13354 - COS Spectroscopy of White Dwarf Companions to Blue Stragglers in NGC 188

Cycle: 21, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

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VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) NGC188-005011+851438	COS/FUV COS/NUV	6	11-Jul-2013 17:06:39.0	yes
02	(2) NGC188-004518+851920	COS/FUV COS/NUV	6	11-Jul-2013 17:06:56.0	yes

12 Total Orbits Used

ABSTRACT

Mass transfer in binary stars yields SNe Ia events, X-ray binaries, CVs, and a host of stellar exotica that in fact are frequent and crucial for understanding the Universe. Mass transfer is a critical astrophysical process.

Key uncertainties remain in mass transfer theory: criteria for stable transfer, when transfer is conservative, impact of orbital eccentricity. Empirically determined conditions both before and after mass transfer will advance answers to these issues. Yet there are very few systems with detailed knowledge of the progenitor binaries.

We propose COS Lyman-alpha spectra of two mass transfer systems, both well-studied blue straggler binaries in the 7-Gyr cluster NGC 188, so as to obtain direct mass measurements of their white dwarf companions.

Our recent ACS/SBC photometry discovered these white dwarf companions to have temperatures greater than 15,000K, implying WD ages less than 140 Myr. Mass transfer has only very recently ended. As evolved stars at 7 Gyr, the progenitor donor stars had initial masses of 1.1 solar masses.

The white dwarfs are the cores of these progenitor donor stars at 7 Gyr. Measurements of their masses can for the first time point to the location of each progenitor donor star on its stellar evolution path at the end of mass transfer, and thereby along a timeline during the mass transfer.

White dwarf masses from COS spectra and rich existing data will provide a remarkably detailed description of these blue straggler binaries before and after mass transfer. We will use them for in-depth tests of mass transfer models, broadly to advance mass transfer physics and specifically to shed light on blue straggler formation.

OBSERVING DESCRIPTION

We propose FUV COS spectroscopy of the Lyman-alpha regions of two blue straggler-WD binaries in the open cluster NGC 188. Using these spectra we will measure masses, radii and Teff for the white dwarf companions in order to model in detail the mass transfer history that formed these systems.

The 7-Gyr age of NGC 188 yields blue stragglers that are actually "yellow" F- and G- type stars, with Wien curves that drop off in the near-UV. These late-type blue stragglers, combined with the relatively close proximity of NGC 188 (2 kpc), allow direct observations of the WD companions in the far-UV with Hubble Space Telescope.

WOCS 5379 (Target 1) is a BS-WD binary with a period of 120 days and a F150LP flux of 1.6x10^-16 erg/s/cm^2. WOCS 4540 (Target 2) is a BS-WD binary with a period of 3030 days and a F150LP flux of 6.8x10^-17 erg/s/cm^2. The F150LP fluxes are determined from previous ACS/SBC observations by these investigators (GO:12492, PI:Mathieu). These fluxes are to be compared with the expected F150LP flux of ~2x10^-18 erg/s/cm^2 from a 6,250 K blue straggler alone.

We will observe both targets using the G140L grating with the "central" wavelength setting of 1105A, providing a spectral range of ~1130-2000A and a spectral resolution of ~0.5A. This region of a WD atmosphere includes the Ly-alpha absorption line at 1216A, which is crucial for determining WD effective temperatures and gravities. Due to rapid settling in the WD atmosphere we do not expect to observe metal lines in our spectra, but certainly will examine the spectra for them. Similar observing plans have been successfully implemented before to determine WD properties in low-accretion-rate CVs with COS (Szkody et al. 2012) and for a WD-yellow giant binary in M67 using GHRS (Figure 3, Landsman et al. 1997).

These studies find that spectra with a S/N of ~10 per resolution element and a resolution of ~1A are sufficient to fit WD atmospheres to FUV spectra and yield the precisions in the WD parameters needed for the science proposed here. We calculate our expected S/N by normalizing synthetic BS-WD binaries to the measured F150LP fluxes from our ACS/SBC photometry. The ACS/SBC flux levels indicate a WD temperature of ~17,000 K in both binaries, so the synthetic SEDs consist of a 17,000 K WD atmosphere with the appropriate temperature BS. For both targets we calculate a final S/N of ~10 per resolution element in 5.4 hours of integration after binning the spectra to 1A bins. (Total exposure time of 19414s ETC runs are COS.sp.514267 and COS.sp.514268 and for WOCS 5379 and WOCS 4540, respectively.)

Although higher S/N is possible by binning G130M spectra, we require the widest wavelength coverage possible for our fitting purposes, which is provided by the G140L grating (Szkody et al. 2012).

Our target coordinates and proper motions are very well known (position errors of ~0.005 arcsecs; Platais et al. 2003), so target acquisition can be done with NUV imaging (40 sec exposure) without preceding the observations with a search pattern.

Including target acquisition and overheads for transitioning between all four FP-POS positions, we propose one 6-orbit visit for each target, for a total of 12 orbits. Our exposure times are such that there is almost equal coverage at each FP-POS position. There are no timing constraints for our observations, and APT calculations indicate high visibility during Cycle 21.

With binary periods of 120 days and 3030 days, our targets are not actively accreting and are not expected to be variable in the UV. We do not anticipate any risk to the COS detectors with these observations.

We emphasize that COS is the only instrument available with the throughput necessary to execute these observations in a reasonable amount of time.

Visit

Proposal 13354, WOCS5379 (01) Thu Jul 11 21:07:05 GMT 2013

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: (none)

Comments: All ETC runs completed with a synthetic blue straggler-white dwarf binary SED with a 6,500 K blue straggler (V magnitude of 15.372) and a 17,000 K white dwarf atmosphere.

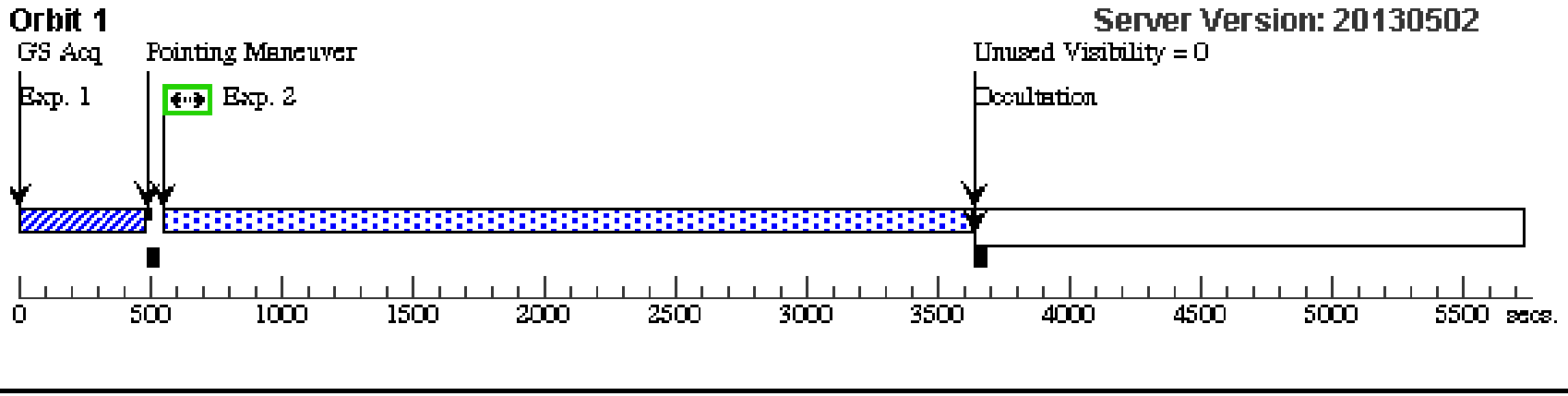
Fixed Targets

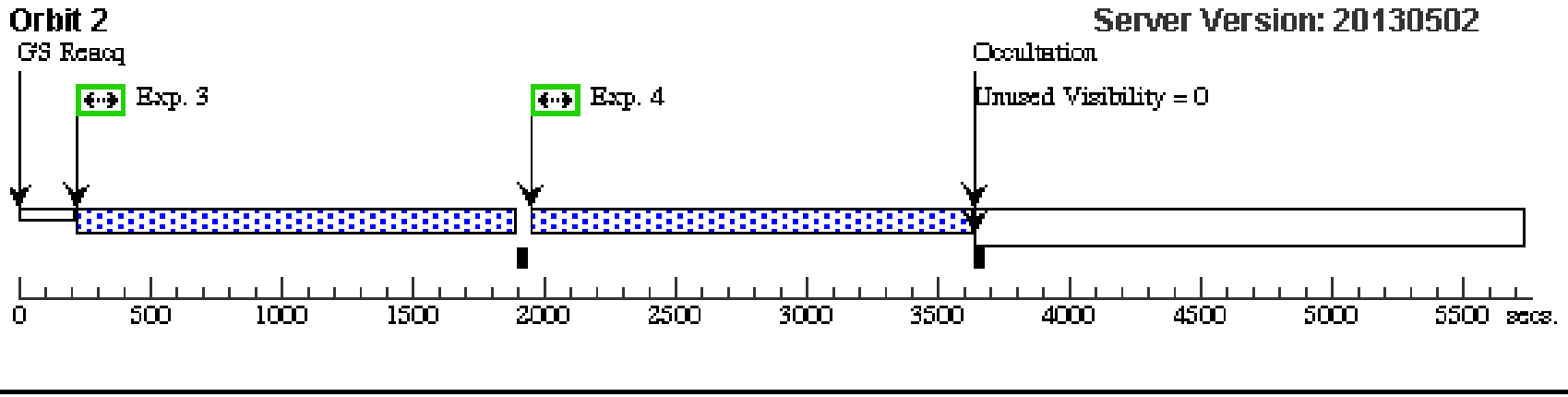
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	NGC188-005011+851438	RA: 00 50 10.7920 (12.5449667d)		V=15.372+/-0.01	Reference Frame: ICRS
	Alt Name1: WOCS5379	Dec: +85 14 38.08 (85.24391d)		B-V=0.570+/-0.014,	
		Equinox: J2000		E(B-V)=0.09+/-0.02	

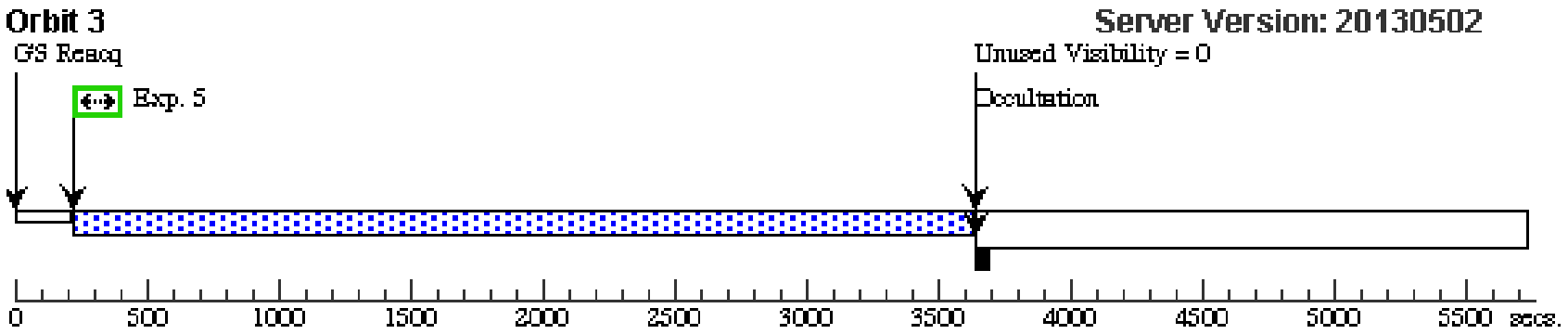
Exposures

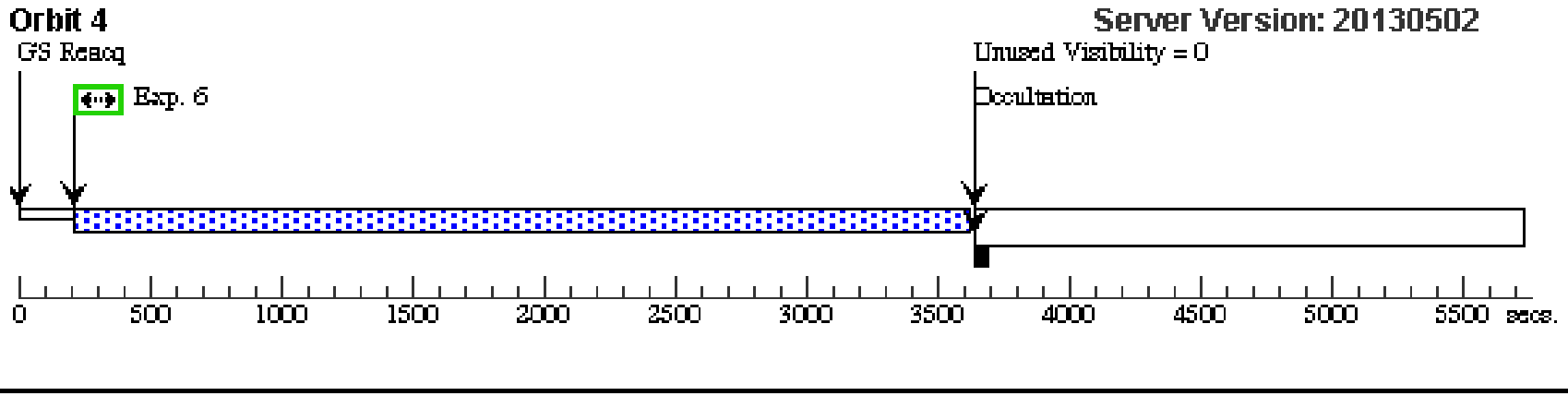
#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.ta.514274)	(1) NGC188-005011+851438	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				40 Secs (40 Secs)	
								[==>]	***[1]***
Comments: The GSCII BOT brings back a health and safety flag on a source exceeding the local source rate. This object is our target, which is incorrectly identified as a O5V star in the catalog as a worst case scenario. The ETC run with our synthetic SED shows there is no threat to the NUV detector.									
2	(COS.sp.514266)	(1) NGC188-005011+851438	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=1; BUFFER-TIME=8773			3000 Secs (2900 Secs)	
								[==>2900.0 Secs]	***[1]***
3	(COS.sp.514264)	(1) NGC188-005011+851438	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=1; BUFFER-TIME=8773			3000 Secs (1622 Secs)	
								[==>1622.0 Secs]	***[2]***
4	(COS.sp.514265)	(1) NGC188-005011+851438	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=2; BUFFER-TIME=8773			1609 Secs (1623 Secs)	
								[==>1623.0 Secs]	***[2]***
5	(COS.sp.514261)	(1) NGC188-005011+851438	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=2; BUFFER-TIME=8773			3360 Secs (3360 Secs)	
								[==>]	***[3]***
6	(COS.sp.514261)	(1) NGC188-005011+851438	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=3; BUFFER-TIME=8773			3360 Secs (3360 Secs)	
								[==>]	***[4]***
7	(COS.sp.514265)	(1) NGC188-005011+851438	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=3; BUFFER-TIME=8773			1609 Secs (1623 Secs)	
								[==>1623.0 Secs]	***[5]***
8	(COS.sp.514264)	(1) NGC188-005011+851438	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=4; BUFFER-TIME=8773			1608 Secs (1622 Secs)	
								[==>1622.0 Secs]	***[5]***
9	(COS.sp.514261)	(1) NGC188-005011+851438	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=4; BUFFER-TIME=8773			3360 Secs (3360 Secs)	
								[==>]	***[6]***

Orbit Structure





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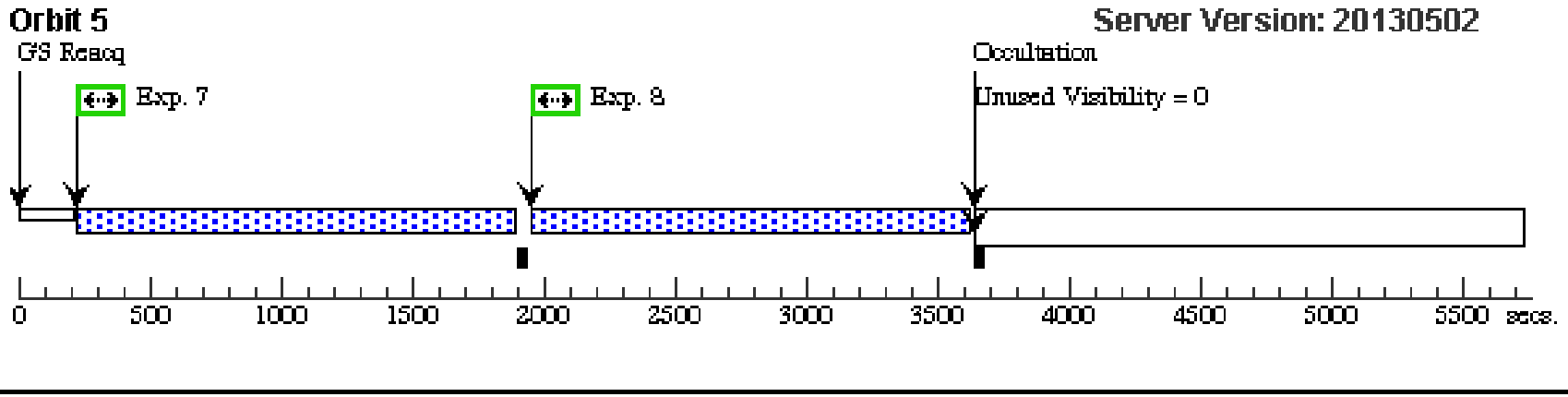
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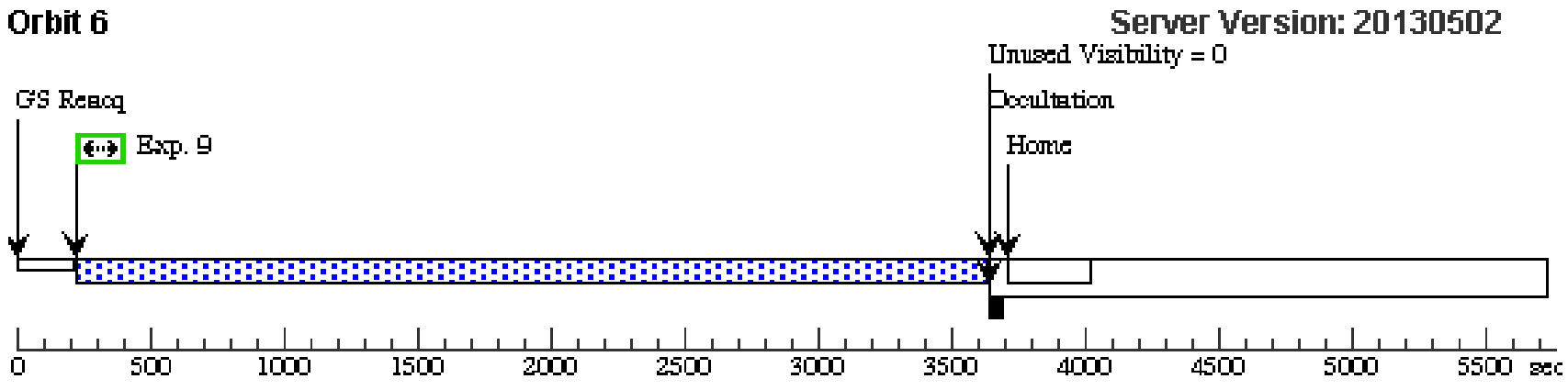
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Visit

Proposal 13354, WOCS4540 (02) Thu Jul 11 21:07:09 GMT 2013

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: (none)

Comments: All ETC runs completed with a synthetic blue straggler-white dwarf binary SED with a 6,750 K blue straggler (V magnitude of 13.857) and a 17,000 K white dwarf atmosphere.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	NGC188-004518+851920	RA: 00 45 18.2700 (11.3261250d)		V=13.857+/-0.008	Reference Frame: ICRS
	Alt Name1: WOCS4540	Dec: +85 19 19.85 (85.32218d)		B-V=0.521+/-0.011,	
		Equinox: J2000		E(B-V)=0.09+/-0.02	

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.ta.514275)	(2) NGC188-004518+851920	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				40 Secs (40 Secs)	
								[==>]	***[1]***
Comments: The GSCII BOT brings back a health and safety flag on a source exceeding the local source rate. This object is our target, which is incorrectly identified as a O5V star in the catalog as a worst case scenario. The ETC run with our synthetic SED shows there is no threat to the NUV detector.									
2	(COS.sp.514269)	(2) NGC188-004518+851920	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=1; BUFFER-TIME=8900			3000 Secs (2900 Secs)	
								[==>2900.0 Secs]	***[1]***
3	(COS.sp.514271)	(2) NGC188-004518+851920	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=1; BUFFER-TIME=8900			3000 Secs (1622 Secs)	
								[==>1622.0 Secs]	***[2]***
4	(COS.sp.514270)	(2) NGC188-004518+851920	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=2; BUFFER-TIME=8900			1609 Secs (1623 Secs)	
								[==>1623.0 Secs]	***[2]***
5	(COS.sp.514272)	(2) NGC188-004518+851920	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=2; BUFFER-TIME=8900			3360 Secs (3360 Secs)	
								[==>]	***[3]***
6	(COS.sp.514272)	(2) NGC188-004518+851920	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=3; BUFFER-TIME=8900			3360 Secs (3360 Secs)	
								[==>]	***[4]***
7	(COS.sp.514270)	(2) NGC188-004518+851920	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=3; BUFFER-TIME=8900			1609 Secs (1623 Secs)	
								[==>1623.0 Secs]	***[5]***
8	(COS.sp.514271)	(2) NGC188-004518+851920	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=4; BUFFER-TIME=8900			1608 Secs (1622 Secs)	
								[==>1622.0 Secs]	***[5]***
9	(COS.sp.514272)	(2) NGC188-004518+851920	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=4; BUFFER-TIME=8900			3360 Secs (3360 Secs)	
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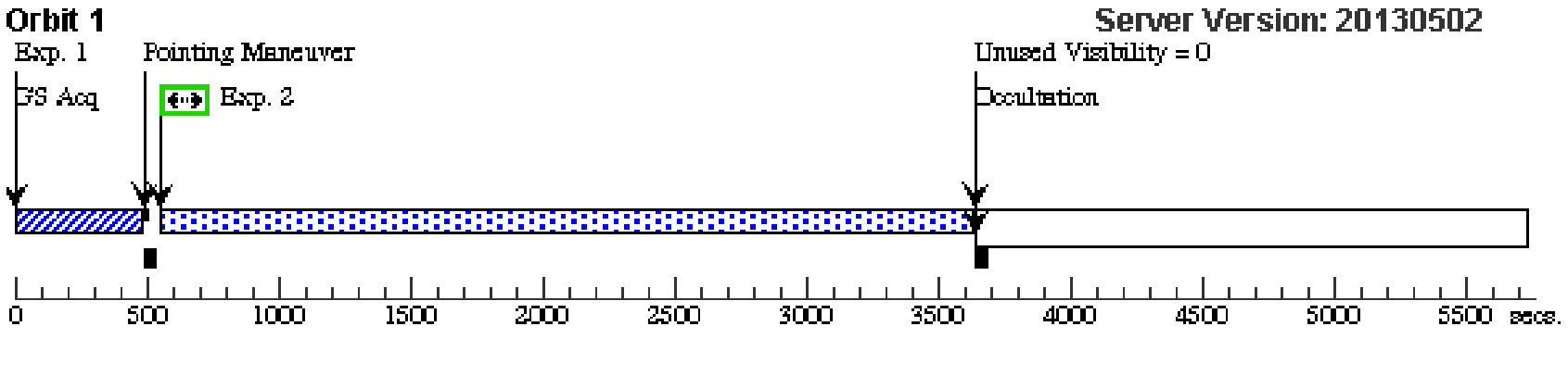
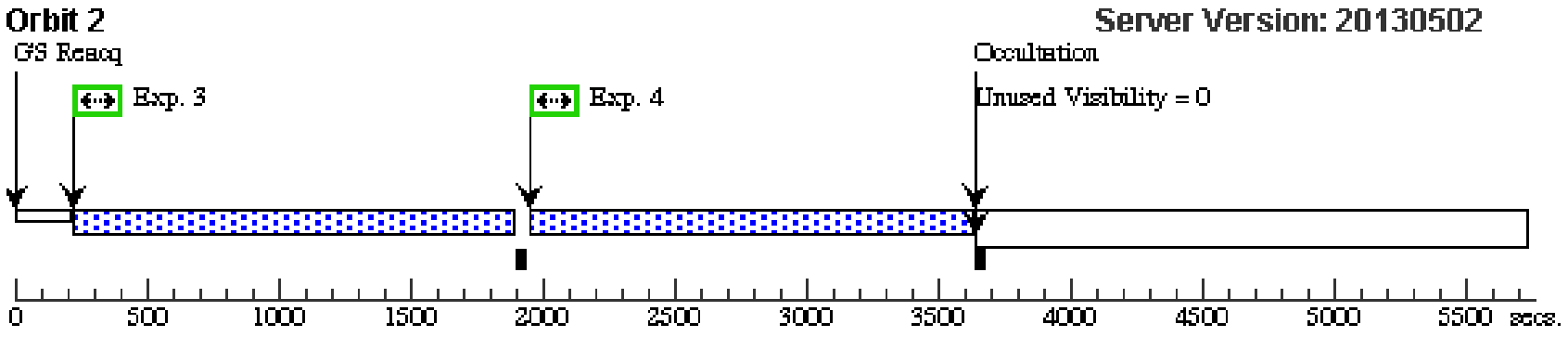
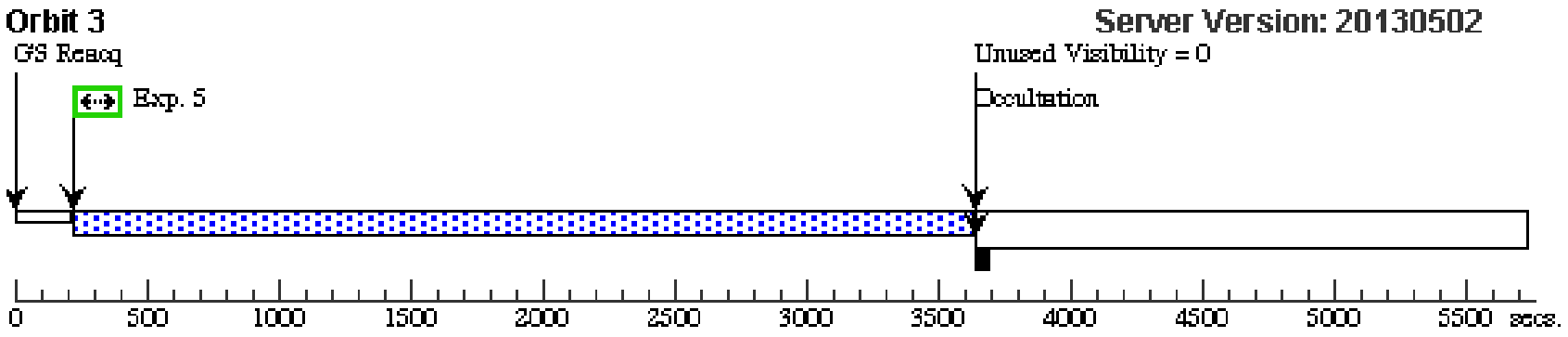
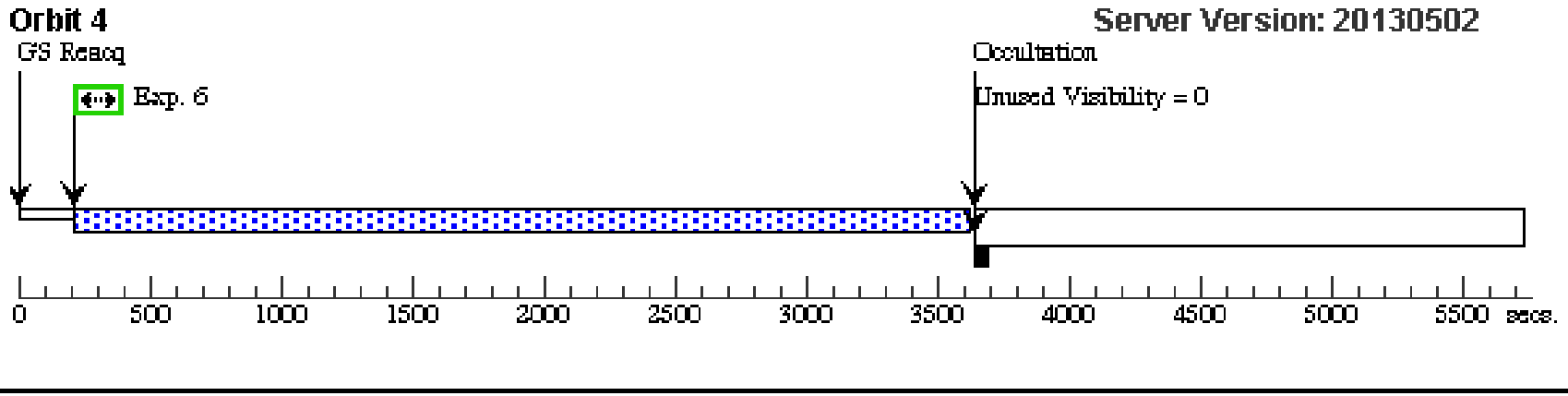
Orbit Structure





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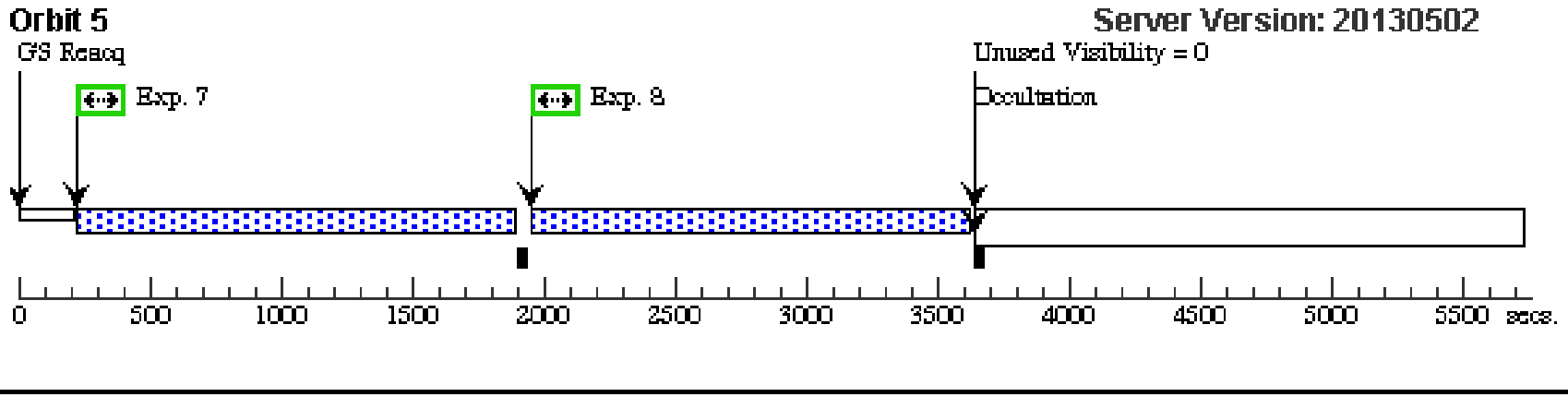
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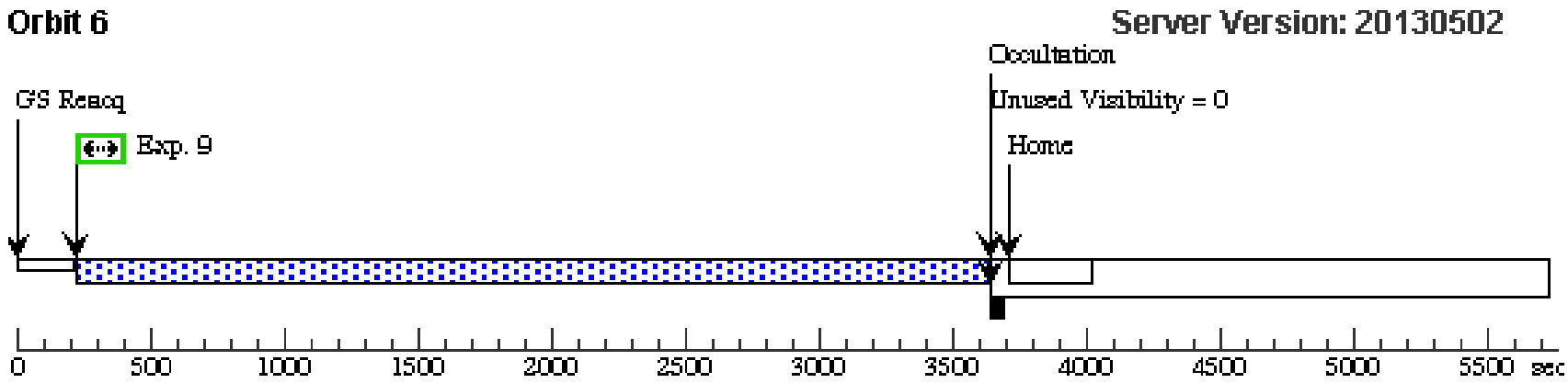
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