



<b>Publication Year</b>	2016
<b>Acceptance in OA</b>	2020-09-07T09:05:39Z
<b>Title</b>	BepiColombo MPO PFM Radiated EMC tests at ESTEC 01/12/2015-09/12/2015 SERENA Instrument Summary Report
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<b>Publisher's version (DOI)</b>	10.13140/RG.2.2.19069.31205
<b>Handle</b>	<a href="http://hdl.handle.net/20.500.12386/27160">http://hdl.handle.net/20.500.12386/27160</a>
<b>Volume</b>	BC-SRN-TN-04108



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## BepiColombo MPO PFM Radiated EMC tests

at ESTEC 01/12/2015 - 09/12/2015

### SERENA Instrument Summary Report

**SERENA NPA-IS (Neutral Particle Analyzer - Ion Spectrometer)**



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reference	BC-SRN-TN-04108		
Issue	1	revision	0
date of issue	2016-01-15		

## DISTRIBUTION

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SERENA Team		1
ESA BC Project Team	ESA/ESTEC	1
ASI-INAF agreement procedure responsible	ASI	1
	TAS-I	1
	ADS (Airbus)	1
	ESA/ESAC	1
	ESA/ESOC	1



## CHANGE LOG

date	issue	revision	Section	reason for change
2016-01-15	1	0		Final delivery



## ABBREVIATIONS

AD	Applicable Document
ADS	Airbus Defense and Space
AFT	Abbreviated Functional Test
AIT	Assembly Integration and Test
AIV	Assembly, Integration and Verification
AOCS	Attitude and Orbital Control System
ASI	Agenzia Spaziale Italiana
BC	BepiColombo
CCS	Central Check-Out System (also core EGSE)
CEM	Channel Electron Multiplier
CGS	Compagnia Generale per lo Spazio
CL	Closed Loop
CPU	Central Process Unit
DL	Data Load
ECR	Engineering Change Request
EGSE	Electrical Ground Support Equipment
EICD	Electrical Interface Control Document
EM	Engineering Model
EMC	ElectroMagnetic Compatibility
ENA	Energetic Neutral Atoms
ESD	Electrostatic Sensitive Device
ETB	Engineering Test Bench
FM	Flight Model
FS	Flight Spare (model)
FSW	Flight Software
H/W or HW	HardWare
HV	High Voltage
IF	InterFace
IST	Integrated (Sub-)System Test
LAN	Local Area Network
MCP	Micro Channel Plate
MICD	Mechanical Interface Control Document
MIS	MPO I/F Simulator
MPO	Mercury Planetary Orbiter
MTL	Mission TimeLine
NA	Not Applicable
NCR	Non Conformance Review
NPA-IS	Neutral Particle Analyzer and Ion Spectrometer





## REFERENCE DOCUMENTS

<b>N</b>	<b>Reference ID</b>	<b>Issue</b>	<b>Title</b>
RD1	BC-ALS-PR-00241	2	MPO PFM EMC_Radiated_Test Procedure
RD2	BC-ASD-LI-00003		Acronyms and Abbreviation directory
RD4	BC-ASD-TS-00010		SERENA IST SPECIFICATION
RD5	BC-EST-RS-01140	2	BC Experiment Interface Document – Part A
RD6	BC-EST-RS-02522	1	SERENA instrument Interface Document Part-B
RD7	BC-SRN-MA-70001		SERENA PI EGSE User manual
RD8			
RD9			

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## 1 Introduction

This document provides a summary report on the testing activities named “Radiated EMC test” executed from the 1<sup>st</sup> of December to the 9<sup>th</sup> of December 2015 in the Rosetta clean room located at ESTEC, Noordwijk (NL), on the MPO with all payloads connected and fully operating. In particular the document describes activities and reports results of the tests performed on the SERENA FS suite as well as analyses data received from the instrument and collected by the SERENA PI-EGSE during the whole test session. Tests execution and management was mainly under the responsibility of TAS-I and ADS teams but supervised by ESA. P/L instrument teams staff was also required for verification purposes. All TM data packets, here generally analysed and discussed, were regularly stored in SERENA PI-EGSE. Moreover several screenshots and graphs showing the instrument behaviour and functionality were collected.

During the Radiated EMC test SERENA worked in both emissive mode (MAXEMI) and susceptibility mode (MAXSUS). All planned tests run on the SERENA suite were performed as expected and successfully. So that the overall instrument behaviour can be considered nominal.

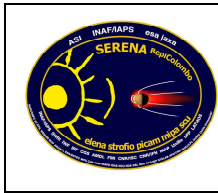
All TM packets were received from each sub-system and for any category. Flux of HK and SCI data was regular, data quality as expected.

Currents and Temperatures were nominal during the whole test session, except some little but nominal oscillations of MIPA TOF Board temperature and some random negligible spikes of ELENA Shutter temperature.

All SERENA settings and thresholds were consistent to the default values. Some sets of OOL happened during the whole test session have not to be considered a concern.

A remarkable event has to be mentioned: on the 8<sup>th</sup> of December, after a reboot foreseen by the nominal procedure, STROFIO was unable to receive and execute TCs again. But power OFF of STROFIO and then power ON again allowed to recover the lost communication between STROFIO and SCU.

See the following sections for further details.



## 2 Background of the Radiated EMC test

The goal of the Radiated EMC test is to demonstrate that BepiColombo is:

- compliant with the BepiColombo satellite level requirements as per the test specification w.r.t. radiated EMC performance;
- self-compatible w.r.t. expected and unexpected radiated emissions.

During each EMC measurement the required operational modes of BepiColombo MPO PFM Satellite were reached by applying relevant functional sequence calling. The Radiated EMC test operations were initially scheduled as follows:

1. Test #2 E-field/TX radiation & Autocompatibility S/C TX LGA/ MGA
2. Test #3 EMC AUTOCOMPATIBILITY S/C TX HGA
3. Test #1 Launcher EMC compatibility (RE & RS)
4. Test #4 RFC AUTOCOMPATIBILITY X-Band HGA and X-Band LGA -X
5. Test #5 RFC AUTOCOMPATIBILITY Ka-Band HGA and X Band LGA +X
6. Test #6 RE RECEIVER NOTCHES

The planning for the test is also reported in the following figure:

Activity	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12
	Sat 28-nov	Mon 30-nov	Tue 01-dic	Wed 02-dic	Thu 03-dic	Fri 04-dic	Sat 05-dic	Mon 07-dic	Tue 08-dic	Wed 09-dic	Thu 10-dic	Fri 11-dic
S/C entrance in the test chamber; Setup Completion; S/C switch on trial; MGA deployment in position RF safety measurements (with IR cameras)	█	█										
Test#2 - RS, Transmitter peaks - antenna back radiation (Orbit mode) Test part with MGA Test part with LGA +X MGA restow			█	█								
Test#2 - RS, Transmitter peaks - antenna back radiation (Orbit mode) RF safety measurements (with test antennas) Test part with LGA -X Test part with HGA				█	█							
Test#3 - EMC AUTOCOMPATIBILITY S/C Tx HGA					█	█						
Test#1 - RE, Launcher notches (Launch Mode) Test#1 - RS, Launcher transmitters (Launch Mode) Test antenna setup (3 test antennas) for the next test phase Test antennas setup RF uplink establishing and verification for uplink paths						█	█					
Test#4 - RFC AUTOCOMPATIBILITY X-Band HGA and X-Band LGA -X X-Band HGA X-Band LGA-X								█	█			
Test#5 - RFC AUTOCOMPATIBILITY Ka-Band HGA and X Band LGA +X Ka-Band HGA X-Band LGA +X									█	█		
MGA GSE removal, HGA WG separation, Tilt to 0°, Dismount phebuis pump										█	█	
Test#6 - RE RECEIVER NOTCHES Test configuration dc set-up EGGE strip off and re-collocation in Rosetta											█	█
ETS required all time to perform measurement												█
ETS required on call all day for support in antenna positioning and setup												█
ETS required only in the morning for support in antenna positioning												█

\*\*\* For further details see step-by-step procedure reported in section 8 of [RD1]

### 3 List of activities

The Radiated EMC tests were executed from the 1<sup>st</sup> of December to the 9<sup>th</sup> of December 2015, according to the following scheme, and with some changes w.r.t. the schedule showed in the previous section due to the S/C activities reconfiguration:

- 01 Dec 2015 → Test #2 - RS transmitter peaks - Antenna Back radiation (Orbit mode)  
(E-field/TX radiation & Autocompatibility S/C TX LGA -X/+X and HGA)
- 02 Dec 2015 → Test #3 - EMC Autocompatibility S/C TX HGA
- 03 Dec 2015 → Test #1 - RE Launcher notches and RS Launcher transmitters (Launch mode)
- 04 Dec 2015 → Test #5 - RFC Autocompatibility Ka-band HGA and X-band LGA +X
- 05 Dec 2015 → P/L off
- 06 Dec 2015 → P/L off
- 07 Dec 2015 → Test #4 - RFC Autocompatibility X-band HGA and X-band LGA -X
- 08 Dec 2015 → Test #2 - RS transmitter peaks - Antenna Back radiation (Orbit mode)  
(E-field/TX radiation & Autocompatibility S/C TX MGA)
- 09 Dec 2015 → Test #6 - RE Receiver Notches

\* Lines highlighted in red are referred to days without P/L activity.

\*\* See [RD1] for further details about step-by-step procedures.

During the whole Radiated EMC test period SERENA was ON and worked in both emissive mode (MAXEMI) and susceptibility mode (MAXSUS).

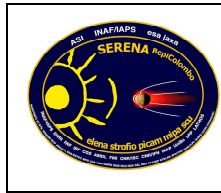
## 4 SERENA H/W & S/W Configuration

Subsystem	Model level	SW version
SRN PI-EGSE	N/A	1.8.37
SRN Data Base	FM	ASCII_SERENA_MIS_DB_V1.9_17122013r045_FM
SRN SCU App SW	FS	V36
ELENA App. SW	FS	V25
PICAM App. SW	FM	V34
MIPA	FM	Included in SCU SW
STROFIO	PFM	V9

### 4.1 Details on SERENA PI-EGSE

The PI EGSE used at ESTEC during the tests is installed on a Sony VAIO PC with the following HW:

- ✓ description: Notebook
- ✓ product: VPCSB2L1E
- ✓ vendor: Sony Corporation
- ✓ version: C60930YV
- ✓ serial: 27547507-5000603
- ✓ width (architecture): 64 bits
- ✓ capabilities: smbios-2.6 dimi-2.6 vsyscall64 vsyscall32
- ✓ configuration: boot=normal chassis=notebook uuid=D0DA0C17-8088-E011-82C7-1AF95D4948F0
- ✓ Motherboard: VAIO
- ✓ BIOS: INSYDE version R1031H4 (25/94/2011), size 1MiB, 2496KiB
- ✓ Memory description: SODIMM, size 4GiB, width 64 bits
- ✓ CPU: product Intel(R) Core(TM) i3-2310M CPU @ 2.1 GHz, size 800MHz, capacity: 2100MHz, width 64 bits, clock 100MHz
- ✓ CACHE: L1 cache 128 KiB, L2 cache 512 KiB, L3 cache 3MiB
- ✓ PCI: Sandy Bridge DRAM Controller, size 32 bits, clock 33MHz
- ✓ HD DISK description: ATA Disk, product Hitachi HTS54505, size 465GiB (500 GB), logical name /dev/sda0
- ✓ CDROM: DVD-RAM writer, product DVD-RAM UJ8A2AS, vendor MATSHITA



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The PI EGSE SW is configured as follows:

- ✓ System: x\_86\_64 GNU/Linux
- ✓ kernel: 2.6.32-5-amd64 #1 SMP Mon Sep 23 22:14:43 UTC 2013
- ✓ Distributor ID: Debian
- ✓ Description: Debian GNU/Linux 6.0.8 (squeeze)
- ✓ Release: 6.0.8
- ✓ Codename: squeeze
  
- ✓ Gnome Desktop
- ✓ Version: 2.30.2
- ✓ Build Date: 11/12/2010

PI-EGSE Network Configuration:

- ✓ ifconfig
- ✓ eth0 Link: Ethernet HWaddr F0:BF:97:5D:41:41  
inet addr: 192.168.201.210 Bcast: 192.168.210.255 Mask: 255.255.255.0  
RX bytes: 3.1 GiB TX bytes 2.7 GiB (22/10/2015 10:35)

SERENA PI-EGSE in ESTEC is having on ifconfig eth0 192.168.201.210  
but is accepting ssh connections both on IP 192.168.212.210 and 192.168.201.210

## 5 Summary of activities and TM analysis

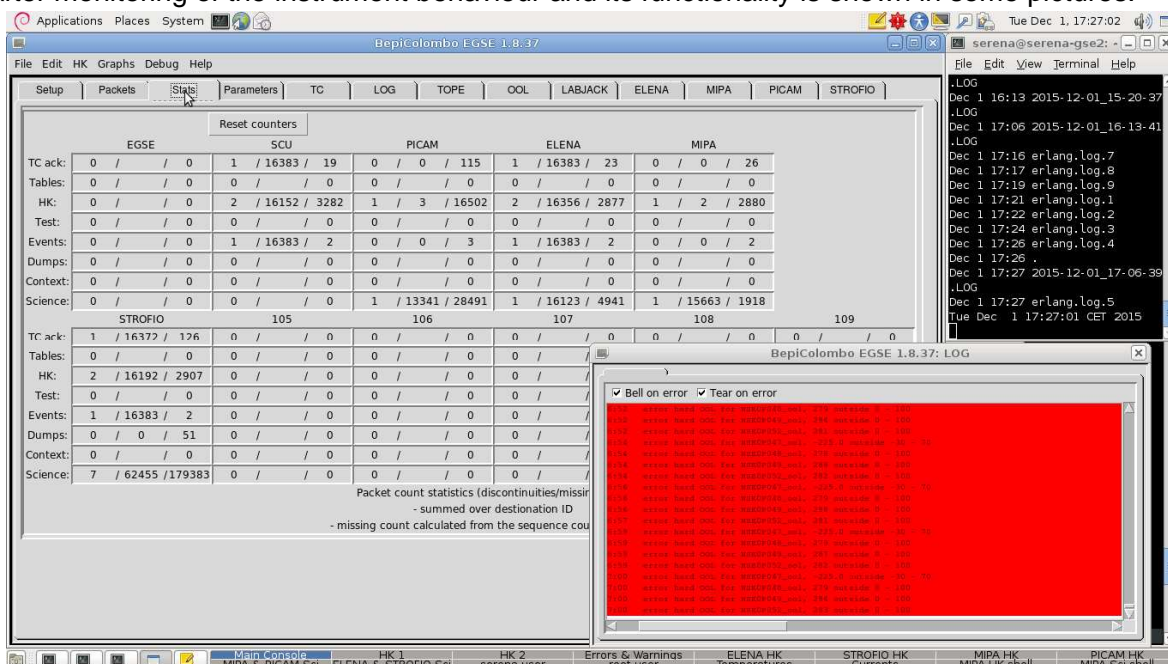
### 5.1 Test performed on Tuesday 01 December 2015

- Test #2 - RS transmitter peaks - Antenna Back radiation (Orbit mode)  
(E-field/TX radiation & Autocompatibility S/C TX LGA -X/+X and HGA)
- +++ Payloads configured in MAX\_SUS
- \*\*\* Further details about procedure in [RD1],  
Chapter 7.5.2 pages 66-69, and Chapter 8.3 pages 100-140

The test planned for this day actually included only LGA +X and MGA. But on Monday 30 November the release of Medium Gain Antenna failed. Consequently it was decided to perform the RS transmitter test with LGA -X and HGA (in place of MGA) originally planned for Wednesday 02 December. This test was successful so it was decided to perform also the RS transmitter test with LGA +X => successful as well!

#### Test on SERENA successfully completed!

All TM packets received, HK and SCI data as expected. Currents and Temperatures were nominal. Hereafter monitoring of the instrument behaviour and its functionality is shown in some pictures:



**Figure 5.1 – All TM packets received from SERENA at the end of test session.**

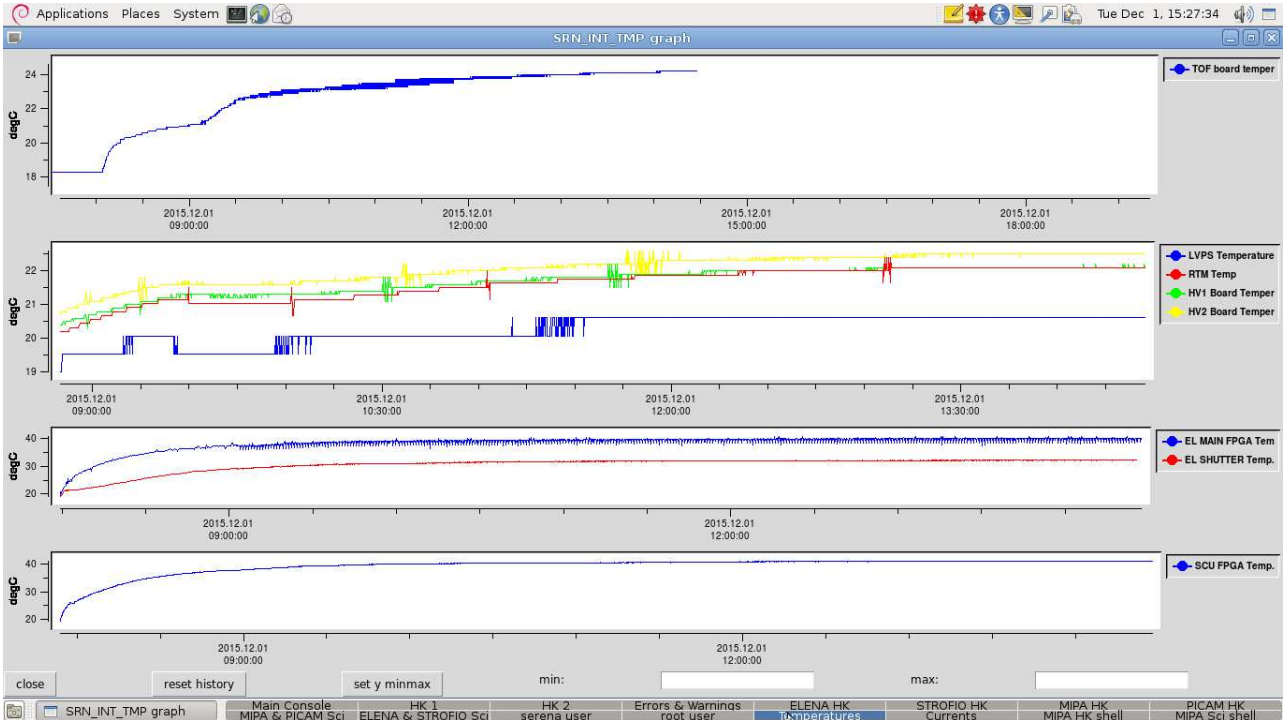


Figure 5.2 –SERENA Temperatures.

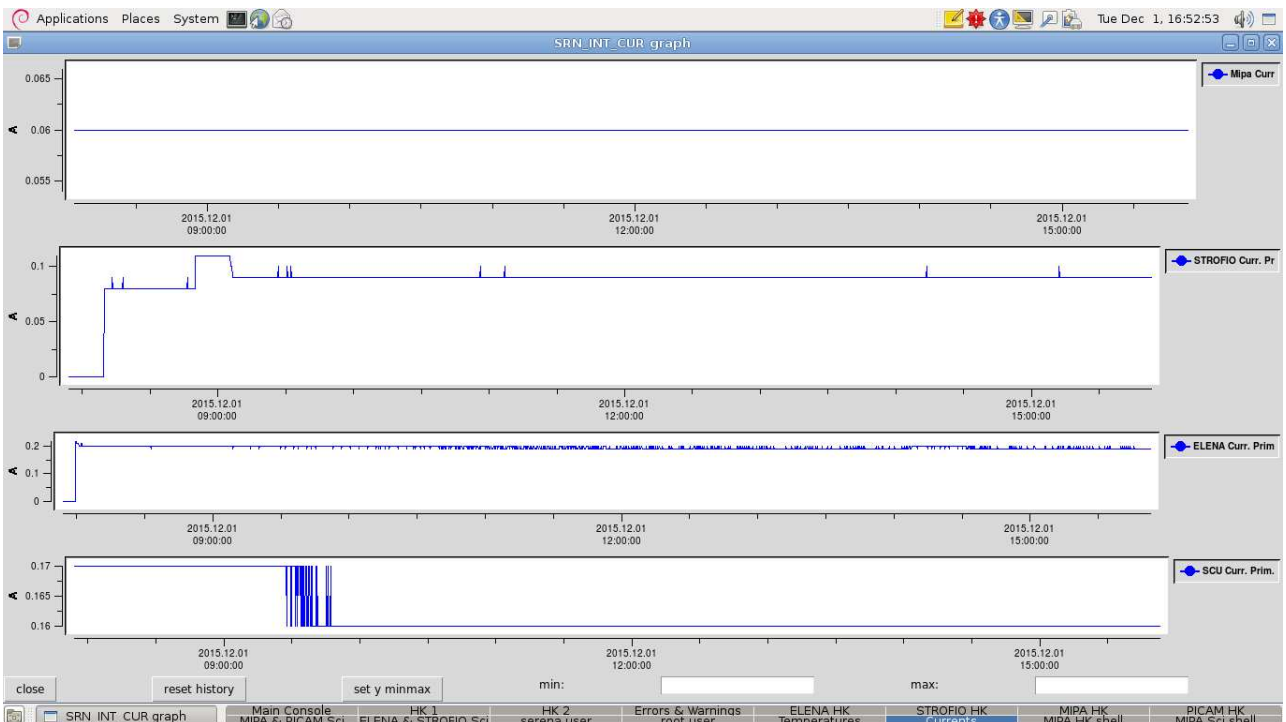


Figure 5.3 –SERENA Currents.

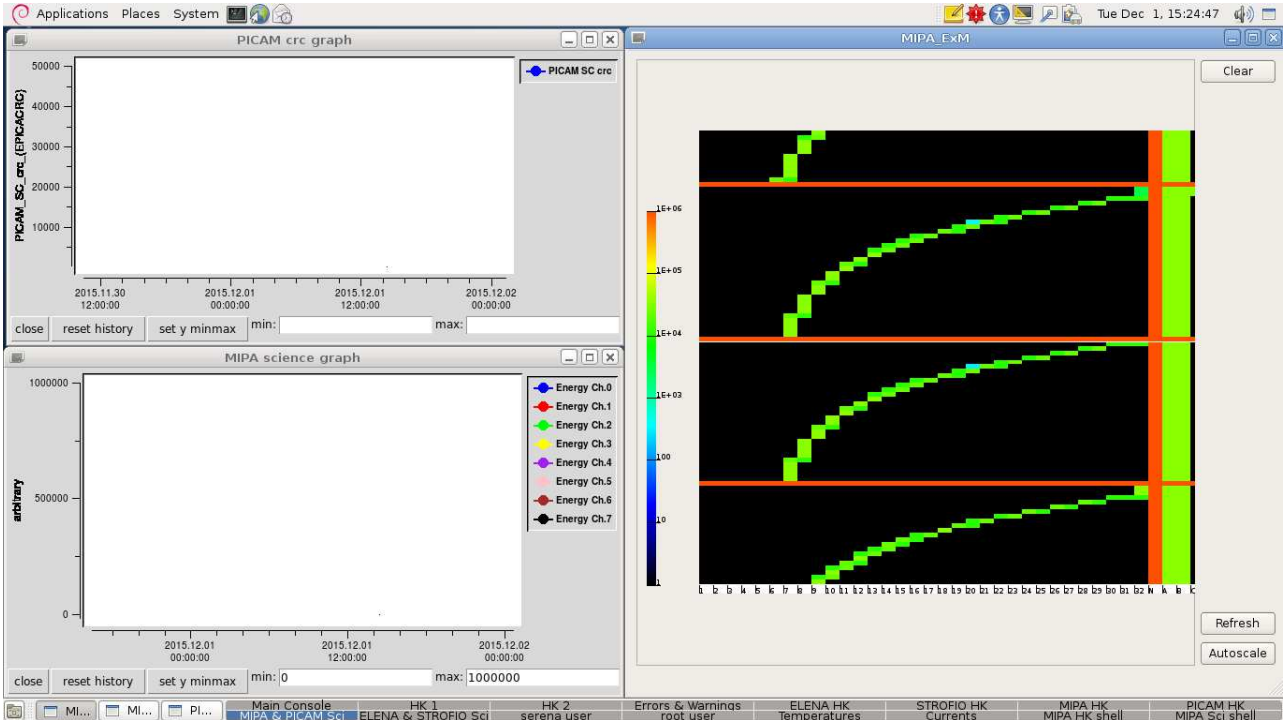


Figure 5.4 –MIPA & PICAM Science.

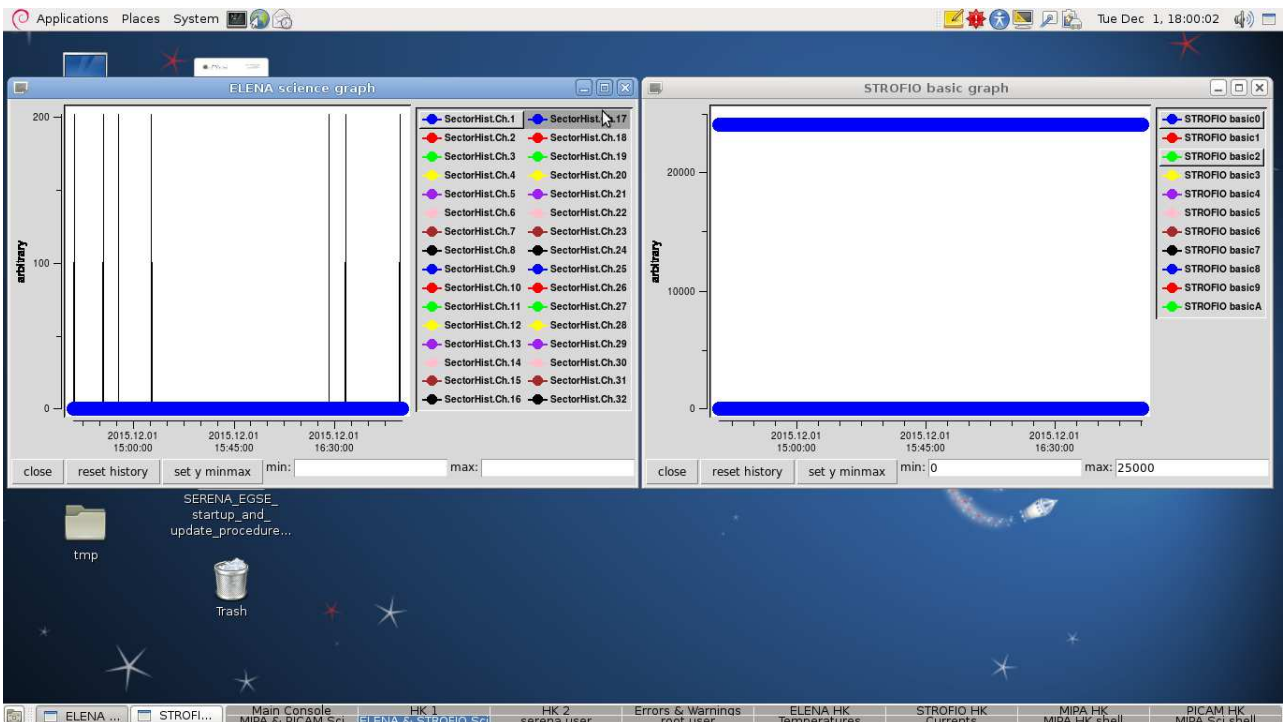


Figure 5.5 –ELENA & STROFIO Science.



## 5.2 Test performed on Wednesday 02 December 2015

- Test #3 - EMC Autocompatibility S/C TX HGA

- Notes:

1 Shift: S/C configuration 3

+++ Payloads configured in MAX\_SUS

\*\*\* Further details about procedure in [RD1],

Chapter 7.5.3 pages 69-71 and Chapter 8.4 pages 141-151 (step 10-80)

Test started at 8:20 and successfully completed at lunch time (13:32).

All TM packets received, HK and SCI data as expected. Currents and Temperatures were nominal.

Hereafter monitoring of the instrument behaviour and its functionality is shown in some pictures:

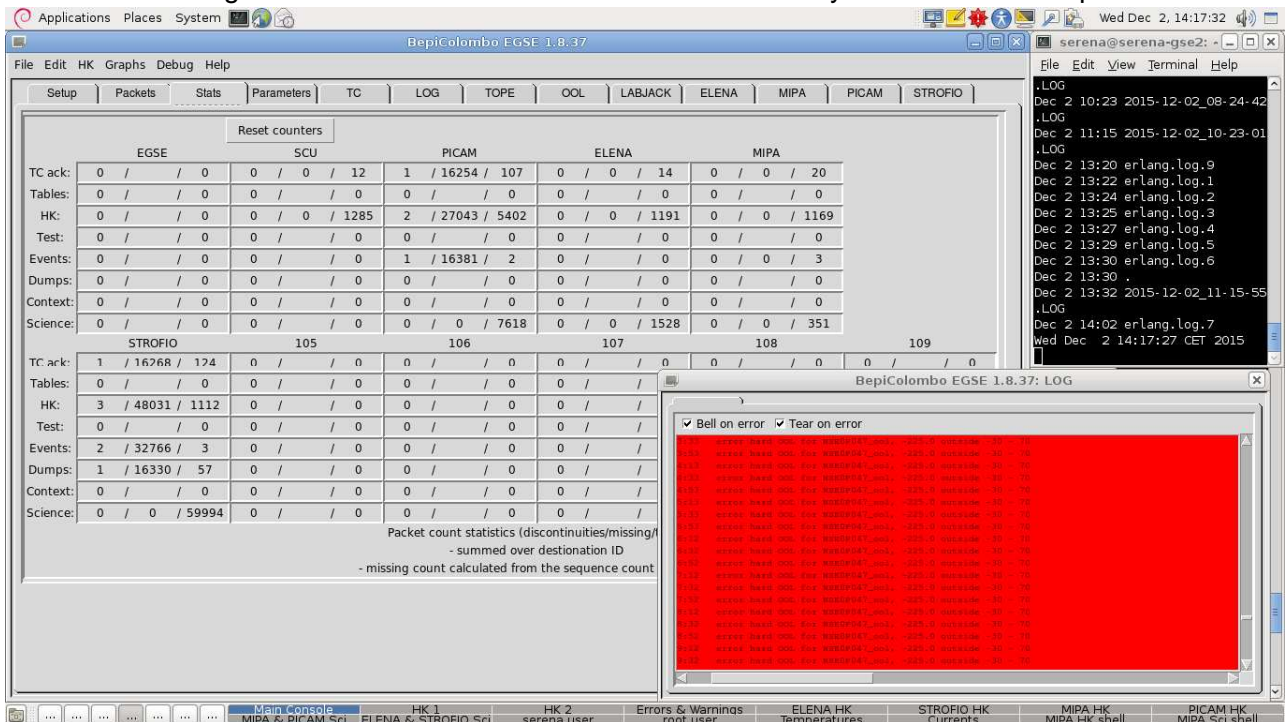


Figure 5.6 – All TM packets received from SERENA at the end of test session.

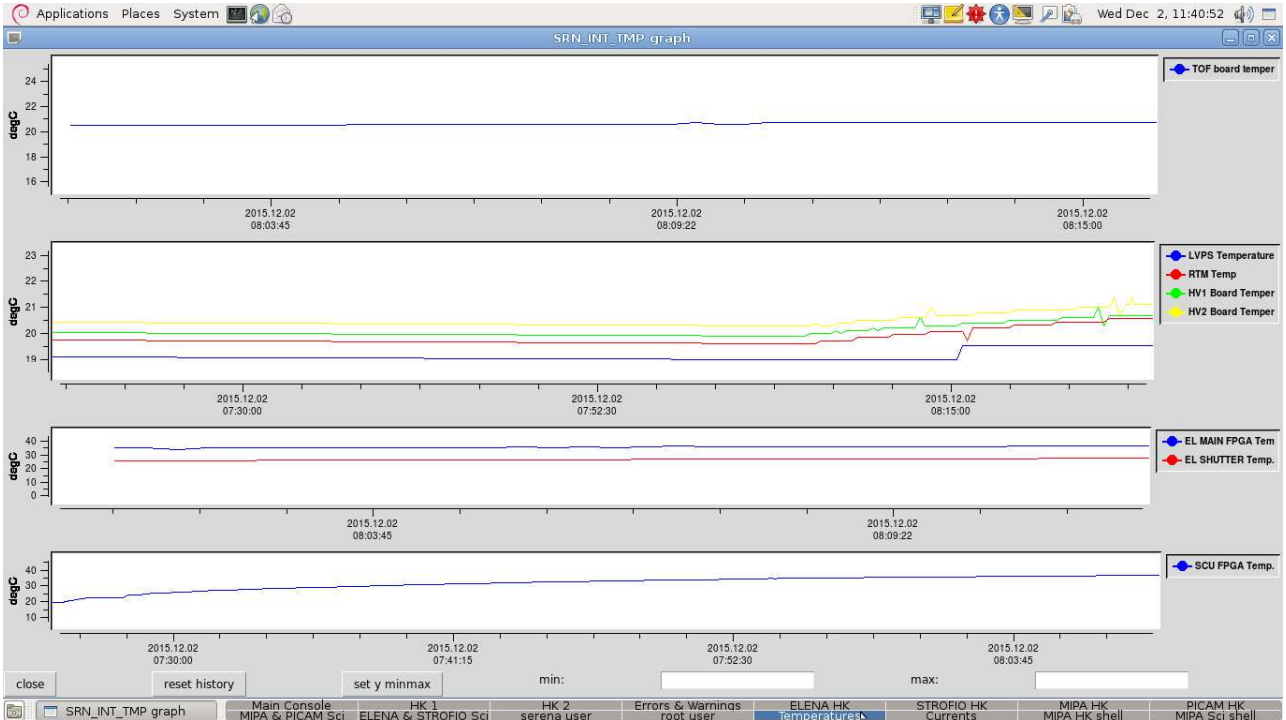


Figure 5.7 –SERENA Temperatures.

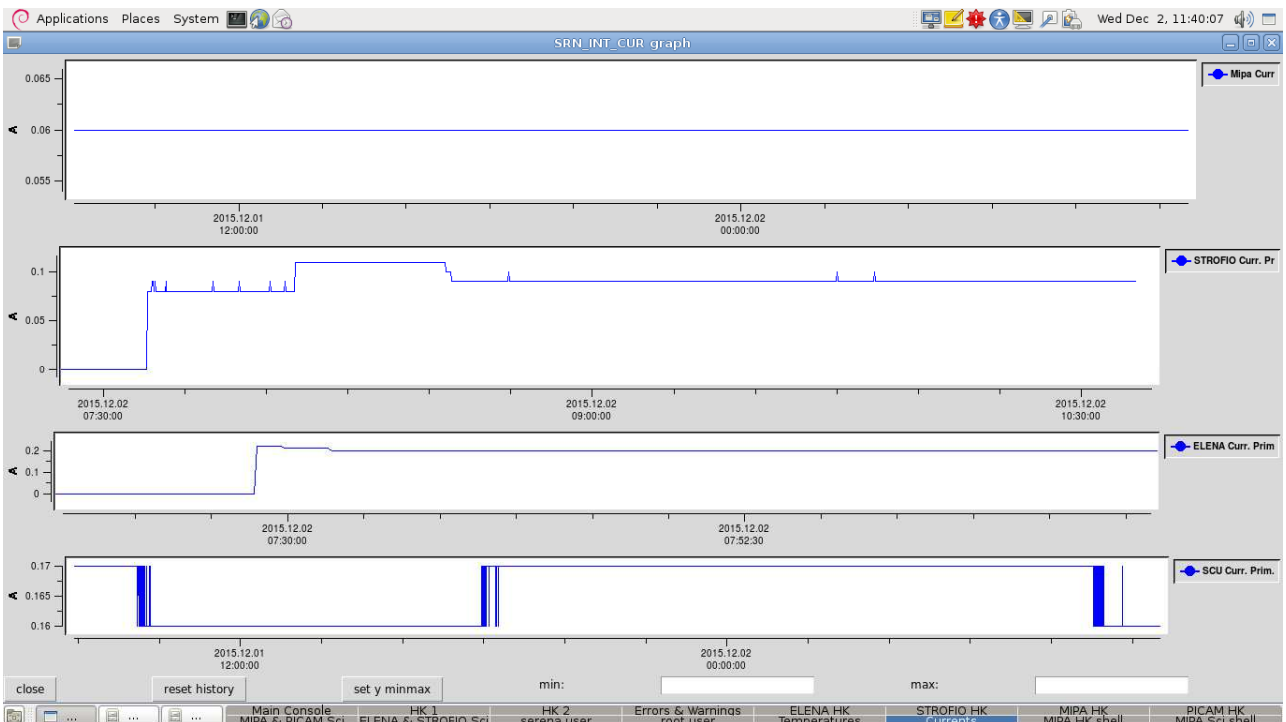


Figure 5.8 –SERENA Currents.

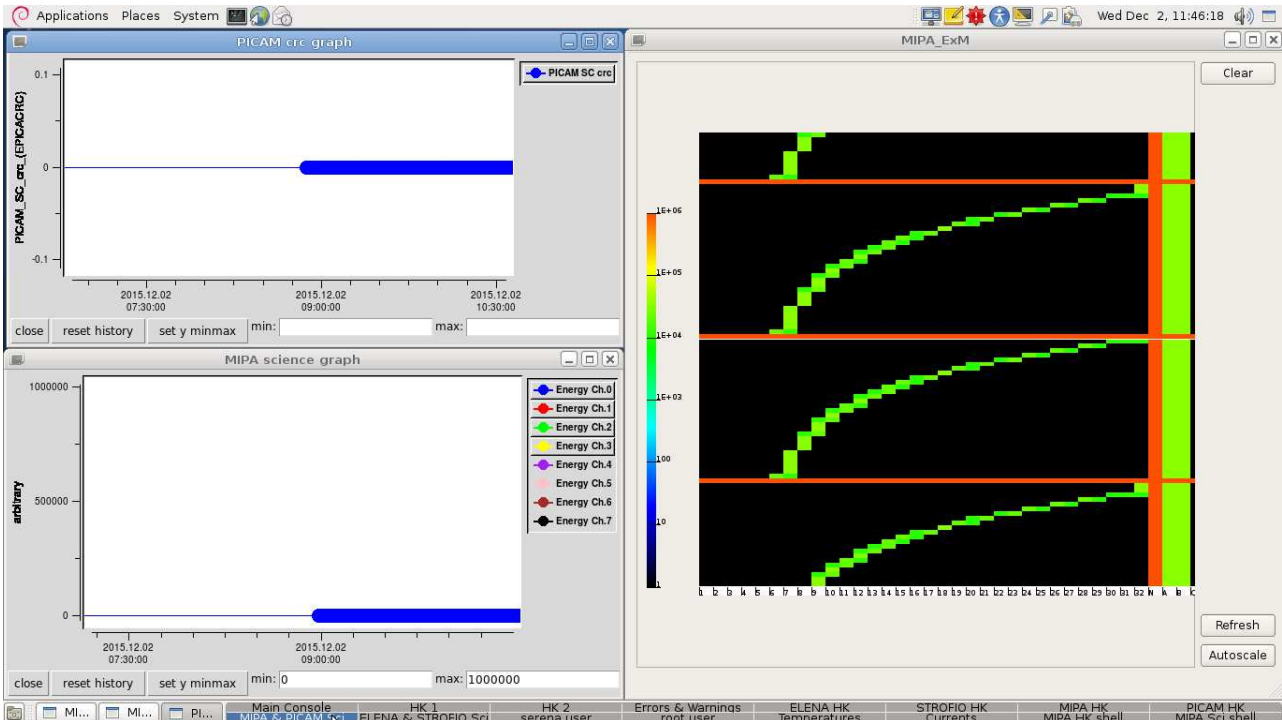


Figure 5.9 –MIPA & PICAM Science.

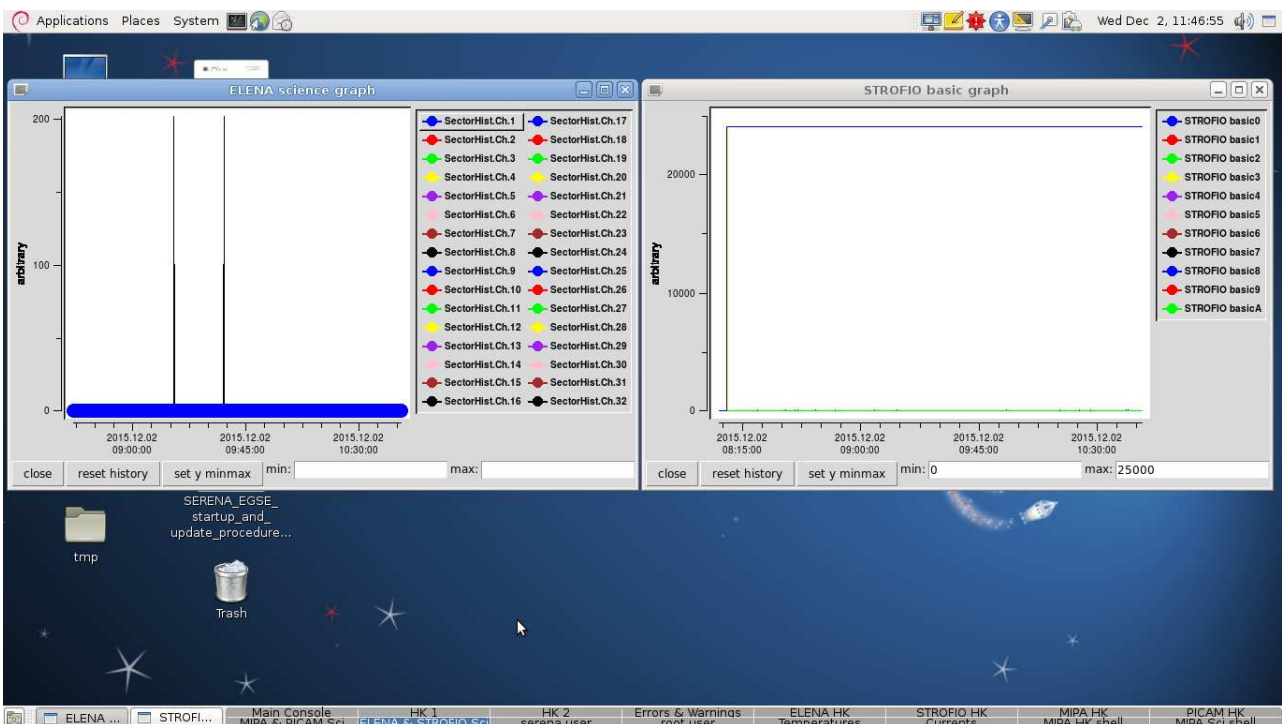
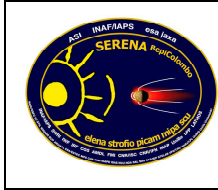


Figure 5.10 –ELENA & STROFIO Science.



### 5.3 Test performed on Thursday 03 December 2015

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- Test #1 - RE Launcher notches and RS Launcher transmitters (Launch mode)

+++ P/L OFF, tests performed only on S/C side

\*\*\* Further details about procedure in [RD1],  
Chapter 7.5.1 pages 63-65, and Chapter 8.2 pages 83-99

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The Launcher mode radiated EMC tests were completed around lunch time.  
In the afternoon activities consisted in test sequences with P/L in off mode and test Antenna set-up for the next test phase.

### 5.4 Test performed on Friday 04 December 2015

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- Test #5 - RFC Autocompatibility Ka-band HGA and X-band LGA +X

- Notes:

- 1 Shift: S/C configuration 1
- Normal Shift: RF reference run + S/C configuration 3.
- In addition BELA laser will be fired.

+++ Payloads configured in MAX\_EMI

\*\*\* Further details about procedure in [RD1],  
Chapter 7.5.4 pages 72-76 and Chapter 8.6 pages 180-204 (step 10-100)

---

Test started at 11:00 and successfully completed at 16:36 when the last HK packet was received.

"Ka-band HGA" test was performed in the morning, "X-band LGA +X" test was executed in the afternoon: both test with P/L switched on to MAX\_EMI mode.

At 12:38 the measurements were stopped due to an issue on the SSMM. At 13:01 the SSMM was switched ON again after a power cycle so the "Ka-band HGA" test was successfully completed.

During this test session more than a connection reset was requested by us due to lost of communication between PI-EGSE and MPO PFS Satellite. This had no impact, however, on TM data that were received regularly after any reset.

At 13:48 STROFIO starts to receive a lot of SCI data but with hundreds of "error YSE56779 parameter ZPAD016 parsing error". This kind of error is likely due to a misinterpretation of a functional parameter (under investigation).

All TM packets received, HK and SCI data as expected. Currents and Temperatures were nominal.



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Hereafter monitoring of the instrument behaviour and its functionality is shown in some pictures:

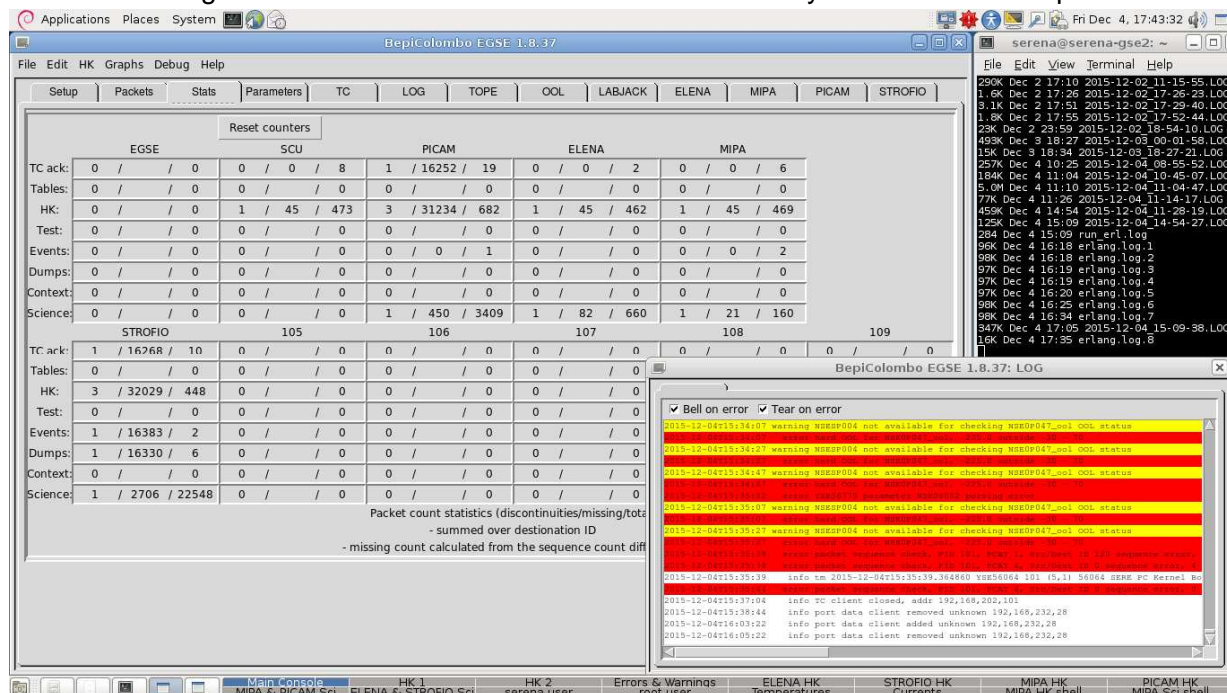


Figure 5.11 – All TM packets received from SERENA at the end of test session.

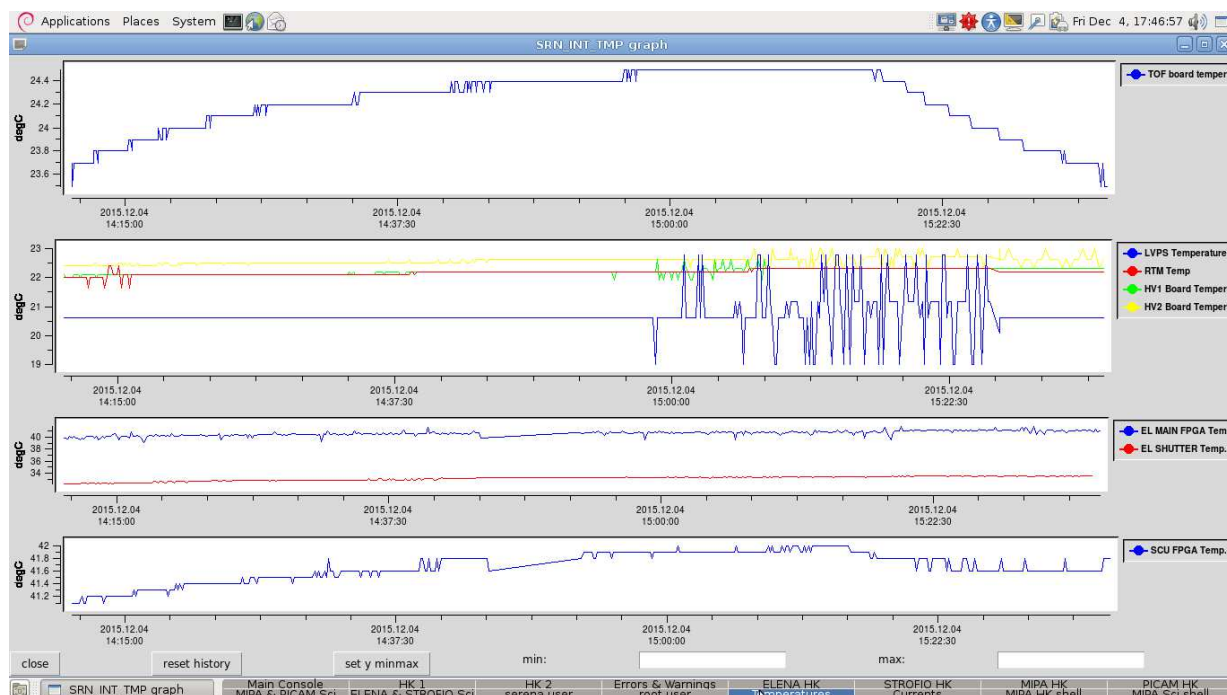
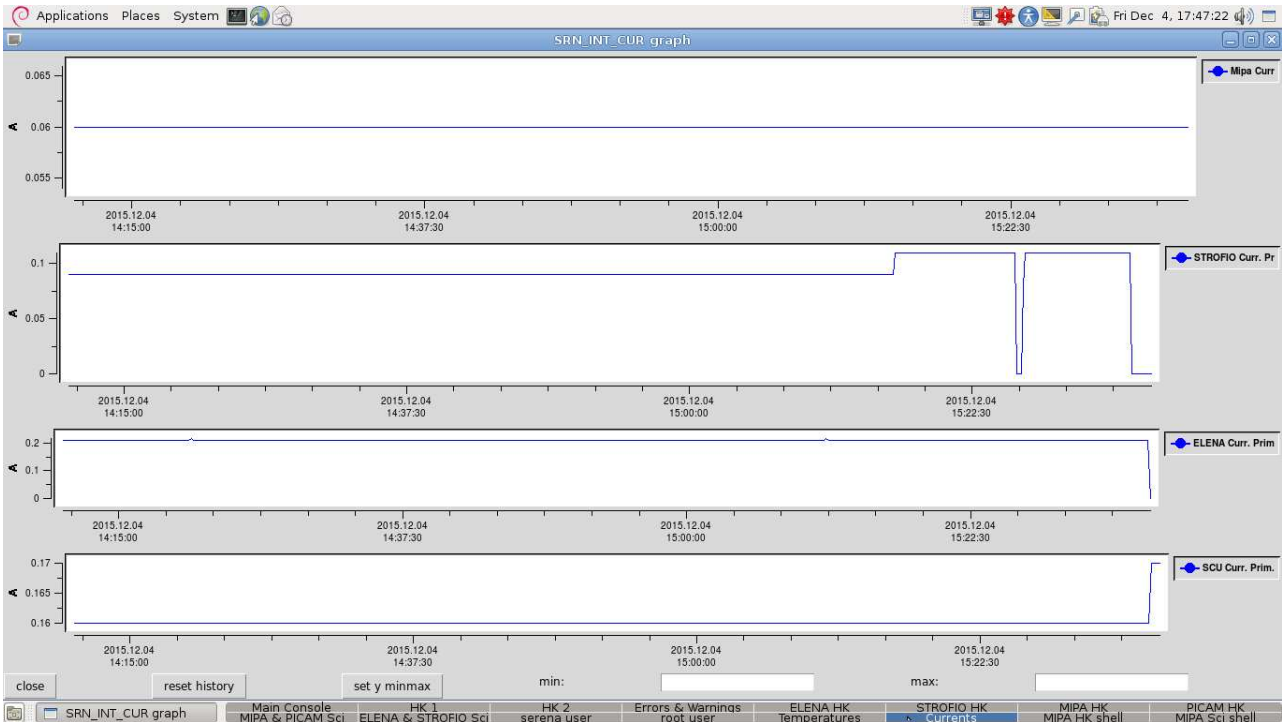
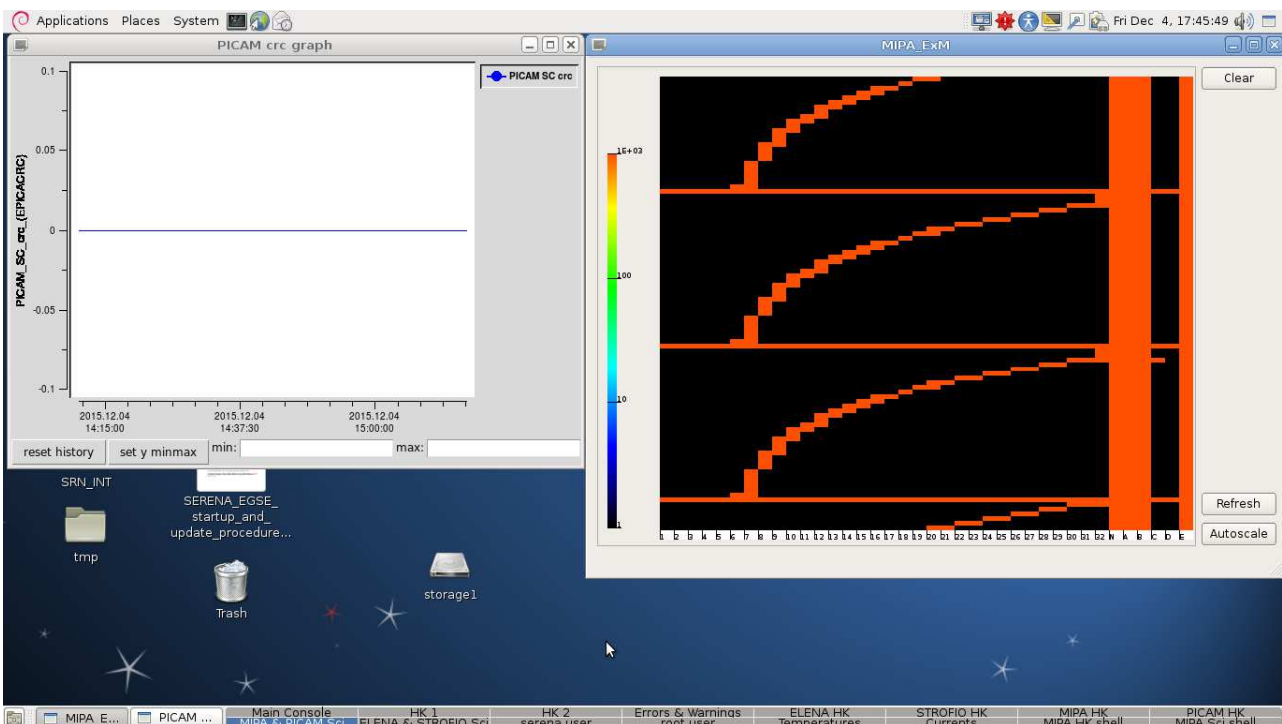


Figure 5.12 –SERENA Temperatures.



**Figure 5.13 –SERENA Currents.**



**Figure 5.14 –MIPA & PICAM Science.**

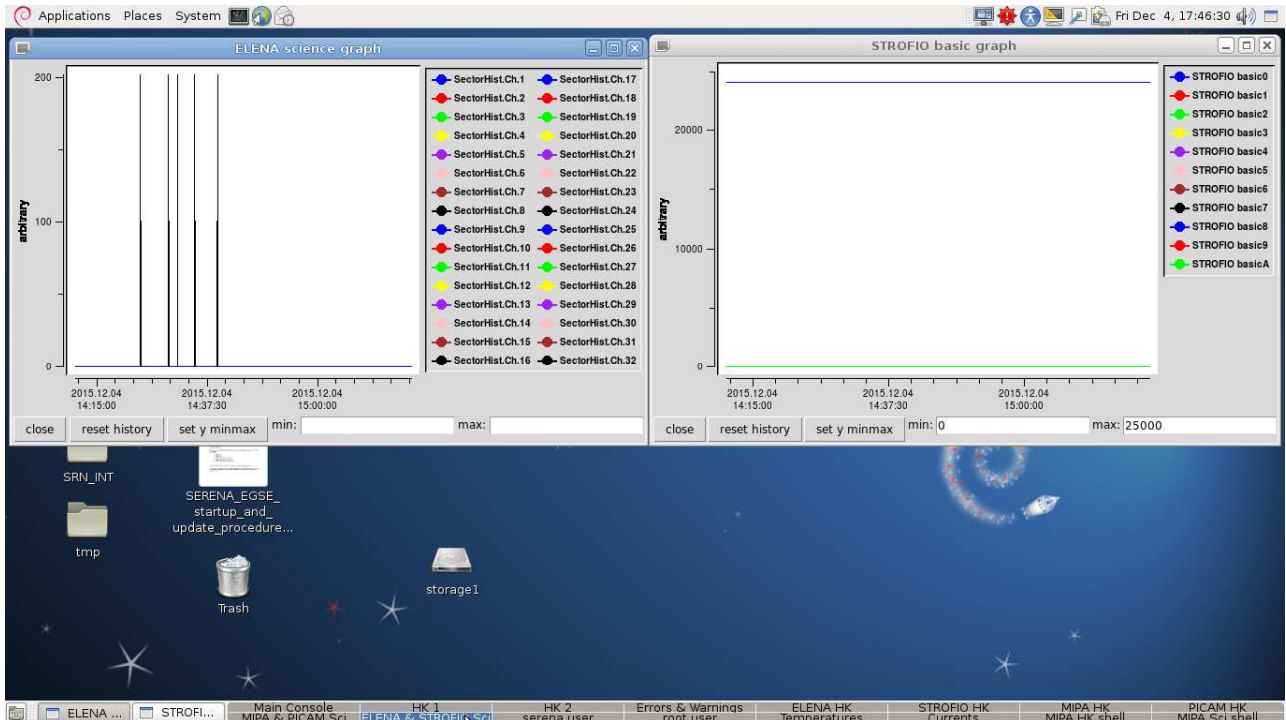


Figure 5.15 –ELENA & STROFIO Science.

## 5.5 Test performed on Monday 07 December 2015

- Test #4 - RFC Autocompatibility X-band HGA and X-band LGA -X

- Notes:

1 Shift: Phebus pump disconnection, S/C configuration 1

Normal Shift: RF reference run + S/C configuration 3.

In addition BELA laser will be fired.

+++ Payloads configured in MAX\_EMI

\*\*\* Further details about procedure in [RD1],

Chapter 7.5.4 pages 72-76 and Chapter 8.5 pages 152-179 (step 10-70)

**Test started at 09:50 and successfully completed at 18:09 when the last SCI packet was received.**

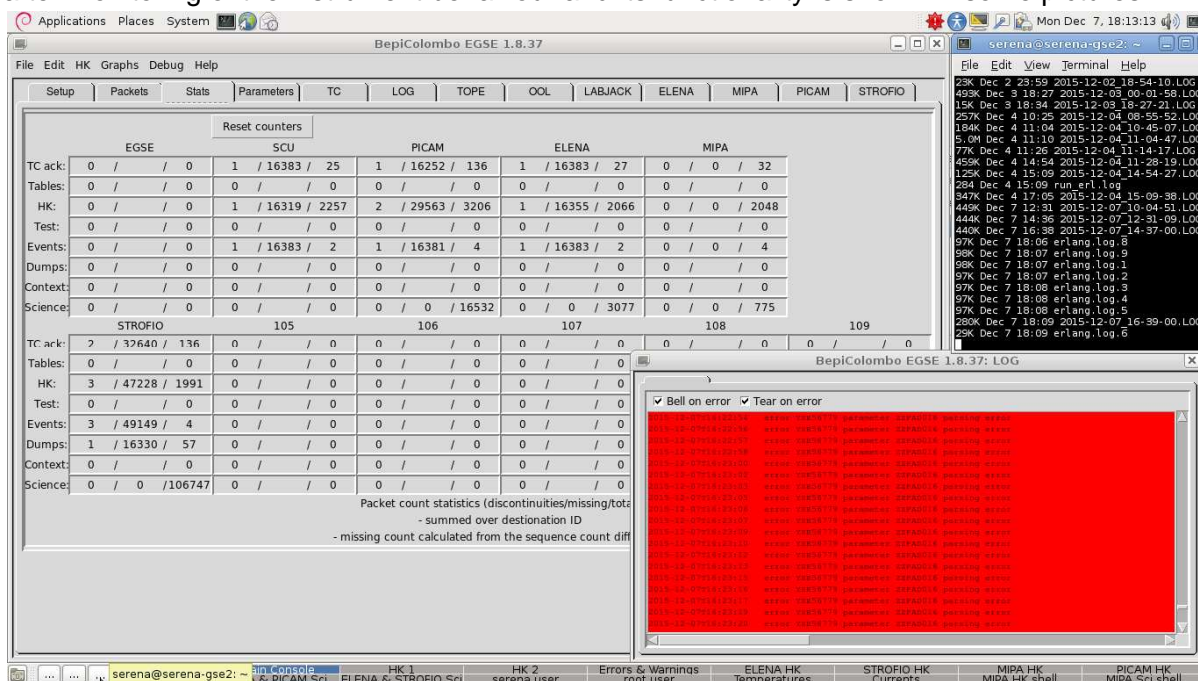
"X-band HGA" test was performed in the morning, "X-band LGA -X" test was executed in the afternoon: both test with P/L switched on to MAX\_EMI mode.

All TM packets received, HK and SCI data as expected. Currents and Temperatures were nominal. Some little but nominal oscillations of MIPA TOF Board temperature occurred around the nominal temp trend.

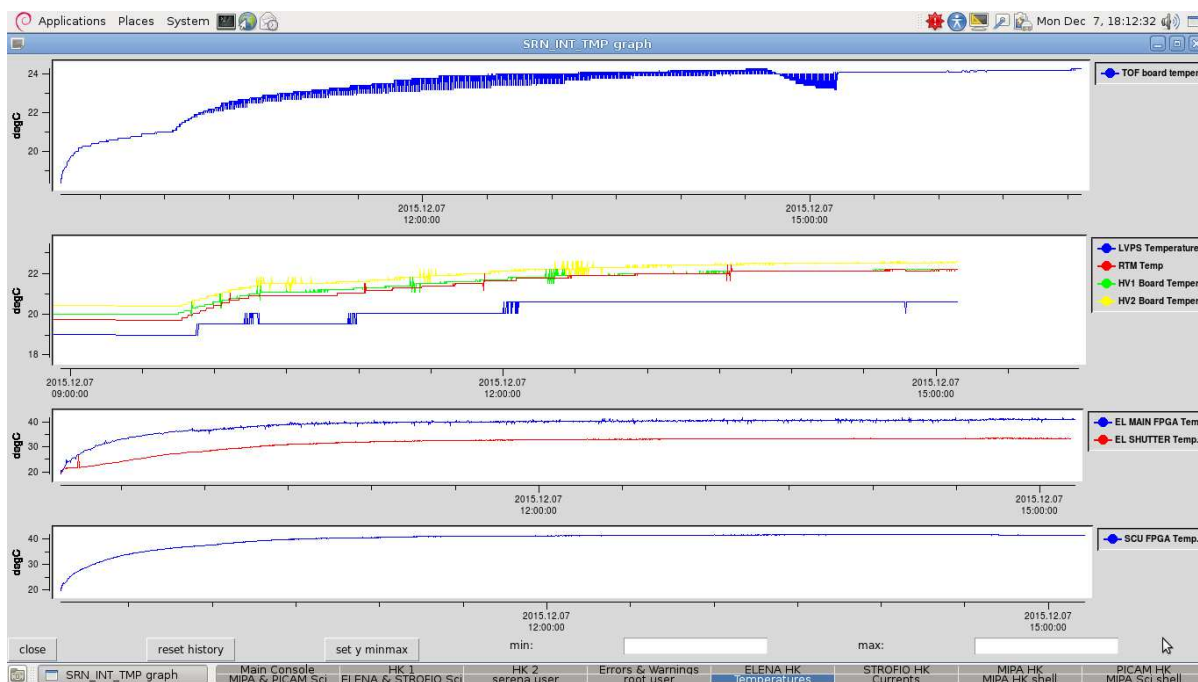


Moreover a random peak for ELENA Shutter temperature was monitored (jump up to 4 degrees) with a duration of 30 seconds: the event is isolated and a negligible spike.

Hereafter monitoring of the instrument behaviour and its functionality is shown in some pictures:

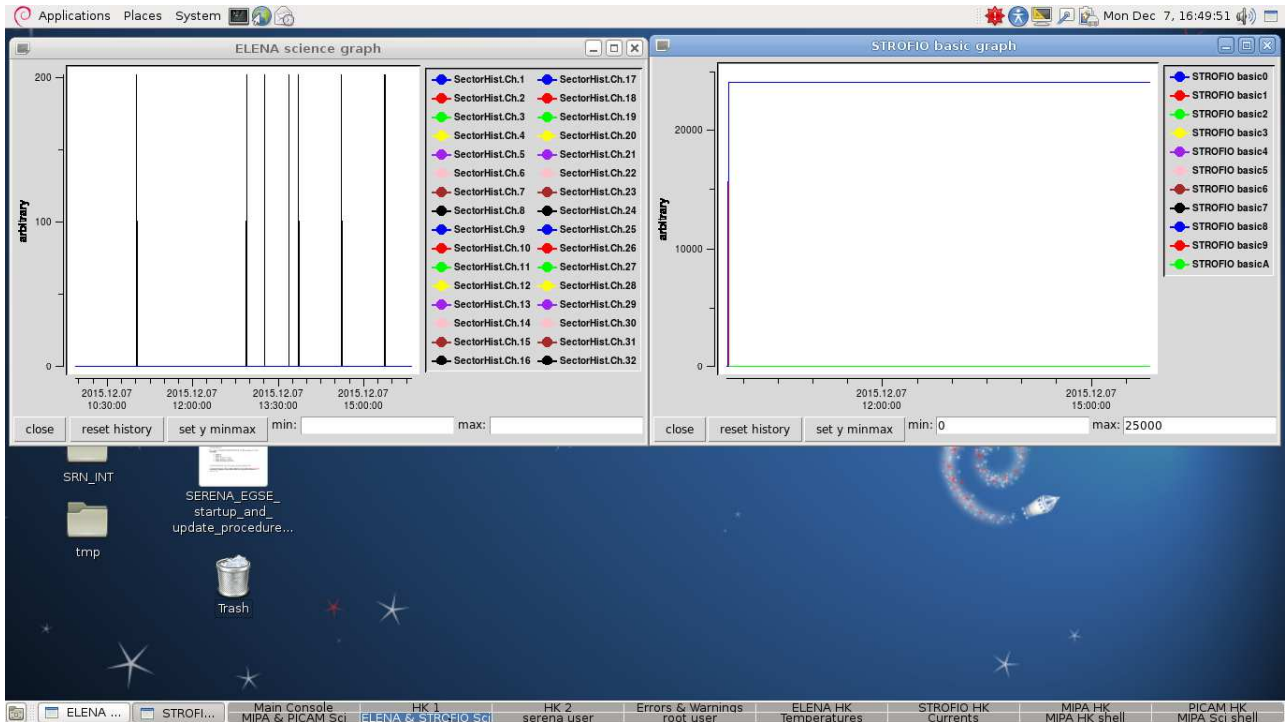


**Figure 5.16 – All TM packets received from SERENA at the end of test session.**



**Figure 5.17 –SERENA Temperatures.**





**Figure 5.20 –ELENA & STROFIO Science.**

## 5.6 Test performed on Tuesday 08 December 2015

- Test #2 - RS transmitter peaks - Antenna Back radiation (Orbit mode)  
 (E-field/TX radiation & Autocompatibility S/C TX MGA)

- Notes:

1 Shift: S/C configuration 2

Normal Shift morning: Test #2 MGA part

Normal Shift afternoon: mech. S/C to vertical

+++ Payloads configured in MAX\_SUS

\*\*\* Further details about procedure in [RD1],

Chapter 7.5.2 pages 66-69 and Chapter 8.3 pages 100-140 (step n. 240)

\*\*\* This test, already performed on Tuesday 01 December, is here again executed but only with the MGA (P/L in MAX\_SUS configuration).

**Test started at 08:18 and successfully completed at 16:19 when the last HK packet was received.**



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All TM packets received, HK and SCI data as expected. Currents and Temperatures were nominal. Some little but nominal oscillations of MIPA TOF Board temperature occurred around the nominal temp trend. Moreover two random peaks for ELENA Shutter temperature were monitored (jump up to 5 degrees) with a duration of 30 seconds: these events are isolated and a negligible spikes.

However a remarkable event happened during this test: after a reboot foreseen by the nominal procedure, STROFIO was unable to receive and execute TCs again. So the "reset STROFIO" TC was sent to the instrument in order to recover the lost communication between STROFIO and SCU but it was unsuccessful. The solution suggested by TAS-I - power OFF STROFIO and then power ON it again - was successful and restored the link to the SCU. The reason of this failure is currently under investigation (BC-SRN-NC-01582 was opened on 8 Dec 2015).

Hereafter monitoring of the instrument behaviour and its functionality is shown in some pictures:

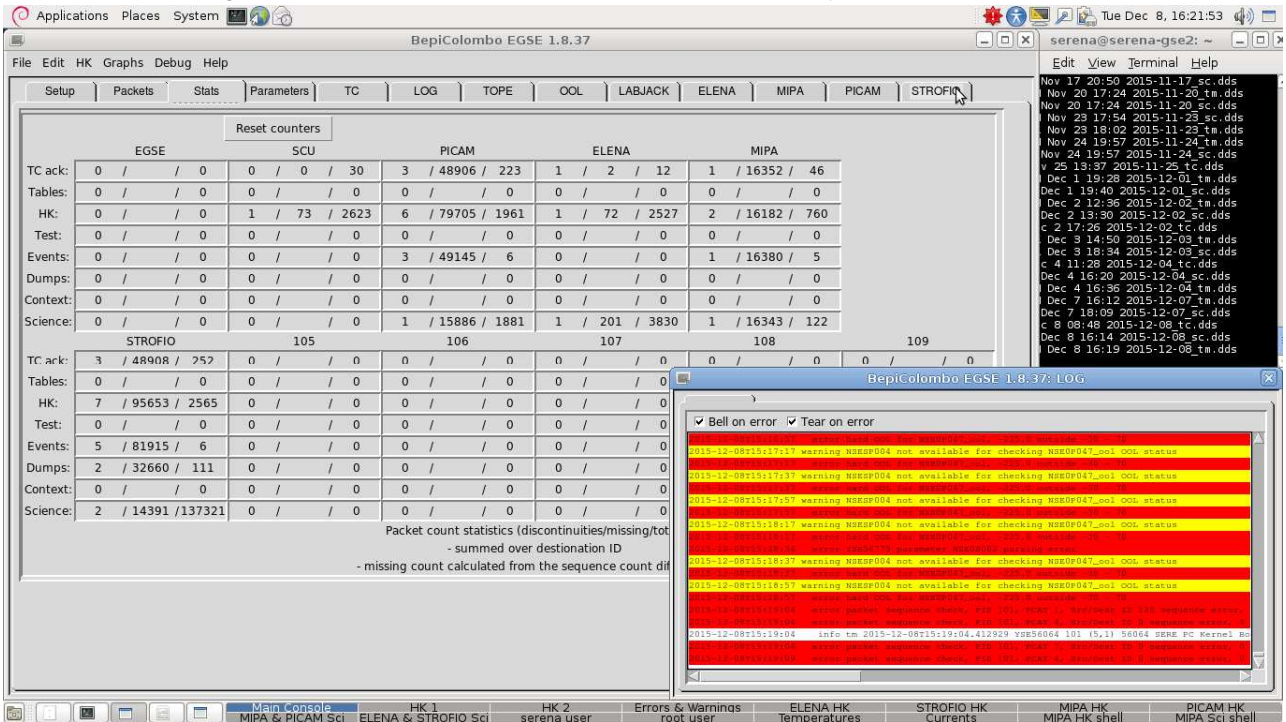
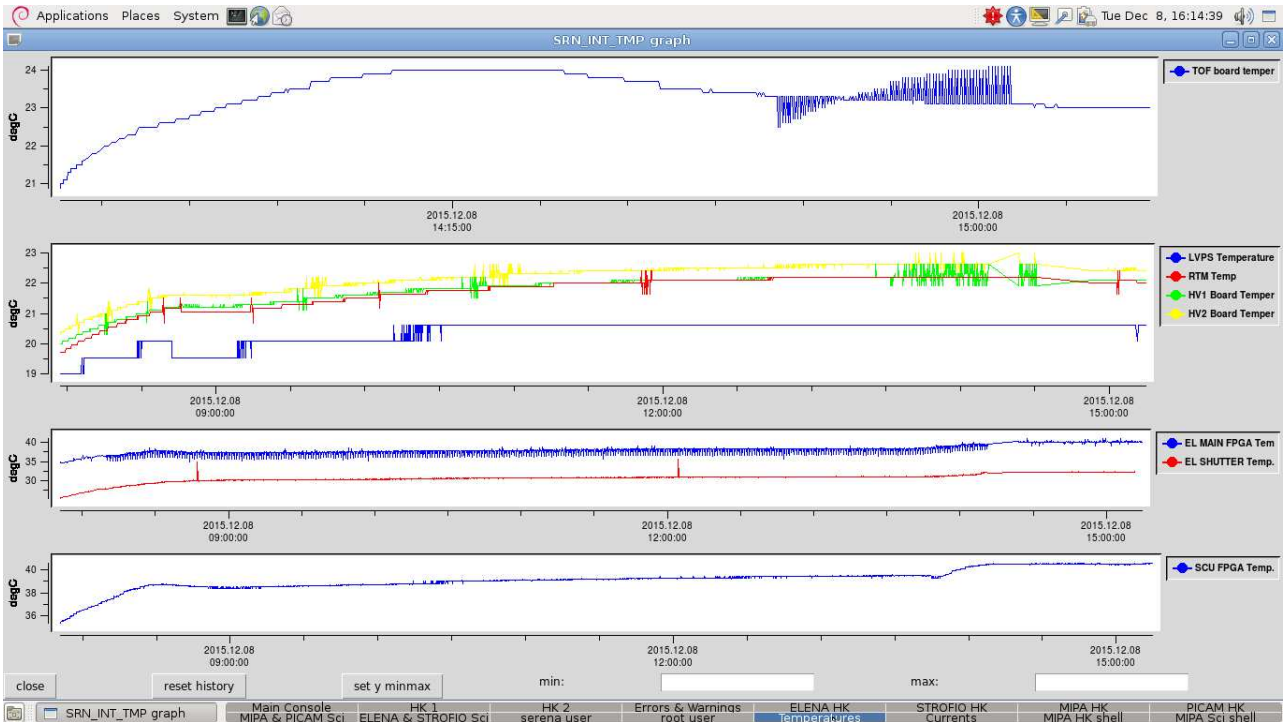


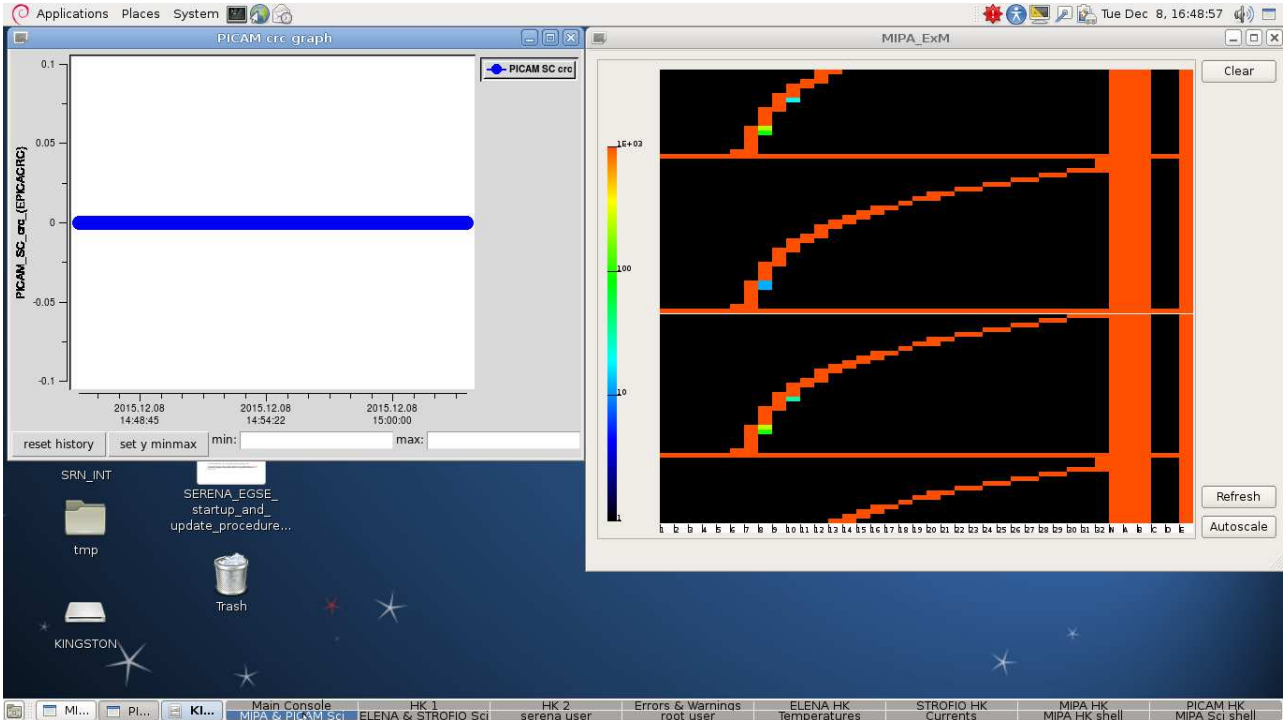
Figure 5.21 – All TM packets received from SERENA at the end of test session.



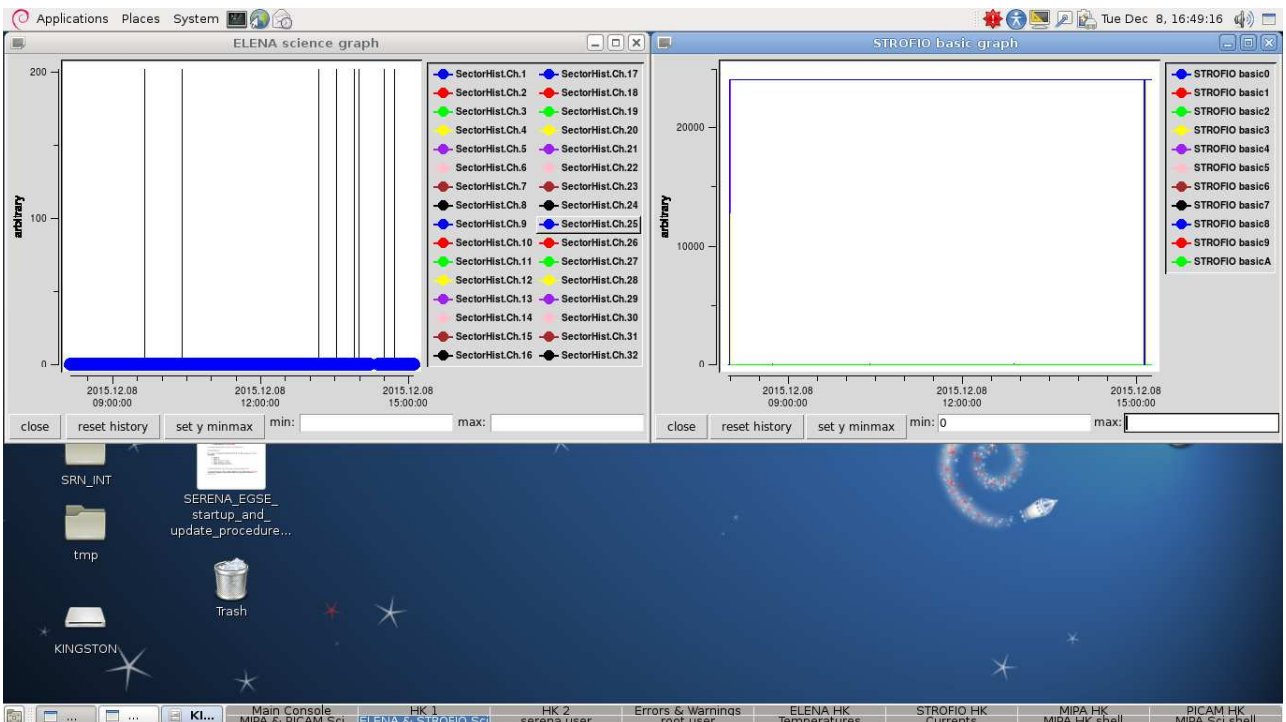
**Figure 5.22 –SERENA Temperatures.**



**Figure 5.23 –SERENA Currents.**



**Figure 5.24 –MIPA & PICAM Science.**



**Figure 5.25 –ELENA & STROFIO Science.**



## 5.7 Test performed on Wednesday 09 December 2015

- Test #6 - RE Receiver Notches

- Notes:

1 Shift: Phebus Pump removal, S/C configuration 5

Normal Shift morning: only MIXS, SIXS, SIMBIO, SERENA are ON.

In addition BELA laser will be fired.

+++ Payloads configured in MAX\_EMI

\*\*\* Further details about procedure in [RD1],

Chapter 7.5.5 pages 77-79 and Chapter 8.7 pages 205-214 (step 10, 20, 30, 70, 80)

**Test started at 08:41 and successfully completed at 18:09 when the last HK packet was received.**

All TM packets received, HK and SCI data as expected. Currents and Temperatures were nominal. Some little but nominal oscillations of MIPA TOF Board temperature and of LVPS Temperature occurred around the nominal temp trend.

Hereafter monitoring of the instrument behaviour and its functionality is shown in some pictures:

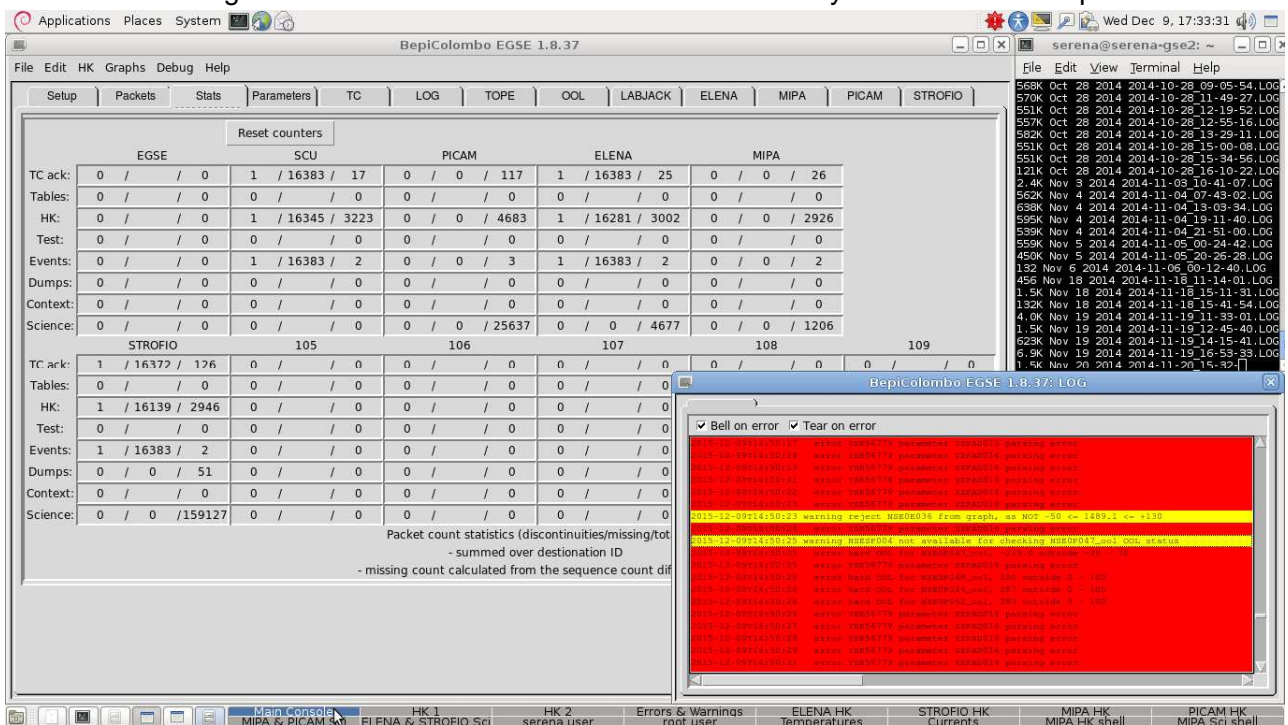


Figure 5.26 – All TM packets received from SERENA at the end of test session.

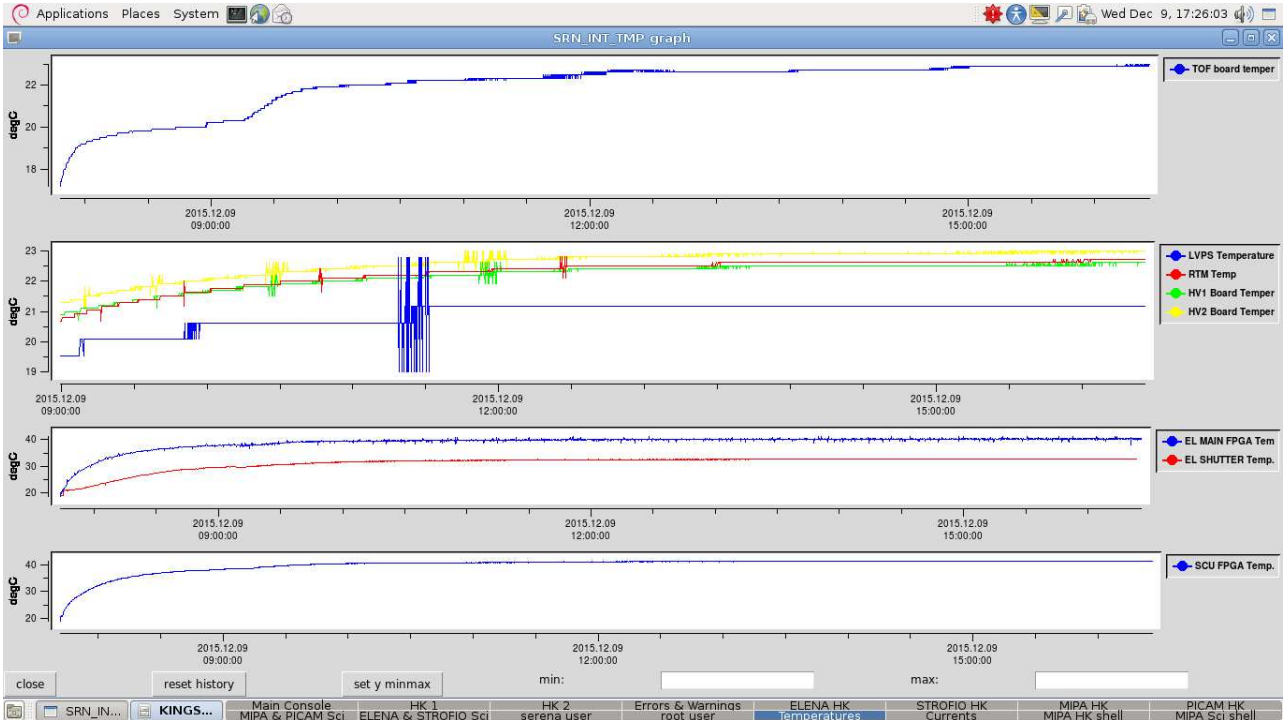


Figure 5.27 –SERENA Temperatures.

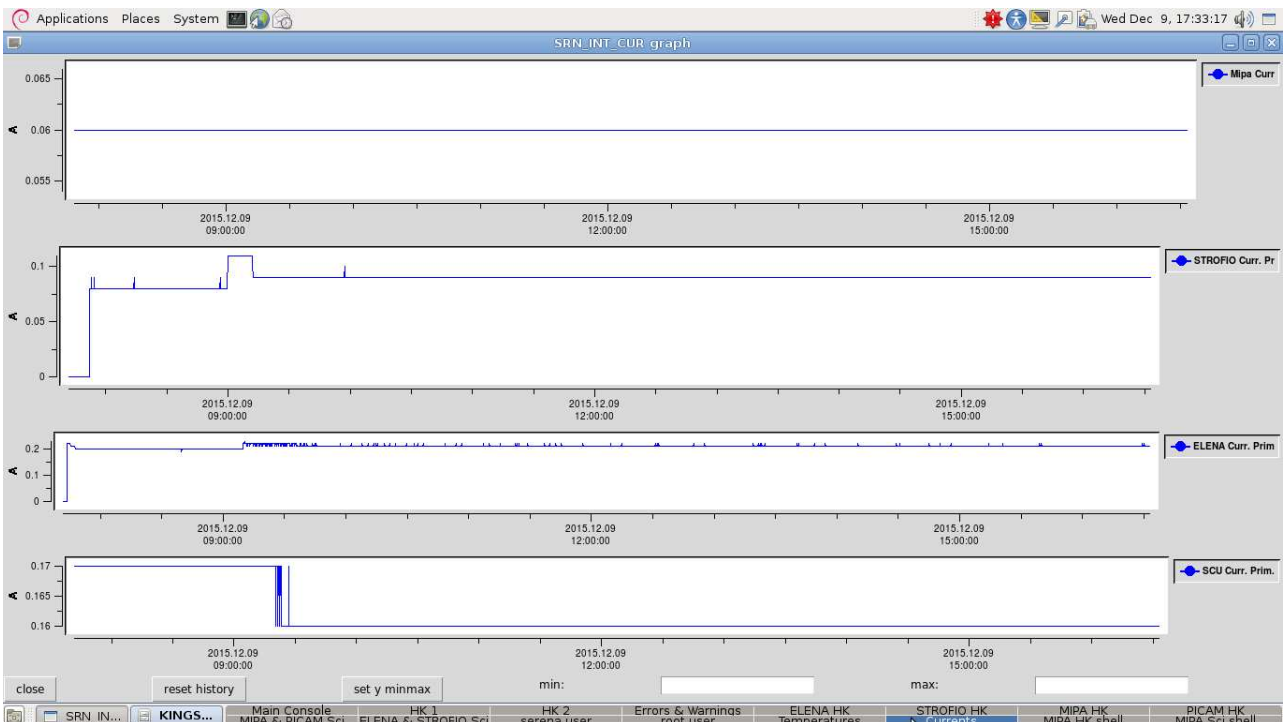
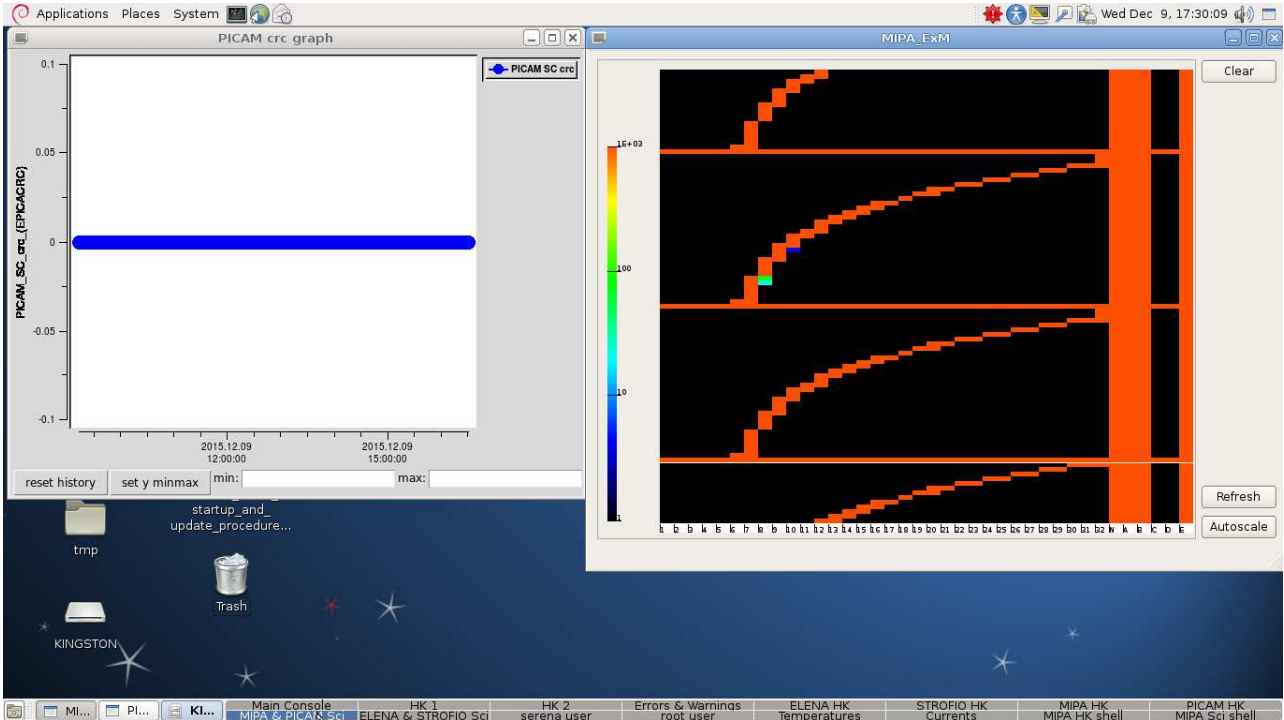
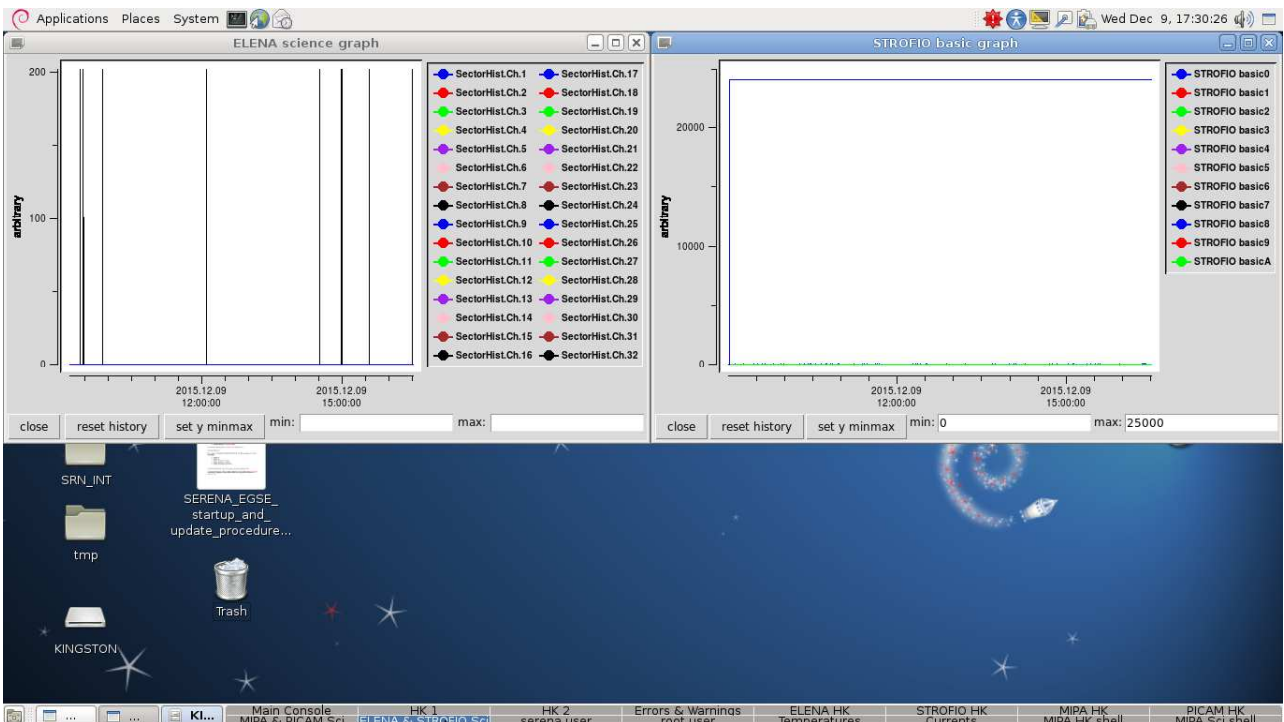


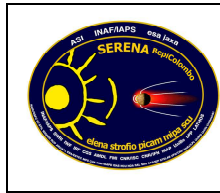
Figure 5.28 –SERENA Currents.



**Figure 5.29 –MIPA & PICAM Science.**



**Figure 5.30 –ELENA & STROFIO Science.**



## 6 Susceptibilities and/or Anomalies

No considerable susceptibility to the radiated emissions was observed for the whole SERENA P/L instrument and its subsystems during the test session. Little oscillations of some sub-system temperatures occurred around the nominal temp trend but in the order of few Celsius degrees, and therefore compliant to the standard and without impact on the instruments operations.

The following set of warnings, however, were monitored along all the test session:

1. error hard OOL for NSE0P047 (MCP temperature) on PICAM: OOL T = -225 => thousand of OOLs occurred during every test session;
2. error hard OOL for NSE0P048 (Ugate+ Voltage Monitor), NSE0P049 (Ugate- Voltage Monitor), NSE0P052 (Ugate Set Monitor) => sets of OOLs concerning PICAM occurred during every test session;
3. error YSE56779 parameter ZZPAD016 parsing error (YSE56779 SERE Strofio Science Raw Ev. Data) => thousand of errors occurred during the flow of STROFIO data at very high rate.

## 7 Conclusion

**The Radiated EMC test on the SERENA FM suite was successfully performed. SERENA worked as expected under all test conditions, and showed a nominal behaviour and a good performance.**

All TM packets were received from each sub-system and for any category. Flux of HK and SCI data was regular, data quality as expected. SCI data packets of STROFIO were always received at very high rate. Data show no missing or corrupted packets except some jumps in the sequence counter.

Currents and Temperatures were nominal during the whole test session. The current peak on STROFIO, happened during the MPO SFT #2 test session, DID NOT OCCUR THIS TIME. Some little but nominal oscillations of MIPA TOF Board temperature occurred around the nominal temp trend on the 7<sup>th</sup> and 8<sup>th</sup> of December. Moreover some random peaks for ELENA Shutter temperature were monitored (jump up to 4-5 degrees) with a duration of 30 seconds: these events are isolated and negligible spikes.

All SERENA settings and thresholds were consistent to the default values. Some sets of OOL, however, happened during the whole test session: most of them occurred during mode transitions and/or are due to the sensor configuration, and will disappear after the next EGSE S/W updates.

Finally only a remarkable event has to be mentioned: during the Test #2 session executed on the 8<sup>th</sup> of December and after a reboot foreseen by the nominal procedure, STROFIO was unable to receive and execute TCs again; but the solution to power OFF STROFIO and then power ON it again allowed to restore the lost link to the SCU. The reason of this failure is currently under investigation (BC-SRN-NC-01582 was opened on 8 Dec 2015).