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**Metis INSTRUMENT
for the
Solar Orbiter Mission**

Metis Commissioning IT-3 Activity Report

Week 11 (9 March 2020 - 15 March 2020)

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1 Introduction

1.1 Scope of the document

This document prepared by the Metis team presents a report on Metis activity during week 11 (09 Mar – 15 Mar 2020) in particular on the IT-3 commissioning activity carried on March 13th.

1.2 Objective of the activity

Aim of IT-3 commissioning activity is to:

- get dark images in the VL before cap ejection
- open door eject Metis cap
- get first VL light
- get sequence of VL image during door close-out
- get dark images in the VL after cap ejection with door closed

The activity flow was interactive and it is summarized in the table below.

Step	Description of the activity
1	Metis switch-On and configuration (UV OFF)
2	0EC301 - VL TNOISE Acq (dark) at DIT=15s 0EC302 - VL TNOISE Acq (dark) at DIT=100s (Tnoise) 0EC303 - VL pB Acq (dark) at DIT=15s - NPOL=4 0EC304 - VL pB Acq (dark) at DIT=100s - NPOL=4
3	0EC312 - VL_FP movie dry run (48x5s)
3	Open door and Cap Ejection 0EC305 - VL pB Acq. at DIT=15s - NPOL=4 0EC306 - VL pB Acq. at DIT=30s - NPOL=4 (*)
4	Close door 0EC307 - VL_FP movie (48x5s)
5	0EC308 - VL TNOISE Acq (dark) at DIT=15s 0EC309 - VL TNOISE Acq (dark) at DIT=100s (Tnoise) 0EC310 - VL pB Acq (dark) at DIT=15s - NPOL=4 0EC311 - VL pB Acq (dark) at DIT=100s - NPOL=4
6	Metis deconfiguration and switch-Off

(*) see par 2.3.1.3

2 Commissioning Activity IT-3

2.1 Timeline

The timeline as run is in Annex 1.

Start of activity: 11:22 UTC, 13 Mar 2020 (DOY 73)

End of activity: 15:47 UTC, 13 Mar 2020 (DOY 73)

Metis is off for the rest of the week.

2.2 Staff

ESOC Control room:

ESA: A. Minogiannis

Virtual control room:

Metis Team: G. Nicolini (Lead), M. Pancrazzi

Virtual PISA Room:

M. Romoli, L. Teriaca, V. Andretta, M. Uslenghi, R. Susino, F. Landini, M. Casti.

Activity performed in remote connection with ESOC due to restriction for COVID-19 control.

2.3 Test Execution Summary

The commissioning activity 3, IT-3, primary goal was to open the head shield door for the first time in flight and allowing thus the ejection of Metis cap.

With the cap ejected and the door open it was planned to acquire the first VL light images to have confirmation of the successful ejection of the cap, of the complete aperture of the door and of the correct behaviour of the instrument, inclusive of the optics.

All task have been performed nominally and the first images of the corona acquired.

The subsequent inspection of these images suggests that there is a small displacement of the internal occulter from its nominal position (the position achieved during on ground calibration). From ground testing, we are confident that this kind of displacement can be corrected.

At the end of the test, images taken with the door closed show diffused light from the door as expected. This could be used to evaluate the vignetting function.

A small movie was also recorded during the door closure.

All the activities planned for the IT-3 have been correctly executed and the test can be considered successful.

Below the activity is described in detail, together with all anomalies or issues encountered.

One-way light travel time (OWLT): 48s.

2.3.1 Summary of Issues

2.3.1.1 Error and warnings TM packets (TM(5,2,3,4))

2.3.1.1.1 TM(5,4) - PSB_nomT_OOL

This is a known fake event usually generated at the Metis power on or during the transition to safe. Two occurrences of this events have been observed:

- at BOOT (2020-03-13T11:24:57.167Z - 15 unsyncOBT)
- after the door aperture (2020-03-13T13:27:03.168Z (15 unsyncOBT)

To be noted that SSC and OBT of the two packets are identical.

2.3.1.1.2 TM(5,4) - HVU_MCP_CURR_OOL

This is a known fake event usually generated after the transition to setup.

Two occurrences of this events have been observed:

- after transition to SETUP (2020-03-13 11:27:35.054 - 637413998 OBT)
- after the door aperture (2020-03-13 13:27:03.169 (637413998 OBT)

To be noted that SSC and OBT of the two packets are identical and the second delivery happened at the same time of the second delivery of the fake alarm described in the previous paragraph.

2.3.1.1.3 TM(5,2) – Watchdog Alert

One occurrence of this events have been observed:

- after transition to SETUP (2020-03-13 13:03:03.088 - 637419726 OBT)

this event occurred during the first acquisition VL_FP (0x0EC412)

2.3.1.2 Checks NOK and anomalies

2.3.1.2.1 TM(1,2)

None

2.3.1.3 TM(1,8)

During the test 1 TMs(1,8) have been received at 2020-03-13T13:38:55.085Z with OBT 637421880:22407. This was due to the insertion of a wrong value in the commanding procedure related to the cadence parameter of the acquisition 0EC306

After correcting the value of the parameter, the Acquisition was repeated, with the same session_Id '0CE306', and successfully performed.

2.3.1.4 Non Conformances

No new anomalies observed during the test.

Anomalies, already traced in the NCR-012, NCR-017 and NCR-020, have been observed during the test.

2.4 Detailed Analysis of the test

2.4.1 Preliminary Checks

The test initial condition were to have Metis OFF and the decontamination heaters off. Indeed both CE and ME interfaces were found within the respective Non-OP range (see Figure 1 and Figure 2).

2.4.2 Continuous check and monitors

We monitored that the temperature of the S/C interfaces at Metis CE and ME were in the expected ranges. Here below is reported the graph of the CE temperature for one of the temperature sensors of the SC.

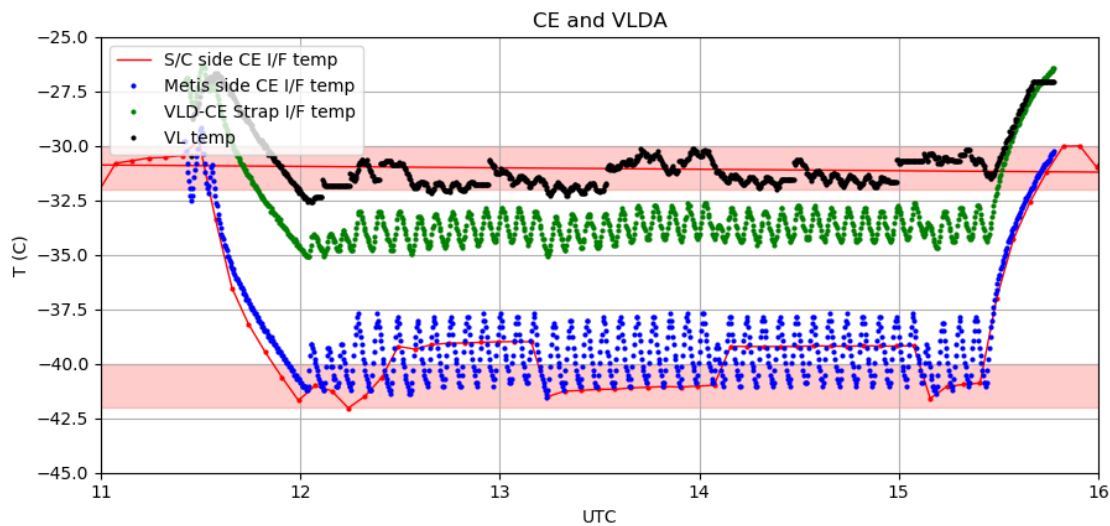


Figure 1: CE interface temperature during the test

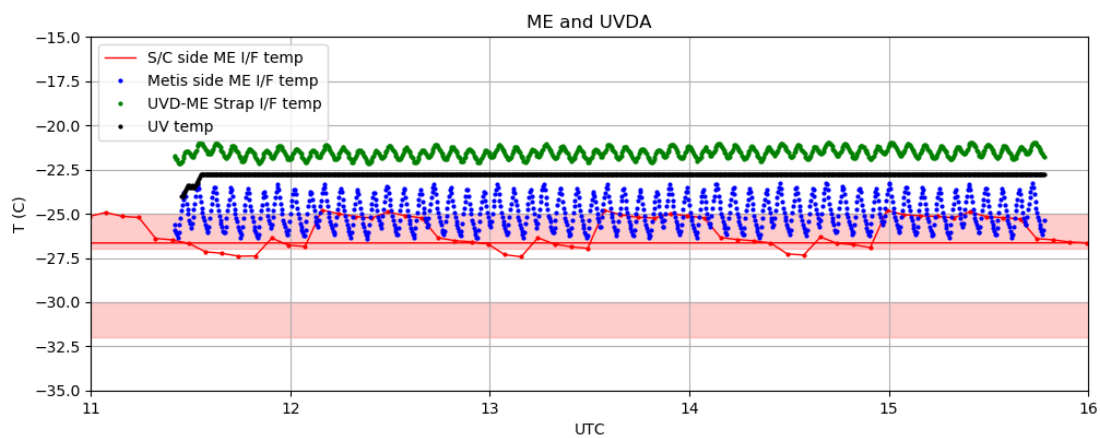


Figure 2: ME interface temperature during the test

In the following figures the temperature of other subsystems are plotted.

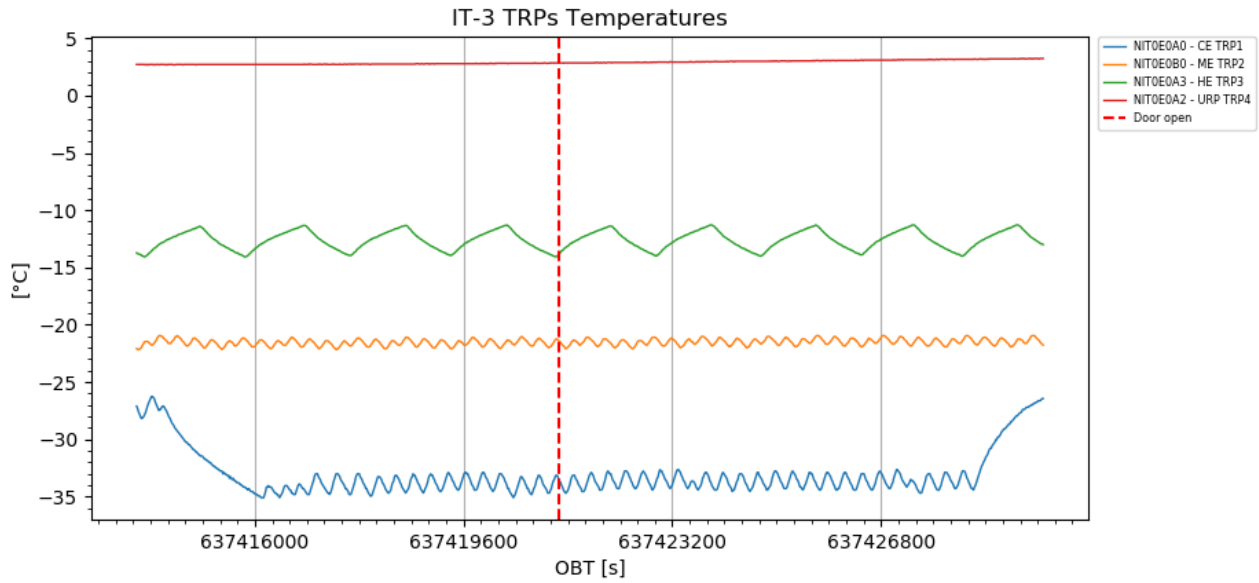


Figure 3: Thermal Reference Points temperatures

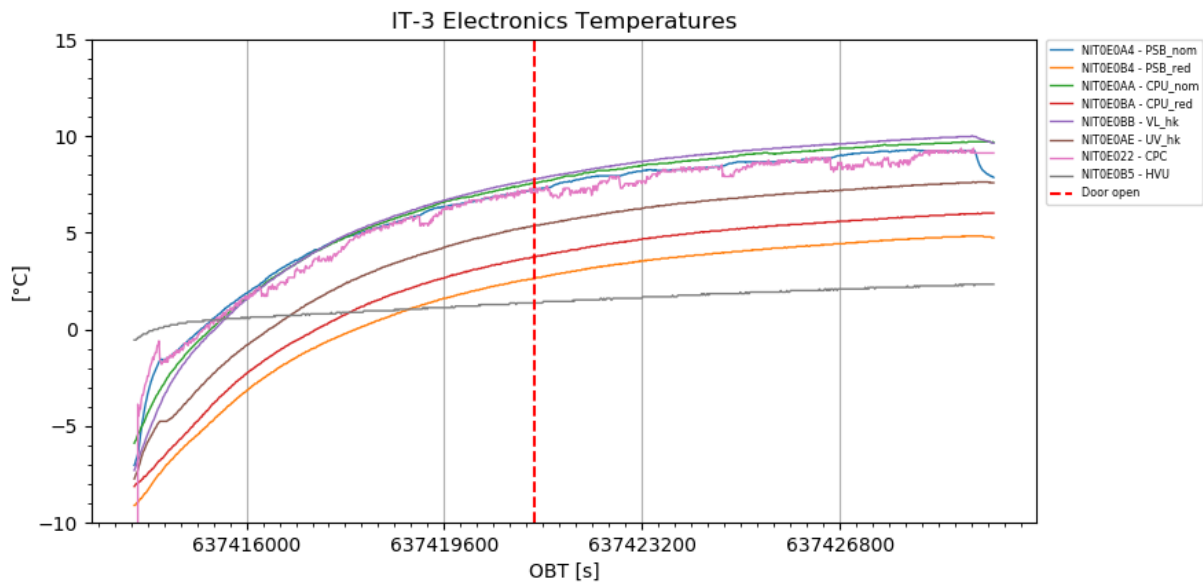


Figure 4: Electronics subsystems temperatures

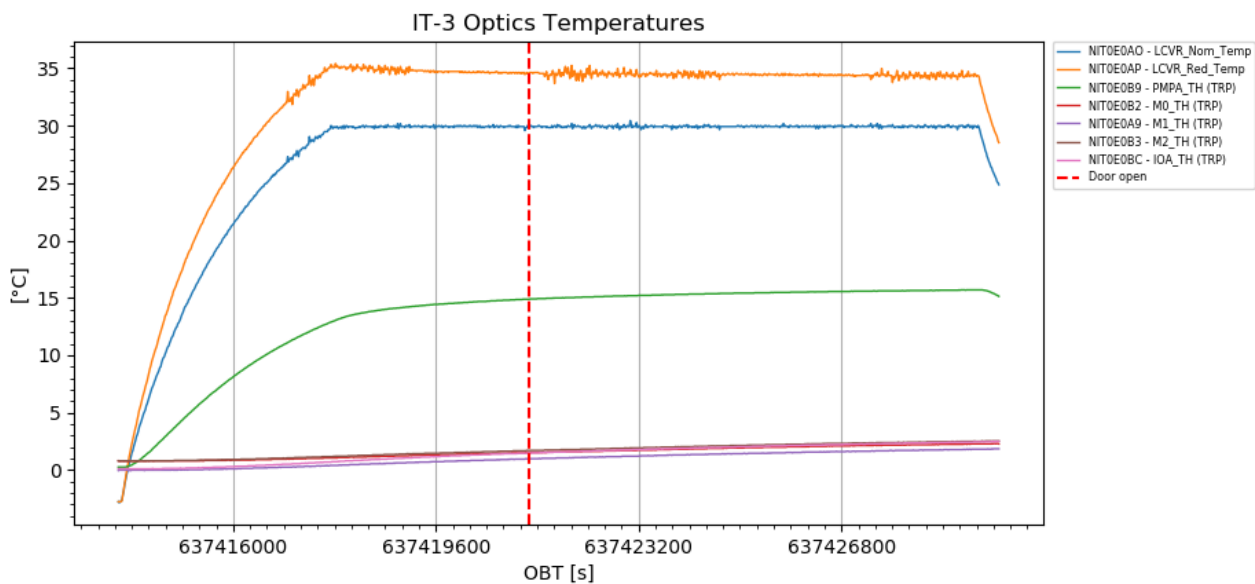


Figure 5: Optical subsystems temperatures

2.4.3 Step 1: Metis Power on and Configuration

Reference file(s):

PDOR_SMET_T003_STP1-ID27-20200121-00005.SOL

Activity description:

Metis nominal Power On and configuration plus CE transition to OP range

Detailed Activity:

Start of the activity:	2020-03-13T11:22:00Z
Metis nominal power on - AITF011A	BOOT report received at: 2020-03-13T11:24:52.130Z ASW: 2.1.0 All TCs successfully accepted and executed. TM(5,4) - PSB_nomT_OOL – received at 2020-03-13T11:24:57.167Z before the instrument time synchronization occurred. The event was expected, see sec. 2.3.1.1.1. Metis state: SAFE
Subsystems configuration to OPS - AITF040A	All TCs successfully accepted and executed. TM(5,4) – HVU_CURR_OOL – received at 2020-03-13T11:27:35.054Z (637413998:55204 OBT), just after the transition to SETUP Mode, The error was not relevant since the HV was disabled (see sec 2.3.1.1.2 for reference). Metis state: OPS VLDA ON UVDA ON PMP ON
Transition of CE Thermal IF to OP range - ATCF901B (v. 0.4) - METIS_CE_OP	All TCs successfully accepted and executed. The transition from the non-op to the op range of the CE I/F lasted about 30 min (see Figure 1)
PMP Configuration - AITF107A	TC successfully accepted and executed. All TM checks as expected.
Switch OFF the UVDA - ZIT24201 – Go to SETUP - ZIT243Z4 – UVDA OFF - ZIT24201 – Go to OPS	TC successfully accepted and executed. All TM checks as expected. Metis state: OPS VLDA ON UVDA OFF PMP ON

Activity outcome

All TCs accepted and executed, TMs checks within the expected ranges.

The transition from the non-op to the op range of the CE I/F lasted about 30 min (see Figure 1)

2.4.4 Step 2: Dark acquisitions before Metis-cap release

Reference file(s):

PDOR_SMET_T003_STP2-ID29-20200121-00011.SOL

PDOR_SMET_T003_STP3-ID38-20200121-00003.SOL

Activity description:

In this step the last dark current acquisitions are performed before the Metis-CAP is released.

The following schemes have been used:

- Temporal Noise DIT=15s, NDIT = 8 – lossless compression
- Temporal Noise DIT=100s, NDIT = 4 – lossless compression
- VL-pB, NPOL=4, DIT=15s, NDIT=4
- VL-pB, NPOL=4, DIT=100s, NDIT=1
- VL-FP, DIT=5s, NIMG=48 (movie dry run)

Detailed Activity:

Configuration of VL channel and compression: - ZIT24523 - VL_IMAGE LL Compr. - ZIT24523 - VL_TEMP_MATRIX LL Compr. - ZIT24207 - Conf VL TEMP_NOISE - ZIT24232 - START ACQ TEMP NOISE	All TCs executed and TM checks are ok. Commanded Settings: DIT = 15s NDIT = 8 Session Id: OEC301 StartAcq 2020-03-13T12:05:28.104Z (637416272 OBT) • vl-temp-matrix_0637416421 • vl-image_0637416436 EndAcq 2020-03-13T12:08:08.067Z (637416432 OBT)
Configuration of VL channel: - ZIT24207 - Conf VL TEMP_NOISE - ZIT24232 - START ACQ TEMP NOISE	All TCs executed and TM checks are ok. Commanded Settings: DIT = 100s NDIT = 4 Session Id: OEC302 StartAcq 2020-03-13T12:08:52.185Z (637416473 OBT) • vl-temp-matrix_0637416903 • vl-image_0637416921 EndAcq 2020-03-13T12:16:10.106Z (637416914 OBT)

Configuration of VL channel: - ZIT24207 - Conf VL-pB - ZIT24232 - START ACQ VL-pB	All TCs executed and TM checks are ok. Commanded Settings: NPOL = 4 DIT = 15s NDIT = 4 Duration = 250s Session Id: 0EC303 StartAcq 2020-03-13T12:16:53.066Z (637416955 OBT) • vl-image_0637417173 • vl-image_0637417204 • vl-image_0637417235 • vl-image_0637417265 EndAcq 2020-03-13T12:21:19.130Z (637417222 OBT)
Configuration of VL channel: - ZIT24207 - Conf VL-pB - ZIT24232 - START ACQ VL-pB	All TCs executed and TM checks are ok. Commanded Settings: NPOL = 4 DIT = 100s NDIT = 1 Duration = 400s Session Id: 0EC304 StartAcq 2020-03-13T12:23:03.081Z (637417326 OBT) • vl-image_0637417437 • vl-image_0637417538 • vl-image_0637417640 • vl-image_0637417740 EndAcq 2020-03-13T12:30:03.145Z (637417741 OBT)
Configuration of VL channel: - ZIT24207 - Conf VL-FP - ZIT24232 - START ACQ VL-FP - ZIT01701 - Connection Test	All TCs executed and TM checks are ok. Commanded Settings: DIT = 5s NIMGs = 48 Session Id: 0EC312 StartAcq 2020-03-13T12:53:32.058Z (637419155 OBT) • 48 vl-images (see Annex 2) -> 3 corrupted EndAcq 2020-03-13T13:06:31.141Z (637419933 OBT) 1x TM(5,2)-Watchdog_Alert at Watchdog_Alert (637419726 OBT) 3x TM(5,2)-SpW link timeout

Activity outcome

All TM checks were within the expected ranges.

1x TM(5,2)-Watchdog_Alert at Watchdog_Alert (637419726 OBT) and 3x TM(5,2)-SpW link timeout received.

3 of the 48 images acquired in VL-FP are corrupted.

A preliminary analysis on the images shows that the level of the dark current as a function of the integration time follows the expected nearly linear behaviour. The slope of the linear fit gives a dark current estimate of 2.65 ± 0.03 ADU/(pixel s), which correspond to 20.5 ± 0.3 e⁻/(pixel s), see well This is consistent with the dark current measured during on-ground calibration .

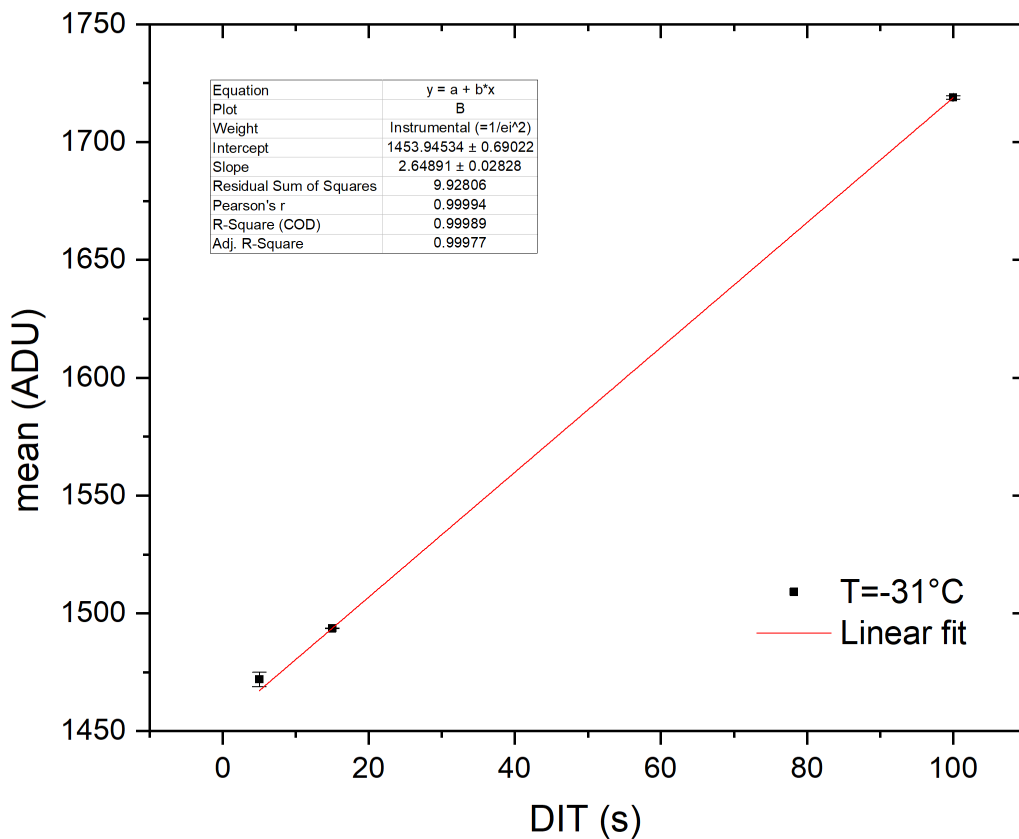


Figure 6: Linear fit of the measured dark current

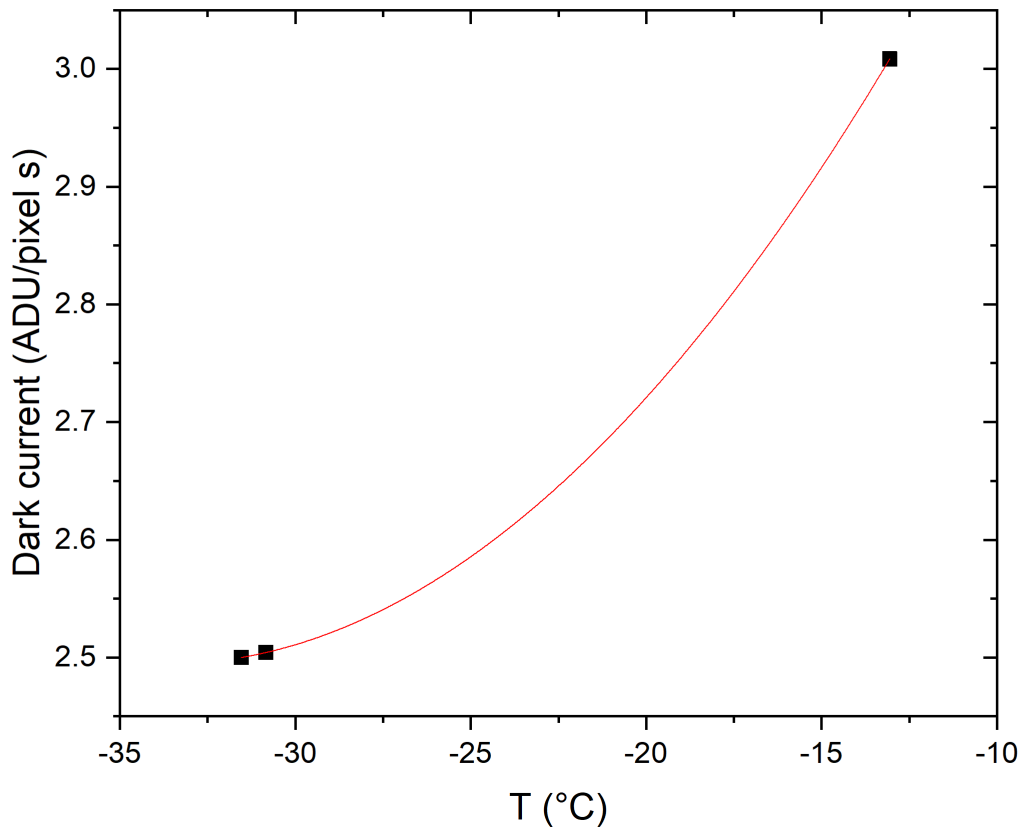


Figure 7: In flight dark current acquisitions comparison as function of T

In Figure 7 the inflight dark current acquisitions are compared as function of the temperature. Despite the limited number of points the results confirm the theoretical expectations.

2.4.5 Step 3: Door aperture, CAP ejection and VL first Light

Reference file:

PDOR_SMET_T003_STP3-ID31-20200121-00006.SOL

Activity description:

In this phase the open door command is sent. Since it is the very first aperture, also the Metis-CAP is ejected.

Once the S/C telemetry has confirmed the door is open, we proceed to acquire some images in VL to confirm that everything is ok. More in detail two VL-pB acquisition are commanded at different exposure time (DIT = 15s and 30s) and averaging on board 4 frames.

Each frame is taken without masking nor binning, lossless compression.

The acquisition should produce the following data products:

8 x VL_IMAGES

Detailed Activity:

Aperture of Metis door - ADMF373A	The sequence execution run smoothly without anomalies. <i>The TM indicates the complete movement (about 500 steps) ended after ~ 4 minutes.</i> This was slightly shorter than expected from the ground testing.
Configuration of VL channel and compression: - ZIT24207 - Conf VL-pB - ZIT24232 - START ACQ TEMP NOISE	All TCs executed and TM checks are ok. Commanded Settings: DIT = 15s NDIT = 4 Cadence = 250s Duration = 250s Session Id: 0EC305 StartAcq 2020-03-13T13:32:50.133Z (637421514 OBT) - vl-image_0637421733 - vl-image_0637421764 - vl-image_0637421796 - vl-image_0637421828 EndAcq 2020-03-13T13:37:16.109Z (637421781 OBT)
Configuration of VL channel and compression: - ZIT24207 - Conf VL-pB - ZIT24232 - START ACQ TEMP NOISE	All TCs executed and TM checks are ok. Commanded Settings: DIT = 30s NDIT = 4 Duration = 488s Session Id: 0EC306 StartAcq 2020-03-13T12:05:28.104Z (637416272 OBT) - vl-image_0637423203 - vl-image_0637423234 - vl-image_0637423266 - vl-image_0637423297 EndAcq 2020-03-13T12:08:08.067Z (637416432 OBT) Due to a procedural error the cadence of this acquisition was set to 480s. Consequently the TC ZIT24207 (config. Acq.) was rejected and the acquisition was started with the same parameters as the previous one but duration set to 488s. This resulted in a repetition of the previous acquisition with DIT=15 but two quadruplets have been produced. Eventually the cadence was corrected to 490s and the acquisition repeated and successfully executed with the same Session ID.

Activity outcome

All TCs executed and TM checks are OK.

Metis door was open and the cap successfully ejected.

No images corrupted observed.

The effective number of VL_IMAGES produce was larger (16) than the expected one (8) due to the procedural error described above.

The preliminary analysis of the first light images acquired pointing at the sun center shown a straylight pattern compatible with a small shift of the internal occulter from the optimal position reached on ground during the calibrations prior delivery.

This is a expected behaviour, i.e. already observed in other coronagraphs in space, and we are confident to recover the situation by actuating the IO mechanism to move the IO to the optimal position.

2.4.6 Step 4: Metis Door closure and movie

Reference file:

PDOR_SMET_T003_STP3-ID38-20200121-00003.SOL

Activity description:

In this test phase the Metis door is closed. During the closure movement a movie is recorded by staring a VL-FP acquisition with DIT = 5s and duration of 48 images (4 minutes).

Detailed Activity:

Closure of Metis door - ADMF374A	The sequence execution run smoothly without anomalies.
Configuration of VL channel: - ZIT24207 - Conf VL-FP - ZIT24232 - START ACQ VL-FP - ZIT01701 - Connection Test	This TC stack was executed 2m00s after the execution of the ADMF374A sequence. All TCs executed and TM checks are ok. Commanded Settings: DIT = 5s NIMGs = 48 Session Id: 0EC307 StartAcq 2020-03-13T14:25:20.115Z (637425446 OBT) • 48 vl-images (see Annex 2) EndAcq 2020-03-13T14:38:23.153Z (637425446 OBT)

Activity outcome

The received TM and Data Products were as expected. No corrupted images observed.

A preliminary analysis on the images confirms the ROM expectation of the scattered light diffused by the read side of the door.

The images acquired during the door closure show a bright spot moving in the Metis FOV likely due to an illuminated surface of the door approaching the Metis aperture. The same spot apparently is not visible in the images acquired with the door completely open.

2.4.7 Step 5: Dark acquisitions after Metis-cap release

Reference file(s):

PDOR_SMET_T003_STP5-ID29b-20200121-00011.SOL

Activity description:

In this step the four acquisitions are performed after the Metis-CAP is released in order to characterise the scattered light.

The following schemes have been used:

- Temporal Noise DIT=15s, NDIT = 8 – lossless compression
- Temporal Noise DIT=100s, NDIT = 4 – lossless compression
- VL-pB, NPOL=4, DIT=15s, NDIT=4
- VL-pB, NPOL=4, DIT=100s, NDIT=1

Detailed Activity:

Configuration of VL channel and compression: - ZIT24523 - VL_IMAGE LL Compr. - ZIT24523 - VL_TEMP_MATRIX LL Compr. - ZIT24207 - Conf VL TEMP_NOISE - ZIT24232 - START ACQ TEMP NOISE	All TCs executed and TM checks are ok. Commanded Settings: DIT = 15s NDIT = 8 Cadence = 120s Session Id: 0EC308 StartAcq 2020-03-13T14:58:07.132Z (637426630 OBT) • vl-temp-matrix_0637426778 • vl-image_0637426791 EndAcq 2020-03-13T15:00:46.159Z (637426789 OBT)
Configuration of VL channel: - ZIT24207 - Conf VL TEMP_NOISE - ZIT24232 - START ACQ TEMP NOISE	All TCs executed and TM checks are ok. Commanded Settings: DIT = 100s NDIT = 4 Cadence = 400s Session Id: 0EC309 StartAcq 2020-03-13T15:01:28.061Z (637426831 OBT) • vl-temp-matrix_0637427260 • vl-image_0637427270 EndAcq 2020-03-13T15:08:46.116Z (637427270 OBT)

Configuration of VL channel: - ZIT24207 - Conf VL-pB - ZIT24232 - START ACQ VL-pB	All TCs executed and TM checks are ok. Commanded Settings: NPOL = 4 DIT = 15s NDIT = 4 Duration = 250s Session Id: OEC310 StartAcq 2020-03-13T15:09:31.104Z (637427313 OBT) • vl-image_0637427532 • vl-image_0637427553 • vl-image_0637427574 • vl-image_0637427596 EndAcq 2020-03-13T15:13:57.130Z (637427580 OBT)
Configuration of VL channel: - ZIT24207 - Conf VL-pB - ZIT24232 - START ACQ VL-pB	All TCs executed and TM checks are ok. Commanded Settings: NPOL = 4 DIT = 100s NDIT = 1 Duration = 410s 0s Session Id: OEC311 StartAcq 2020-03-13T15:15:40.181Z (637427684 OBT) • vl-image_0637427796 • vl-image_0637427897 • vl-image_0637427998 • vl-image_0637428099 EndAcq 2020-03-13T15:22:35.086Z (637428099 OBT)

Activity outcome

All TM checks were within the expected ranges.

A preliminary analysis on the images confirms the ROM expectation of the scattered light diffused by the read side of the door.

2.4.8 Step 6 Instrument deconfiguration and switch OFF

Reference file:

PDOR_SMET_T003_STP6-ID39-20200121-00009.SOL

Activity description:

This activity aims to deconfigure the instrument to bring it to the SAFE mode and power it off. Also the CE interface is stabilised to the Not-Op range.

Detailed Activity:

Disable of S/C FDIR monitoring the VLDA: - SMON_METIS2 - SMON_METIS7 - SMON_METIS8 - SMON_METIS9 - SMON_METIS10 - SMON_METIS17 - SMON_METIS21	All TCs executed and TM checks are ok.
Transition of CE IF to NON-OPS and to SETUP mode: - ATCF901A METIS_CE_NOP - ZIT24201 (Op. Mode Transition to SETUP)	All TCs executed and TM checks are ok. The transition from the OP to the NON-OP range of the CE I/F lasted about 15 min (see Figure 1)
Configuration of VL channel: - ZIT244C1 (set the PMP TCS to 0) - ZIT24302 (Disable Thermal Control) - ZIT243Z3 (SWITCH VLDA OFF) - ZIT243Z5 (SWITCH PMP OFF)	All TCs executed and TM checks are ok.
Configuration of VL channel: - ZIT24201 (Op. Mode Transition to SAFE) - AITF002A METIS Pwr Down	All TCs executed and TM checks are ok.
End of the activity:	2020-03-13T15:47:00Z

Activity outcome

The TCs were successfully executed.

The transition of the CE IF from the OP to the NON-OP range lasted about 15m.

2.5 Conclusions

The IT-3 commissioning activity represents the first set of acquisitions performed in visible light with the door open (the first UV light images will be acquired during IT-4). The planned activities run smoothly with only minor issues not impacting the measurements results.

The last dark measurements carried out prior the door opening with the VLDA confirmed the behaviour and the performance already observed during the ground calibrations and the previous commissioning slots.

The first images acquired pointing at the sun center shown a straylight pattern compatible with a small shift of the internal occulter from the optimal position reached on ground during the calibrations prior delivery.

This is a expected behaviour, i.e. already observed in other coronagraphs in space, and we are confident to recover the situation by actuating the IO mechanism to move the IO to the optimal position.

After the door closure, a series of images have been acquired and the light pattern diffused from the rear side of the door confirmed the theoretical expectations.

During the test three time-out warnings on the spacewire connection have been generated by the SSMM and the off-line data reduction confirmed the presence of three corrupted images.

Fortunately none of them were vital to the scientific analysis because acquired before the door aperture.

One acquisition was repeated due to a mistake in the commanding sequence.

The IT-3 commissioning activity can be therefore considered successful.

The overall test session has been 4 hours and 25 minutes long.

3 Acronyms

ASW	Application SW
CPC	Camera Power Converter unit
DIT	Detector Integration Time
ECSS	European Cooperation for Space Standardization
EGSE	Electrical Ground Support Equipment
EM	Electrical Model
EPROM	Erasable Programmable Random Access Memory
EQM	Electrical Qualification Model
FFT	Full Functional Test
FIFO	First In First Out
FM	Flight Model
FPA	Focal Plane Assembly
FPGA	Field Programmable Gate Array
GSE	Ground Support Equipment
H/W	Hardware
HK	Housekeeping
HVU	High Voltage Unit
IAPS	Intensified Active Pixel Sensor
IF	Interface
INAF	Istituto Nazionale di Astrofisica
LCL	Latching Current Limiters
LCVR	Liquid Crystal Variable Retarder
MCP	Micro Channel Plate
MGSE	Mechanical Ground Support Equipment
MPPU	METIS Processing & Power Unit
N/A	Not Applicable
OBC	On-Board Computer
OGSE	Optical Ground Support Equipment
PROM	Programmable Read Only Memory
S/C	Spacecraft
SW	Software
SpW	Spacewire interface
SFT	Short Functional Test
SO	Solar Orbiter
SpW	Space Wire
SSMM	Solid State Mass Memory
TBC	To Be Confirmed
TBD	To Be Defined
TBW	To Be Written
TC	Tele Command
TM	Telemetry
UV	Ultraviolet
UVDA	Ultraviolet Detector Assembly
VLDA	Visible Light Detector Assembly

ANNEX 1

The Timeline as run is included in the file

`METIS-OATO-RPT-036_1.0_Annex-1_IT-3_Timeline_AsRun.xls`

ANNEX 2

The list of images acquired and the decoded header fields are detailed in

`METIS-OATO-RPT-036_1.0_Annex-2_IT-3_SciDataProducts.csv`