CONSERT Operations Report

Close Observation
Separation Descent Landing
& First Science Sequence

CHANGE RECORDS

ISSUE	DATE	EVOLUTION	AUTHOR
1.0	26/11/14		Y. Rogez
1.1	09/01/15	Corrections from CONSERT ops team	Y. Rogez
1.2	22/12/16	Added MTP8 operation (16/10/2014 close observation sequence)	Y. Rogez
1.3	13/07/17	MTP8 sections wasn't finalized, now done.	Y. Rogez
1.4	26/10/17	MTP8 definition completed.	Y. Rogez

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1 Introduction

This document is the technical report of CONSERT operations from ROSETTA and PHILAE separation (12 nov. 2014) to the end of PHILAE first science sequence (14 nov. 2014). It also describes operations during the close observation phase (16 oct. 2014).

It includes:

- Close Observation period (MTP8 – 16/10/2014, also PDCS in archive)
- Separation Descent Landing (SDL) and First Science Sequence (FSS) block 1 (12/11/14 08:30:00 to 13/11/14 05:45:00) considered as one operational sequence for CONSERT.
- FSS block 6
- FSS final block

Notes
Scale references are arbitrary for power in dB in this document figures.

Applicable documents

[AD 1]

Reference documents

[RD 1] RO-OCN-TN-3850 Stop and start procedure V1-0.doc
[RD 2] RO-OCN-TN-3864 - Consert Save Mode.docx
[RD 3] LIOR_CONSERT_MTP009_SDL-FSS_V2.doc
[RD 4] Schematicview_SDL_FSS_14_11_2014.pdf
[RD 5] LIOR_CONSERT_MTP008_Block6_V2.doc

2 MTP8 – Close Observation CONSERT Operations overview

2.1 Main actions

CONSERT instrument has been operated during MTP8 period, as planned in [RD5]. MTP8 stands for the Mid-Term Planning n°8 of ROSETTA operations. It corresponds to the close observation phase before Philae Separation Descent and Landing. On an archive point of view, it corresponds to the PDCS (“Pre-Delivery Calibration Science”) phase.

The objective of this operation is to perform a mono-static radar sounding of the comet nucleus surface. The procedure executes a ping-pong between OCN and LCN.

OCN and LCN were operated together. Philae was still attached to Rosetta S/C.

Date	Time (UTC)	Duration	Operation description
16/10/2014	11:00:00	03:00:00	MTP8

Table 1 : CONSERT operations summary for MTP8

2.2 Data analysis

2.2.1 Performances

	MTP8
OCN alone	
Noise Level (dB)	N/A
GCW	N/A
Current (mA)	N/A
OCXO	N/A
Main Spectral Line (MHz)	N/A
Main Spectral Line (dB)	N/A
S/P position (°)	N/A
Temperature Range	N/A
Ping-pong	
S/P position (°)	1.8/-1.8 to -11.5/11.5 transition around 11:00:00 and 14:00:00
Ping-pong OCN signal	
Peak level (dB)	39.57 to 26.89
GCW	59 to 0
Current (mA)	95 base 4032 sounding
OCXO	131
Peak Position	N/A
Temperature Range	10/13.5
Ping-pong LCN signal	
Peak level (dB)	22.24 to 39.49
GCW	28 to 7
Current (mA)	115
OCXO	131
Temperature Range	-29.1/-12.5

Table 2 : Performances overview

- Temperatures on LCN are low (but still in operational range).
- Currents are roughly the same.

2.2.2 Solar panel positions

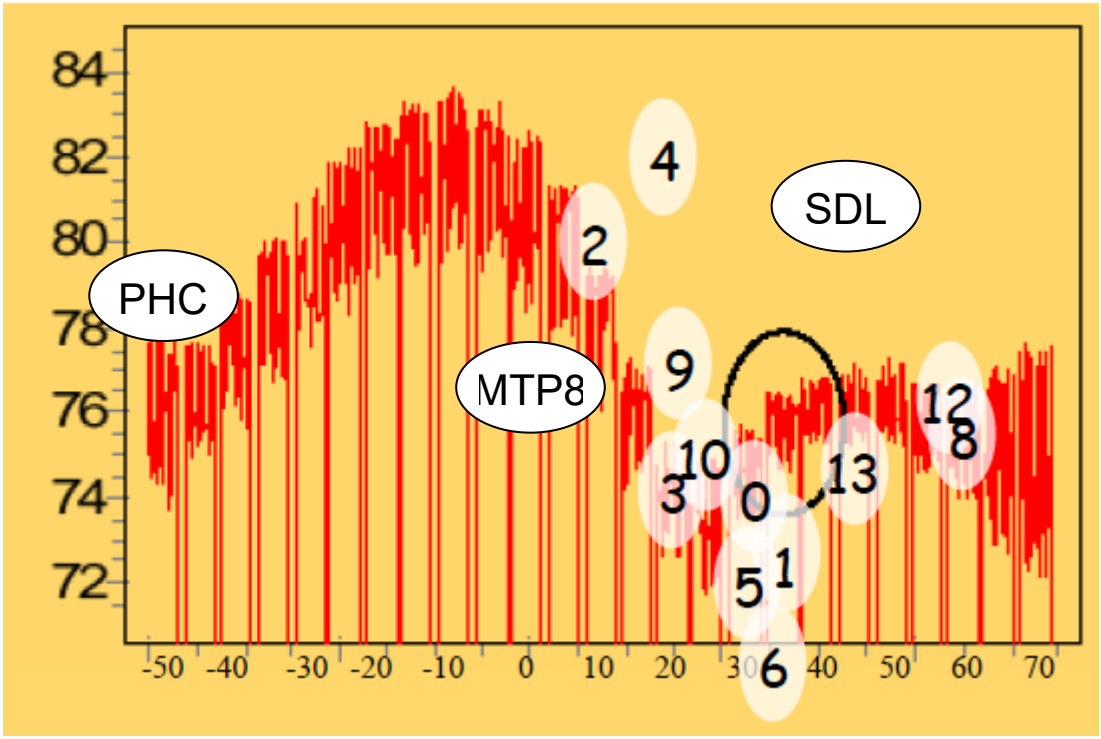

Figure 1 : CONSERT power versus S/P position

One can notice that during this operation sequence, the solar panels were in a very different angular position (~1.8°) by comparison to ones in other tests and science operation phases.

2.2.3 Temperature

		Ocxo Start	Ocxo end	Digi Start	Digi End	Ebox Start	Ebox end
MTP8	**OCN**	15.3	23.3	11.7	20.3	13.1	10.2
	LCN	-20.5	-1	-30.0	-6	-29.2	-16.8

Table 3 : Temperatures for MTP8

2.2.4 Telemetry and data integrity

No lost packets on OCN and LCN.

2.2.5 OCXO

Ping-Pong test	SDL & FSS Block 1
OCN ocxo	131
LCN ocxo	131

Table 4 : OCXO values after tuning

OCXO values when tuning during MTP8 is similar to the one observed during the cruise and PHC.
This means that there is no shift in frequency of OCN OCXO regarding to the LCN one.

2.3 Detailed operational analysis

Operation is successful (12/11/2014 08:21:55 to 13/11/2014 05:42:55)

2.3.1 Timing analysis

		Operation relative times	Expected stack UTC	Observed OBT	Observed UTC time	OCN time
1	OCN ON by OBCP	00:00:00	**11:00:00**			
2	LCN ON by AMST	(1)+ 00:00:05	**11:00:05**			
3	LCN first HK	(2)+ 00:00:15	11:00:20	10:59:13	11:00:23	
4	OCN ping REP			10:59:41	11:00:51	
5	OCN first HK	(1)+ 00:01:05	11:01:05	10:59:58	11:01:08	
6	OCN MT update	(1)+ 00:02:00	**11:02:00**			
	ACK			11:00:49	11:01:59	
7	LCN MT update	(2)+ 00:02:05	**11:02:10**			
	ACK CDMS			11:01:00	11:02:10	
	ACK LCN			11:01:00	11:02:10	
8	End Tuning	(2)+ 00:07:00				
	OCN EVT REP		11:07:05	11:05:57	11:07:07	
	LCN EVT REP		11:07:05	11:05:58	11:07:08	
9	Sounding	(8)+ 00:01:00	11:08:08			
	OCN EVT REP			11:06:56	11:08:06	00:00:59
	LCN first snd			11:10:27	11:11:37	00:04:29
12	End sounding					
	OCN Last snd	(9)+ 02:47:58	13:56:06	13:54:56	13:56:06	13:56:06
	LCN Last snd		no expected date	13:45:41	13:46:51	
	OCN EVT REP			13:54:56	13:56:06	
13	LCN dump					
	cdms ACK					
14	OCN CSA Dump					
	ACK					
15	OCN Last HK			13:59:01	14:00:11	
16	OCN OFF on OBCP	(14)+ 00:00:30	**14:00:10**			

Table 5 : SDL/FSS operations timeline

Timings are OK.

2.3.2 Clock synchronization accuracy

No CSA dumped.

2.3.2.1 Data integrity

All data is OK, no lost packet.

3 SDL+FSS CONSERT Operations overview

3.1 Main actions

CONSERT instrument has been operated during SDL and FSS block 1 period, as planned in [RD 3] and [RD *1*].

Three additional operations have been performed during FSS block 6 and block final, as mentioned in [RD 4]. These were executed interactively by PDOP, based on a special commanding mode defined in [RD 2]. These short measurements were done for operational purposes, to help finding Philae by ranging evaluation.

In all cases, OCN and LCN were operated together.

Date	Time (UTC)	Duration	Operation description
12/11/2014	08:21:55	06:29:42	SDL
12/11/2014	14:51:37	04:04:58	(CONSERT wait mode)
12/11/2014	18:56:35	10:46:20	FSS Block 1
13/11/2014	18:00:00	00:45:00	FSS Block 6.1
14/11/2014	08:00:00	04:45:00	FSS Block 6.2
14/11/2014	22:00:00	01:05:00	FSS Block FINAL

Table 6 : CONSERT operations summary for SDL/FSS

3.2 Data analysis

3.2.1 Performances

	SDL	FSS Block 1	FSS Block 6.1	FSS Block 6.2	FSS Block Final
OCN alone					
Noise Level (dB)	N/A	-20	-19.5	-19.5	-19
GCW	N/A	0	0	0	0
Current (mA)	N/A	95	93.7	93.7	93.7
OCXO	N/A	130	130	130	130
Main Spectral Line (MHz)	N/A	88.6, 93.3	88.6, 93.3	88.6, 93.3, 87.8	88.6, 93.3
Main Spectral Line (dB)	N/A	1	0	-1	-2
S/P position (°)	N/A	-49.8/49.8	-5.7/5.7	-3/3	1.3/-1.3
Temperature Range	N/A	-8.9	11.1	10.1	10.6
Ping-pong					
S/P position (°)	46.8/-46.8 to -57.6/57.6 transition around 10:00:00	-45/45 to -29/29 to -75.6/75.6 to -49.8/49.8	-5.7/5.7	-3/3	1.3/-1.3
Ping-pong OCN signal					
Peak level (dB)	81.26 to 46.27	24 (max)	32.51	33.46	27.86
GCW	24 to 3	0	0/1	0/1	0
Current (mA)	95 base 355 sounding	95 base 355 sounding	88.5 base	95 base	95 base
OCXO	130	130	130	130	130
Peak Position	N/A	N/A	172	95	230
Temperature Range	2/9.5	9.3	11.1	10.1	10.6
Ping-pong LCN signal					
Peak level (dB)	81.73 to 46.78	26.12 (max)	34.78	36.1	30.18
GCW	24 to 8	6/8	2/3	1/2	0
Current (mA)	115	115			
OCXO	131	131	131	131	131
Temperature Range	5.7/31.6	36/31.6	-6.3/-5.8	-16.3/-12.4	-20.2/-19.7

Table 7 : Performances overview

Comparing to values observed in cruise phase, we notice:

- During the noise level measurement on OCN we observe a noise level higher than one measured during cruise (-23dB) due to interferences. Nevertheless this level is lower than the maximum noise level observed during PHC (-17dB).
- On the lander, we observed a huge noise (up to -5dB) pollution during SDL and FSS, significantly higher than the level observed during cruise and PHC. This noise is large band, driving the gain control at low signal. This is analyzed in details in 3.3.1
- OCXO values have not changed.
- Currents are roughly the same.

3.2.2 Solar panel positions

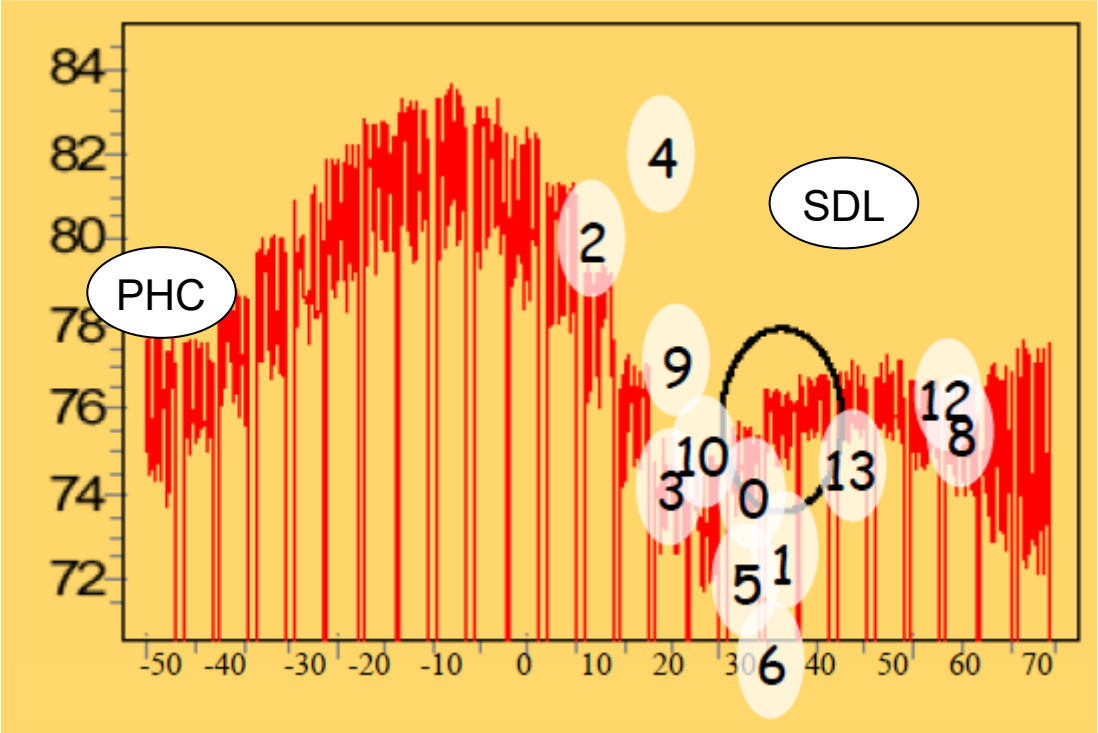

Figure 2 : CONSERT power versus S/P position from -50/+50 to +70/-70 ° by 5° steps and power measured during the different PC tests. Numbers corresponds to each PC ## phase observation.

At the beginning of SDL, when Philae is still attached to Rosetta, the peak power versus solar array position deviate significantly from the calibration curve measured during commissioning. This deviation could be due to the orientation of the main antenna dish on Rosetta.

3.2.3 Temperature

		Ocxo Start	Ocxo end	Digi Start	Digi End	Ebox Start	Ebox end
SDL	**OCN**	3.6	20.3	1.3	15.3	1.8	9.3
	LCN	5.7	31.6	1.3	29	-1.3	22.1
FSS Block 1	**OCN**	18.7	20.3	13.6	15.3	8.8	8
	LCN	34.2	31.6	31.6	27.6	24.9	11.5
FSS Block 6.1	**OCN**	20.3	21.8	15.3	17	11.1	11.1
	LCN	-1	3.6	-6	-3.4	-6.3	-5.8
FSS Block 6.2	**OCN**	21.8	21.8	17	17	10.1	10.6
	LCN	-11.4	-3.4	-14.3	-8.6	-16.3	-12.4
FSS Block FINAL	**OCN**	20.3	21.8	17	17	10.6	10.6
	LCN	-14.3	-11.4	-20.5	-17.3	-20.2	-19.7

Table 8 : Temperatures for all tests

3.2.4 Telemetry and data integrity

The data integrity is globally fine.

7 TM packets have been lost during SDL (12/11/2014).
6 TM packets have been lost during FSS Block 1 (12/11/2014).

Details on data corruptions are given in 3.3.1.3.

3.2.5 OCXO

Ping-Pong test	SDL & FSS Block 1
OCN ocxo	130
LCN ocxo	131

Table 9 : OCXO values after tuning

Note: in FSS Block 6 and FINAL, no tuning is performed between OCN and LCN which is the expected behavior. For these operations, OCXO was forced to the stable values of 130/131.

OCXO values when tuning during SDL/FSS (only one tuning is done) is similar to the one observed during the cruise and PHC.
This means that there is no shift in frequency of OCN OCXO regarding to the LCN one.

3.3 Detailed operational analysis

3.3.1 SDL + FSS Block 1

Operation is successful (12/11/2014 08:21:55 to 13/11/2014 05:42:55)

3.3.1.1 Timing analysis

		Operation relative times		Expected stack UTC	Observed OBT	Observed UTC time	OCN time	Diff
1	OCN ON by OBCP		00:00:00	**08:21:55**				
2	LCN ON by AMST	(1)+	00:00:05	**08:22:00**				
3	LCN first HK	(2)+	00:00:15	08:22:15	08:21:08	8:22:19		0:00:04
4	OCN ping REP				08:21:35	8:22:46		
5	OCN first HK	(1)+	00:01:05	08:23:00	08:21:52	8:23:03		0:00:03
6	OCN MT update	(1)+	00:01:10	**08:23:05**				
	ACK				08:21:53	8:23:04		0:00:01
7	LCN MT update	(2)+	00:01:55	**08:23:55**				
	ACK CDMS				08:22:43	8:23:54		0:00:01
	ACK LCN				08:22:44	8:23:55		0:00:00
8	End Tuning	(2)+	00:07:00					
	OCN EVT REP			08:29:00	08:27:52	8:29:03		0:00:03
	LCN EVT REP			08:29:00	08:27:53	8:29:04		0:00:04
9	Sounding	(8)+	00:01:00	8:30:04				
	OCN EVT REP				08:28:52	8:30:03	00:01:00	0:00:00
	LCN first snd				08:28:53	8:30:04	00:01:00	0:00:00
10	Patch V1							
	OCN ACK			**14:51:37**	14:50:25	14:51:36	14:51:36	0:00:01
	LCN HK			**14:51:37**	14:50:32	14:51:43	14:51:43	0:00:06
11	Restart V1							
	OCN HK			18:56:40	18:55:29	18:56:40	18:56:40	0:00:00
	LCN HK			18:56:40	18:55:28	18:56:39	18:56:39	0:00:01

12	End sounding							
	OCN Last snd			05:41:00	05:39:59	5:41:10	05:41:10	0:00:10
	LCN Last snd			no expected date	04:04:33	4:05:44		
	OCN EVT REP				05:39:59	5:41:10		
13	LCN dump							
	cdms ACK							
14	OCN CSA Dump			05:42:55				
	ACK				05:41:44	5:42:55	05:42:55	0:00:00
15	OCN Last HK				05:42:14	5:43:25		
16	OCN OFF on OBCP	(14)+	00:00:30	05:43:25				

Table 10 : SDL/FSS operations timeline

Timings are globally OK.

However, we notice an unexpected delay on LCN stop&start Patch TC, of about 6s. This has an impact on the sounding numbering consistency, as LCN made 3 more soundings than OCN at the end of SDL. In FSS Block 1, LCN sounding numbers = OCN sounding number + 3.

The OCN end of sounding time is 10s later than expected. This is due to the delay on the switch-ON of about 3 and 4 seconds for OCN and LCN. 3 soundings haven't been done during SDL, and 1 sounding was over-estimated in LIOR. This has no impact on CONSERT observation.

LCN OFF was event driven commanded relative to TD. We observe the switch OFF at a date which is consistent regarding to expectation.

3.3.1.2 Clock synchronization accuracy

OCN has started with a time delay of 3s, LCN has started with a delay of 4s.

CSA is 0.211s: OCN is turned ON before LCN.
Abs(CSA) < 5 s: OK

3.3.1.3 Data integrity

On OCN side, no corrupted data has been found.
On LCN side,

7 data corruptions have been noticed during SDL at TM numbers: 2253, 3278, 3328, 3378, 3403, 3428, 3478. All these corruption occurred on type 3 TM.

6 data corruptions have been noticed during FSS at TM numbers: 17613, 18161, 18379, 18677, 20704, 21885. Corruptions occurred on type 3 and type 1 TM.

3.3.1.4 Highlights and comments

3.3.1.4.1 SDL

Ping-pong worked successfully. It allowed CONSERT to measure distance between Rosetta and Philae, and rotational period of Philae during the descent.

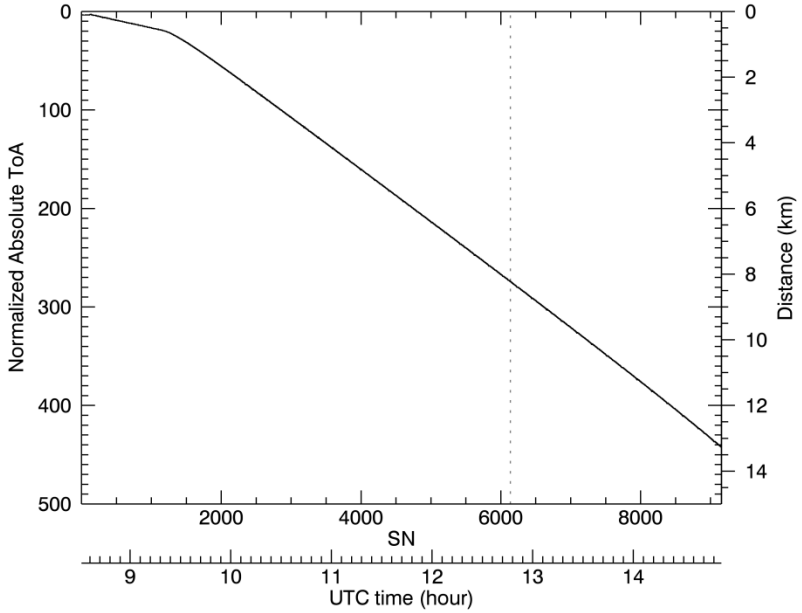

Figure 3 : Distance measurements during SDL

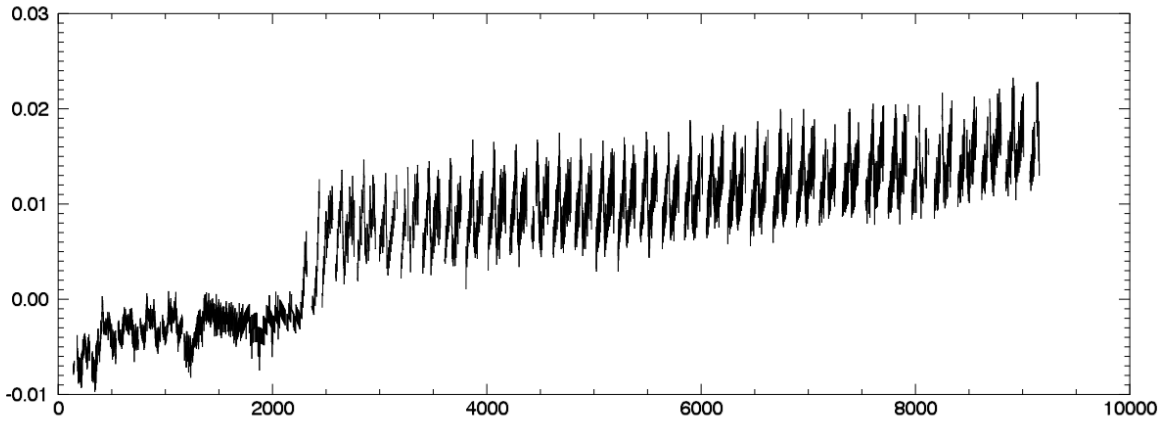

Figure 4 : CONSERT distance evaluation differences (in km) to reconstructed trajectories during SDL

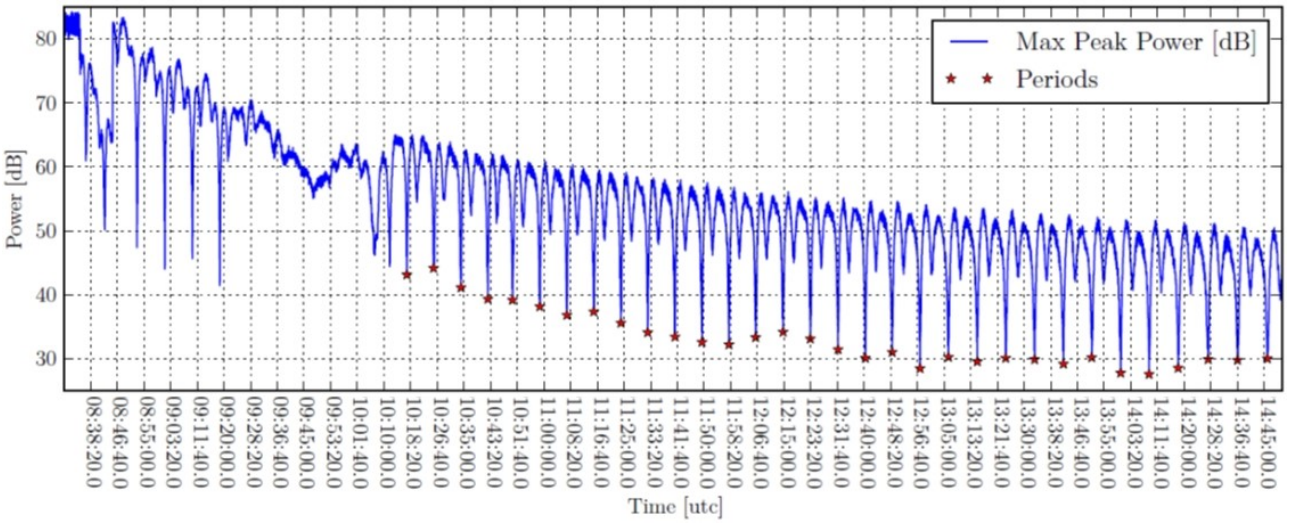

Figure 5 : Rotation period estimation during SDL

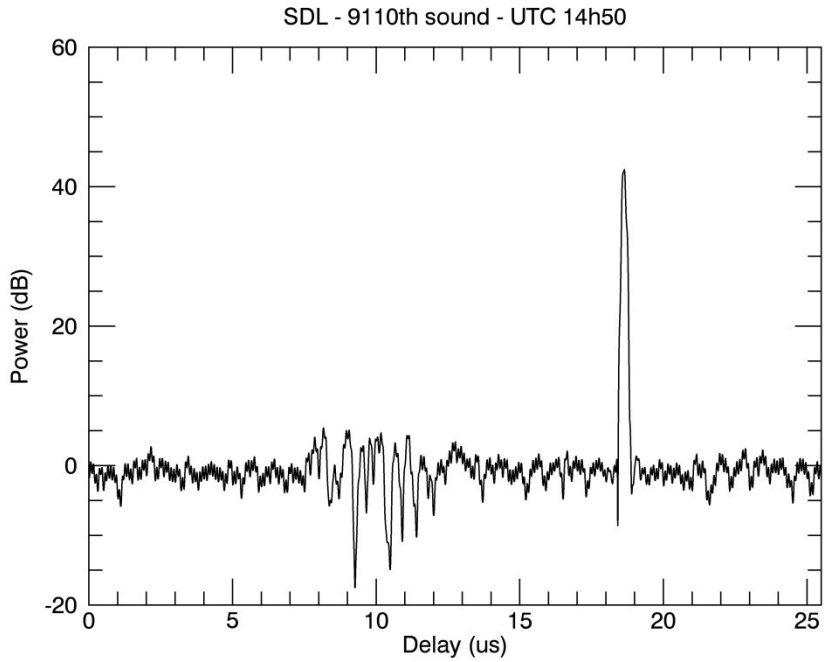

Figure 6 : CONSERT signal at the end of the descent

3.3.1.4.2 FSS

Ping-pong worked successfully in the two first hours and the three last hours. Between these two time ranges, signal to noise ratio was not sufficient to keep CONSERT transponder synchronization between LCN and OCN.

3.3.1.5 SDL and FSS noise level

During SDL and FSS we observe a strong RF pollution on the lander. This large bandwidth pollution is more than 12 dB higher than interferences level observed during cruise and drives the AGC as shown Figure 7: One can see that the mean power level on LCN that drives the AGC (upper green line) is significantly higher than the one observed on OCN.

This pollution sometimes blinds the lander receiver and limits the sensitivity of CONSERT inducing mis-synchronization of the transponder as illustrated by the Figure 8 (time signal for the same OCN and LCN sounding)

These interferences are observed during SDL and FSS 1, they are not during FSS 6 and final.

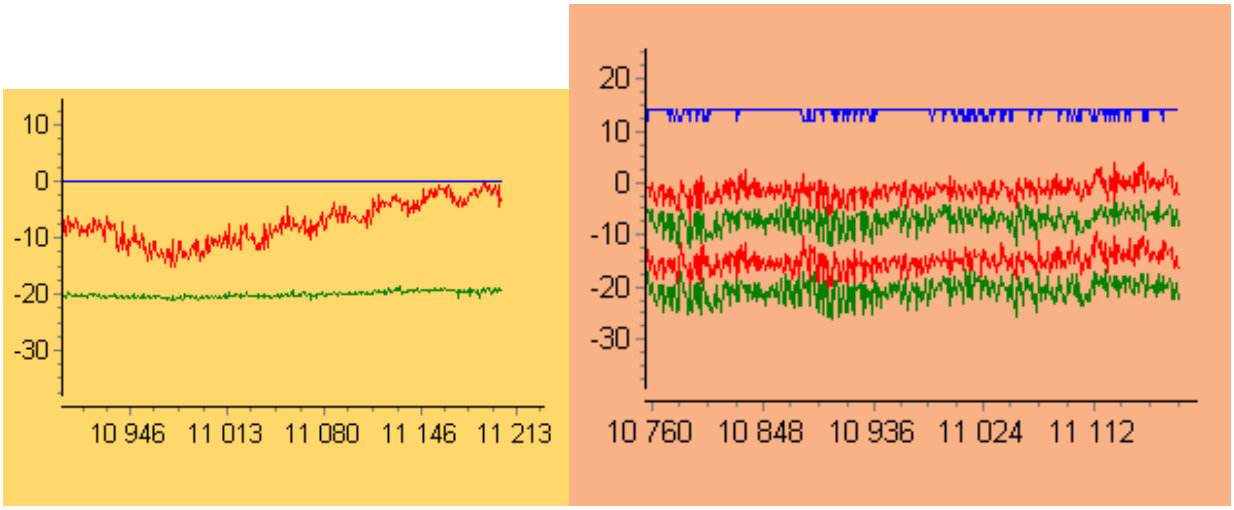

Figure 7 : FSS Block1 OCN (left) and LCN (right) power between 20:00:00 and 20:30:00

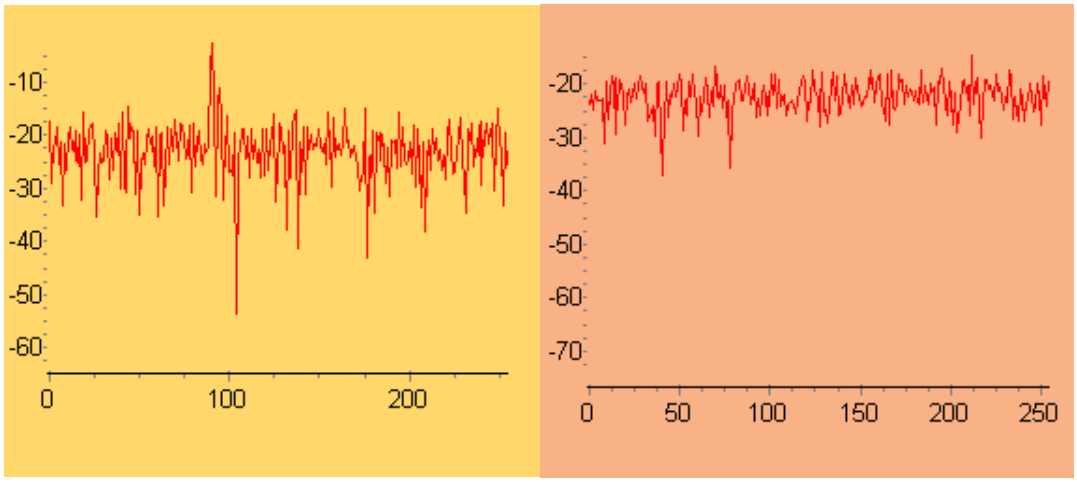

Figure 8 : FSS Block1 OCN (left) and LCN (right) signals

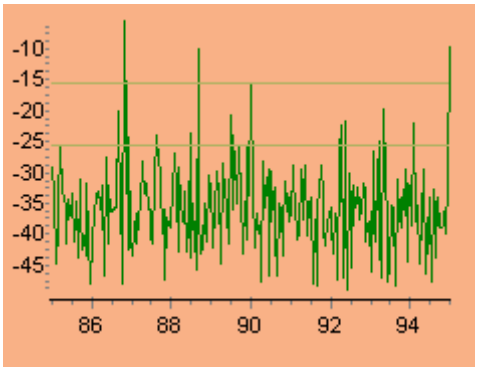

Figure 9 : LCN noise signature FSS Block1
(power in dB versus frequency in MHz)

3.3.1.6 Temperature evolution

3.3.1.6.1 SDL

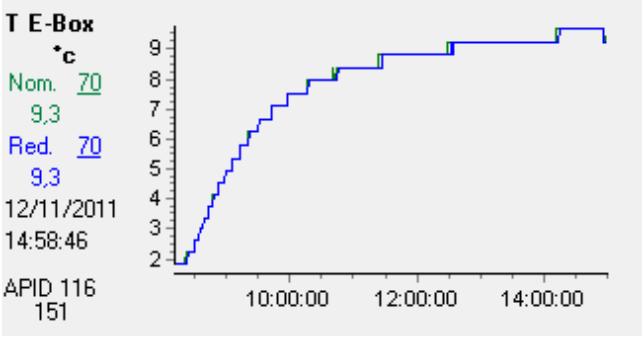

Figure 10 : SDL OCN e-box temperature

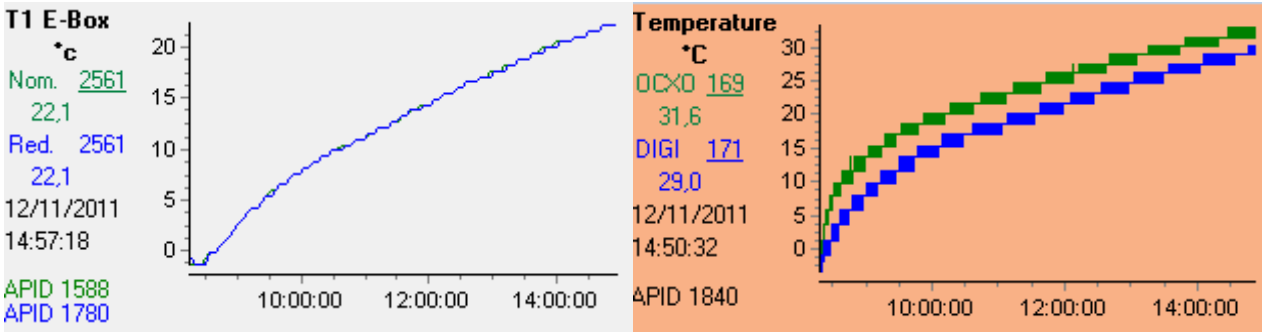

Figure 11 : SDL LCN e-box (left) and internal (right) temperature

3.3.1.6.2 FSS

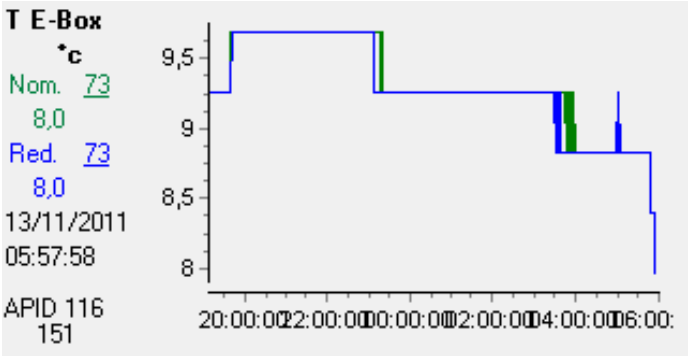

Figure 12 : FSS OCN e-box temperature

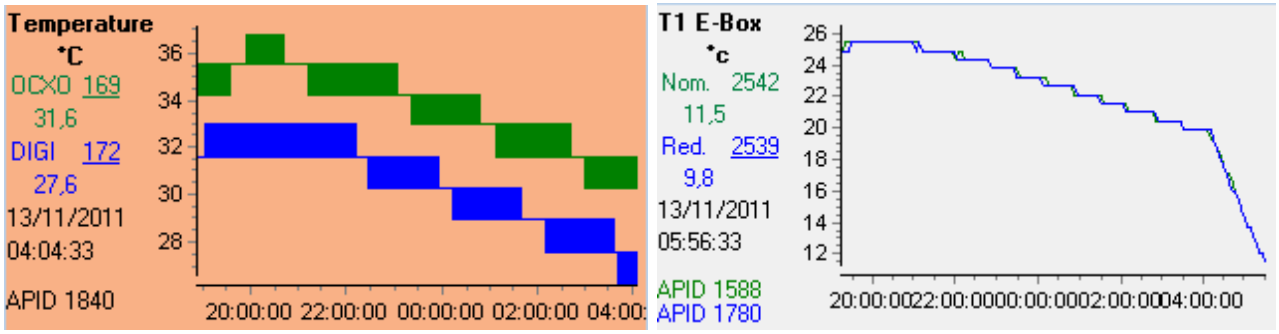

Figure 13 : FSS LCN e-box (left) and internal (right) temperature

3.3.2 FSS Block 6.1

Operation is successful (13/11/2014 18:00:00 to 14/11/2014 00:45:00)

No tuning was performed during this operation. Synchronized signal appears periodically thanks to a stroboscopic effect between OCN and LCN signals.
This operation was performed for the ranging of Philae landing area.

During this observation, 3 signal bursts were performed:

- 22:04:31
- 22:06:26
- 22:08:23

3.3.2.1 Timing analysis

Here timings are given as rough estimates from first and last HK received from instruments.

OCN was turned ON at 18:00:00 then OFF just after 21:08:00 with 4420 soundings.
LCN wasn't switched ON so a second operation has been performed.

OCN was turned ON at 21:35:00 then OFF at 00:45:00 with 4443 soundings.
LCN was turned ON at 21:55:00 then OFF at 22:10:00 with 168 soundings.

3.3.2.2 Data corruptions

No data corruption.

3.3.2.3 Ping-pong observation overview

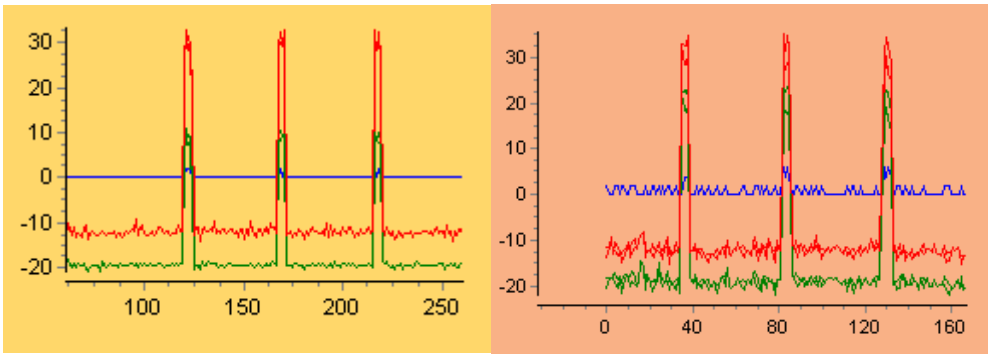

Figure 14 : OCN (left) and LCN (right) signal in FSS Block 6.1 (power in dB versus sounding number)

3.3.2.4 Highlights and comments

Below are two pictures of the noise reference level taken outside of ping-pong signal. On LCN side, we do not observe the wide band (i.e. not a single frequency line) noise level seen during SDL and FSS.

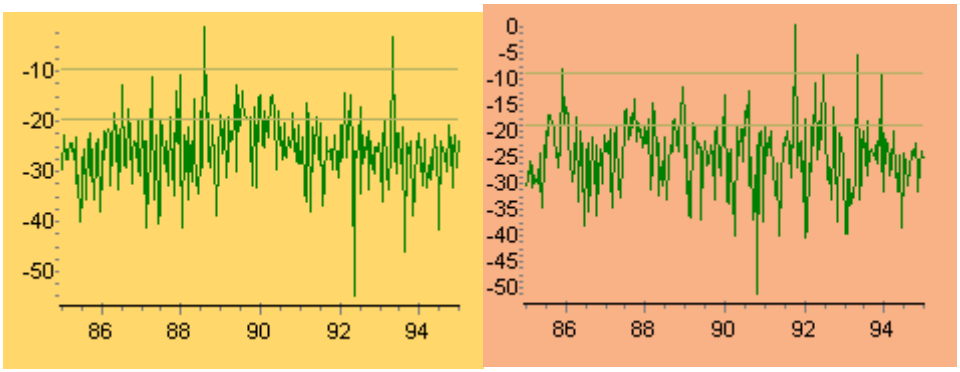

Figure 15 : OCN (left) and LCN (right) noise level in FSS Block 6.1 (power in dB versus frequency in MHz)

OCN: two main lines at 88.59 MHz and 93.3 MHz
LCN: one main line at 91.77 MHz

3.3.3 FSS Block 6.2

Operation is successful (14/11/2014 08:00:00 to 14/11/2014 12:45:00)

No tuning was performed during this operation. Synchronized signal appears periodically thanks to a stroboscopic effect between OCN and LCN signals.
This operation was performed for the ranging of Philae landing area.

During this observation, 12 signal bursts were performed:

- 10:20:55
- 10:22:51
- 10:24:51
- 10:26:42
- 10:28:42
- 10:30:41
- 10:32:37
- 10:34:35
- 10:36:31
- 10:38:27
- 10:40:27
- 10:42:22

3.3.3.1 Timing analysis

Here timings are given as rough estimates from first and last HK received from instruments.

OCN was turned ON at 08:00:00 then OFF at 12:45:00 with 6062 soundings.
LCN was turned ON at 10:12:00 then OFF at 10:42:50 with 529 soundings.

3.3.3.2 Data corruptions

No data corruption.

3.3.3.3 Ping-pong observation overview

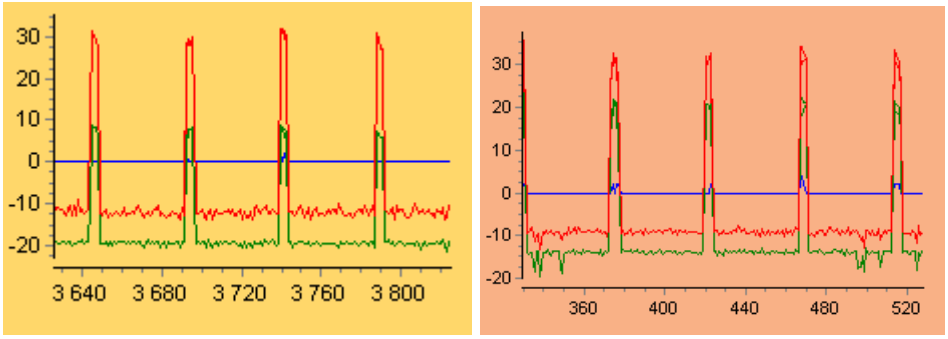

Figure 16 : OCN (left) and LCN (right) signal in FSS Block 6.2 (power in dB versus sounding number)

3.3.3.4 Highlights and comments

Below are two pictures of the noise reference level taken outside of ping-pong signal. On LCN side, we do not observe the wide band (i.e. not a single frequency line) noise level seen during SDL and FSS.

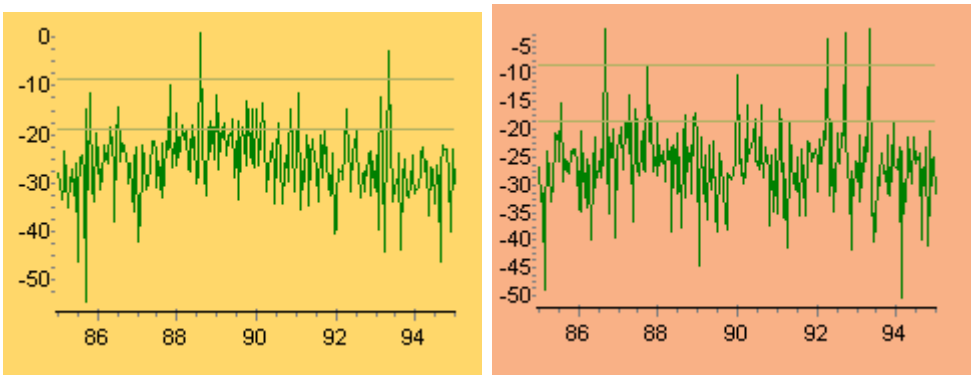

Figure 17 : OCN (left) and LCN (right) noise level in FSS Block 6.2 (power in dB versus frequency in MHz)

OCN: two main lines at 88.59 MHz and 93.3 MHz
LCN: four lines at 86.7 MHz, 92.3 MHz, 92.7 MHz, 93.3 MHz

3.3.4 FSS Block FINAL

Operation is successful (14/11/2014 22:00:00 to 15/11/2014 01:05:00)

No tuning was performed during this operation. Synchronized signal appears periodically thanks to a stroboscopic effect between OCN and LCN signals.
This operation was performed for the ranging of Philae landing area.

During this observation, 3 signal bursts were performed:

- 23:42:02
- 23:44:02
- 23:46:02

3.3.4.1 Timing analysis

Here timings are given as rough estimates from first and last HK received from instruments.
OCN was turned ON at 22:00:00 then OFF at 01:05:00 with 4297 soundings.
LCN was turned ON at 23:34:00 then OFF at 23:46:12 with 114 soundings.

3.3.4.2 Data corruptions

No data corruption.

3.3.4.3 Ping-pong observation overview

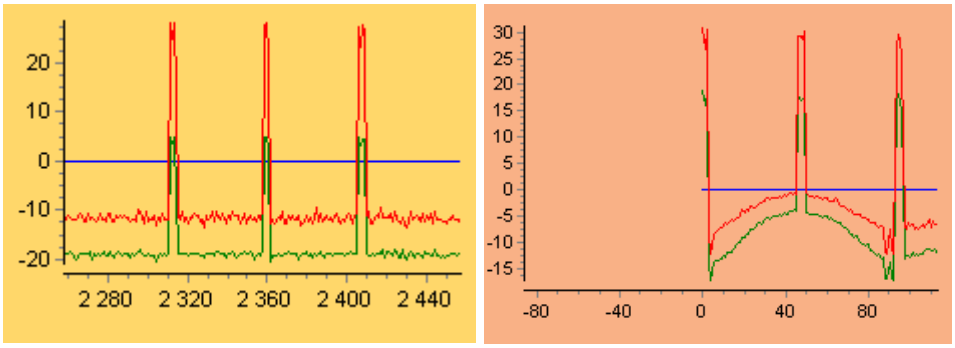

Figure 18 : OCN (left) and LCN (right) signal in FSS Block FINAL (power in dB versus sounding number)

3.3.4.4 Highlights and comments

Below are two pictures of the noise reference level taken outside of ping-pong signal. On LCN side, we do not observe the wide band noise level seen during SDL and FSS.

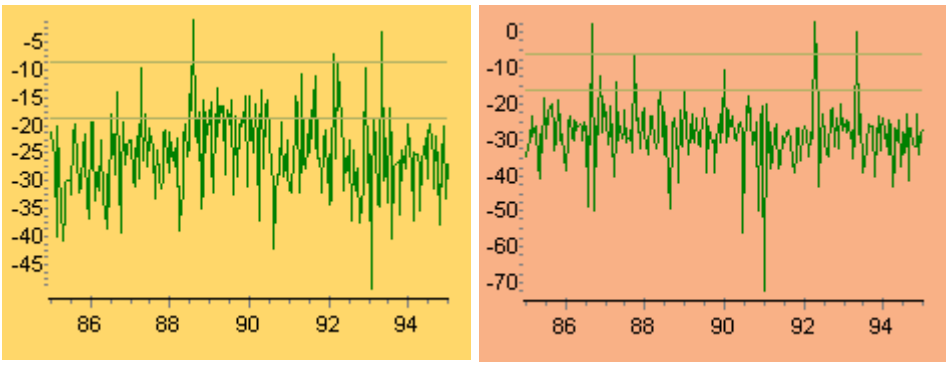

Figure 19 : OCN (left) and LCN (right) noise level in FSS Block FINAL (power in dB versus frequency in MHz)

OCN: two main lines at 88.59 MHz and 93.3 MHz
LCN: three lines at 86.7 MHz, 92.3 MHz, 93.3 MHz

4 SDL & FSS Conclusions

The Separation-Descent-Landing and First Science Sequence operations were successful for CONSERT. LCN and OCN instruments worked nominally.
CONSERT science data is available from FSS Block 1 for analysis.

Most importantly, a high noise level was observed on LCN, during SDL and FSS Block 1. This reduces the CONSERT instrument sensitivity and will make the scientific analysis more complicated for a part of the collected data. This noise level is not present during operations in FSS Block 6 and Block FINAL. **Interferences source has to be identified to secure future operations if any.**

CONSERT was used for Philae hunting, using ranging with signal from FSS block 6 and FINAL. The new method of commanding without tuning was successfully executed and provided expected results.

All instrument parameters and performances are nominal:

- Tuning was successful at beginning of SDL.
- In an operation point of view, the synchronization was successful with CSA lower than 1 second.

Timing issues:

- The LCN patch TC was received and executed 6 seconds later than expected, which induce a difference in sounding numbering in FSS Block1 data.
- OCN was switched-on 3 second late and LCN 4 seconds late, with no impact on operations.

A total of 13 TM corruptions occurred on LCN during SDL/FSS Block1.

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