ABSTRACT

Observations of HST spectrophotometric standard stars show that there is a significant time dependence of the COS NUV MAMA sensitivity (Debes et al. 2016). Time-dependent sensitivity (TDS) monitoring is necessary for accurate flux calibration. Regular calibration observations monitor the decline in sensitivity for all NUV gratings: G185M, G225M, G285M, and G230L. Results from the cycle 22 NUV TDS program show the reflectivity of the G225M and G285M gratings, which are coated in bare-aluminum, declines at a rate of -3 to -2.5%/year and -10.6 to -11.8%/year, respectively. The G185M and G230L gratings, which are coated in MgF$_2$ over aluminum, show a decline of -0.3 to +0.6%/year and -0.4 to +0.9%/year, respectively.

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1. Program Design

The Cosmic Origins Spectrograph (COS) NUV Time-Dependent Sensitivity (TDS) program is executed every cycle and monitors the sensitivity of each NUV grating to detect changes due to contamination or other causes. 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) and synphot files used by the ETC.

The cycle 22 NUV TDS program (13973, PI: Joanna Taylor, CoI: Dr. H. Sana) is identical in setup to its cycle 21 predecessor (13527, PI: K. Azalee Bostroem, CoI: J. Taylor). Program 13973 was allocated 6 external orbits, with two visits with one orbit each executed every four months in January, April, and September 2015. All visits executed successfully. The observed central wavelength settings (cenwaves) were G185M/1786, G185M/1921, G225M/2186, G285M/2617, G285M/3094, G230L/2635, and G230L/2950. These cenwaves constitute the reddest and bluest wavelengths containing only first order light for each grating, with the exception of G225M. 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 same analysis techniques and code used in previous cycles are used in Cycle 22. The ratio of each NUV spectrum is taken with respect to the first spectrum in time and averaged for each stripe for each date. Fitting of the data is performed using the IDL routine LINFIT, which determines a linear fit by minimizing the $\chi^2$ error statistic. This yields slopes and intercepts which can be used in TDSTABs and synphot files.

Figures 1-8 show the linear fit to the data up until the end of Cycle 22, September 2015, for one cenwave of each NUV grating, as well as the residuals for each fit. The G230L (Figure 7) and G185M (Figure 1) gratings, which have a MgF$_2$ coating, exhibit relatively small sensitivity trends with slopes between +0.9 and -0.4 \%/year. The bare-Al gratings G225M (Figure 3) and G285M (Figure 5), continue to decline at a steady rate of approximately -3.0 and -11.0 \%/year respectively. These values are consistent with results from pre-launch grating efficiency tests.

SNR accuracy requirements are 30/resel at the central wavelength for all NUV gratings except G285M, where a SNR of 26 is used. The average measured SNR value per resel at the central wavelength of each cenwave setting is show in Table 1. G185M/1921, G225M/2186, and G230L/2950 are falling slightly below the required SNR of 30. Both G285M cenwaves are falling significantly below the SNR requirement of 26. In order to boost the G285M SNR to 26 another orbit would be required for each M-grating visit. However, since G285M is only used for 4 observations (all target acquisitions) in Cycle 22, we have elected not to modify the NUV TDS program configuration for Cycle 23. While some settings are falling below the required SNR requirements, we are currently meeting the TDS characterization requirement of 2%.

No reference files with updated TDS trends were delivered for this cycle.
Table 1: Measured SNR compared to the required SNR for each grating and cenwave combination.

<table>
<thead>
<tr>
<th>Grating/Cenwave</th>
<th>Measured SNR</th>
<th>Required SNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>G185M/1786</td>
<td>31</td>
<td>30</td>
</tr>
<tr>
<td>G185M/1921</td>
<td>28</td>
<td>30</td>
</tr>
<tr>
<td>G225M/2186</td>
<td>28</td>
<td>30</td>
</tr>
<tr>
<td>G285M/2617</td>
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<td>26</td>
</tr>
<tr>
<td>G285M/3094</td>
<td>18</td>
<td>26</td>
</tr>
<tr>
<td>G230L/2635</td>
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<td>30</td>
</tr>
<tr>
<td>G230L/2950</td>
<td>29</td>
<td>30</td>
</tr>
</tbody>
</table>

3. Future Work

The Cycle 23 NUV TDS program (14441) was reduced from 6 to 4 orbits. Observations will only be taken twice a year (January and July).

Some cenwaves suggest that a piecewise linear function would provide a more robust calibration. For example, G185M/1921 G285M/2617 both show distinctive trends in their residuals (Figures 2 and 6). As resources permit, we will investigate this avenue, and will also explore if a wavelength-dependent solution would improve residuals.

4. Supporting Figures

Figure 1: Relative sensitivity as a function of time for G185M/1921
Figure 2: Residuals to the empirical fit as a function of time for G185M/1921.

Figure 3: Relative sensitivity as a function of time for G225M/2186.
Figure 4: Residuals to the empirical fit as a function of time for G225M/2186.

Figure 5: Relative sensitivity as a function of time for G285M/2617.
Figure 6: Residuals to the empirical fit as a function of time for G285M/2617.

Figure 7: Relative sensitivity as a function of time for G230L/2950.
Figure 8: Residuals to the empirical fit as a function of time for G230L/2950.

References
