16926 - UV Spectroscopy and Host Galaxy Imaging of a Possibly Coalescing Binary Supermassive Black Hole

Cycle: 29, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Prof. Xin Liu (PI) (Contact)	**University of Illinois at Urbana - Champaign**	**xinliuxl@illinois.edu**

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) SDSSJ1430+2303	WFC3/IR	1	19-May-2022 10:00:19.0	yes
51	(1) SDSSJ1430+2303	WFC3/IR	1	19-May-2022 10:00:21.0	yes
02	(1) SDSSJ1430+2303	WFC3/UVIS	1	19-May-2022 10:00:22.0	yes
03	(1) SDSSJ1430+2303	WFC3/UVIS	1	19-May-2022 10:00:22.0	yes
04	(1) SDSSJ1430+2303	STIS/CCD STIS/NUV-MAMA	4	19-May-2022 10:00:24.0	yes

8 Total Orbits Used

ABSTRACT

Binary supermassive black holes (SMBHs) are expected to be common from galaxy mergers. Their final inspirals and coalescences should produce gravitational waves detectable by pulsar-timing arrays and future space interferometers, making them exciting targets for multi-messenger astronomy. Subsequent to the most recent proposal deadline, the first candidate coalescing binary SMBH has just been discovered with rapidly

decaying periods revealed by the remarkable optical and X-ray light curves (with the periods decreasing from ~one year to ~one month in the past three years). Multiple lines of evidence suggest that the system may be an uneven mass-ratio, highly eccentric binary SMBH that will likely merge within ~one to three years, presenting an exciting opportunity for multi-wavelength and potentially multi-messenger observations to witness the first ever binary SMBH merger event, justifying the mid-cycle request. New STIS UV spectroscopy may reveal evidence (or lack thereof) for a cutoff or notch in the NUV spectrum, which may arise from gap opening in the circumbinary accretion disk, and to measure the UV emission lines as tracers of accretion disk winds. Multi-band high-resolution WFC3 imaging is proposed to quantify the structural properties of the host galaxy, enabling bulge stellar mass measurement through robust bulge-disk decomposition for better (total) SMBH mass estimation, and to search for morphological evidence of a past merger. The program will independently test the binary hypothesis and provide the anchor for future follow-up campaigns. It has broad implications for multi-messenger astronomy and for understanding the cosmic formation and evolution of SMBHs.

OBSERVING DESCRIPTION

The target is a redshift z=0.081 Serfect 1 AGN (i.e., the nuclear point source) hosted by an extended galaxy with an effective radius of ~10" (5") along the semi-major (semi-minor) axis. It has been found to host an unusual nuclear transient flare whose period and amplitude are both decreasing rapidly. While the leading hypothesis is a coalescing binary SMBH, complementary observations are needed to fully test the binary hypothesis as well as alternative scenarios.

This program will conduct STIS NUV-MAMA first-order spectroscopy with the G230L grating (3 orbits) and the CCD first-order spectroscopy with the G430L grating (1 orbit) for the nuclear transient flare (point source). This setup will obtain a low-resolution (R~500) spectrum of the AGN flare covering the observed wavelengths ~1570--5700 Anstrom (rest-frame 1452--5272 Angstrom). It will test if there is any NUV flux deficit as expected from circumbinary accretion disk gap opening assuming the fiducial binary model parameters.

The secondary goal with the STIS UV/optical spectroscopy is to measure the UV broad emission line (C IV and Mg II) profiles to test accretion disk wind models. The MAMA G230L grating is preferred over the CCD G230LB grating for its better throughput at the bluer end to measure C IV. The tertiary goal is to identify any spectroscopic post-starburst signatures in the circumnuclear emission as independent evidence for a past galaxy merger (e.g., the Balmer break and strong high-order Balmer absorption).

We use the 0.2" wide slit as a good compromise between resolution and throughput. We do not require any specific PA for the slit to minimize scheduling constraints.

This program will also conduct WFC3 three-band (UVIS F336W and F606W, and IR F105W) imaging (3 orbits in total at 1 orbit per filter) of the host galaxy of the unusual transient flare. The goal is to perform AGN-host and bulge-disk decompositions, enabling robust bulge stellar mass and total galaxy stellar mass estimates from three-band imaging to independently infer an estimate of the (total) SMBH mass, complementary to the broad-emission-line-based virial mass estimate. The deep, high-resolution imaging will also be used to search for morphological evidence of ongoing nuclear starbursts (with F336W imaging) and low-surface-brightness tidal features (with F105W imaging) as independent evidence of a past galaxy merger event. The F336W filter is chosen to cover the rest-frame U band, sampling ongoing star formation and potential nuclear starbursts in the host. The F606W filter is chosen to cover the rest-frame B band to probe young stellar populations in the host. The F105W is chosen to sample the rest-frame Y band to probe the old stellar populations in the host. The central AGN is expected to be minimal at this wavelength to facilitate AGN-host decomposition.

Subarray is used to avoid saturation of the bright galaxy while covering an enough field of view to include the large host galaxy and nearby sources to register absolute astrometry. The 4-point box dither pattern is used to facilitate cosmic-ray and bad-pixel rejection and to better sample the PSF to achieve the best possible image quality.

Visit

Proposal 16926, SDSSJ1430+2303_IR_F105W (01), completed Thu May 19 14:00:25 GMT 2022

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: (none)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-IR-DITHER-BOX-MIN Purpose=DITHER Number Of Points=4 Point Spacing=0.572 Line Spacing=0.365	Coordinate Frame=POS-TARG Pattern Orientation=18.528 Angle Between Sides=74.653 Center Pattern=false		(1), (2)

Fixed Targets

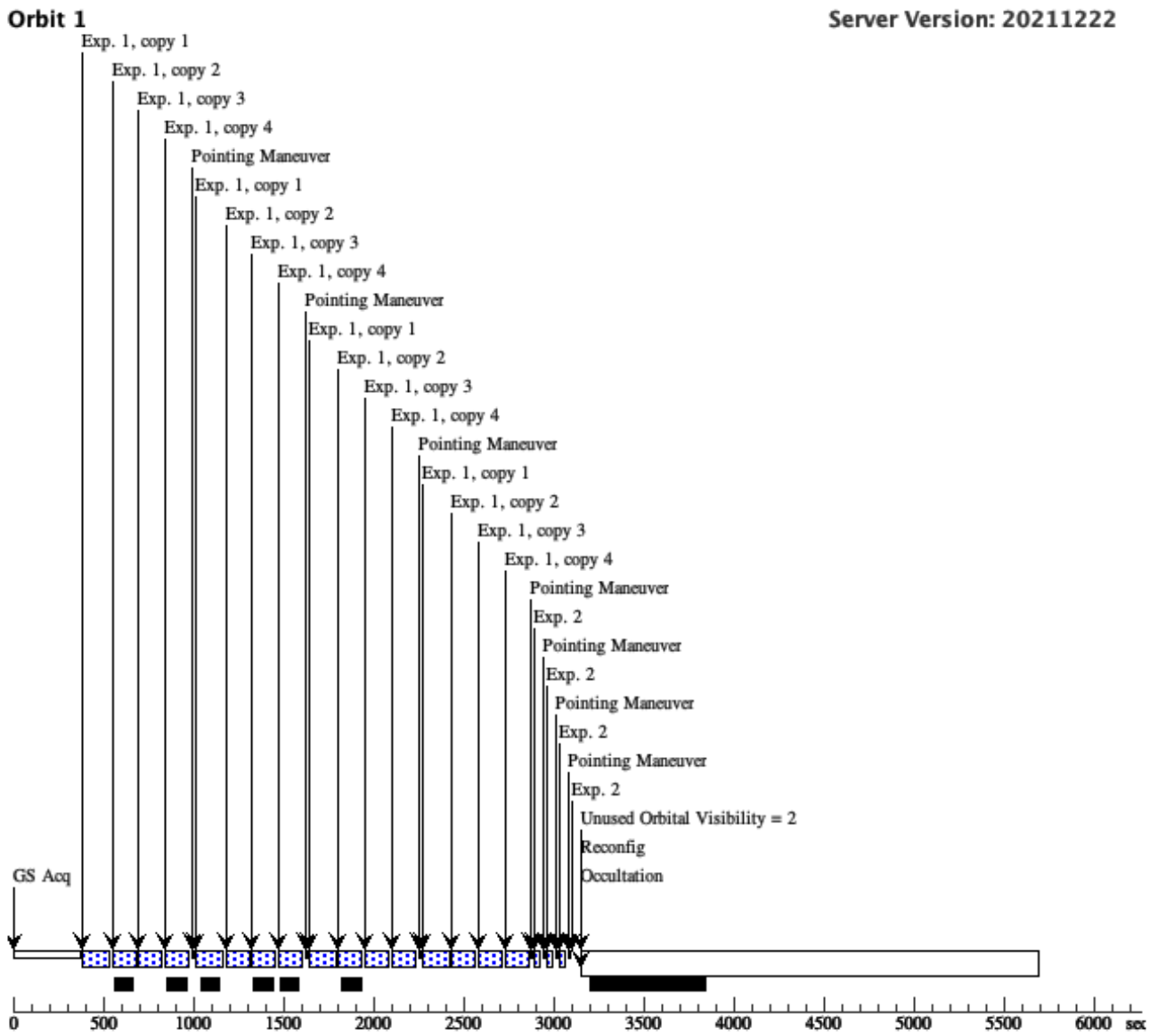
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	SDSSJ1430+2303	RA: 14 30 16.0500 (217.5668750d) Dec: +23 03 44.40 (23.06233d) Equinox: J2000	Redshift: 0.0811	V=14.7+/-0.3 SDSS r = 15.63, SDSS u = 18.44, GALEX NUV = 21.0 (pre-flare), GALEX FUV = 23.5 (AB, model magnitudes), Swift UVW1 = 18.8+/-0.2 (flare)	Reference Frame: ICRS

Comments:
Category=GALAXY
Description=[SEYFERT]
Extended=YES

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) SDSSJ1430+2303	WFC3/IR, MULTIACCUM, IRSUB512	F105W	NSAMP=10; SAMP-SEQ=STEP25		Pattern 1, Exps 1-1 in SDSSJ1430+2303_IR_F105W (01) (1)	128.439646 Secs X 4 (2055.034 Secs)	
								[==>(Pattern 1, Copy 1)]	***[1]***
								[==>(Pattern 1, Copy 2)]	
								[==>(Pattern 1, Copy 3)]	
								[==>(Pattern 1, Copy 4)]	
								[==>(Pattern 2, Copy 1)]	
								[==>(Pattern 2, Copy 2)]	
								[==>(Pattern 2, Copy 3)]	
								[==>(Pattern 2, Copy 4)]	
								[==>(Pattern 3, Copy 1)]	
								[==>(Pattern 3, Copy 2)]	
								[==>(Pattern 3, Copy 3)]	
								[==>(Pattern 3, Copy 4)]	
								[==>(Pattern 4, Copy 1)]	
								[==>(Pattern 4, Copy 2)]	
								[==>(Pattern 4, Copy 3)]	
								[==>(Pattern 4, Copy 4)]	
2		(1) SDSSJ1430+2303	WFC3/IR, MULTIACCUM, IRSUB512	F105W	NSAMP=11; SAMP-SEQ=RAPID		Pattern 1, Exps 2-2 in SDSSJ1430+2303_IR_F105W (01) (1)	9.383297 Secs (37.533 Secs)	
								[==>(Pattern 1)]	***[1]***
								[==>(Pattern 2)]	
								[==>(Pattern 3)]	
								[==>(Pattern 4)]	

Orbit Structure



Visit

Proposal 16926, SDSSJ1430+2303_IR_F105W (51) Thu May 19 14:00:25 GMT 2022

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: (none)

Comments: HOPR repeat of visit 1

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-IR-DITHER-BOX-MIN Purpose=DITHER Number Of Points=4 Point Spacing=0.572 Line Spacing=0.365	Coordinate Frame=POS-TARG Pattern Orientation=18.528 Angle Between Sides=74.653 Center Pattern=false		(1), (2)

Fixed Targets

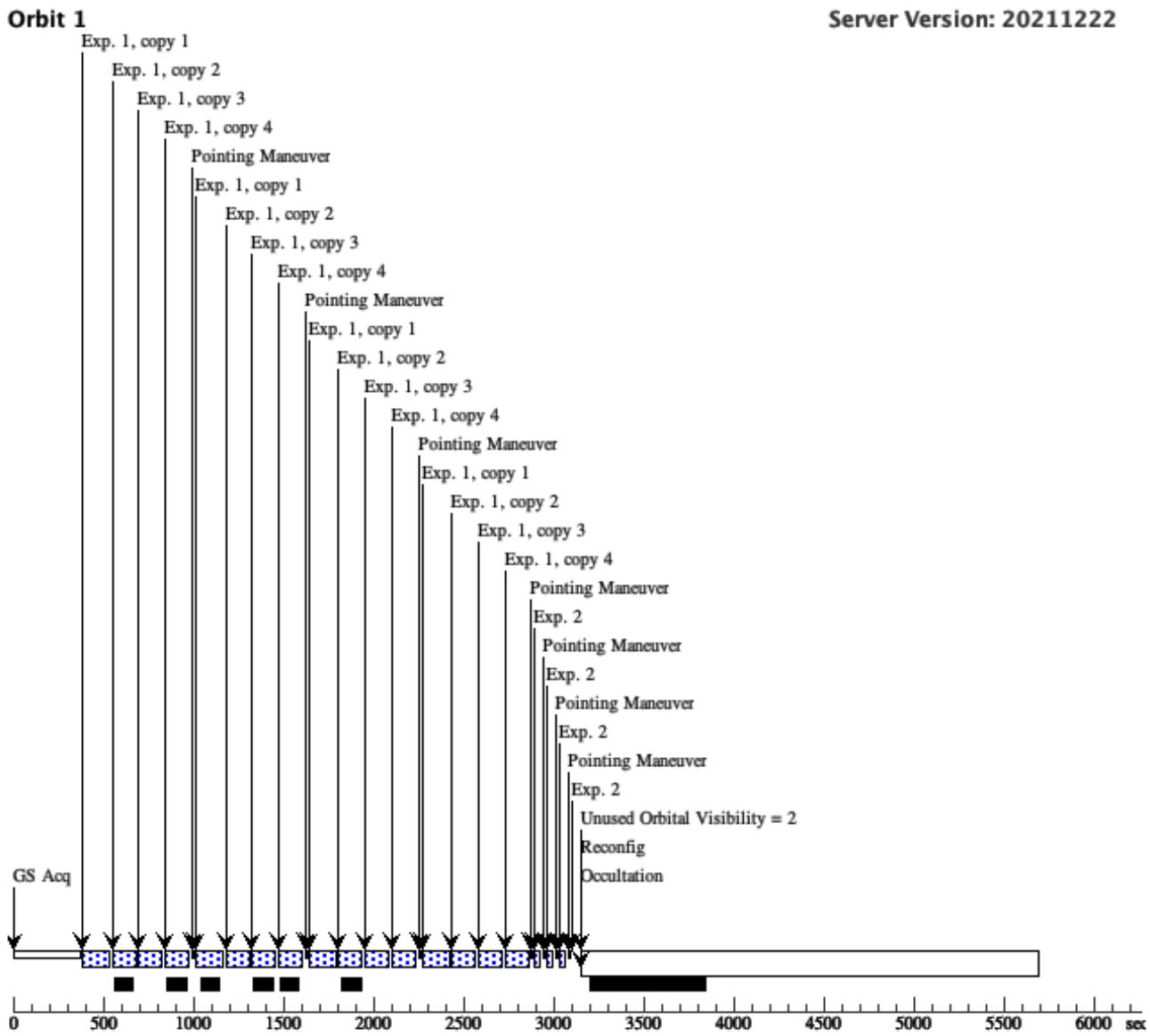
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	SDSSJ1430+2303	RA: 14 30 16.0500 (217.5668750d) Dec: +23 03 44.40 (23.06233d) Equinox: J2000	Redshift: 0.0811	V=14.7+/-0.3 SDSS r = 15.63, SDSS u = 18.44, GALEX NUV = 21.0 (pre-flare), GALEX FUV = 23.5 (AB, model magnitudes), Swift UVW1 = 18.8+/-0.2 (flare)	Reference Frame: ICRS

Comments:
Category=GALAXY
Description=[SEYFERT]
Extended=YES

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) SDSSJ1430+2303	WFC3/IR, MULTIACCUM, IRSUB512	F105W	NSAMP=10; SAMP-SEQ=STEP25		Pattern 1, Exps 1-1 in SDSSJ1430+2303_IR_F105W (51) (1)	128.439646 Secs X 4 (2055.034 Secs)	
								[==>(Pattern 1, Copy 1)]	***[1]***
								[==>(Pattern 1, Copy 2)]	
								[==>(Pattern 1, Copy 3)]	
								[==>(Pattern 1, Copy 4)]	
								[==>(Pattern 2, Copy 1)]	
								[==>(Pattern 2, Copy 2)]	
								[==>(Pattern 2, Copy 3)]	
								[==>(Pattern 2, Copy 4)]	
								[==>(Pattern 3, Copy 1)]	
								[==>(Pattern 3, Copy 2)]	
								[==>(Pattern 3, Copy 3)]	
								[==>(Pattern 3, Copy 4)]	
								[==>(Pattern 4, Copy 1)]	
								[==>(Pattern 4, Copy 2)]	
								[==>(Pattern 4, Copy 3)]	
								[==>(Pattern 4, Copy 4)]	
2		(1) SDSSJ1430+2303	WFC3/IR, MULTIACCUM, IRSUB512	F105W	NSAMP=11; SAMP-SEQ=RAPID		Pattern 1, Exps 2-2 in SDSSJ1430+2303_IR_F105W (51) (1)	9.383297 Secs (37.533 Secs)	
								[==>(Pattern 1)]	***[1]***
								[==>(Pattern 2)]	
								[==>(Pattern 3)]	
								[==>(Pattern 4)]	

Orbit Structure



Visit

Proposal 16926, SDSSJ1430+2303_UVIS_F336W (02), scheduling Thu May 19 14:00:25 GMT 2022

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: (none)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(2)	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		(1)

Fixed Targets

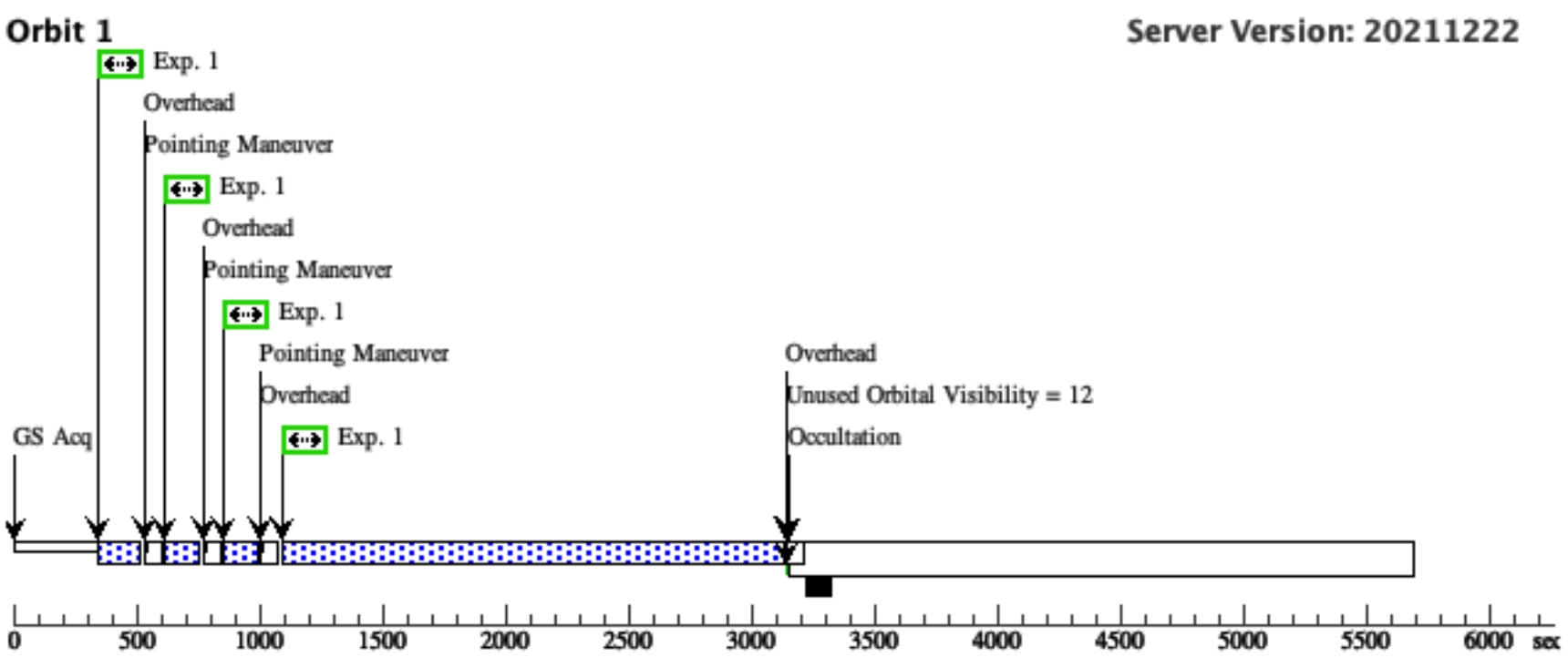
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	SDSSJ1430+2303	RA: 14 30 16.0500 (217.5668750d) Dec: +23 03 44.40 (23.06233d) Equinox: J2000	Redshift: 0.0811	V=14.7+/-0.3 SDSS r = 15.63, SDSS u = 18.44, GALEX NUV = 21.0 (pre-flare), GALEX FUV = 23.5 (AB, model magnitudes), Swift UVW1 = 18.8+/-0.2 (flare)	Reference Frame: ICRS

Comments:
Category=GALAXY
Description=[SEYFERT]
Extended=YES

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) SDSSJ1430+2303	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F336W	FLASH=16		Pattern 2, Exps 1-1 in SDSSJ1430+2303_UVIS_F336W (02) (2)	800 Secs (2459 Secs)	
								[==>140.0 Secs (Pattern 1)] *[==>140.0 Secs (Pattern 2)]* *[==>140.0 Secs (Pattern 3)]* *[==>2039.0 Secs (Pattern 4)]*	***[1]***

Orbit Structure



Visit

Proposal 16926, SDSSJ1430+2303_UVIS_F606W (03), scheduling Thu May 19 14:00:25 GMT 2022

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: (none)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(2)	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		(1)

Fixed Targets

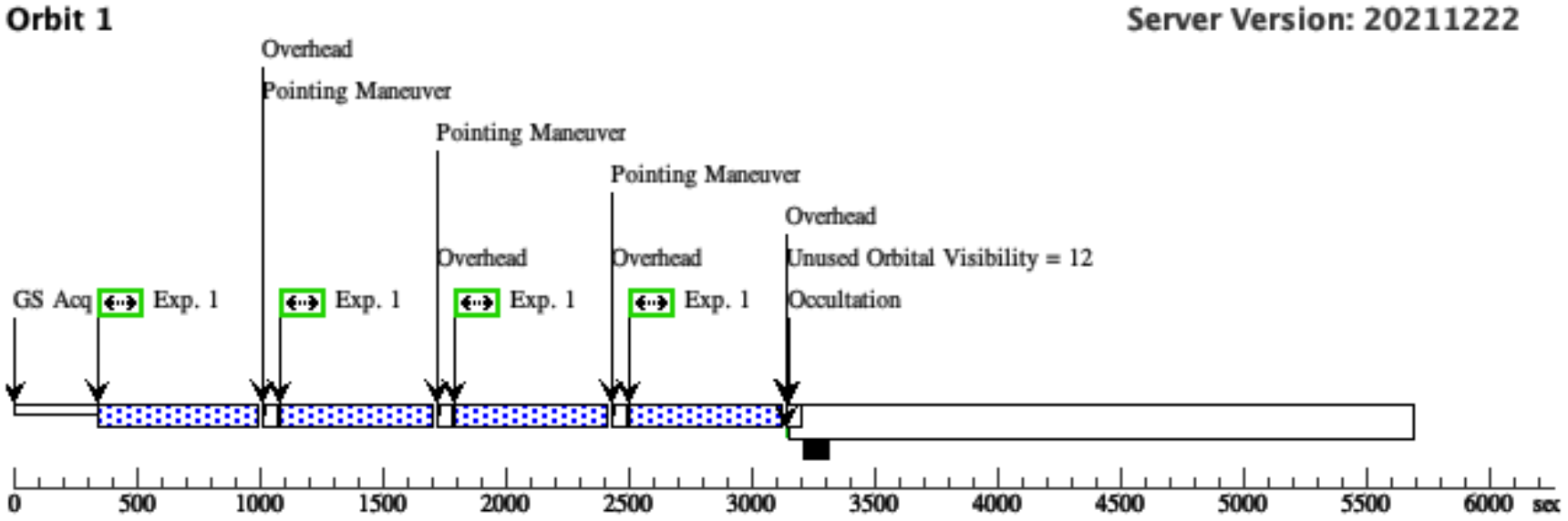
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	SDSSJ1430+2303	RA: 14 30 16.0500 (217.5668750d) Dec: +23 03 44.40 (23.06233d) Equinox: J2000	Redshift: 0.0811	V=14.7+/-0.3 SDSS r = 15.63, SDSS u = 18.44, GALEX NUV = 21.0 (pre-flare), GALEX FUV = 23.5 (AB, model magnitudes), Swift UVW1 = 18.8+/-0.2 (flare)	Reference Frame: ICRS

Comments:
Category=GALAXY
Description=[SEYFERT]
Extended=YES

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) SDSSJ1430+2303	WFC3/UVIS, ACCUM, UVIS2-C1K1C-SUB	F606W			Pattern 2, Exps 1-1 in SDSSJ1430+2303_UVIS_F606W (03) (2)	500 Secs (2496 Secs) *[==>624.0 Secs (Pattern 1)]* *[==>624.0 Secs (Pattern 2)]* *[==>624.0 Secs (Pattern 3)]* *[==>624.0 Secs (Pattern 4)]*	***[1]***

Orbit Structure



Visit

Proposal 16926, SDSSJ1430+2303_STIS_G430L_G230L (04), scheduling Thu May 19 14:00:25 GMT 2022

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/NUV-MAMA, STIS/CCD

Special Requirements: (none)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(3)	Pattern Type=STIS-ALONG-SLIT Purpose=DITHER Number Of Points=2 Point Spacing=0.15 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=90.0 Angle Between Sides= Center Pattern=false		(2)
(4)	Pattern Type=STIS-ALONG-SLIT Purpose=DITHER Number Of Points=3 Point Spacing=0.15 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=90.0 Angle Between Sides= Center Pattern=false		(3)

Fixed Targets

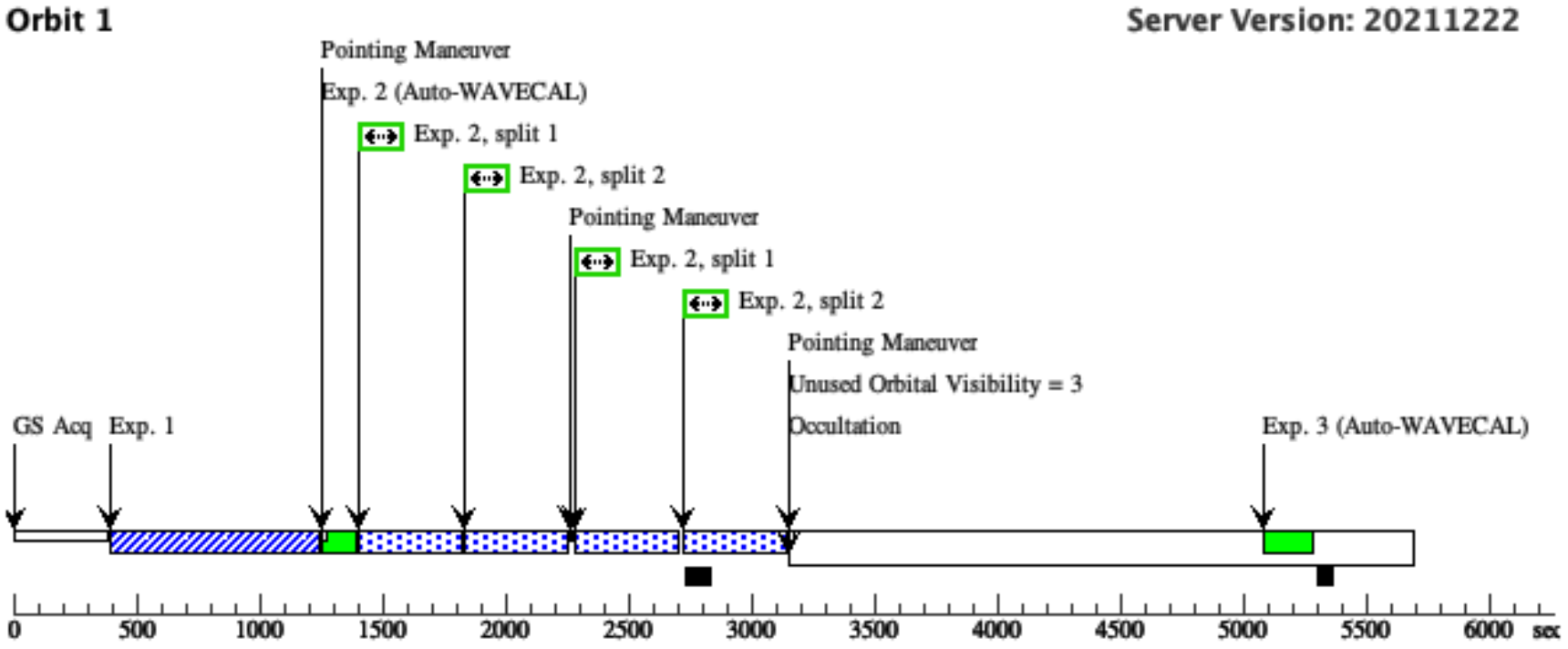
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	SDSSJ1430+2303	RA: 14 30 16.0500 (217.5668750d) Dec: +23 03 44.40 (23.06233d) Equinox: J2000	Redshift: 0.0811	V=14.7+/-0.3 SDSS r = 15.63, SDSS u = 18.44, GALEX NUV = 21.0 (pre-flare), GALEX FUV = 23.5 (AB, model magnitudes), Swift UVW1 = 18.8+/-0.2 (flare)	Reference Frame: ICRS

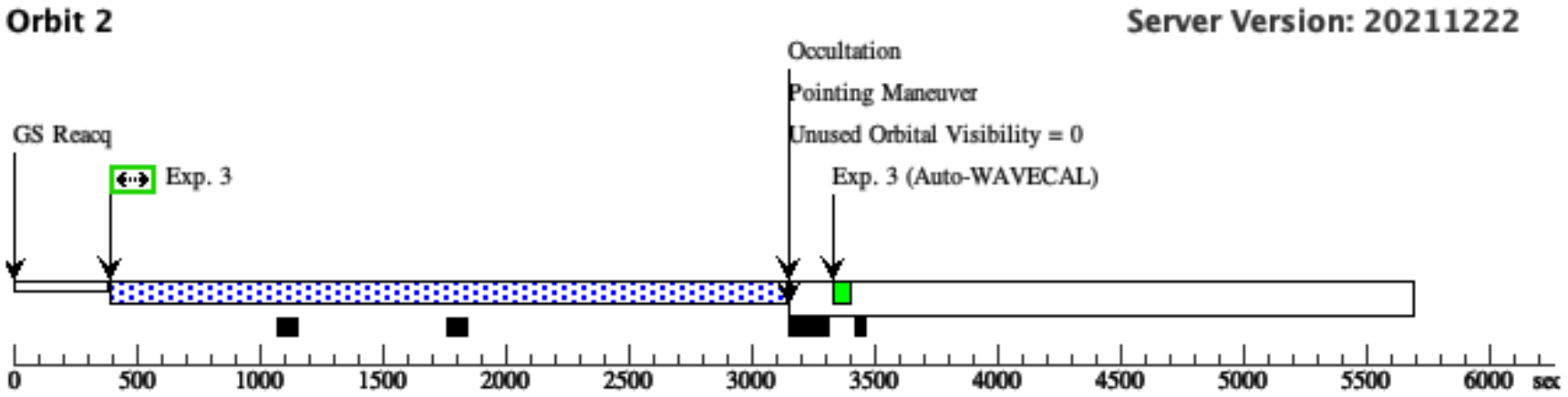
Comments:
Category=GALAXY
Description=[SEYFERT]
Extended=YES

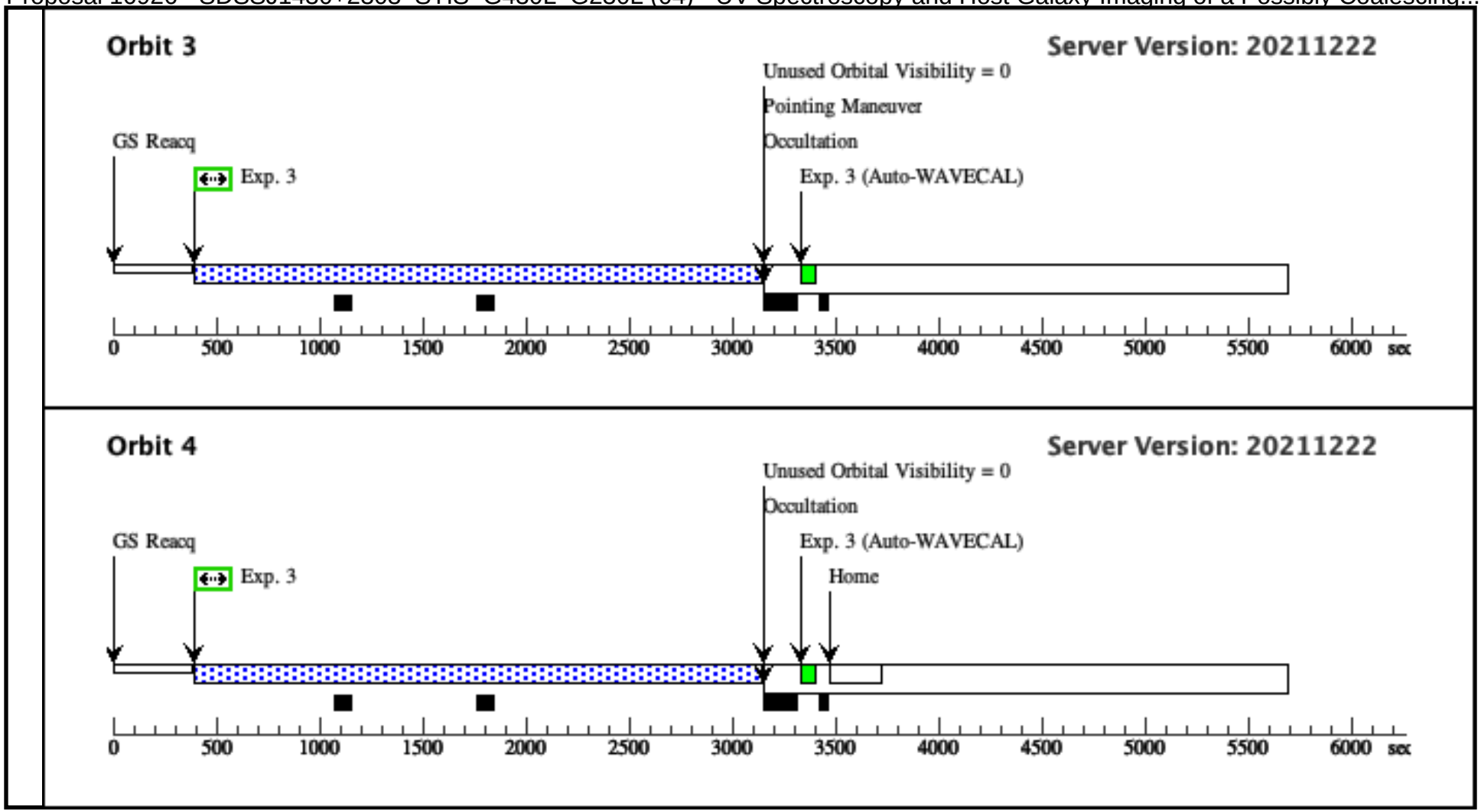
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	acq (STIS.ta.1744638)	(1) SDSSJ1430+2303	STIS/CCD, ACQ, F28X50LP	MIRROR	ACQTYPE=DIFFUSE; CHECKBOX=51; DIFFUSE-CENTER=FLUX-CENTROID			20 Secs (20 Secs) *[==>]*	 ***[1]***
2	(STIS.sp.1742920)	(1) SDSSJ1430+2303	STIS/CCD, ACCUM, 52X0.2E1	G430L 4300 A	CR-SPLIT=2		Pattern 3, Exps 2-2 in SDSSJ1430+2303_STIS_G430L_G230L (04) (3)	1200 Secs (1536 Secs) *[==>384.0 Secs (Pattern 1, Split 1)]* *[==>384.0 Secs (Pattern 1, Split 2)]* *[==>384.0 Secs (Pattern 2, Split 1)]* *[==>384.0 Secs (Pattern 2, Split 2)]*	 ***[1]***
3	(STIS.sp.1742926)	(1) SDSSJ1430+2303	STIS/NUV-MAMA, TIME-TAG, 52X0.2	G230L 2376 A	BUFFER-TIME=685		Pattern 4, Exps 3-3 in SDSSJ1430+2303_STIS_G430L_G230L (04) (4)	3600 Secs (8211 Secs) *[==>2737.0 Secs (Pattern 1)]* *[==>2737.0 Secs (Pattern 2)]* *[==>2737.0 Secs (Pattern 3)]*	 ***[2]*** ***[3]*** ***[4]***

Orbit Structure






Orbit 3
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GS Reacq
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Exp. 3 (Auto-WAVECAL)
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Orbit 4
Server Version: 20211222
Unused Orbital Visibility = 0
Occultation
GS Reacq
Exp. 3
Exp. 3 (Auto-WAVECAL)
Home
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