12539 - A novel approach to find Lyman continuum leaking galaxies at z~0.3 with COS

Cycle: 19, 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) J143004.07+022213.3	COS/FUV COS/NUV	2	06-Feb-2012 21:01:08.0	yes
02	(2) J143832.04+390333.7	COS/FUV COS/NUV	2	06-Feb-2012 21:01:15.0	yes
03	(3) J080250.09+190119.2	COS/FUV COS/NUV	2	06-Feb-2012 21:01:20.0	yes
04	(4) J154459.66+115017.5	COS/FUV COS/NUV	2	06-Feb-2012 21:01:27.0	yes

8 Total Orbits Used

ABSTRACT

What drives the early phase of cosmic reionization is poorly known. Numerous low to intermediate-mass star forming galaxies are the most promising candidates, but the problem is to understand how the ionizing radiation can leak out into the intergalactic medium. Models indeed predict the escape of LyC radiation from dwarf starburst galaxies under certain conditions, but it has proven to be observationally very difficult to confirm this in the local galaxy sample. Except in very few reported cases the envelope of neutral gas seems to halt all Lyman continuum photons.

To better understand this discrepancy, we here propose to observe with COS a small sample of local starburst galaxies selected from the SDSS for their very blue colours, young ages and weak H-alpha emission. This combination can, according to models, occur only when a large fraction of the ionizing radiation escapes from the galaxy. The redshifts of our four targets is z~0.3, which puts the LyC in a spectral region where the sensitivity of COS/G130M is high.

Since it might be counterintuitive to select strong starbursts by weak H-alpha emission, it can be understood that all earlier searches for LyC emission at low redshifts have had a high rate of failure. Selection techniques utilizing star formation indicators like strong optical emission lines will bias the samples towards galaxies with a high neutral gas-fraction, and thereby against LyC escape. With the novel approach for target selection in this proposal, we are instead sure to optimize the success rate.

OBSERVING DESCRIPTION

The scientific goal with this project is to search for escape of radiation in the Lyman continuum (LyC) of a sample of 4 galaxies with predicted high LyC escape fractions. For this purpose we will use the G130M grism of the COS FUV channel in TIME-TAG mode to directly measure the signal in the LyC. The redshifts of the targets span a range of z=0.243-0.353. At these redshifts the Ly-limit will fall where the throughput of COS is high, and is yet low enough that the data from SDSS allow us to properly model the galaxies. The central wavelength settings of G130M depend on the redshift of the galaxy, and have been chosen to fit the position of the Lyman break:

Galaxy	Lyman limit (A)	Central wave (A)	Visibility (min)	f900	S/N
J143004.07+022213.3	1233	1291	54	2.3E-17	11
J143832.04+390333.7	1133	1055	55	2.3E-17	7
J080250.09+190119.1	1193	1291	54	2.1E-17	8
J154459.67+115017.4	1134	1055	54	2.8E-17	9

In the table above are also shown the visibilities, estimated minimum flux densities in the 900 A continnum of the target galaxies and the corresponding S/N. Flux densities are given in units of erg/cm^2/s/A. The size of the galaxies, obtained from the SDSS g band data, were found to match the 2.5 arcsec COS aperture. NUV acquisition images from previous COS programes have however shown that the star-forming regions in UV are much more compact (GO 11522,11727), thus we expect a resolution in the FUV continuum better than R~1000 (at 1150 A for G130M, 1055). This is well within the requirements for this project where we only need to resolve the Lyman break. The LyC flux is however assumed to escape from even smaller regions through channels in the ISM, and can likely be considered as a point source with better resolution for these wavelengths.

Flux density predictions

Two of the galaxies have been observed by GALEX. The ratio between the observed GALEX fuv and SDSS g fluxes, after reddening corrections, was almost the same in the two cases. Therefore, in the two cases were no GALEX data existed, the fuv/g ratio was assumed to be the same. The stability of this ratio as long as the starburst is active is ensured also from the modelling. The flux density shortwards of the Lyman limit was derived from the observed f(lambda)_fuv (lambda ~ 1175 A in the z=0.3 frame) or the value corresponding to the g magnitude. The Starburst99 (Leitherer et al. 1999, ApjS 123, 3) prediction under 100% leakage conditions is f(lambda)_fuv/f(lambda)_LyC ~1.9 while our models (Zackrisson et al. 2001, A&A 375, 814) gives a lower value (~1.3). In our exposure time (ET) estimates we use the more conservative value (1.9). Dust extinction has been found to account for ~50% attenuation of LyC photons in starburst galaxies. Therefore we have used a conservative relative escape fraction of f_esc_rel=10%, even though our models predict much more. The predicted 900 A fluxes can be seen in the table above.

S/N calculations

The Lyman limit of our targets is redshifted to 1133-1233 A. In this spectral range the throughput of the FUV XDL detector changes dramatically with wavelength, and we have therefore limited our LyC S/N calculations to ~30 A baselines although the LyC flux is expected to be significant

down to much shorter wavelengths. In the ET estimates we assume that the LyC is constant over the whole baseline, an assumption based on the coincidence of a rise towards shorter wavelengths for model spectra of young burst populations and that of a similar rise towards shorter wavelengths for the extinction curve. The spectra of the two single detections in Shapley et al. (2006, ApJ 651, 688) also seem to confirm this. For one of our targets, J143004.07+022213.3, the airglow Ly alpha emission line falls in the baseline, decreasing it further with 2 A.

We chose to use the FP-POS strategy for the science exposures, using all 4 positions, 2 for each orbit. The total exposure times on target (5178-5304s) were derived from the alloted 2 orbits with visibility 54 (55) minutes each, minus total overhead (999-1025s). We used the online COS ETC to calculate the S/N in the LyC with settings point source, flat continuum normalized to the LyC flux given in the table, with zodiacal background, airglow and earth shine set to AVERAGE. The calculations were performed at the central wavelength of respectively baseline, and the S/N per resolution element was then multiplied by the square root of the total number of resolution elements in the baseline. From this we could derive a S/N of 7-11 (see table). These numbers have been calculated conservative in all steps, so any change in the S/N should be towards the better. All targets have a 3 sigma detection limit of f_esc,rel ~ 3%.

Acquisition strategy

The coordinates for the targets are obtained from the SDSS, with estimated errors < 0.2 arcsec (J.R. Pier et al. 2003, AJ 125, 1559; Sandor et el. Proceedings of the 8th European VLBI Network Symposium. September 26-29, 2006,Torun, Poland). The errors together with a comparison of the outcome of earlier COS programes (GO 12248), lead us to the conclusion that the ACQ/IMAGE method will give us the pointing precision we need. Integration times for the ACQ/IMAGE exposures were obtained from the COS Imaging Target Acquisition ETC, assuming the point source option and using the GALEX NUV fluxes when available or the corresponding model magnitudes. The GALEX NUV corresponds well to the peak sensitivity wavelength of the COS NUV detector at ~2300A. As an extra safety measure, to account for slight deviations from a pure point source structure, we added 1 magnitude to the NUV magnitudes before loading the ETC. A similar strategy has successfully been used by other teams when observing similar objects (e.g. GO 12248). We reach S/N=40 for exposure times 52-78 s.

BUFFER-TIME estimates

The BUFFER-TIME were in all FUV/G130M exposures found to be considerable longer than the exposure times, hence the BUFFER-TIME was set to the exposure time minus 100 s in all cases to minimize overheads (according to COS instrument handbook). Since the exposures were split in four (one for each FP-POS), we have given the value for the shortest exposure in each visit.

Bright target notes

The flux densities of the targets do not exceed the bright object limit. The conservative case of no extinction was applied to the flux above the Ly-limit of the galaxies, and the target Ly-alpha line does not fall in the wavelength window of the G130M setting for any of the targets. We found no violation of neither the global nor the local count rates in the FUV, and for NUV imaging acquisition the count rate was well below the limit at 360 cts/s in the 9x9 pixel boxes surrounding the targets.

The BOT do return one health-and-safety issue for target 1 and its field. The warning is issued from the GSC II, while GALEX issues no warning. The coordinates of the object (assumed to be a **O5V** star by BOT), coincides with our target. Since our target itself is far from exceeding the bright object limit (GALEX FUV=20.1), we see no problem to observe target 1.

Visit

Proposal 12539, Visit 01, implementation Tue Feb 07 02:01:32 GMT 2012

Diagnostic Status: Warning

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: (none)

Diagnostics

(Visit 01) Warning (Form): If the target coordinates are not known to 0.4" (or better) an ACQ/SEARCH should precede the ACQ/IMAGE.

(Visit 01) Warning (Orbit Planner): VISIBILITY OVERRUN

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	J143004.07+022213.3	RA: 14 30 4.0613 (217.5169221d) Dec: +02 22 13.60 (2.37044d) Equinox: J2000		V=18.9 FUV=20.1	Reference Frame: ICRS

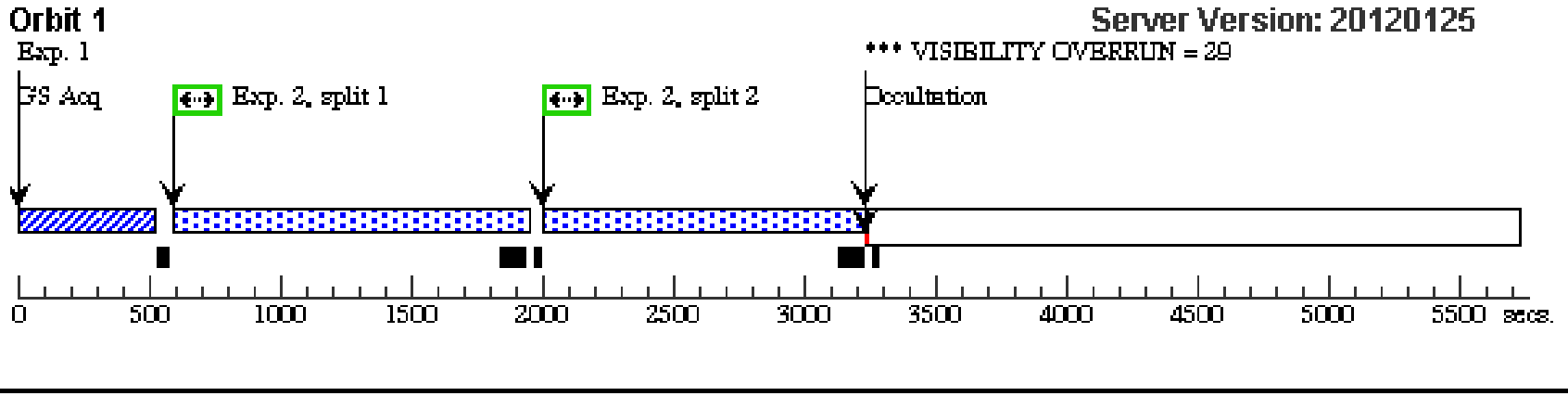
Comments: This object was generated by the targetselector and retrieved from the NED database.
The BOT gives a warning for a source whose coordinates coincides with the target.

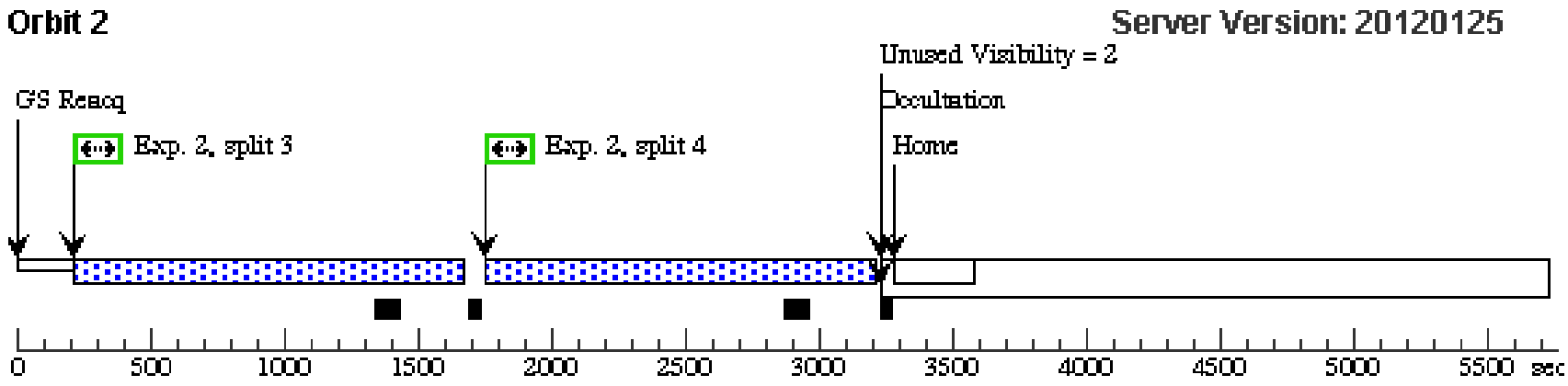
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	Target Aq. (COS.ta.183851)	(1) J143004.07+022213.3	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				57 Secs *[==>]*	***[1]***
2	Exp 1 (COS.sp.183934)	(1) J143004.07+022213.3	COS/FUV, TIME-TAG, PSA	G130M 1291 A	SEGMENT=BOTH; BUFFER-TIME=1085; EXTENDED=NO; FP-POS=ALL; FLASH=YES			1205 Secs *[==>1185.0 Secs (Split 1)]* *[==>1185.0 Secs (Split 2)]* *[==>1410.0 Secs (Split 3)]* *[==>1410.0 Secs (Split 4)]*	***[1]*** ***[2]***

Comments: The BUFFER-TIME= exposure time - 100s differs between the splits. The given BUFFER-TIME is for the shortest exposure.

Orbit Structure





Visit

Proposal 12539, Visit 02, implementation Tue Feb 07 02:01:33 GMT 2012

Diagnostic Status: Warning

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: ON HOLD

On Hold Comments: Waiting the implementation of G130M 1055 setting

Diagnostics

(Visit 02) Warning (Form): If the target coordinates are not known to 0.4" (or better) an ACQ/SEARCH should precede the ACQ/IMAGE.

(Visit 02) Warning (Orbit Planner): VISIBILITY OVERRUN

Fixed Targets

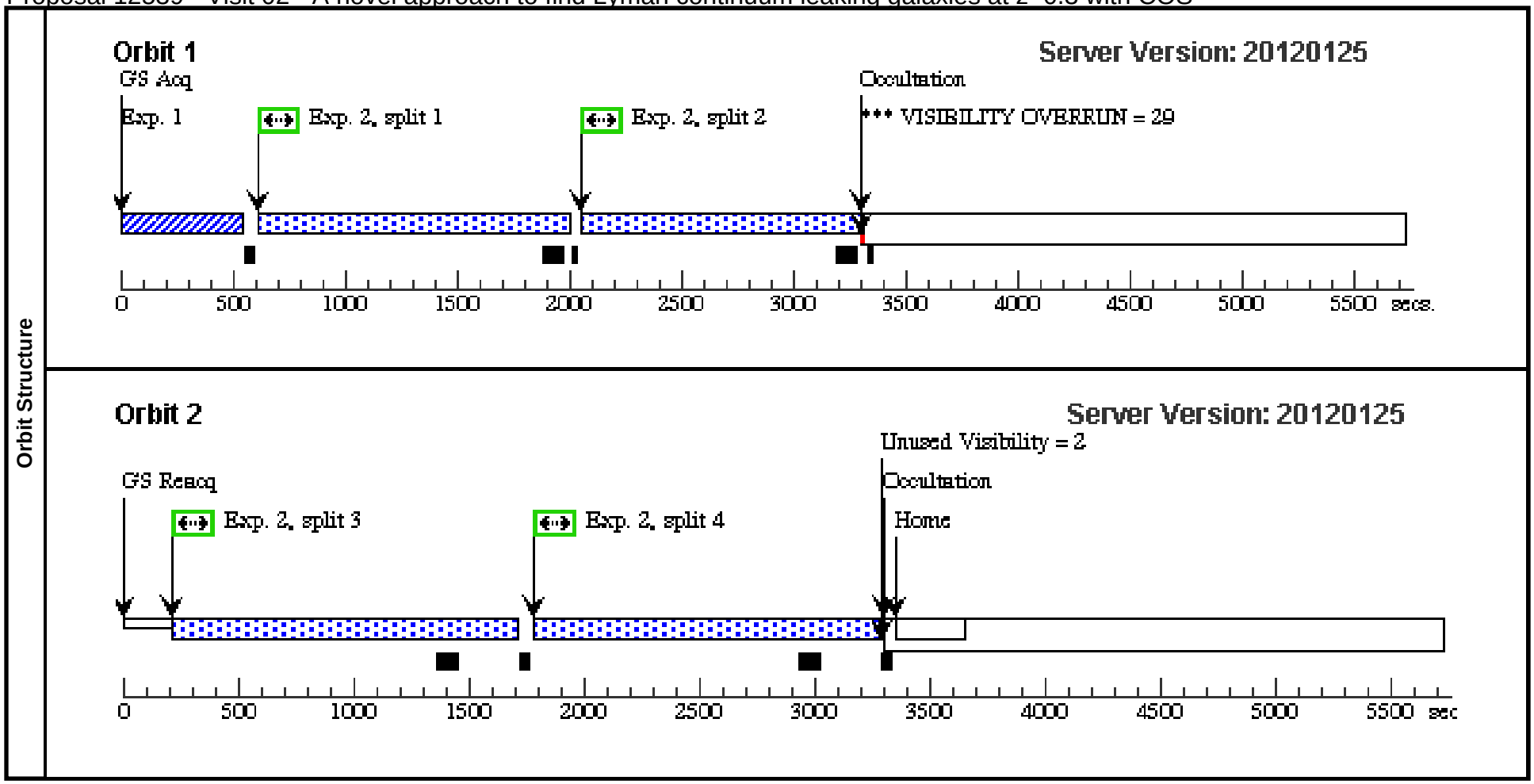
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	J143832.04+390333.7	RA: 14 38 32.0424 (219.6335100d) Dec: +39 03 33.77 (39.05938d) Equinox: J2000		V=19.0	Reference Frame: ICRS

Comments: This object was generated by the targetselector and retrieved from the NED database.

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	Target Aq. (COS.ta.183851)	(2) J143832.04+390333.7	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				67 Secs *[==>]*	 ***[1]***
2	Exp 1 (COS.sp.183952)	(2) J143832.04+390333.7	COS/FUV, TIME-TAG, PSA	G130M 1055 A	BUFFER-TIME=1108; EXTENDED=NO; FLASH=YES; FP-POS=ALL; SEGMENT=BOTH			1210 Secs *[==>1208.0 Secs (Split 1)]* *[==>1209.0 Secs (Split 2)]* *[==>1443.0 Secs (Split 3)]* *[==>1444.0 Secs (Split 4)]*	 ***[1]*** ***[2]***

Comments: The BUFFER-TIME= exposure time - 100s differs between the splits. The given BUFFER-TIME is for the shortest exposure.


Orbit Structure
Orbit 1
Server Version: 20120125
GS Acq
Exp. 1
Exp. 2, split 1
Exp. 2, split 2
Occultation
*** VISIBILITY OVERRUN = 29
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs.
Orbit 2
Server Version: 20120125
Unused Visibility = 2
GS Reacq
Exp. 2, split 3
Exp. 2, split 4
Occultation
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 12539, Visit 03, implementation Tue Feb 07 02:01:34 GMT 2012

Diagnostic Status: Warning

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: (none)

Diagnostics

(Visit 03) Warning (Form): If the target coordinates are not known to 0.4" (or better) an ACQ/SEARCH should precede the ACQ/IMAGE.

(Visit 03) Warning (Orbit Planner): VISIBILITY OVERRUN

Fixed Targets

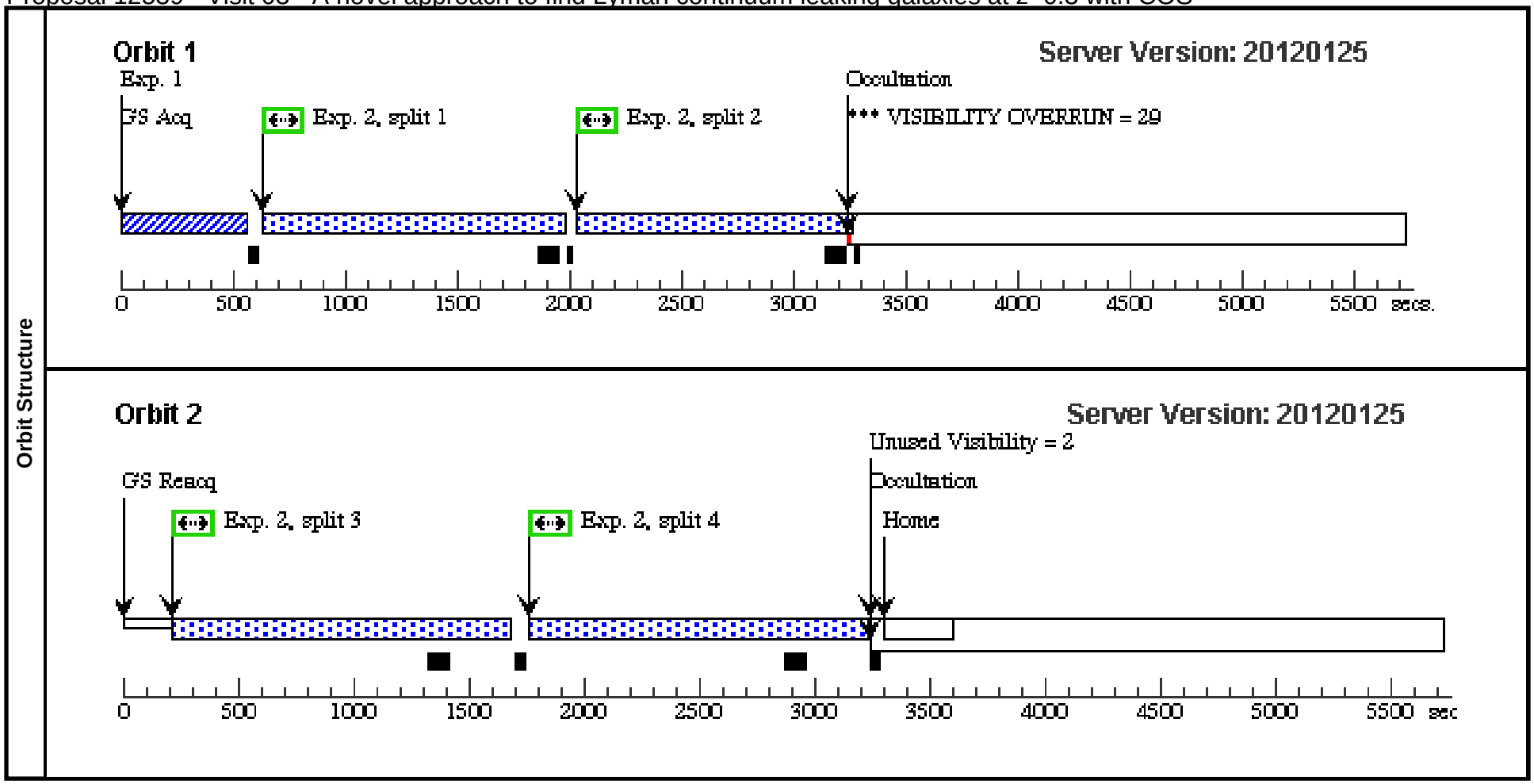
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(3)	J080250.09+190119.2	RA: 08 02 50.0952 (120.7087300d) Dec: +19 01 19.20 (19.02200d) Equinox: J2000		V=19.0	Reference Frame: ICRS

Comments: This object was generated by the targetselector and retrieved from the NED database.

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	Target Aq. (COS.ta.183865)	(3) J080250.09+190119.2	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				78 Secs *[==>]*	 ***[1]***
2	Exp 1 (COS.sp.183966)	(3) J080250.09+190119.2	COS/FUV, TIME-TAG, PSA	G130M 1291 A	BUFFER-TIME=1071; EXTENDED=NO; FLASH=YES; FP-POS=ALL; SEGMENT=BOTH			1200 Secs *[==>1171.0 Secs (Split 1)]* *[==>1172.0 Secs (Split 2)]* *[==>1418.0 Secs (Split 3)]* *[==>1417.0 Secs (Split 4)]*	 ***[1]*** ***[2]***

Comments: The BUFFER-TIME= exposure time - 100s differs between the splits. The given BUFFER-TIME is for the shortest exposure.


Orbit Structure
Orbit 1
Server Version: 20120125
Exp. 1
GS Acq
Exp. 2, split 1
Exp. 2, split 2
Occultation
*** VISIBILITY OVERRUN = 29
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs.
Orbit 2
Server Version: 20120125
Unused Visibility = 2
GS Reacq
Exp. 2, split 3
Exp. 2, split 4
Occultation
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 12539, Visit 04, implementation Tue Feb 07 02:01:35 GMT 2012

Diagnostic Status: Warning

Scientific Instruments: COS/NUV, COS/FUV

Special Requirements: ON HOLD

On Hold Comments: Waiting the implementation of G130M 1055 setting

Diagnostics

(Visit 04) Warning (Orbit Planner): VISIBILITY OVERRUN

(Visit 04) Warning (Form): If the target coordinates are not known to 0.4" (or better) an ACQ/SEARCH should precede the ACQ/IMAGE.

Fixed Targets

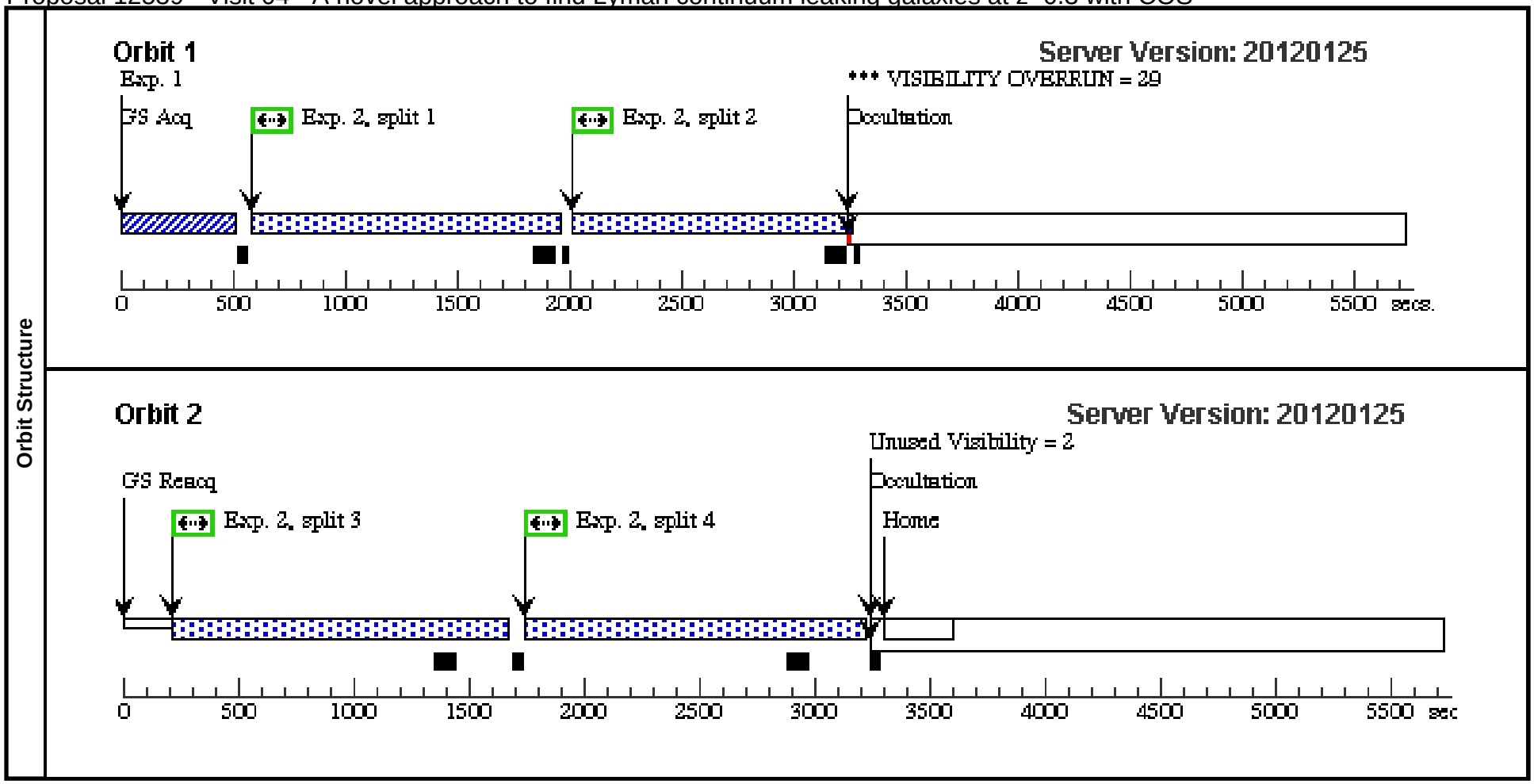
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(4)	J154459.66+115017.5	RA: 15 44 59.6688 (236.2486200d) Dec: +11 50 17.56 (11.83821d) Equinox: J2000		V=18.5 FUV=19.9	Reference Frame: ICRS

Comments: This object was generated by the targetselector and retrieved from the NED database.

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	Target Aq. (COS.ta.183872)	(4) J154459.66+115017.5	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				52 Secs *[==>]*	 ***[1]***
2	Exp 1 (OS.sp.183972)	(4) J154459.66+115017.5	COS/FUV, TIME-TAG, PSA	G130M 1055 A	EXTENDED=NO; FLASH=YES; FP-POS=ALL; SEGMENT=BOTH; BUFFER-TIME=1095			1200 Secs *[==>1196.0 Secs (Split 1)]* *[==>1195.0 Secs (Split 2)]* *[==>1406.0 Secs (Split 3)]* *[==>1425.0 Secs (Split 4)]*	 ***[1]*** ***[2]***

Comments: The BUFFER-TIME= exposure time - 100s differs between the splits. The given BUFFER-TIME is for the shortest exposure.


Orbit Structure
Orbit 1
Server Version: 20120125
Exp. 1
*** VISIBILITY OVERRUN = 29
GS Acq
Exp. 2, split 1
Exp. 2, split 2
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
secs.
Orbit 2
Server Version: 20120125
Unused Visibility = 2
GS Reacq
Occultation
Exp. 2, split 3
Exp. 2, split 4
Home
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec