13658 - Farewell to the Voyagers: Measuring the Local ISM in the Immediate Path of the Two Voyager Spacecraft

Cycle: 22, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
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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) HIP85665	STIS/CCD STIS/FUV-MAMA STIS/NUV-MAMA	3	23-Jul-2014 21:10:53.0	yes
02	(2) HIP86287	STIS/CCD STIS/FUV-MAMA STIS/NUV-MAMA	3	23-Jul-2014 21:10:55.0	yes
03	(3) GJ780	STIS/CCD STIS/FUV-MAMA STIS/NUV-MAMA	3	23-Jul-2014 21:10:57.0	yes
04	(4) GJ754	STIS/CCD STIS/FUV-MAMA STIS/NUV-MAMA	5	23-Jul-2014 21:10:59.0	yes

14 Total Orbits Used

ABSTRACT

Astronomical observations of the interstellar medium often struggle to measure fundamental physical properties of the gas on small scales because most observations are averaged along the line of sight, leading to difficulties in evaluating pressure equilibrium, turbulence, magnetic field structure, and volume density. The local ISM has helped in this regard by providing relatively simple ISM absorption profiles over short path lengths, with low column densities only detectable with strong transitions in the UV . On August 25, 2012, the first human-made object, the Voyager 1 spacecraft, crossed the heliosphere, effectively leaving the solar system and entering the galactic interstellar environment. Voyager 2 is expected to do the same in the coming years, and over the next decade both spacecraft will continue to make daily measurements of fundamental physical properties. We propose to make the first observations of nearby stars along the same line of sight as the current locations of the Voyager spacecraft in order to measure the same interstellar material. The proposed observations are of the very closest stars in these directions and will provide measurements of the kinematic structure, electron density, temperature and turbulence, elemental abundances and small scale structure by comparing two closely spaced sight lines. With both HST and the Voyager spacecraft approaching the end of long and fruitful missions, we have the opportunity to acquire a unique dataset which synthesizes the independent and complimentary in situ observations with the shortest possible line-of-sight observations, to provide an unprecedented study of the galactic ISM surrounding the Sun.

OBSERVING DESCRIPTION

Target Selection and Availability: We plan observations of four late-type (one G and 3 M dwarf) stars that lie along the line of sight of the two Voyager spacecraft, in order to synthesize the astronomical and in situ observations of the LISM.

Two targets have been identified for each Voyager sight line in order to derive constraints on the small scale structure in the material just outside the heliosphere. The targets were selected by choosing the two stars within 10 pc that lie the closest to the current sight line toward the Voyager spacecraft. For Voyager 1, the two targets lie within 10 degrees of the current sight line toward the spacecraft, and for Voyager 2, the two targets lie 9.2 and 13.1 degrees away from the direction of the spacecraft.

Desired Spectral Coverage and Resolution: The high spectral resolution capabilities of STIS are necessary to model the ISM absorption line profiles. Only by resolving the velocity components of the ISM clouds, can accurate physical measurements of temperature, turbulent velocity, and ionization be made, all of which are critical to modeling the structure of the LISM. We

plan to use the high resolution E230H grating to observe MgII and FeII. These "heavy" ions are not significantly broadened thermally, and provide sharp line profiles to resolve the velocity structure
of the ISM along the line of sight. Hydrogen has a broad absorption profile, and does not necessarily require high spectral resolution, and therefore, to maximize S/N, we plan to use the E140M setting. Due to the wide spectral range of STIS, we would obtain practically the entire far-UV band from 1150-1700 A and several more ISM absorption lines (e.g., DI, CII, NI, OI, SiII, SiIII, AlII) in addition to Lyman-alpha. With the velocity structure determined by FeII and MgII, we could utilize all of these lines (Redfield & Linsky 2004). Note that we plan to use the E140H grating for our brightest target, delta Pav. While slightly limiting the spectral range, this will allow us to independently confirm our profile fitting procedure which utilizes the E230H high-resolution spectra to aid in modeling the medium-resolution E140M spectra.

Desired Aperture Size and Geocoronal Emission: The narrow aperture sizes of STIS are critical in order to minimize the contamination by the geocoronal Lyman-alpha emission (an important component of the observations that prevent this experiment from being performed with COS). Depending on the time of year, the Earth's motion can Doppler shift the geocoronal line into the region of astrospheric absorption and contaminate our measurement. Our targets will require a minimal timing constraint to ensure that the geocoronal line is in the core of the ISM absorption (still allowing >6 months to perform observations).

Desired Signal-to-Noise and Exposure Times: Because cool star spectra are emission line sources in the UV, estimating expected S/N for our planned spectra requires first estimating Lyman-alpha and MgII fluxes, which we can do by extrapolating from previously observed stars. Chromospheric line fluxes (such as MgII and Lyman-alpha) are related to X-ray fluxes through a relation from Ayres et al. (1995), which can then be used to estimate Lyman-alpha or MgII fluxes for our stars.
Wood et al. (2005) provide Lyman-alpha spectra for many stars, which serve as the comparison stars for our purposes here.

The two targets along the Voyager 1 sight line do not have X-ray observations. Instead, we take advantage of the correlation between the chromospheric CaII H and K core emission and the Lyman-alpha flux, as demonstrated by Linsky et al. (2013). We use the combined CaII H and K core luminosity from Browning et al. (2010), the bolometric corrections in Leggett et al. (1996), and the correlations derived by Linsky et al. (2013). These correlations are made from existing high-resolution HST/STIS Lyman-alpha observations of other M stars.

After acquisition, peakup, and observational overhead are considered, we expect at least 28 minutes to be available in the first orbit for the E230H exposure. This provides time to attain high S/N of >25 at the half-maximum (that is, one half FWHM from the line center, because it is unlikely that the ISM absorption will be centered at the same velocity as the star) of the strong MgII lines. These S/N levels allow for detection of weak column

densities (log N(MgII) ~ 11.0), even in blended profiles (demonstrated in Redfield & Linsky 2002). After acquisition and overheads are considered, we expect at least 41 minutes of exposure time to be available in the second orbit for the E140M exposure, and 48 minutes in subsequent orbits. To obtain a S/N > 25, which is required to model the Lyman-alpha profile (see Wood et al. 2005), requires 2-4 orbits. Note that our faintest target is slightly lower than the nominal S/N levels. We have limited the total number of orbits for this target to 5 in order to fit within a single visit. While not optimal, a S/N ~ 10 for E230H is sufficient to model the absorption profile of MgII.

Brightness Limits: All of our targets are late-type stars which have UV spectra characterized by minimal continua, but strong emission lines. For this reason, all of our targets fall far short of the global brightness limit. IUE spectra is available for our brightest target, delta Pav to confirm this. For the other targets, HST spectra of M dwarfs (e.g., AU Mic) also confirm this. For example, in the E230H setting, using IUE data, our earliest spectral type target (delta Pav; G8IV) only results in 4.5 counts s^-1. The emission lines also fall far short of the local brightness limit. The two emission lines of interest in this proposal (Lyman-alpha and MgII) are also the brightest, and therefore, the procedure given above for estimating the S/N near their peaks is also utilized to test for brightness limit violations. Again, delta Pav is the strongest MgII emission line sources in our sample, and in
the brightest pixel, only generates 2.0 counts s^-1.

Visit

Proposal 13658, Visit 01 Thu Jul 24 01:11:01 GMT 2014

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/CCD, STIS/FUV-MAMA, STIS/NUV-MAMA

Special Requirements: BETWEEN 22-JUN-2014:00:00:00 AND 13-DEC-2014:00:00:00; BETWEEN 22-JUN-2015:00:00:00 AND 13-DEC-2015:00:00:00; BETWEEN 22-JUN-2016:00:00:00 AND 13-DEC-2016:00:00:00

Fixed Targets

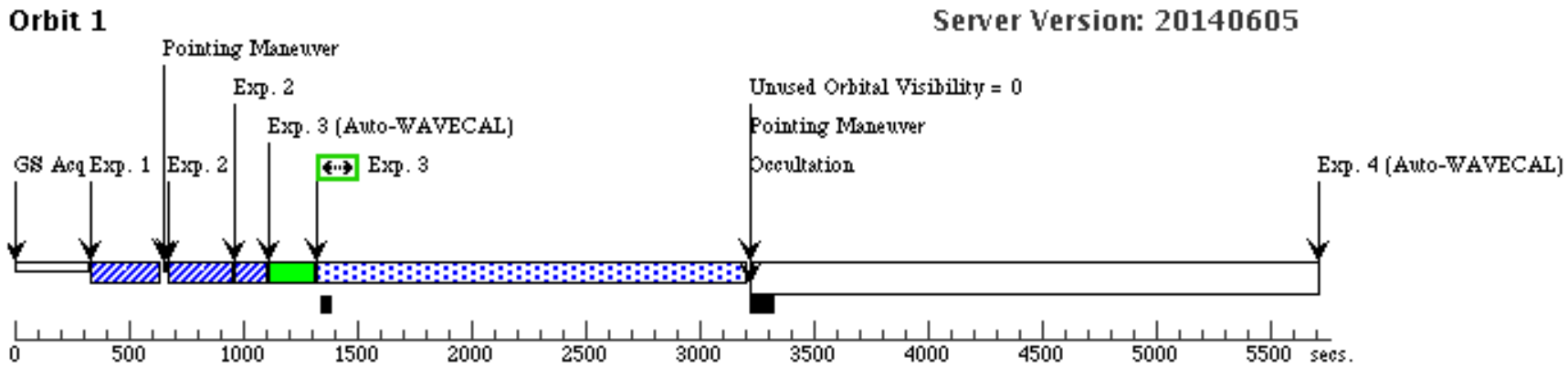
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	HIP85665	RA: 17 30 22.7100 (262.5946250d) Dec: +05 32 56.80 (5.54911d) Equinox: J2000	Proper Motion RA: +0.00193 sec of time/yr Proper Motion Dec: -0.248 arcsec/yr Parallax: 0.10017" Epoch of Position: 1991.25 Radial Velocity: -12.51 km/sec	V=9.32 TYPE=M1V, B-V=1.47, E(B-V)=0, F-LINE(2796)=0.82e-12, W-LINE(2796)=0.35	Reference Frame: ICRS

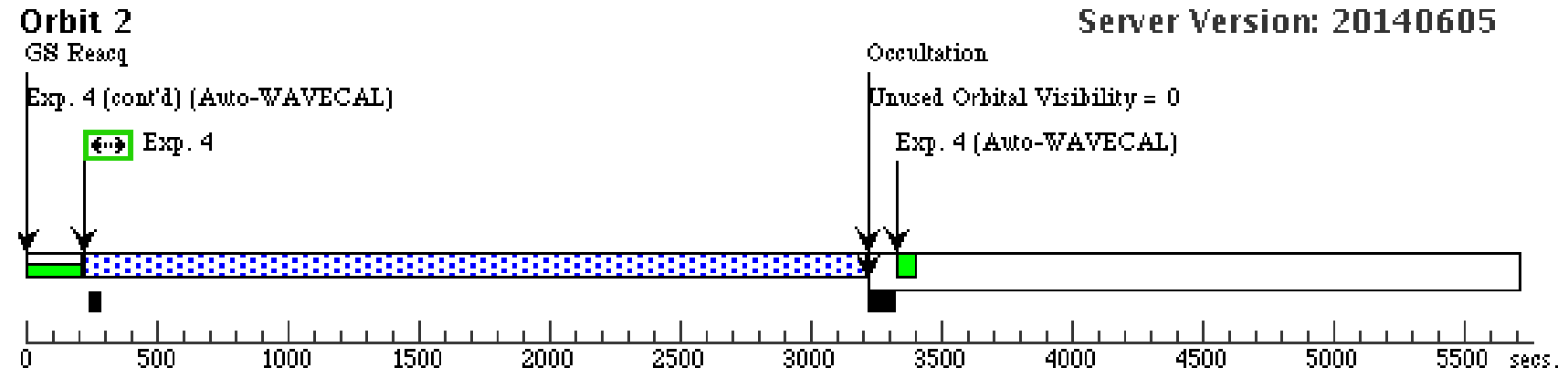
Comments: Target star was identified by the BOT in the observed field. DSS images clearly indicate a bright isolated target star (brightest within 100 arcsec by more than a magnitude). Clearly the target star is the dominant object in the field of view.

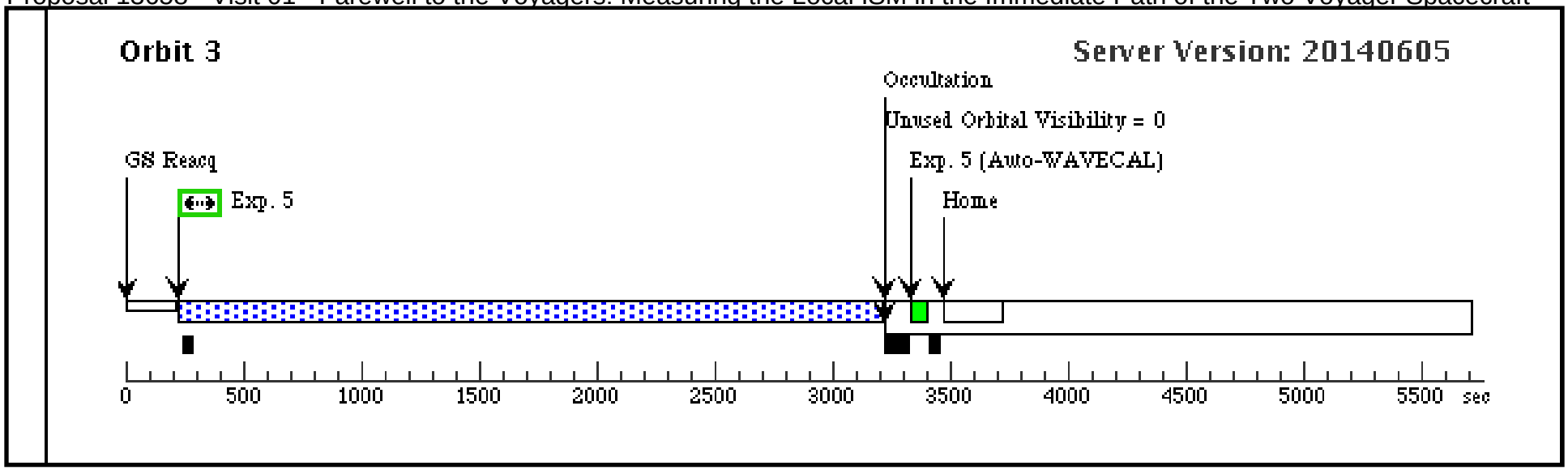
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(STIS.ta.623 432)	(1) HIP85665	STIS/CCD, ACQ, F25ND3	MIRROR	ACQTYPE=POINT			2.5 Secs (2.5 Secs) *[==>]*	*[1]*
	Comments: SNR = 151.0919 *Brightest Pixel = 8,186.92 e*								
2	(STIS.sp.62 4030)	(1) HIP85665	STIS/CCD, ACQ/PEAK, 0.2X0.09	G430L 4300 A				0.7 Secs (0.7 Secs) *[==>]*	*[1]*
	Comments: SNR = 13.1905 *Brightest Pixel = 196.43 e* *Global Source Counts = 417,805.451 e*								
3	(STIS.sp.62 5198)	(1) HIP85665	STIS/NUV-MAMA, ACCUM, 0.2X0.09	E230H 2713 A				1868 Secs (1868 Secs) *[==>]*	*[1]*
	Comments: SNR = 29.6418 *Brightest Pixel = 351.11 e*								
4	(STIS.sp.62 5203)	(1) HIP85665	STIS/FUV-MAMA, ACCUM, 0.2X0.2	E140M 1425 A				2970 Secs (2970 Secs) *[==>]*	*[2]*
	Comments: SNR = 20.2508 *Brightest Pixel = 210.81 e*								
5	(STIS.sp.62 5203)	(1) HIP85665	STIS/FUV-MAMA, ACCUM, 0.2X0.2	E140M 1425 A				2970 Secs (2970 Secs) *[==>]*	*[3]*
	Comments: SNR = 20.2508 *Brightest Pixel = 210.81 e*								

Orbit Structure



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Exp. 5
Exp. 5 (Auto-WAVECAL)
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Visit

Proposal 13658, Visit 02 Thu Jul 24 01:11:01 GMT 2014

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/CCD, STIS/FUV-MAMA, STIS/NUV-MAMA

Special Requirements: BETWEEN 22-JUN-2014:00:00:00 AND 13-DEC-2014:00:00:00; BETWEEN 22-JUN-2015:00:00:00 AND 13-DEC-2015:00:00:00; BETWEEN 22-JUN-2016:00:00:00 AND 13-DEC-2016:00:00:00

Fixed Targets

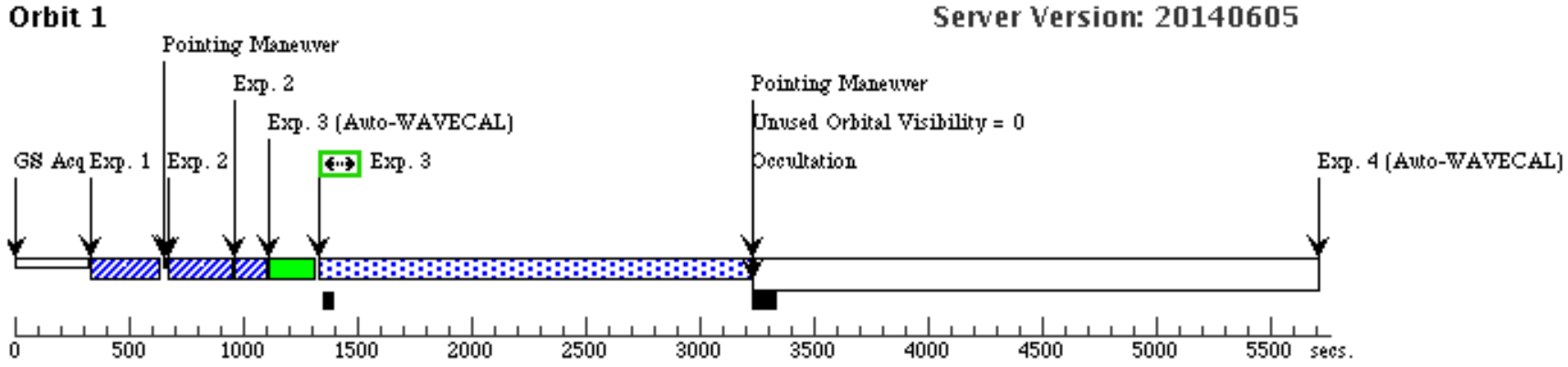
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	HIP86287	RA: 17 37 52.7800 (264.4699167d)	Proper Motion RA: +0.0652 sec of time/yr	V=9.60	Reference Frame: ICRS
	Alt Name1: GJ686	Dec: +18 35 21.50 (18.58931d)	Proper Motion Dec: +0.984 arcsec/yr	TYPE=M1.0V,	
	Alt Name2: LHS452	Equinox: J2000	Parallax: 0.12302"	B-V=1.532,	
			Epoch of Position: 1991.25	E(B-V)=0,	
			Radial Velocity: -9.55 km/sec	F-LINE(2796)=0.85e-12,	
				W-LINE(2796)=0.35	

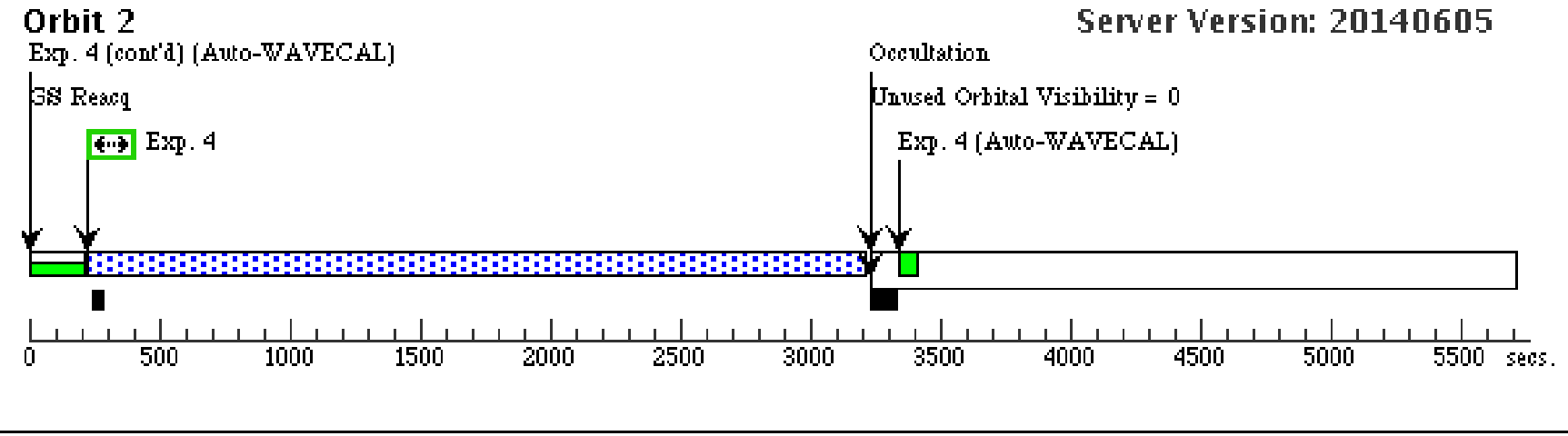
Comments: No target star was identified by the BOT in the observed field. DSS images clearly indicate a bright isolated target star (brightest within 100 arcsec). Clearly the target star is the dominant object in the field of view.

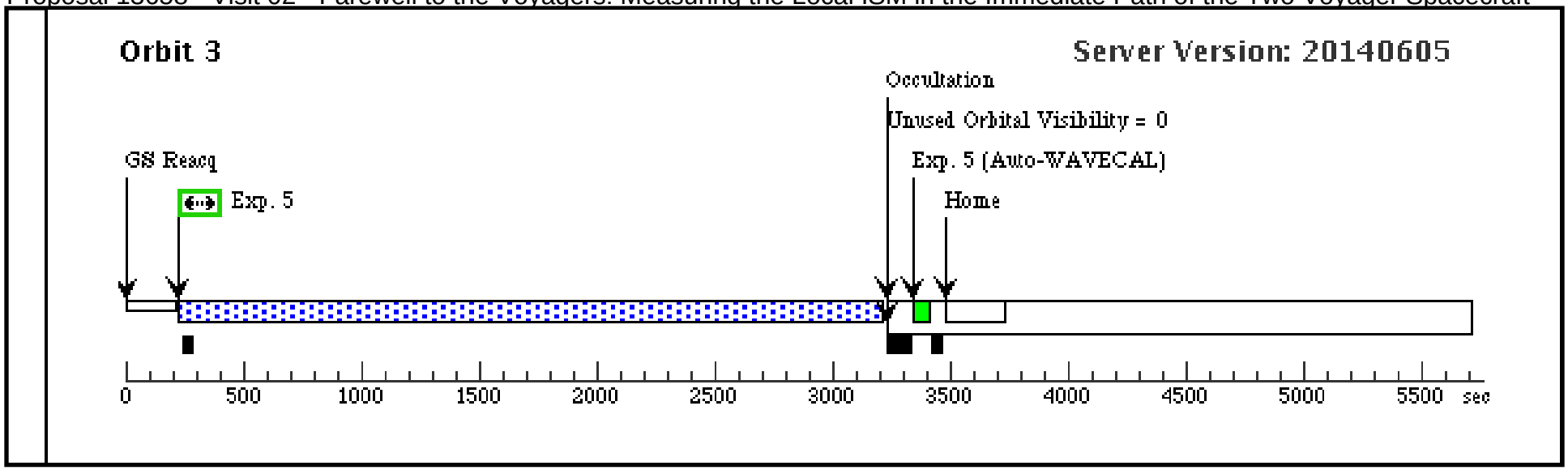
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(STIS.ta.623454)	(2) HIP86287	STIS/CCD, ACQ, F25ND3	MIRROR	ACQTYPE=POINT			3.2 Secs (3.2 Secs)	
								[==>]	***[1]***
	Comments: SNR = 150.2406 *Brightest Pixel = 8,097.14 e*								
2	(STIS.sp.624034)	(2) HIP86287	STIS/CCD, ACQ/PEAK, 0.2X0.09	G430L 4300 A				0.9 Secs (0.9 Secs)	
								[==>]	***[1]***
	Comments: SNR = 13.1192 *Brightest Pixel = 195.14 e* *Global Source Counts = 415,067.349 e*								
3	(STIS.sp.625241)	(2) HIP86287	STIS/NUV-MAMA, ACCUM, 0.2X0.09	E230H 2713 A				1871 Secs (1871 Secs)	
								[==>]	***[1]***
	Comments: SNR = 30.2279 *Brightest Pixel = 364.42 e*								
4	(STIS.sp.625233)	(2) HIP86287	STIS/FUV-MAMA, ACCUM, 0.2X0.2	E140M 1425 A				2979 Secs (2979 Secs)	
								[==>]	***[2]***
	Comments: SNR = 20.5826 *Brightest Pixel = 217.71 e*								
5	(STIS.sp.625233)	(2) HIP86287	STIS/FUV-MAMA, ACCUM, 0.2X0.2	E140M 1425 A				2979 Secs (2979 Secs)	
								[==>]	***[3]***
	Comments: SNR = 20.5826 *Brightest Pixel = 217.71 e*								

Orbit Structure



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Exp. 5
Exp. 5 (Auto-WAVECAL)
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Visit

Proposal 13658, Visit 03 Thu Jul 24 01:11:01 GMT 2014

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/CCD, STIS/FUV-MAMA, STIS/NUV-MAMA

Special Requirements: BETWEEN 22-JUN-2014:00:00:00 AND 01-FEB-2015:00:00:00; BETWEEN 22-JUN-2015:00:00:00 AND 01-FEB-2016:00:00:00; BETWEEN 22-JUN-2016:00:00:00 AND 01-FEB-2017:00:00:00

Fixed Targets

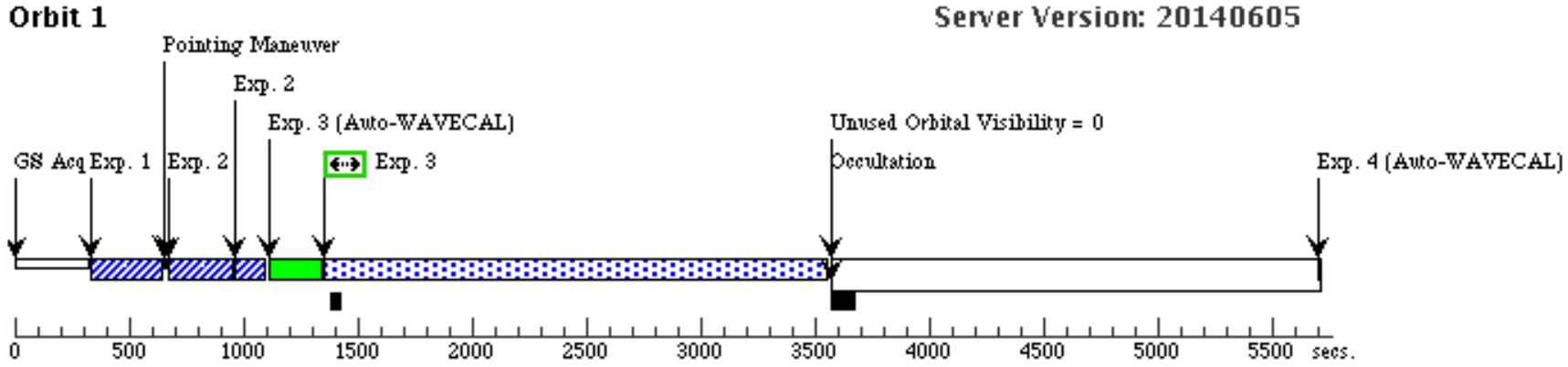
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(3)	GJ780 Alt Name1: DELTA-PAV Alt Name2: HIP99240	RA: 20 08 41.8600 (302.1744167d) Dec: -66 10 45.60 (-66.17933d) Equinox: J2000	Proper Motion RA: +0.200 sec of time/yr Proper Motion Dec: -1.13 arcsec/yr Parallax: 0.16373" Epoch of Position: 1991.25 Radial Velocity: -21.7 km/sec	V=3.56 TYPE=G8IV, B-V=0.76, E(B-V)=0, F-LINE(2796)=11.1e-12, W-LINE(2796)=0.6	Reference Frame: ICRS

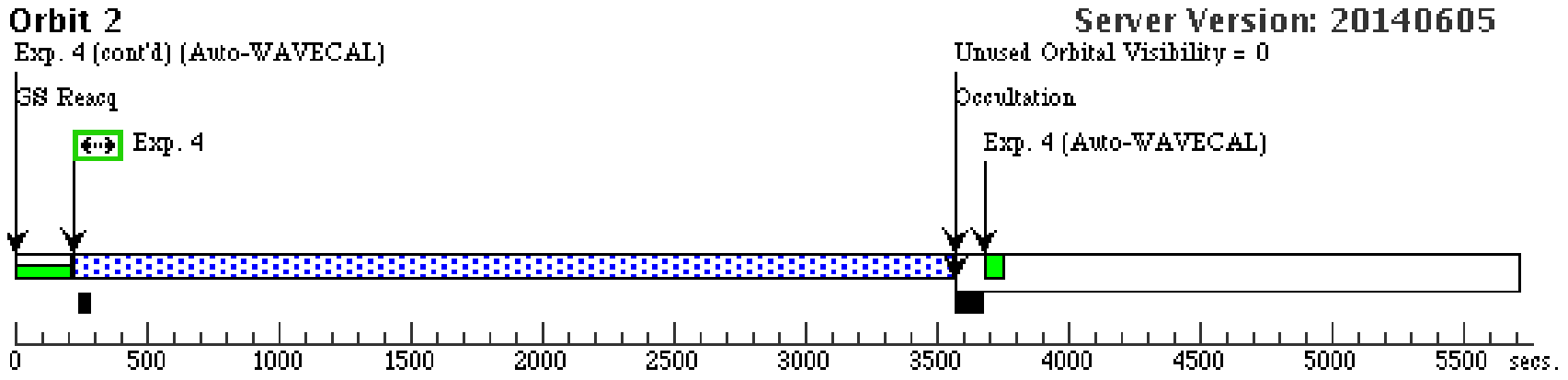
Comments: IUE SPECTRUM: SWP03586, LWP03040
No target star was identified by the BOT in the observed field. DSS images clearly indicate a bright isolated target star. The saturation in the DSS image may be responsible for the BOT being unable to identify a star. Clearly the target star is the dominant object in the field of view.

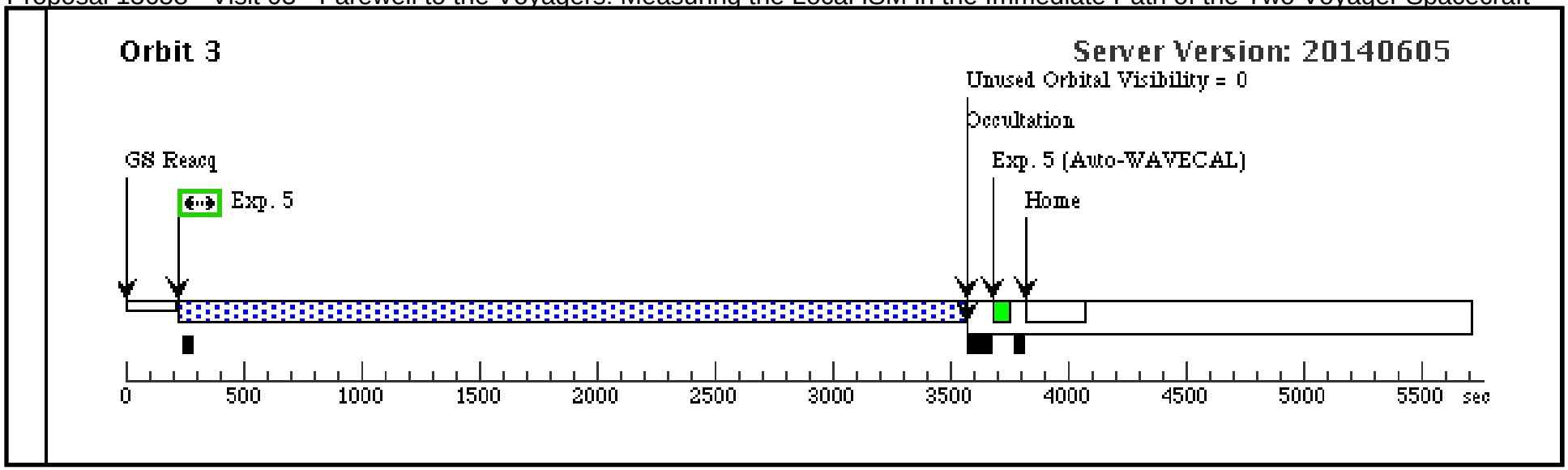
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(STIS.ta.623 468)	(3) GJ780	STIS/CCD, ACQ, F25ND5	MIRROR	ACQTYPE=POINT			3.6 Secs (3.6 Secs) *[==>]*	 ***[1]***
	Comments: SNR = 151.6220 *Brightest Pixel = 8,501.24 e*								
2	(STIS.sp.62 4053)	(3) GJ780	STIS/CCD, ACQ/PEAK, 0.2X0.09	G430M 4451 A				0.2 Secs (0.2 Secs) *[==>]*	 ***[1]***
	Comments: SNR = 93.1010 *Brightest Pixel = 1,037.33 e* *Global Source Counts = 4,971,940.156 e*								
3	(STIS.sp.62 5194)	(3) GJ780	STIS/NUV-MAMA, ACCUM, 0.2X0.09	E230H 2713 A				2185 Secs (2185 Secs) *[==>]*	 ***[1]***
	Comments: SNR = 113.2811 *Brightest Pixel = 4,048.07 e*								
4	(STIS.sp.62 5189)	(3) GJ780	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1271 A				3320 Secs (3320 Secs) *[==>]*	 ***[2]***
	Comments: SNR = 23.1830 *Brightest pixel = 236.04 e*								
5	(STIS.sp.62 5189)	(3) GJ780	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1271 A				3320 Secs (3320 Secs) *[==>]*	 ***[3]***
	Comments: SNR = 23.1830 *Brightest pixel = 236.04 e*								

Orbit Structure



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Exp. 5
Exp. 5 (Auto-WAVECAL)
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Visit

Proposal 13658, Visit 04 Thu Jul 24 01:11:02 GMT 2014

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/CCD, STIS/FUV-MAMA, STIS/NUV-MAMA

Special Requirements: BETWEEN 31-MAY-2014:00:00:00 AND 01-FEB-2015:00:00:00; BETWEEN 31-MAY-2015:00:00:00 AND 01-FEB-2016:00:00:00; BETWEEN 31-MAY-2016:00:00:00 AND 01-FEB-2017:00:00:00

Fixed Targets

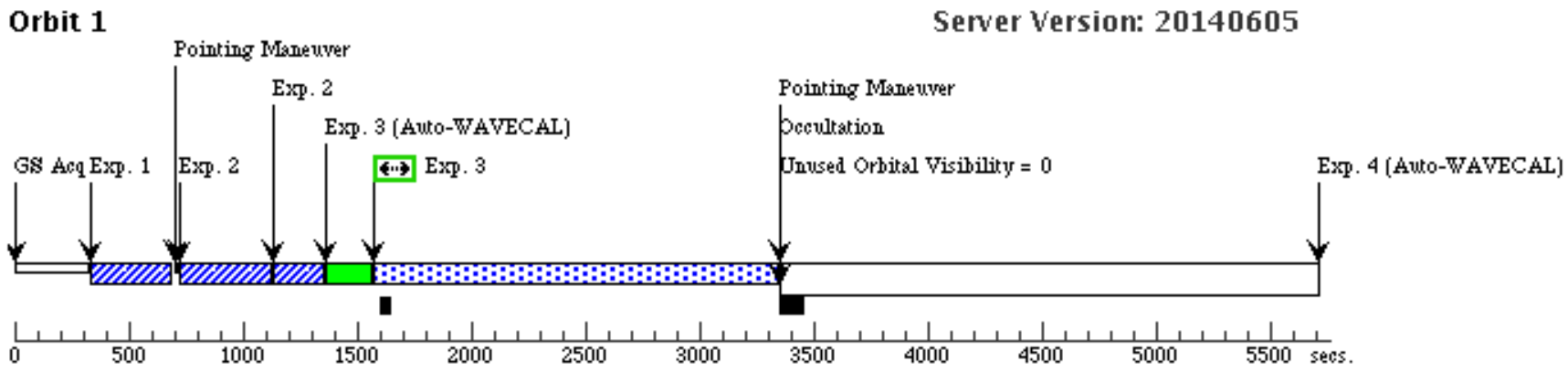
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(4)	GJ754	RA: 19 20 47.9550 (290.1998125d)	Proper Motion RA: +0.0754 sec of time/yr	V=12.23	Reference Frame: ICRS
	Alt Name1: LHS60	Dec: -45 33 28.33 (-45.55787d)	Proper Motion Dec: -3.01 arcsec/yr	TYPE=M4.5,	
		Equinox: J2000	Parallax: 0.169"	B-V=1.7,	
			Epoch of Position: 2000.0	E(B-V)=0,	
				F-LINE(2796)=0.2e-12,	
				W-LINE(2796)=0.35	

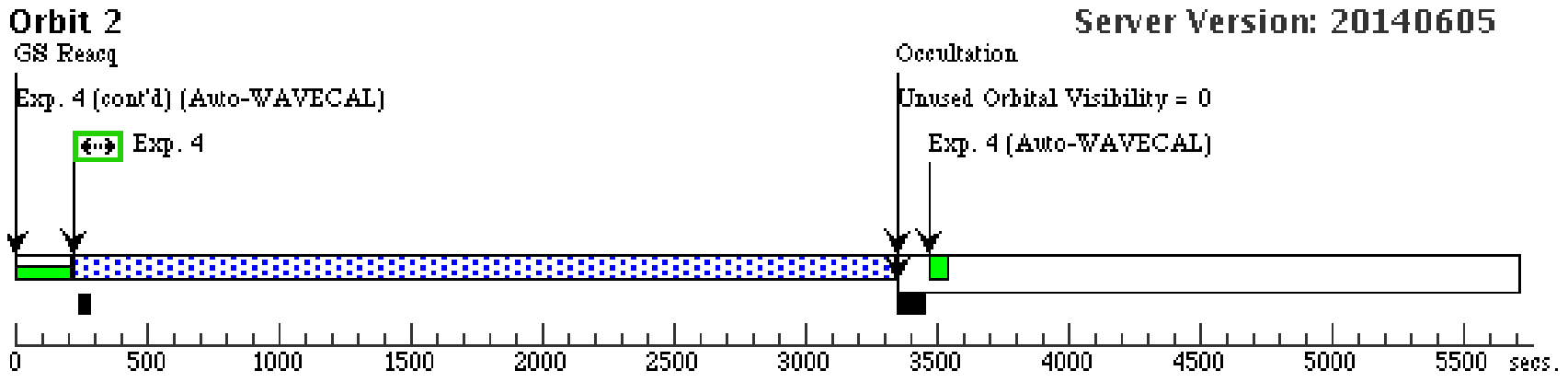
Comments: Target star was identified by the BOT in the observed field. DSS images clearly indicate a bright isolated target star (brightest within 100 arcsec). Clearly the target star is the dominant object in the field of view.

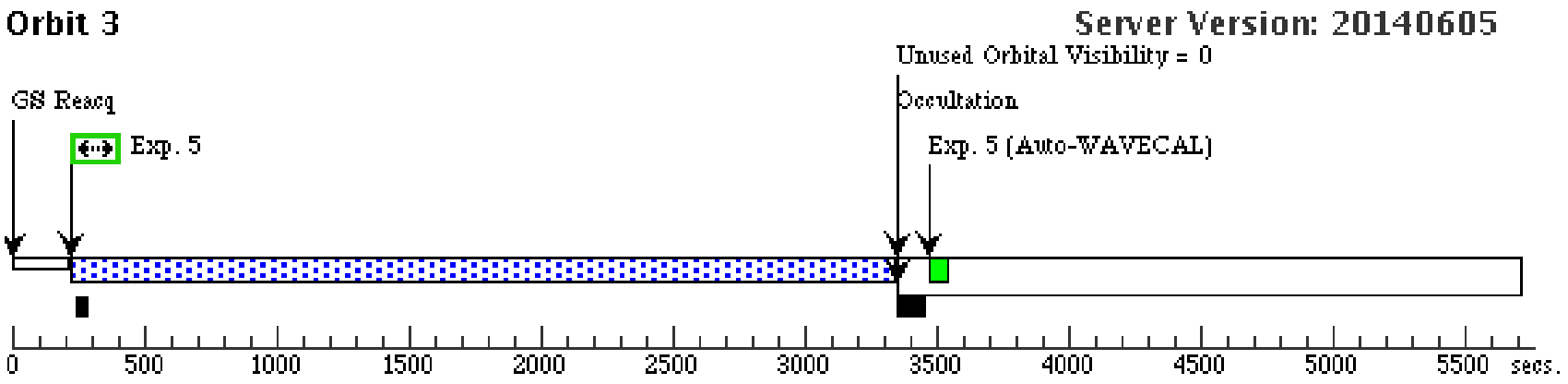
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(STIS.ta.623 477)	(4) GJ754	STIS/CCD, ACQ, F25ND3	MIRROR	ACQTYPE=POINT			15.6 Secs (15.6 Secs)	
								[==>]	***[1]***
	Comments: SNR = 150.1640 *Brightest Pixel = 7,000.17*								
2	(STIS.sp.62 4041)	(4) GJ754	STIS/CCD, ACQ/PEAK, 0.2X0.09	G430L 4300 A				10.8 Secs (10.8 Secs)	
								[==>]	***[1]***
	Comments: SNR = 9.8877 *Brightest Pixel = 229.28 e* *Global Source Counts = 403,281.314 e*								
3	(STIS.sp.62 5246)	(4) GJ754	STIS/NUV-MAMA, ACCUM, 0.2X0.09	E230H 2713 A				1751 Secs (1751 Secs)	
								[==>]	***[1]***
	Comments: SNR = 13.2553 *Brightest Pixel = 82.66 e*								
4	(STIS.sp.62 5249)	(4) GJ754	STIS/FUV-MAMA, ACCUM, 0.2X0.2	E140M 1425 A				3106 Secs (3106 Secs)	
								[==>]	***[2]***
	Comments: SNR = 9.8723 *Brightest Pixel = 51.65 e*								
5	(STIS.sp.62 5249)	(4) GJ754	STIS/FUV-MAMA, ACCUM, 0.2X0.2	E140M 1425 A				3106 Secs (3106 Secs)	
								[==>]	***[3]***
	Comments: SNR = 9.8723 *Brightest Pixel = 51.65 e*								
6	(STIS.sp.62 5249)	(4) GJ754	STIS/FUV-MAMA, ACCUM, 0.2X0.2	E140M 1425 A				3106 Secs (3106 Secs)	
								[==>]	***[4]***
	Comments: SNR = 9.8723 *Brightest Pixel = 51.65 e*								
7	(STIS.sp.62 5249)	(4) GJ754	STIS/FUV-MAMA, ACCUM, 0.2X0.2	E140M 1425 A				3106 Secs (3106 Secs)	
								[==>]	***[5]***
	Comments: SNR = 9.8723 *Brightest Pixel = 51.65 e*								

Orbit Structure



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Unused Orbital Visibility = 0
GS Reacq
Occultation
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Exp. 5 (Auto-WAVECAL)
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3500
4000
4500
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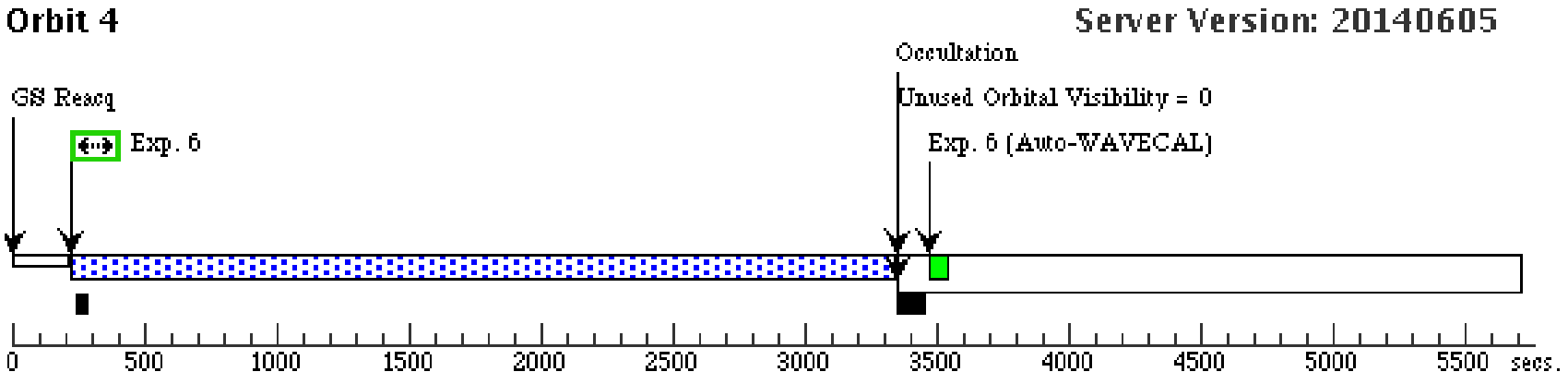
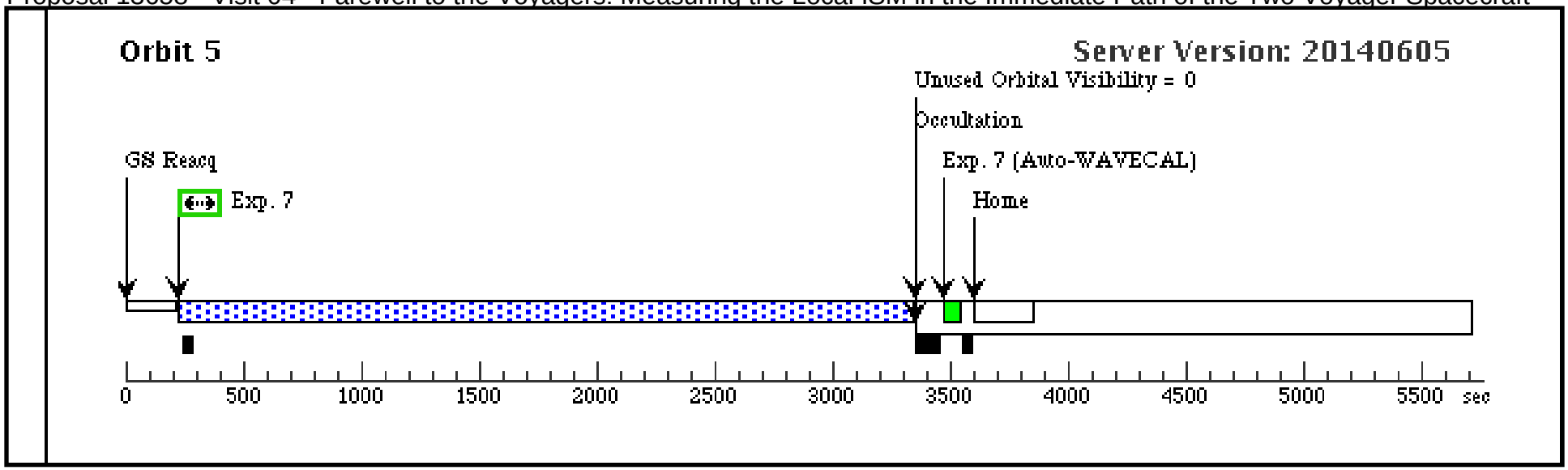
5500
secs.


Orbit 4
Server Version: 20140605
Occultation
GS Reacq
Unused Orbital Visibility = 0
Exp. 6
Exp. 6 (Auto-WAVECAL)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs.


Orbit 5
Server Version: 20140605
Unused Orbital Visibility = 0
Occultation
GS Reacq
Exp. 7
Exp. 7 (Auto-WAVECAL)
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec