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Instrument Science Report COS 2018-18

Verification of COS/FUV Bright Object Aperture (BOA) Operations at Lifetime Position 4

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ABSTRACT

We report the results of the COS/FUV calibration program, 15368, designed to verify operations of the Bright Object Aperture (BOA) at the fourth Lifetime Position (LP4). The bright standard star G191-B2B was observed with the G130M/1291, G160M/1623, and G140L/1280 settings with one lamp exposure taken with the G130M/1291 setting to test a complete set of operations. The spectral resolution was measured for G130M/1291, and cross-dispersion (XD) profiles were constructed and compared to those from LP3 and LP2. We show that the LP4 XD profiles are nearly identical to those at LP3 and the resolving power of G130M is $R \approx 4500$.

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1. Introduction

COS utilizes two 2.5″ diameter apertures for external observations: the Primary Science Aperture (PSA) and the Bright Object Aperture (BOA), which are separated by 13″ in the cross-dispersion (XD) direction. The BOA is used in the observation of bright sources that would violate count-rate limits for the PSA with a transmission of $\approx$0.6% of light compared to the PSA's transmission of $\geq$ 95% for well centered targets (Fox et al. 2017).

When COS moves to new FUV lifetime positions, calibration programs are executed to characterize spectra taken at the new position and verify COS capabilities respectively. In this ISR, we report on the results of the BOA verification program, 15368 (James White, COS FUV BOA performance at LP4). This program was designed to verify the ability to perform observations using the BOA at the Fourth Lifetime Position (LP4), which is located $\sim$ 5″ below LP1 and $\sim$ 2.5″ below LP3 in the cross-dispersion direction. The goal of program 15368 was to simply take spectra using the BOA at LP4 at one cenwave for each of the FUV gratings (G130M, G160M, G140L). As a quick check of the data, we visually inspect each calibrated product with reference to LP3, obtain the XD profiles for each setting and estimate the spectral resolution for G130M, which we then compare to results from the LP2 and LP3 BOA verification programs. This ISR loosely follows analogous BOA verification programs from LP2 (Program 12807, Debes 2013) and LP3 (Program 13933, Fox A. J. et al. 2015).

2. Observations

Program 15368 like the previous two BOA verification programs at LP2 and then LP3 observed the bright standard star, G191-B2B. This target was originally chosen because it is bright enough in the UV ($1.3\text{x}10^{-11}$ erg s^{-1} cm^{-2} $Å^{-1}$ at 1300 Å) to observe with the BOA for all COS/FUV gratings (Fox A. J. et al. 2015). All three observations were taken within a single orbit at FP-POS = 3 and consisted of one 13s G140L/1280 exposure, one 795s G160M/1623 exposure and one 220s G130M/1291 exposure. No accompanying wavelength calibration (wavecal) exposures were taken for G160M or G140L since calibrating the wavelength of these exposures was not necessary for the analysis. However, in order to test the full operations with the BOA, one wavecal exposure was taken for G130M/1291. Each exposure was taken successfully, and the calibrated spectra are shown in Figure 1. An example of a closer look at the C IV interstellar absorption doublet at 1548 Å and 1550 Å are shown in Figure 2.

3. Resolution Check

We measure the resolution for G130M via measuring the line-width (FWHM of a gaussian fit) of interstellar absorption lines to recover the resolving power, $R \equiv \lambda/d\lambda$. In order to compare the LP4 exposure to its LP3 counterpart, we chose to measure the Si II

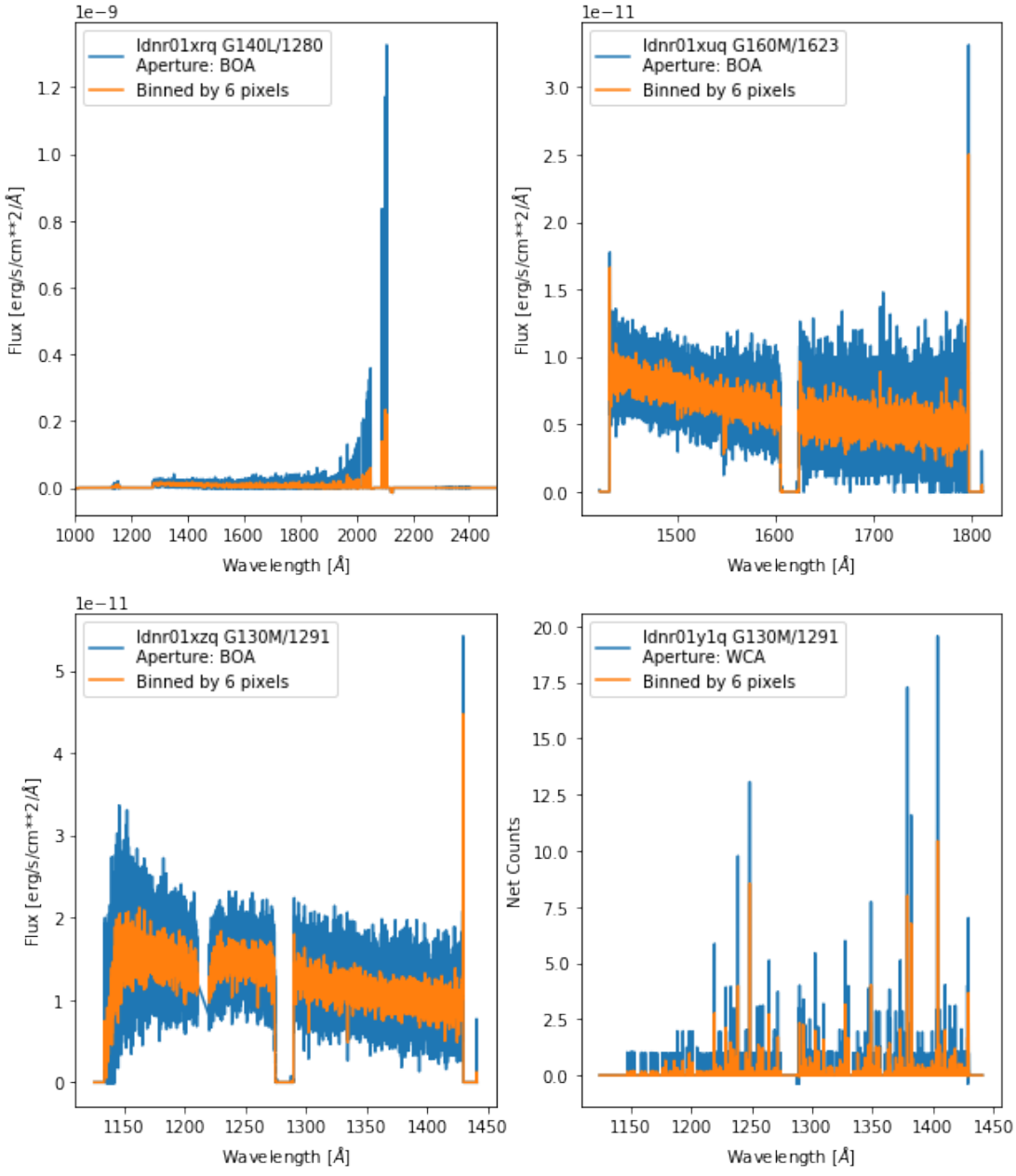

Figure 1. Spectra plotted using each exposure's x1d calibrated product. Note: G140L/1280 (top left), G160M/1623 (top right), G130M/1291 (bottom left), and the wavecal for G130M/1291 (bottom left). For the G130M/1291 BOA spectrum, the Lyα air-glow region occurring between 1210 and 1220 Å has been excluded. The orange spectra in each plot shows the data binned by 6 pixels (approximately one resolution element.

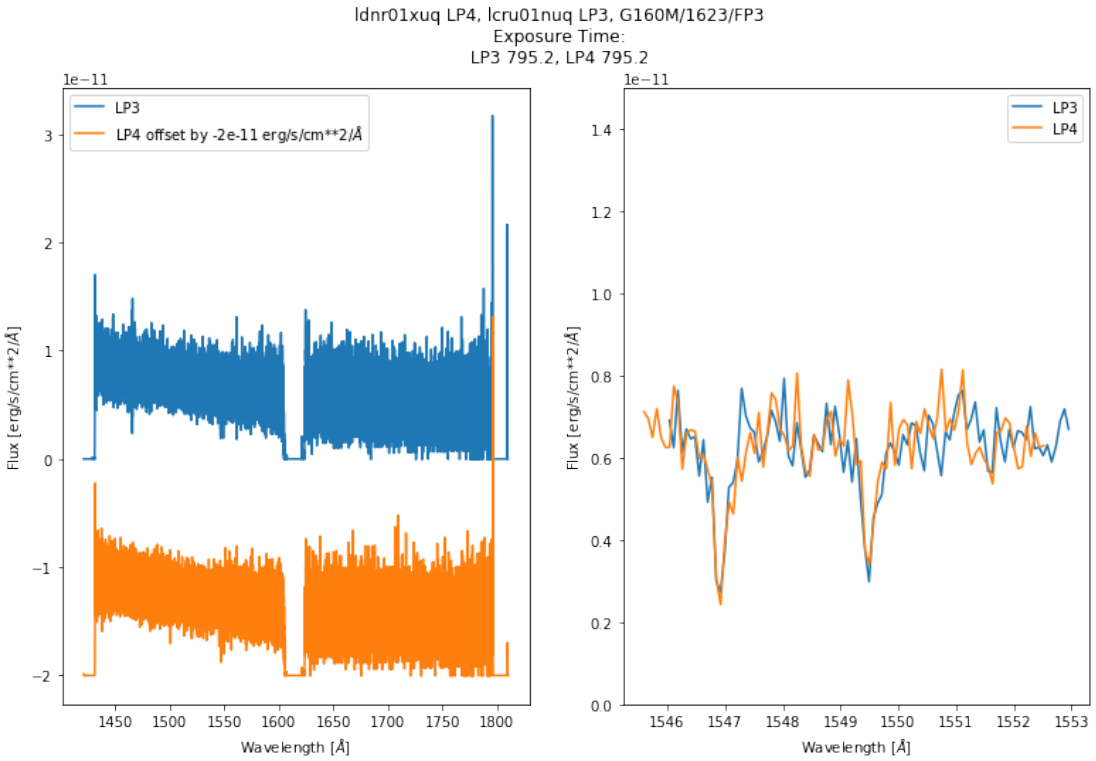

Figure 2. The panel on the left displays the full data (no binning) for G160M/1623 with LP4 offset by -2x10^{-11} erg s^{-1} cm^{-2} Å^{-1}. The panel on the right shows the C IV doublet at 1548 and 1550 Å (binned by 6 pixels). The data taken at LP3 and LP4 are similar, and the resolution is also qualitatively similar when comparing the C IV lines between LP3 and LP4 in the panel on the right.

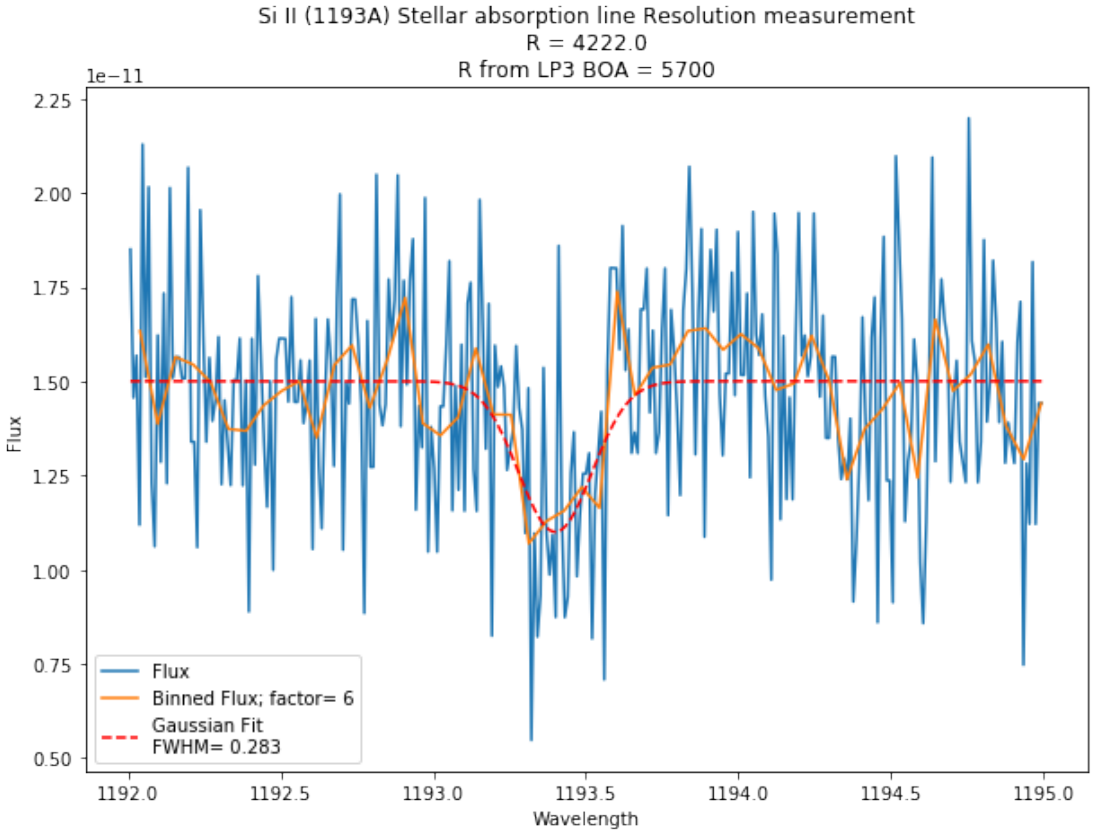

Figure 3. Line-width analysis of the Si II 1193 Å absorption line. The gaussian fit is plotted as a red-dashed line over the orange spectrum (binned by 6 pixels) and the blue spectrum (unbinned). The FWHM of the gaussian fit to the line is ∼0.28 Å which corresponds to R ≈ 4200.

absorption lines at 1193 Å and 1260 Å in Figures 3 and 4 respectively as was done for the LP3 BOA verification program. We estimate the resolving power, R ≈ 4500 (averaging the measurements from the two Si II lines) for G130M/1291. Compared with the resolving power measured at LP3 (R ≈ 5700; Fox A. J. et al. 2015), this is a decline of ≈ 20%. However, considering the lack of additional data to perform a rigorous error analysis, this is only an approximate measurement. It does show however that the capabilities of the BOA at LP4 are indeed comparable to what they were at LP3.

4. Cross-Dispersion Profiles

In Figures 5 - 7 we show examples of comparisons of the XD profiles across LP3 and LP4 for segment A, and for FP-POS = 3 (as that was the only FP-POS where data was taken at LP4). These figures were created by summing the events from the *corrtag* files in YCORR coordinates and filtered to remove PHA values of less than 2 or greater than

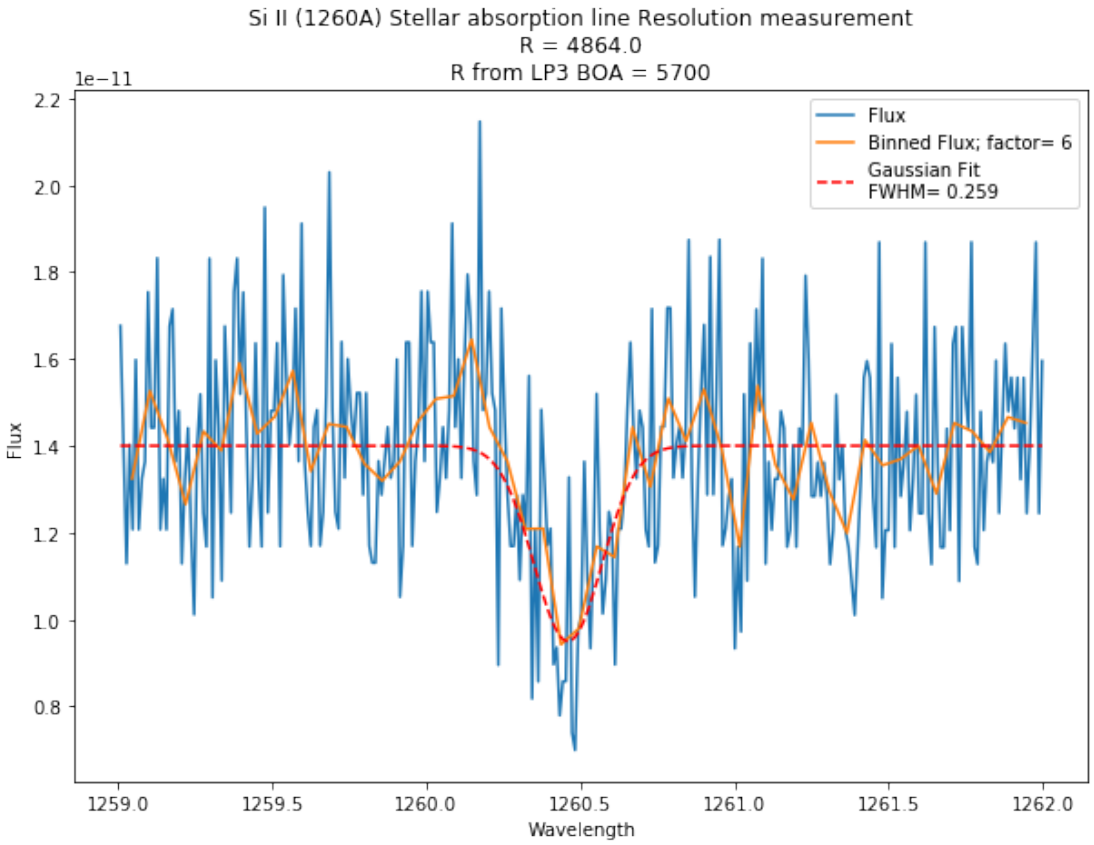

Figure 4. Line-width analysis of the Si II 1260 Å absorption line. The FWHM of the gaussian fit to the line is ∼0.26 Å, which corresponds to an R ≈ 4800.

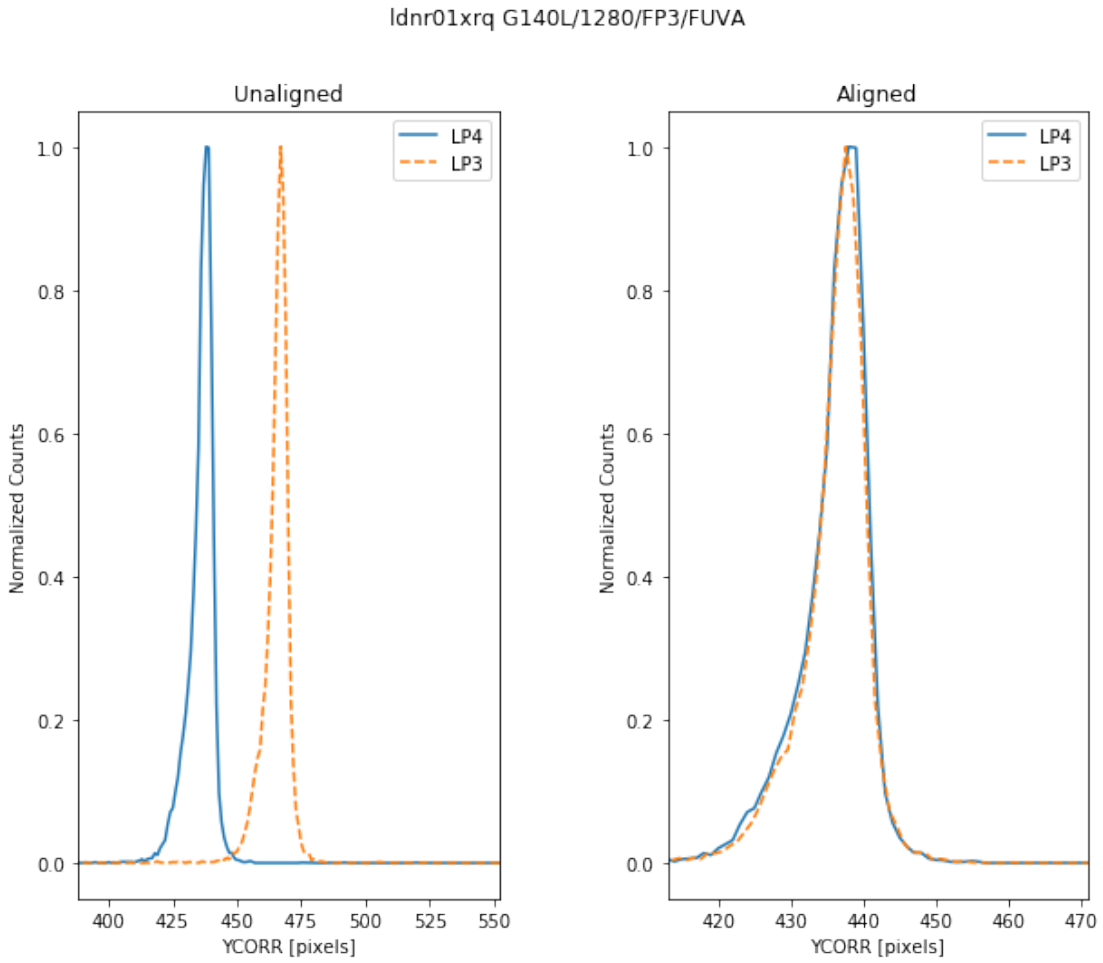

Figure 5. XD profiles across LP3 and LP4 (orange and blue respectively) for G140L/1280. The panel on the left shows where each of these fall in YCORR, while the panel on the right shows the profiles zoomed-in and aligned for comparison.

23, and then normalizing the counts in order to directly compare the profiles. This was done for each exposure across both segments. The LP3 and LP4 profiles are qualitatively very similar (in some cases nearly identical), with small differences mainly in the wings of the profiles. The only notable difference is in the profile for G130M/FUVB where there is a small difference in the lower-YCORR side shoulder of the profile as shown in Figure 8. This feature has also appeared in the previous BOA verification programs, though it changes as a function of position on the detector. For LP4, the shoulder slightly reduces the width of the profile in comparison to LP3.

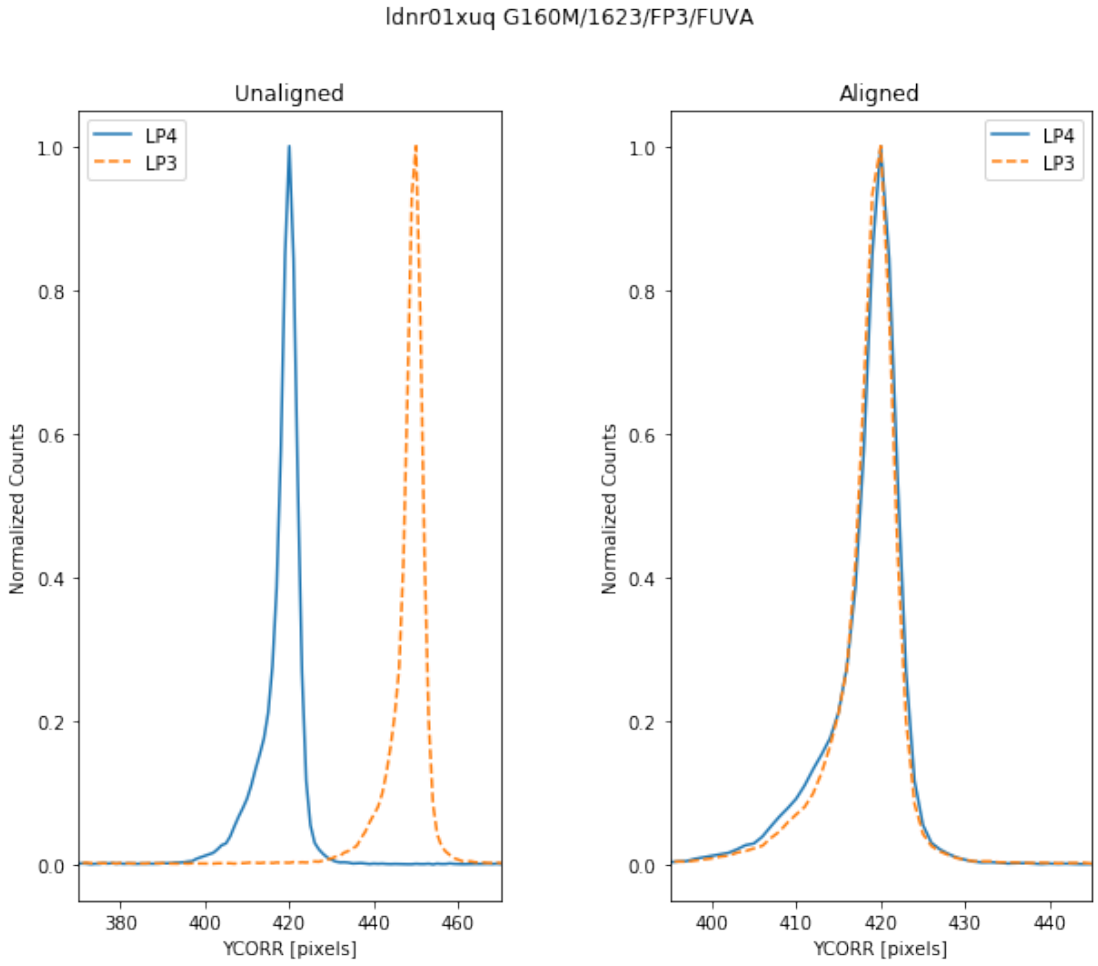

Figure 6. XD profiles across LP3 and LP4 for G160M/1623.

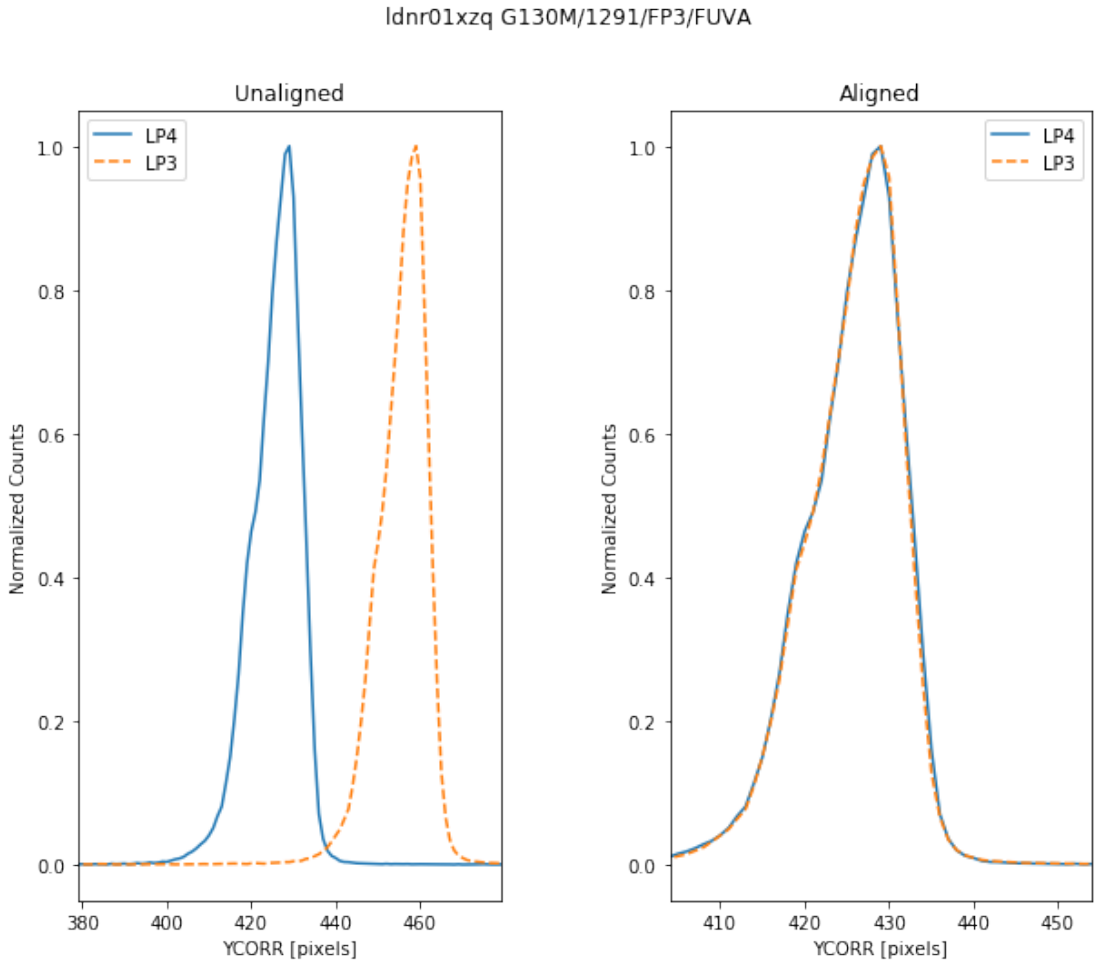

Figure 7. XD profiles across LP3 and LP4 for G130M/1291.

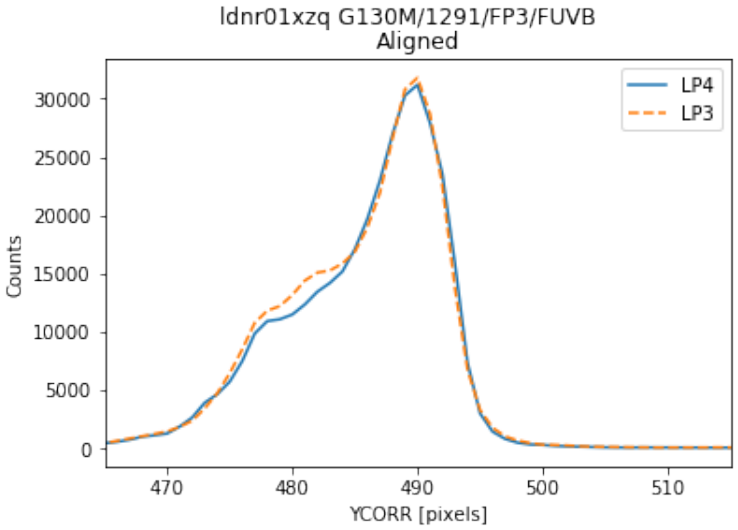

Figure 8. G130M/1291 XD profiles for LP3 and LP4 (orange and blue respectively). The shoulder at the lower end in YCORR (between YCORR=475 and YCORR=485 of the profile has less counts when compared to the LP3 profile.

5. Conclusions

According to the data taken for program 15368, the BOA is still operating as expected at LP4. The spectral resolution is qualitatively comparable at LP4 with respect to LP3, although there is a possible decrease in resolving power for G130M between LP3 and LP4, with the estimate at LP3 of R $\approx$ 5800 potentially dropping to R $\approx$ 4500 at LP4. The line-width analysis for G130M was conducted on two Si II absorption lines which resulted in a dλ = 0.28 Å at 1193 Å and dλ = 0.26 Å at 1260 Å, which results in an average resolving power, R $\approx$ 4500. However, due to the limited nature of the program, a more rigorous analysis with error estimation is not possible at this time, and these measurements are interpreted here as successful operations. The XD profiles between LP3 and LP4 with the BOA are similar with the exception of the lower-shoulder of FUVB G130M/1291, in which there has been a noticeable drop in counts from LP3 to LP4.

Change History for COS ISR 2018-18

Version 1: August 15, 2018 – Original Document

References

Fox, A. J., et al., 2017, COS Instrument Handbook, Version 9.0 (Baltimore: STScI)
Fox, A. J., et al., 2015, COS Instrument Science Report 2015-05