Status and Performance Updates for the Cosmic Origins Spectrograph

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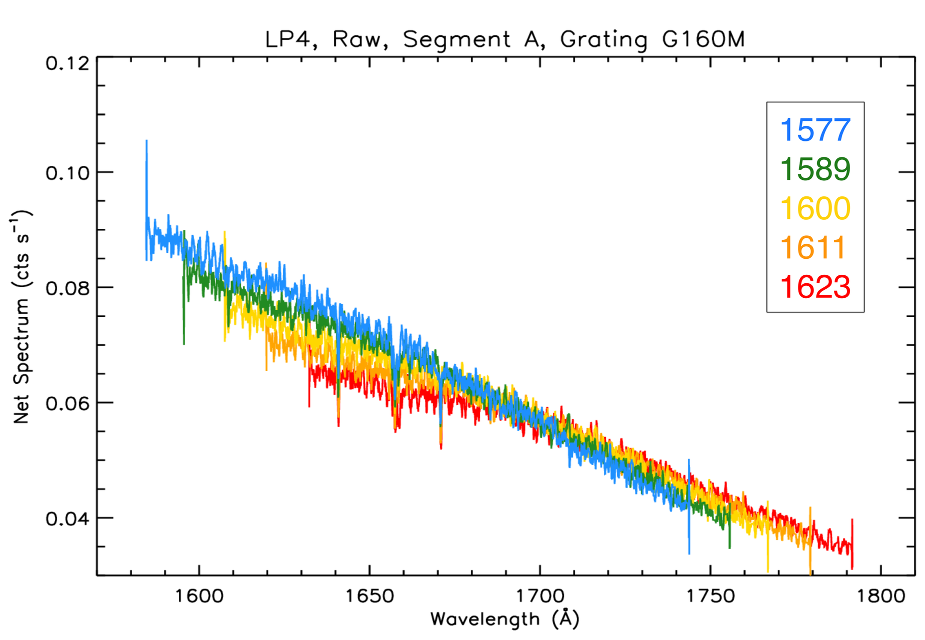
Abstract: The Hubble Space Telescope's (HST) Cosmic Origins Spectrograph (COS) moved the spectra on the FUV detector from Lifetime Position 3 (LP3) to a new pristine location, LP4, in October 2017. The spectra were shifted in the cross-dispersion direction by –2.5" (roughly –31 pixels) from LP3, or –5" (roughly –62 pixels) from the original LP1. This move mitigates the adverse effects of gain sag on the spectral quality and accuracy of COS FUV observations. We present updates regarding the calibration of FUV data at LP4, including the flat fields, flux calibrations, and spectral resolution. We also present updates on the time-dependent sensitivities, and dark rates of both the NUV and FUV detectors.

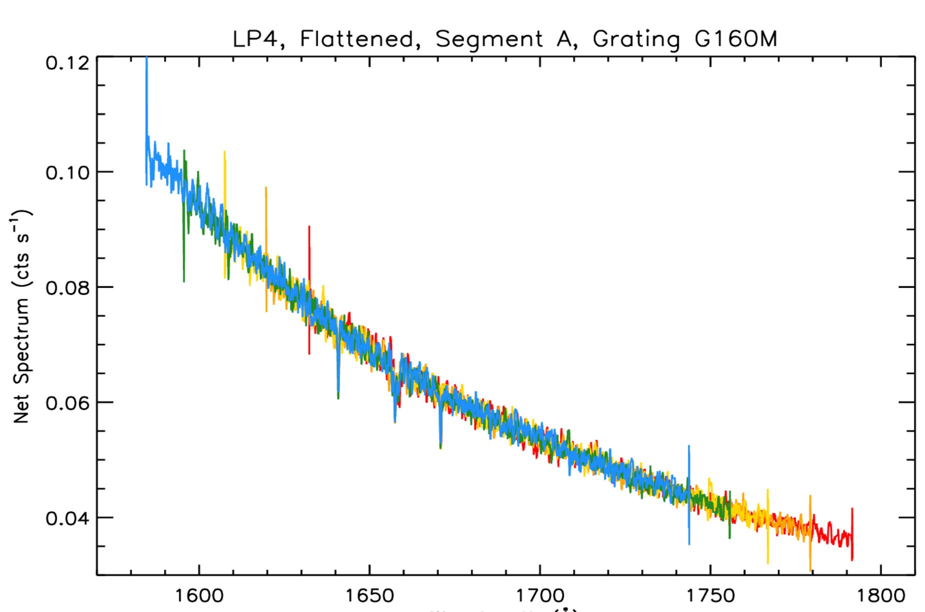
LP4 Flat Fields and Flux Calibration

Observations of HST standard WD 0308–565 were obtained with the G130M, G160M, and G140L gratings to derive low-order flats and sensitivities at LP4.



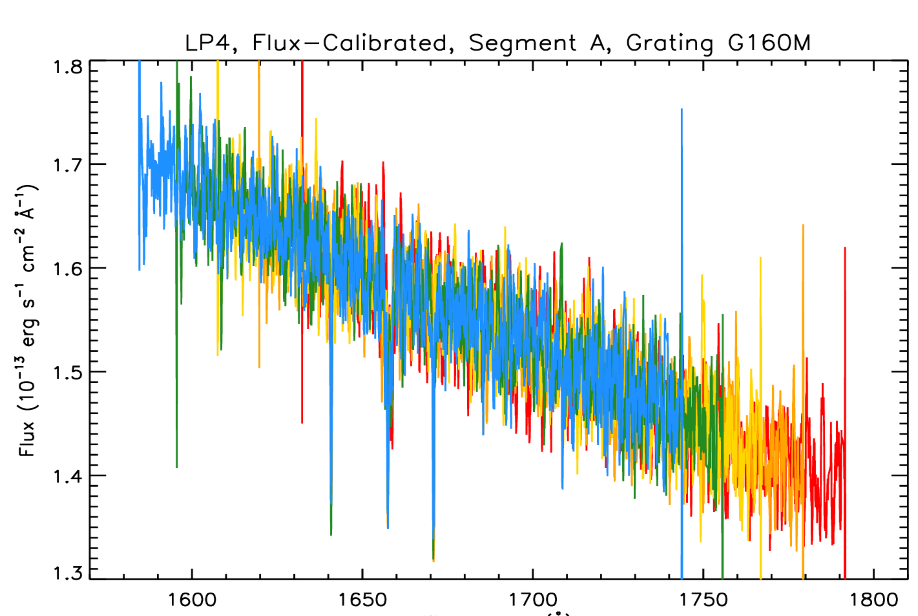
Left: net counts/sec. vs. wavelength for the G160M/FUVA central wavelengths (cenwaves), which are shown in different colors, before flat fielding and flux calibration.

A cubic spline is fit along the x-direction of the well-calibrated portion of both the FUVA and FUVB detectors to derive a flat field for each grating. The flat is tested by comparing the alignment of adjacent cenwaves after flat fielding is complete.



Left: net counts/sec. vs. wavelength for the G160M/FUVA cenwaves after flat fielding. The flat field is validated as evidenced by the alignment of the net counts per adjacent cenwave.

A piecewise quadratic interpolation is used to fit the sensitivity functions. The functions are tested by comparing the calibrated flux to the standard star flux models. The fractional error per resolution element has a mean < 0.5% and standard deviation of 3-4%.

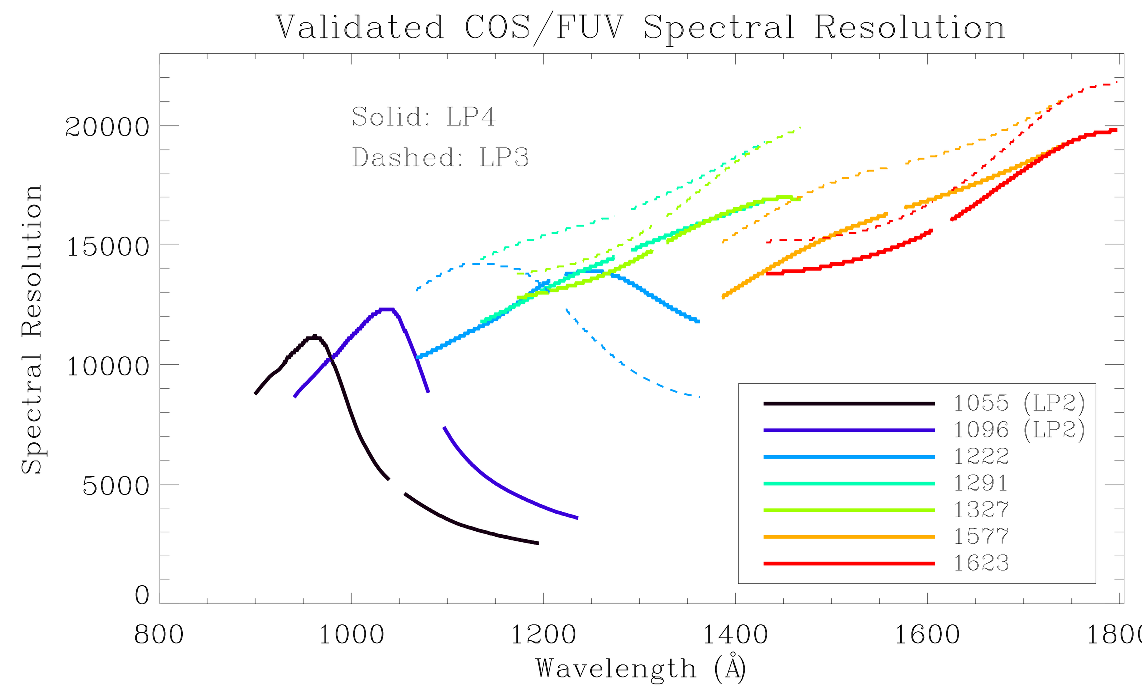


Left: flux vs. wavelength for the G160M/FUVA cenwaves after both flat fielding and flux calibration are complete. Note that the y-axis is different (more zoomed-in) from the above plots.

LP4 Spectral Resolution

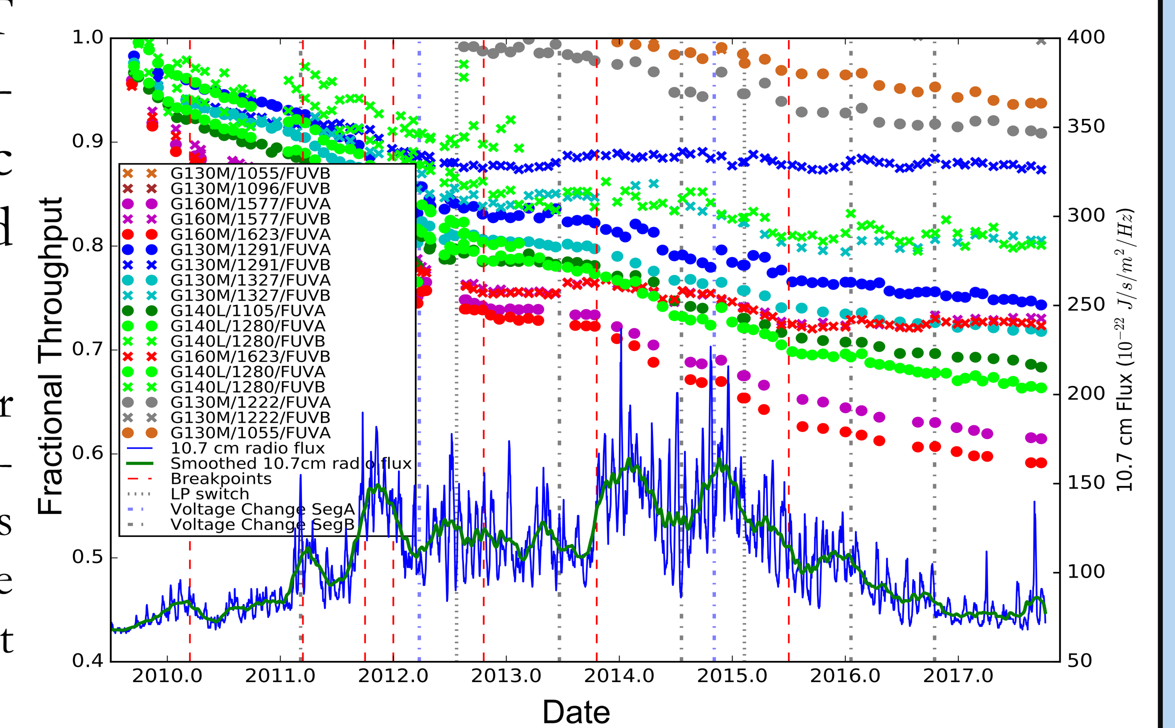
The spectral resolution at LP4 has been confirmed to be ~10-15% below its value at LP3, depending on cenwave and wavelength.

Right: spectral resolution vs. wavelength for seven different cenwaves, five from the G130M grating (1055, 1096, 1222, 1291, and 1327) and two from the G160M grating (1577 and 1623). The two blue mode settings (1055 and 1096) remain at LP2. The resolution curves plotted are generated by the Code V optical model, which has been validated at LP4 through on-orbit observations.

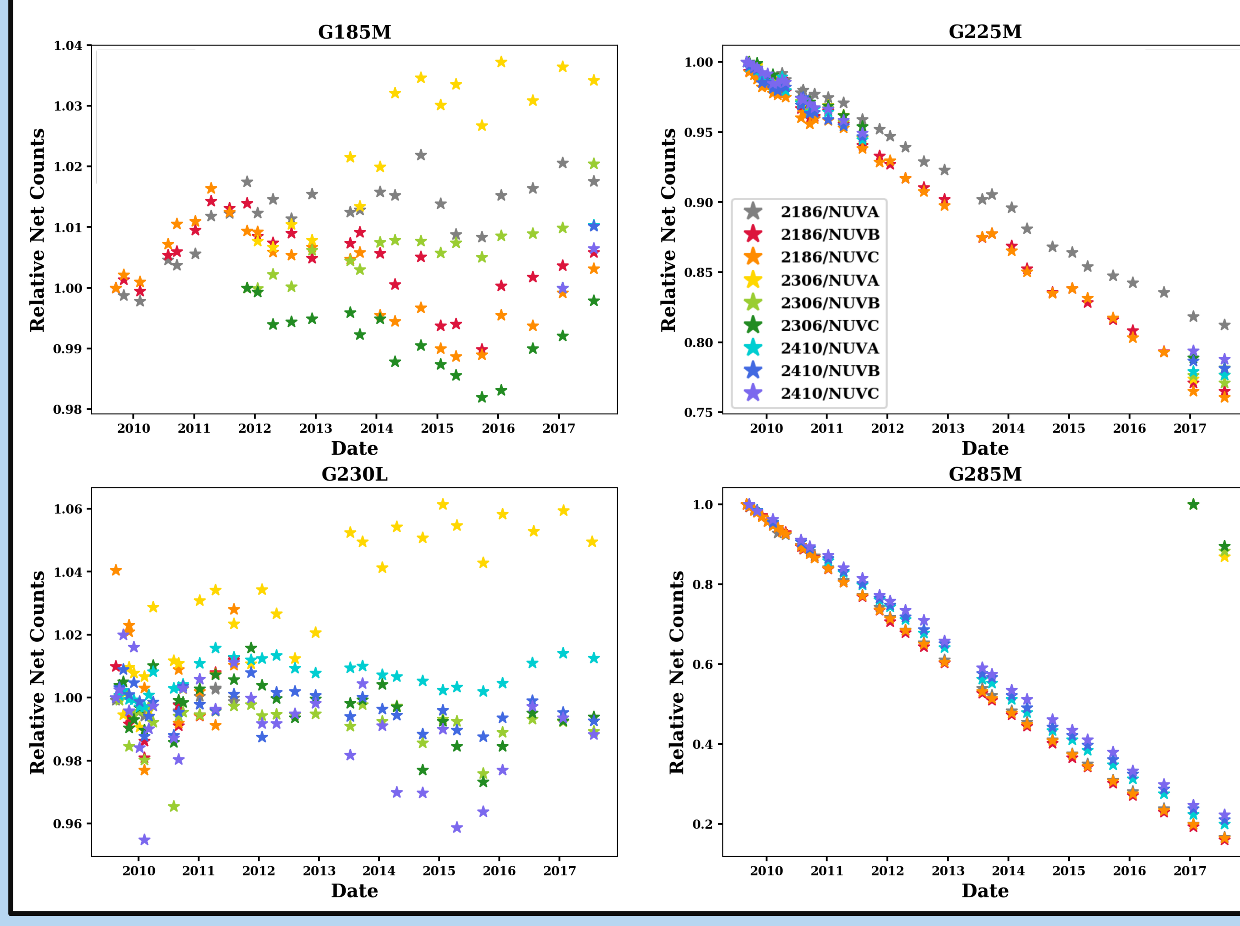


FUV and NUV Time-Dependent Sensitivities

Regular monitoring of HST standard stars shows a time-dependence to the spectroscopic sensitivity of both COS FUV and NUV observing modes.



Right: fractional throughput vs. time for FUV observing modes. The time-dependent sensitivity (TDS) initially shows steep declines, some of which are correlated to the solar cycle (blue curve at bottom). The TDS is not dependent on LP. Since midway through 2015, the FUV sensitivity has had a stable trend of 3% per year, and so a new breakpoint in the slope has been introduced at date 2015.5. New TDS and flux reference files including this breakpoint are to be delivered in January 2018, along with throughput updates for the COS exposure time calculator.

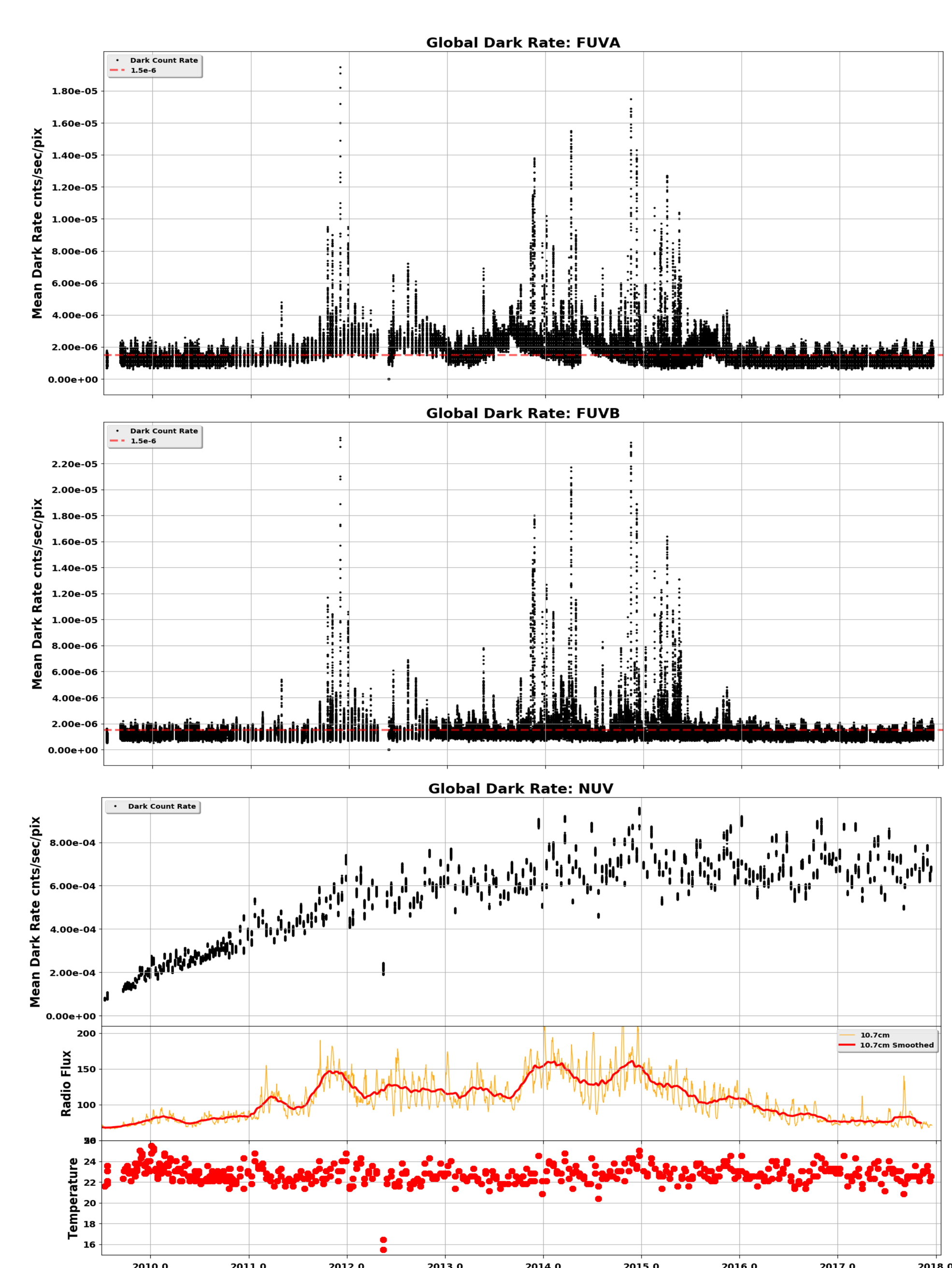


Left: relative net counts (fractional throughput) vs. time for NUV observing modes. Since launch, the TDS for the G225M and G285M observing modes show a decrease of 3% and 10% per year respectively, independent of cenwave. While the G185M and G230L modes show significant scatter, the trends are consistent over time.

FUV and NUV Dark Rates

Dark rates are monitored to track on-orbit time dependence and to check for a developing detector problem. Five exposures are taken every week for the FUV and two every two weeks for NUV.

For the FUV detector (**see right-top and right-middle**), the scatter in dark rate values has decreased since the solar maximum in 2014 (shown in orange curve at bottom). The NUV detector (**see right-bottom**) shows that the rate is flattening out.



The current dark rates used in the COS exposure time calculator are:

- FUVA: 1.78 × 10^{-6} counts/sec/pix
- FUVB: 1.68 × 10^{-6} counts/sec/pix
- NUV: 8.23 × 10^{-4} counts/sec/pix

Two New Observing Modes for Cycle 26

G160M/1533 – Extends the coverage of the grating on the blue end by ~30Å and overlaps with the red end of the G130M/1222 observing mode by ~20Å. This will allow the entire FUV bandpass to be covered with fewer cenwaves.

G140L/800 – Offers continuous spectral coverage from 900-1850Å on FUVA, which simplifies calibrations, makes observations more efficient, and increases the signal-to-noise of background-limited observations by reducing the astigmatism between 900 and 1100Å.

Look for more information in the upcoming Cycle 26 Call for Proposals!