12989 - The Ultraviolet View of Globular Clusters in the Giant Elliptical M87

Cycle: 20, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

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VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) M87	ACS/WFC WFC3/UVIS	2	18-Jul-2012 22:19:46.0	yes
02	(1) M87	ACS/WFC WFC3/UVIS	2	18-Jul-2012 22:19:58.0	yes
03	(1) M87	ACS/WFC WFC3/UVIS	2	18-Jul-2012 22:20:09.0	yes

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
04	(1) M87	ACS/WFC WFC3/UVIS	2	18-Jul-2012 22:20:18.0	yes
05	(1) M87	ACS/WFC WFC3/UVIS	2	18-Jul-2012 22:20:28.0	yes

10 Total Orbits Used

ABSTRACT

With a single WFC3/UVIS pointing, we propose to obtain UV photometry for over 600 globular clusters in M87, the massive cD galaxy hosting ~10,000 globulars at the center of Virgo. When combined with deep archival ACS optical photometry of the same field, we will be able to characterize the contribution of hot horizontal branch stars to the integrated light of these clusters. In the Milky Way, these evolved stars are prevalent in those globular clusters that host complex stellar populations, because both phenomena are symptoms of sub-populations which are highly enriched in helium. The discovery of multiple populations in Galactic globular clusters, driven by the photometric accuracy of HST, has revolutionized globular cluster research, in particular concerning their very formation in the early Universe that must have been a much more complex phenomenon than ever imagined before. This large, fully representative sample of globular clusters with UV-to-optical photometry will reveal to what extent globular cluster formation has proceeded in a distinct fashion in a giant elliptical environment, in particular with respect to the multiple population phenomenon.

OBSERVING DESCRIPTION

Our observations are extremely straightforward. We will obtain 10 orbits of WFC3/UVIS F275W imaging, with two exposures per orbit. Although shorter exposures would reduce the number of cosmic rays that must be masked per exposure, our image stack will provide excellent cosmic-ray masking, and shorter exposures suffer from two problems in the UV, where the sky background is low. First, co-adding a larger number of short exposures would increase the effective readout noise of the image stack – a significant impact on the faint limit in the low sky regime. Second, charge transfer inefficiency (CTI) is worse at low background levels and worse for faint sources, so it is preferable to allocate the source and sky counts over fewer images. Even though WFC3/UVIS is the newest camera on HST, it is apparently suffering from somewhat accelerated radiation damage, compared to earlier instruments. Fortunately, our team is well-equipped to address WFC3 instrument issues. J. Anderson has been working with the WFC3 team to characterize CTI losses and to construct a pixel-based correction for it, similar to the correction that he and L. Bedin developed for ACS.

Each exposure will have its own unique but small dither, such that no GC is placed on the same pixel twice, enabling resampling of the point spread function, and also providing mitigation of cosmic rays and detector artifacts (e.g., hot pixels and dead pixels). The flat- field correction is more complex and uncertain at shorter wavelengths, so the large number of dithers will average out residual errors in the flats. Although all of the exposures will execute at the same orientation (to maximize the area covered at full depth), the particular orientation is unconstrained, to maximize schedulability.

We have estimated the total integration time required by inspecting the extant NUV data for 16 M87 GCs (Sohn et al. 2006). These GCs were observed with the NUV/F25QTZ bandpass on STIS, which overlaps significantly with the UVIS/F275W bandpass on WFC3, allowing a secure prediction of the WFC3 countrates. The Sohn et al. clusters are as faint as mSTIS/NUV = 25 STMAG, and we want to obtain WFC3 photometry of these clusters at a SNR of at least 10. We assumed a hot (Teff = 28,000 K) spectrum and normalized it to mSTIS/NUV = 25 STMAG, and then calculated the required exposure time in the WFC3 ETC, with iterations to ensure that the number of readouts was consistent with two exposures per orbit. Given the fact that the GCs in M87 are not quite point sources, we conservatively calculate the SNR within a 6 pixel radius, and find that a SNR of 10 can be reached with 30,000 s (10 orbits) and 20 exposures. Note that for a given mSTIS/NUV magnitude, there is only weak dependence on the assumed spectral energy distribution (i.e., our faint limit is not significantly changed if we assume a different Teff over 20,000 K).

Our estimate of the expected GC sample size in M87 is straightforward. The STIS/NUV imaging in the center of M87 found 16 GCs in an area of 625 square arcsec. Our WFC3/UVIS pointing covers an area 40× larger to the same depth as the STIS/NUV imaging. Although the underlying light of the galaxy is sharply peaked toward the center, the ACS optical images demonstrate that the spatial distribution of GCs over the WFC3/UVIS area is fairly uniform, such that we expect at least 600 M87 GCs to be detected in the near-UV (F275W).

Visit

Proposal 12989, Visit 01, implementation Thu Jul 19 02:20:36 GMT 2012

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS, ACS/WFC

Special Requirements: ORIENT 300D TO 300 D

Diagnostics

(Visit 01) Warning (Form): The 'SCHED=100' special requirement must be selected for this visit.

(Primary Exposure 1 (Prime + Parallel Group 1-2 in Visit 01)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

(Primary Exposure 3 (Prime + Parallel Group 3-4 in Visit 01)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

(Primary Exposure 5 (Prime + Parallel Group 5-6 in Visit 01)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

(Primary Exposure 7 (Prime + Parallel Group 7-8 in Visit 01)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

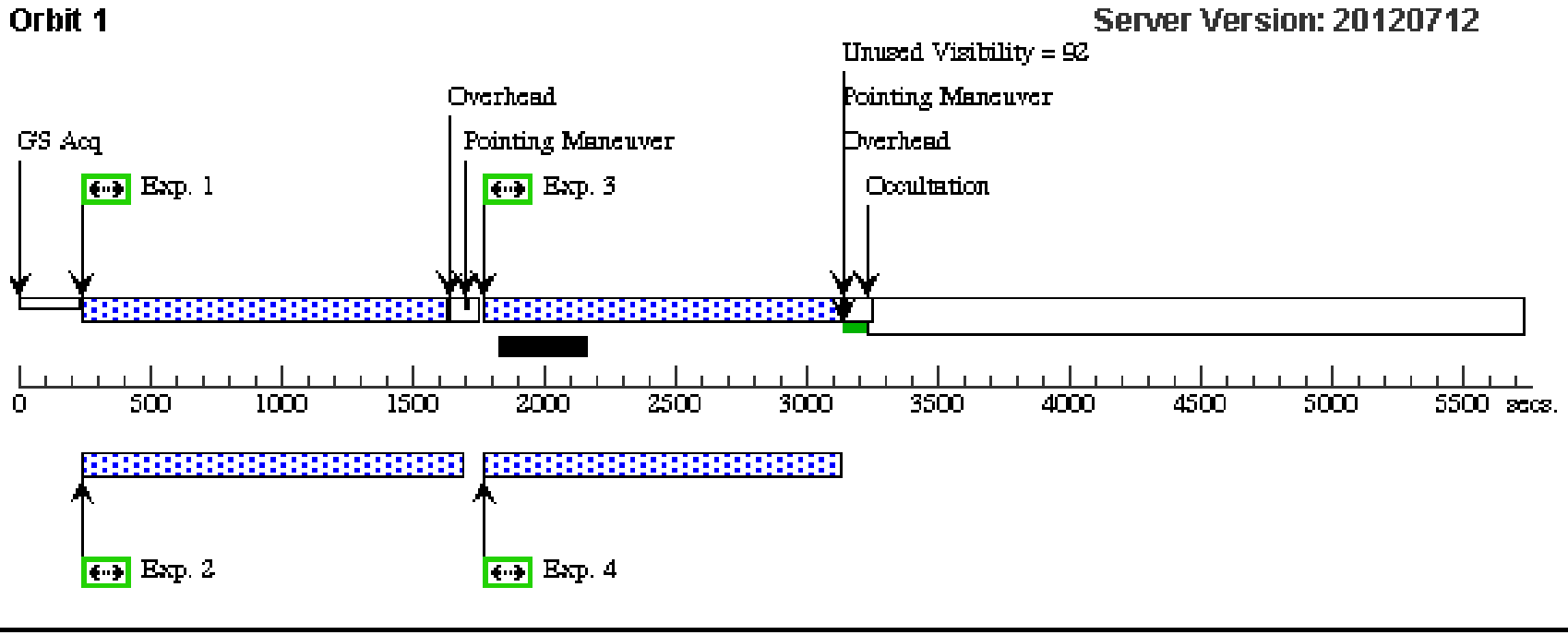
Fixed Targets

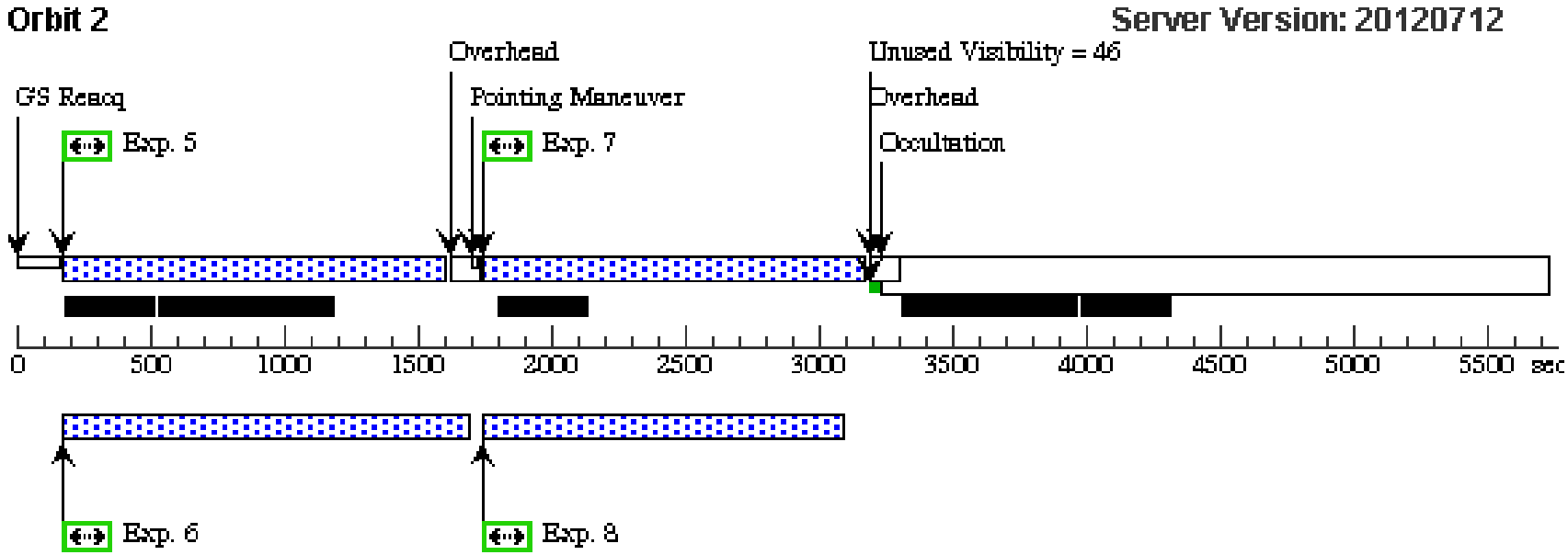
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	M87	RA: 12 30 49.4000 (187.7058333d) Dec: +12 23 28.00 (12.39111d) Equinox: J2000		V=23.0 +/-1	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG -12.40, 2.48; GS ACQ SCENARIO ONEB1B	Prime + Parallel Group 1-2 in Visit 01	1364 Secs *[==>]*	 ***[1]***
2		(1) M87	ACS/WFC, ACCUM, WFCENTER	F606W	CR-SPLIT=NO		Prime + Parallel Group 1-2 in Visit 01	1240 Secs *[==>]*	 ***[1]***
3		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG -11.16,-3.72	Prime + Parallel Group 3-4 in Visit 01	1364 Secs *[==>]*	 ***[1]***
4		(1) M87	ACS/WFC, ACCUM, WFCENTER	F814W	CR-SPLIT=NO		Prime + Parallel Group 3-4 in Visit 01	1180 Secs *[==>]*	 ***[1]***
5		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG -9.92,-9.92	Prime + Parallel Group 5-6 in Visit 01	1436 Secs *[==>]*	 ***[2]***
6		(1) M87	ACS/WFC, ACCUM, WFCENTER	F814W	CR-SPLIT=NO		Prime + Parallel Group 5-6 in Visit 01	1392 Secs *[==>]*	 ***[2]***
7		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG -7.44,7.44	Prime + Parallel Group 7-8 in Visit 01	1435 Secs *[==>]*	 ***[2]***
8		(1) M87	ACS/WFC, ACCUM, WFCENTER	F606W	CR-SPLIT=NO		Prime + Parallel Group 7-8 in Visit 01	1170 Secs *[==>]*	 ***[2]***

Orbit Structure





Visit

Proposal 12989, Visit 02, implementation Thu Jul 19 02:20:39 GMT 2012

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS, ACS/WFC

Special Requirements: SAME ORIENT AS 01

Diagnostics

(Visit 02) Warning (Form): The 'SCHED=100' special requirement must be selected for this visit.

(Primary Exposure 1 (Prime + Parallel Group 1-2 in Visit 02)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

(Primary Exposure 3 (Prime + Parallel Group 3-4 in Visit 02)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

(Primary Exposure 5 (Prime + Parallel Group 5-6 in Visit 02)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

(Primary Exposure 7 (Prime + Parallel Group 7-8 in Visit 02)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

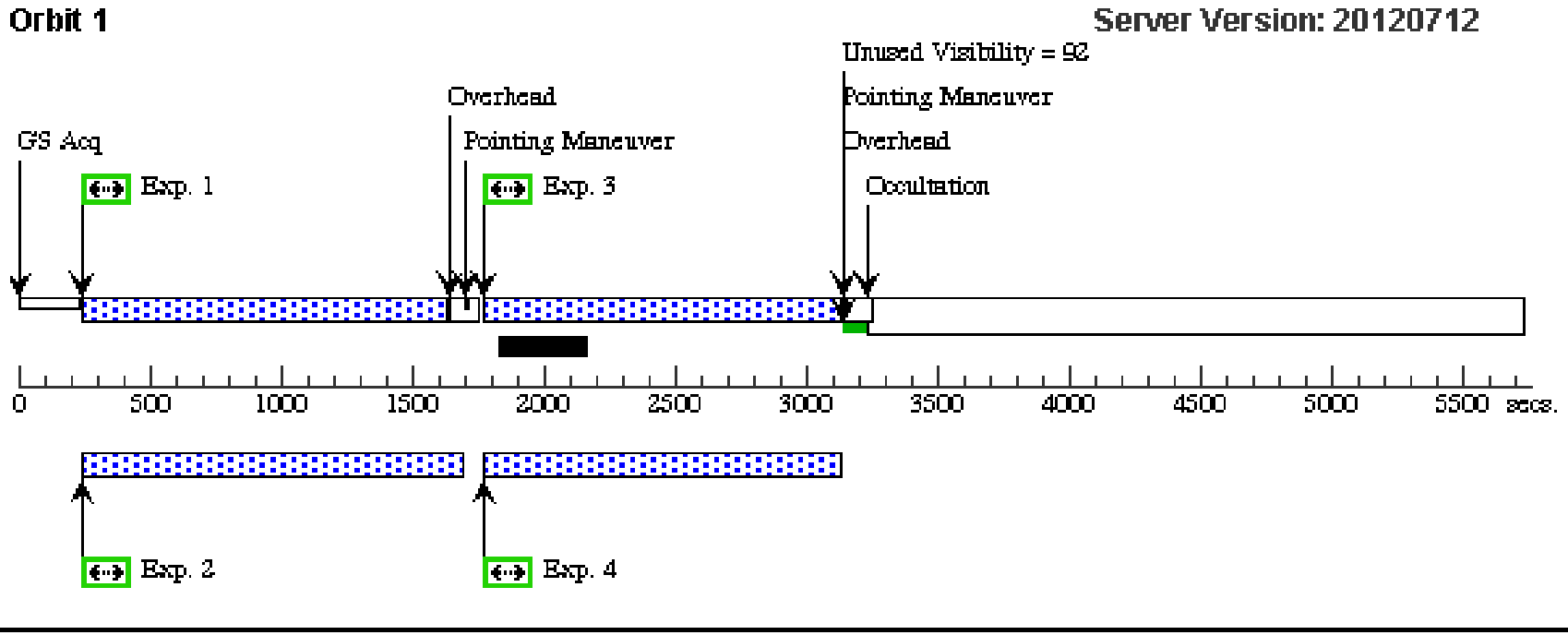
Fixed Targets

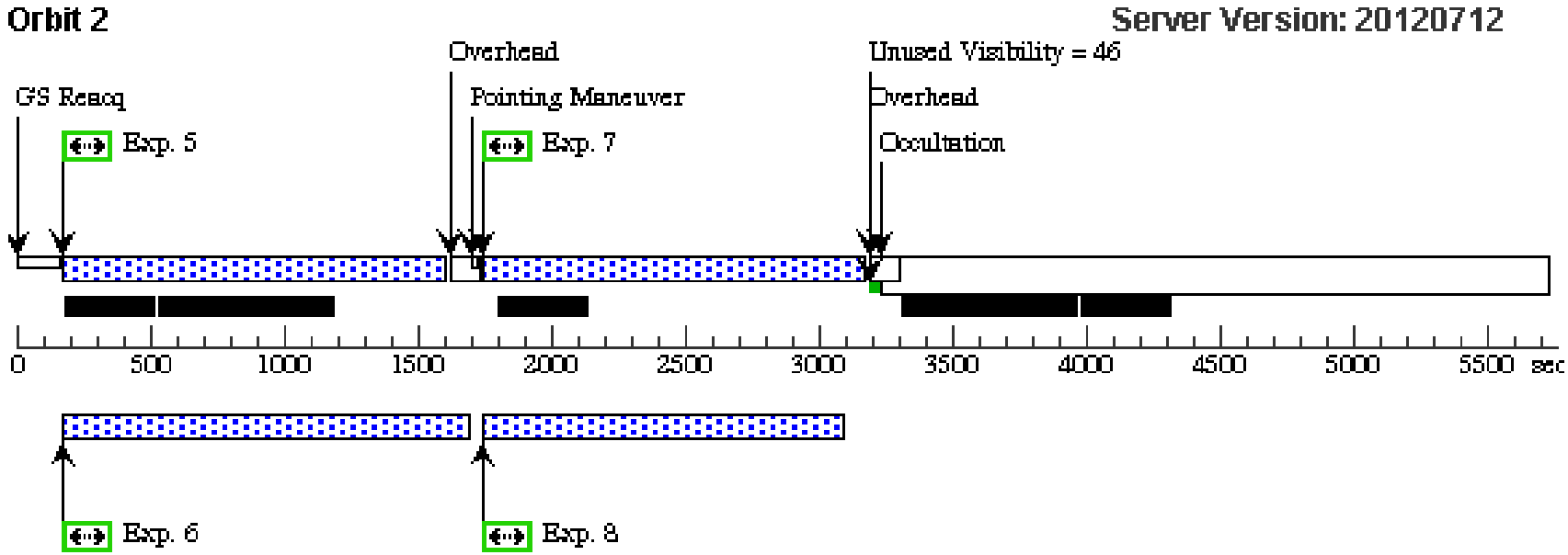
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	M87	RA: 12 30 49.4000 (187.7058333d) Dec: +12 23 28.00 (12.39111d) Equinox: J2000		V=23.0 +/-1	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG -6.20,1.24; GS ACQ SCENARIO ONEB1B	Prime + Parallel Group 1-2 in Visit 02	1364 Secs *[==>]*	 ***[1]***
2		(1) M87	ACS/WFC, ACCUM, WFCENTER	F606W	CR-SPLIT=NO		Prime + Parallel Group 1-2 in Visit 02	1240 Secs *[==>]*	 ***[1]***
3		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG -4.96,-4.96	Prime + Parallel Group 3-4 in Visit 02	1364 Secs *[==>]*	 ***[1]***
4		(1) M87	ACS/WFC, ACCUM, WFCENTER	F814W	CR-SPLIT=NO		Prime + Parallel Group 3-4 in Visit 02	1180 Secs *[==>]*	 ***[1]***
5		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG -3.72,-11.16	Prime + Parallel Group 5-6 in Visit 02	1436 Secs *[==>]*	 ***[2]***
6		(1) M87	ACS/WFC, ACCUM, WFCENTER	F814W	CR-SPLIT=NO		Prime + Parallel Group 5-6 in Visit 02	1392 Secs *[==>]*	 ***[2]***
7		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG -2.48,12.40	Prime + Parallel Group 7-8 in Visit 02	1435 Secs *[==>]*	 ***[2]***
8		(1) M87	ACS/WFC, ACCUM, WFCENTER	F606W	CR-SPLIT=NO		Prime + Parallel Group 7-8 in Visit 02	1170 Secs *[==>]*	 ***[2]***

Orbit Structure





Visit

Proposal 12989, Visit 03, implementation Thu Jul 19 02:20:43 GMT 2012

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS, ACS/WFC

Special Requirements: SAME ORIENT AS 01

Diagnostics

(Visit 03) Warning (Form): The 'SCHED=100' special requirement must be selected for this visit.

(Primary Exposure 1 (Prime + Parallel Group 1-2 in Visit 03)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

(Primary Exposure 3 (Prime + Parallel Group 3-4 in Visit 03)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

(Primary Exposure 5 (Prime + Parallel Group 5-6 in Visit 03)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

(Primary Exposure 7 (Prime + Parallel Group 7-8 in Visit 03)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

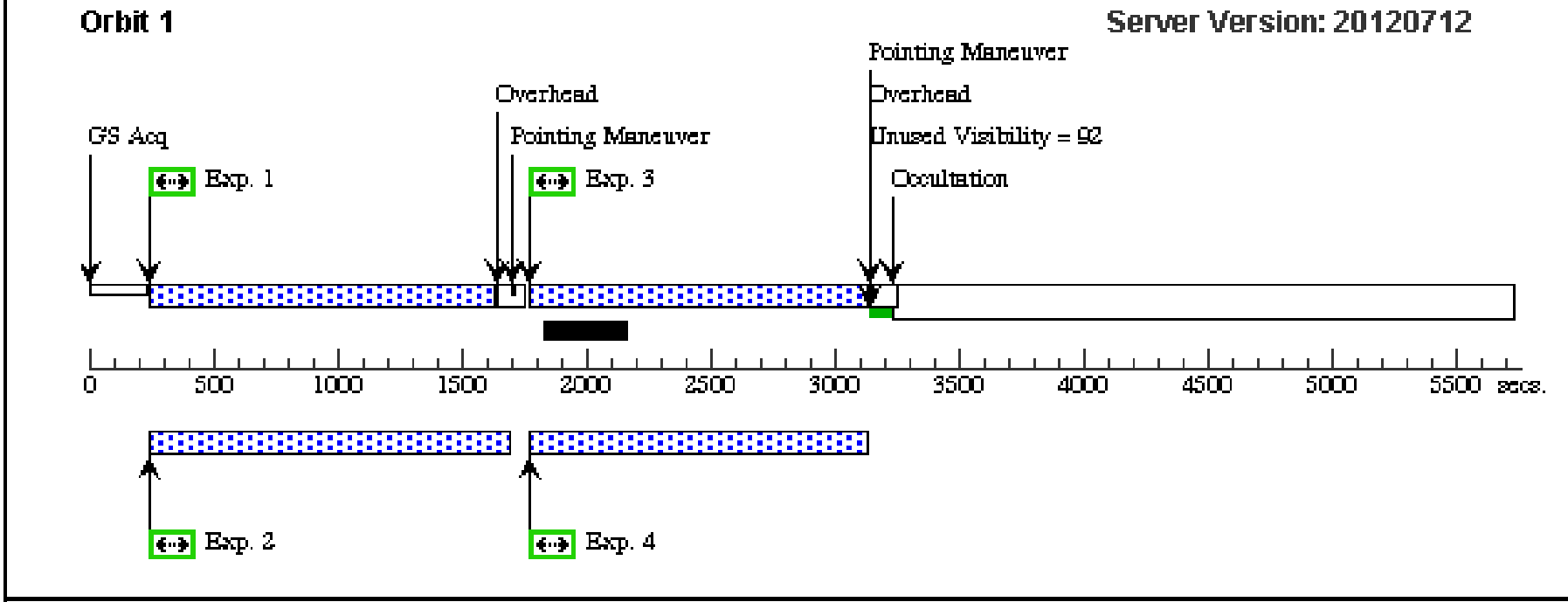
Fixed Targets

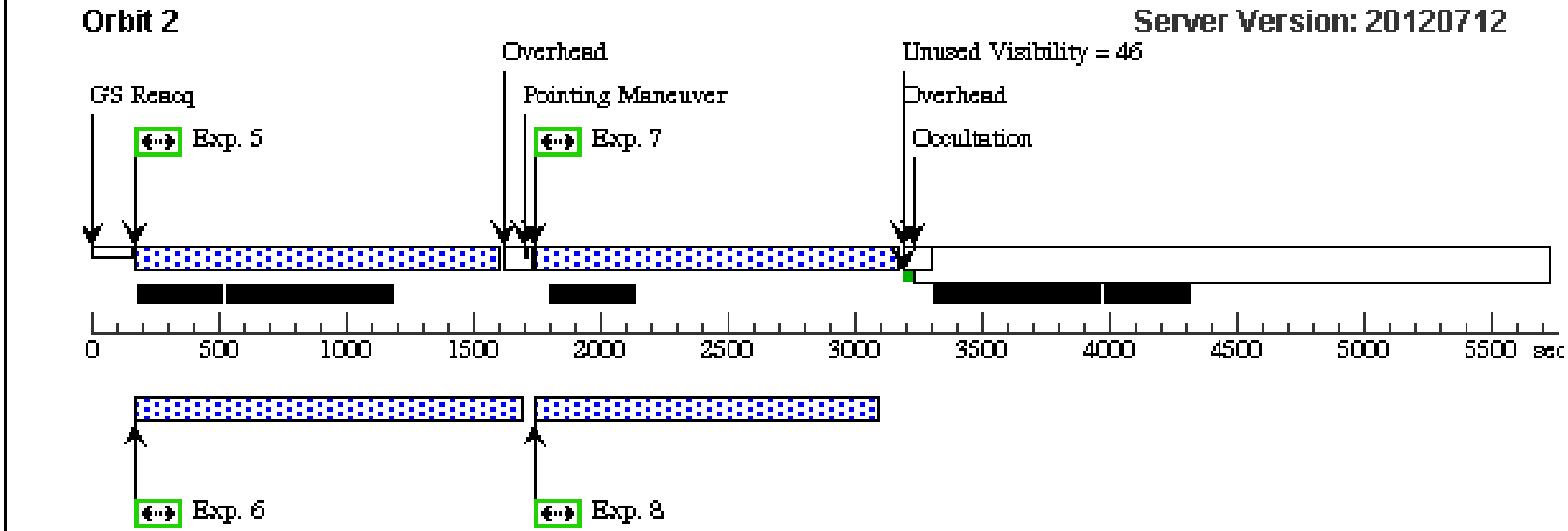
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	M87	RA: 12 30 49.4000 (187.7058333d) Dec: +12 23 28.00 (12.39111d) Equinox: J2000		V=23.0 +/-1	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG -1.24,6.2; GS ACQ SCENARIO ONEB1B	Prime + Parallel Group 1-2 in Visit 03	1364 Secs *[==>]*	 ***[1]***
2		(1) M87	ACS/WFC, ACCUM, WFCENTER	F606W	CR-SPLIT=NO		Prime + Parallel Group 1-2 in Visit 03	1240 Secs *[==>]*	 ***[1]***
3		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG 0.00,0.00	Prime + Parallel Group 3-4 in Visit 03	1364 Secs *[==>]*	 ***[1]***
4		(1) M87	ACS/WFC, ACCUM, WFCENTER	F814W	CR-SPLIT=NO		Prime + Parallel Group 3-4 in Visit 03	1180 Secs *[==>]*	 ***[1]***
5		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG 1.24,-6.20	Prime + Parallel Group 5-6 in Visit 03	1436 Secs *[==>]*	 ***[2]***
6		(1) M87	ACS/WFC, ACCUM, WFCENTER	F814W	CR-SPLIT=NO		Prime + Parallel Group 5-6 in Visit 03	1392 Secs *[==>]*	 ***[2]***
7		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG 2.48,-12.40	Prime + Parallel Group 7-8 in Visit 03	1435 Secs *[==>]*	 ***[2]***
8		(1) M87	ACS/WFC, ACCUM, WFCENTER	F606W	CR-SPLIT=NO		Prime + Parallel Group 7-8 in Visit 03	1170 Secs *[==>]*	 ***[2]***

Orbit Structure





Visit

Proposal 12989, Visit 04, implementation Thu Jul 19 02:20:45 GMT 2012

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS, ACS/WFC

Special Requirements: SAME ORIENT AS 01

Diagnostics

(Visit 04) Warning (Form): The 'SCHED=100' special requirement must be selected for this visit.

(Primary Exposure 1 (Prime + Parallel Group 1-2 in Visit 04)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

(Primary Exposure 3 (Prime + Parallel Group 3-4 in Visit 04)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

(Primary Exposure 5 (Prime + Parallel Group 5-6 in Visit 04)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

(Primary Exposure 7 (Prime + Parallel Group 7-8 in Visit 04)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

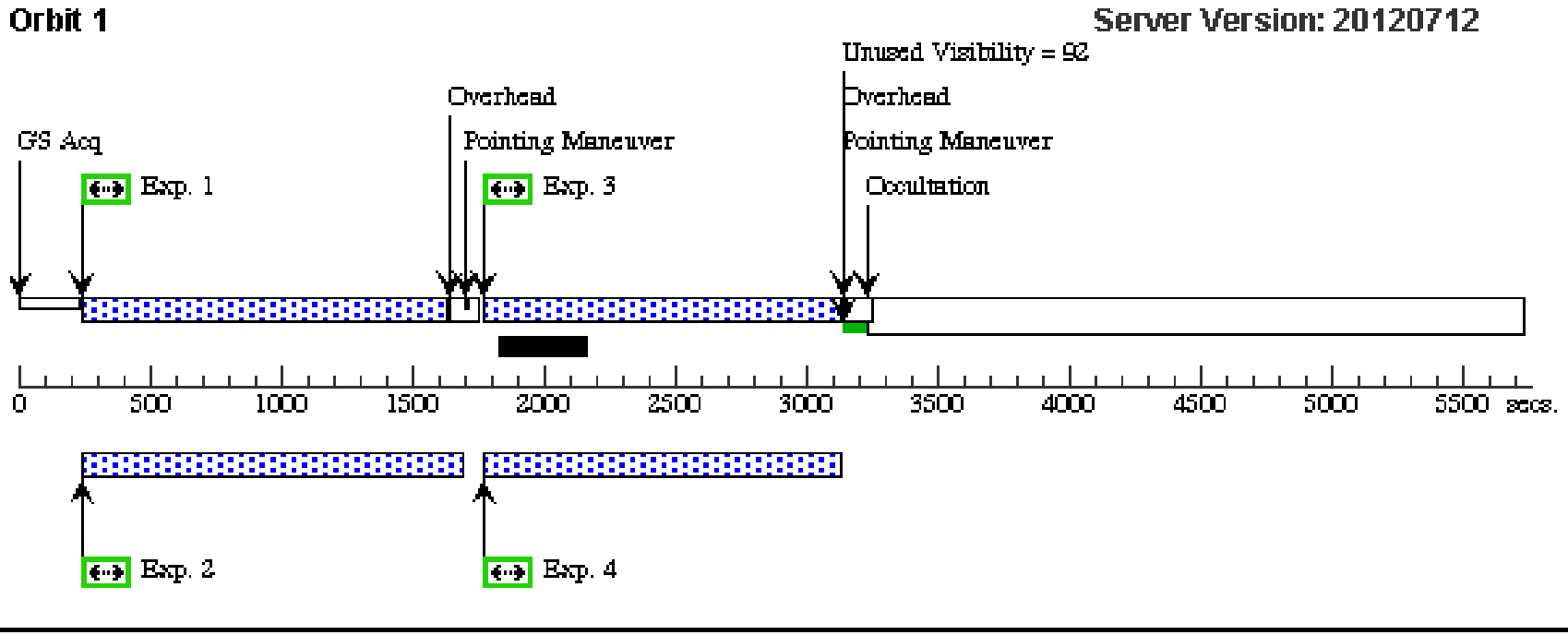
Fixed Targets

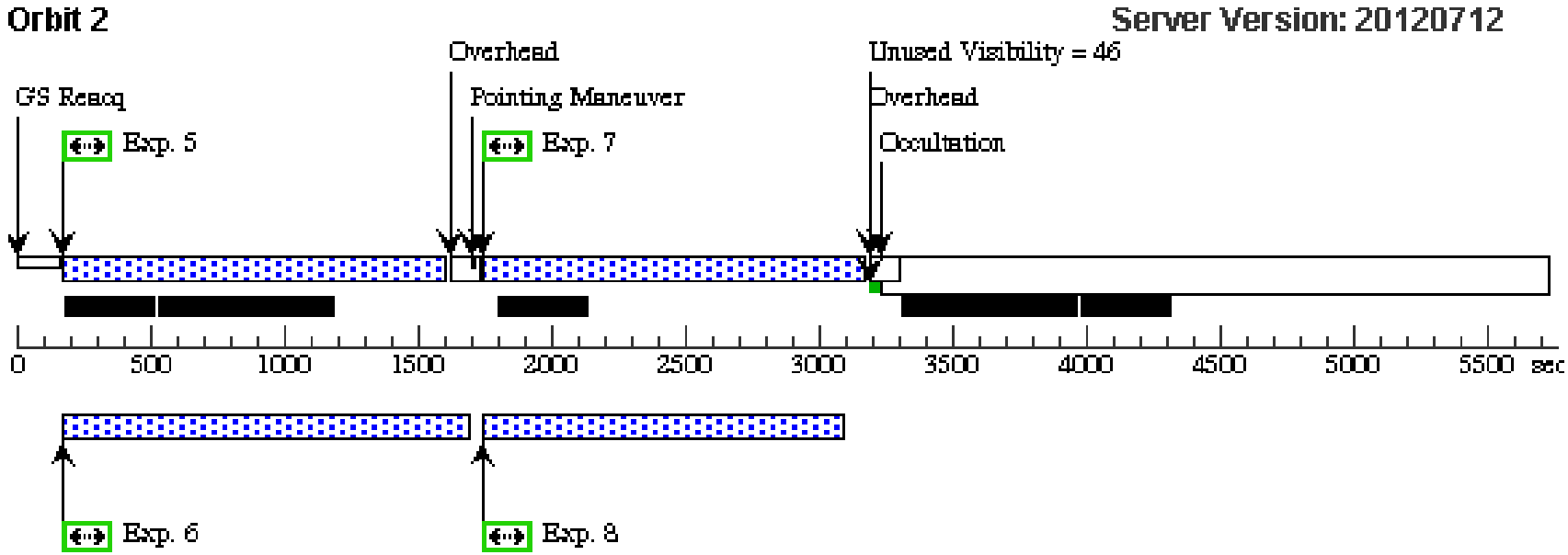
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	M87	RA: 12 30 49.4000 (187.7058333d) Dec: +12 23 28.00 (12.39111d) Equinox: J2000		V=23.0 +/-1	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG 3.72,11.16; GS ACQ SCENARIO ONEB1B	Prime + Parallel Group 1-2 in Visit 04	1364 Secs *[==>]*	 ***[1]***
2		(1) M87	ACS/WFC, ACCUM, WFCENTER	F606W	CR-SPLIT=NO		Prime + Parallel Group 1-2 in Visit 04	1240 Secs *[==>]*	 ***[1]***
3		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG 4.96,4.96	Prime + Parallel Group 3-4 in Visit 04	1364 Secs *[==>]*	 ***[1]***
4		(1) M87	ACS/WFC, ACCUM, WFCENTER	F814W	CR-SPLIT=NO		Prime + Parallel Group 3-4 in Visit 04	1180 Secs *[==>]*	 ***[1]***
5		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG 6.20,-1.24	Prime + Parallel Group 5-6 in Visit 04	1436 Secs *[==>]*	 ***[2]***
6		(1) M87	ACS/WFC, ACCUM, WFCENTER	F814W	CR-SPLIT=NO		Prime + Parallel Group 5-6 in Visit 04	1392 Secs *[==>]*	 ***[2]***
7		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG 7.44,-7.44	Prime + Parallel Group 7-8 in Visit 04	1435 Secs *[==>]*	 ***[2]***
8		(1) M87	ACS/WFC, ACCUM, WFCENTER	F606W	CR-SPLIT=NO		Prime + Parallel Group 7-8 in Visit 04	1170 Secs *[==>]*	 ***[2]***

Orbit Structure





Visit

Proposal 12989, Visit 05, implementation Thu Jul 19 02:20:47 GMT 2012

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS, ACS/WFC

Special Requirements: SAME ORIENT AS 01

Diagnostics

(Visit 05) Warning (Form): The 'SCHED=100' special requirement must be selected for this visit.

(Primary Exposure 1 (Prime + Parallel Group 1-2 in Visit 05)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

(Primary Exposure 3 (Prime + Parallel Group 3-4 in Visit 05)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

(Primary Exposure 5 (Prime + Parallel Group 5-6 in Visit 05)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

(Primary Exposure 7 (Prime + Parallel Group 7-8 in Visit 05)) Warning (Form): Light from the flash may escape from WFC3 and possibly contaminate exposures in other SIs.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	M87	RA: 12 30 49.4000 (187.7058333d) Dec: +12 23 28.00 (12.39111d) Equinox: J2000		V=23.0 +/-1	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG 9.920,9.920; GS ACQ SCENARIO ONEB1B	Prime + Parallel Group 1-2 in Visit 05	1364 Secs *[==>]*	 ***[1]***
2		(1) M87	ACS/WFC, ACCUM, WFCENTER	F606W	CR-SPLIT=NO		Prime + Parallel Group 1-2 in Visit 05	1240 Secs *[==>]*	 ***[1]***
3		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG 11.16,3.72	Prime + Parallel Group 3-4 in Visit 05	1364 Secs *[==>]*	 ***[1]***
4		(1) M87	ACS/WFC, ACCUM, WFCENTER	F814W	CR-SPLIT=NO		Prime + Parallel Group 3-4 in Visit 05	1180 Secs *[==>]*	 ***[1]***
5		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG 12.40,-2.48	Prime + Parallel Group 5-6 in Visit 05	1436 Secs *[==>]*	 ***[2]***
6		(1) M87	ACS/WFC, ACCUM, WFCENTER	F814W	CR-SPLIT=NO		Prime + Parallel Group 5-6 in Visit 05	1392 Secs *[==>]*	 ***[2]***
7		(1) M87	WFC3/UVIS, ACCUM, UVIS-CENTER	F275W	CR-SPLIT=NO; FLASH=8	POS TARG 0.10,0.10	Prime + Parallel Group 7-8 in Visit 05	1435 Secs *[==>]*	 ***[2]***
8		(1) M87	ACS/WFC, ACCUM, WFCENTER	F606W	CR-SPLIT=NO		Prime + Parallel Group 7-8 in Visit 05	1170 Secs *[==>]*	 ***[2]***

Orbit Structure