



13865 - Determining the Nature and Origin of Mass Loss from Active Asteroid P/2013 R3

Cycle: 22, Proposal Category: GO
(Availability Mode: SUPPORTED)

INVESTIGATORS

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VISITS

<i>Visit</i>	<i>Targets used in Visit</i>	<i>Configurations used in Visit</i>	<i>Orbits Used</i>	<i>Last Orbit Planner Run</i>	<i>OP Current with Visit?</i>
10	(1) P2013R3-A	WFC3/UVIS	1	16-Sep-2014 21:11:16.0	yes
20	(1) P2013R3-A	WFC3/UVIS	1	16-Sep-2014 21:11:17.0	yes
30	(1) P2013R3-A	WFC3/UVIS	1	16-Sep-2014 21:11:18.0	yes
40	(1) P2013R3-A	WFC3/UVIS	4	16-Sep-2014 21:11:19.0	yes
50	(1) P2013R3-A	WFC3/UVIS	1	16-Sep-2014 21:11:21.0	yes
60	(1) P2013R3-A	WFC3/UVIS	1	16-Sep-2014 21:11:21.0	yes
70	(1) P2013R3-A	WFC3/UVIS	1	16-Sep-2014 21:11:22.0	yes

10 Total Orbits Used

ABSTRACT

We propose a program of WFC3 images of the active asteroid P/2013 R3 in order to determine the nature and origin of mass loss from this object. R3 has a unique, multiple nucleus structure in which the components are measured to separate at sub-meter per second velocities. It is best explained as a rotational breakup (presumably resulting from the YORP torque). We will obtain images over a wide time base in Cycle 22 in order to determine the orbits of the fragments and we will obtain time-series, high resolution photometry in order to measure their rotations. Rotational breakup and rotational mass-shedding are suspected to be the main mechanisms of destruction for sub-kilometer asteroids. Neither has been observed before but, between P/2013 R3 and P/2013 P5 (subject of another proposal) we have the first, potentially ground-breaking opportunities to observe both.

OBSERVING DESCRIPTION

We request a total of 10 orbits devoted to the temporal evolution of P/2013 R3. Seven single-orbit "evolution" visits to P/2013 R3 are requested between 2014 Oct 01 and 2015 May 30, when the object enters the Sun exclusion zone (elongation 50 deg). Single-orbit visits using the WFC3 F350LP filter provide sufficient sensitivity to image faint structures and enough images for adequate cosmic ray and artifact rejection, as established by our ToO work. A ~30 to 40 day timescale between visits is suggested by the changing observational geometry (Figure 3) and by the likely dynamical evolution of the object. In 30 days, the expected motion between fragments is 1 arcsec (25 pixels). Much faster sampling would be unjustified while slower sampling would risk confusion between changes caused by geometry and changes intrinsic to the object. Separate from the dynamical timescale, each fragment likely has a (not constrained) physical timescale associated with the depletion of dust by radiation pressure. Visits separated by longer than a month risk losing fragments to physical decay. Taking the measured velocity dispersion of the fragments from Jewitt et al. (2014), namely 0.2 to 0.5 m/s, we predict a spread of 0.6×10^7 to 1.5×10^7 m between 2013 Oct and 2014 Oct. At typical geocentric distance 3 AU (Figure 3), this corresponds to 3 to 7 arcseconds motion in the sky plane. Even with a modest acceleration due to Keplerian shear or rocket forces, the entire ensemble of fragments should remain well within the 160 arcsec wide field of WFC3. The science objectives cannot be met using other facilities. The HST is vastly superior to Keck for the program proposed here (compare Figures 1 and 2). We especially need Hubble's high angular resolution and stable point-spread function (PSF) to examine small structures within the diffuse coma and to study the close environs of the nucleus, to constrain the dynamics and mechanisms responsible for the unusual behavior of this active asteroid. There is no adaptive-optics solution for this faint target (the brightest discrete source has $V=26$) and, in any case, the AO PSF is too unstable for coma fitting using Lamy's established technique (e.g., Lamy et al. 2009). During Cycle 22 (as in Cycle 21), the R3 fragments will be extremely faint (see Fig. 4) and will be

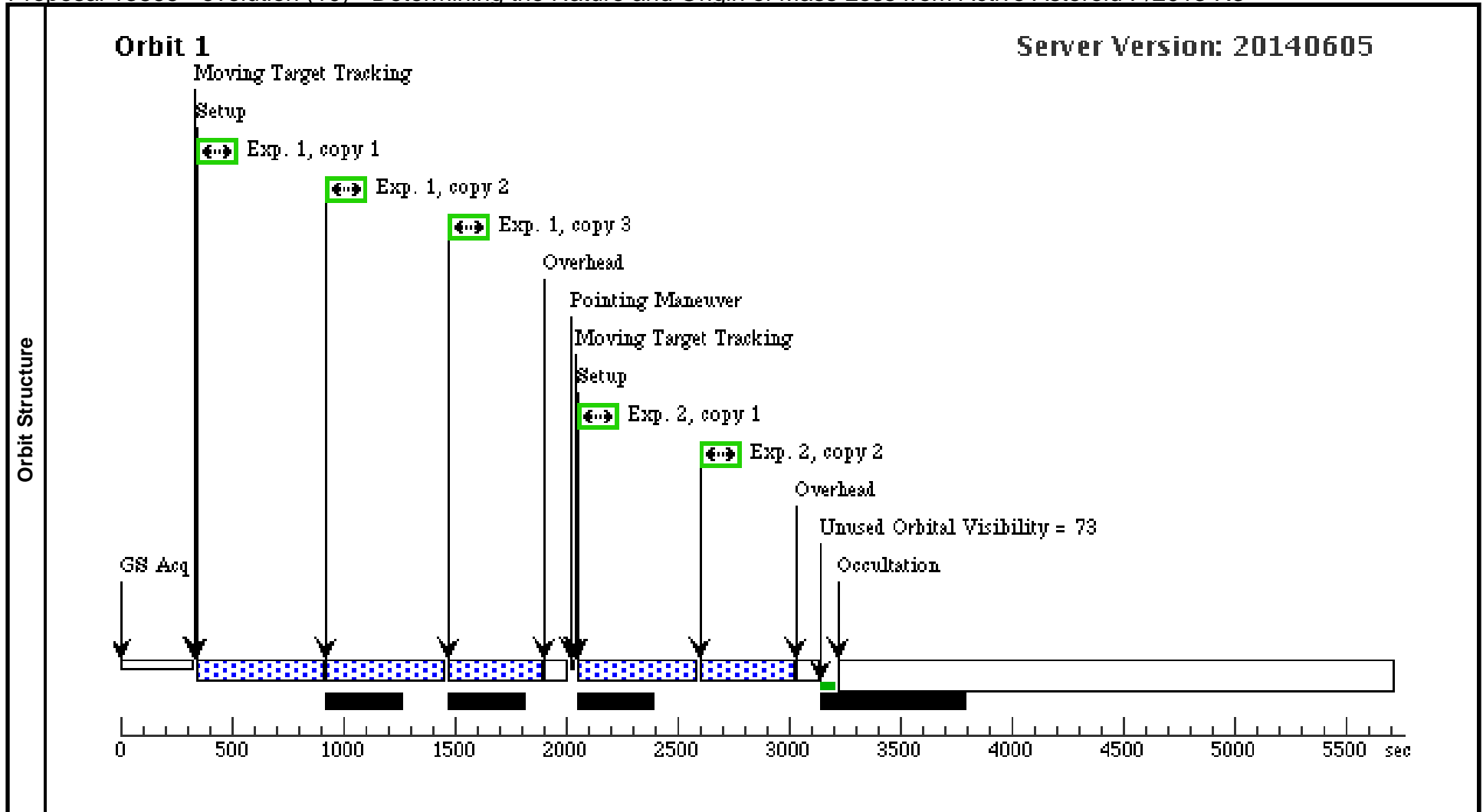
Proposal 13865 (STScI Edit Number: 0, Created: Tuesday, September 16, 2014 8:11:23 PM EST) - Overview

pushing the sensitivity limits of HST. Nevertheless, our previous observations and the WFC3 ETC demonstrate that our program is feasible. For each of the HST orbits, we expect to obtain 6 deep exposures (5 x 348s + 1 x 233s) using the F350LP filter. ETC ID 583446 (using 5 x 348s only) gives $S/N=3.1$ and 12.9 (optimal extraction) in a 0.4 arcsec aperture for $V=27.5$, which shows we can meet our measurement objectives for the R3 fragments. Figure 4 shows the apparent V-band magnitude of a 200 m radius sphere having albedo 0.05 and moving in the orbit of R3. There is a roughly 1 magnitude variation through Cycle 22, with peak brightness expected on UT 2015 Jan 18, and observations before this time being slightly favored over observations after it. R3 is outside the (50 degree) HST solar exclusion zone from UT 2014 Oct 01 to May 30. Scheduling for the dynamics observations is constrained by the need to obtain sufficient visits to connect fragments observed at different times. This was already difficult in our Cycle 21 data with a sampling of ~4 weeks, owing to photometric and morphological evolution on similar timescales. A possible set of observing dates is: 2014 Oct 3, Nov 3, Dec 10, 2015 Jan 18, Mar 04, Apr 10, May 28 (7 orbits). The observations all have flexible observing windows (e.g. 1 week) except that 1) we request the first visit to occur as soon as possible in order to establish the starting morphology in Cycle 22 and to allow a connection to be made to the Cycle 21 data (which ended 2014 Feb) and 2) we request a visit on 2015 Mar 04 to coincide with Earth's passage through the R3 orbital plane. The latter configuration removes all ambiguity about projection effects on material above and below the plane. Scheduling for the rotational/size/shape science is best done near UT 2015 Jan 18, the date of peak brightness (Figure 4). Four consecutive orbits will provide a ~4 hour baseline of coverage over which any true rotational variation should repeat. Observations over a shorter time would be correspondingly more difficult to associate unambiguously with the rotation of the fragments (as opposed to brightness fluctuations from other causes). The 4 orbits near Jan 18 could of course stand-in for one of the dynamics observations. The total request is therefore for $7 + 4 - 1 = 10$ orbits with WFC3.

Proposal 13865 - evolution (10) - Determining the Nature and Origin of Mass Loss from Active Asteroid P/2013 R3

Wed Sep 17 01:11:23 GMT 2014

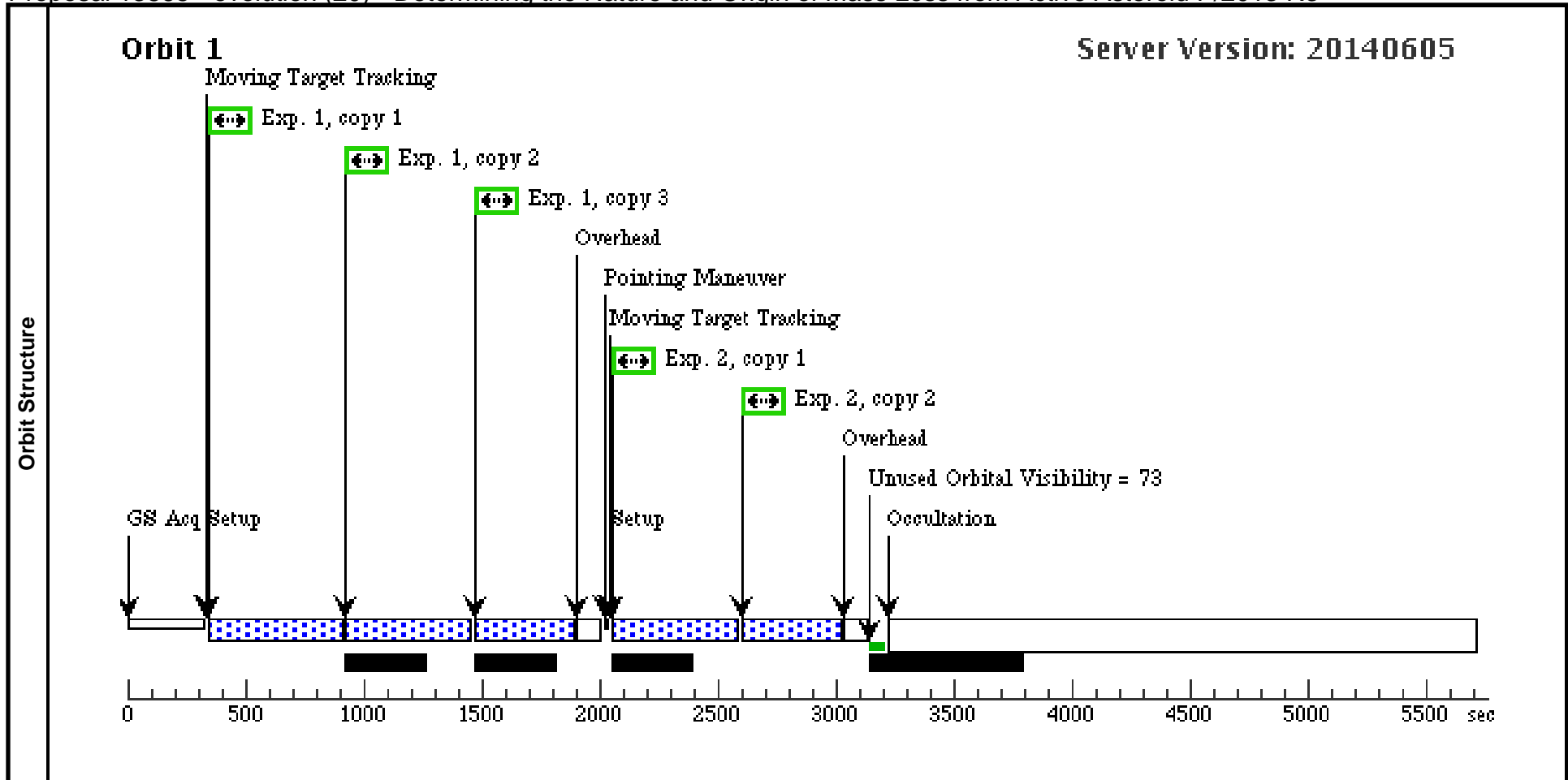
Visit	Proposal 13865, evolution (10), implementation Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS Special Requirements: BETWEEN 29-SEP-2014:00:00:00 AND 06-OCT-2014:00:00:00									
	Solar System Targets	#	Name	Level 1	Level 2	Level 3	Window	Ephem Center		
	(1)	P2013R3-A	TYPE=COMET,Q=2.2037748146257 2.E=0.2733288372094057,I=0.897987 2165430337,O=342.6413289368975, W=8.324789778007844,T=05-AUG- 2013:06:45:16,TimeScale=UTC,EQ UINOX=J2000,EPOCH=18-DEC- 2013:00:00:00,EpochTimeScale=UTC <i>Comments: JPL #1 solution for R3-A</i>					EARTH		
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(1) P2013R3-A	WFC3/UVIS, ACCUM, UVIS2-FIX	F350LP	CR-SPLIT=NO		Sequence 1-2 Non-Int in evolution (10)	420 Secs X 3 (1260 Secs)	
									[==>(Copy 1)] [==>(Copy 2)] [==>(Copy 3)]	[1]
	2		(1) P2013R3-A	WFC3/UVIS, ACCUM, UVIS2-FIX	F350LP	CR-SPLIT=NO	POS TARG 0.2,2.0	Sequence 1-2 Non-Int in evolution (10)	420 Secs X 2 (840 Secs)	
								[==>(Copy 1)] [==>(Copy 2)]	[1]	



Proposal 13865 - evolution (20) - Determining the Nature and Origin of Mass Loss from Active Asteroid P/2013 R3

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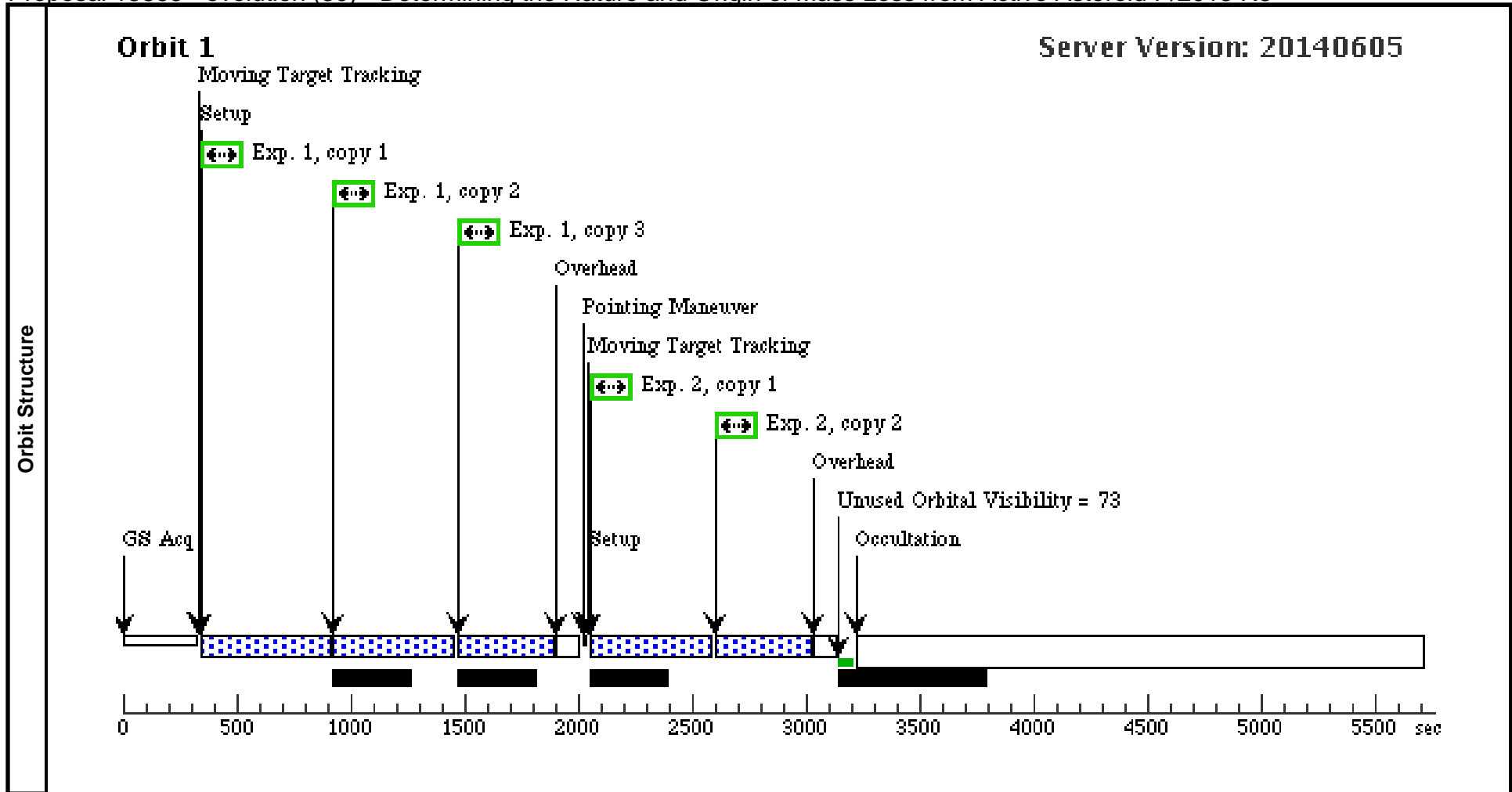
Visit	Proposal 13865, evolution (20), implementation Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS Special Requirements: BETWEEN 27-OCT-2014:00:00:00 AND 09-NOV-2014:00:00:00									
	Solar System Targets	#	Name	Level 1	Level 2	Level 3	Window	Ephem Center		
	(1)	P2013R3-A	TYPE=COMET,Q=2.2037748146257 2.E=0.2733288372094057,I=0.897987 2165430337,O=342.6413289368975, W=8.324789778007844,T=05-AUG- 2013:06:45:16,TimeScale=UTC,EQ UINOX=J2000,EPOCH=18-DEC- 2013:00:00:00,EpochTimeScale=UTC					EARTH		
	<i>Comments: JPL #1 solution for R3-A</i>									
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(1) P2013R3-A	WFC3/UVIS, ACCUM, UVIS2-FIX	F350LP	CR-SPLIT=NO		Sequence 1-2 Non-Int in evolution (20)	420 Secs X 3 (1260 Secs) [=>(Copy 1)] [=>(Copy 2)] [=>(Copy 3)]	[1]
2		(1) P2013R3-A	WFC3/UVIS, ACCUM, UVIS2-FIX	F350LP	CR-SPLIT=NO	POS TARG 0.2,2.0	Sequence 1-2 Non-Int in evolution (20)	420 Secs X 2 (840 Secs) [=>(Copy 1)] [=>(Copy 2)]	[1]	



Proposal 13865 - evolution (30) - Determining the Nature and Origin of Mass Loss from Active Asteroid P/2013 R3

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Visit	Proposal 13865, evolution (30), implementation Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS Special Requirements: BETWEEN 08-DEC-2014:00:00:00 AND 21-DEC-2014:00:00:00									
	Solar System Targets	#	Name	Level 1	Level 2	Level 3	Window	Ephem Center		
	(1)	P2013R3-A	TYPE=COMET,Q=2.2037748146257 2.E=0.2733288372094057,I=0.897987 2165430337,O=342.6413289368975, W=8.324789778007844,T=05-AUG- 2013:06:45:16,TimeScale=UTC,EQ UINOX=J2000,EPOCH=18-DEC- 2013:00:00:00,EpochTimeScale=UTC					EARTH		
	<i>Comments: JPL #1 solution for R3-A</i>									
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(1) P2013R3-A	WFC3/UVIS, ACCUM, UVIS2-FIX	F350LP	CR-SPLIT=NO		Sequence 1-2 Non-Int in evolution (30)	420 Secs X 3 (1260 Secs) [=>(Copy 1)] [=>(Copy 2)] [=>(Copy 3)]	[1]
2		(1) P2013R3-A	WFC3/UVIS, ACCUM, UVIS2-FIX	F350LP	CR-SPLIT=NO	POS TARG 0.2,2.0	Sequence 1-2 Non-Int in evolution (30)	420 Secs X 2 (840 Secs) [=>(Copy 1)] [=>(Copy 2)]	[1]	

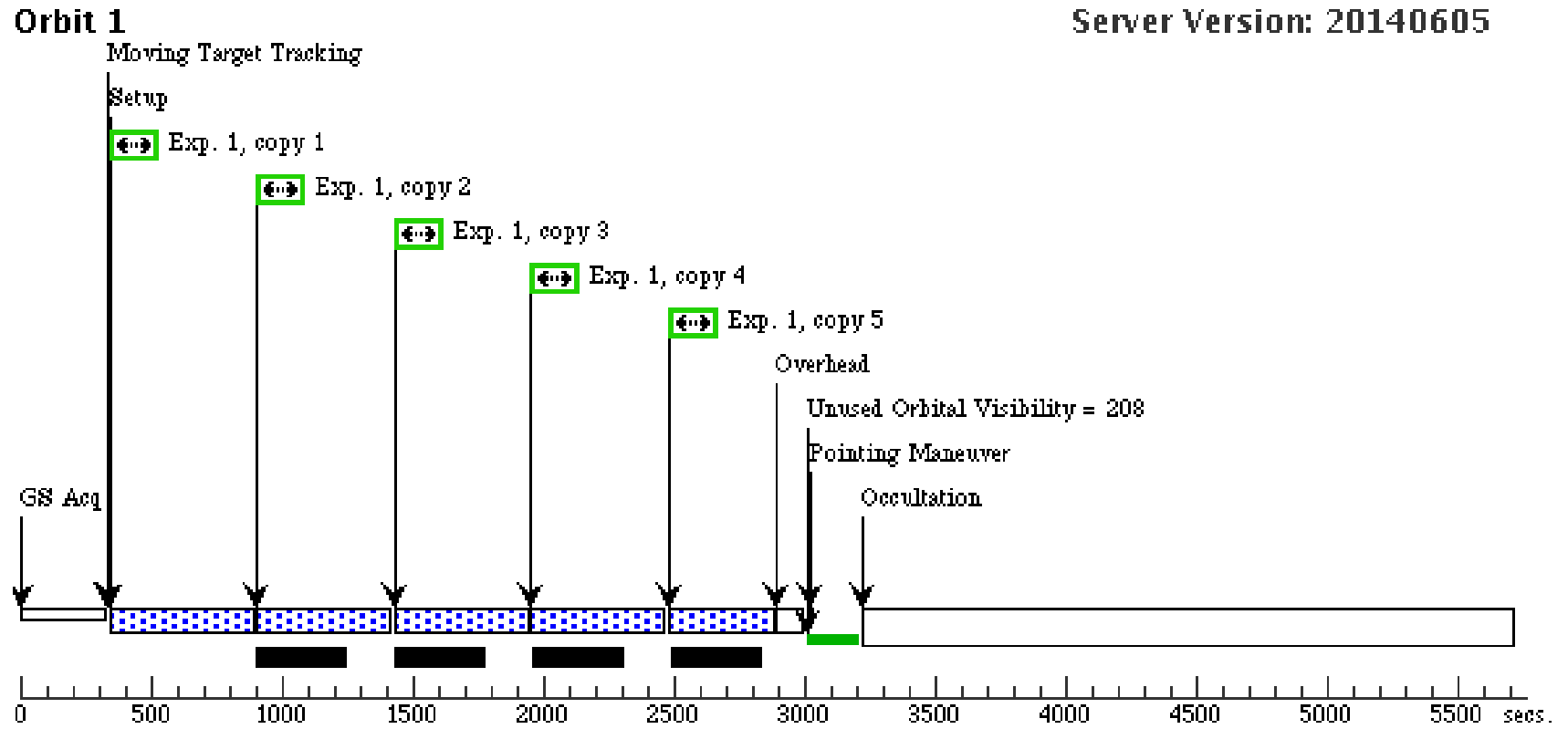


Proposal 13865 - rotation (40) - Determining the Nature and Origin of Mass Loss from Active Asteroid P/2013 R3

Wed Sep 17 01:11:24 GMT 2014

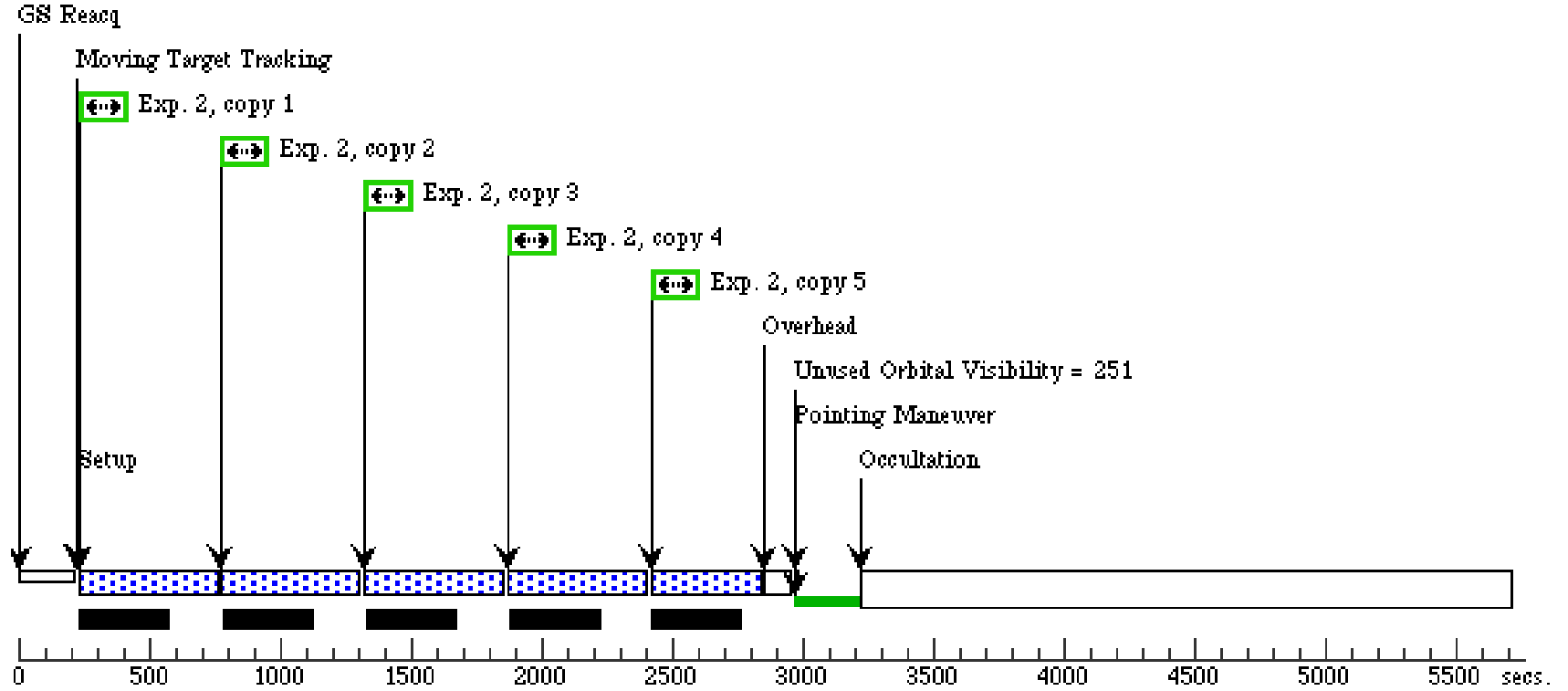
Visit	Proposal 13865, rotation (40), implementation Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS Special Requirements: BETWEEN 17-JAN-2015:00:00:00 AND 20-JAN-2015:00:00:00									
	Solar System Targets	#	Name	Level 1	Level 2	Level 3	Window	Ephem Center		
	(1)	P2013R3-A	TYPE=COMET,Q=2.2037748146257 2.E=0.2733288372094057,I=0.897987 2165430337,O=342.6413289368975, W=8.324789778007844,T=05-AUG- 2013:06:45:16,TimeScale=UTC,EQ UINOX=J2000,EPOCH=18-DEC- 2013:00:00:00,EpochTimeScale=UTC					EARTH		
	<i>Comments: JPL #1 solution for R3-A</i>									
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(1) P2013R3-A	WFC3/UVIS, ACCUM, UVIS2-FIX	F350LP	CR-SPLIT=NO			400 Secs X 5 (2000 Secs)	
									[==>(Copy 1)] [==>(Copy 2)] [==>(Copy 3)] [==>(Copy 4)] [==>(Copy 5)]	[1]
	2		(1) P2013R3-A	WFC3/UVIS, ACCUM, UVIS2-FIX	F350LP	CR-SPLIT=NO	POS TARG 0.2,1.5		420 Secs X 5 (2100 Secs)	
									[==>(Copy 1)] [==>(Copy 2)] [==>(Copy 3)] [==>(Copy 4)] [==>(Copy 5)]	[2]
3		(1) P2013R3-A	WFC3/UVIS, ACCUM, UVIS2-FIX	F350LP	CR-SPLIT=NO	POS TARG 0.4,3.0		420 Secs X 5 (2100 Secs)		
								[==>(Copy 1)] [==>(Copy 2)] [==>(Copy 3)] [==>(Copy 4)] [==>(Copy 5)]	[3]	
4		(1) P2013R3-A	WFC3/UVIS, ACCUM, UVIS2-FIX	F350LP	CR-SPLIT=NO	POS TARG 0.6,4.5		420 Secs X 5 (2100 Secs)		
								[==>(Copy 1)] [==>(Copy 2)] [==>(Copy 3)] [==>(Copy 4)] [==>(Copy 5)]	[4]	

Orbit Structure



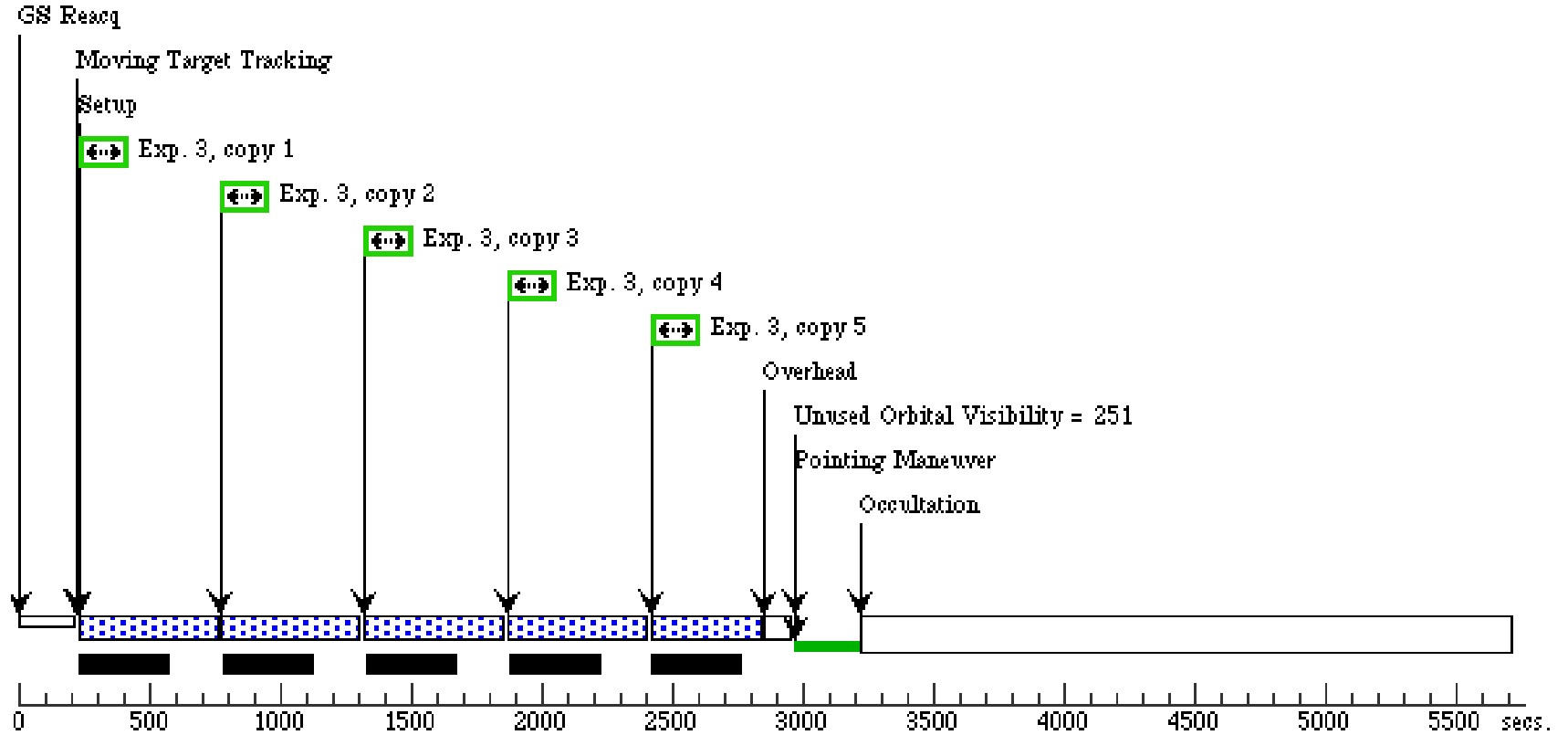
Orbit 2

Server Version: 20140605

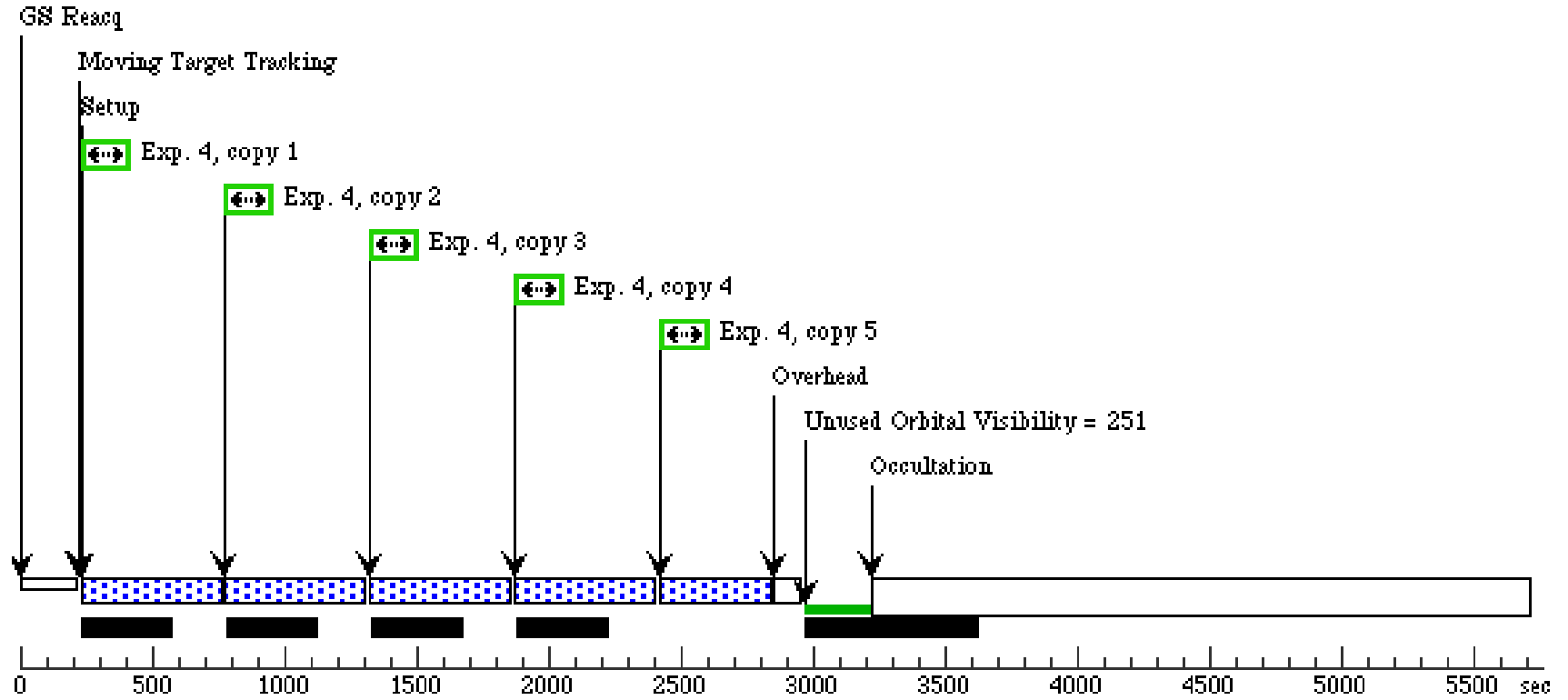


Orbit 3

Server Version: 20140605



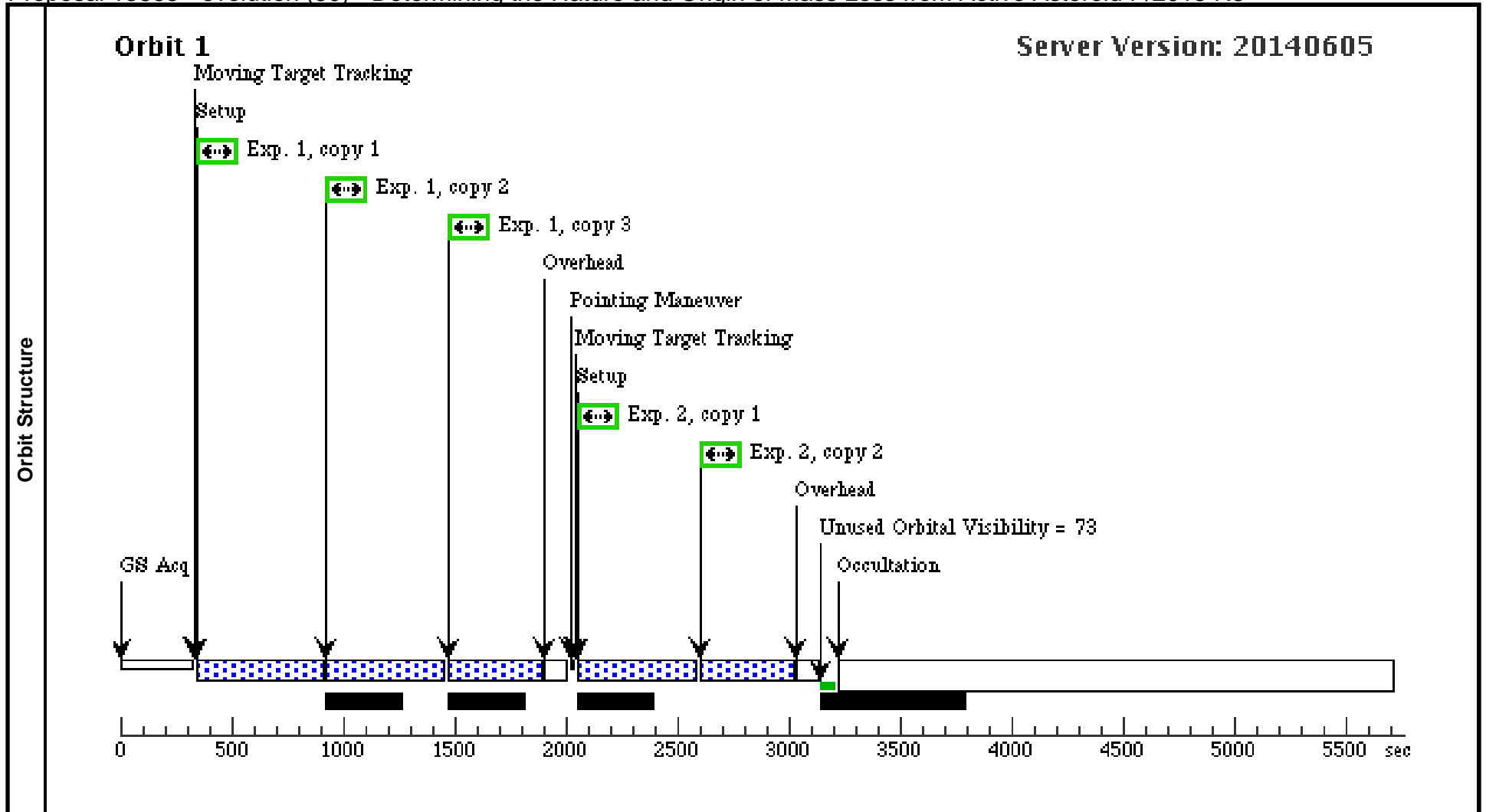
Orbit 4



Proposal 13865 - evolution (50) - Determining the Nature and Origin of Mass Loss from Active Asteroid P/2013 R3

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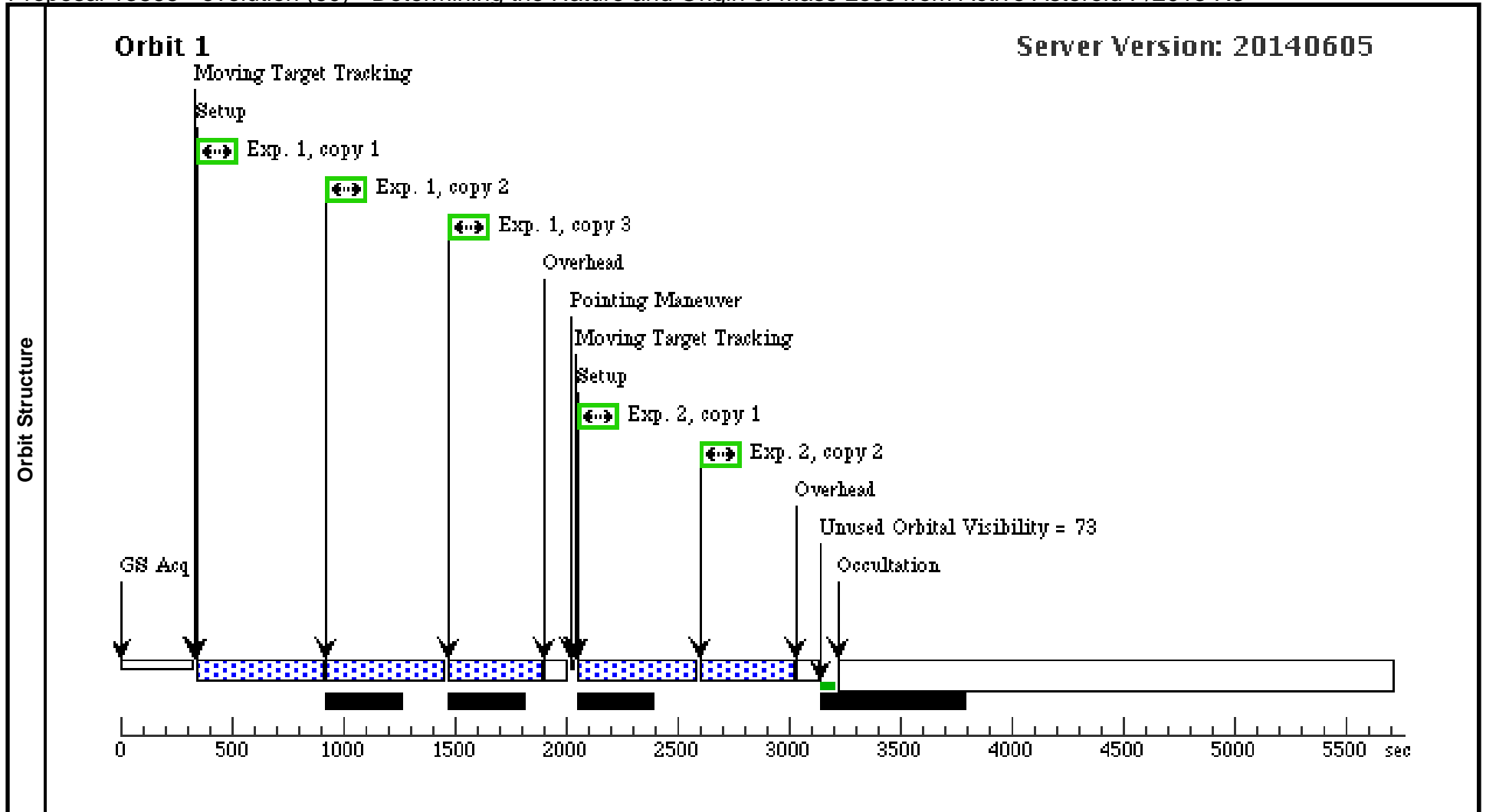
Visit	Proposal 13865, evolution (50), implementation Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS Special Requirements: BETWEEN 03-MAR-2015:18:00:00 AND 05-MAR-2015:06:00:00									
	Solar System Targets	#	Name	Level 1	Level 2	Level 3	Window	Ephem Center		
	(1)	P2013R3-A	TYPE=COMET,Q=2.2037748146257 2.E=0.2733288372094057,I=0.897987 2165430337,O=342.6413289368975, W=8.324789778007844,T=05-AUG- 2013:06:45:16,TimeScale=UTC,EQ UINOX=J2000,EPOCH=18-DEC- 2013:00:00:00,EpochTimeScale=UTC <i>Comments: JPL #1 solution for R3-A</i>					EARTH		
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(1) P2013R3-A	WFC3/UVIS, ACCUM, UVIS2-FIX	F350LP	CR-SPLIT=NO		Sequence 1-2 Non-Int in evolution (50)	420 Secs X 3 (1260 Secs) [=>(Copy 1)] [=>(Copy 2)] [=>(Copy 3)]	[1]
2		(1) P2013R3-A	WFC3/UVIS, ACCUM, UVIS2-FIX	F350LP	CR-SPLIT=NO	POS TARG 0.2,2.0	Sequence 1-2 Non-Int in evolution (50)	420 Secs X 2 (840 Secs) [=>(Copy 1)] [=>(Copy 2)]	[1]	



Proposal 13865 - evolution (60) - Determining the Nature and Origin of Mass Loss from Active Asteroid P/2013 R3

Wed Sep 17 01:11:24 GMT 2014

Visit	Proposal 13865, evolution (60), implementation Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS Special Requirements: BETWEEN 06-APR-2015:00:00:00 AND 13-APR-2015:00:00:00									
	Solar System Targets	#	Name	Level 1	Level 2	Level 3	Window	Ephem Center		
	(1)	P2013R3-A	TYPE=COMET,Q=2.2037748146257 2.E=0.2733288372094057,I=0.897987 2165430337,O=342.6413289368975, W=8.324789778007844,T=05-AUG- 2013:06:45:16,TimeScale=UTC,EQ UINOX=J2000,EPOCH=18-DEC- 2013:00:00:00,EpochTimeScale=UTC <i>Comments: JPL #1 solution for R3-A</i>					EARTH		
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(1) P2013R3-A	WFC3/UVIS, ACCUM, UVIS2-FIX	F350LP	CR-SPLIT=NO		Sequence 1-2 Non-Int in evolution (60)	420 Secs X 3 (1260 Secs) [=>(Copy 1)] [=>(Copy 2)] [=>(Copy 3)]	[1]
2		(1) P2013R3-A	WFC3/UVIS, ACCUM, UVIS2-FIX	F350LP	CR-SPLIT=NO	POS TARG 0.2,2.0	Sequence 1-2 Non-Int in evolution (60)	420 Secs X 2 (840 Secs) [=>(Copy 1)] [=>(Copy 2)]	[1]	



Proposal 13865 - evolution (70) - Determining the Nature and Origin of Mass Loss from Active Asteroid P/2013 R3

Wed Sep 17 01:11:24 GMT 2014

Visit	Proposal 13865, evolution (70), implementation Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS Special Requirements: BETWEEN 25-MAY-2015:00:00:00 AND 01-JUN-2015:00:00:00									
	Solar System Targets	#	Name	Level 1	Level 2	Level 3	Window	Ephem Center		
	(1)	P2013R3-A	TYPE=COMET,Q=2.2037748146257 2.E=0.2733288372094057,I=0.897987 2165430337,O=342.6413289368975, W=8.324789778007844,T=05-AUG- 2013:06:45:16,TimeScale=UTC,EQ UINOX=J2000,EPOCH=18-DEC- 2013:00:00:00,EpochTimeScale=UTC <i>Comments: JPL #1 solution for R3-A</i>					EARTH		
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(1) P2013R3-A	WFC3/UVIS, ACCUM, UVIS2-FIX	F350LP	CR-SPLIT=NO		Sequence 1-2 Non-Int in evolution (70)	420 Secs X 3 (1260 Secs) [=>(Copy 1)] [=>(Copy 2)] [=>(Copy 3)]	[1]
2		(1) P2013R3-A	WFC3/UVIS, ACCUM, UVIS2-FIX	F350LP	CR-SPLIT=NO	POS TARG 0.2,2.0	Sequence 1-2 Non-Int in evolution (70)	420 Secs X 2 (840 Secs) [=>(Copy 1)] [=>(Copy 2)]	[1]	

