11675 - Stellar Forensics: A post-explosion view of the progenitors of core-collapse supernovae

Cycle: 17, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Dr. Justyn R. Maund (PI)	**University of Texas at Austin**	**jrm@astro.as.utexas.edu**
Dr. Stephen J. Smartt (CoI) (ESA Member)	The Queen's University of Belfast	S.Smartt@qub.ac.uk
Dr. J. Craig Wheeler (CoI)	University of Texas at Austin	wheel@astro.as.utexas.edu
Mr. Robert M. Crockett (CoI) (ESA Member)	The Queen's University of Belfast	rcrockett02@qub.ac.uk
Dr. John J. Eldridge (CoI) (ESA Member)	University of Cambridge	jje@ast.cam.ac.uk
Dr. Andrea Pastorello (CoI) (ESA Member)	The Queen's University of Belfast	a.pastorello@qub.ac.uk
Dr. Seppo Mattila (CoI) (ESA Member)	University of Turku	seppo.mattila@utu.fi

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) SN-1999EV	ACS/WFC	2	22-Jul-2009 21:13:01.0	yes
02	(2) SN-2003GD	ACS/WFC	2	22-Jul-2009 21:13:08.0	yes
03	(3) SN-2004A	ACS/WFC	2	22-Jul-2009 21:13:18.0	yes
04	(4) SN-2005CS	ACS/WFC	2	22-Jul-2009 21:13:24.0	yes
05	(5) SN-2006JC	ACS/WFC	2	22-Jul-2009 21:13:32.0	yes
06	(6) SN-2007GR	WFC3/UVIS	1	22-Jul-2009 21:13:41.0	yes

11 Total Orbits Used

ABSTRACT

Recent studies have used high spatial resolution HST observations of SN sites to identify the progenitors of core-collapse SNe on pre-explosion images. These studies have set constraints about the nature of massive stars and their evolution just prior to their explosion as SNe. Now, at late-times when the SNe have faded sufficiently, it is possible to return to the sites of these core-collapse SNe to search for clues about the nature of their progenitors.

We request time to conduct deep, late-time, high-resolution imaging with ACS/HRC of the sites of six core-collapse SNe. In this program we aim to: 1) confirm our identifications, that were made with HST pre-explosion images, of the red supergiant progenitors of four Type IIP SNe (1999ev, 2003gd, 2004A and 2005cs), by observing if the objects identified as the progenitors are now missing; 2) place precise constraints on the progenitor of the Type Ic SN 2007gr by studying its host cluster; and 3) confirm our identification of an LBV-like outburst of an unstable WR star as belonging to the progenitor of a Type Ib-n core-collapse SN (2006jc), using broad and narrow-band imaging to search for emission line stars in its locality. The deep imaging will also allow to probe the stellar populations in the immediate vicinities of these SNe, that were previously obscured by the progenitors and the bright SNe. HST provides the unique combination of high-resolution optical imaging at very faint magnitudes that will facilitate this study.

OBSERVING DESCRIPTION

This phase II proposal outlines observations of 6 separate old SNe (with 1 visit per object). In total 11 orbits have been allocated to this program, with different observing criteria for particular objects.

The principal aim of the observations is to acquire deep, high-resolution imaging at the sites of these SNe with the ACS/HRC. Due to nearby bright objects we also have to use both CR-SPLITS and dither patterns to provide a larger photometric range and to aid removal of cosmic rays and hot pixels. We require three-color broad-band imaging to constrain SEDs and reddening (there are some deviations to this pattern, depending on the object - see below). Importantly, in some cases the target SN may not be present - and this is OK (since we want limits on both the SN and the progenitor brightness, along with any nearby objects).

For Visits (objects) 1-4 (2 orbits ea.), due to relative old age of these objects, we aim to reach B~27, V~27 and I~26.5 at the faint limit. To reach these limits we have determined exposure times of: B~1740s, V~1500s, I~1950s (although due to different orbit properties, there's ~60s fluctuation around these values dependent on the object)

For the three filter observations we employ both CRSPLITS and a dither pattern to remove hot pixels (and to accommodate nearby brighter objects – avoiding saturation and bleeding onto the area of interest). For each of the three filters there are 4 short exposures (2 pairs of CRSPLITs):
CRSPLIT1
CRSPLIT2
DITHER
CRSPLIT1
CRSPLIT2
DITHER

In total, over the course of the whole observation the location of the target area will shift by only 8 pixels due to the dither pattern.

For Visit 5 (2 orbits), we are searching for quiescent LBVs - the broad band faintness limits are relaxed (this time using B,V,R to a limit of 26mag) requiring less time (B=1230s,V=1030,R=1000). We will use a complementary long observation in HALPHA (to search for emission line objects) with exposure time 2220s (to reach a flux 1e-19ergs/cm-2/s-1/A-1). We wish to take the difference between the HALPHA and R-band images to search for emission line objects (which the dither pattern won't affect).
Due to the small lengths of these individual exposures we are not using CR-SPLITS, rather there will be 2 exposures per filter with a dither offset between the 2 to correct for both cosmic rays and hot pixels.
EXPOSURE1
DITHER
EXPOSURE2
DITHER

For Visit 6 (1 orbit) we are acquiring three color imaging of a cluster (in U,V and R) to measure it's SED (cluster mv~22). For likely cluster colors, we only need 1 orbit to go down to ~24 mag (i.e. to measure the SED to good S/N and search for any nearby flux contribution). Exposure times to hit this limit are U=1500, V=480, R=480. Again, due to length of time for each broad-band filter we will use the dither pattern alone - with 2 exposures at different pointings per filter.
EXPOSURE1
DITHER
EXPOSURE2
DITHER

There is 1 scheduling constraint for Visit 6 - which should occur in the second half of Cycle 17 (after May 1st 2009), since the SN will have only faded to acceptable limits in that time. There are no scheduling constraints for Visits 1-5.

Visit

Proposal 11675, Visit 01, implementation Thu Jul 23 01:13:44 GMT 2009

Diagnostic Status: No Diagnostics

Scientific Instruments: ACS/WFC

Special Requirements: (none)

Comments: VISIT FOR TYPE IIP SN1999EV

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(4)	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), (2), (3)

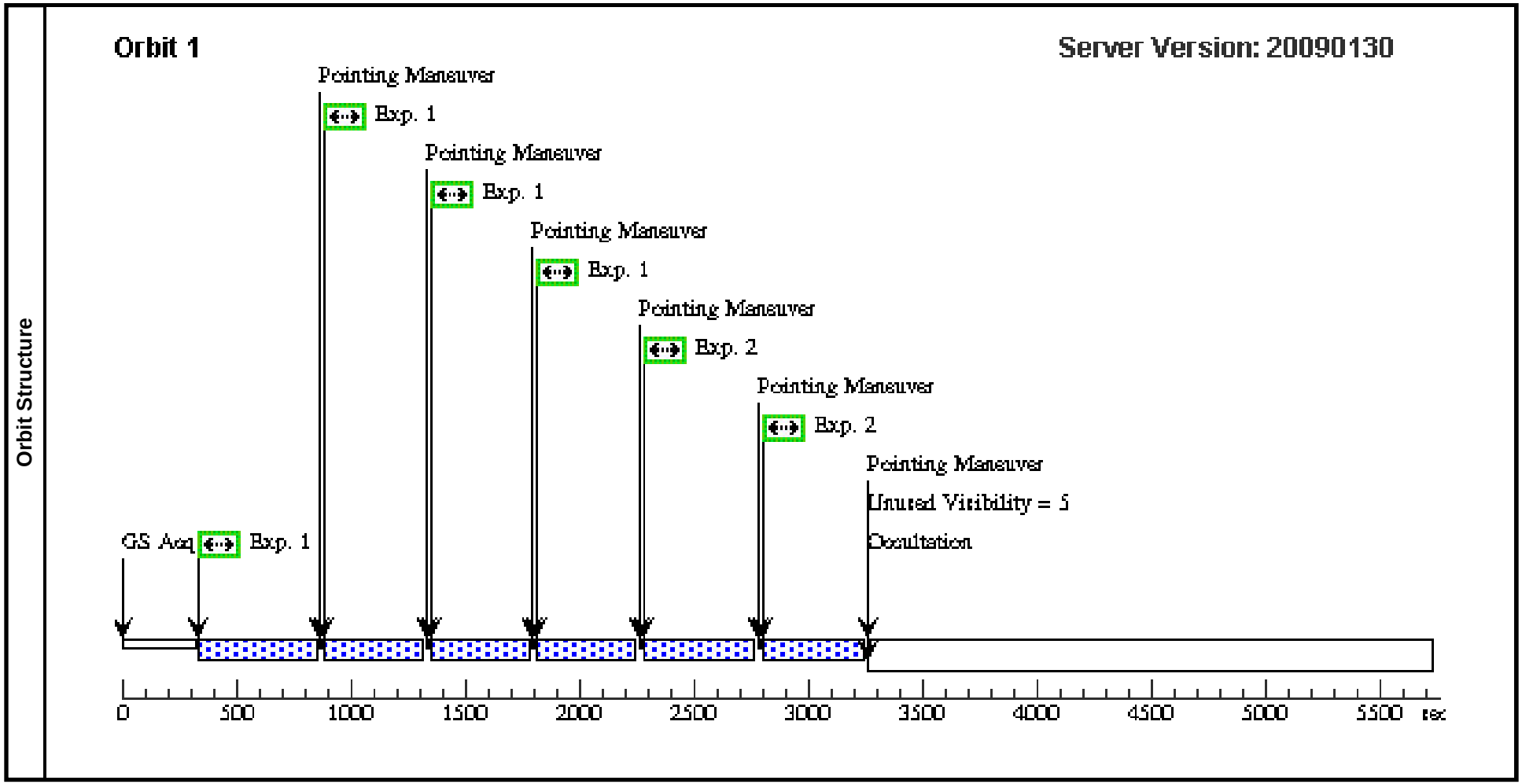
Fixed Targets

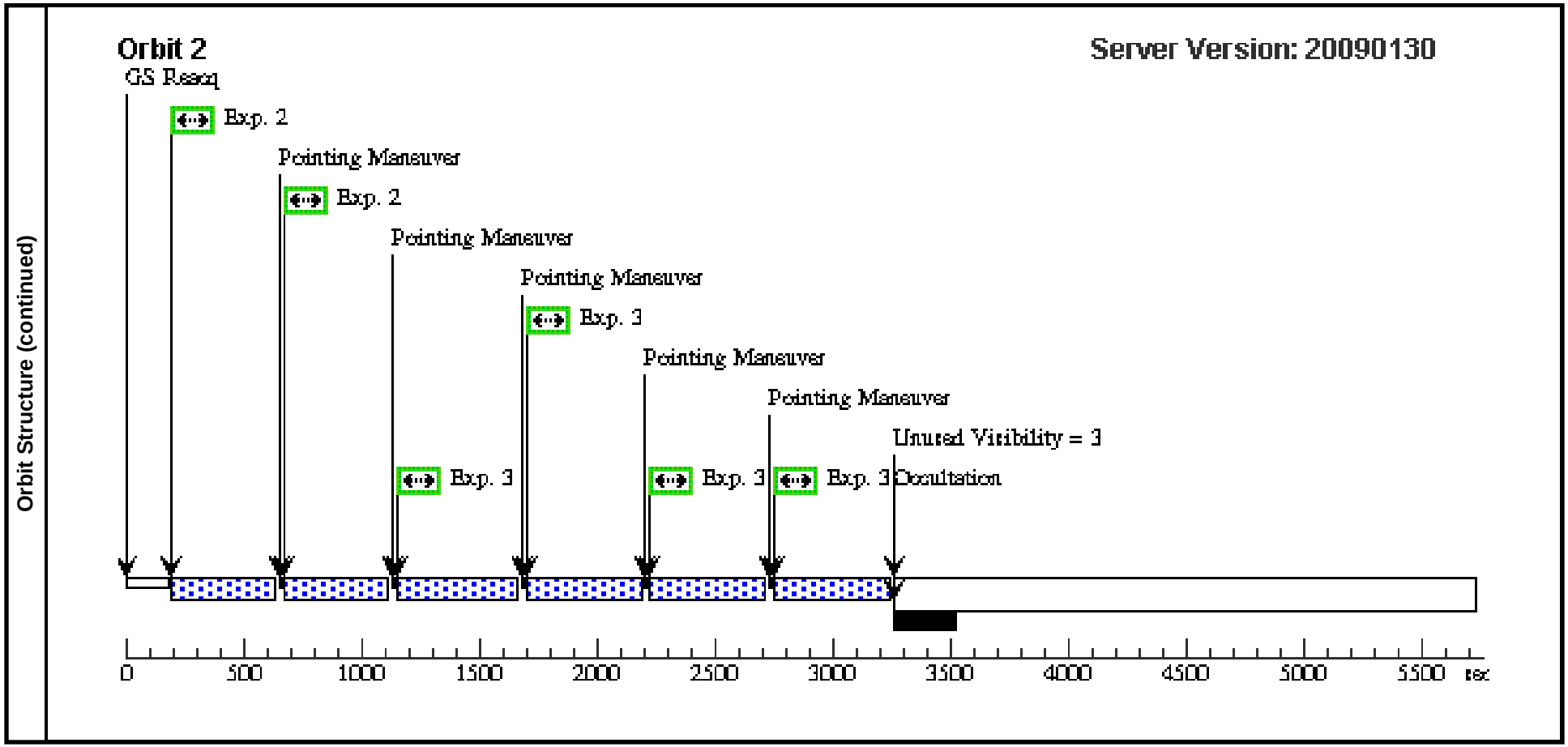
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	SN-1999EV	RA: 12 19 48.3300 (184.9513750d) Dec: +29 37 22.20 (29.62283d) Equinox: J2000		V=26	Reference Frame: NED

Comments: This object was generated by the targetselector and retrieved from the NED database.

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	SN1999EV/V	(1) SN-1999EV	ACS/WFC, ACCUM, WFC1-1K	F555W			Pattern 4, Exps 1-1 (4)	342 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[1]***
2	SN1999EV/I	(1) SN-1999EV	ACS/WFC, ACCUM, WFC1-1K	F814W			Pattern 4, Exps 2-2 (4)	350 Secs	
								[==>352.0 Secs (Pattern 1)] *[==>352.0 Secs (Pattern 2)]*	***[1]***
								[==>352.0 Secs (Pattern 3)] *[==>352.0 Secs (Pattern 4)]*	***[2]***
3	SN1999EV/B	(1) SN-1999EV	ACS/WFC, ACCUM, WFC1-1K	F435W			Pattern 4, Exps 3-3 (4)	400 Secs	
								[==>402.0 Secs (Pattern 1)] *[==>402.0 Secs (Pattern 2)]* *[==>402.0 Secs (Pattern 3)]* *[==>402.0 Secs (Pattern 4)]*	***[2]***


Orbit Structure
Orbit 1
Server Version: 20090130
Pointing Maneuver
Exp. 1
Pointing Maneuver
Exp. 1
Pointing Maneuver
Exp. 1
Pointing Maneuver
Exp. 2
Pointing Maneuver
Exp. 2
Pointing Maneuver
Unused Visibility = 5
Occultation
GS Acq
Exp. 1
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec


Orbit Structure (continued)
Orbit 2
Server Version: 20090130
GS Reacq
Exp. 2
Pointing Maneuver
Exp. 2
Pointing Maneuver
Pointing Maneuver
Exp. 3
Pointing Maneuver
Pointing Maneuver
Unused Visibility = 3
Exp. 3
Exp. 3
Exp. 3
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 11675, Visit 02, implementation Thu Jul 23 01:13:46 GMT 2009

Diagnostic Status: No Diagnostics

Scientific Instruments: ACS/WFC

Special Requirements: (none)

Comments: VISIT FOR TYPE IIP SN2003GD

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(4)	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), (2), (3)

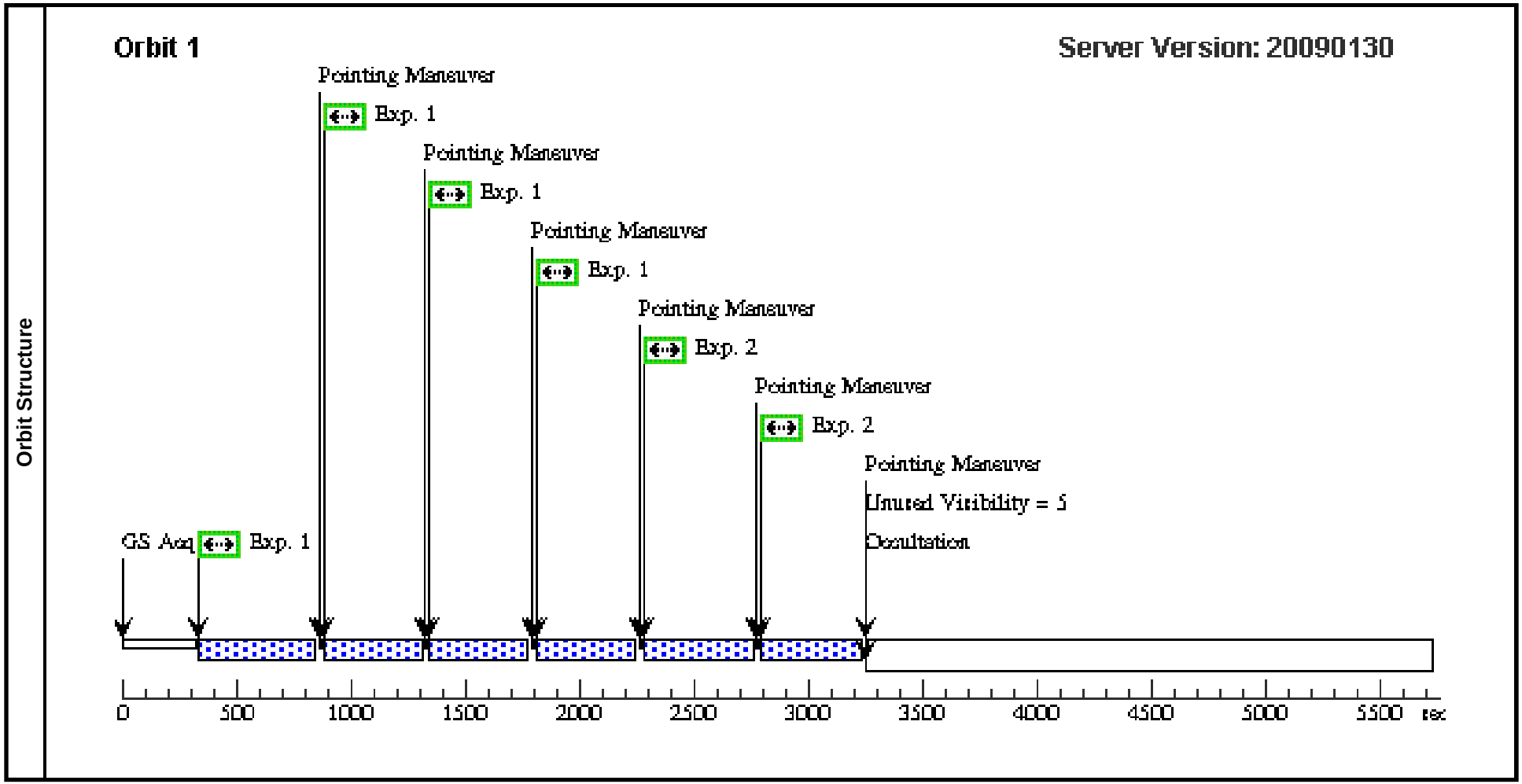
Fixed Targets

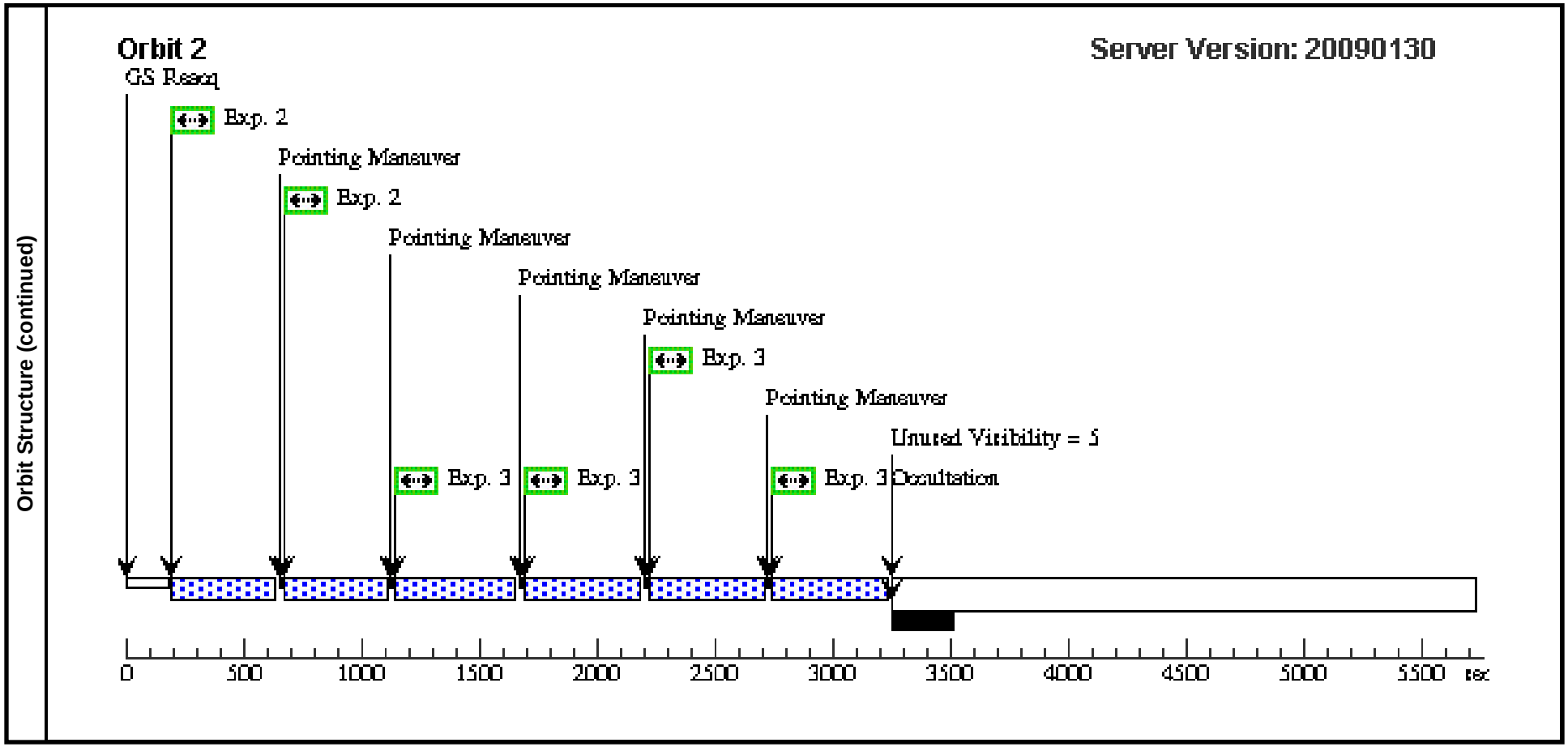
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	SN-2003GD	RA: 01 36 42.6500 (24.1777083d) Dec: +15 44 19.90 (15.73886d) Equinox: J2000		V=26	Reference Frame: NED

Comments: This object was generated by the targetselector and retrieved from the NED database.

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	SN2003GD/V	(2) SN-2003GD	ACS/WFC, ACCUM, WFC1-1K	F555W			Pattern 4, Exps 1-1 (4)	342 Secs	
								[==>341.0 Secs (Pattern 1)] *[==>341.0 Secs (Pattern 2)]* *[==>341.0 Secs (Pattern 3)]* *[==>341.0 Secs (Pattern 4)]*	***[1]***
2	SN2003GD/I	(2) SN-2003GD	ACS/WFC, ACCUM, WFC1-1K	F814W			Pattern 4, Exps 2-2 (4)	350 Secs	
								[==>349.0 Secs (Pattern 1)] *[==>349.0 Secs (Pattern 2)]*	***[1]***
								[==>(Pattern 3)] *[==>(Pattern 4)]*	***[2]***
3	SN2003GD/B	(2) SN-2003GD	ACS/WFC, ACCUM, WFC1-1K	F435W			Pattern 4, Exps 3-3 (4)	400 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[2]***


Orbit Structure
Orbit 1
Server Version: 20090130
Pointing Maneuver
Exp. 1
Pointing Maneuver
Exp. 1
Pointing Maneuver
Exp. 1
Pointing Maneuver
Exp. 2
Pointing Maneuver
Exp. 2
Pointing Maneuver
Unused Vitibility = 5
Occultation
GS Acq
Exp. 1
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec


Orbit Structure (continued)
Orbit 2
Server Version: 20090130
GS Reacq
Exp. 2
Pointing Maneuver
Exp. 2
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Exp. 3
Pointing Maneuver
Unused Visibility = 5
Exp. 3
Exp. 3
Exp. 3
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 11675, Visit 03, implementation Thu Jul 23 01:13:46 GMT 2009

Diagnostic Status: No Diagnostics

Scientific Instruments: ACS/WFC

Special Requirements: (none)

Comments: VISIT FOR TYPE IIP SN2004A

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(4)	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), (2), (3)

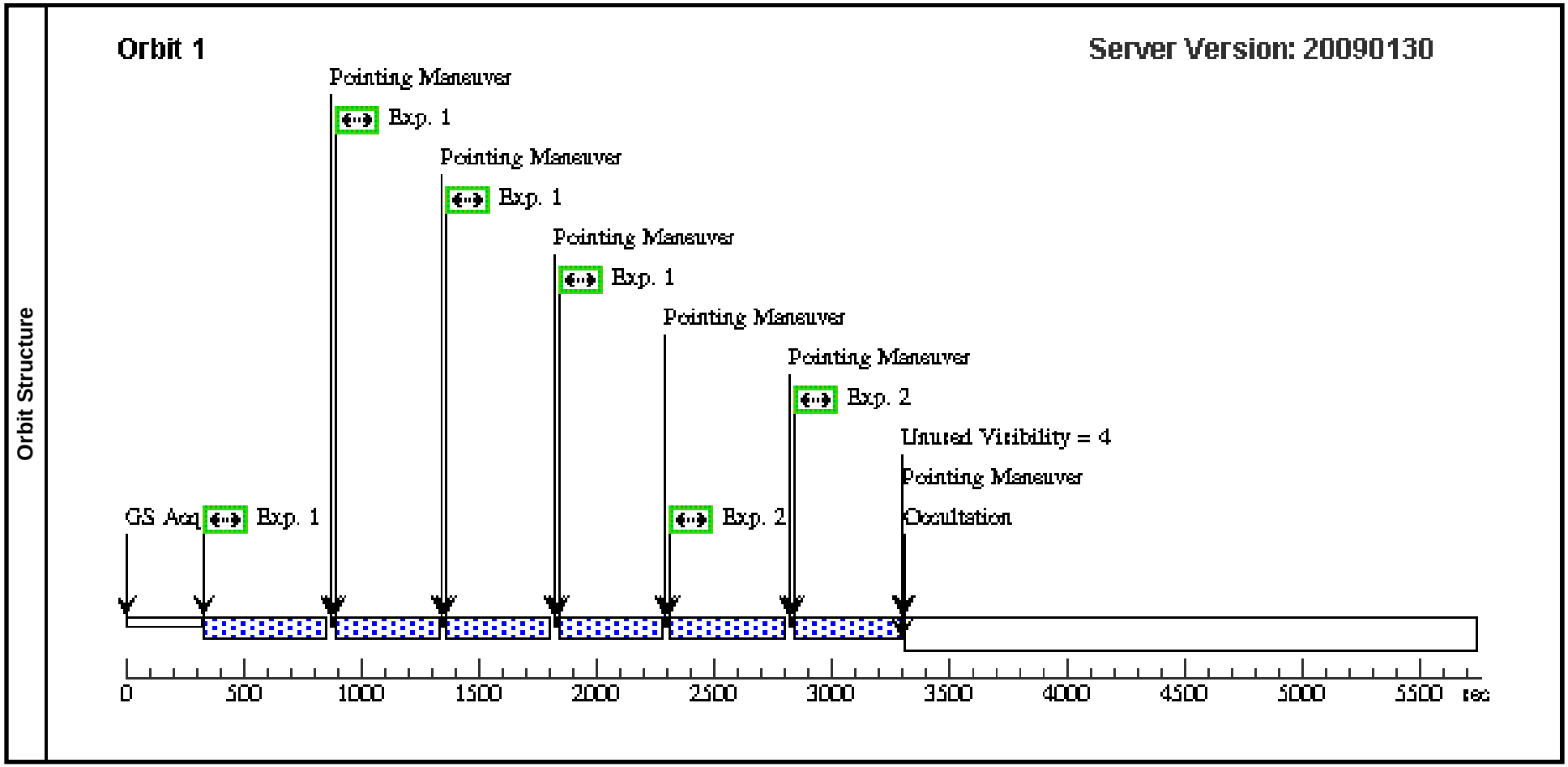
Fixed Targets

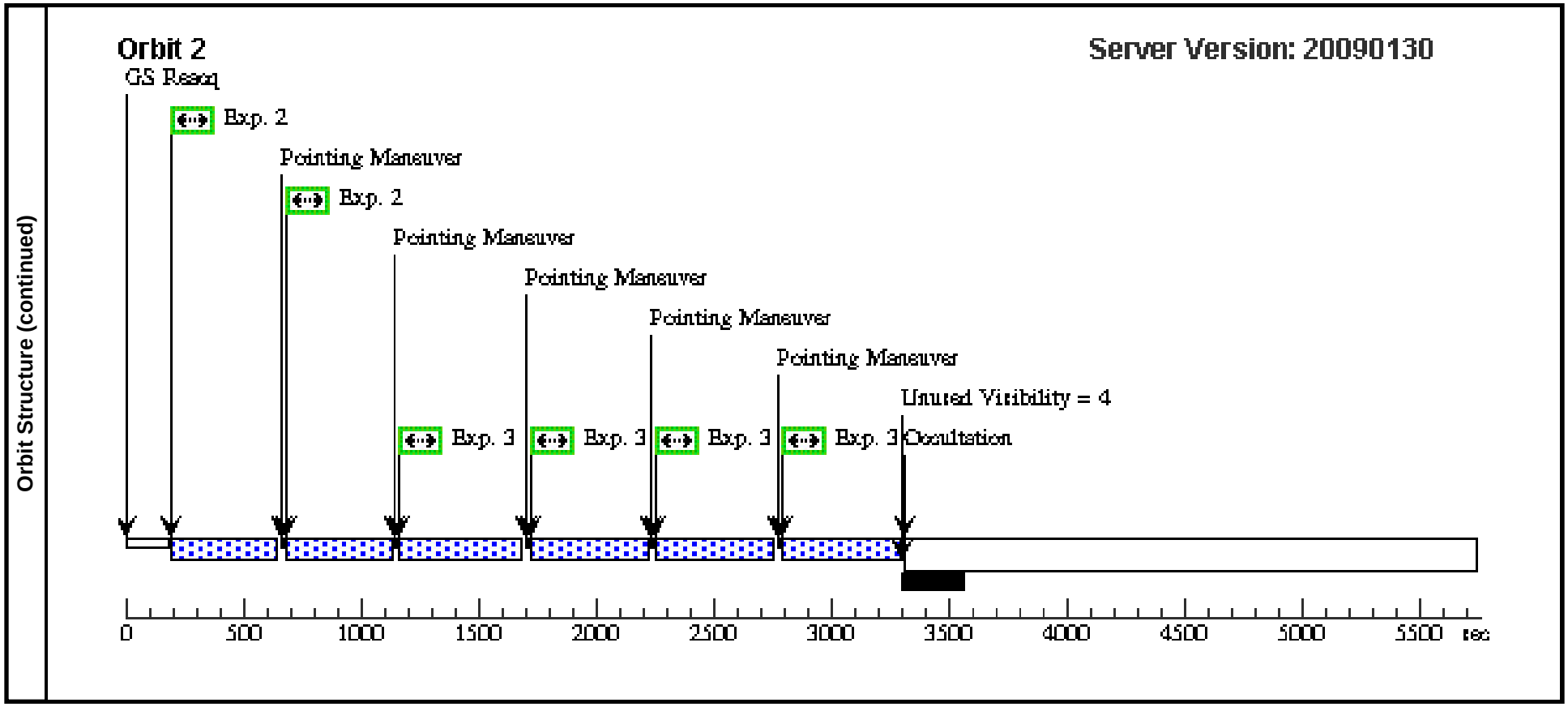
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(3)	SN-2004A	RA: 16 43 1.9000 (250.7579167d) Dec: +36 50 12.50 (36.83681d) Equinox: J2000		V=26	Reference Frame: NED

Comments: This object was generated by the targetselector and retrieved from the NED database.

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	SN2004A/V	(3) SN-2004A	ACS/WFC, ACCUM, WFC1-1K	F555W			Pattern 4, Exps 1-1 (4)	342 Secs	
								[==>350.0 Secs (Pattern 1)] *[==>350.0 Secs (Pattern 2)]* *[==>350.0 Secs (Pattern 3)]* *[==>350.0 Secs (Pattern 4)]*	***[1]***
2	SN2004A/I	(3) SN-2004A	ACS/WFC, ACCUM, WFC1-1K	F814W			Pattern 4, Exps 2-2 (4)	350 Secs	
								[==>358.0 Secs (Pattern 1)] *[==>358.0 Secs (Pattern 2)]*	***[1]***
								[==>359.0 Secs (Pattern 3)] *[==>359.0 Secs (Pattern 4)]*	***[2]***
3	SN2004A/B	(3) SN-2004A	ACS/WFC, ACCUM, WFC1-1K	F435W			Pattern 4, Exps 3-3 (4)	400 Secs	
								[==>409.0 Secs (Pattern 1)] *[==>409.0 Secs (Pattern 2)]* *[==>409.0 Secs (Pattern 3)]* *[==>409.0 Secs (Pattern 4)]*	***[2]***


Orbit Structure
Orbit 1
Server Version: 20090130
Pointing Maneuver
Exp. 1
Pointing Maneuver
Exp. 1
Pointing Maneuver
Exp. 1
Pointing Maneuver
Pointing Maneuver
Exp. 2
Unused Visibility = 4
Pointing Maneuver
Occultation
GS Acq
Exp. 1
Exp. 2
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec


Orbit Structure (continued)
Orbit 2
Server Version: 20090130
GS Reacq
Exp. 2
Pointing Maneuver
Exp. 2
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Unuted Vitibility = 4
Exp. 3
Exp. 3
Exp. 3
Exp. 3
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 11675, Visit 04, implementation Thu Jul 23 01:13:47 GMT 2009

Diagnostic Status: No Diagnostics

Scientific Instruments: ACS/WFC

Special Requirements: (none)

Comments: VISIT FOR TYPE IIP SN2005CS

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(4)	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), (2), (3)

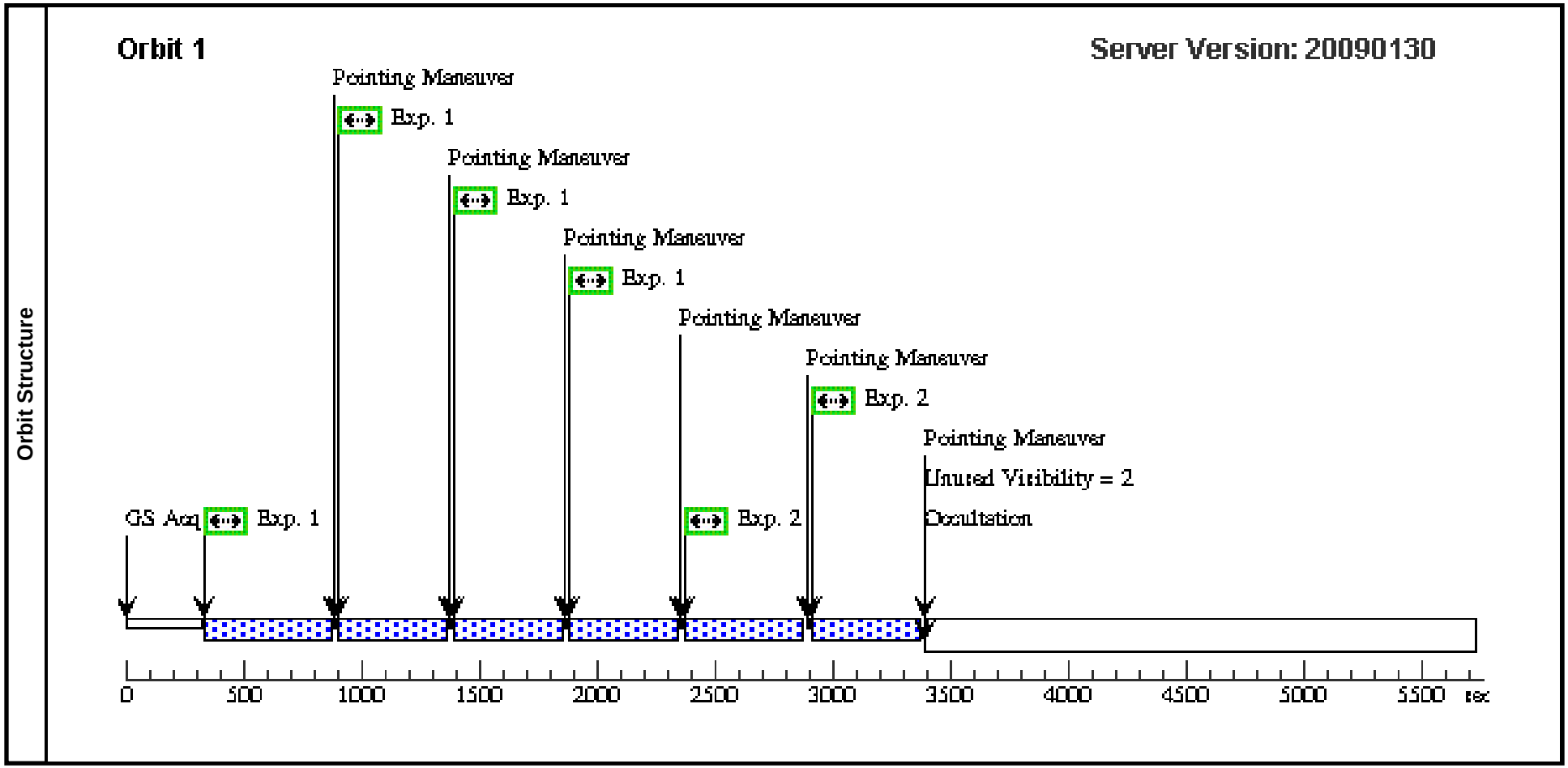
Fixed Targets

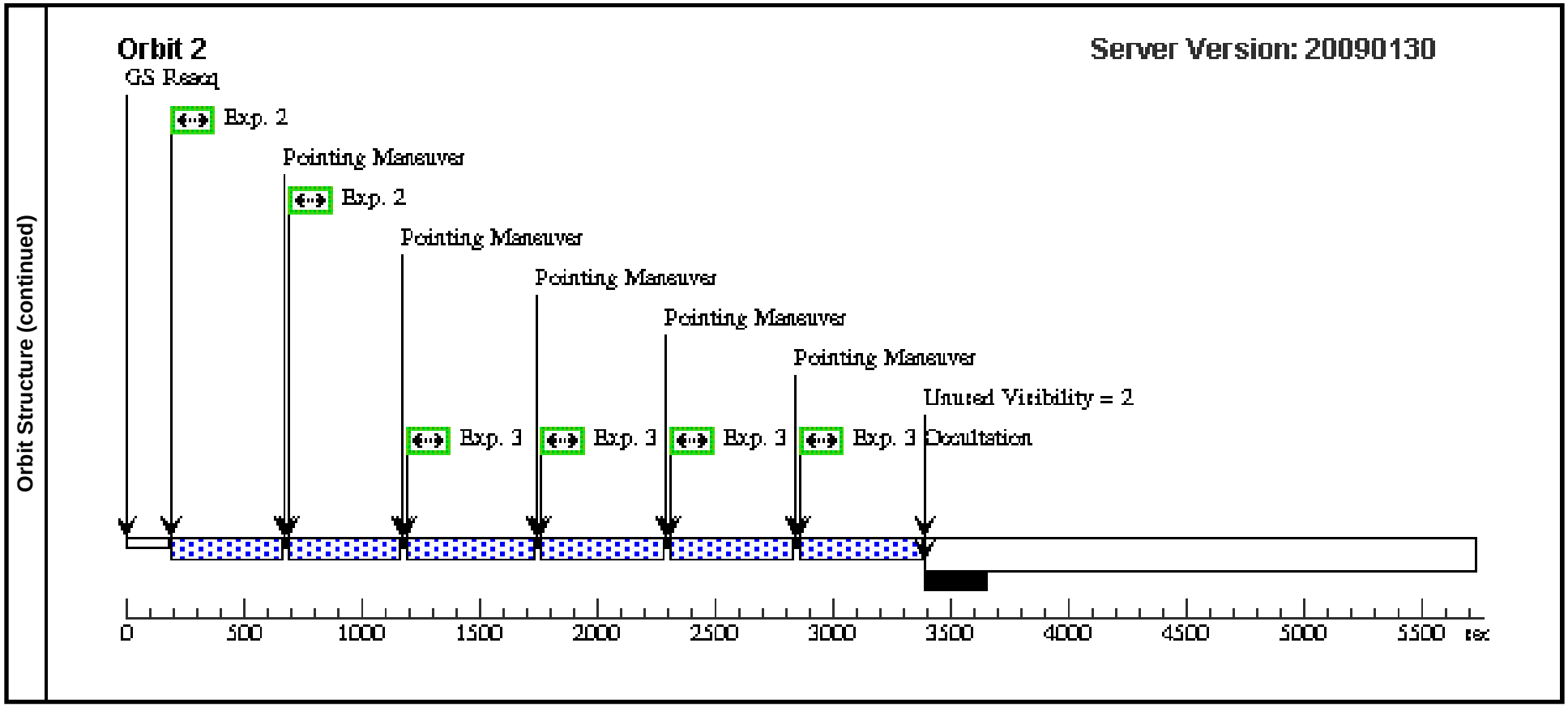
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(4)	SN-2005CS	RA: 13 29 53.3700 (202.4723750d) Dec: +47 10 28.20 (47.17450d) Equinox: J2000		V=26	Reference Frame: NED

Comments: This object was generated by the targetselector and retrieved from the NED database.

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	SN2005CS/V	(4) SN-2005CS	ACS/WFC, ACCUM, WFC1-1K	F555W			Pattern 4, Exps 1-1 (4)	342 Secs	
								[==>365.0 Secs (Pattern 1)] *[==>365.0 Secs (Pattern 2)]* *[==>365.0 Secs (Pattern 3)]* *[==>365.0 Secs (Pattern 4)]*	***[1]***
2	SN2005CS/I	(4) SN-2005CS	ACS/WFC, ACCUM, WFC1-1K	F814W			Pattern 4, Exps 2-2 (4)	350 Secs	
								[==>373.0 Secs (Pattern 1)] *[==>373.0 Secs (Pattern 2)]*	***[1]***
								[==>374.0 Secs (Pattern 3)] *[==>374.0 Secs (Pattern 4)]*	***[2]***
3	SN2005CS/B	(4) SN-2005CS	ACS/WFC, ACCUM, WFC1-1K	F435W			Pattern 4, Exps 3-3 (4)	400 Secs	
								[==>424.0 Secs (Pattern 1)] *[==>424.0 Secs (Pattern 2)]* *[==>424.0 Secs (Pattern 3)]* *[==>424.0 Secs (Pattern 4)]*	***[2]***


Orbit Structure
Orbit 1
Server Version: 20090130
Pointing Maneuver
Exp. 1
Pointing Maneuver
Exp. 1
Pointing Maneuver
Exp. 1
Pointing Maneuver
Pointing Maneuver
Exp. 2
Pointing Maneuver
Unused Visibility = 2
Occultation
GS Acq
Exp. 1
Exp. 2
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec


Orbit Structure (continued)
Orbit 2
Server Version: 20090130
GS Reacq
Exp. 2
Pointing Maneuver
Exp. 2
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Unused Visibility = 2
Exp. 3
Exp. 3
Exp. 3
Exp. 3
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 11675, Visit 05, implementation Thu Jul 23 01:13:48 GMT 2009

Diagnostic Status: No Diagnostics

Scientific Instruments: ACS/WFC

Special Requirements: (none)

Comments: VISIT FOR TYPE IB SN2006JC

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(4)	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), (2), (3), (4)

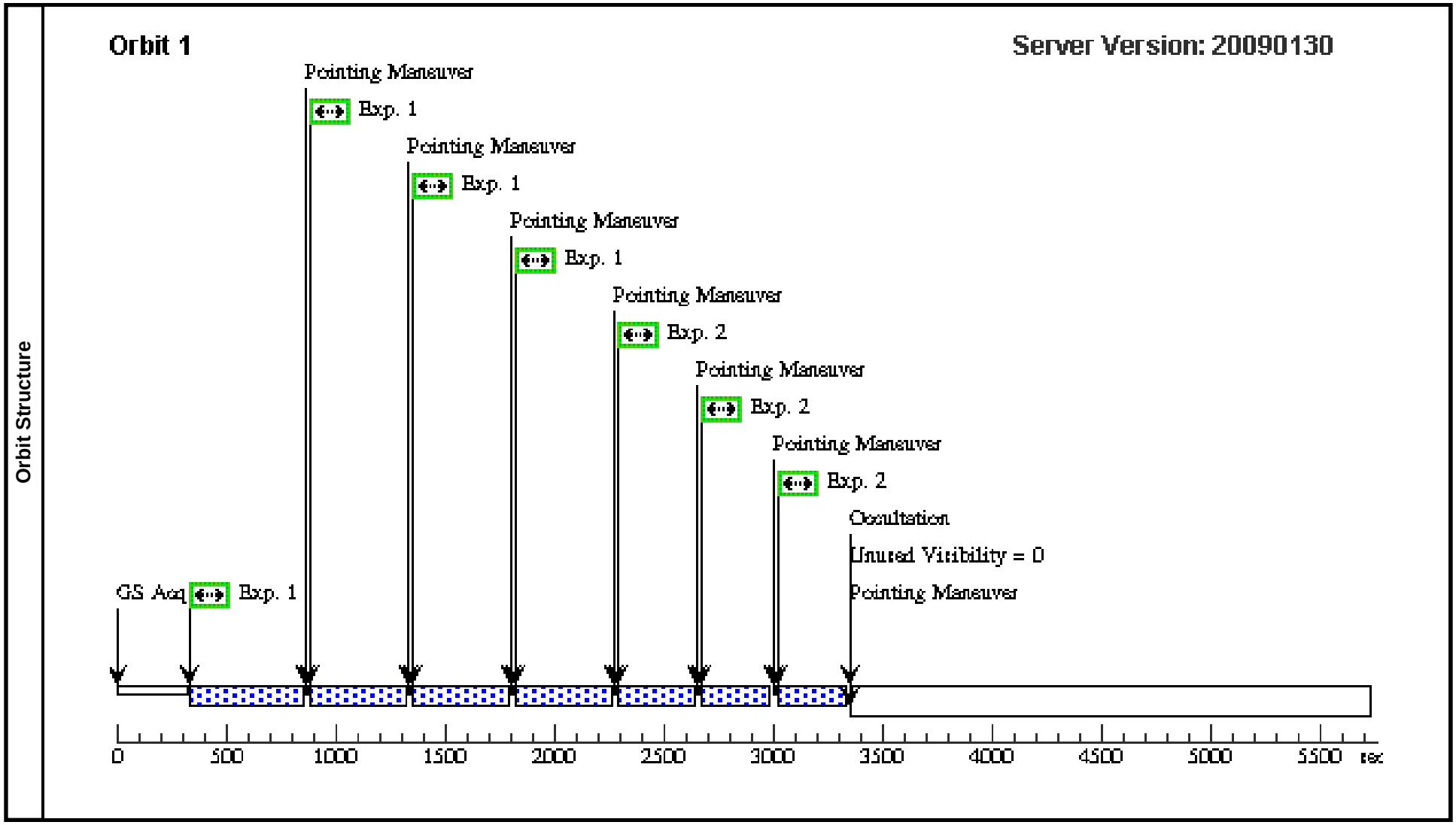
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(5)	SN-2006JC	RA: 09 17 20.7800 (139.3365833d) Dec: +41 54 32.70 (41.90908d) Equinox: J2000		V=26	Reference Frame: NED

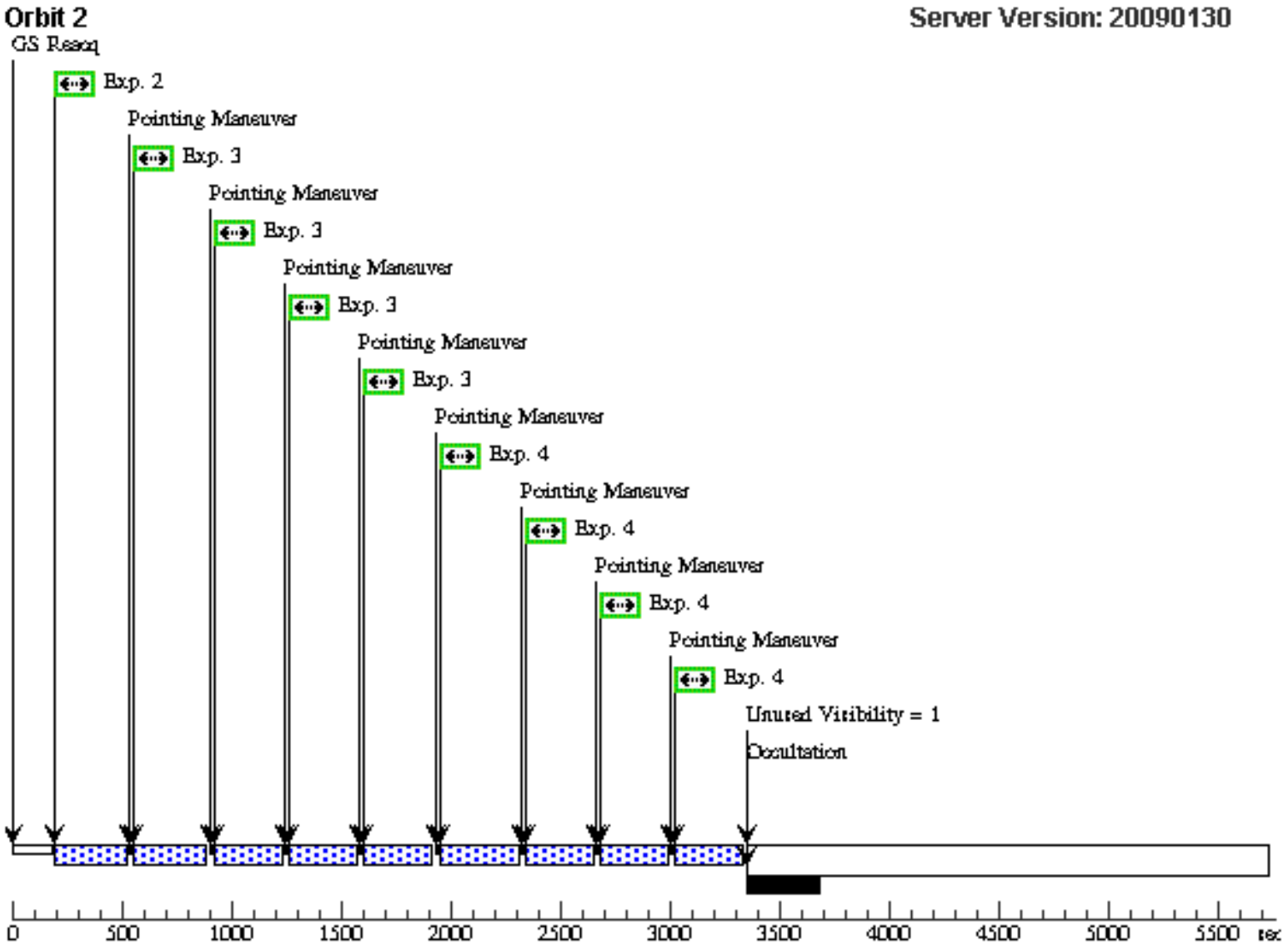
Comments: This object was generated by the targetselector and retrieved from the NED database.

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	SN2006JC/ HALPHA	(5) SN-2006JC	ACS/WFC, ACCUM, WFC1-1K	F658N			Pattern 4, Exps 1-1 (4)	345 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[1]***
2	SN2006JC/ R	(5) SN-2006JC	ACS/WFC, ACCUM, WFC1-1K	F625W			Pattern 4, Exps 2-2 (4)	220 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]*	***[1]***
								[==>237.0 Secs (Pattern 4)]	***[2]***
3	SN2006JC/ V	(5) SN-2006JC	ACS/WFC, ACCUM, WFC1-1K	F555W			Pattern 4, Exps 3-3 (4)	200 Secs	
								[==>217.0 Secs (Pattern 1)] *[==>217.0 Secs (Pattern 2)]* *[==>217.0 Secs (Pattern 3)]* *[==>217.0 Secs (Pattern 4)]*	***[2]***
4	SN2006JC/ B	(5) SN-2006JC	ACS/WFC, ACCUM, WFC1-1K	F435W			Pattern 4, Exps 4-4 (4)	200 Secs	
								[==>217.0 Secs (Pattern 1)] *[==>217.0 Secs (Pattern 2)]* *[==>217.0 Secs (Pattern 3)]* *[==>217.0 Secs (Pattern 4)]*	***[2]***


Orbit Structure
Orbit 1
Server Version: 20090130
GS Acq
Exp. 1
Pointing Maneuver
Exp. 1
Pointing Maneuver
Exp. 1
Pointing Maneuver
Exp. 1
Pointing Maneuver
Exp. 2
Pointing Maneuver
Exp. 2
Pointing Maneuver
Exp. 2
Occultation
Unused Visibility = 0
Pointing Maneuver
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Orbit Structure (continued)



Visit

Proposal 11675, Visit 06, implementation Thu Jul 23 01:13:48 GMT 2009

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: AFTER 01-MAY-2009:00:00:00

Comments: VISIT FOR TYPE IC SN2007GR

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(3)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.173 Line Spacing=0.112	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=false		(1), (2), (3)

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(6)	SN-2007GR	RA: 02 43 27.9800 (40.8665833d) Dec: +37 20 44.70 (37.34575d) Equinox: J2000		V=25	Reference Frame: NED

Comments: This object was generated by the targetselector and retrieved from the NED database.

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	SN2007GR/U	(6) SN-2007GR	WFC3/UVIS, ACCUM, UVIS1-C512A-SUB	F336W	CR-SPLIT=NO		Pattern 3, Exps 1-1 (3)	265 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[1]***
2	SN2007GR/V	(6) SN-2007GR	WFC3/UVIS, ACCUM, UVIS1-C512A-SUB	F555W	CR-SPLIT=NO		Pattern 3, Exps 2-2 (3)	160 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[1]***
3	SN2007GR/R	(6) SN-2007GR	WFC3/UVIS, ACCUM, UVIS1-C512A-SUB	F625W	CR-SPLIT=NO		Pattern 3, Exps 3-3 (3)	160 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[1]***

Orbit Structure