



# 16843 - Dwarf Galaxies with Radio-Selected (and Sometimes Wandering) Massive Black Holes

Cycle: 29, Proposal Category: GO  
(Availability Mode: SUPPORTED)

## INVESTIGATORS

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## VISITS

<i>Visit</i>	<i>Targets used in Visit</i>	<i>Configurations used in Visit</i>	<i>Orbits Used</i>	<i>Last Orbit Planner Run</i>	<i>OP Current with Visit?</i>
01	(1) J001900.30+150710.9	WFC3/UVIS	1	18-Oct-2021 14:00:53.0	yes
02	(2) J010607.17+004633.6	WFC3/UVIS	1	18-Oct-2021 14:00:54.0	yes
03	(3) J090313.10+482415.5	WFC3/UVIS	1	18-Oct-2021 14:00:55.0	yes
04	(4) J090908.65+565522.1	WFC3/UVIS	1	18-Oct-2021 14:00:56.0	yes
05	(5) J093138.47+563319.0	WFC3/UVIS	1	18-Oct-2021 14:00:57.0	yes
06	(6) J113642.72+264337.6	WFC3/UVIS	1	18-Oct-2021 14:00:57.0	yes
07	(7) J122011.25+302008.1	WFC3/UVIS	1	18-Oct-2021 14:00:58.0	yes
08	(8) J122603.63+081519.0	WFC3/UVIS	1	18-Oct-2021 14:00:59.0	yes

8 Total Orbits Used

## ABSTRACT

Using high-resolution observations from the Very Large Array, Reines et al. (2020) discovered a set of compact radio sources in nearby dwarf galaxies with luminosities indicative of accreting massive BHs. Moreover, many of these radio sources are not in the centers of the galaxies with offsets as large as  $\sim 4''$  ( $\sim 2$  kpc). We propose Chandra and HST observations of 8 dwarf galaxies hosting radio-selected massive BHs to 1) firmly establish the presence of massive BHs (some of which are 'wandering') in these dwarf galaxies and characterize the compact X-ray emission from the BHs, 2) place some constraints on the BH masses and Eddington ratios, and 3) search for stellar counterparts of the BHs and determine spatially-resolved star formation rates in the host galaxies.

## OBSERVING DESCRIPTION

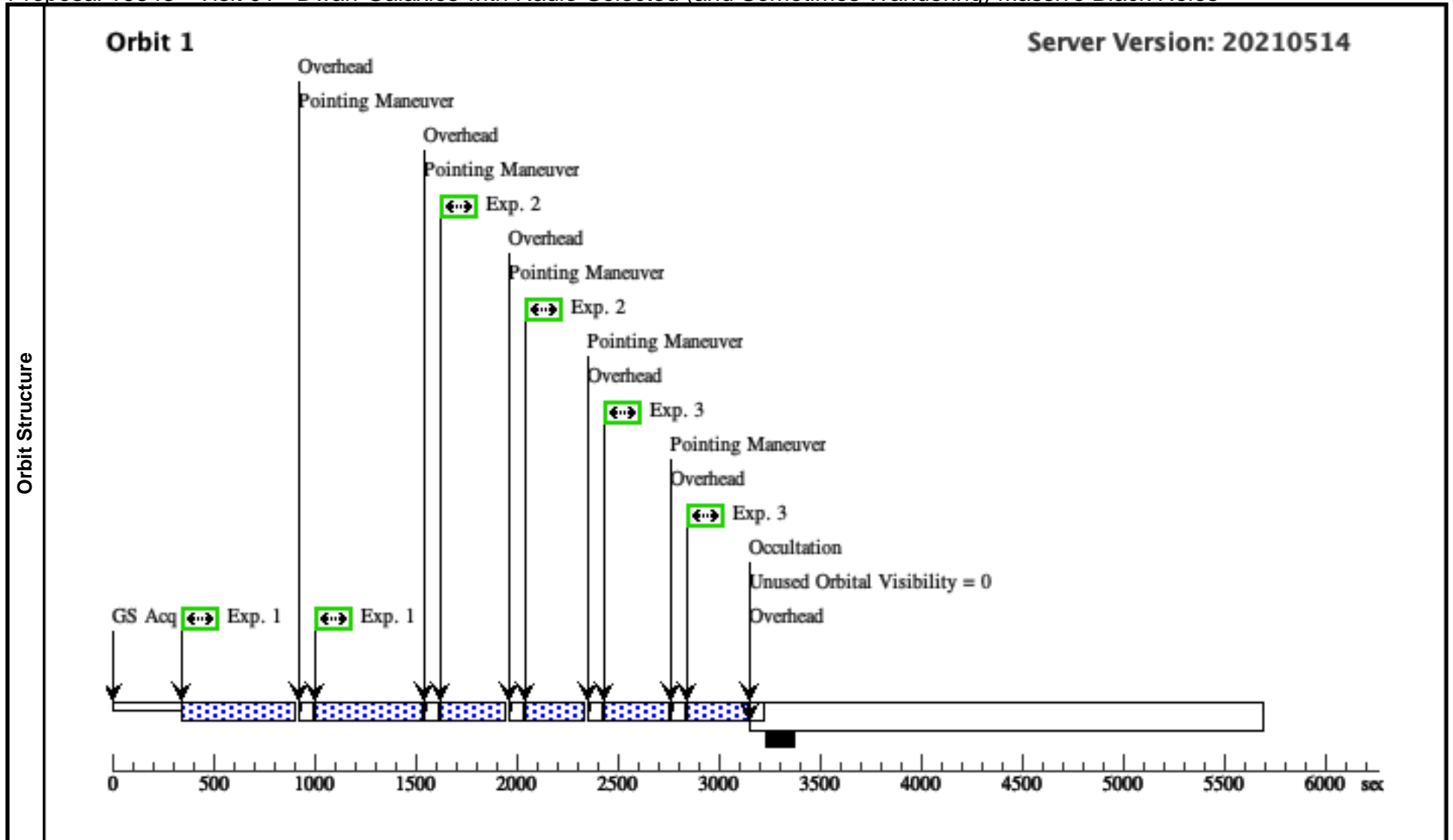
We will obtain HST/WFC3 observations in three filters, including UVIS narrow-band H-alpha imaging (F680N or F665N depending on redshift) and wide-band continuum imaging in F475W and F814W. We choose the wideband filters to bracket the wavelength of H-alpha (for continuum subtraction) and to obtain color information. We can achieve our science goals with one HST orbit per galaxy for a total of 8 orbits.

From prior experience, exposure times are based on detecting a 5 Myr-old,  $\sim 10^5$  Msun star cluster in our most distant target galaxy ( $z = 0.05$ ) with a signal-to-noise ratio of  $S/N = 10$ . Starburst99 models of an instantaneous burst indicate that the corresponding H-alpha flux is  $\sim 10^{-16}$  erg/s/cm<sup>2</sup> with an underlying continuum flux density of  $\sim 5 \times 10^{-19}$  erg/s/cm<sup>2</sup>/Ang. Assuming the cluster is a point source, the WFC3/UVIS exposure time calculator suggests we need  $\sim 17$  minutes in F680N. The required times in F475W and F814W are  $\sim 8$  and  $\sim 9$  minutes, respectively. Note that we have also allowed for 1 magnitude of visual extinction ( $A_V = 1$  mag) in these calculations. We will break the total time into two dithered exposures to improve the PSF sampling and avoid bad pixels, as well as include a post flash to avoid poor charge efficiency. We will use the UVIS 1k x 1k subarray (to avoid buffer dumps) with the more efficient chip 2. Our galaxies are quite compact so using a subarray will not compromise our science or limit our sky subtraction.

Proposal 16843 - Visit 01 - Dwarf Galaxies with Radio-Selected (and Sometimes Wandering) Massive Black Holes

Mon Oct 18 18:00:59 GMT 2021

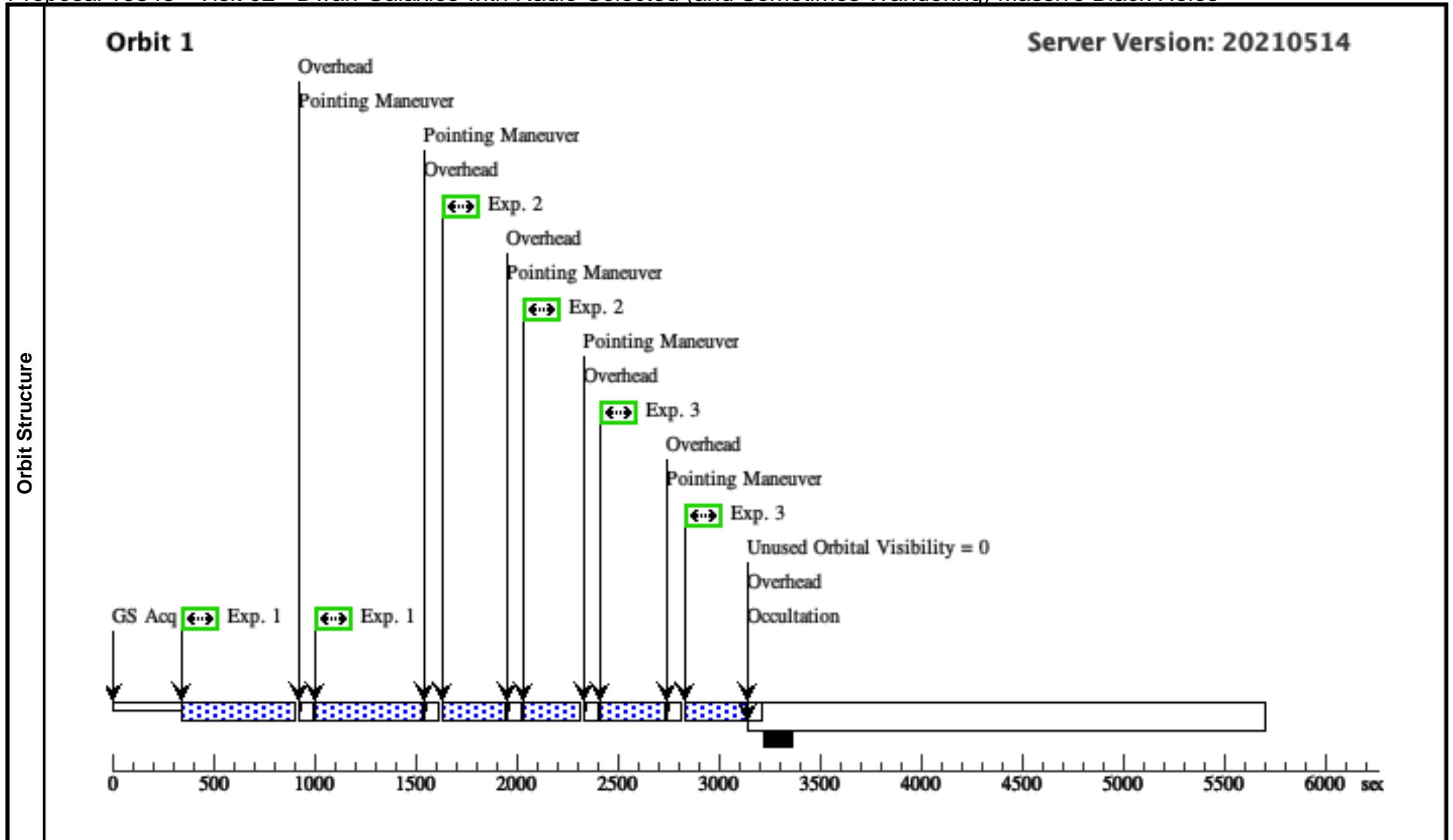
Visit	<b>Proposal 16843, Visit 01, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	Patterns	#	Primary Pattern	Secondary Pattern	Exposures					
		(1)	Pattern Type=WFC3-UVIS-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1), (2), (3)				
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	J001900.30+150710.9	RA: 00 18 59.9900 (4.7499583d) Dec: +15 07 11.03 (15.11973d) Equinox: J2000	Epoch of Position: 2015.5	V=17.8	Reference Frame: ICRS				
	<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> Category=GALAXY Description=[DWARF COMPACT, MAGELLANIC IRREGULAR] Extended=YES									
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(1) J001900.30+150710.9	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F680N	FLASH=15		Pattern 1, Exps 1-1 in Visit 01 (1)	530 Secs (1060 Secs)	
									[==>(Pattern 1)]	[1]
									[==>(Pattern 2)]	
2		(1) J001900.30+150710.9	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F475W	FLASH=12		Pattern 1, Exps 2-2 in Visit 01 (1)	292 Secs (584 Secs)		
								[==>(Pattern 1)]	[1]	
								[==>(Pattern 2)]		
3		(1) J001900.30+150710.9	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F814W	FLASH=11		Pattern 1, Exps 3-3 in Visit 01 (1)	300 Secs (600 Secs)		
								[==>(Pattern 1)]	[1]	
								[==>(Pattern 2)]		



Proposal 16843 - Visit 02 - Dwarf Galaxies with Radio-Selected (and Sometimes Wandering) Massive Black Holes

Mon Oct 18 18:01:00 GMT 2021

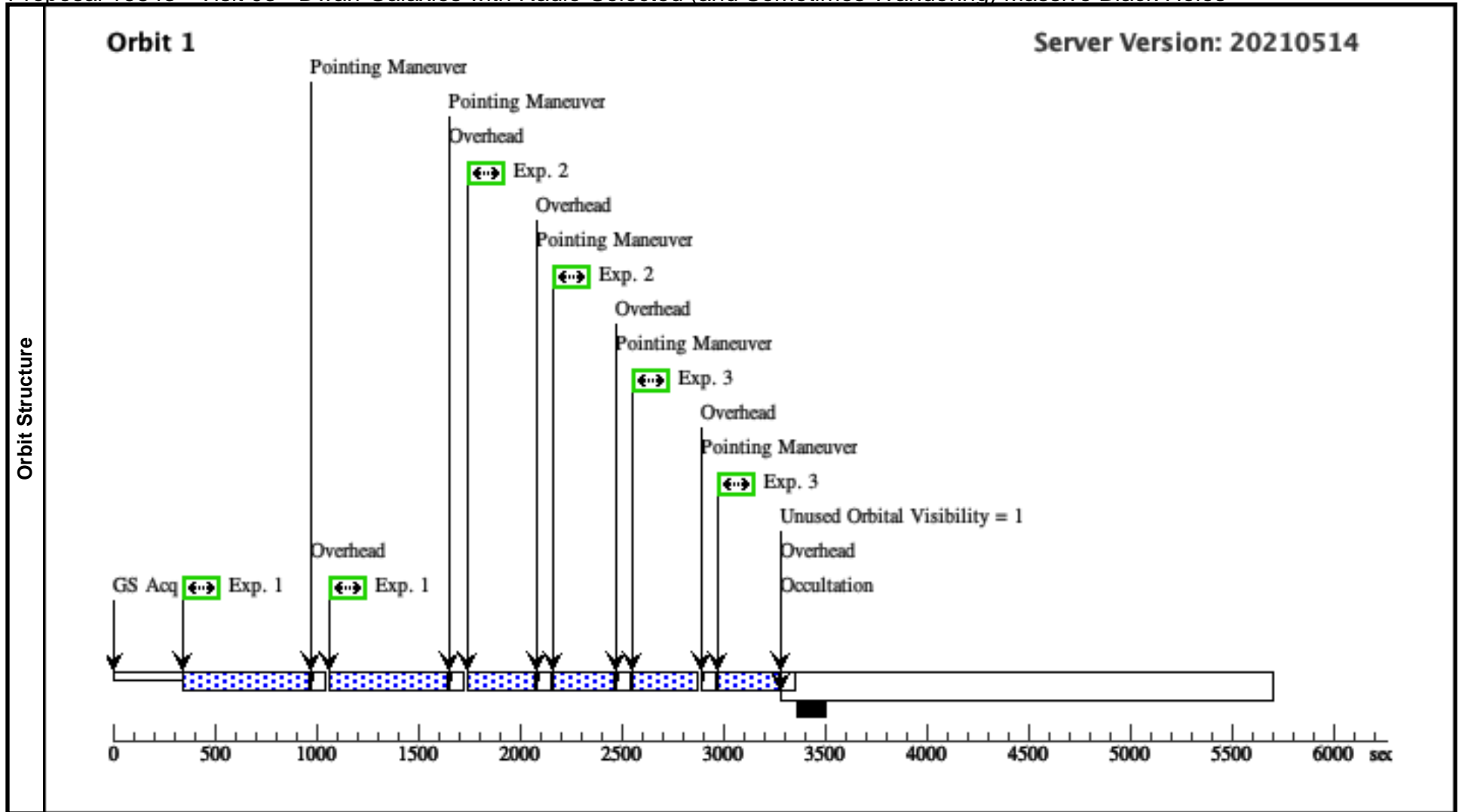
Visit	<b>Proposal 16843, Visit 02, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	Patterns	#	Primary Pattern	Secondary Pattern	Exposures					
		(1)	Pattern Type=WFC3-UVIS-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1), (2), (3)				
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(2)	J010607.17+004633.6	RA: 01 06 7.3100 (16.5304583d) Dec: +00 46 34.32 (.77620d) Equinox: J2000		V=16.3	Reference Frame: ICRS				
	<i>Comments:</i> Category=GALAXY Description=[DWARF COMPACT, MAGELLANIC IRREGULAR] Extended=YES									
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(2) J010607.17+004633.6	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F665N	FLASH=17		Pattern 1, Exps 1-1 in Visit 02 (1)	530 Secs (1060 Secs)	
									[==>(Pattern 1)]	[1]
									[==>(Pattern 2)]	
2		(2) J010607.17+004633.6	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F475W	FLASH=12		Pattern 1, Exps 2-2 in Visit 02 (1)	287 Secs (574 Secs)		
								[==>(Pattern 1)]	[1]	
								[==>(Pattern 2)]		
3		(2) J010607.17+004633.6	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F814W	FLASH=11		Pattern 1, Exps 3-3 in Visit 02 (1)	300 Secs (600 Secs)		
								[==>(Pattern 1)]	[1]	
								[==>(Pattern 2)]		



Proposal 16843 - Visit 03 - Dwarf Galaxies with Radio-Selected (and Sometimes Wandering) Massive Black Holes

Mon Oct 18 18:01:00 GMT 2021

Visit	<b>Proposal 16843, Visit 03, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	Patterns	#	Primary Pattern	Secondary Pattern	Exposures					
		(1)	Pattern Type=WFC3-UVIS-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1), (2), (3)				
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(3)	J090313.10+482415.5	RA: 09 03 12.9700 (135.8040417d) Dec: +48 24 13.72 (48.40381d) Equinox: J2000		V=17.7	Reference Frame: ICRS				
	<i>Comments:</i> Category=GALAXY Description=[DWARF COMPACT, MAGELLANIC IRREGULAR] Extended=YES									
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(3) J090313.10+482415.5	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F680N	FLASH=15		Pattern 1, Exps 1-1 in Visit 03 (1)	586 Secs (1172 Secs)	
									[==>(Pattern 1)]	[1]
									[==>(Pattern 2)]	
2		(3) J090313.10+482415.5	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F475W	FLASH=12		Pattern 1, Exps 2-2 in Visit 03 (1)	300 Secs (600 Secs)		
								[==>(Pattern 1)]	[1]	
								[==>(Pattern 2)]		
3		(3) J090313.10+482415.5	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F814W	FLASH=11		Pattern 1, Exps 3-3 in Visit 03 (1)	300 Secs (600 Secs)		
								[==>(Pattern 1)]	[1]	
								[==>(Pattern 2)]		

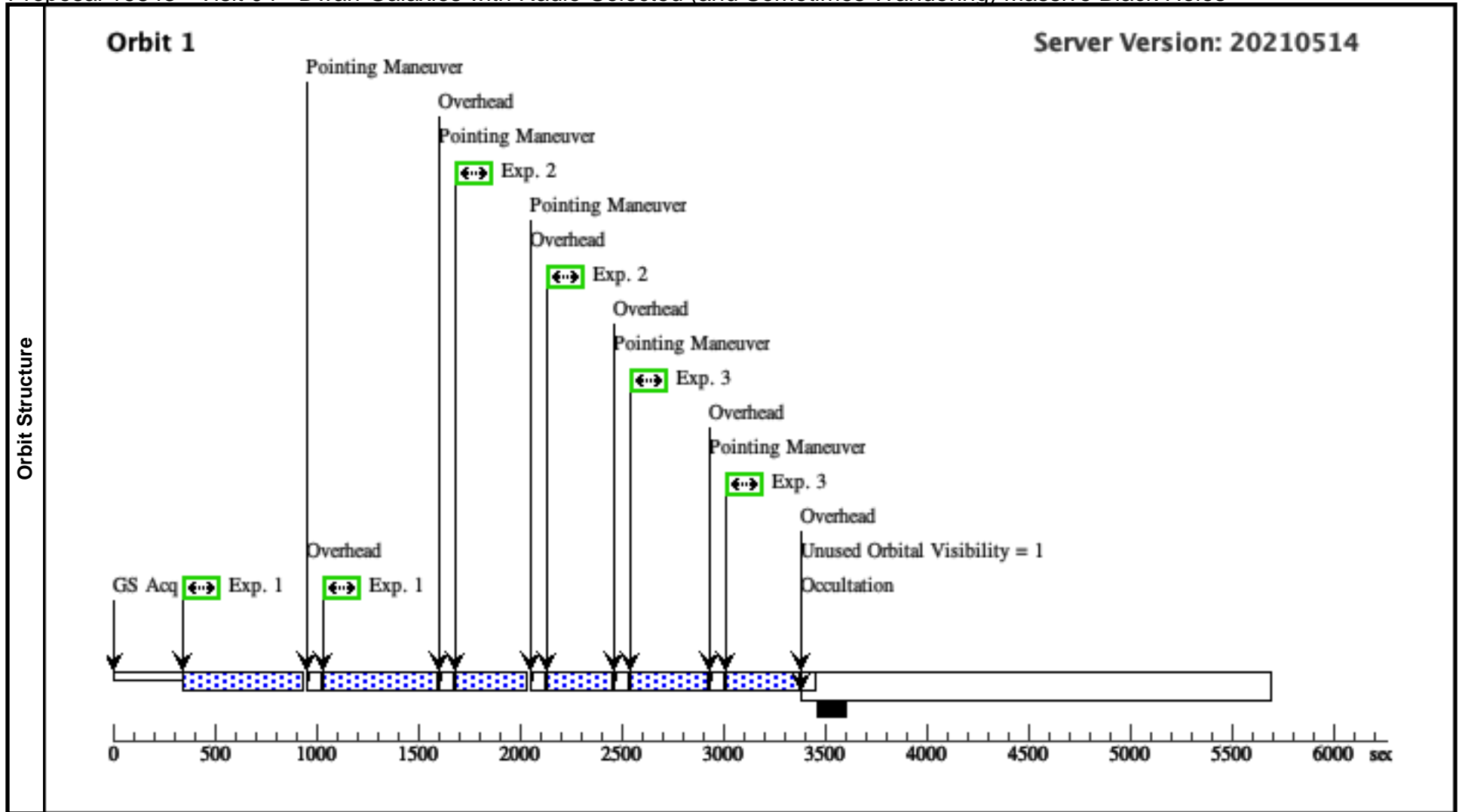




Proposal 16843 - Visit 04 - Dwarf Galaxies with Radio-Selected (and Sometimes Wandering) Massive Black Holes

Mon Oct 18 18:01:00 GMT 2021

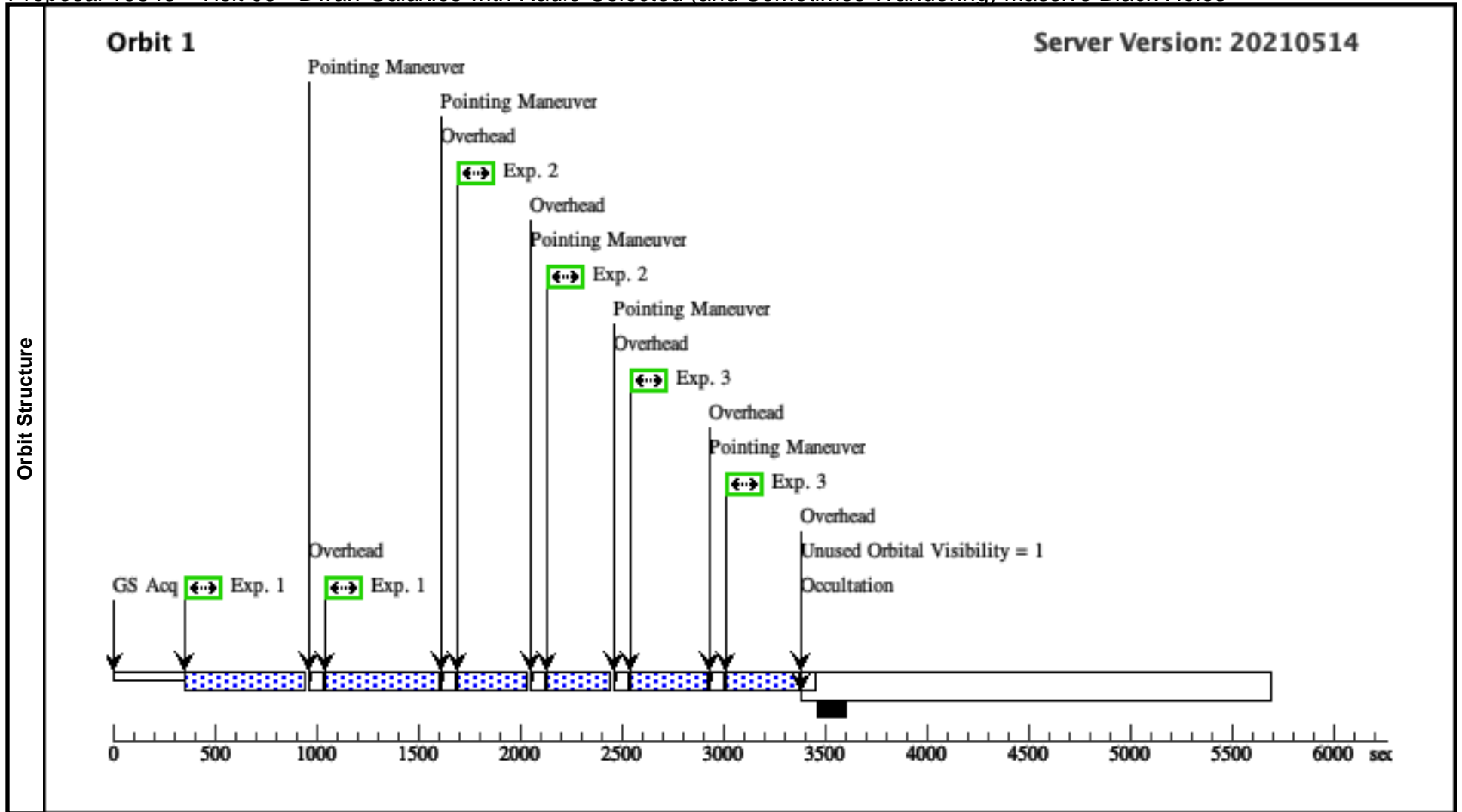
Visit	<b>Proposal 16843, Visit 04, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	Patterns	#	Primary Pattern	Secondary Pattern	Exposures					
		(1)	Pattern Type=WFC3-UVIS-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1), (2), (3)				
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(4)	J090908.65+565522.1	RA: 09 09 8.6900 (137.2862083d) Dec: +56 55 19.74 (56.92215d) Equinox: J2000		V=18.3	Reference Frame: ICRS				
	<i>Comments:</i> Category=GALAXY Description=[DWARF COMPACT, MAGELLANIC IRREGULAR] Extended=YES									
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(4) J090908.65+565522.1	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F680N	FLASH=15		Pattern 1, Exps 1-1 in Visit 04 (1)	560 Secs (1120 Secs)	
									[==>(Pattern 1)] [==>(Pattern 2)]	[1]
	2		(4) J090908.65+565522.1	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F475W	FLASH=12		Pattern 1, Exps 2-2 in Visit 04 (1)	318 Secs (636 Secs)	
								[==>(Pattern 1)] [==>(Pattern 2)]	[1]	
3		(4) J090908.65+565522.1	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F814W	FLASH=11		Pattern 1, Exps 3-3 in Visit 04 (1)	360 Secs (720 Secs)		
								[==>(Pattern 1)] [==>(Pattern 2)]	[1]	



Proposal 16843 - Visit 05 - Dwarf Galaxies with Radio-Selected (and Sometimes Wandering) Massive Black Holes

Mon Oct 18 18:01:00 GMT 2021

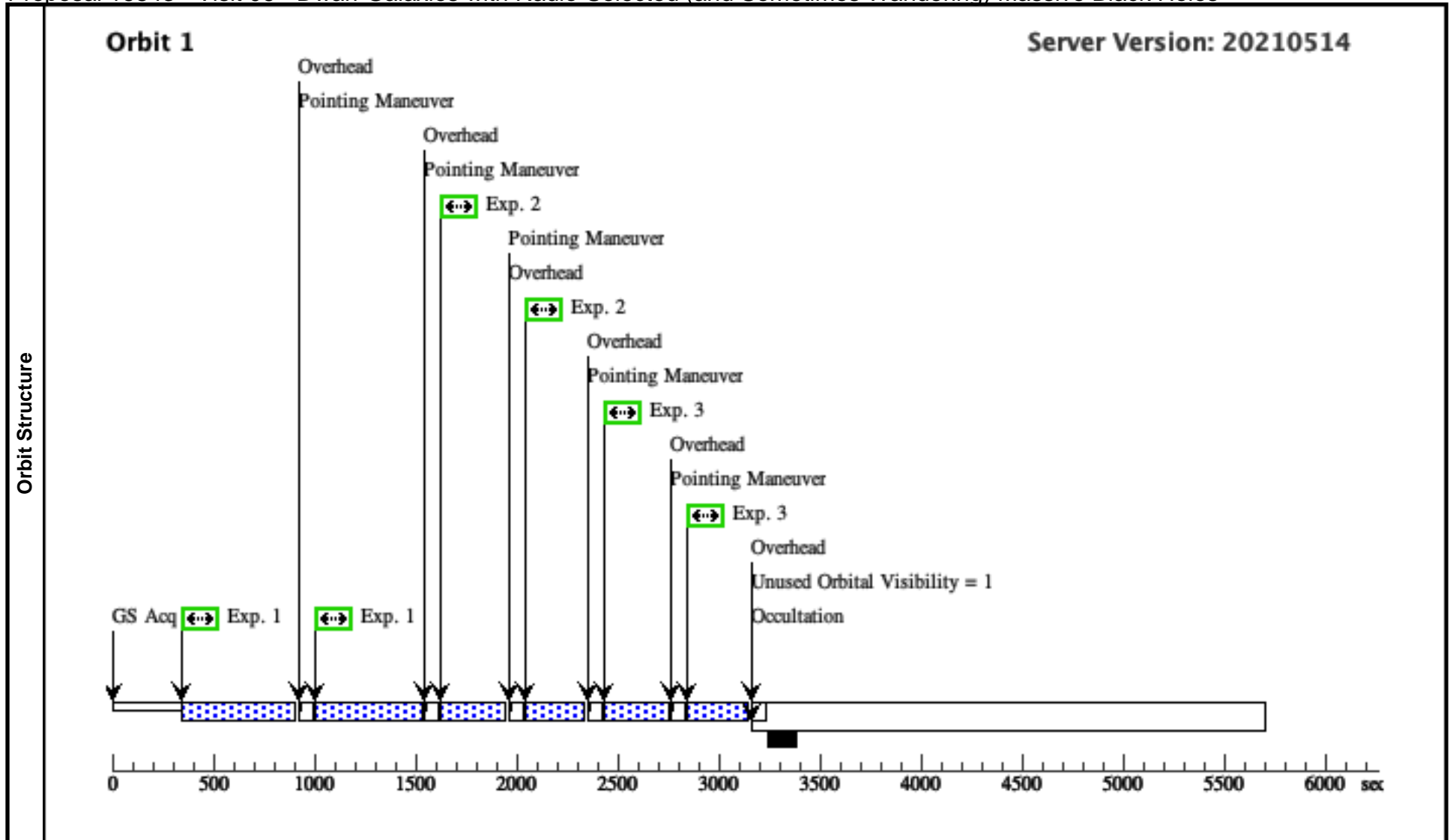
Visit	<b>Proposal 16843, Visit 05, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	Patterns	#	Primary Pattern	Secondary Pattern	Exposures					
	(1)	Pattern Type=WFC3-UVIS-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1), (2), (3)					
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(5)	J093138.47+563319.0	RA: 09 31 38.4200 (142.9100833d) Dec: +56 33 19.87 (56.55552d) Equinox: J2000		V=19.8	Reference Frame: ICRS				
	<i>Comments:</i> Category=GALAXY Description=[DWARF COMPACT, MAGELLANIC IRREGULAR] Extended=YES									
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(5) J093138.47+563319.0	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F680N	FLASH=15	GS ACQ SCENARIO BASE1BE	Pattern 1, Exps 1-1 in Visit 05 (1)	560 Secs (1120 Secs)	
									[=>(Pattern 1)] [=>(Pattern 2)]	[1]
	2		(5) J093138.47+563319.0	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F475W	FLASH=12		Pattern 1, Exps 2-2 in Visit 05 (1)	313 Secs (626 Secs)	
								[=>(Pattern 1)] [=>(Pattern 2)]	[1]	
3		(5) J093138.47+563319.0	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F814W	FLASH=11		Pattern 1, Exps 3-3 in Visit 05 (1)	360 Secs (720 Secs)		
								[=>(Pattern 1)] [=>(Pattern 2)]	[1]	



Proposal 16843 - Visit 06 - Dwarf Galaxies with Radio-Selected (and Sometimes Wandering) Massive Black Holes

Mon Oct 18 18:01:00 GMT 2021

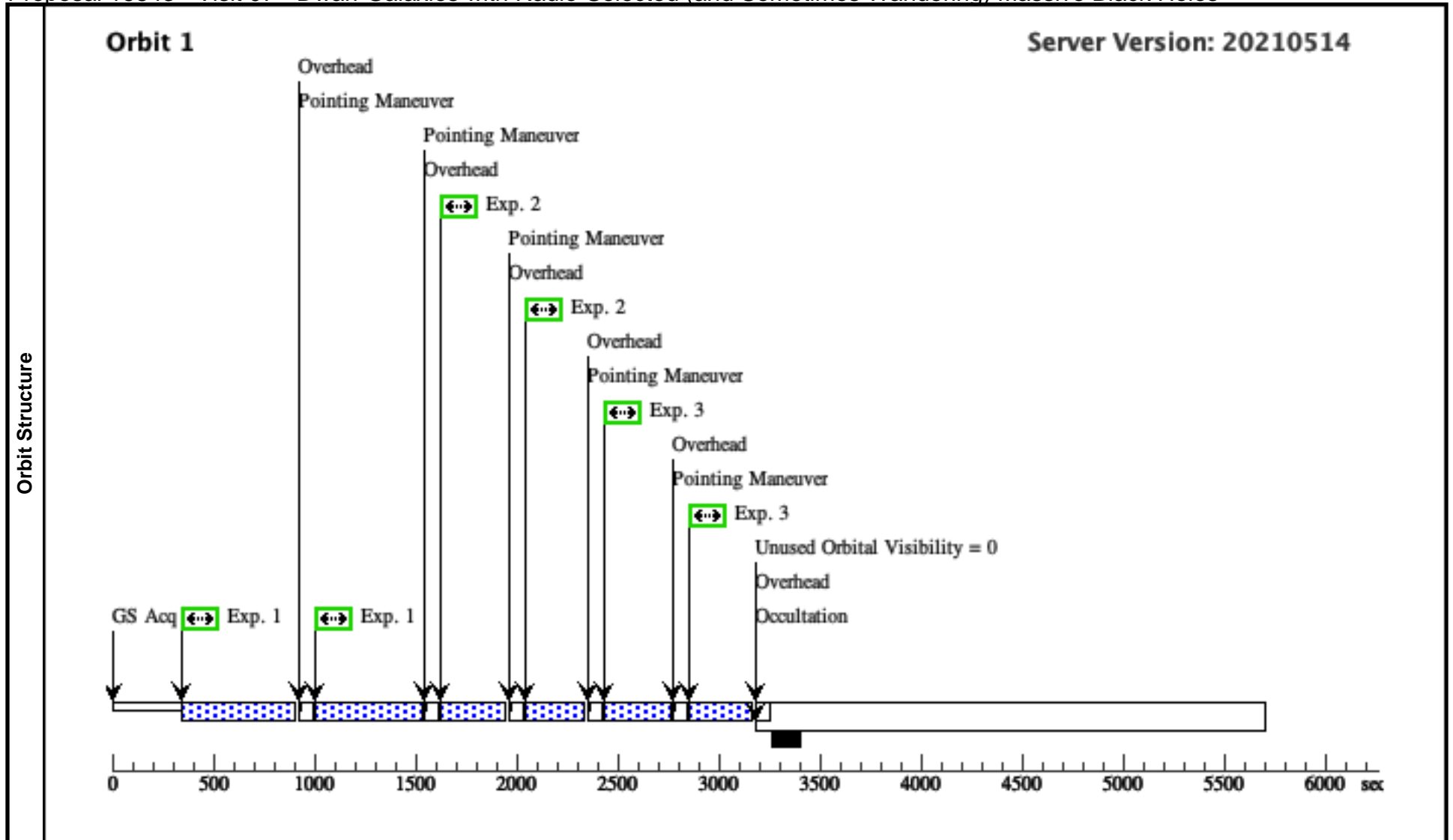
Visit	<b>Proposal 16843, Visit 06, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	Patterns	#	Primary Pattern	Secondary Pattern	Exposures					
		(1)	Pattern Type=WFC3-UVIS-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1), (2), (3)				
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(6)	J113642.72+264337.6	RA: 11 36 42.5800 (174.1774167d) Dec: +26 43 35.65 (26.72657d) Equinox: J2000		V=17.8	Reference Frame: ICRS				
	<i>Comments:</i> Category=GALAXY Description=[DWARF COMPACT, MAGELLANIC IRREGULAR] Extended=YES									
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(6) J113642.72+264337.6	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F680N	FLASH=15		Pattern 1, Exps 1-1 in Visit 06 (1)	530 Secs (1060 Secs)	
									[==>(Pattern 1)]	[1]
									[==>(Pattern 2)]	
2		(6) J113642.72+264337.6	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F475W	FLASH=12		Pattern 1, Exps 2-2 in Visit 06 (1)	292 Secs (584 Secs)		
								[==>(Pattern 1)]	[1]	
								[==>(Pattern 2)]		
3		(6) J113642.72+264337.6	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F814W	FLASH=11		Pattern 1, Exps 3-3 in Visit 06 (1)	304 Secs (608 Secs)		
								[==>(Pattern 1)]	[1]	
								[==>(Pattern 2)]		



Proposal 16843 - Visit 07 - Dwarf Galaxies with Radio-Selected (and Sometimes Wandering) Massive Black Holes

Mon Oct 18 18:01:00 GMT 2021

Visit	<b>Proposal 16843, Visit 07, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	Patterns	#	Primary Pattern	Secondary Pattern	Exposures					
		(1)	Pattern Type=WFC3-UVIS-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1), (2), (3)				
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(7)	J122011.25+302008.1	RA: 12 20 11.2700 (185.0469583d) Dec: +30 20 8.30 (30.33564d) Equinox: J2000		V=17.1	Reference Frame: ICRS				
	<i>Comments:</i> Category=GALAXY Description=[DWARF COMPACT, MAGELLANIC IRREGULAR] Extended=YES									
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(7) J122011.25+302008.1	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F680N	FLASH=15		Pattern 1, Exps 1-1 in Visit 07 (1)	530 Secs (1060 Secs)	
									[==>(Pattern 1)]	[1]
									[==>(Pattern 2)]	
2		(7) J122011.25+302008.1	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F475W	FLASH=12		Pattern 1, Exps 2-2 in Visit 07 (1)	292 Secs (584 Secs)		
								[==>(Pattern 1)]	[1]	
								[==>(Pattern 2)]		
3		(7) J122011.25+302008.1	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F814W	FLASH=11		Pattern 1, Exps 3-3 in Visit 07 (1)	312 Secs (624 Secs)		
								[==>(Pattern 1)]	[1]	
								[==>(Pattern 2)]		





Proposal 16843 - Visit 08 - Dwarf Galaxies with Radio-Selected (and Sometimes Wandering) Massive Black Holes

Mon Oct 18 18:01:00 GMT 2021

Visit	<b>Proposal 16843, Visit 08, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	Patterns	#	Primary Pattern			Secondary Pattern			Exposures	
		(1)	Pattern Type=WFC3-UVIS-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false					(1), (2), (3)	
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(8)	J122603.63+081519.0	RA: 12 26 3.6400 (186.5151667d) Dec: +08 15 19.01 (8.25528d) Equinox: J2000		V=17.0	Reference Frame: ICRS				
	<i>Comments:</i> Category=GALAXY Description=[DWARF COMPACT, MAGELLANIC IRREGULAR] Extended=YES									
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(8) J122603.63+081519.0	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F680N	FLASH=15	GS ACQ SCENARIO BASE1BE	Pattern 1, Exps 1-1 in Visit 08 (1)	515 Secs (1030 Secs) [=>(Pattern 1)] [=>(Pattern 2)]	[1]
	2		(8) J122603.63+081519.0	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F475W	FLASH=12		Pattern 1, Exps 2-2 in Visit 08 (1)	266 Secs (532 Secs) [=>(Pattern 1)] [=>(Pattern 2)]	[1]
	3		(8) J122603.63+081519.0	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F814W	FLASH=11		Pattern 1, Exps 3-3 in Visit 08 (1)	285 Secs (570 Secs) [=>(Pattern 1)] [=>(Pattern 2)]	[1]

