Instrument Science Report HST+COS 2018

Cycle 21-24 HST+COS Target Acquisition Monitoring

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ABSTRACT

This ISR documents the Cosmic Origins Spectrograph (COS) Target Acquisition (TA) monitoring programs for HST Cycles 21–24. During this period, FUV exposures were executed at Lifetime Positions LP2 and LP3, and all NUV exposures were obtained at the nominal (LP1) position. These programs were designed to monitor numerous aspects of both imaging and spectroscopic COS TAs, including checking the TA subarrays, monitoring the required flashes of the internal PtNe lamps, and evaluating the accuracy of numerous COS flight software (FSW) patchable constants required for TA. This project verified that all three COS TA modes (FUV spectroscopic, NUV spectroscopic, and NUV imaging) were, on large, behaving nominally in Cycle 21-24, and determined that no SIAF or FSW parameter updates were required during this time, with the exception of changes to MIRRORB `ACQ/IMAGE` MIRRORB in 2014. These changes included a changing of the lamp current from LOW to MEDIUM, an adjustment of the `LTACAL` exposure time, and a modification of both the MIRRORB WCA and PSA/BOA `ACQ/IMAGE` TA subarrays.

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1 Introduction

Preliminary results of the Hubble Space Telescopes' (HST) Cosmic Origins Spectrograph (COS) target acquisition (TA) programs reviewed here were previously reported in the following COS ISRs:

- COS ISR 2015-02 (Summary of the COS Cycle 20 Calibration Program)
- COS ISR 2015-06 (Summary of the COS Cycle 21 Calibration Program)
- COS ISR 2016-03 (Summary of the COS Cycle 22 Calibration Program)
- COS ISR 2016-09 (Cycle 22 COS Target Acquisition Monitor Summary)
- COS ISR 2017-18 (Cycle 23 COS Target Acquisition Monitor Summary)
- COS ISR 2018-09 (Cycle 24 COS Target Acquisition Monitor Summary)

The information in this ISR supercedes any previous preliminary results or conclusions.

This ISR provides the full details of the following HST+COS calibration **P**rograms:

- **P**13124 (COS Imaging TA and Spectroscopic WCA-PSA/BOA offset verifications, Cycle 20)
- **P**13526 (COS Imaging TA and Spectroscopic WCA-PSA/BOA offset verifications, Cycle 21)
- **P**13972 (COS Imaging TA and Spectroscopic WCA-PSA/BOA offset verifications, Cycle 22)
- **P**14440 (COS Imaging TA and Spectroscopic WCA-PSA/BOA offset verifications, Cycle 23)
- **P**14857 (COS Imaging TA and Spectroscopic WCA-PSA/BOA offset verifications, Cycle 24)

1.1 Introductory Notes and Conventions

There are a few COS conventions to be established before discussing the TA monitoring in detail.

1. COS TAs are performed in raw or "detector" coordinates, not the "user" coordinate system of calibrated COS files. To avoid confusion over the different coordinate systems, we will use along-dispersion (AD) and cross-dispersion (XD) whenever possible. All references to the coordinates "X" and "Y" are in the detector coordinate system unless otherwise specified. In raw NUV coordinates, +X is -XD and +Y is -AD. In raw FUV coordinates, +X is -AD and +Y is +XD. The transformations between user and detector coordinates are :

$$NUV : X_{user} = 1023 - Y_{detector} \, ; Y_{user} = 1023 - X_{detector} \tag{1}$$

$$FUV : X_{user} = 16383 - X_{detector} \, ; Y_{user} = Y_{detector} \tag{2}$$

2. When referencing NUV pixels, we will abbreviate pixel as p. For the FUV, we use DE (or rows/columens) to reference the FUV digital elements.

3. When discussing the various subarrays used during COS TA, boxes will be specified by giving the lowest valued corner (C) and full size (S) for both X and Y. A box is fully specified by giving its XC, XS, YC, & YS. In this TIR, these will always be given in detector coordinates.

4. To clarify the names and locations of various TA parameters, the following convention will be used :
   - COS TA modes and their optional parameters will be in `Courier` (e.g., `ACQ/IMAGE` and `NUM_POS`).
   - Keywords in FITS headers will be in *ITALICIZED ALL CAPITALS* (e.g., *ACQSLEWY*).
   - Flight SoftWare parameters (FSW) will be in SMALL CAPITALS. All TA FSW patchable constants begin with "PCTA_" (e.g., PCTA_CALTARGETOFFSET). In this ISR, this prefix is considered implied after the initial introduction of a paramater, and will not always be included. FSW patchable constants relating to mechanism positions begin with PCMECH_ and will always be included in references.
   - Archived COS files are in FITS (.fits) format. FITS filenames, or portions of a filename, will be in sans-serif (e.g., ld9mg2nrq_rawtag.fits or _spt.fits). COS filenames are in the form IPPPSSOOT_*extension*.fits. The HST naming convention breaks down for COS as I=Instrument="L", PPP=Program ID, SS=Visit ID, OO=Exposure ID, and T="Q" for nominally recorded observations. See the COS DHB for a full breakdown of the HST IPPPSSOOT naming conventions. COS TA files have the *extension* of rawacq, and additional information useful for TA analysis is contained in the IPPPSSOOT_*spt*.fits file known as the support file, and in the IPPPSSOOT_*jit/f*.fits file known as the jitter files.
5. COS contains numerous FUV and NUV central wavelength settings, which are defined in the FSW by the OSM1 or OSM2 rotation positions. In this ISR, the term *CENWAVE*, which is also the FITS keyword name, will be used to mean any of the pre-defined OSM1 + OSM2 rotation settings that uniquely define a central wavelength setting.
6. COS *CENWAVE*s are named for the (predicted) lowest wavelength that lands on the FUVA detector segment for *FP-POS*=3. For convienence, when referring to a specific *CENWAVE* we will either call out the grating and *CENWAVE* is use as GRATING/*CENWAVE* (e.g. G130M/1222), or just use a leading "C" to identify a particular *CENWAVE* (e.g., C1222) in the same manor as "G" is used for GRATING (e.g., G130M). Note that the FITS header keyword equivalent of GRATING is *OPT_ELEM*.
7. Unless specified, all spectroscopic exposures were taken at *FP-POS*=3.
8. When referring to an HST program number, we will use either "HST PID" or a leading "**P**" in a similar fashion an "C=*CENWAVE* " and "G=GRATING", but using a **bold** font.
9. The COS FUV detector has two independent segments, Segment-A and Segment-B. In this ISR, they will be referred to as FUVA & FUVB.
10. `ACQ/IMAGE` can use either of two "MIRROR" modes, MIRRORA or MIRRORB. In this ISR, they will be referred to as MIRA & MIRB.
11. Following the conventions used in APT and the Phase II Proposal Instructions (Rose et al., 2017), NUV `ACQ/PEAKXD` exposures will specify which `STRIPE`[1] is used during TA. In

[1] `STRIPE` is the optional parameter name in APT, therefore the `Courier` font is used.

this ISR, we will always use the default (`STRIPE=DEF`) for a given *CENWAVE* . This default is `STRIPE=MEDIUM` (or STRIPE=B) for all *CENWAVE*s , except G230L/3360 where it is `STRIPE=SHORT` (STRIPE=A).

12. When referring to a particular day, we will use YEAR.DAY. For example, day 60 of 2010 will be referred to as 2010.060. We will also occasionally use decimal years. In these cases, there will only be a single digit in the fractional part (e.g., 2009.9).

13. HST observations are grouped in approximately annual "cycles". 'C##' will be used as shorthand for "HST Cycle ##" (e.g., Cycle 19 = C19).

14. Unit abbreviations:
    - Milli-arcseconds (0.001″) will be abbreviated as mas.
    - Milli-amperes (0.001A) will be abbreviated as mA.
    - Counts per second will be abbreviated as cps.

15. COS has two internal PtNe wavelength calibrations lamps that send light through the Wavelength Calibration Aperture (WCA) and onto the detectors.The two PtNe lamps are referred to in this ISR as P1 and P2. Each lamp has three current settings, LOW, MEDIUM (MED) or HIGH. The P1 lamp is used for spectroscopic lamp flashes during science exposures ("TAGFLASH"es), while the P2 lamp is used for all TA exposures. Both lamps have MED current settings of 10 mA, but the P1 lamp has LOW/HIGH current setting of 6/18 mA. The P2 lamp has LOW/HIGH current settings of 3/14 mA. COS Lamp output generally scales as current^2 ($P = I^2R$).

16. **Note to reviewers: I often switch back and forth between the APT TA routine names (ACQ/) and the FSW equivalents (LTA..). If you find this confusing, I can put in a conversion table and establish a convention for when I use each flavor. Please advise.**

1.2 ISR Organization

In § 2 we will discuss the concepts involved in the TA monitoring strategy along with a basic review of COS TA operations and centering requirements (§ 2.1). In § **??** we will discuss the details of the individual COS TA monitoring programs and, in § 3.4 list the individual exposures. Also in this section, we will discuss the annual HST FGS-to-SI alignment programs and there connection to the COS TA monitoring programs (§ 3.1).

In § 4, we discuss the numerous detector subarrays used in COS TA, and their verification by the programs in this ISR.

In § **??** we will discuss the verification of the FSW parameters, lamp operations, and subarrays associated with COS `ACQ/IMAGE`s.

In § 6, we will discuss the verification of the FSW parameters, lamp operations, and subarrays associated with COS spectroscopic TAs.

2 COS TA Operations Summary

There are three modes of Target Acquisition (TA) for the Cosmic Origins Spectograph (COS); NUV imaging, NUV spectroscopic, and FUV spectroscopic. There are four COS TA (`ACQ/`) procedures; `ACQ/IMAGE`, `ACQ/PEAKD`, `ACQ/PEAKXD`, and `ACQ/SEARCH`. `ACQ/PEAKD` and `ACQ/SEARCH` step the telescope through dwell patterns on the sky. As long as the target light falls correctly within the TA detector sub-arrays, `ACQ/PEAKD` and `ACQ/SEARCH` will continue to nominally assist in TA (barring any unforeseen anomalies, such as detector 'hot-spots'). The `ACQ/IMAGE` and `ACQ/PEAKXD` procedures also rely on the sub-arrays, but also rely on numerous patchable (changeable) constants in the COS flight software (FSW) which assist in target centering.

In both `ACQ/IMAGE` and `ACQ/PEAKXD`, the internal wavelength calibration lamp is flashed to locate the center of the wavelength calibration aperture (WCA). From this location, the center of the science aperture (SA) in use, which could be the PSA or BOA, can be predicted by applying the FSW constants that give the SA offset compared to the WCA center. For `ACQ/IMAGE`, the offset is in both detector 'X' (along-dispersion, AD) and 'Y' (cross-dispersion, XD). For `ACQ/PEAKXD`, which uses dispersed light, this offset is only in the Y (XD) direction. All programs verify that the TA subarrays in use for the given cycle were proper for the `ACQ/m`odes tested, verify that the actively used WCA-to-SA offsets, and monitor, as much as possible, the performance of COS TAs.

To combat the effects of FUV gain sag, the FUV `ACQ/PEAKXD` algorithm was modified in C19 to only use the FUVA segment. All FUV `ACQ/PEAXKD` exposures discussed in this ISR are FUVA-only. [2]

BOA spectroscopic TAs were not supported during C19–C24, accordingly the programs discussed here only verify PSA spectroscopic TAs. WCA-to-PSA offsets are used in `ACQ/PEAKXD`s, and each COS grating has a different XD offset. These offsets are both grating (OPT_ELEM) and lifetime position (LP) dependent.[3] The programs listed here verify the NUV LP1 as well as FUV LP2[4] and LP3[5]. The FUV LP4 uses a different `ACQ/PEAKXD` algorithm (`NUM_POS`>1), and, like `ACQ/PEAKD`, does not use the WCA-to-SA XD offsets[6].

The initial HST/COS target pointing is based on 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 LP2 and LP3. SIAF entries used for TA during C21–C24 are also verified in this program.[7]

These programs, and this ISR, do not attempt to monitor the AD accuracy of the COS spectroscopic TA modes.[8]

[2] The change went into effect on April 18, 2011 (2011.101).

[3] In the COS FSW, these WCA-to-SA XD offsets are stored in the PCTA_CALTARGETOFFSET table.

[4] The default COS FUV spectral location for all *CENWAVE*s was moved from LP1 to LP2 on July 23,2012 (2012.205).

[5] The default COS FUV spectral location was moved to LP3 on February 15, 2015 (2015.046) for all *CENWAVE*s except G130M/1055 and G130M/1096, which still operate at LP2. On October 2, 2017 (2017.275), the default FUV spectral location was moved to LP4, with additional observing and TA constraints as outlined on the COS2025 website (http://www.stsci.edu/hst/cos/cos2025).

[6] All NUV and FUV LP1-3 `ACQ/PEAKXD` observations use the optional parameter, `NUM_POS`=1.

[7] These entries are not really really tested that accurately, because ....

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

2.1 COS TA Centering Requirements

The COS TA centering requirements are based upon the wavelength accuracy requirements in the AD, and for flux and resolution optimization in the XD.[9] The strictest NUV requirements are [AD,XD] = [0.041, 0.3]$''$, while for the FUV they are [AD,XD] = [0.106, 0.3]$''$.[10] Since the AD requirement is in units of km s^{-1}, it is detector, grating, and wavelength dependent as defined in equations 3–9.

$$\Delta\ AD(G185M@1825\AA) = \frac{15 \text{ km s}^{-1} \times 1825\AA}{c \times 0.037\AA/p \times 42.47p/''} = 0.058'' \tag{3}$$

$$\Delta\ AD(G225M@2250\AA) = \frac{15 \text{ km s}^{-1} \times 2250\AA}{c \times 0.035\AA/p \times 42.47p/''} = 0.076'' \tag{4}$$

$$\Delta\ AD(G285M@2850\AA) = \frac{15 \text{ km s}^{-1} \times 2850\AA}{c \times 0.040\AA/p \times 42.47p/''} = 0.084'' \tag{5}$$

$$\Delta\ AD(G230L@2450\AA) = \frac{175 \text{ km s}^{-1} \times 2450\AA}{c \times 0.390\AA/p \times 42.47p/''} = 0.086'' \tag{6}$$

$$\Delta\ AD(G130M@1300\AA) = \frac{15 \text{ km s}^{-1} \times 1300\AA}{c \times 0.00997\AA/p \times 43.5p/''} = 0.150'' \tag{7}$$

$$\Delta\ AD(G160M@1600\AA) = \frac{15 \text{ km s}^{-1} \times 1600\AA}{c \times 0.01223\AA/p \times 42.9p/''} = 0.153'' \tag{8}$$

$$\Delta\ AD(G140L@1800\AA) = \frac{150 \text{ km s}^{-1} \times 1800\AA}{c \times 0.08030\AA/p \times 45.4p/''} = 0.247'' \tag{9}$$

Assuming that the wavelength error budget is split evenly between the COS TA and wavelength scale accuracies, the error budgets for the COS gratings, in arc-seconds ($''$), are given in Table 2.1. By "evenly" we mean that when added in quadrature the total error budget is that given by the second column of Table 2.1. Setting the TA error budget equal to the wavelength scale accuracy, the AD TA requirement given in the third column is the second column divided by $\sqrt{2}$.

[9] The COS requirements are documented in the CEI (Contract End Item) Specification (Smith et. al., 2004).

[10] While the XD requirement for all TAs is $\pm$ 0.3$''$, our 1σ goal is $\pm$ 0.1$''$. This goal ensures that spectra fall on a consistent XD location on the the detector, which aids in extraction and calibration accuracy.

Table 1. COS TA Centering Requirements

OPT_ELEM	Total AD Error Budget	AD TA Requirement[a]	XD TA Requirement[x]
		NUV	
G185M	$0.058''$	$0.041''$	$0.3(0.1)''$
G225M	$0.076''$	$0.054''$	$0.3(0.1)''$
G285M	$0.084''$	$0.059''$	$0.3(0.1)''$
G230L	$0.086''$	$0.061''$	$0.3(0.1)''$
		FUV	
G130M	$0.150''$	$0.106''$	$0.3(0.1)''$
G160M	$0.153''$	$0.108''$	$0.3(0.1)''$
G140L	$0.247''$	$0.175''$	$0.3(0.1)''$

[a]Assuming the total AD error budget (column 2) is split equally between TA centering and wavelength scale accuracy, the AD TA requirements (column 3) are $1/\sqrt{2}$ of the total AD error budget (equations 3–9).

[x]The XD requirement is $0.3''$, but our 1σ goal is $0.1''$.

3 Program Descriptions

COS ACQ/IMAGE has four commonly used combinations of two Science Apertures (SAs), the Primary Science Aperture (PSA) and the Bright Object Aperture (BOA), and two mirror modes, MIRA and MIRB. During the 2009 servicing mission orbital verification (SMOV) phase, a series of C17 calibration programs in NUV imaging mode (**P**11469, **P**11473, & **P**11471) carefully determined the two-dimensional offset from the COS WCA to the center of the PSA when observed with MIRA. These X and Y offsets were loaded in the FSW TA parameters[11]. A target was then centered using a PSA+MIRA ACQ/IMAGE, then a target image was taken along with a MIRB image of the WCA image. These images were used to determine the AD (Y) and XD (X) offsets of the image target and WCA centroids. These values were uploaded in the FSW paramaters. This bootstrapping procedure was repeated with the BOA+MIRA and BOA+MIRB ACQ/IMAGE modes until all four ACQ/IMAGE modes were co-aligned.

In the COS TA Monitoring programs described in this ISR, we re-use this bootstrapping strategy to test the co-alignment of all four ACQ/IMAGE modes[12]. In addition to COS calibration programs listed above, and described in detail is § **??**–3.4, COS ACQ/IMAGE exposures obtained in numerous cycles of the "Focal Plane Calibration (SI-FGS Alignment)" series were used in the COS TA monitoring discussed in this ISR. These programs were developed by the HST Telescope's division (PIs Cox and/or Lallo) for Fine Guidance Sensor (FGS) to Science Instrument (SI) alignment, and are described in § 3.1.

All data for a given cycle were intentionally taken contemporaneously to avoid any long-term detector or spacecraft effects from affecting our results. Our requirement was that all data for a given program were taken within 45 days of each other. There were minor differences in the specific exposures in each cycles TA monitoring program, these are discussed in § 3.3.

3.1 FGS-to-SI Programs

From C17–C23, an FGS-to-SI program executed with COS visits twice a year. These programs contained COS exposures designed to assist in the monitoring of the COS NUV alignent to HST. These programs used the same two target stars with COS in visits spaced six months apart. Both visits observed the astrometric open cluster M35, at orientations that were 180° apart. The two stars observed were 206W3 (in the Fall) and 427W3 (in the Spring). Due to time constraints, the exact content of the COS visits in these programs varied from year to year.

However, the COS portion of each program begins with a PSA×MIRA ACQ/IMAGE on a target should be approximately centered due to observations with other instruments earlier in the visit. Post-observation telemetry data, an the results of the ACQ/IMAGE, are used to refine this assumption. This process verifies the COS NUV PSA aperture position[13] in the SIAF to about 0.5 pixels or (0.012″).

[11] In the COS FSW, these WCA-to-SA offsets are stored as patchable constants in the PCTA_XIMCALTARGETOFFSET (XD) and PCTA_YIMCALTARGETOFFSET (AD)

[12] The underlying assumption of these programs is that that the PSA/MIRA ACQ/IMAGE centering has not changed since SMOV.

[13] Specifically, the *LFPSAA* SIAF entry.

Table 2. Historical List of FGS-to-SI proposals used for COS TA Monitoring.

PID	Cycle	Summary of Contents
P11878	C17	2 sets of PSA `ACQ/IMAGE`s, Target+Lamp TT images, & G230L Spectra
P12399	C18	2 sets of PSA `ACQ/IMAGE`s, 1 set of Target+Lamp TT images + G230L Spectrum (427W3)
P12781	C19	2 sets of PSA `ACQ/IMAGE`s
P13171	C20	2 sets of PSA `ACQ/IMAGE`s
P13616	C21	2 sets of PSA `ACQ/IMAGE`s
P14035	C22	2 sets of PSA `ACQ/IMAGE`s
P14452	C23	2 sets of PSA `ACQ/IMAGE`s, with Lamp-Only TT images after each `ACQ/IMAGE`

After this PSA×MIRA `ACQ/IMAGE`, a PSA×MIRB `ACQ/IMAGE` is then performed (together, a "set"). This bootstraps the PSA×MIRB centering to the PSA×MIRA and to the SIAF verification. This allows us to monitor the properties of the PSA×MIRB image in a controlled way on a centered target.

The historical list of FGS-to-SI proposals, HST cycles (C##), and content are given in Table 2. Where possible, time-tag (TT) images of the lamps and/or targets, along with NUV G230L spectra were acquired.

3.2 COS TA Monitoring Program Structure

Each cycles TA monitoring program contains three single-orbit visits. The number of visits is mandated by the bootstrapping technique between the four different `ACQ/IMAGE` SA×MIR combinations.

Each visit begins with a comparison of the centering of two `ACQ/IMAGE` modes out of the possible four science apertures (SA, PSA or BOA) × (MIRA or MIRB). This back-to-back `ACQ/IMAGE` process allows us to test that all `ACQ/IMAGE` modes are centering the target to the same point in the aperture. This comparison involves not only the `ACQ/IMAGE`s, but NUV detector images of the PtNe lamp (WCA) image and, if possible, coeval target images. These direct lamp+target comparisons are only available for the PSA modes. For the BOA modes, the WCA lamp images and target images are taken consecutively. The lamp+target exposures are interleaved throughout the visit to measure and verify the imaging WCA-to-SA offsets are still accurate for each HST Cycle. Images will usually use the PtNe#2 (P2) lamp, as it is the primary TA lamp, but some images will use PtNe#1 (P1) to monitor both lamps in imaging mode.

In its generic format, the three, one-orbit, visits are configured as follows:

- The first orbit on each program is designed to test the co-alignment of the PSA×MIRA and PSA×MIRB `ACQ/IMAGE` combinations. However, this exact combination of `ACQ/IMAGE`s occurs at the end of each semi-annual visit in the FGS-to-SI alignment programs (see § 3.1). This visit was usually treated as an on-hold contingency visit in case, for whatever reason, the fall visit of the program did not execute in a given cycle.[14] The target for this contigency

[14]Beginning with Cycle 23, this program was replaced with an improved process for aligning the FGSs. Accord-

visit is 206W3, the same target as the Fall visit of the FGS-to-SI alignment program. As discussed further in § **??**, in one case, (C22, **P**13972), this visit was re-purposed to verify a change to the MIRB`ACQ/IMAGE` configuration required due to the increasing background (see § **??**).

- The second orbit of each program takes back-to-back PSA×MIRB and BOA×MIRA `ACQ/IMAGE`s and target (WD1657+343) TIME-TAG images (with lamp flashes). Additionally, NUV and FUV spectra are acquired to test their WCA-to-PSA offsets.

- The third orbit of each program takes back-to-back BOA×MIRA and BOA×MIRB `ACQ/IMAGE`s and target (HIP66578) TIME-TAG images (with lamp flashes). Additional NUV and FUV spectra are acquired to the remaining WCA-to-PSA offsets not tested in the second orbit.

- All visis were executed with in the APT 3-Gyro mode (`3GOBAD`) with the `BASE1B3` guide star requirement set in APT.

The exact configuration of which gratings and which *CENWAVE*s were spectroscopically tested varied with each cycle as the programs evolved. Specifically, with the 2015 change in OSM2 home position[15], NUV spectra were re-ordered for efficiency and some NUV *CENWAVE*s were changed to those that are known to have strong *STRIPE*=B WCA spectra against the increasing detector background (Fix, 2018) and declining NUV sensitivity (Taylor, 2017). In C23–C24, we took G160M/1600 exposures offset in XD by $\pm 0.7''$[16] to test for the effects of Ywalk on FUV spectra at LP3. In addition, one visit of each program, usually the second visit, performed an annual ”family portrait” of all the P1/P2 MIRA/B WCA lamp images to track any drifting of the centroids, or changes in the lamps with time. Further details on the differences between the programs is provided in § 3.3.

3.3 Differences between HST+COS TA monitoring programs

There are several important differences between the various versions of the COS TA monitoring programs:

- In the initial, C20, version of the TA monitoring program (**P**13124), the PSA×MIRB + BOA×MIRA `ACQ/IMAGE` visit (‘01’, 24-Oct-2013), contained G230L/3000, G285M/2850, G130M/1309 & G140L/1280. The BOA×MIRA + BOA×MIRB `ACQ/IMAGE` visit (‘02’, 01-Nov-2013) contained G185M/1890, G225M/2306, and both BOA and PSA G160M/1623 spectra. A 2×2 `ACQ/SEARCH` proceeded the BOA×MIRA `ACQ/IMAGE` in visit ‘02’ due to some uncertainty in the rather large (> 400 mas/yr) proper motion of the target (HIP66578).

- In the C21 TA monitoring program (**P**13526), the a 2×2 `ACQ/SEARCH` present in the beginning of Visit ‘02’ was removed after further verification of the proper motion. Also, the G160M BOA spectrum was dropped in favor of the $\pm 0.7''$ `POS_TARG` exposures to monitor

ingly, we activated this contingency visit to obtain the necessary PSA×MIRA and PSA×MIRB exposures.

[15] In May 2015, the “home” position of the COS Optic Select Mechanism #2 (OSM2, the NUV grating wheel) was changed from G185M/1850 to the MIRA position to reduce wear on the OSM, increase observing efficiency, and reduce mechanism drift and position offsets during `ACQ/IMAGE` TAs. (see HST PR#80893 and PR#80894).

[16] Offsets set by using APT exposure level *POS_TARG*s.

gain sag/Ywalk at LP2 in Visit '02' (17-Nov-2014). In addition, a 'family portait' of the P1 and P2 PtNe lamps were acquired using both MIRA and MIRB NUV imaging. The MIRA lamp images were taken for both the P1 and P2 lamps at LOW current, while for MIRB image the P1 lamp image was taken at LOW current and the P2 lamp was at MED current. Additionally, the C21, **P**13526, contingency visit '03' was activated to verify the count rates associated with the re-configuration of the the MIRB `ACQ/IMAGE` lamp flash of the MIRB `LTACAL` exposures for P2 from LOW to MED current. All MIRB lamp images in the C21 program were also taken at MED current, as compared to LOW for the C20 program. Further details on the MIRB `ACQ/IMAGE` adjustments are given in § **??**.

The optional parameter `WAVECAL=YES` in the BOA×MIRA target+Lamp image of the C20 program was discovered to not have taken the expected internal lamp image expected in the LC6601RYQ_rawtag.fits exposure. Correcting this inconsistency would have required significant APT, TRANS, and commanding changes. As this internal calibration exposure combination is rarely executed, the C21 program included separate `TARGET=WAVE` companion lamp exposures for the target BOA exposure[17] A second MIRA lamp image was added directly after the BOA×MIRA `ACQ/IMAGE`, to verify the repeatability of the WCA lamp location when moving the BOA into and out of position. To create time for the new exposures, the exposure times of the spectroscopic observations were scaled back, but still achieved the required S/N to measure the XD spectral locations.

- In the C22 TA monitoring program (**P**13972), the G185M and G285M exposures were changed from C2850 to C2676 and from C1890 to C1913, respectively, as the WCA lamp spectra much stronger in the latter `STRIPE=B` bandpasses. Beginning with C22, GOs were discouraged from using the G285M for spectroscopic PEAKXD TAs, and the *CENWAVE*s for the other NUV gratings were highlighted in section 2.6 (NUV Spectroscopic Acquisitions) of the C25 COS Instrument Handbook (Fox, 2017) and C25 Phase II Proposal Instructions (Rose, et al., 2017). Prior to C25, GOs were contacted directly by their Contact Scientists (CS) to ensure the success of their NUV spectroscopic `ACQ/PEAKXD`s. The contingency visit ('03') was not executed in C22.
- In the C23 TA monitoring program (**P**14440), each of the one-orbit visits was placed in a non-interruptable sequence to prevent guide-star (GS) re-acquisitions (reacqs) from changing the telescope pointing during a visit. None of the previous visits encountered this situation, but the use of the non-interruptable sequences in APT requires this to be true for this, and all all subsequent programs. The lamp 'family portrait' in Visit '02' is contained in a separate non-interruptable sequence from the other exposures in the visit as any GS reacqs would not affect the internal lamp exposures. Some exposures were slightly lengthened to take advantage of the increased efficiency of the modified OSM2 home position.[18] The contingency visit ('03') was not executed in C23.

[17] The COS apertures are physically configured such that WCA light lands on the detector(s) when the PSA in place, but does not when the BOA is in place (INSERT REF). Therefore, whenever lamp images are required to verify BOA `ACQ/IMAGE` exposures, the BOA is replaced by the PSA so that WCA light falls on the detector at the same location as it would fall for a PSA image.

[18] The OSM2 home position was changed from G185M to MIRA on July 6, 2015 (2015.157).

- In the C24 TA monitoring program (**P**14857), the visit names were changed from '01', '02', and '03' to 'BA', 'BB', and 'PB' to indicate which `ACQ/IMAGE` mode was being tested; PB = PSA×MIRB, BA = BOA×MIRA, and BB = BOA×MIRB. Visits 'BA' and 'BB' of the C24 program are identical to visits '01' and '02' of the C23 program in all other regards. Visit 'PB' of the C24 program is noticeably different than the contingency visit '03' in C23 program. The 'PB' visit only includes those exposures absolutely required to compare the `ACQ/IMAGE` accuracy of PSA×MIRA to PSA×MIRB, while the C23 program also obtained spectra of all three FUV gratings for additional monitoring of spectroscopic TA performance under the assumption that detector 'Y-walk' monitoring would benefit from additional observations near the end of the FUV LP3 lifetime. As all three visits of 14857 executed near the end of the LP3 lifetime, these additional exposures were not required. The C24 version of the FGS-to-SI program was replaced with an improved program (**P**14867[19]) for aligning the FGSs which did not allow the inclusion of these `ACQ/IMAGE` exposures[20]. For C24, we activated this visit to obtain the needed PSA×MIRA to PSA×MIRB `ACQ/IMAGE` alignment verification.

3.4 Exposure Lists

Table 3 gives the operational details of all NUV imaging exposures which opened the external shutter used in this ISR. Table 4 gives the operational details of all NUV imaging WAVECAL exposures Tables 5 and 6 give the details of all spectroscopic exposures used in this ISR. All tables follow the convention that if an entry was extracted from a FITS header, then the column name will appear in *ITALICIZED ALL CAPITALS*.

The columns of the Table 3 give:

1. *ROOTNAME* gives the IPPPSSOOT of the COS exposure,
2. *PROPOSID* gives the HST program id (PID),
3. *TARNMAME* gives the target name as present in the MAST archive,
4. *OBSMODE* gives the observation mode, where "TT" is used for Time-Tag observations,
5. *EXPTYPE* gives the exposure type, which is either `ACQ/IMAGE` or EXT/SCI. *APERTURE* = PSA EXT/SCI images allow co-eval target and lamp images for direct measurement of their WCA-to-SA offset. `ACQ/IMAGE` exposures return before and after target images in OBSTYPE=ACCUM, but do not return lamp images.
6. *EXPTIME* gives the exposure time in seconds. For EXT/SCI PSA images, the lamp time may be different. These lamp times are given in Table **??**.
7. PtNe Lamp# gives the wavelength calibration lamp name, P1 or P2.
8. Lamp Current gives the lamp current setting. The conversion from current setting to current in milli-amps (mA) is given in § 1.1, and in the table footnotes.
9. *APERTURE* gives the COS SA (PSA or BOA).

[19] HST Cycle 24 Focal Plane Calibration (SI-FGS alignment), PI = Edmund Nelan.

[20] The FGSs were used as the prime science instrument in this proposal, which precluded the use of COS during the visit as COS is not an allowed parallel HST instrument.

10. *APERXPOS* gives the AD (X in detector coordinates) aperture position. The default position is *APERXPOS*=22 for all FUV and NUV science and TA exposures.[21]

11. *APERYPOS* gives the XD (Y in detector coordinates) aperture position. It is not uncommon that the XD aperture location (*APERYPOS*) is $\pm$ one step off from its nominal position. Each *APERYPOS* step is $\approx 0.05''$, or about $\frac{1}{6}$ of our XD centering requirement, and $\frac{1}{2}$ of our 1σ XD centering goal. The default NUV and FUV LP1 PSA/BOA positions are *APERYPOS*=$126/-153$, where the WCA has the same XD (*APERYPOS*) position as the PSA. As shown in Table 29 the nominal PSA & WCA *APERYPOS* position for LP2, LP3, and LP4 are +53, +181, and +234, respectively.[22]

12. *OPT_ELEM* gives the grating or MIRROR used as the primary optic.

13. *DATE-OBS* gives the date of the observation in YEAR-MOnth-DAy format.

The columns of the spectroscopic NUV (Table 5) and FUV (Table 6) tables are identical to the columns listed above for Table 3, with the exception that the "Lamp#" and "Lamp Current" columns are not present. In the programs of this ISR, the default P1 lamp usage for spectroscopic observations was overridden with the use of the USELAMP=LINE2 and CURRENT=MEDIUM special commanding in APT to simulate the lamp exposures obtained in `NUM_POS=1ACQ/PEAKXD` (`LTAPKXD`) exposures. In addition, the APT optional parameter FLASH was used to set P2 exposures times that provided counts in excess of those expected during the TA exposures. Since all spectra were taken in TT mode, if required, an exact replica of the counts received in an actual `LTAPKXD` WCA spectrum could be re-produced. The additional counts allow for a better determination of the WCA-to-PSA XD offsets discussed in § 6 and § 6.2.

[21] The trailing "0.1" reported in the FITS headers is a conversion anomaly that is present in all aperture positions (*APERXPOS* & *APERYPOS*).

[22] As explained in the TA enabling ISRs for each FUV LP, due to known behavior of the COS aperture mechanism to miss by one step in *APERYPOS*, entries in the PCMECH_APMXDISPPOSITION FSW table were intentionally offset by $\pm$ on step, depending on travel direction from NUV/FUV LP1, which shared the common PCMECH_APMXDISPPOSITION (*APERYPOS*) entry of +126.

Table 3. COS/NUV TA Monitoring Imaging Exposures - PSA or BOA

ROOTNAME (1)	*PROPOSID* (2)	*TARGNAME* (3)	*OBSMODE*[t] (4)	*EXPTYPE* (5)	*EXPTIME* (s) (6)	PtNe Lamp # (7)	Lamp Current[c] (8)	*APERTURE* (9)	*APERXPOS*[x] (10)	*APERYPOS*[y] (11)	*OPT_ELEM* (12)	*DATE-OBS* (13)
						PSA × MIRA						
lc6ka1i1q	13171	427W3	ACCUM	ACQ/IMAGE	60	P2	Low	PSA	22.1	127.1	MIRA	2013-03-02
lc6ka2imq	13171	206W3	ACCUM	ACQ/IMAGE	60	P2	Low	PSA	22.1	127.1	MIRA	2013-09-01
lci4a1dcq	13616	427W3	ACCUM	ACQ/IMAGE	60	P2	Low	PSA	22.1	127.1	MIRA	2014-04-03
lci4a2e3q	13616	206W3	ACCUM	ACQ/IMAGE	60	P2	Low	PSA	22.1	127.1	MIRA	2014-10-27
lcgq03dbq	13526	206W3	ACCUM	ACQ/IMAGE	15	P2	Low	PSA	22.1	127.1	MIRA	2014-10-06
lcgq03ddq	13526	206W3	TT	EXT/SCI	15	P2	Low	PSA	22.1	127.1	MIRA	2014-10-06
lcgq03drq	13526	206W3	TT	EXT/SCI	12	P2	Low	PSA	22.1	127.1	MIRA	2014-10-06
lcgq03dtq	13526	206W3	ACCUM	ACQ/IMAGE	12	P2	Low	PSA	22.1	127.1	MIRA	2014-10-06
lcsla1i4q	14035	427W3	ACCUM	ACQ/IMAGE	60	P2	Low	PSA	22.1	125.1	MIRA	2015-04-14
lcsla2bhq	14035	206W3	ACCUM	ACQ/IMAGE	60	P2	Low	PSA	22.1	125.1	MIRA	2015-10-02
ldozpbf5q	14857	206W3	ACCUM	ACQ/IMAGE	20	P2	Low	PSA	22.1	125.1	MIRA	2017-09-10
ldozpbf7q	14857	206W3	TT	EXT/SCI	20	P2	Low	PSA	22.1	125.1	MIRA	2017-09-10
ldozpbffq	14857	206W3	TT	EXT/SCI	20	P2	Low	PSA	22.1	125.1	MIRA	2017-09-10
ldozpbfhq	14857	206W3	ACCUM	ACQ/IMAGE	20	P2	Low	PSA	22.1	125.1	MIRA	2017-09-10
						PSA × MIRB						
lc6ka1i3q	13171	427W3	ACCUM	ACQ/IMAGE	300	P2	Low	PSA	22.1	127.1	MIRB	2013-03-02
lc6ka2ioq	13171	206W3	ACCUM	ACQ/IMAGE	300	P2	Low	PSA	22.1	127.1	MIRB	2013-09-01
lci4a1deq	13616	427W3	ACCUM	ACQ/IMAGE	300	P2	Low	PSA	22.1	127.1	MIRB	2014-04-03
lci4a2e5q	13616	206W3	ACCUM	ACQ/IMAGE	300	P2	Med	PSA	22.1	127.1	MIRB	2014-10-27
lcgq01q5q	13526	WD-1657+343	ACCUM	ACQ/IMAGE	12	P2	Med	PSA	22.1	127.1	MIRB	2014-11-19
lcgq01q7q	13526	WD-1657+343	TT	EXT/SCI	16	P2	Med	PSA	22.1	127.1	MIRB	2014-11-19
lcgq01qhq	13526	WD-1657+343	TT	EXT/SCI	12	P2	Med	PSA	22.1	126.1	MIRB	2014-11-19
lcgq01qjq	13526	WD-1657+343	ACCUM	ACQ/IMAGE	12	P2	Med	PSA	22.1	126.1	MIRB	2014-11-19
lcgq03dfq	13526	206W3	TT	EXT/SCI	160	P2	Low	PSA	22.1	127.1	MIRB	2014-10-06
lcgq03dhq	13526	206W3	TT	EXT/SCI	180	P2	Low	PSA	22.1	127.1	MIRB	2014-10-06
lcgq03djq	13526	206W3	TT	EXT/SCI	180	P2	Med	PSA	22.1	127.1	MIRB	2014-10-06
lcgq03dlq	13526	206W3	ACCUM	ACQ/IMAGE	160	P2	Med	PSA	22.1	127.1	MIRB	2014-10-06
lcgq03dnq	13526	206W3	TT	EXT/SCI	180	P2	Med	PSA	22.1	127.1	MIRB	2014-10-06
lcgq03dpq	13526	206W3	TT	EXT/SCI	160	P2	Low	PSA	22.1	127.1	MIRB	2014-10-06
lcri01fzq	13972	WD-1657+343	ACCUM	ACQ/IMAGE	12	P2	Med	PSA	22.1	125.1	MIRB	2015-10-06
lcri01g1q	13972	WD-1657+343	TT	EXT/SCI	12	P2	Med	PSA	22.1	125.1	MIRB	2015-10-06
lcri01gcq	13972	WD-1657+343	TT	EXT/SCI	14	P2	Med	PSA	22.1	126.1	MIRB	2015-10-06
lcri01geq	13972	WD-1657+343	ACCUM	ACQ/IMAGE	12	P2	Med	PSA	22.1	126.1	MIRB	2015-10-06
lcsla1i6q	14035	427W3	ACCUM	ACQ/IMAGE	300	P2	Med	PSA	22.1	125.1	MIRB	2015-04-14
lcsla2bjq	14035	206W3	ACCUM	ACQ/IMAGE	300	P2	Med	PSA	22.1	125.1	MIRB	2015-10-02
ld3701gtq	14440	WD-1657+343	ACCUM	ACQ/IMAGE	13	P2	Med	PSA	22.1	125.1	MIRB	2016-10-18
ld3701gvq	14440	WD-1657+343	TT	EXT/SCI	16	P2	Med	PSA	22.1	125.1	MIRB	2016-10-18
ld3701h5q	14440	WD-1657+343	TT	EXT/SCI	16	P2	Med	PSA	22.1	126.1	MIRB	2016-10-18
ld3701h7q	14440	WD-1657+343	ACCUM	ACQ/IMAGE	13	P2	Med	PSA	22.1	126.1	MIRB	2016-10-18
ldozbadhq	14857	WD-1657+343	ACCUM	ACQ/IMAGE	13	P2	Med	PSA	22.1	125.1	MIRB	2017-09-04
ldozbadjs	14857	WD-1657+343	TT	EXT/SCI	16	P2	Med	PSA	22.1	125.1	MIRB	2017-09-04
ldozbadtq	14857	WD-1657+343	TT	EXT/SCI	16	P2	Med	PSA	22.1	126.1	MIRB	2017-09-04
ldozbadvq	14857	WD-1657+343	ACCUM	ACQ/IMAGE	13	P2	Med	PSA	22.1	126.1	MIRB	2017-09-04
ldozpbf9q	14857	206W3	TT	EXT/SCI	220	P2	Med	PSA	22.1	125.1	MIRB	2017-09-10
ldozpbfbq	14857	206W3	ACCUM	ACQ/IMAGE	220	P2	Med	PSA	22.1	125.1	MIRB	2017-09-10
ldozpbfdq	14857	206W3	TT	EXT/SCI	220	P2	Med	PSA	22.1	125.1	MIRB	2017-09-10
						BOA × MIRA						
lcgq01q9q	13526	WD-1657+343	TT	EXT/SCI	150	P2	Med	BOA	22.1	-153.1	MIRA	2014-11-19
lcgq01qdq	13526	WD-1657+343	ACCUM	ACQ/IMAGE	150	P2	Low	BOA	22.1	-153.1	MIRA	2014-11-19
lcgq02hmq	13526	HIP66578	ACCUM	ACQ/IMAGE	12	P2	Low	BOA	22.1	-153.1	MIRA	2014-11-17
lcgq02i0q	13526	HIP66578	ACCUM	ACQ/IMAGE	12	P2	Low	BOA	22.1	-153.1	MIRA	2014-11-17
lcri01g3q	13972	WD-1657+343	TT	EXT/SCI	150	P2	Med	BOA	22.1	-153.1	MIRA	2015-10-06
lcri01g7q	13972	WD-1657+343	ACCUM	ACQ/IMAGE	150	P2	Low	BOA	22.1	-153.1	MIRA	2015-10-06
lcri02h8q	13972	HIP66578	ACCUM	ACQ/IMAGE	12	P2	Low	BOA	22.1	-153.1	MIRA	2015-10-06
lcri02hmq	13972	HIP66578	ACCUM	ACQ/IMAGE	12	P2	Low	BOA	22.1	-153.1	MIRA	2015-10-06
ld3701gxq	14440	WD-1657+343	TT	EXT/SCI	150	P2	Med	BOA	22.1	-153.1	MIRA	2016-10-18
ld3701h1q	14440	WD-1657+343	ACCUM	ACQ/IMAGE	150	P2	Low	BOA	22.1	-153.1	MIRA	2016-10-18
ld3702mzq	14440	HIP66578	ACCUM	ACQ/IMAGE	16	P2	Low	BOA	22.1	-153.1	MIRA	2016-10-19
ld3702nhq	14440	HIP66578	ACCUM	ACQ/IMAGE	16	P2	Low	BOA	22.1	-153.1	MIRA	2016-10-19
ldozbadlq	14857	WD-1657+343	TT	EXT/SCI	150	P2	Med	BOA	22.1	-153.1	MIRA	2017-09-04
ldozbadpq	14857	WD-1657+343	ACCUM	ACQ/IMAGE	150	P2	Low	BOA	22.1	-153.1	MIRA	2017-09-04
ldozbbleq	14857	HIP66578	ACCUM	ACQ/IMAGE	16	P2	Low	BOA	22.1	-153.1	MIRA	2017-09-06
ldozbblsq	14857	HIP66578	ACCUM	ACQ/IMAGE	16	P2	Low	BOA	22.1	-153.1	MIRA	2017-09-06
						BOA × MIRA						
lcgq02hqq	13526	HIP66578	TT	EXT/SCI	181	P2	Low	BOA	22.1	-153.1	MIRB	2014-11-17
lcgq02huq	13526	HIP66578	ACCUM	ACQ/IMAGE	181	P2	Med	BOA	22.1	-153.1	MIRB	2014-11-17
lcri02hcq	13972	HIP66578	TT	EXT/SCI	181	P2	Low	BOA	22.1	-153.1	MIRB	2015-10-06
lcri02hgq	13972	HIP66578	ACCUM	ACQ/IMAGE	181	P2	Med	BOA	22.1	-153.1	MIRB	2015-10-06
ld3702n4q	14440	HIP66578	TT	EXT/SCI	183	P2	Low	BOA	22.1	-153.1	MIRB	2016-10-19
ld3702n9q	14440	HIP66578	ACCUM	ACQ/IMAGE	183	P2	Med	BOA	22.1	-153.1	MIRB	2016-10-19
ldozbbliq	14857	HIP66578	TT	EXT/SCI	183	P2	Low	BOA	22.1	-153.1	MIRB	2017-09-06
ldozbblmq	14857	HIP66578	ACCUM	ACQ/IMAGE	183	P2	Med	BOA	22.1	-153.1	MIRB	2017-09-06

[c] The P2 wavelength calibration lamp current settings are LOW (3 mA), MED (10 mA) and HIGH (14 mA).

[t] TT = TIME-TAG.

[x] *APERYPOS*, the AD aperture mechanism positions, are stored in the FSW in PCMECH_APMDISPPOSITION. The trailing "0.1" reported in the FITS headers is a conversion anomaly that is present in all aperture positions (*APERXPOS* & *APERYPOS*).

[y] It is not uncommon that the XD aperture location (*APERXPOS*) is ± one step off from its nominal position. The XD aperture mechanism positions are stored in the FSW in PCMECH_APMXDISPPOSITION (see Table 29).

Note. — PSA EXPTYPE=EXT/SCI exposures contain coeval target and PtNe lamp TT images.

Table 4. COS/NUV TA Monitoring Imaging Exposures - WCA only

ROOTNAME (1)	*PROPOSID* (2)	*TARGNAME* (3)	*OBSMODE*[t] (4)	*EXPTYPE* (5)	*EXPTIME* (s) (6)	PtNe Lamp # (7)	Lamp Current[c] (8)	*APERTURE* (9)	*APERXPOS*[x] (10)	*APERYPOS*[y] (11)	*OPT_ELEM* (12)	*DATE-OBS* (13)
					WCA × MIRA							
lcgp01byq	13523	WAVE	TT	WAVECAL	20	P2	Low	WCA	22.1	127.1	MIRA	2013-11-11
lcgp01c3q	13523	WAVE	TT	WAVECAL	20	P1	Low	WCA	22.1	127.1	MIRA	2013-11-11
lcgq01qbq	13526	WAVE	TT	WAVECAL	7	P2	Low	WCA	22.1	126.1	MIRA	2014-11-19
lcgq01qfq	13526	WAVE	TT	WAVECAL	7	P2	Low	WCA	22.1	126.1	MIRA	2014-11-19
lcgq02hoq	13526	WAVE	TT	WAVECAL	7	P2	Low	WCA	22.1	126.1	MIRA	2014-11-17
lcgq02hyq	13526	WAVE	TT	WAVECAL	10	P2	Low	WCA	22.1	126.1	MIRA	2014-11-17
lcgq02icq	13526	WAVE	TT	WAVECAL	10	P1	Low	WCA	22.1	127.1	MIRA	2014-11-17
lcgq02ieq	13526	WAVE	TT	WAVECAL	10	P2	Low	WCA	22.1	127.1	MIRA	2014-11-17
lcri01g5q	13972	WAVE	TT	WAVECAL	10	P2	Low	WCA	22.1	126.1	MIRA	2015-10-06
lcri01g9q	13972	WAVE	TT	WAVECAL	10	P2	Low	WCA	22.1	126.1	MIRA	2015-10-06
lcri02haq	13972	WAVE	TT	WAVECAL	14	P2	Low	WCA	22.1	126.1	MIRA	2015-10-06
lcri02hkq	13972	WAVE	TT	WAVECAL	14	P2	Low	WCA	22.1	126.1	MIRA	2015-10-06
lcri02hyq	13972	WAVE	TT	WAVECAL	14	P1	Low	WCA	22.1	125.1	MIRA	2015-10-06
lcri02i0q	13972	WAVE	TT	WAVECAL	24	P2	Low	WCA	22.1	125.1	MIRA	2015-10-06
ld3701gzq	14440	WAVE	TT	WAVECAL	9	P2	Low	WCA	22.1	126.1	MIRA	2016-10-18
ld3701h3q	14440	WAVE	TT	WAVECAL	10	P2	Low	WCA	22.1	126.1	MIRA	2016-10-18
ld3702n1q	14440	WAVE	TT	WAVECAL	14	P2	Low	WCA	22.1	126.1	MIRA	2016-10-19
ld3702neq	14440	WAVE	TT	WAVECAL	14	P2	Low	WCA	22.1	126.1	MIRA	2016-10-19
ld3702o1q	14440	WAVE	TT	WAVECAL	14	P1	Low	WCA	22.1	125.1	MIRA	2016-10-19
ld3702o3q	14440	WAVE	TT	WAVECAL	24	P2	Low	WCA	22.1	125.1	MIRA	2016-10-19
ldozbadnq	14857	WAVE	TT	WAVECAL	9	P2	Low	WCA	22.1	126.1	MIRA	2017-09-04
ldozbadrq	14857	WAVE	TT	WAVECAL	10	P2	Low	WCA	22.1	126.1	MIRA	2017-09-04
ldozbblgq	14857	WAVE	TT	WAVECAL	14	P2	Low	WCA	22.1	126.1	MIRA	2017-09-06
ldozbblqq	14857	WAVE	TT	WAVECAL	14	P2	Low	WCA	22.1	126.1	MIRA	2017-09-06
ldozbbm4q	14857	WAVE	TT	WAVECAL	16	P1	Low	WCA	22.1	125.1	MIRA	2017-09-06
ldozbbm6q	14857	WAVE	TT	WAVECAL	26	P2	Low	WCA	22.1	125.1	MIRA	2017-09-06
					WCA × MIRB							
lcgp01bpq	13523	WAVE	TT	WAVECAL	40	P2	Low	WCA	22.1	127.1	MIRB	2013-11-11
lcgp01bsq	13523	WAVE	TT	WAVECAL	40	P1	Low	WCA	22.1	127.1	MIRB	2013-11-11
lcgq02hsq	13526	WAVE	TT	WAVECAL	12	P2	Med	WCA	22.1	126.1	MIRB	2014-11-17
lcgq02hwq	13526	WAVE	TT	WAVECAL	12	P2	Med	WCA	22.1	126.1	MIRB	2014-11-17
lcgq02igq	13526	WAVE	TT	WAVECAL	30	P1	Low	WCA	22.1	127.1	MIRB	2014-11-17
lcgq02iiq	13526	WAVE	TT	WAVECAL	20	P2	Med	WCA	22.1	127.1	MIRB	2014-11-17
lcri02heq	13972	WAVE	TT	WAVECAL	24	P2	Med	WCA	22.1	126.1	MIRB	2015-10-06
lcri02hiq	13972	WAVE	TT	WAVECAL	24	P2	Med	WCA	22.1	126.1	MIRB	2015-10-06
lcri02i2q	13972	WAVE	TT	WAVECAL	30	P1	Low	WCA	22.1	125.1	MIRB	2015-10-06
lcri02i4q	13972	WAVE	TT	WAVECAL	24	P2	Med	WCA	22.1	125.1	MIRB	2015-10-06
ld3702n7q	14440	WAVE	TT	WAVECAL	24	P2	Med	WCA	22.1	126.1	MIRB	2016-10-19
ld3702nbq	14440	WAVE	TT	WAVECAL	24	P2	Med	WCA	22.1	126.1	MIRB	2016-10-19
ld3702o5q	14440	WAVE	TT	WAVECAL	30	P1	Low	WCA	22.1	125.1	MIRB	2016-10-19
ld3702o7q	14440	WAVE	TT	WAVECAL	24	P2	Med	WCA	22.1	125.1	MIRB	2016-10-19
ldozbblkq	14857	WAVE	TT	WAVECAL	24	P2	Med	WCA	22.1	126.1	MIRB	2017-09-06
ldozbbloq	14857	WAVE	TT	WAVECAL	24	P2	Med	WCA	22.1	126.1	MIRB	2017-09-06
ldozbbm8q	14857	WAVE	TT	WAVECAL	32	P1	Low	WCA	22.1	125.1	MIRB	2017-09-06
ldozbbmaq	14857	WAVE	TT	WAVECAL	26	P2	Med	WCA	22.1	125.1	MIRB	2017-09-06

[c] The P2 wavelength calibration lamp current settings are LOW (6mA), MED (10mA) and HIGH (18mA). The P2 wavelength calibration lamp current settings are LOW (3mA), MED (10mA) and HIGH (14mA).

[t] TT = TIME-TAG.

[x] *APERYPOS*, the AD aperture mechanism positions are stored in the FSW in PCMECH_APMDISPPOSITION. The trailing "0.1" reported in the FITS headers is a conversion anomaly that is present in all aperture positions (*APERXPOS* & *APERYPOS*).

[y] It is not uncommon that the XD aperture location (*APERXPOS*) is ± one step off from its nominal position.

Note. — All exposures in this table are *EXPTYPE*=WAVECAL (target = WAVE) and contain only TT PtNe lamp (WCA) images, and the indicated MIRROR position (*OPT_ELEM*).

Table 5. COS/NUV TA Spectroscopic Monitoring Exposures

ROOTNAME (1)	*PROPOSID* (2)	TARGNAME (3)	*EXPTIME* (s) (4)	LAMP USED (5)	*OPT_ELEM* (6)	*CENWAVE* (7)	*LIFE_ADJ* (8)	*APERXPOS* (9)	*APERYPOS* (10)	*DATE-OBS* (11)
lcgq01qlq	13526	WD-1657+343	20	P2	G230L	3000	1	22.1	126.1	2014-11-19
lcgq01r6q	13526	WD-1657+343	151	P2	G285M	2850	1	22.1	126.1	2014-11-19
lcgq02i2q	13526	HIP66578	40	P2	G185M	1890	1	22.1	126.1	2014-11-17
lcgq02i4q	13526	HIP66578	52	P2	G225M	2306	1	22.1	126.1	2014-11-17
lcri01ggq	13972	WD-1657+343	20	P2	G230L	3000	1	22.1	126.1	2015-10-06
lcri01giq	13972	WD-1657+343	151	P2	G285M	2676	1	22.1	126.1	2015-10-06
lcri02hoq	13972	HIP66578	52	P2	G225M	2306	1	22.1	126.1	2015-10-06
lcri02hqq	13972	HIP66578	40	P2	G185M	1913	1	22.1	126.1	2015-10-06
ld3701h9q	14440	WD-1657+343	21	P2	G230L	3000	1	22.1	126.1	2016-10-18
ld3701hbq	14440	WD-1657+343	151	P2	G285M	2676	1	22.1	126.1	2016-10-18
ld3702nmq	14440	HIP66578	53	P2	G225M	2306	1	22.1	126.1	2016-10-19
ld3702noq	14440	HIP66578	40	P2	G185M	1913	1	22.1	126.1	2016-10-19
ldozbadxq	14857	WD-1657+343	23	P2	G230L	3000	1	22.1	126.1	2017-09-04
ldozbadzq	14857	WD-1657+343	151	P2	G285M	2676	1	22.1	126.1	2017-09-04
ldozbbluq	14857	HIP66578	53	P2	G225M	2306	1	22.1	126.1	2017-09-06
ldozbblwq	14857	HIP66578	40	P2	G185M	1913	1	22.1	126.1	2017-09-06

The NUV (LP1) XD location of the aperture (*APERYPOS*) is 126 in the FSW table `pcmech_ApMXDispPosition`.).

Note. — All exposures were taken with the PSA at `FP-POS=3`. All exposures executed at the expected aperture position (*APERXPOS* & *APERYPOS*).

Table 6. COS/FUV TA Monitoring Exposures

ROOTNAME (1)	*PROPOSID* (2)	*TARGNAME* (3)	*EXPTIME* (s) (4)	LAMP USED (5)	*CENWAVE* (6)	LP (7)	*APERXPOS* (8)	*APERYPOS* (9)	*OPT_ELEM* (10)	*DATE-OBS* (11)
lcgq01r8q	13526	WD-1657+343	20	P2	1309	2	22.1	52.1	G130M	2014-11-19
lcgq01r8q	13526	WD-1657+343	20	P2	1309	2	22.1	52.1	G130M	2014-11-19
lcgq01raq	13526	WD-1657+343	7	P2	1280	2	22.1	52.1	G140L	2014-11-19
lcgq01raq	13526	WD-1657+343	7	P2	1280	2	22.1	52.1	G140L	2014-11-19
lcgq02i6q	13526	HIP66578	18	P2	1600	2	22.1	52.1	G160M	2014-11-17
lcgq02i8q	13526	HIP66578	22	P2	1600	2	22.1	52.1	G160M	2014-11-17
lcgq02iaq	13526	HIP66578	22	P2	1600	2	22.1	52.1	G160M	2014-11-17
lcri01gkq	13972	WD-1657+343	20	P2	1309	3	22.1	182.1	G130M	2015-10-06
lcri01gkq	13972	WD-1657+343	20	P2	1309	3	22.1	182.1	G130M	2015-10-06
lcri01h6q	13972	WD-1657+343	7	P2	1280	3	22.1	182.1	G140L	2015-10-06
lcri01h6q	13972	WD-1657+343	7	P2	1280	3	22.1	182.1	G140L	2015-10-06
lcri02hsq	13972	HIP66578	22	P2	1600	3	22.1	182.1	G160M	2015-10-06
lcri02huq	13972	HIP66578	25	P2	1600	3	22.1	182.1	G160M	2015-10-06
lcri02hwq	13972	HIP66578	25	P2	1600	3	22.1	182.1	G160M	2015-10-06
ld3701hdq	14440	WD-1657+343	25	P2	1309	3	22.1	182.1	G130M	2016-10-18
ld3701hdq	14440	WD-1657+343	25	P2	1309	3	22.1	182.1	G130M	2016-10-18
ld3701hfq	14440	WD-1657+343	10	P2	1280	3	22.1	182.1	G140L	2016-10-18
ld3701hfq	14440	WD-1657+343	10	P2	1280	3	22.1	182.1	G140L	2016-10-18
ld3702nqq	14440	HIP66578	22	P2	1600	3	22.1	182.1	G160M	2016-10-19
ld3702nsq	14440	HIP66578	25	P2	1600	3	22.1	182.1	G160M	2016-10-19
ld3702nuq	14440	HIP66578	25	P2	1600	3	22.1	182.1	G160M	2016-10-19
ldozbae1q	14857	WD-1657+343	25	P2	1309	3	22.1	182.1	G130M	2017-09-04
ldozbae1q	14857	WD-1657+343	25	P2	1309	3	22.1	182.1	G130M	2017-09-04
ldozbae3q	14857	WD-1657+343	10	P2	1280	3	22.1	182.1	G140L	2017-09-04
ldozbae3q	14857	WD-1657+343	10	P2	1280	3	22.1	182.1	G140L	2017-09-04
ldozbblyq	14857	HIP66578	22	P2	1600	3	22.1	182.1	G160M	2017-09-06
ldozbbm0q	14857	HIP66578	27	P2	1600	3	22.1	182.1	G160M	2017-09-06
ldozbbm2q	14857	HIP66578	27	P2	1600	3	22.1	182.1	G160M	2017-09-06

Note. — All exposures were taken with the PSA at *FP-POS=3*. All exposures executed at the expected aperture positions (*APERXPOS* & *APERYPOS*).

4 Verifying the TA (ACQ/) Subarrays

COS TA subarrays are loaded during the HST ground commanding uniquely for each TA exposure, and are ACQ/ mode, NUV stripe (*STRIPE*), *CENWAVE* , and FUV segment *SEGMENT* and LP dependent. Additionally, these subarrays change with time in response to detector (e.g., increasing background or "hot-spots) or mechanism (e.g., secular OSM drift) monitoring. There are two stages to the TA verification, 1) ensuring that the intended subarrays were commanded as intended, and 2) that those subarrays were valid for the entire duration of usage.

Ideally, one would compare that commanded subarrays for all exposures to those reported in the _rawacq.fits. However, due to issues with the COS TA subarrays[23], in this ISR, the subarrays were inferred from the telemetry reported in the _spt.fits files.

Tables 7, 8, 9, 10 give the TA subarrays for all imaging modes as it has evolved since SMOV. Table **??** gives the TA subarrays for all NUV spectroscopic ACQ/SEARCH and ACQ/PEAKKD that have executed use since SMOV, and Table 13 gives the TA subarrays for all NUV ACQ/PEAKXDs since SMOV. Table 14 gives the TA subarrays for the WCA portion of all FUV ACQ/PEAKXDs separated by LP and *CENWAVE* . Table 14 gives the TA subarrays for the WCA portion of all FUV ACQ/PEAKXDs separated by LP and *CENWAVE* .

Table 15 gives the TA subarrays for the PSA/BOA portion of all FUVA ACQ/s separated by LP and *CENWAVE* , and Table 16 gives the TA subarrays for all LPs and *CENWAVE*s for FUVB. Note that TA has not been enabled for all FUV *CENWAVE*s , so only the TA subarrays that are in use are listed. The FUV table includes subarrays for all four COS LPs even though only the LP2 and LP3 subarrays were monitored in this ISR.

All values indicate that the intended subarrays are being used for all TA and science exposures. All FUV spectra were visually inspected to verify that the TA subarrays were successfully excluding all known detector hot-spots and the bright Geocoronal emission lines that can negatively affect TAs. No action is required based upon this analysis of the TA and science subarrays used in C21.

COS TA subarrays are defined in detector coordinates, and are specified by giving the [X,Y] corners ([XC,YC]) and sizes ([XS,YS]). Table **??** below gives the NUV spectroscopic TA subarrays used for ACQ/SEARCH and ACQ/PEAKD, which have not changed since SMOV. Table **??** below gives the NUV spectroscopic TA subarrays used for ACQ/PEAKXD, which include subarrays to measure the calibration lamp XD location (WCA) as well as the target spectral location of *STRIPE=B (MEDIUM)*). These have not changed there updated in 2010 as STScI PR#.

In this section, we describe the various subarrays used in COS TA. These subarrays are defined by giving the detector coordinate of the lowest valued corner (C) and the full size (S) for both X and Y. A subarray is fully specified by giving its XC, XS, YC, and YS. Unless noted, coordinates are in detector coordinates as this is the system in which COS TAs are performed.

TA subarrays are necessary to remove unwanted detector background or spectral or detector features not associated with the target, such as detector "hot-spots" or Geocoronal emission (see Penton & Keyes, 2011). All COS ACQ/ modes use subarrays, but they different for each mode, detector or detector segment, and *CENWAVE* . The explanation for the sizes and locations of the TA subarrays are beyond the scope of this ISR, but can be found in the TIR COS-2010-03 (Penton & Keyes, 2011), the pre-launch estimates (driven by ray-trace predictions; COS-11-0024A (Penton, 2001), COS-11-0014B (Penton, 2002), & COS-11-0016A (Penton, 2001) and for FUV LP2–4 in

[23] This issues should be addressed for C26 with the corrections outlined in STScI PRs#64849, 64874, 66840, ,

Table 7. 2009–2011.016 COS ACQ/IMAGE and ACQ/SEARCH TA Subarrays.

Aperture	MIRROR	XC	YC	XS	YS
WCA	MIRA	268	95	200	660
WCA	MIRB	103	361	200	660
PSA/BOA	MIRA	572	108	345	816
PSA/BOA	MIRB	410	200	345	816

Note. — Due to increased detector background, these were updated on 2011.017 (PR#67139) as described in Penton & Keyes (2011).

their respective enabling ISRs (Penton 2018 (LP2), Penton 2018 (LP3) and Penton & White 2018 (LP4).) The programs discussed in this ISR do not contain any FUV or NUV spectroscopic ACQ/ exposures, therefore, the bulk of the discussion for the TA subarrays for spectroscopic TAs are contained in the respective enabling ISRs. The spectroscopic exposures discussed in this ISR will, however, be used to verify the appropriateness of the XD locations of the subarrays in § 6.1 (NUV) and § 6.2.

4.1 NUV Imaging TA subarrays

The original (2009) NUV imaging ACQ/IMAGE and ACQ/SEARCH TA subarrays are given in Table 7. This table includes entries for the WCA and PSA and both MIRA and MIRB. The COS FSW uses the same subarrays for the PSA and BOA as the offset on the detector between the aperture locationss is small (Δ [AD,XD]$\sim$[11.0,0.4]p).

Due to rising NUV detector background, and supported by an analysis of OSM repeatability, reductions to the PSA/BOA ACQ/SEARCH and WCA ACQ/IMAGE subarrays sizes were implemented on 2011.017 (STScI PR#67139)[24]. During ACQ/IMAGE, the region of the detector used to determine the source location is small, and is given by the square of the TA parameter PCTA_CHECKBOXSIZE, which is currently set to 9p (81 total pixels). There no adjustment was warranted for the PSA/BOA ACQ/IMAGE subarrays. However, during ACQ/SEARCH, the counts in the full subarray are used (currently 345 × 816=19,376p). NUV ACQ/SEARCH TAs are therefore much more vulnerable (by a factor of 3500) to contamination from background events and SAA passages (Penton & Keyes, 2011). The updated ACQ/SEARCH values are given in Table 9, and the updated ACQ/IMAGE subarrays are given in Table 8.

[24]On-orbit analysis of the OSM positions showed that the the WCA LTAIMCAL MIRA and MIRB lamp image detector locatians were fairly repeatable (usually with ± 50 AD p and ± 10 XDp). As discussed in Penton & Keyes (2011), the WCA TA ACQ/IMAGE subarrays were reduced by ± 50p in XD and ± 180p in AD, and ACQ/SEARCH subarrays were reduced by 125 AD p and 346 XD p.

Table 8. 2011.017–2014.299 COS `ACQ/IMAGE` TA Subarrays.

Aperture	MIRROR	XC	YC	XS	YS
WCA	MIRA	**345**	**324**	**50**	**300**
WCA	MIRB	**184**	**539**	**50**	**300**
PSA/BOA	MIRA	572	108	345	816
PSA/BOA	MIRB	410	200	345	816

Note. — **Bold** values in this table were updated on 2011.017 (PR#67139) due to increased detector background, as described in Penton & Keyes (2011).

Table 9. 2011.017–Present COS `ACQ/SEARCH` TA Subarrays.

APERTURE	MIRROR	XC	YC	XS	YS
PSA/BOA	MIRA	630	284	220	470
PSA/BOA	MIRB	469	499	220	470

Note. — Updated on 2011.017 (PR#67139), as described in Penton & Keyes (2011).

Table 10. 2014.300–Present NUV COS ACQ/IMAGE TA Subarrays.

APERTURE	MIRROR	XC	YC	XS	YS
WCA	MIRA	345	324	50	300
WCA	MIRB	**187**	**566**	50	300
PSA/BOA	MIRA	572	108	345	816
PSA/BOA	MIRB	410	200	345	816

Note. — Due to errors in determining the WCA AD position due to increased NUV detector background, the **bold** subarrays values were updated on Oct. 6, 2014 (2014.279) with PR#78749. Simultaneously, the MIRB ACQ/ lamp exposure time and current settings (for the P2 lamp) were changed from 17s @ LOW current to 12s @ MED current (PR#78749). The FSW WCA-to-SA offsets ([X,Y]IMCALTARGETOFFSET) were adjusted accordingly (PR#79116) on October 16, 2014 (2014.289), prior to use by HST users on Nov. 10, 2014 (2014.314). The default exposure time and current for the P1 lamp image "TAGFLASH"s were changed later with PR#84463.

4.2 COS NUV Spectroscopic TA Subarrays

The NUV spectroscopic TA subarrays for the ACQ/SEARCH and ACQ/PEAKD phases are identical, and are given in Table 12. These subarrays are not grating-specific and are large enough to capture the flux from all three stripes (two for G230L; *STRIPE=C (LONG)* is not used for G230L TA). COS uses the same NUV TA subarrays for the PSA and BOA as the XD offset between the NUV spectra is small (ΔXD∼5p).

The NUV spectroscopic TA SA subarrays for the ACQ/PEAKXD are given in Table 13. These subarrays are large enough to only capture the flux from a single NUV stripe. Stripe-specific subarrays are defined for both the WCA and PSA. If used with an extended source, these subarrays are vulnerable to cross-contamination of stripe light. In this table, only the values of XC are listed. For all NUV ACQ/PEAKXDs, YC=0, YS=1024, and XS=81.

4.3 COS FUV Spectroscopic TA Subarrays

The FUV spectroscopic TA subarrays for the WCA are the same for ACQ/SEARCH, ACQ/PEAKD, and ACQ/PEAKXD and are given in Table 14 for both FUVA and FUVB. Only one subarray is used for the WCA for each FUV segment, these are labeled 'A1' and 'B1'. As the data are taken in "detector" coordinates, all FUV TA subarrays values are valid only for the normal operating temperature range of COS. FUVB is not used in G140L TAs.

The FUV spectroscopic subarrays used for all external targets at LP1–4 for FUVA are given in Table 15 and for FUVB in Table 16. There are two subarrays used for each FUV segment, these are

Table 11. FITS Reported TA `ACQ/IMAGE` Subarrays

PROPOSID (PID)	IPPPSSOOT	*APERTURE* ×MIRROR	WCA XC	WCA YC	WCA XS	WCA YS	SA (PSA or BOA) XC	SA YC	SA XS	SA YS	*DATE-OBS*
MIRA `ACQ/IMAGE` Subarrays											
13171	lc6ka1i1q	PSA×MIRA	345	324	50	300	572	108	345	816	2013-03-02
13171	lc6ka2imq	PSA×MIRA	345	324	50	300	572	108	345	816	2013-09-01
13616	lci4a1dcq	PSA×MIRA	345	324	50	300	572	108	345	816	2014-04-03
13616	lci4a2e3q	PSA×MIRA	345	324	50	300	572	108	345	816	2014-10-27
13526	lcgq01qdq	BOA×MIRA	345	324	50	300	572	108	345	816	2014-11-19
13526	lcgq02hmq	BOA×MIRA	345	324	50	300	572	108	345	816	2014-11-17
13526	lcgq02i0q	BOA×MIRA	345	324	50	300	572	108	345	816	2014-11-17
13526	lcgq03dbq	PSA×MIRA	345	324	50	300	572	108	345	816	2014-10-06
13526	lcgq03dtq	PSA×MIRA	345	324	50	300	572	108	345	816	2014-10-06
14035	lcsla1i4q	PSA×MIRA	345	324	50	300	572	108	345	816	2015-04-14
14035	lcsla2bhq	PSA×MIRA	345	324	50	300	572	108	345	816	2015-10-02
13972	lcri01g7q	BOA×MIRA	345	324	50	300	572	108	345	816	2015-10-06
13972	lcri02h8q	BOA×MIRA	345	324	50	300	572	108	345	816	2015-10-06
13972	lcri02hmq	BOA×MIRA	345	324	50	300	572	108	345	816	2015-10-06
14440	ld3701h1q	BOA×MIRA	345	324	50	300	572	108	345	816	2016-10-18
14440	ld3702mzq	BOA×MIRA	345	324	50	300	572	108	345	816	2016-10-19
14440	ld3702nhq	BOA×MIRA	345	324	50	300	572	108	345	816	2016-10-19
14857	ldozbadpq	BOA×MIRA	345	324	50	300	572	108	345	816	2017-09-04
14857	ldozbbleq	BOA×MIRA	345	324	50	300	572	108	345	816	2017-09-06
14857	ldozbblsq	BOA×MIRA	345	324	50	300	572	108	345	816	2017-09-06
14857	ldozpbf5q	PSA×MIRA	345	324	50	300	572	108	345	816	2017-09-10
14857	ldozpbfhq	PSA×MIRA	345	324	50	300	572	108	345	816	2017-09-10
MIRB `ACQ/IMAGE` Subarrays											
13171	lc6ka1i3q	PSA×MIRB	184	539	50	300	411	200	345	816	2013-03-02
13171	lc6ka1i3q	PSA×MIRB	184	539	50	300	411	200	345	816	2013-03-02
13171	lc6ka2ioq	PSA×MIRB	184	539	50	300	411	200	345	816	2013-09-01
13171	lc6ka2ioq	PSA×MIRB	184	539	50	300	411	200	345	816	2013-09-01
13616	lci4a1deq	PSA×MIRB	184	539	50	300	411	200	345	816	2014-04-03
13616	lci4a2e5q	PSA×MIRB	187	566	50	300	411	200	345	816	2014-10-27
13526	lcgq01q5q	PSA×MIRB	187	566	50	300	411	200	345	816	2014-11-19
13526	lcgq01qjq	PSA×MIRB	187	566	50	300	411	200	345	816	2014-11-19
13526	lcgq02huq	BOA×MIRB	187	566	50	300	411	200	345	816	2014-11-17
13526	lcgq03dlq	PSA×MIRB	187	566	50	300	411	200	345	816	2014-10-06
13972	lcri01fzq	PSA×MIRB	187	566	50	300	411	200	345	816	2015-10-06
13972	lcri01geq	PSA×MIRB	187	566	50	300	411	200	345	816	2015-10-06
13972	lcri02hgq	BOA×MIRB	187	566	50	300	411	200	345	816	2015-10-06
14035	lcsla1i6q	PSA×MIRB	187	566	50	300	411	200	345	816	2015-04-14
14035	lcsla2bjq	PSA×MIRB	187	566	50	300	411	200	345	816	2015-10-02
14440	ld3701gtq	PSA×MIRB	187	566	50	300	411	200	345	816	2016-10-18
14440	ld3701h7q	PSA×MIRB	187	566	50	300	411	200	345	816	2016-10-18
14440	ld3702n9q	BOA×MIRB	187	566	50	300	411	200	345	816	2016-10-19
14857	ldozbadhq	PSA×MIRB	187	566	50	300	411	200	345	816	2017-09-04
14857	ldozbadvq	PSA×MIRB	187	566	50	300	411	200	345	816	2017-09-04
14857	ldozbblmq	BOA×MIRB	187	566	50	300	411	200	345	816	2017-09-06
14857	ldozpbfbq	PSA×MIRB	187	566	50	300	411	200	345	816	2017-09-10

Note. — As correctly reported in the FITS files, the MIRB subarrays values were updated from [XC,YC]=[184,539] to [187,566] on Oct. 6, 2014 (2014.279) with PR#78749. Simultaneously, the MIRB `ACQ/` lamp exposure time and current settings (for the P2 lamp) TAsubarrays.tex:were changed from 17s @ LOW current to 12s @ MED current (PR#78749). The FSW WCA-to-SA offsets ([X,Y]IMCALTARGETOFFSET) were adjusted accordingly (PR#79116) on October 16, 2014 (2014.289)

Table 12 NUV Spectroscopic ACQ/SEARCH and ACQ/PEAKD SA Subarrays

OPT_ELEM	XC	YC	XS	YS
G185M	509	0	420	1024
G225M	512	0	420	1024
G285M	499	0	420	1024
G230L	659	0	275	1024

[1] These are the NUV ACQ/SEARCH and ACQ/PEAKD external target (SA) subarrays. The NUV ACQ/PEAKXD lamp and SA subarrays are given in 13.
[2] Installed by HST commanding on 2009.201 (PR#63095).

Table 13 NUV ACQ/PEAKXD WCA and PSA/BOA Subarray "XC"s[1]

OPT_ELEM	WCA-A	WCA-B	WCA-C	SCI-A	SCI-B	SCI-C
G185M	418	327	192	794	700	565
G225M	430	327	186	804	703	560
G285M	407	313	180	782	688	555
G230L	433	334	194	807	707	564

[1] XC = X-Corner. For all NUV ACQ/PEAKXD TA subarrays: YC=0, YS=1024, and XS=81; where S=Size. Updated on July 19, 2009 (2009.200) with STScI PR#63095. Some early calibration observations used slightly different values.

labeled 'A1', 'A2', 'B1', and 'B2'. The COS FSW uses the same subarrays for the PSA and BOA as the offset between the FUV spectra is small (Δ XD$\sim$3p). As with the other HST spectrographs, FUV TAs are susceptible to contamination from geocoronal light , particularly Lyα 1216Å, OI 1302Å, and SiII1304Å (Penton & Keyes, 2010). The FUV TA subarrays outlined in tables 15 and 16 have been tailored to remove regions of the target spectrum that may contain Geocoronal light. The Geocoronal light fills the aperture and has a very different XD profile which could cause problems with FUV TAs.

In 2014–5, several "hot-spots" appeared during solar maximum. On April 20, 2015 (2015.110) with STScI PR#80571, the FUV LP3 subarrays were adjusted to avoid these hot-spots. Details are given in § 4.4, and the adjusted FUVB subarrays are also given in Table 16.

4.4 Trimming of COS FUV TA subarrays due to FUVB "Hot-Spot".

A "hot-spot" appeared on the COS FUVB segment coincident with increased solar activity in 2014–15. This spot produced enough counts that it could cause mis-centering during all phases of the FUV LP3 (& LP4) spectroscopic TAs. This mis-centerings could be in significant in either the AD or XD. All affected LP3 FUVB TA subarrays were adjusted on April 20, 2015 (2015.110)[25].

In FUVB detector coordinates, the approximate location of the hot-spot is at [X,Y]=[14895,482]. As this is near the detector edge, we are able to avoid this hotspot by stopping the last subarray

[25] See STScI PR#80571 for futher details.

Table 14. FUV WCA Subarrays for LP1–4.

	A1 Subarray				B1 Subarray			
OPT_ELEM	XC	YC	XS	YS	XC	YC	XS	YS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	LP1							
G130M	1201	541[a]	13799	44	1501	585	13799	44
G160M	1201	535[a]	13799	44	1501	579[a]	13799	44
G140L	1201	547[a]	13799	44	...	...	...	...
G140L	4701	547[b]	10299[b]	44	...	...	...	...
	LP2[c]							
G130M	1201	581	13799	44	1501	630	13799	44
G160M	1201	568	13799	44	1501	617	13799	44
G140L	4701	587	10299	44	...	...	...	...
	LP3[d]							
G130M	1201	515	13799	44	1501	567	13799	44
G160M	1201	504	13799	44	1501	559	13799	44
G140L	4701	521	10299	44	...	...	...	...
	LP4[e]							
G130M	1201	483	13799	52	1501	539	13799	52
G160M	1201	475	13799	52	1501	534	13799	52
G140L	4701	491	10299	52	...	...	...	...

[a]These values were updated on 2009.201 (July 20, 2009) with STScI PR#63095, some very early COS calibration and ERO datasets used slightly different TA subarrays.

[b]Additional G140L updates were made on Dec. 4, 2012 (2012.339) with STScI PR#72193 to futher optimize the G140L subarrays.

[c]Updated for LP2 operations on July 18, 2012 (2012.200) with STScI PR#70548.

[d]Updated for LP3 operations on Aug. 26, 2014 (2014.238) with STScI PR#78747.

[e]Updated for LP4 operations on Feb. 20, 2017 (2017.051) with STScI PR#86945.

Table 15. FUVA PSA/BOA Subarrays for LP1–4

OPT_ELEM	*CENWAVE*	A1 Subarray				A2 Subarray			
	(Å)	XC	YC	XS	YS	XC	YC	XS	YS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
LP1									
G130M	1291	1201	6555[b]	437[a]	76	4078	8896[b]	437[a]	76
G130M	1300	1201	7559[b]	437[a]	76	4078	9900[b]	437[a]	76
G130M	1309	1201	8562[b]	437[a]	76	4097[b]	10903[b]	437[a]	76
G130M	1318	1201	9465[b]	437[a]	76	3194[b]	11806[b]	437[a]	76
G130M	1327	1201	10489[b]	437[a]	76	2170[b]	12830[b]	437[a]	76
G160M	ALL	1201	13799	432[a,b]	76	...	...	...	...
G140L	1105	1201	10458[c]	445[a,b]	76	457	14543	445[a,b]	76
G140L	1230[g]	1201	12216[c]	445[a,b]	76	...	...	...	...
G140L	1280	1201	12216[c]	445[a,b]	76	...	...	...	...
G140L	1105	4701[c]	6958[c]	445[a,b]	76	457	14543	445[a,b]	76
G140L	1230[g]	4701[c]	8716[c]	445[a,b]	76	...	...	...	...
G140L	1280	6201[c]	7400[c]	445[a,b]	76	...	...	...	...
LP2[d]									
G130M	1291	1201	472	6555	76	8896	472	4078	76
G130M	1300	1201	472	7559	76	9900	472	4078	76
G130M	1309	1201	472	8562	76	10903	472	4097	76
G130M	1318	1201	472	9465	76	11806	472	3194	76
G130M	1327	1201	472	10489	76	12830	472	2170	76
G160M	ALL	1201	466	13799	76	...	...	...	...
G140L	1105	4701	479	6958	76	14543	479	457	76
G140L	1280	6201	479	7400	76	...	34	...	...
G140L	1105	4701	479	6958	76	14543	479	457	76
G140L	1280	6201	479	7400	76	...	...	...	...
LP3[e]									
G130M	1291	1201	409	6555	76	8896	409	4078	76
G130M	1300	1201	409	7559	76	9900	409	4078	76
G130M	1309	1201	409	8562	76	10903	409	4097	76
G130M	1318	1201	409	9465	76	11806	409	3194	76
G130M	1327	1201	409	10489	76	12830	409	2170	76
G160M	ALL	1201	403	13799	76	...	...	...	...
G140L	1105	4701	418	6958	76	14543	418	457	76
G140L	1280	6201	418	7400	76	...	...	...	...
LP4[f]									
G130M	1291	1201	362	6555	112	8896	362	4078	112
G130M	1300	1201	362	7559	112	9900	362	4078	112
G130M	1309	1201	362	8562	112	10903	362	4097	112
G130M	1318	1201	362	9465	112	11806	362	3194	112
G130M	1327	1201	362	10489	112	12830	362	2170	112
G160M	ALL	1201	356	13799	112	...	...	...	...
G140L	1105	4701	372	6958	112	14543	372	457	112
G140L	1280	6201	372	7400	112	...	...	...	...

[a]Updated on 2009.201 (July 20, 2009) with STScI PR#63095, some very early COS calibration and ERO datasets used slightly different TA subarrays.

[b]Updated early in LP1 on Aug 27, 2009 (2009.2239) with STScI PR#63378.

[c]Additional G140L updates were made on Dec. 4, 2012 (2012.339) with STScI PR#72193 to futher optimize the G140L subarrays.

[d]Updated for LP2 July 18, 2012 (2012.200) with STScI PR#70548.

[e]Updated for LP3 operations on Aug. 26, 2014 (2014.238) with STScI PR#78747.

[f]Updated for LP4 operations on Feb. 20, 2017 (2017.051) with STScI PR#86945.

[g]Starting with C18, the C1230 *CENWAVE* was replaced with C1280 due to first-order light issues. For further details see the C18 COS Instrument Handbook (Dixon et al., 2010) (STScI PR#64041 and #64659).

Table 16. FUVB PSA/BOA Subarrays for LP1–4.

OPT_ELEM	*CENWAVE*	B1 Subarray				B2 Subarray			
	(Å)	XC	YC	XS	YS	XC	YC	XS	YS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
				LP1[c]					
G130M	1291	5036[b]	76	1501	483	7477[b]	76	7773[b]	483[a,b]
G130M	1300	6039[b]	76	1501	483	6474[b]	76	8776[b]	483[a,b]
G130M	1309	7023[b]	76	1501	483	5490[a]	76	9760[a]	483[a,b]
G130M	1318	7977[b]	76	1501	483	4536[b]	76	10714[b]	483[a,b]
G130M	1327	7629[b]	76	2792[b]	483	3593[b]	76	11657[b]	483[a,b]
G160M	ALL	13749	76	1501	477[a,b]	…	…	…	…
G140L	1105	…	…	…	…	…	…	…	…
G140L	1230[g]	…	…	…	…	…	…	…	…
G140L	1280	…	…	…	…	…	…	…	…
				LP2[c]					
G130M	1291	1501	522	5036	76	7773	522	7477	76
G130M	1300	1501	522	6039	76	8776	522	6474	76
G130M	1309	1501	522	7023	76	9760	522	5490	76
G130M	1318	1501	522	7977	76	10714	522	4536	76
G130M	1327	2792	522	7629	76	11657	522	3593	76
G160M	ALL	1501	515	13749	76	…	…	…	…
G140L	1105	…	…	…	…	…	…	…	…
G140L	1280	…	…	…	…	…	…	…	…
				LP3[d](Pre FUVB “Hot-Spot”)					
G130M	1291	1501	460	5036	76	7773	460	7477	76
G130M	1300	1501	460	6039	76	8776	460	6474	76
G130M	1309	1501	460	7023	76	9760	460	5490	76
G130M	1318	1501	460	7977	76	10714	460	4536	76
G130M	1327	2792	460	7629	76	11657	460	3593	76
G160M	ALL	1501	453	13749	76	…	…	…	…
G140L	1105	…	…	…	…	…	…	…	…
G140L	1280	…	…	…	…	…	…	…	…
				LP3[e](Post FUVB “Hot-Spot”)[d]					
G130M	1291	1501	460	5036	76	7773	460	7060[e]	76
G130M	1300	1501	460	6039	76	8776	460	6057[e]	76
G130M	1309	1501	460	7023	76	9760	460	5073[e]	76
G130M	1318	1501	460	7977	76	10714	460	4119[e]	76
G130M	1327	2792	460	7629	76	11657	460	3176[e]	76
G160M	ALL	1501	453	13332	76	…	…	…	…
G140L	1105	…	…	…	…	…	…	…	…
G140L	1280	…	…	…	…	…	…	…	…
				LP4[f]					
G130M	1291	1501	419	5036	112	7773	419	7060	112
G130M	1300	1501	419	6039	112	8776	419	6057	112
G130M	1309	1501	419	7023	112	9760	419	5073	112
G130M	1318	1501	419	7977	112	10714	419	4119	112
G130M	1327	2792	419	7629	112	11657	419	3176	112
G160M	ALL	1501	416	13332	112	…	…	…	…
G140L	1105	…	…	…	…	…	…	…	…
G140L	1280	…	…	…	…	…	…	…	…

[a] Updated during SMOV (2009.201) with STScI PR#63095.

[b] Updated for LP2 operations on July 18, 2012 (2012.200) with STScI PR#70548.

[c] Due to gain sag induced 'Y-walk', the use of the FUVB segment for `ACQ/PEAKXD` (`NUM_POS=1`) TAs was deprecated on April 8, 2011 (2011.098) with STScI PR#67985. FUVB is still used for `ACQ/SEARCH` and `ACQ/PEAKD` TA exposures.

[d] Updated for LP3 operations on Aug. 26, 2014 (2014.238) with STScI PR#78747.

[e] Updated for post “Hot-Spot” LP3 TA operations on April 20, 2015 (2015.110) with STScI PR#80571.

[f] Updated for LP4 operations on Feb. 20, 2017 (2017.051) with STScI PR#86945. At LP4, both FUVA and FUVB are supported for all `ACQ/PEAKXD` (*NUM_POS*> 1) TA exposures. These subarrays also avoid the FUVB “Hot-Spot”.

[g] Starting with C18, the C1230 *CENWAVE* was replaced with C1280 due to first-order light issues. For further details see the C18 COS Instrument Handbook (Dixon et al., 2010) (STScI PR#64041 and #64659).

of the FUVB subarrays at X=14833. For the COS FUV gratings and the FUVB TA subarrays, the impacts were:

G140L: Not affected as no FUVB TA subarrays are used for G140L

G160M: One FUVB subarray is used for each *CENWAVE* with XC1=1501, XS1=13749. These were all changed to XS=13332 (no change in Y).

G130M: Two *CENWAVE*-specific FUVB subarrays are used to avoid Geocoronal Lyα. The X-size (XS) of the second subarray (XS2) will be trimmed to avoid the hotspot (XC1, XS1, XC2 and all the Y definitions do not change).

As of March 2018, no additional hot-spots have appeared on either FUVA or FUVB that required adjustment of the TA subarrays.[26] Due to the possibility of future hot-spots, the number of allow FUV TA subarrays per segment was increased from two to four on Sept 21, 2015 (2015.264) with STScI PR#81263.

[26]**NOTE TO REVIEWER: IF YOU THINK THAT ADDITIONAL DETAILS ARE WARRANTED HERE, I CAN ADD MORE DETAILS.**

5 NUV Imaging TA verification

Note to Reviewers: I am still working with Colin Cox on some details of the initial pointing offsets that are provided outside of the exposures of these programs (from the telemetry stream that creates the jitter files).

In order to streamline the review process of this ISR, I prefer to hold back this entire section until this portion of the analysis has been complete as the offsets from Colin directly affect the conclusions about the validity of the COS SIAF entries, and all offsets trickle down through all of the bootstrapping analysis. The current analysis is contained in file "NimVer.tex" and this is currently commented out "this section in the main .tex file for this ISR (cos_tamon_isr2018.tex). The tables that I think are complete are included in the file "NimVerT.tex".

5.1 Verifying the `ACQ/IMAGE` WCA-to-SA Offsets.

The verification of the `ACQ/IMAGE` WCA-to-SA (PSA or BOA) offsets is a multi-stage bootstrap process similar to the one used to measure the initial offsets in the SMOV enabling program (**P**11471, COS FUV Target Acquisition Algorithm Verification).

Each visit of each cycles monitoring program directly compares two `ACQ/IMAGE` combinations. We can bootstrap these back to PSA×MIRA to test the co-alignment of all four combinations. We call this the 'baseline' bootstrapping, the results of which are shown in Table **??** and discussed in § 5.2

These measurements have certain limitations, so as the $\pm 0.5p$ measurement uncertainity in both directions when measuring the WCA centroid. The WCA lamp exposures of each cycles program assist in removing these limitations from the bootstrapping. The PSA `ACQ/IMAGE` visits level the shutter open when taking these WCA lamp images so that a co-eval target+lamp TT image is acquired. This allows a direct calculation of the WCA-to-PSA offset using any desired centroiding algoritm. The BOA `ACQ/IMAGE` visits take sequential lamp and BOA target images to measure the WCA-to-BOA offsets, but these are not co-eval, and the aperture has been moved between the exposures, which often causes a ± one step offset. Fortunately, this offset can be tracked with the telemetry keywords and accounted for.

5.2 Baseline Bootstrap of `ACQ/IMAGE modes`

The baseline bootstrapping data is given in Table 17.

The basic steps in the verification process are:

1. Step1: Perform a PSA×MIRA `ACQ/IMAGE` **with** a separate WCA lamp image, preferably in TT mode.
   (a) If the PSA×MIRA `ACQ/IMAGE` was taken as part of an FGS-to-SI alignment program, then use this information to estimate the accuracy of the NUV SIAF entry by comparing the slew from the `ACQ/IMAGE` to the known offset inferred from evaluation of the FGS-to-SI program data (from Colin Cox).

Table 17. Basic ACQ/IMAGE Bootstrapping Results

PROPOSID	*ROOTNAME*	Configuration	WCA-Measured[a]		PSA-Measured		PSA-Centered		WCA-to-SA		TA Centering		*DATE-OBS*
		APERTURE	AD (-Y)	XD (-X)	AD (-Y)	XD (-X)	AD (-Y)	XD (-X)	AD (-Y)	XD (-X)	-AD	-XD[b]	
		×*OPT_ELEM*	*LAMPMYCR*	*LAMPMXCR*	*ACQCENTY*	*ACQCENTX*	*ACQPREFY*	*ACQPREFX*	(+Y)	(+X)	*ACQSLEWY*	*ACQSLEWX*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
						C21							
13171	lc6ka2imq	PSA×MIRA	650	508	284.0	459.7	277.3	462.7	372.7	45.3	0.158[c]	-0.070[c]	2013-09-01
13171	lc6ka2ioq	PSA×MIRB	811	304	436.5	258.2	436.9	259.0	374.1	45.0	-0.009	-0.019	2013-09-01
13526	lcgq01qdq	BOA×MIRA	651	520	283.2	472.9	282.6	474.5	368.4	45.5	0.013	-0.038	2014-11-19
13526	lcgq02huq	BOA×MIRB	811	285	440.3	237.9	444.8	238.5	366.2	46.5	-0.105	-0.015	2014-11-17
						C22							
13616	lci4a2e3q	PSA×MIRA	650	517	282.9	471.7	277.3	471.7	372.7	45.3	0.133[c]	0.001[c]	2014-10-27
13616	lci4a2e5q	PSA×MIRB	809	305	436.1	259.7	435.0	259.0	374.0	46.0	0.027	0.016	2014-10-27
13972	lcri01g7q	BOA×MIRA	651	517	287.2	471.0	282.6	471.5	368.4	45.5	0.109	-0.011	2015-10-06
13972	lcri02hgq	BOA×MIRB	810	286	444.2	240.6	443.8	239.5	366.2	46.5	0.010	0.026	2015-10-06
						C23							
14035	lcsla2bhq	PSA×MIRA	653	505	284.8	458.8	280.3	459.7	372.7	45.3	0.105[c]	-0.020[c]	2015-10-02
14035	lcsla2bjq	PSA×MIRB	813	293	439.3	247.9	439.0	247.0	374.0	46.0	0.007	0.022	2015-10-02
14440	ld3701h1q	BOA×MIRA	651	518	287.1	471.7	282.6	472.5	368.4	45.5	0.105	-0.018	2016-10-18
14440	ld3702n9q	BOA×MIRB	811	295	446.1	248.5	444.8	248.5	366.2	46.5	0.030	0.001	2016-10-19
						C24							
14857	ldozpbf5q	PSA×MIRA	654	515	266.2	467.3	281.3	469.7	372.7	45.3	-0.355[c]	-0.058[c]	2017-09-10
14857	ldozpbfbq	PSA×MIRB	813	289	440.0	243.8	439.0	243.0	374.0	46.0	0.023	0.020	2017-09-10
14857	ldozbadpq	BOA×MIRA	651	524	287.4	477.9	282.6	478.5	368.4	45.5	0.113	-0.013	2017-09-04
14857	ldozbblmq	BOA×MIRB	811	293	444.3	246.7	444.8	246.5	366.2	46.5	-0.011	0.006	2017-09-06

[a]Non-repeatability of the OSM and aperture mechanisms, along with environmental factors, result in lamp center offsets of up to 4p in AD and to 10 in XD in these exposures.

[b]BOA ACQ/IMAGEs move the aperture in the XD direction to obtain the WCA lamp image. Occasionally, the aperture mechanism misses the desired location by ± one step of $\sim 0.05''$.

[c]These PSA×MIRA ACQ/IMAGEs were part of the FGS-to-SI programs and do have a proceeding TA. The TA centerings presented here are to be compared to the FGS-to-SI post processing results presented in Table 25.

Note. — If the table caption is in the *ITALICS*, this value was taken directly from the indicated _RAWACQ.FITS header keyword. In detector coordinates, +AD is -Y, +XD is -X.

Table 18. PSA×MIRA Bootstrapping Measurement Adjustments

PROPOSID	*ROOTNAME*	Cycle	WCA-Measured[a] AD (-Y) *LAMPMYCR*	WCA-Measured[a] XD (-X) *LAMPMXCR*	PSA-Measured[d] AD (-Y)	PSA-Measured[d] XD (-X)	PSA-Centered AD (-Y) *ACQPREFY*	PSA-Centered XD (-X) *ACQPREFX*	WCA-to-SA AD (-Y)	WCA-to-SA XD (-X)	TA Centering (-AD) *ACQSLEWY*	TA Centering (-XD)[b] *ACQSLEWX*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	
						PSA×MIRA							
13171	lc6ka2imq	C21	650	508	284.0	459.7	277.3	462.7	372.7	45.3	$0.158 - (0.077) = 0.081$	$-0.070 - (0.070) = 0.000$	2
13616	lci4a2e3q	C22	650	517	282.9	471.7	277.3	471.7	372.7	45.3	$0.133 - (0.118) = 0.015$	$0.001 - (0.050) = -0.049$	2
14035	lcsla2bhq	C23	653	505	284.8	458.8	280.3	459.7	372.7	45.3	$0.105 - (0.065) = 0.040$	$-0.020 - (0.051) = -0.071$	2
14857	ldozpbf5q	C24	654	515	266.2	467.3	281.3	469.7	372.7	45.3	$-0.355 - () =$	$-0.058 - ()$	2
						PSA×MIRB							
13171	lc6ka2ioq	C21	811	304	436.5	258.2	436.9	259.0	374.1	45.0	-0.009	-0.019	2
13616	lci4a2e5q	C22	809	305	436.1	259.7	435.0	259.0	374.0	46.0	0.027	0.016	2
14035	lcsla2bjq	C23	813	293	439.3	247.9	439.0	247.0	374.0	46.0	0.007	0.022	2
14857	ldozpbfbq	C24	813	289	440.0	243.8	439.0	243.0	374.0	46.0	0.023	0.020	2
						BOA×MIRA							
13526	lcgq01qdq	C21	651	520	283.2	472.9	282.6	474.5	368.4	45.5	0.013	-0.038	2
13972	lcri01g7q	C22	651	517	287.2	471.0	282.6	471.5	368.4	45.5	0.109	-0.011	2
14440	ld3701h1q	C23	651	518	287.1	471.7	282.6	472.5	368.4	45.5	0.105	-0.018	2
14857	ldozbadpq	C24	651	524	287.4	477.9	282.6	478.5	368.4	45.5	0.113	-0.013	2
						BOA×MIRB							
13526	lcgq02huq	C21	811	285	440.3	237.9	444.8	238.5	366.2	46.5	-0.105	-0.015	2
13972	lcri02hgq	C22	810	286	444.2	240.6	443.8	239.5	366.2	46.5	0.010	0.026	2
14440	ld3702n9q	C23	811	295	446.1	248.5	444.8	248.5	366.2	46.5	0.030	0.001	2
14857	ldozbblmq	C24	811	293	444.3	246.7	444.8	246.5	366.2	46.5	-0.011	0.006	2

[a]Non-repeatability of the OSM and aperture mechanisms, along with environmental factors, result in lamp center offsets of up to 4p in AD and to 10 in XD in these exposures.

[b]BOA `ACQ/IMAGE`s move the aperture in the XD direction to obtain the WCA lamp image. Occasionally, the aperture mechanism misses the desired location by ± one step of $\sim 0.05''$.

[c]These PSA×MIRA `ACQ/IMAGE`s were part of the FGS-to-SI programs and do **NOT** have a proceeding TA. The TA centering adjustments presented here are to be compared to the FGS-to-SI post processing results presented in Table 25.

Note. — If the table caption is in the `Courier` font, this value was taken directly from the indicated _RAWACQ.FITS header keyword. In detector coordinates, +AD is -Y, +XD is -X.

Table 19. COS TA Monitor `ACQ/IMAGE` Data

ROOTNAME	*EXPTYPE*	*OPT_ELEM*	LAMP	Current	Target ET (s)	Lamp ET (s)	WCA AD	WCA XD	SA AD	SA XD	WtP AD	WtP XD	Lamp counts	Lamp cps	WCA bck	Lamp CPS	Lamp BP	Target BP
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
lcgq01q7q	EXT/SCI	MIRB	P2	MED	16	16	717	214	763.1	588.9	46.1	374.9	4890.0	305.6	167	305.6	4.4	26.7
lcgq01q9q	EXT/SCI	MIRA	P2	MED	150	150	479	370	550.3	739.9	71.3	369.9	1718.0	…	…	…	…	0.2
lcgq02hoq	WAVECAL	MIRA	P2	LOW	7	…	529	372	891.6	635.6	362.6	263.6	2827.0	403.9	97	403.9	9.9	0.3
lcgq02hqq	EXT/SCI	MIRB	P2	LOW	181	…	713	211	784.4	582.7	71.4	371.7	2383.0	…	…	…	…	0.2
lcri01g1q	EXT/SCI	MIRB	P2	MED	12	12	722	210	767.7	584.2	45.7	374.2	3016.0	251.3	166	251.3	4.2	30.0
lcri01g3q	EXT/SCI	MIRA	P2	MED	150	…	474	370	552.0	735.7	78.0	365.7	1964.0	…	…	…	…	0.2
lcri02hcq	EXT/SCI	MIRB	P2	LOW	181	181	715	211	782.3	578.6	67.3	367.6	2406.0	…	…	…	…	0.2
ld3701gvq	EXT/SCI	MIRB	P2	MED	16	16	727	210	772.8	584.3	45.8	374.3	4147.0	259.2	184	259.2	4.3	19.0
ld3701gxq	EXT/SCI	MIRA	P2	MED	150	150	479	371	551.2	735.8	72.2	364.8	1739.0	…	…	…	…	0.2
ld3702n1q	WAVECAL	MIRA	P2	LOW	14	…	515	371	886.6	659.4	371.6	288.4	5589.0	399.2	167	399.2	7.7	0.2
ld3702n4q	EXT/SCI	MIRB	P2	LOW	183	183	723	213	774.9	577.6	51.9	364.6	2081.0	…	…	…	…	0.2
ldozbadjs	EXT/SCI	MIRB	P2	MED	16	16	724	210	769.8	583.4	45.8	373.4	4005.0	250.3	138	250.3	4.4	20.2
ldozbadlq	EXT/SCI	MIRA	P2	MED	150	150	472	371	545.1	735.6	73.1	364.6	1462.0	…	…	…	…	0.2
ldozbblgq	WAVECAL	MIRA	P2	LOW	14	…	507	372	748.6	911.9	241.6	539.9	5721.0	408.6	155	408.6	8.4	0.1
ldozbbliq	EXT/SCI	MIRB	P2	LOW	183	…	713	213	776.2	578.7	63.2	365.7	2283.0	…	…	…	…	0.2

Note. — **Note to reviewer: Some of the numbers in this table are odd, I am researching.**

(b) Measure the [AD,XD] median of the lamp image (as done in `LTAIMCAL`), and the center of the target (in the same image) using both the `LTAIMAGE` 9×9 checkbox + flux-weighted centroid algorithm, and a 2D Gaussian fitting profile.

2. Step 2
3. Step 3
4. Step 4
5. Step 5

These results can be combined to show the measured offsets of PSA+MIRB, BOA+MIRA, and BOA+MIRB when compared to the initial PSA+MIRA `ACQ/IMAGE` of Visit ‘A2’ of **P**14035. These results are shown in Table 20. Combined offsets from PSA+MIRA are provided in both NUV pixels (p) and in arcseconds (″).

Table 20. `ACQ/IMAGE` WCA-to-SA offsets from PSA+MIRA

Aperture	MIRROR	AD Offset (″)	XD Offset (″)	AD Offset (p)	XD Offset (p)
		C21			
		C22			
		C23			
		C24			
PSA	B	0.021	-0.049	0.298	0.893
BOA	A	0.010	0.060	0.425	2.550
BOA	B	0.036	0.070	1.530	2.975

The results of **P**13972 and **P**14035 show that, for `ACQ/IMAGE`s :

- PSA+MIRA is aligned with PSA+MIRB to [AD, XD] $\leq$ [0.022, 0.007]″ (14035, Visit 'A2')
- PSA+MIRB is aligned with BOA+MIRA to [AD, XD] $\leq$ [0.023, 0.100]″ (13972, Visit '01')
- BOA+MIRA is aligned with BOA+MIRB to [AD, XD] $\leq$ [0.022, 0.024]″ (13972, Visit '02')

Discuss PR#81834 : COS ACQ/IMAGE WCA2SCI[X,Y] not calculated properly

5.3 WCA Lamp Images (aka, Lamp Family Portrait)

The four panels of Figures **??**–**??** show a 'family portrait' of the available COS PtNe Lamp (P1 or P2) + MIRROR (MIRA or MIRB) combinations possible with `ACQ/IMAGE`. Panel titles give the lamp and mirror combination, along with the current setting (in milli-amps, mA) and the exposure times. The images and subarrays are in 'detector' coordinates, as used on-board COS. The images show the observed counts/pixel/s (cps) as given by the colorbar on the bottom. The red dashed boxes show the given cycles' `ACQ/IMAGE` WCA subarrays. At the top of the subarrays, text provides the count rate in the brightest pixel (BP) in units of counts per second per NUV MAMA pixel (cps). The blue histogram on the bottom edge shows the cross-dispersion (XD) lamp profile in detector 'X' coordinates, while the green histogram on the left edge shows the along-dispersion (AD) lamp profile in detector 'Y' coordinates. The cross-hairs show the median location of the given configurations' lamp events within the TA subarray. PtNe#2 (P2) lamp was used for all `ACQ/IMAGE`s during C21-24, and was operated at LOW current (6 mA) for the using MIRA images and LOW current (3 mA) or MEDium current (10 mA) for the MIRB, depending on the Cycle. Note the separate MIRB images in about a 2:1 ratio, and the asymmetric (toward -XD) scattered light.

Note to reviewers: Placeholder text alert for possible further analysis to be added. Most of it overlaps with the subarray section, so . . .

Table 21. COS TA `ACQ/IMAGE` Monitoring Results Summary

`ACQ/` Mode	COS Channel	Optical Configuration	Direction AD or XD	Measured Offset[a] (mas)	Requirement (mas)	Goal (mas)
			C21			
			C22			
			C23			
			C24			
IMAGE	NUV	PSA+MIRA	AD	20±14	41–105	40
IMAGE	NUV	PSA+MIRB	AD	10±14	41–105	40
IMAGE	NUV	BOA+MIRA	AD	20±14	41–105	40
IMAGE	NUV	BOA+MIRB	AD	15±14	41–105	40
IMAGE	NUV	PSA+MIRA	XD	75±14	300	100
IMAGE	NUV	PSA+MIRB	XD	20±14	300	100
IMAGE	NUV	BOA+MIRA	XD	95±14	300	100
IMAGE	NUV	BOA+MIRB	XD	12±14	300	100
PEAKXD	NUV	G185M	XD	70±17	300	100
PEAKXD	NUV	G225M	XD	60±17	300	100
PEAKXD	NUV	G285M	XD	20±17	300	100
PEAKXD	NUV	G230L	XD	20±17	300	100
PEAKXD	FUVA	G130M	XD	-30±71	300	100
PEAKXD	FUVA	G160M	XD	-20±71	300	100
PEAKXD	FUVA	G140L	XD	-170±71	300	100

[a]The quoted error bars are associated with a 0.5 uncertainty when measuring the integer WCA coordinate, and 1/3 of an NUV pixel when using the `ACQ/IMAGE` checkbox centering algorithm. Added in quadrature, the approximate `ACQ/IMAGE` measurement error is ≈ 0.6 NUV pixels, or 14 (mas). Each `ACQ/PEAKXD` WCA-to-SA measurement contains an error estimate of $\sqrt{2} * 0.5$ times the plate scale of the detector in use (one half pixel or digital-element uncertainty for each measurement of an integer quantity). For the NUV channel, this is 23.5 (mas)/p or $\sqrt{2} * 0.5 * 23.5 = 17$ (mas). For the FUV channel, this is $\approx \sqrt{2} * 0.5 * 100 \approx 71$ (mas).

Table 22. COS TA Monitor ACQ/IMAGE Data

ROOTNAME (1)	*EXPTYPE* (2)	*OPT_ELEM* (3)	LAMP (4)	Current (5)	Target ET (s) (6)	Lamp ET (s) (7)	WCA AD (8)	WCA XD (9)	SA AD (10)	SA XD (11)	WtP AD (12)	WtP XD (13)	Lamp counts (14)	Lamp cps (15)	WCA bck (16)	Lamp CPS (17)	Lamp BP (18)	Target BP (19)
lcgq01q7q	EXT/SCI	MIRB	P2	MED	16	16	717	214	763.1	588.9	46.1	374.9	4890.0	305.6	167	305.6	4.4	26.7
lcgq01q9q	EXT/SCI	MIRA	P2	MED	150	150	479	370	550.3	739.9	71.3	369.9	1718.0	…	…	…	…	0.2
lcgq01qbq	WAVECAL	MIRA	P2	LOW	7	…	503	372	596.4	869.2	93.4	497.2	2964.0	423.4	61	423.4	7.7	0.3
lcgq01qfq	WAVECAL	MIRA	P2	LOW	7	…	503	372	652.2	793.2	149.2	421.2	2882.0	411.7	71	411.7	7.9	0.3
lcgq01qhq	EXT/SCI	MIRB	P2	MED	12	12	718	212	762.9	589.3	44.9	377.3	3391.0	282.6	151	282.6	3.9	19.9
lcgq02hoq	WAVECAL	MIRA	P2	LOW	7	…	529	372	891.6	635.6	362.6	263.6	2827.0	403.9	97	403.9	9.9	0.3
lcgq02hqq	EXT/SCI	MIRB	P2	LOW	181	…	713	211	784.4	582.7	71.4	371.7	2383.0	…	…	…	…	0.2
lcgq02hsq	WAVECAL	MIRB	P2	MED	12	…	738	212	898.7	439.2	160.7	227.2	3683.0	306.9	165	306.9	4.8	0.2
lcgq02hwq	WAVECAL	MIRB	P2	MED	12	…	738	213	927.8	656.8	189.8	443.8	3575.0	297.9	145	297.9	3.9	0.2
lcgq02hyq	WAVECAL	MIRA	P2	LOW	10	…	522	372	451.2	711.3	-70.8	339.3	4173.0	417.3	147	417.3	7.7	0.2
lcgq02icq	WAVECAL	MIRA	P1	LOW	10	…	537	374	803.3	768.3	266.3	394.3	26040.0	2604.0	120	2604.0	46.7	0.2
lcgq02ieq	WAVECAL	MIRA	P2	LOW	10	…	538	374	559.7	667.1	21.7	293.1	4036.0	403.6	122	403.6	7.4	0.2
lcgq02igq	WAVECAL	MIRB	P1	LOW	30	…	747	215	879.3	654.8	132.3	439.8	2659.0	88.6	364	88.6	1.3	0.1
lcgq02iiq	WAVECAL	MIRB	P2	MED	20	…	747	215	539.0	725.6	-208.0	510.6	6620.0	331.0	250	331.0	4.5	0.1
lcri01g1q	EXT/SCI	MIRB	P2	MED	12	12	722	210	767.7	584.2	45.7	374.2	3016.0	251.3	166	251.3	4.2	30.0
lcri01g3q	EXT/SCI	MIRA	P2	MED	150	…	474	370	552.0	735.7	78.0	365.7	1964.0	…	…	…	…	0.2
lcri01g5q	WAVECAL	MIRA	P2	LOW	10	…	506	372	768.5	842.0	262.5	470.0	4100.0	410.0	117	410.0	9.8	0.2
lcri01g9q	WAVECAL	MIRA	P2	LOW	10	…	506	371	278.3	582.7	-227.7	211.7	3960.0	396.0	148	396.0	9.2	0.2
lcri01gcq	EXT/SCI	MIRB	P2	MED	14	12	723	212	767.4	588.9	44.4	376.9	3381.7	281.8	148	281.8	4.0	28.3
lcri02haq	WAVECAL	MIRA	P2	LOW	14	…	526	372	644.1	719.4	118.1	347.4	5730.0	409.3	195	409.3	8.4	0.1
lcri02hcq	EXT/SCI	MIRB	P2	LOW	181	181	715	211	782.3	578.6	67.3	367.6	2406.0	…	…	…	…	0.2
lcri02heq	WAVECAL	MIRB	P2	MED	24	…	737	213	853.4	647.7	116.4	434.7	7167.0	298.6	308	298.6	4.6	0.1
lcri02hiq	WAVECAL	MIRB	P2	MED	24	…	737	213	606.7	645.2	-130.3	432.2	7316.0	304.8	295	304.8	4.5	0.1
lcri02hkq	WAVECAL	MIRA	P2	LOW	14	…	519	372	551.0	580.0	32.0	208.0	5840.0	417.1	203	417.1	7.9	0.1
lcri02hyq	WAVECAL	MIRA	P1	LOW	14	…	463	372	683.3	807.3	220.3	435.3	36245.0	2588.9	201	2588.9	45.5	0.1
lcri02i0q	WAVECAL	MIRA	P2	LOW	24	…	463	372	781.3	778.6	318.3	406.6	9864.0	411.0	303	411.0	6.9	0.1
lcri02i2q	WAVECAL	MIRB	P1	LOW	30	…	672	213	486.2	739.8	-185.8	526.8	2864.0	95.5	415	95.5	1.3	0.1
lcri02i4q	WAVECAL	MIRB	P2	MED	24	…	671	212	884.3	415.3	213.3	203.3	8082.0	336.8	312	336.8	4.9	0.1
ld3701gvq	EXT/SCI	MIRB	P2	MED	16	16	727	210	772.8	584.3	45.8	374.3	4147.0	259.2	184	259.2	4.3	19.0
ld3701gxq	EXT/SCI	MIRA	P2	MED	150	150	479	371	551.2	735.8	72.2	364.8	1739.0	…	…	…	…	0.2
ld3701gzq	WAVECAL	MIRA	P2	LOW	9	…	505	372	413.8	701.7	-91.2	329.7	3667.0	407.4	94	407.4	8.1	0.2
ld3701h3q	WAVECAL	MIRA	P2	LOW	10	…	505	372	802.6	780.0	297.6	408.0	3999.0	399.9	107	399.9	7.6	0.2
ld3701h5q	EXT/SCI	MIRB	P2	MED	16	1 6	728	212	773.4	589.0	45.4	377.0	4343.0	271.4	185	271.4	4.6	19.1
ld3702n1q	WAVECAL	MIRA	P2	LOW	14	…	515	371	886.6	659.4	371.6	288.4	5589.0	399.2	167	399.2	7.7	0.2
ld3702n4q	EXT/SCI	MIRB	P2	LOW	183	183	723	213	774.9	577.6	51.9	364.6	2081.0	…	…	…	…	0.2
ld3702n7q	WAVECAL	MIRB	P2	MED	24	…	728	212	778.9	703.3	50.9	491.3	7288.0	303.7	277	303.7	4.5	0.1
ld3702nbq	WAVECAL	MIRB	P2	MED	24	…	728	212	248.1	419.3	-479.9	207.3	7140.0	297.5	274	297.5	4.5	0.1
ld3702neq	WAVECAL	MIRA	P2	LOW	14	…	507	372	911.7	878.5	404.7	506.5	5622.0	401.6	153	401.6	8.1	0.1
ld3702o1q	WAVECAL	MIRA	P1	LOW	14	…	531	371	485.9	883.6	-45.1	512.6	37530.0	2680.7	172	2680.7	45.6	0.1
ld3702o3q	WAVECAL	MIRA	P2	LOW	24	…	531	371	665.9	888.6	134.9	517.6	9841.0	410.0	273	410.0	6.9	0.1
ld3702o5q	WAVECAL	MIRB	P1	LOW	30	…	744	211	651.6	609.1	-92.4	398.1	2375.0	79.2	319	79.2	1.5	0.1
ld3702o7q	WAVECAL	MIRB	P2	MED	24	…	743	211	940.2	700.2	197.2	489.2	6674.0	278.1	283	278.1	4.2	0.1
ldozbadjs	EXT/SCI	MIRB	P2	MED	16	16	724	210	769.8	583.4	45.8	373.4	4005.0	250.3	138	250.3	4.4	20.2
ldozbadlq	EXT/SCI	MIRA	P2	MED	150	150	472	371	545.1	735.6	73.1	364.6	1462.0	…	…	…	…	0.2
ldozbadnq	WAVECAL	MIRA	P2	LOW	9	…	499	372	889.8	583.2	390.8	211.2	3688.0	409.8	76	409.8	7.7	0.2
ldozbadrq	WAVECAL	MIRA	P2	LOW	10	…	498	372	311.8	608.8	-186.2	236.8	4009.0	400.9	97	400.9	7.0	0.2
ldozbadtq	EXT/SCI	MIRB	P2	MED	16	16	725	212	769.8	588.9	44.8	376.9	4367.0	272.9	121	272.9	3.7	21.0
ldozbblgq	WAVECAL	MIRA	P2	LOW	14	…	507	372	748.6	911.9	241.6	539.9	5721.0	408.6	155	408.6	8.4	0.1
ldozbbliq	EXT/SCI	MIRB	P2	LOW	183	…	713	213	776.2	578.7	63.2	365.7	2283.0	…	…	…	…	0.2
ldozbblkq	WAVECAL	MIRB	P2	MED	24	…	730	212	585.6	716.8	-144.4	504.8	6957.0	289.9	331	289.9	4.7	0.1
ldozbbloq	WAVECAL	MIRB	P2	MED	24	…	730	212	703.1	689.2	-26.9	477.2	6983.0	291.0	305	291.0	4.0	0.1
ldozbblqq	WAVECAL	MIRA	P2	LOW	14	…	510	372	380.6	845.9	-129.4	473.9	5566.0	397.6	177	397.6	7.9	0.1
ldozbbm4q	WAVECAL	MIRA	P1	LOW	16	…	503	371	815.0	659.6	312.0	288.6	42548.0	2659.2	189	2659.2	44.2	0.1
ldozbbm6q	WAVECAL	MIRA	P2	LOW	26	…	503	371	772.1	616.6	269.1	245.6	10476.0	402.9	300	402.9	7.6	0.1
ldozbbm8q	WAVECAL	MIRB	P1	LOW	32	…	715	211	252.8	463.5	-462.2	252.5	2714.0	84.8	407	84.8	1.4	0.1
ldozbbmaq	WAVECAL	MIRB	P2	MED	26	…	715	211	560.5	575.1	-154.5	364.1	7768.0	298.8	340	298.8	3.7	0.1
ldozpbf7q	EXT/SCI	MIRA	P2	LOW	20	20	511	370	555.5	741.6	44.5	371.6	7790.0	389.5	269	389.5	7.3	17.2
ldozpbf9q	EXT/SCI	MIRB	P2	MED	220	40	734	210	779.2	582.8	45.2	372.8	12877.2	321.9	523	321.9	3.5	0.6
ldozpbfdq	EXT/SCI	MIRB	P2	MED	220	40	734	211	780.3	584.0	46.3	373.0	13043.9	326.1	505	326.1	3.5	0.8
ldozpbffq	EXT/SCI	MIRA	P2	LOW	20	20	514	370	559.3	743.2	45.3	373.2	7798.0	389.9	285	389.9	7.1	23.4

Note. — **Note to reviewer: Some of the numbers in this table are odd, I am researching.**

Table 23 COS NUV Imaging (`ACQ/IMAGE`) WCA-to-SA FSW Target Offsets

Direction (AD or XD)	Detector Coordinate	MIR	PSA	BOA
MIRA				
AD	Y	MIRA	45.3	45.5
XD	X	MIRA	372.7	368.4
MIRB **prior** to Oct-20-2014 (2014.283)				
AD	Y	MIRB	45.0	45.5
XD	X	MIRB	374.1	366.3
MIRB **after**[a] to Oct-20-2014 (2014.283)				
AD	Y	MIRB	46.0	46.5
XD	X	MIRB	374.0	366.2

[a] Installed 2014.283 (STScI PR#79116, ”Update MIRB Cal Target Offsets”).

[x] X (XD) direction offsets, measured from calibration lamp median to the SA center (PCTA_XIMCALTARGETOFFSET).

[y] Y (AD) direction offsets, measured from calibration lamp median to the SA center (PCTA_YIMCALTARGETOFFSET).

5.4 [OPTIONAL] Reconfiguration of MIRB `ACQ/IMAGE`

Note to Reviewers: There are additional Details on the MIRB `ACQ/IMAGE` adjust of 2014. If you feel this document would be a good place to put that information, it could be added here.

5.5 [OPTIONAL] SIAF Verification

Note to Reviewers: There are additional details on the COS SIAF entries that can be inferred from the FGS-to-SI alignment program than are documented here. They mostly live in spreadsheet, that should be in the directory in the repo called "siaf_extra". If you feel this document would be a good place to put that information, it could be added here. Also, nowhere in any ISR are our SIAF entries documented. If requested, they could be added to the ISR either here or in the appendix.

5.6 [OPTIONAL] Importance of S/N to `ACQ/IMAGE`

Note to Reviewers: A great deal of effort was exerted in 2017 to analysis the S/N requirement of `ACQ/IMAGE`s. This allowed the relaxing of the S/N requirements that allowed many of the Mdwarf exposures to proceed. If you feel this document would be a good place to put that information, it could be added here, OR a new ISR could be initiated to document these efforts. Please let me know your thoughts on this.

Table 24. FGS-to-SI Program Initial Pointing Determinations

APERTURE	YEAR.DAY Activated	V2 (″)	V3 (″)
	NUV LP1		
LNMAC	2014.055	+232.7230	-237.5150
LNBOA	2014.055	+232.7230	-237.5150
LNPSA	2014.055	+232.7230	-237.5150
LAPTNBOAOF	2014.055	+223.3488	-246.8892
LAPTNPSAOF	2014.055	+242.0972	-228.1408
	FUV LP1		
LFBOA1	2016.151	+232.7230	-237.5150
LFPSA1	2016.151	+232.7230	-237.5150
LAPTFBOAF1	2016.151	+223.3488	-246.8892
LAPTFPSAF1	2016.151	+242.0972	-228.1408
	FUV LP2		
LFBOA2	2016.151	+235.1580	-235.0100
LFPSA2	2016.151	+235.1580	-235.0100
LAPTFBOAF2	2016.151	+225.7838	-244.3842
LAPTFPSAF2	2016.151	+244.5322	-225.6358
	FUV LP3		
LFBOA3	2016.151	+230.9137	-239.2749
LFPSA3	2016.151	+230.9137	-239.2749
LAPTFBOAF3	2016.151	+221.5395	-248.6491
LAPTFPSAF3	2016.151	+240.2879	-229.9007
	FUV LP4		
LFBOA4	2017.031	+229.1328	-241.0575
LFPSA4	2017.031	+229.1328	-241.0575
LAPTFBOAF4	2017.031	+219.7586	-250.4317
LAPTFPSAF4	2017.031	+238.5070	-231.6833

Note. — Explain APERNAME and reference figures

Table 25. FGS-to-SI Program Initial Pointing Determinations

PID	YEAR.DAY	DATE-OBS	Initial Pointing		Miss-Distance		SIAF	Active SIAF Entry	
			V2 (″)	V3 (″)	V2 (″)	V3 (″)	V2 (″)	Dates[a]	V3 (″)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
P11878	2009.338	04-Dec-2009	232.581	-237.544	-0.191	-0.033	3-Aug-2009	232.772	-237.511
P11878	2010.074	15-Mar-2010	232.488	-237.462	-0.284	0.049	...	232.772	-237.511
P11878	2010.110	20-Apr-2010	232.481	-237.457	-0.291	0.054	...	232.772	-237.511
P11878	2010.309	05-Nov-2010	232.604	-237.561	-0.168	-0.050	...	232.772	-237.511
P12399	2011.070	11-Mar-2011	232.645	-237.438	-0.127	0.073	20-Jun-2011	232.772	-237.511
P12399	2011.255	12-Sep-2011	232.737	-237.507	0.091	-0.062	21-Jun-2011	232.646	-237.445
P12781	2012.087	27-Mar-2012	232.622	-237.515	-0.024	-0.070	...	232.646	-237.445
P12781	2012.268	24-Sep-2012	232.713	-237.578	0.067	-0.133	...	232.646	-237.445
P13171	2013.061	02-Mar-2013	232.647	-237.590	0.001	-0.145	...	232.646	-237.445
P13171	2013.244	01-Sep-2013	232.723	-237.515	**0.077**[b]	**-0.070**[b]	23-Feb-2014	232.646	-237.445
P13616	2014.055	06-Apr-2014	232.535	-237.497	-0.188	0.018	24-Feb-2014	232.723	-237.515
P13616	2014.300	27-Oct-2014	232.841	-237.465	**0.118**	**0.050**	...	232.723	-237.515
P14035	2015.104	14-May-2015	232.617	-237.464	-0.106	0.051	...	232.723	-237.515
P14035	2015.275	02-Oct-2015	232.788	-237.462	**0.065**	**0.053**	...	232.723	-237.515
P14452	2016.092	01-Apr-2016	232.742	-237.485	0.019	0.030	...	232.723	-237.515

[a]Dates in this column show the dates that the [V2,V3] SIAF entries in the this and the following rows were active.

[b]These exposures, and the offsets measured here, were used to adjust the COS SIAF entries on 2014.055 (STScI PR#76982).

Note. — Items in **bold** are used in the analysis of this ISR.

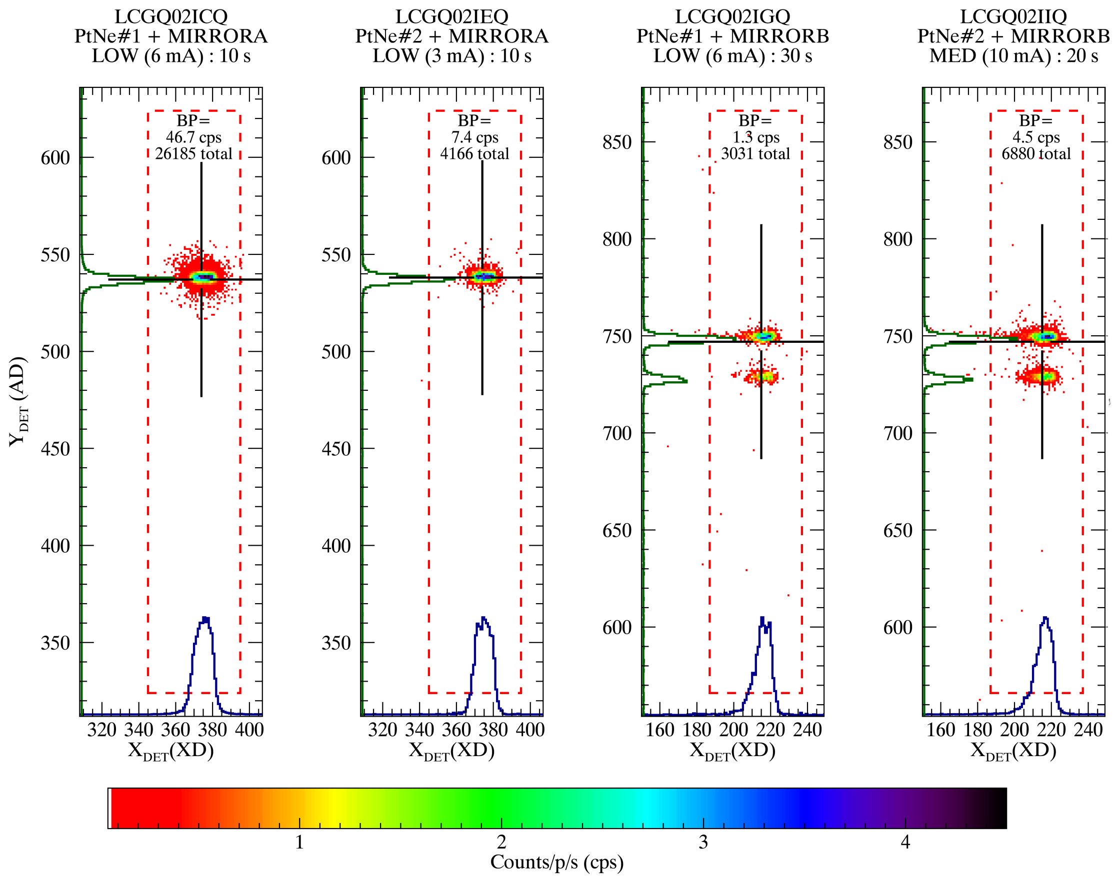

Figure 1 Cycle 21 (**P**13526 PtNe Lamp 'Family Portrait' Counts per second per pixel (cps) NUV images of the internal PtNe lamps (P1 & P2) through the WCA using either MIRRORA (MIRA, left 2 panels) or MIRRORB (MIRB, right 2 panels). The titles give the exposure *ROOTNAME*, configuration, exposure time and lamp current. Cross hairs show median locations and dashed lines show the `LTAIMCAL` TA subarrays. The insert text gives the Brightest Pixel (BP) in cps and the total counts in the subarray. AD and XD profiles are given along each axis, and the color bar at the bottom applies to all four images. Note the separate MIRB images in about a 2:1 ratio, and the asymmetric (toward -XD) scattered light. All panels are in detector (DET) coordinates.

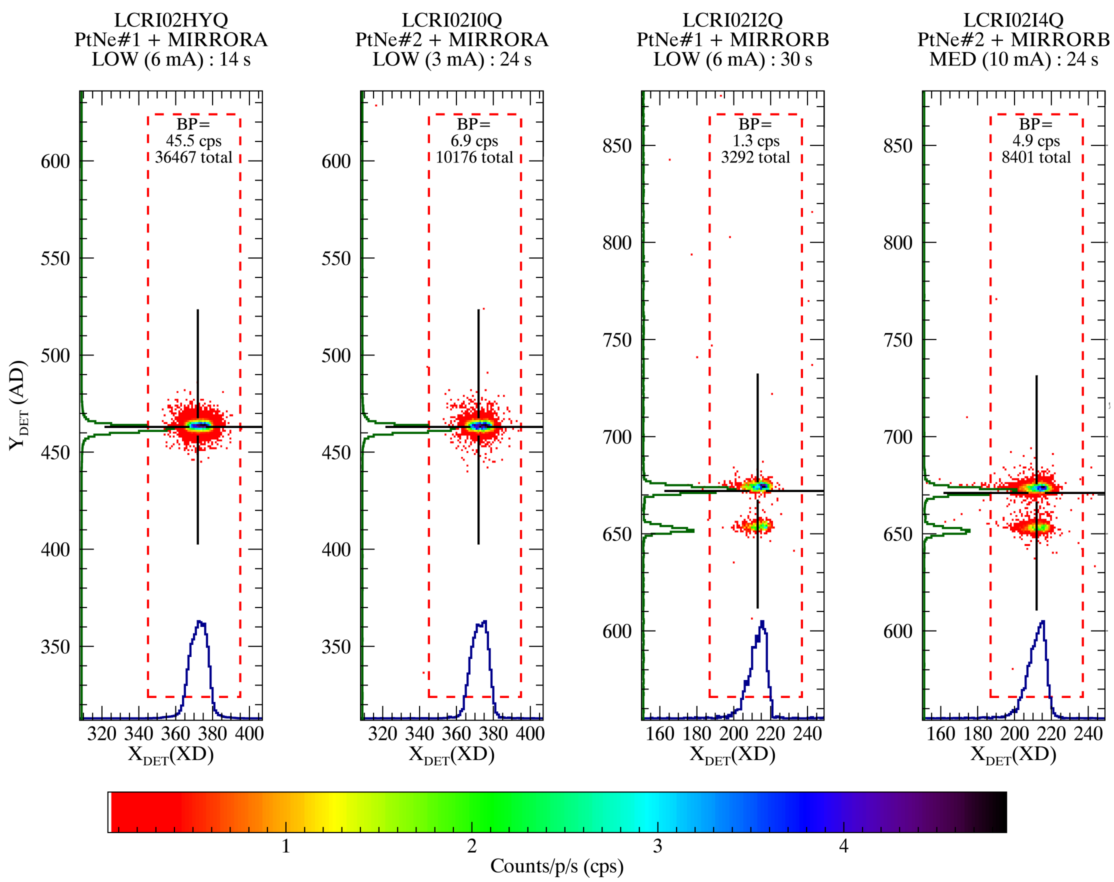

Figure 2 Cycle 22 PtNe Lamp ‘Family Portrait’ (see Fig 1).

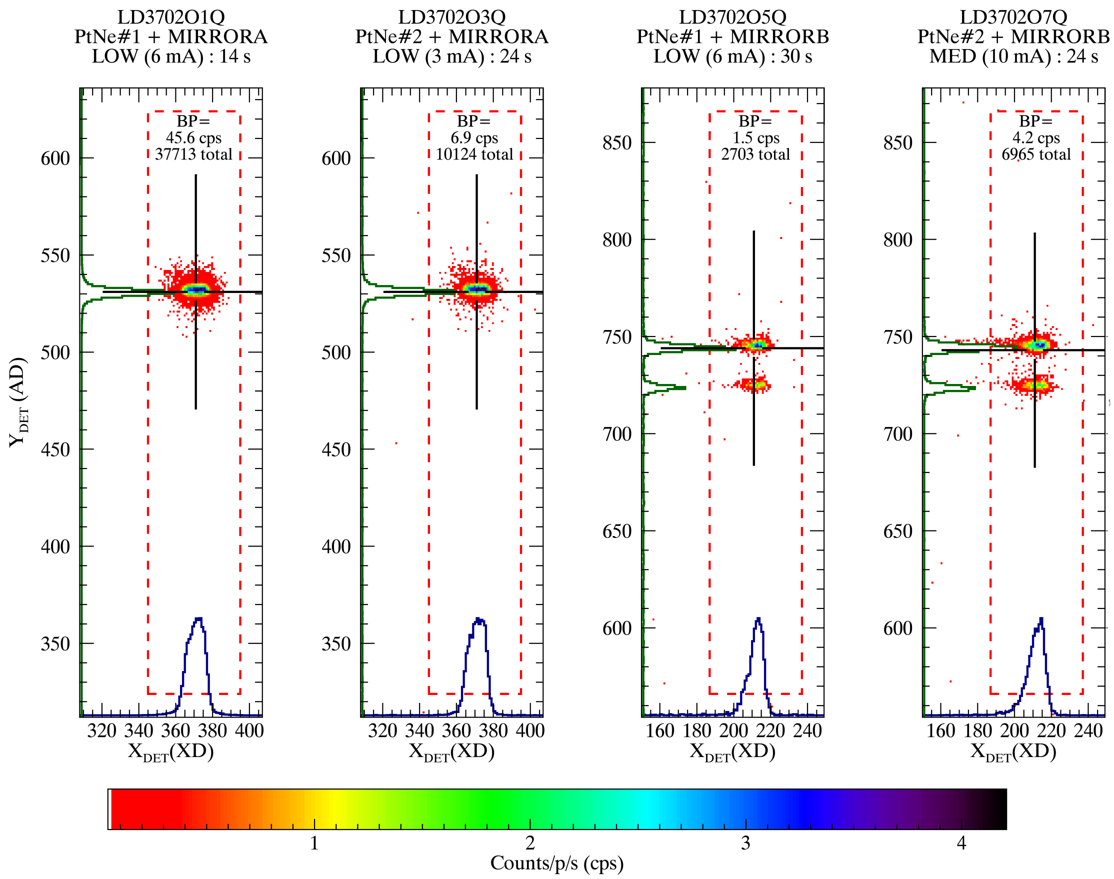

Figure 3 Cycle 23 PtNe Lamp ‘Family Portrait’ (see Fig 1).

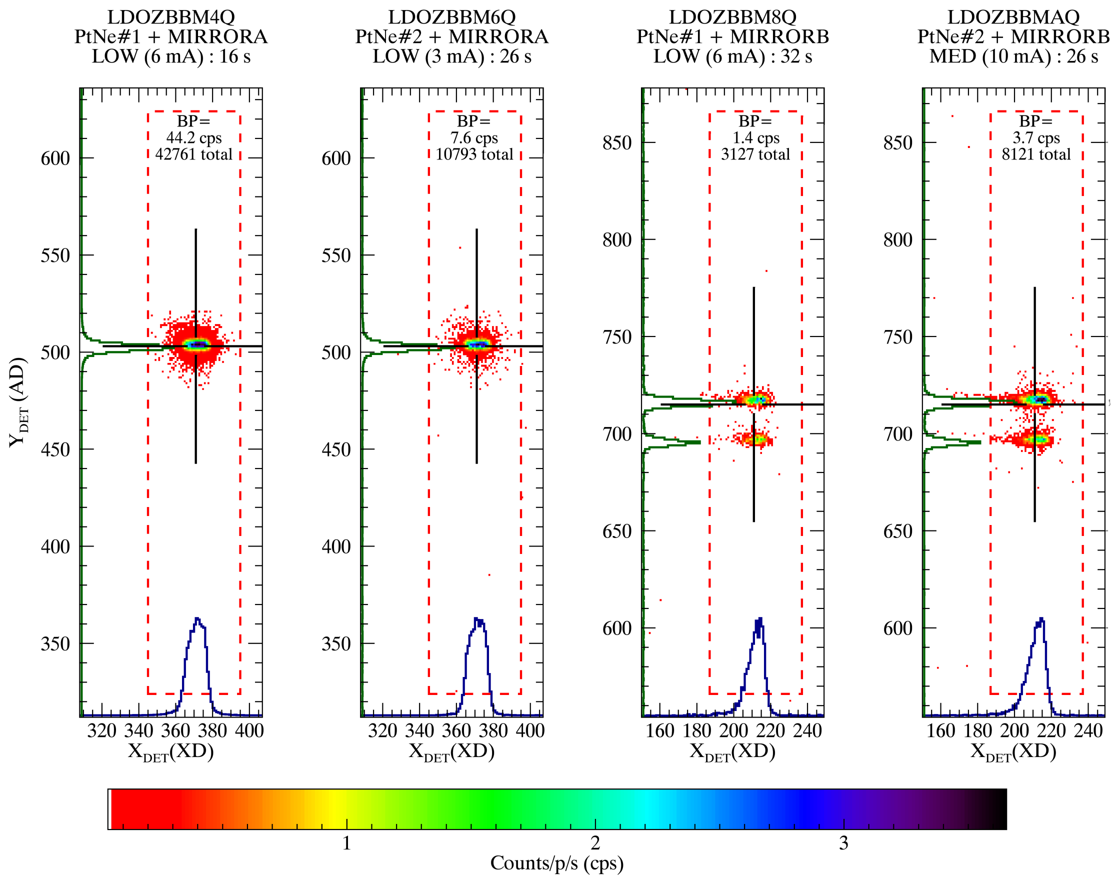

Figure 4 Cycle 24 PtNe Lamp ‘Family Portrait’ (see Fig 1).

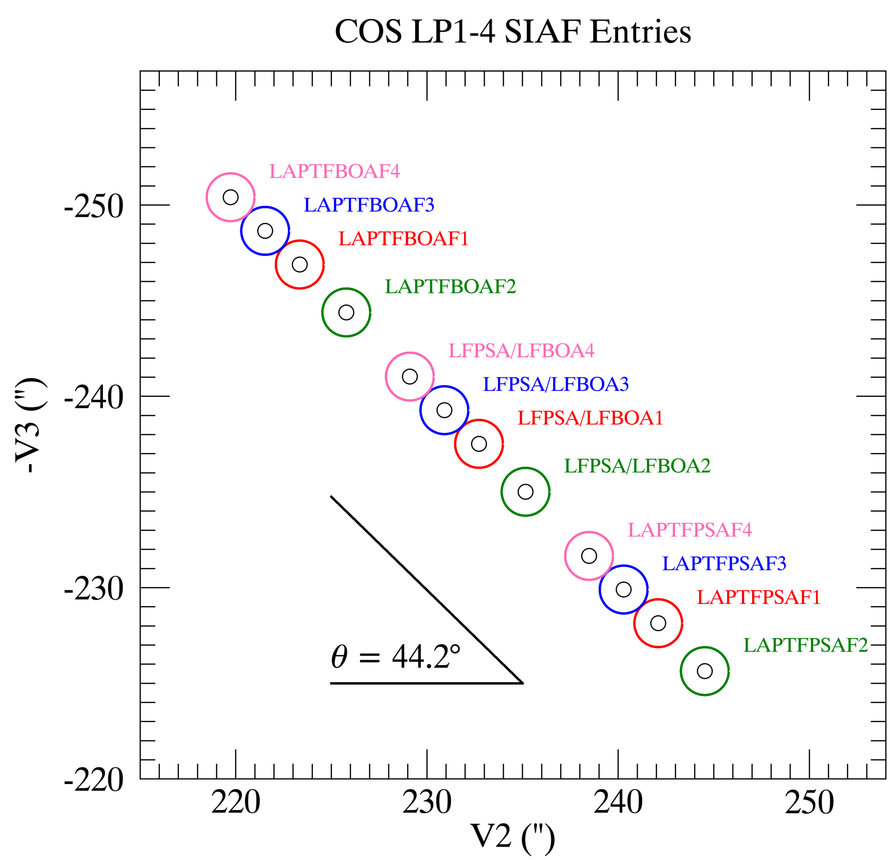

Figure 5 COS SIAF APERTURES . **Note to reviewers, sample SIAF figure1**

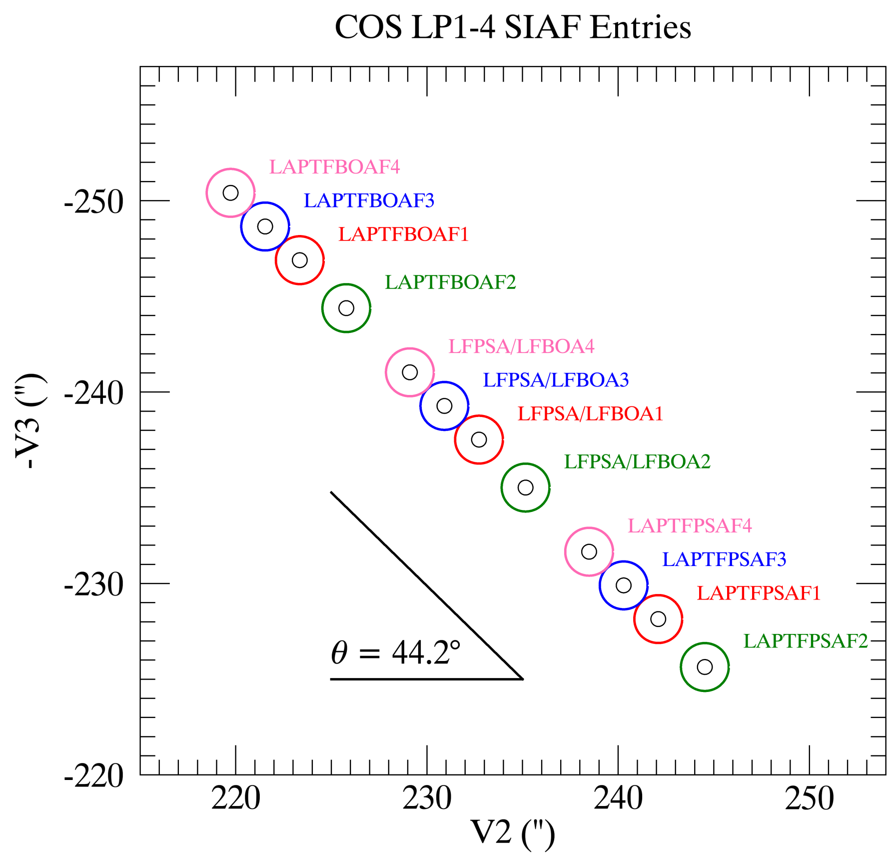

Figure 6 COS SIAF APERTURES . **Note to reviewers, sample SIAF figure2**

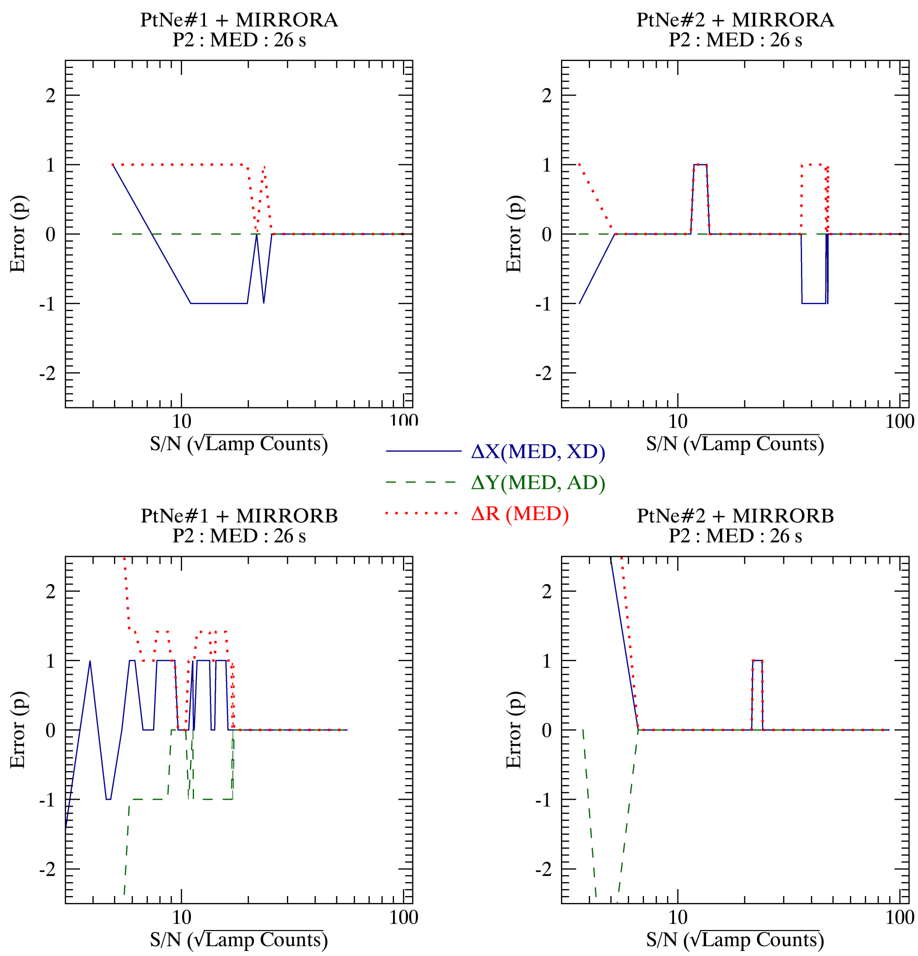

Figure 7 Example of C24 centering changes with S/N. . **Note to reviewers, this is a sample of the data available for the S/N vs centering accuracy discussion.**

6 Spectroscopic TA Verification

After the series of ACQ/IMAGEs that start each visit, the target should be accurately centered. We take advantage of this to monitor certain aspects of COS spectroscopic TAs.

COS spectroscopic TAs consist of up to three stages ACQ/SEARCH, PEAKD, and PEAKXD. The COS spectroscopic ACQ/SEARCH and PEAKD algorithms do not use any FSW patchable constants, and do not flash the internal calibration lamps. The only monitoring required for these TA phases is to ensure that the mechanisms were in their proper positions and that the TA subarrays defined in the HST ground commanding are proper for the mechanism positions used during the acquisitions. As discussed in § 4, the majority of the details will be addressed for each FUV LP in its enabling ISR, or have already been verified for the NUV and FUV LP1 positions in Penton & Keyes (2011).

COS NUV (LP1) and FUV LP2–4 spectroscopic TA in the XD direction uses ACQ/PEAKXD and requires the use of the XD WCA-to-PSA offsets with the nominal NUM_POS=1 algorithm. These offsets are contained for both the NUV and FUV channels in the FSW patchable constant table PCTA_CALTARGETOFFSET, and are provided for reference for all COS LPs in Table 26. This ISR only attempts to verify that these offsets were appropriate for all data obtained during the annual monitoring programs.

Each FUV central wavelength setting (*CENWAVE*) uses a unique OSM1 rotation, whereas all NUV TAs use the same OSM1 rotation independent of *CENWAVE* . However, each NUV *CENWAVE* uses a different OSM2 rotation during TA. Each FUV *CENWAVE* has it's own set of TA subarrays (up to four per segment), while the NUV TA subarrays are not *CENWAVE* specific, but are grating specific.[27]

The verification process is for ACQ/PEAKXD is simple, take a normal spectrum with a target signal-to-noise ratio of least 50 for the entire spectrum (2500 target counts), and directly measure the WCA-to-PSA offset and compare it the FSW value. For NUV exposures, this is almost always STRIPE=B, and for the FUV, only events from FUVA are used at LP2–4. TA subarrays are used to mask out any detector hot-spots or Geocoronal light that could interfere with the centering process. These spectra are also compared to the TA subarrays to verify that they satisfactory.

6.1 NUV Spectroscopic TA verification

The P2 WCA lamp and target XD locations for all NUV spectroscopic exposures is given in Table 6.1. As shown in the two rightmost "$|\Delta|$" columns of Table 6.1, all measured WCA-to-PSA offsets were within 3p in XD there FSW values. This equates to a $< 0.07''$ XD offset due to TA for all NUV monitoring exposures over C21–24.

A visual inspection of the spectra showed all NUV spectra to continue to be well centered in the ACQ/PEAKXD, ACQ/PEAKD, and ACQ/SEARCH NUV spectroscopic subarrays.

Note to reviewers: Table 6.1 doesn't actually show the subarray check. This was just a visual check to make sure that the NUV spectrum was well contained in the subarray. If you think that a table comparing the XD line centers to the subarray edges is worthwhile, it can be easily incorporated.

[27] **Note to reviewer: Do you think it is worthwhile to include the entire PCMECH_OSMTBL in the appendix? If so, i would add a reference to the table and some explanatory text here.**

Table 26. ACQ/PEAKXD WCA-to-PSA offsets

OPT_ELEM	LP1	LP2	LP3
	FUV[f]		
G130M	-898	-943	-892
G140L	-884	-950	-857
G160M	-898	-933	-901
	NUV[n]		
G185M	3742	...	...
G225M	3746	...	...
G230L	3734	...	...
G285M	3749	...	...

[f]Divide the FUV numbers by -10 to get the number of XD rows between the PSA and WCA spectra for a target centered in the aperture.

[n]Divide the NUV numbers by 10 to get the NUV WCA-to-PSA offset.

Note. — The FSW patchable constant PCTA_CALTARGETOFFSETSCALE determines the FSW scaling (currently set to 10). FUV scalings are ”negative” due to parity of HST slews relative to the COS coordinate system. **Note to reviewers: Do you think I should keep the numbers in their FSW values (not scaled), or should I go ahead and scale them ?**

6.2 FUV Spectroscopic TA verification

The P2 WCA lamp and target XD locations for all centered FUV spectroscopic exposures is given in Table 6.1.[28] Explain the last three columns: All FUV monitoring verifications ($|\Delta| = |WtP - eWtp|$) exceeded both the $\pm 0.3''$ requirement, but spectra taken near the end of the LP2 lifetime, and all G140L spectra, exceeded the $\pm 0.1''$ goal.

A visual inspection showed all FUV spectra to continue to be well centered in the FUV spectroscopic subarrays.[29]

[28] The POS_TARG offset spectra are not included in this table as they are beyond the scope of this ISR.

[29] **Note to reviewers: Table 6.1 doesn't actually show the subarray check. This was just a visual check to make sure that the FUV spectra were well contained in the subarray. If you think that a table comparing the XD line centers to the subarray edges is worthwhile, it can be easily incorporated.**

Table 27. NUV Spectroscopic ACQ/PEAKXD Monitoring

ROOTNAME (1)	*DATE-OBS* (2)	*OPT_ELEM* (3)	LP (4)	WCA[a] (p) (5)	PSA[b] (p) (6)	WtP[c] (p) (7)	eWtP[d] (p) (8)	$\lvert\Delta\rvert$[e] (p) (9)	$\lvert\Delta\rvert$[f] ($''$) (10)
				C21 (**P**13526)					
lcgq02i2q	2014-11-17	G185M	1	366.0	742.0	376.0	374.20	1.80	0.04
lcgq02i4q	2014-11-17	G225M	1	370.0	747.0	377.0	374.60	2.40	0.06
lcgq01r6q	2014-11-19	G285M	1	355.0	728.0	373.0	374.90	1.90	0.04
lcgq01qlq	2014-11-19	G230L	1	374.0	748.0	374.0	373.40	0.60	0.01
				C22 (**P**13972)					
lcri02hqq	2015-10-06	G185M	1	367.0	742.0	375.0	374.20	0.80	0.02
lcri02hoq	2015-10-06	G225M	1	371.0	747.0	376.0	374.60	1.40	0.03
lcri01giq	2015-10-06	G285M	1	351.0	726.0	375.0	374.90	0.10	<0.01
lcri01ggq	2015-10-06	G230L	1	374.0	747.0	373.0	373.40	0.40	0.01
				C23 (**P**14440)					
ld3702noq	2016-10-19	G185M	1	366.0	743.0	377.0	374.20	2.80	0.07
ld3702nmq	2016-10-19	G225M	1	370.0	747.0	377.0	374.60	2.40	0.06
ld3701hbq	2016-10-18	G285M	1	352.0	727.0	375.0	374.90	0.10	<0.01
ld3701h9q	2016-10-18	G230L	1	375.0	748.0	373.0	373.40	0.40	0.01
				C24 (**P**14857)					
ldozbblwq	2017-09-06	G185M	1	366.0	743.0	377.0	374.20	2.80	0.07
ldozbbluq	2017-09-06	G225M	1	370.0	747.0	377.0	374.60	2.40	0.06
ldozbadzq	2017-09-04	G285M	1	352.0	727.0	375.0	374.90	0.10	<0.01
ldozbadxq	2017-09-04	G230L	1	374.0	748.0	374.0	373.40	0.60	0.01

[a]XD centroid of the WCA spectrum. For NUV spectra, this is the median calibration lamp location.

[b]XD centroid of the target spectrum taken through the PSA, using the same centroid method as the WCA.

[c]WtP is the absolute value of difference in the XD locations of the measured WCA and PSA spectra ($WtP = |PSA - WCA|$)

[d]eWtP = Expected WCA-to-PSA offset from FSW table XIMCALTARGETOFFSET (see Table 26).

[e]Offset of WtP from a perfectly centered measured in XD rows.

[f]Offset of WtP in arcseconds ($''$). Note that the platescales are different for each grating and LP.

Note. — All spectra were taken at FP-POS=3. All monitoring verifications ($|\Delta| = |WtP - eWtp|$) easily exceeded both the $\pm0.3''$ requirement and the $\pm0.1''$ goal.

Table 28. FUV Spectroscopic ACQ/PEAKXD Monitoring

ROOTNAME	*DATE-OBS*	*OPT_ELEM*	LP	WCA[a] (p)	PSA[b] (p)	WtP[c] (p)	eWtP[d] (p)	$\lvert\Delta\rvert$[e] (p)	$\lvert\Delta\rvert$[f] ($''$)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
				C21 (**P**13526)					
lcgq01r8q	2014-11-19	G130M	2	602.15	508.31	-93.84	-92.80	1.04	0.12
lcgq01raq	2014-11-19	G140L	2	608.76	513.48	-95.28	-93.50	1.78	0.20
lcgq02i6q	2014-11-17	G160M	2	596.07	503.35	-92.71	-91.80	0.91	0.11
				C22 (**P**13972)					
lcri01gkq	2015-10-06	G130M	3	537.32	448.98	-88.34	-89.20	0.86	0.08
lcri01h6q	2015-10-06	G140L	3	544.55	457.36	-87.20	-85.70	1.50	0.15
lcri02hsq	2015-10-06	G160M	3	531.78	442.13	-89.65	-90.10	0.45	0.04
				C23 (**P**14440)					
ld3701hdq	2016-10-18	G130M	3	536.33	447.41	-88.92	-89.20	0.28	0.03
ld3701hfq	2016-10-18	G140L	3	543.43	455.95	-87.48	-85.70	1.78	0.17
ld3702nqq	2016-10-19	G160M	3	531.09	440.96	-90.13	-90.10	0.03	0.00
				C24 (**P**14857)					
ldozbae1q	2017-09-04	G130M	3	535.26	445.66	-89.61	-89.20	0.41	0.04
ldozbae3q	2017-09-04	G140L	3	541.76	454.25	-87.51	-85.70	1.81	0.18
ldozbblyq	2017-09-06	G160M	3	530.84	440.75	-90.09	-90.10	0.01	0.00

[a]XD centroid of the WCA spectrum.For FUV spectra, this is mean lamp photon location.

[b]XD centroid of the target spectrum taken through the PSA, using the same centroid method as the WCA.

[c]WtP is the absolute value of difference in the XD locations of the measured WCA and PSA spectra ($WtP = |PSA - WCA|$)

[d]eWtP = Expected WCA-to-PSA offset from FSW table XIMCALTARGETOFFSET (see Table 26).

[e]Offset of WtP from a perfectly centered measured in XD rows.

[f]Offset of WtP in arcseconds ($''$). Note that the platescales are different for each grating and LP.

Note. — All spectra were taken at FP-POS=3. All FUV monitoring verifications ($|\Delta| = |WtP - eWtp|$) exceeded both the $\pm0.3''$ requirement, but spectra taken near the end of the LP2 lifetime, and all G140L spectra, exceeded the $\pm0.1''$ goal.

7 Results

The main results of the HST Cycles 21–24 COS TA monitoring programs are as follows:

SIAF: Note to reviewers: Placeholder text pending the insertion of Colins' tweaks. All COS NUV ACQ/IMAGEs use identically-valued SIAF entries (*LFPSA* & *LFBOA*). Where available, the exposures in the FGS-to-SI Alignment programs gave good estimates of the accuracy of the existing NUV LP1 *LFPSA*/*LFBOA* SIAF entries as they performed a PSA×MIRA ACQ/IMAGE on a target whose position was already determined by cross-calibration of the other HST Science Instruments (SI). For C21–24, this results of this ISR indicate that the NUV SIAF entry was accurate to at least [AD,XD] = [0.XX,0.YY]″.[30] No SIAF adjustments were identified as being needed for NUV (LP1) or FUV (LP2–3) from the programs of this ISR. However, 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 C22 (February 24, 2014; 2014.055, STScI PR#76982), while COS FUV observations were at LP2. At this time, all COS entries (NUV and FUV) were adjusted in [V2,V3] by [0.077, -0.070]".

Spectroscopic TA Subarrays: Visual inspection of NUV and FUV images, and a comparison of the NUV and FUV spectra XD centriods, indicate that all spectroscopic TA subarrays were appropriately defined for C21–C24. However, NUV PtNe lamp (WCA) monitoring should be continued, as OSM1 and OSM2 secular drift continues to move the WCA lamp images in AD direction. Combined with the increased detector background of the NUV channel, some of the approved NUV central wavelength settings for COS TA may loss effectiveness, for further details see 2.6 of the C25 COS IHB (Fox et al., 2017). Hot-spot monitoring must be continued for both FUVA and FUVB as COS TA is particularly suseptable to contamination from variable localized detector background.

NUV Imaging TAs and Subarrays: The COS ACQ/IMAGE tests indicate that the centering achieved with a PSA×MIRB ACQ/IMAGE is co-aligned with a PSA×MIRA ACQ/IMAGE to within [AD,XD] $\approx$ $[0.010, 0.020]''$, with a measurement error of approximately $0.014''$. ACQ/IMAGE tests reveal that BOA×MIRA is co-aligned with PSA×MIRB to within [AD,XD] $\approx$ $[0.015, 0.100]''$, [31] and that BOA×MIRB is co-aligned with BOA×MIRA to within [AD,XD] $\approx$ $[0.007, 0.062]''$. As shown in the PtNe lamp 'family portraits' of Figures **??– ??** are used during the LTAIMCAL portion ACQ/IMAGE TA FSW routine to locate the position of the aperture mechanism before centering the target. While COS TAs have used the PtNe#2 lamp for all TAs since installation, images of both lamps (P1 and P2) are taken annually with both MIRRORs (MIRA and MIRB) to monitor the observed count rates. No changes of concern were observed in the PtNe lamp count rates between C21–C24. **Note to reviewer: This results may change when Colins SIAF tweaks are included.**

NUV Spectroscopic TAs: Spectroscopic TAs for all NUV gratings in all Cycles met both the $0.3''$ requirement and the $0.1''$ goal.

[30] As determined from the initial pointing before the first COS PSA×MIRA ACQ/IMAGE of each Cycles program(s).

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

FUV Spectroscopic TAs: All FUV monitoring verifications ($|\Delta| = |WtP - eWtp|$) exceeded both the $\pm 0.3''$ requirement, but spectra taken near the end of the LP2 lifetime, and all G140L spectra, exceeded the $\pm 0.1''$ goal. [32] Spectroscopic TAs for all FUV gratings met the $0.3''$ requirement and the G130M and G160M gratings achieved the $0.1''$ goal.

8 Conclusions.

Through constant monitoring, and periodic FSW, ground commanding, and operations updates, HST+COS TA has performed remarkablely well during Cycles 21–24. The STScI Team thanks the GSFC and STScI personal for there outstanding cooperation and contributions in these efforts

NUV detector background has been the biggest source of concern for NUV TAs, while FUV gain-sag induced Y-walk and inherent detector geometric distortions were the biggest concerns of FUV TAs at LP1–3. At FUV LP4, Y-walk will not be as big a concern as the `NUM_POS=1ACQ/PEAKXD` is not affected by either Y-walk or geometric distortions.

Notes to reviewers: This section will be continue to be completed as the review process continues.

[32] Spectroscopic FUV WCA-to-PSA offsets are determined using a mean photon lamp and/or target XD position in the appropriate subarray. The difference between the positions is compared to the FSW value, accounting for any measured offset in the preceding `ACQ/IMAGE`.

9 Acknowledgements

Notes to reviewers: This section will be completed as the review process continues. To be acknowledeged: GFSC: Mike Kelly, Ben Teasdel, Olivia Lupie, Scott Swain, STScI: John Bacinski, George Chapman, Merle Reinhart, James White, Sean Lockwood, Brian York, David Sahnow, Karla Peterson, Josh Goldberg.

10 Change History for COS ISR 2018-XX

Version 0.01: 30-March-2018 Original Draft Document for Review Version 0.02: 03-April-2018 NUV Image Verification Section Debuts with Minor tweeks to tables and text (no external comments) **Note to reviewers: I will be documenting updates here, until Version 1.0 is released, then the notes will be moved to comments.**

11 References

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Table 29. Cross-Dispersion (XD) Aperture Positions (*APERXPOS*)

LIFE_ADJ	NUV		FUV	
(LP)	PSA[a]/WCA[b]	BOA[c]/FCA[d]	PSA/WCA	BOA/FCA
(1)	(2)	(3)	(4)	(5)
LP1	126	-153	126	153
LP2	53	-226	...	...
LP3	181	-98	...	...
LP4	234	-45	...	...

[a]PSA=Primary Science Aperture

[b]WCA=Wavelength Calibration Aperture

[c]BOA=Bright Object Aperture

[d]FCA=Flat-field Calibration Aperture

Note. — COS XD aperture positions (*APERXPOS*) are stored in the PCMECH_APMXDISPPOSITION FSW table. Although LP1-8 are defined in that table for both NUV and FUV, only the NUV LP1 and FUV LP1–4 entries listed here have been used for science observations. Values used for FCA calibration observations are different from those listed here, and are commanded via APT special commanding (e.g., during the semi-annual FUV Gain Map programs, **REFERENCE**). Along-Dispersion (AD) values (*APERYPOS*) are stored in the PCMECH_APMDISPPOSITION FSW table. All COS apertures and LPs use *APERYPOS=22*.

12 [OPTIONAL]Appendix A

Note To Reviewer: If You Think That A Complete Listing Of All TA FSW Parameters And Tables Is Appropriate, I Am Willing To Include These Here. Here is a sample table, that is current referenced.