14872 - A Hidden Potential Counterimage of a Highly Magnified Star at Redshift z=1.49

Cycle: 24, Proposal Category: GO/DD

(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) POSSIBLESTARCOUNTERIMAGE	ACS/WFC	1	11-Jan-2017 21:05:28.0	yes
02	(1) POSSIBLESTARCOUNTERIMAGE	WFC3/IR	1	11-Jan-2017 21:05:29.0	yes
03	(1) POSSIBLESTARCOUNTERIMAGE	ACS/WFC	1	11-Jan-2017 21:05:31.0	yes
04	(1) POSSIBLESTARCOUNTERIMAGE	WFC3/IR	1	11-Jan-2017 21:05:31.0	yes
07	(1) POSSIBLESTARCOUNTERIMAGE	WFC3/IR WFC3/UVIS	1	11-Jan-2017 21:05:32.0	yes
09	(1) POSSIBLESTARCOUNTERIMAGE	WFC3/IR WFC3/UVIS	1	11-Jan-2017 21:05:34.0	yes

6 Total Orbits Used

ABSTRACT

An individual, highly magnified star close to a cluster caustic should provide a unique new window on the composition of dark matter. In late April 2016, we detected a brightening source (named "Icarus") near (<0.1 arcsec) the critical curve of the MACS J1149 galaxy cluster (z=0.54). Its unchanging spectral energy distribution (SED) matches that of a mid-to-late B-type star at the lensed background galaxy's redshift of z=1.49. Near peak brightness in May 2016, the individual star was likely magnified by the cluster by a factor of at least ~2000.

WFC3 imaging taken October 30 2016 after the field re-emerged from behind the sun has revealed an entirely unanticipated new source approximately 0.26 arcsec from Icarus. Its F125W-F160W color is consistent with that of Icarus. If a counterimage, it could potentially have been

"hidden" due to temporary demagnification by a massive object (>20 solar masses) in the intracluster medium. However, this possibility only has a reasonable probability if massive black holes account for at least a modest fraction of dark matter, as has been hypothesized to explain the LIGO detection of merging 30 solar-mass black holes in September, 2015.

An alternate explanation is that the new image is of a different star with similar color undergoing an extreme microlensing event. If dark matter is an ultra-light scalar field, which would be granular (Hui et al. 2016), instead of a smoothly distributed WIMP, then the probability of a second event at the large offset from Icarus may be significantly larger. A measurement of the SED of the new source will determine if it can be the counterimage of Icarus, or if it is instead a different star.

OBSERVING DESCRIPTION

In April 2016, WFC3-IR imaging of the MACS J1149 galaxy-cluster field showed that a source near the cluster
s critical curve had brightened significantly. This source's characteristics are best explained by a highly magnified, individual star at the redshift z=1.49 of the lensed background galaxy. In new WFC3-IR imaging acquired on September 30, 2016, a new source appeared ~0.26" away from the magnified star. To determine if the new source is a counterimage of the highly magnified star identified in April 2016, a first part of the program will acquire three consecutive orbits consisting of ACS F606W + F814W, WFC3 F125W, and ACS F814W + F606W imaging respectively as soon as they may be scheduled.

The program's most important scientific goal is to measure the object's broadband spectral energy distribution to compare it with that of the potential counterimage. Since the source may vary in flux on short time scales, we would like the first three visits to occur ideally one after the other. We have also chosen the order of integrations in different filters to be able to remove any variation in flux that is first-order in time, assuming that visits are scheduling sequentially.

In a second part of the program, three separate visits will be used to construct the source's light curve. Each of these will be split between WFC3-IR F125W and WFC3-IR F160W integrations, and the visits should follow each other by approximately one week. The first of these visits should be scheduled approximately one week after the initial ACS F606W, ACS F814W, and WFC3 F125W visit.

Proposal 14872 - M1149 ACS F606W+F814W (01) - A Hidden Potential Counterimage of a Highly Magnified Star at Redshift z=1.49

Visit

Proposal 14872, M1149 ACS F606W+F814W (01), completed Thu Jan 12 02:05:35 GMT 2017

Diagnostic Status: No Diagnostics

Scientific Instruments: ACS/WFC

Special Requirements: ORIENT 303D TO 303 D; BETWEEN 28-NOV-2016:00:00:00 AND 01-DEC-2016:00:00:00

Comments: Visits 1, 2, and 3 should be scheduled immediately one after the other if possible. We are trying to avoid the possibility that the source could vary between these visits, since our principal science goal is to measure the object's broadband spectral energy distribution.

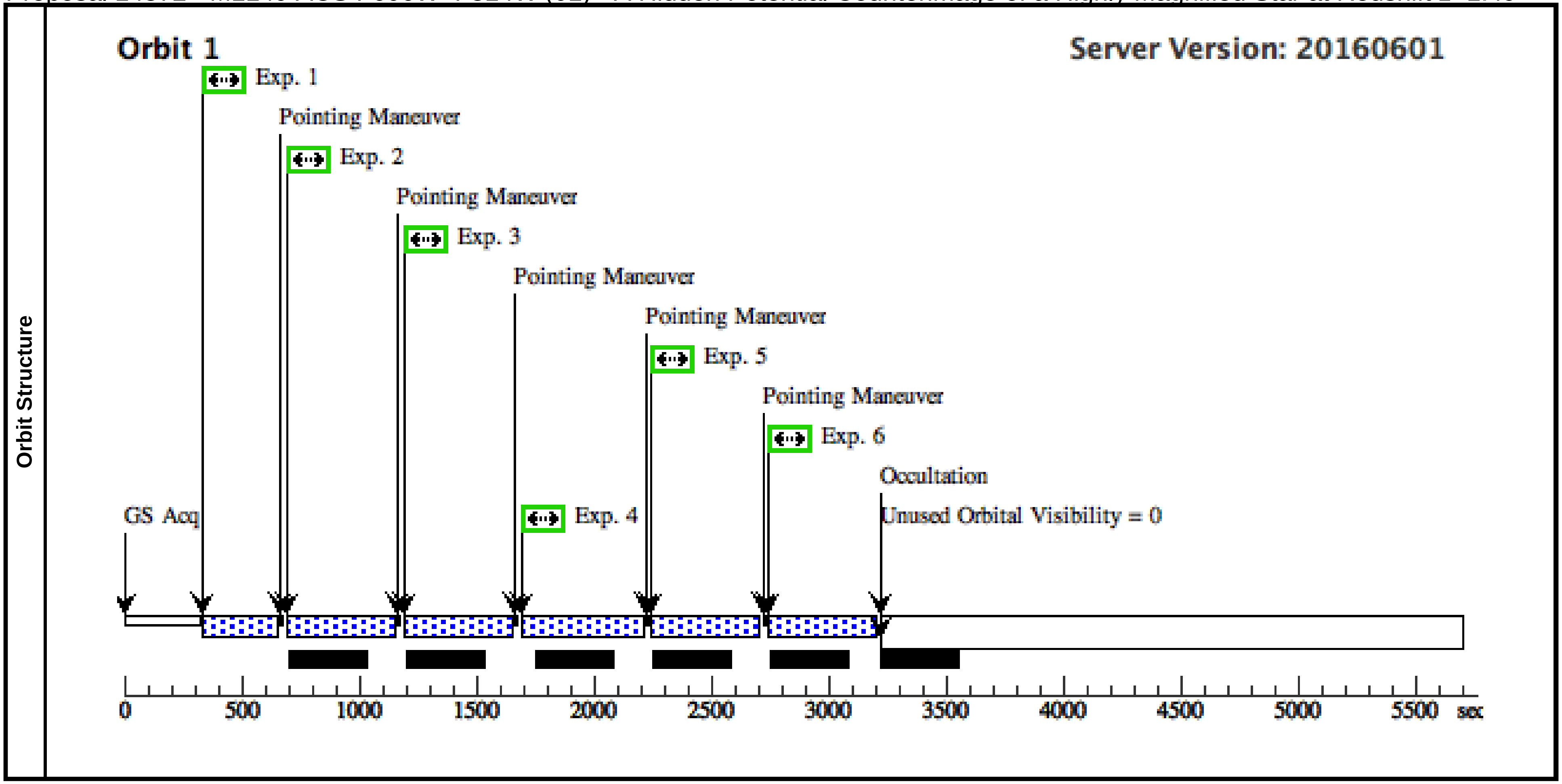
An observation scheduled as early as possible would be best.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	POSSIBLESTARCOUNTERIMAGE	RA: 11 49 35.6720 (177.3986333d) Dec: +22 23 48.15 (22.39671d) Equinox: J2000		V=27+/-1	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) POSSIBLESTAR COUNTERIMAGE	ACS/WFC, ACCUM, WFC1-CTE	F606W		POS TARG 0,0; GS ACQ SCENARIO BASE1B3		112 Secs (112 Secs) *[==>112.0 Secs]*	*[1]*
2		(1) POSSIBLESTAR COUNTERIMAGE	ACS/WFC, ACCUM, WFC1-CTE	F606W		POS TARG 0.247,2.984		337 Secs (337 Secs) *[==>337.0 Secs]*	*[1]*
3		(1) POSSIBLESTAR COUNTERIMAGE	ACS/WFC, ACCUM, WFC1-CTE	F606W		POS TARG 0.494,5.968		337 Secs (337 Secs) *[==>337.0 Secs]*	*[1]*
4		(1) POSSIBLESTAR COUNTERIMAGE	ACS/WFC, ACCUM, WFC1-CTE	F814W		SAME POS AS 1		337 Secs (337 Secs) *[==>337.0 Secs]*	*[1]*
5		(1) POSSIBLESTAR COUNTERIMAGE	ACS/WFC, ACCUM, WFC1-CTE	F814W		SAME POS AS 2		337 Secs (337 Secs) *[==>337.0 Secs]*	*[1]*
6		(1) POSSIBLESTAR COUNTERIMAGE	ACS/WFC, ACCUM, WFC1-CTE	F814W		SAME POS AS 3		337 Secs (337 Secs) *[==>337.0 Secs]*	*[1]*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Orbit 1
Server Version: 20160601
Exp. 1
Pointing Maneuver
Exp. 2
Pointing Maneuver
Exp. 3
Pointing Maneuver
Pointing Maneuver
Exp. 5
Pointing Maneuver
Exp. 6
Occultation
GS Acq
Exp. 4
Unused Orbital Visibility = 0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Proposal 14872 - M1149 WFC3 F125W (02) - A Hidden Potential Counterimage of a Highly Magnified Star at Redshift z=1.49

Visit

Proposal 14872, M1149 WFC3 F125W (02), completed — Thu Jan 12 02:05:35 GMT 2017

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: SCHED 100%; ORIENT 303D TO 303 D; AFTER 01 BY 0.8 Orbits TO 1.2 Orbits; BETWEEN 28-NOV-2016:00:00:00 AND 01-DEC-2016:00:00:00

Comments: Please schedule as soon as possible after Visit 1.

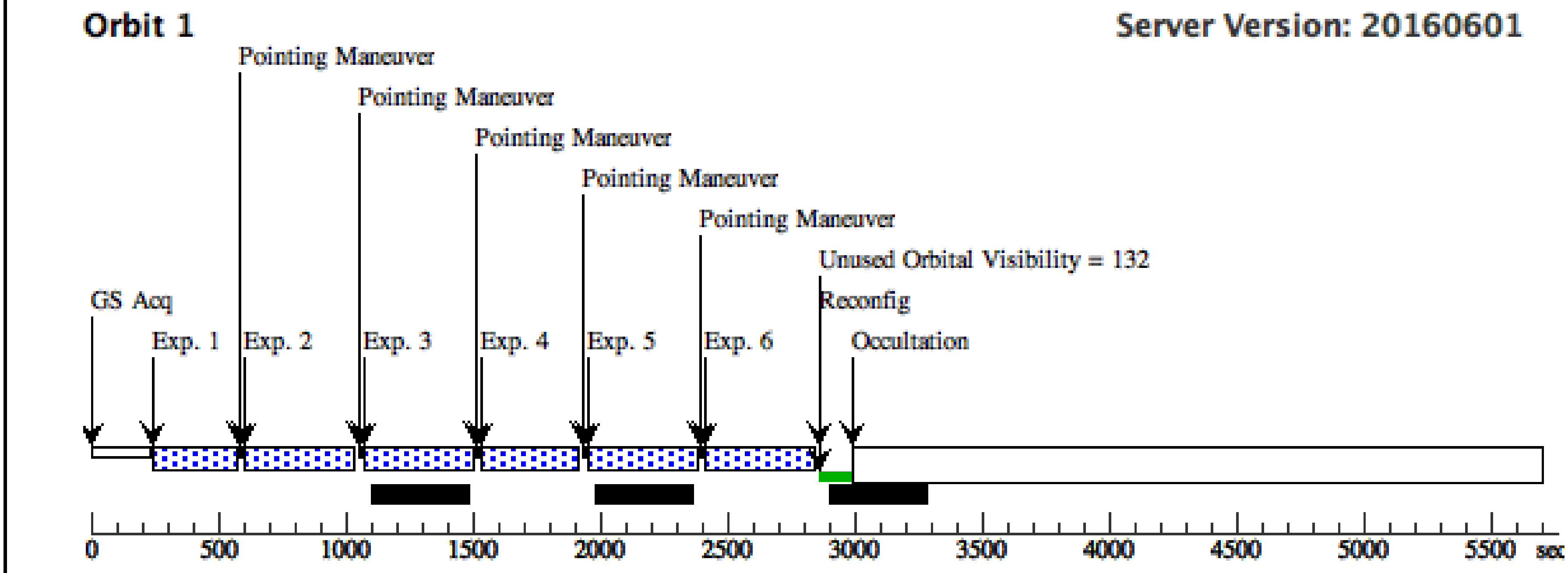
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	POSSIBLESTARCOUNTERIMAGE	RA: 11 49 35.6720 (177.3986333d) Dec: +22 23 48.15 (22.39671d) Equinox: J2000		V=27+/-1	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	F125W	(1) POSSIBLESTARCOUNTERIMAGE	WFC3/IR, MULTIACCUM, IR	F125W	NSAMP=7; SAMP-SEQ=SPARS50	POS TARG 0,0; GS ACQ SCENARIO ONEB1B3		302.934997 Secs (302.935 Secs) [==>]	[1]
2	F125W	(1) POSSIBLESTARCOUNTERIMAGE	WFC3/IR, MULTIACCUM, IR	F125W	NSAMP=9; SAMP-SEQ=SPARS50	POS TARG 0.451,0.403		402.935899 Secs (402.936 Secs) [==>]	[1]
3	F125W	(1) POSSIBLESTARCOUNTERIMAGE	WFC3/IR, MULTIACCUM, IR	F125W	NSAMP=9; SAMP-SEQ=SPARS50	POS TARG 0.902,0.806		402.935899 Secs (402.936 Secs) [==>]	[1]
4	F125W	(1) POSSIBLESTARCOUNTERIMAGE	WFC3/IR, MULTIACCUM, IR	F125W	NSAMP=8; SAMP-SEQ=SPARS50	POS TARG 1.3,0.806		352.935448 Secs (352.935 Secs) [==>]	[1]
5	F125W	(1) POSSIBLESTARCOUNTERIMAGE	WFC3/IR, MULTIACCUM, IR	F125W	NSAMP=9; SAMP-SEQ=SPARS50	POS TARG 1.353,1.209		402.935899 Secs (402.936 Secs) [==>]	[1]
6	F125W	(1) POSSIBLESTARCOUNTERIMAGE	WFC3/IR, MULTIACCUM, IR	F125W	NSAMP=9; SAMP-SEQ=SPARS50	POS TARG 1.804,1.612		402.935899 Secs (402.936 Secs) [==>]	[1]

Orbit Structure



Visit

Proposal 14872, M1149 ACS F814W+F606W (03), completed Thu Jan 12 02:05:35 GMT 2017

Diagnostic Status: No Diagnostics

Scientific Instruments: ACS/WFC

Special Requirements: ORIENT 303D TO 303 D; AFTER 02 BY 0.8 Orbits TO 1.2 Orbits; BETWEEN 28-NOV-2016:00:00:00 AND 01-DEC-2016:00:00:00

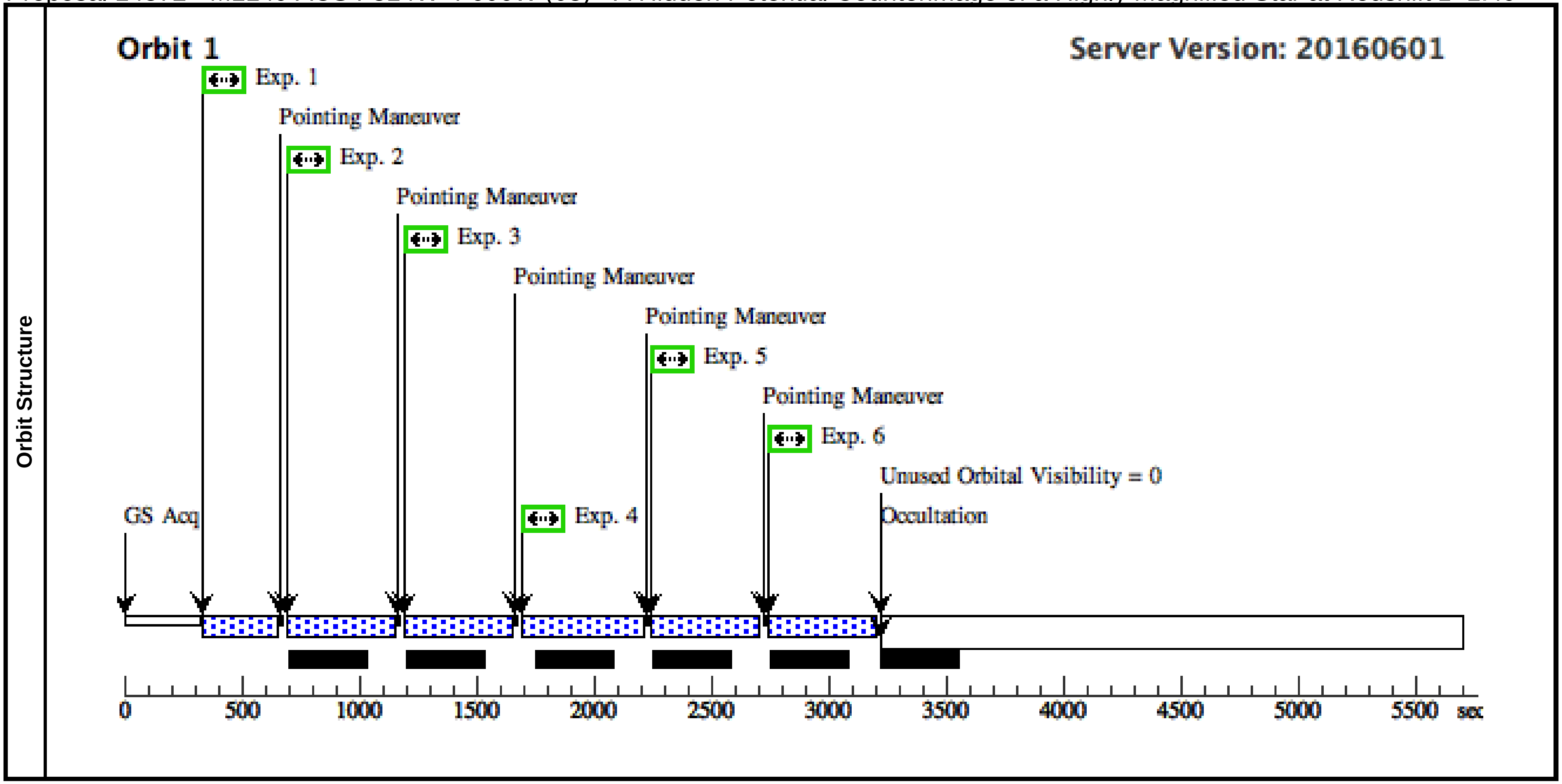
Comments: Please schedule as soon as possible after Visit 2.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	POSSIBLESTARCOUNTERIMAGE	RA: 11 49 35.6720 (177.3986333d) Dec: +22 23 48.15 (22.39671d) Equinox: J2000		V=27+/-1	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) POSSIBLESTAR COUNTERIMAGE	ACS/WFC, ACCUM, WFC1-CTE	F814W		POS TARG 0.12,0; GS ACQ SCENARIO BASE1B3		112 Secs (112 Secs) *[==>112.0 Secs]*	***[1]***
2		(1) POSSIBLESTAR COUNTERIMAGE	ACS/WFC, ACCUM, WFC1-CTE	F814W		POS TARG 0.367,2.984		337 Secs (337 Secs) *[==>337.0 Secs]*	***[1]***
3		(1) POSSIBLESTAR COUNTERIMAGE	ACS/WFC, ACCUM, WFC1-CTE	F814W		POS TARG 0.614,5.968		337 Secs (337 Secs) *[==>337.0 Secs]*	***[1]***
4		(1) POSSIBLESTAR COUNTERIMAGE	ACS/WFC, ACCUM, WFC1-CTE	F606W		SAME POS AS 1		337 Secs (337 Secs) *[==>337.0 Secs]*	***[1]***
5		(1) POSSIBLESTAR COUNTERIMAGE	ACS/WFC, ACCUM, WFC1-CTE	F606W		SAME POS AS 2		337 Secs (337 Secs) *[==>337.0 Secs]*	***[1]***
6		(1) POSSIBLESTAR COUNTERIMAGE	ACS/WFC, ACCUM, WFC1-CTE	F606W		SAME POS AS 3		337 Secs (337 Secs) *[==>337.0 Secs]*	***[1]***


Orbit Structure
Orbit 1
Server Version: 20160601
Exp. 1
Pointing Maneuver
Exp. 2
Pointing Maneuver
Exp. 3
Pointing Maneuver
Pointing Maneuver
Exp. 5
Pointing Maneuver
Exp. 6
Unused Orbital Visibility = 0
GS Acq
Exp. 4
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 14872, M1149 WFC3 F125W/F160W (04), completed Thu Jan 12 02:05:35 GMT 2017

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: SCHED 100%; ORIENT 301D TO 301 D; BETWEEN 05-DEC-2016:00:00:00 AND 07-DEC-2016:00:00:00

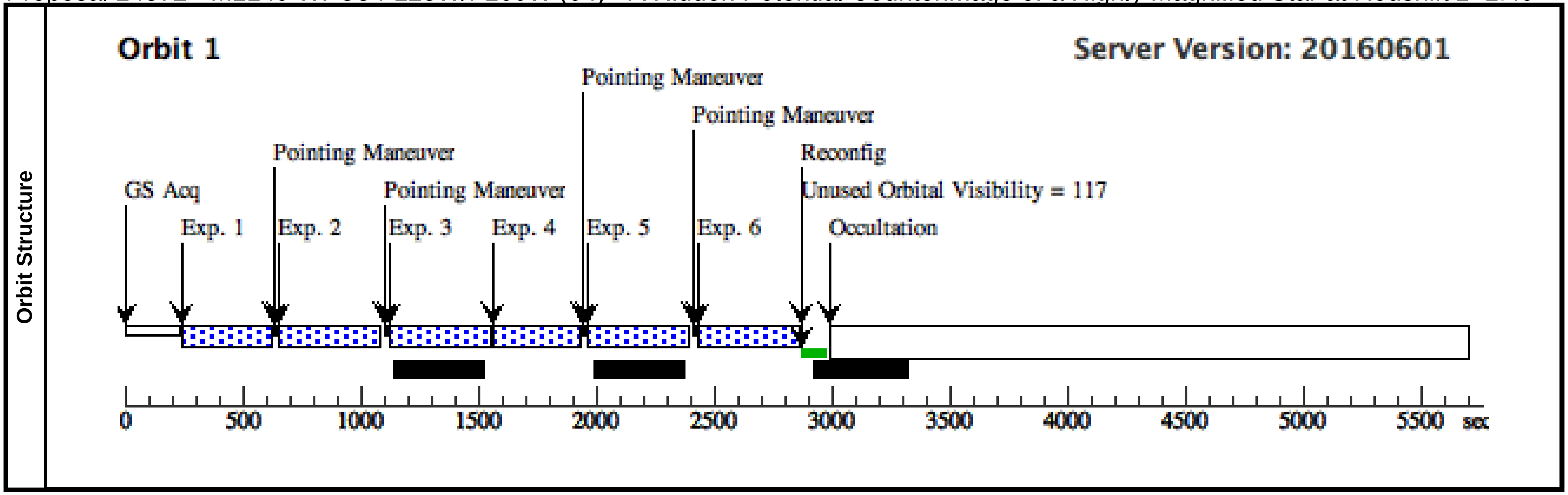
Comments: 3 short WFC3-IR F125W and 3 short WFC3-IR F160W exposures of new source in MACS1149 field.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	POSSIBLESTARCOUNTERIMAGE	RA: 11 49 35.6720 (177.3986333d) Dec: +22 23 48.15 (22.39671d) Equinox: J2000		V=27+/-1	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	F125W	(1) POSSIBLESTAR COUNTERIMAGE	WFC3/IR, MULTIACCUM, IR	F125W	NSAMP=8; SAMP-SEQ=SPARS50	POS TARG 0,0; GS ACQ SCENARIO ONEB1B3		352.935448 Secs (352.935 Secs) *[==>]*	***[1]***
2	F125W	(1) POSSIBLESTAR COUNTERIMAGE	WFC3/IR, MULTIACCUM, IR	F125W	NSAMP=9; SAMP-SEQ=SPARS50	POS TARG 0.451,0.403		402.935899 Secs (402.936 Secs) *[==>]*	***[1]***
3	F125W	(1) POSSIBLESTAR COUNTERIMAGE	WFC3/IR, MULTIACCUM, IR	F125W	NSAMP=9; SAMP-SEQ=SPARS50	POS TARG 0.902,0.806		402.935899 Secs (402.936 Secs) *[==>]*	***[1]***
4	F160W	(1) POSSIBLESTAR COUNTERIMAGE	WFC3/IR, MULTIACCUM, IR	F160W	NSAMP=8; SAMP-SEQ=SPARS50	POS TARG 0.902,0.806		352.935448 Secs (352.935 Secs) *[==>]*	***[1]***
5	F160W	(1) POSSIBLESTAR COUNTERIMAGE	WFC3/IR, MULTIACCUM, IR	F160W	NSAMP=9; SAMP-SEQ=SPARS50	POS TARG 1.353,1.209		402.935899 Secs (402.936 Secs) *[==>]*	***[1]***
6	F160W	(1) POSSIBLESTAR COUNTERIMAGE	WFC3/IR, MULTIACCUM, IR	F160W	NSAMP=9; SAMP-SEQ=SPARS50	POS TARG 1.804,1.612		402.935899 Secs (402.936 Secs) *[==>]*	***[1]***


Orbit Structure
Orbit 1
Server Version: 20160601
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Reconfig
GS Acq
Pointing Maneuver
Unused Orbital Visibility = 117
Exp. 1
Exp. 2
Exp. 3
Exp. 4
Exp. 5
Exp. 6
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Proposal 14872 - M1149 F125W/F606W (07) - A Hidden Potential Counterimage of a Highly Magnified Star at Redshift z=1.49

Visit

Proposal 14872, M1149 F125W/F606W (07), completed — Thu Jan 12 02:05:35 GMT 2017

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR, WFC3/UVIS

Special Requirements: SCHED 100%; ORIENT 263D TO 265 D; ORIENT 305D TO 308 D; BETWEEN 01-JAN-2017:00:00:00 AND 07-JAN-2017:00:00:00

Comments: 3 short WFC3-IR F125W and 3 short WFC3-UVIS F606W exposures of new source in the MACS1149 field.
preferred orient = 264

Patterns

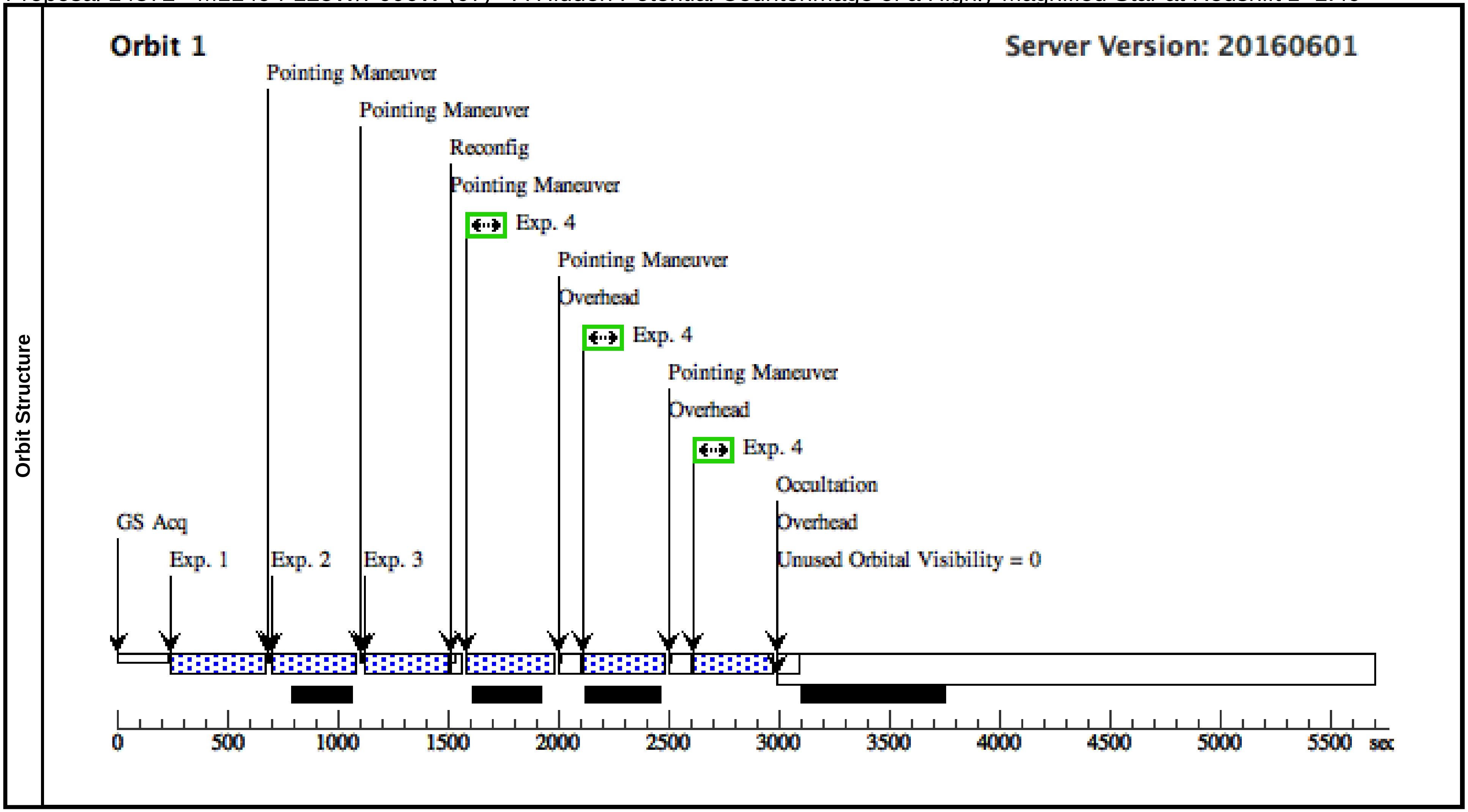
#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-LINE-3PT Purpose=DITHER Number Of Points=3 Point Spacing=0.135 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(4)

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	POSSIBLESTARCOUNTERIMAGE	RA: 11 49 35.6720 (177.3986333d) Dec: +22 23 48.15 (22.39671d) Equinox: J2000		V=27+/-1	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	F125W	(1) POSSIBLESTAR COUNTERIMAGE	WFC3/IR, MULTIACCUM, IR	F125W	NSAMP=9; SAMP-SEQ=SPARS50	GS ACQ SCENARIO ONEB1B3		402.935899 Secs (402.936 Secs) *[==>]*	*[1]*
2	F125W	(1) POSSIBLESTAR COUNTERIMAGE	WFC3/IR, MULTIACCUM, IR	F125W	NSAMP=8; SAMP-SEQ=SPARS50	POS TARG 0.451,0.403		352.935448 Secs (352.935 Secs) *[==>]*	*[1]*
3	F125W	(1) POSSIBLESTAR COUNTERIMAGE	WFC3/IR, MULTIACCUM, IR	F125W	NSAMP=8; SAMP-SEQ=SPARS50	POS TARG 0.902,0.806		352.935448 Secs (352.935 Secs) *[==>]*	*[1]*
4		(1) POSSIBLESTAR COUNTERIMAGE	WFC3/UVIS, ACCUM, UVIS	F606W			Pattern 1, Exps 4-4 in M1149 F125W/F606W (07) (1)	370 Secs (1112 Secs) *[==>375.0 Secs (Pattern 1)]* *[==>375.0 Secs (Pattern 2)]* *[==>362.0 Secs (Pattern 3)]*	*[1]*


Orbit Structure
Orbit 1
Server Version: 20160601
Pointing Maneuver
Pointing Maneuver
Reconfig
Pointing Maneuver
Exp. 4
Pointing Maneuver
Overhead
Exp. 4
Pointing Maneuver
Overhead
Exp. 4
Occultation
Overhead
Unused Orbital Visibility = 0
GS Acq
Exp. 1
Exp. 2
Exp. 3
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 14872, M1149 F110W/F606W (09), implementation Thu Jan 12 02:05:35 GMT 2017

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR, WFC3/UVIS

Special Requirements: SCHED 100%; ORIENT 250D TO 265 D; BETWEEN 23-JAN-2017:00:00:00 AND 30-JAN-2017:00:00:00

Comments: An early date in the window of potential dates for this visit would be best, since the source will likely fade quickly.
3 short WFC3-IR F110W and 3 short WFC3-UVIS F606W exposures of new source in the MACS1149 field.
preferred orient = 263

Patterns

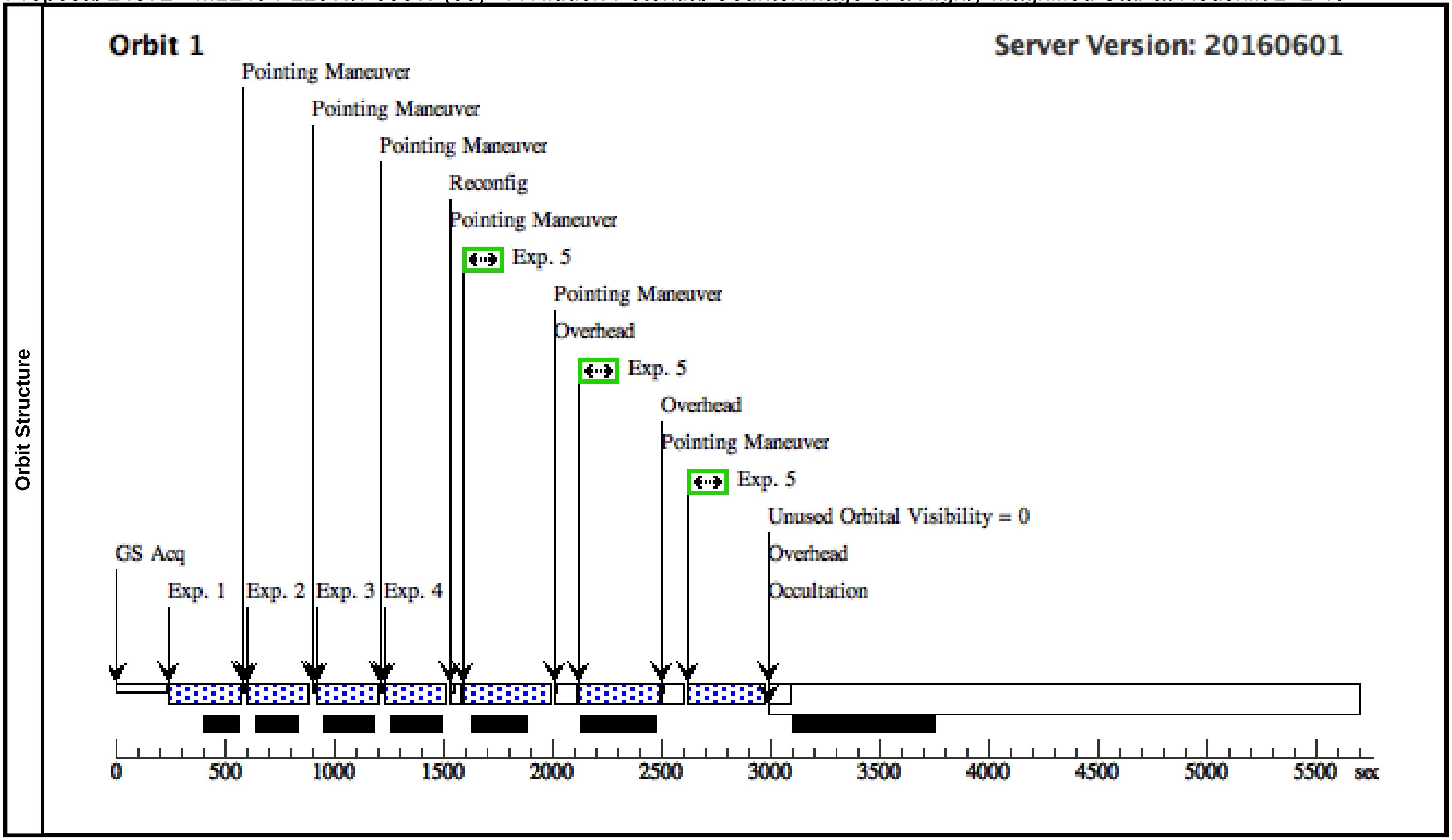
#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-LINE-3PT Purpose=DITHER Number Of Points=3 Point Spacing=0.135 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(5)

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	POSSIBLESTARCOUNTERIMAGE	RA: 11 49 35.6720 (177.3986333d) Dec: +22 23 48.15 (22.39671d) Equinox: J2000		V=27+/-1	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	F110W	(1) POSSIBLESTAR COUNTERIMAGE	WFC3/IR, MULTIACCUM, IR	F110W	NSAMP=13; SAMP-SEQ=SPARS25	GS ACQ SCENARIO ONEB1B3		302.938471 Secs (302.938 Secs) *[==>]*	***[1]***
2	F110W	(1) POSSIBLESTAR COUNTERIMAGE	WFC3/IR, MULTIACCUM, IR	F110W	NSAMP=11; SAMP-SEQ=SPARS25	POS TARG 0.542,0.182		252.937441 Secs (252.937 Secs) *[==>]*	***[1]***
3	F110W	(1) POSSIBLESTAR COUNTERIMAGE	WFC3/IR, MULTIACCUM, IR	F110W	NSAMP=11; SAMP-SEQ=SPARS25	POS TARG 0.339,0.485		252.937441 Secs (252.937 Secs) *[==>]*	***[1]***
4	F110W	(1) POSSIBLESTAR COUNTERIMAGE	WFC3/IR, MULTIACCUM, IR	F110W	NSAMP=11; SAMP-SEQ=SPARS25	POS TARG -0.203,0.303		252.937441 Secs (252.937 Secs) *[==>]*	***[1]***
5		(1) POSSIBLESTAR COUNTERIMAGE	WFC3/UVIS, ACCUM, UVIS	F606W			Pattern 1, Exps 5-5 in M1149 F110W/F606W (09) (1)	370 Secs (1097 Secs) *[==>370.0 Secs (Pattern 1)]* *[==>370.0 Secs (Pattern 2)]* *[==>357.0 Secs (Pattern 3)]*	***[1]***


Orbit Structure
Orbit 1
Server Version: 20160601
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Reconfig
Pointing Maneuver
Exp. 5
Pointing Maneuver
Overhead
Exp. 5
Overhead
Pointing Maneuver
Exp. 5
Unused Orbital Visibility = 0
Overhead
Occultation
GS Acq
Exp. 1
Exp. 2
Exp. 3
Exp. 4
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec