



TIRI Status

**Near-Earth Commissioning So Far
(Results, Calibration Items, Issues encountered)**

TIRI Team (Tatsuaki Okada)



TIRI Status



■ TIRI health and initial function checks:

- ◆ Performed on Oct 10, 16
- ◆ All the functions nominally used worked well, including imaging, filter wheel movement, internal heaters, SEQ commands (such as initial settings, a set of close / wide-band images, a set of close / wide-band / 6-narrow-band images, with/without background subtraction, and shutoff to Safety mode), as well as macro commands (a combination of SEQ commands with delay-time).
- ◆ ROI (Region of Interest) function for image output, not nominally used, has an issue: not properly output (needed to send get-Image twice), still investigating the FPGA processing by MEC.

■ TIRI Imaging tests (Earth-Moon):

- ◆ Performed on Oct 10-11 for Moon, Oct 12-14 for Earth, Oct 15-19 for Earth-Moon system, (unexpectedly) with Earth and Moon within the FOV of all the images.
- ◆ All the data apparently good, checking the schemes (depacketization and decompression).
- ◆ Analysis for radiative correction (conversion to temperature pixel by pixel), geometrical correction (distortion, alignment), instrumental correction (dependency of internal temperatures) still on-going.
- ◆ Analysis for size-of-source effect (unique property for bolometer) on-going.

■ TIRI Dark Frame and Dependency of instrumental temperature:

- ◆ Performed on Oct 24 for Deep Sky as “dark-frame” images, with varied setting temperatures to adjust the best temperature conditions.



TIRI Status



- TIRI CMD upload and Data reception through EDDS (ESOC interface):
 - ◆ Confirmed the commands prepared by TIRI PI team successfully uploading to ESOC properly.
 - ◆ All the data (HK, Status, Images) obtained as ISAS (and ROB) through the EDDS.
 - ◆ A pipeline – data flow process (depacketization, decompression, attached the header information) for constructing Level-1 data in FITS format – basically prepared but still checking in detail.
- TIRI Data archive to the team:
 - ◆ Data still in validation for Level-1 (in DN), especially for subtracted images
 - ◆ Naming: hera_tiri_[Imaging time (UTC, yyyyymmddTHHMMSS)]_[IMG_ID]_[numbering]_l1.fit (numbering: increment as 00, 01, 02, ..., if the same data is downlinked sometimes)
 - ◆ A quick conversion to brightness temperature possible using the pre-flight calibration data, but radiative/geometrical corrections and validation needed before archival to the Hera team.
 - ◆ Data archival site to be open (at ROB). At the beginning, raw data will be open soon.



TIRI Health & Initial checks



■ Initial Check (interactive, on 10, 16 Oct)

Dates	Item	Contents	G/N
Oct 10	Initial function check (Earth & Moon in FOV)	<ul style="list-style-type: none">• Health and function check (SpW-A, Nominal Temperature -settings)• ON/OFF, HK telemetry, Mode Transfer,• Imaging, Data processing (compress, packetization) ,• Filter Wheel movement• Macro-Command loading/execution	Good
Oct 16	Detailed function check (Deep Sky Images, no bright target in TIR)	<ul style="list-style-type: none">• Health and function check (SpW-A/B, Nominal Temperature -settings)• ON/OFF, HK telemetry, Mode Transfer,• Imaging, data processing (subtract, compress, packetization, ROI)• Filter wheel movement (setting positions, number of steps, CW/CCW)• Internal Heaters (self-action),• Macro-Commands loading/execution	Good



TIRI Imaging Tests,



■ Imaging (non-interactive from 10-24 Oct.)

Dates	Item	Contents	Status
Oct 10-11	Moon Obs	<ul style="list-style-type: none">• Pointing to Moon :• a 3deg by 3deg Raster images + an 8-band images x 3 times →corrections for radiation, alinement , distortion, size-of source effect	Done, Analysis on-going
Oct 12-14	Earth Obs	<ul style="list-style-type: none">• Pointing to Earth :8-band images at 18 local times →corrections for filter band ratios	Done, Analysis on-going
Oct 15-19	Earth-Moon Obs	<ul style="list-style-type: none">• Pointing to Earth• a 3deg by 3deg Raster images + an 8-band images x 4 times →corrections for radiation, alinement , distortion, size-of source effect	Done, Analysis on-going
Oct 24	Dark Sky Obs	<ul style="list-style-type: none">• Deep Sky :• Taking at 5 different temperature conditions (at 5 setting points) →corrections for instrument temperature dependency	Done, Analysis on-going



First Earth-Moon Image by TIRI



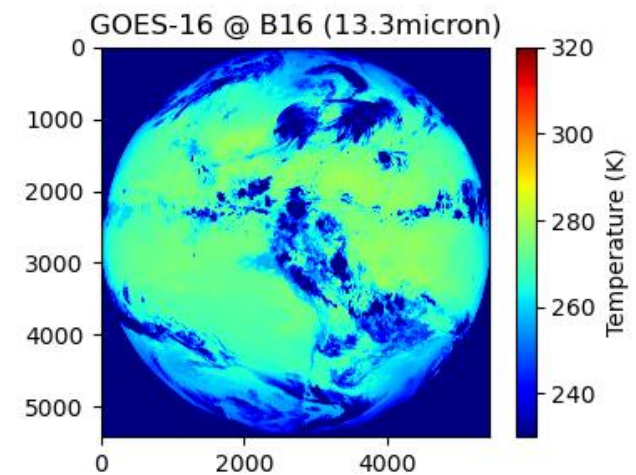
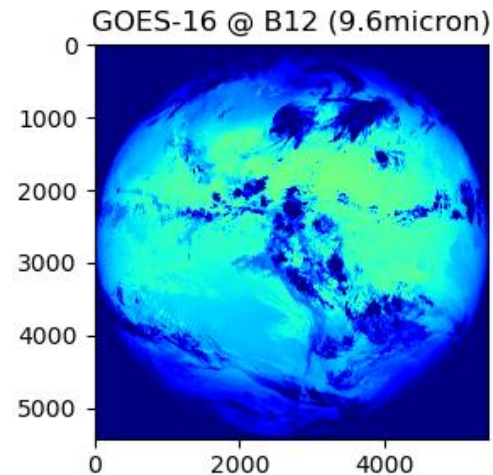
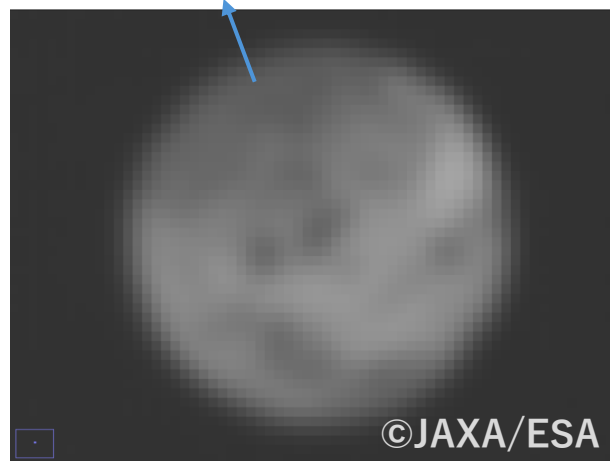
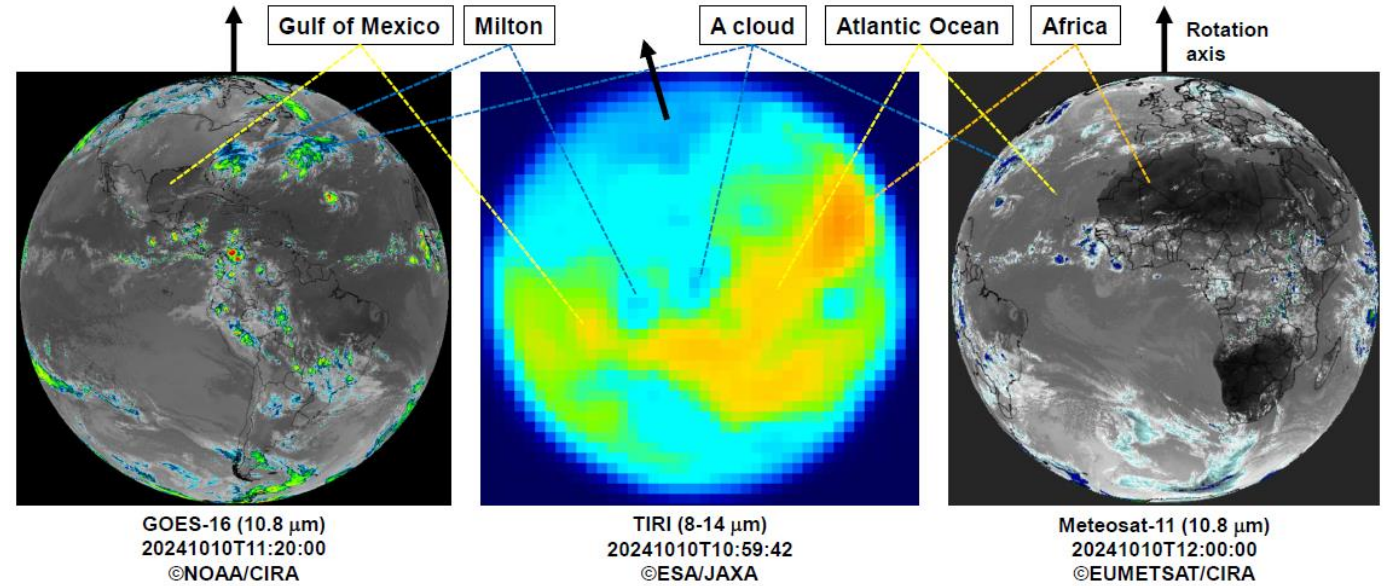
■ Brightness

TIRI
2024/10/10
11:00頃
地球と月
(生画像・画素が見えている)

Moon :
Half moon (the night side is too cold without atmosphere to see in TIR)

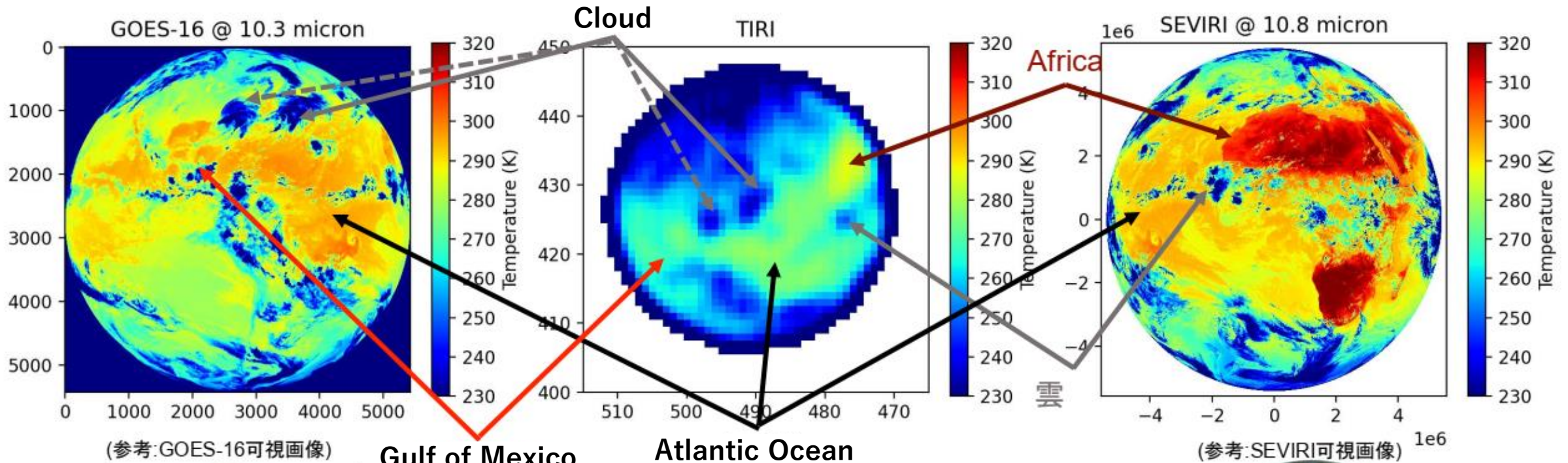
Earth :
Both day & night sides are seen in TIR due to atmosphere

©JAXA/ESA

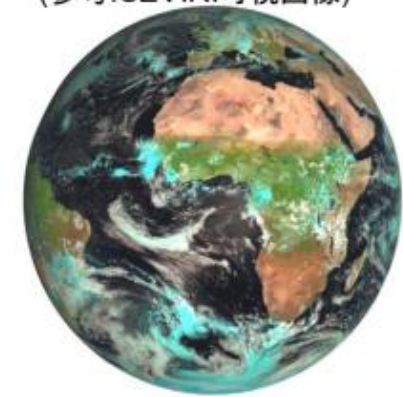


First Earth-Moon Image by TIRI

■ Brightness (work with G. Nishiyama)



- Temp pattern consistent with TIRI and GOES/SEVIRI
- TIRI shows lower temp?
 - Transparency of atmosphere?
 - Size-of-Source Effect (Earth ~ 0.5deg)



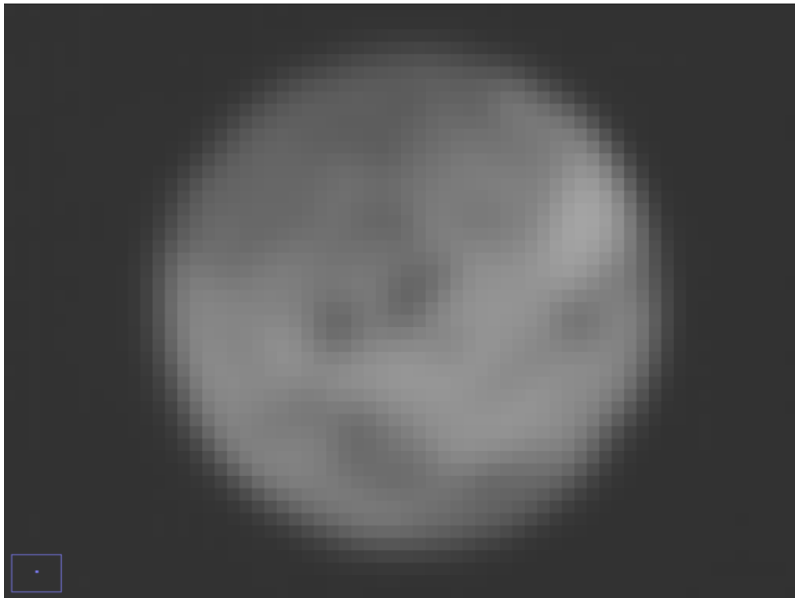


First Earth-Moon Image by TIRI

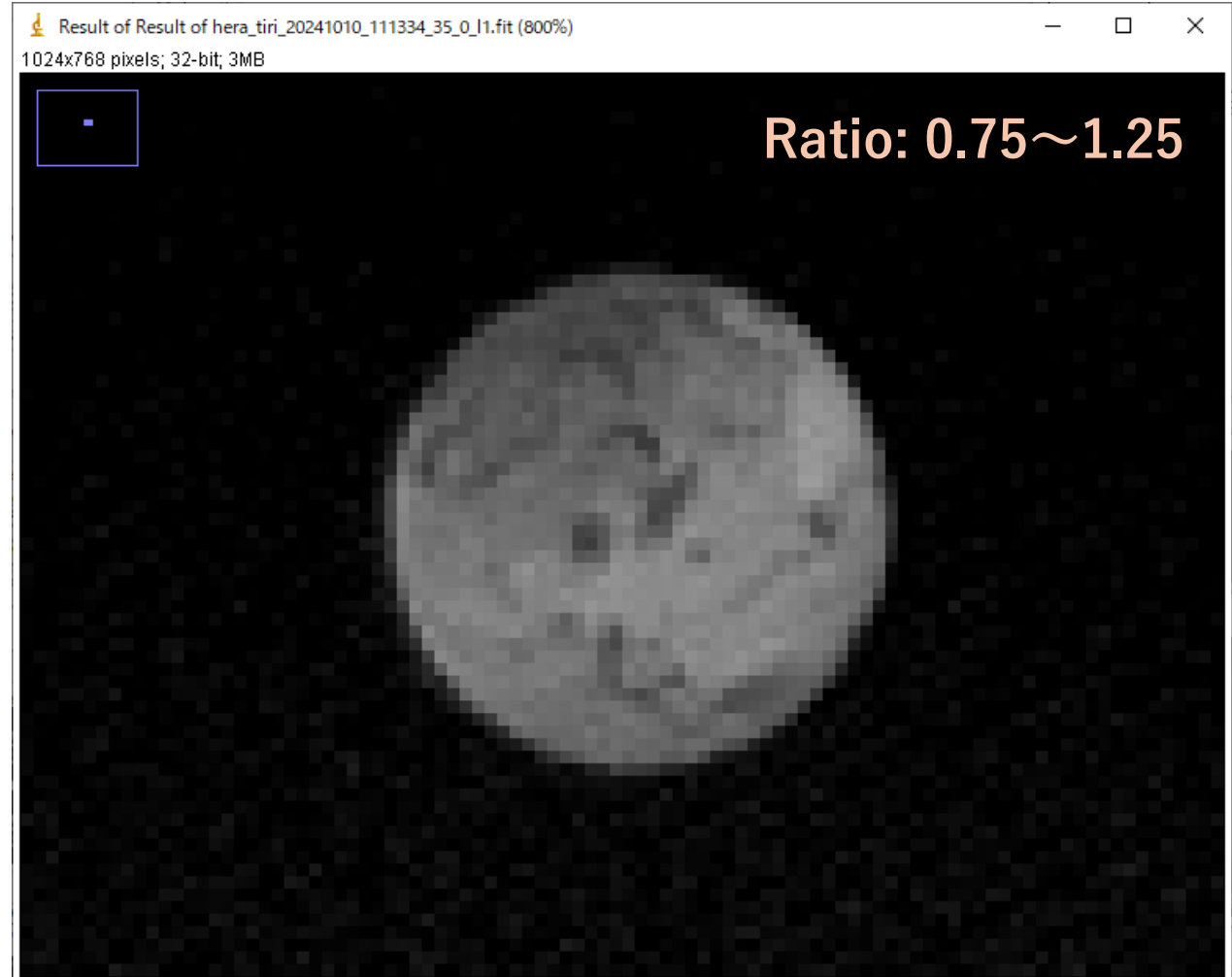


■ Color Ratio

Brightness: Wide (8-14 μ m)



Ratio: F-d (10.6 μ m)/F-e (11.6 μ m)





Earth-Moon by TIRI



3deg x 3deg Raster Images

Instruments: Hera/TIRI
Date of images : 10-11 Oct.



Earth-Centered Images

Instruments : Hera/TIRI
Date of images : 10-15 Oct.
Distance from Hera : 1.4~3.8 Million km



©JAXA/ESA



TIRI Dark Images

- Target: Deep sky
- Imaging:
 - ◆ Close/Wide x 4
 - ◆ 8-band x 1
- Setting temperatures:
 - ◆ 5 settings (wait for 2 hours)

★ It takes 2 hours to stabilize the temperatures inside of TIRI.

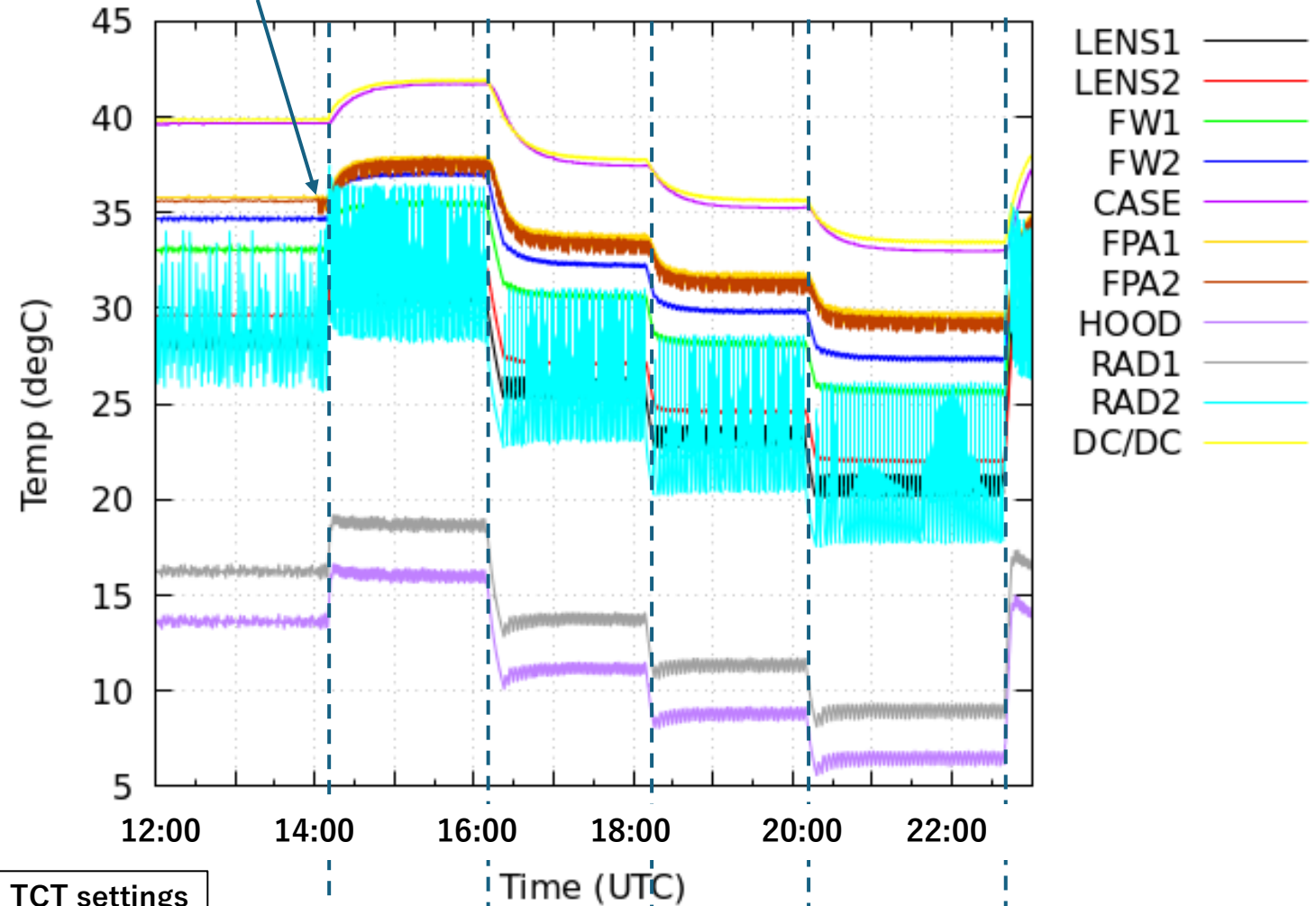
★ Typical operation for TIRI turn-on and observation sequence with enough margins should be

- (1) TCT heater setting points change from TIRI non-op to TIRI operational at ObsTime -3hr,
 - (2) TIRI turn-on and INIT at ObsTime -2hr, and
 - (3) TIRI observation starts at ObsTime.
- (# This is the same as that of Hayabusa2 TIR)

★ 0.5°C (or even smaller) range of the TCT setting points is needed to stabilize the temperature inside of TIRI (i.e., FPA2).
In this case, TCT Heater On/Off cycle is about 2-3 min interval.

TIRI observation started with HK at 2sec interval

2024-10-24



TCT settings		Time (UTC)				
Ch1 On/Off	23.5/24.0	25.5/26.0	21.5/22.0	19.5/20.0	17.5/18.0	23.5/24.0
Ch2 On/Off	25.5/26.0	27.5/28.0	23.5/24.0	21.5/22.0	19.5/20.0	25.5/26.0

TIRI Dark Images

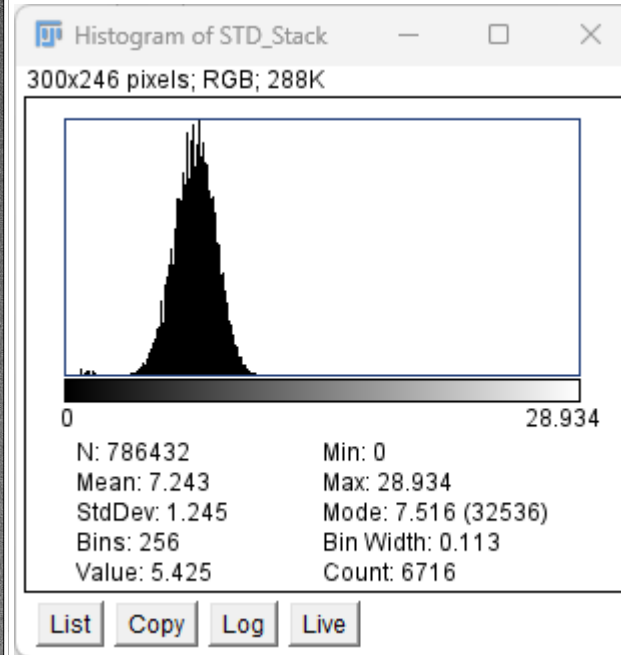
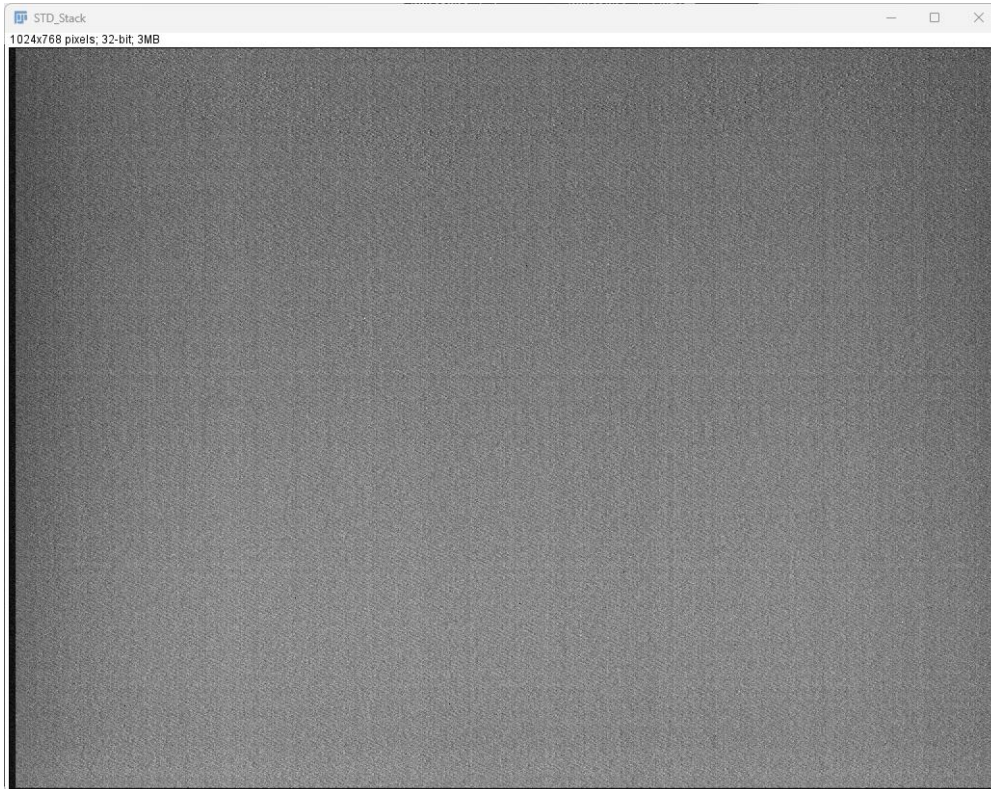
- DN Stability

- ◆ Using the 5 wide band images

- Lower CASE temperature leads higher random noise?

- ◆ But less than 10 DN at any temperature.

Standard deviation image @ CASE ~39.7°C



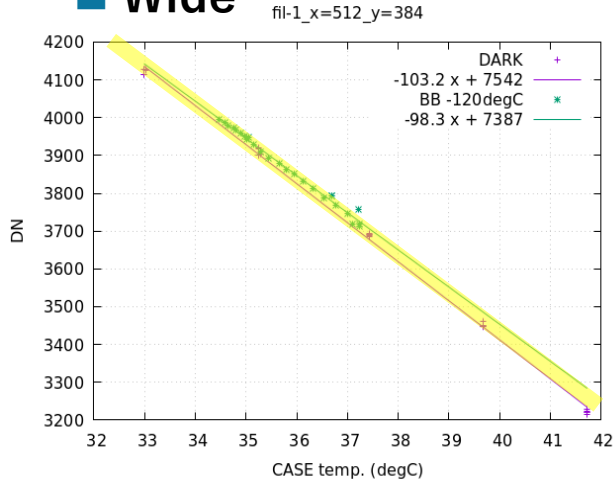
Ch1 Setting T (degC)	CASE temp. (degC)	Stddev ave. (DN)
25.5/26.0	41.7	5.17
23.5/24.0	39.7	7.24
21.5/22.0	37.4	5.32
19.5/20.0	35.3	9.61
17.5/18.0	33.0	9.27

TIRI Dark Images

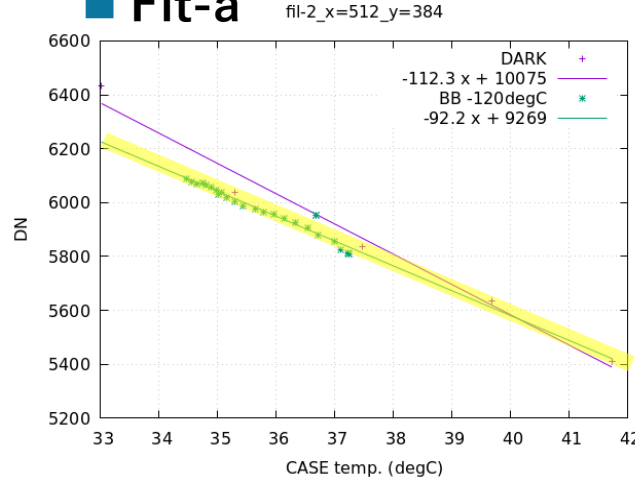
- ◆ “Dark” and “BB-120degC” DN values consistent for CASE-T at 35 to 40 degC.
- ◆ Filter-d, e, f show non-linearity below 35 degC in even column (x=512 here).
- ◆ Large deviation from the trend of Filter a-f for CASE-T at 33 degC.

DN at the center of TIRI images

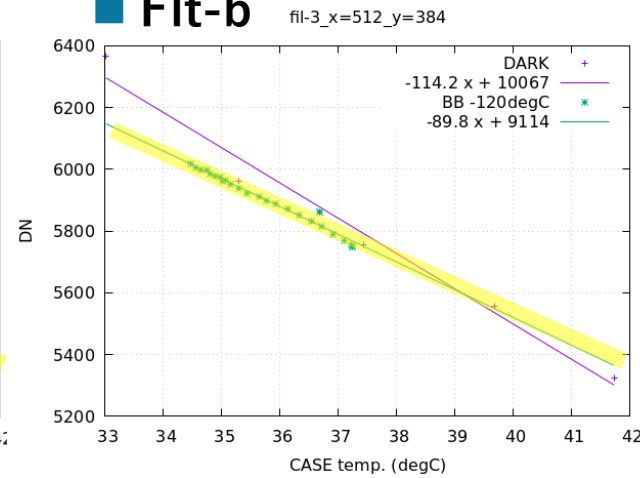
Wide



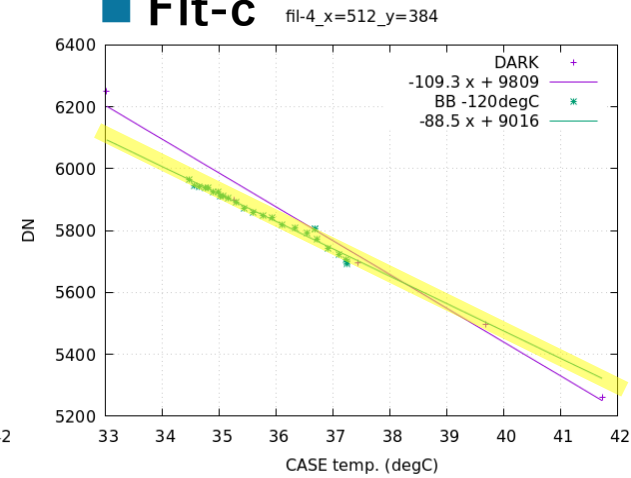
Flt-a



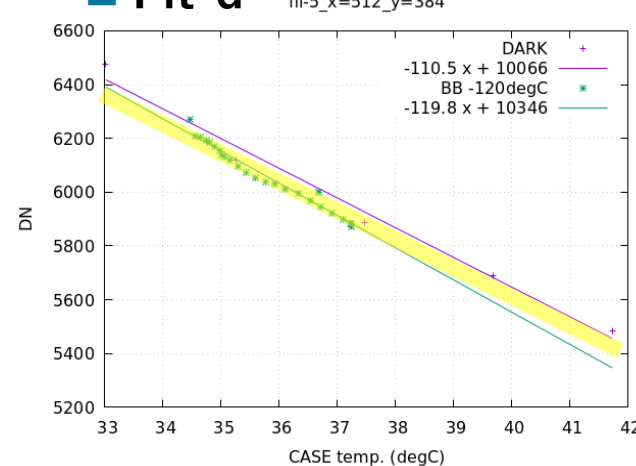
Flt-b



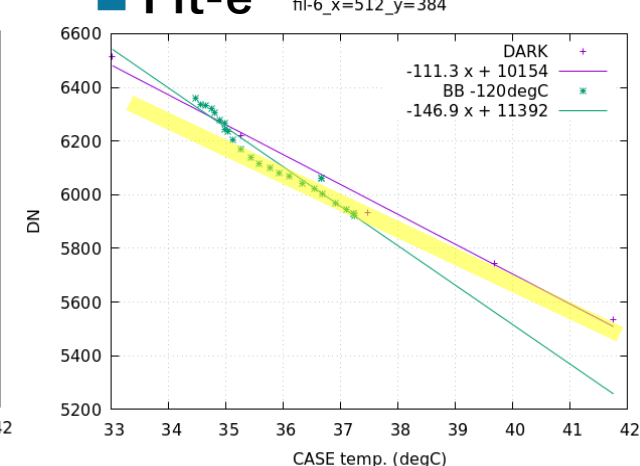
Flt-c



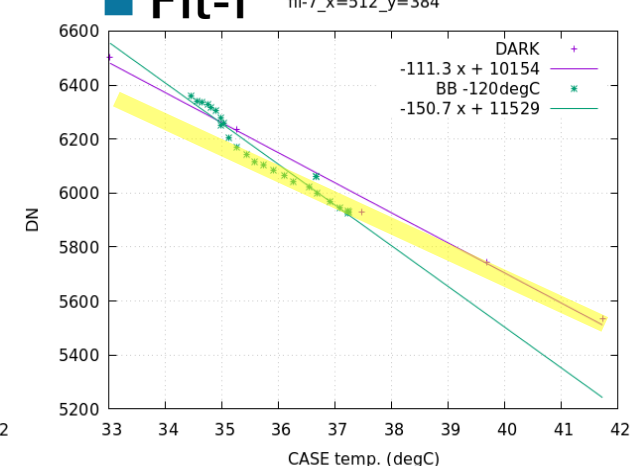
Flt-d



Flt-e



Flt-f





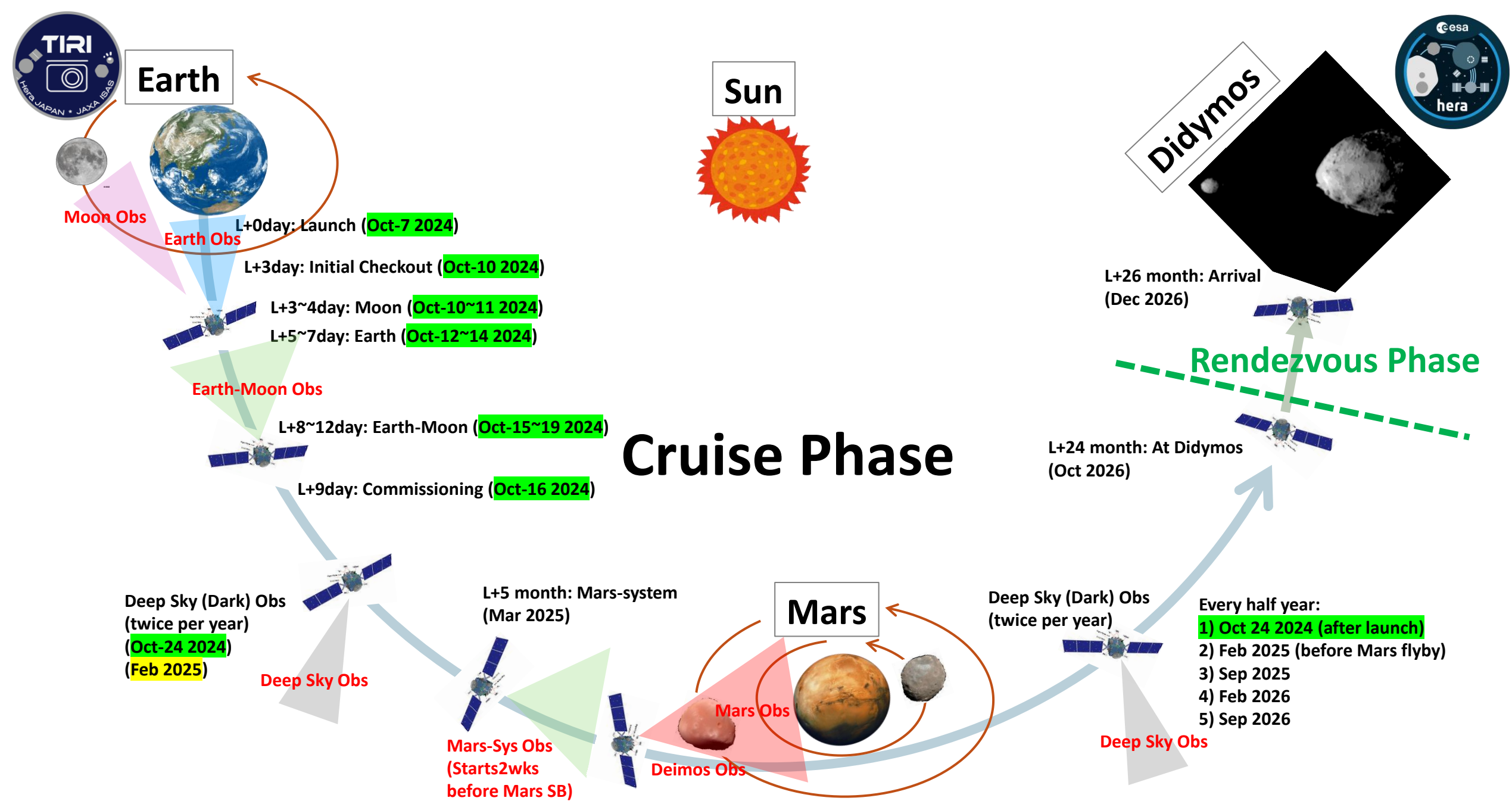




TIRI Operations

Plan for regular 6-month cruise phase checkout

TIRI Team (Tatsuaki Okada)





TIRI Dark Images

- Target: Deep sky
- Imaging:
 - ◆ Close/Wide x 4
 - ◆ 8-band x 1
- Setting temperatures:
 - ◆ 5 settings (wait for 2 hours)

★ It takes 2 hours to stabilize the temperatures inside of TIRI.

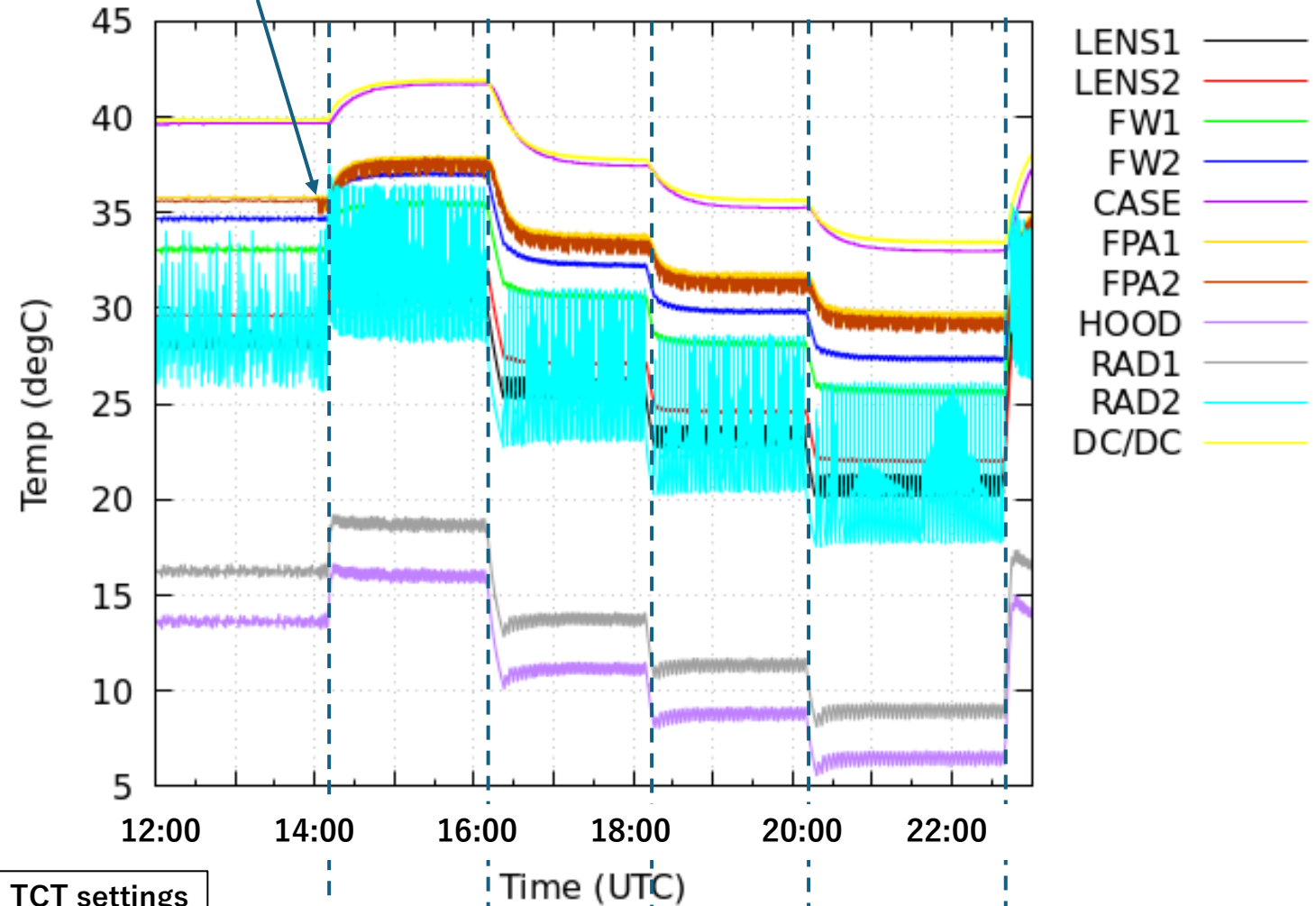
★ Typical operation for TIRI turn-on and observation sequence with enough margins should be

- (1) TCT heater setting points change from TIRI non-op to TIRI operational at ObsTime -3hr,
 - (2) TIRI turn-on and INIT at ObsTime -2hr, and
 - (3) TIRI observation starts at ObsTime.
- (# This is the same as that of Hayabusa2 TIR)

★ 0.5°C (or even smaller) range of the TCT setting points is needed to stabilize the temperature inside of TIRI (i.e., FPA2). In this case, TCT Heater On/Off cycle is about 2-3 min interval.

TIRI observation started with HK at 2sec interval

2024-10-24



TCT settings		Time (UTC)					
Ch1 On/Off	23.5/24.0	25.5/26.0	21.5/22.0	19.5/20.0	17.5/18.0	23.5/24.0	
Ch2 On/Off	25.5/26.0	27.5/28.0	23.5/24.0	21.5/22.0	19.5/20.0	25.5/26.0	



Dark Observations

- To be conducted in late Feb (or early March), but before Mars SB.
 - Similar operation to the first Dark observation.
 - ◆ 5 set of (4 x close/wide + 1 x 8-band) = 120 images (or more)
 - ◆ 10 hours + warming/power-on (3 hours)
 - Setting temperatures may be changed, possibly the width of the temperature (to be discussed).
 - Number of wide-band images may be increased for improved estimate of noise levels.
-
- Test opportunity of PORs for event trigger operation?



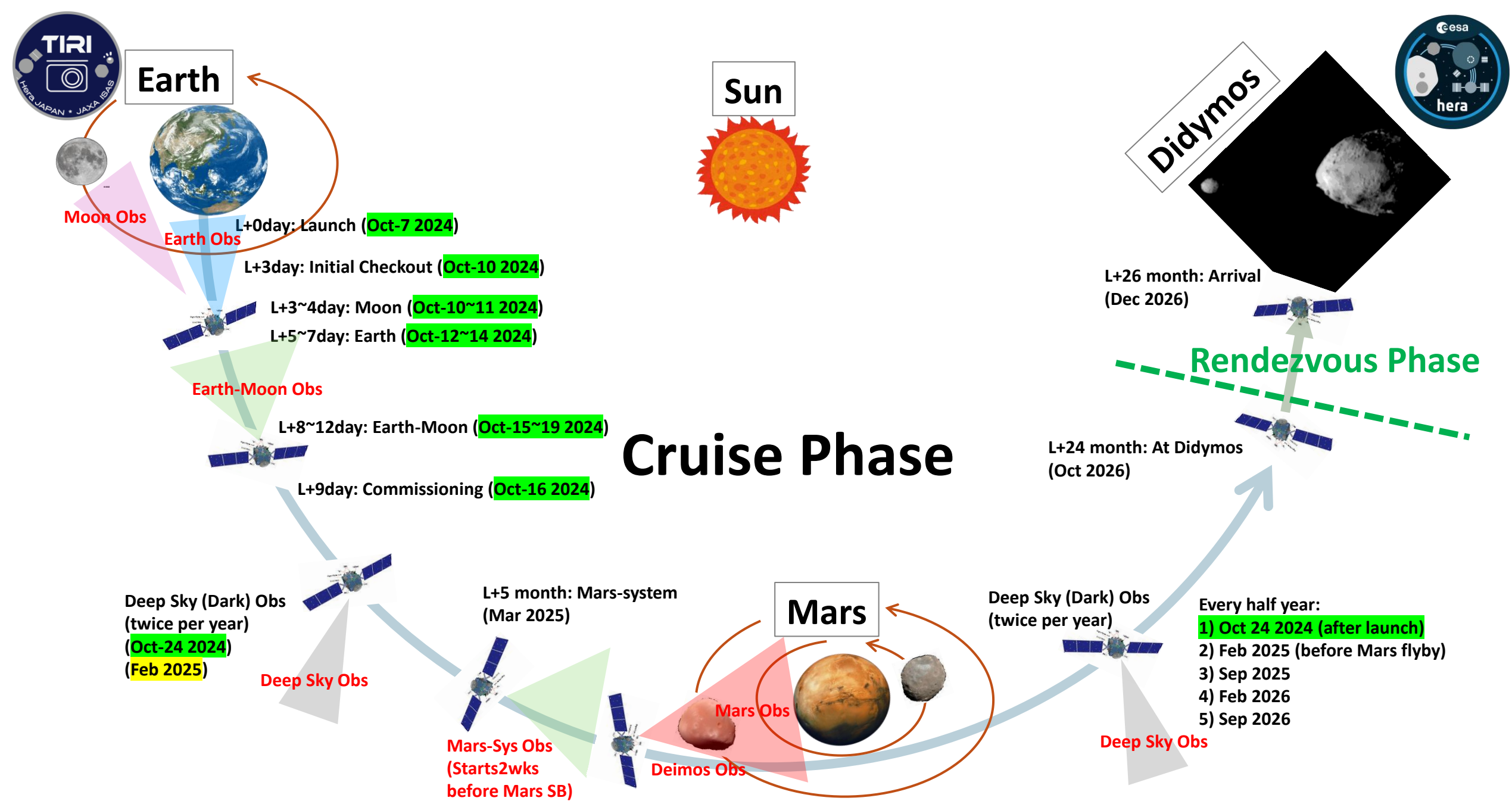


TIRI Operations

Mars Flyby Planning

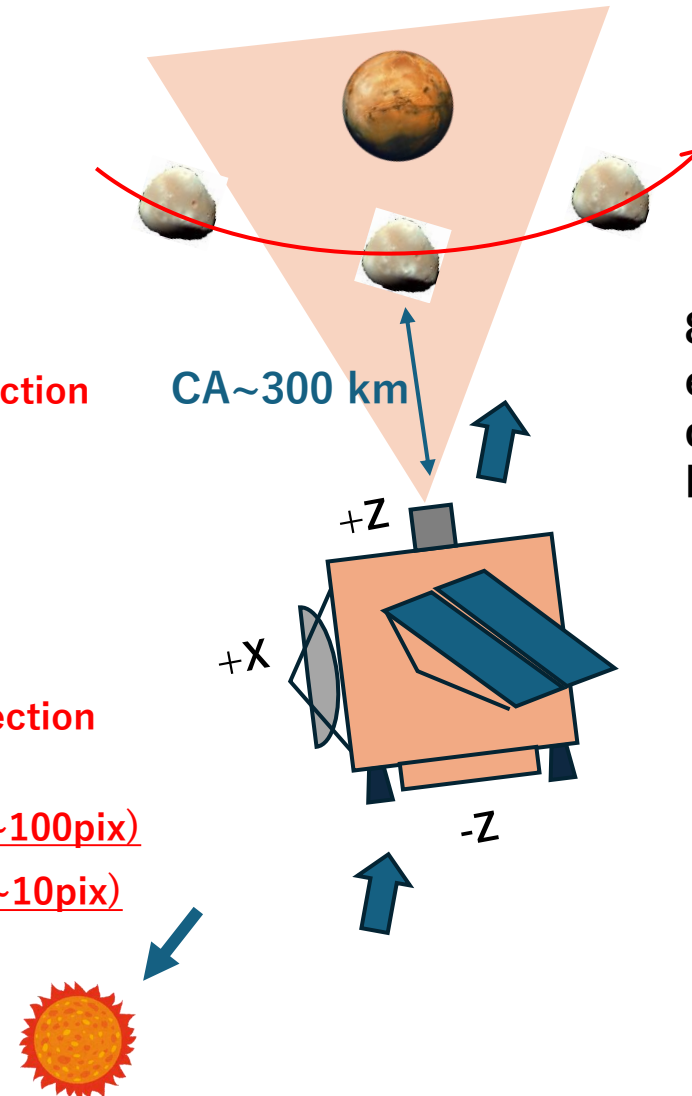
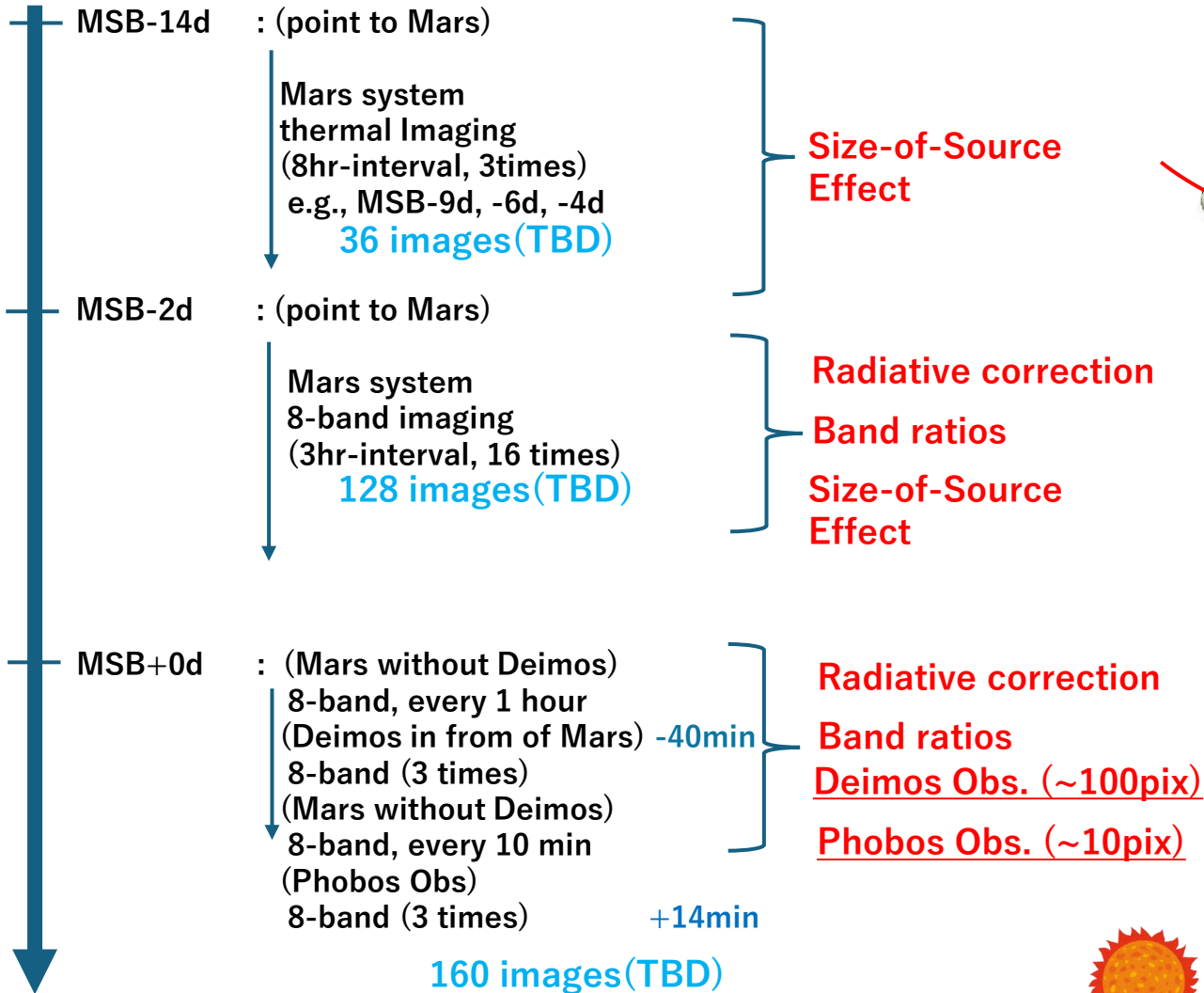
TIRI Team (Tatsuaki Okada)

Updated on 5 Dec 2024



Mars Flyby

■ Mars (+Deimos) Obs



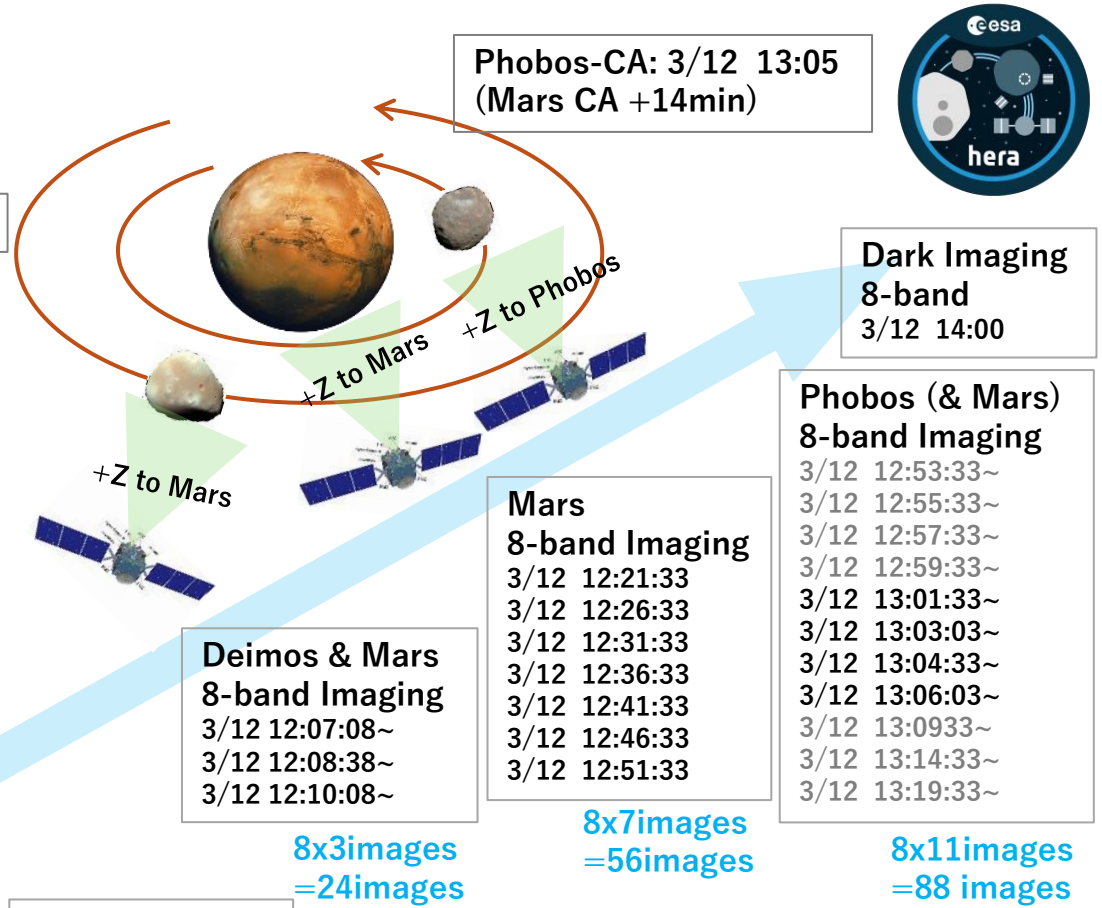
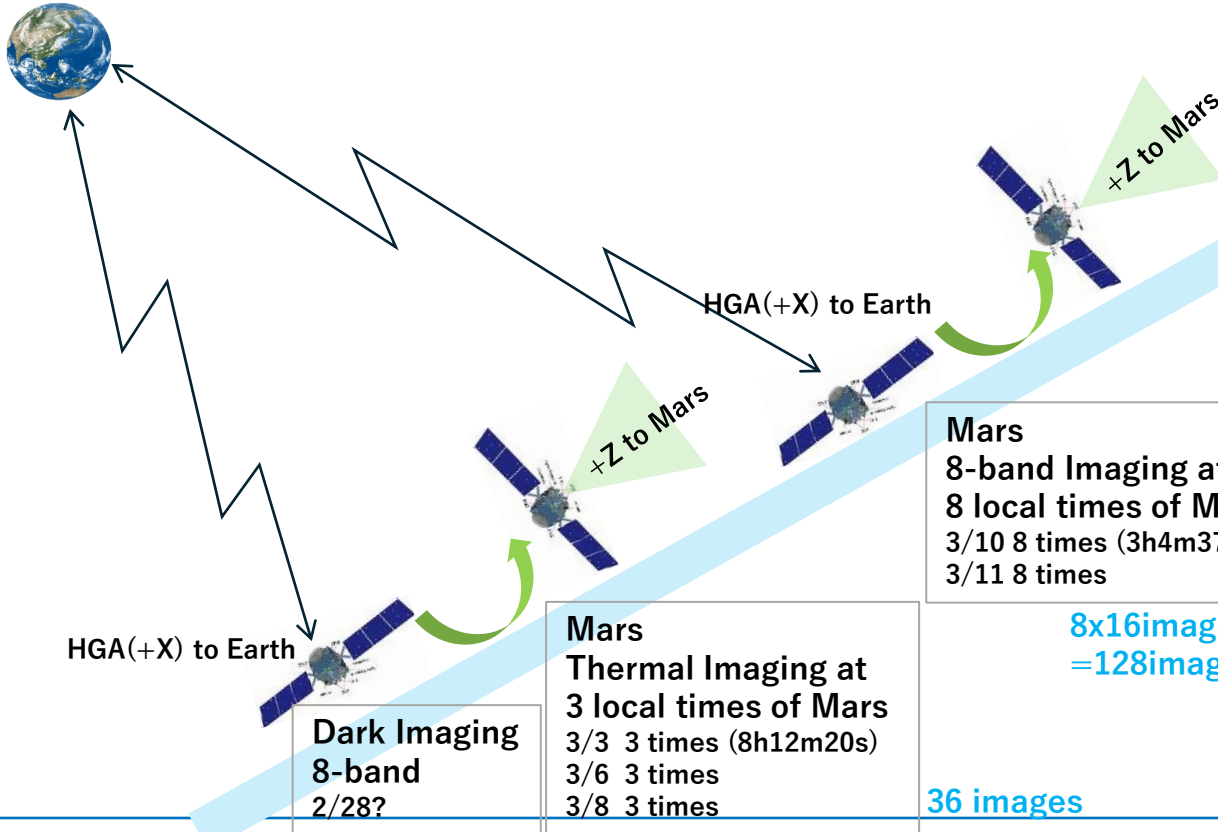
8-band images repeatedly every 86 sec (only twice?) during Deimos within the FOV of TIRI.



Mars Swing By Operations:

To be discussed:

- Slew rate of S/C attitude change
- 1) when to start pointing to Phobos?
- 2) still possible to point to Deimos?



Dark Imaging 8-band
2/28?

Mars Thermal Imaging at 3 local times of Mars
3/3 3 times (8h12m20s)
3/6 3 times
3/8 3 times

36 images

Mars 8-band Imaging at 8 local times of Mars
3/10 8 times (3h4m37.5s)
3/11 8 times

8x16images =128images

Mars 8-band Imaging
3/12 02:00:00
3/12 04:30:00
3/12 06:00:00
3/12 07:30:00
3/12 09:00:00
3/12 10:00:00
3/12 11:00:00
3/12 11:15:00
3/12 11:30:00
3/12 11:45:00
3/12 12:00:00

8x11images =88images

Deimos & Mars 8-band Imaging
3/12 12:07:08~
3/12 12:08:38~
3/12 12:10:08~

8x3images =24images

Mars 8-band Imaging
3/12 12:21:33
3/12 12:26:33
3/12 12:31:33
3/12 12:36:33
3/12 12:41:33
3/12 12:46:33
3/12 12:51:33

8x7images =56images

Phobos (& Mars) 8-band Imaging
3/12 12:53:33~
3/12 12:55:33~
3/12 12:57:33~
3/12 12:59:33~
3/12 13:01:33~
3/12 13:03:03~
3/12 13:04:33~
3/12 13:06:03~
3/12 13:09:33~
3/12 13:14:33~
3/12 13:19:33~

8x11images =88 images

Phobos-CA: 3/12 13:05 (Mars CA +14min)

Mars-CA: 3/12 12:51:33

Deimos-CA: 3/12 12:11:08 (MarsCA -40min)

Attitude Change
3/12 11:50~11:51 +Z to Mars-center +7 deg
3/12 12:15~12:16 +Z to Mars-center +0 deg

3/12 12:51~13:01? from Mars-Center to Phobos

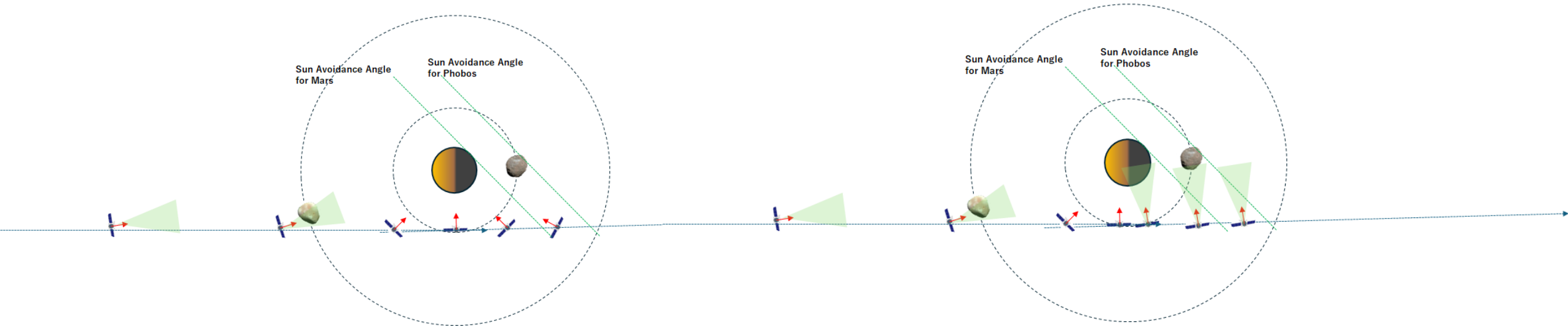


Mars-CA and Phobos Obs



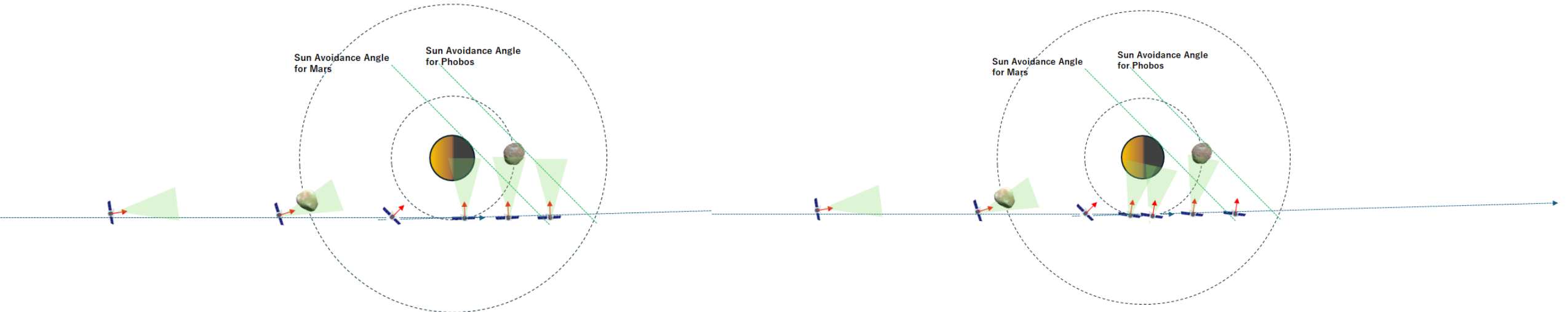
Continued to Keep pointing to Mars Center
(No Phobos images)

Keep the S/C attitude after Mars-CA



Keep the S/C attitude just after Mars-CA

Keep the S/C attitude before Mars-CA

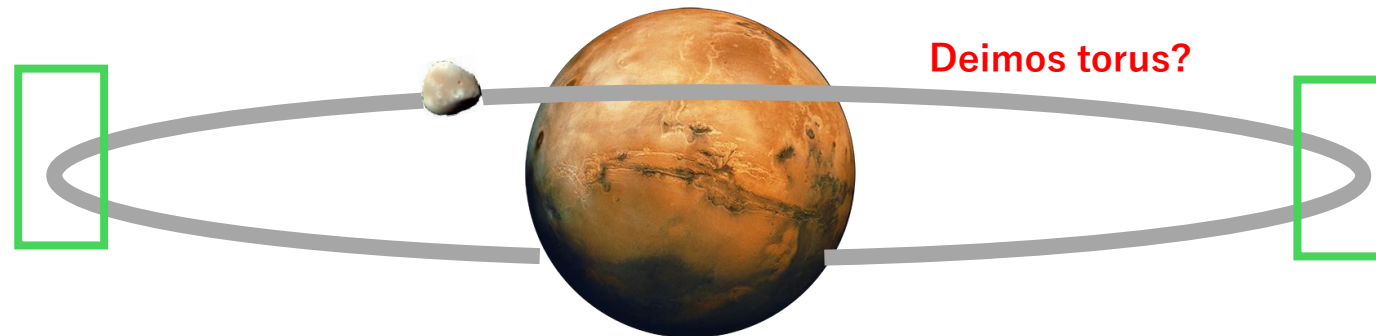


Mars Flyby (proposed by Ernesto Palomba)

A challenge to observe Deimos dust torus by thermal imaging at the highest column density region before the Mars flyby.

Forward scattering observation will be the best way to detect it but cannot be done because the Sun is within the avoidance angles of optical instruments

→ To be done using the data acquired by other observations.





Summary Table



No.	Type	Objective	Observing constraints	Trigger	Obs Mode/ Attitude	Observing sequence	Mode	Frequency	Data per set (MegaByte)	Observation combined with	Mission Phases	Data Volume
7	Science/ Calibration	Mars system observations (1)	Start from the Mars distance of 10 ^{^7} km (~2 wks before flyby) to 2 day before Mars flyby	Thermal images at 8.2 hours interval (3 local times of Mars), at least 3 times (MSB-9d, -6d, -3d) for example: 3/2 22:09, 3/3 06:21, 3/3 14:34, 3/6 00:00, 3/6 08:12, 3/6 16:25, 3/8 01:14, 3/8 09:26, 3/8 17:39 (for each day, N DoM, N-1/3 DoM, and N-2/3 DoM) --> 8.2hours = 1/3 day of Mars (DoM) (1 day of Mars = 24.6hours)	TIRI (+Z) pointing to Mars TIRI-radiator (-X) in shadow	2 x open/close images x 3 times x 3 days = 36 images	IMG		3 times/day x 3 times x 2 band images = 36 images = 54 MB	AFC, HSH	Mars flyby	54
8	Science/ Calibration	Mars system observations (2)	Start from 2 days before to 0 day before Mars flyby (2 whole days)	8 band images at 3.1 hours interval for 2 days (MSB - 2d, -1d) for example: 3/10 :: 01:51, 04:56, 08:00, 11:05, 14:09, 17:14, 20:19, 23:23 3/11 :: 02:28, 05:33, 08:37, 11:42, 14:46, 17:51, 20:56, 3/12 00:00 (for 2 days, 3/12 00:00, -1/8 DoM, -2/8 DoM, -3/8 DoM, ...14/8 DoM, -15/8 DoM) 3.1 hours = 1/8 day of Mars (DoM) (1 day of Mars = 24.6hours) (8 local times of Mars)	TIRI (+Z) pointing to Mars TIRI-radiator (-X) in shadow	8-band images for 3.1 hours interval, 2 days	IMG		8 times/day x 2day x 8 band images = 128 images = 192 MB	AFC, HSH	Mars flyby	192
9	Science Calibration	Mars close observations before Deimos Observations	Start after Mars system observations (2), before Deimos observations	8 band images at 1 or 2 hours interval before Mars Closest Approach for example: 3/12 02:00, 04:30, 06:00, 07:30, 09:00, 10:00, 11:00, 11:15, 11:30, 11:45, 12:00	TIRI (+Z) pointing to Mars TIRI-radiator (-X) in shadow	8-band images for 11 times.	IMG		11 times x 8 band images = 88 images = 132 MB	AFC, HSH	Mars flyby	132
10	Science	Deimos observations	Start from 1.5 minutes (~90sec) before the CA to Deimos (distance ~300 km) ,3 times	Closest Approach to Deimos for example, 3/12 12:07:08~, 12:08:38~, 12:10:08~	TIRI (+Z) pointing to Mars TIRI-radiator (-X) in shadow	8-band images for 3 times	IMG		3 times x 8 band images = 24 images = 36 MB	AFC, HSH	Mars flyby	36
11	Science Calibration	Mars close observations after Deimos Observations	Start after Deimos observations, before Mars-CA	8 band images at 5 min interfaival before Mars Closest Approach for example, 3/12 12:21,12:26, 12:31, 12:36, 12:41, 12:46, 12:51	TIRI (+Z) pointing to Mars TIRI-radiator (-X) in shadow	8-band images for 7 times.	IMG		7 times x 8 band images = 56 images = 84 MB	AFC, HSH	Mars flyby	84
12	Science	Phobos observations	Start poiting to Phobos after Mars-CA, 8-band imaging continually, including 4 sets around the Phbos-CA (distance ~12000 km)	8-band images before Closest Approach to Mars (Phobos), for example, 3/12 13:02:00, 13:03:30, 13:05:00, and finally 1 set of dark images	TIRI (+Z) pointing to Mars TIRI-radiator (-X) in shadow	8-band images for 4 times	IMG		11 times x 8 band images = 88 images = 132 MB		Mars flyby	132
14	Calibration	Deep sky (Dark)	No bright object in FoV (Such as Sun, Earth, Moon, Mars)	Before/After Mars Swing By	TIRI-radiator (-X) in shadow	4 x close/wide + 1 x 8-band imaging Before and after MSB	IMG		2 times x (2band x 4 + 8band x1) =32 Images = 48 MB		Mars flyby	48