



12994 - A Lensing Study of IDCS J1426.5+3508: A Massive Galaxy Cluster at $z=1.75$

Cycle: 20, Proposal Category: GO
(Availability Mode: SUPPORTED)

INVESTIGATORS

<i>Name</i>	<i>Institution</i>	<i>E-Mail</i>
Prof. Anthony H. Gonzalez (PI) (Contact)	University of Florida	anthony@astro.ufl.edu
Prof. Mark Brodwin (CoI)	University of Missouri - Kansas City	brodwinm@umkc.edu
Dr. S. Adam Stanford (CoI)	University of California - Davis	adam@igpp.ucllnl.org
Dr. Jason D. Rhodes (CoI)	Jet Propulsion Laboratory	jason.d.rhodes@jpl.nasa.gov
Dr. Daniel Stern (CoI)	Jet Propulsion Laboratory	daniel.k.stern@jpl.nasa.gov
Dr. Peter Eisenhardt (CoI)	Jet Propulsion Laboratory	peter.r.eisenhardt@jpl.nasa.gov
Dr. Cosimo Fedeli (CoI)	University of Florida	cosimo.fedeli@astro.ufl.edu
Mr. Greg Zeimann (CoI)	University of California - Davis	zeimann@student.physics.ucdavis.edu
Dr. Arjun Dey (CoI)	National Optical Astronomy Observatory, AURA	dey@noao.edu
Prof. Daniel Marrone (CoI)	University of Arizona	dmarrone@email.arizona.edu

VISITS

<i>Visit</i>	<i>Targets used in Visit</i>	<i>Configurations used in Visit</i>	<i>Orbits Used</i>	<i>Last Orbit Planner Run</i>	<i>OP Current with Visit?</i>
01	(1) IDCS1426.5+3508	ACS/WFC	4	16-Jul-2012 21:59:28.0	yes
02	(1) IDCS1426.5+3508	ACS/WFC	4	16-Jul-2012 21:59:40.0	yes
03	(1) IDCS1426.5+3508	ACS/WFC	3	16-Jul-2012 21:59:50.0	yes
04	(1) IDCS1426.5+3508	WFC3/IR	2	16-Jul-2012 22:00:07.0	yes

13 Total Orbits Used

ABSTRACT

We propose ACS/WFC and WFC3/IR imaging of IDCS J1426.5+3508, which at $z=1.75$ is the most massive cluster yet discovered at $z>1.4$, and the first cluster at this epoch for which the Sunyaev-Zel'dovich effect has been observed. Our previous work also revealed a giant arc associated with this cluster, making it the most distant known strong lensing cluster. The existence of this arc revives the longstanding arc statistics problem -- theoretical calculations predict that no such arc should exist across the entire sky. The aim of this program is to constrain the total mass and concentration of the dark matter halo to understand the origin of this discrepancy. A weak lensing determination of the total mass will also provide the first direct calibration of the SZ-lensing mass relation at this epoch. This calibration is of central relevance to programs aiming to use cluster counts out to this redshift to constrain dark energy, such as eROSITA and ground-based SZ searches. Moreover, our observations are designed to also enable detection of multiply imaged sources to enable joint strong+weak lensing analysis to better constrain the mass model. This cluster is extreme in mass for the redshift, anomalous as a strong lensing system, and unique among all clusters currently known.

OBSERVING DESCRIPTION

We are requesting deep imaging for IDCS J1426.5+3508 to obtain a weak lensing mass, identify multiply-imaged, strongly lensed background galaxies, and better constrain the redshift for the recently discovered giant arc associated with this cluster. The spatial resolution, sensitivity, and stability of HST are essential for this program. The shear measurements required for this program and background source density needed for weak lensing are only achievable with HST.

Technical Drivers:

The weak lensing is the primary driver for our technical requirements. The goal of the weak lensing analysis is to obtain a total weak lensing mass with $S/N>5$ (i.e. 20% precision), which will enable a first validation of SZ-based mass estimates at this epoch and help discern the reason theoretical expectations for arc statistics are incorrect. If the resolution is associated with a higher than expected cluster mass, then the S/N will exceed this nominal threshold. The critical ingredients for the lensing analysis are (1) sufficient field-of-view that the lensing map extends out to at least r_{200} , (2) sufficient density of background galaxies from which to reconstruct the shear field, and (3) multiband photometry to reject cluster members and foreground galaxies, which otherwise reduce the S/N .

Area:

The first of these requirements is satisfied by the ACS field-of-view without mosaicing. For the cluster redshift and nominal SZ mass estimate, the radius of the cluster is $r_{200}=830$ kpc, or $106''$. The cluster diameter is thus almost identically matched to the $202''$ width of ACS. For WFC3/IR photometry (see below), we do however require a 2×2 mosaic to match this area.

Depth and Filters:

The requisite background density is dependent upon the desired S/N for the weak lensing mass. Previous ACS studies of galaxy clusters at $z=1-1.5$ have demonstrated that $S/N > 5$ can be achieved for clusters of similar mass given a raw background galaxy density of $\sim 80-100$ per sq. arcmin, even in the presence of $\sim 50\%$ foreground contamination (Jee et al. 2009, 2011). We will use the F606W filter for shape measurements because it provides the most efficient means of reaching the requisite source density. This data will also constrain whether the known arc lies below or above $z \sim 4$ based upon whether it is a Lyman dropout in F606W -- a key input for modeling the strong lensing (Fig. 3).

To guide our expectations for background source counts, we use the Hubble Ultra Deep Field counts and photometric redshifts from Coe et al. (2006). For a cluster at $z=1.75$, a background source density of 100 per sq. arcmin corresponds to a limiting magnitude $F606W=28$ (AB). In addition to the main filter for shape measurements, we also require data in two additional filters to enable color selection of background galaxies. We employ a simple color cut, requiring $F606W-F814W < 0.5$ for candidate background sources. This cut eliminates the majority of low-redshift foreground members, and tests with the HUDF indicate that the residual contamination from foreground galaxies is $\sim 40\%$, an acceptable level for this analysis (Jee et al. 2009, 2011). Meanwhile, the F160W filter provides a band redward of the 4000 Angstrom break, enabling clean rejection of cluster members on the red sequence. For a Bruzual & Charlot (2003) model a passively evolving galaxy with formation redshift $z_f=6$ has $F814-F160 \sim 3$.

The nominal depths, in AB magnitudes, for this program are $F606W=28$ (10 sigma), $F814W=28$ (5 sigma), and $F160W=25.8$ (5 sigma) for a $0.25''$ radius aperture. In the F606W we require 10 sigma sensitivity at the depth corresponding to the target source density to enable robust shape measurements of the background galaxies. For F814W we require only 5 sigma detection for foreground rejection and coarse redshift estimation of lensed sources. Based upon both the HST exposure time calculators and our past observing programs, we calculate that the required exposure times

Proposal 12994 (STScI Edit Number: 0, Created: Monday, July 16, 2012 9:00:16 PM EST) - Overview

to achieve these depths are 20ks in F606W and 12ks in F814W. For F160W, the quoted depth corresponds to 1.2ks (0.5 orbits), which is sufficiently deep for identification of galaxies that lie on the red sequence down to the F606W limit. Previous observations of the cluster include 5ks of data in F814W, which will be re-used and augmented in the current program. A sufficiently deep F160W exposure also exists for the cluster core, but does not cover the full ACS field-of-view. We therefore request a 2x2 mosaic to map this region. Using the visibility estimators in the HST Primer for Cycle 20, the require depths in F606W and F814W can be achieved with 8 orbits and 3 orbit, respectively (augmented by the previous F814W data). In F160W we require two total orbits, split equally between four mosaic pointings. In addition to providing clean rejection of cluster members out to r_{200} , these observations will be coupled with the existing central F160W pointing to push 0.85 mag fainter in the cluster core, which is useful for extracting faint red, strongly-lensed sources as well as probing the faint end of the cluster luminosity function. We also note that all calculations assume average earthshine; LOWSKY is not requested because it only minimally improves the efficiency.

ADDITIONAL COMMENTS

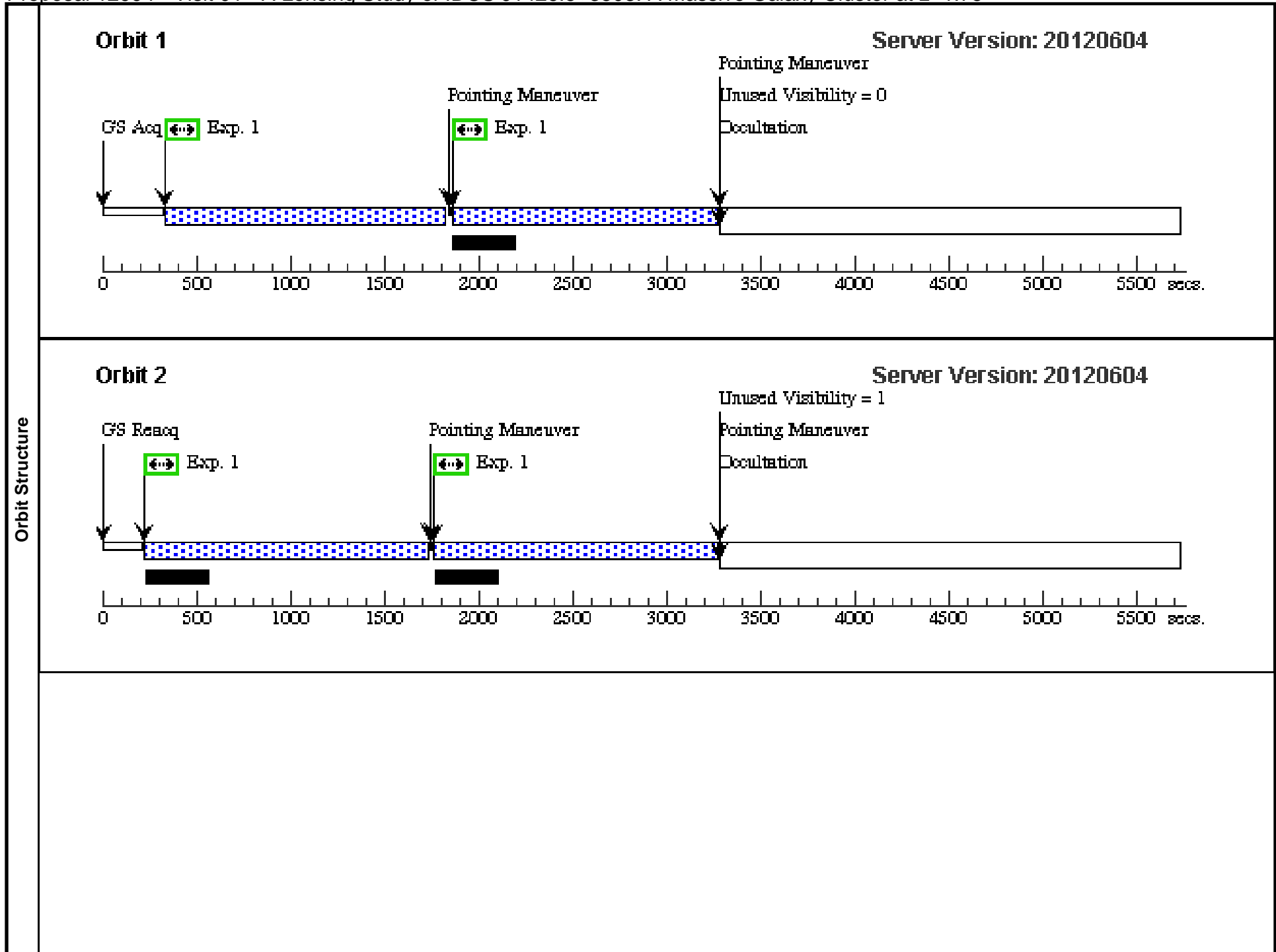
My main concern is making sure that the WFC3/IR mosaic matches the ACS field-of-view, including having the proper orientation constraint. Double-checking that this is correctly entered is greatly appreciated.

Related to the above note, the target coordinate is set to lie halfway between the BCG and gravitational arc, which are separated by 14". The coordinates of these two objects are (14:26:32.55,+35:08:23.6) and (12:26:32.76, +35:08:37.8). The requested orientation constraint below is designed to avoid the BCG lying in the chip gap for the ACS observations and the arc lying very close to the edge of the wfc3/ir coverage during two of the dither positions, so that we will have full exposure on both. If this orientation request significantly impacts schedulability though, it can be removed/relaxed. In this case please let me know though, as I may wish to shift the central coordinate a bit.

Proposal 12994 - Visit 01 - A Lensing Study of IDCS J1426.5+3508: A Massive Galaxy Cluster at z=1.75

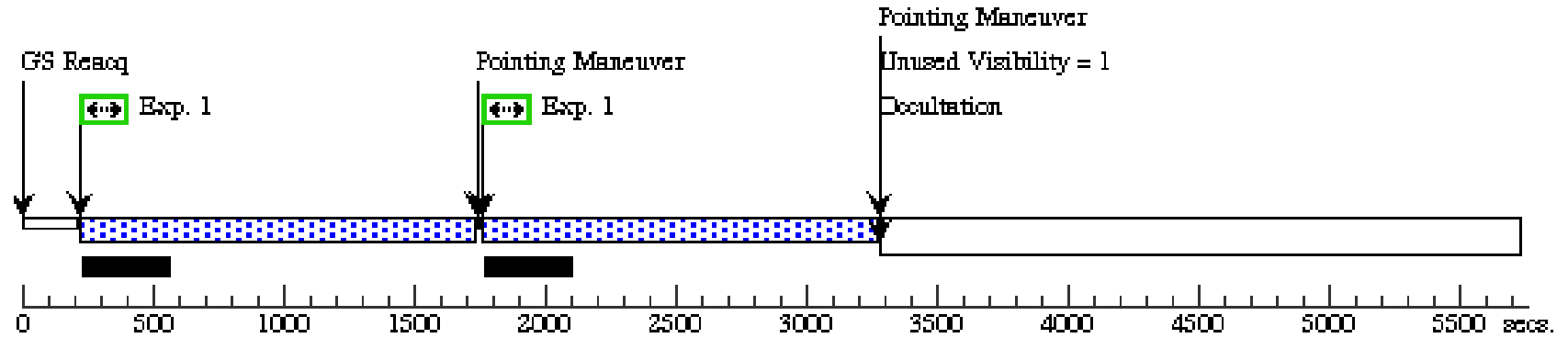
Tue Jul 17 02:00:17 GMT 2012

Visit	Proposal 12994, Visit 01 Diagnostic Status: No Diagnostics Scientific Instruments: ACS/WFC Special Requirements: ORIENT 20D TO 340 D <i>Comments: The target coordinate is set to lie halfway between the BCG and gravitational arc, which are separated by 14". The coordinates of these two objects are (14:26:32.55,+35:08:23.6) and (12:26:32.76,+35:08:37.8). The requested orientation constraint below is designed to avoid the BCG lying in the chip gap for the ACS observations and the arc lying very close to the edge of the wfc3/ir coverage during two of the dither positions, so that we will have full exposure on both. If this orientation request significantly impacts schedulability though, it can be removed/relaxed. In this case please let me know though, as I may wish to shift the central coordinate a bit.</i>									
	Patterns	#	Primary Pattern				Secondary Pattern			
(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=true	Pattern Type=ACS-WFC-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.265 Line Spacing=0.187	Coordinate Frame=POS-TARG Pattern Orientation=20.67 Angle Between Sides=69.05 Center Pattern=false	(1)				
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections		Fluxes	Miscellaneous			
	(1)	IDCS1426.5+3508	RA: 14 26 32.8400 (216.6368333d) Dec: +35 08 31.90 (35.14219d) Equinox: J2000			V=25+/-2	Reference Frame: ICRS			
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
	1		(1) IDCS1426.5+3508	ACS/WFC, ACCUM, WFC-FIX	F606W	CR-SPLIT=NO		Pattern 1, Exps 1-1 in Visit 01 (1)	1100 Secs	
			8						[==>1288.0 Secs (Pattern 1,1)]	[1]
									[==>1288.0 Secs (Pattern 1,2)]	
									[==>1384.0 Secs (Pattern 1,3)]	[2]
									[==>1384.0 Secs (Pattern 1,4)]	
									[==>1384.0 Secs (Pattern 2,1)]	[3]
								[==>1384.0 Secs (Pattern 2,2)]		
								[==>1384.0 Secs (Pattern 2,3)]	[4]	
								[==>1384.0 Secs (Pattern 2,4)]		



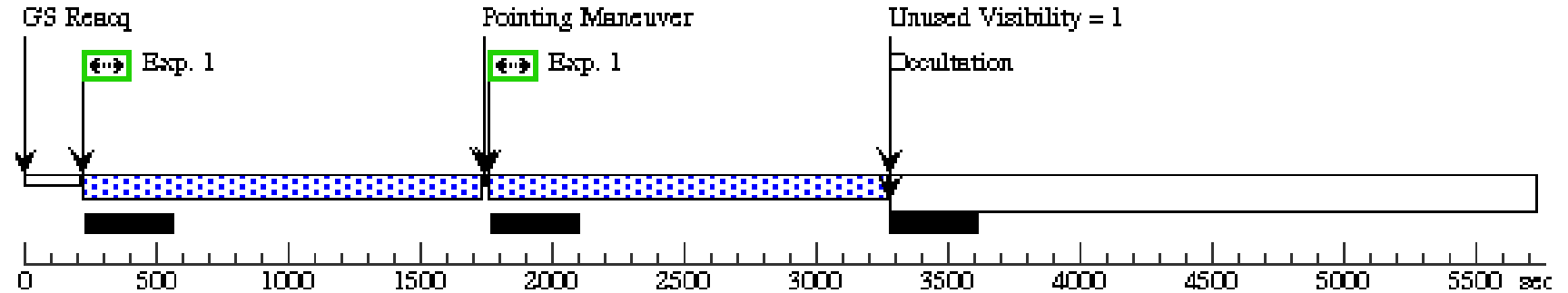
Orbit 3

Server Version: 20120604



Orbit 4

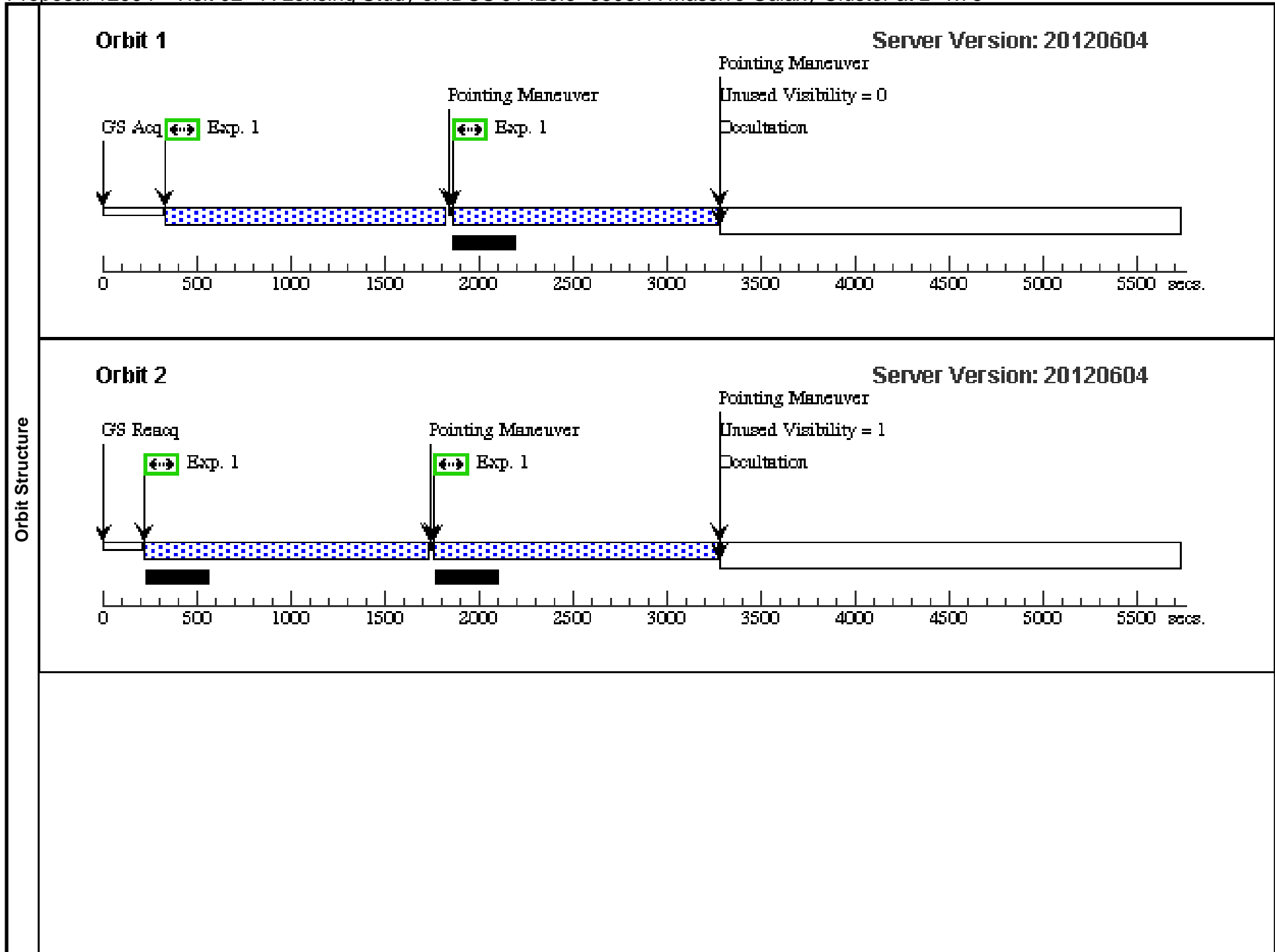
Server Version: 20120604



Proposal 12994 - Visit 02 - A Lensing Study of IDCS J1426.5+3508: A Massive Galaxy Cluster at z=1.75

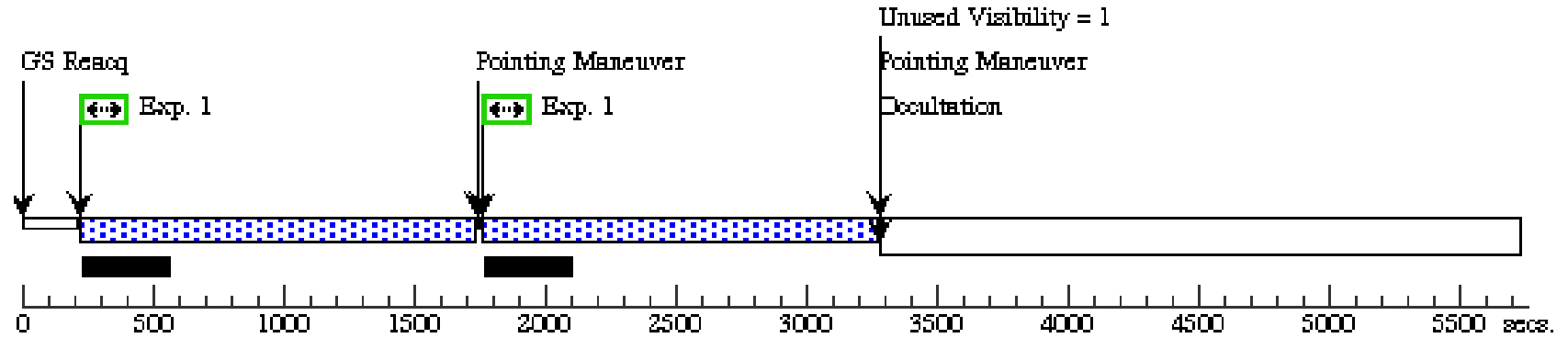
Tue Jul 17 02:00:21 GMT 2012

Visit	Proposal 12994, Visit 02 Diagnostic Status: No Diagnostics Scientific Instruments: ACS/WFC Special Requirements: SAME ORIENT AS 01 <i>Comments: Orientation needs to be the same as for visits 1 and 3.</i>									
	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=true	Pattern Type=ACS-WFC-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.265 Line Spacing=0.187	Coordinate Frame=POS-TARG Pattern Orientation=20.67 Angle Between Sides=69.05 Center Pattern=false	(1)			
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections		Fluxes	Miscellaneous			
	(1)	IDCS1426.5+3508	RA: 14 26 32.8400 (216.6368333d) Dec: +35 08 31.90 (35.14219d) Equinox: J2000			V=25+/-2	Reference Frame: ICRS			
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
	1		(1) IDCS1426.5+3508	ACS/WFC, ACCUM, WFC-FIX	F606W	CR-SPLIT=NO		Pattern 1, Exps 1-1 in Visit 02 (1)	1100 Secs	
			8						[==>1288.0 Secs (Pattern 1,1)]	[1]
									[==>1288.0 Secs (Pattern 1,2)]	
									[==>1384.0 Secs (Pattern 1,3)]	[2]
									[==>1384.0 Secs (Pattern 1,4)]	
									[==>1384.0 Secs (Pattern 2,1)]	[3]
								[==>1384.0 Secs (Pattern 2,2)]		
								[==>1384.0 Secs (Pattern 2,3)]	[4]	
								[==>1384.0 Secs (Pattern 2,4)]		



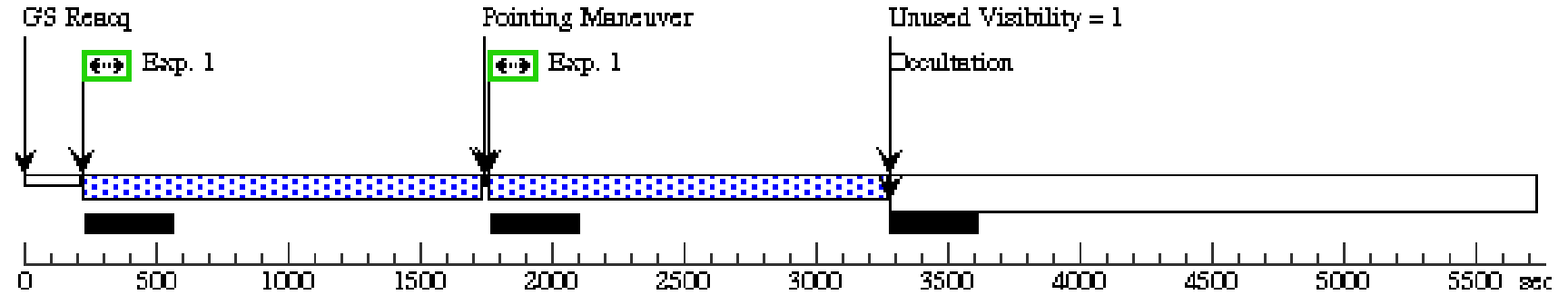
Orbit 3

Server Version: 20120604



Orbit 4

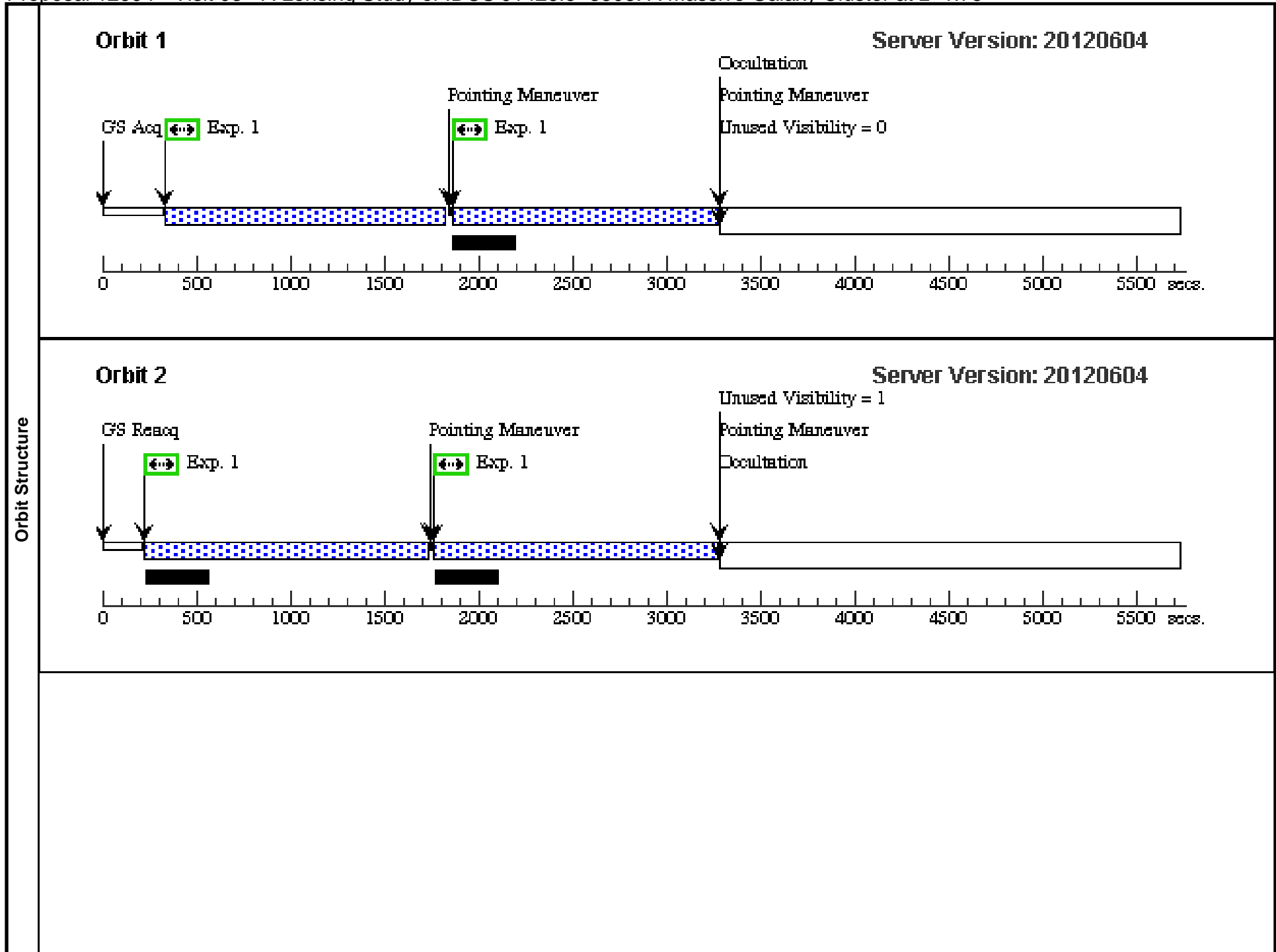
Server Version: 20120604

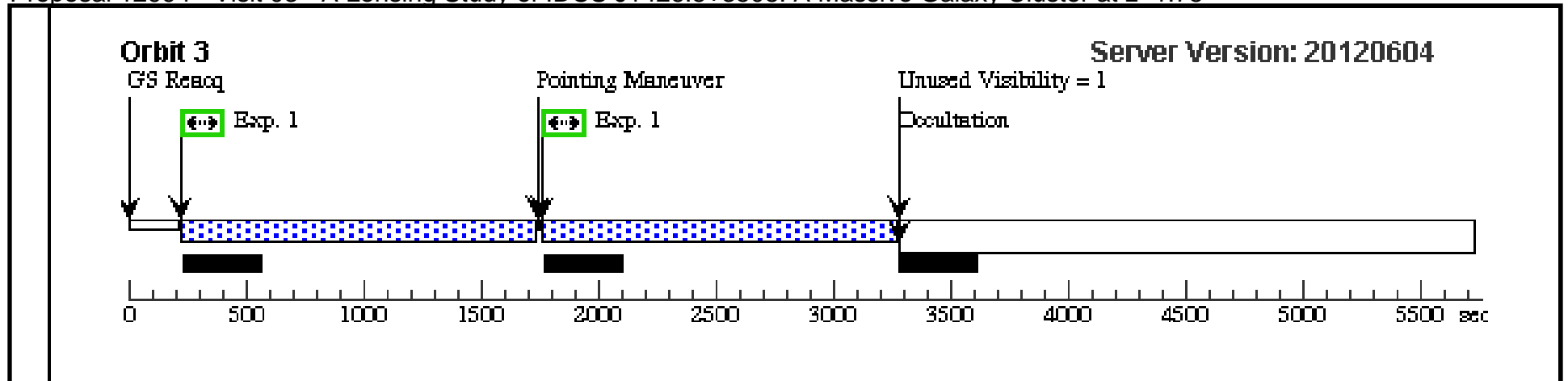


Proposal 12994 - Visit 03 - A Lensing Study of IDCS J1426.5+3508: A Massive Galaxy Cluster at z=1.75

Tue Jul 17 02:00:26 GMT 2012

Visit	Proposal 12994, Visit 03 Diagnostic Status: No Diagnostics Scientific Instruments: ACS/WFC Special Requirements: SAME ORIENT AS 01 <i>Comments: Orientation needs to be the same as visits 1 and 2.</i>									
	Patterns	#	Primary Pattern				Secondary Pattern			
(2)		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=true	Pattern Type=LINE Purpose=DITHER Number Of Points=3 Point Spacing=0.17 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=47.23 Angle Between Sides= Center Pattern=false	(1)				
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections		Fluxes	Miscellaneous			
	(1)	IDCS1426.5+3508	RA: 14 26 32.8400 (216.6368333d) Dec: +35 08 31.90 (35.14219d) Equinox: J2000			V=25+/-2	Reference Frame: ICRS			
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
	1		(1) IDCS1426.5+3508	ACS/WFC, ACCUM, WFC-FIX	F814W	CR-SPLIT=NO		Pattern 2, Exps 1-1 in Visit 03 (2)	1100 Secs	
			8						[==>1288.0 Secs (Pattern 1,1)]	[1]
									[==>1288.0 Secs (Pattern 1,2)]	
									[==>1382.0 Secs (Pattern 1,3)]	[2]
								[==>1382.0 Secs (Pattern 2,1)]		
								[==>1384.0 Secs (Pattern 2,2)]		
								[==>1384.0 Secs (Pattern 2,3)]	[3]	





Proposal 12994 - Visit 04 - A Lensing Study of IDCS J1426.5+3508: A Massive Galaxy Cluster at z=1.75

Tue Jul 17 02:00:29 GMT 2012

Visit	Proposal 12994, Visit 04 Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/IR Special Requirements: ORIENT 135D TO 135D FROM 01 <i>Comments: Orientation needs to be 135 degrees from visit 1. If visibility is an issue, please let me know and I will tweak the program design for slightly different roll angles.</i>									
	Patterns	#	Primary Pattern	Secondary Pattern	Exposures					
		(4)	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		(1), (2), (3), (4)				
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	IDCS1426.5+3508	RA: 14 26 32.8400 (216.6368333d) Dec: +35 08 31.90 (35.14219d) Equinox: J2000		V=25+/-2	Reference Frame: ICRS				
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
	1		(1) IDCS1426.5+3508	WFC3/IR, MULTIACCUM, IR-FIX	F160W	NSAMP=13; SAMP-SEQ=SPAR S25	POS TARG -38,-35	Pattern 4, Exps 1-1 in Visit 04 (4)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]
	2		(1) IDCS1426.5+3508	WFC3/IR, MULTIACCUM, IR-FIX	F160W	NSAMP=13; SAMP-SEQ=SPAR S25	POS TARG -38,+55	Pattern 4, Exps 2-2 in Visit 04 (4)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]
	3		(1) IDCS1426.5+3508	WFC3/IR, MULTIACCUM, IR-FIX	F160W	NSAMP=13; SAMP-SEQ=SPAR S25	POS TARG +36,+55	Pattern 4, Exps 3-3 in Visit 04 (4)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[2]
	4		(1) IDCS1426.5+3508	WFC3/IR, MULTIACCUM, IR-FIX	F160W	NSAMP=14; SAMP-SEQ=SPAR S25	POS TARG +36,-35	Pattern 4, Exps 4-4 in Visit 04 (4)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[2]

