PDS/SBN Rosetta Review
VIRTIS

S. Protopapa

6-11 October 2017

Instrument

The VIRTIS (Visible Infra Red Thermal Imaging Spectrometer) instrument combines a double capability: (1) high-resolution visible and infrared imaging in the 0.25-5 micron range at moderate spectral resolution (VIRTIS-M channel) and (2) high-resolution spectroscopy in the 2-5 micron range (VIRTIS-H channel). The two channels will observe the same comet areas in combined modes to take full advantage of their complementarities.

VIRTIS-M (named -M in the following) is characterized by a single optical head consisting of a Shafer telescope combined with an Offner imaging spectrometer and by two two-dimensional FPAs: the VIS (0.25-1 micron) and IR (1-5 micron). VIRTIS-H (-H) is a high-resolution infrared cross-dispersed spectrometer using a prism and a grating. The 2-5 micron spectrum is dispersed in 8 overlapping orders on a focal plane detector array.

Test Case/VIRTIS-M

Detection of exposed H_2O ice on the nucleus of comet 67P/Churyumov-Gerasimenko as observed by Rosetta OSIRIS and VIRTIS instruments

Barucci et al. 2016 A&A 595, A102 (2016)

N.	Observation name	Cube Parameters	Start time (UT)	End time	Phase (deg)	Incidence (deg)	Emission (deg)	Δ (km)	LST (h)	*T* (K)
1	I1_00383518966	432, 256, 158	2015-02-25T21:04:00	2015-02-25T21:30:19	53.02	66.94	41.92	81.51	12.23	203
2	I1_00385906923	432, 256, 70	2015-03-25T12:23:18	2015-03-25T12:46:34	73.49	67.08	45.83	88.23	15.20	197
3	I1_00385885107	432, 256, 70	2015-03-25T06:19:42	2015-03-25T06:42:58	74.47	53.03	31.27	94.06	12.43	218
4	I1_00373462192	432, 256, 86	2014-11-01T11:31:03	2014-11-01T11:45:22	103.07	60.11	43.28	32.39	11.04	168
5	I1_00377182711	432, 256, 80	2014-12-14T12:59:43	2014-12-14T13:13:02	91.77	43.41	52.15	19.44	15.44	188
6	I1_00376302211	432, 256, 80	2014-12-04T08:24:43	2014-12-04T08:38:01	91.07	57.34	70.64	23.49	14.81	179
7	I1_00369356914	432, 256, 109	2014-09-14T23:09:43	2014-09-14T23:45:57	66.89	78.22	30.26	28.16	11.03	163
8	I1_00377184571	432, 256, 74	2014-12-14T13:30:43	2014-12-14T13:43:02	92.66	48.30	54.87	19.92	15.59	158

Notes. For each spot, we report the observations offering the best signal-to-noise conditions with the pixel position (sample and line) reported in Table 4. For each pixel, basic information about observation time, geometry conditions, distance between the Rosetta spacecraft and comet surface (Δ), Local Solar Time (LST), and retrieved temperature (*T*) are given. The integration time is 3 s for all data reported. The cube parameters indicate the size of the acquisition in bands, sample, line dimensions.

stp045/i1_00383518966

data storage for -M channel

Raw file .qub INT = Array[432, 256, 158]
Cal file .cal FLOAT = Array[432, 256, 150]

Raw data form the Visible and the IR FPA are stored in different files as Qube objects, so as to simplify data handling. For each FPA, science data and dark frames are stored in the same file, interleaved in the Qube core, and appear in the order they are transmitted (Fig. 4.2). Dark frames are acquired at intervals given by the DARK_ACQUISITION_RATE parameter and are temporally stored in the QUBE along the scan.

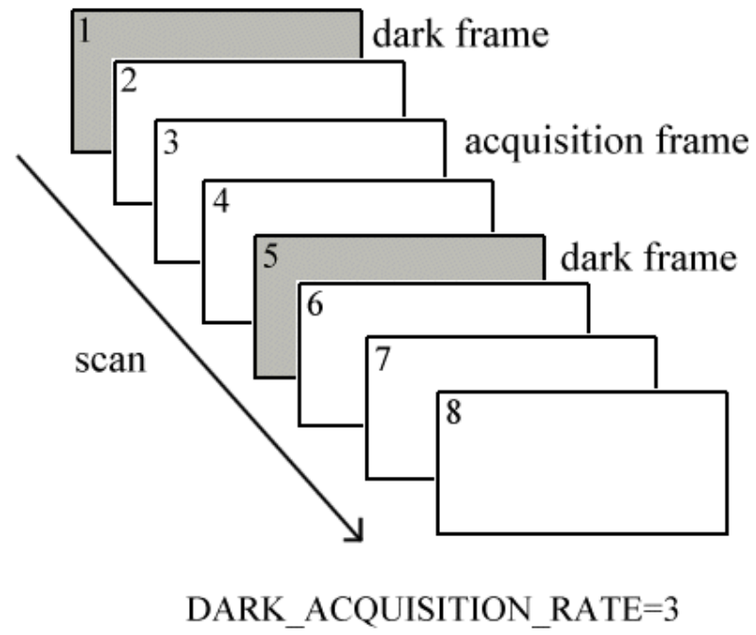
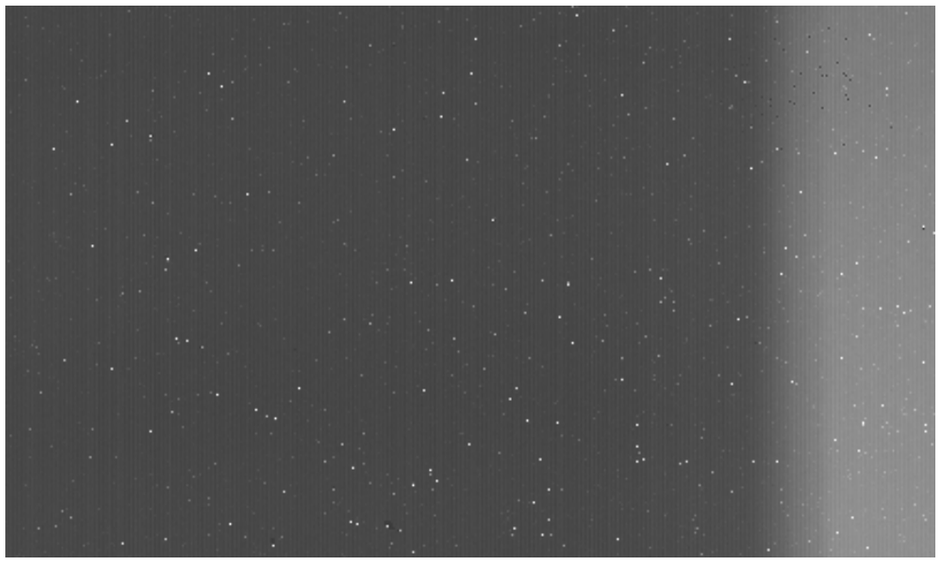
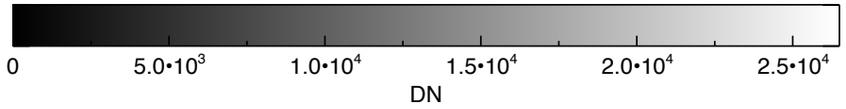


Fig. 4.2 – Structure of dark frames acquisition

The QUBE contains the data calibrated in radiance. Dark frames are removed from the qube, which is therefore smaller than the original raw data qube along the Z/time axis.

data storage for -M channel





dark frame

acquisition frame →

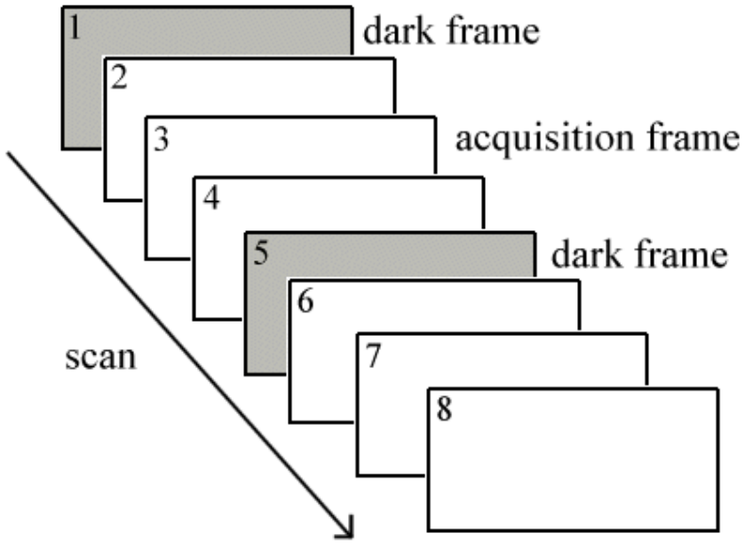
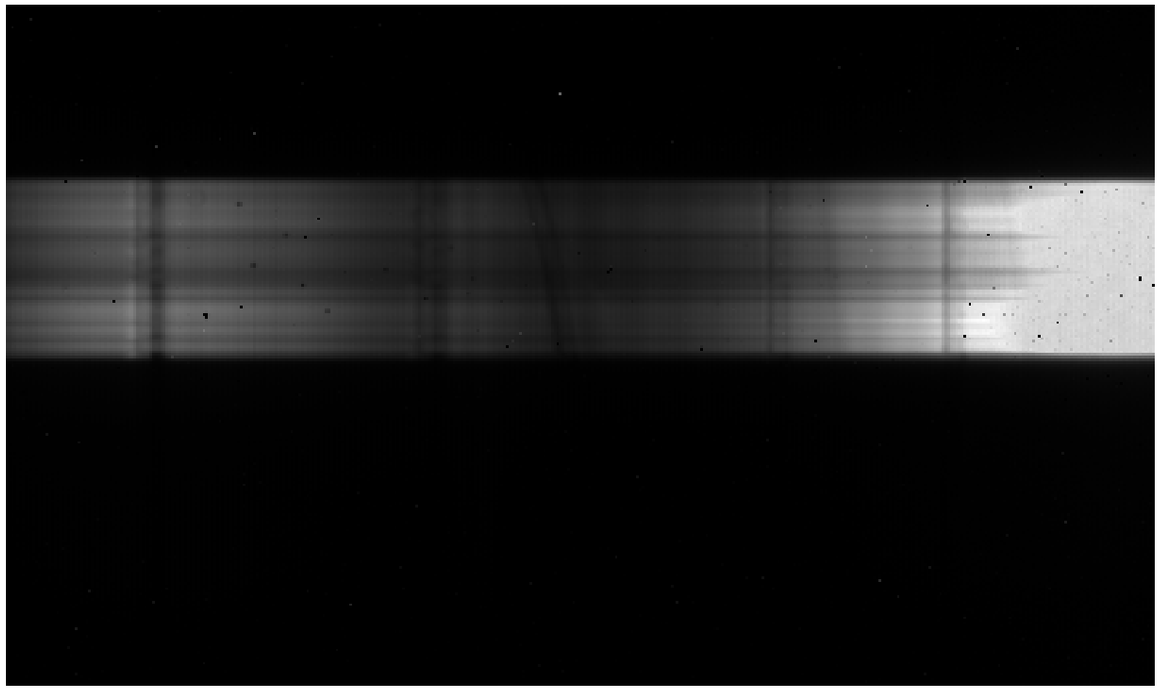
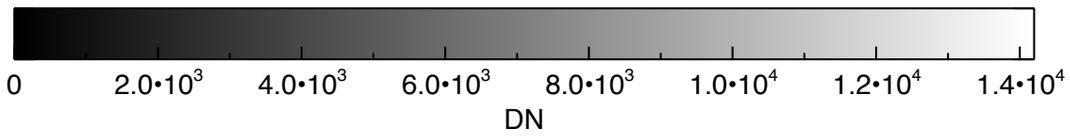


Fig. 4.2 – Structure of dark frames acquisition





data storage for -M channel

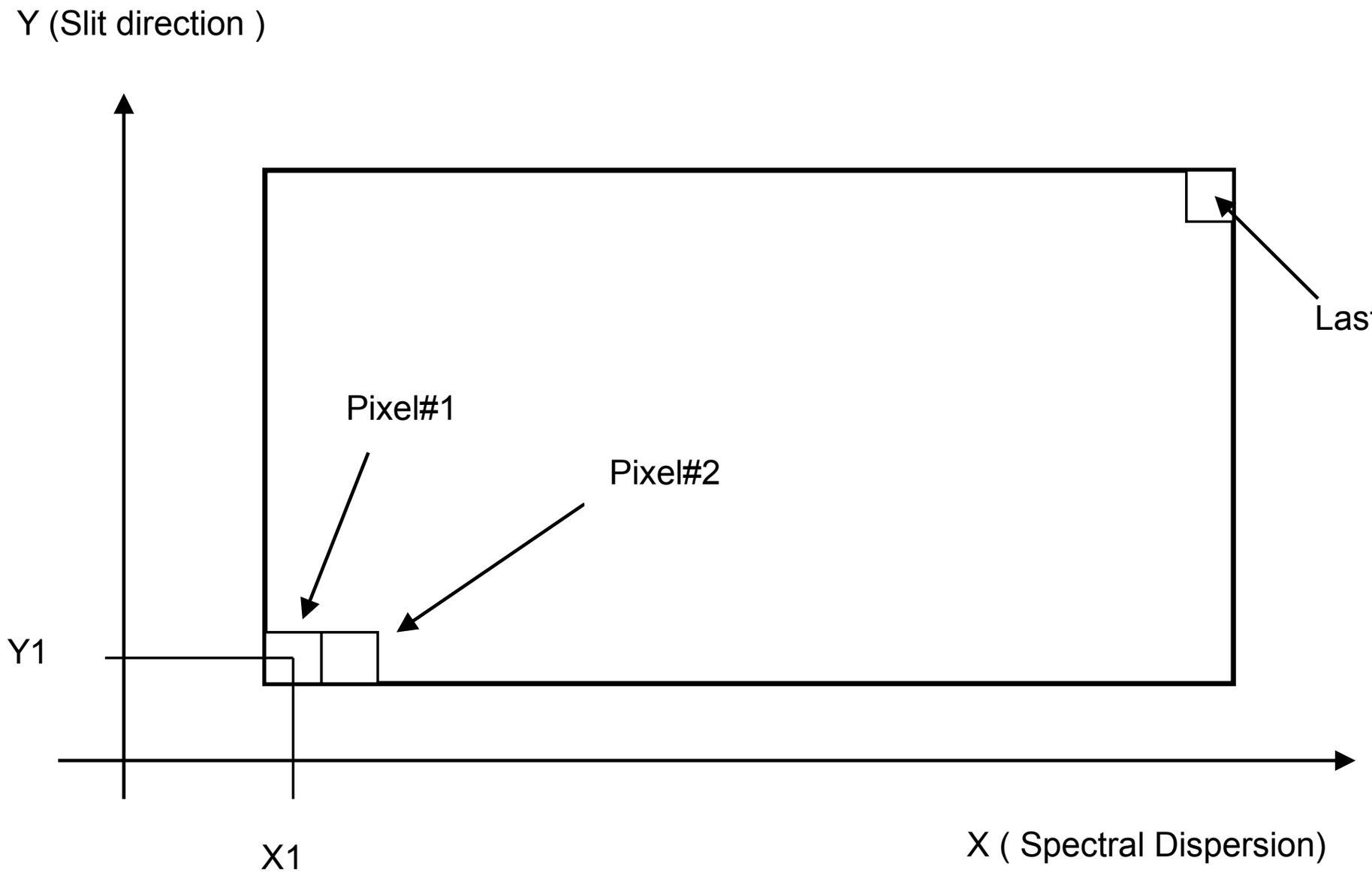


Figure 2.2 Data Organization on the CCD and IR detectors of VIRTIS-M

readpds .cal file

5-Oct-2017 22:27:24 Printed By: **Silvia Protopapa** **Sheet A**

ESA	**Review Item Discrepancy**	**Rosetta EOM Panel:**	**Rosetta_EOM_Science_Panel**

(A) TITLE: readpds .cal file warning **RID No:** Science_Panel-265

ID No: 21343

Orig. Ref.: VIRTIS-US-SP-016 **Originator:** Silvia Protopapa

(B) DATAPACK DOCUMENT:

RO-SGS-PR-1018-App20: VIRTIS Rosetta EOM Science Archive Review Procedure (Issue:1.0)

Page/Section/Para:

(C) DISCREPANCY:

Requirements violated (Datapack Document):

Page/Section/Para:

Description of Discrepancy:

When reading a .cal file using readpds I get the following message ``Warning: empty or malformed HISTORY object."

(D) INITIATOR RECOMMENDED SOLUTION:

Please address

Signature:

(E) PANEL RECOMMENDATIONS:

Status: **Classification:** Major **Signature:**

(F) PANEL CHAIRMAN COORDINATION:

Status: **Group(s):** **Signature:**

readpds .qub file

5-Oct-2017 22:27:04 Printed By: **Silvia Protopapa** **Sheet A**

ESA	Review Item Discrepancy	Rosetta EOM Panel:	Rosetta_EOM_Science_Panel

(A) TITLE: readpds .qub file

RID No: Science_Panel-266

ID No: 21344

Orig. Ref.: VIRTIS-US-SP-017

Originator: Silvia Protopapa

(B) DATAPACK DOCUMENT:

RO-SGS-PR-1018-App20: VIRTIS Rosetta EOM Science Archive Review Procedure (Issue:1.0)

Page/Section/Para:

(C) DISCREPANCY:

Requirements violated (Datapack Document):

Page/Section/Para:

Description of Discrepancy:

When reading a .qub file using readpds I get the following warnings
Warning: empty or malformed HISTORY object.
Warning: invalid SUFFIX_BYTES keyword value found: 2 (must = 4)

(D) INITIATOR RECOMMENDED SOLUTION:

Please address

Signature:

(E) PANEL RECOMMENDATIONS:

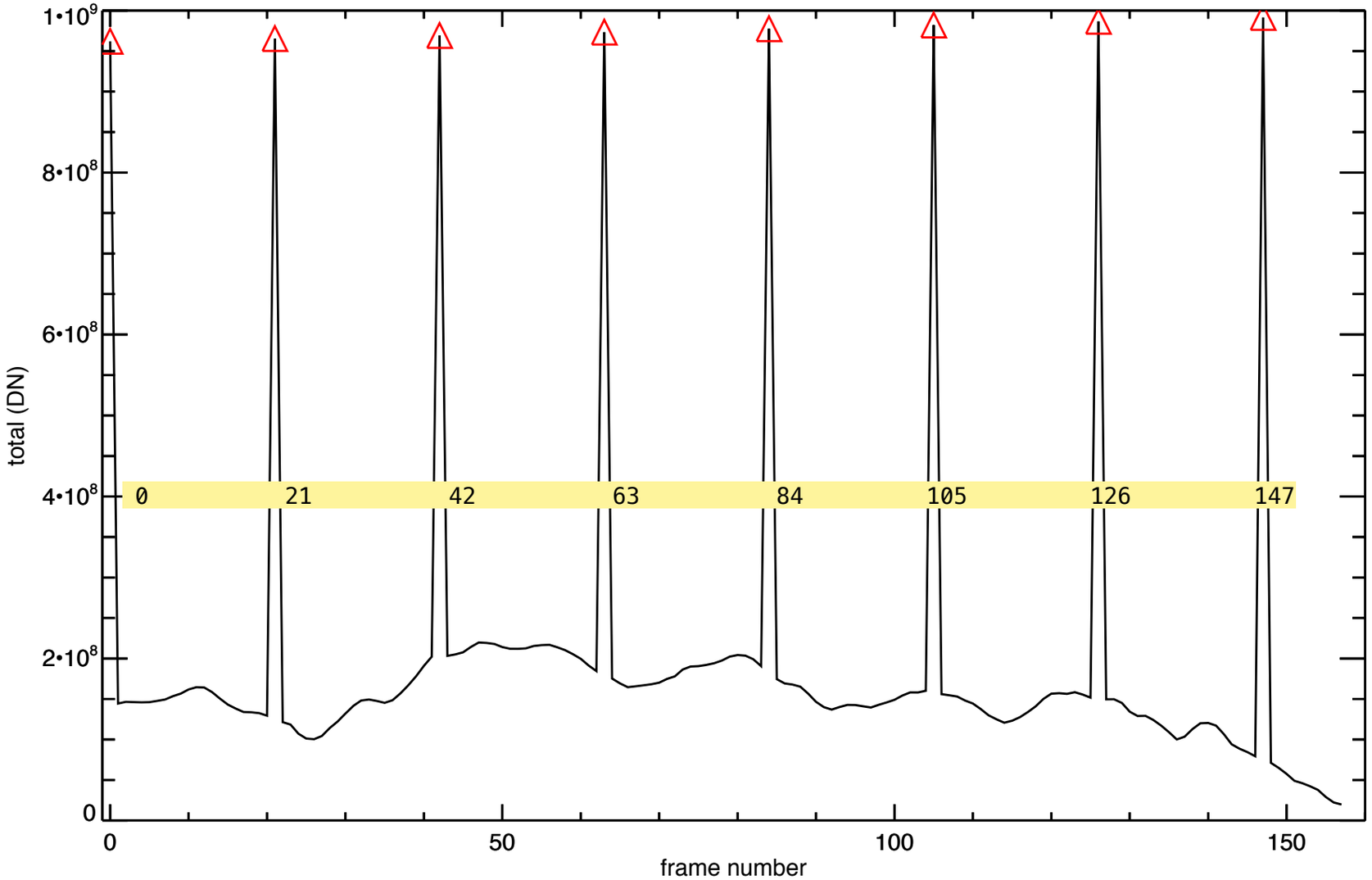
Status: **Classification:** Major **Signature:**

(F) PANEL CHAIRMAN COORDINATION:

Status: **Group(s):** **Signature:**

1. step/reading the data

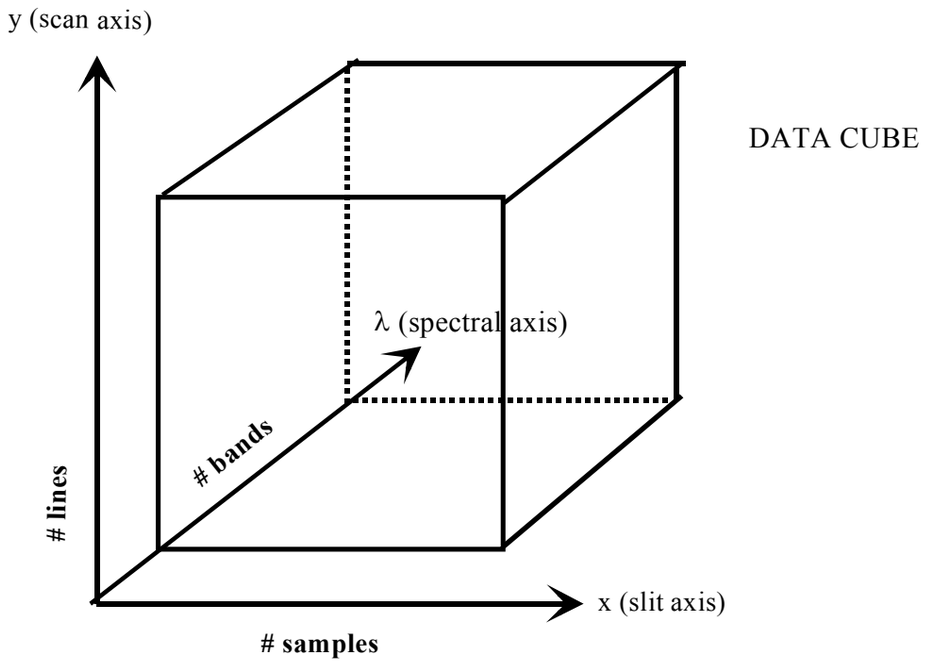
I selected the dark frames in the cube empirically, looking at the total DN per frame. My findings are consistent with the dark_acquisition_rate parameter



Index corresponding to the position of the dark frames in the scan

FRAME_PARAMETER = (3, 1, 10, 20)
FRAME_PARAMETER_DESC = ("EXPOSURE_DURATION", "FRAME_SUMMING", "EXTERNAL_REPETITION_TIME", "DARK_ACQUISITION_RATE")

67P



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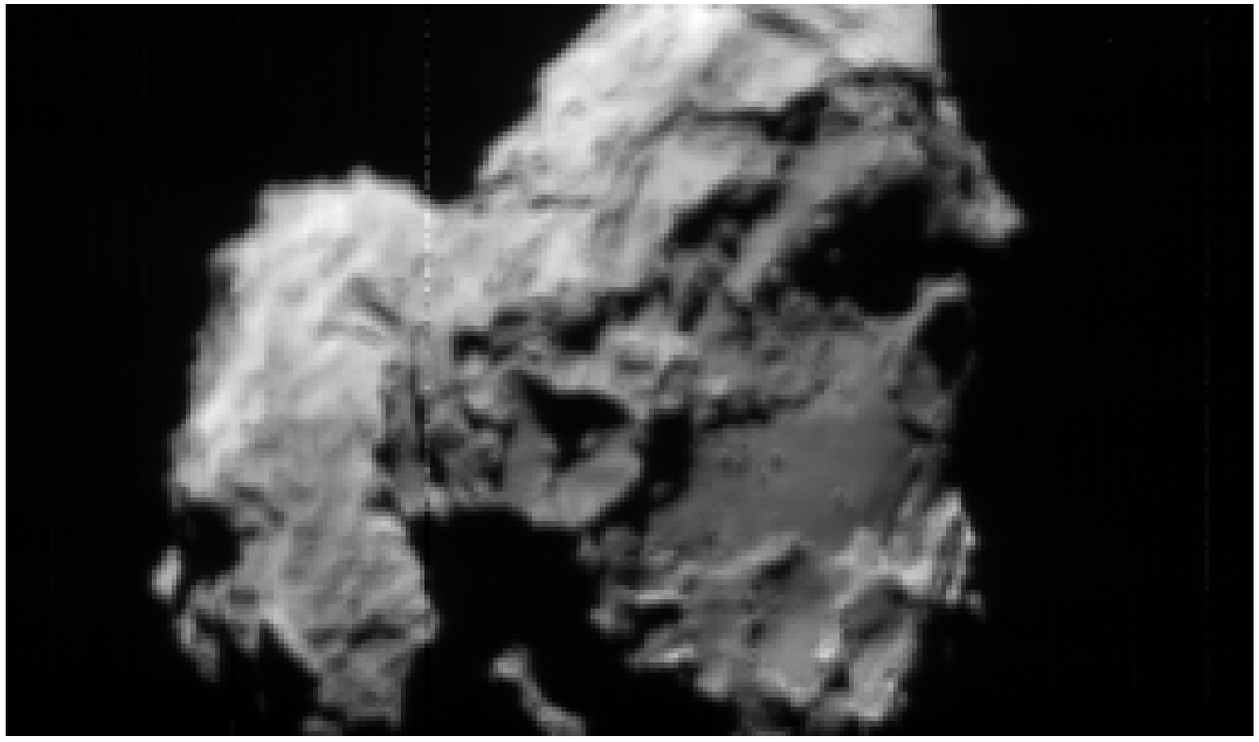
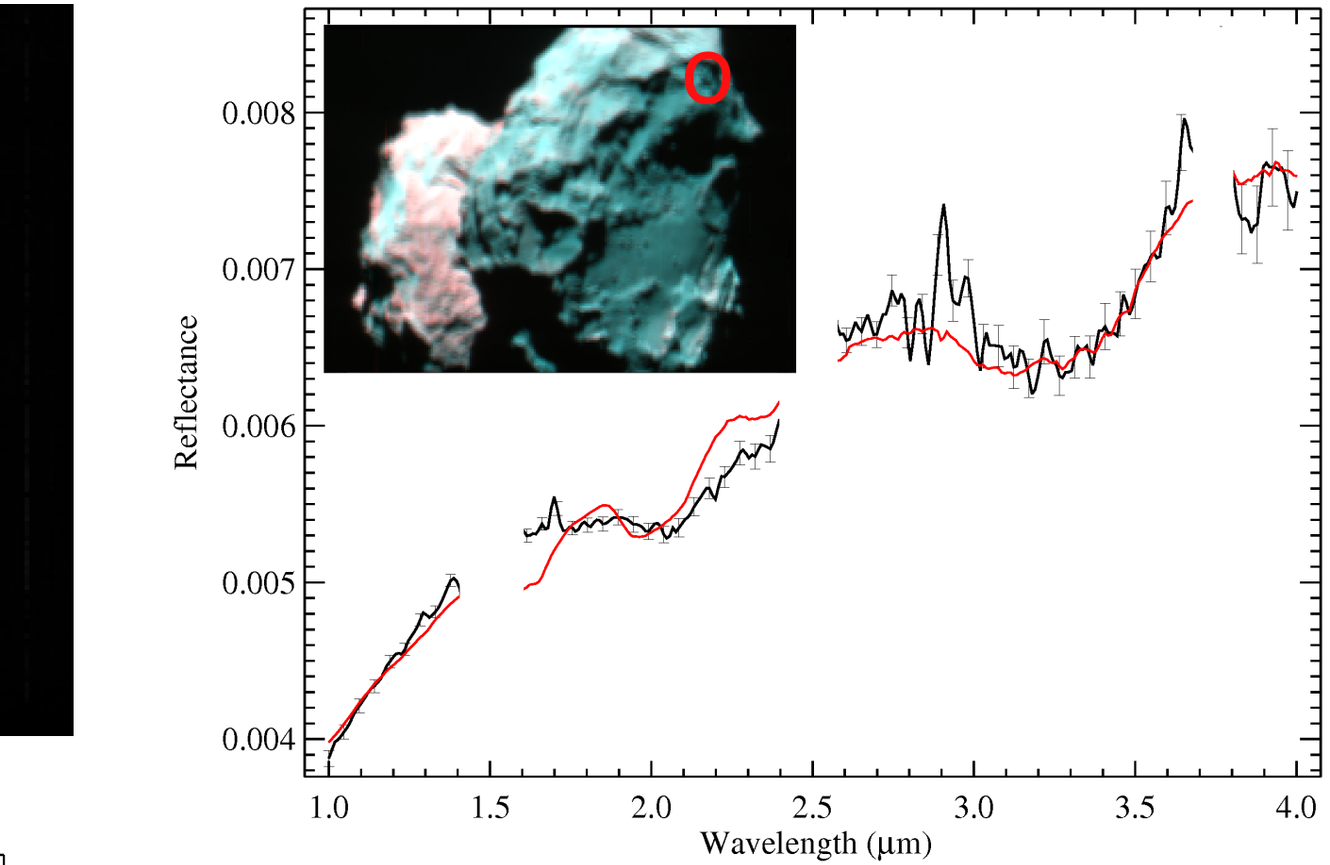
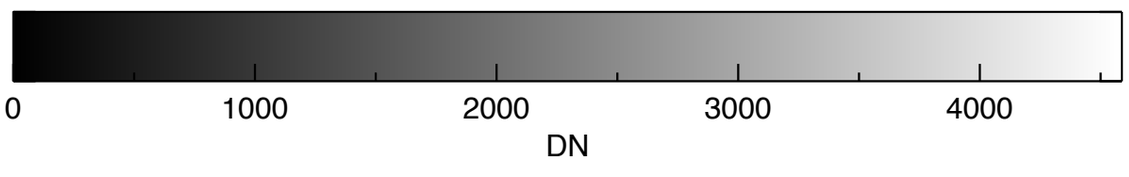
Barucci et al. 2016 A&A 595, A102 (2016)







Calibration pipeline

file analyzed = stp045/i1_00383518966

Strange Pattern

FRAME_PARAMETER = (3, 1, 10, 20)
FRAME_PARAMETER_DESC = ("EXPOSURE_DURATION", "FRAME_SUMMING", "EXTERNAL_REPETITION_TIME", "DARK_ACQUISITION_RATE")
FRAME_PARAMETER_UNIT = ("S", "DIMENSIONLESS", "S", "DIMENSIONLESS")

t_{IR} = 3sec

Considering the exposure time and the responsivity of the instrument, I convert the data from DN to RAD (see left panel)

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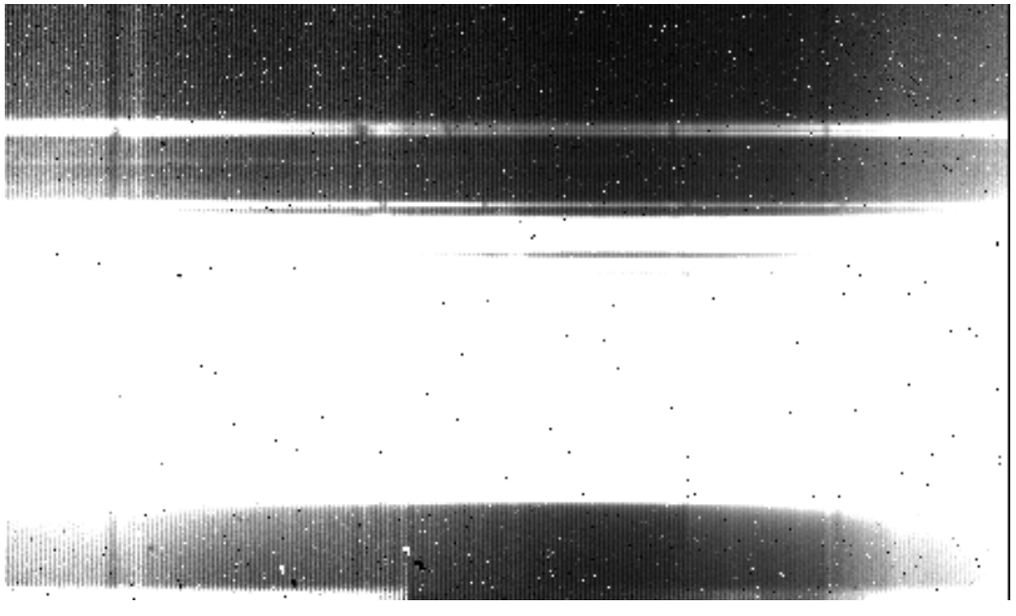
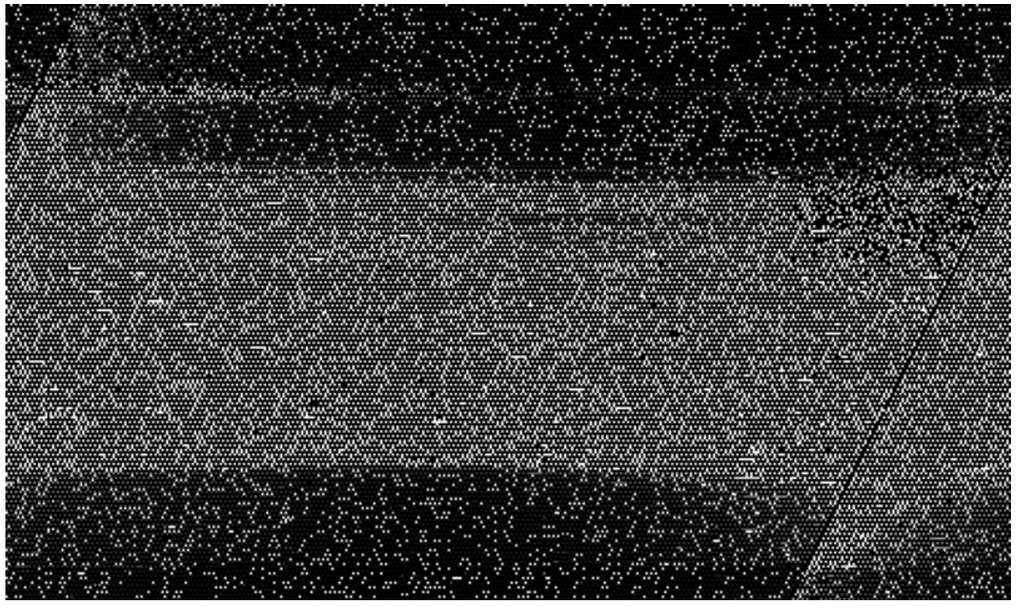


data delivered to PDS



Response function

6-Oct-2017 17:36:16 Printed By: **Silvia Protopapa** **Sheet A**

ESA	Review Item Discrepancy	Rosetta EOM Panel:	Rosetta_EOM_Science_Panel

(A) TITLE: virtis_m_vis_resp_10_v1.lbl/label not correct

RID No: Science_Panel-262

ID No: 21335

Orig. Ref.: VIRTIS-US-SP-014

Originator: Silvia Protopapa

(B) DATAPACK DOCUMENT:

RO-SGS-PR-1018-App20: VIRTIS Rosetta EOM Science Archive Review Procedure (Issue:1.0)

Page/Section/Para:

(C) DISCREPANCY:

Requirements violated (Datapack Document):

Page/Section/Para:
Description of Discrepancy:

AXIS_UNIT = ("DIMENSIONLESS","DIMENSIONLESS")
is not correct. Units are PIXEL and (DN*m^2*um*sterad)/(W*s)

(D) INITIATOR RECOMMENDED SOLUTION:

Please fix it accordingly

Signature:

(E) PANEL RECOMMENDATIONS:

Status: Accepted **Classification:** Major **Signature:**

(F) PANEL CHAIRMAN COORDINATION:

Status: Accepted **Group(s):** **Signature:**

Wavelength calibration

6-Oct-2017 17:41:43 Printed By: **Silvia Protopapa** **Sheet A**

ESA	Review Item Discrepancy	Rosetta EOM Panel:	Rosetta_EOM_Science_Panel

(A) TITLE: VIRTIS-M spectral calibration table/documentation

RID No: Science_Panel-259

ID No: 21332

Orig. Ref.: VIRTIS-US-SP-012

Originator: Silvia Protopapa

(B) DATAPACK DOCUMENT:

RO-SGS-PR-1018-App20: VIRTIS Rosetta EOM Science Archive Review Procedure (Issue:1.0)

Page/Section/Para: ROSETTA – VIRTIS EAICD/page 20/paragraph 2.4.5

(C) DISCREPANCY:

Requirements violated (Datapack Document):

Page/Section/Para:
Description of Discrepancy:

The paragraph states:
``VIRTIS_M_HRES_SPECAL_10_V1.TAB: spectral calibration table for the visible channel in high resolution mode;
VIRTIS_M_NRES_SPECAL_10_V1.TAB: spectral calibration table for the visible channel in nominal resolution mode;"

However, each of these files contains two columns: 1) Spectral calibration table for the visible channel, 2) Spectral calibration table for the infrared channel. Therefore the description provided in the documentation is not correct.

(D) INITIATOR RECOMMENDED SOLUTION:

``VIRTIS_M_HRES_SPECAL_10_V1.TAB: spectral calibration table for the visible channel in high resolution mode;"-->``VIRTIS_M_HRES_SPECAL_10_V1.TAB: spectral calibration table for the visible and infrared channel in high resolution mode;"
``VIRTIS_M_NRES_SPECAL_10_V1.TAB: spectral calibration table for the visible channel in nominal resolution mode;"->VIRTIS_M_NRES_SPECAL_10_V1.TAB: spectral calibration table for the visible and infrared channel in nominal resolution mode;"

Signature:

(E) PANEL RECOMMENDATIONS:

Status: Accepted **Classification:** Minor **Signature:**

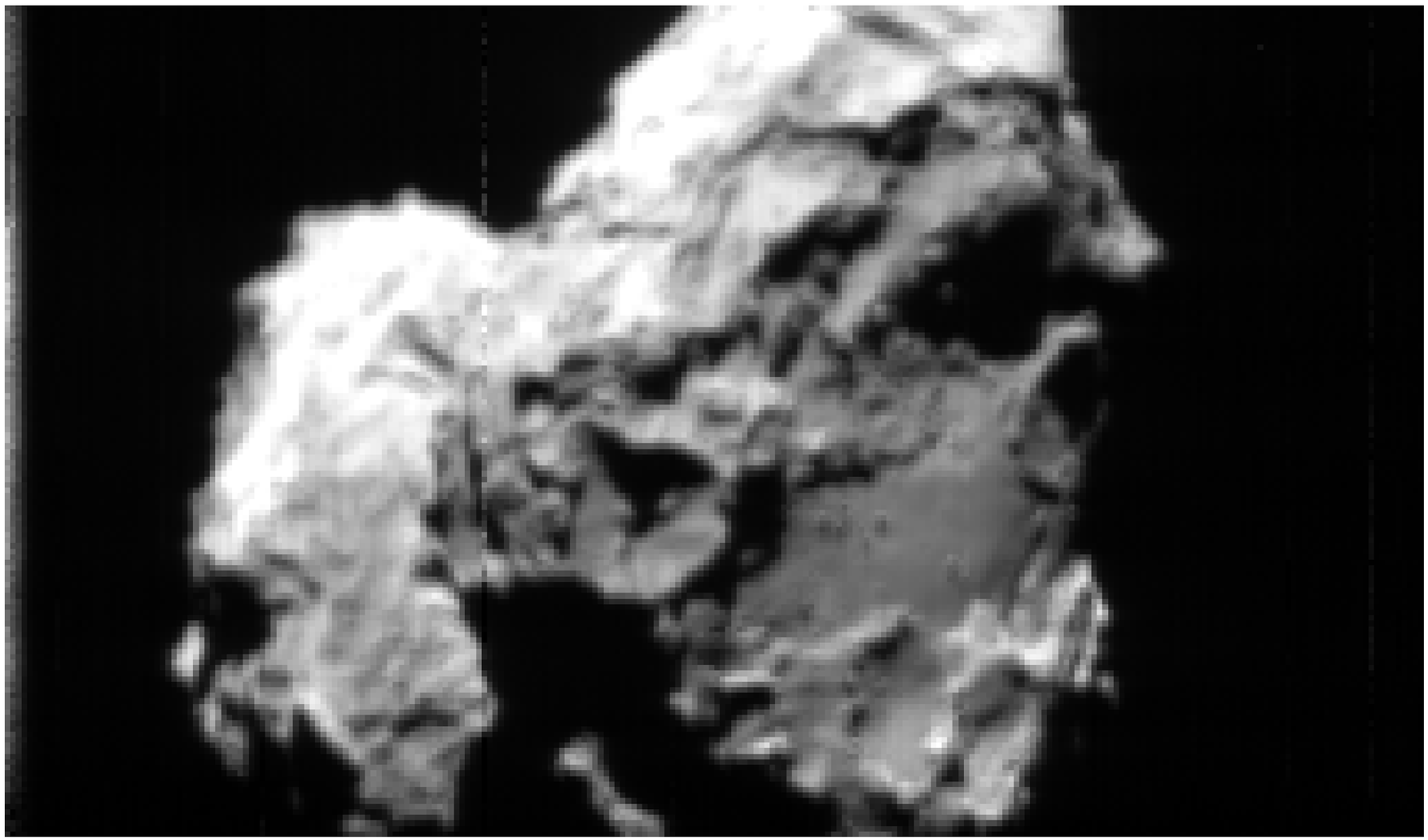
(F) PANEL CHAIRMAN COORDINATION:

Status: Accepted **Group(s):** **Signature:**

Calibration pipeline

I considered the data I calibrated in RAD and generated a spectral cube #samples X #lines X #bands

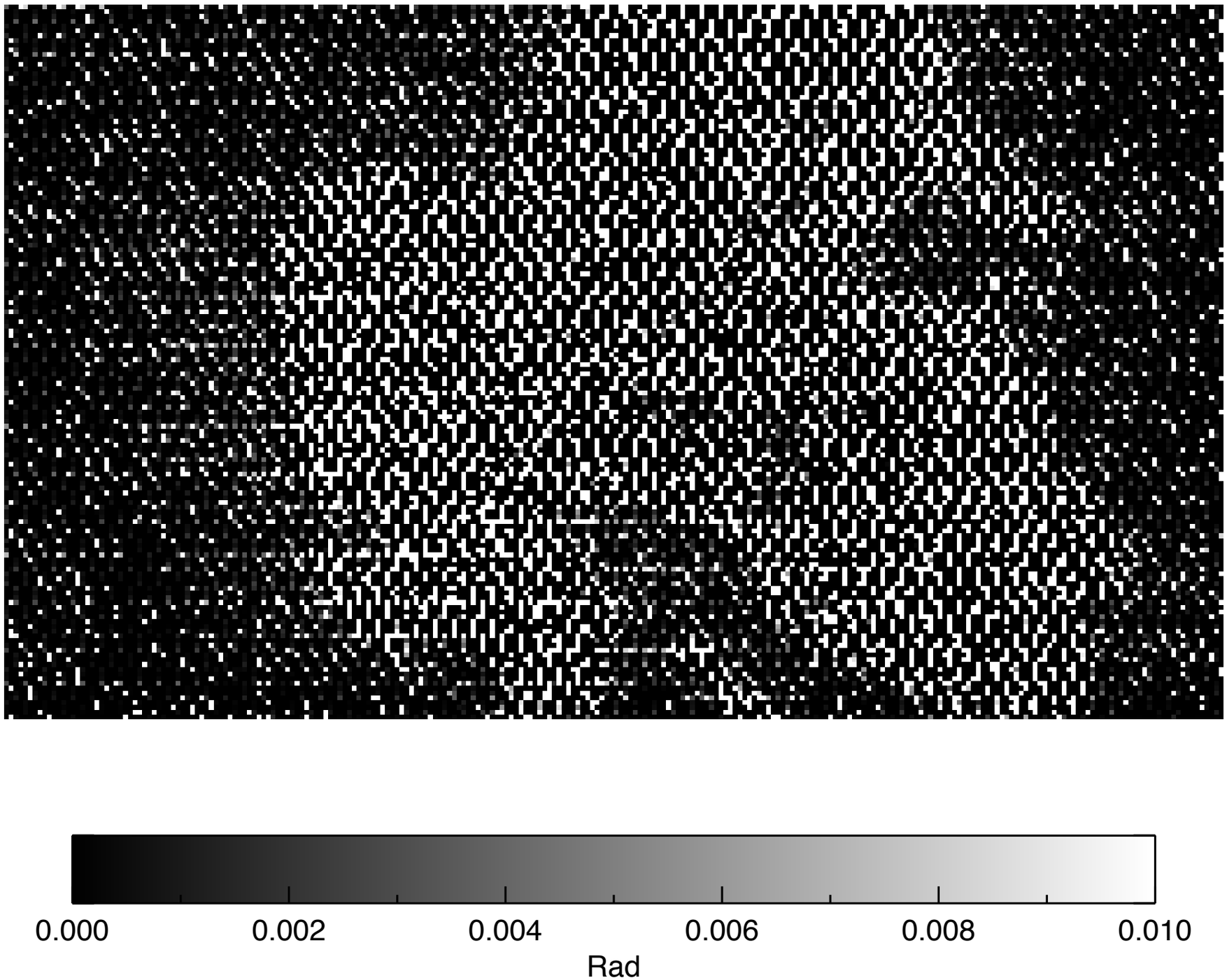
Band = 10 (idl convention)



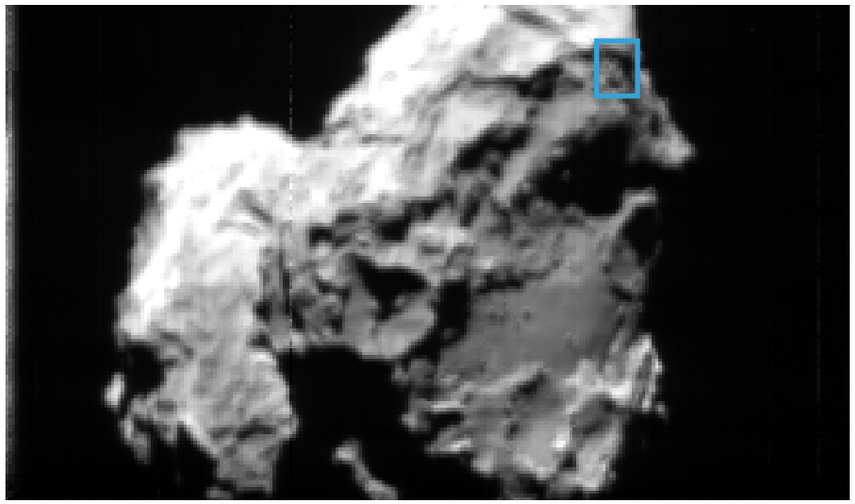
Calibration pipeline

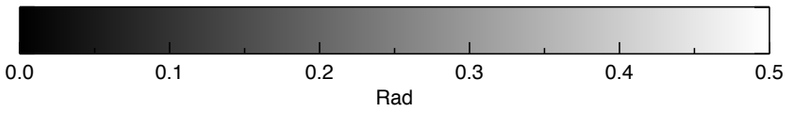
Data cube generated starting from the calibrated data provided to PDS. The pattern is funny. The orientation is different

Band = 10 (idl convention)

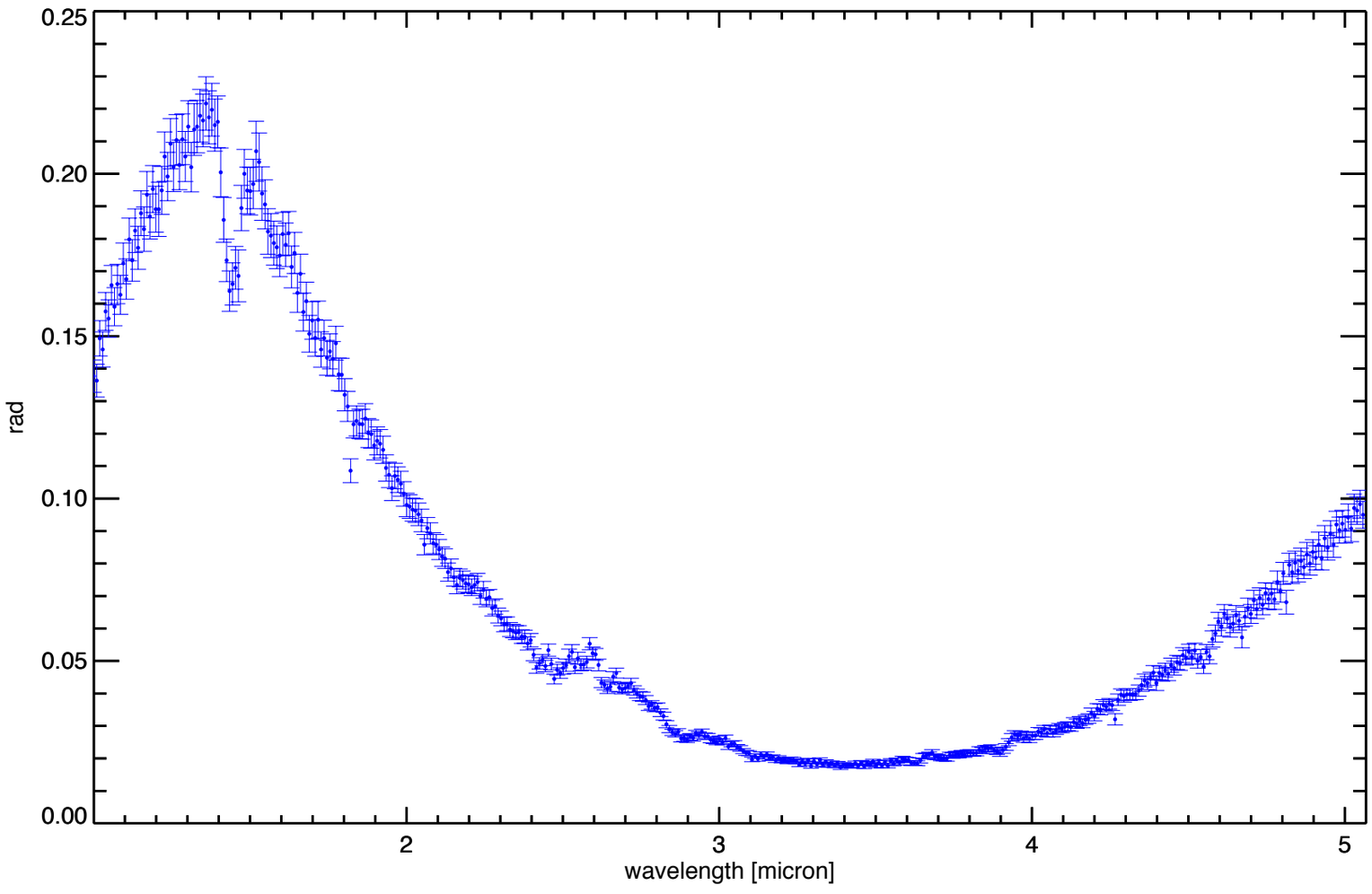


Spectrum Extraction





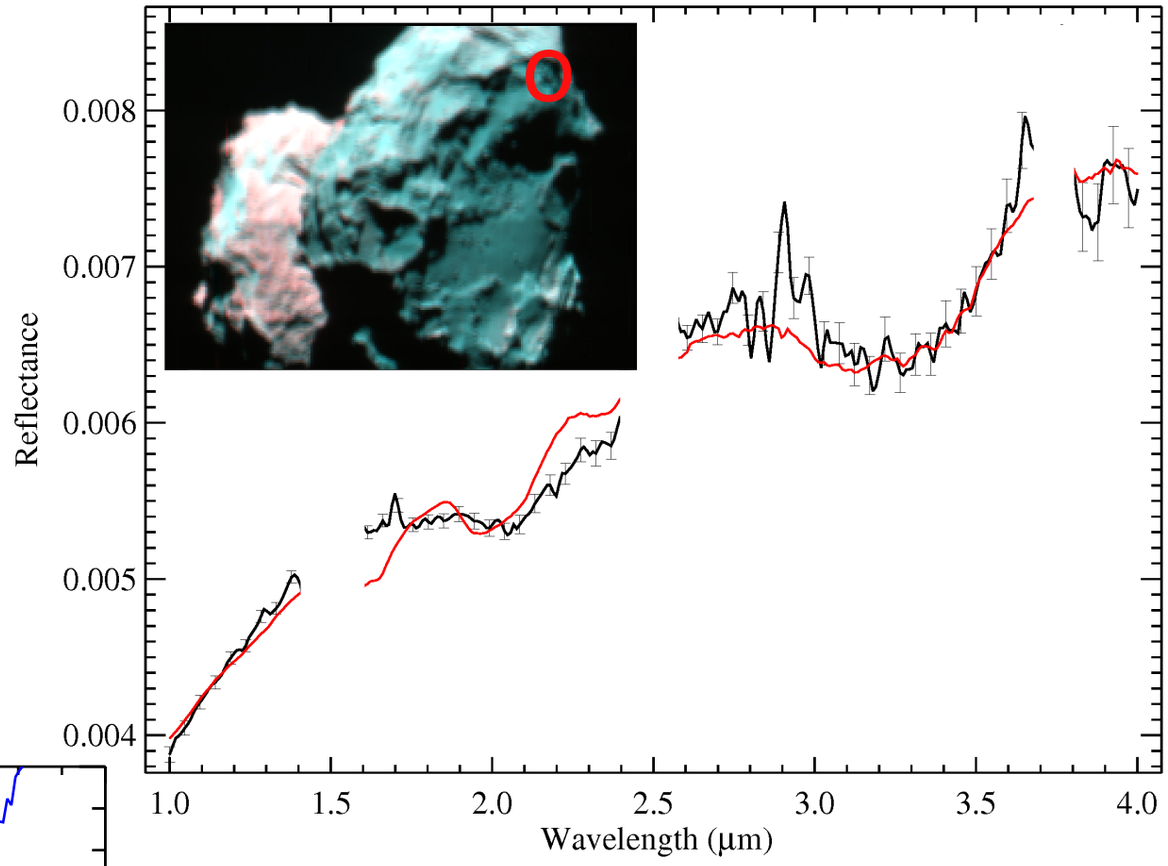
A sigma clipping algorithm is used to identify outliers. The value at each wavelength is the mean of the good pixels in the box and the uncertainty is given by rms deviation of the good pixels.

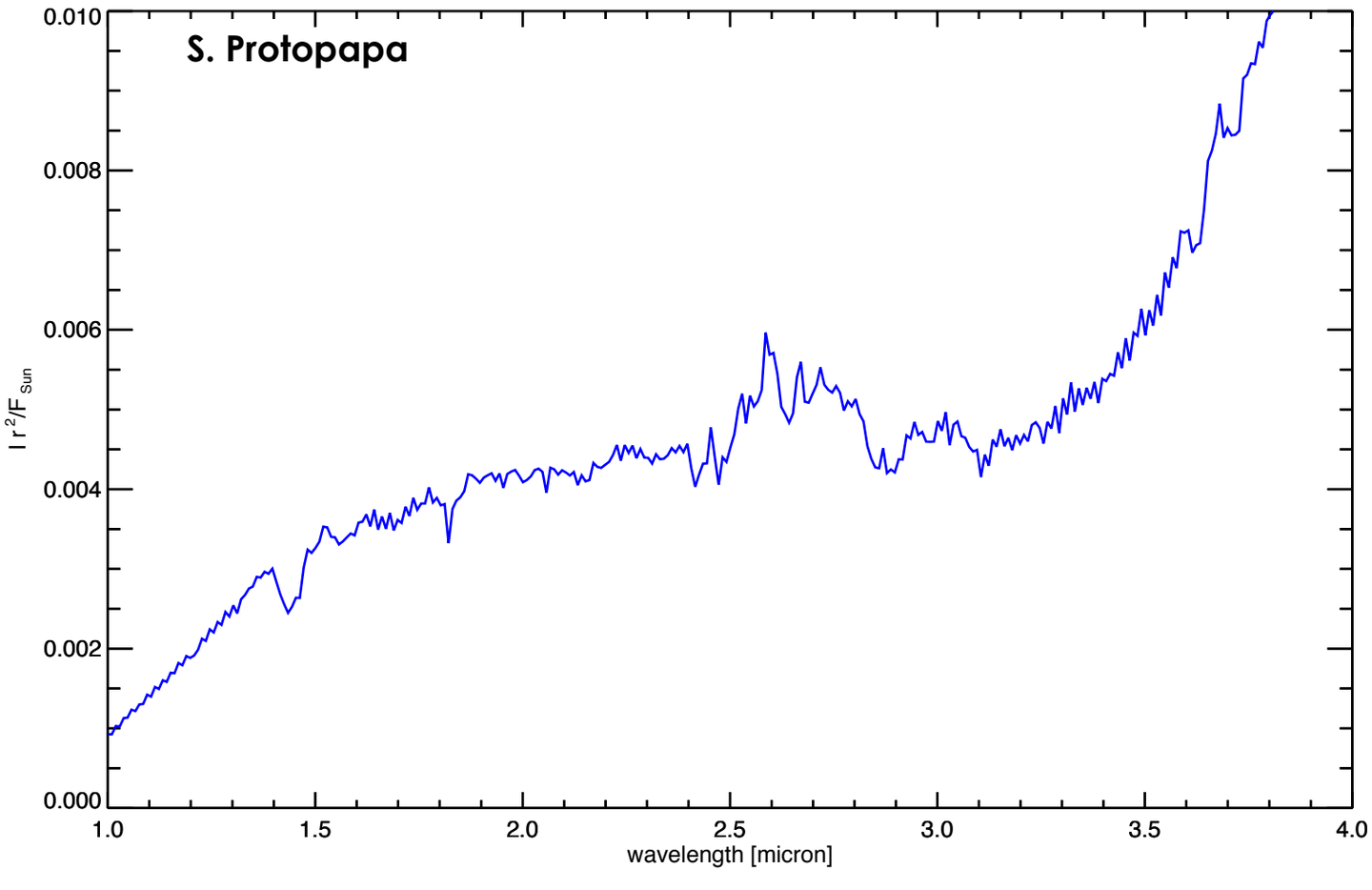


Spectrum Extraction

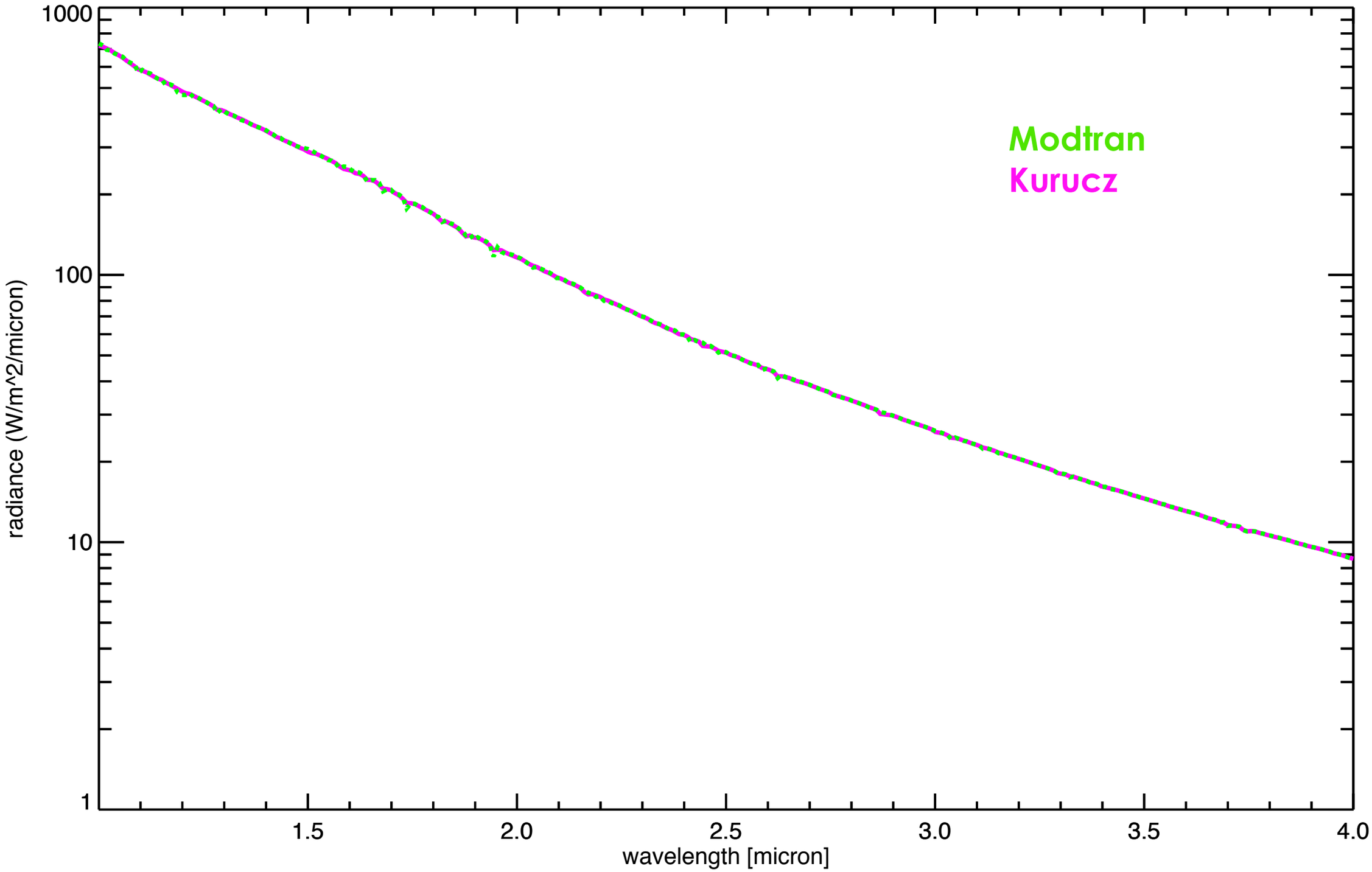
Barucci et al. 2016 A&A 595, A102 (2016)

I divide the radiance spectrum by the Kurucz solar irradiance from 1 AU resampled at ROSETTA VIRTIS_M-IR sampling and resolution in high resolution mode (428 bands).
The values I compute are off by a factor of ~2, possibly because I did not account for the solid angle





Calibration pipeline



Kurucz solar irradiance

5-Oct-2017 22:37:34 Printed By: **Silvia Protopapa** **Sheet A**

ESA	**Review Item Discrepancy**	**Rosetta EOM Panel:**	**Rosetta_EOM_Science_Panel**

(A) TITLE: virtis_res_ir_high_v10.lbl/number of rows **RID No:** Science_Panel-268

ID No: 21348

Orig. Ref.: VIRTIS-US-SP-019 **Originator:** Silvia Protopapa

(B) DATAPACK DOCUMENT:

RO-SGS-PR-1018-App20: VIRTIS Rosetta EOM Science Archive Review Procedure (Issue:1.0)

Page/Section/Para:

(C) DISCREPANCY:

Requirements violated (Datapack Document):

Page/Section/Para:
Description of Discrepancy:

This file provide the Kurucz solar irradiance from 1 AU resampled at ROSETTA VIRTIS_M-IR sampling and resolution in high resolution mode (428 bands). Solar irradiance expressed in (W/m^2/micron)"
According to the label

```
OBJECT                  = TABLE
INTERCHANGE_FORMAT      = ASCII
ROWS                    = 428
ROW_BYTES               = 25
COLUMNS                 = 2
```

However, I was expecting 432 rows and not 428.

(D) INITIATOR RECOMMENDED SOLUTION:

Please address this as it is consider appropriate.

Signature:

(E) PANEL RECOMMENDATIONS:

Status: **Classification:** Major **Signature:**

(F) PANEL CHAIRMAN COORDINATION:

Status: **Group(s):** **Signature:**

Bad pixel map

5-Oct-2017 22:45:41 Printed By: **Silvia Protopapa** **Sheet A**

ESA	**Review Item Discrepancy**	**Rosetta EOM Panel:**	**Rosetta_EOM_Science_Panel**

(A) TITLE: bad pixel map missing **RID No:** Science_Panel-269

ID No: 21349

Orig. Ref.: VIRTIS-US-SP-020 **Originator:** Silvia Protopapa

(B) DATAPACK DOCUMENT:

RO-SGS-PR-1018-App20: VIRTIS Rosetta EOM Science Archive Review Procedure (Issue:1.0)

Page/Section/Para:

(C) DISCREPANCY:

Requirements violated (Datapack Document):

Page/Section/Para:

Description of Discrepancy:

I could not find among the calibration files or in the documentation any information about a bad pixel map.

(D) INITIATOR RECOMMENDED SOLUTION:

Please address it.

Signature:

(E) PANEL RECOMMENDATIONS:

Status: **Classification:** Major **Signature:**

(F) PANEL CHAIRMAN COORDINATION:

Status: **Group(s):** **Signature:**

Flat-fielding

5-Oct-2017 23:00:32 Printed By: **Silvia Protopapa** **Sheet A**

ESA	Review Item Discrepancy	Rosetta EOM Panel:	Rosetta_EOM_Science_Panel

(A) TITLE: VIRTIS-M flat fielding

RID No: Science_Panel-270

ID No: 21350

Orig. Ref.: VIRTIS-US-SP-021

Originator: Silvia Protopapa

(B) DATAPACK DOCUMENT:

RO-SGS-PR-1018-App20: VIRTIS Rosetta EOM Science Archive Review Procedure (Issue:1.0)

Page/Section/Para:

(C) DISCREPANCY:

Requirements violated (Datapack Document):

Page/Section/Para:

Description of Discrepancy:

VIRTIS_M_IR_RESP_10_V1.DAT is a ``432X256 double precision matrix containing the VIRTIS-M-IR instrumental transfer function, including the VIS flat - field". This description is given in page 32 of the ro_virtis_eaicd.pdf document.
1) the description should be ``including the IR flat - field"
2) the fact that the flat field is part of this calibration file is not clear across the document. A clear statement should be given for example in paragraph 2.4.5
3)also from the label does not emerge that this file includes the flat field correction.

(D) INITIATOR RECOMMENDED SOLUTION:

Please address it.

Signature:

(E) PANEL RECOMMENDATIONS:

Status: **Classification:** Major **Signature:**

(F) PANEL CHAIRMAN COORDINATION:

Status: **Group(s):** **Signature:**

VIRTIS-H

5-Oct-2017 22:25:05 Printed By: **Silvia Protopapa** **Sheet A**

ESA	**Review Item Discrepancy**	**Rosetta EOM Panel:**	**Rosetta_EOM_Science_Panel**

(A) TITLE: Errata file /VIRTIS-H calibratio **RID No:** Science_Panel-264

ID No: 21342

Orig. Ref.: VIRTIS-US-SP-015 **Originator:** Silvia Protopapa

(B) DATAPACK DOCUMENT:

RO-SGS-PR-1018-App20: VIRTIS Rosetta EOM Science Archive Review Procedure (Issue:1.0)

Page/Section/Para:

(C) DISCREPANCY:

Requirements violated (Datapack Document):

Page/Section/Para:

Description of Discrepancy:

In the errata file it is stated ``Note that VIRTIS-H calibration is still a preliminary, unchecked calibration, with known inconsistencies. " This is matter of concern. The delivered data set is calibrated and therefore any inconsistency should be addressed prior to delivery and archiving

(D) INITIATOR RECOMMENDED SOLUTION:

Please address.

Signature:

(E) PANEL RECOMMENDATIONS:

Status: **Classification:** Major **Signature:**

(F) PANEL CHAIRMAN COORDINATION:

Status: **Group(s):** **Signature:**