STScI | SPACE TELESCOPE SCIENCE INSTITUTE

Instrument Science Report COS 2017-18

Cycle 23 COS Target Acquisition Monitor Summary

Steven V. Penton[1]

[1] Space Telescope Science Institute, Baltimore, MD

August 28, 2017

ABSTRACT

COS program 14440 was designed to verify that COS Target Acquisitions (TA) were performing nominally during Cycle 23, and to check if any of the TA patchable constants present in the COS flight software (FSW) need updating. All FUV observations in 14440 were performed at LP3, and at the nominal (LP1) NUV position. COS exposures obtained in HST program 14452 (HST Cycle 23 Focal Plane Calibration [SI-FGS Alignment]) were also used in this analysis. All three COS TA modes, FUV spectroscopic, NUV spectroscopic, and NUV imaging were verified in this Monitor. All TA modes were behaving nominally in Cycle 23, and is was determined that no SIAF, subarray, or FSW parameter updates were required during the Cycle 23 calendar period of October 1, 2015 – October 2, 2016.

Contents

1. Introduction

There are 3 modes of COS target acquisition (TA); NUV imaging and NUV and FUV spectroscopic. There are 4 COS TA (ACQ) procedures; ACQ/SEARCH, ACQ/IMAGE, ACQ/PEAKD, and ACQ/PEAKXD. ACQ/PEAKD and ACQ/SEARCH step the

telescope through dwell patterns on the sky. As long as the target light falls completely within the TA detector sub-arrays, ACQ/PEAKD and ACQ/SEARCH will continue to operate nominally. COS program 14440 verifies that all NUV and FUV TA sub-arrays are properly defined and evaluates if the actively used WCA-to-SA offsets[1] are correct. The initial HST/COS target pointing is based upon definitions of the physical locations of the COS apertures in terms of [V2,V3] in the Science Instrument Aperture File (SIAF). All of the actively used NUV (LP1) and FUV (LP3) entries all also verified in this program.

COS TA ACQ/IMAGE and ACQ/PEAKXD[2] procedures rely on TA sub-arrays and patchable constants in the COS flight software (FSW) to properly center an external target. In both ACQ/IMAGE and ACQ/PEAKXD, the internal wavelength calibration lamp is flashed to locate the wavelength calibration aperture (WCA). From its measured location on the detector, the center of the science aperture (SA) in use can be predicted by applying the FSW constants that give the SA offset compared to the WCA center for the combination of optics in use. For ACQ/IMAGE, the offset is in both the along-dispersion (AD) and cross-dispersion (XD) directions. For ACQ/PEAKXD, which uses dispersed light, this offset is only in the XD direction.

- The ACQ/IMAGE TA procedure has four combinations of two SAs, the Primary Science Aperture (PSA) and the Bright Object Aperture (BOA), and two mirror modes, MIRRORA and MIRRORB. Each combination is commonly used, and has a different WCA-to-SA offset in both AD and XD, which must be verified.

- The ACQ/PEAKXD TA procedure used in Cycle 23 relies upon FSW XD WCA-to-PSA offsets. Each COS grating, SA, and lifetime position (LP) combination has a different offset. This program verifies all 4 NUV LP1 and 3 FUV LP3 WCA-to-PSA offsets [3].

- This program does not attempt to monitor the AD accuracy of the COS spectroscopic TA modes. [4]

COS centering requirements are based on wavelength accuracy in the AD, and flux and resolution in the XD. The strictest NUV requirements are [AD,XD] = [0.041, 0.300]″. For the FUV channel, they are [AD,XD] = [0.106, 0.300]″. The XD requirement for all TAs is centering to within $\pm$ 0.3 ″ with a 1σ goal of $\pm$ 0.1″.

Other important COS program 14440 notes:

[1]No BOA spectroscopic TAs were performed in Cycle 22–23, so these offsets were not verified.

[2]Beginning in Cycle 25, the ACQ/PEAKXD algorithm will be enhanced so that two distinct algorithms can be employed. The original ACQ/PEAKXD, used in Cycles 19-24, is referred to as **NUM_POS**=1, while the Cycle 25 (LP4) algorithm uses the ACQ/PEAKD algorithm, but in the cross-dispersion (XD) direction and is referred to as the **NUM_POS**$>$ 1 ACQ/PEAKXD.

[3]For the NUV channel, 4 offsets, one for each grating, were verified at NUV LP1. For the FUV channel, 3 offsets, one for each grating, were evaluated at FUV LP3.

[4]For ACQ/PEAKD, short term fluctuations of the detector background rate due to environmental conditions remains the largest source of along-dispersion pointing error.

- The Cycle 23 monitoring program (14440) was identical in format to the Cycle 22 program (13972).
- All Cycle 23 FUV spectroscopic TAs in this program were taken at LP3[5].
- All NUV spectroscopic observations and TAs continue to be taken at the original (LP1) NUV position.

2. Results

The main results of the HST Cycle 23 COS TA monitoring program are as follows:

SIAF All COS NUV ACQ/IMAGEs use the same SIAF entry. The exposures in 14452 indicate that the existing NUV SIAF entry is accurate to at least [AD,XD] = [0.02,0.08]″.[6] No SIAF adjustments were identified as desired by this program.

TA Sub-arrays: Direct examination of NUV images and NUV and FUV spectra, indicate that all sub-arrays are appropriately defined for Cycle 23 and no adjustments were necessary.

NUV Imaging TAs: $\mathrm{ACQ/IMAGE}$ tests in program 14452 indicate that PSA/MIRRORB is co-aligned with PSA/MIRRORA to within [AD,XD] $\approx [0.010, 0.020]''$, with a measurement error of approximately $0.014''$. $\mathrm{ACQ/IMAGE}$ tests in program 14440 reveal that BOA/MIRRORA is co-aligned with PSA/MIRRORB to within [AD,XD] $\approx [0.015, 0.100]''$,[7] and that BOA/MIRRORB is co-aligned with BOA/MIRRORA to within [AD,XD] $\approx [0.007, 0.062]''$.

NUV Spectroscopic TAs: The G285M and G230L WCA-to-PSA offsets were measured after a PSA/MIRRORB $\mathrm{ACQ/IMAGE}$, and were within a XD offset of $0.020''$ of the FSW value for each grating. The G185M and G225M offsets were measured after a BOA/MIRRORA $\mathrm{ACQ/IMAGE}$, and were measured to be within a XD offset of $0.070''$ and $0.060''$, respectively, of the FSW value. Spectroscopic TAs for all NUV gratings met both the $0.3''$ requirement and the $0.1''$ goal.

FUV Spectroscopic TAs: The G130M and G140L WCA-to-PSA offsets were measured after the same PSA/MIRRORB $\mathrm{ACQ/IMAGE}$. The measured offsets were determined to be offset from the FSW values by $\approx -0.030''$ and $-0.170''$, respectively, with a measurement error estimated at $0.070''$. The G160M offset

[5]The COS FUV channel was moved to LP3 on February 15, 2015, and will be moved to LP4 on October 2, 2017.

[6]Long term SIAF monitoring is used to track any mechanical drift in the location of the COS aperture mechanism, or any changes to the FGS-to-SI alignment that will need adjusting. The last such adjustment was in Cycle 22 (February 2, 2014), while COS FUV observations were at LP2.

[7]The larger XD alignment error is due to a frequent 1 aperture XD (XAPER) step mechanism position error (1 step $\sim 0.048''$).

was measured after a BOA/MIRRORA $\mathrm{ACQ/IMAGE}$, and determined to have a WCA-to-PSA XD offset of $-0.020 \pm 0.070''$, respectively, of the FSW WCA-to-PSA value. Spectroscopic TAs for all FUV gratings met the $0.3''$ requirement and the G130M and G160M gratings achieved the $0.1''$ goal.

3. Conclusions

All COS TA modes were verified to be operating within the requirements during HST Cycle 23. All COS SIAF NUV (LP1) and FUV (LP3) entries were determined to be accurate to the needs of COS operations, and all TA and science mode NUV (LP1) and FUV (LP3) subarrays were determined to be correctly defined. Spectroscopic TAs for all NUV gratings met all XD centering requirements. All three FUV gratings indicated some level of Y-walk in the WCA-to-PSA offsets as they were all in the -XD direction. Only the G140L WCA-to-PSA offset indicates a potential Y-walk problem as its offset error ($0.17''$) is larger than the $0.1''$ XD centering goal and is $\approx 60\%$ of the XD centering requirement. Continued monitoring of the FUV WCA-to-PSA offsets is warranted in Cycle 24 to ensure that FUV spectroscopic TAs are properly centering targets in the XD. Complete details of program 14440 and the Cycle 23 COS TA monitoring program are presented in separate ISRs.