New Cenwave G140L/800 for Hubble's Cosmic Origins Spectrograph

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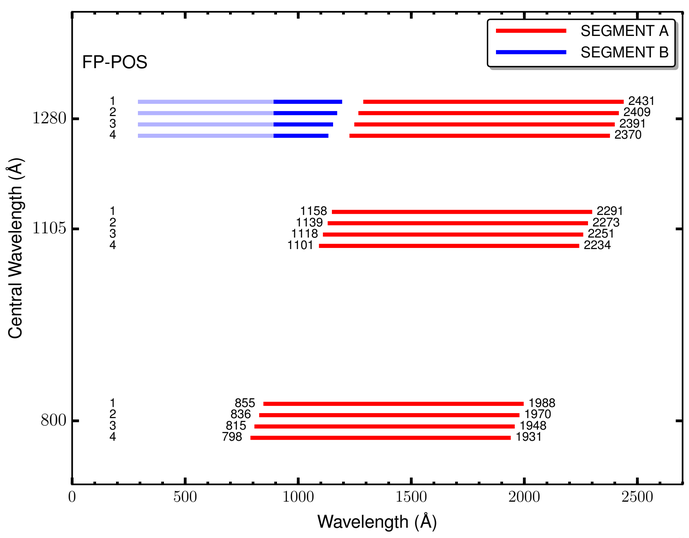
I. Overview

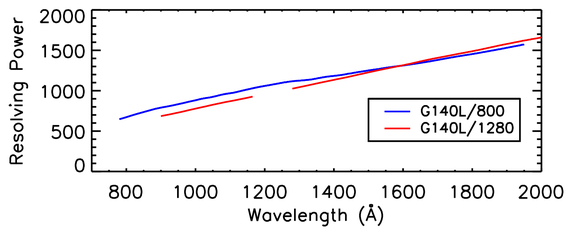
- Starting in Fall 2018 (Cycle 26), two new central wavelength settings (cenwaves) are being offered for the far-ultraviolet (FUV) channel of the Hubble Space Telescope's Cosmic Origins Spectrograph (HST/COS). Here we introduce the G140L/800 cenwave. The nearby poster by Fox et al. (443.04) discusses the G160M/1533 cenwave.
- Cenwave 800…
  - Was first explored by S. McCandliss et al. in outsourced calibration program 12501
  - Enables background-limited spectroscopy with the G140L low-resolution grating (resolving power ~ 1000) at wavelengths below 1100 Å
  - Places wavelengths from 815 to 1950 Å on segment A of the FUV detector, ~ 300 Å below the range of the G140L/1105 cenwave
  - Lacks the gap between detector segments that affects the G140L/1280 cenwave
- The grating focus is chosen to minimize the astigmatic height of the spectrum and therefore the detector background below 1100 Å, allowing higher S/N to be reached for background-dominated targets at these wavelengths than possible with G140L/1280
- Redwine et al. 2016 (PASP, 128, 105006) present a preliminary characterization of this mode and discuss potential science applications, e.g.,
  - Measurement of Lyman continuum escape fractions at low redshift
  - Exploration of the He II Lyman α forest
  - Determination of abundances in evolved planetary systems of white dwarfs



Left: Illustration of the cenwave 800 wavelength coverage compared to those of COS's other two low-resolution modes, cenwaves 1105 and 1280. The region shortward of 912 Å, shown in light blue for cenwave 1280, is included in spectra but is not covered by the standard flux calibration.

Each cenwave has four FP-POS that are slightly offset in wavelength. As with other FUV modes, using all of these facilitates the reduction of fixed-pattern noise.

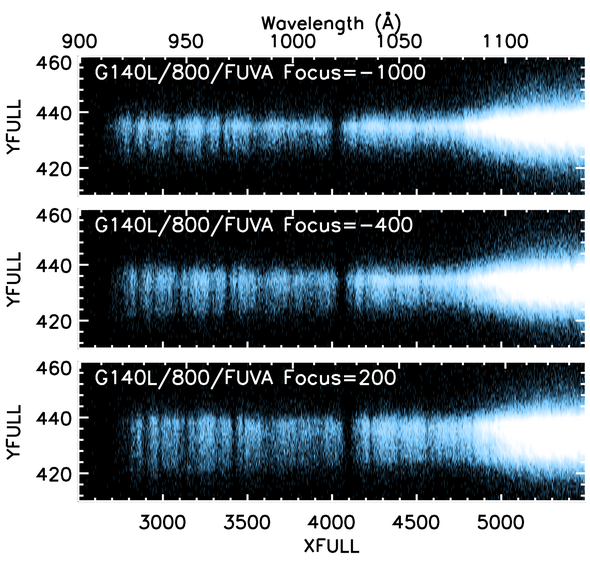
Right: Cenwave 800 resolving power vs. wavelength compared to that of existing G140L cenwave 1280. Curves are based on optical modeling of line-spread functions by E. Elliott.

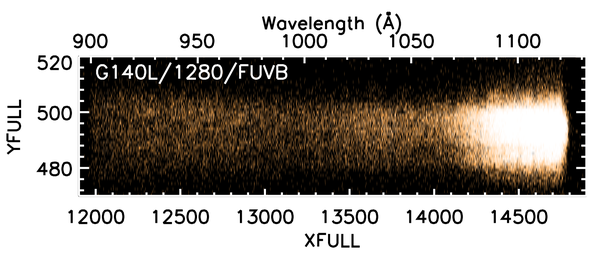


II. Grating Focus Optimization

- We set the focus to minimize the astigmatic height below 1100 Å while preserving the spectral resolution
- We straighten the spectra before extraction, wavelength calibration, and flux calibration

Below Left: The focus sweep for cenwave 800 (PID 15451) obtained spectra of the O5 supergiant AV 75 at 14 focus positions from –1000 to +1000 relative to that of existing cenwave 1105. Three examples are shown of the short-wavelength end of the spectra. Positions –1000 and –400 have small cross-dispersion widths below 1100 Å, while the width is visibly larger for position 200. Since the spectral resolution is degraded at extremely negative focus values, we chose relative position –400 (absolute position –1487).

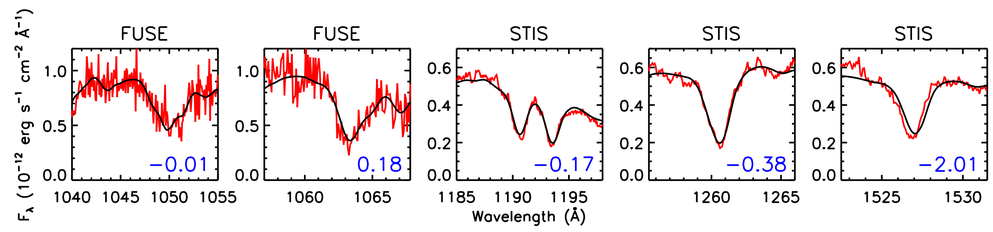




Above: Two-dimensional spectrum of the hot subdwarf WD 0308–565 (PID 14910) obtained with segment B of the FUV detector and existing cenwave 1280. The cross-dispersion width below 1100 Å is much larger than that of cenwave 800 at the adopted focus position, demonstrating a key benefit of the new cenwave.

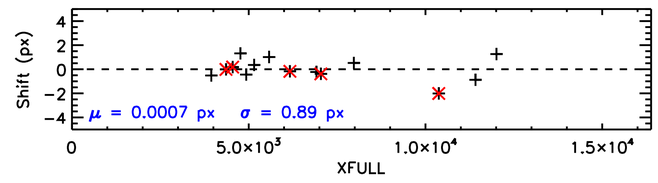
III. Wavelength Calibration

- We cross-correlated a cenwave 800 spectrum of the O5 supergiant AV 75 (PID 15451) with a FUSE spectrum of the same target at short wavelengths and a STIS spectrum of the same target at long wavelengths
- Like other G140L cenwaves, the wavelength solution is quadratic, as opposed to the linear solutions used for the medium-resolution modes



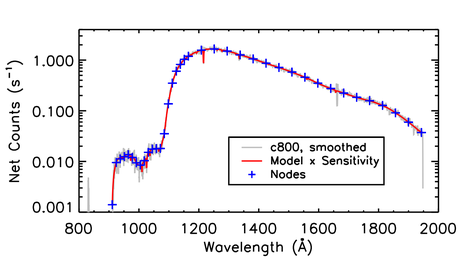
Above: The best wavelength solution aligns the cenwave 800 spectra (red) with FUSE or STIS spectra convolved to the COS G140L resolution (black). Blue text indicates the offset in pixels for each window.

Below: Residuals over all windows have a mean nearly equal to zero and a standard deviation of only 0.89 pixels, small compared to the internal error goal of 4.0 – 6.6 pixels for G140L modes. Red symbols mark the windows illustrated above. The intended wavelength calibration accuracy is ± 3 pixels, similar to the medium-resolution gratings, but there has been limited testing so far.

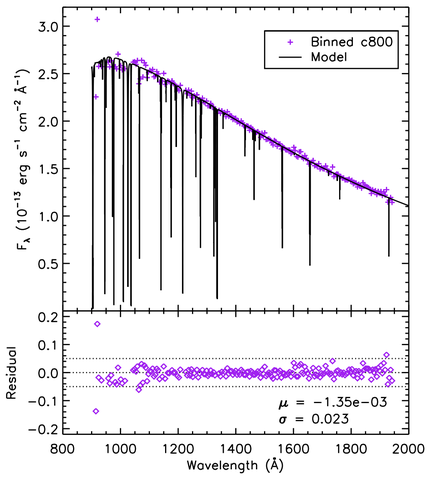


IV. Flux Calibration

- We derived a sensitivity curve by comparing cenwave 800 spectra of the hot subdwarf WD 0308–565 (PID 15483) to a model
- The coverage of cenwave 800 extends below 912 Å, but counts detected at those wavelengths are not currently included in the standard flux calibration. This may be addressed in a future effort if there is interest among the user community.



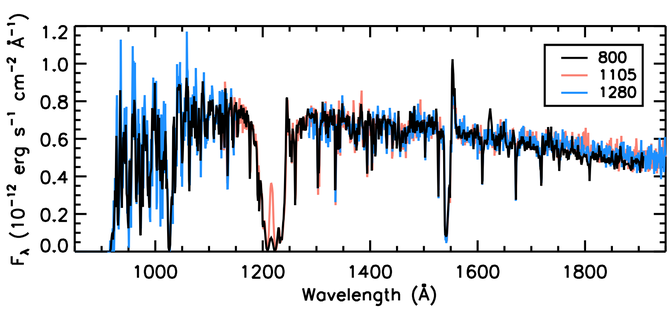
Above: Fitting of the counts. The model is multiplied by the derived sensitivity function to demonstrate its alignment with the counts spectrum.



Left: The cenwave 800 spectrum and model of WD 0308–565 agree. Residuals demonstrate that the calibration accuracy matches that of the other G140L cenwaves: 2% relative and 5% absolute.

V. Summary

- COS's new cenwave G140L/800 offers background-limited spectroscopy below 1100 Å at low resolution (R ~ 1000)
- It places the entire FUV (815 – 1950 Å) on one segment of the detector, so there is no gap between segments as for most other FUV cenwaves
- It has been optimized to reduce the astigmatic height of the spectrum below 1100 Å, allowing for a narrower extraction box, decreased detector background, and higher S/N
- Those who do not need the reduced astigmatic height at short wavelengths should use G140L/1105 or G140L/1280 depending on their wavelength coverage requirements. Above ~ 1220 Å, these cenwaves have smaller astigmatic heights than G140L/800.
- Two programs that use cenwave G140L/ 800 have already been approved for Cycle 26



Left: A fully calibrated cenwave 800 spectrum of AV 75 (PID 15451) agrees well with spectra of the same star obtained 11 days earlier using the other G140L cenwaves (PID 15385)