12584 - Confirming the First Supermassive Black Hole in a Dwarf Starburst Galaxy

Cycle: 19, 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) HE2-10-EW (3) HE2-10-OFFSET CCDFLAT	STIS/CCD	5	30-Jun-2011 21:23:48.0	yes
02	(2) HE2-10-NS (3) HE2-10-OFFSET WAVE	STIS/CCD	3	30-Jun-2011 21:24:01.0	yes

8 Total Orbits Used

ABSTRACT

In the modern universe, supermassive black holes lie at the heart of most, if not all, galaxies with bulges. However, the birth and growth of the first "seed" black holes, back in the earlier universe, is observationally unconstrained. Reines et al. (2011) have recently discovered a candidate million-solar mass black hole in the bulgeless dwarf starburst galaxy Henize 2-10, offering the first opportunity to study a growing black hole in a nearby galaxy much like those in the infant universe. The case for an accreting black hole in Henize 2-10 is strong (e.g. co-spatial non-thermal radio and hard X-ray point sources), but not watertight. Our proposal aims to confirm (or refute) the presence of this candidate black hole using STIS optical

spectroscopy to trace the kinematics and ionization conditions in its immediate vicinity. Existing HST observations show a marginally resolved H-alpha knot coincident with the radio and X-ray point source, so our primary aim is to detect a compact rotating disk of ionized gas, directly yielding a black hole mass. Our secondary aim is to find evidence for AGN-related emission line signatures at the location of the H-alpha knot, and possibly along a narrow jet-like filament. Confirming the presence of a supermassive black hole in Henize 2-10 with these HST observations has immediate implications for our understanding of the birth and early evolution of the first black holes in the high-redshift universe.

OBSERVING DESCRIPTION

Overall, our aim is to measure the gas kinematics in the vicinity of the candidate AGN, with sufficient spectral and spatial resolution to detect black hole related velocities and measure a black hole mass. We also wish to analyze in some detail the ionization conditions both in the vicinity of the candidate AGN and along the narrow emission line filament between the candidate AGN and the more extended emission regions to the east and west. We propose 5 orbits at position angle 100 degrees and 3 orbits at position angle 10 degrees using the 0.2"-slit. The first position includes the location of the candidate AGN and is aligned with the narrow extended H-alpha filament. The second slit is also centered on the candidate AGN but is oriented perpendicular to the first. Two slits are necessary to ensure that any rotating emission will be detected. Although we propose high dispersion observations for both slits, we only need low dispersion observations along our primary slit.

HIGH DISPERSION OBSERVATIONS:

High dispersion observations are essential for our kinematic study. We propose exposures in both slit positions with G750M and G430M. The G750M observations provide, via H-alpha, a high S/N ratio velocity field along the slit. This spectral region will also allow us to search for broad wings on H-alpha which would provide additional evidence for AGN activity. The G430M observations will also provide a kinematic map along the slit, but more importantly, a comparison of the [OIII]5007 and H-beta line profiles will allow us to single out the AGN related emission in the possible presence of more widespread star-formation related emission, with its significantly different [OIII]/H-beta flux ratio (1.3 in this galaxy, compared to 3-10 in AGN related emission).

LOW DISPERSION OBSERVATIONS:

Low dispersion observations covering the full optical range (G430L and G750L) are needed for our ionization study along the primary slit orientation (PA=100 degrees). This slit position includes the candidate AGN and extends east and west along the H-alpha filament and out into the extended emission line regions. These spectra will provide the full complement of diagnostic emission line strengths which we need to characterize the following: (1) evidence for AGN ionization at the site of the putative black hole (e.g. Seyfert or LINER like ratios, and/or [NeV]3426); (2) any shock

related emission located either along the H-alpha filament or in the emission line regions at the end of this filament, possibly arising from the impact of any jet flow; (3) allow us to carefully evaluate the primary alternate possibility that the nuclear source is related to supernova remnants.

EXPOSURE TIMES:

From our HST narrow band image, we estimate the H-alpha flux associated with the candidate AGN to be 8E-16 erg/s/cm^2. Our primary aim is to isolate a rotating emission line component across 3-5 STIS pixels (0.15 - 0.25 arcsec). It is difficult to anticipate the necessary S/N since the rotating component may be superposed on ambient H-alpha emission. Prior experience suggests that good profile analysis (allowing separation of blended components) requires a S/N ~ 25 at line peak. Assuming the nuclear flux is spread over 3-5 STIS pixels and is ~100 km/s FWHM, the STIS exposure time calculator suggests we need ~2400s in G750M, or roughly 1 orbit (allowing for CR-SPLIT dithered exposures and acquisition overheads). Tolerating slightly reduced S/N for the H-beta and [OIII]5007 lines, the G430M exposure requires 2 orbits. For the low dispersion observations our limiting aim is to detect the [NeV]3426 and [OI]6300 lines at the location of the candidate AGN. Assuming typical Seyfert 2 flux ratios of H-alpha/[NeV] ~ 3, and H-alpha/[OI] ~ 10, and a simple detection with S/N ~ 7-8, the STIS exposure time calculator gives a total exposure of ~2400 s for both the G430L and G750L gratings. Thus, we require 2 orbits for the low dispersion observations.

ACQUISITION:

The candidate AGN itself is too faint to acquire directly, so we will use a target acquisition (ACQ) with an offset from a bright point source ~7.9 arcsec to the southeast. Our H-alpha image and other existing HST broadband images, with updated astrometric solutions relative to the GSC2, will be used to obtain precise coordinates and offsets.

SPECIAL REQUIREMENTS:

Our program requires specific slit orientations (ORIENT) which affects the scheduling. Our most important "east-west" slit is quite tightly constrained (PA=100 +/- 1.5 degrees N-E; ORIENT=145/325 +/- 1.5 degrees) because we would like the slit to run along the H-alpha filament and through a (possibly associated) compact knot located 1.6 arcsec to the east from the location of the candidate AGN. Our secondary slit position angle needs to be approximately perpendicular to our first slit (PA=10 +/- 5 degrees N-E; ORIENT=55/235 +/- 5 degrees). The tolerance is set by our desire for maximal sensitivity to any near-nuclear rotation gradient.

Visit

Proposal 12584, Visit 01 Fri Jul 01 01:24:06 GMT 2011

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/CCD

Special Requirements: ORIENT 143.85D TO 146.85 D; ORIENT 323.85D TO 326.85 D

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=STIS-ALONG-SLIT	Coordinate Frame=POS-TARG		(2), (4), (5), (6)
	Purpose=DITHER	Pattern Orientation=90.0		
	Number Of Points=2	Angle Between Sides=		
	Point Spacing=0.375	Center Pattern=false		
	Line Spacing=			

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	HE2-10-EW	Offset from HE2-10-OFFSET by	Redshift: 0.002912	V=(?)	Offset Position (HE2-10-EW)
		RA Offset: 0.234 Secs		H-alpha flux of candidate AGN (H-alpha knot) is 8e-16 erg/s/cm^ 2	Reference Frame: ICRS
		Dec Offset: 7.25 Arcsec			

Comments: The target is visible in narrow-band imaging (WFPC2/PC F658N) and has an H-alpha flux of ~8e-16 erg/s/cm^2. The target is NOT visible in HST broad-band imaging and therefore acquiring this target in the slit requires an offset from a bright nearby point source (HE2-10-OFFSET).

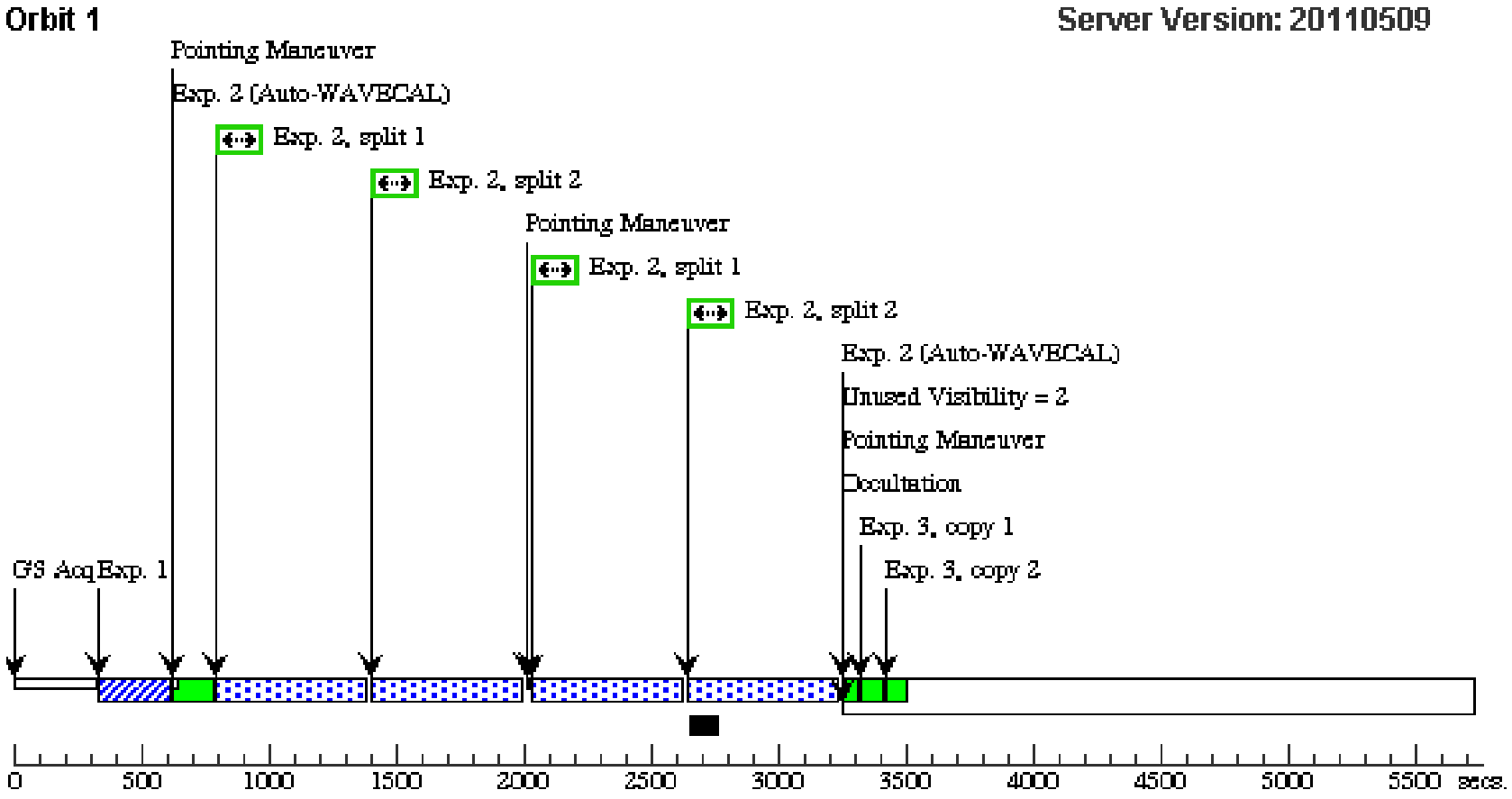
(3)	HE2-10-OFFSET	RA: 08 36 14.8840 (129.0620167d)		V=18.0+/-0.3	Reference Frame: ICRS
		Dec: -26 24 41.30 (-26.41147d)			
		Equinox: J2000			

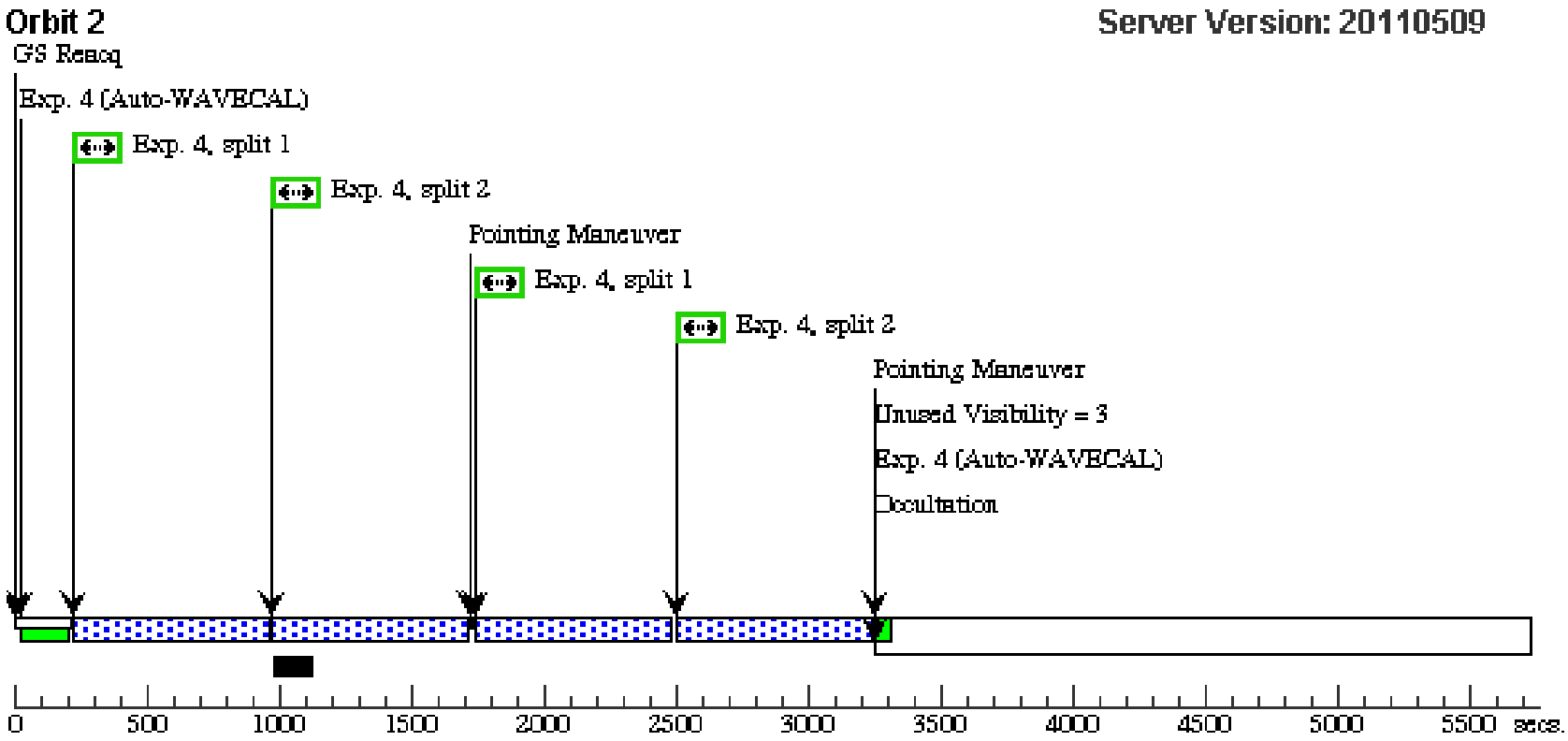
Comments: This is a point source located 7.9 arcseconds (SW) away from the primary target (candidate AGN detected as an H-alpha knot in narrow-band WFPC2/PC F658N imaging). We will use an offset from this source to acquire the primary target. The SED of this point source peaks around ~5500 Angstroms and resembles a G-type main sequence star (although it's probably a compact star cluster within Henize 2-10).

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	Acquisition (178321)	(3) HE2-10-OFFSET	STIS/CCD, ACQ, F28X50LP	MIRROR	ACQTYPE=POINT			13 Secs	
								[==>]	***[1]***
2	EW-LowRes-Red	(1) HE2-10-EW	STIS/CCD, ACCUM, 52X0.2E1	G750L 7751 A	CR-SPLIT=2		Pattern 1, Exps 2-2 in Visit 01 (1)	1124 Secs	
								[==>(Pattern 1, Split 1)] *[==>(Pattern 1, Split 2)]* *[==>(Pattern 2, Split 1)]* *[==>(Pattern 2, Split 2)]*	***[1]***
3	FringeFlat	CCDFLAT	STIS/CCD, ACCUM, 52X0.2	G750L 7751 A				*[==>(Copy 1)]* *[==>(Copy 2)]*	***[1]***
4	EW-LowRes-Blue	(1) HE2-10-EW	STIS/CCD, ACCUM, 52X0.2E1	G430L 4300 A	CR-SPLIT=2		Pattern 1, Exps 4-4 in Visit 01 (1)	1412 Secs	
								[==>(Pattern 1, Split 1)] *[==>(Pattern 1, Split 2)]* *[==>(Pattern 2, Split 1)]* *[==>(Pattern 2, Split 2)]*	***[2]***
5	EW-HighRes-Red	(1) HE2-10-EW	STIS/CCD, ACCUM, 52X0.2E1	G750M 6581 A	CR-SPLIT=2		Pattern 1, Exps 5-5 in Visit 01 (1)	1412 Secs	
								[==>(Pattern 1, Split 1)] *[==>(Pattern 1, Split 2)]* *[==>(Pattern 2, Split 1)]* *[==>(Pattern 2, Split 2)]*	***[3]***
6	EW-HighRes-Blue	(1) HE2-10-EW	STIS/CCD, ACCUM, 52X0.2E1	G430M 4961 A	CR-SPLIT=3		Pattern 1, Exps 6-6 in Visit 01 (1)	2895 Secs	
								[==>(Pattern 1, Split 1)] *[==>(Pattern 1, Split 2)]* *[==>(Pattern 1, Split 3)]*	***[4]***
								[==>(Pattern 2, Split 1)] *[==>(Pattern 2, Split 2)]* *[==>(Pattern 2, Split 3)]*	***[5]***

Orbit Structure

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GS Reacq
Exp. 4 (Auto-WAVECAL)
Exp. 4, split 1
Exp. 4, split 2
Pointing Maneuver
Exp. 4, split 1
Exp. 4, split 2
Pointing Maneuver
Unused Visibility = 3
Exp. 4 (Auto-WAVECAL)
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1000
1500
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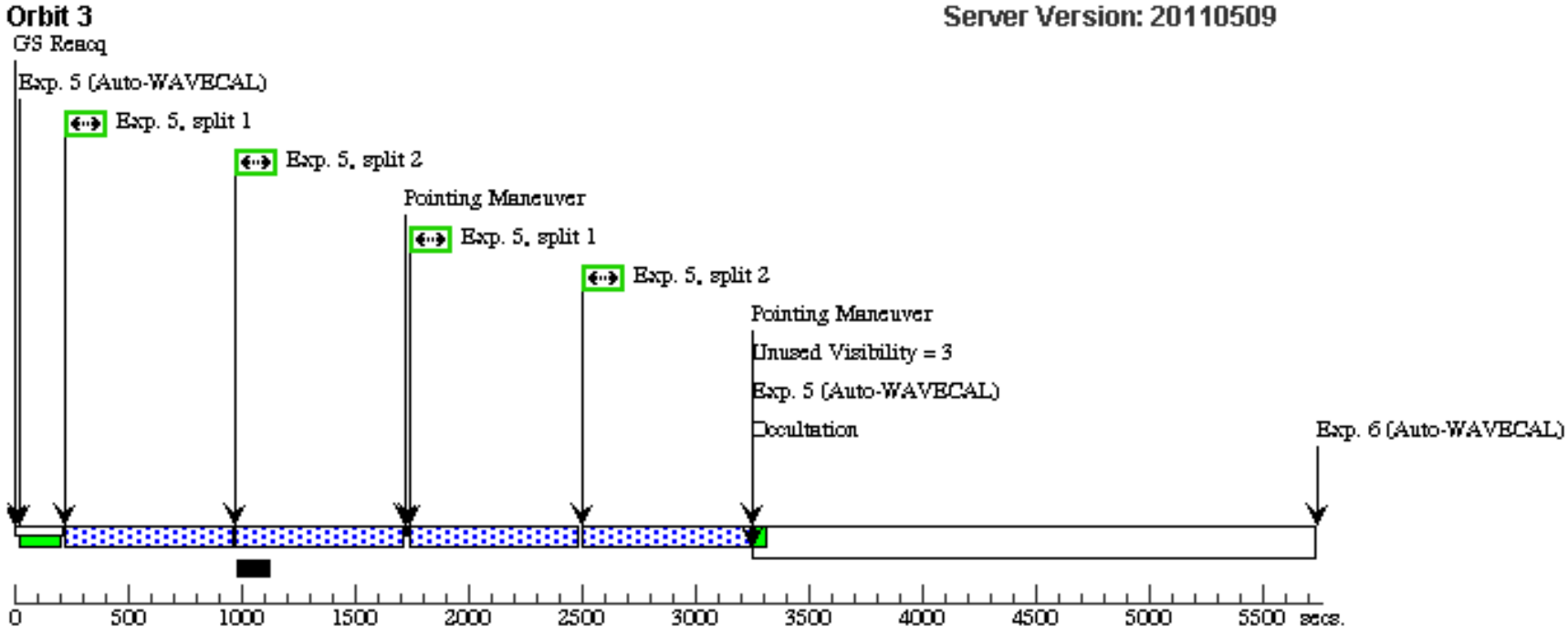
2500
3000
3500
4000
4500
5000
5500
secs.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Server Version: 20110509
GS Reacq
Exp. 5 (Auto-WAVECAL)
Exp. 5, split 1
Exp. 5, split 2
Pointing Maneuver
Exp. 5, split 1
Exp. 5, split 2
Pointing Maneuver
Unused Visibility = 3
Exp. 5 (Auto-WAVECAL)
Occultation
Exp. 6 (Auto-WAVECAL)
0
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1000
1500
2000
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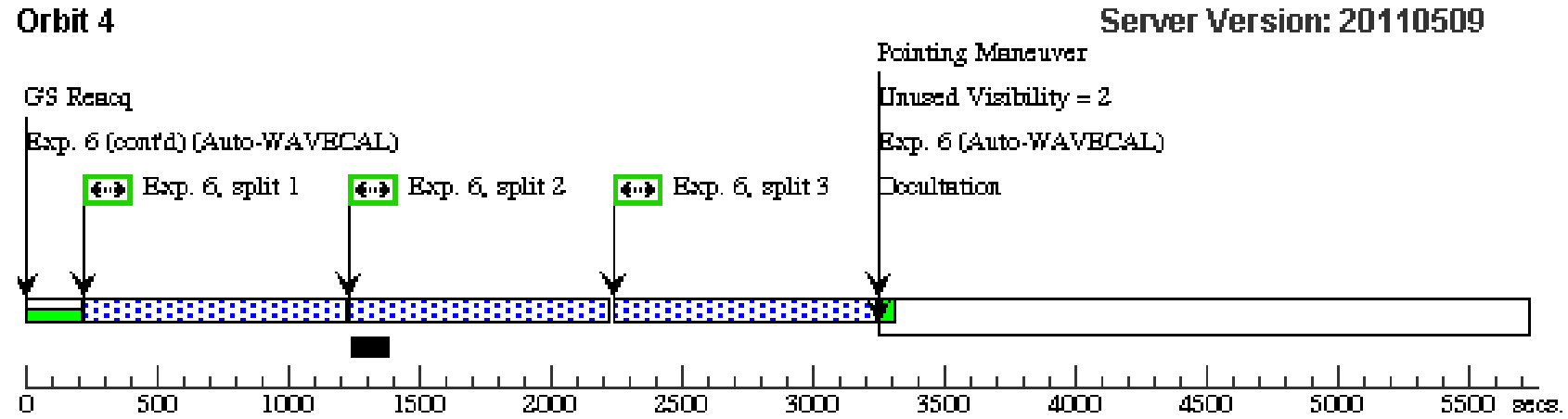
3000
3500
4000
4500
5000
5500
secs.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Server Version: 20110509
Pointing Maneuver
GS Reacq
Unused Visibility = 2
Exp. 6 (cont'd) (Auto-WAVECAL)
Exp. 6 (Auto-WAVECAL)
Exp. 6, split 1
Exp. 6, split 2
Exp. 6, split 3
Occultation
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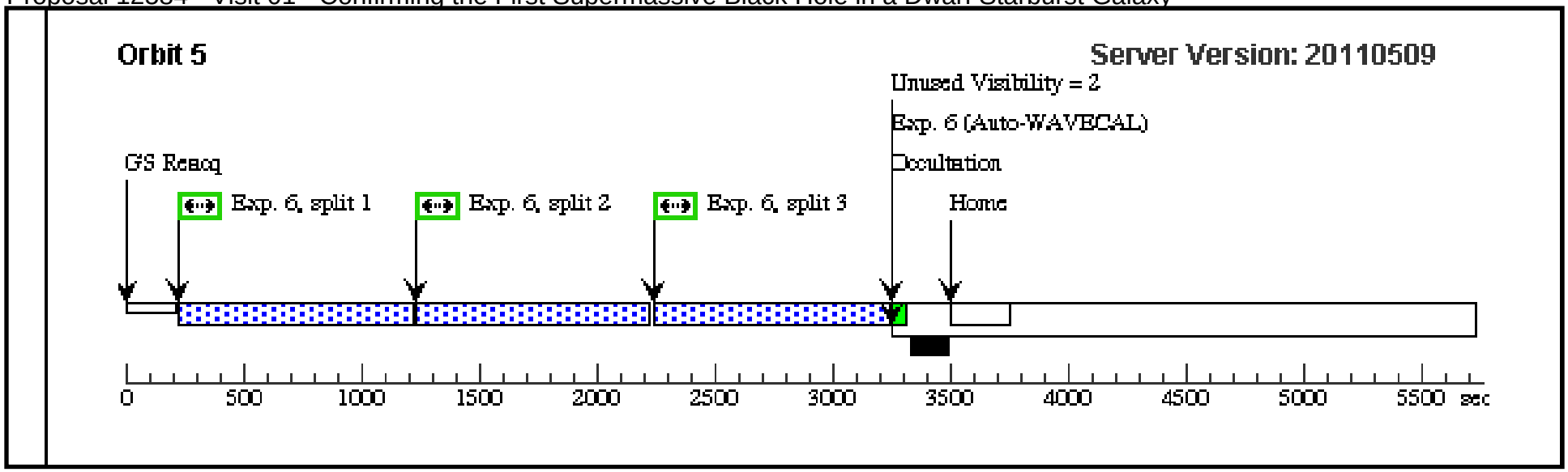
3500
4000
4500
5000
5500
secs.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Server Version: 20110509
Unused Visibility = 2
Exp. 6 (Auto-WAVECAL)
Occultation
GS Reacq
Exp. 6, split 1
Exp. 6, split 2
Exp. 6, split 3
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 12584, Visit 02 Fri Jul 01 01:24:08 GMT 2011

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/CCD

Special Requirements: ORIENT 50.35D TO 60.35 D; ORIENT 230.35D TO 240.35 D

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=STIS-ALONG-SLIT	Coordinate Frame=POS-TARG		(2), (4)
	Purpose=DITHER	Pattern Orientation=90.0		
	Number Of Points=2	Angle Between Sides=		
	Point Spacing=0.375	Center Pattern=false		
	Line Spacing=			

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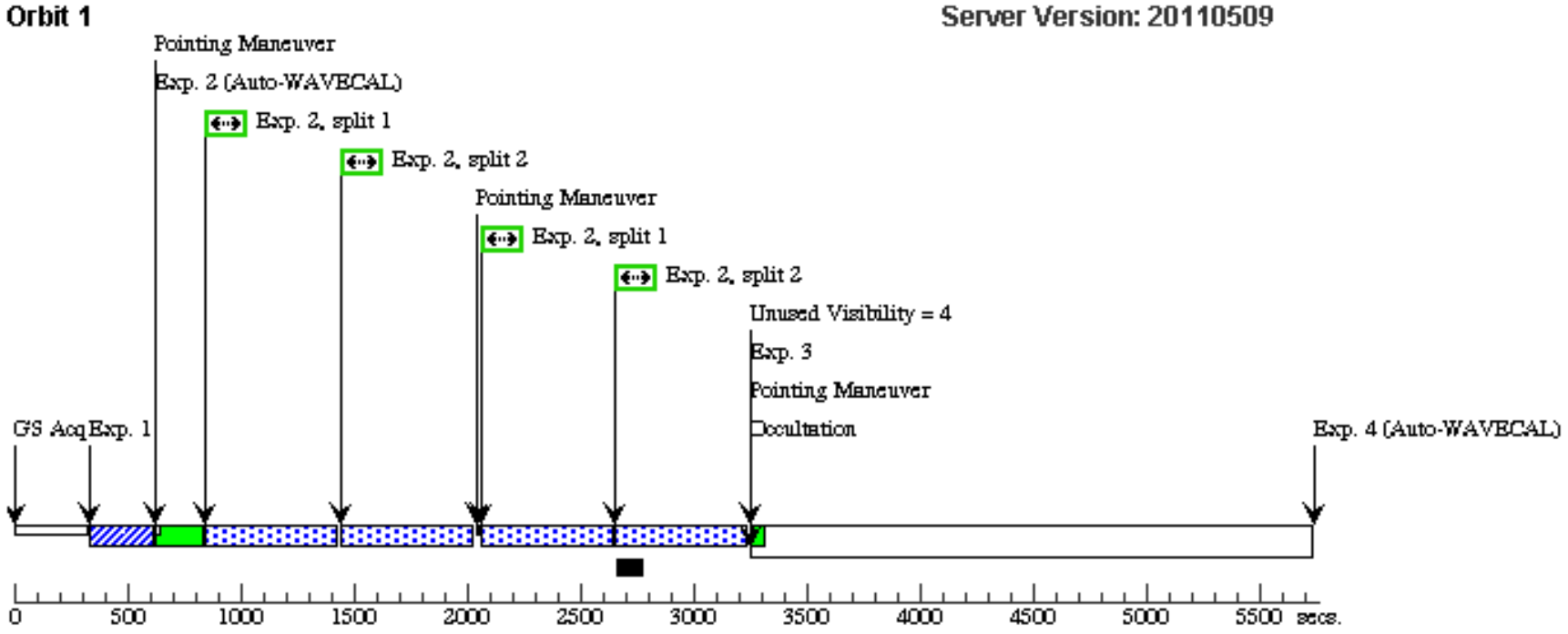
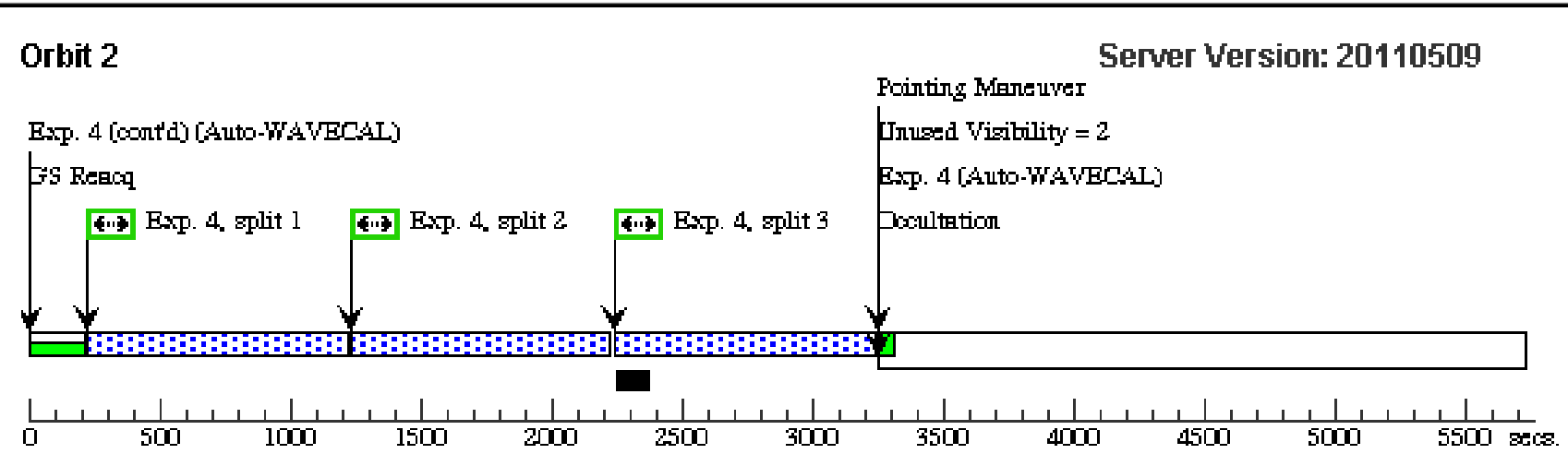
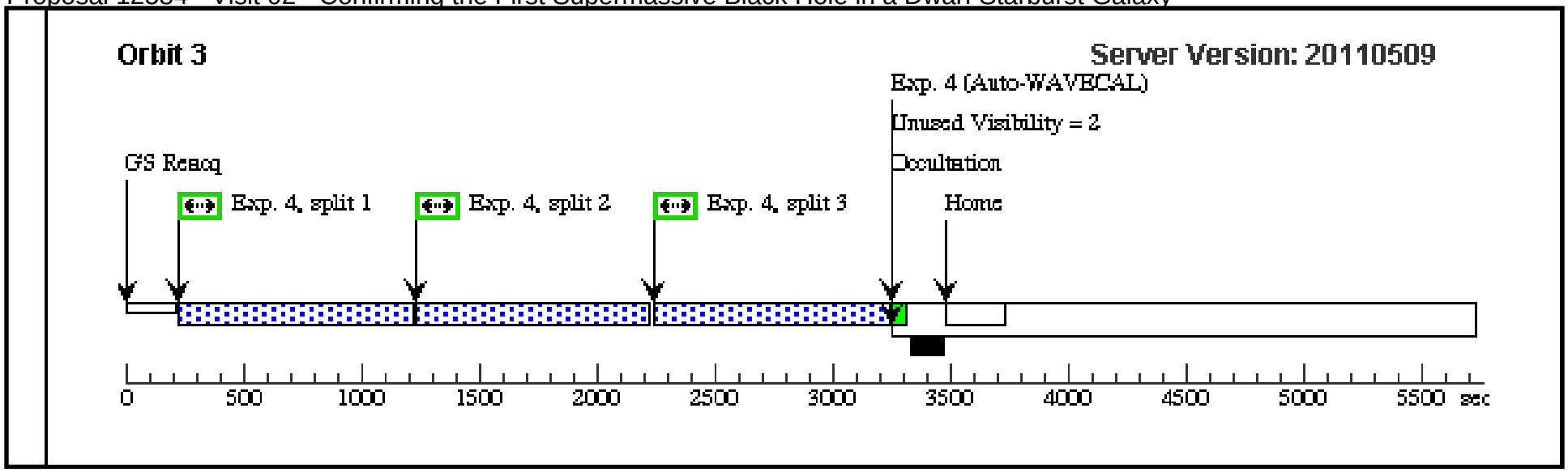
1	Acquisition	(3) HE2-10-OFFSET	STIS/CCD, ACQ, F28X50LP	MIRROR	ACQTYPE=POINT			13 Secs	
								[==>]	***[1]***
2	NS-HighRes -Red	(2) HE2-10-NS	STIS/CCD, ACCUM, 52X0.2E1	G750M 6581 A	CR-SPLIT=2		Pattern 1, Exps 2-2 i n Visit 02 (1)	1098 Secs	
								[==>(Pattern 1, Split 1)]	***[1]***
								[==>(Pattern 1, Split 2)]	
								[==>(Pattern 2, Split 1)]	
								[==>(Pattern 2, Split 2)]	
3	ExtraWaveC al	WAVE	STIS/CCD, ACCUM, 52X0.2	G750M 6581 A				*[==>]*	***[1]***
4	NS-HighRes -Blue	(2) HE2-10-NS	STIS/CCD, ACCUM, 52X0.2E1	G430M 4961 A	CR-SPLIT=3		Pattern 1, Exps 4-4 i n Visit 02 (1)	2895 Secs	
								[==>(Pattern 1, Split 1)]	***[2]***
								[==>(Pattern 1, Split 2)]	
								[==>(Pattern 1, Split 3)]	
								[==>(Pattern 2, Split 1)]	***[3]***
								[==>(Pattern 2, Split 2)]	
								[==>(Pattern 2, Split 3)]	

Orbit Structure






Orbit 3
Server Version: 20110509
Exp. 4 (Auto-WAVECAL)
Unused Visibility = 2
Occultation
GS Reacq
Exp. 4, split 1
Exp. 4, split 2
Exp. 4, split 3
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec