13304 - Mysterious ionization in cooling flow filaments: a test with deep COS FUV spectroscopy

Cycle: 21, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Dr. Grant R. Tremblay (PI) (ESA Member) (Contact)	**European Southern Observatory - Germany**	**grant.tremblay@eso.org**
Dr. Stefi A. Baum (CoI) (AdminUSPI)	Rochester Institute of Technology	baum@cis.rit.edu
Dr. Christopher P. O'Dea (CoI)	Rochester Institute of Technology	cposps@cis.rit.edu
Dr. Rebecca E. A. Canning (CoI)	Stanford University	rcanning@stanford.edu
Dr. Tracy Clarke (CoI)	Naval Research Laboratory	schmarke@gmail.com
Dr. Francoise Combes (CoI) (ESA Member)	Observatoire de Paris	francoise.combes@obspm.fr
Dr. Megan Donahue (CoI)	Michigan State University	donahue@pa.msu.edu
Dr. Alastair C. Edge (CoI) (ESA Member)	University of Durham	alastair.edge@durham.ac.uk
Dr. Eiichi Egami (CoI)	University of Arizona	eegami@as.arizona.edu
Prof. Andrew C. Fabian (CoI) (ESA Member)	University of Cambridge	acf@ast.cam.ac.uk
Dr. Gary J. Ferland (CoI)	University of Kentucky	gary@pa.uky.edu
Dr. Roderick M. Johnstone (CoI) (ESA Member)	University of Cambridge	rmj@ast.cam.ac.uk
Dr. Brian R. McNamara (CoI)	University of Waterloo	mcnamara@uwaterloo.ca
Dr. Rupal Mittal (CoI)	Rochester Institute of Technology	rmittal@astro.rit.edu
Dr. Raymond Oonk (CoI) (ESA Member)	Stichting Astronomisch Onderzoek in Nederland (ASTRON)	oonk@astron.nl
Dr. Helen R Russell (CoI)	University of Waterloo	h2russel@uwaterloo.ca
Dr. Philippe Salome (CoI) (ESA Member)	Observatoire de Paris	philippe.salome@obspm.fr
Dr. Craig L. Sarazin (CoI)	The University of Virginia	sarazin@virginia.edu

Name	*Institution*	*E-Mail*
Prof. Mark Voit (CoI)	Michigan State University	voit@pa.msu.edu
Dr. Michael W. Wise (CoI) (ESA Member)	Stichting Astronomisch Onderzoek in Nederland (ASTRON)	wise@astron.nl

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) ABELL-2597-NUCLEUS	COS/FUV COS/NUV	5	01-Apr-2014 21:03:16.0	yes
02	(1) ABELL-2597-NUCLEUS (2) ABELL-2597-FILAMENT	COS/FUV COS/NUV	9	01-Apr-2014 21:03:35.0	yes
03	(3) ZWCL-3146-FILAMENT	COS/FUV COS/NUV	9	01-Apr-2014 21:03:57.0	yes

23 Total Orbits Used

ABSTRACT

The Cosmic Origins Spectrograph is capable of unraveling a two decade old mystery regarding the filamentary emission line nebulae found in the brightest cluster galaxies (BCGs) of cool core (CC) clusters. These kpc-scale filaments are characterized by elevated H-alpha luminosities and puzzling ionization states that cannot be accounted for by recombination or photionization alone, and are instead excited by an unknown ionization mechanism. The most hotly debated proposed solutions invoke thermal conduction, shocks, or cosmic-ray heating, but progress toward consensus awaits unambiguous spectral discriminants between these models that can only be found in the FUV. We propose deep (9 orbit), off-nuclear observations of two strategically selected BCGs in well-studied cool core clusters with cross-spectrum archival datasets. We also propose a shorter (5 orbit) on-nuclear observation for one of our targets to assess possible AGN contributions to the spectra. These proposed observations represent critical tests that can unambiguously discriminate between the various candidate ionziation models. Constraining the mechanisms by which CC BCG filaments are excited remains one of the most important roadblocks to a better understanding of cooling from hot ambient medium to cold star forming clouds and filaments, a process important for both galaxy and black hole growth. It is therefore important that, before HST ends its mission and we lose FUV capability, we advance our understanding of this decades old mystery.

OBSERVING DESCRIPTION

We will obtain deep COS FUV-mode spectroscopy of Abell 2597 (z=0.08) and ZwCl 3146 (z=0.29) with the G140L grating, tuned to a central wavelength of 1280 angstroms. Our goal is to go very deep (9 orbits, roughly 25 ksec) on the off-nuclear filaments in both of these targets. Additionally, we will take a shallower (5 orbit, ~15 ksec) observation of the A2597 nucleus (to assess possible AGN contribution to the spectra).

Integration times have been estimated with the COS spectroscopic ETC using a conservative range of surface brightnessess whose median is centered on an inferred C I surface brightness of 1e-16 ersgs/sec/cm2/arcsec2. The ETC suggests that we will reach an SNR of >~ 1 (per 0.08 angstrom pixel wavelength bin) for a 25 ksec exposure using the faintest, most conservative line and continuum cases for both targets. The filaments will fill the COS aperture, spreading over 100 wavelength bins for a combined effective SNR of >8 (on the conservative end), allowing flux measurements to 15% accuracy. Binning over 50 angstroms will allow us to detect the continuum and the lines of interest at an SNR of ~10, even after accounting for vignetting and attenuation due to declining effective area. At shorter wavelengths, we will likely detect more counts allowing for fine-grained definition of the continuum near the short wavelength turnover. After accounting for overheads, we can achieve this 25 ksec exposure time in 9 orbits for each off-nuclear pointing. We further estimate that 5 orbits will be required for the on-nucleus (i.e. significantly brighter) pointing in A2597. We estimate that similar SNR will be reached for both lines and continuum for this on-nucleus observation. With this observing strategy, contaminating geocoronal Ly-alpha emission will fall in the FUV detector gap between segments B and A and will not be recorded in the data. We therefore do not require umbral shadow observations and are not subject to special scheduling constraints for any of our two targets.

Our observations are all well below the brightness limits for COS. We will observe using the recommended TIME-TAG mode to allow temporal sampling, improved thermal correction, and exclusion of poor quality data from the final co-addition. All four FP-POS settings will be used, as recommended.

Visit

Proposal 13304, 5 Orbits on A2597 Nucleus (01), implementation Wed Apr 02 01:04:10 GMT 2014

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: (none)

Fixed Targets

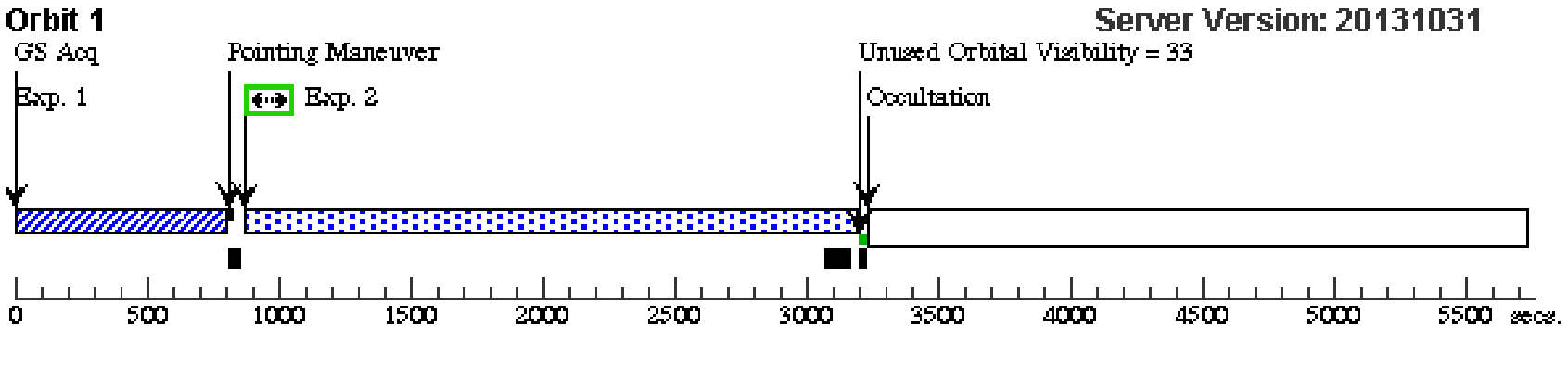
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	ABELL-2597-NUCLEUS	RA: 23 25 19.6700 (351.3319583d) Dec: -12 07 25.79 (-12.12383d) Equinox: J2000		V=16.6	Reference Frame: ICRS

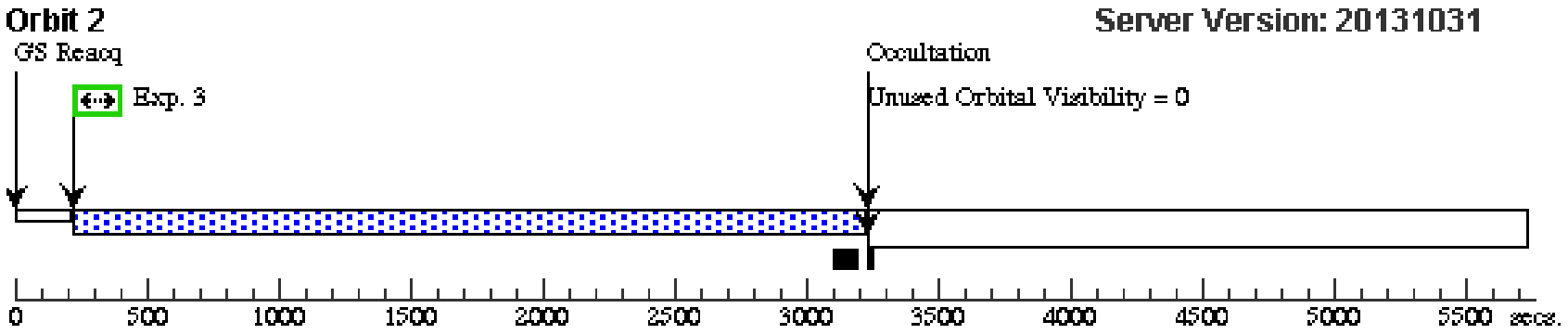
Comments: The listed coorindates are for the desired center of the 4"x4" ACQ/IMAGE search field. We would like the COS Primary Science Aperture to be centered around the brightest region within this field.

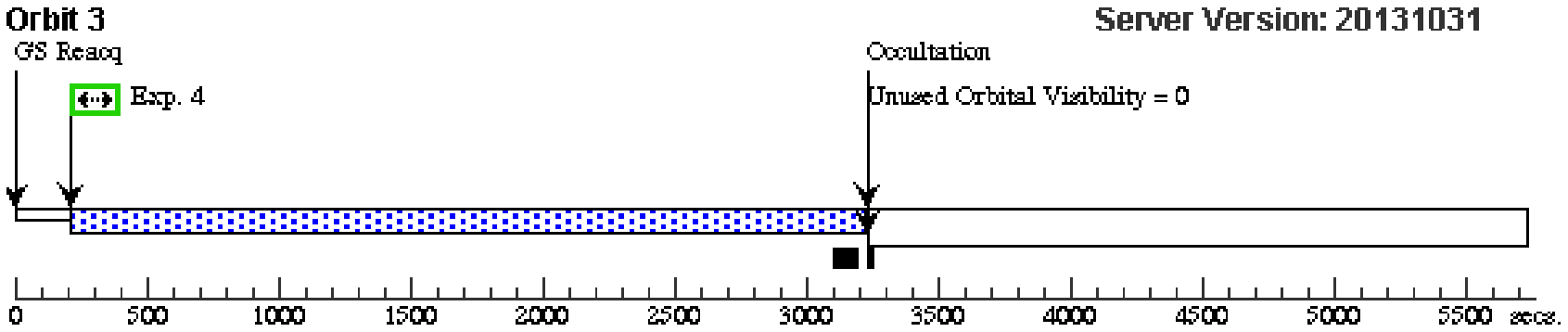
Exposures

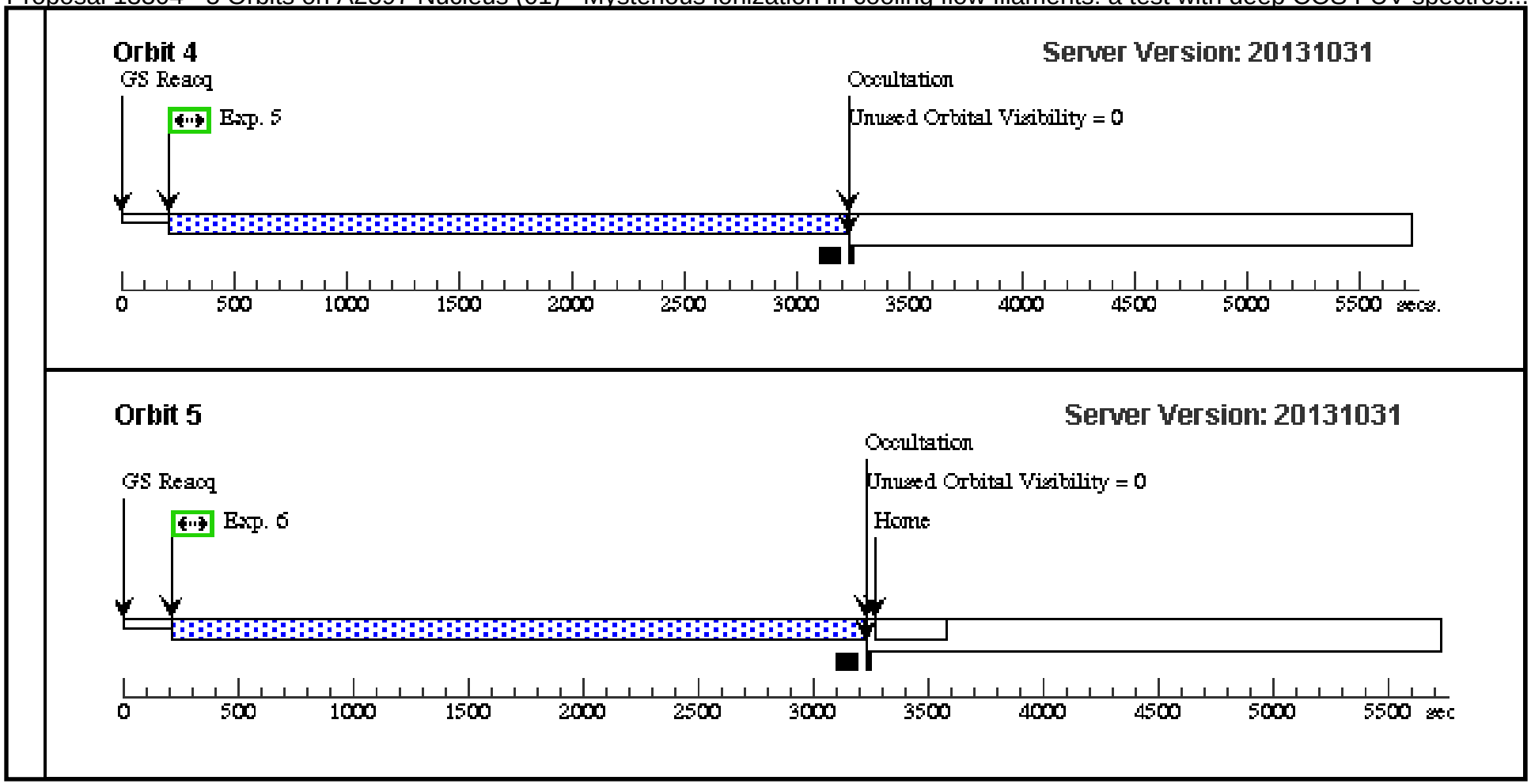
#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(0/5) 200 sec acquisition of A2597 Nucleus (COS.ta.562769)	(1) ABELL-2597-NUCLEUS	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				200 Secs (200 Secs) *[==>]*	***[1]***
2	(1/5) A2597 Nucleus science exposure (515603)	(1) ABELL-2597-NUCLEUS	COS/FUV, TIME-TAG, PSA	G140L 1280 A	FP-POS=1; EXTENDED=YES; FLASH=YES; BUFFER-TIME=2040			2140 Secs (2140 Secs) *[==>]*	***[1]***
3	(2/5) A2597 Nucleus science exposure (515603)	(1) ABELL-2597-NUCLEUS	COS/FUV, TIME-TAG, PSA	G140L 1280 A	FP-POS=1; EXTENDED=YES; FLASH=YES; BUFFER-TIME=2853			2953 Secs (2953 Secs) *[==>]*	***[2]***
4	(3/5) A2597 Nucleus science exposure (515603)	(1) ABELL-2597-NUCLEUS	COS/FUV, TIME-TAG, PSA	G140L 1280 A	FP-POS=2; EXTENDED=YES; FLASH=YES; BUFFER-TIME=2853			2953 Secs (2953 Secs) *[==>]*	***[3]***
5	(4/5) A2597 Nucleus science exposure (515603)	(1) ABELL-2597-NUCLEUS	COS/FUV, TIME-TAG, PSA	G140L 1280 A	FP-POS=3; EXTENDED=YES; FLASH=YES; BUFFER-TIME=2853			2953 Secs (2953 Secs) *[==>]*	***[4]***
6	(5/5) A2597 Nucleus science exposure (515603)	(1) ABELL-2597-NUCLEUS	COS/FUV, TIME-TAG, PSA	G140L 1280 A	FP-POS=4; EXTENDED=YES; FLASH=YES; BUFFER-TIME=2853			2953 Secs (2953 Secs) *[==>]*	***[5]***

Orbit Structure





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Visit

Proposal 13304, 9 Orbits on A2597 Filament (02), implementation Wed Apr 02 01:04:14 GMT 2014

Diagnostic Status: Warning

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: (none)

Diagnostics

(9 Orbits on A2597 Filament (02)) Warning (Orbit Planner): LONG SU LIKELY TO INTERSECT THE SAA

Fixed Targets

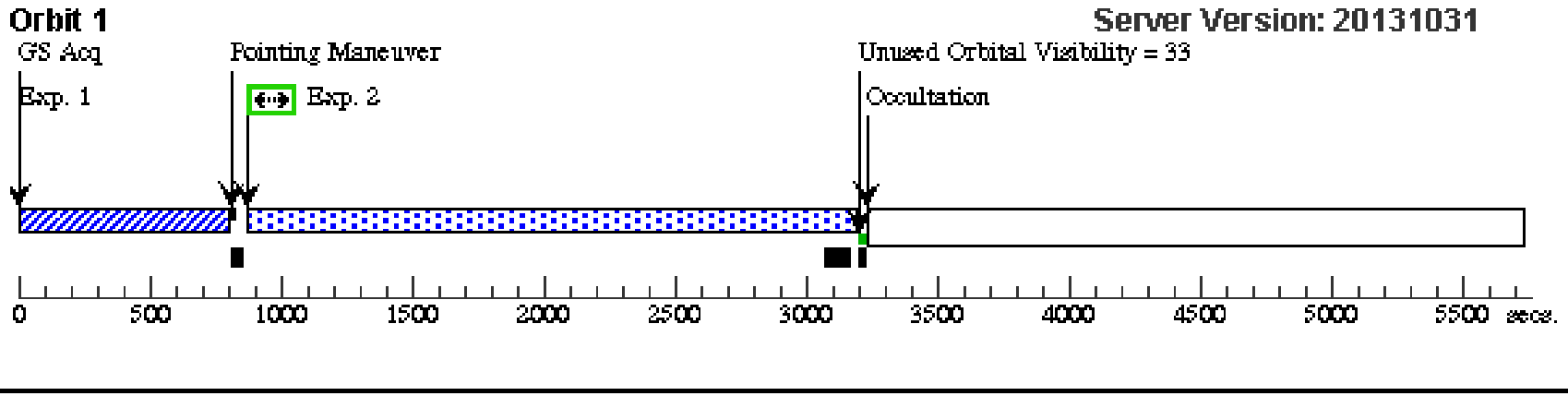
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	ABELL-2597-NUCLEUS	RA: 23 25 19.6700 (351.3319583d) Dec: -12 07 25.79 (-12.12383d) Equinox: J2000		V=16.6	Reference Frame: ICRS
Comments: The listed coorindates are for the desired center of the 4"x4" ACQ/IMAGE search field. We would like the COS Primary Science Aperture to be centered around the brightest region within this field.					
(2)	ABELL-2597-FILAMENT	Offset from ABELL-2597-NUCLEUS RA Offset: 0.168 Secs Dec Offset: 3.88 Arcsec		V=16.6	Offset Position (ABELL-2597-FILAMENT)
Comments: This is an offset calculated from the brightest FUV knot cospatial with the A2597 nucleus. We wish to acquire on this knot, and then offset to the filament. Positioning of this offset intentionally avoids the rim of likely shocked gas at the northern edge of the radio lobe.					

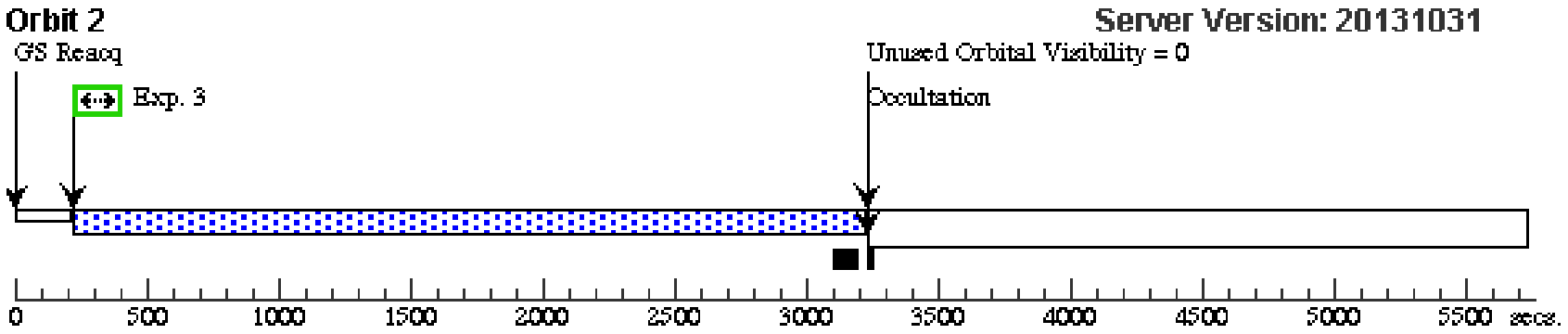
Exposures

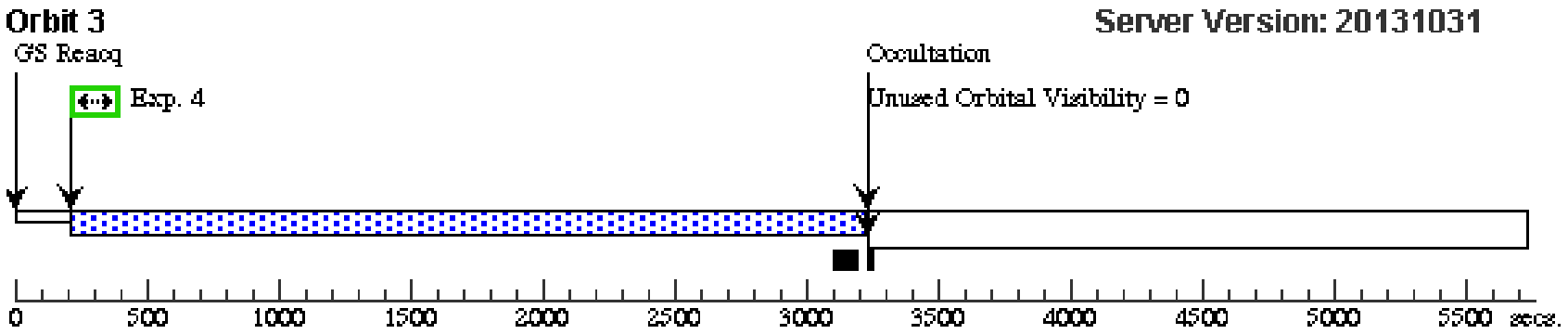
#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(0/9) 200 sec Acq. of Nucleus + Offset to Filament (COS.ta.562769)	(1) ABELL-2597-NUCLEUS	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				200 Secs (200 Secs) *[==>]*	***[1]***
2	(1/9) A2597 Filament science exposure (515644)	(2) ABELL-2597-FILAMENT	COS/FUV, TIME-TAG, PSA	G140L 1280 A	EXTENDED=YES; FLASH=YES; BUFFER-TIME=2040; FP-POS=1			2140 Secs (2140 Secs) *[==>]*	***[1]***
3	(2/9) A2597 Filament science exposure (515644)	(2) ABELL-2597-FILAMENT	COS/FUV, TIME-TAG, PSA	G140L 1280 A	EXTENDED=YES; FLASH=YES; BUFFER-TIME=2853; FP-POS=1			2953 Secs (2953 Secs) *[==>]*	***[2]***
4	(3/9) A2597 Filament science exposure (515644)	(2) ABELL-2597-FILAMENT	COS/FUV, TIME-TAG, PSA	G140L 1280 A	EXTENDED=YES; FLASH=YES; BUFFER-TIME=2853; FP-POS=2			2953 Secs (2953 Secs) *[==>]*	***[3]***
5	(4/9) A2597 Filament science exposure (515644)	(2) ABELL-2597-FILAMENT	COS/FUV, TIME-TAG, PSA	G140L 1280 A	EXTENDED=YES; FLASH=YES; BUFFER-TIME=2853; FP-POS=2			2953 Secs (2953 Secs) *[==>]*	***[4]***
6	(5/9) A2597 Filament science exposure (515644)	(2) ABELL-2597-FILAMENT	COS/FUV, TIME-TAG, PSA	G140L 1280 A	EXTENDED=YES; FLASH=YES; BUFFER-TIME=2853; FP-POS=3			2953 Secs (2953 Secs) *[==>]*	***[5]***
7	(6/9) A2597 Filament science exposure (515644)	(2) ABELL-2597-FILAMENT	COS/FUV, TIME-TAG, PSA	G140L 1280 A	EXTENDED=YES; FLASH=YES; BUFFER-TIME=2853; FP-POS=3			2953 Secs (2953 Secs) *[==>]*	***[6]***
8	(7/9) A2597 Filament science exposure (515644)	(2) ABELL-2597-FILAMENT	COS/FUV, TIME-TAG, PSA	G140L 1280 A	EXTENDED=YES; FLASH=YES; BUFFER-TIME=2853; FP-POS=3			2953 Secs (2953 Secs) *[==>]*	***[7]***
9	(8/9) A2597 Filament science exposure (515644)	(2) ABELL-2597-FILAMENT	COS/FUV, TIME-TAG, PSA	G140L 1280 A	EXTENDED=YES; FLASH=YES; BUFFER-TIME=2853; FP-POS=4			2953 Secs (2953 Secs) *[==>]*	***[8]***

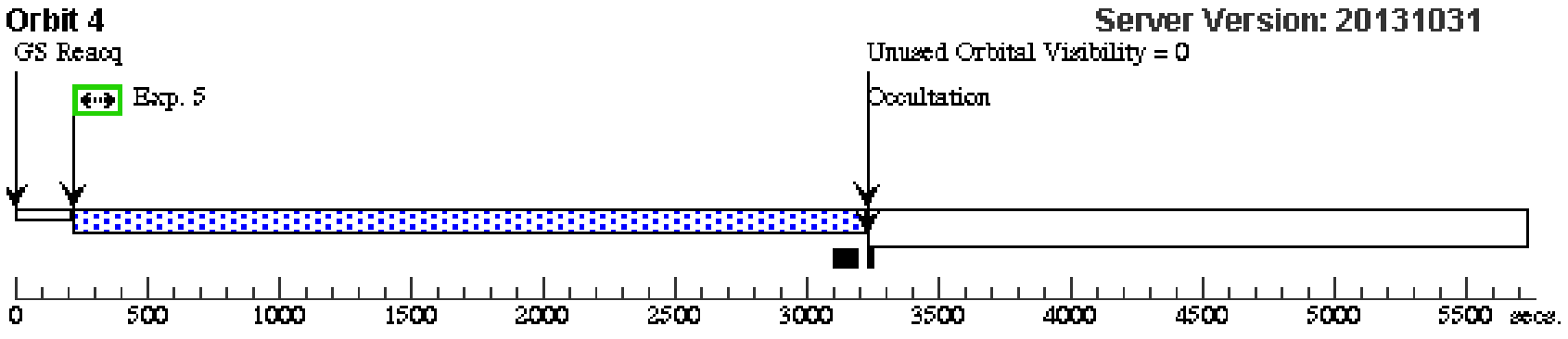
	10	(9/9) A2597 Filament science exposure (515644)	(2) ABELL-2597-FILAMENT	COS/FUV, TIME-TAG, PSA	G140L 1280 A	EXTENDED=YES; FLASH=YES; BUFFER-TIME=2853; FP-POS=4	2953 Secs (2953 Secs) *[==>]*	***[9]***

Orbit Structure





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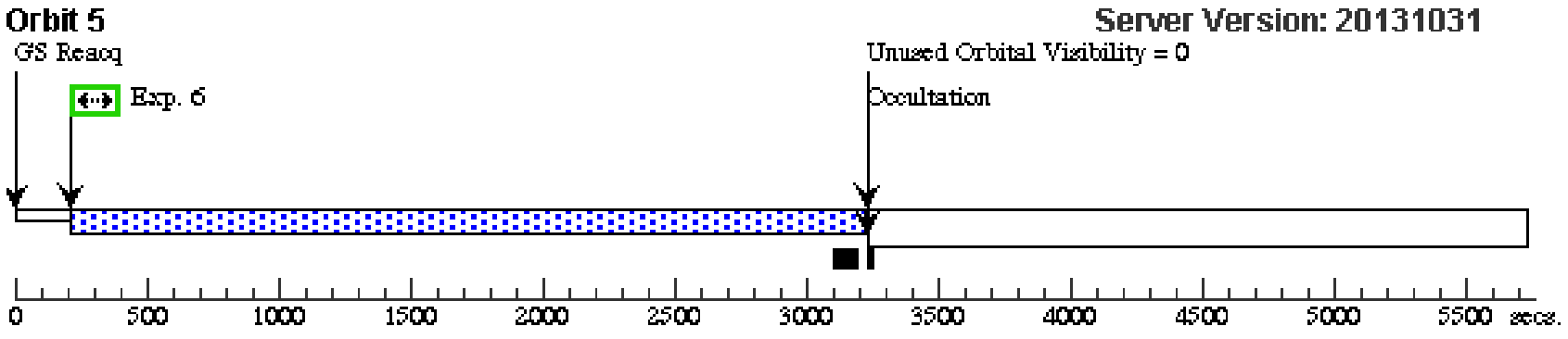
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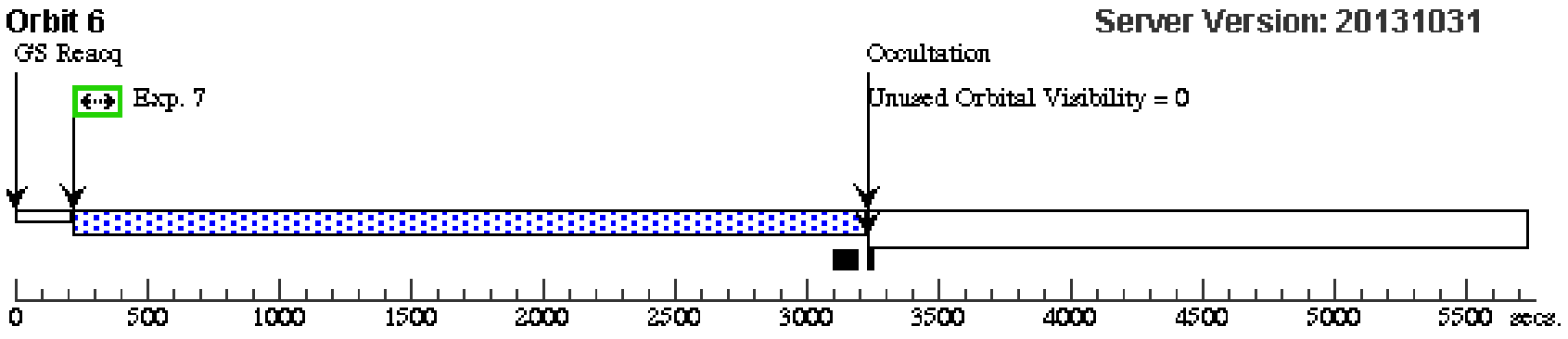
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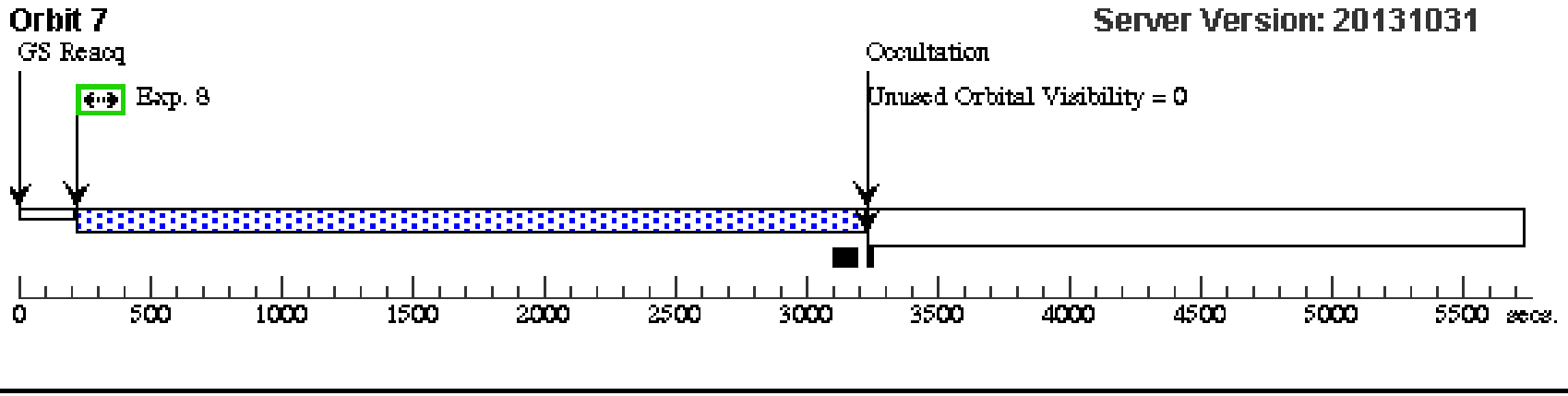
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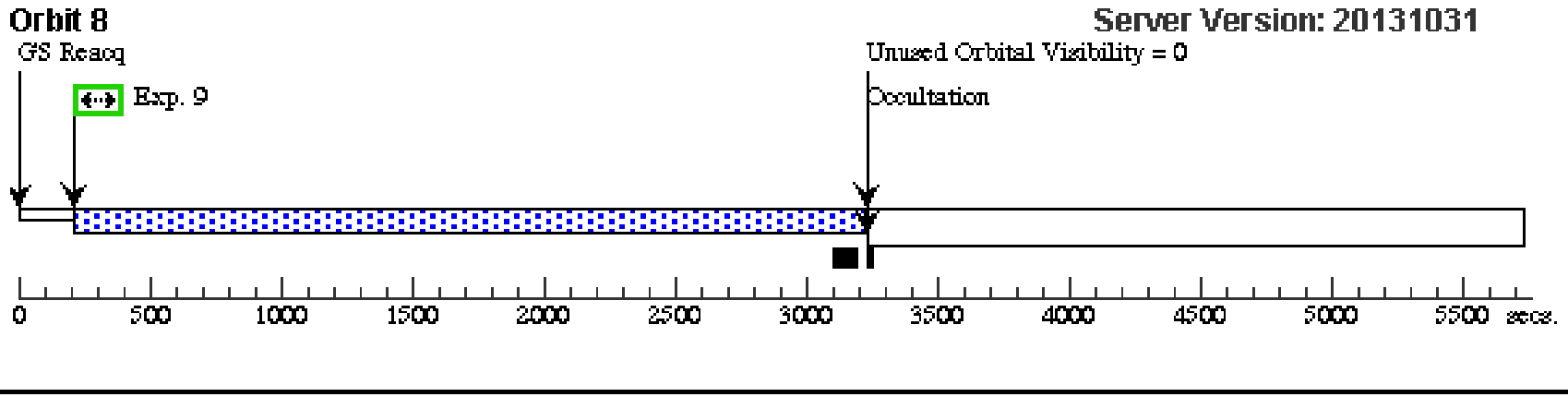
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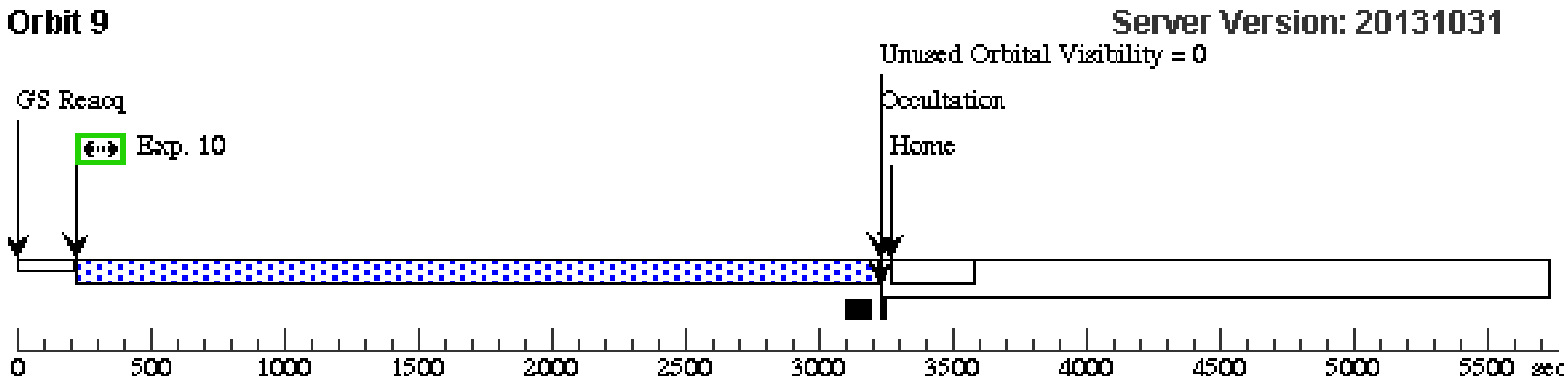
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Visit

Proposal 13304, 9 Orbits on Zw3146 Filament (03), implementation Wed Apr 02 01:04:17 GMT 2014

Diagnostic Status: Warning

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: (none)

Diagnostics

(9 Orbits on Zw3146 Filament (03)) Warning (Orbit Planner): LONG SU LIKELY TO INTERSECT THE SAA

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(3)	ZWCL-3146-FILAMENT	RA: 10 23 39.7890 (155.9157875d) Dec: +04 11 8.86 (4.18579d) Equinox: J2000		V=20.0	Reference Frame: ICRS

Comments: The listed coorindates are for the desired center of the 4"x4" ACQ/IMAGE search field. We would like the COS Primary Science Aperture to be centered around the brightest region within this field.

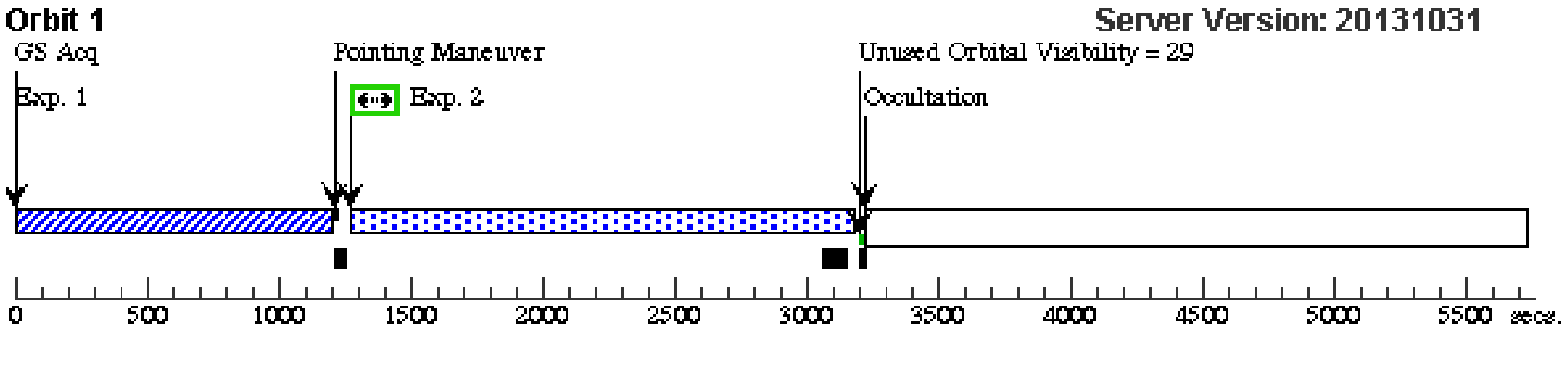
This pointing intentionally avoids the nucleus (location of the unresolved radio source).

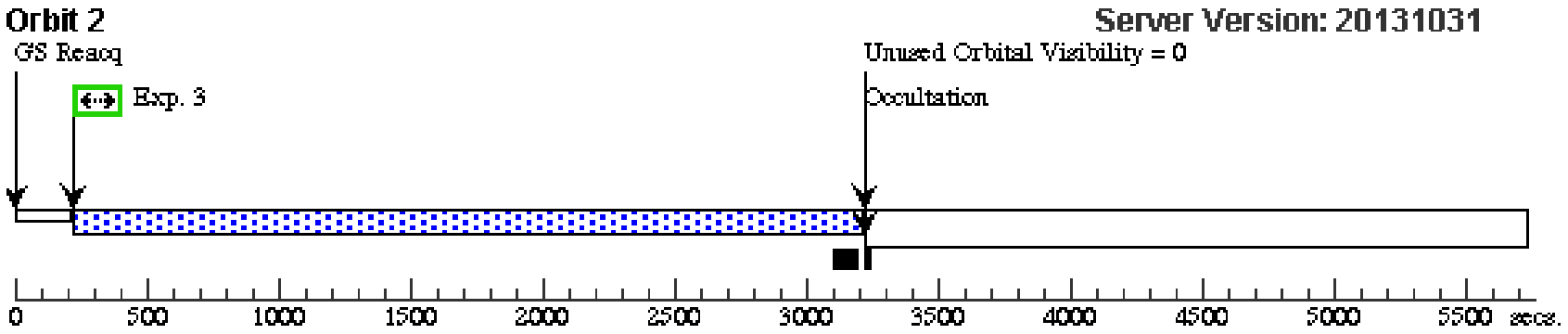
Exposures

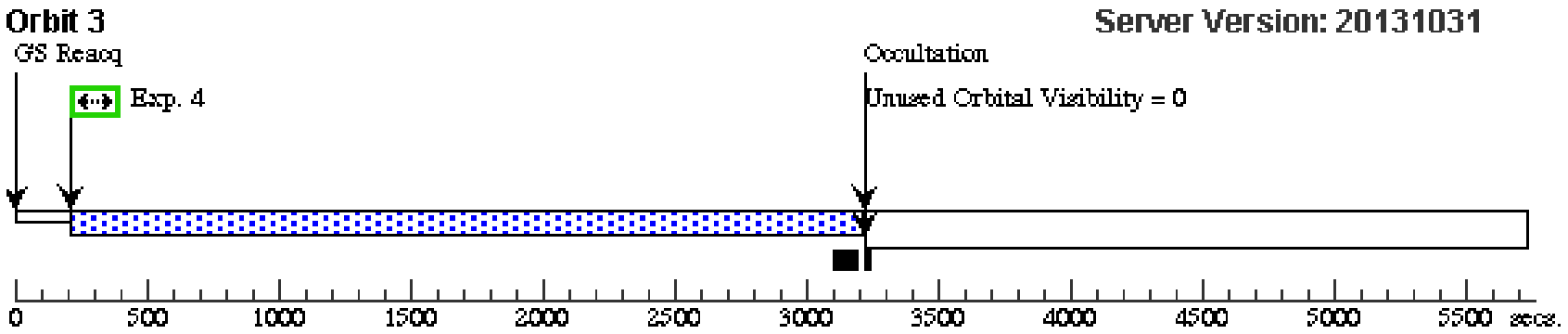
#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(0/9) 400 sec acquisition of Zw3146 Filament (COS.ta.562768)	(3) ZWCL-3146-FILAMENT	COS/NUV, ACQ/IMAGE, PSA	MIRRORA		GS ACQ SCENARIO BASE1B3		400 Secs (400 Secs) *[==>]*	***[1]***
2	(1/9) Zw3146 Filament science exposure (515644)	(3) ZWCL-3146-FILAMENT	COS/FUV, TIME-TAG, PSA	G140L 1280 A	EXTENDED=YES; FLASH=YES; BUFFER-TIME=1634; FP-POS=1			1734 Secs (1734 Secs) *[==>]*	***[1]***
3	(2/9) Zw3146 Filament science exposure (515644)	(3) ZWCL-3146-FILAMENT	COS/FUV, TIME-TAG, PSA	G140L 1280 A	EXTENDED=YES; FLASH=YES; BUFFER-TIME=2845; FP-POS=1			2945 Secs (2943 Secs) *[==>2943.0 Secs]*	***[2]***
4	(3/9) Zw3146 Filament science exposure (515644)	(3) ZWCL-3146-FILAMENT	COS/FUV, TIME-TAG, PSA	G140L 1280 A	EXTENDED=YES; FLASH=YES; BUFFER-TIME=2845; FP-POS=2			2945 Secs (2943 Secs) *[==>2943.0 Secs]*	***[3]***
5	(4/9) Zw3146 Filament science exposure (515644)	(3) ZWCL-3146-FILAMENT	COS/FUV, TIME-TAG, PSA	G140L 1280 A	EXTENDED=YES; FLASH=YES; BUFFER-TIME=2845; FP-POS=2			2945 Secs (2943 Secs) *[==>2943.0 Secs]*	***[4]***
6	(5/9) Zw3146 Filament science exposure (515644)	(3) ZWCL-3146-FILAMENT	COS/FUV, TIME-TAG, PSA	G140L 1280 A	EXTENDED=YES; FLASH=YES; BUFFER-TIME=2845; FP-POS=3			2945 Secs (2943 Secs) *[==>2943.0 Secs]*	***[5]***
7	(6/9) Zw3146 Filament science exposure (515644)	(3) ZWCL-3146-FILAMENT	COS/FUV, TIME-TAG, PSA	G140L 1280 A	EXTENDED=YES; FLASH=YES; BUFFER-TIME=2845; FP-POS=3			2945 Secs (2943 Secs) *[==>2943.0 Secs]*	***[6]***
8	(7/9) Zw3146 Filament science exposure (515644)	(3) ZWCL-3146-FILAMENT	COS/FUV, TIME-TAG, PSA	G140L 1280 A	EXTENDED=YES; FLASH=YES; BUFFER-TIME=2845; FP-POS=3			2945 Secs (2943 Secs) *[==>2943.0 Secs]*	***[7]***
9	(8/9) Zw3146 Filament science exposure (515644)	(3) ZWCL-3146-FILAMENT	COS/FUV, TIME-TAG, PSA	G140L 1280 A	EXTENDED=YES; FLASH=YES; BUFFER-TIME=2845; FP-POS=4			2945 Secs (2943 Secs) *[==>2943.0 Secs]*	***[8]***

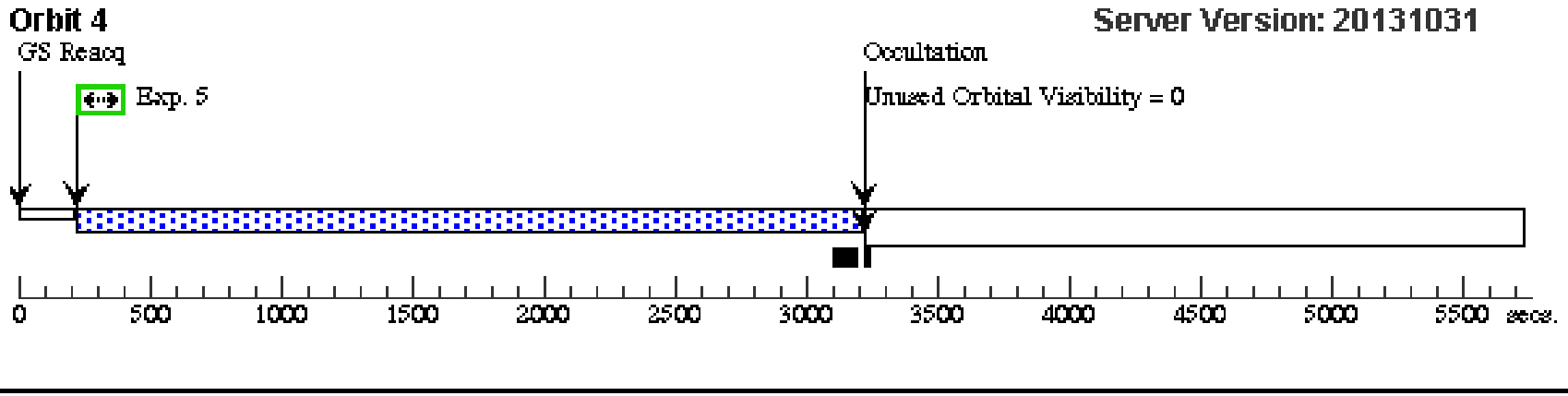
	10	(9/9) Zw3146 Filament science exposure (515644)	(3) ZWCL-3146-FILAMENT	COS/FUV, TIME-TAG, PSA	G140L 1280 A	EXTENDED=YES; FLASH=YES; BUFFER-TIME=2845; FP-POS=4	2945 Secs (2943 Secs) *[==>2943.0 Secs]*	 ***[9]***

Orbit Structure





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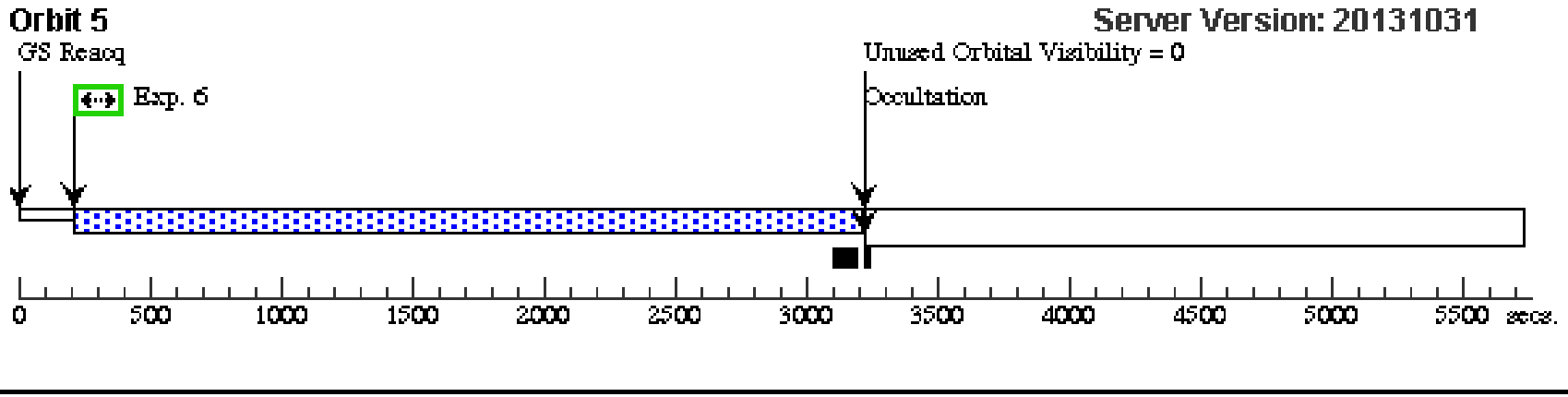
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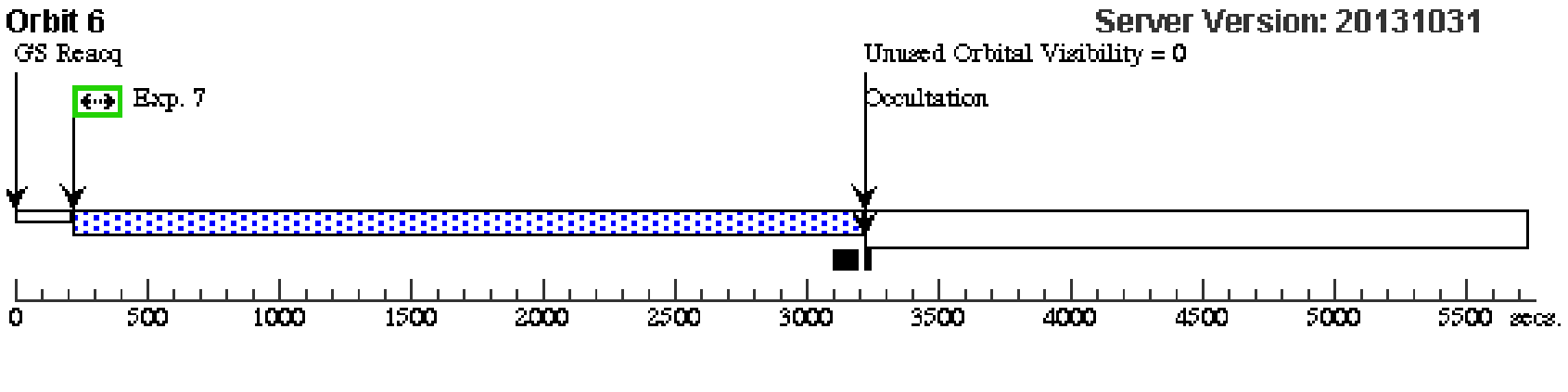
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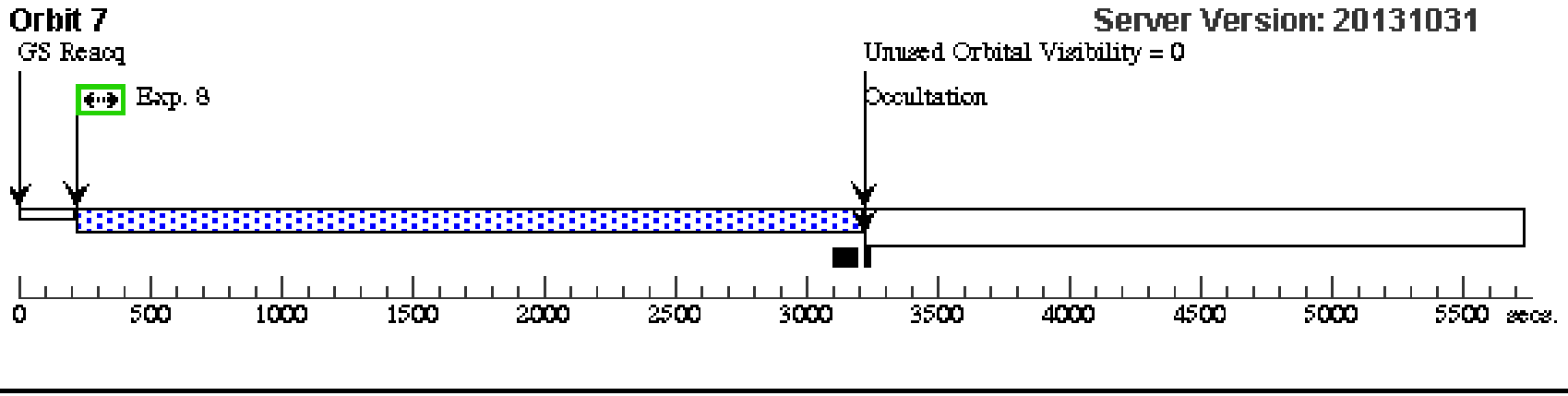
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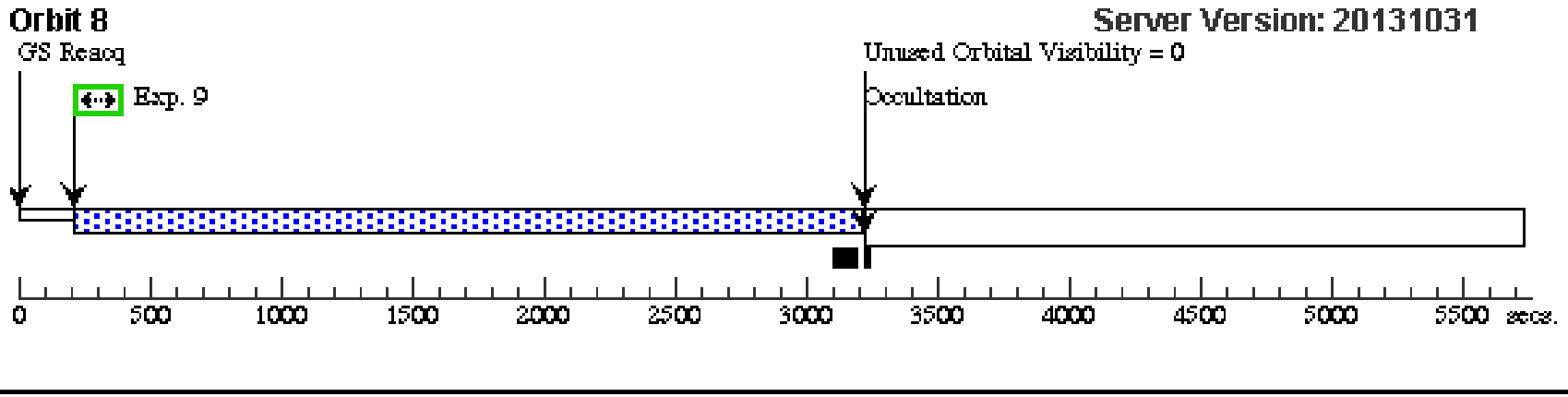
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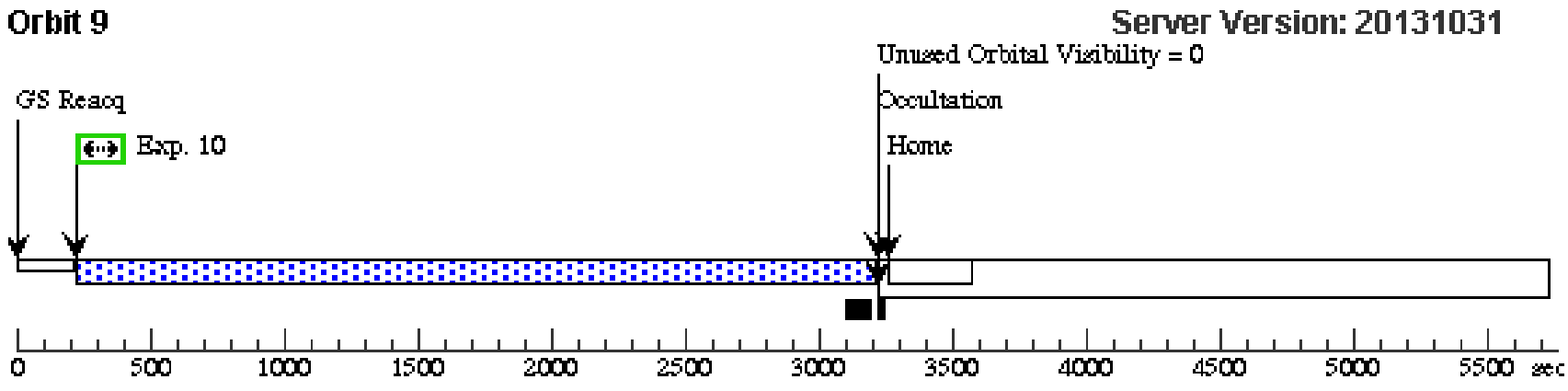
Orbit 9
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