16009 - Interstellar Object C/2019 Q4

Cycle: 27, Proposal Category: GO/DD

(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) C2019-Q4	WFC3/UVIS	1	17-Dec-2019 14:00:57.0	yes
02	(1) C2019-Q4	WFC3/UVIS	1	17-Dec-2019 14:00:58.0	yes
03	(1) C2019-Q4	WFC3/UVIS	1	17-Dec-2019 14:00:59.0	yes
04	(1) C2019-Q4	WFC3/UVIS	1	17-Dec-2019 14:00:59.0	yes
05	(2) C12019-Q4-V5	WFC3/UVIS	1	17-Dec-2019 14:01:00.0	yes
06	(4) C2019-Q4-V6	WFC3/UVIS	1	17-Dec-2019 14:01:00.0	yes
07	(5) C2019-Q4-V7	WFC3/UVIS	1	17-Dec-2019 14:01:01.0	yes

7 Total Orbits Used

ABSTRACT

Newly announced comet C/2019 Q4 is the second detected interstellar object in the solar system, with the unprecedented eccentricity e = 3.08. It is likely a comet ejected from the circumplanetary formation environment of another star. We propose early-time HST observations to provide a baseline characterization of the object, addressing several issues raised by 'Oumuamua, the first such object. HST is uniquely capable of isolating the nucleus from the coma and so providing the best measure of its dimensions. The size will enable an improved estimate of the number density and total mass of interstellar bodies, needed to confront formation models. Time-resolved measurements will show whether or not Q4 exhibits an extreme lightcurve, as did 'Oumuamua, with the superb HST resolution reducing the confounding effects of near-nucleus coma on the measured amplitude. The morphology of ejected dust, and its temporal variation under a range of viewing geometries, will reveal dust particle and ejection properties through the application of a sophisticated 3D dust dynamics model. The observations proposed here will cover the period before perihelion, and provide a rational basis for planning additional observations in 2020, should they be necessary.

OBSERVING DESCRIPTION

We request 7 orbits with WFC3 and the F350LP filter to image C/2019 Q4. The broad F350LP filter gives maximum sensitivity to faint coma. The seven orbits would be used as follows. The initial four consecutive orbits will provide a 7 hour lightcurve of the embedded nucleus. This will immediately show whether or not there is a large amplitude lightcurve of the 'Oumuamua type (the latter had m = 2.5 magnitudes with a 8 hour (double-peaked) period). Establishing this fact will immediately address the question of whether extreme shapes are somehow a feature of interstellar objects (a possibility for which several theories have already been proposed, e.g. Vavilov and Medvedev 2019). The four orbits will also permit deep imaging of the coma and high signal-to-noise profile construction, the latter needed for the best nucleus extraction. The coma imaging, from a perspective ~11 degrees below the orbit plane, will provide input to our Monte-Carlo dust dynamics model. Three additional orbits are requested spaced by about one month from the initial four. These orbits will provide additional perspectives on the dust distribution, needed to limit the dust properties. In addition, these orbits will enable measurement of longer-term changes in this unique target. Depending on what the HST shows, these proposed observations may provide a platform for additional requests. For example, if the body disintegrates, we would propose for additional observations to characterize this process. As a secondary benefit, sub-arcsecond astrometry from all 6 orbits will assist with orbit fitting and the search for non-gravitational acceleration, as was the case for 'Oumuamua (Micheli et al. 2018). The science objectives cannot be met using other facilities. We need Hubble's high angular resolution and stable point-spread function (PSF) to photometrically isolate the nucleus from surrounding dust. The object leaves the 55 deg exclusion zone on 2019 October 8. Being the first such object caught pre-perihelion, we are uncertain about its evolution, including the possibility of disintegration (c.f. Sekanina 2018, Jewitt et al 2019). Early scheduling would be advantageous to determine the

morphology as a baseline for future measurements, and as insurance against sudden thermal shock destruction of the object. This geometry will provide the best separation of syndyne and synchrone (Finson and Probstein 1968) type dust trajectories and hence the best constraints on the particle size (note: radiation pressure induces size-dependent spatial separation of particles in the orbital plane, which cannot be observed when the out-of-plane angle is small). geometry strongly favors early observation. The science objectives benefit from orbits #1 through #4 executing as soon as possible by providing improved signal-to-noise ratios and bullet-proof cosmic ray rejection. This is important for the dust modeling given the reported small scale of the dust (few arcsec) and the rapid decrease of surface brightness with distance. High SNR is important in the application of our profile-fitting model, which fits and makes an extrapolation of the coma inwards to extract from the nucleus+coma image. For example, the online exposure time calculator indicates that at 28.5 mag arcsec-2, we achieve SNR ~ 5 per pixel in four orbits (6 images per orbit of 300s each in F350LP). High SNR is also important in the search for companions. In four orbits, we reach V ~ 28.2 at SNR = 5 according to the ETC. The angle of the Earth above the orbit plane determines the extent to which the orbit-plane distribution of dust can be inferred. In addition, the time baseline of orbits #1 - #4 provides our best constraint on the nucleus shape. The additional orbits #5, #6 and #7 should be spaced from the first and from each other by about one month, in order to examine the target from a varying out-of-plane perspective and to assess temporal changes. The current 1-sigma ephemeris uncertainty exceeds the acceptable 10 arcsec by mid-October owing to the short arc of observations available at the time of writing this proposal (Sep 11). However, as with all high profile targets, this will shrink as additional astrometry is continuously included in the fit, including our own measurements to be acquired in scheduled time at the Kitt Peak 0.9-m and NOT 2.4-m. Ephemeris accuracy for HST observations is expected to remain at the 1 sigma = 1 arcsec level, of no concern to these observations. We understand that we will have essentially no control over the spacecraft roll angle, which means that we will not be able to optimize the orientation of the dust coma on the CCD (e.g., to orient the tail along the longest dimension of the detector). However, the field-of-view of the WFC3 2k subarray is large enough and the target coma small enough that we should obtain excellent data, no matter what spacecraft roll angle is used.

Visit

Proposal 16009, Visit 01, completed Tue Dec 17 19:01:02 GMT 2019

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: BEFORE 13-OCT-2019:00:00:00

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(2)	Pattern Type=LINE	Coordinate Frame=POS-TARG		(1)
	Purpose=DITHER	Pattern Orientation=45		
	Number Of Points=2	Angle Between Sides=		
	Point Spacing=0.8	Center Pattern=false		
	Line Spacing=			

Solar System Targets

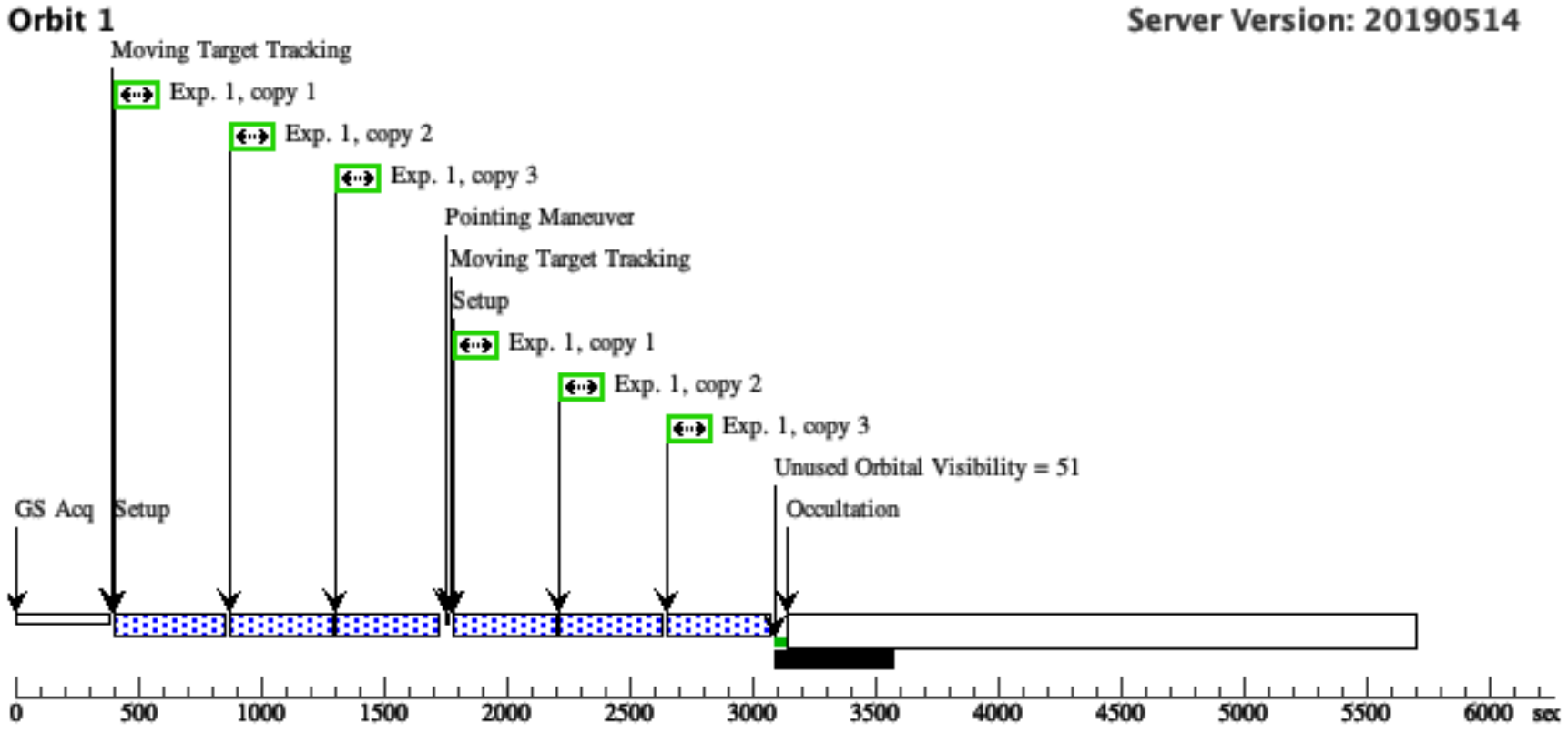
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	C2019-Q4	TYPE=COMET,Q=2.008117570265085,E=3.360320629591126,I=44.03901258700353,O=308.1591586745812,W=209.0829393013172,T=08-DEC-2019:12:35:50,TTimeScale=TDB,EQUINOX=J2000,EPOCH=12-SEP-2019:00:00:00,EpochTimeScale=TDB				EARTH

Comments: Description=Interstellar comet
Extended=NO

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) C2019-Q4	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP	CR-SPLIT=NO		Pattern 2, Exps 1-1 in Visit 01 (2)	260 Secs X 3 (1560 Secs)	
								[==>(Pattern 1, Copy 1)]	***[1]***
								[==>(Pattern 1, Copy 2)]	
								[==>(Pattern 1, Copy 3)]	
								[==>(Pattern 2, Copy 1)]	
								[==>(Pattern 2, Copy 2)]	
								[==>(Pattern 2, Copy 3)]	

Orbit Structure



Visit

Proposal 16009, Visit 02, completed Tue Dec 17 19:01:02 GMT 2019

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: AFTER_01 BY 0.8_Orbits TO 1.2_Orbits

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(2)	Pattern Type=LINE	Coordinate Frame=POS-TARG		(1)
	Purpose=DITHER	Pattern Orientation=45		
	Number Of Points=2	Angle Between Sides=		
	Point Spacing=0.8	Center Pattern=false		
	Line Spacing=			

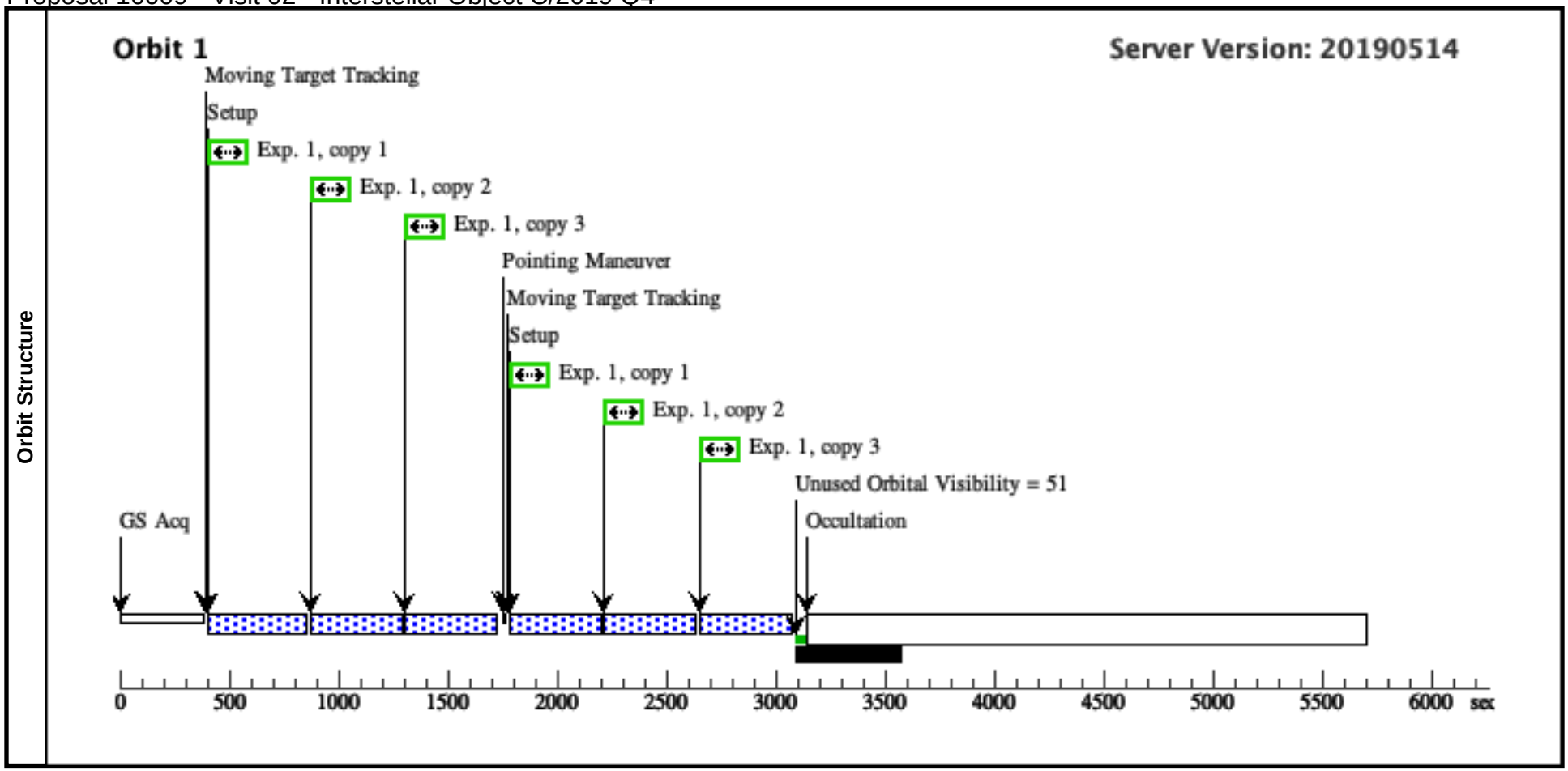
Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	C2019-Q4	TYPE=COMET,Q=2.008117570265085,E=3.360320629591126,I=44.03901258700353,O=308.1591586745812,W=209.0829393013172,T=08-DEC-2019:12:35:50,TTimeScale=TDB,EQUINOX=J2000,EPOCH=12-SEP-2019:00:00:00,EpochTimeScale=TDB				EARTH

Comments: Description=Interstellar comet
Extended=NO

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) C2019-Q4	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP	CR-SPLIT=NO	POS TARG 0.2,0	Pattern 2, Exps 1-1 in Visit 02 (2)	260 Secs X 3 (1560 Secs)	
								[==>(Pattern 1, Copy 1)]	***[1]***
								[==>(Pattern 1, Copy 2)]	
								[==>(Pattern 1, Copy 3)]	
								[==>(Pattern 2, Copy 1)]	
								[==>(Pattern 2, Copy 2)]	
								[==>(Pattern 2, Copy 3)]	


Orbit Structure
Orbit 1
Server Version: 20190514
Moving Target Tracking
Setup
Exp. 1, copy 1
Exp. 1, copy 2
Exp. 1, copy 3
Pointing Maneuver
Moving Target Tracking
Setup
Exp. 1, copy 1
Exp. 1, copy 2
Exp. 1, copy 3
Unused Orbital Visibility = 51
Occultation
GS Acq
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
sec

Visit

Proposal 16009, Visit 03, completed Tue Dec 17 19:01:02 GMT 2019

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: AFTER_01 BY 2.8_Orbits TO 3.2_Orbits

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(2)	Pattern Type=LINE	Coordinate Frame=POS-TARG		(1)
	Purpose=DITHER	Pattern Orientation=45		
	Number Of Points=2	Angle Between Sides=		
	Point Spacing=0.8	Center Pattern=false		
	Line Spacing=			

Solar System Targets

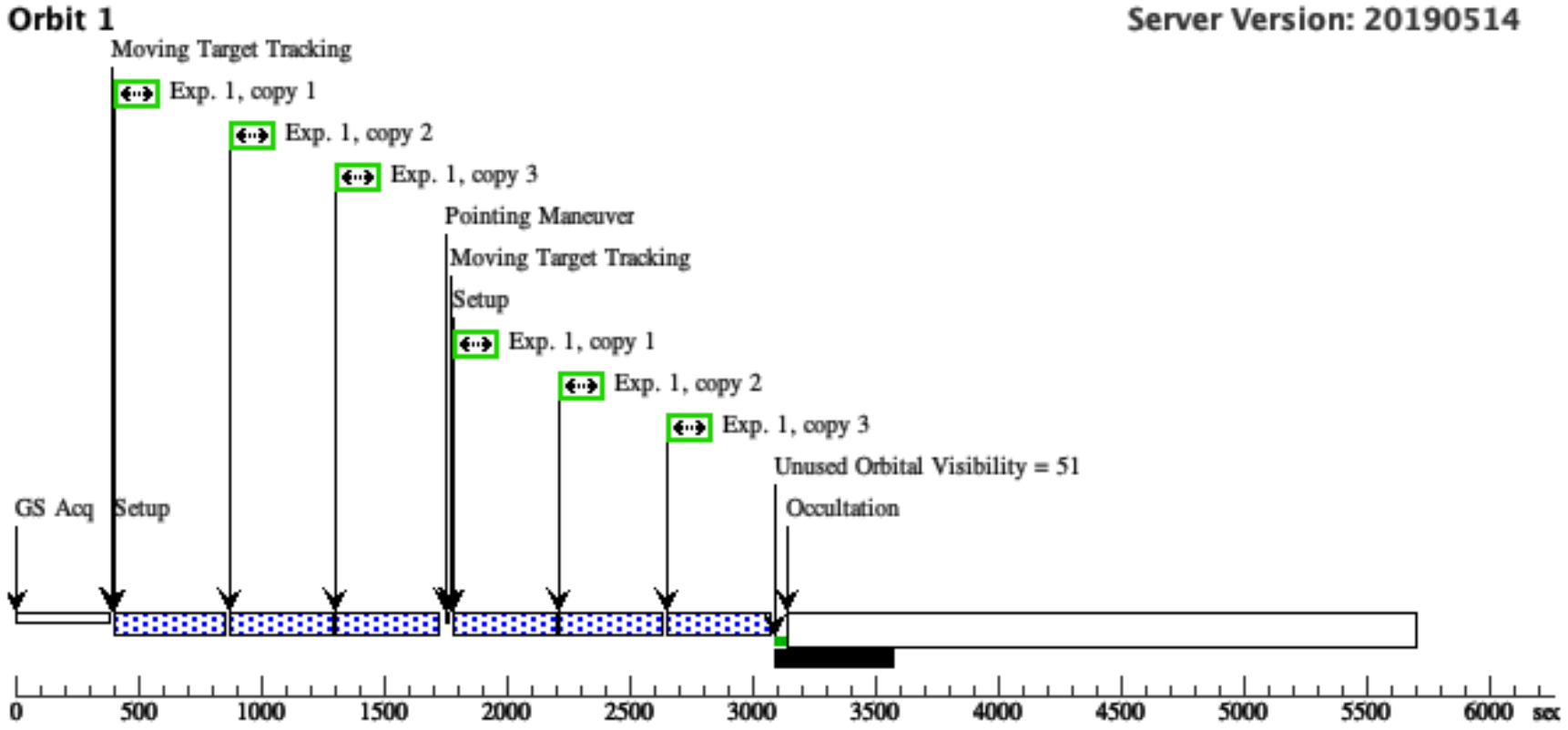
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	C2019-Q4	TYPE=COMET,Q=2.008117570265085,E=3.360320629591126,I=44.03901258700353,O=308.1591586745812,W=209.0829393013172,T=08-DEC-2019:12:35:50,TTimeScale=TDB,EQUINOX=J2000,EPOCH=12-SEP-2019:00:00:00,EpochTimeScale=TDB				EARTH

Comments: Description=Interstellar comet
Extended=NO

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) C2019-Q4	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP	CR-SPLIT=NO	POS TARG 0.4,0	Pattern 2, Exps 1-1 in Visit 03 (2)	260 Secs X 3 (1560 Secs)	
								[==>(Pattern 1, Copy 1)]	***[1]***
								[==>(Pattern 1, Copy 2)]	
								[==>(Pattern 1, Copy 3)]	
								[==>(Pattern 2, Copy 1)]	
								[==>(Pattern 2, Copy 2)]	
								[==>(Pattern 2, Copy 3)]	

Orbit Structure



Visit

Proposal 16009, Visit 04, completed Tue Dec 17 19:01:02 GMT 2019

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: AFTER_01 BY 3.8_Orbits TO 4.2_Orbits

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(2)	Pattern Type=LINE	Coordinate Frame=POS-TARG		(1)
	Purpose=DITHER	Pattern Orientation=45		
	Number Of Points=2	Angle Between Sides=		
	Point Spacing=0.8	Center Pattern=false		
	Line Spacing=			

Solar System Targets

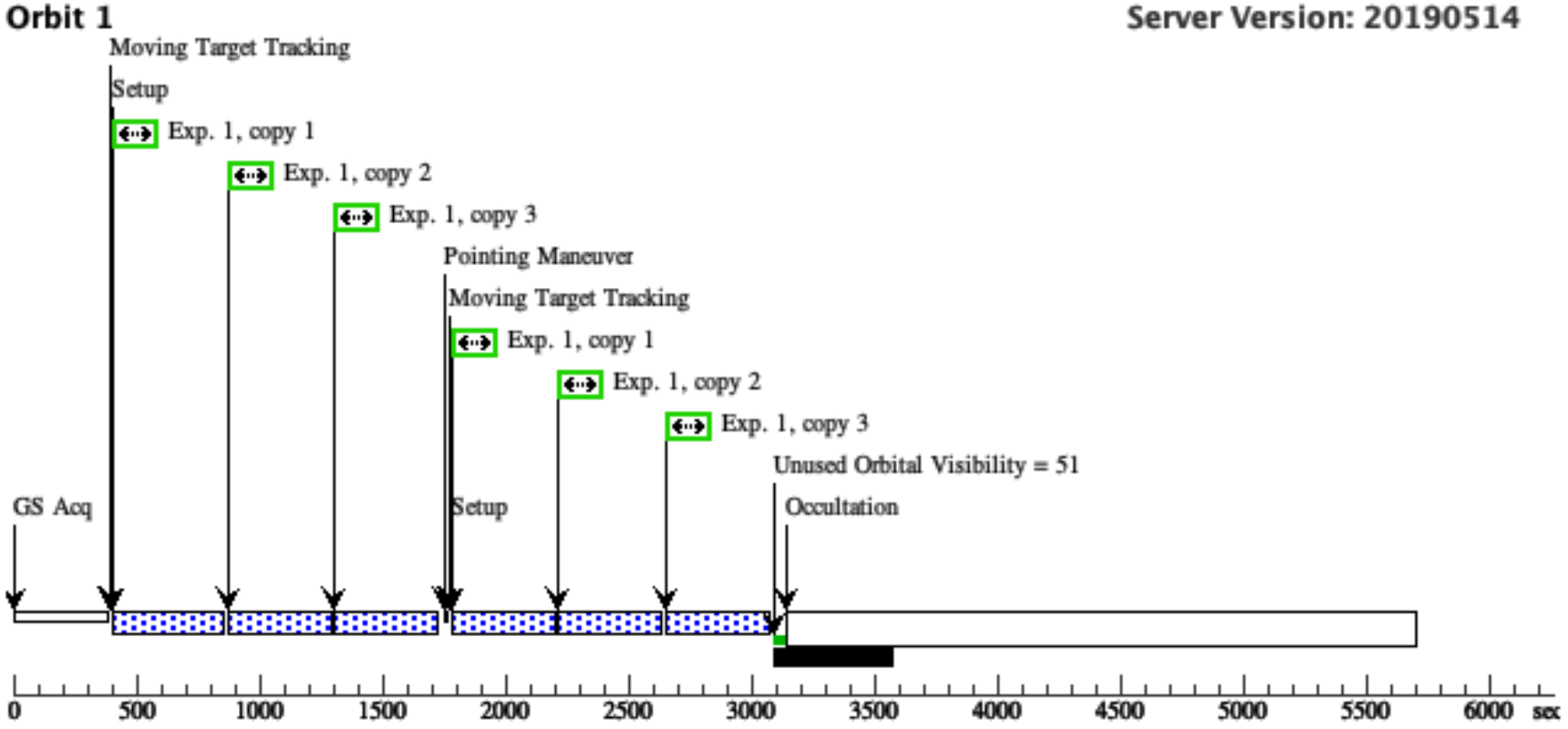
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	C2019-Q4	TYPE=COMET,Q=2.008117570265085,E=3.360320629591126,I=44.03901258700353,O=308.1591586745812,W=209.0829393013172,T=08-DEC-2019:12:35:50,TTimeScale=TDB,EQUINOX=J2000,EPOCH=12-SEP-2019:00:00:00,EpochTimeScale=TDB				EARTH

Comments: Description=Interstellar comet
Extended=NO

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) C2019-Q4	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP	CR-SPLIT=NO	POS TARG 0.6,0	Pattern 2, Exps 1-1 in Visit 04 (2)	260 Secs X 3 (1560 Secs)	
								[==>(Pattern 1, Copy 1)]	***[1]***
								[==>(Pattern 1, Copy 2)]	
								[==>(Pattern 1, Copy 3)]	
								[==>(Pattern 2, Copy 1)]	
								[==>(Pattern 2, Copy 2)]	
								[==>(Pattern 2, Copy 3)]	

Orbit Structure



Visit

Proposal 16009, Visit 05, completed Tue Dec 17 19:01:02 GMT 2019

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: BETWEEN 11-NOV-2019:00:00:00 AND 18-NOV-2019:00:00:00

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(2)	Pattern Type=LINE	Coordinate Frame=POS-TARG		(2)
	Purpose=DITHER	Pattern Orientation=45		
	Number Of Points=2	Angle Between Sides=		
	Point Spacing=0.8	Center Pattern=false		
	Line Spacing=			

Solar System Targets

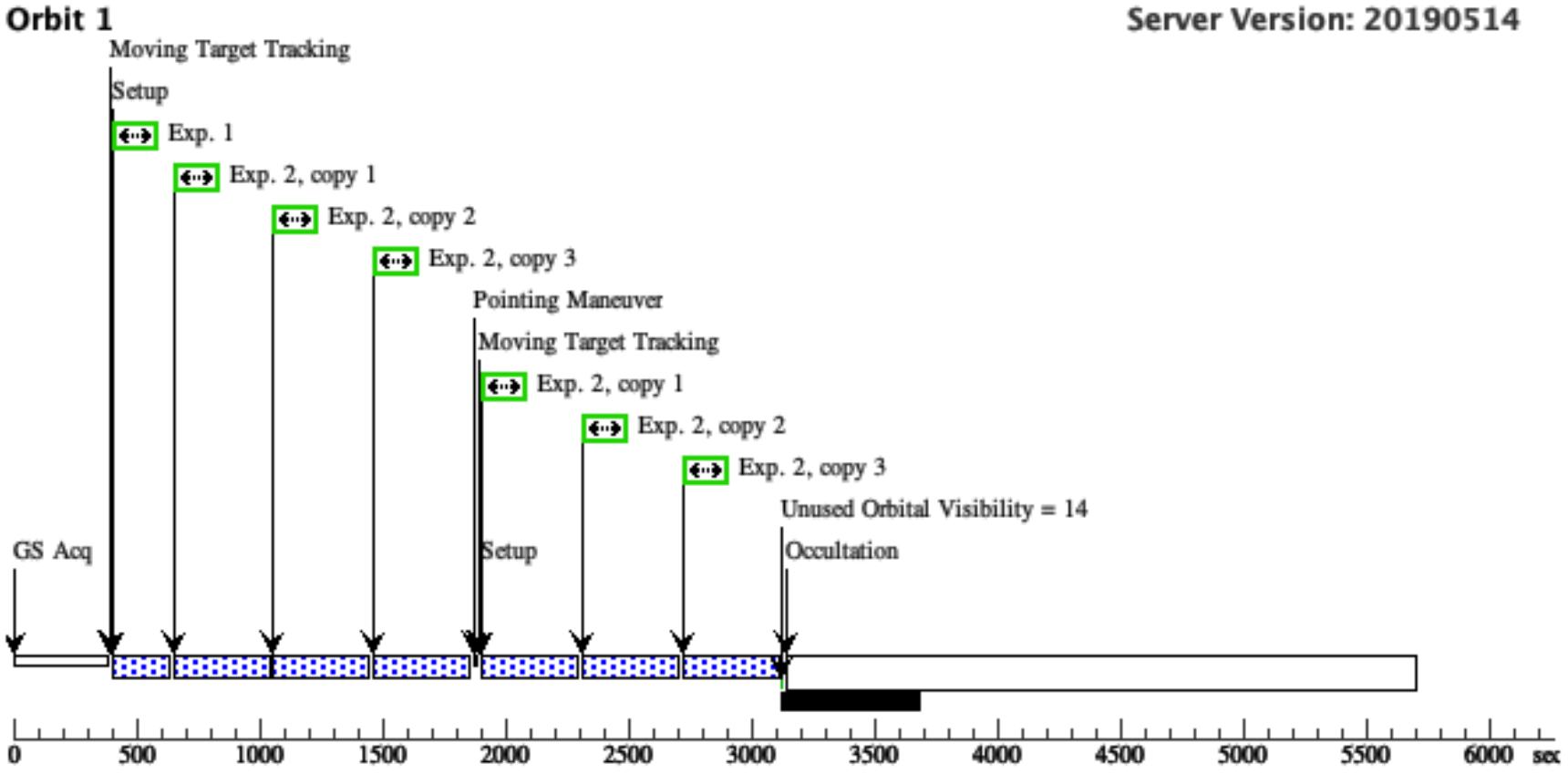
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(2)	C12019-Q4-V5	TYPE=COMET,Q=2.005818383084455,E=3.353491649120846,I=44.05785522652224,O=308.1419761457706,W=209.1427356972629,T=08-DEC-2019:13:49:13,TTimeScale=TDB,EQUINOX=J2000,EPOCH=21-SEP-2019:00:00:00,EpochTimeScale=TDB				EARTH

Comments: Description=Interstellar comet
Extended=NO

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(2) C12019-Q4-V5	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP	CR-SPLIT=NO; FLASH=9			30 Secs (30 Secs)	
								[==>]	***[1]***
2		(2) C12019-Q4-V5	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP	CR-SPLIT=NO		Pattern 2, Exps 2-2 in Visit 05 (2)	230 Secs X 3 (1380 Secs)	
								[==>(Pattern 1, Copy 1)]	***[1]***
								[==>(Pattern 1, Copy 2)]	
								[==>(Pattern 1, Copy 3)]	
								[==>(Pattern 2, Copy 1)]	
								[==>(Pattern 2, Copy 2)]	
								[==>(Pattern 2, Copy 3)]	

Orbit Structure



Visit

Proposal 16009, Visit 06, completed Tue Dec 17 19:01:02 GMT 2019

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: BETWEEN 07-DEC-2019:13:00:00 AND 09-DEC-2019:12:30:00

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(2)	Pattern Type=LINE	Coordinate Frame=POS-TARG		(2)
	Purpose=DITHER	Pattern Orientation=45		
	Number Of Points=2	Angle Between Sides=		
	Point Spacing=0.8	Center Pattern=false		
	Line Spacing=			

Solar System Targets

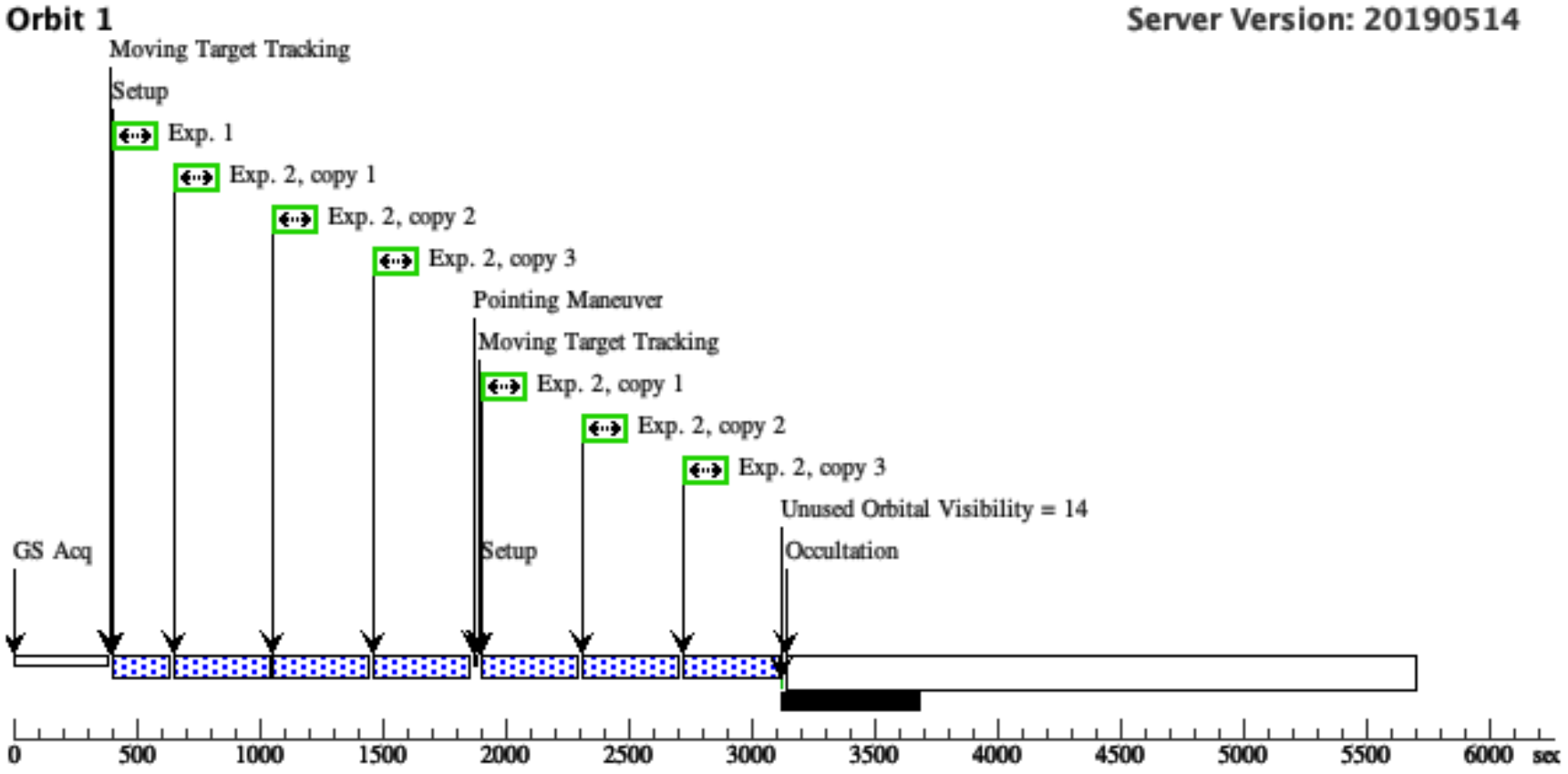
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(4)	C2019-Q4-V6	TYPE=COMET,Q=2.006657665923882,E=3.357489728570803,I=44.05175011952899,O=308.1488660165818,W=209.1176753018978,T=08-DEC-2019:13:03:06,TTimeScale=TDB,EQUINOX=J2000,EPOCH=20-DEC-2019:00:00:00,EpochTimeScale=TDB,A1=3.370896911621E-7,A2=2.360367965698E-7,A3=0.				EARTH

Comments: Description=Interstellar comet
Extended=YES

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(4) C2019-Q4-V6	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP	CR-SPLIT=NO; FLASH=9			30 Secs (30 Secs)	
								[==>]	***[1]***
2		(4) C2019-Q4-V6	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP	CR-SPLIT=NO		Pattern 2, Exps 2-2 in Visit 06 (2)	230 Secs X 3 (1380 Secs)	
								[==>(Pattern 1, Copy 1)]	***[1]***
								[==>(Pattern 1, Copy 2)]	
								[==>(Pattern 1, Copy 3)]	
								[==>(Pattern 2, Copy 1)]	
								[==>(Pattern 2, Copy 2)]	
								[==>(Pattern 2, Copy 3)]	

Orbit Structure



Visit

Proposal 16009, Visit 07, implementation Tue Dec 17 19:01:02 GMT 2019

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: BETWEEN 01-JAN-2020:00:00:00 AND 06-JAN-2020:00:00:00

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(2)	Pattern Type=LINE	Coordinate Frame=POS-TARG		(2)
	Purpose=DITHER	Pattern Orientation=45		
	Number Of Points=2	Angle Between Sides=		
	Point Spacing=0.8	Center Pattern=false		
	Line Spacing=			

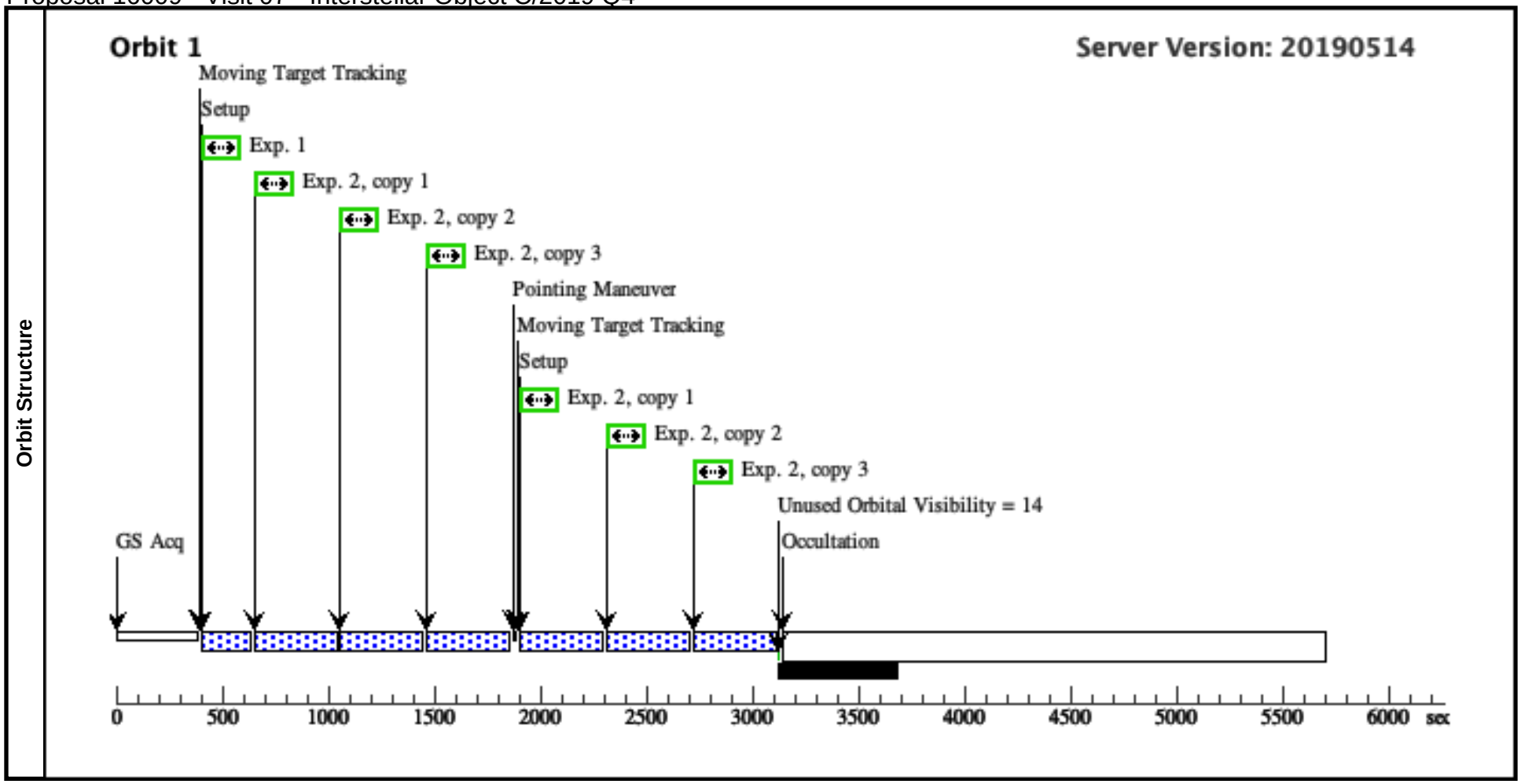
Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(5)	C2019-Q4-V7	TYPE=COMET,Q=2.006646919889602,E=3.357489316443313,I=44.05247152804048,O=308.1494484383344,W=209.1223857291233,T=08-DEC-2019:13:12:54,TTimeScale=TDB,EQUINOX=J2000,EPOCH=20-DEC-2019:00:00:00,EpochTimeScale=TDB,A1=2.001994848251E-8,A2=1.551358127594E-7,A3=-7.238847255707E-8				EARTH

Comments: Description=Interstellar comet
Extended=YES

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(5) C2019-Q4-V7	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP	CR-SPLIT=NO; FLASH=9		Sequence 1-2 Non-Int in Visit 07	30 Secs (30 Secs)	
								[==>]	***[1]***
2		(5) C2019-Q4-V7	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP	CR-SPLIT=NO		Sequence 1-2 Non-Int in Visit 07	230 Secs X 3 (1380 Secs)	
							Pattern 2, Exps 2-2 in Sequence 1-2 Non-Int in Visit 07 (2)	*[==>(Pattern 1, Copy 1)]* *[==>(Pattern 1, Copy 2)]* *[==>(Pattern 1, Copy 3)]* *[==>(Pattern 2, Copy 1)]* *[==>(Pattern 2, Copy 2)]* *[==>(Pattern 2, Copy 3)]*	***[1]***


Orbit Structure
Orbit 1
Server Version: 20190514
Moving Target Tracking
Setup
Exp. 1
Exp. 2, copy 1
Exp. 2, copy 2
Exp. 2, copy 3
Pointing Maneuver
Moving Target Tracking
Setup
Exp. 2, copy 1
Exp. 2, copy 2
Exp. 2, copy 3
Unused Orbital Visibility = 14
Occultation
GS Acq
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
sec