DAWN-FC

DAWN - Framing Camera

Dawn FC DC041 Report

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Prepared by:
P. Gutiérrez-Marqués
T. Maue
S. Schröder

Approval Sheet

Prepared by: *P. Gutiérrez-Marqués* (signature/date)

Approved by: *A. Nathues* (signature/date)

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1 General aspects

1.1 Scope

This document contains the operations reports as well as the results of the analysis of the data acquired by both Framing Cameras during the DC041 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 conducted operations, including the different activities and a brief description of each.

Given that this was partly a re-run of a former activity, all sequences were merged into the background sequence, so no activity log is provided. Instead, a brief summary of the execution of the activity is included in section 3.

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	DC041 Walkthrough	DC041_Walkthrough_r2.ppt
AD2	FC Semi-Annual Checkout Sequence	DA-FC-MPAE-TN-076, 1/a
AD3	UDP Library 3.04.02 Patch Procedure	DA-FC-MPAE-PR-082, D/-

1.4 Reference Documents

no.	document name	document number, Iss./Rev.
RD1	Dawn FC DC038 Report	DA-FC-MPAE-RP-290, 1/-
RD2	Dawn FC DC034 Report	DA-FC-MPAE-RP-285, 1/-
RD3	DC018 Report	DA-FC-MPAE-RP-286, 1/-
RD4	DC014 Report	DA-FC-MPAE-RP-287, 1/-
RD5	Framing Camera ICO Report	DA-FC-MPAE-RP-268, D/c

2 Description of the activities

2.1 Overview

The operations of the Framing Cameras within the frame of DC041 were planned to be conducted between July 19th 2010 (DOY 200) and 21st (DOY 202). There three major activities:

- FC1 non-pointed semi-annual checkout and UDP library patch
- FC2 pointed semi-annual checkout and UDP library patch
- Geometrical cross-calibration between FC2 and VIR

All the image acquisition FC sequences were merged into the background sequence, and the UDP patch sequences were uploaded as separate absolutely-timed sequences, so no tele-command slots were scheduled. However, for verification of the FC1 patching, in case the sequence had to be aborted due to a failure in the patch, there was a window from 2010-200T21:05 to 2010-201T07:00. Conversely, for FC2 this window was from 2010-201T18:00 to 2010-202T04:45.

2.2 FC1 non-pointed semi-annual checkout and UDP library patch

The background of this activity is the need for the mechanisms on the cameras to be operated twice a year for maintenance. FC1 was due for this maintenance because its last operation had been during DC034 in December 2009. The details of the activity are described in AD2. A total of 65 images were acquired during this activity.

Additionally, during the Vesta Survey ISB it was identified that the UDP library loaded during DC034 contained a bug that prevented the macro-command TCMonitor from acquiring images with the correct exposure times. While this bug did not endanger the instruments or the mission, it limited the ability of the camera to return scientifically meaningful images with the already developed sequences, so the decision was made to patch the UDP library. The detail information and procedure for this activity is described in AD3. This activity did not include the acquisition of any image, but some acquisitions in the semi-annual checkout used TCMonitor to prove that the patch was successful.

2.3 FC2 pointed semi-annual checkout and UDP library patch

The rationale for this activity is foremost maintenance of the camera mechanisms. In addition, pointed observations of several targets (stardard stars, star fields, mission targets) allow a long term monitoring of the camera performance. The details of the activity are described in AD2. The selected targets are described in Table 1. This activity produced a total of 186 images.

Table 1: Target selection for FC2 pointed semi-annual checkout

Type of target	Selected target
Photometric standard star	Vega
Solar analog star	HR 2290
Mission target	Ceres
Star cluster	20 Cephei

FC2 also underwent the UDP library patch described above, following the procedure described in AD3.

2.4 Geometrical cross-calibration

This activity is a re-run of DC038 and DC034 (see RD1 and RD2). It was developed to provide information about the co-alignment between the VIR instrument and FC2 by acquiring data with both instruments simultaneously. It includes observations of the star Canopus (Alpha Carinae, V_mag = -0.72) acquired at several different image stations, and was initiated and outlined by the VIR team.

The first image station was occupied for 10-minutes. Canopus was in the center of the FC2 FOV. The FC acquired a clear filter image at the beginning, in the middle, and at the end of this period, followed by two OpNav images. The second image station had Canopus in the upper left corner of the FC2 FOV. Clear filter images were acquired at the beginning, after 5 minutes, and after 10 minutes. At the third image station the FC acquired 3 clear filter images with Canopus in the lower right corner of the FOV. At the fourth image station Canopus was again in the center of the FC2 FOV for the duration of 3 image acquisitions. For acquisition of the final observations the spacecraft performed a slow slew that made Canopus appear to move through the FC2 FOV from bottom to top in 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 these were acquired in the clear filter F1.

3 Operations summary

All the sequences were uploaded to the s/c without incidence and were started according to schedule.

During the operations of FC1, the spacecraft was transmitting the H/K and event stream in real time to ground, allowing a quick confirmation of the success of the UDP library patch. After all images were played back and FC1 was already off, we were able to confirm that the images acquired through TCMonitor showed the correct exposure times.

The verification approach for the FC2 patch was different in that it relied on the playback of the engineering virtual recorder (VR3) to confirm that the patching of the UDP had been successful. However, a glitch in the H/K and event stream prevented this confirmation and forced the FC team to make the assessment based only on the exposure time shown by the images. Fortunately, the images acquired with TCMonitor were transmitted early to ground and the confirmation of success arrived well in time. After the activity was over, the event stream was reconstructed and the camera notifications of success were retrieved.

4 Health status assessment

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

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.

5 Image analysis

The images acquired during the operational slot were analyzed in four aspects. First, the correctness of the exposure times was assessed, given that this was the first time that these sequences were run following the design in AD2. Second, the dark current was analyzed to evaluate the evolution of bulk dark current and warm pixel generation rate. Third, the status of the extra charge was assessed. Finally, the position of the reference star Canopus throughout the geometrical cross-calibration was calculated for comparison with the acquisitions made by VIR.

5.1 Exposure times

The exposure times used for most of the activity were inherited from DC038 and provided images of good quality.

Four callamp-illuminated images in the extra charge investigation sequences erroneously had their exposure times updated to 10 seconds, resulting in saturation. Our recommendation for future instances of the checkout is to reduce the exposure time for these images to 0.8 seconds.

5.2 Dark current

The dark current generation rate was analyzed and compared with previous on ground and in flight measurements. The bulk dark current on FC1, shown on Figure 1, is consistent with that determined during ICO (dotted line). For FC2 the situation is very similar, as depicted in Figure 2.

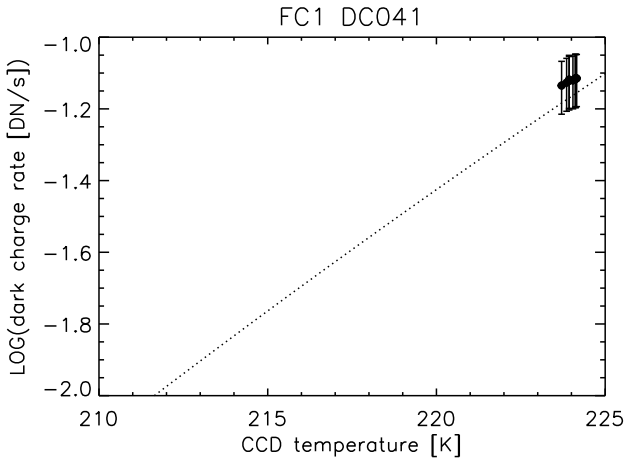

Figure 1: FC1 bulk dark current for DC041

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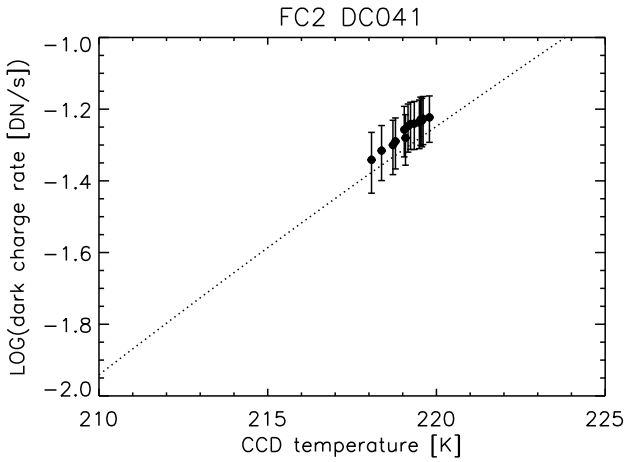

Figure 2: FC2 bulk dark current for DC041

To assess the generation rate of number of warm pixels, we plot histograms for DC041 in Figure 3 and for ICO in Figure 4. The number of warm pixels has increased slightly since launch.

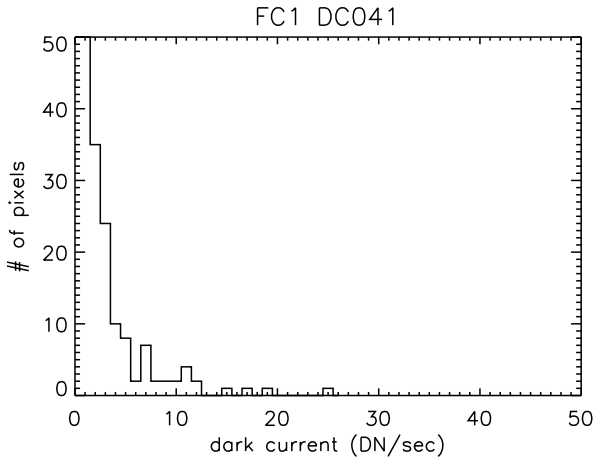

Figure 3: FC1 warm pixel histogram in DC041

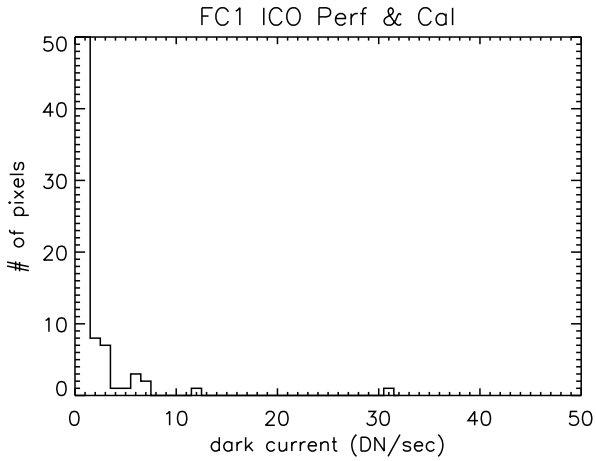

Figure 4: FC1 warm pixel histogram in ICO

Figure 5 and Figure 6 show the same plots for FC2. For both cameras, the hottest pixel has a dark current generation rate below 50 DN/s.

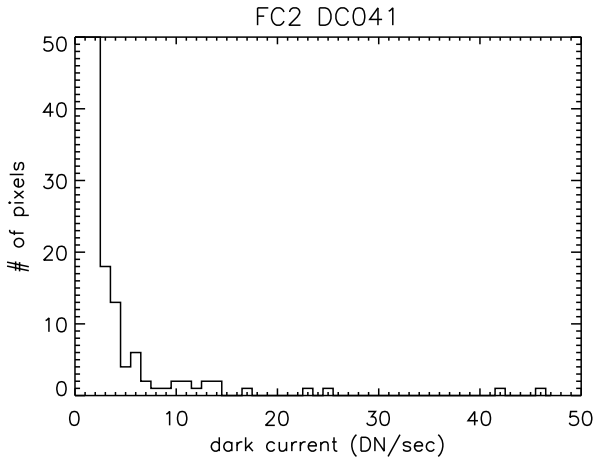

Figure 5: FC2 hot pixel histogram in DC041

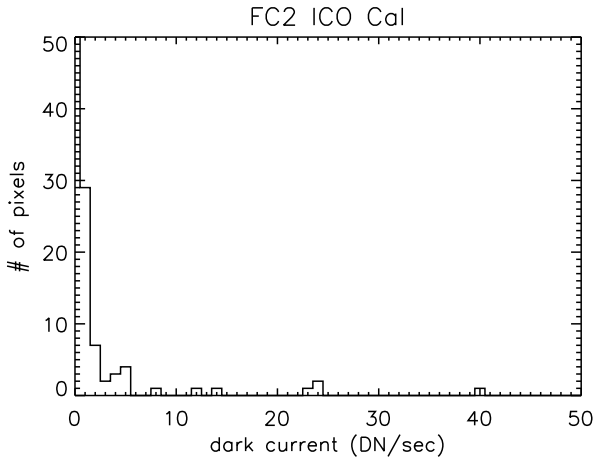

Figure 6: FC2 hot pixel histogram in ICO

5.3 Extra charge

An important part of the semi-annual checkout is monitoring the evolution of the extra charge for both Framing Cameras. FC1 is known to show extra charge, and it is found again in the DC041 images, as shown in Figure 7. The level of extra charge has not increased compared to DC034 (Figure 8). No extra charge has been detected in the past for FC2 at the illumination levels provided by the calibration lamp, and this is still the case in DC041. As the spacecraft approaches Vesta, there are a number of activities planned to conduct the same investigation with the higher photon flux that the asteroid can provide.

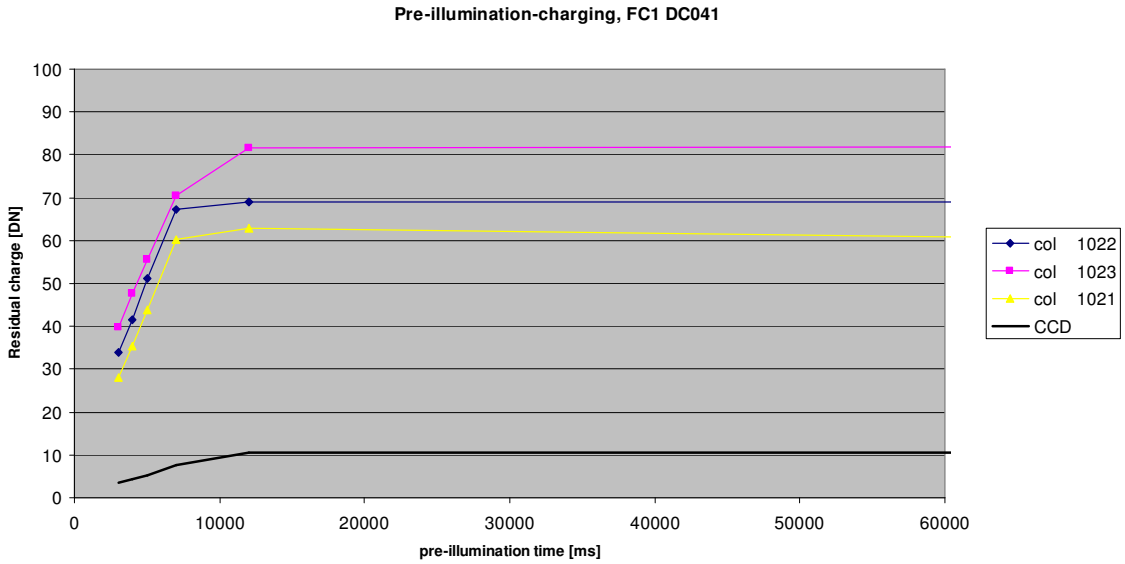

Figure 7: FC1 extra charge levels in DC041

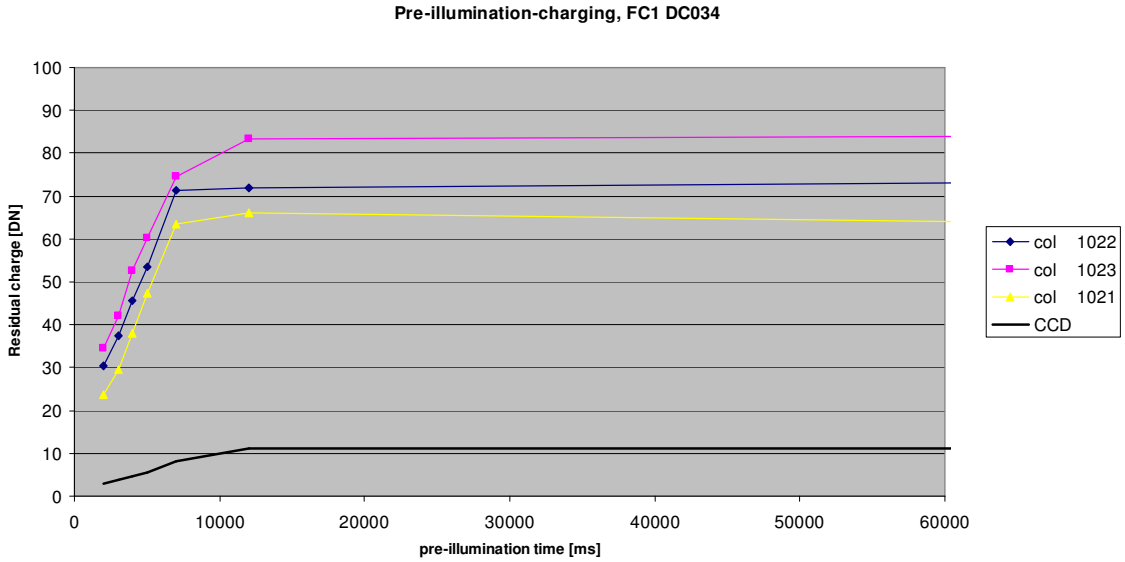

Figure 8: FC1 extra charge levels in DC034

5.4 Canopus positions

The position of Canopus in the FC2 image frame was calculated by fitting a 2D Gaussian to the stellar brightness profile for each of the 20 images acquired during the activity. The positions are numbered 0 to 19 indicating the order in which they were acquired (0 to 2 are centered on Canopus; 3 to 5 are in the upper right quadrant; 6 to 8 in the lower left; 9 to 11 had Canopus at VIR's boresight; 12 to 14 are slightly off the boresight and 14 to 19 were acquired during the slow slew). Figure 9 depicts the position of Canopus for each image in DC041.

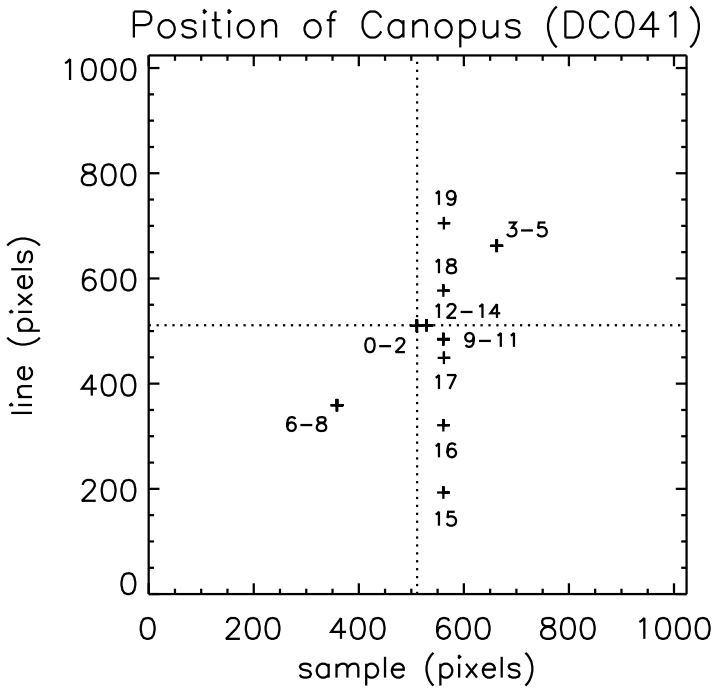

Figure 9: Canopus position in the FC2 image frame in DC041

Correspondingly, Figure 10 displays the position of the star during DC038. The observation pattern was flipped with respect to the previous slots, but otherwise they are very similar.

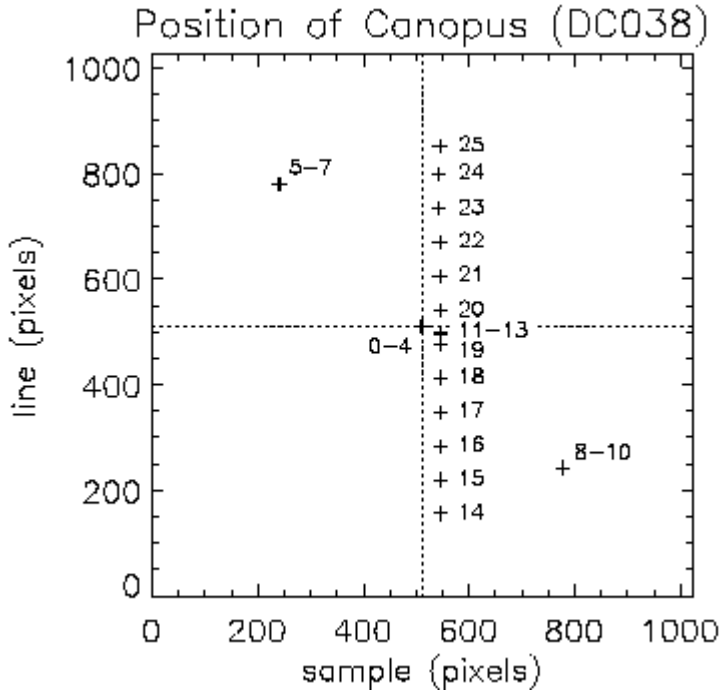

Figure 10: Canopus position in the FC2 image frame in DC038

Table 2 shows the calculated positions of Canopus for DC041.

Table 2: Canopus position in DC041 in pixel coordinates

Img #	DC041 X	DC041 Y
0	511.146	510.789
1	510.711	510.736
2	210.564	510.748
3	662.789	662.078
4	662.848	662.213
5	663.838	662.227
6	358.116	359.082
7	359.055	359.055
8	358.608	359.223
9	561.919	485.530
10	561.502	484.530
11	561.205	484.873
12	529.893	511.460
13	529.964	511.173
14	529.375	511.428
15	561.095	193.720
16	561.902	321.842
17	562.073	449.870
18	561.968	577.771
19	562.116	705.663

6 Conclusions

Concerning the hardware, the operational slot demonstrated that the camera is in good operational condition, including the mechanisms.

With respect to the operational procedures, this slot demonstrated again an excellent performance of the instrument, spacecraft and mission teams. Additionally, it demonstrated that the procedure for patching the UDP library is working fine. The command sequences for the pointed and non-pointed semi-annual checkout for both FC1 and FC2 need to be updated to address the issue of the overexposure of the illuminated images in the extra charge monitoring block.

At mission level, we can confirm that no streak [RD5] was found in the images acquired during this operational slot. This does not mean that there are none, because exposure times were so short that a streak, if present, would also be very short and easy to mistake for a high-energy

particle hit. The FC team will continue to monitor the images acquired in flight in search for occurrences of streaks.

Finally, the observations of Canopus under different pointing conditions were as successful as for DC038, and allowed an accurate determination of the position of the star. The FC team believes the data set is of sufficient quality to determine the geometric co-alignment between FC and VIR. Additionally, FC also observed for the first time one of its targets, Ceres, shown in Figure 11

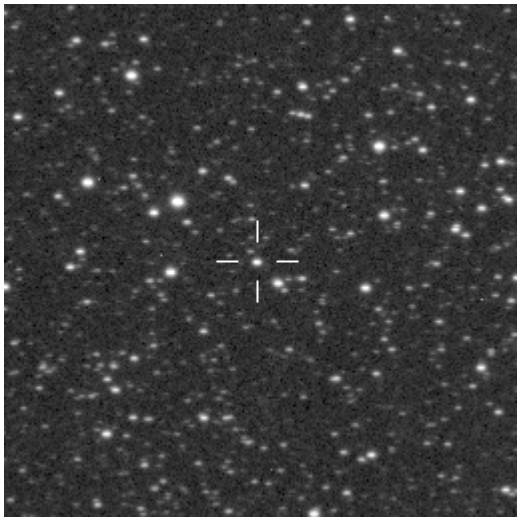

Figure 11: F1 image of Ceres as seen by FC2 during DC041