10550 - The Nature of LSB galaxies revealed by their Globular Clusters

Cycle: 14, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Dr. Markus Kissler-Patig (PI) (ESA Member)	**European Southern Observatory - Germany**	**mkissler@eso.org**
Dr. Andres Jordan (CoI) (ESA Member)	European Southern Observatory - Germany	ajordan@eso.org
Dr. Paul Goudfrooij (CoI) (AdminUSPI)	Space Telescope Science Institute	goudfroo@stsci.edu
Dr. Martin A. Zwaan (CoI) (ESA Member)	European Southern Observatory - Germany	mzwaan@eso.org

VISITS

Visit	*Targets*	*Configurations*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) UGC-00477	ACS/WFC	1	20-Jun-2005 11:13:25.0	yes
02	(2) UGC-03459	ACS/WFC	1	20-Jun-2005 11:13:30.0	yes
03	(3) UGC-03587	ACS/WFC	1	20-Jun-2005 11:13:33.0	yes
04	(4) UGC-06138	ACS/WFC	1	20-Jun-2005 11:13:36.0	yes
05	(5) UGC-11131	ACS/WFC	1	20-Jun-2005 11:13:39.0	yes
06	(6) UGC-11651	ACS/WFC	1	20-Jun-2005 11:13:42.0	yes

6 Total Orbits Used

ABSTRACT

Low Surface Brightness (LSB) galaxies encompass many of the extremes in galaxy properties. Their understanding is essential to complete our picture of galaxy formation and evolution. Due to their historical under-representation on galaxy surveys, their importance to many areas of astronomy has only recently began to be realized. Globular clusters are superb tracers of the formation histories of galaxies and have been extensively used as such in high surface brightness galaxies.
We propose to investigate the nature of massive LSB galaxies by studying their globular cluster systems. No globular cluster study has been reported for LSB galaxies to date. Yet, both the presence or absence of globular clusters set very strong constraints on the conditions prevailing during LSB galaxy formation and evolution. Both in dwarf and giant high surface brightness (HSB) galaxies, globular clusters are known to form as a constant fraction of baryonic mass. Their presence/absence immediately indicates similarities or discrepancies in the formation and evolution conditions of LSB and HSB galaxies. In particular, the presence/absence of metal-poor halo globular clusters infers similarities/differences in the halo formation and assembly processes of LSB vs. HSB galaxies, while the presence/absence of metal-rich globular clusters can be used to derive the occurrence and frequency of violent events (such as mergers) in the LSB galaxy assembly history.
Two band imaging with ACS will allow us to identify the globular clusters (just resolved at the selected distance) and to determine their metallicity (potentially their rough age). The composition of the systems will be compared to the extensive census built up on HSB galaxies. Our representative sample of six LSB galaxies (cz < 2700 km/s) are selected such, that a large system of globular clusters is expected.
Globular clusters will constrain phases of LSB galaxy formation and evolution that can currently not be probed by other means. HST/ACS imaging is the only facility capable of studying the globular cluster systems of LSB galaxies given their distance and relative scarcity.

OBSERVING DESCRIPTION

Requirements to meet the Scientific Objectives:

To meet goals our scientific goals we need a representative sample of globular clusters in each galaxy.
The number of globular clusters is known to scale with galaxy luminosity (i.e. roughly constant specific frequency SN, defined as the number of globular clusters per unit MV = ?15 of the galaxy) with some dependence on galaxy type. The SN of LSB galaxies is unknown, but we conservatively assume it is low, i.e. in the regime of late-type galaxies, SN~1. In our selected

galaxies (L?±0.5 mag), we expect between 50 and several 100 globular clusters. Thus, an adequate minimum number of several tens of globular clusters in each of the two broad sub-populations is met by sampling the GCLF up to a magnitude or more past the turn-over (Mg(TO)~?6.8 mag). To derive colors with the required accuracy (~0.1 mag or better, see Fig. 1), we aim at a S/N~10 at these magnitudes (Mg~?5.5 mag or g~25.0 to 26.5 given the distance of our targets).
Any general conclusions on the formation and evolution of LSB galaxies must be supported by the study of a minimum sample of massive LSB galaxies. We restrict ourselves in this study to LSB galaxies selected by their rotational velocity (measured through the 21-cm velocity width W20) to have masses roughly of the Milky Way or above. This ensures that these systems should have enough globular cluters for our analysis. The sample was further selected to span a range of total luminosities around L?, as well as about 2 magnitudes in surface brightness. Finally, we applied a distance cut-off ((m ? M)~32.5, 2500 km/s) to ensure that star clusters are still resolved in the ACS images.

ACS deep wide-field Imaging in two Colors:

ACS deep wide-field images in Sloan g (F475W) and Sloan i (F775W) will be used to investigate the globular cluster systems of LSB galaxies. The Sloan bandpasses were chosen to optimize sensitivity for globular clusters type objects and to provide a long color baseline for high sensitivity to metallicity and some sensitivity to age (e.g. the mean color difference between metal-poor [Fe/H]~?1.5 dex, and metal-rich [Fe/H]~?0.5 dex globular clusters will be (g ? i)~0.3 mag; the mean difference in magnitude between a 13 Gyr and a 4 Gyr population will be around g ~1 mag). The globular cluster identification will be performed both through colors (chosen to allow discrimination of stars and OB associations), and the fact that most globular clusters will still be barely resolved at the chosen distances. We will line dither to facilitate cosmic ray removal and increase effective spatial resolution. Our strategy, recipes and data reduction scripts

were confirmed on the large dataset of ACS Virgo globular clusters study (Jordan et al. 2004). The requirement of resolving the globular clusters sets the upper distance to our targets, which in turn defines the visual peak magnitude of the GCLF to be probed and the limiting magnitude to be reached at a S/N~10: g~26.5 and i~25.5. This goal can be reached in 1100s and 650s, respectively, according to the ACS exposure time calculator (varying by ±10% depending the star clusters age/metallicicty, i.e. spectral type). Assuming 1 target acquisition, the g-band time split into 3 dithered exposures, the i-band split into 2, we arrive at a total duration of ~52 min per galaxy, i.e. both exposures fit in 1 HST orbit (assuming our worst case: DEC 0 deg, 2-gyro mode).

Galaxy Sample Selection:

Our goal is to meet the criteria listed in the above section while selecting a representative sample of massive LSB galaxies. LSB galaxies much more luminous than L? are very rare (i.e. not typical/representative), while LSB galaxies significantly fainter than MB > ?18 mag are not expected to host significant globular cluster populations (see above). Thus, we focus here on LSB galaxies with luminosities around L?. Among these, we selected 6 galaxies as a minimum number spanning the typical ranges of surface brightness, H I mass, MHI/LB ratios found in LSB galaxies. The galaxies were selected following the above criteria from the catalogs of Bothun et al. (1985) and OÍNeil et al. (2004). Their work is largely based on the Uppsala General Catalog (UGC, Nilson 1973) which we went back to in order to select the galaxies in size and to compute the photographic surface brightness (?mpg). Absolute magnitudes (MB0) were derived with the most recent data compiled in the Nasa Extragalactic Database (NED), using the Schlegel et al. (1998) reddening maps. All galaxies were further visually inspected on Digital Sky Survey (DSS) images. The six selected galaxies are:
Name MB0 ?mpg H I W20 rad.vel.
[mag] [mag] [km/s] [km/s]

UGC 477 -19.0 26.3 246 2649
UGC 3459 -19.9 25.8 311 2475
UGC 3587 -19.0 25.5 220 1267
UGC 6138 -18.5 25.9 224 2574
UGC 11131 -19.4 24.0 206 1803
UGC 11651 -18.7 26.5 276 1525

REAL TIME JUSTIFICATION

N/A

CALIBRATION JUSTIFICATION

N/A

ADDITIONAL COMMENTS

none

Visit

Proposal 10550, Visit 01 Mon Jun 20 15:13:43 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=3 Point Spacing=0.17 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=47.2 Angle Between Sides= Center Pattern=false		(1)
(2)	Pattern Type=ACS-WFC-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=47.2 Angle Between Sides= Center Pattern=false		(2)

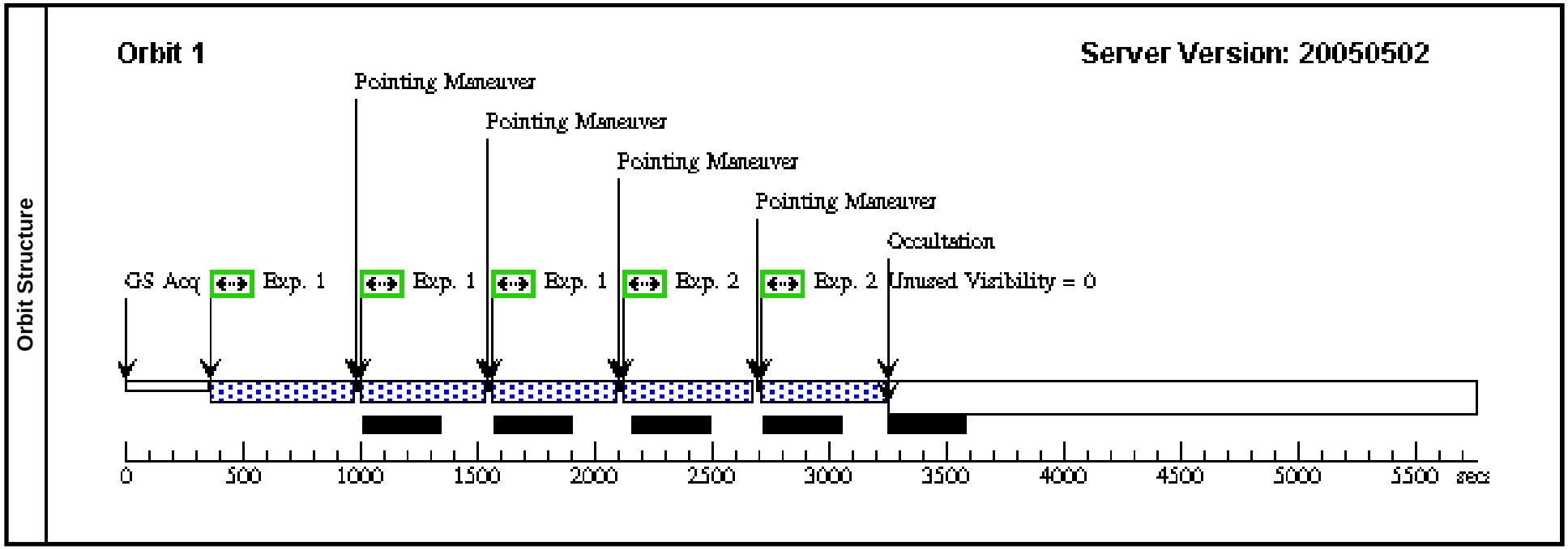
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	UGC-00477	RA: 00 46 13.1000 (11.5545833d) Dec: +19 29 24.00 (19.49000d) Equinox: J2000 Plate Id: (?)		V=13.4	Coordinate Source: 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		(1) UGC-00477	ACS/WFC, ACCUM, WFC	F475W	CR-SPLIT=NO		Pattern 1-1 (1)	404.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]*	***[1]***
2		(1) UGC-00477	ACS/WFC, ACCUM, WFC	F775W	CR-SPLIT=NO		Pattern 2-2 (2)	405.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]*	***[1]***


Orbit Structure
Orbit 1
Server Version: 20050502
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Occultation
GS Acq
Exp. 1
Exp. 1
Exp. 1
Exp. 2
Exp. 2
Unused Visibility = 0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs

Visit

Proposal 10550, Visit 02 Mon Jun 20 15:13:44 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=3 Point Spacing=0.17 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=47.2 Angle Between Sides= Center Pattern=false		(1)
(2)	Pattern Type=ACS-WFC-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=47.2 Angle Between Sides= Center Pattern=false		(2)

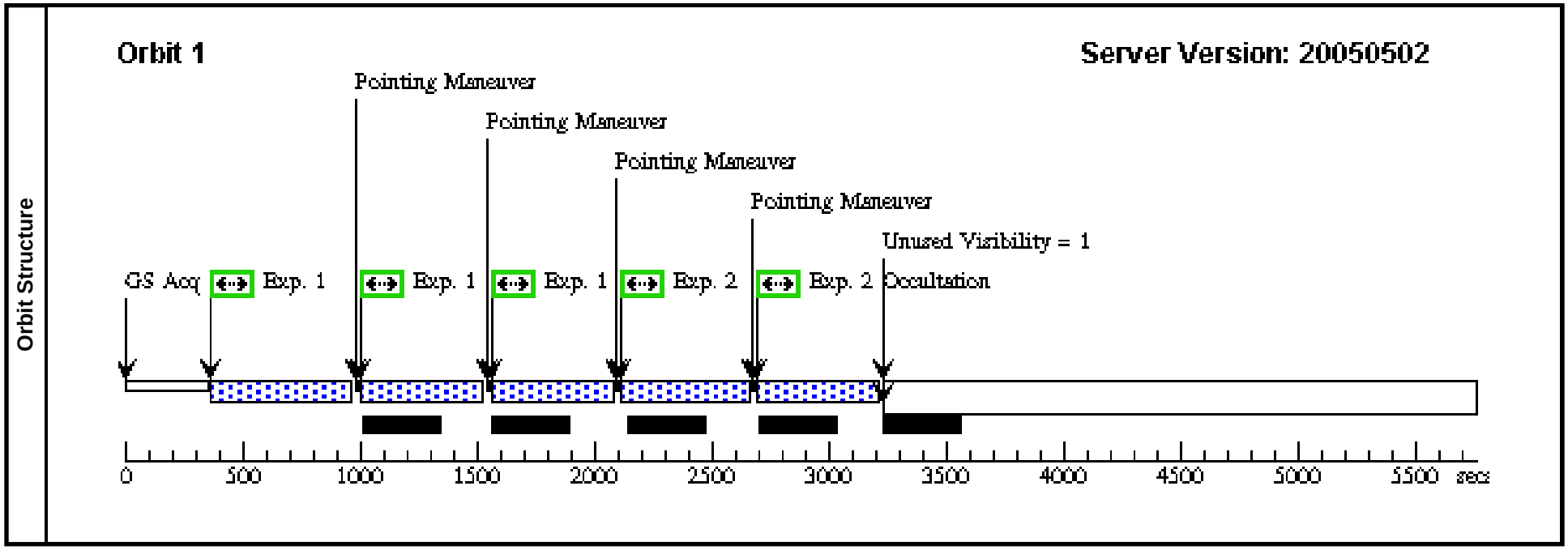
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	UGC-03459	RA: 06 23 59.9000 (95.9995833d) Dec: +04 42 39.00 (4.71083d) Equinox: J2000 Plate Id: (?)		V=12.9	Coordinate Source: 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		(2) UGC-03459	ACS/WFC, ACCUM, WFC	F475W	CR-SPLIT=NO		Pattern 1-1 (1)	400.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]*	***[1]***
2		(2) UGC-03459	ACS/WFC, ACCUM, WFC	F775W	CR-SPLIT=NO		Pattern 2-2 (2)	400.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]*	***[1]***


Orbit Structure
Orbit 1
Server Version: 20050502
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Unused Visibility = 1
GS Acq
Exp. 1
Exp. 1
Exp. 1
Exp. 2
Exp. 2
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs

Visit

Proposal 10550, Visit 03 Mon Jun 20 15:13:45 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=3 Point Spacing=0.17 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=47.2 Angle Between Sides= Center Pattern=false		(1)
(2)	Pattern Type=ACS-WFC-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=47.2 Angle Between Sides= Center Pattern=false		(2)

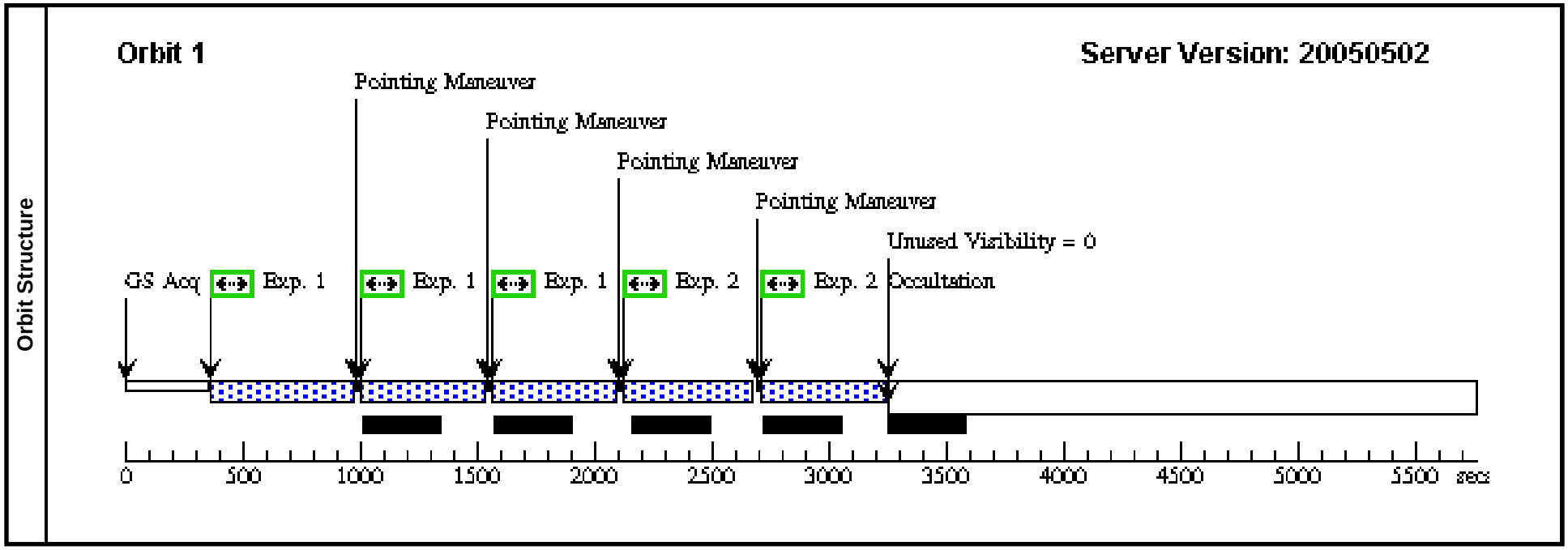
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(3)	UGC-03587	RA: 06 53 54.8000 (103.4783333d) Dec: +19 17 59.00 (19.29972d) Equinox: J2000 Plate Id: (?)		V=12.3	Coordinate Source: 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		(3) UGC-03587	ACS/WFC, ACCUM, WFC	F475W	CR-SPLIT=NO		Pattern 1-1 (1)	404.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]*	***[1]***
2		(3) UGC-03587	ACS/WFC, ACCUM, WFC	F775W	CR-SPLIT=NO		Pattern 2-2 (2)	405.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]*	***[1]***


Orbit Structure
Orbit 1
Server Version: 20050502
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Unused Visibility = 0
GS Acq
Exp. 1
Exp. 1
Exp. 1
Exp. 2
Exp. 2
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs

Visit

Proposal 10550, Visit 04 Mon Jun 20 15:13:46 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=3 Point Spacing=0.17 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=47.2 Angle Between Sides= Center Pattern=false		(1)
(2)	Pattern Type=ACS-WFC-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=47.2 Angle Between Sides= Center Pattern=false		(2)

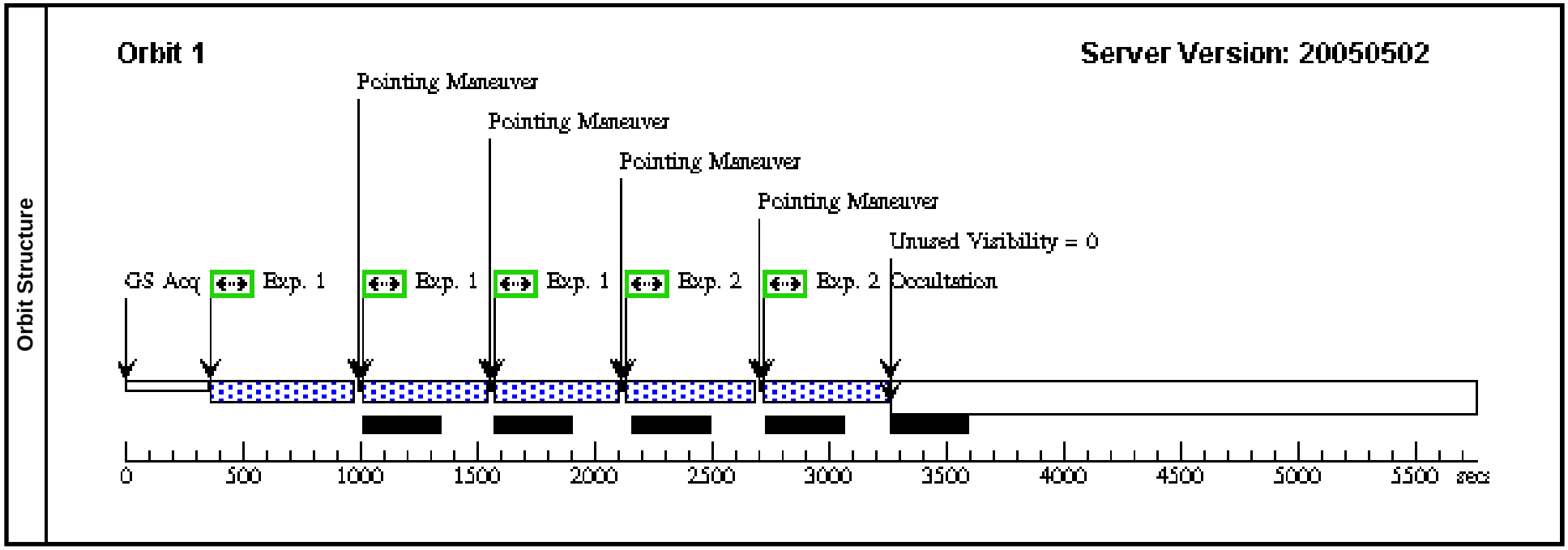
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(4)	UGC-06138	RA: 11 04 39.7000 (166.1654167d) Dec: +27 43 26.00 (27.72389d) Equinox: J2000 Plate Id: (?)		V=14.1	Coordinate Source: 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		(4) UGC-06138	ACS/WFC, ACCUM, WFC	F475W	CR-SPLIT=NO		Pattern 1-1 (1)	406.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]*	***[1]***
2		(4) UGC-06138	ACS/WFC, ACCUM, WFC	F775W	CR-SPLIT=NO		Pattern 2-2 (2)	407.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]*	***[1]***


Orbit Structure
Orbit 1
Server Version: 20050502
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Unused Visibility = 0
GS Acq
Exp. 1
Exp. 1
Exp. 1
Exp. 2
Exp. 2
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs

Visit

Proposal 10550, Visit 05 Mon Jun 20 15:13:47 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=3 Point Spacing=0.17 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=47.2 Angle Between Sides= Center Pattern=false		(1)
(2)	Pattern Type=ACS-WFC-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=47.2 Angle Between Sides= Center Pattern=false		(2)

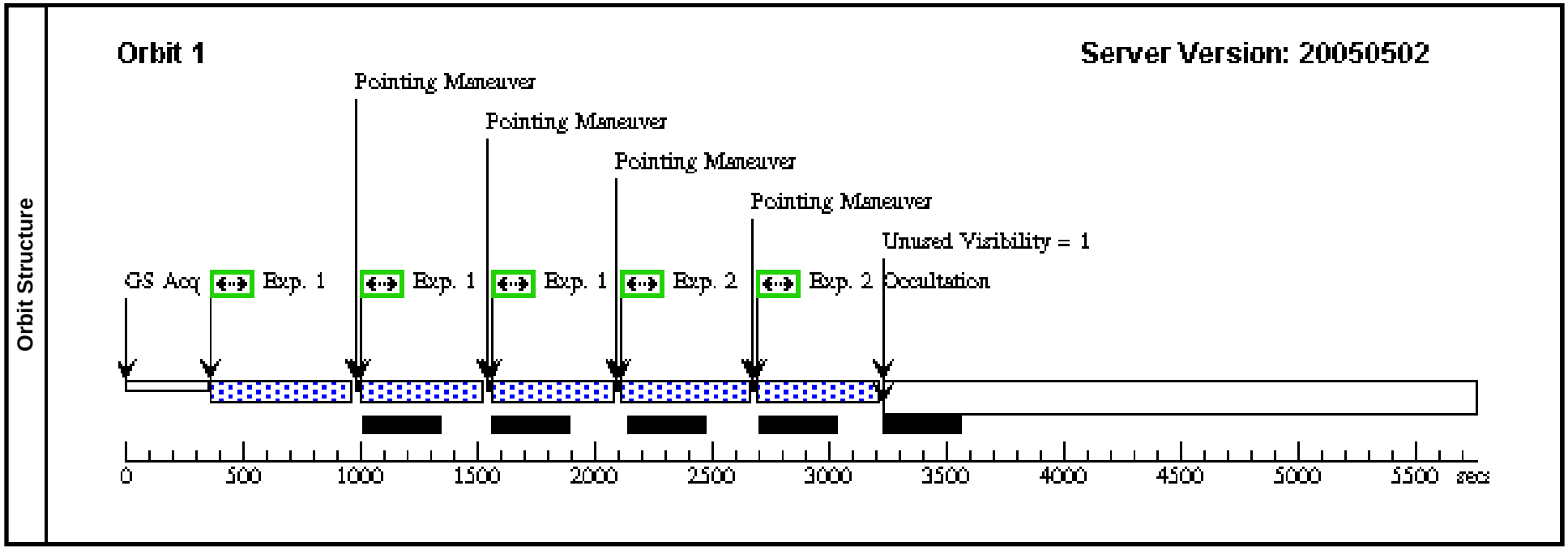
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(5)	UGC-11131	RA: 18 10 22.6000 (272.5941667d) Dec: +01 35 33.00 (1.59250d) Equinox: J2000 Plate Id: (?)		V=12.5	Coordinate Source: 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		(5) UGC-11131	ACS/WFC, ACCUM, WFC	F475W	CR-SPLIT=NO		Pattern 1-1 (1)	400.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]*	***[1]***
2		(5) UGC-11131	ACS/WFC, ACCUM, WFC	F775W	CR-SPLIT=NO		Pattern 2-2 (2)	400.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]*	***[1]***


Orbit Structure
Orbit 1
Server Version: 20050502
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Unused Visibility = 1
GS Acq
Exp. 1
Exp. 1
Exp. 1
Exp. 2
Exp. 2
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs

Visit

Proposal 10550, Visit 06 Mon Jun 20 15:13:48 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=3 Point Spacing=0.17 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=47.2 Angle Between Sides= Center Pattern=false		(1)
(2)	Pattern Type=ACS-WFC-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=47.2 Angle Between Sides= Center Pattern=false		(2)

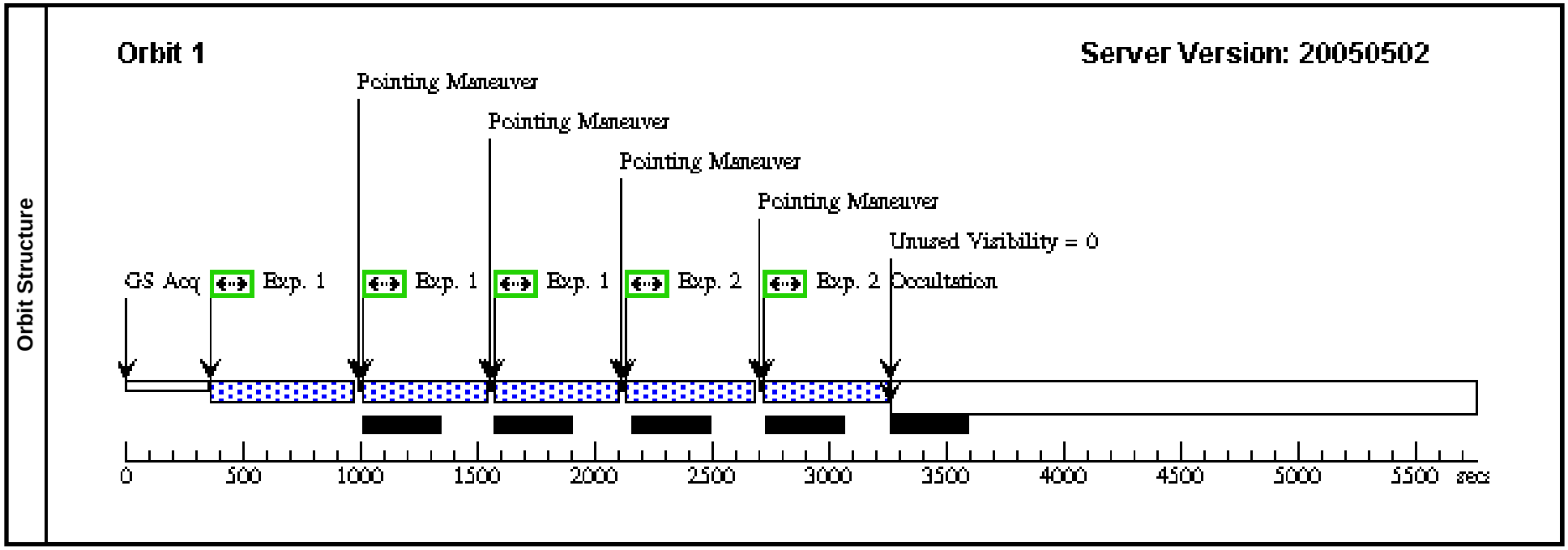
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(6)	UGC-11651	RA: 20 57 15.4000 (314.3141667d) Dec: +25 57 53.00 (25.96472d) Equinox: J2000 Plate Id: (?)		V=12.8	Coordinate Source: 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		(6) UGC-11651	ACS/WFC, ACCUM, WFC	F475W	CR-SPLIT=NO		Pattern 1-1 (1)	406.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]*	***[1]***
2		(6) UGC-11651	ACS/WFC, ACCUM, WFC	F775W	CR-SPLIT=NO		Pattern 2-2 (2)	407.0 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]*	***[1]***


Orbit Structure
Orbit 1
Server Version: 20050502
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Unused Visibility = 0
GS Acq
Exp. 1
Exp. 1
Exp. 1
Exp. 2
Exp. 2
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs