17585 - The Discovery of a Fourth Low-Mass Planet in an Unusual Super-Puff System

Cycle: 30, Proposal Category: GO/DD

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*
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Dr. Guangwei Fu (CoI)	The Johns Hopkins University
Dr. Kevin Stevenson (CoI)	The Johns Hopkins University Applied Physics Laboratory
Prof. Xi Zhang (CoI)	University of California - Santa Cruz
Dr. Luis Welbanks (CoI)	Arizona State University
Dr. Renyu Hu (CoI)	Jet Propulsion Laboratory
Aaron Bello-Arufe (CoI)	Jet Propulsion Laboratory
Dr. Yui Kawashima (CoI)	ISAS, Japan Aerospace Exploration Agency
Dr. Leslie Hebb (CoI)	Hobart and William Smith Colleges
Dr. Richard Freedman (CoI)	SETI Institute

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) KEPLER-51	WFC3/IR	6	17-Oct-2023 23:00:43.0	yes
02	(1) KEPLER-51	WFC3/IR	6	17-Oct-2023 23:01:32.0	yes

12 Total Orbits Used

ABSTRACT

The Kepler-51 system consists of three known "super-puff" exoplanets - ultra-low density objects that challenge current theories of planet formation and evolution, with masses measured exclusively from transit timing variations (TTVs). The transmission spectra of Kepler-51b and d were observed with JWST to investigate their atmospheric composition and to search for high altitude hazes and/or planetary rings that may be responsible for their large observed radii. However, the JWST mid-transit time of Kepler-51d was discrepant from TTV predictions by 2 hours, compared to the prediction uncertainty of 2.7 minutes. In order to match the new observations, a fourth planet must be included in the TTV models, with the uncertainty in its mass and period greatly increasing the uncertainty on the masses of the three known planets and their future transit times. As a result, not only is it more difficult to interpret the JWST spectra, but we now run the risk of missing future transits of the Kepler-51 planets altogether. We therefore propose to observe the next transits of Kepler-51c and d in late Oct/early Nov 2023 with HST. Observing these two planets would provide the tightest constraints possible on the mass and period of the fourth planet and reduce the uncertainties on the masses and future transit times of the other three planets. These transits cannot be observed from the ground due to the faintness of the host star and the availability of large telescopes, nor can we wait for subsequent transits due to the increasing uncertainty of the transit time with time. With HST being the ideal space telescope for this observation and the timing of these transits, we request DD time.

OBSERVING DESCRIPTION

There are two transits observations, one each of Kepler-51c and Kepler-51d.

Visit

Proposal 17585, Kepler-51c (01), implementation Wed Oct 18 03:01:35 GMT 2023

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: ORIENT 260D TO 270 D; ORIENT 80D TO 230 D; ORIENT 305D TO 50 D; Period 85.313 D AND ZERO-PHASE HJD2460247.321

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	KEPLER-51	RA: 19 45 55.1429 (296.4797621d) Dec: +49 56 15.65 (49.93768d) Equinox: J2000	Proper Motion RA: 0.075 mas/yr Proper Motion Dec: -7.4509999194560805 mas/yr Epoch of Position: 2000	V=14.885+/-0.126 J = 13.562, H = 13.291, K=13.197	Reference Frame: SIMBAD

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

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	F139M	NSAMP=15; SAMP-SEQ=RAPID	POS TARG 0,0; PHASE 0.9974456504 TO 0.9979340538	Sequence 1-2 Non-Int in Kepler-51c (01)	4.167225 Secs (4.167 Secs)	
								[==>]	***[1]***
2		(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	G141	NSAMP=15; SAMP-SEQ=SPARS10	POS TARG 0,0	Sequence 1-2 Non-Int in Kepler-51c (01)	103.128633 Secs X 23 (2371.959 Secs)	
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3		(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	F139M	NSAMP=15; SAMP-SEQ=RAPID	POS TARG 0,0	Sequence 3-4 Non-Int in Kepler-51c (01)	4.167225 Secs (4.167 Secs)	
								[==>]	***[2]***

	4	(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	G141	NSAMP=15; SAMP-SEQ=SPARS10	POS TARG 0,0	Sequence 3-4 Non-Int in Kepler-51c (01)	103.128633 Secs X 23 (2371.959 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)]* *[==>(Copy 13)]* *[==>(Copy 14)]* *[==>(Copy 15)]* *[==>(Copy 16)]* *[==>(Copy 17)]* *[==>(Copy 18)]* *[==>(Copy 19)]* *[==>(Copy 20)]* *[==>(Copy 21)]* *[==>(Copy 22)]* *[==>(Copy 23)]*	***[2]***
	5	(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	F139M	NSAMP=15; SAMP-SEQ=RAPID	POS TARG 0,0	Sequence 5-6 Non-Int in Kepler-51c (01)	4.167225 Secs (4.167 Secs) *[==>]*	***[3]***
	6	(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	G141	NSAMP=15; SAMP-SEQ=SPARS10	POS TARG 0,0	Sequence 5-6 Non-Int in Kepler-51c (01)	103.128633 Secs X 10 (1031.286 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]* *[==>(Copy 7)]* *[==>(Copy 8)]* *[==>(Copy 9)]* *[==>(Copy 10)]*	***[3]***
	7	(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	F139M	NSAMP=15; SAMP-SEQ=RAPID	POS TARG 0,0	Sequence 7-8 Non-Int in Kepler-51c (01)	4.167225 Secs (4.167 Secs) *[==>]*	***[4]***

8	(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	G141	NSAMP=15; SAMP-SEQ=SPARS10	POS TARG 0,0	Sequence 7-8 Non-Int in Kepler-51c (01)	103.128633 Secs X 11 (1134.415 Secs)	
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9	(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	F139M	NSAMP=15; SAMP-SEQ=RAPID	POS TARG 0,0	Sequence 9-10 Non-Int in Kepler-51c (01)	4.167225 Secs (4.167 Secs)	
							[==>]	***[5]***
10	(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	G141	NSAMP=15; SAMP-SEQ=SPARS10	POS TARG 0,0	Sequence 9-10 Non-Int in Kepler-51c (01)	103.128633 Secs X 12 (1237.544 Secs)	
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11	(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	F139M	NSAMP=15; SAMP-SEQ=RAPID	POS TARG 0,0	Sequence 11-12 Non-Int in Kepler-51c (01)	4.167225 Secs (4.167 Secs)	
							[==>]	***[6]***
12	(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	G141	NSAMP=15; SAMP-SEQ=SPARS10	POS TARG 0,0	Sequence 11-12 Non-Int in Kepler-51c (01)	103.128633 Secs X 11 (1134.415 Secs)	
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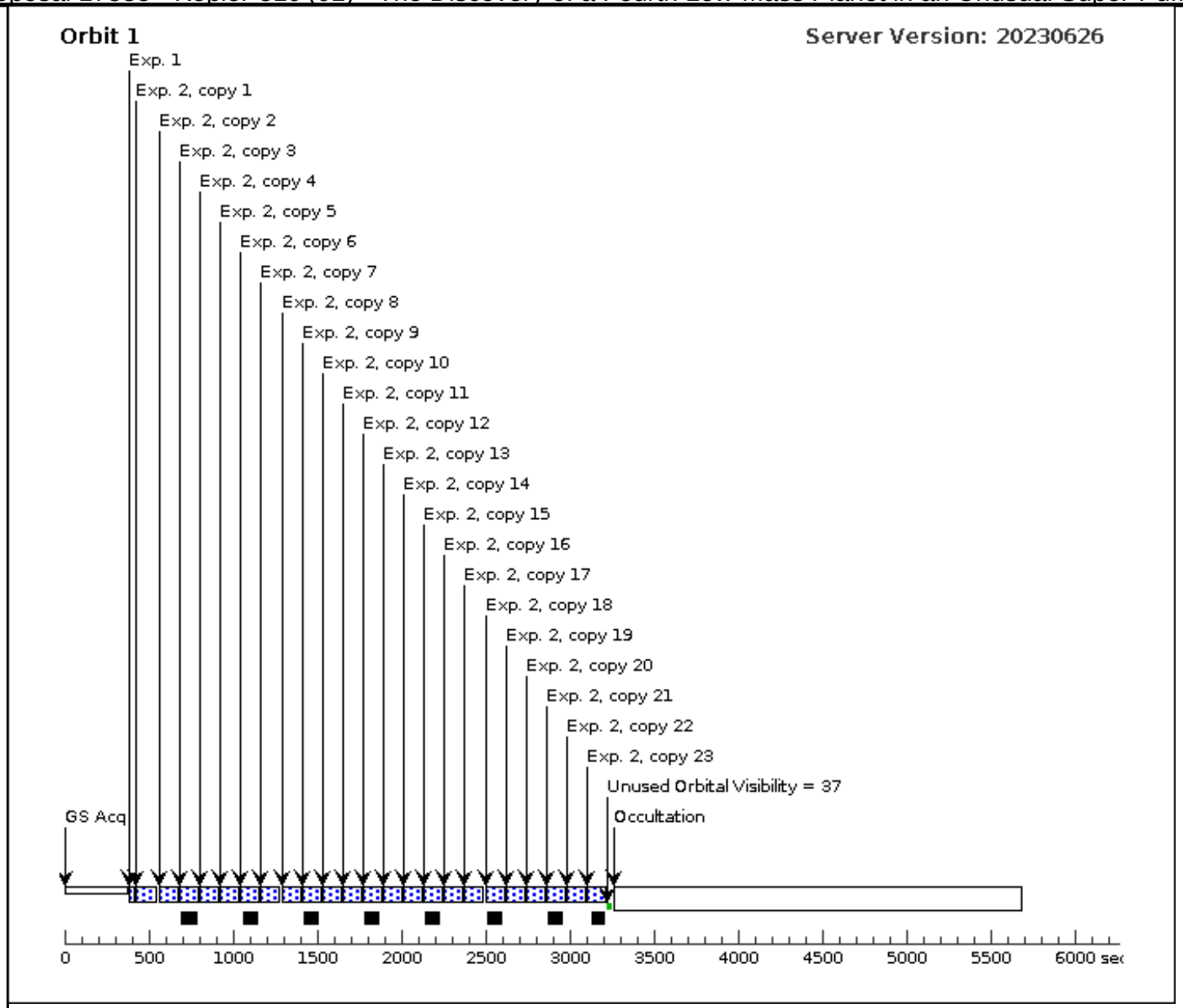

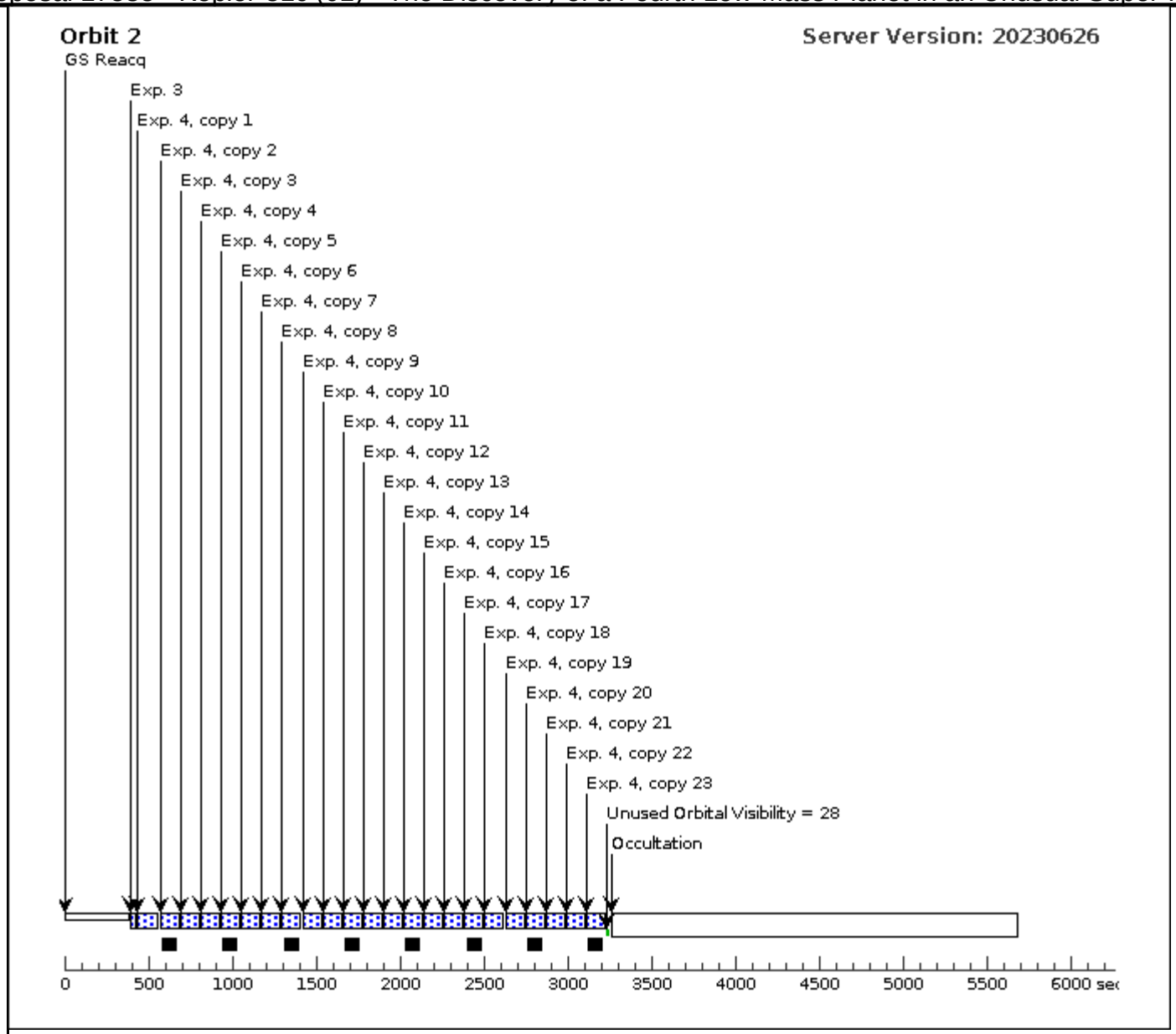
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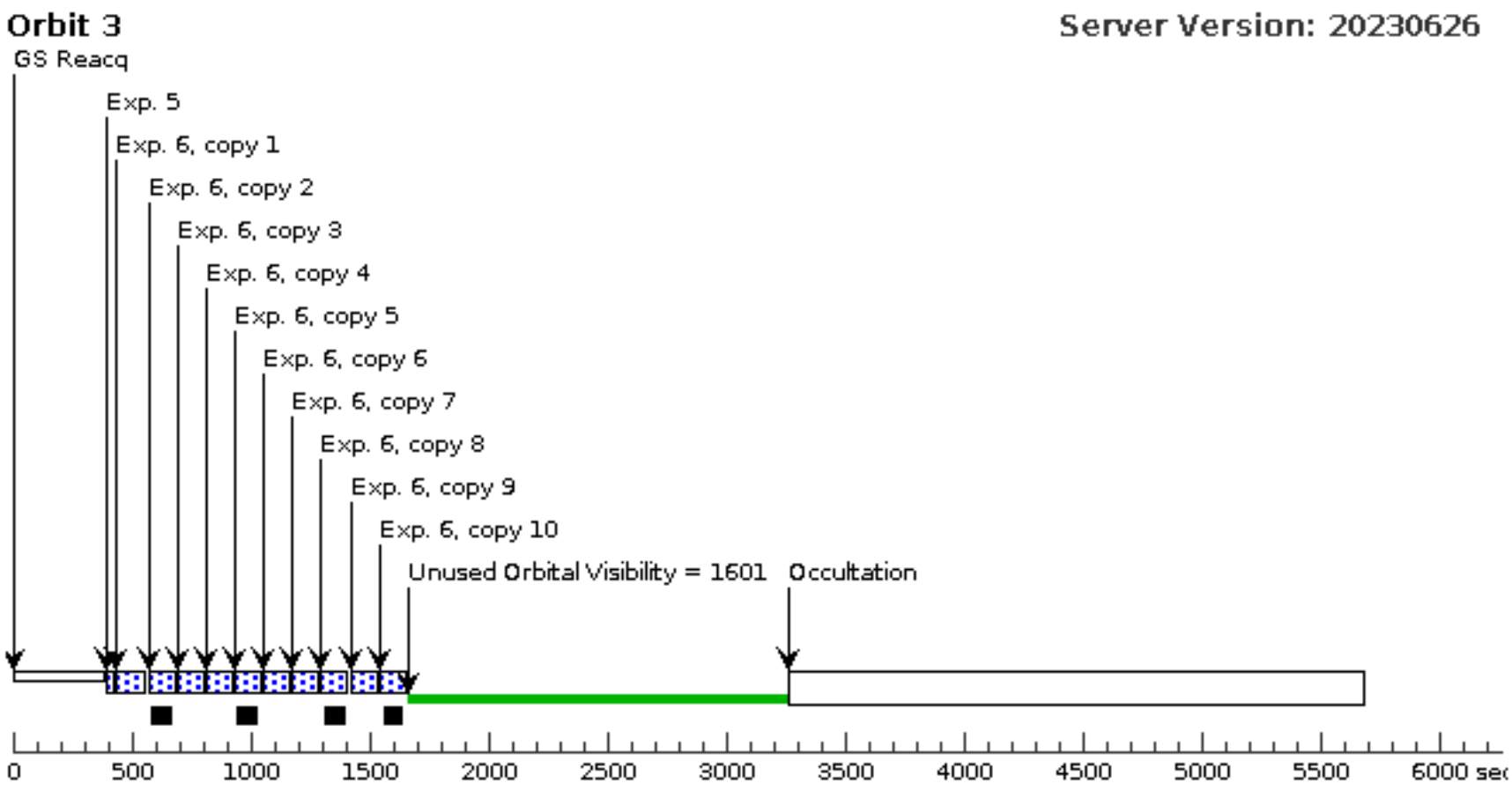
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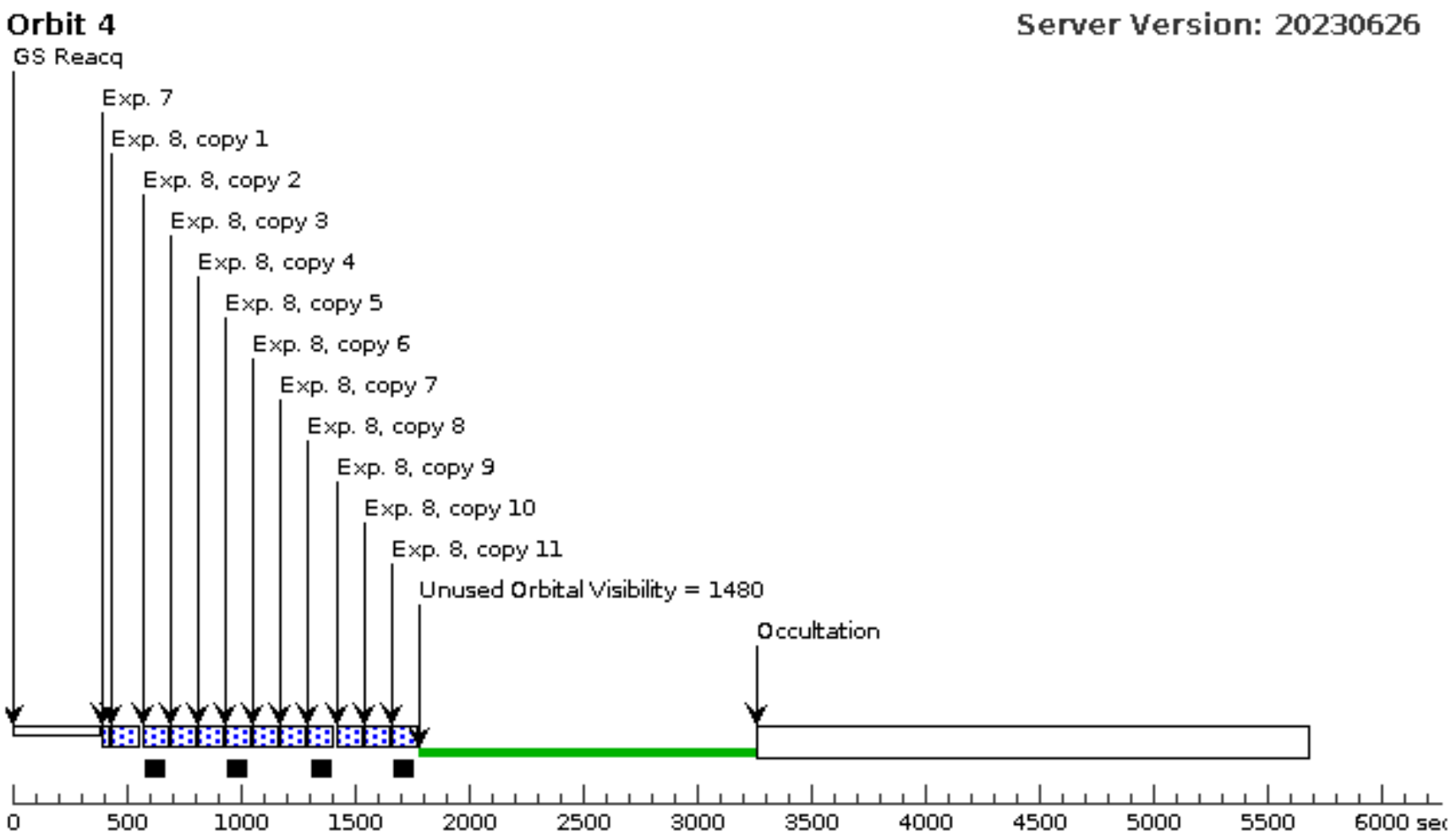
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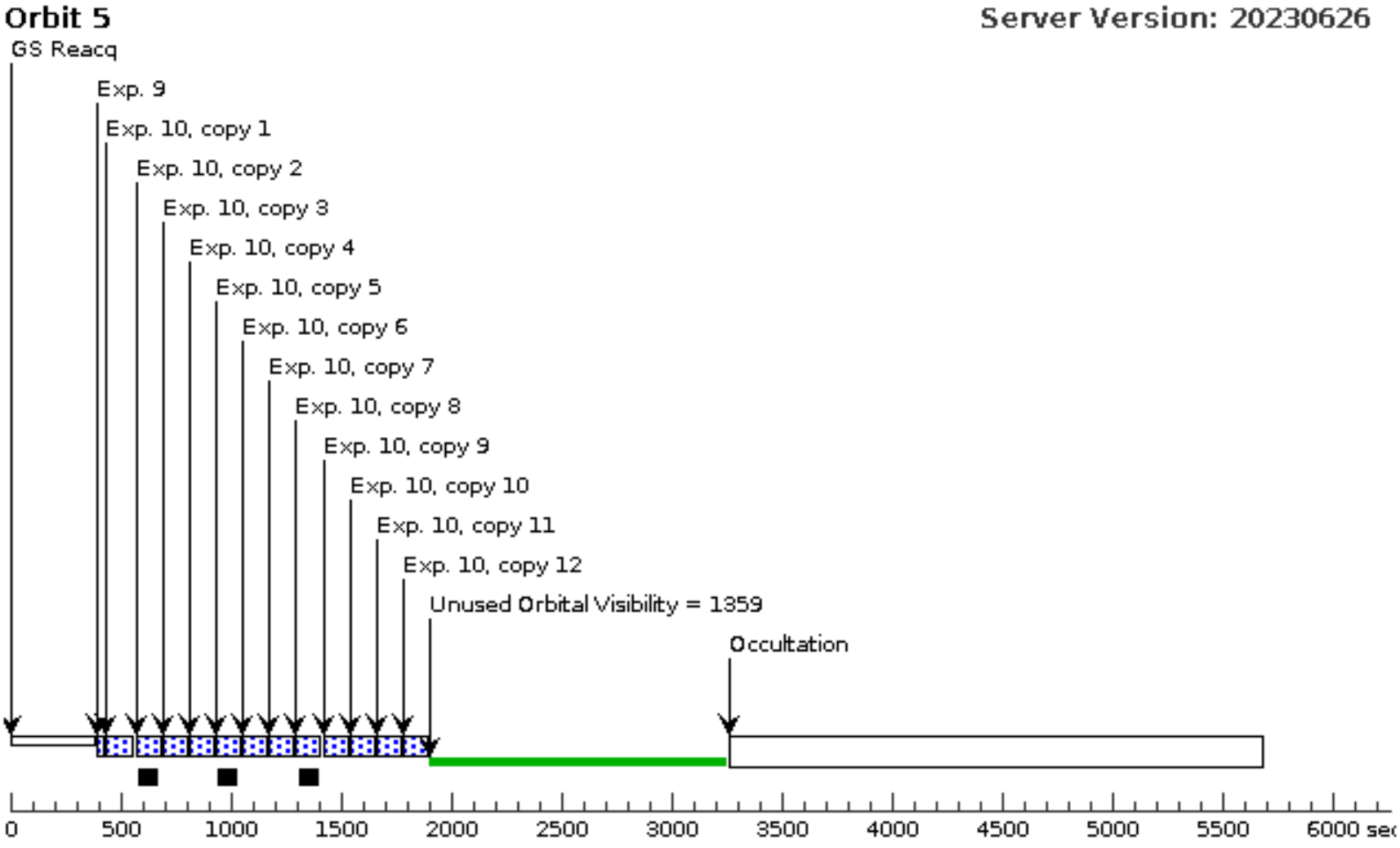
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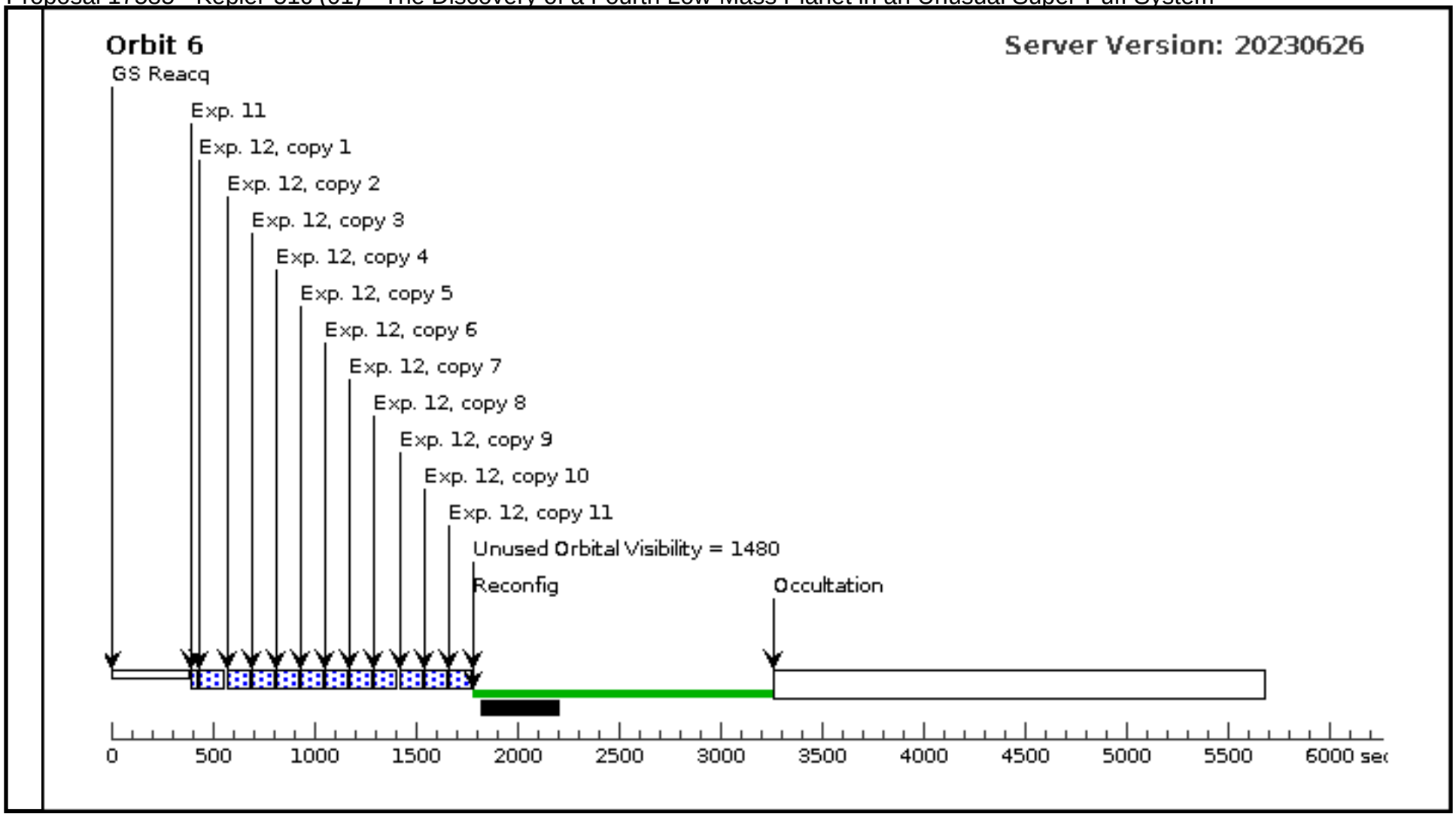
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Visit

Proposal 17585, Kepler-51d (02), implementation Wed Oct 18 03:01:35 GMT 2023

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: ORIENT 260D TO 270 D; ORIENT 80D TO 230 D; ORIENT 305D TO 50 D; Period 130.1845 D AND ZERO-PHASE HJD2460252.0300

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	KEPLER-51	RA: 19 45 55.1429 (296.4797621d) Dec: +49 56 15.65 (49.93768d) Equinox: J2000	Proper Motion RA: 0.075 mas/yr Proper Motion Dec: -7.4509999194560805 mas/yr Epoch of Position: 2000	V=14.885+/-0.126 J = 13.562, H = 13.291, K=13.197	Reference Frame: SIMBAD

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

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	F139M	NSAMP=15; SAMP-SEQ=RAPID	PHASE .99725 TO .99758333	Sequence 1-2 Non-Int in Kepler-51d (02)	4.167225 Secs (4.167 Secs)	
								[==>]	***[1]***
2		(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	G141	NSAMP=15; SAMP-SEQ=SPARS10		Sequence 1-2 Non-Int in Kepler-51d (02)	103.128633 Secs X 23 (2371.959 Secs)	
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								[==>(Copy 11)]	
								[==>(Copy 12)]	***[1]***
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								[==>(Copy 23)]	
3		(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	F139M	NSAMP=15; SAMP-SEQ=RAPID		Sequence 3-4 Non-Int in Kepler-51d (02)	4.167225 Secs (4.167 Secs)	
								[==>]	***[2]***

	4	(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	G141	NSAMP=15; SAMP-SEQ=SPARS10	Sequence 3-4 Non-Int in Kepler-51d (02)	103.128633 Secs X 23 (2371.959 Secs)	
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	5	(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	F139M	NSAMP=15; SAMP-SEQ=RAPID	Sequence 5-6 Non-Int in Kepler-51d (02)	4.167225 Secs (4.167 Secs)	
							[==>]	***[3]***

	6	(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	G141	NSAMP=15; SAMP-SEQ=SPARS10	Sequence 5-6 Non-Int in Kepler-51d (02)	103.128633 Secs X 23 (2371.959 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)]* *[==>(Copy 13)]* *[==>(Copy 14)]* *[==>(Copy 15)]* *[==>(Copy 16)]* *[==>(Copy 17)]* *[==>(Copy 18)]* *[==>(Copy 19)]* *[==>(Copy 20)]* *[==>(Copy 21)]* *[==>(Copy 22)]* *[==>(Copy 23)]*	***[3]***
	7	(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	F139M	NSAMP=15; SAMP-SEQ=RAPID	Sequence 7-8 Non-Int in Kepler-51d (02)	4.167225 Secs (4.167 Secs) *[==>]*	***[4]***

	8	(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	G141	NSAMP=15; SAMP-SEQ=SPARS10	Sequence 7-8 Non-Int in Kepler-51d (02)	103.128633 Secs X 23 (2371.959 Secs)	
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	9	(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	F139M	NSAMP=15; SAMP-SEQ=RAPID	Sequence 9-10 Non-Int in Kepler-51d (02)	4.167225 Secs (4.167 Secs)	
							[==>]	***[5]***

	10	(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	G141	NSAMP=15; SAMP-SEQ=SPARS10	Sequence 9-10 Non-Int in Kepler-51d (02)	103.128633 Secs X 23 (2371.959 Secs)	
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	11	(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	F139M	NSAMP=15; SAMP-SEQ=RAPID	Sequence 11-12 Non-Int in Kepler-51d (02)	4.167225 Secs (4.167 Secs)	
							[==>]	***[6]***

	12	(1) KEPLER-51	WFC3/IR, MULTIACCUM, GRISM256	G141	NSAMP=15; SAMP-SEQ=SPARS10	Sequence 11-12 Non-Int in Kepler-51d (02)	103.128633 Secs X 23 (2371.959 Secs)	
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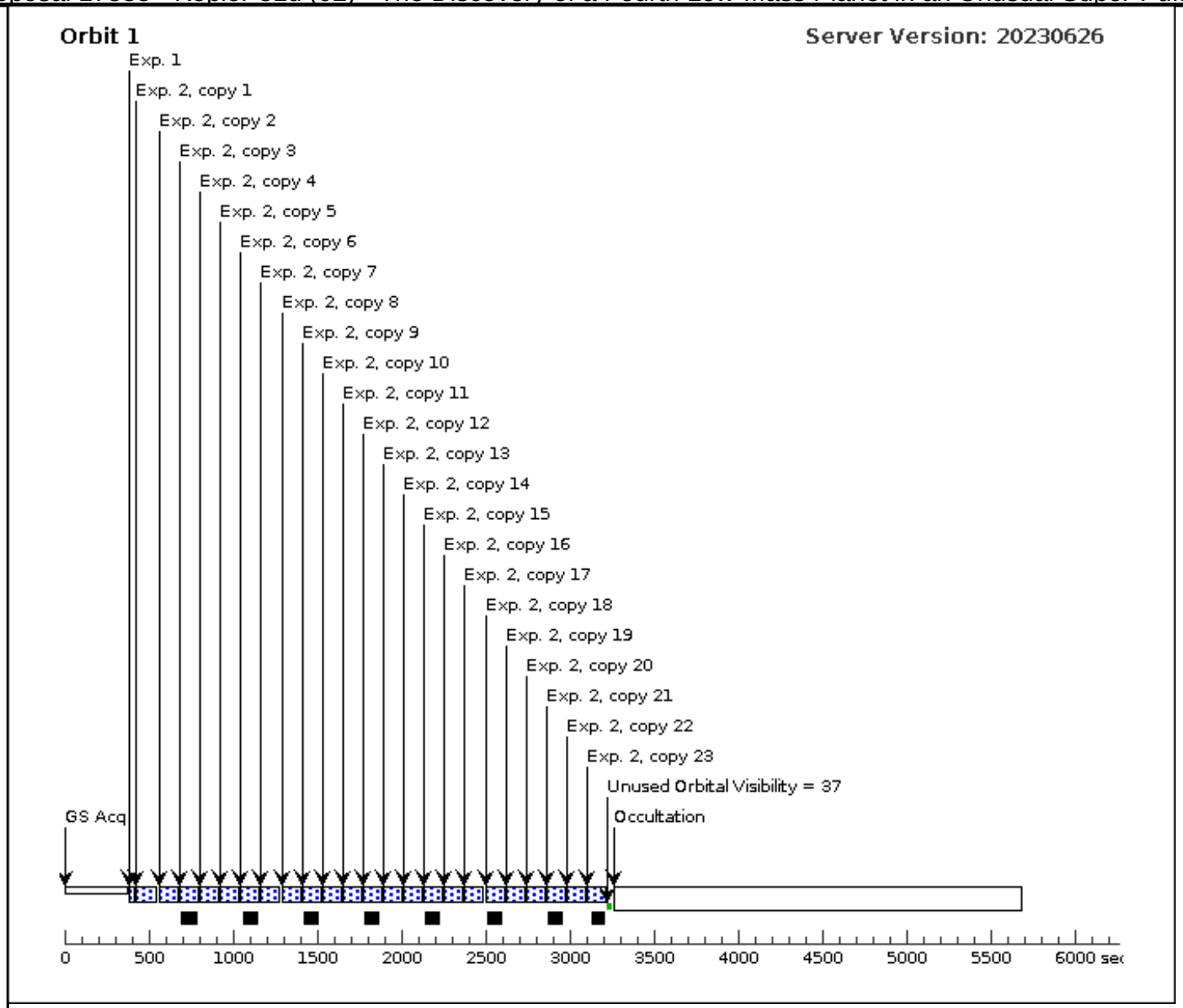
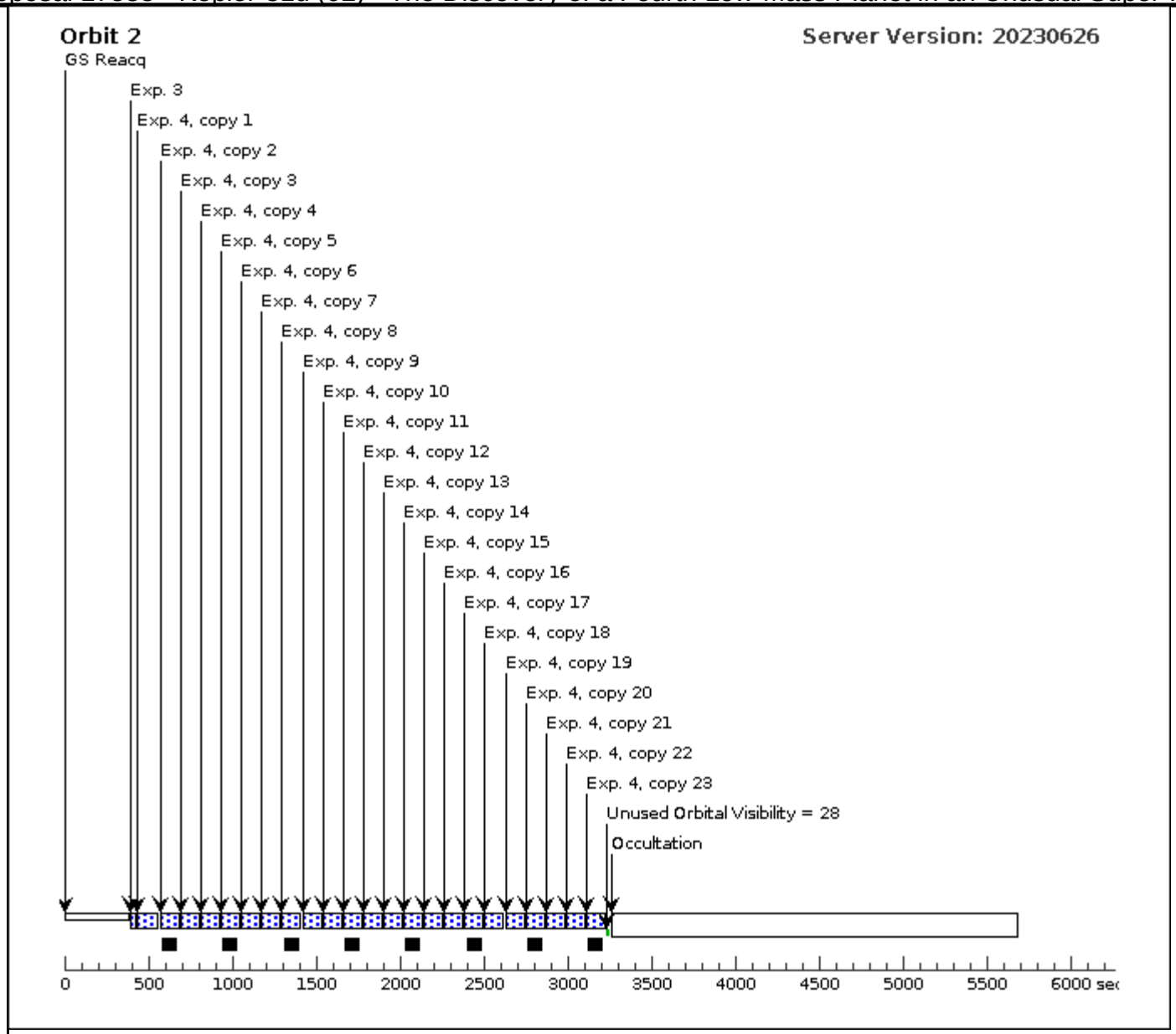
Orbit Structure

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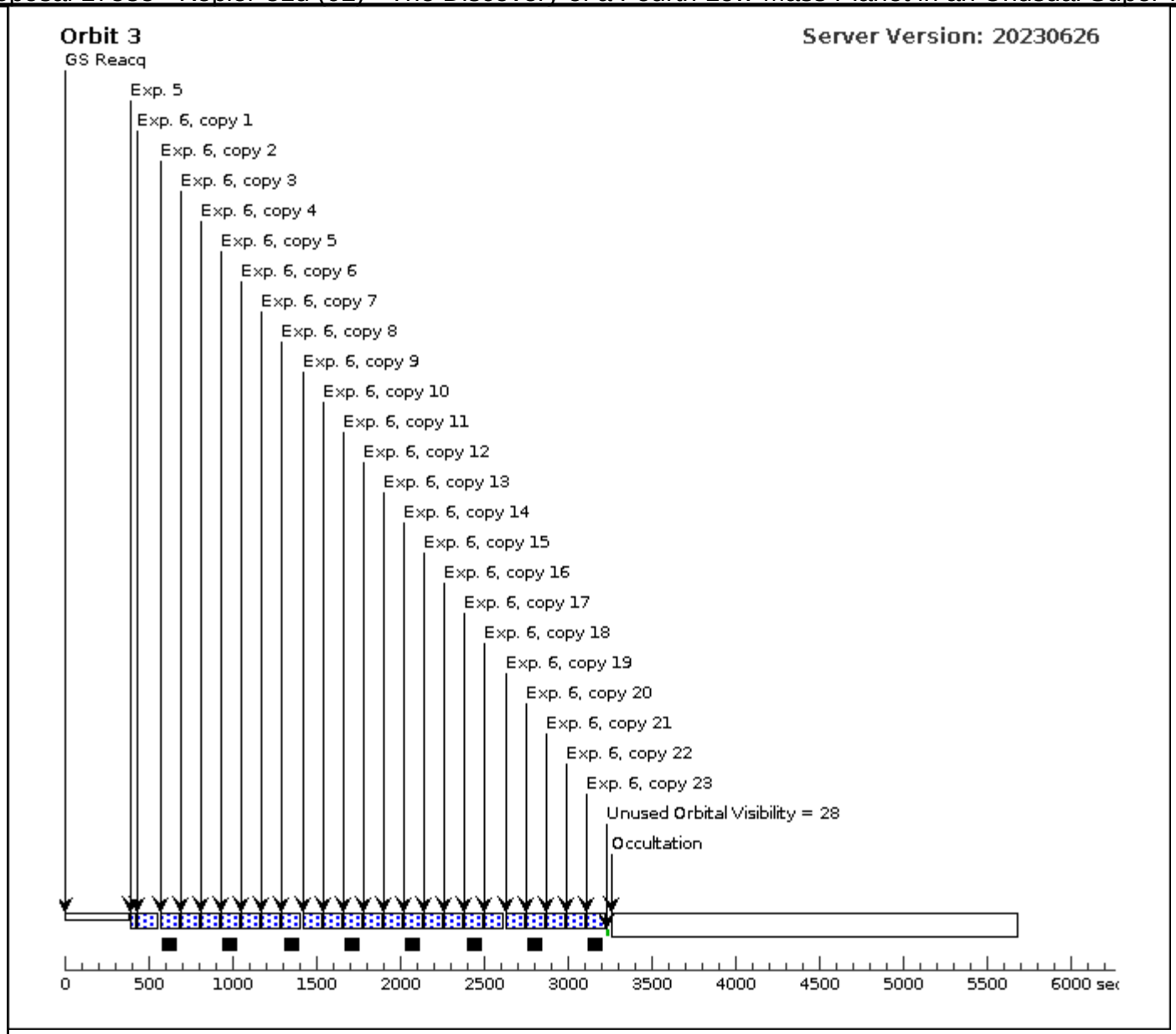
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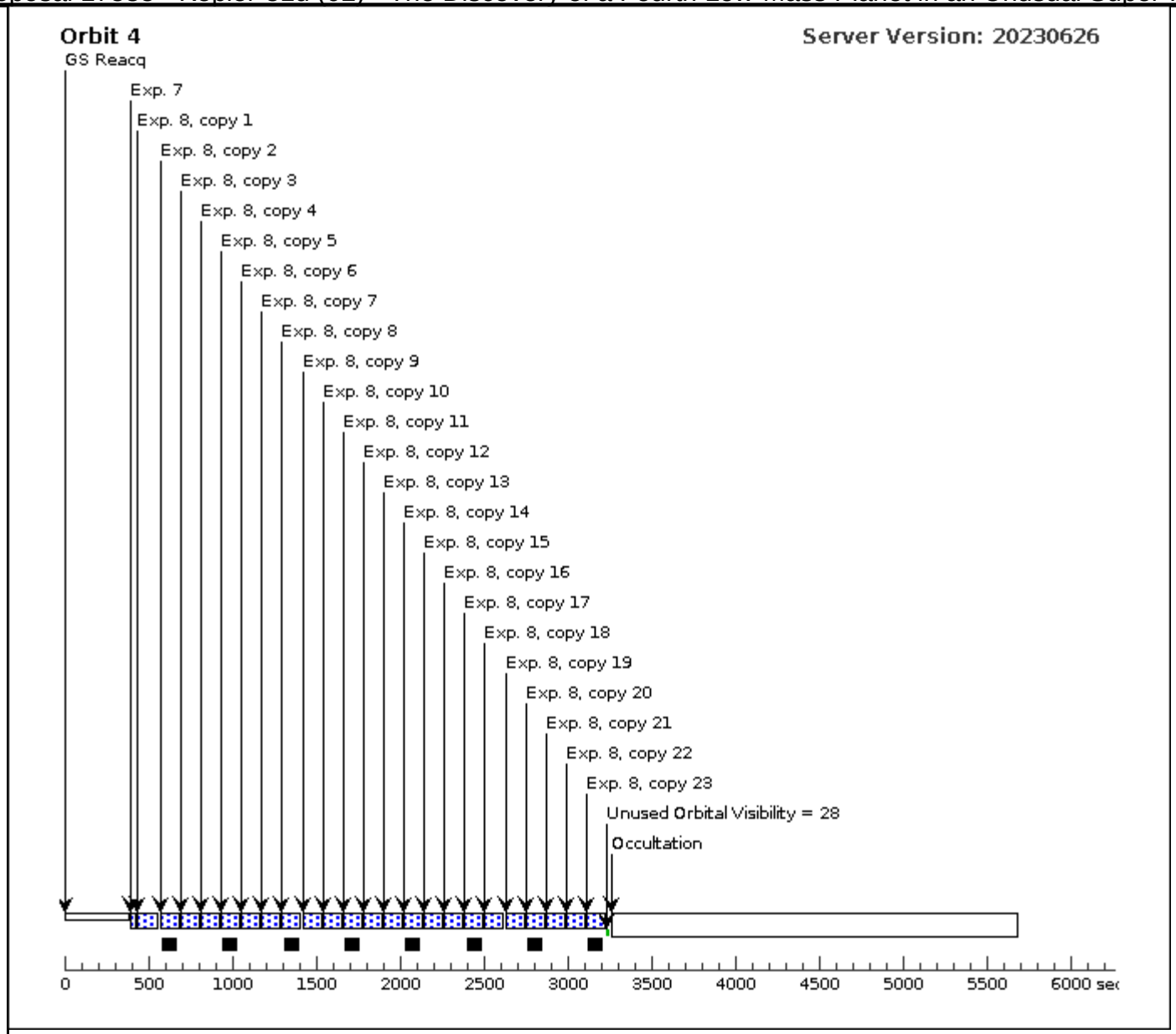
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Exp. 8, copy 12
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Exp. 8, copy 15
Exp. 8, copy 16
Exp. 8, copy 17
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Exp. 8, copy 19
Exp. 8, copy 20
Exp. 8, copy 21
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Exp. 8, copy 23
Unused Orbital Visibility = 28
Occultation
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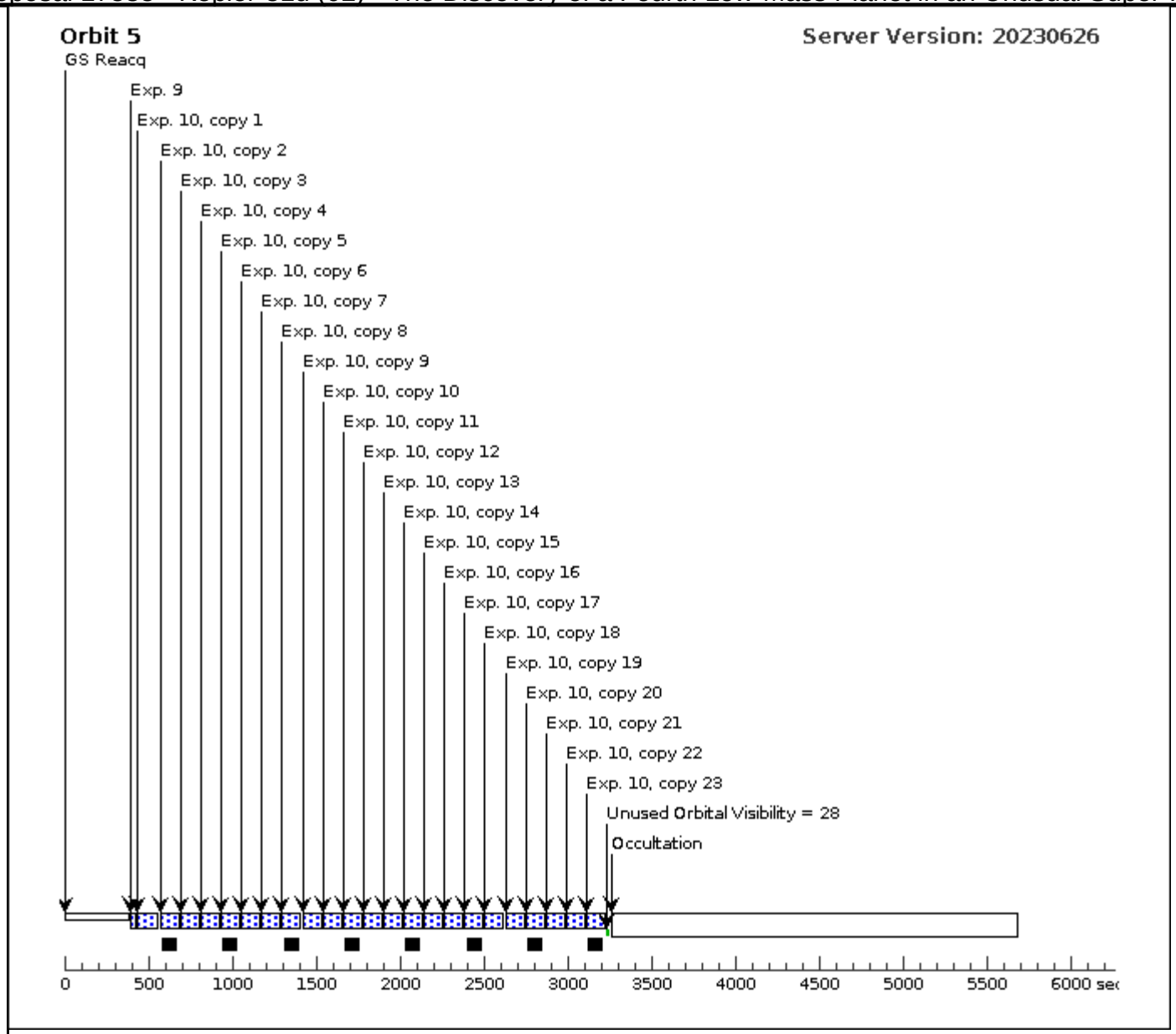
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GS Reacq
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Exp. 10, copy 16
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Exp. 10, copy 18
Exp. 10, copy 19
Exp. 10, copy 20
Exp. 10, copy 21
Exp. 10, copy 22
Exp. 10, copy 23
Unused Orbital Visibility = 28
Occultation
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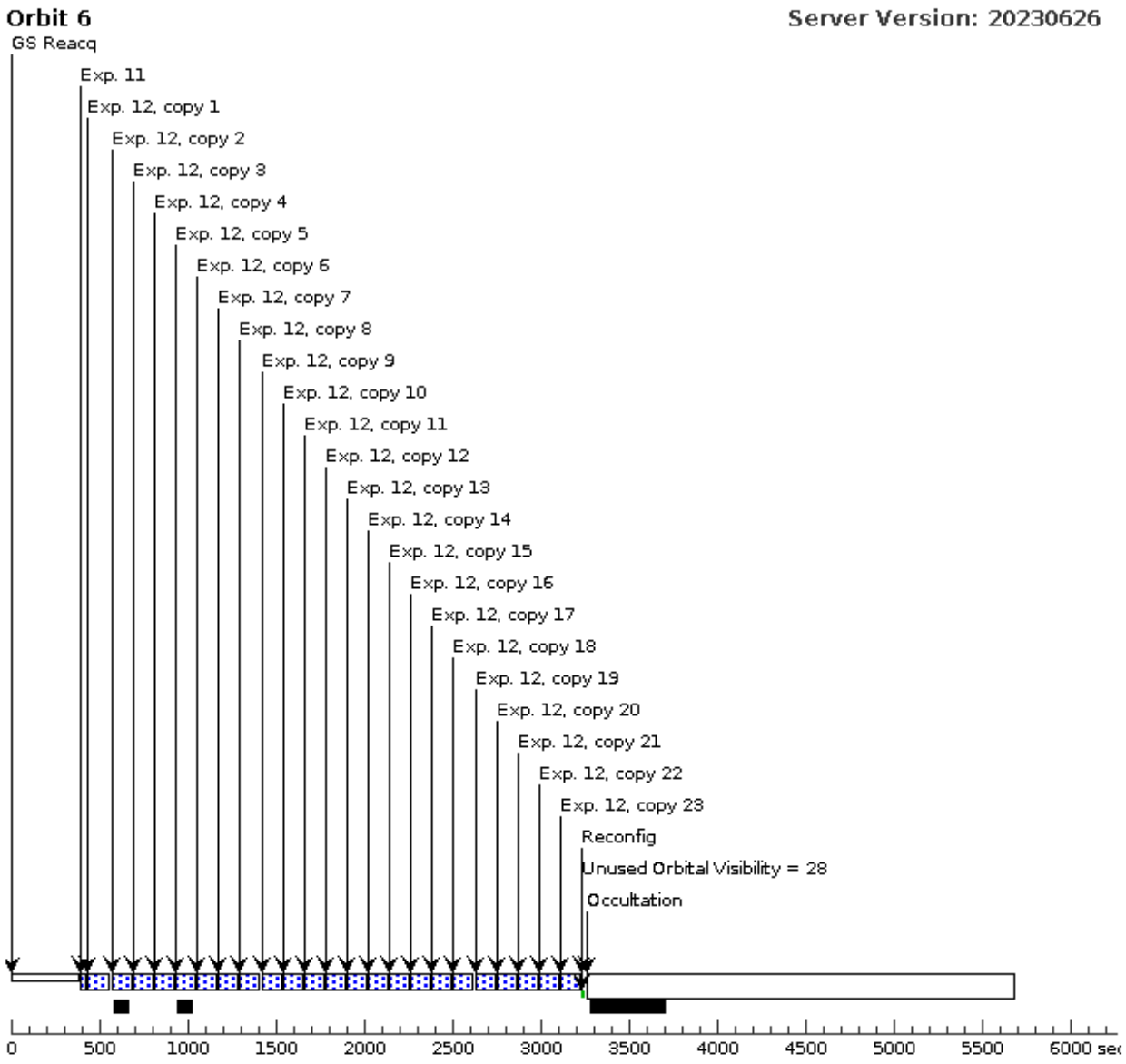
Orbit 6
Server Version: 20230626
GS Reacq
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Exp. 12, copy 11
Exp. 12, copy 12
Exp. 12, copy 13
Exp. 12, copy 14
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Reconfig
Unused Orbital Visibility = 28
Occultation
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