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

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

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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Operating the visible channels

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

During swing-by
- Venus swing-by: No data
- Mercury swing-by: Interesting data
Since 2019, 87 observations during flips

- c404 and c422 only
- HV = 1000V
- Observation rate = 2s
- Integration time = 1s
Since 2019, 87 observations during flips

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- HV = 1000V
- Observation rate = 2s
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2 types of observations during flips:
- 1 scanner position → observe the sky
Observation during flips: method

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Data points: phe_par_sc_nuva_FLIP_20210401T044500_20210401T064600.fits
- Commanded angle: 125.0°
- Slitmode: {'Across'}
- Exposure time: 1.0 s
- HV: 1021 V

Graph showing NUV count rate against start acquisition time.
Observation during flips: method

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Projection of the FoV on the sky

PHEBUS LOS and slit projection on sky – from 2022-03-09T05:02:10, to 2022-03-09T08:01:15.
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
- Multiple scanner positions → follow a star
Observation during flips: method

phe_par_sc_nuva_FLIP_20211011T180200_20211011T200100.fits
commanded angle = 174.5°, slitmode = {'Across'}, exposure time = {1.0}s, HV = 1020V

NUV count rate [cps]

Start acquisition time

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2. Issues with the dark current

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4. Results from the first Swing-By
Visible channels’ dark current

Dark observations NUV K

Mean: 293.9
Mean: 234.1

Slit mode
- REMOVED
- ACROSS

NUV K count rate [cps]

Arbitrary units

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Visible channels’ dark current

Dark observations NUV K with slit ACROSS

Count rate [cps]

Temperature [°C]

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Visible channels' dark current

Dark observations NUV K with slit REMOVED

28 March 2022

8, 9, 10 October 2021

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

$$F = \int \phi(\lambda) T(\lambda) d\lambda$$
Visible channels’ transmission

Transmission vs. Wavelength [nm]

NUV-K and NUV-Ca transmission curves are shown for different wavelengths.
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:**
   \[ CR = F \times A_{\text{eff}} \]
Visible channels effective area

c404 effective area = 1.19E-02 ± 3.25E-04 cm²

c422 effective area = 9.35E-03 ± 4.94E-04 cm²
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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
- 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
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:

- \( f_1, h_1 = 6.3 \text{kR}, 2 \text{180km} \)
- \( f_2, h_2 = 0.8 \text{kR}, 8 \text{310km} \)
Comparison with MESSENGER data during flybys

Adapted from Vervack et al., 2010
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°):

• $f_0 \sim 9$ kR
• $h \sim 1500 – 2000$ km
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