11624 - Black hole superkicks: Imaging the site of a gravitational wave recoil event

Cycle: 17, 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) SDSSJ092712.65+294344.0 (2) SDSSJ092717.59+294343.9	ACS/WFC WFC3/IR	4	24-Apr-2009 21:01:00.0	yes

4 Total Orbits Used

ABSTRACT

Recent numerical relativity simulations of coalescing, binary supermassive black holes (SMBHs) predict kick velocities as large as several thousand km/s due to anisotropic emission of gravitational waves. We have recently discovered the best candidate to date for such a recoiling SMBH, the quasar SDSS0927+2943. It shows an exceptional optical emission-line spectrum with two sets of emission lines; one set of very narrow emission lines, and a second set of broad Balmer and broad high-ionization forbidden lines which are blueshifted by 2650 km/s relative to the narrow emission

lines. This is the predicted spectroscopic signature of a SMBH recoiling from the core of its host galaxy, carrying with it the broad-line gas while leaving behind the bulk of the narrow-line gas. We apply for HST imaging in two filters for two orbits each in order to confirm the recoil model by detecting the host galaxy of the SMBH and measuring the angular offset of the recoiling SMBH from the host galaxy core; and determining, if possible, the morphology of the host galaxy in order to constrain its merger history. Confirmation of the SMBH ejection model for SDSSJ0927+2943 with HST will show decisively that kicks large enough to remove SMBHs completely from their host galaxies do occur, a result that would have profound implications for models of SMBH evolution and galaxy assembly and for numerical relativity.

OBSERVING DESCRIPTION

We propose to obtain imaging observations of SDSSJ0927+2943 in two bands, and an image of a nearby star for accurate PSF modelling, with a total observing time of 4 orbits.

For the NIR imaging (restframe red), WFC3-IR is our instrument of choice because of its high sensitivity. We will use WFC3 in combination with the filter F110W. This broadband filter ensures a high throughput, and will trace well the stellar population of the (elliptical) host galaxy. In order to detect the host galaxy out to one Petrosian radius with a S/N of 10, we need an exposure time of 3000s with WFC3/F110W. Together with the PSF star (see below) and overheads this fills two orbits.

In order to obtain the image in the red band (restframe blue), we will use ACS-WFC in combination with the broad-band filter F606W. For a detection with S/N=10 of the possible post-merger younger stellar populations with bright individual knots we estimate an exposure time of 2800s with ACS-WFC/F606W. In order to optimize ACS buffer dumps, and since our target source does not widely extend across the whole WFC field, we are using the WFC1-2k aperture.

Accurate PSF modelling and subtraction is very important for galaxies with active cores at high redhsift (z=0.7 in our case). In our case, an advantage is the expected shift of the recoiling quasar w.r.t the galaxy core. Since the quasar itself is significantly brighter (SDSS-r magnitude of 18.3) than the host galaxy, its central pixels will inevitably be saturated in long exposures. We will therefore split the total science exposure in several sub-exposures of durations of 3s, 10, and 30s, and then use the remaining time per orbit. Dithering will be performed in order to remove CRs and hot pixels, and to better sample the PSF.

For accurate PSF modelling we will observe a nearby star, within the same orbit as the science exposure. We have carefully inspected the SDSS field around our target source, and find that the star SDSSJ092717.59+294343.9 is well-suited. It has a brightness of 15.5 mag, and is located at a distance

of 60 arcsec from SDSSJ0927+2943. Since changes of pointing direction up to 2 arcmin are allowed within one orbit, we will obtain an image of this star during the same orbit, located at exactly the same position on the detector as our target source. In order to also sample the inner part of the PSF, we will take two images of the star, one of 3 s duration to ensure that the core is unsaturated, and one of 100s duration. We will take these images in each filter.

Visit

Proposal 11624, Visit 01, implementation Sat Apr 25 01:01:08 GMT 2009

Diagnostic Status: Warning

Scientific Instruments: WFC3/IR, ACS/WFC

Special Requirements: (none)

Diagnostics

(Visit 01) Warning (Orbit Planner): VISIBILITY OVERRUN

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=ACS-WFC-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=3.011 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=85.28 Angle Between Sides= Center Pattern=false		(1-2), (3-4), (5-7)
(2)	Pattern Type=WFC3-IR-DITHER-BOX-MIN Purpose=DITHER Number Of Points=4 Point Spacing=0.572 Line Spacing=0.365	Coordinate Frame=POS-TARG Pattern Orientation=18.528 Angle Between Sides=74.653 Center Pattern=false		(8), (9), (10), (11)

Fixed Targets

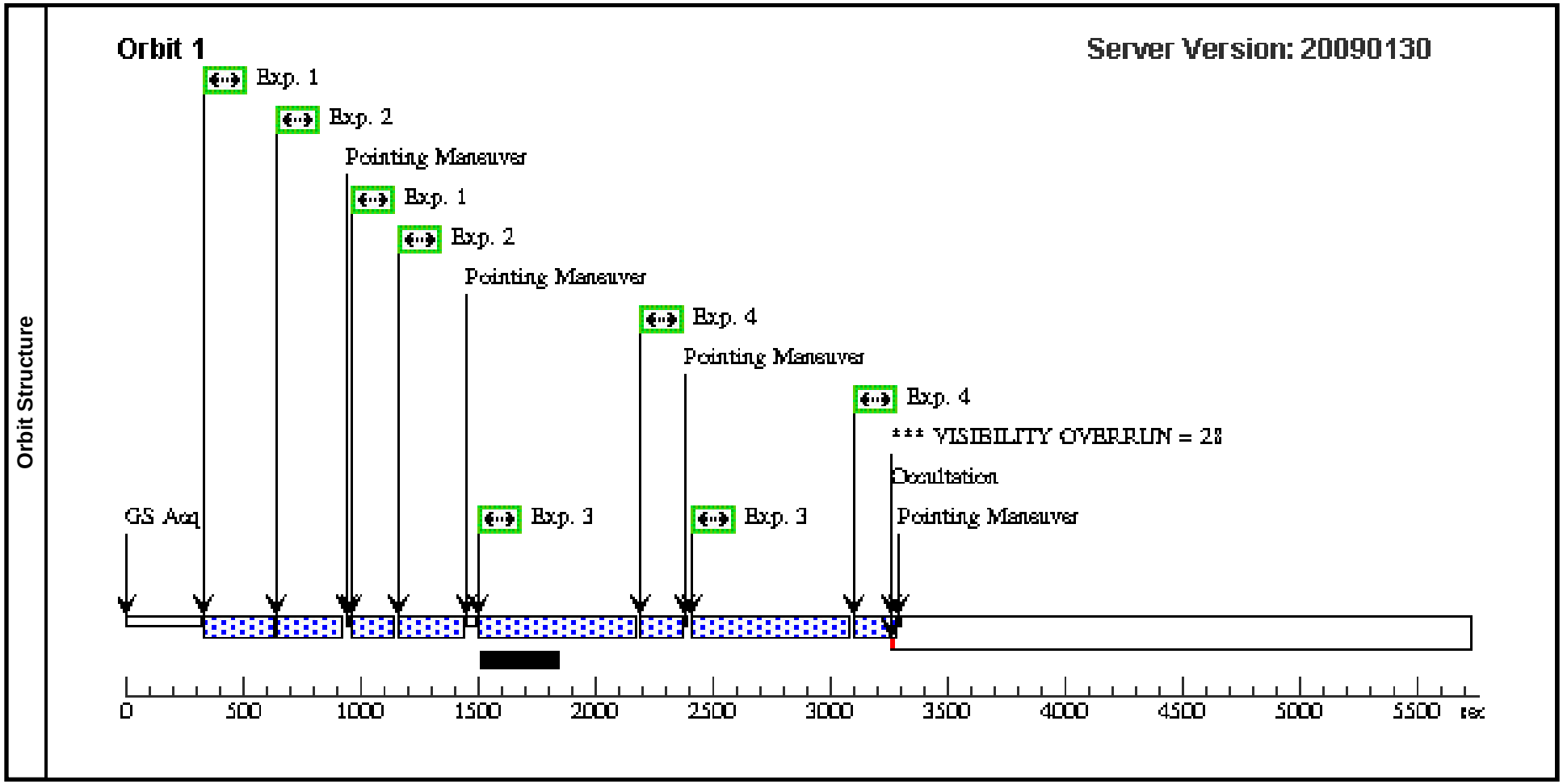
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	SDSSJ092712.65+294344.0	RA: 09 27 12.6500 (141.8027083d) Dec: +29 43 44.00 (29.72889d) Equinox: J2000		V=18.3	Reference Frame: ICRS
(2)	SDSSJ092717.59+294343.9	RA: 09 27 17.5900 (141.8232917d) Dec: +29 43 43.90 (29.72886d) Equinox: J2000		V=15.5	Reference Frame: ICRS

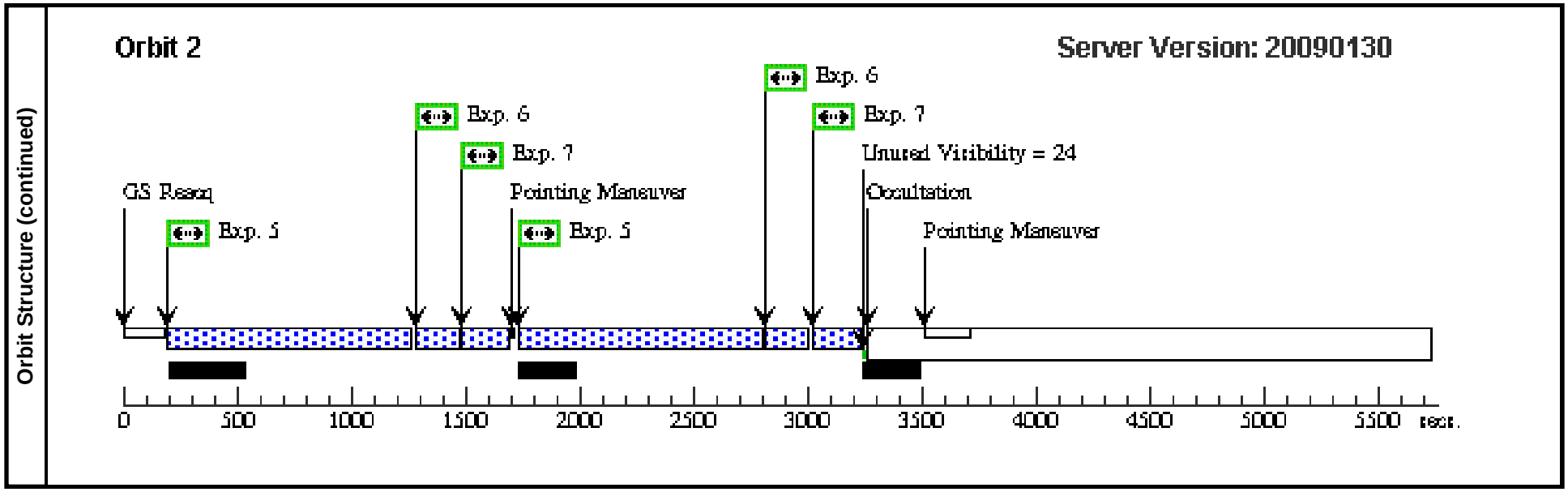
Exposures

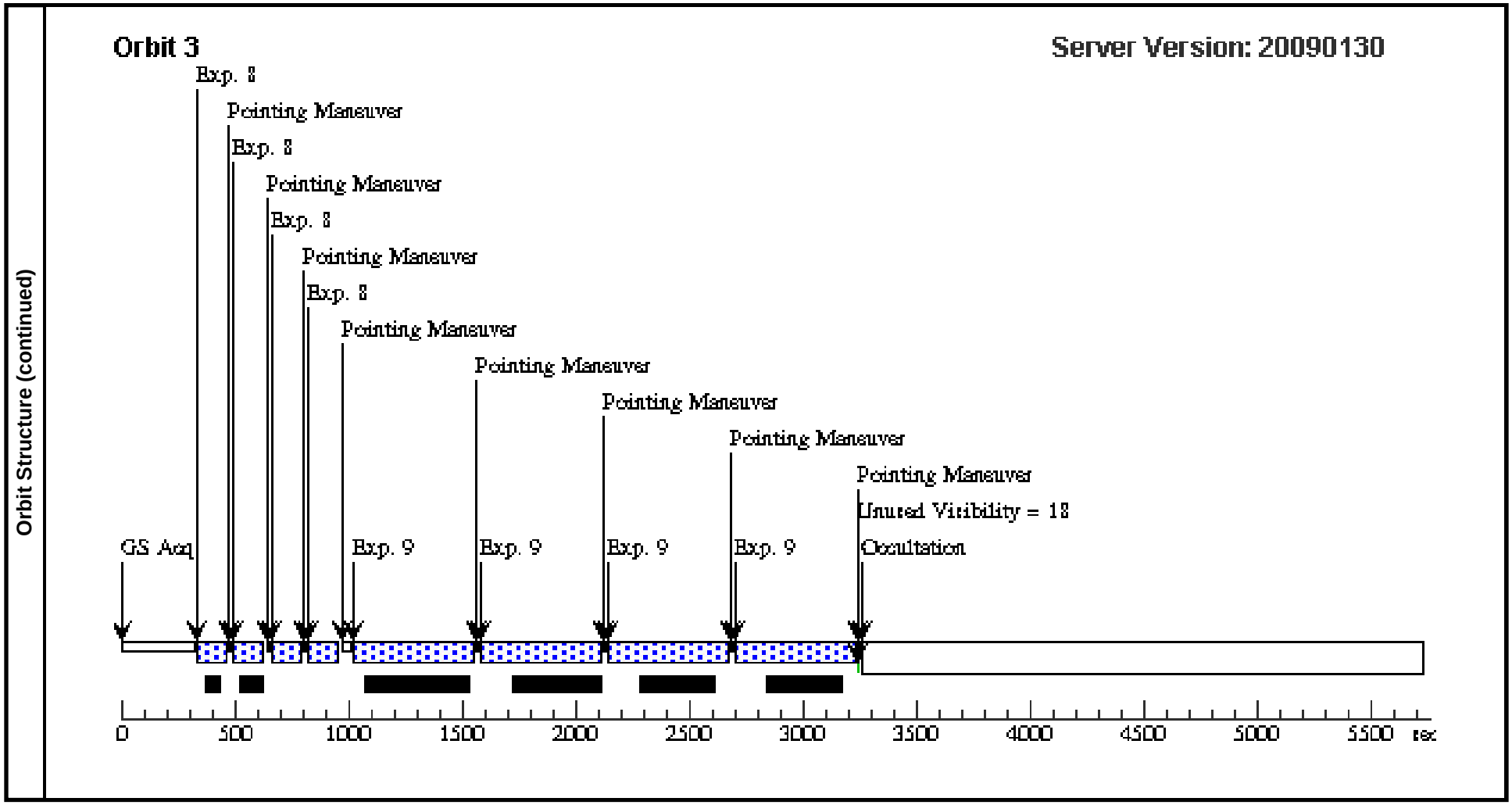
#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	exp01-psfstar	(2) SDSSJ092717.59+294343.9	ACS/WFC, ACCUM, WFC1-2K	F606W			Sequence 1-4 Non-Int Pattern 1, Exps 1-2 (1)	3 Secs *[==>(Pattern 1)]* *[==>(Pattern 2)]*	***[1]***
2	exp02-psfstar	(2) SDSSJ092717.59+294343.9	ACS/WFC, ACCUM, WFC1-2K	F606W			Sequence 1-4 Non-Int Pattern 1, Exps 1-2 (1)	100 Secs *[==>(Pattern 1)]* *[==>(Pattern 2)]*	***[1]***

Exposures (continued)

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
3	exp03-target-500s	(1) SDSSJ092712.65+294344.0	ACS/WFC, ACCUM, WFC1-2K	F606W			Sequence 1-4 Non-Int Pattern 1, Exps 3-4 (1)	500 Secs *[==>(Pattern 1)]* *[==>(Pattern 2)]*	***[1]***
4	exp05-target-3s	(1) SDSSJ092712.65+294344.0	ACS/WFC, ACCUM, WFC1-2K	F606W			Sequence 1-4 Non-Int Pattern 1, Exps 3-4 (1)	3 Secs *[==>(Pattern 1)]* *[==>(Pattern 2)]*	***[1]***
5	exp06-orb2-target-900s	(1) SDSSJ092712.65+294344.0	ACS/WFC, ACCUM, WFC1-2K	F606W			Sequence 5-7 Non-Int Pattern 1, Exps 5-7 (1)	900 Secs *[==>(Pattern 1)]* *[==>(Pattern 2)]*	***[2]***
6	exp07-orb2-target-30s	(1) SDSSJ092712.65+294344.0	ACS/WFC, ACCUM, WFC1-2K	F606W			Sequence 5-7 Non-Int Pattern 1, Exps 5-7 (1)	10 Secs *[==>(Pattern 1)]* *[==>(Pattern 2)]*	***[2]***
7	exp08-orb2-target-10s	(1) SDSSJ092712.65+294344.0	ACS/WFC, ACCUM, WFC1-2K	F606W			Sequence 5-7 Non-Int Pattern 1, Exps 5-7 (1)	30 Secs *[==>(Pattern 1)]* *[==>(Pattern 2)]*	***[2]***
8	exp09-orb3-IR-psfstar	(2) SDSSJ092717.59+294343.9	WFC3/IR, MULTIACCUM, IR	F110W	NSAMP=5; SAMP-SEQ=SPARS25		Sequence 8-9 Non-Int Pattern 2, Exps 8-8 (2)	*[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[3]***
9	exp10-orb3-IR-target	(1) SDSSJ092712.65+294344.0	WFC3/IR, MULTIACCUM, IR	F110W	NSAMP=15; SAMP-SEQ=STEP50		Sequence 8-9 Non-Int Pattern 2, Exps 9-9 (2)	*[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[3]***
10	exp11-orb4-IR-target	(1) SDSSJ092712.65+294344.0	WFC3/IR, MULTIACCUM, IR	F110W	NSAMP=15; SAMP-SEQ=STEP50		Sequence 10-11 Non-Int Pattern 2, Exps 10-10 (2)	*[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[4]***
11	exp12-orb4-IR-psfstar	(2) SDSSJ092717.59+294343.9	WFC3/IR, MULTIACCUM, IR	F110W	NSAMP=5; SAMP-SEQ=SPARS25		Sequence 10-11 Non-Int Pattern 2, Exps 11-11 (2)	*[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[4]***


Orbit Structure
Orbit 1
Server Version: 20090130
Exp. 1
Exp. 2
Pointing Maneuver
Exp. 1
Exp. 2
Pointing Maneuver
Exp. 4
Pointing Maneuver
Exp. 4
*** VISIBILITY OVERRUN = 28
Occultation
GS Acq
Exp. 3
Exp. 3
Pointing Maneuver
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec


Orbit Structure (continued)
Orbit 2
Server Version: 20090130
GS Reacq
Exp. 5
Exp. 6
Exp. 7
Pointing Maneuver
Exp. 5
Exp. 6
Exp. 7
Unused Visibility = 24
Occultation
Pointing Maneuver
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec.


Orbit Structure (continued)
Orbit 3
Server Version: 20090130
Exp. 8
Pointing Maneuver
Exp. 8
Pointing Maneuver
Exp. 8
Pointing Maneuver
Exp. 8
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Unused Visibility = 18
GS Acq
Exp. 9
Exp. 9
Exp. 9
Exp. 9
Occultation
0
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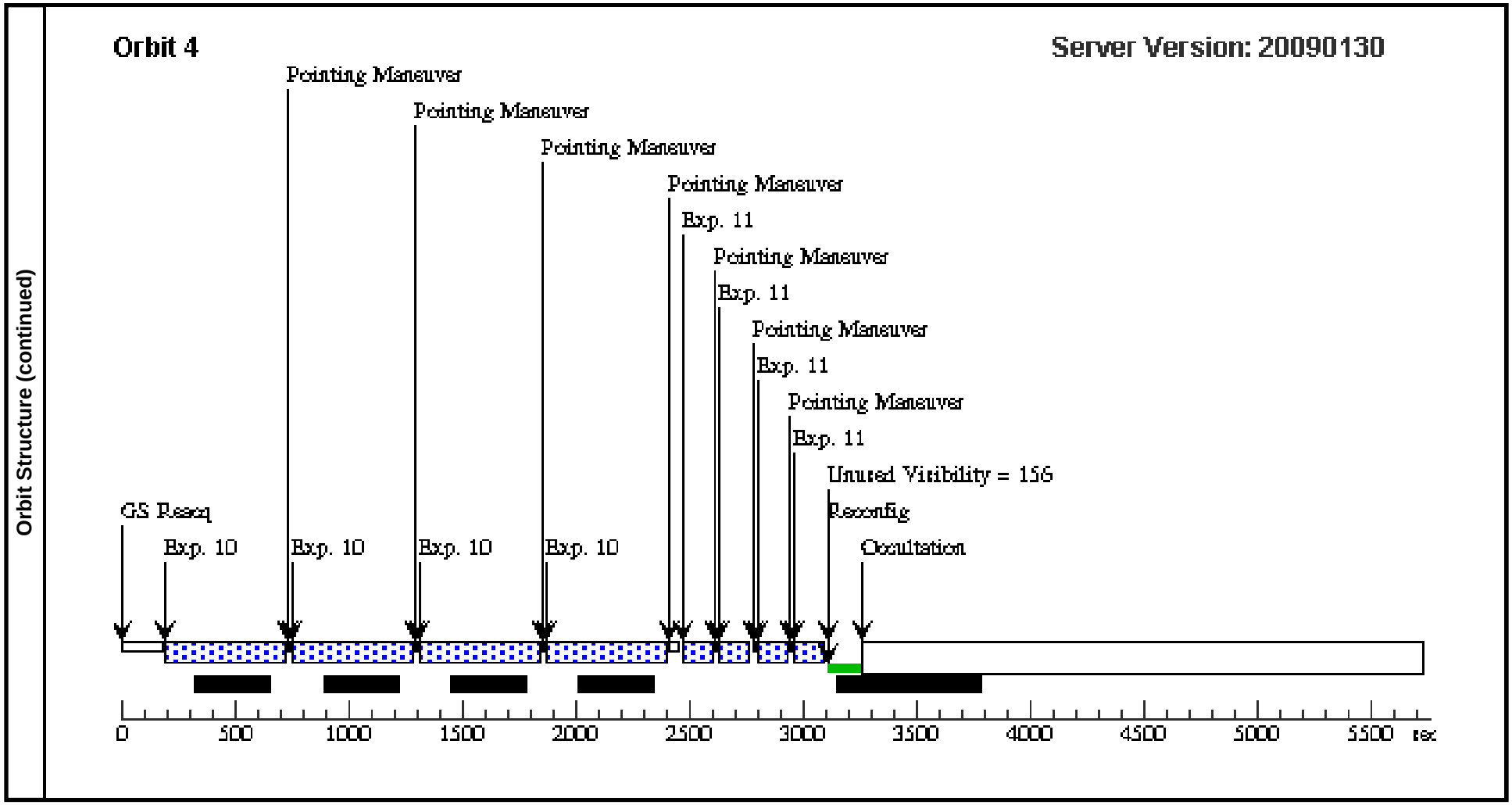
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec


Orbit Structure (continued)
Orbit 4
Server Version: 20090130
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Exp. 11
Pointing Maneuver
Exp. 11
Pointing Maneuver
Exp. 11
Pointing Maneuver
Exp. 11
Unused Visibility = 156
Reconfig
GS Reacq
Exp. 10
Exp. 10
Exp. 10
Exp. 10
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec