Simulating the 600 s flash for SPLIT-wavecals at LP6

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ABSTRACT

The majority of COS science observations have used concurrent TAGFLASH Pt-Ne lamp exposures for wavelength calibration, whereby the wavelength calibration lamp is flashed at certain intervals during an exposure. However, the COS wavelength calibration lamp cannot be flashed when the aperture block is at a position greater than 113 steps, which corresponds to +5.4” arcseconds on the sky relative to Lifetime Position (LP) 1, due to a light leak through the Flat-field Calibration Aperture (FCA). Therefore at LP6, located at +6.5” above LP1, the aperture block must be moved to a different position such that the lamp can be flashed and the wavelength zero point can be correctly accounted for, a process called ‘SPLIT-wavecals’. To reduce overheads due to SPLIT-wavecals, we undertook a study to determine whether a lampflash could be effectively removed without significantly increasing the uncertainty on the wavelength calibration or smearing the line profile resulting from uncorrected Optics Select Mechanism (OSM) drift. This ISR first describes the tests of four methods used to simulate observations without the 600 s lampflash while correcting for OSM drifts, and then presents a description of the adopted method. The chosen method minimizes the uncertainty on the FUV wavelength calibration. We found that the along-dispersion shift (in pixels) at 600 s was best replicated by a fractional value of the shift at the end of the exposure, with an additional dependence on exposure time. This correction was implemented in CalCOS starting with version 3.4.0 for LP6 observations.
1. Introduction

The majority of COS science observations have used concurrent TAGFLASH Pt-Ne lamp exposures for wavelength calibration. In TAGFLASH mode, the wavelength calibration lamp is flashed at certain intervals during an exposure (see Figure 1), and the positions of lamp lines relative to templates are used to correct the XDOPP position of events for the Optics Select Mechanism (OSM) drift during the wavelength calibration step (WAVECORR) of the CalCOS pipeline (Keyes et al. 2011; White et al. 2016). When more than one lampflash is present, CalCOS linearly interpolates between the shifts derived from flashes to correct the wavelength of each event to produce fully corrected coordinates (XFULL). The OSM drift can result in non-negligible (2–3 pixels, ∼ 0.3 – 0.5 resel) offsets after a major OSM1 movement, which rotates the mechanism to a different grating position (Soderblom et al. 2022). A user can choose either AUTO or GO wavecals which are observed during or directly after a science exposure for lifetime positions (LPS) 1–5, with the current TAGFLASH wavecal rules having a flash at 600 s for exposures longer than 960 s. After a major grating movement (e.g., NUV Collimating Mirror 1, NCM1–G130M), exposures of 960–2400 s in length have three lamp flashes (t=0s, t=600 s, t=end; see Figure 1 Keyes et al. 2011).

The wavelength calibration lamp cannot be flashed safely when the Primary Science Aperture (PSA) is above +5.4” from LP1 due to a light leak from the flat-field calibration aperture (FCA; Oliviera et al. 2013). Therefore for LP6 (+6.5” above LP1) the aperture block is moved to a different position to flash the lamp, called the...
SPLIT-wavecal procedure (James et al. 2023a). Keeping the number and frequency of flashes implemented in the TAGFLASH rules with the SPLIT-WAVECAL procedure would incur significant overheads (24–30% per orbit; James et al. 2023b) for observations with multiple exposures per orbit. To reduce these overheads, we undertook a study to determine whether the middle lampflash at 600 s could be effectively removed without significantly increasing the uncertainty on the wavelength calibration, or degrading the resolution by smearing the line profiles (see Figure 1 for a schematic). This ISR outlines the tests of four methods that could be used in CalCOS to simulate observations without the 600 s lampflash while correcting for OSM drifts, and then outlines the chosen method minimizes the uncertainty on the FUV wavelength calibration and smearing of line profile resulting from uncorrected OSM drift. We found that the shift in pixels at 600 s was best replicated by a fractional value of the shift value at the end of the exposure, with an additional dependence on exposure time.

The behavior of the shifts as a function of time and OSM1 movement is detailed in James et al. (2023b), as are the OSM1 movements themselves. In brief, the shift with time for exposures obtained after an NCM1-G130M movement roughly followed a decaying exponential, whereas for exposures taken after an NCM1-G160M movement, the shift is approximately flat with time, with some scatter. There was no evidence that the shift distribution had a dependence on LP (and therefore time of observation), cenwave or FP-POS. Therefore all COS exposures for a certain grating were used to predict the 600 s shift. This study examines the feasibility of SPLIT-wavecals for G160M and G130M exposures, since these modes were expected to move to LP6 in the future. The study of G140L exposures was outside of the scope of this project, since observations using G140L are not predicted to move to LP6. This study relies critically on the behavior of the OSM movement from 2009-2020, and if the wheel lubrication was ever changed (from e.g. spinning the mechanism), the results may not be applicable.

2. Method

Starting with COS data in the archive up to the end of December 2020, we selected all exposures in the ‘Interval 1’ TAGFLASH rules (see Keyes et al. 2011), which are those which have $t_{\text{since}} < 600$ s elapsed since an OSM1 major movement to the beginning of the exposure. Additionally, we selected exposures which had three lampflashes (0 s, 600 s, end of exposure), and had exposure times between 960s and 2400s. The TAGFLASH rules are explained in detail in Keyes et al. (2011), and an example of an Interval 1 exposure is given in Figure 1. The number of exposures used in this study broken down by OSM1 movement is summarized in Table 1, with the most common movements being from NCM1 to G130M, followed by NCM1 to G160M. Exposures that had an anomaly during the observation were removed from the analysis.

We used different ways to estimate the shift at 600 s, including linear interpolation (Section 2.1), an exponential fit (Section 2.2), using the end shift with a fixed offset (Section 2.3), and taking a fractional value of the shift value at the end of the exposure,
Figure 1. Top: Schematic showing the TAGFLASH operations for LPs1-5 where exposures longer than 960s after a major OSM1 movement have three lamp flashes in order to measure the relative drift in the dispersion direction, which is used to correct the wavelength calibration. Bottom: the proposed method for LP6, which removes the middle lamp flash and simulates the drift at 600 s using an interpolation method. James et al. (2023a) details the modifications made to the lampflash rules for SPLIT-wavecals.

with an additional dependence on exposure time (Section 2.4). We chose the method with the most exposures (for all OSM1 movements) with a difference between the actual shift at 600 s and the shift estimated at 600 s being < 0.5 pixels, which we call the residual shift. We highlight that the adopted method was also the most easily implementable in CalCOS. The goal of introducing a wavelength uncertainty < 0.5 pixels was set so that the extra uncertainty in wavelength calibration that may occur by removing the 600 s lampflash did not significantly add to the total error budget, which is typically ±3 pixels in the dispersion direction (Plesha et al. 2018), and so that the line profiles would not get smeared significantly as a result of uncorrected drift that occurs during the exposure.

Each set of OSM1 movements was initially analyzed separately, and whilst there are differences depending on where the OSM1 started and ended, a general trend was noticed that exposures ending in G130M and G160M behaved differently (see also
Figure 2. Schematic of the linear interpolation method.

James et al. 2023b), allowing us to group our findings based on end OSM1 position. Furthermore, the need to separate the results based only on the end OSM1 position was driven by CalCOS having no knowledge of where the OSM1 position was previously, since previous OSM positions are derived from telemetry data which is not available to the data reduction pipeline.

The shift value calculated by CalCOS is based only on the information from that exposure, and is given as the SHIFT1A and SHIFT1B keywords. Information about the shifts was read from individual lampflash files in the MAST archive. OSM1 position information was assembled from the SMS files from the ‘TSINCELASTOSM’ and ‘OSM1’ columns. We performed a normalization such that the shifts at 600 s and the end of the exposure were relative to the first lampflash, which was defined to be at zero.

Table 1. Number of exposures in Interval 1 and with exposure times $960 < t_{\text{exp}} < 2400$ s (thus having three lamp flashes), split by OSM1 movement. Exposures that had an anomaly were removed.

<table>
<thead>
<tr>
<th>OSM1 movement</th>
<th>FUVA</th>
<th>FUVB</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCM1–G130M</td>
<td>672</td>
<td>666</td>
</tr>
<tr>
<td>NCM1–G160M</td>
<td>222</td>
<td>222</td>
</tr>
<tr>
<td>G130M–G130M</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>G160M–G160M</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>G130M–G160M</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>G160M–G130M</td>
<td>209</td>
<td>209</td>
</tr>
<tr>
<td>All–G130M</td>
<td>700</td>
<td>694</td>
</tr>
<tr>
<td>All–G160M</td>
<td>434</td>
<td>434</td>
</tr>
</tbody>
</table>

2.1 Straight line interpolation

The simplest method to estimate the shift at 600 s was a linear interpolation between the shift from the first and last lampflashes, as shown in Figure 2. This is what CalCOS would do if there were only two lampflashes at the beginning and the end of the
exposure. The difference between the actual shift at 600 s and the shift estimated at 600 s is shown in Figure 3 for OSM1 movements ending in G130M and G160M in Interval 1 with exposures times longer than 960s. We see systematic offsets in the residuals between the estimated shift and the measured shift at 600 s. ∼80% of G160M and ∼37% of G130M exposures in Interval 1 had a residual shift < 0.5 pixels. This means that using the straight line interpolation for G130M FUV A exposures creates a bias of more than 0.5 pixels for 20% of the G160M exposures, and for 65% of the G130M exposures. The straight line interpolation method therefore does not adequately estimate the 600 s shift for a large enough fraction of G130M exposures.

2.2 Exponential fit

For OSM1 movements ending in G130M, James et al. (2023b) showed that the drift rate with time has a decaying exponential trend. We therefore fit an exponential to the first and last shift values in the lampflash files, to predict the shift at 600 s, as shown in Figure 4. The functional form of the shift was \( \Delta X = A + B \times \exp(-t/\tau) \), where \( \Delta X \) is the shift as a function of time, \( t \) is the time since exposure start, and \( \tau \), \( A \) and \( B \) are constants which describe the shape of the exponential. We determined a \( \tau \) value based on fitting an exponential to all exposures in a movement set (e.g., NCM1–G130M) simultaneously, and then took the average of these six \( \tau \) values, which was 5.86 × 10^{-3}. The difference between the actual shift at 600 s and the estimated shift at 600 s is shown in Figure 5 for OSM1 movements ending in G130M and in G160M in Interval 1 with exposures times longer than 960s. We found that 63% of G160M and 59% of G130M exposures in Interval 1 had residual shifts < 0.5 pixels. We also weighted the \( \tau \) value by the number of exposures in each OSM1 movement set (see Table 1) so that \( \tau \) was more representative of the most common OSM1 movements, and this yielded similar results, with \( \tau = 1.20 \times 10^{-3} \). Predicting the 600 s shift based on an exponential fitting method (either weighted or unweighted) does not adequately estimate the 600 s shift for a large enough fraction of exposures. Additionally, for exposure times < 1500 s, the shift was poorly characterized compared to the shift for longer exposures. Furthermore, this method was not preferred due to the complexity of estimating the \( \tau \) parameters needed to estimate the shift at 600 s compared to other methods, and also because of the need to repeat this analysis periodically and update the \( \tau \) value, based on the evolving drift of the instrument.

2.3 End shift offset

Currently, for G130M exposures, the majority of the drift happens in the first 1000s (James et al. 2023b). We therefore used the value of the end shift in place of the 600 s shift, see Figure 6. Figure 7 shows that this leads to wide distributions of residuals and a mean offset in the residuals of 0.4–0.6 pixels. We also applied a fixed offset of 0.5 pixels to the end shift to correct for this offset to replicate the shift at 600 s, as shown in Figure 8 and Figure 9. Whilst this did center the residuals around zero, there was a
Figure 3. Histograms of the difference between the actual shift and the estimated shift at 600 s using a linear interpolation (Section 2.1), for OSM1 movements ending in G130M (top row) and ending in G160M (bottom row) exposures in Interval 1 with exposures times > 960 s, for FUVA (left) and FUVB (right). Also shown in each panel is the mean and standard deviation of the distribution of the residuals. Dashed vertical lines show the ±0.5 pixel goal.
Figure 4. Schematic of the exponential interpolation method.

large dispersion in the residuals, with 73% of G160M and 65% of G130M exposures in Interval 1 having a residual shift < 0.5 pixels, so improvements to the method were sought to reduce the number of datasets with large residual shifts.

2.4 Fractional end shift offset method

We found a correlation between the fraction of the total shift that occurred at 600 s, and the total shift at the end of the exposure, with a secondary dependence on exposure time, see Figure 10. We found that the shift in pixels at 600 s could be described by a piecewise function with 6 free parameters -

- MIN_EXPTIME is the minimum exposure time to which the following set of parameters applies. This value is fixed at 960 s, since this is consistent with the TAGFLASH rules.
- ENDSHIFT, which is the size of the end shift relative to the first shift.
- TCROSSOVER describes a break in behavior around 1500s, as the following parameters were found to depend on the exposure time.
- FRACSHORT the fractional value of the end shift value if exposure time < TCROSSOVER.
- FRACLONG the fractional value of the end shift value if exposure time ≥ TCROSSOVER.
- OFFSET_SHORT is the offset shift in the piecewise function applied to exposures with < TCROSSOVER.
- OFFSET_LONG is the offset shift in the piecewise function applied to exposures ≥ TCROSSOVER.

For each exposure, we calculate the shift at 600 s as:

if exposure time ≥ TCROSSOVER: $\text{OFFSET_LONG} + \text{FRACLONG} \times \Delta \text{ENDSHIFT}$

if exposure time < TCROSSOVER: $\text{OFFSET_SHORT} + \text{FRACSHORT} \times \Delta \text{ENDSHIFT}$

A schematic of the parameters is shown in Figure 11.
Figure 5. The difference between the actual shift and the estimated shift at 600 s using an exponential function (Section 2.2), for all OSM1 movements ending in G130M (top row) and for those ending in G160M (bottom row) exposures in Interval 1 with exposures times > 960 s, for FUVA (left) and FUVB (right). Also shown in each panel is the mean and standard deviation of the distribution of the residuals. Dashed vertical lines show the ±0.5 pixel goal.
We determined the parameters separately for G130M and G160M exposures by running over a grid of different parameter values, and finding the combination that maximized the number of exposures with a residual shift $< 0.5$ pixels. The parameter ranges were chosen to span a range of plausible values based on the trends seen in Figure 10 whilst balancing this with computational runtime.

- For TCROSSOVER we used 100 s steps from 1500–1900 s.
- For FRACSHORT we used steps of 0.05 over a range of 0.55–0.85.
- For FRACLONG we used steps of 0.05 over a range of 0.35–0.65.
- For OFFSET_LONG we used steps of 0.05 over a range of 0.15–0.25 for G160M and -0.15 to -0.25 for G130M.
- For OFFSET_SHORT we used steps of 0.1 over a range of 0.25–0.45 for G160M and -0.25 to -0.45 for G130M.
- MIN_EXPTIME is set to mimic the lampflash rules for LP1–LP5, where there are more than two lamp flashes for exposures longer than 960s in Interval 1 (those $< 600$ s since the OSM1 mechanism moved).

The best fitting parameters are in Table 2. We measured the performance of this method by checking the percentage of G160M exposures that had a 0.5 pixel residual between the measured and predicted shift at 600 s, see Table 3. We found that 87% of FUV A and 93% of FUVB exposures using G160M had a residual shift $< 0.5$ pixels. For G130M, 92% of FUV A and 85% of FUVB exposures had a residual shift $< 0.5$ pixels. The difference between the actual shift at 600 s and the estimated shift at 600 s is shown in Figure 12 for OSM1 movements ending in G130M and G160M in Interval 1 with exposures times longer than 960s. This method is the best at predicting the shift at 600 s, with the largest fraction of exposures $< 0.5$ pixels, and with a small number of exposures showing offsets of up to 1 pixel.

3 Testing

Fractional end shift offset method had the most exposures (for all OSM1 movements) with a difference between the actual shift at 600 s and the shift estimated at 600 s being...
Figure 7. The difference between the actual shift and the estimated shift at 600 s using the end shift (Section 2.3), for all OSM1 movements ending in G130M (top row) and for those ending in G160M (bottom row) exposures in Interval 1 with exposures times > 960 s, for FUVA (left) and FUVB (right). Also shown in each panel is the mean and standard deviation of the distribution of the residuals. Dashed vertical lines show the ±0.5 pixel goal.

< 0.5 pixels, and was therefore chosen to be implemented in CalCOS. The results for all methods are summarized in Table 3, with separate results reported for each segment, although in the text we average the results for the segments for ease of readability.

We undertook testing of the chosen method to determine whether the line profile
Figure 8. Schematic of the end shift offset method, with a +0.5 offset.

Table 2. Best-fit parameters that describe the 600 s simulated flash.

<table>
<thead>
<tr>
<th>Grating</th>
<th>MIN</th>
<th>EXPTIME</th>
<th>TCROSSOVER</th>
<th>FRACSHORT</th>
<th>FRACLONG</th>
<th>OFFSET_SHORT</th>
<th>OFFSET_LONG</th>
</tr>
</thead>
<tbody>
<tr>
<td>G130M</td>
<td>960</td>
<td>1500</td>
<td>0.65</td>
<td>0.55</td>
<td>-0.35</td>
<td>-0.25</td>
<td></td>
</tr>
<tr>
<td>G160M</td>
<td>960</td>
<td>1500</td>
<td>0.70</td>
<td>0.55</td>
<td>0.15</td>
<td>0.25</td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Summary of each method and the fraction of datasets which are within the 0.5 pixel goal, for OSM1 movements ending in G130M and G160M, for segments FUV A and FUVB.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight line interpolation</td>
<td>0.31</td>
<td>0.42</td>
<td>0.76</td>
<td>0.83</td>
</tr>
<tr>
<td>(Sec 2.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exponential (Sec 2.2)</td>
<td>0.70</td>
<td>0.48</td>
<td>0.67</td>
<td>0.59</td>
</tr>
<tr>
<td>End shift (Sec 2.3)</td>
<td>0.49</td>
<td>0.44</td>
<td>0.57</td>
<td>0.57</td>
</tr>
<tr>
<td>End shift offset (Sec 2.4)</td>
<td>0.68</td>
<td>0.63</td>
<td>0.70</td>
<td>0.75</td>
</tr>
<tr>
<td>Fractional end shift offset</td>
<td>0.92</td>
<td>0.85</td>
<td>0.88</td>
<td>0.93</td>
</tr>
<tr>
<td>(Sec 2.4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Widths changed due to smearing as a result of simulating the shift at 600 s. We used the shift values from archival G130M and G160M datasets in Interval 1 with 3 lampflashes, the same ones used in previous sections. Additional high S/N data of Epsilon-Eri (PID 15365) was also used for testing, and was processed through the old (v3.3.11) and updated (v3.4.0) versions of CalCOS. We calculated the difference in the FWHM of the LSFs using the measured shift at 600 s, and the simulated shift at 600 s using the best-fit parameters from Section 2.4. We found that the residual of the FWHMs of the line profiles were centered on zero with a negligible (sub-pixel) difference in the FWHMs when using the SPLIT-wavecal procedure. Line profiles of high S/N split-wavecal
Figure 9. The difference between the actual shift and the estimated shift at 600 s using the end shift offset (Section 2.3), for all OSM1 movements ending in G130M (top row) and for those ending in G160M (bottom row) exposures in Interval 1 with exposures times > 960 s, for FUVA (left) and FUVB (right). Also shown in each panel is the mean and standard deviation of the distribution of the residuals. Dashed vertical lines show the ±0.5 pixel goal.

datasets were run through the new CalCOS version and compared to the TAGFLASH version of the data, to check that the line profiles did not show significant broadening when using the SPLIT-wavecal procedure. The spectral and spatial resolution of G160M LP6 data is summarized in Kerman et al. (2023a) and Kerman et al. (2023b).
Figure 10. The fraction of the total shift that occurred at 600 s as a function of the total shift at the end of the exposure, for all OSM1 movements ending in G130M (top row) and for those ending in G160M (bottom row) exposures in Interval 1 with exposures times longer than 960s, for segments FUVA (left) and FUVB (right). Points are color-coded by the exposure time at the last lampflash.

3.1 Intervals 2 and 3

According to the TAGFLASH rules, exposures with $600 < t_{\text{since}} < 2400$ s since a major OSM1 movement fall in Interval 2, and exposures with $t_{\text{since}} > 2400$ s since a major OSM1 movement fall in Interval 3 (Keyes et al. 2011). Under the SPLIT-wavecal rules,
exposures in Intervals 2 and 3 have two lamp flashes for exposures longer than 360 s and 800 s, respectively.

There is no way for CalCOS to know which interval an exposure is in, as this depends on the time since the last major OSM1 move, and this information is not available to the CalCOS pipeline. This means that the 600 s shift will be calculated and inserted for Interval 2 and 3 exposures at LP6 (which are those \( t > 600 \) s since a major OSM1 move), which only have a lampflash at the beginning and another at the end or at an intermediate time (depending on the exposure time and interval, see Keyes et al. 2011). We therefore checked that the new method for simulating the 600 s shift does not significantly change the wavelength calibration of Interval 2 and 3 exposures. Currently, CalCOS linearly interpolates between the first and last lampflashes to calculate the shift as a function of time. In Interval 2 and 3 exposures there is no movement of the OSM1 mechanism within these intervals, since they are intervals within a single observational setup, so all are of the type G130M→G130M or G160M→G160M.

To test this, we selected Interval 2 and 3 exposures with exposure times longer than 960s, and calculated the difference in shift at 600 s when using linear interpolation between the first and last shift, and when using the fractional end shift offset method, see Figures 13 and 14 for G160M exposures. The mean residual is 0.1 – 0.4 pixels and > 83% of exposures had a residual shift < 0.5 pix. Whilst there is a bias in the residuals, the magnitude is small and we conclude that adding in a 600 s shift estimated from the end shift does not significantly change the wavelength calibration for the majority of Interval 2 and 3 exposures. Monitoring of these residuals should be undertaken to determine if future improvements are needed.

4 Supporting Software and ground system updates

In 2022, TRANS was updated to enable SPLIT-wavecals and to correctly associate the SPLIT-wavecal and science exposures in the association (asn) files. The SPLIT-wavecal exposures have the designation as EXP-SWAVE members in the association files. Extensive ground system testing was performed to confirmed that SPLIT-wavecals
Figure 12. The difference between the actual shift at 600 s and the estimated shift at 600 s using the fractional end shift offset method (Section 2.4), for all OSM1 movements ending in G130M (top row) and for those ending in G160M (bottom row) exposures in Interval 1 with exposures times longer than 960s, for FUVA (left) and FUVB (right). Also shown in each panel is the mean and standard deviation of the distribution of the residuals. Dashed vertical lines show the ±0.5 pixel goal.
Figure 13. The difference between the shift at 600 s from linear interpolation, and the estimated shift at 600 s for G160M exposures using the fractional end shift offset method in Interval 2 with exposures times longer than 960 s, for FUV A (left) and FUVB (right). Also shown in each panel is the mean and standard deviation of the distribution of the residuals. Dashed vertical lines show the $\pm 0.5$ pixel goal, and the solid vertical line indicates the mean of the distribution.

operated as expected (James 2023a).

The fractional end shift offset method discussed in Section 2.4 was implemented in CalCOS version 3.4.0 in March 2022. Additionally, the WCPTAB reference file was updated for LP6 observations to add in six of the seven free parameters used by CalCOS.
Figure 14. The difference between the shift at 600 s from linear interpolation, and the estimated shift at 600 s for G160M exposures using the fractional end shift offset method in Interval 3 with exposures times longer than 960s, for FUVA (left) and FUVB (right). Also shown in each panel is the mean and standard deviation of the distribution of the residuals. Dashed vertical lines show the ±0.5 pixel goal, and the solid vertical line indicates the mean of the distribution.

for this calculation: MIN_EXPTIME, TCROSSOVER, FRACSHORT, FRACLONG, OFFSET_SHORT, and OFFSET_LONG. ENDSHIFT is calculated by CalCOS already and is stored in the SHIFT1[A/B] values in the headers of the x1d lampflash files. The values used in the WCPTAB from this study can be found in Table 2. CalCOS will

Instrument Science Report COS 2024-08(v1) Page 18
only apply this shift if the following conditions are all met: 1. The exposure is FUV. 2. The association containing the exposure has EXP-SWAVE members. 3. There are two compatible wavecals in the association (same CENWAVE, FP-POS) 4. The exposure time is greater than the MIN_EXPTIME column from the WCPTAB for the row with matching SEGMENT, CENWAVE. Additionally, CalCOS will apply the shift if the other segment with the same rootname has a SPLIT-wavecal. In all other cases, the calculation of the SHIFT1A and SHIFT1B values remains the same.

Since we did not test what happened to the drift for exposures longer than 2400s, it cannot be guaranteed that these exposures do not have larger wavelength calibration uncertainties. Since most of the drift happens within the first 1000 s (James et al. 2023b), there is no reason to expect a significant increase in wavelength calibration uncertainty compared to shorter exposures.

5 Summary

We undertook a study to determine the feasibility of removing the 600 s lampflash without significantly increasing the uncertainty on the wavelength calibration or smearing the line profile. The removal of the middle lampflash was key to minimizing overheads at LP6 where we cannot flash the calibration lamp. Several methods were attempted and we found that the shift in pixels at 600 s was best replicated by a fractional value of the shift value at the end of the exposure, with an additional dependence on exposure time. This method is the one that minimized the residuals between the actual and predicted shift at 600 s, with ~ 90% of exposures having a residual shift < 0.5 pixels, meaning that the wavelength calibration accuracy is not significantly affected. The parameters predicting the 600 s shift were included in a new LP6-specific WCPTAB for use in CalCOS. Monitoring of the parameters used to predict the 600 s shift should be conducted regularly to determine if they need to change over time to maintain the wavelength calibration of LP6 exposures within specification.

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