Consiglio Nazionale delle Ricerche

Visible Channels (404nm & 422nm) in-flight performance and calibration

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PHEBUS team meeting - June 13, 2022 - Montigny le Bx

Mercury image, credit : NASA

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PROBING OF HERMEAN EXOSPHERE BY ULTRAVIOLET SPECTROSCOPY

1. Types of observation with the visible channels
2. Issues with the dark current
3. Calibration of the visible channels
4. Results from the first Swing-By

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Mercury image, credit : NASA

Operating the visible channels

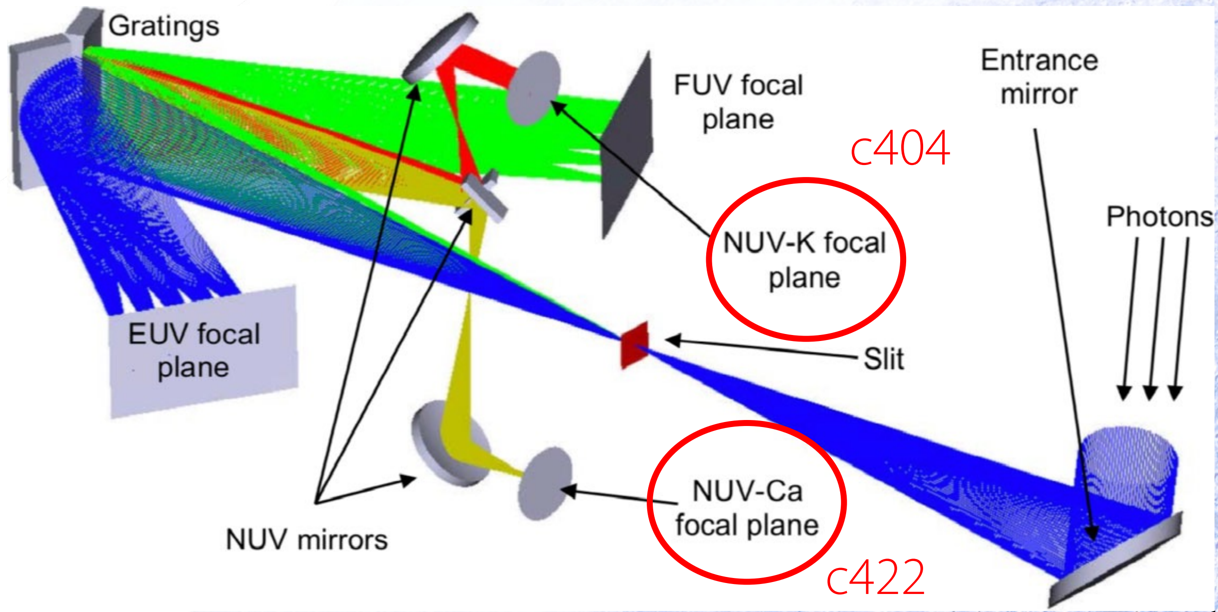
PROBING OF HERMEAN EXOSPHERE BY ULTRAVIOLET SPECTROSCOPY

❑During flips

- for calibration (i.e. stars observation)
- for zodiacal light

❑During swing-by

- Venus swing-by: No data
- Mercury swing-by: Interesting data



Mercury image, credit : NASA

PROBING OF HERMEAN EXOSPHERE BY ULTRAVIOLET SPECTROSCOPY

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Observation during flips

Since 2019, 87 observations during flips

- c404 and c422 only
- HV = 1000V
- Observation rate = 2s
- Integration time = 1s

Mercury image, credit : NASA

Observation during flips

Probing of Hermean Exosphere By Ultraviolet Spectroscopy

Since 2019, 87 observations during flips

- c404 and c422 only
- HV = 1000V
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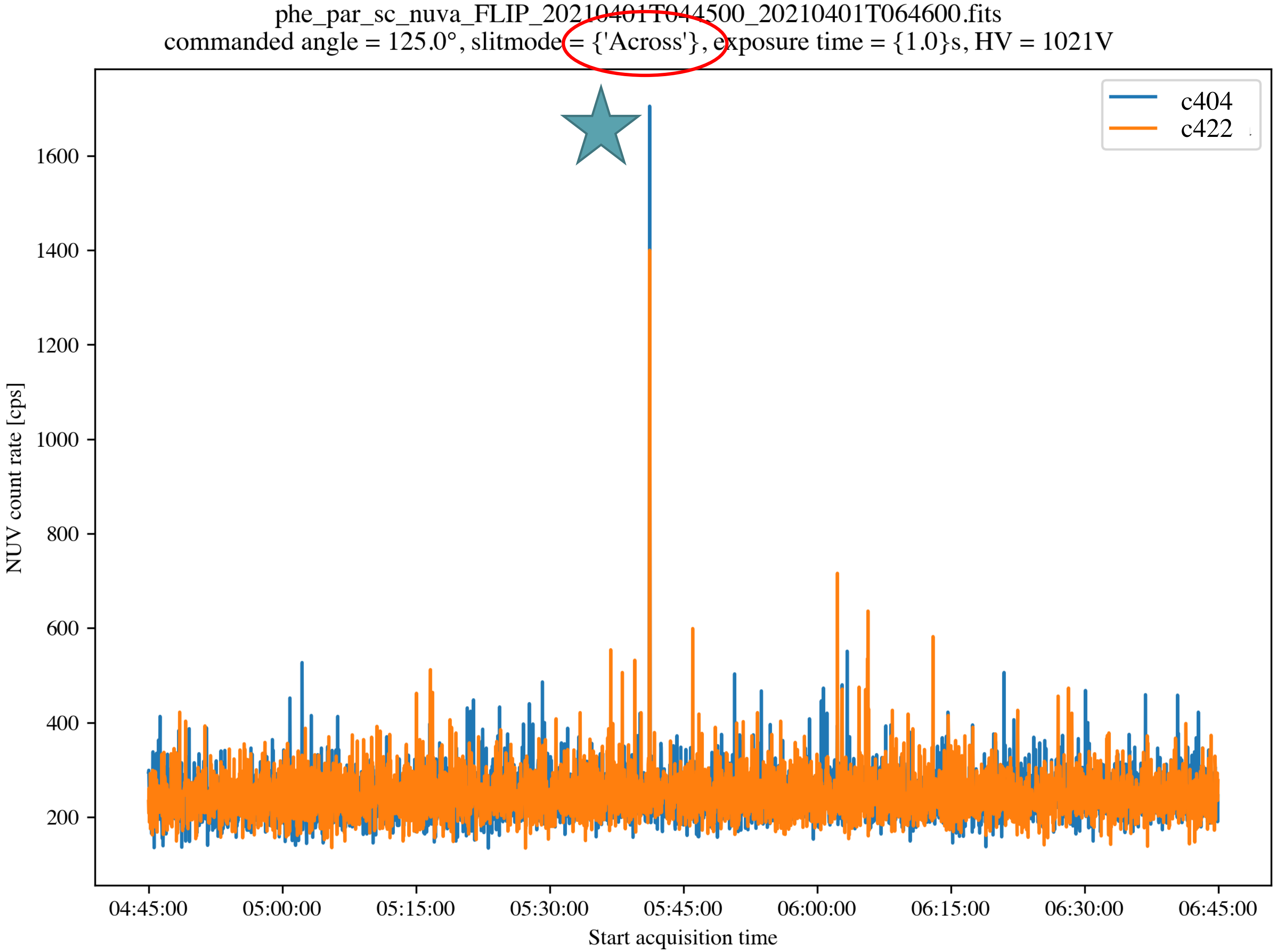
- Integration time = 1s

❑ 2 types of observations during flips:

- 1 scanner position → observe the sky

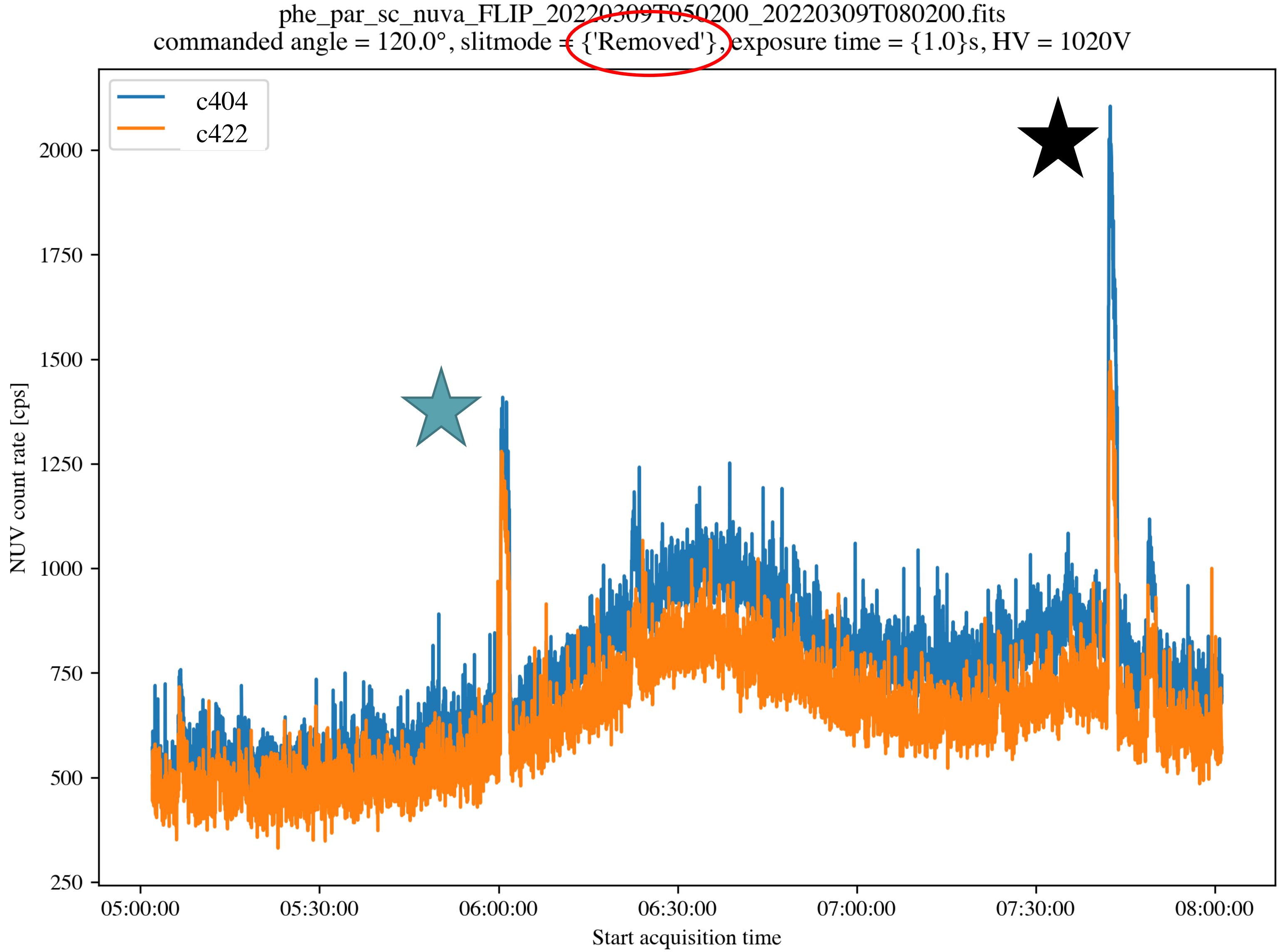
Mercury image, credit : NASA

Observation during flips: method



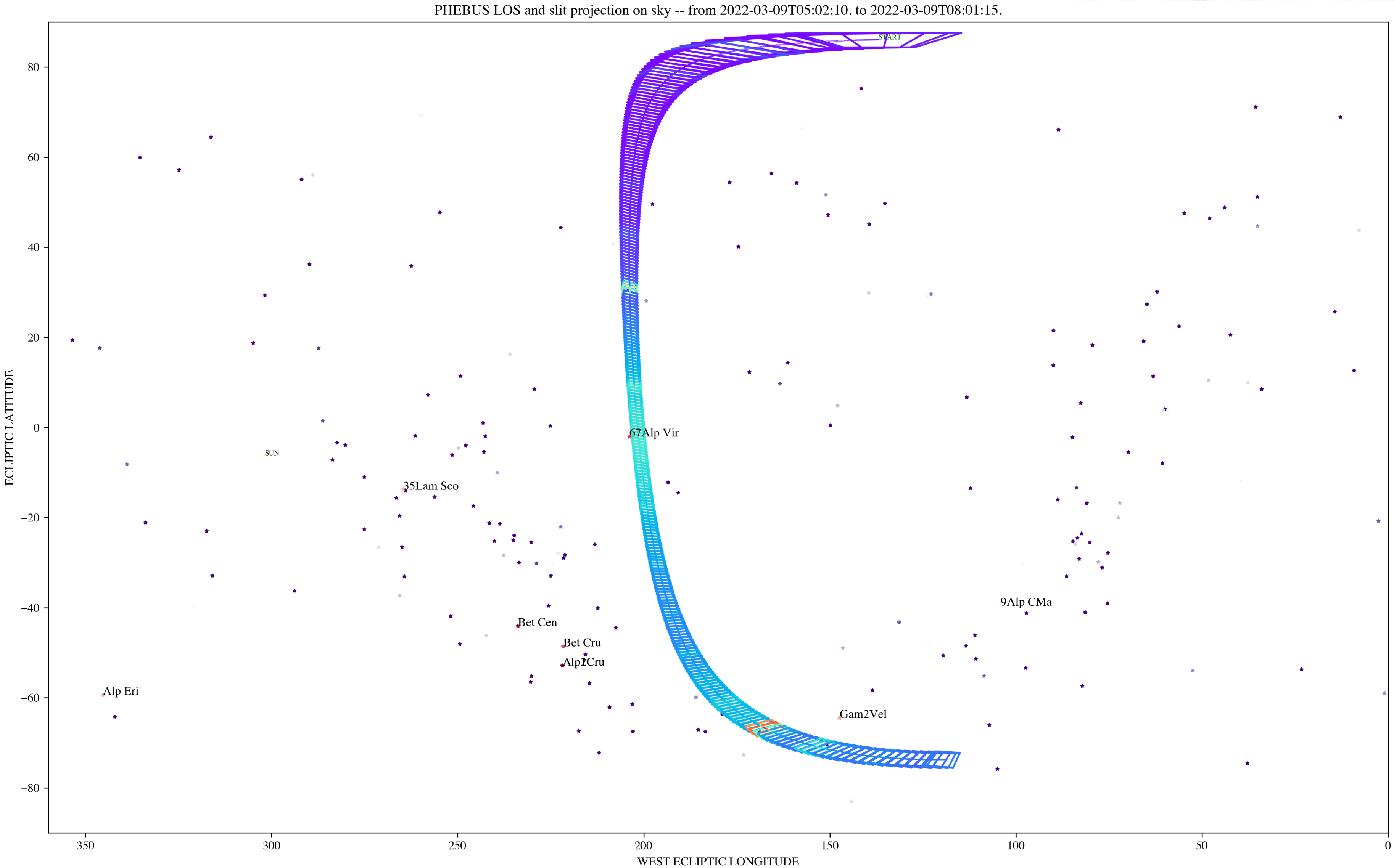
Mercury image, credit : NASA

Observation during flips: method



Mercury image, credit : NASA

Projection of the FoV on the sky



Mercury image, credit : NASA

Observation during flips

PROBING OF HERMEAN EXOSPHERE BY ULTRAVIOLET SPECTROSCOPY

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Since 2019, 87 observations during flips

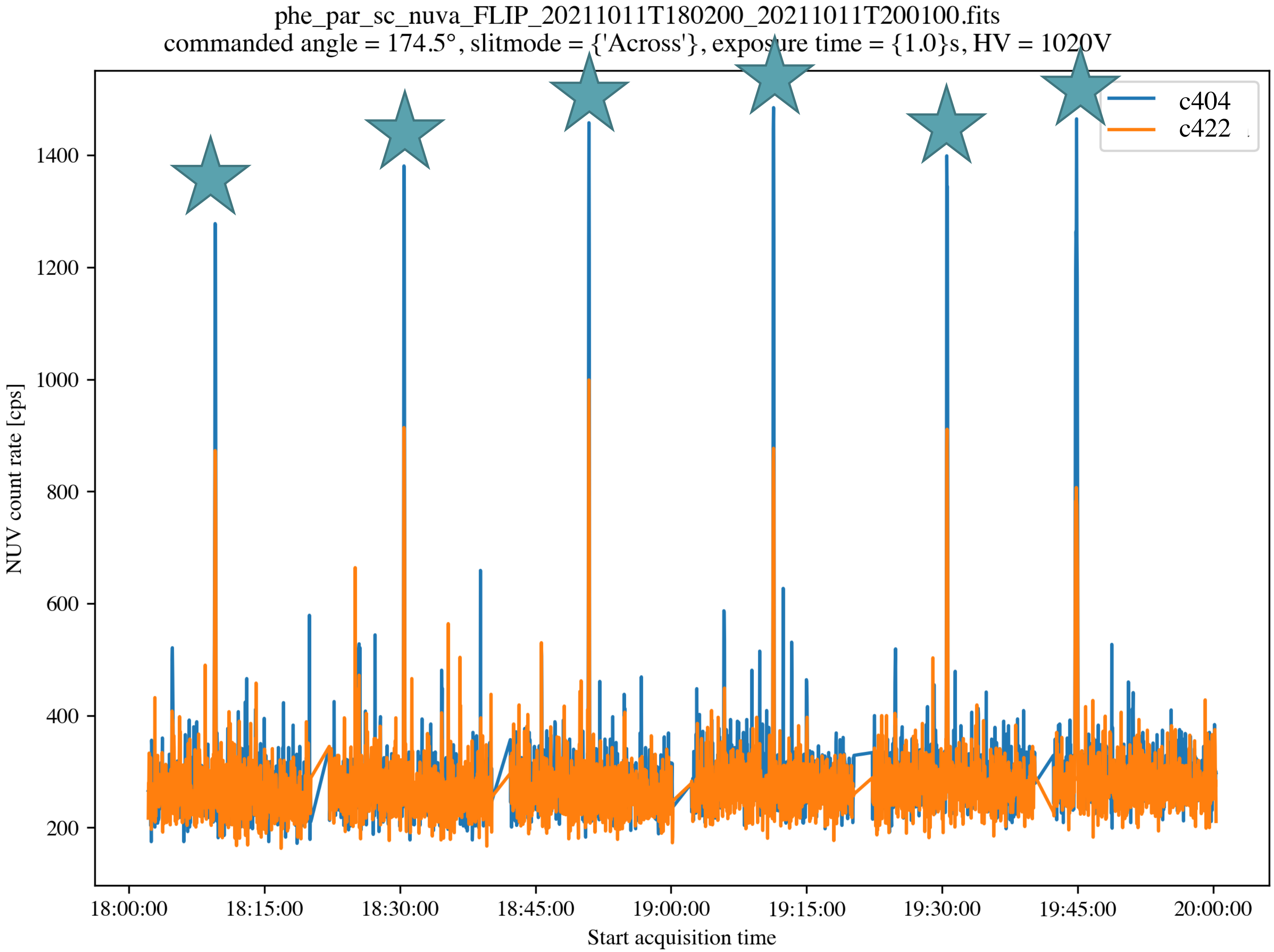
- c404 and c422 only
- HV = 1000V
- Observation rate = 2s
- Integration time = 1s

❑ 2 types of observations during flips:

- 1 scanner position → observe the sky
- Mutliple scanner positions → follow a star

Mercury image, credit : NASA

Observation during flips: method



Mercury image, credit : NASA

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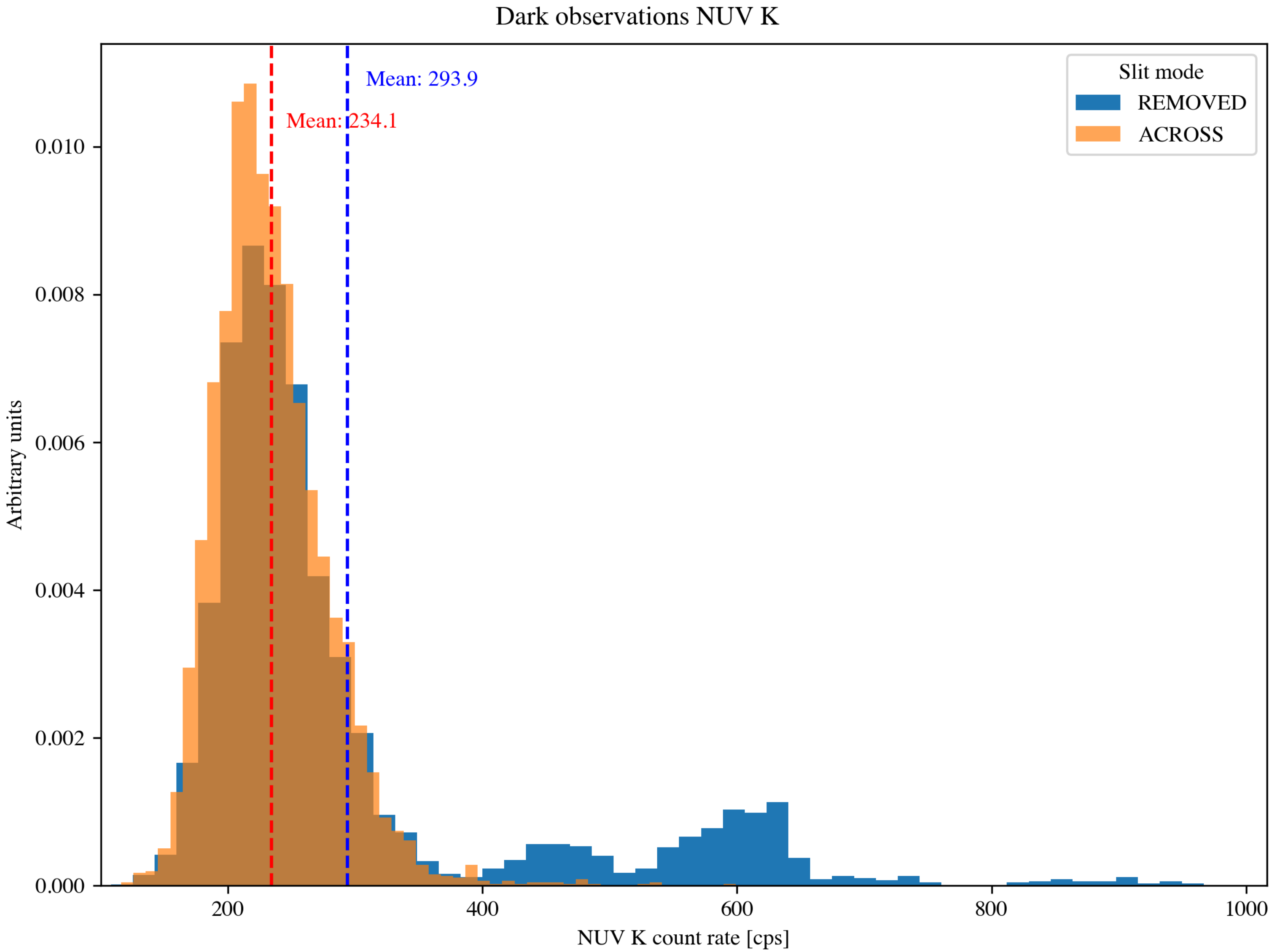
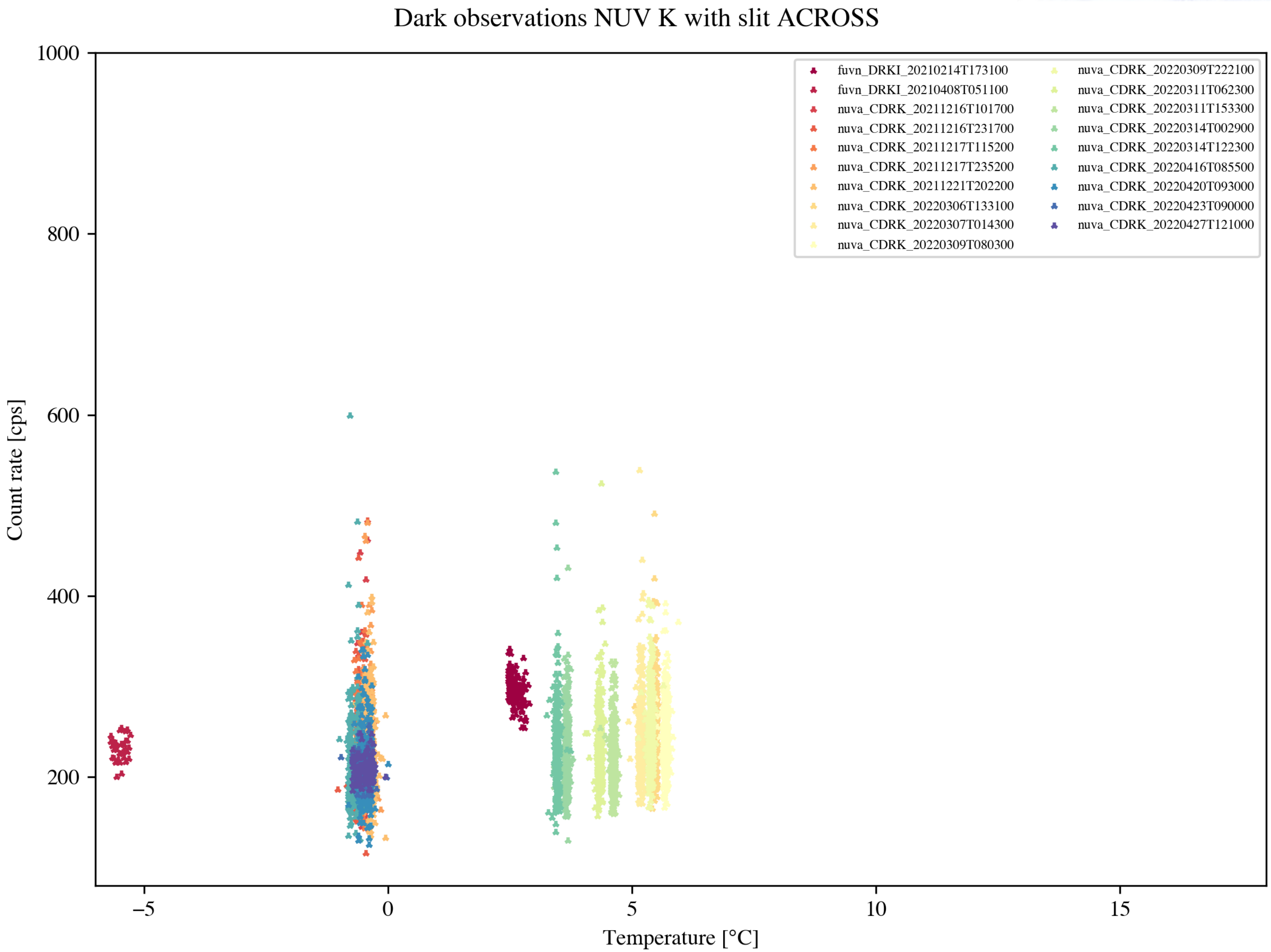
Mercury image, credit : NASA

Visible channels' dark current



Mercury image, credit : NASA

Visible channels' dark current



Probing of Hermean Exosphere By Ultraviolet Spectroscopy

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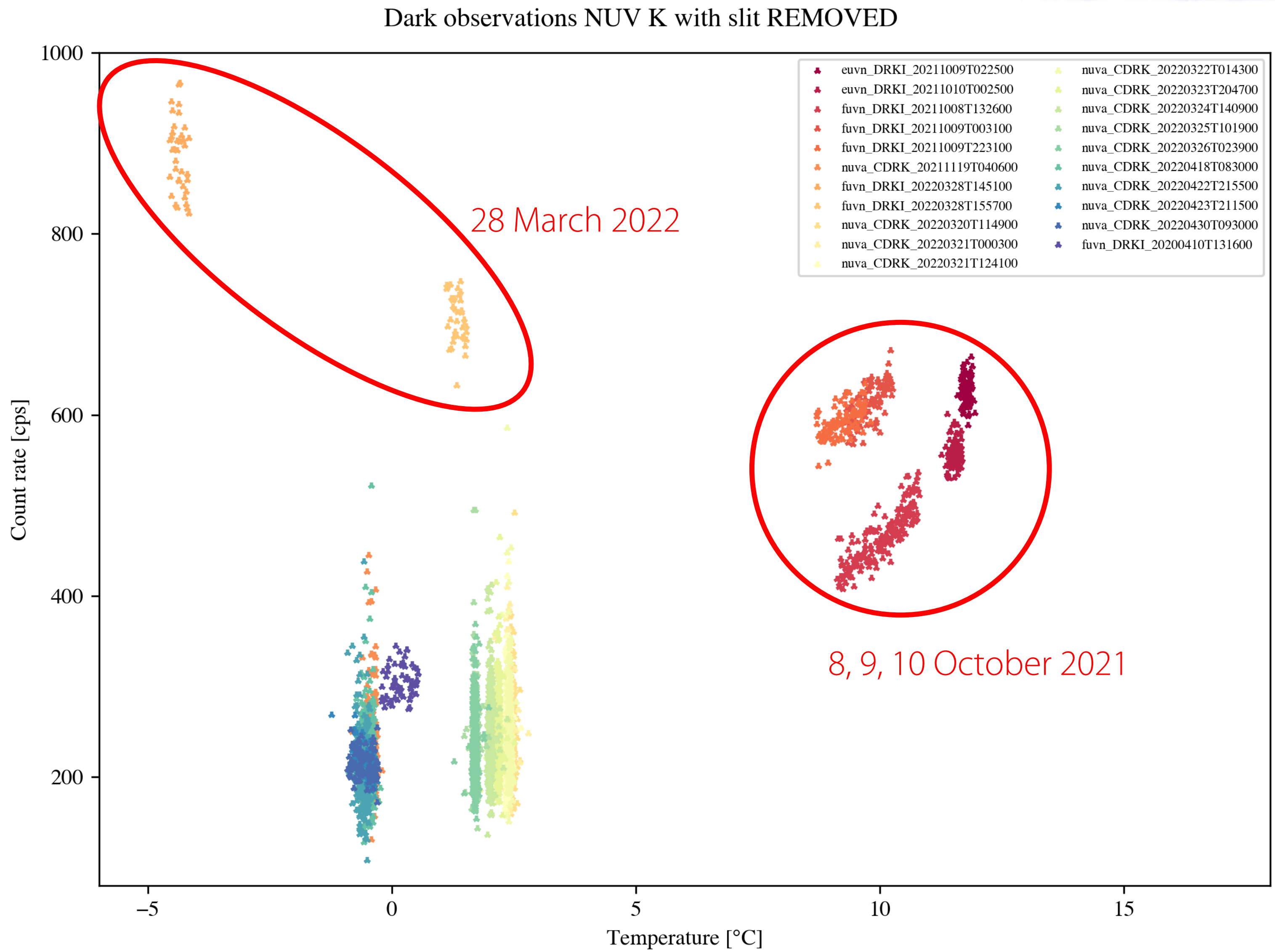
Mercury image, credit : NASA

Visible channels' dark current

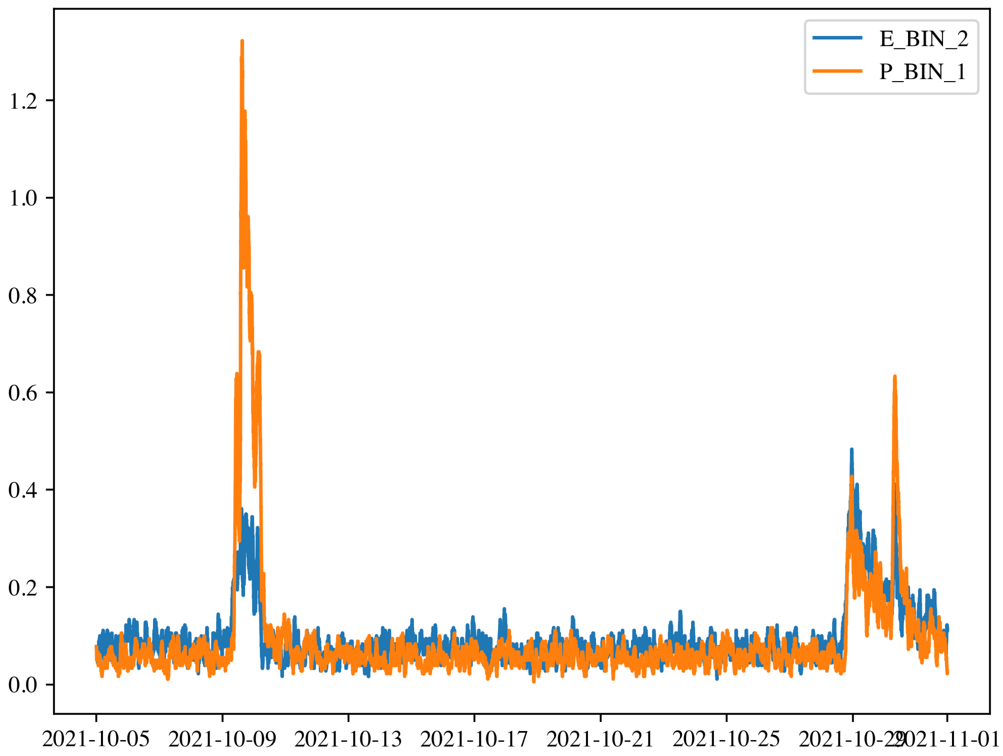


PROBING OF HERMEAN EXOSPHERE BY ULTRAVIOLET SPECTROSCOPY

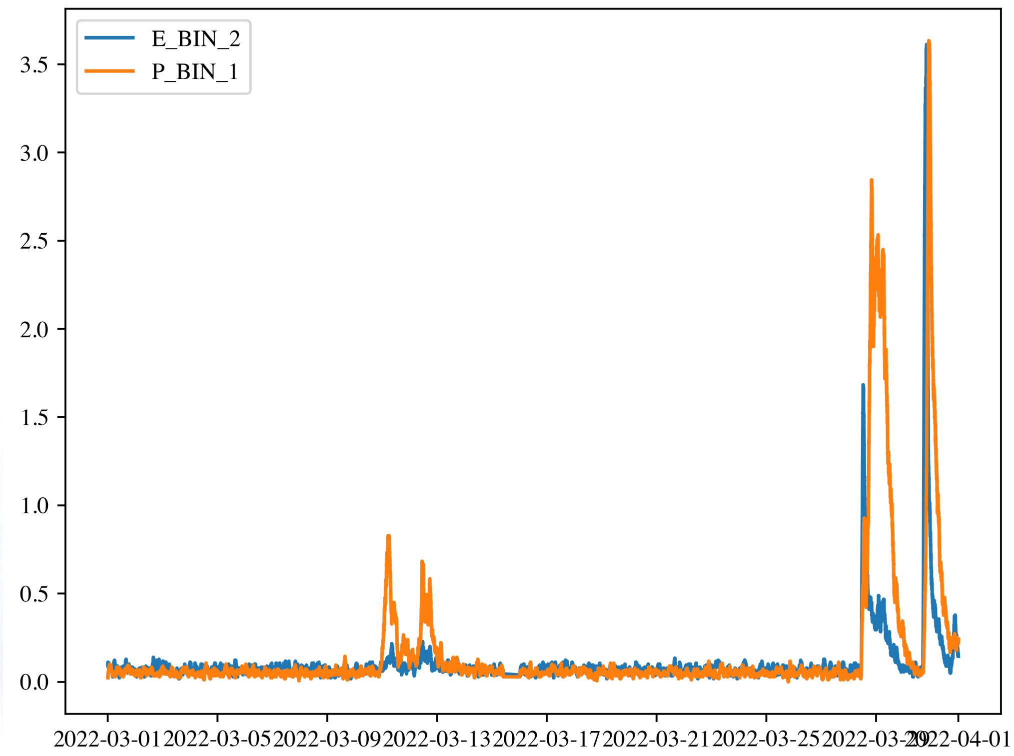
Mercury image, credit : NASA

Radiation monitor data

BERM data for October 2021.
Data are averaged over 90 minutes



BERM data for March 2022.
Data are averaged over 90 minutes



Mercury image, credit

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Mercury image, credit : NASA

Calibration method

1. **Detect count rate peaks: if the peak occurs on both detectors at the same time it means a star was in PHEBUS FoV**

Calibration method

PROBING OF HERMEAN EXOSPHERE BY ULTRAVIOLET SPECTROSCOPY

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2. **Determine which star was in PHEBUS FoV by reconstructing the geometry of observation**

Mercury image, credit : NASA

Calibration method

1. Detect count rate peaks: if the peak occurs on both detectors at the same time it means a star was in PHEBUS FoV
2. **Determine which star was in PHEBUS FoV by reconstructing the geometry of observation**
   - 13 different stars were observed during flips with slit across: alpha eridani, beta aurigae, , theta aurigae, beta canis majoris, alpha carinae, epsilon canis majoris, gamma velorum, beta carinae, alpha leonis, theta carinae, alpha virginis, alpha cygnus and alpha gruis

Calibration method

PROBING OF HERMEAN EXOSPHERE BY ULTRAVIOLET SPECTROSCOPY

1. Detect count rate peaks: if the peak occurs on both detectors at the same time it means a star was in PHEBUS FoV
2. Determine which star was in PHEBUS FoV by reconstructing the geometry of observation
3. **Retrieve the visible spectrum of this star**

Mercury image, credit : NASA

Calibration method

1. Detect count rate peaks: if the peak occurs on both detectors at the same time it means a star was in PHEBUS FoV
2. Determine which star was in PHEBUS FoV by reconstructing the geometry of observation
3. **Retrieve the visible spectrum of this star**
   - Burnashev, 1985
   - Krisciunas et al., 2017

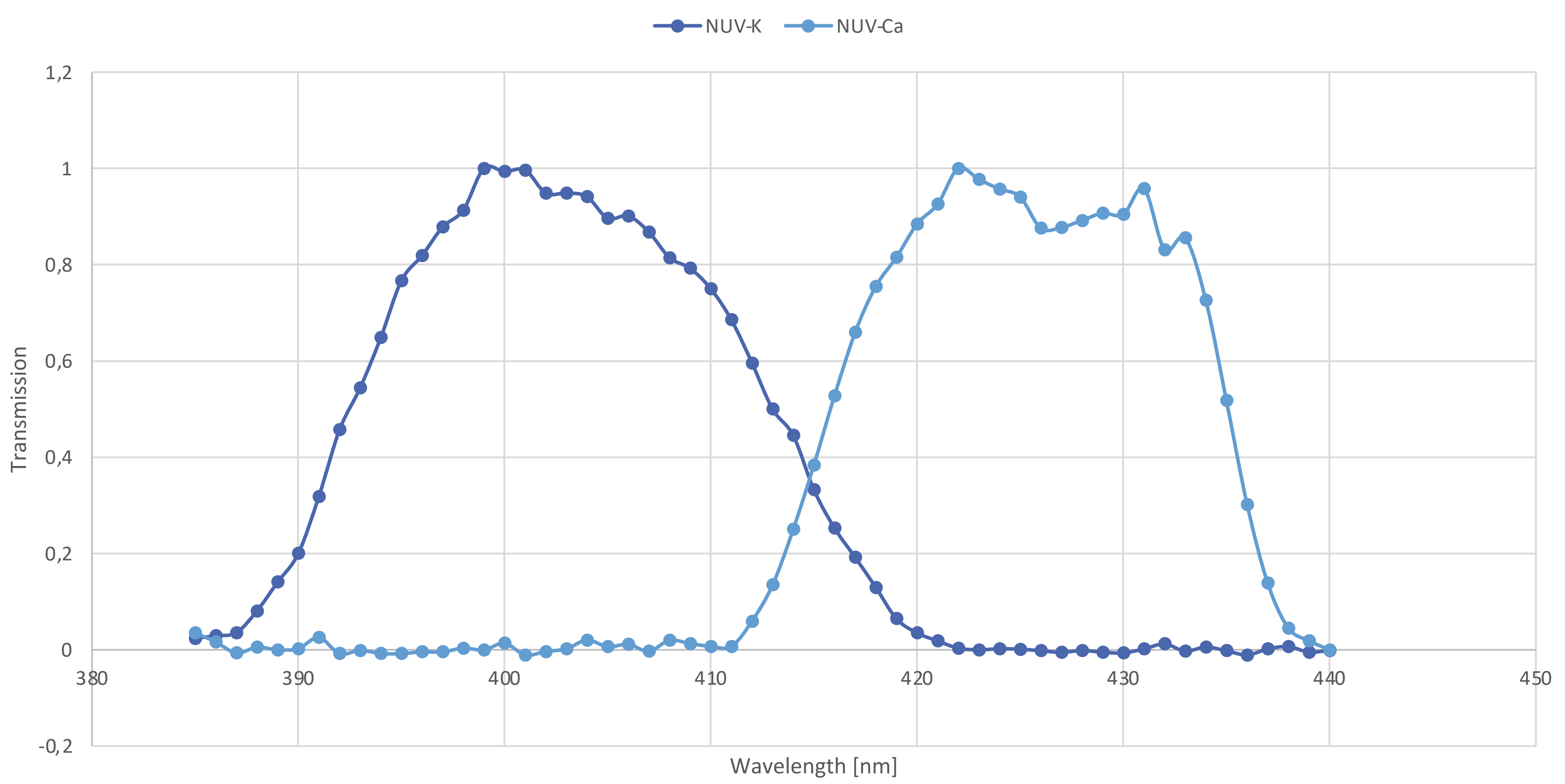
Mercury image, credit : NASA

Calibration method

1. Detect count rate peaks: if the peak occurs on both detectors at the same time it means a star was in PHEBUS FoV
2. Determine which star was in PHEBUS FoV by reconstructing the geometry of observation
3. Retrieve the visible spectrum of this star
4. **Compute its transmitted flux *F* [ph.s^{-1}.cm^{-2}] on each detector:**

$$\mathbf{F} = \int \phi(\lambda)\, \mathbf{T}(\lambda) \mathbf{d}\lambda$$

Visible channels' transmission



Mercury image, credit : NASA

Calibration method

CNRS, Université de Versailles St-Quentin-en-Yvelines, Sorbonne Université, LATMOS, cnes, IKI, DESP, Consiglio Nazionale delle Ricerche

PROBING OF HERMEAN EXOSPHERE BY ULTRAVIOLET SPECTROSCOPY

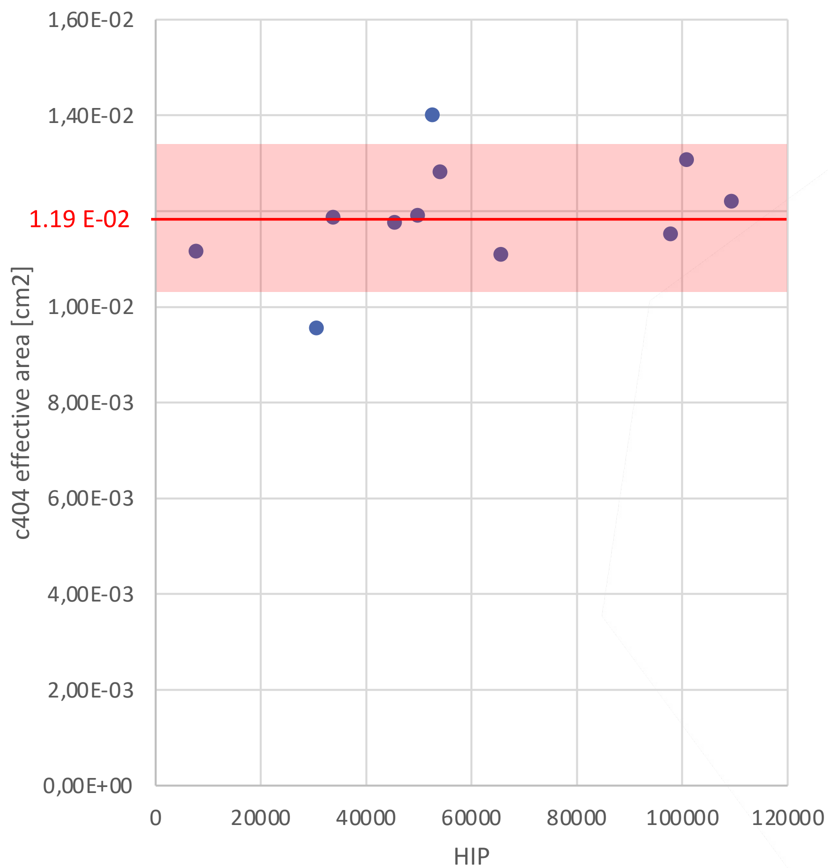
1. Detect count rate peaks: if the peak occurs on both detectors at the same time it means a star was in PHEBUS FoV
2. Determine which star was in PHEBUS FoV by reconstructing the geometry of observation
3. Retrieve the visible spectrum of this star
4. Compute its transmitted flux ***F*** [ph.s^{-1}.cm^{-2}] on each detector
5. **Compute the effective area of each detector:**

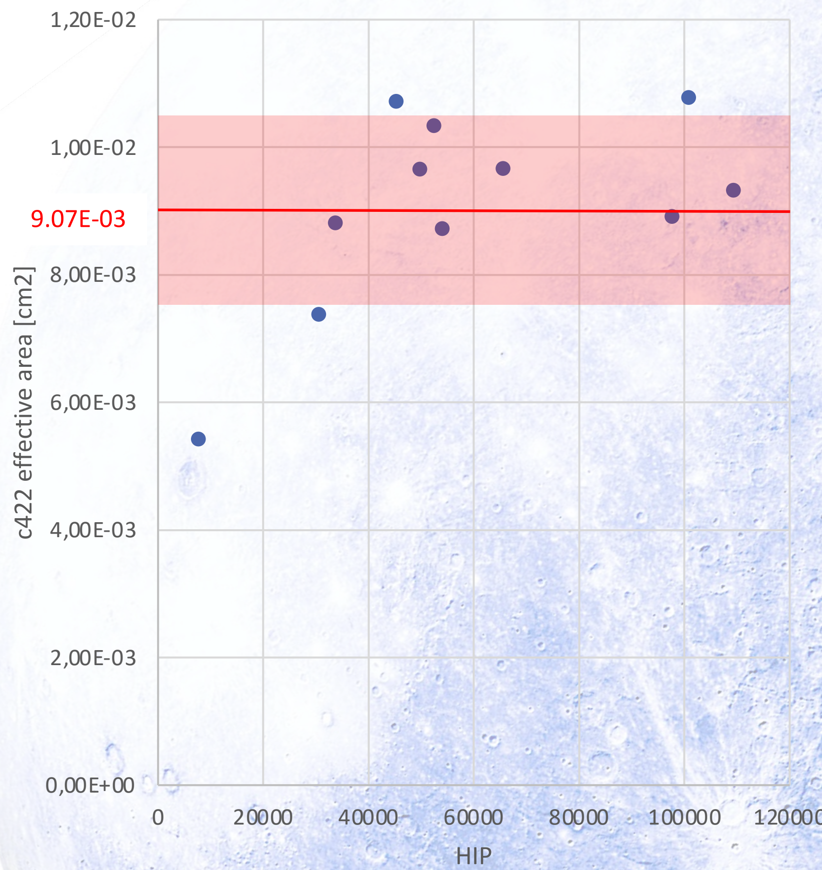
$$\mathbf{CR = F \times A_{eff}}$$

Visible channels effective area

c404 effective area = 1,19E-02 ± 3,25E-04 cm2

c422 effective area = **9,35E-03 ± 4,94E-04** cm2





Mercury image, credit : NASA

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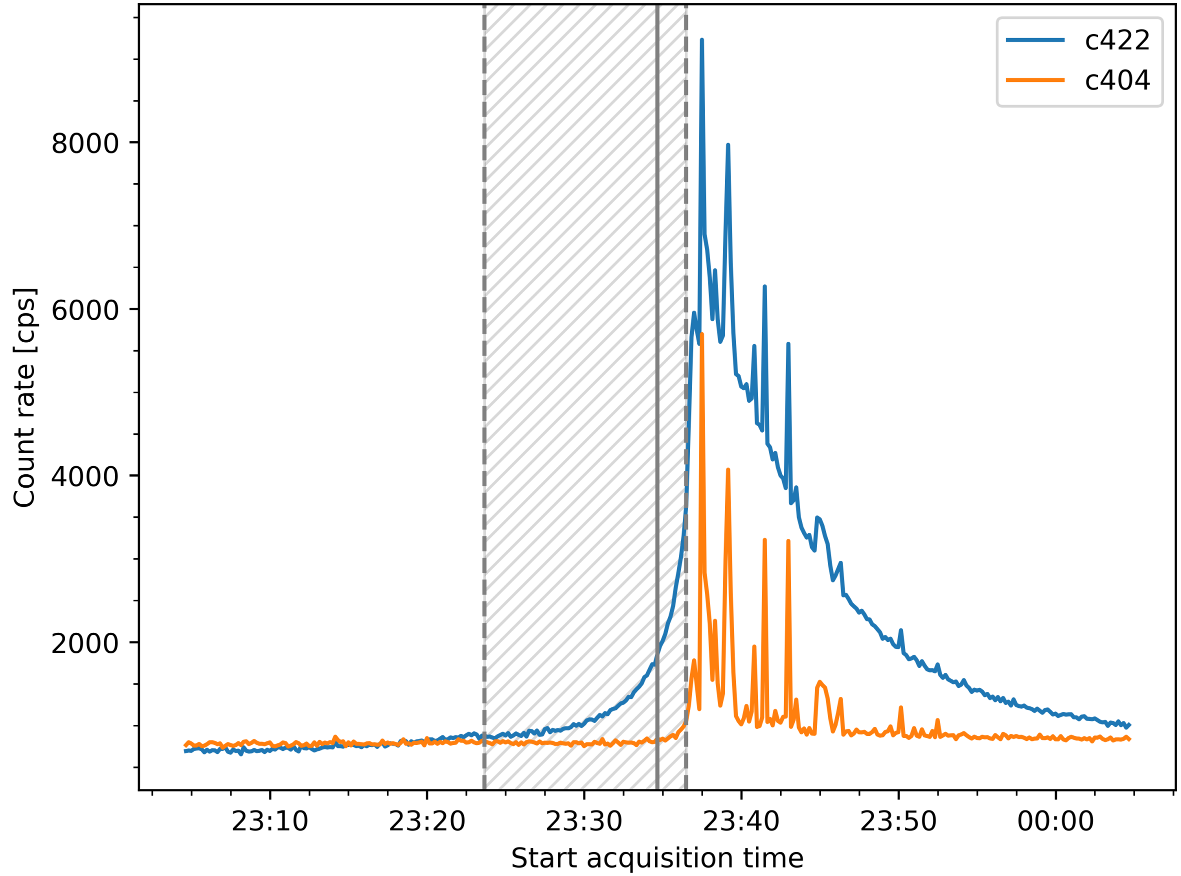
Mercury image, credit : NASA

Visible channels' results for MSB1

- Transit in the shadow of Mercury
- c422: Ca detection
- c404: possible Ca contamination or Mn detection
- Bursts
- Observation time not long enough



c422 data processing

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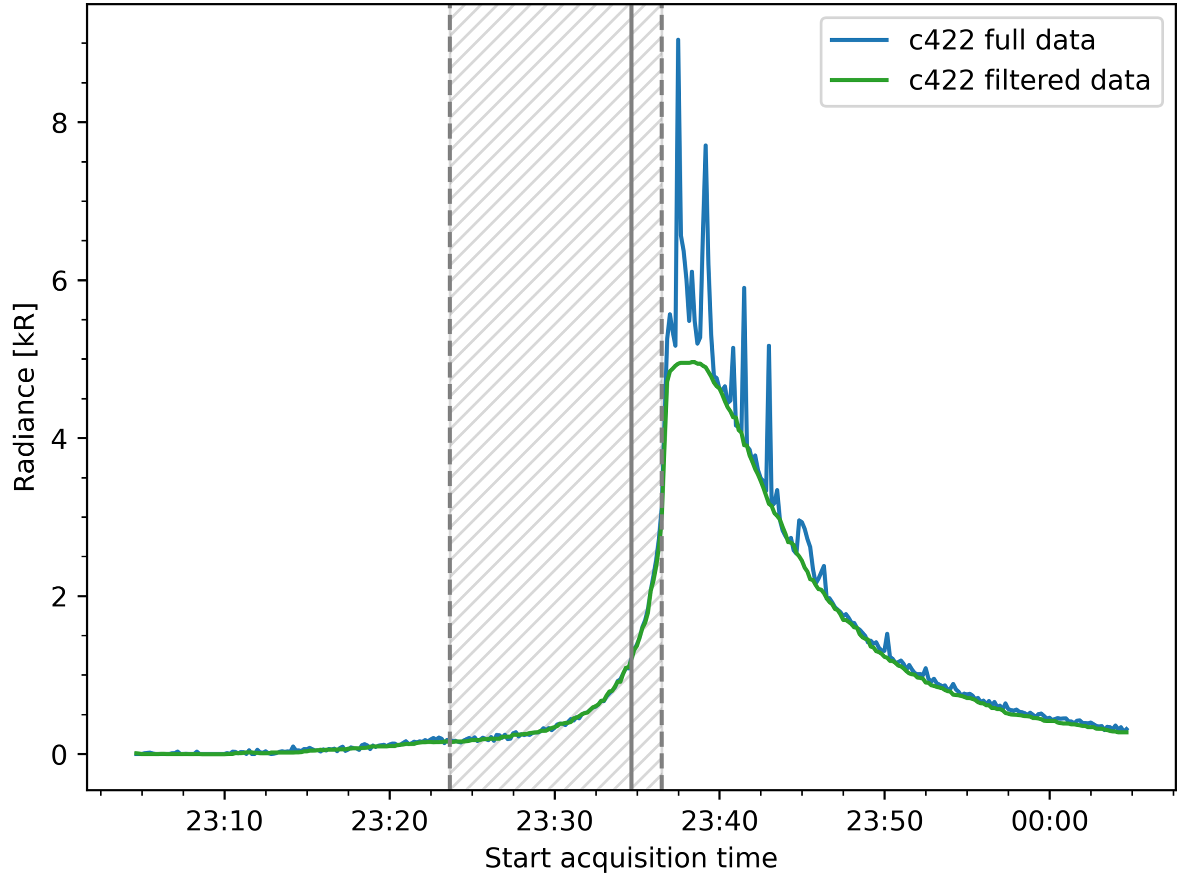
- ❑ Correct the data for the different contributions
- ❑ Remove the peaks and smooth the curve
- ❑ Convert to radiance (R) using the effective area calibrated in-flight



Mercury im

Exponential fit to the c422 data

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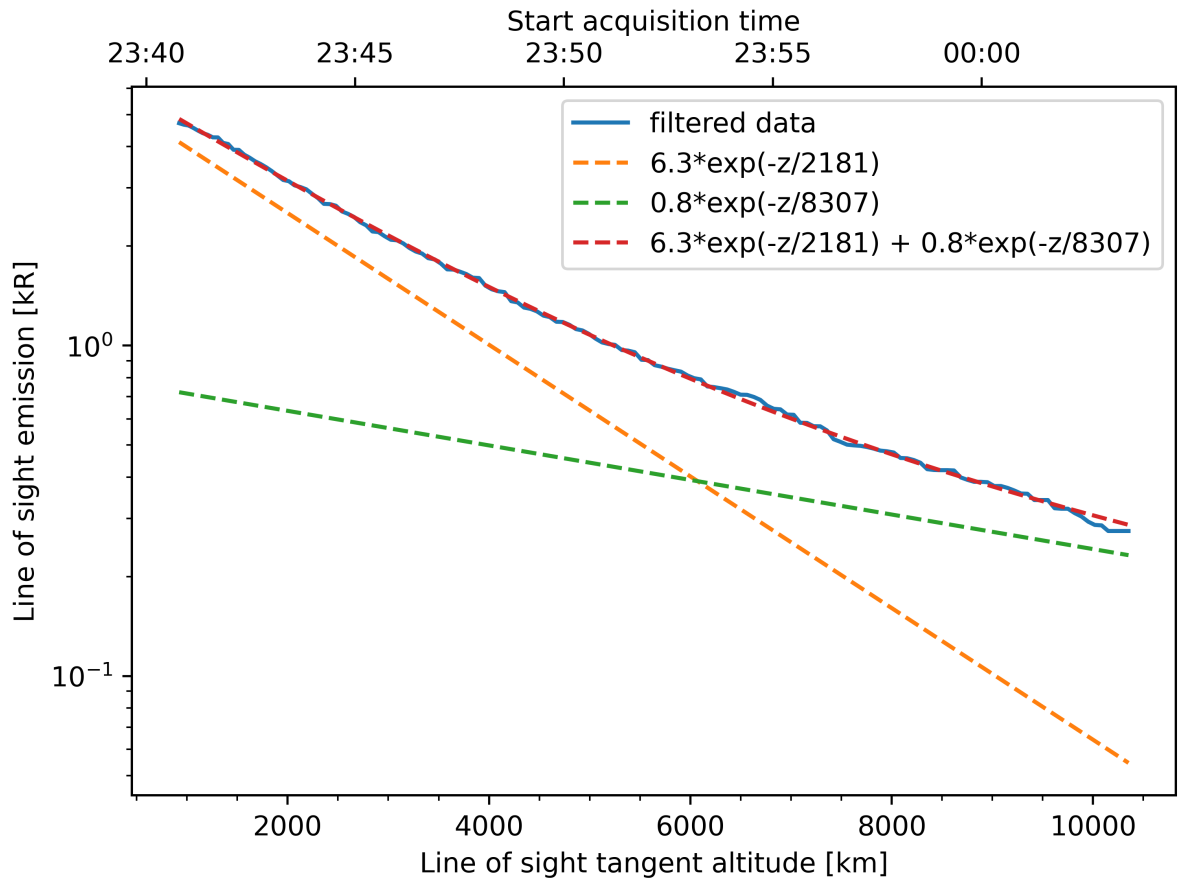
- **Exponential fit on the dayside data:**

$$f(z) = f_0 e^{-z/h}$$

With f_0 the radiance at the surface, z the altitude above the surface and h the e-folding width

- **Two populations:**
  - f_1, h_1 = 6.3kR, 2 180km
  - f_2, h_2 = 0.8kR, 8 310km



Mercury ima

Comparison with MESSENGER data during flybys

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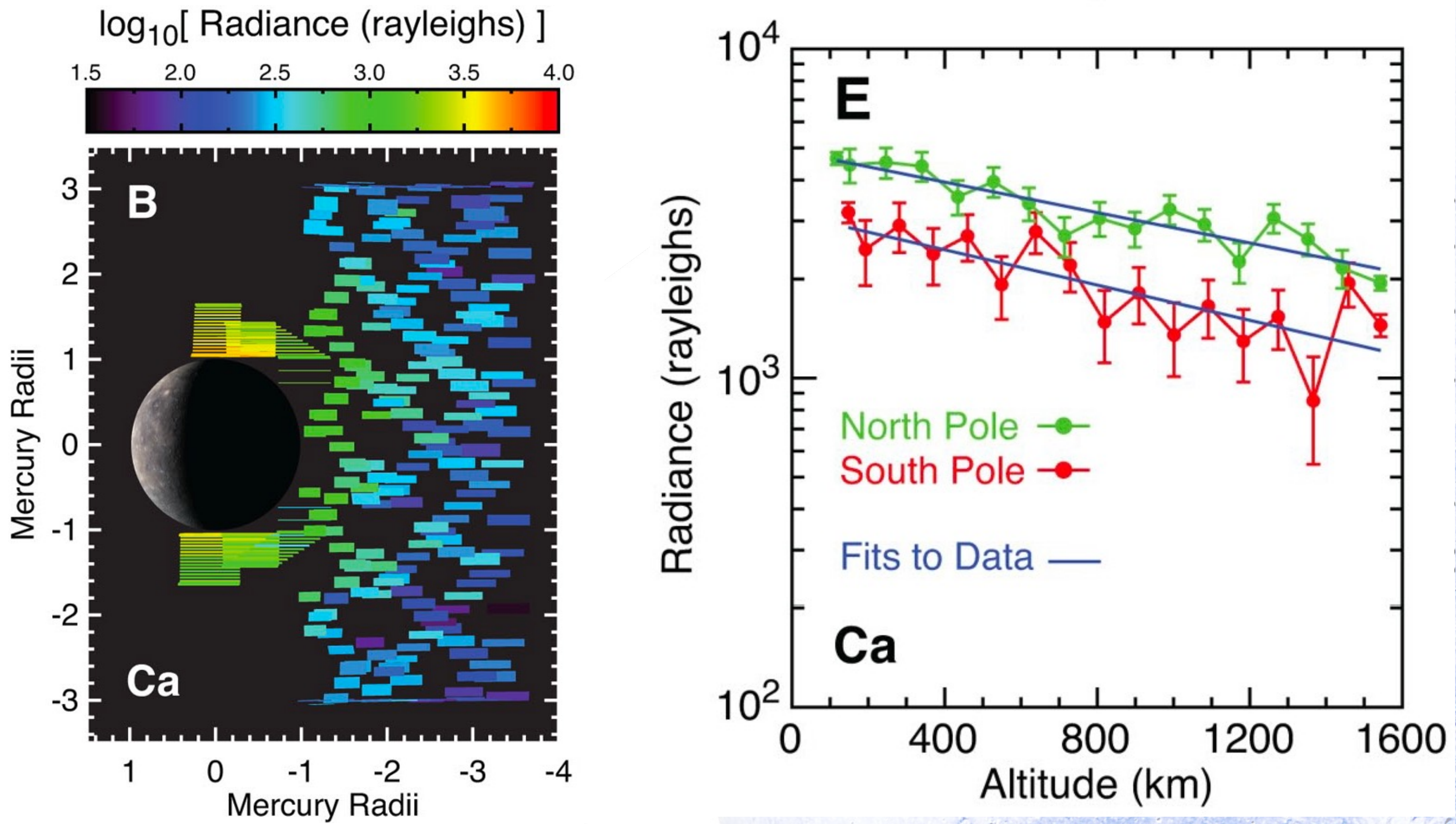


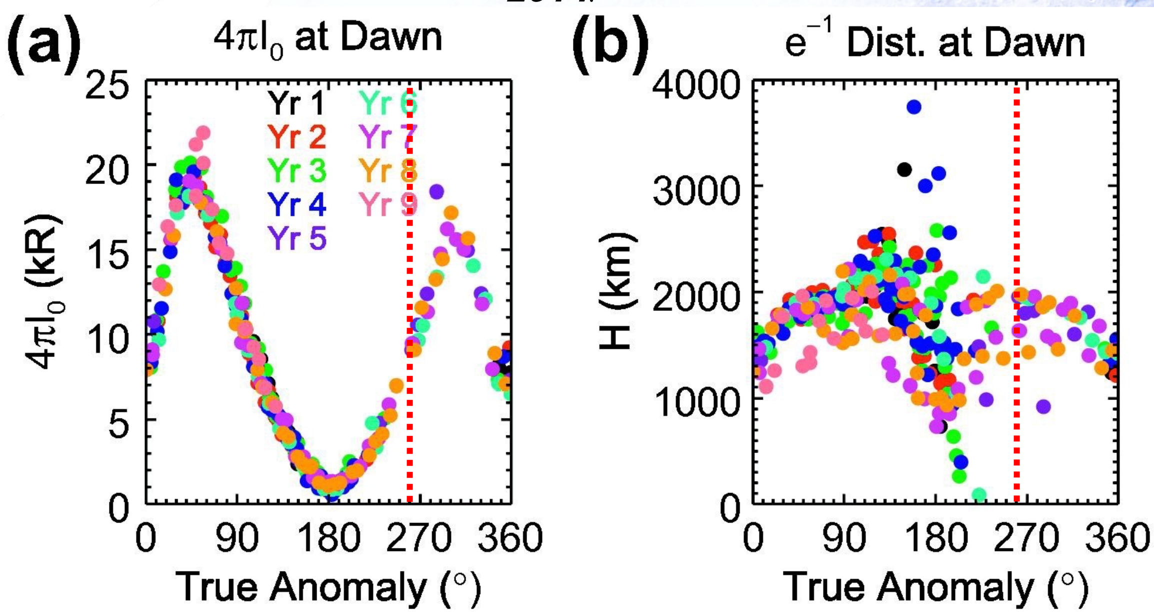
Adapted from Vervack et al., 2010

Mercury image, credit : NASA

Comparison with MESSENGER data in orbital phase

- **a) Intensity at the surface and b) e-folding distance over Mercury dawn determined from exponential fits to radial limb scan data.**
- **Based on Burger et al., 2014, for the MSB1 TAA (i.e. 263°):**
  - f_0 ~ 9 kR
  - h ~ 1500 – 2000 km

Adapted from Burger et al., 2014.



Mercury image, credit : NA

Perspectives

PROBING OF HERMEAN EXOSPHERE BY ULTRAVIOLET SPECTROSCOPY

- ❑ **Use Chamberlain (1963) model: derive the temperature and the density at the exobase**
- ❑ **Process c404 data: model Ca contamination**
- ❑ **Identify the bursts' origin:**
  - surface
  - magnetosphere
  - particles
- ❑ **Plan for second Mercury Swing-By:**
  - Longer and more distant observation
  - FUV detector to observe Magnesium

Mercury image, credit : NASA