



## 10836 - The Red Sequence at $1.3 < z < 1.4$ in Galaxy Clusters

Cycle: 15, Proposal Category: GO

(Availability Mode: SUPPORTED)

### INVESTIGATORS

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### 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) 1416.7.15A	NIC3	2	02-Feb-2007 21:40:43.0	yes
02	(4) 1416.7.15B	NIC3	2	02-Feb-2007 21:40:51.0	yes
03	(6) 1416.7.15D	NIC3	2	02-Feb-2007 21:40:56.0	yes
04	(2) 1315.5.16A	NIC3	2	02-Feb-2007 21:41:02.0	yes
05	(8) 1315.5.16B	NIC3	2	02-Feb-2007 21:41:07.0	yes
06	(9) 1315.5.16C	NIC3	2	02-Feb-2007 21:41:16.0	yes
07	(10) 1315.5.16D	NIC3	2	02-Feb-2007 21:41:21.0	yes
08	(3) 1315.12	NIC3	2	02-Feb-2007 21:41:26.0	yes
09	(5) 1012.28A	NIC3	2	02-Feb-2007 21:41:31.0	yes

<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>
10	(7) 1113.77	NIC3	2	02-Feb-2007 21:41:36.0	yes

20 Total Orbits Used

### **ABSTRACT**

We propose to obtain NIC3/F160W imaging of three new IRAC-selected galaxy clusters at  $1.3 < z < 1.5$ . In combination with deep ACS/F850LP images being obtained in Cycle 14, the resulting precision photometry in a rest  $\sim U - R$  color will allow us to construct color-magnitude diagrams which can be used to measure the slope and scatter in the red sequence galaxies, thereby constraining the history of star formation in the early-type galaxies. The number of morphologically-selected early-type galaxies more luminous than  $L^*$  will allow us to test the predictions of the hierarchical merging scenario for galaxy formation in clusters at the highest available redshifts in galaxy clusters.

### **OBSERVING DESCRIPTION**

We require high precision color measurements so that we can determine the average scatter in a color spanning the 4000  $\AA$  break down to levels of  $\sim 0.02$  mag to constrain the evolutionary history of the stellar populations in the galaxies selected by their morphologies in the ACS data to be early-types (Blakeslee et al. 2003; Mei et al. 2006). We are already obtaining deep imaging with ACS/WFC in the F850LP band to sample rest frame  $U$  in Cycle 14. For the red band above the 4000  $\AA$  break we must turn to NICMOS. Although the F110W filter samples close to rest frame  $B$ , we chose to use F160W because of its greater sensitivity and because its passband is cleaner---the F110W filter overlaps with the ACS F850LP bandpass. We have chosen to ask for NIC3 observations even though its PSF is much larger than that

of ACS/WFC, in order to be able to cover most of the ACS FOV in a reasonable number of orbits. The ACS data will yield better morphological information, despite sampling a relatively blue rest frame portion of the spectrum. The morphologies that are determined from the NIC3 data will be used to see if the bluer rest frame wavelengths bias the ACS morphologies, particularly for the larger, more luminous early-type galaxies. The primary use of the NIC3 data is in enabling the construction of the color-magnitude diagram with very high precision. It is very difficult to combine ground-based near-IR photometry with ACS photometry in making a color-mag diagram for a high- $z$  galaxy cluster due to blending issues in the dense cluster core, and also due to the required very high S/N at relatively faint limits. An excellent example of the superior results that can be obtained using HST for both bands in constructing a color-magnitude diagram of a high redshift galaxy cluster is shown in Figure 5. The ground-based attempt used the VLT and obtained spent 10 hours of integration in the near-IR band. Yet clearly the intrinsic scatter and slope of the red sequence can be measured far more accurately using the HST-only photometry.

At  $z=1.35$ , an  $L^*$  early-type galaxy will have  $H_{160} = 19.8$ .

At  $H_{160} = 21.8$ , 2 magnitudes below  $L^*$ , a single 900-s exposure with NIC3 yields a  $S/N = 26$  as measured in an aperture containing 80% of the total light. For our targets there is enough visibility time, after allowing for guide star and instrument overheads, to obtain three 900-s exposures per orbit. Thus in two orbits containing six 900-s exposures, the achieved S/N will be 63, slightly higher than

desired---but it would be impractical and inefficient to reduce the exposure time per pointing below 2 orbits. With 6 dither positions per pointing we will have enough to adequately reduce the data.

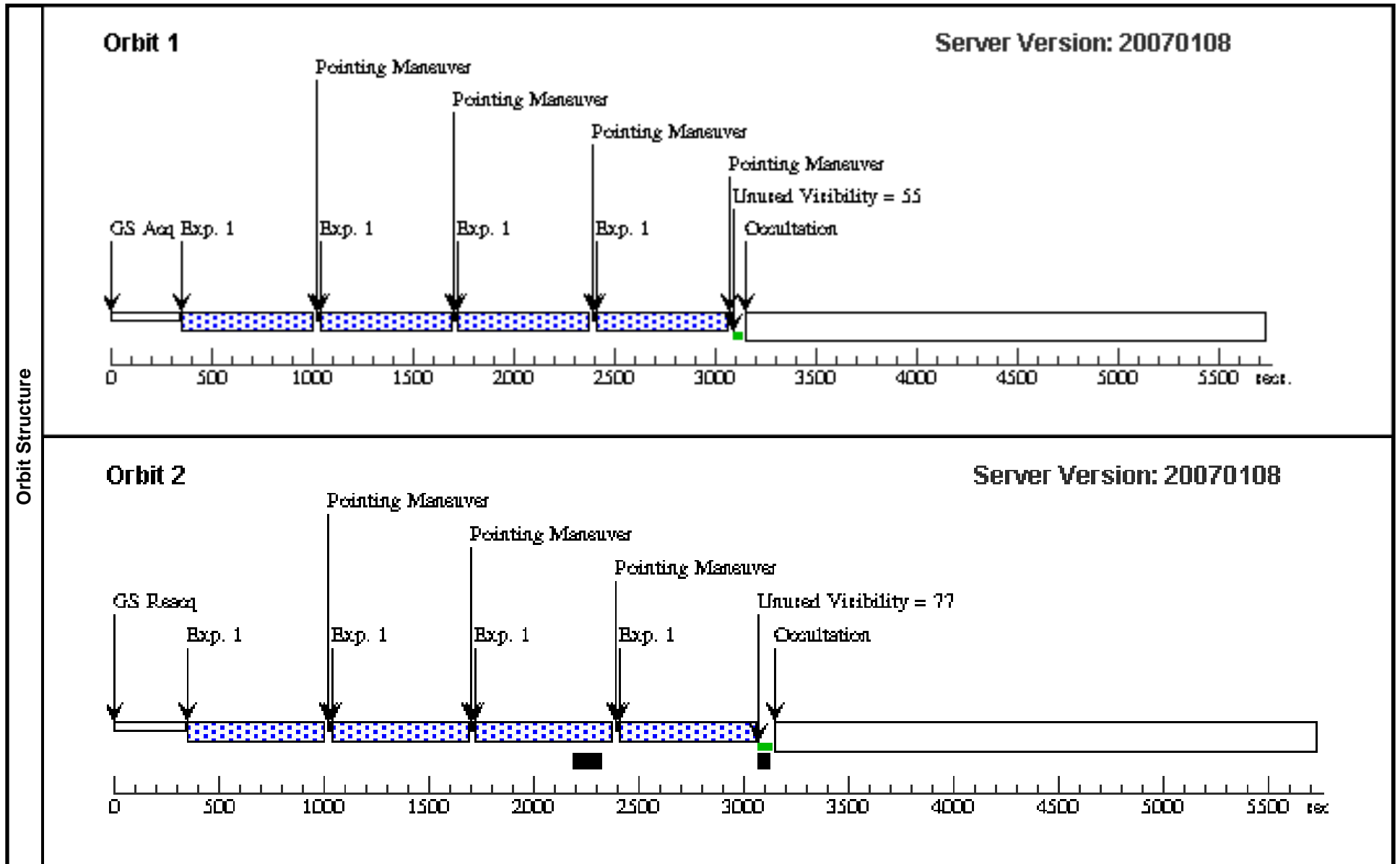
We can cover nearly all of the ACS field with a  $3 \times 3$  mosaic of 9 NIC3 pointings, allowing for 3 arcsec of overlap between the pointings. The relative areas of the proposed NIC3 mosaic and a single ACS FOV are illustrated in Figures 1-3 for each of the three target clusters.

Thus the total request for each cluster is 18 orbits, and 54 orbits for the whole proposal. For each cluster the NIC3 orbits will need to be divided into 4 visits, with some restriction on the allowable roll angle so as to keep the tiling of the area relatively efficient and keep gaps from appearing between pointings in different visit.

Proposal 10836 - Visit 01 - The Red Sequence at  $1.3 < z < 1.4$  in Galaxy Clusters

Sat Feb 03 02:41:39 GMT 2007

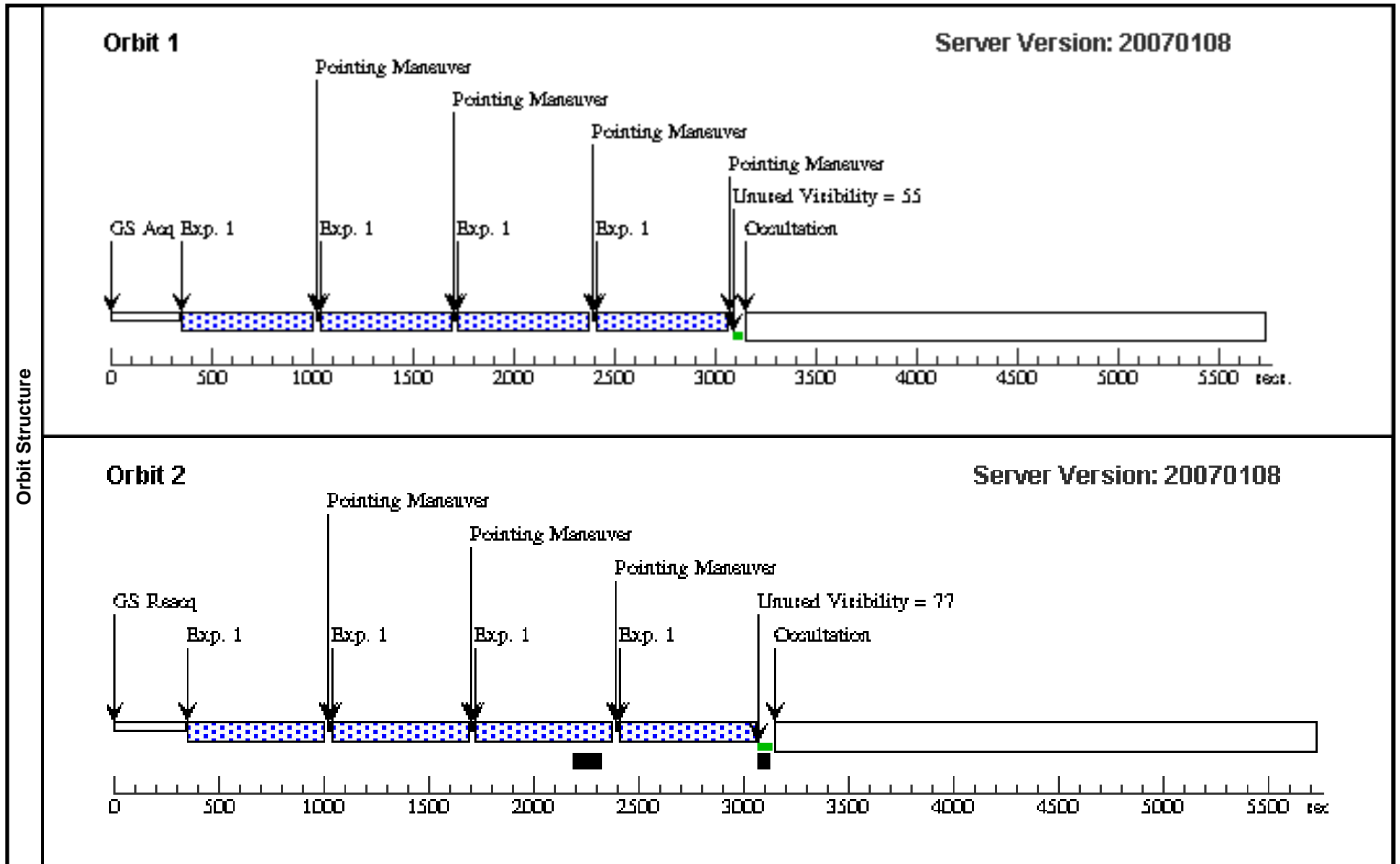
Visit	<b>Proposal 10836, Visit 01, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: NIC3 Special Requirements: (none)										
	Patterns	#	Primary Pattern				Secondary Pattern			Exposures	
		(1)	Pattern Type=NIC-SPIRAL-DITH Purpose=DITHER Number Of Points=8 Point Spacing=1.1 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=0 Angle Between Sides= Center Pattern=true				(1)			
Fixed Targets	#	Name	Target Coordinates		Targ. Coord. Corrections	Fluxes		Miscellaneous			
	(1)	1416.7.15A	RA: 14 33 50.6470 (218.4610292d) Dec: +33 25 30.73 (33.42520d) Equinox: J2000			V=26.0+/-1.0		Reference Frame: ICRS			
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]		Orbit
	1	7.15a	(1) 1416.7.15A	NIC3, MULTIACCUM, NIC3	F160W	NSAMP=12; SAMP-SEQ=SPARS 64		Pattern 1-1 (1)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]	
								[==>(Pattern 5)] [==>(Pattern 6)] [==>(Pattern 7)] [==>(Pattern 8)]	[2]		



Proposal 10836 - Visit 02 - The Red Sequence at  $1.3 < z < 1.4$  in Galaxy Clusters

Sat Feb 03 02:41:40 GMT 2007

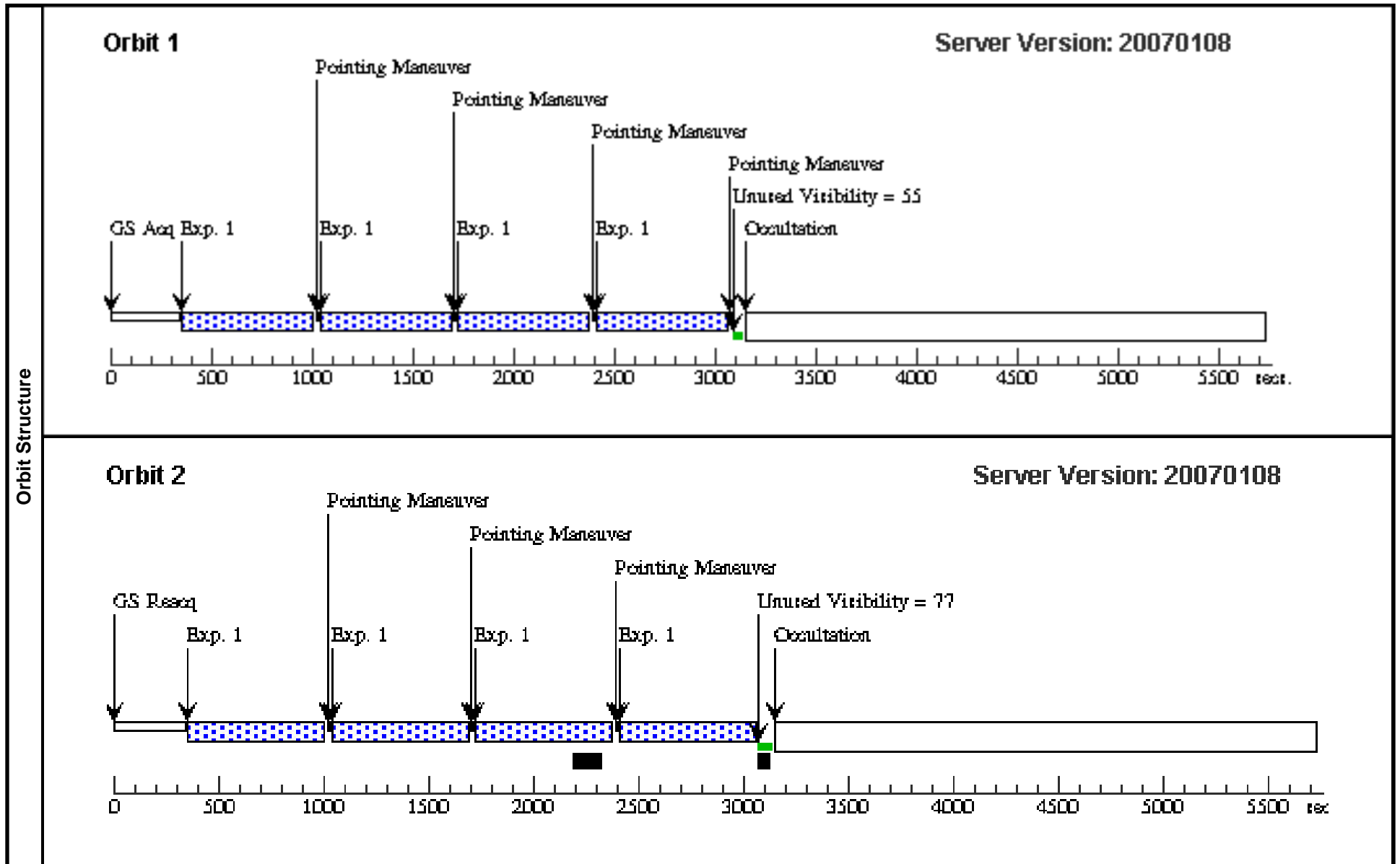
Visit	<b>Proposal 10836, Visit 02, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: NIC3 Special Requirements: (none)										
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Fixed Targets	#	Name	Target Coordinates		Targ. Coord. Corrections		Fluxes		Miscellaneous		
	(4)	1416.7.15B	RA: 14 33 50.7230 (218.4613458d) Dec: +33 26 25.18 (33.44033d) Equinox: J2000					V=25.0+/-1.0		Reference Frame: ICRS	
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]		Orbit
	1	7.15b	(4) 1416.7.15B	NIC3, MULTIACCUM, NIC3	F160W	NSAMP=12; SAMP-SEQ=SPARS 64		Pattern 1-1 (1)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]	
								[==>(Pattern 5)] [==>(Pattern 6)] [==>(Pattern 7)] [==>(Pattern 8)]	[2]		



Proposal 10836 - Visit 03 - The Red Sequence at  $1.3 < z < 1.4$  in Galaxy Clusters

Sat Feb 03 02:41:41 GMT 2007

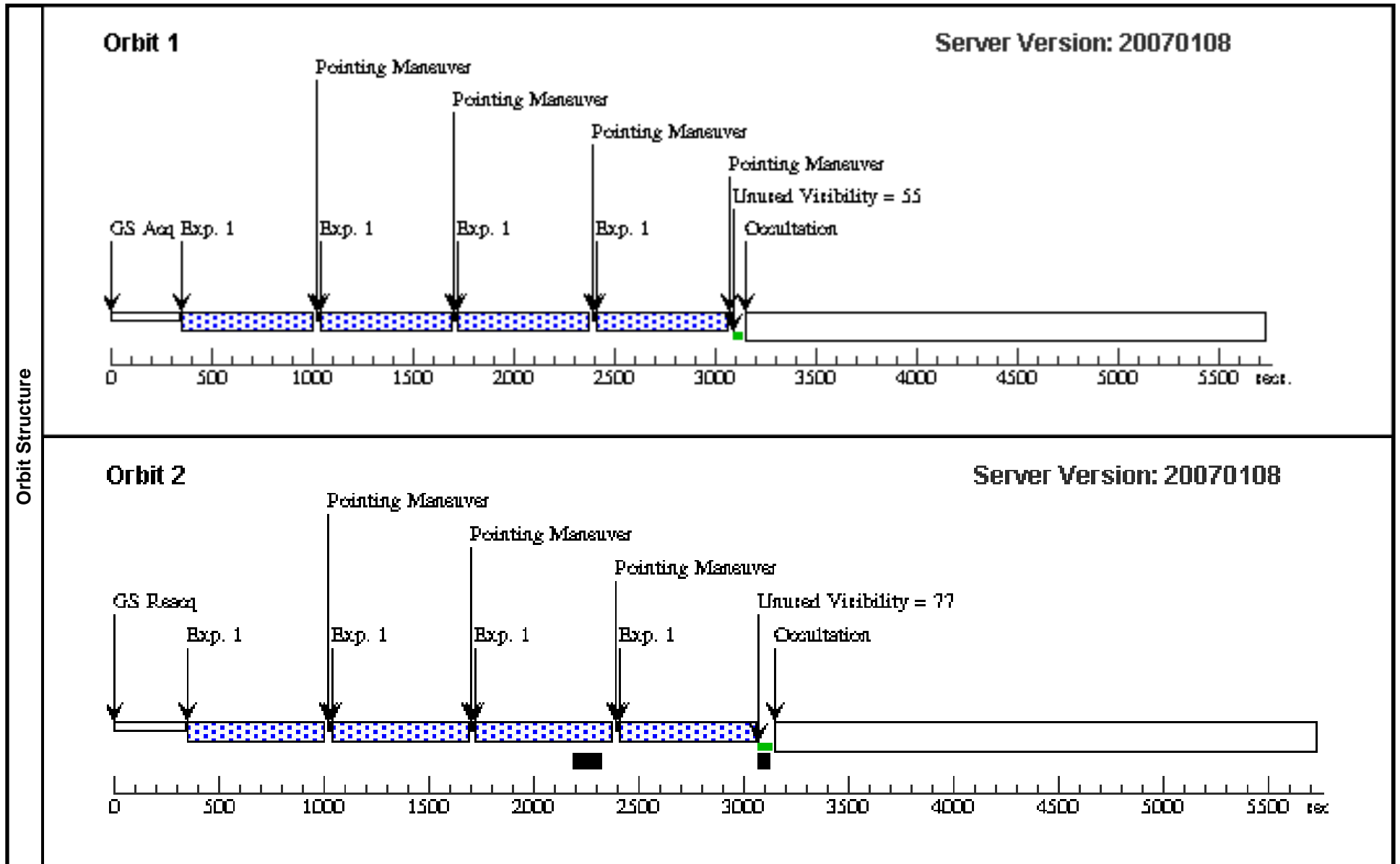
Visit	<b>Proposal 10836, Visit 03, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: NIC3 Special Requirements: (none)										
	Patterns	#	Primary Pattern				Secondary Pattern			Exposures	
		(1)	Pattern Type=NIC-SPIRAL-DITH Purpose=DITHER Number Of Points=8 Point Spacing=1.1 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=0 Angle Between Sides= Center Pattern=true				(1)			
Fixed Targets	#	Name	Target Coordinates		Targ. Coord. Corrections		Fluxes		Miscellaneous		
	(6)	1416.7.15D	RA: 14 33 54.6300 (218.4776250d) Dec: +33 26 20.11 (33.43892d) Equinox: J2000					V=25.0+/-1.0	Reference Frame: ICRS		
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]		Orbit
	1	7.15d	(6) 1416.7.15D	NIC3, MULTIACCUM, NIC3	F160W	NSAMP=12; SAMP-SEQ=SPARS 64		Pattern 1-1 (1)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]	
								[==>(Pattern 5)] [==>(Pattern 6)] [==>(Pattern 7)] [==>(Pattern 8)]	[2]		



Proposal 10836 - Visit 04 - The Red Sequence at  $1.3 < z < 1.4$  in Galaxy Clusters

Sat Feb 03 02:41:42 GMT 2007

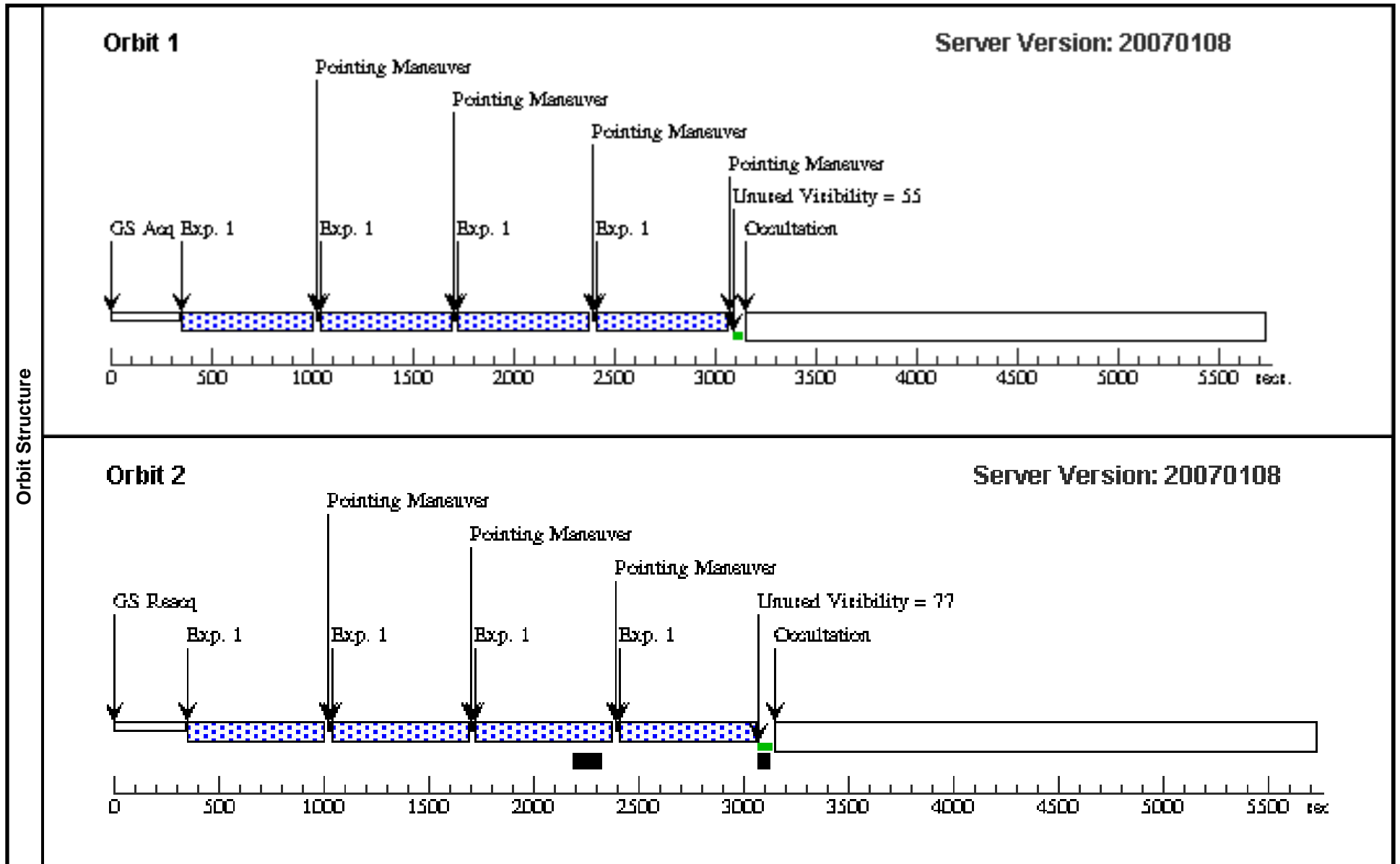
Visit	<b>Proposal 10836, Visit 04, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: NIC3 Special Requirements: (none)										
	Patterns	#	Primary Pattern				Secondary Pattern			Exposures	
		(1)	Pattern Type=NIC-SPIRAL-DITH Purpose=DITHER Number Of Points=8 Point Spacing=1.1 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=0 Angle Between Sides= Center Pattern=true				(1)			
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections		Fluxes	Miscellaneous				
	(2)	1315.5.16A	RA: 14 38 7.8940 (219.5328917d) Dec: +34 13 45.46 (34.22929d) Equinox: J2000			V=26.0+/-1.0	Reference Frame: ICRS				
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]		Orbit
	1	5.16a	(2) 1315.5.16A	NIC3, MULTIACCUM, NIC3	F160W	NSAMP=12; SAMP-SEQ=SPARS 64		Pattern 1-1 (1)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]	
								[==>(Pattern 5)] [==>(Pattern 6)] [==>(Pattern 7)] [==>(Pattern 8)]	[2]		



Proposal 10836 - Visit 05 - The Red Sequence at  $1.3 < z < 1.4$  in Galaxy Clusters

Sat Feb 03 02:41:43 GMT 2007

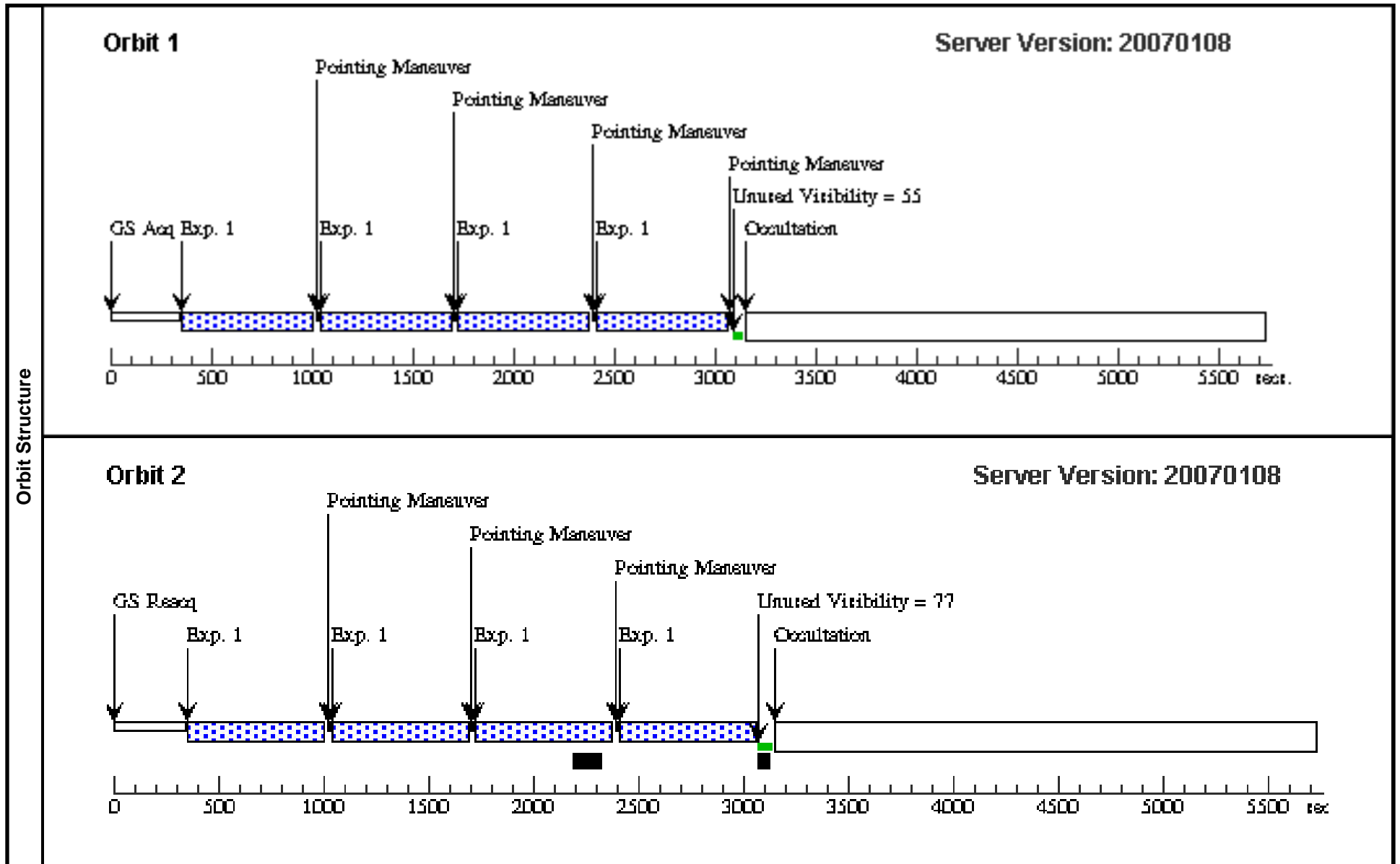
Visit	<b>Proposal 10836, Visit 05, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: NIC3 Special Requirements: (none)										
	Patterns	#	Primary Pattern				Secondary Pattern			Exposures	
		(1)	Pattern Type=NIC-SPIRAL-DITH Purpose=DITHER Number Of Points=8 Point Spacing=1.1 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=0 Angle Between Sides= Center Pattern=true				(1)			
Fixed Targets	#	Name	Target Coordinates		Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(8)	1315.5.16B	RA: 14 38 6.5470 (219.5272792d) Dec: +34 14 36.84 (34.24357d) Equinox: J2000			V=25.0+/-1.0	Reference Frame: ICRS				
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]		Orbit
	1	5.16b	(8) 1315.5.16B	NIC3, MULTIACCUM, NIC3	F160W	NSAMP=12; SAMP-SEQ=SPARS 64		Pattern 1-1 (1)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]	
								[==>(Pattern 5)] [==>(Pattern 6)] [==>(Pattern 7)] [==>(Pattern 8)]	[2]		



Proposal 10836 - Visit 06 - The Red Sequence at  $1.3 < z < 1.4$  in Galaxy Clusters

Sat Feb 03 02:41:43 GMT 2007

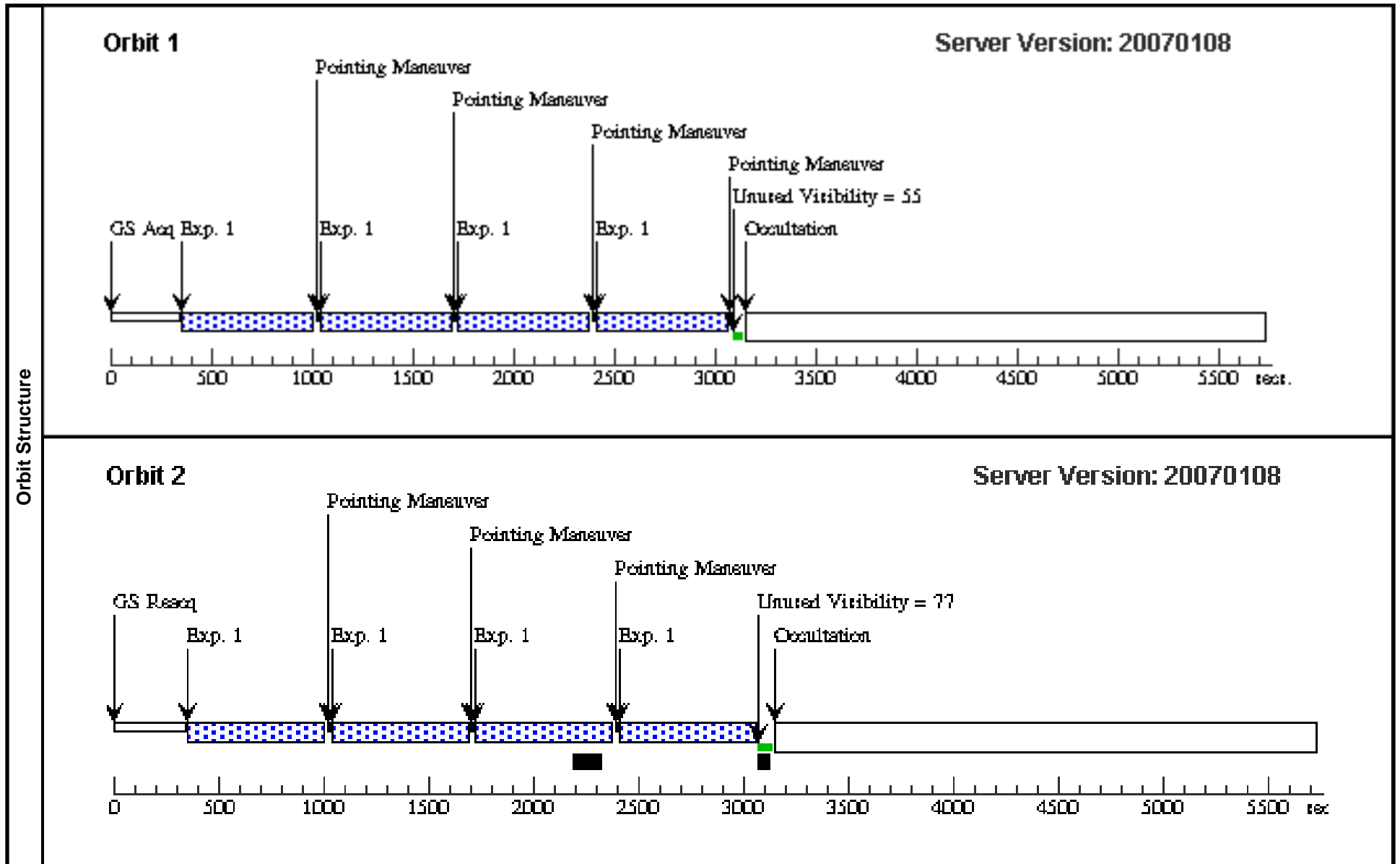
Visit	<b>Proposal 10836, Visit 06, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: NIC3 Special Requirements: (none)										
	Patterns	#	Primary Pattern				Secondary Pattern			Exposures	
		(1)	Pattern Type=NIC-SPIRAL-DITH Purpose=DITHER Number Of Points=8 Point Spacing=1.1 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=0 Angle Between Sides= Center Pattern=true						(1)	
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections		Fluxes	Miscellaneous				
	(9)	1315.5.16C	RA: 14 38 11.8220 (219.5492583d) Dec: +34 12 58.38 (34.21622d) Equinox: J2000			V=25.0+/-1.0	Reference Frame: ICRS				
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]		Orbit
	1	5.16c	(9) 1315.5.16C	NIC3, MULTIACCUM, NIC3	F160W	NSAMP=12; SAMP-SEQ=SPARS 64		Pattern 1-1 (1)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]	
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Proposal 10836 - Visit 07 - The Red Sequence at  $1.3 < z < 1.4$  in Galaxy Clusters

Sat Feb 03 02:41:44 GMT 2007

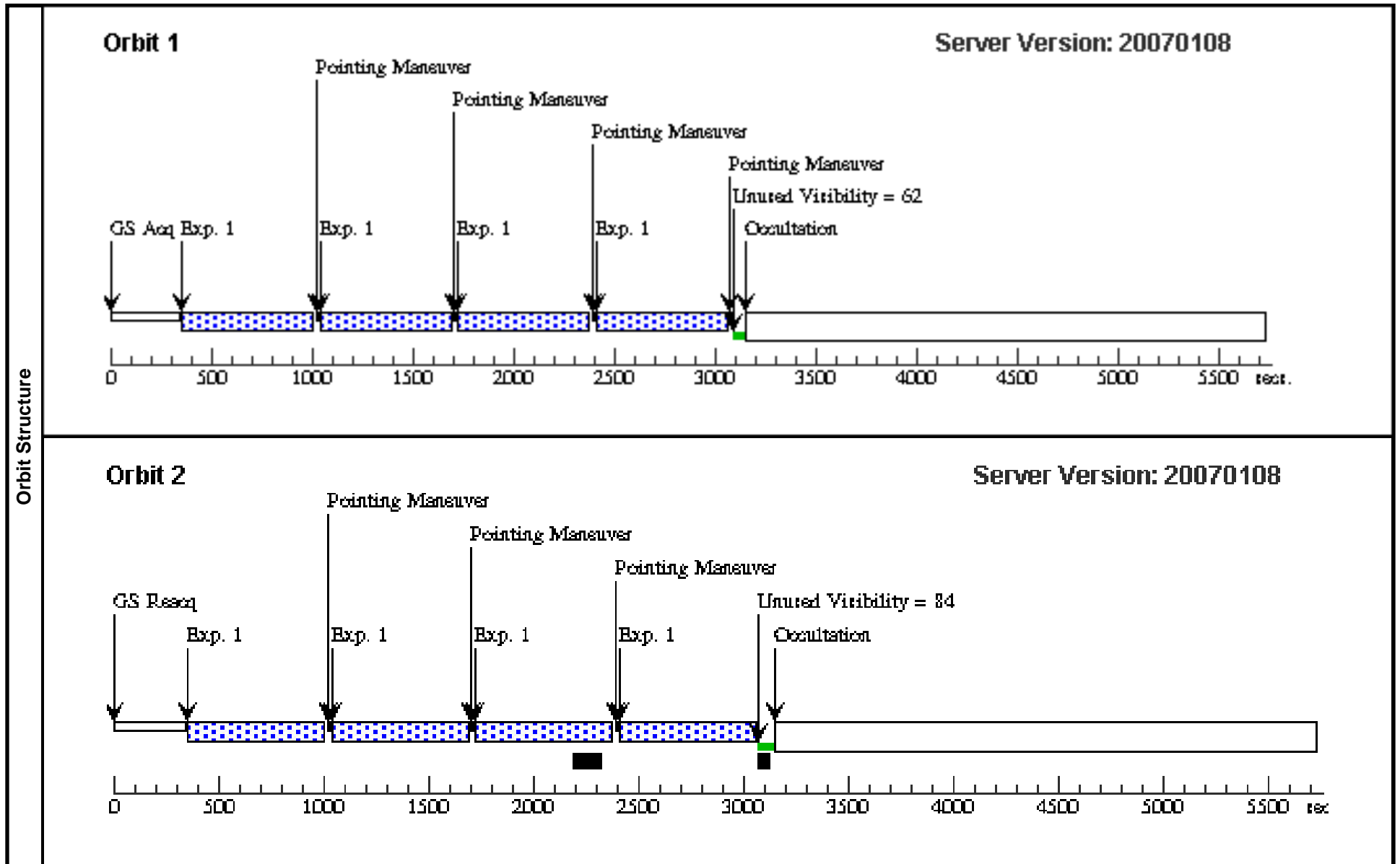
Visit	<b>Proposal 10836, Visit 07, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: NIC3 Special Requirements: (none)									
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		(1)	Pattern Type=NIC-SPIRAL-DITH Purpose=DITHER Number Of Points=8 Point Spacing=1.1 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=0 Angle Between Sides= Center Pattern=true				(1)		
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections		Fluxes	Miscellaneous			
	(10)	1315.5.16D	RA: 14 38 10.6420 (219.5443417d) Dec: +34 14 24.18 (34.24005d) Equinox: J2000			V=25.0+/-1.0	Reference Frame: ICRS			
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
	1	5.16d	(10) 1315.5.16D	NIC3, MULTIACCUM, NIC3	F160W	NSAMP=12; SAMP-SEQ=SPARS 64		Pattern 1-1 (1)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]
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Proposal 10836 - Visit 08 - The Red Sequence at  $1.3 < z < 1.4$  in Galaxy Clusters

Sat Feb 03 02:41:44 GMT 2007

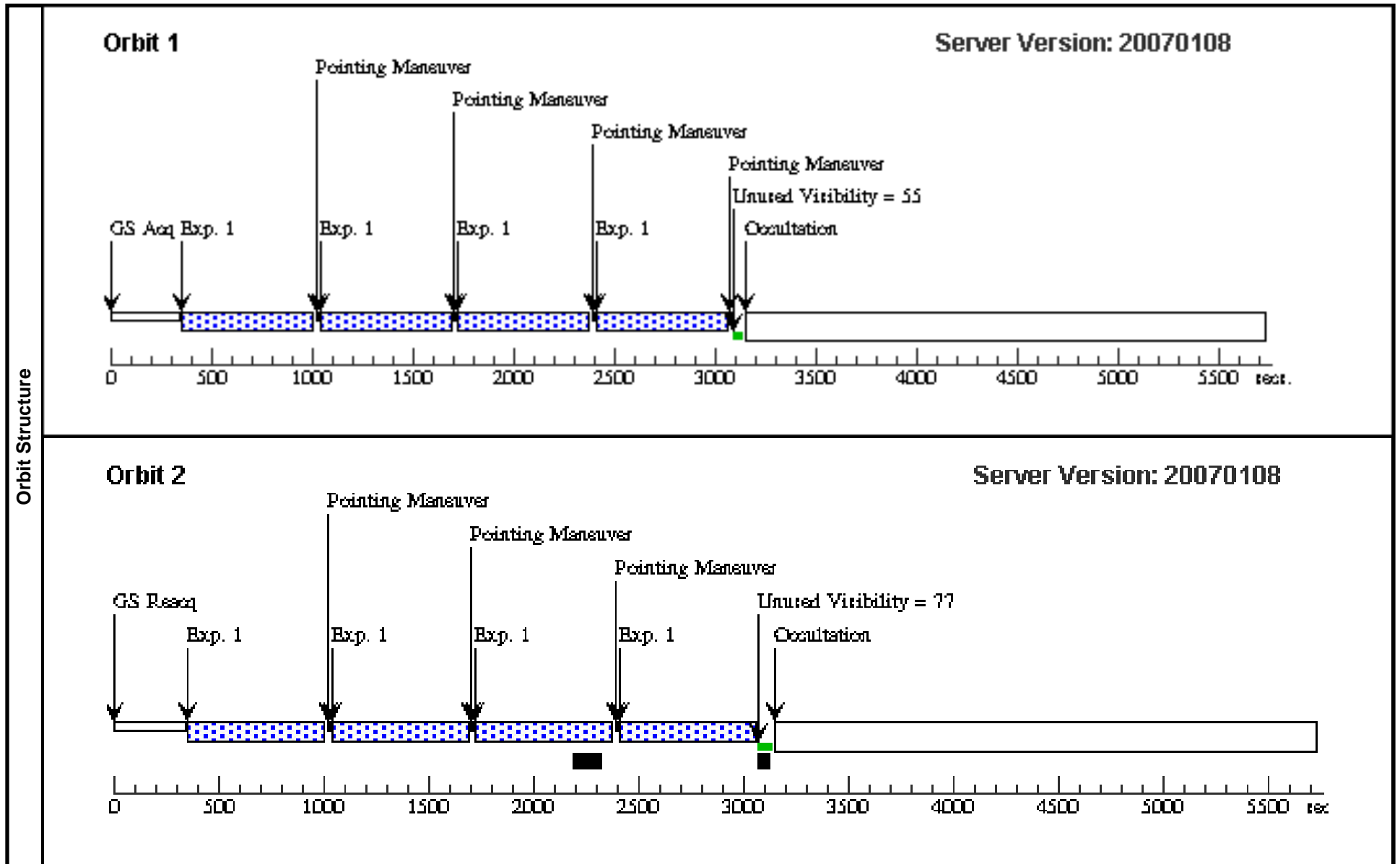
Visit	<b>Proposal 10836, Visit 08, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: NIC3 Special Requirements: (none)										
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Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous					
	(3)	1315.12	RA: 14 34 46.3300 (218.6930417d) Dec: +35 19 45.00 (35.32917d) Equinox: J2000		V=26.0+/-1.0	Reference Frame: ICRS					
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]		Orbit
	1	12a	(3) 1315.12	NIC3, MULTIACCUM, NIC3	F160W	NSAMP=12; SAMP-SEQ=SPARS 64		Pattern 1-1 (1)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]	
								[==>(Pattern 5)] [==>(Pattern 6)] [==>(Pattern 7)] [==>(Pattern 8)]	[2]		



Proposal 10836 - Visit 09 - The Red Sequence at  $1.3 < z < 1.4$  in Galaxy Clusters

Sat Feb 03 02:41:45 GMT 2007

Visit	<b>Proposal 10836, Visit 09, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: NIC3 Special Requirements: (none)									
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Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections		Fluxes	Miscellaneous			
	(5)	1012.28A	RA: 14 34 29.7672 (218.6240300d) Dec: +34 27 5.89 (34.45164d) Equinox: J2000			V=25.0+/-1.0	Reference Frame: ICRS			
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
	1	28a	(5) 1012.28A	NIC3, MULTIACCUM, NIC3	F160W	NSAMP=12; SAMP-SEQ=SPARS 64		Pattern 1-1 (1)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]
								[==>(Pattern 5)] [==>(Pattern 6)] [==>(Pattern 7)] [==>(Pattern 8)]	[2]	



Proposal 10836 - Visit 10 - The Red Sequence at  $1.3 < z < 1.4$  in Galaxy Clusters

Sat Feb 03 02:41:46 GMT 2007

Visit	<b>Proposal 10836, Visit 10, implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: NIC3 Special Requirements: (none)									
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Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(7)	1113.77	RA: 14 29 15.7440 (217.3156000d) Dec: +34 37 12.00 (34.62000d) Equinox: J2000		V=25.0+/-1.0	Reference Frame: ICRS				
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
	1	77a	(7) 1113.77	NIC3, MULTIACCUM, NIC3	F160W	NSAMP=12; SAMP-SEQ=SPARS 64		Pattern 1-1 (1)	[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]
								[==>(Pattern 5)] [==>(Pattern 6)] [==>(Pattern 7)] [==>(Pattern 8)]	[2]	

