DAWN-FC

DAWN - Framing Camera

Dawn FC DC034 Report

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1 General aspects

1.1 Scope

This document contains the results of the analysis of the data acquired by the Framing Cameras during the DC034 operational slot. The scope of the activities was exclusively engineering, so no associated science report will be released.

1.2 Introduction

This report is structured in several parts.

Section 2 describes the planned operations, including the different activities and a brief description of each.

Section 3 contains a detailed log of the execution.

Section 4 reports on the general health status of the cameras.

Section 5 explains the evolution of the sensors since launch and analysis their change in performance.

The conclusions are covered in section 6.

1.3 Applicable Documents

no.	document name	document number, Iss./Rev.
AD1		

1.4 Reference Documents

no.	document name	document number, Iss./Rev.
RD1	Software Review Certification Record	FC-FSW-SRCR-010, 28-Sep-2009

2 Description of the activities

2.1 Overview

The operations of the Framing Cameras within the frame of DC034 were planned to be conducted between Nov 30th 2009 (DOY 334) and Dec 4th (DOY 338). They were divided into three mayor activities:

- Geometrical cross-calibration between FC2 and VIR
- FC2 flight software update and mini-calibration
- FC1 flight software update and mini-calibration

The telemetry passes were scheduled as follows:

DOY 335 0700 to 1500. Scheduled for FC2 software update.

DOY 336 0745 to 1545. Scheduled for FC1 software update.

DOY 337 0945 to 1745. Not scheduled for FC activities.

DOY 338 0945 to 1745. Backup slot for FC.

2.2 Geometrical cross-calibration

This activity was developed to provide information about the co-alignment between the VIR instrument and the Framing Camera (FC2) by acquiring data with both instruments simultaneously. It consists of five concurrent observations of the star Canopus (Alpha Carinae, V_mag = -0.72) and was initiated and outlined by the VIR team.

The first 10-minute observation shows Canopus in the center of the FOV of both instruments with the FC acquiring a clear filter image at the beginning, in the middle, and at the end, followed by two OpNav images. The second observation shows Canopus in the upper left corner of the FOV. One clear filter image was acquired at the beginning, after 5 minutes and after 10 minutes. During the third observation the FC acquired 3 clear filter images with Canopus in the lower right corner of the FOV. In the fourth observation Canopus shows up again in the center of three images. During the final observation the space craft performed a slow slew that made Canopus appear to move through the FOV from bottom to top on twelve consecutive images.

The total number of images acquired with the door open was 26. Among these were 24 science images (250 ms exposure time) and 2 windowed OpNav images (500 ms exposure time). All of them were acquired in the clear filter F1.

2.3 FC2 flight software update and mini-calibration

The purpose of this activity was to update the FC2 flight software to the most current version. It is composed of two parts, the Low-Level Software (LLSW) version 3.04 and its related UDP Library version 3.04.02. Both elements underwent their corresponding acceptance process and were approved for flight before the beginning of the activities as reported on RD1.

The LLSW update was preloaded and its execution was planned to happen mostly in the blind (out of telemetry pass) but finishing after the connection was established with the s/c so that we could get confirmation that the update was successful.

Immediately after that confirmation, the camera will be power-cycled and the files for the UDP library update will be uploaded. First the prologue, waiting for confirmation that the previous library was correctly deleted; then all the nine files containing the library, waiting again for confirmation that the update was successful; finally the epilogue that would store the library to non-volatile RAM and power down the camera.

The final part of this activity was a standard CCD mini-cal to analyze the evolution of the sensor performance.

2.4 FC1 flight software update and mini-calibration

The sequence of activities for FC1 was almost identical to those of FC2 with the only difference that s/c operational constrains prevented the pre-load of the LLSW update files, so they were scheduled for upload at the very beginning of the corresponding pass and then continue in the same approach as for FC2.

3 Activity log

This is the log of the activities as registered by the operations team during the execution. All referred dates and times are UTC.

3.1 DOY 335

07:00:00

Flight identified that downlink had been established at 06:00 and therefore we had telemetry

Connection was established to DSC and Lindau

The LLSW upload sequence was running, FC2 on at around 271 mA

CCD still floating down at -64.2 °C

CH still controlled by the SC @ -18.6 °C with ~ 0.5 duty cycle

FC2 interface temperature climbing from -1.5 °C

07:09:20

LLSW upload ended.

Camera booting at SCLK 7:03:00 @ 356 mA

SW version is 3.04

07:13:14

Camera is go for di3245, UDP library prologue, 071419Z

Waiting for confirmation that the UDP manager reset is OK before proceeding with the upload

Thermal control of the CH still done by the SC

07:18:48

Playback started

07:25:00

FC is off before di3245 got to the SC. We are good to go.

07:35:00

Flight reports that di3245 has completed execution and requests confirmation that we are good to go.

FC requests to wait for the end of the playback in order to re-gain visibility of the events.

07:52:00

FC confirms the reception of 36 images as scheduled

RT HK received confirming the successful execution of the UDP library prologue and the permanent storage of LLSW 3.04

08:02:00

The uplink strategy will be to wait the uplink and execution time between files ~ 10 min but not two-way light-travel times.

Operations will resume at 08:10:00

08:11:25

di4010 sent at 081222Z

08:23:00

di4011 sent at 082355Z

08:33:00

di4012 sent at 083354Z

08:45:05

di4013 sent at 084605Z

Confirmation of 230 UDPs of part 1

08:50:30

Flight manager reports that the last file was aborted during transmission. We have to wait for confirmation that the command is cleanly rejected by the s/c without any hiccups and then proceed with the re-send.

09:00:00

Confirmation of 85 UDPs of part 2

13:20:00

No update on the status of DSS-25. Discussions with Flight result in the conclusion that the camera can stay in the present condition as long as needed (including overnight). The s/c is taking care of the thermal control of the CH at -18.7 °C with a duty cycle of 40%. The CCD stays floating cold at -64.0 °C.

The operational approach to be followed is that we continue uplink as soon as we regain control, even if we have to leave one part incomplete until tomorrow.

13:40:00

The Ops team informs that the commissioning of the uplink will take approximately 30 min from the moment the failure is declared solved. In view of this, 1400Z has beenbeen set as a deadline for continuing operations. There should be enough time margin to complete the activities within the backup slot.

14:06:00

After confirmation that DSS-24 is not coming back we stop operations for the day and agree to reconvene at 0715 UTC (2315 PST, 0815 CET), 30 min before beginning of the pass for discussion of the strategy to be followed.

3.2 DOY 336

07:37:00

FC Team on console. Flight requests confirmation that operations will continue with di4013. FC confirms

07:41:00

Telemetry established to Lindau. CH @ -18.6 °C, CCD @ -64.2 °C, Current @ 355 mA

Op temperatures also fine. HK counter @ 8723

Command counter @ 396, event counter @ 5

Waiting for HK to DSC

07:48:00

Telemetry connection established to DSC

Flight confirms that commanding is expected at 07:55

07:58:09

Command window is open

di4013 (149 commands) sent at 075934Z

After discussions with Flight, it is agreed that 8 min separation from the previous bit-1 time is safe enough and would provide additional time margin.

08:07:33

Di4014 (150 commands) sent at 080847Z

08:16:42

Di4015 (18 commands) sent at 081716Z

08:20:00

Di4016 (72 commands) sent at 082155Z

Command counter @ 546, event counter @ 5

08:27:13

Di4017 (67 commands) sent at 082809Z

08:32:18

Command counter @ 696, event counter @ 5

Di4018 (35 commands) sent at 083218Z

08:36:27

Part 3 successfully loaded 145 UDPs.

Command counter@ 714, event counter @ 6

Now all six parts are underway, waiting for ground confirmation that everything is up before transmitting the epilogue.

FC1 CCD @ -63.2 °C

FC1 CH @ -18.6 °C

FC1 CH heaters @ 40%

FC confirms that the FC1 CCD heaters are off

08:44:52

Part 4 successfully loaded 49 UDPs

Command counter @ 787, event counter @ 7

08:47:29

Part 5 successfully loaded 39 UDPs

Command counter @ 855, event counter @ 8

08:52:38

Part 6 successfully loaded 16 UDPs

Command counter @ 891, event counter @ 9

FC is go for di4019, UDP library epilogue

Di4019 sent at 085450Z

09:02:01

Agreement is that we wait for confirmation that FC2 is off at the end of the epilogue before proceeding with mini-cal dz296d

09:24:14

Command counter @ 897, event counter @ 115

FC confirms that the upload has been successful. Waiting for the 5 min pause before power down.

09:26:55

FC confirms that FC2 is off. Heaters stay off.

Proceeding with dz296d

Dz296d sent at 092751Z

09:33:50

Flight confirms that we are go to proceed with the upload of the FC1 LLSW Update files

Di4021 sent at 093419Z

09:41:23

Di4022 sent at 094211Z

09:46:05

FC2 is on for mini-cal. CH non-op heaters are off.

Thermal control is looking good at 37 % duty cycle on the camera head

In response to Flight question, the lifetime table shows that the mechanisms are good to go

Di4023 sent at 094919Z

09:55:22

Di4024 sent at 095551Z

First images acquired.

10:01:45

Di4025 sent at 100242Z

10:16:04

Di4026 sent at 101205Z

10:18:07

Di4027 sent at 101819Z

10:25:11

Di4028 sent at 102559Z

This completes the upload of the set inactive FC1 LLSW upload files. We will wait for confirmation of the completion of FC2 mini-cal prior to the transmission of di4020 that would start the FC1 update.

Flight confirms the files are in position up to file buffer 13

10:43:05

CALExtraChargeBlock completed with 51 images acquired

10:48:56

Door opened successfully

10:54:43

Filter wheel moved to F2

10:56:13
Filter wheel moved to F3

10:58:07
Filter wheel moved to F4

10:59:14
Filter wheel moved to F5

11:00:34
Filter wheel moved to F6

11:02:14
Filter wheel moved to F7
Flight confirms that all the files for FC1 LLSW update are in the right file buffers.

11:03:42
Filter wheel moved to F8

11:05:06
Image acquisition completed with 72 images
Filter wheel moved to F1

11:06:26
Door confirmed to be closed.

11:11:00
FEE is off.

11:16:22
Playback started

12:00:19

Playback completed except for the last packet of the last images
All images appear nominal

12:19:49
Back from playback mode

12:23:20
FC2 is off. Waiting for completion of the playback

12:28:41
FC2 playback is complete
FC team is Go for the FC1 activities
Flight confirms that it is possible to playback the mini-cal data if it is executed in the blind.

12:31:27
Di4020 sent at 123209Z

12:40:34
EGSE sessions re-initiated, first at DSC, then in Lindau

12:53:50
FC1 is on for LLSW update
Current @ 270 mA

13:14:44
FC1 booted to LLSW 3.04
Waiting for the sequence to complete and power down the camera before proceeding

13:24:57
FC is go for the upload of di3261
Di3261 sent at 132748Z

13:31:27

FC1 is off at the end of the LLSW update sequence.

13:45:17
FC1 is booted @ 354 mA. S/C keeps control of the CH

13:47:14
FC1 UDP manager is reset. FC is go for upload of di4030
Command counter @ 1, event counter @ 3
Di4030 (150 commands) sent at 134825Z

13:57:29
Di4031 (133 commands) sent at 135629Z

14:04:09
Di4032 (110 commands) sent at 140431Z

14:09:24
Commands are clocking into the camera

14:12:32
Di4033 (150 commands) sent at 141313
Command counter @ 151, event counter @ 3

14:20:20
Part 1 loaded successfully 230 UDPs
Command counter @ 285, event counter @4
Di4034 (150 commands) sent at 142126

14:25:59
Part 2 loaded successfully 85 UDPs
Command counter @ 396, event counter @ 5

14:29:21

Di4035 (18 commands) sent at 142958Z

14:32:45

Di4036 (72 commands) sent at 143321Z

Command counter @ 546, event counter @ 5

14:37:57

Di4037 (67 commands) sent at 143843Z

14:43:24

Di4038 (35 commands) sent at 144405Z

Operations will hold now until we receive confirmation that all UDPs have been uploaded before continuing with the epilogue

Command counter @ 696, event counter @ 5

14:47:17

Part 3 successfully loaded 145 UDPs.

Command counter @ 714, event counter @ 6

14:53:07

Part 4 successfully loaded 49 UDPs.

Command counter @ 787, event counter @ 7

14:58:32

Part 5 successfully loaded 39 UDPs.

Command counter @ 855, event counter @ 8

15:02:32

Part 6 successfully loaded 16 UDPs.

Command counter @ 891, event counter @ 9

Di4039 (epilogue) sent at 150251Z

15:17:15

Flight confirms an extension of the transmitter up to 1543. di4039 should complete by 1535, giving us about 8 minutes for transmitting the mini-cal.

15:20:20

Epilogue is executing in the camera

15:29:55

UDP library upload successful. Command counter @ 897, event counter @ 115

HK counter 907

Waiting the 5 minutes for the power down of the camera.

FC Team is GO for the upload of dz286h (FC2 mini cal).

15:34:37

FC is off

Dz286h (FC mini cal) sent at 153512Z

This is the end of the FC2 activities for today. The mini cal will continue to execute out of pass and the data played back at the beginning of pass on 2009-12-03T09:45Z (DOY 337) prior to VIR playback.

3.3 DOY 337

09:40:00

Telemetry is flowing both to Lindau and DSC

Both cameras off, CHs controlled by the S/C

FC1 CCD @ 19.6 °C, CH @ -18.3 °C

FC2 CCD @ 20.9 °C, CH @ -18.3 °C

Duty cycle is approximately 50% on both CCDs and between 10 and 20% on the CHs

09:56:37

Di2766 sent at 0957

10:15:20

Playback has started

First images show a clear indication of extra charge.

10:25:51

Flight informs that the playback of the engineering data will happen at 1214Z ERT

11:06:10

Playback completed, pending the last packet of the last image

Dz203a sent at 111130Z

11:36:23

Last packet completed, 72 images downloaded

FC Team goes to get some sleep and the engineering playback will happen in the blind but the results will be analyzed in the morning.

15:59:45

FC Team back at DSC for the Tagup.

First assessment of the engineering plot is reassuring that FC1 is in good shape.

2 door movements (open and close) and 8 filter wheel movements (once around the wheel) were consumed.

4 Health status assessment

During the operational slot both cameras performed nominal from the engineering point of view.

The replacement of the flight software on both cameras went as planned and both are running now the most current version of the software.

All the images were acquired as scheduled and received without any missing packet, both the ones associated to the mini-cal and VIR geometric cross-calibration.

The only point worth mentioning is the bigger scatter of the current measurements in the +5 V analog line for FC2 when compared to FC1. The reason for the difference is purely operational and lies in the fact that FC2 was being polled for science data (XB) at the time of the update, while FC1 was not.

5 Sensor performance

The images acquired during the operational slot were analyzed to provide three different assessments: the evolution of dark current, the effect of extra charge and the adequacy of the requested exposure times to the intended targets.

5.1 Dark current

The dark current generation rate was analyzed for both cameras and compared with previous measurements, included some on ground.

5.1.1 FC1

The FC1 bulk dark current as determined during DC034 appears to have increased since ICO, as shown in Figure 1.

While all post-launch data suffer from systematic errors smaller than 1 DN due to the integer format of the returned pre-scan region average, this error is too small to account for the increase In any case the impact is very small for the exposure times considered for normal operaton.

5.1.2 FC2

The bulk dark current, shown on Figure 2, is consistent with that determined during ICO/MGA (dotted line). The images for this analysis were taken from the VIR geometric cross-calibration activity.

The percentage of hot pixels is now 1.5 %, defined as pixels that have dark current larger than bulk mean plus 4 sigma. This is up from 0.32% during the ICO calibration campaign. The increase is 20% smaller than expected from ICO results, perhaps due to increased distance to the Sun.

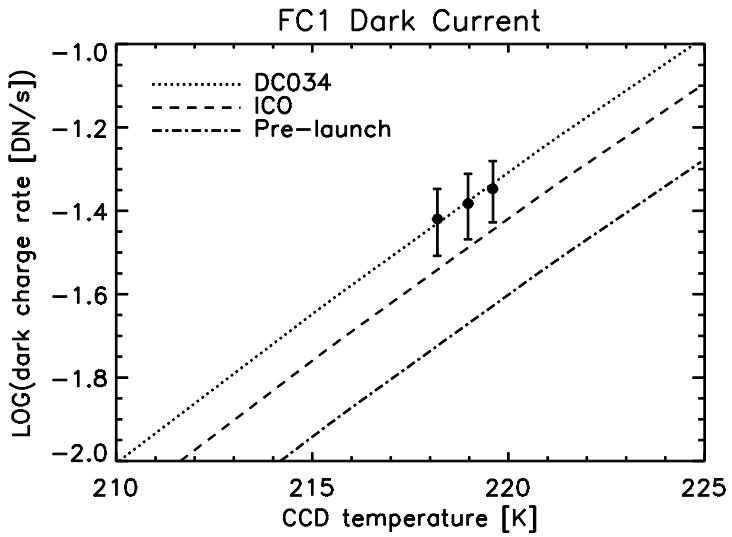

Figure 1: Comparison of FC1 dark current with previous measurements.

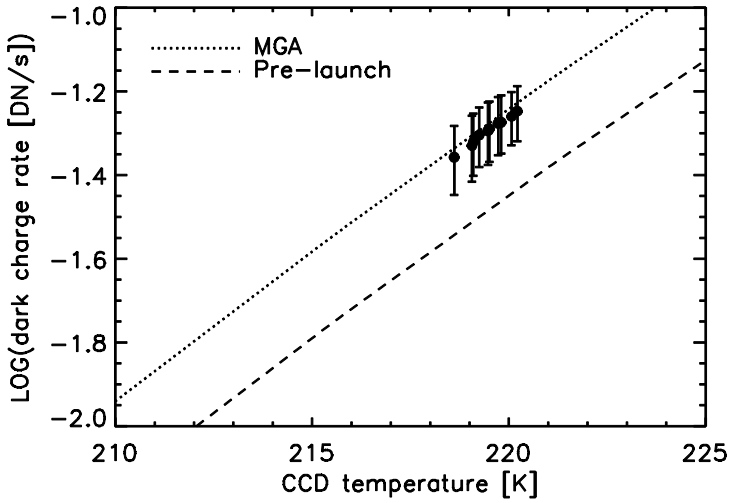

Figure 2: Comparison of FC2 dark current with previous measurements.

5.2 Extra charge

The CCD mini-cal has been executed for the purpose of extra charge determination four times on each of the FCs including DC034, as summarized in Table 1 and Table 2. The temperature variations between the different runs lie within a 2 K band for FC1 and a 4 K band for FC2 and the temperature profile shows the same shape in all cases.

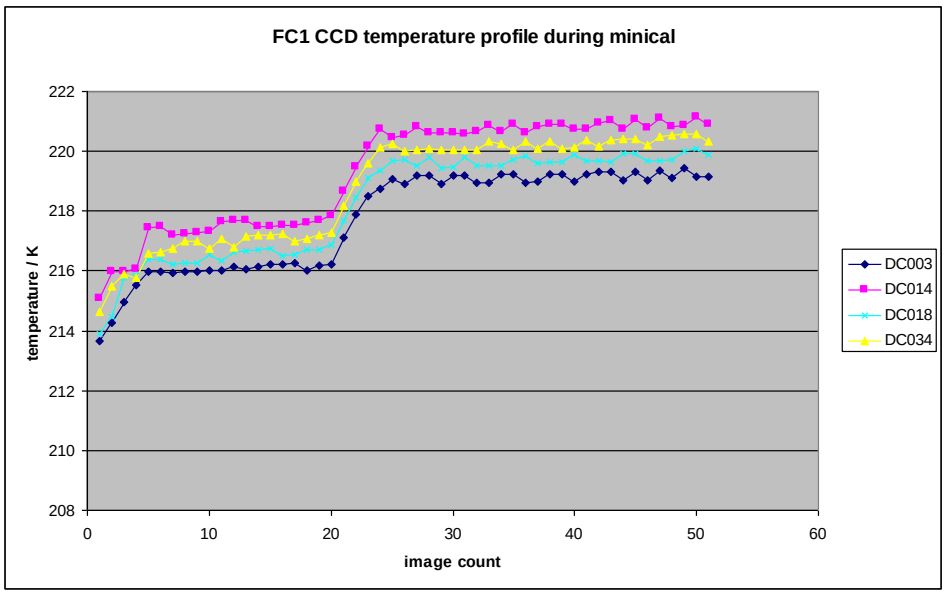

Figure 3: FC1 CCD temperature profile during mini-cal.

Table 1: Summary of CCD mini-cal runs on FC1.

	Activity Name	Date
DC003	ICO CCDcal	2007/12/12

DC014	s/w upload	2008/04/03
DC018	Mini-cal	2008/08/26
DC034	s/w upload	2009/12/03

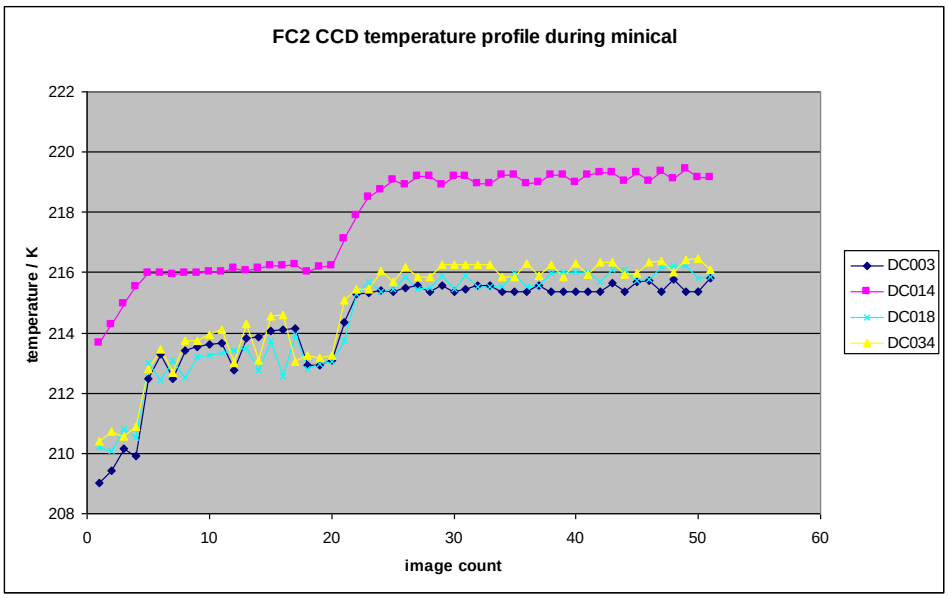

Figure 4: FC2 CCD temperature profile during mini-cal.

Table 2: Summary of CCD mini-cal runs on FC2

	Activity Name	**Date**
DC003	ICO calibration	2007/12/13
DC014	s/w upload	2008/04/02
DC018	mini-cal	2008/08/26
DC034	s/w upload	2009/12/02

With respect to the evaluation of the extra charge, no correlation has been found between the CCD temperature and the amount of extra charge present on FC1 images.

For FC2 no extra charge at all was found at the signal levels provided by the calibration lamp in DC034 or any of the previous runs. The accumulated histogram in Figure 5 shows the readout noise but absolutely no indication of extra charge.

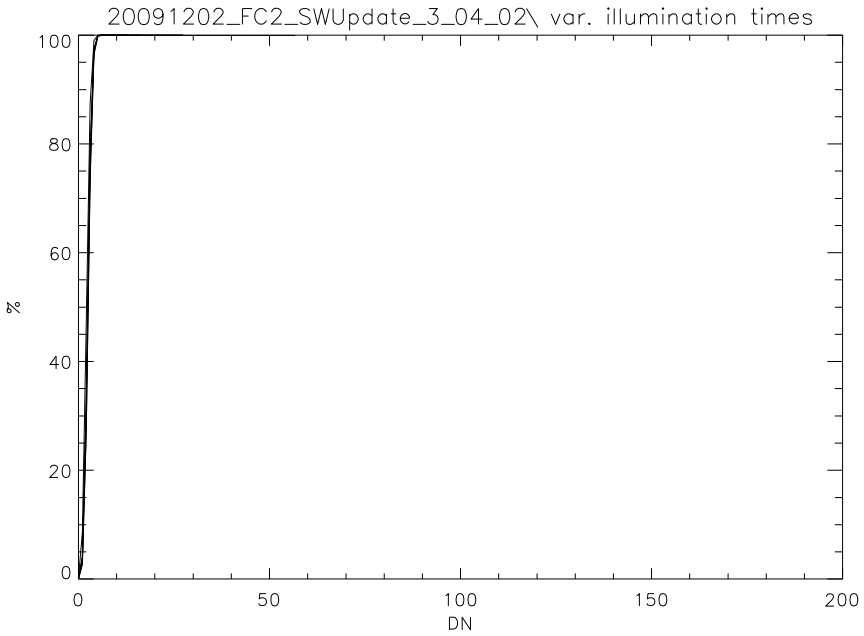

Figure 5: Accumulated histogram for FC2 cal-lamp images.

The accumulated histograms for FC1 data show extra charge distribution of pre-illuminated cal-lamp images (Figure 6). The signal level of the most affected pixels goes up to 200 DNs. The cal-lamp images were acquired with pre-illumination times of 1, 2, 3, 5, 10 and 60 seconds (plots from top to bottom show increasing pre-illumination times).

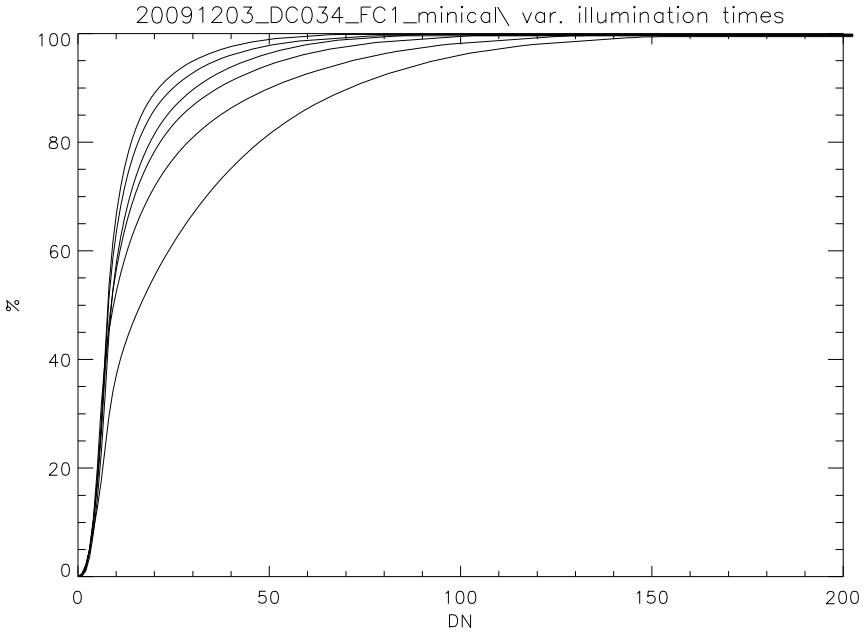

Figure 6: Accumulated histogram of extra charge on FC1 at six different pre-illumination times.

The comparison of the 60 s pre-illumination images from DC003, DC014 and DC034 (Figure 7) show no significant change in the amount of extra charge on the FC1 CCD. DC018 is missing in

this comparison because it was executed with pre-clear of the CCD, thus rendering the images unsuitable for comparison.

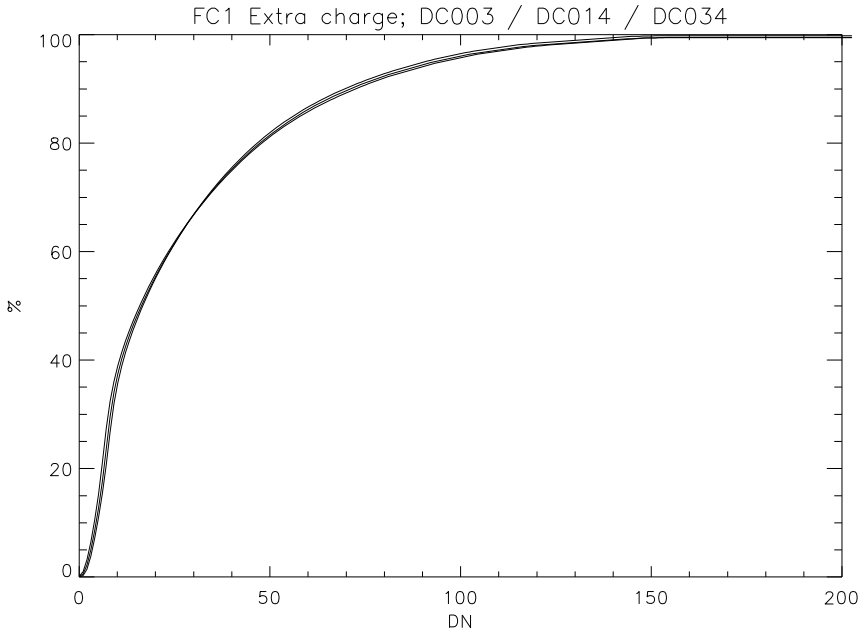

Figure 7: Comparison of the 60 s pre-illumination extra charge histograms

The typical signature of the extra charge on FC1 is shown on Figure 8

Figure 8: Typical extra charge pattern on FC1 (0, 0 at bottom left).

5.3 Exposure times

During the VIR geometric cross-calibration in DC034 FC2 acquired images of Canopus. In these images, the exact location of the star can be determined by a Gaussian fit. While this method is inherently inaccurate due to the small pixel fill factor of the CCD, the inaccuracy is increased in this case due to the overexposure of almost half of the images (11 out of 24).

The recommendation for future executions of this activity is to reduce the exposure time off all the science acquisitions by 50% to avoid overexposure. The minimum signal was 7418 DN, so the reduction will still render usable images.

6 Conclusions

Concerning the hardware, the operational slot demonstrated that both cameras are in good operational condition, including the mechanisms that had not seen operations for a longer period than specified. The aging of the sensors has proved to be slightly better than anticipated in view of previous reports.

The software was updated to the new version (3.04.02) and the camera is fully functional. During the evaluation of the images, it was found that the floating point average of the extra scan region was still a fixed point average. The commanding sequence was confirmed to have requested floating point and the source of the discrepancy is being traced. In any case, the problem has been tagged as minor, so it will only be addressed if a future s/w update is necessary for other reasons.

With respect to the operational procedures, this slot demonstrated again an excellent performance of the instrument, spacecraft and mission teams, including appropriate reactions to the unexpected failure of the ground systems and the achievement of the planned operations with sufficient time margin.

At mission level, we can confirm that no streak was found in the images acquired during this operational slot. This does not mean that there are none, because the observation sequence was not optimal for this purpose and we could have mistaken a streak for a cosmic hit. It does not mean either that the particles producing the streaks are gone, because the observation geometry has not been compared with previous occasions and not be as well suited as before for the detection of such particles. The FC team will continue to monitor the images acquired in flight in search for new occurrences of streaks.