15254 - The host galaxy of the gravitational wave recoiling black hole candidate 3C186

Cycle: 25, 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) 3C-186	ACS/WFC	1	11-Mar-2019 16:00:21.0	yes
11	(1) 3C-186	WFC3/IR	2	11-Mar-2019 16:00:23.0	yes
02	(1) 3C-186	ACS/WFC WFC3/IR	5	11-Mar-2019 16:00:26.0	yes

8 Total Orbits Used

ABSTRACT

We discovered a gravitational wave (GW) recoiling black hole (BH) candidate in our HST WFC3 snapshot images of the radio-loud QSO 3C186. These events are expected to happen as a result of BH-BH mergers. This extremely energetic phenomenon leads to the production of an intense field of GWs, which in most cases are emitted anisotropically. As a result, the merged black hole may receive a kick and be displaced from the center of the host galaxy with velocities that can be as high as ~4000 km/s. Depending on the relative orientation of the kick with respect to the line-of-sight, if the BH is active we expect to observe an offset QSO. Furthermore, the broad lines may be offset with respect to the narrow lines, which are emitted in the frame of the host. 3C186 shows all of the predicted observational features of a such an event. Spectra show offsets between narrow and broad emission lines of ~2100km/s, and our HST image clearly shows that the QSO is offset by 1.3" with respect to the isophotal center of the host galaxy. Scenarios alternative to the GW kick as the origin for the observed features are unlikely, but still viable. Only HST allows us to obtain spatially resolved information, high sensitivity and stable PSF to better investigate the host galaxy properties. We will use ACS and WFC3 to obtain deep images and study the morphology of the host galaxy. We will unambiguously establish whether the host galaxy of 3C186 underwent a major merger and we will be able to set accurate constraints on the age of the merger. The proposed observations will have a tremendous impact on our knowledge of supermassive BH mergers and the associated emission of gravitational waves.

OBSERVING DESCRIPTION

We image the host galaxy of the quasar 3c186 in three bands. ACS/F606W, WFC-IR/F140W and WFC-IR/F160W. We require a S/N of at least 20 on the fainter regions of the host galaxy (possible tidal tails) that are barely detected in the WFC3-IR F140W snapshot image (F_lam ~ 1x10^-19 erg cm^-2 s^-1 A^-1 arcsec^-2). We therefore need 2 and 3 orbits with F140W and F160W, respectively. 3 orbits are needed to achieve a similar S/N on the same region in the ACS F606W image.

The aperture for ACS was chosen in order to lower the impact of imperfect CTE (by a factor of ~2 with respect to the standard WFC central aperture.

Quadrant was chosen because it has the lowest amplifier readnoise. This is important to reveal the faintest structures of the host galaxy (which is one of the main scientific goals of the program). Even with this configuration, most of the FOV of the ACS is still covered by WFC3-IR, which will still enable archival studies of the large scale environment of the target.

Since a few pixels (~2-3) in the quasar core will be saturated in the ACS images, we also take one short exposure at the beginning of each ACS orbit. This will help significantly with the PST subtraction. The short exposure is taken at the same position as the first dither point of the "SPIRAL" 5-point dither pattern. We will use the information in the unsaturated pixels from the short exposure to reconstruct the PSF in saturated images. This technique was successfully used for our Cycle 19 SNAP image of the same target.

For the WFC3-IR orbits we use a 4-point dither box enlarged with respect to the standard size, in order to reduce the effects of persistance on the faint edges of the host galaxy. We expect the host galaxy to extend to at least 9" from the QSO center.

Orientations are chosen in order to avoid diffraction spikes from the QSO falling onto interesting features close to the nucleus of the galaxy. Having the observations divided into two visits, using all of the three filters in each visit, will help in case bleeding (for ACS) and/or diffraction spikes fall onto a sigificant feature in either of the two visits, assuming the observations are taken at different orientations. These are not strict requirements of the program, but it might be useful to keep the current structure to improve the accuracy of the PSF subtraction, unless scheduling issues may raise.

Visit

Proposal 15254, ACS (01), scheduling Mon Mar 11 20:00:27 GMT 2019

Diagnostic Status: No Diagnostics

Scientific Instruments: ACS/WFC

Special Requirements: ORIENT 110D TO 116 D

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(4)	Pattern Type=SPIRAL	Coordinate Frame=POS-TARG		(2)
	Purpose=DITHER	Pattern Orientation=47.23		
	Number Of Points=5	Angle Between Sides=		
	Point Spacing=0.145	Center Pattern=false		
	Line Spacing=			

Fixed Targets

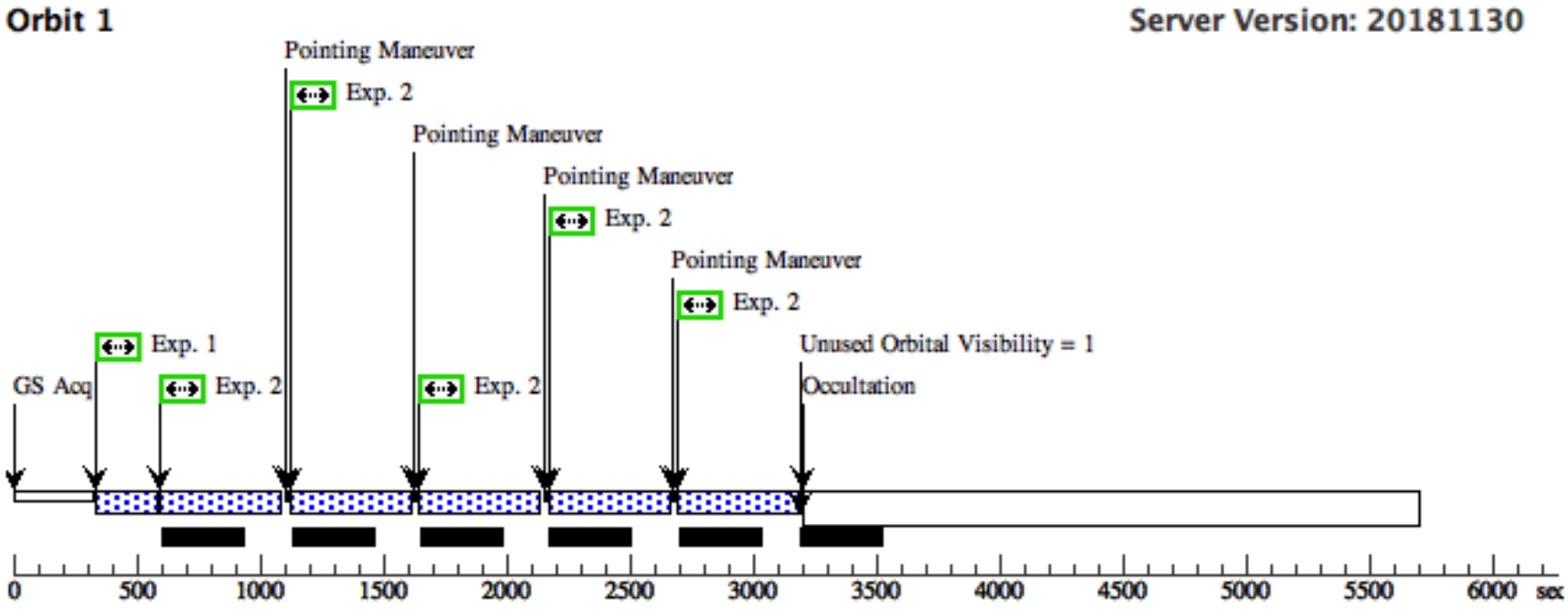
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	3C-186	RA: 07 44 17.4700 (116.0727917d) Dec: +37 53 17.24 (37.88812d) Equinox: J2000		V=18.14	Reference Frame: SIMBAD

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=GALAXY
Description=[QUASAR]

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	ACS	(1) 3C-186	ACS/WFC, ACCUM, WFC1-FIX	F606W		POS TARG 40,5		30 Secs (30 Secs)	
								[==>]	***[1]***
2	ACS	(1) 3C-186	ACS/WFC, ACCUM, WFC1-FIX	F606W		POS TARG 40,5	Pattern 4, Exps 2-2 in ACS (01) (4)	366 Secs (1830 Secs)	
								[==>(Pattern 1)]	
								[==>(Pattern 2)]	
								[==>(Pattern 3)]	***[1]***
								[==>(Pattern 4)]	
								[==>(Pattern 5)]	

Orbit Structure



Visit

Proposal 15254, WFC3 F110W, WFC3 F160W (11), scheduling Mon Mar 11 20:00:28 GMT 2019

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: ORIENT 110D TO 116 D; AFTER .01 BY 0.9 Orbits TO 1.1 Orbits

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(3)	Pattern Type=WFC3-IR-DITHER-BOX-MIN Purpose=DITHER Number Of Points=4 Point Spacing=11.44 Line Spacing=7.3	Coordinate Frame=POS-TARG Pattern Orientation=18.528 Angle Between Sides=74.653 Center Pattern=false		(1), (3)

Fixed Targets

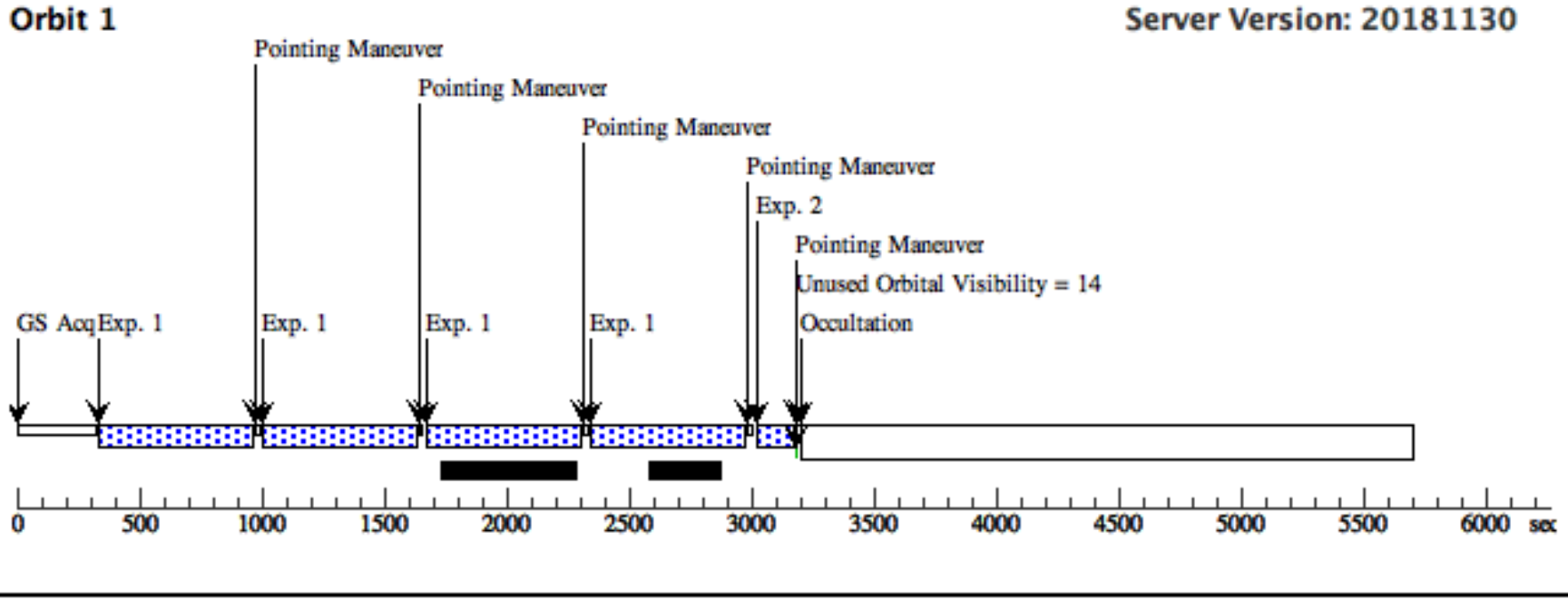
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	3C-186	RA: 07 44 17.4700 (116.0727917d) Dec: +37 53 17.24 (37.88812d) Equinox: J2000		V=18.14	Reference Frame: SIMBAD

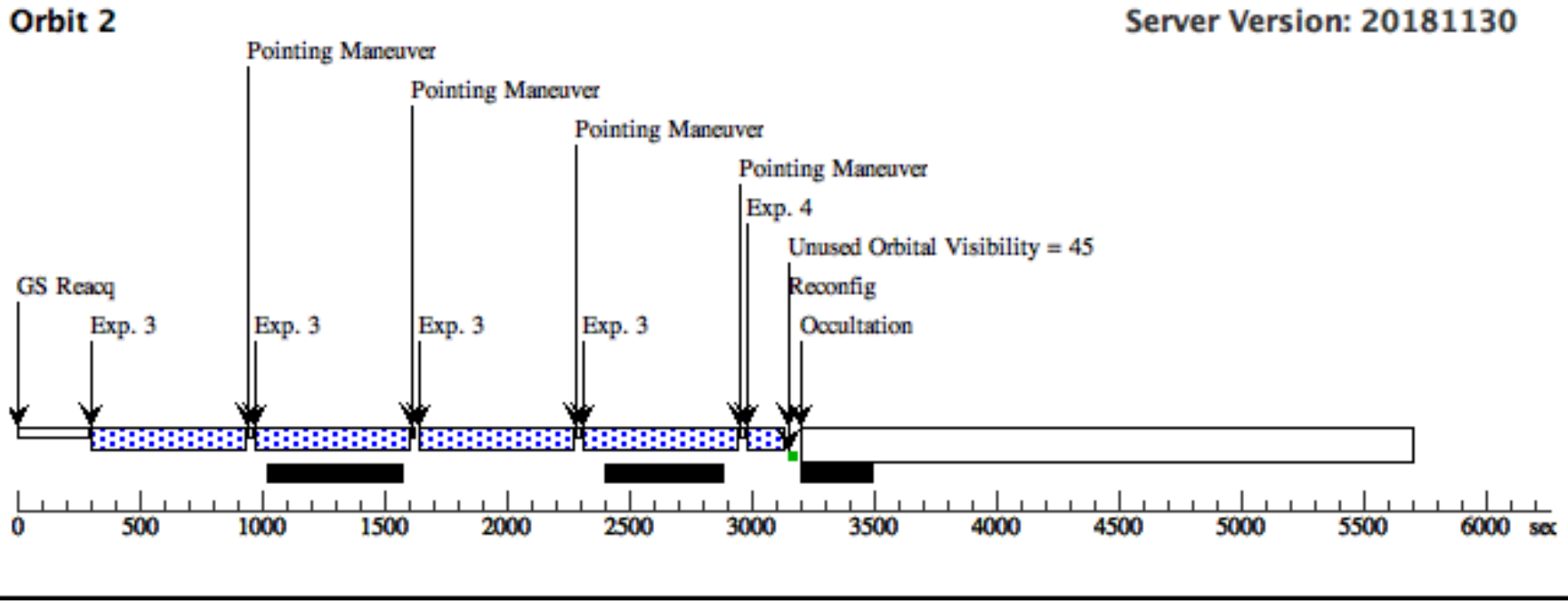
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=GALAXY
Description=[QUASAR]

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	WFC3 F110W	(1) 3C-186	WFC3/IR, MULTIACCUM, IR	F110W	SAMP-SEQ=STEP200; NSAMP=10		Pattern 3, Exps 1-1 in WFC3 F110W, WFC3 F160W (11) (3)	599.231134 Secs (2396.925 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[1]***
2	WFC3 F110W	(1) 3C-186	WFC3/IR, MULTIACCUM, IR	F110W	SAMP-SEQ=STEP25; NSAMP=9	POS TARG 7.8,7.8		124.231771 Secs (124.232 Secs) *[==>]*	***[1]***
3	WFC3 F160W	(1) 3C-186	WFC3/IR, MULTIACCUM, IR	F160W	SAMP-SEQ=STEP200; NSAMP=10		Pattern 3, Exps 3-3 in WFC3 F110W, WFC3 F160W (11) (3)	599.231134 Secs (2396.925 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[2]***
4	WFC3 F160W	(1) 3C-186	WFC3/IR, MULTIACCUM, IR	F160W	SAMP-SEQ=STEP25; NSAMP=9	POS TARG 7.8,7.8		124.231771 Secs (124.232 Secs) *[==>]*	***[2]***

Orbit Structure





Visit

Proposal 15254, ACS, WFC3 F110W, WFC3 F160W (02), completed Mon Mar 11 20:00:28 GMT 2019

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR, ACS/WFC

Special Requirements: (none)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(3)	Pattern Type=WFC3-IR-DITHER-BOX-MIN Purpose=DITHER Number Of Points=4 Point Spacing=11.44 Line Spacing=7.3	Coordinate Frame=POS-TARG Pattern Orientation=18.528 Angle Between Sides=74.653 Center Pattern=false		(5), (7), (9)
(4)	Pattern Type=SPIRAL Purpose=DITHER Number Of Points=5 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=47.23 Angle Between Sides= Center Pattern=false		(2), (4)

Fixed Targets

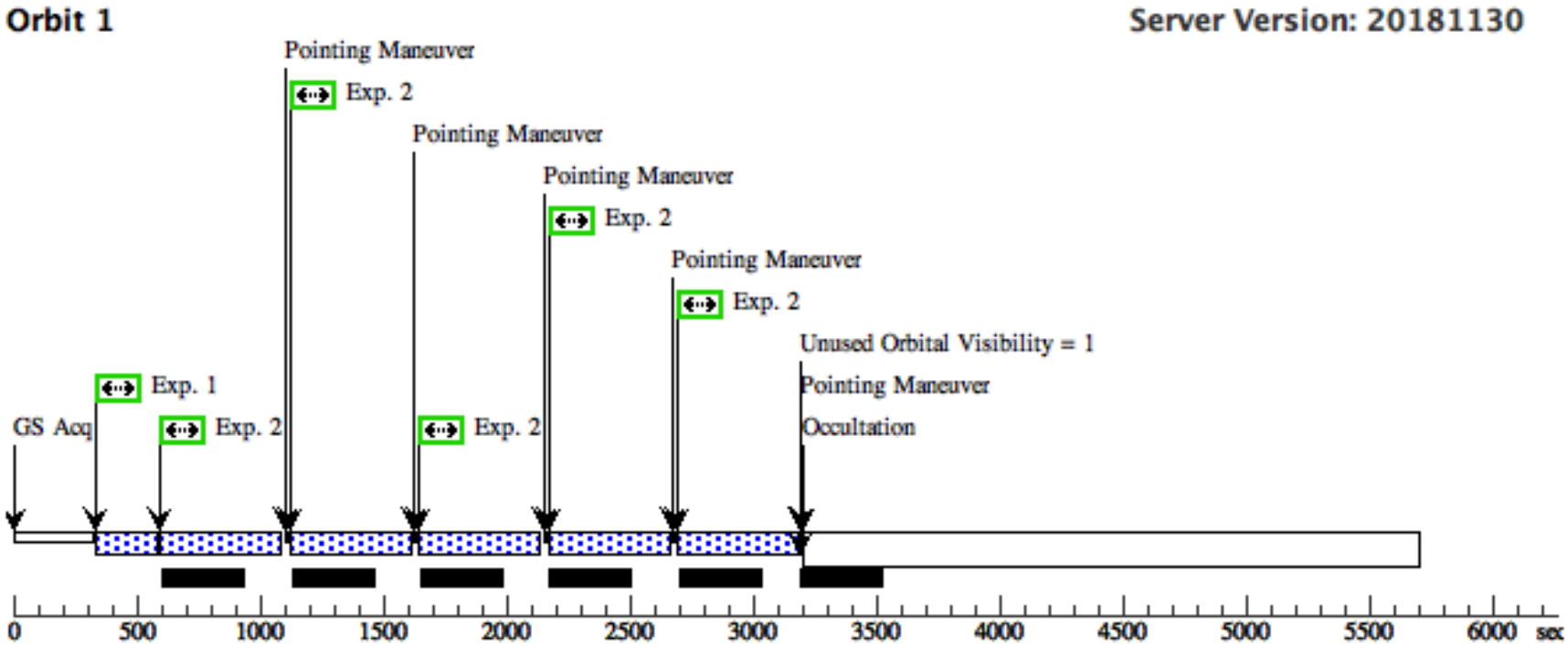
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	3C-186	RA: 07 44 17.4700 (116.0727917d) Dec: +37 53 17.24 (37.88812d) Equinox: J2000		V=18.14	Reference Frame: SIMBAD

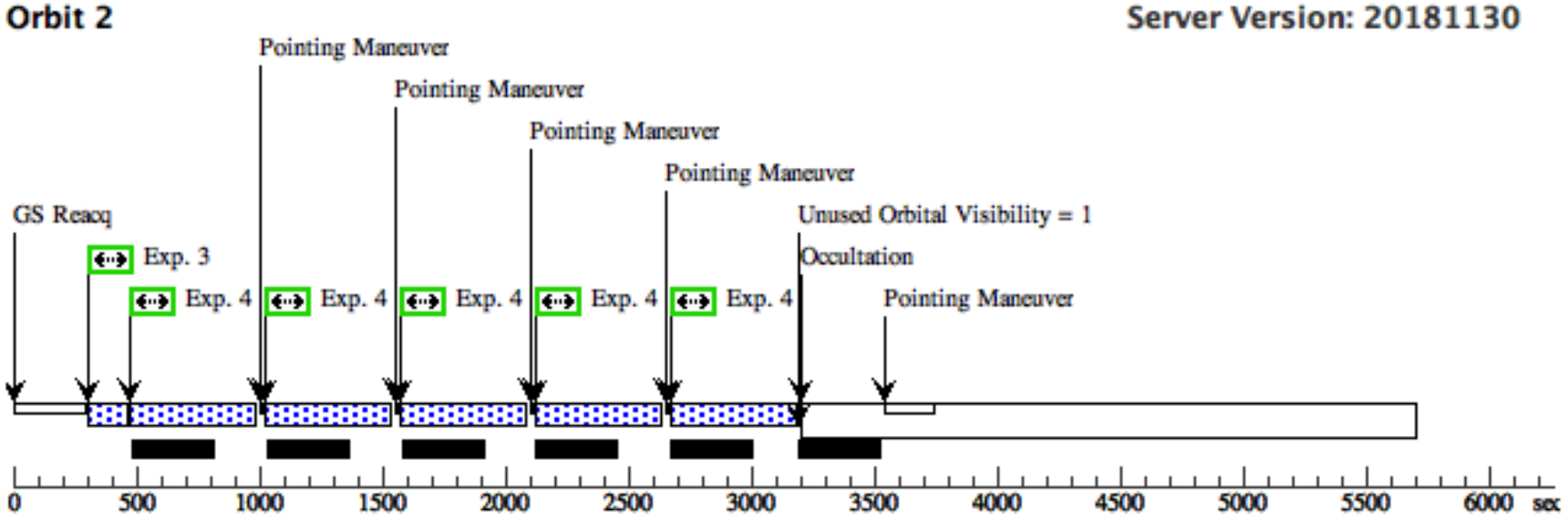
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=GALAXY
Description=[QUASAR]

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	ACS	(1) 3C-186	ACS/WFC, ACCUM, WFC1-FIX	F606W		POS TARG 40,5		30 Secs (30 Secs)	
								[==>]	***[1]***
2	ACS	(1) 3C-186	ACS/WFC, ACCUM, WFC1-FIX	F606W		POS TARG 40,5	Pattern 4, Exps 2-2 in ACS, WFC3 F110W, WFC3 F160W (02) (4)	366 Secs (1830 Secs)	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]*	***[1]***
3	ACS	(1) 3C-186	ACS/WFC, ACCUM, WFC1-FIX	F606W		POS TARG 40,5		30 Secs (30 Secs)	
								[==>]	***[2]***
4	ACS	(1) 3C-186	ACS/WFC, ACCUM, WFC1-FIX	F606W		POS TARG 40,5	Pattern 4, Exps 4-4 in ACS, WFC3 F110W, WFC3 F160W (02) (4)	391 Secs (1955 Secs)	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]* *[==>(Pattern 5)]*	***[2]***
5	WFC3 F160W	(1) 3C-186	WFC3/IR, MULTIACCUM, IR	F160W	SAMP-SEQ=STEP100; NSAMP=12		Pattern 3, Exps 5-5 in ACS, WFC3 F110W, WFC3 F160W (02) (3)	599.232292 Secs (2396.929 Secs)	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[3]***
6	WFC3 F160W	(1) 3C-186	WFC3/IR, MULTIACCUM, IR	F160W	SAMP-SEQ=STEP25; NSAMP=9	POS TARG 7.8,7.8		124.231771 Secs (124.232 Secs)	
								[==>]	***[3]***
7	WFC3 F160W	(1) 3C-186	WFC3/IR, MULTIACCUM, IR	F160W	SAMP-SEQ=STEP100; NSAMP=12		Pattern 3, Exps 7-7 in ACS, WFC3 F110W, WFC3 F160W (02) (3)	599.232292 Secs (2396.929 Secs)	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[4]***
8	WFC3 F160W	(1) 3C-186	WFC3/IR, MULTIACCUM, IR	F160W	SAMP-SEQ=STEP25; NSAMP=9	POS TARG 7.8,7.8		124.231771 Secs (124.232 Secs)	
								[==>]	***[4]***
9	WFC3 F110W	(1) 3C-186	WFC3/IR, MULTIACCUM, IR	F110W	SAMP-SEQ=STEP100; NSAMP=12		Pattern 3, Exps 9-9 in ACS, WFC3 F110W, WFC3 F160W (02) (3)	599.232292 Secs (2396.929 Secs)	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[5]***
10	WFC3 F110W	(1) 3C-186	WFC3/IR, MULTIACCUM, IR	F110W	SAMP-SEQ=STEP25; NSAMP=9	POS TARG 7.8,7.8		124.231771 Secs (124.232 Secs)	
								[==>]	***[5]***

Orbit Structure

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Pointing Maneuver
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Exp. 3
Exp. 4
Exp. 4
Exp. 4
Exp. 4
Exp. 4
Unused Orbital Visibility = 1
Occultation
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1000
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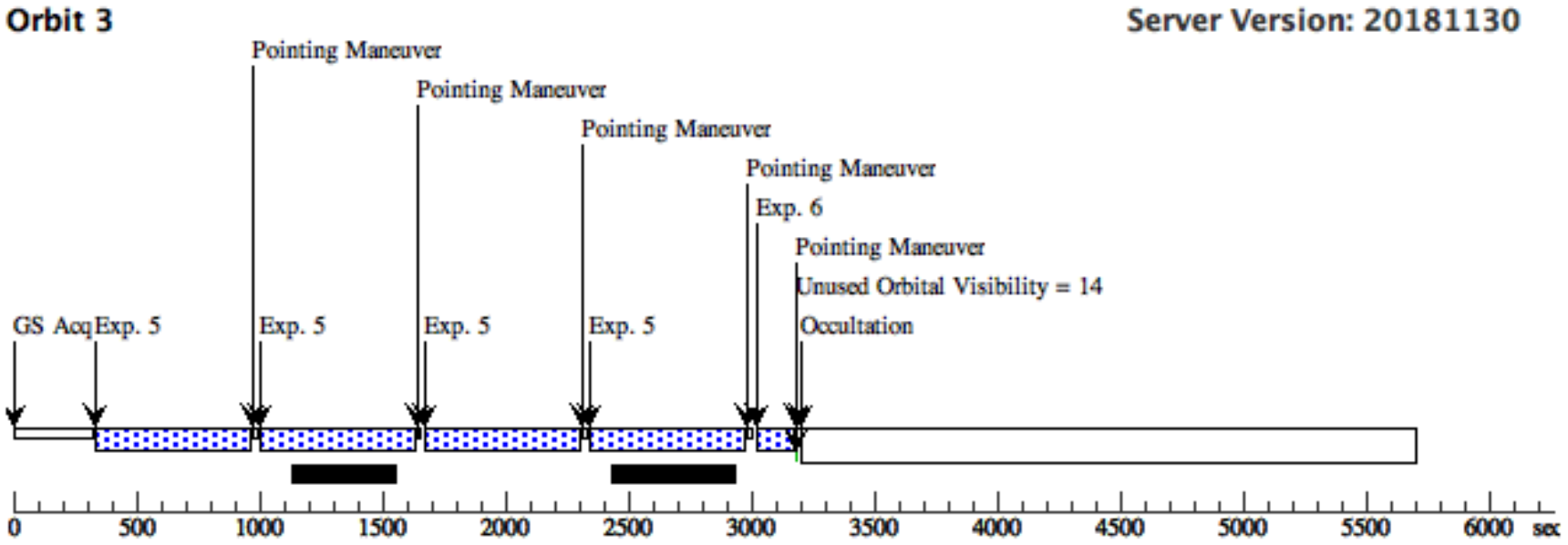
sec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Pointing Maneuver
Pointing Maneuver
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Exp. 6
Pointing Maneuver
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GS Acq
Exp. 5
Exp. 5
Exp. 5
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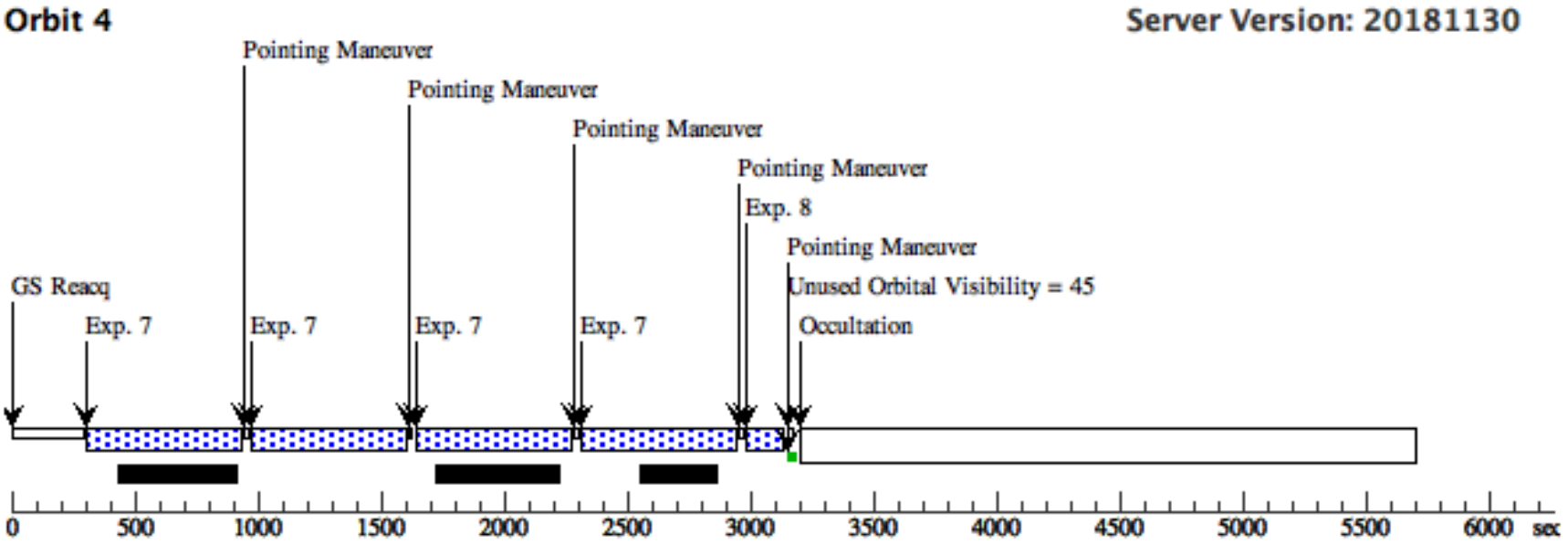
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Pointing Maneuver
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Exp. 8
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Unused Orbital Visibility = 45
GS Reacq
Exp. 7
Exp. 7
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Occultation
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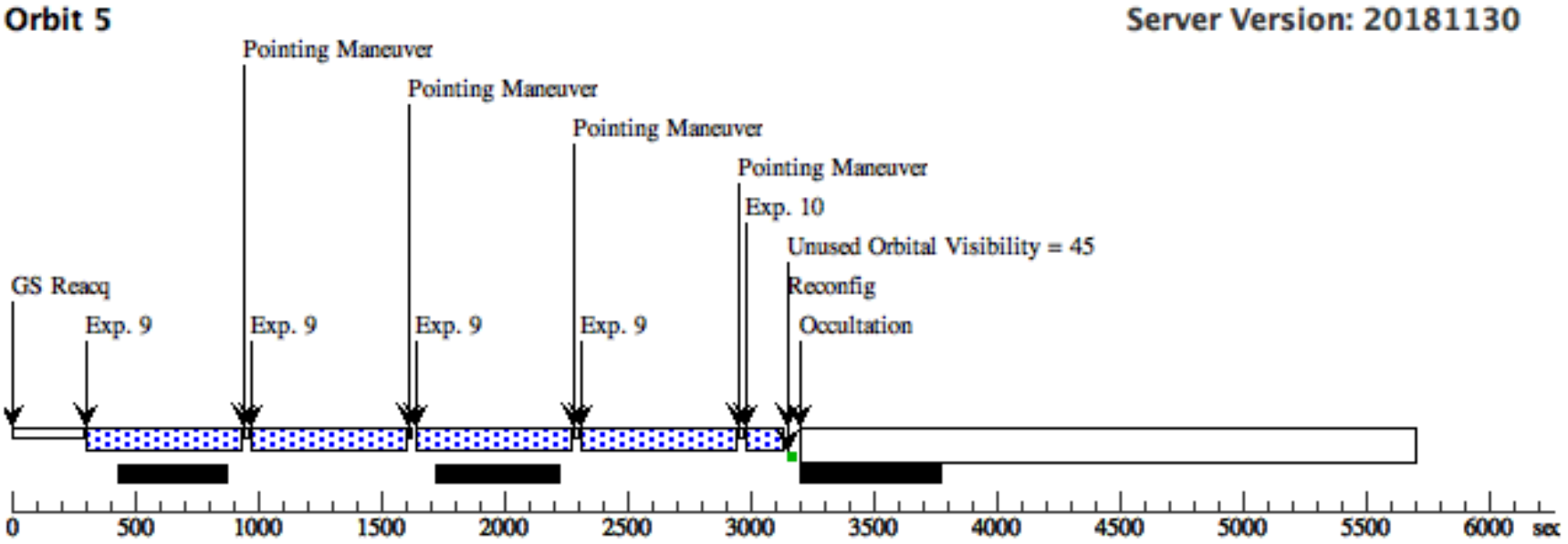
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Exp. 9
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Reconfig
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sec