10579 - ULX counterparts: the key to finding intermediate-mass black holes

Cycle: 14, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Dr. Timothy Paul Roberts (PI) (ESA Member)	**University of Leicester**	**tro@star.le.ac.uk**
Dr. Michael R. Goad (CoI) (ESA Member)	University of Leicester	mrg@astro.soton.ac.uk
Mr. Andrew J. Levan (CoI) (ESA Member)	University of Leicester	anl@star.le.ac.uk

VISITS

Visit	*Targets*	*Configurations*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
03	(2) NGC2403-X1	ACS/HRC ACS/WFC	2	17-Aug-2005 21:25:04.0	yes
07	(4) NGC4485-X1	ACS/HRC ACS/WFC	2	17-Aug-2005 21:25:13.0	yes
09	(5) NGC5055-X2	ACS/WFC	1	17-Aug-2005 21:25:17.0	yes
10	(5) NGC5055-X2	ACS/HRC	1	17-Aug-2005 21:25:21.0	yes
11	(6) M83-IXO82	ACS/HRC ACS/WFC	2	17-Aug-2005 21:25:27.0	yes
13	(7) IC-342-X1	ACS/HRC ACS/WFC	2	17-Aug-2005 21:25:36.0	yes

Visit	*Targets*	*Configurations*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
15	(8) IC-342-X2	ACS/HRC ACS/WFC	2	17-Aug-2005 21:25:43.0	yes

12 Total Orbits Used

ABSTRACT

The origin and formation mechanism for supermassive black holes (SMBHs) found in the centres of most, if not all, galaxies remains one of the outstanding questions in astrophysics. Most scenarios involve the presence of massive black holes in the early universe, formed by the collapse of primordial Population III stars. It is predicted that a relic of this population could still be present in galactic halos in the current epoch, possessing masses from a few hundred times solar mass upwards. However, to date no CONCLUSIVE evidence for such a class of "intermediate-mass" black holes has been found. The most likely current candidates are the ultraluminous X-ray sources (ULXs), which show tantalising evidence for IMBHs (e.g. the extreme X-ray luminosities and low disk temperatures expected from accreting IMBHs).

We propose to address this issue by identifying optical counterparts for six of the nearest ULXs. We will use this programme as a pathfinder for future radial velocity measurements, which will allow the orbital parameters and hence the first undisputed mass constraints for these systems to be determined.

OBSERVING DESCRIPTION

For each of our six targets we will obtain two orbits of imaging. One of these will utilize the ACS/WFC for B (F435W) and V-R (F606W) observations (note that we choose F606W over F555W, which is closer in coverage to the classic V filter, due to its superior throughput which allows far higher sensitivity observations). We will perform two exposures in each of the filters to enable cosmic ray rejection, these exposures will have a typical length of ~500s. This will allow

us to reach 5-sigma magnitude limits of F435W = 26.6 and F606W = 27.2 corresponding to$M_B =-2.6 and Mv = -2.0 at a distance of 7 Mpc (the mean distance of our sample), and is sufficiently deep to observe B-stars on the main sequence.

Our second orbit will use the ACS/HRC to obtain U-band (F330W) observations of the same targets. We will perform four exposures within the orbit utilising a small dither pattern to aid with cosmic-ray rejection and PSF recovery via the drizzle algorithm. The depth of the subsequently combined image will be F330W = 24.5 (equivalent to a B star with F606W = 26). This will provide a second colour (U-B), allowing the spectral type of any faint blue stellar companions to be constrained. The use of the HRC will also utilise the unmatched PSF of HST to its maximum effect, providing the highest resolution observations available to resolve potentially complex regions of the underlying galaxy.

To precisely position our ULXs onto the celestial frame of the HST images we will perform relative astrometry between the ACS/WFC and Chandra frames. The increased field of view of ACS/WFC with respect to WFPC2 means that we can expect a larger number of X-ray sources to fall within our field of view. In the event that insufficient sources are unambigously identified on the ACS frame we will use ground-based images as intermediates to aid the alignment. We will align the ACS/HRC field to that of the WFC utilising common point source in each field. Via this method we will be able to recover the

positions of ULXs on our ACS frames to positional accuracies of <
0."3.

Visit

Proposal 10579, Visit 03 Thu Aug 18 01:25:45 GMT 2005

Diagnostic Status: No Diagnostics

Scientific Instruments: ACS/WFC, ACS/HRC

Special Requirements: (none)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=ACS-WFC-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.15 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=34.1 Angle Between Sides= Center Pattern=false		(1), (2)
(2)	Pattern Type=ACS-HRC-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.15 Line Spacing=0.098	Coordinate Frame=POS-TARG Pattern Orientation=19.9 Angle Between Sides=63.5 Center Pattern=false		(3)

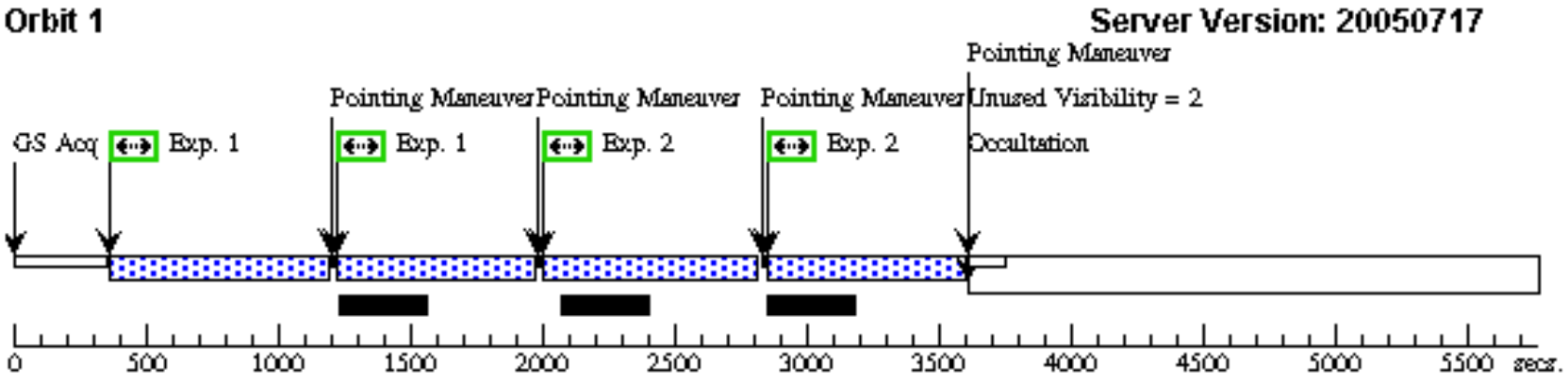
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	NGC2403-X1	RA: 07 36 25.5500 (114.1064583d) Dec: +65 35 40.00 (65.59444d) Equinox: J2000 Plate Id: (?)		V=(?) fx = 7.1e-13 erg/cm^2/s (0.5 - 2 keV)	Coordinate Source: Chandra location

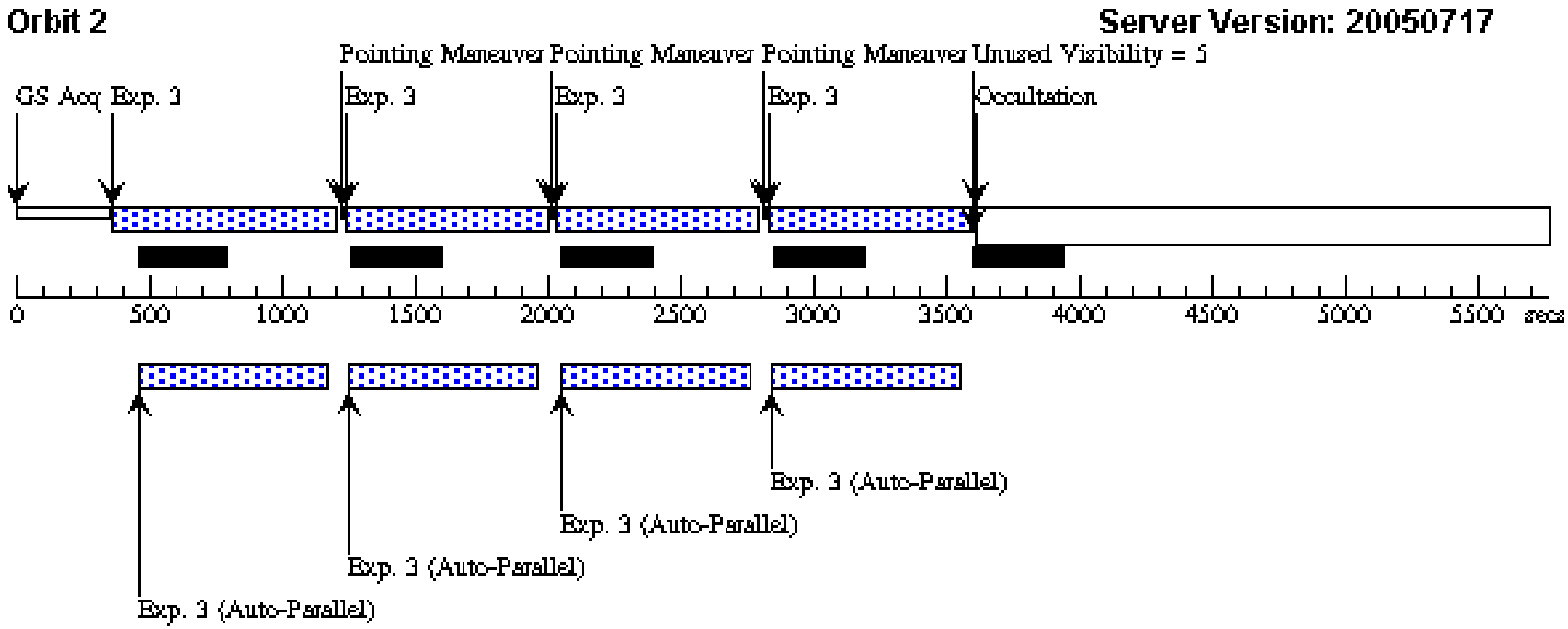
Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(2) NGC2403-X1	ACS/WFC, ACCUM, WFC1	F435W	CR-SPLIT=NO		Pattern 1-1 (1)	500.0 Secs	
								[==>624.0 Secs (Pattern 1)] *[==>624.0 Secs (Pattern 2)]*	***[1]***
2		(2) NGC2403-X1	ACS/WFC, ACCUM, WFC1	F606W	CR-SPLIT=NO		Pattern 2-2 (1)	500.0 Secs	
								[==>624.0 Secs (Pattern 1)] *[==>624.0 Secs (Pattern 2)]*	***[1]***
3		(2) NGC2403-X1	ACS/HRC, ACCUM, HRC	F330W	CR-SPLIT=NO		Pattern 3-3 (2)	728.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[2]***

Orbit Structure



Orbit Structure (continued)



Visit

Proposal 10579, Visit 07 Thu Aug 18 01:25:46 GMT 2005

Diagnostic Status: No Diagnostics

Scientific Instruments: ACS/WFC, ACS/HRC

Special Requirements: (none)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=ACS-WFC-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.15 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=34.1 Angle Between Sides= Center Pattern=false		(1), (2)
(2)	Pattern Type=ACS-HRC-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.15 Line Spacing=0.098	Coordinate Frame=POS-TARG Pattern Orientation=19.9 Angle Between Sides=63.5 Center Pattern=false		(3)

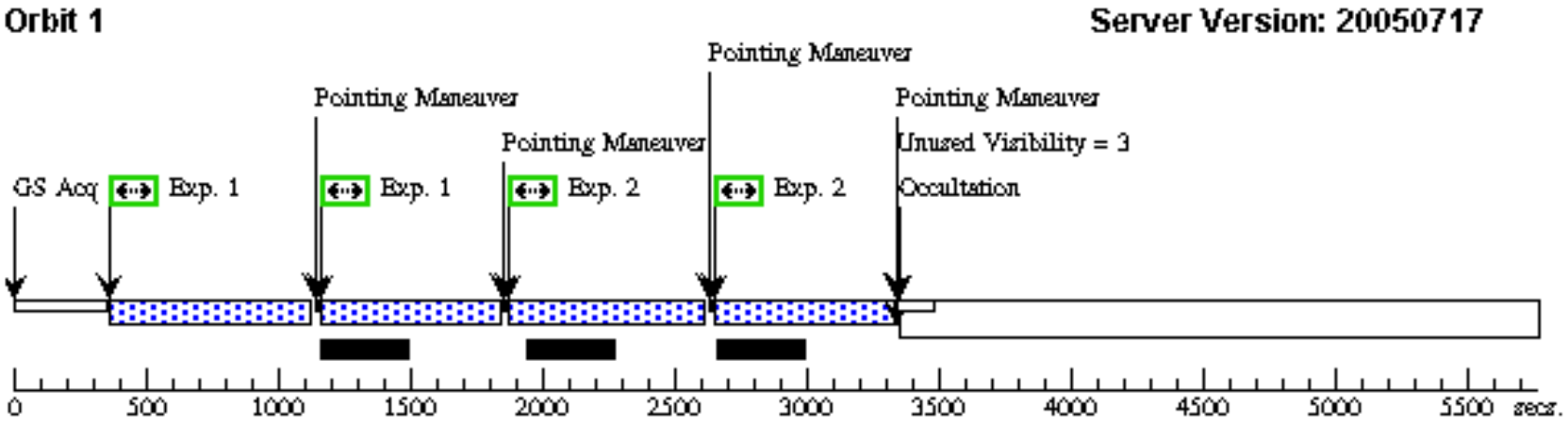
Fixed Targets

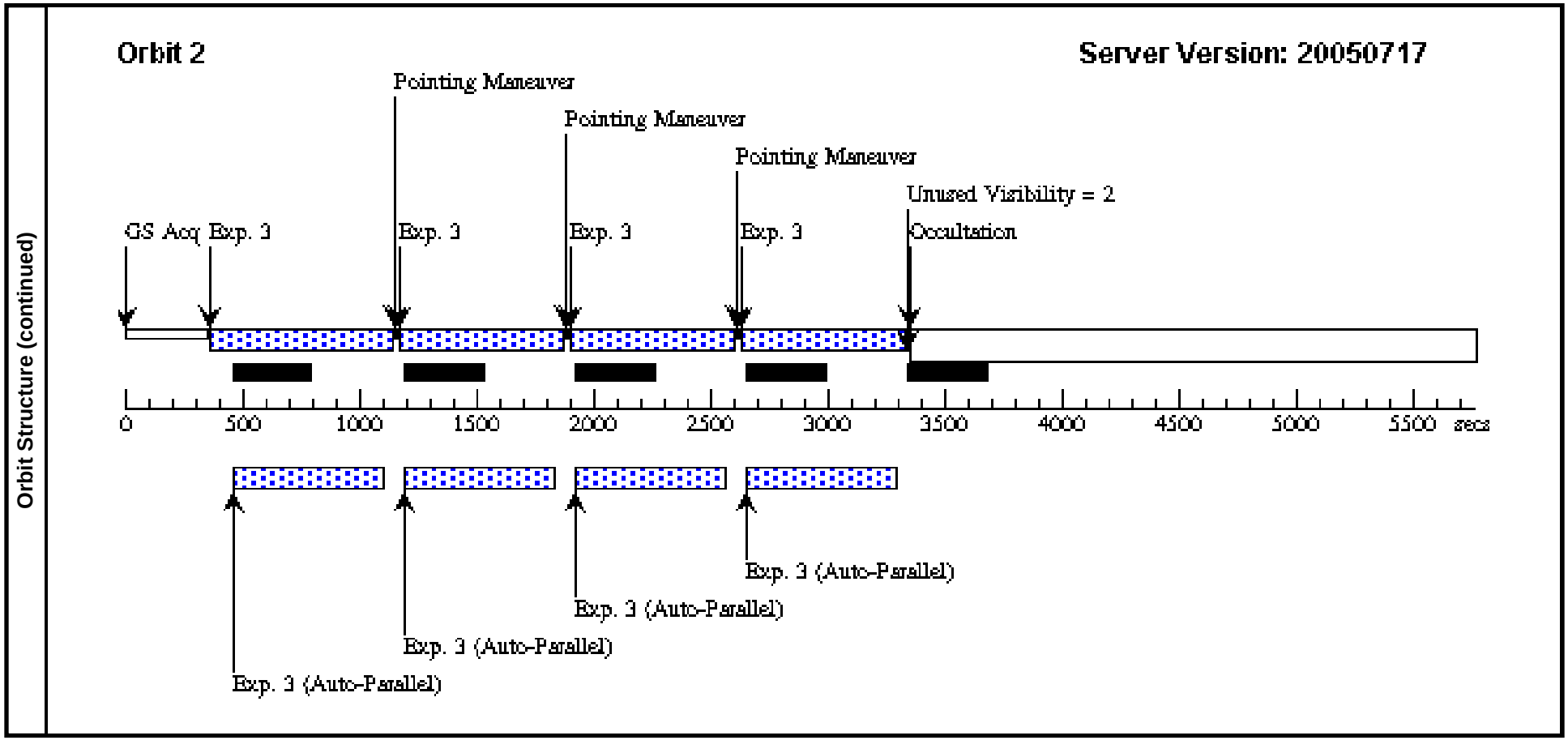
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(4)	NGC4485-X1	RA: 12 30 30.5600 (187.6273333d) Dec: +41 41 42.30 (41.69508d) Equinox: J2000 Plate Id: (?)		V=(?) fx = 1.8e-13 erg/cm^2/s (0.5 - 2 keV)	Coordinate Source: Chandra location

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(4) NGC4485-X1	ACS/WFC, ACCUM, WFC1	F435W	CR-SPLIT=NO		Pattern 1-1 (1)	500.0 Secs	
								[==>558.0 Secs (Pattern 1)] *[==>558.0 Secs (Pattern 2)]*	***[1]***
2		(4) NGC4485-X1	ACS/WFC, ACCUM, WFC1	F606W	CR-SPLIT=NO		Pattern 2-2 (1)	500.0 Secs	
								[==>558.0 Secs (Pattern 1)] *[==>558.0 Secs (Pattern 2)]*	***[1]***
3		(4) NGC4485-X1	ACS/HRC, ACCUM, HRC	F330W	CR-SPLIT=NO		Pattern 3-3 (2)	663.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[2]***

Orbit Structure




Orbit Structure (continued)
Orbit 2
Server Version: 20050717
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Unused Visibility = 2
GS Acq
Exp. 3
Exp. 3
Exp. 3
Exp. 3
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs
Exp. 3 (Auto-Parallel)
Exp. 3 (Auto-Parallel)
Exp. 3 (Auto-Parallel)
Exp. 3 (Auto-Parallel)

Visit

Proposal 10579, Visit 09 Thu Aug 18 01:25:48 GMT 2005

Diagnostic Status: No Diagnostics

Scientific Instruments: ACS/WFC

Special Requirements: (none)

Patterns

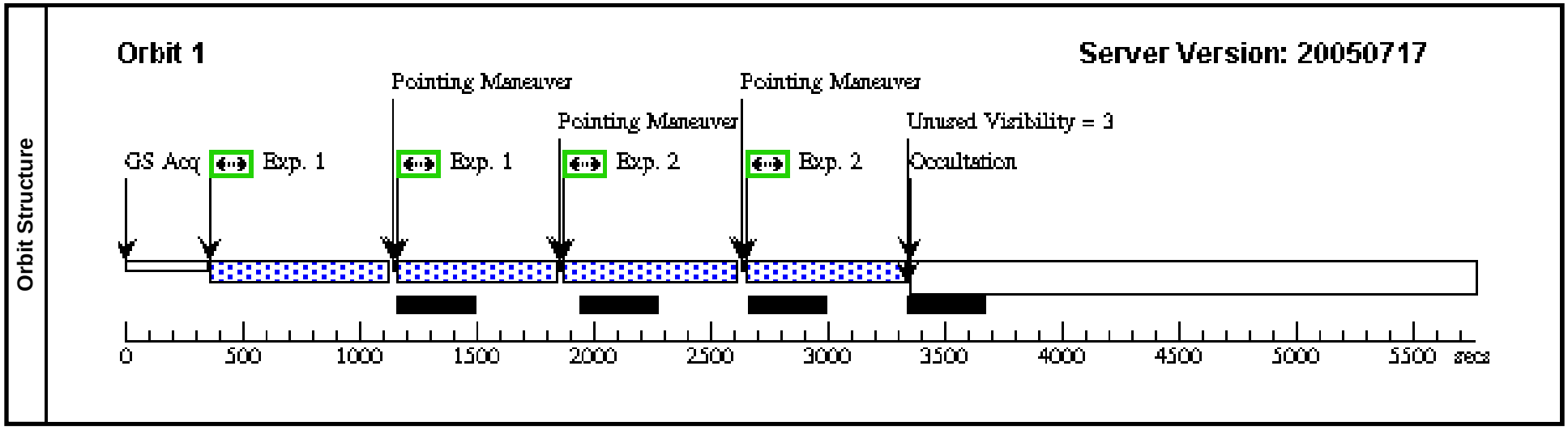
#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=ACS-WFC-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.15 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=34.1 Angle Between Sides= Center Pattern=false		(1), (2)

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(5)	NGC5055-X2	RA: 13 15 19.5000 (198.8312500d) Dec: +42 03 2.20 (42.05061d) Equinox: J2000 Plate Id: (?)		V=(?) fx = 7.3e-13 erg/cm^2/s (0.5 - 2 keV)	Coordinate Source: Chandra location

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(5) NGC5055-X2	ACS/WFC, ACCUM, WFC1	F435W	CR-SPLIT=NO		Pattern 1-1 (1)	500.0 Secs	
								[==>558.0 Secs (Pattern 1)] *[==>558.0 Secs (Pattern 2)]*	***[1]***
2		(5) NGC5055-X2	ACS/WFC, ACCUM, WFC1	F606W	CR-SPLIT=NO		Pattern 2-2 (1)	500.0 Secs	
								[==>558.0 Secs (Pattern 1)] *[==>558.0 Secs (Pattern 2)]*	***[1]***


Orbit Structure
Orbit 1
Server Version: 20050717
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Unused Visibility = 3
GS Acq
Exp. 1
Exp. 1
Exp. 2
Exp. 2
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs

Visit

Proposal 10579, Visit 10 Thu Aug 18 01:25:48 GMT 2005

Diagnostic Status: No Diagnostics

Scientific Instruments: ACS/HRC

Special Requirements: (none)

Patterns

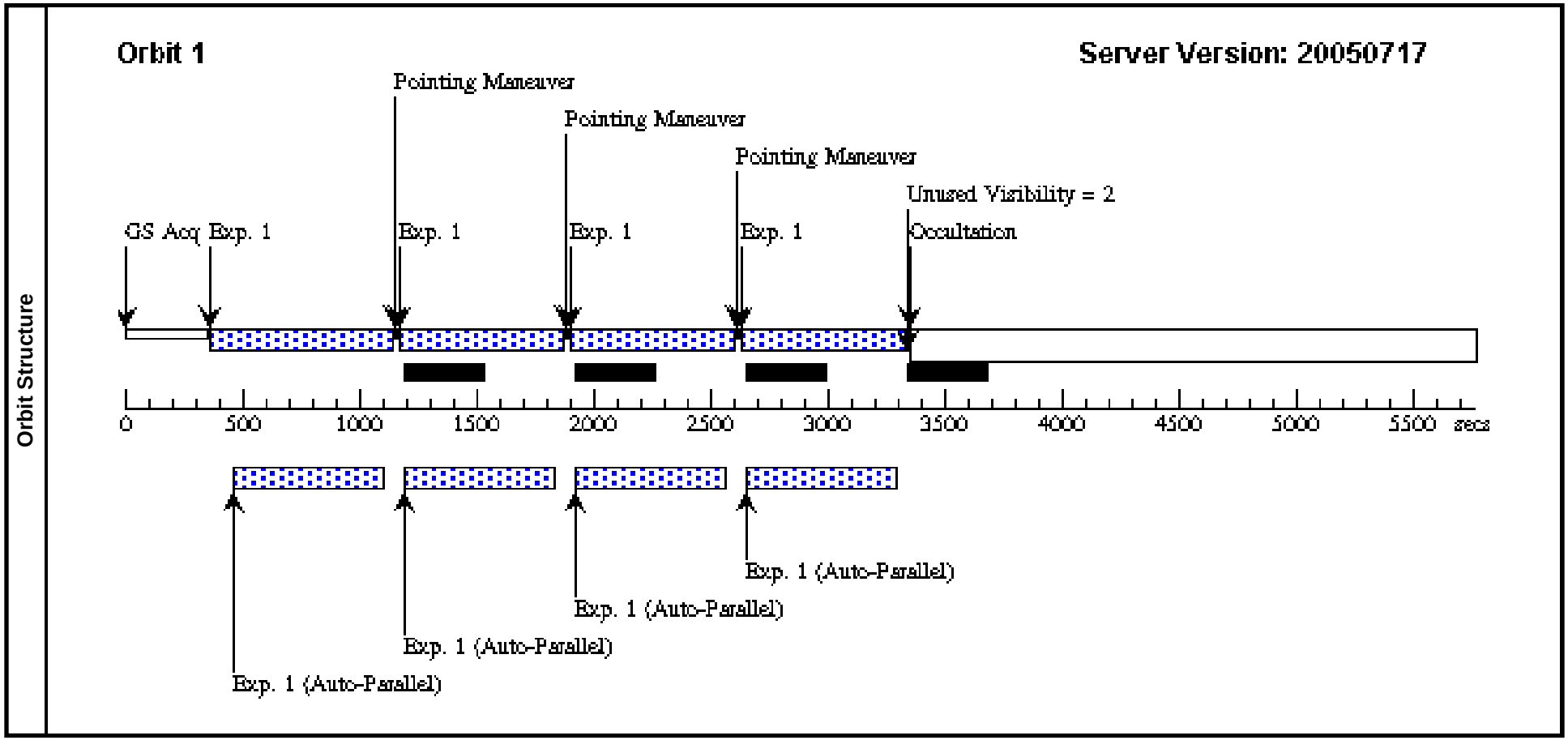
#	Primary Pattern		Secondary Pattern	Exposures
(2)	Pattern Type=ACS-HRC-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.15 Line Spacing=0.098	Coordinate Frame=POS-TARG Pattern Orientation=19.9 Angle Between Sides=63.5 Center Pattern=false		(1)

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(5)	NGC5055-X2	RA: 13 15 19.5000 (198.8312500d) Dec: +42 03 2.20 (42.05061d) Equinox: J2000 Plate Id: (?)		V=(?) fx = 7.3e-13 erg/cm^2/s (0.5 - 2 keV)	Coordinate Source: Chandra location

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(5) NGC5055-X2	ACS/HRC, ACCUM, HRC	F330W	CR-SPLIT=NO		Pattern 1-1 (2)	663.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[1]***


Orbit Structure
Orbit 1
Server Version: 20050717
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Unused Visibility = 2
GS Acq
Exp. 1
Exp. 1
Exp. 1
Exp. 1
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs
Exp. 1 (Auto-Parallel)
Exp. 1 (Auto-Parallel)
Exp. 1 (Auto-Parallel)
Exp. 1 (Auto-Parallel)

Visit

Proposal 10579, Visit 11 Thu Aug 18 01:25:48 GMT 2005

Diagnostic Status: No Diagnostics

Scientific Instruments: ACS/WFC, ACS/HRC

Special Requirements: (none)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=ACS-WFC-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.15 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=34.1 Angle Between Sides= Center Pattern=false		(1), (2)
(2)	Pattern Type=ACS-HRC-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.15 Line Spacing=0.098	Coordinate Frame=POS-TARG Pattern Orientation=19.9 Angle Between Sides=63.5 Center Pattern=false		(3)

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(6)	M83-IXO82	RA: 13 37 20.1000 (204.3337500d) Dec: -29 53 46.00 (-29.89611d) Equinox: J2000 Plate Id: (?)		V=(?) fx = 3.8e-13 erg/cm^2/s (0.5 - 2 keV)	Coordinate Source: Chandra location

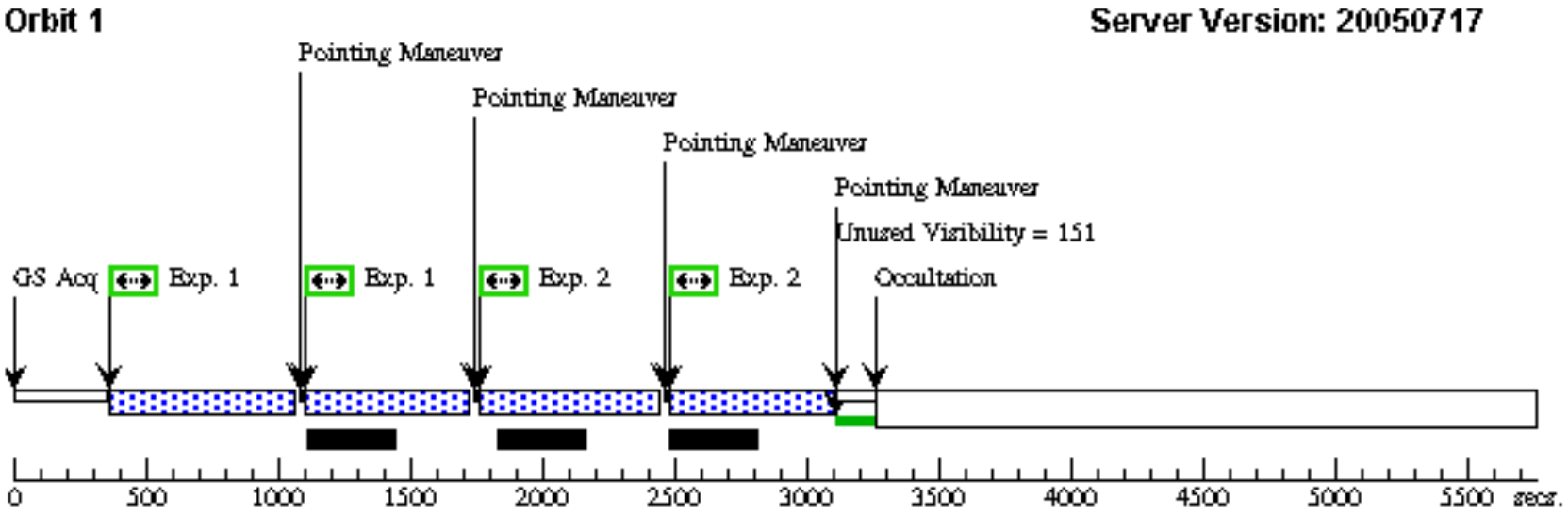
Comments: We would prefer to have the Chandra observation of this source taken (and analysed) before these observations are performed, so that we have the most accurate X-ray position of the ULX to point HST at. However, as the X-ray position is already good to < 5 arcsec, this is not an absolute necessity.

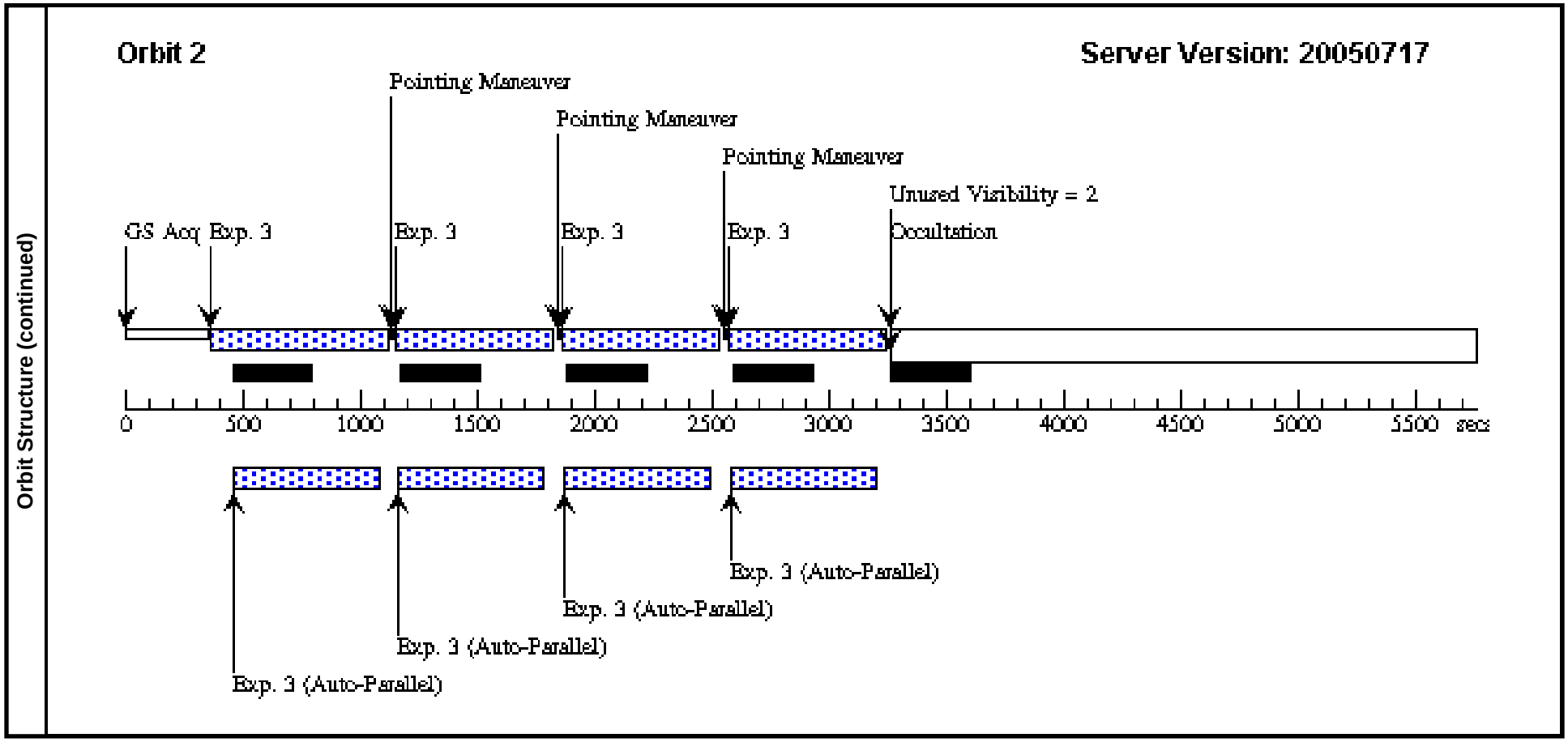
Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(6) M83-IXO82	ACS/WFC, ACCUM, WFC1	F435W	CR-SPLIT=NO		Pattern 1-1 (1)	500.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]*	***[1]***
2		(6) M83-IXO82	ACS/WFC, ACCUM, WFC1	F606W	CR-SPLIT=NO		Pattern 2-2 (1)	500.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]*	***[1]***
3		(6) M83-IXO82	ACS/HRC, ACCUM, HRC	F330W	CR-SPLIT=NO		Pattern 3-3 (2)	642.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[2]***

Comments: We would prefer to have the Chandra observation of this source taken (and analysed) before these observations are performed, so that we have the most accurate X-ray position of the ULX to point HST at. However, as the X-ray position is already good to < 5 arcsec, this is not an absolute necessity.

Orbit Structure




Orbit Structure (continued)
Orbit 2
Server Version: 20050717
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Unused Visibility = 2
GS Acq
Exp. 3
Exp. 3
Exp. 3
Exp. 3
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs
Exp. 3 (Auto-Parallel)
Exp. 3 (Auto-Parallel)
Exp. 3 (Auto-Parallel)
Exp. 3 (Auto-Parallel)

Visit

Proposal 10579, Visit 13 Thu Aug 18 01:25:49 GMT 2005

Diagnostic Status: No Diagnostics

Scientific Instruments: ACS/WFC, ACS/HRC

Special Requirements: (none)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=ACS-WFC-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.15 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=34.1 Angle Between Sides= Center Pattern=false		(1), (2)
(2)	Pattern Type=ACS-HRC-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.15 Line Spacing=0.098	Coordinate Frame=POS-TARG Pattern Orientation=19.9 Angle Between Sides=63.5 Center Pattern=false		(3)

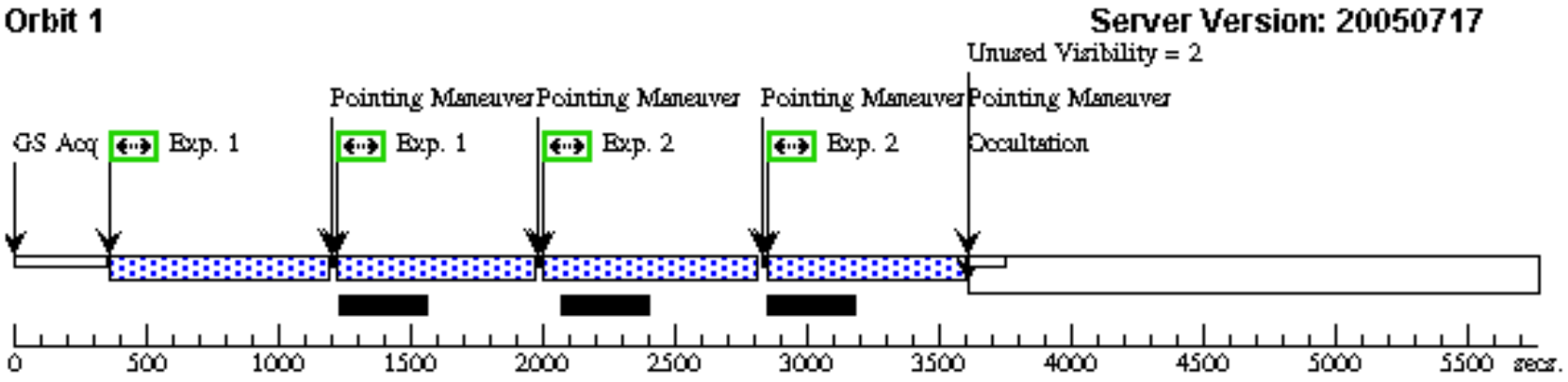
Fixed Targets

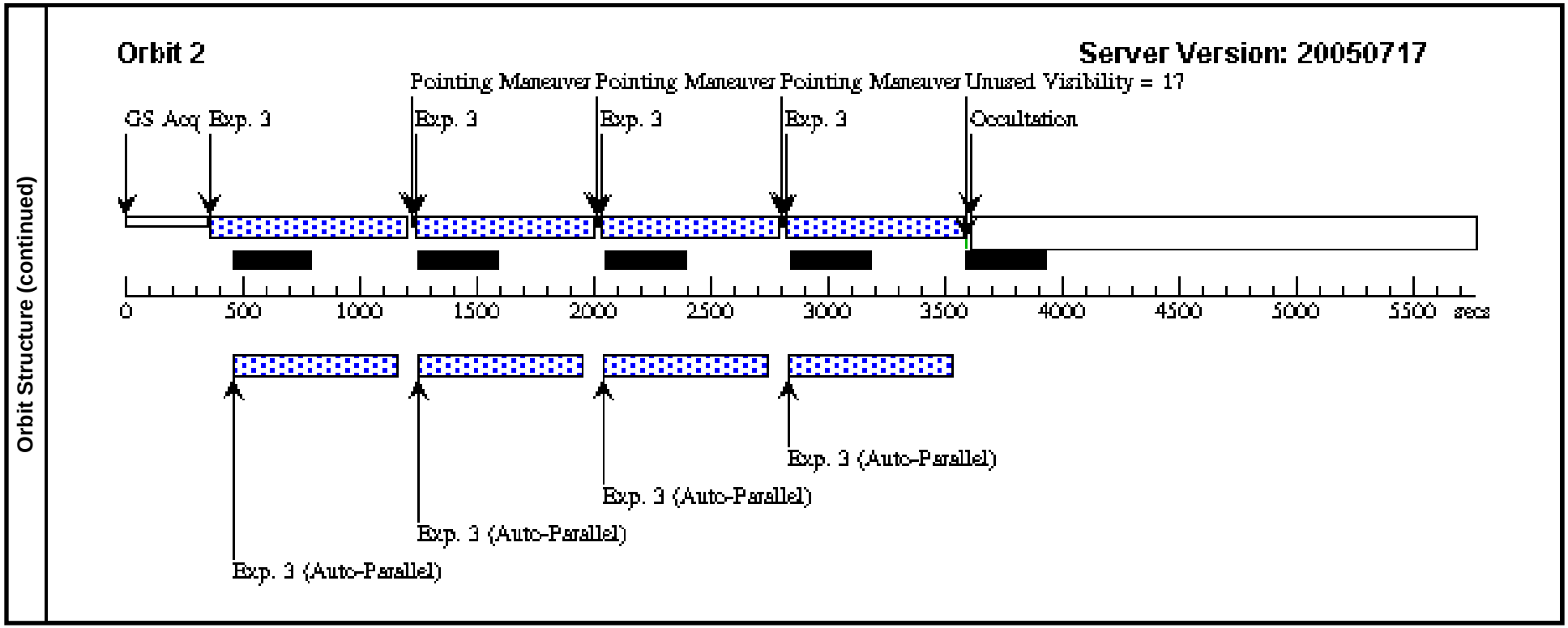
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(7)	IC-342-X1	RA: 03 45 55.6800 (56.4820000d) Dec: +68 04 54.90 (68.08192d) Equinox: J2000 Plate Id: (?)		V=25.0+/-2.0	Coordinate Source: Chandra

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(7) IC-342-X1	ACS/WFC, ACCUM, WFC2	F435W	CR-SPLIT=NO		Pattern 1-1 (1)	500.0 Secs	
								[==>624.0 Secs (Pattern 1)] *[==>624.0 Secs (Pattern 2)]*	***[1]***
2		(7) IC-342-X1	ACS/WFC, ACCUM, WFC2	F606W	CR-SPLIT=NO		Pattern 2-2 (1)	500.0 Secs	
								[==>624.0 Secs (Pattern 1)] *[==>624.0 Secs (Pattern 2)]*	***[1]***
3		(7) IC-342-X1	ACS/HRC, ACCUM, HRC	F330W	CR-SPLIT=NO		Pattern 3-3 (2)	725.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[2]***

Orbit Structure




Orbit Structure (continued)
Orbit 2
Server Version: 20050717
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Unused Visibility = 17
GS Acq
Exp. 3
Exp. 3
Exp. 3
Exp. 3
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs
Exp. 3 (Auto-Parallel)
Exp. 3 (Auto-Parallel)
Exp. 3 (Auto-Parallel)
Exp. 3 (Auto-Parallel)

Visit

Proposal 10579, Visit 15 Thu Aug 18 01:25:49 GMT 2005

Diagnostic Status: No Diagnostics

Scientific Instruments: ACS/WFC, ACS/HRC

Special Requirements: (none)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=ACS-WFC-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.15 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=34.1 Angle Between Sides= Center Pattern=false		(1), (2)
(2)	Pattern Type=ACS-HRC-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.15 Line Spacing=0.098	Coordinate Frame=POS-TARG Pattern Orientation=19.9 Angle Between Sides=63.5 Center Pattern=false		(3)

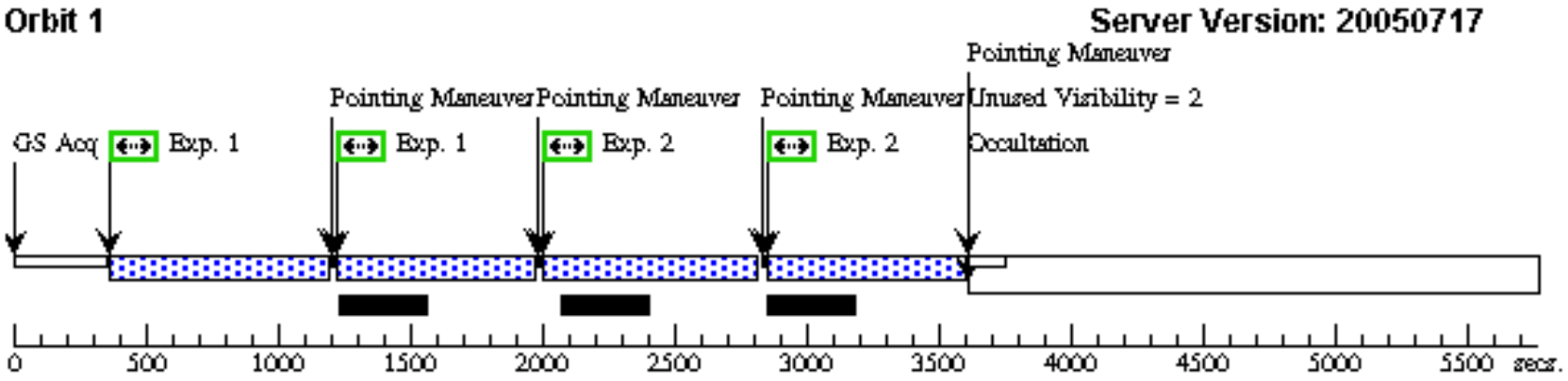
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(8)	IC-342-X2	RA: 03 46 15.7300 (56.5655417d) Dec: +68 11 12.60 (68.18683d) Equinox: J2000 Plate Id: (?)		V=25.0+/-2.0	Coordinate Source: Chandra

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(8) IC-342-X2	ACS/WFC, ACCUM, WFC2	F435W	CR-SPLIT=NO		Pattern 1-1 (1)	500.0 Secs	
								[==>624.0 Secs (Pattern 1)] *[==>624.0 Secs (Pattern 2)]*	***[1]***
2		(8) IC-342-X2	ACS/WFC, ACCUM, WFC2	F606W	CR-SPLIT=NO		Pattern 2-2 (1)	500.0 Secs	
								[==>624.0 Secs (Pattern 1)] *[==>624.0 Secs (Pattern 2)]*	***[1]***
3		(8) IC-342-X2	ACS/HRC, ACCUM, HRC	F330W	CR-SPLIT=NO		Pattern 3-3 (2)	725.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[2]***

Orbit Structure



Orbit Structure (continued)