14247 - Confirmation of an Intermediate-Mass Black Hole in an Extragalactic Globular Cluster

Cycle: 23, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Prof. Jimmy A. Irwin (PI) (Contact)	**University of Alabama**	**jairwin@ua.edu**
Dr. Drew Reid Clausen (CoI)	California Institute of Technology	dclausen@tapir.caltech.edu
Prof. Steinn Sigurdsson (CoI)	The Pennsylvania State University	steinn@astro.psu.edu
Prof. Michael Eracleous (CoI)	The Pennsylvania State University	mxe17@psu.edu

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) CXO-J033831.8-352604	COS/FUV COS/NUV	3	22-Jul-2015 22:26:57.0	yes
02	(1) CXO-J033831.8-352604	COS/FUV COS/NUV	3	22-Jul-2015 22:26:59.0	yes
03	(1) CXO-J033831.8-352604	COS/FUV COS/NUV	2	22-Jul-2015 22:27:01.0	yes
04	(1) CXO-J033831.8-352604	COS/FUV COS/NUV	2	22-Jul-2015 22:27:02.0	yes

10 Total Orbits Used

ABSTRACT

The long and controversial search for black holes within globular clusters has reached the point where extragalactic globular clusters provide fertile hunting grounds for finding black holes of both stellar and intermediate-mass (IMBH) varieties. While a luminous X-ray point source within a cluster can indicate the presence of a black hole, little can generally be said of its mass without further observation. In the event that a black hole tidally disrupts a passing star in the cluster, optical/UV emission lines from the X-ray-illuminated debris can not only demonstrate the existence of a black hole in the cluster, but can also provide powerful constraints on the mass of the black hole, the composition of the disrupted star, and even the time since the tidal disruption event took place. We propose an HST COS G140L UV spectrum of a globular cluster within the Fornax elliptical galaxy NGC1399 that exhibits unusual optical [N II] and [O III] forbidden emission lines that are believed to result from such a tidal disruption event by a ~100 solar mass black hole. Our models predict that the ratios of the expected emission lines from carbon, nitrogen, and oxygen that should be present in the UV spectrum of the source will be able to distinguish a stellar-mass black hole from an IMBH as the disruptor, as well as determine the nature of the disrupted star. If the mass of the black hole is constrained to be in excess of 100 solar masses, this would provide one of the most compelling pieces of evidence to date that IMBHs exist within globular clusters.

OBSERVING DESCRIPTION

For the position of the source, we registered an HST/ACS B-band image of NGC1399 to the ICRS coordinate system using matched USNOB-1 stars that fell within the field of view. The coordinates of our source agreed well with the position found for the source by two other independent studies of NGC1399's globular cluster system to within 0.1": Paolillo et al. (2011) - who registered an HST/ACS/606W image to USNOB-1 stars with quoted positional accuracies of 0.2", and Kim et al. (2013) - who registered ground-based imaging to USNOB-1 star positions and also obtained an absolute astrometry accuracy of 0.2". Given the agreement of these three matching studies, we are confident that the coordinates of our source are accurate to 0.2" in RA and Dec.

Our source has a magnitude of 23.8 in Johnson U (Kim et al. 2013), so using the "Elliptical galaxy with strong UV upturn" template of the COS ETC (since a metal-rich globular cluster would have a similar stellar population), we calculate that an exposure of 400 seconds will detect the source at S/N=25 for acquisition purposes. This will be a lower limit, since we did not include the flux from any emission lines that might be present in the NUV spectrum.

We kept all visits to 2-3 orbits each as requested for Cycle 23. All four FP-POS steps were used during each visit, although they were judiciously

spaced throughout the 2-3 orbit period to reduce unnecessary overhead.

Visit

Proposal 14247, Visit 01 Thu Jul 23 02:27:03 GMT 2015

Diagnostic Status: Warning

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: (none)

Diagnostics

(Exposure 2 (Visit 01)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 3 (Visit 01)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 4 (Visit 01)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 5 (Visit 01)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 6 (Visit 01)) Warning (Form): Sensitive exposures should have an ETC run number provided.

Fixed Targets

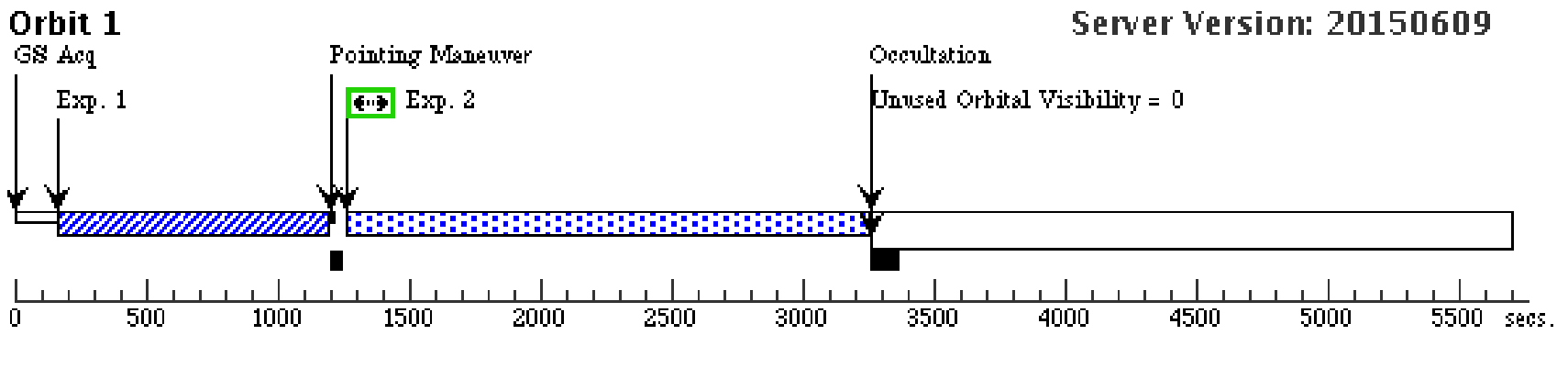
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	CXO-J033831.8-352604	RA: 03 38 31.8100 (54.6325417d) Dec: -35 26 4.50 (-35.43458d) Equinox: J2000		V=22.4 B=23.2 U = 23.8	Reference Frame: ICRS

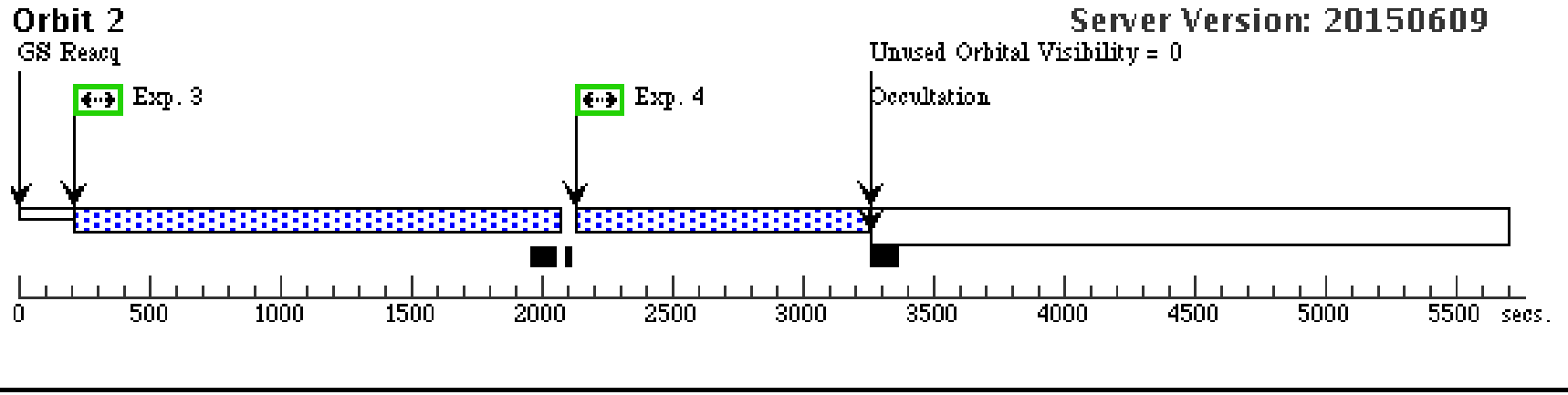
Comments: Extended=NO

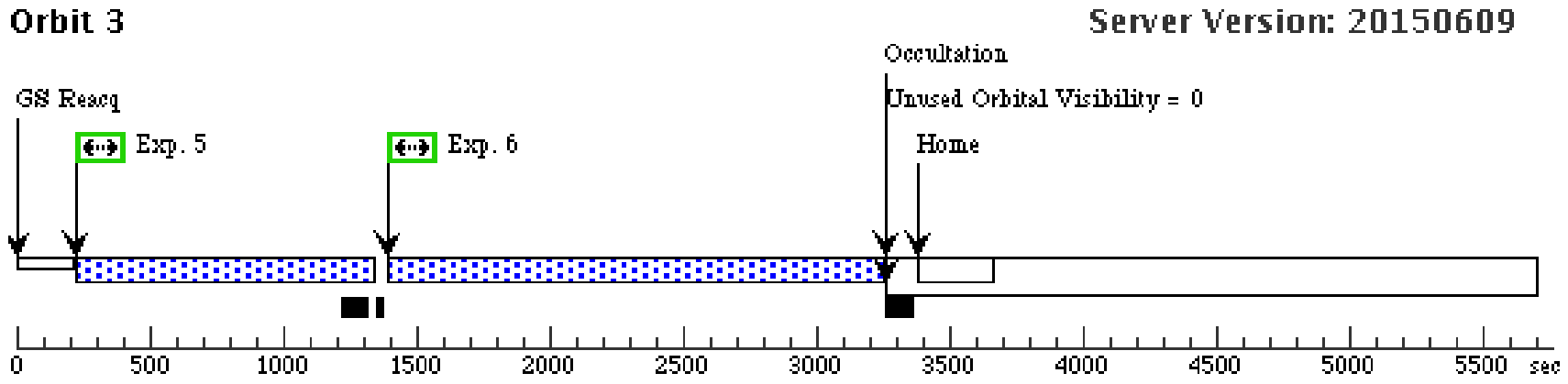
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.ta.732807)	(1) CXO-J033831.8-352604	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				400 Secs (400 Secs) *[==>]*	 ***[1]***
2		(1) CXO-J033831.8-352604	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=1; BUFFER-TIME=1808			1808 Secs (1808 Secs) *[==>]*	 ***[1]***
3		(1) CXO-J033831.8-352604	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=2; BUFFER-TIME=1708			1808 Secs (1808 Secs) *[==>]*	 ***[2]***
4		(1) CXO-J033831.8-352604	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=3; BUFFER-TIME=1068			1068 Secs (1068 Secs) *[==>]*	 ***[2]***
5		(1) CXO-J033831.8-352604	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=3; BUFFER-TIME=968			1068 Secs (1068 Secs) *[==>]*	 ***[3]***
6		(1) CXO-J033831.8-352604	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=4; BUFFER-TIME=1808			1808 Secs (1808 Secs) *[==>]*	 ***[3]***

Orbit Structure







Visit

Proposal 14247, Visit 02 Thu Jul 23 02:27:04 GMT 2015

Diagnostic Status: Warning

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: (none)

Diagnostics

(Exposure 2 (Visit 02)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 3 (Visit 02)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 4 (Visit 02)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 5 (Visit 02)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 6 (Visit 02)) Warning (Form): Sensitive exposures should have an ETC run number provided.

Fixed Targets

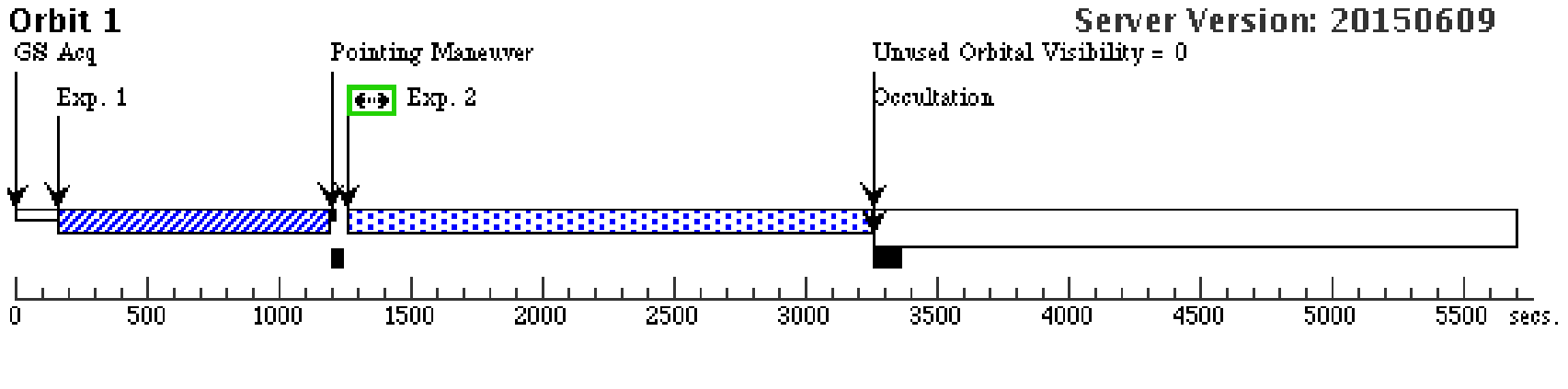
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	CXO-J033831.8-352604	RA: 03 38 31.8100 (54.6325417d) Dec: -35 26 4.50 (-35.43458d) Equinox: J2000		V=22.4 B=23.2 U = 23.8	Reference Frame: ICRS

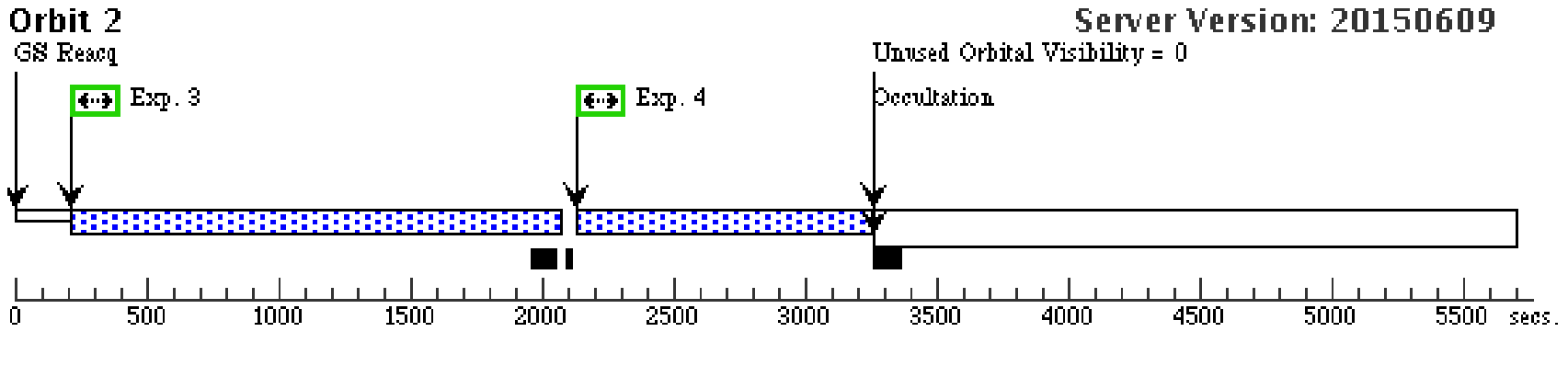
Comments: Extended=NO

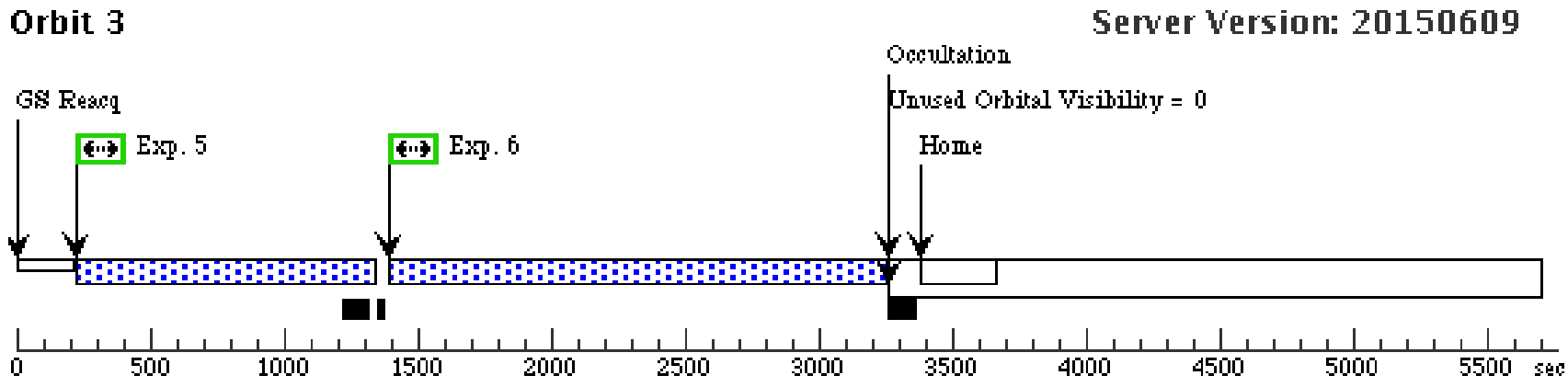
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.ta.732807)	(1) CXO-J033831.8-352604	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				400 Secs (400 Secs) *[==>]*	 ***[1]***
2		(1) CXO-J033831.8-352604	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=1; BUFFER-TIME=1808			1808 Secs (1808 Secs) *[==>]*	 ***[1]***
3		(1) CXO-J033831.8-352604	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=2; BUFFER-TIME=1708			1808 Secs (1808 Secs) *[==>]*	 ***[2]***
4		(1) CXO-J033831.8-352604	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=3; BUFFER-TIME=1068			1068 Secs (1068 Secs) *[==>]*	 ***[2]***
5		(1) CXO-J033831.8-352604	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=3; BUFFER-TIME=968			1068 Secs (1068 Secs) *[==>]*	 ***[3]***
6		(1) CXO-J033831.8-352604	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=4; BUFFER-TIME=1808			1808 Secs (1808 Secs) *[==>]*	 ***[3]***

Orbit Structure







Visit

Proposal 14247, Visit 03 Thu Jul 23 02:27:04 GMT 2015

Diagnostic Status: Warning

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: (none)

Diagnostics

(Exposure 2 (Visit 03)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 3 (Visit 03)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 4 (Visit 03)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 5 (Visit 03)) Warning (Form): Sensitive exposures should have an ETC run number provided.

Fixed Targets

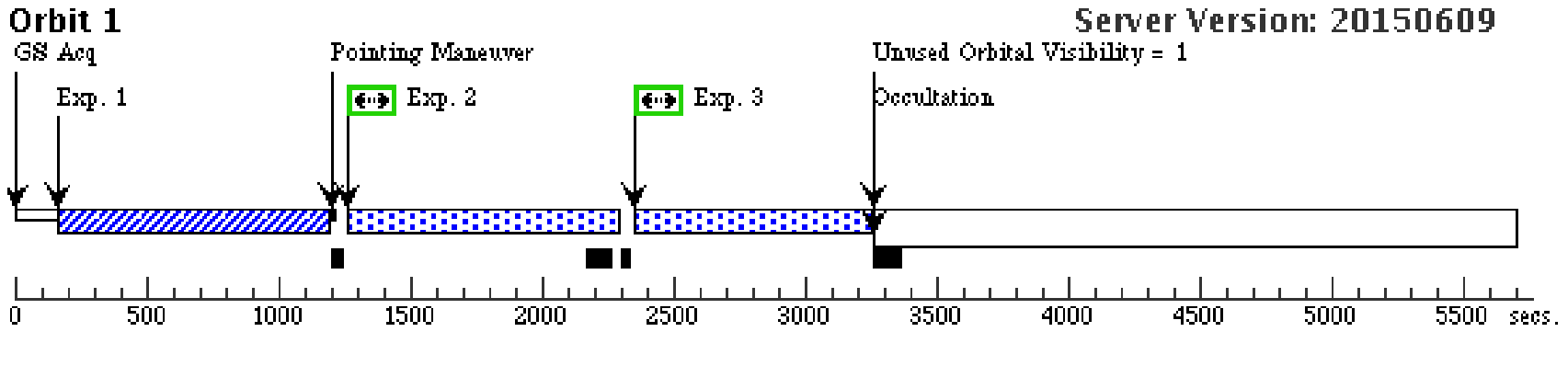
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	CXO-J033831.8-352604	RA: 03 38 31.8100 (54.6325417d) Dec: -35 26 4.50 (-35.43458d) Equinox: J2000		V=22.4 B=23.2 U = 23.8	Reference Frame: ICRS

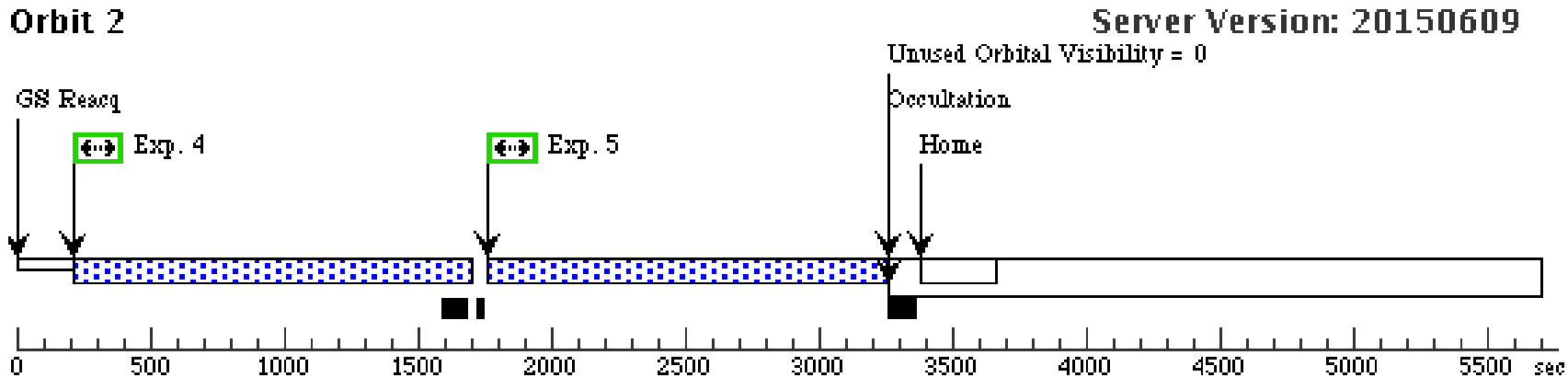
Comments: Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.ta.732807)	(1) CXO-J033831.8-352604	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				400 Secs (400 Secs) *[==>]*	 ***[1]***
2		(1) CXO-J033831.8-352604	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=1; BUFFER-TIME=746			846 Secs (846 Secs) *[==>]*	 ***[1]***
3		(1) CXO-J033831.8-352604	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=2; BUFFER-TIME=846			846 Secs (846 Secs) *[==>]*	 ***[1]***
4		(1) CXO-J033831.8-352604	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=3; BUFFER-TIME=1338			1438 Secs (1438 Secs) *[==>]*	 ***[2]***
5		(1) CXO-J033831.8-352604	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=4; BUFFER-TIME=1438			1438 Secs (1438 Secs) *[==>]*	 ***[2]***

Orbit Structure





Visit

Proposal 14247, Visit 04 Thu Jul 23 02:27:04 GMT 2015

Diagnostic Status: Warning

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: (none)

Diagnostics

(Exposure 2 (Visit 04)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 3 (Visit 04)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 4 (Visit 04)) Warning (Form): Sensitive exposures should have an ETC run number provided.

(Exposure 5 (Visit 04)) Warning (Form): Sensitive exposures should have an ETC run number provided.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	CXO-J033831.8-352604	RA: 03 38 31.8100 (54.6325417d) Dec: -35 26 4.50 (-35.43458d) Equinox: J2000		V=22.4 B=23.2 U = 23.8	Reference Frame: ICRS

Comments: Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.ta.732807)	(1) CXO-J033831.8-352604	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				400 Secs (400 Secs) *[==>]*	 ***[1]***
2		(1) CXO-J033831.8-352604	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=1; BUFFER-TIME=746			846 Secs (846 Secs) *[==>]*	 ***[1]***
3		(1) CXO-J033831.8-352604	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=2; BUFFER-TIME=846			846 Secs (846 Secs) *[==>]*	 ***[1]***
4		(1) CXO-J033831.8-352604	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=3; BUFFER-TIME=1338			1438 Secs (1438 Secs) *[==>]*	 ***[2]***
5		(1) CXO-J033831.8-352604	COS/FUV, TIME-TAG, PSA	G140L 1105 A	FP-POS=4; BUFFER-TIME=1438			1438 Secs (1438 Secs) *[==>]*	 ***[2]***

Orbit Structure