MA_MISS FM TEST CAMPAIGN AT ROVER LEVEL – DATA ANALYSIS

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	NOME	FIRMA	DATA
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1. Applicable Documents

- [1] Thales Alenia Space – Fourth PSF & PPL Functional Test Window on Rover PFM - Test Organization and Procedures (2019) – Cod: EXM-RM-TNO-AI-0564
- [2] Thales Alenia Space – Annex 1 - As-Run Test Procedures (2019) – Cod: EXM-RM-TNO-AI-0564
- [3] Thales Alenia Space – Fourth PSF & PPL Functional Test Window on Rover PFM PFT - Minutes of meeting – Cod: EXM-RM-MIN-AI-5570
- [4] Thales Alenia Space – MAPPING PPL&PSF SCRIPTS - OBSW - PFM TEST PHASES 10-04-2019.xlsx
- [5] Thales Alenia Space – RM GTM&FM AIV plan for Ma_Miss-Rev SN.doc
- [6] INAF – Functional Test Definition (Ma_MISS).xlsx
- [7] Leonardo – MAMISS AIT_Rover_PFM.pptx

- [8] EXM-RM-RSP-GAM-0030 – Ma_MISS SW Interface Control Document

2. Purpose and Summary

This document reports on the Test Campaign performed during 2019-2020 on the Ma_MISS Flight Model, integrated onboard the ExoMars Rover. Tests have been carried out both by using the Drill movement (Acquisition type C) and without Drill motion (Acquisition type A), and consisted in acquiring signals with and without targets, with Ma_MISS lamp switched on/off, at different integration times; several Operation Procedures (OPs) have been tested. Moreover functional health checks have also been carried out.

3. Experimental Setup and Data Acquisition

The experimental setup used for the acquisitions is described in the document [1] and references therein.
The chain of data processing starting from the measure (raw binary data) down the scientific team (calibrated, PDS4 and analyzed) is illustrated below (fig.1).

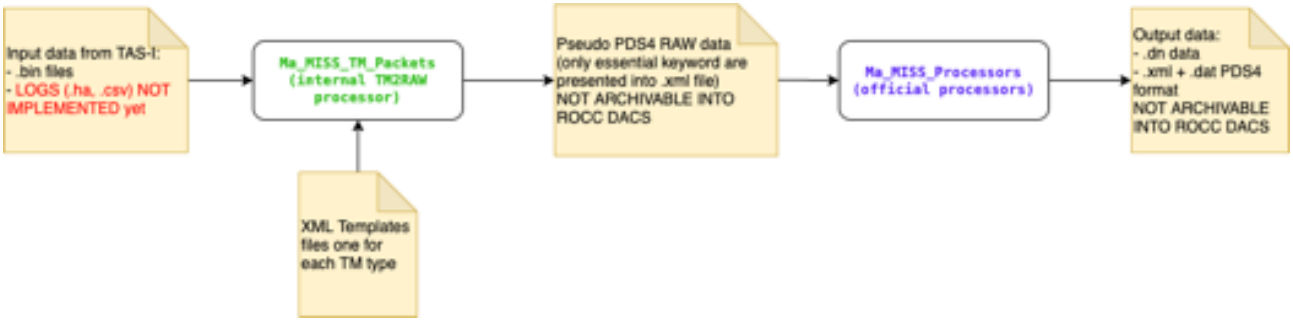


Fig.1. The chain of data acquisition, distribution and processing (raw to calibrated) from TASI to INAF.

4. Measurements and Results

Here the session measurements carried out during the 2019-2020 test campaign are summarized:- Green = acquisitions OK / - Red = errors/gaps

#session	*date*	*test*	T_{DET}	t_{INT}	*notes*
1_post_acoustic_test	25-oct-19	Acq.A: OP30 + OP31	249K	1 ms	• dark subtraction OP31-OP30→ noise • dark subtraction OP30 by SW-MMS: artifacts for S>65000DN
2_TVAC-Vacuum_checkout-Ma_MISS_A	07-nov-19	Acq.A: OP30 + 3xOP31	225K	OP30: 1 ms OP31: 0.5, 1, 3 ms	• dark subtraction OP30 by SW-MMS: OK
3_TVAC-Equipment_Warmup-Ma_MISS_A	15-nov-19	Acq.A: OP30 + 2xOP31	225K	OP30: 1 ms OP31: 0.5 ms + 1 ms [16 acq]	• OP31 with 1 ms: only 16 acquisitions • dark subtraction OP30 by SW-MMS: OK
4_TVAC-HotCase_GN2-Ma_MISS_A	16-nov-19	Acq.A: OP30 + 2xOP31	249K	1 ms	• dark subtraction OP30 by SW-MMS: artifacts for S>65000DN • OP31 with 1 ms: only 16 acquisitions
5_EMC-Ma_MISS_C_13-12-2019	13-dec-19	Acq.C: + OP31	249K	1 ms [Calib. + Ring] 0.5 ms [OP30]	• AcqC: 203 acquisitions - Calibration 40 pt - OP30 1 pt [tag = COLUMN] + 2 dark - Ring 156 pt • OP31 with 1 ms: only 12 acquisitions • Dark subtraction OP30 by SW-MMS: artifacts for S>65000DN
6_Final-SPTandIST-Ma_MISS_A_26-01-2020	26-jan-20	Acq.A: OP30 + 3xOP31	249K	OP30: 1ms OP31: 0.5, 1, 3 ms	• Dark subtraction OP30 by SW-MMS: artifacts for S>65000DN → correction with LDO algorithm
7_2020_10_16	16-oct-20	Acq.A: 2xOP 30 + 4xOP31	249K	OP30: 1 & 3ms OP31: 1 & 3ms	• OP31: 2xLamp ON & 2xLamp OFF

1_post_acoustic_test: 25-oct-2019

During this test the OP30 (Single Point Acquisition) and the OP31 (Diagnostic) were performed. All acquisitions were carried out without any drill movement (Acquisition Type A). Measurements were performed in hot conditions, that is with the detector temperature set at 249K. All acquisitions were recorded with integration time = 1 ms.

- The OP30 consists of three acquisitions: (i) a first dark, (ii) an acquisition with lamp on (without target, i.e. ghost), and (iii) a third dark (fig.2-4).
  During the OP30 execution the Ma_MISS SW performs the dark subtraction, thus the data are delivered already with dark subtracted, along with the two darks data. This SW subtraction anyway produces some artifacts in the data (fig.4), that must be corrected. An algorithm provided by Leonardo has been used on order to correct the data. The algorithm (MatLab script) is illustrated below, for a single row:

  y=signal (with dark subtracted by Ma_MISS SW) on the row 88
  y_d1=dark1 (to be added) on the row 88

```
j=0;
for j=1:Nchannels

    y88_sum(j)=y88(j)+y88_d1(j);

    if y88_sum(j) > 65535
        y88_c(j)=y88_sum(j)-65535;
    else
        y88_c(j)=y88_sum(j);
    end

end
```

The procedure is repeated for the rows 88-91. The Ma_MISS SW indeed does not subtract the dark from the row 92, thus this correction is not necessary. Once the algorithm has been applied (fig.5), the second dark must be subtracted by the output signal (that is, y88_c – y88_d2), in order to retrieve the correct ghost signal (fig.6).

- The OP31 consists of a diagnostic acquisition, that is a scan performed all along the 255 detector rows. The diagnostic operation is executed by consecutively acquiring detector packages of 5 rows, by shifting from the first to the last row. This produces an image of the whole detector window, and is useful in order to check the status of the detector, for example after particularly stressing tests, and will be used after the landing on Mars. While when executing the OP30 the single package of rows 88-92 is addressed and acquired, in the case of OP31 51 different packages of rows

are acquired consecutively (fig.10), in order to cover the whole detector window. The result is that the rows 88-91 are addressed in the Acquisition#18, while the row 92 is addressed in the Acquisition#19. Thus different patterns of noise can arise in these different acquisitions. Here the OP31 was only executed with the Ma_MISS lamp on, thus a suitable dark to be subtracted was not available. We tried to subtract the darks measured during the OP30 (only on the corresponding 88-92 rows) but this operation produced data that were affected by a very high level of noise, especially on the 88-91 rows.

OP30

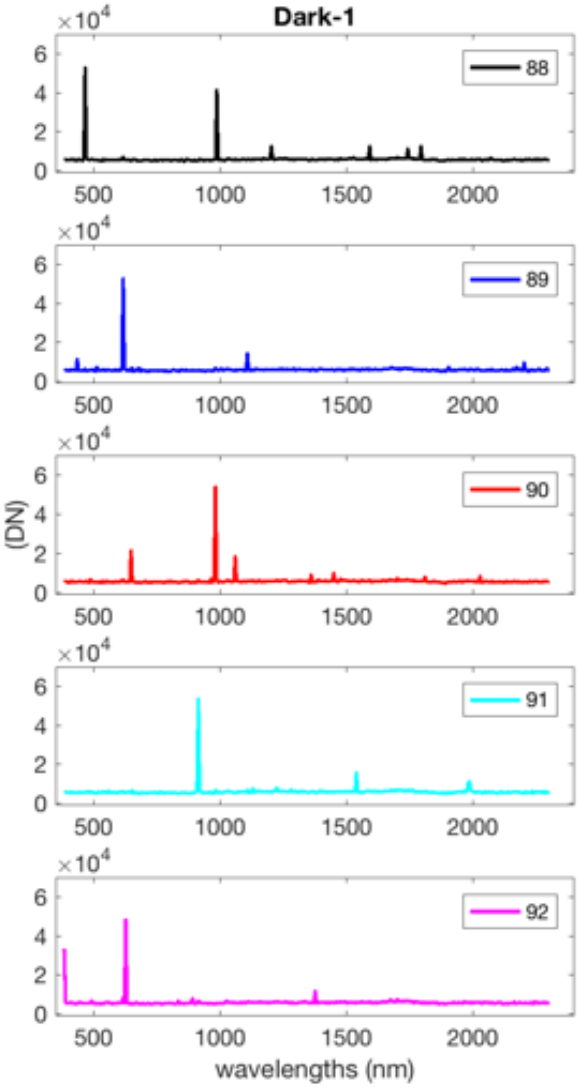


Fig.2. OP30 dark 1

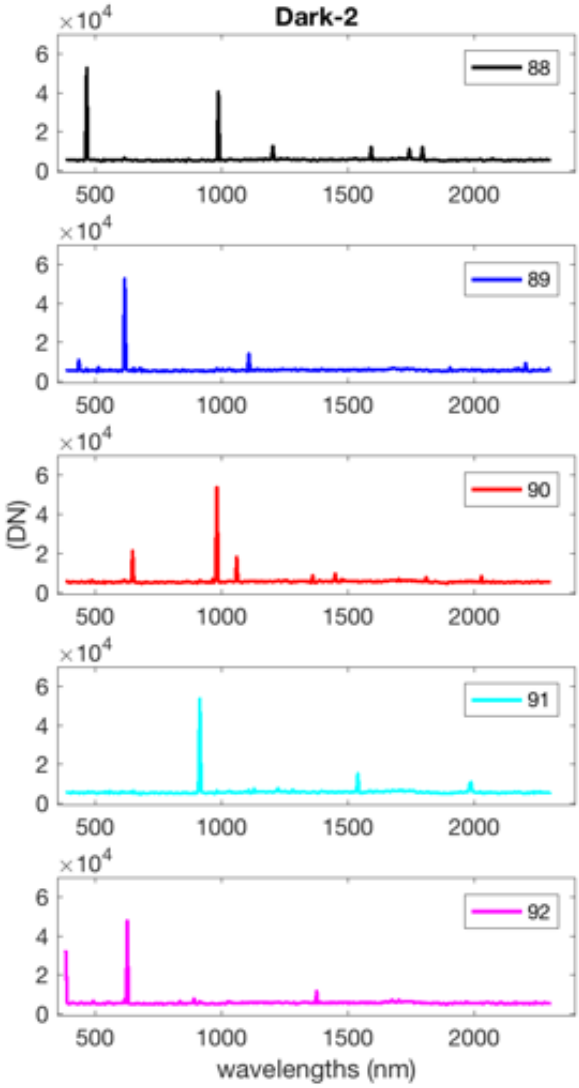
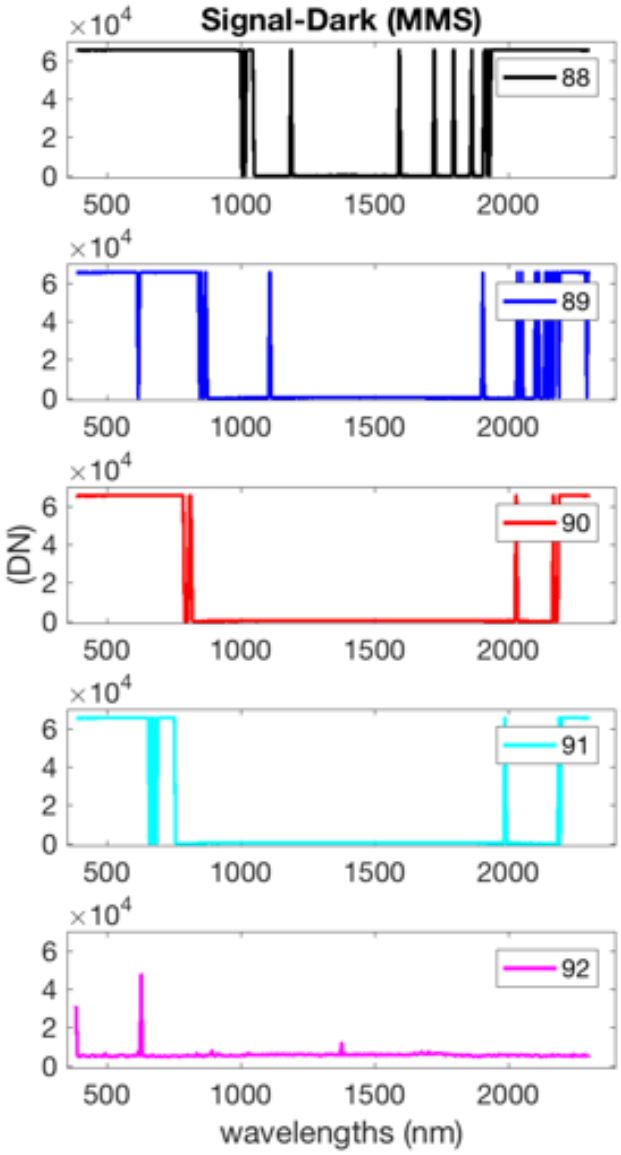


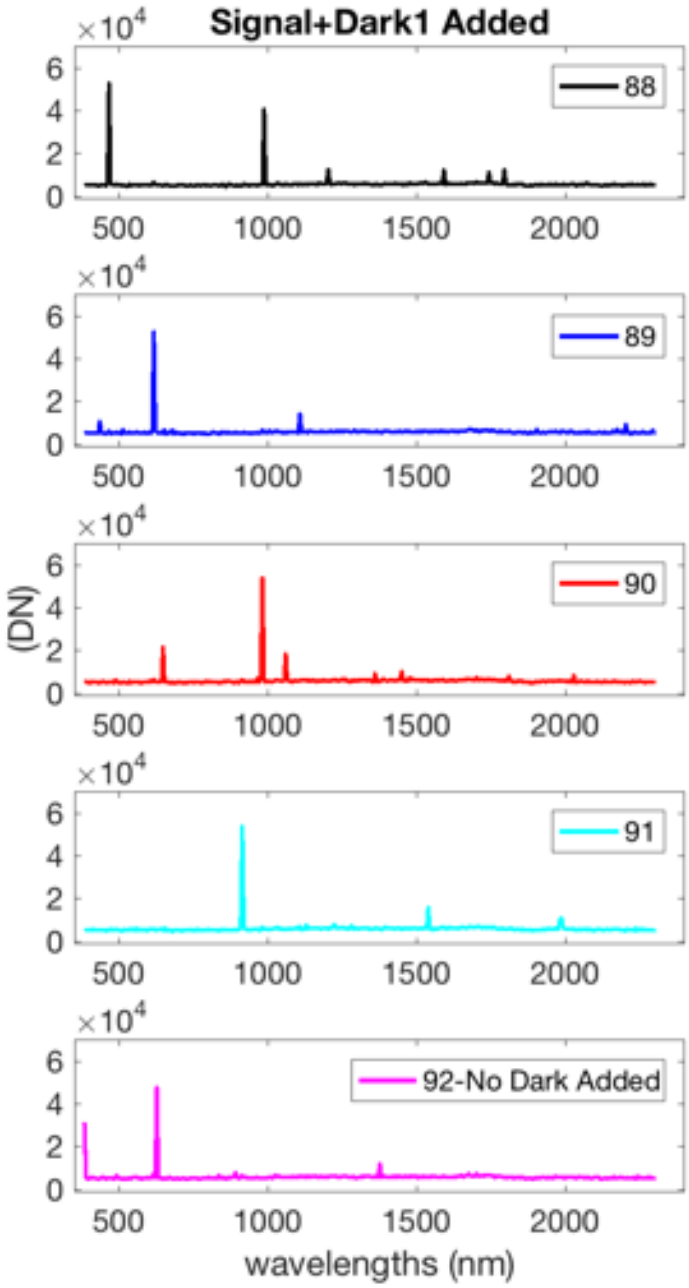
Fig.3. OP30 dark 2



Row 92: Here the MMS-SW does not subtract the dark

Fig.4. OP30, signal with dark automatically subtracted by Ma_MISS SW

Signal with dark subtracted by MMS-SW (except the row 92)



- MANUAL addition of dark according to the correction algorithm
- Only on the rows 88-91

Fig.5. OP30: the signal in fig.3, after manual addition of dark 1

+dark1 –dark2 ➔ offset=0

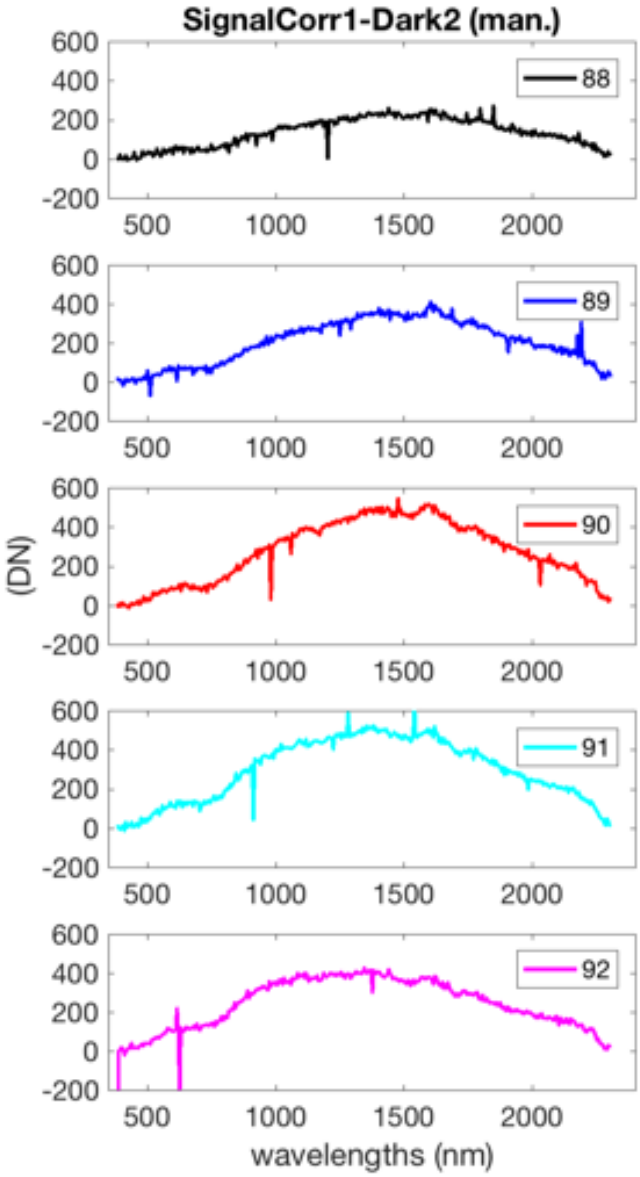


Fig.6. OP30: the signal in fig.4, after subtraction of dark 2. This is the finally corrected ghost signal.

OP31 – Diagnostic

Diagnostic acquired with:

- Lamp ON
- No target = ghost signal
- Tdet = -25°C

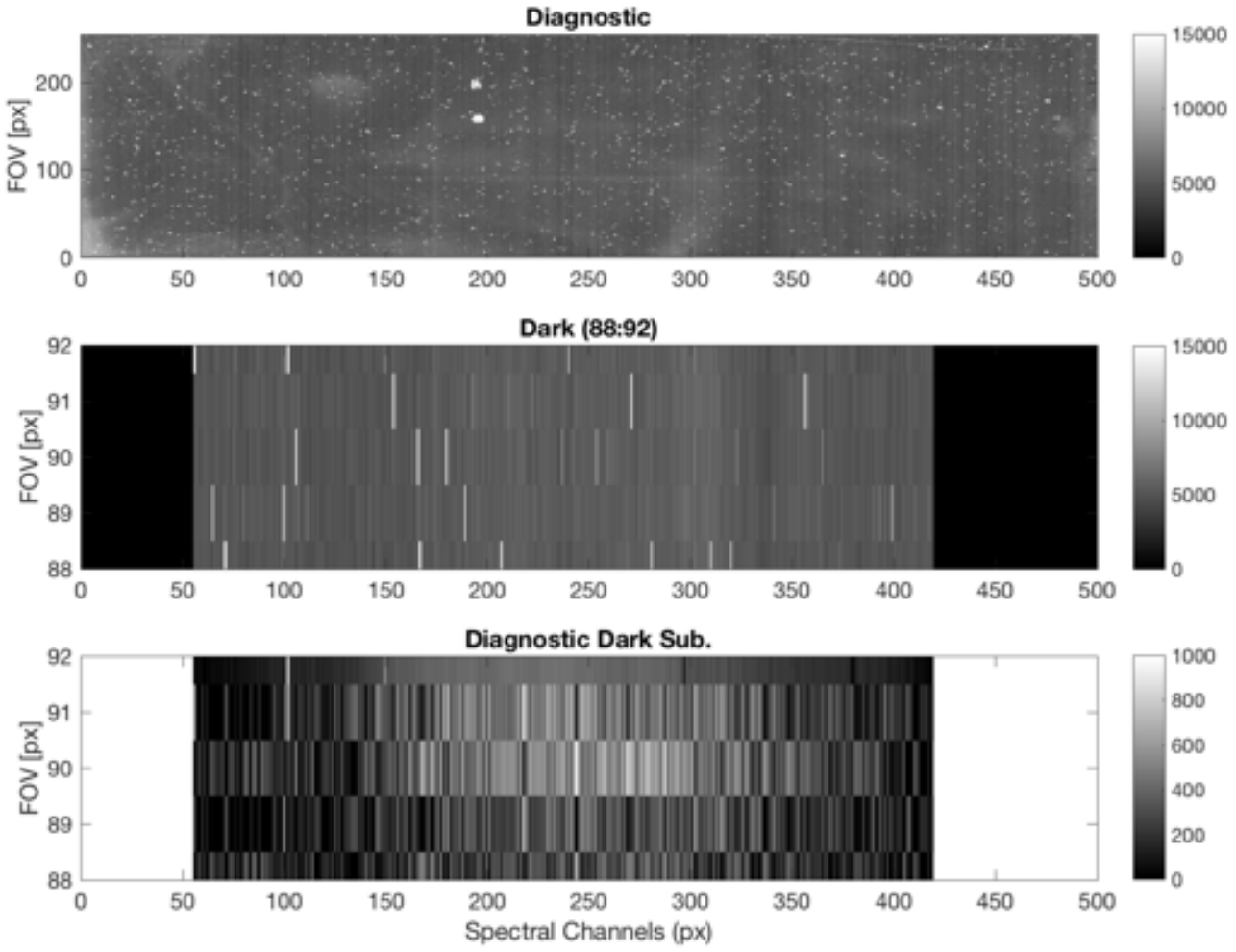


Fig.7. OP31 (Diagnostic), top panel: image of the detector. Around the row 90 the illumination spot is visible. Centre: dark acquired during OP30. Bottom: signal after dark subtraction.

Diagnostic – 12/12/2017 – acq.49&63 [for comparison]

Acquired with:

- Lamp ON
- Target = lamp spectrum
- Tdet = -25°C
- During spectrometer alignment phase **(Dec-2017)**

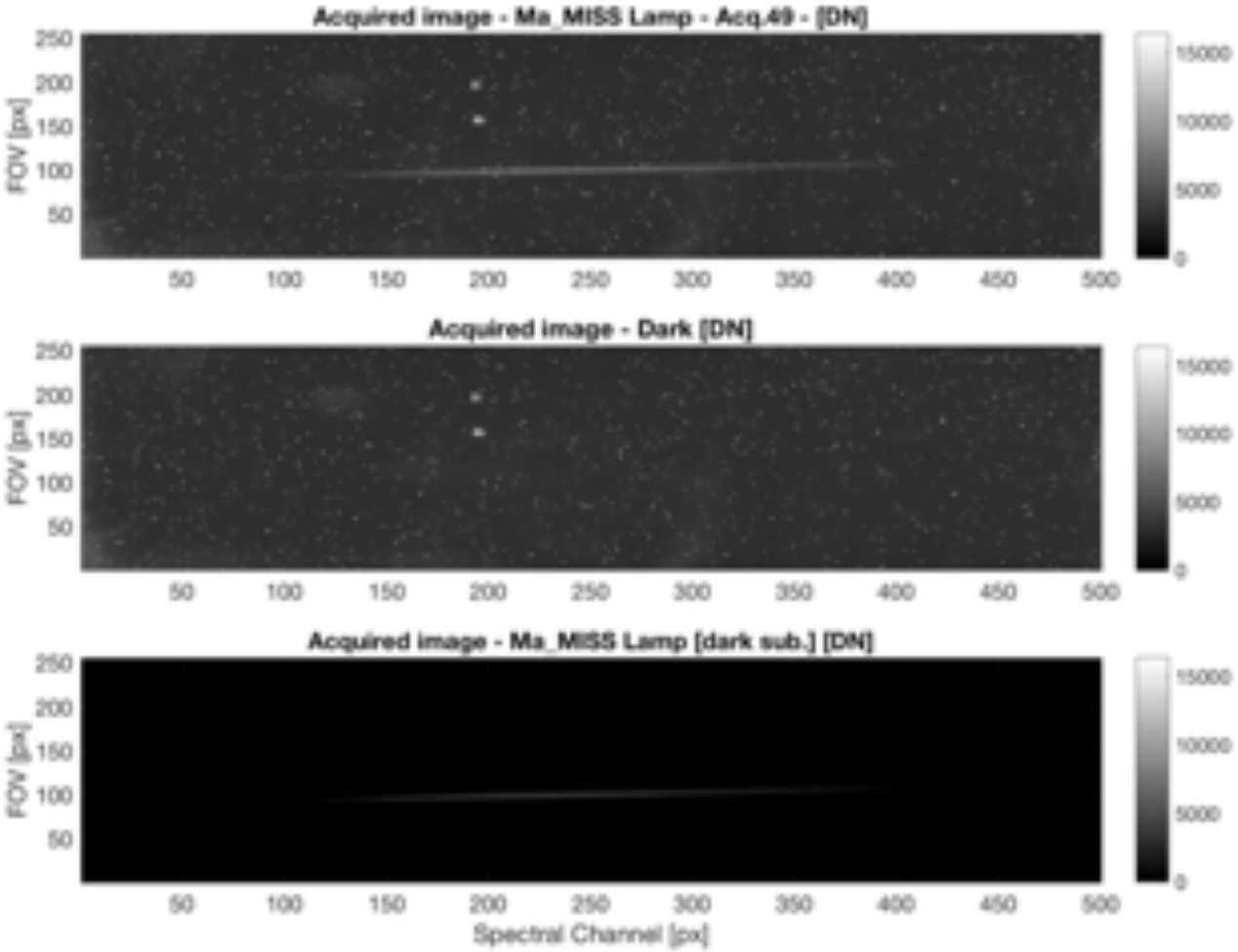


Fig.8. Diagnostic acquired during spectrometer alignment phase (2017)

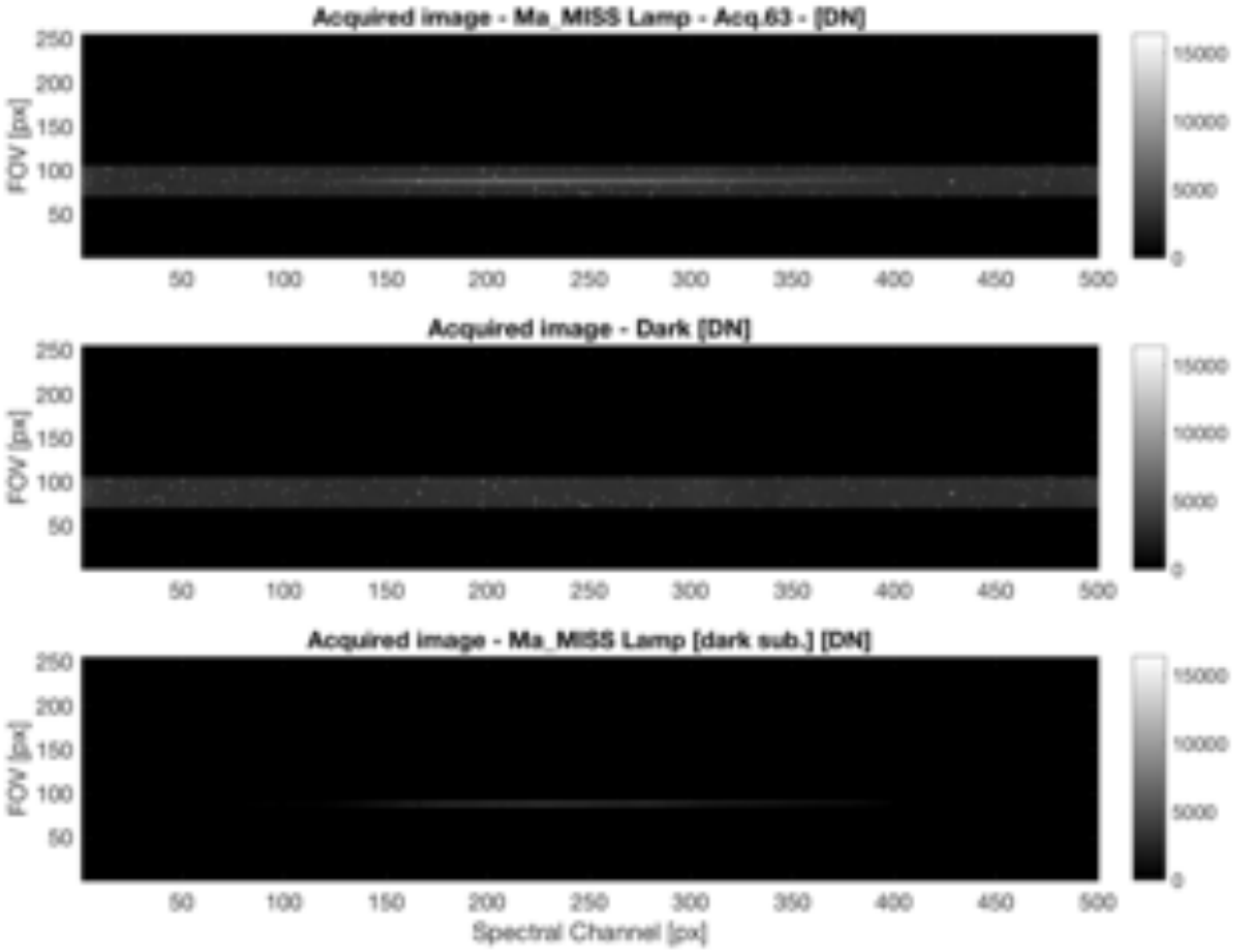


Fig.9. Diagnostic acquired during spectrometer alignment phase (2017)

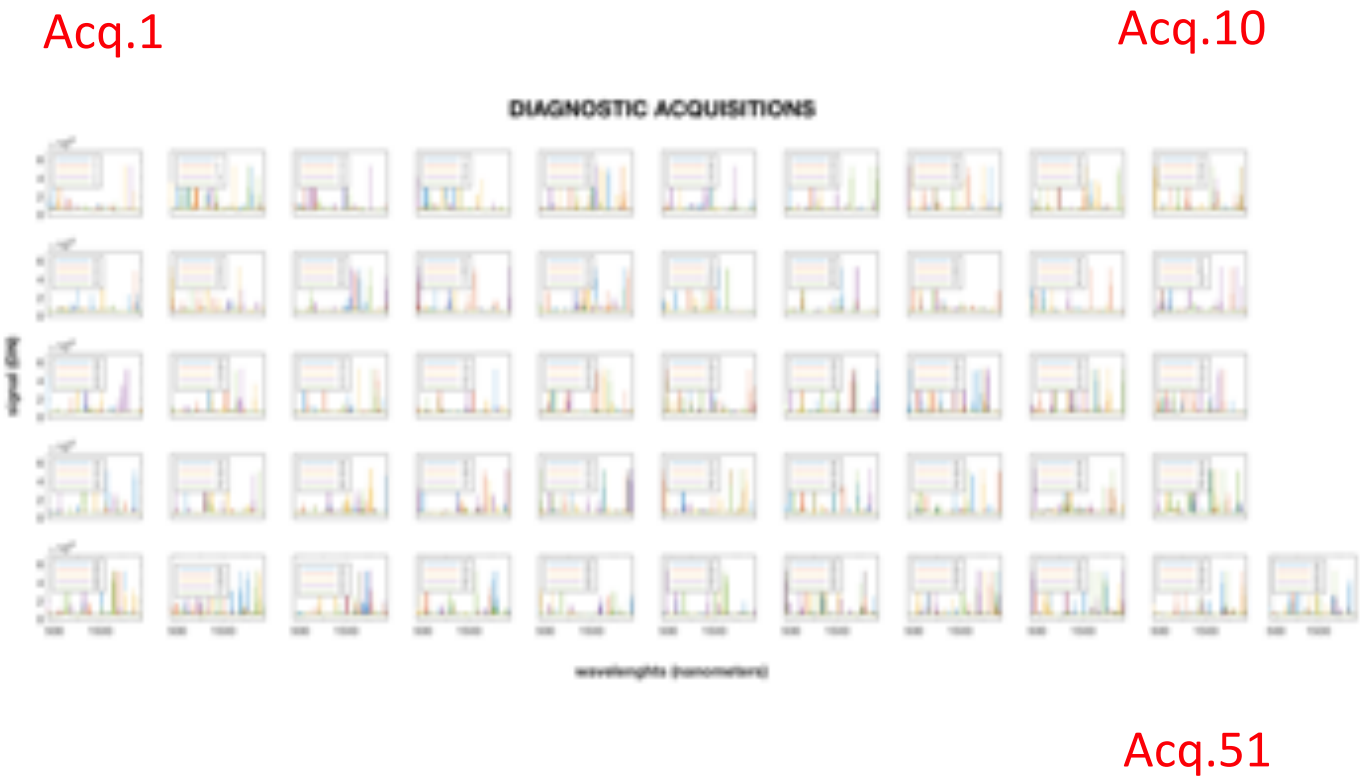
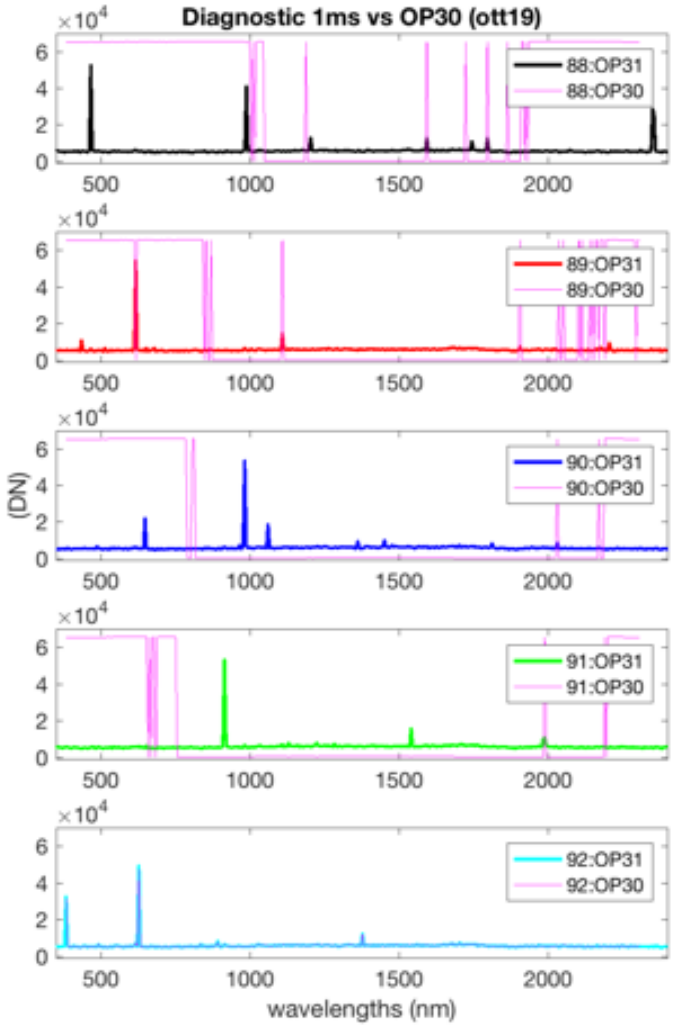


Fig.10. OP31 Diagnostic acquisitions; the signal on the 51 packages (each with 5 rows) is showed. The 88-91 rows, i.e. the same that are addressed during the execution of OP30 Single Point (together with row 92), are comprised in the Acquisition#18; the row 92 is comprised in the subsequent Acquisition#19.

OP31 vs OP30(LampOn)

- **OP30**: used acq. With Lamp ON, acquired at 16:14
- **OP31**: 51 acquisitions between 16:24 and 16:26
- Rows 88-91: the MMS-SW executes automatic dark subtraction
- **Row92**: no automatic SW dark subtraction: **identical signal** in OP30 (16:14) and in OP31 (16:25)



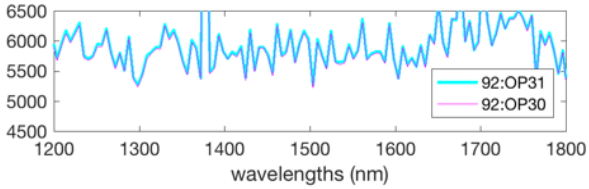


Fig.11. Comparison between the OP31 (rows 88-92) and the OP30 with lamp on (rows 88-92). Fig.12: zoom on row 92.

OP31 vs OP30(LampOn)

- **OP30**: used acq. With Lamp ON, acquired at 16:14
- **OP31**: 51 acquisitions between 16:24 and 16:26
- Rows 88-91: the MMS-SW executes automatic dark subtraction
- **Row92**: no automatic SW dark subtraction: **identical signal** in OP30 (16:14) and in OP31 (16:25)
- After sum OP30+Dark1 on rows 88-91 the signal DOES **NOT** coincide with the signal from OP31
- On row 92 we have Signal x2

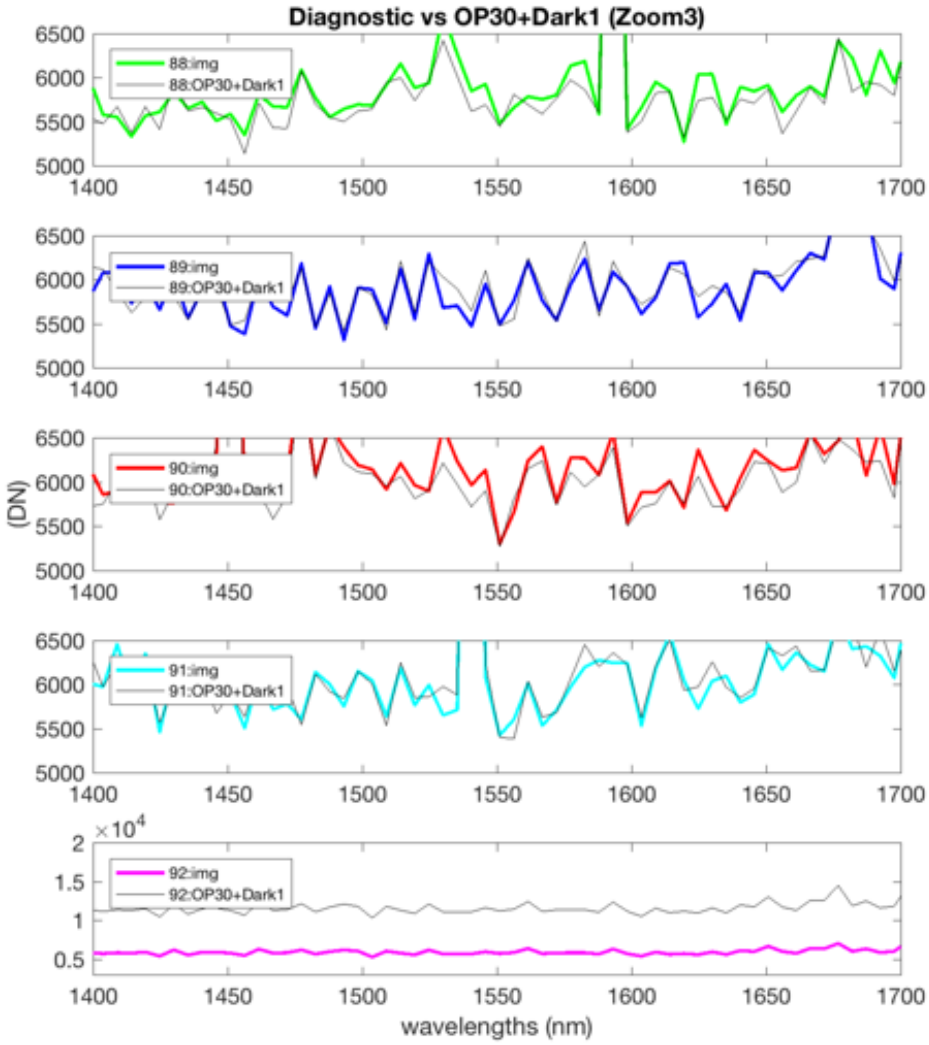


Fig.12. Comparison for the signal on rows 88-92, between OP31 (lamp ON) and OP30+dark.

OP31-dark vs OP30-dark

- **Dark**: used acq. dark#2 from OP30, acquired at 16:16
- **OP31**: 51 acquisitions between 16:24 and 16:26
- Dark subtraction on corresponding rows 88-92
- The corrected signal is very different with respect to the case of OP30 (shown in fig.6) except for row 92
- Noise fluctuations >> OP30

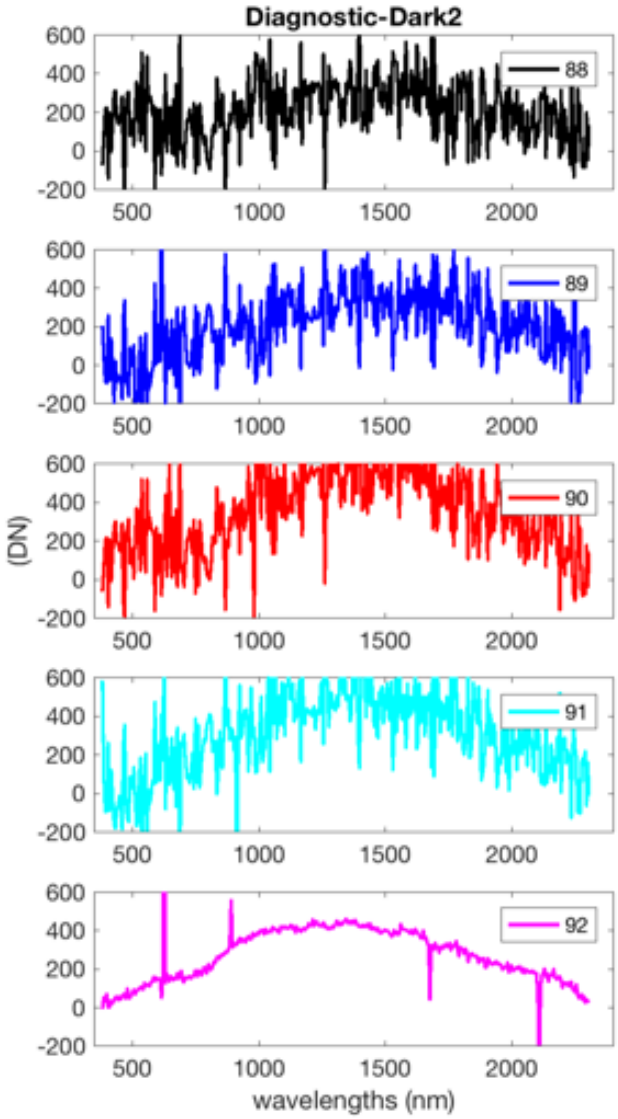


Fig.13. Diagnostic after subtraction of dark#2 from OP30

OP31-dark vs OP30-dark

- **Dark**: used acq. dark#2 from OP30, acquired at 16:16
- **OP31**: 51 acquisitions between 16:24 and 16:26
- Dark subtraction on corresponding rows 88-92
- The corrected signal is very different with respect to the case of OP30 (shown in fig.6) except for row 92
- Noise fluctuations >> OP30

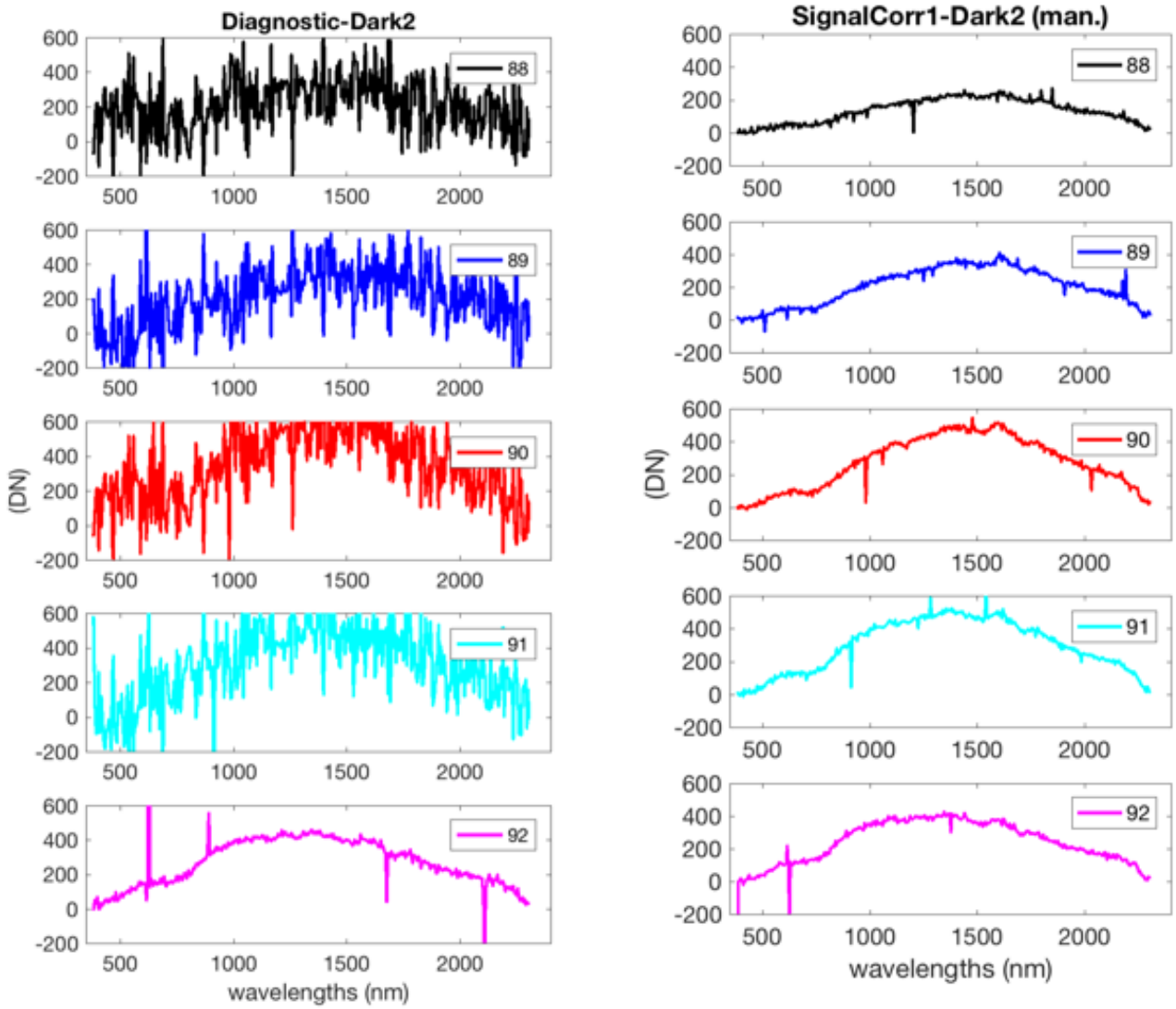


Fig.14. Left: Diagnostic after subtraction of dark#2 from OP30. Right: OP30 after dark subtraction (as fig.6).

OP31 vs OP30(dark)

- OP31 Diagnostic signal compared with OP30(dark) signal, for rows 88-92
- Here we can see that the same rows have been addressed and analyzed (same pattern of spikes and defective pixels for both OPs)

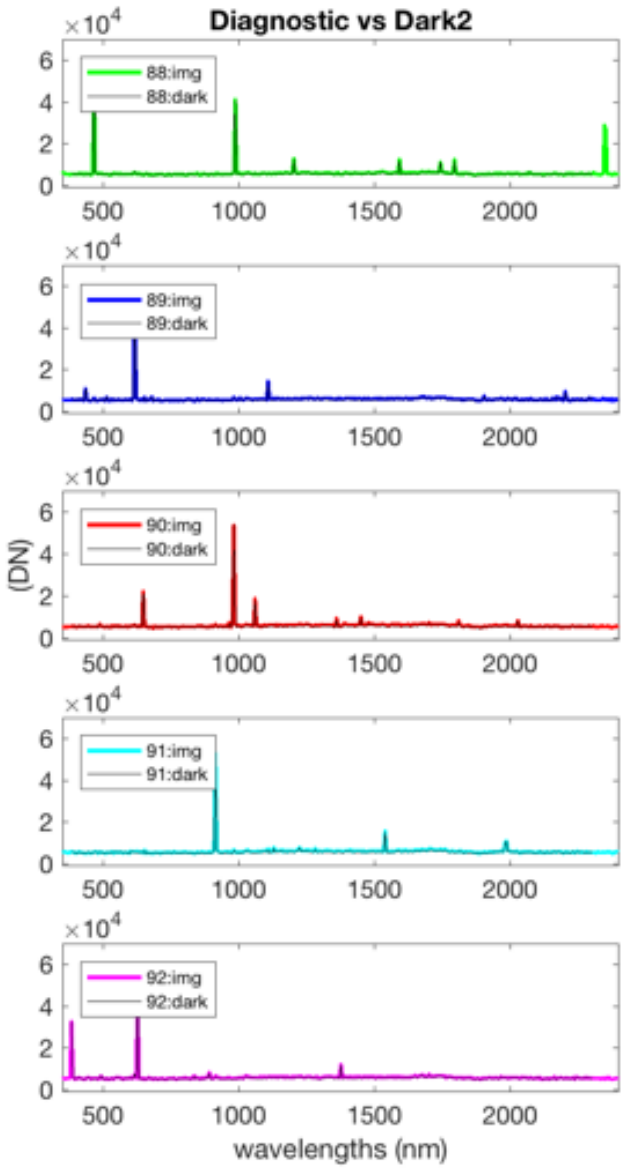


Fig.15. OP31 Diagnostic signal on rows 88-92 compared with dark#2 from OP30

OP31 vs OP30(dark)

- OP31 Diagnostic signal compared with OP30(dark) signal, for rows 88-92
- Here we can see that the same rows have been addressed and analyzed (same pattern of spikes and defective pixels for both OPs)
- Zoom on the central spectral range
- At this scale it appears evident that there are differences between the signal patterns

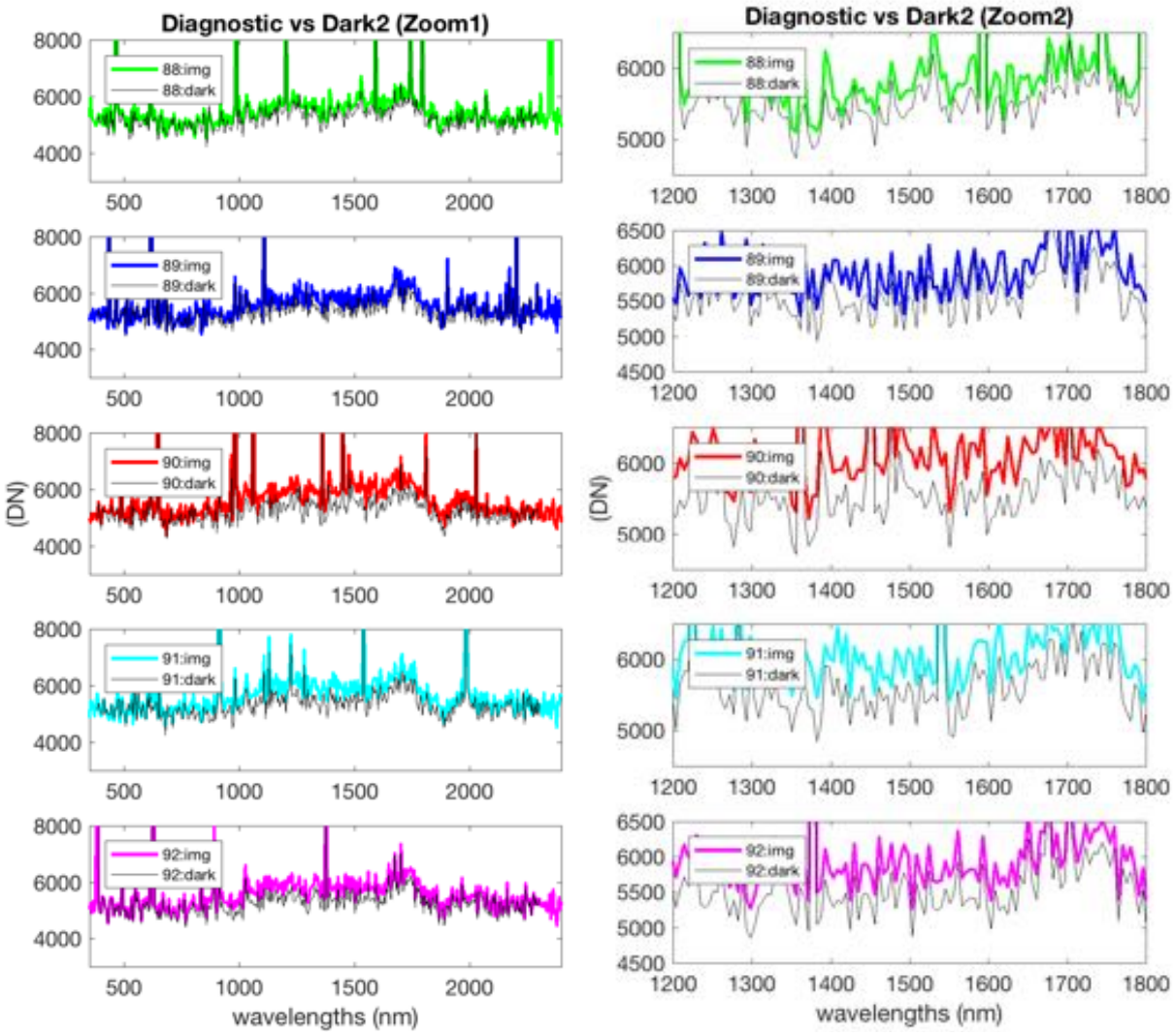


Fig.16. OP31 Diagnostic signal on rows 88-92 compared with dark#2 from OP30.

Here we compare:

- on the left the OP30+dark1 with the dark2
- on the right we compare the OP30+dark1 with the Diagnostic [zoom1]

OP30+dark1 vs dark2 (OP30) OP30+dark vs OP31

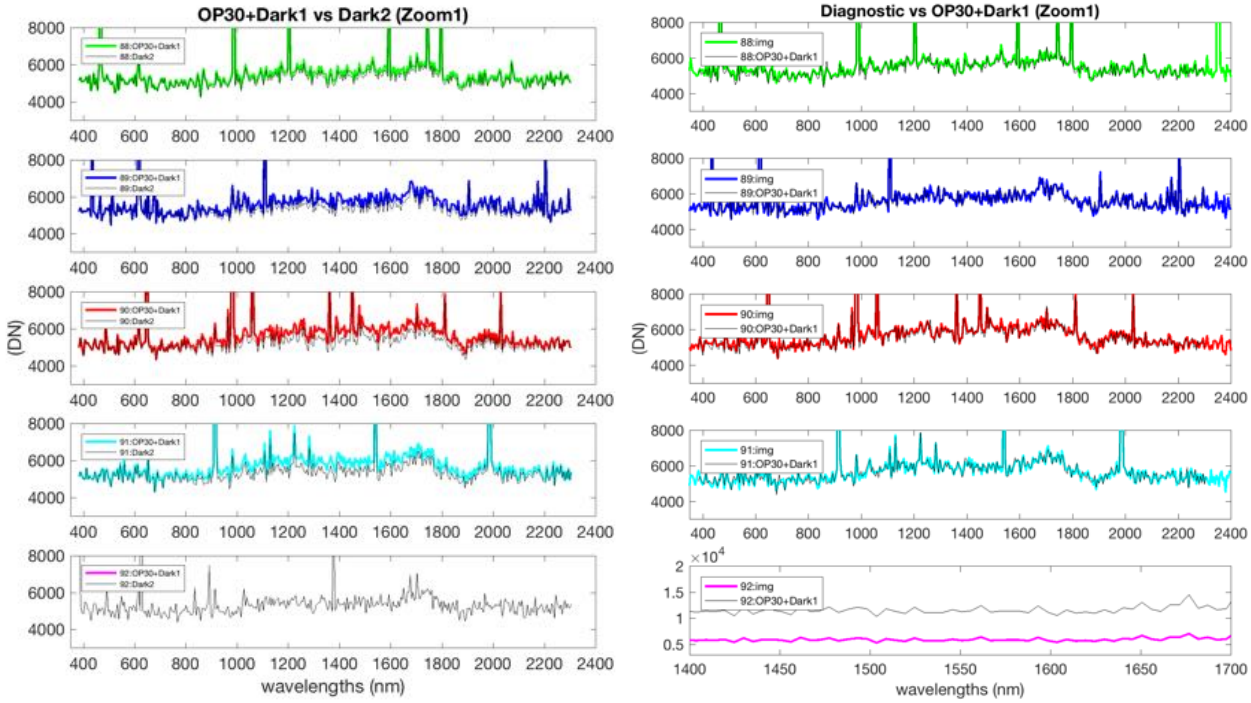


Fig.17. Comparison between OP30 with dark added and OP31.

Here we compare:

- on the left the OP30+dark1 with the dark2
- on the right we compare the OP30+dark1 with the Diagnostic [zoom3]

OP30+dark1 vs dark2 (OP30) OP30+dark vs OP31

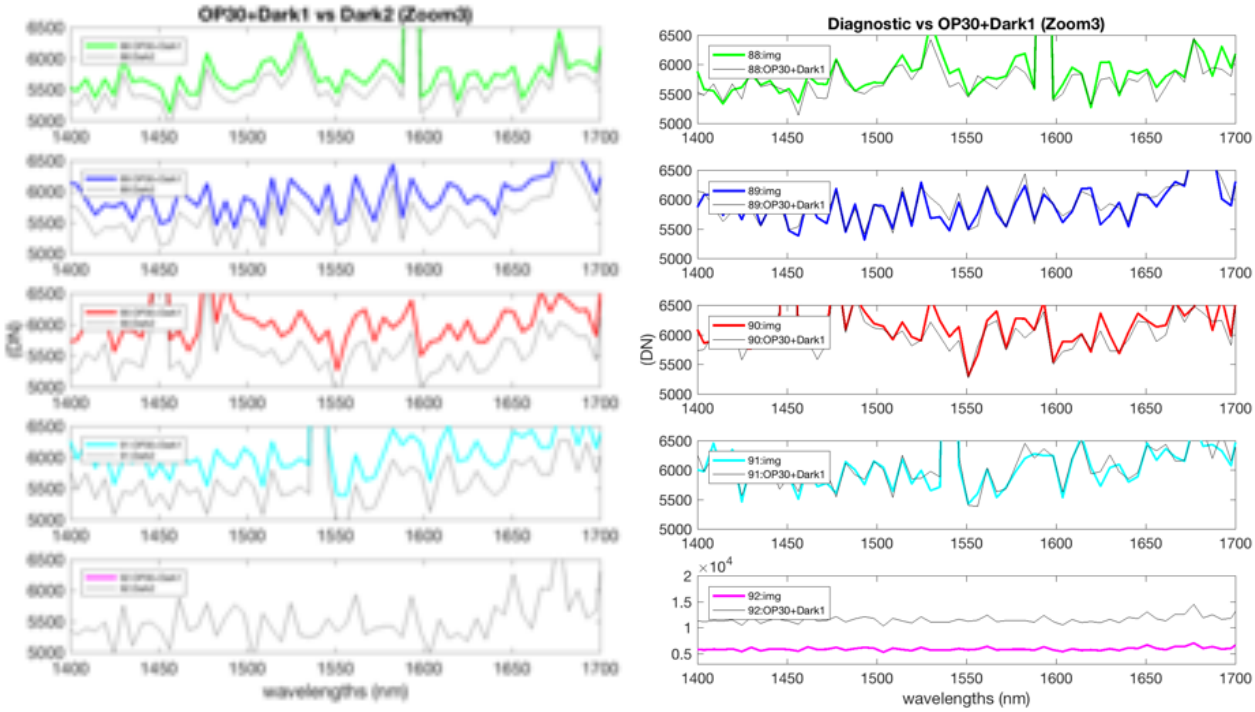


Fig.18. Comparison between OP30 with dark added and OP31.

- All these comparisons (figg.11-18) have been performed with the aim of understand the reason for the arising of such noisy data, after subtraction of OP31 with dark from OP30.
- In principle the OP30, after correction of all artifacts for SW dark subtraction and the OP31 should give the same signal on the same rows (88-92), if acquisitions are executed with the same integration times and in the same experimental conditions (detector temperature, ecc.).
- In all these comparisons we can conclude that the dark from OP30 cannot be subtracted by the signal from OP31, even if the OPs have been executed at few minutes from one each other and in the same experimental conditions.

Housekeepings

- **Red circles**: HK relative to **OP30(dark)**, acquired at 16:16
- **Blue crosses**: HK relative to **OP31(diagnostic)**, acquired between 16:24 and 16:26
- The temperatures of PE and strap change by <2K, while Tdet remains constant

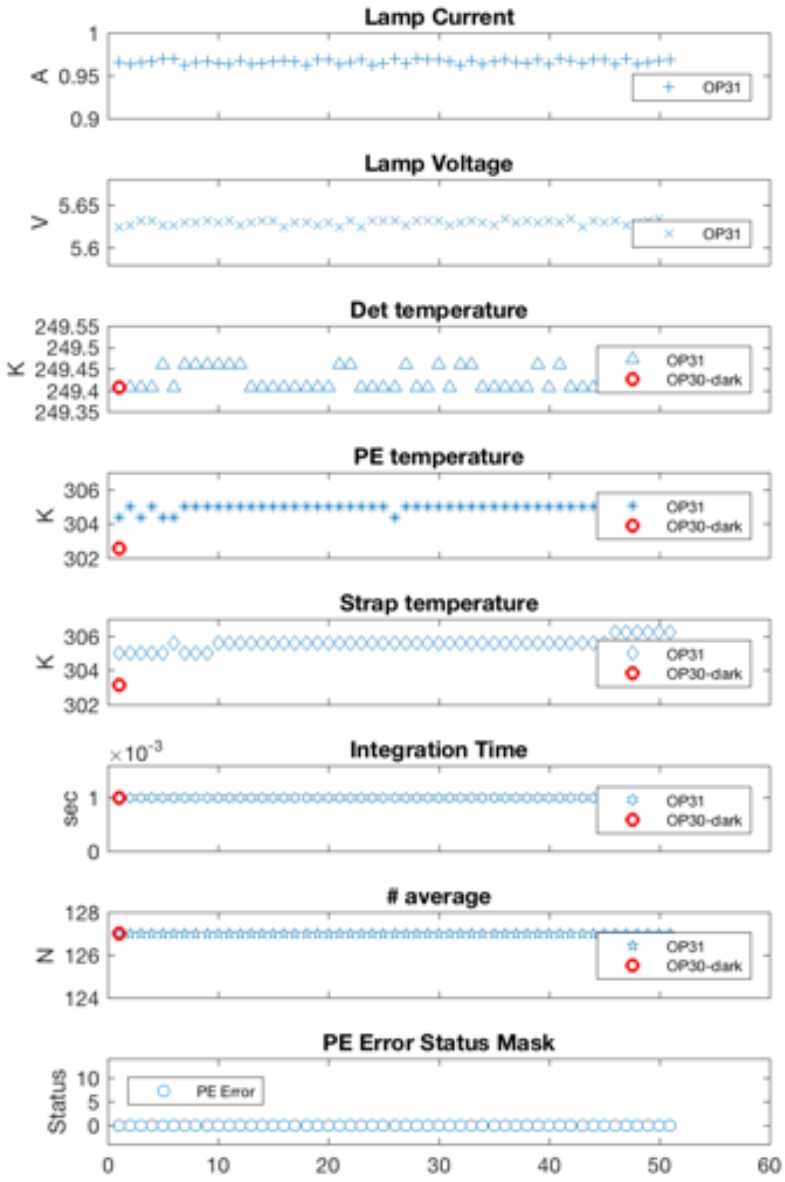
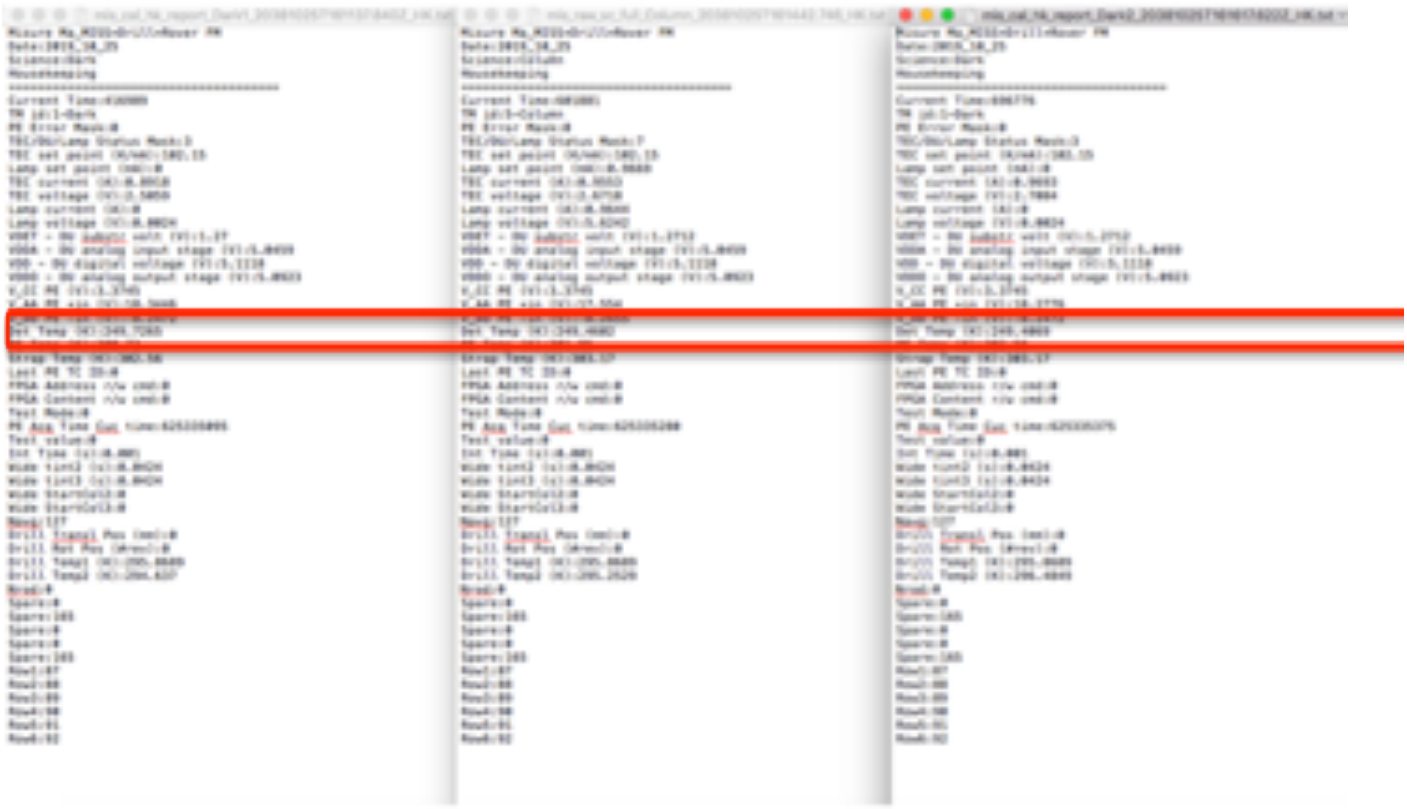


Fig.19. Housekeepings from OP31 and OP30 (dark).

Housekeepings OP30

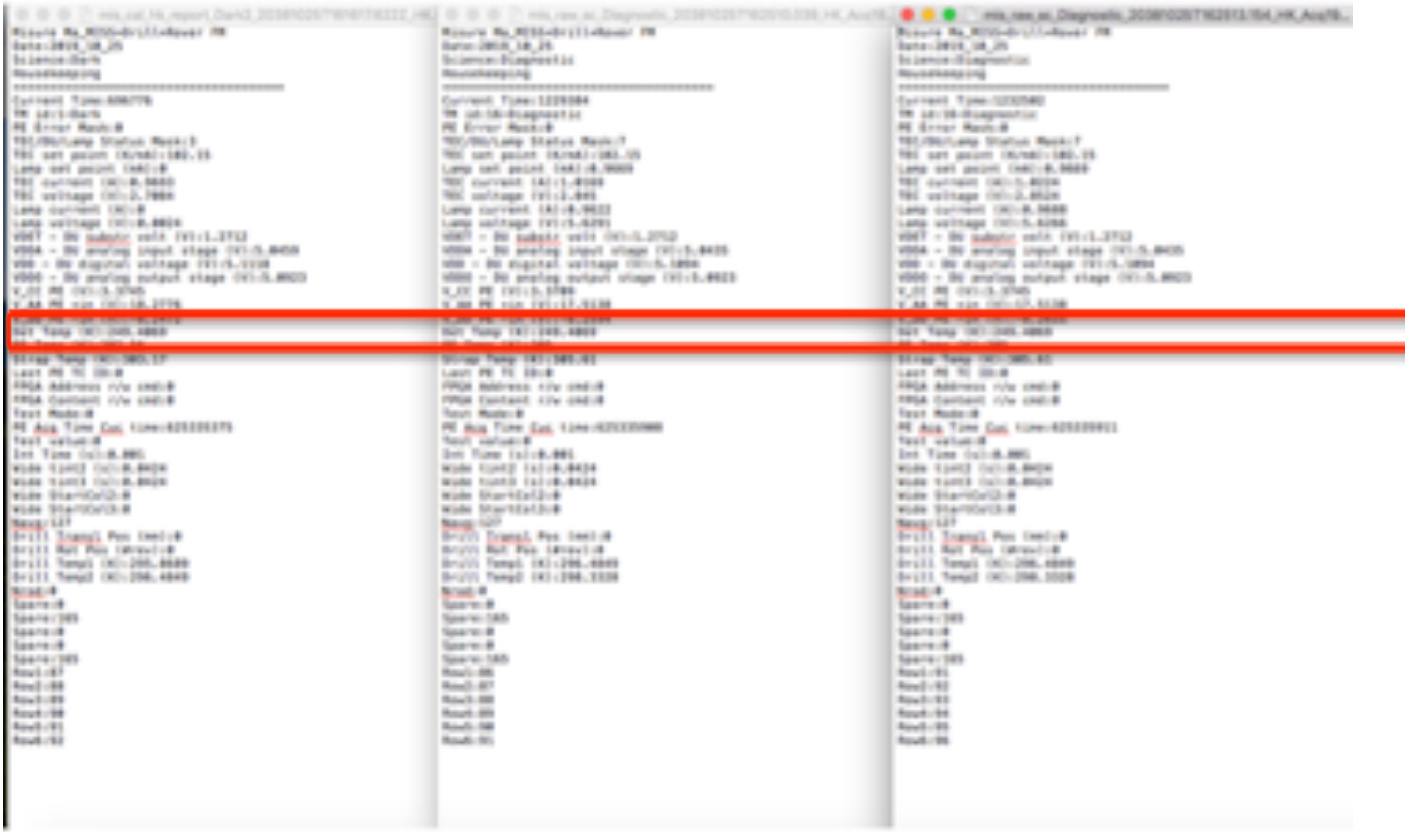


OP30 (Dark n.1) OP30 (Lamp ON) OP30 (Dark n.2)

Tdet=249.73K Tdet=249.46K Tdet=249.41K

Fig.20. Housekeepings from OP30 (dark1&2 and lamp on).

Housekeepings OP30 & OP31



OP30 (Dark n.2) OP31 (Acq.18) OP31 (Acq.19)

> Rows 88-91 > Rows 92-96

Tdet=249.41K Tdet=249.41K Tdet=249.41K

Fig.21. Housekeepings from OP30 (dark2) and OP31 (acq.#18 and #19).

Conclusions:

• **OP30=OK** data correction:

➢ dark#1 to be manually added to the OP30 signal (which comes with dark subtracted by MMS SW)
➢ dark#2 to be subtracted from the previous quantity, in order to have an offset = 0

• OP31=errors in data correction:

➢ A diagnostic with lamp OFF (=Diagnostic DARK) has not been acquired, thus in order to subtract a dark row-by-row we used the dark#2 from OP30
➢ After this dark subtraction (from OP30, acquired just 4’ before) on the rows 88-92, we have a very noisy signal on the rows 88-91, while the signal corrected on the row 92 is ok
➢ Signal on the rows 88-91: is very different when comparing OP30 (with lamp on) and OP31; row 92 has identical signal in the two OPs (acquisitions made at 16:16 (OP30) and 16:25 (OP31, row 92))
➢ HK are not changed, except for PE and strap temperatures (about T=2K) between OP30 and OP31
➢ This fact may depend on (i) dark subtraction by MMS-SW, that is executed on rows 88-91 and not 92; (ii) sequence of very close acquisitions executed during OP31
➢ The acquisition of a Diagnostic Dark (OP31 with lamp OFF) soon after/before the execution of a Diagnostic OP31 with lamp ON is strongly recommended, with the aim of check this aspect and try to correct the diagnostic signal with its own dark, acquired in the same identical conditions (i.e. scan of the whole detector).

2_TVAC-Vacuum_checkout-Ma_MISS_A:

07-nov-2019

During this test session the OP30 (Single Point Acquisition) and OP31 (Diagnostic) were executed. Both procedures were carried out without drill movement (Acquisition type A), and with the instrument in thermal vacuum chamber, with the detector cooled down at 225K, thus this was a “cold case” with respect to the previous session#1. The OPs were executed without any target in front of the Sapphire Window, thus again only the ghost signal (internal reflection) was observed.

- The OP30 was acquired with one integration time, t=1 ms; here the automatic dark subtraction by MMS-SW did not give any artifact, likely due to the operation of detector at nominal (cold) temperature.
- The OP31 was executed with three different integration times, t=0.5, 1 and 3 ms. All diagnostics were acquired with the lamp switched on.

OP30

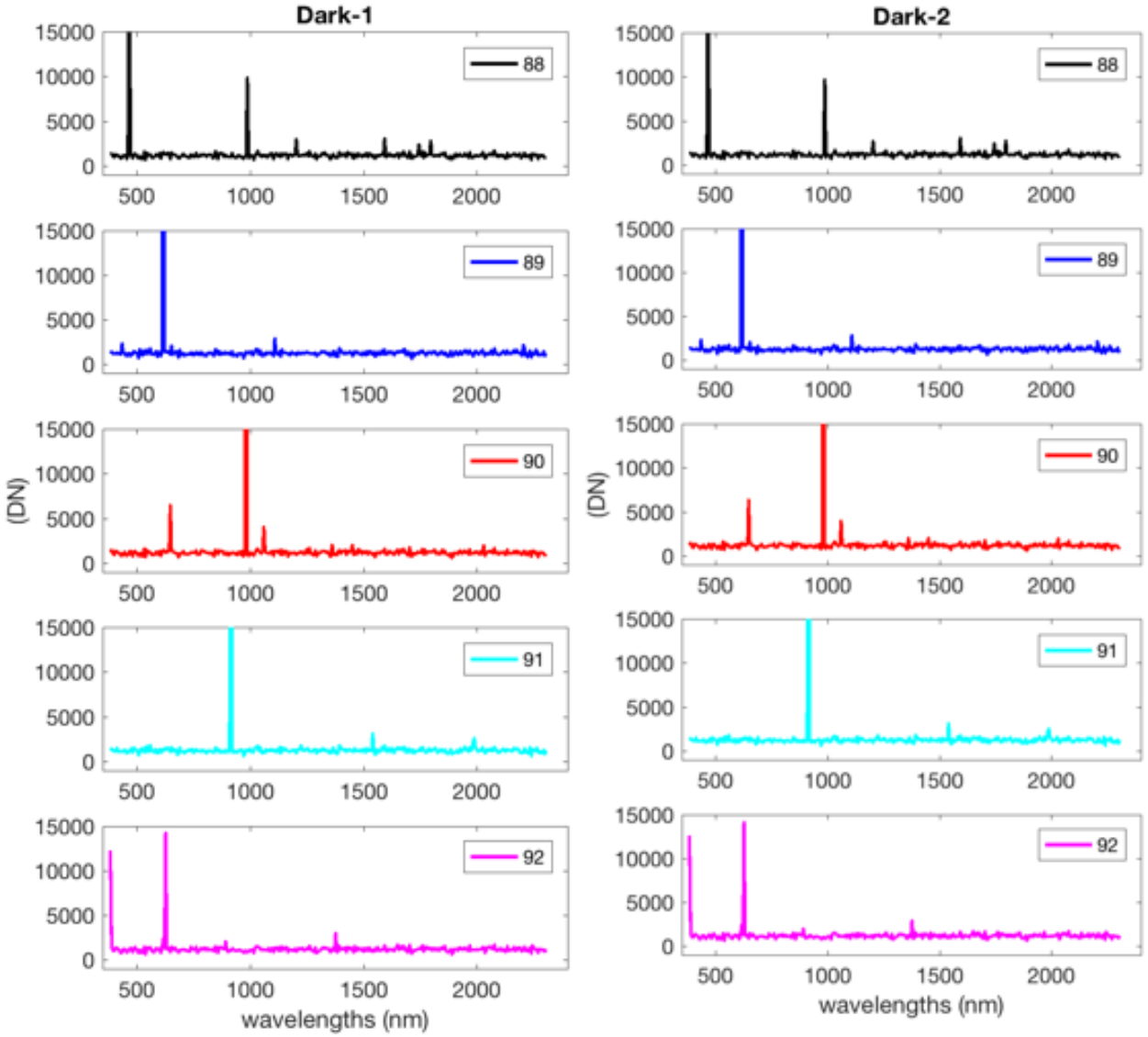


Fig.22. OP30 acquired during Session#2. Dark#1 (left) and dark#2 (right), both with integration time = 1ms.

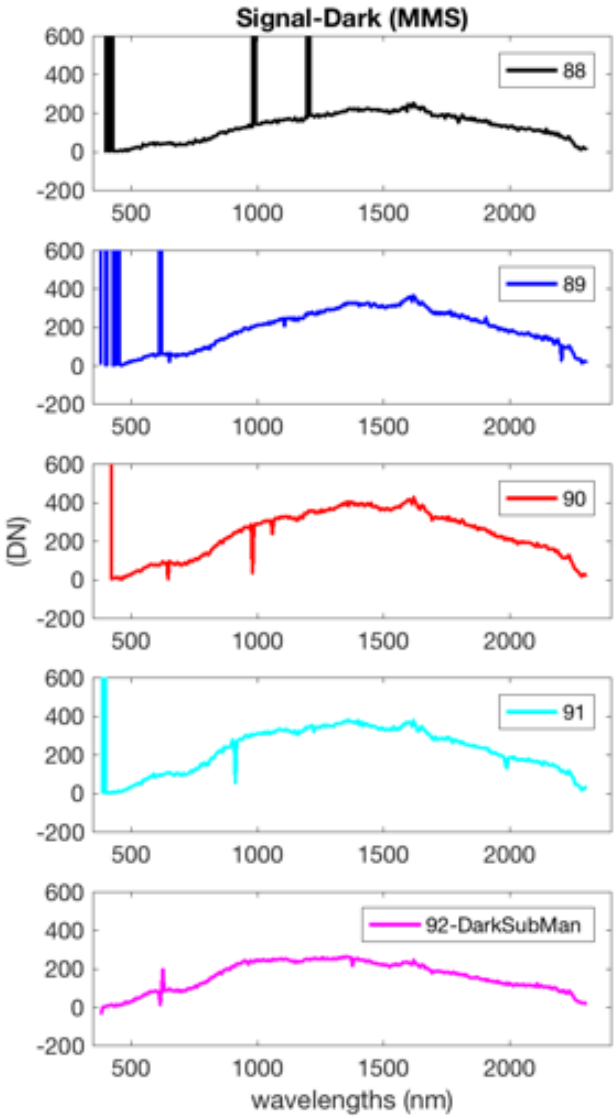


Fig.23. OP30 acquired during Session#2; lamp on. Here the ghost signal is well corrected with automatic dark subtraction by MMS-SW. The ghost signal with 1 ms integration time is about 400 DN at the center of the spectral band. The artifacts appearing in pixels with >65000 DN during the Session#1 now did not appear, likely due to the operation of detector at nominal (cold) temperature.

OP31

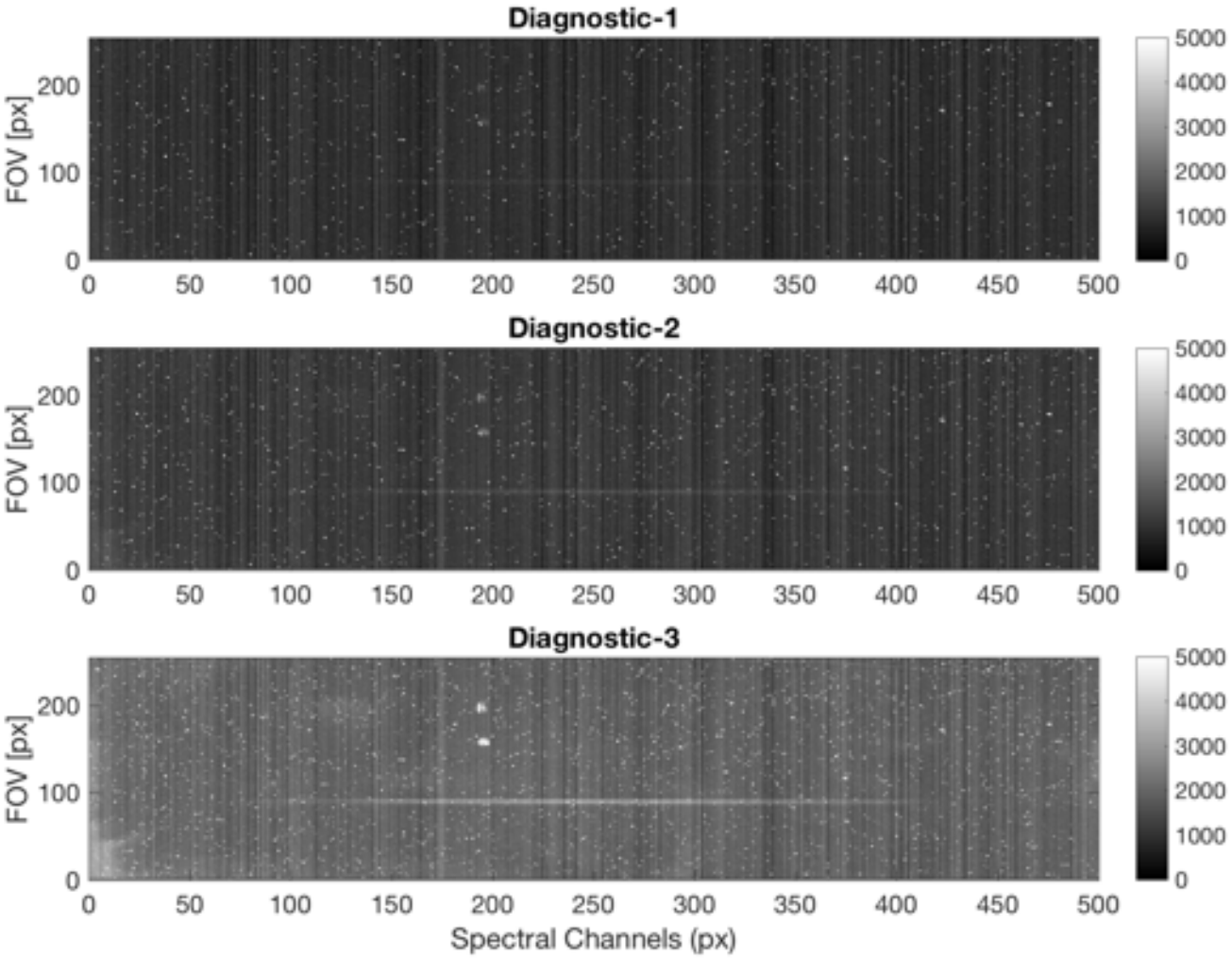


Fig.24. OP31 executed during Session#2. The three diagnostics, acquired with 0.5 (top), 1 (center) and 3 ms (bottom) represent the image of the whole detector window. Near the row 90 the illumination spot (horizontal line) is visible. Vertical lines are due to striping noise.

OP31 (nov'19) vs OP31 (oct'19)

Here we compare (fig.25) the signal from OP31 executed during the November Session#2 (T_{DET}=225K, cold) with the signal from OP31 executed during the October Session#1 (T_{DET}=249K, hot), both acquired with t=1 ms. The signal acquired in the "cold case" is on average about 25% with respect to the signal acquired in the "hot case" (purple lines).

Oct'19 T_{DET}=249.5K

Nov'19 T_{DET}=225K

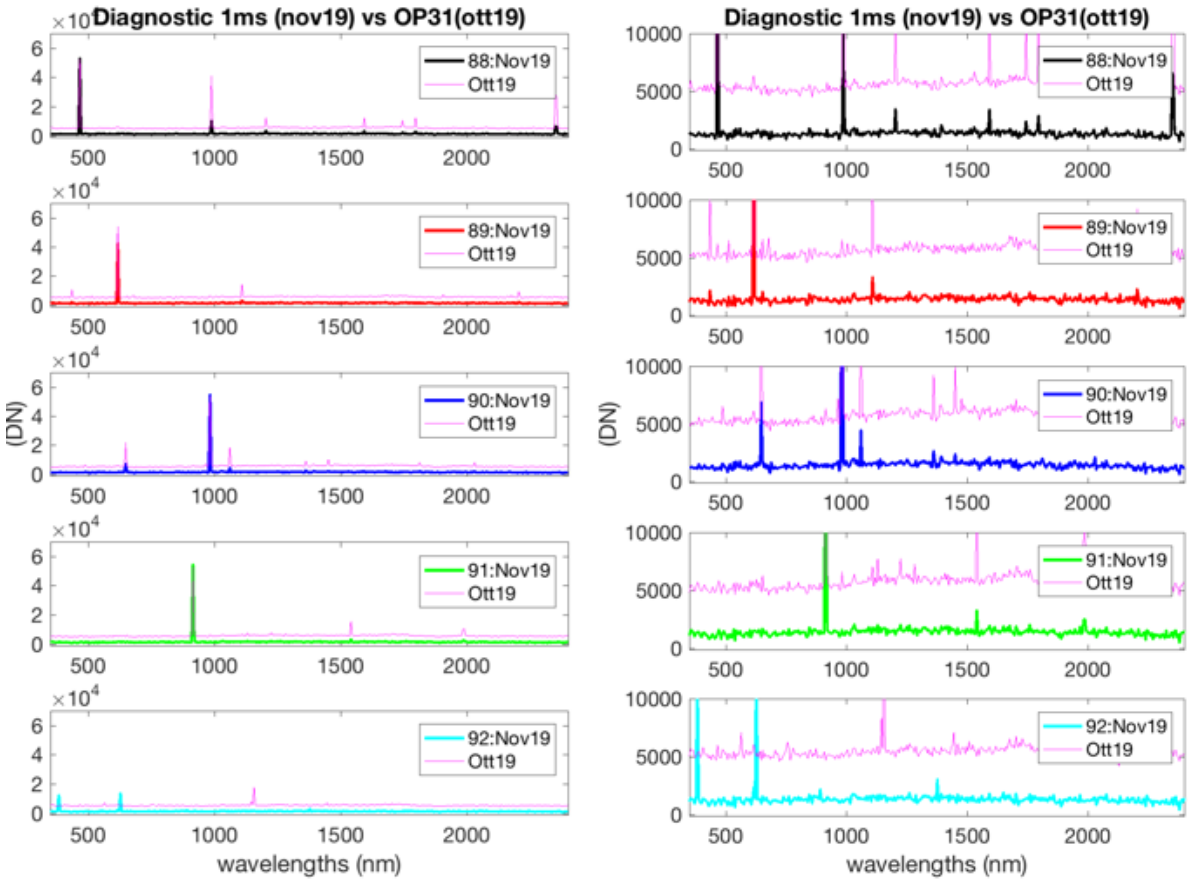
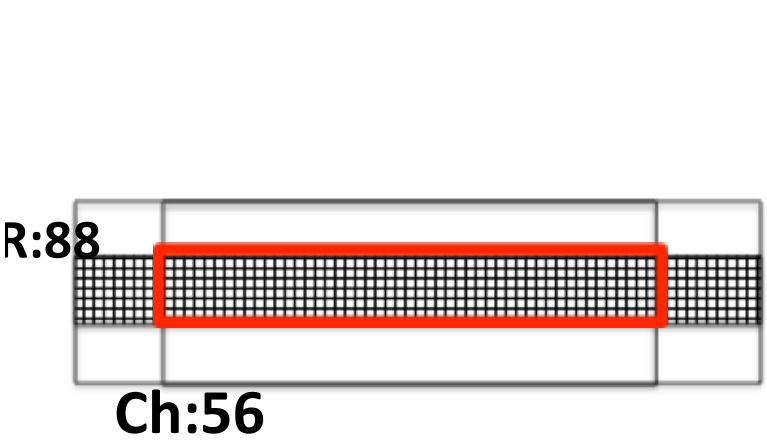


Fig.25. The OP31 acquired in Nov'19 (Session#2, *cold*) compared with the OP31 acquired in Oct'19 (Session#1, *hot*). On the right the view is zoomed along the Y-axis.

OP31 – dark subtraction

As in the Session#1 (Oct'19) we tryed to use the dark from the OP30 (dark#2) for the correction of OP31 data, given that an OP31 acquired with lamp off was missing (acquisition not planned). We can see in fig.26 that the process of dark subtraction again results in a signal that, although characterized by a spectral profile that is similar to the one expected for the ghost, with a maximum in the central band approximately around 400DN, nevertheless is characterized by a very high level of noise. This occurs for all rows except for the 92. This result again confirms the fact that a Diagnostic with lamp switched off is necessary in order to correct the data. In order to check for any shift of the acquired rows, different windows have been used for dark subtraction. Obviously the dark from OP30 was been acquired from the 88-92 rows, but different rows from the OP31 have been tested. In the first (nominal) case the same rows (88-92) have been used from OP31 (fig.26). Moreover the starting column (cut on) has been chosen nominally at channel 56.



The external rectangle indicates the whole detector (255x500 px). The internal black rectangle corresponds to the effective area of the detector used for signal acquisition (5x364 px) in the full mode. The internal red rectangle indicates the window used for the process of dark subtraction, in this case rows 88-92 and starting channel ch56 (nominal). The starting row (R) and column (Ch) are indicated.

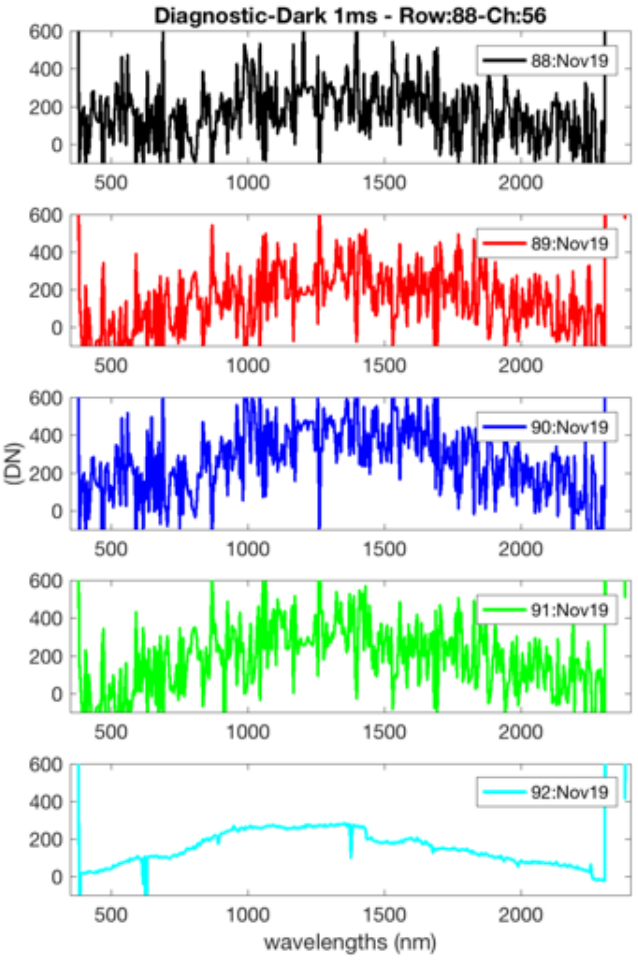
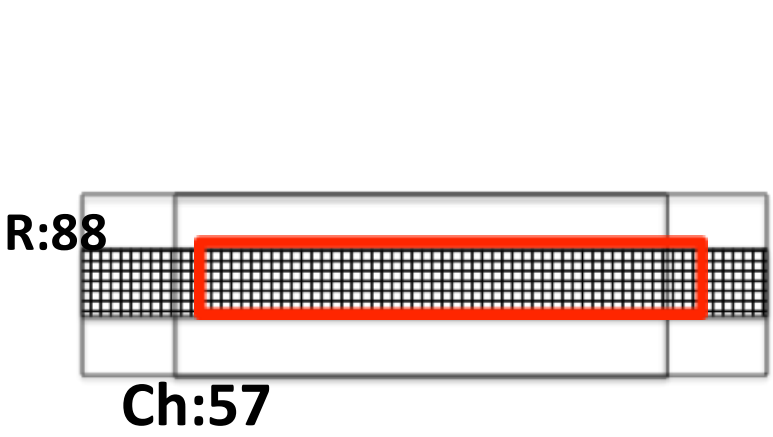


Fig.26. Diagnostic (OP31, Ses#2, Nov'19) after dark subtraction on rows 88-92. The dark#2 from OP30 was used. On the left the window used for dark subtraction, corresponding to nominal rows 88-92 and starting channel 56.

OP31 – dark subtraction

Here we tried to shift the columns from OP31 for dark subtraction, thus we used the same 88-92 rows but with the starting channel (cut-on) set at ch57 (fig.27). The result is a spectral profile that is much more noisy than what resulted in the previous nominal case.



The external rectangle indicates the whole detector (255x500 px). The internal black rectangle corresponds to the effective area of the detector used for signal acquisition (5x364 px) in the full mode. The internal red rectangle indicates the window used for the process of dark subtraction, in this case rows 88-92 and starting channel ch57 (shift of one channel towards longer wavelengths).

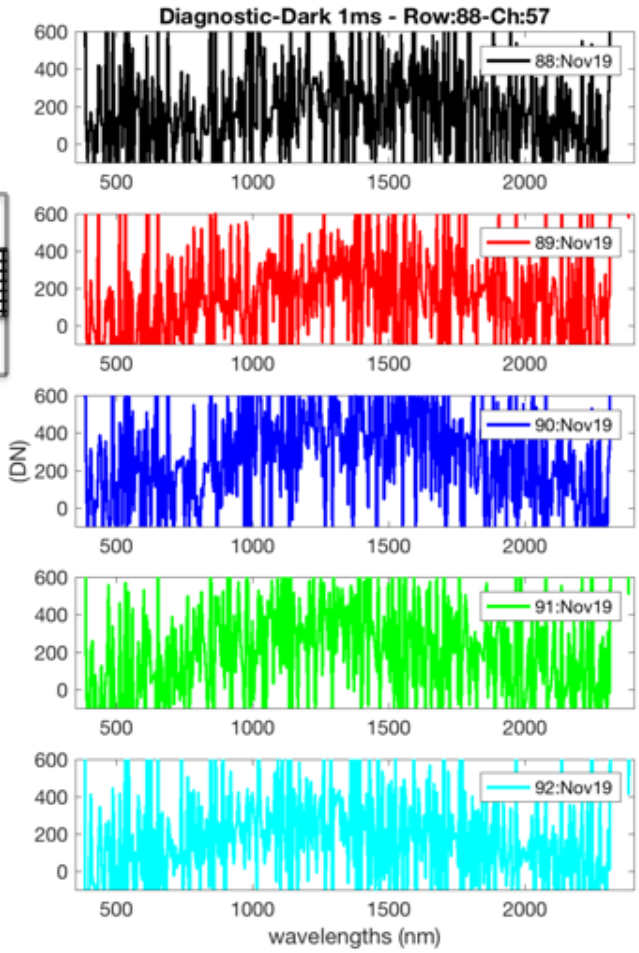
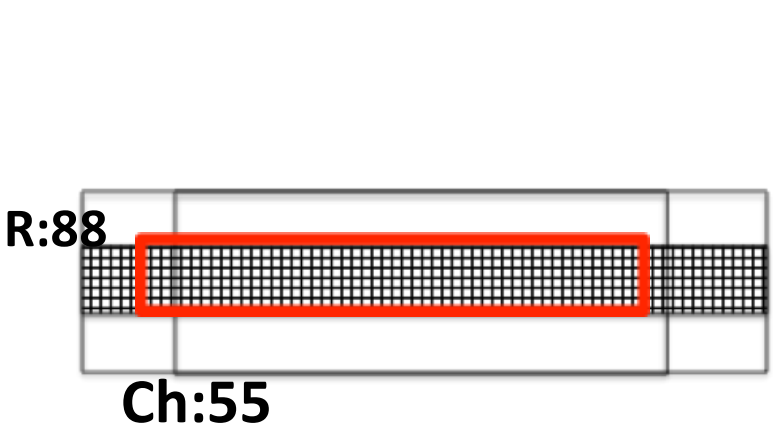


Fig.27. Diagnostic (OP31, Ses#2, Nov'19) after dark subtraction on rows 88-92. The dark#2 from OP30 was used. On the left the window used for dark subtraction, corresponding to nominal rows 88-92 and starting channel 57.

OP31 – dark subtraction

Here we tried to shift again the columns from OP31 for dark subtraction, thus we used the same 88-92 rows but with the starting channel (cut-on) set at ch55 (fig.28). The result is again a spectral profile that is much more noisy than what resulted in the previous nominal case. In some rows the typical spectral profile of ghost signal is quite recognizable, but with a very large amplitude of noise fluctuations, comparable with the maximum signal itself.



The external rectangle indicates the whole detector (255x500 px). The internal black rectangle corresponds to the effective area of the detector used for signal acquisition (5x364 px) in the full mode. The internal red rectangle indicates the window used for the process of dark subtraction, in this case rows 88-92 and starting channel ch55 (shift of one channel towards shorter wavelengths).

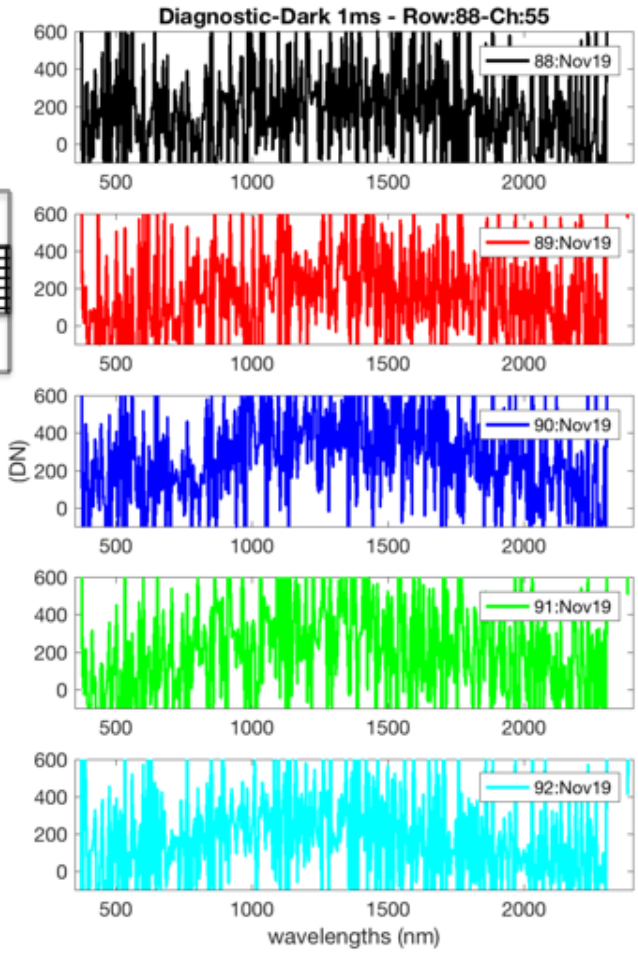
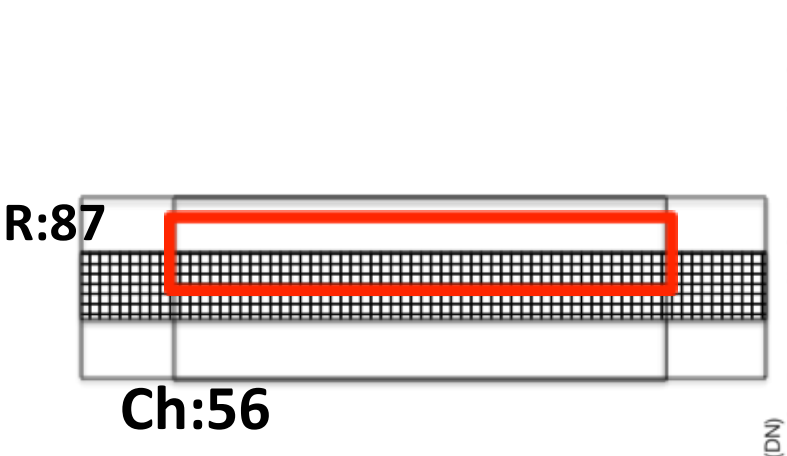


Fig.28. Diagnostic (OP31, Ses#2, Nov'19) after dark subtraction on rows 88-92. The dark#2 from OP30 was used. On the left the window used for dark subtraction, corresponding to nominal rows 88-92 and starting channel 55.

OP31 – dark subtraction

In this case we tried to shift the rows from OP31 for dark subtraction: thus we used the nominal cut-on and cut-of channels (ch56 and ch419 respectively), while shifted the window towards up (rows 87-91, fig.29). The result is a spectral profile that is similar to the nominal case, but now on the fifth row (92) the signal is no more corrected.



The external rectangle indicates the whole detector (255x500 px). The internal black rectangle corresponds to the effective area of the detector used for signal acquisition (5x364 px) in the full mode. The internal red rectangle indicates the window used for the process of dark subtraction, in this case rows 87-91 (shift of one channel towards up along the FOV direction) and starting channel ch56.

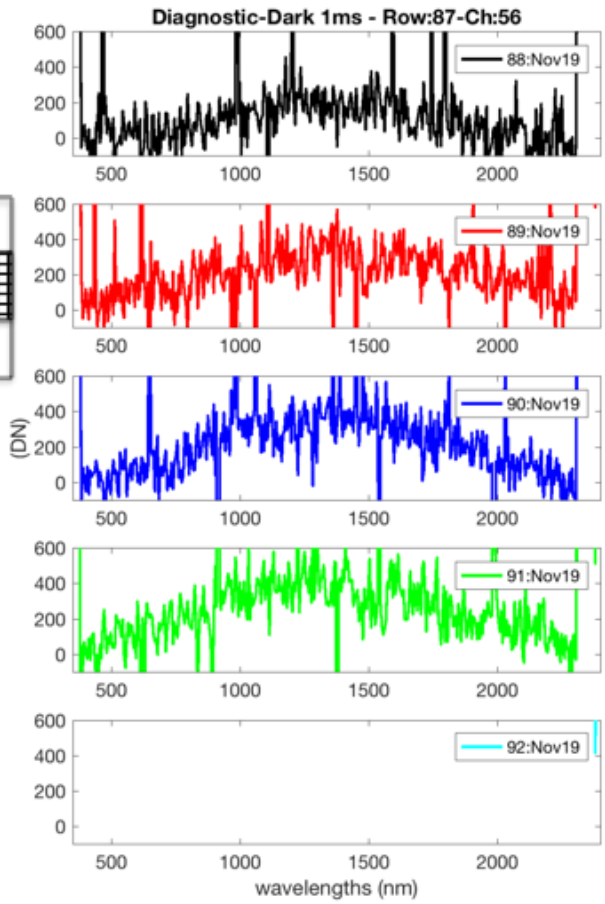
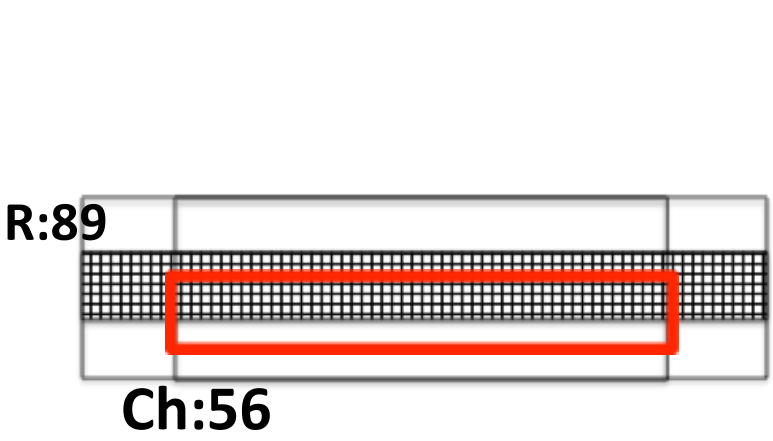


Fig.29. Diagnostic (OP31, Ses#2, Nov'19) after dark subtraction on rows 87-91. The dark#2 from OP30 was used. On the left the window used for dark subtraction, corresponding to rows 87-91 and starting channel 56.

OP31 – dark subtraction

Finally shifted the window along the rows towards down in the FOV direction for dark subtraction: thus we used the nominal cut-on and cut-of channels (ch56 and ch419 respectively), while shifted the window towards down (rows 89-93, fig.30). The result is a spectral profile that is similar to the nominal case, but now on the first row (88) the signal is no more corrected.



The external rectangle indicates the whole detector (255x500 px). The internal black rectangle corresponds to the effective area of the detector used for signal acquisition (5x364 px) in the full mode. The internal red rectangle indicates the window used for the process of dark subtraction, in this case rows 89-93 (shift of one channel towards down along the FOV direction) and starting channel ch56.

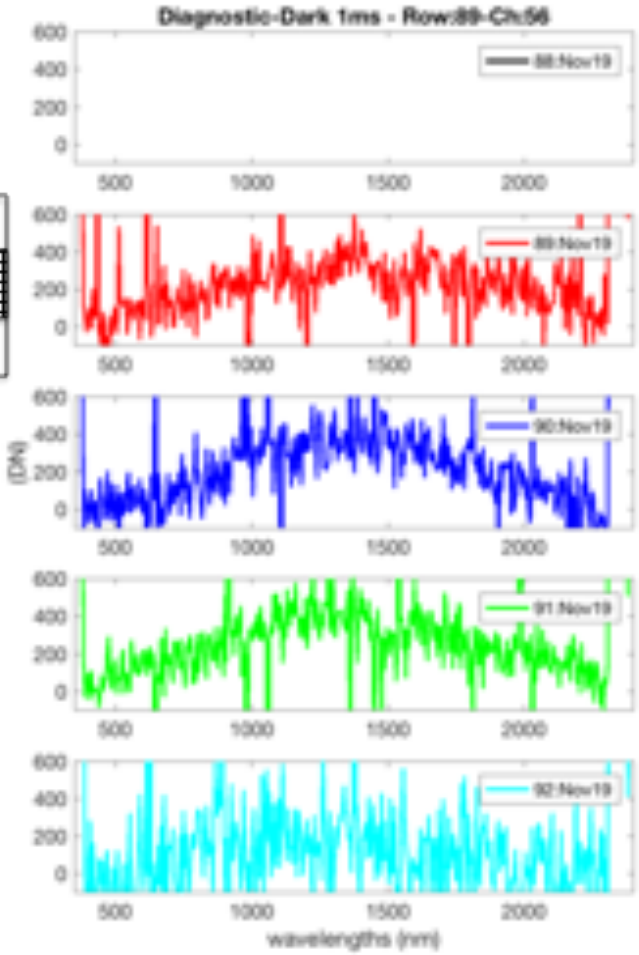


Fig.30. Diagnostic (OP31, Ses#2, Nov’19) after dark subtraction on rows 89-93. The dark#2 from OP30 was used. On the left the window used for dark subtraction, corresponding to rows 89-93 and starting channel 56.

Housekeepings

- T_{DET} = 225K (cold case with respect to OP31 of 25-oct)
- PE Error Status Mask: value 0x0C = 12 from acq. 29-51 only in the Diagn.1 (0.5 ms)
- *wrong DU_DATA_VALID signal* [from EXM-RM-RSP-GAM-0030]

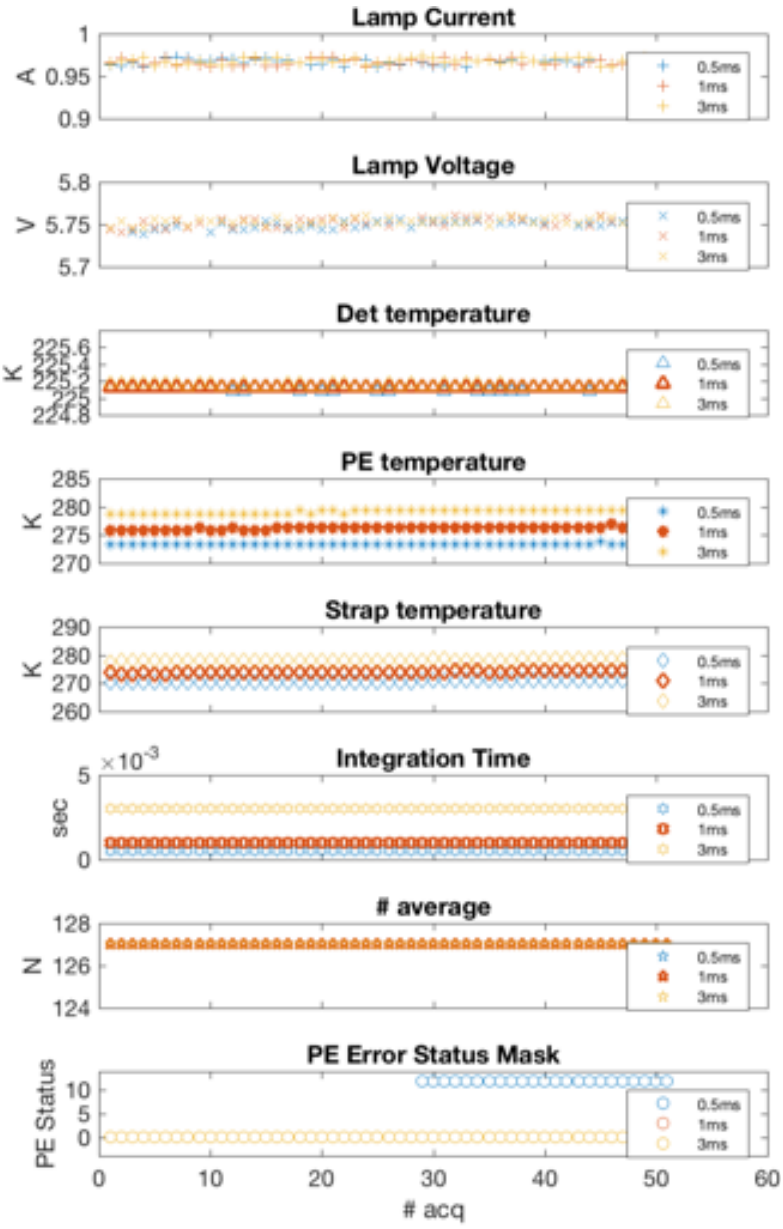


Fig.31. Some of the housekeepings corresponding to the 51 acquisitions of each of the three diagnostics performed.

3_TVAC-Equipment_Warmup-Ma_MISS_A:

15-nov-2019

During this test session the OP30 (Single Point Acquisition) and OP31 (Diagnostic) were executed. Both procedures were carried out without drill movement (Acquisition type A), and with the instrument in thermal vacuum chamber, with the detector for a second time cooled down at 225K, thus this was another "cold case" with respect to the session#1 of October. The OPs were executed without any target in front of the Sapphire Window, thus again only the ghost signal (internal reflection) was observed.

- The OP30 was acquired with one integration time, t=1 ms; here the automatic dark subtraction by MMS-SW did not give any artifact, likely due to the operation of detector at nominal (cold) temperature.
- The OP31 was executed with two different integration times, t=0.5, 1 ms. All diagnostics were acquired with the lamp switched on. In the first OP31 (0.5 ms) all 51 acquisitions have been correctly executed and recorded; in the second OP31 (1 ms) only 16 acquisitions from the detector scan have been executed.

OP30

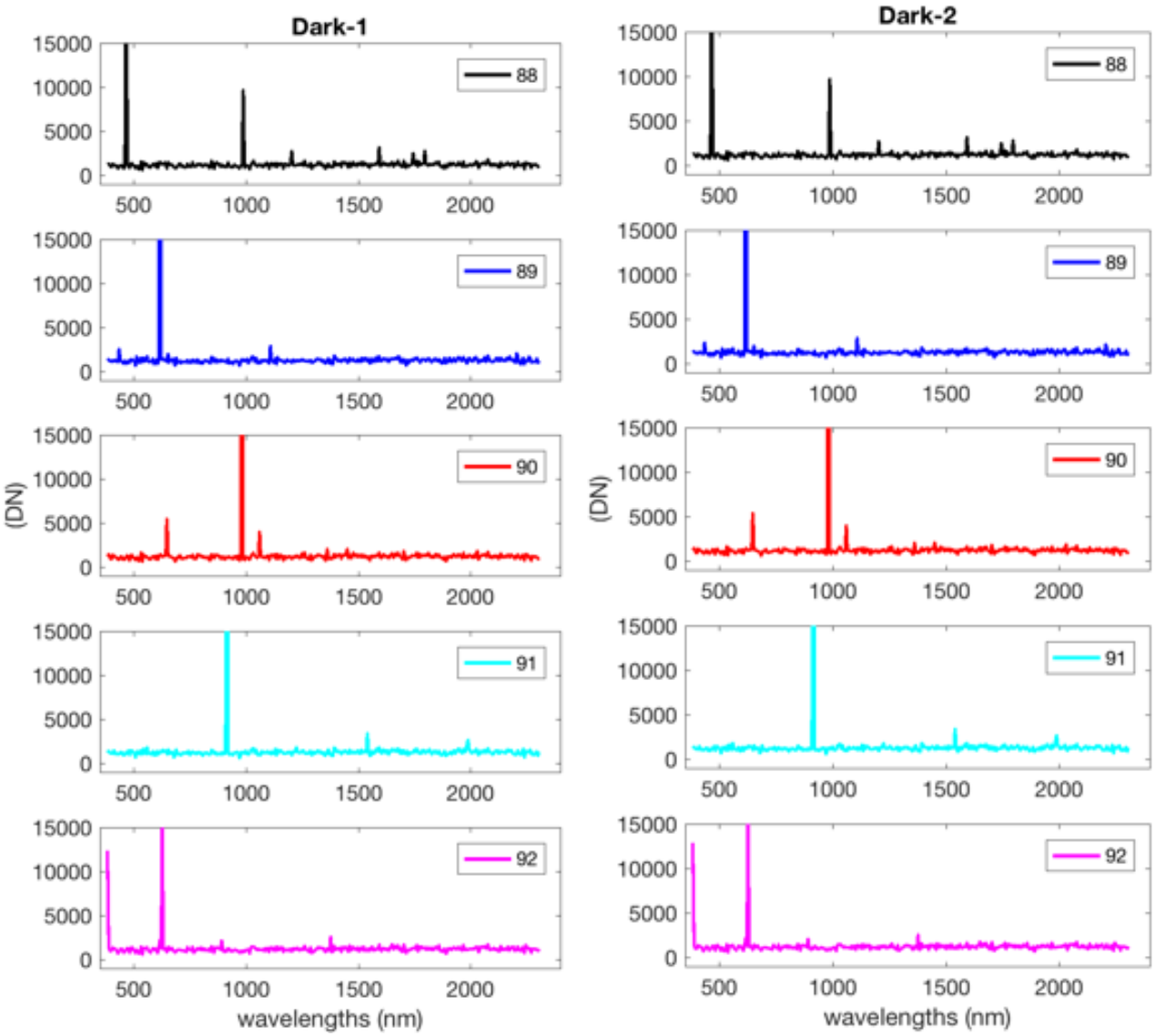


Fig.32. OP30 acquired during Session#3. Dark#1 (left) and dark#2 (right), both with integration time = 1ms.

OP30

- Rows 88-91: dark automatically subtracted by the SW-MMS→ the SW artifacts for pixel with signal >65000 DN has disappeared

- Row 92: dark subtracted manually

- t_int = 1 ms

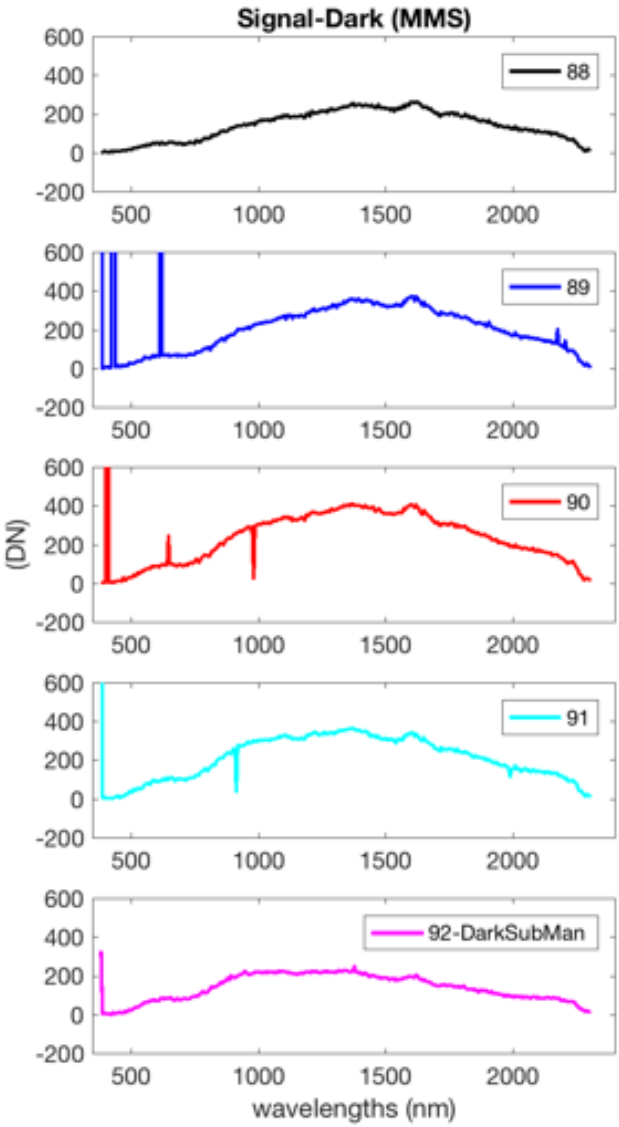


Fig.33. OP30 acquired during Session#3. Signal with dark automatically subtracted by the MMS-SW.

OP30

- Rows 88-91: dark automatically subtracted by the SW-MMS→ the SW artifacts for pixel with signal >65000 DN has disappeared

- Row 92: dark subtracted manually

- t_int = 1 ms

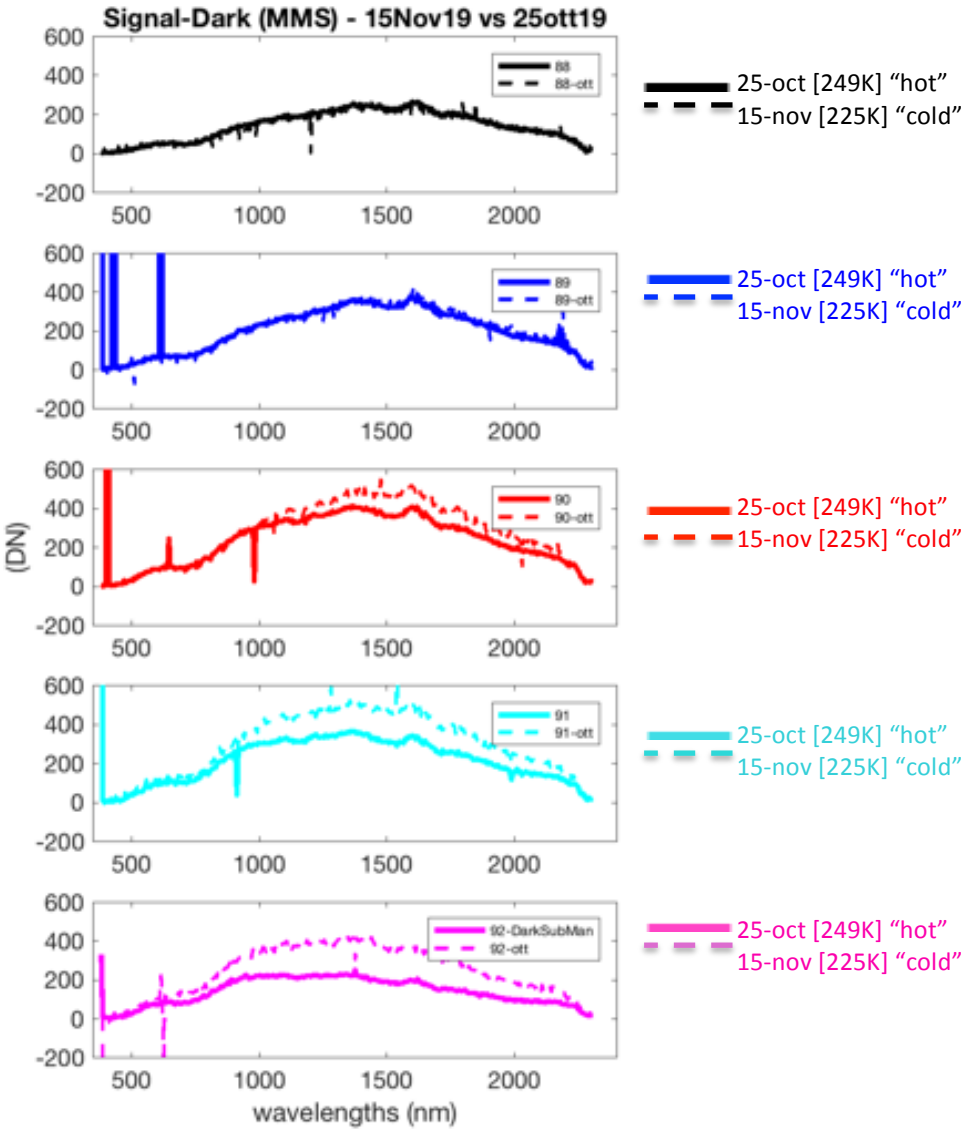


Fig.34. OP30 acquired during Session#3 (15-nov-19, "cold"). Comparison with OP30 acquired during session#1 (25-oct-19, "hot").

OP31

The OP31 was executed with two different integration times, t=0.5, 1 ms. All diagnostics were acquired with the lamp switched on. In the first OP31 (0.5 ms) all 51 acquisitions have been correctly executed and recorded; in the second OP31 (1 ms) only 16 acquisitions from the detector scan have been executed, thus this is a partial scan.

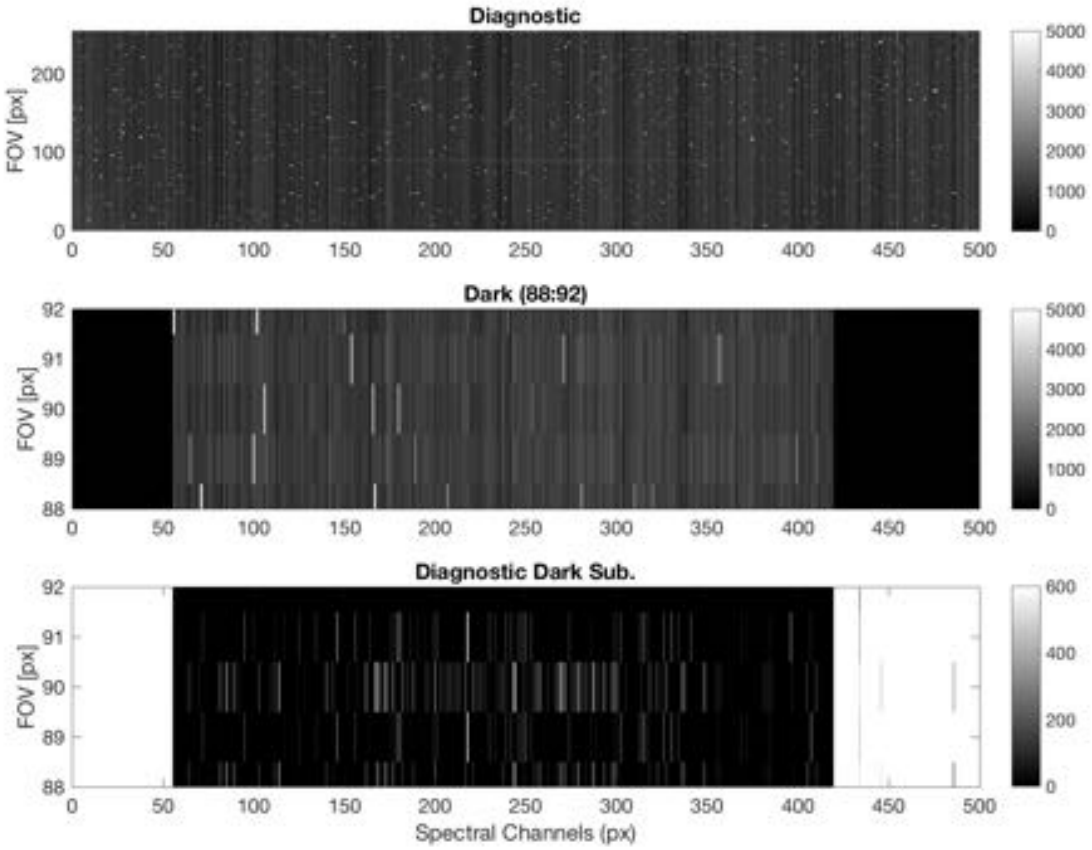


Fig.35. OP31 acquired during Session#3 (15-nov-19, "cold"), with 0.5 ms. Top panel: the raw signal, in which the illumination spot on the detector is visible at around the row 90. Central panel: dark#2 from OP30. Bottom panel: diagnostic signal (rows 88-92) with dark subtracted. Even in this case the subtraction of dark from OP30 results in very noisy data.

4_TVAC-HotCase_GN2-Ma_MISS_A:

16-nov-2019

During this test session the OP30 (Single Point Acquisition) and OP31 (Diagnostic) were executed. Both procedures were carried out without drill movement (Acquisition type A), and with the instrument ouside the thermal vacuum chamber, with the detector at 249K, thus this was another “hot case” (similarly to October). The OPs were executed without any target in front of the Sapphire Window, thus again only the ghost signal (internal reflection) was observed.

- The OP30 was acquired with one integration time, t=1 ms; here the automatic dark subtraction by MMS-SW again gave artifacts, likely due to the operation of detector at not-nominal (hot) temperature, thus it was necessary to apply the algorithm for the correction of data before of dark subtraction, as in the Session#1 (25-Oct-19).
- The OP31 was executed with two different integration times, t=0.5, 1 ms. All diagnostics were acquired with the lamp switched on. In the first OP31 (0.5 ms) all 51 acquisitions have been correctly executed and recorded; in the second OP31 (1 ms) for the second time only 16 acquisitions from the detector scan have been executed.

OP30

Here the two dark#1 and dark#2 from OP30 are shown, executed with acquisition time = 1 ms.

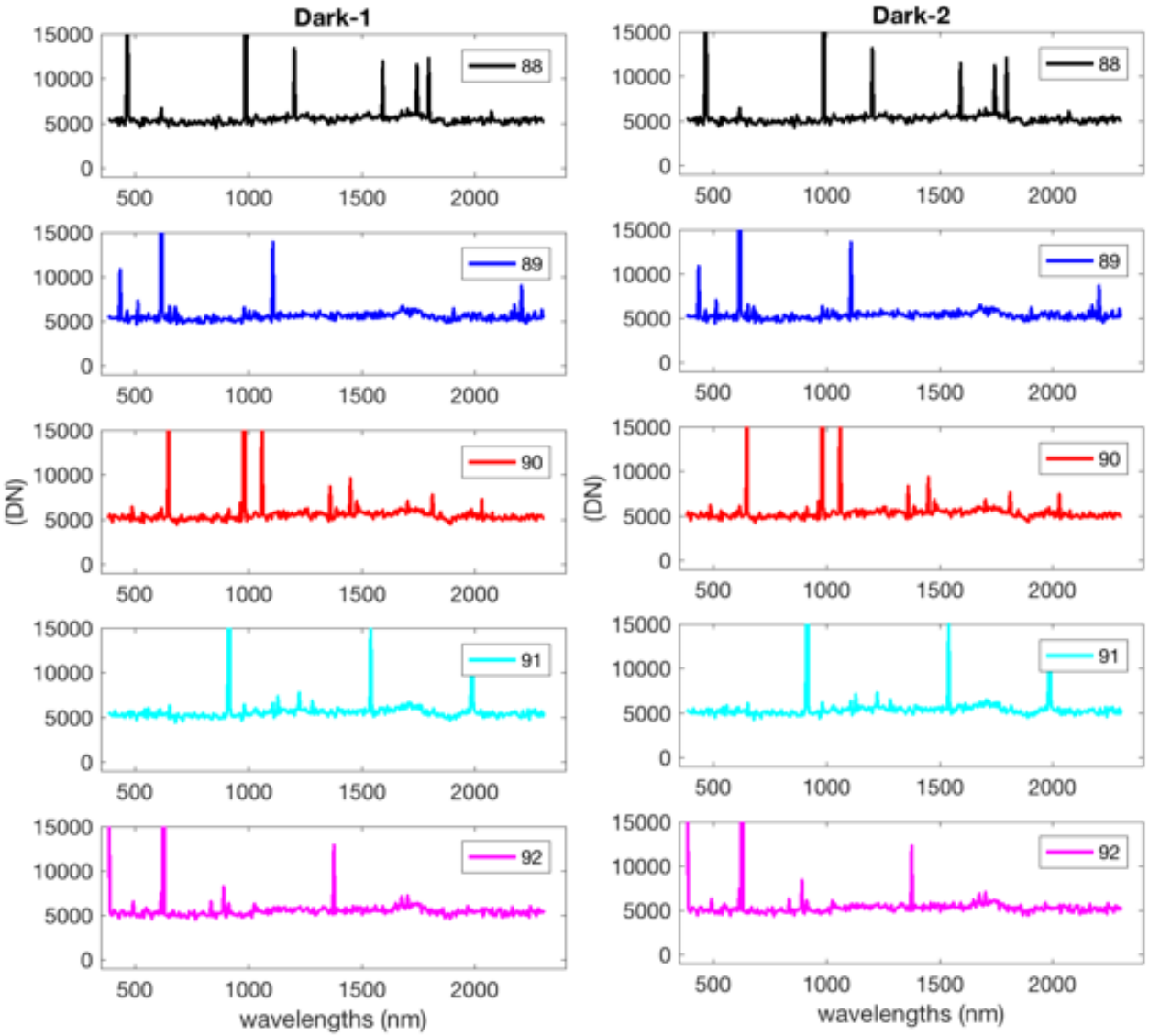


Fig.36. OP30 acquired during Session#4. Dark#1 (left) and dark#2 (right), both with integration time = 1ms.

OP30

Here the signal from OP30 is displayed, executed with acquisition time = 1 ms. The dark subtraction, computed by the MMS-SW, produces the artifacts visible in all rows 88-91, for which the dark subtraction is performed. The application of the Leonardo algorithm for data correction is necessary (see Session#1 and below).

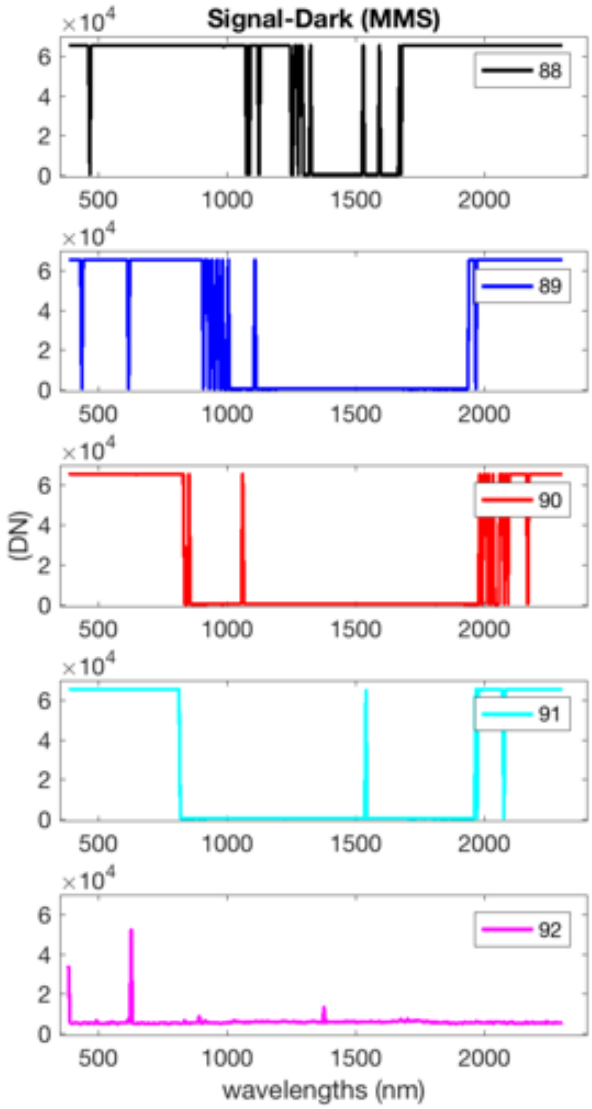


Fig.37. OP30 acquired during Session#4. Signal with dark subtracted by MMS-SW. Artifacts appear on rows 88-91.

OP30

- Here the corrected signal is shown, after application of correction algorithm for pixels with >65000DN and dark#2 subtraction.
- The correct signal is compared with OP30 acquired during Session#1 (Oct) and Session#3 (16-Nov)

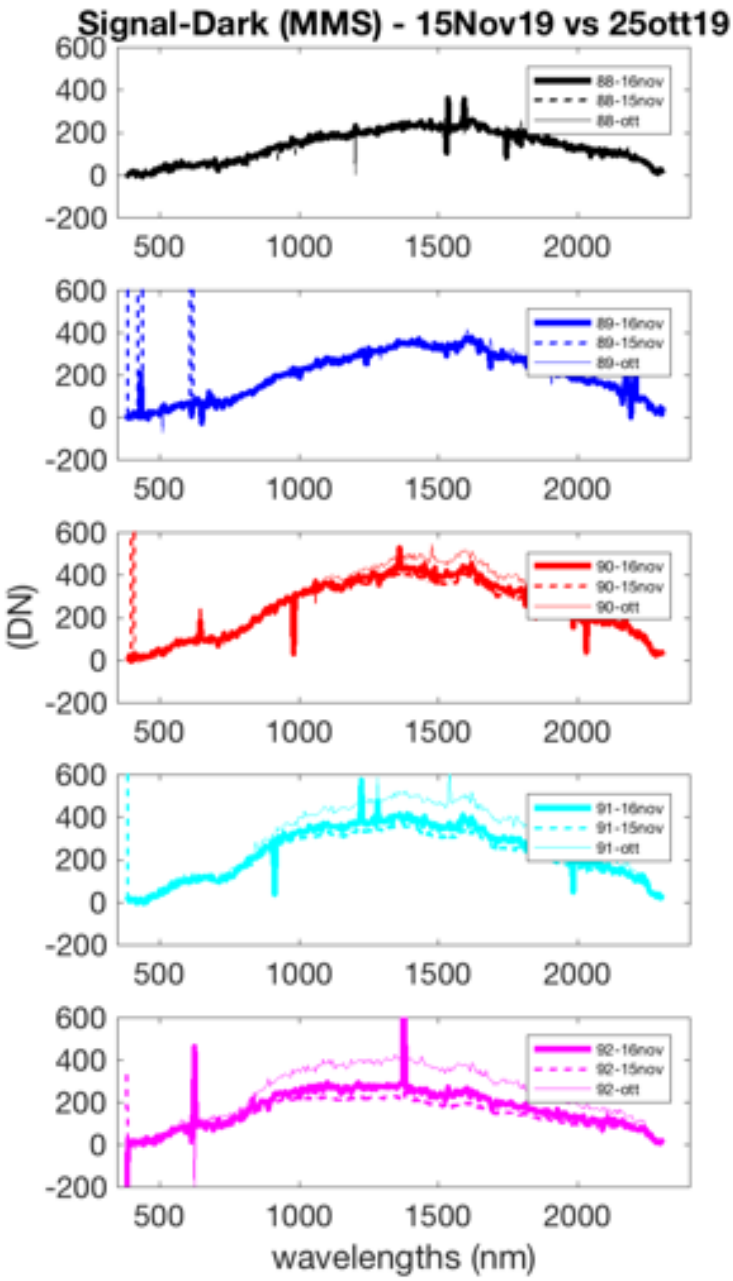


Fig.38. OP30 acquired during Session#4. Signal corrected for dark.

5_EMC-Ma_MISS_C: 13-12-2019

During the Session#5 both acquisition type A (no drill) and type C (with drill movement) were acquired. All operations were executed with the detector temperature at 249K (hot case).

- Acquisition C: executed with drill movement observing the Calibration Target

  The following operations were executed:

  - OP30 (Single Point Acquisition) on the BG20 sector and integration time = 0.5 ms
  - Calibration on the C.T., with 40 pt and integration time = 1 ms
  - Ring with 156 pt and integration time = 1 ms

- Acquisition A: the OP31 (Diagnostic) was executed, with integration time = 1 ms; however this detector scan is partial, because only 12 acquisitions were completed, upon 51 needed to complete the scan.

OP30 – Calibration Target BG20

Here we show the correct signal acquired during the OP30, performed observing the spectral sector BG20 of the calibration target with t = 1 ms. The dark subtraction was computed after data correction by the Leonardo algorithm for pixels with >65000DN.
The signal on the spectral sector BG20 is very low, much lower than what expected for this sector, maybe because of an incorrect positioning on the spectral sector.

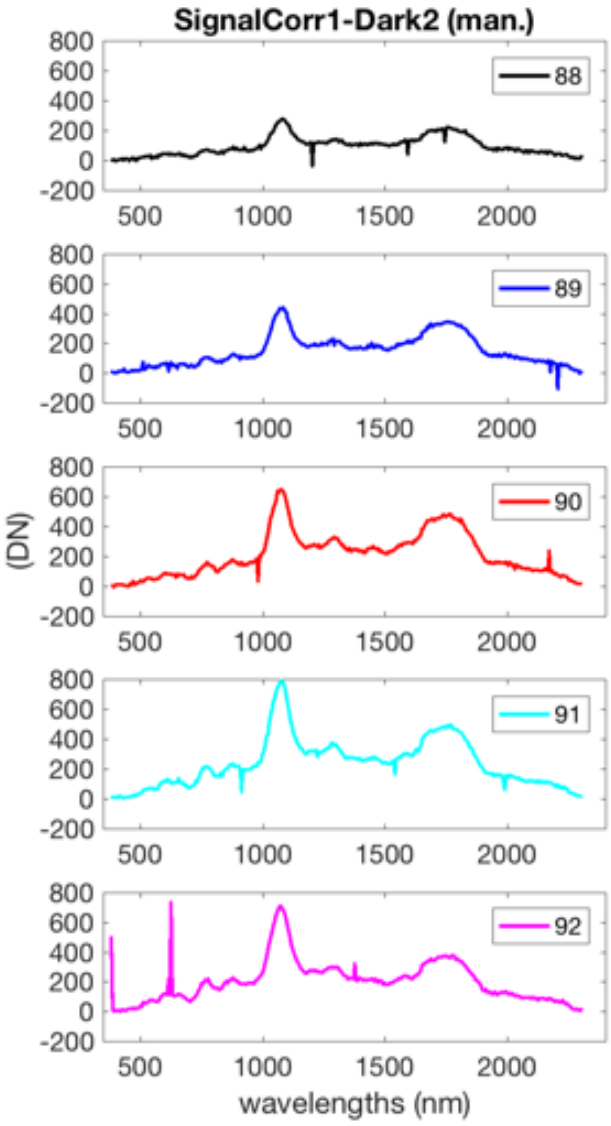


Fig.39. OP30 (Single Point Acquisition) executed on a point on the Calibration Target, spectral sector BG20.

Calibration – C.Target

Here we show the correct signal acquired during the Calibration ring executed on the Calibration Target, performed acquiring 40 equally spaced points the calibration target with t = 1 ms. The dark subtraction was computed after data correction by the Leonardo algorithm for pixels with >65000DN. Here shown is the signal corresponding to the Chrome Sector, which is characterized by the highest number of DN.

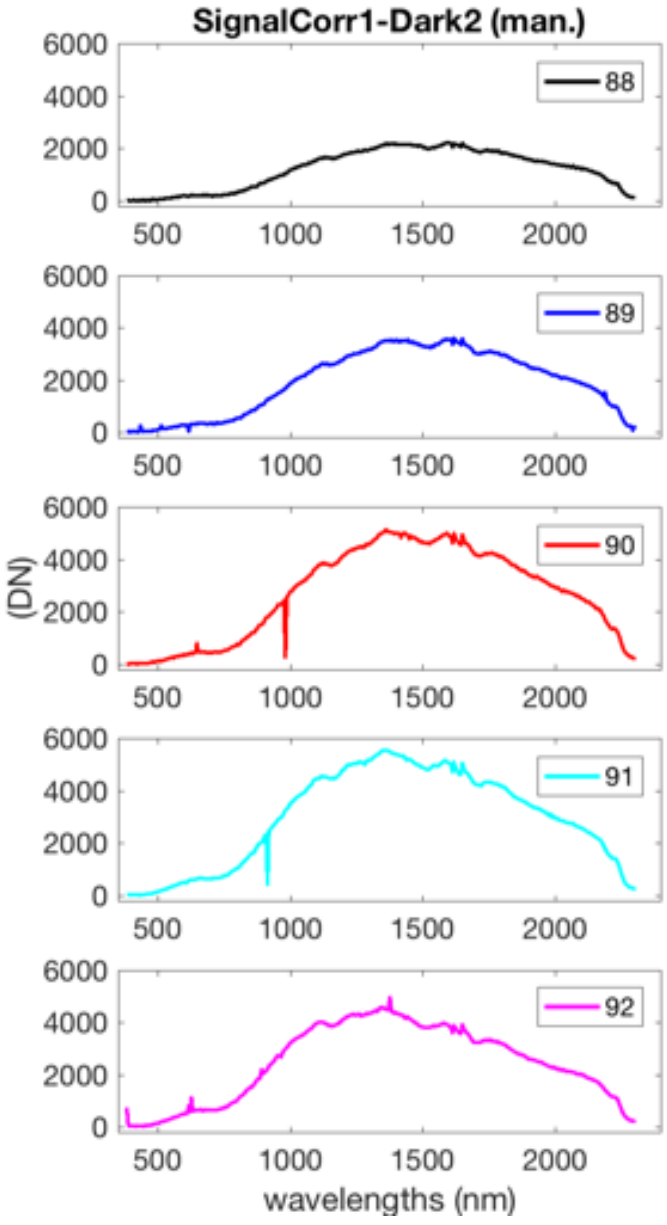


Fig.40. Calibration (40 pt) executed on the Calibration Target. Here is shown the signal on Chrome Sector.

6_Final-SPTandIST-Ma_MISS_A:

26-01-2020

During this test session again only Acquisitions type A were executed (without drill). In particular both the OP30 (Single Point Acquisition) and OP31 (Diagnostic) were executed. Both procedures were carried out with the instrument ouside the thermal vacuum chamber, with the detector at 249K, thus this was another “hot case” (similarly to October). The OPs were executed without any target in front of the Sapphire Window, thus again only the ghost signal (internal reflection) was observed.

- The OP30 was acquired with one integration time, t=1 ms; here the automatic dark subtraction by MMS-SW again gave artifacts, likely due to the operation of detector at not-nominal (hot) temperature, thus it was necessary to apply the algorithm for the correction of data before of dark subtraction, as in the Session#1 (25-Oct-19).
- The OP31 was executed with three different integration times, t=0.5, 1 and 3 ms. All diagnostics were acquired with the lamp switched on.

OP30

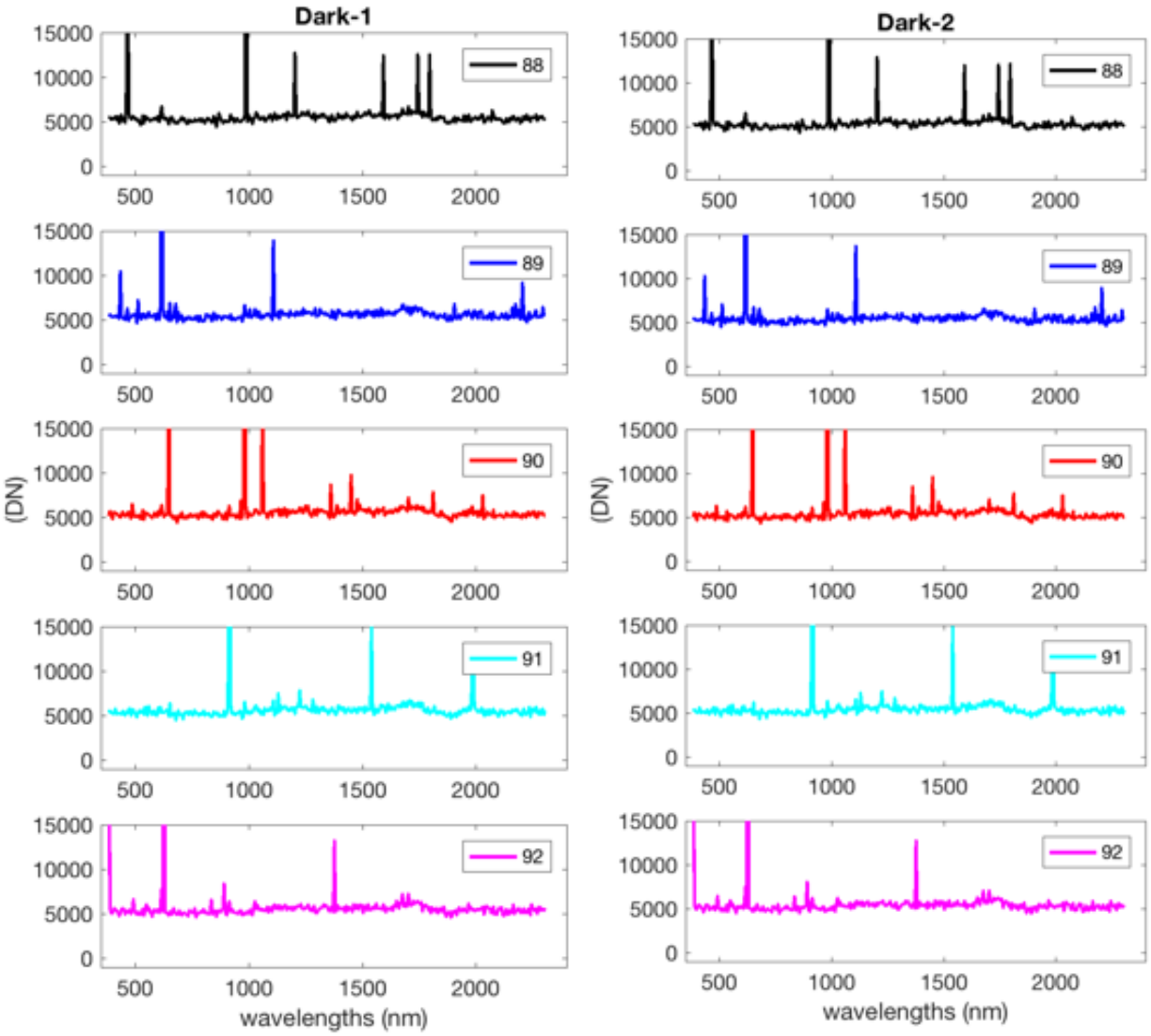


Fig.41. OP30 acquired during Session#6. Dark#1 (left) and dark#2 (right), both with integration time = 1ms.

OP30

Here the signal from OP30 is displayed, executed with acquisition time = 1 ms. The dark subtraction, computed by the MMS-SW, produces the artifacts visible in all rows 88-91, for which the dark subtraction is performed. The application of the Leonardo algorithm for data correction is necessary (see Session#1 and below).

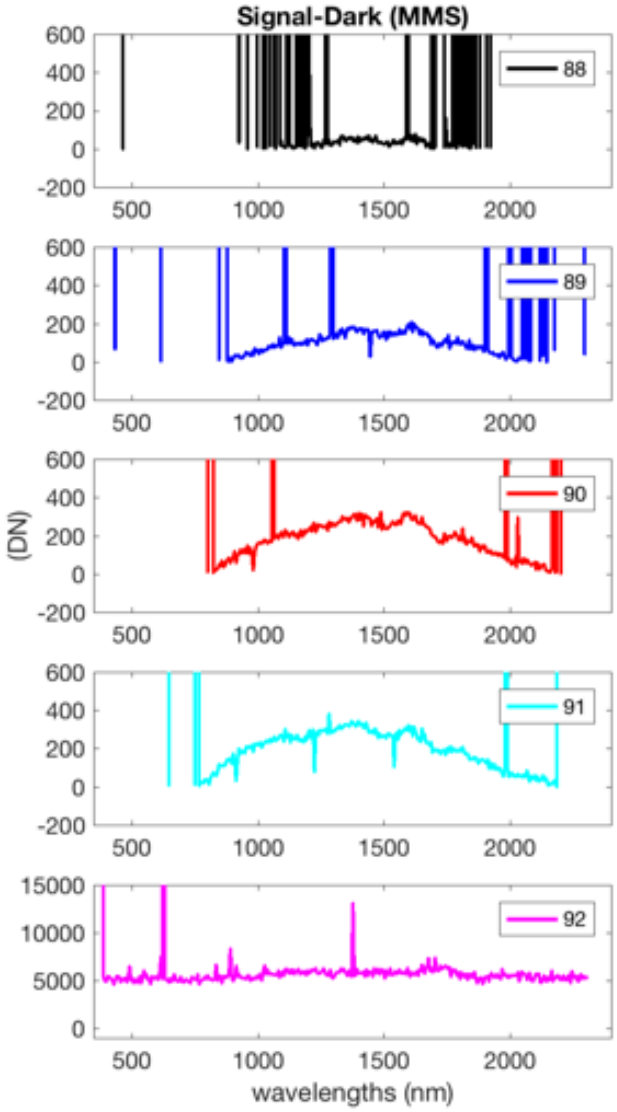


Fig.42. OP30 acquired during Session#6. Signal with dark subtracted by instrument SW, with clear artifacts.

OP30

The correct signal after dark#2 subtraction is shown. The ghost signal is around 400 DN on the central rows and in the center of the spectral range, as expected. By adding the dark#1 and subtracting the dark#2 the resulting offset is zero.

+dark1 –dark2➔offset=0

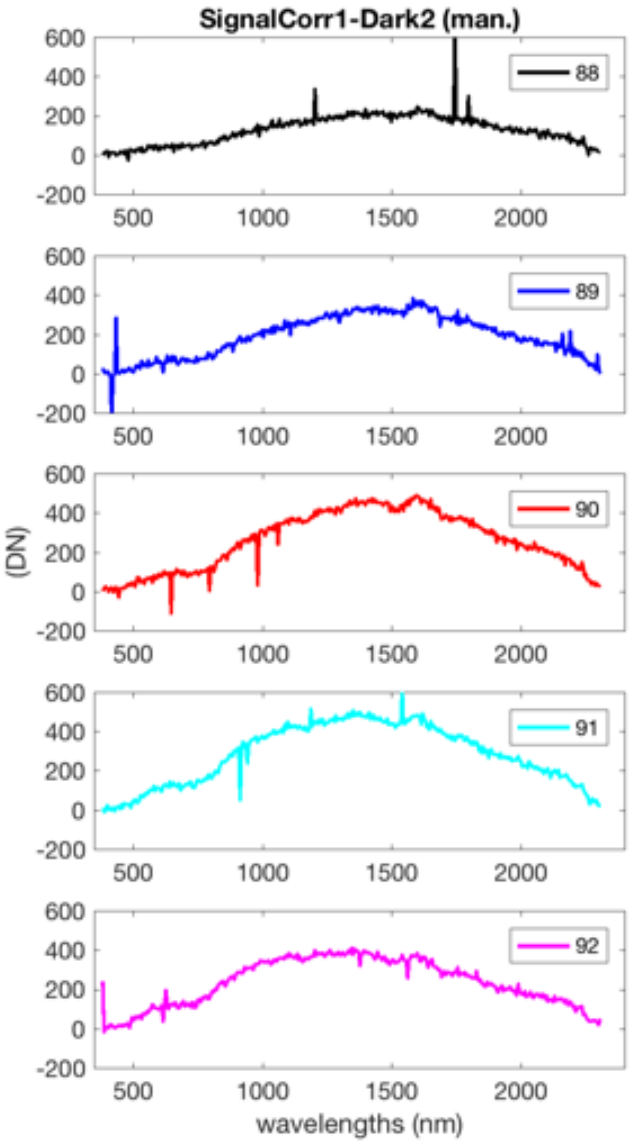


Fig.43. OP30 acquired during Session#6. Signal after correction for dark.

OP30 vs Time

Here we report a comparison between the various OP30 executed during the different test sessions, all after correction for dark. The spectral profile is as expected for the ghost signal with 1 ms, and the level of DN is quite consistent, although in two sessions (#1 and #7) the signal was higher (nearly twice on row92).

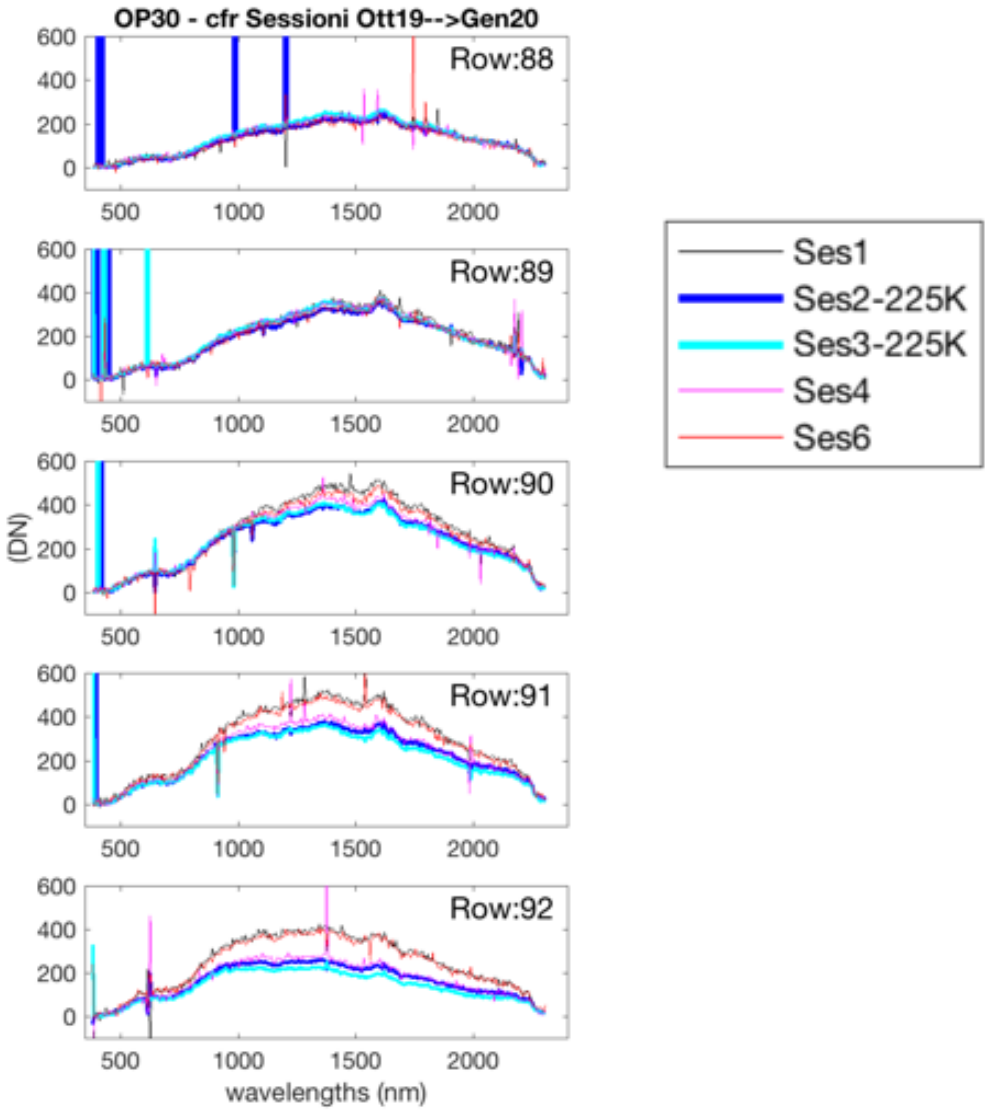


Fig.44. OP30 after dark correction; comparison between different sessions.

OP30 vs Time - GHOST – HKs

The housekeepings relative to the five OP30 shown are reported in table below. The only difference, apart from the two acquisitions executed with detector in cold conditions (#2 & #3) appears in the PE temperature and drill temperatures 1&2. Anyway this should not justify an increase in the signal level as seen on several rows in the Sessions #1 & #6.

Session	T_{DET}(K)	T_{PE}(K)	Lamp A	Lamp V	t_{exp}(ms)	Drill Transl	Drill Rot (#rev)	Drill Temp1	Drill Temp2	N_{AVG}
#1	249.46	301.95	0.96	5.62	1	0	0	295.87	295.25	128
#2	225.07	264.13	0.96	5.75	1	0	0	264.76	260.76	128
#3	224.97	247.66	0.96	5.65	1	0	0	243.51	261.07	128
#4	249.41	294.02	0.96	5.63	1	-0.09	0	289.09	287.24	128
#6	249.46	307.44	0.97	5.65	1	0	0	298.02	297.71	128

OP31

Here the Diagnostic operations acquired with three different integration times are shown. The signal is still raw. The dark subtraction (by using dark from OP30) again produces the well known artifacts.

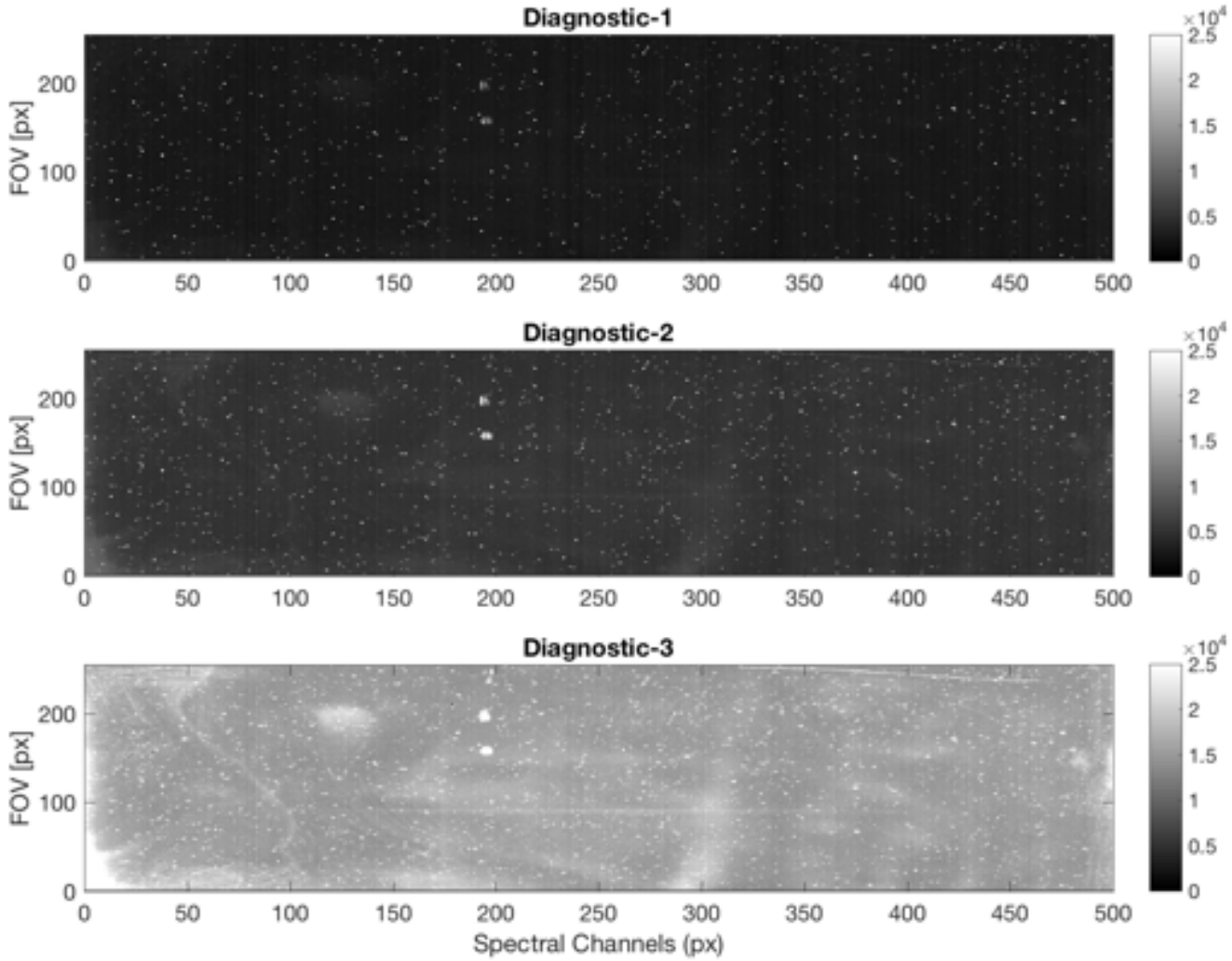


Fig.45. Three OP31 (Diagnostic) acquired during Session#6, with three integration times. Top: 0.5 ms. Center: 1 ms. Bottom: 3 ms.

OP31

The diagnostic signal on the rows 87-91 (acquisition package 18) is shown; signal at different integration times are compared on the same.

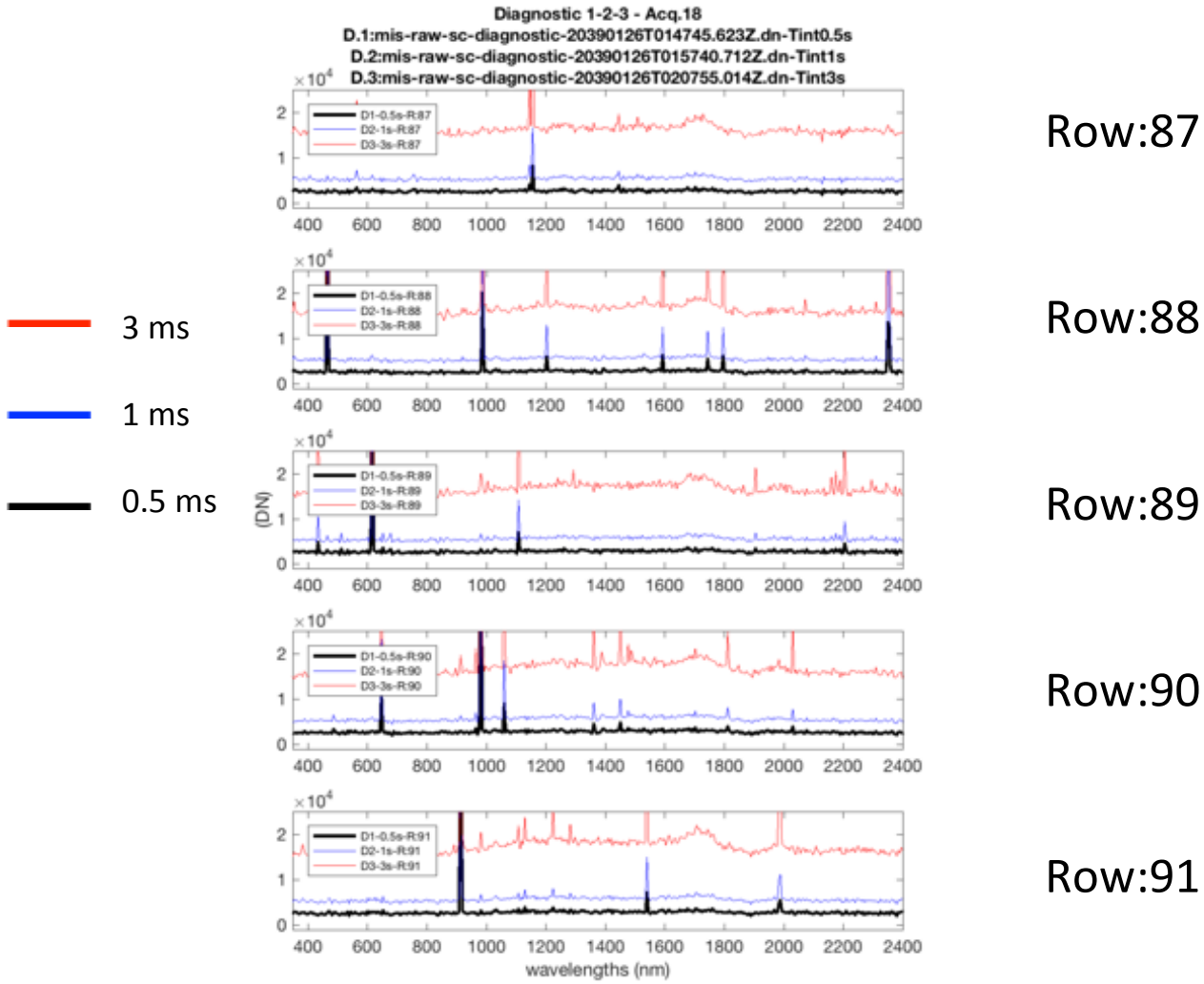


Fig.46. Uncorrected signal from OP31 (Diagnostic) acquired during Session#6, with three integration times, compared on each row.

OP31 – dark subtraction

We tried to subtract the dark#2 from OP30 to the OP31 signal, on rows 88-92. As expected from all other tests performed, the dark subtraction results in very noisy data, although with the recognizable spectral profile typical of ghost, on rows 88-91. We were able to perform such computing only with the OP31 measured with integration time of 1 ms, in order to use a dark acquired with the same integration time.

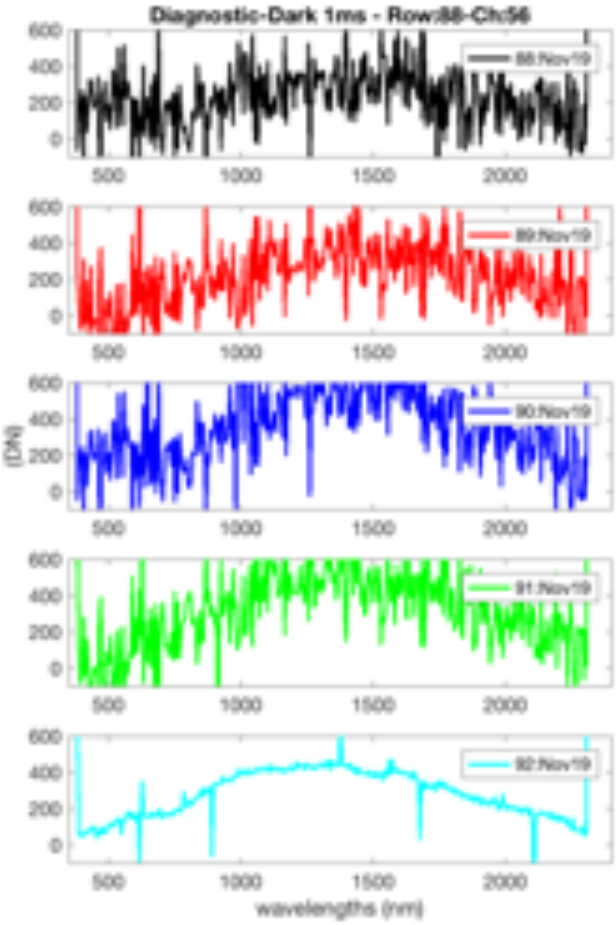
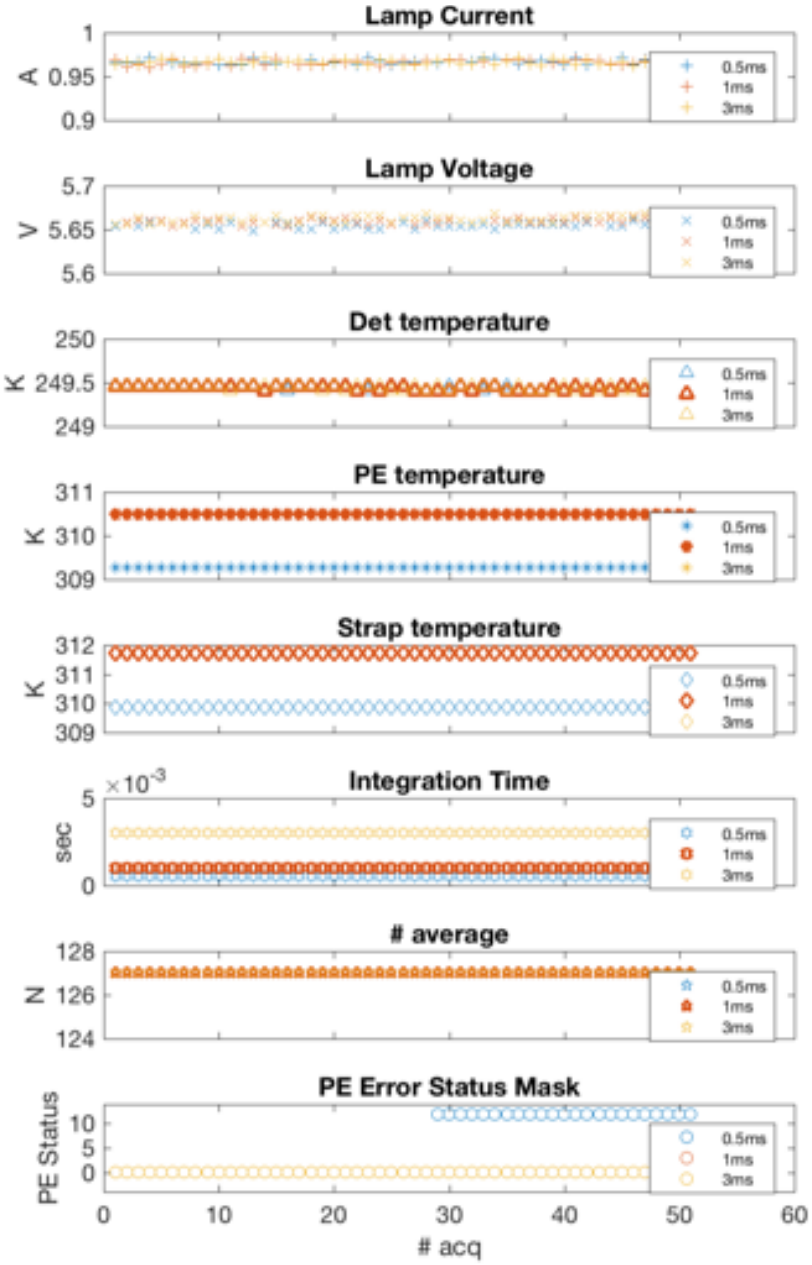


Fig.47. Corrected signal from OP31 (Diagnostic) acquired during Session#6. Dark subtraction has been performed using data from OP30 and 1 ms integration time.

OP31 – Housekeepings

The main HKs corresponding to the three OP31 acquired are shown.



- T_{DET} = 249K
- PE Error Status Mask: value 0x0C = 12 from acq. 29-51 only in Diagn.1 (0.5 ms) [➔ *this also occurred during the session#2, 07-11-2019*]
- *wrong DU_DATA_VALID signal* [from EXM-RM-RSP-GAM-0030]

Fig.48. A selection of HKs corresponding to the three diagnostics executed.

7_2020_10_16: 16-10-2020

During this last test session only Acquisitions type A were executed (without drill). Both the OP30 (Single Point Acquisition) and OP31 (Diagnostic) were executed. Procedures were carried out with the instrument ouside the thermal vacuum chamber, with the detector at 249K. The OPs were executed without any target in front of the Sapphire Window, so only the ghost signal was measured.

- The OP30 was acquired with two integration times, t=1, 3 ms; here the automatic dark subtraction by MMS-SW again gave artifacts, likely due to the operation of detector at not-nominal (hot) temperature, thus it was necessary to apply the algorithm for the correction of data before of dark subtraction, as in the Session#1 (25-Oct-19).
- The OP31 was executed with two different integration times, t=0.5 and 3 ms. Each diagnostic was executed with both lamp ON and OFF. This allowed to correct data for dark subtraction by using a dark acquired with identical experimental and SW conditions (i.e. OP31 dark).

OP31

Here the image of the detector acquired with the first diagnostic with integration time 1 ms is shown. Top panel, image with lamp switched on. Central panel, lamp switched off (OP31 dark). Bottom panel, image after correction for dark subtraction. The illumination spot by the lamp is clear around row 90.

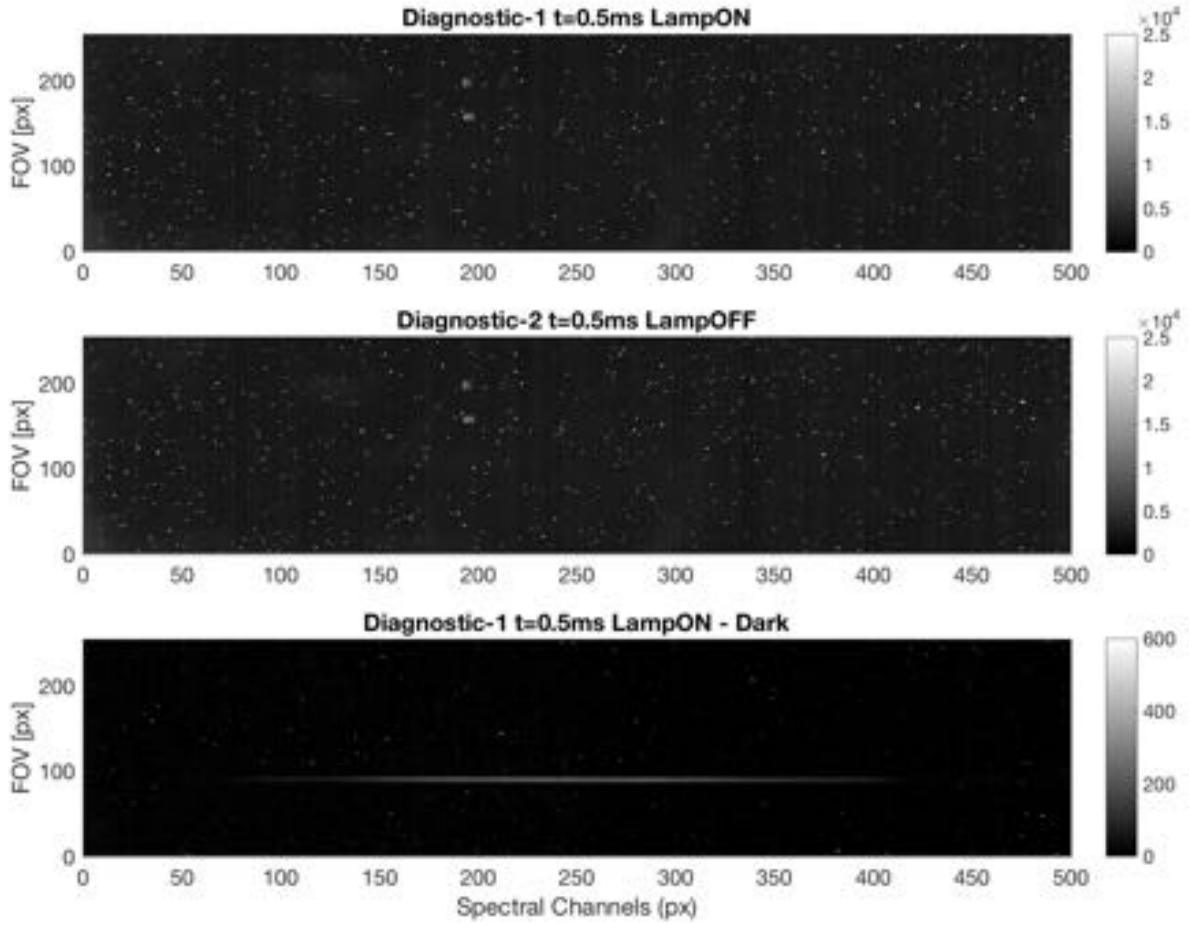


Fig.49. Diagnostic executed with integration time of 1 ms.

OP31

The second diagnostic with integration time 3 ms is shown (image of the detector). Top panel, image with lamp switched on. Central panel, lamp switched off (OP31 dark). Bottom panel, image after correction for dark subtraction.

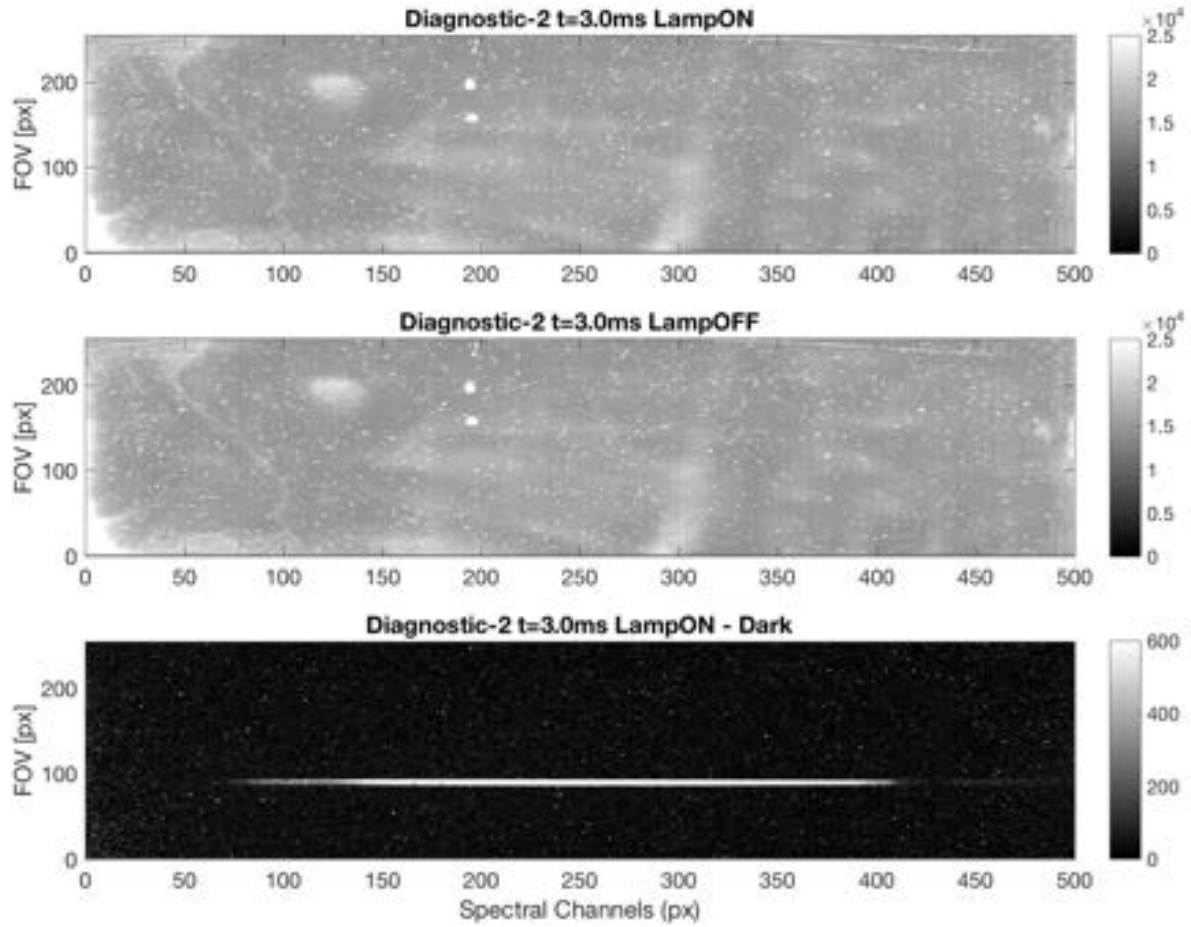


Fig.50. Diagnostic executed with integration time of 3 ms.

OP31 – Dark subtraction

The diagnostic signal on rows 88-92 after correction for dark is shown. Here we were able to use the dark acquired with the OP31 keeping the lamp off (OP31 dark). This time the corrected data, contrary to the other sessions, are characterized by low noise and the ghost spectral profile is clearly recognizable. The (correct) signal measured with integration time 3 ms is roughly six times the signal measured with 0.5 ms (200DN vs >1200DN).

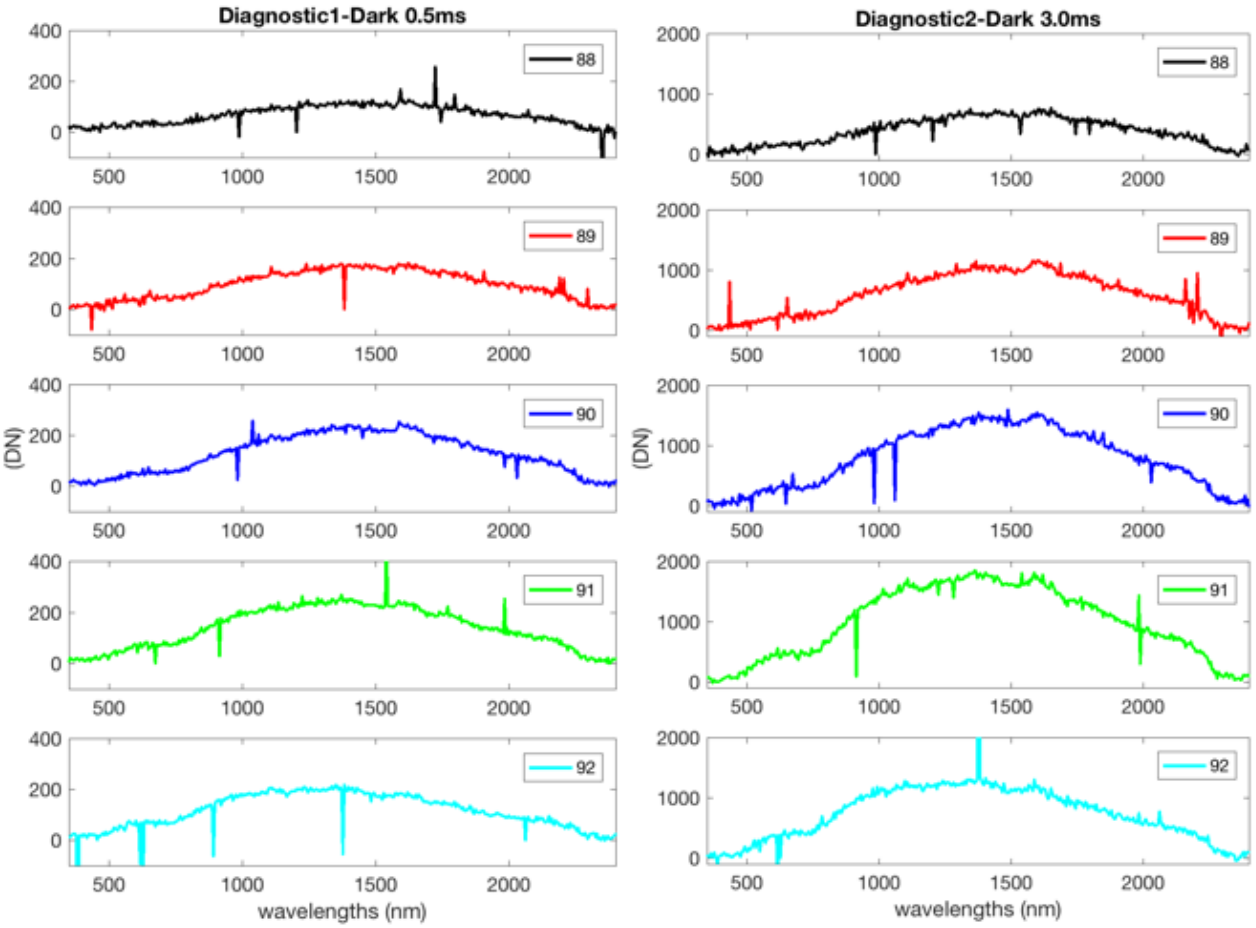


Fig.51. Spectral profile on rows 88-92 acquired with OP31 at two different integration times, after dark subtraction.

OP30 – Dark

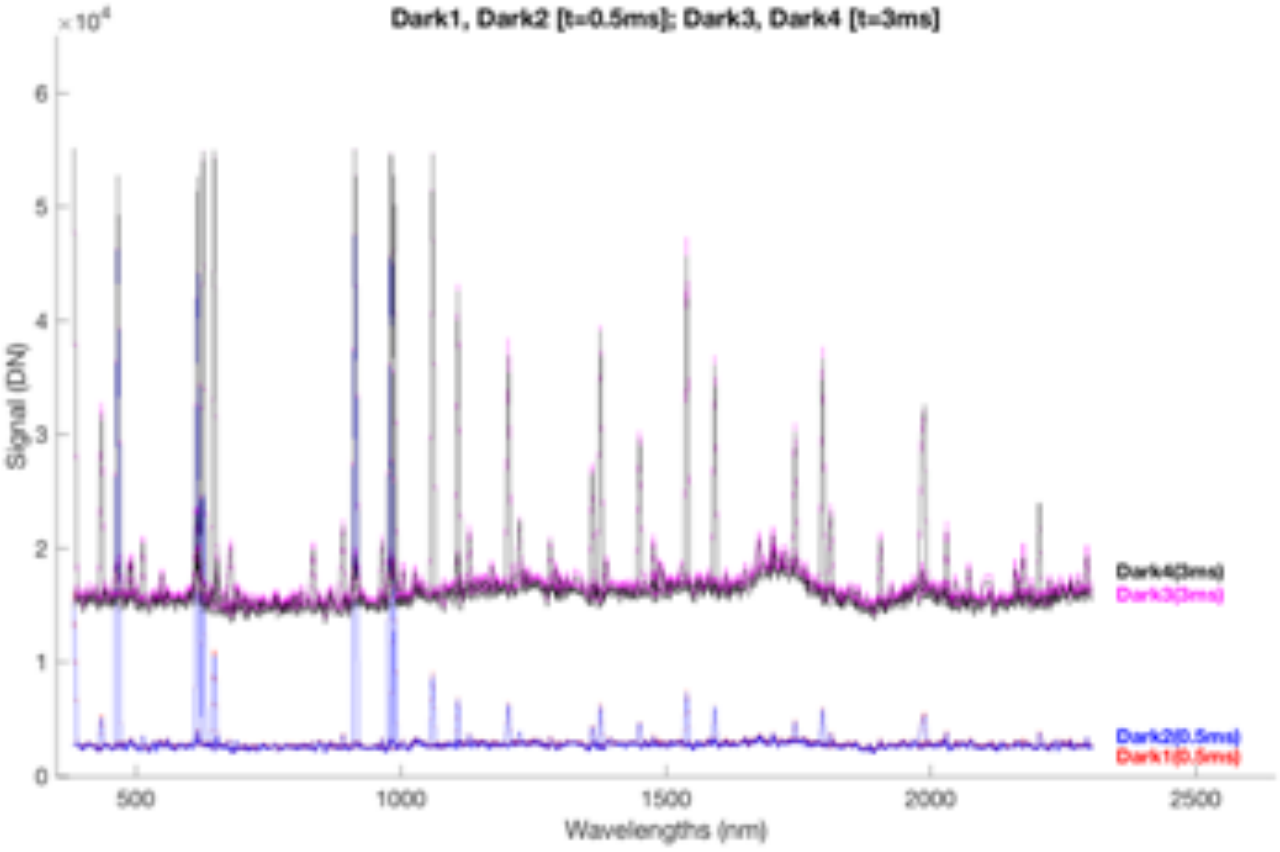


Fig.51. Spectral profile (dark) on rows 88-92 acquired with OP30 at two different integration times.

OP30 – Dark subtraction

The OP30 spectral profiles on rows 88-92 after dark subtraction are shown. Top panel: signal with integration time 0.5 ms. Bottom panel: signal with 3 ms.

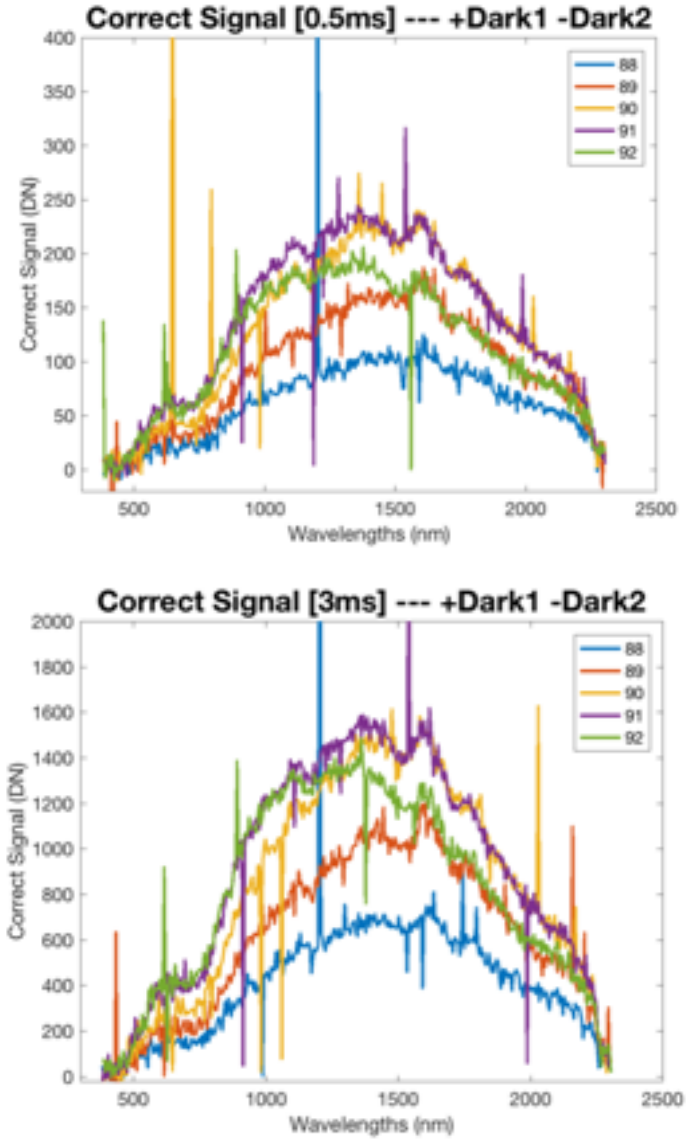


Fig.52. Spectral profile (lamp on) on rows 88-92 acquired with OP30 at two different integration times, after correction.

6. Conclusions

Acquisition type A: without Drill

- Executed **OP30** (*Single Point Acquisition*) in 7 test sessions, with different integration times (0.5, 1 & 3 ms)
- Data processing: the **dark subtraction** is automatically performed by the instrument SW; the signal with subtracted dark is provided, together with two files with dark (for each OP30)
- In the cases in which the detector is at **nominal temperature** (cold = 225K) the dark subtraction is made correctly [Session#2, 7/11/19 and Session#3, 15/11/19]
- In the cases in which the detector is at **high temperature** (hot = 249K, Sessions #1, #4, #5, #6, #7) the dark subtraction produces some artifacts in pixels with signal >65000DN → an **algorithm** of **data correction must be applied** and subsequently the dark#2 must be subtracted in post-processing.

- Executed **OP31** (*Diagnostic*) in 7 test sessions, with different integration times (0.5, 1 & 3 ms)
- The diagnostic permits to perform a complet scan of the detector, allowing to make a check of the detector window status
- Data processing: the **dark subtraction** must be computed by the user in post-processing. In all the tests performed, except for the session#7 (Oct-2020) the diagnostic was alway executed with lamp on, without a corresponding OP31 with lamp off (OP31 *dark*). The use of the dark acquired in OP30 for the data correction revealed unopportune, because the characteristics of the different SW modes of acquisition (between OP30 and complet scan) resulted in final data too much noisy
- The correct dark subtraction is possible with the tests performed during the Session#7 (Oct-2020), when **Diagnostics with lamp ON/OFF have been executed.**
- **Other OPs still should be tested**

Acquisition type C: +Drill

- Executed **OP30** (*Single Point Acquisition*) in 1 test session (13/12/19), with different integration times (0.5 & 1 ms)
- The **Calibration Target** was used
- OP30 executed on the spectral sector BG20 with integration time = 0.5 ms
- **Calibration** executed on the C.T., with 40 pt and 1 ms
- **Ring** executed on the C.T., with 156 pt and 1 ms
- **Column**: MISSING