

Cycle 24 COS/NUV Spectroscopic Sensitivity Monitor

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ABSTRACT

Observations of HST spectrophotometric standard stars show that there is a time dependence of the COS NUV MAMA sensitivity (Fox et al. 2016). Time-dependent sensitivity (TDS) monitoring is necessary for accurate flux calibration. Regular calibration observations monitor the decline in sensitivity for all 4 NUV gratings: G185M, G225M, G285M, and G230L. Results from the Cycle 24 NUV TDS program show the reflectivity of the G225M and G285M gratings, which are coated in bare-aluminum, exhibit a steep time-dependent degradation at a rate of -3 to -2.5%/year and -11.3 to -10.3%/year respectively. The G185M and G230L gratings, which are coated in MgF₂ over aluminum, are declining at rates of -0.2 to +0.6%/year and -0.2 to +0.8%/year respectively.

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1. Program Design

The Cosmic Origins Spectrograph (COS) NUV Time-Dependent Sensitivity (TDS) program executes every cycle and monitors the sensitivity of each NUV grating. These changes are characterized as a function of grating, cenwave, and stripe, and are used to update the COS NUV time-dependent sensitivity reference file (TDSTAB) as well as synphot files used which are used by the ETC.

The Cycle 24 NUV TDS program (14858, PI: Joanna Taylor) differs from its Cycle 23 predecessor (14441, PI: Joanna Taylor) in that four central wavelength settings (cenwaves) were added. In addition to the existing cenwaves- G185M/1786, G185M/1921, G225M/2186, G285M/2617, G285M/3094, G230L/2635- we also added G185M/2010, G285M/2850, G225M/2306 and G225M/2410. With these additions, we now obtain data at the bluest, central, and reddest cenwaves containing only first order light for each grating, with the exception of G230L. Increasing the wavelength coverage for each grating will allow us to investigate the possibility of a wavelength dependence in the TDS trends.

To accommodate these extra cenwaves, Program 14858 was allocated 6 external orbits- an increase of 2 orbits compared to Cycle 23. Taking advantage of the added orbits, the exposure time of the medium-resolution exposures was also increased to boost the SNR. Three orbits are used each for both the low- and medium-resolution gratings. The visits are spaced six months apart, with observations in January and July 2017. All visits executed successfully. Due to sensitivity differences on the medium- and low-resolution gratings, two spectrophotometric white dwarf standard star targets are used: WD1057+719 for G230L and G191B2B for G185M, G225M, and G285M.

2. Analysis and Results

The computation of the time-dependent sensitivities for COS NUV data is described in previous ISRs (Osten et al. 2010, Osten et al. 2011). The code used to perform the analysis was updated from IDL to Python (3.x), but analysis techniques used in previous cycles remain identical: The ratio of each NUV spectrum is taken with respect to the first spectrum in time and averaged for each stripe for each date. Using a linear least squares fit yields slopes and intercepts which can be used in TDSTABs and synphot files.

For the newly added cenwaves, two of the four (G225M/2410 and G225M/2306) were previously observed in Cycles 17 and 18, providing an anchor to the derived fits. The remaining two (G185M/2010 and G285M/2850), however, have never been observed as part of the TDS program. These require another cycle's worth of data to provide enough data points to allow a reliable fit. The necessary orbits for Cycle 25 have already approved and will be a part of Program 15387 (PI: Joanna Taylor).

Figures 1-9 show the linear fit for each observed cenwave except those with only two data points (G185M/2010 and G285M/2850) as well as the residuals of the fit. The G230L (Figures 6 and 7) and G185M (Figures 1 and 2) gratings, which have a MgF₂ coating, exhibit relatively small sensitivity trends with slopes less than +/- 1 %/year. The bare-Al gratings G225M (Figures 3, 4, and 5) and G285M (Figures 8 and 9), continue to decline at a steady rate of approximately -3 and -11 %/year

respectively. These values are consistent with results from pre-launch grating efficiency tests.

Note in Figures 8 and 9 that the fits are beginning to significantly diverge from the G285M measurements. To address this problem a breakpoint needs to be added to the TDSTAB. Currently, we do not apply any breakpoints to the NUV TDS correction.

SNR accuracy requirements are 30/resel at the central wavelength for all NUV gratings except G285M. Instead, a SNR of 26 is required for G285M due to its rapidly deteriorating sensitivity. The average measured SNR values per resel at the central wavelength of each cenwave setting are shown in Table 1. These were calculated by fitting a second-order polynomial to the 1-D spectrum and dividing by the deviation of the data from the fit. While some settings fell below the required SNR requirements, the TDS characterization requirement of 2% is still met.

Table 1: Measured SNR compared to the required SNR for each grating and cenwave combination. Rows marked with an * designate cenwaves added in Cycle 24.

Grating/Cenwave	Measured SNR	Required SNR
G185M/1786	30	30
G185M/1921	30	30
G185M/2010*	29	30
G225M/2186	30	30
G225M/2306*	30	30
G225M/2410*	29	30
G285M/2617	20	26
G285M/2850*	19	26
G285M/3094	21	26
G230L/2635	48	30
G230L/2950	32	30

3. Future Work

In Cycle 25, we will continue observing the 4 cenwaves added in Cycle 24. Once a baseline is established a full analysis of a possible wavelength-dependence in the NUV TDS can be completed. Additionally, the large residuals in the G285M fits suggest that a breakpoint should be added to adequately fit data for all time. The G285M grating is, historically, the least utilized COS mode so this will be done as resources are available.

4. Supporting Figures

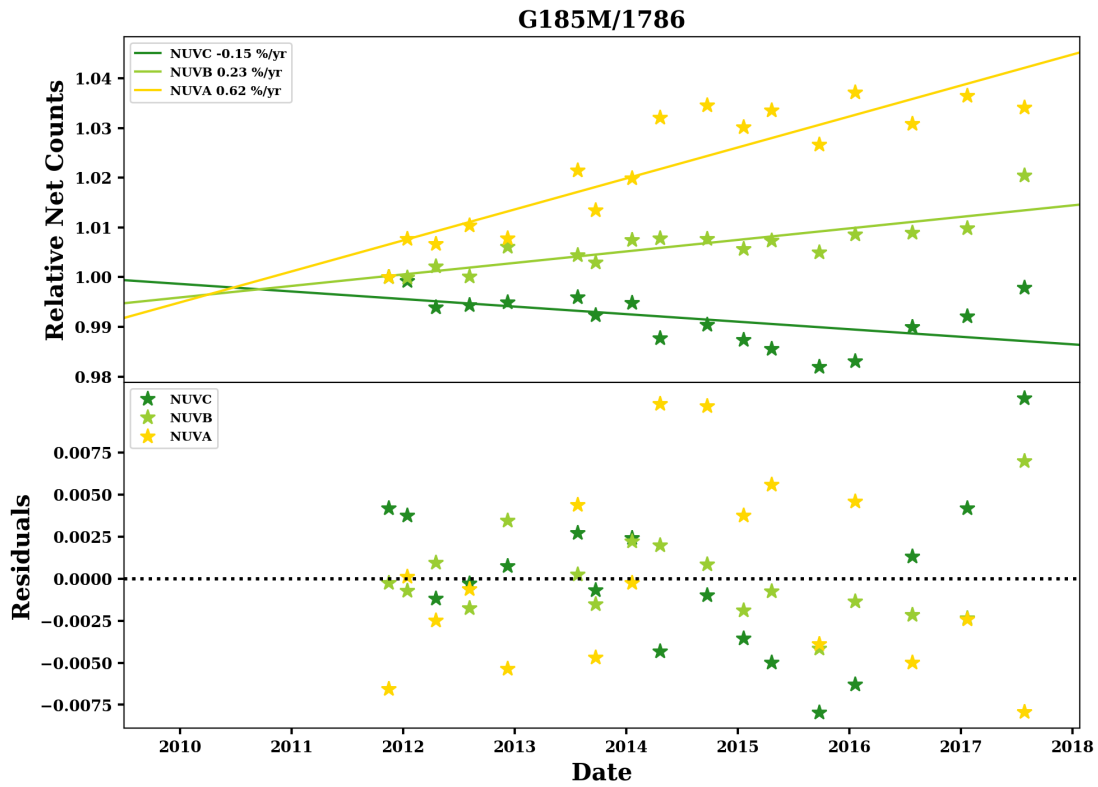


Figure 1: Relative sensitivity and residuals as function of time for G185M/1786.

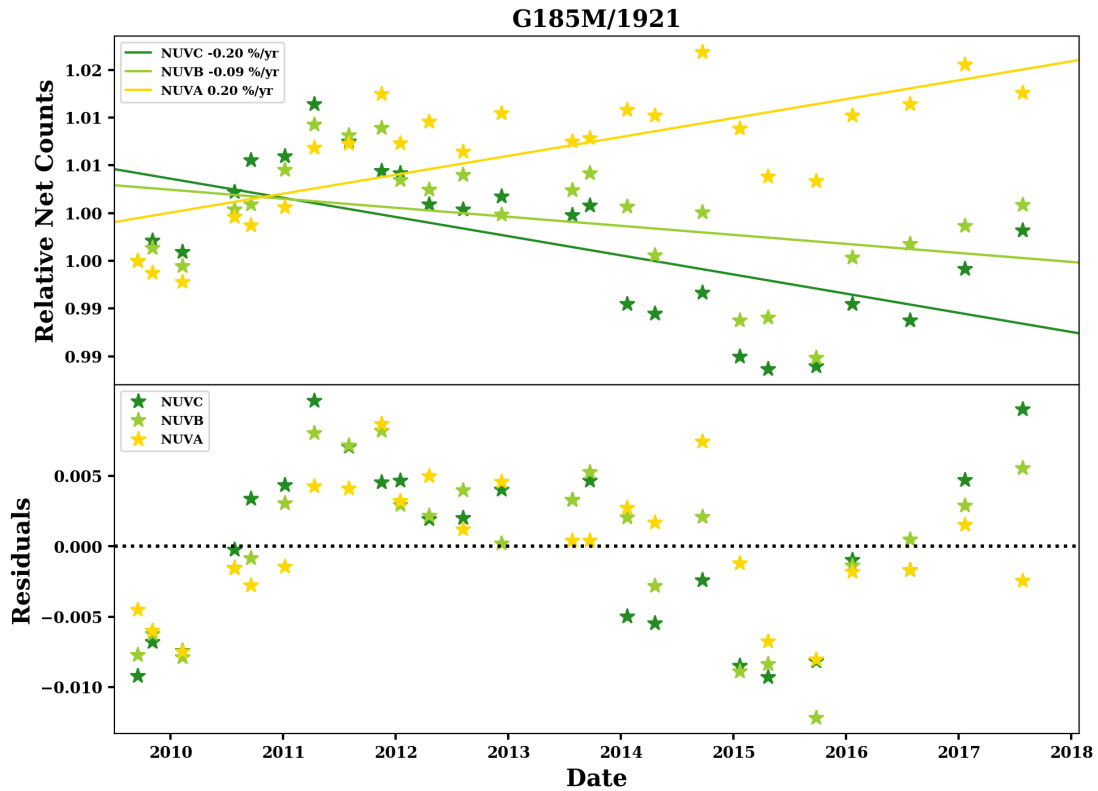


Figure 2: Relative sensitivity and residuals as function of time for G185M/1921.

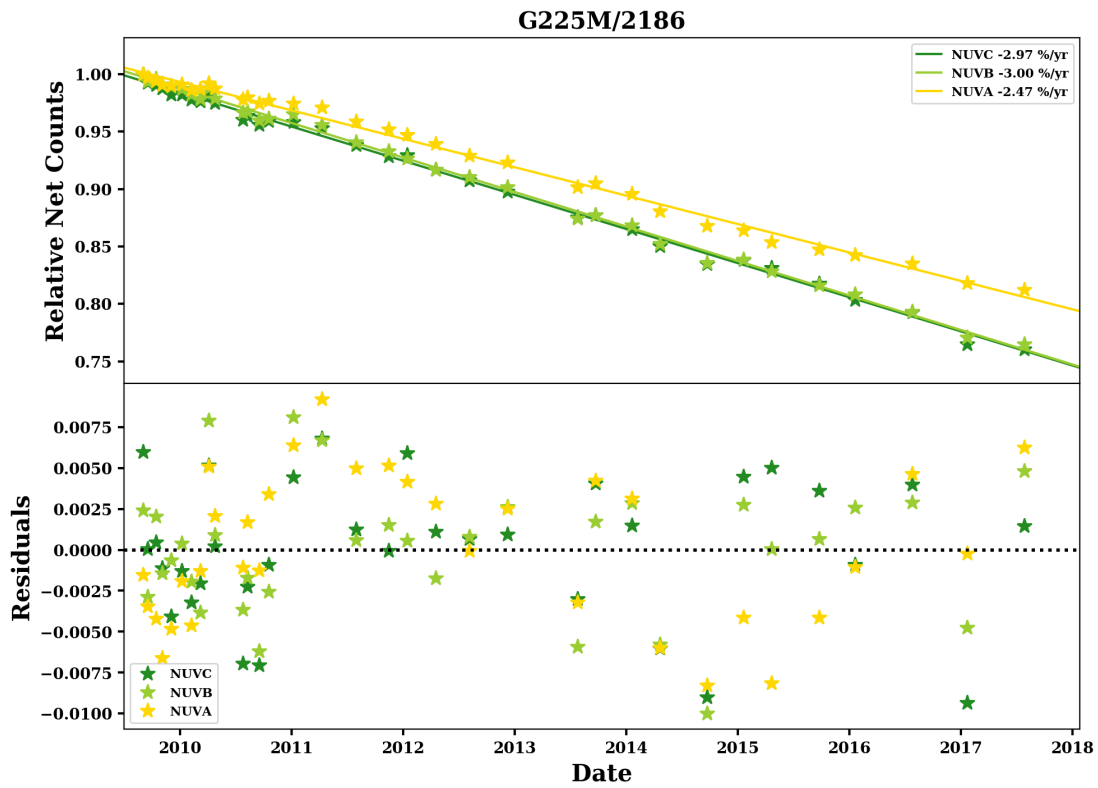


Figure 3: Relative sensitivity and residuals as function of time for G185M/2186.

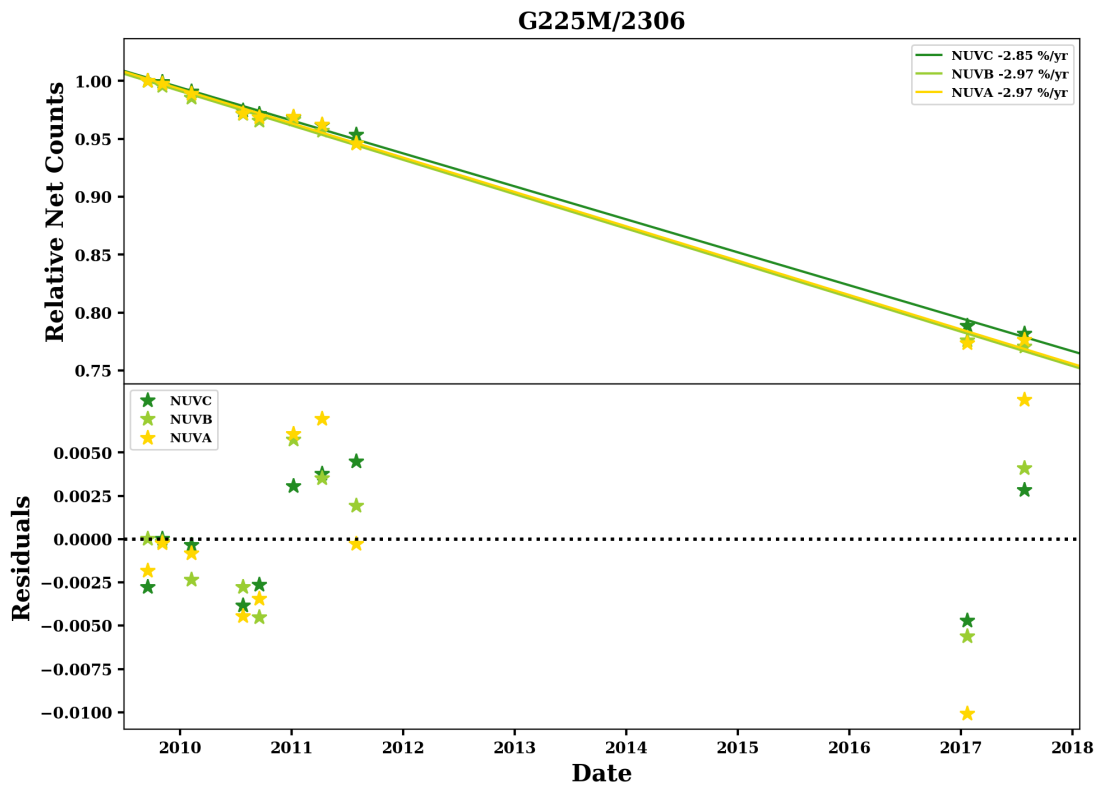


Figure 4: Relative sensitivity and residuals as function of time for G225M/2306.

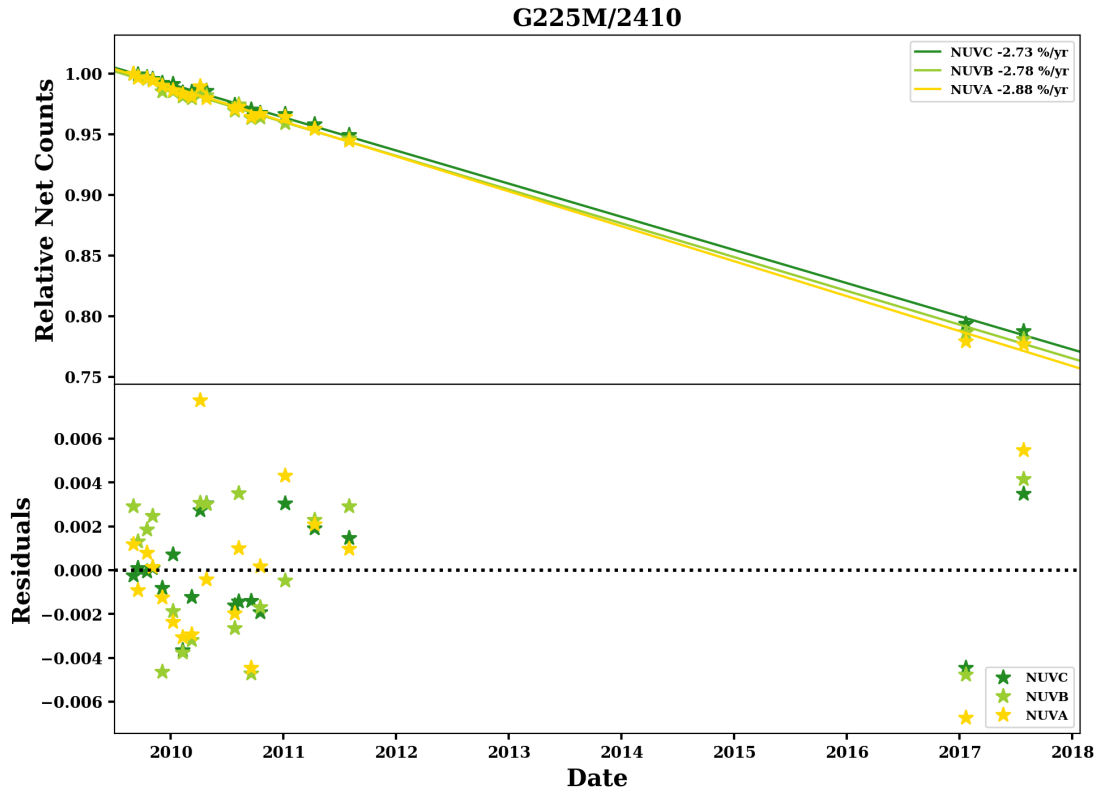


Figure 5: Relative sensitivity and residuals as function of time for G225M/2410.

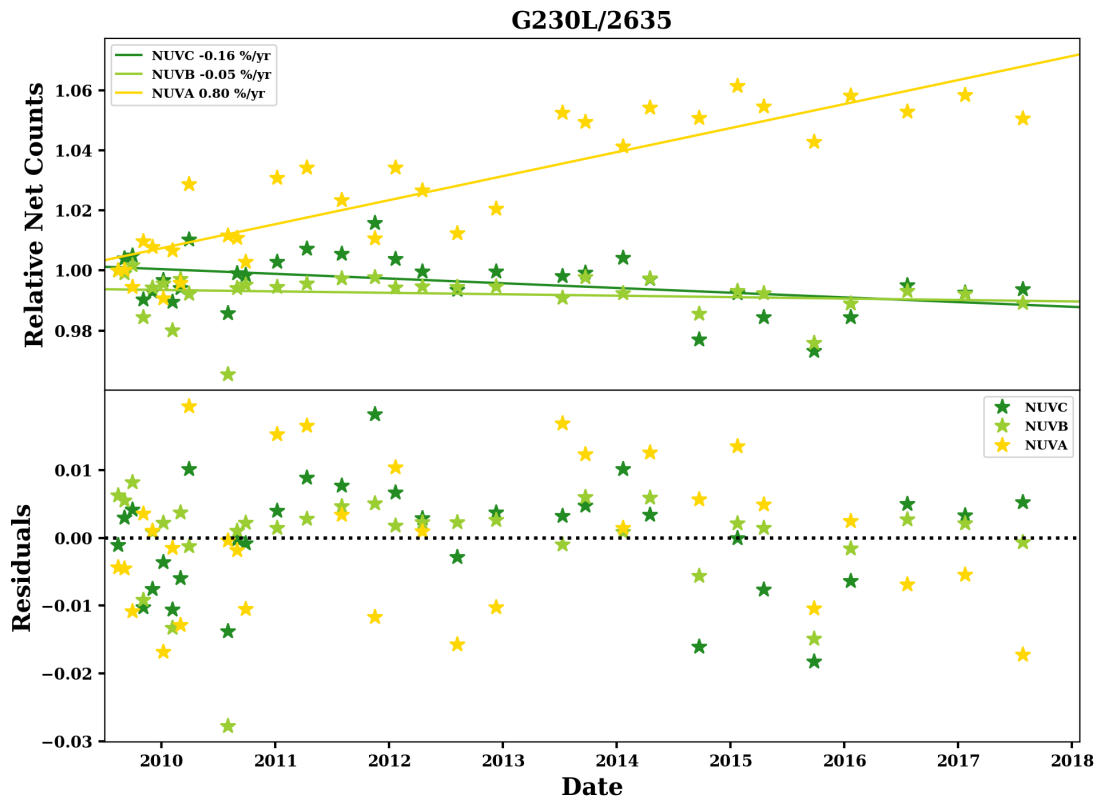


Figure 6: Relative sensitivity and residuals as function of time for G230L/2635.

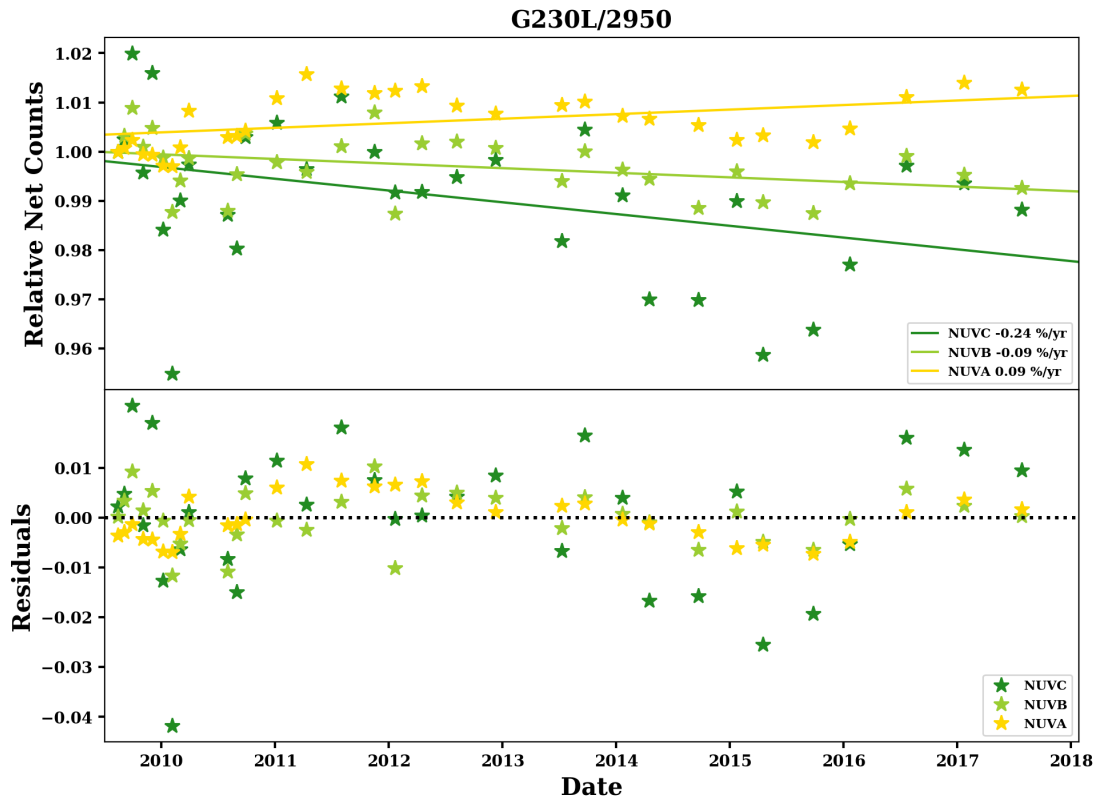


Figure 7: Relative sensitivity and residuals as function of time for G230L/2950.

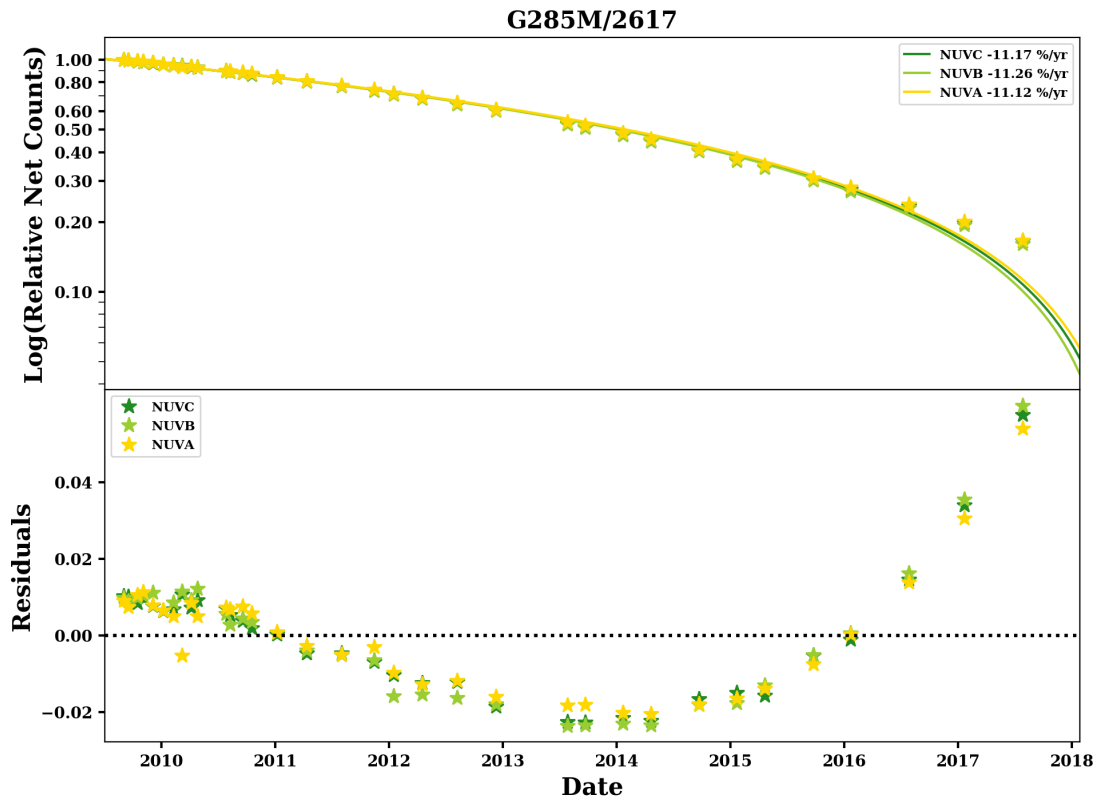


Figure 8: Relative sensitivity and residuals as function of time for G285M/2617.

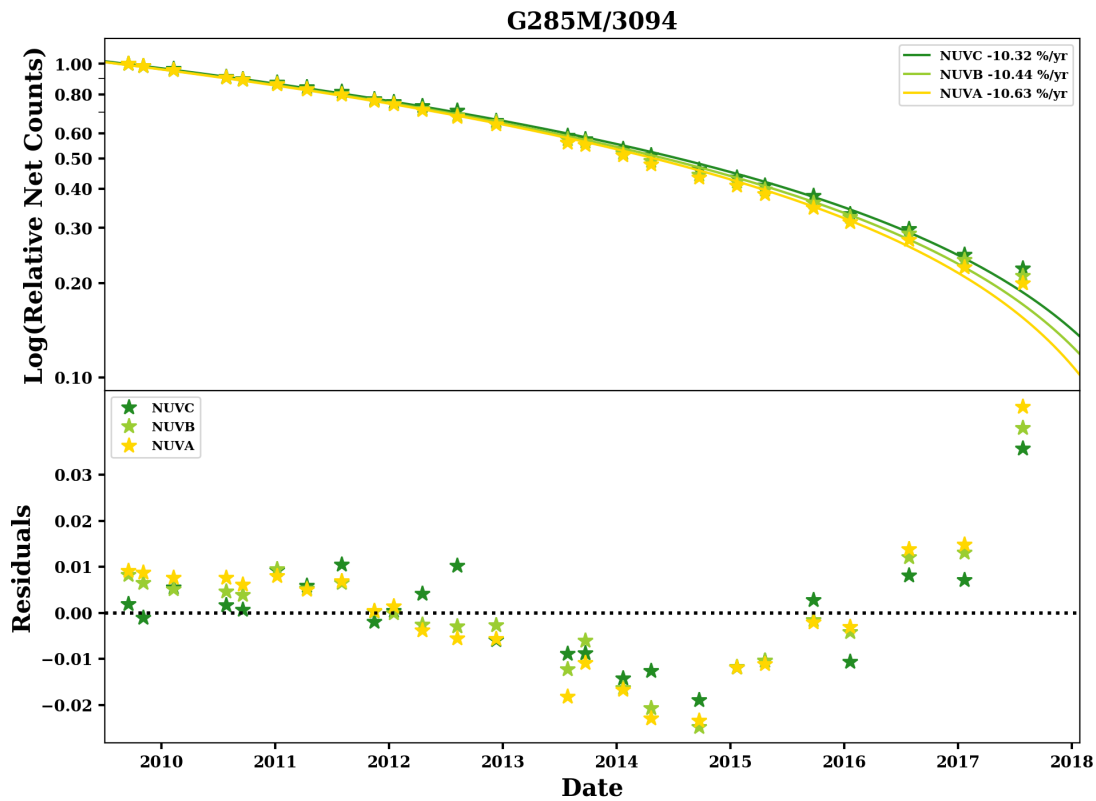


Figure 9: Relative sensitivity and residuals as function of time for G285M/3094.

References

- Fox, A. J. et al., 2017, COS Instrument Handbook, Version 9.0, Baltimore: STScI
- Osten, R.A., et al., 2011, COS Instrument Science Report 2011-02, “Updated Results from the COS Spectroscopic Sensitivity Monitoring Program”
- Osten, R. A., et al., 2010, COS Instrument Science Report 2010-15, “Early Results from the COS Spectroscopic Sensitivity Monitoring Programs”