Cycle 27 COS Calibration Plan
Spring Orbit Request

May 2019

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for the COS Team

Summary of COS Orbit Requested for Cycle 27

(Programs Remaining Unchanged since Cycle 26)

Title (PI)	External	Internal	Frequency (orbits x repeats)
FUV Monitors			
COS FUV Detector Dark Monitor (Dashtamirova)		260	5x52
COS FUV Gain Maps (Sahnow)		8+(2*)	4x2 + (if HV change)
COS FUV Spectroscopic Sensitivity Monitor (Sankrit)	28+(26)		5x5 + 3x1 +(if trend changes)
COS FUV Wavelength Scale Monitor (Fischer)	3		3x1
COS FUV Target Acquisition Monitor (Sahnow)	2		2x1
NUV Monitors			
COS NUV Detector Dark Monitor (Magness)		52	2 x26
COS NUV MAMA Fold Distribution (Wheeler)		1	1x1
COS NUV Spectroscopic Sensitivity Monitor (Fischer)	4**		3x2
COS NUV Wavelength Scale Monitor (Fischer)	1		1x1
COS NUV Target Acquisition Monitor (Sahnow)	3		3x1
Contingency Programs			
COS FUV Detector Recovery After Anomalous Shutdown (Wheeler)		(17)	
COS NUV Detector Recovery After Anomalous Shutdown (Wheeler)		(4)	
Cycle 27 Spring Request	**41+ (26)**	**321+(23)**	

* Per HV change.
() indicate contingency orbits

**Original request was for 6 orbits. This was subsequently updated.

Cycle 27 vs. Cycle 26

- All of the programs remain unchanging since the Cycle 26 delta request and Spring request.
- The only modification in number of orbits requested is for the FUV TDS monitoring program. In Cycle 26 delta request, the new cenwaves (G140L/800 and G160M/1533) were only included in this program from visit 03 onwards. Now we include the new cenwaves from visit 01. This increases the number of orbits from 26 in Cycle 26 delta request to 28 in Cycle 27.

COS Side 2 Programs Carried Over to Cycle 27

- Programs are carried along each cycle's calibration plan (keeping the same ID) so that the impact of any changes to operating conditions can be evaluated and modifications to the programs implemented as needed.

- No changes are needed to the programs listed below at this time.

- **Engineering programs** (22 Internal orbits)
  - 13187 - COS Side 2 Dump Test and Verification of COS Memory Loads (1 internal orbit)
  - 13188 - COS Side 2 Science Data Buffer Check/Self-Tests for CS Buffer RAM and DIB RAM (14 internal orbits)
  - 13189 - COS Side 2 NUV Detector Recovery After MEB Side Switch (2 internal orbits)
  - 13190 - COS Side 2 FUV Detector Recovery After MEB Side Switch (4 internal orbits)
  - 13191 - COS Side 2 NUV MAMA Fold Test (1 internal orbit)

- **Science programs** (7 Internal + 4 external)
  - 13192 - COS Side 2 Initial NUV Channel Checkout (2 external orbits, 1 internal orbit)
  - 13193 - COS Side 2 Initial FUV Checkout (2 external orbits, 1 internal orbit)
  - 13194 - COS Side 2 Internal NUV Wavelength Verification (2 internal orbits)
  - 13195 - COS Side 2 Internal FUV Wavelength Verification (3 internal orbits)

Total Cycle 27 Carry Over: 29 internal + 4 external orbits

FUV Monitors

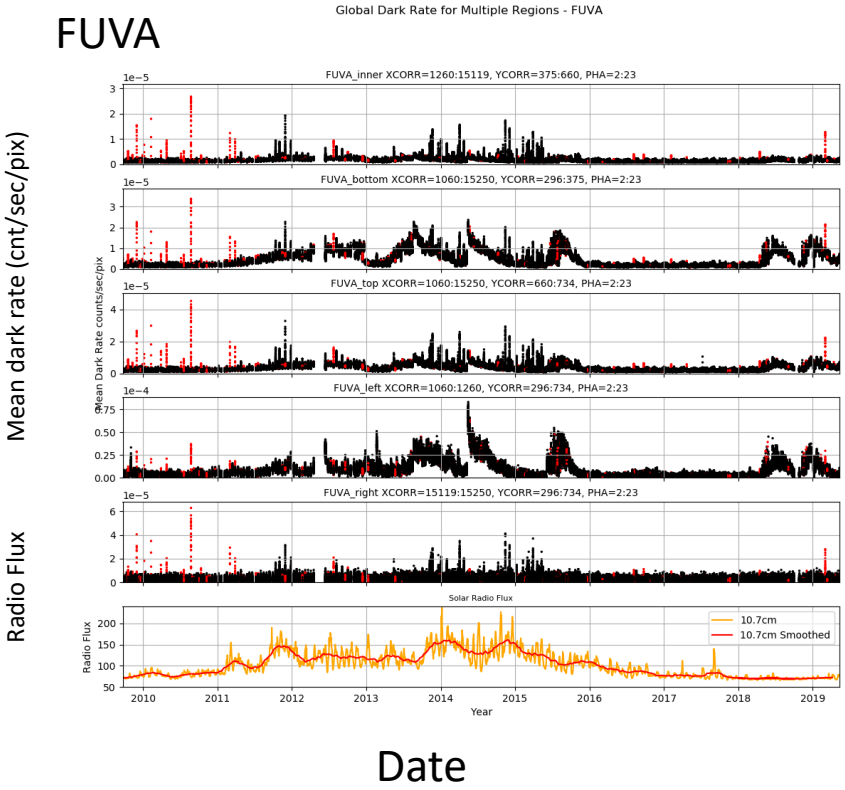
COS FUV Detector Dark Monitor
PI: Dzhuliya Dashtamirova

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 < 1800s.
Fraction GO/GTO Programs Supported	97% of COS exposure time in Cycle 26
Resources Required: Observations	260 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 26	No changes.

COS FUV Dark Rate Trends

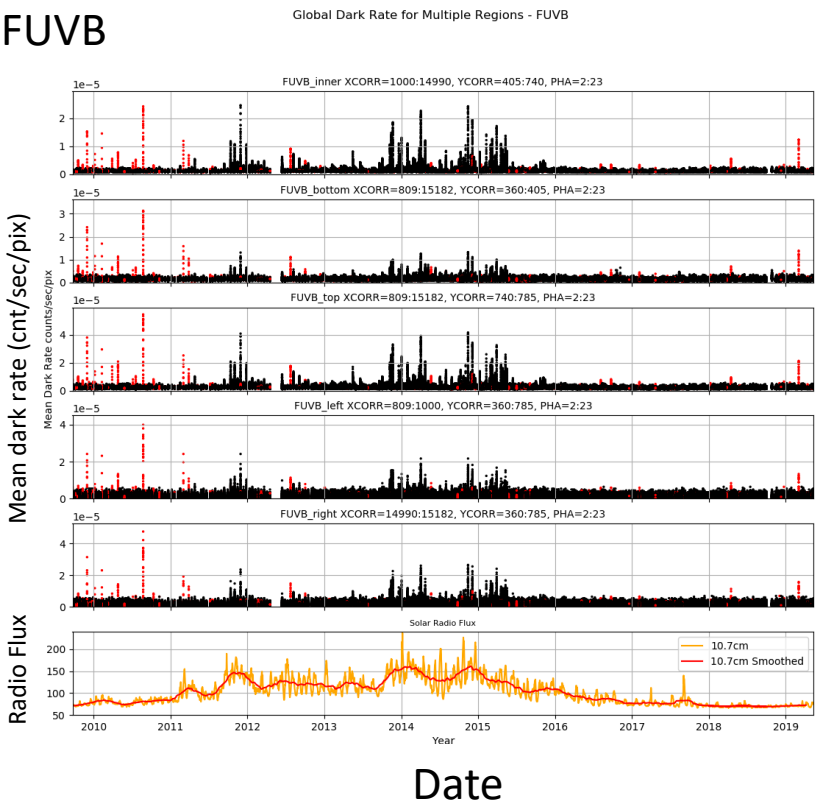
Temporal variability of the dark level

FUVA



Temporal variability of the dark level

FUVB



<u>COS FUV dark rate monitoring:</u>

- Dark rate trends are constant over the past few years
- Fewer dark-rate spikes as the radio flux from the Sun decreases (decreased solar activity)
- Baseline jump on FUVA similar in magnitude to events seen in the past.

COS FUV Detector Gain Maps
PI: David Sahnow

Purpose	Obtain gain maps of the FUV detector before and after changes to the nominal high voltage levels, and periodically during the cycle. These data will be used to check that the expected modal gain is achieved for HV changes, and to track the modal gain as a function of time.
Description	Use the deuterium lamp to illuminate the appropriate LP2/LP3/LP4 regions of the COS FUV detector at the following times: • LP4 Standard Modes: Snapshot to monitor the change in gain every 6 months (2 orbits) • LP4 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	97% of COS exposure time in Cycle 26
Resources Required: Observations	8 internal orbits
Resources Required: Analysis	2 FTE weeks. Existing CCI / gain map procedures will be used to process these data 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 and immediately before and immediately after any HV change.
Changes from Cycle 26	No changes.

COS FUV Spectroscopic Sensitivity Monitor
PI: Ravi Sankrit

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, 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/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.
Fraction GO/GTO Programs Supported	97% of COS exposure time in Cycle 26
Resources Required: Observations	28 external orbits + (26 contingency external orbits needed if major changes in trends are seen during cycle)
Resources Required: Analysis	6 FTE weeks
Products	Time-Dependent Sensitivity reference file as necessary, update to ETC throughputs, the COS monitoring webpages, and a summary ISR
Accuracy Goals	- 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 l> 1030 Å for 1096/FUVB, l>1130 Å 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 Å bin (used in the TDS analysis). - TDS calibration better than 2% for standard modes and 10% for blue modes
Scheduling & Special Requirements	• Monitoring sequence should occur every 2 months starting in December 2019 • 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 2020, resulting in a reduced monitoring sequence for the month of June (1 visit)
Changes from Cycle 26	• Added new cenwaves, G160M/1533 and G140L/800 to monitor for all visits (rather than visit 03 onwards, as in Cycle 26 delta request), resulting in two additional orbits

COS FUV Wavelength Scale Monitor
PI: Will Fischer

Purpose	This program monitors the offset (zero-point) between the wavelength scale set by the internal wavecal versus that defined by absorption lines in external target AV 75 obtained through the PSA.
Description	This program monitors the zero-point offset between the internal and external wavelength scales. To verify and monitor this, the program takes spectra of AV 75 with the G130M/1096-1222-1291-1327, G160M/1577-1623, and G140L/1105-1280 cenwaves. Spectra are compared to convolved STIS spectra and those obtained with previous iterations of the program.
Fraction GO/GTO Programs Supported	97% of COS exposure time in Cycle 26
Resources Required: Observations	3 external orbits
Resources Required: Analysis	4 FTE weeks
Products	Update of wavelength dispersion reference file, if necessary, and a summary ISR
Accuracy Goals	G140L 150 km/s, 7.5-12.5 pixels G130M 15 km/s, 5.7-7.5 pixels G160M 15 km/s, 5.8-7.2 pixels
Scheduling & Special Requirements	Executes once per cycle. ORIENT is set to avoid bright field targets, so visibility is restricted. March (15 days): preferred window to maintain pattern of ~12 months between visits.
Changes from Cycle 26	No changes.

COS FUV Target Acquisition Monitor
PI: David Sahnow

Purpose	Monitor COS FUV ACQ/PEAKD and PEAKXD Performance at LP4 (with NUM_POS > 1).
Description	At LP4 the cross-dispersion (XD) target acquisition (TA) uses the new NUM_POS > 1 algorithm for ACQ/PEAKXD. This is the same algorithm used for ACQ/PEAKD, but oriented in the XD direction. This method moves the telescope through a linear pattern of XD steps that completely or partially vignette the target light with the PSA. This allows the targets position relative to the edges of the aperture to be defined, and allows the target to be centered. This pattern moves the target up and down on the FUV detector (in Y). Because there are detector effects such as gain sag and Y-walk, and areas of the detector with non-uniform response (like previous LPs), it is desirable to monitor the FUV PEAKXD centering over multiple cycles to watch for unexpected changes. Each FUV grating is tested, and the G130M test includes an along-dispersion ACQ/PEAKD to verify the NUV-to-FUV LP4 SIAF entries in both AD and XD.
Fraction GO/GTO Programs Supported	10% of Cycle 26 target acquisitions used the FUV channel.
Resources Required: Observations	2 external orbits.
Resources Required: Analysis	1 FTE weeks for analysis and documentation.
Products	Summary ISR.
Accuracy Goals	FUV Spectroscopic XD TAs are required to center the target to within ±0.3" (~ ±3 rows), with the goal of routine centering to ± 0.1" (~ 1 row). Targets not centered to within 0.3" are subject to vignetting and loss of spectral resolution. Along-dispersion centering requirements are cenwave-specific, but the strictest requirement is ±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 26	No changes

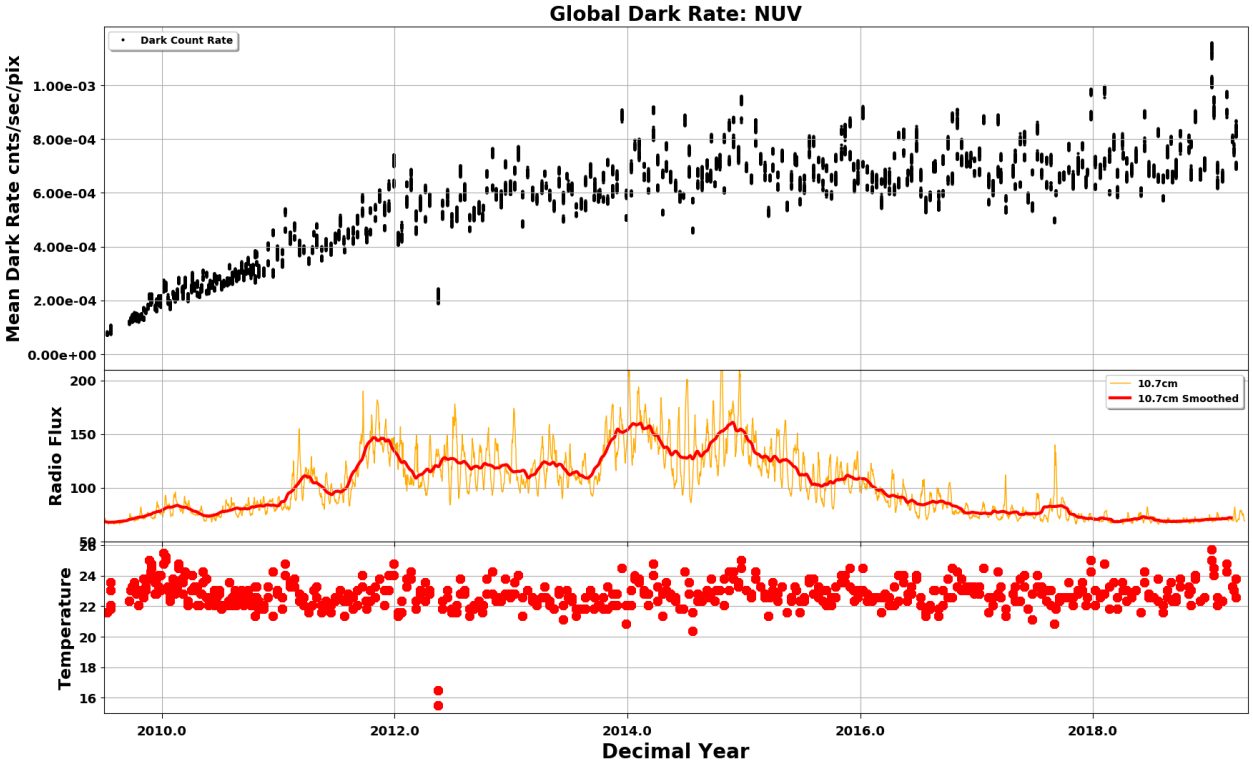
NUV Monitors

COS NUV Detector Dark Monitor
PI: Camellia Magness

Purpose	Perform routine monitoring of the MAMA detector dark current. 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 NUV detector dark rate by taking TIME-TAG science exposures without illuminating the detector. Twice every other week a 22-min exposure is taken with the NUV (MAMA) detector with the shutter closed. The length of the exposures is chosen to make them fit in Earth occultation. All orbits < 1800s.
Fraction GO/GTO Programs Supported	3% of COS total exposure time in Cycle 26
Resources Required: Observations	52 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. As allowed by resources and necessitated by data quality: update bad-pixel tables. Update monitor webpage
Accuracy Goals	30%
Scheduling & Special Requirements	Twice every other week, in Earth occultation
Changes from Cycle 26	No changes.

COS NUV Dark Trends

Temporal Variability of the Dark Level



Date

<u>COS NUV dark monitoring:</u>

- Dark rate trend shows approximately linear increase with time, flattening since ~2012
- Dark rate variability decreases as the radio flux from the Sun decreases (decreased solar activity)

COS NUV MAMA Fold Distribution
PI: Thomas Wheeler

Purpose	The fold analysis provides a measurement of the distribution of charge cloud sizes incident upon the anode providing some measure of changes in the pulse-height distribution of the MCP and, therefore, MCP gain.
Description	While globally illuminating the detector with a flat field, the valid event (VE) rate counter is monitored while various combinations of row and column folds are selected.
Fraction GO/GTO Programs Supported	~90% of Cycle 26 target acquisitions use the NUV.
Resources Required: Observations	1 internal orbit
Resources Required: Analysis	0.5 FTE day.
Products	The results are sent to the COS Team and Ball Aerospace (Steve Franka)
Accuracy Goals	5% accuracy on the peak position of the fold distribution
Scheduling & Special Requirements	This proposal is executed annually.
Changes from Cycle 26	No changes.

COS NUV Spectroscopic Sensitivity Monitor
PI: Will Fischer

Purpose	Monitor sensitivity of NUV gratings to detect any change due to contamination or other causes. Track time dependence of the sensitivity with wavelength. The NUV gratings on COS have degraded at an overall steady rate since the start of on-orbit operations, with the bare-Aluminum gratings (G225M and G285M) degrading at a faster rate (~-3 and -11%/yr) than the MgF_2 coated gratings (G185M and G230L, ~0%/yr).
Description	This program obtains exposures with NUV gratings using external targets WD1057+719 (G230L) and G191B2B (G185M, G225M). The following modes are monitored: G230L/2635-2950, G185M/1786-1921-2010, and G225M/2186-2306-2410. Due to its rapidly declining sensitivity, G285M was removed from the monitoring in Cycle 26. These cenwaves constitute the reddest, middle, and bluest central wavelengths containing only first-order light, with the exception of G230L. Current data indicate a wavelength dependence of the TDS. To better characterize this effect, observations of G185M/2010 and G225M/2306-2410 were added to the monitoring program in Cycle 24 to provide data at both the extreme cenwaves and the middle cenwaves for the M gratings. Data from another cycle are needed before reliable fits and conclusions can be made.
Fraction GO/GTO Programs Supported	3% of COS total exposure time in Cycle 26
Resources Required: Observations	4** external orbits - 2 visits of 2 orbits each.
Resources Required: Analysis	5 FTE weeks
Products	Time-Dependent Sensitivity Reference File and a summary ISR. As permitted by resources and data quality: add wavelength dependence to TDS reference files.
Accuracy Goals	Characterize evolution of TDS within 2% .
Scheduling & Special Requirements	Observe at 6 month intervals.
Changes from Cycle 26	No changes.

**Original request was for 6 orbits. This was subsequently updated.

COS NUV Wavelength Scale Monitor
PI: Will Fischer

Purpose	This program monitors the offset (zero-point) between the wavelength scale set by the internal wavecal versus that defined by absorption lines in external target HD 6655 obtained through the PSA.
Description	This program monitors the zero-point offset between the internal and external wavelength scales. To verify and monitor this, the program takes spectra of HD 6655 with the G185M/2010, G225M/2217, and G230L/2635-2950-3000 cenwaves. Spectra are compared to convolved STIS spectra and those obtained with previous iterations of the program.
Fraction GO/GTO Programs Supported	3% of COS total exposure time in Cycle 26
Resources Required: Observations	1 external orbit. Schedulability is set to 60% to fit all observations within the orbit.
Resources Required: Analysis	3 FTE weeks
Products	Update of wavelength dispersion reference file, if necessary, and a summary ISR
Accuracy Goals	G230L 175 km/s, 2.0-3.7 pixels G185M 15 km/s, 1.7-2.4 pixels G225M 15 km/s, 2.3-3.2 pixels
Scheduling & Special Requirements	Executes once per cycle. Star is in a crowded field, and all the stars have significant proper motion. Careful selection of guide stars is required. Aug/Sept (31 days): preferred window to maintain pattern of ~12 months between visits, acquire good GS pair
Changes from Cycle 26	No changes.

COS NUV Target Acquisition Monitor
PI: David Sahnow

Purpose	Monitor COS NUV Target Acquisition (TA) Parameters and Performance. Measure/monitor the WCA-to-PSA/BOA offsets used for imaging target acquisition, and WCA-to-PSA offsets for NUV spectroscopic TAs.
Description	There are 4 NUV ACQ/IMAGE mechanism combinations: 2 science apertures (SAs: PSA & BOA) x 2 mirror modes (MIRRORA & MIRRORB). During SMOV, the WCA-to-PSA+MIRRORA offset was determined by an aperture scan; the other WCA-to-SA offsets were bootstrapped from this offset. We verify the ACQ/IMAGE co-alignment in a similar manner. Three targets of different brightnesses are required to bootstrap across the pairings. All NUV spectroscopic WCA-PSA offsets, all WCA-SA imaging offsets, and co-alignment for all ACQ/IMAGE modes are monitored by this program. PSA spectra of the targets are obtained with all NUV gratings to track any changes in the spectroscopic WCA-to-PSA offsets. All FUV TA monitoring is now done in a separate program.
Fraction GO/GTO Programs Supported	90% of Cycle 26 target acquisitions used the NUV.
Resources Required: Observations	3 external one-orbit visits. Each visit uses a target of different brightness to match the ACQ/IMAGE modes being verified.
Resources Required: Analysis	2 FTE weeks for analysis, and verifying WCA-to-SA offsets. Should changes be warranted to existing offsets, additional effort will be needed, as this requires changes to the COS flight software (FSW) or SIAF.
Products	Updated NUV imaging WCA-to-SA offsets, NUV Spectroscopic WCA-to-PSA offsets and summary ISR.
Accuracy Goals	Imaging WCA-to-SA offsets need to be known to better than 0.5 NUV pixels in both dispersion and cross-dispersion (XD). Spectroscopic WCA-to-PSA offsets to 0.5 XD pixel.
Scheduling & Special Requirements	Executes annually (in the Fall). All three visits should execute within 30 days of each other.
Changes from Cycle 26	No changes.

Contingency Programs

COS FUV Detector Recovery after Anomalous Shutdown
PI: Thomas Wheeler

Purpose	The safe and orderly turn-on and ramping-up the COS FUV high voltage in a conservative manner after a HV anomalous shutdown.
Description	Day 01 activities, visits 01-07, contain both QE grid off and on HV ramping to HVLow (100/100) with diagnostics (DCE dumps) and darks to exclude QE grid involvement in the shutdown. Subsequent to day 01, all HV rampings, diagnostics and darks will be with the QE grid on. The HV commanded values for the subsequent days are: 154/151, 160/157, 167,163, etc. until the desired HV is obtained.
Fraction GO/GTO Programs Supported	This is a contingency proposal and only activated in the event of an anomalous shutdown of the FUV detector.
Resources Required: Observations	17 internal orbits
Resources Required: Analysis	If activated, 0.5 FTE day per test.
Products	After thorough data analysis for each test day, a Go/No-Go to proceed will be given.
Accuracy Goals	
Scheduling & Special Requirements	This is a contingency proposal activated only in the event of an anomalous shutdown.
Changes from Cycle 26	No changes.

COS NUV Detector Recovery after Anomalous Shutdown
PI: Thomas Wheeler

Purpose	The safe and orderly recovery of the NUV-MAMA detector after an anomalous shutdown.
Description	The recovery procedure consists of four separate tests (i.e. visits) to check the MAMA's health after an anomalous shutdown. Each must be successfully completed before proceeding onto the next. They are: (1) signal processing electronics check, (2) slow, intermediate voltage high-voltage ramp-up, (3) ramp-up to full operating voltage, and (4) fold analysis test.
Fraction GO/GTO Programs Supported	This is a contingency proposal and only activated in the event of an anomalous shutdown of the NUV detector.
Resources Required: Observations	4 internal orbits
Resources Required: Analysis	If activated, 0.5 FTE day per visit.
Products	For tests 1-3, only a Go/No-Go to proceed will be given. For test 4, the results will be sent to the COS Team and Ball Aerospace (Steve Franka).
Accuracy Goals	
Scheduling & Special Requirements	This is a contingency proposal activated only in the event of an anomalous shutdown.
Changes from Cycle 26	No changes.