14798 - Origin and Evolution of the First Known Ultra-Young Asteroid Family and its Doubly-Synchronous Binary Member

Cycle: 24, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
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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) P2012F5	WFC3/UVIS	5	25-Jan-2017 21:01:23.0	yes
02	(1) P2012F5	WFC3/UVIS	5	25-Jan-2017 21:01:26.0	yes

10 Total Orbits Used

ABSTRACT

Our GO-14192 and DD-14475 programs executed in late 2015 and early 2016, providing spectacular WFC3/UVIS images of the unusual disrupted asteroid P/2012 F5. We have detected at least nine star-like fragments of the main nucleus, still cocooned in their birth dust trail, suggesting that P/2012 F5 is a newborn asteroid family, only a few years old. Given that the main nucleus rotates at a critical rate, this ultra-young system is the best candidate for a family generated by rotational fission, as opposed to all the other asteroid families, which are of collisional origin. To our great surprise, the largest fragment of the main nucleus is most probably a small, doubly-synchronous binary, challenging the established theory of formation of binary asteroids. Capitalizing on these exciting early results, we propose a long-term monitoring program of P/2012 F5, with which we wish to secure new data from the next two oppositions. The requested additional HST orbits are critically needed to quantify the ejection parameters

of the fragments and thereby verify the suspected cause of the fragmentation. They will also provide absolutely unique insight into the evolution of the first known ultra-young asteroid binary. Hubble is the only facility with sufficient sensitivity and wide-field angular resolution to carry out this investigation, which is more than likely to have a profound impact on asteroid science, including our solar system and systems around other stars.

OBSERVING DESCRIPTION

1. Target and Scheduling

Our target is the fragmented asteroid P/2012 F5, which has a bright nucleus and many fainter fragments embedded in a long dust trail. At the time of the planned HST observations the nucleus is of 22 mag and the brightest fragment of about 27 mag (R-band magnitudes). The TARGETS component contains the orbital elements of the main nucleus, automatically retrieved by APT from the JPL's HORIZONS, which ensure the ephemeris precision better than 1 arcsec. The nucleus and the fragments are dispersed along a straight line, which has a sky PA of about 286.5 deg. The expected angular distance between the easternmost component (the main nucleus) and the westernmost component (one of the faint fragments) is 45 arcsec, however, the associated dust trail extends further out, and can be several arcminutes long.

These observations are *time-critical* and should be scheduled in two 5-orbit visits in the time slots defined by the BETWEEN Special Requirement (ideally close to the centers of these slots). These slots were optimized for maximum scientific return based on several parameters of the target. In particular, they ensure near-maximum brightness, negligible observing-geometry changes within a visit, and a sufficient time separation of the visits.

2. Visit Design

In Visit 1 we place the target's nucleus in quadrant B, approximately (500,500) px from its outer corner, which is achieved by a combination of the selected UVIS1-FIX aperture and a large POS TARG offset of (61.50,24.25) arcsec. Thanks to the selected ORIENT Special Requirement all the known fragments will also be present in quadrant B and lined up roughly along the detector data rows. Moreover, full-frame readout makes it possible to detect new fragments at larger separations from the nucleus in quadrant A.

In Visit 2 we place the target's nucleus in the UVIS2-C1K1C-CTE aperture, approximately (500,500) px from the outer corner of quadrant C. Thanks to the selected ORIENT Special Requirement all the known fragments will also be present in quadrant C and lined up roughly along the HST's U3

axis, which minimizes geometric distortions. Moreover, full-frame readout makes it possible to detect new fragments at larger separations from the nucleus in quadrant B.

3. Orbit Design

Each orbit has basically the same architecture. We consistently use WFC3/UVIS with the F350LP filter, which offers the best SNR on asteroid nuclei. We wish to take five full-frame images per orbit, which is small enough to ensure parallel buffer dumps and good overall observing efficiency, but large enough to adequately sample the light curves of the main nucleus and largest fragment. The orbital visibility at the time of the preferred observations allows us to take all five images with 438 sec integration time when a GS is re-acquired, or four images with 438 sec integration time and one image with 295 sec integration time when a new GS is acquired. We purposely leave 150 sec of unused orbital visibility, which is needed to allow for scheduling in the preferred time slots.

To maximize observing efficiency dithering is applied between consecutive orbits (i.e. all five exposures taken during a single orbit will not be dithered) through changing the POS TARG offsets, which incurs no overheads but naturally mitigates the effect of bad pixels in a deep, visit-averaged image. To minimize the influence of geometric distortions, the POS TARG offsets move the target along the HST's U3 axis.

Visit

Proposal 14798, Visit 01, implementation

Thu Jan 26 02:01:28 GMT 2017

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: ORIENT 324.5D TO 324.5 D; BETWEEN 13-FEB-2017:00:00:00 AND 16-FEB-2017:00:00:00

Solar System Targets

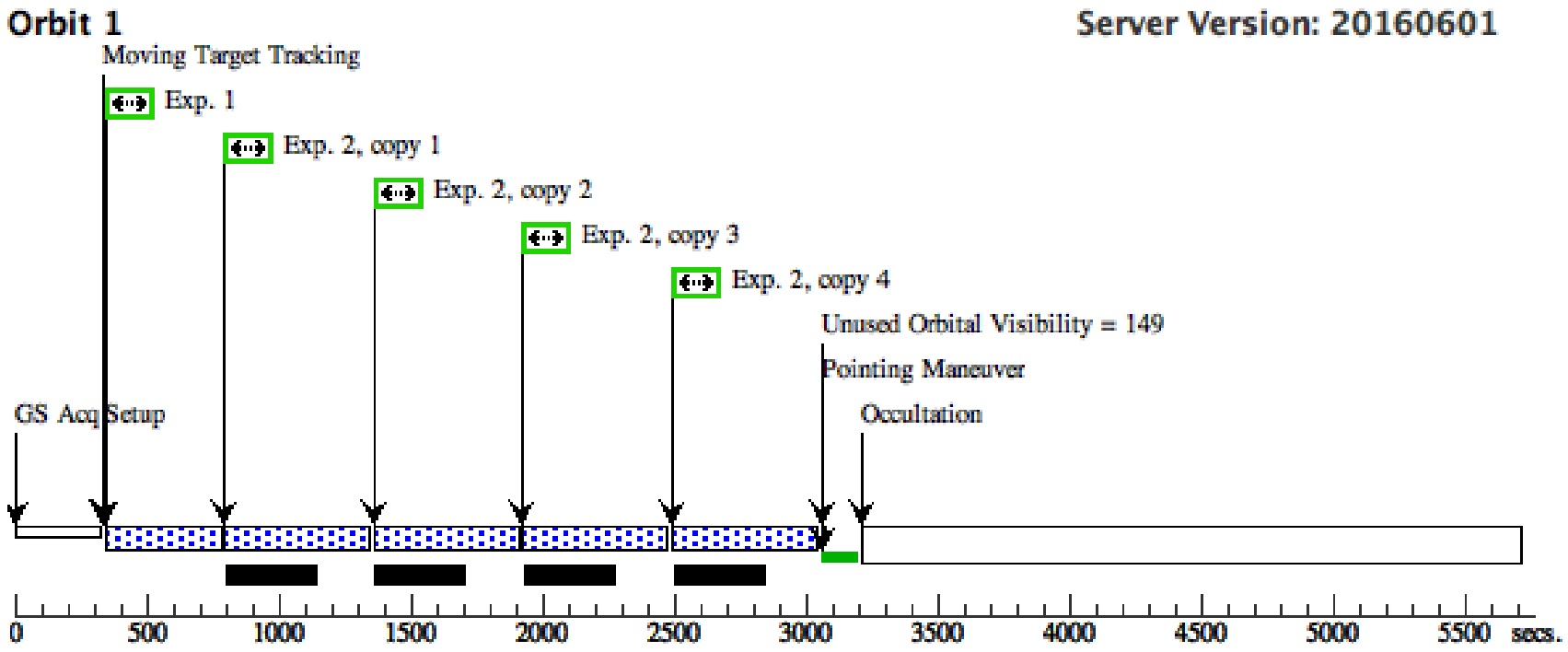
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	P2012F5	TYPE=COMET,Q=2.8773739883836 8,E=.04208657647672002,I=9.739682 411701132,O=216.8596526258896,W =177.4017799220638,T=28-MAR-2010:01:59:12,TTimeScale=UTC,EQ UINOX=J2000,EPOCH=04-FEB-2012:00:00:00,EpochTimeScale=TDB				EARTH

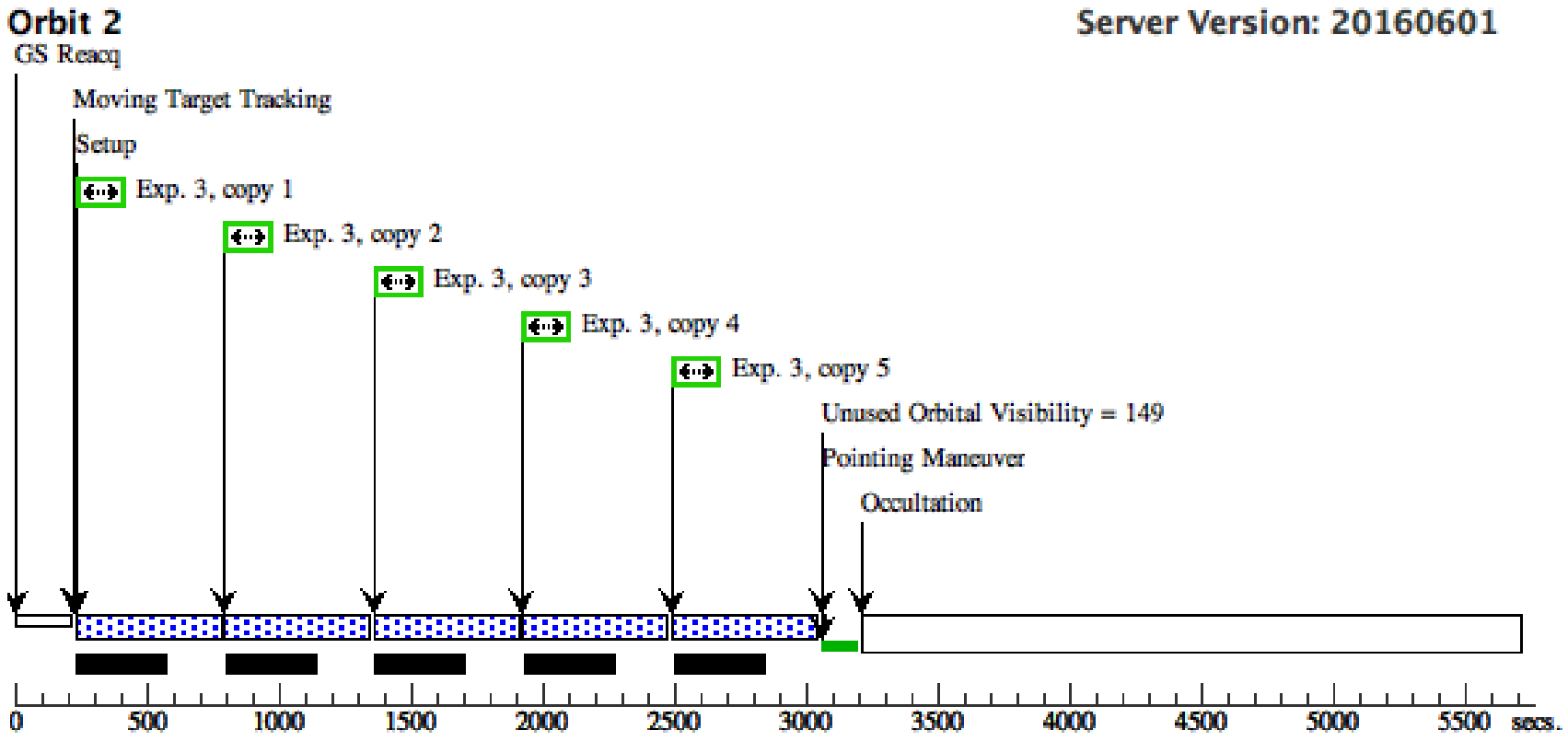
Comments: Extended=YES

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) P2012F5	WFC3/UVIS, ACCUM, UVIS1-FIX	F350LP		POS TARG 61.50,24.25		295 Secs (295 Secs)	
								[==>]	***[1]***
2		(1) P2012F5	WFC3/UVIS, ACCUM, UVIS1-FIX	F350LP		POS TARG 61.50,24.25		438 Secs X 4 (1752 Secs)	
								[==>(Copy 1)] *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]*	***[1]***
3		(1) P2012F5	WFC3/UVIS, ACCUM, UVIS1-FIX	F350LP		POS TARG 60.75,23.50		438 Secs X 5 (2190 Secs)	
								[==>(Copy 1)] *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]*	***[2]***
4		(1) P2012F5	WFC3/UVIS, ACCUM, UVIS1-FIX	F350LP		POS TARG 60.00,22.75		438 Secs X 5 (2190 Secs)	
								[==>(Copy 1)] *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]*	***[3]***
5		(1) P2012F5	WFC3/UVIS, ACCUM, UVIS1-FIX	F350LP		POS TARG 59.25,22.00		438 Secs X 5 (2190 Secs)	
								[==>(Copy 1)] *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]*	***[4]***
6		(1) P2012F5	WFC3/UVIS, ACCUM, UVIS1-FIX	F350LP		POS TARG 58.50,21.25		438 Secs X 5 (2190 Secs)	
								[==>(Copy 1)] *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]*	***[5]***

Orbit Structure

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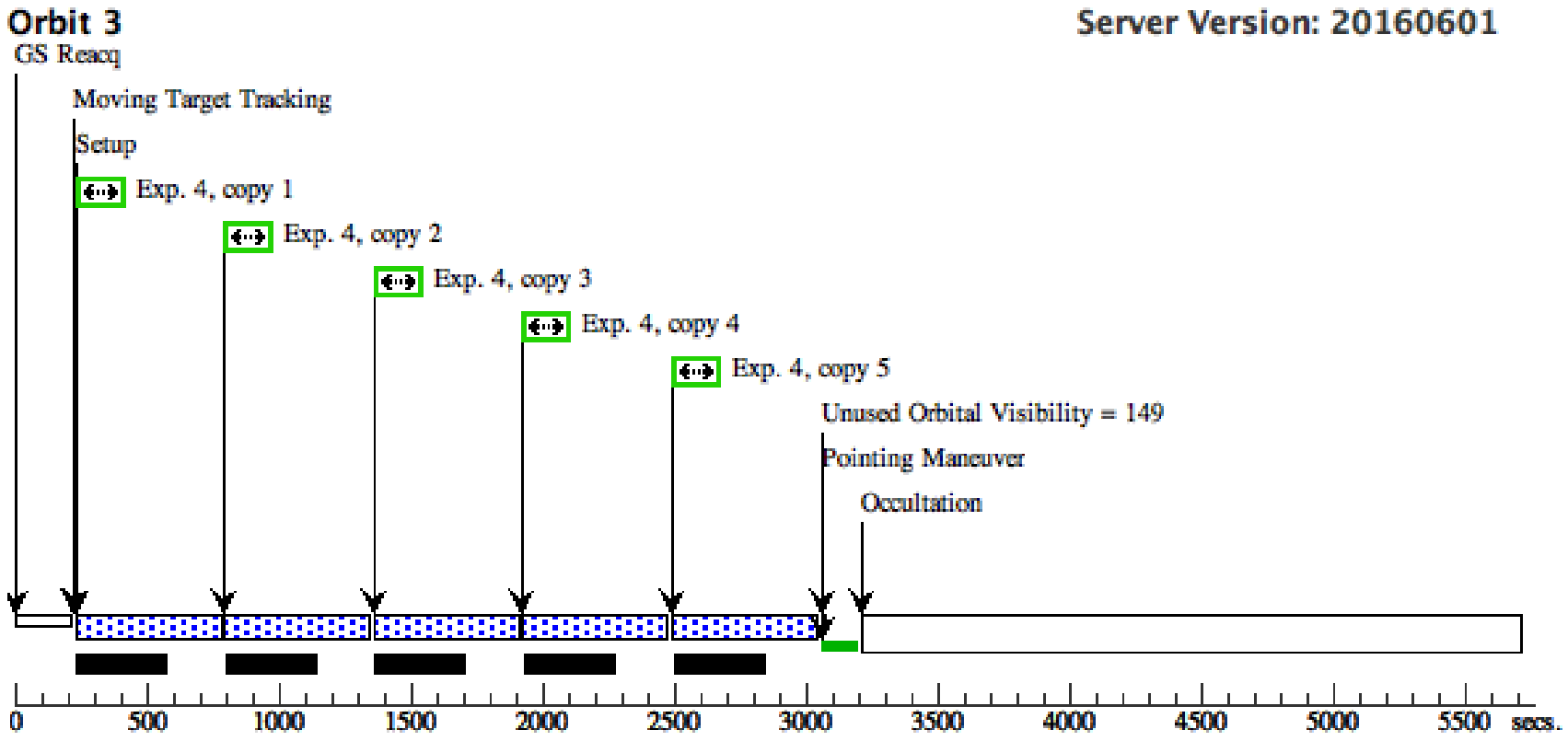
secs.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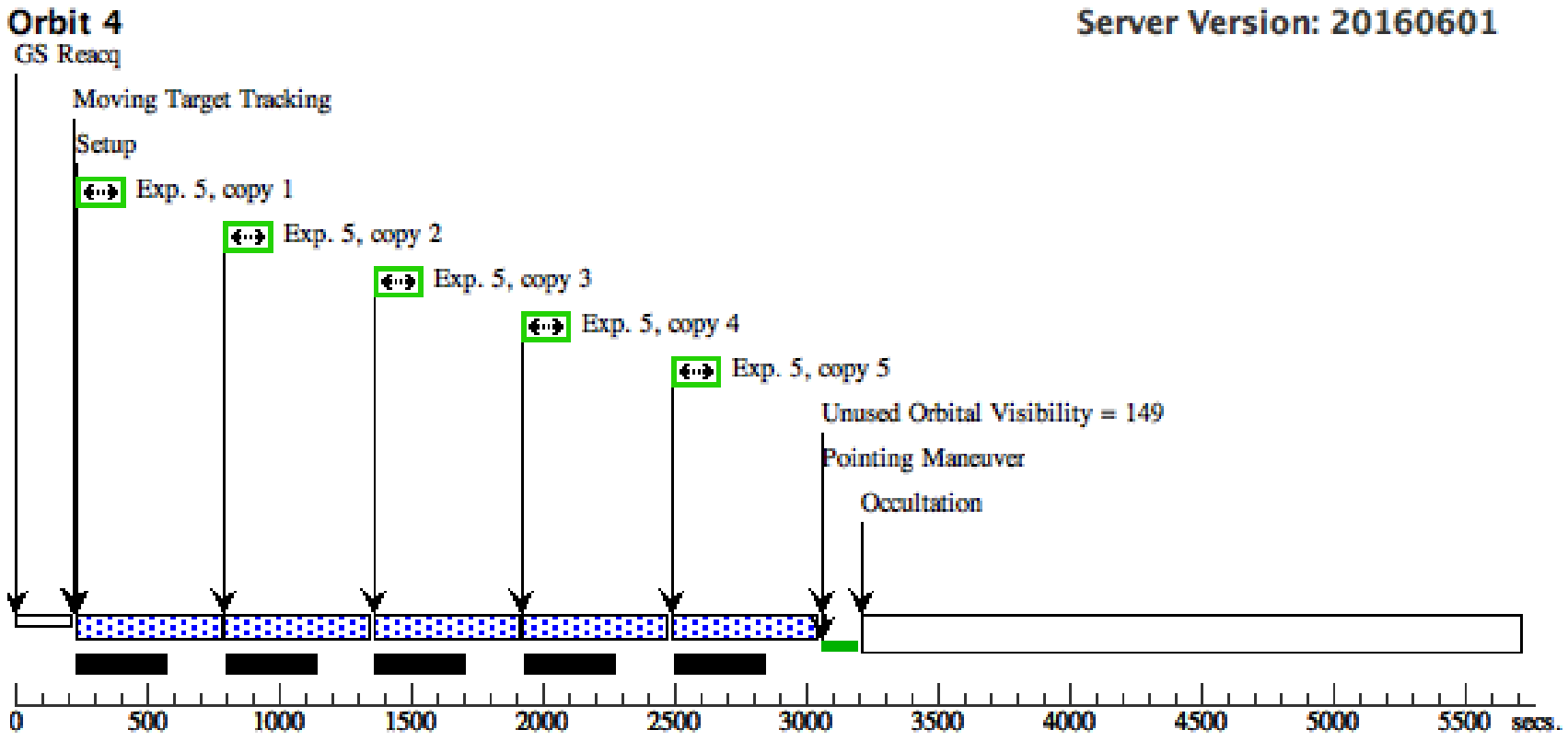
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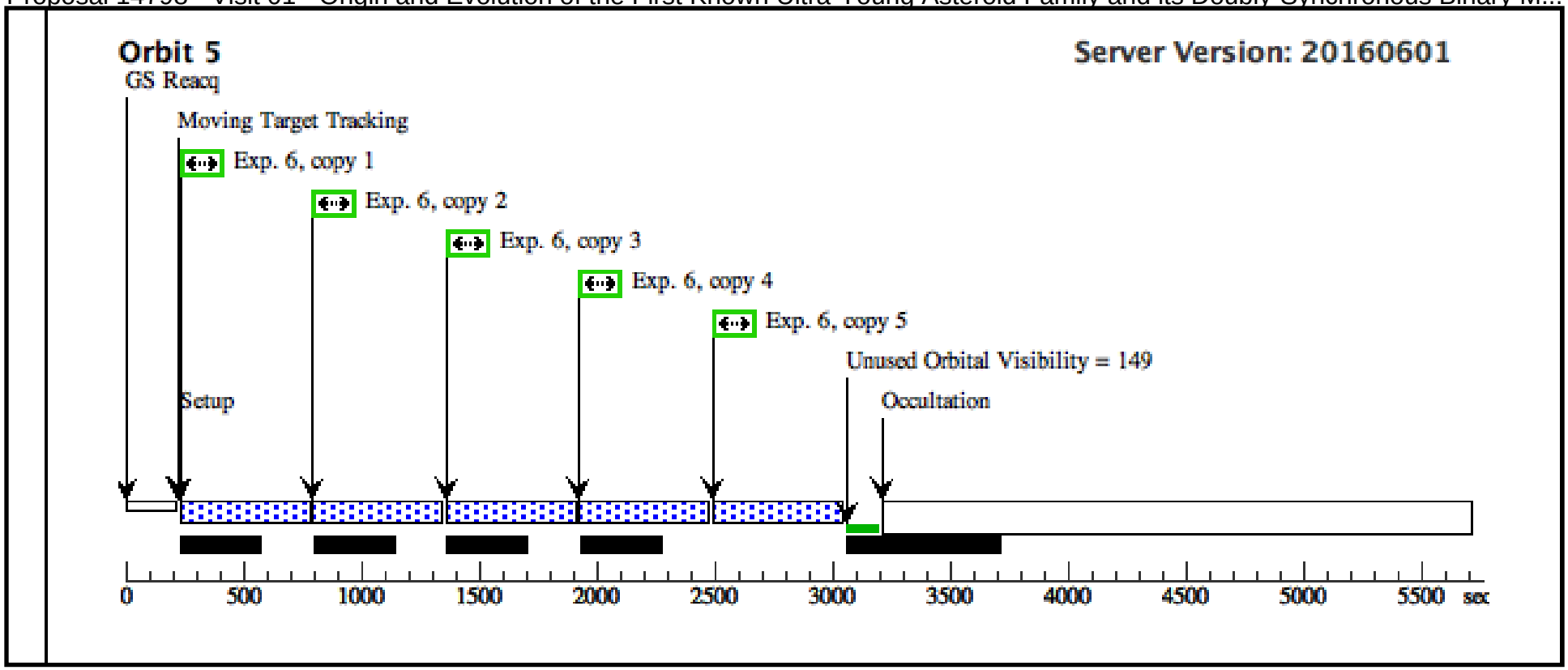
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Unused Orbital Visibility = 149
Setup
Occultation
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Visit

Proposal 14798, Visit 02, implementation

Thu Jan 26 02:01:28 GMT 2017

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: ORIENT 99.5D TO 99.5 D; BETWEEN 06-MAR-2017:00:00:00 AND 09-MAR-2017:00:00:00

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	P2012F5	TYPE=COMET,Q=2.8773739883836 8,E=.04208657647672002,I=9.739682 411701132,O=216.8596526258896,W =177.4017799220638,T=28-MAR-2010:01:59:12,TTimeScale=UTC,EQ UINOX=J2000,EPOCH=04-FEB-2012:00:00:00,EpochTimeScale=TDB				EARTH

Comments: Extended=YES

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) P2012F5	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F350LP		POS TARG 0.00,0.00		295 Secs (295 Secs)	
								[==>]	***[1]***
2		(1) P2012F5	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F350LP		POS TARG 0.00,0.00		438 Secs X 4 (1752 Secs)	
								[==>(Copy 1)] *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]*	***[1]***
3		(1) P2012F5	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F350LP		POS TARG 1.25,1.25		438 Secs X 5 (2190 Secs)	
								[==>(Copy 1)] *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]*	***[2]***
4		(1) P2012F5	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F350LP		POS TARG 2.50,2.50		438 Secs X 5 (2190 Secs)	
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5		(1) P2012F5	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F350LP		POS TARG 3.75,3.75		438 Secs X 5 (2190 Secs)	
								[==>(Copy 1)] *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]*	***[4]***
6		(1) P2012F5	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F350LP		POS TARG 5.00,5.00		438 Secs X 5 (2190 Secs)	
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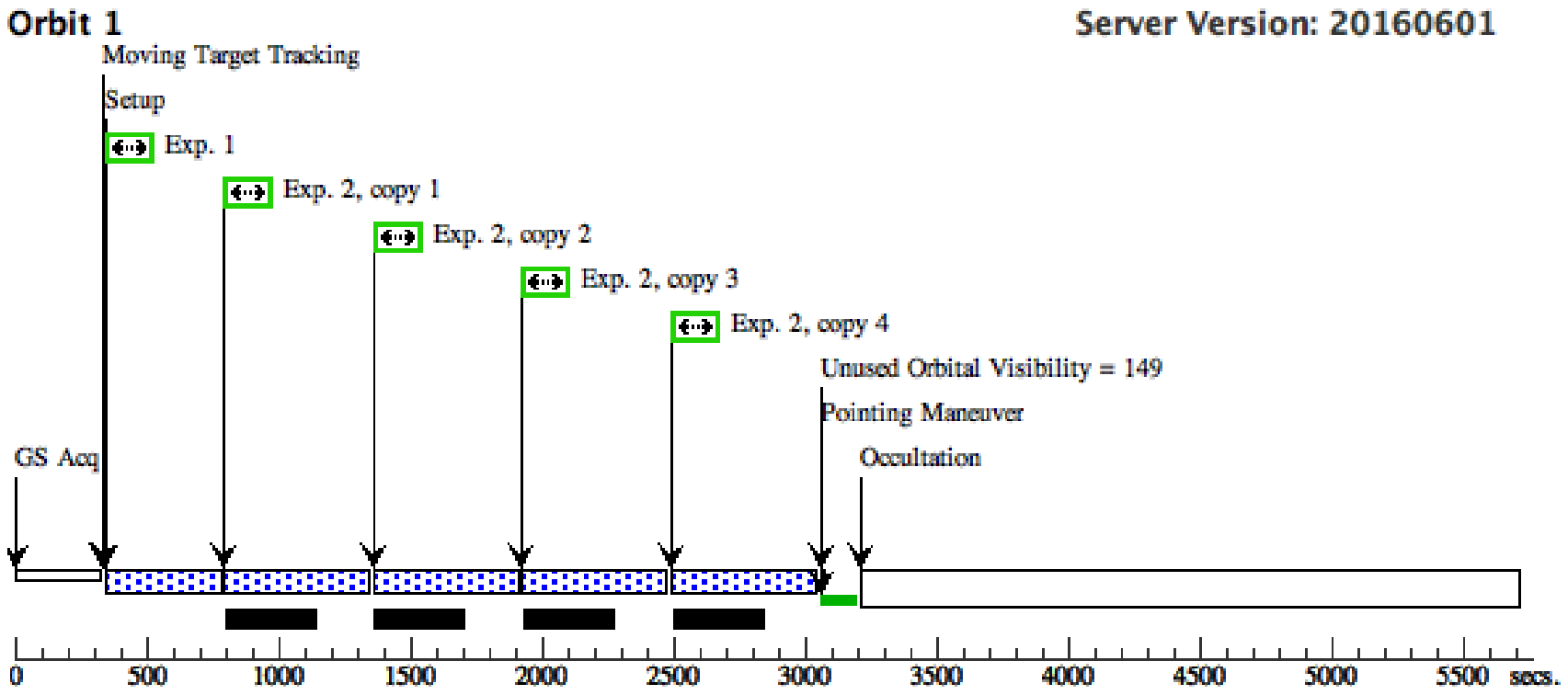
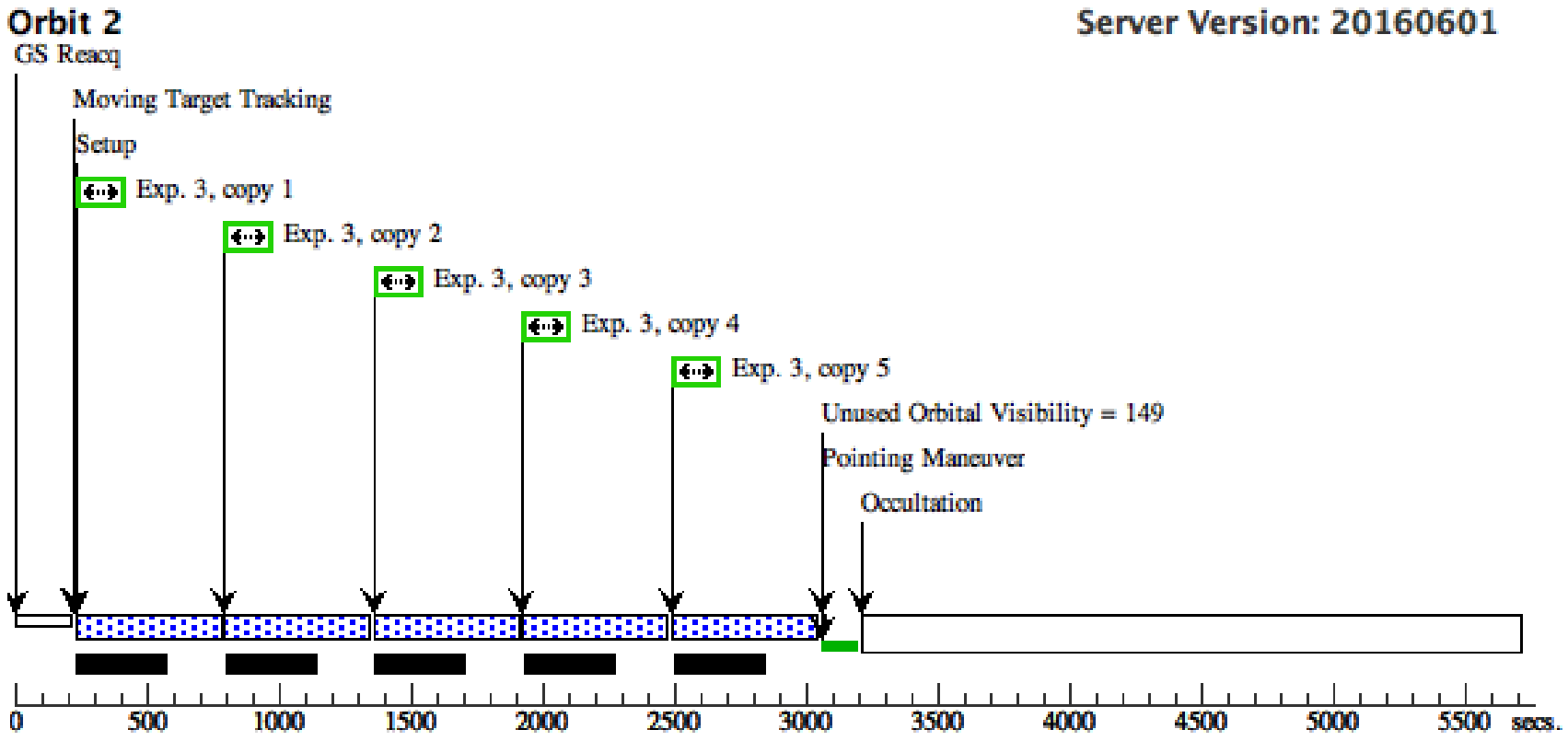
Orbit Structure

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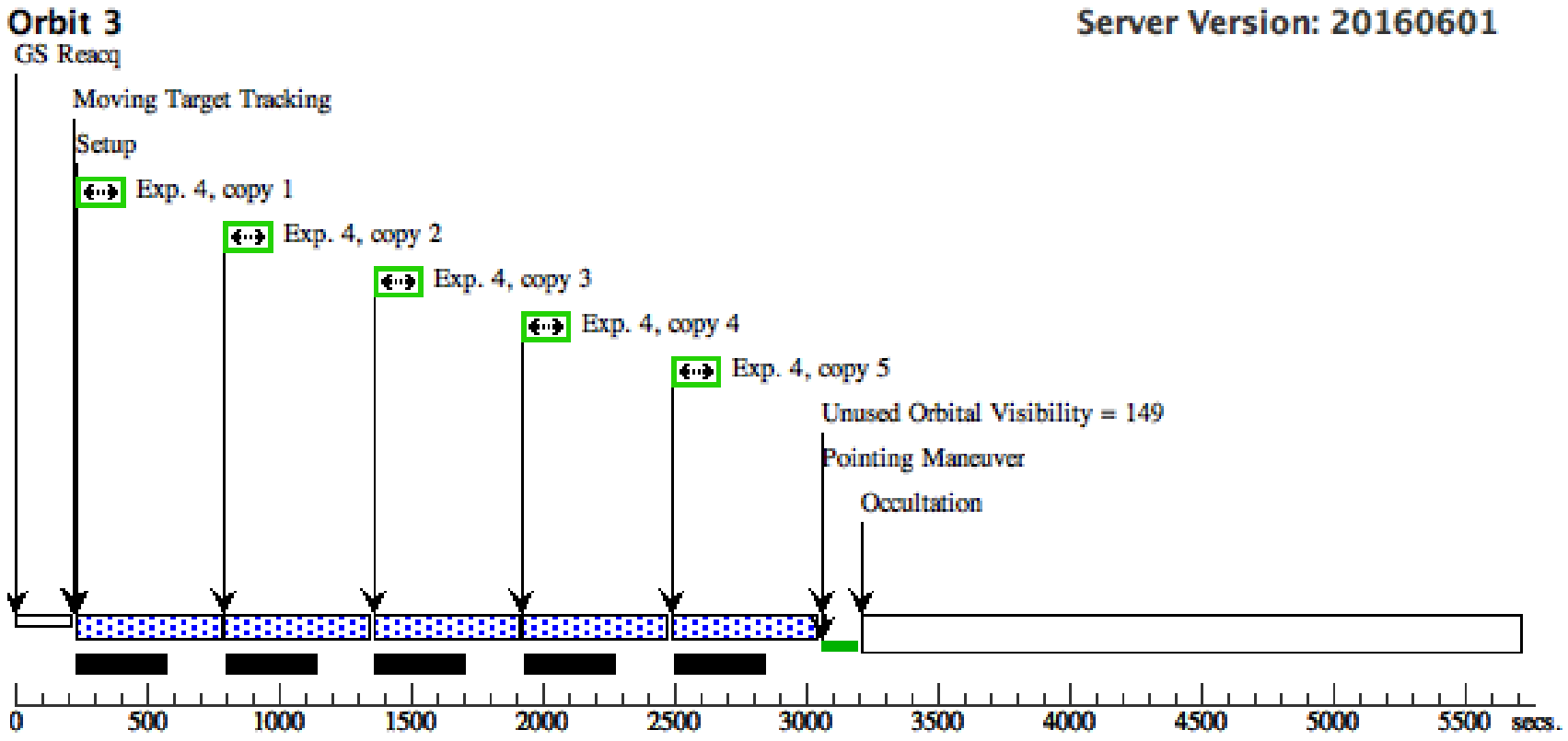
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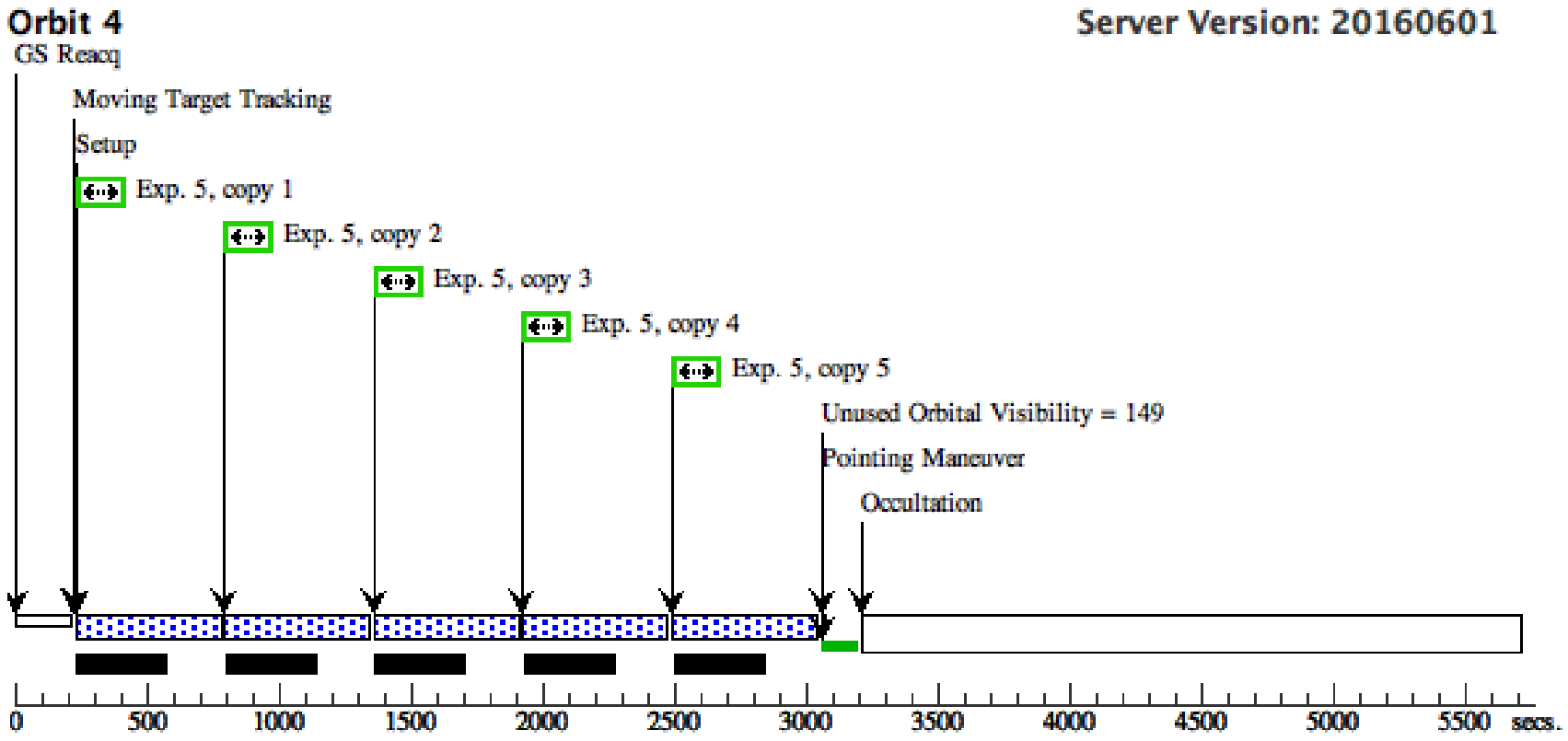
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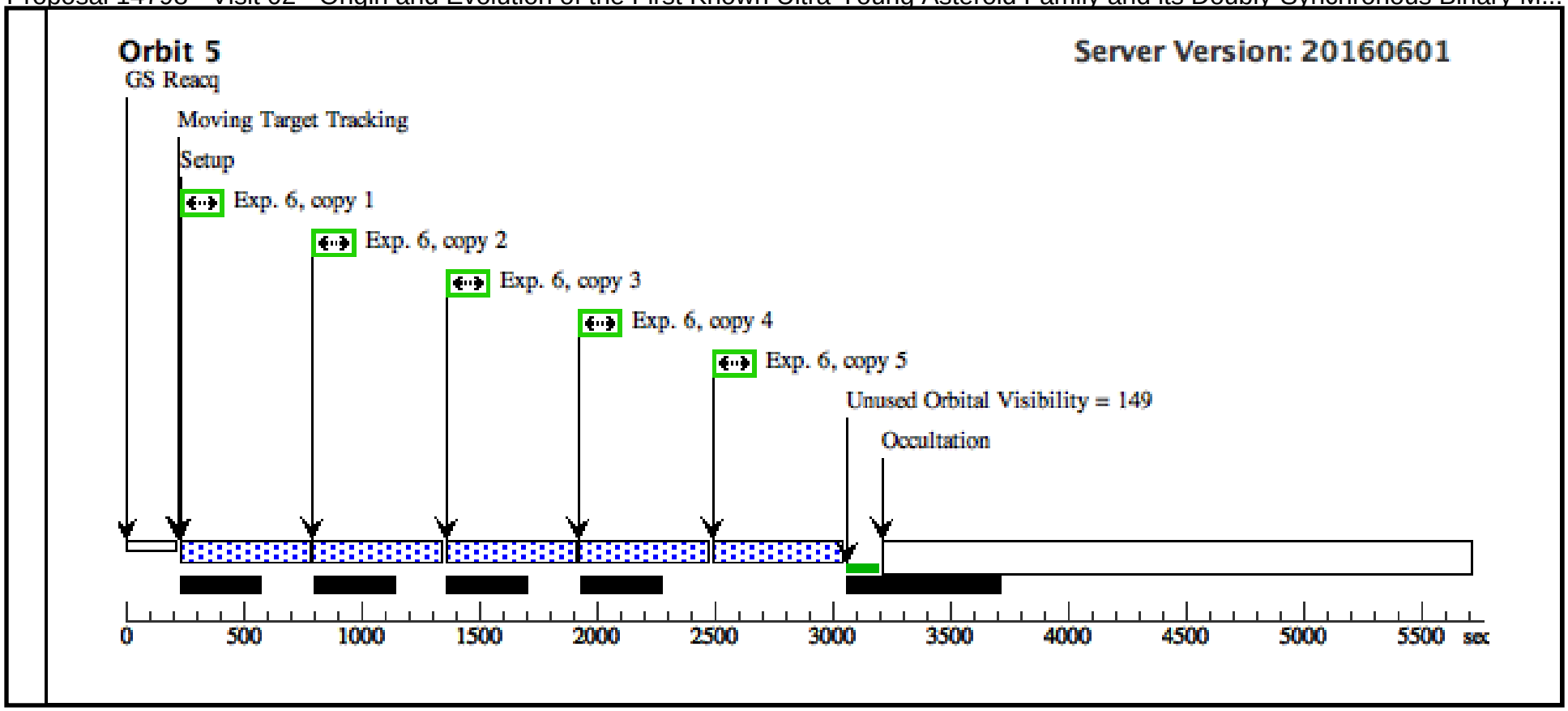
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