



14170 - A Complete Census: Mapping the Ly α Emission and Stellar Continuum in a Lensed Main-Sequence Galaxy at $z=2.39$ Hosting an AGN-driven Nuclear Outflow

Cycle: 23, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

<i>Name</i>	<i>Institution</i>	<i>E-Mail</i>
Dr. Eva Wuyts (PI) (ESA Member) (Contact)	Max-Planck-Institut fur extraterrestrische Physik	evawuyts@mpe.mpg.de
Prof. Michael D. Gladders (CoI) (AdminUSPI) (Contact)	University of Chicago	gladders@oddjjob.uchicago.edu
Dr. Jane R. Rigby (CoI)	NASA Goddard Space Flight Center	jane.r.rigby@nasa.gov
Prof. Keren Sharon (CoI)	University of Michigan	kerens@umich.edu
Dr. Matthew Bayliss (CoI)	Colby College	mbbayliss@gmail.com
Dr. Haakon Dahle (CoI) (ESA Member)	University of Oslo	hdahle@astro.uio.no
Prof. L Felipe Barrientos (CoI)	Pontificia Universidad Catolica de Chile	barrientos@astro.puc.cl
Mr. Michael Florian (CoI)	University of Chicago	mflorian@uchicago.edu
Ms. Traci Lin Johnson (CoI)	University of Michigan	tljohn@umich.edu

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) SGAS2-0033	WFC3/IR WFC3/UVIS	3	21-Jul-2015 21:58:42.0	yes
02	(1) SGAS2-0033	WFC3/IR WFC3/UVIS	2	21-Jul-2015 21:58:45.0	yes

5 Total Orbits Used

ABSTRACT

We propose to image the Ly-alpha and stellar continuum emission for an exceptionally bright lensed main-sequence galaxy at $z=2.39$. Its chance alignment close to a natural guide star (very rare for arcs in cluster environments) has allowed high signal-to-noise SINFONI+AO observations of all the rest-frame optical diagnostic emission lines ([OIII], H-beta, [OI], H-alpha, [NII] and [SII]). We find an underlying broad component with $\text{FWHM} \sim 740$ km/s in both the Balmer and forbidden lines, and measure line ratios which place the outflow robustly in the region of the BPT diagrams associated with AGN ionisation. At this redshift, Ly-alpha uniquely falls in the F410M WFC3 medium-band filter. With a modest investment of six orbits, we will map the Ly-alpha emission and stellar UV continuum of this source at spatial scales $\sim < 100$ pc - similar resolution to the SINFONI+AO data. This will allow us to compare the spatial extent and morphology (smooth or clumpy) of the Ly-alpha, UV and dust-corrected H-alpha emission and disentangle the effects of star formation and AGN ionisation on each tracer. This is a truly unique opportunity where a combination of gravitational lensing, AO guide star, the right source redshift, and the presence of a weak AGN allow a complete and magnified view of three main tracers of the physical conditions and structure of the interstellar medium in a star-forming galaxy at cosmic noon.

OBSERVING DESCRIPTION

This 5 orbit observation of a lensed AGN-hosting galaxy is intended to

1. measure the the Ly-A emission map of the galaxy using the F410M filter, in which the emission line is well-centered;
2. measure the continuum emission of the galaxy using four broad band filters spanning the available wavelength space redward of the Ly-A line (F555W,F814W,F105W,F140W).
3. search for an characterize secondary lensed features - of this galaxy , or others - that will aid in the reconstrcution of the lens mass model, critical to system characterization

The primary lensed source is remarkably bright, and so exposure time, per se, is not the dominant concern for the broad band observations. Rather, PSF reconstruction, and rejection of defects and cosmic rays is more of a concern. Extensive previous experience suggests an integration ratio of ~ 2 -2.5 to 1 for UVIS to IR works very well for high- z lensed galaxies, and we aim for that here.

Proposal 14170 (STScI Edit Number: 0, Created: Tuesday, July 21, 2015 8:58:46 PM EST) - Overview

Based on existing ground based data, the lensing appears to be due to a sub-cluster offset from the core of a main galaxy cluster. Since information about the main cluster (photometry, possibly weak and/or strong lensing signals) is of benefit to the lensing reconstruction of the targeted source, and because the sub- and main clusters can both be imaged in the same field, we have arranged the pointing to include both. This has the added benefit of moving the main lensed galaxy target off the center of the field, toward the readout registers in the UVIS channel, which aids in suppressing CTE loss effects.

A further issue is a consequence of the situation that makes this target so particularly compelling - namely that it has a bright (13th-15th mag, depending on filter) star quite nearby ($<10''$). Thus keeping exposures as reasonably short as possible (to avoid bleeding, minimize persistence etc), without otherwise compromising data quality via read noise etc, is important. The peak pixel counts are very similar in the IR channels - only very slightly brighter in F105W. The plan sketched below and implemented here in APT yields peak counts per pixel at about $1-3 \times 10^6$ (all values from BOT, much lower in the mid-band F410M filter). We have carefully evaluated the ghosting, diffraction spikes, and bleeding that can/do occur with such data, by examining in detail similarly bright stars in familiar data taken using similar strategies from the Large program GO13003 (PI:Gladders).

In all filters the biggest issue is diffraction spikes from the secondary supports. After that, filter ghosts are a concern in some cases, and in probably one UVIS filter very modest bleeding from saturation. For the IR channel there is the additional issue of persistence. In addition to the primary image of the lensed source, there are numerous possible secondary images suggested in the ground-based data, as well as a number of lensed galaxies; all of these must be characterised with the best possible fidelity to ensure best science return. Putting this all together we have chosen a specific orient to place the primary lensed image as well as all suggested possible secondary features, and lens galaxies, in regions free of both diffraction spikes and ghosts. NOTE - though this is a highly constrained roll angle, it is not itself highly constraining, as there are nearly 180 days available on this target for that angle, according to the Visit Roll Angle report.

There various considerations lead to the following plan:

- 1) We break the 5 orbits up into 2 visits of 3 and 2 orbits respectively. Each visit gets some F410M imaging, plus all the imaging for one IR filter, and one UVIS broadband filter (in the first orbit of the visit).
- 2) The 3 orbit visit contains 7 IR subframes, done at the start of each orbit, in a 3, 2, 2 arrangement. These are the shortest IR images (SPARS25, NSAMP=5) and are assigned to the filter in which the nearby star will be brightest (F105W). The two orbit visit contains 5 IR subframes, done at the

Proposal 14170 (STScI Edit Number: 0, Created: Tuesday, July 21, 2015 8:58:46 PM EST) - Overview

start of each orbit, in a 3, 2 arrangement. These are SPARS25, NSAMP=7 and are assigned to the other IR filter F140W. Total integration times are 712, 765 sec in F105W, F140W respectively. Dither patterns are simple 3pt line dithers for the 3-image orbits, and 2-point dithers for the 2-image orbits. This will yield reasonable PSF reconstruction, but keeps dithers small to avoid persistence spreading spatially. We do not require ultra-precise photometry, and are confident (based on past experience again) that we can flat-field out IR blobs to a level sufficient for our purposes. The IR 'death star' feature is also not of concern to us. Since the contiguous inter-orbit pointing stability is better than about 0.2 IR pixels, we also include a small POSTARG offset in the 3-orbit visit in order to further optimize the PSF sampling in the IR.

3) The first orbit in each visit, in addition to the beginning section with IR images, contains 4 UVIS broad band images. F555W is more sensitive, per second, than F814W, and so is placed in the 2-orbit visit where the IR imaging takes somewhat more time, and hence the F555W images are slightly shorter duration than the F814W images. Total integration times are 1748, 1900 sec in F555W, F814W respectively. The dither pattern is a single step across the chip gap, with a sub-pixel dither at each position. We have used this exact pattern effectively in other programs.

4) the remaining 2nd and 3rd orbits in one visit, and the 2nd orbit in the other, are assigned to F410M imaging. Since this is a filter only a few hundred Å wide, we wish to minimize the impact of readnoise (and added noise from FLASH) while at the same time maximizing PSF reconstruction, defect rejection, etc. Since there are three near-empty orbits available for this imaging, we simply use 2 exposures per orbit, each about 1200 sec long. The total integration time achieved is 7258 seconds. We use a simple 2-point line-dither for each image pair in one orbit, noting that the contiguous inter-orbit pointing uncertainty is 0.13-0.5 UVIS pixels (WFC3-2010-09), and so there is little point in attempting any more complex dither strategies here. We DO however add a simple POSTARG offset in Y of (0,1.2,-1.2) across the available three orbits in order to bridge the UVIS chip gap: this isn't relevant for the primary target, but costs basically nothing in exposure time, so we err on the conservative here.

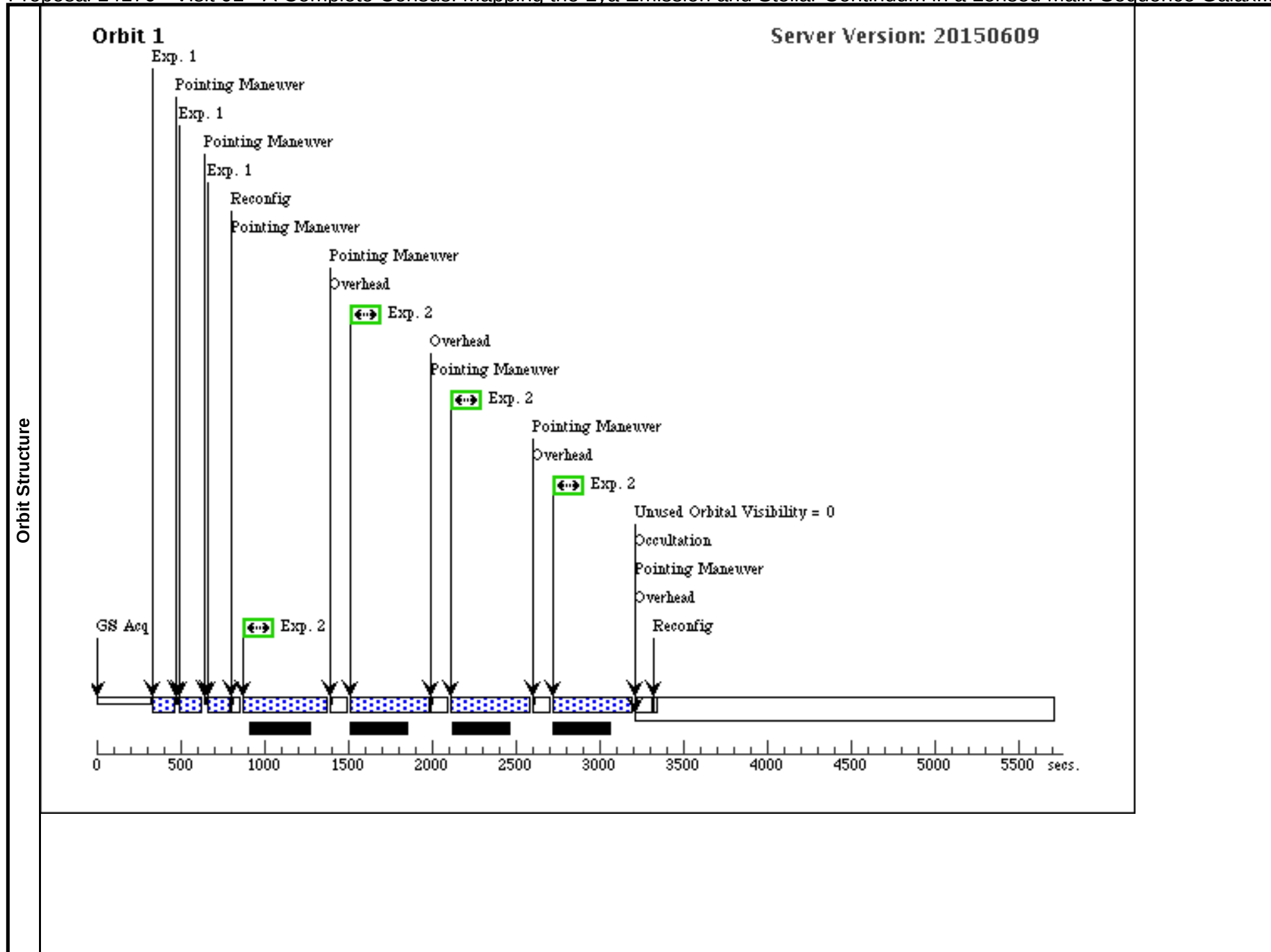
5) In all cases, on the UVIS side, FLASH is used if flagged by APT, to achieve a 12 count background level.

Proposal 14170 - Visit 01 - A Complete Census: Mapping the Ly α Emission and Stellar Continuum in a Lensed Main-Sequence Galax...

Visit	Proposal 14170, Visit 01 Wed Jul 22 01:58:46 GMT 2015				
	Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/IR, WFC3/UVIS Special Requirements: ORIENT 51.5D TO 52.5 D				
Patterns	#	Primary Pattern		Secondary Pattern	
	(1)	Pattern Type=WFC3-UVIS-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(4), (6)
	(7)	Pattern Type=WFC3-IR-DITHER-LINE-3PT Purpose=DITHER Number Of Points=3 Point Spacing=0.605 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=41.788 Angle Between Sides= Center Pattern=false		(1)
	(8)	Pattern Type=WFC3-UVIS-MOS-DITH-LINE Purpose=MOSAIC Number Of Points=2 Point Spacing=2.4 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=85.754 Angle Between Sides= Center Pattern=true	Pattern Type=WFC3-UVIS-MOS-DITH-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.119 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=33.606 Angle Between Sides= Center Pattern=false
	(9)	Pattern Type=WFC3-IR-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.636 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=41.788 Angle Between Sides= Center Pattern=false		(3), (5)
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes
	(1)	SGAS2-0033	RA: 00 33 40.0000 (8.4166667d) Dec: +02 42 51.20 (2.71422d) Equinox: J2000		V=20.3+/-0.10 Reference Frame: ICRS

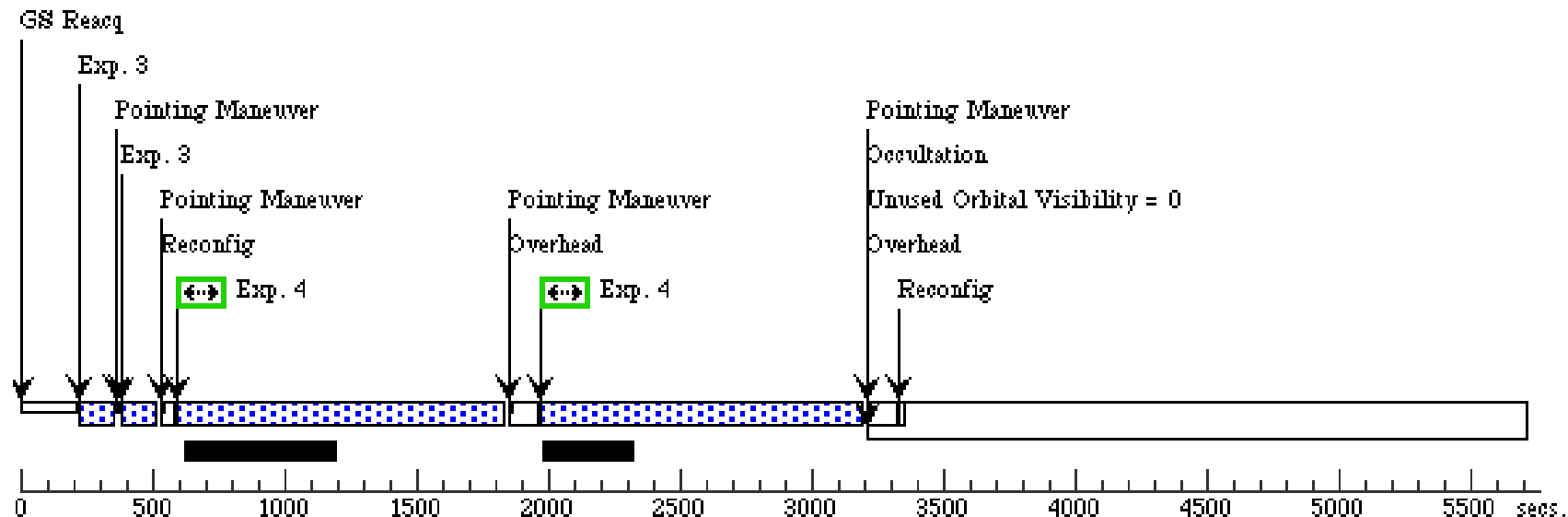
Proposal 14170 - Visit 01 - A Complete Census: Mapping the Ly α Emission and Stellar Continuum in a Lensed Main-Sequence Galax...

Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(1) SGAS2-0033	WFC3/IR, MULTIACCUM, IR-FIX	F105W	NSAMP=5; SAMP-SEQ=SPAR S25		Pattern 7, Exps 1-1 i n Visit 01 (7)	102.934351 Secs (308.803 Secs)	
									[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)]	[1]
	2		(1) SGAS2-0033	WFC3/UVIS, ACCUM, UVIS-CENTER	F814W	FLASH=2		Pattern 8, Exps 2-2 i n Visit 01 (8)	456 Secs (1900 Secs)	
									[==>475.0 Secs (Pattern 1,1)] [==>475.0 Secs (Pattern 1,2)] [==>475.0 Secs (Pattern 2,1)] [==>475.0 Secs (Pattern 2,2)]	[1]
	3		(1) SGAS2-0033	WFC3/IR, MULTIACCUM, IR-FIX	F105W	NSAMP=5; SAMP-SEQ=SPAR S25		Pattern 9, Exps 3-3 i n Visit 01 (9)	102.934351 Secs (205.869 Secs)	
									[==>(Pattern 1)] [==>(Pattern 2)]	[2]
	4		(1) SGAS2-0033	WFC3/UVIS, ACCUM, UVIS-CENTER	F410M	FLASH=8		Pattern 1, Exps 4-4 i n Visit 01 (1)	1197 Secs (2444 Secs)	
									[==>1222.0 Secs (Pattern 1)] [==>1222.0 Secs (Pattern 2)]	[2]
	5		(1) SGAS2-0033	WFC3/IR, MULTIACCUM, IR-FIX	F105W	NSAMP=5; SAMP-SEQ=SPAR S25	POS TARG 0.0325,0 .0325	Pattern 9, Exps 5-5 i n Visit 01 (9)	102.934351 Secs (205.869 Secs)	
									[==>(Pattern 1)] [==>(Pattern 2)]	[3]
	6		(1) SGAS2-0033	WFC3/UVIS, ACCUM, UVIS-CENTER	F410M	FLASH=8	POS TARG null,1.2	Pattern 1, Exps 6-6 i n Visit 01 (1)	1197 Secs (2466 Secs)	
									[==>1233.0 Secs (Pattern 1)] [==>1233.0 Secs (Pattern 2)]	[3]



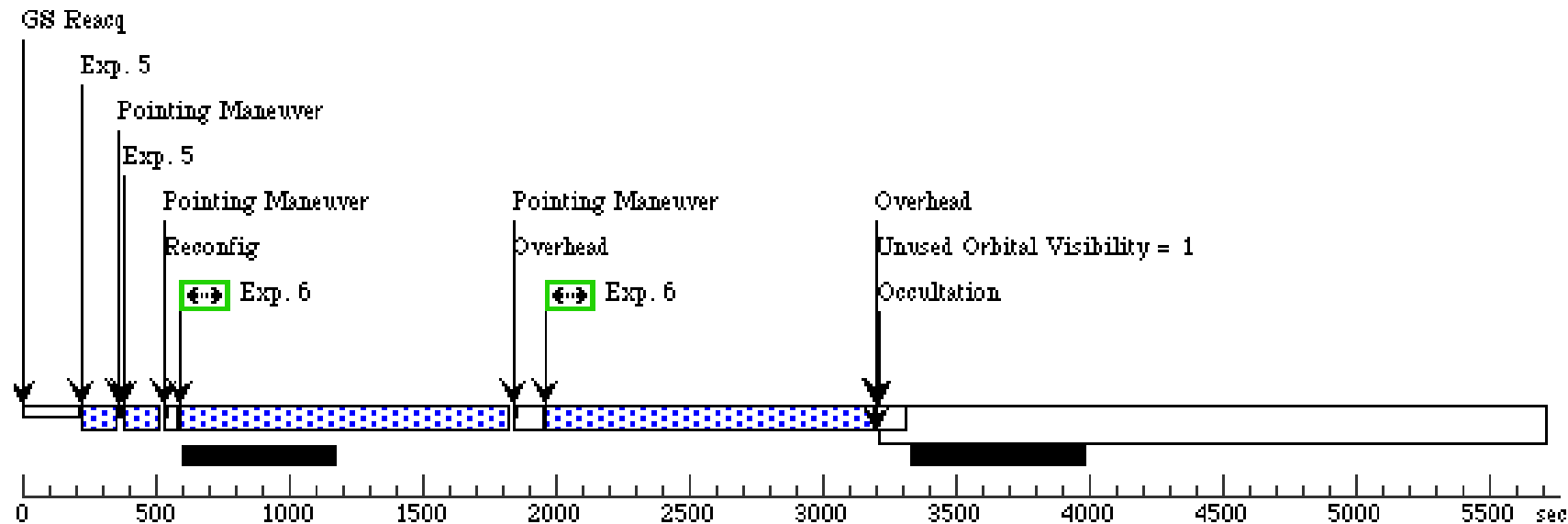
Orbit 2

Server Version: 20150609



Orbit 3

Server Version: 20150609



Proposal 14170 - Visit 02 - A Complete Census: Mapping the Ly α Emission and Stellar Continuum in a Lensed Main-Sequence Galax...

Visit	Proposal 14170, Visit 02 Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/IR, WFC3/UVIS Special Requirements: SAME ORIENT AS 01					Wed Jul 22 01:58:47 GMT 2015
Patterns	#	Primary Pattern		Secondary Pattern		Exposures
	(1)	Pattern Type=WFC3-UVIS-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false			(4)
	(7)	Pattern Type=WFC3-IR-DITHER-LINE-3PT Purpose=DITHER Number Of Points=3 Point Spacing=0.605 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=41.788 Angle Between Sides= Center Pattern=false			(1)
	(8)	Pattern Type=WFC3-UVIS-MOS-DITH-LINE Purpose=MOSAIC Number Of Points=2 Point Spacing=2.4 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=85.754 Angle Between Sides= Center Pattern=true	Pattern Type=WFC3-UVIS-MOS-DITH-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.119 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=33.606 Angle Between Sides= Center Pattern=false	(2)
	(9)	Pattern Type=WFC3-IR-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.636 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=41.788 Angle Between Sides= Center Pattern=false			(3)
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
	(1)	SGAS2-0033	RA: 00 33 40.0000 (8.4166667d) Dec: +02 42 51.20 (2.71422d) Equinox: J2000		V=20.3+/-0.10	Reference Frame: ICRS

Proposal 14170 - Visit 02 - A Complete Census: Mapping the Ly α Emission and Stellar Continuum in a Lensed Main-Sequence Galax...

Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(1) SGAS2-0033	WFC3/IR, MULTIACCUM, IR-FIX	F140W	NSAMP=7; SAMP-SEQ=SPAR S25		Pattern 7, Exps 1-1 i n Visit 02 (7)	152.935381 Secs (458.806 Secs)	
									[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)]	[1]
	2		(1) SGAS2-0033	WFC3/UVIS, ACCUM, UVIS-CENTER	F555W	FLASH=2		Pattern 8, Exps 2-2 i n Visit 02 (8)	381 Secs (1748 Secs)	
									[==>437.0 Secs (Pattern 1,1)] [==>437.0 Secs (Pattern 1,2)] [==>437.0 Secs (Pattern 2,1)] [==>437.0 Secs (Pattern 2,2)]	[1]
	3		(1) SGAS2-0033	WFC3/IR, MULTIACCUM, IR-FIX	F105W	NSAMP=7; SAMP-SEQ=SPAR S25		Pattern 9, Exps 3-3 i n Visit 02 (9)	152.935381 Secs (305.871 Secs)	
									[==>(Pattern 1)] [==>(Pattern 2)]	[2]
	4		(1) SGAS2-0033	WFC3/UVIS, ACCUM, UVIS-CENTER	F410M	FLASH=8	POS TARG null,-1.2	Pattern 1, Exps 4-4 i n Visit 02 (1)	1197 Secs (2346 Secs)	
									[==>1173.0 Secs (Pattern 1)] [==>1173.0 Secs (Pattern 2)]	[2]

