



# 18122 - When Changing-Look Quasars Wake-Up, Do They Look the Same as Before They Went to Sleep?

Cycle: 33, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

## INVESTIGATORS

<i>Name</i>	<i>Institution</i>
<b>Laura Duffy (PI) (Contact)</b>	<b>The Pennsylvania State University</b>
Prof. Michael Eracleous (CoI) (CoPI) (AdminUSPI)	The Pennsylvania State University
Prof. Jessie Caye Runnoe (CoI)	Vanderbilt University
John Ruan (CoI) (CSA Member)	Bishop's University
Dr. Qian Yang (CoI)	Smithsonian Institution Astrophysical Observatory

## 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) 2MASS-J10115298+5442063	COS/FUV COS/NUV	1	22-Dec-2025 15:00:14.0	yes
02	(1) 2MASS-J10115298+5442063	STIS/CCD STIS/NUV-MAMA	2	22-Dec-2025 15:00:15.0	yes
03	(2) WISEA-J233602.97+001728.9	COS/FUV COS/NUV	1	22-Dec-2025 15:00:15.0	yes
04	(2) WISEA-J233602.97+001728.9	STIS/CCD STIS/NUV-MAMA	2	22-Dec-2025 15:00:16.0	yes

6 Total Orbits Used

## **ABSTRACT**

Changing-look quasars (CLQs) show dramatic variability in their broad emission lines and non-stellar continuum strengths on time scales of months to years, challenging models for quasar accretion flows. The currently favored theory for the observed behavior is that the transition from a high, quasar-dominated state to a low, galaxy-dominated state is caused by a changing accretion rate leading to a transition in the accretion flow structure. The typical, geometrically thin, optically thick disk changes to an advection dominated accretion flow (ADAF), as is seen in X-ray binaries. Direct observations of such changes in the accretion flow structure, however, have not yet been made. Thus, we propose to observe two CLQs that have recently returned to a high state to thoroughly test the changing-accretion flow hypothesis. Testing this hypothesis is important for understanding the stability of quasar accretion flows and has implications for feedback from the AGN onto the host galaxy. Both targets were well-characterized in their low states with HST UV spectroscopy, and both have recently turned back on according to optical observations. With new UV spectra, we will probe the structure of the accretion flow by comparing the high state UV-optical spectral energy distributions (SEDs) with low-state UV-optical SEDs and with theoretical models of ADAFs and thin disk SEDs. We will also probe the structure of the broad line region (BLR) by characterizing UV broad emission lines and comparing measurements to predictions from various BLR models. This will serve as a conclusive test of the hypothesis that changes in the accretion flow structure are responsible for the changing look.

## **OBSERVING DESCRIPTION**

### Target Selection

We propose to observe two targets at  $z \sim 0.24$ : J1011+5442 and J2336+0017. Recent ZTF g-band magnitudes are  $\sim 19$  and  $\sim 20$ , respectively. The combination of COS+G140L and STIS+G230L+NUV-MAMA spectra will probe the Ly $\alpha$ , N V, Si IV, C IV, and C III] broad emission lines at high significance for both objects. Our proposed targets are the only two known turn-off CLQs that have (a) gone back and forth between high and low states, (b) been observed in both the rest-frame UV and optical in their low states, and (c) since returned to a high state. Archival HST observations of these two targets in their low states also show hallmarks of ADAFs and allow us to design an economical observing program.

### Instrument Choice and Exposure Times

For our first test, we will observe the continuum shape of the two targets in the rest-frame bandpass 1000--2500 Angstrom. This wavelength range covers the portion of the UV SED that differs the most between thin disk quasar SEDs and ADAF SEDs. To cover the longer-wavelength range of

the above bandpass, we request STIS+G230L+NUV-MAMA. Although the COS+G230L configuration is more sensitive than the STIS+G230L+NUV-MAMA, the latter is considerably more efficient because it can obtain a spectrum over the entire wavelength range of interest (~1800-2500 Angstrom, rest-frame) with one grating setting. The spectral resolution of STIS+G230L (~200 km/s) is considerably lower than that of the COS+G230L, but that is fine for our purposes since we are interested in wide continuum windows and emission lines of FWHM of a few thousand km/s. For our second test, we wish to observe strong UV emission lines. In the low-state UV spectra, only a modest Ly $\alpha$  line was detectable. Thus, we choose COS+G140L for the short-wavelength portion of the UV spectrum, because this instrument is much more sensitive than STIS+G140L. To supplement the UV spectra, we will also obtain contemporaneous optical spectra, within 2--3 weeks of the HST observations, using facilities to which we have institutional access to cover the long-wavelength portion of the SED over rest-frame wavelengths ~4000-8000 Angstrom.

We carried out simulations with the ETCs, assuming the SDSS composite quasar spectrum, available in the COS and STIS ETCs, as high-state CLQs resemble normal quasars spectroscopically. We estimated exposure times to attain high significance detections of both the continuum and any broad emission lines. We find the following.

For the COS+G140L, after binning the spectrum to 150 km/s bins, one 2400 s exposure per target will yield S/N~15 in the lines and ~10 in the continuum, which will allow us to make the requisite measurements. Hence, considering orbital visibility (52--58 minutes) and acquisition, as well as other overheads, one orbit per target will be sufficient. We note that prior COS+G140L observations of both targets in their low states were able to obtain significant detections of both Ly $\alpha$  and the continuum in one orbit. Both targets have brightened significantly in the optical in the time since those observations, thus, even if the UV spectra have not changed in the same way as the optical, we can obtain the required exposure time in one orbit per target.

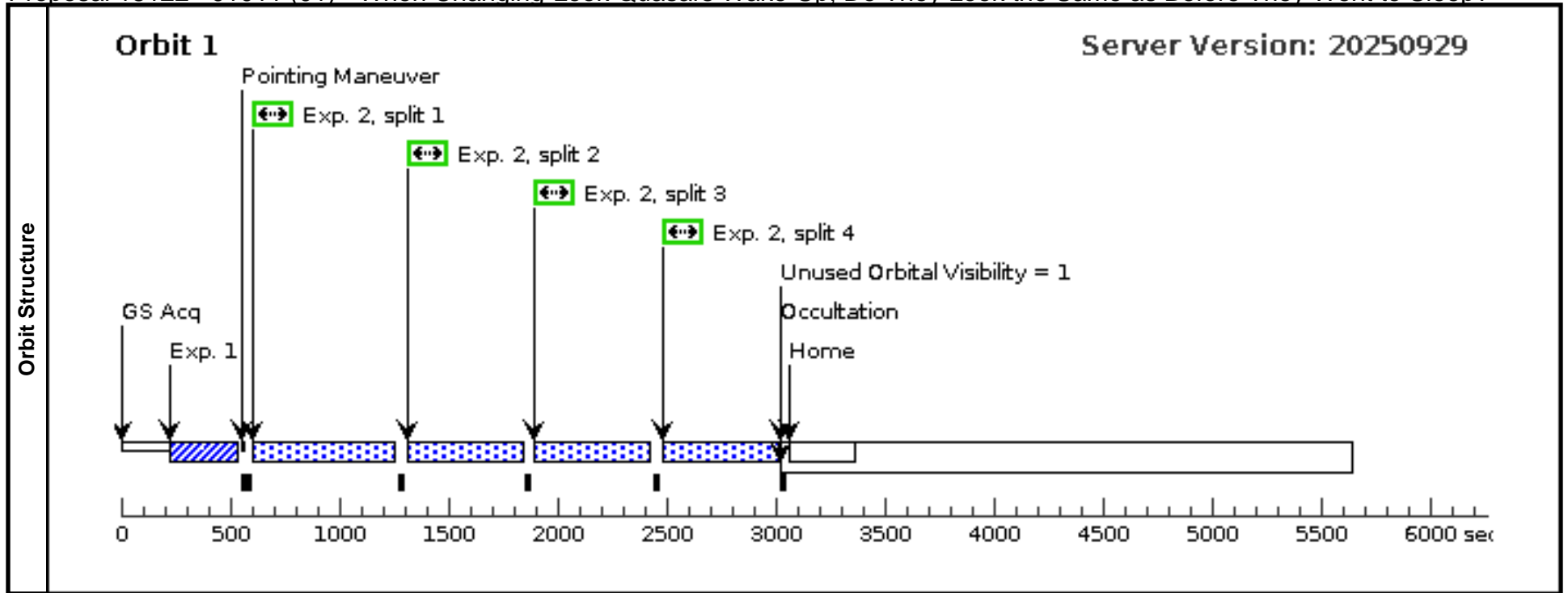
For the STIS G230L, the emission lines of interest are CIV and CIII] Because the spectral bins of the STIS+G230L are much wider than the COS+G140L, we only need to bin the spectra to two pixels per 400 km/s bin. Thus, in order to achieve S/N of ~15 in the lines and ~10 in the continuum, we require 5000 seconds of exposure per target. Considering orbital visibility and including overhead, this amounts to two orbits per object.

Our total time request is six orbits; three for J1011+5442, and three for J2336+0017 (one orbit for each with COS+G140L and two orbits for each with STIS+G230L).

Proposal 18122 - J1011 (01) - When Changing-Look Quasars Wake-Up, Do They Look the Same as Before They Went to Sleep?

Mon Dec 22 20:00:16 GMT 2025

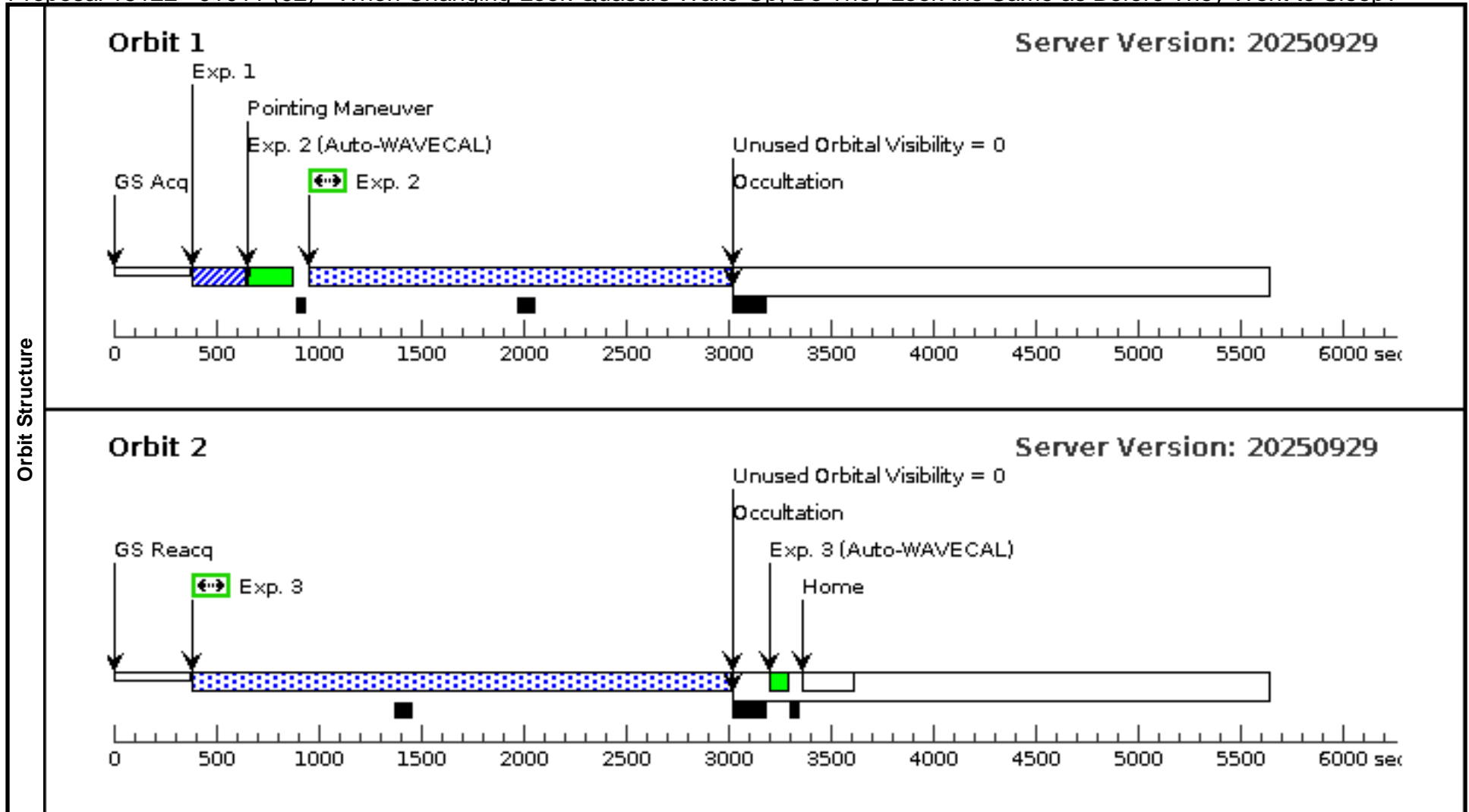
Visit	<b>Proposal 18122, J1011 (01), scheduling</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: COS/FUV, COS/NUV Special Requirements: (none)									
	Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous			
		(1)	2MASS- J10115298+5442063 Alt Name1: SDSS- J101152.97+544206.4	RA: 10 11 52.9800 (152.9707500d) Dec: +54 42 6.42 (54.70178d) Equinox: J2000	Epoch of Position: 2000 Redshift: 0.246	V=18.31 GALEX_FUV =19.067, GALEX_NUV = 18.790	Reference Frame: ICRS			
	<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> SIMBAD listed proper motion for this target. When retrieving targets with PM from SIMBAD, APT requests the coordinates be calculated with an epoch of the year 2000. Do not modify this epoch. Always review coordinates using the Target Confirmation tool, which graphically displays the PM. Category=GALAXY Description=[BLR, NUCLEUS, QSO, QUASAR] Extended=NO									
Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	COS ACQ (COS.ta.202 5458)	(1) 2MASS-J101152 98+5442063	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				50 Secs (50 Secs) [==>]	[1]
2	COS SCI (COS.sp.217 7874)	(1) 2MASS-J101152 98+5442063	COS/FUV, TIME-TAG, PSA	G140L 1280 A	BUFFER-TIME=95 65; FP-POS=ALL			478 Secs (1912 Secs) [==>(Split 1)] [==>(Split 2)] [==>(Split 3)] [==>(Split 4)]	[1]	



Proposal 18122 - J1011 (02) - When Changing-Look Quasars Wake-Up, Do They Look the Same as Before They Went to Sleep?

Mon Dec 22 20:00:16 GMT 2025

Visit	<b>Proposal 18122, J1011 (02), implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: STIS/NUV-MAMA, STIS/CCD Special Requirements: (none)									
	Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous			
		(1)	2MASS- J10115298+5442063 Alt Name1: SDSS- J101152.97+544206.4	RA: 10 11 52.9800 (152.9707500d) Dec: +54 42 6.42 (54.70178d) Equinox: J2000	Epoch of Position: 2000 Redshift: 0.246	V=18.31 GALEX_FUV =19.067, GALEX_NUV = 18.790	Reference Frame: ICRS			
	<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> SIMBAD listed proper motion for this target. When retrieving targets with PM from SIMBAD, APT requests the coordinates be calculated with an epoch of the year 2000. Do not modify this epoch. Always review coordinates using the Target Confirmation tool, which graphically displays the PM. Category=GALAXY Description=[BLR, NUCLEUS, QSO, QUASAR] Extended=NO									
Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	STIS ACQ	(1) 2MASS-J101152 98+5442063	STIS/CCD, ACQ, F28X50LP	MIRROR				9 Secs (9 Secs) [==>]	[1]
	2	STIS SCI 1 (STIS.sp.21 77870)	(1) 2MASS-J101152 98+5442063	STIS/NUV-MAMA, TIME-TAG, 52X0.5	G230L 2376 A	BUFFER-TIME=10 00			2000 Secs (2025 Secs) [==>2025.0 Secs ]	[1]
	3	STIS SCI 2 (STIS.sp.21 77870)	(1) 2MASS-J101152 98+5442063	STIS/NUV-MAMA, TIME-TAG, 52X0.5	G230L 2376 A	BUFFER-TIME=10 00			2000 Secs (2618 Secs) [==>2618.0 Secs ]	[2]



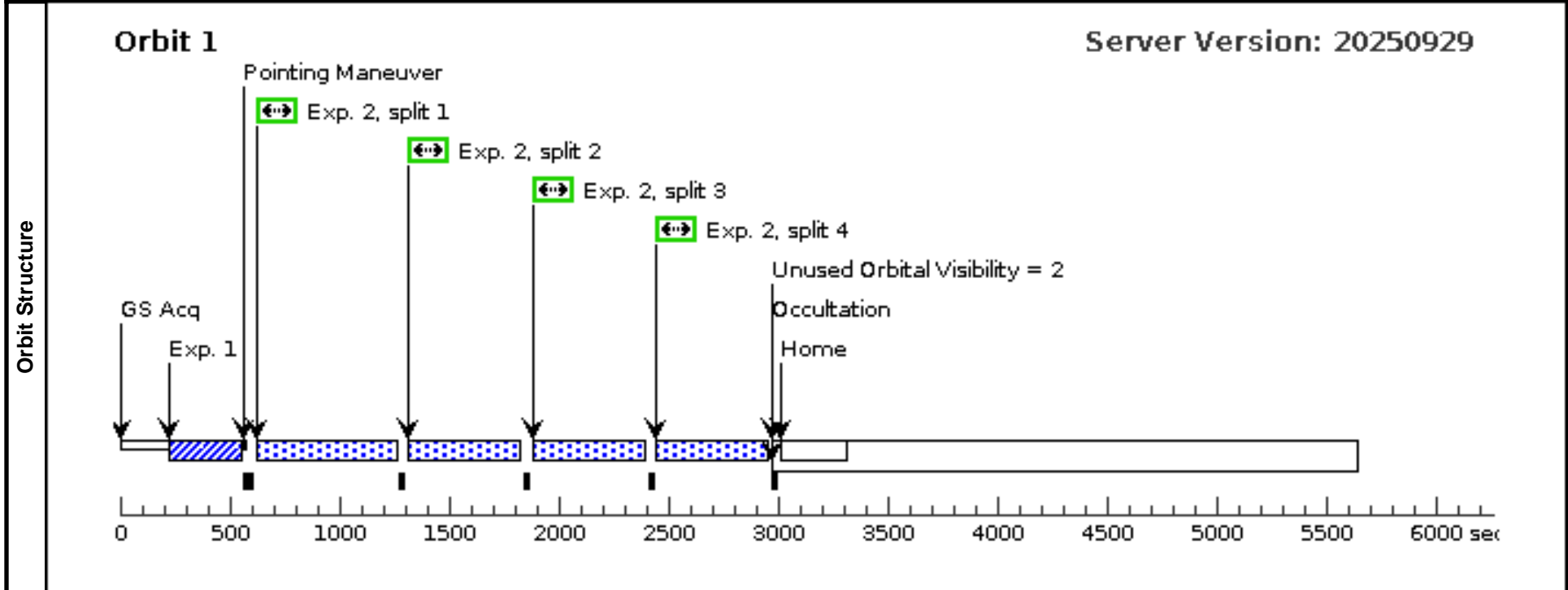
Proposal 18122 - J2336 (03) - When Changing-Look Quasars Wake-Up, Do They Look the Same as Before They Went to Sleep?

Mon Dec 22 20:00:16 GMT 2025

<b>Visit</b>	Proposal 18122, J2336 (03), scheduling				
	Diagnostic Status: No Diagnostics				
	Scientific Instruments: COS/FUV, COS/NUV				
	Special Requirements: (none)				

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	WISEA-J233602.97+001728.9	RA: 23 36 2.9800 (354.0124167d) Dec: +00 17 28.77 (.29133d) Equinox: J2000	Epoch of Position: 2000 Redshift: 0.243	V=19.66 GALEX_FUV = 21.486, GALEX_NUV = 21.459	Reference Frame: ICRS
Alt Name1: SDSS-J233602.98+001728.7					
<i>Comments: This object was generated by the targetselector and retrieved from the NED database.</i> Category=GALAXY Description=[BLR, NUCLEUS, QSO, QUASAR] Extended=NO					

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	COS ACQ (COS.ta.2024861)	(2) WISEA-J233602.97+001728.9	COS/NUV, ACQ/IMAGE, PSA	MIRRORA				58 Secs (58 Secs) [==>]	[1]
2	COS SCI (COS.sp.2177967)	(2) WISEA-J233602.97+001728.9	COS/FUV, TIME-TAG, PSA	G140L 1280 A	FP-POS=ALL; BUFFER-TIME=98 75			462 Secs (1848 Secs) [==>(Split 1)] [==>(Split 2)] [==>(Split 3)] [==>(Split 4)]	[1]



Proposal 18122 - J2336 (04) - When Changing-Look Quasars Wake-Up, Do They Look the Same as Before They Went to Sleep?

Mon Dec 22 20:00:16 GMT 2025

Visit	<b>Proposal 18122, J2336 (04), implementation</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: STIS/NUV-MAMA, STIS/CCD Special Requirements: (none)																																																	
	Fixed Targets	<table border="1"> <thead> <tr> <th>#</th> <th>Name</th> <th>Target Coordinates</th> <th>Targ. Coord. Corrections</th> <th>Fluxes</th> <th>Miscellaneous</th> </tr> </thead> <tbody> <tr> <td>(2)</td> <td>WISEA- J233602.97+001728.9 Alt Name1: SDSS- J233602.98+001728.7</td> <td>RA: 23 36 2.9800 (354.0124167d) Dec: +00 17 28.77 (.29133d) Equinox: J2000</td> <td>Epoch of Position: 2000 Redshift: 0.243</td> <td>V=19.66 GALEX_FUV = 21.486, GALEX_NUV = 21.459</td> <td>Reference Frame: ICRS</td> </tr> <tr> <td colspan="6"> <i>Comments: This object was generated by the targetselector and retrieved from the NED database.</i>  <i>Category=GALAXY</i>  <i>Description=[BLR, NUCLEUS, QSO, QUASAR]</i>  <i>Extended=NO</i> </td> </tr> </tbody> </table>										#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous	(2)	WISEA- J233602.97+001728.9 Alt Name1: SDSS- J233602.98+001728.7	RA: 23 36 2.9800 (354.0124167d) Dec: +00 17 28.77 (.29133d) Equinox: J2000	Epoch of Position: 2000 Redshift: 0.243	V=19.66 GALEX_FUV = 21.486, GALEX_NUV = 21.459	Reference Frame: ICRS	<i>Comments: This object was generated by the targetselector and retrieved from the NED database.</i> <i>Category=GALAXY</i> <i>Description=[BLR, NUCLEUS, QSO, QUASAR]</i> <i>Extended=NO</i>																										
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