

Time-Dependent Spectroscopic Sensitivity Monitoring of the Cosmic Origins Spectrograph

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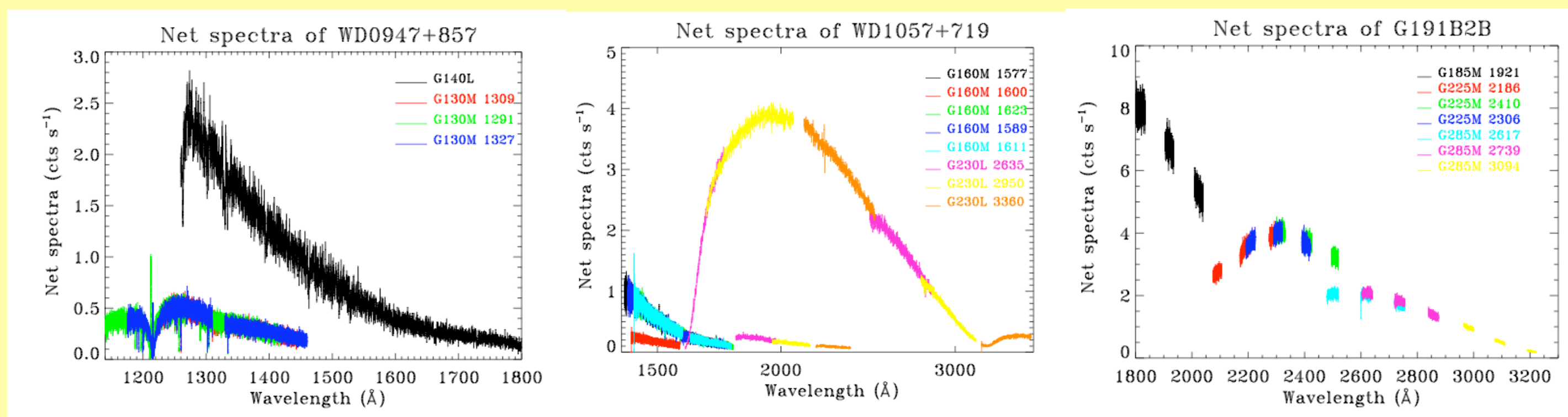
After the initial on-orbit determination of spectroscopic sensitivities was made for the near ultraviolet (NUV) and far ultraviolet (FUV) channels on the Cosmic Origins Spectrograph (COS) onboard the Hubble Space Telescope (HST), additional monitoring has continued in Cycle 17 as part of the Cycle 17 COS Calibration Program. Low- and medium-resolution gratings are observed roughly monthly and quarterly, respectively, using external observations of spectrophotometric standard stars.

Of particular interest are two of the NUV medium resolution gratings. The G225M and G285M gratings are coated with bare aluminum. Because of concerns about the long term stability of the coatings, grating efficiency testing (GET) was conducted semi-annually from 2003 until payload integration in April, 2009 using the COS internal PtNe lamps to compare the strengths of spectral features common to multiple NUV gratings. The GET procedure was executed early in the Servicing Mission Observatory Verification (SMOV) and will be repeated approximately semi-annually during Cycle 17. The first on-orbit efficiency measures were consistent with the ground-based trends, which indicated an efficiency loss of 4% per year (relative) for the G285M grating and 2% per year for the G225M grating. Monitoring of the time-dependent sensitivity (TDS) using external targets for these gratings occurs at a monthly frequency to capture any on-orbit changes.

We present initial determination of TDS changes in the FUV and NUV channels through December 2009, using both external targets and GET data.

FUV Cycle 17 Sensitivity Monitoring Observations

grating	target	cenwave	2009 obs'n date
G140L	WD0947+857	1105, 1230	Sept. 15
			Sept. 29
			Nov. 2
			Dec. 14
G130M	WD0947+857	1309, 1291, 1327	Sept. 15
			Dec. 14
G160M	WD1057+719	1577, 1600, 1623, 1589, 1611	Sept. 8
			Nov. 13

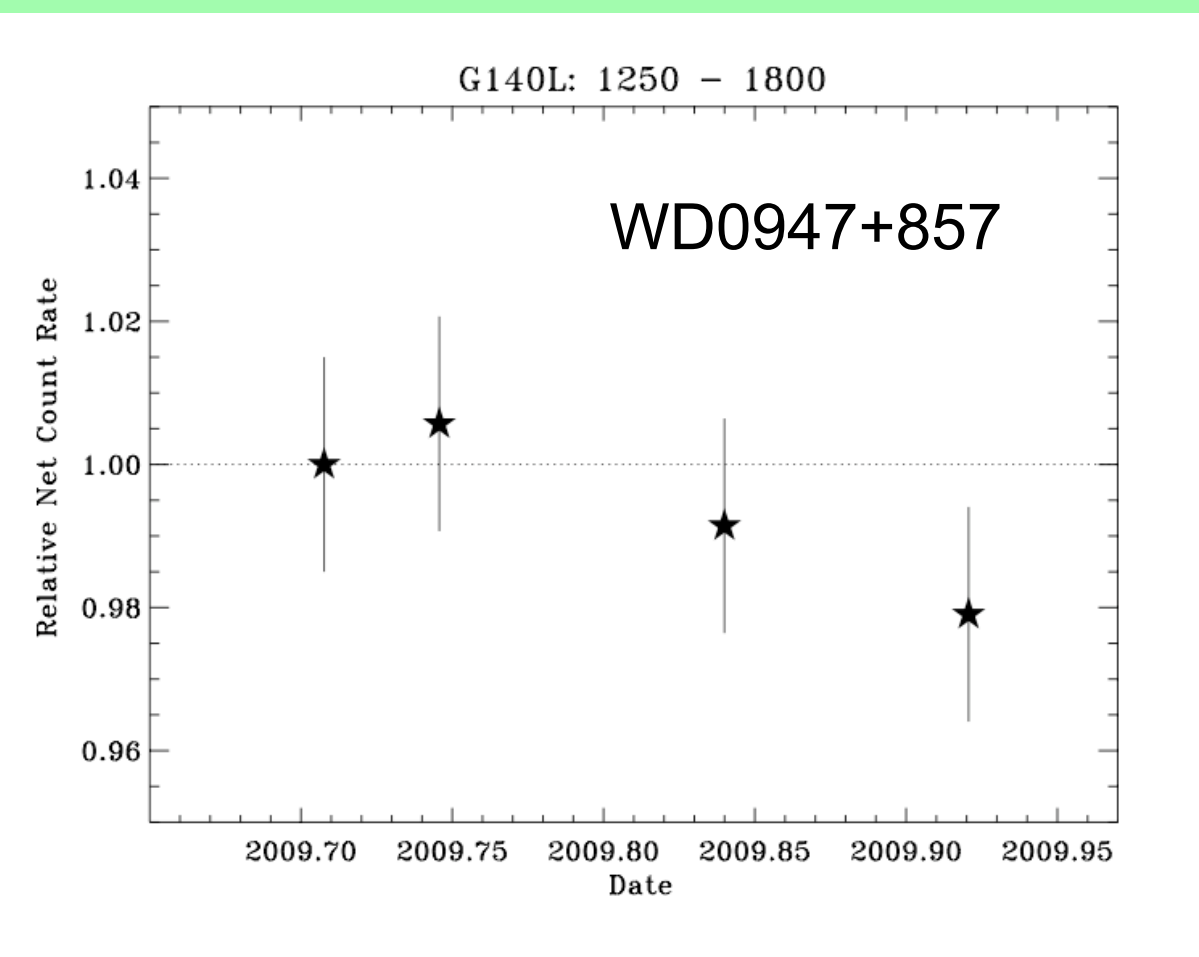


The initial determinations of absolute sensitivity for the gratings on COS were performed during Servicing Mission Observatory Verification (SMOV; see poster by Derck Massa, 464.16). The calibration observations during Cycle 17 use spectrophotometric standard stars to monitor any time-dependent sensitivity changes through the Primary Science Aperture (PSA), such as might occur if contaminants build up somewhere in the optical system. For the FUV and NUV spectroscopic sensitivity monitoring, three standard stars are used. The one dimensional, pipeline-extracted net spectra of these objects in the grating and central wavelength settings used for monitoring are shown above. Observations with the low-resolution gratings are performed roughly monthly. With their larger wavelength coverage those observations should reveal any wavelength-dependent changes in sensitivity. The medium-resolution modes are monitored approximately quarterly, with the exception of the G225M and G285M NUV channels, due to a concern about catching any continuing sensitivity degradation. The tables to the left and right list the observations obtained to date in programs 11897 (FUV Spectroscopic Sensitivity Monitor) and 11896 (NUV Spectroscopic Sensitivity Monitor) respectively. External observations of the same target with the same exposure time are used for a given grating/cenwave combination. The time-dependent sensitivity (TDS) is computed by performing a ratio of the net count rate spectra to the initial net count rate spectrum, averaging in wavelength, and determining the slope of the resultant trend with time. Since we are only a few months into Cycle 17, there have been only a handful of observations. The plots below illustrate the TDS trends for the gratings which have had more than two observations.

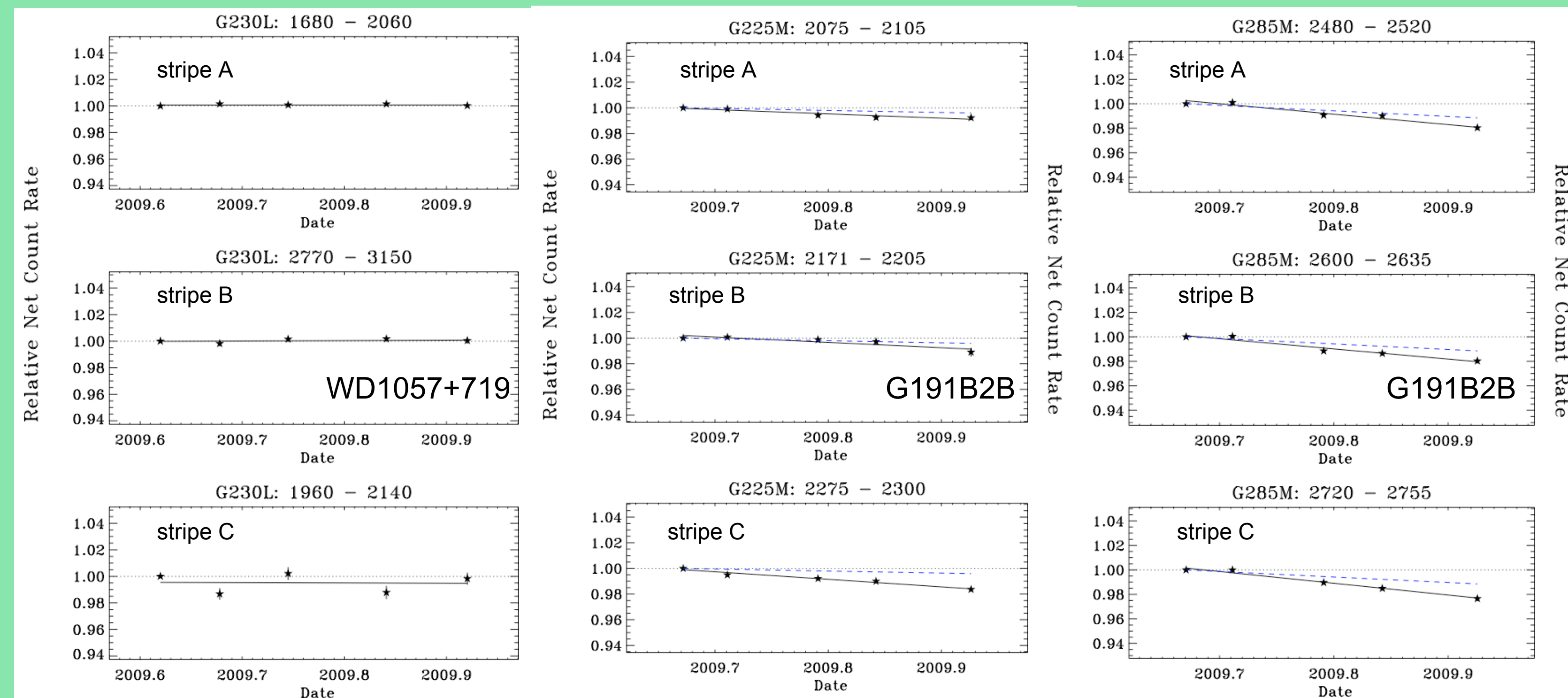
NUV Cycle 17 Sensitivity Monitoring Observations

grating	target	cenwave	2009 obs'n date
G230L	WD1057+719	2635, 2950, 3360*	Aug. 14*
			Sept. 4
			Sept. 29
			Nov. 3*
			Dec. 1
G185M	G191B2B	1921	Sept. 16
			Nov. 3
G225M	G191B2B	2186, 2410, 2306+	Sept. 1
			Sept. 16+
			Oct. 15
			Nov. 3+
			Dec. 3
G285M	G191B2B	2617, 2739, 3094**	Sept. 1
			Sept. 16**
			Oct. 15
			Nov. 3**
			Dec. 3

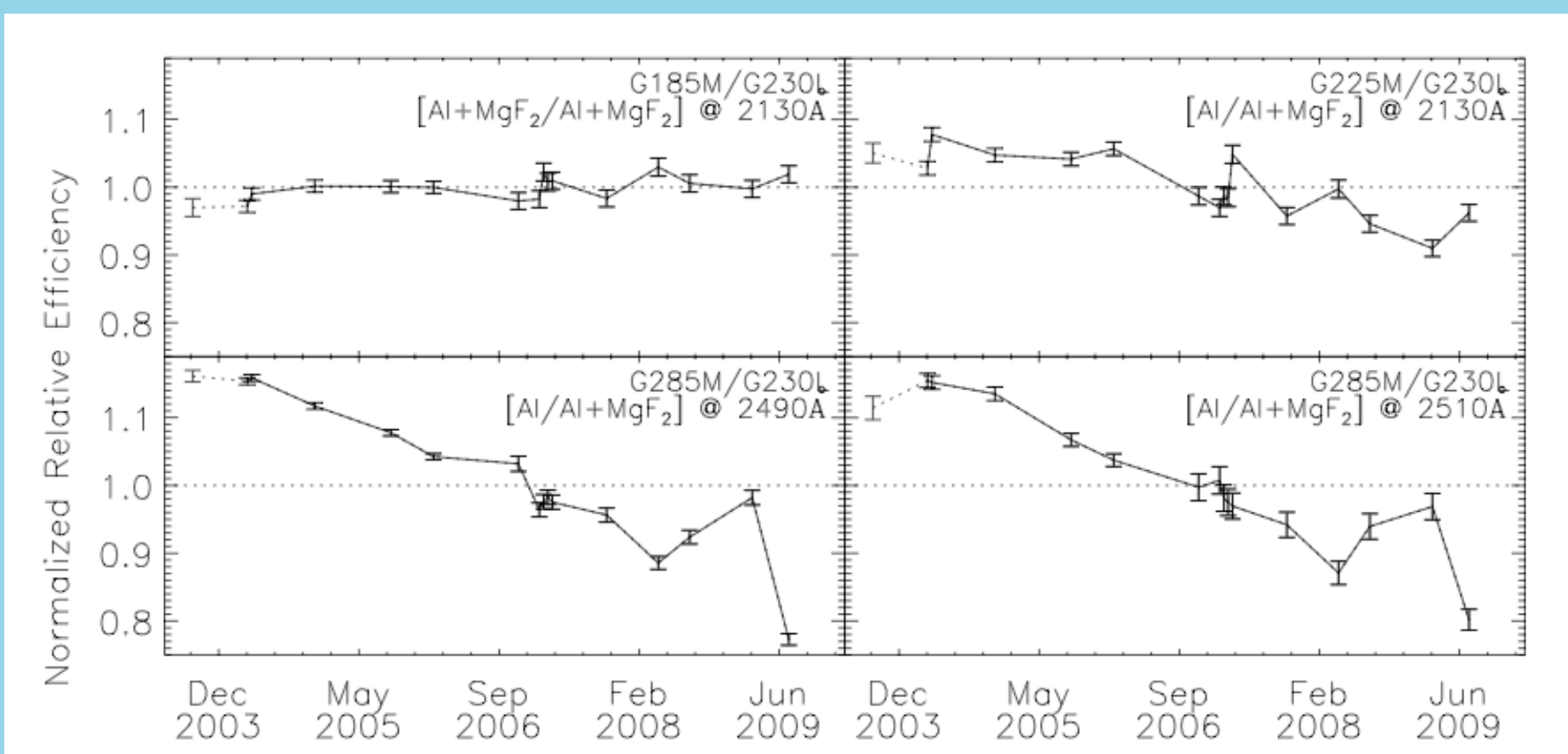
*, +, ** = selected cenwave setting was only observed on the dates noted



FUV TDS: The table above lists observations to determine TDS to date in program 11897. Only the G140L grating has had more than two visits, and the TDS trend is plotted above for the G140L 1105 cenwave setting. The trend is wavelength dependent, showing a larger scatter at longer wavelengths where both the sensitivity and the target are declining. Results from the thermal stability test indicate repeatability variations of about 3% (Ed Smith, priv. comm.). Given the small number of measurements and the apparent observation-to-observation scatter suggested by the repeatability tests, it is not yet possible to draw any firm conclusions about the rate of sensitivity change for the COS FUV modes.



NUV TDS: The table above lists the observations to determine TDS to date in program 11896. Selected cenwave settings of the G230L, G225M, and G285M gratings have had more than two visits, and the TDS trends for G230L (2635 A), G225M (2186 A), and G285M (2617 A) are plotted above. The error bars plotted are the standard error of the mean, and do not take into account other systematic effects. Repeated measurements at the same epoch indicate a repeatability of 1-2%. There is no apparent sensitivity degradation of the G230L grating in the ~6 months since COS was installed on HST. The G185M grating also appears to be stable, as found during ground tests. The G225M and G285M gratings are coated with bare aluminum, and ground tests indicated a degradation of grating efficiency relative to the G230L grating. The ground-based GET slopes of -1.6 %/yr and -4.5%/yr (see left) are overlaid on the G225M and G285M TDS plots, respectively, as a blue dashed line. The G225M and G285M gratings do show an apparent decline in sensitivity faster than the rates determined on the ground. However, systematic effects may increase the intrinsic scatter. For the G285M data, there is consistency in trends computed for the same wavelength range from different central wavelength settings and stripes. This was confirmed by manual computation of the total number of counts in the same region of each spectral stripe relative to the number of counts in the initial dataset. We will continue to monitor the G225M and G285M gratings roughly monthly during Cycle 17 to assess any sensitivity loss, and develop a time-dependent sensitivity reference file to correct for the actual sensitivity at subsequent epochs past SMOV. In addition, two more on-orbit GETs will be performed in Cycle 17.



Grating Efficiency Test (GET) observations

grating	cenwave	texp
G185M	1986	210
G185M	2010	195
G225M	2186	300
G225M	2217	225
G225M	2390	75
G225M	2410	300
G285M	2617	90
G285M	2637	300
G230L	2635	30
G230L	3360	105

NUV GETs: The IDT developed a procedure for monitoring the relative efficiencies of the COS NUV gratings during extended storage. Starting in Sept. 2003, and continuing up through launch, approximately every 6 months internal observations with the PtNe lamps were performed to compare the strengths of spectral features common to multiple NUV gratings. The table at left lists the gratings and cenwave combinations used in the GET. The exposure times are those used during the on-orbit GET during SMOV, which took place during visit 3 of program 11496. The test consists of 10 NUV exposures, with a wait of at least 15 minutes, and a repeat of the 10 NUV exposures. The ground GETs began with an 20 minute wait as well; the waiting times ensure that the lamp has cooled from any prior use. The figure above left plots the temporal trends in normalized relative efficiency. The G185M and G230L gratings are coated with Al+MgF₂, while the G225M and G285M gratings have a bare Al coating. The Al+MgF₂-coated gratings show no decline in efficiency, while the Al-coated gratings do show a decline. The figure above right displays the sensitivity change (in %/yr) for different combinations of gratings as a function of wavelength. The G285M gratings showed a consistent degradation of 4.5%/yr across wavelengths compared to G230L, and the G225M gratings showed a decline of about 1.6%/yr compared to G230L.

