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EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

COS Lifetime extension update: COS2030

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October, 2020

Things to consider for Lifetime Positions

- COS FUV detector is susceptible to gain-sag.
- As the usage increases, the efficiency of converting photons into signal decreases
- This means we have to move where the spectra fall on the detector -> the “lifetime position (LP)”
- Our last LP move was to LP4 in October 2017.

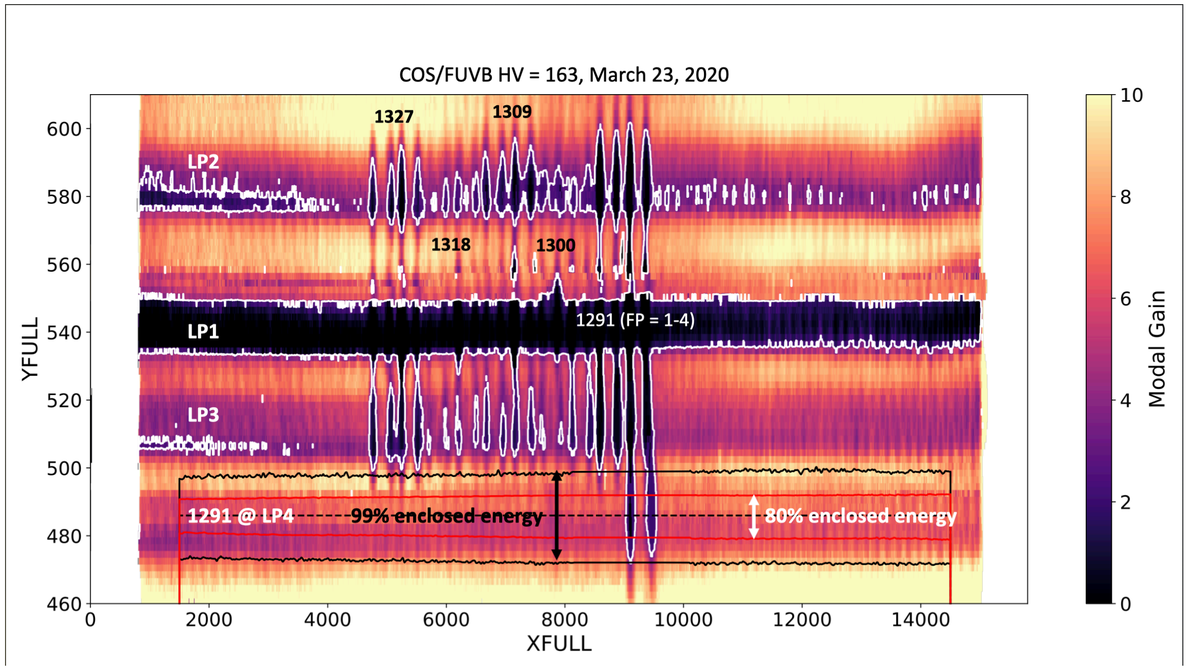
<u>When we move lifetime position, we consider:</u>

(1) Where can we go on the detector?

(2) How can we operate in that position?

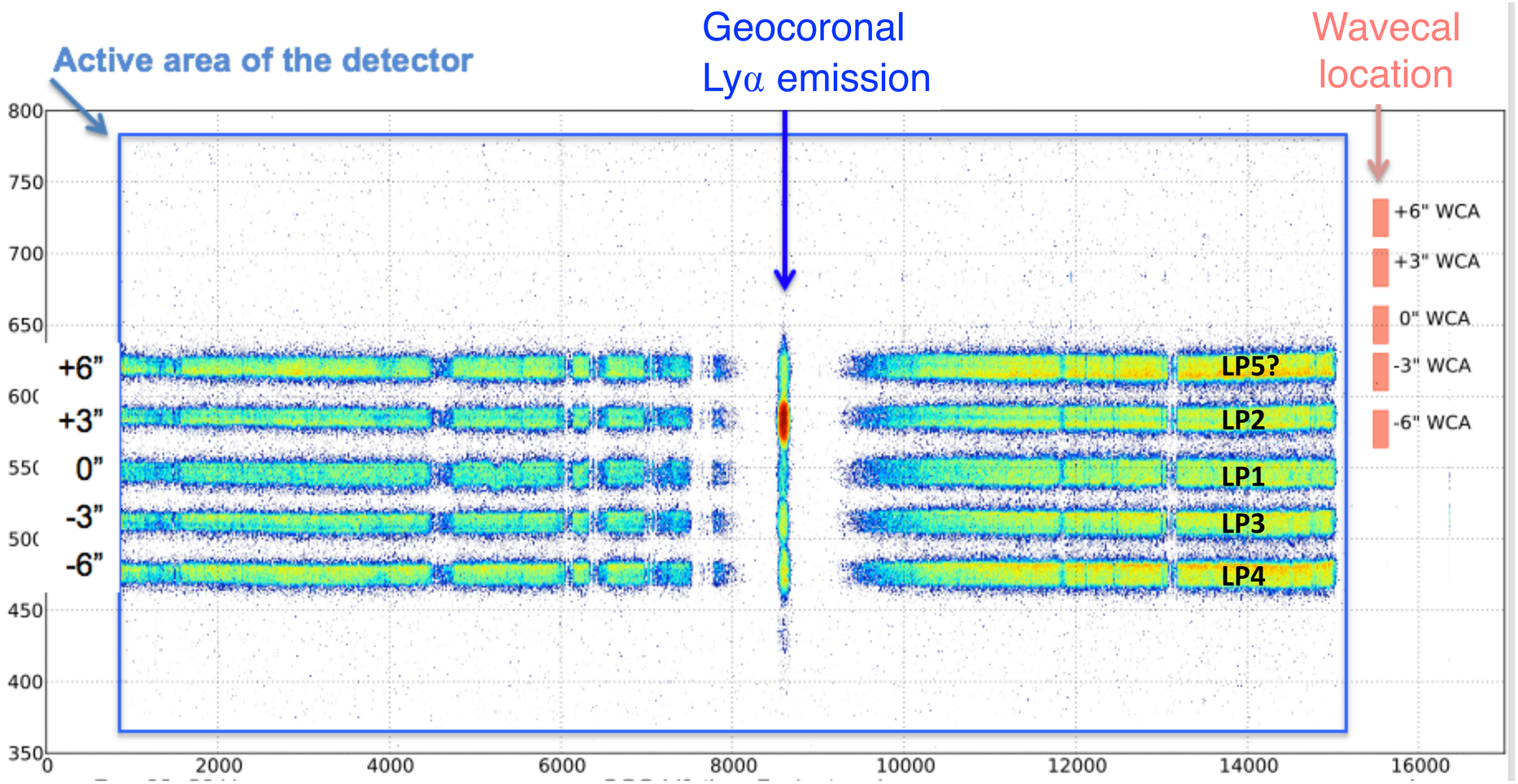
(3) What would the impact be on the user?

(4) How long can we stay in that position?



Example gain map for COS FUV detector (Segment B) showing gain-sag holes at LP1-4

Where can we go?: COS FUV Detector Lifetime Positions



- 2-D image of G130M/FUV spectra at different LPs
- Other grating settings (G160M + G140L) project at slightly different locations

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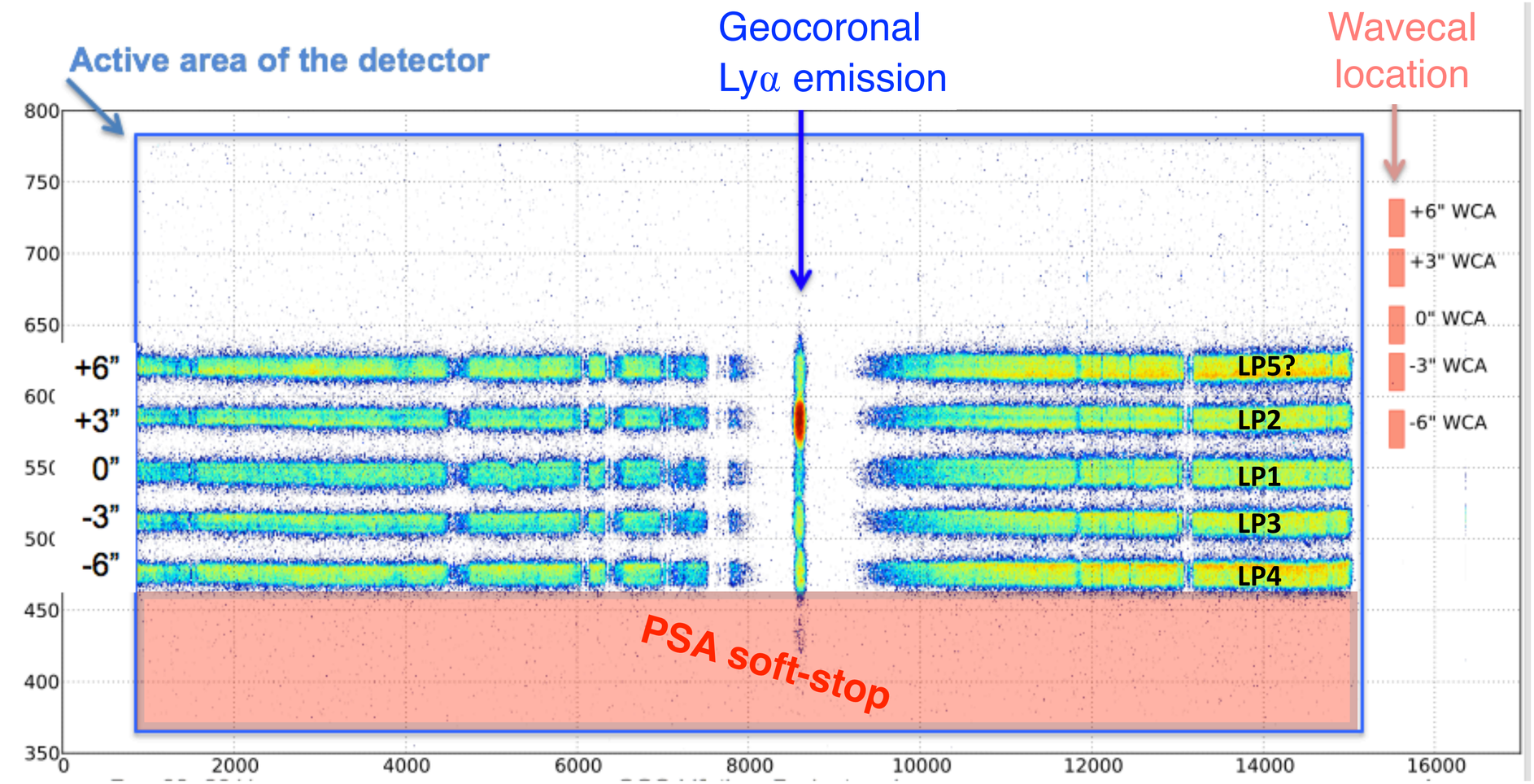

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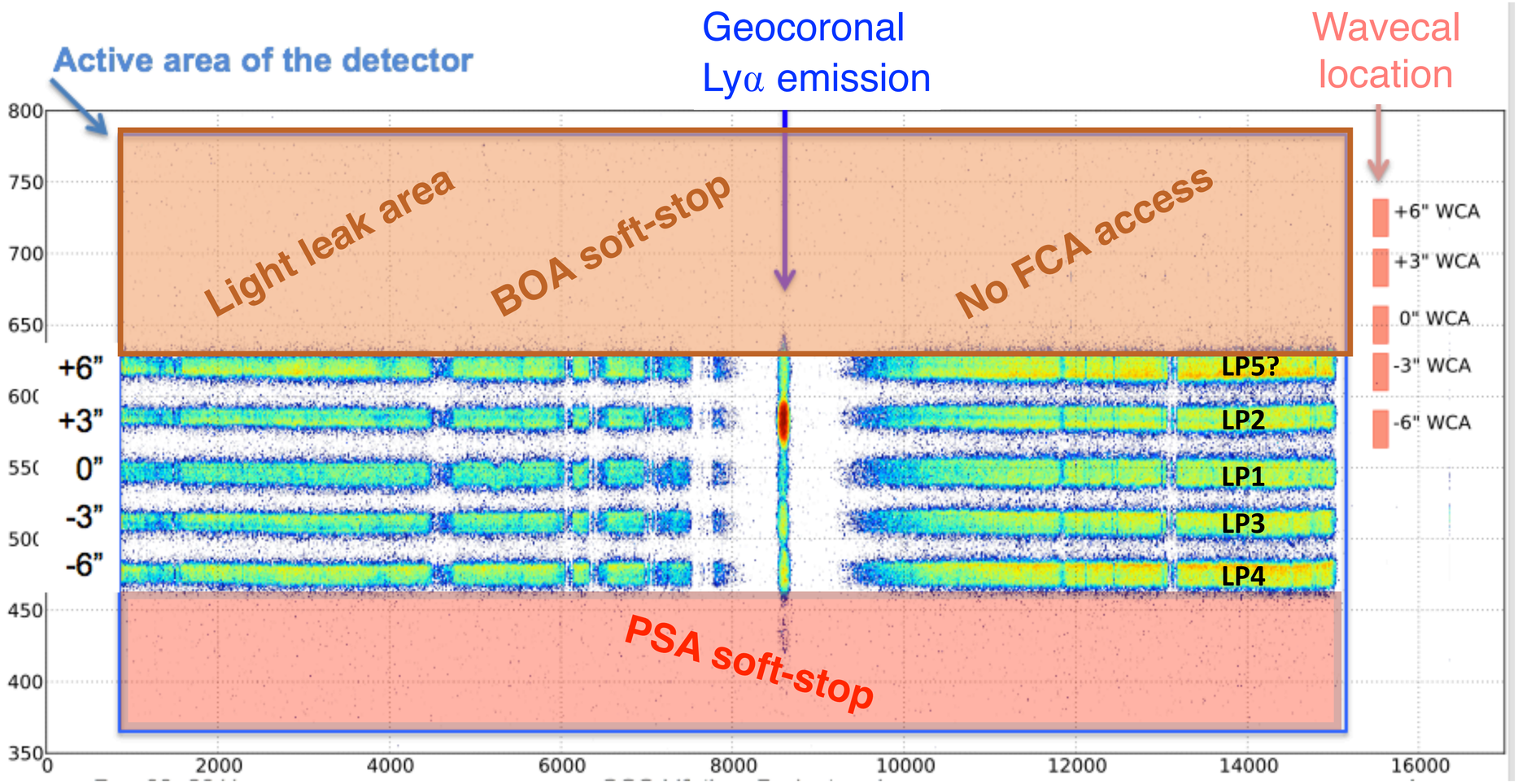

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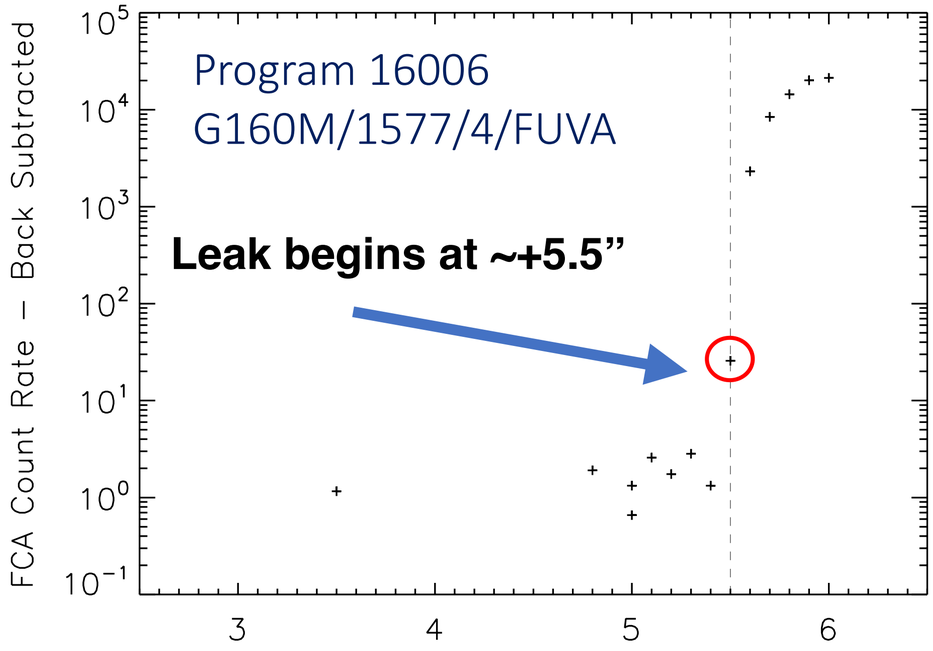
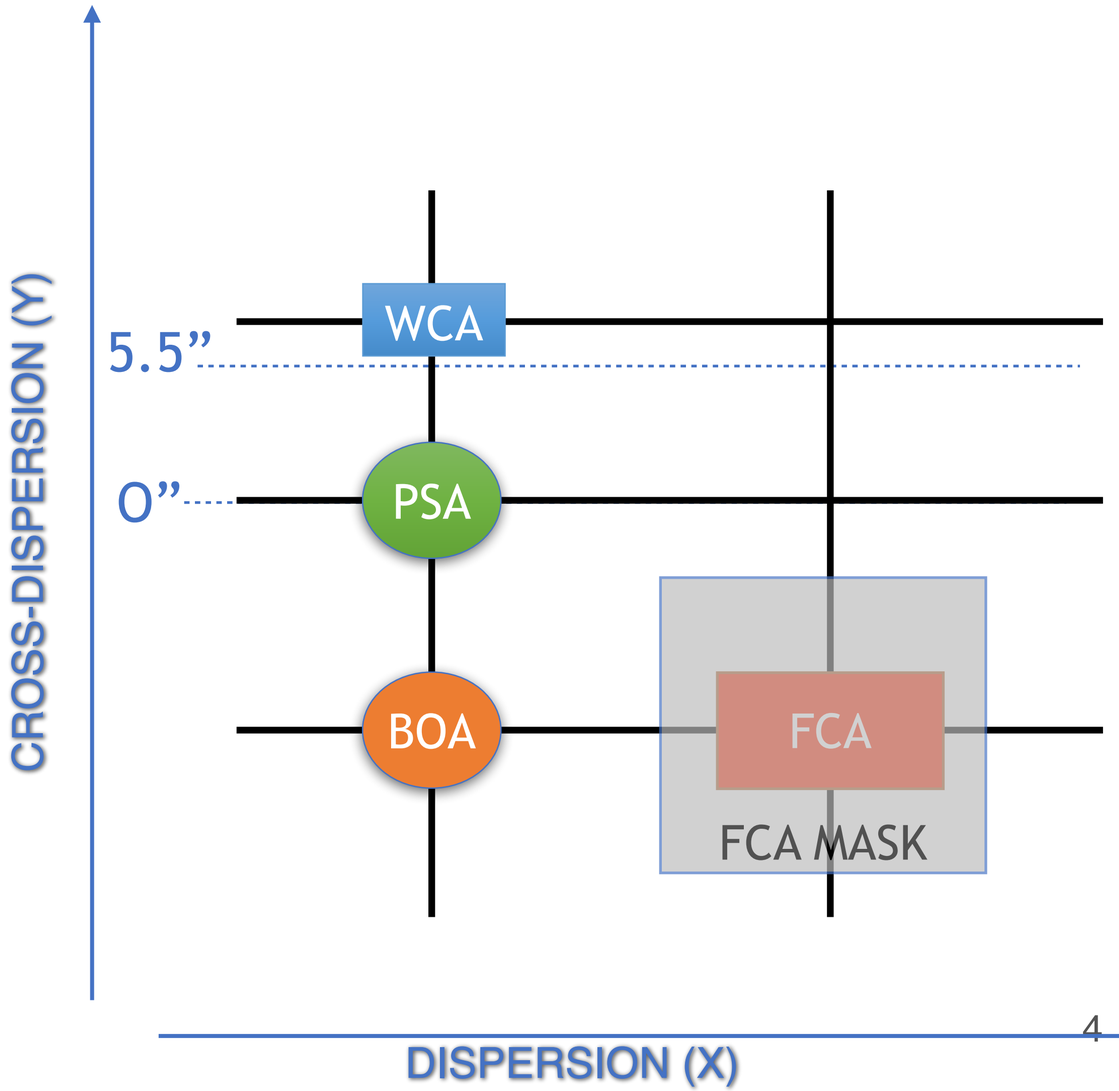
Why can't all gratings go >5.5"?: The light leak

- Light leak through FCA begins at +5.5", but +5.4" would have no light leak
- Light leak prevents science + wavecals being taken concurrently
- Program 16106 evaluated placement of LP5 at 5.4" by obtaining external data at 5.4" in G130M and G160M





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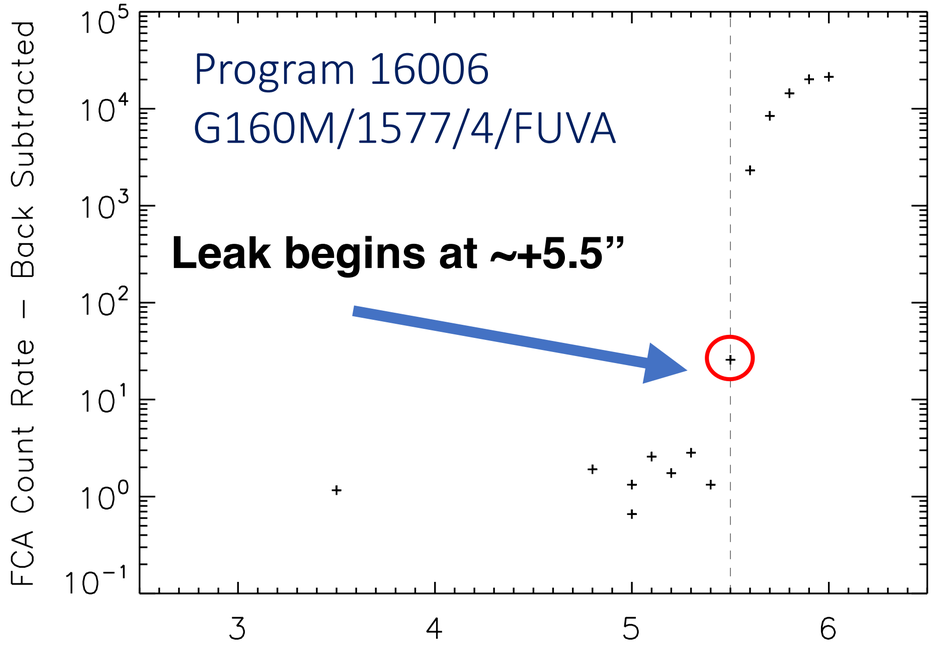

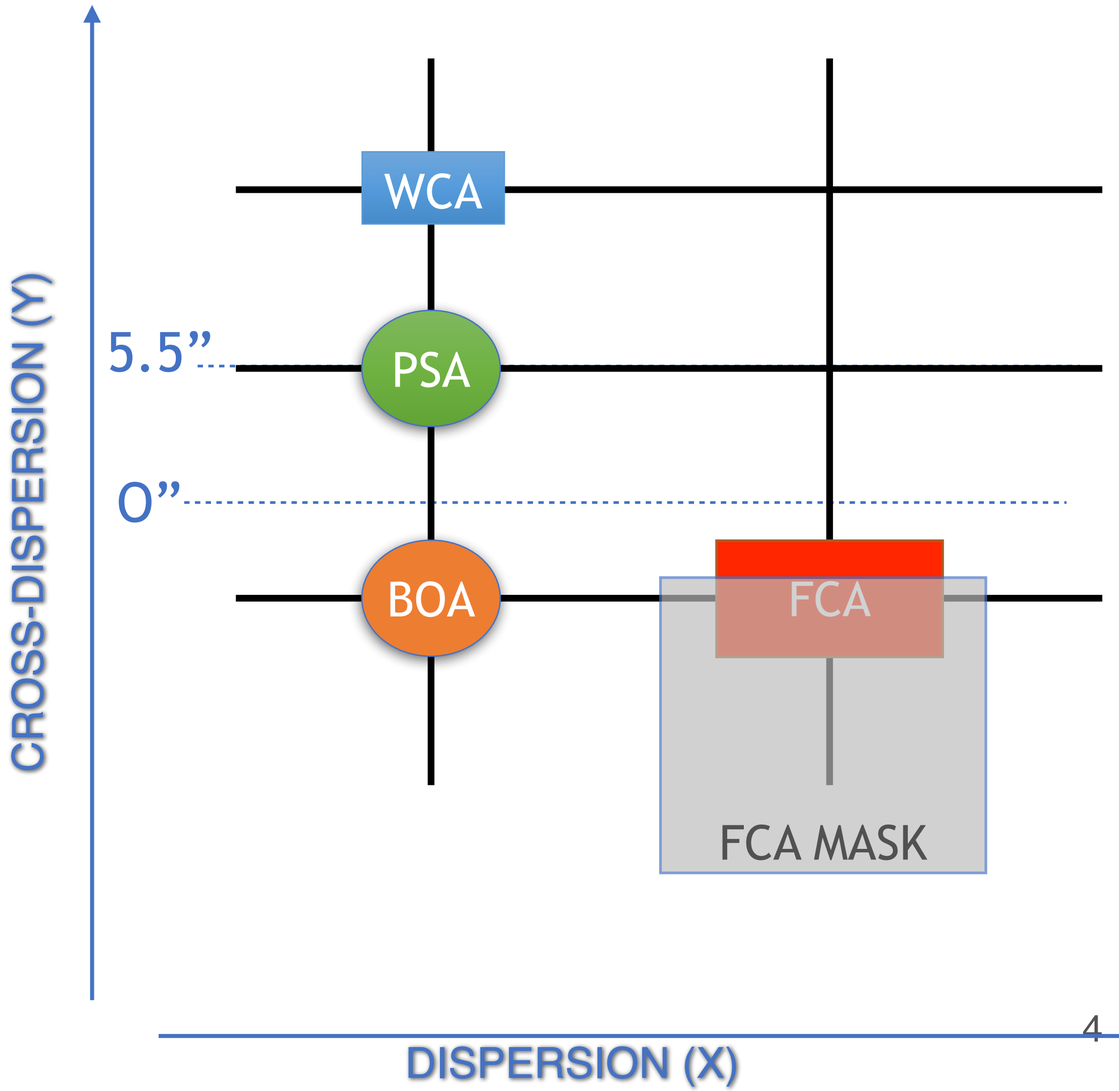

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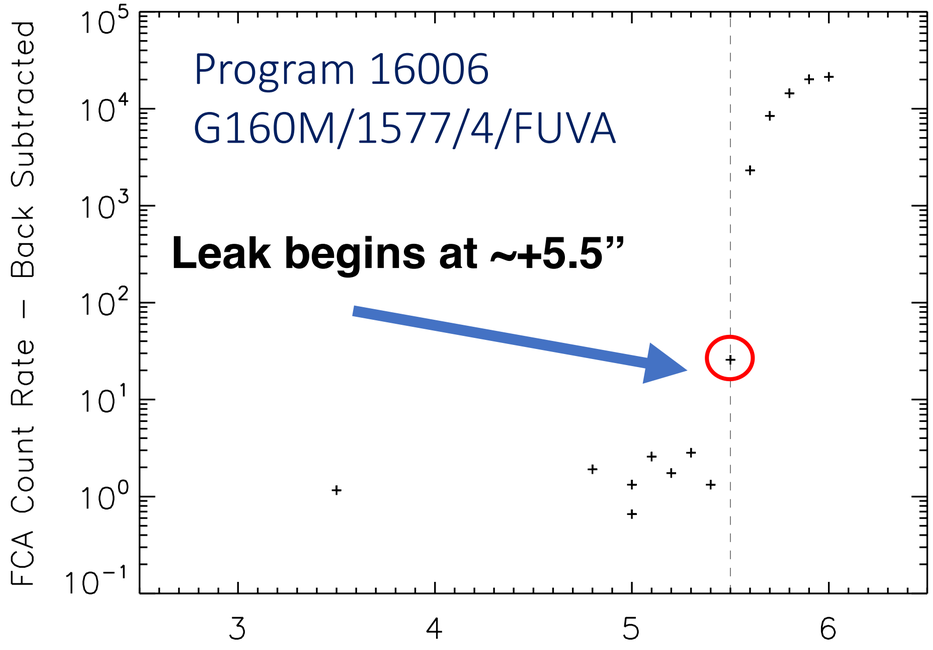
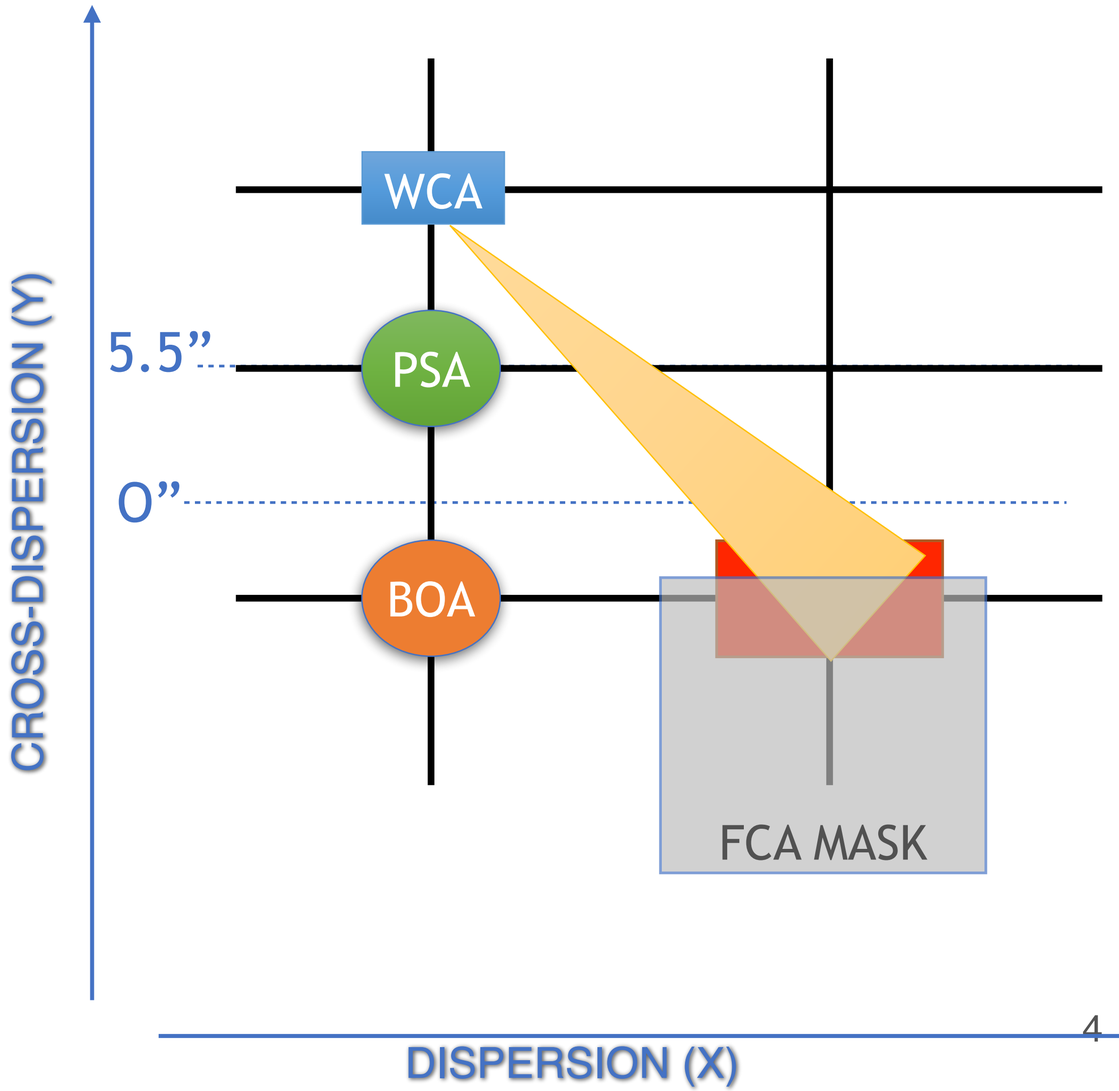
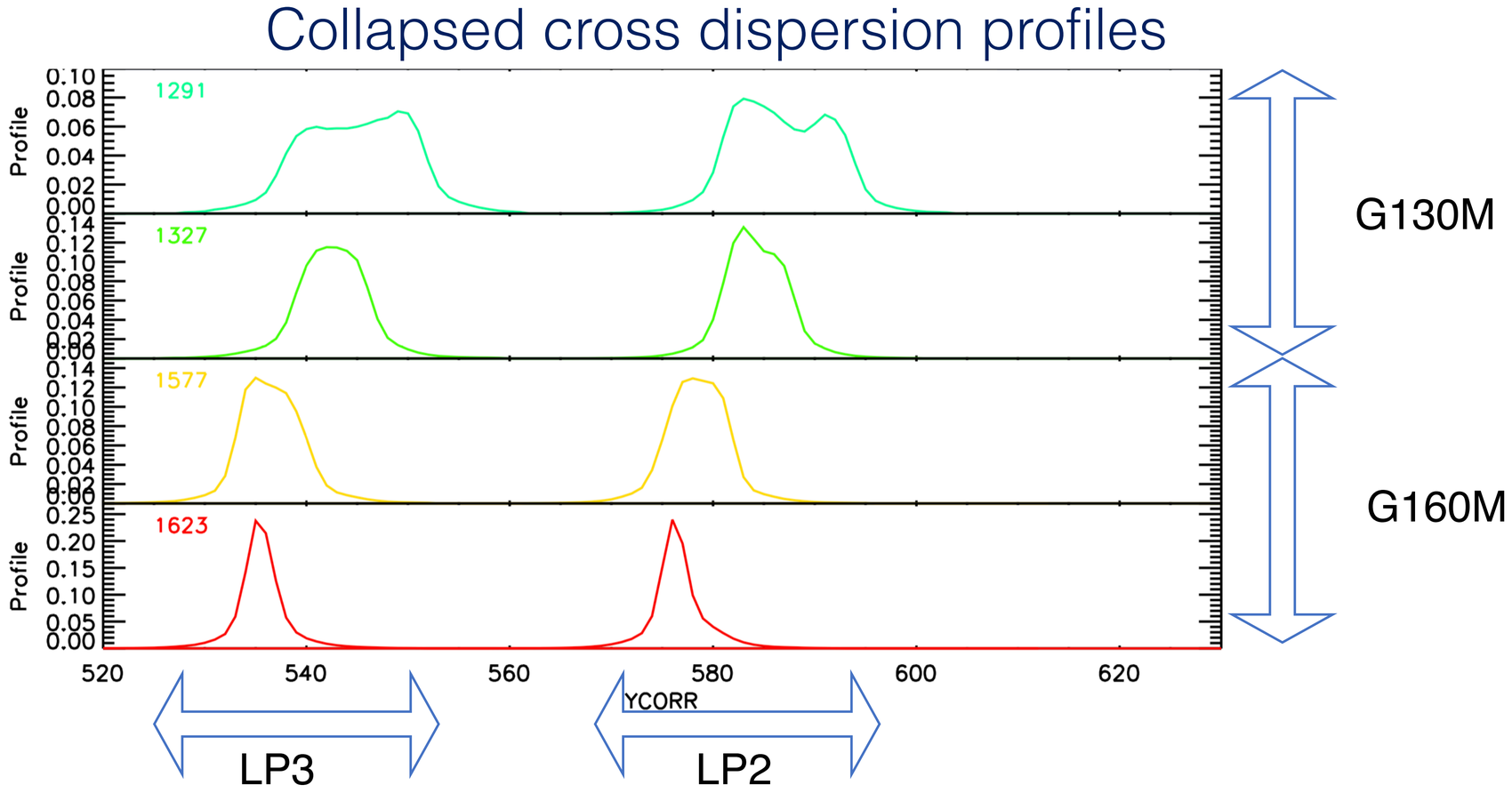




Where can we go?: G160M is lower on the detector than G130M

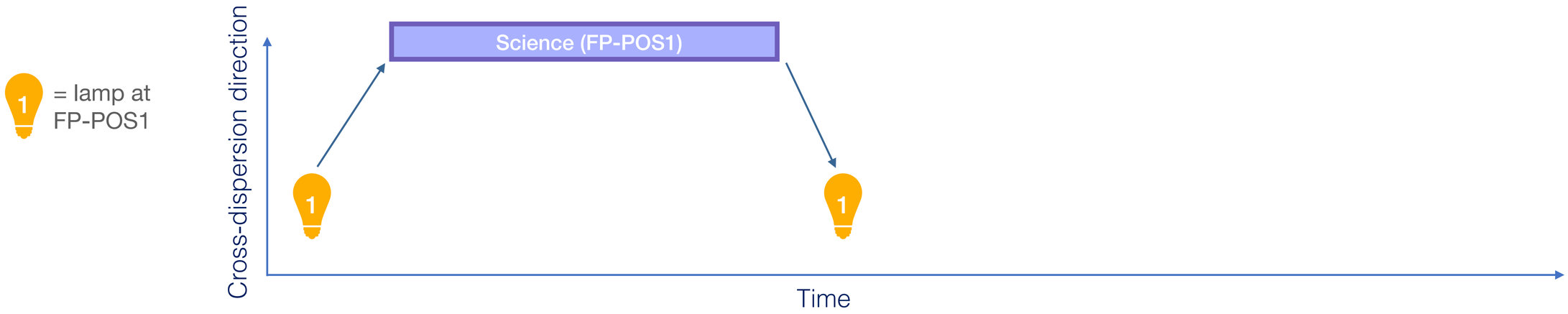


- While G130M fits at 5.4”, G160M projects lower on the detector & would overlap with gainsag from LP2
- G160M will have to be placed >5.4” – where **wavecal data cannot be taken concurrently with science data**

How can we operate at >5.5”?: LP-split Wavecals

At positions > 5.5” we cannot obtain wavecal + science at the same position due to light leak + WCA falling off the active area.

- Typical sequence: TA -> LP-split wavecal -> science @ >5.5” -> LP-split wavecal, repeat sequence per exposure



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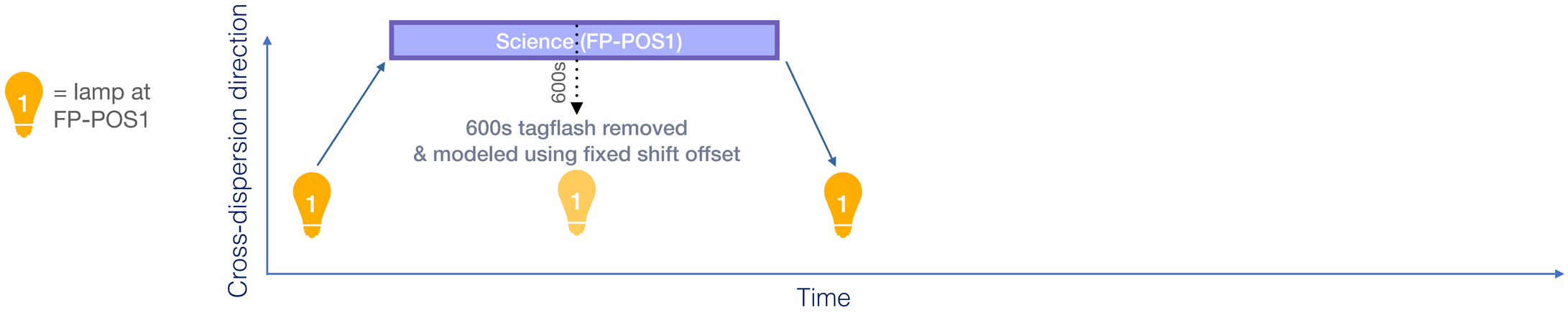

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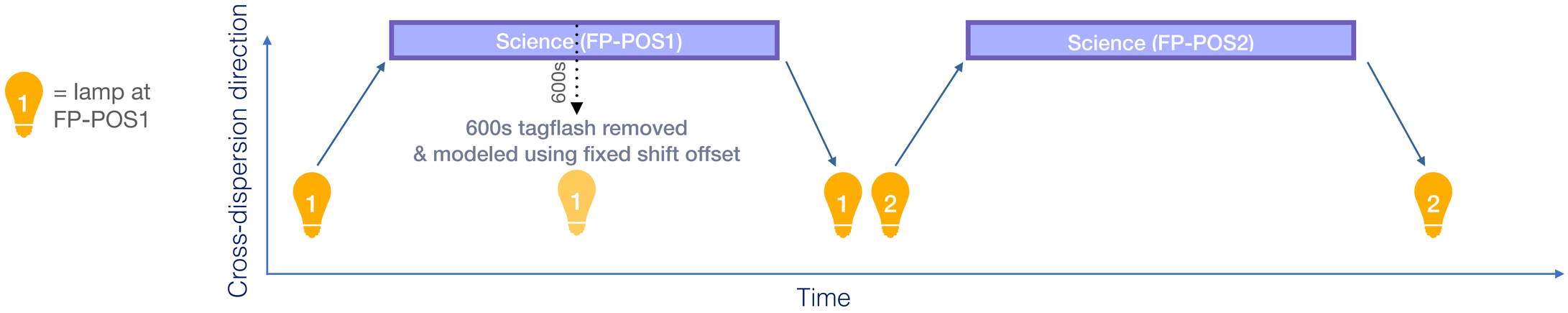

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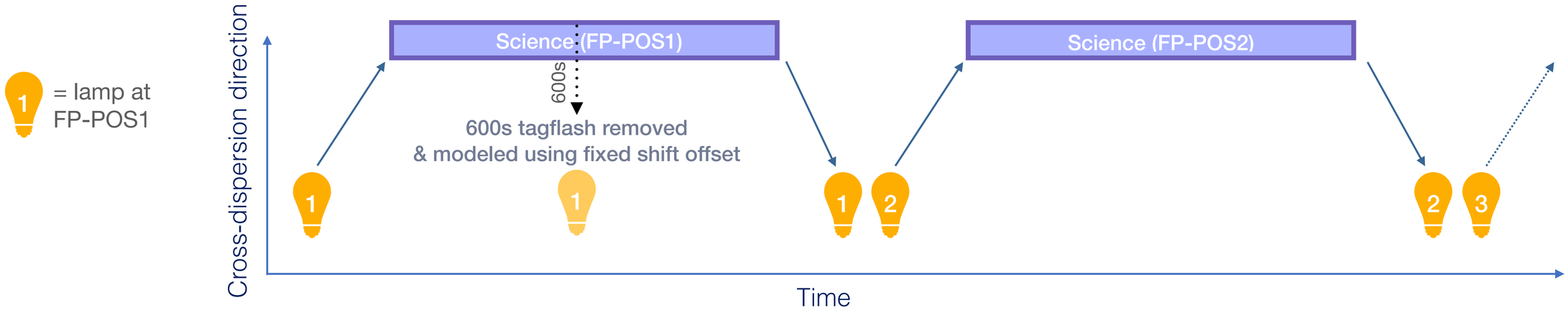

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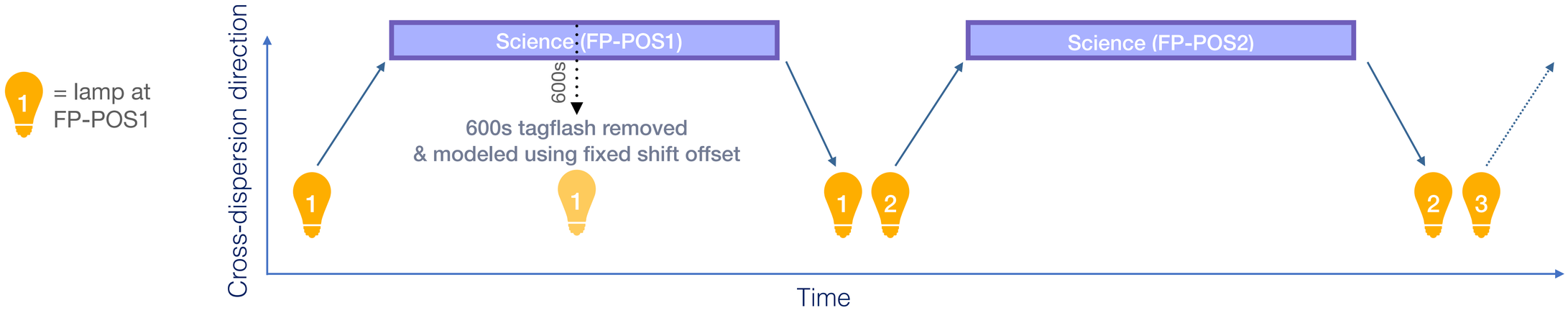

What would the impact be on the user?

Increased overheads: 20-30% increase for 3-4 exposures per orbit (no 600s wavecal)

10-15% increase for 1-2 exposures per orbit (no 600s wavecal)

➡ only G160M 1-2 exposures per orbit go to LP6

Where can we go?: Considering new possibilities

The previously defined lifetime positions were limited by two main constraints at the top of the detector:

- There is a light leak > 5.5” and wavecals have to be taken without moving the aperture block
- The PSA and BOA have to illuminate the same part of the detector for a given LP, and the BOA soft stop prevents > 6”

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When considering 6” over the last year, *we solved these issues*

- Showed aperture mechanism stable so wavecals can be taken at a different LP (LP-split wavecals)
- Wavecal light leak solved by LP-split wavecals
- Methods to reduce overheads (model 600s lampflash, reduce FP-POS requirements)
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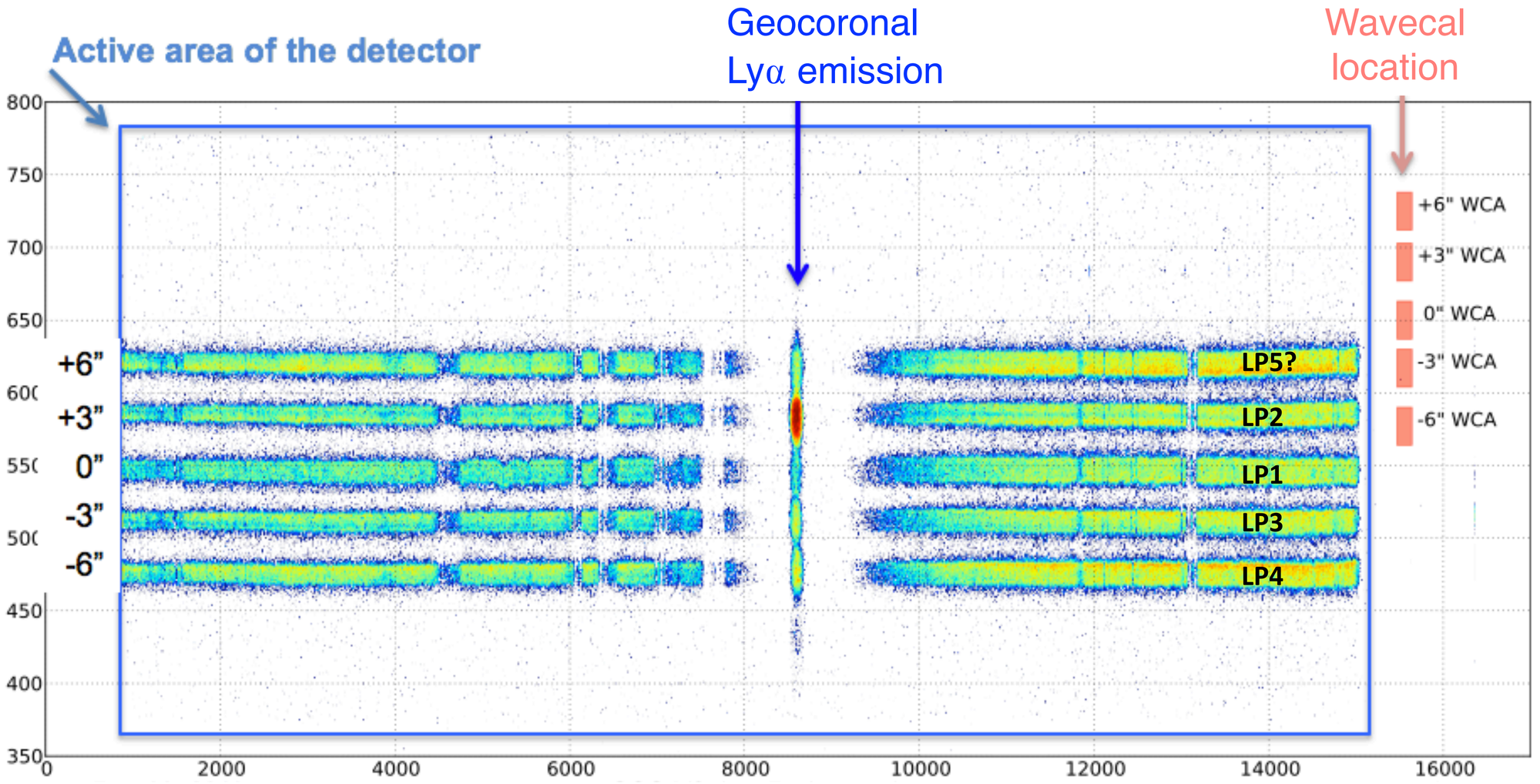
We can use more of the detector now that we solved those issues

We can also operate in a hybrid mode using multiple LPs at the same time to expand lifetime

Potential new COS FUV Detector Lifetime Positions



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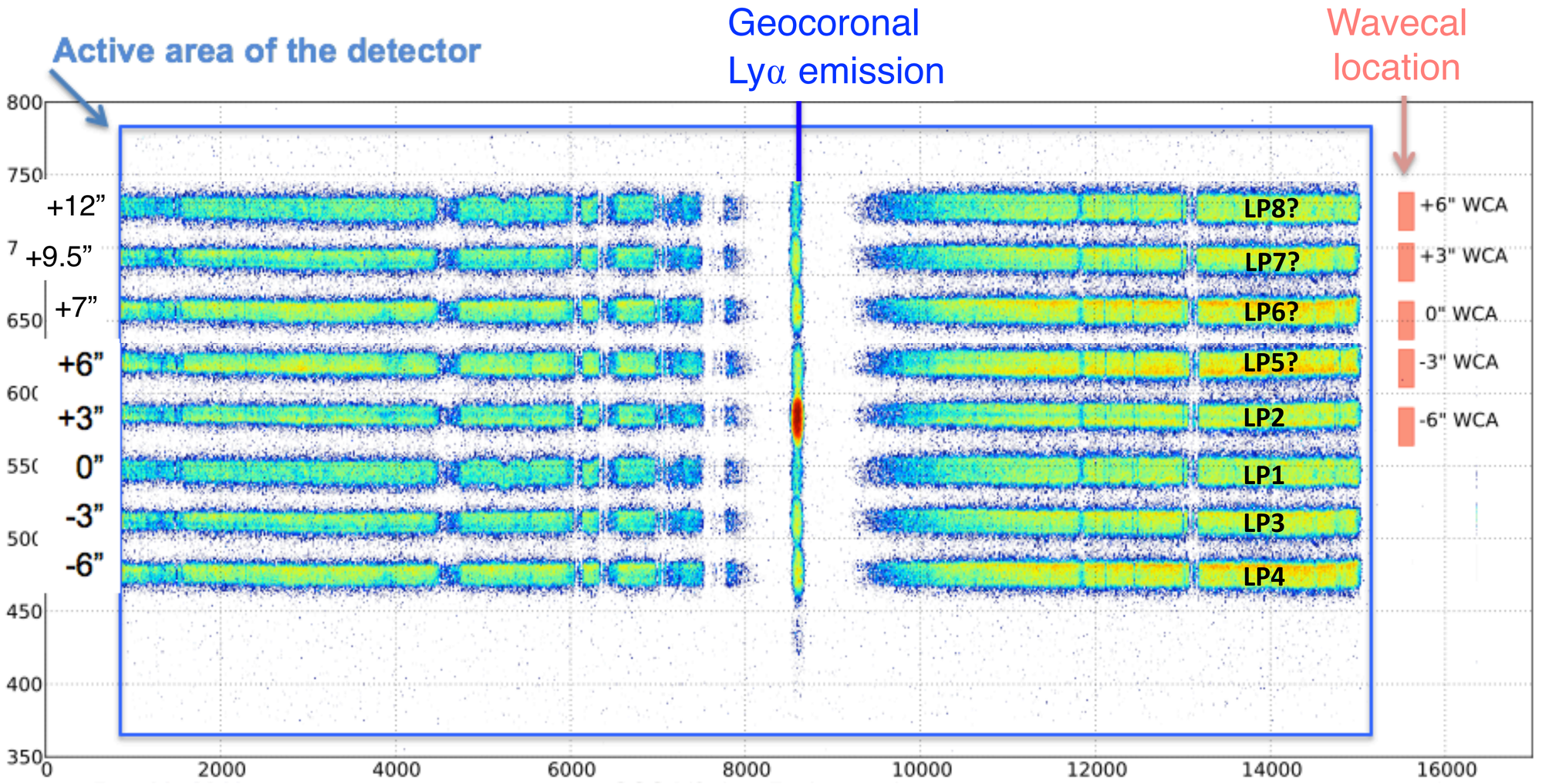

Note: Cartoon, not real data

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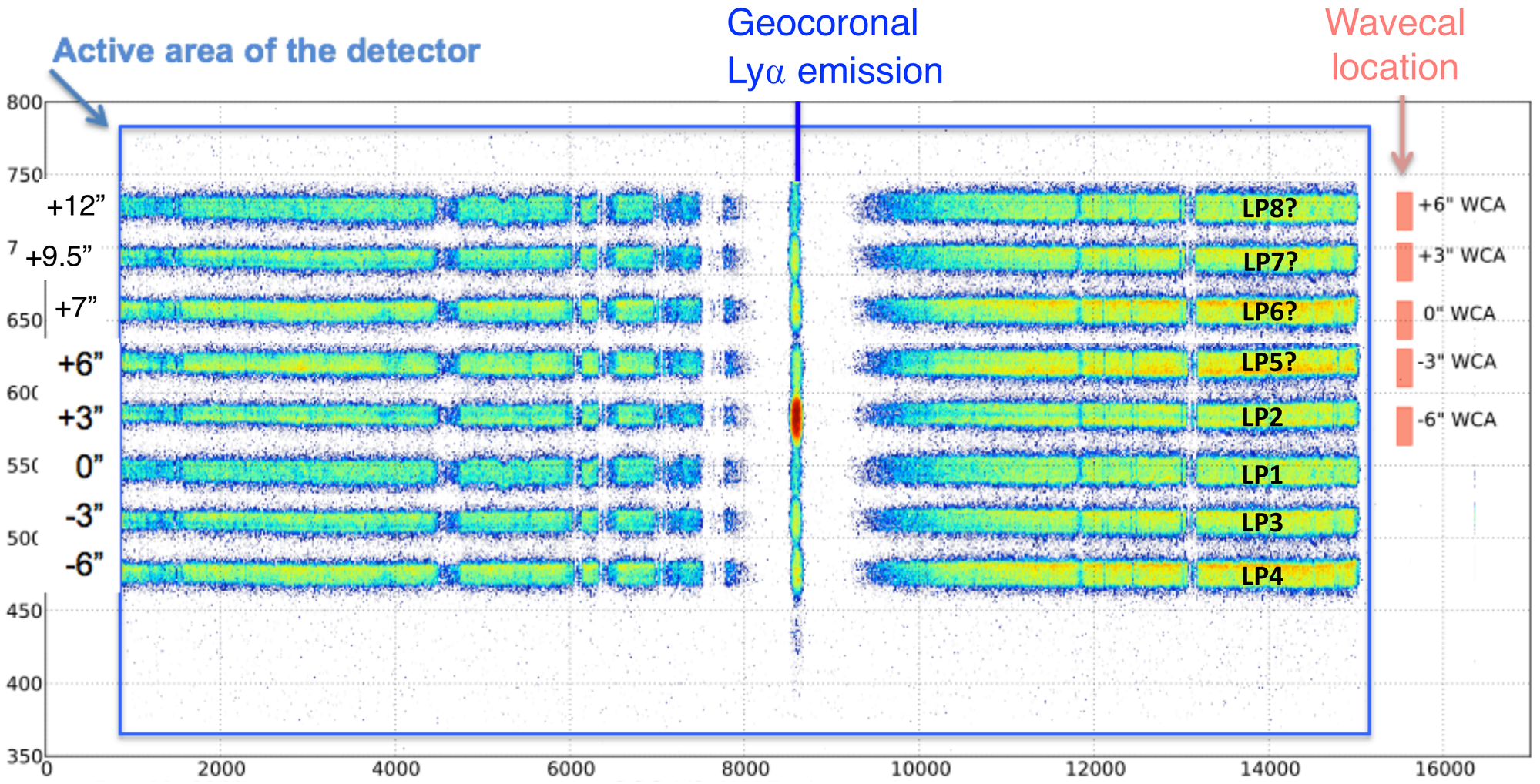
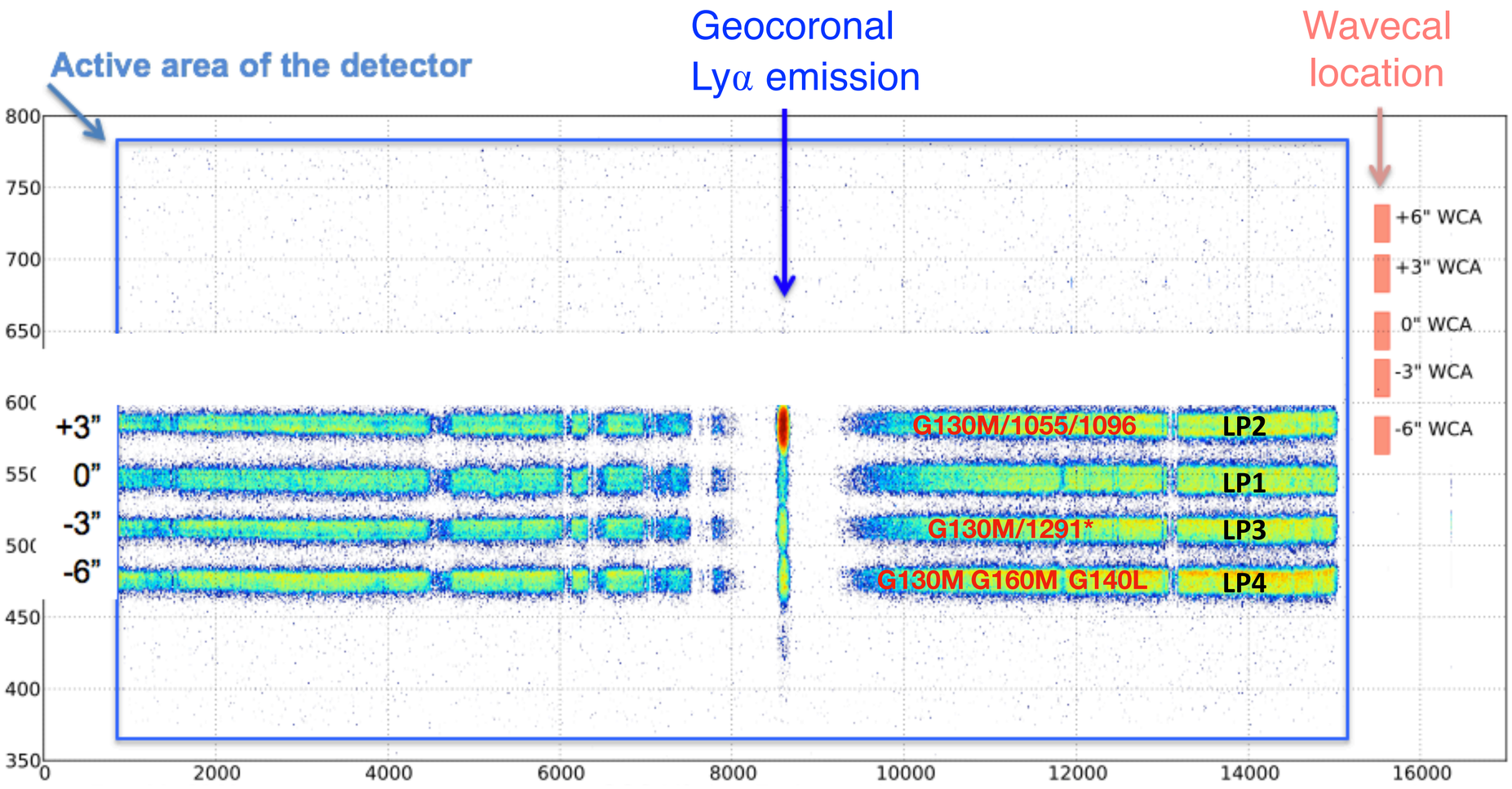


- We don’t know the resolution
- We don’t know the focus

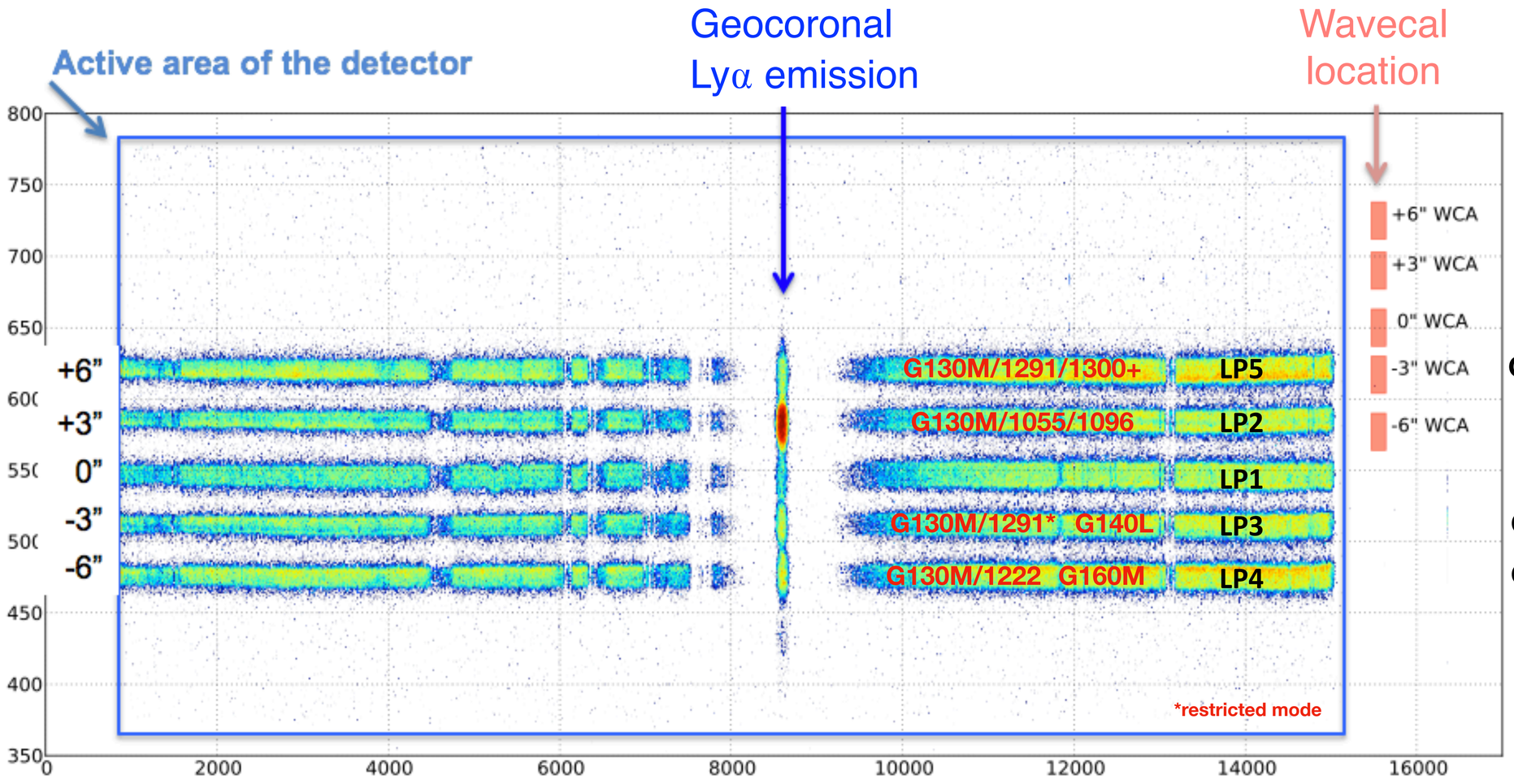
Note: Cartoon, not real data

COS FUV Detector: Today



*restricted mode
(enables coverage of Lya, since COS2025 rules at LP4 made this unfeasible due to holes)

COS FUV Detector: Cycle 29



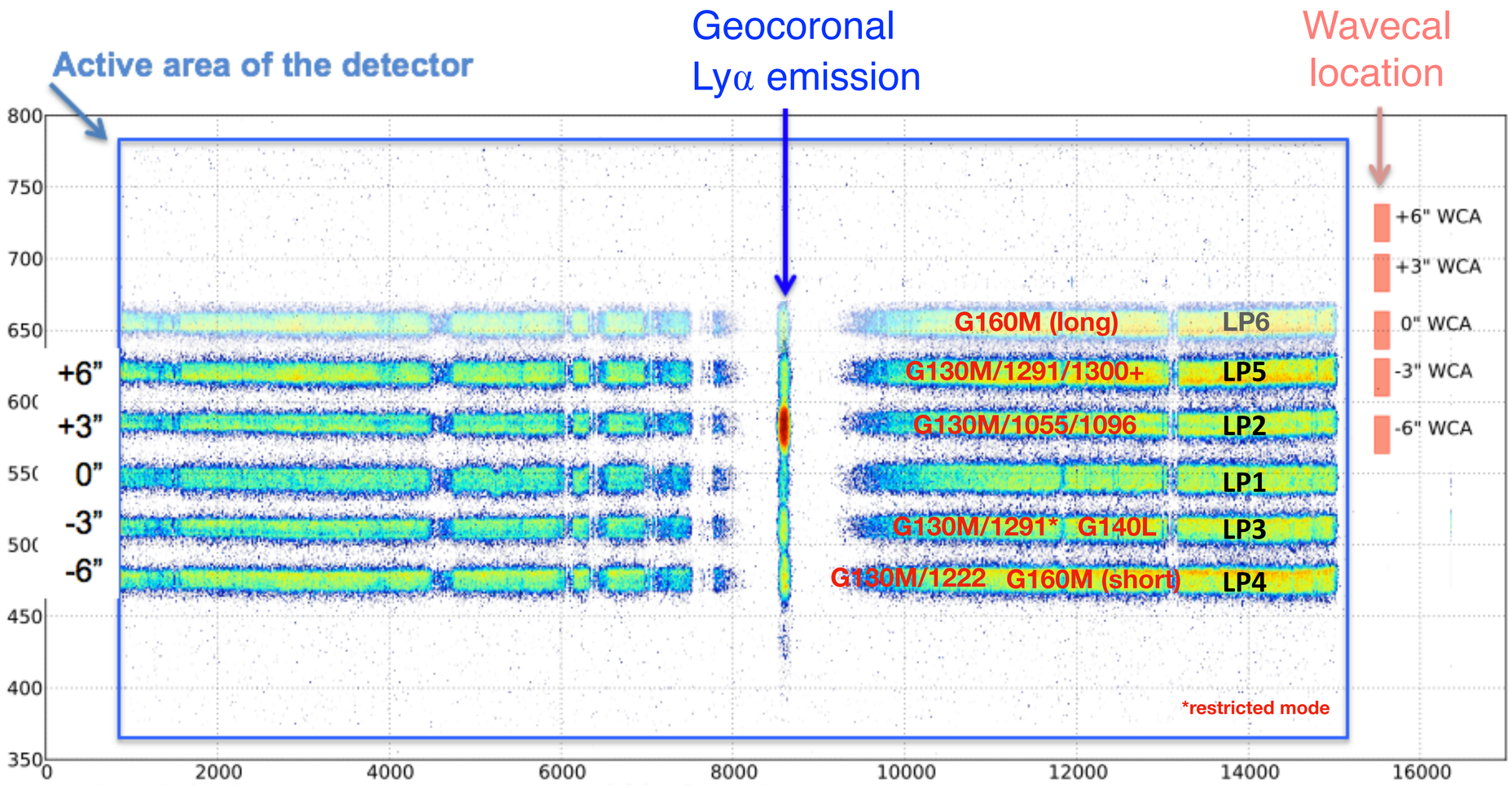
G130M/1291 & 1300s move to LP5

G140L move to LP3

G160M & G130M/1222 stay at LP4

We will explain the reasoning behind each of these moves soon

COS FUV Detector: Mid-Cycle 29 (hopefully)



G160M long exp move to LP6

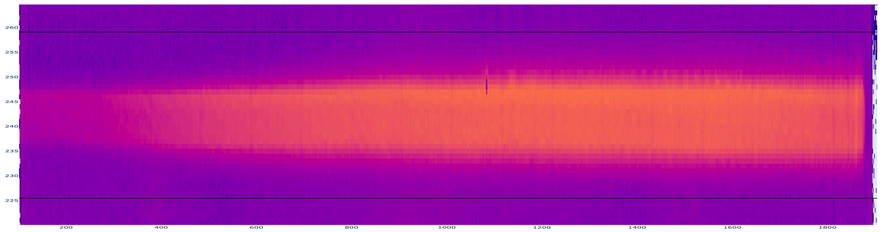
G160M short exp stay at LP4
G130M stay at LP4

We will explain the reasoning behind each of these moves soon

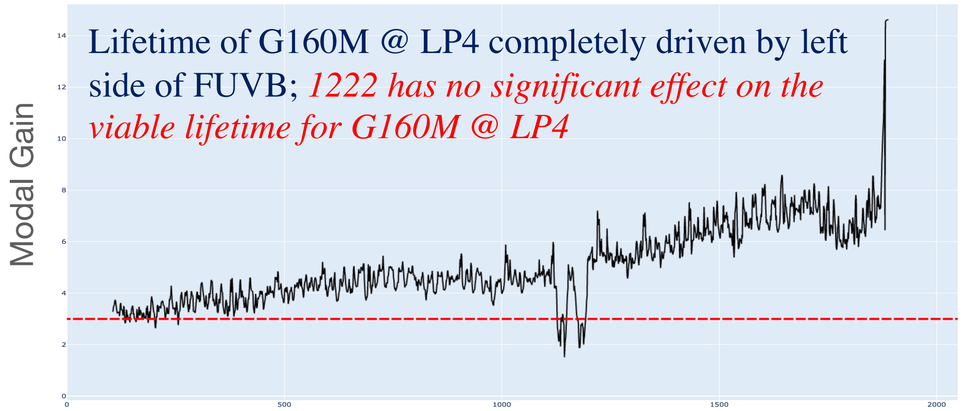
Why isn’t G130M/1222 moving to LP5?

- At LP5 the G130M-1222 configuration has a much shorter lifetime than the other G130M settings because it projects wider onto the detector → overlaps with gainsag regions from LP2
- G130M-1222 is a relatively smooth light distribution so it does not have a significant impact on the remaining lifetime of G160M-short exposures at LP4
- The left side of the detector drives the lifetime but G130M/1222 has very few counts on the left side of FUVB

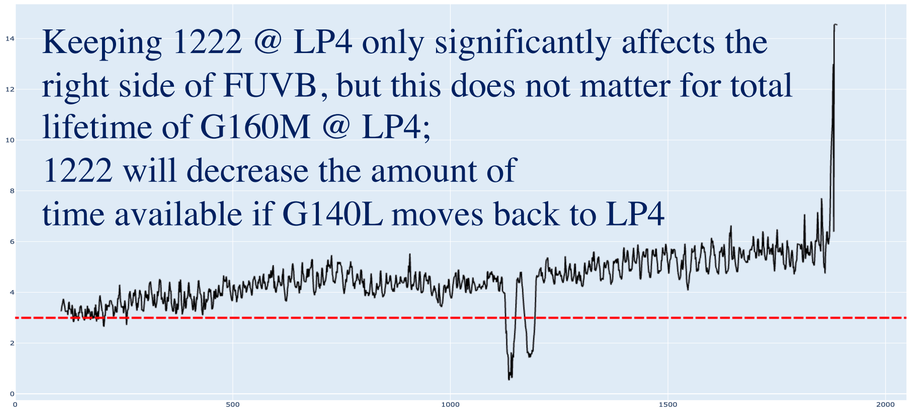
1222 Count Distribution (FUVB)



G130M-1222 moves to LP5



G130M-1222 stays at LP4



How did we optimize the hybrid LP-mode?

Advanced gain modeling (C. Johnson):

- Each grating & cenwave have different profile shapes
- Modeling tool uses cumulative count and extracted charge maps for each configuration for every week of COS data enabling detailed mapping of counts
- Models naturally include pixel offsets, addition of background count levels, impacts from calibration exposures
- Several combinations were explored to maximize the time available at each position before the modal gain approaches 3 & ~5% flux loss (= “sagged”)
- Model requires an input timeline of events, and plan to run regularly

Gain modeling: input timeline

Everything stays the same until Oct. 2021, start of Cycle 29

Oct 2021:

- ➡ G130M-1291 and G130M-1300s move to LP5
- ➡ G140L moves to LP3

March 2022:

- ➡ G160M-long moves to LP6

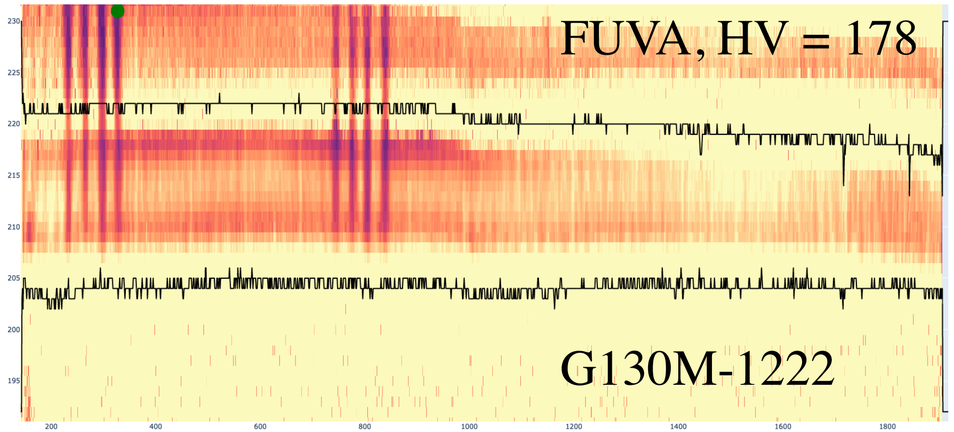
End of Life (EOL) Events Allowed within the Model

- G130M blue modes reaches end of life (EOL) at LP2 and move to LP6
- G140L reaches EOL at LP3 and moves back to LP4
- G160M-short and G130M-1222 reach EOL at LP4, move to LP6.
- G140L will stay at LP4 a little longer, and then move to LP6
- G130M-1291 and G130M-1300s reach EOL at LP5
- G160M, G130M-1222, and G140L reach EOL at LP6

Disclaimer: modeling timeline is approximate and based off of current usage rates; the lifetime estimates are probably conservative so it is likely that the dates above will shift to later years unless the usage increases

Gain modeling: Mid 2027 →LP4 EOL for G160M (short) & 1222

2027-04-01



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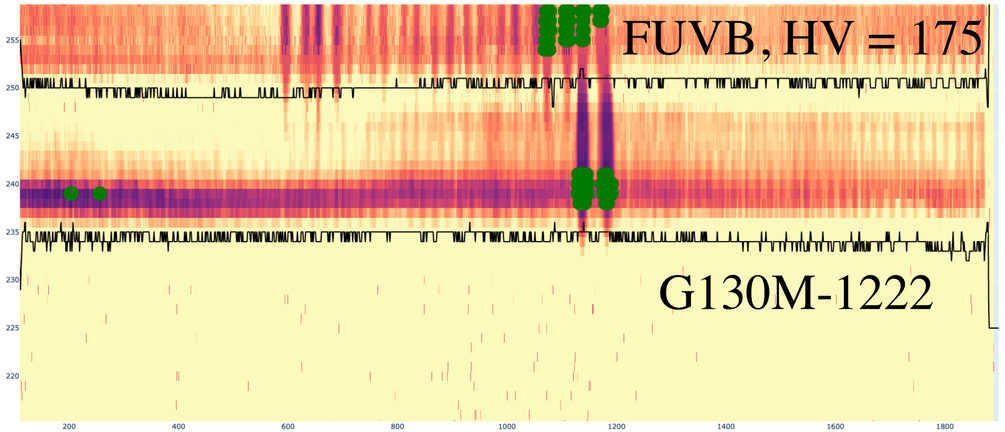
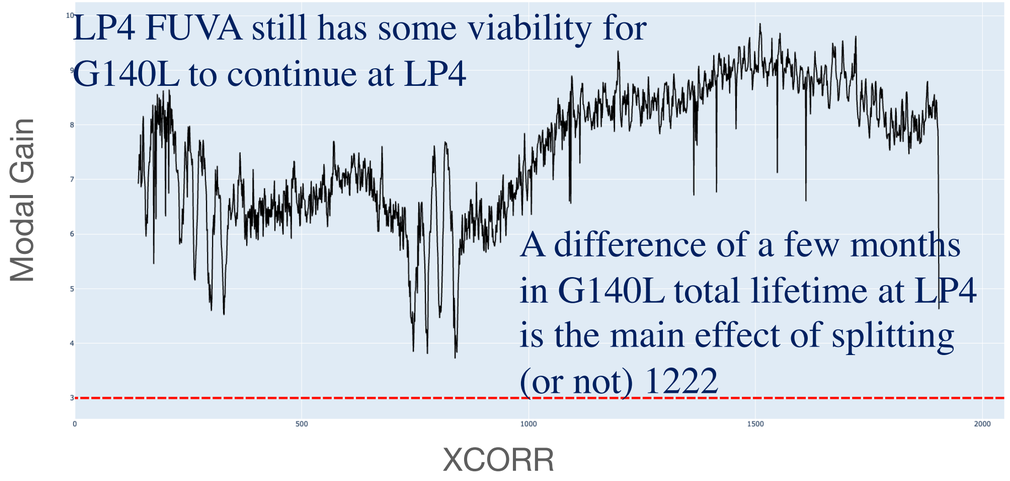
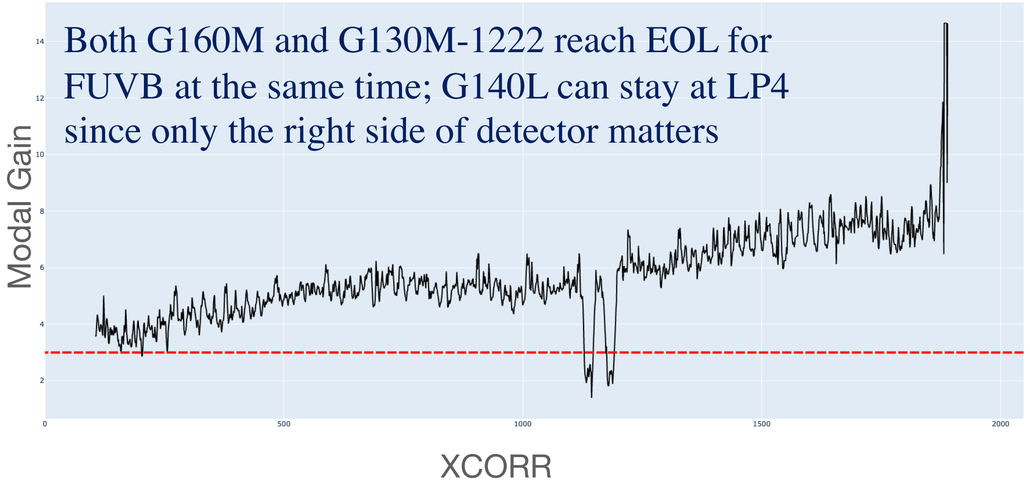
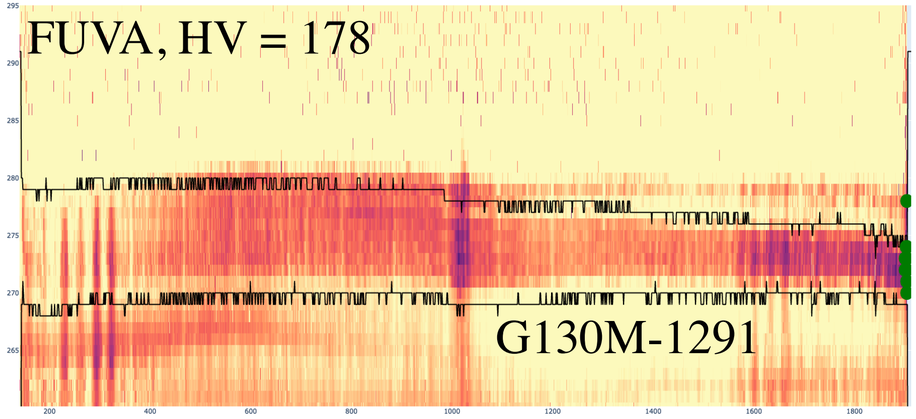


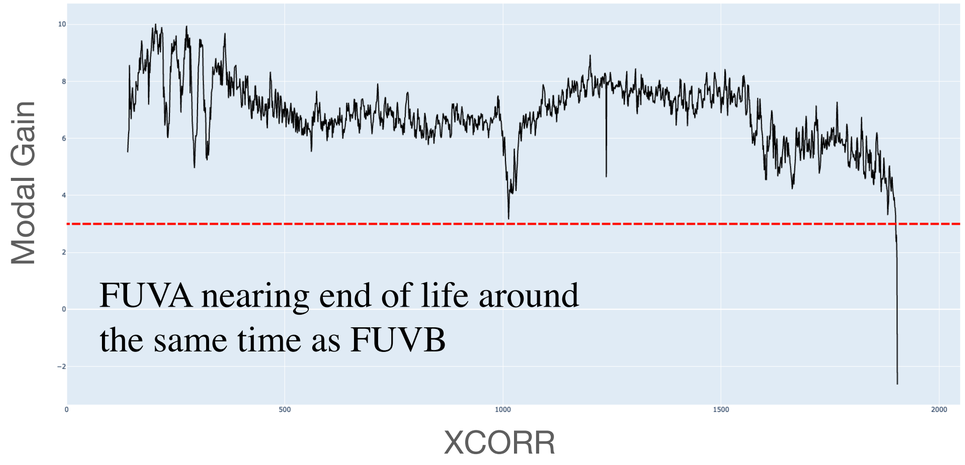




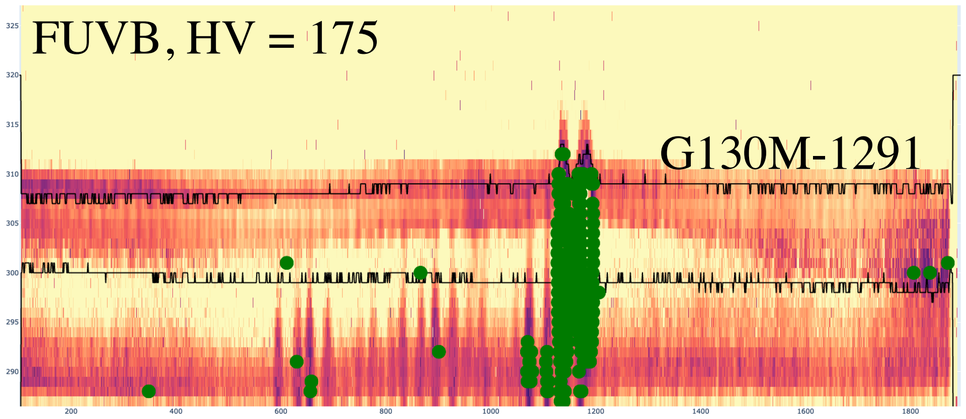
Gain modeling: Mid 2030 → LP5 EOL for G130M (1291, 1300s)

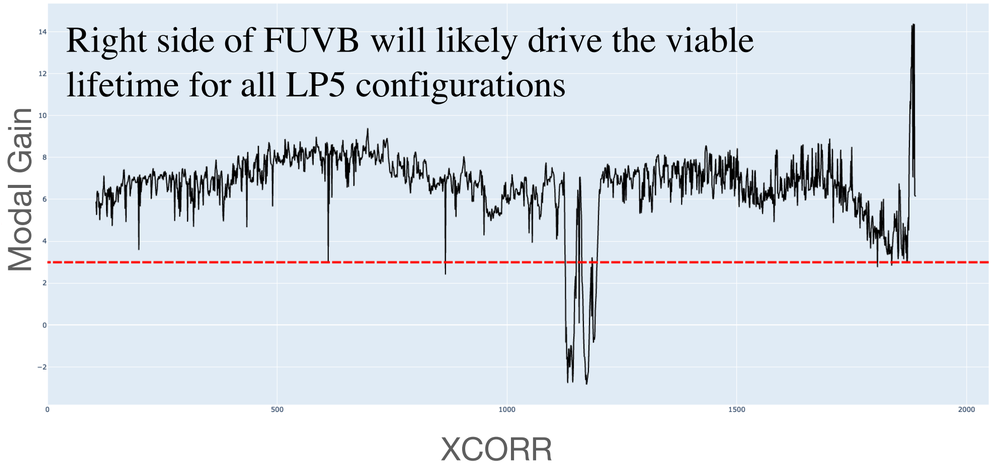
2030-04-01





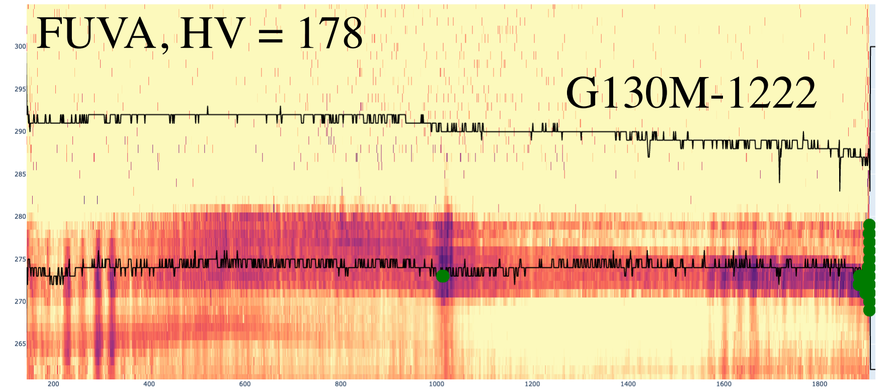
2030-04-01

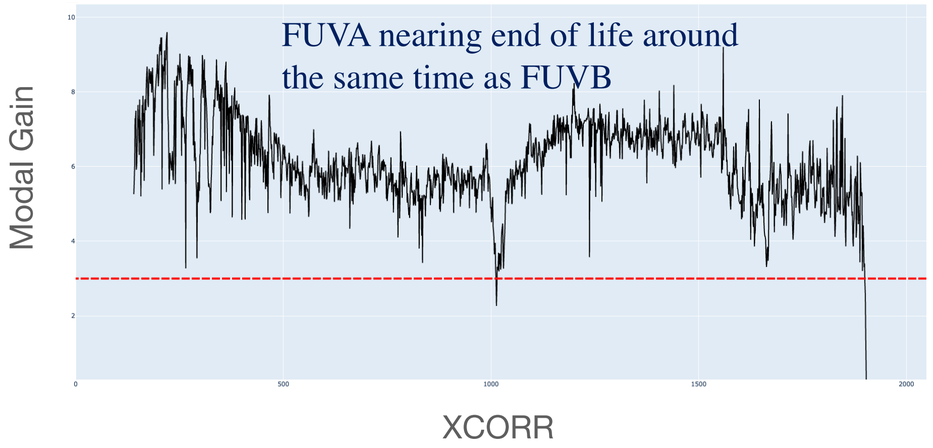




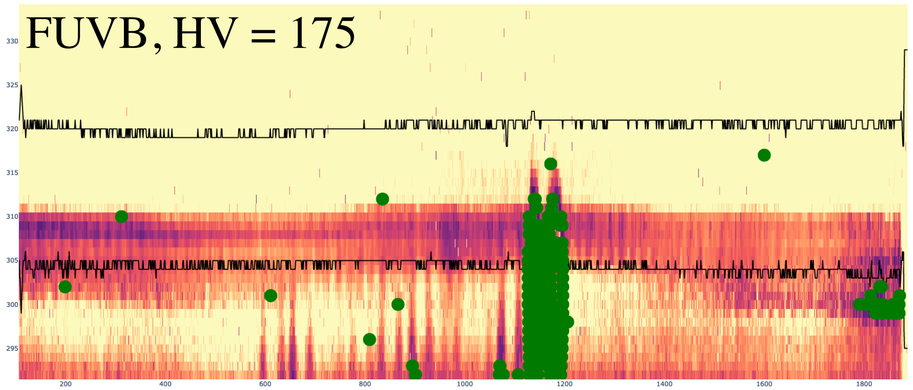
Gain modeling: Mid 2030 → LP6 EOL (G160M, G140L, bluemodes)

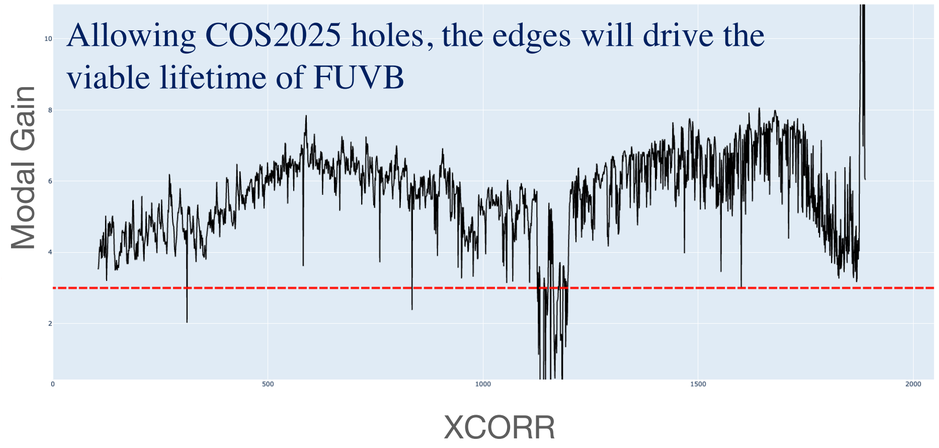
2030-04-01





2030-04-01





The COS2030 Plan

LP5 Calibration + LP6 Exploratory

LP6 Calibration

	Grating/Cenwave Lifetime Position					
Date	Blue Modes	G130M-1222	G130M-1291 + 1300s	G160M-short	G160M-long	G140L
Today	2	4	4	4	4	4
Oct. 2021	2	4	4→5	4	4	4→3
Mar. 2022	2	4	5	4	4→6	3
Mid-2025	2→6	4	5	4	6	3
Late-2025	6	4	5	4	6	3→4
Mid-2027	6	4→6	5	4→6	6	4
Mid-2028	6	6	5	6	6	4→6
Mid-2030	6→?	6→?	5→?	6→?	6→?	6→?

The COS/FUV Hybrid-LP Mode (2021/2022)