15405 - Which way home? Finding the origin of our Solar System's first interstellar visitor

Cycle: 25, 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) A-2017-U1	WFC3/UVIS	1	18-Dec-2017 16:02:41.0	yes
02	(1) A-2017-U1	WFC3/UVIS	1	18-Dec-2017 16:02:42.0	yes
03	(1) A-2017-U1	WFC3/UVIS	1	18-Dec-2017 16:02:43.0	yes
04	(2) A-2017-U1-UPDATED	WFC3/UVIS	1	18-Dec-2017 16:02:44.0	yes
05	(3) OUMUAMUA	WFC3/UVIS	1	18-Dec-2017 16:02:44.0	yes

5 Total Orbits Used

ABSTRACT

We request HST/WFC3/UVIS observations of A/2017 U1, a recently discovered fast moving and fast fading object that appears to originate from outside the Solar System. Rapid follow-up observations from the ground established the object's orbit as hyperbolic and thus ruled out that A/2017 U1 is a comet or asteroid. The proposed observations are critical to (a) determine the object's rotation period in order to allow observations to be performed at maximal brightness, and (b) obtain precise astrometry along an extended arc length in order to identify the region from which this object originated.

A/2017 U1 is the first known interloper from outside the Solar System, and the observations proposed here play a pivotal role in determining its origin.

OBSERVING DESCRIPTION

The proposed observation consists of two components that serve tightly related purposes: 1) Extend the astrometric arc in order to permit a refined orbit estimation that may allow us to uncover where the target originated. 2) Obtain critical light curve observations as the object is fading to provide accurate predictions of the rotational phase for our ongoing follow-up observations.

To achieve the first goal, we split our observation into three visits, distributed evenly over a 40-day period in order to maximize the observed arc of the interloper's orbit. The beginning of this period, and hence the time of the first visit, is set by the requirement to align HST's astrometric observations with those performed with groundbased facilities, which results in a date of November 22, 2017 (or within a day thereof) for the first visit. The end of the 40-day period, and hence the time of the third visit, is defined by the date at which our target is predicted to have faded to V=27.5 which we consider the limiting magnitude for a credible detection with HST in a single orbit. We expect this to occur on January 01, 2018, but stress that adjustments in our photometric model may alter this prediction by a few days. The second visit should be scheduled near the midpoint between the first and the third visit in order to provide the best possible constraints on the target's highly eccentric orbit. Again, some flexibility is required to allow adjustment as the result of improvements in our model predictions.

To achieve the second goal, we allocate three orbits to the first visit, and one orbit each to the subsequent second and third visit. The longer, first visit aims to sample the target's light curve at high precision and over a sufficiently long time to tightly constrain both amplitude and period, both of which are crucial parameters of the photometric model that underlies the predictions driving the timing of visits two and three.

All observations will be performed with WFC3/UVIS and the F350LP filter in order to maximize system throughput. Since ours is a moving target, no dithering is required. We do, however, split each orbit into 5 subexposures using CR-SPLIT in order to allow efficient removal of cosmic rays and limit the track length of GAIA reference stars in the field that form the basis of our astrometric solution. Since our target is located at high Galactic latitude, the surface density of reference stars is low; we therefore request additional flexibility to allow scheduling of all visits (within the aforementioned windows) such that the number of GAIA stars is maximized.

Visit

Proposal 15405, Epoch 1 part 1 (01), completed Mon Dec 18 21:02:45 GMT 2017

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS

Special Requirements: ORIENT 51D TO 53 D; BETWEEN 21-NOV-2017:00:00:00 AND 21-NOV-2017:06:15:00

Comments: This visit is intended to be scheduled as soon as possible without being a disruptive turn-around. Otherwise the timing is not critical but candidate times for scheduling need to be checked for stellar contamination and for having sufficient numbers of Gaia reference stars. This visit is the timing anchor for visits 2 and 3.

Diagnostics

(Exposure 1 (Pattern 1, Exps 1-1 in Sequence 1-1 Non-Int in Epoch 1 part 1 (01)) special requirements) Warning (Form): Be very careful mixing POS TARG and Center_Pattern = Yes

Patterns

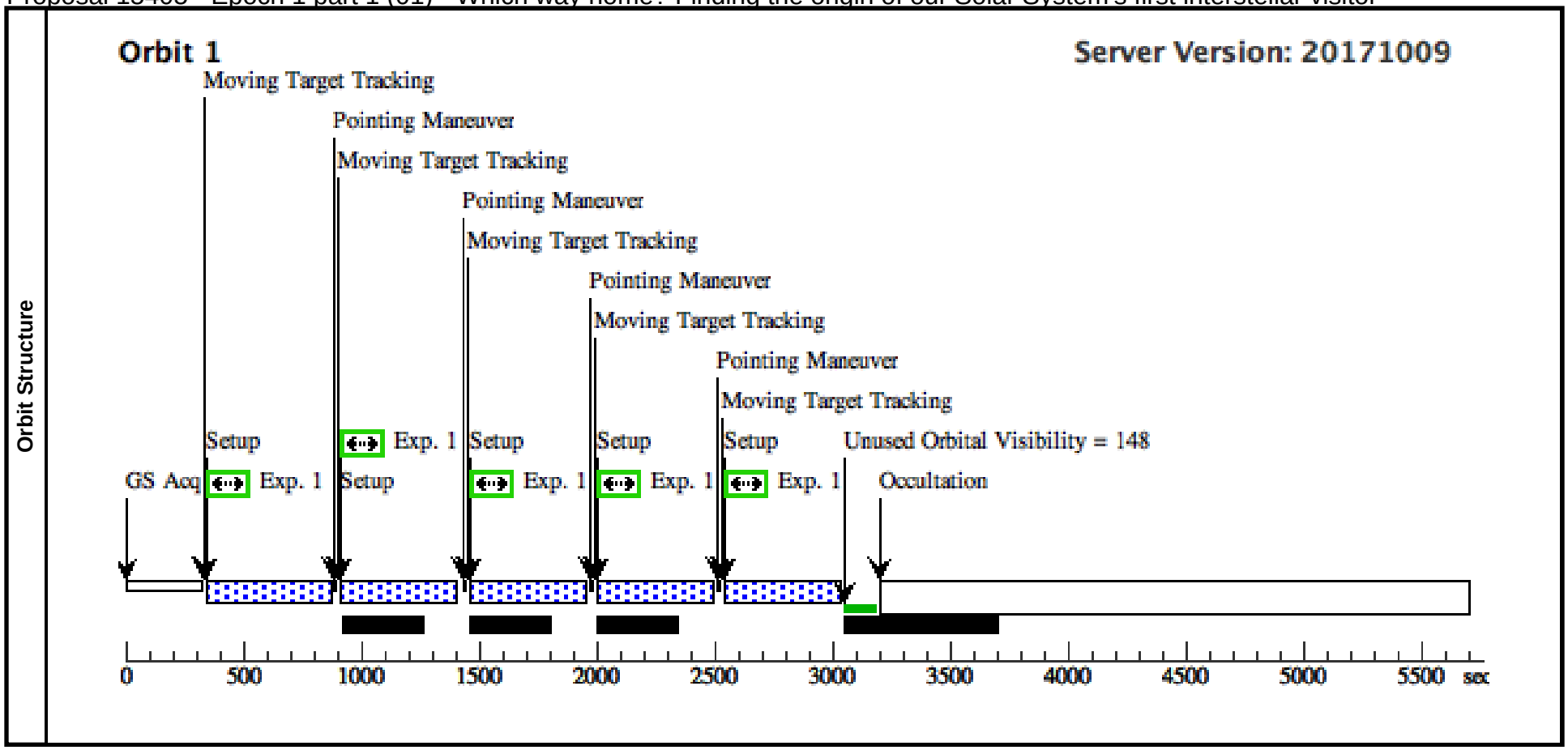
#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=LINE	Coordinate Frame=CELESTIAL		(1)
	Purpose=OTHER	Pattern Orientation=0		
	Number Of Points=5	Angle Between Sides=		
	Point Spacing=.030	Center Pattern=true		
	Line Spacing=			

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	A-2017-U1	TYPE=COMET,Q=0.2544189102683901,E=1.197091100469663,I=122.600523808621,O=24.60311659652012,W=241.5361324795846,T=09-SEP-2017:11:19:55,TTimeScale=TDB,EQUINOX=J2000,EPOCH=27-OCT-2017:00:00:00,EpochTimeScale=TDB				EARTH

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) A-2017-U1	WFC3/UVIS, ACCUM, UVIS2	F350LP		POS TARG 16.000,12.960	Sequence 1-1 Non-Int in Epoch 1 part 1 (01) Pattern 1, Exps 1-1 in Sequence 1-1 Non-Int in Epoch 1 part 1 (01) (1)	380 Secs (1900 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]*	***[1]***


Orbit Structure
Orbit 1
Server Version: 20171009
Moving Target Tracking
Pointing Maneuver
Moving Target Tracking
Pointing Maneuver
Moving Target Tracking
Pointing Maneuver
Moving Target Tracking
Pointing Maneuver
Moving Target Tracking
Setup
Exp. 1
Setup
Setup
Setup
Unused Orbital Visibility = 148
GS Acq
Exp. 1
Setup
Exp. 1
Exp. 1
Exp. 1
Occultation
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500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 15405, Epoch 1 part 2 (02), completed Mon Dec 18 21:02:46 GMT 2017

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS

Special Requirements: ORIENT 50D TO 52 D; AFTER 01 BY 0.8 Orbits TO 1.2 Orbits; BETWEEN 21-NOV-2017:00:00:00 AND 21-NOV-2017:06:15:00

Comments: This visit should be close in time to visit 1. The timing applied here is an initial guess and may need to be modified slightly as more lightcurve information becomes available. This initial request is for this visit to be consecutive to visit 1. However, it could also be consecutive with visit 3 if that works better.

Diagnostics

(Exposure 1 (Pattern 1, Exps 1-1 in Sequence 1-1 Non-Int in Epoch 1 part 2 (02)) special requirements) Warning (Form): Be very careful mixing POS TARG and Center_Pattern = Yes

Patterns

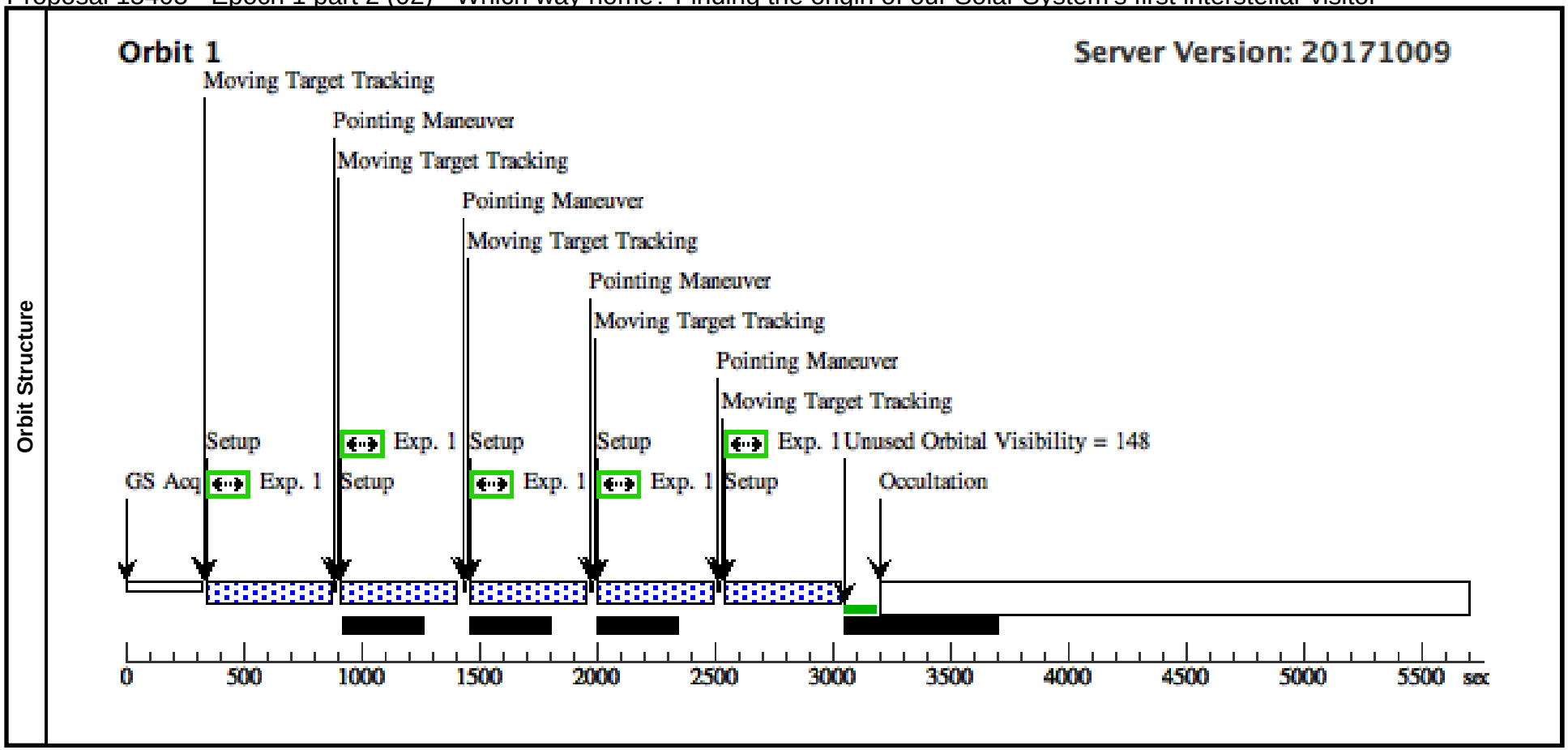
#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=LINE	Coordinate Frame=CELESTIAL		(1)
	Purpose=OTHER	Pattern Orientation=0		
	Number Of Points=5	Angle Between Sides=		
	Point Spacing=.030	Center Pattern=true		
	Line Spacing=			

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	A-2017-U1	TYPE=COMET,Q=0.2544189102683901,E=1.197091100469663,I=122.600523808621,O=24.60311659652012,W=241.5361324795846,T=09-SEP-2017:11:19:55,TTimeScale=TDB,EQUINOX=J2000,EPOCH=27-OCT-2017:00:00:00,EpochTimeScale=TDB				EARTH

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) A-2017-U1	WFC3/UVIS, ACCUM, UVIS2	F350LP		POS TARG 32,0; GS ACQ SCENARIO BASE1B3	Sequence 1-1 Non-Int in Epoch 1 part 2 (02) Pattern 1, Exps 1-1 in Sequence 1-1 Non-Int in Epoch 1 part 2 (02) (1)	380 Secs (1900 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]*	***[1]***


Orbit Structure
Orbit 1
Server Version: 20171009
Moving Target Tracking
Pointing Maneuver
Moving Target Tracking
Pointing Maneuver
Moving Target Tracking
Pointing Maneuver
Moving Target Tracking
Pointing Maneuver
Moving Target Tracking
Setup
Exp. 1
Setup
Setup
Exp. 1
Unused Orbital Visibility = 148
GS Acq
Exp. 1
Setup
Exp. 1
Exp. 1
Setup
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 15405, Epoch 1 part 3 (03), completed Mon Dec 18 21:02:46 GMT 2017

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS

Special Requirements: ORIENT 85D TO 87 D; BETWEEN 22-NOV-2017:12:00:00 AND 22-NOV-2017:13:45:00

Comments: This visit should be close in time to visit 1. The timing applied here is an initial guess and may need to be modified slightly as more lightcurve information becomes available. This initial request is based on a rotational period of 4 hours and is intended to run 5 orbits after visit 1.

Diagnostics

(Exposure 1 (Pattern 1, Exps 1-1 in Sequence 1-1 Non-Int in Epoch 1 part 3 (03)) special requirements) Warning (Form): Be very careful mixing POS TARG and Center_Pattern = Yes

Patterns

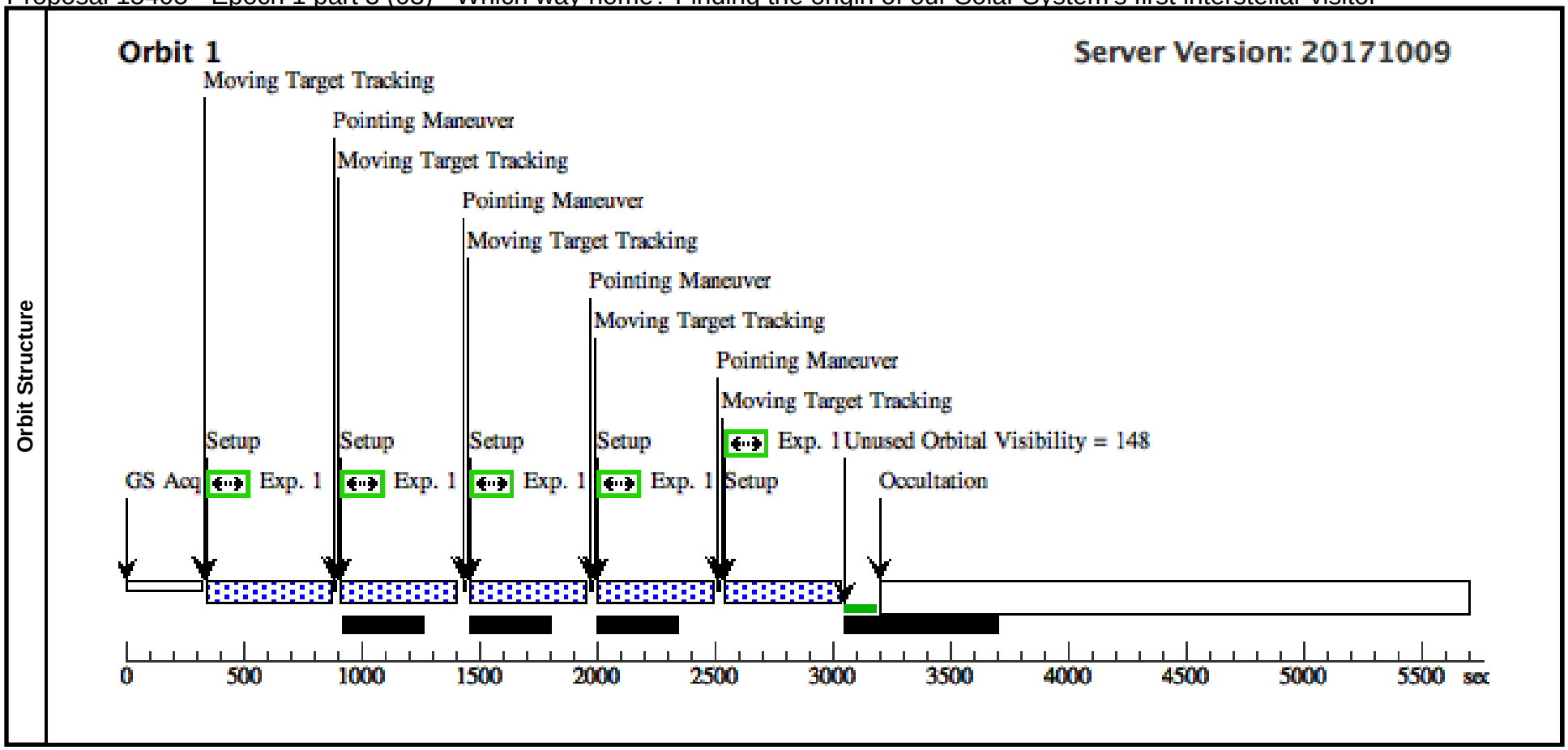
#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=LINE	Coordinate Frame=CELESTIAL		(1)
	Purpose=OTHER	Pattern Orientation=0		
	Number Of Points=5	Angle Between Sides=		
	Point Spacing=.030	Center Pattern=true		
	Line Spacing=			

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	A-2017-U1	TYPE=COMET,Q=0.2544189102683901,E=1.197091100469663,I=122.600523808621,O=24.60311659652012,W=241.5361324795846,T=09-SEP-2017:11:19:55,TTimeScale=TDB,EQUINOX=J2000,EPOCH=27-OCT-2017:00:00:00,EpochTimeScale=TDB				EARTH

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) A-2017-U1	WFC3/UVIS, ACCUM, UVIS2	F350LP		POS TARG 24.000,0.000	Sequence 1-1 Non-Int in Epoch 1 part 3 (03) Pattern 1, Exps 1-1 in Sequence 1-1 Non-Int in Epoch 1 part 3 (03) (1)	380 Secs (1900 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]*	***[1]***


Orbit Structure
Orbit 1
Server Version: 20171009
Moving Target Tracking
Pointing Maneuver
Moving Target Tracking
Pointing Maneuver
Moving Target Tracking
Pointing Maneuver
Moving Target Tracking
Pointing Maneuver
Moving Target Tracking
Setup
Setup
Setup
Setup
Exp. 1
Unused Orbital Visibility = 148
GS Acq
Exp. 1
Exp. 1
Exp. 1
Exp. 1
Setup
Occultation
0
500
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sec

Visit

Proposal 15405, Epoch 2 (04), completed Mon Dec 18 21:02:46 GMT 2017

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: BETWEEN 11-DEC-2017:00:00:00 AND 13-DEC-2017:00:00:00

Comments: This timing for this visit is roughly half way between visit 1 and 5. The only thing critical about the timing is to get this data for rotational phase refinements to support scheduling the last visit. There is more latitude in the timing than indicated if there is a problem with this request.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=LINE	Coordinate Frame=CELESTIAL		(1)
	Purpose=OTHER	Pattern Orientation=0		
	Number Of Points=5	Angle Between Sides=		
	Point Spacing=.030	Center Pattern=true		
	Line Spacing=			

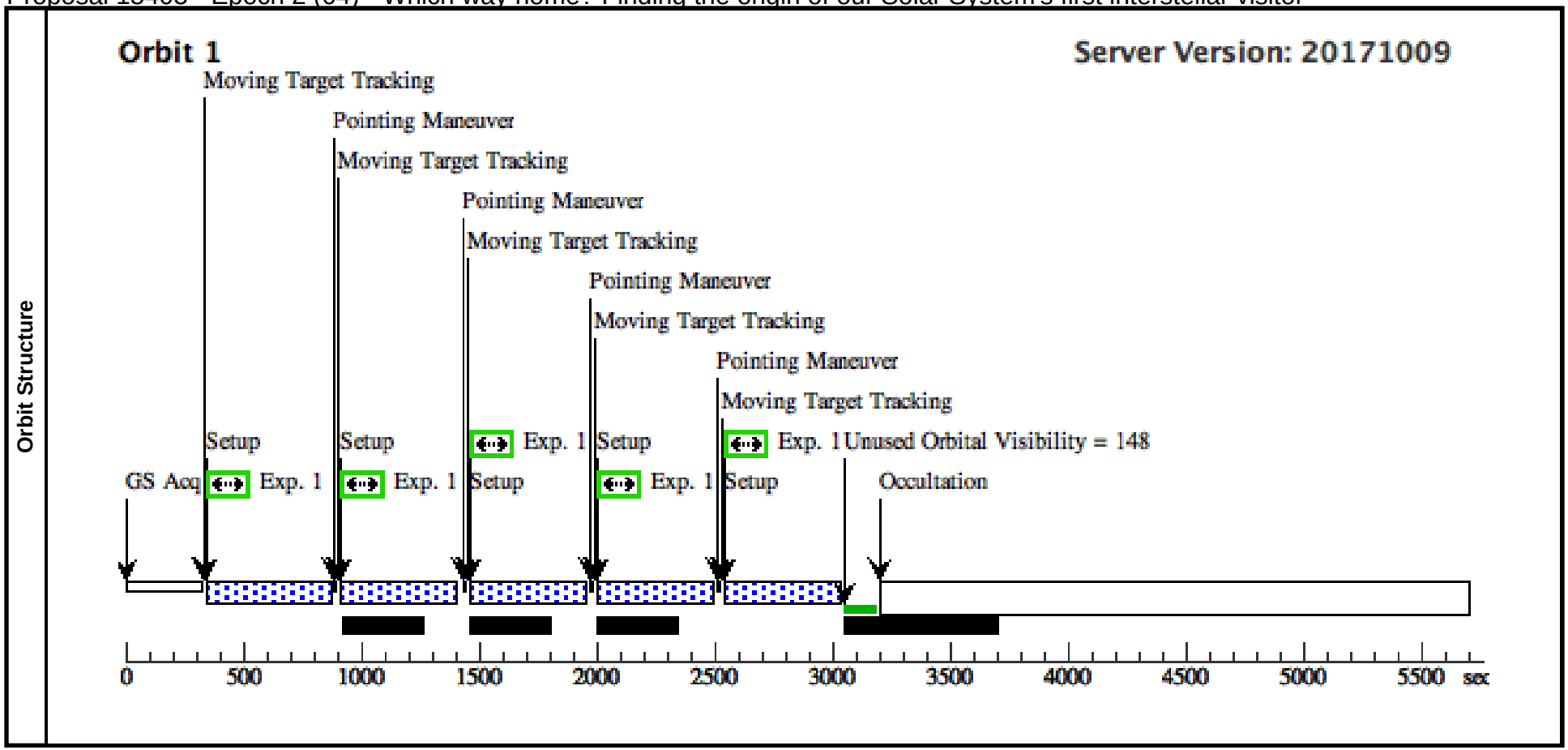
Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(2)	A-2017-U1-UPDATED	TYPE=COMET,Q=0.2553352156734523,E=1.1994907679102,I=122.6864296097109,O=24.59924632942247,W=241.7015187109427,T=09-SEP-2017:11:46:05,TTimeScale=TDB,EQUINOX=J2000,EPOCH=31-OCT-2017:00:00:00,EpochTimeScale=TDB				EARTH

Comments: orbital elements update from JPL on Nov. 29

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(2) A-2017-U1-UPDATED	WFC3/UVIS, ACCUM, UVIS2	F350LP			Sequence 1-1 Non-Int in Epoch 2 (04) Pattern 1, Exps 1-1 in Sequence 1-1 Non-Int in Epoch 2 (04) (1)	380 Secs (1900 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]*	***[1]***


Orbit Structure
Orbit 1
Server Version: 20171009
Moving Target Tracking
Pointing Maneuver
Moving Target Tracking
Pointing Maneuver
Moving Target Tracking
Pointing Maneuver
Moving Target Tracking
Pointing Maneuver
Moving Target Tracking
Setup
Setup
Exp. 1
Setup
Exp. 1
Unused Orbital Visibility = 148
GS Acq
Exp. 1
Exp. 1
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Exp. 1
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Occultation
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Visit

Proposal 15405, Epoch 3 (05), implementation Mon Dec 18 21:02:46 GMT 2017

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS

Special Requirements: BETWEEN 01-JAN-2018:00:00:00 AND 03-JAN-2018:00:00:00

Comments: This timing for this visit is set when we anticipate the target will reach V=27.5 at maximum light.
The final scheduling for this will depend on updates provided by the other visits.

Diagnostics

(Exposure 1 (Pattern 1, Exps 1-1 in Sequence 1-1 Non-Int in Epoch 3 (05)) special requirements) Warning (Form): Be very careful mixing POS TARG and Center_Pattern = Yes

Patterns

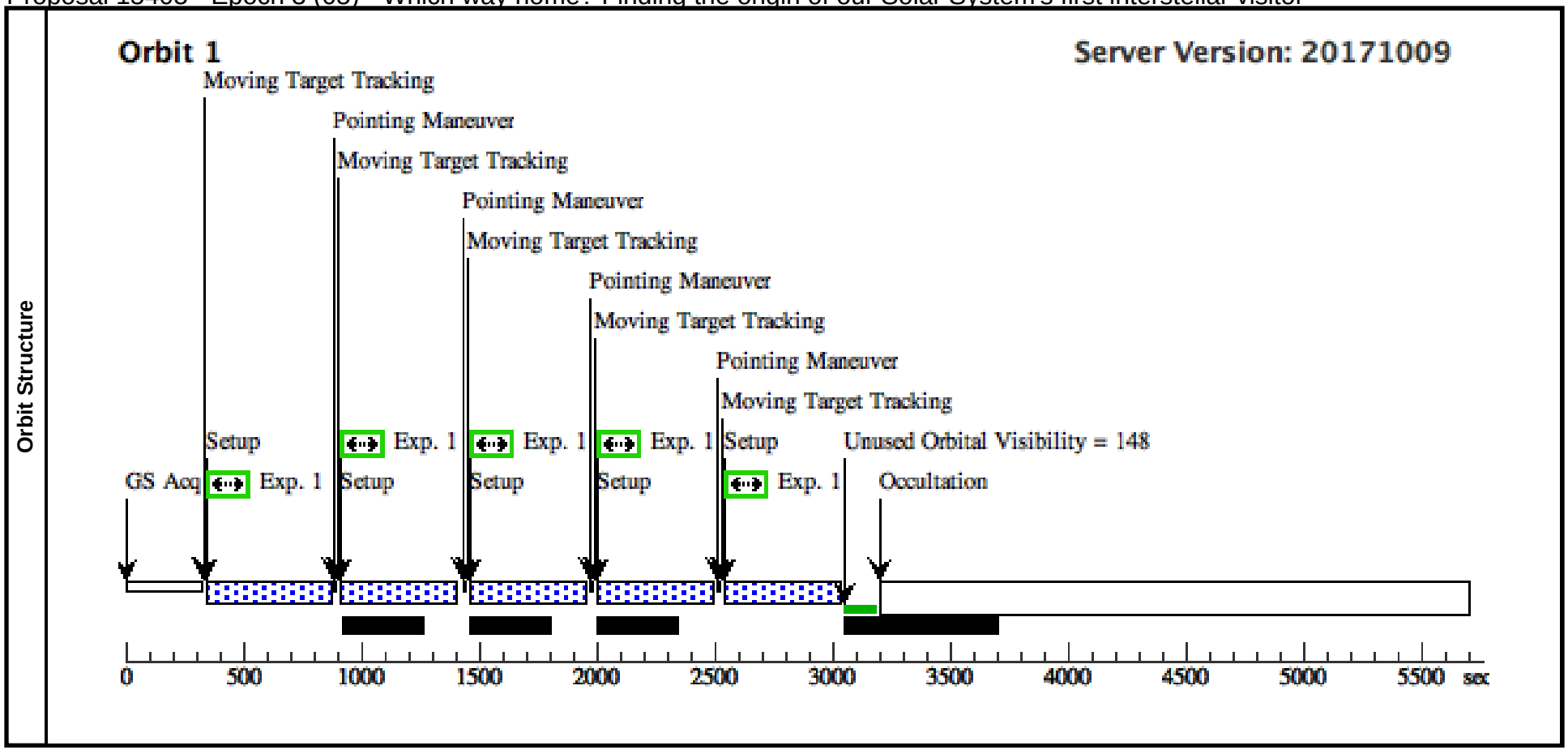
#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=LINE	Coordinate Frame=CELESTIAL		(1)
	Purpose=OTHER	Pattern Orientation=0		
	Number Of Points=5	Angle Between Sides=		
	Point Spacing=.030	Center Pattern=true		
	Line Spacing=			

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(3)	OUMUAMUA	TYPE=COMET,Q=0.2558123336343649,E=1.200914723821507,I=122.7325277932375,O=24.59699783461255,W=241.7946554840634,T=09-SEP-2017:12:12:09,TTimeScale=TDB,EQUINOX=J2000,EPOCH=01-JAN-2018:00:00:00,EpochTimeScale=TDB				EARTH

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(3) OUMUAMUA	WFC3/UVIS, ACCUM, UVIS2	F350LP		POS TARG 32.0,-6.8	Sequence 1-1 Non-Int in Epoch 3 (05) Pattern 1, Exps 1-1 in Sequence 1-1 Non-Int in Epoch 3 (05) (1)	380 Secs (1900 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]*	***[1]***


Orbit Structure
Orbit 1
Server Version: 20171009
Moving Target Tracking
Pointing Maneuver
Moving Target Tracking
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Pointing Maneuver
Moving Target Tracking
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Moving Target Tracking
Setup
Exp. 1
Exp. 1
Exp. 1
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Unused Orbital Visibility = 148
GS Acq
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Exp. 1
Occultation
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