



12567 - Bridging STIS's Neutral Density Desert

Cycle: 19, Proposal Category: GO

(Availability Mode: AVAILABLE)

INVESTIGATORS

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VISITS

<i>Visit</i>	<i>Targets used in Visit</i>	<i>Configurations used in Visit</i>	<i>Orbits Used</i>	<i>Last Orbit Planner Run</i>	<i>OP Current with Visit?</i>
01	(1) G191B2B	STIS/CCD STIS/FUV-MAMA	2	17-Jun-2011 21:21:12.0	yes
02	(1) G191B2B	STIS/CCD STIS/NUV-MAMA	2	17-Jun-2011 21:21:23.0	yes
03	(1) G191B2B	STIS/CCD STIS/NUV-MAMA	2	17-Jun-2011 21:21:33.0	yes
04	(2) HD172167	STIS/CCD STIS/FUV-MAMA	3	17-Jun-2011 21:21:43.0	yes

9 Total Orbits Used

ABSTRACT

This is a calibration proposal focused on a set of unsupported ND-filtered long slits (31X0.05NDA,B,C) that can be used with the STIS echelles, and which provide attenuations intermediate between the standard spectroscopic slits (0.2X0.06, 0.2X0.09, or 0.1X0.03) and the (only two) supported ND

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slits: 0.2X0.05ND (ND=2) and 0.3X0.05ND (ND=3). These intermediate NDs (0.6-1.4) potentially are valuable for bright continuum sources, mainly hot stars, for which currently the supported ND slits must be used to mitigate MAMA global count rate violations. Because there is such a large jump from the normal clear spectroscopic slits (ND~0) to the next supported ND step (ND=2), there are many cases where an observation just barely exceeds the global rate with a clear aperture, and therefore must shift to the ND=2 slit, but now requires something like 100 times the exposure duration to achieve a target S/N. Adding the currently unsupported slits to STIS's toolkit will pave the way for more efficient future projects involving echelle spectroscopy, especially for the top tier of bright hot stars not yet observed by this powerful instrument.

To qualify the 31X0.05ND slit set, HST standard G191B2B (DA) will be measured to determine wavelength dependent throughputs across the FUV+NUV range, and across the full field of each MAMA camera. Pole-on rapid rotator Vega (A0V) -- well-known visible photometric standard, and which has a bright, rich, and complex FUV spectrum -- will provide a test for any lineshape degradation by the long slits in the high-res echelle configuration. The high-S/N Vega FUV echelle spectra will have unique scientific value as well.

OBSERVING DESCRIPTION

Specific objectives of the Cycle 19 calibration project:

- (1) Establish the photometric throughput of the three ND-filtered long slits.
- (2) Measure any spectral degradation that might occur using the long slits, relative to the default short echelle spectroscopic apertures (0.2" high).

PHOTOMETRIC THROUGHPUT. The wavelength-dependent attenuation of the long slits is an important factor for estimating appropriate exposure times in a Phase I development effort, as well as post facto for correcting the extracted echelle x1d spectra so that at least the slope of the spectral energy distribution is correct, if not also the absolute level. (The absolute accuracy depends to a large extent on how well centered the target was, particularly for very narrow slits.) The attenuation function can be derived by comparing a sequence of observations of a standard star through the clear 0.2×0.2 photometric aperture and the test ND slits, say using the three medium resolution echelle settings to cover the full FUV+NUV spectral range (and sample the full area of each camera). An optimum target is the DA white dwarf G191B2B, a prime HST calibration star, which has been observed, at one time or another, by literally every one of the 44 supported echelle settings of STIS. Although G191B2B is only 12th-magnitude in the visible, it has a bright, nearly pure continuum distribution in the ultraviolet, with flux densities of $1\text{E-}11$ erg/cm²/s/Å at 1200 Å, smoothly declining to $1\text{E-}12$ at 2800 Å. The negative spectral gradient is closely compensated by the rise in STIS's efficiency toward longer wavelengths, so

that CR levels are nearly uniform over wavelength, a desirable property for a calibration target.

The G191B2B observing strategy utilizes three separate visits of 2 orbits each (to ease scheduling). In each visit, one of the medium-res echelles, for example E140M-1425 in Visit 1, is used to obtain exposures in the three long ND slits and in the 0.2×0.2 clear aperture. The visit begins with an imaging target acquisition using the CCD (F28X50LP aperture), followed by an initial 150 s exposure with E140M through the 0.2X0.2 slot. Next is a peak-up in the 31X0.05NDC slit (with MIRROR), and a 1.7 ks exposure of E140M through the same slit. The second orbit begins with an additional 0.4 ks of exposure in the same configuration, followed by a peak-up in the NDB slit and a 860 s E140M with that slit; then finally a peak-up with NDA, followed by a 350 s E140M exposure to fill out the orbit. The multiple peak-ups are vital to ensure the best possible target centering for each aperture individually, especially the unsupported ND's whose offsets relative to supported apertures might be less well determined.

The other two visits utilize the NUV prime settings of E230M (1978 and 2707), with similar exposure times. These were set to yield roughly similar total counts for each of the three ND long-slit exposures, and about twice the counts in the reference 0.2×0.2 observation. Although the maximum S/N will be relatively modest (22 per resol for the clear slot), the calibration factor ratios can be established very accurately (<1%) by averaging over each echelle order (several hundred resols). The smooth energy distribution of the WD is an advantage in that regard.

SPECTRAL DEGRADATION. The main concern with using long slits for STIS echelle spectroscopy is that the spectral orders typically are less than an arcsecond apart, so bleeding of the extended spatial point spread function (psf) wings in the cross-dispersion direction can serve as a source of scattered light, above and beyond the normal echelle scatter for point sources truncated by the default short (0.2" tall) slits. The added cross-dispersion scatter could reduce spectral contrast. The extent to which this might be a problem for the ND-filtered long slits is unknown, in the absence of concrete test data. In principle, the issue might not be too severe for continuum spectra, because, as mentioned earlier, obeying the global constraint tends to hold down the peak CRs in the orders, which in turn suppresses the influence of the far wings of the psf. There is some support for this conjecture from the Mendel et al. (2006) study. However, a more carefully controlled experiment is needed to properly evaluate the potential degradation.

Candidate targets for this test should meet two basic criteria: (1) a rich, spectrally complex energy distribution that nevertheless is well characterized; and (2) high enough flux densities to allow the experiment to be carried out in a few orbits or less. A secondary consideration was to choose an object for which the calibration spectra might be scientifically entertaining as well. After significant deliberation, we settled on Vega, a nearby bright sharp-lined, heavily line-blanketed A0 star that has served ably for many decades as a ground-based photometric standard, although recently — and somewhat ironically — it has been recognized to be a very rapid rotator ($v_{\text{rot}} \sim 211$ km/s) seen at high inclination ($i \sim 6$ deg), leading to a nonuniform

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surface temperature distribution across the visible pole-on hemisphere (Hill, Gulliver, & Adelman 2010). Vega has been observed extensively by IUE and HST–GHRS, but not so far with STIS, at least in the UV echelle modes. A detailed abundance study of Vega was published recently by Fitzpatrick (2010), and the star has been subjected to numerous modeling efforts over the years, including ever finer synthesis of the line spectrum (ibid; Yoon et al. 2010). All these reasons make Vega a good spectral calibration reference. Incidentally, Vega has a dust ring at ~ 100 au (Marsh et al. 2006); recently a weak, dominantly polar magnetic field was detected (Petit et al. 2010); and possibly even coronal X-rays (Ayres 2008). These phenomena perhaps make Vega a more intriguing object scientifically, but they do not affect its suitability as a calibration target.

Our objective here is to answer the question, “Do the ND long slits compromise in any way the quality of spectra extracted from the echellegrams?” Thus, the basic comparison should be between a spectrum taken with the ND long slits and a reference taken with a short spectroscopic aperture. Probably any of the ND long slits would be suitable for the purpose, although we selected specifically NDC because it has not yet been used in any stellar observations. (As noted earlier, NDA and NDB have been used previously, 18 and 2 times respectively, in GO programs, but the existing data were not taken under as controlled conditions as we propose here, and thus are not as suitable for the calibration analysis.) The observations also should be collected in a high-resolution echelle setting so that the long and short slit spectra can be compared as free of resolution effects as possible. We chose E140H-1271 for the test, because with NDC the global CR for Vega, based on ETC simulations with a carefully calibrated Kurucz model, is close to — but safely below — the threshold; while for the short ND slit, $0.2 \times 0.05\text{ND}$, the count rates are high enough to achieve good S/N in relatively short exposures.

The target is acquired with the CCD and F25ND5, then a dispersed light pickup is done with the CCD and G230LB-2375 in the $0.2 \times 0.05\text{ND}$ aperture, which is followed by a context exposure with the medium resolution echelle, E140M-1425, of 1.8 ks to fill out the first orbit. The context exposure provides an important resolution test to compare against the long and short slit observations with E140H, on an object with complex absorption profiles (rapid rotator at high inclination): if the important spectral information can be extracted from the E140M exposure for a star like Vega with $v \sin i = 21$ km/s, then it might not be necessary to use the full suite of three E140H settings for other similar objects. This test is relevant mainly as a feasibility study in advance of a possible future ASTRAL-like hot-star proposal, but also will produce a high-quality (S/N ~ 140 at 1450 Å) 1150–1700 Å spectrum of this important object, which will greatly eclipse the existing IUE and GHRS spectra in resolution and S/N.

The second orbit begins with another dispersed light peak-up with the $0.2 \times 0.05\text{ND}$ aperture, followed by a pair of 1 ks exposures with E140H-1271. The third orbit begins with an additional 1 ks of exposure in E140H-1271 with the ND short slit, making 3 ks altogether; followed by a dispersed light peak-up, now with the NDC long slit; and finally a pair of 425 s exposures through that slit with E140H-1271. This results, effectively, in about 60% more exposure depth in NDC versus ND. The fact that we omit a $0.2 \times 0.05\text{ND}$ peak-up at the beginning of orbit 3 should not have a big impact

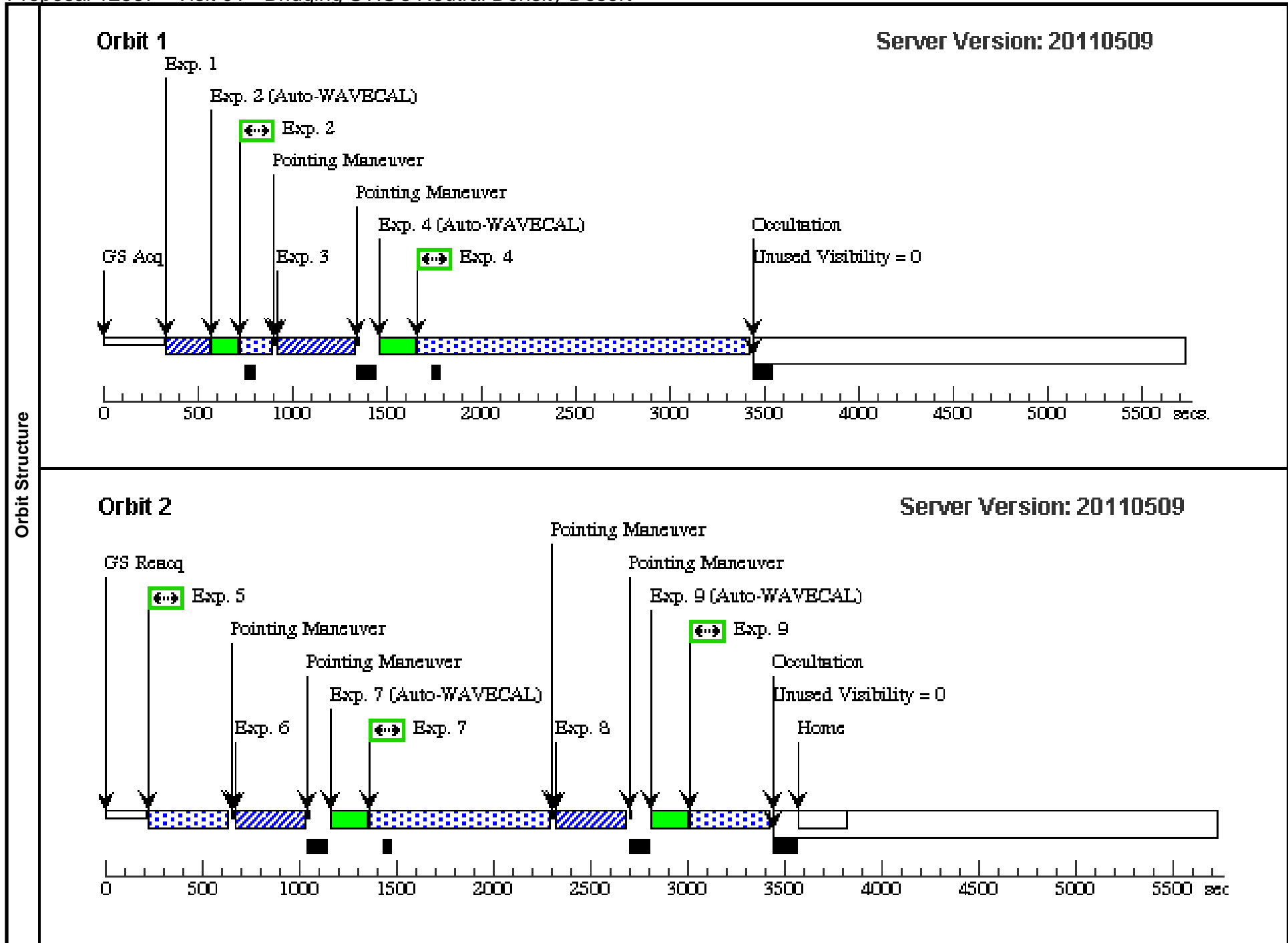
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on the third ND segment, as long as there is good lock on the guide stars: we are concerned most with the spectral content of the exposure rather than its absolute level (which could be lower than the preceding pair, if the target image had drifted partly out of the narrow slit, although this would be unlikely). We would use, in any case, the first E140H ND exposure, immediately following the peak-up, to set the absolute flux level, and scale the subsequent two ND segments to it. The E140H-1271 spectra would provide high S/N (~ 120 at 1350 Å), and super-high resolution, over the range 1170–1370 Å, which contains an important selection of interstellar absorptions, including Si III, H I, D I, O I and C II, as well as numerous strong stellar features. The various E140H exposures are divided into multiple segments to mitigate possible thermal drifts, and suppress fixed pattern noise, as has been found to be good practice with previous STIS programs (e.g., ASTRAL).

Proposal 12567 - Visit 01 - Bridging STIS's Neutral Density Desert

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Visit	Proposal 12567, Visit 01, implementation Diagnostic Status: No Diagnostics Scientific Instruments: STIS/CCD, STIS/FUV-MAMA Special Requirements: SCHED 30%										
	Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	G191B2B Alt Name1: WD0501+527	RA: 05 05 30.6139 (76.3775579d) Dec: +52 49 51.84 (52.83107d) Equinox: J2000	Proper Motion RA: +0.00745 arcsec/yr Proper Motion Dec: -0.08954 arcsec/yr Parallax: 0.01670" Epoch of Position: 2010	V=+11.781+/-0.0	Reference Frame: ICRS					
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit	
	1	(STIS.ta.179 639)	(1) G191B2B	STIS/CCD, ACQ, F28X50LP	MIRROR				0.1 Secs [==>]	[1]	
	<i>Comments: STIS.ta.179639: S/N=40 in 0.026s; time to sat= 4.5s</i>										
	2	(STIS.sp.17 9730)	(1) G191B2B	STIS/FUV-MAMA, ACCUM, 0.2X0.2	E140M 1425 A				150 Secs [==>]	[1]	
	<i>Comments: STIS.sp.179730; max S/N~18 in 100s w/ 0.2X0.2 ap; StarCAT WD0501+527 spectrum</i>										
	3	(STIS.ta.179 671)	(1) G191B2B	STIS/CCD, ACQ/PEAK, 31X0.05NDC	MIRROR				0.5 Secs [==>]	[1]	
	<i>Comments: STIS.ta.179671: S/N=40 in 2.8s; time to sat= 127s (for 0.2X0.05ND); multiplied by 0.18 for NDC</i>										
	4	(STIS.sp.17 9730)	(1) G191B2B	STIS/FUV-MAMA, ACCUM, 31X0.05NDC	E140M 1425 A				1695 Secs [==>]	[1]	
	<i>Comments: STIS.sp.179730; max S/N~18 in 100s w/ 0.2X0.2 ap; StarCAT WD0501+527 spectrum; scaled to NDC (fac=0.043), max S/N~17 (for tot exp 2.1 ks)</i>										
	5	(STIS.sp.17 9730)	(1) G191B2B	STIS/FUV-MAMA, ACCUM, 31X0.05NDC	E140M 1425 A				399 Secs [==>]	[2]	
<i>Comments: STIS.sp.179730; max S/N~18 in 100s w/ 0.2X0.2 ap; StarCAT WD0501+527 spectrum; scaled to NDC (fac=0.043), max S/N~17 (for tot exp 2.1 ks)</i>											
6	(STIS.ta.179 671)	(1) G191B2B	STIS/CCD, ACQ/PEAK, 31X0.05NDB	MIRROR				0.20 Secs [==>]	[2]		
<i>Comments: STIS.ta.179671: S/N=40 in 2.8s; time to sat= 127s (for 0.2X0.05ND2); multiplied by 0.073 for NDB</i>											
7	(STIS.sp.17 9730)	(1) G191B2B	STIS/FUV-MAMA, ACCUM, 31X0.05NDB	E140M 1425 A				860 Secs [==>]	[2]		
<i>Comments: STIS.sp.179730; max S/N~18 in 100s w/ 0.2X0.2 ap; StarCAT WD0501+527 spectrum; scaled to NDB (fac=0.105), max S/N~17</i>											
8	(STIS.ta.179 671)	(1) G191B2B	STIS/CCD, ACQ/PEAK, 31X0.05NDA	MIRROR				0.1 Secs [==>]	[2]		
<i>Comments: STIS.ta.179671: S/N=40 in 2.8s; time to sat= 127s (for 0.2X0.05ND2); multiplied by 0.029 for NDA</i>											
9	(STIS.sp.17 9730)	(1) G191B2B	STIS/FUV-MAMA, ACCUM, 31X0.05NDA	E140M 1425 A				350 Secs [==>]	[2]		
<i>Comments: STIS.sp.179730; max S/N~18 in 100s w/ 0.2X0.2 ap; StarCAT WD0501+527 spectrum; scaled to NDA (fac=0.26), max S/N~17</i>											



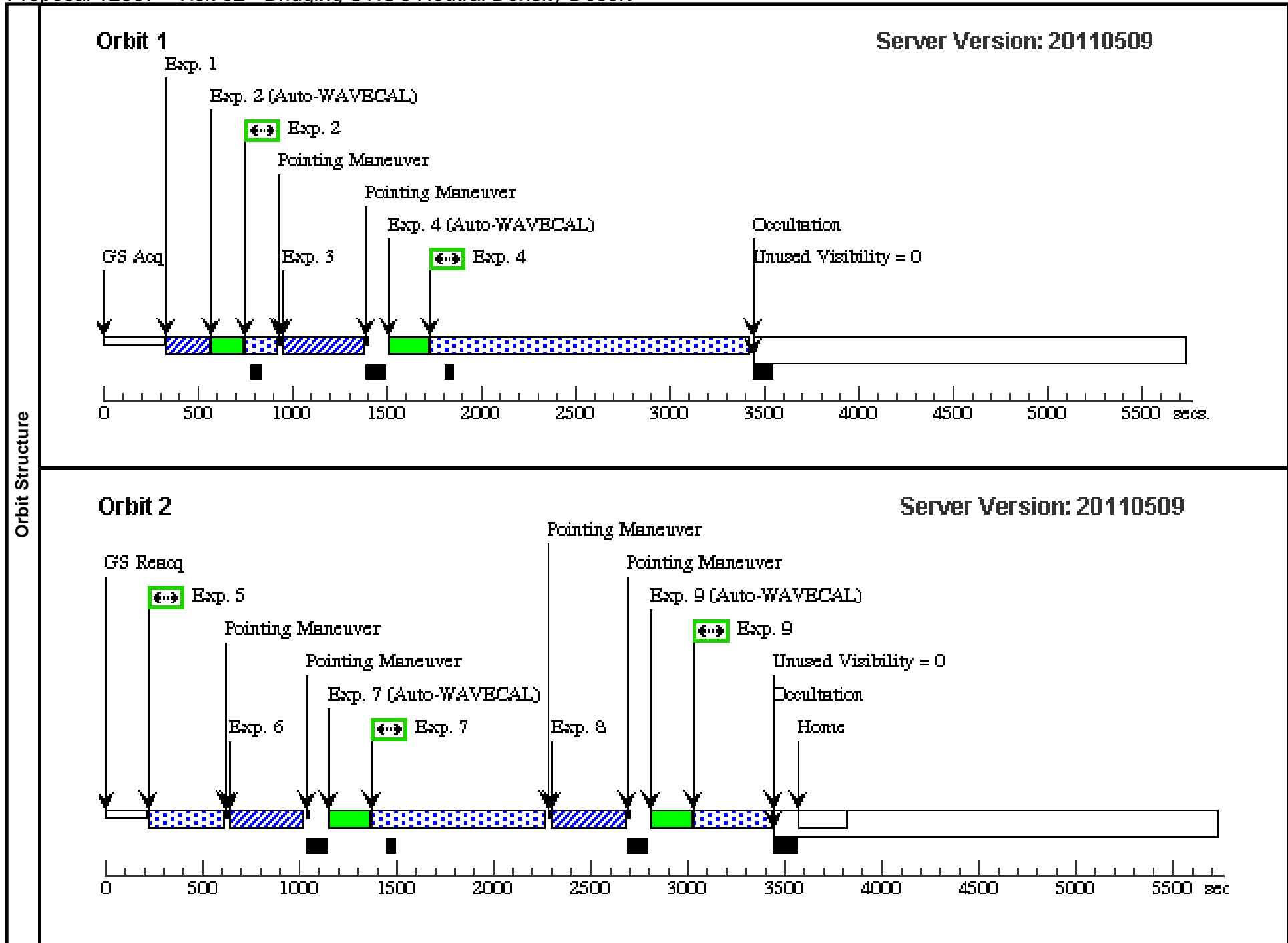
Proposal 12567 - Visit 02 - Bridging STIS's Neutral Density Desert

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Visit	Proposal 12567, Visit 02, implementation				
	Diagnostic Status: No Diagnostics				
	Scientific Instruments: STIS/CCD, STIS/NUV-MAMA				
	Special Requirements: SCHED 30%				

Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
	(1)	G191B2B Alt Name1: WD0501+527	RA: 05 05 30.6139 (76.3775579d) Dec: +52 49 51.84 (52.83107d) Equinox: J2000	Proper Motion RA: +0.00745 arcsec/yr Proper Motion Dec: -0.08954 arcsec/yr Parallax: 0.01670" Epoch of Position: 2010	V=+11.781+/-0.0	Reference Frame: ICRS

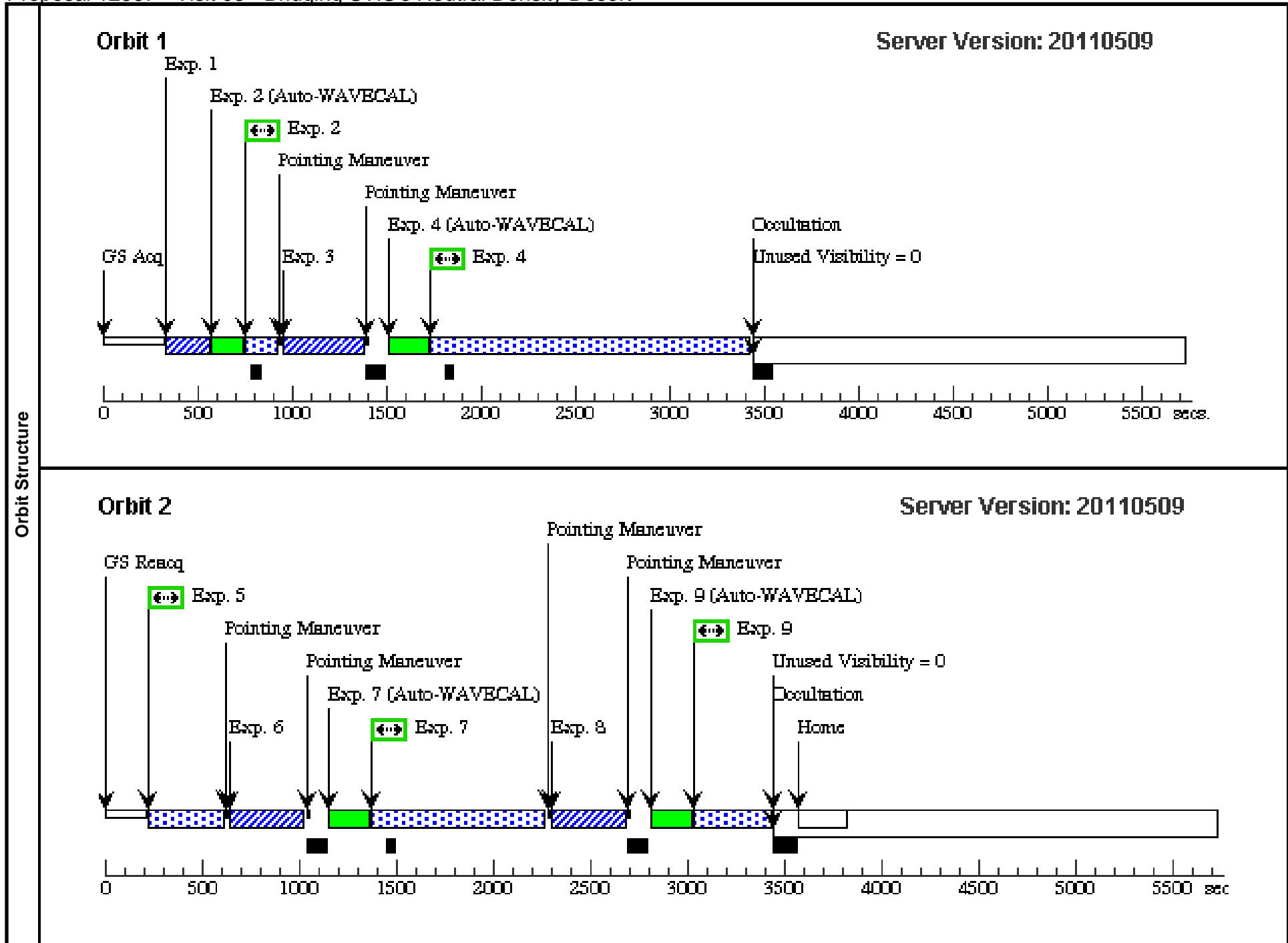
Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
	1	(STIS.ta.179 639)	(1) G191B2B	STIS/CCD, ACQ, F28X50LP	MIRROR					0.1 Secs [==>]
<i>Comments: STIS.ta.179639: S/N=40 in 0.026s; time to sat= 4.5s</i>										
2	(STIS.sp.17 9732)	(1) G191B2B	STIS/NUV-MAMA, ACCUM, 0.2X0.2	E230M 1978 A					150 Secs [==>]	[1]
<i>Comments: STIS.sp.179732; max S/N~18 in 100s w/ 0.2X0.2 ap; StarCAT WD0501+527 spectrum</i>										
3	(STIS.ta.179 671)	(1) G191B2B	STIS/CCD, ACQ/PEAK, 31X0.05NDC	MIRROR					0.5 Secs [==>]	[1]
<i>Comments: STIS.ta.179671: S/N=40 in 2.8s; time to sat= 127s (for 0.2X0.05ND); multiplied by 0.18 for NDC</i>										
4	(STIS.sp.17 9732)	(1) G191B2B	STIS/NUV-MAMA, ACCUM, 31X0.05NDC	E230M 1978 A					1625 Secs [==>]	[1]
<i>Comments: STIS.sp.179732; max S/N~18 in 100s w/ 0.2X0.2 ap; StarCAT WD0501+527 spectrum; scaled to NDC (fac=0.043), max S/N~17 (for tot exp 2.0 ks)</i>										
5	(STIS.sp.17 9732)	(1) G191B2B	STIS/NUV-MAMA, ACCUM, 31X0.05NDC	E230M 1978 A					374 Secs [==>]	[2]
<i>Comments: STIS.sp.179732; max S/N~18 in 100s w/ 0.2X0.2 ap; StarCAT WD0501+527 spectrum; scaled to NDC (fac=0.043), max S/N~17 (for tot exp 2.0 ks)</i>										
6	(STIS.ta.179 671)	(1) G191B2B	STIS/CCD, ACQ/PEAK, 31X0.05NDB	MIRROR					0.20 Secs [==>]	[2]
<i>Comments: STIS.ta.179671: S/N=40 in 2.8s; time to sat= 127s (for 0.2X0.05ND2); multiplied by 0.073 for NDB</i>										
7	(STIS.sp.17 9732)	(1) G191B2B	STIS/NUV-MAMA, ACCUM, 31X0.05NDB	E230M 1978 A					820 Secs [==>]	[2]
<i>Comments: STIS.sp.179732; max S/N~18 in 100s w/ 0.2X0.2 ap; StarCAT WD0501+527 spectrum; scaled to NDB (fac=0.105), max S/N~17</i>										
8	(STIS.ta.179 671)	(1) G191B2B	STIS/CCD, ACQ/PEAK, 31X0.05NDA	MIRROR					0.1 Secs [==>]	[2]
<i>Comments: STIS.ta.179671: S/N=40 in 2.8s; time to sat= 127s (for 0.2X0.05ND2); multiplied by 0.029 for NDA</i>										
9	(STIS.sp.17 9732)	(1) G191B2B	STIS/NUV-MAMA, ACCUM, 31X0.05NDA	E230M 1978 A					335 Secs [==>]	[2]
<i>Comments: STIS.sp.179732; max S/N~18 in 100s w/ 0.2X0.2 ap; StarCAT WD0501+527 spectrum; scaled to NDA (fac=0.26), max S/N~17</i>										



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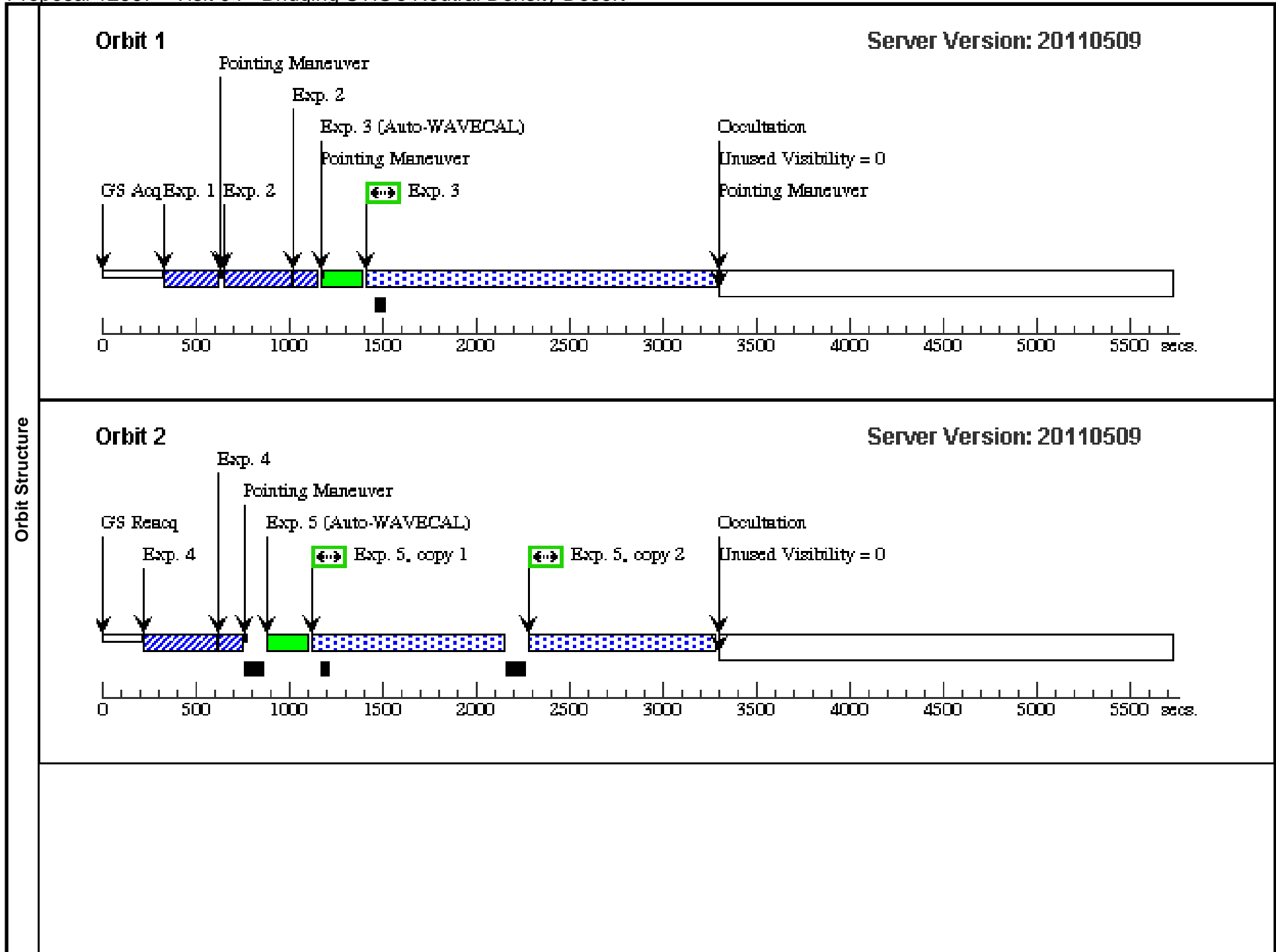
Visit	Proposal 12567, Visit 03, implementation Diagnostic Status: No Diagnostics Scientific Instruments: STIS/CCD, STIS/NUV-MAMA Special Requirements: SCHED 30%										
	Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	G191B2B Alt Name1: WD0501+527	RA: 05 05 30.6139 (76.3775579d) Dec: +52 49 51.84 (52.83107d) Equinox: J2000	Proper Motion RA: +0.00745 arcsec/yr Proper Motion Dec: -0.08954 arcsec/yr Parallax: 0.01670" Epoch of Position: 2010	V=+11.781+/-0.0	Reference Frame: ICRS					
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit	
	1	(STIS.ta.179 639)	(1) G191B2B	STIS/CCD, ACQ, F28X50LP	MIRROR				0.1 Secs [==>]	[1]	
	<i>Comments: STIS.ta.179639: S/N=40 in 0.026s; time to sat= 4.5s</i>										
	2	(STIS.sp.17 9733)	(1) G191B2B	STIS/NUV-MAMA, ACCUM, 0.2X0.2	E230M 2707 A				150 Secs [==>]	[1]	
	<i>Comments: STIS.sp.179733; max S/N~18 in 100s w/ 0.2X0.2 ap; StarCAT WD0501+527 spectrum</i>										
	3	(STIS.ta.179 671)	(1) G191B2B	STIS/CCD, ACQ/PEAK, 31X0.05NDC	MIRROR				0.5 Secs [==>]	[1]	
	<i>Comments: STIS.ta.179671: S/N=40 in 2.8s; time to sat= 127s (for 0.2X0.05ND); multiplied by 0.18 for NDC</i>										
	4	(STIS.sp.17 9733)	(1) G191B2B	STIS/NUV-MAMA, ACCUM, 31X0.05NDC	E230M 2707 A				1625 Secs [==>]	[1]	
	<i>Comments: STIS.sp.179733; max S/N~18 in 100s w/ 0.2X0.2 ap; StarCAT WD0501+527 spectrum; scaled to NDC (fac=0.043), max S/N~17 (for tot exp 2.0 ks)</i>										
	5	(STIS.sp.17 9733)	(1) G191B2B	STIS/NUV-MAMA, ACCUM, 31X0.05NDC	E230M 2707 A				374 Secs [==>]	[2]	
<i>Comments: STIS.sp.179733; max S/N~18 in 100s w/ 0.2X0.2 ap; StarCAT WD0501+527 spectrum; scaled to NDC (fac=0.043), max S/N~17 (for tot exp 2.0 ks)</i>											
6	(STIS.ta.179 671)	(1) G191B2B	STIS/CCD, ACQ/PEAK, 31X0.05NDB	MIRROR				0.20 Secs [==>]	[2]		
<i>Comments: STIS.ta.179671: S/N=40 in 2.8s; time to sat= 127s (for 0.2X0.05ND2); multiplied by 0.073 for NDB</i>											
7	(STIS.sp.17 9733)	(1) G191B2B	STIS/NUV-MAMA, ACCUM, 31X0.05NDB	E230M 2707 A				820 Secs [==>]	[2]		
<i>Comments: STIS.sp.179733; max S/N~18 in 100s w/ 0.2X0.2 ap; StarCAT WD0501+527 spectrum; scaled to NDB (fac=0.105), max S/N~17</i>											
8	(STIS.ta.179 671)	(1) G191B2B	STIS/CCD, ACQ/PEAK, 31X0.05NDA	MIRROR				0.1 Secs [==>]	[2]		
<i>Comments: STIS.ta.179671: S/N=40 in 2.8s; time to sat= 127s (for 0.2X0.05ND2); multiplied by 0.029 for NDA</i>											
9	(STIS.sp.17 9733)	(1) G191B2B	STIS/NUV-MAMA, ACCUM, 31X0.05NDA	E230M 2707 A				335 Secs [==>]	[2]		
<i>Comments: STIS.sp.179733; max S/N~18 in 100s w/ 0.2X0.2 ap; StarCAT WD0501+527 spectrum; scaled to NDA (fac=0.26), max S/N~17</i>											



Proposal 12567 - Visit 04 - Bridging STIS's Neutral Density Desert

Sat Jun 18 01:21:50 GMT 2011

Visit	Proposal 12567, Visit 04, implementation Diagnostic Status: No Diagnostics Scientific Instruments: STIS/CCD, STIS/FUV-MAMA Special Requirements: SCHED 30% <i>Comments: Because this calibration program will have an impact on Cycle 20 proposal planning, it would be most helpful if at least Visit # 4 were scheduled as early in Cycle 19 as practical; Visits 1-3 are less critical for Cycle 20 planning, and could be scheduled later in Cycle 19.</i>																																																																																																																																																																										
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Orbit 3

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