12725 - A Deep Search for Satellites in the Pluto System: Providing Critical, Safety-of-Flight Support to NASA's New Horizons Mission

Cycle: 18, 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) PLUTO	WFC3/UVIS	1	01-Sep-2011 21:30:09.0	yes
02	(1) PLUTO	WFC3/UVIS	1	01-Sep-2011 21:30:18.0	yes
04	(1) PLUTO	WFC3/UVIS	1	01-Sep-2011 21:30:26.0	yes
05	(1) PLUTO	WFC3/UVIS	1	01-Sep-2011 21:30:33.0	yes

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
07	(1) PLUTO	WFC3/UVIS	1	01-Sep-2011 21:30:39.0	yes
08	(1) PLUTO	WFC3/UVIS	1	01-Sep-2011 21:30:47.0	yes

6 Total Orbits Used

ABSTRACT

We propose a simple, 9-orbit (3 orbits at each of 3 epochs) DD program with two objectives: (1) as a safety-of-flight issue, perform a deep search (V=25-26) for satellites in the 0.9 arcsec radius region between Pluto and Charon where NASA's New Horizons mission will fly, and (2) confirm or reject the candidate P5 and P6 satellites seen in recent HST imaging, while performing an even deeper search (V=27) for satellites in the region between Charon and Hydra so observations of them can be planned before the New Horizons mission planning is frozen prior to the on-spacecraft rehearsal. Hubble is uniquely qualified to achieve these time-critical objectives, which we hope to achieve before the Pluto system enters the Hubble solar exclusion zone in early November.

OBSERVING DESCRIPTION

Our program has two principal measurement objectives: (1) search for faint satellites within ~0.4" of Pluto, which defines the outer edge of one of the orbital stability zones, and (2) search for even fainter satellites farther out, particularly in the regions near P5 and P6.

Unfortunately, these different objectives require different observing strategies.
We must take many (32) relatively short exposures (30s) to search for satellites within Charon’s orbit, going deep but preventing saturation in the region of interest. To achieve maximum sensitivity for the deep search outside Charon’s orbit, we use longer exposures (175s) and take fewer images (12) to minimize overhead.

After running multiple sensitivity calculations with the WFC3 ETC (see below) and determining how best to pack the images into a Hubble orbit using APT, we have selected the following 3-orbit plan for each epoch of observations (all images employ the WFC3 with the F350LP filter; the measurement objectives are given in parentheses):

Orbit #1:
-Take one 3s image (providing unsaturated images of Pluto and Charon for astrometry)
-Take 16 x 30s images (deep search for faint satellites within Charon's orbit)
-Take 16 x 30s images at a dithered location (5 pixels offset in both x and y)

Orbit #2:
-Take one 3s image (providing unsaturated images of Pluto and Charon for astrometry)
-Take 6 x 175s images (deep search for faint satellites outside of Charon's orbit)
-Take 6 x 175s images at a dithered location (5 pixels offset in both x and y)

Orbit #3:
-Repeat of Orbit #2 (enable detection of apparent motion for satellites seen in orbit #2)

The above sequence of 3 consecutive orbits will be repeated at one additional epoch, for a total of 2 epochs and 6 orbits.

Note that our observations are in the background noise limited regime.
Scattered and diffracted light from Pluto and Charon dwarf all other background sources.
P4 should be detectable in many of the individual 175s images (it was detected in 37 of the 48 images taken during cycle 17 [GO-11556] using F350LP with 180s exposure times), which is a nice feature to have. Using two consecutive orbits allows us to detect the relative motions of satellites located between the orbits of Charon and Hydra, which provides a powerful tool for distinguishing between artifacts and real objects in orbit around Pluto. Using 30s exposures allows us to probe the dynamically stable region within ~0.4" of Pluto.

The throughput of the F350LP filter is ~1.6x larger than that of the F606W filter, which was used during our previous 2011 observations.

This sensitivity improvement is critical as P5 and P6 are extremely faint (V26.7) and are embedded in bright, scattered light from Pluto and Charon (V=14 and 16, respectively). The intensity of the scattered light level is well determined from our previous Hubble observations, and we have used these numbers in the WFC3 ETC to calculate the sensitivity of our planned observations.
The zodiacal light in the ETC is scaled by a factor of 11 to simulate the scattered light level at Nix's distance from Pluto.
A scaling factor of 170 is used to simulate the scattered light level at ~0.4" from Pluto, which defines the outer edge of the innermost orbital stability zone. Despite these high background light levels, the ETC shows SNR=9.2 for V=26.7 for a single orbit of observations at Nix's distance from Pluto (using a 3 pixel radius aperture; WFC3 ETC ID 231401) when using the 175s exposures.
We find SNR=3.2 is achieved for V=26.0 in a single orbit of observations at ~0.4" from Pluto (WFC3 ETC ID 233059) when using the 30s exposures.
Given the large Pluto-relative motions of objects located within Charon's orbit, we may have to employ sophisticated shift-and-add techniques to achieve the full sensitivity. In all cases, we plan to subtract the contributions from Pluto and Charon, using either images taken from a different epoch or model light distributions.
We have successfully applied both techniques in previous Hubble programs.

We request 3 orbits of observations as soon as possible (e.g., September),
followed by 3 orbits of observations ~6.4 days later.
The 6.4 day cadence is requested to place Pluto and Charon at the same relative location on the WFC3 CCD (6.4 days is the rotational period of Pluto and Charon around their barycenter), which will allow us to create a more accurate model for the scattered light from Pluto and Charon that can be subtracted from images to better reveal any faint satellites. For the same reason, all observations should be performed at the same Hubble roll angle.

Visit

Proposal 12725, Visit 01, scheduled Fri Sep 02 01:30:52 GMT 2011

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: (none)

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	PLUTO	STD=PLUTO				EARTH

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	3s, orbit #1	(1) PLUTO	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO		Sequence 1-3 Non-Int in Visit 01	3 Secs	
								[==>]	***[1]***
2	30s, orbit #1	(1) PLUTO	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO		Sequence 1-3 Non-Int in Visit 01	30 Secs X 16	
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3	30s at dither, orbit #1	(1) PLUTO	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO	POS TARG 0.2,0.2	Sequence 1-3 Non-Int in Visit 01	30 Secs X 16	
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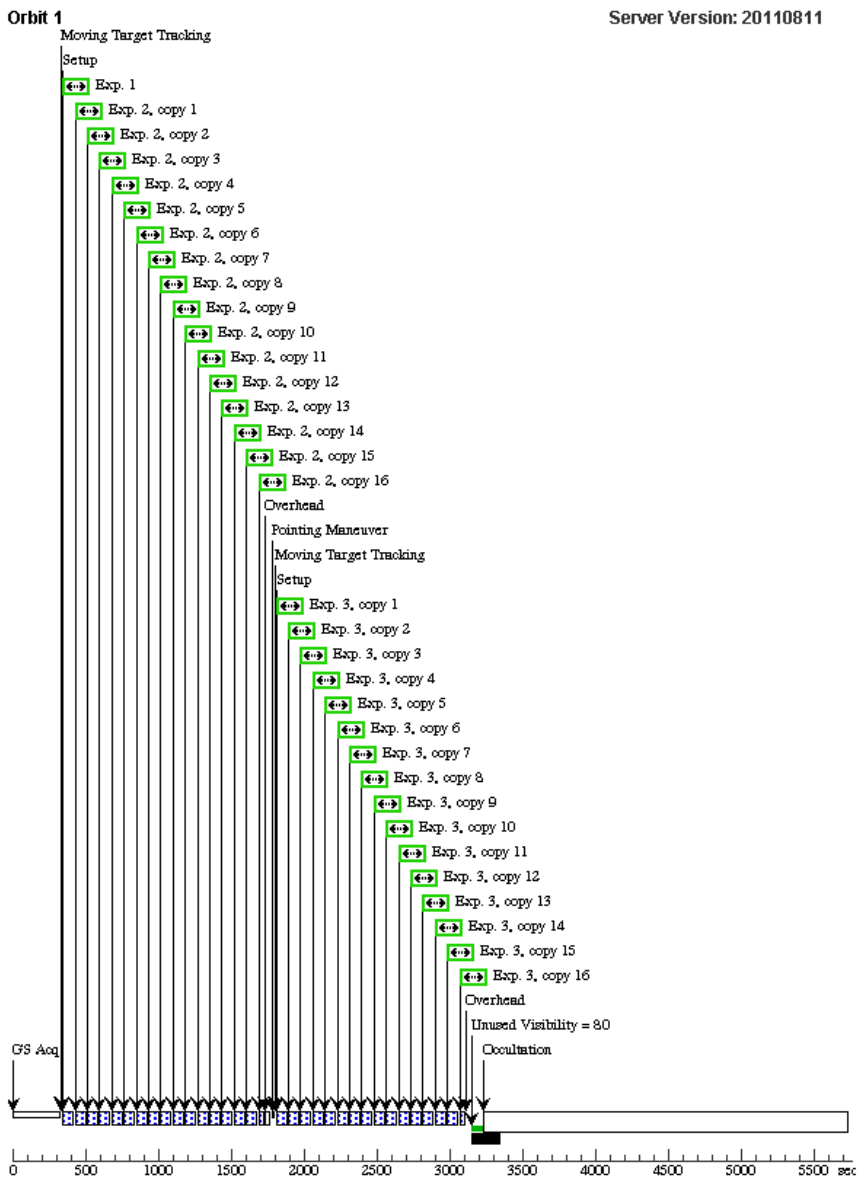
Orbit Structure



Visit

Proposal 12725, Visit 02, scheduled Fri Sep 02 01:30:54 GMT 2011

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: SAME ORIENT AS 01; AFTER 01 BY 0.75 Orbits TO 1.25 Orbits

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	PLUTO	STD=PLUTO				EARTH

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	3s, orbit #2	(1) PLUTO	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO		Sequence 1-3 Non-Int in Visit 02	3 Secs	
								[==>]	***[1]***
2	175s, orbit #2	(1) PLUTO	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO		Sequence 1-3 Non-Int in Visit 02	175 Secs X 6	
								[==>(Copy 1)] *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]* *[==>(Copy 5)]* *[==>(Copy 6)]*	***[1]***
3	175s at dither, orbit #2	(1) PLUTO	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO	POS TARG 0.2,0.2	Sequence 1-3 Non-Int in Visit 02	175 Secs X 6	
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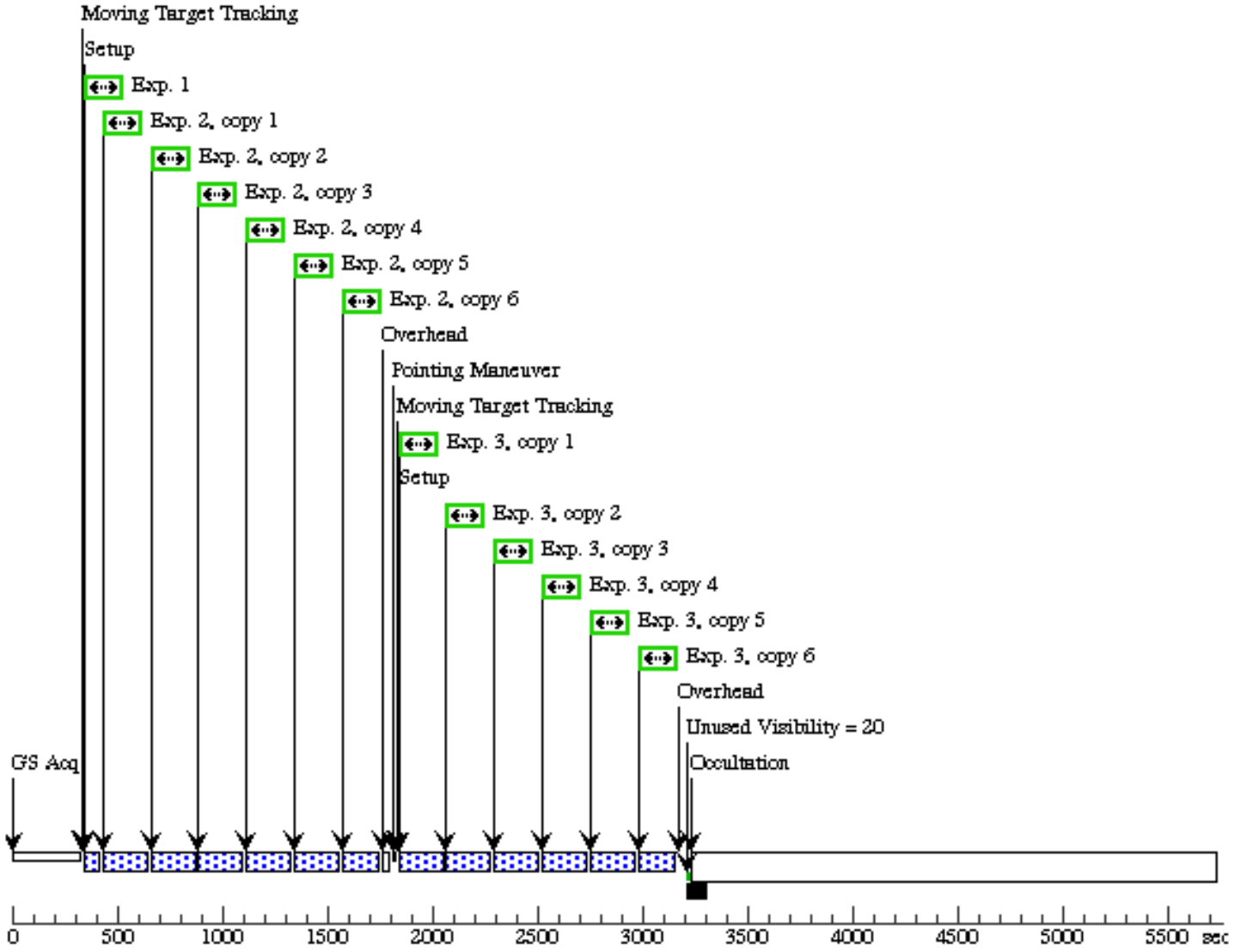
Orbit Structure



Visit

Proposal 12725, Visit 04, scheduling Fri Sep 02 01:30:55 GMT 2011

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: SAME ORIENT AS 01; AFTER 01 BY 6.3553 D TO 6.3906 D

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	PLUTO	STD=PLUTO				EARTH

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	3s, orbit #1	(1) PLUTO	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO		Sequence 1-3 Non-Int in Visit 04	3 Secs	
								[==>]	***[1]***
2	30s, orbit #1	(1) PLUTO	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO		Sequence 1-3 Non-Int in Visit 04	30 Secs X 16	
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3	30s at dither, orbit #1	(1) PLUTO	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO	POS TARG 0.2,0.2	Sequence 1-3 Non-Int in Visit 04	30 Secs X 16	
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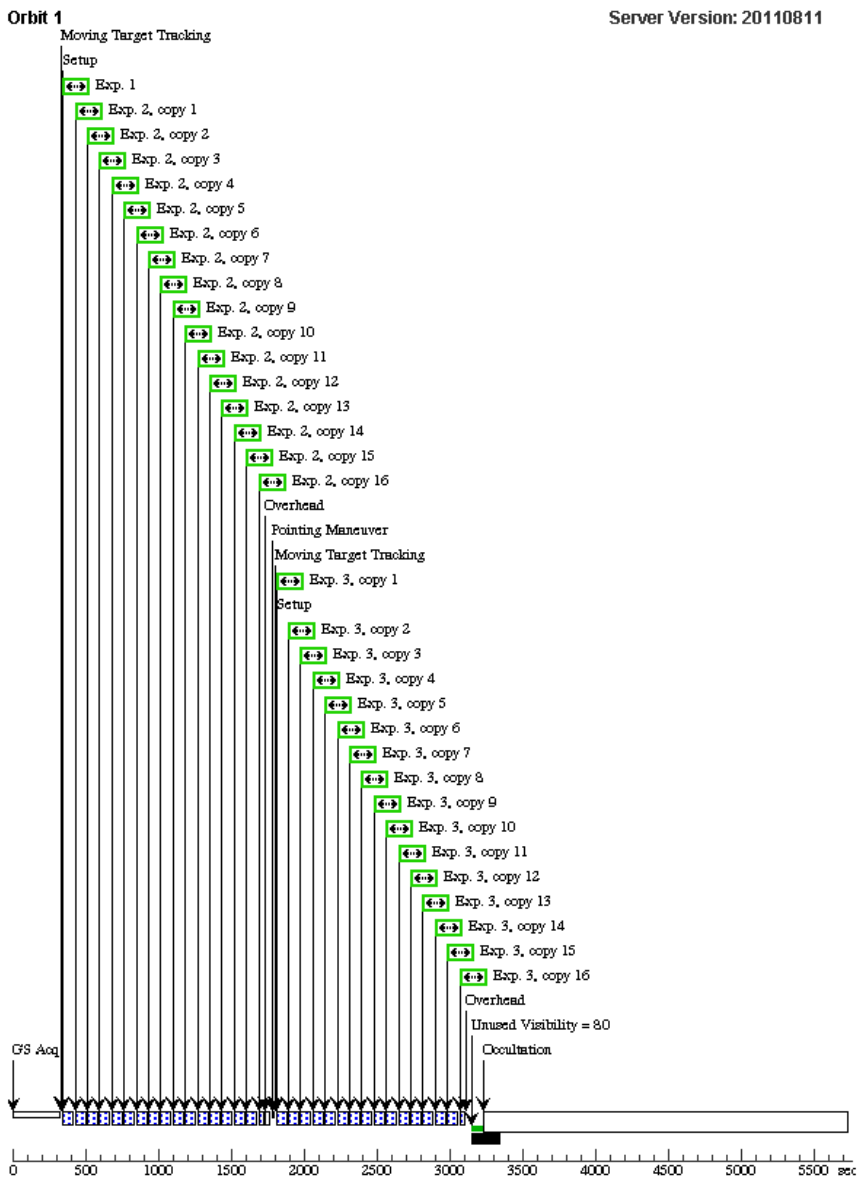
Orbit Structure



Visit

Proposal 12725, Visit 05, scheduling Fri Sep 02 01:30:55 GMT 2011

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: SAME ORIENT AS 01; AFTER 04 BY 0.75 Orbits TO 1.25 Orbits

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	PLUTO	STD=PLUTO				EARTH

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	3s, orbit #2	(1) PLUTO	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO		Sequence 1-3 Non-Int in Visit 05	3 Secs	
								[==>]	***[1]***
2	175s, orbit #2	(1) PLUTO	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO		Sequence 1-3 Non-Int in Visit 05	175 Secs X 6	
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3	175s at dither, orbit #2	(1) PLUTO	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO	POS TARG 0.2,0.2	Sequence 1-3 Non-Int in Visit 05	175 Secs X 6	
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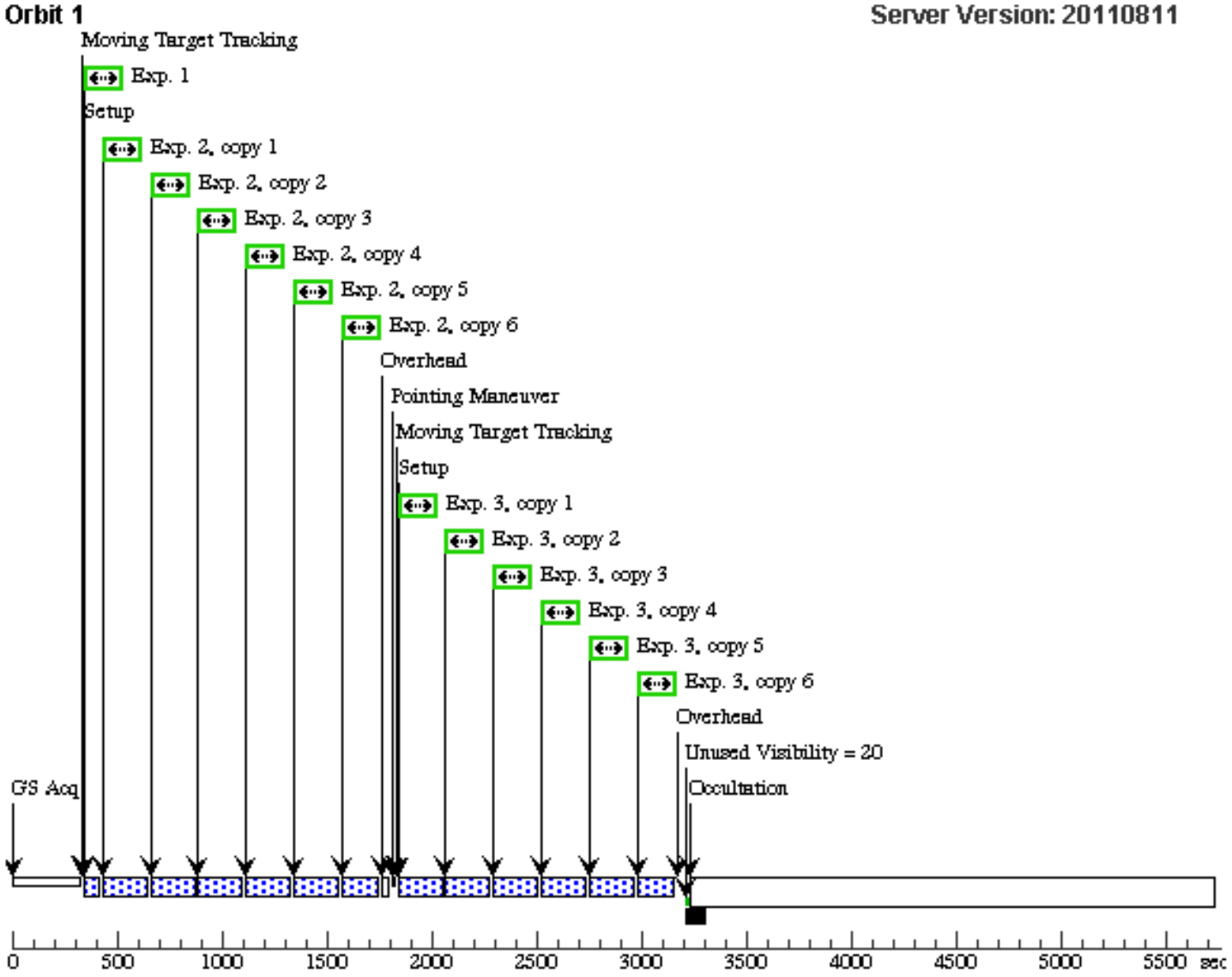
Orbit Structure



Visit

Proposal 12725, Visit 07, implementation Fri Sep 02 01:30:56 GMT 2011

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: AFTER_04 BY 6.2928 D TO 6.3281 D

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	PLUTO	STD=PLUTO				EARTH

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	3s, orbit #1	(1) PLUTO	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO		Sequence 1-3 Non-Int in Visit 07	3 Secs	
								[==>]	***[1]***
2	30s, orbit #1	(1) PLUTO	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO		Sequence 1-3 Non-Int in Visit 07	30 Secs X 16	
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3	30s at dither, orbit #1	(1) PLUTO	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO	POS TARG 0.2,0.2	Sequence 1-3 Non-Int in Visit 07	30 Secs X 16	
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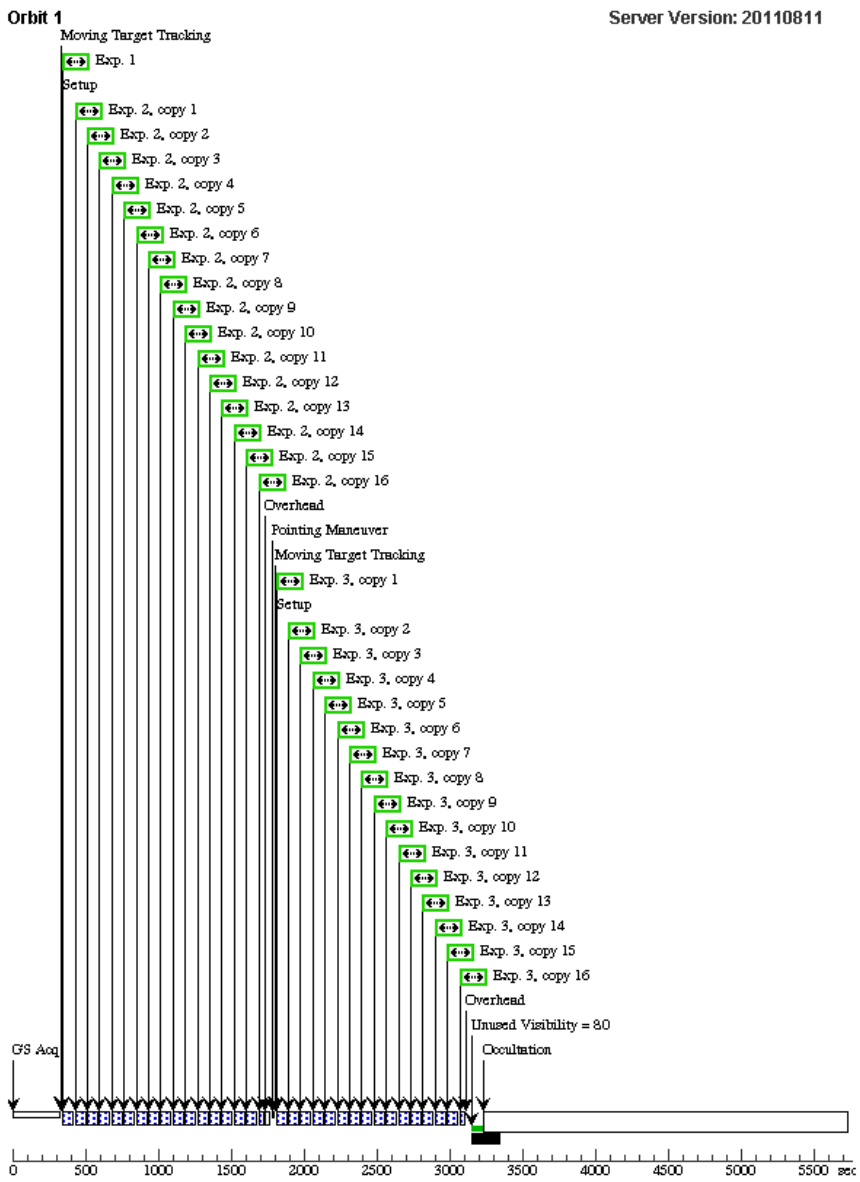
Orbit Structure



Visit

Proposal 12725, Visit 08, implementation Fri Sep 02 01:30:57 GMT 2011

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: SAME ORIENT AS 07; AFTER 07 BY 0.75 Orbits TO 1.25 Orbits

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	PLUTO	STD=PLUTO				EARTH

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	3s, orbit #2	(1) PLUTO	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO		Sequence 1-3 Non-Int in Visit 08	3 Secs	
								[==>]	***[1]***
2	175s, orbit #2	(1) PLUTO	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO		Sequence 1-3 Non-Int in Visit 08	175 Secs X 6	
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3	175s at dither, orbit #2	(1) PLUTO	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO	POS TARG 0.2,0.2	Sequence 1-3 Non-Int in Visit 08	175 Secs X 6	
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Orbit Structure