Technical Evaluation Report
"The NUV Gap Coverage Analysis"

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Prepared By: ______________________________ ____________

J. Morse, COS Project Scientist, CU/CASA … Date

Reviewed By: ______________________________ ____________

E. Wilkinson, COS … CU/CASA … Date

Approved By: ______________________________ ____________

J. Andrews, COS Experiment Manager, CU/CA… … Date

Approved By: ______________________________ ____________

J. Green, COS Principal I… …ASA … Date

Web-Released Document

Center for Astrophysics & Space Astronomy
University of Colorado
Campus Box 593
Boulder, Colorado 80309

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This report documents work on the COS NUV channel as a result of discussions at the Science Team Meeting held at STScI on 21 May. Here we concentrate on optimizing the spacing of the NCM3a,b,c camera mirrors for meeting the science goals set out by the COS Science Team when using the R=20,000 NUV modes.

Determining the mirror spacing that optimizes the medium-resolution (R=20,000) modes:

The wavelength gap (DGap) between the 3 stripes on the NUV detector is set basically by the distance between the three camera mirrors (NCM3a,b,c) that image different portions of the 1st-order spectrum from each grating. At the Science Team meeting, we decided to optimize the mirror separation (i.e., DGap) for covering important ISM/nebular/cometary lines, rather than strictly for painting the full NUV wavelength range (1700-3200Å), which was seen as redundant to STIS. I received about 60 important NUV features to cover from members of the Science Team as well as some r-process and boron lines from Dave Leckrone. I then simulated the wavelength coverage obtained for a set of grating settings for various values of DGap, and checked to see how many separate exposures would be needed to observe the important features.

The wavelength coverages per stripe (DLam) for each grating are approximately G190M 28 Å, G225M 35 Å, G285M 41 Å; and we get three stripes from each grating per exposure. The gratings are tilted to different angles in order to scan all the wavelengths. The actual DLam for each grating varies somewhat, especially at the extremes of the scan range for each grating, because the dispersion is not constant over the entire wavelength region covered by each grating, and because the focal lengths are slightly different for the separate NCM3 mirrors.

The ratio (Rat) of the gap to the wavelength coverage (Rat = DGap/DLam) indicates the number of exposures needed to completely fill in all the wavelengths between the stripes. So for Rat < 1, it takes 1 exposure to fill in the gaps; for 1 < Rat < 2, it takes 2 exposures; for 2 < Rat < 3, it takes 3 exposures; etc.

The baseline design had been Rat ≈ 2.55, set mainly by Ball's preliminary analysis of how to mount the three camera mirrors to the optical bench using ACS and STIS-type mirror mounts. However, Rat ≈ 2.55 turns out to be quite inefficient, both for painting the full NUV wavelength range and for covering the NUV lines in our line list.

At the Science Team Meeting, I showed that Rat = 3.64 is probably the most efficient way to paint the full NUV wavelength range (15 total exposures for 1700-3100 Å, or 18 total exposures for 1700-3200 Å). However, aside from deciding that we would rather focus on covering NUV lines of interest, this involved moving the camera mirrors farther apart. This is mechanically difficult because one of the mirrors would have to be moved down by the FUV detector head, so that there was no clear sight-line available to the NCM3a mirror stem — i.e., this presented problems for Ball's integration and alignment methods.

We also discussed Rat = 0.91, where one grating movement would fill in the wavelength gaps (with a little overlap). But this turns out NOT to be very efficient at covering the NUV lines of interest. In addition, this involved moving the mirrors very close together, so that mounting and aligning them would be difficult. In addition, Tinsley would have to polish the mirrors in spec right up to the very edges, which drives the cost up considerably.

After trying a few other mirror separations, I honed in on a value of Rat = 1.82 as best meeting our science goals. Rat = 1.82 means that 2 grating movements will completely fill in the wavelength gaps (with some overlap between exposures), and the implied mirror separation actually beats fairly well with the wavelengths of our NUV lines of interest. This Rat means that the camera mirrors must be moved somewhat closer together than the baseline, but there is still sufficient separation to require only minor modifications to the mounts, the polishing specs on Tinsley are no more difficult, and there are clear sight-lines to the mirror stems for alignment.

With Rat = 1.82, G185M requires only 3 judiciously selected exposures to cover all 12 NUV lines of interest in our list between 1700-2000 Å. G225M covers all 23 lines in 6 exposures, and all but 3 lines in 4 exposures. G285M covers 26 lines in 6 exposures, and all but 4 lines in 4 exposures. In other words, in 11 exposures, we could cover 54 NUV lines that are on our list, which is significantly faster than taking 15 exposures to simply paint the whole wavelength region. Of course, certain projects will only want to cover certain lines. Some example exposures include:

G185M
Exposure 1: Si II 1808, Si I 1813/1814, Si III] 1892, C III] 1909, Si I 1978
Exposure 2: Si I 1841, CO_2 edge 1850, Fe I 1852, C I 1931, Co II 1941

G225M
Exposure 1: Zn II/Cr II/Co II 2026, Cr II 2056, Co II 2058, Zn I 2139, NO 2143, C II ~2225, Fe II 2249
Exposure 2: Mn II 2306, C_2 band 2313, C II] 2325, Si II] 2335, [Ne IV] 2420
Exposure 3: Fe II 2261, Fe II/Al I 2368, Fe II 2375, Fe II 2383, [O II] 2470

G285M
Exposure 1: Sc II 2563, CS band/Mn I 2576, Fe II 2587, Mn II 2595, V II 2684, Mn I 2795, Mg II 2796, Mg II 2303, OH 2820

Exposure 2: OH 2820, Os I 2833, Pb I 2839, Mg I 2853, Pt I 2930, Os I 3059, Pt I 3065, OH/OD 3080

Alternatively, if one did want to paint wavelengths to do Ly α forest lines (distributed randomly), we are actually fairly well optimized for QSOs out to z = 0.9. An exposure sequence would be:

FUV G130M, 1 Exposure: 1150-1450 Å

FUV G160M, 1 Exposure: 1405-1775 Å

NUV G185M, 3 Exposures: 1771-2010 Å

NUV G225M, 3 Exposures: 2004-2302 Å

— An additional 3 G225M exposures would reach z ~ 1.0.

— Covering the whole 1700-3200 Å region takes 18 exposures, 6 per grating.