16450 - Measuring the Rock-to-Ice Ratio in an Exoplanet

Cycle: 28, 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) HD-134004	WFC3/IR	5	22-Feb-2021 16:01:42.0	yes
02	(1) HD-134004	WFC3/IR	5	22-Feb-2021 16:01:54.0	yes

10 Total Orbits Used

ABSTRACT

With atmospheres hotter than 2000 K, ultra-hot Jupiters provide the unique opportunity to measure both refractory atomic metals and volatile molecules like H2O in their cloud-free transmission spectrum. The recently observed UV-optical (0.2-0.8 micron) transmission spectrum of ultra-hot Jupiter WASP-178b indicates strong absorption at short-wavelengths by atomic metals, consistent with refractory abundances between 1 and 4 times solar. Here, we propose to complete WASP-178b's UV-IR transit spectrum (0.2-1.7 micron) with WFC3/IR/G102 and G141, enabling the measurement of volatile abundances through H2O. With a measurement of refractory abundances at short wavelength and volatile abundances in the

IR, we can determine the planet's rock-to-ice ratio, providing insight into WASP-178b's formation and migration history. With the addition of WASP-178b's IR spectrum, we can better compare the planet to the broader ultra-hot Jupiter population, including whether the planet has TiO and VO in its atmosphere.

OBSERVING DESCRIPTION

Our WFC3/G102 and G141 observations will provide a transmission spectrum for the transiting exoplanet WASP-178b across the 0.8-1.7 micron wavelength range. We are targeting the absorption signatures of water and metal oxides.

**Observing strategy:

To construct the transmission spectrum, we require two transits of WASP-178b to be observed, with WFC3 G102 and G141. The observations will be made in slitless spectroscopic mode. Our observing setup is very similar to that used in many previous successful exoplanet transit programs, such as Program 14916 (PI Spake).

At the start of the HST visit, a standard phase-constrained acquisition image will be taken. The subsequent observing strategy consists of taking repeated exposures for the duration of the transit, plus time before and after the transit to establish the out-of-transit baseline flux.

We will use the round-trip spatial scanning mode with a scan rate of 0.0607766 and 0.759707 arcsec/sec for the G102 and G141 visit, respectively. We will use SPARS25 and NSAMP=7. These parameters were determined using the STScI-sponsored Exo-CTK/PandExo. We will read out a subarray size of 256 pixels to reduce overheads. Individual exposure times will be 134.354 sec, resulting in a scan across 8.2 and 10.2 arcsec per exposure for G102 and G141, respectively, leaving plenty of room on the detector to estimate the background flux.

Each transit of WASP-178b lasts 208 minutes. We therefore require 5 consecutive HST orbits. The first orbit serves to allow the telescope to thermally relax into its new pointing position, which is a standard procedure adopted by all HST transiting exoplanet observations. The remaining orbits will provide good phase coverage during 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 16 science exposures per HST orbit (8 forward, 8 reverse), coming to a total of 32 in-transit and 32 out-of-transit exposures.

**Signal-to-noise estimates:

WASP-178b is a bright target in the conventional sense (J=9.775mag). The challenge with exoplanet transmission spectroscopy is to measure subtle changes in the system brightness across different wavelength channels, via variations in the transit depth. We used the HST Exposure Time Calculator with the observational setup described above to calculate a SNR of ~2000 per resolution element per exposure. Note that this flux will be spread over 70-80 pixel columns due to the spatial scan (see above), so there is no risk of saturation.

Visit

Proposal 16450, G141 Transit (01), completed Mon Feb 22 21:01:56 GMT 2021

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: Period 3.3448285 D AND ZERO-PHASE HJD2456927.06839

Comments: WFC3/G141 5-orbit transit time series visit. It is essential that the five HST orbits be scheduled in a contiguous block, free of the SAA. We have defined each HST orbit within a non-interruptible sequence, to ensure that all exposures defined within the sequence are taken during the same HST orbit.

We will use round-trip spatial scanning mode to increase observing efficiency.

Y= -7" offset has been applied such that the target spatial scan is near the middle of the 256 subarray.

Nearby stars are relatively dim (J>15), but we will work with the scheduling and instrument teams to optimize any roll constraints if they are determined to be necessary.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	HD-134004 Alt Name1: WASP-178 Alt Name2: KELT-26	RA: 15 09 4.8790 (227.2703292d) Dec: -42 42 17.88 (-42.70497d) Equinox: J2000	Proper Motion RA: -9.082053709930597E-4 sec of time/yr Proper Motion Dec: -0.005653000039274048 arcsec/yr Parallax: 0.0023119" Epoch of Position: 2015.5	V=9.95+/-0.03	Reference Frame: SIMBAD

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. Lothringer added parallax, magnitudem uncertainty, and alternate names.
Category=STAR
Description=[A0-A3 V-IV, EXTRA-SOLAR PLANETARY SYSTEM]
Extended=NO

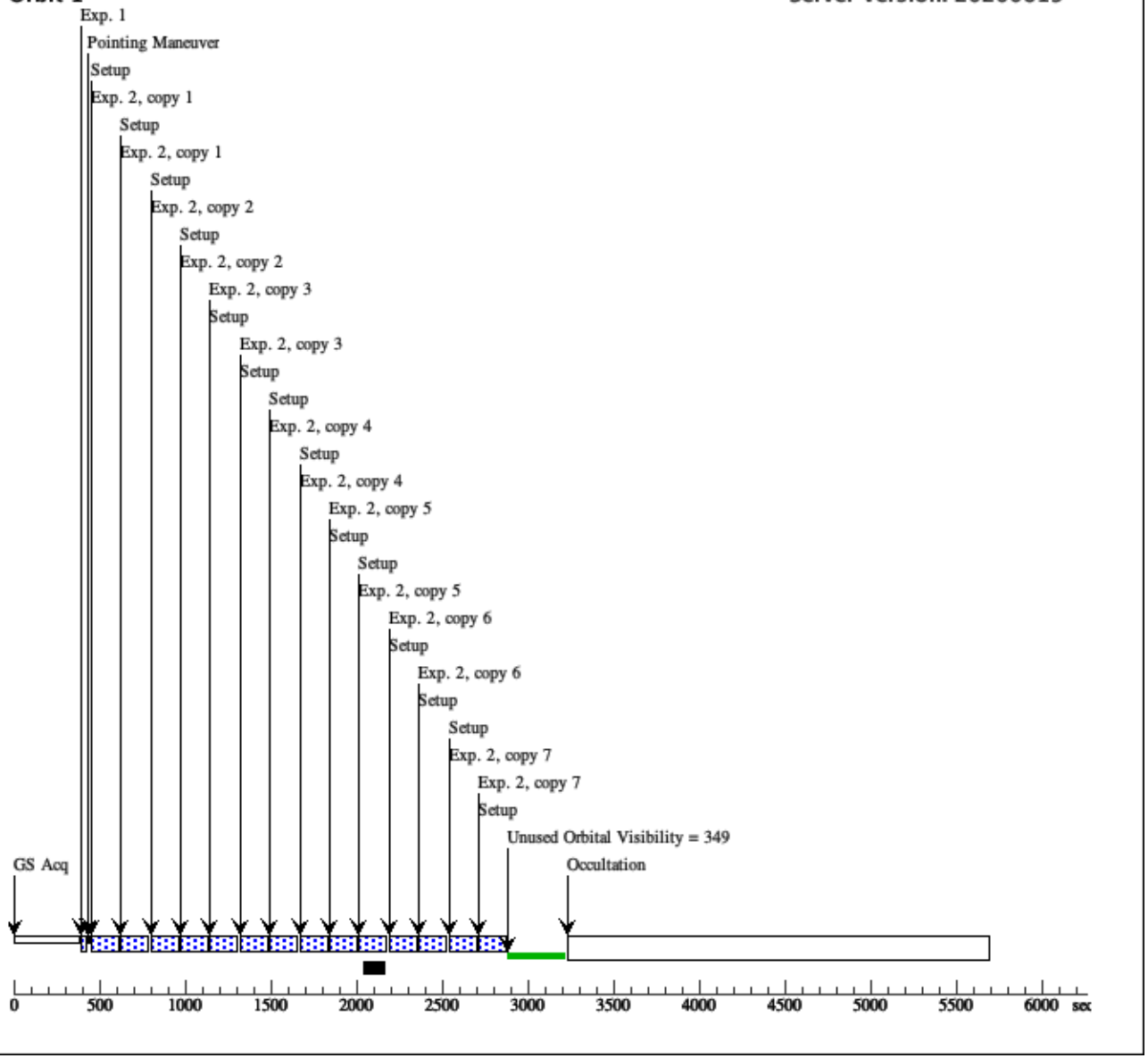
Exposures

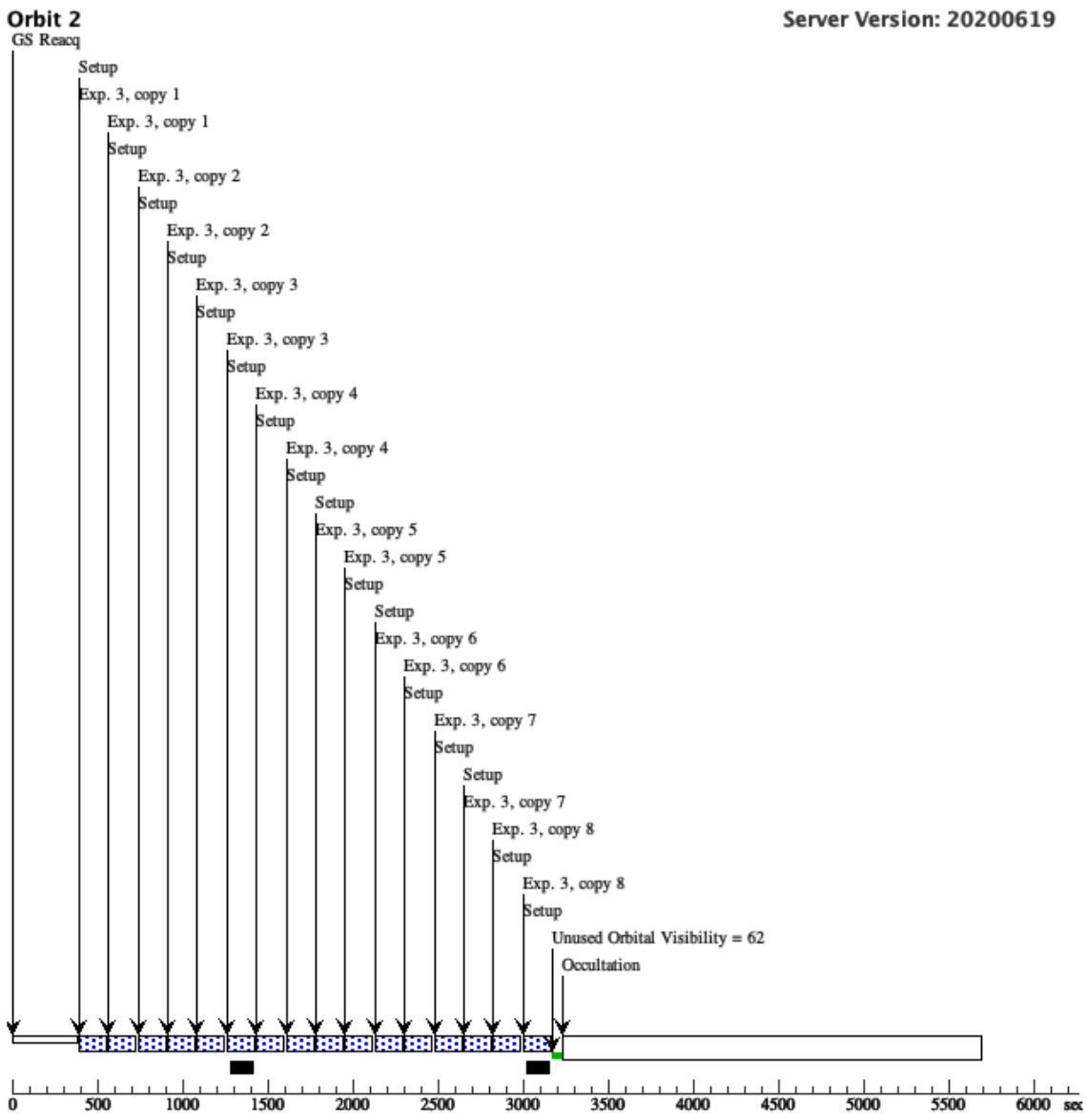
#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Direct Image (WFC3IR.im.1472511)	(1) HD-134004	WFC3/IR, MULTIACCUM, GRISM256	F132N	SAMP-SEQ=RAPID; NSAMP=2	POS TARG null,-7; PHASE 0.9430 TO 0.949	Sequence 1-2 Non-Int in G141 Transit (01)	0.55563 Secs (0.556 Secs) *[==>]*	***[1]***
Comments: Direct image to assist with wavelength calibration. Saturated, but the image is only used to find the reference detctor possition.									
2	Orbit 1 - Science Scans x 8 Round-trip (WFC3IR.ss.1472513)	(1) HD-134004	WFC3/IR, MULTIACCUM, GRISM256	G141	SAMP-SEQ=SPARS25; NSAMP=7	POS TARG null,-7; SPATIAL SCAN 0.0759707,90.0 Degrees ,Round trip	Sequence 1-2 Non-Int in G141 Transit (01)	134.354049 Secs X 7 (1880.957 Secs) *[==>(Copy 1, Forward)]* *[==>(Copy 1, Reverse)]* *[==>(Copy 2, Forward)]* *[==>(Copy 2, Reverse)]* *[==>(Copy 3, Forward)]* *[==>(Copy 3, Reverse)]* *[==>(Copy 4, Forward)]* *[==>(Copy 4, Reverse)]* *[==>(Copy 5, Forward)]* *[==>(Copy 5, Reverse)]* *[==>(Copy 6, Forward)]* *[==>(Copy 6, Reverse)]* *[==>(Copy 7, Forward)]* *[==>(Copy 7, Reverse)]*	***[1]***
3	Orbit 2 - Science Scans x 8 Round-trip (WFC3IR.ss.1472513)	(1) HD-134004	WFC3/IR, MULTIACCUM, GRISM256	G141	SAMP-SEQ=SPARS25; NSAMP=7	POS TARG null,-7; SPATIAL SCAN 0.0759707,90.0 Degrees ,Round trip	Sequence 3-3 Non-Int in G141 Transit (01)	134.354049 Secs X 8 (2149.665 Secs) *[==>(Copy 1, Forward)]* *[==>(Copy 1, Reverse)]* *[==>(Copy 2, Forward)]* *[==>(Copy 2, Reverse)]* *[==>(Copy 3, Forward)]* *[==>(Copy 3, Reverse)]* *[==>(Copy 4, Forward)]* *[==>(Copy 4, Reverse)]* *[==>(Copy 5, Forward)]* *[==>(Copy 5, Reverse)]* *[==>(Copy 6, Forward)]* *[==>(Copy 6, Reverse)]* *[==>(Copy 7, Forward)]* *[==>(Copy 7, Reverse)]* *[==>(Copy 8, Forward)]* *[==>(Copy 8, Reverse)]*	***[2]***

	4	Orbit 3 - Science Scans x 8 Round-trip (WFC3IR.ss.1472513)	(1) HD-134004	WFC3/IR, MULTIACCUM, GRISM256	G141	SAMP-SEQ=SPARS25; NSAMP=7	POS TARG null,-7; SPATIAL SCAN 0.0759707,90.0 Degrees ,Round trip	Sequence 4-4 Non-Int in G141 Transit (01)	134.354049 Secs X 8 (2149.665 Secs) *[==>(Copy 1, Forward)]* *[==>(Copy 1, Reverse)]* *[==>(Copy 2, Forward)]* *[==>(Copy 2, Reverse)]* *[==>(Copy 3, Forward)]* *[==>(Copy 3, Reverse)]* *[==>(Copy 4, Forward)]* *[==>(Copy 4, Reverse)]* *[==>(Copy 5, Forward)]* *[==>(Copy 5, Reverse)]* *[==>(Copy 6, Forward)]* *[==>(Copy 6, Reverse)]* *[==>(Copy 7, Forward)]* *[==>(Copy 7, Reverse)]* *[==>(Copy 8, Forward)]* *[==>(Copy 8, Reverse)]*	***[3]***
	5	Orbit 4 - Science Scans x 8 Round-trip (WFC3IR.ss.1472513)	(1) HD-134004	WFC3/IR, MULTIACCUM, GRISM256	G141	SAMP-SEQ=SPARS25; NSAMP=7	POS TARG null,-7; SPATIAL SCAN 0.0759707,90.0 Degrees ,Round trip	Sequence 5-5 Non-Int in G141 Transit (01)	134.354049 Secs X 8 (2149.665 Secs) *[==>(Copy 1, Forward)]* *[==>(Copy 1, Reverse)]* *[==>(Copy 2, Forward)]* *[==>(Copy 2, Reverse)]* *[==>(Copy 3, Forward)]* *[==>(Copy 3, Reverse)]* *[==>(Copy 4, Forward)]* *[==>(Copy 4, Reverse)]* *[==>(Copy 5, Forward)]* *[==>(Copy 5, Reverse)]* *[==>(Copy 6, Forward)]* *[==>(Copy 6, Reverse)]* *[==>(Copy 7, Forward)]* *[==>(Copy 7, Reverse)]* *[==>(Copy 8, Forward)]* *[==>(Copy 8, Reverse)]*	***[4]***

	6	Orbit 5 - Science Scans x 8 Round-trip (WFC3IR.ss.1472513)	(1) HD-134004	WFC3/IR, MULTIACCUM, GRISM256	G141	SAMP-SEQ=SPARS25; NSAMP=7	POS TARG null,-7; SPATIAL SCAN 0.0759707,90.0 Degrees,Round trip	Sequence 6-6 Non-Int in G141 Transit (01)	134.354049 Secs X 8 (2149.665 Secs) *[==>(Copy 1, Forward)]* *[==>(Copy 1, Reverse)]* *[==>(Copy 2, Forward)]* *[==>(Copy 2, Reverse)]* *[==>(Copy 3, Forward)]* *[==>(Copy 3, Reverse)]* *[==>(Copy 4, Forward)]* *[==>(Copy 4, Reverse)]* *[==>(Copy 5, Forward)]* *[==>(Copy 5, Reverse)]* *[==>(Copy 6, Forward)]* *[==>(Copy 6, Reverse)]* *[==>(Copy 7, Forward)]* *[==>(Copy 7, Reverse)]* *[==>(Copy 8, Forward)]* *[==>(Copy 8, Reverse)]*	***[5]***

Orbit Structure

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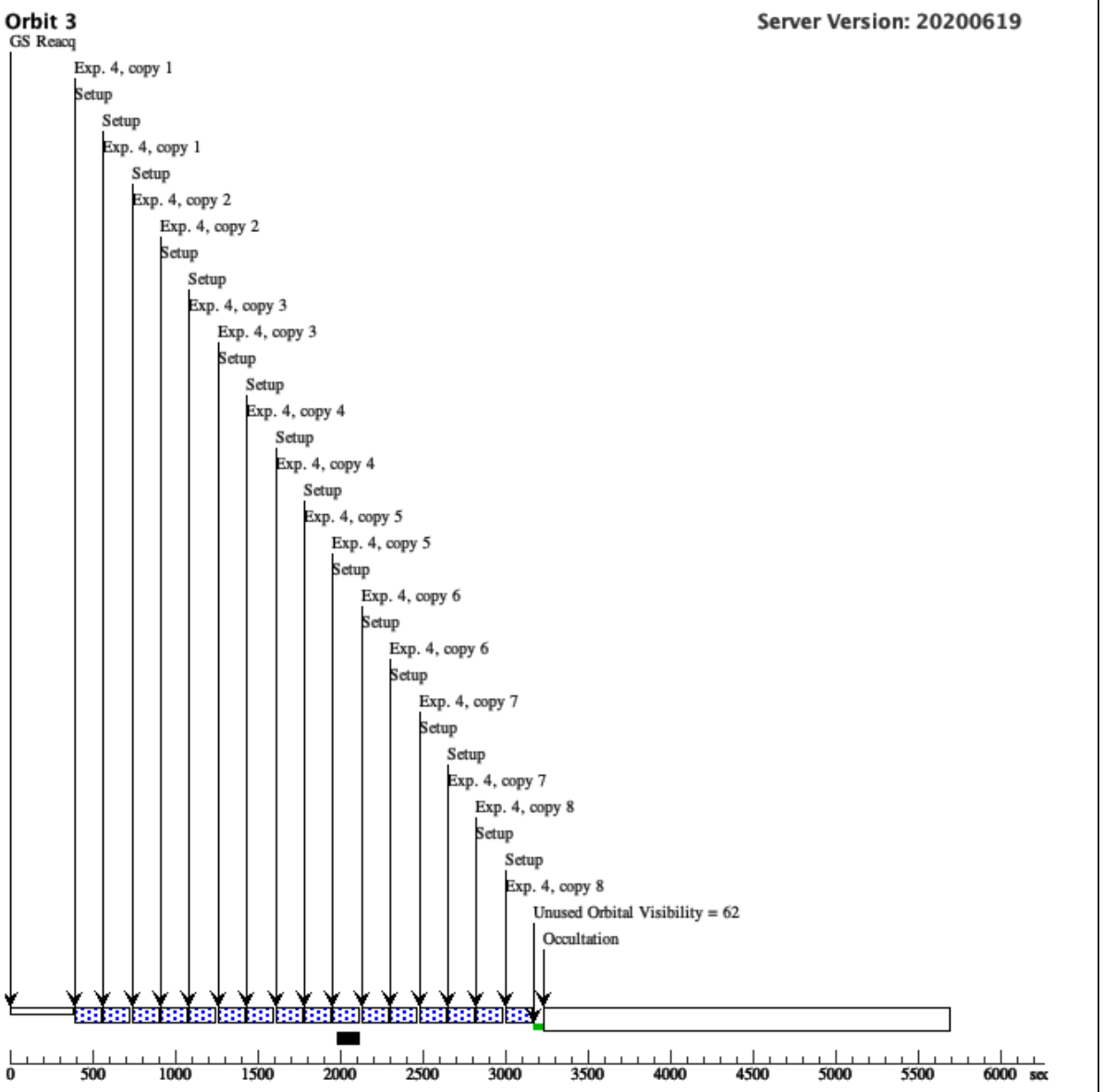
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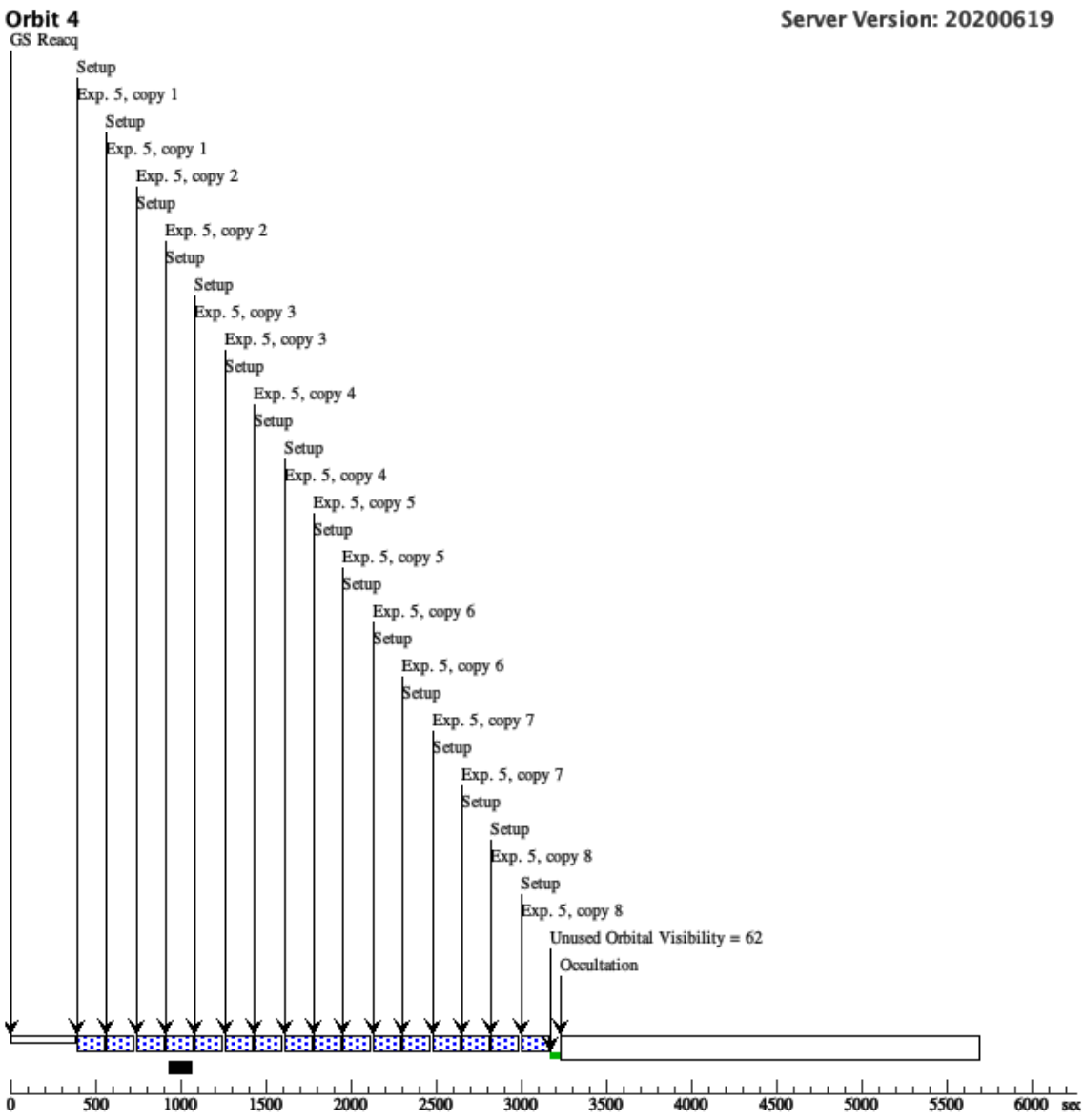
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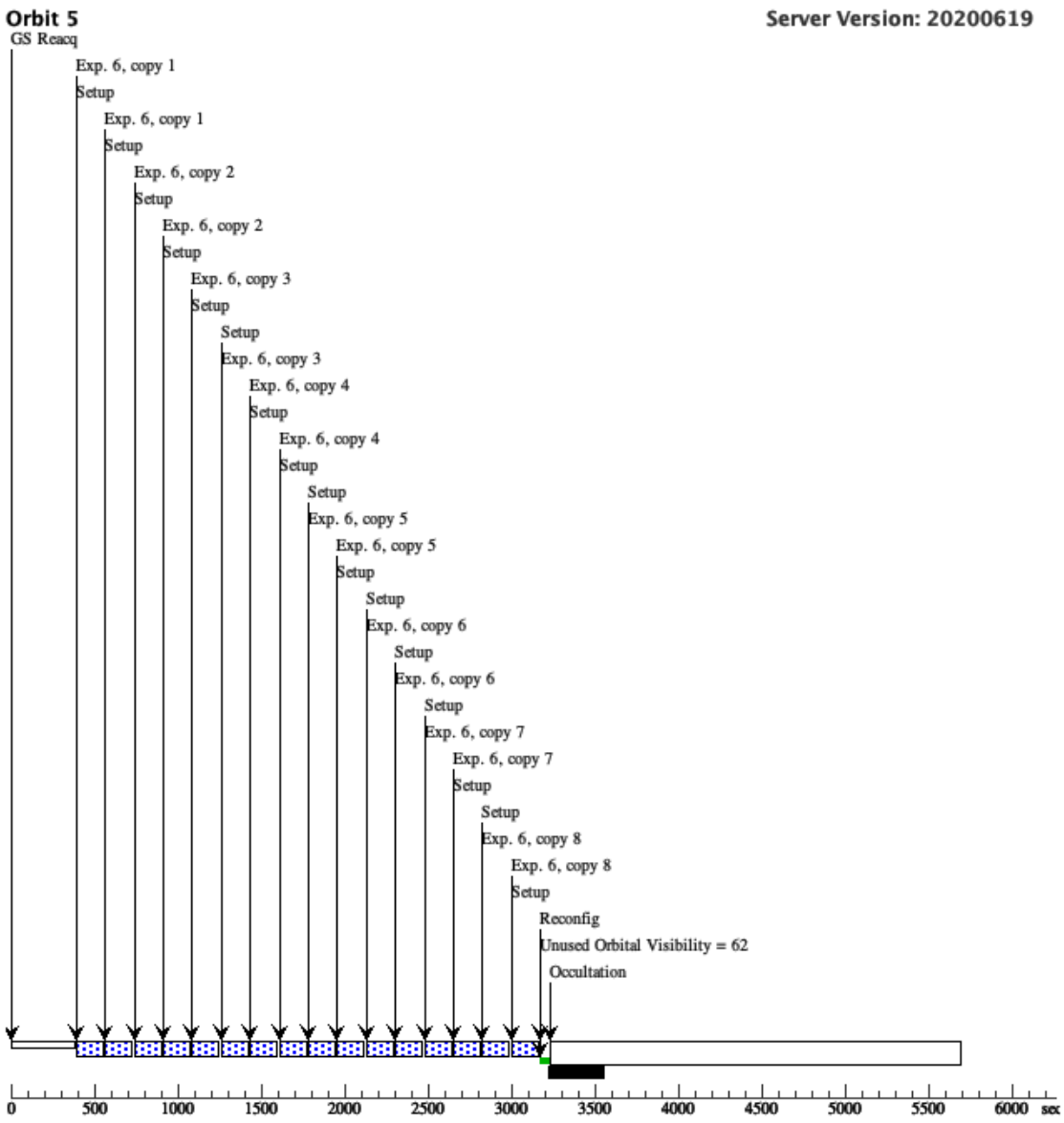
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Unused Orbital Visibility = 62
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Visit

Proposal 16450, G102 Transit (02), implementation Mon Feb 22 21:01:57 GMT 2021

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: Period 3.3448285 D AND ZERO-PHASE HJD2456927.06839

Comments: WFC3/G102 5-orbit transit time series visit. It is essential that the five HST orbits be scheduled in a contiguous block, free of the SAA. We have defined each HST orbit within a non-interruptible sequence, to ensure that all exposures defined within the sequence are taken during the same HST orbit.

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Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. Lothringer added parallax, magnitudem uncertainty, and alternate names.
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Extended=NO

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#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
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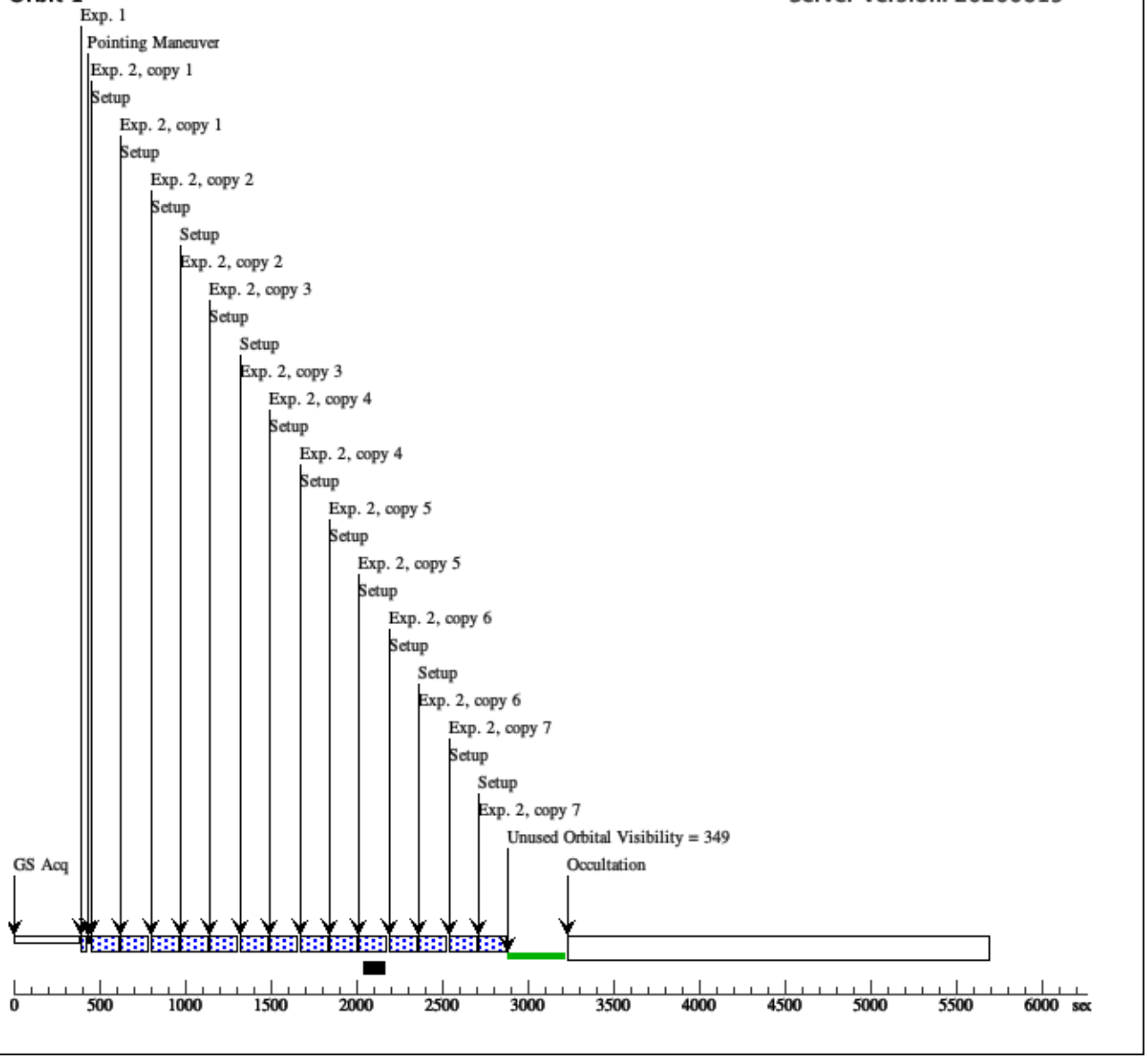
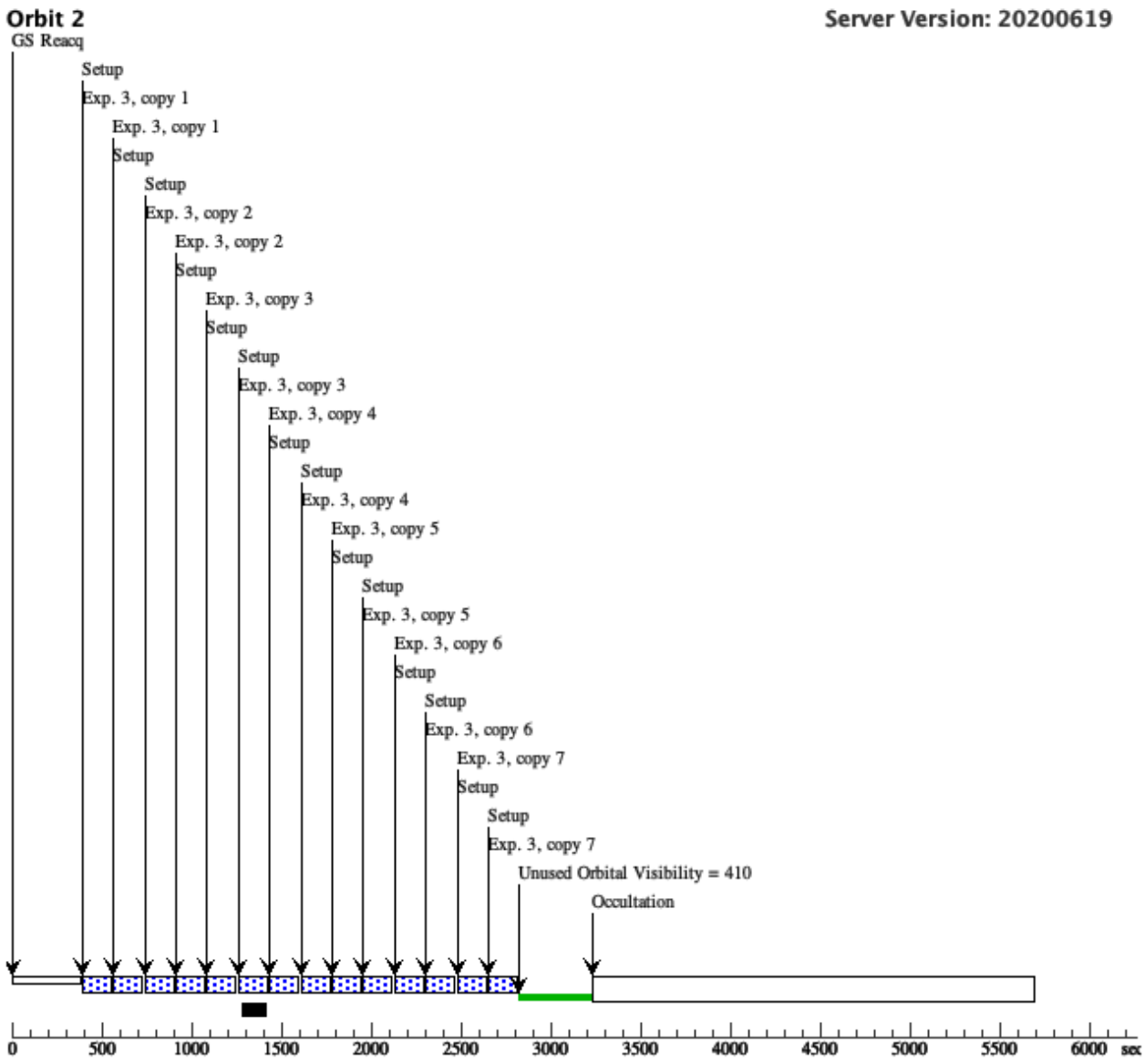
Comments: Direct image to assist with wavelength calibration. Saturated, but the image is only used to find the reference detctor possition.									
2	Orbit 1 - Science Scans x 8 Round-trip (WFC3IR.ss.1472514)	(1) HD-134004	WFC3/IR, MULTIACCUM, GRISM256	G102	SAMP-SEQ=SPARS25; NSAMP=7	POS TARG null,-7; SPATIAL SCAN 0.0607766,90.0 Degrees ,Round trip	Sequence 1-2 Non-Int in G102 Transit (02)	134.354049 Secs X 7 (1880.957 Secs) *[==>(Copy 1, Forward)]* *[==>(Copy 1, Reverse)]* *[==>(Copy 2, Forward)]* *[==>(Copy 2, Reverse)]* *[==>(Copy 3, Forward)]* *[==>(Copy 3, Reverse)]* *[==>(Copy 4, Forward)]* *[==>(Copy 4, Reverse)]* *[==>(Copy 5, Forward)]* *[==>(Copy 5, Reverse)]* *[==>(Copy 6, Forward)]* *[==>(Copy 6, Reverse)]* *[==>(Copy 7, Forward)]* *[==>(Copy 7, Reverse)]*	*[1]*
3	Orbit 2 - Science Scans x 8 Round-trip (WFC3IR.ss.1472514)	(1) HD-134004	WFC3/IR, MULTIACCUM, GRISM256	G102	SAMP-SEQ=SPARS25; NSAMP=7	POS TARG null,-7; SPATIAL SCAN 0.0607766,90.0 Degrees ,Round trip	Sequence 3-3 Non-Int in G102 Transit (02)	134.354049 Secs X 7 (1880.957 Secs) *[==>(Copy 1, Forward)]* *[==>(Copy 1, Reverse)]* *[==>(Copy 2, Forward)]* *[==>(Copy 2, Reverse)]* *[==>(Copy 3, Forward)]* *[==>(Copy 3, Reverse)]* *[==>(Copy 4, Forward)]* *[==>(Copy 4, Reverse)]* *[==>(Copy 5, Forward)]* *[==>(Copy 5, Reverse)]* *[==>(Copy 6, Forward)]* *[==>(Copy 6, Reverse)]* *[==>(Copy 7, Forward)]* *[==>(Copy 7, Reverse)]*	*[2]*

	4	Orbit 3 - Science Scans x 8 Round-trip (WFC3IR.ss.1472514)	(1) HD-134004	WFC3/IR, MULTIACCUM, GRISM256	G102	SAMP-SEQ=SPARS25; NSAMP=7	POS TARG null,-7; SPATIAL SCAN 0.0 607766,90.0 Degrees ,Round trip	Sequence 4-4 Non-Int in G102 Transit (02)	134.354049 Secs X 7 (1880.957 Secs) *[==>(Copy 1, Forward)]* *[==>(Copy 1, Reverse)]* *[==>(Copy 2, Forward)]* *[==>(Copy 2, Reverse)]* *[==>(Copy 3, Forward)]* *[==>(Copy 3, Reverse)]* *[==>(Copy 4, Forward)]* *[==>(Copy 4, Reverse)]* *[==>(Copy 5, Forward)]* *[==>(Copy 5, Reverse)]* *[==>(Copy 6, Forward)]* *[==>(Copy 6, Reverse)]* *[==>(Copy 7, Forward)]* *[==>(Copy 7, Reverse)]*	***[3]***
	5	Orbit 4 - Science Scans x 8 Round-trip (WFC3IR.ss.1472514)	(1) HD-134004	WFC3/IR, MULTIACCUM, GRISM256	G102	SAMP-SEQ=SPARS25; NSAMP=7	POS TARG null,-7; SPATIAL SCAN 0.0 607766,90.0 Degrees ,Round trip	Sequence 5-5 Non-Int in G102 Transit (02)	134.354049 Secs X 7 (1880.957 Secs) *[==>(Copy 1, Forward)]* *[==>(Copy 1, Reverse)]* *[==>(Copy 2, Forward)]* *[==>(Copy 2, Reverse)]* *[==>(Copy 3, Forward)]* *[==>(Copy 3, Reverse)]* *[==>(Copy 4, Forward)]* *[==>(Copy 4, Reverse)]* *[==>(Copy 5, Forward)]* *[==>(Copy 5, Reverse)]* *[==>(Copy 6, Forward)]* *[==>(Copy 6, Reverse)]* *[==>(Copy 7, Forward)]* *[==>(Copy 7, Reverse)]*	***[4]***

	6	Orbit 5 - Science Scans x 8 Round-trip (WFC3IR.ss.1472514)	(1) HD-134004	WFC3/IR, MULTIACCUM, GRISM256	G102	SAMP-SEQ=SPARS25; NSAMP=7	POS TARG null,-7; SPATIAL SCAN 0.0607766,90.0 Degrees,Round trip	Sequence 6-6 Non-Int in G102 Transit (02)	134.354049 Secs X 7 (1880.957 Secs) *[==>(Copy 1, Forward)]* *[==>(Copy 1, Reverse)]* *[==>(Copy 2, Forward)]* *[==>(Copy 2, Reverse)]* *[==>(Copy 3, Forward)]* *[==>(Copy 3, Reverse)]* *[==>(Copy 4, Forward)]* *[==>(Copy 4, Reverse)]* *[==>(Copy 5, Forward)]* *[==>(Copy 5, Reverse)]* *[==>(Copy 6, Forward)]* *[==>(Copy 6, Reverse)]* *[==>(Copy 7, Forward)]* *[==>(Copy 7, Reverse)]*	***[5]***

Orbit Structure

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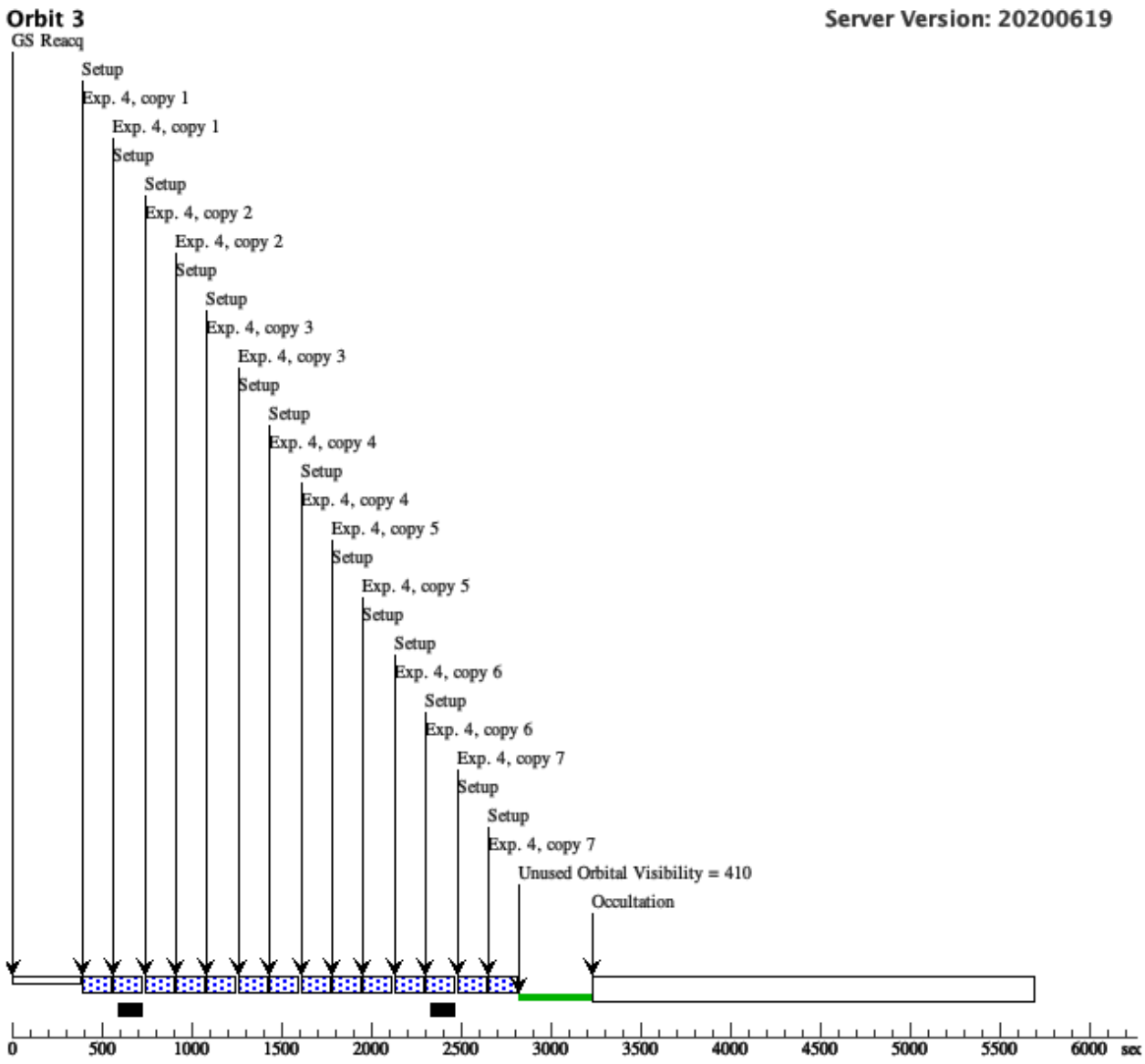
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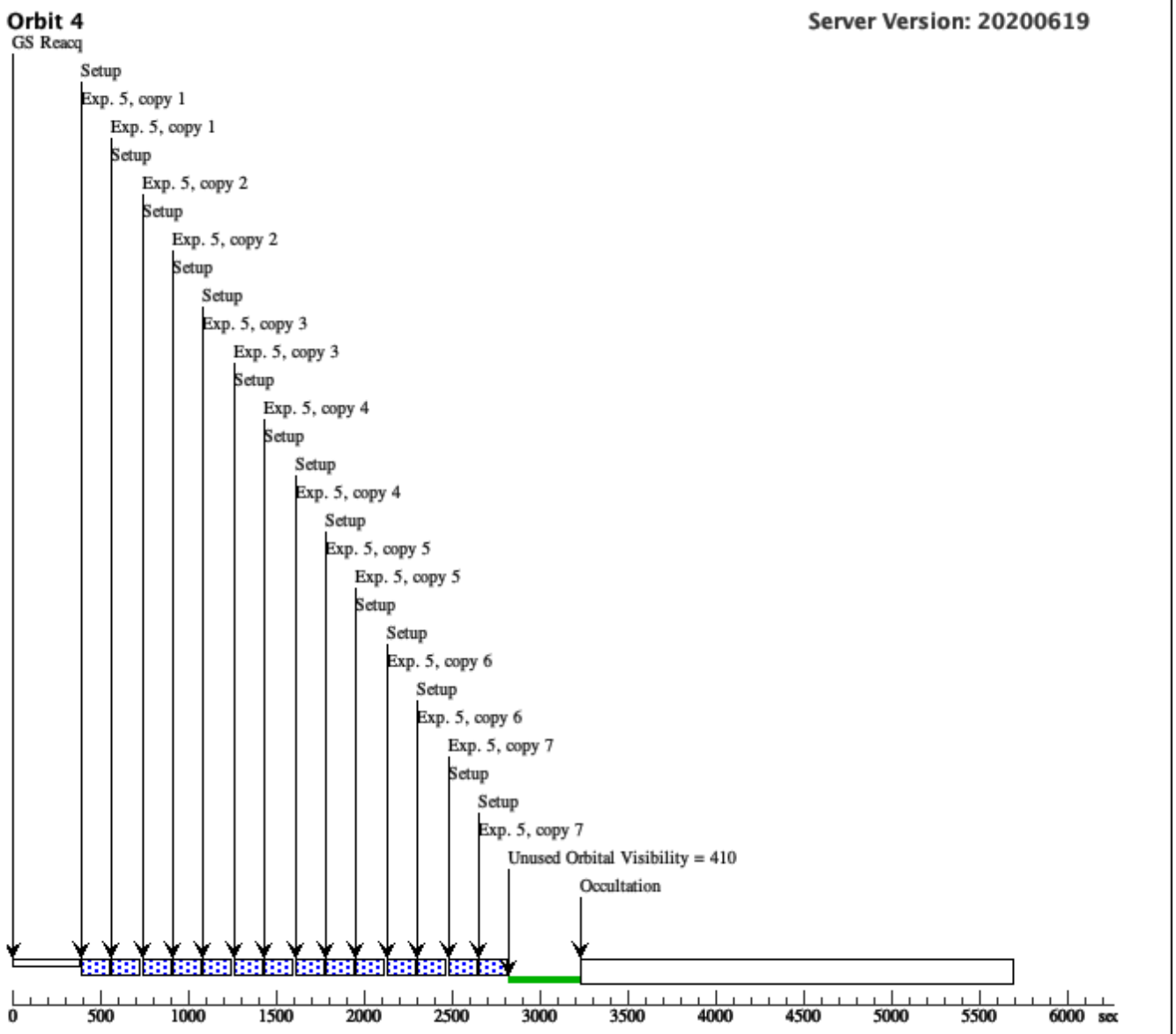
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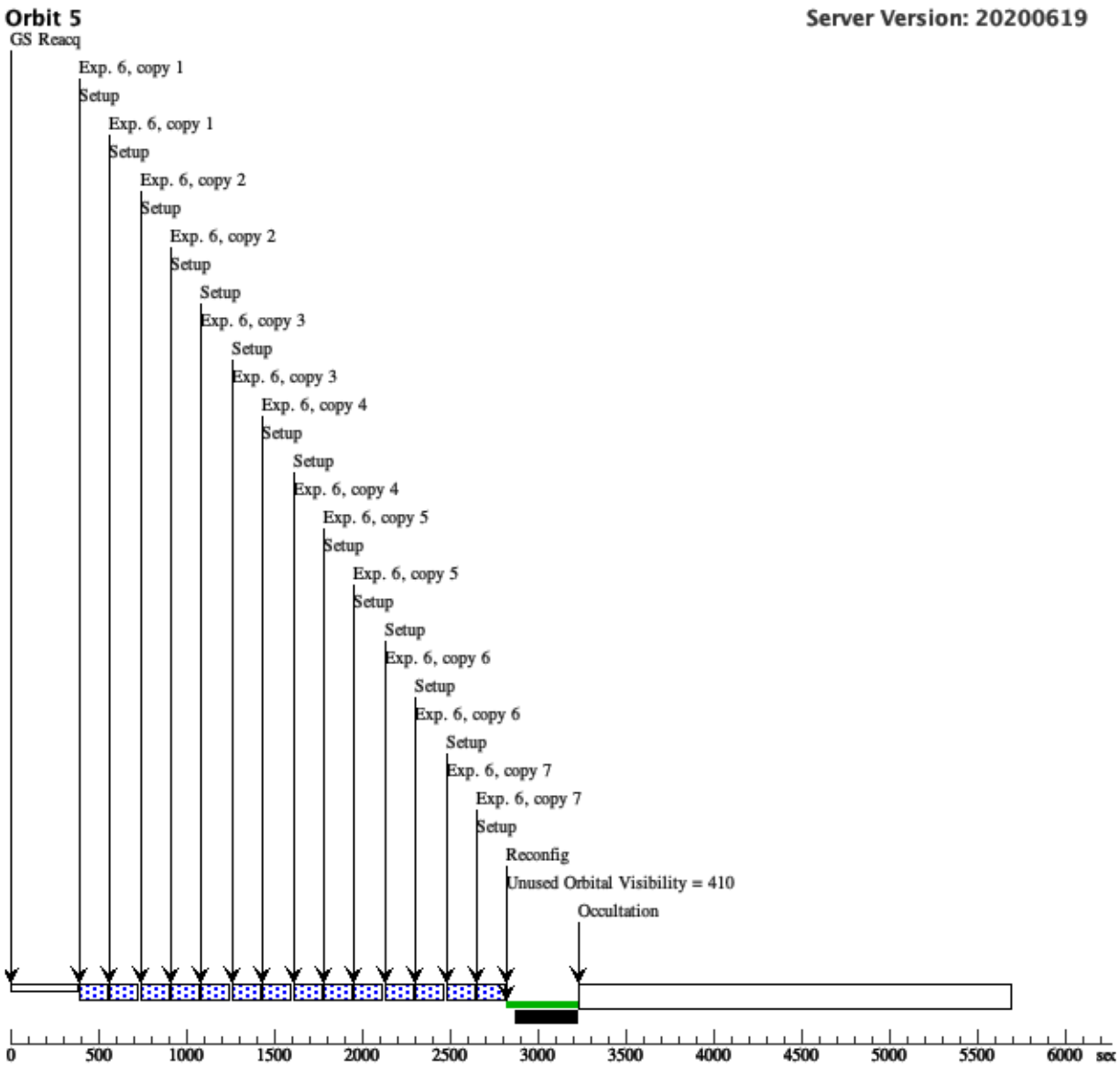
sec


Orbit 5
Server Version: 20200619
GS Reacq
Exp. 6, copy 1
Setup
Exp. 6, copy 1
Setup
Exp. 6, copy 2
Setup
Exp. 6, copy 2
Setup
Setup
Exp. 6, copy 3
Setup
Exp. 6, copy 3
Exp. 6, copy 4
Setup
Setup
Exp. 6, copy 4
Exp. 6, copy 5
Setup
Exp. 6, copy 5
Setup
Setup
Exp. 6, copy 6
Setup
Exp. 6, copy 6
Setup
Exp. 6, copy 7
Exp. 6, copy 7
Setup
Reconfig
Unused Orbital Visibility = 410
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
sec