BC-SIM-IAPSUPA-TR-001
HRIC NECP report

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Contents

1. Introduction

1.1. Scope

The present document has been issued with the aim of describing the NECP (Near Earth Commissioning Phase) Tests of HRIC.

1.2. Reference Documents

RD1. BC-SIM-GAF-MA-002 rev.10_SIMBIO-SYS FM User Manual, 24/07/2018

RD2. Space-Kernels delivered July 28, 2017 v0.4.4.

RD3. BC-SIM-PI-RP-001 - Issue 2 - rev1_31-March-2017_IFAR_SPR

RD4. MIB BepiColombo Database Extract 13.09.2017

RD5. BC-EST-RS-02523_Simbio-Sys_EID-B_iss_1-1_ 26.10.2016

RD6. BC-SIM-TR-002 NECP Data Produced Analysis

RD7. Della Corte et al. 2018 "Performances of the SIMBIO-SYS High Resolution Imaging Channel on Board BepiColombo/ESA Spacecraft Channel Performance Parameters as Derived by on Ground Calibration Measurements". 5th IEEE International Workshop on Metrology for AeroSpace (MetroAeroSpace) Year: 2018

RD8. BC-SIM-TN-001-SIMBIOSYS_FOPs_Decription_Issue1_v6_01Jan2020 (20.500.12386/23810)

RD9. BC-SIM-TR-001 - SIMBIO-SYS NECP Data Produced Analysis (20.500.12386/24814)

1.3. Acronyms

FOP	Flight Operation Procedure
FPA	Focal Plane Assembly
OB	Optical Bench
PE	Proximity Electronic
TC	Telecommand
HRIC	High Resolution Imaging Channel

2. Definitions and assumptions

In this section the main physical and technical terms are defined. The physical and instrumental assumptions are also included.

2.1. HRIC Sensors

Table 1 Main sensor of HRIC covering the temperature measurement of the FPA, PE, the backside of the Detector and the HRIC OB, the Current and Voltage measurement of the TEC and the PE

NSS11040	HRIC Temperature FPA1	YSS40001	SIMB HRIC Housekeeping	K
NSS11041	HRIC Temperature FPA2	YSS40001	SIMB HRIC Housekeeping	K
NSS11042	HRIC Temperature PE	YSS40001	SIMB HRIC Housekeeping	K
NSS11043	HRIC Temp Tele1 *	YSS40001	SIMB HRIC Housekeeping	K
NSS11044	HRIC Temp Tele2 *	YSS40001	SIMB HRIC Housekeeping	K
NSS11050	HRIC PE 3.3V Measured	YSS40001	SIMB HRIC Housekeeping	V
NSS11051	HRIC TEC Current	YSS40001	SIMB HRIC Housekeeping	A

Table 2

Table 3 HRIC temperature sensor position

Unit	Instrument Controlled Thermistors	Temperature	Location	Parameter Name
HRIC Optics 1	PT1000	-40/+65	TIRD filter	HRIC_Temp_Tele_1
HRIC Optics 2	PT1000	-40/+65	FPA package	HRIC_Temp_Tele_2
HRIC SCA 1	DT470	-40/+65	FPA SCA	HRIC_Temp_FPA_1
HRIC SCA 2	DT470	-40/+65	FPA SCA	HRIC_Temp_FPA_2
HRIC PE	PT1000	-40/+65	PE hot spot	HRIC_Temp_PE

The housekeeping sensor related to HRIC are reported in Table 1.The Position of the temperature sensor are showed in Table 3.

The two values TFPA1 TFPA2 are predicted to respond to the switch on of the detector (increasing value) and to be the feedback value for the TEC.

(a) (b)

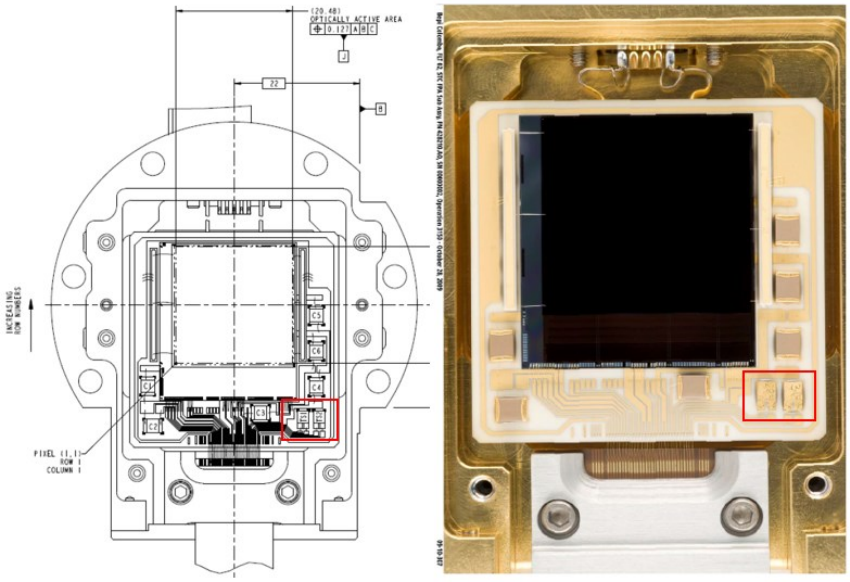

Figure 1 HRIC-FPA temperature sensors [RD2] Channel next to the FPA, called SCA1 (on the left) and SCA2 (on the right) and associated respectively to the NSS11040 and NSS11041.

3. NECP DAYS Division

Day number	Out of pass	Test name
DAY1		Functional tests
		TEC tests
	X	Performance
DAY2		Functional tests (Redundant)
		Inter-channel Test
DAY3		Max data-rate
		Max stress
		ORBIT

Table 4 Table of the Tests

4. DAY1 Functional tests

4.1. Test description and commanding

All the test details and command timelines are reported in RD6.

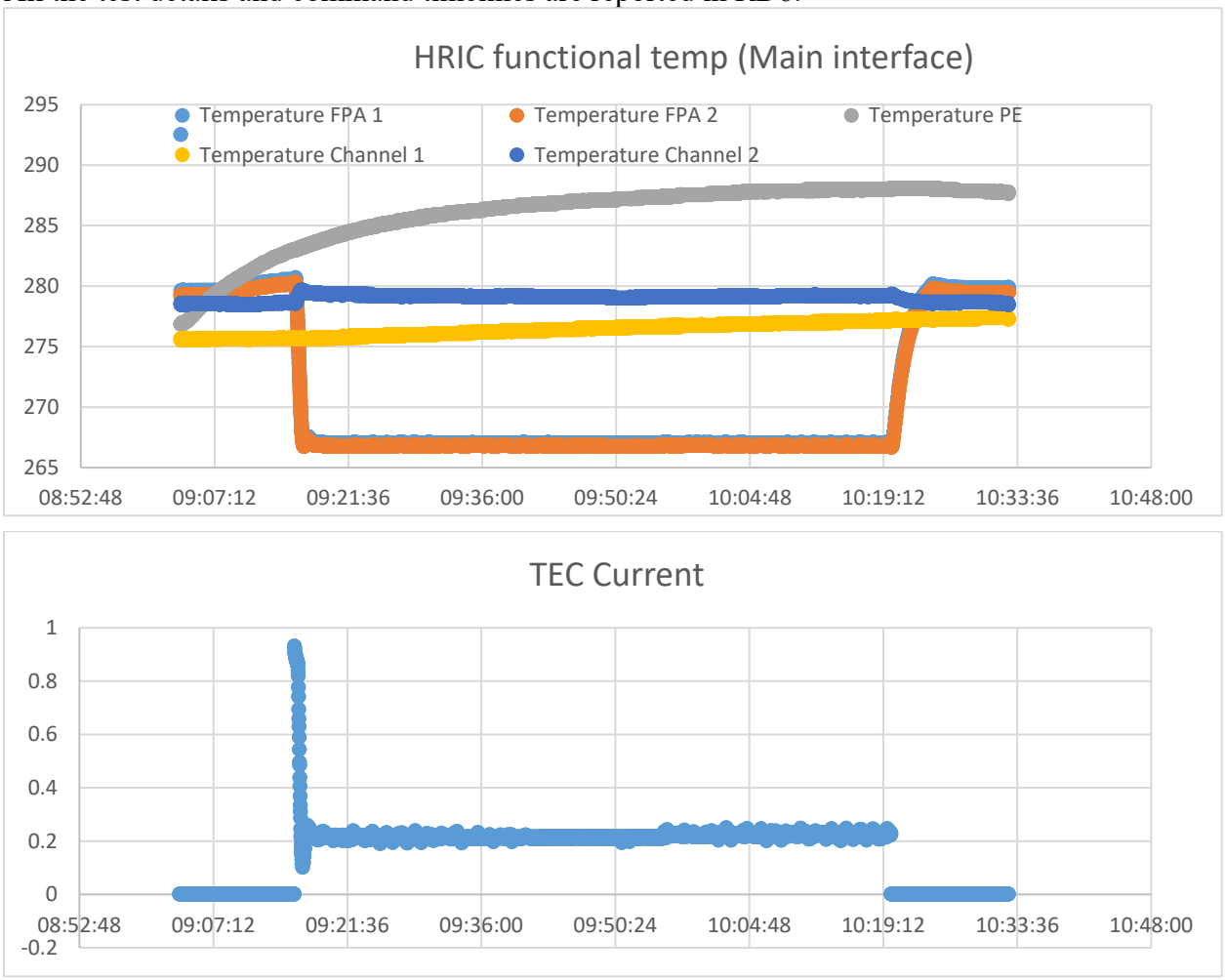

Figure 2 Temperatures and Tec Current sensors for the first day of the functional test main of NECP.

The diagram of Figure 2, shows the trends of the HK related to the temperatures (upper panel) and TEC current (lower panel) during the functional test of HRIC. The temperatures trends show expected behaviour: since the PE power on, PE temperature start to grow up reaching at the end of the test a maximum value of about 287 K. The temperature sensors linked to the detector show a trend connected to the operations: the temperatures after the switch on of the TEC drops down to the setting point. The Temperature Channel 2 that is connected to the external case of the FPA show a trend linked to the TEC and FPA activation with a small temperature increase. The Temperature channel 1 shows a small increasing trend from the beginning of the test: the increase of the temperature during the test is less than 1 °C.

The current of the TEC (lower panel) shows a peak at the switch on: this is due to the small temperature difference between the commanded set point and the actual temperature of the FPA at the switch on and

due to wrong parameters values for the TEC used. In Fact, the bad parameters for the soft start of the TEC were not able to limit the current to the device. This error was checked by the team in the following test.

4.2. Images analysis

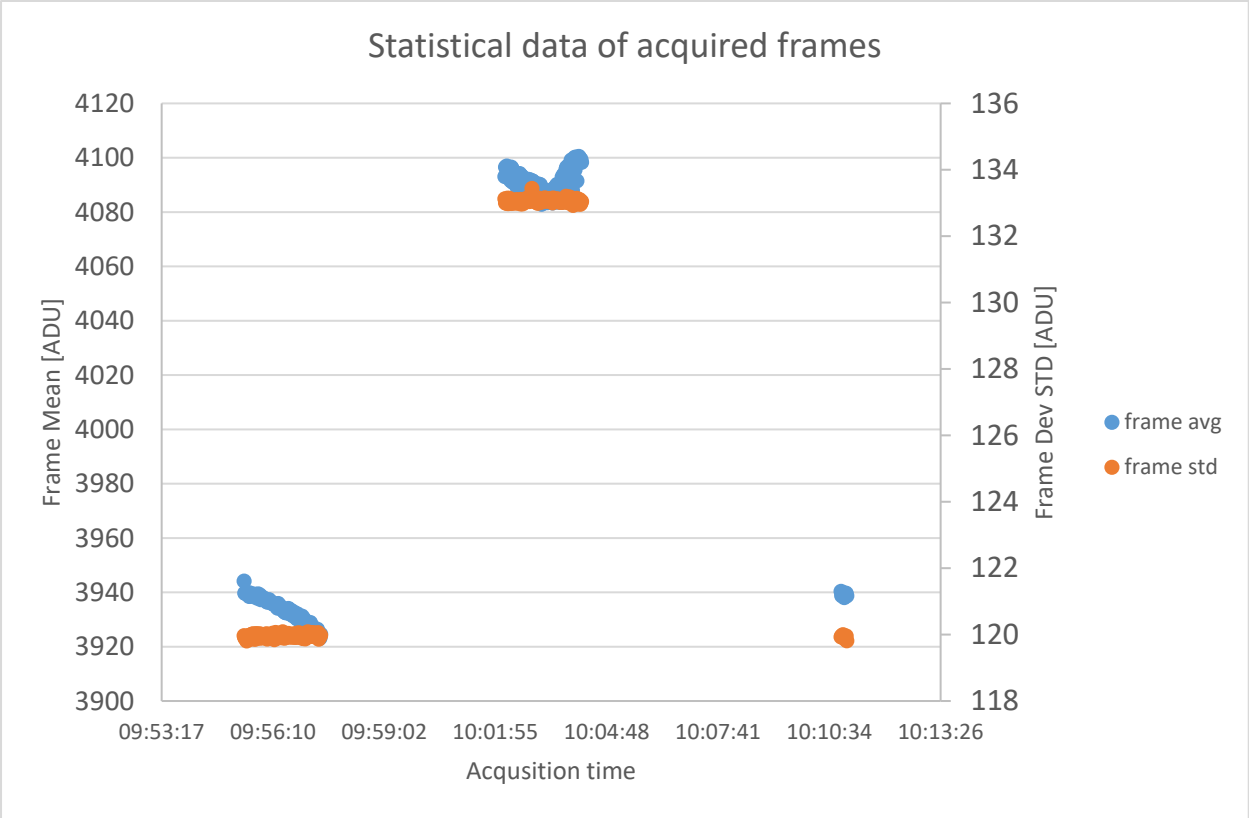

Figure 3 In the plot are reported the average and the standard deviation over the whole frame for the pixel readings. The frames have been acquired in three steps changing the integration time: a) short integration time .000038 s; b) long integration time 0.3148 s; c) short integration time 0.000038 s.

The analysis of the frames acquired during the functional test show that the signals read from the detector are compatible with the values characterized during the on-ground calibrations. Average Signal Level and Standard deviation measured on the frames are compatibles with the same parameters acquired in similar conditions during the calibration campaign.

For both the measurements at short integration times and long integrations times the average values show small (in amplitude) trends. These do not show any simple correlation with the housekeeping parameters. Further investigation are ongoing to explain the observed trends.

5. DAY1 TEC setting tests

In order to check the TEC soft-start and the parameters settings, during the first day of the NECP a dedicated, un-foreseen, test session was setup. During this test, the TEC parameters were set as reported in the relevant section of RD1. To avoid any over-stress of the device and consequently also for the FPA the test was setup in the safest way: a first activation of the TEC with a very small

difference between the actual value and the set point for the FPA temperature, and a second step with the nominal Temperature set point for the FPA.

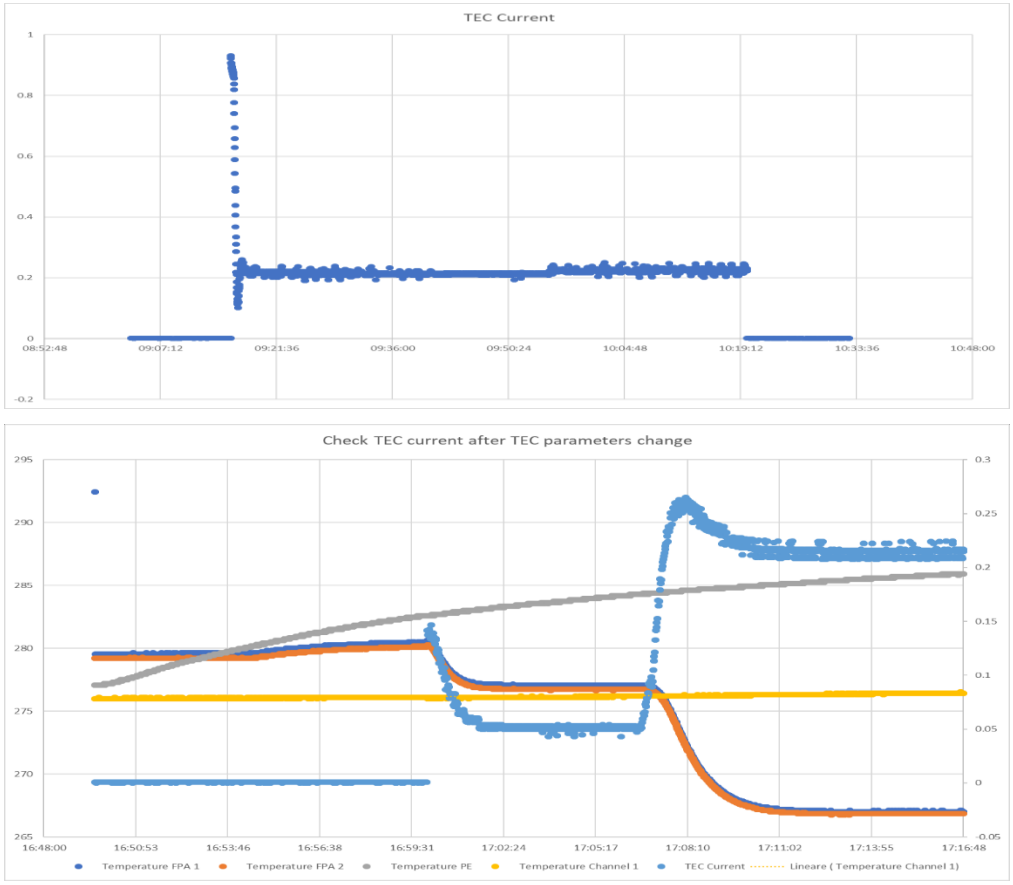

Figure 4 TEC current and Temperatures trends obtained before (upper panel) and after (lower panel) the correction of the TEC parameters. With the correct values for the parameters the TEC current trend (blue dots on the lower panel) show the soft start as expected. In the plot the current trend show two different steps: this is because the TEC set point was changed during the test, as evident by the Temperature trends.

In **Figure 4** are reported the current Trends for the TEC and the FPA temperatures. In the Upper panel the behavior observed during the functional test with the high current peak at the switch-on of the TEC. In the lower panel the TEC behavior after setting the right parameters for the TEC: at the first switch-on of the TEC the current raise at about 0.1A (much lower than the safe limit for the device). When the FPA Temperature was set to the nominal values the TEC current raise slowly within several second, after a small overshot the current reach a safe value of about 0.2 A when the FPA temperature reached the set point.

6. DAY1 Performance Tests

6.1. Test description

During the out of pass phase in the nigh between the 10 and 11 December 2018 SIMBIO-SYS performed the performances test of the HRIC channel. The performed tests are (details on commanding and timelines are reported in RD6):

- Test of data compression

- Dark measurements
- Test detector reset
- Test spurious charge

6.2. Test Results

6.2.1. Data Compression

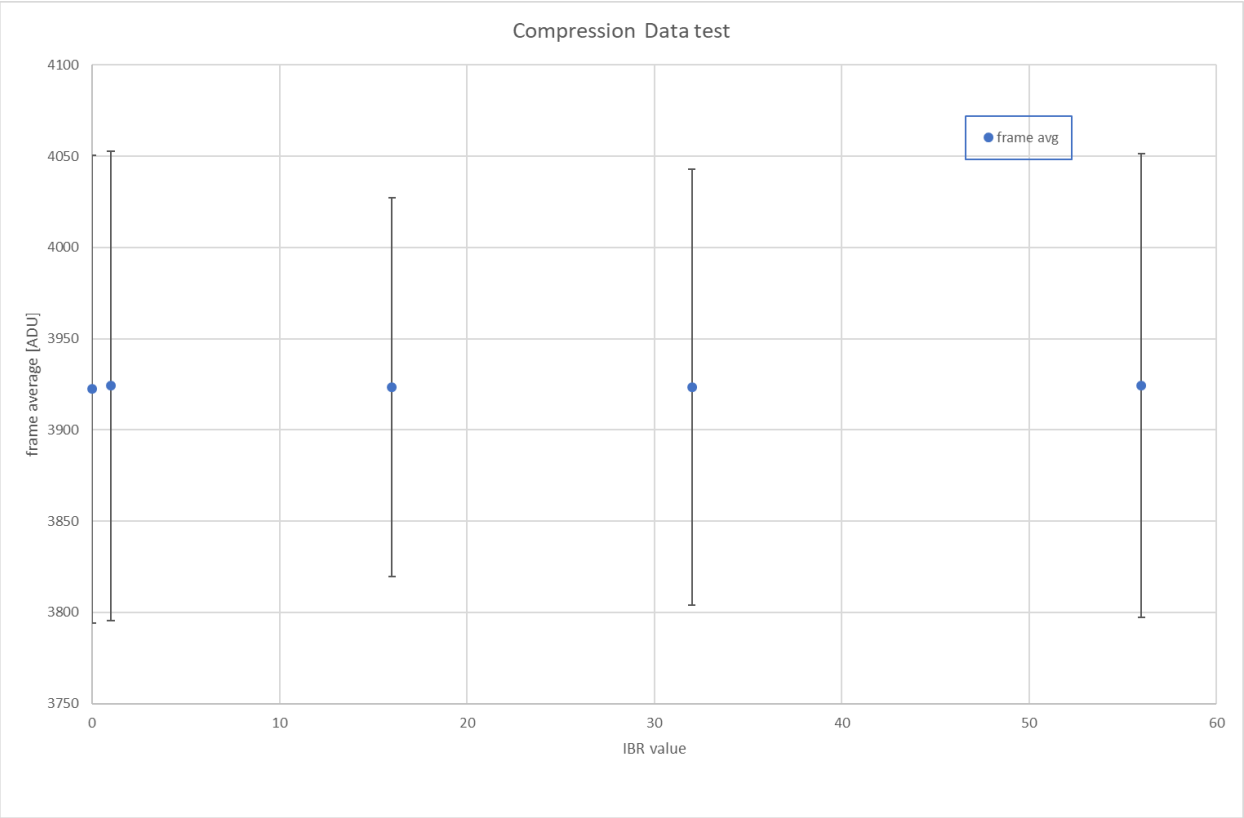

Figure 5 Frame Average and standard deviation (reported as error bars) for acquisitions with same integration times.

During this test the same detector was acquired using the same integration time (96ms) and 5 different values of the compression (ibr=0,1,16,32,56 corresponding to compression levels: bit packing, lossless, 14, 7, 3.5). The differences between the acquisition considering the average and the standard deviation on the pixel values are negligible for the acquired scene (almost uniform dark image).

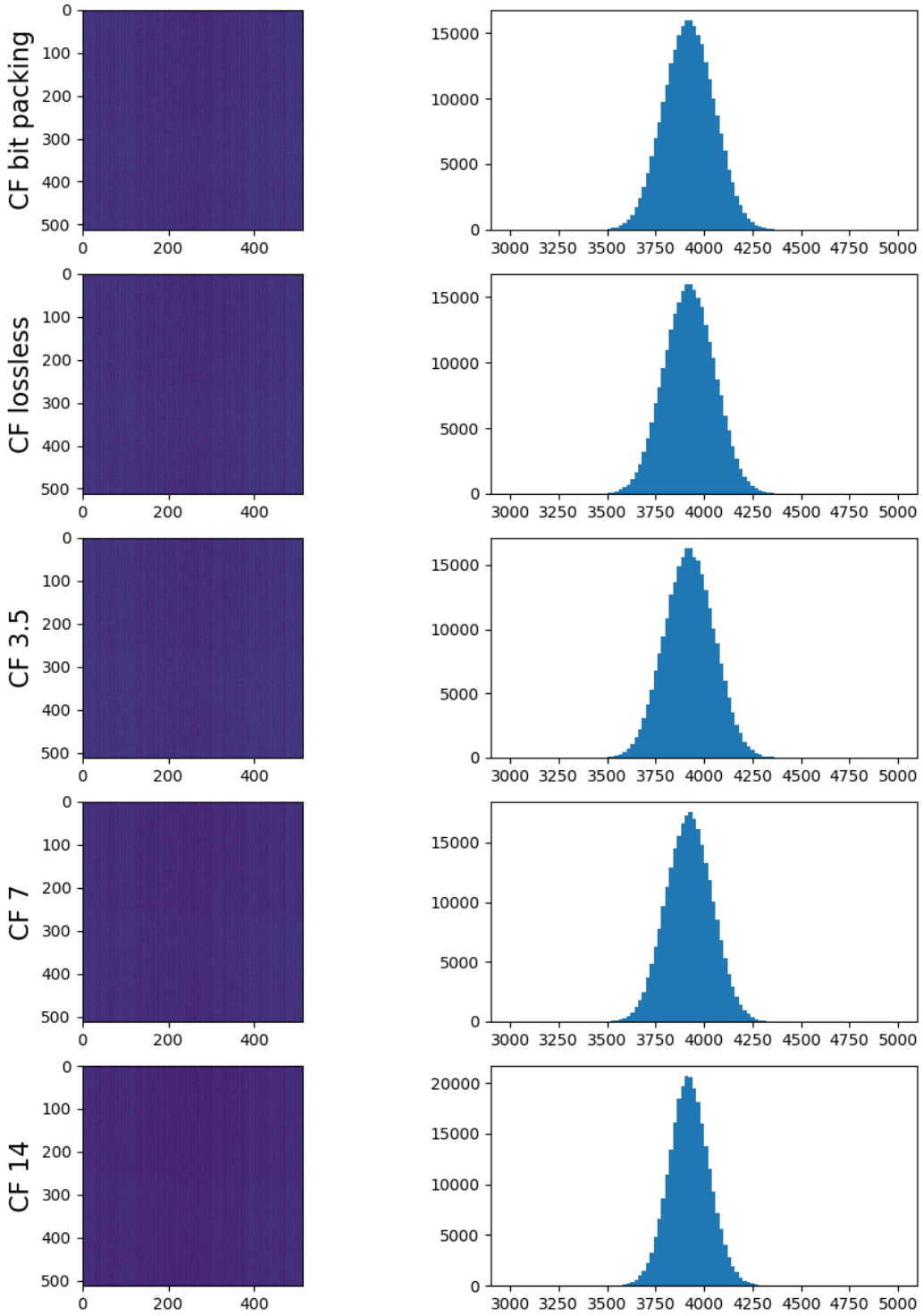

Figure 6 Frame acquired (left column) and the corresponding Histograms of the pixel values (right column) for 5 different compression level.

Considering the Frames and the pixel values histograms as expected the distribution of the pixel values is less disperse as the compression factor increases. In fact, the effect of applying an increasing compression factor results in the removal of high frequency variation in the pixels.

6.2.2. Dark measurements

During Dark test/measurement the areas of the detector corresponding to the Panchromatic, and to the three Broad Band filters have been acquired with different integration times starting from the minimal (400 nano-seconds in the configuration used for the ROIC) up to about 6 seconds. The values of the average of the acquired frames are reported in **Figure 7** and **Figure 8**. The trend shown in the plot is compatibles with the trends measured during the calibration campaign on ground and reported in RD7.

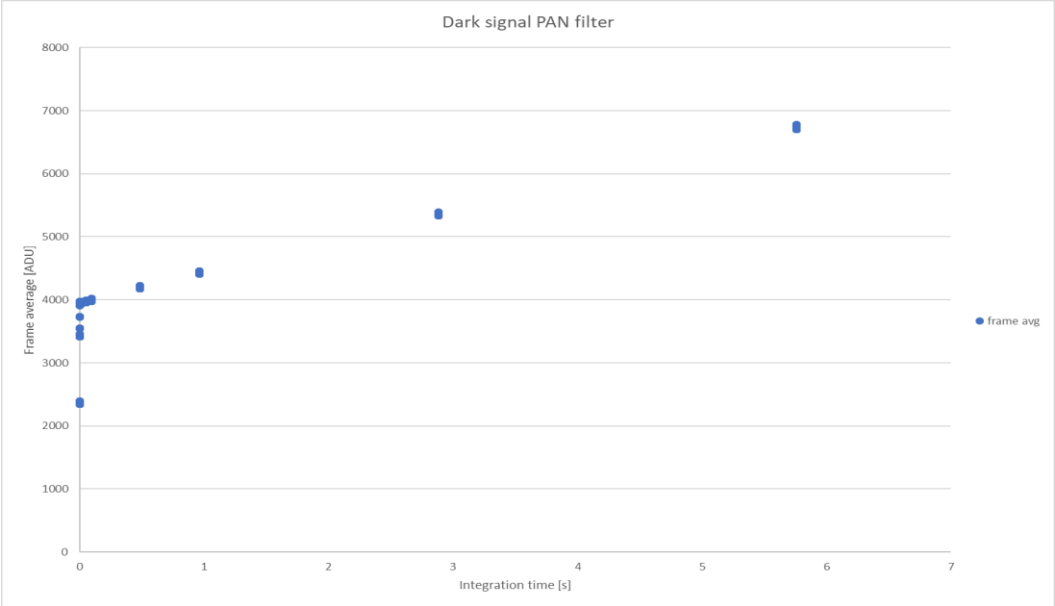

Figure 7 Average of the pixel values over the frames acquired during the DARK test. In the plot are reported the values of the average of the frame for the Panchromatic filter.

Using the data collected during the DARK measurements also the FPN and the RON of the detector have been checked w.r.t the values obtained during the calibration campaign. The values obtained for both FPN and RON are in good agreement with the values obtained in RD7 (**Figure 9** and **Figure 10**).

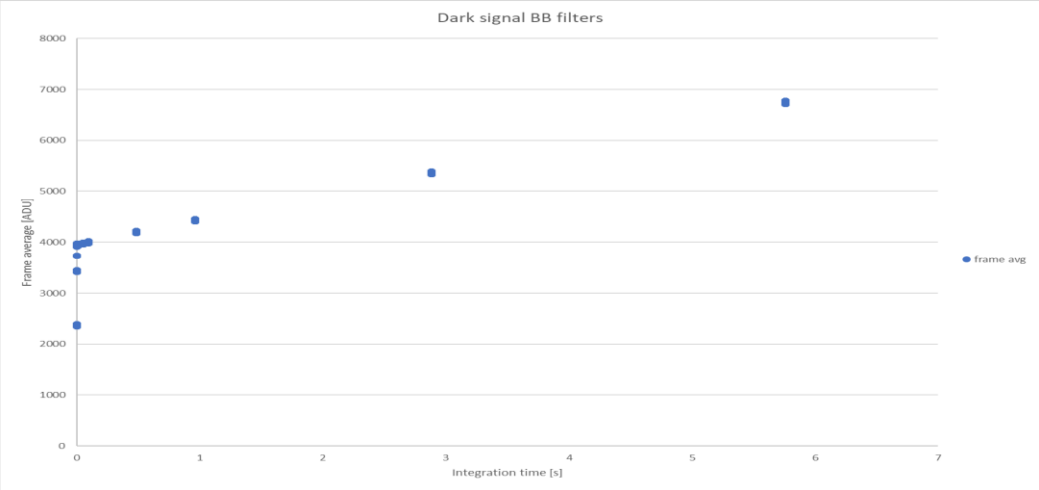

Figure 8 Average of the pixel values over the frames acquired during the DARK test. In the plot are reported the values of the average of the frame for the BroadBand filters.

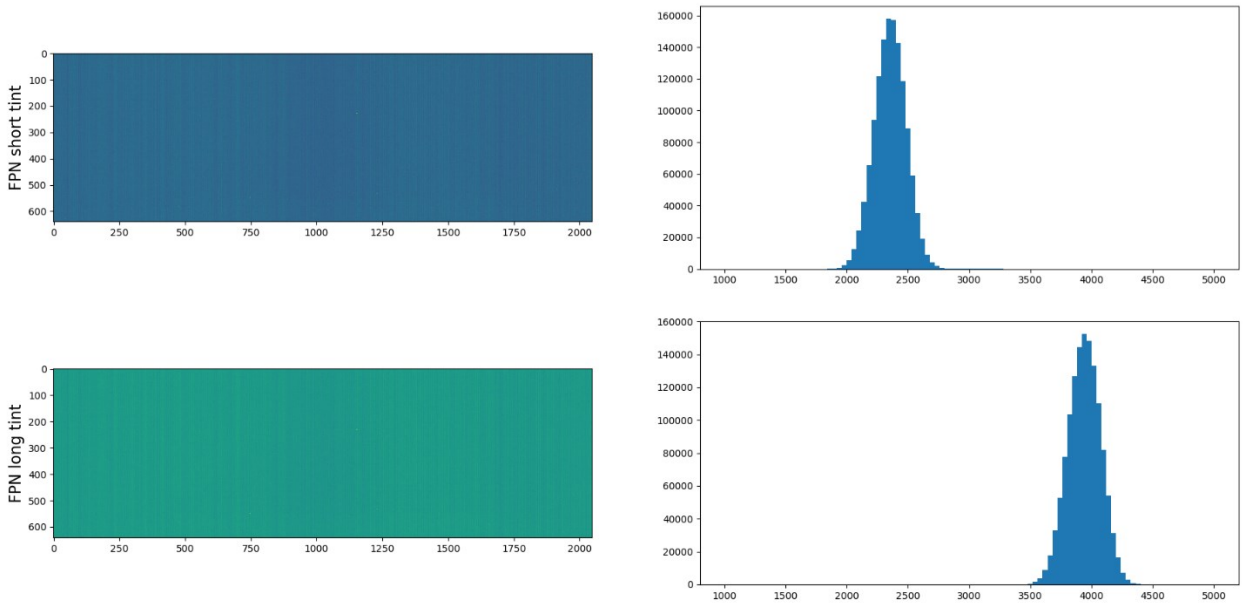

Figure 9 FPN frame at short time (average of 10 acquisition at minimum integration time (upper panel) and 48 microseconds (lower panel).

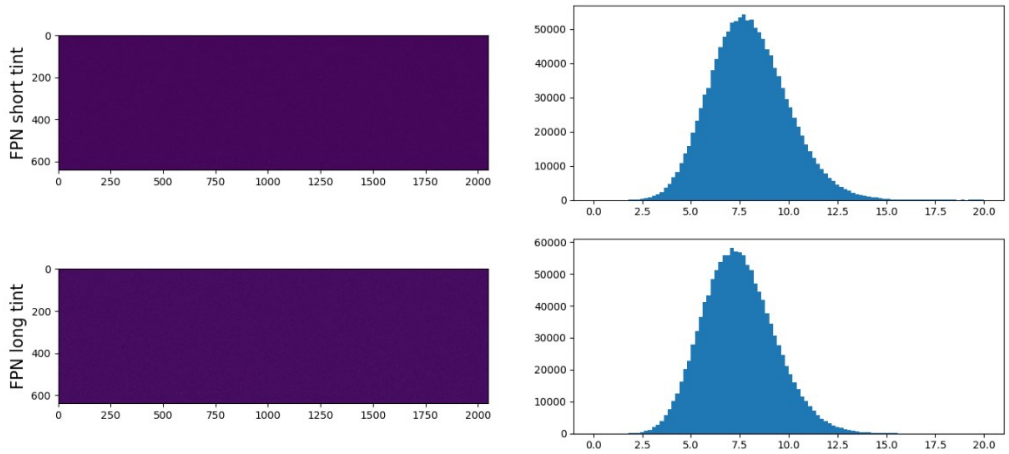

Figure 10 RON frame at short time (average of 10 acquisition at minimum integration time (upper panel) and 48 microseconds (lower panel).

6.2.3. Test reset

In order to check if is present an issue of charge accumulation on the pixels between 2 resets without image acquisition, several frames have been acquired with different integration times and delays between the frames. The average of the frames pixels values is plotted in **Figure 11** w.r.t. the acquisition time. The values during the sequence of acquisition are quite stable the only difference between the series is due to the DARK behaviour. As checked before the launch no reset issue is present on the HRIC detector (within the RON of the detector).

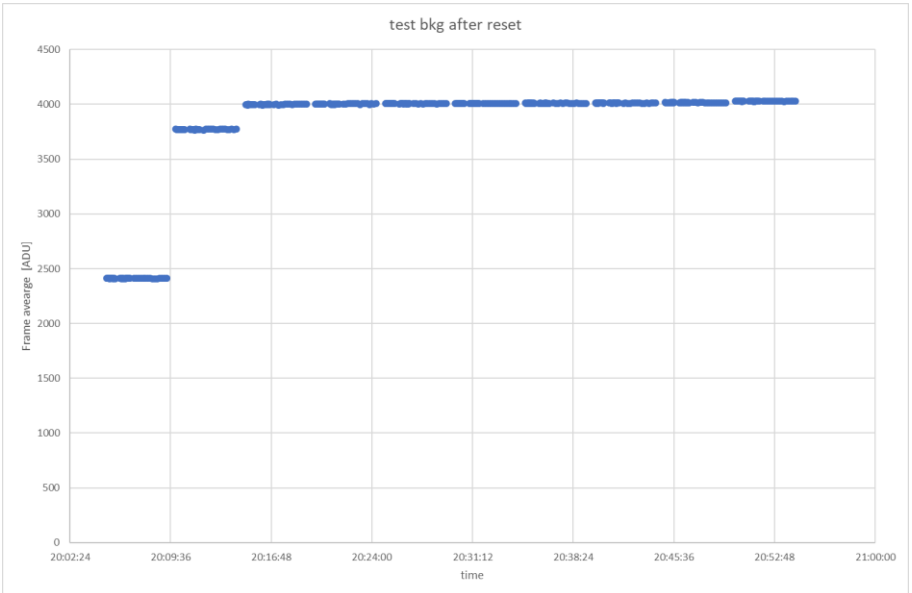

Figure 11 Value of the average of the pixel values obtained in the frame acquired to check the behaviour of the detector pixels reset after acquisition.

6.2.4. Spurious Charge measurements

(TBW) analyses ongoing.

7. DAY2 Redundant Functional test

7.1. Test description and commanding

For the description and commanding timeline of the test refer to RD6

7.2. HKs interpretation

The functional tests on the redundant interface were a subset of the tests performed on the main interface: only a reduced number of images have been acquired. In **Figure 12** are reported the temperature trends during the test. All the trends are nominal, in this case the thermometer on the TIRD did not show any trend coupled with the PE temperature, probably because of the short duration of the test, in any case this behaviour will be checked in the next check-out of the instrument. The TEC current behaviour is nominal (**Figure 13**). The statistical analysis of the acquired frame didn't show any trend and the behaviour is nominal (**Figure 14**).

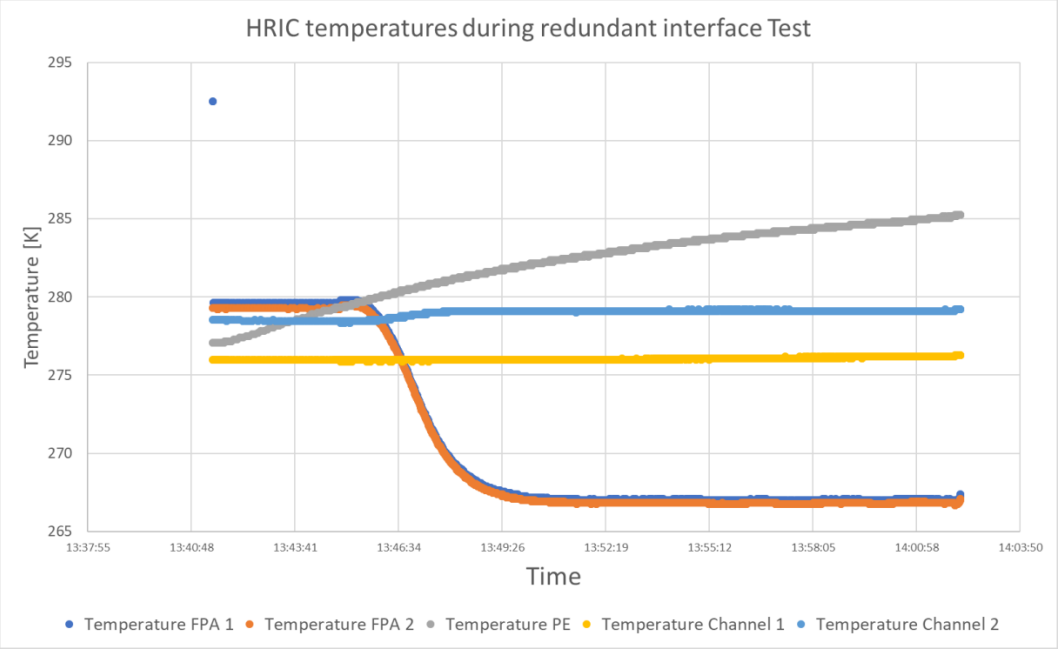

Figure 12 HRIC Temperature trends during the functional tests on the redundant interface.

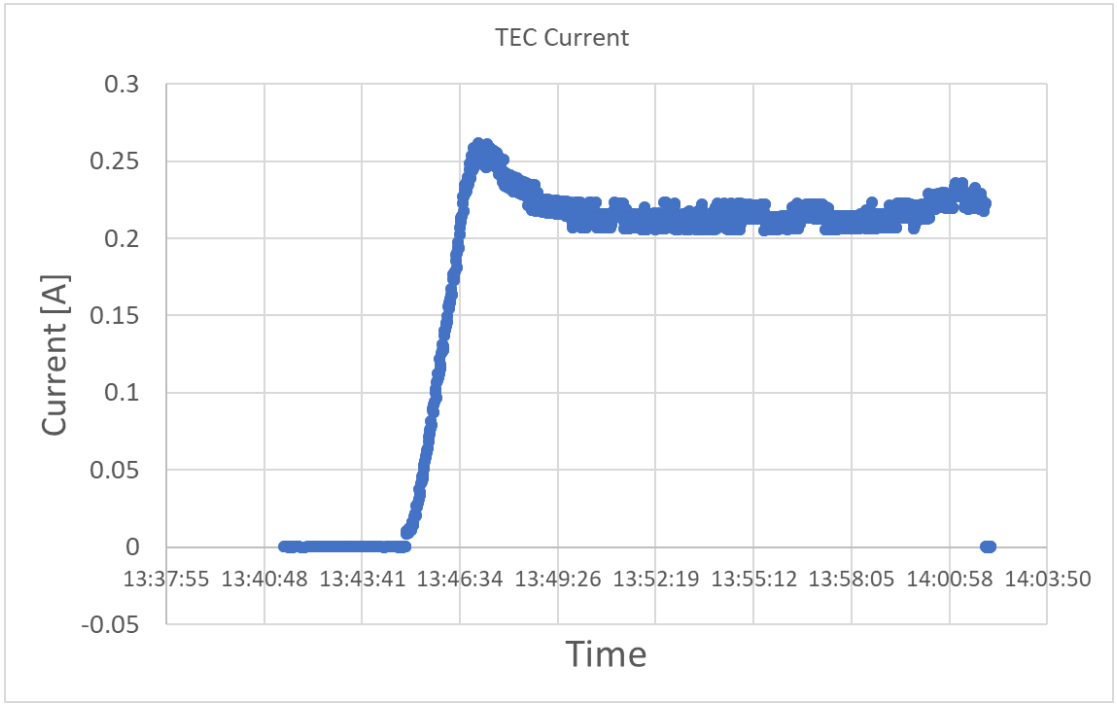

Figure 13 TEC current trend during the Redundant interface switch on of HRIC.

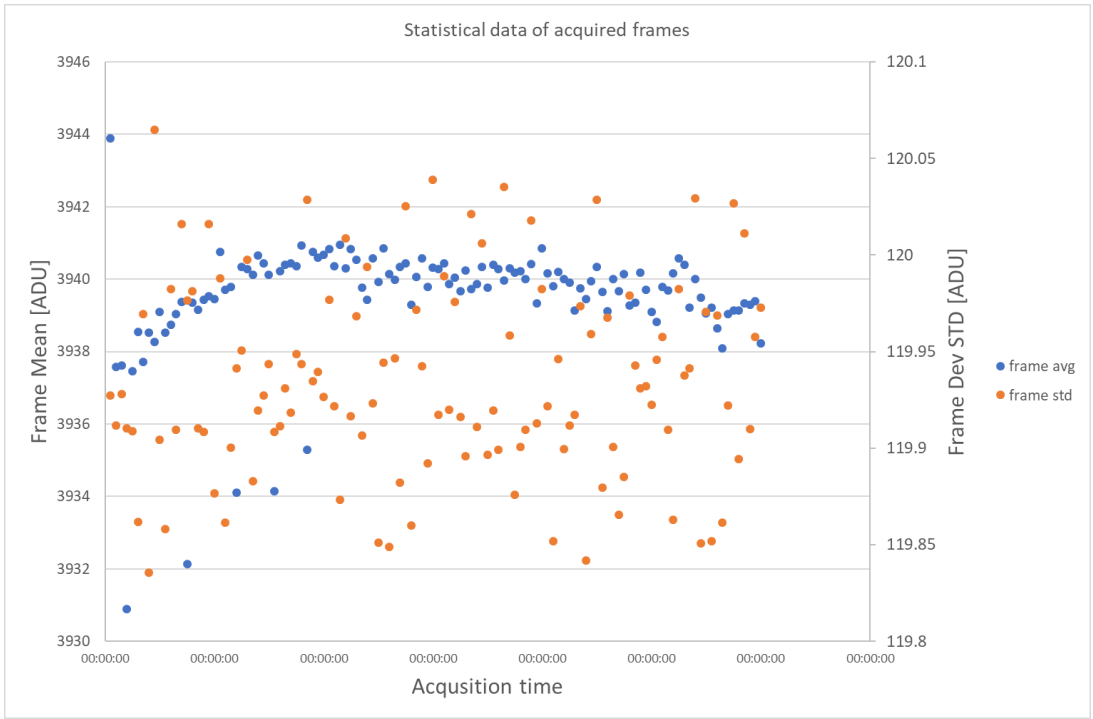

Figure 14 Averages and standard deviations of the frames acquired by HRIC during the functional test on the redundant interface.