



# 16000 - EVOLUTION OF RECENTLY DISCOVERED SPATIALLY RESOLVED JET/OUTFLOW IN THE SYMBIOTIC MWC 560

Cycle: 27, Proposal Category: GO  
(Availability Mode: AVAILABLE)

## 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) V-MW-560	WFC3/UVIS	4	21-Feb-2020 14:20:02.0	yes
02	(1) V-MW-560	WFC3/UVIS	4	21-Feb-2020 14:20:12.0	yes

8 Total Orbits Used

## ABSTRACT

We propose to carry out coordinated Chandra, HST, and XMM observations of the MWC 560 symbiotic interacting binary system, as a follow-up to the 2016 Chandra discovery of an extended jet/outflow. When combined, these observations will result in a comprehensive picture of the central source and the dynamic jet/outflow from as close as few hundred AU from its source, to the region of its interaction with the circumbinary environment into which the jet propagates. We will determine its evolution and origin, including association with powerful past outbursts in the system.

## OBSERVING DESCRIPTION

We plan HST observations (in Cycle 27) using WFC3 high-spatial resolution imaging in several spectral lines and the continuum. This would allow us to unambiguously study the components of the system, including the ejected material (jet/outflow) and the core. We request a total of 4 orbits, in 1 visit. The selected set of filters (see table below) will separate line and continuum emission, to distinguish shocked from photoionized gas, and to determine the shock speed and the nature of the photoionizing continuum. Difference and ratio maps will reveal changes in local physical conditions.

We plan to carry out the observations in a dither mode to improve the sampling of the PSF, and to deal with cosmic rays. The pixel size for WFC3 is 0.04 arcsecond/pixel. We plan to use a standard dither pattern which fractionally samples the pixels across the detector; namely, the WFC3-UVIS-DITHER-BOX pattern as described in <https://hst-docs.stsci.edu/display/HPIOM/7.3+WFC3+patterns#id-7.3WFC3Patterns-W-UDitherbox>. This pattern has steps in pixels of (0, 0), (4.0, 1.5), (2.5, 4.0), and (-1.5, 2.5). This will allow us to reach 0.025 arcsecond/pixel when combining the dithered images using the `it drizzle` software, doubling the number of pixels covering the regions of interest. We will use a combination of long and short exposure times to compensate for the high contrast between the red-giant and surrounding emission(s). This technique was used effectively in a number of observations (e.g., symbiotics CH Cyg and R Aqr). The exposure times were estimated using the latest version of the online Exposure Time Calculator assuming a combined red-giant plus white-dwarf spectrum normalized to  $V=9.5$  with  $E(B-V)=0.18$ . The reddening estimate was determined with the use of the Pan-STARRS 1 3D Dust Mapping online tool. Given the variable nature of this system, we set the exposure times conservatively to minimize the chance of saturation while still allowing to observe the object in the selected filters even when it is up to a magnitude brighter. We request use of the UVIS 1K subarray readout modes in order to minimize readout overhead times and buffer memory usage. This increases the number of total exposures we can get in each orbit while still providing a sufficient field-of-view which covers the extended emission. The overheads listed in the online Phase-1 proposal instructions are 2.1 min/exposure (2.4 min for the first exposure). To this are added the times for guide star acquisition for each orbit (6 min x 4 orbits=24 min) and 1 min efficiency/orbit (4 min). These overheads added to the combined exposure times for a 4-point dither pattern for each filter result in a final total of ~200 min, which is enough to fit into the time available in 4 orbits for ~216 min, with 54 minutes per orbit, based on the visibility charts provided by "Available Science Time and Visibility Tool". The sets of exposures can be split across the orbits to maximize efficiency. The Cycle 27, APT shows good visibility of the target over extended periods in 2019/2020.

{Summary of HST/WFC3 Observations} {FILTERS and EXPOSURES for Visit 2} F280N MgII -- 4 x 360 s plus 4 x 10 s exp. F275W cont. -- 4 x 15 s exp. F336W cont. -- 3 x 10 s exp. F373N [OII] -- 4 x 90 s exp. plus 4 x 3 s exp. FQ437N [O III] -- 4 x 10 s F502N [O III] -- 4 x 1s plus 4 x 10 s plus 4 x 120 s exp. plus 2 x 550s exp. F547M cont.-- 4 x 0.5 s exp. F656N H-alpha -- 4 x 1 s plus 4 x 30 s plus 2 x 360 s exp. F673N [S II] -- 4 x 1 s plus 4 x 30 s exp.

Proposal 16000 - Visit 01 - EVOLUTION OF RECENTLY DISCOVERED SPATIALLY RESOLVED JET/OUTFLOW IN THE SYMBIOTI...

Fri Feb 21 19:20:13 GMT 2020

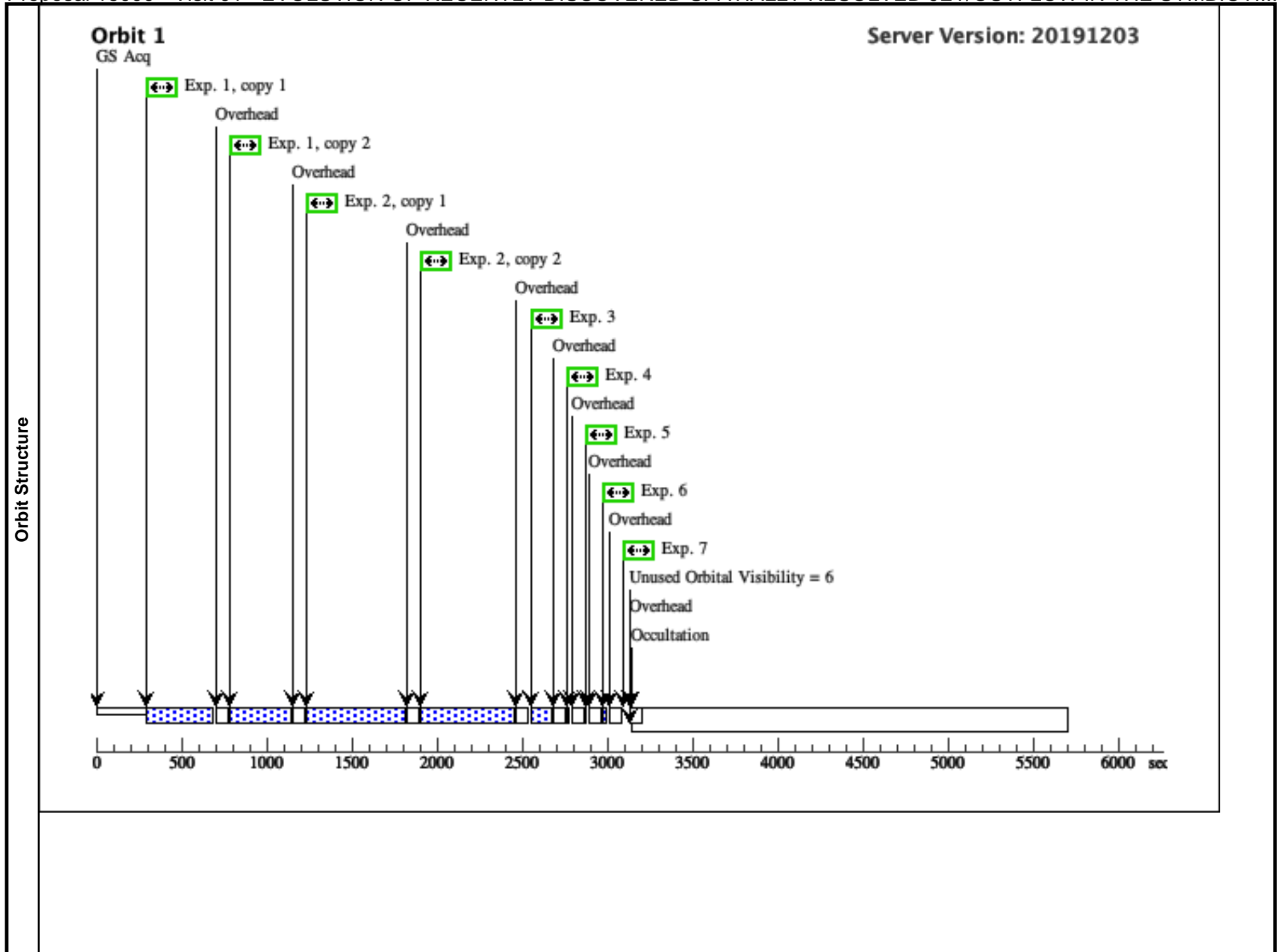
<b>Visit</b>	<b>Proposal 16000, Visit 01, failed</b> <b>Diagnostic Status: Warning</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none)					
	(Exposure 17 (Pattern 1, Exps 17-17 in Visit 01)) Warning (Form): POS TARG & PATTERN should be used carefully with WFC3 quad filters to avoid placing the target on the vignettted part of the field of view or moving it to another quadrant.					
<b>Diagnosics</b>						
<b>Patterns</b>	<b>#</b>	<b>Primary Pattern</b>	<b>Secondary Pattern</b>	<b>Exposures</b>		
	(1)	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	(3-15), (17)		
<b>Fixed Targets</b>	<b>#</b>	<b>Name</b>	<b>Target Coordinates</b>	<b>Targ. Coord. Corrections</b>	<b>Fluxes</b>	<b>Miscellaneous</b>
	(1)	V-MW-560	RA: 07 25 51.2848 (111.4636867d)		V=11+/-1.0	Reference Frame: ICRS
Alt Name1: V694-MON Dec: -07 44 8.09 (-7.73558d) Alt Name2: DR1- Equinox: J2000 3054628260437829760 Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. Category=EXT-STAR Description=[ACCRETION DISK, JET, SYMBIOTIC STAR]						

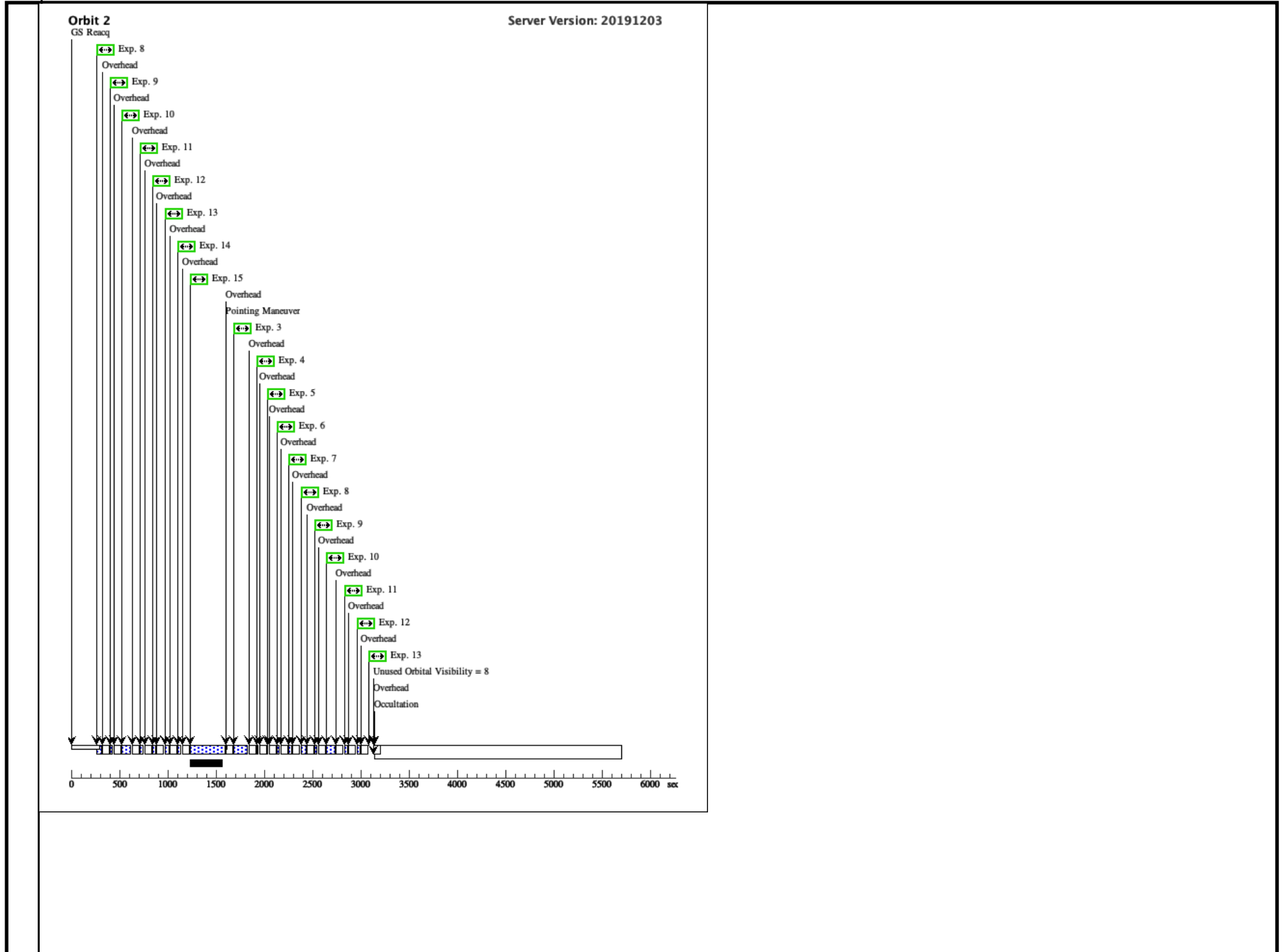
Proposal 16000 - Visit 01 - EVOLUTION OF RECENTLY DISCOVERED SPATIALLY RESOLVED JET/OUTFLOW IN THE SYMBIOTI...

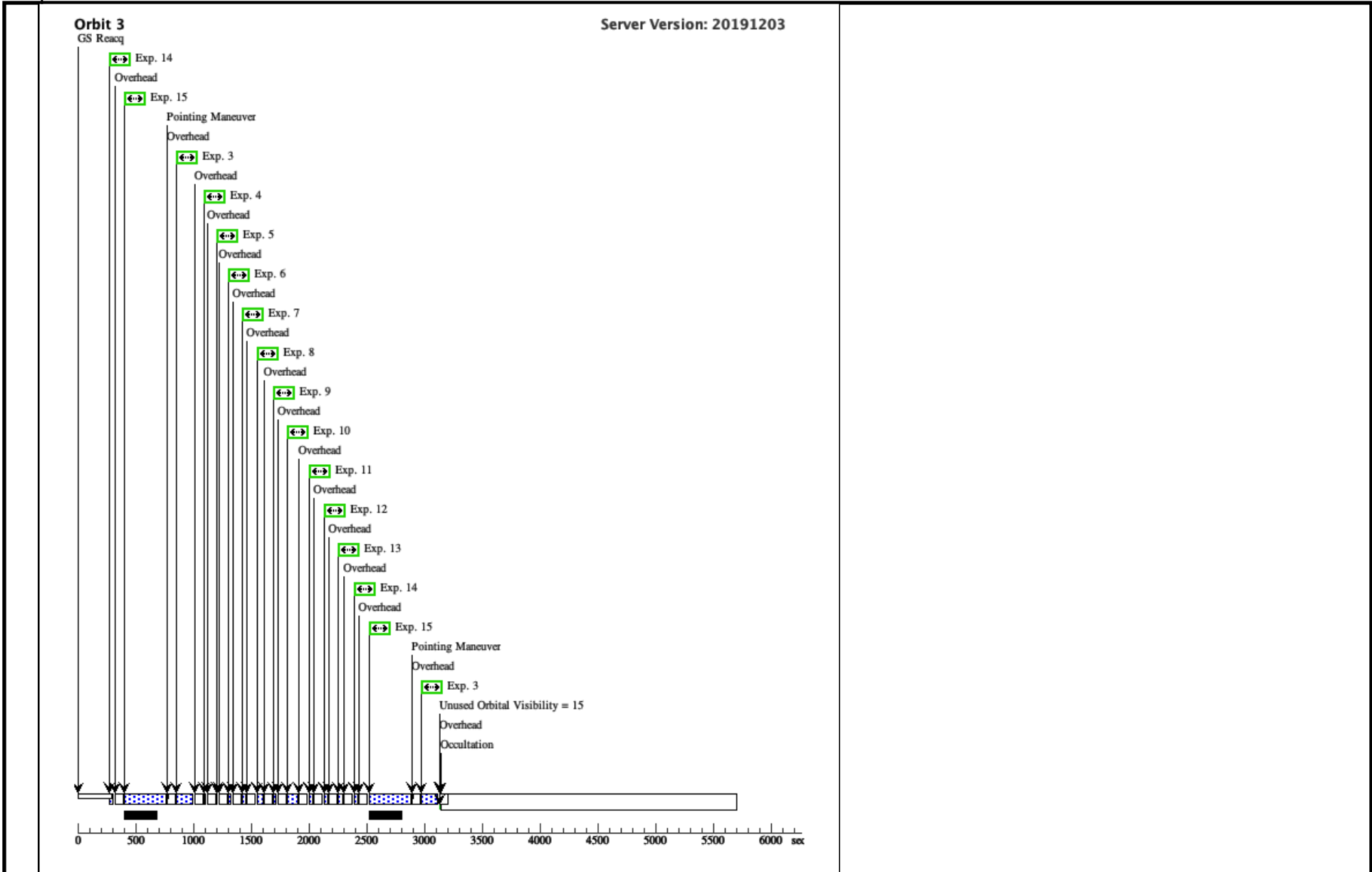
Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F656N	CR-SPLIT=NO; FLASH=12.0			360 Secs X 2 (720 Secs) [==>(Copy 1)] [==>(Copy 2)]	[1]
	2		(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F502N	CR-SPLIT=NO; FLASH=12.0			550 Secs X 2 (1100 Secs) [==>(Copy 1)] [==>(Copy 2)]	[1]
	3	(WFC3UVI S.im.137577 4)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F502N	CR-SPLIT=NO; FLASH=12.0		Pattern 1, Exps 3-15 in Visit 01 (1)	120 Secs (480 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1] [2] [3]
	4	(WFC3UVI S.im.137577 4)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F502N	CR-SPLIT=NO; FLASH=12.0		Pattern 1, Exps 3-15 in Visit 01 (1)	10 Secs (40 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1] [2] [3] [4]
	5	(WFC3UVI S.im.137577 4)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F502N	CR-SPLIT=NO; FLASH=12.0; BLADE=A		Pattern 1, Exps 3-15 in Visit 01 (1)	1 Secs (4 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1] [2] [3] [4]
	6	(WFC3UVI S.im.137577 5)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F656N	CR-SPLIT=NO; FLASH=12.0; BLADE=A		Pattern 1, Exps 3-15 in Visit 01 (1)	5 Secs (20 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1] [2] [3] [4]
	7	(WFC3UVI S.im.137577 5)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F656N	CR-SPLIT=NO; FLASH=12.0		Pattern 1, Exps 3-15 in Visit 01 (1)	30 Secs (120 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1] [2] [3] [4]
	8	(WFC3UVI S.im.137578 1)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F275W	CR-SPLIT=NO; FLASH=12.0		Pattern 1, Exps 3-15 in Visit 01 (1)	15 Secs (60 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[2] [3] [4]
	9	(WFC3UVI S.im.137577 3)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F373N	CR-SPLIT=NO; FLASH=12.0		Pattern 1, Exps 3-15 in Visit 01 (1)	10 Secs (40 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[2] [3] [4]

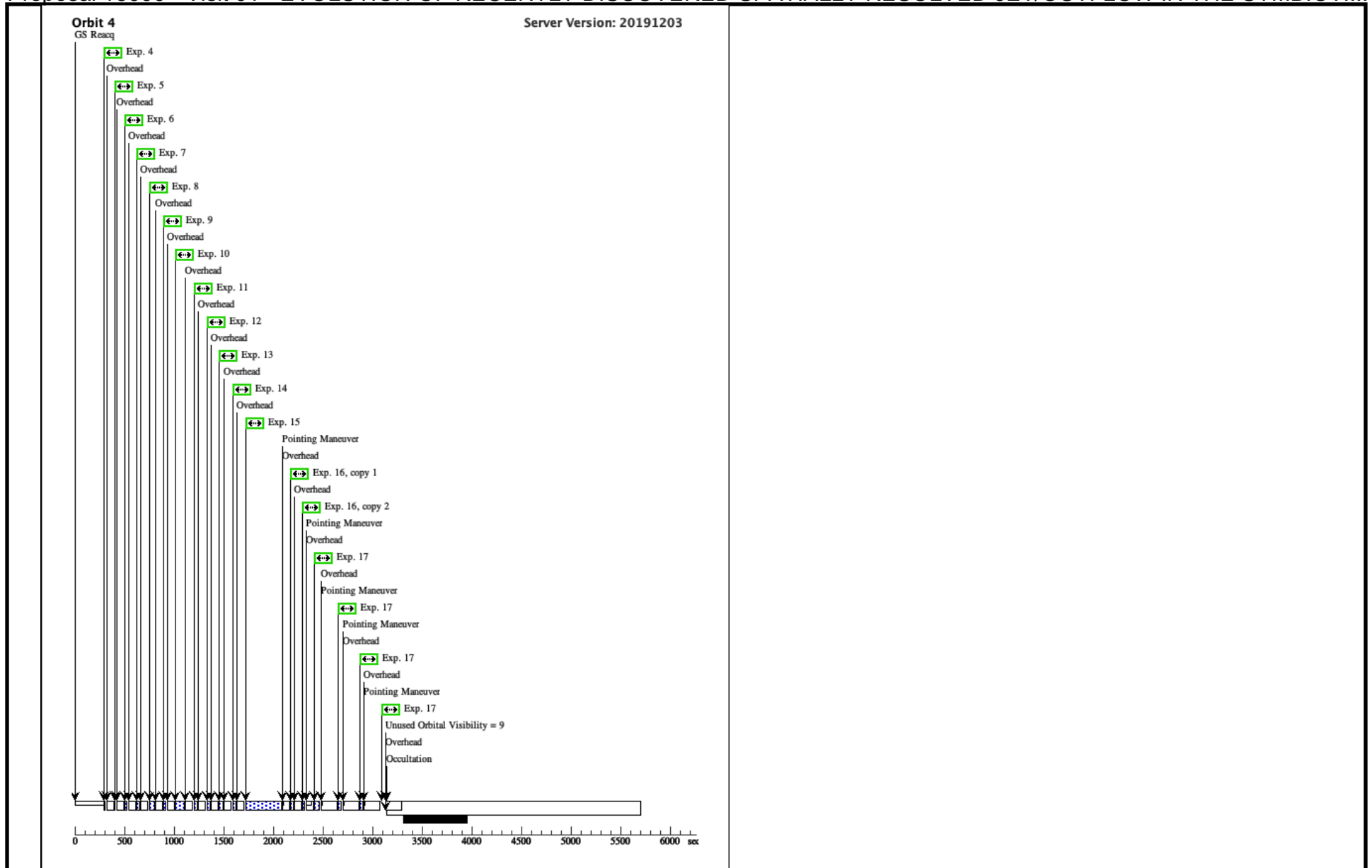
Proposal 16000 - Visit 01 - EVOLUTION OF RECENTLY DISCOVERED SPATIALLY RESOLVED JET/OUTFLOW IN THE SYMBIOTI...

10	(WFC3UVI S.im.137577 3)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F373N	CR-SPLIT=NO; FLASH=12.0	Pattern 1, Exps 3-15 in Visit 01 (1)	90 Secs (360 Secs)	
							[==>(Pattern 1)]	[2]
							[==>(Pattern 2)]	[3]
							[==>(Pattern 3)]	[4]
							[==>(Pattern 4)]	
11	(WFC3UVI S.im.137578 2)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F673N	CR-SPLIT=NO; FLASH=12.0; BLADE=A	Pattern 1, Exps 3-15 in Visit 01 (1)	5 Secs (20 Secs)	
							[==>(Pattern 1)]	[2]
							[==>(Pattern 2)]	[3]
							[==>(Pattern 3)]	[4]
							[==>(Pattern 4)]	
12	(WFC3UVI S.im.137578 2)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F673N	CR-SPLIT=NO; FLASH=12.0	Pattern 1, Exps 3-15 in Visit 01 (1)	30 Secs (120 Secs)	
							[==>(Pattern 1)]	[2]
							[==>(Pattern 2)]	[3]
							[==>(Pattern 3)]	[4]
							[==>(Pattern 4)]	
13	(WFC3UVI S.im.137577 8)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F547M	CR-SPLIT=NO; FLASH=12.0	Pattern 1, Exps 3-15 in Visit 01 (1)	10 Secs (40 Secs)	
							[==>(Pattern 1)]	[2]
							[==>(Pattern 2)]	[3]
							[==>(Pattern 3)]	[4]
							[==>(Pattern 4)]	
14	(WFC3UVI S.im.137578 0)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F280N	CR-SPLIT=NO; FLASH=12.0	Pattern 1, Exps 3-15 in Visit 01 (1)	10 Secs (40 Secs)	
							[==>(Pattern 1)]	[2]
							[==>(Pattern 2)]	[3]
							[==>(Pattern 3)]	[4]
							[==>(Pattern 4)]	
15	(WFC3UVI S.im.137577 2)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F280N	CR-SPLIT=NO; FLASH=12.0	Pattern 1, Exps 3-15 in Visit 01 (1)	360 Secs (1440 Secs)	
							[==>(Pattern 1)]	[2]
							[==>(Pattern 2)]	[3]
							[==>(Pattern 3)]	[4]
							[==>(Pattern 4)]	
16	(WFC3UVI S.im.137578 0)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F336W	CR-SPLIT=NO; FLASH=12.0		20 Secs X 2 (40 Secs)	
							[==>(Copy 1)]	[4]
							[==>(Copy 2)]	
17	(WFC3UVI S.im.115330 4)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS-QUAD-SUB	FQ437N	CR-SPLIT=NO; FLASH=12.0	Pattern 1, Exps 17-17 in Visit 01 (1)	30 Secs (120 Secs)	
							[==>(Pattern 1)]	[4]
							[==>(Pattern 2)]	
							[==>(Pattern 3)]	
							[==>(Pattern 4)]	









Proposal 16000 - Visit 02 - EVOLUTION OF RECENTLY DISCOVERED SPATIALLY RESOLVED JET/OUTFLOW IN THE SYMBIOTI...

<b>Visit</b>	<b>Proposal 16000, Visit 02, implementation</b> <span style="float: right;">Fri Feb 21 19:20:14 GMT 2020</span> <b>Diagnostic Status: Warning</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none)					
	<b>Diagnosics</b> (Exposure 17 (Pattern 1, Exps 17-17 in Visit 02)) Warning (Form): POS TARG & PATTERN should be used carefully with WFC3 quad filters to avoid placing the target on the vignettted part of the field of view or moving it to another quadrant.					
<b>Patterns</b>	<b>#</b>	<b>Primary Pattern</b>	<b>Secondary Pattern</b>	<b>Exposures</b>		
	(1)	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		(3-15), (17)	
<b>Fixed Targets</b>	<b>#</b>	<b>Name</b>	<b>Target Coordinates</b>	<b>Targ. Coord. Corrections</b>	<b>Fluxes</b>	<b>Miscellaneous</b>
	(1)	V-MW-560	RA: 07 25 51.2848 (111.4636867d)		V=11+/-1.0	Reference Frame: ICRS
Alt Name1: V694-MON Dec: -07 44 8.09 (-7.73558d) Alt Name2: DR1- Equinox: J2000 3054628260437829760 Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. Category=EXT-STAR Description=[ACCRETION DISK, JET, SYMBIOTIC STAR]						

Proposal 16000 - Visit 02 - EVOLUTION OF RECENTLY DISCOVERED SPATIALLY RESOLVED JET/OUTFLOW IN THE SYMBIOTI...

Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F656N	CR-SPLIT=NO; FLASH=12.0			360 Secs X 2 (720 Secs) [==>(Copy 1)] [==>(Copy 2)]	[1]
	2		(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F502N	CR-SPLIT=NO; FLASH=12.0			550 Secs X 2 (1100 Secs) [==>(Copy 1)] [==>(Copy 2)]	[1]
	3	(WFC3UVI S.im.141199 9)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F502N	CR-SPLIT=NO; FLASH=12.0		Pattern 1, Exps 3-15 in Visit 02 (1)	120 Secs (480 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1] [2] [3]
	4	(WFC3UVI S.im.141199 9)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F502N	CR-SPLIT=NO; FLASH=12.0		Pattern 1, Exps 3-15 in Visit 02 (1)	10 Secs (40 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1] [2] [3] [4]
	5	(WFC3UVI S.im.141199 9)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F502N	CR-SPLIT=NO; FLASH=12.0; BLADE=A		Pattern 1, Exps 3-15 in Visit 02 (1)	1 Secs (4 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1] [2] [3] [4]
	6	(WFC3UVI S.im.141199 8)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F656N	CR-SPLIT=NO; FLASH=12.0; BLADE=A		Pattern 1, Exps 3-15 in Visit 02 (1)	1 Secs (4 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1] [2] [3] [4]
	7	(WFC3UVI S.im.141199 8)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F656N	CR-SPLIT=NO; FLASH=12.0		Pattern 1, Exps 3-15 in Visit 02 (1)	30 Secs (120 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1] [2] [3] [4]
	8	(WFC3UVI S.im.137578 1)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F275W	CR-SPLIT=NO; FLASH=12.0		Pattern 1, Exps 3-15 in Visit 02 (1)	15 Secs (60 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[2] [3] [4]
	9	(WFC3UVI S.im.141222 9)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F373N	CR-SPLIT=NO; FLASH=12.0		Pattern 1, Exps 3-15 in Visit 02 (1)	3 Secs (12 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[2] [3] [4]

Proposal 16000 - Visit 02 - EVOLUTION OF RECENTLY DISCOVERED SPATIALLY RESOLVED JET/OUTFLOW IN THE SYMBIOTI...

10	(WFC3UVI S.im.141222 9)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F373N	CR-SPLIT=NO; FLASH=12.0	Pattern 1, Exps 3-15 in Visit 02 (1)	90 Secs (360 Secs)	[2]
							[==>(Pattern 1)]	
							[==>(Pattern 2)]	[3]
							[==>(Pattern 3)]	[4]
							[==>(Pattern 4)]	
11	(WFC3UVI S.im.141200 0)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F673N	CR-SPLIT=NO; FLASH=12.0; BLADE=A	Pattern 1, Exps 3-15 in Visit 02 (1)	1 Secs (4 Secs)	[2]
							[==>(Pattern 1)]	
							[==>(Pattern 2)]	[3]
							[==>(Pattern 3)]	[4]
							[==>(Pattern 4)]	
12	(WFC3UVI S.im.141200 0)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F673N	CR-SPLIT=NO; FLASH=12.0	Pattern 1, Exps 3-15 in Visit 02 (1)	30 Secs (120 Secs)	[2]
							[==>(Pattern 1)]	
							[==>(Pattern 2)]	[3]
							[==>(Pattern 3)]	[4]
							[==>(Pattern 4)]	
13	(WFC3UVI S.im.141200 1)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F547M	CR-SPLIT=NO; FLASH=12.0	Pattern 1, Exps 3-15 in Visit 02 (1)	0.5 Secs (2 Secs)	[2]
							[==>(Pattern 1)]	
							[==>(Pattern 2)]	[3]
							[==>(Pattern 3)]	[4]
							[==>(Pattern 4)]	
14	(WFC3UVI S.im.137578 0)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F280N	CR-SPLIT=NO; FLASH=12.0	Pattern 1, Exps 3-15 in Visit 02 (1)	10 Secs (40 Secs)	[2]
							[==>(Pattern 1)]	
							[==>(Pattern 2)]	[3]
							[==>(Pattern 3)]	[4]
							[==>(Pattern 4)]	
15	(WFC3UVI S.im.137577 2)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F280N	CR-SPLIT=NO; FLASH=12.0	Pattern 1, Exps 3-15 in Visit 02 (1)	360 Secs (1440 Secs)	[2]
							[==>(Pattern 1)]	
							[==>(Pattern 2)]	[3]
							[==>(Pattern 3)]	[4]
							[==>(Pattern 4)]	
16	(WFC3UVI S.im.137578 0)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F336W	CR-SPLIT=NO; FLASH=12.0		10 Secs X 3 (30 Secs)	[4]
							[==>(Copy 1)]	
							[==>(Copy 2)]	
							[==>(Copy 3)]	
17	(WFC3UVI S.im.115330 4)	(1) V-MW-560	WFC3/UVIS, ACCUM, UVIS-QUAD-SUB	FQ437N	CR-SPLIT=NO; FLASH=12.0	Pattern 1, Exps 17-17 in Visit 02 (1)	10 Secs (40 Secs)	[4]
							[==>(Pattern 1)]	
							[==>(Pattern 2)]	
							[==>(Pattern 3)]	
							[==>(Pattern 4)]	

