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TITLE: **Planck-LFI CPV: 1 Hz frequency spikes** (P_PVP_LFI_0050_01, P_PVP_LFI_0025_01, P_PVP_LFI_0150_01, P_PVP_LFI_0027_01)

DOC. TYPE: **Test Report**

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CHANGE RECORD

Issue	Date	Sheet	Description of Change	Release
0.1	June 2009	All	First draft of document including SPIKE-01 test	0.1
0.2	July 2009	All	Second draft of document including SPIKE-01bis test	0.2
1.0	October 2009	All	First issue of document	1.0

TABLE OF CONTENTS

1 ACRONYMS

AIV	Assembly, Integration, Verification
ASW	Application Software
BEM	Back End Module
BEU	Back End Unit
CCS	Central Check-out System
CDMU	Central Data Management Unit
CPV	Calibration Performance Verification
CSL	Centre Spatiale de Liège
DAE	Data Acquisition Electronics
DPU	Digital Processing Unit
EGSE	Electrical ground Support Equipment
FEM	Front End Module
I-EGSE	Instrument EGSE
IST	Integrated Satellite Test
OBC	On Board Clock
RAA	Radiometer Array Assembly
REBA	Radiometric Electronic Box Assembly
S/C	Spacecraft
SCOE	Spacecraft Control and Operation System
SCS	Sorption Cooler System
SPU	Signal Processing Unit
SUSW	Start- Up Software
SVM	Service Module
TBC	To Be Checked
TBW	To Be Written
TC	Telecommand
TM	Telemetry
UFT	Unit Functional Test

2 APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable Documents

[AD1] Herschel/Planck Instrument Interface document Part A, SCI-PT-IIDA-04624 Issue 3.3

[AD2] Herschel/Planck Instrument Interface document Part B, SCI-PT-IIDB-04142 Issue 3.1

[AD3] Herschel/Planck Instrument Interface document Part B, SCI-PT-IIDB-04142 Issue 3.1, Annex 3, ICD 750800115

[AD4] Herschel/Planck Instrument Interface document Part A, SCI-PT-IIDA-04624 Issue 3.3 Annex 10

[AD5] Data analysis and scientific performance of the LFI FM instrument, PL-LFI-PST-AN-006 3.0

[AD6] Planck-LFI TV-TB test report: executive summary, PL-LFI-PST-RP-040 1.1

[AD7] Testing plan of the LFI instrument during the Planck Commissioning and CPV phase, PL-LFI-PST-PL-043 (4.2)

2.2 Reference Documents

[RD1] Planck Instrument Testing at PFM S/C levels, H-P-3-ASP-TN-0676, Issue 1.0

[RD2] Planck LFI User Manual, PL-LFI-PST-MA-001 Issue 2.1

[RD3] Quick Look Data Analysis Of LFI Spikes during SPIKE_01 test (Ph-5-01-b of TV/TB tests), PL-LFI-PST-RP-034

3 Introduction

Spurious frequency spikes at the fundamental frequency of 1 Hz are known to be present in the LFI scientific data caused by an anomalous interaction by the DAE housekeeping sequencer and the scientific channels. The effect is a spurious signal that adds to the radiometric output after detection and is characterised by frequency spikes at the fundamental frequency of 1 Hz.

These spikes are characterised by a series of tests run during all the test campaign in order to check this effect in different situations:

- Spikes produced by the DAE when all the radiometers are off;
- Spikes produced by the DAE when the BEMs are on and the FEMs are off;
- Spikes produced by the DAE when the radiometers are on in different switching conditions.

Tests performed on ground at satellite level have shown that the effect of these spikes on the LFI science is expected to be very small; therefore the main objectives of the same tests performed during CPV is to compare results with those obtained during the CSL test campaign.

4 Spikes produced by the DAE with FEMs and BEMs off (SPIKE_01)

4.1 Test Execution

4.1.1 Test configuration

The test configuration is the following

SCOS 2K EGSE 3.1 Release 1.2
RTSILib version 1.0
RTSI Client version 1.2
LEVEL1 (TMH/TQL) version 5.1
LIFE Machine version OM 3.00
IDIS 2.7.3.4

LFI Personnel involved during the test is:

LFI Instrument Operation Manager	Anna Gregorio (UniTs anna.gregorio@ts.infn.it)
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Test leader	Aniello Mennella
LFI IOT	Anna Gregorio, Aniello Mennella, Cristian Franceschet, Chris Butler, Marco Frailis, Samuele Galeotta, Andrea Zacchei
Industry support	Paolo Leutenegger

4.1.2 Pass-fail criteria, verification matrix

CPV **P_PVP_LFI_0050_01**

June, 04 2009 18:40z **DoY 155** **OD 22**

Duration **4:00:00**

Test name: Spike test 01

Test objectives: Characterise DAE frequency spikes with FEMs and BEMs off.
Once the Scientific Telemetry is active and the SCS cool down is proceeding this
test can be conducted in parallel and it is used for a reference point because the same test was performed on ground during TV-TB test campaign. LFI is in

DAE Set-up mode: power groups are still OFF.

Verification matrix					
Check	Passed?			Recovered?	
	Yes	No	Notes	Yes	No
No unexpected events packets (LFI IOT expects OOL alarm for the FPU sensors)	Yes		4 KHz phase switch was not initialised in DAE. Therefore data appeared to be switching but in reality were not. This unwanted effect was cured in data analysis		
No unexpected features	Yes				
Data saved and stored at DPC	Yes				

4.1.3 Procedure/ Test sequence and environmental conditions

4.1.3.1 Test procedure

Step	Description	START REF.	DURATION	Time (UTC)	RCA	YES	NO	Notes
1	Spike Test 1bis (UM § 13.1.2.1.1)	0:00:00		6/4/09 18:40				
1.1	Disable DAE HK Sequencer	0:00:00	0:00:02	6/4/09 18:40	All	yes		
1.2	Acquire Data (2 hours)	0:00:02	2:00:00	6/4/09 18:40		yes		
1.30	Enable DAE HK Sequencer	2:00:02	0:00:02	6/4/09 20:40		yes		
1.4	Acquire Data (2 hours)	2:00:04	2:00:00	6/4/09 20:40		yes		
1.5	Apply Default DAE Configuration as current configuration	4:00:04	0:00:02	6/4/09 22:40		yes		
1.6	end of the test	4:00:06		6/4/09 22:40				

4.1.3.2 Temperatures

The test was run right after the switch on the SCS. In Figures 11 and 12 we show the BEU and FEU temperature behaviour during the test. The increase in BEU temperature is consequent to the REBA and DAE switch on. The gap in housekeeping data is caused by the switch off of the DAE housekeeping sequencer during the first part of the test.

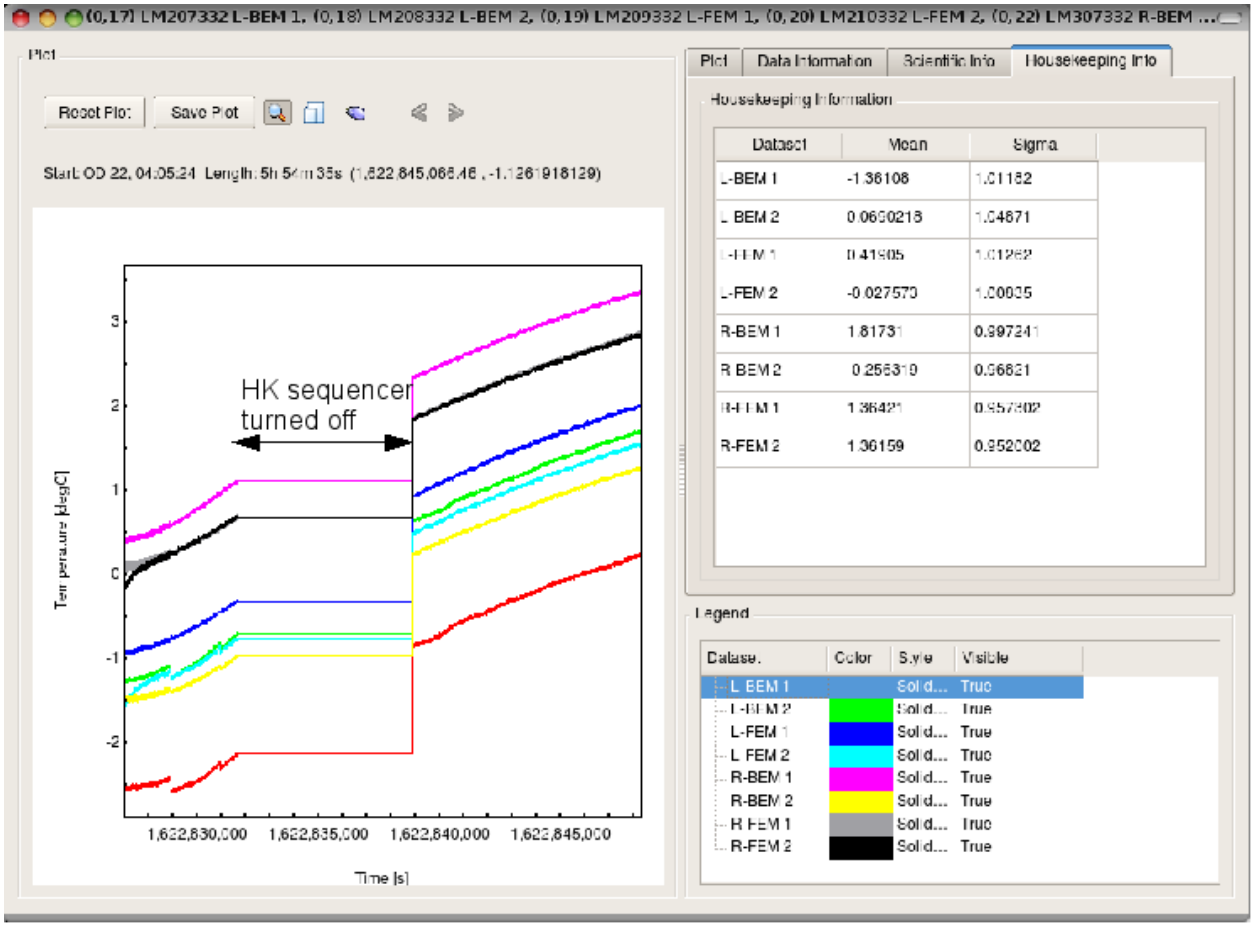

Figure 1 – BEU temperatures during the test. The temperature increase is the result of the switch on of REBA and DAE boxes that preceded this test

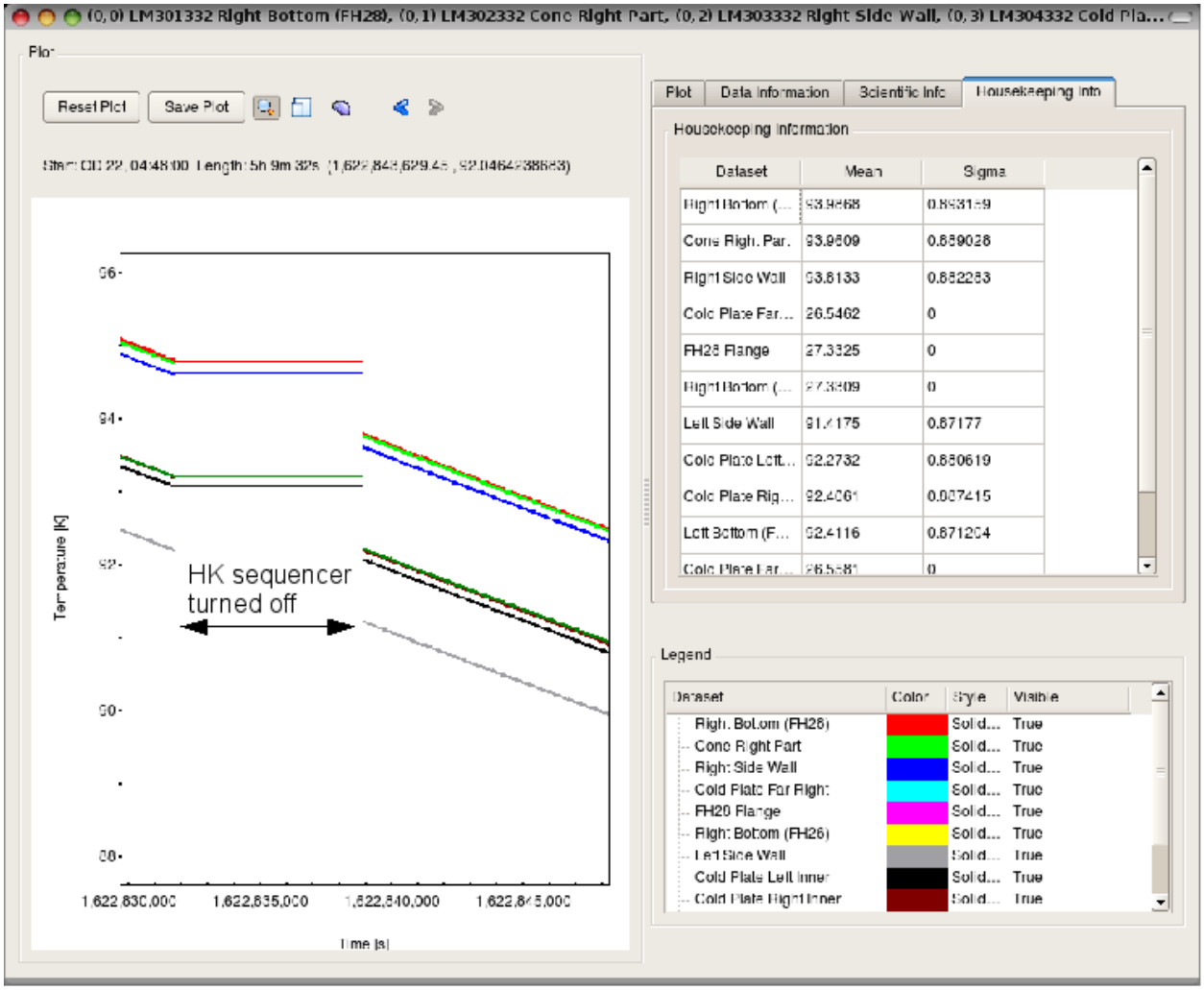

Figure 2 – FEU temperatures during the test.

4.1.3.3 Results and Conclusions

The test was executed in the scheduled time and the procedure was correctly applied.

4.1.3.4 Non nominal features

Because the phase switch status was not initialised yet in the DAE the data were acquired as they were switching between sky and ref. This of course does not have a physical sense, because the receivers were off and no switching actually occurred. This fact was taken care of in the data analysis by interlacing together sky and reference samples (for each detector) to form a single datastream.

4.1.4 Data Analysis

Data acquired during this test have been analysed in frequency space to characterise spikes with and without the DAE housekeeping sequencer.

In Fig. Error: Reference source not found we report an example of amplitude spectrum with the housekeeping sequence OFF (left panel) and ON (right panel). The complete set of plots is reported in appendices 1 and 2.

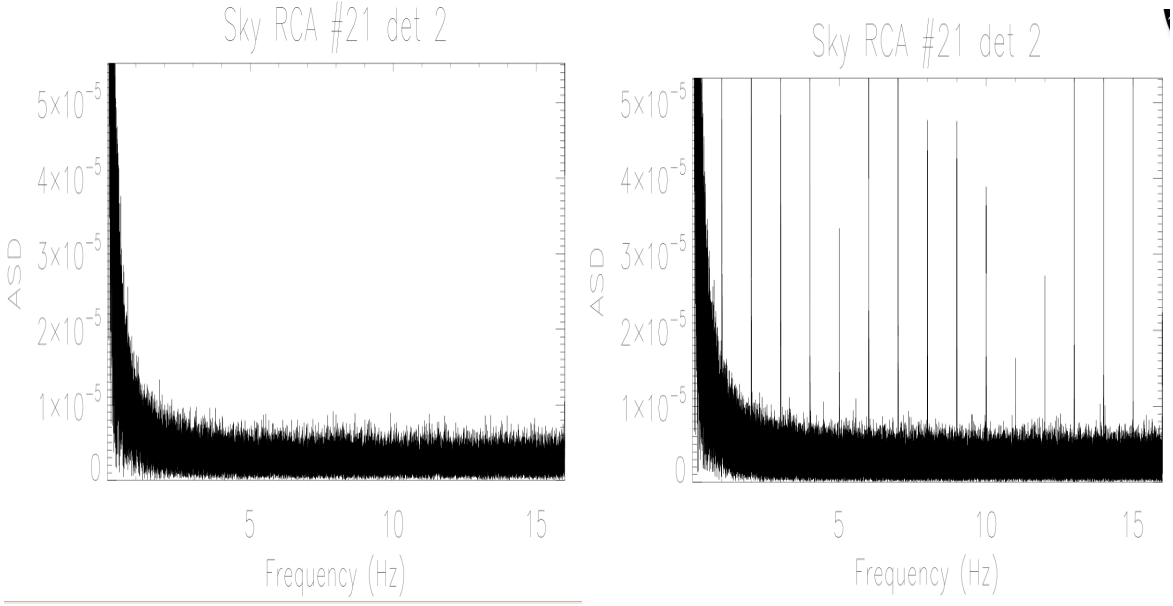

Figure 3 – Frequency spikes relative to detector LFI21S-10 with DAE housekeeping sequencer OFF (left panel) and ON (right panel)

In Fig. Error: Reference source not found we show the anomalous spike observed on the DAE output LFI22M-00 and LFI22M-01. This spike, observed since the instrument level tests, is not connected to the status of the DAE housekeeping sequencer and its source has not been understood. Its effects on the scientific data, however has always shown to be negligible.

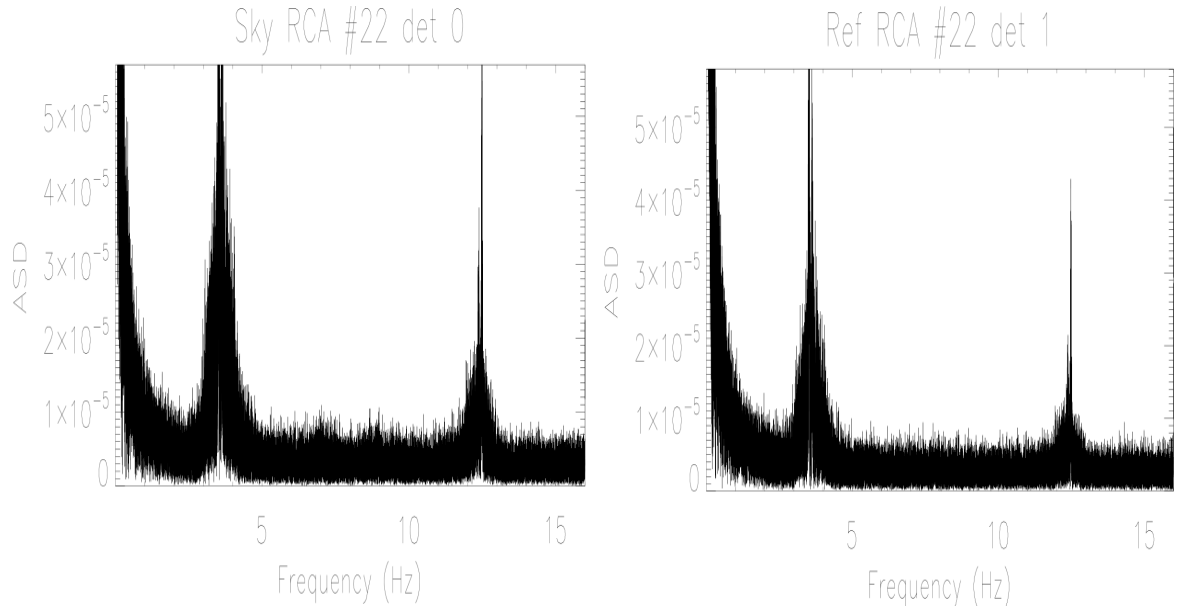

Figure 4 – Anomalous frequency spike on DAE channels LFI21M-00 and LFI21M-01.

Finally, a comparison of DAE spikes in frequency and amplitudes between this test and the same test run in CSL [RD3] has revealed that the frequency spikes are essentially repeatable. Figure Error: Reference source not found shows such comparison for two channels, as examples of the best and worst match. The complete set of plots is shown in Appendix 3.

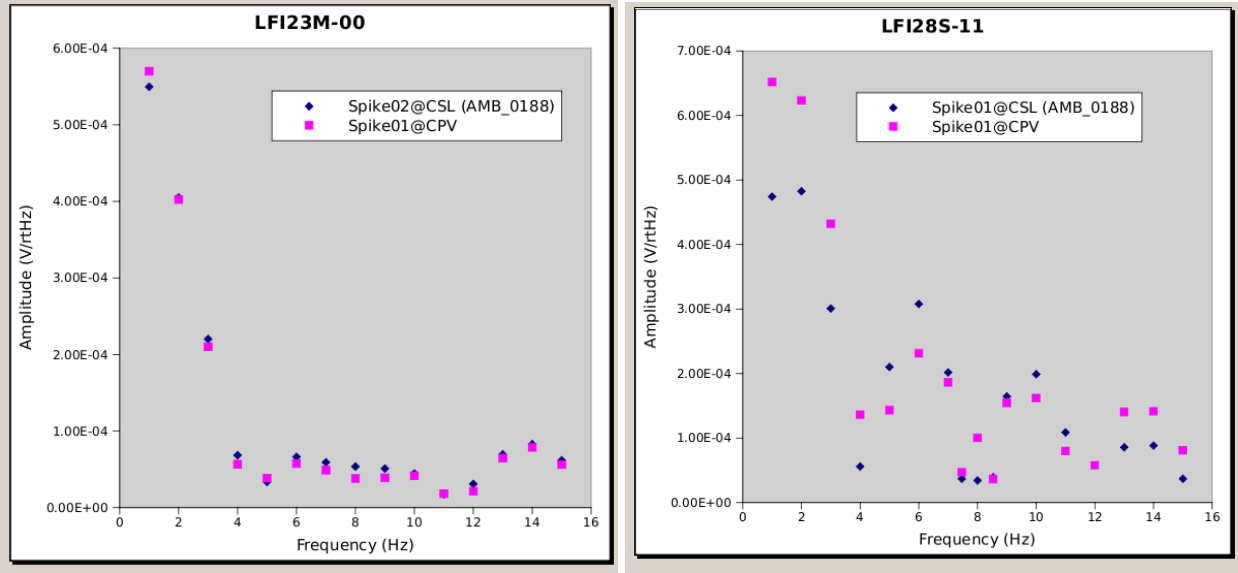

Figure 5 – Comparison of frequency spikes in test SPIKE-01 between CPV and CSL.

5 Spikes produced by the DAE with FEMs off and BEMs on (SPIKE_01bis)

5.1 Test Execution

5.1.1 Test configuration

The test configuration is the following

SCOS 2K EGSE 3.1 Release 1.2
RTSILib version 1.0
RTSI Client version 1.2
LEVEL1 (TMH/TQL) version 5.1
LIFE Machine version OM 3.00
IDIS 2.7.3.4

LFI Personnel involved during the test is:

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Test leader	Aniello Mennella
LFI IOT	Anna Gregorio, Aniello Mennella, Cristian Franceschet, Chris Butler, Marco Frailis, Samuele Galeotta, Andrea Zacchei
Industry support	Paola Battaglia

5.1.2 Pass-fail criteria, verification matrix

CPV **P_PVP_LFI_0150_01**
June, 14 2009 14:00z **DoY 165** **OD 31**
Duration **4:00:00**
Test name: Spike test 01 part B

Test objectives:

Characterise DAE frequency spikes with FEMs off.
Once the Scientific Telemetry is active and the SCS cool down is proceeding this
test can be conducted in parallel and it is used for a reference point because the same test was performed on ground during TV-TB test campaign. LFI is in

Normal Science mode: power groups are ON but biases are set in order to have
FEMs off.

Verification matrix					
Check	Passed?			Recovered?	
	Yes	No	Notes	Yes	No
No unexpected events packets (LFI IOT expects OOL alarm for the FPU sensors)	Yes				
No unexpected features	Yes				
FEM on again at the end of the test	Yes				
Data saved and stored at DPC	Yes				

5.1.3 Procedure/ Test sequence and environmental conditions

5.1.3.1 Test procedure

Step	Description	START REF.	DURATION	Time (UTC)	RCA	YES	NO	Notes
1	Spike Test 1bis (UM § 13.1.2.1.1)	0:00:00		6/14/09 14:00				
1.1	Disable DAE HK Sequencer	0:00:00	0:00:02	6/14/09 14:00	All	yes		
1.2	Acquire Data (2 hours)	0:00:02	2:00:00	6/14/09 14:00		yes		
1.30	Enable DAE HK Sequencer	2:00:02	0:00:02	6/14/09 16:00		yes		
1.4	Acquire Data (2 hours)	2:00:04	2:00:00	6/14/09 16:00		yes		
1.5	Apply Default DAE Configuration as current configuration	4:00:04	0:00:02	6/14/09 18:00		yes		
1.6	end of the test	4:00:06		6/14/09 18:00				

5.1.3.2 Temperatures

In Figures 6 and 7 we show the BEU and FEU temperature behaviour during the test. The gap in housekeeping data is caused by the switch off of the DAE housekeeping sequencer during the first part of the test.

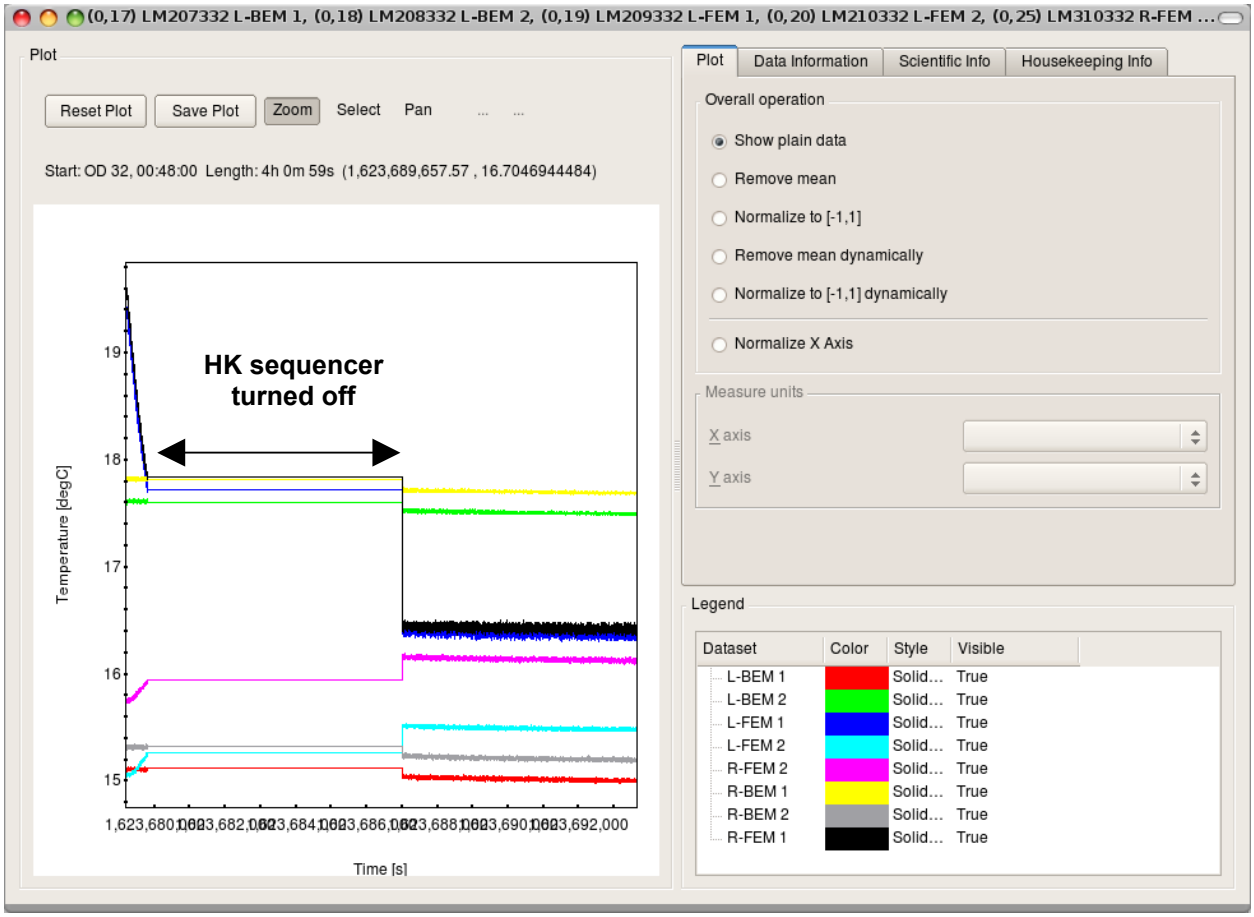

Figure 6 – BEU temperatures during the test.

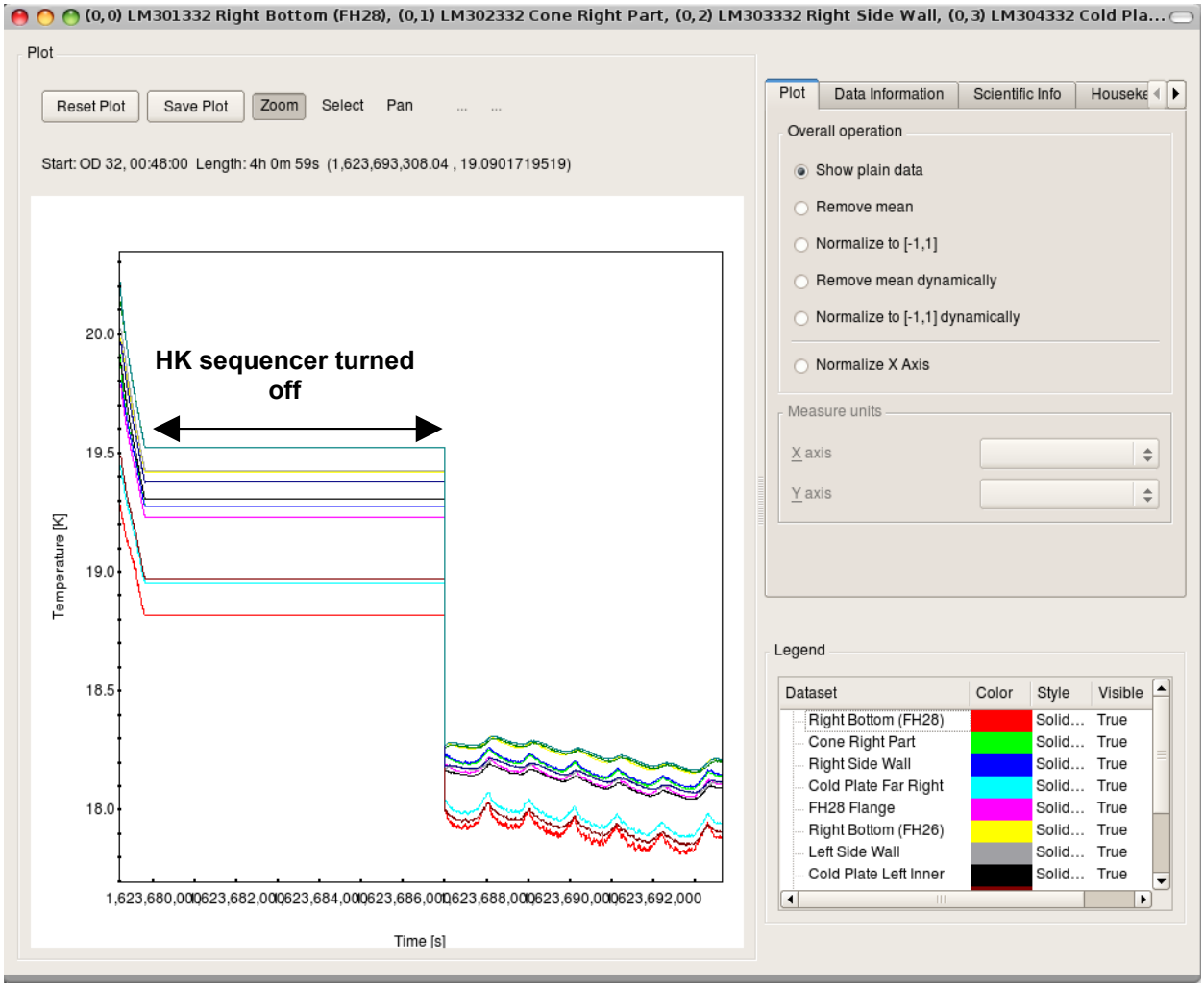

Figure 7 – FEU temperatures during the test.

5.1.3.3 Results and Conclusions

The test was executed in the scheduled time and the procedure was correctly applied.

5.1.3.4 Non nominal features

None

5.1.4 Data Analysis

Data acquired during this test have been analysed in frequency space to characterise spikes with and without the DAE housekeeping sequencer.

In Fig. 8 we report an example of amplitude spectrum with the housekeeping sequence OFF (left panel) and ON (right panel). The complete set of plots is reported in appendices 4 and 5

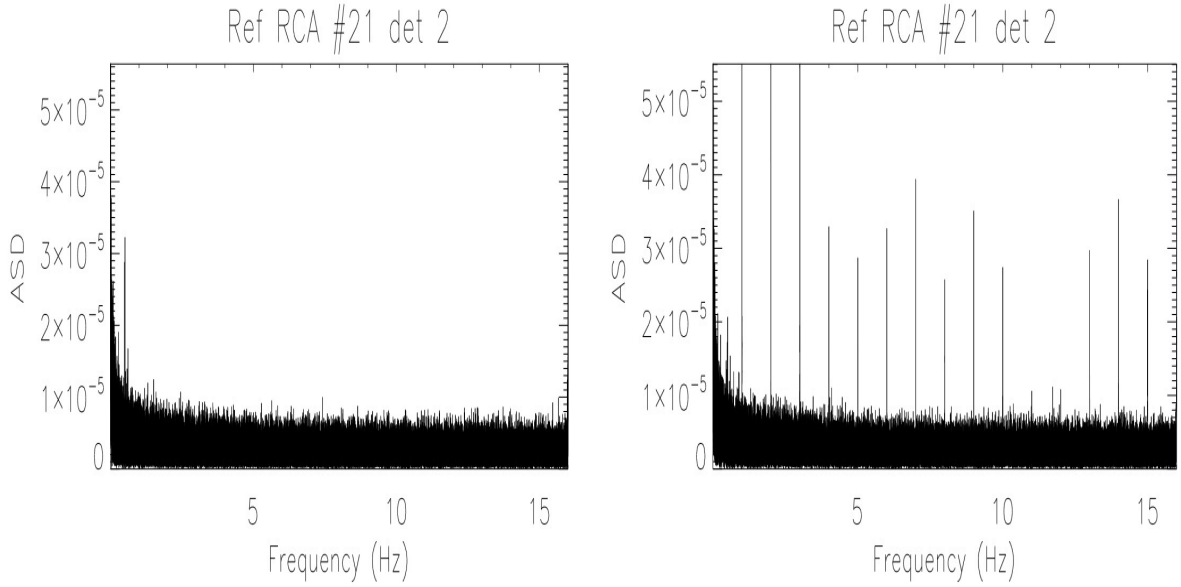

Figure 8 – Frequency spikes relative to detector LFI21S-10 with DAE housekeeping sequencer OFF (left panel) and ON (right panel)

In Fig. 9 we show the anomalous spike observed on the DAE output LFI22M-00 and LFI22M-01. This spike, observed since the instrument level tests, is not connected to the status of the DAE housekeeping sequencer and its source has not been understood. Its effects on the scientific data, however has always shown to be negligible.

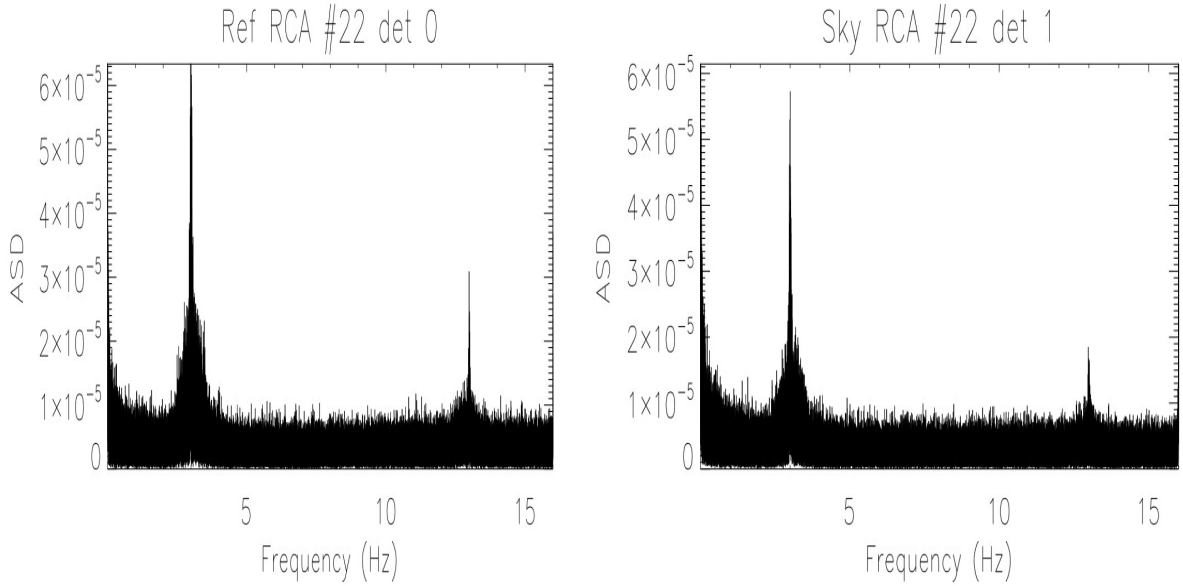

Figure 9 – Anomalous frequency spike on DAE channels LFI21M-00 and LFI21M-01.

Finally, a comparison of DAE spikes in frequency and amplitudes between this test and the same test run in CSL [RD3] has revealed that the frequency spikes are essentially repeatable. Figure 10

shows such comparison for two channels, as examples of the best and worst match. The complete set of plots is shown in Appendix 6.

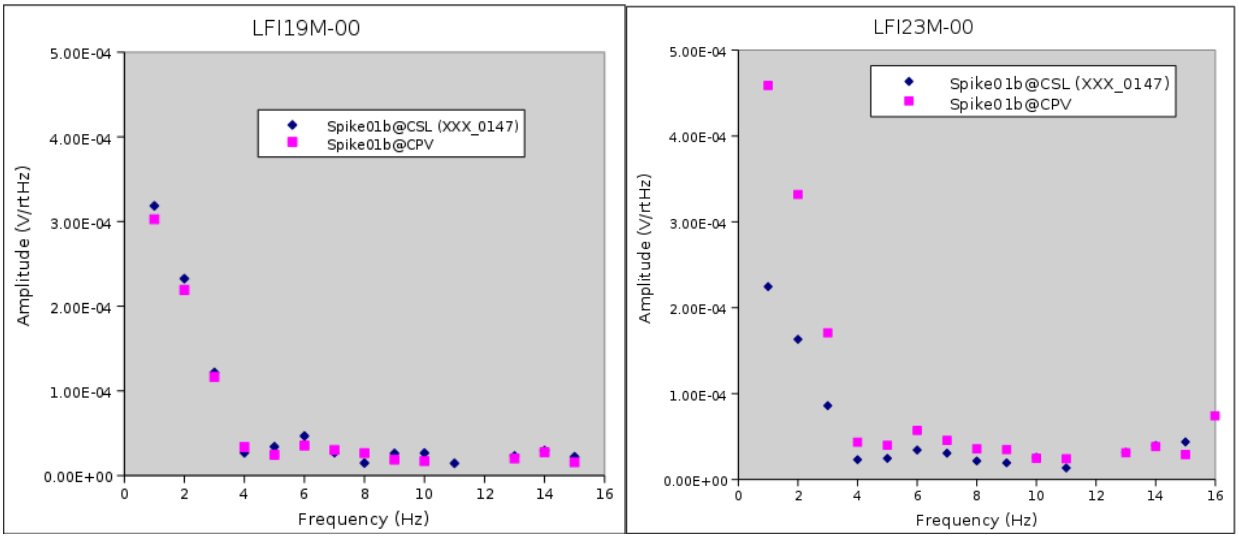

Figure 10 – Comparison of frequency spikes in test SPIKE-01 between CPV and CSL.

6 Spikes produced by the DAE when both FEMs and BEMs are on (SPIKE-02)

This test is aimed at the characterisation of the DAE frequency spikes when the full instrument is on. It consists of two series 8 1-hour acquisitions each (for a total of 16 data acquisitions). The first series is conducted with the DAE HK sequencer off and the second one is conducted with the DAE HK sequencer on.

During each series we operate the receiver both is switched and unswitched conditions exercising all the possible phase switch configurations (see next section). The only exception is the receiver LFI23 for which the B/D switching configuration is avoided, as it is known to produce non-nominal behaviour.

The objectives of this test are the following:

- to verify that the 1 Hz spikes are correlated with the status of the DAE HK sequencer;
- to verify that the frequency spikes do not depend, at first order, on the phase switch configuration;
- to verify that no new spikes are introduced by 4 KHz switching.

6.1 Test Execution

6.1.1 Test configuration

The test configuration is the following

SCOS 2K EGSE 3.1 Release 1.2
RTSILib version 1.0
RTSI Client version 1.2
LEVEL1 (TMH/TQL) version 5.1
LIFE Machine version OM 3.00
IDIS 2.7.3.4

LFI Personnel involved during the test is:

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LFI CPV Manager	Francesco Cuttaia (IASF-BO cuttaia@iasfbo.inaf.it)
Test leader	Aniello Mennella

LFI IOT	Anna Gregorio, Aniello Mennella, Francesco Cuttaia, Cristian Franceschet, Chris Butler, Marco Frailis, Samuele Galeotta, Andrea Zacchei
Industry support	Paola Battaglia

6.1.2 Pass-fail criteria, verification matrix

CPV **P_PVP_LFI_0025_01**

June, 13-14 2009 **DoY 164-165** **OD 31**

Duration **16:00:00**

Test name: Spike test 02

Test objectives: Once the Scientific Telemetry is active and the SCS cool down is proceeding this test can be conducted in parallel and it will used for a reference point because the same test was performed on ground during TV-TB test campaign.
LFI is in Normal Science mode: power groups are ON and nominal biases (resulting from TV-TB test campaign) are set.

Verification matrix					
Check	Passed?			Recovered?	
	Yes	No	Notes	Yes	No
No unexpected events packets (LFI IOT expects OOL alarm for the FPU sensors)	Yes				
No unexpected features	Yes				
Data saved and stored at DPC	Yes				

6.1.3 Procedure/ Test sequence and environmental conditions

6.1.3.1 Test procedure

The complete procedure is reported in the table below

Step	Description	START REF.	DURATION	Time (Local)	RCA	YES	NO	Notes
4	Spike Test 2 (UM § 13.1.2.1.2)	0:00:00		2009/06/13 21:11:00				
4.1	Disable A/C 4kHz	0:00:00	0:00:02	2009/06/13 21:11:00	All	Yes		
4.2	Disable B/D 4kHz	0:00:02	0:00:02	2009/06/13	All	Yes		

				21:11:02				
4.3	Set A/C P/S Status (0)	0:00:04	0:00:02	2009/06/13 21:11:04	All	Yes		
4.4	Set B/D P/S Status (0)	0:00:06	0:00:02	2009/06/13 21:11:06	All	Yes	no	Here the data show that B/D switching has been enabled for about half an hour and then the nominal procedure has been recovered
4.5	Enable A/C 4kHz	0:00:08	0:00:02	2009/06/13 22:00:00	All	Yes		
4.6	Acquire Data (1 hour)	0:00:10	1:00:00	2009/06/13 22:00:02		Yes		
4.7	Set B/D P/S Status (1)	1:00:10	0:00:02	2009/06/13 23:00:02	All	Yes		
4.8	Acquire Data (1 hour)	1:00:12	1:00:00	2009/06/13 23:00:04		Yes		
4.9	Disable A/C 4kHz	2:00:12	0:00:02	2009/06/14 00:00:04	All	Yes		
4.1	Set A/C P/S Status (0)	2:00:14	0:00:02	2009/06/14 00:00:06	All	Yes		
4.11	Set B/D P/S Status (0)	2:00:16	0:00:02	2009/06/14 00:00:08	All	Yes		
4.12	Enable B/D 4kHz on all but RCA23	2:00:18	0:00:02	2009/06/14 00:00:10	All ~~(23)~~	YES		Here the procedure leaves 23 completely unswitched
4.13	Acquire Data (1 hour)	2:00:20	1:00:00	2009/06/14 00:00:12		Yes		
4.14	Set A/C P/S Status (1)	3:00:20	0:00:02	2009/06/14 01:00:12	All	Yes		
4.15	Acquire Data (1 hour)	3:00:22	1:00:00	2009/06/14 01:00:14		Yes		
4.16	Disable B/D 4kHz	4:00:22	0:00:02	2009/06/14 02:00:14	All	Yes		
4.17	Set B/D P/S Status (0)	4:00:24	0:00:02	2009/06/14 02:00:16	All	Yes		
4.18	Acquire Data (1 hour)	4:00:26	1:00:00	2009/06/14 02:00:18		Yes		
4.19	Set A/C P/S Status (0)	5:00:26	0:00:02	2009/06/14 03:00:18	All	Yes		
4.2	Acquire Data (1 hour)	5:00:28	1:00:00	2009/06/14 03:00:20		Yes		
4.21	Set B/D P/S Status (1)	6:00:28	0:00:02	2009/06/14 04:00:20	All	Yes		
4.22	Acquire Data (1 hour)	6:00:30	1:00:00	2009/06/14 04:00:22		Yes		
4.23	Set A/C P/S Status (1)	7:00:30	0:00:02	2009/06/14 05:00:22	All	Yes		
4.24	Acquire Data (1 hour)	7:00:32	1:00:00	2009/06/14 05:00:24		Yes		
4.25	Set A/C P/S Status (0)	8:00:32	0:00:02	2009/06/14 06:00:24	All	Yes		
4.26	Set B/D P/S Status (0)	8:00:34	0:00:02	2009/06/14 06:00:26	All	Yes		
4.27	Disable DAE HK Sequencer	8:00:36	0:00:02	2009/06/14 06:00:28		Yes		
4.28	Enable A/C 4kHz	8:00:38	0:00:02	2009/06/14 06:00:30	All	Yes		
4.29	Acquire Data (1 hour)	8:00:40	1:00:00	2009/06/14 06:00:32		Yes		
4.3	Set B/D P/S Status (1)	9:00:40	0:00:02	2009/06/14 07:00:32	All	Yes		

4.31	Acquire Data (1 hour)	9:00:42	1:00:00	2009/06/14 07:00:34		Yes		
4.32	Disable A/C 4kHz	10:00:42	0:00:02	2009/06/14 08:00:34	All	Yes		
4.33	Set A/C P/S Status (0)	10:00:44	0:00:02	2009/06/14 08:00:36	All	Yes		
4.34	Set B/D P/S Status (0)	10:00:46	0:00:02	2009/06/14 08:00:38	All	Yes		
4.35	Enable B/D 4kHz on all but RCA23	10:00:48	0:00:02	2009/06/14 08:00:40	All ~~(23)~~	YES		Here the procedure leaves 23 completely unswitched
4.36	Acquire Data (1 hour)	10:00:50	1:00:00	2009/06/14 08:00:42		Yes		
4.37	Set A/C P/S Status (1)	11:00:50	0:00:02	2009/06/14 09:00:42	All	Yes		
4.38	Acquire Data (1 hour)	11:00:52	1:00:00	2009/06/14 09:00:44		Yes		
4.39	Disable B/D 4kHz	12:00:52	0:00:02	2009/06/14 10:00:44	All	Yes		
4.40	Set B/D P/S Status (0)	12:00:54	0:00:02	2009/06/14 10:00:46	All	Yes		
4.41	Acquire Data (1 hour)	12:00:56	1:00:00	2009/06/14 10:00:48		Yes		
4.42	Set A/C P/S Status (0)	13:00:56	0:00:02	2009/06/14 11:00:48	All	Yes		
4.43	Acquire Data (1 hour)	13:00:58	1:00:00	2009/06/14 11:00:50		Yes		
4.44	Set B/D P/S Status (1)	14:00:58	0:00:02	2009/06/14 12:00:50	All	Yes		
4.45	Acquire Data (1 hour)	14:01:00	1:00:00	2009/06/14 12:00:52		Yes		
4.46	Set A/C P/S Status (1)	15:01:00	0:00:02	2009/06/14 13:00:52	All	Yes		
4.47	Acquire Data (1 hour)	15:01:02	1:00:00	2009/06/14 13:00:54		Yes		
4.48	Set A/C P/S Status (0)	16:01:02	0:00:02	2009/06/14 14:00:54	All	Yes		
4.49	Set B/D P/S Status (0)	16:01:04	0:00:02	2009/06/14 14:00:56	All	Yes		
4.50	Enable DAE HK Sequencer	16:01:06	0:00:02	2009/06/14 14:00:58		Yes		
4.51	Apply Default DAE Configuration as current configuration	16:01:08	0:00:02	2009/06/14 14:01:00		Yes		
	end of the test	16:01:10		2009/06/14 14:01:02				

6.1.3.2 Temperatures

In Figures 11, 12 and 13 we plot the FEU, BEU and 4K cooler temperatures recorded during the SPIKE-02 test. The gap in housekeeping data is caused by the switch off of the DAE housekeeping sequencer during the second part of the test.

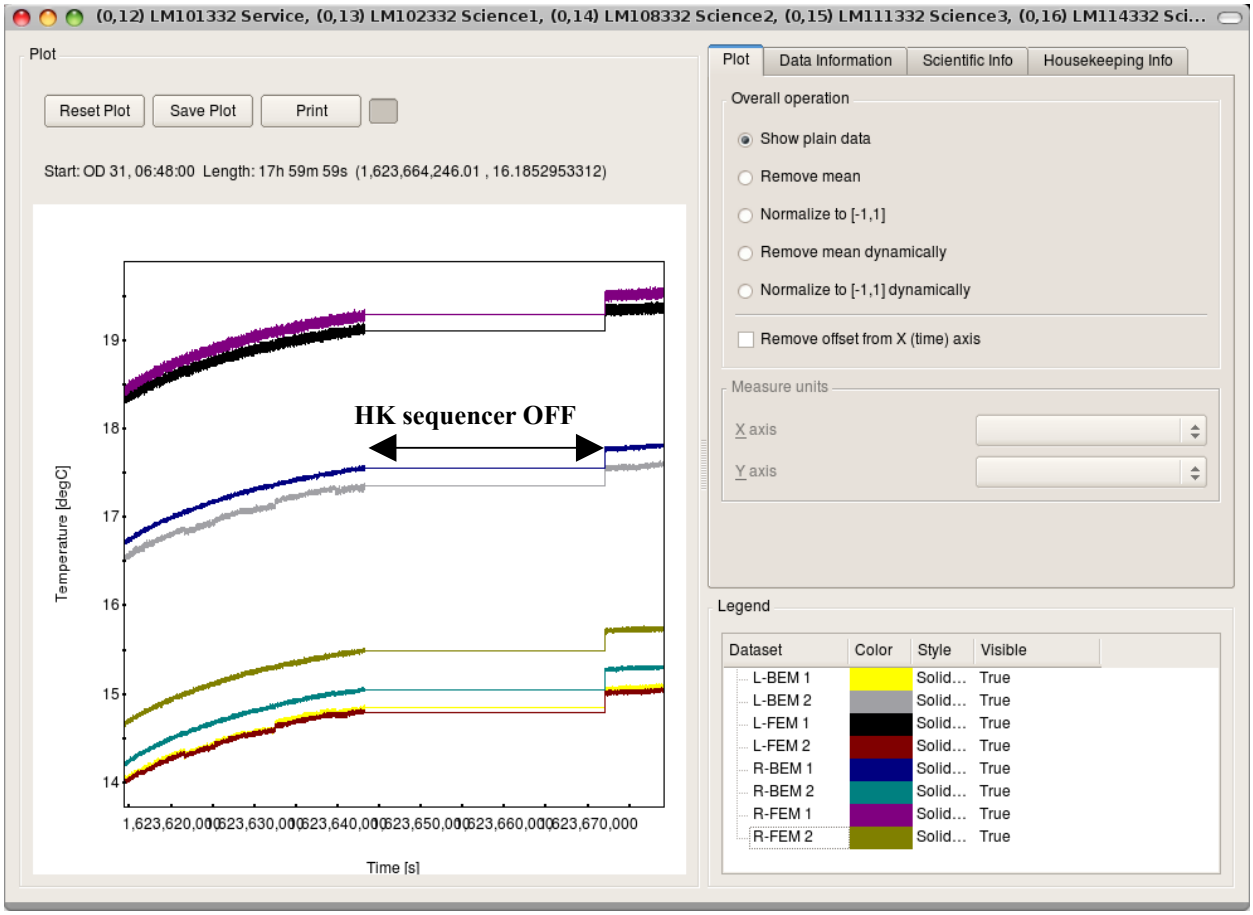


Figure 11 – BEU temperatures during the test.

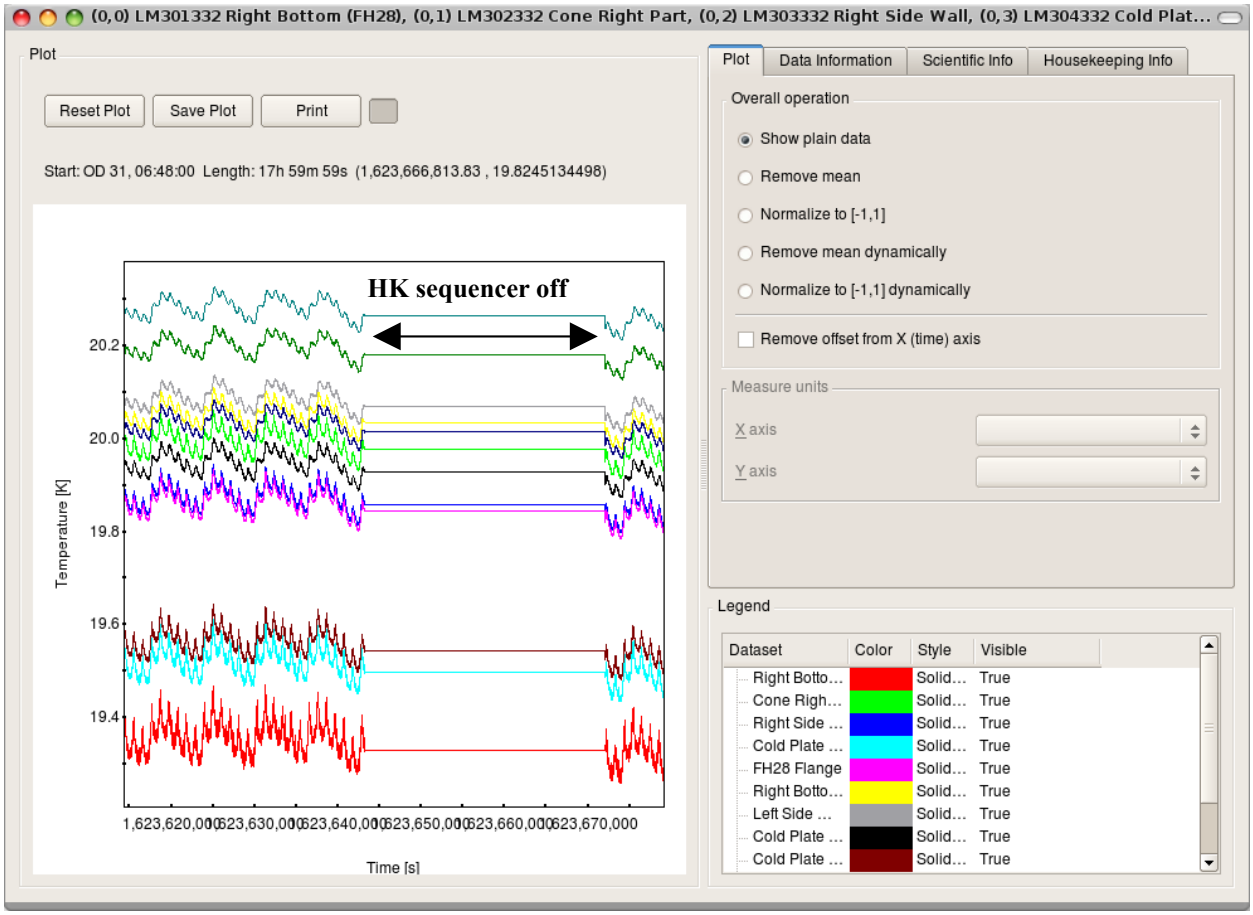


Figure 12 – FEU temperatures during the test.

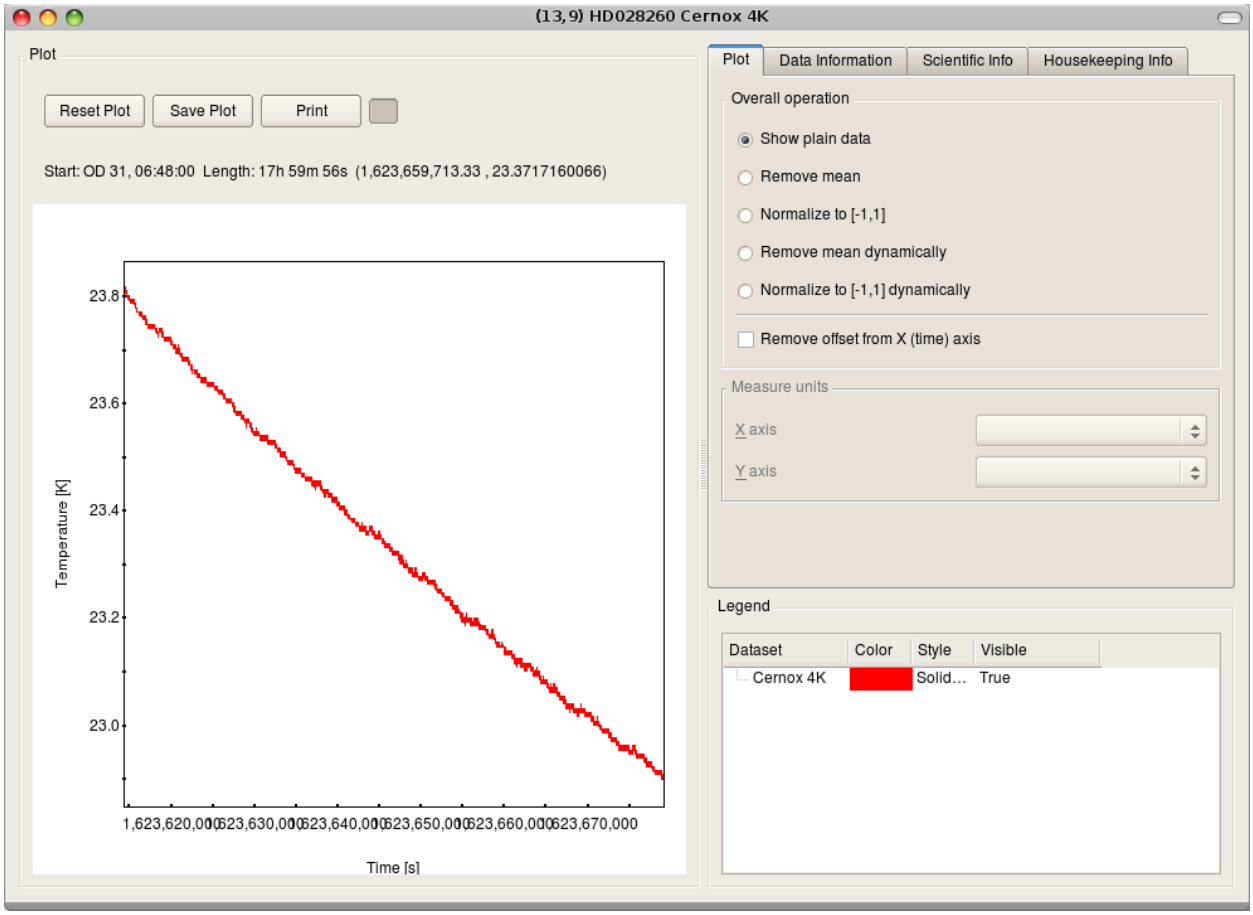


Figure 13 – 4K temperature during the test.

6.1.3.3 Bias and DAE configuration

The test has been run in the same bias configuration that was used for CSL, i.e. the set of biases that resulted from the tuning activity performed during instrument-level tests. The biases for all 44 ACAs and phase switches are reported in the following table.

RCA	FEM arm	vg1	vg2	vd	I1	I2
LFI18	S2	208	205	114	255	255
	S1	192	197	138	255	255
	M1	190	194	126	255	255
	M2	198	201	125	255	255
LFI19	S2	204	216	125	255	255
	S1	215	209	120	255	255
	M1	213	206	124	255	255
	M2	211	208	126	255	255
LFI20	S2	188	201	127	255	255
	S1	199	221	132	255	255
	M1	209	219	121	255	255
	M2	215	221	127	255	255

	S2	216	223	132	255	255
LFI21	S1	181	197	136	255	255
	M1	198	207	141	255	255
	M2	196	197	136	255	255
	S2	206	204	130	255	255
LFI22	S1	204	189	128	255	255
	M1	203	194	125	255	255
	M2	178	176	130	255	255
	S2	190	208	122	255	255
LFI23	S1	181	211	118	255	255
	M1	207	192	120	255	255
	M2	210	195	119	255	255
	M2	227	213	183	91	255
LFI24	M1	219	217	183	128	250
	S2	225	213	152	86	215
	S1	219	219	157	84	235
	M1	227	212	184	174	235
LFI25	M2	219	212	185	89	250
	S1	224	216	167	93	255
	S2	223	212	166	119	225
	M2	226	217	170	153	210
LFI26	M1	232	209	169	98	245
	S2	232	217	169	93	230
	S1	228	226	172	135	230
	M1	240	108	156	178	180
LFI27	M2	244	90	157	144	214
	S1	237	102	157	138	192
	S2	246	114	156	128	200
	M1	243	101	157	132	162
LFI28	M2	240	112	156	117	188
	S1	240	84	157	111	168
	S2	245	121	158	99	173

The DAE gain values were all set to 0 (corresponding to a physical value of 1) while the DAE offsets were optimised in order to avoid saturation. The DAE offset values used in this test are listed in the following table.

RCA	DAE channel	DAE offset
	M-00	0
LFI18	M-01	0
	S-10	128
	S-11	128
LFI19	M-00	214
	M-01	204
	S-10	220

LFI20	S-11	224
	M-00	128
	M-01	128
	S-10	128
	S-11	128
LFI21	M-00	194
	M-01	204
	S-10	180
	S-11	180
LFI22	M-00	255
	M-01	255
	S-10	255
	S-11	255
LFI23	M-00	100
	M-01	100
	S-10	180
	S-11	180
LFI24	M-00	255
	M-01	255
	S-10	255
	S-11	255
LFI25	M-00	255
	M-01	255
	S-10	255
	S-11	255
LFI26	M-00	255
	M-01	255
	S-10	255
	S-11	255
LFI27	M-00	21
	M-01	0
	S-10	51
	S-11	50
LFI28	M-00	60
	M-01	41
	S-10	60
	S-11	143

6.1.3.4 Phase switch configurations

In each 8-hours series of data acquisitions the eight 1-hour steps are characterised by the following phase switch configurations:

STEP1					STEP2				
RCA	A/C 4KHz	B/D 4KHz	A/C pos	B/D pos	RCA	A/C 4KHz	B/D 4KHz	A/C pos	B/D pos
LFI18	1	0	0	0	LFI18	1	0	0	1
LFI19	1	0	0	0	LFI19	1	0	0	1
LFI20	1	0	0	0	LFI20	1	0	0	1
LFI21	1	0	0	0	LFI21	1	0	0	1
LFI22	1	0	0	0	LFI22	1	0	0	1
LFI22	1	0	0	0	LFI22	1	0	0	1
LFI23	1	0	0	0	LFI23	1	0	0	1
LFI24	1	0	0	0	LFI24	1	0	0	1
LFI25	1	0	0	0	LFI25	1	0	0	1
LFI26	1	0	0	0	LFI26	1	0	0	1
LFI27	1	0	0	0	LFI27	1	0	0	1
LFI28	1	0	0	0	LFI28	1	0	0	1

STEP3					STEP4				
RCA	A/C 4KHz	B/D 4KHz	A/C pos	B/D pos	RCA	A/C 4KHz	B/D 4KHz	A/C pos	B/D pos
LFI18	0	1	0	0	LFI18	0	1	1	0
LFI19	0	1	0	0	LFI19	0	1	1	0
LFI20	0	1	0	0	LFI20	0	1	1	0
LFI21	0	1	0	0	LFI21	0	1	1	0
LFI22	0	1	0	0	LFI22	0	1	1	0
LFI22	0	1	0	0	LFI22	0	1	1	0
LFI23	0	0	0	0	LFI23	0	0	1	0
LFI24	0	1	0	0	LFI24	0	1	1	0
LFI25	0	1	0	0	LFI25	0	1	1	0
LFI26	0	1	0	0	LFI26	0	1	1	0
LFI27	0	1	0	0	LFI27	0	1	1	0
LFI28	0	1	0	0	LFI28	0	1	1	0

STEP5					STEP6				
RCA	A/C 4KHz	B/D 4KHz	A/C pos	B/D pos	RCA	A/C 4KHz	B/D 4KHz	A/C pos	B/D pos

LFI18	0	0	1	0	LFI18	0	0	0	0
LFI19	0	0	1	0	LFI19	0	0	0	0
LFI20	0	0	1	0	LFI20	0	0	0	0
LFI21	0	0	1	0	LFI21	0	0	0	0
LFI22	0	0	1	0	LFI22	0	0	0	0
LFI22	0	0	1	0	LFI22	0	0	0	0
LFI23	0	0	1	0	LFI23	0	0	0	0
LFI24	0	0	1	0	LFI24	0	0	0	0
LFI25	0	0	1	0	LFI25	0	0	0	0
LFI26	0	0	1	0	LFI26	0	0	0	0
LFI27	0	0	1	0	LFI27	0	0	0	0
LFI28	0	0	1	0	LFI28	0	0	0	0

STEP7					STEP8				
RCA	A/C 4KHz	B/D 4KHz	A/C pos	B/D pos	RCA	A/C 4KHz	B/D 4KHz	A/C pos	B/D pos
LFI18	0	0	0	1	LFI18	0	0	1	1
LFI19	0	0	0	1	LFI19	0	0	1	1
LFI20	0	0	0	1	LFI20	0	0	1	1
LFI21	0	0	0	1	LFI21	0	0	1	1
LFI22	0	0	0	1	LFI22	0	0	1	1
LFI22	0	0	0	1	LFI22	0	0	1	1
LFI23	0	0	0	1	LFI23	0	0	1	1
LFI24	0	0	0	1	LFI24	0	0	1	1
LFI25	0	0	0	1	LFI25	0	0	1	1
LFI26	0	0	0	1	LFI26	0	0	1	1
LFI27	0	0	0	1	LFI27	0	0	1	1
LFI28	0	0	0	1	LFI28	0	0	1	1

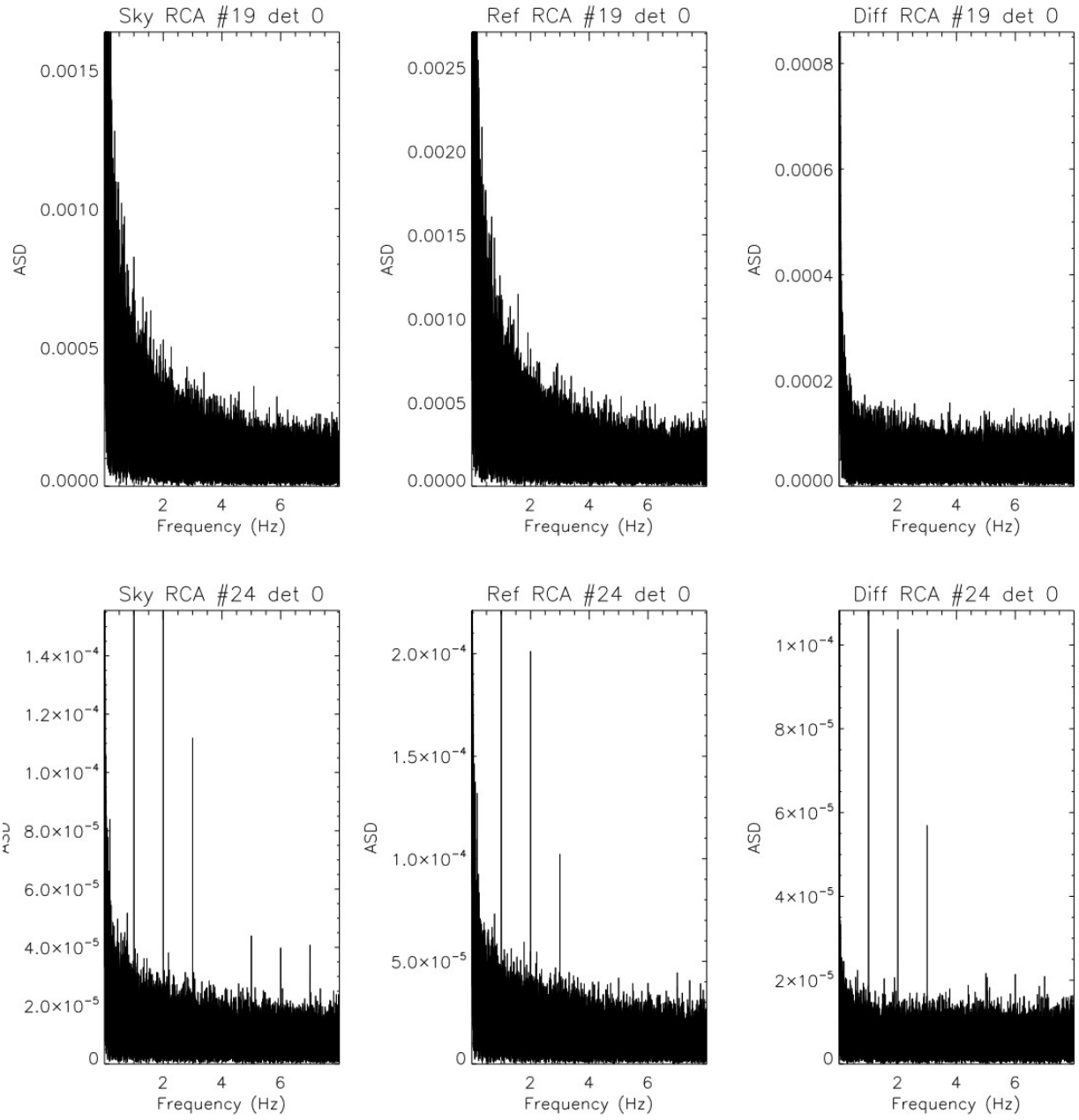
6.1.3.5 Results and Conclusions

6.1.3.6 Non nominal features

6.1.4 Data Analysis

Data acquired during this test have been analysed in frequency space to characterise spikes with and without the DAE housekeeping sequencer in all the phase switch configurations. The complete set of plots is provided in Annex 7.

The first noticeable and expected feature is that frequency spikes are visible only in the 44 GHz channels. This was expected, as the radiometer noise level for the 30 and 44 receivers is larger than the spike amplitudes (see the three sample plots in Fig 14).


Sky RCA #19 det 0
Ref RCA #19 det 0
Diff RCA #19 det 0
Sky RCA #24 det 0
Ref RCA #24 det 0
Diff RCA #24 det 0
ASD
Frequency (Hz)

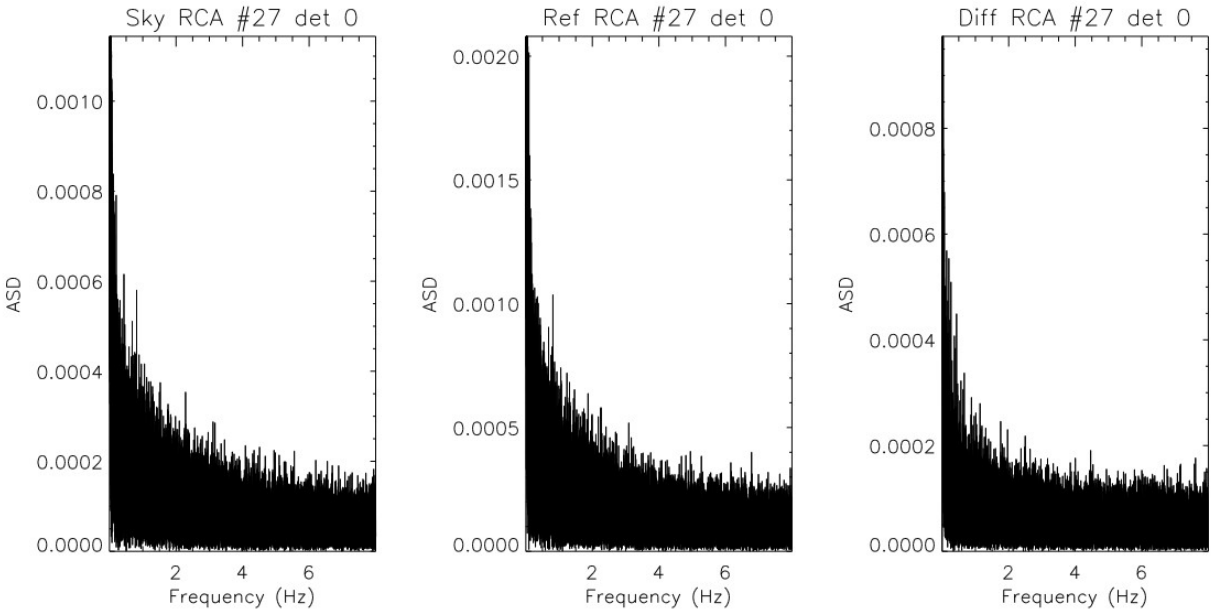


Figure 14 – Example of amplitude spectra from 70 GHz (LFI19M-00, top graph), 44 GHz (LFI24M-00, middle graph) and 30 GHz channels (LFI27M-00, bottom graph)

The only exception is LFI22M, which shows a marginal trace of the anomalous spike in the differenced data spectrum.

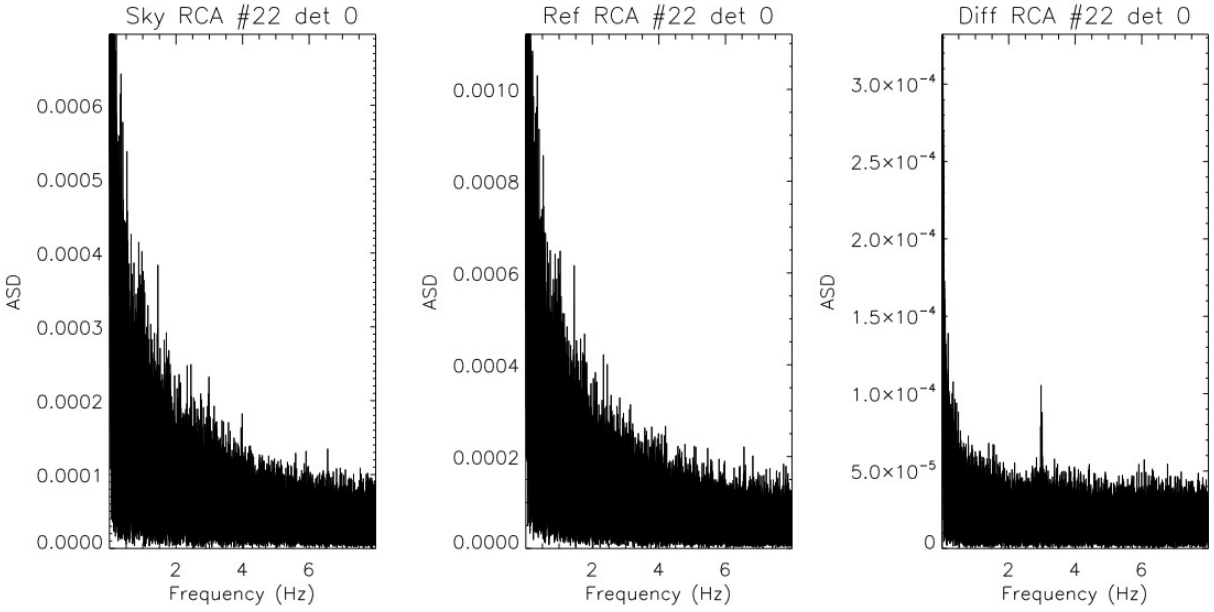
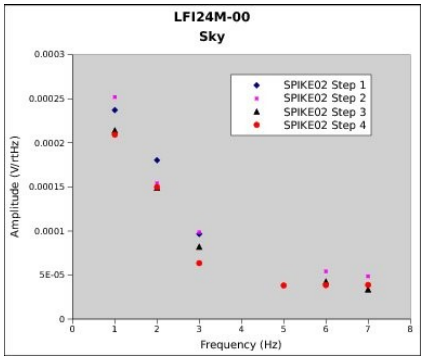
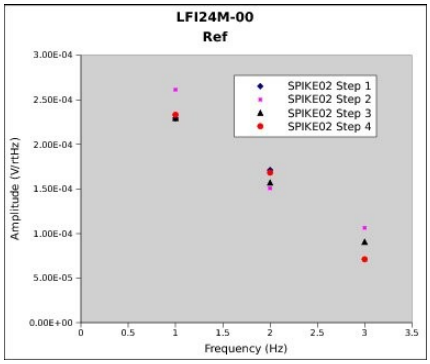
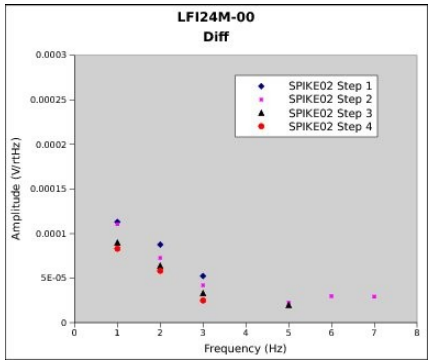


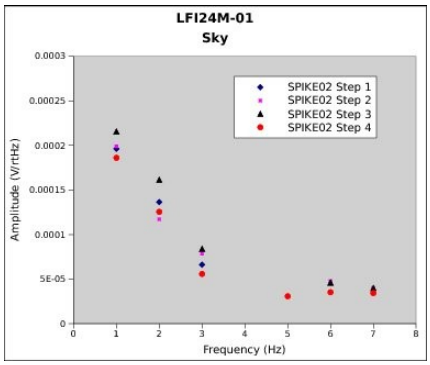
Figure 15 – Anomalous spike in LFI22M-00, visible in the spectrum of differenced data.

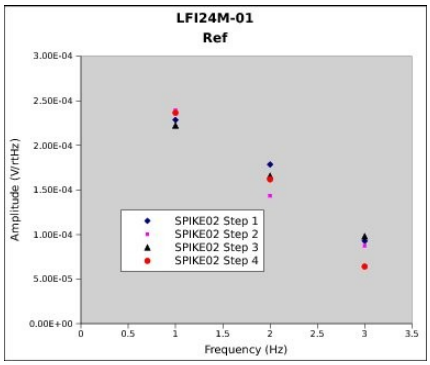
Finally we have compared the spikes in the 44 GHz channels in frequency and amplitude for all the 4 phase switch configurations. This comparison is reported in the series of plots presented below. We can see that spikes are generally the same for all four phase switch states, with differences that lay within the repeatability of this kind of test. Notice that for some channels in LFI26 no spikes were visible at all.

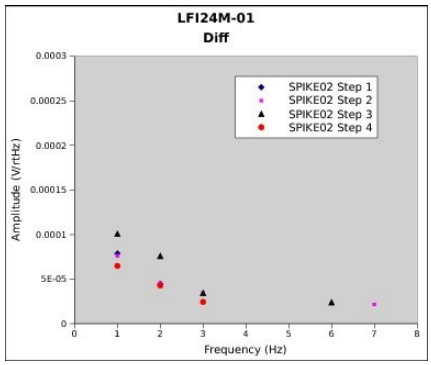

LFI24M-00
Sky
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)

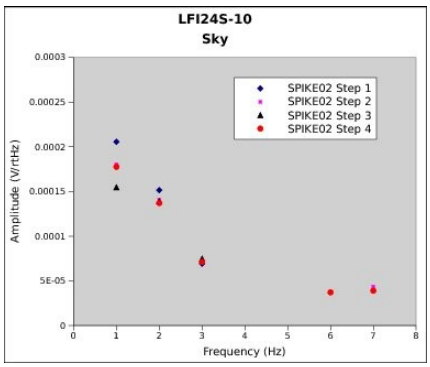

LFI24M-00
Ref
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)

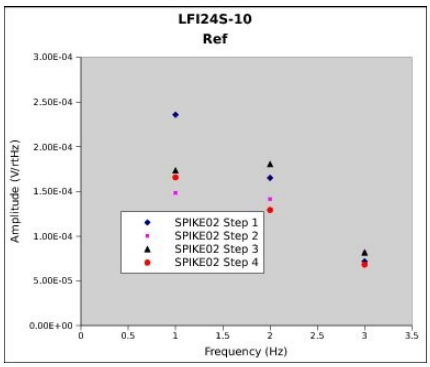

LFI24M-00
Diff
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)

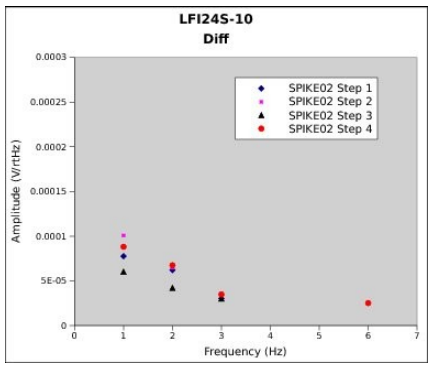

LFI24M-01
Sky
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)

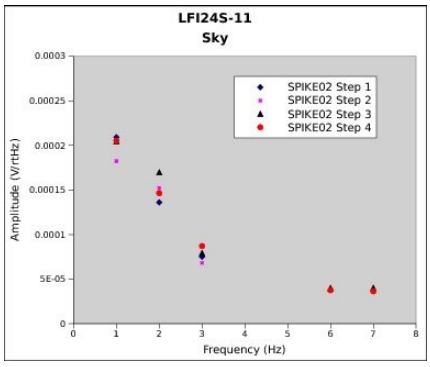

LFI24M-01
Ref
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)

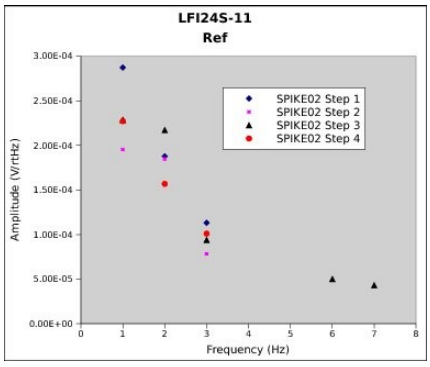

LFI24M-01
Diff
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)

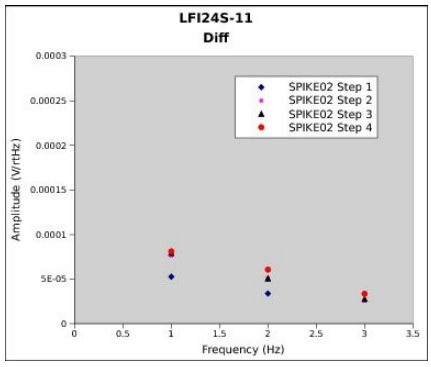

LFI24S-10
Sky
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)

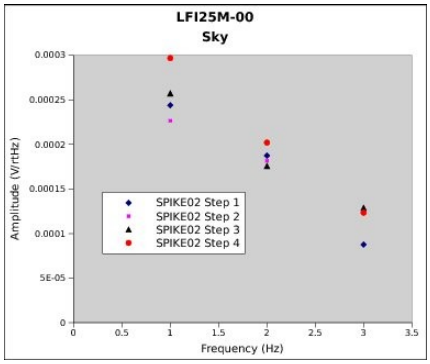

LFI24S-10
Ref
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)

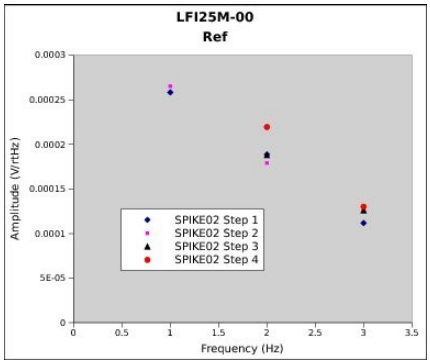

LFI24S-10
Diff
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)

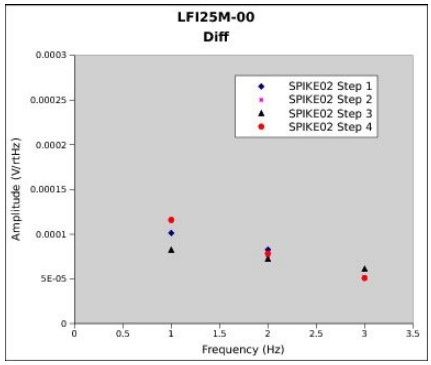

LFI24S-11
Sky
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)

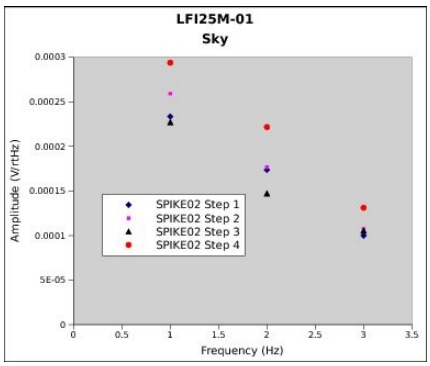

LFI24S-11
Ref
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)

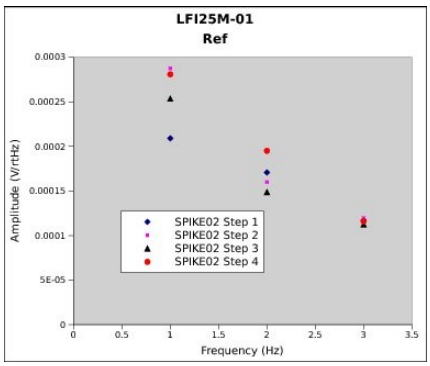

LFI24S-11
Diff
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)

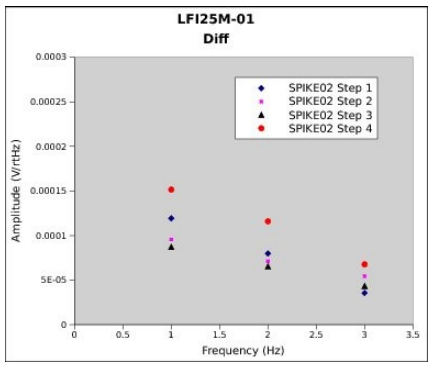

LFI25M-00
Sky
Amplitude (V/rtHz)
Frequency (Hz)
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4

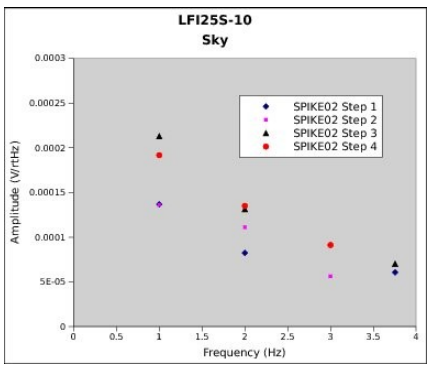

LFI25M-00
Ref
Amplitude (V/rtHz)
Frequency (Hz)
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4

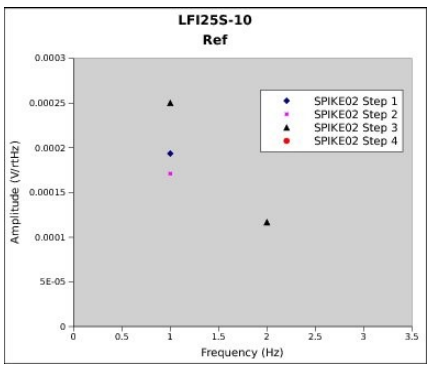

LFI25M-00
Diff
Amplitude (V/rtHz)
Frequency (Hz)
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4

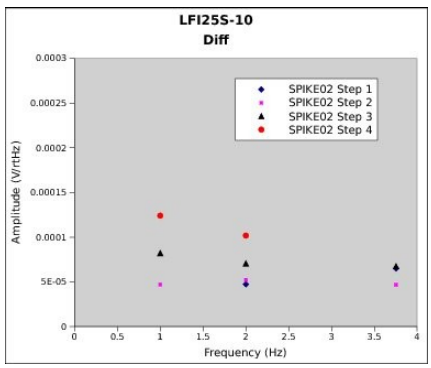

LFI25M-01
Sky
Amplitude (V/rtHz)
Frequency (Hz)
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4

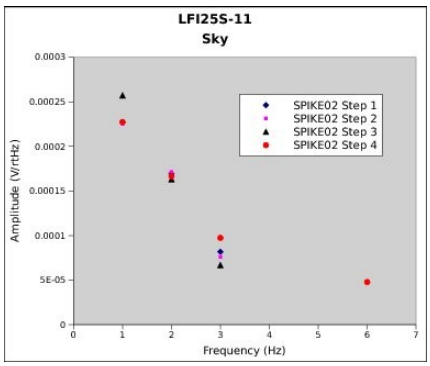

LFI25M-01
Ref
Amplitude (V/rtHz)
Frequency (Hz)
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4

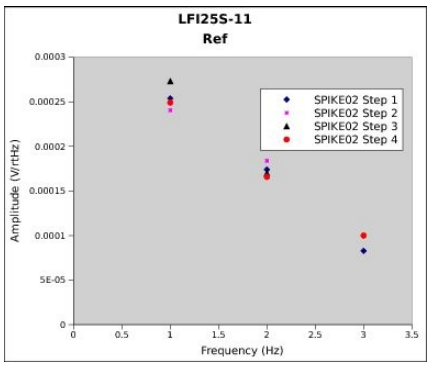

LFI25M-01
Diff
Amplitude (V/rtHz)
Frequency (Hz)
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4

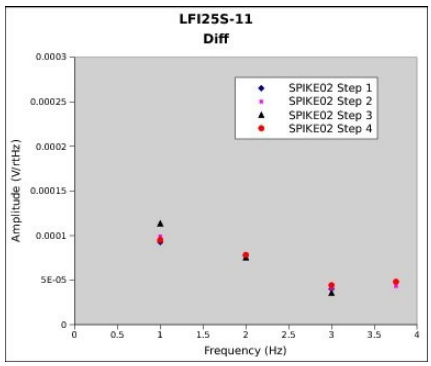

LFI25S-10
Sky
Amplitude (V/rtHz)
Frequency (Hz)
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4

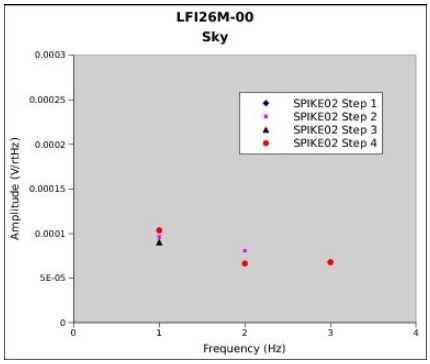

LFI25S-10
Ref
Amplitude (V/rtHz)
Frequency (Hz)
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4

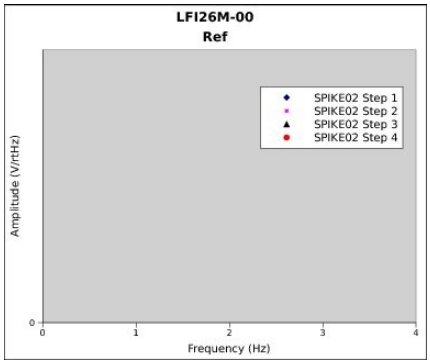

LFI25S-10
Diff
Amplitude (V/rtHz)
Frequency (Hz)
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4

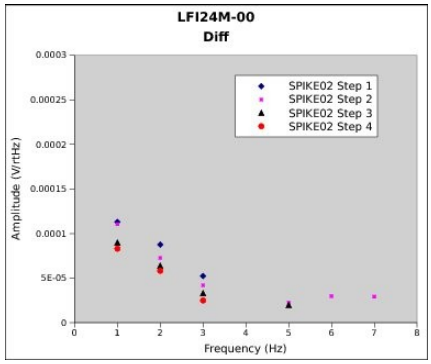

LFI25S-11
Sky
Amplitude (V/rtHz)
Frequency (Hz)
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4

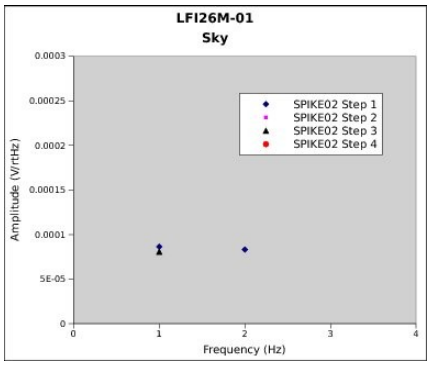

LFI25S-11
Ref
Amplitude (V/rtHz)
Frequency (Hz)
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4

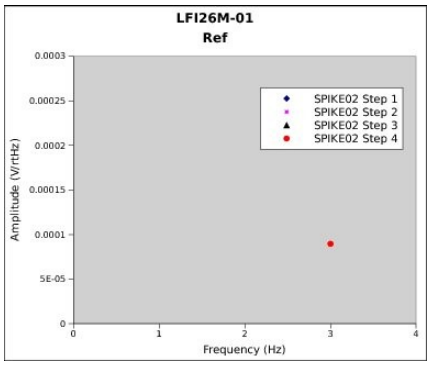

LFI25S-11
Diff
Amplitude (V/rtHz)
Frequency (Hz)
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4

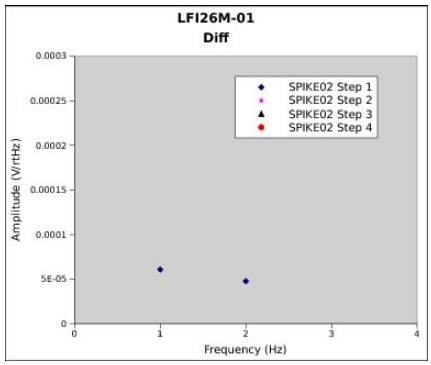

LFI26M-00
Sky
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)

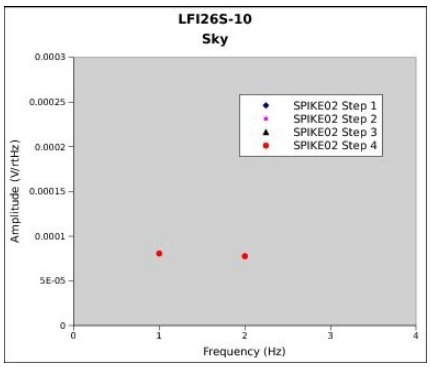

LFI26M-00
Ref
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)

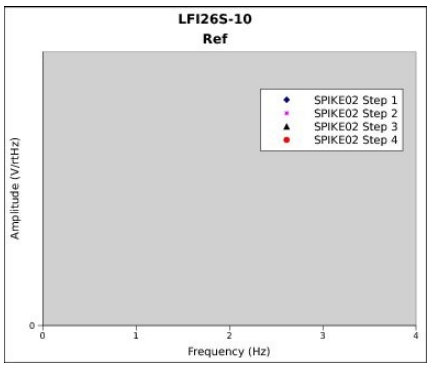

LFI24M-00
Diff
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)

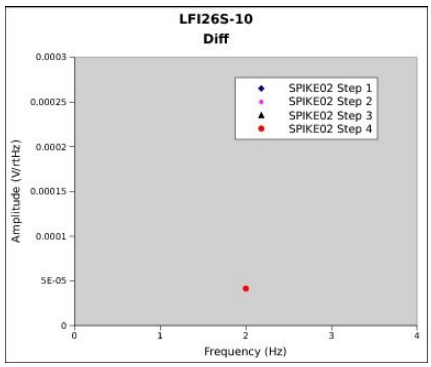

LFI26M-01
Sky
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)

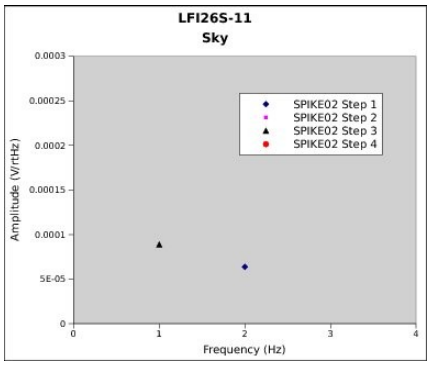

LFI26M-01
Ref
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)

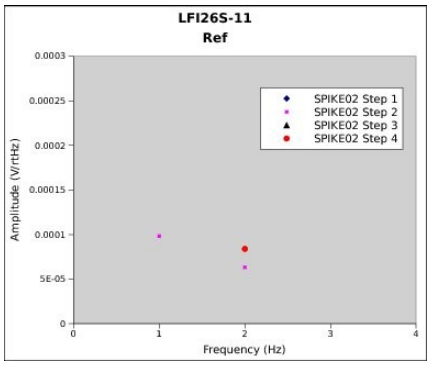

LFI26M-01
Diff
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)

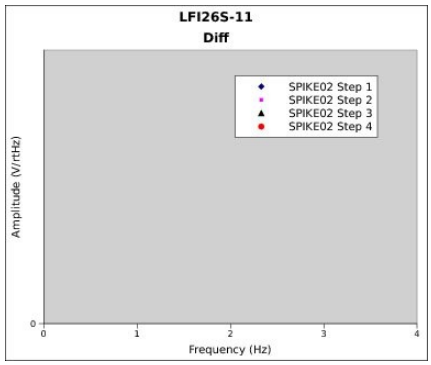

LFI26S-10
Sky
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)


LFI26S-10
Ref
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)


LFI26S-10
Diff
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)


LFI26S-11
Sky
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)


LFI26S-11
Ref
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)


LFI26S-11
Diff
SPIKE02 Step 1
SPIKE02 Step 2
SPIKE02 Step 3
SPIKE02 Step 4
Amplitude (V/rtHz)
Frequency (Hz)

7 Spikes produced by the DAE in nominal conditions (SPIKE03)

This test is aimed at the characterisation of the DAE frequency spikes when the full instrument is on and in nominal conditions. It consists of two acquisitions with the LFI in nominal mode, one with the DAE HK sequencer off and the second one is conducted with the DAE HK sequencer on.

The objectives of this test is to check for 1Hz frequency spikes and build spike templates for frequency domain removal

7.1 Test Execution

7.1.1 Test configuration

The test configuration is the following

SCOS 2K EGSE 3.1 Release 1.2
RTSILib version 1.0
RTSI Client version 1.2
LEVEL1 (TMH/TQL) version 5.1
LIFE Machine version OM 3.00
IDIS 2.7.3.4

LFI Personnel involved during the test is:

LFI Instrument Operation Manager	Anna Gregorio (UniTs anna.gregorio@ts.infn.it)
LFI Calibration Scientist	Aniello Mennella (UniMi aniello.mennella@fisica.unimi.it)
LFI CPV Manager	Francesco Cuttaia (IASF-BO cuttaia@iasfbo.inaf.it)
Test leader	Aniello Mennella
LFI IOT	Anna Gregorio, Aniello Mennella, Francesco Cuttaia, Cristian Franceschet, Chris Butler, Marco Frailis, Samuele Galeotta, Andrea Zacchei
Industry support	Paola Battaglia

7.1.2 Pass-fail criteria, verification matrix

CPV P_PVP_LFI_0027_01
July, 30-31st 2009 DoY 211-212 OD 78-79
Duration 16.00.00
Test name: Spike test 03
Test objectives: Once the LFI is in nominal configuration with final settings (biases and science processing) this test will used for a reference point because the same test was performed on ground during TV-TB test campaign.

Verification matrix					
Check	Passed?			Recovered?	
	Yes	No	Notes	Yes	No
No unexpected events packets	Yes				
No unexpected features	Yes				
Data saved and stored at DPC	Yes				

7.1.3 Procedure/ Test sequence and environmental conditions

7.1.3.1 Test procedure

The complete procedure is reported in the table below

Step	Description	START REF.	DURATION	Time (UTC)	RCA	YES	NO	Notes
1	Spike Test 3 (UM § 13.1.2.1.1)	0.00.00		7/29/09 23:55				
1,1	Acquire Data (8 hours)	0.00.00	8:00:00	7/30/09 7:55	All	yes		
1,2	Disable DAE HK Sequencer	8:00:00	0:00:01	7/30/09 7:55		yes		
1,30	Acquire Data (8 hours)	8:00:01	8:00:00	7/30/09 15:55		yes		
1,4	Enable HK Sequencer	16:00:01	0:00:01	7/30/09 15:55		yes		
1,5	Apply Default DAE Configuration as current configuration	16:00:02	0:00:01	7/30/09 15:55		yes		
1,6	end of the test	16:00:03		7/30/09 15:55				

7.1.3.2 Temperatures

In Figures 16, 17 and 17 we plot the FEU, BEU and 4K cooler temperatures recorded during the SPIKE-03 test. The gap in housekeeping data is caused by the switch off of the DAE housekeeping sequencer during the second part of the test.

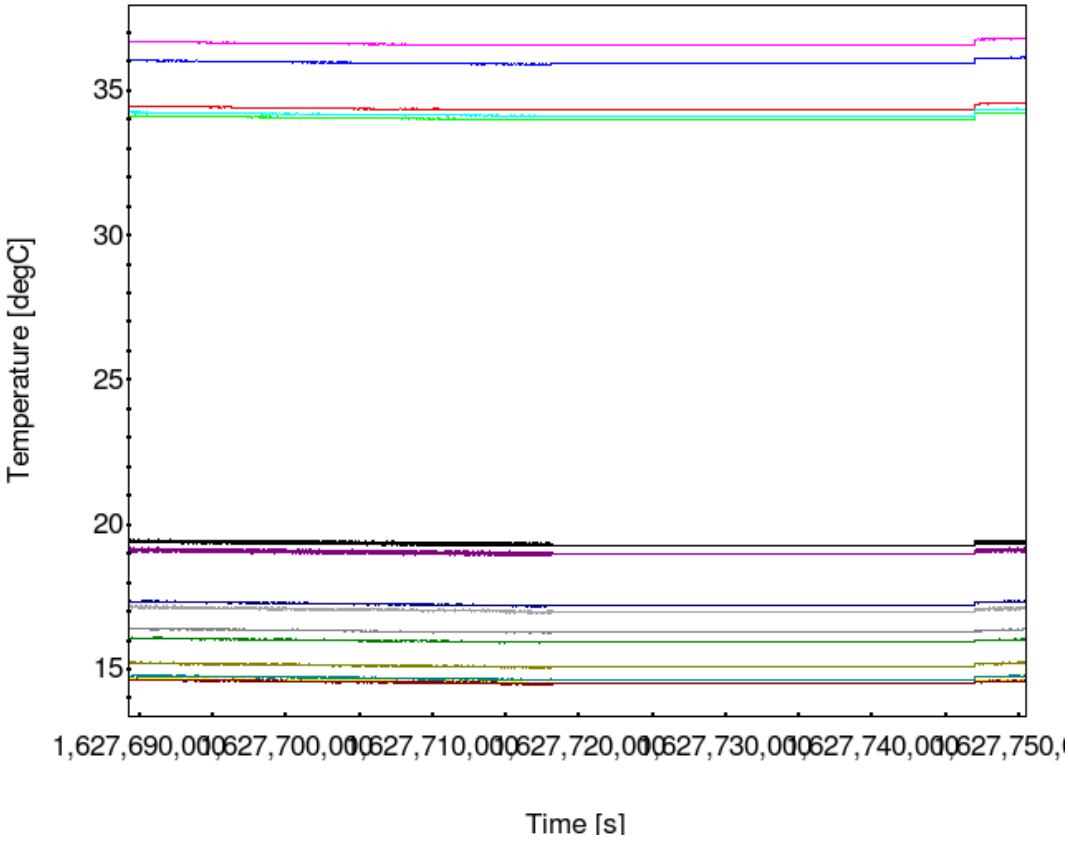


Figure 16 – BEU temperatures during the test.

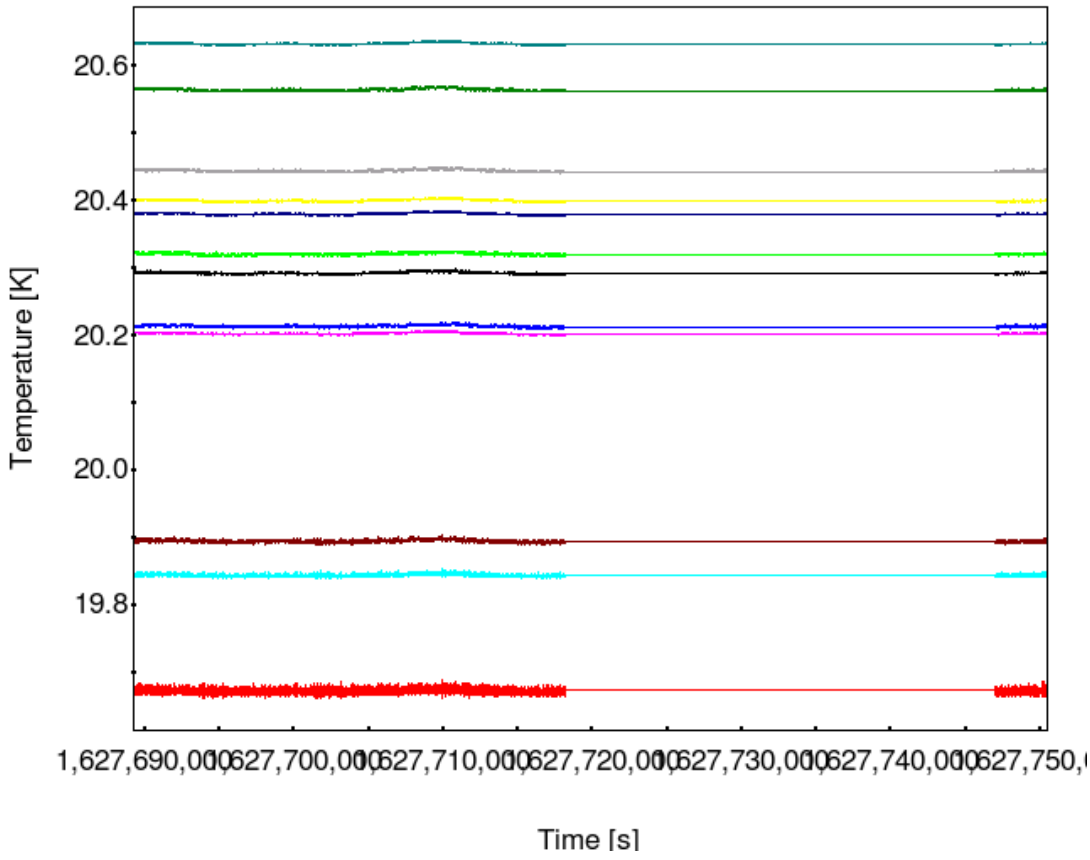


Figure 17 – FEU temperatures during the test.

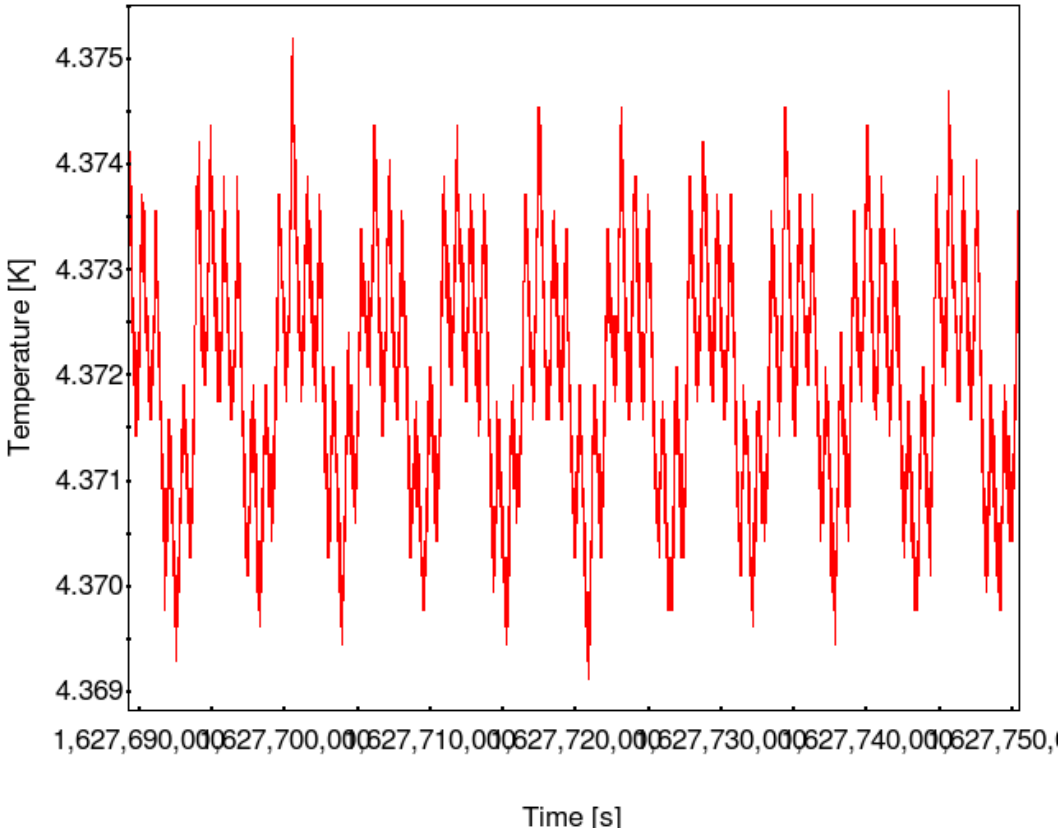


Figure 18 – 4K temperature during the test.

7.1.3.3 Bias and DAE configuration

Front-end bias, DAE and REBA configuration was set in the nominal configuration derived after tuning.

7.1.4 Data Analysis

Frequency spikes were not detectable in the power spectra during this test. Appendixes 8 and 9 report the full set of power spectra from differenced data and undifferenced data (reference load) acquired with the DAE housekeeping sequencer on. These plots show that 1 Hz spikes are not visible, as was expected from CSL data. Two examples are provided in Fig. 19.

Spike templates, therefore, cannot be derived from this test. Longer data acquisition will be needed to reduce the noise level and highlight the 1 Hz signal in time and/or frequency domain. This will be done during the First Light Survey and nominal operations.

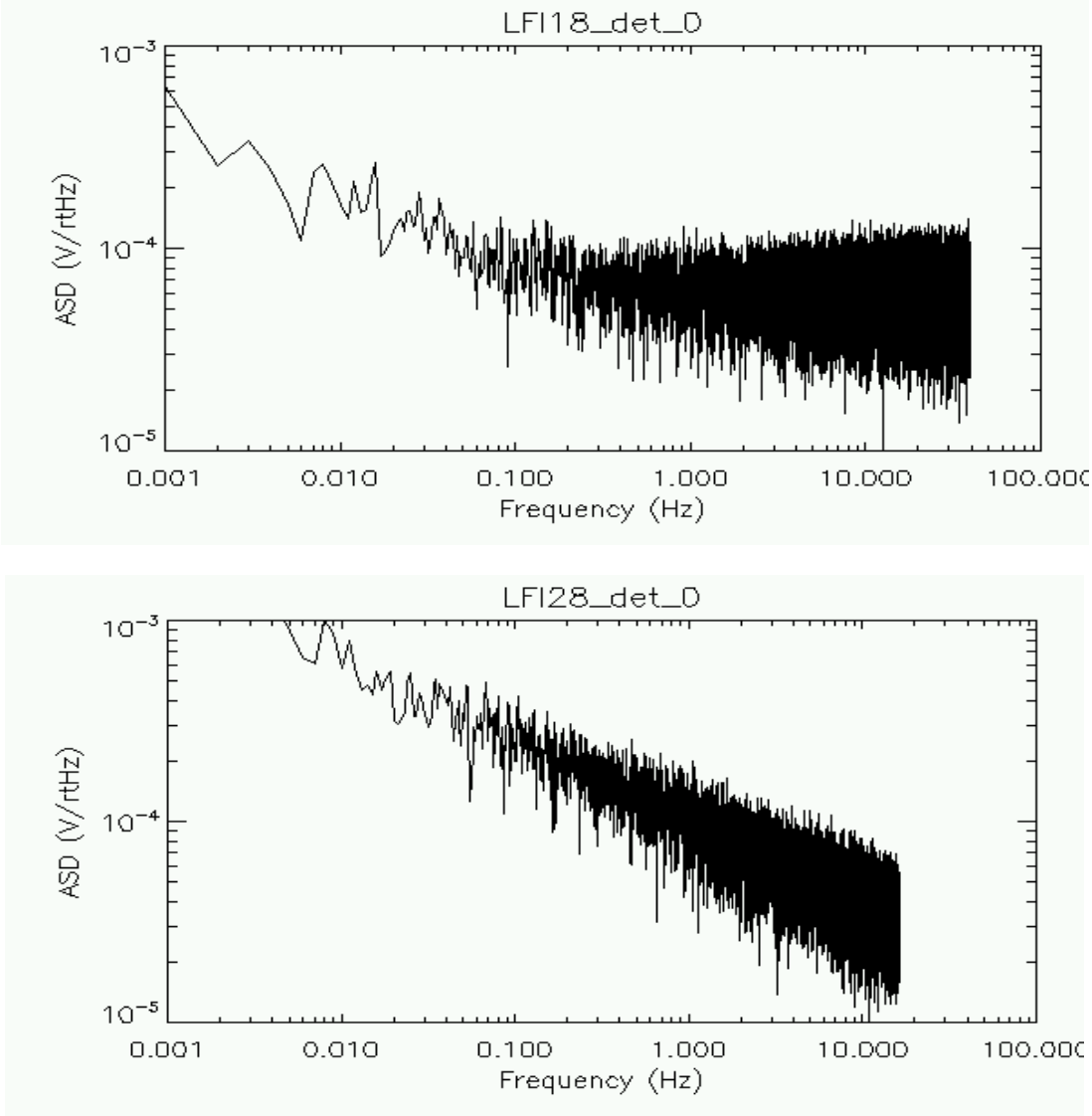


Figure 19 – Example of amplitude spectra from 70 GHz (LFI18M-00, top graph) differenced data and 30 GHz (LFI28M-00, bottom graph) undifferenced data. No 1 Hz spikes are visible.

8 Conclusions and recommendations

8.1 SPIKE-01

The test was run successfully and the results confirm the repeatability of frequency spikes between ground and CPV tests.

8.2 SPIKE-01bis

The test was run successfully and the results confirm the repeatability of frequency spikes between ground and CPV tests.

8.3 SPIKE-02

The test was run successfully and the results confirm that frequency spikes are independent of the radiometer phase switch configuration.

8.4 SPIKE-03

The test was run successfully and the results show that 1 Hz spikes are not detectable when the instrument is working in its nominal configuration.

Longer datasets will be necessary to reduce receiver noise and detect the effect in time and/or frequency domains.