



## 16719 - Characterization of Unforeseen Chromospheres in Isolated White Dwarfs

Cycle: 29, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

### INVESTIGATORS

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Dr. Stefano Bagnulo (CoI) (ESA Member)	Armagh Observatory and Planetarium
Dr. John D. Landstreet (CoI) (CSA Member)	The University of Western Ontario
Dr. Nicholas Achilleos (CoI) (ESA Member)	University College London
Prof. Tom R. Marsh (CoI) (ESA Member)	The University of Warwick

### 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) GD356	STIS/CCD STIS/NUV-MAMA	6	23-Feb-2023 18:00:21.0	yes
03	(1) GD356	STIS/CCD STIS/NUV-MAMA	6	23-Feb-2023 18:00:24.0	yes
02	(1) GD356	STIS/CCD STIS/FUV-MAMA	6	23-Feb-2023 18:00:27.0	yes

18 Total Orbits Used

## **ABSTRACT**

In a newly identified class of single, magnetic white dwarfs, an unknown energy transport mechanism powers active chromospheres, transforming their Balmer lines from absorption to emission. The temperature inversion mechanism defies conventional explanation, with the least-unlikely model invoking current loops through conducting exoplanets. However, these emission-line white dwarfs are closely clustered on the HR diagram, thus indicating an intrinsic process must be responsible, and that it occurs at a particular evolutionary stage. We propose spin-resolved ultraviolet spectroscopy of the class prototype to constrain the properties of its chromospherically active region. This is only possible with Hubble, where sensitive constraints on the temperature and emission profile of the emitting region require ultraviolet data. Optical data provide a precise rotation period and phase, with larger amplitudes toward shorter wavelengths, and the ultraviolet will further characterize the continuum, and line emission variability. Ultraviolet observations will distinguish between variability driven by the temperature or magnetic opacity of the emission region. Importantly, anti-phase behaviour is expected between the ultraviolet and optical in the case where spot temperature is the main driver of variability. These observations are crucial to our understanding of this evolutionary-activated chromospheric phenomenon, with implications for not only this whole class of stellar remnants, but for magnetic stars in general.

## **OBSERVING DESCRIPTION**

The observational goals are two-fold. First, we will obtain a phase-resolved, low-resolution, FUV and NUV spectra covering two rotational cycles. This will be necessary to observe continuum variation with the rotational phase and obtain temperature information of the heated region. This will be done by probing the spectral slope of the star + spot system, and characterizing the excess due to the heated region. Second, we will re-bin the spectra to obtain a photometric proxy in these regimes. The TIME-TAG mode will be used to produce high-cadence light curves covering two rotational cycles. The amplitude of variations and relative phase information of these light curves would then be compared to the optical results, thus further constraining the nature of the emitting spot. Hence, the use of STIS MAMA detectors in the TIME-TAG mode would provide both photometry and spectroscopy simultaneously allowing us to characterise GD 356 in these regimes.

Instrument Choice: We select STIS to obtain a low-resolution, FUV spectrum of GD 356. We must select G140L with TIME-TAG mode to help identify airglow. Using the ETC based on the GALEX NUV flux for the target (16.9 AB mag) and an 8000 K blackbody, it is predicted that  $S/N = 3.0$  can be achieved in 1000 s per resolution element. Considering the resulting spectrum would be of  $R=1000$  (and approximately 1000 elements) then re-binning the whole spectrum would conclude in  $S/N = 95$  after 1000 s or  $S/N = 47$  after 250 s with  $S/N > 1$  in the majority of individual resolution elements. This is superior to imaging which we estimate to achieve optimum  $S/N = 38$  every 250 s. These estimates are in agreement with

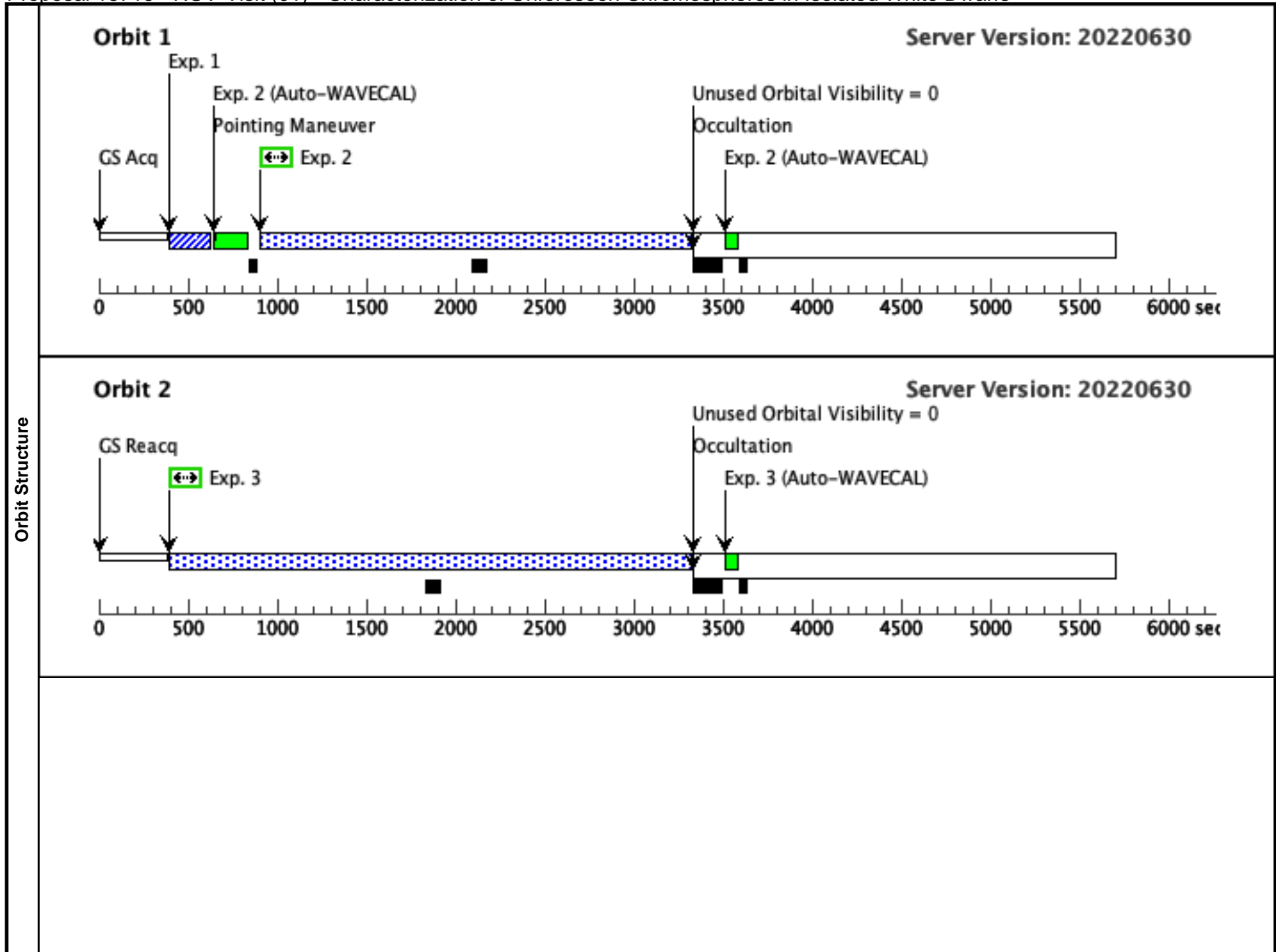
IUE spectra analysis that estimated GALEX NUV=17.1 AB mag, and thus the same exposure times are sufficient to achieve our goals. We also select STIS to obtain NUV spectra of the science target. STIS is superior to COS for efficient, NUV wavelength coverage. We will use the G230L grating to acquire multiple spectra covering roughly 1600-3100 Å, although we expect  $S/N > 20$  below 2200 Å, and  $S/N > 5$  below 1800 Å, based on the conservative case of photospheric emission alone with the same exposure times as the FUV. Thus, we expect somewhat better  $S/N$ , depending on the contribution of the heated region to the UV continuum.

Visit Structure: In this proposal we are interested in the phase-resolved variability of GD 356 ( $P = 116$  min), and thus require a complete coverage of a rotational cycle per UV regime. It would take HST 5 consecutive orbits to obtain a fully complete coverage. However, only one more orbit would be required to fully cover two rotational cycles. Therefore, to optimally utilise HST's time we ask for two rotational cycles to be covered per UV band. Thus, a total of 12 orbits would provide a full phase coverage two times in FUV and NUV.

Proposal 16719 - NUV-Visit (01) - Characterization of Unforeseen Chromospheres in Isolated White Dwarfs

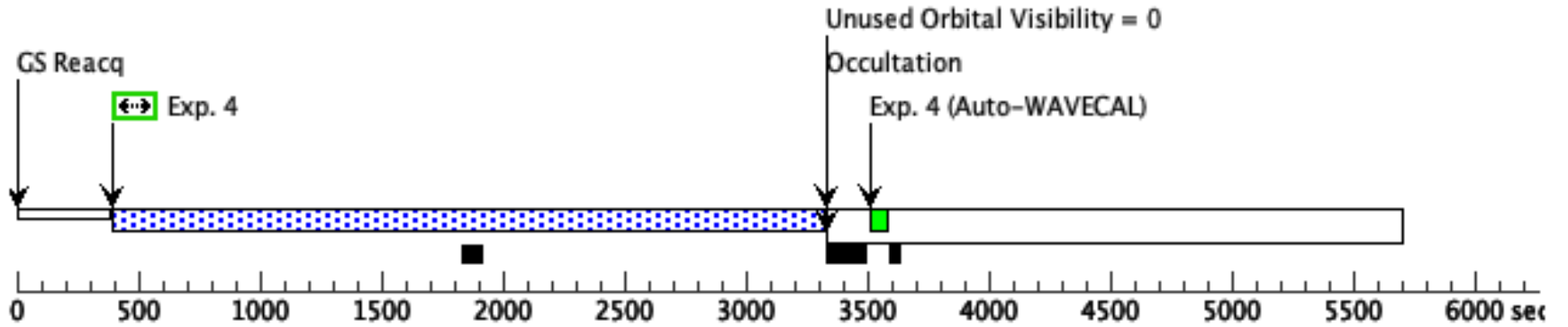
Thu Feb 23 23:00:28 GMT 2023

<b>Visit</b>	<b>Proposal 16719, NUV-Visit (01), failed</b> <b>Diagnostic Status: Warning</b> Scientific Instruments: STIS/NUV-MAMA, STIS/CCD Special Requirements: (none)									
	(NUV-Visit (01)) Warning (Orbit Planner): LONG STIS MAMA SU LIKELY TO INTERSECT THE SAA									
<b>Fixed Targets</b>	<b>#</b>	<b>Name</b>	<b>Target Coordinates</b>	<b>Targ. Coord. Corrections</b>		<b>Fluxes</b>	<b>Miscellaneous</b>			
	(1)	GD356	RA: 16 40 57.1485 (250.2381188d) Dec: +53 41 9.32 (53.68592d) Equinox: J2000	Proper Motion RA: -0.013439988636384301 sec of time/yr Proper Motion Dec: -0.19061100008457288 arcsec/yr Epoch of Position: 2000	V=15.1+/-0.1 Galex NUV = 16.9 AB mag	Reference Frame: ICRS				
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. Category=STAR Description=[DA]										
<b>Exposures</b>	<b>#</b>	<b>Label (ETC Run)</b>	<b>Target</b>	<b>Config,Mode,Aperture</b>	<b>Spectral Els.</b>	<b>Opt. Params.</b>	<b>Special Reqs.</b>	<b>Groups</b>	<b>Exp. Time (Total)/[Actual Dur.]</b>	<b>Orbit</b>
	1	ACQ (STIS.ta.152 2424)	(1) GD356	STIS/CCD, ACQ, F28X50LP	MIRROR	ACQTYPE=POINT			2 Secs (2 Secs) [==>]	[1]
	2	(STIS.sp.15 22309)	(1) GD356	STIS/NUV-MAMA, TIME-TAG, 52X0.2	G230L 2376 A	BUFFER-TIME=12 00			2405 Secs (2405 Secs) [==>]	[1]
	3	(STIS.sp.15 22309)	(1) GD356	STIS/NUV-MAMA, TIME-TAG, 52X0.2	G230L 2376 A	BUFFER-TIME=14 50			2913 Secs (2913 Secs) [==>]	[2]
	4	(STIS.sp.15 22309)	(1) GD356	STIS/NUV-MAMA, TIME-TAG, 52X0.2	G230L 2376 A	BUFFER-TIME=14 50			2913 Secs (2913 Secs) [==>]	[3]
	5	(STIS.sp.15 22309)	(1) GD356	STIS/NUV-MAMA, TIME-TAG, 52X0.2	G230L 2376 A	BUFFER-TIME=14 50			2913 Secs (2913 Secs) [==>]	[4]
	6	(STIS.sp.15 22309)	(1) GD356	STIS/NUV-MAMA, TIME-TAG, 52X0.2	G230L 2376 A	BUFFER-TIME=14 50			2913 Secs (2913 Secs) [==>]	[5]
	7	(STIS.sp.15 22309)	(1) GD356	STIS/NUV-MAMA, TIME-TAG, 52X0.2	G230L 2376 A	BUFFER-TIME=14 50			2913 Secs (2913 Secs) [==>]	[6]



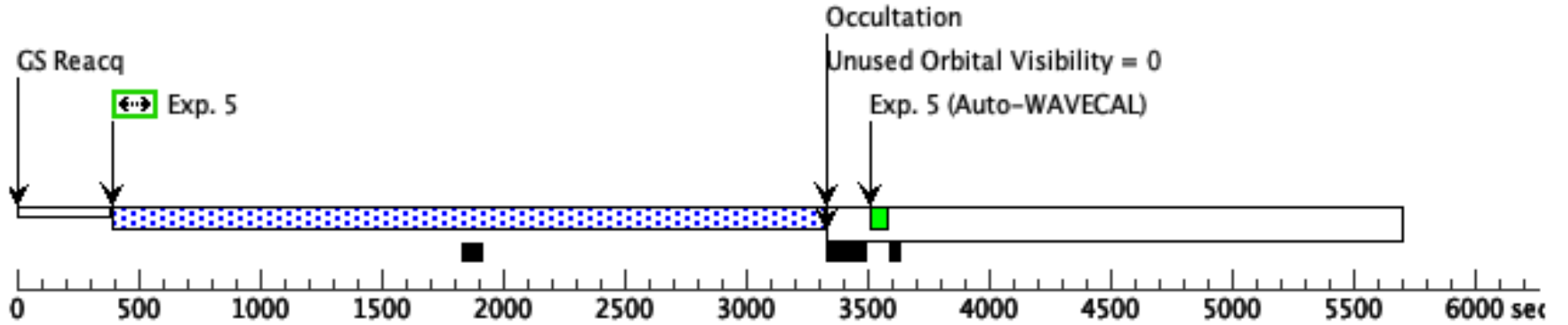
**Orbit 3**

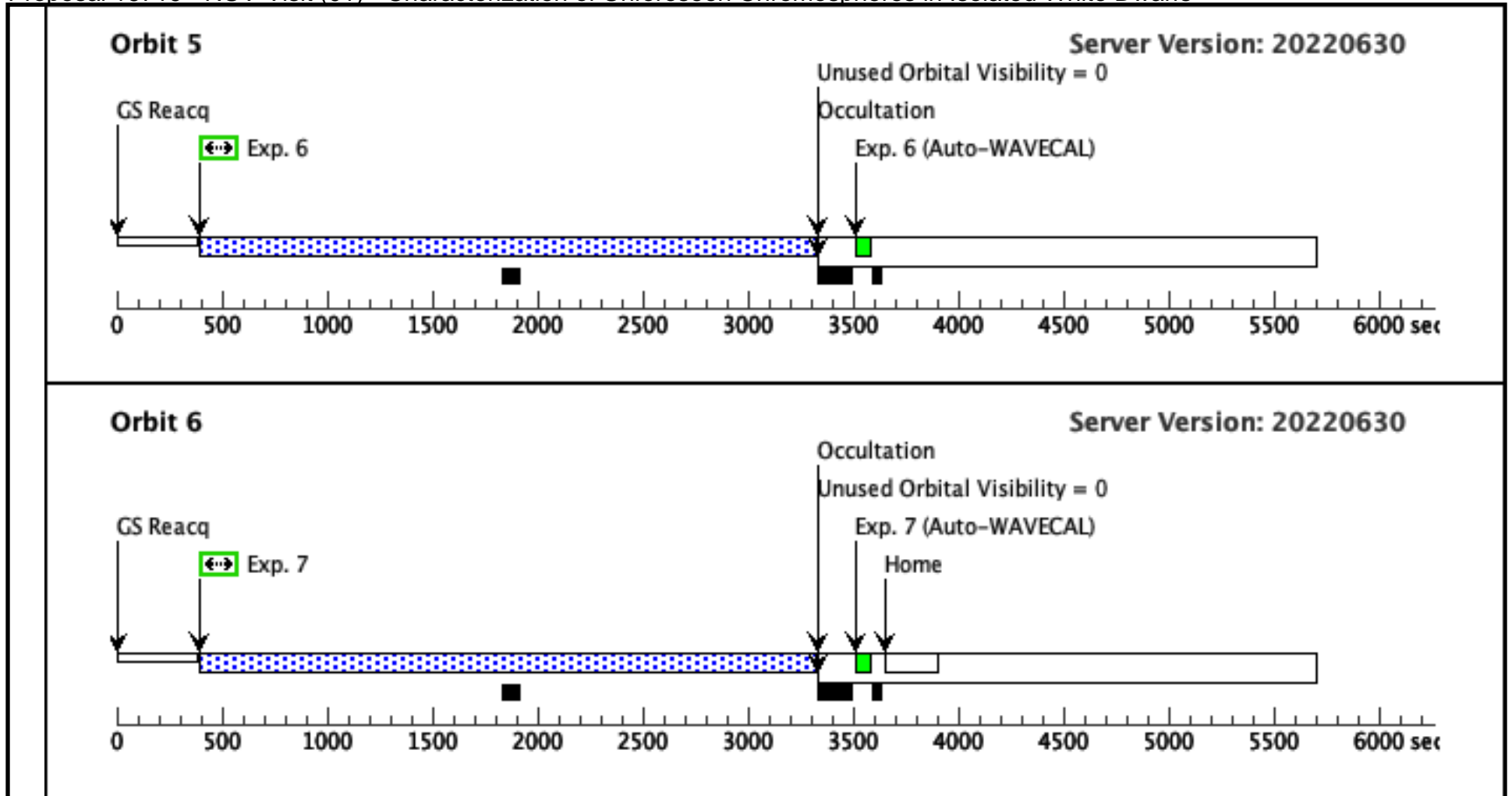
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**Orbit 4**

Server Version: 20220630

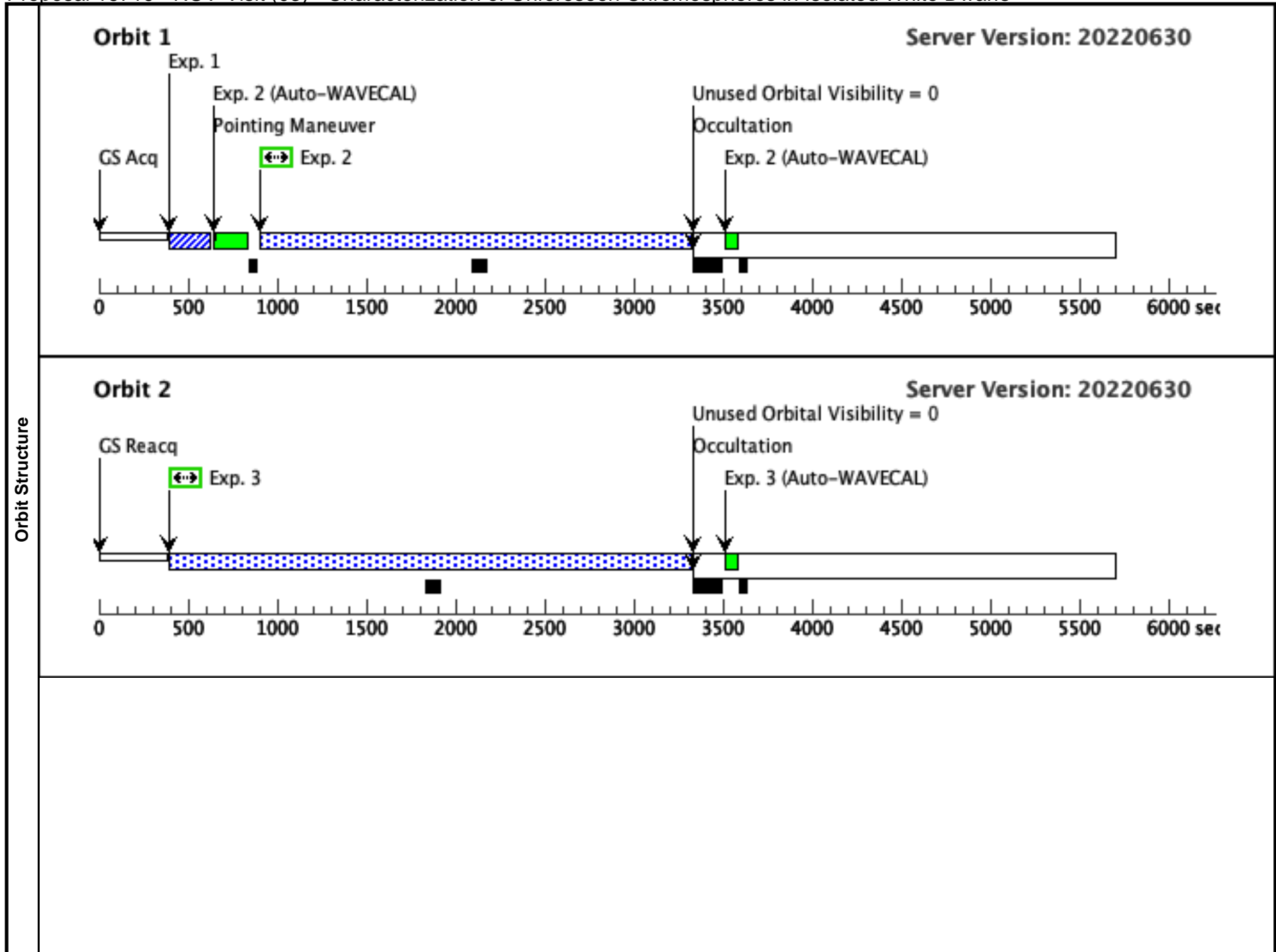




Proposal 16719 - NUV-Visit (03) - Characterization of Unforeseen Chromospheres in Isolated White Dwarfs

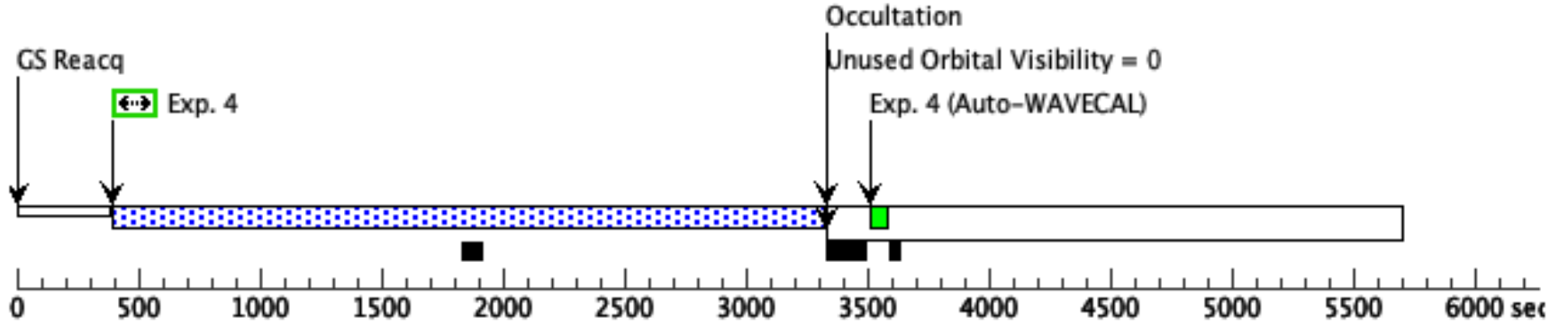
Thu Feb 23 23:00:28 GMT 2023

<b>Visit</b>	<b>Proposal 16719, NUV-Visit (03)</b> <b>Diagnostic Status: Warning</b> Scientific Instruments: STIS/NUV-MAMA, STIS/CCD Special Requirements: (none)									
	(NUV-Visit (03)) Warning (Orbit Planner): LONG STIS MAMA SU LIKELY TO INTERSECT THE SAA									
<b>Fixed Targets</b>	<b>#</b>	<b>Name</b>	<b>Target Coordinates</b>	<b>Targ. Coord. Corrections</b>		<b>Fluxes</b>	<b>Miscellaneous</b>			
	(1)	GD356	RA: 16 40 57.1485 (250.2381188d) Dec: +53 41 9.32 (53.68592d) Equinox: J2000	Proper Motion RA: -0.013439988636384301 sec of time/yr Proper Motion Dec: -0.19061100008457288 arcsec/yr Epoch of Position: 2000	V=15.1+/-0.1 Galex NUV = 16.9 AB mag	Reference Frame: ICRS				
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. Category=STAR Description=[DA]										
<b>Exposures</b>	<b>#</b>	<b>Label (ETC Run)</b>	<b>Target</b>	<b>Config,Mode,Aperture</b>	<b>Spectral Els.</b>	<b>Opt. Params.</b>	<b>Special Reqs.</b>	<b>Groups</b>	<b>Exp. Time (Total)/[Actual Dur.]</b>	<b>Orbit</b>
	1	ACQ (STIS.ta.152 2424)	(1) GD356	STIS/CCD, ACQ, F28X50LP	MIRROR	ACQTYPE=POINT			2 Secs (2 Secs) [==>]	[1]
	2	(STIS.sp.15 22309)	(1) GD356	STIS/NUV-MAMA, TIME-TAG, 52X0.2	G230L 2376 A	BUFFER-TIME=12 00			2405 Secs (2405 Secs) [==>]	[1]
	3	(STIS.sp.15 22309)	(1) GD356	STIS/NUV-MAMA, TIME-TAG, 52X0.2	G230L 2376 A	BUFFER-TIME=14 50			2913 Secs (2913 Secs) [==>]	[2]
	4	(STIS.sp.15 22309)	(1) GD356	STIS/NUV-MAMA, TIME-TAG, 52X0.2	G230L 2376 A	BUFFER-TIME=14 50			2913 Secs (2913 Secs) [==>]	[3]
	5	(STIS.sp.15 22309)	(1) GD356	STIS/NUV-MAMA, TIME-TAG, 52X0.2	G230L 2376 A	BUFFER-TIME=14 50			2913 Secs (2913 Secs) [==>]	[4]
	6	(STIS.sp.15 22309)	(1) GD356	STIS/NUV-MAMA, TIME-TAG, 52X0.2	G230L 2376 A	BUFFER-TIME=14 50			2913 Secs (2913 Secs) [==>]	[5]
	7	(STIS.sp.15 22309)	(1) GD356	STIS/NUV-MAMA, TIME-TAG, 52X0.2	G230L 2376 A	BUFFER-TIME=14 50			2913 Secs (2913 Secs) [==>]	[6]



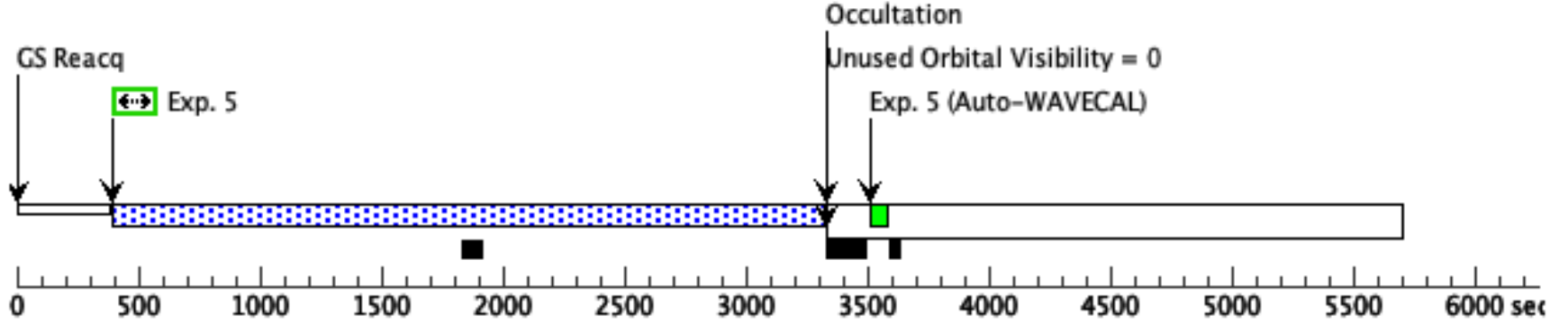
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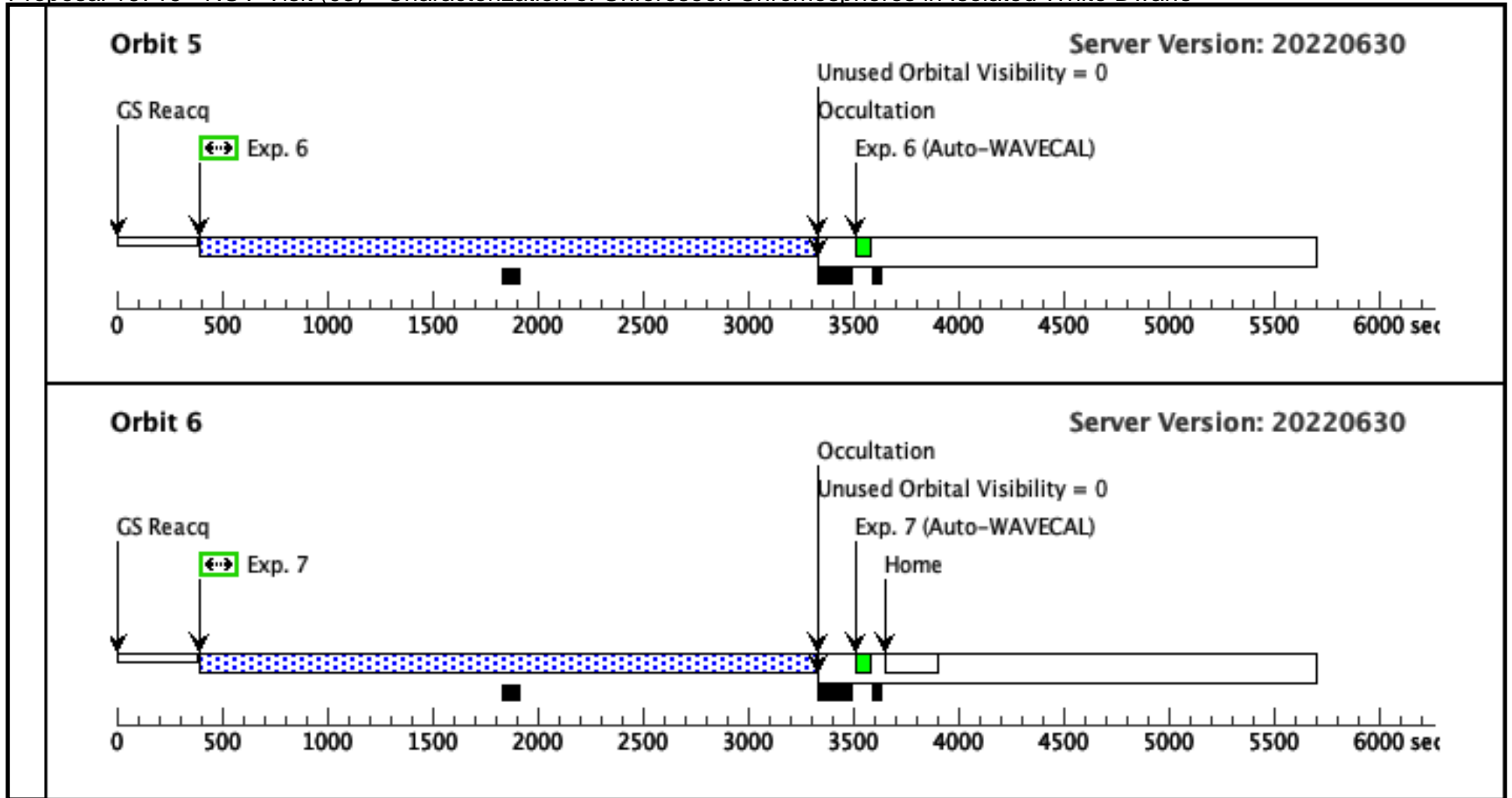
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**Orbit 4**

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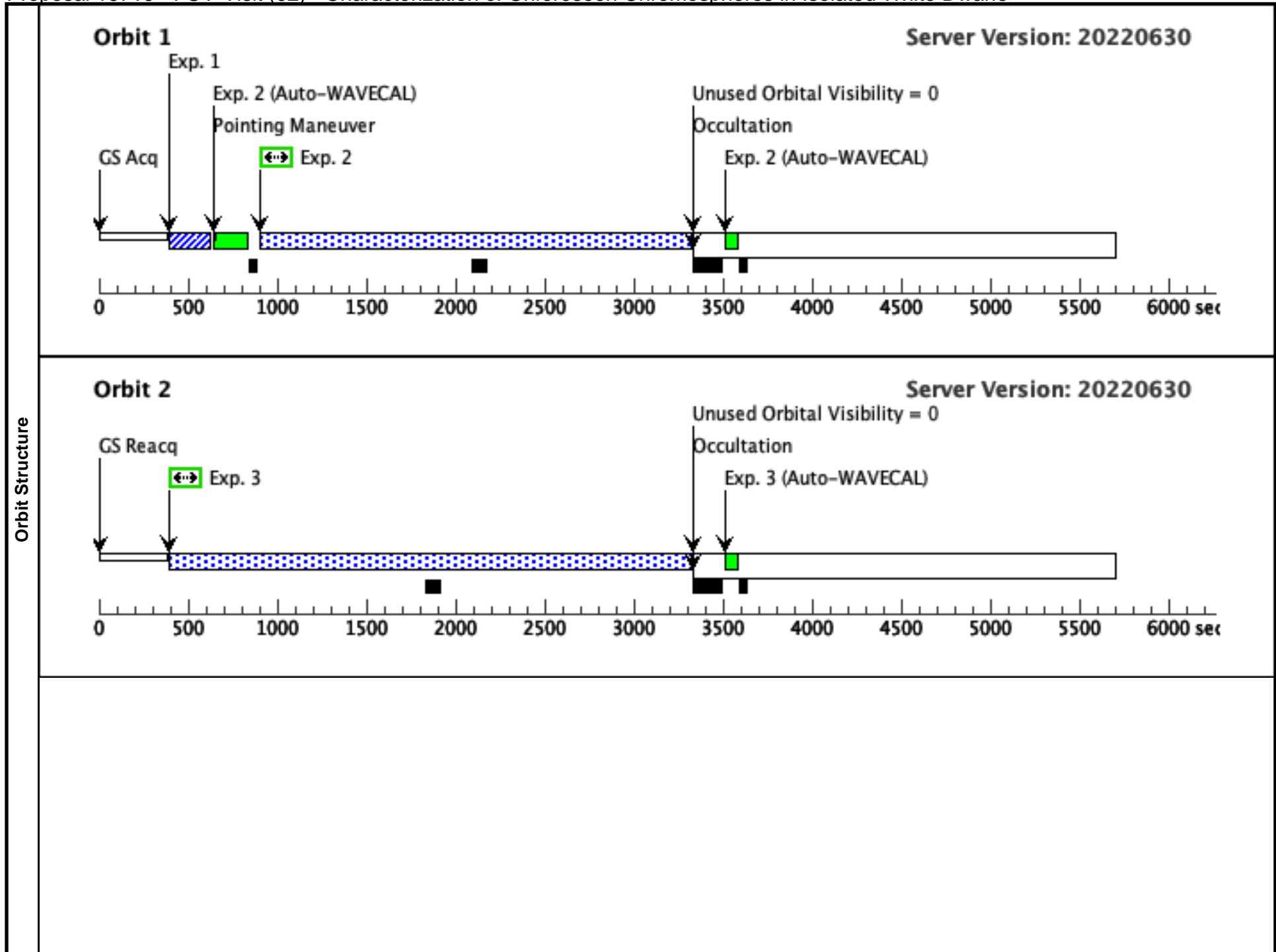




Proposal 16719 - FUV-Visit (02) - Characterization of Unforeseen Chromospheres in Isolated White Dwarfs

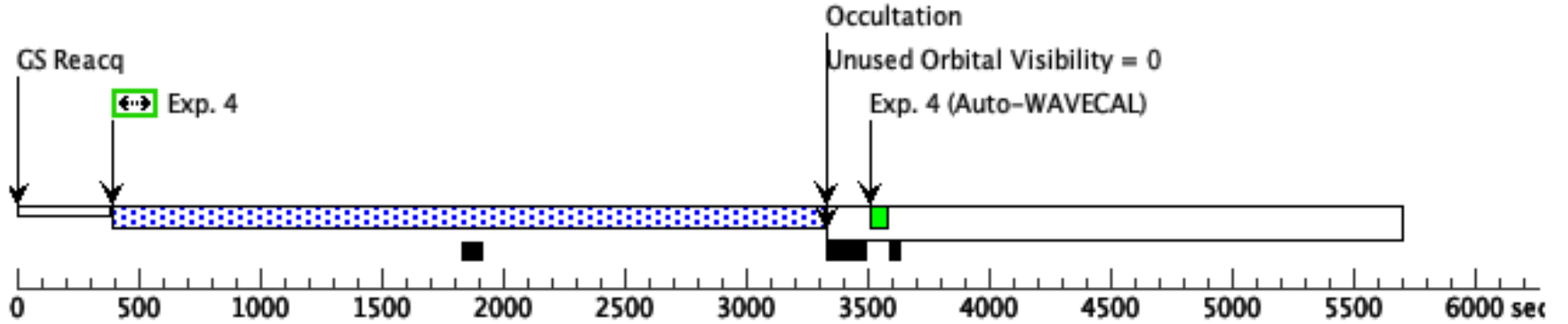
Thu Feb 23 23:00:28 GMT 2023

<b>Visit</b>	Proposal 16719, FUV-Visit (02), completed <b>Diagnostic Status: Warning</b> Scientific Instruments: STIS/CCD, STIS/FUV-MAMA Special Requirements: (none)									
	(FUV-Visit (02)) Warning (Orbit Planner): LONG STIS MAMA SU LIKELY TO INTERSECT THE SAA									
<b>Fixed Targets</b>	<b>#</b>	<b>Name</b>	<b>Target Coordinates</b>	<b>Targ. Coord. Corrections</b>		<b>Fluxes</b>	<b>Miscellaneous</b>			
	(1)	GD356	RA: 16 40 57.1485 (250.2381188d) Dec: +53 41 9.32 (53.68592d) Equinox: J2000	Proper Motion RA: -0.013439988636384301 sec of time/yr Proper Motion Dec: -0.19061100008457288 arcsec/yr Epoch of Position: 2000	V=15.1+/-0.1 Galax NUV = 16.9 AB mag	Reference Frame: ICRS				
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<b>Exposures</b>	<b>#</b>	<b>Label (ETC Run)</b>	<b>Target</b>	<b>Config,Mode,Aperture</b>	<b>Spectral Els.</b>	<b>Opt. Params.</b>	<b>Special Reqs.</b>	<b>Groups</b>	<b>Exp. Time (Total)/[Actual Dur.]</b>	<b>Orbit</b>
	1	ACQ (STIS.ta.152 2424)	(1) GD356	STIS/CCD, ACQ, F28X50LP	MIRROR	ACQTYPE=POINT			2 Secs (2 Secs) [==>]	[1]
	2	(STIS.sp.15 22310)	(1) GD356	STIS/FUV-MAMA, TIME-TAG, 52X0.2	G140L 1425 A	BUFFER-TIME=12 00			2405 Secs (2405 Secs) [==>]	[1]
	3	(STIS.sp.15 22310)	(1) GD356	STIS/FUV-MAMA, TIME-TAG, 52X0.2	G140L 1425 A	BUFFER-TIME=14 50			2913 Secs (2913 Secs) [==>]	[2]
	4	(STIS.sp.15 22310)	(1) GD356	STIS/FUV-MAMA, TIME-TAG, 52X0.2	G140L 1425 A	BUFFER-TIME=14 50			2913 Secs (2913 Secs) [==>]	[3]
	5	(STIS.sp.15 22310)	(1) GD356	STIS/FUV-MAMA, TIME-TAG, 52X0.2	G140L 1425 A	BUFFER-TIME=14 50			2913 Secs (2913 Secs) [==>]	[4]
	6	(STIS.sp.15 22310)	(1) GD356	STIS/FUV-MAMA, TIME-TAG, 52X0.2	G140L 1425 A	BUFFER-TIME=14 50			2913 Secs (2913 Secs) [==>]	[5]
	7	(STIS.sp.15 22310)	(1) GD356	STIS/FUV-MAMA, TIME-TAG, 52X0.2	G140L 1425 A	BUFFER-TIME=14 50			2913 Secs (2913 Secs) [==>]	[6]



**Orbit 3**

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**Orbit 4**

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