



## 13702 - Mapping the LyC-Emitting Regions of Local Galaxies

Cycle: 22, Proposal Category: GO

(Availability Mode: SUPPORTED)

### 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) HARO-11	ACS/WFC	1	23-Jan-2015 21:03:41.0	yes
02	(1) HARO-11	WFC3/UVIS	3	23-Jan-2015 21:03:43.0	yes
03	(1) HARO-11	WFC3/UVIS	1	23-Jan-2015 21:03:44.0	yes
04	(2) TOLOLO-1247-232	ACS/WFC	1	23-Jan-2015 21:03:45.0	yes
05	(2) TOLOLO-1247-232	ACS/WFC	5	23-Jan-2015 21:03:47.0	yes
06	(2) TOLOLO-1247-232	WFC3/UVIS	1	23-Jan-2015 21:03:48.0	yes

12 Total Orbits Used

### ABSTRACT

We propose to map the optically thin regions in the only two, known Lyman-continuum (LyC) emitting galaxies in the local universe, Haro 11 and Tol 1247-232. This will be done with the recently developed technique of ionization-parameter mapping (IPM), based on nebular emission-line imaging. We will use ACS/WFC and WFC3/UVIS to carry out narrow-band imaging in [O II] and [O III], as well as nearby continuum, where

necessary. Together with existing data, our results will clarify the conditions for LyC emission and will yield more realistic estimates of the escape fraction of LyC radiation from these galaxies.

## **OBSERVING DESCRIPTION**

We plan to carry out ionization-parameter mapping with narrow-band imaging in [Oiii] 4959,5007 and [Oii] 3727 for Haro 11 and Tol 1247-232. We will also require continuum imaging to generate continuum-subtracted, emission-line images.

Haro 11 and Tol 1247-232 are redshifted to  $z = 0.0206$  and  $0.0480$ , respectively. The ACS ramp filters will allow us to tune the bandpasses to the necessary redshifted emission-line wavelengths, which is necessary for Tol 1247-232. Haro 11 is also accessible with WFC3 narrow-band filters, so we choose the instruments according to sensitivity. For the ACS ramp filters, FR505N is used for [Oiii] imaging, and its 2% bandpass corresponds to a width of about 100 Å. This allows obtaining both [Oiii] 4959,5007 simultaneously, while centering the bandpass to avoid H-beta 4861. We will use FR388N for [Oii] imaging of Tol 1247-232, and its 2% bandpass corresponds to about 78 Å width. The nearest bright emission line is [Ne iii] 3869, which is too far to be a contamination concern. For Haro 11, we use WFC3/UVIS FQ378N, which similarly excludes [Ne iii].

The angular sizes of the target galaxies are only a few arcsec, so they will easily fit within the ramp filter monochromatic regions on the order of 30 arcsec diameter, which correspond to one ACS quadrant. We will therefore only require readout of the WFC1-MRAMPQ quadrant on ACS. Haro 11 similarly fits easily within a WFC/UVIS quadrant, as necessary for using the FQ378N quadrant filter.

We can estimate our exposure times by scaling directly from the existing HST H-alpha observations. Haro 11 was observed by ACS/WFC FR656N for 680 s. We need to obtain a  $S/N = 10$  in the outer, low surface-brightness regions in each of [Oii] and [Oiii]. This corresponds to surface brightness of about  $5 \times 10^{-15} \text{ erg s}^{-1} \text{ cm}^{-2} \text{ arcsec}^{-2}$ , according to the ACS Ramp Filter ETC. For Haro 11, the measured reddening in Knot C implies that we need an additional factor of 1.2 in depth at [Oiii] relative to H-alpha (James et al. 2013). We can obtain the corresponding depth in 3 x 800 s in FR505N centered at 5110 Å (1 ACS orbit). We compared with the WFC3/UVIS F508N, but find that ACS FR505N is more efficient. For [Oii] at 3803 Å, however, WFC3 FQ378N is much more efficient than ACS FR388N. At [Oii], the aggregate reddening implies a factor of 1.5 deeper exposures than at H-alpha. Since we expect the reddening to be much lower in the outer, low surface-brightness regions, we aim for a factor of 1.3 deeper than the existing H-alpha data, since the sensitivity is so much worse at this wavelength. The corresponding depth can be achieved with 6 x 1200 s in WFC3 FQ378N (3 WFC3 orbits).

## Proposal 13702 (STScI Edit Number: 2, Created: Friday, January 23, 2015 9:03:49 PM EST) - Overview

The redshift of Tol 1247-232 requires using the ACS ramp filters. It turns out that this galaxy has the same reddening as Haro 11, Knot C ( $c(H\text{-beta})=0.3$ ; Terlevich et al. 1993), and so we request the same depth observations as for Haro 11 in both bands. For [Oiii], we again use ACS filter FR505N, now centered at 5247 Å, with the same 2400-s exposure time (1 ACS orbit). For [Oii], we observe with FR388N for an exposure time of 10 x 1200 s, centered at 3906 Å (5 ACS orbits). Thus, our emission-line observations require a total of 7 ACS orbits and 3 WFC3 orbits.

We will need continuum observations that are uncontaminated by line emission to obtain the best continuum subtraction for our targeted emission-line observations. Note that we also plan to make use of the existing H-alpha observations, so we need to ensure that we will have continuum observations for these, too. There are sufficient existing HST continuum observations for Haro 11 in [Oiii]: 471 s in ACS/WFC F550M, which the ACS ETC shows is perfectly matched to the depth of our total proposed [Oiii] observations in FR505N. There is also a 600-s exposure in F775W by WFC3 for Tol 1247-232, which serves as continuum for H-alpha. The remaining bands will need either new or supplementary observations.

The [Oii] continuum observations need to be obtained with the more blue-sensitive WFC3, since there is no U filter on ACS. We therefore propose to obtain all the other continuum data with this instrument. For Haro 11, the existing ACS/HRC F330W data are only 1/3 as deep as we require, and so we propose to obtain about 600 s x 2 with WFC3/UVIS in F336W. There are no suitable H-alpha continuum data for this galaxy, so we also will obtain about 300 s x 2 in F763M. For Tololo 1247-232, there is no available [Oiii] continuum, so we plan to obtain 300 s x 3 in F547M. The existing F336W data are also about 25% shallower than the depth needed, so we include an additional 900-s frame to supplement this. Thus we request 1 orbit for each galaxy using WFC3 to obtain continuum data.

All multiple observations will be dithered. Our request totals 7 ACS orbits and 5 WFC3 orbits.

Proposal 13702 - Haro 11 [O III] (01) - Mapping the LyC-Emitting Regions of Local Galaxies

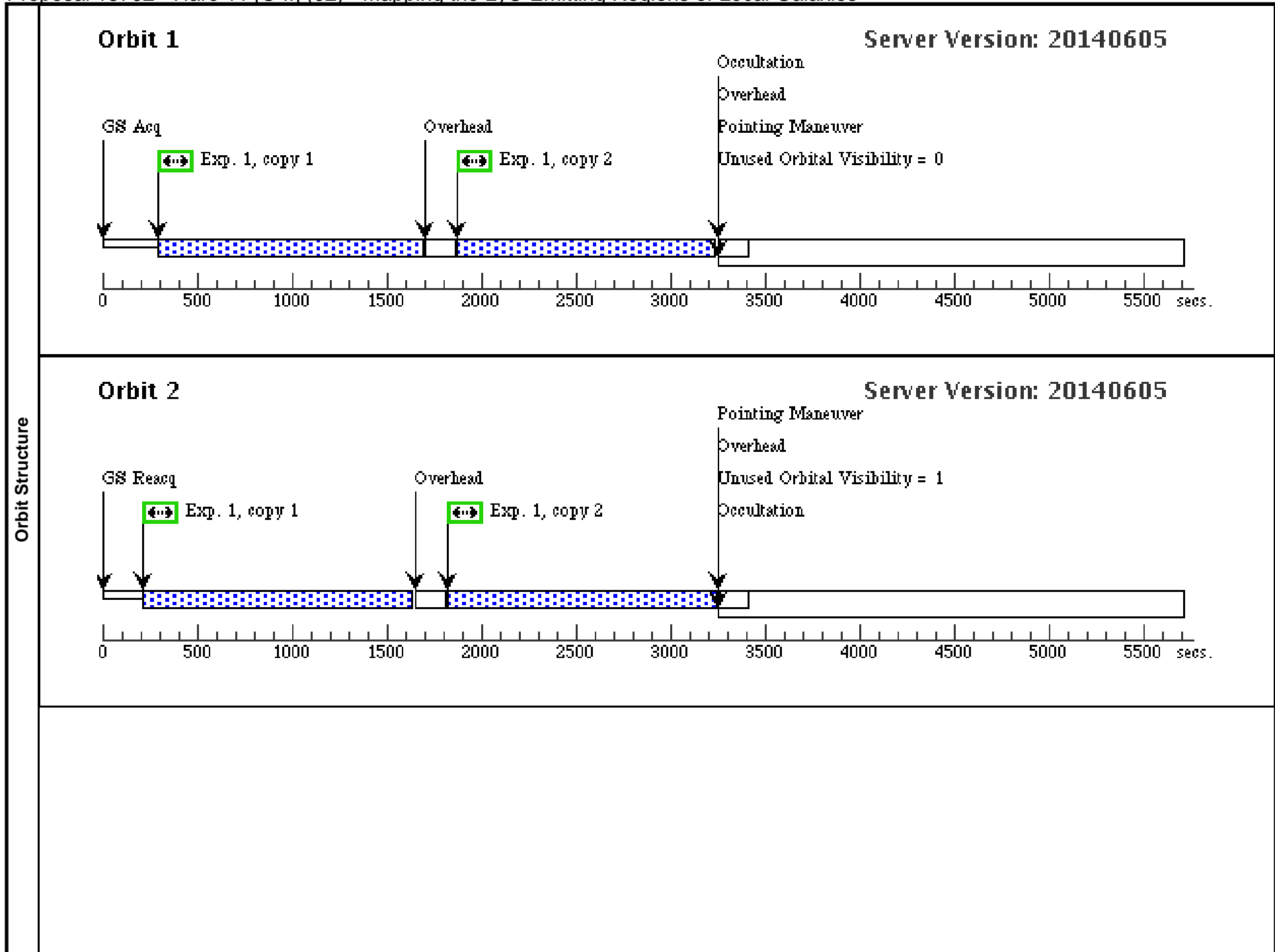
Sat Jan 24 02:03:49 GMT 2015

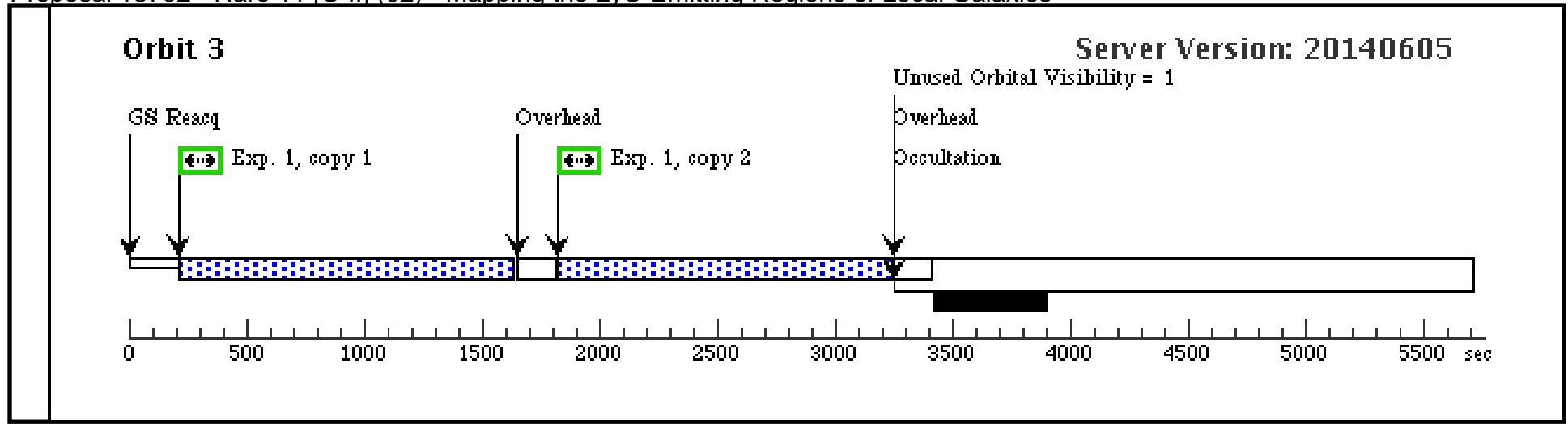
<b>Visit</b>	Proposal 13702, Haro 11 [O III] (01), implementation Diagnostic Status: Warning Scientific Instruments: ACS/WFC Special Requirements: (none)									
	(Exposure 1 (Pattern 5, Exps 1-1 in Haro 11 [O III] (01))) Warning (Form): POS TARG & PATTERN should be used carefully with ACS ramp or WFC3 quad filters as central wavelengths & transmission efficiencies vary within the apertures.									
<b>Diagnosics</b>										
<b>Patterns</b>	#	Primary Pattern		Secondary Pattern	Exposures					
	(5)	Pattern Type=ACS-WFC-DITHER-LINE Purpose=DITHER Number Of Points=3 Point Spacing=3.011 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=85.28 Angle Between Sides= Center Pattern=false		(1)					
<b>Fixed Targets</b>	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	HARO-11	RA: 00 36 52.6992 (9.2195800d) Dec: -33 33 16.99 (-33.55472d) Equinox: J2000		V=13.8+/-0.2 5e-15 erg s-1 cm-2 arcsec-2	Reference Frame: NED				
Comments: This object was generated by the targetselector and retrieved from the NED database. Data confirmed and updated. Surface brightness represents desired depth for diffuse outer regions.										
<b>Exposures</b>	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	(1) HARO-11		ACS/WFC, ACCUM, WFC1-MRAMP	FR505N 5110 A			Pattern 5, Exps 1-1 in Haro 11 [O III] (01) (5)	743 Secs (2379 Secs) [==>793.0 Secs (Pattern 1)] [==>793.0 Secs (Pattern 2)] [==>793.0 Secs (Pattern 3)]	[1]
<b>Orbit Structure</b>	Orbit 1 <span style="float: right;">Server Version: 20140605</span>									
	<p>                     GS Acq [Exp. 1]      Pointing Maneuver      Pointing Maneuver      Unused Orbital Visibility = 1                      [Exp. 1]      [Exp. 1]      [Exp. 1]      Occultation                 </p> <p>0      500      1000      1500      2000      2500      3000      3500      4000      4500      5000      5500 sec</p>									

Proposal 13702 - Haro 11 [O II] (02) - Mapping the LyC-Emitting Regions of Local Galaxies

Sat Jan 24 02:03:50 GMT 2015

<b>Visit</b>	Proposal 13702, Haro 11 [O II] (02), scheduling Diagnostic Status: Warning Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	(Exposure 1 (Pattern 2, Exps 1-1 in Haro 11 [O II] (02))) Warning (Form): POS TARG & PATTERN should be used carefully with ACS ramp or WFC3 quad filters as central wavelengths & transmission efficiencies vary within the apertures.									
<b>Diagnosics</b>										
<b>Patterns</b>	#	Primary Pattern	Secondary Pattern	Exposures						
	(2)	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		(1)					
<b>Fixed Targets</b>	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	HARO-11	RA: 00 36 52.6992 (9.2195800d)		V=13.8+/-0.2	Reference Frame: NED				
		Alt Name1: ESO-350-IG-038	Dec: -33 33 16.99 (-33.55472d)		5e-15 erg s-1 cm-2 arcsec-2					
		Equinox: J2000 Comments: This object was generated by the targetselector and retrieved from the NED database. Data confirmed and updated. Surface brightness represents desired depth for diffuse outer regions.								
<b>Exposures</b>	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	(1) HARO-11		WFC3/UVIS, ACCUM, UVIS-QUAD-SUB	FQ378N	FLASH=12		Pattern 2, Exps 1-1 in Haro 11 [O II] (02) (2)	1200 Secs X 2 (8416 Secs)	
									[==>1366.0 Secs (Pattern 1, Copy 1)]	[1]
									[==>1366.0 Secs (Pattern 1, Copy 2)]	
									[==>1421.0 Secs (Pattern 2, Copy 1)]	[2]
								[==>1421.0 Secs (Pattern 2, Copy 2)]		
								[==>1421.0 Secs (Pattern 3, Copy 1)]	[3]	
								[==>1421.0 Secs (Pattern 3, Copy 2)]		

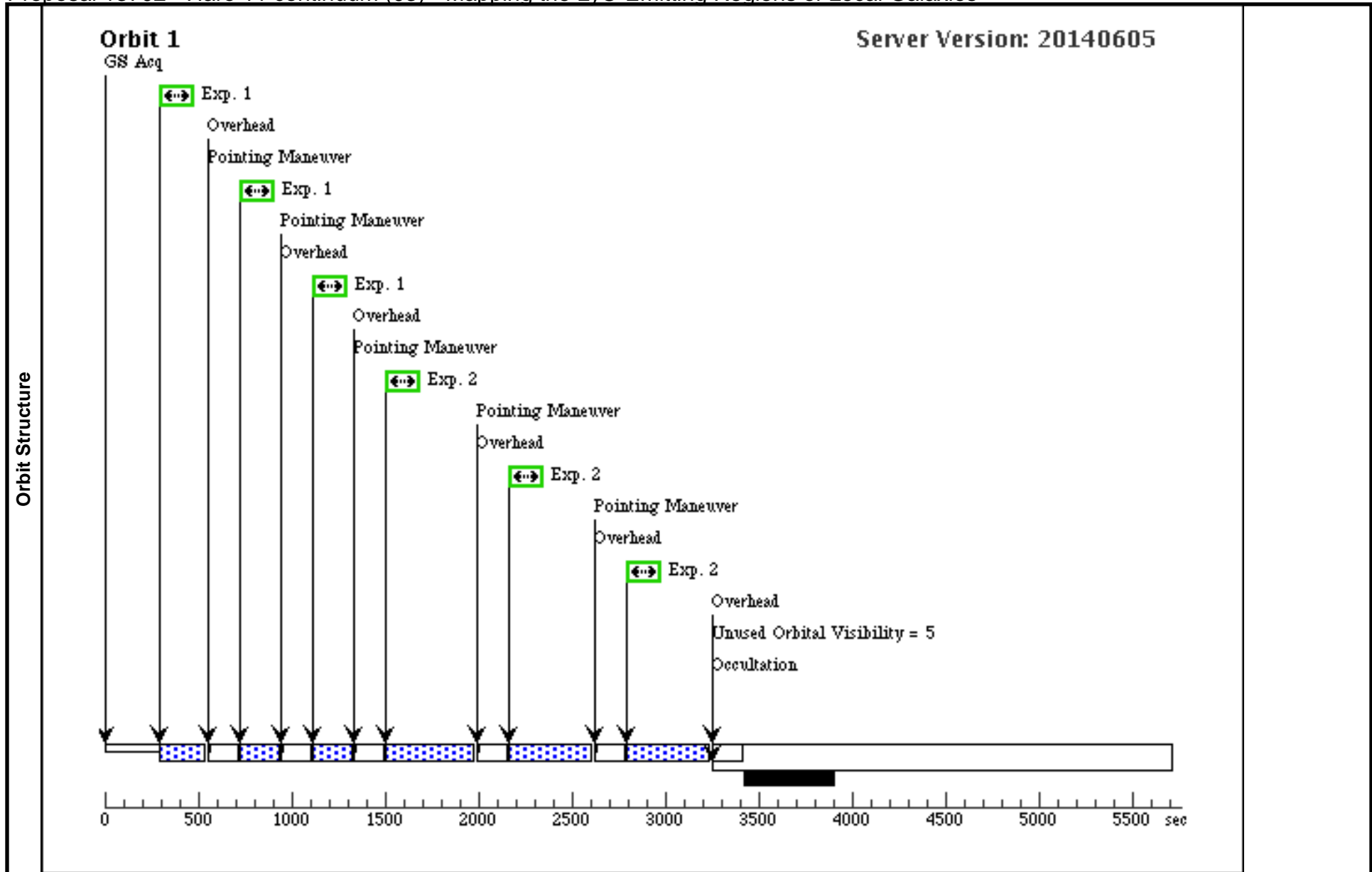




Proposal 13702 - Haro 11 continuum (03) - Mapping the LyC-Emitting Regions of Local Galaxies

Sat Jan 24 02:03:50 GMT 2015

Visit	<b>Proposal 13702, Haro 11 continuum (03), scheduled</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	Patterns	#	Primary Pattern	Secondary Pattern	Exposures					
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Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	HARO-11	RA: 00 36 52.6992 (9.2195800d) Dec: -33 33 16.99 (-33.55472d) Equinox: J2000		V=13.8+/-0.2 5e-15 erg s-1 cm-2 arcsec-2	Reference Frame: NED				
<i>Comments: This object was generated by the targetselector and retrieved from the NED database.                      Data confirmed and updated.</i> <i>Surface brightness represents desired depth for diffuse outer regions.</i>										
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	H-alpha cont inuum	(1) HARO-11	WFC3/UVIS, ACCUM, UVIS1-2K2B-SUB	F763M	FLASH=12		Pattern 2, Exps 1-1 in Haro 11 continuum (03) (2)	200 Secs (627 Secs)	
									[==>209.0 Secs (Pattern 1)] [==>209.0 Secs (Pattern 2)] [==>209.0 Secs (Pattern 3)]	[1]
2	[O II] continuum (U-band)	(1) HARO-11	WFC3/UVIS, ACCUM, UVIS1-2K2B-SUB	F336W	FLASH=12			Pattern 2, Exps 2-2 in Haro 11 continuum (03) (2)	435 Secs (1332 Secs)	
									[==>444.0 Secs (Pattern 1)] [==>444.0 Secs (Pattern 2)] [==>444.0 Secs (Pattern 3)]	[1]



<b>Visit</b>	<b>Proposal 13702, Tol 1247 [O III] (04), implementation</b> <b>Diagnostic Status: Warning</b> Scientific Instruments: ACS/WFC Special Requirements: ORIENT 290D TO 324 D
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<b>Diagnostics</b>	(Exposure 1 (Pattern 5, Exps 1-1 in Tol 1247 [O III] (04))) Warning (Form): POS TARG & PATTERN should be used carefully with ACS ramp or WFC3 quad filters as central wavelengths & transmission efficiencies vary within the apertures.
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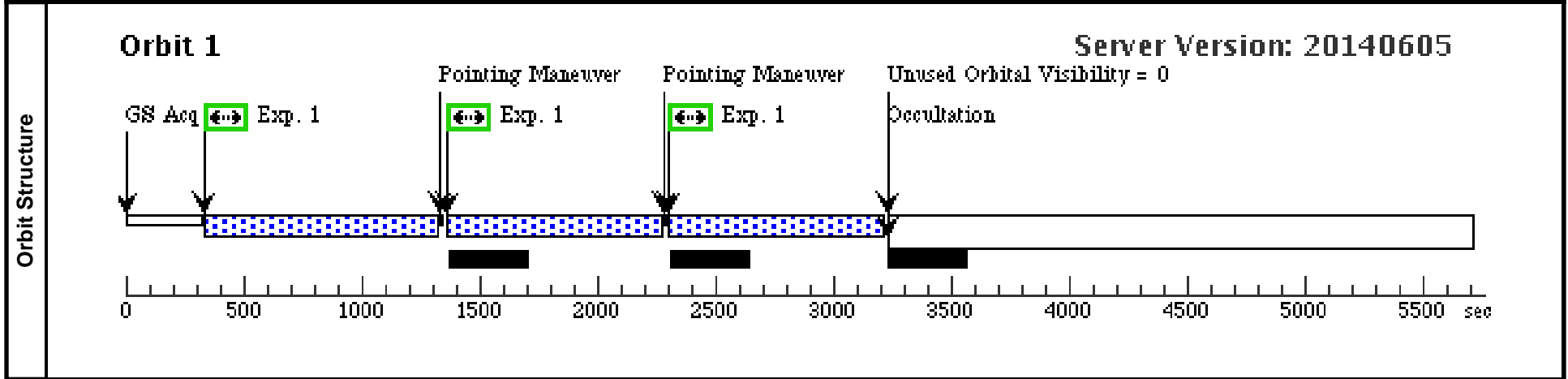
<b>Patterns</b>	#	Primary Pattern	Secondary Pattern	Exposures
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<b>Fixed Targets</b>	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
	(2)	TOLOLO-1247-232	RA: 12 50 18.9000 (192.5787500d) Dec: -23 33 57.60 (-23.56600d) Equinox: J2000		V=15.4+/-0.1 5e-15 erg s-1 cm-2 arcsec-2	Reference Frame: NED

*Comments: This object was generated by the targetselector and retrieved from the NED database. Data confirmed and updated.*

*Surface brightness represents desired depth for diffuse outer regions.*

<b>Exposures</b>	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(2) TOLOLO-1247-232		ACS/WFC, ACCUM, WFC1-MRAMP	FR505N 5247 A			Pattern 5, Exps 1-1 in Tol 1247 [O III] (04) (5)	735 Secs (2355 Secs) [==>785.0 Secs (Pattern 1)] [==>785.0 Secs (Pattern 2)] [==>785.0 Secs (Pattern 3)]



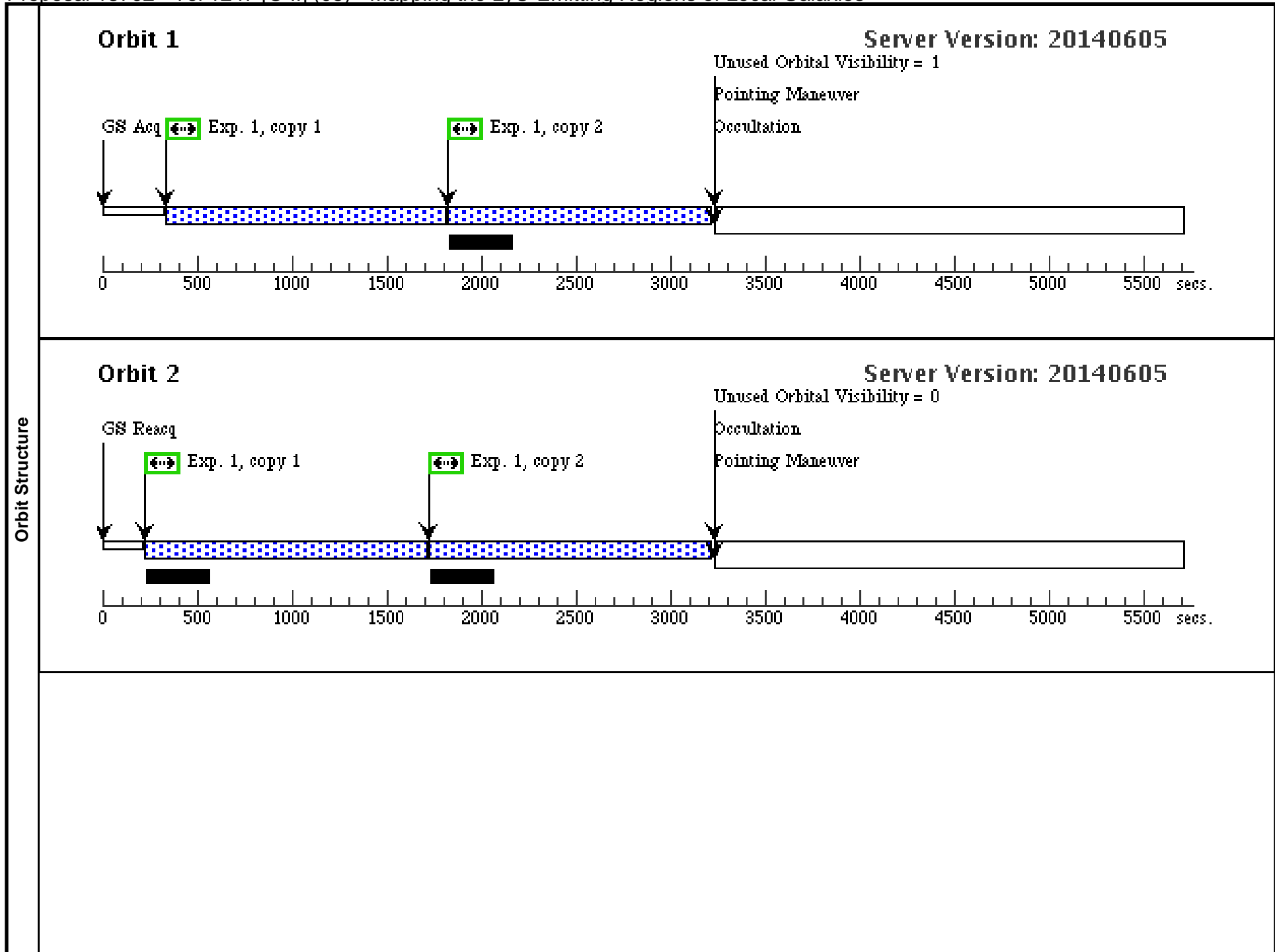
Proposal 13702 - Tol 1247 [O II] (05) - Mapping the LyC-Emitting Regions of Local Galaxies

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<b>Visit</b>	<b>Proposal 13702, Tol 1247 [O II] (05), implementation</b> <b>Diagnostic Status: Warning</b> Scientific Instruments: ACS/WFC Special Requirements: ORIENT 22D TO 70 D					
	(Exposure 1 (Pattern 4, Exps 1-1 in Tol 1247 [O II] (05))) Warning (Form): POS TARG & PATTERN should be used carefully with ACS ramp or WFC3 quad filters as central wavelengths & transmission efficiencies vary within the apertures. (Exposure 2 (Pattern 1, Exps 2-2 in Tol 1247 [O II] (05))) Warning (Form): POS TARG & PATTERN should be used carefully with ACS ramp or WFC3 quad filters as central wavelengths & transmission efficiencies vary within the apertures.					
<b>Diagnosics</b>						
<b>Patterns</b>	<b>#</b>	<b>Primary Pattern</b>	<b>Secondary Pattern</b>	<b>Exposures</b>		
	(1)	Pattern Type=ACS-WFC-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=3.011 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=85.28 Angle Between Sides= Center Pattern=false	(2)		
(4)	Pattern Type=ACS-WFC-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.265 Line Spacing=0.187	Coordinate Frame=POS-TARG Pattern Orientation=20.67 Angle Between Sides=69.05 Center Pattern=false	(1)			
<b>Fixed Targets</b>	<b>#</b>	<b>Name</b>	<b>Target Coordinates</b>	<b>Targ. Coord. Corrections</b>	<b>Fluxes</b>	<b>Miscellaneous</b>
	(2)	TOLOLO-1247-232	RA: 12 50 18.9000 (192.5787500d) Dec: -23 33 57.60 (-23.56600d) Equinox: J2000		V=15.4+/-0.1 5e-15 erg s-1 cm-2 arcsec-2	Reference Frame: NED
<i>Comments: This object was generated by the targetselector and retrieved from the NED database.                  Data confirmed and updated.</i>						
<i>Surface brightness represents desired depth for diffuse outer regions.</i>						

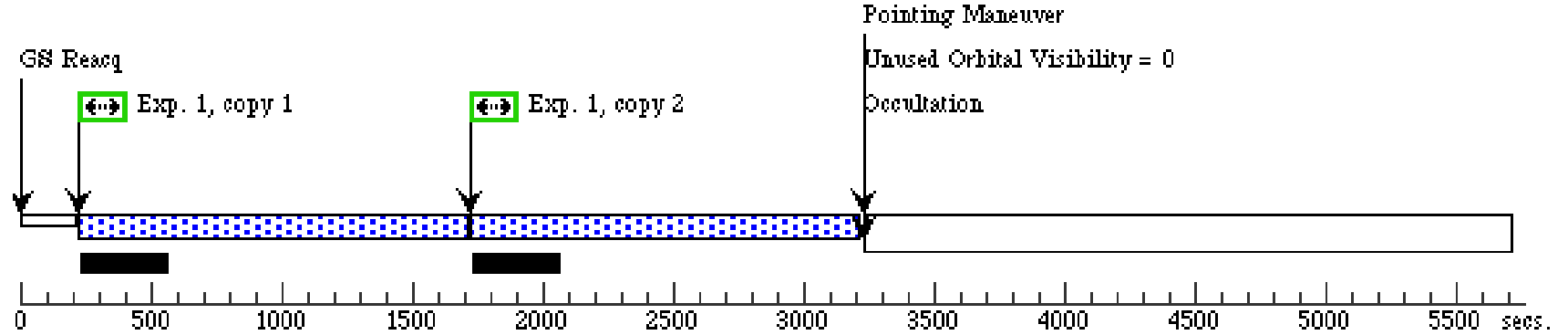
Proposal 13702 - Tol 1247 [O II] (05) - Mapping the LyC-Emitting Regions of Local Galaxies

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
<b>Exposures</b>	1	(2) TOLOLO-1247-2 32	ACS/WFC, ACCUM, WFC1-MRAMP	FR388N 3906 A			Pattern 4, Exps 1-1 i n Tol 1247 [O II] (05 ) (4)	1250 Secs X 2 (10742 Secs)	
								[==>1270.0 Secs (Pattern 1, Copy 1)]	[1]
								[==>1270.0 Secs (Pattern 1, Copy 2)]	
								[==>1367.0 Secs (Pattern 2, Copy 1)]	[2]
								[==>1367.0 Secs (Pattern 2, Copy 2)]	
								[==>1367.0 Secs (Pattern 3, Copy 1)]	[3]
								[==>1367.0 Secs (Pattern 3, Copy 2)]	
								[==>1367.0 Secs (Pattern 4, Copy 1)]	[4]
							[==>1367.0 Secs (Pattern 4, Copy 2)]		
2	(2) TOLOLO-1247-2 32	ACS/WFC, ACCUM, WFC1-MRAMP	FR388N 3906 A				Pattern 1, Exps 2-2 i n Tol 1247 [O II] (05 ) (1)	1200 Secs (2710 Secs)	
								[==>1355.0 Secs (Pattern 1)]	[5]
								[==>1355.0 Secs (Pattern 2)]	



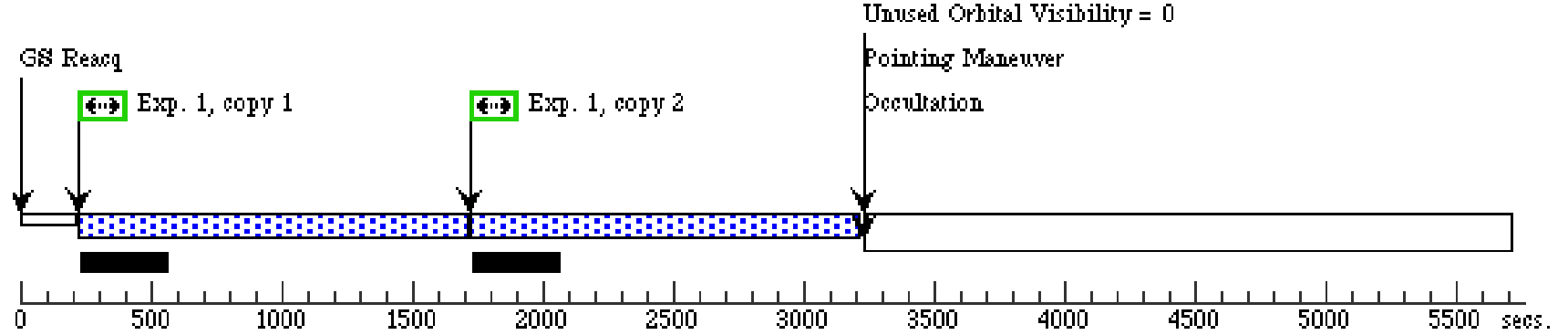
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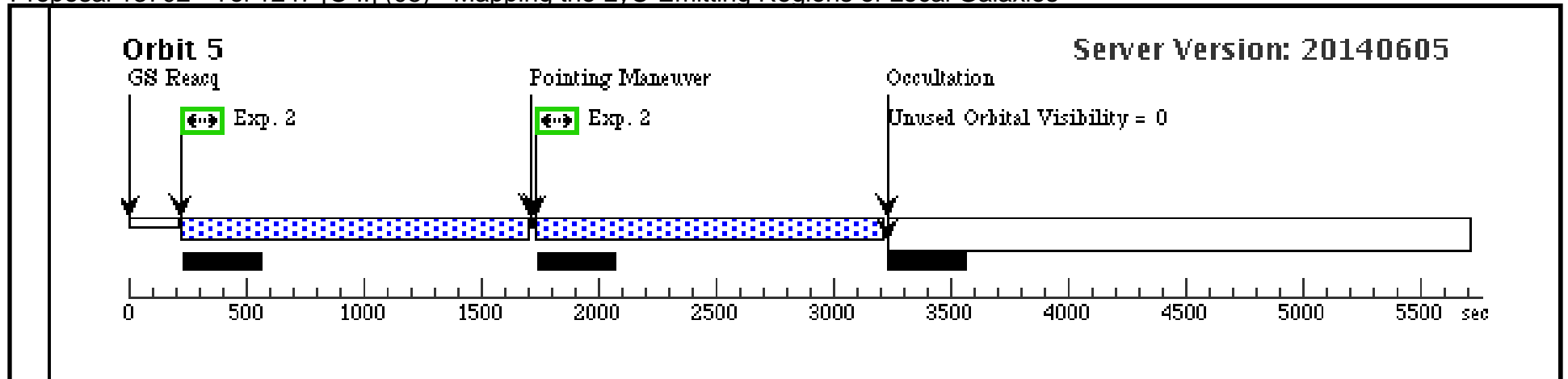
Server Version: 20140605



### Orbit 4

Server Version: 20140605





Proposal 13702 - Tol 1247 continuum (06) - Mapping the LyC-Emitting Regions of Local Galaxies

Sat Jan 24 02:03:50 GMT 2015

Visit	<b>Proposal 13702, Tol 1247 continuum (06), scheduling</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
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Patterns	(2)	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		(1)						
	(3)	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		(2)						
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(2)	TOLOLO-1247-232	RA: 12 50 18.9000 (192.5787500d) Dec: -23 33 57.60 (-23.56600d) Equinox: J2000		V=15.4+/-0.1 5e-15 erg s-1 cm-2 arcsec-2	Reference Frame: NED				
<i>Comments: This object was generated by the targetselector and retrieved from the NED database. Data confirmed and updated.</i> <i>Surface brightness represents desired depth for diffuse outer regions.</i>										
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	[O III] continuum	(2) TOLOLO-1247-232	WFC3/UVIS, ACCUM, UVIS1-2K2B-SUB	F547M	FLASH=12			Pattern 2, Exps 1-1 in Tol 1247 continuum (06) (2)	300 Secs (1095 Secs) [==>365.0 Secs (Pattern 1)] [==>365.0 Secs (Pattern 2)] [==>365.0 Secs (Pattern 3)]
2	[O II] continuum (U-band)	(2) TOLOLO-1247-232	WFC3/UVIS, ACCUM, UVIS1-2K2B-SUB	F336W	FLASH=12			Pattern 3, Exps 2-2 in Tol 1247 continuum (06) (3)	450 Secs (1030 Secs) [==>515.0 Secs (Pattern 1)] [==>515.0 Secs (Pattern 2)]	[1]

