

Cycle 29 COS Calibration Plan Fall Orbit Request for Changing Programs

Sept 2021

Elaine Frazer & Kate Rowlands
for the COS Team

Summary of the Cycle 29 Requests

For Cycle 29, the COS team will make changes to 5 of the FUV regular calibration programs to account for the following new lifetime position rules:

- G130M cenwaves 1291, 1300, 1309, 1318, and 1327 move to LP5
- All G140L cenwaves move to LP3
- G130M/1222 and all G160M cenwaves remain at LP4
- G130M cenwaves 1055 and 1096 remain at LP2

The changing programs include the following (to be discussed in more detail later):

- COS FUV Gain Maps
- COS FUV Spectroscopic Sensitivity Monitor
- COS FUV Target Acquisition Monitor
- COS FUV Change in Spectroscopic Sensitivity Trends,
- COS FUV Characterization of Modal Gain When Changing High Voltage

The non-changing programs include:

- COS FUV Detector Dark Monitor (included in Fall request)
 - The team did not include this program in the Spring request because we wanted to investigate whether including exposures at different HVs would be beneficial. After reviewing the accepted GO proposals for Cycle 29, it was determined these changes would not be necessary
- The COS FUV Wavelength Scale Monitor (already approved in Spring request)
 - The only changes needed (moving exposures to different LPs) happen automatically through APT
- All NUV programs (already approved in Spring request)

Summary of COS Calibration Orbits for Cycle 29 (Fall Request)

Title (PI)	External	Internal	Frequency (orbits x repeats)
FUV Monitors			
COS FUV Detector Dark Monitor (Dashtamirova)		265	5x52
COS FUV Gain Maps (Sahnow)		8	4x2
COS FUV Spectroscopic Sensitivity Monitor (Rowlands)	31 [28]		3x5 + 2x5 + 2x2 + 2x1 [3x6 + 2x5]
COS FUV Target Acquisition Monitor (Dieterich)	3 [2]		3x1 [2x1]
Contingency Programs			
COS FUV Change in Spectroscopic Sensitivity Trends (Rowlands)	(26)		
COS FUV Characterization of Modal Gain When Changing High Voltage (Sahnow)		(2)	
Cycle 29 Fall Request	34 (26) [30 (26)]	273+(2)	

() indicate contingency orbits

[] indicate # of orbits requested in Cycle 28

Red: Changes from Cycle 28

Summary of approved Cycle 29 COS calibration programs (Spring Request)

Title (PI)	External	Internal	Frequency (orbits x repeats)
FUV Monitors			
COS FUV Wavelength Scale Monitor (W. Fischer)	3		3x1
NUV Monitors			
COS NUV Detector Dark Monitor (Dashtamirova)		52	2 x26
COS NUV MAMA Fold Distribution (Wheeler)		1	1x1
COS NUV Spectroscopic Sensitivity Monitor (W. Fischer)	4		2x2
COS NUV Wavelength Scale Monitor (W. Fischer)	1		1x1
COS NUV Target Acquisition Monitor (Dieterich)	3		3x1
Contingency Programs			
COS FUV Detector Recovery After Anomalous Shutdown (Wheeler)		(17)	
COS NUV Detector Recovery After Anomalous Shutdown (Wheeler)		(4)	
Cycle 29 Spring Request	11	53+(21)	

() indicate contingency orbits

COS Cycle 29 Summary of Full Calibration Plan

Title (PI)	External	Internal	Frequency (orbits x repeats)
FUV Monitors			
COS FUV Wavelength Scale Monitor (W. Fischer)	3		3x1
COS FUV Detector Dark Monitor (Dashtamirova)		265	5x52
COS FUV Gain Maps (Sahnow)		8	4x2
COS FUV Spectroscopic Sensitivity Monitor (Rowlands)	31 [28]		3x5 + 2x5 + 2x2 + 2x1 [3x5 + 2x5]
COS FUV Target Acquisition Monitor (Dieterich)	3 [2]		3x1 [2x1]
NUV Monitors			
COS NUV Detector Dark Monitor (Dashtamirova)		52	2 x26
COS NUV MAMA Fold Distribution (Wheeler)		1	1x1
COS NUV Spectroscopic Sensitivity Monitor (W. Fischer)	4		2x2
COS NUV Wavelength Scale Monitor (W. Fischer)	1		1x1
COS NUV Target Acquisition Monitor (Dieterich)	3		3x1
Contingency Programs			
COS FUV Detector Recovery After Anomalous Shutdown (Wheeler)		(17)	
COS NUV Detector Recovery After Anomalous Shutdown (Wheeler)		(4)	
COS FUV Change in Spectroscopic Sensitivity Trends (Rowlands)	(26)		
COS FUV Characterization of Modal Gain When Changing High Voltage (Sahnow)		(2)	
Cycle 29 Complete Request	45 (26) [41 (26)]	326+(23)	

FUV Monitors

COS FUV Detector Dark Monitor

PI: Dzhulyia Dashtamirova

Purpose	Perform routine monitoring of FUV XDL detector dark rate. The main purpose is to look for evidence of a change in the dark rate, both to track on-orbit time dependence and to check for a developing detector problem.
Description	Monitor the FUV detector dark rate by taking TIME-TAG science exposures with no light on the detector. Five times every week, a 22-min exposure is taken with the FUV detector with the shutter closed. The length of the exposures is chosen to make them fit in Earth occultations. All orbits are < 1800s. Dark rate trends can be viewed on the COS Website .
Fraction GO/GTO Programs Supported	93% of COS exposure time in Cycle 28.
Resources Required: Observations	265 internal orbits. All orbits < 1800s.
Resources Required: Analysis	2 FTE weeks.
Products	Provide ETC and IHB dark rate estimates, along with weekly monitoring for changes and a summary in the end of cycle ISR. Update monitor and COS webpages. As allowed by resources and necessitated by data quality: improve dark subtraction method and update bad-pixel tables.
Accuracy Goals	Obtain enough counts to track 1% level changes on timescales of ~1-3 months.
Scheduling & Special Requirements	5x / week at nominal HV during Earth occultation.
Changes from Cycle 28	No changes. The team did not include this program in the Spring request because we wanted to investigate whether including exposures at different HVs would be beneficial. After reviewing the accepted GO proposals for Cycle 29, it was determined these changes would not be necessary. An additional 5 orbits were necessary due to Cycle 29 being 53 weeks long.

COS FUV Detector Gain Maps

PI: David Sahnou

Purpose	Obtain gain maps of the FUV detector periodically during the cycle. These data will be used to track the modal gain as a function of time.
Description	Use the deuterium lamp to illuminate the appropriate regions of the COS FUV detector every 6 months at the following locations: <ul style="list-style-type: none"> • LP5 G130M Standard Modes: Snapshot to monitor the change in gain every 6 months (2 orbits) • LP4 G160M Standard Modes and G130M/1222: Snapshot to monitor the change in gain every 6 months (2 orbits) • LP3 Standard Modes: Snapshot to monitor the change in gain every 6 months (2 orbits) • LP2 Blue Modes: Snapshot to monitor the change in gain every 6 months (2 orbits)
Fraction GO/GTO Programs Supported	93% of COS exposure time in Cycle 28.
Resources Required: Observations	8 internal orbits.
Resources Required: Analysis	2 FTE weeks. Existing CCI / gain map procedures will be used to process these data as part of normal gain monitoring.
Products	Gain map files. These will be used to update the GSAGTAB (and possibly the BPIXTAB), and also improve the models of gain vs. HV and gain vs. exposure.
Accuracy Goals	0.1 pulse height bin.
Scheduling & Special Requirements	Every 6 months.
Changes from Cycle 28	Removed G130M/1222 orbits as they are now at the same HV as LP4. Added LP5 standard modes orbits. No net change in orbit count.

Overview of Changes - I

- In Cycle 28, two orbits each were included for taking gain maps at the detector location and HV values used by LP2, LP3, LP4 (standard modes) and LP4 (cenwave I222)
 - Since the LP4 cI222 HV values are now the same as the standard modes at LP4, those two orbits are no longer needed
- In Cycle 29, the addition of LP5 requires two new gain map exposures
 - The aperture block locations on the detector for LP5 are identical to those for LP2, but the HV values are different
- **The result is no net change to the total number of orbits for the gain map program**

Overview of Changes – 2

- In order to make the visits for each LP more similar, the visits were modified in Cycle 28 to add a short LPI deuterium exposure
 - This change will continue in Cycle 29
 - This has the additional advantage that the gain is now being measured at LPI, which had not been checked for many years

COS FUV Spectroscopic Sensitivity Monitor

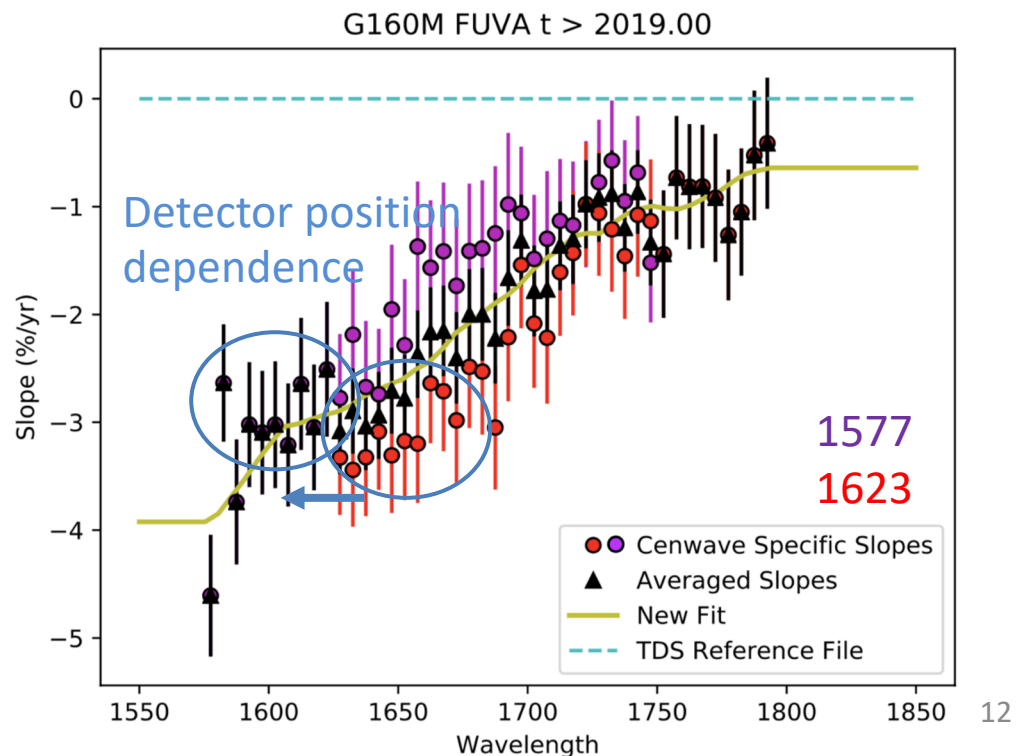
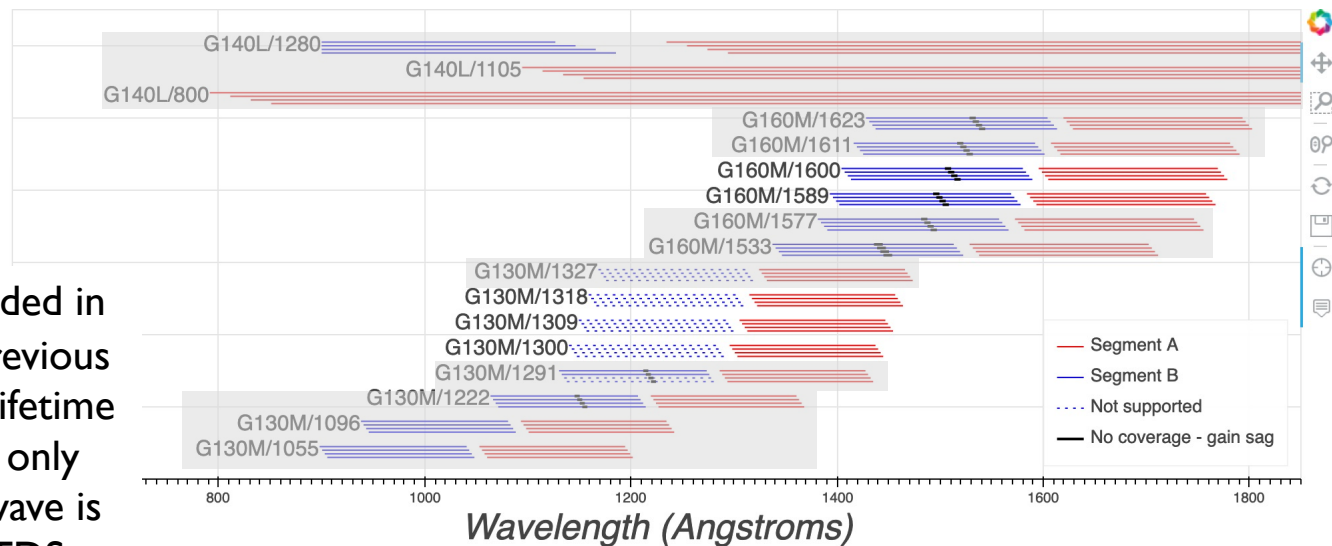
PI: Kate Rowlands

Purpose	Monitor the sensitivity of each FUV grating to detect any change due to contamination or other causes. The FUV gratings are the most heavily used modes on COS and have also experienced several changes in the time-dependent spectroscopic sensitivity since launch. These trends are grating, segment, and wavelength dependent.
Description	To track the TDS as a function of wavelength we obtain exposures of two standard stars (WD0308-565 and GD71) every 2 months with all FUV gratings. The monitoring sequence consists of two visits, for a total of 5 orbits. The 2-orbit visit (GD71) covers the G130M/1096/FUVB, G160M/1533/FUVA, G160M/1577/FUVA, G160M/1611/FUVA and G160M/1623/FUVA modes. The 3-orbit visit (WD0308-565) covers G130M/1222, G130M/1291, G130M/1327/FUVA, G130M/1055/FUVA, G160M/1533/FUVB, G160M/1577/FUVB, G160M/1611/FUVB, G160M/1623/FUVB, G140L/800, G140L/1105, and G140L/1280 modes. The standard shortest and longest wavelength settings for each grating, the G130M “blue-modes” and 1291, and the two new cenwaves are covered in the program. TDS trends can be viewed on the COS Website .
Fraction GO/GTO Programs Supported	93% of COS exposure time in Cycle 28.
Resources Required: Observations	31 external orbits
Resources Required: Analysis	9 FTE weeks
Products	Time-Dependent Sensitivity reference file as necessary, update to ETC throughputs, the COS monitoring webpages, and a summary ISR
Accuracy Goals	<ul style="list-style-type: none"> - SNR of 15 per resel at wavelength of least sensitivity for the standard modes, SNR of 25 per resel at wavelength of most sensitivity for the blue modes. For the blue modes, this will ensure $S/N > 15$ for $\lambda > 1030 \text{ \AA}$ for 1096/FUVB, $\lambda > 1130 \text{ \AA}$ for 1055/FUVA and 1222/FUVB. SNR of 5 per resel in the short wavelength region for G140L/800, which yields SNR of 32 per 20 \AA bin (used in the TDS analysis). - TDS calibration better than 2% relative and 5% absolute for standard modes and blue modes
Scheduling & Special Requirements	<ul style="list-style-type: none"> • Monitoring sequence should occur every 2 months starting in December 2021 • The FUVA turn-off of the GD71 visit should be hidden in the GS-ACQ • GD71 is not visible from late April to early August 2022, resulting in a reduced monitoring sequence for the month of June (1 visit)
Changes from Cycle 28	<ul style="list-style-type: none"> • Added monitoring of cenwave 1611, which is a well-used, but non-tracked cenwave, which will enable the investigation of detector vs wavelength dependence of the TDS • Added LP4-LP5 and LP4-LP3 connection visits to check sensitivity changes during the LP moves for G130M and G140L • Added LP4-LP6 connection visits to check sensitivity changes in preparation for G160M becoming available at LP6 in Cycle 30 • Three extra orbits are requested for these changes

COS FUV Spectroscopic Sensitivity Monitor, cont.

Monitored cenwaves (in grey):

- Not all cenwaves are included in TDS monitoring due to previous concerns about detector lifetime
- For the tracked cenwaves, only data obtained at that cenwave is used in the derivation of TDS parameters
- Slopes for untracked cenwaves are obtained in the standard way by averaging individual adjacent cenwave slopes, but it is not clear how well this estimation performs
- Monitoring data over the last few cycles showed evidence for sensitivity changes that were detector location dependent (see plot on bottom right)



Testing detector position vs wavelength dependence of the TDS

- For untracked cenwaves, we don't currently know how to weigh between detector position and wavelength. A third monitored cenwave in between the current ones will allow us to separate the wavelength and detector position effects on the TDS, which is likely grating dependent
- Investigation of detector-wavelength dependence needs adjacent pairs of tracked cenwaves, but our current setup monitors the shortest and longest cenwaves in a grating
 - Some tests can be done with 1533, 1577 and 1623, but the wavelength overlap would be better with 1577, 1611 and 1623, and we need another cenwave to confirm trends
- Therefore we request to add monitoring of cenwave G160M/1611, which will let us assess how well the TDS of cenwave 1611 is tracked by our current averaging method
 - c1611 usage is 8% of exposures (most used of all G160M cenwaves in Cycle 28)
 - Fits within current orbit allocation
 - Need a full cycle's worth of data to adequately fit trends
 - Adding one cenwave 6 times a year is not a concern for detector lifetime
 - Tracking of well-used cenwaves accurately is important as we approach solar maximum, where more variations in the TDS are expected

Overview of Changes

- G130M cenwaves ≥ 1291 move to LP5
- G140L cenwaves move to LP3
- Add monitoring of G160M/1611
 - GD71 1611/FUVA, WD0308-565 1611/FUVB
 - Fits within current orbit request
- TDS connection visits for G130M/1291 and 1327 (LP4-LP5) and G140L/800 (LP4-LP3).
 - Test TDS dependence on lifetime position, 1 year baseline comparison.
 - TDS slope dependence between LP4 and LP3 has already been tested for G140L/1105 and 1280 and was shown to be negligible (Sankrit 2019).
 - Extra exposures fit within current orbit request.
- TDS connection visits for G160M/1533, 1577, 1611 and 1623 (LP4-LP6).
 - Enable scaling between LPs for LP6 flux calibration program
 - 3 additional orbits
- Additional NUV/ACQ/IMAGE in orbit of WD0308 visits to make visits more robust to late GS reacquisition

COS FUV Target Acquisition Monitor

PI: Serge Dieterich

Purpose	Monitor COS FUV ACQ/PEAKD and PEAKXD Performance at LP4 and LP5
Description	The FUV acquisition algorithms compute the centroiding of raw counts falling on the acquisition subarrays at several NUM-POS offsets, which cause the light from the target to be partially blocked by the aperture. In the cross dispersion (XD) direction, these offsets also cause the spectrum to move along the Y direction in the detector. Because there are detector effects such as gain sag and Y-walk, areas of the detector with non-uniform response, and asymmetric vignetting for the off-axis beam, it is desirable to monitor the FUV PEAKXD centering over multiple cycles to watch for unexpected changes and to compare the results at different LPs. All FUV gratings (G130M, G160M, G140L) are tested in PEAKXD. Gratings G130M at LP5 is also tested in PEAKD to verify the NUV to FUV LP5 SIAF entries for the FUV acquisition subarrays in both AD and XD. The default NUM-POS is 3 for PEAKXD and 5 for PEAKD. G130M and G140L PEAKXD are also tested with NUM-POS=5. Any difference in centroiding of a point source in PEAKXD with NUM-POS=3 and NUM-POS=5 would most likely be indicative of disparities in flux due to the PSF's asymmetry as it moves off-axis.
Fraction GO/GTO Programs Supported	~1% of Cycle 28 target acquisitions used the FUV channel. In Cycle 29, most ULLYSES observations use FUV acquisition.
Resources Required: Observations	3 external orbits.
Resources Required: Analysis	2 FTE weeks for analysis and documentation.
Products	Summary ISR.
Accuracy Goals	FUV Spectroscopic XD TAs are required to center the target to within $\pm 0.3''$ ($\sim \pm 3$ rows), with the goal of routine centering to $\pm 0.1''$ (~ 1 row). Targets not centered to within $0.3''$ are subject to vignetting and loss of spectral resolution and flux calibration. Along-dispersion centering requirements are cenwave-specific, but the strictest requirement is $\pm 0.106''$ for the G130M grating.
Scheduling & Special Requirements	Executes annually, and should execute within ± 30 days from Visit PB of NUV program (same target).
Changes from Cycle 28	G130M spectroscopic acquisitions are moving to LP5, and G140L science exposures are moving to LP3 after FUV acquisition at LP4. There is an additional test of PEAKXD with NUM-POS=5 at G140L at LP4. One extra orbit is requested for this additional test.

Overview of Changes

- In Cycle 28, this program tested the NUM-POS=3 PEAKXD target acquisition mechanism at LP4 for the G130M/1291, G140L/1280, and G160M/1600 modes. For G130M/1291, it also tested the NUM-POS=5 PEAKXD and PEAKD target acquisition mechanisms
- For Cycle 29, all G130M/1291 acquisition tests will be moving to LP5, while the G140L/1280 and G160M/1600 acquisition tests will remain at LP4
- We include an additional NUM-POS=5 PEAKXD scan for G140L at LP4, which adds an extra orbit to this request
 - This test is necessary at both LP4 and LP5 due to the asymmetrical nature of the COS PSF. As the PSF gets highly vignetted at the edge of the PSA, it is possible that this asymmetry would cause NUM-POS=3 and NUM-POS=5 to work differently because different parts of the PSF get vignetted. Because the effect is due to total off-axis displacement, which is due to NUM-POS plus LP, it is highly LP dependent. The results of this test also depend on the HV, which can change often and is different for each LP

Contingency Programs

COS FUV Change in Spectroscopic Sensitivity Trends

PI: Kate Rowlands

Purpose	To supplement the COS FUV Spectroscopic Sensitivity Monitor that runs every 2 months in the event that TDS trends change rapidly. With the extra orbits in this program, the TDS trends will be observed monthly.
Description	To track the TDS as a function of wavelength we obtain exposures of two standard stars (WD0308-565 and GD71) every 2 months with all FUV gratings. The monitoring sequence consists of two visits, for a total of 5 orbits. The 2-orbit visit (GD71) covers the G130M/1096/FUVB, G160M/1533/FUVA, G160M/1577/FUVA, G160M/1611/FUVA and G160M/1623/FUVA modes. The 3-orbit visit (WD0308-565) covers G130M/1222, G130M/1291, G130M/1327/FUVA, G130M/1055/FUVA, G160M/1533/FUVB, G160M/1577/FUVB, G160M/1611/FUVB, G160M/1623/FUVB, G140L/800, G140L/1105, and G140L/1280 modes.
Fraction GO/GTO Programs Supported	93% of COS exposure time in Cycle 28.
Resources Required: Observations	26 external orbits
Resources Required: Analysis	6 FTE weeks
Products	These data will be used along with the data obtained in the COS FUV Spectroscopic Sensitivity Monitor to create a new Time-Dependent Sensitivity reference file, update ETC throughputs, update the COS monitoring webpages, and write a summary ISR.
Accuracy Goals	<ul style="list-style-type: none"> • SNR of 15 per resel at wavelength of least sensitivity for the standard modes, SNR of 25 per resel at wavelength of most sensitivity for the blue modes. For the blue modes, this will ensure $S/N > 15$ for $\lambda > 1030 \text{ \AA}$ for 1096/FUVB, $\lambda > 1130 \text{ \AA}$ for 1055/FUVA and 1222/FUVB. SNR of 5 per resel in the short wavelength region for G140L/800, which yields SNR of 32 per 20 \AA bin (used in the TDS analysis). • TDS calibration better than 2% for standard modes and 5% for blue modes
Scheduling & Special Requirements	<ul style="list-style-type: none"> • This is a contingency proposal only activated in the event that TDS trends are seen to be changing rapidly • The extra monitoring sequence should occur every 2 months starting in the month the program is activated and should be the alternate month of the standard COS FUV TDS program • The FUVA turn-off of the GD71 visit should be hidden in the GS-ACQ • GD71 is not visible from late April to early August 2022, resulting in a reduced monitoring sequence for the months of May and July (1 visit)
Changes from Cycle 28	Added monitoring of cenwave 1611, which is a well-used, but non-tracked cenwave. No additional orbits are necessary.

11/3/21

COS FUV Characterization of Modal Gain When Changing High Voltage

PI: David Sahnou

Purpose	Obtain gain maps of the FUV detector before and after changes to the nominal high voltage levels. These data will be used to check that the expected modal gain is achieved for HV changes.
Description	<p>Up to two one-orbit contingency visits will be needed for each HV change made during Cycle 29. One will be taken immediately before the change using the current HV values, and one will be taken after at the new value. The team tries to coordinate HV changes close in time to the regular FUV gain map program visits, so only one visit of this contingency program may be necessary. The deuterium lamp will be used to illuminate the regions of the COS FUV detector currently in use.</p> <p>The program includes inactive visits for each LP (LP2, LP3, LP4, and LP5). When it is determined that the HV of one LP needs changing, this structure allows the program to be “ready to go” at the right LP by just selecting the correct visit.</p>
Fraction GO/GTO Programs Supported	93% of COS exposure time in Cycle 28.
Resources Required: Observations	2 internal orbits
Resources Required: Analysis	1 FTE week. Existing CCI / gain map procedures will be used to process these data as part of normal gain monitoring.
Products	Gain map files. These will be used to check that the expected modal gain is achieved after the HV has changed.
Accuracy Goals	0.1 pulse height bin
Scheduling & Special Requirements	This is a contingency proposal only activated immediately before and immediately after any HV change.
Changes from Cycle 28	Added inactive visits for LP5.