15469 - Characterizing a new prototype Saturn-mass exoplanet with the clearest atmosphere yet

Cycle: 25, 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) 2MASS-J00041112-4721382	WFC3/IR	5	04-Dec-2018 17:02:57.0	yes
51	(1) 2MASS-J00041112-4721382	WFC3/IR	5	04-Dec-2018 17:03:08.0	yes

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
02	(1) 2MASS-J00041112-4721382	WFC3/IR	5	04-Dec-2018 17:03:19.0	yes

15 Total Orbits Used

ABSTRACT

Rarely in astrophysics does one have the chance to characterize an exoplanet atmosphere free of clouds. Transmission spectra of such exoplanets are the only way to constrain elemental abundances (e.g. Na, K, and water) and metallicity objectively, as clouds and hazes obscure the amplitudes of absorption features. Cloud-free exoplanet atmospheres are therefore of very high value for the field. Our team has recently published the optical transmission spectrum of the hot Saturn WASP-96b (~1300K) obtained with VLT FORS2. Unlike the optical transmission spectrum of any other hot-Jupiter observed to date, the spectrum of WASP-96b shows very clear pressure-broadened wings of the sodium line, evidence of potassium and a near-UV Rayleigh scattering slope; the latter defining the hydrogen continuum level and proving the planet has a clear atmosphere at the limb. The clear atmosphere of WASP-96b rivals the top three currently known such planets: WASP-39b, HD209458b and WASP-17b, each of which show narrow absorption features and non-negligible haze in their optical spectra. We propose to use WFC3+G102 and WFC3+G142 to measure the near-infrared transmission spectrum of WASP-96b, which will allow us to retrieve precise absolute water and metallicity abundance constraints. Even today, few such constraints exist with well-measured Na and water abundances. The spectrum of WASP-96b can become a standard benchmark for the theory of irradiated gas-giants and an outstanding target for abundance measurements with the James Webb Space Telescope.

OBSERVING DESCRIPTION

Our WFC3 observations will provide infrared transmission spectrum for the 'hot Saturn' exoplanet WASP-96b, covering the wavelength range from 0.9 to 1.6 microns.

**Observing strategy:

To measure the planet's transmission spectrum we will observe one transit of WASP-96b with WFC3 G102 and one transit with WFC3 G141. Each of the observations will be made in slitless spectroscopic mode. Our observing setup is very similar to that used in previous successful programs, such as Prog 15135, 14468 (PI Evans; G102 secondary eclipses and G141 primary transit of WASP-121b), Prog 14767 (PI Sing; G141 secondary eclipse of WASP-121b), and Prog 13467 (PI Bean; G102 transits for WASP-12b).

Each visit starts with a standard phase-constrained acquisition image. Then each visit continues with repeated exposures covering the transit plus time before and after the transit to establish the out-of-transit baseline flux. We provide similar phase constrains of the acquisition image of each visit.

These observations use the forward spatial scanning mode with rates optimised for the individual grisms. Table 1 lists the scan rates, sequences, NSAMP and the resulting exposure times and scan lengths.

Table 1

Grism	Scan.rate	SPARS	NSAMP	Exp.time	Scan.length	N.rows
	arcsec/sec			sec	arcsec	px
G102	0.013	25	9	179	2.33	47
G141	0.022	25	8	156	3.45	69

We will read out a subarray size of 256 pixels to reduce overheads. We apply no offsets to the position of the spectra on the detector, because there is enough space above and below the scan to estimate the background flux.

The transit of WASP-96b lasts for 146 minutes. We therefore require 5 consecutive HST orbits for each visit. The first orbit serves to allow the telescope to thermally relax into its new pointing position and for the detector charge-traps to fill, which is a standard procedure adopted by all HST WFC3 transiting exoplanet observations. The remaining orbits will provide good phase coverage during the transit, and allow for sufficient time (2 HST orbits - one before transit, one after transit) to establish the baseline stellar flux necessary to accurately measure the transit depth. We will obtain 11 science exposures per HST orbit, coming to a total of 16 in-transit and 28 out-of-transit science exposures per visit.

We choose not to use bi-directional spatial scanning, e.g. as has been done for WASP-12b in Program 13467 (PI Bean). This is because although bi-directional spatial scanning would allow an additional 1 exposure to be acquired per HST orbit (i.e. 12 per orbit), the instrumental systematics are different for each scan direction, which is likely more of a disadvantage.

**Signal-to-noise estimates:

WASP-96b is moderately bright target (J=11.27). We used the HST Exposure Time Calculator with the observational setup described above to calculate a SNR of ~1057 and ~1260 per resolution element per exposure for G102 and G141, respectively. Note that this flux will be spread over ~47 and ~69 pixel columns due to the spatial scan (see above), so there is no risk of saturation. According to the HST Exposure Time Calculator, with this setup the brightest pixel per exposure will reach around 31,000 electrons (see linked ETC Run #'s in the observing sequences).

Visit

Proposal 15469, WASP-96 WFC3 G102 transit (01), failed Tue Dec 04 22:03:20 GMT 2018

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: SCHED 100%; Period 3.4252602 D AND ZERO-PHASE HJD 2456258.0621

Comments: Observation of transiting exoplanet WASP-96b with WFC3 G102.
It is essential that the 5 HST orbits are scheduled in a continuous block to cover a transit event.
Each of the 5 HST orbits contain a non-interruptible sequence.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	2MASS-J00041112-4721382	RA: 00 04 11.1240 (1.0463500d)	Proper Motion RA: 23.1 mas/yr	V=12.2	Reference Frame: SIMBAD
		Dec: -47 21 38.25 (-47.36063d)	Proper Motion Dec: 3.7 mas/yr		
	Alt Name1: WASP-96	Equinox: J2000	Epoch of Position: 2000		

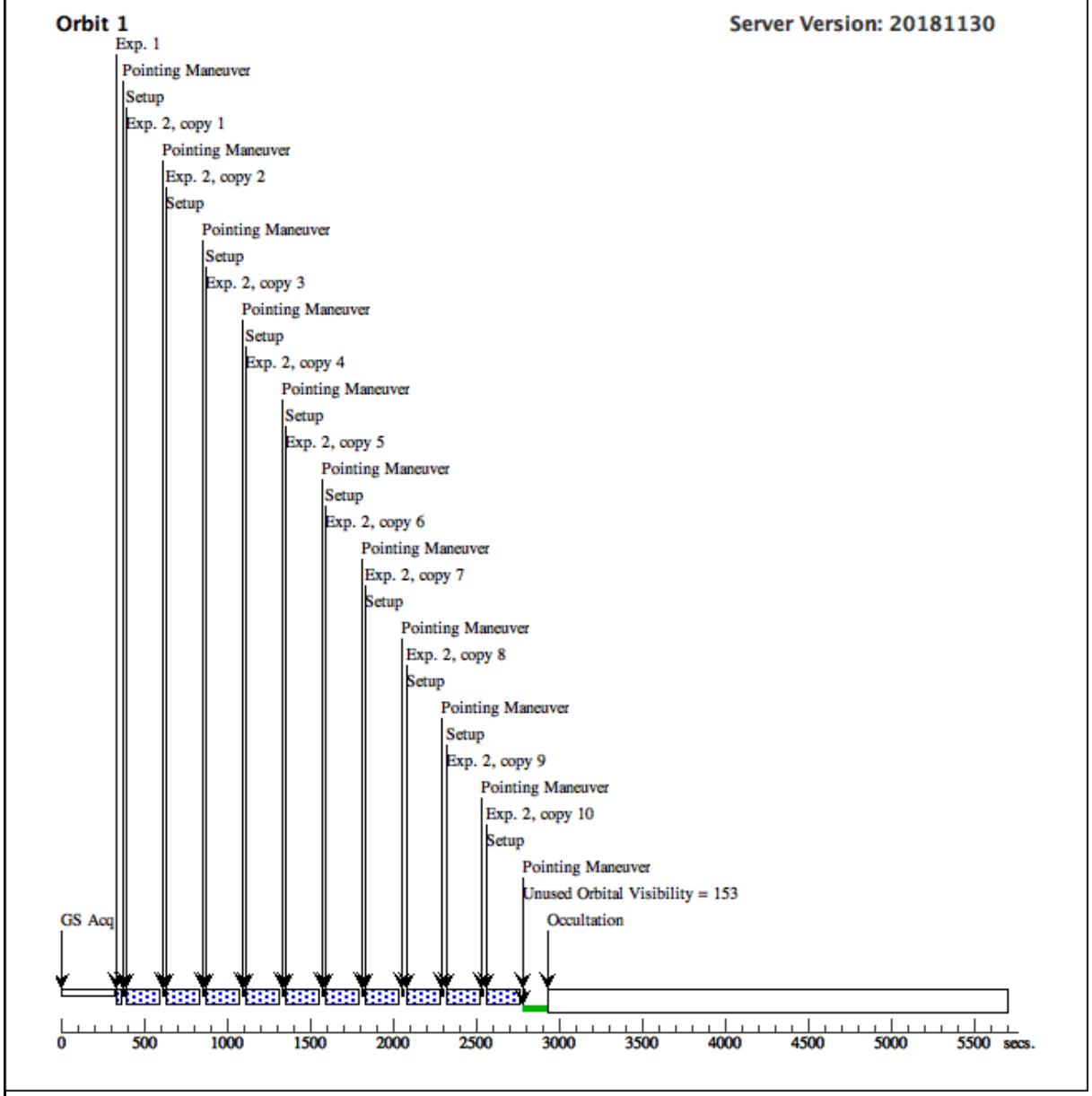
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=EXT-STAR
Description=[EXTRA-SOLAR PLANET]

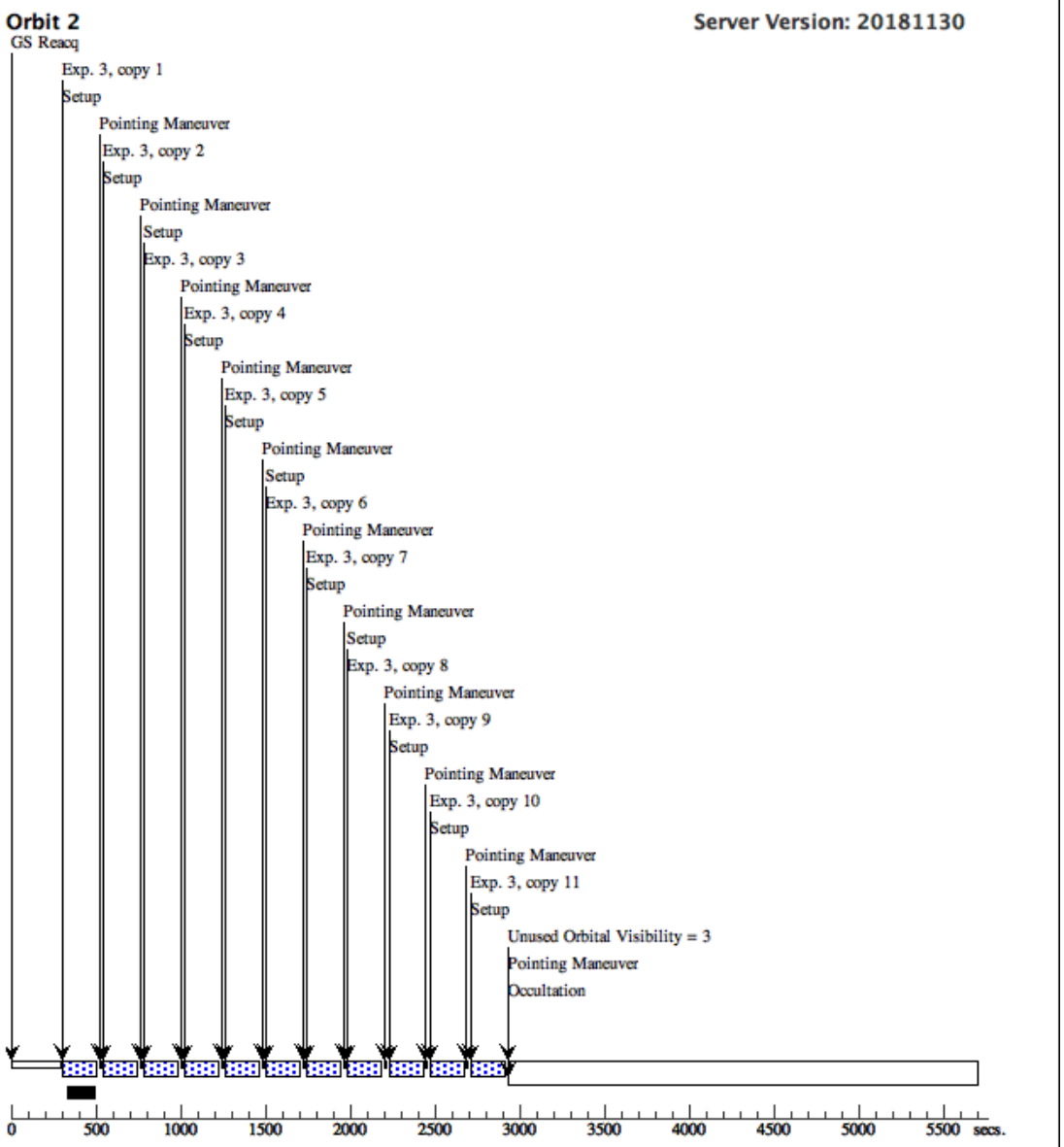
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Acquisition (WFC3IR.im.1259347)	(1) 2MASS-J00041112-4721382	WFC3/IR, MULTIACCUM, GRISM256	F127M	SAMP-SEQ=RAPID; NSAMP=4	PHASE 0.937 TO 0.940; GS ACQ SCENARIO BASE1B3	Sequence 1-2 Non-Int in WASP-96 WFC3 G102 transit (01)	1.11126 Secs (1.111 Secs) *[==>]*	***[1]***
2	Science 1 (WFC3IR.ss.1259324)	(1) 2MASS-J00041112-4721382	WFC3/IR, MULTIACCUM, GRISM256	G102	NSAMP=9; SAMP-SEQ=SPARS25	POS TARG 0,0; SPATIAL SCAN 0.013,90.0 Degrees,Forward	Sequence 1-2 Non-Int in WASP-96 WFC3 G102 transit (01)	179.046127 Secs X 10 (1790.461 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]*	***[1]***
3	Science 2 (WFC3IR.ss.1259324)	(1) 2MASS-J00041112-4721382	WFC3/IR, MULTIACCUM, GRISM256	G102	NSAMP=9; SAMP-SEQ=SPARS25	SPATIAL SCAN 0.013,90.0 Degrees,Forward	Sequence 3-3 Non-Int in WASP-96 WFC3 G102 transit (01)	179.046127 Secs X 11 (1969.507 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]* *[==>(Copy 11)]*	***[2]***
4	Science 3 (WFC3IR.ss.1259324)	(1) 2MASS-J00041112-4721382	WFC3/IR, MULTIACCUM, GRISM256	G102	NSAMP=9; SAMP-SEQ=SPARS25	SPATIAL SCAN 0.013,90.0 Degrees,Forward	Sequence 4-4 Non-Int in WASP-96 WFC3 G102 transit (01)	179.046127 Secs X 11 (1969.507 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]* *[==>(Copy 11)]*	***[3]***

	5	Science 4 (WFC3IR.ss.1259324)	(1) 2MASS-J00041112-4721382	WFC3/IR, MULTIACCUM, GRISM256	G102	NSAMP=9; SAMP-SEQ=SPARS25	SPATIAL SCAN 0.0 13,90.0 Degrees,Forward	Sequence 5-5 Non-Int in WASP-96 WFC3 G102 transit (01)	179.046127 Secs X 11 (1969.507 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]* *[==>(Copy 11)]*	***[4]***
	6	Science 5 (WFC3IR.ss.1259324)	(1) 2MASS-J00041112-4721382	WFC3/IR, MULTIACCUM, GRISM256	G102	NSAMP=9; SAMP-SEQ=SPARS25	SPATIAL SCAN 0.0 13,90.0 Degrees,Forward	Sequence 6-6 Non-Int in WASP-96 WFC3 G102 transit (01)	179.046127 Secs X 11 (1969.507 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]* *[==>(Copy 11)]*	***[5]***

Orbit Structure

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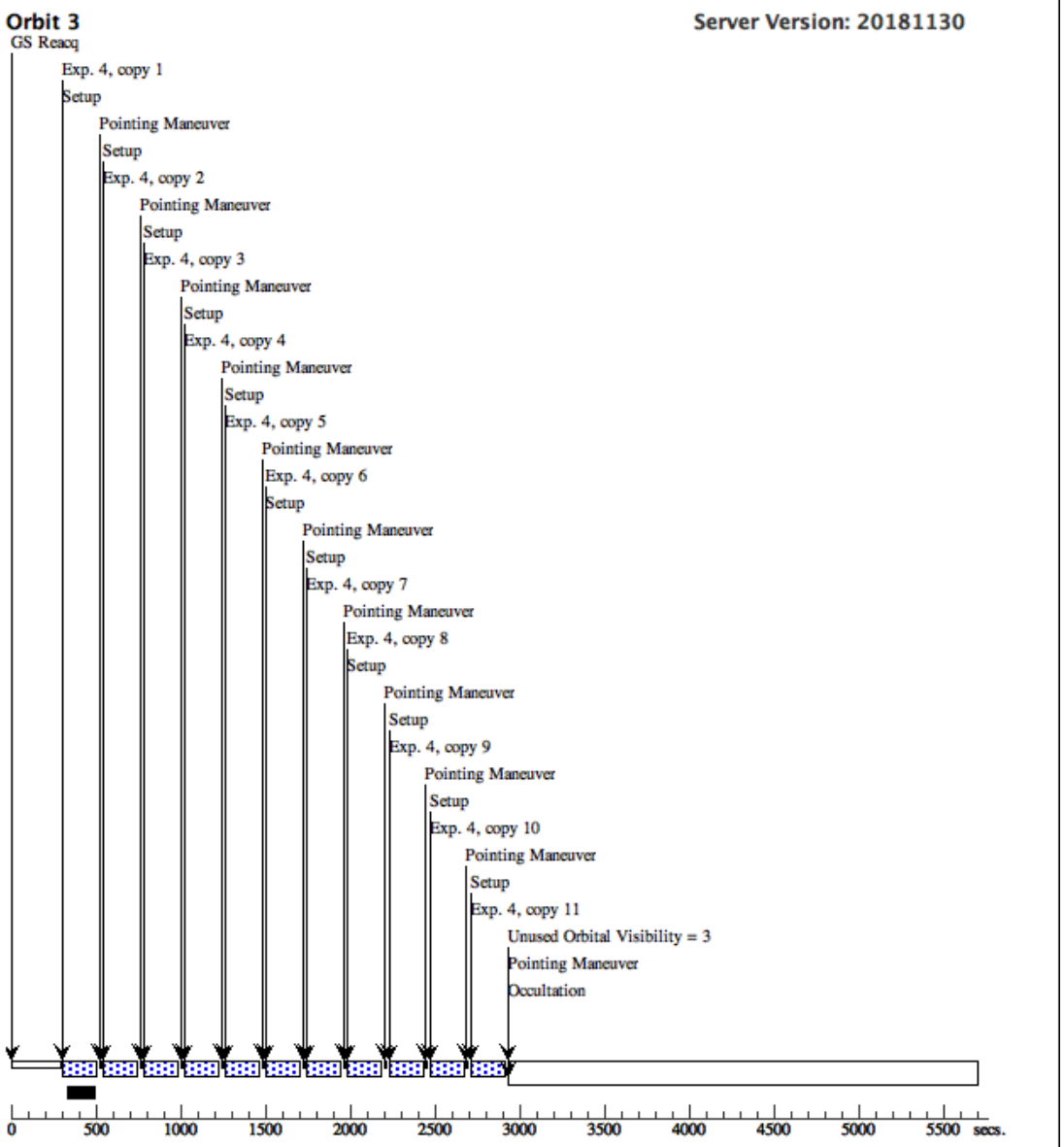
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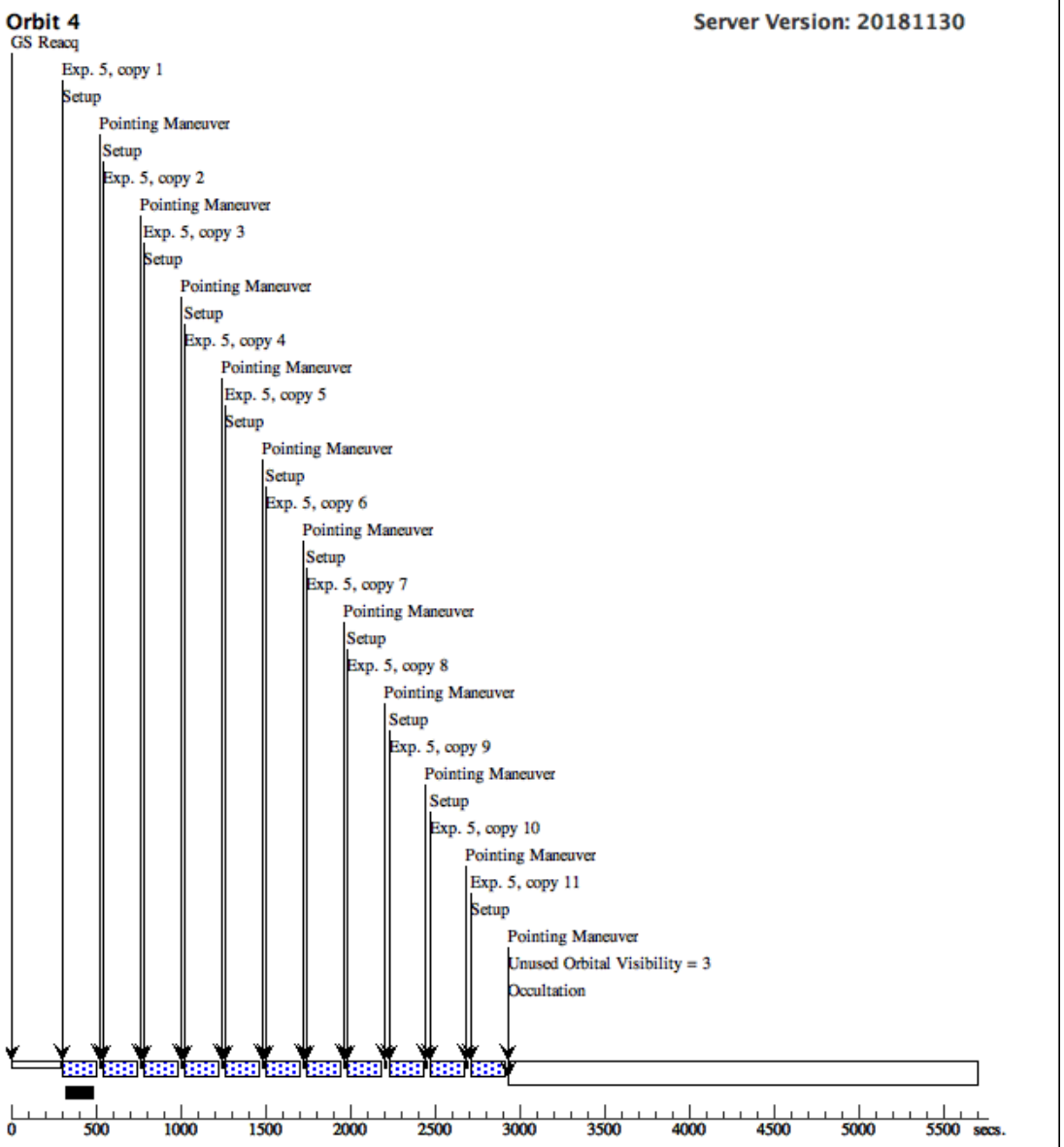
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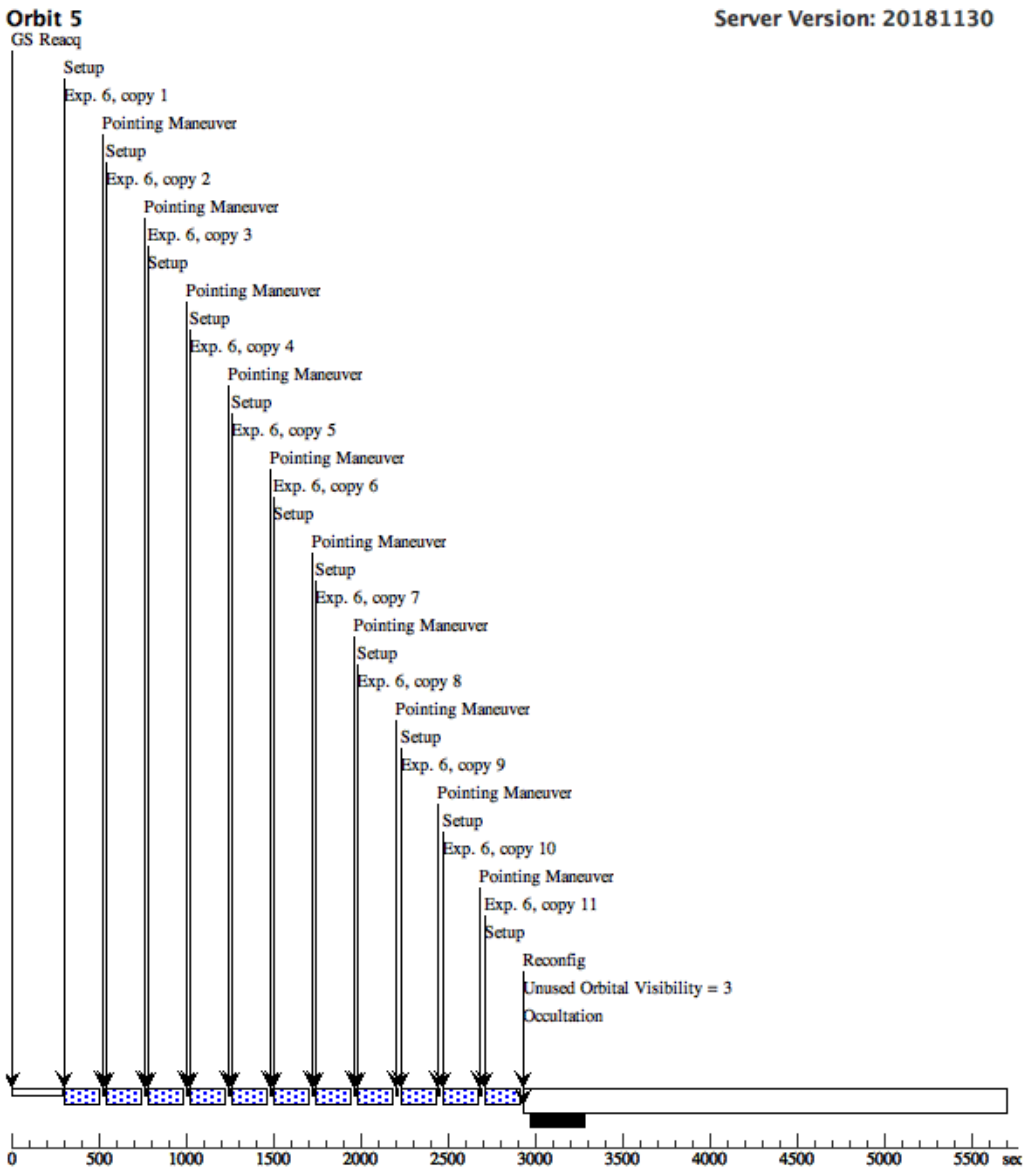
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Visit

Proposal 15469, WASP-96 WFC3 G102 transit (51), implementation Tue Dec 04 22:03:21 GMT 2018

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: SCHED 100%; Period 3.4252602 D AND ZERO-PHASE HJD 2456258.0621

Comments: Observation of transiting exoplanet WASP-96b with WFC3 G102.
It is essential that the 5 HST orbits are scheduled in a continuous block to cover a transit event.
Each of the 5 HST orbits contain a non-interruptible sequence.

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		Dec: -47 21 38.25 (-47.36063d)	Proper Motion Dec: 3.7 mas/yr		
	Alt Name1: WASP-96	Equinox: J2000	Epoch of Position: 2000		

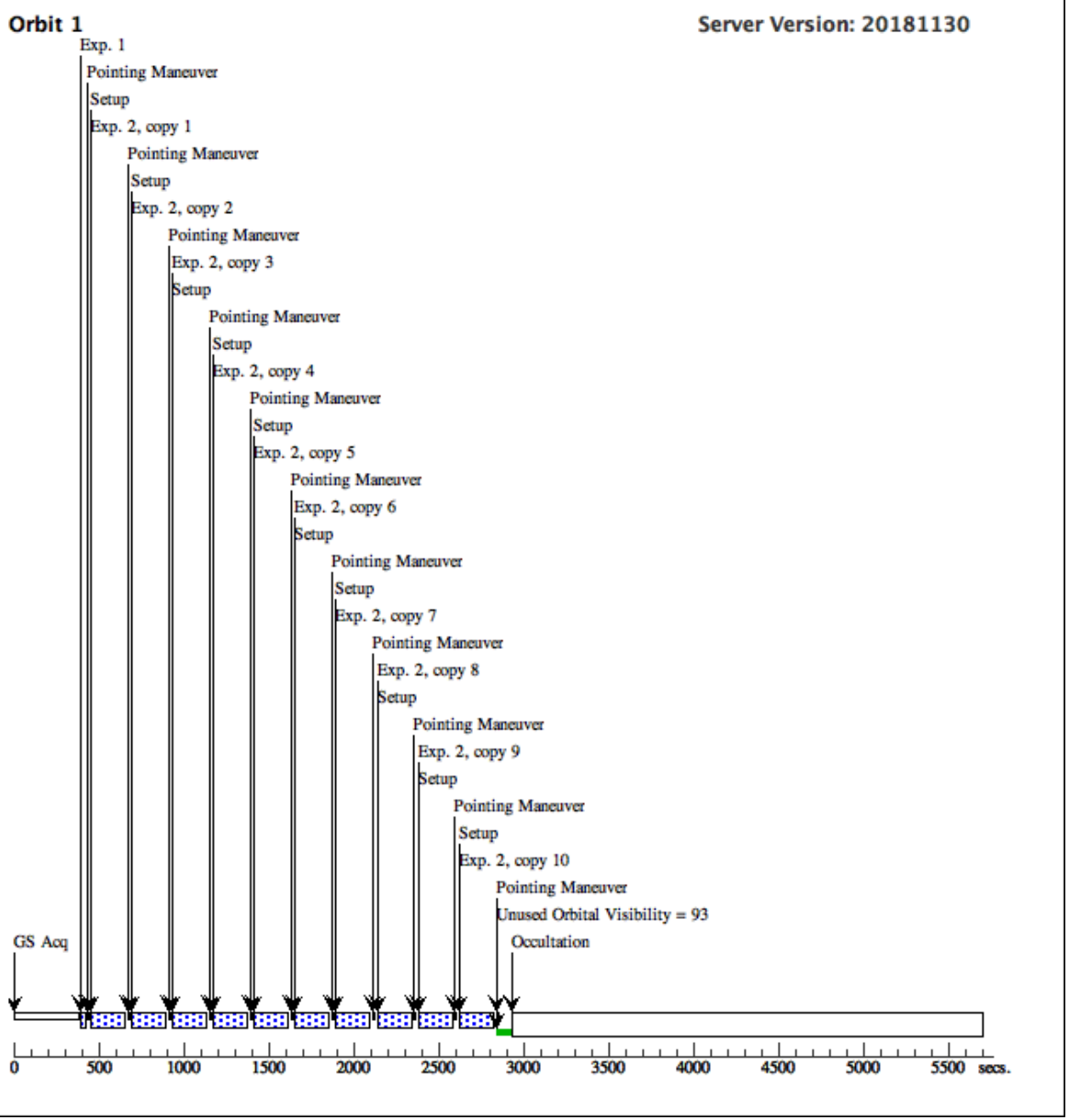
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=EXT-STAR
Description=[EXTRA-SOLAR PLANET]

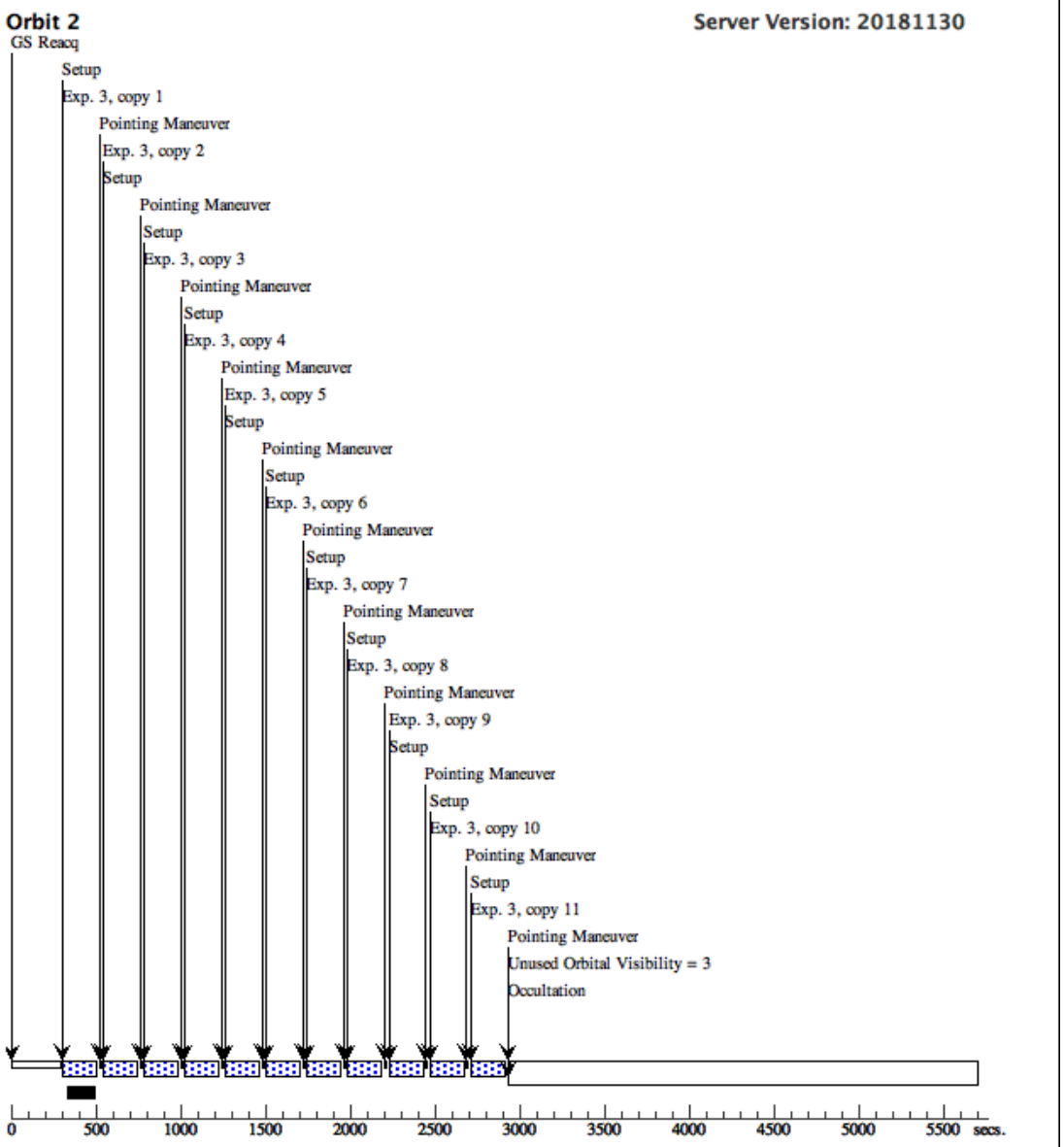
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Acquisition (WFC3IR.im.1259347)	(1) 2MASS-J00041112-4721382	WFC3/IR, MULTIACCUM, GRISM256	F127M	SAMP-SEQ=RAPID; NSAMP=4	PHASE 0.937 TO 0.940; GS ACQ SCENARIO BASE1BE	Sequence 1-2 Non-Int in WASP-96 WFC3 G102 transit (51)	1.11126 Secs (1.111 Secs) *[==>]*	***[1]***
2	Science 1 (WFC3IR.ss.1259324)	(1) 2MASS-J00041112-4721382	WFC3/IR, MULTIACCUM, GRISM256	G102	NSAMP=9; SAMP-SEQ=SPARS25	POS TARG 0,0; SPATIAL SCAN 0.013,90.0 Degrees,Forward	Sequence 1-2 Non-Int in WASP-96 WFC3 G102 transit (51)	179.046127 Secs X 10 (1790.461 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]*	***[1]***
3	Science 2 (WFC3IR.ss.1259324)	(1) 2MASS-J00041112-4721382	WFC3/IR, MULTIACCUM, GRISM256	G102	NSAMP=9; SAMP-SEQ=SPARS25	SPATIAL SCAN 0.013,90.0 Degrees,Forward	Sequence 3-3 Non-Int in WASP-96 WFC3 G102 transit (51)	179.046127 Secs X 11 (1969.507 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]* *[==>(Copy 11)]*	***[2]***
4	Science 3 (WFC3IR.ss.1259324)	(1) 2MASS-J00041112-4721382	WFC3/IR, MULTIACCUM, GRISM256	G102	NSAMP=9; SAMP-SEQ=SPARS25	SPATIAL SCAN 0.013,90.0 Degrees,Forward	Sequence 4-4 Non-Int in WASP-96 WFC3 G102 transit (51)	179.046127 Secs X 11 (1969.507 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]* *[==>(Copy 11)]*	***[3]***

	5	Science 4 (WFC3IR.ss.1259324)	(1) 2MASS-J00041112-4721382	WFC3/IR, MULTIACCUM, GRISM256	G102	NSAMP=9; SAMP-SEQ=SPARS25	SPATIAL SCAN 0.0 13,90.0 Degrees,Forward	Sequence 5-5 Non-Int in WASP-96 WFC3 G102 transit (51)	179.046127 Secs X 11 (1969.507 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]* *[==>(Copy 11)]*	***[4]***
	6	Science 5 (WFC3IR.ss.1259324)	(1) 2MASS-J00041112-4721382	WFC3/IR, MULTIACCUM, GRISM256	G102	NSAMP=9; SAMP-SEQ=SPARS25	SPATIAL SCAN 0.0 13,90.0 Degrees,Forward	Sequence 6-6 Non-Int in WASP-96 WFC3 G102 transit (51)	179.046127 Secs X 11 (1969.507 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]* *[==>(Copy 11)]*	***[5]***

Orbit Structure

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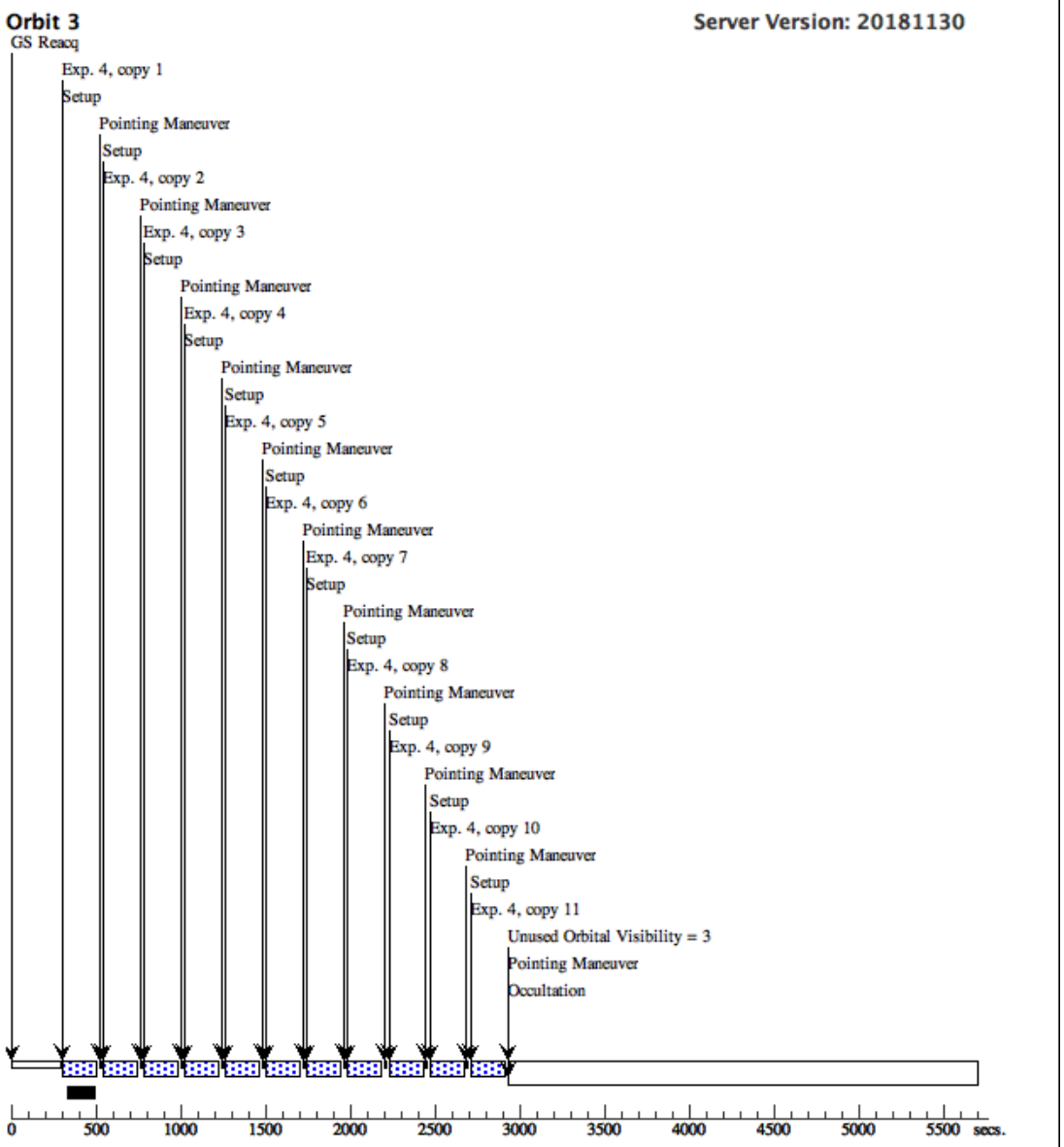
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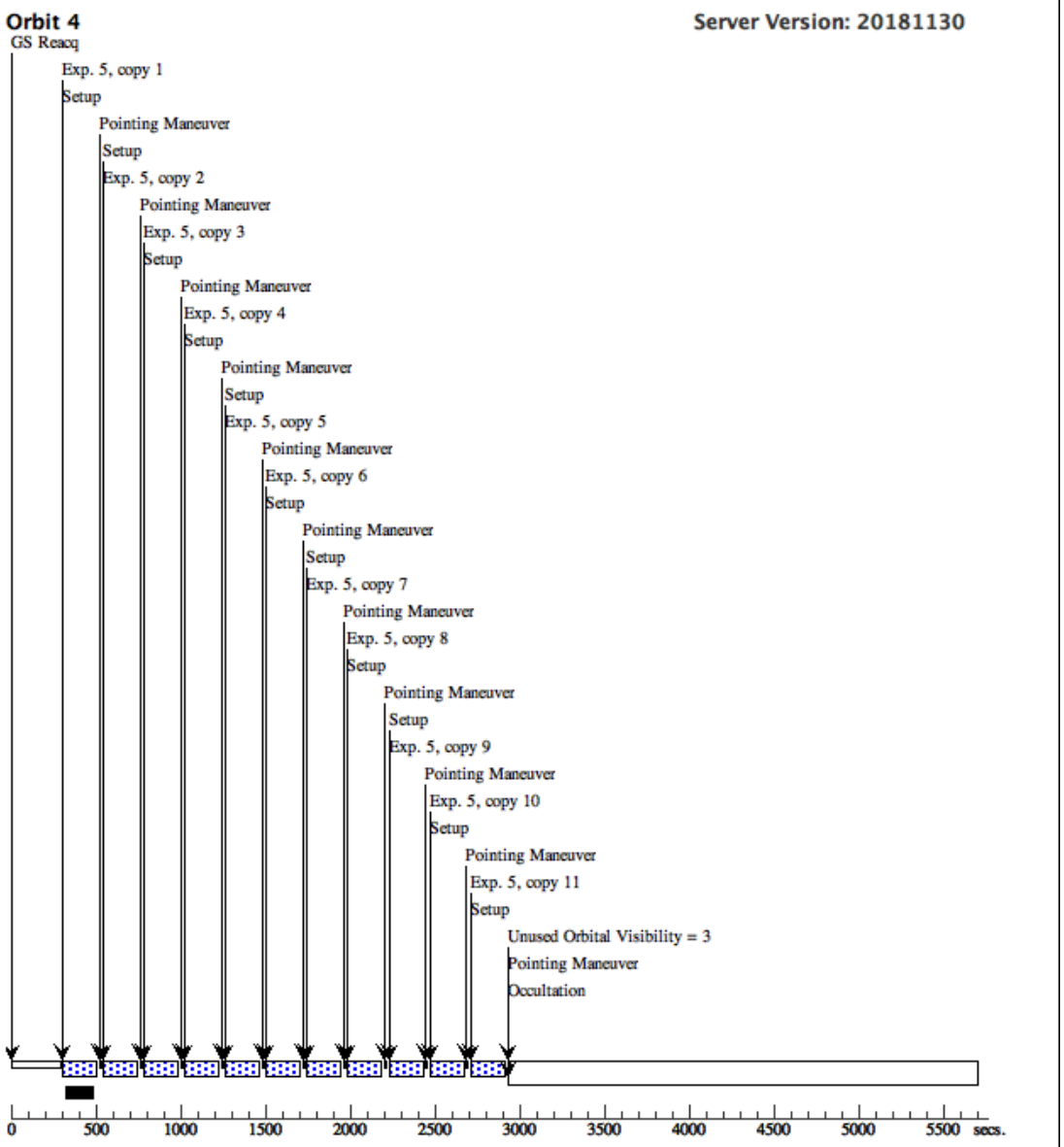
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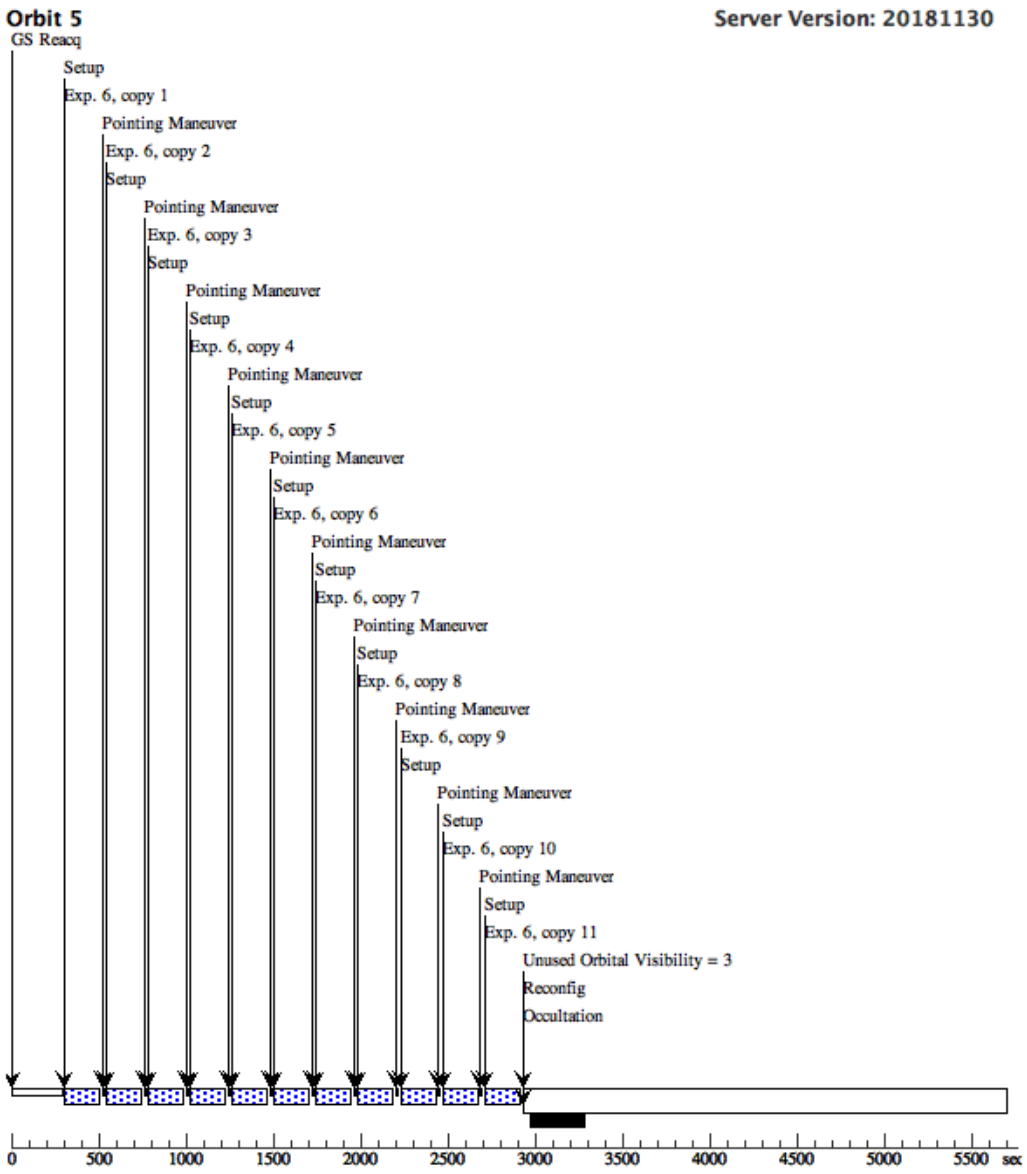
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Exp. 6, copy 10
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Exp. 6, copy 11
Unused Orbital Visibility = 3
Reconfig
Occultation
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2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 15469, WASP-96 WFC3 G141 transit (02), implementation Tue Dec 04 22:03:21 GMT 2018

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: SCHED 100%; Period 3.4252602 D AND ZERO-PHASE HJD2456258.0621

Comments: Observation of transiting exoplanet WASP-96b with WFC3 G141.
It is essential that the 5 HST orbits are scheduled in a continuous block to cover a transit event.
Each of the 5 HST orbits contain a non-interruptible sequence.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	2MASS-J00041112-4721382	RA: 00 04 11.1240 (1.0463500d)	Proper Motion RA: 23.1 mas/yr	V=12.2	Reference Frame: SIMBAD
		Dec: -47 21 38.25 (-47.36063d)	Proper Motion Dec: 3.7 mas/yr		
	Alt Name1: WASP-96	Equinox: J2000	Epoch of Position: 2000		

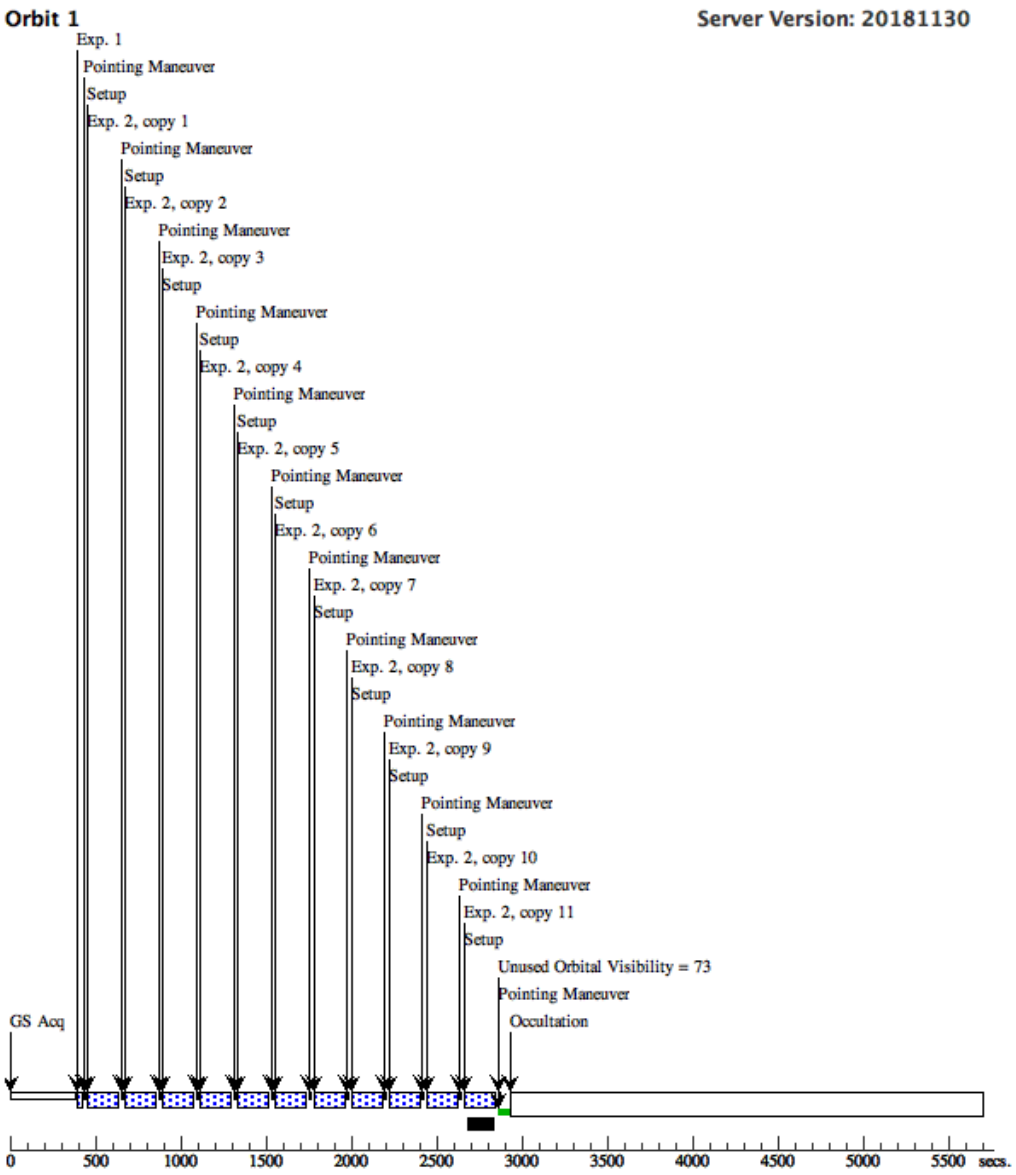
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=EXT-STAR
Description=[EXTRA-SOLAR PLANET]

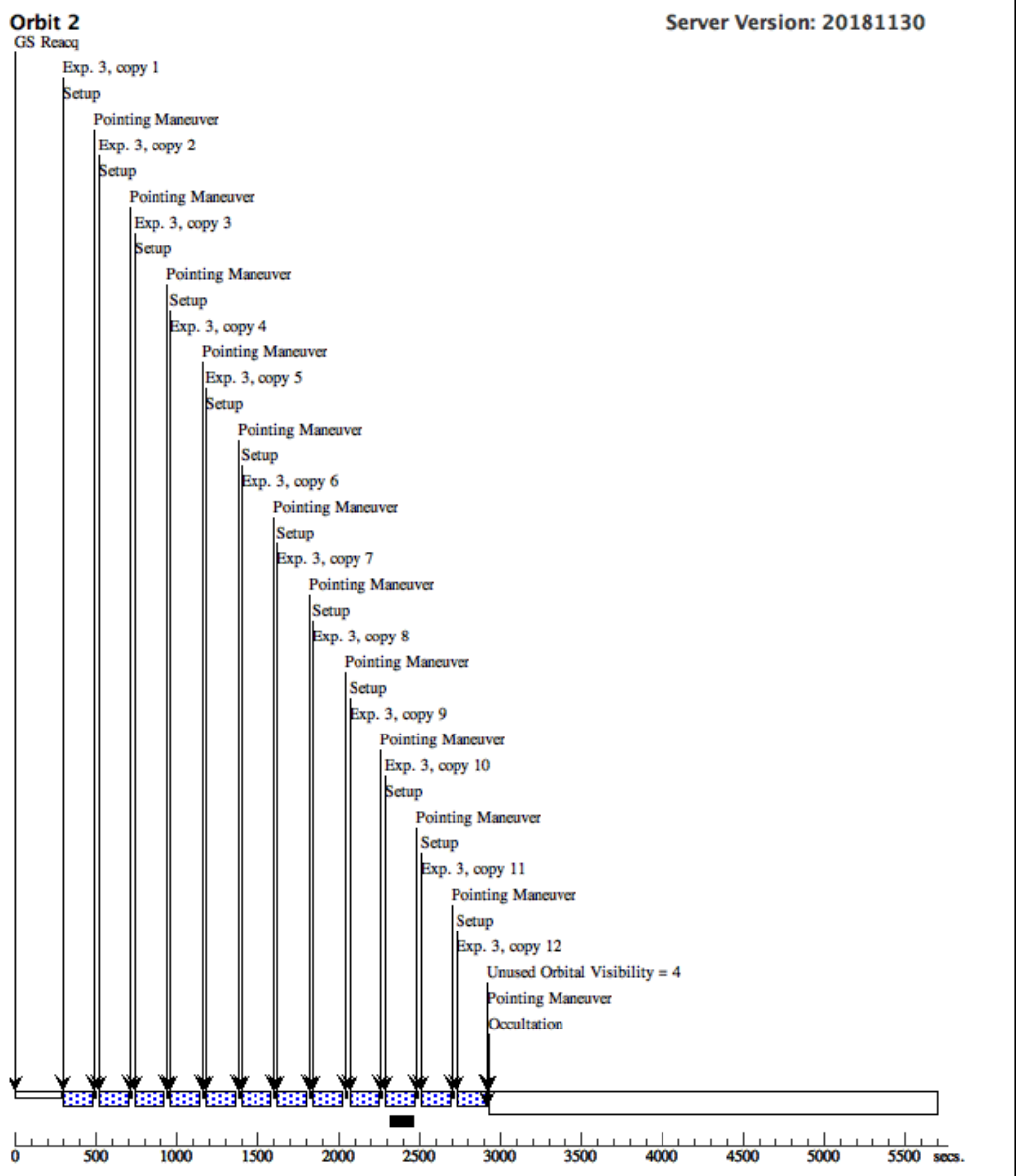
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Acquisition (WFC3IR.im.1259344)	(1) 2MASS-J00041112-4721382	WFC3/IR, MULTIACCUM, GRISM256	F139M	NSAMP=5; SAMP-SEQ=RAPID	PHASE 0.937 TO 0.940; GS ACQ SCENARIO BASE1BE	Sequence 1-2 Non-Int in WASP-96 WFC3 G141 transit (02)	1.389075 Secs (1.389 Secs) *[==>]*	***[1]***
2	Science 1 (WFC3IR.ss.1259355)	(1) 2MASS-J00041112-4721382	WFC3/IR, MULTIACCUM, GRISM256	G141	NSAMP=8; SAMP-SEQ=SPARS25	SPATIAL SCAN 0.022,90.0 Degrees,Forward	Sequence 1-2 Non-Int in WASP-96 WFC3 G141 transit (02)	156.700088 Secs X 11 (1723.701 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]* *[==>(Copy 11)]*	***[1]***
3	Science 2 (WFC3IR.ss.1259355)	(1) 2MASS-J00041112-4721382	WFC3/IR, MULTIACCUM, GRISM256	G141	NSAMP=8; SAMP-SEQ=SPARS25	SPATIAL SCAN 0.022,90.0 Degrees,Forward	Sequence 3-3 Non-Int in WASP-96 WFC3 G141 transit (02)	156.700088 Secs X 12 (1880.401 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]* *[==>(Copy 11)]* *[==>(Copy 12)]*	***[2]***
4	Science 3 (WFC3IR.ss.1259355)	(1) 2MASS-J00041112-4721382	WFC3/IR, MULTIACCUM, GRISM256	G141	NSAMP=8; SAMP-SEQ=SPARS25	SPATIAL SCAN 0.022,90.0 Degrees,Forward	Sequence 4-4 Non-Int in WASP-96 WFC3 G141 transit (02)	156.700088 Secs X 12 (1880.401 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]* *[==>(Copy 11)]* *[==>(Copy 12)]*	***[3]***

	5	Science 3 (WFC3IR.ss.1259355)	(1) 2MASS-J00041112-4721382	WFC3/IR, MULTIACCUM, GRISM256	G141	NSAMP=8; SAMP-SEQ=SPARS25	SPATIAL SCAN 0.022,90.0 Degrees,Forward	Sequence 5-5 Non-Int in WASP-96 WFC3 G141 transit (02)	156.700088 Secs X 12 (1880.401 Secs)	
									[==>(Copy 1)] *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]* *[==>(Copy 11)]* *[==>(Copy 12)]*	***[4]***
	6	Science 3 (WFC3IR.ss.1259355)	(1) 2MASS-J00041112-4721382	WFC3/IR, MULTIACCUM, GRISM256	G141	NSAMP=8; SAMP-SEQ=SPARS25	SPATIAL SCAN 0.022,90.0 Degrees,Forward	Sequence 6-6 Non-Int in WASP-96 WFC3 G141 transit (02)	156.700088 Secs X 12 (1880.401 Secs)	
									[==>(Copy 1)] *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]* *[==>(Copy 11)]* *[==>(Copy 12)]*	***[5]***

Orbit Structure

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Exp. 3, copy 12
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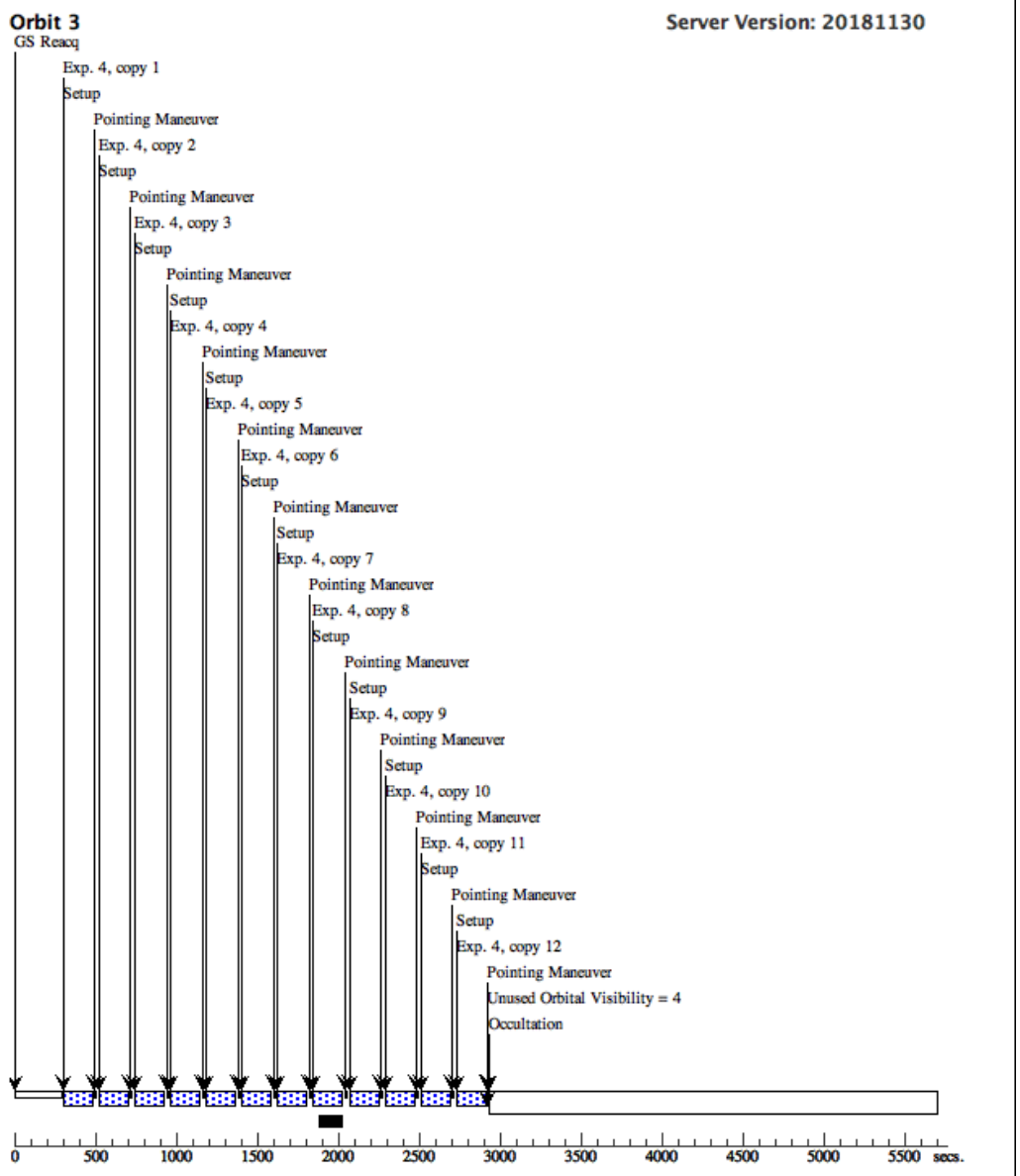
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Setup
Exp. 4, copy 12
Pointing Maneuver
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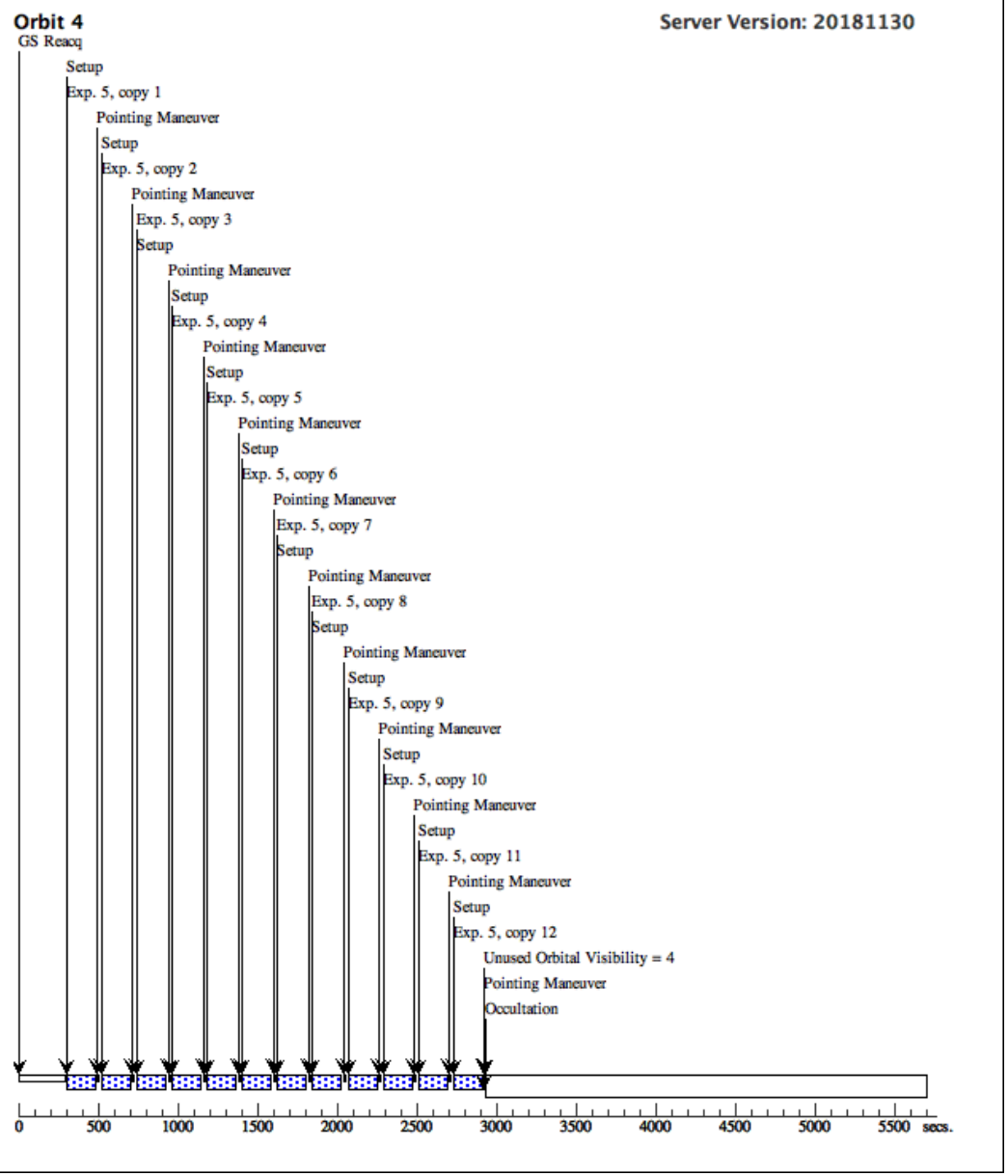
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Exp. 5, copy 12
Unused Orbital Visibility = 4
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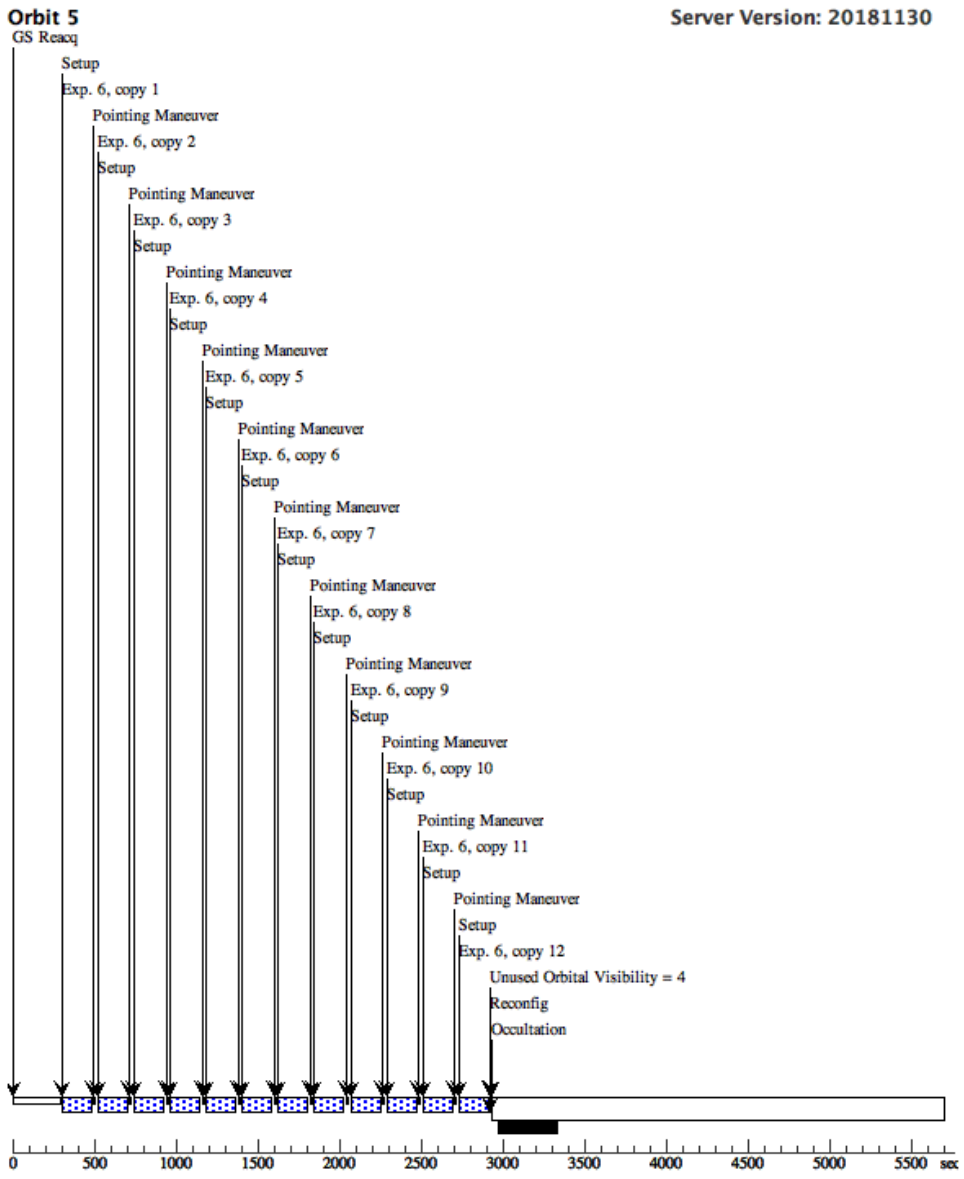
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Reconfig
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