Updated Status and Performance for the Cosmic Origins Spectrograph

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Abstract

The Cosmic Origins Spectrograph (COS) was installed on the Hubble Space Telescope (HST) in May 2009. COS is designed to perform high-sensitivity, medium- and low-resolution spectroscopy of astronomical objects in the 1150-3200 Å wavelength range. COS significantly enhances the spectroscopic capabilities of HST at ultraviolet wavelengths, providing observers with unparalleled opportunities for observing faint UV sources. Provided here is an update on some aspects of detector performance and current calibration projects from Cycle 18 along with new additions for Cycle 19. Included are discussions on the time dependent sensitivity as well as recent and upcoming additions to CalCOS. We also present initial characteristics of a new G130M/1222 central wavelength setting for the Far-Ultraviolet (FUV) channel. This new mode, available in Cycle 20, provides a resolving power of R>10,000 from 1065 to 1365 angstroms while placing the damaging flux of the Lyα airglow line in the gap between detector segments A and B.

Time Dependent Sensitivity

Regular monitoring of *HST* spectrophotometric primary standard stars has shown that there is a time dependence to the spectroscopic sensitivity of COS observing modes. Previously, this sensitivity decline has been described by a fit with two piecewise linear continuous segments and a breakpoint at 2010.2. Recent observations taken up through October 2011 indicate that a third slope has developed, and thus a second breakpoint is needed.

Finding the appropriate breakpoints required fitting various linear solutions to the observations from the sensitivity monitoring programs. An example of this, for the G140L/1105 mode, is shown in Figure 1. The first breakpoint was allowed to vary between 2010.0 and 2010.5 and the second from 2011.0 to 2011.4. Goodness of fit measurements for each set of breakpoints led to first and second break points of 2010.2 and 2011.2 respectively. This measurement has been found to be consistent for all grating, segment, and wavelength combinations.

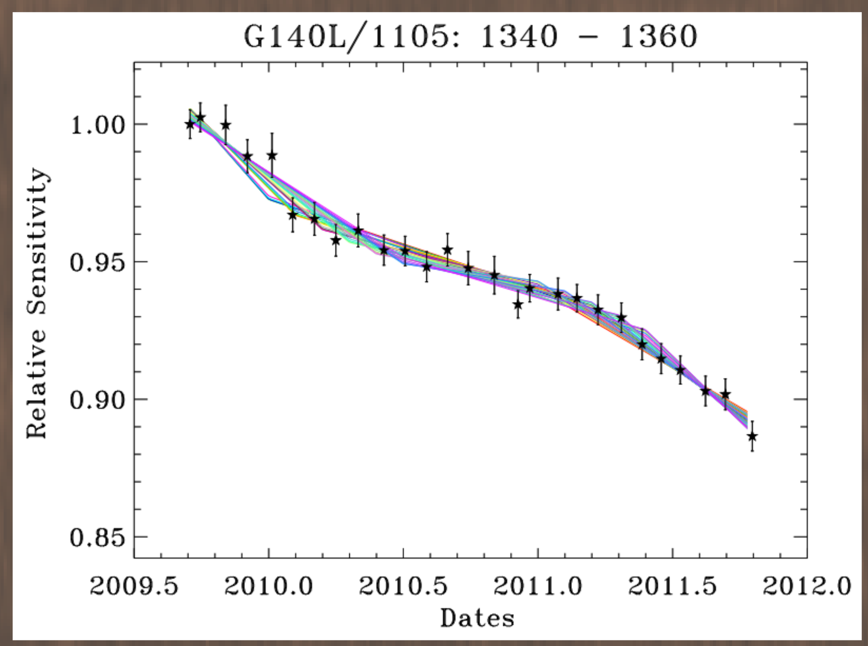


Fig 1: Plot of the relative sensitivity versus time for a 20 Angstrom section of the G140L/1105 setting of COS FUV spectroscopic sensitivity monitor program. Black stars are individual data points with error bars; colored lines indicate fits using two breaks. The first break varied between 2010.0-2010.5 and the second break varied between 2011.0-2011.4. Goodness of fit for each combination determined the optimal breakpoints.

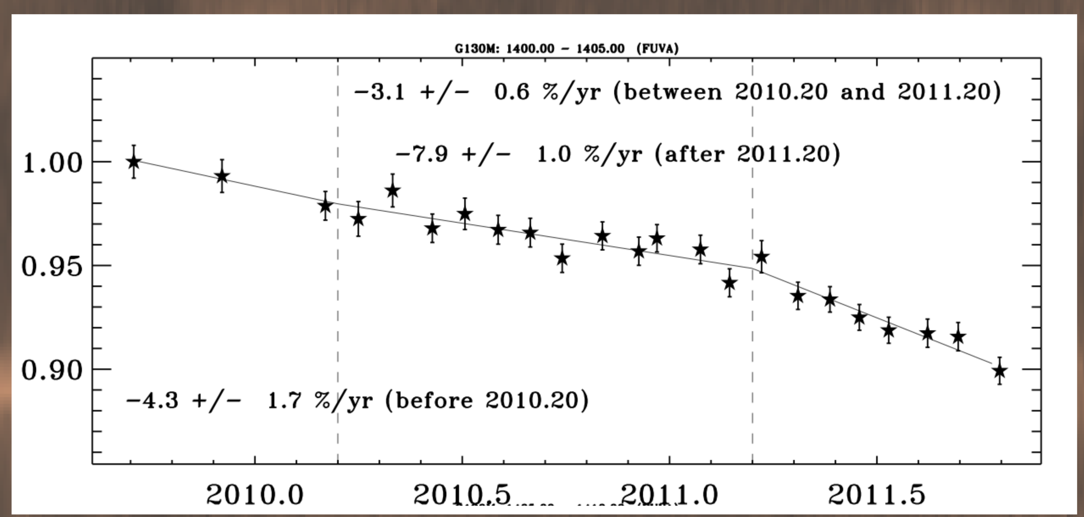
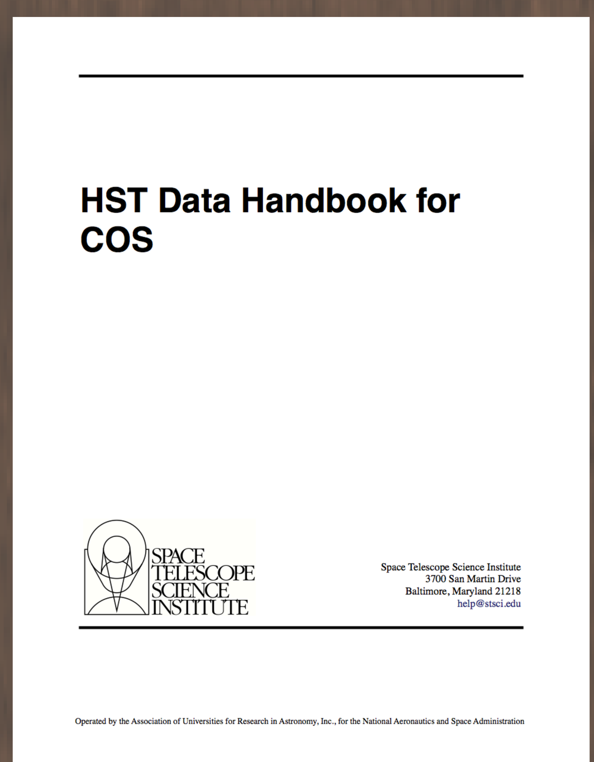


Fig 2: Plot of relative sensitivity versus time for a 5 Angstrom section of the G130M/1309 setting spectroscopic sensitivity monitor data (repeated monitoring of the white dwarf standard WD0947+857). Dashed vertical lines indicate the times of breaks in the sensitivity trend, at 2010.2 and 2011.2, respectively. The solid black line shows the fit to the data using continuous linear segments with the break points fixed at 2010.2 and 2011.2. The slopes for the different trends are listed on the graph.

Figure 2 shows the fitted rates of sensitivity decline with time for the G130M/1309 mode. Using the determined breakpoints of 2010.2 and 2011.2 we find the sensitivity decline to be -4.3 %/year until 2010.2, -3.1 %/year from 2010.2 to 2011.2, and -7.9 %/year after 2011.2. Regular sensitivity monitoring will be on going to continue to characterize this behavior.

New Data Handbook

A new version of the COS data handbook, designed to help users understand and manipulate the data from COS, is set to be released early in January of 2012. This handbook provides a quick COS overview and an in depth explanation of COS data files, calibration steps and software, error sources, and tools and techniques for data analysis. In particular for this new version, which updates the pre-launch version released in March of 2009, included are descriptions of important changes that have been implemented in the COS calibration pipeline, data producs, and STSDAS analysis tools in the 2+ years of science operations. Please visit the STScI website for the most up to date COS Handbooks.



New FUV Observing Mode: G130M/1222

Starting in Cycle 20, there will be a new COS configuration available for FUV observations. This new setting utilizes the G130M grating at a central wavelength of 1222 Å. Observing with the G130M/1222 setting utilizes the separation of the two FUV detectors by placing the geocoronal lyman alpha line in the gap between segments A and B, thereby eliminating this source of damaging high-intensity flux. This new observing mode will facilitate studies of Ly β, O VI, and Ly α absorption in the low-redshift IGM (z = 0.125), the He II Ly α forest at the epoch of He II re-ionization (z = 2.51–2.73), molecular hydrogen in planetary nebulae and in translucent clouds, and high-ionization AGN outflows at low redshifts.

The G130M/1222 mode samples wavelengths between approximately 1065 and 1365 Å with a resolving power R>10,000. The sensitivity of this setting is comparable to other G130M modes and higher than the G140L modes. Preliminary measurements indicate that the resolving power is R>13,000 at 1135 Å, but this represents a lower limit; predicted values exceed 14,000 at 1065 Å and 17,000 at 1135 Å. For more information, please see the Cycle 20 COS Instrument Handbook.

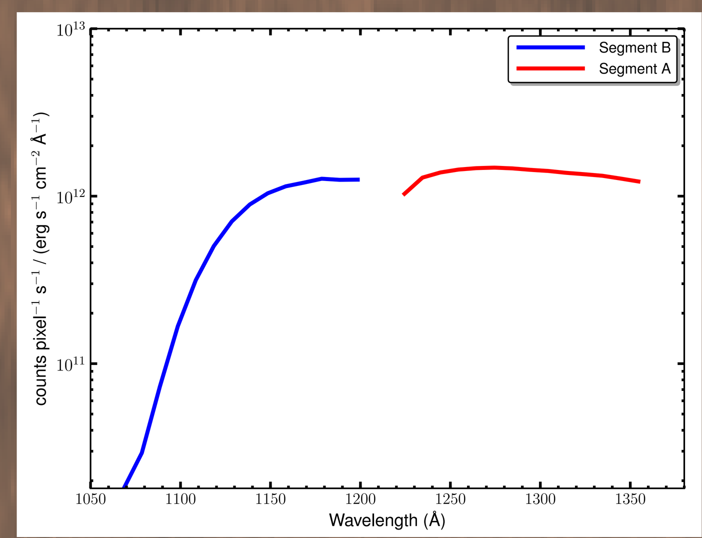


Fig 3: Sensitivity versus wavelength for the new G130M/1222 setting. Note the gap in coverage at Lyα caused by the physical separation of the detector segments.

CALCOS Updates

A new version of the COS Calibration pipeline (CALCOS) is due to be installed in January 2012 in the on-the-fly-recalibration (OTFR) pipeline. Important new features for this release include the addition of a correction to the Y-walk caused by gain sag and the addition of a timeline extension for corrtag files. Users wishing to take advantage of these new updates should re-request their data from the archive after the installation is complete, or download the current release of STScI_Python.

Y-walk, a mis-registration of detected photons in the Y direction, is a consequence of gain-sag (see COS ISR 2011-05 for information on gain-sag). A correction for this effect has been added to CALCOS as a WALKCORR calibration step and associated WALKTAB reference file. This new calibration step corrects the Y location of each detected photon based on the pulse height amplitude of the event, resulting in a re-aligned spectrum free of y-walk.

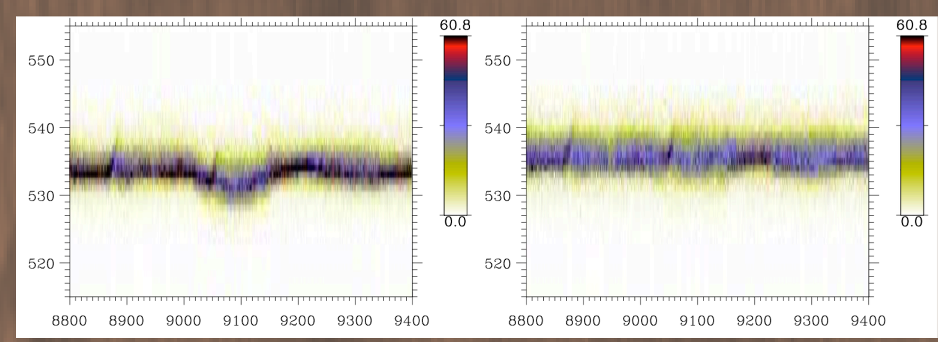


Fig 4: The Y-walk correction applied to FUV G160M data from sensitivity monitoring programs. The region shown is from detector pixels 8800 to 9400, which encompasses a region of severe gain sag at x=9100 from geo-coronal Lyα. *(Left)* uncorrected, *(right)* corrected.

A TIMELINE extension has been added to corrtag data files to provide information about the observation at one-second intervals throughout the exposure. A timefilter tool has also been developed that allows users to flag intervals of time in the corrtag table as bad, based on the information in the TIMELINE extension. This will give users the ability to filter out parts of their exposures that satisfy certain conditions; e.g. when the sun was above the horizon, *HST* was past a certain longitude, or O I airglow line was too strong.

# row	TIME	LONGITUDE	LATITUDE	SUN_ALT	TARGET_ALT	RADIAL_VEL	SHIFT1	LY_ALPHA	OI_1304	OI_1356	DARKRATE
#	s	degree	degree	degree	degree	km /s	pixel	count /s	count /s	count /s	count /s /pixel
1	0.032	65.959007	8.998860	-59.03	18.22	-5.4433	-17.294	0.	0.	0.	6.05822E-10
2	1.032	66.011200	9.027463	-59.09	18.26	-5.4440	-17.294	0.	0.	0.	6.05822E-10
3	2.032	66.063400	9.056057	-59.15	18.31	-5.4448	-17.294	0.	0.	0.	0.
4	3.032	66.115608	9.084642	-59.21	18.35	-5.4455	-17.295	0.	0.	0.	3.02911E-10
5	4.032	66.167831	9.113219	-59.27	18.40	-5.4462	-17.295	0.	0.	0.	3.02911E-10
6	5.032	66.220055	9.141788	-59.33	18.44	-5.4470	-17.295	0.	0.	0.	6.05822E-10

Fig 5: The first 6 rows of a sample timeline extension from a COS FUV observation. Information provided on a second-by-second basis include longitude, latitude, sun altitude, target altitude, radial velocity, spectrum x shift value, lyα line strength, OI line strengh, and detector dark rate.