13781 - WO-Type Wolf-Rayet Stars: the Last Hurrah of the Most Massive Stars?

Cycle: 22, 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) LH41-1042 (2) LMC195-1 (4) LH41-44OFFSET	COS/FUV COS/NUV	3	29-Sep-2014 21:06:15.0	yes
02	(3) SAND2	COS/FUV	3	29-Sep-2014 21:06:17.0	yes
03	(1) LH41-1042 (2) LMC195-1 (4) LH41-44OFFSET	STIS/CCD STIS/FUV-MAMA STIS/NUV-MAMA	3	29-Sep-2014 21:06:19.0	yes

9 Total Orbits Used

ABSTRACT

WO-type Wolf-Rayet (WR) stars are considered the final evolutionary stage of the highest mass stars, immediate precursors to Type Ic (He-poor) core-collapse supernovae. These WO stars are rare, and until recently only 6 were known. Our knowledge about their physical properties is mostly

based on a single object, Sand 2 in the LMC. It was the only non-binary WO star both bright and unreddened enough that its FUV and NUV spectra could be obtained by FUSE and HST/FOS. A non-LTE analysis showed that Sand 2 is very hot and its (C+O)/He abundance ratio is higher than that found in WC-type WRs, suggesting it is indeed highly evolved. However, the O VI resonance doublet in the FUV required a considerably cooler temperature (120,000 K) model than did the optical O VI lines (170,000 K). Further, the enhanced chemical abundances did not match the predictions of stellar evolutionary models. Another non-LTE study found a 3x higher (C+O)/He abundance ratio and a cooler temperature. We have recently discovered two other bright, single, and lightly reddened WOs in the LMC, allowing us to take a fresh look at these important objects. Our newly found WOs span a range in excitation type, from WO2 to WO4. Sand 2 is intermediate (WO3). We will use COS and STIS to obtain FUV and NUV spectra. These UV data will be combined with ground-based optical and NIR Magellan spectra for a detailed analysis with CMFGEN with the latest atomic data. Knowing the degree of chemical evolution of these WO stars is crucial to determining their evolutionary status, and thus in understanding the final stages of the most massive stars.

OBSERVING DESCRIPTION

Overview: We will observe three WO-type Wolf-Rayet stars: LH41-1042, LMC195-1, and Sand2 as follows:

Sand 3: 3 orbit COS with two G130M settings. All exposures take place at all four FP-POS in order to improve the signal-to-noise.

LH41-1042 and LMC195-1. These stars are located in the Lucke-Hodge 41 region, and are separated from each other by 8-arcsec. (aWe will obtain a 3-orbit observation with COS G130M/1096 to obtain the critical OVI 1032,38 line. Because of the close proximity of a B0.2 supergiant (which a F225W WFC3 exposure shows to be a 0.3" separated double) there are safety concerns with the other FUV settings, and so we then devote a 4-orbit visit with STIS to obtain
both FUV and NUV spectra.

Acqusition: The acquisition of Sand 2 is straightforward, as the region is not crowded; there are 18-19th mag stars 10" away. Sand 2 is in the GSC-II and we use those coordinates. We use the PSA and Mirror B.

The field containing LH41-1042 and LMC195-1 is somewhat crowded with bright blue stars and we do the acquistion in dispersed light throught he PSA with COS on a nearby offset star (LH41-1042, a V=13.28 B1 I).

Science exposures: We are fortunate that Sand 2 has been previously observed with FUSE and HST/FOS, and hence we know the observed fluxes. We use this spectrum to estimate exposure times, and scale for the other two stars using the F225W fluxes measured from our WFC3 image.

Sand 2 (FOS fluxes averaged over the F225W bandpass): 1.3E-14
LH41-1042 F225W bandpass: 4.0E-14
LMC195-1 F225W bandpass: 1.4E-14

Safety concerns: the Lucke-Hodge 41 field containing LMC195-1 and LH41-1042 is crowded with bright blue stars. Fortunately, we have two excellent resources: (a) All of the potentially dangerous stars have spectral types, either published or from our own recent Magellan data. (b) We have a WFC3 F225W exposure that allows us to measure the NUV flux of potential hazards. Full details have been forward to Dr. Nolan Walborn on July 14th, along with a figure.
Using a the combined flux of 4.27E-13 for this B0.2I composite, an effective wavelength of 2374A, adopting the B1V Kurucz model (which should have a similar temperature to that of a B0.2 supergiant), and using E(B-V)=0.13 with an LMC reddening law, we find that the G130M/1096 exposures should be safe (ETC 620478) but that other COS FUV exposures would not be.
There are no safety concerns with this star with STIS using the 0.2"x0.2" aperture as only
one of the two components could fall into the aperture at a given time.

Visit

Proposal 13781, LH41COS (01), implementation Tue Sep 30 01:06:20 GMT 2014

Diagnostic Status: Warning

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: (none)

Diagnostics

(LH41COS (01)) Warning (Orbit Planner): INEFFICIENT ORDERING OF FP-POS POSITIONS

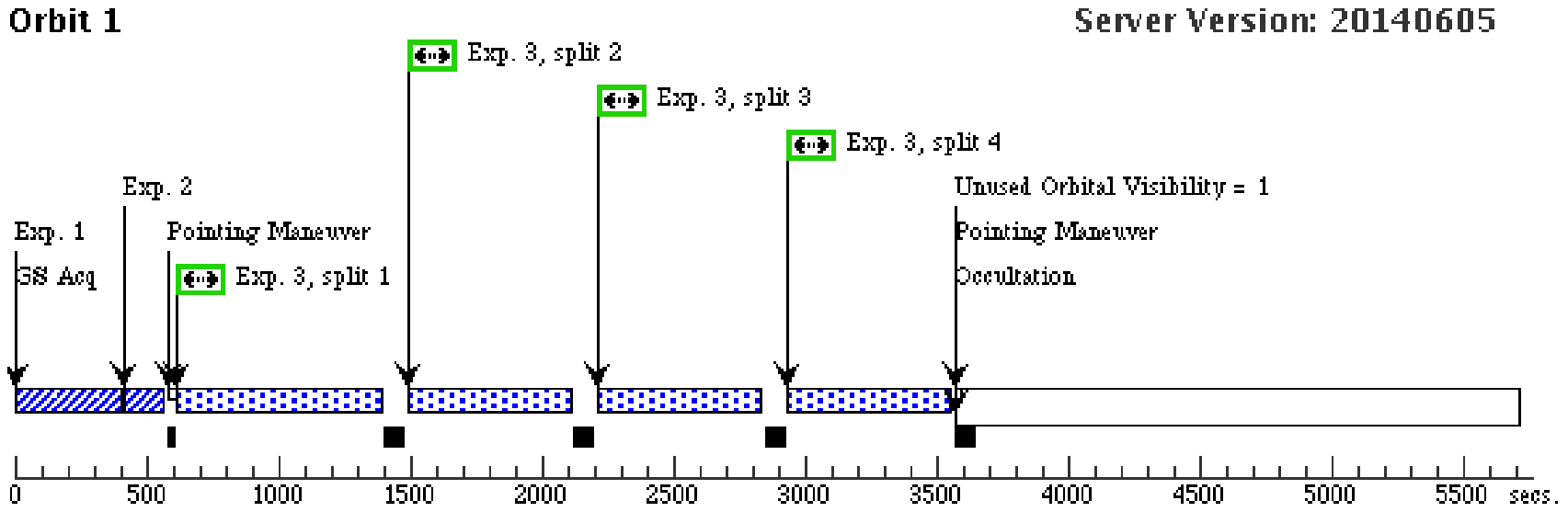
Fixed Targets

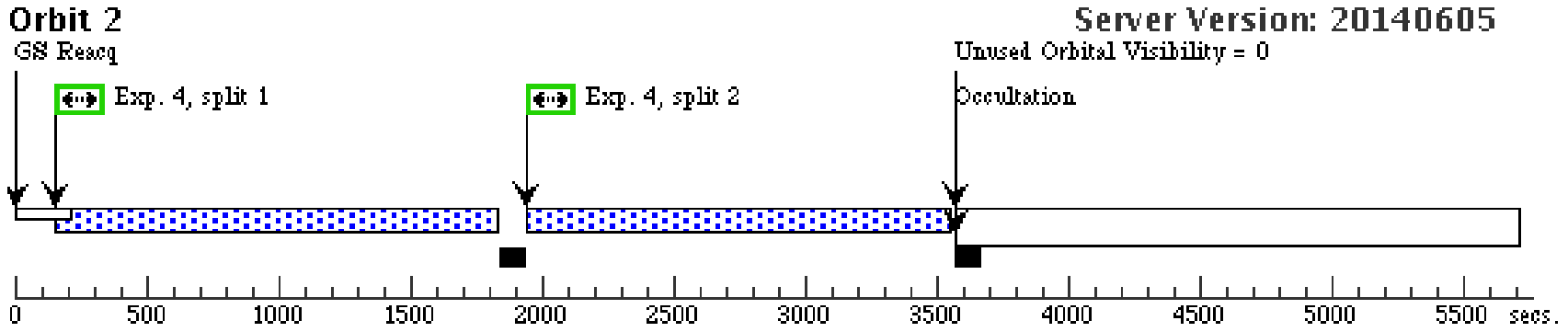
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	LH41-1042	RA: 05 18 10.8680 (79.5452833d) Dec: -69 13 10.89 (-69.21969d) Equinox: J2000		V=13.95+/-0.1 Flux in F225W filter is 4.0E-14	Reference Frame: ICRS
Comments: Coordinates measured from WFC3 image iby705010_drz.fits[SCI]					
(2)	LMC195-1	RA: 05 18 10.3060 (79.5429417d) Dec: -69 13 1.95 (-69.21721d) Equinox: J2000		V=14.80+/-0.1 Flux in F225W filter is 1.4E-14	Reference Frame: ICRS
Comments: Coordinates measured from WFC3 image iby705010_drz.fits[SCI]					
(4)	LH41-44OFFSET	RA: 05 18 6.3070 (79.5262792d) Dec: -69 12 35.87 (-69.20996d) Equinox: J2000		V=13.28+/-0.05 B-V=-0.16, E(B-V)=0.13, Flux in F225W is 1.4E-13	Reference Frame: ICRS
Comments: Coordinates measured from WFC3 image iby705010_drz.fits					

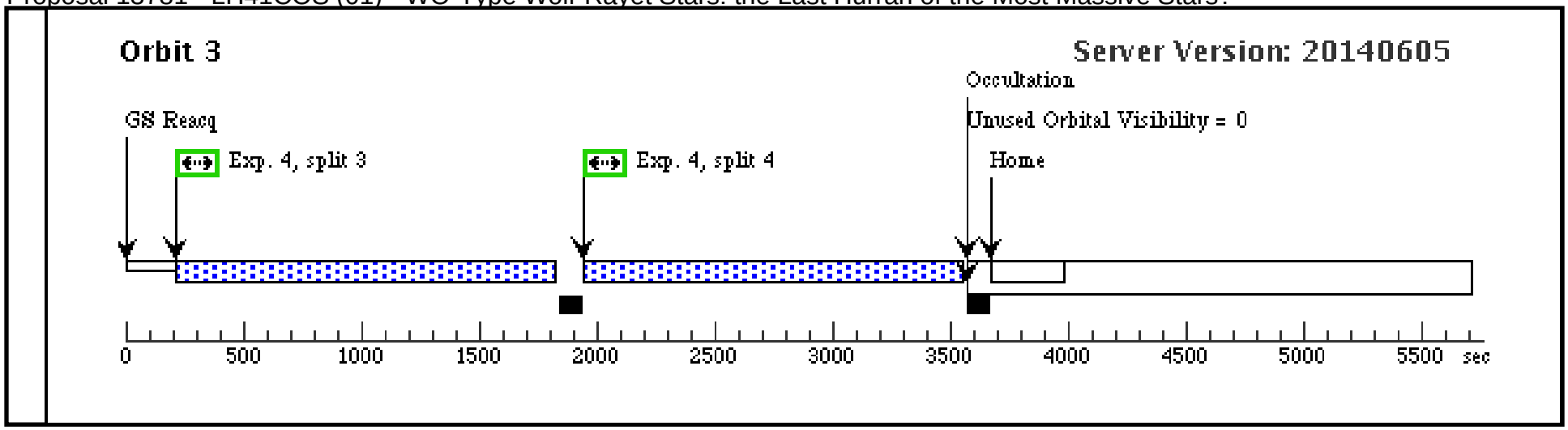
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Acq (631145)	(4) LH41-44OFFSET	COS/NUV, ACQ/PEAKXD, PSA	G230L 3000 A				0.3 Secs (0.3 Secs) *[==>]*	 ***[1]***
Comments: Exposure time is 0.3sec using a Kurucz B1V model normalized to a V magnitude of (13.28 (ETC 631143), and is 0.2 sec when normalized to a F225W flux of 1.4E-14.									
2	Acq (631145)	(4) LH41-44OFFSET	COS/NUV, ACQ/PEAKD, PSA	G230L 3000 A	NUM-POS=5; STEP-SIZE=0.9; CENTER=FLUX-WT-FLR			0.3 Secs (0.3 Secs) *[==>]*	 ***[1]***
3	LH41-1042 G130M/1096 (631017)	(1) LH41-1042	COS/FUV, TIME-TAG, PSA	G130M 1096 A	BUFFER-TIME=1000; FP-POS=ALL			500 Secs (2272 Secs) *[==>568.0 Secs (Split 1)]* *[==>568.0 Secs (Split 2)]* *[==>568.0 Secs (Split 3)]* *[==>568.0 Secs (Split 4)]*	 ***[1]***
Comments: Expect a S/N of 8 per spectral resolution element at 1035A.									
4	LMC195-1 G130M/1096 (631018)	(2) LMC195-1	COS/FUV, TIME-TAG, PSA	G130M 1096 A	BUFFER-TIME=2000; FP-POS=ALL			1200 Secs (6228 Secs) *[==>1557.0 Secs (Split 1)]* *[==>1557.0 Secs (Split 2)]* *[==>1557.0 Secs (Split 3)]* *[==>1557.0 Secs (Split 4)]*	 ***[2]*** ***[3]***
Comments: Expect a SN of 7.7 per spectral resolution element at 1035A.									

Orbit Structure



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Visit

Proposal 13781, Sand2COS (02), implementation Tue Sep 30 01:06:20 GMT 2014

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV

Special Requirements: (none)

Fixed Targets

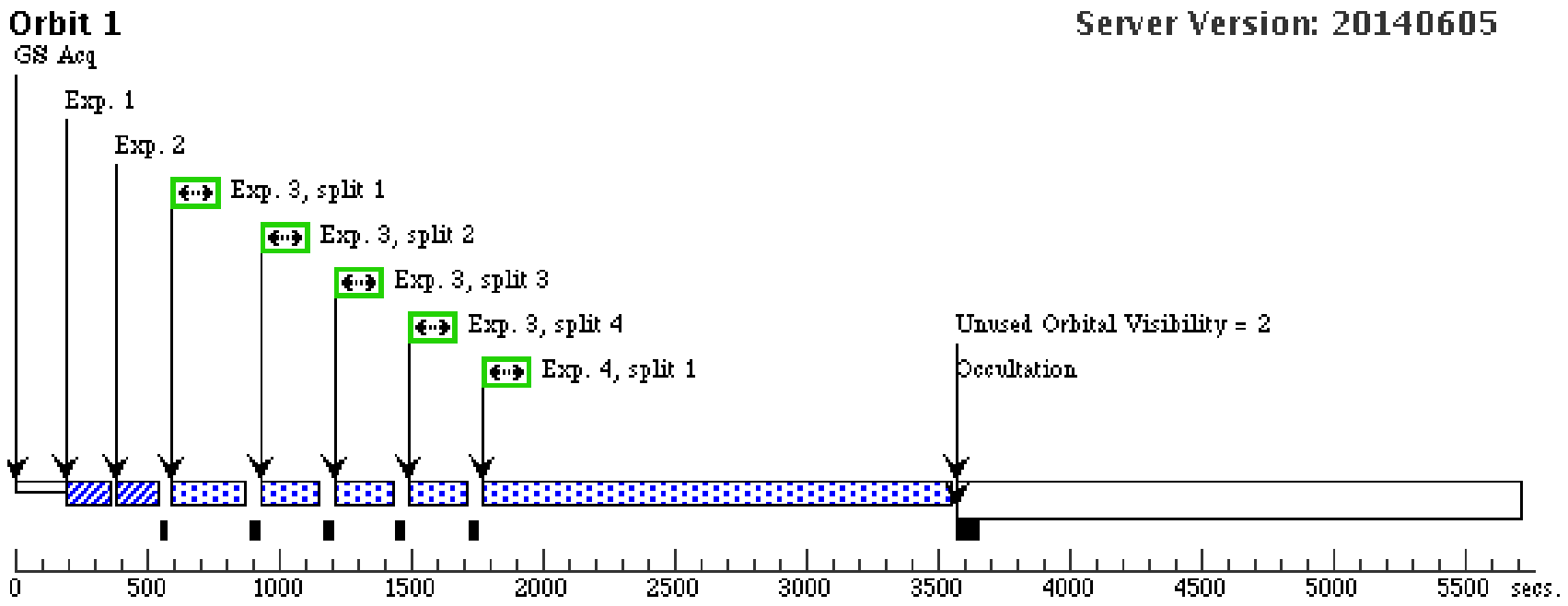
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(3)	SAND2	RA: 05 39 34.3300 (84.8930417d) Dec: -68 44 9.33 (-68.73593d) Equinox: J2000		V=15.20+/-0.05 B-V=+0.42, U-B=-1.17. Flux averaged over F225W bandpass is 1.3E-14	Reference Frame: ICRS

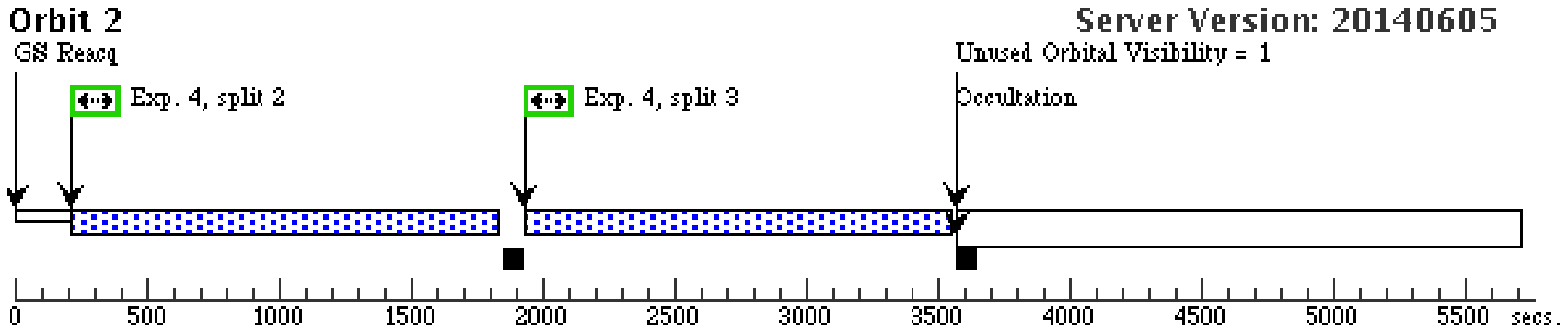
Comments: Coordinates are from the GSC-II.

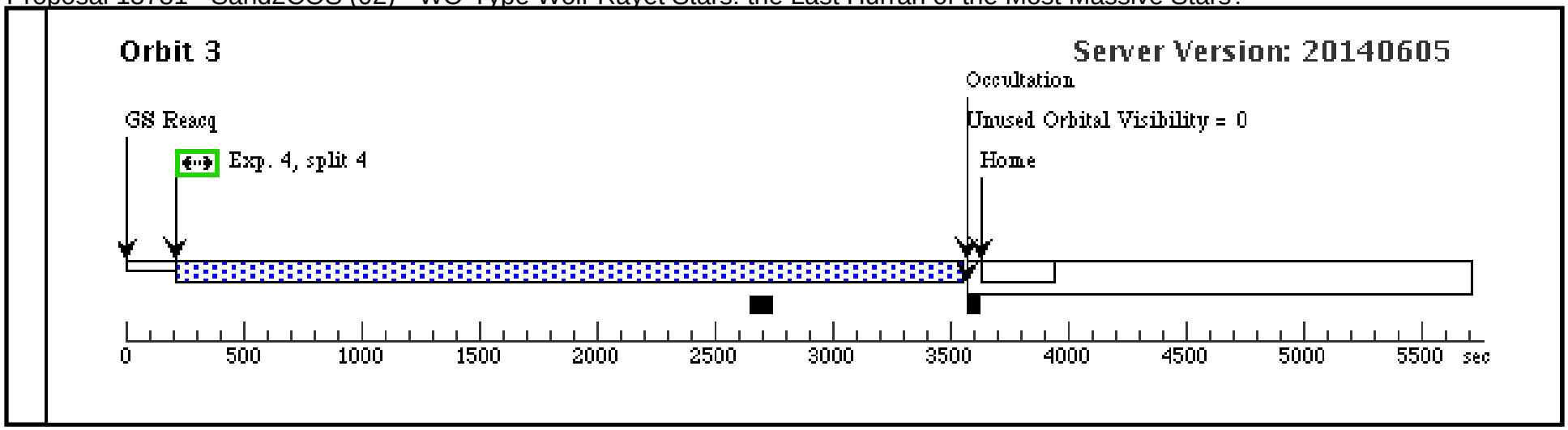
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(637510)	(3) SAND2	COS/FUV, ACQ/PEAKXD, PSA	G130M 1300 A				2.0 Secs (2 Secs) *[==>]*	 ***[1]***
2	(637510)	(3) SAND2	COS/FUV, ACQ/PEAKD, PSA	G130M 1300 A	STEP-SIZE=0.9; NUM-POS=5; CENTER=FLUX-WT-FLR			2.0 Secs (2 Secs) *[==>]*	 ***[1]***
3	G130M/1300 (631074)	(3) SAND2	COS/FUV, TIME-TAG, PSA	G130M 1300 A	FP-POS=ALL; BUFFER-TIME=1000			50 Secs (656 Secs) *[==>164.0 Secs (Split 1)]* *[==>164.0 Secs (Split 2)]* *[==>164.0 Secs (Split 3)]* *[==>164.0 Secs (Split 4)]*	 ***[1]***
Comments: Expect to reach a SN of 2.5 per FP at 1170 assuming a continuum flux of 2E-14									
4	G130M/1096 (631073)	(3) SAND2	COS/FUV, TIME-TAG, PSA	G130M 1096 A	BUFFER-TIME=2400; FP-POS=ALL			1500 Secs (8032 Secs) *[==>1614.0 Secs (Split 1)]* *[==>1566.0 Secs (Split 2)]* *[==>1566.0 Secs (Split 3)]* *[==>3286.0 Secs (Split 4)]*	 ***[1]*** ***[2]*** ***[3]***
Comments: Expect to reach a SN of 2 in 4000 sec (total) of integration at 1032A.									

Orbit Structure



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GS Reacq
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sec

Visit

Proposal 13781, LH41STIS (03), implementation Tue Sep 30 01:06:21 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)	LH41-1042	RA: 05 18 10.8680 (79.5452833d) Dec: -69 13 10.89 (-69.21969d) Equinox: J2000		V=13.95+/-0.1 Flux in F225W filter is 4.0E-14	Reference Frame: ICRS
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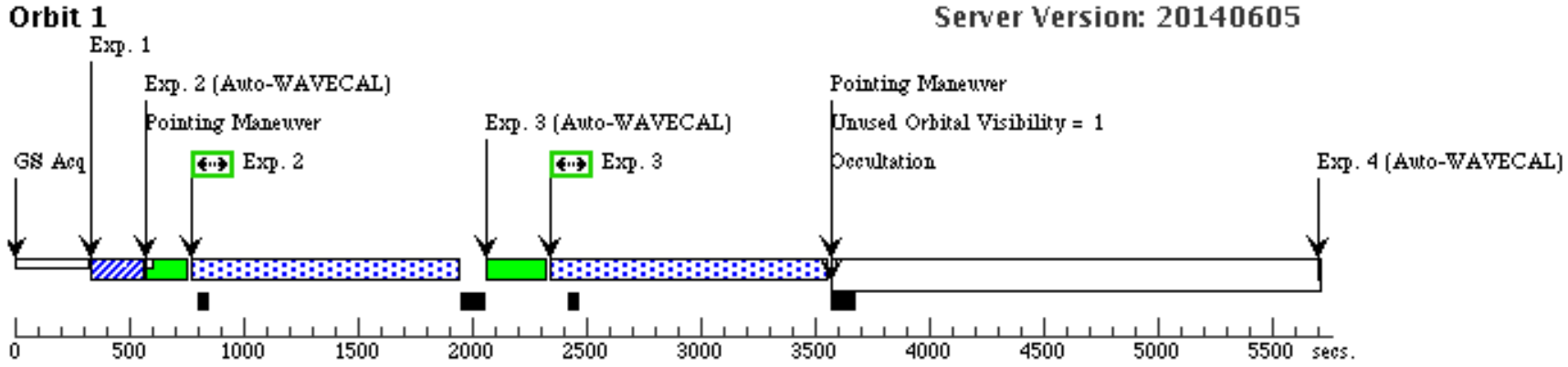
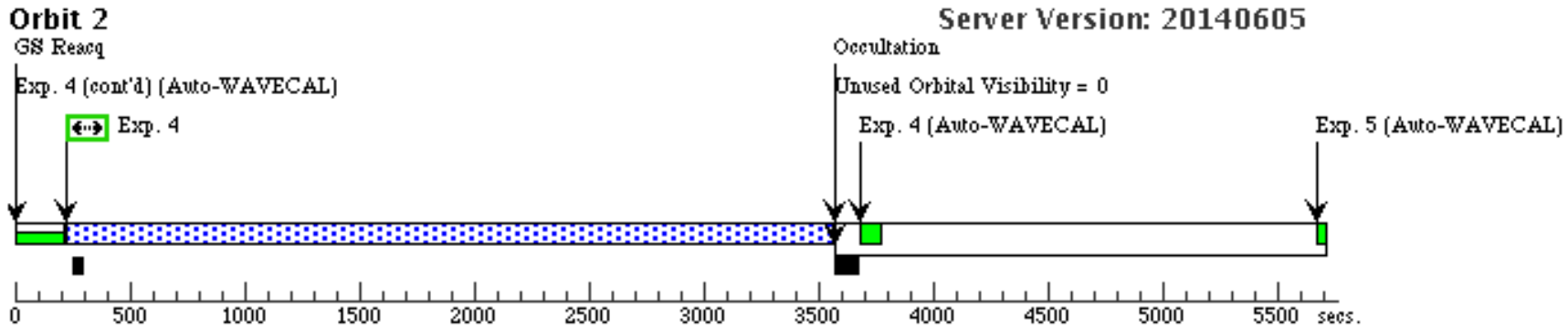
(2)	LMC195-1	RA: 05 18 10.3060 (79.5429417d) Dec: -69 13 1.95 (-69.21721d) Equinox: J2000		V=14.80+/-0.1 Flux in F225W filter is 1.4E-14	Reference Frame: ICRS
Comments: Coordinates measured from WFC3 image iby705010_drz.fits[SCI]					
(4)	LH41-44OFFSET	RA: 05 18 6.3070 (79.5262792d) Dec: -69 12 35.87 (-69.20996d) Equinox: J2000		V=13.28+/-0.05 B-V=-0.16, E(B-V)=0.13, Flux in F225W is 1.4E-13	Reference Frame: ICRS
Comments: Coordinates measured from WFC3 image iby705010_drz.fits					

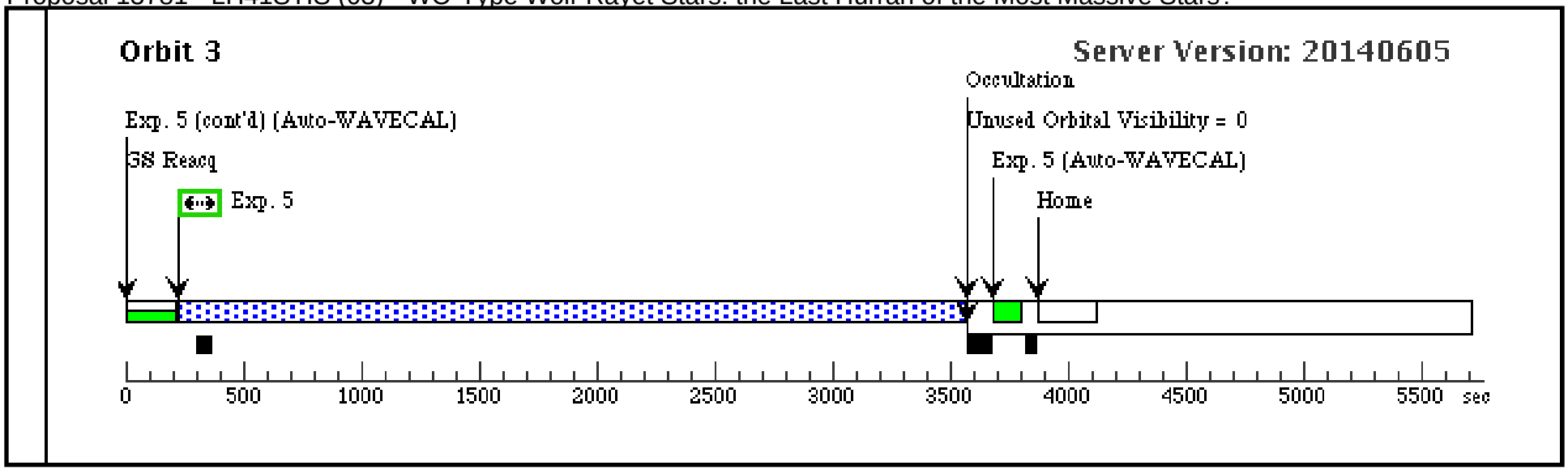
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	STIS ACQ (622334)	(4) LH41-44OFFSET	STIS/CCD, ACQ, F28X50LP	MIRROR	ACQTYPE=POINT			0.1 Secs (0.1 Secs) *[==>]*	*[1]*
2	LH41-1042 G140L (631117)	(1) LH41-1042	STIS/FUV-MAMA, ACCUM, 0.2X0.2	G140L 1425 A				1120 Secs (1141 Secs) *[==>1141.0 Secs]*	*[1]*
Comments: Expect a S/N of approx 70 at 1400A									
3	LH41-1042 230L (631121)	(1) LH41-1042	STIS/NUV-MAMA, ACCUM, 0.2X0.2	G230L 2376 A				1120 Secs (1141 Secs) *[==>1141.0 Secs]*	*[1]*
Comments: Expect a S/N of about 60 at 2200A									
4	LMC195-1 G140L (631130)	(2) LMC195-1	STIS/FUV-MAMA, ACCUM, 0.2X0.2	G140L 1425 A				2500 Secs (3308 Secs) *[==>3308.0 Secs]*	*[2]*
Comments: Expected S/N of 70 at 1400A									
5	LMC195-1 G230L (631127)	(2) LMC195-1	STIS/NUV-MAMA, ACCUM, 0.2X0.2	G230L 2376 A				2500 Secs (3266 Secs) *[==>3266.0 Secs]*	*[3]*
Comments: Expected S/N of 60 at 2200A									

Orbit Structure



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