ENGINEERING CHANGE ORDER Center for Astrophysics & Space Astronomy University of Colorado, Boulder				**ECO No.** COS-058 Date 2 March 2001 Sheet 1 of 16
Drawing/Document Title	Drwg/Doc No.	Revision Letter Current	 New	Special Distribution
OP-01	COS-01-0001	10	11	
				Stop Production Now ❑ Yes ❑ No

Description of Change:

1. **Section 2.1.1.2, p. 30 of Rev 10:** The LSHUTINI macro was deleted some time ago, so the only remaining macro is to "Move External Shutter". Delete the first sentence of this section that begins, "The external shutter is operated…" along with the bullets 1) and 2). Delete sub-section 2.1.1.2.1 entirely, and delete the title of the sub-section for 2.1.1.2.2. Section 2.1.1.2 will then only contain the text formerly in 2.1.1.2.2 that begins, "The "Move External Shutter" macro commands …", and ends "… 60,000 total movements."

2. **Replace Section 5.2 intro paragraph and 5.2.1 with the following text and figures.**

5.2 TARGET ACQUISITION PROCEDURES

Elements of the discussion in this section are excerpted from Ball SER-FSW-001 ("Target Acquisition Concepts for COS") and the CU TER's COS-11-0014 ("Recommended TA FSW and Operations Changes, based upon the TAACOS: Phase I Reports for the FUV and NUV Channels"), COS-11-0016 ("TAACOS FUV Phase I Report"), COS-11-0024 ("TAACOS: NUV Phase I Report"), and COS-11-0027 ("TAACOS: Target Acquisition with the TA1 Mirror"). Refer to those documents for details, which are treated incompletely here for the sake of brevity. Some details have been revised during the preparation of this document. In cases of conflict this document should take precedence.

COS has two autonomous modes of target acquisition: dispersed light target acquisition with either the FUV or NUV detector, and imaging target acquisition with the TA1 mirror and NUV detector. They use

Reason for Change: Updates to COS operations in OP-01.	Disposition/Effectivity				
	To Comply With ECO				
	Use As Is				
	Rework To ECO				
	Scrap And Rebuild				
	Record change Only				
	Other (See Above)				

Prepared By:	Jon Morse	Date	2 March 2001	CCB Required	❑Approved
Approved By:		Date		❑Yes ❑No	❑NotApproved
Approved By:		Date			Immediate
Approved By:		Date		❑Class I	Incorporation
Approved By:		Date		❑Class II	❑Yes ❑No
Approved By:		Date		Completion	
Project Mgr:		Date		Date	

only hardware and software capabilities within COS.

5.2.1 COS Autonomous Target Acquisition

The autonomous target acquisition modes are designed to center the HST aberrated point spread function (PSF) of a UV point in a COS science aperture, as shown in Fig. 5.2-1. In practice, they should be suited to most COS science targets:

1. A UV point source in an uncrowded field (i.e., no other UV-bright target within ~10 arcseconds) whose flux is within the acceptable range for one or more of the COS spectroscopic and imaging modes.
2. A UV point source at a fixed offset from the UV science target that can be acquired by COS, and that is within the range of small angle maneuvers that HST can perform.
3. A small but resolved target that does not entirely fill the aperture.
4. An extended object that is larger than the aperture, but which has a region of enhanced brightness for the target.
5. Extended diffuse objects with no preferred precise target position (no target acquisition required).

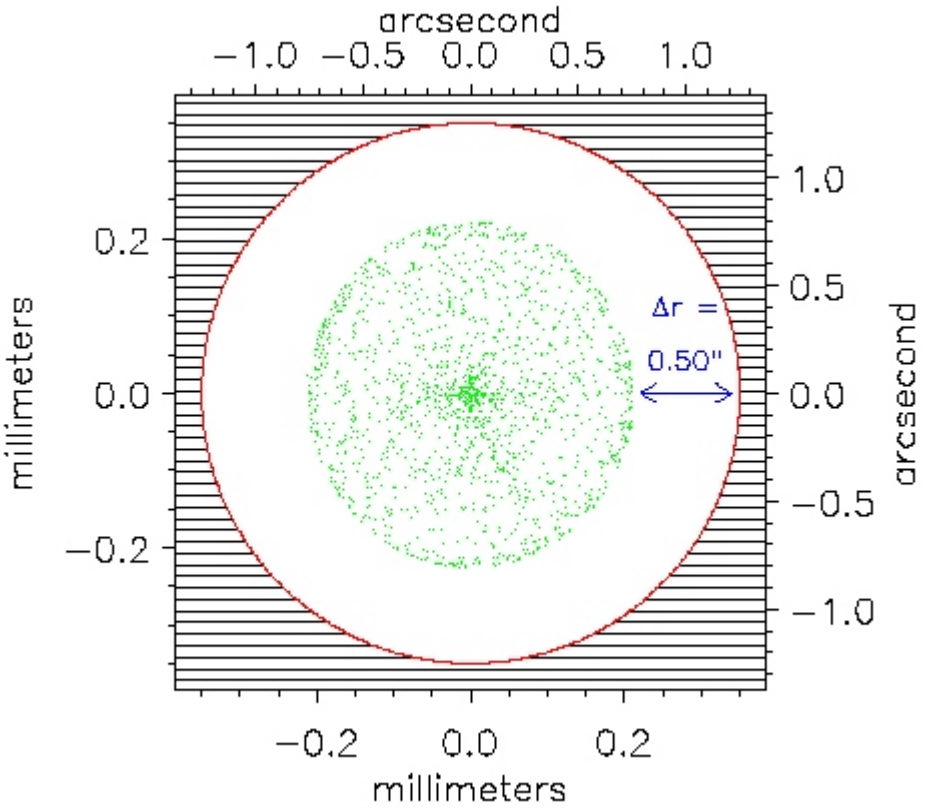

Figure 5.2-1: The HST PSF as compared to the COS PSA. The aberrated, out of focus, HST PSF (in green) is approximately circular with a radius of ~0.2 mm at the COS aperture plate. The COS PSA is circular with a radius of 0.35 mm, which corresponds to 1.25" on the sky. The HST PSF is smaller in radius than the COS PSA by 0.136 mm or ~0.5".

The first event in the acquisition process is for HST to slew to a position based upon the coordinates provided by the proposer and STScI selected guide stars. The COS external shutter will be closed during all such slews, as a normal precaution in the BOP plan. Experience with GHRS, FOS, and STIS acquisitions shows that, using the HST Guide Star Catalog I (GSC I), the initial pointing places the target within ±1 arcsecond of the center of the aperture 60% to 75% of the time, and within ±2.5 arcseconds essentially 100% of the time. The initial pointing precision is expected to improve with GSC II, which will be in use by the time COS is installed.

After the initial slew and acquisition of guide stars the sequence of events unique to the COS autonomous target acquisition (TA) process will begin. The Phase I Configuration is applicable to all COS TA modes, then the discussion is broken out into subsections applicable to dispersed light TA, followed by imaging TA. The motivation for the sequence of events that occur in either dispersed light or imaging TA is similar, though the implementation differs. Sub-arrays that are necessary for dispersed light or imaging TA are discussed in Section 5.2.2.

Phase 1 Configuration

The initial setup (not necessarily in this order) includes initializing the flight software for the acquisition, ensuring that the external shutter is closed, turning on the detector and letting it warm up (if applicable), moving the mechanisms to their required positions, and whatever else may be included in a standard preparation. This phase does not require any unique COS target acquisition flight software capabilities.

5.2.1.1 Dispersed Light Target Acquisition

Phase 2 Calibrate aperture locations in detector pixel coordinates

The goal of target acquisition is to move the HST to place the target at a preferred position within the aperture. Light which enters COS from a fixed location at the aperture plane will not always fall on precisely the same pixels, due to variations in the mechanical position of the grating, and variations in the conversion of photoelectron events to digitized pixel values. Phase 2 of target acquisition is an attempt to compensate for these small variations by measuring the pixel location of light from a fixed calibration aperture, whose offset from the center of the science aperture is known. The external shutter should remain closed for this phase.

2a. Turn on one of the spectral calibration (PtNe) lamps and record its spectrum through the WCA in Time-tag mode for a prescribed length of time to achieve an appropriate S/N. Use only the counts that arise from pixels within a sub-array that encloses the spectral calibration image (see Tables 5.2-1 and 5.2-3). (In

the nominal configuration for this phase, the flat-field aperture is behind a mask and any light that might enter the FCA should not be able to reach the detector.)

2b. Determine the position of this comparison spectrum in the direction perpendicular to dispersion, in units of detector pixels. The simplest algorithm is to find the mean position of the events in the cross-dispersion direction. Computer simulations (TAACOS) indicate this method is sufficient for both the FUV and NUV detectors. The comparison spectrum has an offset from the optimum location of the target spectrum. The offset may be different for each grating because the cross-dispersion image profile of the calibration spectrum may differ slightly for each grating. The offsets for each grating will be calibrated during ground and SMOV testing.

It is not necessary to save and downlink the full image data from this phase. The measured comparison spectrum mean position and the total counts should be downlinked.

Phase 3 Target Search

HST initially slews to the nominal target position, regardless of whether a target search is executed or whether the target search is even-ordered or odd-ordered. For even-ordered search patterns, the target acquisition FSW will compute the small slew necessary to move HST from the nominal target position to the first dwell point of the spiral, such that the nominal target position is the geometric center of the completed spiral.

Since we cannot be 100% certain that the initial pointing of the HST will place the target in the aperture, a search can be performed to move the target into the aperture. This phase can be used for targets intended to be observed with either the Primary Science Aperture or the Bright Object Aperture. The PSA and BOA are separated in the cross-dispersion direction by 3.7 mm = 13.2 arcseconds. In addition to screening target regions to verify no bright source would fall into the aperture not being used, the size of the search pattern for the BOA must not exceed ~10 arcseconds in the direction of the PSA in order to minimize the chance that light from a bright target could spill into the un-attenuated primary aperture.

The external shutter will remain open for the target search phase. It shall remain open during the small angle maneuvers between dwell points. The same exposure time should be used at all dwell points. BOP checks are performed at each dwell point of the target search and peak-up phases.

3a. The search consists of moving the telescope through a square spiral pattern of 2 – 5 dwell points on a side. The dwell points of a spiral search will therefore cover an area on the sky of $\{[\Delta DW \times (n-1)] + (2 \times 1.25)\}^2$ arcseconds^2, where ΔDW is the offset in arcseconds between dwell point centers, n is the number of dwell points on a side of the spiral search, and 1.25 arcseconds is the radius of the aperture. (In reality, the area covered is a few arcseconds larger on a side because the aberrated wings of a target centered outside the aperture can still be detected.) Simulations show that dwell point offsets larger than 2 arcsecs will introduce

target acquisition errors due to unsampled areas within the search pattern. Therefore the square area on the sky covered should be less than [2 × (n-1)] + 2.5 arcseconds on a side. TAACOS simulations indicate the optimum dwell point offset is $\Delta DW_{optimum} = 1.767$ arcsecs, the largest dwell point offset which leaves no interior sky positions unsampled. The choice of the number of dwell points on a side (2, 3, 4, or 5) should be left to the observer and should be made based upon their assessment of the quality of the target coordinates. The flight software algorithm for commanding the search pattern will be adapted from STIS. Note that including even numbered spiral searches requires an offset from the nominal target coordinates to the center of the first dwell point.

Two flux measurements are made at each dwell point. The first is a check of the count rate against the BOP limit. The BOP check sums the counts over the entire detector, not just the sub-array for the spectrum. If the BOP check is passed, the second is a measurement of the count rate summed over the sub-array(s) that include the target spectrum (see Tables 5.2-2 and 5.2-4), which in the FUV exclude strong geocoronal airglow lines. This is a measure of the brightness of the target spectrum at the current dwell point.

If the BOP check fails, the flight software will close the external shutter and the TA software will exit. This response to BOP violation will ensure the safety of the detector and will preserve the current timeline. The shutter will be re-opened by a command inserted by the ground system at the start of the next phase of target acquisition or, if subsequent phases are not performed, at the start of the next science exposure.

3b. After completing the search pattern, the series of flux measurements are analyzed and the preferred position is computed. The flight software will compute a flux-weighted centroid of all of the positions whose flux exceeds a patchable threshold. This will be the default algorithm. An alternative, “return to brightest point” procedure will also be available.

3c. Request a slew to point the telescope at the preferred position, starting at its current pointing at the last dwell point in the spiral. After the slew, the target will be in the aperture, but not necessarily well centered. Note that when the centroid algorithm is used the pointing of the HST after this phase will probably not be one of the dwell points visited during the search.

The total flux detected at each dwell point should be retained for downlink. It is not necessary to save the entire spectrum image from each point. The location of the computed centroid and the parameters of the requested slew should be downlinked.

This centroid process may place the target in the aperture with precision that is sufficient for many science observations. If additional precision is needed, two autonomous peakup steps (dispersion and cross-dispersion) are available. A spiral search could also be repeated with the same or fewer dwell points. The

precision of the centroid algorithm and the need for additional target search or peakup steps will be determined during SMOV.

Phase 4 Peakup in cross-dispersion direction

The next step is to move the telescope to improve the centering of the target in the direction perpendicular to dispersion.

4a. Record the target spectrum in Time-tag mode for a prescribed period of time by accumulating counts within the sub-array (see Table 5.2-2 and Table 5.2-5) for the grating and detector in use.

4b. Compute the location of the spectrum in the cross-dispersion direction. Use the same algorithm as in step 2b. Here, too, the units are detector pixels.

4c. From the measured comparison spectrum and the tabulated offset, calculate the location on the detector where the target spectrum will be when the target is properly centered in the aperture. The size and location of the science target sub-array are established during the observation planning process and are not changed here. The sub-array size and location will be designed to avoid bright airglow lines in the FUV spectrum (see Sec. 5.2.2.). The sub-array will be large enough to capture the target spectrum with the target anywhere in the science aperture, and with the largest likely range of locations on the detector.

4d. Calculate the telescope slew needed to move the target so that its spectrum aligns with the preferred location. The preferred position will be the location of the calibration spectrum found in step 2b modified by the fixed offset stored in a table of calibration data.

4e. Request the slew. The directions of all slews commanded by target acquisition are specified in the detector (X,Y) coordinates. The magnitude is in units of 2^{-27} radians. The angle between the COS detector coordinates and the HST (V2,V3) directions will be measured during pre-launch testing, determined accurately during SMOV, and rotation matrices for each detector will be included in a ground calibration database, parts of which may be loaded into and used by the NSSC-1.

The data downlinked from phase 4 should include both the measured cross-dispersion mean of the science spectrum and the desired cross-dispersion coordinate computed by the flight software.

Phase 5 Peakup in the dispersion direction

For this phase, we try to maximize the flux through the aperture, rather than define a location of the spectrum on the detector. We assume that the flux is maximum when the target is at the center. The external

shutter must be open for this phase, and shall remain open during the small angle maneuvers described below.

5a. This peakup consists of a linear scan of the telescope in a direction that displaces the spectrum parallel to its dispersion. The total flux in the spectrum within the sub-arrays (see Tables 5.2-2 and 5.2-4) is measured at each dwell point. The same exposure time is used at each dwell point. Each flux measurement should be BOP checked. The response to a failed BOP check is the same as that described in step 3a.

The calculation of the linear scan will be adopted from the STIS flight software. The scan will be defined by a set of parameters such as the number of dwell points and their spacing. It will be possible to alter these parameters, especially during testing and calibration. Sensible default values will be defined, and general observers will not routinely choose these parameters. The order in which to visit the dwell points is not specifiable by any macro parameters or patchable constants, but is built into the logic of the target acquisition of the flight software (exactly as is done for STIS).

5b. The default algorithm will be the flux-weighted centroid. A "return to brightest" option will also be available. During normal science operations, one preferred algorithm will be identified and used as the default by the flight software. General observers will not specify which algorithm to use.

5c. Request the slew needed to move the target to the preferred point from its current pointing at one end of the linear scan. At the end of the peakup phase the target should be well centered in the aperture.

The data to be downlinked include the fluxes measured at each dwell point, the computed flux-weighted centroid or brightest dwell point, and the parameters of the slew requested by the flight software.

Three lines on the observing proposal exposure logsheet should be used to specify a COS autonomous dispersed light TA. The first line should trigger the initial configuration, the aperture calibration, and the target search phases. The calibration and the search will be performed with the same grating. A second line will request the peakup in the cross dispersion direction, or a second spiral search. A third line could request a peakup in the dispersion direction. The second and third lines (peakups) are optional. TAACOS simulations indicate that the order of the peakups is not important. In principle, the peakup and/or additional spiral search could be done with a different grating than the one used for the initial search or science observations.

It should be noted that although the steps outlined above are envisioned to be used in dispersed-light target acquisition, there is nothing in the TA FSW that would preclude using the TA1 mirror if target acquisition were being performed with the NUV channel.

Post-peakup offset

This step allows a small adjustment of the pointing to be made by the ground system following the autonomous peakup. The FUV and NUV channels may have a slightly different optimum target location, due to possible differences in the alignment of the optics on the mechanisms. It is not absolutely necessary to do the acquisition and the spectrum observation with the same grating, or even the same channel. This is a small adjustment to the location of the object currently centered in the aperture. It is not an offset to a separate nearby target.

5.2.1.2 Imaging Target Acquisition with the TA1 Mirror

COS will be capable of performing autonomous imaging target acquisition using the TA1 mirror on OSM2 and the NUV detector. Experience with STIS suggests that this may be the fastest and most accurate method of centering a point source in the COS science aperture. (We note that if COS is operated with only one detector on at a time, it almost certainly would not be faster to use the NUV imaging TA mode and then switch to the FUV channel for science observations, instead of performing dispersed light target acquisition using the FUV detector.) Imaging TA with the TA1 mirror is limited to targets for which the initial HST slew can position the target within 1.7" of the center of the science aperture – i.e., the target coordinates must be good enough so that the target can be placed somewhere within the science aperture.

The Phase I Configuration will place the NCM1 mirror on OSM1 to its proper position for illuminating the NUV channel; then OSM2 will place the TA1 mirror to its proper position, where either the primary TA1 image or the TA1-Rear-View-Mirror-Mode (TA1-RVMM) – that uses the front surface reflection off the TA1 order sorter filter – is accessed. After the Phase I Configuration is complete, the TA1 imaging TA mode uses the following sequence. The procedure is depicted in Figure 5.2-2 below.

Phase 2 Calibrate Aperture Location (LTAIMCAL)

Due to possible mechanism mis-alignments, it is necessary to flash the wavelength calibration lamp, with OSM2 rotated to the TA1 mirror, to determine the position on the detector corresponding to the wavelength calibration image. The extraction sub-array for this TA phase is provided in Section 5.2.2. Once the location of the wavelength calibration image is determined, a known offset is applied (via patchable constants) to calculate the detector location corresponding to the center of the science aperture. If the flux of the target is high enough such that the TA1-RVMM is used to image the science target, then the wavelength calibration image should also be obtained with the TA1-RVMM.

2a. Turn on one of the spectral calibration (PtNe) lamps and record its spectrum through the WCA in Time-tag mode for a prescribed length of time to achieve an appropriate S/N. Use only the counts that arise from pixels within a sub-array that encloses the spectral calibration image (see Table 5.2-6). The external shutter should be closed during this phase.

2b. Determine the position of the wavelength calibration image in both X and Y pixel positions on the NUV detector using a median algorithm. TAACOS simulations show that using the median algorithm to determine the X and Y centroids of the wavelength calibration image should produce approximately ± 0.01" errors in the predicted location of the center of the science aperture.

It is not necessary to save and downlink the wavelength calibration image. The measured X and Y centroids and total counts should be downlinked.

Phase 3 Science Image Centering (LTAIMAGE)

After measuring the X and Y centroids of the wavelength calibration lamp image and knowing the X and Y pixel offsets to the detector position of the center of the science aperture being used (where the offsets to the PSA and BOA will be the same since the current plan is to move the BOA to the same position as the PSA for bright objects), a short exposure of the science target is then obtained, the X and Y centroids measured, and an HST small angle maneuver is executed to place the target at the center of the science aperture. Note that for targets with flux greater than $\sim 1.3 \times 10^{-14}$ ergs/cm^2/s/Å, to avoid BOP rate violation it is necessary to attenuate the TA1 image either by observing with the TA1-RVMM or the BOA science aperture, or both (see Section 5.3.9 for a discussion of exposure times *versus* science target flux).

3a. Following a BOP check exposure, record the science target image in ACCUM mode within the appropriate sub-array (see Table 5.2-7).

3b. Compute the pixel positions of a 170p×170p (or 4" × 4") "small box" that is centered on the detector at the expected location of the science aperture center, based on the offsets calculated in the previous phase. Compute the X and Y pixel centroids of the science target within the "small box" using a STIS-based Moving Box Plus Flux Centroid (MBPFC) algorithm. The MBPFC algorithm moves a 9×9 pixel box across all possible box locations within the "small box" to find the position containing the maximum counts. At this maximum count position, the flux-weighted X and Y centroids of the science target are calculated within the 9×9 pixel box.

3c. Calculate the telescope slew needed to move the target so that it is centered at the preferred location.

3d. Request the slew.

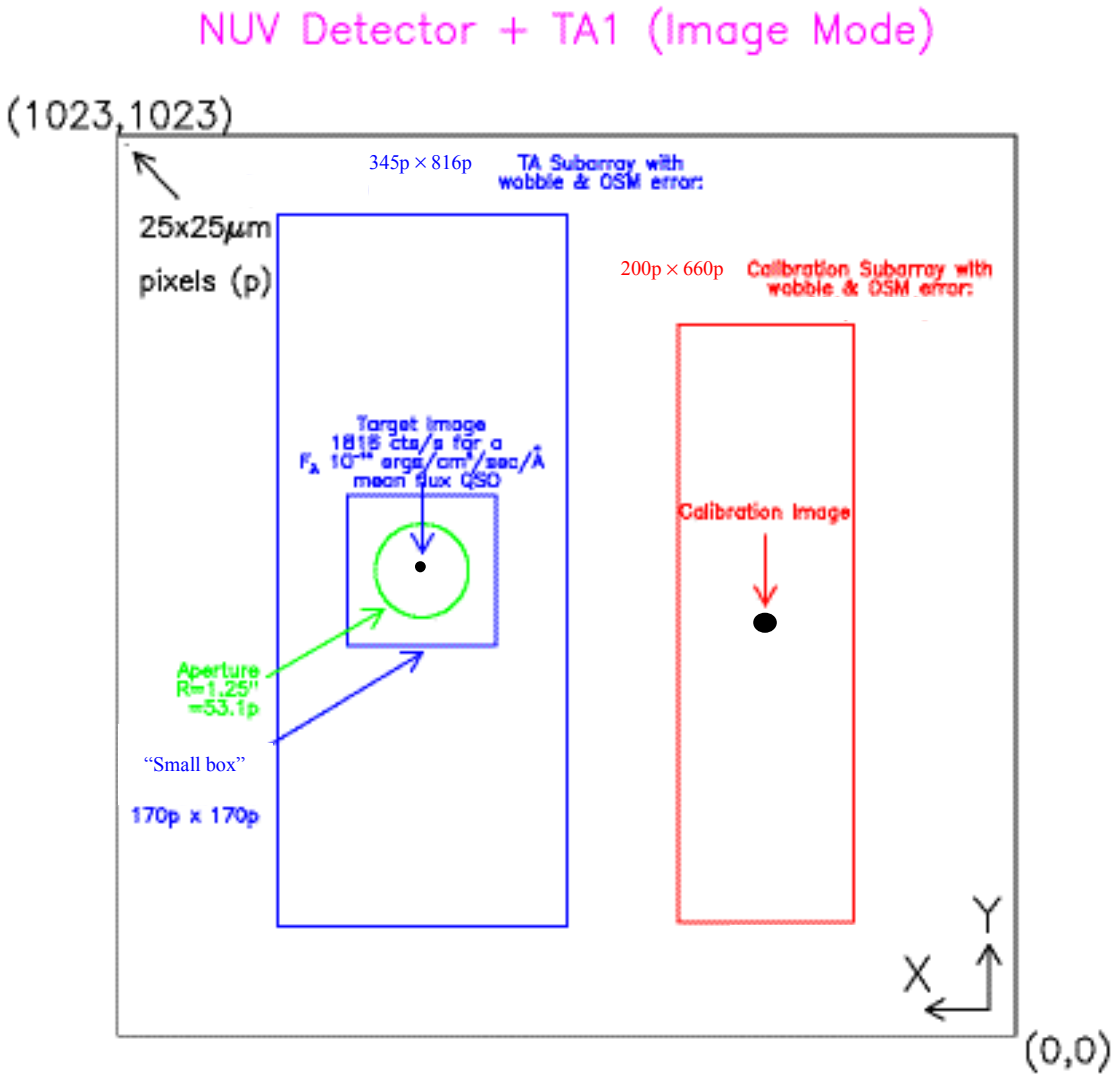

Figure 5.2-2: TA1 imaging target acquisition sub-array summary. The wavelength calibration image is recorded within the large red sub-array (defined in Table 5.2-6). The science target image is recorded in the large blue sub-array (defined in Table 5.2-7). Based on the measured position of the calibration image and known X and Y offsets to the center of the science aperture, a "small box" is defined within which the science target position is measured using the MBPFC method. A slew is then requested to move the target to the center of the science aperture.

The ACCUM image from this phase should be downlinked, along with the total counts, the computed X and Y centroids of the science target, the X and Y pixel locations of the preferred target position, and the X and Y offsets commanded in the slew. A subsequent exposure can then be commanded and downlinked to verify that the target ended up in the preferred location.

3. Section 5.3.5, top of page 132 (Rev 10): After the first sentence, that begins "A total exposure map can be used…", add the following text then continue the paragraph:

A total exposure map is a detector image that includes every event ever downlinked from COS to the ground. It does not include those events associated with target acquisition phases that do not downlink the data nor events that have been excluded by the FSW because they occurred outside the bounds of any sub-arrays that have been used.

4. Section 5.3.5, middle of page 132: Add the following paragraphs to the end of the section:

When the spectrum is repositioned onto a "fresh" region of the FUV detector active area, the gain for the events within the spectrum is re-initialized back to the original levels, i.e., at installation of COS into the HST. It is anticipated that no adjustment to any of the detector operating parameters will be needed. After adjusting the spectrum, the sensitivity curves will need to be updated via standard star observations to account for the higher gain.

However, in the event that COS loses the ability to reposition the spectrum on the detector – e.g., if the aperture mechanism fails – there is another way to restore the gain of those regions experiencing gain sag. In this case, the high voltage (HV) of the entire microchannel plate stack can be raised by a couple of hundred volts. In doing so, the gain for *all* events will be increased, not just those events from regions experiencing gain sag. While this will eliminate loss of detection quantum efficiency due to gain sag, it may also seriously affect the imaging performance of the detector by altering the size, shape, and magnitude of the charge cloud from the MCP stack. It is also likely that the dark rate of the detector will increase modestly. If the HV is altered for any reason, an extensive recalibration of the resolution performance and sensitivity curves is required. Lastly, there is always the potential for coronal discharge and/or HV arcing to occur when the HV is increased beyond nominal settings. It is strongly recommended that the STScI consult with the COS PI and IDT if the HV needs to be adjusted either up or down.

5. Replace Section 5.3.9 starting on page 134 (Rev 10) with the following text and figures:

5.3.9 NUV Imaging Observations

Some elements of the discussion in this section are based on material presented in the CU TER's COS-11-0024 ("TAACOS: NUV Phase I Report") and COS-11-0027 ("TAACOS: Target Acquisition with the TA1 Mirror"). In areas of discrepancy, this document shall take precedence.

The NUV optics mounted on OSM2 include a flat mirror (TA1) that produces an image of the sky with a field of view slightly larger than the diameter of the aperture. It will have several uses. During SMOV it will be used to verify alignment and the NUV plate scale – e.g., checking the distance from the calibration aperture to the target in the science aperture when it is properly centered. During normal science operations, it will be used for NUV imaging target acquisition, to measure the offset of the target in the aperture in the dispersion direction in order to improve the precision of the wavelength scale, or to map the field as an early acquisition image as described in Sec. 5.2.3. There will be no Doppler corrections made during NUV imaging observations, nor will FP-SPLITs be allowed.

The field of view imaged by TA1 is circular, essentially limited by the size of the aperture. Sources located within ~0.3 arcseconds of on-axis will transmit essentially their total flux and will be in focus. Sources located further off-axis will begin to vignette, because flux from the aberrated halo is lost outside the aperture, and will be out of focus due to off-axis aberrations (e.g., coma). Sources can be detected out to a radius of ~2 arcseconds off-axis, for a total circular field of view of ~4 arcseconds diameter.

The mirror will have two values of reflectivity: a primary reflection off the mirror surface (designated TA1) to be used for faint sources, and an attenuated reflection (designated "TA1-Rear-View-Mirror-Mode" or TA1-RVMM) for bright targets. The spectral coverage includes the entire NUV bandpass from ~1650-3200Å, limited at the short wavelength end by the order separation filter. The attenuated TA1-RVMM is achieved by using the front surface reflection of the order separation filter, which is mounted at a slight angle from normal incidence. The TA1-RVMM will have roughly 4% of the throughput of the primary TA1 imaging mode. Each reflectivity mode (TA1 and TA1-RVMM) can be accessed by commanding different step numbers of OSM2. There will not be any selectable filters.

The images produced by the TA1 and TA1-RVMM reflections are located on the NUV MAMA detector as shown in Figure 5.3-3. The TA1 reflective surfaces are tilted slightly (relative to the NUV gratings) so that the images appear between the stripes. This helps to mitigate charge extraction at the locations of the science and wavelength calibration spectral stripes. The images are formed by the NCM3b camera mirror.

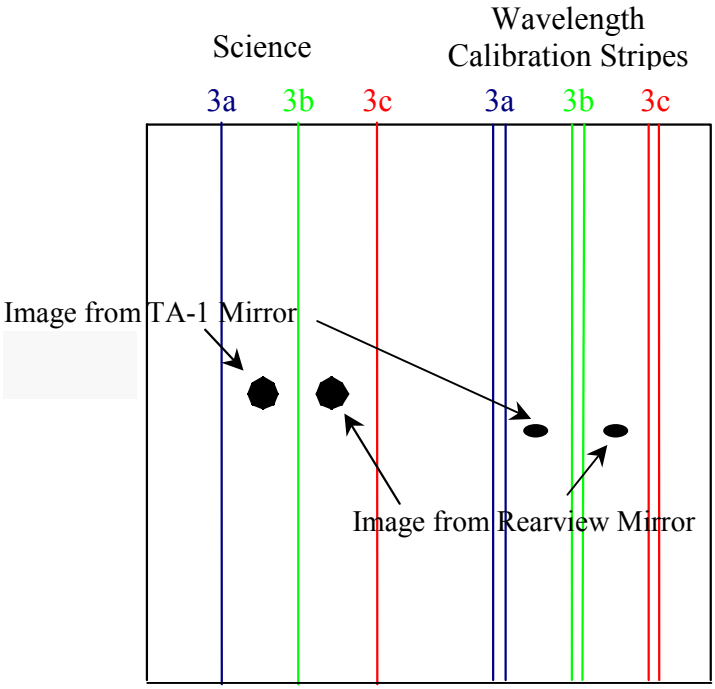

Figure 5.3-3: Depiction of the locations of the TA1 images on the NUV MAMA detector. The science and wavelength calibration images from the primary TA1 mirror reflection are displaced 1.375 mm (= 55 pixels) toward the left (higher column numbers), and the TA1-RVMM images are displaced –1.375 mm (= -55 pixels) toward the right (lower column numbers) of the associated science and wavelength calibration stripe B (i.e., NCM3b stripe).

The dynamic range for a given reflectivity mode will essentially be limited by the count rate capability of the MAMA detector, combined with the throughputs attained through the PSA and BOA for science targets and WCA for the wavelength calibration lamp. A major concern when using the TA1 imaging mode is over-illumination of the NUV MAMA. The local count rate limit is ~200 counts/s/pixel. The central pixel of a TA1 image of a sample QSO spectral source achieves this count rate at a mean flux level of approximately $F_\lambda=1.3\times10^{-14}$ ergs/cm^2/s/Å. Because of the uncertain flux and variability of astrophysical targets, the exposure times used for TA1 imaging should be conservative. For targets brighter than $F_\lambda=1.3\times10^{-14}$ ergs/cm^2/s/Å, two methods of flux attenuation are possible. The first is to use the TA1-RVMM mode, which attenuates the flux by a factor of ~25. The second is to use the BOA, which attenuates flux by a factor of 100. Very bright targets could be attenuated with both the BOA and TA1-RVMM. Simulations show that sources with mean $F_\lambda > \sim 6 \times 10^{-11}$ ergs/cm^2/s/Å would not be observable with the TA1 mirror.

Exposure time estimates for each of the TA1 imaging modes are shown in Figure 5.3-4. The solid lines plot the exposure times that attain S/N = 14 (~200 total counts) in the brightest pixel in a NUV+TA1

image, whereas the dashed lines show the exposure times to achieve S/N = 100 in the brightest pixel. The shortest exposure times shown for each imaging mode assume a maximum local count rate of 100 counts/s/pixel. Exposure times in green are un-attenuated (through the PSA); those in red, blue, and magenta have been attenuated by the RVMM, BOA, and BOA+RVMM, respectively.

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OP-01	COS-01-0001	10	11	
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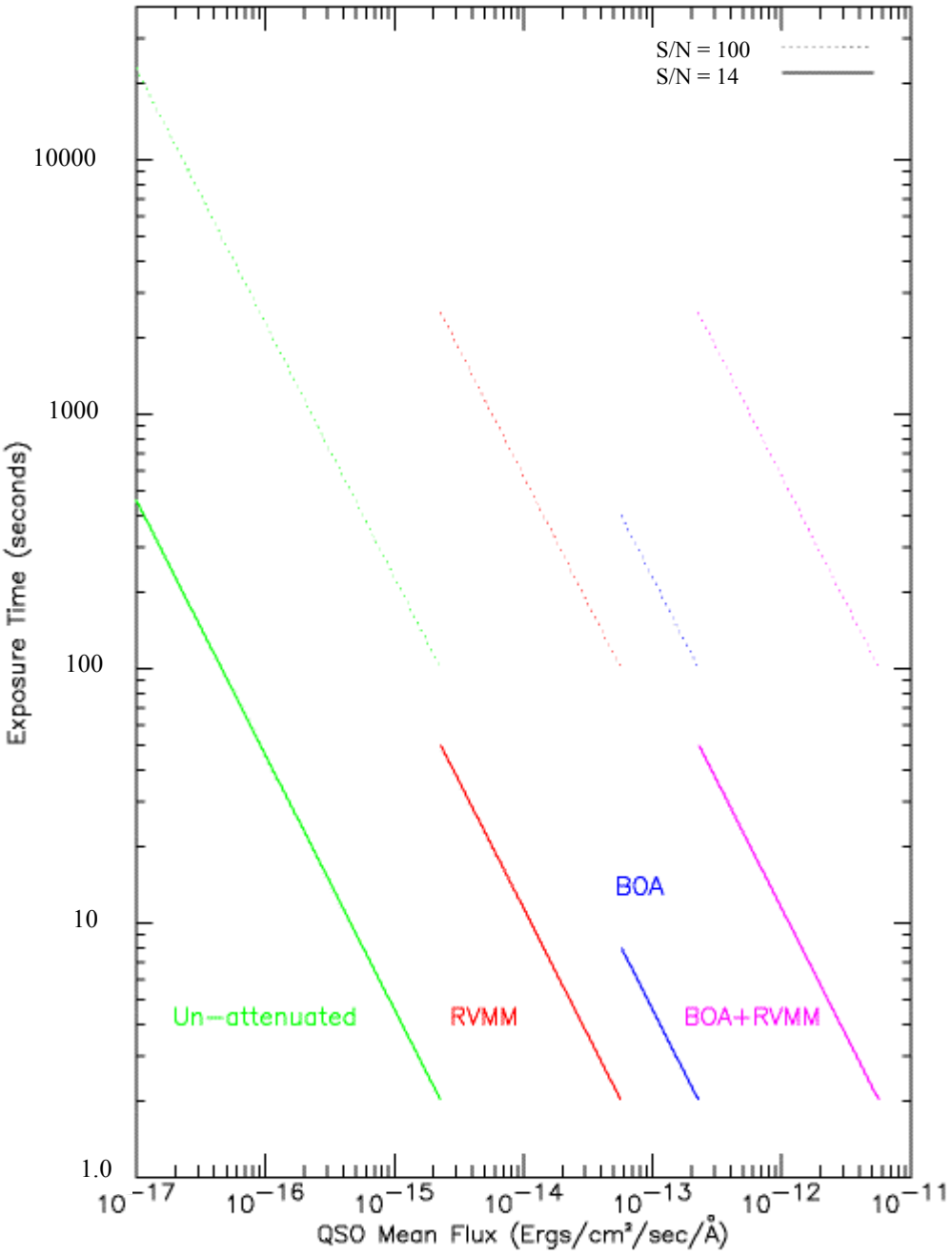

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Figure 5.3-4: Estimated exposure times *versus* QSO mean flux for each of the TA1 imaging modes. Green curves are for the un-attenuated TA1 images through the PSA, red curves are through the PSA with the TA1-RVMM, blue curves are for TA1 images using the BOA, and magenta curves are for TA1-RVMM images through the BOA. The lower set of solid-line curves achieve S/N = 14 in the brightest pixel, while the upper dashed-line curves achieve S/N = 100 in the brightest pixel.