XUV anomalies

B. LUSTREMENT

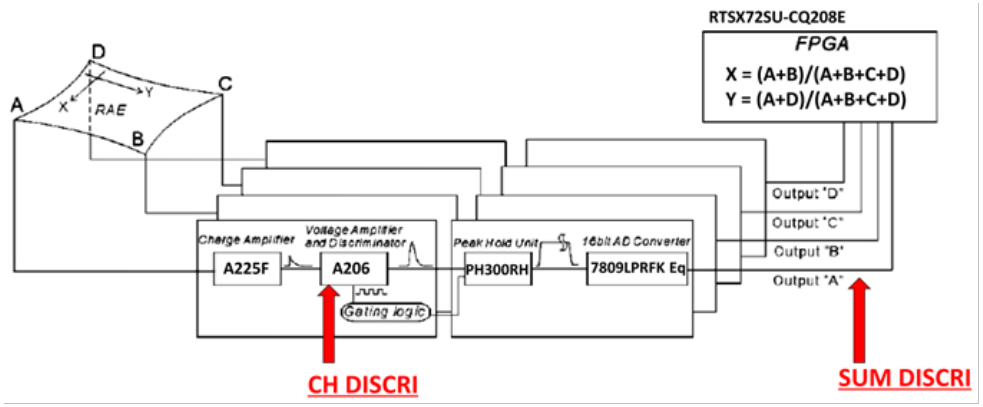
Agenda

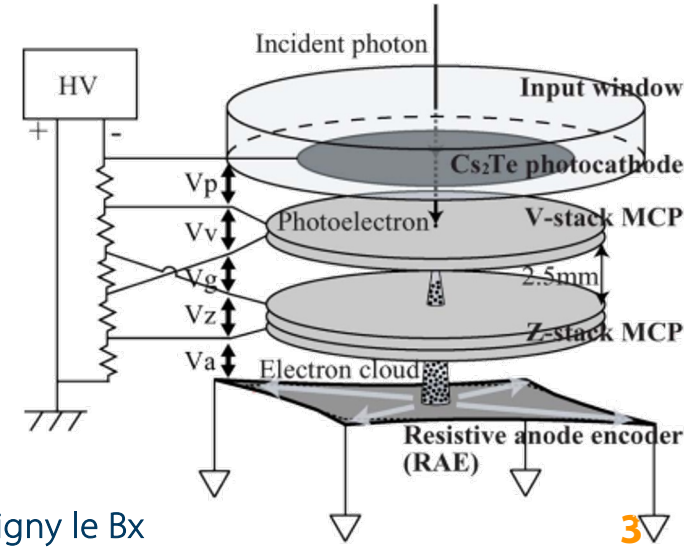
- **(Brief) xUV detectors overview**
- **FUV anomaly**
- **EUV anomaly**

xUV detectors overview

- **The EUV and FUV detectors share a same architecture:**
  - Photocathode → Photo-electrons generation
  - Micro Channel Plate (5 stages V+Z stack) → Electrons multiplication
  - Resistive Anode Encoder → Electron cloud collection (charge, position)

  - HV power supply needed to accelerate the electrons
  - 2D localization of the electron cloud thanks to a barycenter calculation (4 outputs, one at each corner of the RAE)
  - Charge filtering of the events (discriminators)

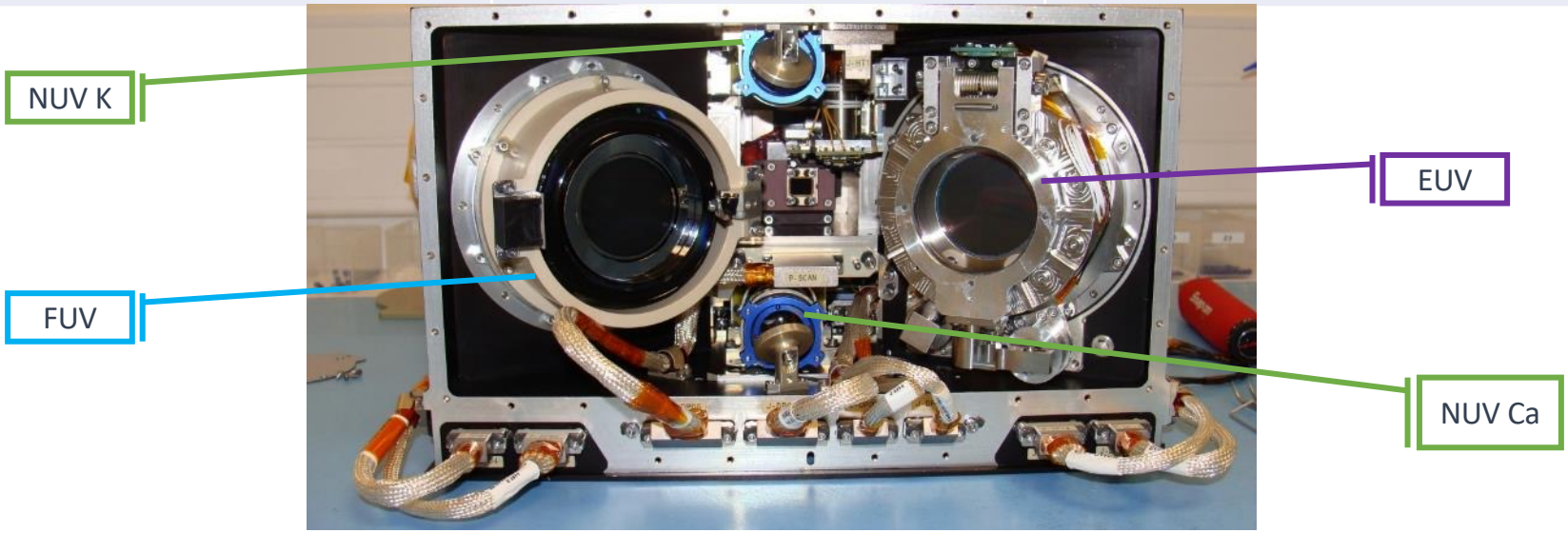




xUV detectors overview

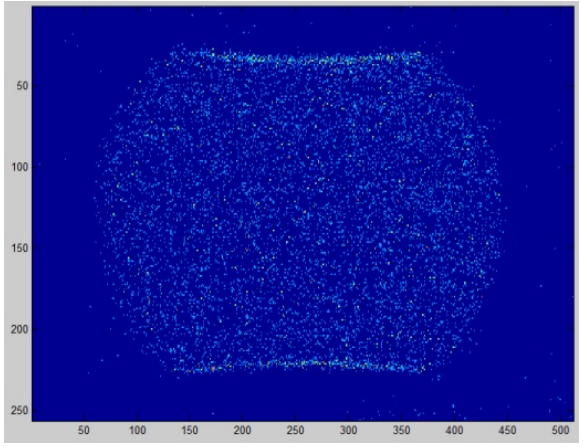
- **Main differences FUV/EUV**

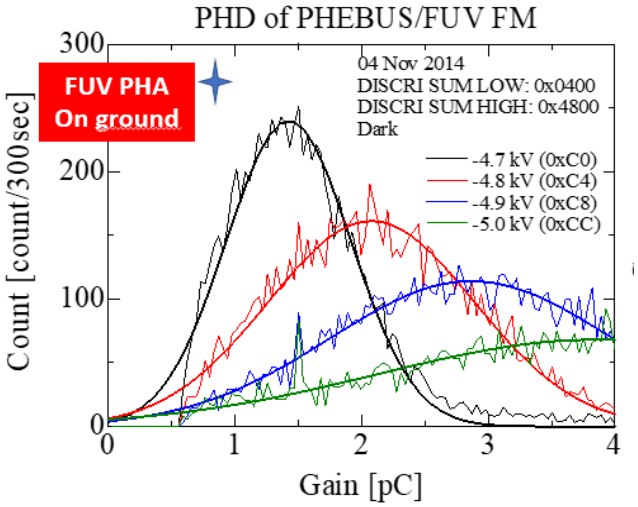
	FUV	EUV
Photocathode	CsTe (145 – 315 nm)	CsI (55 – 155 nm)
Position of the photocathode	Internal face of the MgF2 window	MCP input surface
Packaging	Sealed	Vacuum chamber, with openable window (mechanism)
Nominal HV *(as defined on ground)*	~4800V	~3600V-3700V



xUV detectors overview

- **Electronics and operating modes**
  - Each detector has its own electronics (HV, 4x Analog chain, Controller/FPGA)
  - Two operating modes:
    - IMG (left): The detector provides a 2D matrix showing the localization of the counts on the RAE
      - Localization of the events is known, but the charge level is lost → Used for science
    - PHA (right): The detector provides a Pulse Height Distribution curve for each of the four channels + sum
      - The charge level of the event is known, but the localization is lost → Used for test/diagnosis
    - + « Test » mode (simulated pulse injection) → Electronics chain testing





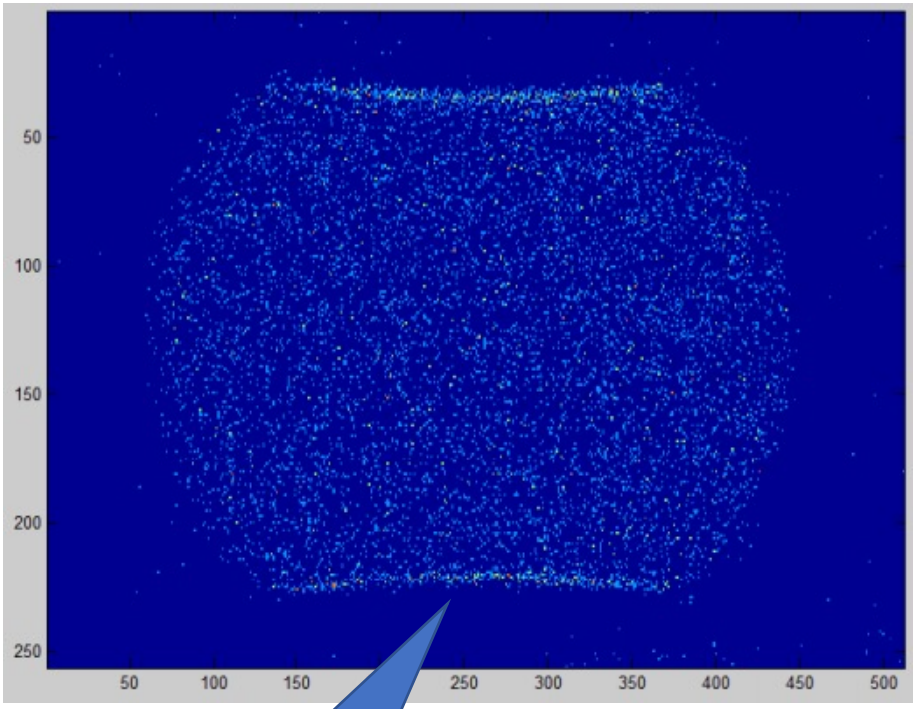
FUV Anomaly

- **During the commissioning of the detectors with HV ON (May 2019) the FUV have shown a high level of noise.**
  - Dark count : 100 to 1000 times higher than on ground
  - Spatial distribution of the counts is not homogeneous
  - Noise increase → resolution degraded (barycentre calculation)
  - High count rate → limited lifetime
  - Behaviour of the detector is stable since 2019
    - Something happened between Oct18 and May19
  - Root cause not understood (radiations, electrostatic effect, internal outgassing, …)

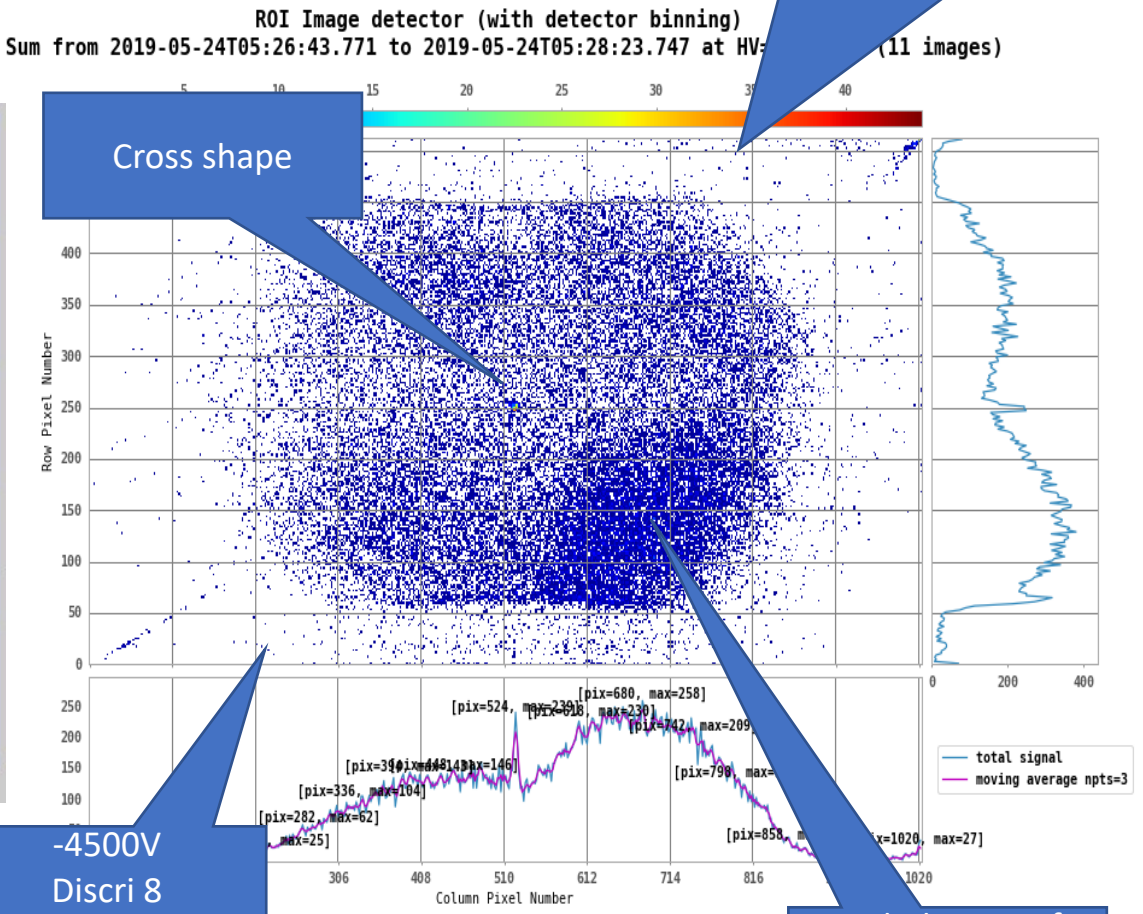
FUV Anomaly

- **IMG :**

Counts revealed out of the nominal area : indicates a high count rate (position calculated while mixing several events) → Upstream the Electronics



-4800V
Discri 8
305s exposure



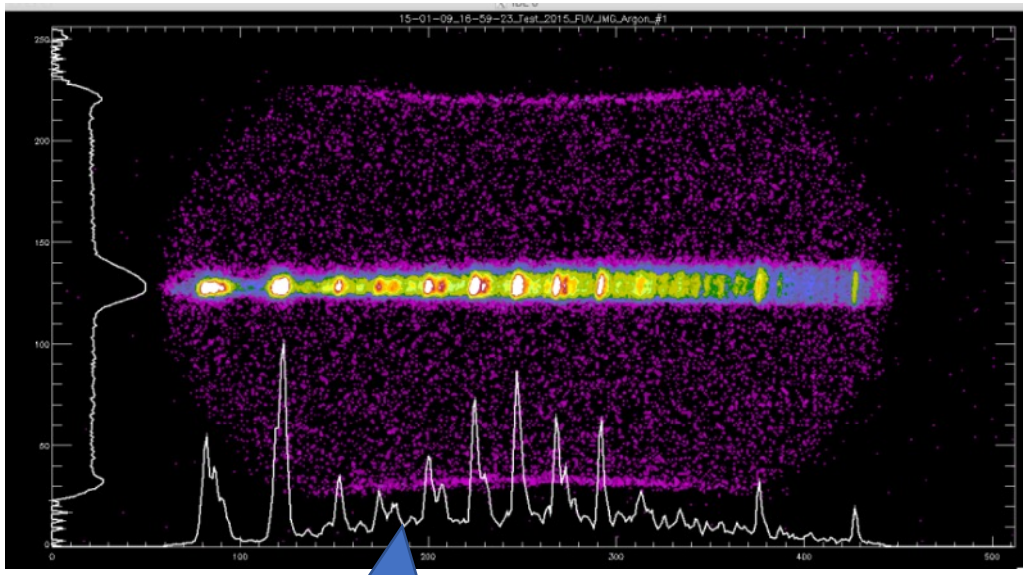
Cross shape

-4500V
Discri 8
55s exposure

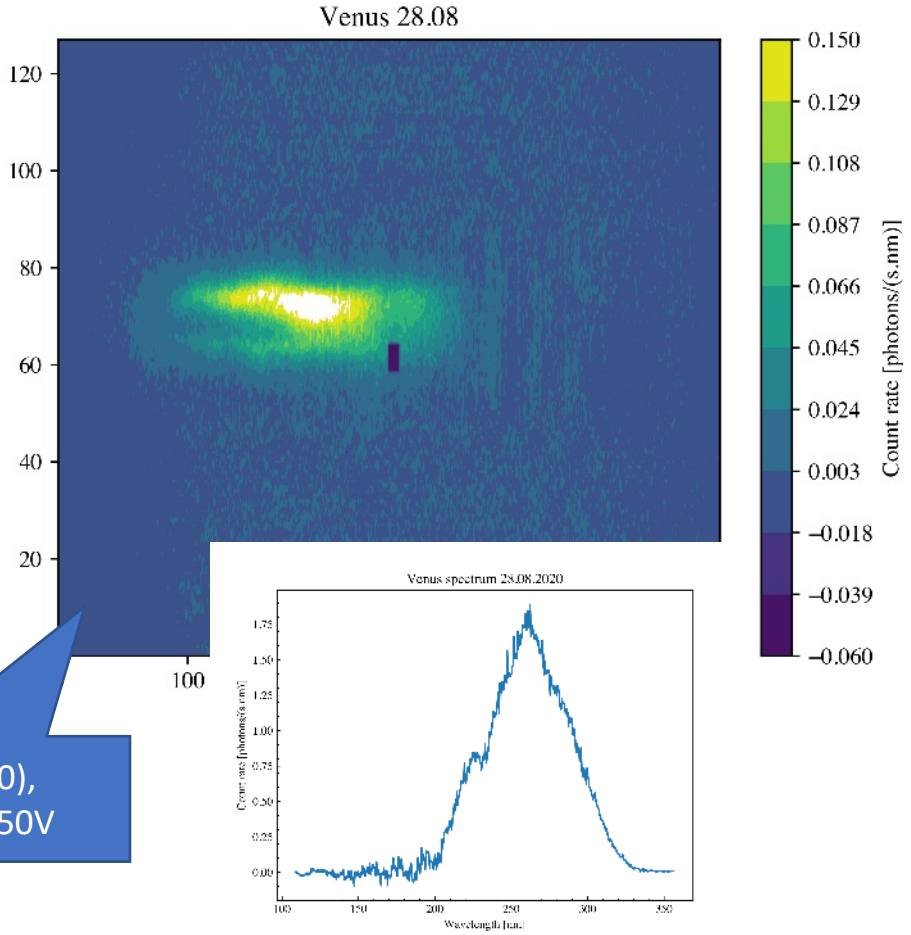
High density of counts in this corner

FUV Anomaly

- **Resolution :**



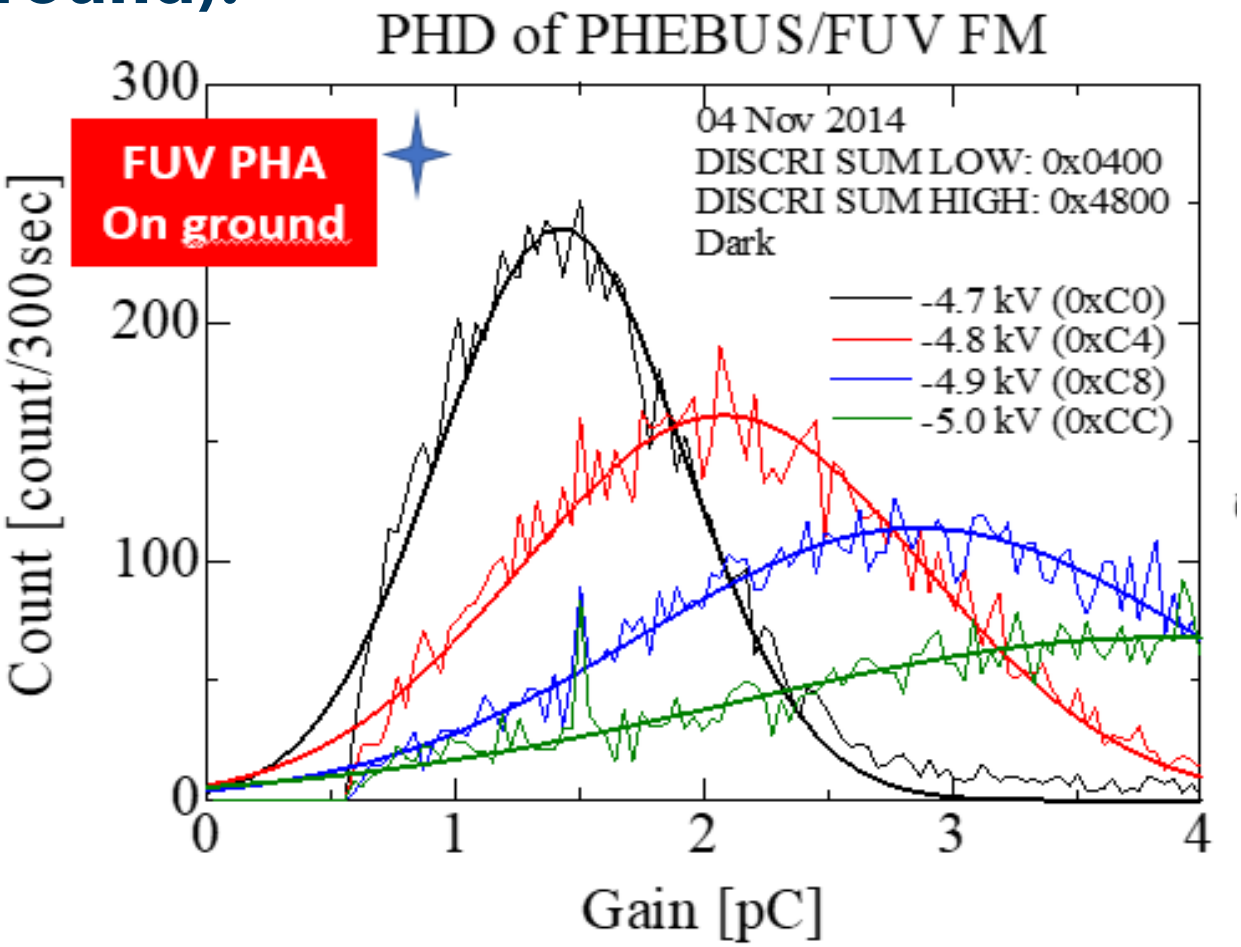
Argon spectrum
(2015, ground calibration)
Res : 1,6-1,7 nm (FWHM)



Venus (28/08/2020),
Res. : ~30 nm @ 4550V

FUV Anomaly

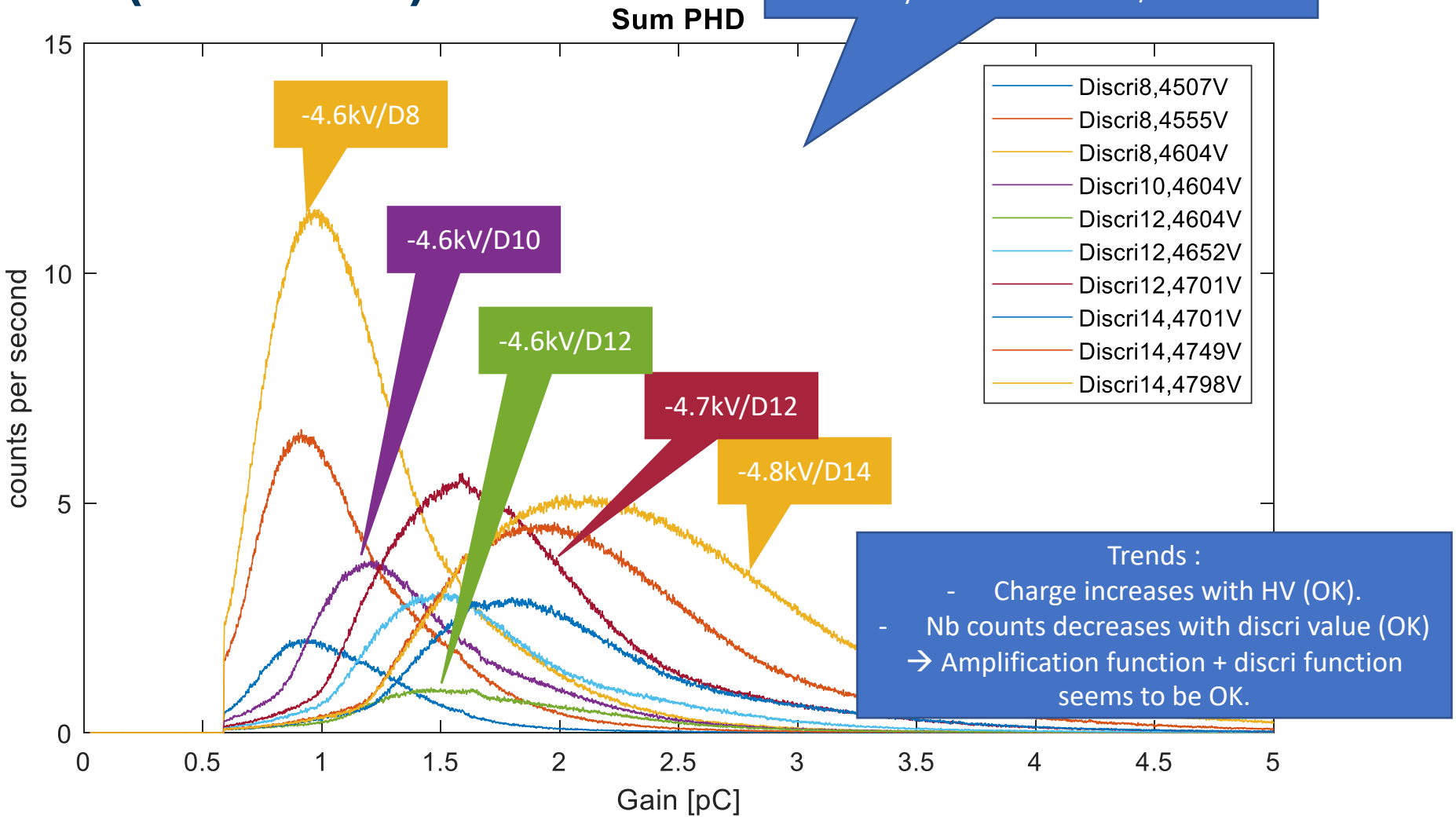
- **PHA (ground):**



FUV Anomaly

« PHA vs. HV vs. Discri » test. Need to increase the « discri value » while increasing the HV setpoint to avoid getting too many counts on the RAE/Electronics

- **PHA (June 2021) :**



Trends :
- Charge increases with HV (OK).
- Nb counts decreases with discri value (OK)

→ Amplification function + discri function seems to be OK.

FUV Anomaly

- **Possible causes**

Hypothesis	Comment/status
Radiation, scintillation of the MgF2 window	Radiation test done, does not explain the current situation
Electrostatic charging	A test has been done on the FS up to -2kV dc. The detector is not sensitive to this.
Internal contamination	Could explain the high count rate. Difficult to investigate, low probability : Contamination from where ?
HV converter malfunction	Not compatible with observations (gain changes with HV, relevant charge levels)
Voltage divider malfunction	Not compatible with observations (gain changes with HV, relevant charge levels)
Analog chain malfunction	Internal tests shown normal behaviour of the electronics and analog chain
Discriminators malfunction	Not really compatible with observation. First attempt of in-flight extensive testing failed (commanding issues). Dedicated test will be part of the next checkout.

FUV Anomaly

- **What has been tried to improve performances :**
  - « Play » with the Discri values
    - The idea : If the noise corresponds to counts having a low charge (which is usually the case), increasing the discriminators thresholds would remove it partially.
    - Increasing the Discri value has a positive effect on the detector's performance, but does not allow recovering the expected performances.
    - « Optimum setpoint » : ~4.8kV/Discri14
  - « Play » with the discri mode (« or »/« and »)
    - The idea : The « AND » mode selects only the events that are « seen » by all four channels of the RAE, while the « OR » mode (usually used) selects the events if at least one channel sees it.
    - On the paper, using the « AND » mode can improve the SNR at the center of the detector. But after having tested it, this option is not considered anymore (useful area significantly reduced).

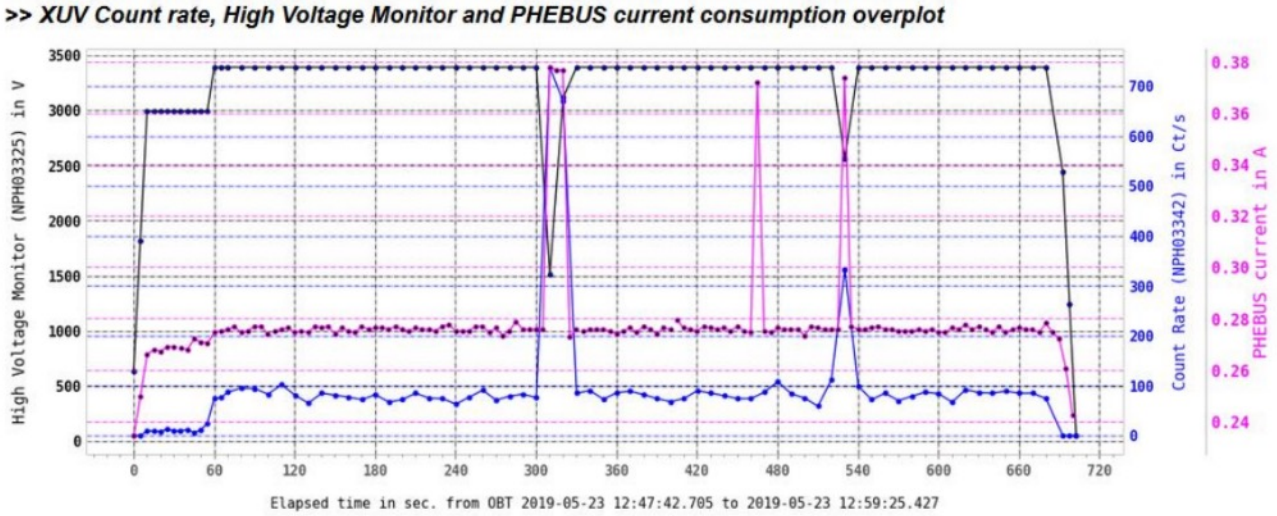
FUV Anomaly

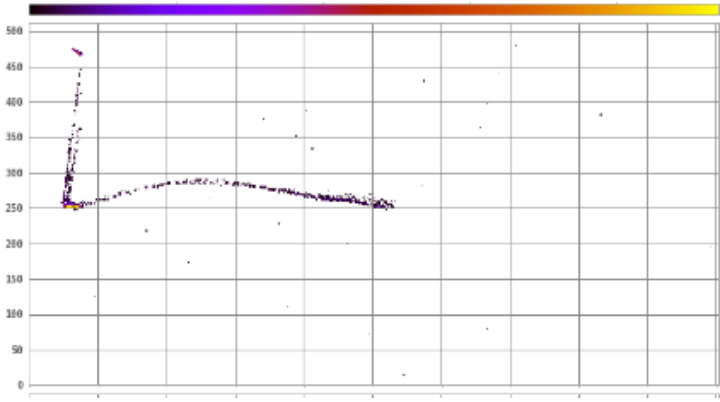
- **Conclusion/Plan**
  - Not so many hypotheses or things to investigate…
  - It would worse it processing/analysing again the PHA vs HV data acquired in flight (sum and channel data) + comparison with FS.
  - Discri test in flight should be part of the next checkout

EUV Anomaly

- **During the commissioning of the detectors with HV ON (in May 2019) an « event » occured during a HV ramp on the EUV detector, showing simultaneously :**
  - Count rate increase
  - PHEBUS primary current increase (monitored by the S/C)
  - HV drop
  - + image acquired showing a specific pattern (« trail »)

Discharge/avalanche ?





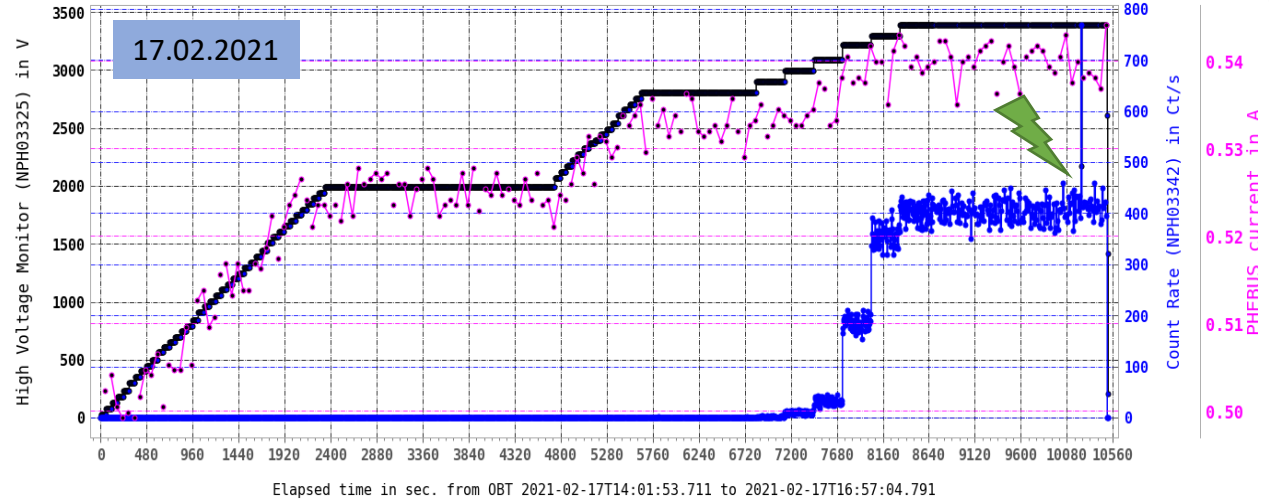
EUV Anomaly

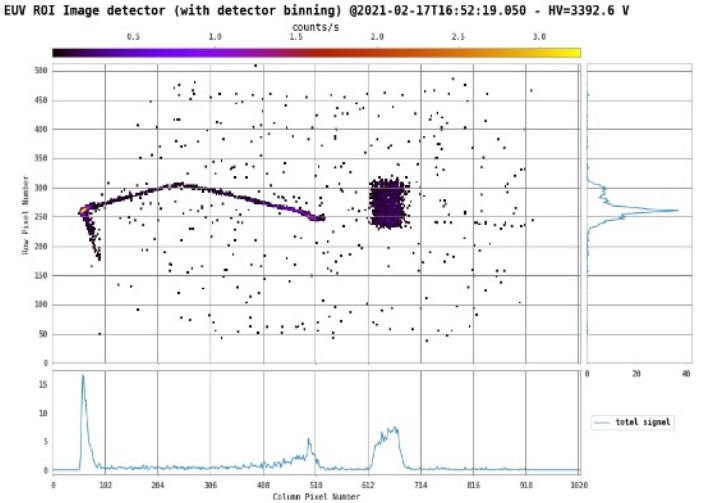
- **Some general comments :**
  - 11 occurrences since May 2019 (barely 50% of the observations)
  - The symptoms are ~stable (CR, primary current, HV monitoring, images)
    - No clue in the others HKs (voltages, temperatures)
  - The conditions under which the even occurs are not yet fully understood
    - -2,5 kV to -3,4 kV
    - With or without outgassing prior observation (usually few days before)
    - Within a quite large range of temperature (MCP : -6°C to +22°C / Elec : -6°C to +36°C)
    - In counting regime (> |-2,8 kV|) or not
    - In observation mode or during the HV ramp
  - Typical duration of an event : few tenths of seconds (10 – 70 s)
  - The occurrence of the event does not damage the detector (except possible stress)
  - After an occurrence, the detector recovers and science continues as if nothing had happened (no idea about a possible repetition rate)
  - No degradation seen on the sensitivity of the detector (i.e. no hot spot nor cold spot)

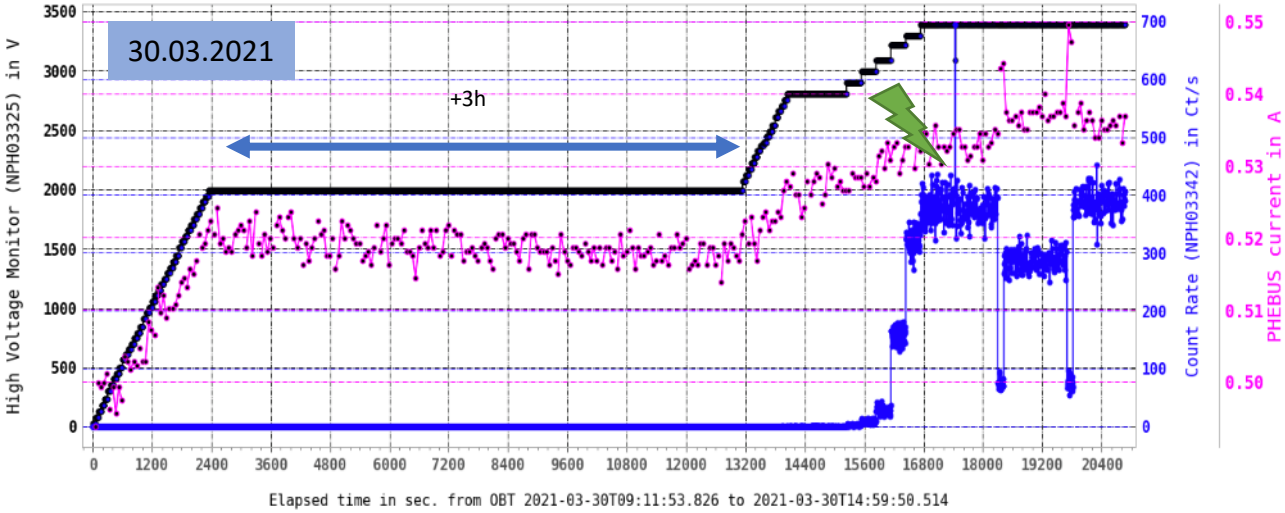
EUV Anomaly

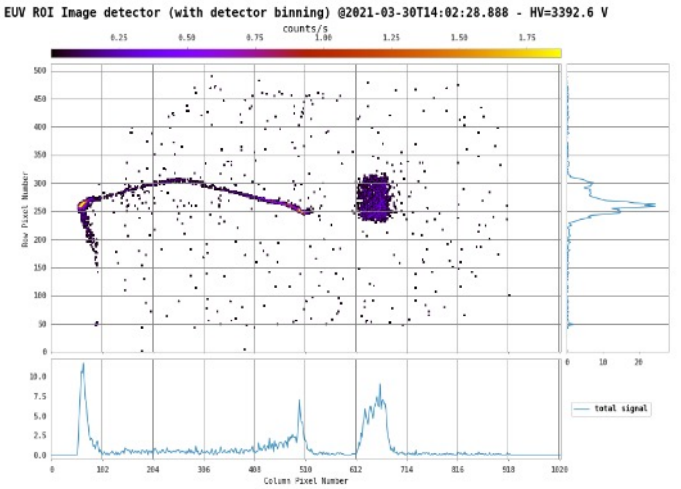
	Context			Conditions at the time of the event				
	Date	**Activity**	**HV ramp**	**Duration after Switch ON**	**HV**	**MCP Temp.**	**Electronics Temp.**	**Counting regime ?**
#1	23/05/2019	NECP3	Fast (1 min)	5 min	3.4 kV	~-0.5 °C	~+2°C	Yes
#2	29/08/2019	NECP4	Fast (1 min)	0 min	Pendant la rampe	~-6°C	~-6°C	Yes
#3	16/03/2020	Rallumage EUV	Very slow (5h)	5 h	3,15 kV	~+14°C	~+29°C	Yes
#4	17/03/2020	Observation MuSco	Slow (1 h)	50 min	2,5 kV	~+2°C	~+13°C	Non
#5	17/03/2020	Observation fond IP	15 min	10-15 min	2,9 kV	~+4°C	~+13°C	Yes (on the edge)
#6	17/02/2021	Observation Venus	Slow (2h40)	3 h	3.4 kV	~+19°C	~+33°C	Yes
#7	30/03/2021	Observation cône He	Very slow (5h40)	4,5 h	3.4 kV	~+22°C	~+36°C	Yes
#8	25/06/2021	Observation BetaCanis Major / IPB	~30-40 min	~1h	3.4 kV	~+7°C	~+21°C	Yes
#9	10/08/2021	Observation Venus	~30-40 min	~1h	3.4 kV	~+8°C	~+22C	Yes
#10	01/10/2021	Mercury Fly By	~30-40 min	~30 min	3.3 kV	~+9°C	~+21C	Yes
#11	09/10/2021	Mercury/Venus	~30-40 min	~25 min	2.7 kV	~+13°C	~+23C	Yes (on the edge)

EUV Anomaly


17.02.2021
High Voltage Monitor (NPH03325) in V
Count Rate (NPH03342) in Ct/s
PHEBUS current in A
Elapsed time in sec. from OBT 2021-02-17T14:01:53.711 to 2021-02-17T16:57:04.791


EUV ROI Image detector (with detector binning) @2021-02-17T16:52:19.050 - HV=3392.6 V
counts/s
Row Pixel Number
Column Pixel Number
total signal

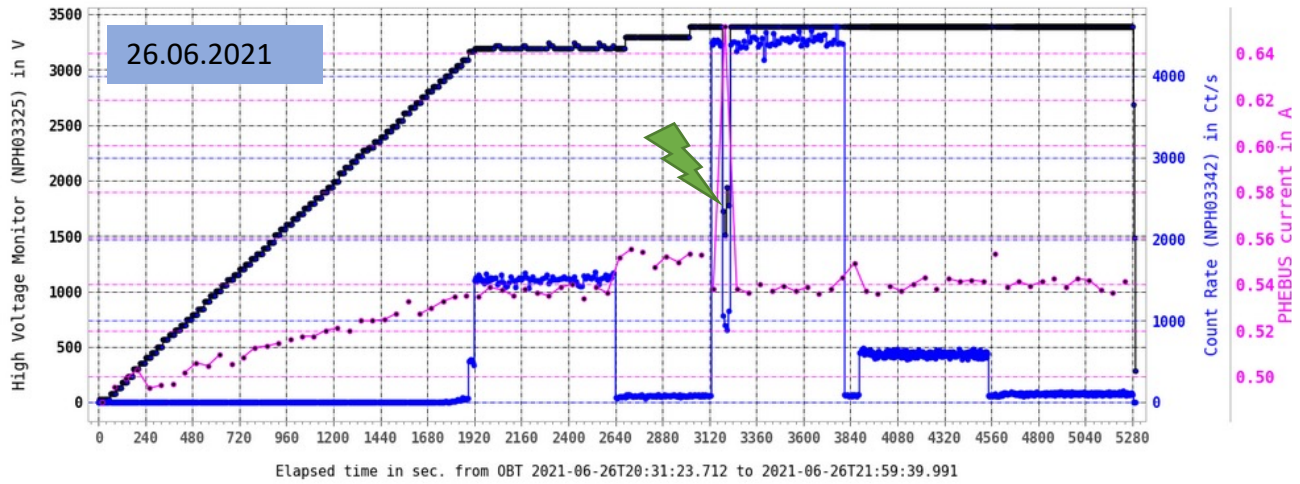

30.03.2021
+3h
High Voltage Monitor (NPH03325) in V
Count Rate (NPH03342) in Ct/s
PHEBUS current in A
Elapsed time in sec. from OBT 2021-03-30T09:11:53.826 to 2021-03-30T14:59:50.514

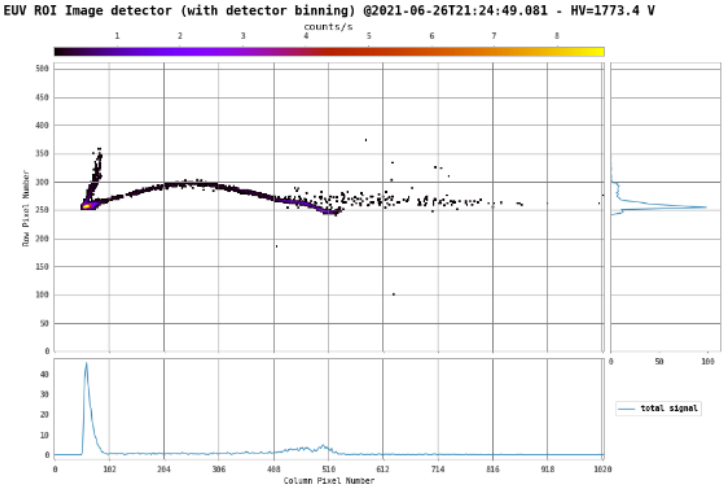

EUV ROI Image detector (with detector binning) @2021-03-30T14:02:28.888 - HV=3392.6 V
counts/s
Row Pixel Number
Column Pixel Number
total signal

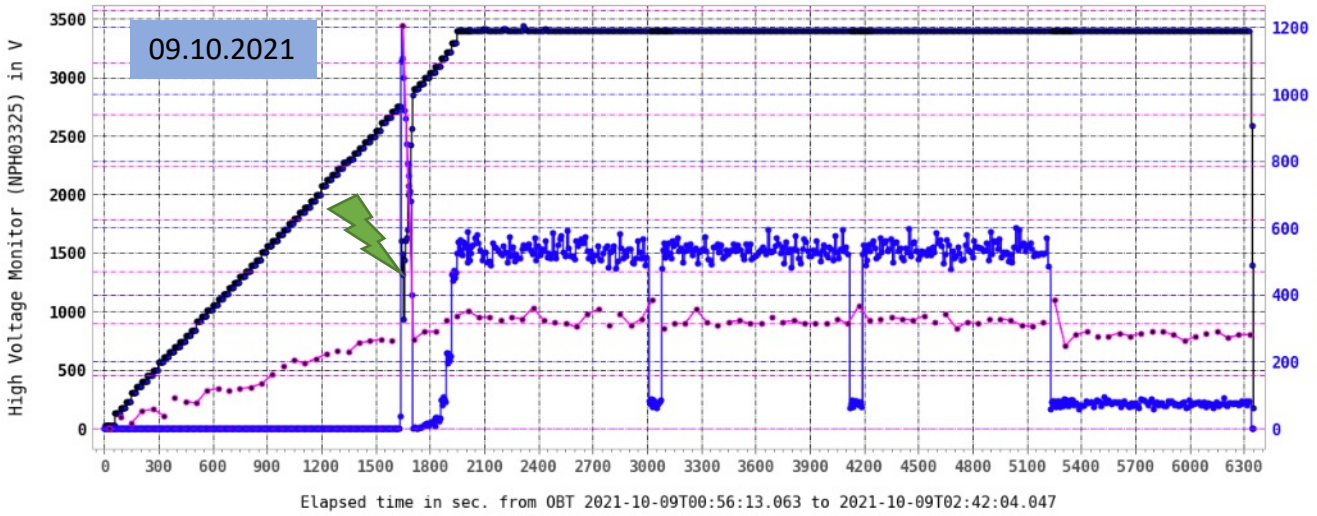
EUV Anomaly

PROBING OF HERMEAN EXOSPHERE BY ULTRAVIOLET SPECTROSCOPY

>> XUV Count rate, High Voltage Monitor and PHEBUS current consumption overplot





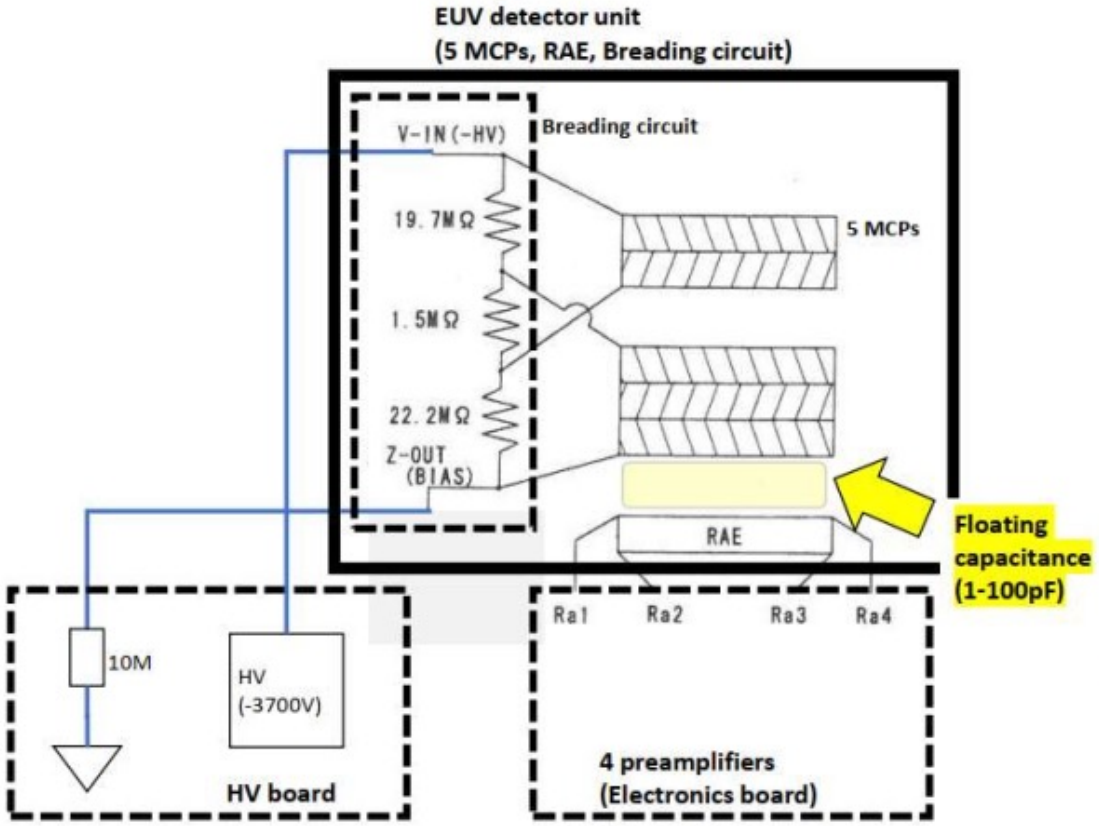


« Event setpoint »

- HV drop @1500V
- Primary current + 100mA
- CR reaches 700-1200 cps typ.
- Trail on the images (if any)

EUV Anomaly

- **How to explain the « trail » ?**
  - Parasitic capacitor between the RAE and MCP generates « ghost counts » when the HV fluctuates.
  - We know that the HV varies during the event (previous slides)
  - Currently investigating whether we can verify this by test with the EUV FS :
    - Test #1 : Direct measurement of the capacitor
    - Test #2 : Pulse injection on « Bias » while operating the detector



19

EUV Anomaly

- **Does it take place in the MCP or Electronics ?**
  - MCP exposed to the internal environment of the instrument (« optical cavity »)
  - Electronics in a separate box, vented directly into the S/C
  - No clear evidence yet, but it is more probable that the event takes place in the HV circuit (no hot/cold spot identified yet).
- **Root cause ?**
  - The main assumption since 2019 and until recently was that a HV discharge could be generated due to outgassing… But :
    - The instrument is in space for more than 3.5 years…
    - We have done several « forced outgassing » (detector ON, HV ON 1 kV for several days) without having noticed any improvement
    - Some analyses have been done showing that the sizing of the vents is OK

➢ **Now investigating around the HV electronics itself**

EUV Anomaly

- **Recent work & work in progress/plan…**
  - Electrical/thermal stress analysis for the PHEBUS main electronics (+12 V line)
    - Done, no stress identified
    - +~3 W during the event
    - It is not yet demonstrated that the increase of the primary current seen during the event is the consequence of having the HV converter in current limitation mode. → Test needed
  - Behaviour/stability of the HV converter
    - Working on a test plan to better understand the electrical (dynamic) behaviour of the PICO converter
    - Hardware available:
      - Representative HV board for any kind of test
      - EUV FS @ LATMOS for low risk test
  - Build an electrical model of the detector, including parasitic components (R, L, C)
  - Test on EUV FS
    - Inject transient voltage on last stage of the MCP, other HV terminals shorten (i.e. no electric field in the MCP)
    - → Should produce a trail on the images
  - Extended analysis of the EUV data (images, …) on going. This will provide clues on :
    - The cause of the trail (parasitic capacitor)
    - The charge drawn during the event

Thank you !

Questions ?