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Cycle 24 COS FUV Detector Gain Maps

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ABSTRACT

Program 14519 used the onboard deuterium lamp to illuminate the LP3 region of the COS FUV detector immediately before and after the nominal high voltage on Segment B was changed on October 17, 2016. Exposures were also taken at LP2 approximately one year after the previous LP2 gain maps were obtained, and at LP3 using the G130M/1222 high voltage values. The pulse height information obtained was used to create gain maps in order to monitor the detector gain sag and to determine when high voltage changes and Lifetime Position changes were needed.

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1. Introduction

Monitoring the gain of the COS FUV detector is crucial to ensure optimal performance. When the modal gain at a particular location on the detector drops below a value of about 3, approxmately 5% of the counts there fall below the lower pulse height threshold, which leads to an apparent local loss of sensitivity (Sahnow et al. 2011). The amount of gain sag is a function of the number of photon events incident on the detector, the high voltage (HV), and other factors. The largest gain drops are seen in the regions of the detector where Lyman-α airglow lines fall, since they have collected the most counts.

Gain map files are created at each commanded HV approximately weekly by measuring the modal gain from Pulse Height Distributions (PHDs) made using all of the counts collected during the TIME-TAG science exposures that have executed during that time. However, since ~25 counts in a binned pixel are necessary to reliably measure the peak of the PHD, the regions of the detector where the gain can be measured varies from week to week, depending on the data taken. For areas on the wings of the cross dispersion profiles, it may be rare to ever collect enough counts for a valid measurement.

In order to ensure more complete areal coverage at each Lifetime Position (LP) and HV, exposures of the internal deuterium lamp are also occasionally obtained. These lamps illuminate a wider area in the cross-dispersion direction (y axis) of the detector so that modal gain measurements can be made everywhere that photons from science targets fall. These gain map exposures are taken both before and after any change to the nominal detector high voltage or Lifetime Position, or at regular intervals when the voltage is not changed. Because of the strongly varying intensity of the lamp as a function of wavelength, data is collected using both G130M/1309 and G160M/1600. The former is the best choice for obtaining approximately uniform coverage on Segment A, while the latter does the same for Segment B. In order to maximize the number of counts in the PHD, data from both lamps is combined when constructing the gain maps.

2. Execution

During Cycle 24, Program 14519 obtained deuterium data over five one-orbit visits, which are listed in Table 1; all visits successfully collected the expected data. Each visit followed the same procedure:

- Adjust the HV values if necessary
- Adjust the aperture in the cross-dispersion direction so that the deuterium lamp illuminates the appropriate region on Segment A when using G130M/1309
- Take a 400 second deuterium lamp exposure at FP-POS=1 using both detector segments
- Adjust the aperture to a second cross-dispersion location to obtain additional coverage on Segment A and take a 400 second deuterium lamp exposure at FP-POS=4 using both detector segments
- Adjust the aperture in the cross-dispersion direction so that the deuterium lamp will illuminate the appropriate region on Segment B when using G160M/1600

- Take a 400 second deuterium lamp exposure using both detector segments
- Adjust the aperture to a second cross-dispersion location to obtain additional coverage on Segment B and take another 400 second deuterium lamp exposure
- Return the HV to the nominal values for the standard observing modes

The two offset positions for each grating were chosen so that when the data from the exposures are combined, the count rate is roughly uniform and they overlap with the science spectra at the same LP. The aperture offset values (LAPXSTP) are shown in Table 1; these were determined by measuring the position of spectra as a function of aperture position during previous deuterium observations.

Visit B1 executed at LP3 on October 16, 2016, immediately before the nominal HV for the Standard Modes on Segment B was increased from 169 to 175. Visit B2 executed at LP3 the next day, immediately after the HV increase. The HV for Segment A was not changed, and remained at 167 for both visits.

Visit D1 executed at LP2 on November 7, 2016. It used the Blue Modes HV values of 173/175 (for Segments A/B), and was scheduled approximately six months after the previous gain map data was obtained at that position (Program 14439 visit D1, obtained on April 25, 2016). Visit D2, with identical parameters as D1, ran on April 25, 2017.

Visit C1 executed at LP3 on January 30, 2017, and used the G130M/1222 HV values of 171/175. This was approximately one year after the previous deuterium exposure using the 1222 HV values (Program 14439 visit C1 on January 17, 2016).

Two contingency visits, A1 and A2, would have been used if the G130M/1222 Segment A HV had changed during Cycle 24. Contingency visit D3 would have been used if the Blue Mode Segment A HV had been changed.

Table 1 Visits executed in Program 14519

Visit	**Date**	**LP**	**Mode**	**HV (A/B)**	**LAPXSTP (G130M)**	**LAPXSTP (G160M)**	**Notes**
B1	10/16/16	3	Standard	167/169	-72,-128	-84,-140	Before HVB change
B2	10/17/16	3	Standard	167/175	-72,-128	-84,-140	After HVB change
D1	11/7/16	2	Blue	173/175	-213,-267*	-225,-267*	~6 months after previous LP2/Blue Modes data
C1	1/30/17	3	1222	171/175	-72,-128	-84,-140	~1 year after previous 1222 data
D2	4/25/17	2	Blue	173/175	-213,-267*	-225,-267*	~6 months after previous LP2/Blue Modes data

* The commanded value of LAPXSTP for these positions was set to -267 in order to avoid the soft stop at -275

3. Summary of Analysis and Results

The standard gain map creation routines were used to make fits to the peak of the pulse height distibution for each binned pixel in order to calculate the modal gain. Figure 1 shows the gain as a function of X pixel before and after the Segment B HV increase on October 17, 2016 at the center of the LP3 detector location. A similar plot showing the modal gain measured at LP2 in Visits D1 and D2 is displayed in Figure 2, while Figure 3 shows the gain at LP3 obtained in Visit C1.

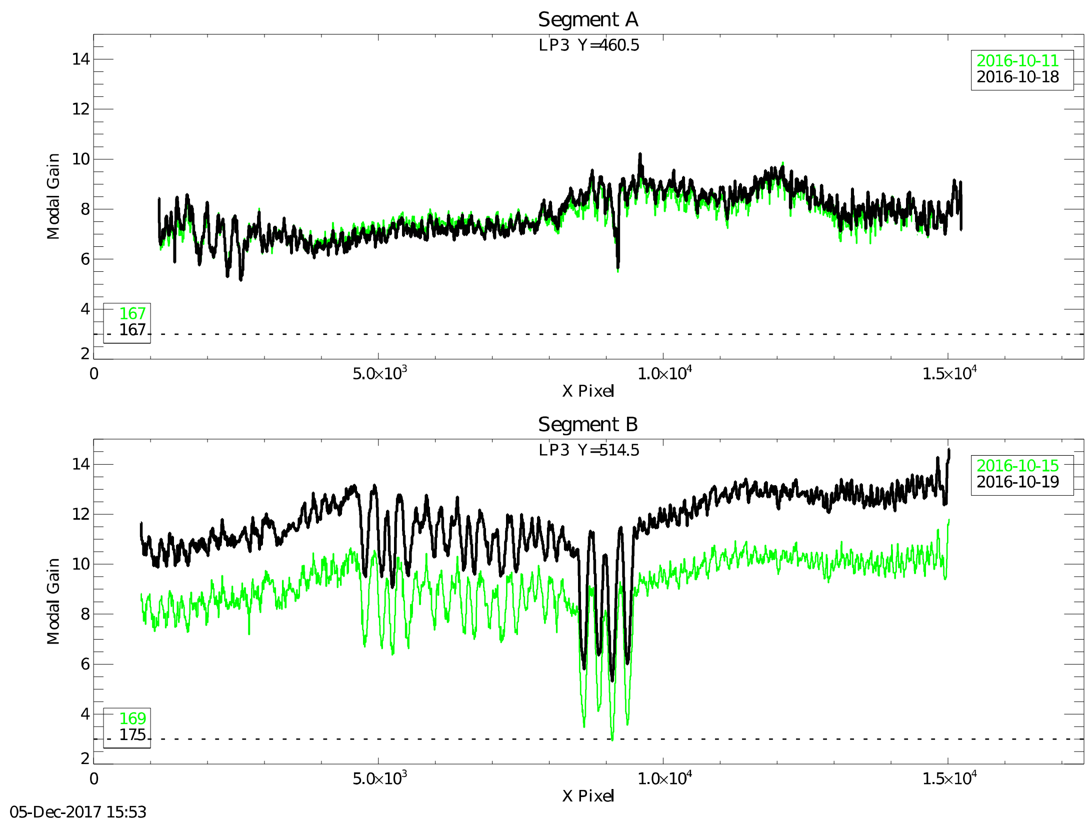

Figure 1 Modal gain as a function of X pixel at the center of the LP3 region of the detector before (**green**) and after (**black**) the Segment B HV increase on October 17, 2016. The HV, shown in the lower left, did not change on Segment A, so the gain remains unchanged. On Segment B, where the HV increased from a commaned value of 169 to 175 for the standard modes, the average increase in modal gain is ~2.4 gain bins.

The primary purpose of this program was to obtain gain maps in order to determine the slope of the modal gain vs. extracted charge curve over the entire illuminated area of the detector at all high voltage values used during the cycle. Making measurements at the time of each HV change allows a more accurate determination of the slope, which leads to more accurate predictions of when the gain is likely to drop to 3, and thus when a high voltage change or Lifetime Position change is needed.

Data from this program, along with data from other gain measurements, is also used in the construction of the GSAGTAB, which flags the regions where the modal gain has dropped too low.

Gain map measurements will continue in Cycle 25 as Program 14941.

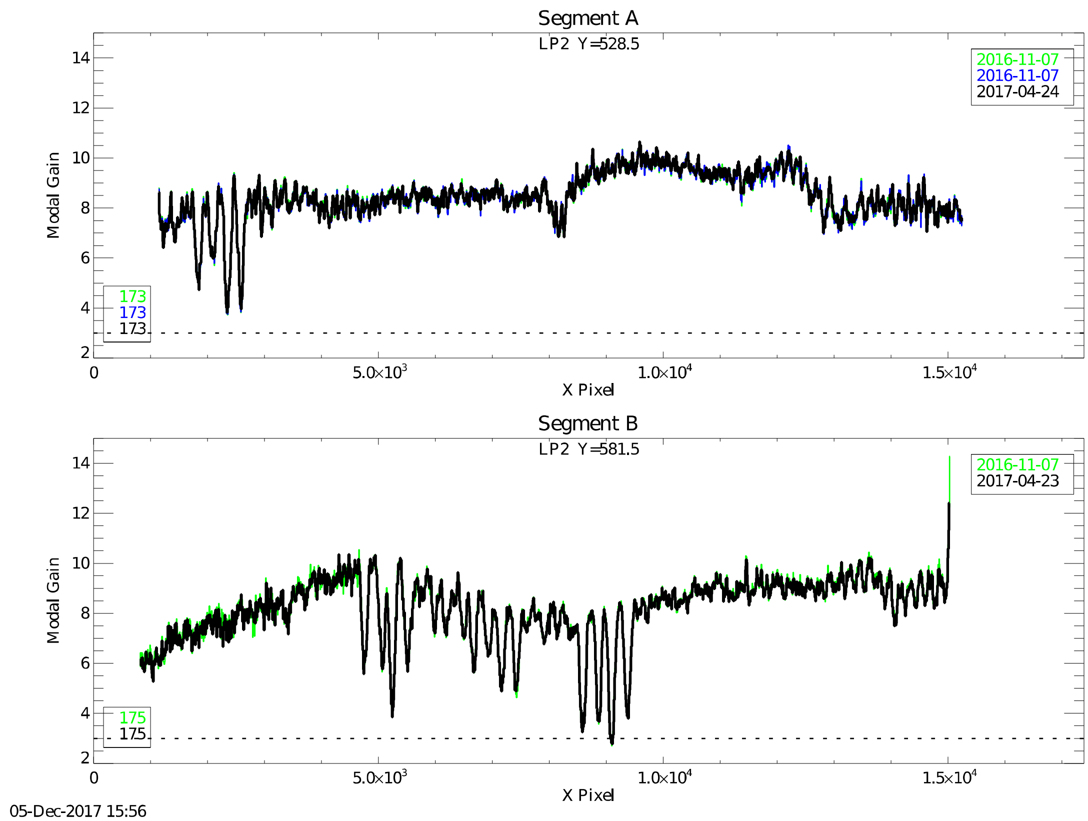

Figure 2 Modal gain as a function of X pixel at the center of the LP2 (Blue Mode) region of the detector measured in program 14519, visits D1 and D2. There was a negligible difference between the gain measured in the two, which is not surprising since this mode is not used extensively. The deepest hole has a modal gain of ~3, where throughput losses are ~5%.

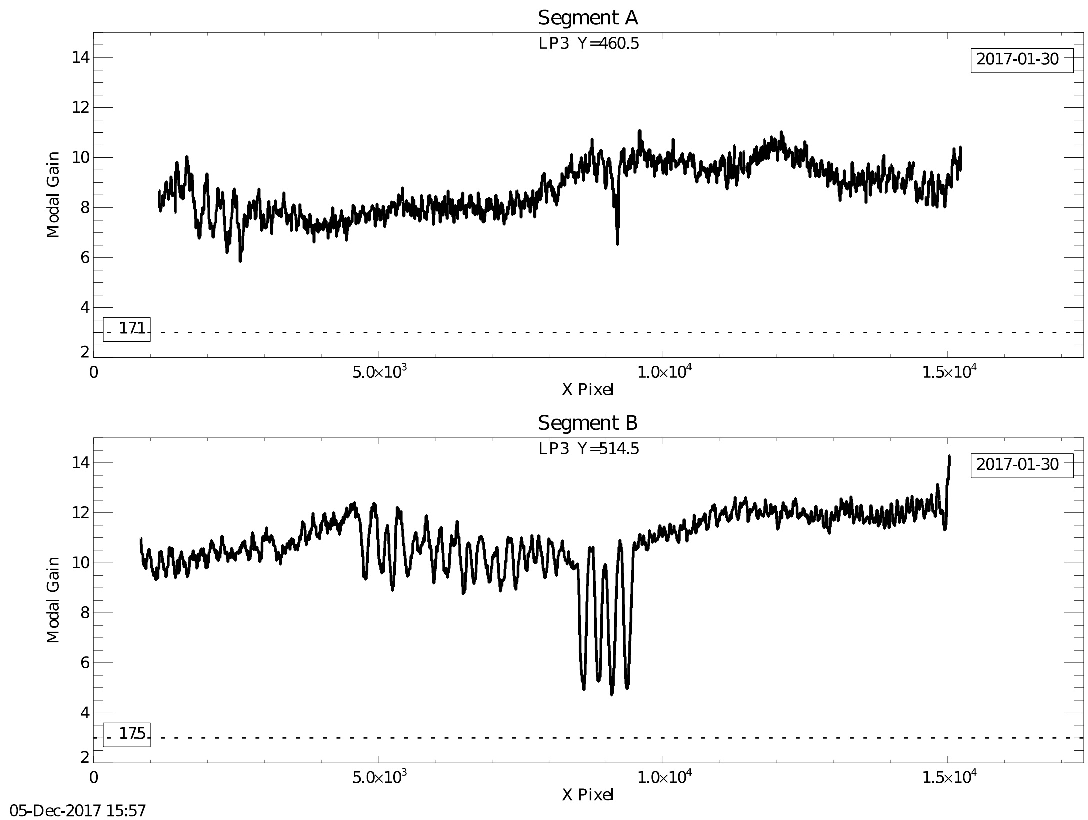

Figure 3 Modal gain as a function of X pixel at the center of the LP3 region of the detector using the G130M/1222 HV values, as measured in program 14519 Visit C1.

Change History for COS ISR 2018-01

Version 1: 13 February 2018

References

D. Sahnow et al., 2011, Instrument Science Report COS 2011-05, "Gain sag in the FUV detector of the Cosmic Origins Spectrograph"