Title: **HACS Measurements for STM during TB / TV Testing**

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1 Introduction

This report describes the alignment measurements performed with the STM during the TB / TV test campaign. After the environmental testing the alignment will be checked again and the new alignment status will be compared with the pre-test data.

The main tasks for the STM are as follows:

- Verification of CVV shrinkage due to temperature change w.r.t. outer CVV temperature inside the TV chamber using the HACS (Herschel Alignment Camera System). No absolute alignment required.
- Confirmation of the FEM.

The most critical part of the Herschel alignment is the alignment of the LOU w.r.t. the HIFI FPU. The requirements are valid for operational conditions in-orbit, whereas the alignment will be carried out at ambient conditions. In orbit the CVV will cool down and the LOU (mounted at the outside) will move w.r.t. the HIFI FPU (shrinkage of CVV). This effect must be determined and needs to be pre-compensated by a corresponding offset on ground. For the PLM alignment the shrinkage effect has been calculated with the Finite Element Model (FEM) and will be verified during TB / TV testing with the HACS. Therefore, the LOU alignment will be monitored inside the TV chamber at nearly operational conditions. Comparing the result to the reference measurement performed at room temperature at FN the shrinking can be calculated.

No absolute alignment is foreseen with the STM, only the actual positions will be measured and the differences between ambient and cold conditions will be calculated to determine the values needed for the pre-compensation to be applied for the FM.

2 Test Report Summary

2.1 Measurements performed

The following alignment measurements have been performed with the STM for the TB/TV test campaign:

- Reference measurement with HACS at room temperature at FN
- Monitoring of LOU alignment during the TB/TV test using HACS

The raw measurement data are stored in the measurement files stored each day by the HACS S/W. A representative set of data used for data evaluation is attached to this document. This report summarizes the achieved HACS STM results.

2.2 STM Alignment Procedure

The applicable STM PLM Alignment procedure is:
H-EPLM Alignment Procedure for STM, HP-2-ASED-PR-0034, issue 1, dated 7.07.05.
The mounting and operation of the HACS is described in the following document: HIFI Alignment Camera System User manual, HP-2-TER-MA-0001, issue 2, dated 8.06.05

2.3 Test Readiness Review

The TRR has been held on 5.10.05.
TRR for H-EPLM STM TB/TV Test, HP-2-ASED-MN-1074
(Review for the complete TB/TV test).

2.4 Procedure Variation Summary

No.	Page	Variation Description	Action required
		None	

Table 2-1: Procedure Variation Summary

2.5 Non Conformance Report Summary

NCR No.	Non Conformance Title	Date generated	Originator	Remark
HP-142410-ASED-NC-1505	HACS end-to-end test in LSS chamber failed. (An end-to-end test failed since the green reference spot for the +z camera and both red reference spots were not visible)	23.09.05	D. Schink	NRB 30.09.05 Closed
HP-142410-ASED-NC-1583	Measurement Problems detected during HACS operation. (1. Alternate sign in Rx and Rz for –z Camera; 2. Warning message to overwrite image file)	13.10.05	D. Schink	NRB 13.10.05 Presently open, but can be closed, problem solved by Terma

Table 2-2: Non Conformance Report Summary (generated during TB7TV Test Campain)

2.6 Finite Element Model Results for LOU Alignment

The HACS measurement results needs to be compared against the prediction from the FEM. Here only the FEM results for LOU alignment w.r.t. the HIFI FPU are relevant. The FEM considers the following load cases as shown in Table 2-3. For a comparison with the HACS measurements inside the TV chamber only the TB/TV case and the 1bar contribution (due to cryostat evacuation) needs to be considered (the sum is given in the last column of Table 2-3).

For the following load cases the LOU FEM results are listed below. The values are taken from the following document: H-EPLM Thermal Distortion Analysis-CDR Status, HP-2-ASED-TN-0046, Issue 2.

Load Case	X [mm]	Y [mm]	Z [mm]	Rx [arcsec]	Ry [arcsec]	Rz [arcsec]
Ground case PPB-AD +z PPB-AD -z	 2.77 2.77	 -1.55 -1.56	 0.012 0.009	 -1.5 -3.0	 -0.03 -0.05	 -7.7 -7.6
TB/TV case PPB-AD +z PPB-AD -z	 -1.14 -1.14	 2.16 2.18	 -0.56 0.61	 10.1 4.5	 -1.2 0.47	 -59.9 -61.8
In-orbit LC2 PPB-AD +z PPB-AD -z	 -1.16 -1.16	 2.18 2.19	 -0.58 0.61	 9.9 4.8	 -0.73 0.97	 -57.0 -59.0
1g PPB-AD +z PPB-AD -z	 0.10 0.09	 0.003 -0.002	 -0.024 0.033	 -14,3 9.3	 0.32 -0.91	 -32.5 -28.8
1bar PPB-AD +z PPB-AD -z	 -0.10 -0.11	 0.10 0.10	 -0.006 0.003	 -1.5 2.2	 0.98 1.0	 -39.9 -39.6
Σ TV+ 1bar PPB-AD +z PPB-Ad -z	 -1.24 -1.25	 2.26 2.28	 -0.57 0.61	 8.6 6.7	 -0.22 1.47	 -99.8 -101.4

Table 2-3: FEM LOU related values for the different Load Cases

1) For the Ground Case the Cryostat has been cooled down but the CVV is at ambient

In order to compare the FEM results with the HACS measurements the following effects must be considered:

- LOU and HIFI FPU alignment devices behaviour as function of temperature
- Impact of strap tensioning after cool down (controlled with theodolite) see HP-2-ASED-TR-0094
- PPB on +z side is not equipped with a cross hair drawing on the flat surface. A cross hair was additionally drawn by ASED for theodolite measurements. However, placed with an offset of 0.3mm. This offset must be considered for all measurements performed with theodolite (see HP-2-ASED-TR-0094).

2.7 LOU and HIFI FPU alignment devices behaviour as function of temperature

In order to compare the HACS measurement results with the FEM, the stability of the LOU Pentaprism Block (PPB) and the HIFI FPU Alignment Device (AD) needs to be considered. For the used PPBs and Ads these values are not known. These values are taken from the following documents:

- LOU Pentaprism Test Report, SRON-G/HIFI/TR/2004-002, issue 1 (for LOU QM)
- Qualification report FPU AD's, FPSS-00784, Issue 1, dated 6.02.2006 (for AD FM

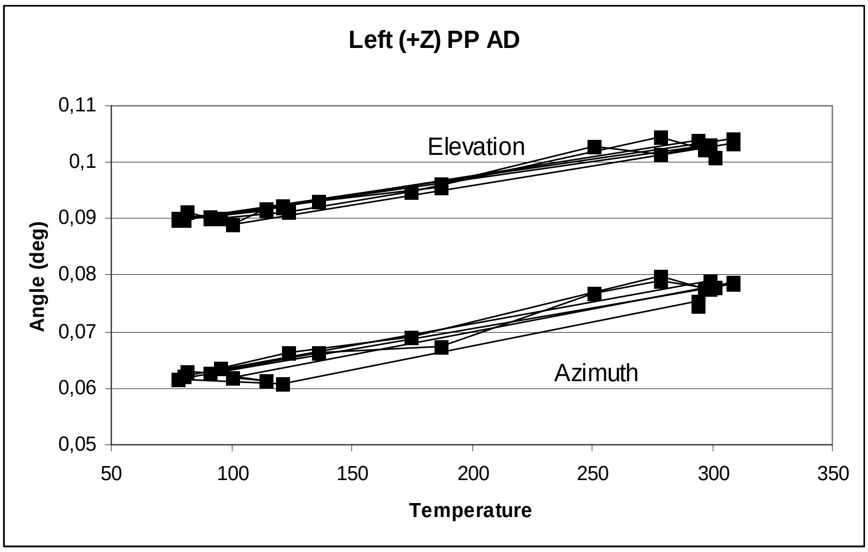

Figure 2-1: Misalignment of +z PPB vs temperature

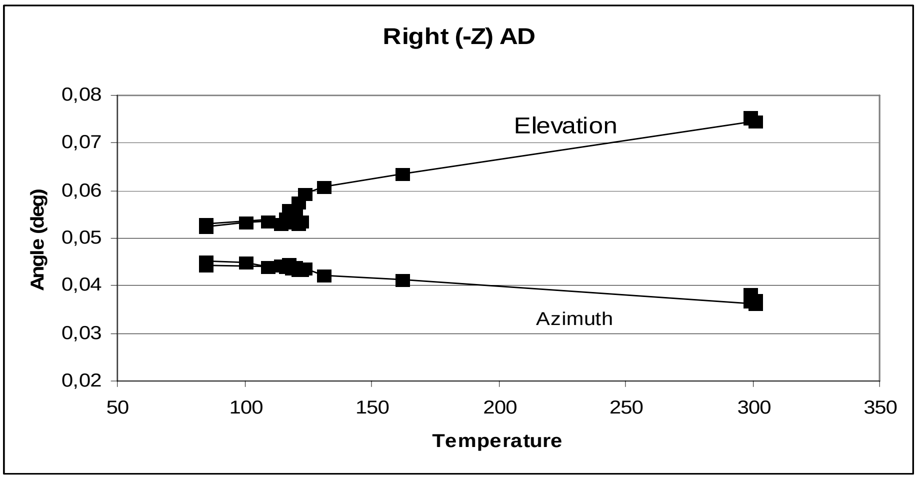

Figure 2-2: Misalignment of -z PPB vs temperature

From both figures the rotation about the x- and y axis can be derived:

	+Z Camera	-Z Camera	Remark
ΔRx	-58 arcsec	+29 arcsec	Temperature change from 300K to 100K
ΔRz	-54 arcsec	-83 arcsec	Temperature change from 300K to 100K

Table 2-4: Stability of PPB Alignment between 300K and 100K

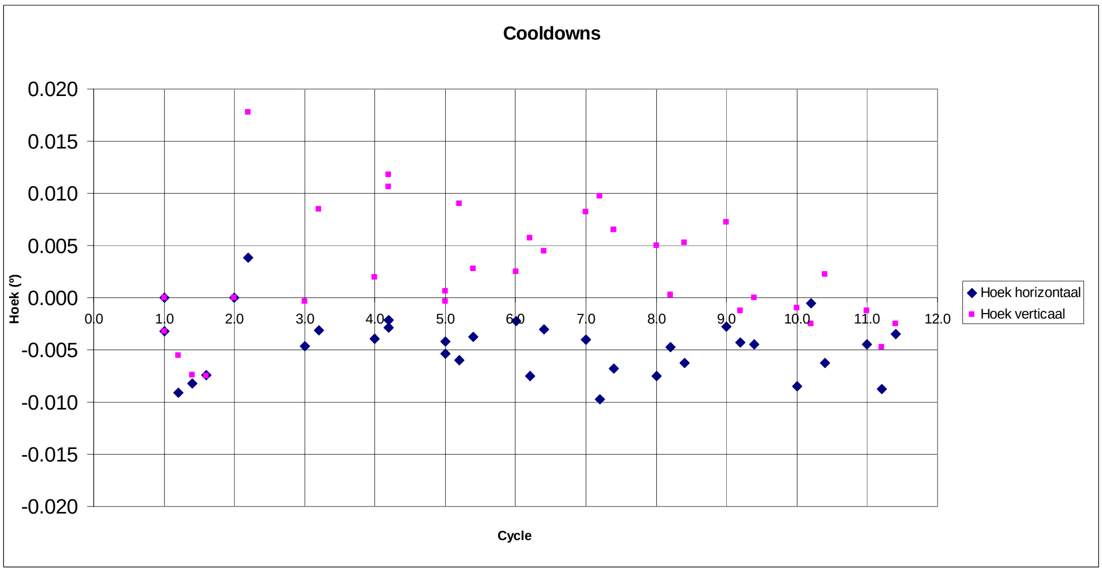

Figure 2-3: Misalignment of -AD vs temperature

1	293 K – 77 K – 4 K – 293 K
2	293 K – 77 K (2e cycle, not stabilized)
3	293 K – 77 K (10e cycle)
4	293 K – 77 K (10e cycle)
5	293 K – 77 K – 293K (15e cycle)
6	293 K – 77 K– 293K (20e cycle)
7	293 K – 77 K– 293K (22e cycle)
8	293 K - 4 K– 293K (23e cycle)
9	293 K - 4 K– 293K (25e cycle)
10	293 K - 4 K– 293K (27e cycle)
11	293 K - 4 K– 293K (30e cycle)

The stability for the AD can be derived from the last figure:

	+Z Camera	-Z Camera	Remark
ΔRx	20 arcsec	20 arcsec	Temperature change from 293K to 4K
ΔRz	-20 arcsec	-20 arcsec	Temperature change from 293K to 4K

Table 2-5: Stability of FPU AD Alignment between 293K and 4K

2.8 HACS Measurement Results

The first measurement with the HACS has been performed at FN. This is the reference measurement under warm conditions (see Table 2-7). The values shown are the differences between the LOU PPB and the HIFI FPU AD. Please refer also to the Test Report HP-2-ASED-TR-0094 where the results are discussed and compared to theodolite measurements.

After this measurement under warm conditions, the cryostat has been cooled down to LHe temperature. After cool down the strap pretension has been controlled and corrected. This was done under theodolite control. The values were already reported in HP-2-ASED-TR-0094. The impact of strap tensioning needs to be considered because it can change the position of the OB. The impact is shown in the following table:

	+z	-z	Remark
Δx[mm]	-0.3 1)	-0.25	new-old
Δy[mm]	n.A.	n.A.	
Δz[mm]	-0,28	0.2	
ΔRx[arcsec]	-10.8	-28.8	
ΔRy[arcsec]	-25.8	-25.8	Calculated from Δx
ΔRz[arcsec]	53.3	35.3	

Table 2-6: Impact of Strap Tensioning after Cool Down

1) The PPB on +z side was not delivered with cross hair. This was additionally drawn by ASED for theodolite measurements. The offset of 0.3mm is included in this value.

The minor angular differences in the above table might be partially due to the mounting principle of the AD to the HIFI MTD. Here the AD is bolted across a rectangular joint of two MTD-structure plates. During internal cool down this might lead to a certain distortion of the AD mounting bracket thus causing tilts.

In order to determine the shrinkage of the CVV under nearly in-orbit conditions (CVV cold) HACS measurements have been performed during the TB/TV test campaign. Here the HACS has been operated continuously. After closing the TV chamber cover the HACS Laser attenuation has been optimised according to the operation manual. The following values have been used for the measurements for optimum illumination levels.

	+z Camera	-z camera
Green Laser	2100	2050
Red Laser	2200	2280

Table 2-7: Laser Attenuation

The mounted HACS Cameras are shown in the Figure 2-4 (harness and glass fibre cables not connected).

On Alcatel / ESA request the HACS measurement range in x direction has been improved. This has been achieved by shifting the LOU Support Plate by appr. 0.8mm in –x direction as proposed by ASED in HP-ASED-FX-0320-05 and agreed by alcatel in H-P-ASP-LT-6665. In order to reduce the “Blind Range” it was agreed to shift the LOU by 0.8mm in –x direction with the

Advantage: Blind range is reduced to 0.67mm (instead 0f 1.47mm)
Drawback: HACS measurement range is reduced to 1.7mm in +x direction (instead of 2.5mm)

The LOU shrinkage is 1.2mm bigger (in –x direction) than for the HIFI FPU (see FEM analysis, HP-2-ASED-TN-0046, issue 2). To compensate this effect the LOU should have an offset of 1.2mm in x direction at warm conditions. Taking into account the a.m. LOU shift of 0.8mm in –x direction the LOU offset is reduced from 1.2mm to 0.4mm. As agreed the offset correction was only applied for the –z camera. This explains the difference in x direction from table 2-10.

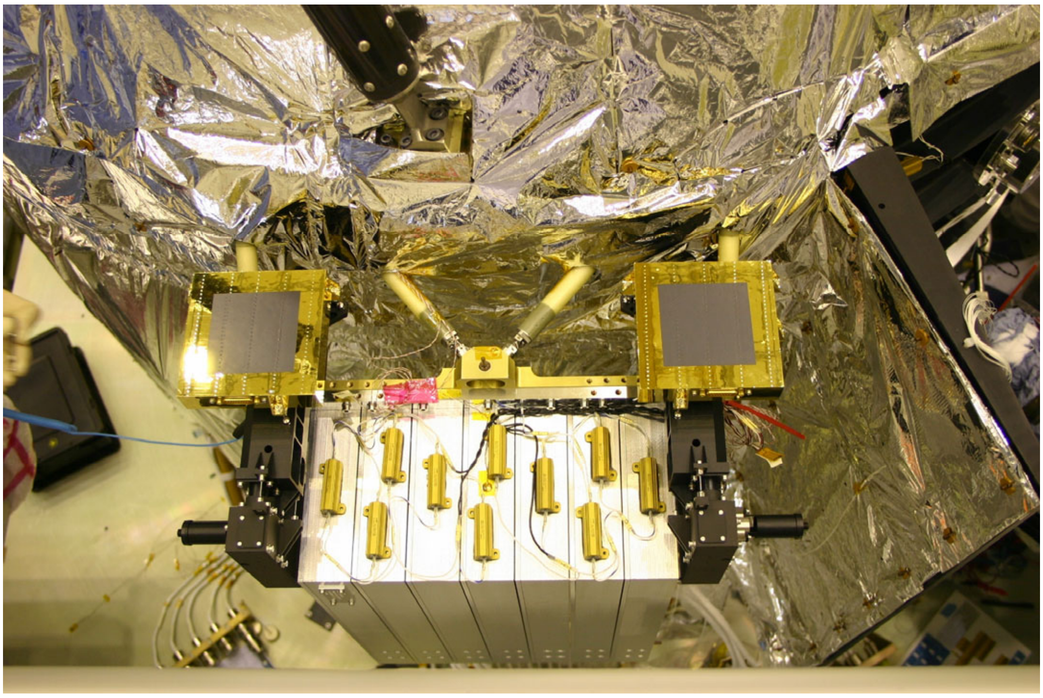

Figure 2-4: HACS Integration on LOU Support Bracket

The HACS has been operated during cool down of the TV chamber and during the warm-up period. The measurements have been repeated every 10min. and are stored by the HACS S/W in a measurement file for each day. A representative subset of data have been extracted from the measurement files which have been used for data evaluation (see annex). After the TB/TV campaign a standard theodolite measurement has been performed.

For data evaluation the measurements from the HACS measurement data file, stored at the HACS PC, need to be related to the CVV temperature file stored at the same time (see Annex).

The following table summarizes the HACS measurement results between LOU PPB and HIFI FPU AD at the beginning and end of the cool down phase. The measurements before Cryostat cool down have been performed at FN on 14./15.07.05. The HACS measurements after CVV cool down have been performed inside the TV chamber at the end of the CVV cool down phase. Inside the TV chamber the HACS has been operated continuously. To compare the measurements with the FEM only the 1st measurement performed at warm conditions and the last measurement taken inside the TV chamber needs to be compared.

	+z Camera	-z Camera	Remark
x[mm]	-1.0 -0.63	-0.41 0.06	1) 2)
y[mm]	1.72 2.00	2.39 2.40	1) 2)
z[mm]	0.02 -0.16	-0.8 -0.42	1) 2)
Rx[arcsec]	-435 -566	478 418	1) 2)
Ry[arcsec]	-305 -353	-305 -353	1) 2)
Rz[arcsec]	-117 -38	-59 -103	1) 2)

Table 2-8: HACS Measurement Results at Room Temperature inside TV Chamber

1) Measured at FN with HACS at warm conditions
2) Measured inside TV chamber at the end of cool down phase, CVV temperature at 99.3K (mean of temperature sensors 2320 and 1002).

2.9 Comparison of HACS Measurements and FEM Prediction

In order to compare the results with the FEM the stability of the PPB mounted at the LOU and the AD mounted at the HIFI FPU needs to be considered (see chapter 2-7). The values have been taken from Table 2-4 and Table 2-5 and are included in the Table 2-8 as well as the impact of strap re-tensioning from Table 2-6.

	+z Camera	-z Camera	Remark
Δx[mm]			
Measured	-0.37	-0.35	1)
FEM	-1.24	-1.25	
PPB+AD effect	n.A.	n.A.	
Strap tensioning	-0.3	-0.25	
HACS corrected	-0.67	-0.6	
Difference	-0.57	-0.65	3) FEM-HACS corrected
Δy[mm]			
Measured	-0.28	-0.01	1) 2)
FEM	2.26	2.28	
PPB+AD effect	n.A.	n.A.	
Strap tensioning			not measured
HACS corrected	n.A.	n.A.	
Difference	2.54	2.29	3)
Δz[mm]			
Measured	0.18	0.38	1)
FEM	-0.57	0.61	
PPB+AD effect	n.A.	n.A.	
Strap tensioning	-0.28	0.2	
HACS corrected	-0.1	0.58	
Difference	-0.47	0.03	3)
ΔRx[arcsec]			
Measued	131	60	1)
FEM	8.6	6.7	
PPB+AD effect	-78	-9	
Strap tensioning	-10.8	-28.8	
HACS corrected	44.7	22.2	
Difference	-36.1	-15.5	3)
ΔRy[arcsec]			
Measured	48	48	1)
FEM	-0.22	1.47	
PPB+AD effect	n.A.	n.A.	
Strap tensioning	-25.8	-25.8	calculated from x value
HACS corrected	22.2	22.2	
Difference	-22.0	-20.7	3)
ΔRz[arcsec]			
Measured	79	44	1)
FEM	-99.8	-101.4	
PPB+AD effect	-34	-63	
Strap tensioning	-53.3	-35.3	
HACS corrected	-8.3	-54.3	
Difference	-91.5	-47.1	3) 4)

Table 2-9: Change between LOU and FPU during cool down inside TV chamber (PPB and AD stability considered)

1) Difference between warm and cold value as measured

2) The measurement accuracy in y direction is appr. ≤±2mm. Compared to the requirement in y direction of ±15mm this is acceptable.

3) This is the difference as absolute value between the FEM and the corrected HACS measuremnments

4)After STM vibration testing it has been observed that some of the LOU Support Plate screws were missing in the region of the lower strut pair (NC 1984). The missing screws led to a visible gap (appr. 0.1mm) between LOU base plate and the support plate at the lower strut pair. By mechanical loads on the LOU during the integration of the alignment cameras the gap could have been changed leading to the observed rotation of the LOU around z (0.1mm gap, distance between lower and upper strut pair of 339mm would lead to 61arcsec).

Measurement accuracy:

1. HACS
   x, z: ±0.1mm
   y: ≤±2mm
   Rotation: ±10arcsec

2. Theodolite ±20arcsec (for a single measurement)
3. Translation: ±0.4mm performed using theodolite and concentric rings on AD and CVV alignment window (for a single measurement)

The sign error in the Rx and Rz measurements has been discussed with Terma. The reason for this is the missing cross hair drawing on +z PPB. The crosshair drawing attenuates the red reference spot so much, that it goes from being the brightest spot to being the weakest spot (see Annex to HP-142410-ASED-NC-1521). If a pentaprism is used without crosshair the software will switch reference and measurement spot and thus produce rotation X, Z results with a sign error. This sign error will not occur for the FM. The sign error is corrected in Table 2-8 and 2-9.

3 Conclusion

The HACS has been operated continuously during the TB/TV test campaign where the CVV has reached nearly in-orbit temperature. The reference measurement under warm conditions has been performed in FN. The task of the HACS measurement was to verify the relative alignment of the LOU w.r.t. the HIFI FPU and compare the shrinkage of the cryostat with the prediction of the FEM.

The results of this measurement are shown in Table 2-8. For a comparison with the FEM some effects as the thermal behavior of LOU PPB and FPU AD and the effect on alignment due to strap tensioning after cryostat cool down must be considered. These effects have been discussed in chapter 2.7 and 2.8 and are included in Table 2-9.

Taking into account above mentioned effects the HACS measurement results show good agreement with the Finite Element Model within the measurement accuracy. Except the remaining deviation in x direction (0.57mm for +z camera and 0.65mm for –z camera). Nearly the same offset was observed by a comparison of theodolite measurements with HACS measurements. This can be explained by a deviation within the LOU PPBs between the axis used by the theodolite (lower part of PPB) the axis used by the HACS (upper part of the PPB). The difference needs to be known for the FM.

There are also effects from the PPB itself. Please refer to Figure 2-2 for elevation around 120k. HIFI explained the step by a non stable reference mirror for the measurements.

The missing LOU Support Plate screws (observed after vibration, see page 18 and existing NC) could lead to a misalignment around z axis of appr. 60arcsec.

Lessons learned for STM:

1. The PPBs needs to be calibrated for the FM. This is agreed with HIFI (HP-2-ASED-MN-1198, dated 5.04.06).
2. The Temperature behavior of the PPB and the Ad needs to be known for the FM (big error contribution up to 83 arcsec, see chapter 2.7). Measurements have already performed at HIFI.

4 Annex

HACS Measurement Data

The HACS measurement data are taken from the HACS measurement files stored by the HACS S/W each day. A measurement was performed every 10min. A reduced data set is shown in Annex 1 and Annex 2 together with the relevant CVV temperatures.

Annex 1: During Cool Down Period in TV Chamber

Annex 2: During Warm Up Period in TV Chamber

Cool Down

Date	Time [UTC]	T Mean	Plus z x [mm]	Minus z	Plus z y [mm]	Minus z	Plus z z [mm]	Minus z	Rx [arcsec]		Ry [arcsec]		Rz [arcsec]		CVV 2320 T [K]	LOU 2321 T [K]	CVV 1002 T [K]	LOU 2310 T [K]
		236,3		-2,28	0,00	3,20		0,73		268				104	229,9	238,3	242,71	238,9
		225,8		-2,06	0,00	2,60		0,64		271				121	219,9	226	231,61	226,5
		215,2		-1,85	0,00	3,00		0,51		280				129	210	213,6	220,36	214
12.10.2005	05:10	204,4		-1,65	0,00	3,69		0,38		292				135	200	201,2	208,83	201,6
12.10.2005	09:00	193,7		-1,45	0,00	4,29		0,26		307				135	190	189,3	197,41	189,5
12.10.2005	14:08	182,0	-2,08	-1,25	0,49	4,66	0,10	0,12	569	318	-426	-426	-83	140	179,1	176,7	184,92	176,9
	21:18	172,3	-1,88	-1,08	1,03	3,53	0,05	0,02	564	351	-413	-413	-77	134	170	166,7	174,6	166,8
13.10.2005	02:30	161,7	-1,67	-0,89	1,77	4,19	0,00	-0,07	562	367	-400	-400	-71	131	160	156,3	163,37	156,4
	11:44	151,1	-1,47	-0,72	1,39	2,42	-0,05	-0,17	559	379	-390	-390	-65	126	150	146,8	152,25	146,8
14.10.2005	00:16	140,6	-1,29	-0,55	1,72	2,84	-0,09	-0,24	560	389	-380	-380	-62	123	140	138,3	141,26	138,3
	18:46	130,2	-1,10	-0,39	2,19	2,44	-0,12	-0,31	559	398	-370	-370	-58	120	130	131,1	130,35	131,1
16.10.2005	02:36	119,8	-0,93	-0,23	2,26	2,57	-0,15	-0,35	558	408	-360	-360	-54	117	120	126,1	119,62	126,1
17.10.2005	18:58	109,8	-0,77	-0,06	2,22	2,64	-0,13	-0,37	566	409	-362	-362	-39	103	110	118,7	109,5	118,7
20.10.2005	14:02	99,3	-0,63	0,06	2,00	2,40	-0,16	-0,42	566	416	-353	-353	-38	103	100	112,6	98,61	112,5

Warm-up

Date	Time	T Mean	Plus x [mm]	Minus	Plus y [mm]	Minus	Plus z [mm]	Minus	Rx [arcsec]		Ry [arcsec]		Rz [arcsec]		CVV 2320 T [K]	LOU 2321 T [K]	CVV 1002 T [K]	LOU 2310 T [K]
05.11.2005	20:34	107,8	-0,78	-0,12	2,00	3,42	-0,29	-0,34	544	455	-340	-340	-73	135	109,8	146,2	105,8	148,3
	21:12	115,9	-0,93	-0,31	2,24	3,31	-0,37	-0,31	507	493	-320	-320	-85	147	119,7	163,6	112,05	173,2
	21:50	124,9	-1,07	-0,47	2,15	2,91	-0,44	-0,29	480	511	-306	-306	-100	158	129,8	176,5	119,94	186,1
	22:36	134,5	-1,19	-0,62	2,13	2,73	-0,50	-0,28	461	518	-290	-290	-113	162	139,9	190,5	129,02	200
	23:32	144,5	-1,36	-0,82	1,25	2,64	-0,56	-0,25	437	522	-278	-278	-128	165	150,1	206,1	138,96	215,4
06.11.2005	00:36	154,6	-1,53	-1,00	1,45	2,33	-0,62	-0,20	424	526	-272	-272	-134	156	160,1	221,6	149,04	225,2
	01:40	164,5	-1,73	-1,20	1,22	2,17	-0,63	-0,18	414	535	-271	-271	-151	168	170,1	226	158,97	231,3
	02:50	174,6	-1,91	-1,38	2,40	1,75	-0,63	-0,17	419	528	-275	-275	-159	177	179,9	227,3	169,31	231,1
	04:16	185,4		-1,55	0,00	0,00		-0,14	428	518			-165	184	190,1	227,2	180,63	229,7
	05:56	196,1		-1,74	0,00	0,00		-0,08	444	497			-175	193	200	227,2	192,17	229,7
	14:46	209,7		-1,92	0,00	0,00		0,09	519	417			-150	168	210	227,3	209,41	229,6
	17:16	219,6		-2,17	0,00	0,00		0,26	508	416			-161	160	220	259	219,26	268

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X	Alberti von Mathias Dr.	ASG22		Schweickert Gunn	ASG22
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	Bayer Thomas	ASA42	X	Stritter Rene	AED11
	Brune Holger	ASA45		Suess Rudi	OTN/ASA44
	Edelhoff Dirk	AED2		Thörmer Klaus-Horst Dr.	OTN/AED65
	Fehringer Alexander	ASG13		Wagner Klaus	ASG22
X	Fricke Wolfgang Dr.	AED 65	X	Wietbrock Walter	AET12
	Geiger Hermann	ASA42	X	Wöhler Hans	ASG22
	Grasl Andreas	OTN/ASA44			
	Grasshoff Brigitte	AET12			
	Hartmann Hans	AED32	X	Alcatel Alenia Space Cannes	ASP
X	Hauser Armin	ASG22	X	ESA/ESTEC	ESA
	Hendry David	Terma			
	Hengstler Reinhold	ASA42		**Instruments:**	
	Hinger Jürgen	ASG22		MPE (PACS)	MPE
X	Hohn Rüdiger	AED65		RAL (SPIRE)	RAL
X	Hölzle Edgar Dr.	AED32	X	SRON (HIFI)	SRON
	Huber Johann	ASA42		**Subcontractors:**	
	Hund Walter	ASE252		Air Liquide, Space Department	AIR
X	Idler Siegmund	AED312		Air Liquide, Space Department	AIRS
	Ilsen Stijn	Terma		Air Liquide, Orbital System	AIRT
	Ivády von András	FAE12		Alcatel Alenia Space Antwerp	ABSP
X	Jahn Gerd Dr.	ASG22		Austrian Aerospace	AAE
	Kalde Clemens	ASM2		Austrian Aerospace	AAEM
	Kameter Rudolf	OTN/ASA42		APCO Technologies S. A.	APCO
X	Kettner Bernhard	AET42		Bieri Engineering B. V.	BIER
	Knoblauch August	AET32		BOC Edwards	BOCE
	Koelle Markus	ASA43		Dutch Space Solar Arrays	DSSA
	Koppe Axel	AED312		EADS Astrium Sub-Subsyst. & Equipment	ASSE
X	Kroeker Jürgen	AED65		EADS CASA Espacio	CASA
	La Gioia Valentina	Terma		EADS CASA Espacio	ECAS
	Lamprecht Ernst	OTN/ASQ22		EADS Space Transportation	ASIP
	Lang Jürgen	ASE252		Eurocopter	ECD
	Langenstein Rolf	AED15		European Test Services	ETS
	Langfermann Michael	ASA41		HTS AG Zürich	HTSZ
	Much Christoph	ASA43		Linde	LIND
	Müller Jörg	ASA42		Patria New Technologies Oy	PANT
	Müller Martin	ASA43		Phoenix, Volkmarsen	PHOE
	Peltz Heinz-Willi	ASG13		Prototech AS	PROT
	Pietroboni Karin	AED65		QMC Instruments Ltd.	QMC
	Platzer Wilhelm	AED2		Rembe, Brilon	REMB
	Reichle Konrad	ASA42		Rosemount Aerospace GmbH	ROSE
	Runge Axel	OTN/ASA44		RYMSA, Radiación y Microondas S.A.	RYM
X	Schink Dietmar	AED32		SENER Ingenieria SA	SEN
X	Schlosser Christian	OTN/ASA44		Stöhr, Königsbrunn	STOE
	Schmidt Rudolf	FAE12		Terma A/S, Herlev	TER