglecting furthermore “t_others” this finally leads to a lifetime of 3.62 years -101 days /+153 days, i. e. 3.34 years worst case.

Another issue has been raised concerning the impact on lifetime if small and large nozzles remained open over the full lifetime (LEOP failure case). A related calculation resulted in a lifetime loss of one day.

6.6 Instrument Interface Temperatures for IID-B Allocations

For verification of the instrument interface temperatures according to IID-B some extra calculations have been performed. They are based on hot orbit environmental conditions at L2. the HTT is fixed at its in-orbit (hot) target temperature of 1.65 K.

For analysis the following modes have been calculated:

- PACS nominal operation
- PACS cooler pump (peak) operation
- SPIRE nominal operation in Photometer mode (PH JFET operational)
- SPIRE nominal operation in Spectrometer mode (SP JFET operational)
- SPIRE cooler pump (peak) in Photometer mode (PH JFET operational), including L0 and L1 goals
- SPIRE cooler pump (peak) in Spectrometer mode (SP JFET operational), including L0 and L1 goals
- HIFI nominal operation

The dissipation of the LOU is considered with 4.71 W for all modes [RD 60].

All runs stated above have been run with the in-orbit hot mass flow (fixed).

The calculation approach is that for each operational mode the corresponding interface heat loads given in Table 6.6-1 are allocated to the interface nodes of the relevant instrument model in the TMM. All other nodes of this instrument are set inactive to avoid thermal contact between the single interfaces and thus additional parasitic interface heat flows.

The given uncertainties are adopted from section 6.3.2.

The temperature limits required at the instrument interfaces are specified in the instrument interface control documents (IID-Bs) for PACS [AD 02], SPIRE [AD 03] and HIFI/LOU [AD 04] (partly updated by RfD's) and are shown in section 3.1. An extract of the these requirements is also given in Table 6.6-1 for direct comparison to the predicted temperatures.

The L0 I/F nodes listed in Table 6.6-1 for PACS and SPIRE are located between the instrument flexible links and ASED rigid/open pods, on flex link side. For HIFI the L0 I/F node is located between flex link and FPU, on FPU side. The L1 and L3 I/F nodes are all located between flexible links and instrument, on instrument side.

	Interface	I/F Requirement		Node	Analysis Results
		Heat Load	Temperature		2.28 mg/s
Level 0	PACS Red Detector	1.0 mW	1.6 K … 1.75 K	724	1.683 K ± 0.06 K
	PACS Blue Detector	2.2 mW	1.6 K … 2 K	723	1.724 K ± 0.06 K
	PACS Cooler Pump	2.2 mW	1.6 K … 5 K	761	1.711 K ± 0.06 K
		500 (peak) mW	1.6 K … 12.06 K (5)		5.844 K ± 0.06 K
	PACS Cooler Evapor.	15.1 mW	1.6 K … 1.85 K	762	1.725 K ± 0.06 K
	SPIRE Detector	4 mW	< 2 K	814	1.755 K ± 0.06 K
		1 mW (goal)	< 1.71 K (goal)		(1.678 K ± 0.06 K)
	SPIRE Cooler Pump	2 mW	< 2 K	815	1.700 K ± 0.06 K
		500 mW (peak)	< 10 K (peak)		5.753 K ± 0.06 K
	SPIRE Cooler Evap.	15 mW	< 1.85 K	816	1.729 K ± 0.06 K
		15 mW (goal)	< 1.75 K (goal)		(1.729 K ± 0.06 K)
	HIFI Detector	6.8 mW	< 2.1 K (4)	949	1.993 K ± 0.06 K
Level 1	PACS FPU	30 mW	2 K … 5 K	781	3.35 K ± 0.09 K
				782	4.02 K ± 0.09 K
				783	4.38 K ± 0.09 K
	SPIRE FPU	15 mW	< 5.5 K	800	4.74/4.51 K ± 0.16 K
		13 mW (goal)	< 3.7 K (goal)		(4.53/4.30 K ± 0.16 K) (3)
	HIFI L1	15.5 mW	< 6.4 K (4)	939	6.12 K ± 0.22 K
Level 2	OBP near PACS	0 mW	< 15 K (7)	371	13.6 K ± 0.6 K
	OBP near SPIRE	0 mW	< 15.5 K (8)	381	14.6/13.2 K ± 0.6 K (3)
		0 mW (goal)	< 8K (goal)		
	Instr. Shield/SPIRE	0 mW	< 16 K	315	14.6/13.2 K ± 0.6 K (3)
	HIFI FPU	22 mW	< 20 K	919	14.3 K ± 0.6 K
Level 3	SPIRE PM-JFET	56.64 mW (6)	< 20 K (8)	831	18.8 K ± 0.5 K
	SPIRE SM-JFET	25 mW	< 16.5 K (8)	832	15.3 K ± 0.5 K
LOU	LOU (HIFI)	4710 mW	90 K …150 K	4201	(121/125) K (1) +3/-7 K

(1) cold/hot case environment at L2
(2) sensitivity analysis
(3) Photometer/Spectrometer mode temperatures
(4) value acc. RFD [AD 11]; L0 was 2.0 K, L1 was 6.0 K before
(5) value acc. RFD [AD 14]; PACS L0 was 10 K, PM JFET was 15 K before
(6) value acc. RFW [AD 15]; was 50 mW before
(7) value acc. RFD [AD 16]; was 12 K before
(8) value acc. RFD [AD 17]; L2 was 12 K, PM-JFET was 15.6 K [AD 14], SM-JFET was 15 K before

Table 6.6-1: Specified versus calculated instrument interface temperatures for IID-B allocations

Compared to the last issue 5 status of this report, the LOU now is about 6 K colder due to reduced dissipation of 4.71 W (7 W before) [RD 60].

Table 6.6-1 shows that all instrument requirements are met (except the goals). If there should anyhow be the need to further reduce the instrument interface temperatures once Herschel is in orbit (e. g. because the helium mass flow is lower than currently predicted), there will be the possibility to increase the mass flow artificially by periodic operation of the DLCMs. A typical scenario has been investigated in more detail in [RD 63].

In addition to above steady state investigations also transient instrument interface temperatures have been calculated using a typical instrument operations timeline. The results are shown in detail in section 6.4, together with the related interface heat flows.

7 Summary and Conclusions

The status of the H-EPLM Thermal Model in its PFM final flight configuration is described in detail and the corresponding analysis results are reported.

Calculation of the contractual lifetime using the instrument TMMs according to IID-B conditions [AD 12] leads to 3.76 years including uncertainties, which is compliant to the requirement of 3.5 years, with significant margin. Considering a “realistic” lifetime performance (neglecting 15% ESA margin and lifetime compensation factors “t_others”) the predictions end up with 4.25 years including uncertainties.

The instrument interface temperature requirements for L0, L1, L2 and L3 have been analysed for a nominal massflow based on orbit hot case (i.e. worst case conditions) and are fully met.

Transient analyses using an instrument operations timeline have been conducted for hot and cold case environment at L2 orbit as well as for a nearly full HTT and a nearly empty HTT. Evaluation of instrument timeline results show that the HIFI temperature stability goals are met.

8 ANNEX 1: Nodal Temperature Listing

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
	HERSCHEL					
99998	INACTIVE_NODE	0	0	0	0	0
99999	DEEP SPACE	3	3	3	3	293
	EPLM					
10	MAIN TANK HTT LHe	1.60914	1.5936	1.60261	1.55538	1.8
13	MAIN TANK HTT wall upp	1.60916	1.59363	1.60264	1.5554	1.80024
20	AUXILIARY TANK HOT	19.6008	18.8306	19.24214	18.1138	54.7374
75	PACS L1 Photometer T242	2.65045	2.63135	2.64122	2.39807	6.09209
85	SPIRE L1 T248	4.66181	4.6247	4.64297	4.11647	11.92644
88	PH JFET L3 T251, T252	13.36519	13.24774	13.31104	11.46651	20.53717
89	SP JFET L3 T249, T250	13.41149	13.29395	13.35731	11.47405	20.47184
91	HIFI L0 pod-braid T228	1.80081	1.78427	1.7937	1.70937	2.33652
92	HIFI L0	1.89433	1.87662	1.88665	1.78268	2.60593
95	HIFI L1 T244	5.52929	5.54013	5.53342	5.03256	8.72778
111	MLI ON MAIN TANK LOW	3.4777	3.23465	3.36264	3.00275	59.11542
112	MLI ON MAIN TANK CYL	3.52707	3.28294	3.41158	3.04422	58.21516
113	MLI ON MAIN TANK UPP	3.54917	3.30562	3.43383	3.02915	52.44816
121	MLI ON AUX TANK LOW	21.99968	20.99447	21.53037	20.06841	71.02308
122	MLI ON AUX TANK UPP	21.29806	20.36393	20.86226	19.50063	68.13792
201	SF lo strut HTT end	1.61764	1.60147	1.61081	1.56268	1.89034
211	SF lo belt pZ	19.39705	18.63715	19.04318	17.93004	54.3399
212	SF lo belt mY	19.41955	18.65949	19.0656	17.95219	54.38325
213	SF lo belt mZ	19.39839	18.63898	19.04475	17.9323	54.32358
214	SF lo belt pY	19.38483	18.62549	19.03122	17.91892	54.29576
221	SF lo corner pZmY	19.39966	18.63982	19.04582	17.93275	54.33869
222	SF lo corner mZmY	19.42382	18.66394	19.06996	17.95679	54.3773
223	SF lo corner mZpY	19.39071	18.63166	19.03724	17.92534	54.29085
224	SF lo corner pZpY	19.38184	18.62267	19.02831	17.91627	54.27891
231	SF up strut HTT end	1.61338	1.59773	1.6068	1.55888	1.81362
241	SF up belt pZ	13.38778	13.19713	13.29952	12.0323	23.66443
242	SF up belt mY	13.52028	13.31839	13.4267	12.15398	24.75035
243	SF up belt mZ	13.48158	13.28245	13.38929	12.11296	24.58717
244	SF up belt pY	13.41472	13.22244	13.32569	12.04726	23.79605
251	SF up corner pZmY	13.38498	13.19458	13.29684	12.0325	23.62916
252	SF up corner mZmY	13.55476	13.35033	13.45998	12.18512	24.93977
253	SF up corner mZpY	13.46327	13.26586	13.3718	12.09509	24.39782
254	SF up corner pZpY	13.4032	13.2125	13.31491	12.03598	23.57756
271	Susp. Straps pZmY low	28.69296	27.74714	28.25323	26.86805	73.33891
272	Susp. Straps pZmY low	28.77943	27.82798	28.33703	26.94013	73.99826
273	Susp. Straps mZmY low	28.82714	27.87201	28.38293	26.9811	74.41652
274	Susp. Straps mZmY low	28.86514	27.90885	28.42042	27.01605	74.49161
275	Susp. Straps mZpY low	28.80364	27.85146	28.36087	26.96409	73.9728
276	Susp. Straps mZpY low	28.69768	27.75196	28.25798	26.87414	73.25821
277	Susp. Straps pZpY low	28.57265	27.63539	28.13697	26.76791	72.36545
278	Susp. Straps pZpY low	28.56772	27.63059	28.1321	26.76321	72.37393
281	Susp. Straps pZmY upp	27.47538	26.68808	27.10962	25.8052	61.78194
282	Susp. Straps pZmY upp	28.54386	27.71908	28.16048	26.65676	65.76061
283	Susp. Straps mZmY upp	30.9489	29.96526	30.49099	28.92156	77.99161
284	Susp. Straps mZmY upp	31.94679	30.90394	31.46034	29.79486	83.37229
285	Susp. Straps mZpY upp	30.52876	29.57776	30.08565	28.485	77.06348
286	Susp. Straps mZpY upp	26.40348	25.62175	26.04017	24.72218	61.93078

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
287	Susp. Straps pZpY upp	27.80283	27.0602	27.45821	25.8877	57.34091
288	Susp. Straps pZpY upp	27.58052	26.84317	27.23845	25.77348	56.66236
291	S. Str. pZmY upp har.IF	23.23209	22.60405	22.94051	21.64925	47.83757
292	S. Str. pZmY upp har.IF	25.65811	24.94121	25.32476	23.5577	56.7424
293	S. Str. mZmY upp har.IF	29.6315	28.67515	29.18637	27.5364	69.44246
294	S. Str. mZmY upp har.IF	30.93471	29.91476	30.45918	28.70978	74.86154
295	S. Str. mZpY upp har.IF	28.92129	28.02389	28.50309	26.76092	68.3745
296	S. Str. mZpY upp har.IF	19.29345	18.77383	19.05145	17.76834	43.1197
297	S. Str. pZpY upp har.IF	25.17334	24.56086	24.88919	22.73785	46.00087
298	S. Str. pZpY upp har.IF	24.82425	24.21215	24.54043	22.65472	45.27318
310	Instr. Shield Cyl.	12.74637	12.6058	12.68162	11.42645	19.92628
311	Instr. Shield Top	12.74866	12.60777	12.68377	11.42837	19.9991
315	Instr. Shield Baffle	12.74917	12.60817	12.68422	11.42874	20.0274
371	Opt. Bench +Z	12.72916	12.59052	12.66535	11.41003	19.25084
372	Opt. Bench +Z -Y	12.47752	12.36016	12.42382	11.22307	17.13712
373	Opt. Bench +Z mid	12.711	12.57318	12.64756	11.39417	19.41408
374	Opt. Bench +Z +Y	12.7312	12.59246	12.66734	11.41212	19.26923
375	Opt. Bench -Y	12.72643	12.58644	12.66193	11.39943	20.14494
376	Opt. Bench centre	12.72743	12.58648	12.66248	11.3984	20.24497
377	Opt. Bench +Y	12.78886	12.64506	12.72258	11.45969	20.14705
378	Opt. Bench -Z -Y	12.88735	12.73699	12.81798	11.54857	20.92723
379	Opt. Bench -Z mid	12.77503	12.6317	12.70896	11.44314	20.38927
380	Opt. Bench -Z +Y	12.80237	12.65771	12.73569	11.47164	20.21974
381	Opt. Bench -Z	12.76914	12.62644	12.70337	11.43939	20.28917
400	V102	1.64768	1.62613	1.63826	1.58201	2.83786
401	V103	1.61863	1.6024	1.61178	1.56424	2.85603
402	V104	1.6352	1.61589	1.62685	1.57456	1.83005
403	V106	1.6182	1.60204	1.61139	1.56398	2.33632
404	SV123	2.14556	2.08548	2.11789	2.01	6.75667
405	V701	19.38991	18.63015	19.0361	17.92314	54.33134
406	V702	19.41157	18.65203	19.05787	17.94521	54.36547
407	V105	19.37889	18.62023	19.0256	17.91426	54.26907
408	SV723	19.36631	18.60746	19.01293	17.90135	54.26019
411	Tubing HOT-V701 supp 13	2.5041	2.37673	2.44411	2.24344	21.06703
412	Tubing HOT-V701 supp 12	3.98467	3.68959	3.84496	3.4086	33.04256
413	Tubing HOT-V701 supp 11	8.25511	7.73168	8.01114	7.23777	41.555
414	Tubing HOT-V701 supp 27	16.16962	15.46006	15.83911	14.79812	51.10545
415	Tubing HOT-V701 supp 09	16.31597	15.57971	15.97315	14.89137	51.90418
416	Tubing HOT-V701 supp 01	17.44105	16.6903	17.09147	15.98953	53.0517
417	Tubing HOT-V701 LSFW str	19.60038	18.83021	19.24175	18.11345	54.73313
421	Tubing HOT-V105 supp 12	11.56494	11.26785	11.43032	10.89438	29.77711
422	Tubing HOT-V105 supp 11	4.75765	4.52637	4.65027	4.26535	31.23105
423	Tubing HOT-V105 supp 10	3.55312	3.32225	3.44357	3.09382	32.74249
424	Tubing HOT-V105 supp 07	8.75757	8.26639	8.52883	7.80328	41.42537
431	Tubing SV123-L1 supp 75	9.57774	9.04028	9.32638	8.51019	41.78823
432	Tubing SV123-L1 supp 18	6.25664	5.87524	6.0785	5.49101	25.55503
433	Tubing V103-L1 @ V103	4.97975	4.68932	4.8441	4.39648	20.21953
434	Tubing V103-L1 supp 14	4.29361	4.00387	4.1572	3.71529	1.88459
435	Tubing V103-L1 supp 15	2.97054	2.78992	2.88557	2.60173	1.8758
440	Filling port outer end	65.72482	62.66499	64.2932	59.05803	292.15818
441	Filling port middle	64.66442	61.67352	63.26518	58.15268	277.63135
442	Filling port middle	62.68669	59.82179	61.34642	56.45683	257.61031
443	Filling port Sline I/F	59.38301	56.71981	58.13861	53.60998	235.77116
444	Filling port Fline I/F	59.18353	56.53193	57.94456	53.43518	233.22005
445	Filling port inner end	59.18353	56.53193	57.94456	53.43518	233.22005

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
451	Safety line @ FP IF	55.30614	52.89911	54.18192	50.11399	209.32871
452	Safety line	51.02958	48.88364	50.02736	46.43355	186.60092
453	Safety line	46.44761	44.57025	45.57081	42.48009	164.52014
454	Safety line	41.41375	39.82294	40.67069	38.13151	141.83212
455	Safety line @ strap IF	35.67842	34.40637	35.08406	33.17788	118.41228
456	Safety line	31.40395	30.2445	30.86217	29.1224	105.16419
457	Safety line support 34	26.32541	25.27752	25.8358	24.2602	91.12529
458	Safety line	21.76613	20.86722	21.34606	19.99316	76.42337
459	Safety line support 20	15.48567	14.77736	15.1546	14.08602	58.28943
461	Tubing SV123 - HTT	2.64082	2.53754	2.59273	2.42326	1.82993
462	Tubing HTT-V104 supp 6	1.94496	1.89428	1.92173	1.82146	1.81225
463	Tubing HTT-V104 supp 75	1.91779	1.87018	1.89602	1.79922	1.82732
471	Filling line @ FP IF	55.62321	53.17232	54.47848	50.29666	196.71791
472	Filling line	52.04325	49.77429	50.98343	47.10323	171.54354
473	Filling line	48.3357	46.23744	47.35601	43.7647	150.45014
474	Filling line supp 35	44.42237	42.49312	43.52359	40.20611	131.60905
475	Filling line	41.04988	39.2779	40.22422	37.16596	117.05413
476	Filling line	37.45578	35.82905	36.69748	33.8876	104.46434
477	Filling line	33.49747	32.01322	32.80681	30.23465	92.92294
478	Filling line supp 5	28.93387	27.59164	28.30919	25.97492	81.71067
479	Filling line	24.27385	23.0801	23.71798	21.64206	71.156
480	Filling line supp 4	18.05326	16.99954	17.56265	15.75651	59.79788
481	Filling line	15.49261	14.57206	15.06398	13.49161	52.42905
482	Filling line	12.20121	11.4564	11.85429	10.58215	44.13549
483	Filling line supp 2	6.82799	6.28549	6.57375	5.65955	33.59961
484	Filling line @ V102	5.27705	4.87679	5.08904	4.41758	25.86842
485	Filling line supp 3	2.23163	2.14952	2.19344	2.05279	12.13026
494	Filling line supp 31	8.0356	7.38314	7.73035	6.62828	45.79144
495	Filling line supp 22	4.04181	3.67389	3.86721	3.27791	42.32319
496	Filling line supp 23	3.41674	3.17217	3.30089	2.93528	43.81592
497	Filling line supp 24	6.04846	5.6099	5.84273	5.19679	44.72908
498	Filling line supp 25	9.45336	8.94317	9.21478	8.46374	46.6588
499	Filling line supp 26	14.6123	13.95599	14.30635	13.343	50.77298
505	Supp bracket L1 entrance	2.11422	2.05221	2.08563	1.97144	6.96716
510	Vline wall HTT-L1 sup 16	1.61181	1.59613	1.60522	1.55804	16.06815
511	Vline wall HTT-L1	1.61869	1.60246	1.61184	1.56432	16.77058
512	Vline wall HTT-L1 sup 17	1.62092	1.6046	1.61403	1.56664	14.14562
513	Vline wall HTT-L1 sup L1	1.62537	1.60878	1.61835	1.57092	1.88751
514	Vline wall HTT-L1 @L1 IF	1.8886	1.88376	1.88676	1.81442	2.07944
520	Vline wall PACS I/F 1	2.39354	2.38337	2.38873	2.20938	4.2037
521	Vline wall PACS I/F 1	2.52127	2.50786	2.51483	2.30618	5.0354
522	Vline wall PACS I/F 1	2.47433	2.4652	2.46996	2.27769	4.39427
523	Vline wall PACSI/F1/2	2.39864	2.40149	2.40002	2.2429	2.98633
524	Vline wall PACSI/F1/2	2.48728	2.49041	2.48873	2.31346	3.12004
525	Vline wall PACS I/F 2	2.84658	2.8326	2.83966	2.56373	5.83776
526	Vline wall PACS I/F 2	2.91994	2.90134	2.91077	2.61301	6.53763
527	Vline wall PACS I/F 2	2.89725	2.88209	2.88975	2.6016	5.88961
528	Vline wall PACSI/F2/3	2.87236	2.86369	2.86799	2.59335	4.36393
529	Vline wall PACSI/F2/3	2.9498	2.93748	2.94366	2.64769	4.70148
530	Vline wall PACS I/F 3	3.06837	3.04591	3.05732	2.72335	6.43889
531	Vline wall PACS I/F 3	3.10841	3.08211	3.0955	2.74824	7.12524
532	Vline wall PACS I/F 3	3.10692	3.08319	3.09523	2.75279	6.55242
533	Vline wall PACS-SPIRE	3.12344	3.10343	3.1135	2.7758	5.84323
534	Vline wall PACS-SPIRE	3.21729	3.20425	3.21052	2.87432	5.54785
535	Vline wall PACS-SPIRE	3.62942	3.62526	3.62655	3.26053	6.14312

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
536	Vline wall SPIRE IF12	4.41341	4.38854	4.40044	3.91861	9.99461
537	Vline wall SPIRE IF12	4.57678	4.5453	4.56064	4.05227	11.01725
538	Vline wall SPIRE IF12	4.55786	4.53147	4.54413	4.04631	10.33077
539	Vline wall SPIRE-HIFI	4.63721	4.63335	4.63409	4.17126	8.21148
543	Vline wall SPIRE-HIFI	5.17195	5.18896	5.17877	4.71434	8.31927
544	Vline wall HIFI I/F	5.35476	5.3698	5.36077	4.87991	8.48499
545	Vline wall HIFI I/F	5.46735	5.48033	5.47245	4.98004	8.61552
546	Vline wall HIFI I/F	5.45946	5.47428	5.46543	4.97671	8.5445
550	Vline wall L1-L2	5.46091	5.47822	5.46804	4.98367	8.46309
551	Vline wall L1-L2	5.58198	5.61487	5.59626	5.13384	8.42714
552	Vline wall L1-L2	6.06343	6.1275	6.09237	5.65587	8.47185
553	Vline wall L1-L2	7.69055	7.76769	7.72664	7.20598	9.01973
554	Vline wall L1-L2	11.75918	11.69343	11.72986	10.67426	13.95922
560	Vline wall Lev.2 OB	12.43971	12.32533	12.38742	11.19466	16.77841
561	Vline wall Lev.2 OB	12.72869	12.59015	12.66492	11.40993	19.19626
562	Vline wall Lev.2 OB	12.79371	12.64962	12.7273	11.46402	20.1477
563	Vline wall Lev.2 OB	12.76947	12.62677	12.7037	11.43953	20.28426
570	Vline wall L2-L3	12.83139	12.69481	12.76842	11.44266	20.28238
571	Vline wall L2-L3	13.1179	12.9987	13.06295	11.45618	20.32573
580	Vline wall PM JFET	13.28774	13.17067	13.23378	11.46342	20.43783
581	Vline wall PM JFET	13.34131	13.22421	13.28733	11.46566	20.49153
582	Vline wall PM JFET	13.34095	13.22419	13.28713	11.46588	20.46455
583	Vline wall PM/SM JFET	13.35858	13.24224	13.30496	11.4683	20.41549
584	Vline wall SM JFET	13.398	13.28098	13.34407	11.47268	20.44766
585	Vline wall SM JFET	13.4063	13.28897	13.35222	11.47357	20.45921
586	Vline wall SM JFET	13.40501	13.28772	13.35095	11.47351	20.45276
590	Vline wall L3-TS1	13.40184	13.28442	13.34772	11.47363	20.43961
591	Vline wall L3-TS1	13.45442	13.33838	13.40098	11.55248	20.44383
592	Vline wall L3-TS1	23.88915	23.55821	23.74077	23.11617	26.61736
610	Vline wall TS1-2 pymz	34.58488	33.49764	34.07947	32.5018	82.00593
611	Vline wall TS2-3 pymz	45.55685	43.74882	44.70987	42.31019	146.17057
612	Vline w. TS3-CVV pymz	54.99091	52.58678	53.86497	50.23668	218.91449
620	Vline wall TS1-2 mypz	34.56887	33.48209	34.06369	32.4849	82.63404
621	Vline wall TS2-3 mypz	45.55671	43.74842	44.70961	42.30995	146.96115
622	Vline w. TS3-CVV mypz	54.99093	52.5868	53.86498	50.2367	218.91449
643	MLI on filling port	46.34423	44.91619	45.68046	43.22567	138.15324
644	MLI on filling port	46.24413	44.81986	45.58214	43.13346	136.77155
1001	Susp bolt lo pZmY TS1	34.84316	33.71584	34.31857	32.67933	90.48298
1002	Susp bolt lo pZmY TS1	35.02973	33.8876	34.4981	32.83054	92.71449
1003	Susp bolt lo mZmY TS1	35.08734	33.94074	34.55356	32.8807	93.36732
1004	Susp bolt lo mZmY TS1	35.17459	34.0225	34.63819	32.9554	93.74229
1005	Susp bolt lo mZpY TS1	35.07684	33.93268	34.54421	32.87577	92.56698
1006	Susp bolt lo mZpY TS1	34.84287	33.71646	34.31869	32.68333	90.13125
1007	Susp bolt lo pZpY TS1	34.60804	33.50024	34.09271	32.48863	87.6853
1008	Susp bolt lo pZpY TS1	34.59527	33.48802	34.08022	32.47695	87.731
1011	@TS 1 lower bulk 1	34.13647	33.07721	33.6443	32.08954	78.93237
1012	@TS 1 lower bulk 2	34.29573	33.22322	33.79725	32.21847	81.13173
1013	@TS 1 lower bulk 3	34.38381	33.30406	33.88187	32.29145	82.39659
1014	@TS 1 lower bulk 4	34.42433	33.34198	33.92114	32.32655	82.61824
1015	@TS 1 lower bulk 5	34.3349	33.26026	33.83539	32.25478	81.21278
1016	@TS 1 lower bulk 6	34.15131	33.09153	33.65887	32.10492	78.85597
1017	@TS 1 lower bulk 7	33.98641	32.94006	33.50037	31.96922	76.90692
1018	@TS 1 lower bulk 8	33.97817	32.93218	33.49231	31.96138	76.91517
1021	@TS 1 lower cyl 1	34.06906	33.01711	33.58042	32.0347	76.34374
1022	@TS 1 lower cyl 2	34.35055	33.27509	33.85072	32.25951	80.60865

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
1023	@TS 1 lower cyl 3	34.40209	33.32133	33.89969	32.30441	82.24408
1024	@TS 1 lower cyl 4	34.43073	33.34843	33.92758	32.3311	82.11407
1025	@TS 1 lower cyl 5	34.37035	33.29475	33.87039	32.2846	80.24922
1026	@TS 1 lower cyl 6	34.04857	32.99892	33.56099	32.02295	75.88051
1027	@TS 1 lower cyl 7	33.63927	32.62355	33.16784	31.68596	70.96578
1028	@TS 1 lower cyl 8	33.63371	32.61811	33.16235	31.68055	71.02136
1031	@TS 1 upper cyl 1	34.01181	32.96493	33.52559	31.98651	75.53231
1032	@TS 1 upper cyl 2	34.32785	33.25427	33.82891	32.23803	81.03502
1033	@TS 1 upper cyl 3	34.35556	33.27835	33.85484	32.26377	82.47154
1034	@TS 1 upper cyl 4	34.36088	33.28398	33.86029	32.2718	81.55815
1035	@TS 1 upper cyl 5	34.32892	33.25699	33.83072	32.24905	79.5976
1036	@TS 1 upper cyl 6	34.00607	32.96037	33.52038	31.98675	74.94024
1037	@TS 1 upper cyl 7	33.49837	32.49484	33.03275	31.56936	68.85792
1038	@TS 1 upper cyl 8	33.49109	32.48783	33.02561	31.56281	68.95979
1041	@TS 1 upper bulk 1	34.00066	32.95307	33.51405	31.97512	76.97132
1042	@TS 1 upper bulk 2	34.19948	33.13509	33.70487	32.13543	80.09965
1043	@TS 1 upper bulk 3	34.27771	33.20656	33.77986	32.20035	81.44319
1044	@TS 1 upper bulk 4	34.27853	33.20775	33.78085	32.20316	81.01754
1045	@TS 1 upper bulk 5	34.19909	33.13573	33.70495	32.1402	79.31505
1046	@TS 1 upper bulk 6	33.99833	32.9517	33.51216	31.97692	76.44796
1047	@TS 1 upper bulk 7	33.77843	32.7499	33.30089	31.79629	73.75405
1048	@TS 1 upper bulk 8	33.77789	32.74911	33.30022	31.79473	73.92068
1061	Susp bolt up pZmY TS1	34.31605	33.24038	33.81612	32.23946	80.00368
1062	Susp bolt up pZmY TS1	34.72696	33.61815	34.21127	32.55888	86.38657
1063	Susp bolt up mZmY TS1	34.59891	33.49725	34.08651	32.46586	86.56744
1064	Susp bolt up mZmY TS1	34.62116	33.51846	34.10825	32.48786	85.89217
1065	Susp bolt up mZpY TS1	34.74991	33.64167	34.23438	32.59654	85.44813
1066	Susp bolt up mZpY TS1	34.2167	33.14895	33.72047	32.16348	78.80259
1067	Susp bolt up pZpY TS1	33.28757	32.29786	32.82849	31.39532	67.99542
1068	Susp bolt up pZpY TS1	33.26077	32.27271	32.80249	31.37522	67.94657
1090	TS 1 LO Baffles.	34.3553	33.27689	33.854	32.25935	87.10789
1111	TS 1 lower bulk MLI 1	36.52707	35.17684	35.89541	33.99428	127.41101
1112	TS 1 lower bulk MLI 2	36.63528	35.27958	36.00108	34.08796	126.71412
1113	TS 1 lower bulk MLI 3	36.68669	35.3295	36.05182	34.13571	125.51407
1114	TS 1 lower bulk MLI 4	36.71842	35.3598	36.08287	34.16412	125.18893
1115	TS 1 lower bulk MLI 5	36.66621	35.3095	36.03152	34.11756	125.96887
1116	TS 1 lower bulk MLI 6	36.53873	35.18843	35.90702	34.00681	126.74267
1117	TS 1 lower bulk MLI 7	36.41868	35.07511	35.79012	33.90285	127.20108
1118	TS 1 lower bulk MLI 8	36.41224	35.06879	35.78374	33.89648	127.45829
1121	TS 1 lower cyl MLI 1	37.54908	36.09237	36.86678	34.83991	131.0766
1122	TS 1 lower cyl MLI 2	37.70217	36.24061	37.0177	34.97558	129.61843
1123	TS 1 lower cyl MLI 3	37.76113	36.29881	37.07642	35.03185	126.96907
1124	TS 1 lower cyl MLI 4	37.68746	36.23419	37.00703	34.98156	124.59089
1125	TS 1 lower cyl MLI 5	37.71846	36.25727	37.03413	34.99557	127.8357
1126	TS 1 lower cyl MLI 6	37.53606	36.08074	36.85439	34.83227	129.76981
1127	TS 1 lower cyl MLI 7	37.27413	35.83183	36.59853	34.60206	130.50387
1128	TS 1 lower cyl MLI 8	37.27015	35.82776	36.59451	34.598	130.98895
1131	TS 1 upper cyl MLI 1	36.28984	34.96088	35.66821	33.79632	122.89544
1132	TS 1 upper cyl MLI 2	36.51539	35.17342	35.88768	33.98576	124.49236
1133	TS 1 upper cyl MLI 3	36.48995	35.15357	35.86497	33.97643	120.93895
1134	TS 1 upper cyl MLI 4	36.48881	35.15403	35.86459	33.97988	117.14084
1135	TS 1 upper cyl MLI 5	36.51785	35.17757	35.89091	33.99636	119.71621
1136	TS 1 upper cyl MLI 6	36.2863	34.95829	35.6651	33.79735	121.10057
1137	TS 1 upper cyl MLI 7	35.89375	34.59077	35.28432	33.46221	120.97513
1138	TS 1 upper cyl MLI 8	35.88775	34.58484	35.27836	33.45664	121.55584

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
1141	TS 1 upper bulk MLI 1	36.97355	35.56656	36.31458	34.35352	130.88957
1142	TS 1 upper bulk MLI 2	37.10138	35.68806	36.43947	34.46415	131.06717
1143	TS 1 upper bulk MLI 3	37.137	35.72359	36.4751	34.49963	129.75771
1144	TS 1 upper bulk MLI 4	37.13622	35.7235	36.47463	34.50102	128.47486
1145	TS 1 upper bulk MLI 5	37.10137	35.68909	36.43994	34.46823	129.03633
1146	TS 1 upper bulk MLI 6	36.97232	35.56612	36.31371	34.35534	129.70665
1147	TS 1 upper bulk MLI 7	36.82039	35.42243	36.16563	34.22346	130.02655
1148	TS 1 upper bulk MLI 8	36.81983	35.42163	36.16496	34.22212	130.41372
1211	TS 1 low strap I/F 1	34.12951	33.07137	33.6379	32.08453	78.26235
1212	TS 1 low strap I/F 2	34.3384	33.26287	33.8385	32.2524	81.2824
1213	TS 1 low strap I/F 3	34.41098	33.32906	33.90801	32.31349	82.67612
1214	TS 1 low strap I/F 4	34.50749	33.4191	34.00144	32.39548	83.30489
1215	TS 1 low strap I/F 5	34.39329	33.31484	33.89197	32.30385	81.39161
1216	TS 1 low strap I/F 6	34.13276	33.07506	33.64133	32.09121	78.05102
1217	TS 1 low strap I/F 7	33.87326	32.83698	33.39204	31.87757	74.97367
1218	TS 1 low strap I/F 8	33.85826	32.82277	33.37741	31.86416	74.94061
1221	TS 1 upp strap I/F 1	34.12198	33.06772	33.63231	32.08158	74.33254
1222	TS 1 upp strap I/F 2	34.53991	33.45132	34.0339	32.40583	81.41861
1223	TS 1 upp strap I/F 3	34.40331	33.32216	33.90072	32.30403	82.47905
1224	TS 1 upp strap I/F 4	34.41969	33.33803	33.91684	32.32134	81.85843
1225	TS 1 upp strap I/F 5	34.55105	33.46413	34.04573	32.43385	80.53737
1226	TS 1 upp strap I/F 6	34.02593	32.97962	33.53998	32.00921	73.23164
1227	TS 1 upp strap I/F 7	33.06429	32.09902	32.61692	31.21616	61.48048
1228	TS 1 upp strap I/F 8	33.03802	32.07441	32.59146	31.19615	61.35025
2001	Susp bolt lo pZmY TS2	46.01012	44.17987	45.15309	42.63409	148.0409
2002	Susp bolt lo pZmY TS2	45.96276	44.13795	45.10835	42.59998	147.49996
2003	Susp bolt lo mZmY TS2	45.85536	44.0425	45.00665	42.52231	145.60544
2004	Susp bolt lo mZmY TS2	45.84599	44.03503	44.99808	42.51608	145.10496
2005	Susp bolt lo mZpY TS2	45.92687	44.10715	45.07474	42.57495	146.51674
2006	Susp bolt lo mZpY TS2	45.97064	44.14521	45.11584	42.60662	147.26931
2007	Susp bolt lo pZpY TS2	45.9963	44.16753	45.1399	42.62459	147.15518
2008	Susp bolt lo pZpY TS2	46.00682	44.17679	45.14986	42.63196	147.44684
2011	@TS 2 lower bulk 1	45.30812	43.5158	44.46863	42.07065	145.48448
2012	@TS 2 lower bulk 2	45.25313	43.46697	44.41661	42.03093	144.27014
2013	@TS 2 lower bulk 3	45.19358	43.41425	44.36034	41.98793	142.62403
2014	@TS 2 lower bulk 4	45.1936	43.41457	44.3605	41.98806	142.1986
2015	@TS 2 lower bulk 5	45.25413	43.4685	44.41785	42.03196	143.3929
2016	@TS 2 lower bulk 6	45.30835	43.5165	44.46907	42.0711	144.73451
2017	@TS 2 lower bulk 7	45.33765	43.54232	44.49671	42.09217	145.60457
2018	@TS 2 lower bulk 8	45.33764	43.54213	44.49661	42.09205	145.89485
2021	@TS 2 lower cyl 1	45.29551	43.50187	44.45532	42.05946	145.53533
2022	@TS 2 lower cyl 2	45.20281	43.41957	44.36763	41.9927	143.36339
2023	@TS 2 lower cyl 3	45.03504	43.27085	44.20902	41.87152	138.65531
2024	@TS 2 lower cyl 4	45.03412	43.27073	44.20847	41.87094	137.51193
2025	@TS 2 lower cyl 5	45.20954	43.42694	44.37466	41.99815	141.43608
2026	@TS 2 lower cyl 6	45.29769	43.50462	44.45776	42.06148	144.16418
2027	@TS 2 lower cyl 7	45.33578	43.53806	44.49362	42.08872	145.5402
2028	@TS 2 lower cyl 8	45.3353	43.53737	44.49304	42.08822	146.05787
2031	@TS 2 upper cyl 1	45.27377	43.47487	44.43088	42.03618	147.51327
2032	@TS 2 upper cyl 2	45.18321	43.39376	44.34487	41.96975	148.05439
2033	@TS 2 upper cyl 3	45.01167	43.24166	44.18268	41.84584	143.26523
2034	@TS 2 upper cyl 4	44.99209	43.22574	44.16484	41.83303	138.77906
2035	@TS 2 upper cyl 5	45.18899	43.40127	44.35147	41.97612	142.59649
2036	@TS 2 upper cyl 6	45.27736	43.47902	44.43473	42.03951	145.51337
2037	@TS 2 upper cyl 7	45.31216	43.50957	44.46748	42.0644	146.73572

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
2038	@TS 2 upper cyl 8	45.31131	43.50853	44.46654	42.06357	147.38962
2041	@TS 2 upper bulk 1	45.26341	43.45707	44.41672	42.02047	148.7305
2042	@TS 2 upper bulk 2	45.21592	43.41469	44.37169	41.98582	148.4363
2043	@TS 2 upper bulk 3	45.15597	43.36158	44.31503	41.94253	146.72418
2044	@TS 2 upper bulk 4	45.15209	43.35865	44.3116	41.9402	145.33787
2045	@TS 2 upper bulk 5	45.21669	43.41631	44.37287	41.98724	146.27043
2046	@TS 2 upper bulk 6	45.26468	43.45878	44.4182	42.02188	147.48671
2047	@TS 2 upper bulk 7	45.28727	43.47865	44.43948	42.03808	148.24288
2048	@TS 2 upper bulk 8	45.28682	43.47807	44.43897	42.0376	148.64881
2050	@TS 2 baffle	45.28048	43.45862	44.42597	42.02142	150.25977
2061	Susp bolt up pZmY TS2	45.52757	43.7157	44.6788	42.2387	147.00005
2062	Susp bolt up pZmY TS2	45.44441	43.64173	44.60007	42.17893	145.60592
2063	Susp bolt up mZmY TS2	45.05829	43.29862	44.23463	41.89933	136.1873
2064	Susp bolt up mZmY TS2	45.04932	43.29207	44.22677	41.89282	133.96242
2065	Susp bolt up mZpY TS2	45.4565	43.65538	44.61287	42.18945	142.56937
2066	Susp bolt up mZpY TS2	45.52143	43.71131	44.67348	42.23524	145.29628
2067	Susp bolt up pZpY TS2	45.53876	43.72624	44.68964	42.24683	145.84353
2068	Susp bolt up pZpY TS2	45.53992	43.72695	44.6906	42.24738	146.51008
2090	TS 2 LO Baffles.	45.17599	43.38256	44.33572	41.9555	166.39721
2111	TS 2 lower bulk MLI 1	49.79786	47.54525	48.7411	45.52403	205.89235
2112	TS 2 lower bulk MLI 2	49.80791	47.5522	48.74964	45.52565	208.33957
2113	TS 2 lower bulk MLI 3	49.79109	47.53601	48.73309	45.51006	209.62493
2114	TS 2 lower bulk MLI 4	49.78326	47.52959	48.7259	45.50513	209.58812
2115	TS 2 lower bulk MLI 5	49.78903	47.53666	48.7323	45.51387	208.26489
2116	TS 2 lower bulk MLI 6	49.77881	47.52941	48.72353	45.51213	205.82508
2117	TS 2 lower bulk MLI 7	49.75495	47.50952	48.7016	45.49974	203.11869
2118	TS 2 lower bulk MLI 8	49.76249	47.5158	48.70856	45.50444	203.15596
2121	TS 2 lower cyl MLI 1	50.37061	48.08273	49.29763	46.00982	205.00886
2122	TS 2 lower cyl MLI 2	50.39986	48.10554	49.32379	46.02135	209.36141
2123	TS 2 lower cyl MLI 3	50.41607	48.12131	49.33982	46.02851	211.44156
2124	TS 2 lower cyl MLI 4	50.3341	48.04478	49.26032	45.96727	211.1342
2125	TS 2 lower cyl MLI 5	50.37534	48.08581	49.30148	46.00643	209.24998
2126	TS 2 lower cyl MLI 6	50.34504	48.06157	49.27412	45.99386	204.93765
2127	TS 2 lower cyl MLI 7	50.21587	47.95019	49.15349	45.91493	196.55729
2128	TS 2 lower cyl MLI 8	50.22563	47.95832	49.16249	45.92107	196.6603
2131	TS 2 upper cyl MLI 1	49.52019	47.28003	48.46905	45.28796	207.33571
2132	TS 2 upper cyl MLI 2	49.50451	47.26322	48.45281	45.2697	209.66904
2133	TS 2 upper cyl MLI 3	49.42217	47.18699	48.37336	45.20366	210.50254
2134	TS 2 upper cyl MLI 4	49.4031	47.17107	48.35576	45.19098	210.17521
2135	TS 2 upper cyl MLI 5	49.48673	47.25017	48.43724	45.26056	209.29058
2136	TS 2 upper cyl MLI 6	49.50259	47.26616	48.45319	45.27784	207.41894
2137	TS 2 upper cyl MLI 7	49.48511	47.25179	48.43723	45.26985	204.62022
2138	TS 2 upper cyl MLI 8	49.49223	47.2575	48.44368	45.27406	204.63494
2141	TS 2 upper bulk MLI 1	50.03255	47.75253	48.96282	45.70616	210.56596
2142	TS 2 upper bulk MLI 2	50.03384	47.75227	48.96336	45.70306	212.06589
2143	TS 2 upper bulk MLI 3	50.01346	47.73322	48.9436	45.68564	212.84986
2144	TS 2 upper bulk MLI 4	50.00431	47.72577	48.93525	45.67996	212.76712
2145	TS 2 upper bulk MLI 5	50.01717	47.73905	48.94831	45.69336	211.96726
2146	TS 2 upper bulk MLI 6	50.01701	47.74005	48.94871	45.69697	210.58678
2147	TS 2 upper bulk MLI 7	50.00928	47.73363	48.94162	45.69375	209.16935
2148	TS 2 upper bulk MLI 8	50.01552	47.73867	48.9473	45.69748	209.16234
2211	TS 2 low strap I/F 1	45.32451	43.53028	44.4841	42.08311	145.59583
2212	TS 2 low strap I/F 2	45.25283	43.46663	44.41628	42.03141	143.97647
2213	TS 2 low strap I/F 3	45.14318	43.36946	44.31263	41.95221	140.95563
2214	TS 2 low strap I/F 4	45.14249	43.36933	44.3122	41.95183	140.20814

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
2215	TS 2 low strap I/F 5	45.25524	43.46977	44.41902	42.03361	142.62638
2216	TS 2 low strap I/F 6	45.32436	43.53079	44.48425	42.08339	144.5671
2217	TS 2 low strap I/F 7	45.3575	43.55992	44.51547	42.10714	145.62941
2218	TS 2 low strap I/F 8	45.35761	43.5598	44.51547	42.10708	146.02155
2221	TS 2 upp strap I/F 1	45.30347	43.50614	44.46144	42.06319	146.26462
2222	TS 2 upp strap I/F 2	45.20512	43.4188	44.3684	41.99287	143.96154
2223	TS 2 upp strap I/F 3	44.79765	43.05726	43.98303	41.69853	132.65215
2224	TS 2 upp strap I/F 4	44.79026	43.05208	43.97666	41.69296	130.07092
2225	TS 2 upp strap I/F 5	45.22533	43.43951	44.38883	42.00863	140.4089
2226	TS 2 upp strap I/F 6	45.30601	43.50932	44.46428	42.0656	144.28741
2227	TS 2 upp strap I/F 7	45.34177	43.54061	44.49789	42.09094	145.905
2228	TS 2 upp strap I/F 8	45.34121	43.53982	44.49722	42.09034	146.69781
3001	Susp bolt lo pZmY TS3	55.12274	52.6937	53.98516	50.25099	217.64257
3002	Susp bolt lo pZmY TS3	55.14526	52.71446	54.00681	50.26561	220.30406
3003	Susp bolt lo mZmY TS3	54.98979	52.57472	53.85861	50.15113	221.4561
3004	Susp bolt lo mZmY TS3	54.89569	52.49336	53.76986	50.0828	221.39357
3005	Susp bolt lo mZpY TS3	54.84606	52.44891	53.72267	50.04759	220.19403
3006	Susp bolt lo mZpY TS3	54.82708	52.429	53.70386	50.0391	217.56144
3007	Susp bolt lo pZpY TS3	54.89156	52.48569	53.76462	50.08836	213.16707
3008	Susp bolt lo pZpY TS3	54.97402	52.56016	53.84356	50.14837	213.23005
3011	@TS 3 lower bulk 1	54.58442	52.19729	53.46637	49.86239	214.104
3012	@TS 3 lower bulk 2	54.65008	52.25634	53.52885	49.90701	216.83097
3013	@TS 3 lower bulk 3	54.67259	52.27683	53.55036	49.92201	218.33036
3014	@TS 3 lower bulk 4	54.65892	52.26488	53.53745	49.91247	218.32118
3015	@TS 3 lower bulk 5	54.61622	52.22662	53.49686	49.88339	216.81596
3016	@TS 3 lower bulk 6	54.55083	52.16774	53.43461	49.83908	214.0906
3017	@TS 3 lower bulk 7	54.48313	52.1067	53.37013	49.79312	211.10069
3018	@TS 3 lower bulk 8	54.4964	52.11838	53.38268	49.8023	211.11687
3021	@TS 3 lower cyl 1	54.5406	52.15811	53.42482	49.83394	211.54981
3022	@TS 3 lower cyl 2	54.64939	52.25581	53.52831	49.90764	216.30306
3023	@TS 3 lower cyl 3	54.67798	52.28192	53.55566	49.92663	218.5192
3024	@TS 3 lower cyl 4	54.66037	52.26667	53.53912	49.91451	218.49876
3025	@TS 3 lower cyl 5	54.60645	52.21843	53.4879	49.87798	216.29713
3026	@TS 3 lower cyl 6	54.49891	52.12166	53.38554	49.80518	211.5627
3027	@TS 3 lower cyl 7	54.2687	51.91475	53.16647	49.64823	202.5302
3028	@TS 3 lower cyl 8	54.2845	51.92859	53.18138	49.65915	202.60185
3031	@TS 3 upper cyl 1	54.60549	52.21505	53.48594	49.87692	216.47731
3032	@TS 3 upper cyl 2	54.66506	52.26879	53.54272	49.91743	218.96669
3033	@TS 3 upper cyl 3	54.68042	52.28327	53.55763	49.92785	220.26741
3034	@TS 3 upper cyl 4	54.66443	52.26959	53.5427	49.91708	220.25722
3035	@TS 3 upper cyl 5	54.62665	52.23576	53.50679	49.89144	219.01164
3036	@TS 3 upper cyl 6	54.56942	52.18387	53.45213	49.85241	216.74333
3037	@TS 3 upper cyl 7	54.50278	52.12345	53.38848	49.80688	213.59037
3038	@TS 3 upper cyl 8	54.51682	52.13561	53.40166	49.81644	213.546
3041	@TS 3 upper bulk 1	54.62187	52.22915	53.50124	49.88769	218.27152
3042	@TS 3 upper bulk 2	54.66161	52.26512	53.53918	49.91481	219.89928
3043	@TS 3 upper bulk 3	54.67489	52.27765	53.55208	49.92401	220.85625
3044	@TS 3 upper bulk 4	54.6627	52.26727	53.54072	49.91589	220.86108
3045	@TS 3 upper bulk 5	54.63315	52.24081	53.51264	49.89582	219.94439
3046	@TS 3 upper bulk 6	54.59485	52.206	53.47601	49.8696	218.38328
3047	@TS 3 upper bulk 7	54.56396	52.17769	53.44637	49.84834	216.8097
3048	@TS 3 upper bulk 8	54.57477	52.18697	53.45648	49.85561	216.7722
3061	Susp bolt up pZmY TS3	54.79091	52.38299	53.66313	50.0045	216.95071
3062	Susp bolt up pZmY TS3	54.84509	52.4324	53.71503	50.04159	219.78644
3063	Susp bolt up mZmY TS3	54.77849	52.37438	53.65244	49.99411	220.59647

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
3064	Susp bolt up mZmY TS3	54.72858	52.33181	53.60571	49.9592	220.442
3065	Susp bolt up mZpY TS3	54.69604	52.30249	53.57468	49.937	219.60219
3066	Susp bolt up mZpY TS3	54.64414	52.25393	53.52463	49.90285	216.95765
3067	Susp bolt up pZpY TS3	54.59053	52.20364	53.47259	49.86626	212.11888
3068	Susp bolt up pZpY TS3	54.63383	52.24198	53.51366	49.89665	212.17195
3111	TS 3 lower bulk MLI 1	64.19072	60.94242	62.66533	57.03304	286.94034
3112	TS 3 lower bulk MLI 2	63.94257	60.71039	62.42318	56.86585	287.07993
3113	TS 3 lower bulk MLI 3	63.3499	60.15959	61.84736	56.41337	287.1586
3114	TS 3 lower bulk MLI 4	62.99588	59.82624	61.49874	56.12576	287.15812
3115	TS 3 lower bulk MLI 5	62.96178	59.79418	61.4654	56.10044	287.07915
3116	TS 3 lower bulk MLI 6	63.16947	59.98773	61.67029	56.27698	286.93967
3117	TS 3 lower bulk MLI 7	63.72361	60.50851	62.21168	56.70655	286.79173
3118	TS 3 lower bulk MLI 8	64.12091	60.8778	62.59768	56.98152	286.79252
3121	TS 3 lower cyl MLI 1	63.58074	60.36291	62.07325	56.64324	286.9982
3122	TS 3 lower cyl MLI 2	63.35122	60.16524	61.85876	56.49589	287.22997
3123	TS 3 lower cyl MLI 3	62.48204	59.40968	61.04246	55.91933	287.04697
3124	TS 3 lower cyl MLI 4	61.91886	58.91123	60.50592	55.49727	287.34149
3125	TS 3 lower cyl MLI 5	61.77835	58.78654	60.37285	55.39273	287.22967
3126	TS 3 lower cyl MLI 6	62.0017	58.96826	60.5796	55.55604	286.99881
3127	TS 3 lower cyl MLI 7	62.96615	59.80962	61.48555	56.20342	286.59327
3128	TS 3 lower cyl MLI 8	63.42042	60.21493	61.91814	56.52195	286.59631
3131	TS 3 upper cyl MLI 1	62.34252	59.17314	60.85976	55.66788	285.44069
3132	TS 3 upper cyl MLI 2	62.2384	59.08241	60.76259	55.58349	285.60774
3133	TS 3 upper cyl MLI 3	61.44191	58.41438	60.02442	55.05342	285.69694
3134	TS 3 upper cyl MLI 4	60.60673	57.70208	59.24713	54.503	285.69623
3135	TS 3 upper cyl MLI 5	60.55743	57.66215	59.20221	54.4817	285.6108
3136	TS 3 upper cyl MLI 6	61.06416	58.08478	59.66861	54.80033	285.45832
3137	TS 3 upper cyl MLI 7	61.7926	58.70079	60.34484	55.29364	285.25289
3138	TS 3 upper cyl MLI 8	62.20432	59.05243	60.72919	55.57455	285.25006
3141	TS 3 upper bulk MLI 1	62.94508	59.74428	61.44972	56.23841	286.98208
3142	TS 3 upper bulk MLI 2	62.73184	59.56048	61.25045	56.0809	287.07159
3143	TS 3 upper bulk MLI 3	62.22662	59.13547	60.78242	55.74591	287.125
3144	TS 3 upper bulk MLI 4	61.50034	58.50728	60.10188	55.2418	287.12527
3145	TS 3 upper bulk MLI 5	61.4382	58.4536	60.04354	55.20275	287.07409
3146	TS 3 upper bulk MLI 6	62.00767	58.94476	60.57612	55.60005	286.98817
3147	TS 3 upper bulk MLI 7	62.49585	59.3554	61.028	55.9248	286.90313
3148	TS 3 upper bulk MLI 8	62.85706	59.66742	61.36658	56.17951	286.90112
3211	TS 3 low strap I/F 1	54.58102	52.19468	53.46339	49.86137	212.97444
3212	TS 3 low strap I/F 2	54.66661	52.27161	53.54483	49.91942	216.69974
3213	TS 3 low strap I/F 3	54.68606	52.28945	53.56346	49.93202	218.54059
3214	TS 3 low strap I/F 4	54.66769	52.27351	53.54617	49.91922	218.52384
3215	TS 3 low strap I/F 5	54.61919	52.23008	53.50008	49.88623	216.68566
3216	TS 3 low strap I/F 6	54.53445	52.15371	53.41939	49.82899	212.97147
3217	TS 3 low strap I/F 7	54.39065	52.0243	53.28249	49.73116	206.95572
3218	TS 3 low strap I/F 8	54.40754	52.03918	53.29847	49.74292	207.00088
3221	TS 3 upp strap I/F 1	54.59354	52.20526	53.47503	49.86978	214.3265
3222	TS 3 upp strap I/F 2	54.67386	52.27754	53.5515	49.92426	217.83637
3223	TS 3 upp strap I/F 3	54.68784	52.29067	53.56503	49.93321	219.51236
3224	TS 3 upp strap I/F 4	54.66822	52.27379	53.54664	49.91972	219.48891
3225	TS 3 upp strap I/F 5	54.62393	52.23414	53.50456	49.8897	217.84492
3226	TS 3 upp strap I/F 6	54.54547	52.16322	53.42974	49.83658	214.46503
3227	TS 3 upp strap I/F 7	54.40948	52.04065	53.30018	49.74395	208.62568
3228	TS 3 upp strap I/F 8	54.42681	52.05583	53.31653	49.75595	208.63813
4011	@CVV LOW BULK 1	69.00932	65.69497	67.45304	61.42357	293.15
4012	@CVV LOW BULK 2	68.6564	65.35691	67.10504	61.16591	293.15

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
4013	@CVV LOW BULK 3	67.86013	64.59931	66.32317	60.51546	293.15
4014	@CVV LOW BULK 4	67.39123	64.14711	65.85628	60.10746	293.15
4015	@CVV LOW BULK 5	67.36367	64.12079	65.82905	60.08645	293.15
4016	@CVV LOW BULK 6	67.67021	64.41412	66.13461	60.36369	293.15
4017	@CVV LOW BULK 7	68.43516	65.15049	66.89001	60.99874	293.15
4018	@CVV LOW BULK 8	68.95287	65.64258	67.39813	61.3813	293.15
4021	@CVV LOW CYL 1	68.09113	64.8015	66.55135	60.76854	293.15
4022	@CVV LOW CYL 2	67.74352	64.49091	66.22115	60.52362	293.15
4023	@CVV LOW CYL 3	66.43513	63.30288	64.96832	59.55389	293.15
4024	@CVV LOW CYL 4	65.80914	62.75715	64.37475	59.08551	293.15
4025	@CVV LOW CYL 5	65.64073	62.60568	64.21426	58.95274	293.15
4026	@CVV LOW CYL 6	65.99389	62.90659	64.54714	59.23023	293.15
4027	@CVV LOW CYL 7	67.38865	64.16031	65.87504	60.24112	293.15
4028	@CVV LOW CYL 8	67.98279	64.70251	66.44661	60.68522	293.15
4031	@CVV UPP CYL 1	67.6662	64.37052	66.1276	60.49029	293.15
4032	@CVV UPP CYL 2	67.48138	64.20171	65.95127	60.32928	293.15
4033	@CVV UPP CYL 3	66.29605	63.17601	64.83732	59.47412	293.15
4034	@CVV UPP CYL 4	65.04131	62.07477	63.65443	58.58161	293.15
4035	@CVV UPP CYL 5	64.98925	62.03454	63.60782	58.56565	293.15
4036	@CVV UPP CYL 6	65.79505	62.73063	64.36126	59.11795	293.15
4037	@CVV UPP CYL 7	66.91927	63.7144	65.42092	59.94572	293.15
4038	@CVV UPP CYL 8	67.51426	64.23756	65.98365	60.38458	293.15
4041	@CVV UPP BULK 1	67.43809	64.14783	65.90409	60.37391	293.15
4042	@CVV UPP BULK 2	67.13112	63.87465	65.61313	60.13089	293.15
4043	@CVV UPP BULK 3	66.43345	63.27182	64.95909	59.63621	293.15
4044	@CVV UPP BULK 4	65.4302	62.38243	64.00865	58.89384	293.15
4045	@CVV UPP BULK 5	65.35728	62.31907	63.93995	58.84714	293.15
4046	@CVV UPP BULK 6	66.16831	63.038	64.70775	59.4521	293.15
4047	@CVV UPP BULK 7	66.85306	63.63054	65.3496	59.94008	293.15
4048	@CVV UPP BULK 8	67.33958	64.06131	65.81068	60.30606	293.15
4050	CVV -Z Radiator low cyl.	65.5255	62.48976	64.09597	58.84282	293.15
4051	CVV -Z Rad. arithm. low	65.62198	62.58018	64.1909	58.92334	293.15
4052	CVV -Z Rad. arithm. upp	64.58267	61.67712	63.22489	58.25853	293.15
4053	CVV -Z Radiator upp cyl.	64.40212	61.52667	63.05895	58.14001	293.15
4055	CVV -Y Radiator	66.29581	63.17881	64.83753	59.46725	293.15
4057	CVV +Y Radiator	65.82957	62.76061	64.39275	59.13035	293.15
4070	Cryostat baffle pz	66.89635	63.64457	65.38032	59.97392	293.15
4071	Cryostat baffle my	66.54025	63.33926	65.04782	59.70762	293.15
4072	Cryostat baffle mz	65.55706	62.46823	64.11779	58.99351	293.15
4073	Cryostat baffle py	66.4186	63.23233	64.93252	59.62426	293.15
4075	Cryostat inner baffle	66.33202	63.11537	64.83092	59.53886	293.15
4079	Cryostat baffle top	66.35439	63.15875	64.86413	59.56843	293.15
4081	Pretension 1	66.51681	63.34497	65.03223	59.51545	293.15
4082	Pretension 2	66.21427	63.07444	64.74473	59.30158	293.15
4083	Pretension 3	64.96059	61.93788	63.54536	58.37027	293.15
4084	Pretension 4	64.33615	61.39499	62.95451	57.90516	293.15
4085	Pretension 5	64.17784	61.25265	62.80366	57.78065	293.15
4086	Pretension 6	64.51371	61.53607	63.11905	58.0453	293.15
4087	Pretension 7	65.87288	62.75716	64.41233	59.03192	293.15
4088	Pretension 8	66.40425	63.24243	64.92368	59.43021	293.15
4090	CVV LOU windows	66.8986	63.69622	65.40308	59.90734	292.47218
4101	CVV MLI low bulk 1 low	175.26863	159.44317	167.88469	148.11407	293.15
4102	CVV MLI low bulk 2 low	167.3184	151.42008	159.56673	136.45395	293.15
4103	CVV MLI low bulk 3 low	159.27353	143.13762	151.09635	124.50491	293.15
4104	CVV MLI low bulk 4 low	152.84727	136.93938	144.68695	117.3025	293.15

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
4105	CVV MLI low bulk 5 low	151.77712	135.85413	143.59661	116.05275	293.15
4106	CVV MLI low bulk 6 low	156.30134	140.26568	148.16687	121.8125	293.15
4107	CVV MLI low bulk 7 low	163.86074	148.06615	156.1658	133.57206	293.15
4108	CVV MLI low bulk 8 low	174.93872	159.07598	167.52983	147.71159	293.15
4111	CVV MLI low bulk 1 upp	167.89483	154.99981	162.45055	150.3179	293.15
4112	CVV MLI low bulk 2 upp	141.58399	130.97535	136.92549	124.84717	293.15
4113	CVV MLI low bulk 3 upp	121.87067	110.4923	116.12556	97.16181	293.15
4114	CVV MLI low bulk 4 upp	121.56393	110.02802	115.63052	95.26458	293.15
4115	CVV MLI low bulk 5 upp	120.26563	108.85083	114.37468	94.00425	293.15
4116	CVV MLI low bulk 6 upp	117.88828	106.80159	112.29187	94.07832	293.15
4117	CVV MLI low bulk 7 upp	136.75466	125.99789	132.09841	121.33718	293.15
4118	CVV MLI low bulk 8 upp	167.88248	154.96875	162.44127	150.45187	293.15
4121	CVV MLI low cyl 1	164.33917	152.34524	159.44647	149.3909	293.15
4122	CVV MLI low cyl 2	140.10886	130.04997	135.88551	125.72192	293.15
4127	CVV MLI low cyl 7	133.76357	123.73775	129.58772	120.78683	293.15
4128	CVV MLI low cyl 8	163.72966	151.7497	158.84452	148.90422	293.15
4131	CVV MLI upp cyl 1	161.42889	149.46534	156.54825	146.9726	293.15
4132	CVV MLI upp cyl 2	136.24227	126.15407	132.03674	122.61966	293.15
4137	CVV MLI upp cyl 7	131.22924	121.21495	127.07148	118.79005	293.15
4138	CVV MLI upp cyl 8	160.79256	148.86381	155.93207	146.50642	293.15
4141	CVV MLI upp bulk 1 low	142.11999	129.2444	136.66752	127.41525	293.15
4142	CVV MLI upp bulk 2 low	123.83998	112.56733	119.05226	110.75273	293.15
4143	CVV MLI upp bulk 3 low	77.74769	70.92505	74.82911	69.26298	293.15
4146	CVV MLI upp bulk 6 low	72.9357	66.25364	70.07701	65.09079	293.15
4147	CVV MLI upp bulk 7 low	120.8517	109.6282	116.07029	108.04314	293.15
4148	CVV MLI upp bulk 8 low	141.93058	129.06217	136.48553	127.32681	293.15
4151	CVV MLI upp bulk 1 upp	134.32545	120.93088	128.5656	119.27814	293.15
4152	CVV MLI upp bulk 2 upp	119.34671	107.77282	114.37198	106.04933	293.15
4153	CVV MLI upp bulk 3 upp	87.83202	79.47134	84.2389	78.06826	293.15
4156	CVV MLI upp bulk 6 upp	86.42689	78.0749	82.83228	76.78333	293.15
4157	CVV MLI upp bulk 7 upp	116.76973	105.5429	111.94336	103.94999	293.15
4158	CVV MLI upp bulk 8 upp	133.79101	120.45401	128.05672	118.85893	293.15
4170	Cryost. baf. MLI pz	137.88524	124.8869	132.3478	123.2105	293.15
4171	Cryost. baf. MLI my	108.5744	98.45996	104.25797	96.94784	293.15
4173	Cryost. baf. MLI py	107.75917	97.66866	103.45245	96.2377	293.15
4179	Cryost. baf. MLI top	111.30609	101.18043	106.9715	99.34663	293.15
4180	Cryo-baf. SLI collar pz	130.65341	118.79886	125.60784	116.80773	293.15
4181	Cryo-baf. SLI collar my	112.66364	102.54811	108.34585	100.58342	293.15
4182	Cryo-baf. SLI collar mz	92.63055	84.32474	89.06932	82.67398	293.15
4183	Cryo-baf. SLI collar py	111.78547	101.68107	107.47135	99.81757	293.15
4201	LOU supp. plate LOA1 mx	125.36211	121.38483	123.60753	97.91635	293.15
4202	LOU supp. plate LOA2 mx	125.4001	121.42158	123.64492	97.93273	293.15
4203	LOU supp. plate LOA3 mx	125.41104	121.43224	123.65571	97.93771	293.15
4204	LOU supp. plate LOA4 mx	125.4109	121.4321	123.65556	97.93733	293.15
4205	LOU supp. plate LOA5 mx	125.41072	121.43195	123.6554	97.93753	293.15
4206	LOU supp. plate LOA6 mx	125.3974	121.41914	123.64233	97.93131	293.15
4207	LOU supp. plate LOA7 mx	125.35126	121.37508	123.59717	97.91093	293.15
4211	LOU supp. plate LOA1 px	125.37428	121.39632	123.61937	97.9215	293.15
4212	LOU supp. plate LOA2 px	125.40161	121.42238	123.64611	97.93508	293.15
4213	LOU supp. plate LOA3 px	125.40966	121.43027	123.65407	97.93814	293.15
4214	LOU supp. plate LOA4 px	125.40696	121.4256	123.65049	97.93957	293.15
4215	LOU supp. plate LOA5 px	125.40942	121.43005	123.65384	97.93801	293.15
4216	LOU supp. plate LOA6 px	125.40032	121.42119	123.64486	97.93446	293.15
4217	LOU supp. plate LOA7 px	125.36231	121.38533	123.60785	97.91618	293.15
4230	LOU_Attenuator_Plate	125.51594	121.32993	123.66735	98.32173	293.09585

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
4235	LOU_Attenuators	125.52824	121.29441	123.65808	98.40922	293.08133
4240	LOU_Window_Bracket	73.22135	68.81602	71.19867	64.10819	292.75654
4242	LOU_Steel_Baffle	70.90462	66.93017	69.07034	62.5698	292.79913
4245	LOU_Flight_Spare_Windows	73.41818	68.9641	71.37367	64.2251	292.70549
4250	LOU_CVV_IF_Cover	68.15311	64.71901	66.55387	60.73913	292.99719
4260	LOU MLI cap px inside	117.00443	112.1344	114.89064	95.53181	293.15
4261	LOU MLI cap px outside	118.74609	108.6024	114.44267	106.13791	293.15
4263	LOU_supp_MLI_pY	136.33727	126.49551	132.22321	122.04295	293.15
4270	LOU Radiator low.	112.52484	109.21154	111.07209	92.38514	293.15
4271	LOU Radiator upp.	120.59229	116.88901	118.96224	95.97438	293.15
4279	LOU Rad. straps pX I/F	125.27724	121.30516	123.52499	97.88325	293.15
4280	LOU Rad. straps pX	124.37461	120.45185	122.64483	97.51922	293.15
4281	LOU Rad. supp. pZpX	121.8181	117.98774	120.13117	96.50829	293.15
4283	LOU Rad. supp. pZmX	116.07924	112.44772	114.48436	94.13817	293.15
4285	LOU Rad. supp. pZ	119.5045	115.77568	117.86373	95.51524	293.15
4287	LOU Rad. supp. mZpX	122.74022	118.90448	121.05003	96.84621	293.15
4289	LOU Rad. supp. mZmX	114.21628	110.77794	112.70721	93.17211	293.15
4301	LOU_harn_3132 @ LOU I/F	132.36062	127.1778	130.06549	106.21351	293.15
4302	LOU_harness_3132	145.81297	138.89679	142.73493	122.17855	293.15
4303	LOU_harness_3132	160.83645	152.49451	157.08458	138.3865	293.15
4304	LOU_harness_3132	181.04275	170.77431	176.34058	156.94166	293.15
4305	LOU_harness_Strut 32	217.65131	202.91238	210.76661	186.31256	293.15
4306	LOU harn_Strut 32 @ SVM	255.55387	234.67576	245.60821	213.22377	293.15
4311	LOU_harn_3334 @ LOU I/F	131.19162	126.11225	128.93722	105.47246	293.15
4312	LOU_harness_3334	141.13824	134.9532	138.37017	118.60414	293.15
4313	LOU_harness_3334	153.08766	145.92284	149.84245	132.23312	293.15
4314	LOU_harness_3334	170.99242	162.22814	166.94707	149.17561	293.15
4315	LOU_harness_Strut 33	204.9277	191.95049	198.78579	176.65843	293.15
4316	LOU harn_Strut 33 @ SVM	243.83792	224.66654	234.68403	204.35319	293.15
4361	LOU Waveguid 1 @ LOU I/F	128.71142	122.31795	125.91797	105.77522	293.15
4362	LOU Waveguid 2	133.71982	125.65083	130.22159	115.47817	293.15
4363	LOU Waveguid 3	135.56912	127.54031	132.0633	120.30225	293.15
4364	LOU Waveguid 4	146.80388	138.86461	143.25911	131.99218	293.15
4365	LOU Waveguid 5	182.27653	171.8113	177.43249	161.78564	293.15
4366	LOU Waveguid 6 @ SVM I/F	274.06888	251.57377	263.32559	229.21369	293.15
4411	CVV MLI low bulk 1 int	86.06984	79.99632	83.43373	76.17967	293.15
4412	CVV MLI low bulk 2 int	77.01931	72.25572	74.84317	67.9348	293.15
4417	CVV MLI low bulk 7 int	76.30888	71.50625	74.14292	67.45988	293.15
4418	CVV MLI low bulk 8 int	86.66024	80.502	83.99537	76.74871	293.15
4421	CVV MLI low cyl 1 int	83.74337	78.0477	81.30166	74.91838	293.15
4422	CVV MLI low cyl 2 int	75.6187	71.08668	73.6203	67.37739	293.15
4427	CVV MLI low cyl 7 int	74.5179	69.96592	72.49894	66.48493	293.15
4428	CVV MLI low cyl 8 int	84.02279	78.26798	81.56488	75.20379	293.15
4431	CVV MLI upp cyl 1 int	82.64858	76.96692	80.23231	74.06374	293.15
4432	CVV MLI upp cyl 2 int	74.7294	70.18721	72.7224	66.64799	293.15
4437	CVV MLI upp cyl 7 int	73.39848	68.90639	71.42124	65.6321	293.15
4438	CVV MLI upp cyl 8 int	82.36235	76.71378	79.96158	73.86228	293.15
4455	CVV -Y Rad. MLI	129.19629	120.05273	125.34208	115.46539	293.15
4456	CVV -Y Rad. MLI int	68.84825	64.60325	66.96422	61.04777	293.15
4457	CVV +Y Rad. MLI	142.87082	131.97998	138.3558	129.18018	293.15
4458	CVV +Y Rad. MLI int	70.88625	66.10631	68.7535	63.26306	293.15
4470	Cryost. baf. MLI pz int	79.0329	73.02922	76.39263	70.2788	293.15
4471	Cryost. baf. MLI my int	70.68905	66.16126	68.65621	63.0496	293.15
4473	Cryost. baf. MLI py int	70.18259	65.78232	68.1956	62.64513	293.15
4541	CVV TS2 gap	67.39528	64.10594	65.86147	60.34293	282.92142

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
4542	CVV TS2 gap	67.08842	63.83402	65.57123	60.10061	282.91713
4543	CVV TS2 gap	66.39254	63.2338	64.91943	59.60741	282.88185
4544	CVV TS2 gap	65.39282	62.34789	63.97252	58.86726	282.83422
4545	CVV TS2 gap	65.3213	62.28561	63.90507	58.82141	282.8844
4546	CVV TS2 gap	66.13075	63.0027	64.67114	59.42542	282.93306
4547	CVV TS2 gap	66.814	63.59252	65.31083	59.91185	282.9478
4548	CVV TS2 gap	67.29718	64.01981	65.76847	60.27532	282.9155
4901	H501	61.65846	58.89712	60.36345	55.91546	288.73622
4902	Tube_4902	63.40558	60.61893	62.10287	57.60849	241.83818
4903	V502 external	62.88875	60.04926	61.55752	56.87544	279.60733
4910	LHV_Support_1	66.42153	63.29135	64.95572	59.5456	292.86009
4911	V501_Support	66.22428	63.11788	64.76997	59.42206	289.77198
4912	V503_Support	66.25408	63.14403	64.79798	59.44028	290.27217
4913	Tube_4913	64.88102	61.94725	63.50942	58.62112	259.35712
4914	Tube_4914	64.88182	61.94797	63.51018	58.62171	259.39206
4915	Tube_Jct4913_14_16	64.85993	61.92811	63.48918	58.60005	260.22464
4916	Tube_4916	64.80389	61.87728	63.43543	58.54441	262.41542
4917	Tube_4917	64.30266	61.42519	62.9576	58.23772	251.13647
4918	Tube_4918	64.26986	61.39725	62.92693	58.21297	251.08507
4919	Tube_Jct4917_18_02	63.9773	61.13284	62.64758	58.00827	247.87313
4920	LHV_Support_2	65.79921	62.7488	64.36559	59.07913	293.0339
4921	V505_Support	65.73787	62.69503	64.30794	59.03651	292.54584
4922	V504_Support	65.70975	62.67058	64.28179	59.02281	291.51711
4923	Tube_4923	65.02436	62.07428	63.64281	58.65033	268.17774
4924	Tube_Jct4916_23_25	64.8894	61.95414	63.51568	58.57178	266.62547
4925	Tube_4925	64.73973	61.82179	63.37438	58.4586	268.64737
4926	Tube_Jct4925_37_38	65.11726	62.1576	63.72988	58.67545	278.65115
4927	Tube_4927	64.7937	61.86192	63.41847	58.36875	283.08759
4928	Tube_4928	65.09808	62.13629	63.70931	58.65033	275.26864
4930	SV521_Support	65.8025	62.75154	64.3686	59.08109	293.13425
4931	V506	65.8022	62.75129	64.36833	59.08089	293.13359
4932	P501	65.80233	62.7514	64.36845	59.08098	293.1339
4936	Tube_4936	63.41152	60.5242	62.05413	57.2163	292.56627
4937	Tube_4937	65.29064	62.30755	63.89064	58.75502	289.38956
4938	Tube_4938_1	65.40463	62.41949	64.00407	58.87004	277.10974
4939	Tube_4939	65.50017	62.49682	64.09013	58.9069	280.14205
4940	A_Frame	65.68482	62.64703	64.2571	58.99111	292.82449
4941	Support_mY_up	65.68516	62.64755	64.25751	58.99185	292.86065
4942	Support_mY_low	65.77083	62.7234	64.33858	59.05681	293.06414
4943	P502_Support_Plate	65.70108	62.66177	64.27265	59.00415	292.89464
4944	P502	65.70049	62.66128	64.2721	59.00375	292.89306
4945	Support_pY	65.65571	62.62031	64.22908	58.967	292.9913
4946	Tube_4946	65.68247	62.64507	64.25494	58.98971	292.34832
4947	Tube_4947	65.68252	62.64511	64.25498	58.98974	292.34825
4948	pY_Nozzle_Support	62.83616	60.01766	61.50802	56.67986	292.96674
4949	mY_Nozzle_Support	62.9961	60.16443	61.66134	56.80096	292.89093
4950	mZ_Nozzle_Support	65.67956	62.64266	64.25227	58.98769	292.81171
4961	V502 internal	59.41768	56.83502	58.2095	54.26843	233.74494
4962	H501 internal	59.68044	57.08887	58.46808	54.5069	231.26383
4970	pY_Nozzle_tube	64.78544	61.8031	63.38166	58.19094	292.31254
4971	mY_Nozzle_tube	64.82352	61.83749	63.41781	58.22086	292.2911
4972	pY_Nozzle_tube_bracket_1	62.83283	60.01473	61.50488	56.67751	292.9691
4973	mY_Nozzle_tube_bracket_1	62.993	60.16171	61.65842	56.79876	292.89297
4975	pY_Nozzle_supp_strut_1	62.62593	59.84317	61.31639	56.55442	293.04024
4976	pY_Nozzle_supp_strut_2	62.5315	59.72488	61.20662	56.41317	293.0452

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4978	mY_Nozzle_supp_strut_1	62.78857	59.99652	61.47404	56.67948	292.89311
4979	mY_Nozzle_supp_strut_2	62.73847	59.91222	61.40441	56.57329	292.94237
5000	GHe tank outlet	1.60916	1.59363	1.60264	1.5554	1.80024
5010	GHe Tank-PACS	1.61176	1.59609	1.60517	1.55801	1.81158
5011	GHe Tank-PACS	1.61828	1.60211	1.61146	1.56404	1.82679
5012	GHe Tank-PACS	1.62083	1.60453	1.61395	1.56659	1.87458
5013	GHe Tank-PACS	1.6244	1.60793	1.61744	1.57021	1.88194
5014	GHe PACS I/F 1	1.84495	1.84178	1.84393	1.78448	1.99972
5020	GHe PACS I/F 1	2.08053	2.08391	2.08236	1.98935	2.36916
5021	GHe PACS I/F 1	2.18236	2.18707	2.18474	2.07386	2.5504
5022	GHe PACS I/F 1	2.31407	2.31767	2.31585	2.17633	2.84407
5023	GHe PACS I/F 1/2	2.39383	2.39737	2.39554	2.24042	2.93971
5024	GHe PACS I/F 2	2.48478	2.48835	2.48645	2.31231	3.07388
5025	GHe PACS I/F 2	2.66172	2.66319	2.66227	2.4471	3.48427
5026	GHe PACS I/F 2	2.73071	2.73007	2.73022	2.49702	3.69073
5027	GHe PACS I/F 2	2.81427	2.80919	2.81163	2.5542	4.02604
5028	GHe PACS I/F 2/3	2.86943	2.86131	2.86533	2.59197	4.22592
5029	GHe PACS I/F 3	2.94365	2.93232	2.93799	2.64452	4.47219
5030	GHe PACS I/F 3	3.0085	2.99343	3.00104	2.68876	4.7961
5031	GHe PACS I/F 3	3.03706	3.01997	3.02863	2.70759	4.97296
5032	GHe PACS I/F 3	3.0738	3.05434	3.06421	2.73316	5.24162
5033	GHe PACS-SPIRE	3.11223	3.09309	3.10272	2.76758	5.44198
5034	GHe PACS-SPIRE	3.21373	3.20105	3.20713	2.87182	5.50924
5035	GHe SPIRE I/F 1	3.62566	3.62229	3.62317	3.25853	5.97896
5036	GHe SPIRE I/F 1	4.10179	4.10035	4.1	3.6908	6.82429
5037	GHe SPIRE I/F 1	4.27296	4.26822	4.26959	3.83722	7.24709
5038	GHe SPIRE I/F 1	4.44997	4.43684	4.44261	3.97747	7.93386
5039	GHe SPIRE I/F 2	4.63707	4.6332	4.63395	4.17112	8.17595
5043	GHe HIFI I/F	5.15721	5.17643	5.16507	4.70563	8.2667
5044	GHe HIFI I/F	5.28801	5.30846	5.29653	4.8299	8.31329
5045	GHe HIFI I/F	5.36072	5.38153	5.36946	4.89818	8.3425
5046	GHe HIFI I/F	5.42676	5.44547	5.43457	4.95462	8.38649
5050	GHe L1-L2	5.45731	5.47517	5.46471	4.98144	8.41969
5051	GHe L1-L2	5.5692	5.60226	5.58354	5.12255	8.42288
5052	GHe L1-L2	6.01773	6.08531	6.04826	5.62164	8.44412
5053	GHe L1-L2	7.58109	7.67445	7.62488	7.13933	8.6985
5054	GHe L1-L2	11.63063	11.59114	11.61411	10.61625	11.26067
5060	GHe Lev.2 OB	12.43909	12.32477	12.38684	11.19422	16.31638
5061	GHe Lev.2 OB	12.72847	12.58994	12.66471	11.40977	19.1615
5062	GHe Lev.2 OB	12.79366	12.64957	12.72725	11.46398	20.11891
5063	GHe Lev.2 OB	12.76949	12.62679	12.70372	11.43955	20.27853
5070	GHe L2-L3	12.83126	12.69471	12.76831	11.44266	20.28149
5071	GHe PM JFET I/F	13.11733	12.99828	13.06246	11.45617	20.31426
5080	GHe PM JFET I/F	13.26119	13.14622	13.20822	11.46258	20.35145
5081	GHe PM JFET I/F	13.30975	13.19502	13.25689	11.46463	20.37154
5082	GHe PM JFET I/F	13.33611	13.22007	13.28264	11.46573	20.39971
5083	GHe SM JFET I/F	13.35856	13.24222	13.30495	11.4683	20.41386
5084	GHe SM JFET I/F	13.3919	13.27552	13.33827	11.47217	20.42437
5085	GHe SM JFET I/F	13.40064	13.28396	13.34687	11.4731	20.42985
5086	GHe SM JFET I/F	13.40434	13.28719	13.35034	11.47346	20.43723
5090	GHe L3-TS1	13.40185	13.28442	13.34772	11.47363	20.43936
5091	GHe L3-TS1	13.45438	13.33834	13.40094	11.55242	20.44369
5092	GHe L3-TS1	23.88121	23.55042	23.7329	23.10736	25.33642
5110	GHe TS 1 / line pymz	33.0573	32.09251	32.61015	31.20998	61.44714
5111	GHe TS 1 / line pymz	34.02519	32.97894	33.53927	32.0086	73.22267

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
5112	GHe TS 1 / line pymz	34.55065	33.46376	34.04534	32.43353	80.5318
5113	GHe TS 1 / line pymz	34.41979	33.33813	33.91694	32.32143	81.8572
5119	GHe TS 1 / line pymz	34.58476	33.49752	34.07934	32.50167	82.00582
5120	GHe TS 1 / line mypz	33.03105	32.06792	32.58471	31.18999	61.31684
5121	GHe TS 1 / line mypz	34.12115	33.06696	33.63151	32.0809	74.32263
5122	GHe TS 1 / line mypz	34.5396	33.45103	34.0336	32.40558	81.41321
5123	GHe TS 1 / line mypz	34.40342	33.32226	33.90082	32.30411	82.47809
5129	GHe TS 1 / line mypz	34.56875	33.48197	34.06357	32.48476	82.63392
5210	GHe TS 2 / line pymz	44.78249	43.0448	43.96913	41.68596	129.54493
5211	GHe TS 2 / line pymz	45.22499	43.43921	44.38852	42.00838	140.40062
5212	GHe TS 2 / line pymz	45.30595	43.50926	44.46422	42.06556	144.28445
5213	GHe TS 2 / line pymz	45.34175	43.54058	44.49786	42.09092	145.90377
5219	GHe TS 2 / line pymz	45.55669	43.74866	44.70971	42.31003	146.17037
5220	GHe TS 2 / line mypz	44.78986	43.04997	43.97548	41.69151	132.12569
5221	GHe TS 2 / line mypz	45.2048	43.41852	44.3681	41.99264	143.95253
5222	GHe TS 2 / line mypz	45.30339	43.50607	44.46137	42.06314	146.26286
5223	GHe TS 2 / line mypz	45.34118	43.53979	44.49719	42.09032	146.69747
5229	GHe TS 2 / line mypz	45.55655	43.74826	44.70945	42.30978	146.96095
5310	GHe TS 3 / line pymz	54.26206	51.90853	53.16003	49.64264	202.41681
5311	GHe TS 3 / line pymz	54.49873	52.12149	53.38537	49.80505	211.55574
5312	GHe TS 3 / line pymz	54.60637	52.21836	53.48782	49.87792	216.29352
5313	GHe TS 3 / line pymz	54.66032	52.26664	53.53908	49.91448	218.49448
5320	GHe TS 3 / line mypz	54.27785	51.92236	53.17493	49.65356	202.49046
5321	GHe TS 3 / line mypz	54.5404	52.15793	53.42463	49.8338	211.54291
5322	GHe TS 3 / line mypz	54.64931	52.25574	53.52823	49.90759	216.29944
5323	GHe TS 3 / line mypz	54.67795	52.2819	53.55564	49.92661	218.51489
5329	GHe TS 3 out	54.99067	52.58655	53.86473	50.23645	218.91418
5330	GHe V502 out	59.39471	56.81789	58.18943	54.25923	229.70645
5331	GHe H501 out	59.67979	57.08825	58.46745	54.50634	231.26028
5332	GHe ext.Tube 4902 out	63.39708	60.61088	62.09458	57.60141	241.78425
5333	GHe ext.Tube 4917 out	64.30059	61.42333	62.95563	58.23627	251.10436
5334	GHe ext.Tube 4918 out	64.26787	61.39545	62.92503	58.21157	251.05311
5335	GHe ext.Tube 4913/14 out	64.88006	61.94638	63.5085	58.62051	259.33714
5336	GHe ext.Tube 4916 out	64.80406	61.87744	63.4356	58.54459	262.36081
5337	GHe ext.Tube 4923 out	65.02386	62.07383	63.64234	58.65009	268.14176
5338	GHe ext.Tube 4928 out	65.09791	62.13615	63.70916	58.65033	275.25238
5339	GHe ext.Tube 4927 out	64.79439	61.86255	63.41913	58.36939	283.06972
5340	GHe ext.Tube 4925 out	64.73988	61.82192	63.37452	58.45879	268.63303
5341	GHe ext.Tube 4938 out	65.40311	62.41812	64.00264	58.8691	277.0904
5342	GHe ext.Tube 4939 out	65.49995	62.49664	64.08993	58.90681	280.02126
5343	GHe ext.Tube 4946 out	65.68206	62.64473	64.25456	58.98952	291.89113
5344	GHe ext.Tube 4947 out	65.6821	62.64477	64.25461	58.98955	291.89106
5345	GHe ext.Tube 4970 out	64.78749	61.80502	63.38365	58.19277	292.31158
5346	GHe ext.Tube 4971 out	64.82548	61.83933	63.41972	58.22261	292.29019
5900	Mass Flow Rate [mg/s]	2.28327	2.12271	2.20676	1.73853	25.792
5901	Helium: Init Mass [kg]	337	337	337	337	337
5902	Helium: Act Mass [kg]	337	337	337	337	337
5903	Helium: Cons Mass [kg]	0	0	0	0	0
5950	Lifetime [days]	1427.2	1529.3	1474.0	1850.3	196.4
5951	Heat to Tank [mW]	51.90938	48.16859	50.1329	39.24907	597.75522
6201	SVM SHIELD tip +Y	128.66802	116.7672	122.74771	104.5397	293.15
6202	SVM SHIELD tip -Y	131.5696	119.48178	125.59344	107.16338	293.15
6204	SVM SHIELD +Y	132.70559	119.90185	126.32438	106.83959	293.15
6205	SVM SHIELD -Y	135.87274	122.71844	129.35372	109.43663	293.15
6206	SVM SHIELD -Z	123.6227	113.45745	118.56418	102.37202	293.15

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
6301	SVM SHIELD SLI tip +Y	110.48271	101.42586	106.45208	96.90395	293.15
6302	SVM SHIELD SLI tip -Y	114.23081	105.21326	110.2173	99.96885	293.15
6304	SVM SHIELD SLI +Y	114.77759	104.94784	110.12929	97.23918	293.15
6305	SVM SHIELD SLI -Y	121.23488	111.23527	116.53929	103.16511	293.15
6306	SVM SHIELD SLI -Z	91.02118	83.34483	87.20823	75.14557	293.15
6501	STRUT1_CVVSVM	254.2505	253.10791	253.70901	216.40362	293.15
6502	STRUT1_CVVSVM	191.18506	188.15769	189.76143	164.2545	293.15
6503	STRUT1_CVVSVM	119.56448	115.95408	117.87076	103.19939	293.15
6511	STRUT2_CVVSVM	224.13357	221.51801	222.8723	193.09921	293.15
6512	STRUT2_CVVSVM	188.57835	183.75994	186.27248	161.29583	293.15
6513	STRUT2_CVVSVM	152.16805	147.00072	149.70626	128.02695	293.15
6521	STRUT3_CVVSVM	232.96922	229.01039	231.05552	199.89537	293.15
6522	STRUT3_CVVSVM	201.3121	194.47039	198.03155	171.16449	293.15
6523	STRUT3_CVVSVM	163.28089	156.22612	159.90267	136.55159	293.15
6531	STRUT4_CVVSVM	255.17322	254.30169	254.7395	216.5743	293.15
6532	STRUT4_CVVSVM	191.05396	188.92663	190.00651	163.56299	293.15
6533	STRUT4_CVVSVM	118.58916	115.59226	117.14728	102.22439	293.15
6541	STRUT5_CVVSVM	241.20224	238.33108	239.81121	207.80027	293.15
6542	STRUT5_CVVSVM	185.51488	180.60634	183.10894	161.26274	293.15
6543	STRUT5_CVVSVM	131.06081	125.33276	128.34405	114.18344	293.15
6551	STRUT6_CVVSVM	229.76666	226.37895	228.05945	198.45282	293.15
6552	STRUT6_CVVSVM	175.94894	170.78929	173.38814	153.02262	293.15
6553	STRUT6_CVVSVM	125.44827	119.81026	122.75509	109.46202	293.15
6561	STRUT7_CVVSVM	249.21397	247.96996	248.54755	214.08417	293.15
6562	STRUT7_CVVSVM	201.69384	198.28914	199.8806	176.08229	293.15
6563	STRUT7_CVVSVM	174.52629	169.27421	171.74667	152.39472	293.15
6564	STRUT7_CVVSVM	157.01517	150.35814	153.51503	136.07944	293.15
6565	STRUT7_CVVSVM	143.49076	136.17094	139.67259	123.46482	293.15
6566	STRUT7_CVVSVM	130.15305	123.07593	126.51342	112.05679	293.15
6567	STRUT7_CVVSVM	116.16478	109.74676	112.91772	100.48918	293.15
6568	STRUT7_CVVSVM	102.7186	97.07297	99.91138	89.31975	293.15
6569	STRUT7_CVVSVM	89.65067	84.72795	87.24987	78.2606	293.15
6570	STRUT7_CVVSVM	75.69632	71.68857	73.80136	66.58491	293.15
6571	STRUT8_CVVSVM	248.65379	247.56159	248.06323	213.69077	293.15
6572	STRUT8_CVVSVM	200.15426	197.12338	198.52201	174.97422	293.15
6573	STRUT8_CVVSVM	172.4814	167.65455	169.89901	150.8379	293.15
6574	STRUT8_CVVSVM	154.92803	148.59033	151.56001	134.30157	293.15
6575	STRUT8_CVVSVM	141.97439	134.6685	138.11842	121.72383	293.15
6576	STRUT8_CVVSVM	129.97664	122.51537	126.07491	110.84129	293.15
6577	STRUT8_CVVSVM	116.35084	109.49263	112.81207	99.53827	293.15
6578	STRUT8_CVVSVM	102.27471	96.42124	99.30264	88.2059	293.15
6579	STRUT8_CVVSVM	88.98572	84.01541	86.51823	77.31194	293.15
6580	STRUT8_CVVSVM	75.31083	71.31676	73.40363	66.16199	293.15
6581	STRUT9_CVVSVM	247.86645	246.88632	247.33259	213.09708	293.15
6582	STRUT9_CVVSVM	198.90206	196.11507	197.39226	173.77746	293.15
6583	STRUT9_CVVSVM	169.99555	165.43883	167.54659	148.27888	293.15
6584	STRUT9_CVVSVM	150.41264	144.20899	147.10849	129.48315	293.15
6585	STRUT9_CVVSVM	140.16468	133.07511	136.40089	119.45656	293.15
6586	STRUT9_CVVSVM	131.56067	124.14746	127.64566	111.36883	293.15
6587	STRUT9_CVVSVM	122.70164	115.66282	119.02121	103.95063	293.15
6588	STRUT9_CVVSVM	113.40114	107.06406	110.12376	96.47123	293.15
6589	STRUT9_CVVSVM	96.30181	90.9773	93.60254	82.5713	293.15
6590	STRUT9_CVVSVM	77.97205	73.80866	75.94479	67.87974	293.15
6591	STRUT10_CVVSVM	247.76233	246.88097	247.27909	213.12775	293.15
6592	STRUT10_CVVSVM	198.11802	195.62056	196.75379	173.657	293.15

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
6593	STRUT10_CVVSVM	169.45756	165.37935	167.24284	148.8402	293.15
6594	STRUT10_CVVSVM	151.27607	145.76681	148.30159	131.77965	293.15
6595	STRUT10_CVVSVM	138.38052	131.75287	134.82819	118.96433	293.15
6596	STRUT10_CVVSVM	127.44377	120.19818	123.58722	108.30568	293.15
6597	STRUT10_CVVSVM	115.9244	108.89502	112.22269	98.26041	293.15
6598	STRUT10_CVVSVM	102.85007	96.58769	99.60122	87.60009	293.15
6599	STRUT10_CVVSVM	89.21214	83.96846	86.55149	76.74258	293.15
6600	STRUT10_CVVSVM	75.13489	71.0232	73.13532	65.67582	293.15
6601	STRUT11_CVVSVM	247.48765	246.61335	247.01207	212.91955	293.15
6602	STRUT11_CVVSVM	197.64931	195.0656	196.25706	173.14138	293.15
6603	STRUT11_CVVSVM	168.35081	163.86096	165.96378	147.5088	293.15
6604	STRUT11_CVVSVM	149.10767	142.47846	145.63571	129.00037	293.15
6605	STRUT11_CVVSVM	139.26502	132.03705	135.47382	119.64318	293.15
6606	STRUT11_CVVSVM	132.33169	124.69624	128.33608	112.97102	293.15
6607	STRUT11_CVVSVM	126.77986	119.1434	122.81803	108.08752	293.15
6608	STRUT11_CVVSVM	121.3245	113.90901	117.52473	103.62885	293.15
6609	STRUT11_CVVSVM	101.38208	95.38074	98.34285	87.15692	293.15
6610	STRUT11_CVVSVM	79.95662	75.54099	77.7827	69.60429	293.15
6611	STRUT12_CVVSVM	247.45028	246.60925	246.98901	212.83287	293.15
6612	STRUT12_CVVSVM	197.11175	194.65265	195.77208	172.61236	293.15
6613	STRUT12_CVVSVM	167.27877	163.09775	165.02327	146.52092	293.15
6614	STRUT12_CVVSVM	147.32665	141.34552	144.13474	127.44584	293.15
6615	STRUT12_CVVSVM	136.58863	129.74291	132.94288	116.97305	293.15
6616	STRUT12_CVVSVM	128.30394	120.93214	124.39402	108.89452	293.15
6617	STRUT12_CVVSVM	120.67189	113.33774	116.81514	102.13463	293.15
6618	STRUT12_CVVSVM	112.38961	105.5332	108.83173	95.44321	293.15
6619	STRUT12_CVVSVM	95.3609	89.72944	92.4993	81.72881	293.15
6620	STRUT12_CVVSVM	77.45622	73.19321	75.38097	67.4747	293.15
6621	STRUT13_CVVSVM	247.7499	246.80903	247.23852	213.13484	293.15
6622	STRUT13_CVVSVM	199.03652	196.35384	197.5883	174.20549	293.15
6623	STRUT13_CVVSVM	170.44181	165.97299	168.05486	149.17261	293.15
6624	STRUT13_CVVSVM	151.45357	145.19979	148.15244	131.04959	293.15
6625	STRUT13_CVVSVM	142.06889	134.98275	138.32728	121.81764	293.15
6626	STRUT13_CVVSVM	134.83515	127.32774	130.88699	114.8154	293.15
6627	STRUT13_CVVSVM	127.89952	120.61696	124.1034	108.91155	293.15
6628	STRUT13_CVVSVM	120.54037	113.76848	117.04946	103.00445	293.15
6629	STRUT13_CVVSVM	101.69069	95.98679	98.78849	87.25748	293.15
6630	STRUT13_CVVSVM	80.40904	76.06404	78.26161	69.84386	293.15
6631	STRUT14_CVVSVM	244.88211	243.43628	244.13361	211.56114	293.15
6632	STRUT14_CVVSVM	199.97126	196.12011	197.99857	175.72145	293.15
6633	STRUT14_CVVSVM	177.25966	170.99479	174.10069	155.51108	293.15
6634	STRUT14_CVVSVM	160.11344	152.6063	156.29663	138.64368	293.15
6635	STRUT14_CVVSVM	156.28543	148.00518	152.09464	134.53437	293.15
6636	STRUT14_CVVSVM	153.60292	144.96916	149.2585	131.73712	293.15
6637	STRUT14_CVVSVM	150.26285	141.73348	146.00234	128.88646	293.15
6638	STRUT14_CVVSVM	145.0162	137.02286	141.04987	124.84168	293.15
6639	STRUT14_CVVSVM	123.33184	116.03275	119.73086	105.42023	293.15
6640	STRUT14_CVVSVM	92.36303	86.82097	89.6572	79.27252	293.15
6641	STRUT15_CVVSVM	247.78499	246.77418	247.23833	213.08232	293.15
6642	STRUT15_CVVSVM	199.61192	196.77813	198.08555	174.31701	293.15
6643	STRUT15_CVVSVM	171.03672	166.42421	168.57085	148.95235	293.15
6644	STRUT15_CVVSVM	151.17327	144.95882	147.87732	129.76535	293.15
6645	STRUT15_CVVSVM	142.06356	135.07571	138.36944	120.96052	293.15
6646	STRUT15_CVVSVM	134.0198	126.94598	130.30102	113.68197	293.15
6647	STRUT15_CVVSVM	125.39993	118.70049	121.90385	106.45095	293.15

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6648	STRUT15_CVVSVM	117.44306	111.32636	114.27142	99.83056	293.15
6649	STRUT15_CVVSVM	99.84905	94.56157	97.15227	85.33067	293.15
6650	STRUT15_CVVSVM	79.83142	75.66636	77.77801	69.27525	293.15
6651	STRUT16_CVVSVM	248.39207	247.26096	247.78293	213.39467	293.15
6652	STRUT16_CVVSVM	199.62322	196.41771	197.90909	174.1178	293.15
6653	STRUT16_CVVSVM	170.89784	165.65286	168.11795	148.62232	293.15
6654	STRUT16_CVVSVM	151.2416	144.0776	147.48086	129.65167	293.15
6655	STRUT16_CVVSVM	140.28125	132.5923	136.26737	119.56577	293.15
6656	STRUT16_CVVSVM	130.05097	122.4752	126.13276	110.82551	293.15
6657	STRUT16_CVVSVM	119.7086	112.61799	116.07983	102.34037	293.15
6658	STRUT16_CVVSVM	111.39944	104.59539	107.94401	95.1216	293.15
6659	STRUT16_CVVSVM	94.83857	89.26154	92.0638	81.72841	293.15
6660	STRUT16_CVVSVM	77.45098	73.22188	75.41994	67.70852	293.15
6661	STRUT17_CVVSVM	248.45029	247.2503	247.82324	213.69111	293.15
6662	STRUT17_CVVSVM	201.18735	197.89104	199.47858	175.90624	293.15
6663	STRUT17_CVVSVM	172.96953	167.78751	170.31681	151.30813	293.15
6664	STRUT17_CVVSVM	152.61025	145.95173	149.25567	132.57299	293.15
6665	STRUT17_CVVSVM	143.29854	136.22614	139.77701	124.36056	293.15
6666	STRUT17_CVVSVM	134.13482	127.04134	130.66023	116.64904	293.15
6667	STRUT17_CVVSVM	126.07606	119.19663	122.75696	109.83589	293.15
6668	STRUT17_CVVSVM	119.07862	112.39867	115.87212	103.46915	293.15
6669	STRUT17_CVVSVM	102.70875	96.64317	99.82847	89.16507	293.15
6670	STRUT17_CVVSVM	81.95975	77.24842	79.73794	71.55884	293.15
6671	STRUT18_CVVSVM	214.92263	211.8683	213.41005	185.02813	293.15
6672	STRUT18_CVVSVM	165.84842	161.47694	163.72548	144.87726	293.15
6673	STRUT18_CVVSVM	121.50918	116.4404	119.11325	106.95071	293.15
6681	STRUT19_CVVSVM	227.62082	224.3682	226.02094	196.72155	293.15
6682	STRUT19_CVVSVM	194.42865	188.7069	191.63542	166.95582	293.15
6683	STRUT19_CVVSVM	157.76011	151.80643	154.88076	133.46979	293.15
6691	STRUT20_CVVSVM	249.6983	248.47601	249.10459	213.51638	293.15
6692	STRUT20_CVVSVM	186.68065	183.6384	185.22439	161.24863	293.15
6693	STRUT20_CVVSVM	117.92903	114.03415	116.07839	101.93179	293.15
6701	STRUT21_CVVSVM	217.15983	213.12422	215.21558	186.73766	293.15
6702	STRUT21_CVVSVM	192.24497	185.8909	189.20909	163.71458	293.15
6703	STRUT21_CVVSVM	166.76719	160.19667	163.63895	139.78739	293.15
6711	STRUT22_CVVSVM	254.46958	253.40752	253.96338	216.50417	293.15
6712	STRUT22_CVVSVM	192.14285	189.44946	190.86201	164.67156	293.15
6713	STRUT22_CVVSVM	120.14246	116.60879	118.47765	103.47144	293.15
6721	STRUT23_CVVSVM	254.48279	253.41772	253.97565	216.51876	293.15
6722	STRUT23_CVVSVM	192.11692	189.44079	190.84713	164.68006	293.15
6723	STRUT23_CVVSVM	119.95312	116.49715	118.32813	103.3882	293.15
6731	STRUT24_CVVSVM	254.5347	253.45106	254.0197	216.55372	293.15
6732	STRUT24_CVVSVM	192.29356	189.5567	190.99534	164.79148	293.15
6733	STRUT24_CVVSVM	120.30624	116.72997	118.62384	103.60495	293.15
8401	MLI FRAME_pZ	134.8977	122.4363	129.58629	120.56102	293.15
8402	MLI FRAME_CORNER_mY	127.68723	116.23902	122.80247	114.0894	293.15
8403	MLI FRAME_mY	94.5567	86.23817	91.02803	84.5876	293.15
8404	FRAME_CORNER_mZ	74.6277	69.18226	72.22428	67.59937	293.15
8405	MLI FRAME_pY	93.13453	84.82703	89.60913	83.29256	293.15
8406	MLI FRAME_CORNER_pY	126.20112	114.76827	121.3196	112.74591	293.15
8411	MLI TUBE_to_CVV_mYpZ	133.18457	121.17009	128.08551	119.35293	293.15
8412	MLI TUBE_to_CVV_mYmZ	118.14241	107.83285	113.74916	105.84754	293.15
8413	TUBE_to_CVV_mZmY	68.16485	63.99859	66.2846	61.8441	293.15
8414	TUBE_to_CVV_mZpY	67.54432	63.12162	65.55727	61.06744	293.15
8415	MLI TUBE_to_CVV_pYmZ	116.8072	106.56531	112.43436	104.73997	293.15

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
8416	MLI TUBE_to_CVV_pYpZ	132.30262	120.27377	127.19191	118.51254	293.15
8608	Tel. harness SVM I/F	189.3855	179.6622	184.75097	166.14883	293.15
8609	Tel. harness	128.76226	123.46557	126.30012	116.74586	293.15
8614	Tel. harness	96.8807	92.86631	95.04258	88.97036	293.15
8615	Tel. harness	86.38625	82.17927	84.49414	79.39209	293.15
8616	Tel. harness TMS I/F	82.61785	77.3956	80.28991	75.27096	293.15
8620	Tel. CBs on TMS	81.52059	75.70271	78.92972	73.81821	293.15
9001	CVV CBs 1	67.96594	64.69636	66.43564	60.67675	293.15
9002	CVV CBs 2	67.79909	64.58477	66.29475	60.57173	293.15
9003	CVV CBs 3	66.67034	63.49065	65.17972	59.69934	293.15
9004	CVV CBs 4	65.82092	62.7762	64.38828	59.09826	293.15
9005	CVV CBs 5	65.40655	62.4038	63.99384	58.76555	293.15
9006	CVV CBs 6	65.98782	62.90634	64.54359	59.23207	293.15
9007	CVV CBs 7	67.45125	64.24321	65.94701	60.2862	293.15
9008	CVV CBs 8	68.02176	64.75756	66.49315	60.71602	293.15
9011	IP_08_09_10_11_12	88.35477	85.66277	87.08221	79.78792	293.15
9012	IH_02_05	119.5459	117.20818	118.43404	104.86287	293.15
9013	IS_04_05	78.11489	74.47861	76.35264	69.64572	293.15
9014	IS_03_07_08_09	93.61545	89.35654	91.52773	83.94897	293.15
9015	IS_02_11_13	91.29995	86.85584	89.0881	80.13138	293.15
9016	IS_10	85.57906	82.06309	83.83386	76.72152	293.15
9017	IP_03_04_14	115.79813	111.69049	113.8306	100.88044	293.15
9018	IP_13	105.45967	102.7023	104.15321	90.83077	293.15
9021	IP Rail2728_Strut24	196.32138	189.58294	193.09942	166.97887	293.15
9022	IH Rail2900_Strut29	191.81842	187.2098	189.60834	162.99935	293.15
9023	IS Rail3334_Strut38	138.97451	130.19913	134.46253	117.46481	293.15
9024	IS Rail3800_Strut38	150.57476	140.99737	145.76269	129.087	293.15
9025	IS Rail3900_Strut38	145.17468	135.05372	140.02164	122.2873	293.15
9026	IS Rail4041_Strut40	135.79774	128.01512	131.75954	115.21649	293.15
9027	IP Rail2122_Strut22	201.62734	195.38916	198.60555	172.836	293.15
9028	IP Rail2400_Strut24	194.91564	188.86918	192.02074	165.22401	293.15
9032	IH_01_03_04	102.18739	98.9869	100.67206	90.27728	293.15
9033	IS_06	93.87893	89.99117	91.93226	84.19624	293.15
9034	ICE_13_ICE14_Strut36	135.46176	128.04504	131.60022	113.94371	293.15
9035	IS Rail3900_Strut39	135.0365	126.50504	130.61216	113.69108	293.15
9036	CCH_ICA_10_ICB_10	73.07347	70.20306	71.68925	66.08968	293.15
9037	IP_05_06_15	101.57894	99.12763	100.41597	88.89946	293.15
9038	IP_01_02_07	105.1747	101.91543	103.63309	93.39708	293.15
9042	IH Rail3132_Strut30	207.57281	200.10913	203.99542	176.19899	293.15
9043	IS Rail3800_Strut38	135.47121	127.30253	131.25779	114.99415	293.15
9045	IS_01_12	93.95283	90.21623	92.10288	84.1829	293.15
9046	CCH Rail4200_Strut41	137.6213	129.55629	133.46174	116.66792	293.15
9047	IP Rail2400_Strut24	194.62786	188.33191	191.61458	164.52716	293.15
9048	IP Rail2526_Strut24	194.37471	187.95819	191.30597	165.19729	293.15
9055	IS Rail4041_Strut40	146.77089	139.10957	142.86633	125.90033	293.15
9056	CCH Rail4200_Strut42	134.79544	128.23593	131.33956	113.55282	293.15
9057	ICE_11_ICE12_Strut44	138.99484	131.74055	135.40398	119.30702	293.15
9065	ICA_12_ICB12_Strut41	144.99939	137.76857	141.30769	124.33824	293.15
9066	CCH_ICE_10_ICE_20	73.27035	70.02469	71.70561	65.85171	293.15
9076	CCH Rail4344_Strut43	136.56259	126.5196	131.37656	112.83519	293.15
9086	ICA_11_Strut41	143.02733	135.64456	139.20773	121.64237	293.15
9096	ICB_11_Strut42	138.07459	130.76172	134.25321	115.72273	293.15
9101	PACS int. harn. 11	6.60622	6.54583	6.57814	5.75833	11.66475
9102	PACS int. harn. 11	9.56194	9.47659	9.52271	8.44686	14.15833
9103	PACS int. harn. 11	11.63723	11.52895	11.58762	10.39511	16.29136

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9104	PACS int. harn. 11	12.49838	12.37941	12.44392	11.24144	17.26354
9105	PACS int. harn. 11	17.14855	16.78348	16.97916	15.72702	32.26476
9106	PACS int. harn. 11	23.87532	23.20555	23.56414	22.20674	50.79841
9107	PACS int. harn. 11	31.44852	30.47496	30.99604	29.43018	70.84655
9108	PACS int. harn. 11	34.60629	33.50951	34.09652	32.45825	79.34636
9109	PACS int. harn. 11	41.56354	40.01449	40.8393	38.31386	125.29738
9110	PACS int. harn. 11	53.30508	50.95453	52.20498	48.16728	200.29777
9111	PACS int. harn. 11	63.37404	60.38521	61.9751	56.73754	264.09917
9121	PACS int. harn. 13	12.01673	11.9854	12.00213	5.72745	11.63702
9122	PACS int. harn. 13	15.622	15.5697	15.59792	8.41887	14.08828
9123	PACS int. harn. 13	14.99537	14.91176	14.95703	10.37351	16.18321
9124	PACS int. harn. 13	12.48726	12.36992	12.43357	11.22096	17.13761
9125	PACS int. harn. 13	13.03573	12.89756	12.97214	11.40834	19.18819
9126	PACS int. harn. 13	13.35261	13.19604	13.28041	11.65849	20.36882
9127	PACS int. harn. 13	26.18883	25.52458	25.88058	23.39762	48.32033
9128	PACS int. harn. 13	33.60552	32.59536	33.13692	31.62866	67.24118
9129	PACS int. harn. 13	41.00621	39.53054	40.31687	37.72905	117.29836
9130	PACS int. harn. 13	53.16351	50.85665	52.08344	47.87454	196.3441
9131	PACS int. harn. 13	63.41575	60.44535	62.02471	56.67461	262.92885
9141	PACS int. harn. 15	9.35331	9.3102	9.33321	5.7905	11.93999
9142	PACS int. harn. 15	12.53809	12.46718	12.50538	8.5015	14.76034
9143	PACS int. harn. 15	13.25907	13.15513	13.21129	10.46582	17.13957
9144	PACS int. harn. 15	12.62019	12.49191	12.5613	11.3192	18.21713
9145	PACS int. harn. 15	22.44775	22.21876	22.34139	14.73923	27.94919
9146	PACS int. harn. 15	28.66525	28.23913	28.46695	19.94212	41.09278
9147	PACS int. harn. 15	27.56432	26.86314	27.23866	24.07429	51.37049
9148	PACS int. harn. 15	33.70424	32.68691	33.23217	31.69404	68.23345
9149	PACS int. harn. 15	41.00481	39.53476	40.31763	37.68432	117.98532
9150	PACS int. harn. 15	52.95028	50.67444	51.8836	47.66598	196.77614
9151	PACS int. harn. 15	62.97118	60.04997	61.60148	56.31569	263.07854
9201	PACS int. harn. res.	3.2209	3.17808	3.20002	2.80533	9.89502
9202	PACS int. harn. res.	12.74945	12.60952	12.68504	11.42742	19.34372
9206	PACS int. harn. res.	25.02417	24.40324	24.73603	22.76775	46.08293
9208	PACS int. harn. res.	33.66158	32.6481	33.19135	31.67149	67.63685
9212	PACS int. harn. res.	12.48183	12.36407	12.42794	11.22706	17.16915
9213	PACS int. harn. res.	12.72391	12.58576	12.66033	11.40653	19.18741
9214	PACS int. harn. res.	12.73819	12.59893	12.67409	11.41693	19.29953
9215	PACS int. harn. res.	13.13401	12.97154	13.05906	11.75348	20.73065
9216	PACS int. harn. res.	24.94019	24.31348	24.64951	22.8222	45.81246
9218	PACS int. harn. res.	33.50858	32.50788	33.04447	31.56064	65.87954
9226	PACS int. harn. res.	23.34036	22.70403	23.04487	21.74543	48.27836
9228	PACS int. harn. res.	34.53036	33.44155	34.02437	32.40164	78.19284
9301	SPIRE int. harn. 3	14.13062	13.95906	14.05103	12.21031	23.89737
9302	SPIRE int. harn. 3	15.05967	14.81139	14.94411	13.34424	28.11179
9303	SPIRE int. harn. 3	15.92465	15.60749	15.77685	14.3836	31.75708
9304	SPIRE int. harn. 3	16.33565	15.98638	16.17283	14.87445	33.4272
9305	SPIRE int. harn. 3	23.08897	22.37706	22.75638	21.22082	56.77076
9306	SPIRE int. harn. 3	32.46482	31.31252	31.92645	29.97348	88.24182
9307	SPIRE int. harn. 3	41.51841	39.93717	40.77625	38.31269	126.01262
9308	SPIRE int. harn. 3	45.66133	43.82389	44.79883	42.00759	152.83402
9309	SPIRE int. harn. 3	49.40596	47.33262	48.43192	45.14753	179.31037
9310	SPIRE int. harn. 3	56.37453	53.87795	55.20057	51.0373	228.01257
9311	SPIRE int. harn. 3	62.78652	59.91517	61.43568	56.50036	272.31615
9321	SPIRE int. harn. 11	7.84136	7.77511	7.81001	6.44953	14.88779
9322	SPIRE int. harn. 11	10.55826	10.45853	10.51191	8.86599	17.3384

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9323	SPIRE int. harn. 11	12.2766	12.14487	12.21574	10.69801	19.49387
9324	SPIRE int. harn. 11	12.84996	12.70214	12.78179	11.50611	20.4895
9325	SPIRE int. harn. 11	19.9037	19.43575	19.6858	17.75216	40.77082
9326	SPIRE int. harn. 11	28.5665	27.7132	28.16904	26.19593	66.1143
9327	SPIRE int. harn. 11	33.60026	32.53971	33.10629	31.0344	82.67279
9328	SPIRE int. harn. 11	35.5165	34.35424	34.97527	33.19555	90.25247
9329	SPIRE int. harn. 11	41.68657	40.15614	40.96894	38.40614	132.99503
9330	SPIRE int. harn. 11	52.21402	50.00768	51.17696	47.32099	204.14637
9331	SPIRE int. harn. 11	61.2793	58.52211	59.98235	55.14994	265.23677
9341	SPIRE int. harn. res.	4.78102	4.73911	4.75992	4.20804	13.21346
9342	SPIRE int. harn. res.	12.828	12.68114	12.76029	11.49472	20.41225
9346	SPIRE int. harn. res.	28.98238	28.0812	28.56251	26.86861	69.34638
9348	SPIRE int. harn. res.	35.44725	34.29047	34.90863	33.14703	89.42455
9361	PM JFET int. hn. res.	13.53602	13.41527	13.48031	11.47269	20.95347
9364	PM JFET int. hn. res.	14.35492	14.11832	14.2451	12.97865	26.13294
9365	PM JFET int. hn. res.	21.47852	20.85154	21.1863	19.75704	49.77057
9366	PM JFET int. hn. res.	30.82275	29.76583	30.33022	28.54321	78.26696
9367	PM JFET int. hn. res.	41.58969	40.02483	40.85657	38.50208	119.74793
9368	PM JFET int. hn. res.	46.63544	44.72866	45.74185	42.95619	156.13763
9374	PM JFET int. hn. res.	14.48816	14.24454	14.37498	13.10811	26.64927
9375	PM JFET int. hn. res.	22.03779	21.387	21.73412	20.27825	51.87684
9376	PM JFET int. hn. res.	31.7985	30.70596	31.28874	29.44477	81.60393
9377	PM JFET int. hn. res.	41.78251	40.22216	41.0507	38.69804	120.3025
9378	PM JFET int. hn. res.	46.58416	44.70081	45.70056	42.94168	155.57857
9381	SM JFET int. hn. res.	13.44218	13.32317	13.38731	11.47692	20.56722
9384	SM JFET int. hn. res.	14.58547	14.33668	14.46983	13.19232	27.0251
9385	SM JFET int. hn. res.	21.49545	20.87072	21.20376	19.70559	51.09474
9386	SM JFET int. hn. res.	30.64573	29.59973	30.15727	28.24435	80.66273
9387	SM JFET int. hn. res.	41.79491	40.21286	41.05247	38.58367	124.54566
9388	SM JFET int. hn. res.	46.97083	45.04772	46.06805	43.17327	163.34219
9401	HIFI int. harn. 1	13.37737	13.24686	13.31726	11.3702	20.05701
9402	HIFI int. harn. 1	13.65756	13.53636	13.60184	11.32838	19.04881
9403	HIFI int. harn. 1	13.17675	13.05828	13.12242	11.28642	17.98621
9404	HIFI int. harn. 1	12.5289	12.40823	12.47365	11.26538	17.43153
9405	HIFI int. harn. 1	18.1382	17.72941	17.94823	16.53636	36.6059
9406	HIFI int. harn. 1	25.9598	25.21162	25.61171	23.89174	59.5916
9407	HIFI int. harn. 1	32.56755	31.52967	32.08461	30.29903	80.26725
9408	HIFI int. harn. 1	35.39503	34.2364	34.85592	33.04918	89.35876
9409	HIFI int. harn. 1	42.09086	40.50896	41.35102	38.71076	132.31652
9410	HIFI int. harn. 1	53.49709	51.15874	52.40268	48.31868	203.75375
9411	HIFI int. harn. 1	63.31529	60.36934	61.93649	56.70869	265.10913
9421	HIFI int. harn. 2	17.87609	17.77647	17.83016	11.37224	20.06924
9422	HIFI int. harn. 2	20.02978	19.94483	19.99068	11.33385	19.08378
9423	HIFI int. harn. 2	17.2879	17.19533	17.24541	11.29533	18.04759
9424	HIFI int. harn. 2	12.55714	12.43563	12.50149	11.27603	17.50783
9425	HIFI int. harn. 2	18.33321	17.92608	18.14399	16.53797	36.9185
9426	HIFI int. harn. 2	26.1287	25.37737	25.77911	23.9353	60.16818
9427	HIFI int. harn. 2	32.70636	31.66778	32.22305	30.3223	80.76566
9428	HIFI int. harn. 2	35.42985	34.26797	34.88919	33.07061	89.83631
9429	HIFI int. harn. 2	42.23135	40.64087	41.48761	38.74646	132.74679
9430	HIFI int. harn. 2	53.67183	51.32971	52.5757	48.36677	204.1211
9431	HIFI int. harn. 2	63.39922	60.4529	62.02025	56.72981	265.25188
9441	HIFI int. harn. 3	13.29847	13.16722	13.23802	11.37016	20.05675
9442	HIFI int. harn. 3	13.53986	13.41766	13.48368	11.32827	19.04807
9443	HIFI int. harn. 3	13.10538	12.98631	13.05078	11.28623	17.98493

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9444	HIFI int. harn. 3	12.52854	12.40788	12.47329	11.26516	17.42997
9445	HIFI int. harn. 3	18.13763	17.72896	17.94772	16.53541	36.59452
9446	HIFI int. harn. 3	25.95825	25.21026	25.61025	23.88996	59.56916
9447	HIFI int. harn. 3	32.5648	31.52722	32.08201	30.29657	80.22953
9448	HIFI int. harn. 3	35.39155	34.23324	34.85259	33.04644	89.3129
9449	HIFI int. harn. 3	42.08915	40.50752	41.34943	38.70881	132.28417
9450	HIFI int. harn. 3	53.49692	51.15873	52.40258	48.31769	203.7377
9451	HIFI int. harn. 3	63.3155	60.36961	61.93673	56.70839	265.10443
9461	HIFI int. harn. 4	17.44473	17.34281	17.39774	11.37213	20.06864
9462	HIFI int. harn. 4	19.43957	19.35221	19.39936	11.33356	19.08206
9463	HIFI int. harn. 4	16.8918	16.79723	16.84839	11.29486	18.04459
9464	HIFI int. harn. 4	12.55574	12.43428	12.50011	11.27547	17.50412
9465	HIFI int. harn. 4	18.33641	17.9294	18.14724	16.53765	36.91477
9466	HIFI int. harn. 4	26.12898	25.37784	25.77948	23.93331	60.15635
9467	HIFI int. harn. 4	32.70831	31.66983	32.22505	30.32205	80.76255
9468	HIFI int. harn. 4	35.43003	34.26813	34.88936	33.07079	89.83545
9469	HIFI int. harn. 4	42.23316	40.64249	41.48934	38.74761	132.75319
9470	HIFI int. harn. 4	53.67411	51.33184	52.57792	48.36836	204.1302
9471	HIFI int. harn. 4	63.40021	60.45384	62.02122	56.73051	265.25585
9481	HIFI int. harn. 5	24.21418	24.14241	24.18106	11.36606	20.03216
9482	HIFI int. harn. 5	28.38047	28.3227	28.35387	11.31729	18.97781
9483	HIFI int. harn. 5	23.1434	23.07684	23.11284	11.2683	17.86168
9484	HIFI int. harn. 5	12.52535	12.40635	12.47088	11.24373	17.27676
9485	HIFI int. harn. 5	18.83238	18.4411	18.65053	16.50014	35.79228
9486	HIFI int. harn. 5	26.14548	25.41115	25.8039	23.7608	58.21115
9487	HIFI int. harn. 5	32.91975	31.89988	32.44517	30.2471	79.26893
9488	HIFI int. harn. 5	35.35703	34.20359	34.82039	33.01724	88.5533
9489	HIFI int. harn. 5	42.11424	40.56947	41.39133	38.60199	131.24079
9490	HIFI int. harn. 5	53.55627	51.25202	52.4775	48.14851	202.55439
9491	HIFI int. harn. 5	63.37112	60.43942	61.99886	56.63082	264.60231
9501	HIFI int. coax tube	13.4841	13.29521	13.39665	12.12335	24.93304
9502	HIFI int. coax tube	15.2831	14.99046	15.14711	13.85942	33.66233
9503	HIFI int. coax tube	16.81334	16.43895	16.63918	15.30902	38.95978
9504	HIFI int. coax tube	32.60348	31.52654	32.10193	29.99523	100.85939
9505	HIFI int. coax tube	42.32445	40.80224	41.61187	38.86101	141.58825
9506	HIFI int. coax tube	51.12173	49.05472	50.15439	46.516	186.35791
9507	HIFI int. coax tube	55.71462	53.34912	54.60742	50.47342	222.46181
9508	HIFI int. coax tube	62.04251	59.26228	60.74097	55.90521	272.13341
9509	HIFI int. coax tube	64.22955	61.29044	62.8533	57.75516	283.2196
9510	HIFI int. coax tube	65.4924	62.44147	64.06308	58.78621	288.61251
9551	HIFI int. coax core	16.395	16.12965	16.27094	15.00449	44.24687
9552	HIFI int. coax core	18.73211	18.36587	18.5603	17.16248	68.35598
9553	HIFI int. coax core	21.25882	20.76722	21.02702	19.46571	92.51021
9554	HIFI int. coax core	25.3473	24.58875	24.98723	23.01193	125.70416
9555	HIFI int. coax core	30.65992	29.39718	30.05619	27.29586	160.76245
9556	HIFI int. coax core	37.71113	35.80478	36.79527	32.99375	201.42649
9557	HIFI int. coax core	42.19734	39.82159	41.07607	36.51505	226.19228
9558	HIFI int. coax core	48.58412	45.93524	47.33351	42.2513	260.05108
9559	HIFI int. coax core	53.656	50.80317	52.30866	47.05086	275.77701
9560	HIFI int. coax core	59.84891	56.76171	58.39046	52.94945	286.42197
9700	HOT depl. harness on ISF	19.42497	18.66503	19.07108	17.95784	54.38116
9801	Styc. Br. on TS1/strap 3	34.48374	33.39969	33.98001	32.36642	77.49489
9802	Styc. Br. on TS1/strap 4	35.25782	34.11314	34.72533	32.94787	87.28731
9803	Styc. Br. on TS1/strap 5	34.40331	33.32216	33.90072	32.30403	82.47905
9804	Styc. Br. on TS1/strap 6	34.41969	33.33803	33.91684	32.32134	81.85843

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
9805	Styc. Br. on TS1/strap 7	35.28253	34.14163	34.7515	33.01985	86.83431
9806	Styc. Br. on TS1/strap 8	34.06448	33.01548	33.57726	32.04123	73.5389
9807	Styc. Br. on TS1/strap 1	33.55429	32.55123	33.08901	31.59065	66.05993
9808	Styc. Br. on TS1/strap 2	33.44894	32.45392	32.98753	31.51534	65.04456
9921	Cover Act. harn.	77.44227	74.46488	76.0431	70.61662	293.14964
9922	Cover Act. harn.	84.48193	81.54403	83.08874	77.51977	293.14938
9923	Cover Act. harn.	129.93993	122.99203	126.55371	112.75286	293.11365
9924	Cover Act. harn.	152.97312	145.83955	149.57562	134.88268	293.04393
18401	FRAME_pZ	88.28202	79.62967	84.47656	77.11334	293.15
18402	FRAME_CORNER_mY	82.94445	75.56759	79.6726	73.67246	293.15
18403	FRAME_mY	79.44341	72.92804	76.47609	70.53837	293.15
18405	FRAME_pY	78.44594	71.80633	75.42616	69.50936	293.15
18406	FRAME_CORNER_pY	82.86369	75.49594	79.59588	73.61392	293.15
18411	TUBE_to_CVV_mYpZ	76.74404	70.88566	74.12177	68.1695	293.15
18412	TUBE_to_CVV_mYmZ	75.93227	70.20175	73.37003	67.53213	293.15
18415	TUBE_to_CVV_pYmZ	75.70326	69.9837	73.14812	67.36317	293.15
18416	TUBE_to_CVV_pYpZ	76.65557	70.8044	74.0363	68.10365	293.15
18421	TUBE_to_FRAME_I/F_mYpZ	82.77012	75.40885	79.50217	73.51083	293.15
18422	TUBE_to_FRAME_I/F_mYmZ	82.3622	75.11634	79.14467	73.24382	293.15
18423	TUBE_to_FRAME_I/F_mZmY	81.22356	75.35515	78.61186	73.50601	293.15
18424	TUBE_to_FRAME_I/F_mZpY	79.14123	72.72152	76.30575	71.09722	293.15
18425	TUBE_to_FRAME_I/F_pYmZ	82.27334	75.03686	79.06036	73.18115	293.15
18426	TUBE_to_FRAME_I/F_pYpZ	82.73383	75.37906	79.46874	73.48759	293.15
22100	Harn. Rail 2100 low	78.17121	73.02336	75.68562	66.6446	293.15
22101	Harn. Rail 2100 upp	68.21946	64.90478	66.66751	60.964	293.15
22122	Harn. Rail 2122	67.49085	64.24943	65.97025	60.30964	293.15
22300	Harn. Rail 2300	67.38865	64.16031	65.87504	60.24112	293.15
22400	Harn. Rail 2400	69.07194	65.72548	67.50394	61.31959	293.15
22526	Harn. Rail 2526	68.29453	64.98527	66.74435	60.88426	293.15
22728	Harn. Rail 2728	68.6898	65.35985	67.13066	61.19131	293.15
22900	Harn. Rail 2900	69.21233	65.86637	67.64541	61.44864	293.15
23132	Harn. supp. tube LOU +z	142.36711	133.80604	138.66152	125.34636	293.15
23334	Harn. supp. tube LOU -z	134.64057	127.44748	131.49177	118.26087	293.15
23800	Harn. Rail 3800	66.40248	63.26319	64.92111	59.48276	293.15
23900	Harn. Rail 3900	65.75712	62.69496	64.3137	58.98699	293.15
24041	Harn. Rail 4041	65.88992	62.828	64.44826	59.11832	293.15
24132	Harn. Rail 3132	68.55183	65.22476	66.99345	61.02694	293.15
24200	Harn. Rail 4200	65.64383	62.61009	64.22278	58.992	293.15
24334	Harn. Rail 3334	66.54508	63.39524	65.0691	59.62386	293.15
24344	Harn. Rail 4344	65.88546	62.80901	64.44416	59.15623	293.15
65011	STRUT1_CVVSVM_MLI	209.19607	203.39929	206.64661	178.28923	293.15
65012	STRUT1_CVVSVM_MLI	204.82619	198.63308	201.98715	173.05761	293.15
65013	STRUT1_CVVSVM_MLI	206.3669	199.59025	203.12473	172.73595	293.15
65014	STRUT1_CVVSVM_MLI	213.97422	208.54522	211.43731	180.35472	293.15
65015	STRUT1_CVVSVM_MLI	179.53235	171.34411	175.97636	157.52385	293.15
65016	STRUT1_CVVSVM_MLI	178.21709	169.84694	174.4274	154.07649	293.15
65017	STRUT1_CVVSVM_MLI	177.05684	165.55665	171.69449	150.79344	293.15
65018	STRUT1_CVVSVM_MLI	176.59524	165.79503	171.77211	153.52072	293.15
65019	STRUT1_CVVSVM_MLI	162.68159	151.27178	157.97732	147.68025	293.15
65020	STRUT1_CVVSVM_MLI	161.3104	149.43972	156.17077	143.59531	293.15
65021	STRUT1_CVVSVM_MLI	165.07431	151.72783	158.98125	142.70614	293.15
65022	STRUT1_CVVSVM_MLI	164.65136	152.38806	159.38344	146.92426	293.15
65111	STRUT2_CVVSVM_MLI	186.7398	178.42925	183.05284	161.09133	293.15
65112	STRUT2_CVVSVM_MLI	188.63447	182.72385	185.94764	161.00712	293.15
65113	STRUT2_CVVSVM_MLI	190.95651	182.52133	186.86013	160.13084	293.15

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
65114	STRUT2_CVVSVM_MLI	190.35546	180.97051	185.98222	161.84927	293.15
65115	STRUT2_CVVSVM_MLI	174.10156	163.15248	169.35571	152.838	293.15
65116	STRUT2_CVVSVM_MLI	164.01754	154.32531	159.68723	142.69477	293.15
65117	STRUT2_CVVSVM_MLI	173.909	161.89868	168.26462	147.05714	293.15
65118	STRUT2_CVVSVM_MLI	177.36221	165.31271	171.87794	152.59344	293.15
65119	STRUT2_CVVSVM_MLI	165.22016	153.74143	160.42402	147.66195	293.15
65120	STRUT2_CVVSVM_MLI	153.12019	142.65663	148.67089	136.18086	293.15
65121	STRUT2_CVVSVM_MLI	165.27445	152.36794	159.36353	141.39446	293.15
65122	STRUT2_CVVSVM_MLI	169.38916	156.74565	163.8027	147.77025	293.15
65211	STRUT3_CVVSVM_MLI	201.85474	195.2388	198.8456	171.74807	293.15
65212	STRUT3_CVVSVM_MLI	189.52497	182.1155	186.01635	158.86457	293.15
65213	STRUT3_CVVSVM_MLI	195.92051	187.23139	191.65887	163.07922	293.15
65214	STRUT3_CVVSVM_MLI	213.02274	206.79784	210.0156	180.00303	293.15
65215	STRUT3_CVVSVM_MLI	174.3537	163.65833	169.66839	152.44997	293.15
65216	STRUT3_CVVSVM_MLI	168.91217	158.11385	163.84319	143.36719	293.15
65217	STRUT3_CVVSVM_MLI	176.54413	164.20692	170.61932	147.4533	293.15
65218	STRUT3_CVVSVM_MLI	178.48859	166.74887	173.1249	153.38968	293.15
65219	STRUT3_CVVSVM_MLI	161.11806	150.00127	156.38832	143.1446	293.15
65220	STRUT3_CVVSVM_MLI	153.42113	142.21996	148.31833	131.40662	293.15
65221	STRUT3_CVVSVM_MLI	163.54965	150.43149	157.32045	136.82373	293.15
65222	STRUT3_CVVSVM_MLI	167.40513	155.31763	162.13279	147.23278	293.15
65311	STRUT4_CVVSVM_MLI	214.12068	209.79767	212.04993	178.93575	293.15
65312	STRUT4_CVVSVM_MLI	223.74275	220.45216	222.13669	186.84445	293.15
65313	STRUT4_CVVSVM_MLI	222.58663	218.57057	220.55459	184.57408	293.15
65314	STRUT4_CVVSVM_MLI	214.85401	209.87829	212.41358	178.65103	293.15
65315	STRUT4_CVVSVM_MLI	161.94547	153.5999	158.11458	139.2175	293.15
65316	STRUT4_CVVSVM_MLI	157.63994	150.13613	154.0981	133.74678	293.15
65317	STRUT4_CVVSVM_MLI	170.61279	160.0599	165.48899	142.36746	293.15
65318	STRUT4_CVVSVM_MLI	173.13147	162.46354	168.10893	146.79203	293.15
65319	STRUT4_CVVSVM_MLI	144.13634	133.71903	139.57666	127.68074	293.15
65320	STRUT4_CVVSVM_MLI	130.77566	121.69295	126.74719	115.032	293.15
65321	STRUT4_CVVSVM_MLI	152.87683	140.51892	147.07606	130.12804	293.15
65322	STRUT4_CVVSVM_MLI	157.62739	145.02377	151.8266	135.71141	293.15
65411	STRUT5_CVVSVM_MLI	190.48288	184.54179	187.68413	161.10931	293.15
65412	STRUT5_CVVSVM_MLI	192.4563	184.83904	188.59298	159.45196	293.15
65413	STRUT5_CVVSVM_MLI	196.28331	187.67171	191.93831	162.45961	293.15
65414	STRUT5_CVVSVM_MLI	198.32736	190.81809	194.75049	167.26105	293.15
65415	STRUT5_CVVSVM_MLI	164.90803	155.34717	160.42058	141.82608	293.15
65416	STRUT5_CVVSVM_MLI	169.81531	158.31855	164.15334	141.2698	293.15
65417	STRUT5_CVVSVM_MLI	170.5086	158.43504	164.53106	140.893	293.15
65418	STRUT5_CVVSVM_MLI	172.53862	161.30626	167.26273	147.33335	293.15
65419	STRUT5_CVVSVM_MLI	144.07125	134.40174	139.88587	128.23088	293.15
65420	STRUT5_CVVSVM_MLI	129.73167	121.41342	125.98052	113.94982	293.15
65421	STRUT5_CVVSVM_MLI	134.99625	125.27449	130.43242	115.79378	293.15
65422	STRUT5_CVVSVM_MLI	161.58661	150.39924	156.59249	141.89556	293.15
65511	STRUT6_CVVSVM_MLI	200.08421	192.56578	196.30698	166.90709	293.15
65512	STRUT6_CVVSVM_MLI	202.88332	198.01948	200.40753	170.31625	293.15
65513	STRUT6_CVVSVM_MLI	208.17003	202.90701	205.47931	174.95595	293.15
65514	STRUT6_CVVSVM_MLI	198.39232	190.3975	194.34919	164.56275	293.15
65611	STRUT7_CVVSVM_MLI	197.58937	193.17929	195.27959	166.14424	293.15
65612	STRUT7_CVVSVM_MLI	191.55433	186.95256	189.05203	159.66252	293.15
65613	STRUT7_CVVSVM_MLI	195.77316	189.73216	192.58965	162.86355	293.15
65614	STRUT7_CVVSVM_MLI	207.5368	202.90428	205.12529	175.01745	293.15
65711	STRUT8_CVVSVM_MLI	191.37462	186.8005	188.90189	159.60933	293.15
65712	STRUT8_CVVSVM_MLI	192.85419	189.61632	191.09181	161.7611	293.15

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
65713	STRUT8_CVVSVM_MLI	204.1053	200.66643	202.25405	171.86395	293.15
65714	STRUT8_CVVSVM_MLI	194.05068	188.43521	191.04634	161.41702	293.15
65811	STRUT9_CVVSVM_MLI	192.58858	189.48466	190.88911	161.49003	293.15
65812	STRUT9_CVVSVM_MLI	188.11264	184.34705	186.06134	156.80458	293.15
65813	STRUT9_CVVSVM_MLI	191.68244	186.59057	188.92069	159.20744	293.15
65814	STRUT9_CVVSVM_MLI	204.73628	201.24447	202.86167	172.46622	293.15
65911	STRUT10_CVVSVM_MLI	188.37995	184.62854	186.33805	157.23016	293.15
65912	STRUT10_CVVSVM_MLI	191.99657	189.39497	190.55574	161.4827	293.15
65913	STRUT10_CVVSVM_MLI	203.69996	200.81237	202.13045	172.05698	293.15
65914	STRUT10_CVVSVM_MLI	191.07924	186.21941	188.44179	158.86902	293.15
66011	STRUT11_CVVSVM_MLI	193.83851	191.32787	192.47078	163.27371	293.15
66012	STRUT11_CVVSVM_MLI	186.91166	183.43767	185.01532	156.01512	293.15
66013	STRUT11_CVVSVM_MLI	190.09111	185.41196	187.56472	158.00981	293.15
66014	STRUT11_CVVSVM_MLI	203.27597	200.22191	201.63224	171.78373	293.15
66111	STRUT12_CVVSVM_MLI	186.75518	183.3216	184.87537	155.81991	293.15
66112	STRUT12_CVVSVM_MLI	191.81447	189.32934	190.43472	161.30714	293.15
66113	STRUT12_CVVSVM_MLI	203.32579	200.42289	201.74745	171.51424	293.15
66114	STRUT12_CVVSVM_MLI	189.871	185.24535	187.36865	157.74332	293.15
66211	STRUT13_CVVSVM_MLI	195.59897	193.091	194.23064	164.78764	293.15
66212	STRUT13_CVVSVM_MLI	188.15555	184.42339	186.12741	157.04151	293.15
66213	STRUT13_CVVSVM_MLI	190.89942	186.06485	188.27849	158.6571	293.15
66214	STRUT13_CVVSVM_MLI	203.02848	200.01626	201.3941	171.18073	293.15
66311	STRUT14_CVVSVM_MLI	186.60319	182.30931	184.31617	156.23349	293.15
66312	STRUT14_CVVSVM_MLI	194.14521	190.67333	192.31278	164.0147	293.15
66313	STRUT14_CVVSVM_MLI	201.35682	197.33832	199.24696	170.27136	293.15
66314	STRUT14_CVVSVM_MLI	189.78662	184.32185	186.89575	158.26077	293.15
66411	STRUT15_CVVSVM_MLI	192.306	189.24754	190.62887	161.37859	293.15
66412	STRUT15_CVVSVM_MLI	190.00716	185.74695	187.71786	158.4457	293.15
66413	STRUT15_CVVSVM_MLI	192.54389	187.20458	189.65586	160.02967	293.15
66414	STRUT15_CVVSVM_MLI	202.28903	198.96958	200.49924	170.2935	293.15
66511	STRUT16_CVVSVM_MLI	191.48409	187.41894	189.26411	159.7594	293.15
66512	STRUT16_CVVSVM_MLI	193.79438	190.05083	191.79964	162.45493	293.15
66513	STRUT16_CVVSVM_MLI	204.50008	200.57686	202.42366	172.19424	293.15
66514	STRUT16_CVVSVM_MLI	195.08618	189.66805	192.21087	162.37787	293.15
66611	STRUT17_CVVSVM_MLI	194.86906	191.12659	192.89053	163.656	293.15
66612	STRUT17_CVVSVM_MLI	193.66481	188.44057	190.9344	162.31998	293.15
66613	STRUT17_CVVSVM_MLI	195.7552	189.62426	192.5757	163.40766	293.15
66614	STRUT17_CVVSVM_MLI	204.70364	200.8884	202.69519	172.52441	293.15
66711	STRUT18_CVVSVM_MLI	188.42308	182.58637	185.47222	157.36044	293.15
66712	STRUT18_CVVSVM_MLI	197.27511	192.71419	195.03227	167.25179	293.15
66713	STRUT18_CVVSVM_MLI	205.22947	200.78376	203.00807	174.40621	293.15
66714	STRUT18_CVVSVM_MLI	193.71193	187.26694	190.41068	161.82798	293.15
66811	STRUT19_CVVSVM_MLI	175.74523	169.3193	172.62914	147.21866	293.15
66812	STRUT19_CVVSVM_MLI	184.58175	176.47902	180.78127	156.70029	293.15
66813	STRUT19_CVVSVM_MLI	188.21419	178.9555	183.66261	156.71162	293.15
66814	STRUT19_CVVSVM_MLI	187.71616	180.47914	184.06703	155.54953	293.15
66815	STRUT19_CVVSVM_MLI	151.68333	143.45848	147.87364	129.42291	293.15
66816	STRUT19_CVVSVM_MLI	169.04197	158.21321	164.07282	145.25017	293.15
66817	STRUT19_CVVSVM_MLI	173.49543	161.32343	167.65627	145.25666	293.15
66818	STRUT19_CVVSVM_MLI	158.41884	148.68812	153.64804	131.63822	293.15
66819	STRUT19_CVVSVM_MLI	136.26092	127.03055	132.22056	119.46432	293.15
66820	STRUT19_CVVSVM_MLI	156.93637	145.89762	152.01906	136.83611	293.15
66821	STRUT19_CVVSVM_MLI	164.15565	151.01205	157.97077	138.47913	293.15
66822	STRUT19_CVVSVM_MLI	125.63757	117.18193	121.77947	107.28806	293.15
66911	STRUT20_CVVSVM_MLI	207.3198	203.21765	205.40763	174.94739	293.15

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
66912	STRUT20_CVVSVM_MLI	229.94923	227.43704	228.7811	195.21021	293.15
66913	STRUT20_CVVSVM_MLI	221.75318	217.66407	219.72732	186.05401	293.15
66914	STRUT20_CVVSVM_MLI	204.29741	198.9693	201.65324	170.27289	293.15
66915	STRUT20_CVVSVM_MLI	164.30775	154.84413	160.0563	143.06356	293.15
66916	STRUT20_CVVSVM_MLI	170.51841	160.57694	166.22668	150.35015	293.15
66917	STRUT20_CVVSVM_MLI	170.35774	157.00877	164.09918	144.42474	293.15
66918	STRUT20_CVVSVM_MLI	166.08274	155.15434	160.79311	139.41296	293.15
66919	STRUT20_CVVSVM_MLI	146.78253	136.07202	142.14176	130.83677	293.15
66920	STRUT20_CVVSVM_MLI	156.90565	145.70177	152.24648	141.93704	293.15
66921	STRUT20_CVVSVM_MLI	160.11828	146.97963	154.06586	137.82789	293.15
66922	STRUT20_CVVSVM_MLI	150.48594	138.02169	144.59984	127.8288	293.15
67011	STRUT21_CVVSVM_MLI	178.40373	170.06954	174.71159	153.89968	293.15
67012	STRUT21_CVVSVM_MLI	186.10312	176.06326	181.59806	160.52762	293.15
67013	STRUT21_CVVSVM_MLI	186.17255	175.51888	181.09806	156.88843	293.15
67014	STRUT21_CVVSVM_MLI	188.13206	180.04217	184.26009	158.32145	293.15
67015	STRUT21_CVVSVM_MLI	166.60136	156.33673	162.11369	145.74181	293.15
67016	STRUT21_CVVSVM_MLI	177.6166	165.77653	172.40024	154.80378	293.15
67017	STRUT21_CVVSVM_MLI	177.60898	164.92246	171.70154	150.67644	293.15
67018	STRUT21_CVVSVM_MLI	167.92363	156.68647	162.67838	142.54445	293.15
67019	STRUT21_CVVSVM_MLI	158.95072	148.23948	154.42319	141.22494	293.15
67020	STRUT21_CVVSVM_MLI	170.52127	158.62201	165.41158	150.81799	293.15
67021	STRUT21_CVVSVM_MLI	172.34378	159.16287	166.35753	148.30227	293.15
67022	STRUT21_CVVSVM_MLI	152.40291	141.75493	147.70588	132.49992	293.15
67111	STRUT22_CVVSVM_MLI	205.70875	199.61254	202.98904	174.77953	293.15
67112	STRUT22_CVVSVM_MLI	213.21351	208.04618	210.8913	180.99835	293.15
67113	STRUT22_CVVSVM_MLI	210.34745	204.26545	207.44457	176.35389	293.15
67114	STRUT22_CVVSVM_MLI	205.18137	198.71423	202.1145	172.05886	293.15
67115	STRUT22_CVVSVM_MLI	175.79829	165.61378	171.38734	154.31972	293.15
67116	STRUT22_CVVSVM_MLI	176.36499	166.30637	172.04209	155.48817	293.15
67117	STRUT22_CVVSVM_MLI	177.93855	166.70096	172.75693	152.44425	293.15
67118	STRUT22_CVVSVM_MLI	175.17161	164.26801	170.13378	149.77257	293.15
67119	STRUT22_CVVSVM_MLI	160.91588	149.50823	156.09745	144.86153	293.15
67120	STRUT22_CVVSVM_MLI	162.6553	151.19179	157.89871	147.35016	293.15
67121	STRUT22_CVVSVM_MLI	165.67141	152.66533	159.87497	145.09957	293.15
67122	STRUT22_CVVSVM_MLI	162.02816	149.32092	156.2765	141.08796	293.15
67211	STRUT23_CVVSVM_MLI	208.53668	202.96013	206.07786	177.4409	293.15
67212	STRUT23_CVVSVM_MLI	207.08137	200.54395	204.12363	175.61017	293.15
67213	STRUT23_CVVSVM_MLI	207.02577	200.23548	203.7957	173.59031	293.15
67214	STRUT23_CVVSVM_MLI	213.25583	208.11056	210.82163	179.23983	293.15
67215	STRUT23_CVVSVM_MLI	174.85983	165.0505	170.67997	154.41697	293.15
67216	STRUT23_CVVSVM_MLI	178.36674	167.71314	173.68595	155.88521	293.15
67217	STRUT23_CVVSVM_MLI	178.64375	167.22092	173.35876	152.76226	293.15
67218	STRUT23_CVVSVM_MLI	174.34946	163.91009	169.63588	150.67058	293.15
67219	STRUT23_CVVSVM_MLI	160.83525	149.53378	156.16926	145.96442	293.15
67220	STRUT23_CVVSVM_MLI	165.28179	153.17769	160.14173	148.03902	293.15
67221	STRUT23_CVVSVM_MLI	166.63158	153.3312	160.65837	145.26431	293.15
67222	STRUT23_CVVSVM_MLI	160.69847	148.59196	155.43961	142.79965	293.15
67311	STRUT24_CVVSVM_MLI	207.2025	200.80426	204.36256	176.37195	293.15
67312	STRUT24_CVVSVM_MLI	212.13213	207.19688	209.89224	179.69532	293.15
67313	STRUT24_CVVSVM_MLI	210.49033	204.37776	207.56687	176.36829	293.15
67314	STRUT24_CVVSVM_MLI	206.55264	199.82128	203.40647	173.92037	293.15
67315	STRUT24_CVVSVM_MLI	178.58062	168.1436	174.08696	157.21277	293.15
67316	STRUT24_CVVSVM_MLI	173.37076	163.61899	169.1477	152.22145	293.15
67317	STRUT24_CVVSVM_MLI	177.44213	166.25114	172.27646	151.88053	293.15
67318	STRUT24_CVVSVM_MLI	178.10808	166.96545	173.03748	153.40727	293.15

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
67319	STRUT24_CVVSVM_MLI	164.03808	152.37469	159.19719	148.32438	293.15
67320	STRUT24_CVVSVM_MLI	159.10658	147.81636	154.3993	143.81188	293.15
67321	STRUT24_CVVSVM_MLI	165.0934	152.13137	159.31824	144.59871	293.15
67322	STRUT24_CVVSVM_MLI	166.02038	153.10363	160.31815	146.0036	293.15
	EPLM:PACS					
711	Top Optic Housing	3.2187	3.1754	3.19759	2.80427	9.9611
712	Spectrometer Housing	3.21921	3.17642	3.19834	2.80397	9.89251
713	Collimator Housing	3.21097	3.16859	3.1903	2.79877	9.84819
714	Photometer Optic Hous.	3.00017	2.96695	2.98404	2.65433	8.30871
721	2K Feed-Through Red D	1.75327	1.73575	1.74567	1.65762	2.65381
722	2K Feed-Through Blue D	1.95537	1.93584	1.94671	1.74833	3.47454
723	2K StSt I/F Blue Det.	1.63512	1.61973	1.62862	1.57089	1.90085
724	2K_StSt I/F Red Det.	1.63023	1.61471	1.62367	1.5712	1.90309
731	Grating Assy	3.22359	3.18136	3.20299	2.79877	9.84819
741	Red Detector *	1.83654	1.81859	1.82864	1.71888	2.96468
742	Red Detector CRE	3.22605	3.18363	3.20538	2.78974	9.81121
743	CFRP-Strut Red Det.	2.52788	2.49751	2.51349	2.26143	7.06822
744	Harness Red Det. Int	2.53666	2.50628	2.52227	2.25751	7.40249
751	Blue Detector *	2.04553	2.02587	2.03673	1.8014	3.6989
752	Blue Detector CRE	3.22858	3.18615	3.2079	2.79081	9.8148
753	CFRP-Strut Blue Det.	2.63237	2.60115	2.61754	2.30269	7.309
754	Harness Blue Det. Int	2.64093	2.60974	2.62611	2.29884	7.53287
761	Photometer Cooler Pump	1.63395	1.61883	1.62759	1.55993	1.83291
762	Photometer Cooler Evap	1.61579	1.60023	1.60925	1.55787	1.82588
763	Photometer Buffer *	1.66071	1.64516	1.65413	1.57199	1.99155
771	CFRP-Strut (OB) 1	9.15575	9.04213	9.1031	8.06381	16.21291
772	CFRP-Strut (OB) 2	9.0945	8.98444	9.04364	8.02311	15.07239
773	CFRP-Strut (OB) 3	9.15679	9.04298	9.10405	8.06477	16.23851
781	Level 1,1 I/F	2.65355	2.63432	2.64426	2.40034	6.1132
782	Level 1,2 I/F	2.98761	2.96328	2.97567	2.65535	7.4676
783	Level 1,3 I/F	3.14279	3.1113	3.12737	2.76529	8.13265
	EPLM:SPIRE					
800	L1 Strap IF1 @ SOB	4.66272	4.62554	4.64384	4.11717	11.93412
801	PH_JFET_ENCLOSURE	13.53563	13.41494	13.47995	11.4721	20.94925
802	SP_JFET_ENCLOSURE	13.44196	13.32298	13.38711	11.47665	20.56511
803	FPU_OPTICAL_BENCH	4.71785	4.67667	4.69704	4.15428	13.18478
804	RF_FILTER_BOXES	4.7797	4.73783	4.75861	4.20699	13.2112
805	BSM	4.7298	4.68875	4.70906	4.15428	13.18478
806	SMECm	4.74149	4.70057	4.72082	4.15428	13.18478
807	PH_CALIB	4.72998	4.68893	4.70924	4.15428	13.18478
808	SPEC_CALIB	4.71785	4.67667	4.69704	4.15428	13.18478
809	PH_DETECTOR_ENCLOSURE	1.65156	1.63569	1.64482	1.58923	2.23961
810	SP_DETECTOR_ENCLOSURE	1.63521	1.61964	1.62862	1.57671	2.02868
811	L0 Enclosure Flexible S	1.63249	1.61694	1.62592	1.57455	2.00015
812	L0 Pump Flexible Strap	1.66357	1.64832	1.65714	1.56767	1.89405
813	L0 Evap Flexible Strap	1.61854	1.60294	1.61197	1.5597	1.84014
814	L0 Enclosure External S	1.62943	1.61393	1.62288	1.57219	1.96696
815	L0 Pump External Strap	1.65281	1.63767	1.64642	1.56542	1.87203
816	L0 Evaporator External	1.61336	1.59781	1.60682	1.55735	1.81703
817	COOLER_PUMP	1.68931	1.67425	1.68295	1.72745	3.56014
818	COOLER_SHUNT	1.61986	1.60425	1.61329	1.56089	1.85261
819	COOLER_EVAP	0.28	0.28	0.28	1.62219	2.62657
820	COOLER_EVAP_HS	1.61992	1.60431	1.61335	1.56083	1.85176

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821	COOLER_PUMP_HS	1.66791	1.65269	1.66148	1.56879	1.90511
822	PH_DETECTORS	0.28145	0.28143	0.28144	1.62218	2.62648
823	SP DETECTORS	0.28363	0.28356	0.2836	1.62202	2.62352
826	SMEC coils	4	4	4	4	4
830	L1 Strap IF2 @ SOB	4.66272	4.62554	4.64385	4.11717	11.93421
831	PH_L3 IF	13.36566	13.24821	13.31151	11.46653	20.53791
832	SP_L3 IF	13.41158	13.29403	13.35739	11.47406	20.472
	EPLM:HIFI					
910	HIFI_FPU_Main_structure	12.73375	12.59259	12.66868	11.39522	20.63905
911	Calibration_source_assem	12.74053	12.59946	12.6755	11.39522	20.63905
912	Focal_Plane_Chopper	12.73701	12.59589	12.67195	11.39522	20.63905
913	Diplexer_Rooftop_Transla	12.73375	12.59259	12.66868	11.39522	20.63905
914	Second_stage_amplifier	12.74215	12.60111	12.67713	11.39522	20.63905
919	L2-boundary	12.73034	12.58952	12.66544	11.39707	20.41701
920	Mixer_Sub_Assembly	12.71337	12.57264	12.64849	11.37218	20.58373
921	First_stage_amplifier	12.72043	12.5798	12.6556	11.37218	20.58373
922	EMC-filtering	12.71378	12.57306	12.6489	11.37218	20.58373
925	Magnet_current_dissipati	9.90689	9.81812	9.86575	8.90811	15.80586
930	Console_level1_decks	5.56462	5.57424	5.5682	5.06234	8.7932
935	Magnet_current_dissipati	4.25636	4.26006	4.25754	3.88431	6.65359
939	L1_boundary	5.53029	5.54109	5.5344	5.03341	8.72952
940	Console_level0_decks	1.90628	1.88865	1.89863	1.79147	2.65994
941	Mixer_Unit	1.90839	1.89079	1.90076	1.79147	2.65994
942	Heater	1.90628	1.88865	1.89863	1.79147	2.65994
943	LO-power	1.90691	1.88929	1.89927	1.79147	2.65994
949	L0-boundary	1.89577	1.87805	1.88808	1.78384	2.60962
	EPLM:CCC					
4800	Cryostat Cover door	66.50353	63.31228	65.01448	59.67864	293.15
4801	Cover Heat Shield CHS	65.67737	61.85933	63.8722	58.64081	237.7214
4802	Internal MLI -X side	65.84531	62.15851	64.10586	58.85305	252.00196
4803	Internal MLI +X side	66.34056	63.02932	64.79056	59.47514	284.44037
4810	Inlet Junction	66.42463	63.17314	64.90529	59.57837	288.43514
4811	Outlet Junction	66.42463	63.17314	64.90529	59.57837	288.43514
4820	Cover Dewar	4.2	4.2	4.2	4.2	4.2
4821	GHe cover dome inlet	5	5	5	5	5
4822	GHe cover shield outlet	5	5	5	5	5
4823	GHe cover dome outlet	5	5	5	5	5
	EPLM:HSS					
7000	SOLGEN CELLS Mid low	396.13283	371.13461	386.88974	371.05708	293.15
7001	SOLGEN CELLS -Y low	375.77317	352.07453	367.00889	351.99392	293.15
7002	SOLGEN CELLS +Y low	375.85934	352.18392	367.10645	352.13759	293.15
7010	SOLGEN CELLS Mid cent	397.53751	372.50869	388.28693	372.50564	293.15
7011	SOLGEN CELLS -Y cent	376.49723	352.8027	367.73951	352.79877	293.15
7012	SOLGEN CELLS +Y cent	376.49723	352.80335	367.73978	352.80021	293.15
7020	SOLGEN CELLS Mid up	395.56385	370.23103	386.18621	370.22762	293.15
7021	SOLGEN CELLS -Y up	374.51966	350.39063	365.57636	350.36829	293.15
7022	SOLGEN CELLS +Y up	374.51772	350.3888	365.57449	350.36685	293.15
7050	SUNSHADE OSR Mid low	277.71035	224.06161	254.32088	224.0533	293.15
7051	SUNSHADE OSR -Y low	263.71065	213.35076	241.75359	213.3422	293.15
7052	SUNSHADE OSR +Y low	263.70909	213.34854	241.75179	213.34048	293.15
7053	SUNSHADE flap -Y	260.36209	208.75599	238.07591	208.74936	293.15
7054	SUNSHADE flap +Y	260.36115	208.75475	238.07487	208.74837	293.15

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7060	SUNSHADE OSR Mid lcen	276.20452	219.41152	251.71175	219.40974	293.15
7061	SUNSHADE OSR -Y lcen	261.57758	208.10004	238.48674	208.09728	293.15
7062	SUNSHADE OSR +Y lcen	261.57732	208.09961	238.48642	208.09694	293.15
7070	SUNSHADE OSR Mid ucen	276.13547	219.12305	251.58379	219.12286	293.15
7071	SUNSHADE OSR -Y ucen	261.49155	207.77407	238.33288	207.773	293.15
7072	SUNSHADE OSR +Y ucen	261.49139	207.77379	238.33268	207.77279	293.15
7080	SUNSHADE OSR Mid up	276.15833	219.13303	251.605	219.13299	293.15
7081	SUNSHADE OSR -Y up	261.61372	207.66347	238.38154	207.66335	293.15
7082	SUNSHADE OSR +Y up	261.61363	207.66337	238.38145	207.66325	293.15
7100	SOLGEN MLI Mid low	271.07724	253.07836	264.46102	252.11435	293.15
7101	SOLGEN MLI -Y low	258.30796	241.14175	251.94303	239.95769	293.15
7102	SOLGEN MLI +Y low	258.00894	240.88116	251.66746	239.80225	293.15
7103	SOLGEN -x rib MLI +Z low	285.14031	265.29705	277.41505	262.17881	293.15
7104	SOLGEN -x rib MLI -Y low	269.60321	250.81621	262.27372	247.75627	293.15
7105	SOLGEN -x rib MLI +Y low	269.46414	250.7326	262.17299	247.81316	293.15
7106	SOLGEN -x rib MLI +Z up	269.80089	252.49661	263.33443	252.06617	293.15
7107	SOLGEN -x rib MLI -Y up	256.40657	239.96064	250.25452	239.50016	293.15
7108	SOLGEN -x rib MLI +Y up	256.21095	239.79478	250.0759	239.41622	293.15
7110	SOLGEN MLI Mid cent	269.49926	252.26308	263.05331	251.82158	293.15
7111	SOLGEN MLI -Y cent	256.00665	239.61214	249.86243	239.08605	293.15
7112	SOLGEN MLI +Y cent	255.76013	239.37641	249.62297	238.90665	293.15
7120	SOLGEN MLI Mid up	268.64272	251.21245	262.12199	250.80755	293.15
7121	SOLGEN MLI -Y up	254.92182	238.27599	248.67881	237.80399	293.15
7122	SOLGEN MLI +Y up	254.65351	238.02322	248.41948	237.6026	293.15
7130	SOLGEN MLI Mid up2	267.00911	249.54015	260.4729	249.3817	293.15
7131	SOLGEN MLI -Y up2	253.45328	236.74501	247.18518	236.53352	293.15
7132	SOLGEN MLI +Y up2	253.30659	236.6094	247.04407	236.41486	293.15
7133	SOLGEN +x rib MLI +Z low	270.24683	252.65455	263.64614	252.10866	293.15
7134	SOLGEN +x rib MLI -Y low	256.8001	239.97498	250.47024	239.35191	293.15
7135	SOLGEN +x rib MLI +Y low	256.57373	239.76213	250.25271	239.19285	293.15
7136	SOLGEN +x rib MLI +Z up	268.17432	250.39876	261.48507	250.19086	293.15
7137	SOLGEN +x rib MLI -Y up	254.76612	237.72951	248.33629	237.47891	293.15
7138	SOLGEN +x rib MLI +Y up	254.68886	237.65988	248.26311	237.41912	293.15
7140	SUNSHADE MLI Mid low2	202.37233	167.65017	187.12095	167.06093	293.15
7141	SUNSHADE MLI -Y low2	193.19896	160.78731	178.95542	160.08155	293.15
7142	SUNSHADE MLI +Y low2	193.00734	160.53481	178.73975	159.8744	293.15
7143	SSHADE rib MLI +Z low	200.86951	169.06782	186.87422	168.24316	293.15
7144	SSHADE rib MLI -Y low	192.34069	162.70509	179.29001	161.65821	293.15
7145	SSHADE rib MLI +Y low	192.03491	162.2901	178.94055	161.32955	293.15
7146	SSHADE rib MLI +Z up	193.13887	158.46665	177.94048	157.9962	293.15
7147	SSHADE rib MLI -Y up	183.75108	151.1993	169.48152	150.72367	293.15
7148	SSHADE rib MLI +Y up	183.75402	151.20125	169.48454	150.73717	293.15
7150	SUNSHADE MLI Mid low	199.76975	163.57646	183.91142	163.13173	293.15
7151	SUNSHADE MLI -Y low	190.36113	156.56317	175.54587	156.08268	293.15
7152	SUNSHADE MLI +Y low	190.31142	156.49684	175.49091	156.0426	293.15
7153	SUNSHADE flap MLI -Y in	189.04583	154.63629	174.07395	154.18472	293.15
7154	SUNSHADE flap MLI +Y in	189.01986	154.60308	174.04495	154.1517	293.15
7155	SUNSHADE flap MLI -Y out	180.92197	145.13634	165.46258	145.09456	293.15
7156	SUNSHADE flap MLI +Y out	180.90463	145.11337	165.44341	145.07825	293.15
7160	SUNSHADE MLI Mid lcen	195.36999	156.69437	178.62191	156.46648	293.15
7161	SUNSHADE MLI -Y lcen	185.53271	149.31403	169.81729	149.01815	293.15
7162	SUNSHADE MLI +Y lcen	185.50774	149.28456	169.79074	148.9949	293.15
7170	SUNSHADE MLI Mid ucen	192.112	152.54165	175.06666	152.52763	293.15
7171	SUNSHADE MLI -Y ucen	182.21801	144.95212	166.14328	144.91691	293.15
7172	SUNSHADE MLI +Y ucen	182.20385	144.9279	166.12574	144.90049	293.15

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7180	SUNSHADE MLI Mid up	191.78017	152.21826	174.74403	152.21306	293.15
7181	SUNSHADE MLI -Y up	181.93836	144.47813	165.80416	144.47046	293.15
7182	SUNSHADE MLI +Y up	181.9231	144.46319	165.78921	144.45621	293.15
7203	SOLGEN SVM gapMLI pZ	263.65315	181.18677	256.70882	167.90337	293.15
7204	SOLGEN SVM gapMLI mY pZ	246.67064	174.40808	240.01204	161.5252	293.15
7205	SOLGEN SVM gapMLI pY pZ	246.95187	174.47172	240.28749	161.56837	293.15
7206	SOLGEN SVM gapMLI mZ	231.64391	195.89773	224.09424	185.9879	293.15
7207	SOLGEN SVM gapMLI mY mZ	213.81723	180.82131	206.72424	170.92546	293.15
7208	SOLGEN SVM gapMLI pY mZ	213.66616	180.51475	206.59424	170.76808	293.15
7213	SOLGEN SVM gapMLI mX	258.6929	222.17081	249.82825	205.75924	293.15
7214	SOLGEN SVM gapMLI mY mX	245.8436	216.10803	237.06055	199.83496	293.15
7215	SOLGEN SVM gapMLI pY mX	245.6924	215.80268	236.92118	199.5392	293.15
7301	STRUT_HSSSVM_01_SVM_end	275.19745	258.23672	267.65946	246.75164	293.15
7302	STRUT_HSSSVM_01	275.08118	259.3605	268.26304	250.09627	293.15
7303	STRUT_HSSSVM_01	278.16217	263.15345	271.82496	255.75656	293.15
7304	STRUT_HSSSVM_01	284.52028	269.69653	278.42892	263.84787	293.15
7305	STRUT_HSSSVM_01_HSS_end	294.30959	279.12961	288.22656	274.537	293.15
7321	STRUT_HSSSVM_02_SVM_end	274.51533	257.51451	266.95305	245.9729	293.15
7322	STRUT_HSSSVM_02	274.31635	258.5971	267.49837	249.36174	293.15
7323	STRUT_HSSSVM_02	277.50078	262.50686	271.17468	255.19483	293.15
7324	STRUT_HSSSVM_02	284.13517	269.31683	278.05512	263.58774	293.15
7325	STRUT_HSSSVM_02_HSS_end	294.36933	279.16625	288.28924	274.71182	293.15
7341	STRUT_HSSSVM_03_SVM_end	274.62082	257.60384	267.05075	246.03867	293.15
7342	STRUT_HSSSVM_03	274.42541	258.68926	267.59931	249.4297	293.15
7343	STRUT_HSSSVM_03	277.60282	262.59291	271.26903	255.25849	293.15
7344	STRUT_HSSSVM_03	284.22604	269.39324	278.13902	263.64437	293.15
7345	STRUT_HSSSVM_03_HSS_end	294.44524	279.22989	288.3592	274.75861	293.15
7361	STRUT_HSSSVM_04_SVM_end	275.36133	258.3753	267.81139	246.85794	293.15
7362	STRUT_HSSSVM_04	275.26296	259.51377	268.43148	250.21494	293.15
7363	STRUT_HSSSVM_04	278.34709	263.30849	271.99605	255.87857	293.15
7364	STRUT_HSSSVM_04	284.68767	269.83651	278.58368	263.95887	293.15
7365	STRUT_HSSSVM_04_HSS_end	294.44766	279.24468	288.354	274.6277	293.15
7401	STRUT_HSSCVV_05_CVV_end	91.59066	87.11591	89.65155	84.26866	293.15
7402	STRUT_HSSCVV_05	133.30605	127.28818	130.84483	125.55914	293.15
7403	STRUT_HSSCVV_05	170.60086	163.6188	167.86981	162.60917	293.15
7404	STRUT_HSSCVV_05	215.79562	207.08819	212.53419	206.57795	293.15
7405	STRUT_HSSCVV_05_HSS_end	288.99122	275.20874	283.95816	275.03268	293.15
7421	STRUT_HSSCVV_06_CVV_end	100.44727	94.18908	97.73613	91.0654	293.15
7422	STRUT_HSSCVV_06	144.15341	136.33218	140.92523	134.36148	293.15
7423	STRUT_HSSCVV_06	180.94426	172.52572	177.61676	171.34042	293.15
7424	STRUT_HSSCVV_06	224.59245	214.85953	220.9169	214.24812	293.15
7425	STRUT_HSSCVV_06_HSS_end	294.70886	280.28992	289.43133	280.08113	293.15
7441	STRUT_HSSCVV_07_CVV_end	100.77612	94.46501	98.04218	91.29634	293.15
7442	STRUT_HSSCVV_07	144.67779	136.76597	141.40925	134.72321	293.15
7443	STRUT_HSSCVV_07	181.39556	172.90278	178.03485	171.65177	293.15
7444	STRUT_HSSCVV_07	224.90854	215.12562	221.21051	214.47002	293.15
7445	STRUT_HSSCVV_07_HSS_end	294.81946	280.3843	289.53462	280.15881	293.15
7461	STRUT_HSSCVV_08_CVV_end	92.44001	87.79939	90.42803	84.84321	293.15
7462	STRUT_HSSCVV_08	133.91273	127.78386	131.40317	125.97776	293.15
7463	STRUT_HSSCVV_08	171.38129	164.23615	168.57685	163.13692	293.15
7464	STRUT_HSSCVV_08	216.22137	207.42682	212.91955	206.86084	293.15
7465	STRUT_HSSCVV_08_HSS_end	289.08988	275.28906	284.04776	275.0946	293.15
7501	STRUT_HSSCVV_09_CVV_end	85.1506	78.3631	82.20525	75.34414	293.15
7502	STRUT_HSSCVV_09	116.8494	104.90958	111.84036	102.94961	293.15
7503	STRUT_HSSCVV_09	145.49688	128.91353	138.60748	127.6384	293.15

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
7504	STRUT_HSSCVV_09	176.96998	153.94286	167.35869	153.21798	293.15
7505	STRUT_HSSCVV_09_HSS_end	221.40267	186.32053	206.51167	186.07643	293.15
7521	STRUT_HSSCVV_10_CVV_end	90.81638	82.91666	87.38805	79.76782	293.15
7522	STRUT_HSSCVV_10	126.78613	113.20691	121.08109	111.07979	293.15
7523	STRUT_HSSCVV_10	156.24303	138.15309	148.7175	136.75965	293.15
7524	STRUT_HSSCVV_10	187.93327	163.44288	177.72717	162.64336	293.15
7525	STRUT_HSSCVV_10_HSS_end	233.64574	196.537	217.90107	196.24625	293.15
7541	STRUT_HSSCVV_11_CVV_end	91.19803	83.25909	87.75397	80.06	293.15
7542	STRUT_HSSCVV_11	127.20222	113.58718	121.48372	111.41957	293.15
7543	STRUT_HSSCVV_11	156.59178	138.47324	149.05492	137.04681	293.15
7544	STRUT_HSSCVV_11	188.10781	163.61488	177.90121	162.7959	293.15
7545	STRUT_HSSCVV_11_HSS_end	233.68366	196.57764	217.93983	196.27729	293.15
7561	STRUT_HSSCVV_12_CVV_end	85.54693	78.71568	82.58301	75.63724	293.15
7562	STRUT_HSSCVV_12	117.37198	105.37449	112.33848	103.34354	293.15
7563	STRUT_HSSCVV_12	145.8419	129.24223	138.94677	127.92304	293.15
7564	STRUT_HSSCVV_12	177.15478	154.13246	167.54721	153.38515	293.15
7565	STRUT_HSSCVV_12_HSS_end	221.48058	186.40033	206.59046	186.14384	293.15
7601	STRUT_HSSCVV_13_SSH_end	328.78785	303.91849	319.0681	303.88497	293.15
7602	STRUT_HSSCVV_13_SSD_end	278.3683	240.1826	262.14413	240.15517	293.15
7621	STRUT_HSSCVV_14_SSH_end	328.80426	303.932	319.08326	303.89613	293.15
7622	STRUT_HSSCVV_14_SSD_end	278.37584	240.18965	262.15143	240.16036	293.15
	EPLM:TEL					
8001	TEL_M1_MIRROR	85.09428	76.84348	81.41073	75.14918	293.15
8002	TEL_M1_MIRROR	85.11658	76.85891	81.42986	75.16472	293.15
8003	TEL_M1_MIRROR	85.05442	76.81684	81.37695	75.12378	293.15
8004	TEL_M1_MIRROR	85.07099	76.82721	81.39074	75.13411	293.15
8005	TEL_M1_MIRROR	85.09305	76.84248	81.4096	75.14835	293.15
8006	TEL_M1_MIRROR	85.11555	76.85802	81.42889	75.16399	293.15
8040	TEL_HEXAPOD	82.49794	74.75491	79.03621	73.26453	293.15
8050	TEL_M2_MIRROR	82.49365	74.75232	79.0327	73.26206	293.15
8060	TEL_M2_SCREEN	66.62591	57.88866	62.71222	57.06702	293.15
8101	TEL_M1_SLI1	93.25465	84.13957	89.25469	82.42258	293.15
8102	TEL_M1_SLI1	93.1756	83.9959	89.14283	82.27857	293.15
8103	TEL_M1_SLI1	92.96122	83.92329	88.99948	82.21089	293.15
8104	TEL_M1_SLI1	92.18827	83.17513	88.23235	81.46775	293.15
8105	TEL_M1_SLI1	93.2737	84.15455	89.27227	82.44126	293.15
8106	TEL_M1_SLI1	93.14226	83.96218	89.10934	82.25152	293.15
8110	TEL_M1_BAFFLE UP DISC	76.18012	67.15635	72.14055	65.9175	293.15
8111	TEL_M1_BAFFLE CYL	88.17384	79.12109	84.18659	77.51265	293.15
8112	TEL_M1_BAFFLE LOW DISC	90.36331	81.70683	86.58744	79.90599	293.15
8201	TEL_M1_SLI2	104.34503	94.16305	99.93844	92.36046	293.15
8202	TEL_M1_SLI2	104.6401	94.07002	100.0498	92.26983	293.15
8205	TEL_M1_SLI2	104.22359	94.04255	99.81748	92.25746	293.15
8206	TEL_M1_SLI2	104.48703	93.91586	99.89633	92.1413	293.15
8301	TEL_M1_SLI3	120.89212	109.56288	116.05496	107.53264	293.15
8302	TEL_M1_SLI3	115.02227	102.51618	109.58841	100.61776	293.15
8303	TEL_M1_SLI3	87.76241	79.4388	84.15177	77.76307	293.15
8304	TEL_M1_SLI3	86.13272	77.83334	82.51862	76.17141	293.15
8305	TEL_M1_SLI3	120.29089	108.96797	115.45768	107.02643	293.15
8306	TEL_M1_SLI3	114.71448	102.18948	109.27315	100.36192	293.15
8311	TEL_M1_SLI3	110.56206	100.18028	106.10373	98.33257	293.15
8313	TEL_M1_SLI3	104.6692	94.8443	100.43859	93.05834	293.15
8315	TEL_M1_SLI3	110.43616	100.05729	105.97903	98.22451	293.15
8501	M1 HEATER 44001	85.34345	77.08102	81.65687	75.38502	293.15

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
8502	M1 HEATER 44002	85.38815	77.12031	81.69966	75.42439	293.15
8503	M1 HEATER 44003	85.41353	77.13954	81.72224	75.4434	293.15
8504	M1 HEATER 44004	85.43679	77.15331	81.7406	75.45629	293.15
8505	M1 HEATER 44005	85.4786	77.18903	81.78016	75.49229	293.15
8506	M1 HEATER 44006	85.47891	77.18932	81.78046	75.49256	293.15
8507	M1 HEATER 44007	85.45391	77.16916	81.75722	75.47176	293.15
8508	M1 HEATER 44008	85.48126	77.19169	81.78281	75.49441	293.15
8509	M1 HEATER 44009	85.48204	77.19226	81.78351	75.49501	293.15
8510	M1 HEATER 44010	85.47795	77.18977	81.78002	75.49224	293.15
8511	M1 HEATER 44011	85.45414	77.17089	81.75858	75.47401	293.15
8512	M1 HEATER 44012	85.38919	77.12107	81.7006	75.42519	293.15
8522	M1 HEATER 48002	85.47244	77.19724	81.78192	75.50229	293.15
8524	M1 HEATER 48004	85.48299	77.2041	81.78955	75.5063	293.15
8526	M1 HEATER 48006	85.52188	77.23112	81.82409	75.53527	293.15
8528	M1 HEATER 48008	85.52281	77.23197	81.82497	75.53577	293.15
8530	M1 HEATER 48010	85.47727	77.19845	81.78383	75.50048	293.15
8532	M1 HEATER 48012	85.46795	77.19323	81.7776	75.49828	293.15
8541	TEL_M2_HEATER 44001	82.00881	74.31881	78.56628	72.83344	293.15
8542	TEL_M2_HEATER 44002	82.00896	74.31893	78.56642	72.83355	293.15
99998	Space	3	3	3	3	3
	EPLM:LOU					
4210	LOU baseplate	125.41276	121.43394	123.65742	97.93863	293.15
4262	LOU mx side MLI	138.26631	129.43034	134.47881	120.42456	293.15
	SVM					
6001	SVM wall pZ	318	291	305	265	293
6002	SVM wall pYpZ	318	291	305	265	293
6003	SVM wall pY	318	291	305	265	293
6004	SVM wall pYmZ	318	291	305	265	293
6005	SVM wall mZ	318	291	305	265	293
6006	SVM wall mYmZ	318	291	305	265	293
6007	SVM wall mY	318	291	305	265	293
6008	SVM wall mYpZ	318	291	305	265	293
6020	SVM I/F to CVV struts	293	293	293	245	293
6021	SVM I/F to SVM shield	293	266	280	240	293
6022	SVM I/F to Sshld str.	293	266	280	240	293
6023	SVM I/F to waveguides	293	266	280	240	293
6024	SVM I/F to harness	293	266	280	240	293
6051	SVM top pZ	230	203	216	168	293
6052	SVM top pYpZ	230	203	216	168	293
6053	SVM top pY	230	203	216	168	293
6054	SVM top pYmZ	230	203	216	168	293
6055	SVM top mZ	230	203	216	168	293
6056	SVM top mYmZ	230	203	216	168	293
6057	SVM top mY	230	203	216	168	293
6058	SVM top mYpZ	230	203	216	168	293
6101	SVM top disc pZ	230	203	216	168	293
6102	SVM top disc pYpZ	230	203	216	168	293
6103	SVM top disc pY	230	203	216	168	293
6104	SVM top disc pYmZ	230	203	216	168	293
6105	SVM top disc mZ	230	203	216	168	293
6106	SVM top disc mYmZ	230	203	216	168	293
6107	SVM top disc mY	230	203	216	168	293
6108	SVM top disc mYpZ	230	203	216	168	293

Node	LABEL	Orbit hot T [K]	Orbit cold T [K]	Orbit avg T [K]	Orbit Safe T [K]	Ground T [K]
6151	MLI THR pZ	230	203	216	168	293
6152	MLI THR pY	230	203	216	168	293
6153	MLI THR mZ	230	203	216	168	293
6154	MLI THR mY	230	203	216	168	293
6155	MLI SAS pZ	230	203	216	168	293
6156	MLI SAS pZ BRK	230	203	216	168	293
6157	MLI SAS mZ	230	203	216	168	293
6158	MLI SAS mZ BRK	230	203	216	168	293
6159	MLI AAD	230	203	216	168	293
6160	MLI VMC	230	203	216	168	293
6161	MLI SREM	230	203	216	168	293

END OF DOCUMENT

	Name	Dep./Comp.		Name	Dep./Comp.
	Baldock Richard	FAE12			
	Barlage Bernhard	AED13			
	Bayer Thomas	ASA42			
	Brune Holger	ASA45			
	Chen Bing	HE Space			
	Davis William	Captec			
	Edelhoff Dirk	AED21			
X	Fricke Wolfgang Dr.	AED 65			
	Geiger Hermann	ASA42			
	Grasl Andreas	OTN/ASA44			
	Grasshoff Brigitte	AET12			
	Hamer Simon	Terma			
	Hendrikse Jeffrey	HE Space			
	Hendry David	Terma			
	Hengstler Reinhold	ASA42			
X	Hinger Jürgen	ASG23			
	Hofmann Rolf	ASE252			
X	Hohn Rüdiger	AED65			
	Hopfgarten Michael	AET32			
	Huber Johann	ASA42			
	Hund Walter	ASE252			
	Ivády von András	FAE12			
X	Jahn Gerd Dr.	ASG23			
	Kölle Markus	ASA43			
	Koppe Axel	AED312	X	ESA/ESTEC	ESA
X	Kroeker Jürgen	AED65	X	Thales Alenia Space Cannes	TAS-F
X	Lang Jürgen	ASE252		Thales Alenia Space Torino	TAS-I
	Langenstein Rolf	AED15			
X	Langfermann Michael	ASA41			
	Martin Olivier	Altec		**Instruments:**	
	Much Christoph	ASA43	X	MPE (PACS)	MPE
	Müller Martin	ASA43	X	RAL (SPIRE)	RAL
	Peltz Heinz-Willi	ASG15	X	SRON (HIFI)	SRON
	Pietroboni Karin	AED65			
	Reichle Konrad	ASA42			
	Runge Axel	OTN/ASA44		**Subcontractors:**	
	Schink Dietmar	AED321		Austrian Aerospace	AAE
	Schmidt Thomas	AED15		Austrian Aerospace	AAEM
X	Schweickert Gunn	ASG23		BOC Edwards	BOCE
	Steininger Eric	AED321		Dutch Space Solar Arrays	DSSA
X	Stritter Rene	AED11		EADS Astrium Sub-Subsyst. & Equipment	ASSE
	Suess Rudi	OTN/ASA44		EADS CASA Espacio	CASA
X	Wagner Klaus	ASG23		EADS CASA Espacio	ECAS
X	Wietbrock Walter	AET12		European Test Services	ETS
	Wöhler Hans	ASG23		Patria New Technologies Oy	PANT
	Wössner Ulrich	ASE252		SENER Ingenieria SA	SEN
				Thales Alenia Space, Antwerp	TAS-ETCA