# Mio SWG meeting

13 June 2024


Go Murakami

BepiColombo project

Japan Aerospace Exploration Agency (JAXA)

# Mio Science Working Group meeting

**13 June 2024 09:00-11:00JST**

- **1. Updated status of Mio [Taeko Seki & Go Murakami]**
- **2. Upcoming operations plan [Taeko Seki & Go Murakami]**
  - 2024/H2
  - Preparations for Mercury arrival: separation and deployments
  - Mercury flybys #4, #5, and #6
  - Check out operations after MOI
- **3. Updates on baseline observation plans**
  - Reports of the updated thermal analysis [Hiroto Tanaka]
- **4. Data handling and archiving**
  - Time calibration for L1 [Shoya Matsuda]
  - Status of Mio Science Center [Yoshi Miyoshi]
  - Request to each PI team [Go Murakami]
- **5. Others**

# Operations

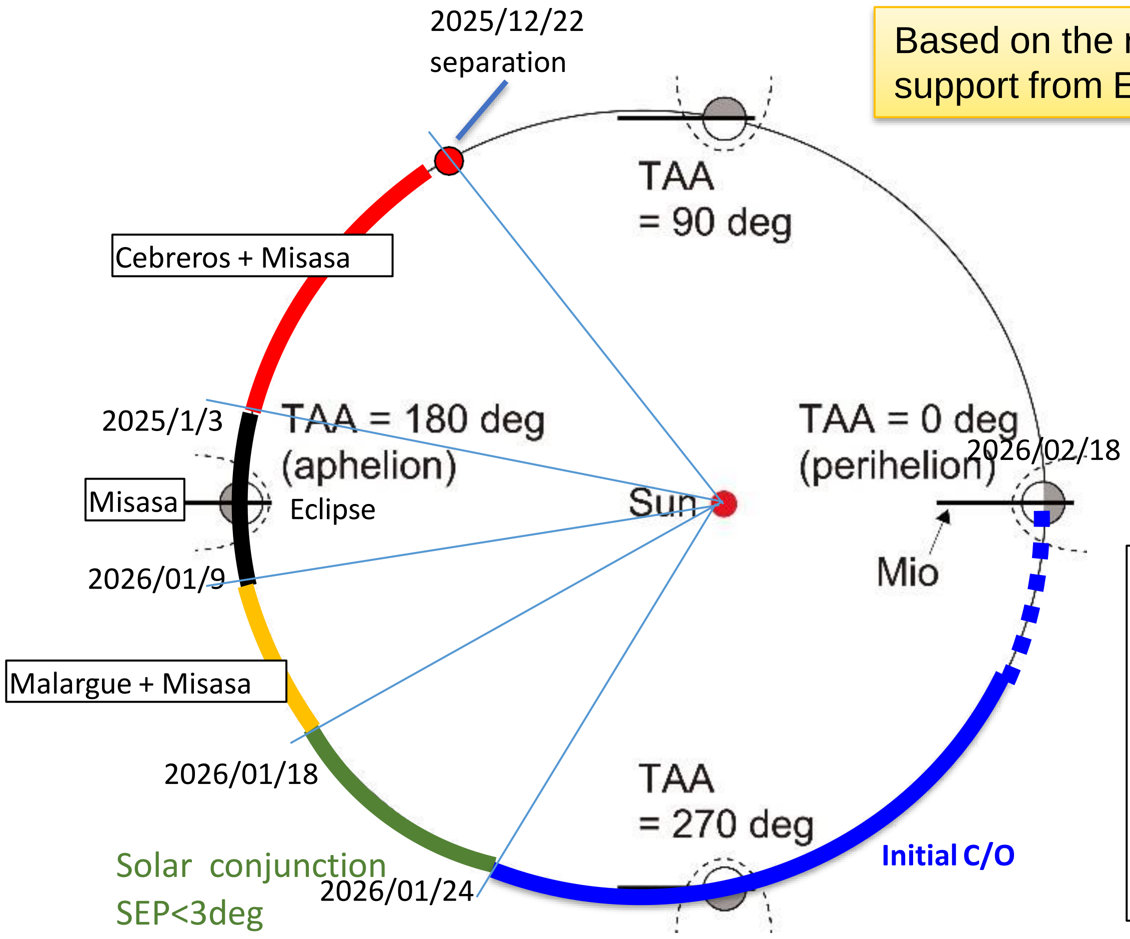
**MIO Operation schedule up to Mercury orbit insertion**

2024.6.11

| | | | |
|---|---|---|---|
| | **Checkout/maintenance** | | |
| | **2024/4/9** | Cruise C/O#11 | 10 hrs<br>Routine checkout sequence<br>+ Battery cell UVC status check, MWE check (short interval commanding)<br>-> completed |
| | **2024/2H** | Cruise C/O#12 | 9+TBD hrs<br>Routine checkout sequence<br>+ MWE check (short interval commanding)<br><br>TBD: MSA OCL test if interactive slot without WOL is arrangeable |
| | | Cruise checkout in 2025 to be confirmed | |
| | **Before 2025/11** | MC/AT/RQ/ST table upload | To be requested but may not be possible before MOI. |
| | | | |
| | **Science observation** | | |
| | **2024/9/5** | MSB4 | 200km<br>High temperature conditions expected like MSB3. |
| | **2024/12/2** | MSB5 | 40,000km |
| | **2025/1/9** | MSB6 | 393km |

# Schedule after separation (updated)

Based on the revised 2 ground station plan with support from ESTRACK. This is now the baseline.




<5deg: 2026/1/15-
<3deg : 2026/1/18-24

Ground stations assigned :

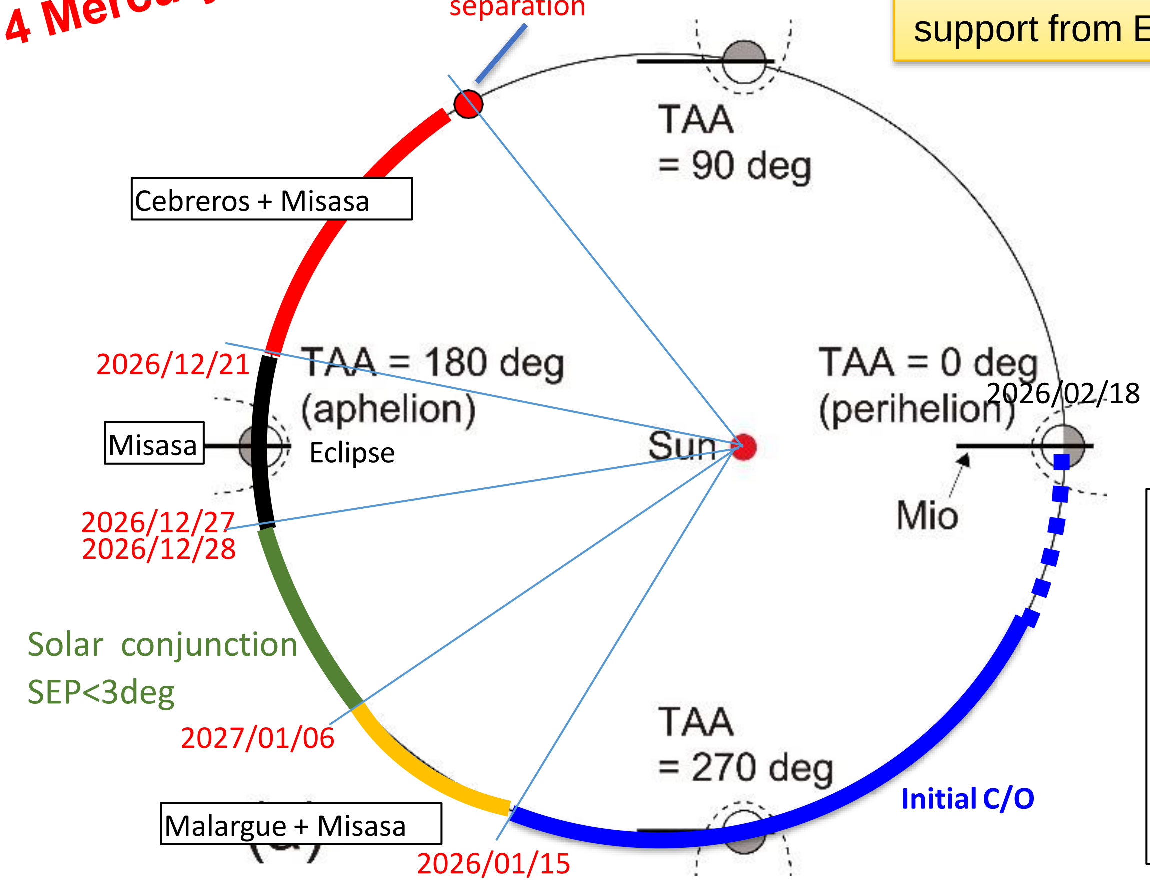
| | |
|---|---|
| separation(12/22) to 1/2 | 2 stations |
| 1/3 to 1/8 (TBD) | 1 station |
| 1/9 (TBD) to 1/16 | 2 stations |
| 1/16- | 1 station |

Able to return to HGA and finish activities with 4 days margin before solar conjunction

# Schedule after separation (updated)

**Just in case of 4 Mercury years delay**

Based on the revised 2 ground station plan with support from ESTRACK.   This is now the baseline.




Ground stations assigned :

| | |
|---|---|
| separation(12/22) to 1/2 | 2 stations |
| 1/3 to 1/8 (TBD) | 1 station |
| 1/9 (TBD) to 1/16 | 2 stations |
| 1/16- | 1 station |

Able to return to HGA and finish activities with 4 days margin before solar conjunction

**Eclipse and solar conjunction will be consecutive**

# Restrictions in Dec 2025 – Jan 2026 (updated)

## RF link by MGA

- HGA link unavailable during extension ops.
- Downlink: 1-bit communication method, 64 seconds per bit
- Uplink : 15.625bps, takes 60-90sec to release each TC
- One-way light time(OWLT) is 10~12 min

## Limited visibility -> improved with ESTRACK support

- 2 ground stations during extension ops. MISASA+CEB then MISASA+MLG
- 1-2 hours daily interruption by occultation. until 31 December
- Eclipse season 3-10 January. SI instruments powered off due to power budget restriction

=> In nominal case, Mefisto and WPT is fully deployed before eclipse

## Limited window

- Solar conjunction. 18-24 January (SEP angle < 3deg)

baseline: antenna/MAST fully deployed before conjunction
motivation:
- full extension means more HGA availability
- Strong thermal constraints while approaching perihelion

# Schedule (updated)

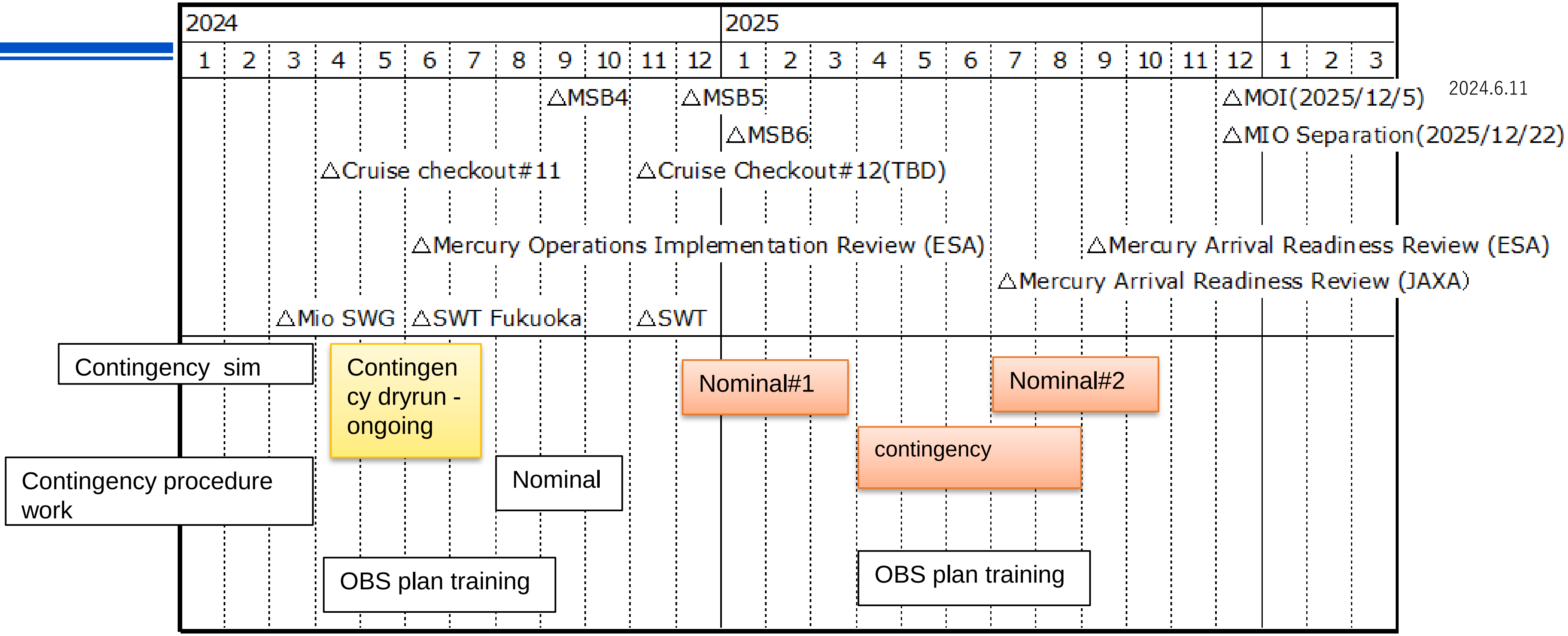
Based on the revised 2 ground station support plan.
The new plan allows several days of margin before conjunction.
This is now the baseline.

| Date UTC | Events | MGA | HGA | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2025/12/22 | MIO separation | | | | | | | |
| 12/22 | SEP1 | ✓ | | | | ✓ | ✓ | |
| 12/23 | SEP2 | ✓ | | Occultation | | ✓ | ✓ | |
| 12/24 | SEP3 | ✓ | ✓ | Occultation | | ✓ | ✓ | |
| 12/26 | EXT1 | | ✓ | Occultation | | ✓ | ✓ | |
| 12/27 | EXT2 | ✓ | ✓ | Occultation | Spin up | ✓ | ✓ | |
| 12/28 | EXT3 | ✓ | | Occultation | mef 5m | ✓ | ✓ | |
| 12/28 | EXT4 | ✓ | | Occultation | wpt 5m | ✓ | ✓ | |
| 12/29 | EXT5 | ✓ | | Occultation | | ✓ | ✓ | |
| 12/30 | EXT6 | ✓ | | Occultation | mef 10m | ✓ | ✓ | |
| 12/31 | EXT7 | ✓ | | Occultation | Wpt 10m | ✓ | ✓ | |
| 2026/1/1 | EXT8 | ✓ | | | mef 15m | ✓ | ✓ | |
| 1/2 | EXT9 | ✓ | | | wpt 15m | ✓ | ✓ | |
| 1/3 – 9 | ACS checkout | | ✓ | Eclipse | | ✓ | | |
| 1/10 | EXT10 | ✓ | ✓ | | | ✓ | | ✓ |
| 1/11 | EXT11 | ✓ | | | Mast 5m | ✓ | | ✓ |
| 1/12 | EXT12 | ✓ | | | Spin up | ✓ | | ✓ |
| 1/12 | EXT13 | ✓ | ✓ | | | ✓ | | ✓ |
| 1/13, 14 | (margin) | | ✓ | | | ✓ | | ✓ |
| 1/15 | Setup for solar conjunction | ✓ | ✓ | | | ✓ | | ✓ |
| 1/16, 17 | (margin) | | | | | | | |

MLG support until 1/16

# MIO Contact pass daily coverage chart (MIS/CEB/MLG)

# Preparing for Mercury Arrival




- 2024 2Q contingency (SEP/OBS unfinished cases and updates from 1Q sim)
- 2024 3Q Nominal (SEP/EXT) … for project system and subsystem focus on simulating real-time scale
- 2024 2-3Q OBS plan training

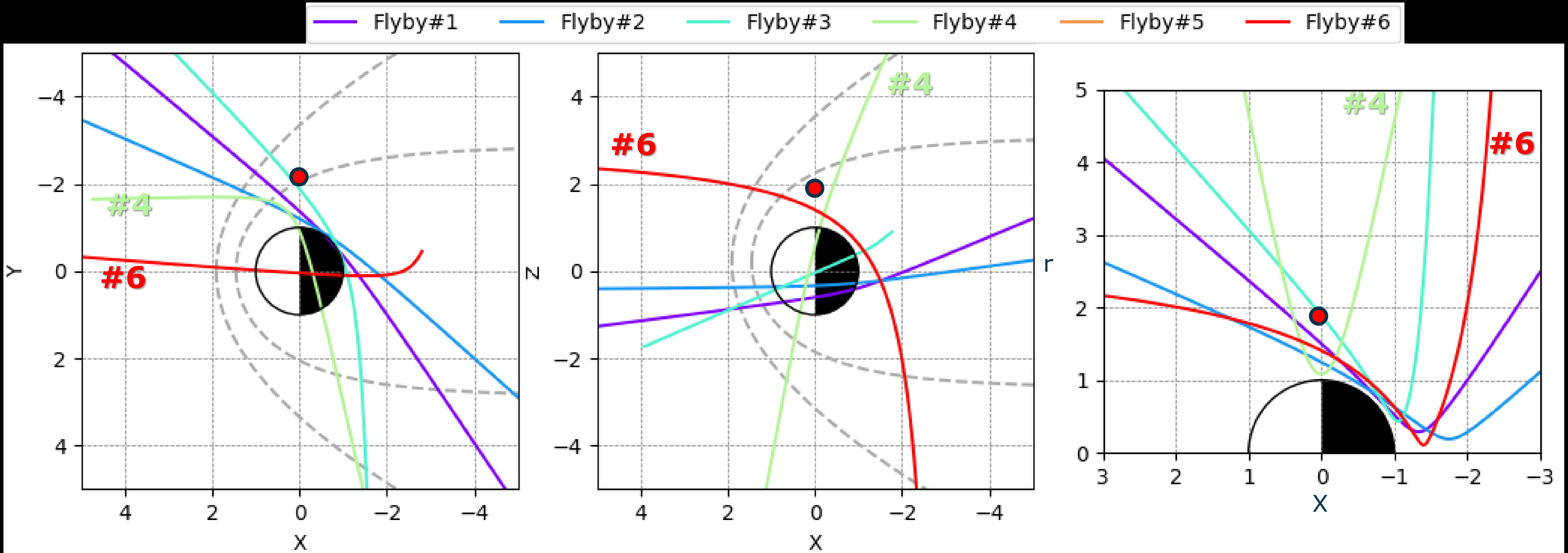
------ Larger-scale campaigns from 2024 4Q with ground stations, support team, etc. -------

- 2024 4Q-2025 1Q Nominal#1 (SEP/EXT)
- 2025 2-3Q contingency
- 2025 3-4Q Nominal#2 …

# Upcoming flybys

#4: Sep 2024
(#5: Dec 2024)
#6: Jan 2025

**Requests**:
-About ±24h observation (depending on result of thermal analysis)
-Direct open FoV to Mercury during closest approach if possible
-No WOL from CA-3.0h to CA+1.0h if possible (HV start 10 min after WOL, taking 1.7h for HV ramp)
-Before the observation sequence, MSA requires interactive operations to check science data generation. MGF requests early power on (just after MSA) for drift investigation.

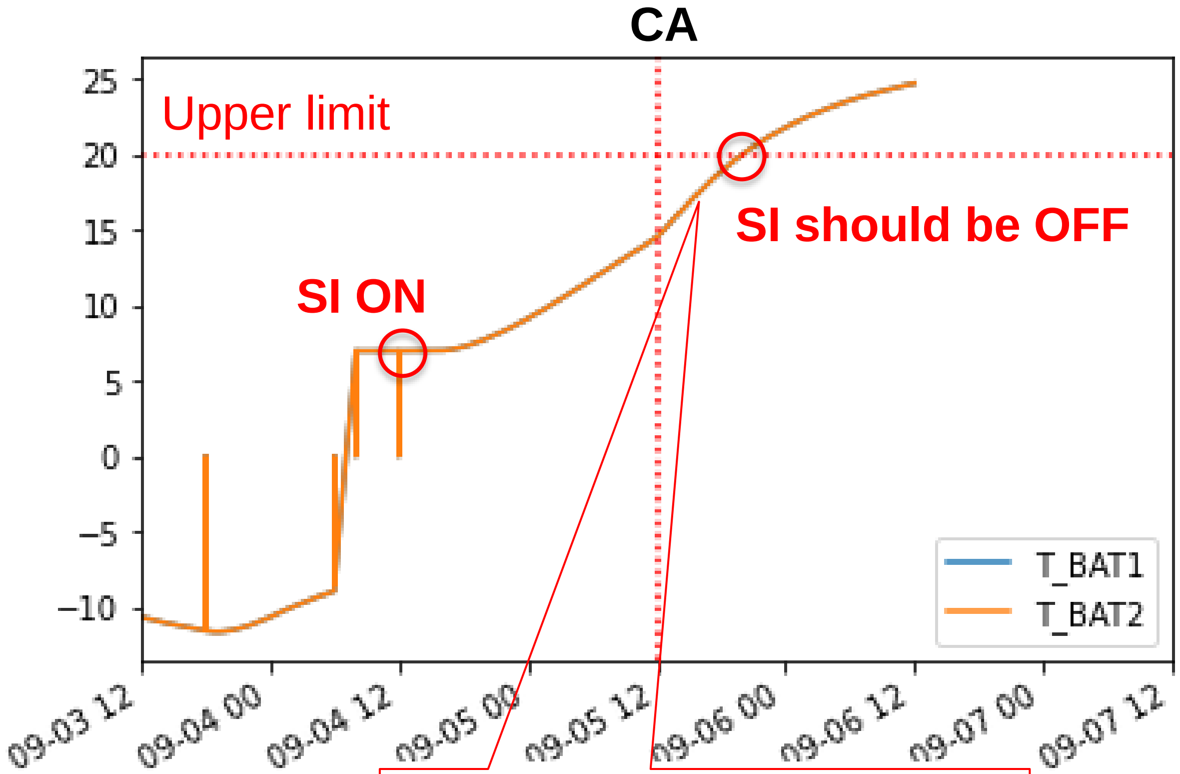


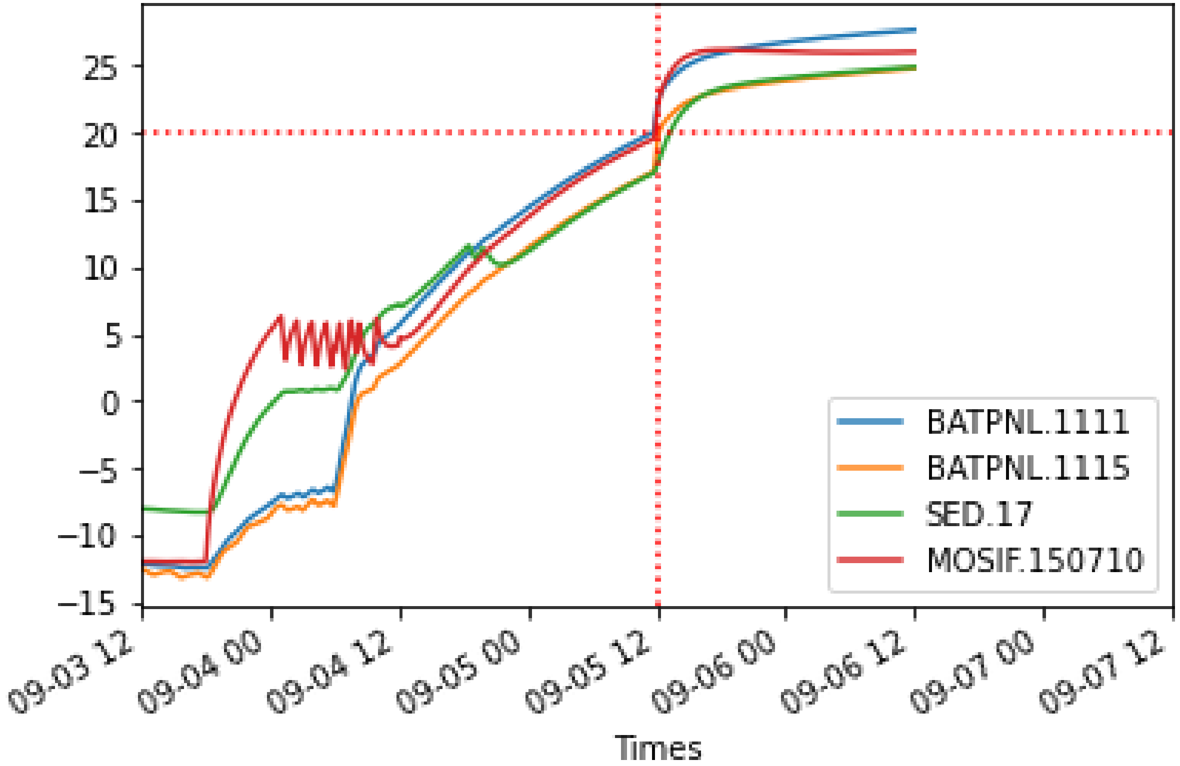
# MSB#4: Assumptions

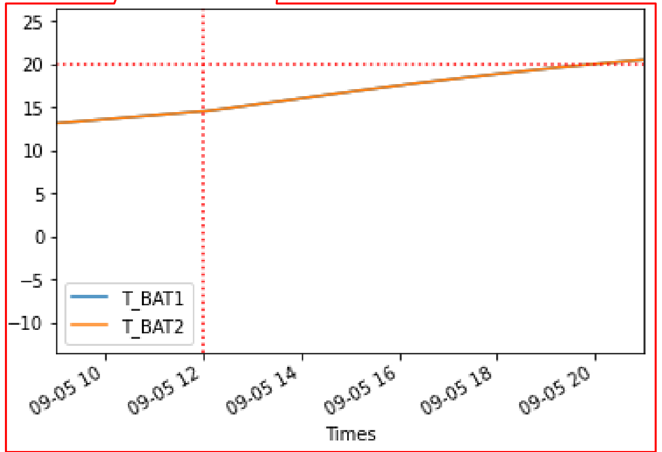
- Orbit/ Attitude : SPICE
  - MSB#4: 0.32-0.31 AU (2024/9/5 11:59:05 H=200km)
  - c.f. MSB#5: 0.31 AU (2024/12/2 4:53:05 H=40,000km)
  - c.f. MSB#6: 0.45 AU (2025/1/9 11:31:10 H=399km)
  - c.f. MSB#3: 0.33-0.32 AU

- Instrument ON/OFF schedule :
  - CA-42h: MOSIF Heater ON
  - CA-30h: MMO ON
  - CA-28h: MGF/MSA ON
  - CA-24h: SI ON

# MSB#4: BAT Temperature




BAT temperature reach 20 degC (upper limit) at CA +8h

**Observation will start at CA -24h and end at CA +8h**

# MC upload timing

| | | |
|---|---|---|
| 1) | Before 2025/11 | TBC, may not be possible due to conflicts |
| 2) | Pre-separation activity | last chance before separation |
| 3) | Initial checkout | add macro commands for observation/updates to in-flight parameters |
| 4) | Before science observation | update observation parameters after checkout/test observations |
| 5) | During observation phase | update foreseen, timing is irregular |

# Table/macro update plan

- We have original plans provided in January 2018
  - MEA, MIA, ENA, MSASI, MGF are available
  - **Any updates?**
  - **Other instruments?**
  - **-> ENA requested additional long macro commands**

| Instrument | Timing | | Table type | Macro number or area | | Size | Purpose | Change point | Comments |
|---|---|---|---|---|---|---|---|---|---|
| | After | Before | | | | | | | |
| MEA | Preparation for nominal science observation | Nominal science observation | MEA MDP | 0x1FCF AC50 | MDP MEA Table Area | 1440B | Change Calibration Table | Calibration Table | |
| MEA | Nominal science observation | Nominal science observation | MEA MDP | 0x1FCF AC50 | MDP MEA Table Area | 1440B | Change Calibration Table | Calibration Table | |

| Instrument | Timing | | Table type | Macro number or area | | Size | Purpose | Change point | Comments |
|---|---|---|---|---|---|---|---|---|---|
| | After | Before | | | | | | | |
| MGF | MAST deployment | Nominal science observation | MC-S | 0x0E7 | // MGF_PARAM_SET | - | Finalize the parameters to roughly calibrate the data provided to other instruments | Change the whole parameters | |

# Operations: C/O at Mercury

- Main purpose: health check and function check after 7-years cruise and MMO separation
- Baseline plan: ~~same procedures as NECP C/O (but with different setup: telemetry rate, DR available, MMO timeline available, etc…)~~
- **-> Strong constraints due to thermal issue (interactive operations are difficult)**
- New baseline (draft):
  - Timeline operations (including out of communication pass)
  - Skip cruise observation procedures (already checked)
  - Only critical operations (e.g., HV) will be performed during the communication pass with timeline (+ partially interactive?)

- JAXA Mio system team will propose a draft strategy/plan for the initial C/O at Mercury by 30 April 2024 **-> Delayed (thermal analysis has just been completed)**
- **-> PI teams will provide detailed information by the next SWT meeting in Japan**
  - **Activity, brief procedure, and duration**

# Operations: C/O at Mercury

**Critical operations planned**

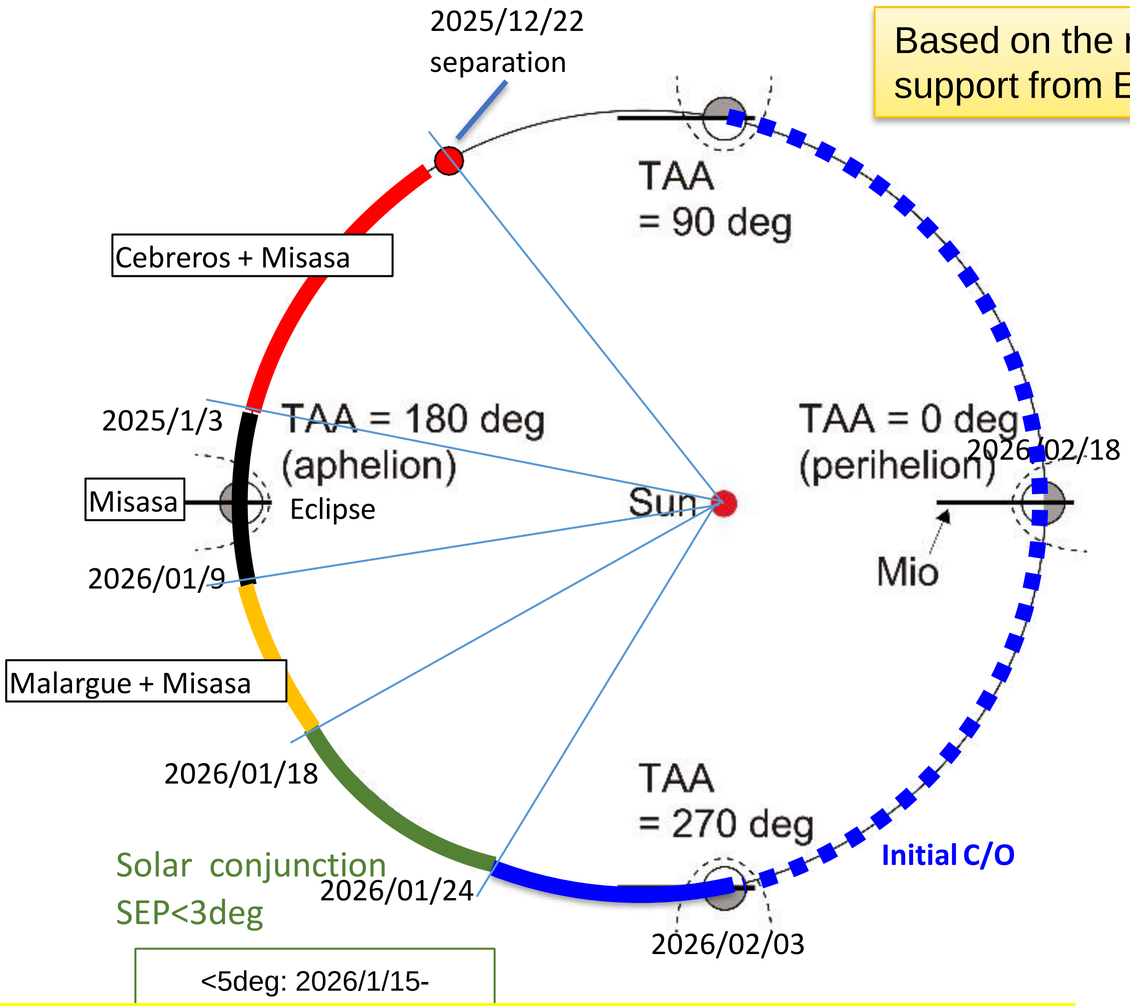
-**HEP-i**: no operations during cruise
-**MSASI**: no operations during cruise
-**MSA**: increase HV higher than that during cruise

-> High priority instruments for the C/O slots in

No parallel activities expected (same as NECP)

| | BepiColombo/MMO | | | |
|---|---|---|---|---|
| Plasma (SW, MS) | MPPE | **MEA** | Low-energy electrons | 3eV-26keV |
| | | **MIA** | Low-energy ions | **15eV-29keV** |
| | | **MSA** | Ion mass spectroscopy | **1eV-38keV**<br>1-60 amu/e<br>m/Δm = 40 (<13keV)<br>m/Δm = 10 (>13keV) |
| | | **HEP-ion** | High-energy ions | 30keV-1.5MeV |
| | | **HEP-ele** | Hihg-energy electrons | 30keV-700keV |
| | | **ENA** | Plasma imaging | 10eV-3.3keV |
| | MGF | | Magnetic field | DC - 64Hz<br>L: <0.25Hz, M: 8Hz |
| | PWI | | Electric field, plasma wave, radio wave | DC - 10MHz (E)<br>few - 640kHz (B) |
| Exosphere | MSASI | | Na-exosphere image | **Spatial resol.: 3-30km**<br>**R = 65000** |
| Dust | MDM | | Dust environment | 10s pg*km/s |
| Radiation | SPM | | Solar particle monitor | Proton > ~40 MeV |

# Schedule after separation (updated)




Based on the revised 2 ground station plan with support from ESTRACK. This is now the baseline.

Less consecutive communication time at TAA < ±90°

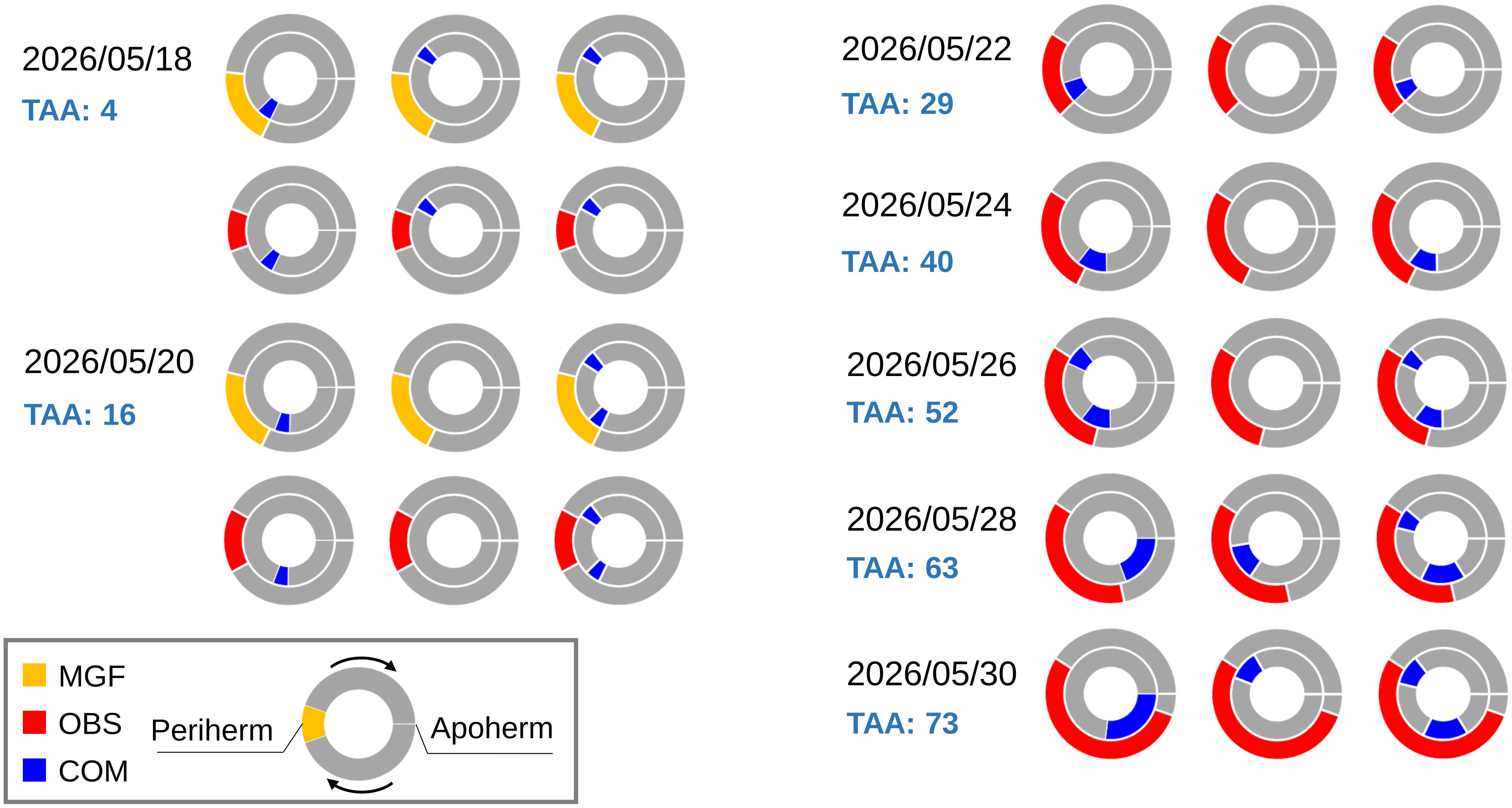
**-> Strong constraints to interactive operations**

| Date | TAA | Operations |
|---|---|---|
| 2026/1/25 | 234.8 | |
| 2026/1/26 | 238.3 | |
| 2026/1/27 | 241.8 | |
| 2026/1/28 | 245.4 | |
| 2026/1/29 | 249.1 | |
| 2026/1/30 | 252.9 | |
| 2026/1/31 | 256.8 | |
| 2026/2/1 | 260.8 | |
| 2026/2/2 | 264.9 | |
| 2026/2/3 | 269.2 | |
| 2026/2/4 | 273.6 | |
| 2026/2/5 | 278.2 | |

**Commissioning for critical operations (HEP-I, MSASI, MSA, …)**

JAXA Mio system team will propose a draft strategy/plan for the initial C/O at Mercury by 30 June 2024

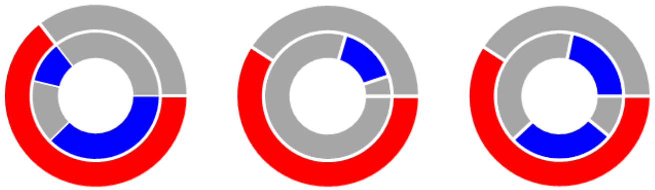
# Operational Plan / Latest ver.



# Operational Plan / Latest ver.

2026/06/01

**TAA: 82**



2026/06/03

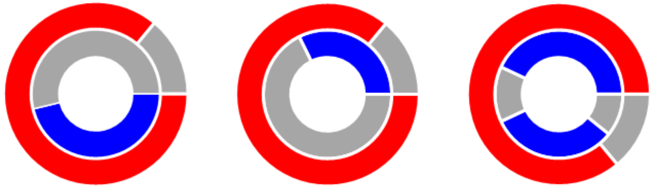
**TAA: 91**

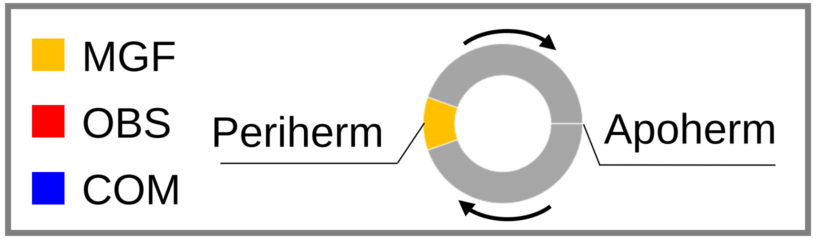
2026/06/07

**TAA: 108**

2026/06/11

**TAA: 122**



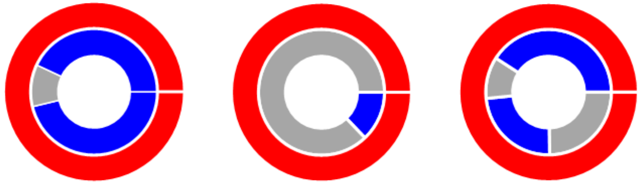



2026/06/15

**TAA: 135**

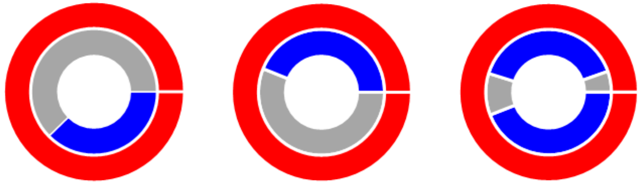
2026/06/19

**TAA: 148**



2026/06/23

**TAA: 159**

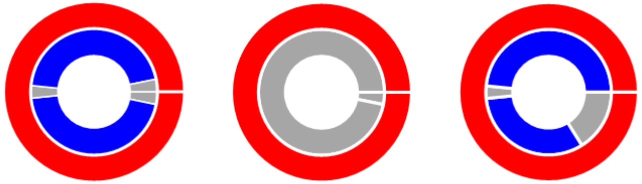


2026/06/27

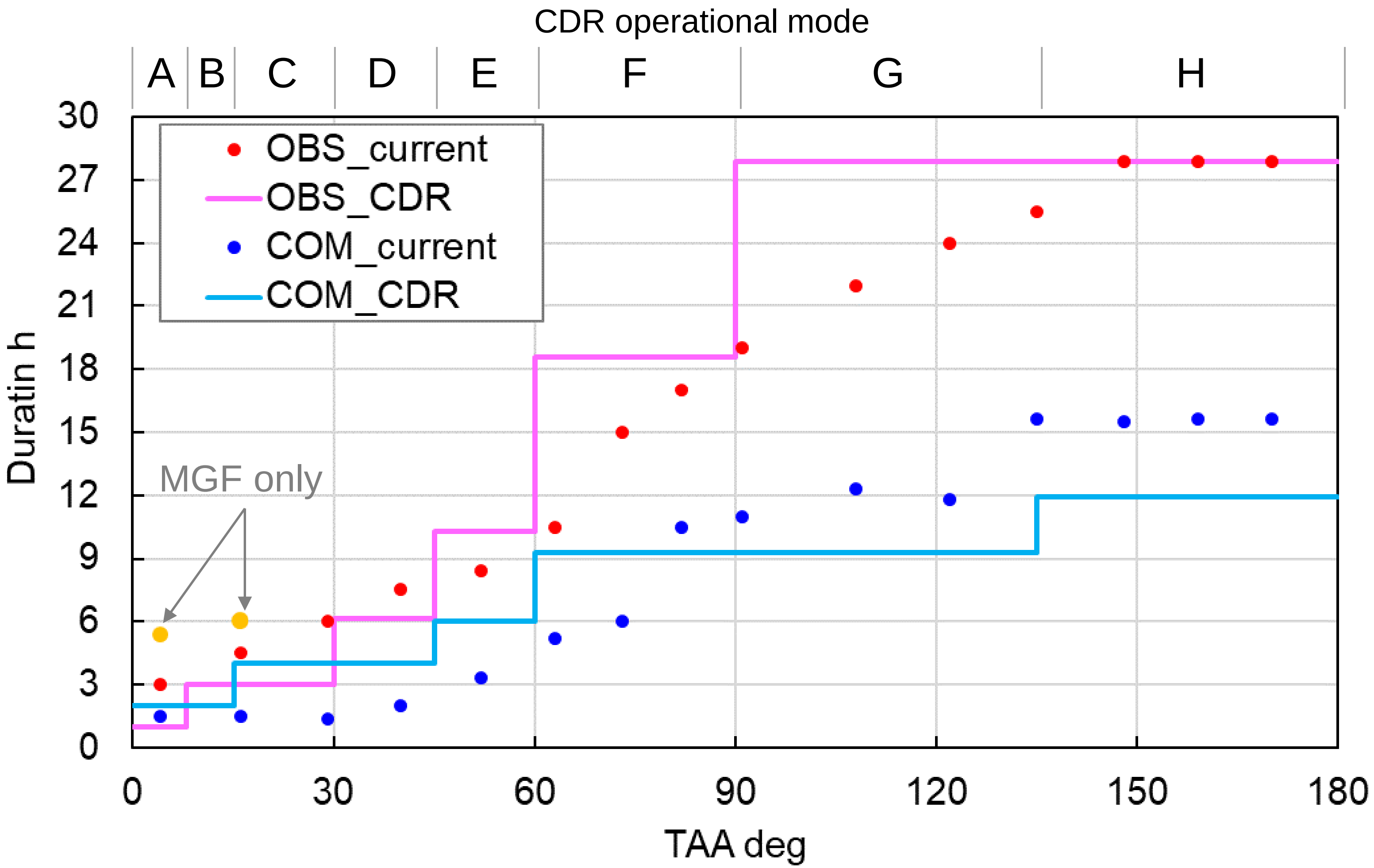
**TAA: 170**

2026/07/01

**TAA: 181**



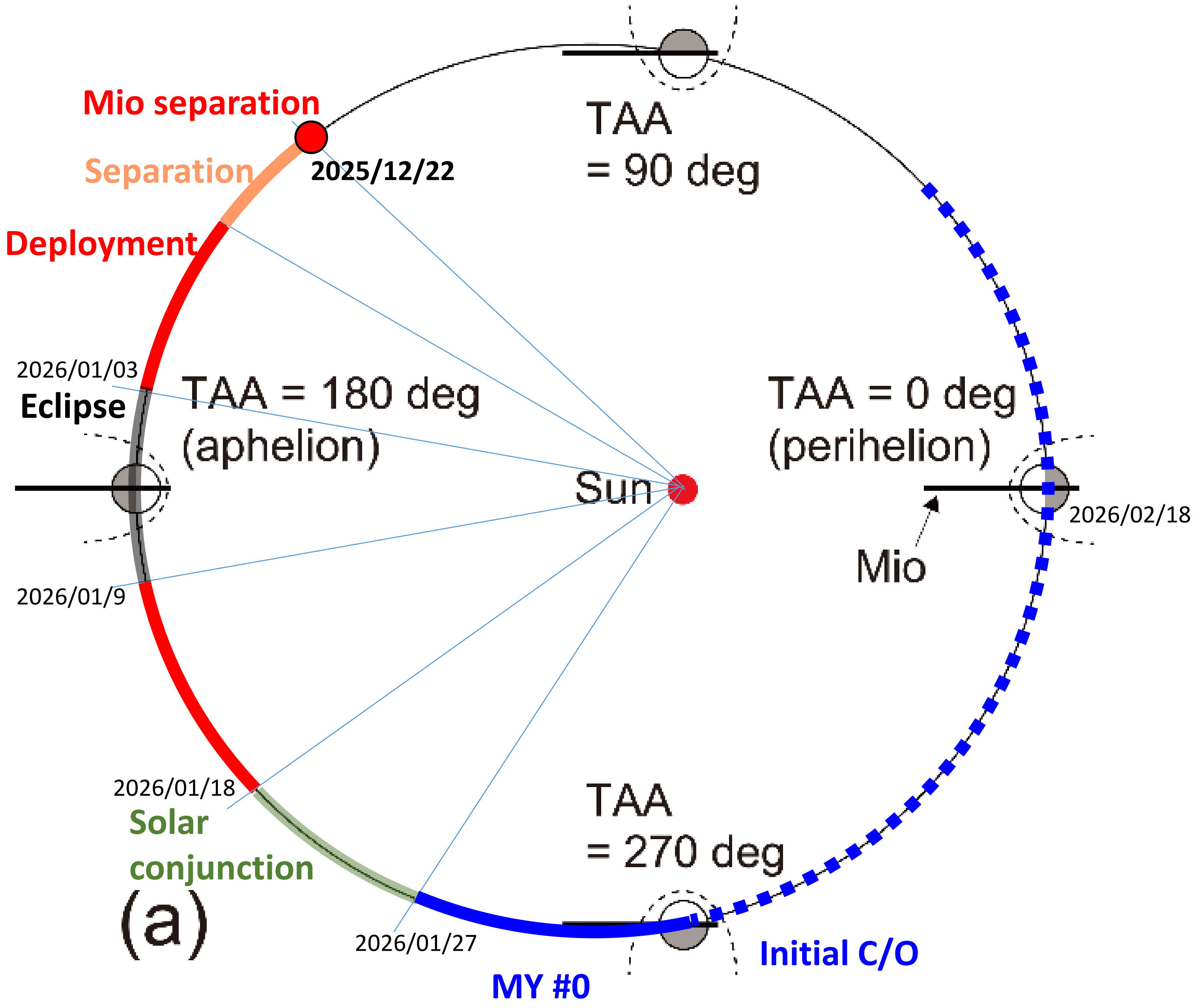
# OBS / COM durations : Comparison with CDR plans



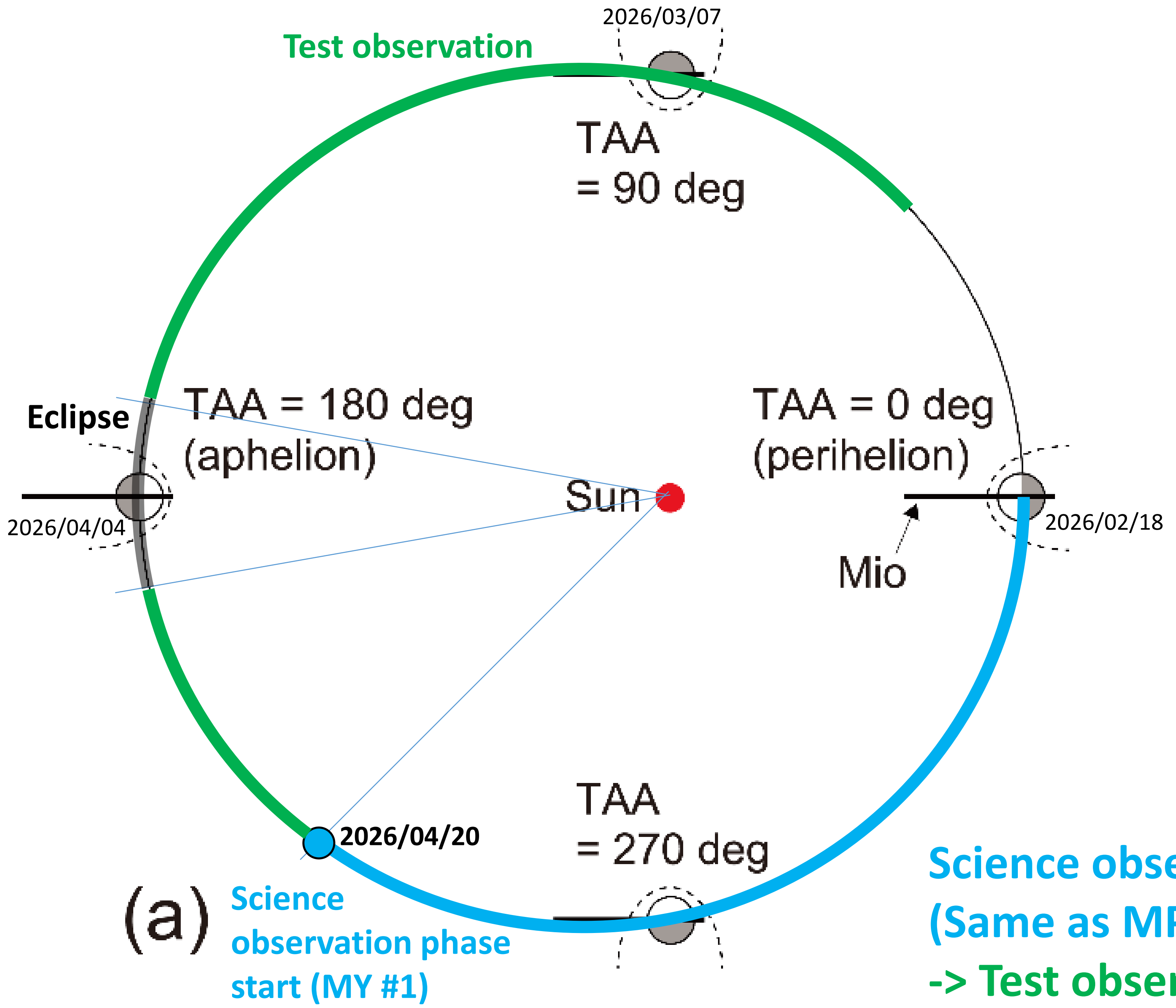

- Total OBS duration is 90.5% of the CDR plan
- Total COM duration is 111.9% of the CDR plan

# Operations: instrument optimizations for nominal science observations

- Main purpose: optimizations of instrument observation modes, parameters (e.g., HV), timings, and so on
- No information/plan now
- -> We need brief information list: activity, duration, observation mode, data mode, requested geometry
- **【To be asked to each PI team】**

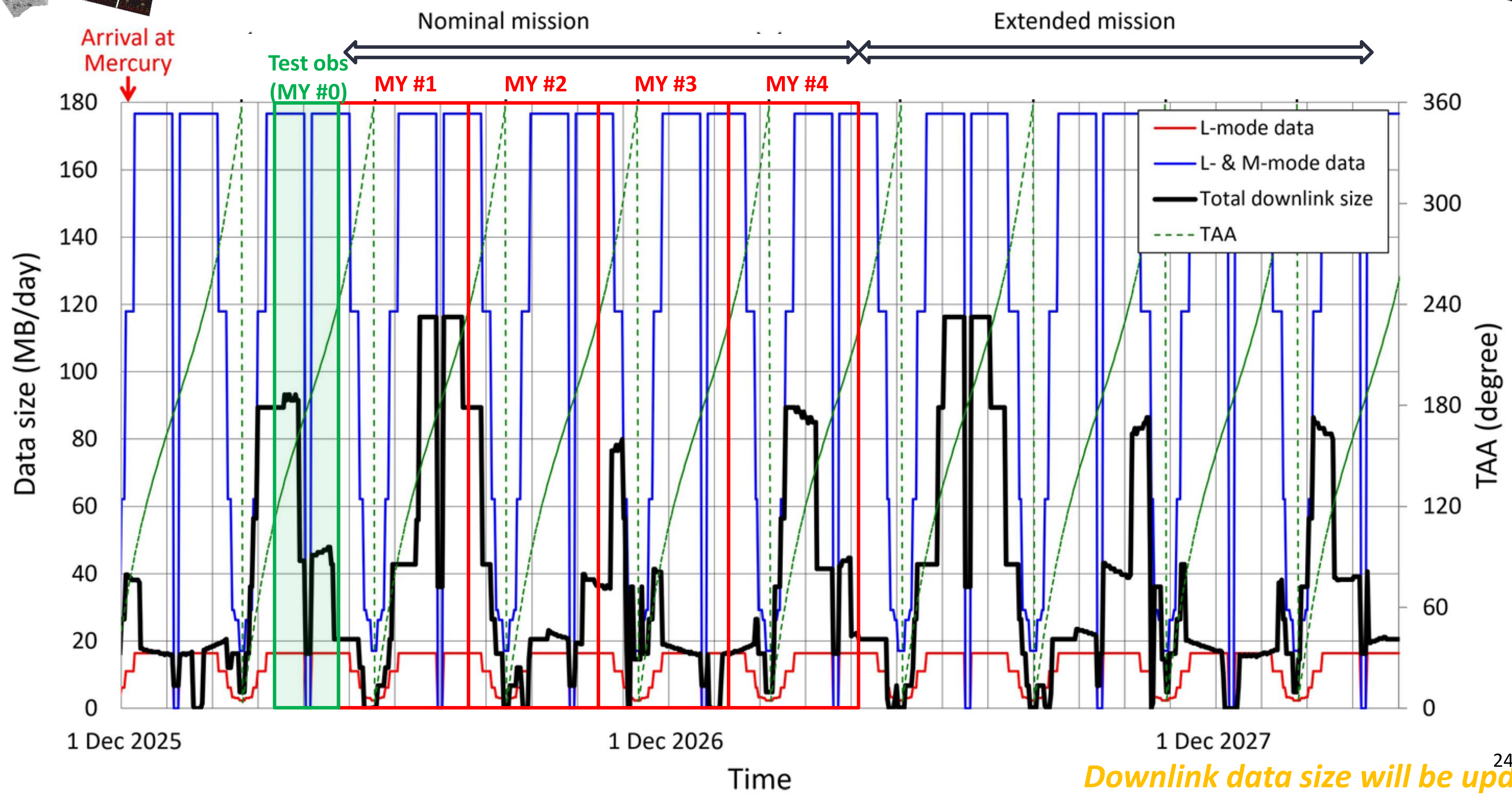


Mio separation
2025/12/22
Separation
Deployment
2026/01/03
Eclipse
2026/01/9
2026/01/18
Solar conjunction
2026/01/27
MY #0
Initial C/O
TAA = 90 deg
TAA = 180 deg (aphelion)
TAA = 0 deg (perihelion)
TAA = 270 deg
Sun
Mio
2026/02/18
(a)




Science observation phase: 2026/04/20 (TAA 225)-
(Same as MPO)
-> Test observation: ~5-6 weeks

# Baseline downlink plan




*Downlink data size will be updated*

# Mio Science Working Group meeting

**13 June 2024 09:00-11:00JST**

- **1. Updated status of Mio [Taeko Seki & Go Murakami]**
- **2. Upcoming operations plan [Taeko Seki & Go Murakami]**
  - 2024/H2
  - Preparations for Mercury arrival: separation and deployments
  - Mercury flybys #4, #5, and #6
  - Check out operations after MOI
- **3. Updates on baseline observation plans**
  - Reports of the updated thermal analysis [Hiroto Tanaka]
- **4. Data handling and archiving**
  - Time calibration for L1 [Shoya Matsuda]
  - Status of Mio Science Center [Yoshi Miyoshi]
  - Request to each PI team [Go Murakami]
- **5. Others**

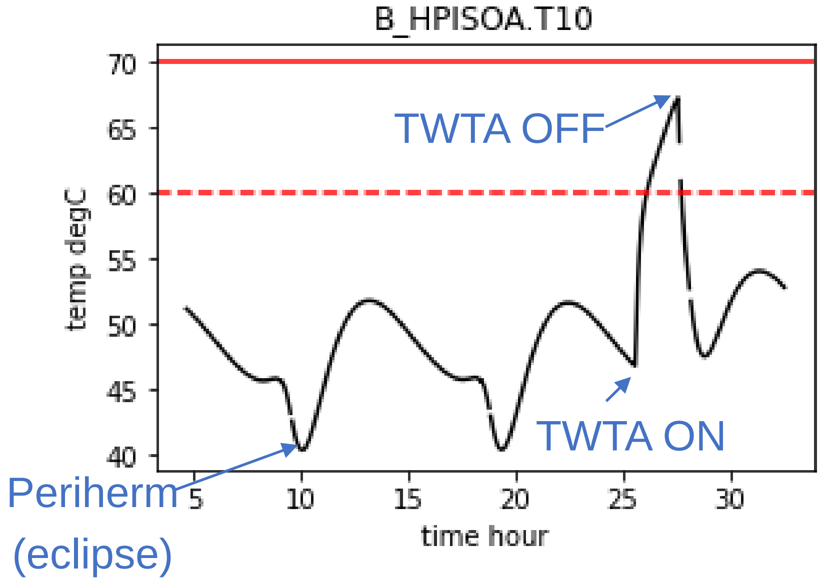
# Current status of MMO operational plans

JAXA R&D / Mio team

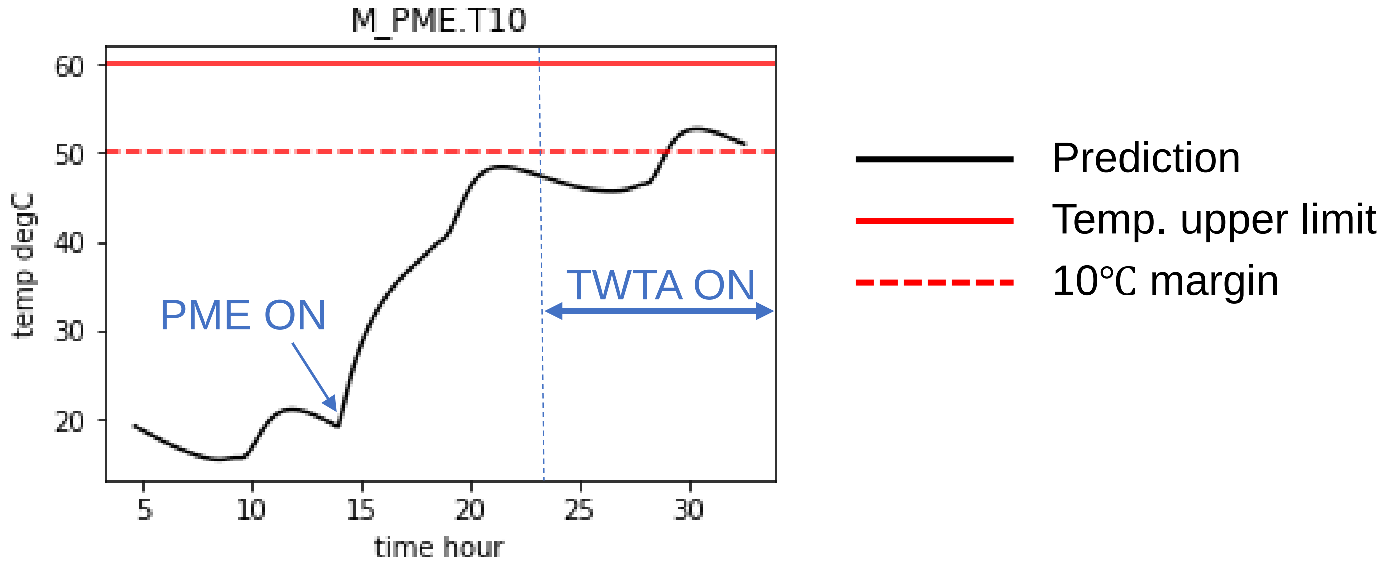
# Thermal issues of operational plans

- Thermal mathematical model was updated reflecting on-orbit operation data.
- Predicted temperature increases of 5 to 10 ℃ compared to pre-launch analysis.
- Thermal constraints becomes more severe than assumed before launch.

e.g.) TAA = 0°



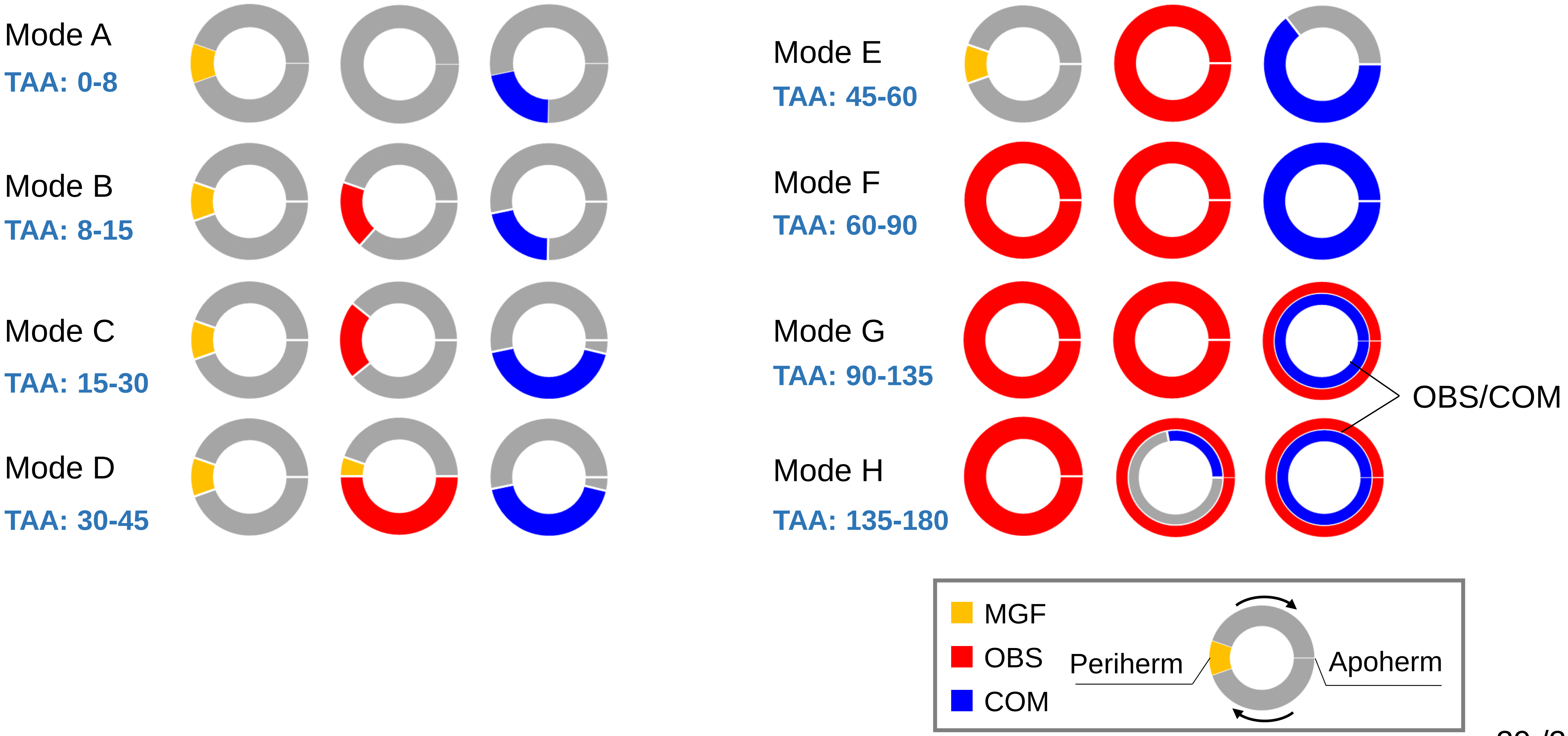

e.g.) TAA = 90°



# Update from last SWG meeting

- Thermal analysis by latest correlated thermal mathematical model
- 16 operational cases referring the communication visible time in 2026/5/18 – 7/1
- TAA based observable range will be shown

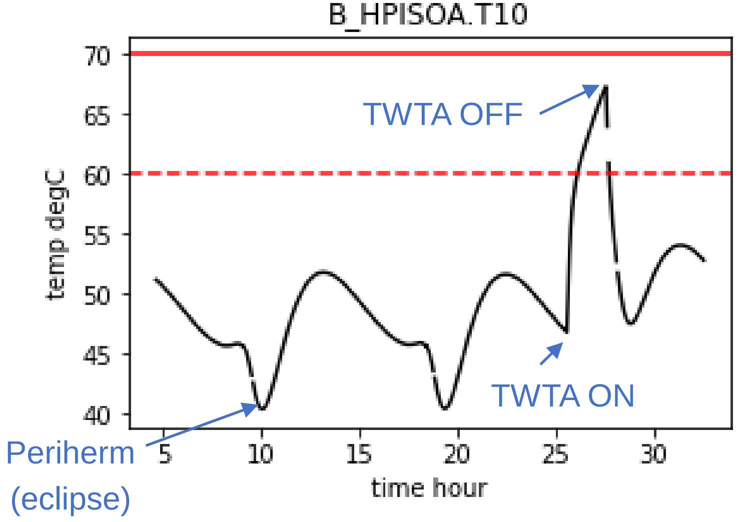
# Operational Plan / CDR



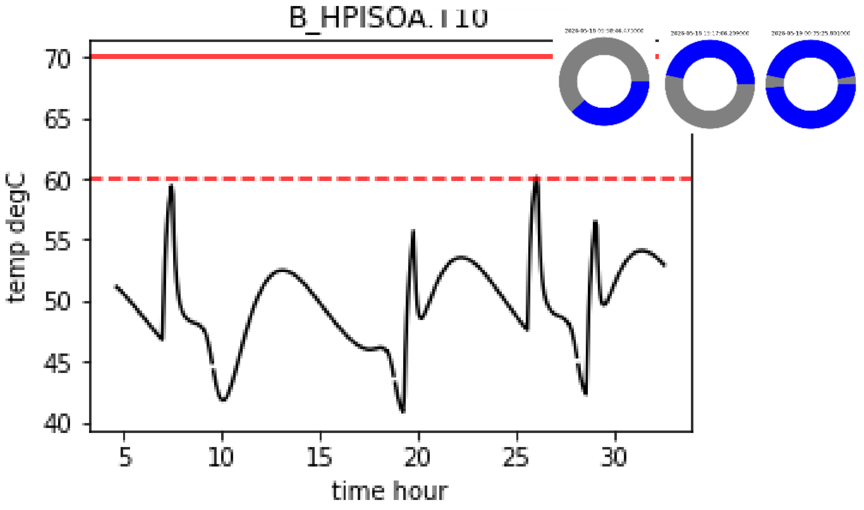
# Plan update procedure

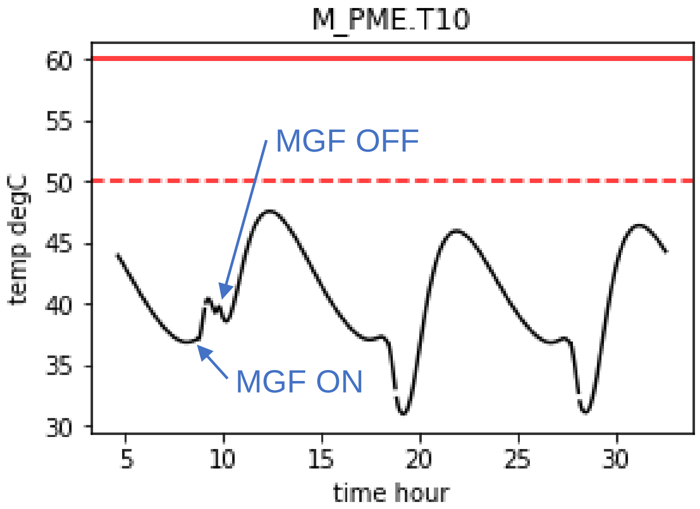
■ CDR plan

■ Updated plan

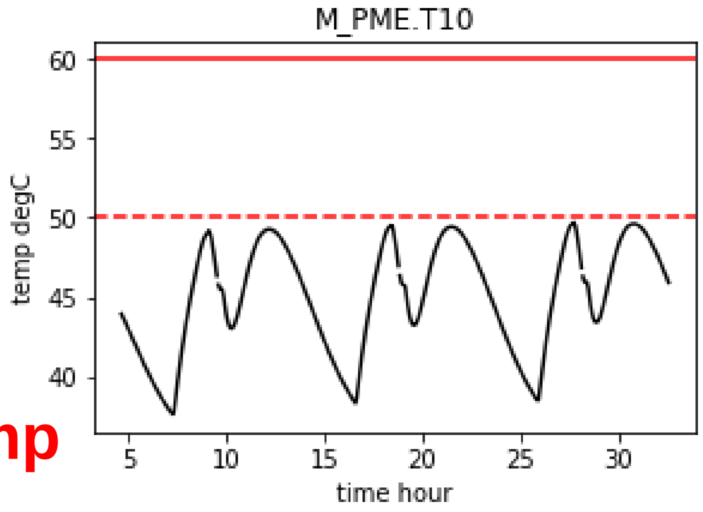



**STEP1:**
**Adjust the COM duration**
Referring actual visible time in May to July, 2026




**STEP2:**
**Maximize OBS duration**
Select the phase near periherm




**with satisfying allowable Temp**

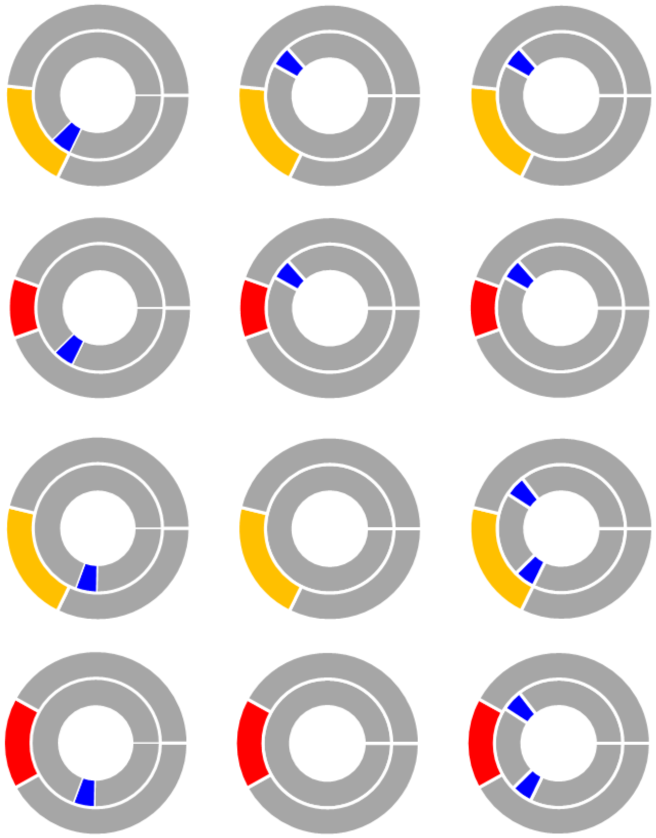
# Operational Plan / Latest ver.

2026/05/18

**TAA: 4**

2026/05/20

**TAA: 16**



2026/05/22

**TAA: 29**

2026/05/24

**TAA: 40**

2026/05/26

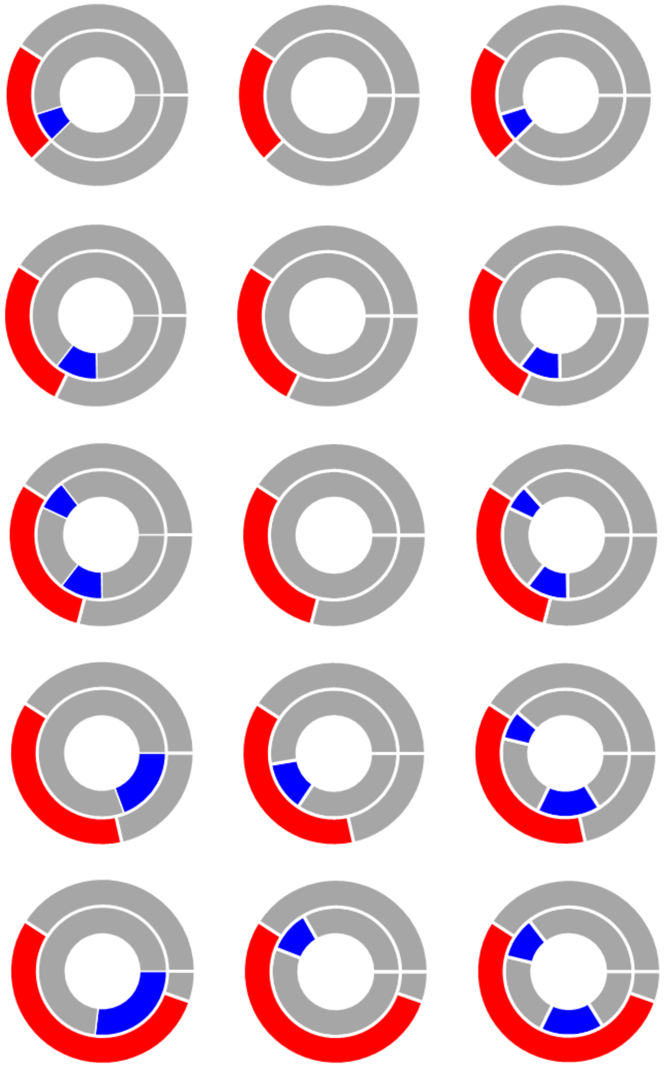
**TAA: 52**

2026/05/28

**TAA: 63**

2026/05/30

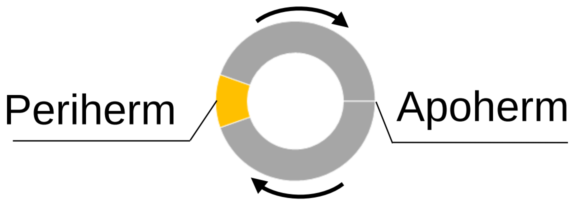
**TAA: 73**



MGF

OBS

COM



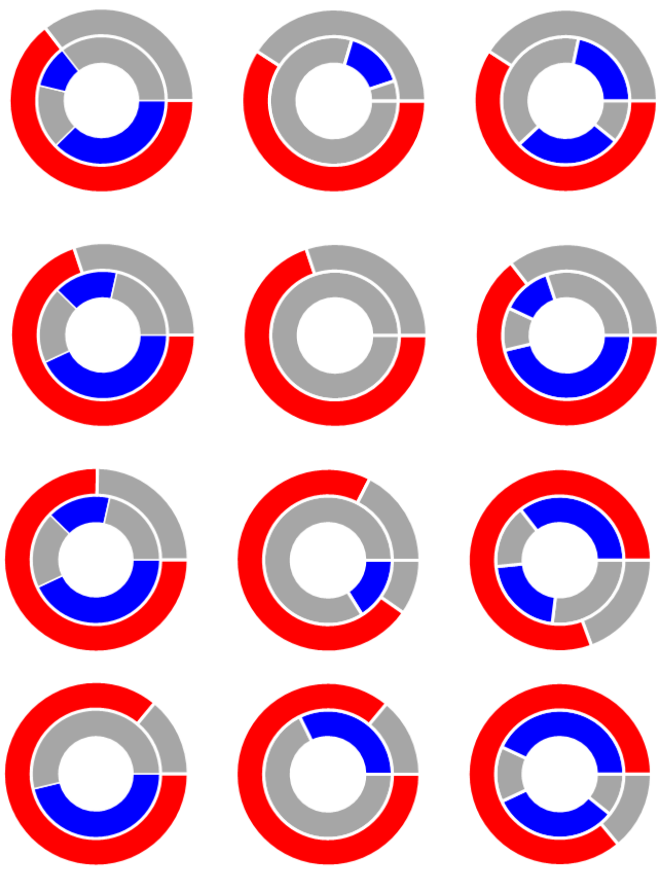
# Operational Plan / Latest ver.

2026/06/01
**TAA: 82**

2026/06/03
**TAA: 91**

2026/06/07
**TAA: 108**

2026/06/11
**TAA: 122**



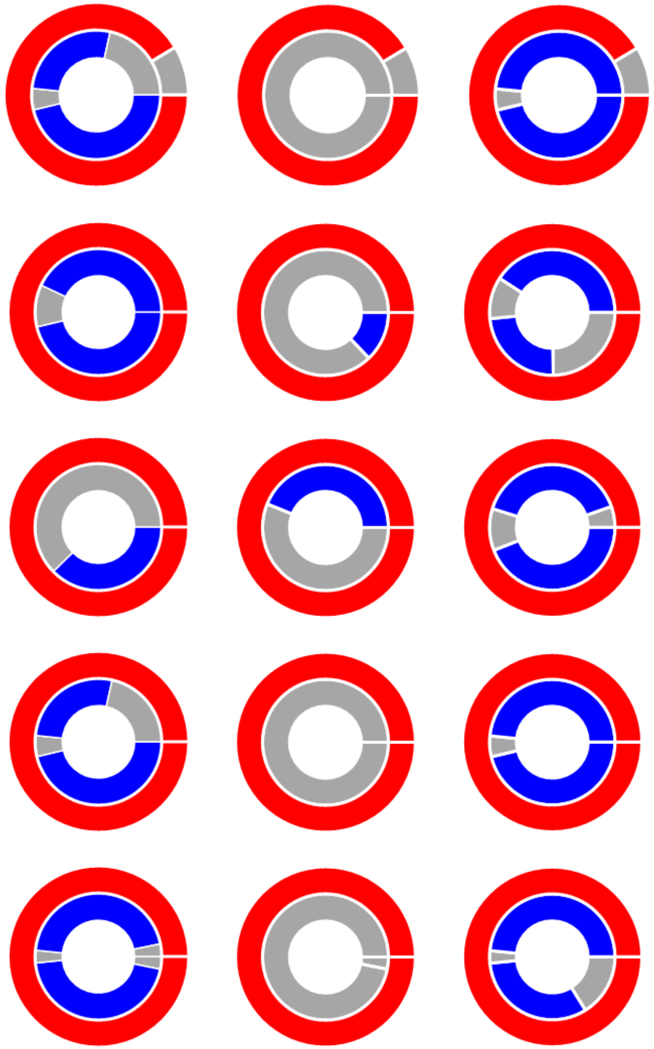
2026/06/15
**TAA: 135**

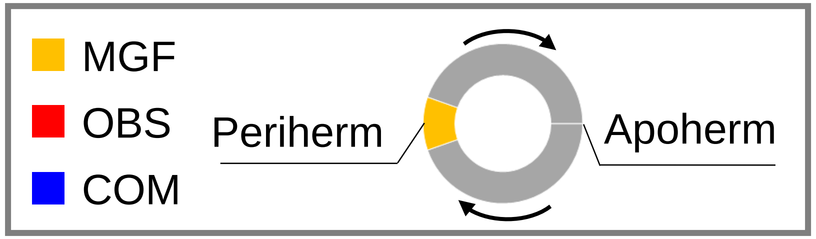
2026/06/19
**TAA: 148**

2026/06/23
**TAA: 159**

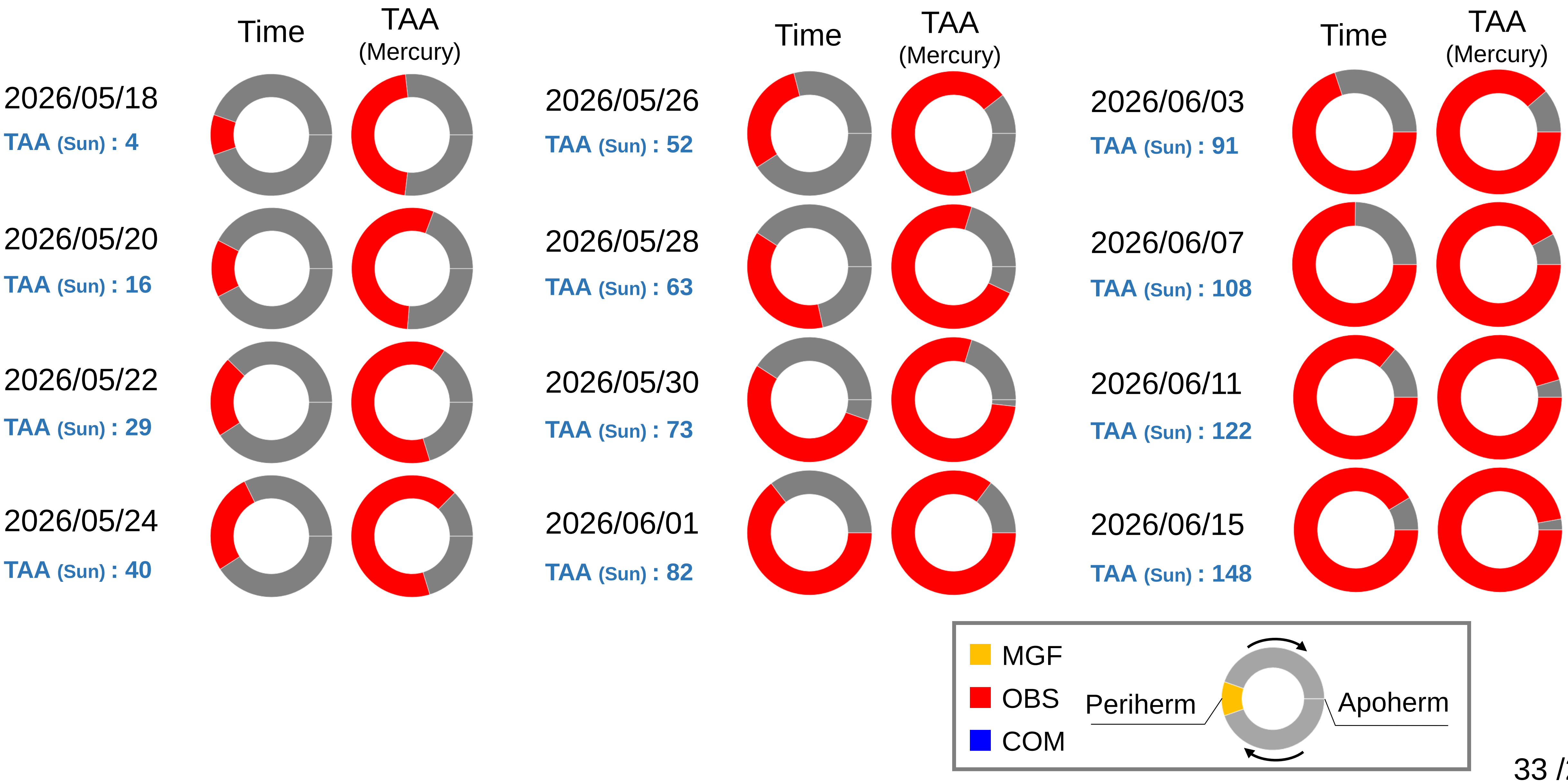
2026/06/27
**TAA: 170**

2026/07/01
**TAA: 181**

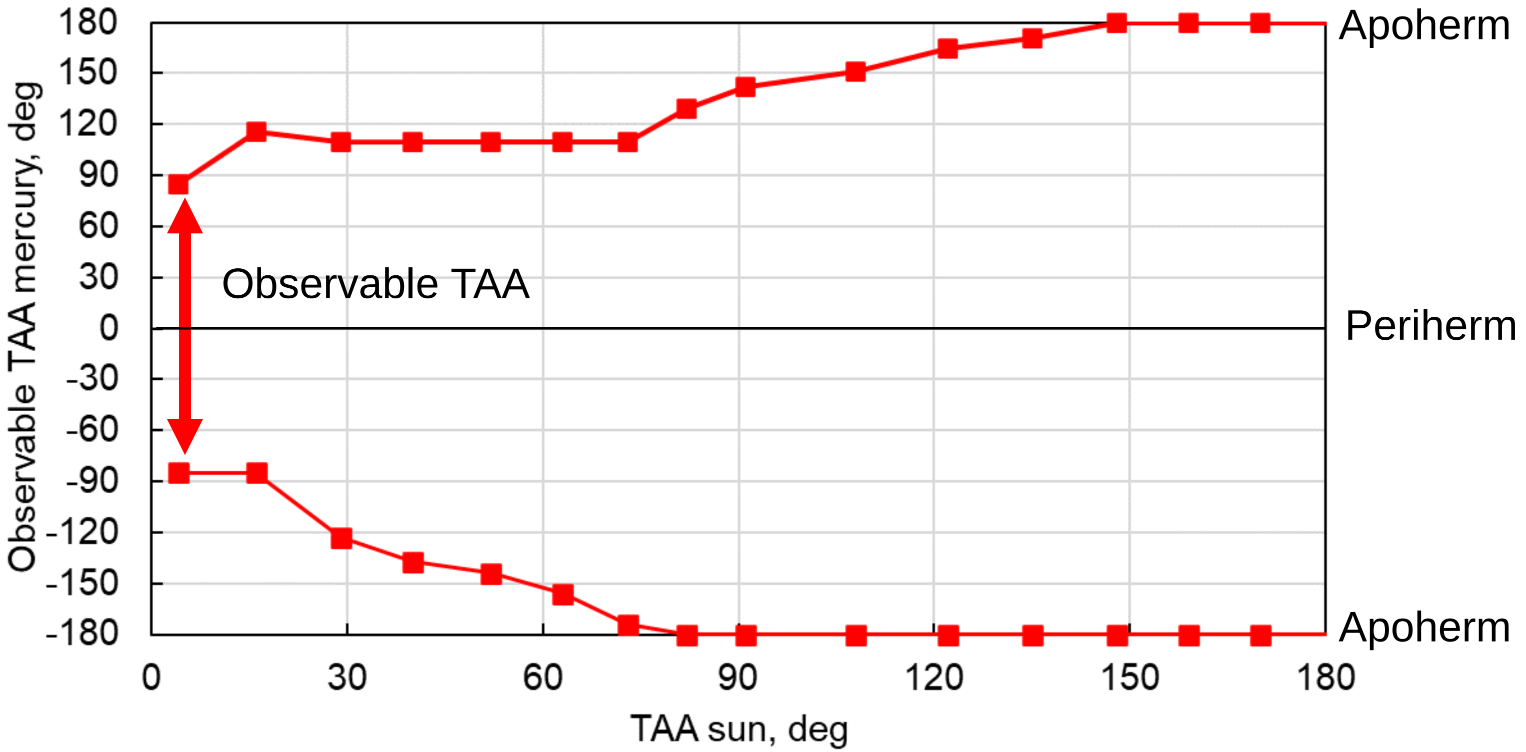




# Observable TAA

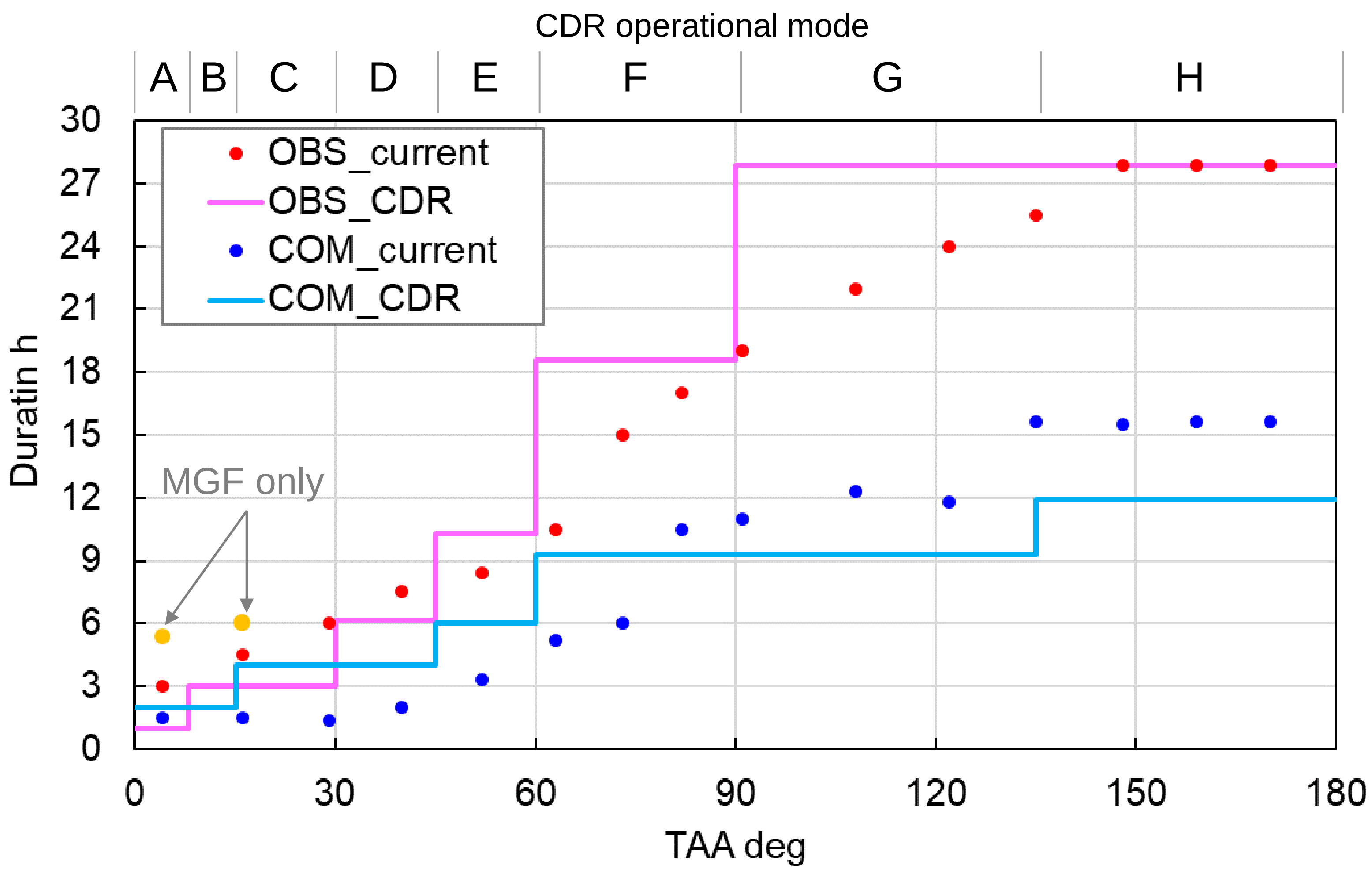


# Observable TAA




- In the most severe condition, the observation area will be TAA ±85 deg
- While it is difficult to extend the observation duration, it is still possible to adjust the observable phase.

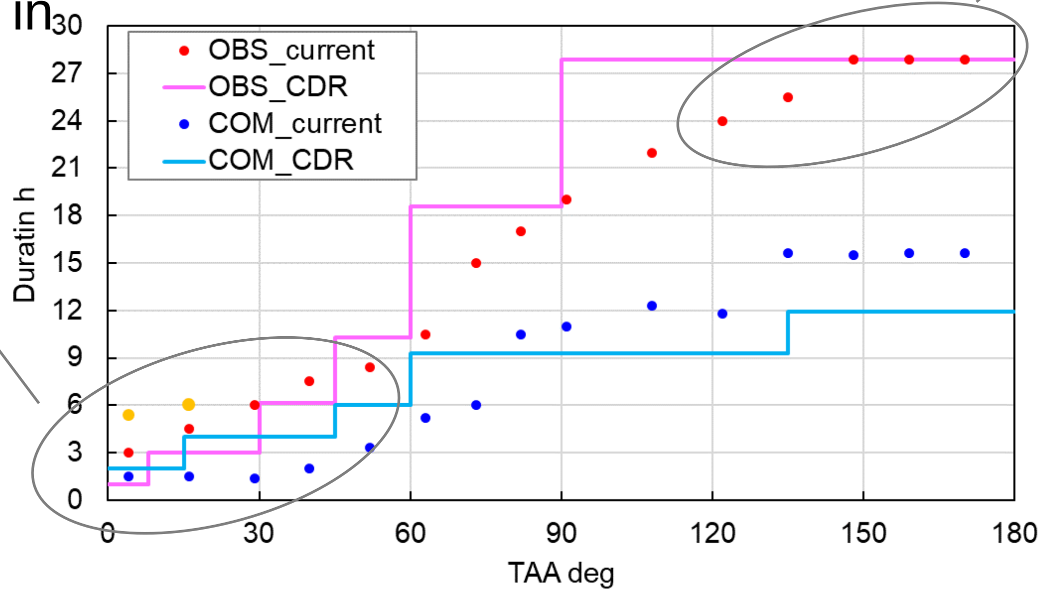
# OBS / COM durations : Comparison with CDR plans



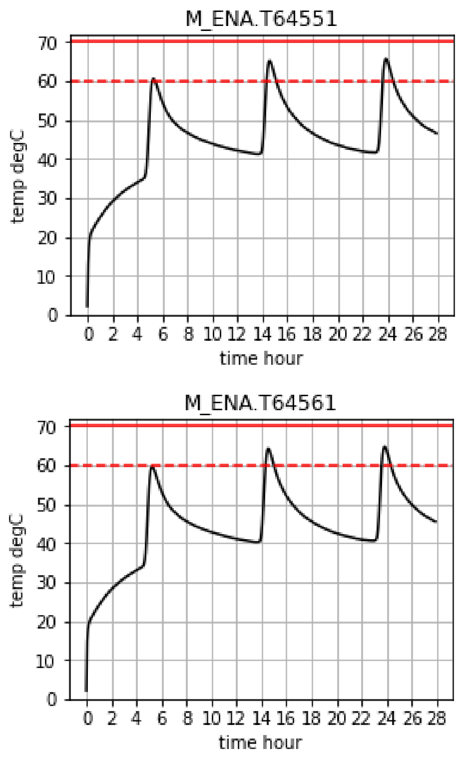

- Total OBS duration is 90.5% of the CDR plan
- Total COM duration is 111.9% of the CDR plan

# Major Concerns

①BUS equipment cannot satisfy a 10℃ margin even in Standby mode

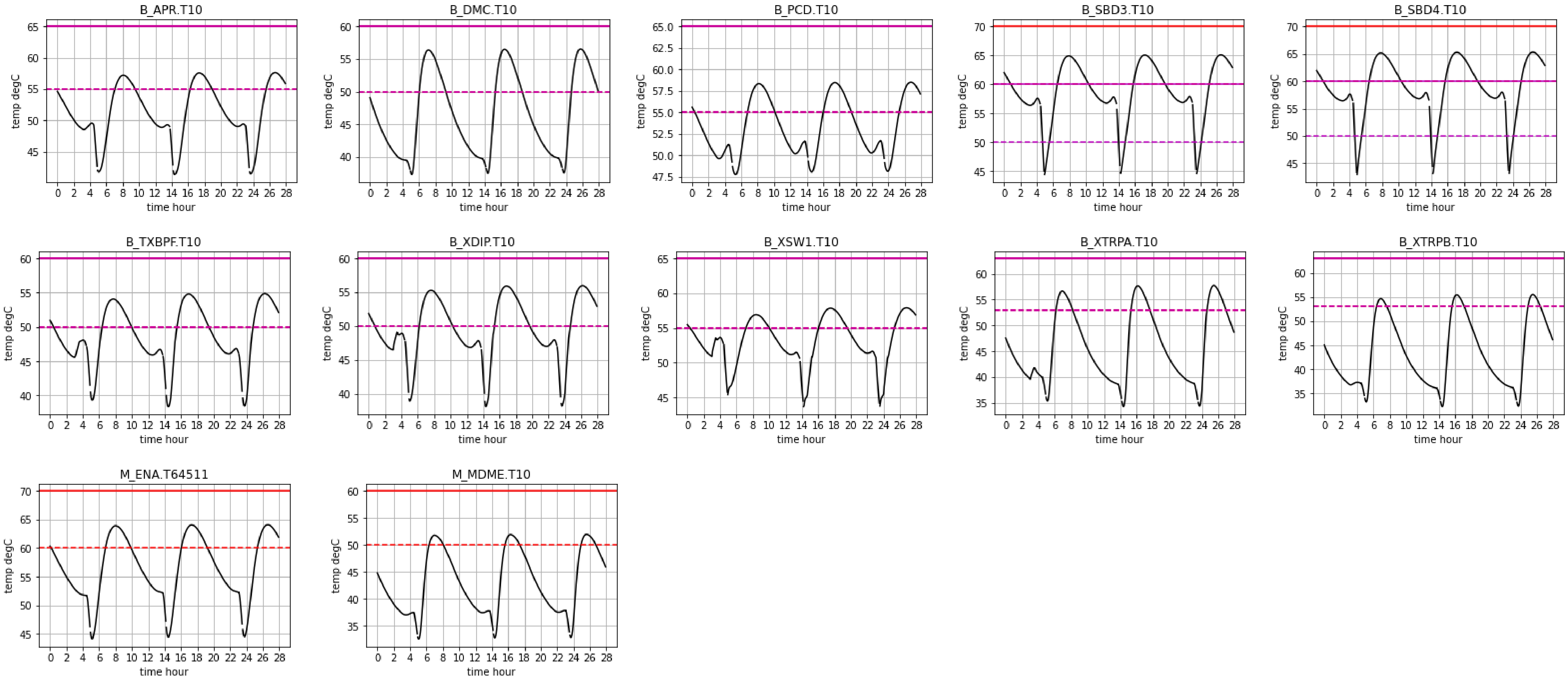



②ENA (HVPS & IFE) cannot satisfy a 10℃ margin



# Concerns① TAA = 4

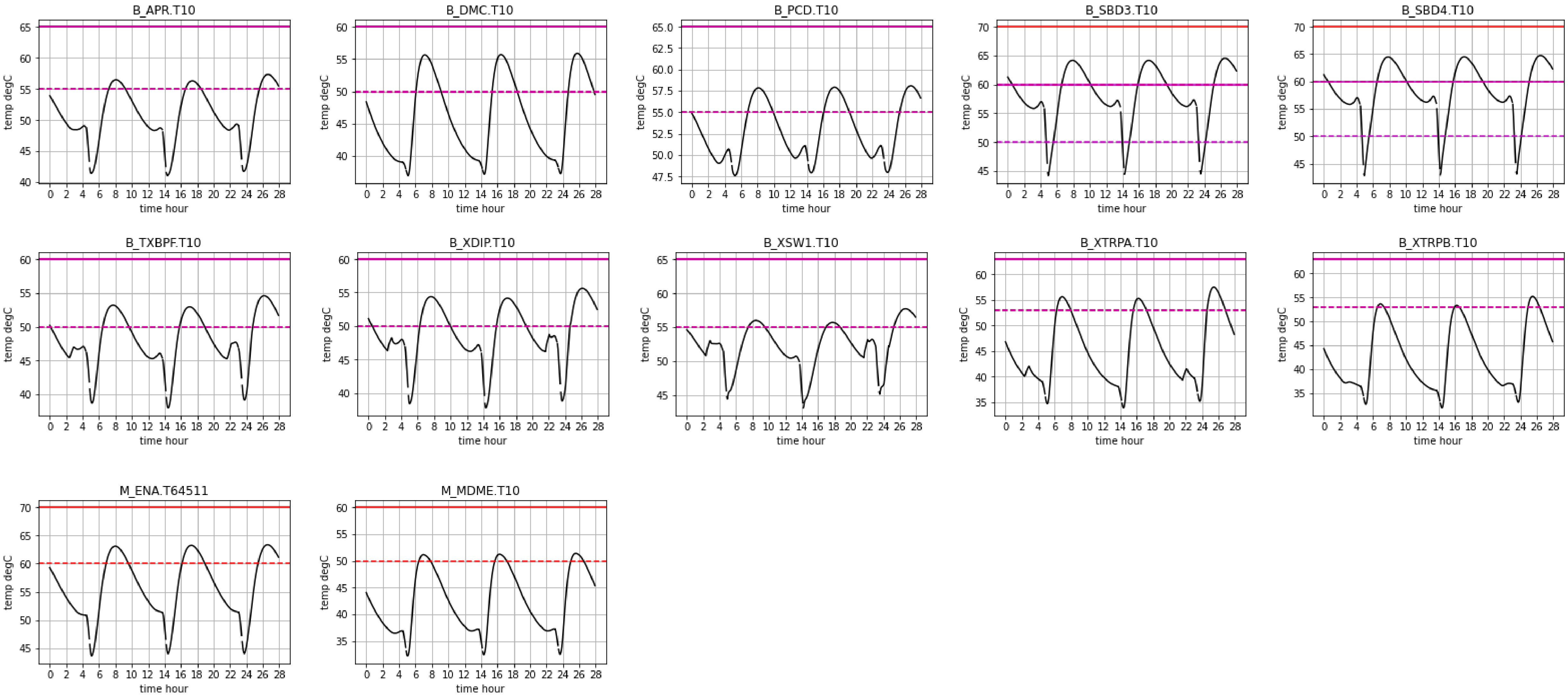
Prediction
Operating upper limit
Operating 10℃ margin
Non-Operating upper limit
Non-Operating 10℃ margin




Discussing with NEC to relax the allowable temperature of these equipment.

# Concerns① TAA = 16

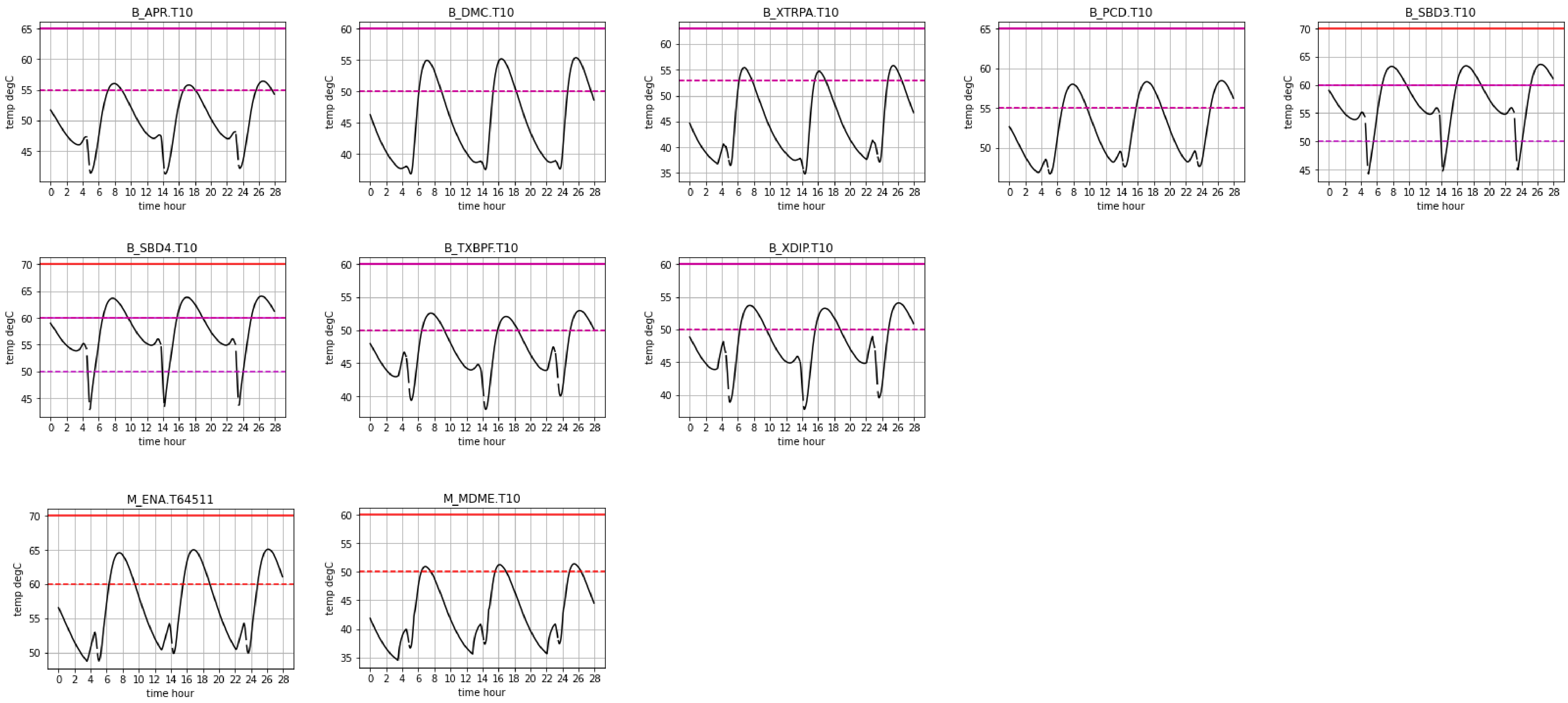
Prediction
Operating upper limit
Operating 10℃ margin
Non-Operating upper limit
Non-Operating 10℃ margin




Discussing with NEC to relax the allowable temperature of these equipment.

# Concerns① TAA = 29

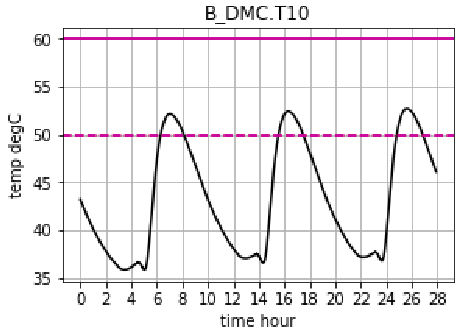
Prediction
Operating upper limit
Operating 10℃ margin
Non-Operating upper limit
Non-Operating 10℃ margin

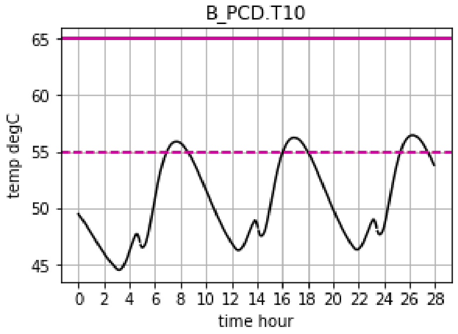


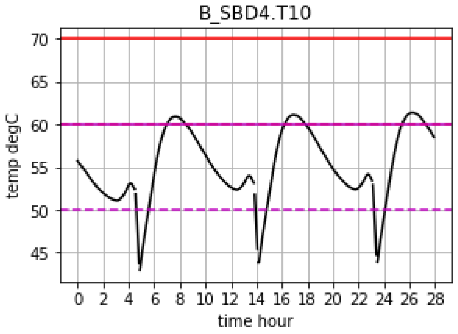

Discussing with NEC to relax the allowable temperature of these equipment.

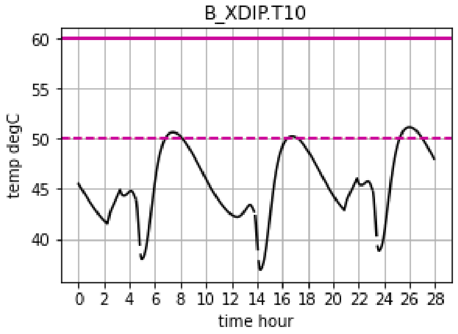
# Concerns① TAA = 40

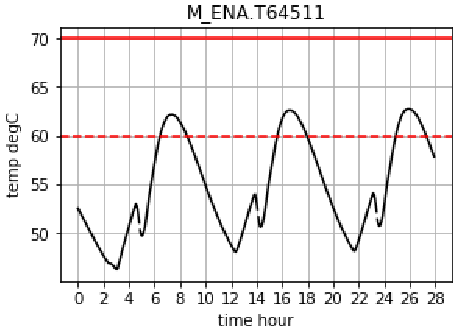
Prediction
Operating upper limit
Operating 10℃ margin
Non-Operating upper limit
Non-Operating 10℃ margin



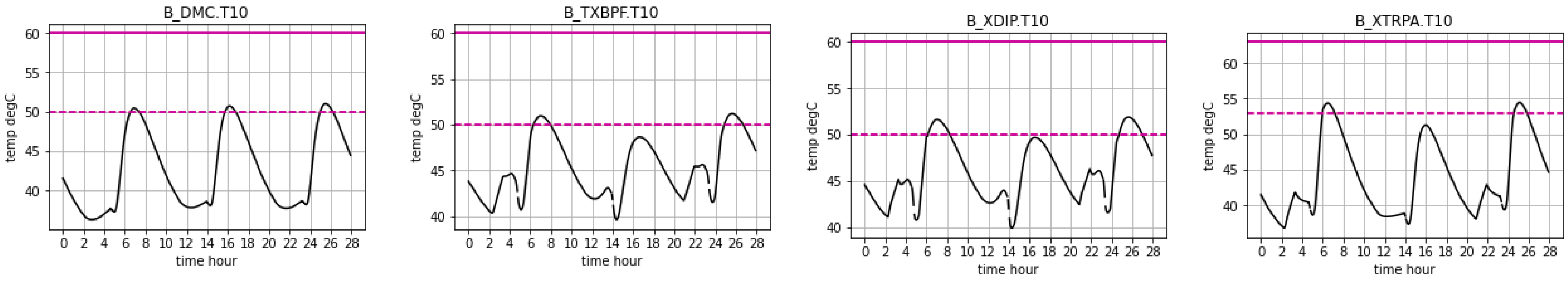




Discussing with NEC to relax the allowable temperature of these equipment.

# Concerns① TAA = 52

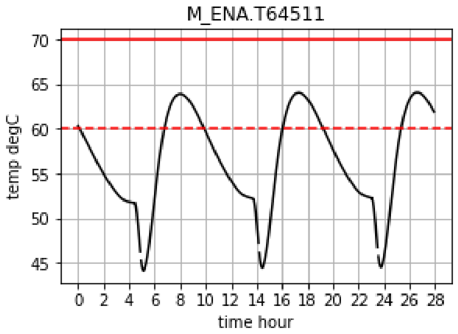
Prediction
Operating upper limit
Operating 10℃ margin
Non-Operating upper limit
Non-Operating 10℃ margin

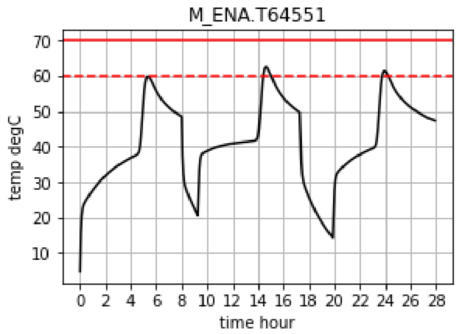


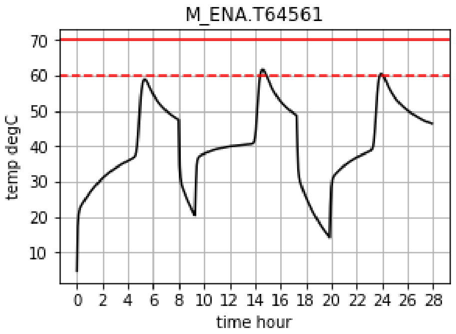

Discussing with NEC to relax the allowable temperature of these equipment.

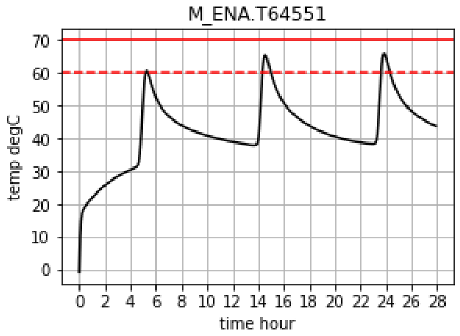
# Concerns② ENA temperature

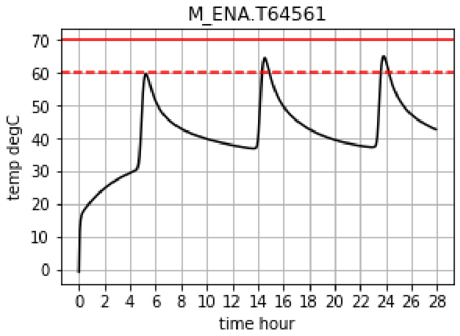
MAIN | HVPS | IFE | HVPS | IFE



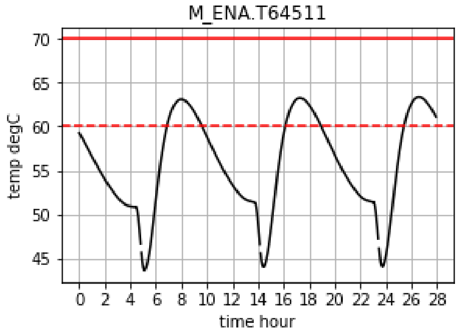



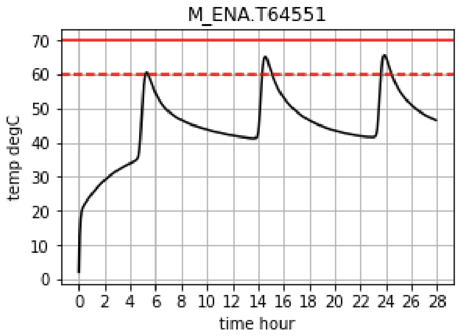



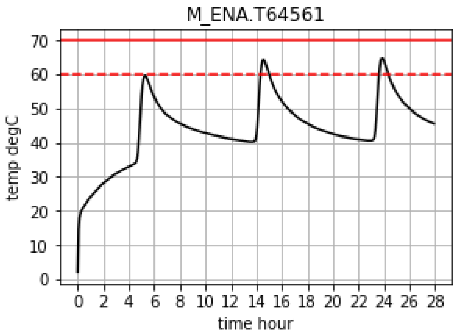

TAA = 4 deg

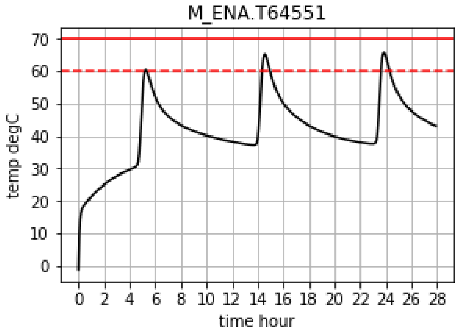
TAA = 122 deg

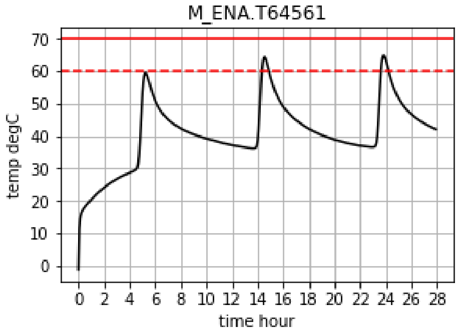
TAA = 159 deg



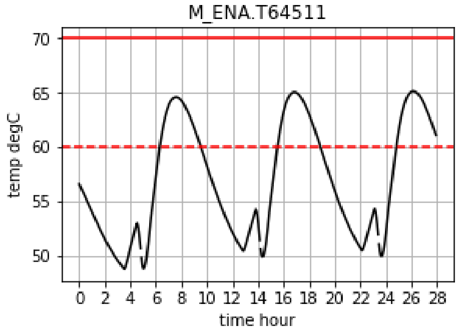



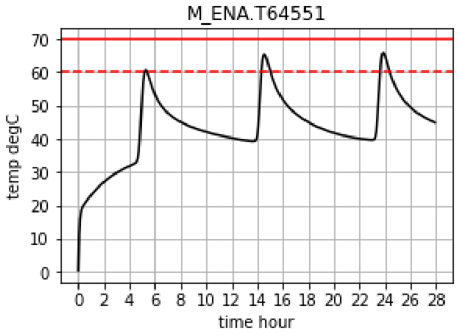



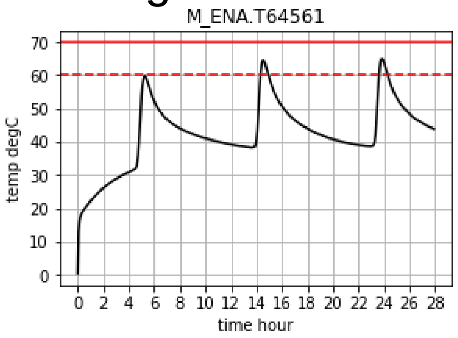

TAA = 16 deg

TAA = 135 deg

TAA = 170 deg




TAA = 29 deg

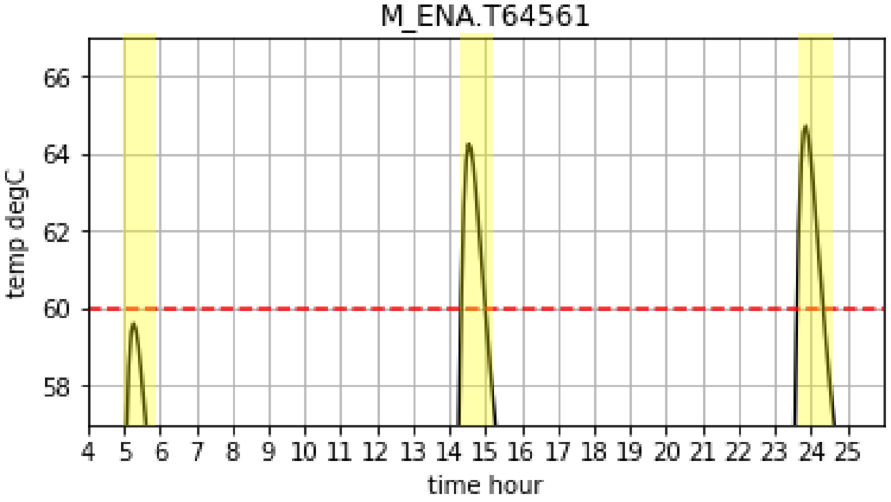
TAA = 148 deg

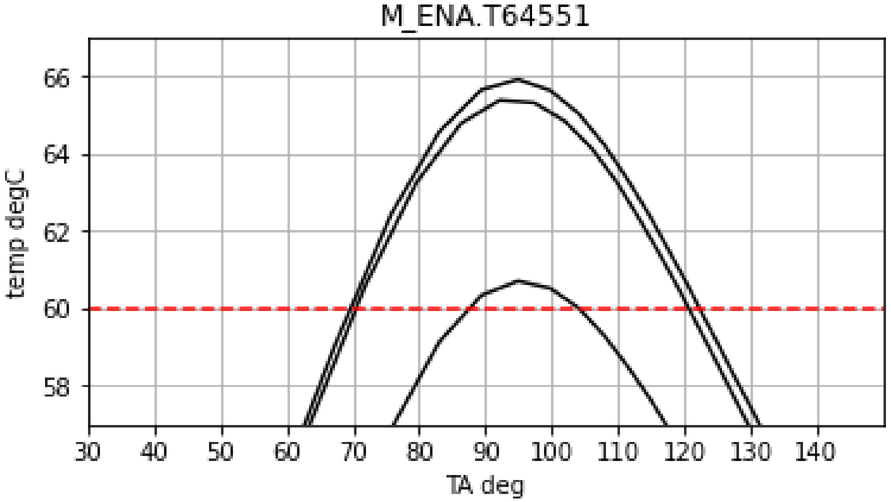
# Concerns② ENA temperature

- Worst case : TAA = 148 deg

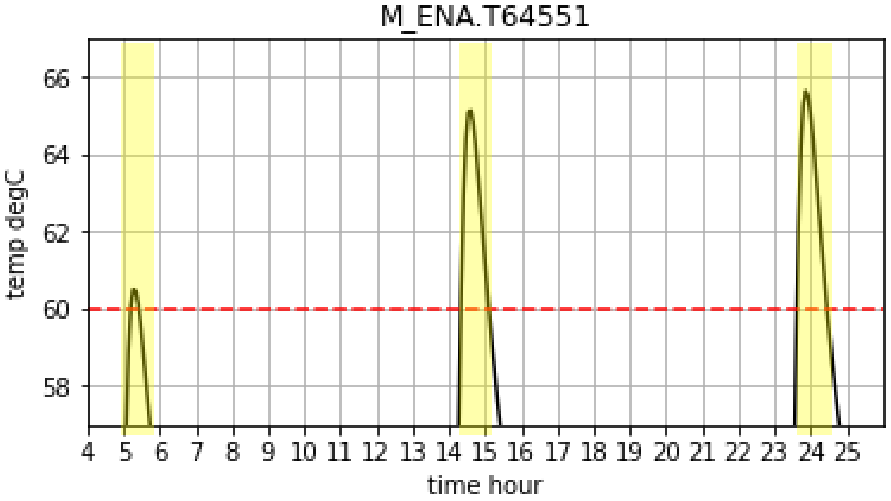
The temperature margin is insufficient for **about 1 hour**, **TAA = 68~123 deg**

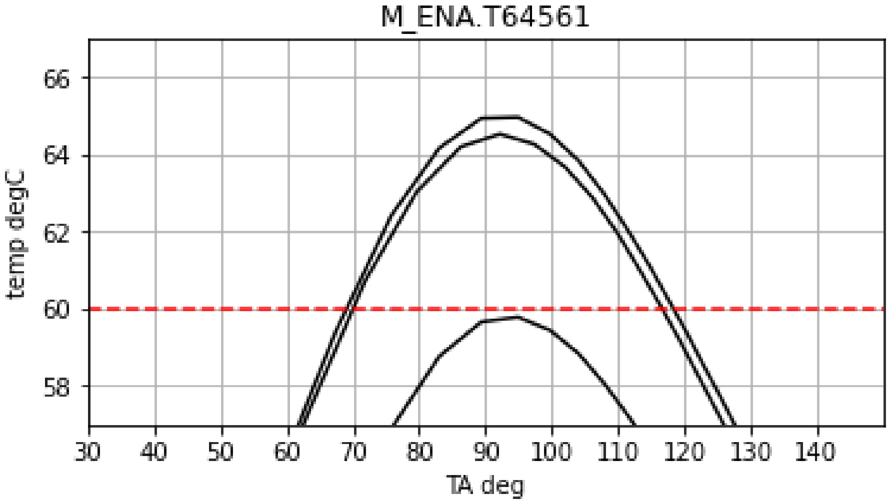
IFE




HVPS



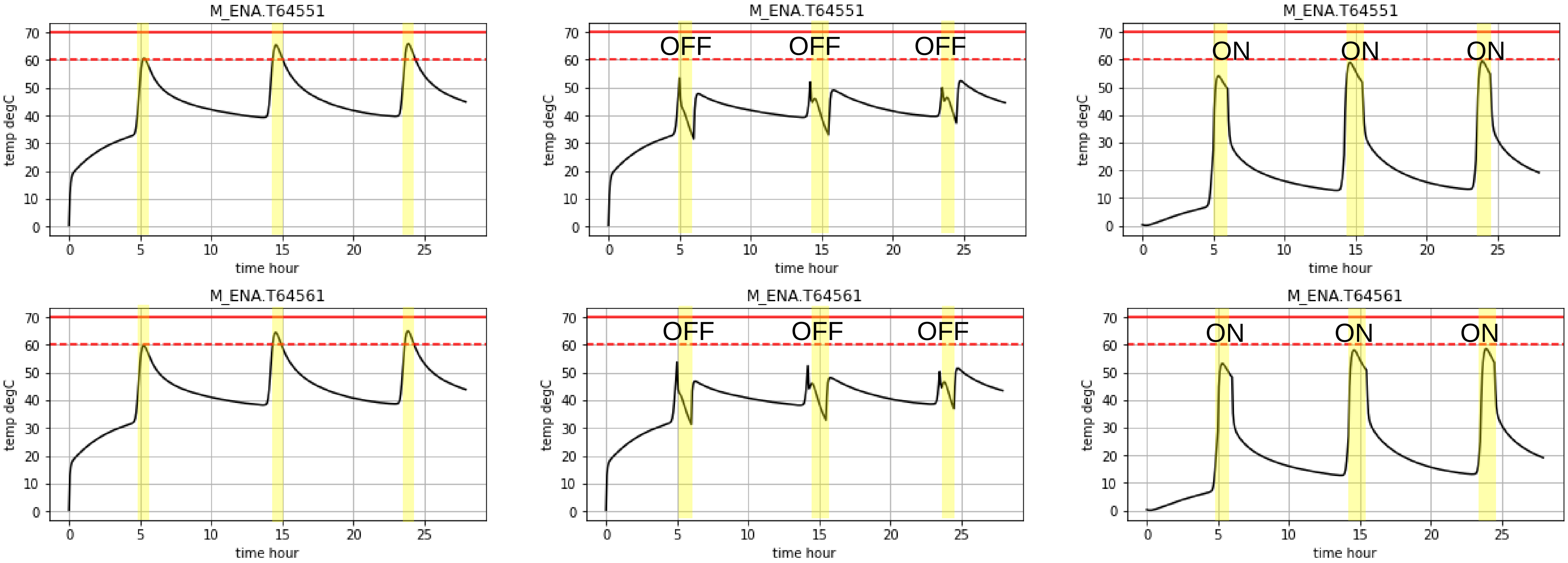



# Optional plan

- Ensure temperature margin by controlling the ENA's ON/OFF individually with other observation equipment.
- Switching ENA ON or OFF only in areas with insufficient temperature margin and complete all observations over multiple cycles.

HVPS

IFE




Full-ON
Worst hot case @ TAA=148

Point-OFF

Point-ON

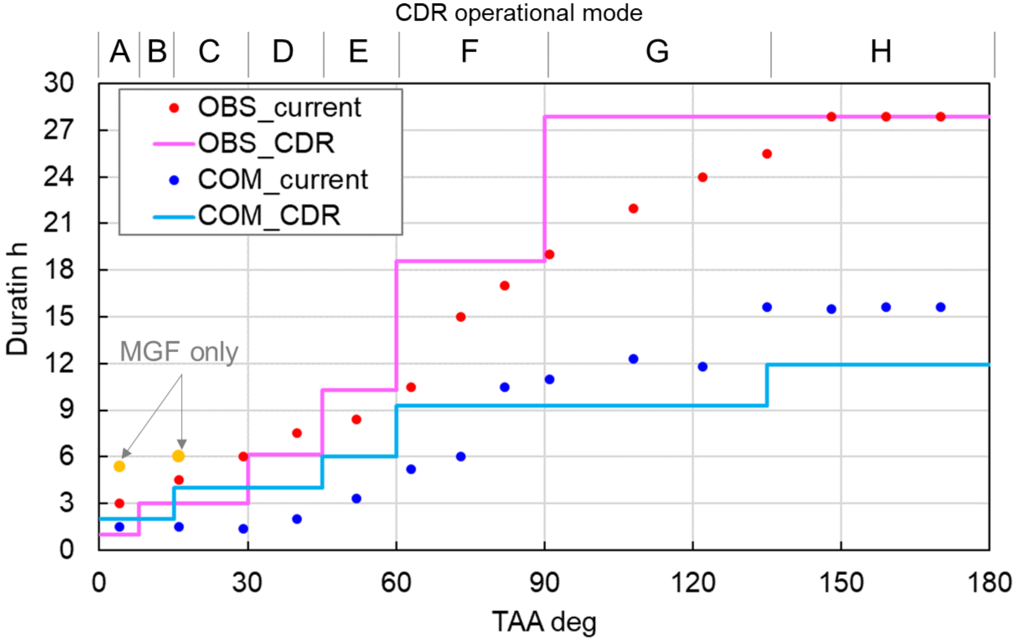
# Summary

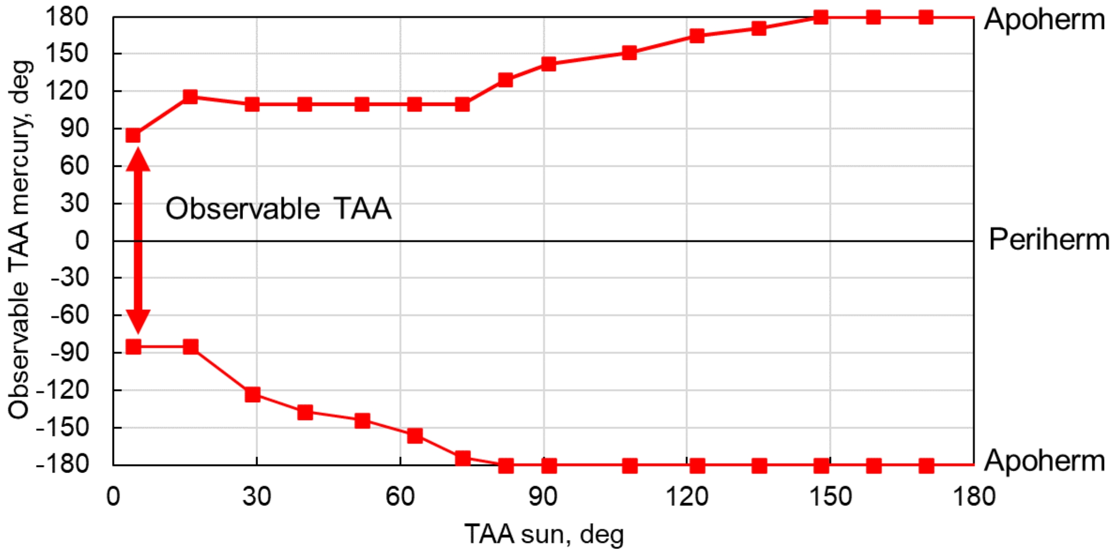
- The operational plan was updated considering the following parameters to meet thermal constraints:

  - Maximize COM duration: Referenced actual visibility times from May to July 2026.

  - Maximize OBS duration: Prioritized selection near periherm.

- Full observations are possible in the most severe thermal condition within ±85° of TAA_Mercury.
- Compared to the CDR, 90.5% of OBS time and 111.9% of COM time are secured.
- Some concerns remain with Bus equipment and ENA, and discussions are ongoing with NEC and ENA team.
- All plans will be updated depending on the temperature status after separation.

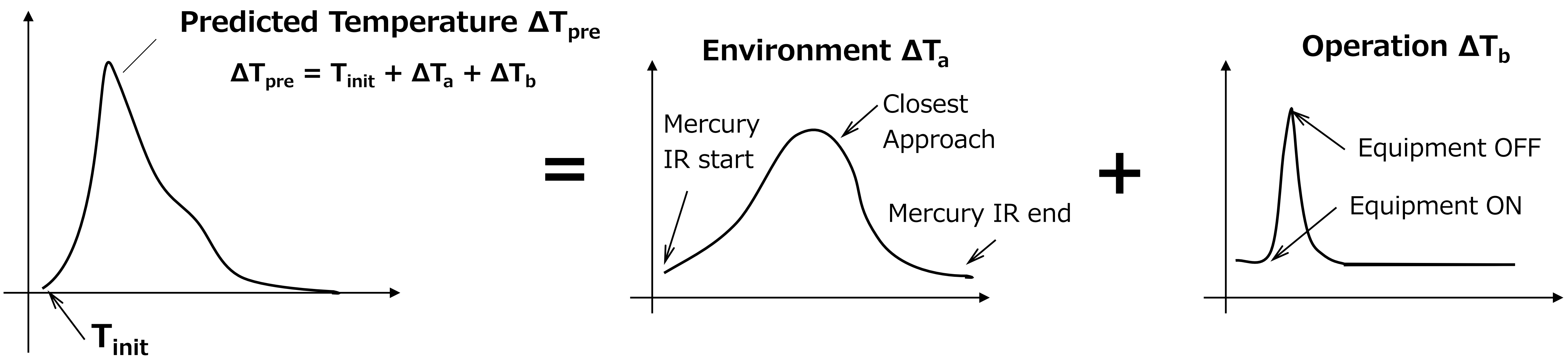


# Toward accelerating thermal analysis

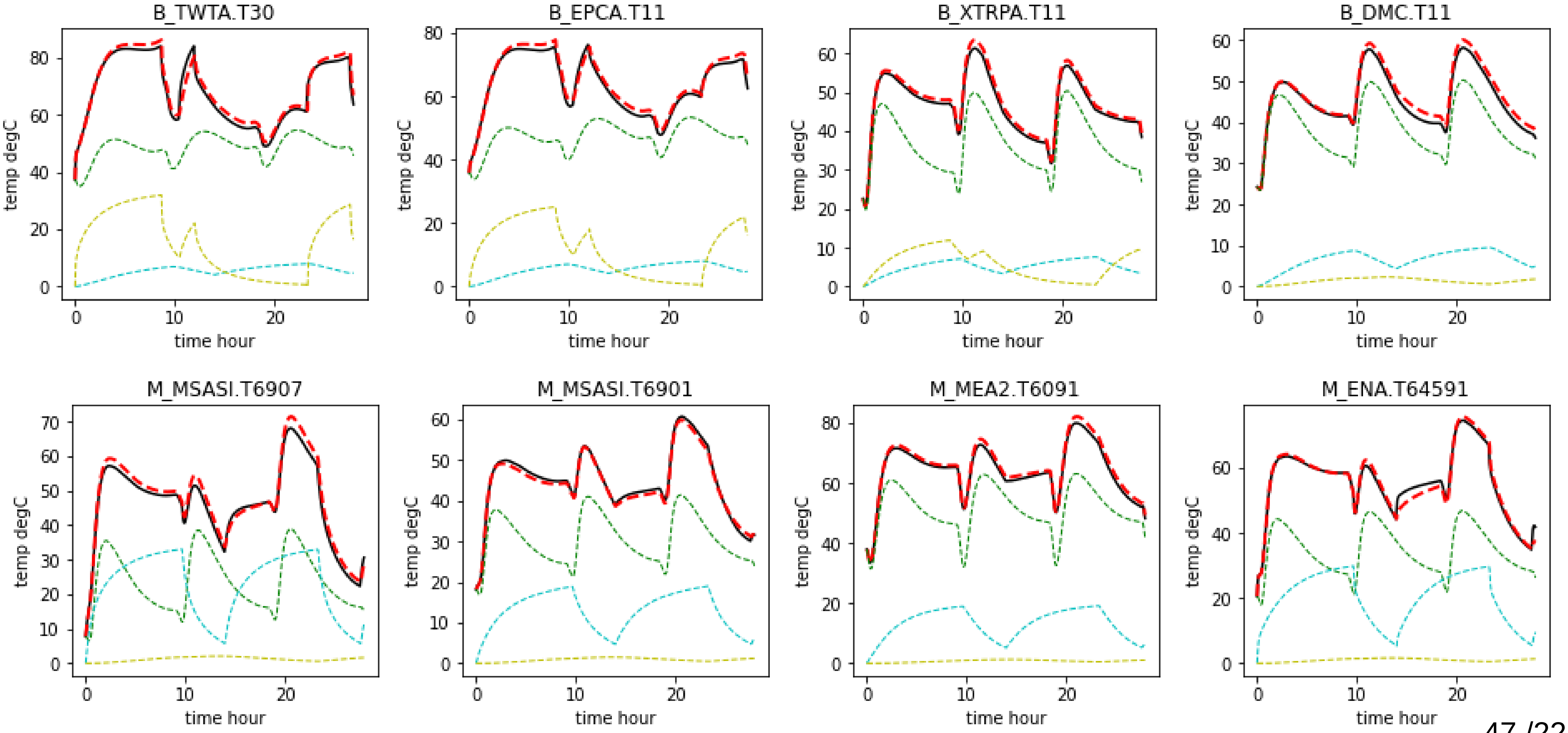
- We are developing the **thermal surrogate model** consists of combination of training data
- Computing cost decreases in the order of **1 h ⇒ 1 sec**
- Surrogate model will be used for further plan optimization, daily operation planning after arriving at the Mercury

## Concept of surrogate model



# Prediction results : TAA = 0°

SINDA
Surrogate
Environment
OBS ΔT
COM ΔT



# Mio Science Working Group meeting

**13 June 2024 09:00-11:00JST**

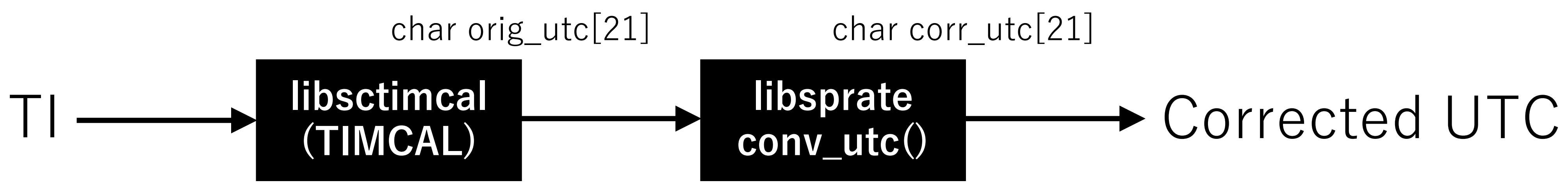
- **1. Updated status of Mio [Taeko Seki & Go Murakami]**
- **2. Upcoming operations plan [Taeko Seki & Go Murakami]**
  - 2024/H2
  - Preparations for Mercury arrival: separation and deployments
  - Mercury flybys #4, #5, and #6
  - Check out operations after MOI
- **3. Updates on baseline observation plans**
  - Reports of the updated thermal analysis [Hiroto Tanaka]
- **4. Data handling and archiving**
  - Time calibration for L1 [Shoya Matsuda]
  - Status of Mio Science Center [Yoshi Miyoshi]
  - Request to each PI team [Go Murakami]
- **5. Others**

# Time calibration (correction of 1 spin delay arise MDP-SI system)

- The MDP-TI delivered from MDP to SI contains a 1-spin delay.
  Correction of this 1-spin delay is required to determine the correct UTC.
  **(Note that the UTC calculation by the TIMCAL library does not consider this 1-spin delay.)**

- **To correct the 1-spin delay, please use the following library (libsprate).**
  **The interface file (L1 or L1p) for Mio S/C should be calibrated in time.**
  **(Note that Mio S/C does not calibrate science data, also time tags.)**

  **Library:** /nasA_mmo/matsuda/sys/libsprate
  **Sample code:** /nasA_mmo/matsuda/sys/libsprate_sample



# Report from BepiColombo/Mio Science Center

**ISEE/Nagoya University**
Y. Miyoshi, T. Hori, C.-W. Jun, A. Shinbori, N. Kitamura, K. Yamamoto, S. Chiba, T. Segawa
**ISAS/JAXA**
G. Murakami, S. Murakami, I. Shinohara, K. Asamura
**Kanazawa Univ.**
S. Matsuda
**CNRS**
S. Aizawa
**Kyoto University**
Y. Harada
**UCB**
T. Hara

https://miosc.isee.nagoya-u.ac.jp/

# contents

**Status Report**

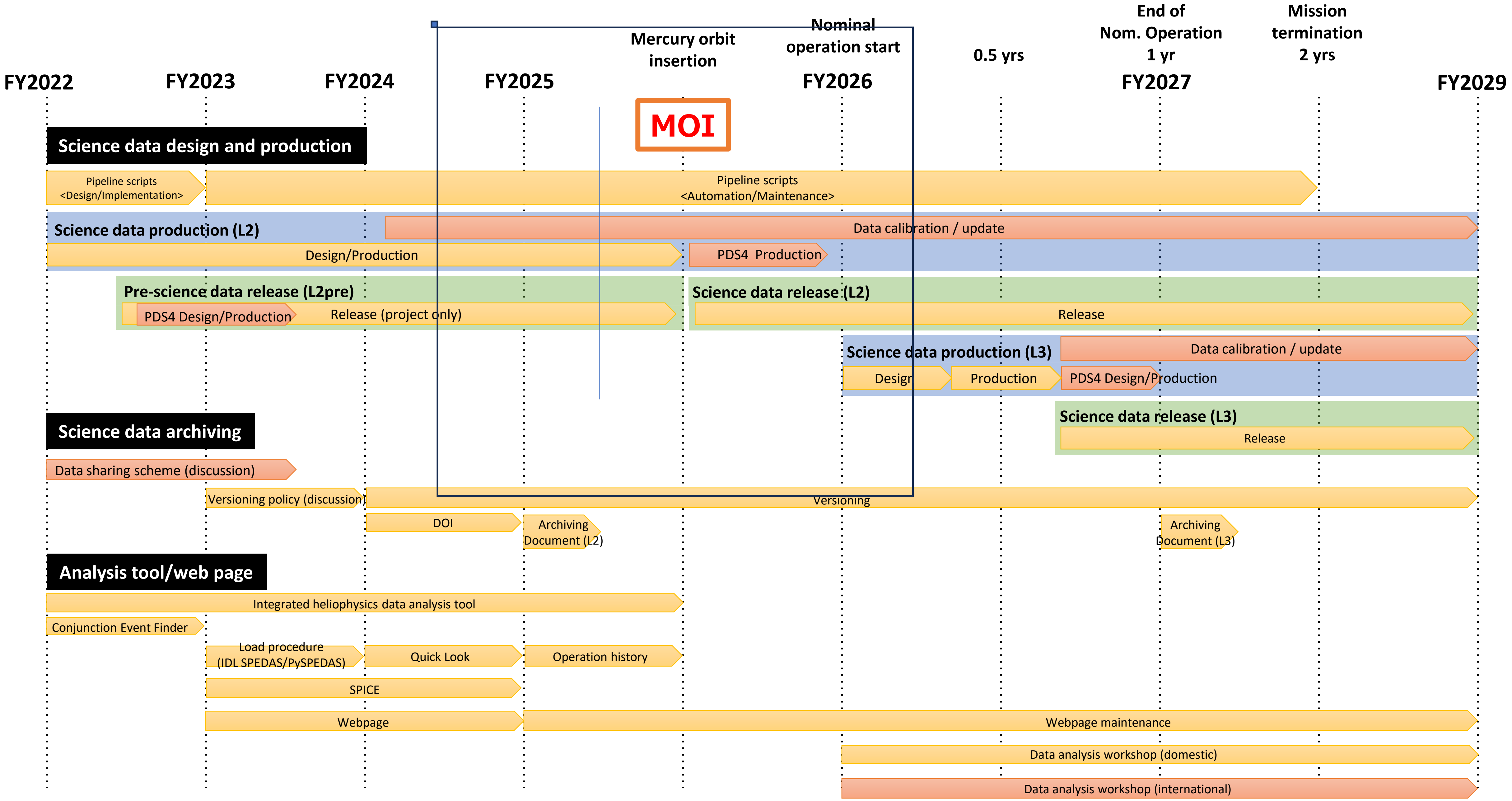
1: Schedule (L1pre/PDS)

2: Data Pipeline (before/after MOI)

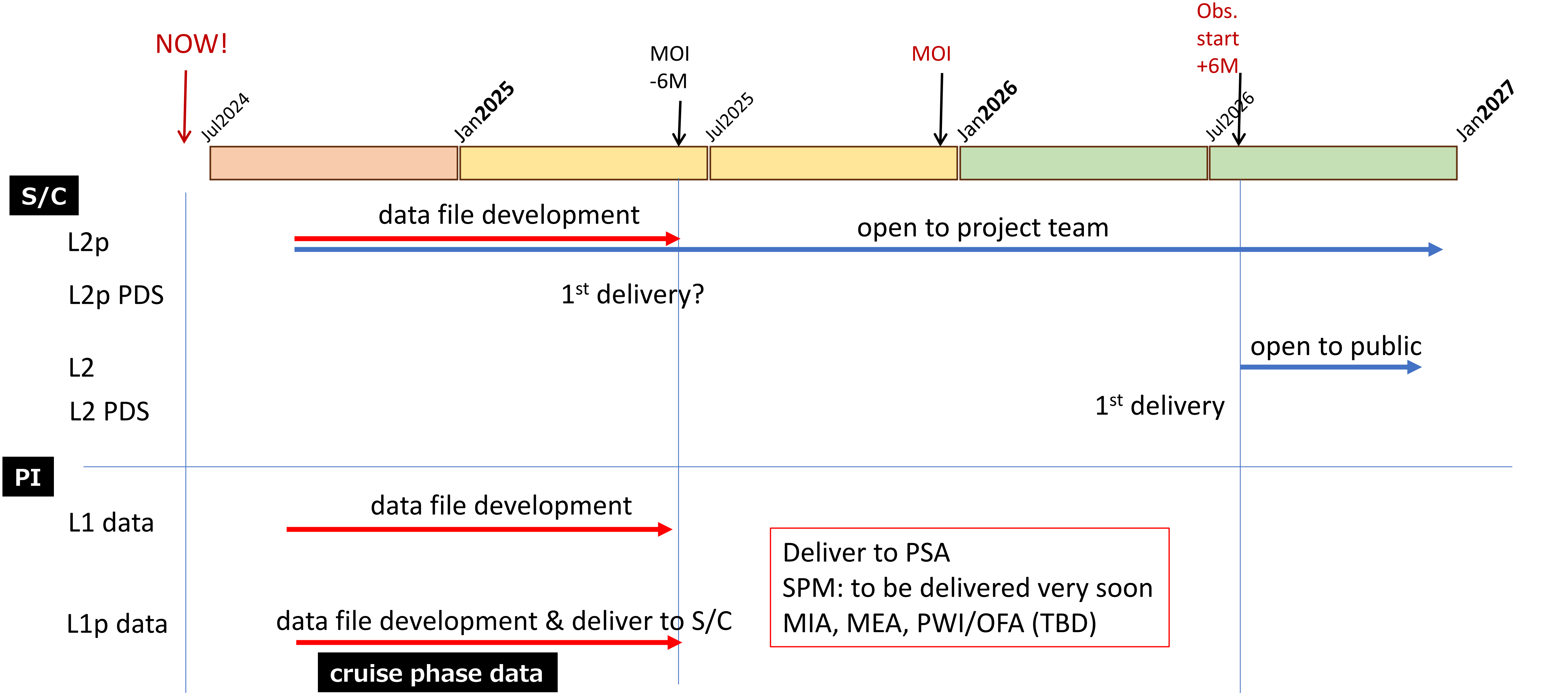
3: Release of L2pre CDF files of SPM?

4: Discussion Points/

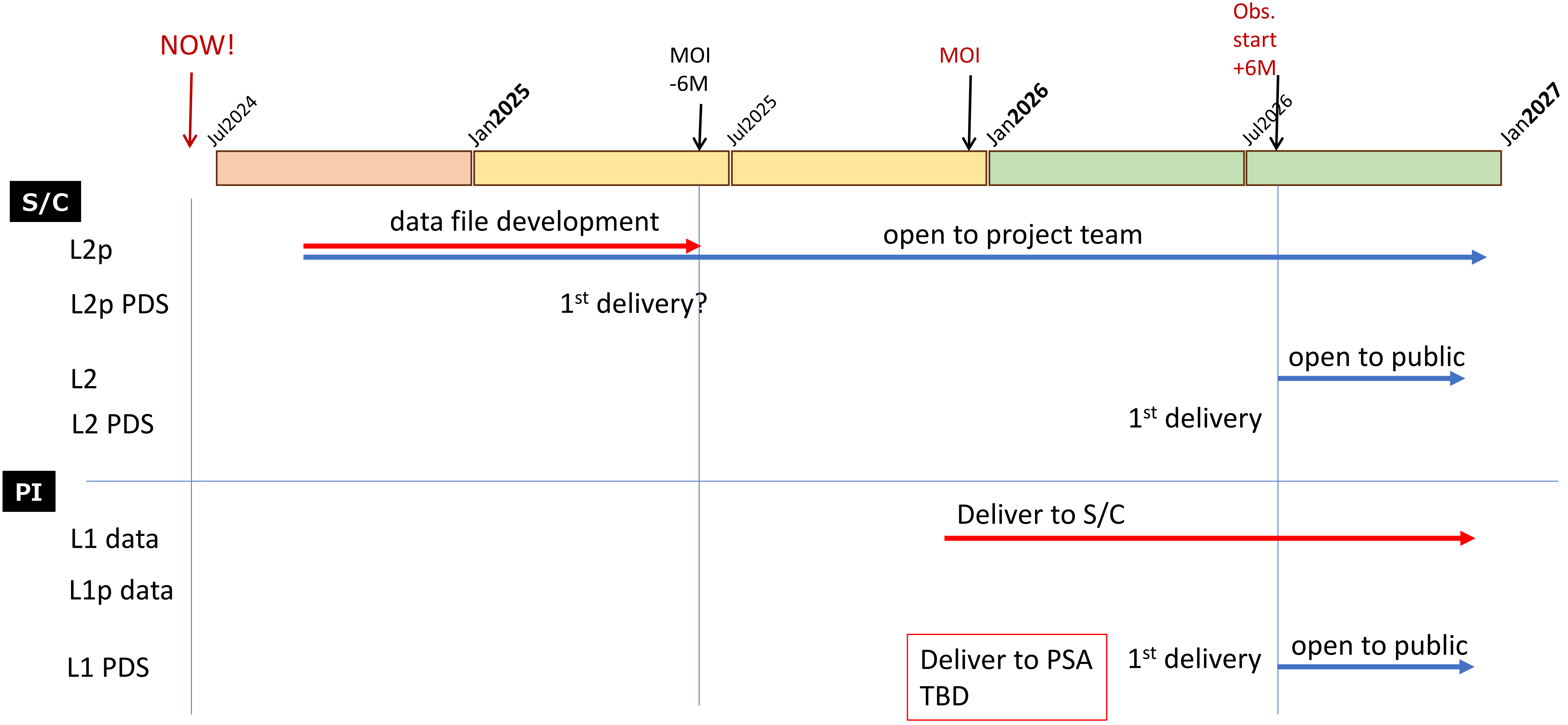
# Data Handling Schedule



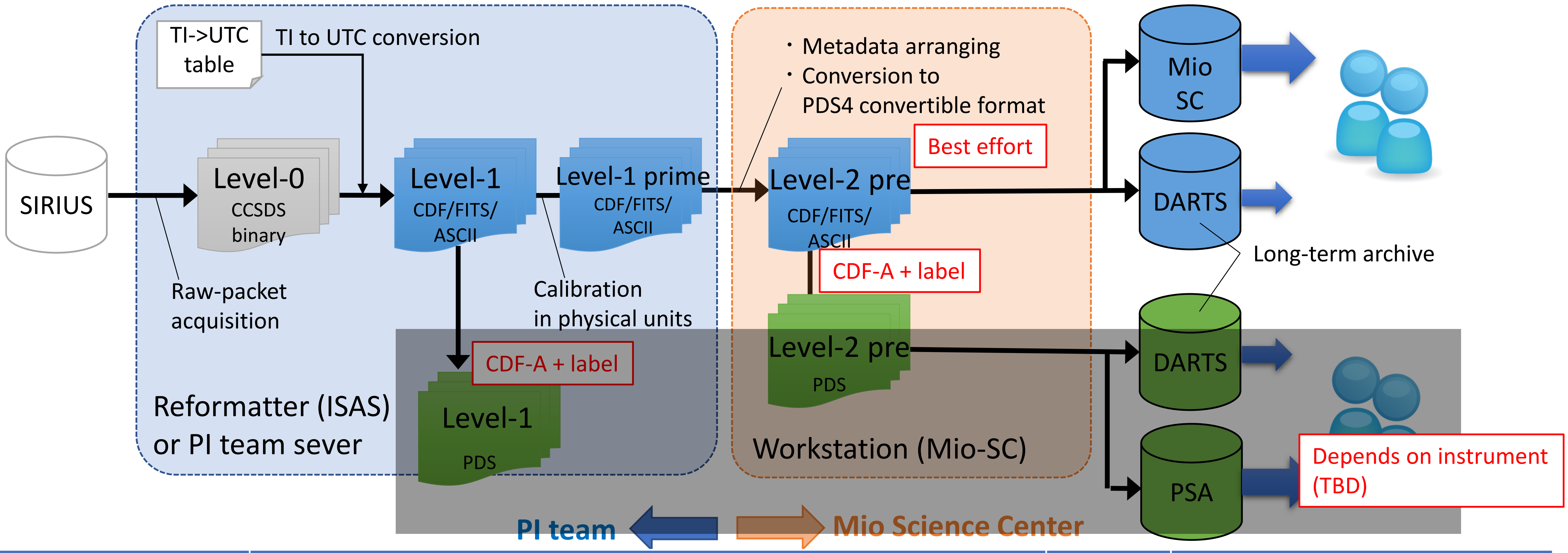
# Tentative timeline of the MMO data archive development (Cruise Phase data 20240612)



# Tentative timeline of the MMO data archive development (after MOI 20240612)

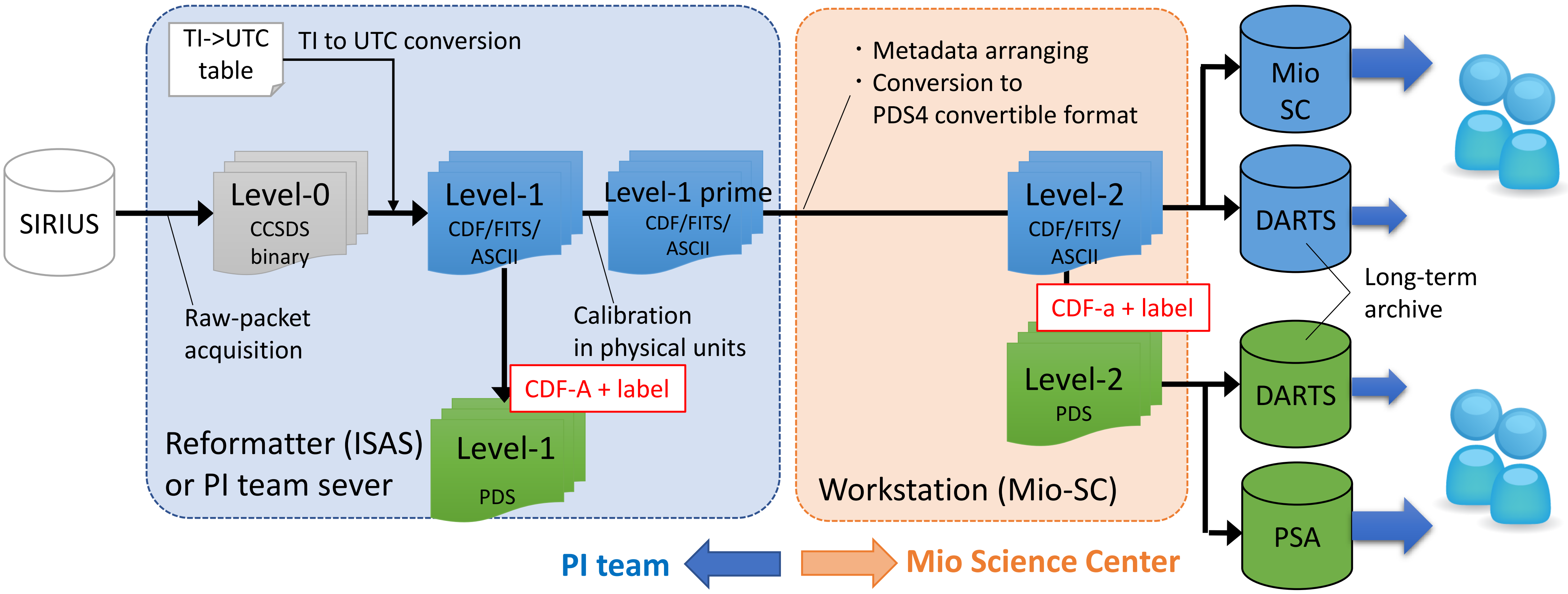


# Data Pipeline (Cruise Phase Data 20240612)




| Level | Contents | Scope | File format |
|---|---|---|---|
| Level-0 (L0) | Raw-telemetry | Internal | CCSDS-Binary |
| Level-1 (L1) | Uncalibrated data converted from Level-0 raw-telemetry | Internal | CDF, FITS, ASCII |
| Level-1 prime (L1p) | Calibrated data in physical units | Internal | CDF, FITS, ASCII |
| Level-2 pre (L2pre) | Cruise-phase data calibrated in physical units with metadata (best efforts) | Internal | CDF, FITS, ASCII |
| Level-2 (L2) | Calibrated data in physical units with full metadata | Public | CDF, FITS, ASCII |
| Level-3 (L3) | Processed data by combining data from multiple instruments | Public | CDF, FITS, ASCII |

# Data Pipeline (after MOI Data 20240612)




| Level | Contents | Scope | File format |
|---|---|---|---|
| Level-0 (L0) | Raw-telemetry | Internal | CCSDS-Binary |
| Level-1 (L1) | Uncalibrated data converted from Level-0 raw-telemetry | Internal | CDF, FITS, ASCII |
| Level-1 prime (L1p) | Calibrated data in physical units | Internal | CDF, FITS, ASCII |
| Level-2 pre (L2pre) | Cruise-phase data calibrated in physical units with metadata | Internal | CDF, FITS, ASCII |
| Level-2 (L2) | Calibrated data in physical units with full metadata | Public | CDF, FITS, ASCII |
| Level-3 (L3) | Processed data by combining data from multiple instruments | Public | CDF, FITS, ASCII |

# Data Product Plan

## Before Mercury orbit insertion (MOI):

Science Data: **Lv.2pre data** files

- Mainly archived as CDF or FITS files.
- **The data files are released from the web data repository of the science center to the project team.**
  - Also delivered to and archived in ESA's PSA.

## After MOI:

Science Data: **Lv.2 data** files

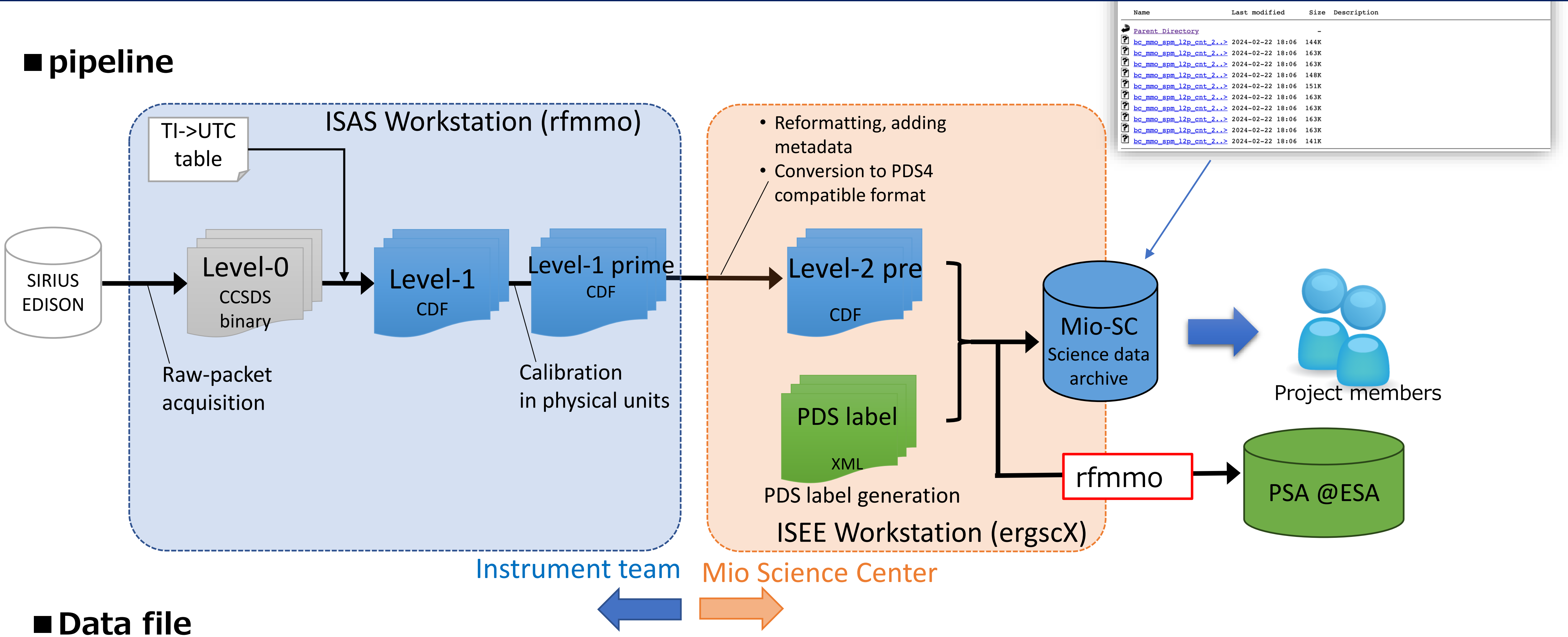
- Mainly archived as CDF or FITS files.
- Data production target: **Partially and fully calibrated datasets of all instruments**
- The data files are released from the web data repository of the science center.
  - Also delivered to and archived in ESA's PSA.

## Data Analysis Environment: (common to before and after MOI)

- The science center develops and releases the Mio plug-in for SPEDAS/PySPEDAS to the science community.

# Status-2: Release Plan: L2pre CDF files of SPM

## ■ pipeline

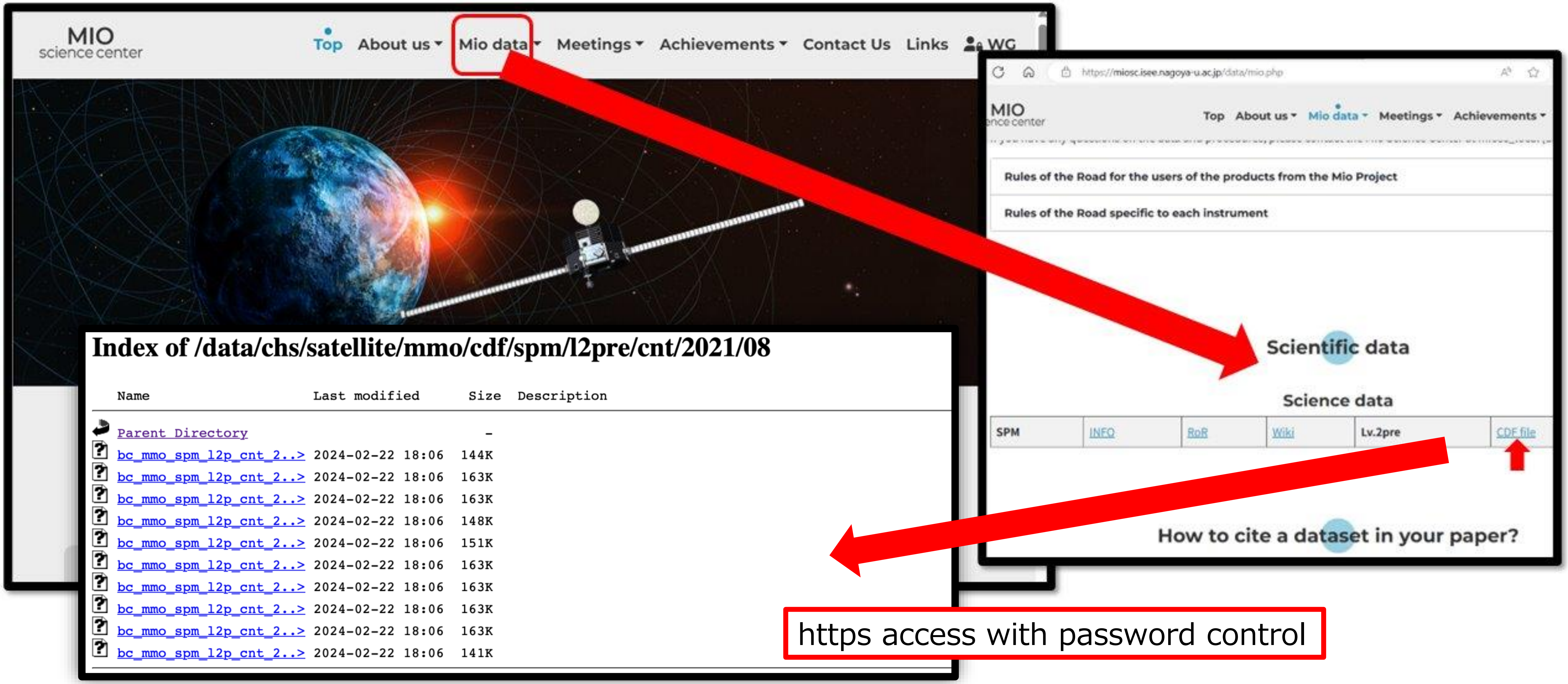



## ■ Data file

- SPM raw count (and possibly tentative flux values?) data as Lv.2pre dataset
    - Period: s/c launch through the latest date (~6 yrs)

**Mio-SPM point of contact: mio_spm_info@isee.nagoya-u.ac.jp**

# Release Plan: L2pre CDF files of SPM from the S/C webpage



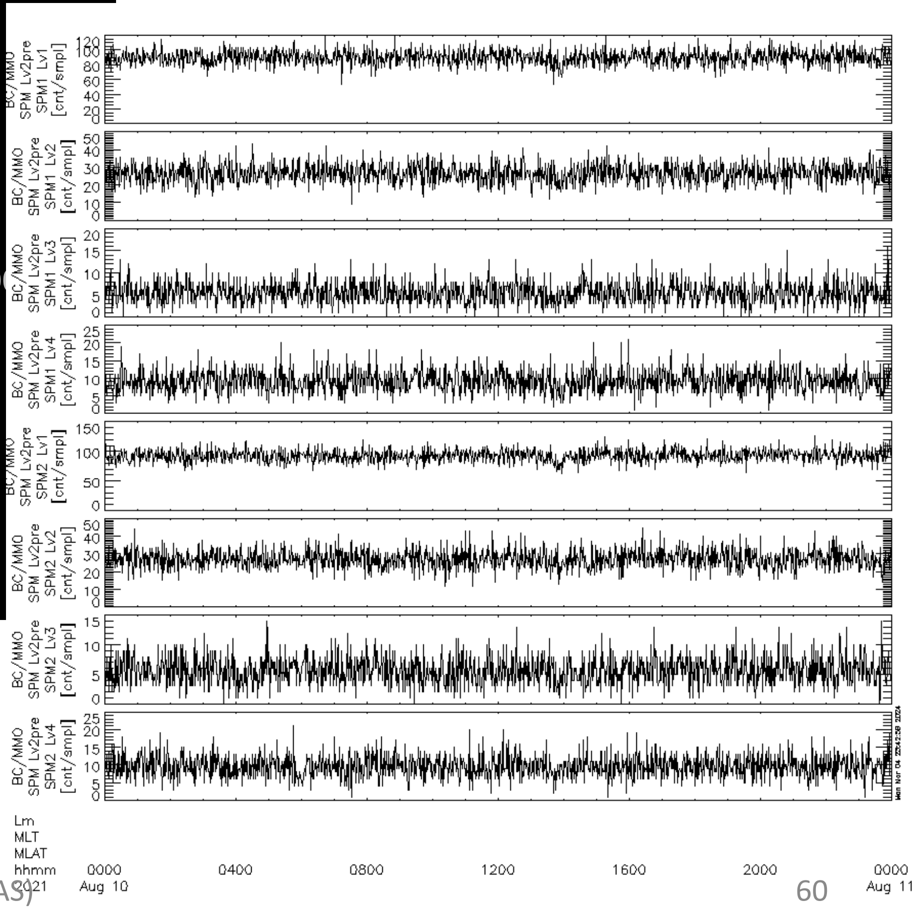

L2pre CDF files of SPM data / IDL SPEDAS plug-in will be opened to the Mio project team soon.

# Release Plan: IDL/SPEDAS plugin for Mio/SPM

```
MMO> timespan,'2021-08-10' & mmo_load_spm
TIMESPAN(53): Time range set from 2021-08-10/00:00:00 to 2021-08-11/00:00:00
ROOT_DATA_DIR(76): Warning: No Root Data Directory has been defined!
Using default: "c:/data/" (Which might change in the future!)
ROOT_DATA_DIR(79): To define the Root Data Directory, see
documentation in C:¥Program
Files¥Harris¥spedas_3_20¥idl¥general¥misc¥root_data_dir.pro
SPD_DOWNLOAD_FILE(221): Downloading:
https://chs.isee.nagoya-u.ac.jp/data/chs/satellite/mmo/cdf/spm/l2pre/cnt/2021/08/
SPD_DOWNLOAD_FILE(244): Download failed. Trying a second time.
SPD_DOWNLOAD_FILE(308): Unauthorized to access:
https://chs.isee.nagoya-u.ac.jp/data/chs/satellite/mmo/cdf/spm/l2pre/cnt/2021/08/
SPD_DOWNLOAD(238): No matching remote files found. Searching for local files.
SPD_MMS_CDF_LOAD_VARS(223): Loading file:
"C:¥data¥chs¥satellite¥mmo¥cdf¥spm¥l2pre¥cnt¥2021¥08¥bc_mmo_spm_l2p_cnt_20210810_r00-v00-0
STORE_DATA(261): Altering tplot variable: 21 mmo_spm_l2p_spm1_lv1_cnt
STORE_DATA(261): Altering tplot variable: 22 mmo_spm_l2p_spm1_lv2_cnt
STORE_DATA(261): Altering tplot variable: 23 mmo_spm_l2p_spm1_lv3_cnt
STORE_DATA(261): Altering tplot variable: 24 mmo_spm_l2p_spm1_lv4_cnt
STORE_DATA(261): Altering tplot variable: 25 mmo_spm_l2p_spm2_lv1_cnt
STORE_DATA(261): Altering tplot variable: 26 mmo_spm_l2p_spm2_lv2_cnt
STORE_DATA(261): Altering tplot variable: 27 mmo_spm_l2p_spm2_lv3_cnt
MMO> tplot, 'mmo_spm_l2p_spm?_lv?_cnt'
```

Downloading CDF files from the science center repository

Plot



# Q/A and Discussions

**[from S/C]**

**- (L2pre: Cruise Phase Data)**
We need the L1p data from the cruise phase delivered to SC as soon as possible

**- (L2: Science Data after MOI)**
We will be intensifying the design and development of the L2 data and its PDS archive around 2025, so your cooperation is appreciated.

**- (PDS delivery of L1 data)**
Regarding the PDS 1st delivery at MOI+6M, we expect the PI team to take the lead in preparing the L1 data. SC will provide as much support as possible.

**- (EAICD for L2 PDS archive)**
Since it needs to be included in the PDS archive, we will generate the EAICD.
Your cooperation is appreciated.

# Summary and Plans

**[Schedule/Pipeline]**

- Schedule on the data production plan for L1/L2.
- Milestones after/before MOI will be scheduled.
- S/C wants to discuss the detailed schedule with the PI teams.

**[Plans]**

- Release of SPM L2pre data CDF files from S/C to the project team.

# Request to each PI team

- **Instrument context product [urgent]**
  - Example of PWI is available
  - Contents:
    - PDS4 bundle info: LID, version, …
    - Reference paper
    - Instrument description
- EAICD (Experiment to Archive Interface Control Document): kind of user manual and/or data definition document, to be provided by PI **[31 Oct 2024]**
  - Sample/template document will be distributed **by the next SWT**
- Dedicated data handling meeting with each team: on-going

# (Reference: PWI context product)

- <logical_identifier>urn:jaxa:darts:context:instrument:mmo.pwi
- <title>Plasma Wave Investigation
- <reference_text>
  - Kasaba, Y., Kojima, H., Moncuquet, M., Wahlund J.-E, Yagitani, S., Sahraoui, F., Henri, P., Karlsson, T., Kasahara, Y., Kumamoto, A., Ishisaka, K., Issautier, K., Wattieaux, G., Imachi, T., Matsuda, S., Lichtenberger, J., and Usui H., Plasma Wave Investigation (PWI) Aboard BepiColombo Mio on the Trip to the First Measurement of Electric Fields, Electromagnetic Waves, and Radio Waves Around Mercury. Space Sci Rev 216, 65 (2020)
- <name>PWI
- <type>Plasma Wave Spectrometer

# (Reference: PWI context product)

- <description>
  - The Plasma Wave Investigation (PWI) aboard the BepiColombo Mio (Mercury Magnetospheric Orbiter, MMO) will enable the first observations of electric fields, plasma waves, and radio waves in and around the Hermean magnetosphere and exosphere. The PWI has two sets of receivers (EWO with AM2P, SORBET) connected to two electric field sensors (MEFISTO and WPT) and two magnetic field sensors (SCM: LF-SC and DB-SC).
  - The PWI measures electric field from DC to 10 MHz using two dipole antennae with a 32-m tip-to-tip length in the spin plane and the magnetic field from 0.3 Hz to 20 kHz using a three-axis sensor and from 2.5 kHz to 640 kHz using a single-axis sensor at the tip of a 4.5-m solid boom extended from the spacecraft' s side panel. Those receivers and sensors will provide (1) in-situ measurements of electron density and temperature that can be used to determine the structure and dynamics of the Hermean plasma environment; (2) in-situ measurements of the electron and ion scale waves that characterize the energetic processes governed by wave–particle interactions and non-MHD interactions; (3) information on radio waves, which can be used to remotely probe solar activity in the heliocentric sector facing Mercury, to study electromagnetic-energy transport to and from Mercury, and to obtain crustal information from reflected electromagnetic waves; and (4) information concerning dust impacts on the spacecraft body detected via potential disturbances.

# Thank you!