Title:	**TMM Correlation for L1 and L3 Performance Measurements**
CI-No:	121 143 and 121 144

Prepared by:	G. Jahn	Date:	27.07.07
Checked by:	J. Kroeker		30.7.07
Product Assurance:	R. Stritter		30.07.07
Configuration Control:	W. Wietbrock		31.07.07
Project Management:	Dr. W. Fricke		31/07/2007

Distribution: See Distribution List (last page)

Issue	Date	Sheet	Description of Change	Release
1	27.07.07	All	First Issue	

Table of Content

Table of Figures

List of Tables

1 Scope

This technical note describes the TMM correlation of the L1 and L3 conductance measurement results obtained from the H-EPLM STM TB/TV qualification performed in the LSS chamber at ESTEC in October 2005.

2 Reference Documents and Abbreviations

2.1 Reference Documents

RD 01 H-EPLM STM TB/TV Test Report, Doc.No.: HP-2-ASED-TR-0110, Issue 1, dated 17.01.2006

RD 02 Evaluation of Instrument Thermal Interface Test Results, HP-2-ASED-RP-0180, Issue 1.1, dated 27.07.2006

RD 03 TMM Correlation for L0 Conductance Measurements, Doc.No.: HP-2-ASED-TN-0138, Issue 1, dated 28.06.2006

RD 04 H-EPLM TMM Issue 4.4 delivered with HP-2-ASED-EM-0144-06, dated 29.06.2006

RD 05 Evaluation of H-EPLM STM TB/TV Test Results, HP-2-ASED-RP-0174, Issue 1.1, dated 28.06.2006

2.2 Relevant Temperature Sensor Nomenclature

Sensor acronym	*Sensor Location*	*Type*
MT101	TH-HIFI-1, on L0 IF	C100
MT102	TH-HIFI-2, on L0 IF	C100
MT103	TH-HIFI-3, on L1 IF	C100
MT104	TH-HIFI-4, on L1 IF	C100
MT105	TH-HIFI-5, on FPU	C100
MT106	TH-HIFI-6, on FPU	C100
MT107	TH-HIFI-7, on FPU	Pt1000
MT108	TH-LOU-1, on LOU baseplate	Pt1000
MT109	TH-LOU-2, on LOU baseplate	Pt1000
MT110	TH-LOU-3, on LOU baseplate	Pt1000
MT201	TH-SPIRE-1, on detector L0 rigid pod	C100
MT202	TH-SPIRE-2, on detector L0 rigid pod	C100
MT203	TH-SPIRE-3, on cooler evaporator L0 rigid/open tank pod	C100
MT204	TH-SPIRE-4, on cooler evaporator L0 rigid/open tank pod	C100
MT205	TH-SPIRE-5, on cooler pump L0 rigid pod	C100
MT206	TH-SPIRE-6, on cooler pump L0 rigid pod	C100
MT207	TH-SPIRE-7, on SPIRE optical bench	C100
MT208	TH-SPIRE-8, on SPIRE optical bench	C100
MT213	TH-SPIRE-9, on SPIRE optical bench	Pt1000
MT250	TH-S-JFET-1, on S-J-FET baseplate	C100
MT251	TH-S-JFET-2, on S-J-FET baseplate	C100
MT252	TH-S-JFET-3, on S-J-FET baseplate	Pt1000
MT253	TH-P-JFET-1, on P-J-FET baseplate	C100
MT254	TH-P-JFET-2, on P-J-FET baseplate	C100
MT255	TH-P-JFET-3, on P-J-FET baseplate	Pt1000
MT301	TH-PACS-1, on Red Detector Assy (FPFPU.DET)	C100
MT302	TH-PACS-2, on Red Detector Assy (FPFPU.DET)	C100
MT303	TH-PACS-3, on Blue Detector Assy (FPFPU.BOL)	C100
MT304	TH-PACS-4, on Blue Detector Assy (FPFPU.BOL)	C100
MT305	TH-PACS-5, on cooler pump (FPFPU.COOL)	C100
MT306	TH-PACS-6, on cooler pump (FPFPU.COOL)	C100
MT307	TH-PACS-7, on cooler evaporator (FPFPU.COOL)	C100
MT308	TH-PACS-8, on cooler evaporator (FPFPU.COOL)	C100
MT309	TH-PACS-9, on L1-interface of Photometer optics	C100
MT310	TH-PACS-10, on L1-interface of Photometer optics	C100
MT311	TH-PACS-11, on L1-interface of collimator	C100
MT312	TH-PACS-12, on L1-interface of collimator	C100
MT313	TH-PACS-13, on L1-interface of Spectrometer housing	C100
MT314	TH-PACS-14, on L1-interface of Spectrometer housing	C100
MT315	TH-PACS-15, on FPU	Pt1000
T101	DLCM-1, tank lower side; -x-y; integrated in DLCM housing	C100
T102	DLCM-2, tank lower side; -x+y; integrated in DLCM housing	C100
T103	HTT lower side; -x+z-y; nearby outside	Pt1000

Sensor acronym	*Sensor Location*	*Type*
T104	DLCM-2, tank lower side; -x+y; integrated in DLCM housing	C100
T105	DLCM-1, tank lower side; -x-y; integrated in DLCM housing	C100
T106	HTT lower side; -x-z+y; nearby outside	C100
T107	HTT upper side; +x-z+y; nearby outside	C100
T111	HTT upper side; +x-y-z; integrated into PPS housing	C100
T112	HTT upper side; +x-y-z; integrated into PPS housing	C100
T113	Filling port end piece	C100
T114	Filling port end piece	C100
T202	OB Plate near PACS mounting foot (+z)	C100
T207	OB Plate near HIFI mounting foot (+z/-y)	Pt1000
T208	OB Plate near HIFI mounting foot (+z/-y)	C100
T211	Instrument Shield, close to HIFI	Pt1000
T212	Instrument Shield, close to PACS	C100
T213	Instrument Shield, close to SPIRE	C100
T221	L0 Cooling Strap 1; to PACS RED Detector	C100
T222	L0 Cooling Strap 2; to PACS Sorption Cooler Evaporator	C100
T223	L0 Cooling Strap 3; to PACS Sorption Cooler Pump	C100
T224	L0 Cooling Strap 4; to PACS BLUE Detector	C100
T225	L0 Cooling Strap 5; to SPIRE SM Detector enclosure	C100
T226	L0 Cooling Strap 6; to SPIRE Cooler Pump	C100
T227	L0 Cooling Strap 7; to SPIRE Cooler Evaporator	C100
T228	L0 Cooling Strap 8; to HIFI L0	C100
T231	L1 Ventline upstream strap 1 to PACS Phot.Optics (L1 Inlet)	C100
T232	L1 Ventline downstream strap 1 to PACS Phot.Optics	C100
T233	L1 Ventline downstream strap 2 to PACS Collimator	C100
T234	L1 Ventline downstream strap 3 to PACS Spect.Housing	C100
T235	L1 Ventline upstream strap 4 to SPIRE Optical Bench	C100
T236	L1 Ventline downstream strap 4 to SPIRE Optical Bench	C100
T237	L1 Ventline downstream strap 5 to HIFI interface (L1 outlet)	C100
T242	L1; on Strap 1 on PACS FPU Side	C100
T244	L1, on Strap 5 on HIFI FPU side	C100
T246	L3 Ventline to 6-JFET (JFET-Phot)	C100
T247	L3 Ventline to 2-JFET (JFET-Spec)	C100
T248	L1; on Strap 4 on SPIRE FPU side	C100
T249	On Spire 2-JFET (JFET-Spec)	Pt1000
T250	On Spire 2-JFET (JFET-Spec)	C100
T251	On Spire 6-JFET (JFET-Phot)	Pt1000
T252	On Spire 6-JFET (JFET-Phot)	C100
T253	OB Plate near SPIRE foot (center)	Pt1000
T254	OB Plate near SPIRE foot (center)	C100
T255	OB Plate near SPIRE foot (-z+y)	Pt1000
T256	OB Plate near SPIRE foot (-z+y)	C100
T258	OB Plate near SPIRE foot (-y-z)	C100

3 Test Conditions

3.1 Conditions During the Different Test Phases

The L1 and L3 measurement has been performed during the test phase TP4 from 21.-23.October 2005 and during TP6 from 29.-31.October 2005 applying different electrical heating power on the L1and L3 MTD's. During TP4 the spacecraft was tilted by 14° and the helium filling level was about 90%. The mass flow was routed via PPS (valve V106 open) and adjusted to about 2.3 mg/s.

In TP6 L1 and L3 measurement has been performed with a higher mass flow of about 4.7 mg/s. During TP6 the venting helium was not routed via PPS (valve V104 open) and therefore the spacecraft was not tilted. The venting He routing during the different test phases is illustrated in **Figure 3.1-1**.

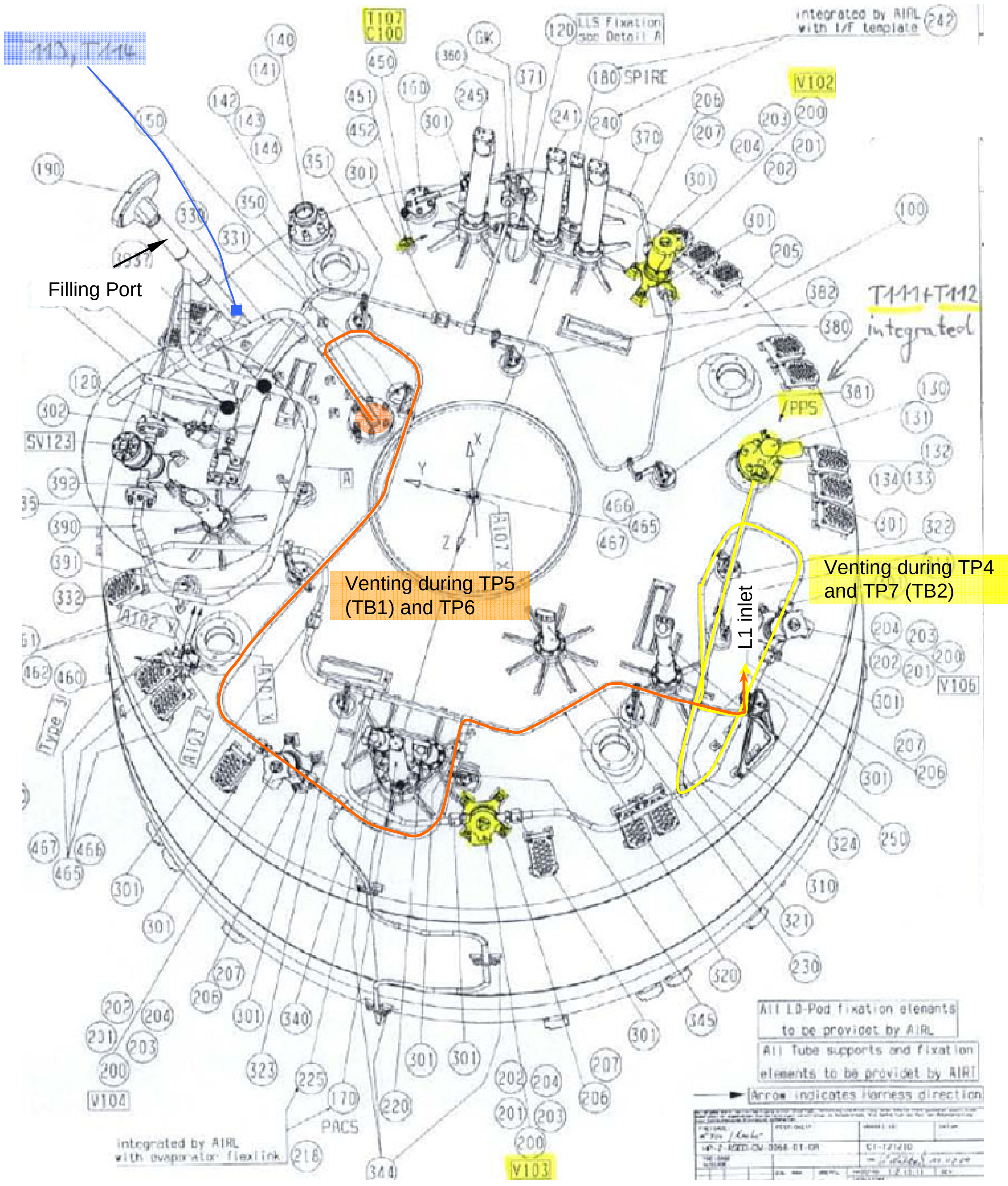

Figure 3.1-1: Helium Venting Paths during Test Phases TP4, TP5, TP6 and TP7

3.2 Correlation between Temperature Sensors and Thermal Nodes

The location of the TMM ventline and helium nodes versus the location of the temperature sensors during test is compiled in **Table 3.2-1**. Here the ventline origin is set to the helium node 5013 (L = 0.0 m). For the L2 ventline section temperature sensors mounted on the Optical Bench Plate (OBP) are taken as reference, see also **Figure 3.2-1**.

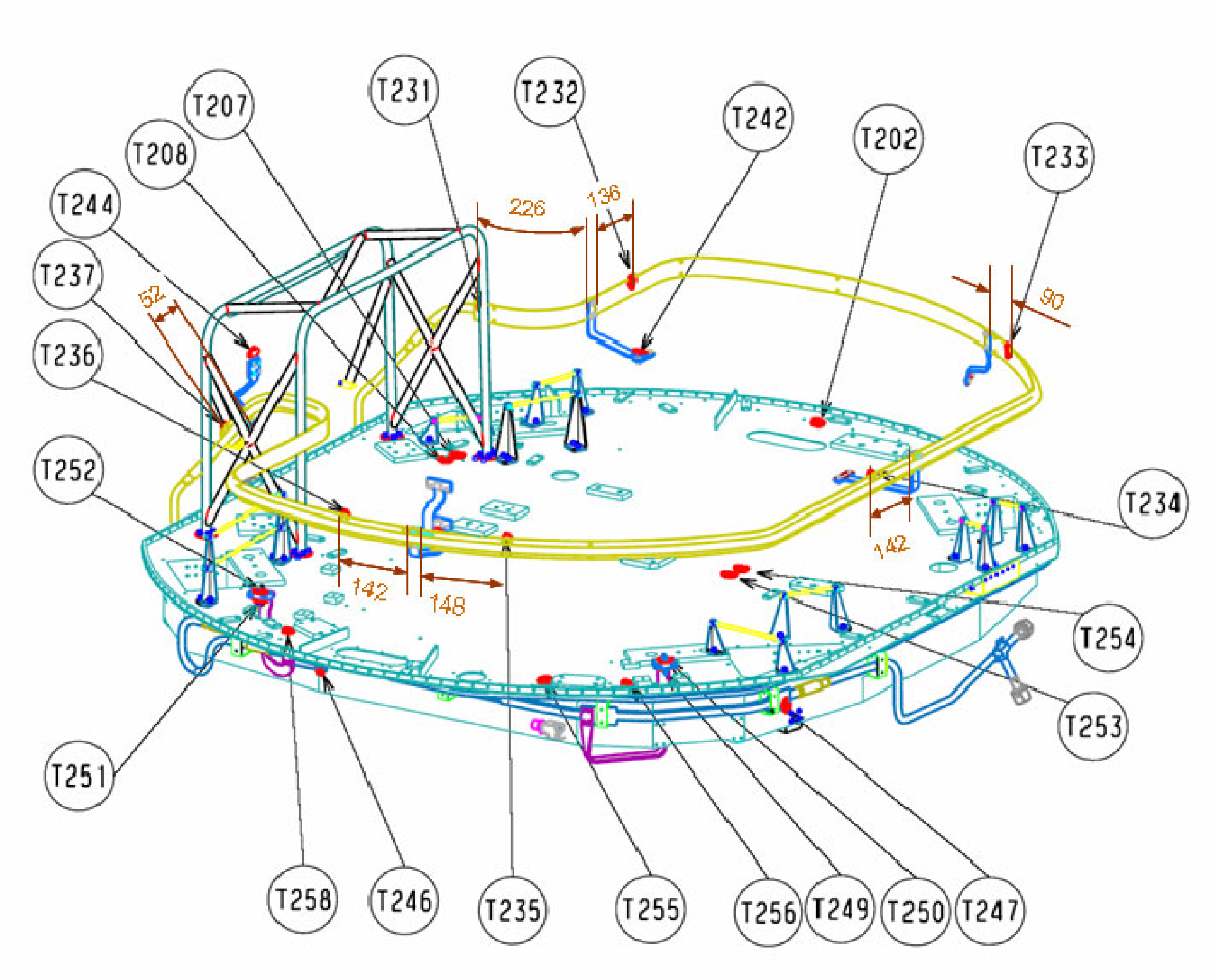

Figure 3.2-1: Distribution of Temperature Sensors on Optical Bench Assembly (L1, L2, L3)

TMM wall	L wall [m]	TMM gas	L gas [m]	Test Sensor	L wall [m]
513	-0.248	5013	0		
514	0.032	5014	0.262	T231	0.086
520	0.287	5020	0.312		
521	0.322	5021	0.332		
522	0.357	5022	0.382	T232	0.468
523	0.617	5023	0.767		
524	0.917	5024	1.277		
525	1.302	5025	1.327		
526	1.337	5026	1.347		
527	1.372	5027	1.397	T233	1.437
528	1.567	5028	1.737		
529	1.872	5029	2.007		
530	2.032	5030	2.057		
531	2.067	5031	2.077		
532	2.102	5032	2.127		
533	2.187	5033	2.247	T234	2.219
534	2.427	5034	2.607		
535	2.857	5035	3.107	T235	3.009
536	3.132	5036	3.157		
537	3.167	5037	3.177		
538	3.202	5038	3.227	T236	3.319
539	3.577	5039	3.927		
543	4.152	5043	4.192		
544	4.217	5044	4.242		
545	4.252	5045	4.262		
546	4.287	5046	4.312	T237	4.314
550	4.377	5050	4.442		
551	4.507	5051	4.572		
552	4.637	5052	4.702		
553	4.767	5053	4.832		
554	4.897	5054	4.962		
560	4.962	5060	5.622	T208 *	5.472
561	6.282	5061	6.942	T202 *	6.672
562	7.417	5062	7.892	T256 *	8.272
563	8.772	5063	8.772	T258 *	8.772
570	8.897	5070	9.022		
571	9.147	5071	9.272		
580	9.297	5080	9.322		
581	9.332	5081	9.342		
582	9.367	5082	9.392	T246	9.411
583	9.642	5083	9.892		
584	9.917	5084	9.942		
585	9.952	5085	9.962		
586	9.987	5086	10.012		
590	10.342	5090	10.412	T247	10.322
591	11.1	5091	11.292		

*) Sensor located on OBP near ventline

Table 3.2-1: TMM Node and Test Sensor Distribution on Ventline

4 Measured Performance versus TMM Calculation

4.1 Ventline Performance for TB1 and TB2 Test Phases

Since no equilibrium conditions have been achieved during the different test phases, a correlation using a steady state approach was not found. Hence transient analysis has been performed with the TMM Iss.4 Rev.4 to compare the predicted and measured L1 and L3 temperature interfaces behaviour. In the following figures, the measurements are indicated by dashed lines while the TMM results for the corresponding sensor are given as solid lines.

4.1.1 Phase TP4

The initial conditions for this transient run have been defined by a steady-state run (no heating, 10 mg/s) and an initial transient phase (no heating, ~2.2 mg/s). The overall cryostat behaviour is then represented well by the TMM for the heating phases as shown in the following figures. During the heating phase, the mass flow rate in the TMM was adjusted with a steady slope between 2.21 and 2.44 mg/s according to the TB/TV as-run procedure.

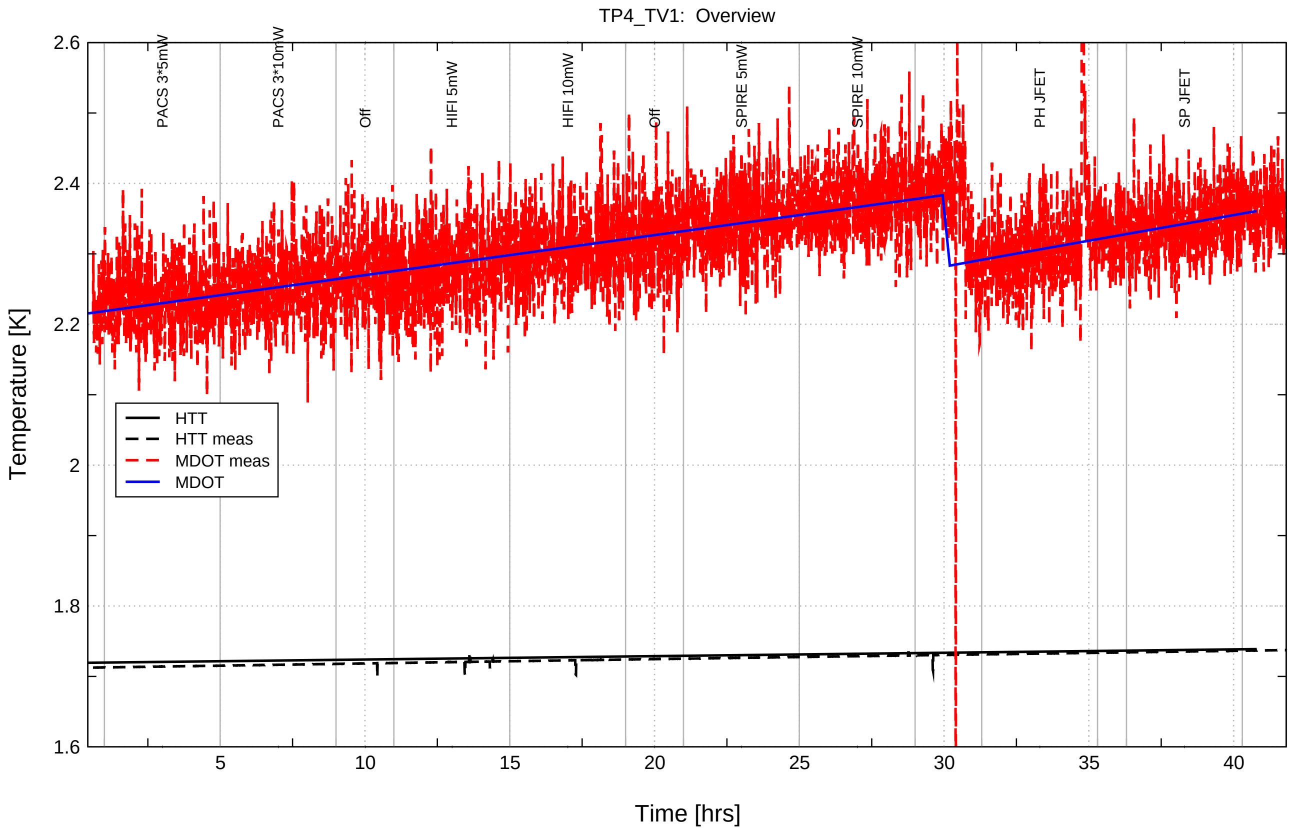

Figure 4.1-1: HTT temperature and mass flow rate [mg/s]: TMM versus Test, TP4

Measurements are indicated by dashed lines, TMM results by solid lines.

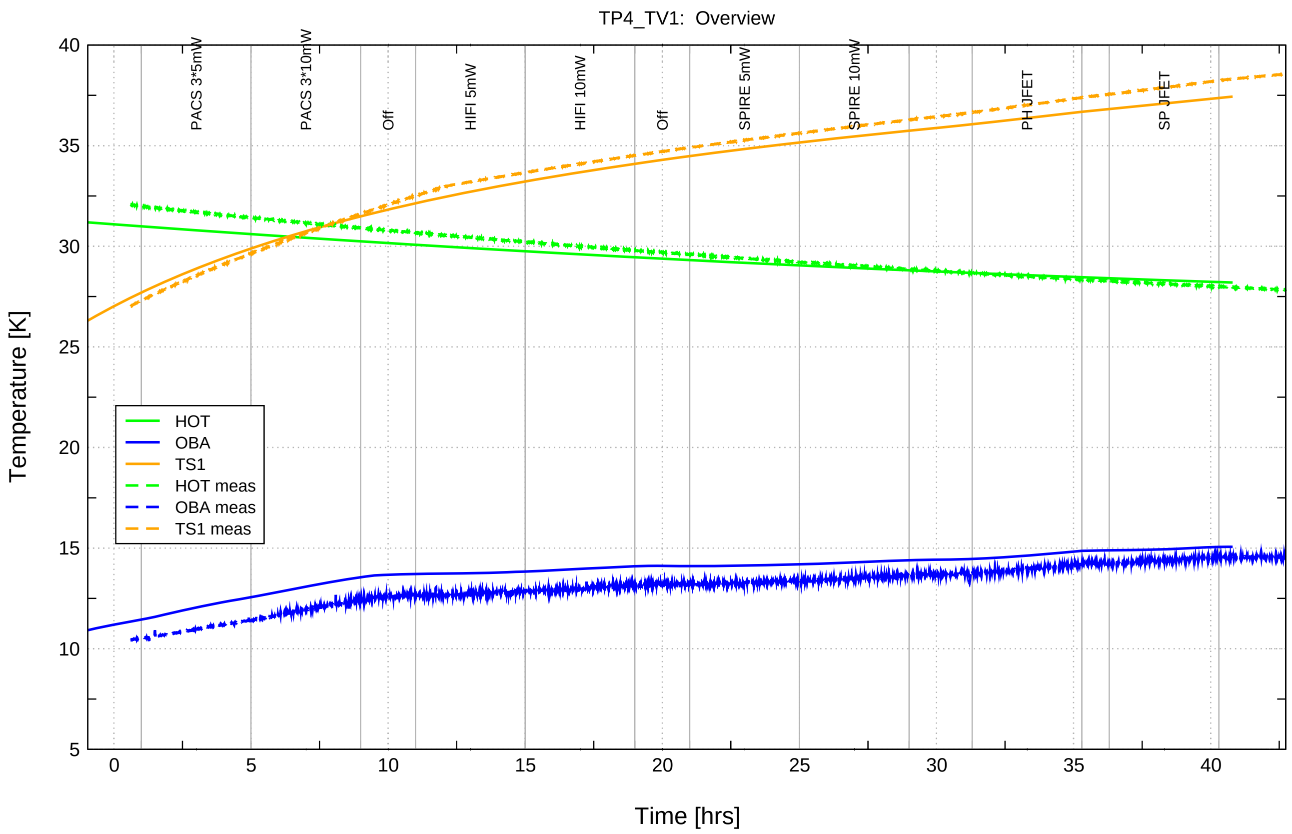

Figure 4.1-2: HOT, OBA and TS1 temperatures: TMM versus Test, TP4

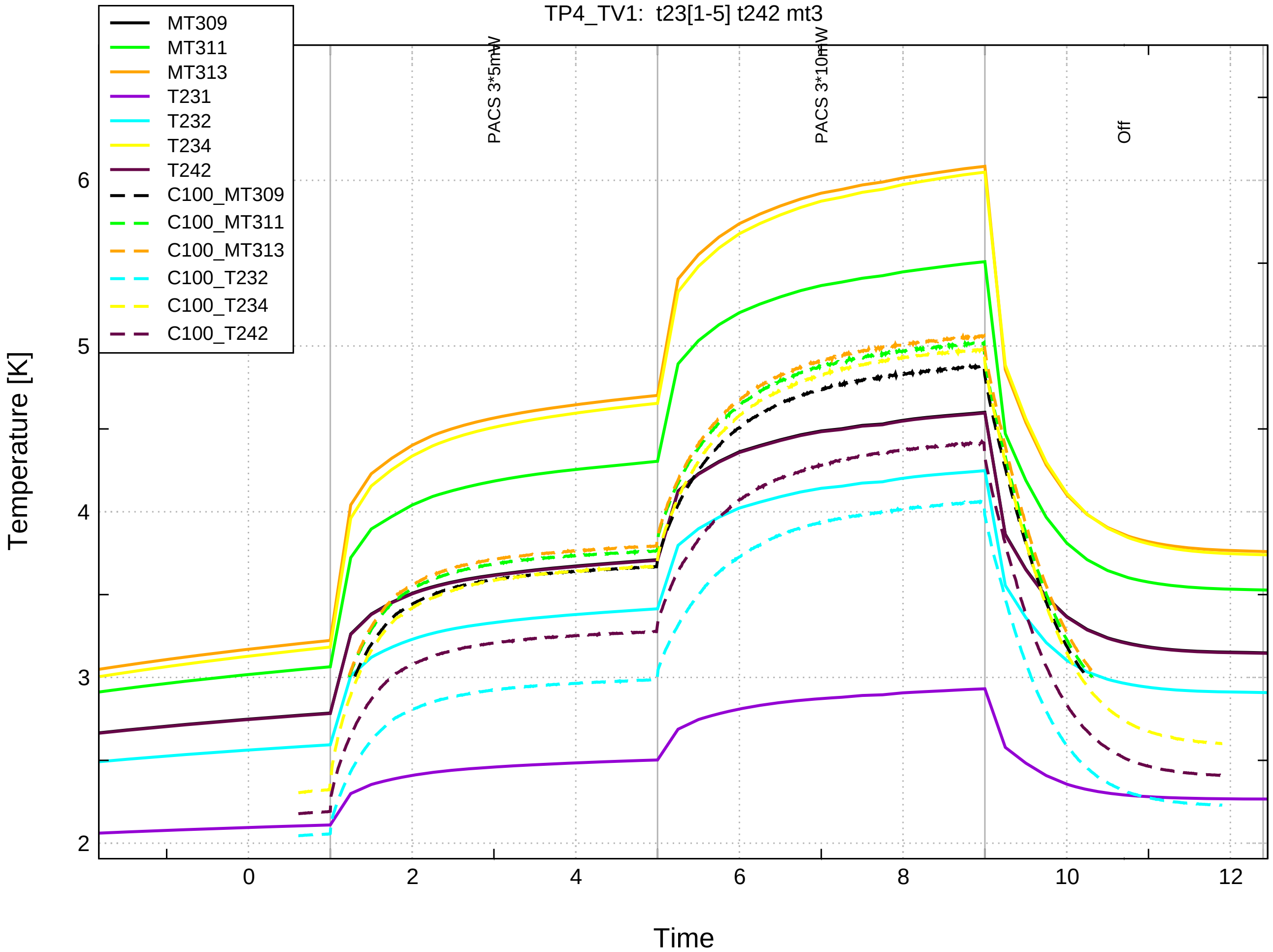

Figure 4.1-3: PACS temperatures: TMM versus Test, TP4

MT309 TH-PACS-9, on L1-interface of Photometer optics

MT311 TH-PACS-11, on L1-interface of collimator

MT313 TH-PACS-13, on L1-interface of Spectrometer housing

T231 L1 Ventline upstream strap 1 to PACS Photometer Optics (L1 Inlet) (measurement invalid for TP4)

T232 L1 Ventline downstream strap 1 to PACS Photometer Optics

T234 L1 Ventline downstream strap 3 to PACS Spectrometer Housing

T242 L1; on Strap 1 on PACS FPU Side

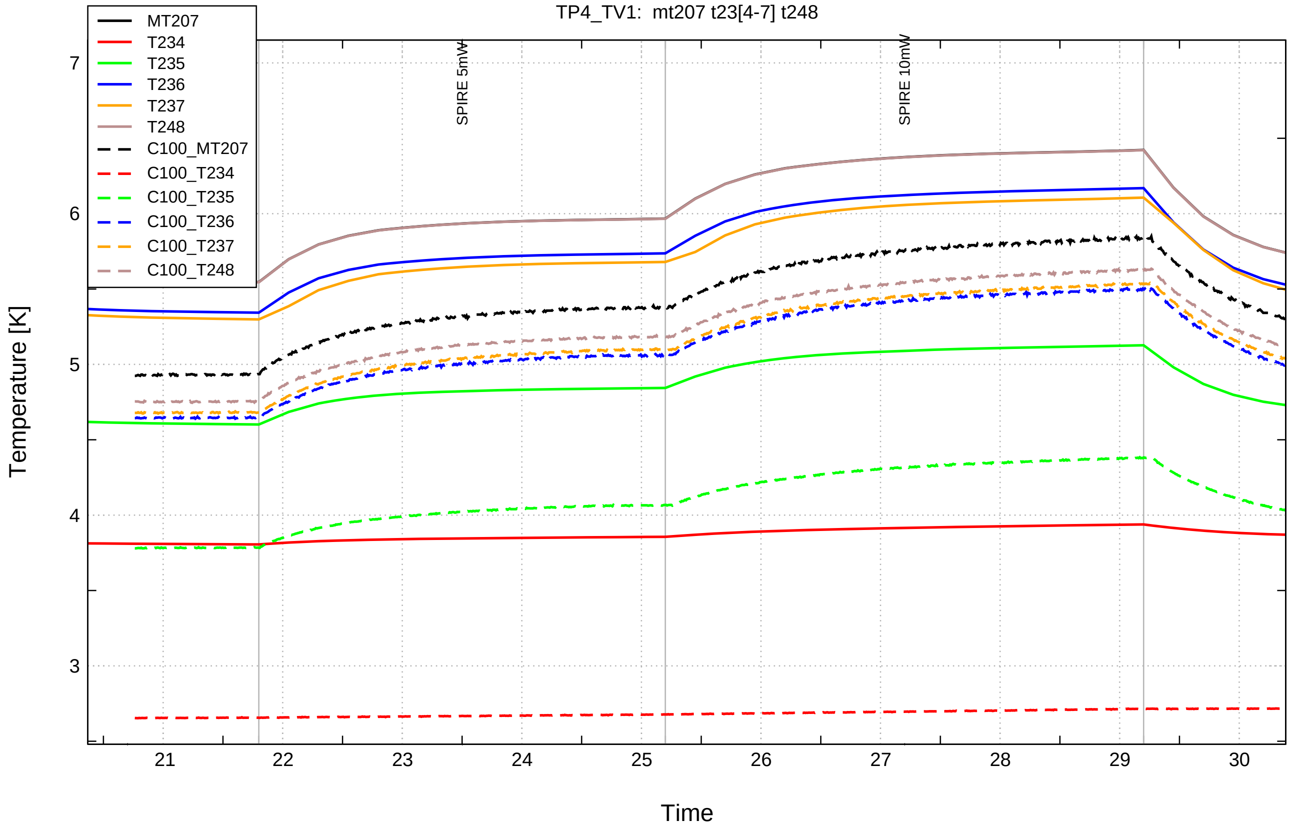

Figure 4.1-4: SPIRE temperatures: TMM versus Test, TP4

MT207 TH-SPIRE-7, on SPIRE optical bench

T234 L1 Ventline downstream strap 3 to PACS Spectrometer Housing

T235 L1 Ventline upstream strap 4 to SPIRE Optical Bench

T236 L1 Ventline downstream strap 4 to SPIRE Optical Bench

T237 L1 Ventline downstream strap 5 to HIFI interface (L1 outlet)

T248 L1; on Strap 4 on SPIRE FPU side

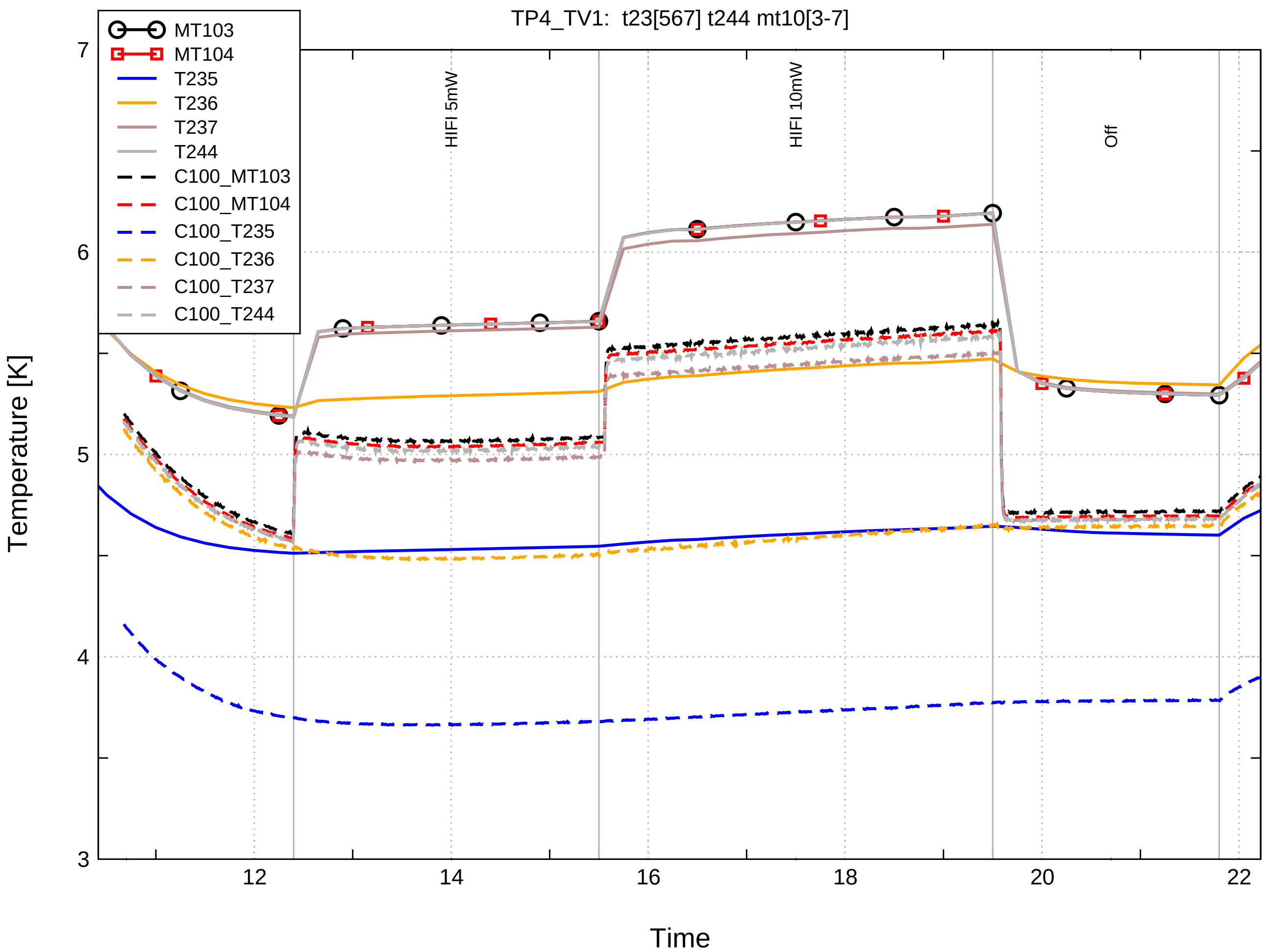

Figure 4.1-5: HIFI temperatures: TMM versus Test, TP4

MT103 TH-HIFI-3, on L1 IF

MT104 TH-HIFI-4, on L1 IF

T235 L1 Ventline upstream strap 4 to SPIRE Optical Bench

T236 L1 Ventline downstream strap 4 to SPIRE Optical Bench

T237 L1 Ventline downstream strap 5 to HIFI interface (L1 outlet)

T244 L1, on Strap 5 on HIFI FPU side

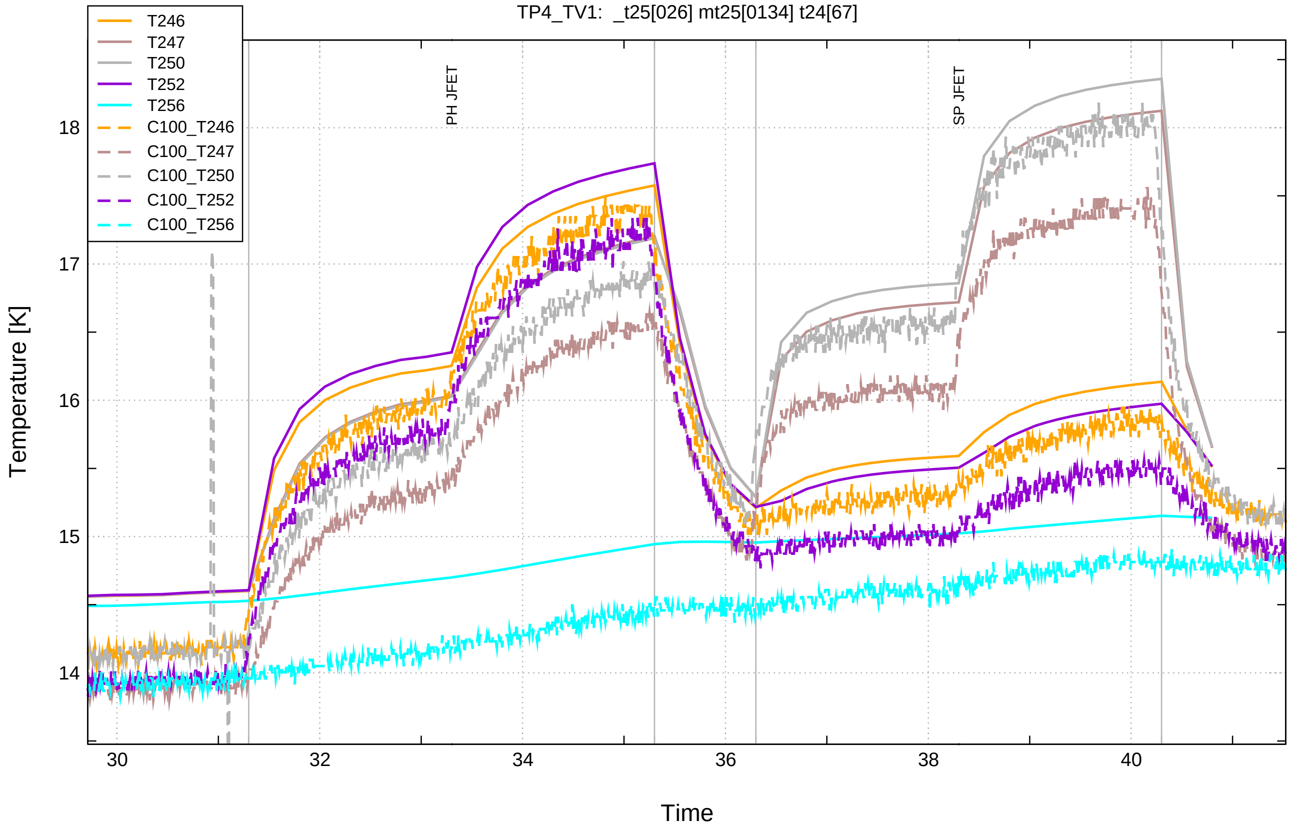

Figure 4.1-6: JFET temperatures: TMM versus Test, TP4

MT250 TH-S-JFET-1, on S-J-FET baseplate (out of range during measurements)

MT251 TH-S-JFET-2, on S-J-FET baseplate (out of range during measurements)

MT253 TH-P-JFET-1, on P-J-FET baseplate (out of range during measurements)

MT254 TH-P-JFET-2, on P-J-FET baseplate (out of range during measurements)

T246 L3 Ventline to 6-JFET (JFET-Phot)

T247 L3 Ventline to 2-JFET (JFET-Spec)

T250 On Spire 2-JFET (JFET-Spec)

T252 On Spire 6-JFET (JFET-Phot)

T256 OB Plate near SPIRE foot (-z+y)

During the MTD thermal interfaces tests in TP4, the mass flow rate through the helium subsystem was close to the in-orbit operation predictions, and also the vent path followed the orbit scenario closely (venting from HTT via the passive phase separator (PPS), but then through the electromagnetic valve V106 only instead of going through V103 and V106 in parallel).

Conclusions from TP4 measurements and analysis:

- In general, the L1 temperature level is predicted slightly higher than measured
- TMM results for the PACS interface temperature and gradients to the vent line are conservative. The MTD internal gradients are predicted higher than actually measured.

- Although the temperature gradient between the SPIRE MTD box and the SPIRE L1 interface is higher than predicted, the SPIRE temperature TMM results are still above the measurements, and also the temperature gradients to the vent line are slightly higher than measured (conservative).
- HIFI temperatures are predicted too high; the measured temperature gradient from the MTD to the upstream vent line node is by 0.27 K higher than predicted in the 10 mW case (0.2 K higher for 5 mW case). Temperature gradients from MTD to the downstream vent line node are well in line with the predictions.
- For L3, the Photometer and Spectrometer JFET prediction correlates very well with the measurement; also the temperature gradients from the Spectrometer JFETs to the L3 vent line correlate well with the measurement. During the PH-JFET operation, the gradient from the Photometer JFET interface (T252) to the downstream vent line node (T246) is reversed in the prediction as compared to the measurement. This could be linked to a calibration offset between the two sensors or to a possible contact between the JFET strap and the OBP at the OBP feed-through. Note that the mass flow rate assumed for the TMM calculations is slightly higher than the measured value for the JFET operation. The overall JFET correlation is thus considered ok.

4.1.2 Phase TP6

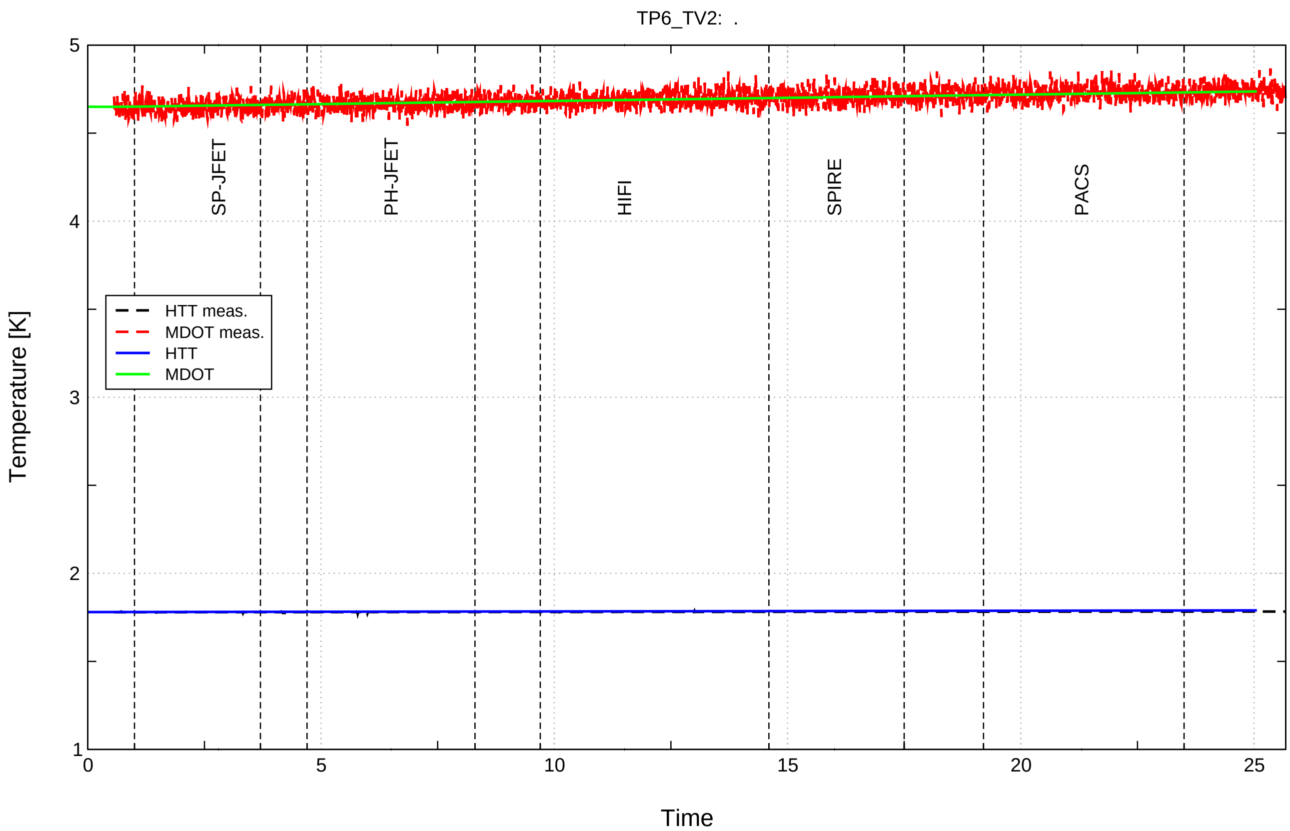

Figure 4.1-7: HTT temperature and mass flow rate [mg/s]: TMM versus Test, TP6

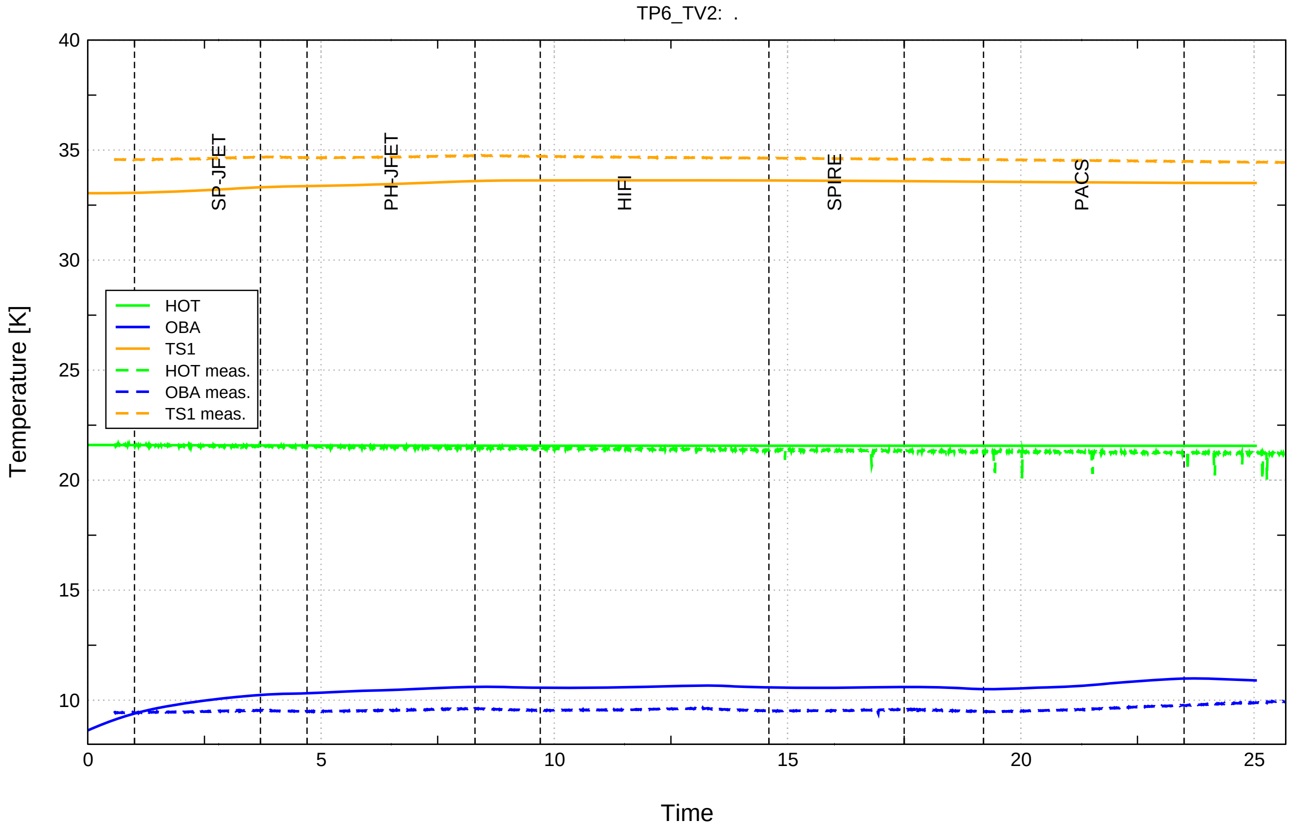

Figure 4.1-8: HOT, OBA and TS1 temperatures: TMM versus Test, TP6

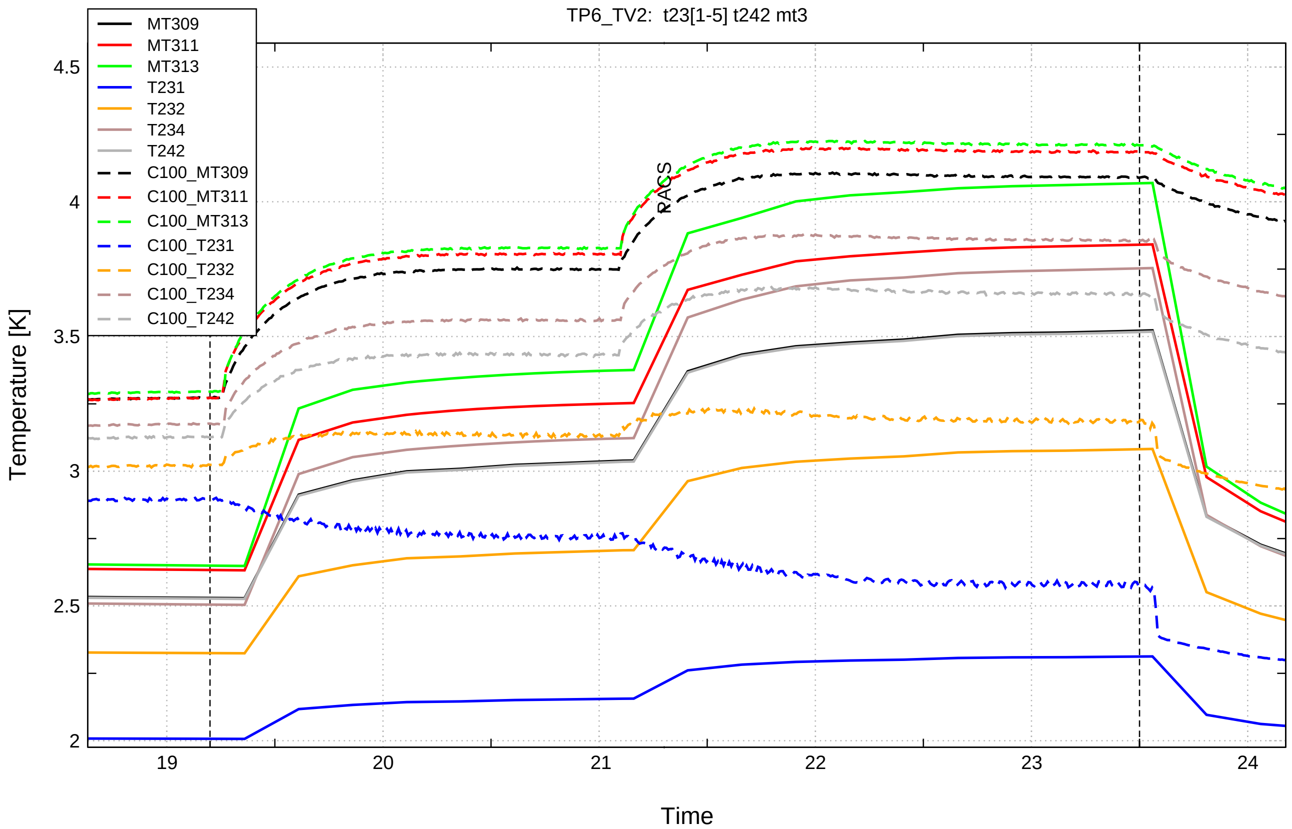

Figure 4.1-9: PACS temperatures: TMM versus Test, TP6

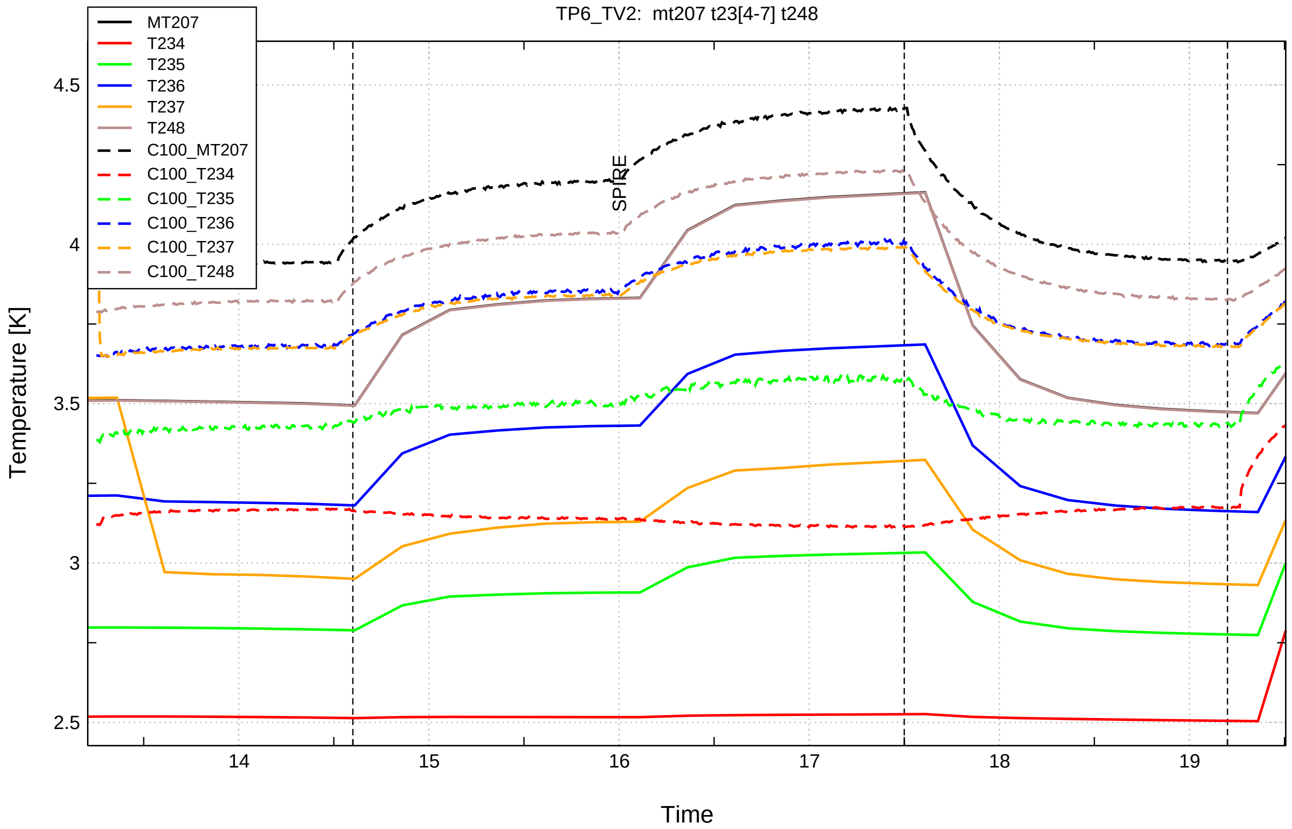

Figure 4.1-10: SPIRE temperatures: TMM versus Test, TP6

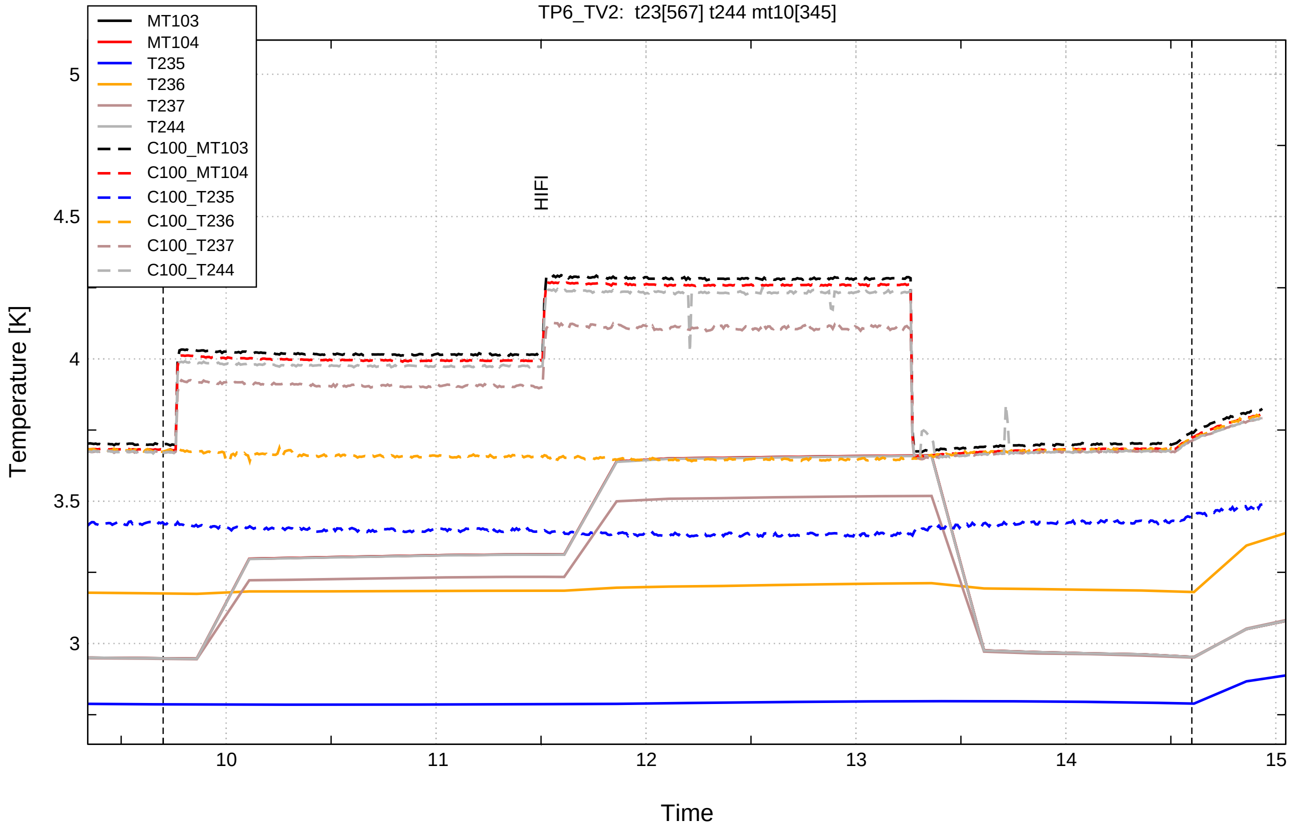

Figure 4.1-11: HIFI temperatures: TMM versus Test, TP6

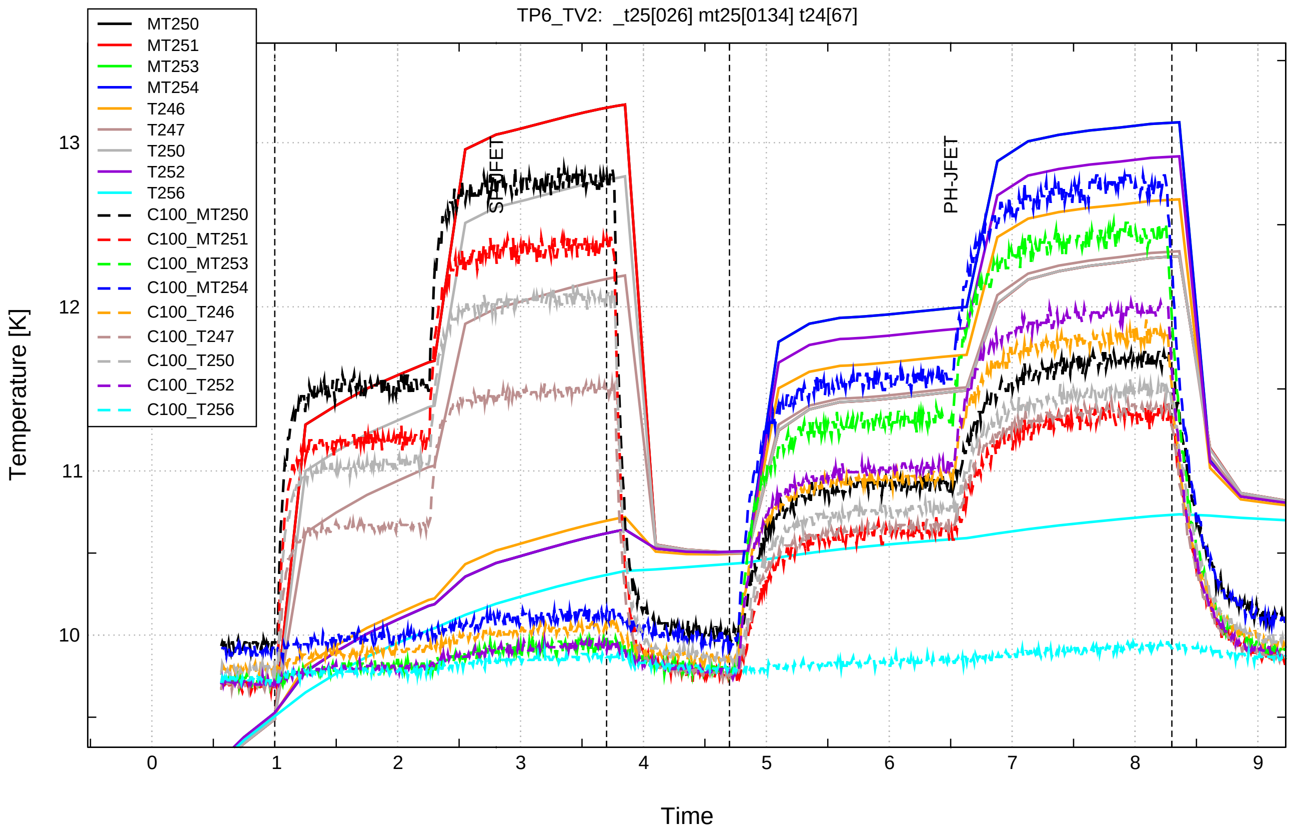

Figure 4.1-12: JFET temperatures: TMM versus Test, TP6

The measurements performed during TP6 are blurred by the unexpected behaviour of the L1 inlet, which initially showed a significantly higher temperature than predicted, and a drop in temperature when the (downstream) L1 straps of PACS were heated. This behaviour is assigned to thermo-acoustic oscillations. These effects can not be reproduced with the TMM. Otherwise, the overall thermal behaviour during the heating phase is represented well in the transient TMM runs.

Conclusions from TP6 measurements and analysis:

- The L1 temperature level is strongly influenced by the oscillations. In general, the predicted temperatures are lower than the measurements, which is in line with the high L1 inlet temperature during the test.
- The temperature gradients within the PACS MTD are again smaller than predicted. At the end of the PACS heating phase (where the impact of the oscillation is least severe), the gradient from the vent line upstream sensor (T231) to the average MTD sensors is well in line with the predictions.
- As for TP4, the temperature gradient between the SPIRE MTD box and the SPIRE L1 interface is higher than predicted. Due to the high L1 inlet temperature, the measured temperatures are above the predictions for TP6, but the gradients from the MTD to the vent line are again smaller than predicted (i.e. the TMM is conservative).
- The HIFI temperature increase measurement is 0.07 K higher than predicted (for 10 mW). Note that also the HIFI MTD box temperature is predicted 1.2 K higher than measured.
- The JFET box (baseplate) temperature predictions have to be compared to average values of MT250/MT251 and MT253/MT254, respectively.
- The measured gradient from the JFET interface to the vent line matches the predicted values well. The reversed gradients (T252/T246) observed during TP4 are not present in TP6

4.2 Transient calculations with increased gas/wall conductance

The transient analysis of the STM1 TV tests has been repeated with an increased gas / wall conductance (factor 3 on HTRANS above previous status as identified for STM2 correlation) in order to check the validity of the results.
As shown in the following figures, the overall impact on the correlation is minor; the HIFI L1 offset is slightly decreased (from 0.27 to 0.2 K).

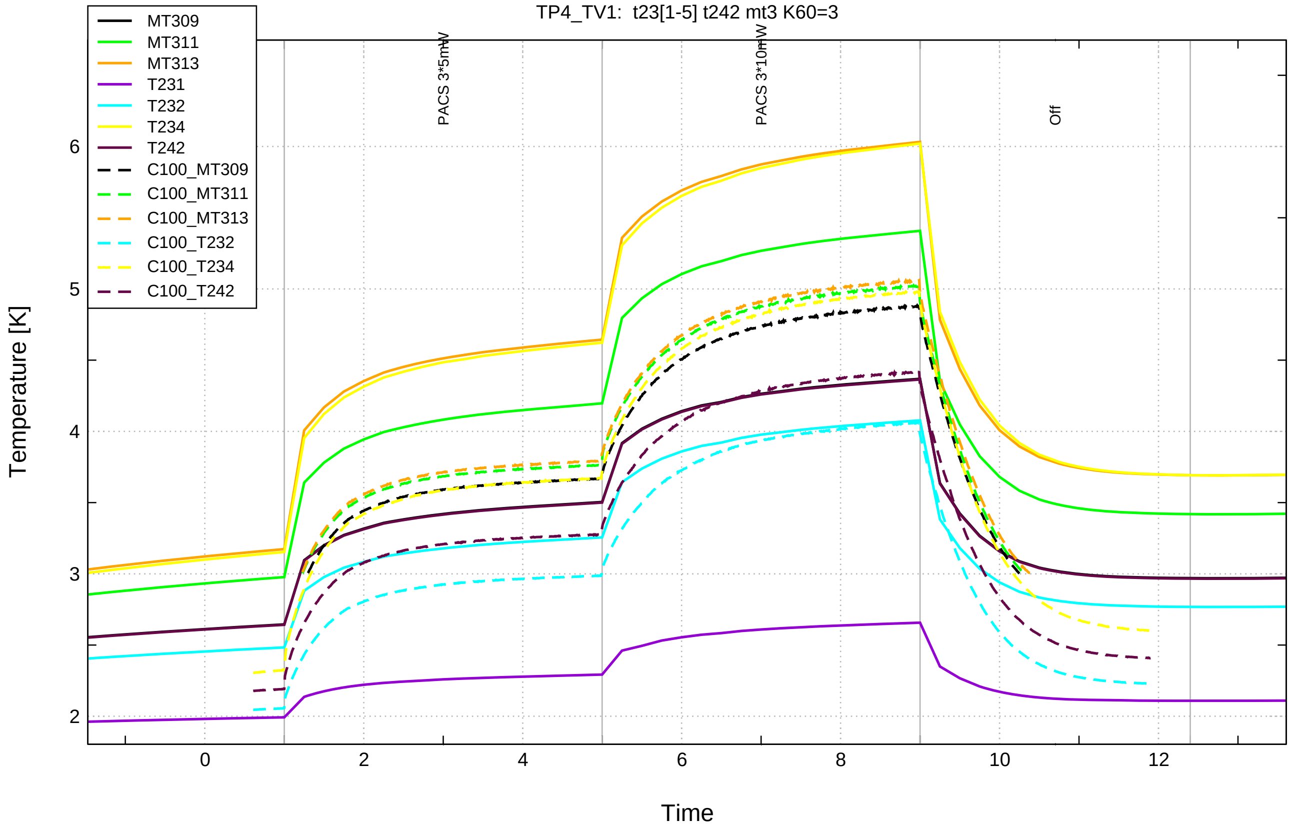

Figure 4.2-1: PACS temperatures: TMM versus Test, TP4, increased gas/wall conductance

MT309 TH-PACS-9, on L1-interface of Photometer optics

MT311 TH-PACS-11, on L1-interface of collimator

MT313 TH-PACS-13, on L1-interface of Spectrometer housing

T231 L1 Ventline upstream strap 1 to PACS Photometer Optics (L1 Inlet) (measurement invalid for TP4)

T232 L1 Ventline downstream strap 1 to PACS Photometer Optics

T234 L1 Ventline downstream strap 3 to PACS Spectrometer Housing

T242 L1; on Strap 1 on PACS FPU Side

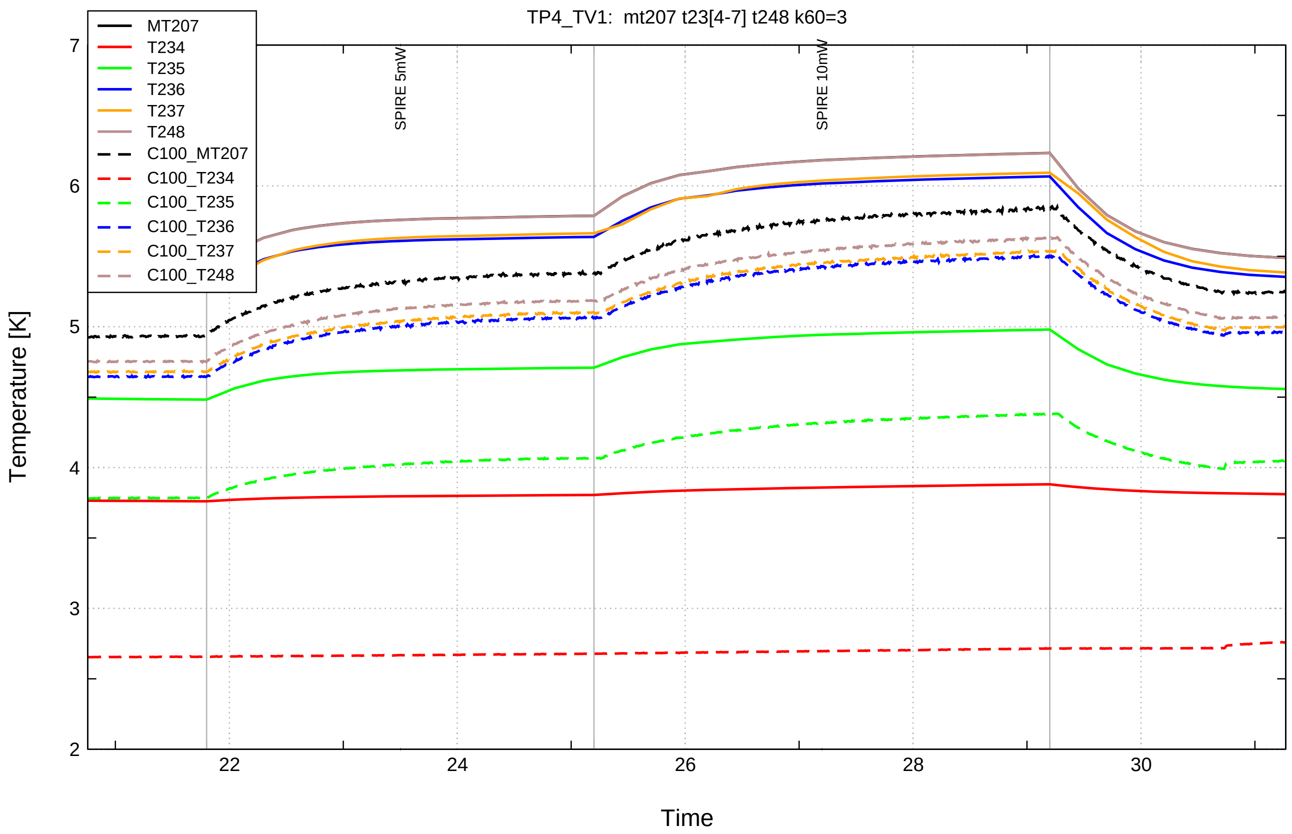

Figure 4.2-2: SPIRE temperatures: TMM versus Test, TP4, increased gas/wall conductance

MT207 TH-SPIRE-7, on SPIRE optical bench

T234 L1 Ventline downstream strap 3 to PACS Spectrometer Housing

T235 L1 Ventline upstream strap 4 to SPIRE Optical Bench

T236 L1 Ventline downstream strap 4 to SPIRE Optical Bench

T237 L1 Ventline downstream strap 5 to HIFI interface (L1 outlet)

T248 L1; on Strap 4 on SPIRE FPU side

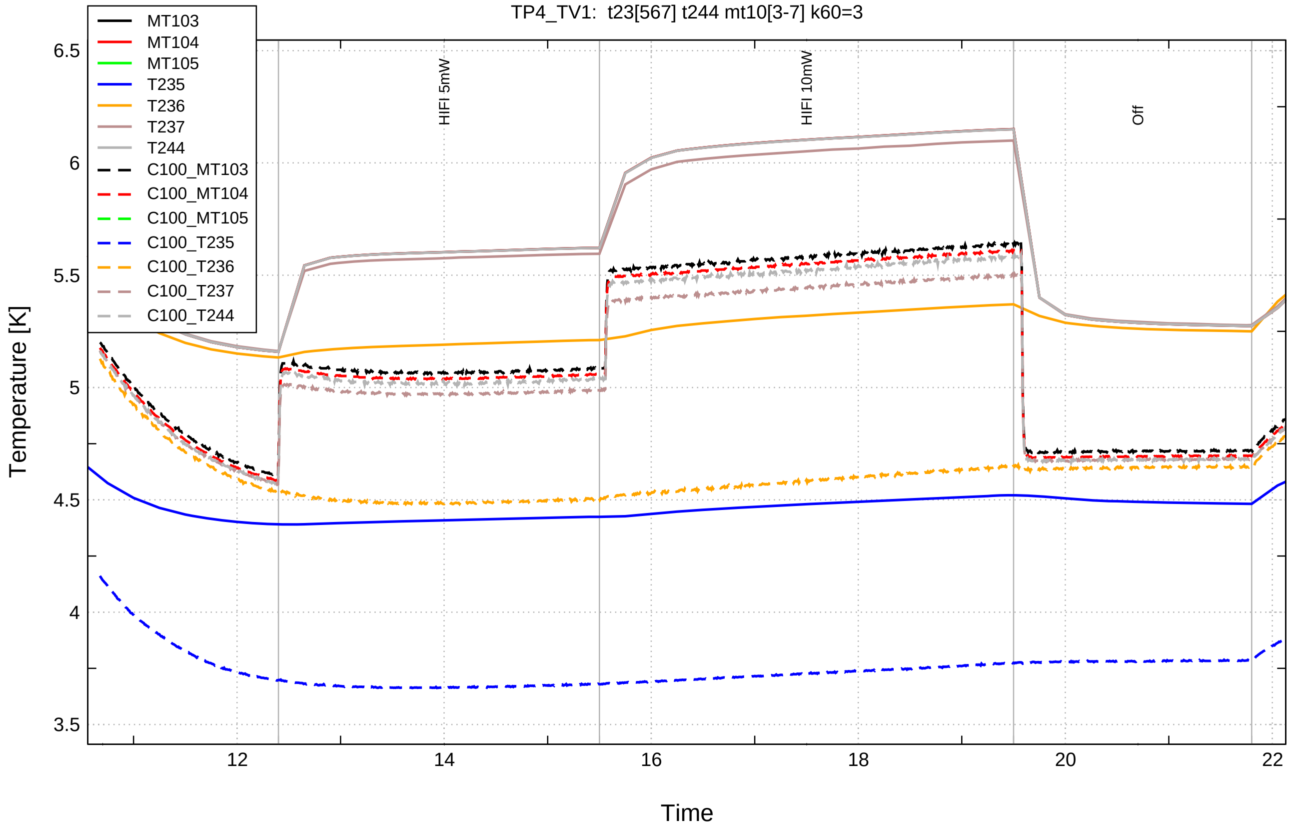

Figure 4.2-3: HIFI temperatures: TMM versus Test, TP4, increased gas/wall conductance

MT103 TH-HIFI-3, on L1 IF

MT104 TH-HIFI-4, on L1 IF

T235 L1 Ventline upstream strap 4 to SPIRE Optical Bench

T236 L1 Ventline downstream strap 4 to SPIRE Optical Bench

T237 L1 Ventline downstream strap 5 to HIFI interface (L1 outlet)

T244 L1, on Strap 5 on HIFI FPU side

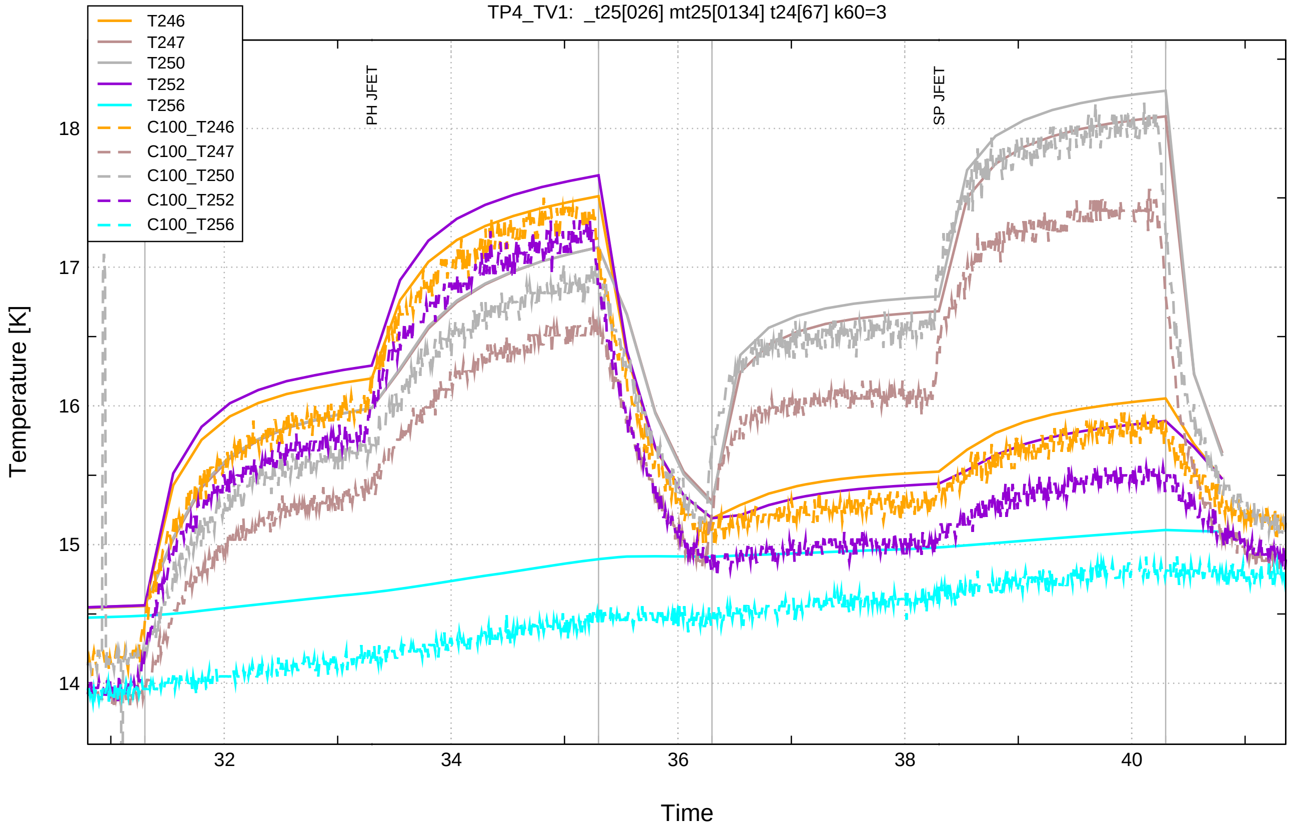

Figure 4.2-4: JFET temperatures: TMM versus Test, TP4, increased gas/wall conductance

MT250 TH-S-JFET-1, on S-J-FET baseplate (out of range during measurements)
MT251 TH-S-JFET-2, on S-J-FET baseplate (out of range during measurements)
MT253 TH-P-JFET-1, on P-J-FET baseplate (out of range during measurements)
MT254 TH-P-JFET-2, on P-J-FET baseplate (out of range during measurements)
T246 L3 Ventline to 6-JFET (JFET-Phot)
T247 L3 Ventline to 2-JFET (JFET-Spec)
T250 On Spire 2-JFET (JFET-Spec)
T252 On Spire 6-JFET (JFET-Phot)
T256 OB Plate near SPIRE foot (-z+y)

4.2.1 Phase TP6

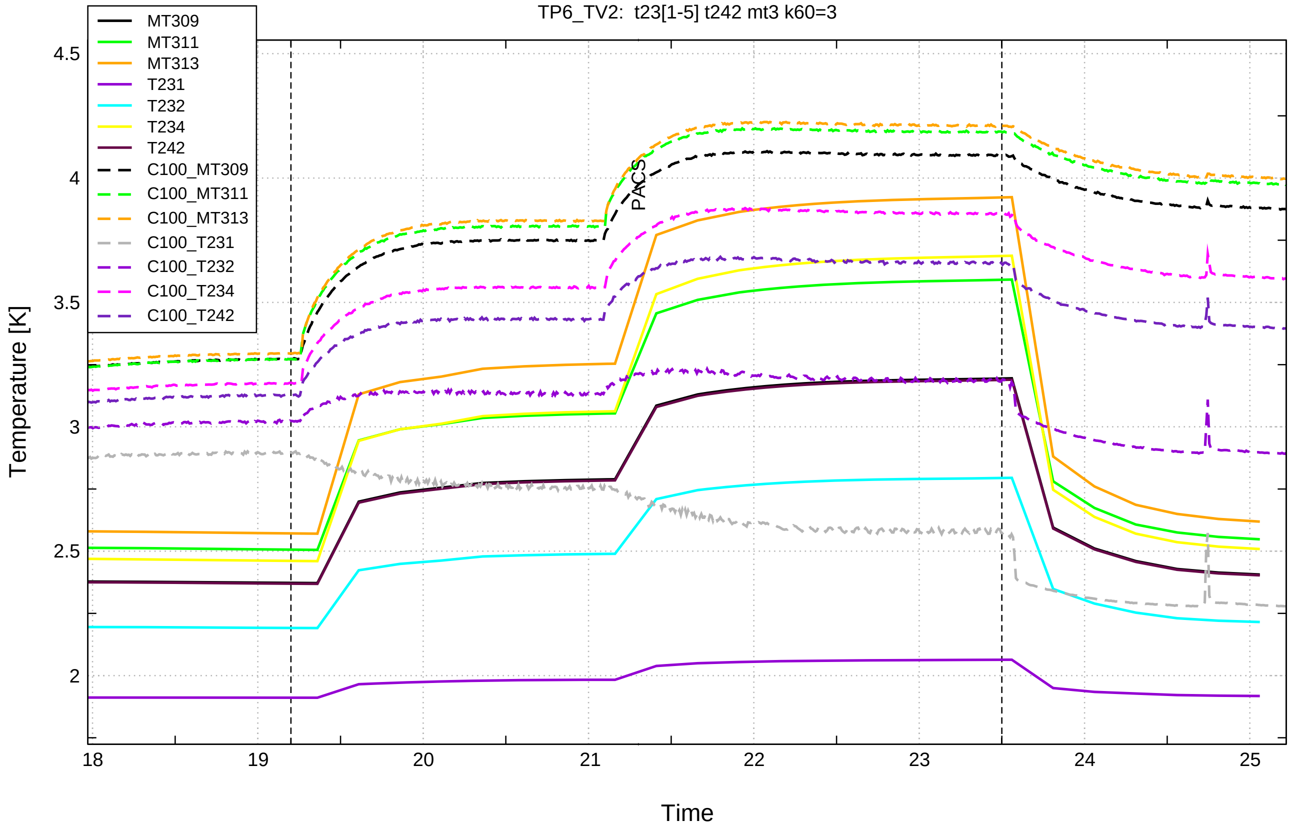

Figure 4.2-5: PACS temperatures: TMM versus Test, TP6, increased gas/wall conductance

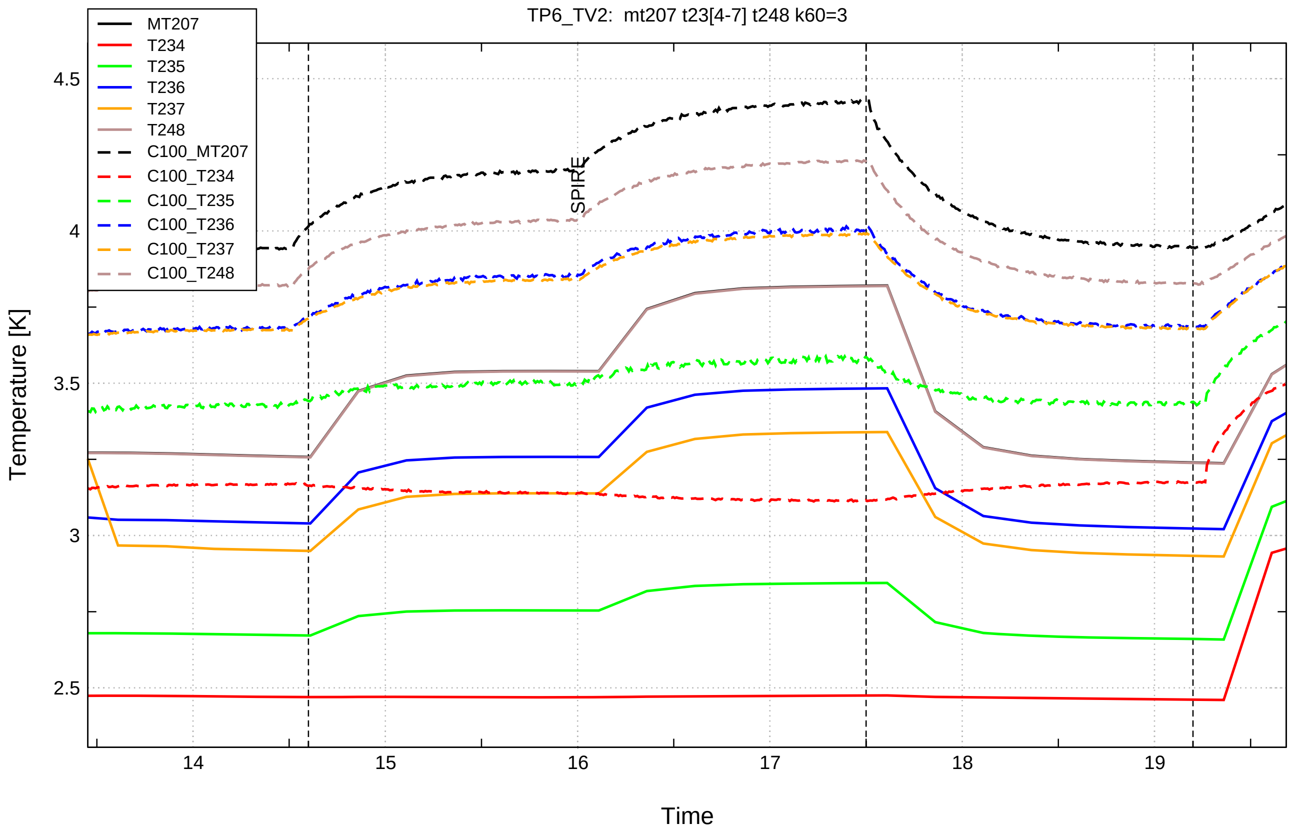

Figure 4.2-6: SPIRE temperatures: TMM versus Test, TP6, increased gas/wall conductance

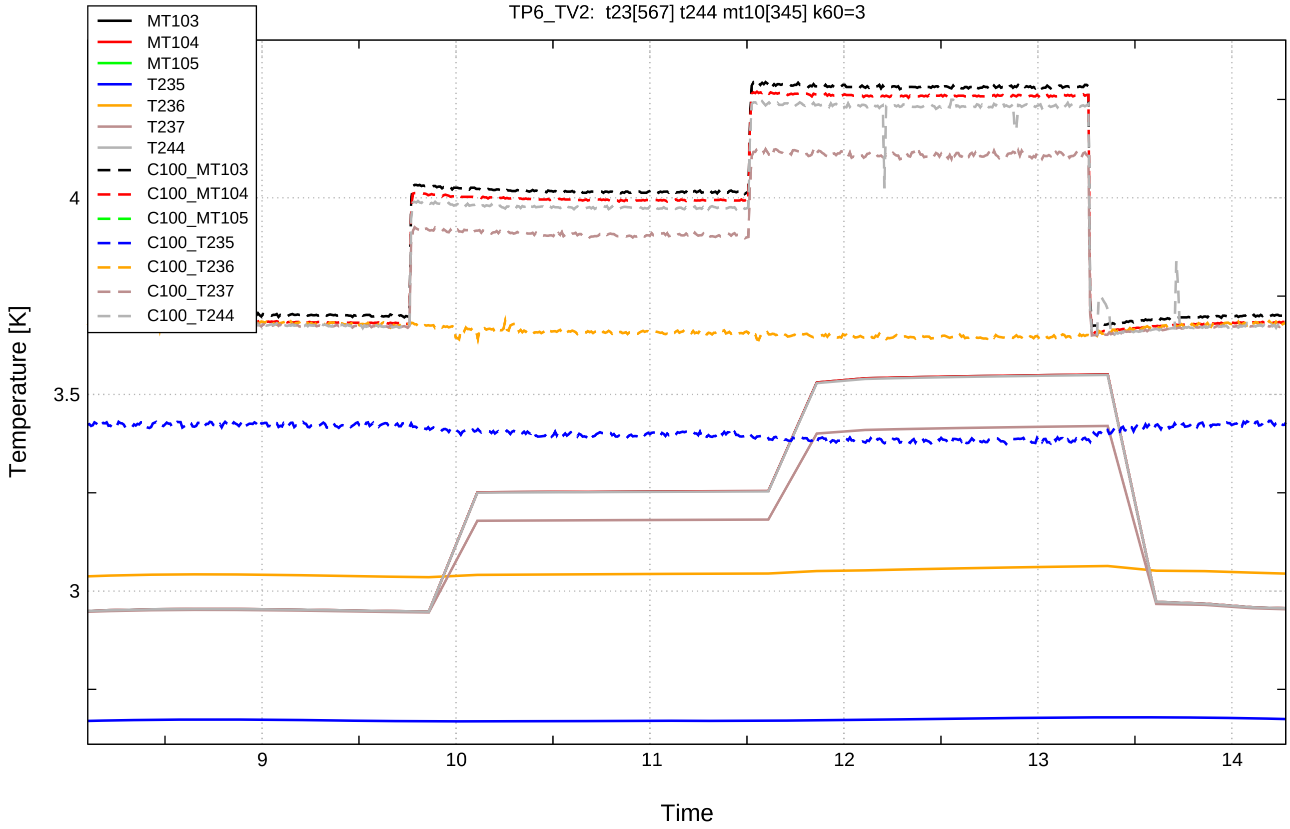

Figure 4.2-7: HIFI temperatures: TMM versus Test, TP6, increased gas/wall conductance

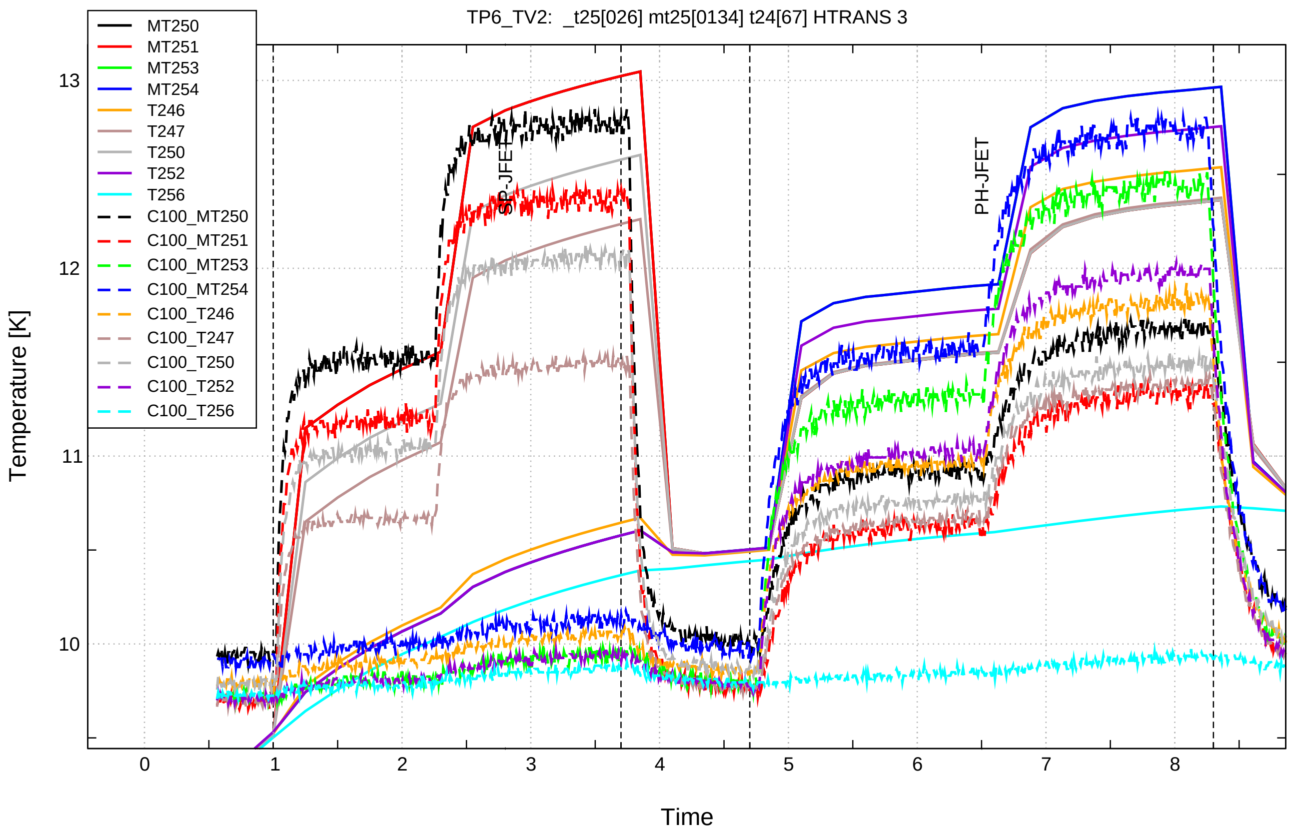

Figure 4.2-8: JFET temperatures: TMM versus Test, TP6, increased gas/wall conductance

5 Summary and Conclusions

TMM correlation of the L1 and L3 conductance calculation has been performed based on the measurement results obtained from the H-EPLM STM TB/TV test in the LSS chamber at ESTEC.

The main differences between measurements and transient TMM Iss.4 Rev.4 results are related to MTD internal issues, especially the small measured temperature gradients within the PACS MTD, the higher gradients from the SPIRE box to the SPIRE L1 thermal interface and higher gradients within the JFET boxes.

The modelling of the flight H/W of the thermal interfaces and of the conduction from the vent line wall into the He gas has been shown to be slightly conservative in most cases. For HIFI, a correlation offset of up to 0.2 K has to be considered for a heat flow of 10 mW across the L1 interface.

A cross-check of the correlation has been performed with increased gas/wall heat conductance as derived during the STM2 correlation campaign and implemented in TMM Iss.4 Rev.4. No further updates to the L1 and L3 interfaces as implemented in TMM Iss.4 Rev.10 have to be implemented.

E N D O F D O C U M E N T

	Name	Dep./Comp.		Name	Dep./Comp.
	Alberti von Mathias Dr.	ASG23		Schuler Günter	ASA42
	Baldock Richard	FAE12		Schweickert Gunn	ASG23
	Barlage Bernhard	AED13	X	Sonn Nico	ASG51
	Bayer Thomas	ASA42		Steininger Eric	AED32
	Brune Holger	ASA45	X	Stritter Rene	AED11
	Edelhoff Dirk	AED2		Suess Rudi	OTN/ASA44
	Fehringer Alexander	ASG13		Theunissen Martijn	DSSA
X	Fricke Wolfgang Dr.	AED 65	X	Wagner Klaus	ASG23
	Geiger Hermann	ASA42		Wietbrock Walter	AET12
	Grasl Andreas	OTN/ASA44		Wöhler Hans	ASG23
	Grasshoff Brigitte	AET12		Wössner Ulrich	ASE252
	Hamer Simon	Terma			
	Hendry David	Terma			
	Hengstler Reinhold	ASA42			
X	Hinger Jürgen	ASG23			
X	Hohn Rüdiger	AED65			
	Hölzle Edgar Dr.	AED32			
	Huber Johann	ASA42			
	Hund Walter	ASE252			
X	Idler Siegmund	AED312			
	Ivády von András	FAE12			
X	Jahn Gerd Dr.	ASG23			
	Kalde Clemens	ASM2			
	Kameter Rudolf	OTN/ASA42			
	Kettner Bernhard	AET42			
	Knoblauch August	AET32		Alcatel Alenia Space Torino	AAS-I
	Koelle Markus	ASA43	X	ESA/ESTEC	ESA
X	Koppe Axel	AED312	X	Thales Alenia Space Cannes	TAS-F
X	Kroeker Jürgen	AED65			
	La Gioia Valentina	Terma		**Instruments:**	
	Lang Jürgen	ASE252	X	MPE (PACS)	MPE
	Langenstein Rolf	AED15	X	RAL (SPIRE)	RAL
X	Langfermann Michael	ASA41	X	SRON (HIFI)	SRON
	Martin Olivier	ASA43			
	Maukisch Jan	ASA43			
	Much Christoph	ASA43		**Subcontractors:**	
	Müller Jörg	ASA42		Alcatel Alenia Space Antwerp	ABSP
	Müller Martin	ASA43		Austrian Aerospace	AAE
	Peltz Heinz-Willi	ASG13		Austrian Aerospace	AAEM
	Pietroboni Karin	AED65		BOC Edwards	BOCE
	Platzer Wilhelm	AED2		Dutch Space Solar Arrays	DSSA
	Reichle Konrad	ASA42		EADS Astrium Sub-Subsyst. & Equipment	ASSE
	Runge Axel	OTN/ASA44		EADS CASA Espacio	CASA
X	Schink Dietmar	AED32		EADS CASA Espacio	ECAS
	Schlosser Christian	OTN/ASA44		European Test Services	ETS
	Schmidt Rudolf	FAE12		Patria New Technologies Oy	PANT
	Schmidt Thomas	AED15		SENER Ingenieria SA	SEN