15109 - Caught Red-Handed: A Novel Search for the Culprit Behind Thermal Inversions in Exoplanet Atmospheres

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) HD-15082	WFC3/IR	5	20-Oct-2017 20:00:30.0	yes

5 Total Orbits Used

ABSTRACT

Thermal inversions have been one of the mostly hotly debated topics in exoplanet atmospheres over the last decade. Recent observations show conclusively that thermal inversions do exist for some of the most highly irradiated planets. The likeliest culprit for the inversions is strong absorption by titanium and vanadium oxide (TiO/VO) gas, which heats the upper atmosphere. However, TiO/VO have never been detected, despite many attempts. It is possible that these efforts failed because they focused on planets that were too cool, or were foiled by clouds and haze.

We propose a novel search for TiO in the atmosphere of WASP-33b, a planet with a known thermal inversion (Haynes et al. 2015). We will measure

the planet's thermal emission spectrum with the WFC3/G102 grism, where TiO is expected to have strong spectral features. This is the first proposed use of this grism for exoplanet emission spectroscopy. WASP-33b has the single highest signal-to-noise in thermal emission of any exoplanet known, and with one eclipse observation we will be sensitive to temperature differences in the upper atmosphere of <50 Kelvin. If TiO is present, we will detect it at high confidence (>10 sigma) and definitively settle the thermal inversion debate.

OBSERVING DESCRIPTION

We will obtain time series WFC3/G102 spectroscopy over five consecutive orbits coinciding with the secondary eclipse of WASP-33b. The observations must be scheduled to avoid the SAA crossing. We specify phase constraints such that orbits 3 and 4 occur during the eclipse event. Orbits 1, 2, and 5 will be used as baseline.

Each orbit will begin with a direct image of the target star with the F139M filter for wavelength calibration. The remainder of each orbit will consist of 83 s exposures using the NSAMP = 9, SPARS10 readout pattern. To keep the fluence below saturation, we will use spatial scan mode with a 0.343 arcsec/sec scan rate (yielding a total scan height of 170 pixels). This setup will keep the maximum per pixel counts to below 30k electrons. We will alternate between forward and reverse scanning along the detector.

We will also acquire one staring mode exposure at the beginning of orbit 1 to get a spatially separated spectrum of the nearby (~1") companion star (Moya et al. 2011).

Visit

Proposal 15109, WASP-33b G102 eclipse (01), implementation Sat Oct 21 00:00:35 GMT 2017

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: SCHED 100%; Period 1.21987016 D AND ZERO-PHASE HJD2452984.82964

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	HD-15082	RA: 02 26 51.0582 (36.7127425d)	Proper Motion RA: -1.26 mas/yr	V=8.14	Reference Frame: SIMBAD
		Dec: +37 33 1.73 (37.55048d)	Proper Motion Dec: -9.22 mas/yr		
		Equinox: J2000	Epoch of Position: 2000.		

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.

Exposures

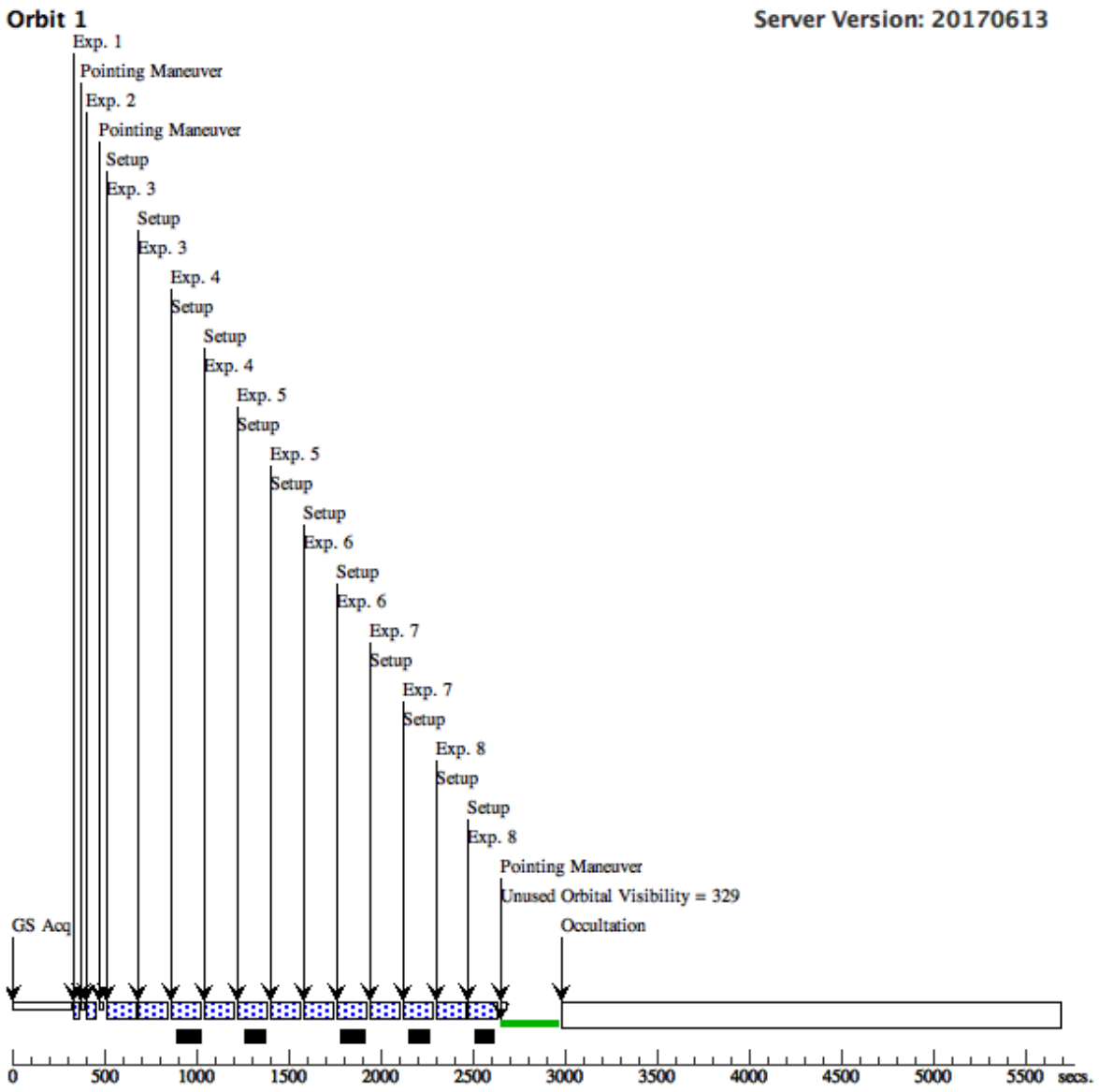
#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	F139M	SAMP-SEQ=RAPID; NSAMP=2	PHASE 0.33 TO 0.42	Sequence 1-8 Non-Int in WASP-33b G102 eclipse (01)	1.706054 Secs (1.706 Secs) *[==>]*	***[1]***
2		(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	SAMP-SEQ=SPARS25; NSAMP=2	POS TARG -16.5,0	Sequence 1-8 Non-Int in WASP-33b G102 eclipse (01)	23.774278 Secs (23.774 Secs) *[==>]*	***[1]***
3		(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 1-8 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[1]***
4		(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 1-8 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[1]***
5		(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 1-8 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[1]***
6		(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 1-8 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[1]***
7		(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 1-8 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[1]***
8		(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 1-8 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[1]***
9		(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	F139M	SAMP-SEQ=RAPID; NSAMP=2		Sequence 9-16 Non-Int in WASP-33b G102 eclipse (01)	1.706054 Secs (1.706 Secs) *[==>]*	***[2]***
10		(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 9-16 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[2]***
11		(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 9-16 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[2]***
12		(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 9-16 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[2]***

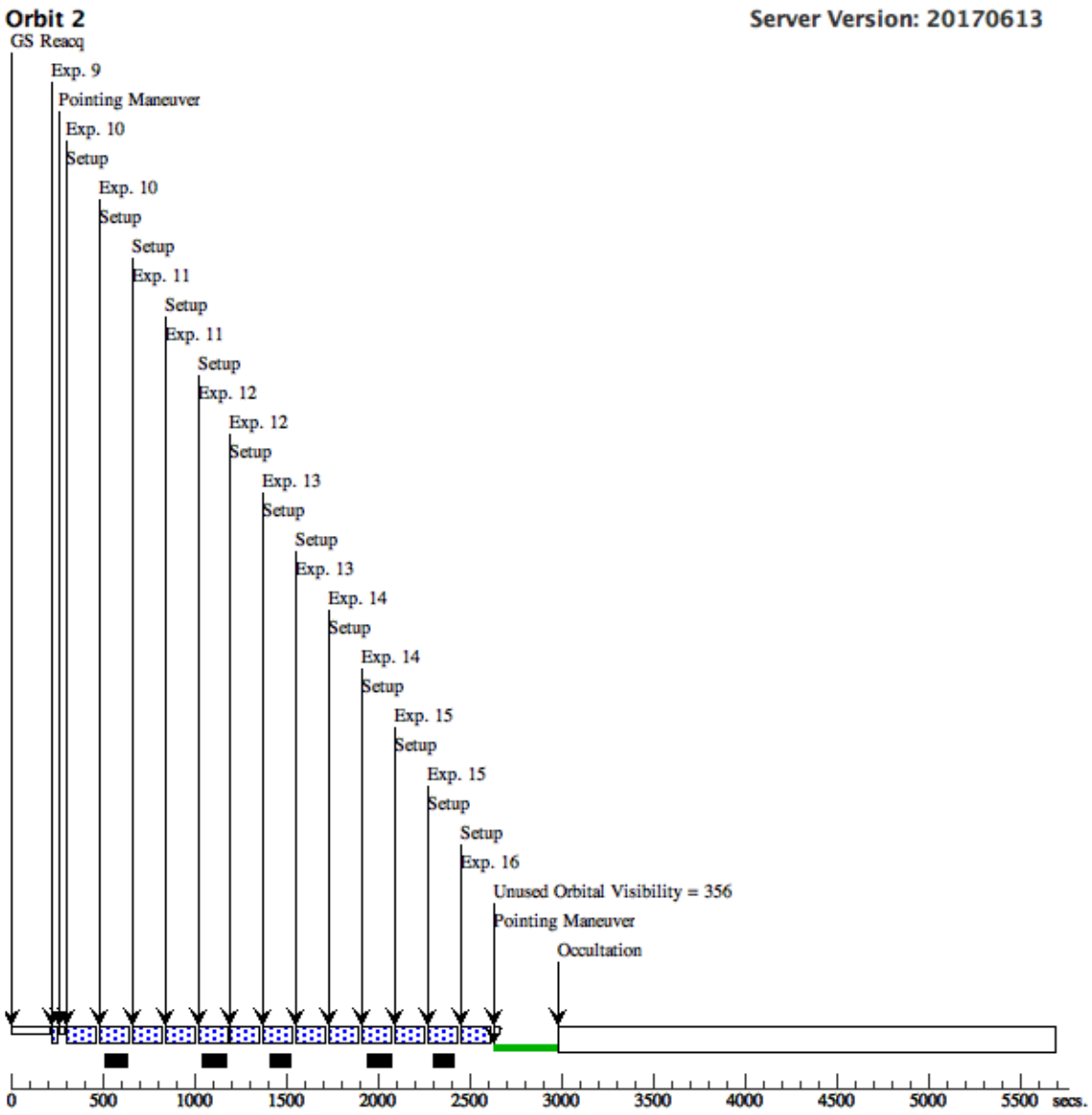
13	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 9-16 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[2]***
14	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 9-16 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[2]***
15	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 9-16 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[2]***
16	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Forward	Sequence 9-16 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (138.381 Secs) *[==>]*	***[2]***
17	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	F139M	SAMP-SEQ=RAPID; NSAMP=2		Sequence 17-24 Non-Int in WASP-33b G102 eclipse (01)	1.706054 Secs (1.706 Secs) *[==>]*	***[3]***
18	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 17-24 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[3]***
19	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 17-24 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[3]***
20	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 17-24 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[3]***
21	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 17-24 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[3]***
22	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 17-24 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[3]***
23	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 17-24 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[3]***

24	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Forward	Sequence 17-24 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (138.381 Secs) *[==>]*	***[3]***
25	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	F139M	SAMP-SEQ=RAPID; NSAMP=2		Sequence 25-32 Non-Int in WASP-33b G102 eclipse (01)	1.706054 Secs (1.706 Secs) *[==>]*	***[4]***
26	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 25-32 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[4]***
27	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 25-32 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[4]***
28	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 25-32 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[4]***
29	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 25-32 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[4]***
30	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 25-32 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[4]***
31	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 25-32 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[4]***
32	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Forward	Sequence 25-32 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (138.381 Secs) *[==>]*	***[4]***
33	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	F139M	SAMP-SEQ=RAPID; NSAMP=2		Sequence 33-40 Non-Int in WASP-33b G102 eclipse (01)	1.706054 Secs (1.706 Secs) *[==>]*	***[5]***
34	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 33-40 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[5]***

	35	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 33-40 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[5]***
	36	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 33-40 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[5]***
	37	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 33-40 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[5]***
	38	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 33-40 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[5]***
	39	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Round trip	Sequence 33-40 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (276.761 Secs) *[==>(Forward)]* *[==>(Reverse)]*	***[5]***
	40	(1) HD-15082	WFC3/IR, MULTIACCUM, GRISM512	G102	NSAMP=7; SAMP-SEQ=SPARS25	POS TARG -16.5,-25; SPATIAL SCAN 0.343,90.0 Degrees,Forward	Sequence 33-40 Non-Int in WASP-33b G102 eclipse (01)	138.380533 Secs (138.381 Secs) *[==>]*	***[5]***

Orbit Structure

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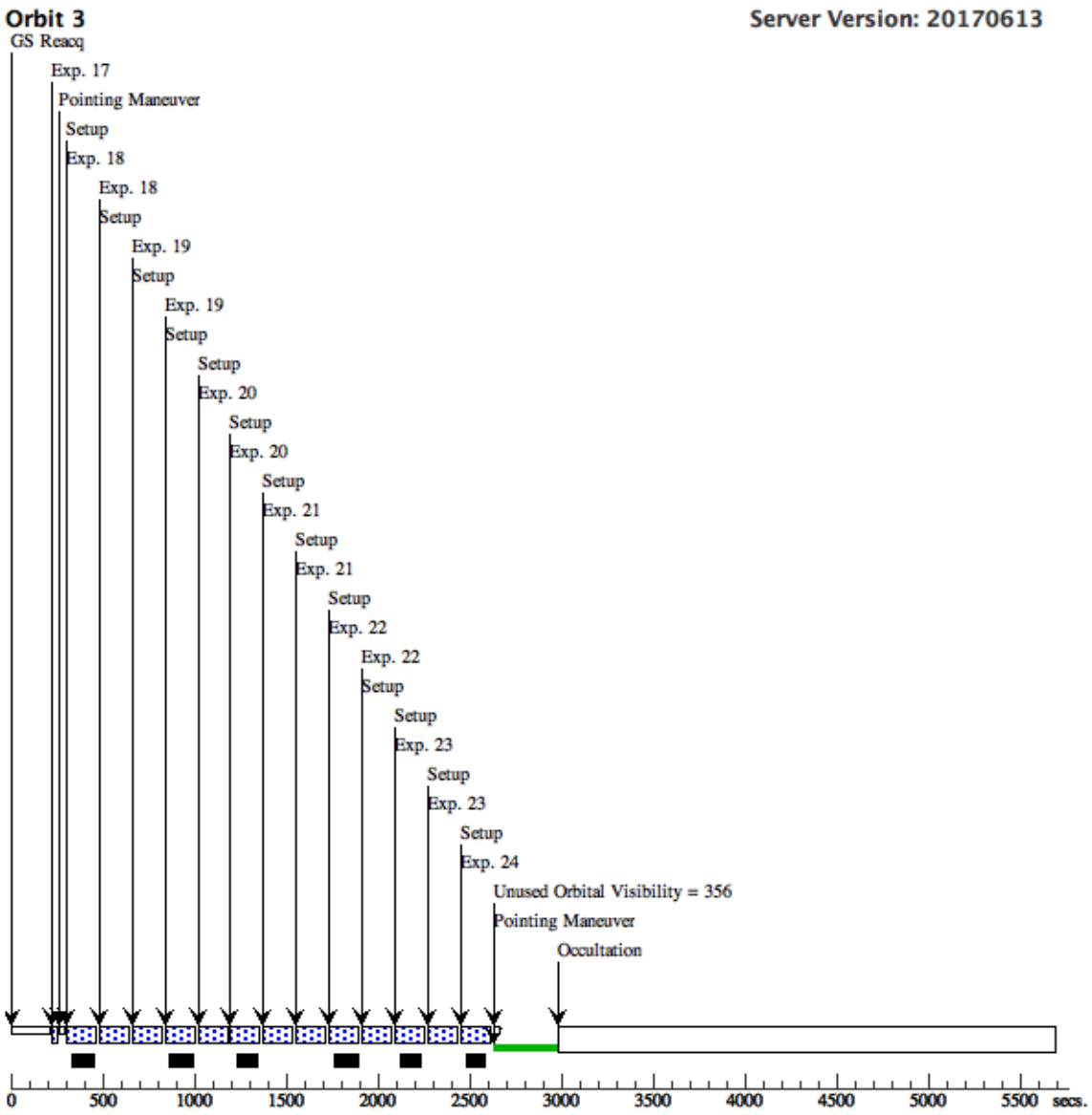
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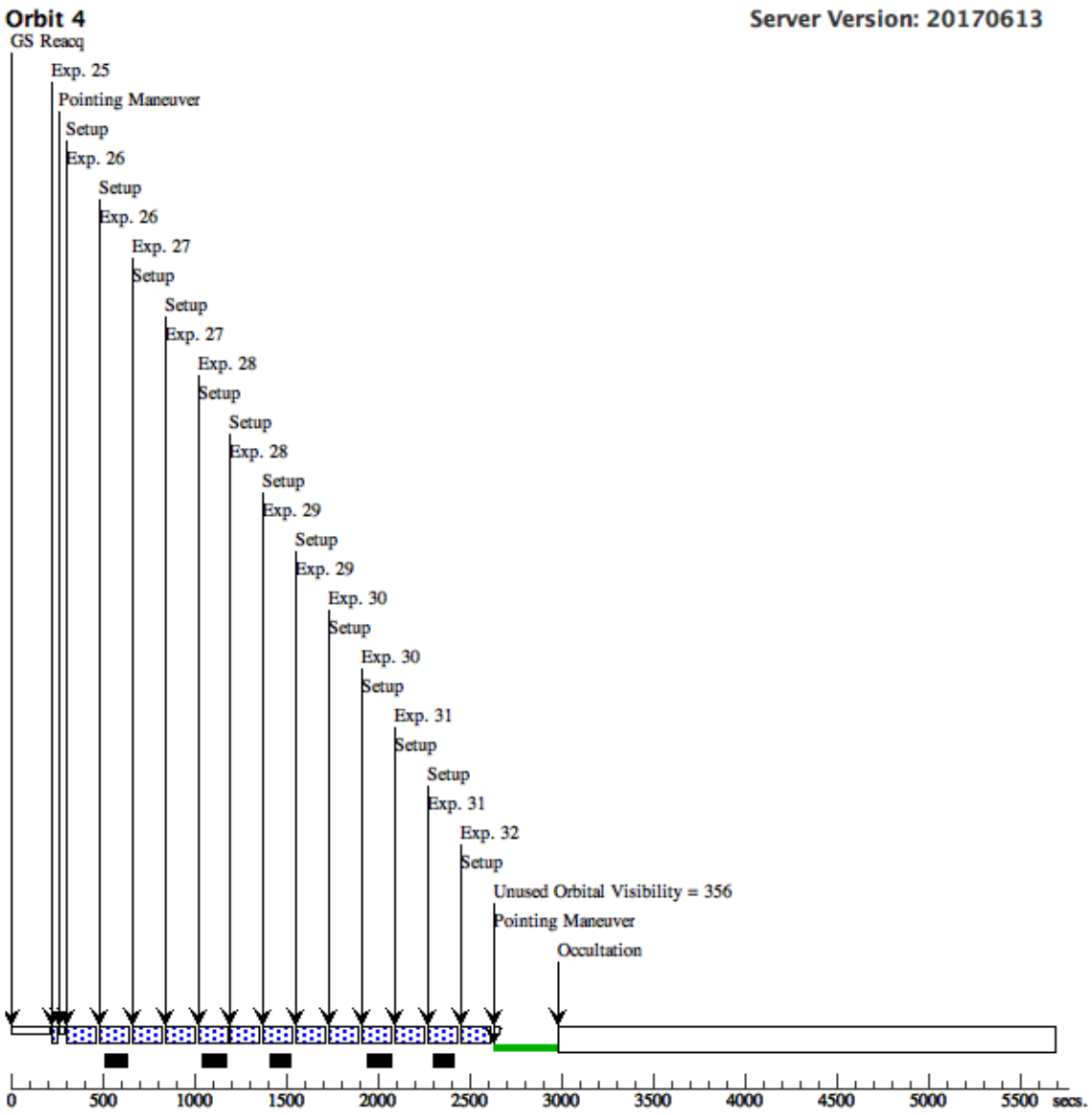
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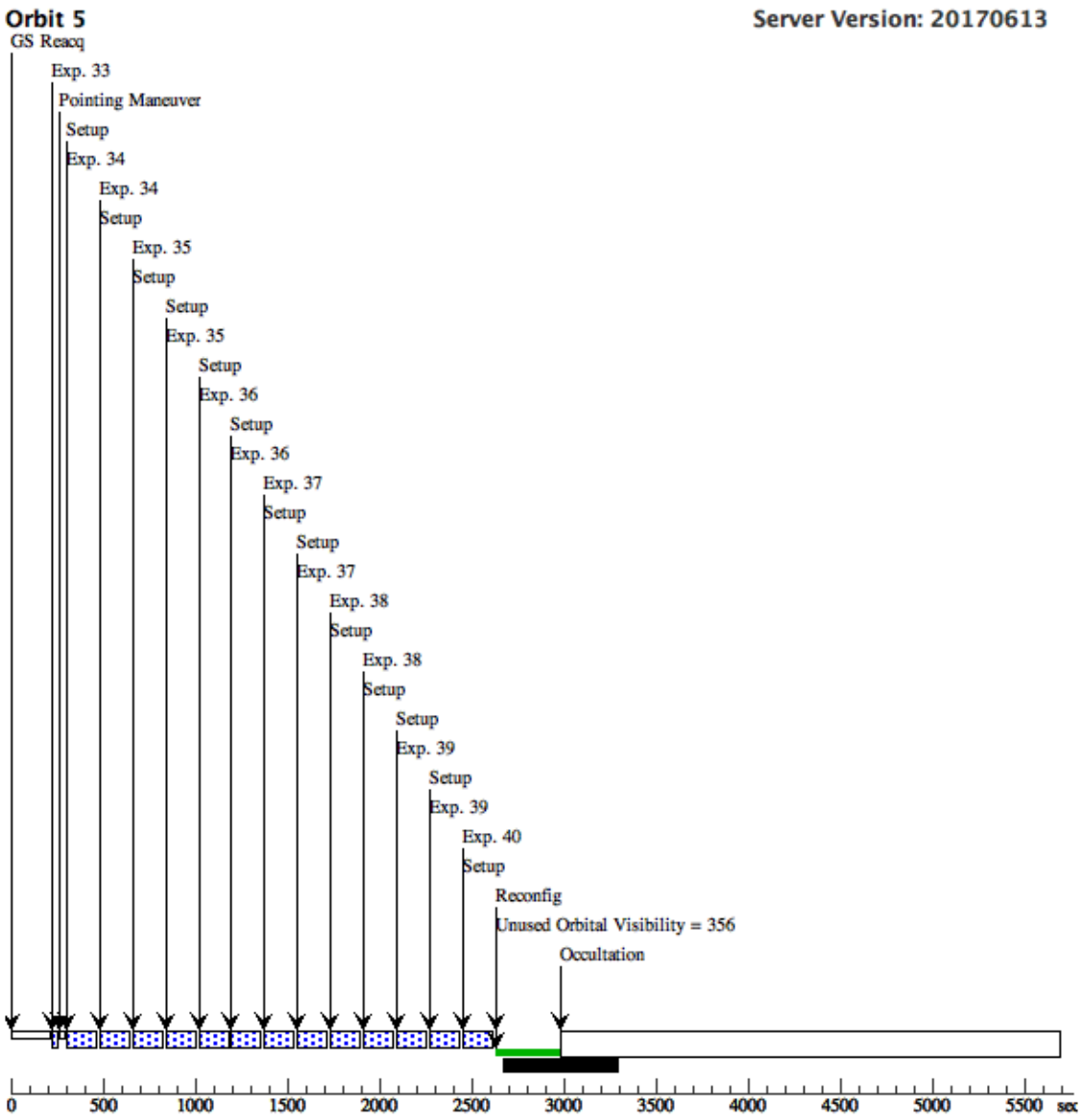
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Exp. 40
Setup
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