TITLE: **Planck LFI – Test Report on the TMH/TQL (QM and FM) by Using A Known Signal Tests Data**

DOC. TYPE: TECHNICAL NOTE

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CHANGE RECORD

Issue	Date	Sheet	Description of Change	Release
0.0	2006 Feb 01		Starting of the document	
1.0	2006 Mar 28		First Issue	
1.1	2006 Nov 09		Definition of correspondence between test plan and tests described in this report	
1.2	2006 Dec 14		Added new test procedures to complete the test cases coverage	SGS-IR
1.3	2008 Jan 21		Review of entire doc	SGS-RR

TABLE OF CONTENTS

1 SCOPE

Describe methods, test procedures and results of the validation of TMH/TQL version QM/FM/OM by using a signal generator. The FM version of the TMH/TQL includes only bug fixes to the QM version (found during the QM testing) and a change in the interpretation of the tertiary header of the scientific telemetry packets, due to a modification in the header structure performed by Laben (Alcatel Alenia Space - Milan) in June 2006.
Note that the data set acquired to perform the described test is always applied before any release of OM to validate its correct telemetry handling.

1.1 LIMITS OF APPLICABILITY

Scope of this test is to validate the QM and FM TMH/TQL in its relevant aspects in particular

1. Scientific Telemetry registration,
2. Scientific Telemetry OBT Reconstruction,
3. Scientific Telemetry reconstruction and conversion to physical units of different PTypes,
4. Generation of model examples for DPC-L1 and DPC-L2 of timelines with saturated data,
5. HK Telemetry registration and conversion
6. Verification of TQL functionalities not covered by the previous tests

with a particular regard to processing and reconstruction of PType 1, since this processing type was chosen also during the DM testing campaign.

The plan for the test is described in [AD-1].

A report on data acquisition is in [AD-2].

Mathematical details of methods are described in [AD-3].

2 APPLICABLE/REFERENCE DOCUMENTS

2.1 APPLICABLE DOCUMENTS

[AD-1] Planck-LFI Communications, ICD,
M. Miccolis
PL-LFI-PST-ID –013

[AD-2] Telemetry Handling System – User Requirements Document
F.Pasian, D.Maino, A.Zacchei
PL-LFI-OAT-UR-004

[AD-3] Planck LFI – Characterization of the Compression Rate for the New Baseline for the Scientific Data Streams Coding
M. Maris
PL-LFI-OAT-TN–029

[AD-4] Planck LFI – Characterization of the Onboard Processing Parameters
M. Maris
PL-LFI-OAT-TN–030

[AD-5] Planck LFI – Test Plan for the TMH/TQL Software
M. Maris, X. Dupac.
PL-LFI-OAT-PL–009

2.2 REFERENCE DOCUMENTS

[RD-1] Reconfiguration for LFI on-board data processing and scientific telemetry
M. Miccolis, A. Mennella, M. Bersanelli, M. Maris
PL-LFI-PST-TN-037

[RD-2] PL-LFI-OAT-RP-012
M.Maris, October 2005

[RD-3] PL-LFI-OAT-RP-013
M.Maris, October 2005

[RD-4] Addendum PL-LFI-OAT-TN-14/T1

[RD-5] Addendum PL-LFI-OAT-TN-14/T2

[RD-6] Addendum PL-LFI-OAT-TN-14/T3

2.3 ACRONYMS LIST

ADU	Analog / Digital Unit
DM	Demonstration Model
FM	Flight Model
FP	Floating Point
OBT	On Board Time
OM	Operations Model
PType	Processing Type
QM	Qualification Model
TMH	Telemetry Handler
TMU	Telemetry Unscrambler
TOI	Time Ordered Information
TOD	Time Ordered Data
TQL	Telemetry Quick-Look

3 LIST OF PROBLEMS DETECTED

In this section we briefly outline the list of problems detected, and solved, during the test campaign.

3.1 QM TESTING

1. Time Stamping Error in TOIs without Switching.
   With switching off, time stamp of sky (or load) signals are not monotonically increasing. Instead they are repeated in couples as in the example below:

   1.1234234e9, 1.1234234e9, 1.24234e9, 1.24234e9, …

2. Some problem with HK Telemetry Registration

3. Scientific Telemetry PType 0 and 4, 2 and 5, 3 and 6 are not properly registered when acquired together.

4. Some problem with the reconstruction of onboard processing, probably associated to problems in the REBA software.

3.2 FM TESTING

1. The scientific data never appears in calibrated mode (V) even selecting this visualization mode. They are only displayed in the uncalibrated format (ADU). This is due to the fact that the Calibration Curve referred to the Blancking Time 01 (default) was not inserted on the calibration.science File

2. For Naver = 400 and PType 1 packets are not displayed in the scientific plot. More analysis will be performed on the TOIs.

4 METHODS OF SCIENTIFIC DATA ANALYSIS

4.1 STAND-ALONE TESTS AND COMPARISON TESTS

The overall scheme for testing the various processing types exploits the ability of REBA to send at the same time two different PType of the same data. As shown in Fig.4.1 the different PTypes correspond to different steps in the processing chain. In particular the following couples of PTypes represent consecutive steps in the onboard processing:
(PType 0, PType 1), (PType 0, PType 4), (PType 1, PType 2), (PType 2, PType 5), (PType 1, PType 3), (PType 1, PType 6).

Then there are two possible testing schemes:
1. Stand-alone test
2. Comparison test

In a stand-alone test a single PType is acquired and analyzed looking for proper time ordering and reconstruction.

In a comparison test “consecutive” PTypes are acquired together and compared; comparison tests allow to track in a more rigorous manner the processing effects.

4.2 TOI BLOCKING

A TOI generated by the TMH is split into blocks.

Each block is characterized by having:
1. stationary input signal (signal is uninterrupted, it has constant period, phase, amplitude, shape and duty cycle),
2. uninterrupted acquisition,
3. constant acquisition parameters: GMF_1, GMF_2, SECOND_QUANT, OFFSET_ADJUST, N_AVER, SWITCHING and PType.
4. absence of any kind of bad or flagged data.

Splitting is performed by hand just looking to the regions of each TOI where there is homogeneity.

Tables of blocks defining for each block the aforementioned parameters and the limits of each block within the given TOI are provided as a by-product of each test.

4.3 SIGNAL FITTING

Signal fitting is performed within a single block.

Signal fitting assumes a wave shape and values of the wave parameters to be used as guess parameters for fitting.

Signal fitting is performed with various levels of accuracy whose definition depends on the kind (shape) of the signal.

4.4 REPORTING

Automated reports in the form of graphs and tables are generated by the analysis codes. Such reports are not part of this document but are provided as addenda to the present document.

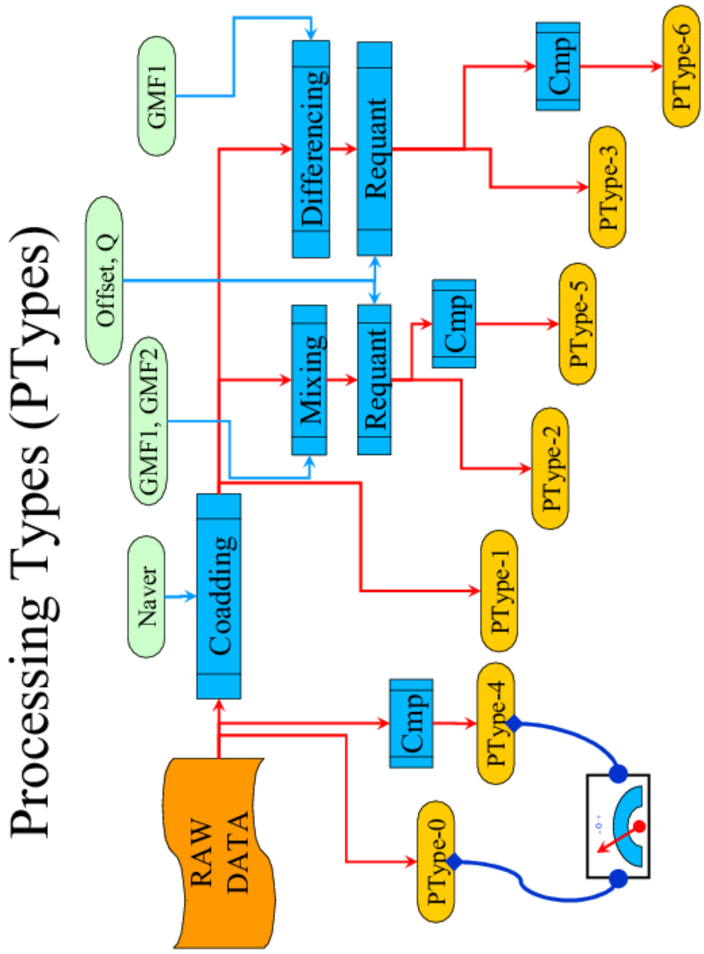


Fig 4.1: Schematic representation of the on board processing, processing parameters and processing types for the LFI.

5 SCIENTIFIC DATA REGISTRATION

5.1 TEST IDENTIFIER AND TEST PLAN REFERENCE

5.1.1 TEST ID: TMH-QM-SDR-01

TMH-QM-SDR-01

5.1.2 TEST PLAN REFERENCES

This test procedure covers the following test cases:

Test ID	Motivation
RAW-TM-01	Possible gaps in the packet stream would be identified as gaps in the TOI and graphical display
OBT-SCI-01a	Errors in the OBT handling would result in plot anomalies
RAW-TM-02	Improper packet commutation can be highlighted by improper injection of signals related to a given DSA into the incorrect TOI in the FITS file or in the display
DDR-SCI-001	The same of test HDM-TR-04
DDR-SCI-002	The same of test HDM-TR-04, but limited to PTYPE 1
DDR-SCI-004	Wrong acquisition and conversion of a known signal would be noticed by examining the values in the TOI and the graphical display
DDR-SCI-016	Wrong decoding would come out from the values in the TOIs or displayed. This test covers only PTYPE 1
GDS-SCI-001	Improper data registration would result by examining the TQL display. Limited only to PTYPE 1

5.2 SCOPE OF THE TEST

To test that data streams belonging to different DSA are properly registered in FITS files.

5.3 PROCEDURE

The signal generator is connected at each DAE analogical gate in turn (the other gates are left unplugged), the signal is acquired and then the probe of the signal generator is unplugged and connected to another gate. This is done acquiring continuously data till all the gates are plugged.

TMH is executed.

TOIs for each DSA are scanned looking where the signal appears.

The test fails if signal appears in TOIs corresponding to unplugged gates or is not present in the TOI corresponding to the plugged gate.

5.4 DATA SELECTION

Test XXX_9001 has been used.

5.5 RESULT

Fig.5.1 is a synoptic of the TOIs from this test.

It is evident how the presence of a signal in one of the TOIs excludes signals in others (apart from short transients, corresponding to the plugging/unplugging operations) and there are no holes in the data.

5.6 CONCLUSION

The TMH properly register scientific data.

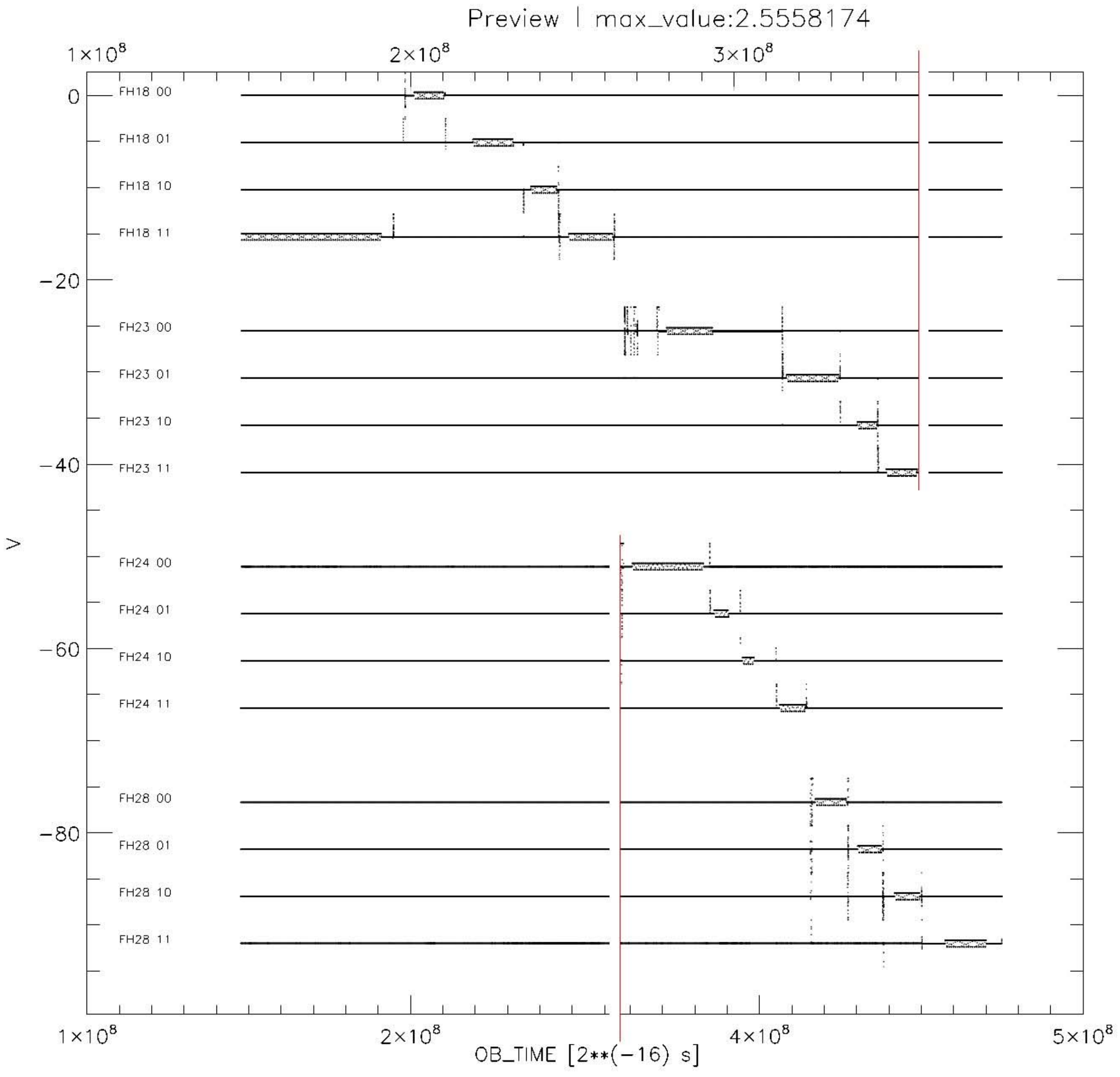


Fig.5.1: Simplified plot of 16 channels, made with a composition of Volt patterns per each feed horn, so y-axis is in Volt but not true values. The red line cuts the plot at the same OB_TIME value. Above the plot, the max measured value is reported.

6 PTYPE 0 PROCESSING

6.1 TEST IDENTIFIER AND TEST PLAN REFERENCE

6.1.1 TEST ID: TMH-QM-PT0-01

TMH-QM-PT0-01

6.1.2 TEST PLAN REFERENCES

This test procedure covers the following test cases:

Test ID	Motivation
RAW-TM-01	Possible gaps in the packets stream would be identified as gaps in the TOI and graphical display
OBT-SCI-01a	Errors in the OBT handling would result in plot anomalies
OBT-SCI-01b	Assessed by the analysis of signal phases with respect to the packets timestamp
RAW-TM-02	Improper packet commutation can be highlighted by improper injection of signals related to a given DSA into the incorrect TOI in the FITS file or in the display
DDR-SCI-001	The same of test HDM-TR-04
DDR-SCI-002	The same of test HDM-TR-04, but limited to PTYPE 0
DDR-SCI-003	Wrong acquisition and conversion of a known signal would be noticed by examining the values in the TOI and the graphical display
DDR-SCI-016	Wrong decoding would come out from the values in the TOIs or displayed. This test covers only PTYPE 0
GDS-SCI-001	Improper data registration would result by examining the TQL display. Limited only to PTYPE 0

6.2 SCOPE OF THE TEST

To demonstrate that PType 0 data are properly reconstructed.

6.3 DATA SELECTION

The data sets are from: XXX_9008, XXX_9009, XXX_9010, XXX_9011.

6.4 PROCEDURE

A set of square waves are acquired. Data are registered and the square waves are analyzed looking for amplitude, period, phases relative to packet generation.

6.5 RESULT

Many problems with the acquisition of this kind of data in LABEN (from the hardware point of view) prevent us to have time series of sufficient quality to carry out the test.

6.6 CONCLUSION

It has been impossible to carry out the test. Note that the PType 0 acquisition mode can't be used during operations due to excess of science telemetry.

7 PTYPE 1 PROCESSING

7.1 TEST IDENTIFIER AND TEST PLAN REFERENCE

7.1.1 TEST ID: TMH-QM-PT1-01

TMH-QM-PT1-01

7.1.2 TEST PLAN REFERENCES

This test procedure covers the following tests cases:

Test ID	Motivation
RAW-TM-01	Possible gaps in the packets stream would be identified as gaps in the TOI and graphical display
OBT-SCI-01a	Errors in the OBT handling would result in plot anomalies
OBT-SCI-01b	Assessed by the analysis of signal phases with respect to the packets timestamp
OBT-SCI-01c	This planned test is realized trough the correlation of signals between PTYPE 0 and PTYPE 1
OBT-SCI-003	Limited to PTYPEs 0 and 1. This planned test is accomplished by the "comparison analysis"
RAW-TM-02	Improper packet commutation can be highlighted by improper injection of signals related to a given DSA into the incorrect TOI in the FITS file or in the display
DDR-SCI-001	The same of test HDM-TR-04
DDR-SCI-002	The same of test HDM-TR-04, but limited to PTYPE 1
DDR-SCI-003	Wrong acquisition and conversion of a known signal would be noticed by examining the values in the TOI and the graphical display
DDR-SCI-004	Wrong acquisition and conversion of a known signal would be noticed by examining the values in the TOI and the graphical display
DDR-SCI-016	Wrong decoding would come out from the values in the TOIs or displayed. This test covers only PTYPE 1
GDS-SCI-001	Improper data registration would result by examining the TQL display. Limited only to PTYPE 1

7.2 SCOPE OF THE TEST

To demonstrate that PType1 data are properly reconstructed.

7.3 DATA SELECTION

The data sets are from:

XXX_9015 for comparison testing
XXX_9022 for stand-alone testing

7.4 PROCEDURE

7.4.1 COMPARISON TESTING

1. In XXX_9022 PType 0 and PType 1 has been acquired together.
2. TMH generates two kinds of files: RAW files containing PType 0 and AVR Files containing PType 1.
3. The two data sets has to be compared taking in account of the different sampling rate.
4. Matching of data is carried on comparing the OBT of the two data streams and phasing the maxima in the square waves of the two data streams.

7.4.2 STAND-ALONE TESTING

XXX_9022 has been acquired splitting the run in time blocks.

Each time block is characterized by a constant set of REBA parameters, signal generator setup, and switching status.

In general, the separation between blocks is marked by a "*silent period*" where the signal generator have been switched off, or by an "*acquisition stop*" where acquisition has been stopped, usually when the parameters of the REBA setup have been changed.

A semiautomatic procedure has been used to split the run in BLOCKS and analyze them uniformly.

The following analysis has been carried out:

1. consistency checks for blocking,
2. fitting of silent intervals obtaining zero points and rms of noise,
3. fitting of square waves obtaining: period, duty-cycle, average high level and average low level and their RMS,
4. fitting of triangular waves obtaining: period, amplitude;
5. comparison of amplitudes from fit with amplitudes in the signal generator.

The results of the different fittings, as the blocking scheme, are reported in Tab. 7.1. This table is used also for OBT reconstruction (see related section).

7.5 RESULT

7.5.1 COMPARISON TESTING

During acquisition it has been discovered that REBA generates fake spikes in data streams when PType 0 and PType 1 are acquired together.

This prevents us from having data of sufficient quality to perform the test.

The test was not carried on.

7.5.2 STAND-ALONE TESTING

A linear fit between the fitted V_{fit} and the generator values $V_{\mathrm{generator}}$

V_{fit} = Intercept + Slope $V_{\mathrm{generator}}$

has been performed, Pearson statistics have been used as a way to assess linearity. Results are shown in Tab 7.1. Fit has been performed either comparing the High levels, the Low levels or both.

The ideal case would be obviously

Intercept = 0, Slope =1, Pearson = 1 .

The linearity over the full range of voltages allowed by the ADC is very good and slopes are only slightly different. These differences may be due to the slow drift in square waves. Intercepts only seems to show some asymmetry between the LOW and HIGH cases. The rms of High and Low signals seems comparable to the rms of the "signal off" part of the data set.

Tab. 7.1 Reconstruction of PTYPE 1 data for XXX_9022			
Sample	**Intercept**	**Slope**	**Pearson**
Sq. W., LOW	+0.00593 ± 0.00043	0.9918 ± 0.0011	0.999970
Sq. W., HIGH	-0.00340 ± 0.00048	0.9944 ± 0.0012	0.999964
Sq. W., HIGH + LOW	+0.001755 ± 0.00014	0.98152 ± 0.00036	0.999993

Tab 7.1: Reconstruction of PTYPE1 for the XXX_9022 test set.

7.6 CONCLUSION

The comparison testing has not been carried on due to problem in acquiring the needed data. These problems do not depend on the TMH but are likely due to the acquisition system before the TMH/TQL.
Must be noted that the acquisition of PTYPE 0 and PTYPE 1 at the same time is not a normal operation since the amount of data produced is too heavy to be supported by the hardware.

Looking at the stand-alone testing, it is possible to conclude that at first order, PType 1 data are properly reconstructed.

Second order effects, at the level of some mV, in reconstructing the signals are evidenced, however a more accurate analysis will be required in order to disentangle whether they can be ascribed to calibration tables in TMH or if they can be attributed to the drifts in the square waves.

8 PTYPE 2 PROCESSING

8.1 TEST IDENTIFIER AND TEST PLAN REFERENCE

8.1.1 TEST ID: TMH-QM-PT2-01

TMH-QM-PT2-01

8.1.2 TEST PLAN REFERENCES

This test procedure covers the following test cases:

Test ID	Motivation
RAW-TM-01	Possible gaps in the packets stream would be identified as gaps in the TOI and graphical display
OBT-SCI-01a	Errors in the OBT handling would result in plot anomalies
OBT-SCI-01b	Assessed by the analysis of signal phases with respect to the packets timestamp
OBT-SCI-03	Limited to PTYPEs 1 and 2. This planned test is accomplished by the "comparison analysis"
RAW-TM-02	Improper packet commutation can be highlighted by improper injection of signals related to a given DSA into the incorrect TOI in the FITS file or in the display
DDR-SCI-001	The same of test HDM-TR-04
DDR-SCI-002	The same of test HDM-TR-04, but limited to PTYPEs 1 and 2
DDR-SCI-004	Wrong acquisition and conversion of a known signal would be noticed by examining the values in the TOI and the graphical display
DDR-SCI-005	Several values for second quantization and offset are used
DDR-SCI-006	Several values of mixing parameters are used
DDR-SCI-016	Wrong decoding would come out from the values in the TOIs or displayed. This test covers only PTYPEs 1 and 2
GDS-SCI-001	Improper data registration would result by examining the TQL display. Limited only to PTYPEs 1 and 2

8.2 SCOPE OF THE TEST

To demonstrate that PType2 data are properly reconstructed.

8.3 DATA SELECTION

The data sets are from: XXX_9022 both for comparison and stand-alone testing.

8.4 PROCEDURE

See PType 1 testing stand-alone for a description of data acquisition.

8.5 RESULT

Fig. 8.1 shows the differences between PType 2 and PType 1 data in ADU (not rescaled to V).

It is possible to see that the differences between PType 1 and PType 2 are small and compatible with the expected quantization error which for the parameters used is approximately ½ ADU.

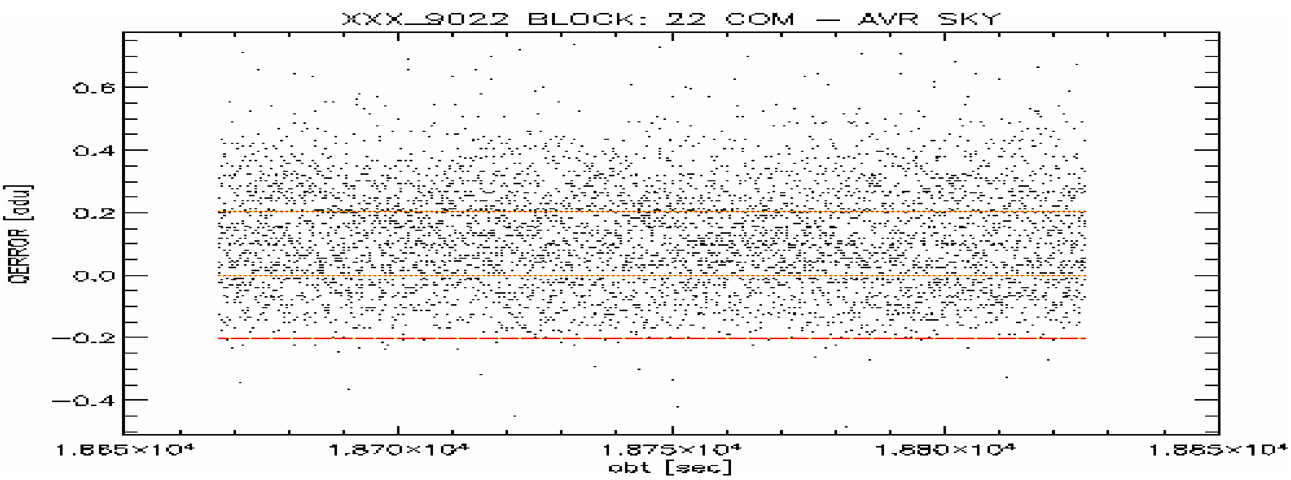
A problem arises with the distribution of quantization errors which does not follow exactly the expectation. As it is evident the quantization errors are not symmetrically distributed about zero.

A deepest analysis is shown in Fig.8.2 where the processing leading to PType 2 generation from PType 1 data has been carried on according the documented onboard algorithm. It is possible to see that the expected processing error does not distribute as the real one.

Better display of this effect is in subsequent Fig.8.3 where a scatter plot of sky vs. load processing error is performed. Again real data does not follow the expectation.

This problem with the distribution of quantization errors however does not occurs always, there are cases (see Fig.8.4) where the processing error behaves as expected.

This problem has been already detected in [RD-6].



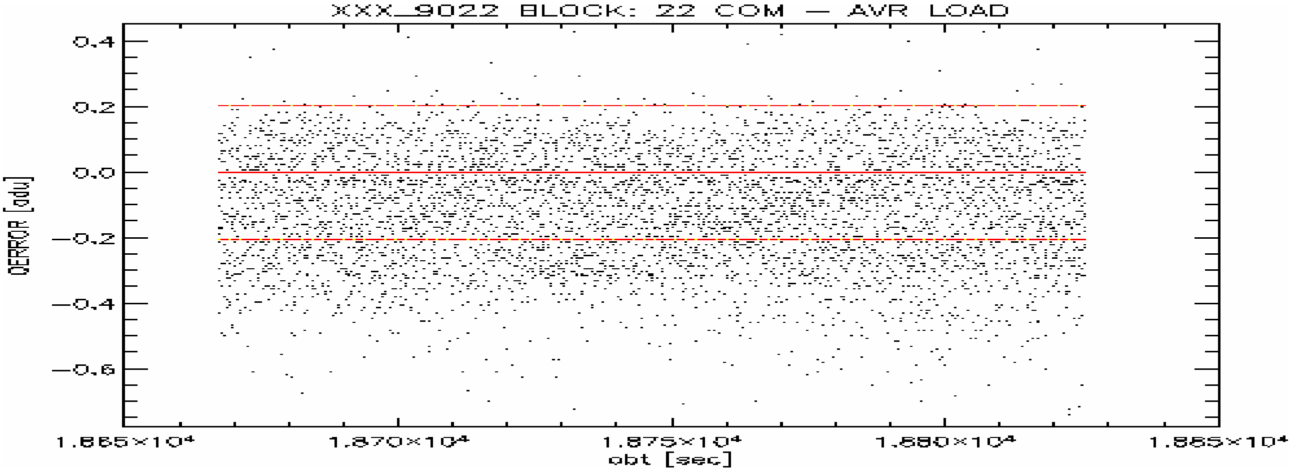


Fig.8.1 Quantization error for SKY (upper frame) and LOAD (lower frame) of block 22 in the test XXX_9022 (dots) compared to the expected averaged quantization error (red) and the RMS of the quantization error (red lines). GMF_1=1, GMF_2=0, SECOND_QUANT=1, OFFSET_ADJUST=0, NAVER=126

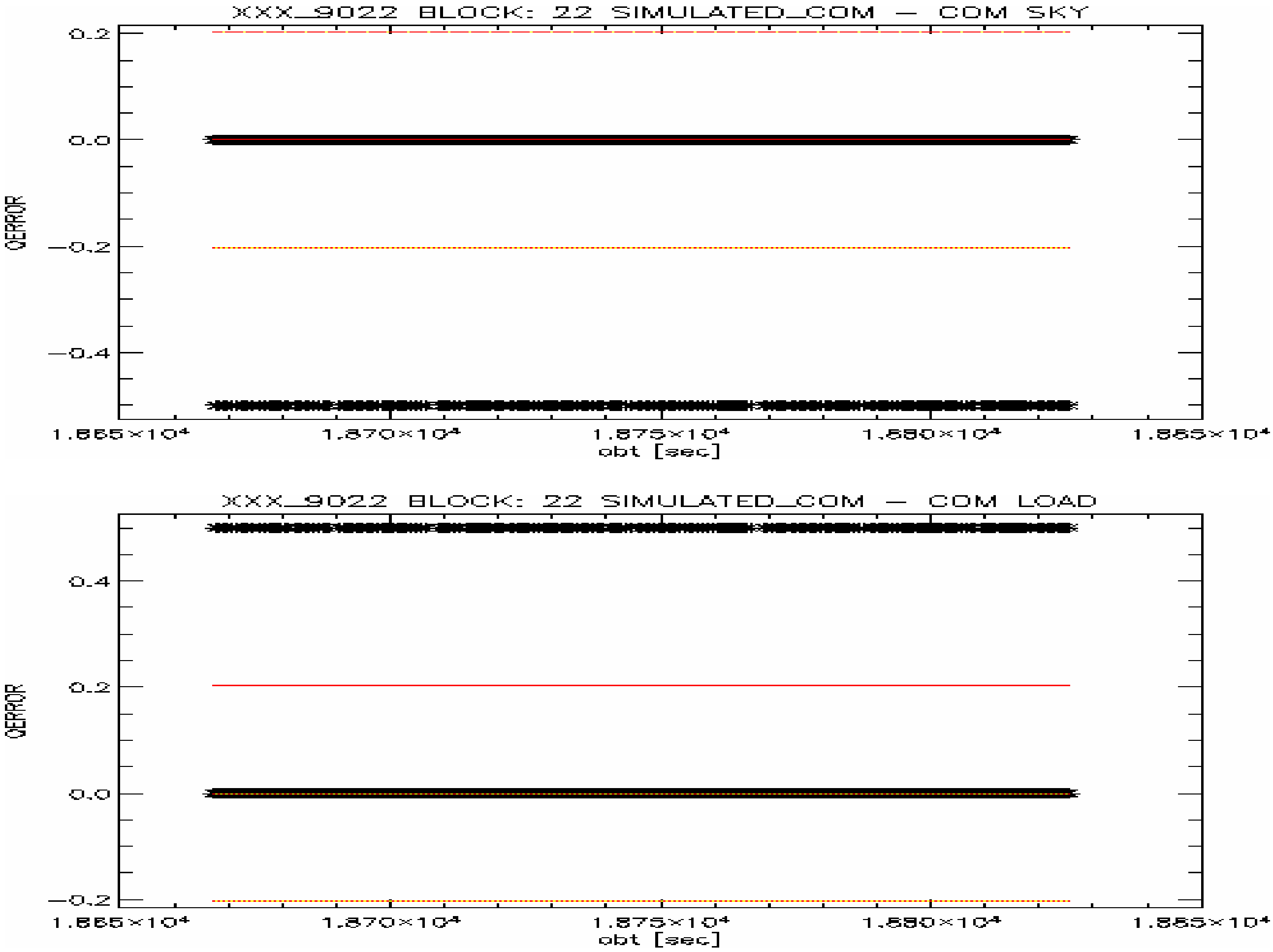


Fig.8.2 Differences between PType 2 generated by simulating on board processing and the true PType 2 data of block 22. Upper frame for SKY lower frame for LOAD. Red lines represents are the expected mean and RMS of the quantization error (see Fig.8.1).

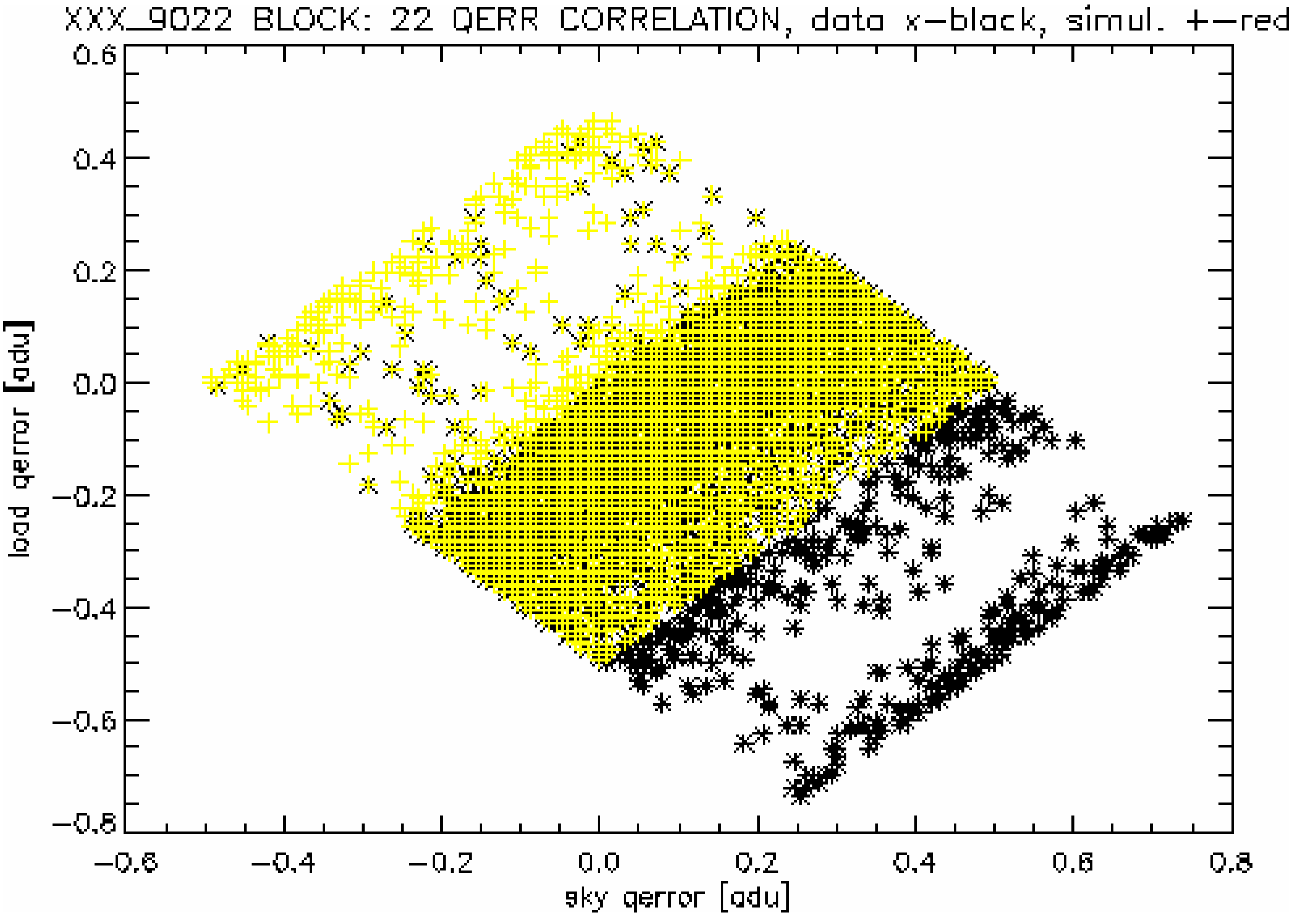


Fig.8.3 Distribution of quantization errors for LOAD vs quantization errors for LOAD for true PType 2 data of Block 22 of test XXX_9022 (black crosses) and simulated processing (yellow crosses).

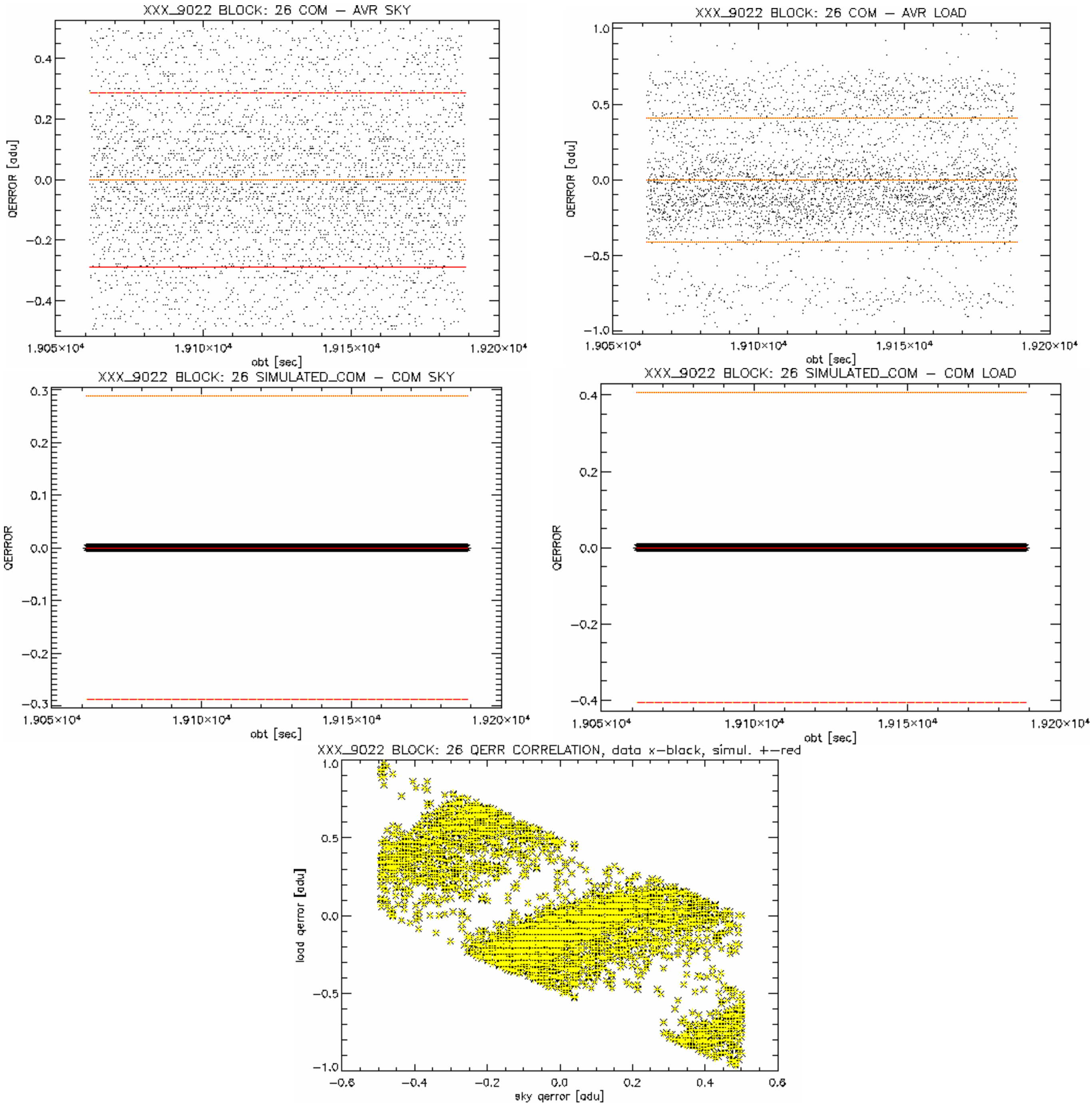


Fig.8.4 The same of Figures.8.1 to 8.3 but for block 26. In this case the problem outlined in Fig.8.3 is not present.

8.6 CONCLUSION

PType 2 are properly reconstructed.

The only problem seems an asymmetric distribution of the processing errors when compared with the expected processing error obtained simulating processing of PType 1 data using the same onboard algorithm and processing pars.

The difference however is small being at most of the order of some ADU.

9 PTYPE 3 PROCESSING

9.1 TEST IDENTIFIER AND TEST PLAN REFERENCE

9.1.1 TEST ID: TMH-QM-PT3-01

TMH-QM-PT3-01

9.1.2 TEST PLAN REFERENCES

This test procedure covers the following test cases:

Test ID	**Motivation**
RAW-TM-01	Possible gaps in the packets stream would be identified as gaps in the TOI and graphical display
OBT-SCI-01a	Errors in the OBT handling would result in plot anomalies
OBT-SCI-03	Limited to PTYPEs 1 and 3. This planned test is accomplished by the “comparison analysis”
RAW-TM-02	Improper packet commutation can be highlighted by improper injection of signals related to a given DSA into the incorrect TOI in the FITS file or in the display
DDR-SCI-001	The same of test HDM-TR-04
DDR-SCI-002	The same of test HDM-TR-04, but limited to PTYPEs 1 and 3
DDR-SCI-007	Several values for second quantization, offset and GMF1 are used
DDR-SCI-016	Wrong decoding would come out from the values in the TOIs or displayed. This test covers only PTYPEs 1 and 3
GDS-SCI-001	Improper data registration would result by examining the TQL display. Limited only to PTYPEs 1 and 3

9.2 SCOPE OF THE TEST

To demonstrate that PType 3 data are properly reconstructed.

9.3 DATA SELECTION

The data sets are from: XXX_9027

9.4 PROCEDURE

Triangular waves are acquired with both PType 1 and PType 3.

Only comparison test is carried on.

9.5 RESULT

Graphical output of TMH confirms proper decompression on the graphical display.

9.6 CONCLUSION

Graphical output of TMH confirms proper decompression on the graphical display.

10 PTYPE 4 PROCESSING

10.1 TEST IDENTIFIER AND TEST PLAN REFERENCE

10.1.1 TEST ID: TMH-QM-PT4-01

TMH-QM-PT4-01

10.1.2 TEST PLAN REFERENCES

This test procedure covers the following test cases:

Test ID	Motivation
RAW-TM-01	Possible gaps in the packets stream would be identified as gaps in the TOI and graphical display
OBT-SCI-01a	Errors in the OBT handling would result in plot anomalies
OBT-SCI-01b	Assessed by the analysis of signal phases with respect to the packets timestamp
OBT-SCI-03	Limited to PTYPEs 0 and 4. This planned test is accomplished by the "comparison analysis"
RAW-TM-02	Improper packet commutation can be highlighted by improper injection of signals related to a given DSA into the incorrect TOI in the FITS file or in the display
DDR-SCI-001	The same of test HDM-TR-04
DDR-SCI-002	The same of test HDM-TR-04, but limited to PTYPEs 0 and 4
DDR-SCI-008	Comparison between PTYPE 0 and PTYPE 4
DDR-SCI-011	Test performed by examining the compression rate of PTYPE 4
GDS-SCI-001	Improper data registration would result by examining the TQL display. Limited only to PTYPEs 0 and 4

10.2 SCOPE OF THE TEST

To demonstrate that PType 4 data are properly reconstructed.

10.3 DATA SELECTION

The data sets are from: XXX_9010.

10.4 PROCEDURE

Square waves are acquired both with PType 0 and PType 4.

Both PType 0 and PType 4 are written as _RAW_ files.

Only comparison test is carried on.

10.5 RESULT

Badness in PType 0 data already described for the PType 0 testing and the same problem affecting the registration of contemporaneous acquisition of PType 2 and PType 5 prevents the execution of this test for the QM version

10.6 CONCLUSION

Test postponed.

However, the decompression of PType 4 data is executed with the same software modules for decompression of PType 5 (resulting in PType 2). Since, once the registration problem has been solved in the FM version, no errors were detected on PType 5 data (see section 11), the present test is redundant with respect to the verification of the decompression.

11 PTYPE 5 PROCESSING

11.1 TEST IDENTIFIER AND TEST PLAN REFERENCE

11.1.1 TEST ID: TMH-QM-PT5-01

TMH-QM-PT5-01

11.1.2 TEST PLAN REFERENCES

This test procedure covers the following test cases:

Test ID	Motivation
RAW-TM-01	Possible gaps in the packets stream would be identified as gaps in the TOI and graphical display
OBT-SCI-01a	Errors in the OBT handling would result in plot anomalies
OBT-SCI-01b	Assessed by the analysis of signal phases with respect to the packets timestamp
OBT-SCI-03	Limited to PTYPEs 2 and 5. This planned test is accomplished by the "comparison analysis"
RAW-TM-02	Improper packet commutation can be highlighted by improper injection of signals related to a given DSA into the incorrect TOI in the FITS file or in the display
DDR-SCI-001	The same of test HDM-TR-04
DDR-SCI-002	The same of test HDM-TR-04, but limited to PTYPEs 2 and 5
DDR-SCI-005	Several values for second quantization and offset are used
DDR-SCI-006	Several values of mixing parameters are used
DDR-SCI-009	Compressed and decompressed values are compared
DDR-SCI-012	Data acquired in within this test are preliminary to the optimization test
DDR-SCI-013	Data acquired in within this test are preliminary to the assessment of the susceptibility of compression rate and quantization errors
DDR-SCI-016	Wrong decoding would come out from the values in the TOIs or displayed. This test covers only PTYPEs 2 and 5
GDS-SCI-001	Improper data registration would result by examining the TQL display. Limited only to PTYPEs 2 and 5

11.2 SCOPE OF THE TEST

To demonstrate that PType5 data are properly reconstructed.

11.3 DATA SELECTION

This test is done using data from: XXX_9028 and XXX_9029.

11.4 PROCEDURE

1. PType 2 and PType 5 data are acquired together.
2. Data from PType 5 processing are compared with data from PType 2 processing.

11.5 RESULT

An early attempt to carry out this analysis reveals the registration problem described as follow: the TMH QM did not register properly the contemporaneous acquisition of PType 2 and PType 5. Both data streams were inserted in the same TOI and it is unpractical to attempt a separation. The problem came from the lack of analysis of this case in the requirements.

Once the problem has been fixed, the test was repeated.

No differences were revealed between PType 2 and PType 5 data.

11.6 CONCLUSION

An insufficient handling of PType 2 and PType 5 data acquired at the same time has been revealed in TMH. The problem has been fixed. It has affected only the tuning tests for quantization, not the QM RAA calibration tests.

No differences has been detected between PType 2 and PType 5.

The compression/decompression procedure passed this test.

12 PTYPE 6 PROCESSING

12.1 TEST IDENTIFIER AND TEST PLAN REFERENCE

12.1.1 TEST ID: TMH-QM-PT6-01

TMH-QM-PT6-01

12.1.2 TEST PLAN REFERENCES

This test covers the following tests:

Test ID	Motivation
RAW-TM-01	Possible gaps in the packets stream would be identified as gaps in the TOI and graphical display
OBT-SCI-01a	Errors in the OBT handling would result in plot anomalies
OBT-SCI-01b	Assessed by the analysis of signal phases with respect to the packets timestamp
OBT-SCI-03	Limited to PTYPEs 3 and 6. This planned test is accomplished by the "comparison analysis"
RAW-TM-02	Improper packet commutation can be highlighted by improper injection of signals related to a given DSA into the incorrect TOI in the FITS file or in the display
DDR-SCI-001	The same of test HDM-TR-04
DDR-SCI-007	Several values for second quantization, offset and GMF1 are used
DDR-SCI-010	Proper conversion of PType 6 verified
DDR-SCI-014	Data acquired in this test are preliminary to the optimization test
DDR-SCI-015	Data acquired in this test are preliminary to the assessment of the susceptibility of compression rate and quantization errors
DDR-SCI-016	Wrong decoding would come out from the values in the TOIs or displayed. This test covers only PTYPEs 3 and 6
GDS-SCI-001	Improper data registration would result by examining the TQL display. Limited only to PTYPEs 3 and 6

12.2 SCOPE OF THE TEST

To demonstrate that PType 3 and 6 are properly reconstructed.

12.3 DATA SELECTION

The data sets are from: XXX_9030

12.4 PROCEDURE

Triangular waves are acquired both with PType 3 and PType 6.

Data are stored by TMH in _DIF_ files.

Only comparison test is carried on.

12.5 RESULT

The same problem affecting the registration of contemporaneous acquisition of PType 2 and PType 5 prevents the execution of this test in time for the deadline for the first release.

12.6 CONCLUSION

Test postponed.

However, the decompression of PType 6 data is executed with the same software modules for decompression of PType 5 (resulting in PType 2). Since, once the registration problem has been solved in the FM version, no errors were detected on PType 5 data (see section 11), the present test is redundant with respect to the verification of the decompression.

13 OBT PROCESSING

More details on testing OBT processing are in Section 19.

13.1 TEST IDENTIFIER AND TEST PLAN REFERENCE

13.1.1 TEST ID: TMH-QM-OBT-01

TMH-QM-OBT-01

13.1.2 TEST PLAN REFERENCES

This test procedure covers the following test cases:

Test ID	Motivation
RAW-TM-01	Possible gaps in the packets stream would be identified as gaps in the TOI and graphical display
OBT-SCI-01a	Errors in the OBT handling would result in plot anomalies
OBT-SCI-01b	Assessed by the analysis of signal phases with respect to the packets timestamp
OBT-SCI-03	Limited to PTYPEs 1and 2. This planned test is accomplished by the "comparison analysis"
RAW-TM-02	Improper packet commutation can be highlighted by improper injection of signals related to a given DSA into the incorrect TOI in the FITS file or in the display
DDR-SCI-001	The same of test HDM-TR-04
DDR-SCI-002	The same of test HDM-TR-04, but limited to PTYPEs 1 and 2
DDR-SCI-004	Wrong acquisition and conversion of a known signal would be noticed by examining the values in the TOI and the graphical display
DDR-SCI-005	Type 1 and 2 are compared
DDR-SCI-006	Type 1 and 2 are compared
DDR-SCI-016	Wrong decoding would come out from the values in the TOIs or displayed. This test covers only PTYPEs 1 and 2
GDS-SCI-001	Improper data registration would result by examining the TQL display. Limited only to PTYPEs 1 and 2

13.2 SCOPE OF THE TEST

To demonstrate that: On Board Time (OBT) is properly reconstructed.

In the current release the test has been carried out only for PType 1 and PType 2 data.

13.2.1 DEFINITIONS AND TESTING CRITERIA

We recall the following definitions and testing criteria.

For PType 1 or higher Sampling Period shall be always

DT = Naver / *f*sampling

with *f*sampling = the sampling frequency.

Defects in the OBT distribution are anomalies in the OBT timeline.

It is expected that for any couple of consecutive samples [*i*, *i+1*], with *i* =0 denoting the first sample in the TOI, the OB_TIME follows the following rules, assuming Naver constant over time.

$OBT[i+1] - OBT[i] \equiv DT$,

equivalent to

$OBT[i] = i \times DT + OBT[0]$.

Holes are defines as cases for which

$OBT[i+1] - OBT[i] > DT$.

Defect are defines as cases for which either

$0 < OBT[i+1] - OBT[i] < DT$.

$OBT[i+1] - OBT[i] < 0$.

Holes are allowed only when the acquisition has been stopped.

Defects are not allowed.

13.3 DATA SELECTION

For PType 1 and PType 2 test XXX_9022 (see section 7)

13.4 PROCEDURE

OBT reconstruction is verified for each PType in different steps:

1. check whether the sampling rate derived from OBT is consistent with Naver;
2. check whether there are defects (holes) in the OBT;
3. check that holes (if present) in OBT are just due to acquisition stops;
4. measure periods, duty-cycles of signals and check if they are consistent with the periods imposed by the signal generator;
5. check the correlation between the time stamp (OBT) of packet and OBT in TOI is correct;
6. it two different PTypes have been acquired together check their correlation.

13.5 RESULTS

13.5.1 SAMPLING RATE

Apart the case of SWITCH OFF samples, no defects are found in the sampling rate for Types 1 and 2.

As already described, the TOI acquired with SWITCH OFF had inconsistent OBT reconstruction.

This is likely due to a misinterpretation of requirements and this is not harmful for QM tests.

After fixing the problem the test has been properly performed.

13.5.2 DEFECTS OR HOLES

No defects or unexplained holes in the OB_TIME have been found when switching is ON.

Holes just occurs where the acquisition have been stopped.

13.5.3 PERIODS

Periods in the measured waveforms have been fitted by using the Lomb and Scargle periodogram.

Tab.13.1 Reconstructed Periods in Some Test Case for XXX_9022

Block	Shape	Generated Period [sec]	Reconstructed Period [sec]
1	Squared	1.	$1.+(92.7 \pm 2.1)\times 10^{-6}$
4	Squared	1.	$1.+(90.8 \pm 1.9)\times 10^{-6}$
16	Triangular	1.	$1.+(82.0 \pm 0.4)\times 10^{-6}$

The Lomb and Scargle periodogram allows the determination of the period independently from the determination of the amplitude. Moreover, the method is quantitatively robust against interruptions or irregularities in the sampling time.

Phase folding has been then performed to check period determination, determine the phase of the waveform (zero point in time) and measure the amplitudes.

Tab.13.1 compares some of the periods from the Lomb and Scargle periodogram with periods of the source signal. It is possible to see the very good correspondence between generated and measured periods.

Of course, the best determination of periods occurs for Triangular waves. Apart from this, the accuracy of period determination is not correlated with any other parameter, except the case of saturation of PType 2.

Minor differences are recorded, which are highly significant compared to the errors. However, at this level it is difficult to disentangle between reconstruction errors the unavoidable lack of accuracy in the signal generator.

13.5.4 PACKETS – PEAK CORRELATION

Packet – Peak correlation is used to asses the use of OBT as a way to correlate packets to events occurring at different time lines.

The measure of Packet – Peak correlation is assessed by measuring the time interval between the first peak contained in the packet and the time stamp of the packet. For uncompressed packets, packets are generated periodically and DTpk_pck may be predicted. Comparing predicted DTpk_pck with measured DTpk_pck it is possible to asses the level of correlation by the peak-packet correlation index. The test fails if *CI*pp > 1/(1000*Naver) ~ 1E-6.

In this test no case for a bad packet – peak correlation has been detected, having *CI*pp < 1E-11 always.

13.5.5 PTYPE – PTYPE CORRELATION

This test attempts to correlate samples measured by different PTypes relative to the same signal.

We compare *CI*pp between PType 1 and PType 2. In our case, we obtain a quite good correlation coefficient 0.81. The departure from the ideal case of 1 is due to the variance intrinsic to the *CI*pp statistics.

A more powerful test is the cross correlation of PTypes and is described in Sect.16.3

13.6 CONCLUSION

The OBT for PType 1 and PTtype 2 for scientific data are properly handled.

14 HK PROCESSING

14.1 TEST IDENTIFIER AND TEST PLAN REFERENCE

14.1.1 TEST ID: TMH-QM-HK-001

TMH-QM-HK-01

14.1.2 TEST PLAN REFERENCES

This test procedure covers the following test cases:

Test ID	Motivation
RAW-TM-02	Improper housekeeping packet commutation would be seen as lost packets in the TMU archive
DDR-HK-01	Any difference in the comparison between values injected into the HK packets and the values stored in the TMU archive would highlight an incorrect registration
DDR-HK-02	Any difference in the comparison between values injected into the HK packets and the values stored in the TMU archive would highlight an incorrect registration

14.2 SCOPE OF THE TEST

To test housekeeping data streams. In particular, to assess that HK data are properly registered in the TMU archive by the TMH system and that the TM2TOI program correctly generates HK TOIs from the TMU archive.

14.3 DATA SELECTION

This test is performed using data from XXX_9007. The XXX_9007 dataset contains only housekeeping telemetry generated by the DAE and the REBA. The types of housekeeping packets included are: DAE SLOW HK, DAE FAST HK, REBA HK and REBA DIAGNOSTIC HK (see Communications IDC, PL-LFI-PST-ID-013, [AD-03]). This dataset has been generated during an acquisition lasting 1 hour and 25 minutes.

14.4 PROCEDURE

14.4.1 DATA PREPARATION

Differently from the scientific telemetry, it wasn't possible to inject known signals into the housekeeping packets directly through the DAE/REBA chain. Hence, we have developed a software called HVS (Housekeeping Validation System) that is able to manipulate the binary representation of an HK packet with the goal of generating HK packets with known parameter values starting from a set of real HK packets. The first task performed by the HVS system is to iterate over all the packets, setting each parameter value to zero.

14.4.2 INCREASING THE DATASET

The period of the DAE SLOW HK packets is of 64 seconds. Hence, the XXX_9007 contains only 75 packets of that type. Their number is insufficient for the next verification step, which requires, for each packet type, a number of samples equal to the total length in bits of the source data. To overcome this problem, the HVS system is able to increase the number of packets in the dataset, introducing new packets with coherent on board time, sample time and source sequent count values and keeping constant the proportion of each packet type. With this feature, we have produced a dataset corresponding to an acquisition lasting 6 days.

14.4.3 SETTING THE HK PARAMETERS VALUES

The next task performed by the HVS system is to set the HK parameters values following a known pattern. For each HK packet type, it iterates over all the samples, setting to 1 one bit a time. Hence, for each sample, only a single bit of a single parameter is changed. This implies that for a given HK packet, each parameter in turn takes increasing power of 2 values. The purpose of this pattern is to verify that in the TMH system the offset and the length of each parameter has been correctly defined.

14.4.4 HK TOI VERIFICATION

A sample of the HK TOIs generated by the TM2TOI program is examined using the FITS Viewer to check the proper registration of the HK parameters into the timelines.

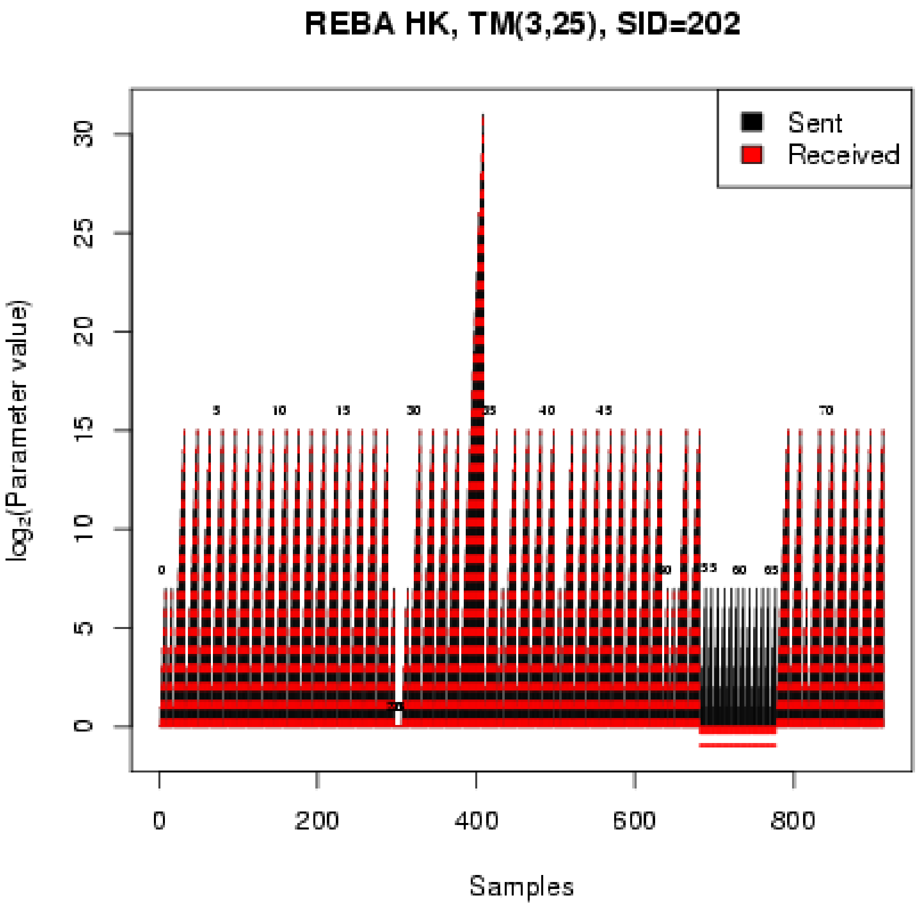


Fig.14.1: Comparison of testing values in HK parameters (black) with values in the corresponding TOIs (red). Parameters are ordered according to their position in the packet (denoted by the number on the top of each peak). The "sample" axis is the location in the test sequence where that sample is tested with the given value. The samples are sorted for increasing order and values of each parameter. The difference in the heights of the peaks is due to the differences in the dynamical range of each parameter. The abscissa gives the $\log_2$ of each value. The value 0 is represented by a -1 value on the logarithmic scale. The problem with the registration of HK parameters is evidenced by the anomalous distribution of red points around the sample 700.

14.5 RESULTS

The TMH QM properly handles the HK Telemetry but one bug has been detected as outlined below, due to problems in the SCOS MIB Tables that the TQL/TMH uses to decode the packet structure.

Action have been issued to fix this problem in the FM version.
The problem was fixed in the FM version and consequently in the OM version.

14.5.1 ERRONEOUS REGISTRATION OF HK SPARE PARAMETERS

The test has proven that there is an error both in the Planck LFI – Communications ICD [AD-03] and in the MIB tables defining the parameters of the REBA HK packet and the REBA DIAGNOSTIC packet. In particular, the Communications ICD specifies that in the SPU Science Processing I of REBA HK, the Detector Mask A0 parameter is preceded by a spare of 2 bytes. The same structure should be followed by the REBA DIAGNOSTIC HK. But in the `plf.dat` table the spare is placed after the Detector mask B5 for the REBA HK. The error is evident in the Fig.14.1, where sent and received values for the REBA HK samples are superimposed, highlighting the differences in the region starting at sample number 682 and corresponding to the DETECTOR MASK parameters.

14.6 CONCLUSIONS

The test proves to be useful in verifying the handling of HK Telemetry by TMH.
Only one problem have been detected:

1. Erroneous registration of HK spare parameters.

due to defects in the MIB Tables, that was reflected on the TMH.

An action has been issued to fix this problem in the FM version.
The problem was fixed in the FM version and consequently in the OM version.

15 HK PROCESSING: ADU TO PHYSICAL UNIT

15.1 TEST IDENTIFIER AND TEST PLAN REFERENCE

15.1.1 TEST ID: TMH-QM-HK-02

TMH-QM-HK-02

15.1.2 TEST PLAN REFERENCES

This test procedure covers the following test cases:

Test ID	Motivation
DDR-HK-003	Proper housekeeping conversion based on a look-up table is tested
DDR-HK-004	Proper housekeeping conversion based on polynomial law is tested
GDS-HK-002	Some of the housekeeping parameters are displayed during the test
GDS-HK-003	Some of the housekeeping parameters are displayed during the test

15.2 SCOPE OF THE TEST

To verify that correct conversion of the housekeeping parameters, based on the MIB tables cap.dat (look-up table conversion) and mcf.dat (conversion based on polynomial law) is performed by the TMH/TQL system.

15.3 DATA SELECTION

This test is performed using data from XXX_9007, containing only a subset of the housekeeping telemetry and no scientific telemetry. The MIB tables cap.dat and mcf.dat must be the same used in the SCOS 2000 system.

15.4 PROCEDURE

First, the data is sent to the SCOS 2000 system trough an ingest program. An instance of the TMH/TQL system is started and the housekeeping display is activated, selecting the "New_Hk_Time" option (each parameter is displayed as a function of time). Besides, the checkbox "converted data" in the HK display is selected. The value of each selected housekeeping parameter is cross-checked with the value displayed in the SCOS 2000 Alphanumeric Display.

15.5 RESULTS

This test passed successfully since no differences between the values displayed in the SCOS system and the values plotted in the TQL display have been detected..

16 TQL: PARALLEL SESSIONS AND PLAYBACK

16.1 TEST IDENTIFIER AND TEST PLAN REFERENCE

16.1.1 TEST ID: GDS-QM-FN-01

GDS-QM-FN-01

16.1.2 TEST PLAN REFERENCES

This test procedure covers the following test cases:

Test ID	Motivation
GDS-GEN-001	The scope of this test procedure covers exactly the test case

16.2 SCOPE OF THE TEST

To verify that the TQL is able to receive on-line TM data while a second instance of the TQL replays an archived TM.

16.3 DATA SELECTION

This test is performed using data from XXX_9014, containing a sinusoid signal from FH 28.

16.4 PROCEDURE

First, the data is sent to the SCOS 2000 system trough an ingest program. An instance of the TMH/TQL system is started and the data received is displayed trough the scientific display. Then, another instance of the TQL is started and a local copy of the XXX_9014 is opened using the "Open FITS pkt File" item in the File menu of the TQL.

16.5 RESULTS

Both instances of the TQL have been launched without problems. Fig. 15.1 is a snapshot of the two sessions while they are receiving and displaying the scientific telemetry from the SCOS 2000 system and from file respectively.

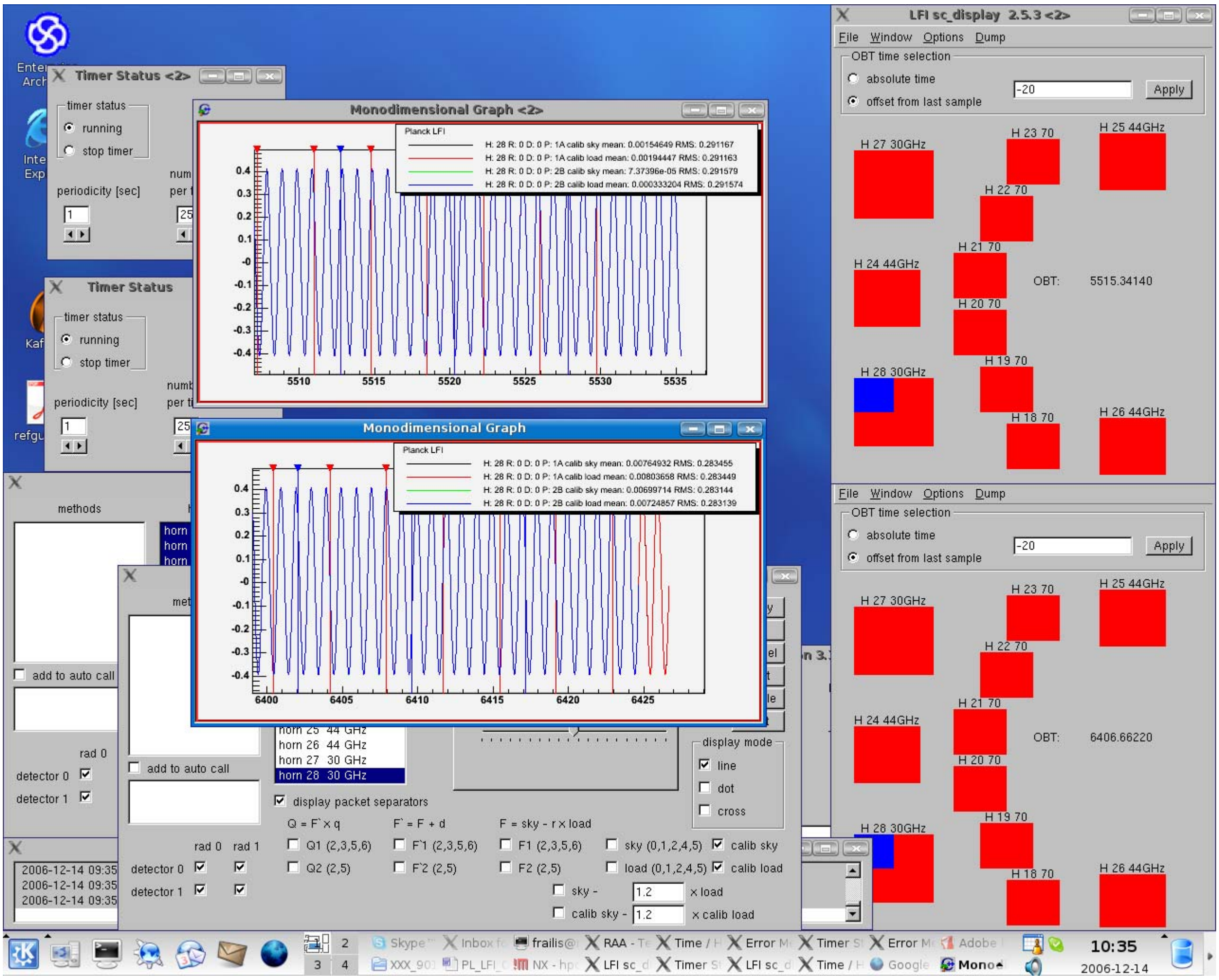


Fig. 15.1 Two sessions of the TQL. The first session is receiving the telemetry from a SCOS 2000 system. The other session is reading the telemetry from file.

17 TQL: LAYOUT CONFIGURATION AND SAVING

17.1 TEST IDENTIFIER AND TEST PLAN REFERENCE

17.1.1 TEST ID: GDS-QM-FN-02

GDS-QM-FN-02

17.1.2 TEST PLAN REFERENCES

This test procedure covers the following test cases:

Test ID	Motivation
GDS-GEN-002	The scope of this test procedure covers exactly the test case

17.2 SCOPE OF THE TEST

To verify that it is possible to configure and edit the layout of the display while the TQL is running, that the layout can be saved and that it can be restored

17.3 DATA SELECTION

This test is performed using data from XXX_9014, containing a sinusoid signal from FH 28.

17.4 PROCEDURE

An instance of the TQL system is started and a local copy of the XXX_9014 test is opened using the "Open FITS pkt File" item in the File menu of the TQL. While the telemetry is processed, a scientific mono-dimensional display is opened, together with an housekeeping display and a mode display. On each display, some parameters are modified on-line (time interval covered, packets separators disabled, etc.). Then the entire layout configuration is saved using the "Save" item in the File menu. The TQL system is restarted with the saved configuration and the XXX_9014 is reopened to verify that the layout has been maintained.

17.5 RESULTS

.All procedures were performed successfully.

18 TQL: ON-LINE ANALYSIS

18.1 TEST IDENTIFIER AND TEST PLAN REFERENCE

18.1.1 TEST ID: GDS-QM-AN-01

GDS-QM-AN-01

18.1.2 TEST PLAN REFERENCES

This test procedure covers the following test cases:

Test ID	Motivation
ASW-SCI-001	The FFT calculation is part of the on-line analysis test
ASW-SCI-002	The averages, variances and RMS calculation is part of the on-line analysis test
ASW-SCI-003	The R-Factor calculation is part on the on-line analysis test

18.2 SCOPE OF THE TEST

To verify the proper on-the-fly computation of the FFT, mean, variance, R-Factor with the TQL. Each function is computed by a ROOT script launched by the TQL.

18.3 DATA SELECTION

This test is performed using data from XXX_9022, containing a square wave signal (see section 19.1) and data from XXX_9014, containing a sinusoid signal.

18.4 PROCEDURE

An instance of the TQL system is started and a local copy of the XXX_9022 test is opened using the "Open FITS pkt File" item in the File menu of the TQL. While the telemetry is processed, a scientific mono-dimensional display is opened. Then, from the File menu, the "New Script" item is selected, loading, in turn, the following scripts: fft.C, statistics.C, r_mean.C, r_variance.C. The same procedure is repeated for the dataset XXX_9014 test.

18.5 RESULTS

On the basis of the input signal properties, the goodness of the FFT, R-Factor and statistics calculation performed by the TQL has been successfully assessed on-site.

19 STAND-ALONE DATA ANALYSIS

We report in detail an example of the stand-alone data analysis procedure for Type 1 and 2 data to clarify the interpretation of addenda. Section 20 will illustrate the comparison analysis.

19.1 DATA SET

We consider BLOCK 2 of XXX_9022, where a square wave of period of 1 sec, peak-peak amplitude ~ 0.84V and duty cycle = 25% has been used, switching is left off. We consider FH=28, DTC=0, RAD=0. The processing parameters are: Naver=126, GMF1=1, GMF2=1, OFFSET_ADJUST=0, SECOND_QUANT=1; hence, data are sent just on the SKY timeline in the TOI. The data block includes all the samples with odd indexes (parity ODD) in TOI with index between 15002 and 30000 (i.e. sample 15003, 15005, 15007, …) equivalent to OBT in the range 15596.7 sec and 15827.4 sec.

The data in the block are shown in Fig.19.1. Since the transient between the low and the high state in the square wave is very fast, no more than a sample for each front is acquired in the transient state resulting in the pattern of diagonal dots.

In addition, the block includes also at its left and right side a portion of data with signal off. An automated procedure discriminates between the part with signal off and on.

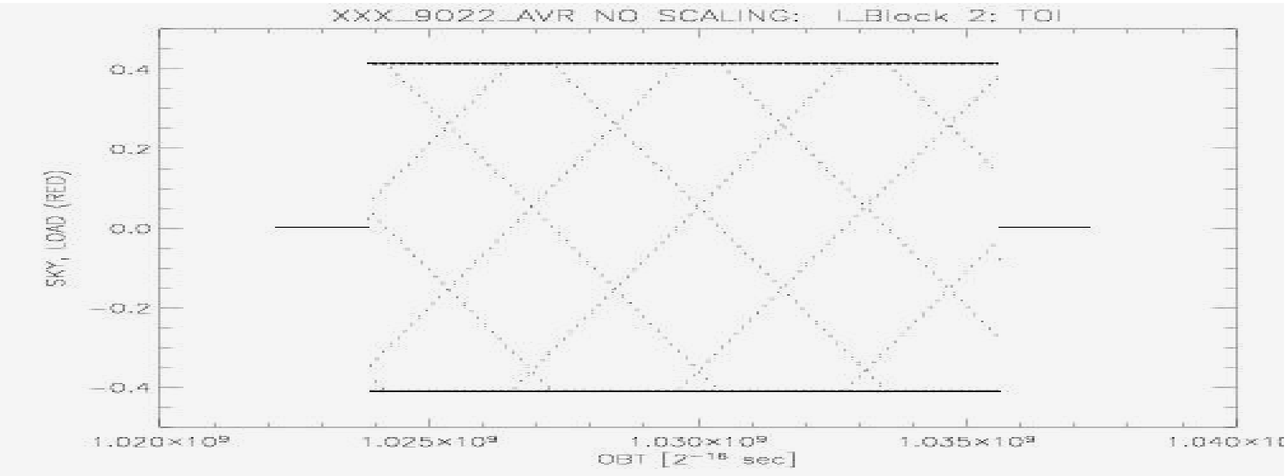


Fig.19.1: Data in the selected block 2 of XXX_9022 already converted in V.

19.2 PERIOD DETERMINATION

After identified the region where the signal is on, the Lomb-Scargle Periodogram (LSP) is applied to assess the period of the signal as measured by the OBT time scale. The LSP has the advantage over the FFT to be robust against perturbations due to erroneous inclusion of short no-signal zones or holes in data. The LSP is automatically scanned looking for the peak with the highest power giving a first approximation for the period. The period is further refined fitting the LSP peak with a SYNC function having two free parameters: the difference in the peak period δp with respect to the approximated period and the peak normalization. The fitting procedure estimates also the error in the two free parameters. The error in δp is taken as the error in the period estimate. Fig.19.2 shows the fitting procedure.

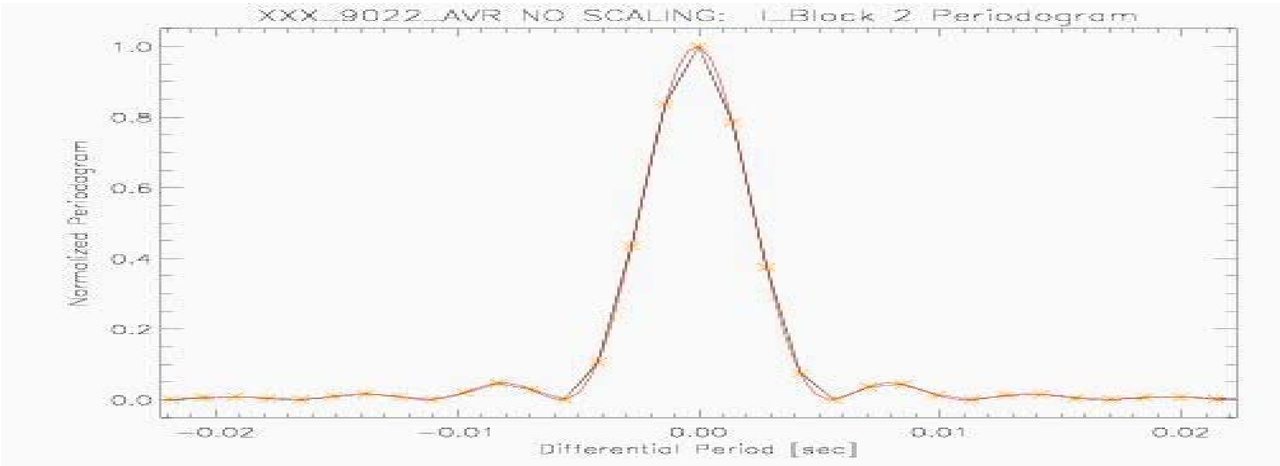


Fig.19.2: Fitting of the Lomb-Scargle periodogram. Yellow points joined by the black line are the data from the LSP. The red line is the model fitting. The horizontal axis is the difference between the refined period and the best period from the bare LSP.

19.3 HIGH, LOW STATES, AMPLITUDE AND PHASES DETERMINATION

The phases and amplitude determination depends on the wave shape.

To have a meaningful phase, a zero point in OBT has to be established. We take the convention that the zero point in OBT is the OBT of the first sample in the data block. In the case here analyzed the zero point is OBT[15002].

19.3.1 SQUARE WAVES

In case of square waves amplitude and phases are determined by using a chi2 fitting combined with a phase-folded diagram, The duty-cycle is defined by the instrumental set-up, the period is determined by the previous procedure. Fig.19.3 shows the result of the procedure outlined below for the case in study.

Phase is determined by fitting a square wave with the period given by the refined LSP periodogram, assuming as amplitude and duty cycle the values given by the instrumental set-up and leaving only the phase as a free parameter. In the square wave modelling the transients are not considered.

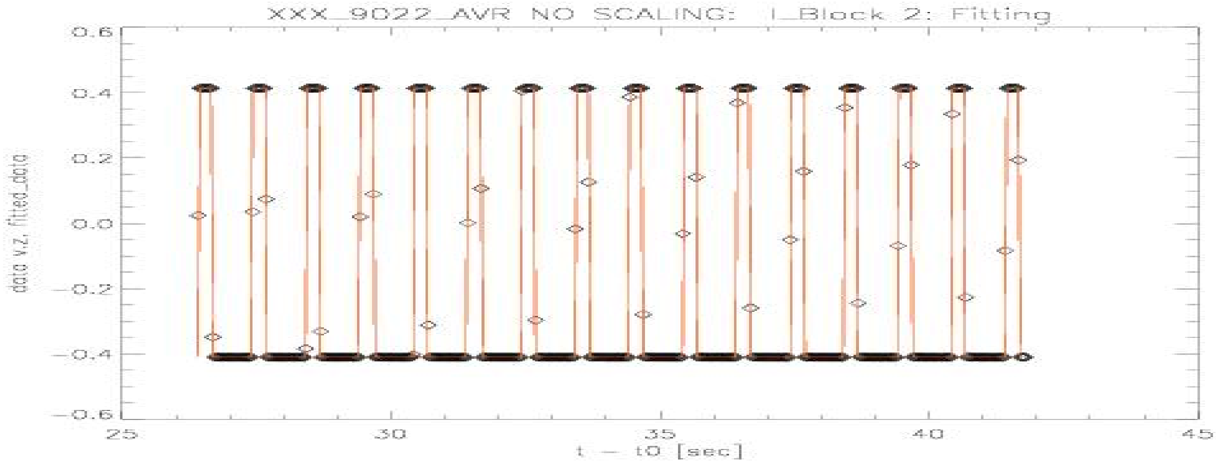


Fig.19.3: Example of fitting of a portion of square wave signal (diamonds) with a square wave model (red line). The time axis is the OBT elapsed from the time origin taken at the beginning of block (OBT[15002]).

The chi2 procedure computes the chi2 between the model, calculated for a given phase, ϕ, and the signal. A thin grid of phases is explored and the best (least) chi2 is used to assess the best phase. The use of a search on a discretised grid of phases has been imposed by the fact that chi2, as a function of the phase, is not a continuous function for a square wave.

A phase-folding diagram, like the one in Fig.19.4, is then used to fix the V_{low} and V_{high} and the amplitudes. In the diagram, samples (black dots) has been folded taking in account the period and phase. Red dots represent the fitted model.

The "folding" variable is defined as follow:

$$\text{folding}(i) = (t(i)\text{-}t0)/p + \phi - \text{trunc}\big((t\text{-}t0)/p + \phi\big)$$

where p is the period of the squared wave, t(i) the OBT of the i-th sample, t0 is the OBT time, trunc[x] is a function which removes the fractional part of x. Note that it is always:

$$0 \le \text{folding}(i) < 1.$$

It is assumed that samples are classified with the following convention:

the i-th sample is in the *high* state if $0 \le \text{folding}(i) < \text{duty-cycle}$ otherwise it is *low*.

This classification rule does not take into account the transient, consequently a transient window w is assumed and the classification rule becomes the i-th sample is in the *high* state if $w/2 \leq \text{folding}(i) < \text{duty-cycle}-w/2$,

the i-th sample is in the *low* state if $\text{duty-cycle}+w/2 \leq \text{folding}(i) < 1 - w/2$.

It is evident how the over-sampling implicit in the folding procedure allows to sample even the very fast transients in the square wave. In case of a well reconstructed square wave, samples from the transient of the square wave shall fall rigorously on a straight line. Indeed, the dispersion of points over the transient phases is compatible with noise giving a further test for the goodness of the fitting of period and phase.

Once a phase-folding diagram has been obtained, estimators for V_{low} and V_{high} are determined by averaging respectively the low and the high samples, while their RMS gives an estimate of the error.

The amplitude is then obtained from the estimated V_{low} and V_{high}.

This procedure does not take in account of drifts in the signal generator while producing low and high states.

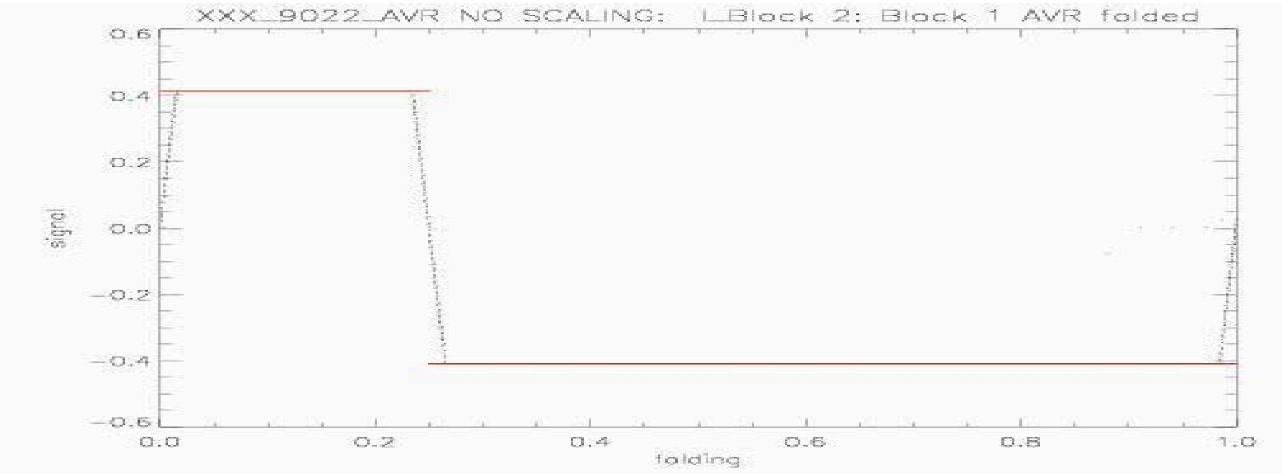


Fig.19.4 Phase-folding diagram for the Block 2, odd samples, of XXX_9022 test. Data are plotted in black and the model in red.

19.3.2 TRIANGULAR WAVES

For triangular waves it has not much meaning to define a low and high state. Rather the peak-peak amplitude and the level of voltage asymmetries shall be determined.

For triangular waves phase-folded diagrams, as that in Fig.19.6, are used to better refine the phase determination and the peak-peak amplitude (see Fig.19.5 for the fitting of the corresponding triangular wave).

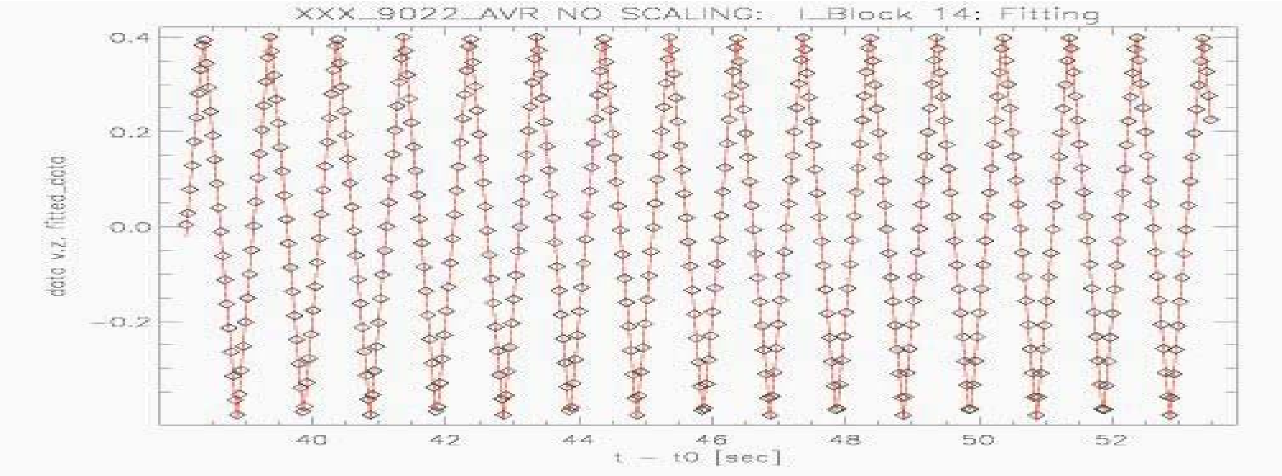


Fig.19.5: Fitting of the triangular wave in Block 7 of XXX_9022

.

The model for the triangular wave assumes that the transition between the growing and the decreasing ramp is instantaneous.

The peak-peak amplitude for the triangular wave is determined by the moments of the cumulative distribution function of the values of the samples. In this way the determination of the peak-peak amplitude is decoupled from the determination of period and phase.

The phase is again determined by the chi2 method used for the square waves but further refined by the phase – folded diagrams.

In the case of triangular wave we take the convention that the growing ramp occurs for

$0 \leq \text{folding(i)} < 0.5$

while the turning point between the growing and the decreasing ramp shall occurs at

folding(i) = 0.5.

Analogously, the opposite turning point shall occur at folding(i) = 0.

As shown in the figure, the signal at the turning point is smoothed out when compared to the simplified model. A parabolic fit can be performed to the data around folding(i) = 0.5 and folding(i) = 0.0 or 1.0, allowing to compute corrections to the peak-peak amplitude and phase ϕ.

The uncertainties on these corrections fixes the accuracy by which it is possible to determine these two free parameters.

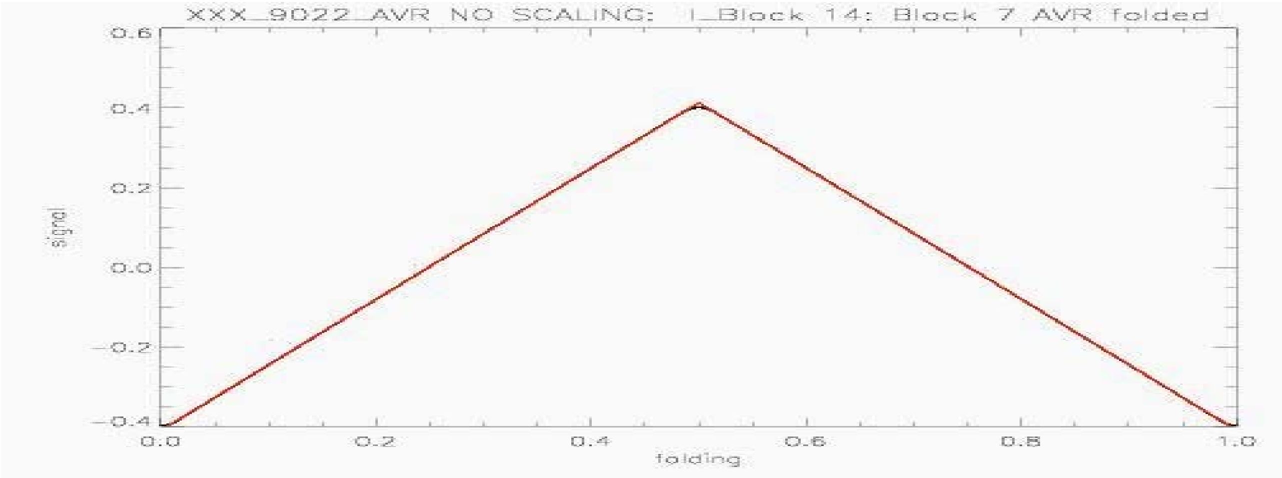


Fig.19.6 Phase-folded diagram for the triangular wave in Block 7 of XXX_9022. The red points represents a triangular model which does not consider the transient between the growing and the decreasing phase.

19.4 PEAK – PACKET CORRELATION

Packet – Peak correlation is used to asses the use of OBT as a way to correlate packets to events occurring at different time lines.

The measure of Packet – Peak correlation is assessed by measuring the time interval between the first peak contained in the packet, and the time stamp of the packet:

For square waves the packet position is defined as the OBT for which

folding(OBT_peak) = duty-cycle/2

then a square wave "belongs" to a packet if

OBT_packet ≤ OBT_peak.

Fig.19.7 represents the correspondence between "peaks" for the square wave analysed (represented by the dots on the top of the figure) and the packets (represented by the vertical bars).

Then the first index for peak-packet correlation is

DTpk_pck = OBT_peak – OBT_packet .

For uncompressed packets, packets are generated periodically with period:

Ppck = Nsamples × Naver/fsampling ,

with Nsamples = number of samples in the packet.

Denoting with *i*pck a packet index, *i*peak a peak index, *P*pks the period of the peaks and assuming as origin of time T_0 the time of the first peak (*i*peak = 0) then the DTpk_pck may be predicted.

The statistics to test the Packet – Peak correlation is the Packet – Peak correlation index defined as:

*CI*pp = abs(DTpk_pck - DTpk_pck_calc)/DT

where DTpk_pck_calc is the DTpk_pck calculated.

The test fails if *CI*pp > 1/(1000*Naver) ~ 1E-6.

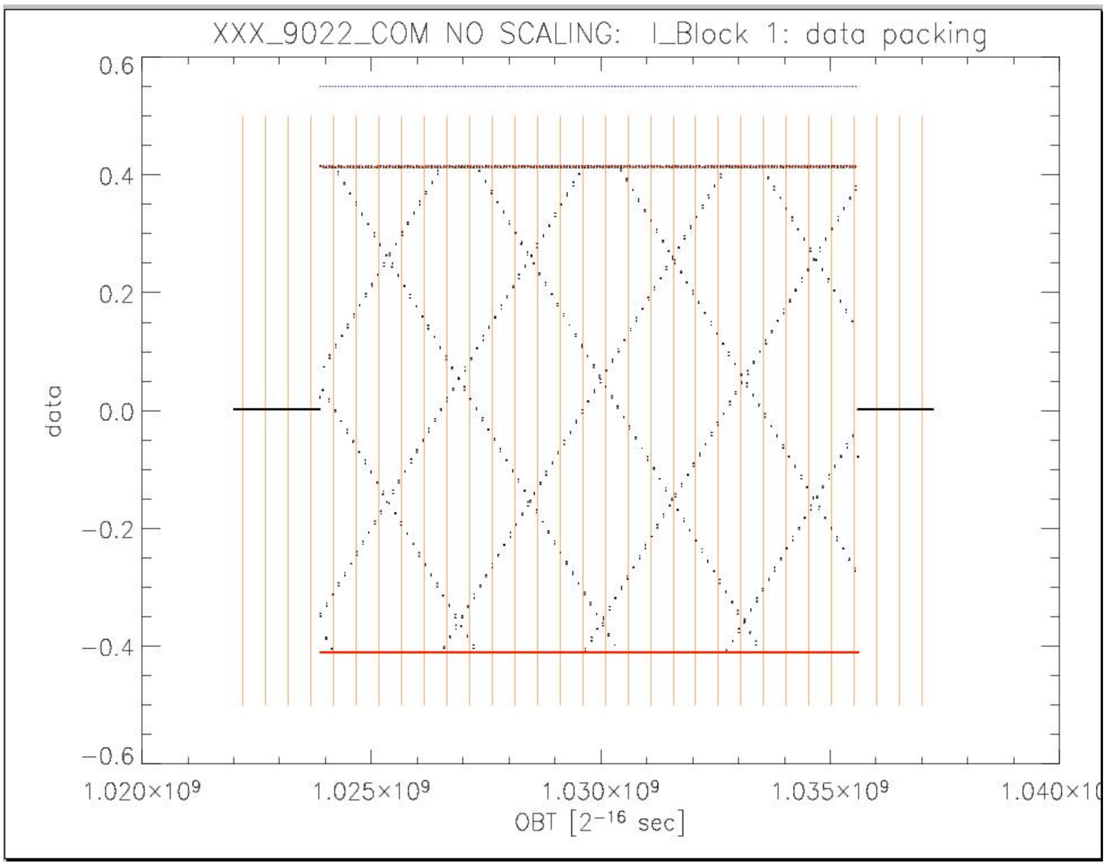


Fig. 19.7 Correspondence between "peaks" for the square wave in test XXX_9022 (represented by the dots on the top of the figure) and the packets (represented by the vertical bars).

Tab.19.1 – Example of Analysis for the XXX_9022 test			
Square Wave			
	PType 1	**PType 2**	**Difference/error**
Period [sec]	1.0000899 ± 0.000002	1.0000921 ± 0.000002	0.8
ϕ	-0.580 ± 0.002	-0.3801 ± 0.0020	
Vlow [V]	-0.410941 ± 0.000086	-0.410931 ± 0.00010	0.08
Vhigh [V]	+0.41379 ± 0.00017	+0.4138040 ± 0.0001647	0.06
Amplitude [V]	0.82478 ± 0.00019	0.82477 ± 0.00019	0.04
Peak-Packet	1.4E-12	1.4E-12	
Triangular Wave			
	PType 1	**PType 2**	**Difference/error**
Period [sec]	1.0000834 ± 0.0000007	1.0000834 ± 0.0000007	0.0
ϕ	+0.8601293 ± 0.0000097	-0.480841 ± 0.000010	
Vlow [V]	-0.398029 ± 0.000026	-0.397647 ± 0.000031	9.5
Vhigh [V]	+0.401057 ± 0.000024	0.401478 ± 0.000028	11.3
Amplitude [V]	0.799086 ± 0.000035	0.799125 ± 0.000042	0.7
Peak-Packet	3.2E-12	9.2E-13	

19.5 FINAL RESULTS

To summarize we obtain the results in Tab.19.1 for the cases illustrated here.

It is evident the high accuracy in relative OBT reconstruction, as the highest sensitivity of the triangular wave to the quantization effects as shown by the differences between PType 1 and 2 in V_{high} and V_{low}. Even triangular waves are more suited in testing OBT reconstruction and peak-packet correlation.

20 COMPARISON DATA ANALYSIS

We report in detail an example of the stand-alone data analysis procedure for Type 1 and 2 data to clarify the interpretation of the related addenda. The same data set of Section 19 has been used.

20.1 DATA SET

We consider BLOCK 2 of XXX_9022, where a square wave of period of 1 sec, peak-peak amplitude ~ 0.84V and duty cycle = 25% has been used, switching is left off. We consider FH=28, DTC=0, RAD=0. The processing parameters are: Naver=126, GMF1=1, GMF2=-1, OFFSET_ADJUST=0, SECOND_QUANT=1, So that data are sent just on the SKY timeline in the TOI. The data block includes all the samples with odd indexes (parity ODD) in TOI with index between 15002 and 30000 (i.e. sample 15003, 15005, 15007, …) equivalent to OBT in the range 15596.7 sec and 15827.4 sec. Data are not saturated.

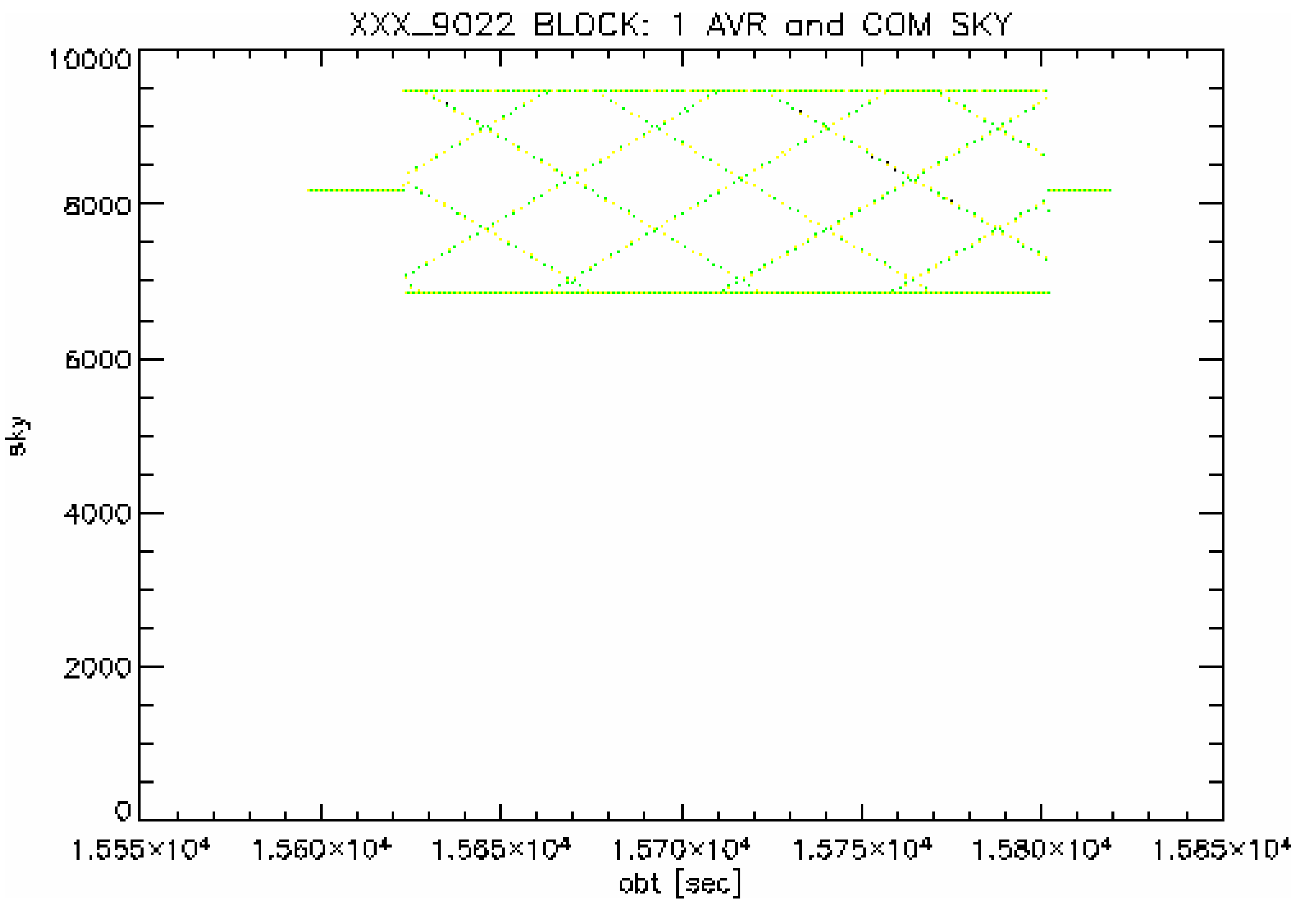


Fig. 20.1 Sky of Block 2 of XXX_9022, switch off. Black = AVR, Gold = COM. Note that the black points are uniformly covered by gold ones.

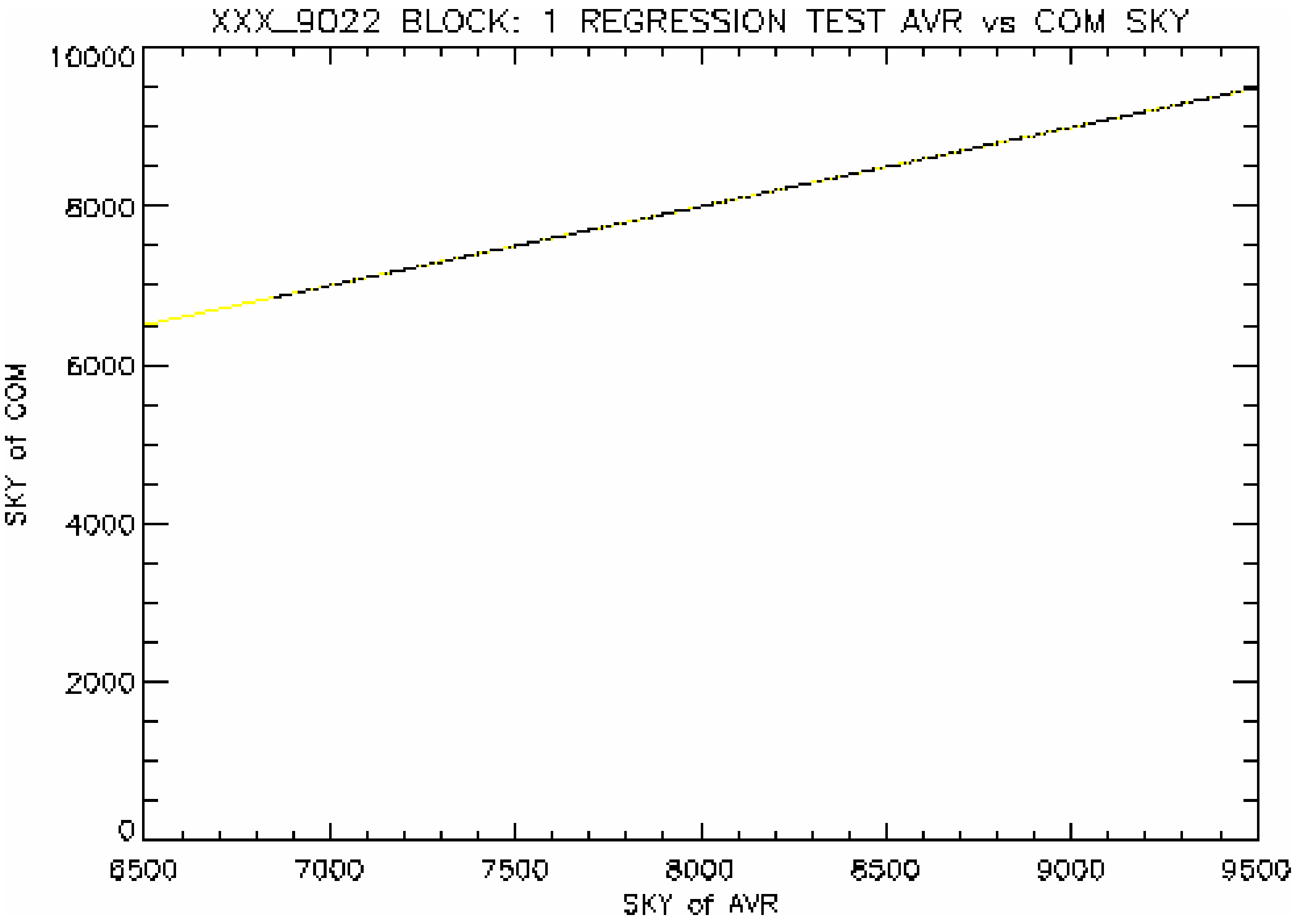


Fig. 20.2 Regression tests for sky of Block 2 of XXX_9022, switch off. Points are the original data, the yellow line the ideal relation.

20.2 REGRESSION TEST OF COM VS AVR

The first check is to look for regression of COM vs AVR. In the ideal case all the points would fall on the 1-1 line. This test is displayed in Fig.20.2 where the regression test of COM vs AVR is shown. As it is possible to see, no regression problems occurs.

20.3 PROCESSING ERROR

A more refined test is to evaluate the processing error defined as

$$\mathrm{QERROR} = V_{\mathrm{COM}} - V_{\mathrm{AVR}} .$$

The error, compared to the expectation from processing parameters, is shown in Fig.20.3.

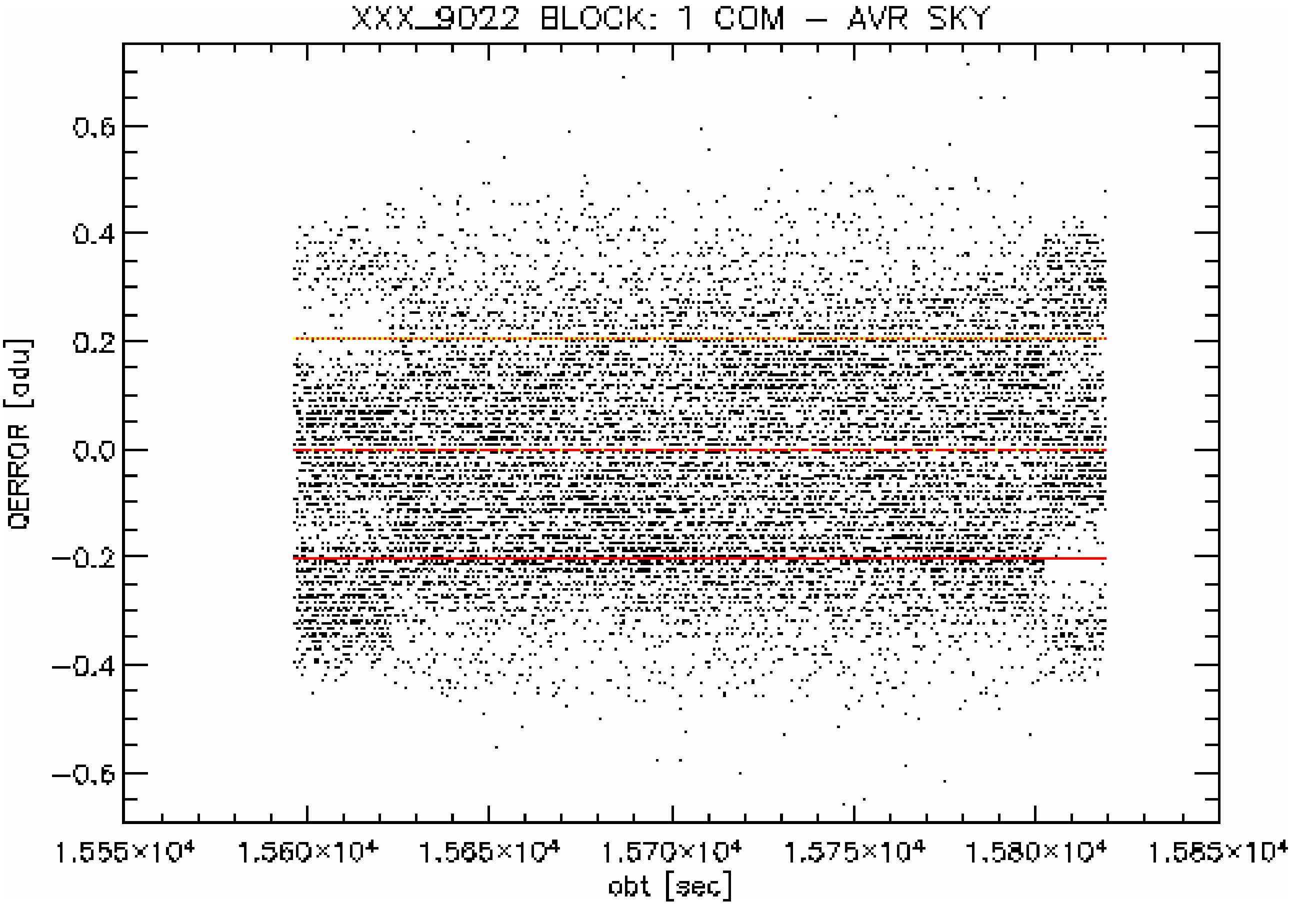


Fig.20.3 Processing Error for Block 2 of XXX_9022. The red lines represent the average expected processing error and the ±1σ band. Note that the distribution of this error is visibly not Gaussian. Besides, digitization of data is very tiny and the distribution of noise in the region where the signal generator is off is not uniform.

It is easily seen the effect of digitization which in this case is very tiny. Some structure in the noise is clearly present, especially at the left and right side where the signal was off. More over the noise is not Gaussian distributed.

In this case having not LOAD signal, the analysis of Sect.8 has been not carried on.

20.4 CORRELATION BETWEEN PTYPE 5 AND PTYPE 2

Matching between PType 2 and PType 5 data is performed by matching OBT of PType2 with OBT of PTtype1. An improper matching would result in wrong estimation of the Qerror. Cross correlation has been performed using the cross correlation index defined as

$$Cxx(lag) = \mathrm{covar}(V_{COM}, V_{AVR})/\sqrt{(\mathrm{var}(V_{COM})\ \mathrm{var}(V_{AVR}))}$$

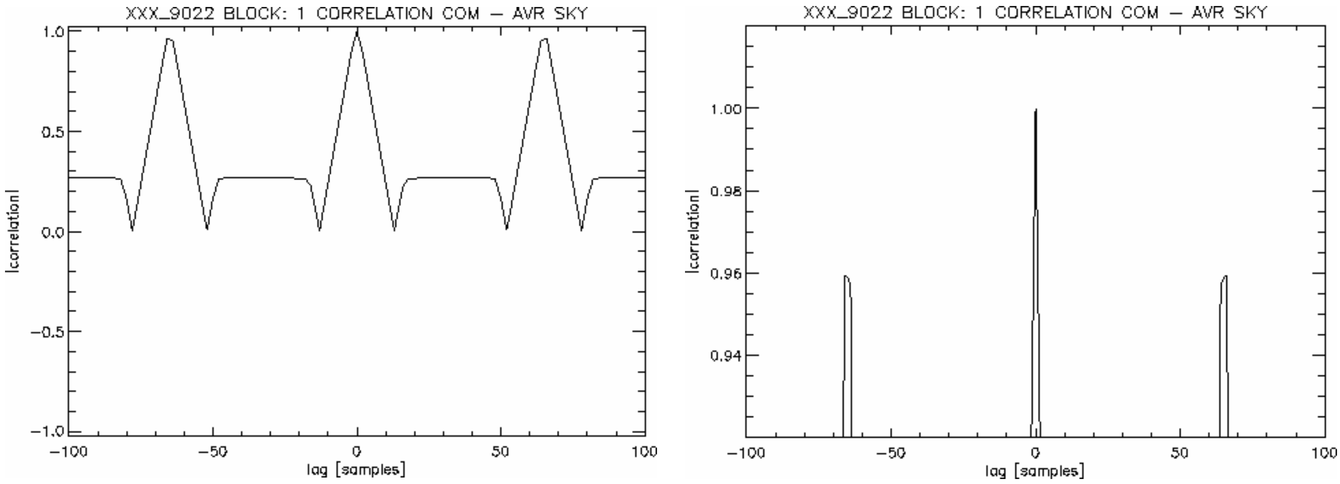


Fig.20.4 Correlation test between PType 1 and PType 2 for block 2 of test XXX_9022. The plot on the left refers to the full test, on the right a zoom on the central correlation peaks.

the cross-correlation is calculated by shifting of *d* samples of PType 2 data with respect to PType 1 data, taking *lag* = 0 as the case for patching PType 2 with PType 1 using only OBT. In case OBT assigns the proper matching it will be always

$$Cxx(lag) < Cxx(0), \text{ for any } lag \neq 0 .$$

21 FINAL CONCLUSIONS

This report represents a systematic validation of the TMH/TQL.

The current Issue reveals some problems in the TMH/TQL QM software and, as a by product, some minor problem in REBA QM software.

Actions have been issued to fix the problems. In most cases problems have been recovered while still analysing data.

All the open issue were solved in the TMH/TQL FM/OM software and data set was reapplied to verify its consistency.

Currently we may assess that TMH/TQL is able to properly:

1. Display properly the data
2. Register HK telemetry
3. Handle Scientific Telemetry
4. Reconstruct PType 1 and PType 2 data
5. Reconstruct On Board Times

APPENDIX A: REBA COMPRESSION RATES

We report the analysis of the REBA compression rate and the related addenda.

DATA SET

We consider
- XXX_9028 square waves, constant REBA processing pars, PType=5.
- XXX_9029 triangular waves, variable REBA processing pars, PType=5.

We take data from all of the 4 detectors of FH=28.

SCOPES

Scope of the analysis is to fix the correlation between
1. Compression rate (Cr)
2. Compressor Efficiency (Cr_Eff)
3. Entropy for data in the packet
4. REBA Processing Pars
5. Expected (theoretical) quantization error.

Where Cr_Eff is

Cr_Eff = Cr/Cr_Th ,

with Cr_Th the theoretical compression rate given by

Cr_Th = 16 bits/Entropy .

The expected quantization error is

1/second_quant * 1/sqrt(12.) * 1/abs(gmf_2-gmf_1)*sqrt(gmf_2^2+gmf_1^2) ,

ANALYSIS

CR AS A FUNCTION OF PROCESSING PARS

Only XXX_9029 provides meaningful data for this analysis.

It is evident from Fig.A.1 that it is not possible, in this case, to drawn any strong correlation between Cr and the processing pars.

This is expected since with the mixing scheme it is not possible to characterize the Cr as a function of a single REBA parameter in the case of a strongly deterministic signal like this.

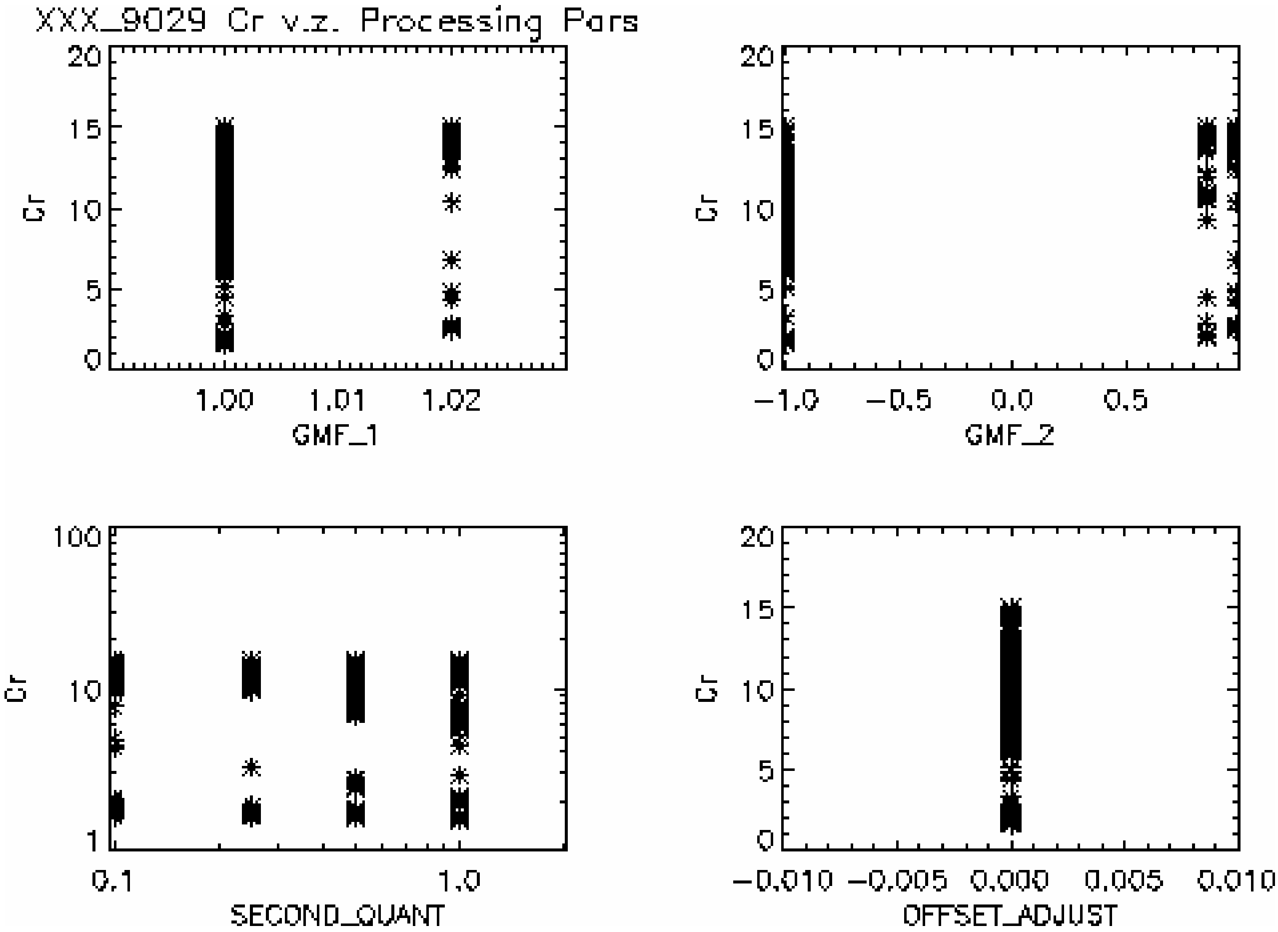


Fig.A.1 Cr as a function of processing pars for test XXX_9029.

CR AS A FUNCTION OF EXPECTED COMPRESSION ERROR

Only XXX_9029 provides meaningful data for this analysis.

Cr is roughly a function of Qerr and saturates when Qerr > 1 adu the reason is likely due to the fact that no more than 2048 samples may be compressed into a packet by REBA.

In particular it is evident as Dtc =0 , Rad = 0 (crosses) has a minor population of packets with very low compression rates.

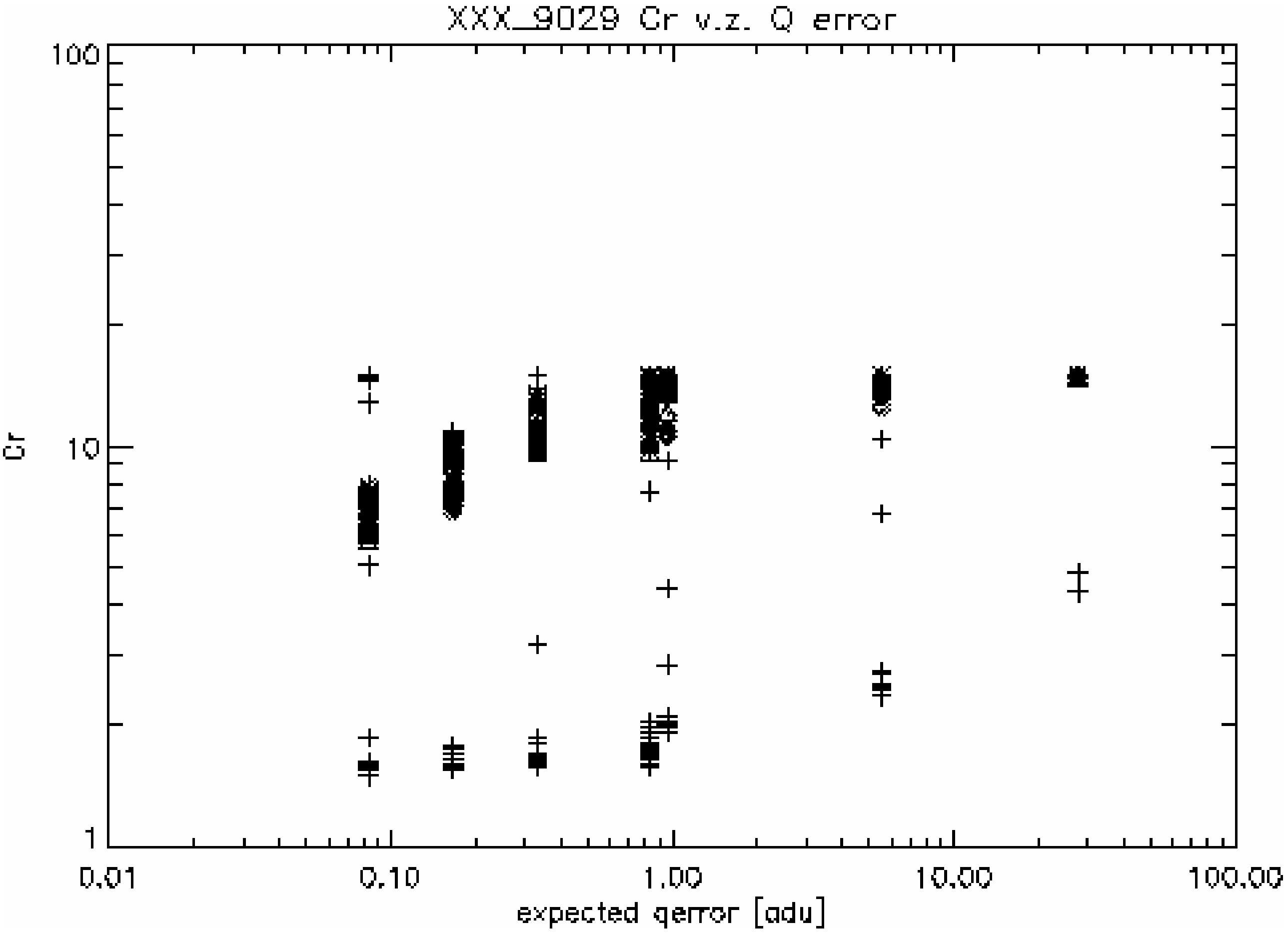
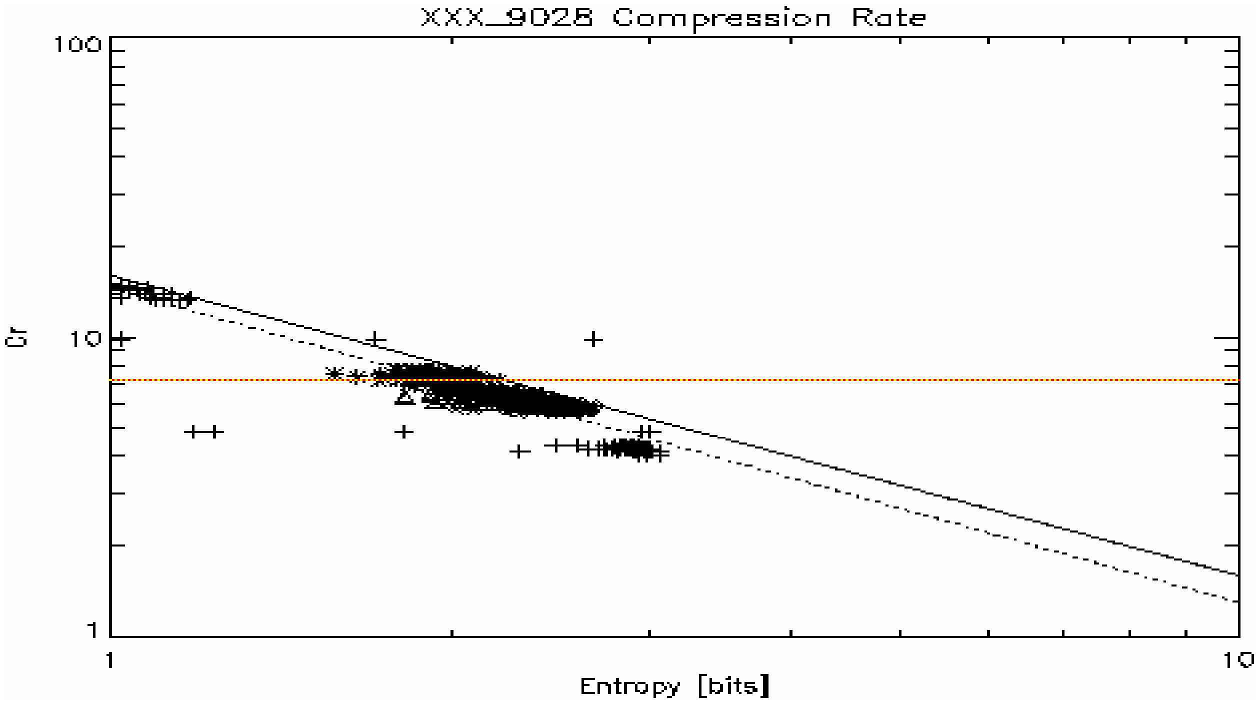


Fig.A.2 Cr as a function of processing pars for test XXX_9029. From here + are for DTC = 0, RAD = 0, ◊ are for DTC = 0, RAD = 1, * are for DTC = 1, RAD = 0 and ▽ are for DTC = 1, RAD = 1.

CR AS A FUNCTION OF ENTROPY

As demonstrated by Fig.A.3 the Cr is best characterized as a function of entropy. A linear trend, log – log space is evident. The full-line is the Cr_Th as a function of entropy, while the dashed line a relation obtained by fitting Cr v.z. Entropy in log – log space. It is evident as always the Cr is less then Cr_Th. The difference growing for increasing entropy. Up to a factor of 10 compression is obtained. However,



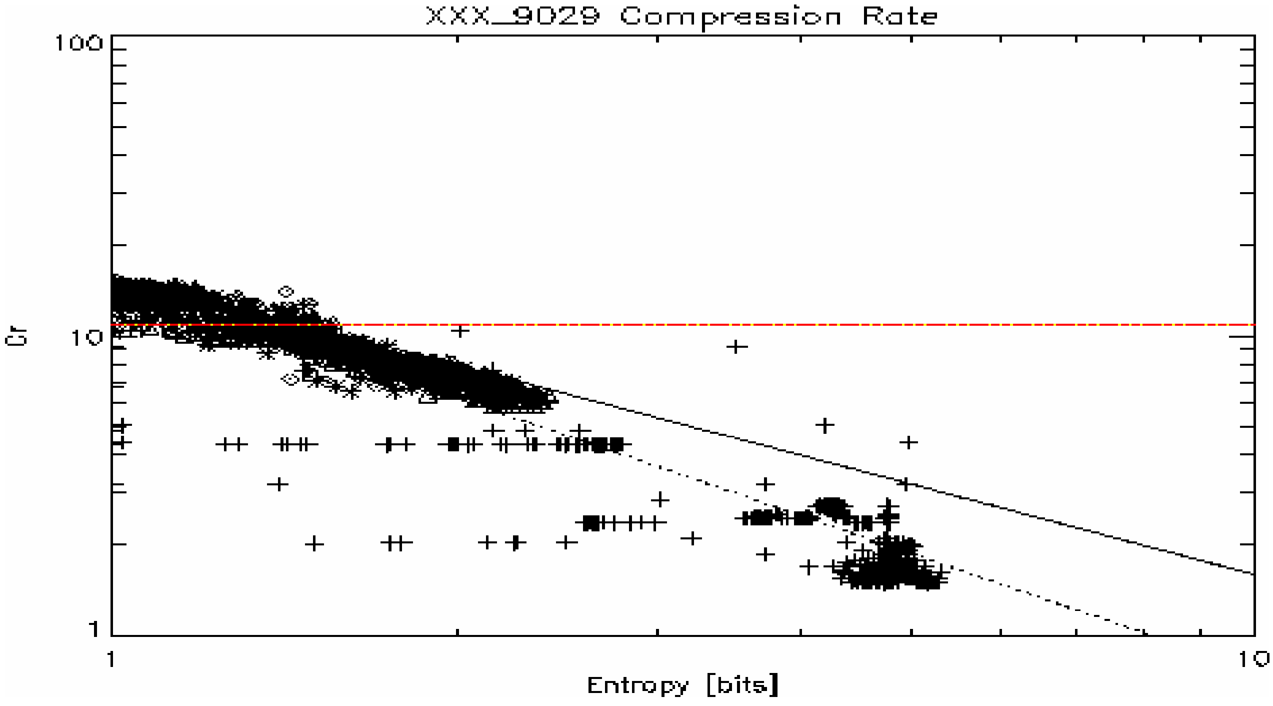


Fig. A.3 Cr as a function of entropy for XXX_9028 (upper frame) and XXX_9029 (lower frame). Symbols as in Fig.A.2. Red horizontal line is the Averaged Cr, The black full line is the Cr_Th while the dotted black line is a best fit of Cr v.z. entropy in log – log space.

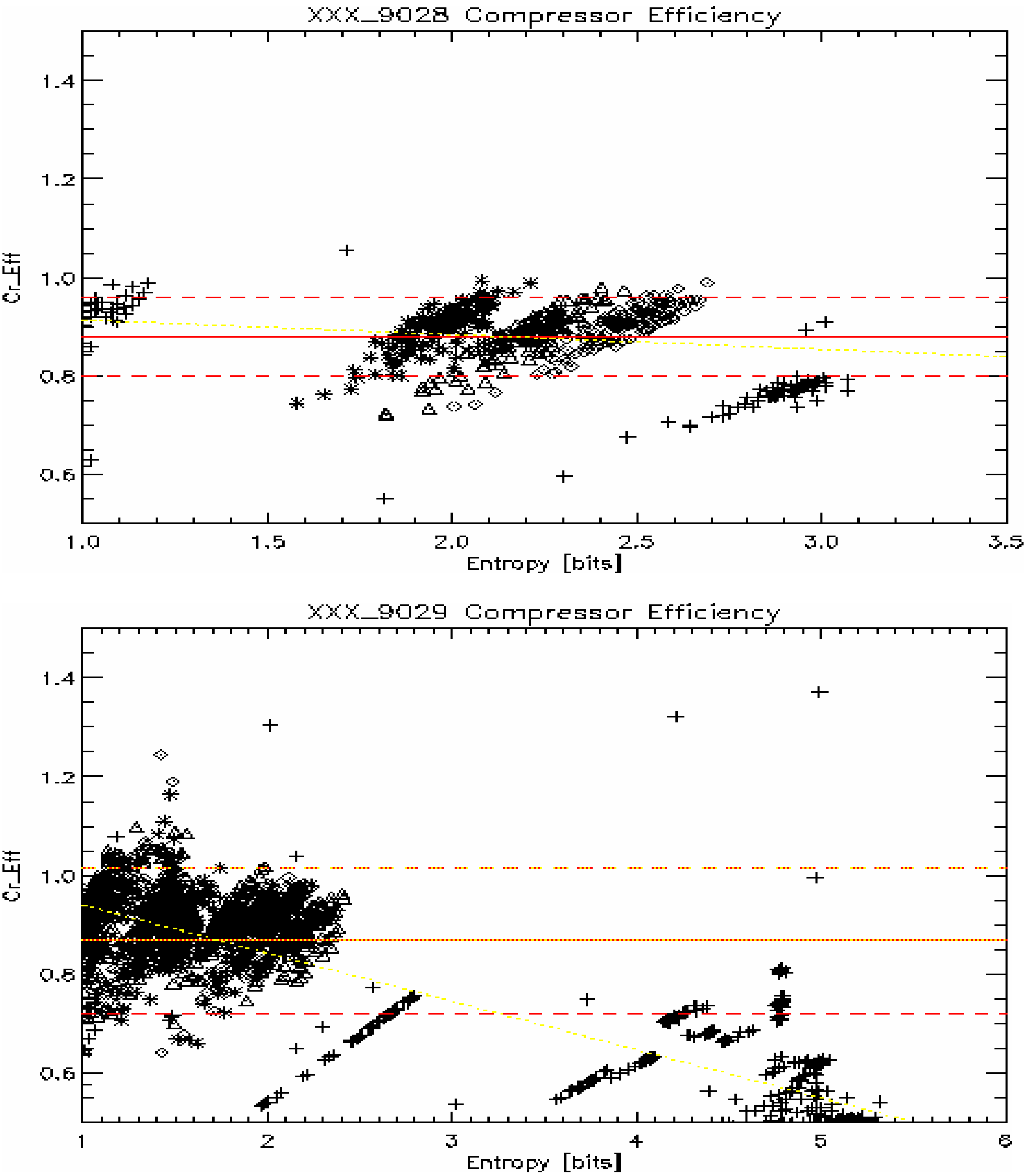


Fig A.4 Cr_Eff as a function of entropy for XXX_9028 (upper frame) and XXX_9029 (lower frame). Symbols as in Fig.A.2. Red horizontal line is the Averaged Cr_Eff, dashed horizontal lines the ±1σ range and the dashed line an attempt of fit with a polynomial in linear – linear space.

CR_EFF AS A FUNCTION OF ENTROPY

Fig.A.4 gives the Cr_Eff as a function of entropy. It is evident as both for square waves and triangular waves the compression efficiency is, in average, 0.8 – 0.9 decreasing for increasing entropy.

CONCLUSIONS

It is possible to conclude that the compressor efficiency in general is less than 90% and that increasing the entropy the compressor efficiency decreases linearly or quadraticaly. However, more analysis will be required in order to drawn firm conclusions on the compressor itself.