15343 - Phaethon Near Earth

Cycle: 25, Proposal Category: GO

(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) PHAETHON	S/C WFC3/UVIS	1	13-Nov-2017 18:00:25.0	yes
02	(1) PHAETHON	S/C WFC3/UVIS	1	13-Nov-2017 18:00:27.0	yes
03	(1) PHAETHON	S/C WFC3/UVIS	1	13-Nov-2017 18:00:29.0	yes

3 Total Orbits Used

ABSTRACT

Planet-crossing asteroid (3200) Phaethon, source of the Geminid meteoroid stream, will pass close to Earth in December 2017. Observations with HST are proposed to image debris ejected from this object at 1 AU heliocentric distance, to estimate the ejection velocities as the Earth passes through the orbit plane, and to estimate the dust production rate for comparison with the rates needed to sustain the Geminid stream in steady-state.

These measurements will help determine the mechanism behind the ejection of the Geminids, a long-standing puzzle. While the release of micron-sized particles (probably by thermal fracture) has been recorded at Phaethon's perihelion (0.14 AU), mass loss has never been detected otherwise, raising the puzzle of the ejection mechanism and duration. The close approach (0.07 AU) on December 17 gives a once-in-a-lifetime opportunity to observe Phaethon at high sensitivity with a resolution of a few kilometers.

OBSERVING DESCRIPTION

We propose a sequence of imaging observations with WFC3 based on similar satellite-search observations of 1 Ceres (deMario et al. 2016), 4 Vesta (McFadden et al. 2012) and Pluto (e.g. Weaver et al. 2006). Phaethon will have V = 11.5 at closest approach on UT December 17. We will take short, unsaturated exposures to probe the near-nucleus environment along with long integrations in which the nucleus is allowed to saturate in order to obtain sensitivity at larger projected distances. The 2 km pixels of WFC3 (when at the minimum distance, (0.07 AU) will give marginal resolution of the 5 km diameter nucleus, although this is not a primary objective of our proposal, since the nucleus itself is already well-characterized. More usefully, we will have sufficient resolution to detect satellites to the edge of the Hill sphere of Phaethon (radius rH = 65 km, at perihelion). Scaling from deMario et al. (2016) we expect a limiting magnitude Vlim = 24 in 4s integrations in the 50 to 100 pixel (200 to 400) radius range, corresponding to object radii 8 m (at the same albedo as Phaethon). Deeper, stacked integrations will reach Vlim = 28.4 at radii > 400, corresponding to object radii 1 m. We will employ the F350LP broadband filter (a cut-off filter, with effective wavelength 6230A and full width at half maximum 4760A, when imaging a sun-like spectrum) because it conveys maximum sensitivity to faint sources. What is the relation between trail photometry and the mass production rate from Phaethon? The most useful metric for a linear structure is the flux density (or magnitude) per arcsecond along the trail. We convert from photometry to scattering cross-section in the usual way, assuming an albedo (0.05) for the trail particles (Agarwal et al. 2010). In this way, we can connect the photometry (per unit length of trail) to the cross-section in the same length, C, to the mass production rate. Thus we can easily detect or place valuable limits to the mass loss given observations near closest approach. The trail brightness at more usual geocentric distances 1 AU is fainter by a factor 200, or nearly 6 magnitudes. Suppression of the background is key to these observations. As with Ceres and Vesta, both about 3.5 magnitudes brighter than Phaethon, this is to be achieved by azimuthal difference imaging (ADI). This uses observations taken at different position angles in order to vary the relative locations of obscuring artifacts such as diffraction spikes, window and filter ghosts, PSF wings, and saturation/bleeding. This strategy was employed for similar Ceres observations in HST program 13503, designed by Co-I Mutchler. For this purpose, we request observations on 3 consecutive orbits, with one position angle per orbit. For the deeper full-frame images, we will place our target at the UVIS-CENTER aperture location (slightly oset from the chip gap). We will align the chip gap to be approximately perpendicular to the direction of the projected orbit of Phaethon and then rotate the position angle to achieve the background suppression. A typical sequence will consist of 180s x 3, 30s x 3 (both full frame) and 4s x 6 (partial frame, to gain readout speed) integrations. For our shortest subarray exposures, we will

utilize post-flash and enforce the use of shutter blade A for greatest sensitivity and stability. We will combine images to remove cosmic rays and suppress noise and the larger obscuring artifacts mentioned above. The ADI subtraction technique requires three or more different role position angles, and these must necessarily be obtained one per orbit. Therefore, we request three orbits for this measurement. In view of the spectacular successes demonstrated with direct WFC3 imaging of Ceres, Vesta and Pluto and the unique, time-critical nature of the Phaethon fly-by, we elected to employ the tested method. The observations should be scheduled as close as is possible to plane-crossing of Phaethon, which occurs on UT 2017 December 17d 05h 44m. Geocentric distance (0.0691 AU), is also a minimum at this time. Plane-crossing gives us maximum sensitivity to extended dust structures because of projection along the line of sight, and also enables a measurement of the perpendicular extent (and ejection velocity) that is not possible otherwise. The plane angle changes by approximately 0.25 degrees per hour around plane crossing, so observations within 2 hours of plane crossing will keep the plane angles < 0.5 degrees. The geocentric distance is constant at the sub-percent level over this interval and is not an important consideration for the scheduling.

Proposal 15343 - Visit 01 - Phaethon Near Earth

Visit

Proposal 15343, Visit 01, implementation Mon Nov 13 23:00:30 GMT 2017

Diagnostic Status: Error

Scientific Instruments: WFC3/UVIS, S/C

Special Requirements: ORIENT 52D TO 52 D; BETWEEN 17-DEC-2017:02:00:00 AND 17-DEC-2017:11:15:00; SEQ 01,02,03 WITHIN 3 Orbits

Diagnostics

(Exposure 1 (Sequence 1-6 Non-Int in Visit 01)) Error (Form): Illegal selection: S/C.

(Exposure 1 (Sequence 1-6 Non-Int in Visit 01)) Error (Form): POINTING is not a valid selection.

(Exposure 1 (Sequence 1-6 Non-Int in Visit 01)) Error (Form): This attribute is not allowed to have this value: Aperture = V1
It is an Available option and cannot normally be used in a GO proposal.

(Exposure 1 (Sequence 1-6 Non-Int in Visit 01)) Error (Form): This attribute is not allowed to have this value: Config = S/C
It is an Available option and cannot normally be used in a GO proposal.

(Exposure 1 (Sequence 1-6 Non-Int in Visit 01)) Error (Form): This attribute is not allowed to have this value: Mode = POINTING
It is an Available option and cannot normally be used in a GO proposal.

(Exposure 1 (Sequence 1-6 Non-Int in Visit 01)) Error (Form): V1 is not a valid selection.

(Exposure 1 (Sequence 1-6 Non-Int in Visit 01) special requirements) Error (Form): Special Requirement SAA CONTOUR is not allowed for this exposure.

(Exposure 5 (Sequence 1-6 Non-Int in Visit 01)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser

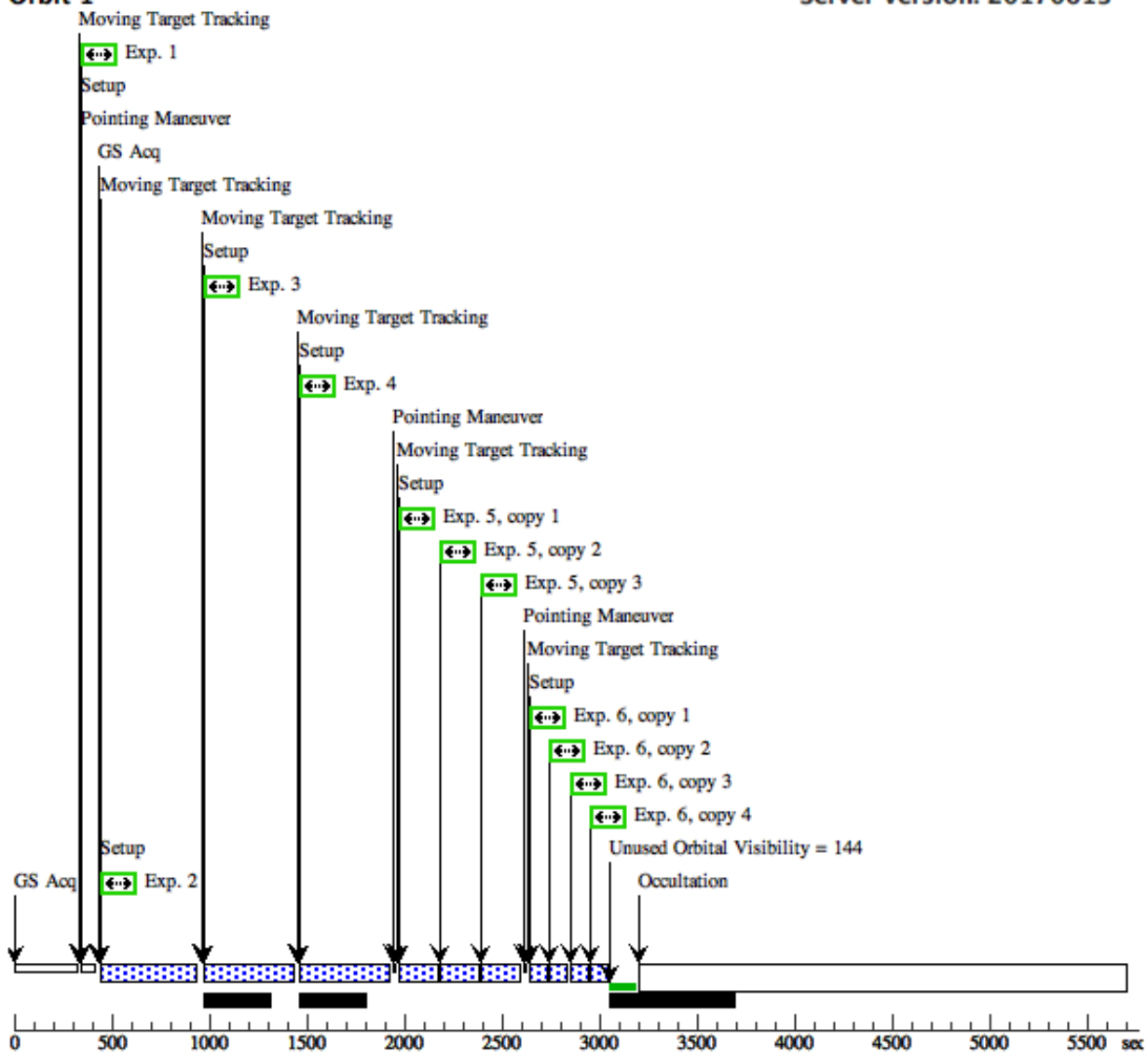
Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	PHAETHON	TYPE=ASTEROID,A=1.27112887628073,E=0.8899326468811029,I=22.1844138570854,O=265.3899157874748,W=322.0167282759962,M=220.5660987379586,EQUINOX=J2000,EPOCH=07-MAY-2010:00:00:00,EpochTimeScale=TDB				HUBBLE

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) PHAETHON	S/C, POINTING, V1			POS TARG -0.2727, -5.4941; SAA CONTOUR 29; GSPAIR NBIN0002 89F1NBIN000367F2 ; GS ACQ SCENARIO BASE1B3	Sequence 1-6 Non-Int in Visit 01	1 Secs (1 Secs) *[==>]*	***[1]***
2		(1) PHAETHON	WFC3/UVIS, ACCUM, UVIS-CENTER	F350LP		POS TARG 0,-1; NEW OBSET; EXP PCS MODE GYRO	Sequence 1-6 Non-Int in Visit 01	348 Secs (348 Secs) *[==>]*	***[1]***
3		(1) PHAETHON	WFC3/UVIS, ACCUM, UVIS-CENTER	F350LP		POS TARG 0,-1; NEW ALIGNMENT ; EXP PCS MODE GYRO	Sequence 1-6 Non-Int in Visit 01	348 Secs (348 Secs) *[==>]*	***[1]***
4		(1) PHAETHON	WFC3/UVIS, ACCUM, UVIS-CENTER	F350LP		POS TARG 0,-1; NEW ALIGNMENT ; EXP PCS MODE GYRO	Sequence 1-6 Non-Int in Visit 01	348 Secs (348 Secs) *[==>]*	***[1]***
5		(1) PHAETHON	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		NEW ALIGNMENT ; EXP PCS MODE GYRO	Sequence 1-6 Non-Int in Visit 01	30 Secs X 3 (90 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]*	***[1]***
6		(1) PHAETHON	WFC3/UVIS, ACCUM, UVIS2-M1K1C-SUB	F350LP	FLASH=12	NEW ALIGNMENT ; EXP PCS MODE GYRO	Sequence 1-6 Non-Int in Visit 01	4 Secs X 4 (16 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]*	***[1]***

Orbit Structure



Proposal 15343 - Visit 02 - Phaethon Near Earth

Visit

Proposal 15343, Visit 02, implementation Mon Nov 13 23:00:31 GMT 2017

Diagnostic Status: Error

Scientific Instruments: WFC3/UVIS, S/C

Special Requirements: ORIENT 20D TO 25D FROM 01; BETWEEN 17-DEC-2017:02:00:00 AND 17-DEC-2017:11:15:00

Diagnostics

(Exposure 1 (Sequence 1-6 Non-Int in Visit 02)) Error (Form): Illegal selection: S/C.

(Exposure 1 (Sequence 1-6 Non-Int in Visit 02)) Error (Form): POINTING is not a valid selection.

(Exposure 1 (Sequence 1-6 Non-Int in Visit 02)) Error (Form): This attribute is not allowed to have this value: Aperture = V1
It is an Available option and cannot normally be used in a GO proposal.

(Exposure 1 (Sequence 1-6 Non-Int in Visit 02)) Error (Form): This attribute is not allowed to have this value: Config = S/C
It is an Available option and cannot normally be used in a GO proposal.

(Exposure 1 (Sequence 1-6 Non-Int in Visit 02)) Error (Form): This attribute is not allowed to have this value: Mode = POINTING
It is an Available option and cannot normally be used in a GO proposal.

(Exposure 1 (Sequence 1-6 Non-Int in Visit 02)) Error (Form): V1 is not a valid selection.

(Exposure 1 (Sequence 1-6 Non-Int in Visit 02) special requirements) Error (Form): Special Requirement SAA CONTOUR is not allowed for this exposure.

(Exposure 5 (Sequence 1-6 Non-Int in Visit 02)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser

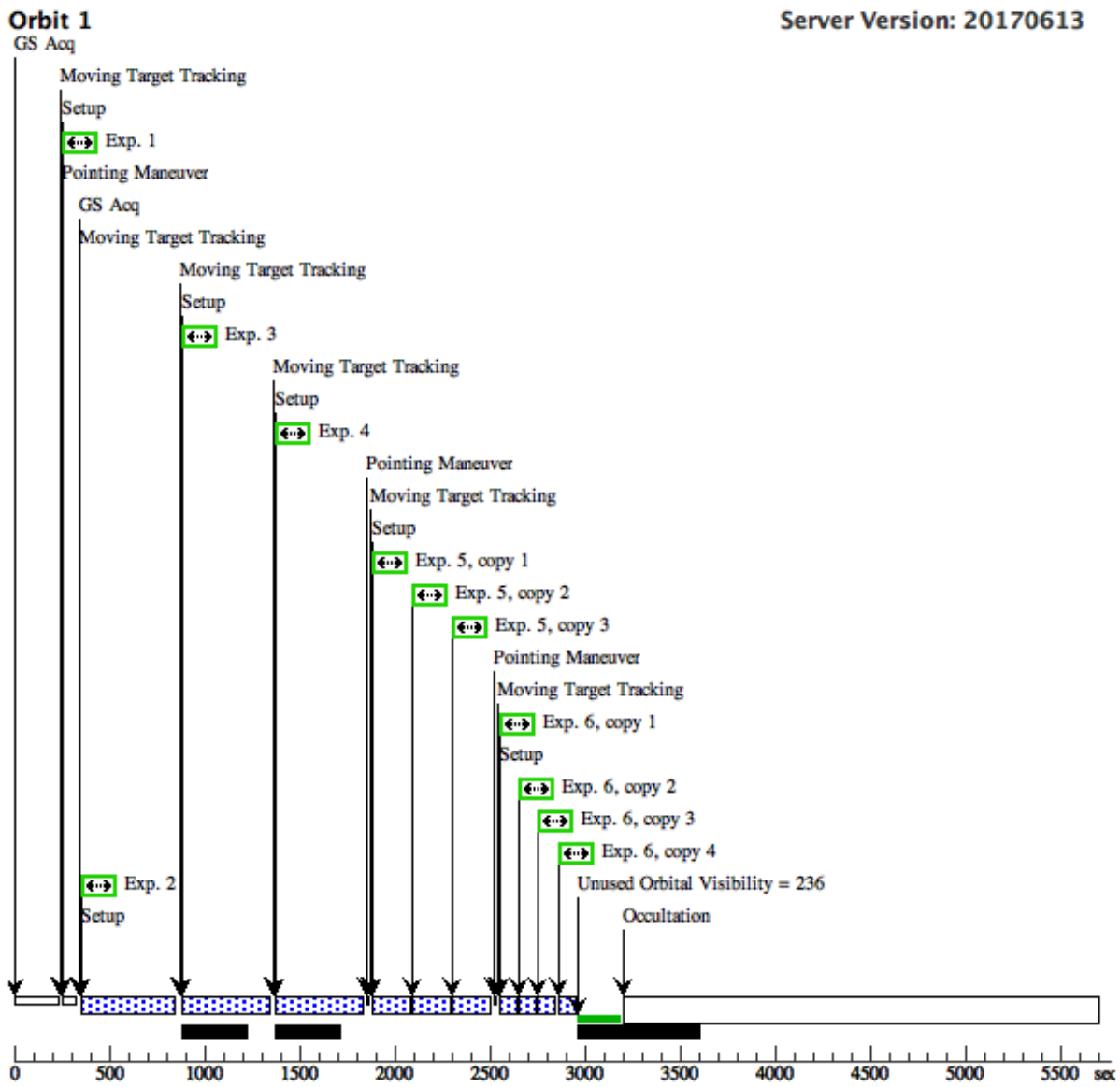
Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	PHAETHON	TYPE=ASTEROID,A=1.27112887628073,E=0.8899326468811029,I=22.1844138570854,O=265.3899157874748,W=322.0167282759962,M=220.5660987379586,EQUINOX=J2000,EPOCH=07-MAY-2010:00:00:00,EpochTimeScale=TDB				HUBBLE

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) PHAETHON	S/C, POINTING, V1			POS TARG -0.2727, -5.4941; SAA CONTOUR 29; GSPAIR NBI900003 1F10000000000F0; GS ACQ SCENARIO ONEB1B3	Sequence 1-6 Non-Int in Visit 02	1 Secs (1 Secs) *[==>]*	***[1]***
2		(1) PHAETHON	WFC3/UVIS, ACCUM, UVIS-CENTER	F350LP		POS TARG 0,3; NEW OBSET; EXP PCS MODE GYRO	Sequence 1-6 Non-Int in Visit 02	348 Secs (348 Secs) *[==>]*	***[1]***
3		(1) PHAETHON	WFC3/UVIS, ACCUM, UVIS-CENTER	F350LP		POS TARG 0,3; NEW ALIGNMENT; EXP PCS MODE GYRO	Sequence 1-6 Non-Int in Visit 02	348 Secs (348 Secs) *[==>]*	***[1]***
4		(1) PHAETHON	WFC3/UVIS, ACCUM, UVIS-CENTER	F350LP		POS TARG 0,3; NEW ALIGNMENT; EXP PCS MODE GYRO	Sequence 1-6 Non-Int in Visit 02	348 Secs (348 Secs) *[==>]*	***[1]***
5		(1) PHAETHON	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		NEW ALIGNMENT; EXP PCS MODE GYRO	Sequence 1-6 Non-Int in Visit 02	30 Secs X 3 (90 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]*	***[1]***
6		(1) PHAETHON	WFC3/UVIS, ACCUM, UVIS2-M1K1C-SUB	F350LP	FLASH=12	NEW ALIGNMENT; EXP PCS MODE GYRO	Sequence 1-6 Non-Int in Visit 02	4 Secs X 4 (16 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]*	***[1]***

Orbit Structure



Visit

Proposal 15343, Visit 03, implementation Mon Nov 13 23:00:31 GMT 2017

Diagnostic Status: Error

Scientific Instruments: WFC3/UVIS, S/C

Special Requirements: ORIENT 40D TO 45D FROM 01; BETWEEN 17-DEC-2017:02:00:00 AND 17-DEC-2017:11:15:00

Diagnostics

(Exposure 1 (Sequence 1-6 Non-Int in Visit 03)) Error (Form): Illegal selection: S/C.

(Exposure 1 (Sequence 1-6 Non-Int in Visit 03)) Error (Form): POINTING is not a valid selection.

(Exposure 1 (Sequence 1-6 Non-Int in Visit 03)) Error (Form): This attribute is not allowed to have this value: Aperture = V1
It is an Available option and cannot normally be used in a GO proposal.

(Exposure 1 (Sequence 1-6 Non-Int in Visit 03)) Error (Form): This attribute is not allowed to have this value: Config = S/C
It is an Available option and cannot normally be used in a GO proposal.

(Exposure 1 (Sequence 1-6 Non-Int in Visit 03)) Error (Form): This attribute is not allowed to have this value: Mode = POINTING
It is an Available option and cannot normally be used in a GO proposal.

(Exposure 1 (Sequence 1-6 Non-Int in Visit 03)) Error (Form): V1 is not a valid selection.

(Exposure 1 (Sequence 1-6 Non-Int in Visit 03) special requirements) Error (Form): Special Requirement SAA CONTOUR is not allowed for this exposure.

(Exposure 5 (Sequence 1-6 Non-Int in Visit 03)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	PHAETHON	TYPE=ASTEROID,A=1.27112887628073,E=0.8899326468811029,I=22.1844138570854,O=265.3899157874748,W=322.0167282759962,M=220.5660987379586,EQUINOX=J2000,EPOCH=07-MAY-2010:00:00:00,EpochTimeScale=TDB				HUBBLE

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) PHAETHON	S/C, POINTING, V1			POS TARG -0.2727, -5.4941; SAA CONTOUR 29; GSPAIR NBI8000275F20000000000F0; GS ACQ SCENARIO ONEB1B3	Sequence 1-6 Non-Int in Visit 03	1 Secs (1 Secs) *[==>]*	***[1]***
2		(1) PHAETHON	WFC3/UVIS, ACCUM, UVIS-CENTER	F350LP		POS TARG 0,-1; NEW OBSET; EXP PCS MODE GYRO	Sequence 1-6 Non-Int in Visit 03	348 Secs (348 Secs) *[==>]*	***[1]***
3		(1) PHAETHON	WFC3/UVIS, ACCUM, UVIS-CENTER	F350LP		POS TARG 0,-1; NEW ALIGNMENT; EXP PCS MODE GYRO	Sequence 1-6 Non-Int in Visit 03	348 Secs (348 Secs) *[==>]*	***[1]***
4		(1) PHAETHON	WFC3/UVIS, ACCUM, UVIS-CENTER	F350LP		POS TARG 0,-1; NEW ALIGNMENT; EXP PCS MODE GYRO	Sequence 1-6 Non-Int in Visit 03	348 Secs (348 Secs) *[==>]*	***[1]***
5		(1) PHAETHON	WFC3/UVIS, ACCUM, UVIS2-2K2C-SUB	F350LP		NEW ALIGNMENT; EXP PCS MODE GYRO	Sequence 1-6 Non-Int in Visit 03	30 Secs X 3 (90 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]*	***[1]***
6		(1) PHAETHON	WFC3/UVIS, ACCUM, UVIS2-M1K1C-SUB	F350LP	FLASH=12	NEW ALIGNMENT; EXP PCS MODE GYRO	Sequence 1-6 Non-Int in Visit 03	4 Secs X 4 (16 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]*	***[1]***

Orbit Structure