443.04

New Cenwave G160M/1533 for Hubble's Cosmic Origins Spectrograph

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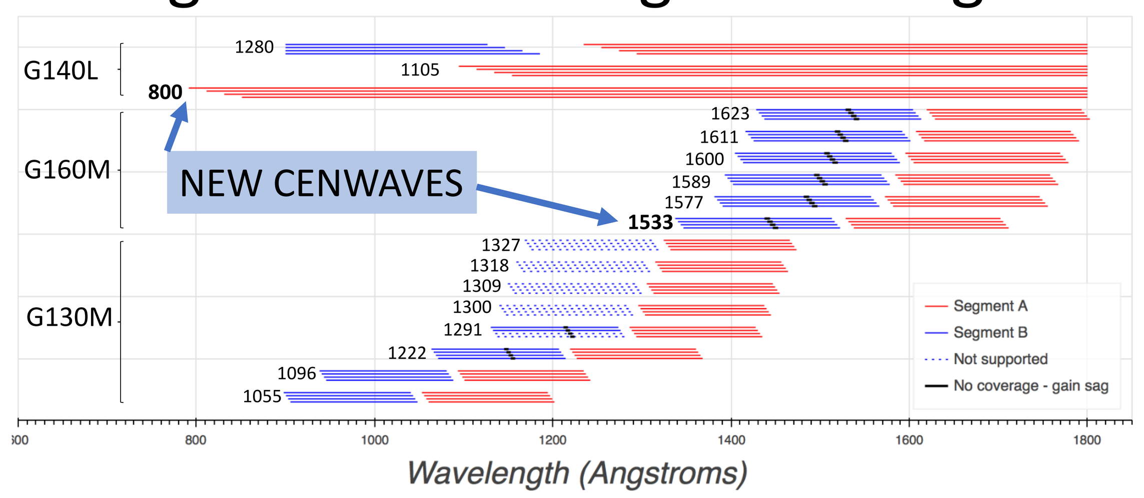
Figure 1: Wavelength Coverage



Wavelength coverage for all COS/FUV settings, including the two new cenwaves G140L/800 and G160M/1533. The four horizontal lines per cenwave indicate the FP-POS settings. The small black lines indicate gain-sagged regions.

Introduction

Starting in late 2018 (Cycle 26), two new central wavelength settings (cenwaves) are being offered for the far-ultraviolet (FUV) channel of the Cosmic Origins Spectrograph (COS) on the *Hubble Space Telescope (HST)*: G160M/1533 and G140L/800. This poster introduces and characterizes the G160M/1533 cenwave, which improves observing efficiency by bridging the FUV wavelength coverage. It extends the coverage of the G160M medium-resolution grating by 44 Å toward shorter wavelengths, covering 1339–1520 Å (segment FUVB) and 1530–1710 Å (FUVA). In concert with the G130M/1222 cenwave, the FUV range from 1067–1710 Å can now be covered at medium-resolution and at high S/N (with four FP-POS positions) with two cenwaves instead of the three that were previously necessary. The 1533 cenwave thus enhances the value of 1222. The G160M/1533 cenwave is now implemented for COS observations. The G140L/800 cenwave is described in a partner poster by Fischer et al. (443.03).

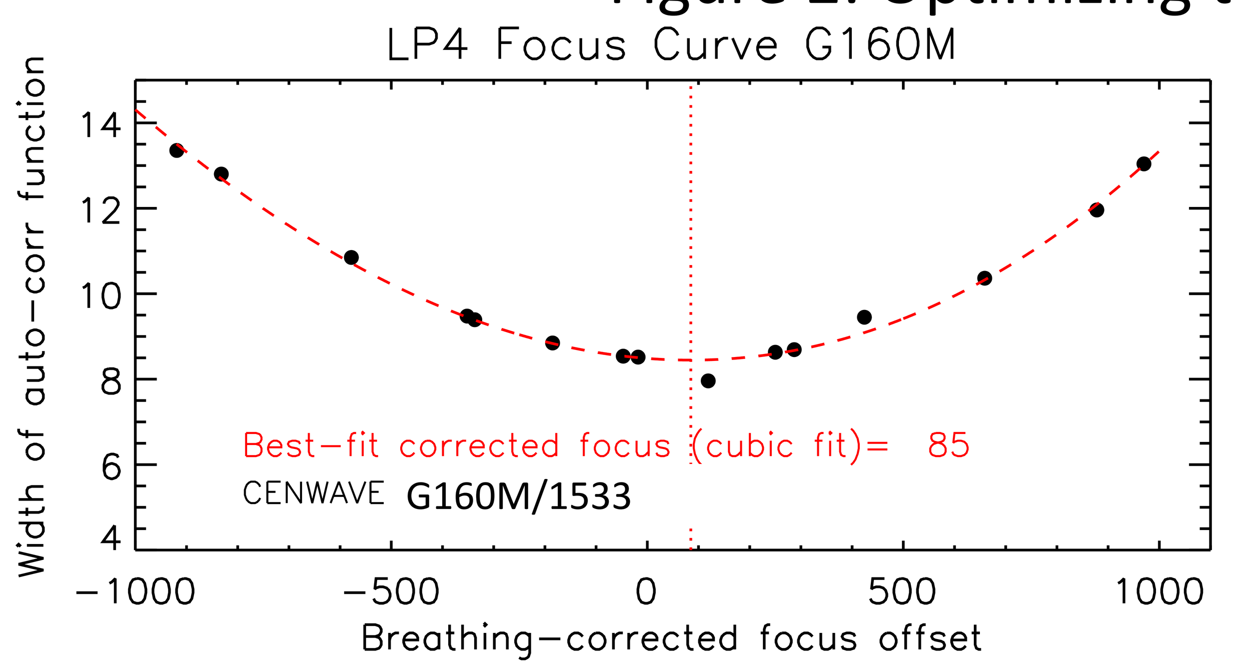
G160M/1533 at a Glance

Wavelength coverage: 1339–1520 Å (FUVB)
1530–1710 Å (FUVA)
Spectral resolution: R=12,000 @ 1400 Å
R=18,000 @ 1700 Å
Flux calibration accuracy: 2% relative, 5% absolute
Wavelength accuracy: ±3 pixels (±6 km s^{-1})
FP-POS allowed: 1,2,3,4, ALL
Typical use case: combine with G130M/1222 to cover the full FUV at high S/N with only two cenwaves
Detector Lifetime Position: LP4

Implementation and Calibration

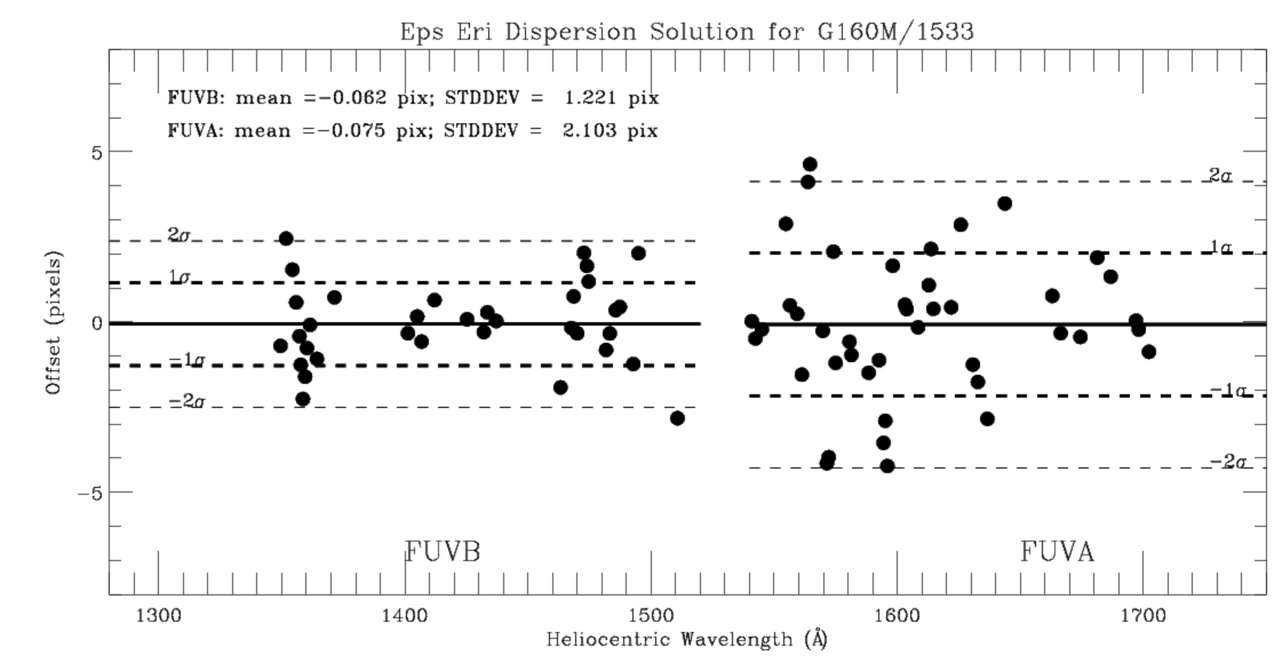
To implement the new cenwave 1533, we first focused the setting using a focus-sweep program (Figure 2). We then implemented the new mode in the COS data reduction pipeline (**CalCOS**) by creating new reference files for the lamp template (LAMPTAB), dispersion solution (DISPTAB; Figure 3), spectral extraction regions (XTRACTAB, TWOZXTAB, PROFTAB), spectral trace (TRACETAB; Figure 4), and flux calibration (FLUXTAB; Figure 5). These reference files were tested and delivered to the *HST* data processing pipeline on November 20, 2018. Cenwave 1533 is now a fully supported mode in APT with the same calibration accuracy and spectral resolution as the other G160M cenwaves, though it is not available for target acquisitions. Two General Observer (GO) programs in Cycle 26 use cenwave 1533 (Program IDs 15639 and 15646), both studying external galaxies.

Figure 2: Optimizing the Focus Position



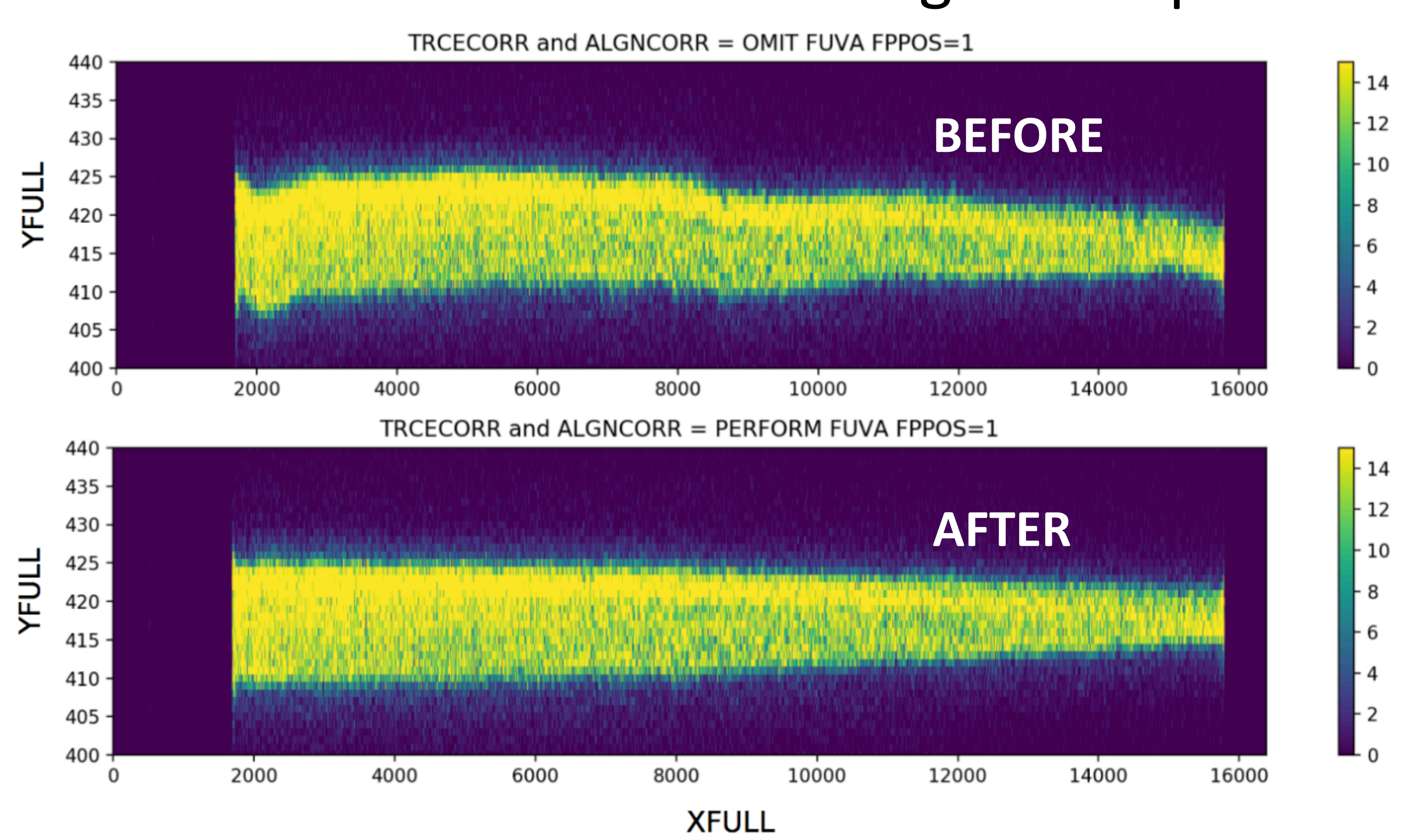
Summary: Focus curve for G160M/1533, showing the width of the auto-correlation function (ACF) as a function of focus position corrected for thermal breathing of the telescope.
Description: The curve is obtained from 1533 observations of the star Feige 48. The width of the ACF provides a statistical measure of the widths of the absorption lines, and hence of the spectral resolution and the focus: the better focused the instrument, the narrower the absorption lines, and the narrower the width of the ACF. The focus minimum obtained from a cubic fit (+85; red dashed line) provides the best-fit focus. This value was uploaded in the HST flight software.

Figure 3: Wavelength Solution



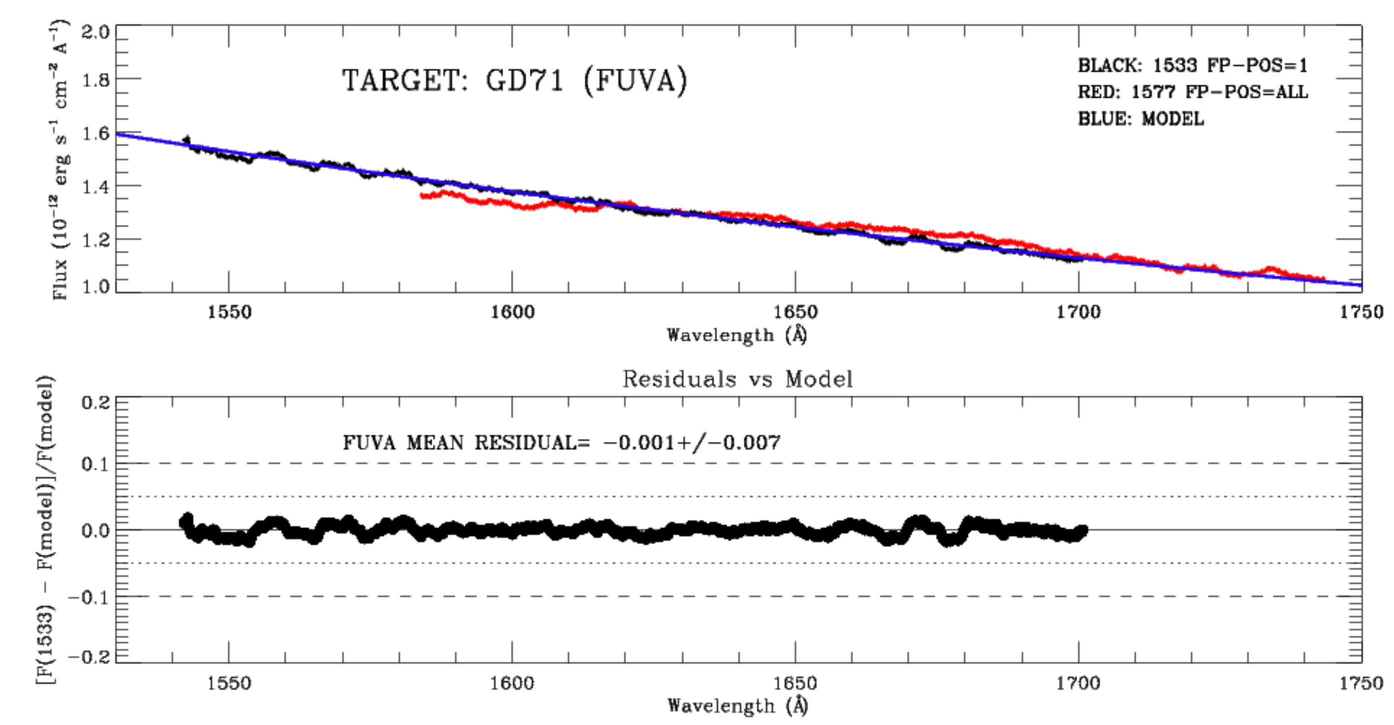
Summary: Illustration of the accuracy (in pixels) of the 1533 dispersion solution as a function of wavelength.
Description: We cross-correlated the COS 1533 spectrum of the emission-line star Epsilon Eridanus with a high-resolution STIS E140M spectrum of the same target in a number of wavelength windows, each containing a narrow emission line. By minimizing the pixel offsets (COS–STIS) as a function of wavelength, we determined the zeropoint and dispersion of each detector segment. The plot shows the residuals once the final dispersion and zeropoints have been applied, and confirms that the wavelengths are accurate to within ±3 pixels, meeting our calibration goal.

Figure 4: Spectral Trace



Summary: Illustration of the removal of the spectral trace from a FUV 2D flat-fielded image.
Description: The top panel shows an uncorrected 2-D image of the standard star WD0308-565 observed with the new cenwave 1533 with FP-POS=1. The lower panel shows a corrected image after the trace has been removed by the TRCECORR and ALGNCORR steps in the **CalCOS** pipeline. The axes are both in units of pixels: XFULL is the dispersion direction and YFULL is the cross-dispersion direction. The color scale is in units of counts. These data-reduction steps are applied to all COS FUV observations to straighten the spectrum before extraction.

Figure 5: Flux Calibration



Summary: Illustration of the observations used to flux calibrate the 1533 cenwave on segment FUVA.
Description: The top panel compares flux-calibrated G160M/1533 observations of the bright standard star GD71 (black) to a spectrophotometric model (blue) and to existing calibrated G160M/1577 observations (red). The lower panel shows the fractional residuals between 1533 and the model. The 1533 and 1577 data are smoothed by 500 pixels for display. The standard deviation of the residual is 0.7%, well within our nominal flux calibration accuracy of 2% (relative) and 5% (absolute). Similar results are found for FUVB.

Takeaway

If your COS science program requires full FUV coverage (~1100–1700 Å) , consider using the new 1533 cenwave in tandem with the existing G130M/1222 cenwave. This combination provides efficient use of HST orbits without placing Lyman-α on the detector, thus safeguarding the detector lifetime, and also enables high S/N science since (unlike 1291) both the 1533 and 1222 cenwaves allow four spectral dithers (FP-POS positions).

Questions? See COS Instrument Handbook (http://www.stsci.edu/hst/cos/documents/handbooks/current/cos_cover.html), COS webpage (www.stsci.edu/hst/cos) or contact Andy (afox@stsci.edu) or Elaine (efrazer@stsci.edu) here at the AAS.