12981 - Our Interstellar Backyard: Determining the Boundary Conditions for the Heliosphere

Cycle: 20, Proposal Category: GO

(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) SIRIUSA (2) SIRIUSB	STIS/CCD STIS/FUV-MAMA STIS/NUV-MAMA	5	21-Feb-2014 21:01:41.0	yes
51	(3) SIRIUSA-COPY (4) SIRIUSB-COPY	STIS/CCD STIS/FUV-MAMA STIS/NUV-MAMA	5	21-Feb-2014 21:02:06.0	yes

10 Total Orbits Used

ABSTRACT

Understanding the outer heliosphere, which is formed from the interaction of the solar wind and the Local Interstellar Cloud (LIC) surrounding the Sun, is essential to interpreting the data from the NASA Voyager 1, Voyager 2, and IBEX missions and for being able to characterize our past and future galactic environment. We propose to determine the boundary conditions of the heliosphere from high resolution (114,000-200,000) and high

signal-to-noise (50-200) STIS UV observations of the LIC toward the nearby white-dwarf Sirius B. With these observations, we will be able to independently and accurately determine the LIC temperature, density and ionization, which are the required parameters to set the boundary conditions. We will use the CIV diagnostic to search for and characterize the conductive interface theoretically required to maintain the He ionization and explain interstellar neutrals observed inside of the heliosphere. The high spectral resolution and high sensitivity data are key to modeling weak (CII*, MgI, CIV) and strong features (e.g., OI, CII) and to resolve the two clouds known to exist along this sightline. The results of this study will provide a detailed look at the heliosphere boundary conditions from an interstellar perspective for comparison with the results of MHD heliosphere models and a better understanding of the ionization conditions in galactic warm, diffuse, partially-ionized interstellar gas. Only STIS on HST can provide the key missing diagnostics to help us understand the heliospheric observations made by these NASA missions.

OBSERVING DESCRIPTION

We plan to observe Sirius B, the white-dwarf companion of Sirius A, with STIS E140H and E230H in three different settings and at the highest possible S/N with the number of approved orbits to achieve our scientific objectives. The target acquisition strategy is explained in the Additional Comments.

- E140H - 1271 - 0.1x0.03: With this setting, we will cover the following species: HI 1215, DI 1215, C II 1334, C II* 1335, N I 1199,1200,1201, O I 1302, Si II 1190, 1193, 1260, 1304, Si III 1206, and S II 1250 1253, 1259. The most important species and weakest transition for our science goals is CII*. We require to have S/N~80 at 1335, allowing us to have a 5 sigma detection of CII*. We will use the Jenkins slit, which will allow us to achieve the highest possible resolution of 1.5 km/s. We favor this slit over the wider slits because in this wavelength setting, we have a large number of ions that we can model with the best STIS resolution. This gain is invaluable for determining accurate column densities and the temperature of the gas. The value of b_instr. = 0.9 km/s means that the intrinsic properties of the gas will dominate the broadening. The highest resolution will also allow us to best separate the Blue Cloud (BC) and Local Interstellar cloud (LIC) components that are separated by 6 km/s. To estimate the flux at 1335 A, we use the previous GHRS ECH-A observations (Z3G0510RT) that gives F=1.2e-10 cgs.

- E140H - 1489 - 0.2x0.09: With this setting, we will cover the following species CIV 1548, 1550, SiIV 1393, 1402, SiII 1526. The most important ion is CIV. We therefore require to have minimum S/N~70 at lambda~1550, which will allow us to have a 4-5 sigma detection of CIV. There is no HST observation at 1500 A. The IUE observations of Sirius B through the large aperture (swp02751) gives F = 1.3e-10 cgs at 1300, which is quite similar to the STIS observations, but overestimates the flux at 1800 A compared to the HST observations. We therefore used several HST standard DA WD and set the flux at 1.2e-10 cgs at 1300 to estimate the S/N at 1550, all giving about the same S/N for the same exposure time.

- E230H - 2762, 2812, 2862, 2912 - 0.2x0.09: With these settings, we will cover the following species: MgII 2796, 2803 and MgI 2852. All three features are key for our observations, but the MgI absorption will be the weakest. We need S/N~200 to have a 3-4 sigma detection of MgI at 2852 A. In the high resolution mode, using FP-SPLIT would require to use too many short exposures according to the STIS handbook. As the MgI and MgII lines are present in four different central wavelength settings, we use that approach to eliminate the fixed-pattern noise. At 2852 A, F = 9.7e-12 cgs based on HST STIS G230MB observations (O8P901040).

ADDITIONAL COMMENTS

We have tested several methods to acquire Sirius and came to the conclusion that the most accurate way was to first acquire Sirius A and then slew to Sirius B from the offset we estimated below.

To make sure that Sirius is centered on the aperture, we will now first obtain an image of Sirius B using F28X50OII. This filter will maximize the contrast between Sirius B and the scattered light from Sirius A. Indeed, we note that from the failed observations that if we assume that the observed was solely from the diffuse light of Sirius A, it is 1/153 times the flux of Sirius B at 2850 A. At 3740 A, the flux of Sirius B is about 1/2 its value at 2850. Using ETC generated spectrum of Sirius A (STIS.sp.537050) and STIS observations OBLNO1040 of Sirius A, we estimate that the flux ratio between 2850 and 3740 is close to a factor of two. So even if the light that entered the aperture in the May 2013 observations was due to Sirius A, it would still be a factor of 40 less than that from Sirius B (as the actual spectrum did look like the expected spectrum of Sirius B, the relative amount of scattered light from Sirius A must have been much smaller than assumed above). So the ACQ of Sirius B should be obtained with no issue, which will then be followed with an ACQ/PEAK 0.2x0.09 and ACQ/PEAK 0.1x0.03 to center Sirius B on the aperture.

As there are currently two epoch in 2014 where Sirius B can be observed we calculate the coordinates at the median of both epoch windows: 2014.1116 and 2014.2211.

Estimation of the coordinates of Sirius A for the observing windows:

Using WFC2 and WFC3 images, we determined the position of Sirius A:

YYYY-MM-DD RA DEC

Sirius A 2011-10-01 06 45 08.294 -16 43 12.23

Sirius A 2008-01-03 06 45 08.470 -16 43 08.03

There are 3.74103 years between the two exposures. The proper motion of Sirius A is therefore
pm_RA (marcsec/yr) pm_DEC (marcsec/yr)
Sirius A -705.7 -1122.7

From this proper motion, we estimated the RA and DEC of Sirius A for the epoch of the scheduled observations.
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For Epoch = 2014.1116, the position of Sirius A is:
Sirius A: 06 45 8.182 -16 43 14.88
For Epoch = 2014.2211, the position of Sirius A is:
Sirius A: 06 45 8.178 -16 43 15.01
===

Estimation of the offset between Sirius A and B for the new observing windows:

Below is the position of Sirius B relative to Sirius A. The three columns provide the epoch, position angle and separation. Separation is measured in seconds of arc. Position angle is measured from north through east, i.e., due north is 0 degrees, due east is 90 degrees, etc. These calculations were kindly provided by Brian Mason (US Naval Observatory).

Orbital elements are as follows:
P = 50.0899 a = 7.5916 i = 135.1708 W = 224.2615
T = 1894.0609 e = 0.5920 w = 326.3971

Epoch	theta	sep
2014.1116	80.25	10.1112
2014.2211	80.00	10.1405

The offsets in RA and DEC for Sirius B relative to Sirius A for are therefore:

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Epoch = 2014.1116:

dRA_s = sin(theta) * sep * cos(DEC_Sirius)/15. = 0.636 +/- 0.001 seconds

dDEC = cos(theta) * sep = 1.712 +/- 0.003 arcseconds

Epoch = 2014.2211

dRA_s = sin(theta) * sep * cos(DEC_Sirius)/15. = 0.638 +/- 0.001 seconds

dDEC = cos(theta) * sep = 1.761 +/- 0.003 arcseconds

==

For Epoch = 2014.1116, the position of Sirius B should therefore be:

Sirius B: 06 45 8.819 -16 43 13.171

For Epoch = 2014.2211, the position of Sirius B should therefore be:

Sirius B: 06 45 8.815 -16 43 13.246

==

Test of accuracy:

Brian Mason also calculated the ephemeris for Sirius for the two epochs where there are WFC2 and WFC3 images of Sirius. From these images, we measured the RA and DEC of Sirius A and B. This leads to:

We estimated RA, DEC for Sirius A from WFC2 image, and then find RA, DEC of Sirius B using the ephemeris 2008.0060 97.83 8.0054

Sirius B 2008.0060: 06 45 08.98 -16 43 09.12

compared to position of Sirius B in WFC2 image: 06 45 09.02 -16 43 09.10

We estimated RA, DEC for Sirius A from WFC2 image, and then find RA, DEC of Sirius B using the ephemeris 2011.7488 86.12 9.4013

Sirius B 2011.7488: 06 45 08.89 -16 43 11.59

compared to position of Sirius B in WFC2 image: 06 45 08.95 -16 43 11.56

Visit

Proposal 12981, Visit 01, failed Sat Feb 22 02:02:19 GMT 2014

Diagnostic Status: No Diagnostics

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

Special Requirements: (none)

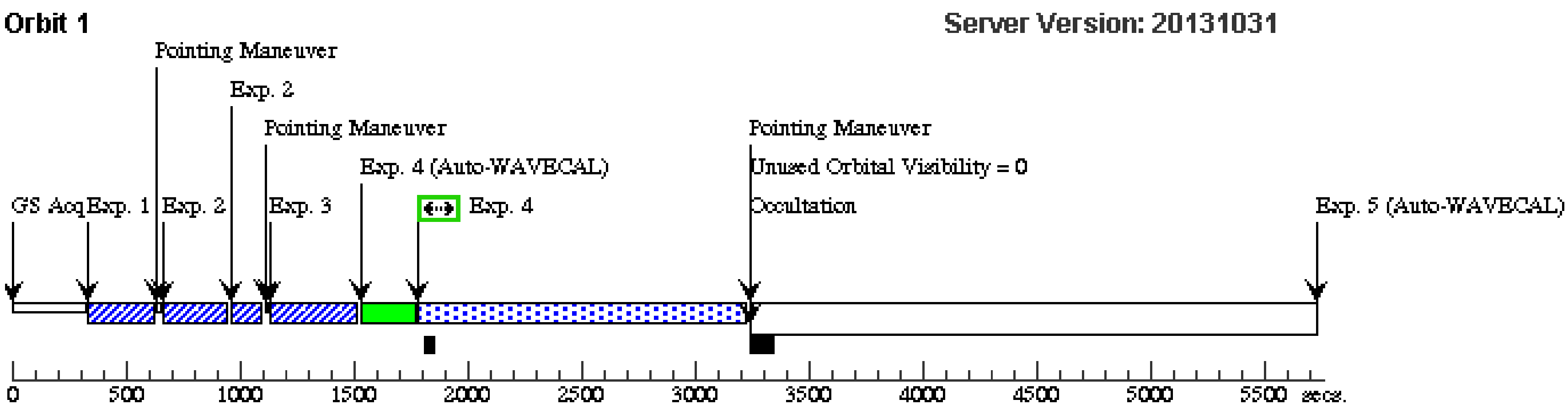
Fixed Targets

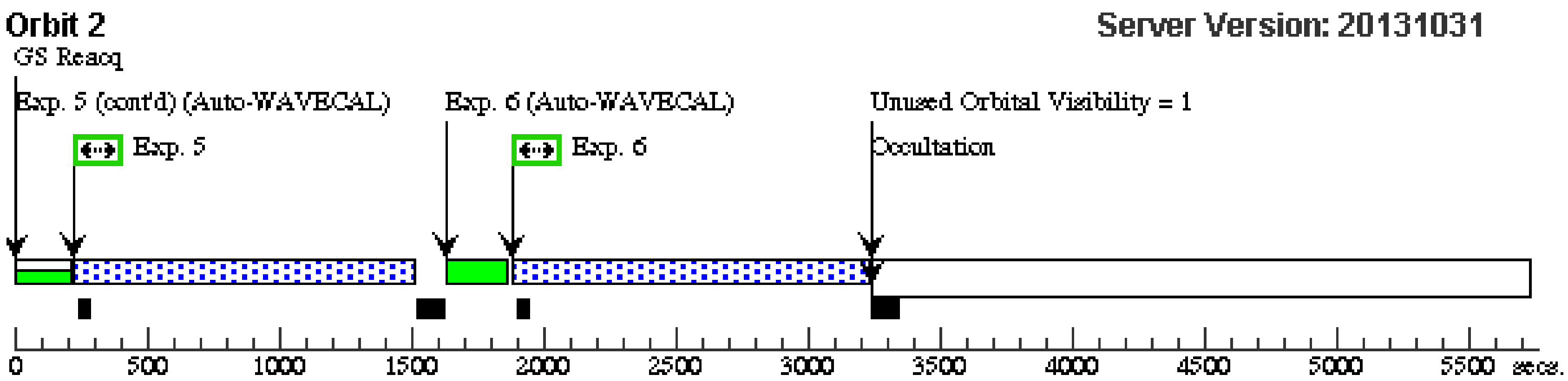
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	SIRIUSA	RA: 06 45 8.2180 (101.2842417d) Dec: -16 43 14.04 (-16.72057d) Equinox: J2000	Proper Motion RA: -705.7 mas/yr Proper Motion Dec: -1122.7 mas/yr Epoch of Position: 2013.36	V=-1.47	Reference Frame: ICRS
Comments: We estimated the position of Sirius A for epoch 2013.36 by correcting for its proper motion using the 2008 and 2011 HST observations rather than using the Hipparcos proper motions because the latter would give a position that is offset relative to the 2008 and 2011 observations.					
(2)	SIRIUSB	Offset from SIRIUSA RA Offset: 0.6537 Secs Dec Offset: 1.3735 Arcsec		V=8.44+/-0.01 F(1335) = 1.2E-10 cgs, F(2850) = 1E-11 cgs (GHRS/STIS)	Offset Position (SIRIUSB)
Comments: Brian Mason (USNO) has calculated accurate ephemeris for Sirius for the scheduled observations at epochs 2013.3367 to 2013.3846 (see Additional Comments for more details).					

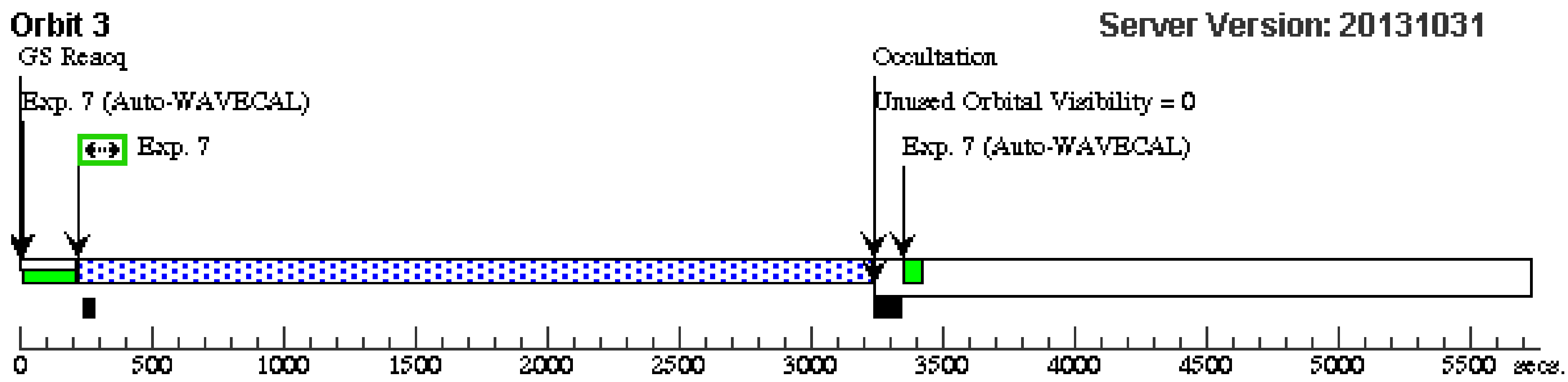
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(STIS.ta.495719)	(1) SIRIUSA	STIS/CCD, ACQ, F25ND5	MIRROR				0.1 Secs (0.1 Secs) *[==>]*	***[1]***
2	(STIS.sp.494668)	(2) SIRIUSB	STIS/CCD, ACQ/PEAK, 0.2X0.09	G230LB 2375 A				1 Secs (1 Secs) *[==>]*	***[1]***
3	(STIS.sp.494668)	(2) SIRIUSB	STIS/CCD, ACQ/PEAK, 0.1X0.03	G230LB 2375 A				1 Secs (1 Secs) *[==>]*	***[1]***
4	(STIS.sp.496828)	(2) SIRIUSB	STIS/FUV-MAMA, ACCUM, 0.1X0.03	E140H 1271 A				1579.0 Secs (1425 Secs) *[==>1425.0 Secs]*	***[1]***
5	(STIS.sp.495931)	(2) SIRIUSB	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1489 A				1250 Secs (1274 Secs) *[==>1274.0 Secs]*	***[2]***
6	(STIS.sp.495933)	(2) SIRIUSB	STIS/NUV-MAMA, ACCUM, 0.2X0.09	E230H 2762 A				1250 Secs (1332 Secs) *[==>1332.0 Secs]*	***[2]***
7	(STIS.sp.495934)	(2) SIRIUSB	STIS/NUV-MAMA, ACCUM, 0.2X0.09	E230H 2812 A				2980 Secs (2992 Secs) *[==>2992.0 Secs]*	***[3]***
8	(STIS.sp.495935)	(2) SIRIUSB	STIS/NUV-MAMA, ACCUM, 0.2X0.09	E230H 2862 A				2980 Secs (2992 Secs) *[==>2992.0 Secs]*	***[4]***
9	(STIS.sp.495936)	(2) SIRIUSB	STIS/NUV-MAMA, ACCUM, 0.2X0.09	E230H 2912 A				2980.0 Secs (2992 Secs) *[==>2992.0 Secs]*	***[5]***

Orbit Structure



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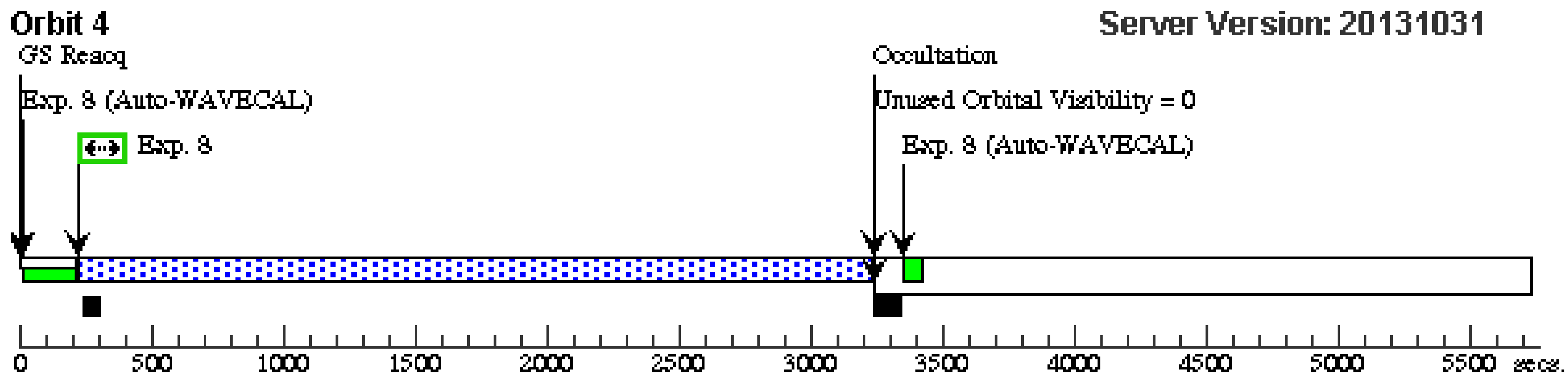
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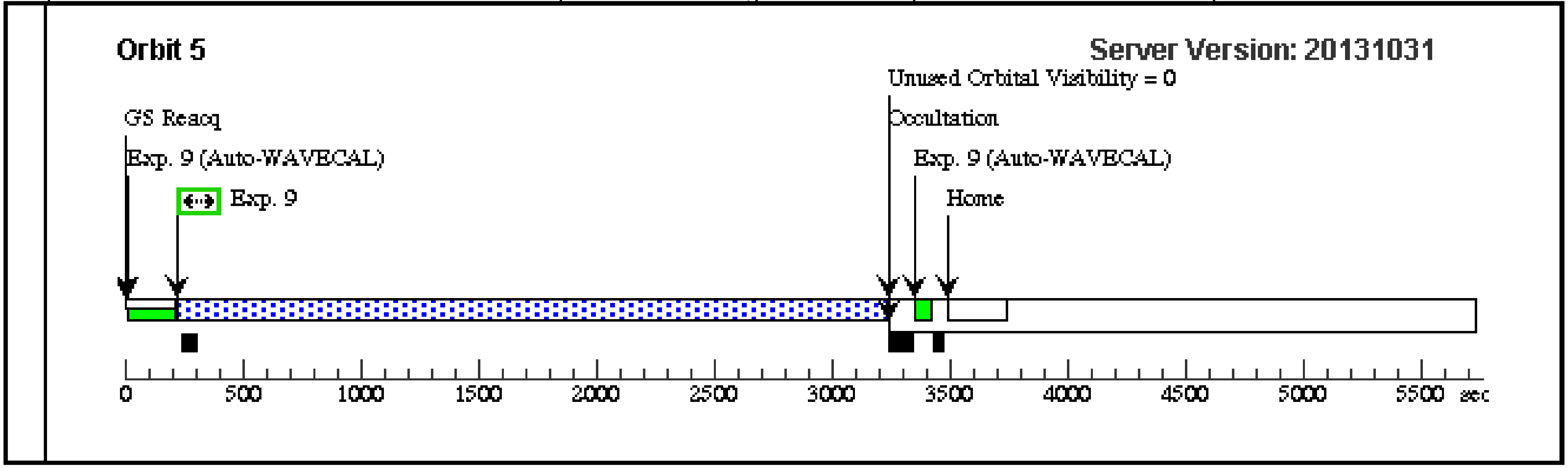
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sec

Visit

Proposal 12981, Visit 51, implementation Sat Feb 22 02:02:23 GMT 2014

Diagnostic Status: No Diagnostics

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

Special Requirements: ORIENT 10D TO 60 D; ORIENT 100D TO 150 D; ORIENT 190D TO 240 D; ORIENT 280D TO 330 D; BETWEEN 10-MAR-2014:00:00:00 AND 01-APR-2014:00:00:00

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(3)	SIRIUSA-COPY	RA: 06 45 8.1780 (101.2840750d) Dec: -16 43 15.01 (-16.72084d) Equinox: J2000	Proper Motion RA: -705.7 mas/yr Proper Motion Dec: -1122.7 mas/yr Epoch of Position: 2014.2211	V=-1.47	Reference Frame: ICRS

Comments: We estimated the position of Sirius A for epoch 2014.2211 by correcting for its proper motion using the 2008 and 2011 HST observations rather than using the Hipparcos proper motions because the latter would give a position that is offset relative to the 2008 and 2011 observations.

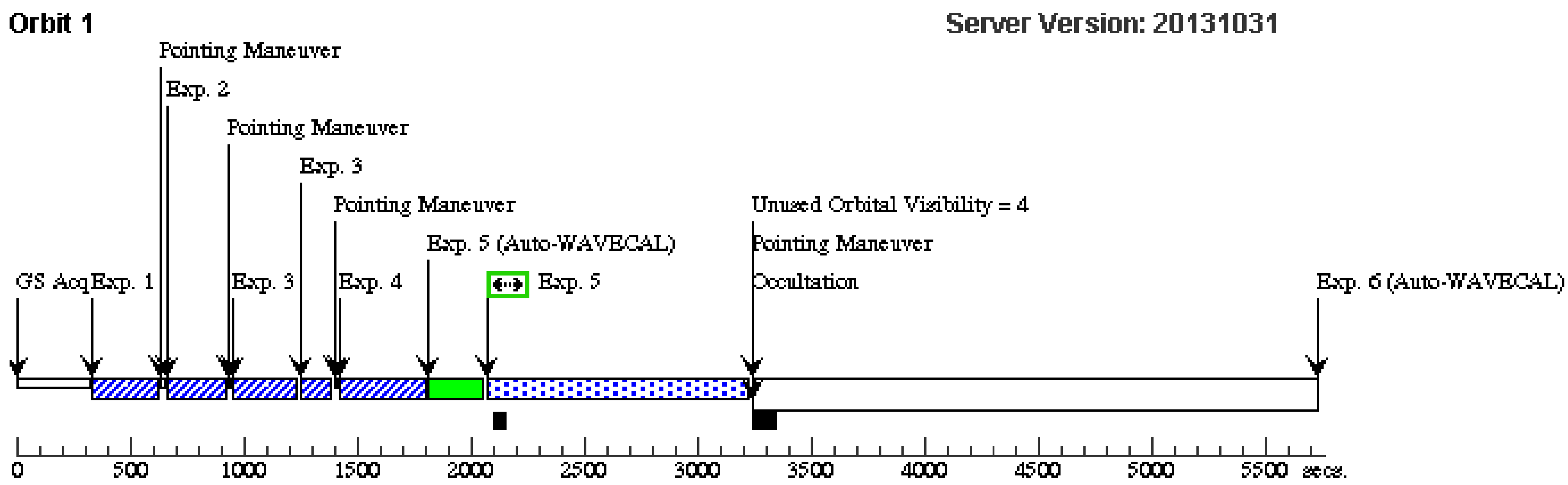
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(4)	SIRIUSB-COPY	Offset from SIRIUSA-COPY RA Offset: 0.638 Secs Dec Offset: 1.761 Arcsec		V=8.44+/-0.01 F(1335) = 1.2E-10 cgs, F(2850) = 1E-11 cgs (GHRS/STIS)	Offset Position (SIRIUSB-COPY)

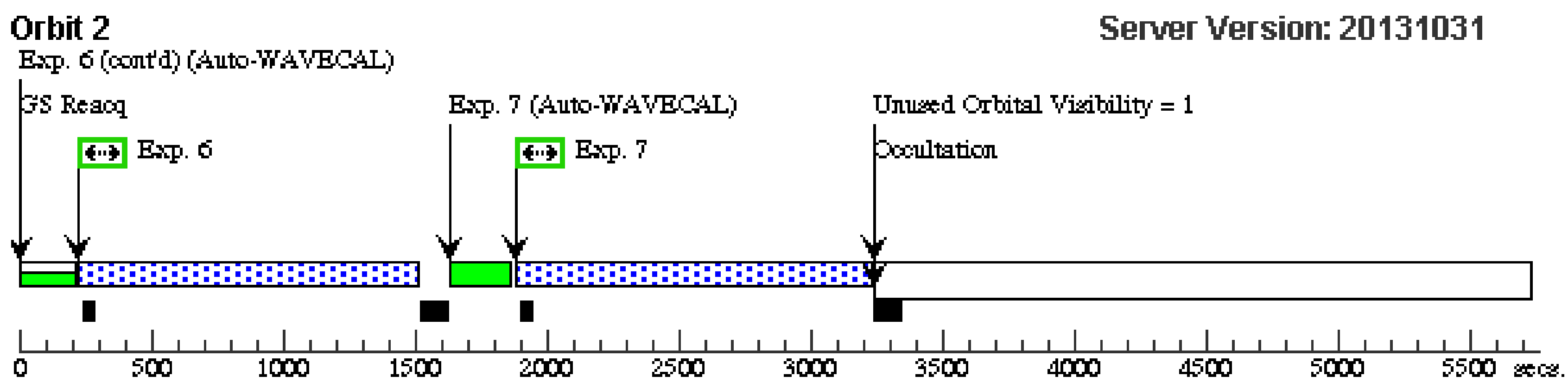
Comments: Brian Mason (USNO) has calculated accurate ephemeris for Sirius for the scheduled observations at epoch 2014.2211.

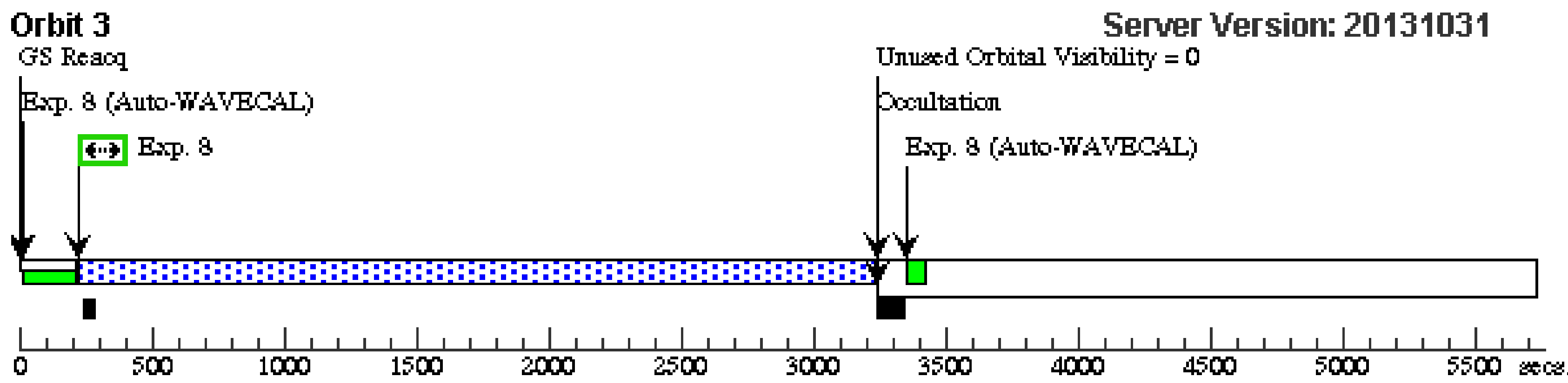
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(STIS.ta.495719)	(3) SIRIUSA-COPY	STIS/CCD, ACQ, F25ND5	MIRROR		GS ACQ SCENARIO BASE1B3		0.1 Secs (0.1 Secs) *[==>]*	***[1]***
2	(STIS.im.520220)	(4) SIRIUSB-COPY	STIS/CCD, ACQ, F28X50OII	MIRROR				0.1 Secs (0.1 Secs) *[==>]*	***[1]***
3	(STIS.sp.494668)	(4) SIRIUSB-COPY	STIS/CCD, ACQ/PEAK, 0.2X0.09	G230LB 2375 A				1 Secs (1 Secs) *[==>]*	***[1]***
4	(STIS.sp.494668)	(4) SIRIUSB-COPY	STIS/CCD, ACQ/PEAK, 0.1X0.03	G230LB 2375 A				1 Secs (1 Secs) *[==>]*	***[1]***
5	(STIS.sp.520221)	(4) SIRIUSB-COPY	STIS/FUV-MAMA, ACCUM, 0.1X0.03	E140H 1271 A				1134.0 Secs (1134 Secs) *[==>]*	***[1]***
6	(STIS.sp.495931)	(4) SIRIUSB-COPY	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1489 A				1250 Secs (1274 Secs) *[==>1274.0 Secs]*	***[2]***
7	(STIS.sp.495933)	(4) SIRIUSB-COPY	STIS/NUV-MAMA, ACCUM, 0.2X0.09	E230H 2762 A				1250 Secs (1332 Secs) *[==>1332.0 Secs]*	***[2]***
8	(STIS.sp.495934)	(4) SIRIUSB-COPY	STIS/NUV-MAMA, ACCUM, 0.2X0.09	E230H 2812 A				2980 Secs (2992 Secs) *[==>2992.0 Secs]*	***[3]***
9	(STIS.sp.495935)	(4) SIRIUSB-COPY	STIS/NUV-MAMA, ACCUM, 0.2X0.09	E230H 2862 A				2980 Secs (2992 Secs) *[==>2992.0 Secs]*	***[4]***
10	(STIS.sp.495936)	(4) SIRIUSB-COPY	STIS/NUV-MAMA, ACCUM, 0.2X0.09	E230H 2912 A				2980.0 Secs (2992 Secs) *[==>2992.0 Secs]*	***[5]***

Orbit Structure



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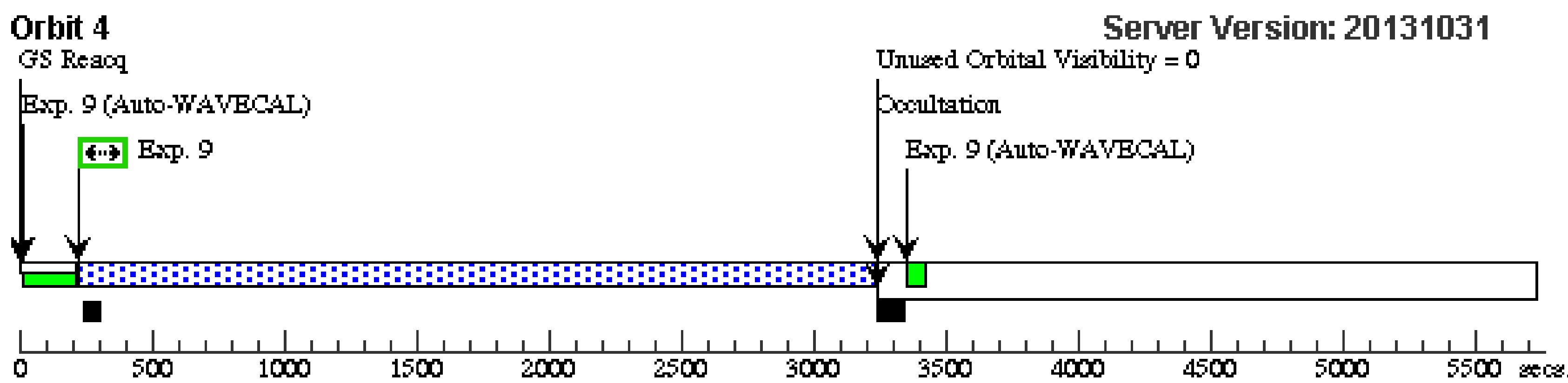
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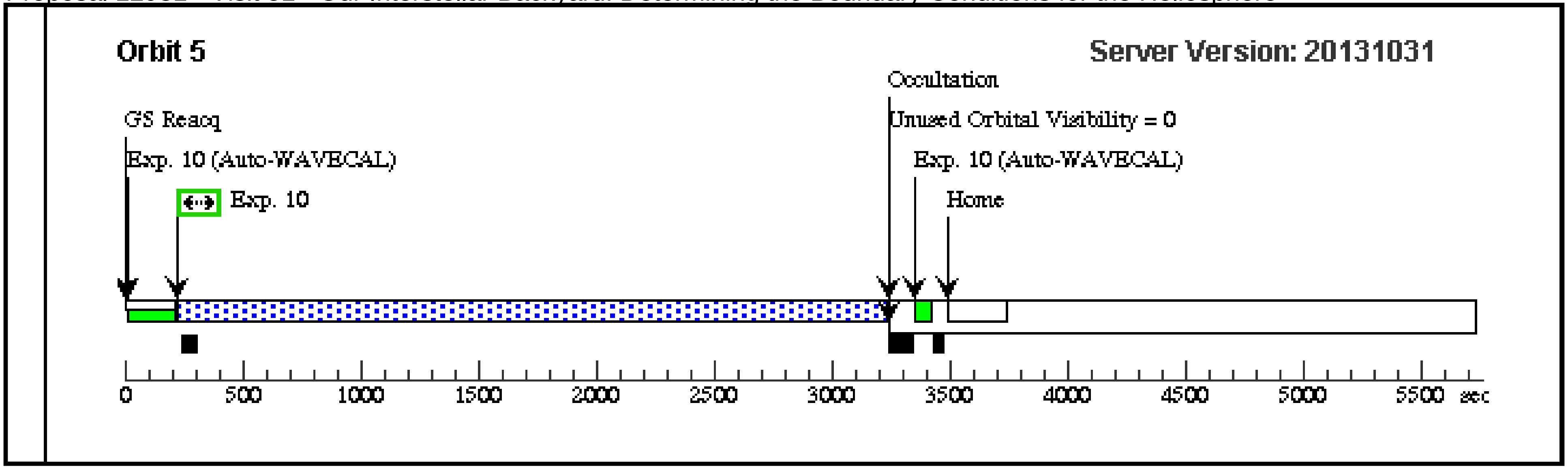
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