14220 - Mapping the Substellar Mass-Luminosity Relation Down to the L/T Transition

Cycle: 23, 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) 2MASSIJ1017075+130839	WFC3/UVIS	1	08-Oct-2015 21:40:00.0	yes
02	(2) GL417B	WFC3/UVIS	1	08-Oct-2015 21:40:02.0	yes
03	(3) 2MASSIJ2132114+134158	WFC3/UVIS	1	08-Oct-2015 21:40:03.0	yes
04	(4) 2MASSWJ0920122+351742	WFC3/UVIS	1	08-Oct-2015 21:40:05.0	yes
05	(5) 2MASSWJ1728114+394859	WFC3/UVIS	1	08-Oct-2015 21:40:06.0	yes
06	(6) SDSSJ205235.31-160929.8	WFC3/UVIS	1	08-Oct-2015 21:40:07.0	yes
07	(7) DENIS-PJ225210.73-173013.4	WFC3/UVIS	1	08-Oct-2015 21:40:08.0	yes
08	(8) DENIS-PJ063001.4-184014	WFC3/UVIS	1	08-Oct-2015 21:40:11.0	yes

8 Total Orbits Used

ABSTRACT

Substellar models underpin our theoretical understanding of brown dwarfs and gas-giant exoplanets, so assessing their accuracy is paramount. The past several years have seen progress in testing models thanks to a growing number of dynamical (total) masses for brown dwarf binaries determined via (relative) orbit monitoring from ground-based AO. However, the strongest tests of models require individual masses, particularly for calibrating the mass-luminosity relation. This is poorly constrained over the range of spectral types most influenced by clouds (mid-L to early-T). Given the observed prevalence of clouds in the atmospheres of directly imaged planets, testing models at such temperatures is crucial.

We propose a 3-year program to obtain individual masses for a sample of 11 substellar binaries. Our proposal builds on nearly a decade of orbital monitoring from the ground to measure dynamical total masses. Our goal is thus to measure precise mass ratios, utilizing HST's unique wide-field, high-angular resolution astrometric capabilities. We will obtain WFC3-UVIS images capturing our targets and numerous reference stars so that we can measure the relative amount of orbital motion in each component to determine mass ratios. Three of our targets have I-band photocenter orbits measured at USNO and VLT and thus only require one epoch of resolved I-band imaging to unlock individual masses. We will use this first large sample of substellar individual masses to map out the mass-luminosity relation over a wide range of temperatures (1000-2000 K) including the L/T transition. This will become a touchstone sample for tests of ultracool atmospheric models in the era of JWST.

OBSERVING DESCRIPTION

Our program consists of two distinct observing modes and accompanying goals. The primary one is to obtain absolute astrometry of the individual components of seven tight (<~0.1 arcsec) brown dwarf binaries that already have known relative orbits (and thereby total dynamical masses). Obtaining absolute astrometry at multiple epochs over 3 years will allow us to disentangle proper motion from the orbital motion of each component, and by measuring the ratio of component orbital motion will allow a precise measurement of the mass ratio and thus individual masses. The key observational goal is to obtain as high of precision absolute position measurements for as many reference stars as possible across all epochs. This motivates us to place our targets near the center of the full UVIS FOV, using the UVIS-CENTER aperture, so that data taken at different roll angles will share the maximum number of reference stars in common. We expect the dominant source of our astrometric errors will be set by how well we can deblend our tightest (~50 mas) binaries with flux ratios of ~1-2 mag. We expect positional errors on 4 mas in the most unfavorable cases.

The second observing mode/goal is to image three astrometric binaries at a single epoch each in order to measure their optical flux ratios.

Coincidentally, the optimal times to observe this sample result in one of these binaries being observed in each of Cycles 23, 24, and 25. Their photocenter orbits have previously been determined in seeing-limited optical imaging, so a single HST epoch will break the degeneracy between mass ratio and flux ratio, enabling individual mass measurements of both components. Thus our goal is high-precision relative photometry of these tight (50-100 mas) binaries, and we will use the UVIS2-C512C-CTE aperture to minimize image degradation caused by CTE losses.

Visit

Proposal 14220, Visit 01, implementation Fri Oct 09 01:40:13 GMT 2015

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: (none)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-LINE-3PT Purpose=DITHER Number Of Points=3 Point Spacing=0.135 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1), (2)

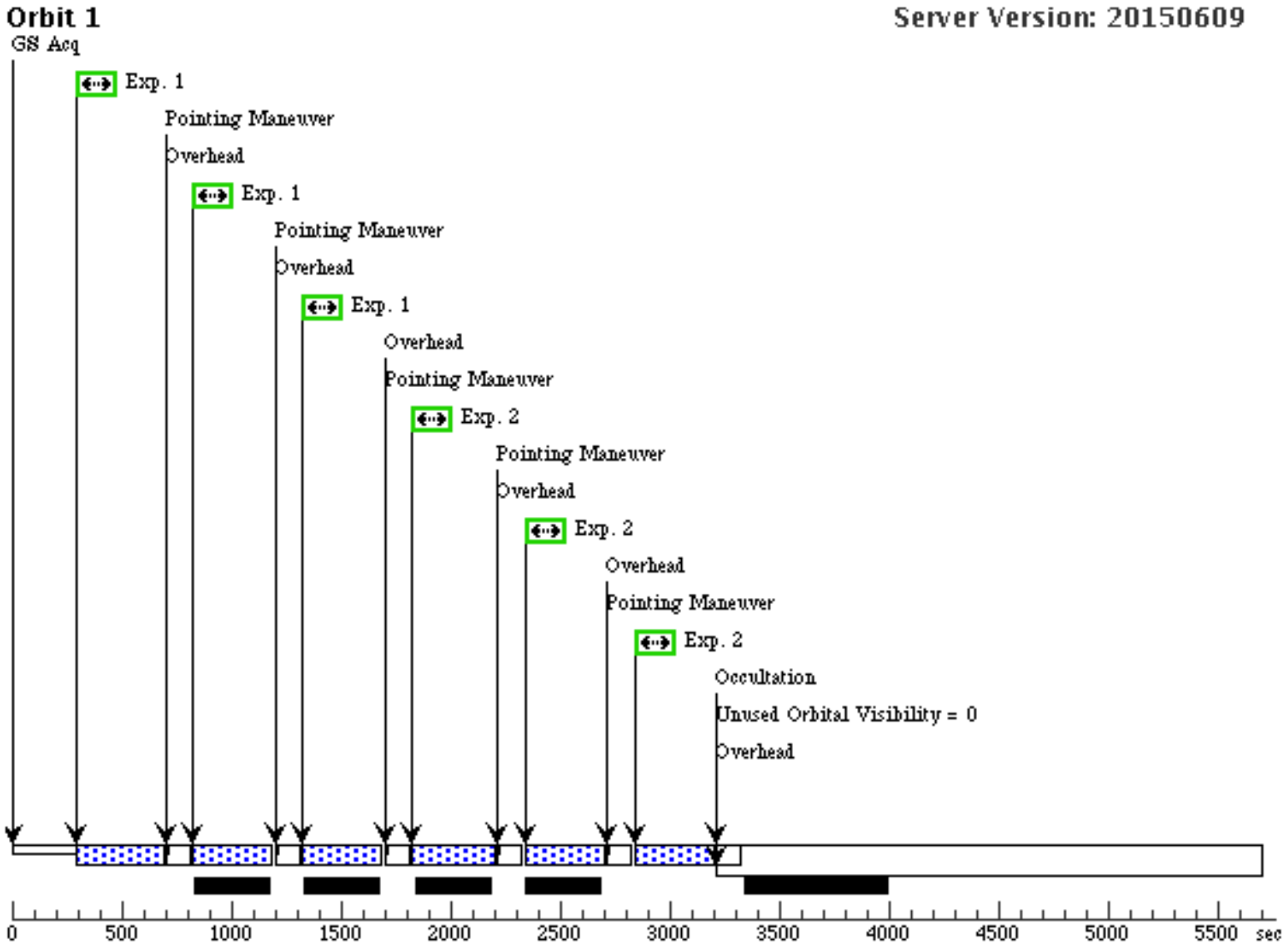
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	2MASSIJ1017075+130839	RA: 10 17 7.6381 (154.2818254d) Dec: +13 08 39.10 (13.14419d) Equinox: J2000	Proper Motion RA: 45.3 mas/yr Proper Motion Dec: -114.5 mas/yr Epoch of Position: 2008.13	V=(?) J=14.1	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) 2MASSIJ1017075+130839	WFC3/UVIS, ACCUM, UVIS	F814W	FLASH=4		Pattern 1, Exps 1-1 in Visit 01 (1)	360 Secs (1098 Secs) *[==>366.0 Secs (Pattern 1)]* *[==>366.0 Secs (Pattern 2)]* *[==>366.0 Secs (Pattern 3)]*	***[1]***
2		(1) 2MASSIJ1017075+130839	WFC3/UVIS, ACCUM, UVIS	F850LP	FLASH=9		Pattern 1, Exps 2-2 in Visit 01 (1)	360 Secs (1098 Secs) *[==>366.0 Secs (Pattern 1)]* *[==>366.0 Secs (Pattern 2)]* *[==>366.0 Secs (Pattern 3)]*	***[1]***

Orbit Structure



Visit

Proposal 14220, Visit 02, implementation Fri Oct 09 01:40:14 GMT 2015

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: BETWEEN 01-NOV-2015:00:00:00 AND 30-NOV-2015:00:00:00

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-LINE-3PT Purpose=DITHER Number Of Points=3 Point Spacing=0.135 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1), (2)

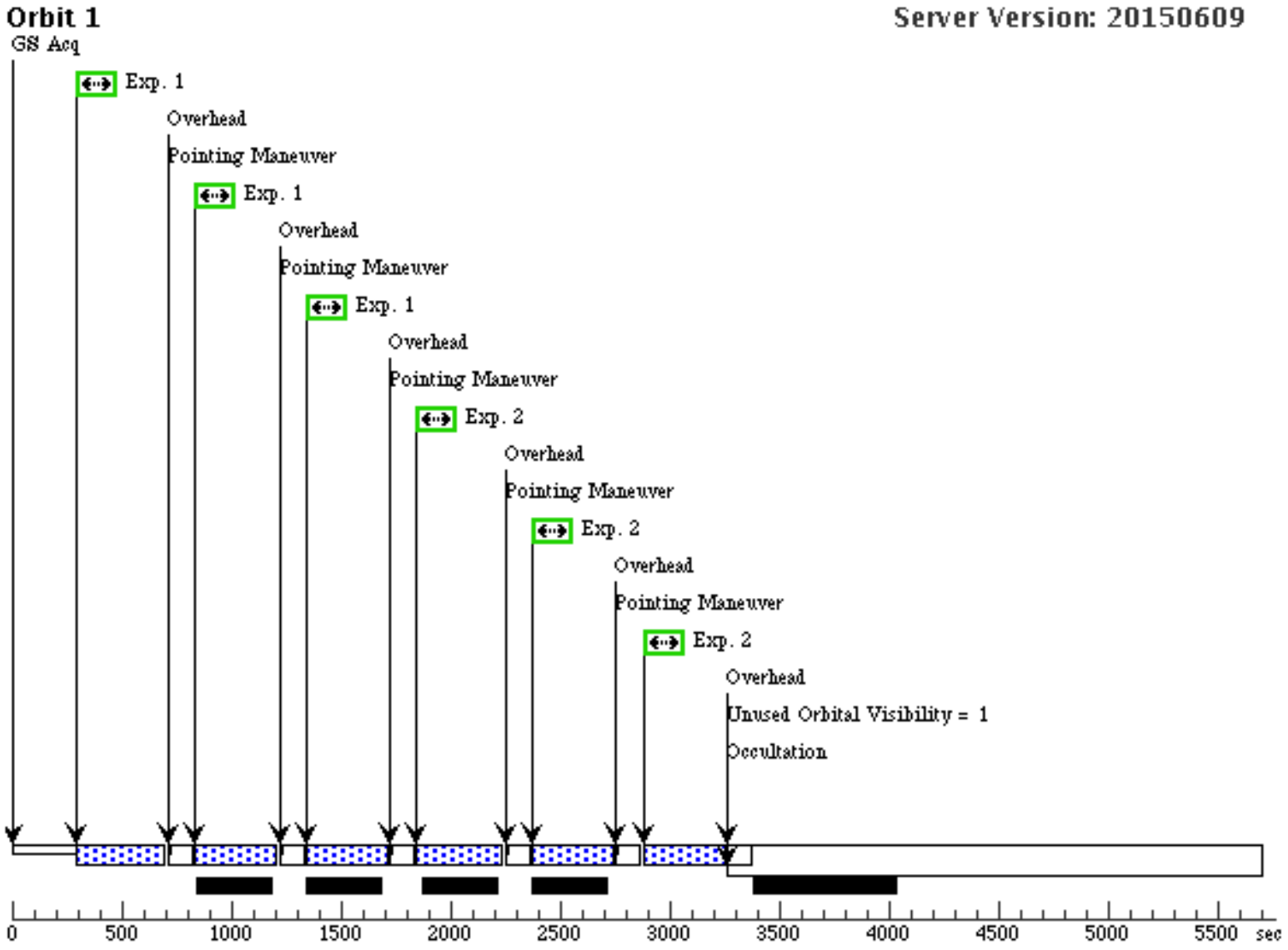
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	GL417B	RA: 11 12 25.6745 (168.1069771d) Dec: +35 48 13.17 (35.80366d) Equinox: J2000	Proper Motion RA: -248.9 mas/yr Proper Motion Dec: -151.0 mas/yr Epoch of Position: 1998.35	V=(?) J=14.6	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(2) GL417B	WFC3/UVIS, ACCUM, UVIS	F814W	FLASH=4		Pattern 1, Exps 1-1 in Visit 02 (1)	360 Secs (1122 Secs) *[==>374.0 Secs (Pattern 1)]* *[==>374.0 Secs (Pattern 2)]* *[==>374.0 Secs (Pattern 3)]*	***[1]***
2		(2) GL417B	WFC3/UVIS, ACCUM, UVIS	F850LP	FLASH=9		Pattern 1, Exps 2-2 in Visit 02 (1)	360 Secs (1122 Secs) *[==>374.0 Secs (Pattern 1)]* *[==>374.0 Secs (Pattern 2)]* *[==>374.0 Secs (Pattern 3)]*	***[1]***

Orbit Structure



Visit

Proposal 14220, Visit 03, implementation Fri Oct 09 01:40:14 GMT 2015

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: (none)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-LINE-3PT Purpose=DITHER Number Of Points=3 Point Spacing=0.135 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1), (2)

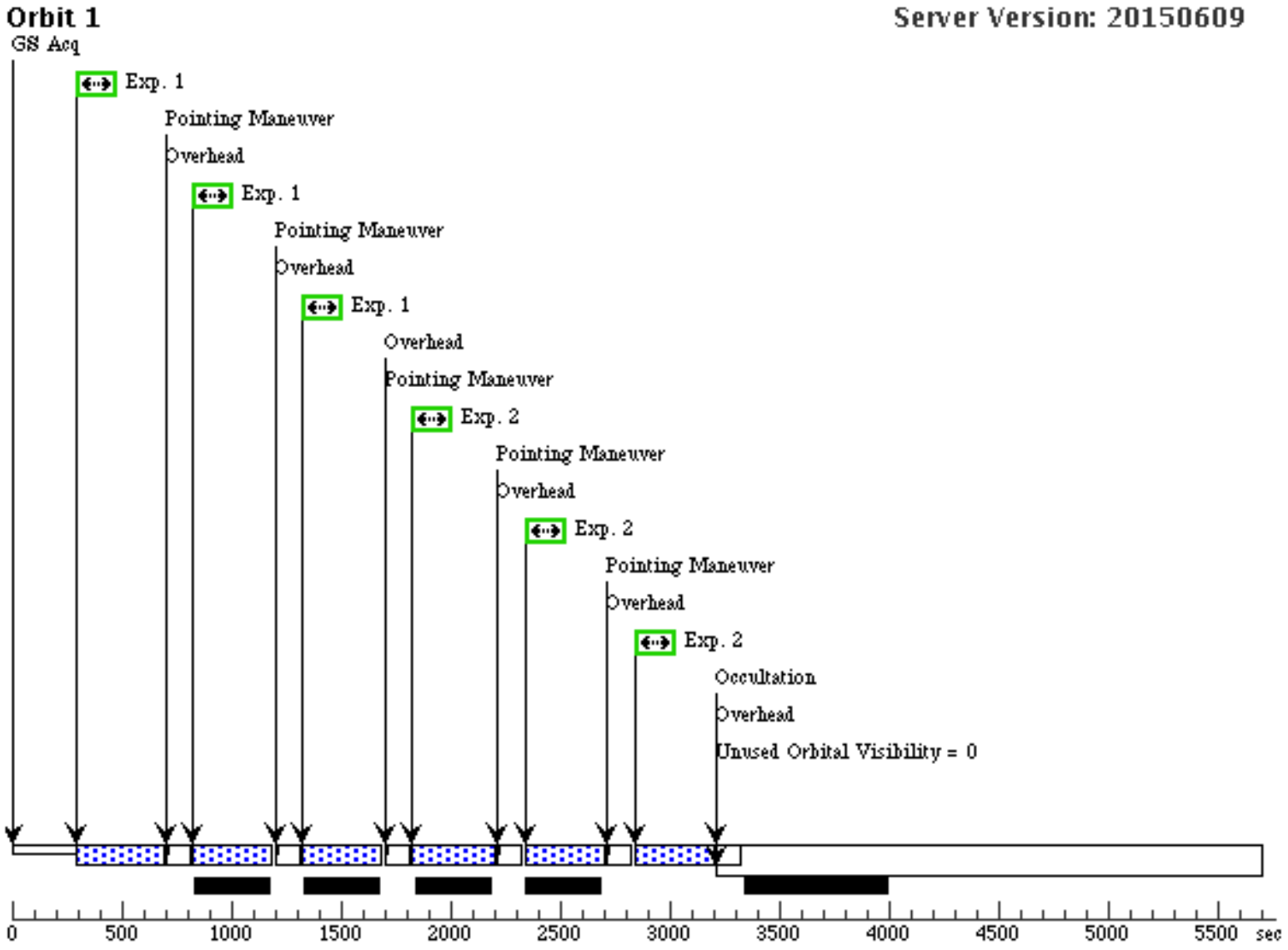
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(3)	2MASSIJ2132114+134158	RA: 21 32 11.5126 (323.0479692d) Dec: +13 41 58.22 (13.69951d) Equinox: J2000	Epoch of Position: 2007.58	V=(?) J=15.8	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(3) 2MASSIJ2132114+134158	WFC3/UVIS, ACCUM, UVIS	F814W	FLASH=4		Pattern 1, Exps 1-1 in Visit 03 (1)	360 Secs (1098 Secs) *[==>366.0 Secs (Pattern 1)]* *[==>366.0 Secs (Pattern 2)]* *[==>366.0 Secs (Pattern 3)]*	***[1]***
2		(3) 2MASSIJ2132114+134158	WFC3/UVIS, ACCUM, UVIS	F850LP	FLASH=9		Pattern 1, Exps 2-2 in Visit 03 (1)	360 Secs (1098 Secs) *[==>366.0 Secs (Pattern 1)]* *[==>366.0 Secs (Pattern 2)]* *[==>366.0 Secs (Pattern 3)]*	***[1]***

Orbit Structure



Visit

Proposal 14220, Visit 04, implementation Fri Oct 09 01:40:14 GMT 2015

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: BETWEEN 01-NOV-2015:00:00:00 AND 30-NOV-2015:00:00:00

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-LINE-3PT Purpose=DITHER Number Of Points=3 Point Spacing=0.135 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1), (2)

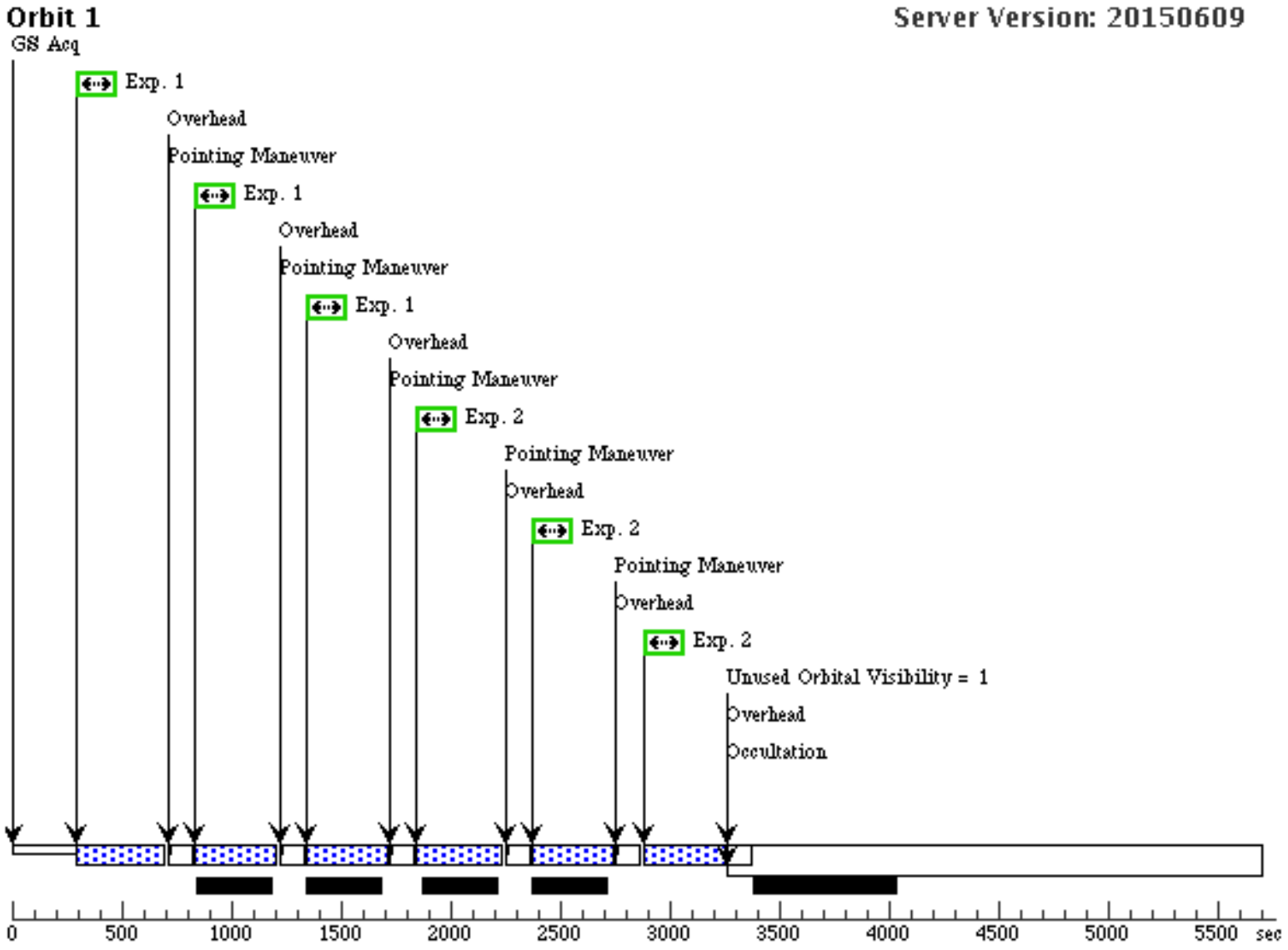
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(4)	2MASSWJ0920122+351742	RA: 09 20 12.1687 (140.0507029d) Dec: +35 17 41.49 (35.29486d) Equinox: J2000	Proper Motion RA: -187.1 mas/yr Proper Motion Dec: -199.0 mas/yr Epoch of Position: 2007.89	V=(?) J=15.6	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(4) 2MASSWJ0920122+351742	WFC3/UVIS, ACCUM, UVIS	F814W	FLASH=4		Pattern 1, Exps 1-1 in Visit 04 (1)	360 Secs (1122 Secs) *[==>374.0 Secs (Pattern 1)]* *[==>374.0 Secs (Pattern 2)]* *[==>374.0 Secs (Pattern 3)]*	***[1]***
2		(4) 2MASSWJ0920122+351742	WFC3/UVIS, ACCUM, UVIS	F850LP	FLASH=9		Pattern 1, Exps 2-2 in Visit 04 (1)	360 Secs (1122 Secs) *[==>374.0 Secs (Pattern 1)]* *[==>374.0 Secs (Pattern 2)]* *[==>374.0 Secs (Pattern 3)]*	***[1]***

Orbit Structure



Visit

Proposal 14220, Visit 05, implementation Fri Oct 09 01:40:14 GMT 2015

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: (none)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-LINE-3PT Purpose=DITHER Number Of Points=3 Point Spacing=0.135 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1), (2)

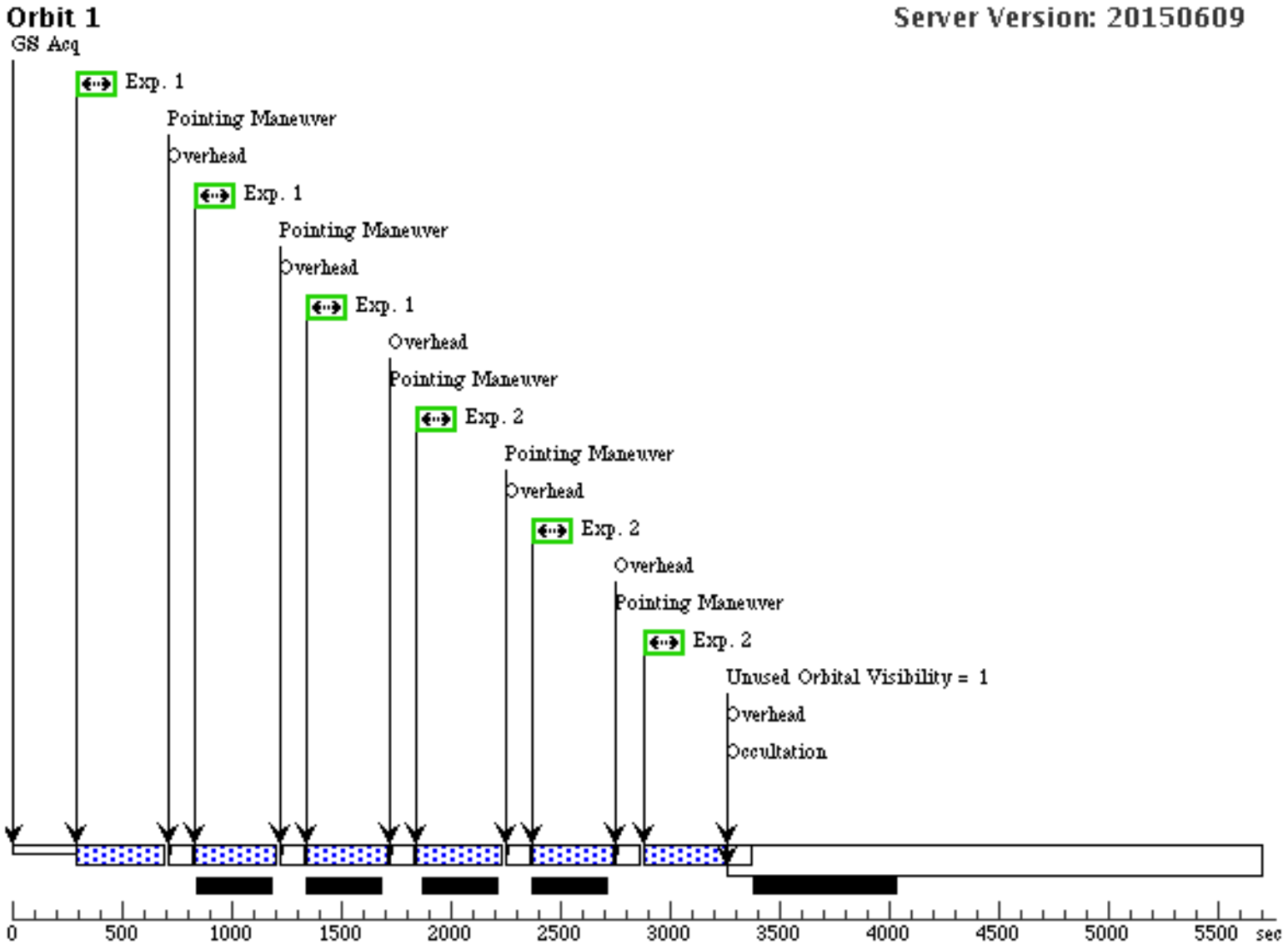
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(5)	2MASSWJ1728114+394859	RA: 17 28 11.5446 (262.0481025d) Dec: +39 48 59.14 (39.81643d) Equinox: J2000	Proper Motion RA: 35.8 mas/yr Proper Motion Dec: -18.4 mas/yr Epoch of Position: 2008.30	V=(?) J=16.0	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(5) 2MASSWJ1728114+394859	WFC3/UVIS, ACCUM, UVIS	F814W	FLASH=4		Pattern 1, Exps 1-1 in Visit 05 (1)	360 Secs (1122 Secs) *[==>374.0 Secs (Pattern 1)]* *[==>374.0 Secs (Pattern 2)]* *[==>374.0 Secs (Pattern 3)]*	***[1]***
2		(5) 2MASSWJ1728114+394859	WFC3/UVIS, ACCUM, UVIS	F850LP	FLASH=9		Pattern 1, Exps 2-2 in Visit 05 (1)	360 Secs (1122 Secs) *[==>374.0 Secs (Pattern 1)]* *[==>374.0 Secs (Pattern 2)]* *[==>374.0 Secs (Pattern 3)]*	***[1]***

Orbit Structure



Visit

Proposal 14220, Visit 06, implementation Fri Oct 09 01:40:14 GMT 2015

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: (none)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-LINE-3PT Purpose=DITHER Number Of Points=3 Point Spacing=0.135 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1), (2)

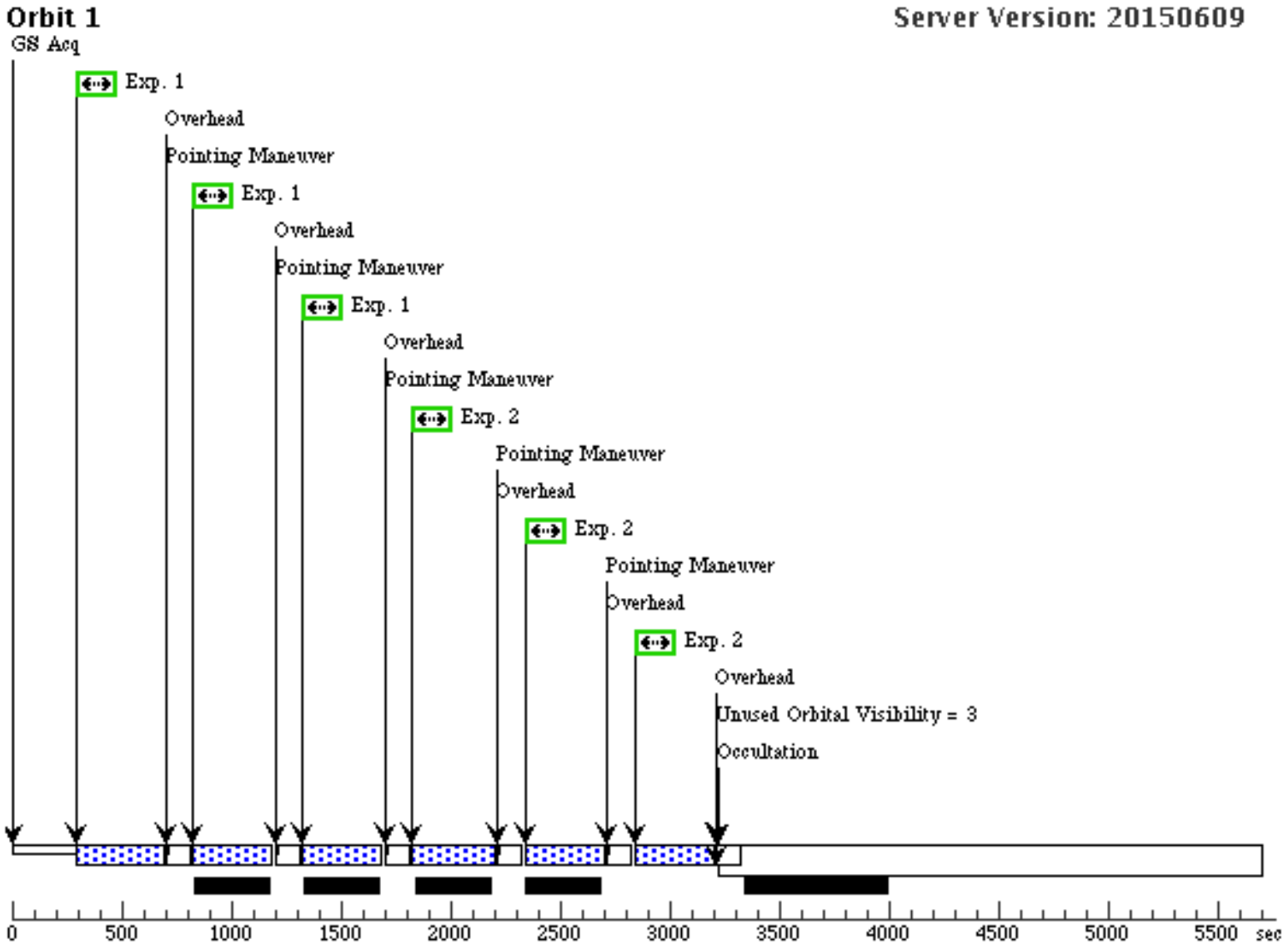
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(6)	SDSSJ205235.31-160929.8	RA: 20 52 35.4408 (313.1476700d) Dec: -16 09 28.92 (-16.15803d) Equinox: J2000	Proper Motion RA: 399.7 mas/yr Proper Motion Dec: 152.7 mas/yr Epoch of Position: 2007.58	V=(?) J=16.3	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(6) SDSSJ205235.31-160929.8	WFC3/UVIS, ACCUM, UVIS	F814W	FLASH=4		Pattern 1, Exps 1-1 in Visit 06 (1)	360 Secs (1098 Secs) *[==>366.0 Secs (Pattern 1)]* *[==>366.0 Secs (Pattern 2)]* *[==>366.0 Secs (Pattern 3)]*	***[1]***
2		(6) SDSSJ205235.31-160929.8	WFC3/UVIS, ACCUM, UVIS	F850LP	FLASH=9		Pattern 1, Exps 2-2 in Visit 06 (1)	360 Secs (1098 Secs) *[==>366.0 Secs (Pattern 1)]* *[==>366.0 Secs (Pattern 2)]* *[==>366.0 Secs (Pattern 3)]*	***[1]***

Orbit Structure



Visit

Proposal 14220, Visit 07, implementation Fri Oct 09 01:40:15 GMT 2015

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: BETWEEN 16-APR-2016:00:00:00 AND 02-MAY-2016:00:00:00

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-LINE-3PT Purpose=DITHER Number Of Points=3 Point Spacing=0.135 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1), (2)

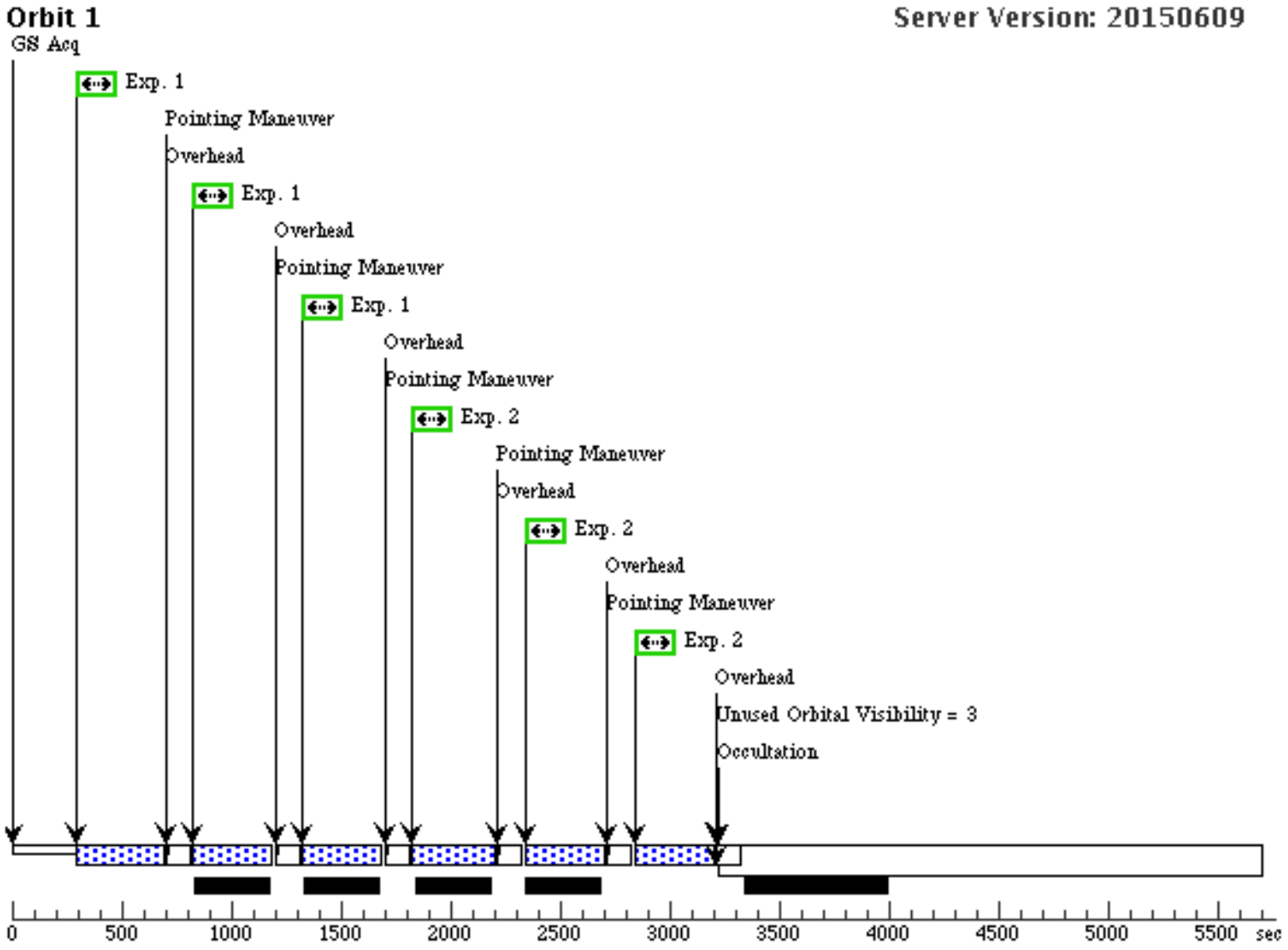
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(7)	DENIS-PJ225210.73-173013.4	RA: 22 52 10.9885 (343.0457854d) Dec: -17 30 11.16 (-17.50310d) Equinox: J2000	Proper Motion RA: 397.3 mas/yr Proper Motion Dec: 144.3 mas/yr Epoch of Position: 2007.59	V=(?) J=14.3	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(7) DENIS-PJ225210.73-173013.4	WFC3/UVIS, ACCUM, UVIS	F814W	FLASH=4		Pattern 1, Exps 1-1 in Visit 07 (1)	360 Secs (1098 Secs) *[==>366.0 Secs (Pattern 1)]* *[==>366.0 Secs (Pattern 2)]* *[==>366.0 Secs (Pattern 3)]*	***[1]***
2		(7) DENIS-PJ225210.73-173013.4	WFC3/UVIS, ACCUM, UVIS	F850LP	FLASH=9		Pattern 1, Exps 2-2 in Visit 07 (1)	360 Secs (1098 Secs) *[==>366.0 Secs (Pattern 1)]* *[==>366.0 Secs (Pattern 2)]* *[==>366.0 Secs (Pattern 3)]*	***[1]***

Orbit Structure



Visit

Proposal 14220, Visit 08, implementation Fri Oct 09 01:40:15 GMT 2015

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: BEFORE 12-MAY-2016:00:00:00

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(2)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.173 Line Spacing=0.112	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=false		(1), (2)

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(8)	DENIS-PJ063001.4-184014	RA: 06 30 1.4093 (97.5058721d) Dec: -18 40 14.30 (-18.67064d) Equinox: J2000	Proper Motion RA: 322.7 mas/yr Proper Motion Dec: -501.5 mas/yr Epoch of Position: 1999.0515	V=(?) I=15.7	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(8) DENIS-PJ06300 1.4-184014	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F814W	FLASH=12		Pattern 2, Exps 1-1 in Visit 08 (2)	37 Secs X 4 (592 Secs)	
								[==>(Pattern 1, Copy 1)]	***[1]***
								[==>(Pattern 1, Copy 2)]	
								[==>(Pattern 1, Copy 3)]	
								[==>(Pattern 1, Copy 4)]	
								[==>(Pattern 2, Copy 1)]	
								[==>(Pattern 2, Copy 2)]	
								[==>(Pattern 2, Copy 3)]	
								[==>(Pattern 2, Copy 4)]	
								[==>(Pattern 3, Copy 1)]	
								[==>(Pattern 3, Copy 2)]	
								[==>(Pattern 3, Copy 3)]	
								[==>(Pattern 3, Copy 4)]	
								[==>(Pattern 4, Copy 1)]	
								[==>(Pattern 4, Copy 2)]	
								[==>(Pattern 4, Copy 3)]	
								[==>(Pattern 4, Copy 4)]	
2		(8) DENIS-PJ06300 1.4-184014	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F850LP	FLASH=12		Pattern 2, Exps 2-2 in Visit 08 (2)	52 Secs X 3 (624 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)]	
								[==>(Pattern 3, Copy 1)]	
								[==>(Pattern 3, Copy 2)]	
								[==>(Pattern 3, Copy 3)]	
								[==>(Pattern 4, Copy 1)]	
								[==>(Pattern 4, Copy 2)]	
								[==>(Pattern 4, Copy 3)]	

Orbit Structure