



## 15899 - Late-time UV spectroscopy of Tidal Disruption Events with HST

Cycle: 27, Proposal Category: GO

(UV Initiative)

(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) AT2018ZR	STIS/CCD STIS/FUV-MAMA	3	08-Oct-2019 15:03:18.0	yes
02	(1) AT2018ZR	STIS/CCD STIS/FUV-MAMA	2	08-Oct-2019 15:03:19.0	yes
03	(1) AT2018ZR	STIS/CCD STIS/NUV-MAMA	3	08-Oct-2019 15:03:21.0	yes
04	(2) ZTF18ABXFTQM	STIS/CCD STIS/FUV-MAMA STIS/NUV-MAMA	3	08-Oct-2019 15:03:22.0	yes

11 Total Orbits Used

## **ABSTRACT**

Once every  $10^5$  years, an accretion-powered flare may temporarily illuminate a supermassive black hole (SMBH) following a tidal disruption event (TDE), in which a star is shredded by tidal stresses close to the SMBH. TDEs provide a new window to study these otherwise dormant SMBHs and probe different accretion modes (super-Eddington to sub-Eddington) on a monthly timescale. Recent studies provide evidence for significant state changes in the late-time TDE emission properties (X-ray re-brightening, light curve flattening) that may be attributed to delayed disk formation or transitions in the accretion processes. These findings highlight our lack of understanding of how and when circularization occurs in TDEs. In light of this, we propose late-time follow-up UV spectroscopic observations of two TDEs that have been observed by HST in their early phases, in order to study the evolution of debris streams on the timescale of a year.

Since the UV band captures the strongest atomic transitions (N, C, Si) expected from TDEs, UV spectroscopy will allow us to measure these lines and infer the kinematics, density, and abundance in this late-time TDE environment. Past HST STIS observations of these two targets have identified cold, fast outflows ( $0.05c$ ) initiated by super-Eddington accretion. One of our targets, AT2018zr, has undergone a remarkable UV spectral hardening that may be related to an increased contribution from the disk. With the proposed HST observations, we wish to ascertain whether such disk exists by searching for high-ionization emission lines similar to those seen in QSOs.

## **OBSERVING DESCRIPTION**

We propose to observe two TDE targets, AT2018zr and ZTF18abxftqm, in Cycle 27 in the wavelength range of 1200 - 3000 Angstrom.

Extrapolating from existing data, we average the results from a linear-fit and a  $t^{-5/3}$  power-law fit to estimate the UVW2 mag of these two targets to be 21.4 and 20.4 mag in October 2019. For the NUV spectrum, we will use STIS NUV-MAMA with the G230L grating instead of COS because we require a broad wavelength coverage to capture NUV features in 1700 - 3000Å (where the rest wavelengths of Fe and MgII transitions fall). We compared the FUV spectrum output from both COS and STIS with the G140L grating with HST ETC and found the required exposure time to reach the desired S/N to be comparable. Therefore, we choose to obtain the FUV spectrum with HST STIS with the G140L.

To estimate the required exposure time, we assume the SED is a blackbody with a temperature of 20,000 K, as typical of TDEs. We assume an orbital visibility of 54 min, an overhead of 6 min for guide star acquisition at the beginning of a visit, 4 min for guide star reacquisition at the beginning of each subsequent

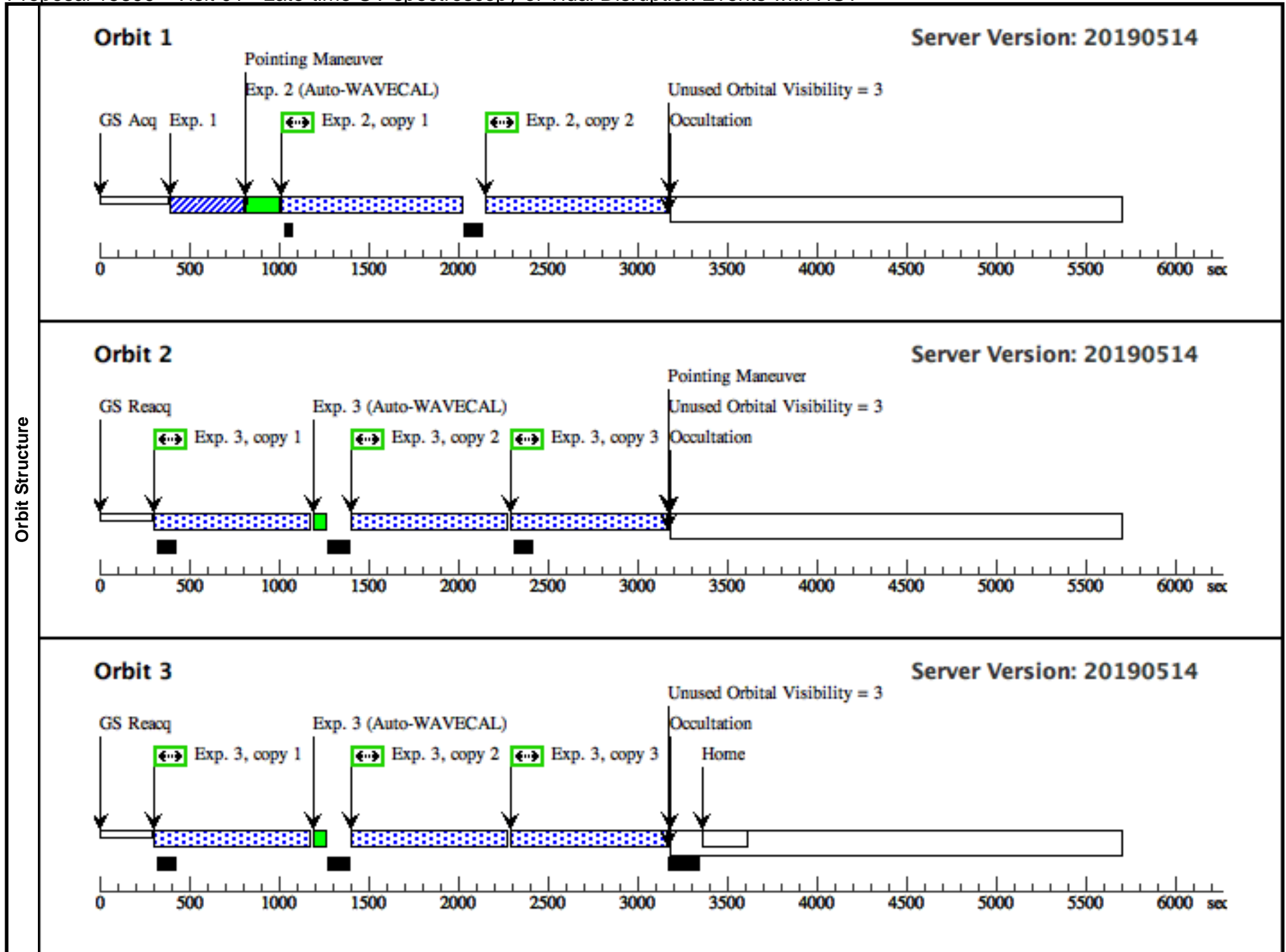
orbits, 6 min for target acquisition, 8 min spectroscopy overhead for each grating, and 4 min for each exposure time interval that exceeds 2300 seconds at the same grating position. This amounts to an on-source time of 34 min in the first orbit, and 44 min in the subsequent orbits.

A 5 orbits observation with STIS FUV-MAMA would result in a  $S/N > 5$  per resolution element from the continuum emission alone with the G140L grating for AT2018zr. A 3 HST orbits observation would result in a  $S/N > 5$  per resolution element from the continuum emission alone with the G230L grating with STIS NUV-MAMA. For ZTF18abxftqm, we require 2 HST orbits for the FUV spectrum, and 1 HST orbit for the NUV spectrum with the same configuration to achieve the same level of  $S/N$ . The assumed  $S/N$  will allow us to detect strong narrow ( $W_r > 1\text{\AA}$ ) absorption lines in the spectrum. In summary, we request for (5 + 3) orbits for AT2018zr and (2 + 1) orbits for ZTF18abxftqm, totaling 11 orbits of HST time in Cycle 27.

Proposal 15899 - Visit 01 - Late-time UV spectroscopy of Tidal Disruption Events with HST

Tue Oct 08 19:03:23 GMT 2019

Visit	<b>Proposal 15899, Visit 01, scheduling</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: STIS/CCD, STIS/FUV-MAMA Special Requirements: BEFORE 01-MAY-2020:00:00:00									
	Patterns	#	Primary Pattern				Secondary Pattern			Exposures
		(2)	Pattern Type=STIS-ALONG-SLIT	Coordinate Frame=POS-TARG						
		Purpose=DITHER	Pattern Orientation=90.0							
		Number Of Points=2	Angle Between Sides=							
		Point Spacing=0.55	Center Pattern=false							
		Line Spacing=								
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	AT2018ZR	RA: 07 56 54.5500 (119.2272917d) Dec: +34 15 43.60 (34.26211d) Equinox: J2000		V=21	Reference Frame: ICRS				
	<i>Comments:</i> Category=GALAXY Description=[ACCRETION DISK, NUCLEUS] Extended=NO									
Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	(1383618)	(1) AT2018ZR	STIS/CCD, ACQ, F28X50LP	MIRROR				45 Secs (45 Secs) [==>]	[1]
	2	(1366521)	(1) AT2018ZR	STIS/FUV-MAMA, ACCUM, 52X0.2	G140L 1425 A				1000 Secs X 2 (2000 Secs) [==>(Copy 1)] [==>(Copy 2)]	[1]
	3	(1366521)	(1) AT2018ZR	STIS/FUV-MAMA, ACCUM, 52X0.2	G140L 1425 A			Pattern 2, Exps 3-3 in Visit 01 (2)	860 Secs X 3 (5160 Secs) [==>(Pattern 1, Copy 1)] [==>(Pattern 1, Copy 2)] [==>(Pattern 1, Copy 3)] [==>(Pattern 2, Copy 1)] [==>(Pattern 2, Copy 2)] [==>(Pattern 2, Copy 3)]	[2] [3]

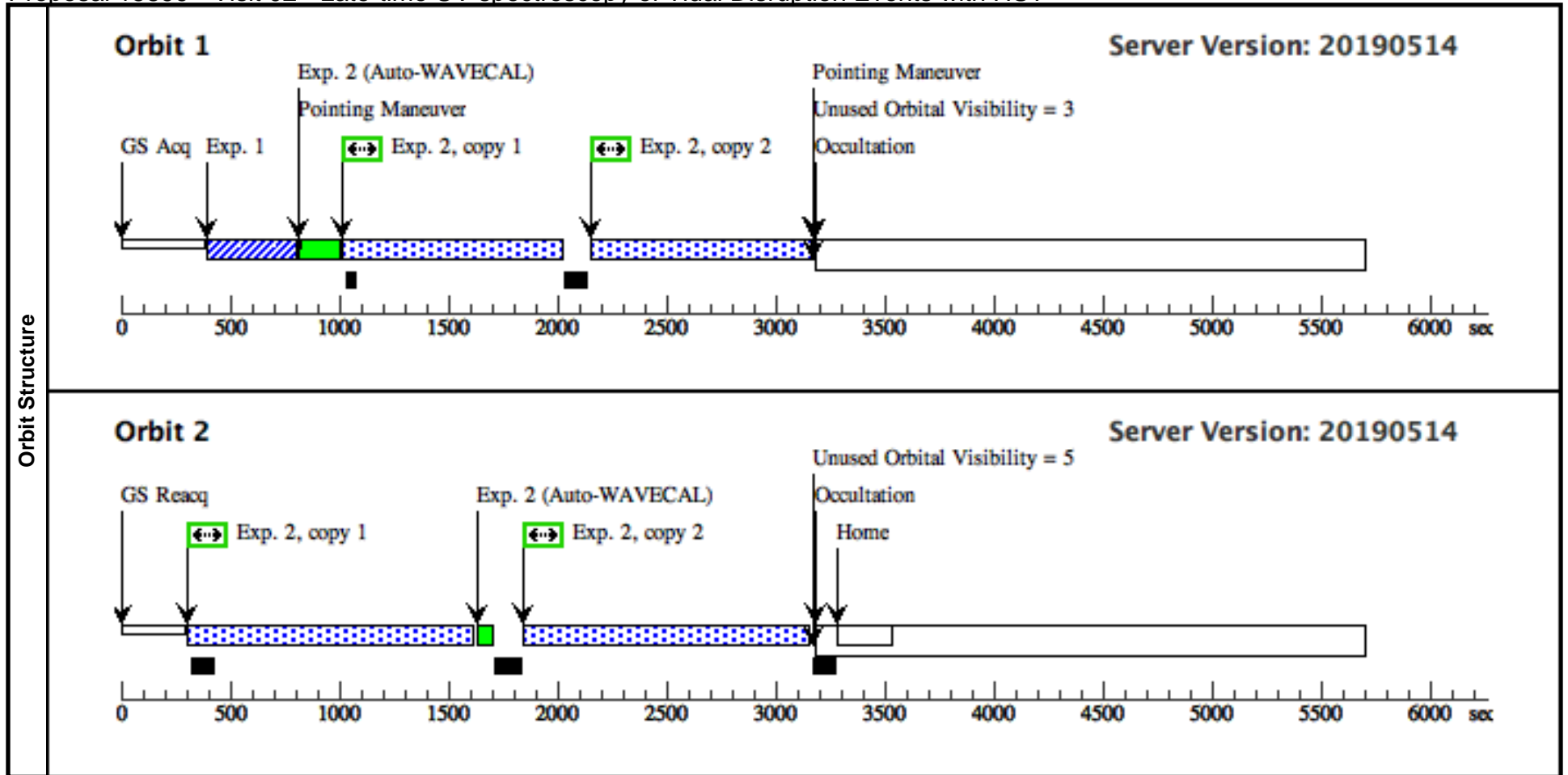


Orbit Structure

Proposal 15899 - Visit 02 - Late-time UV spectroscopy of Tidal Disruption Events with HST

Tue Oct 08 19:03:23 GMT 2019

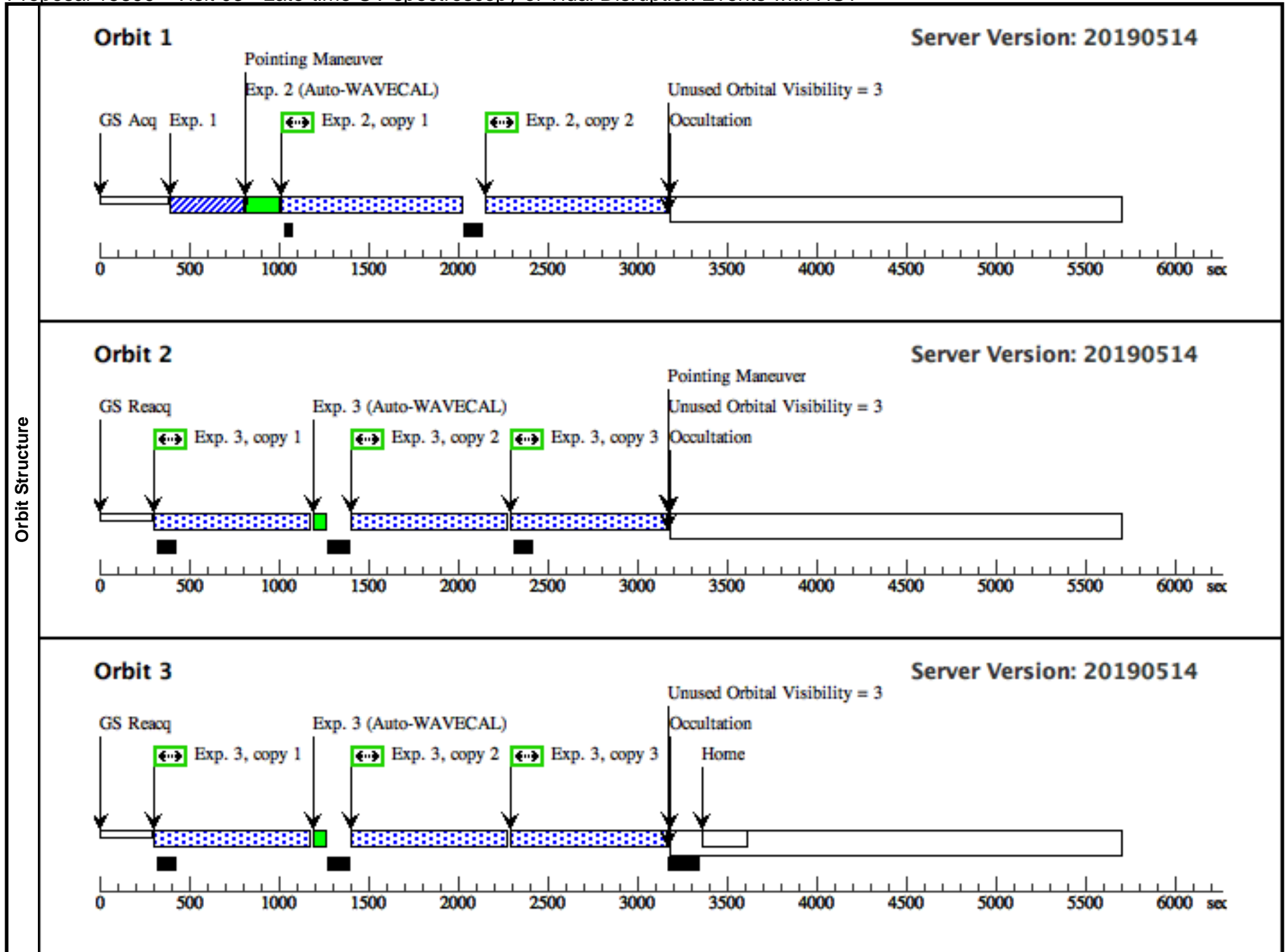
Visit	<b>Proposal 15899, Visit 02, scheduling</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: STIS/CCD, STIS/FUV-MAMA Special Requirements: GROUP 02.01 WITHIN 5D									
	Patterns	#	Primary Pattern			Secondary Pattern			Exposures	
		(2)	Pattern Type=STIS-ALONG-SLIT Purpose=DITHER Number Of Points=2 Point Spacing=0.55 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=90.0 Angle Between Sides= Center Pattern=false					(2)	
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	AT2018ZR	RA: 07 56 54.5500 (119.2272917d) Dec: +34 15 43.60 (34.26211d) Equinox: J2000		V=21	Reference Frame: ICRS				
	<i>Comments:</i> Category=GALAXY Description=[ACCRETION DISK, NUCLEUS] Extended=NO									
Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	(1383618)	(1) AT2018ZR	STIS/CCD, ACQ, F28X50LP	MIRROR				45 Secs (45 Secs)	
								[==>]	[1]	
	2	(1366521)	(1) AT2018ZR	STIS/FUV-MAMA, ACCUM, 52X0.2	G140L 1425 A			Pattern 2, Exps 2-2 in Visit 02 (2)	1300 Secs X 2 (4600 Secs)	
								[==>1000.0 Secs (Pattern 1, Copy 1)]	[1]	
								[==>1000 Secs (Pattern 1, Copy 2)]		
								[==>(Pattern 2, Copy 1)]		
								[==>(Pattern 2, Copy 2)]	[2]	



Proposal 15899 - Visit 03 - Late-time UV spectroscopy of Tidal Disruption Events with HST

Tue Oct 08 19:03:23 GMT 2019

Visit	<b>Proposal 15899, Visit 03, scheduling</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: STIS/NUV-MAMA, STIS/CCD Special Requirements: BEFORE 20-MAY-2020:00:00:00; GROUP 03.01.02 WITHIN 15D									
	Patterns	#	Primary Pattern			Secondary Pattern			Exposures	
		(2)	Pattern Type=STIS-ALONG-SLIT	Coordinate Frame=POS-TARG						(3)
		Purpose=DITHER	Pattern Orientation=90.0							
		Number Of Points=2	Angle Between Sides=							
		Point Spacing=0.55	Center Pattern=false							
		Line Spacing=								
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	AT2018ZR	RA: 07 56 54.5500 (119.2272917d) Dec: +34 15 43.60 (34.26211d) Equinox: J2000		V=21	Reference Frame: ICRS				
	<i>Comments:</i> Category=GALAXY Description=[ACCRETION DISK, NUCLEUS] Extended=NO									
Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	(1383618)	(1) AT2018ZR	STIS/CCD, ACQ, F28X50LP	MIRROR				45 Secs (45 Secs) [==>]	[1]
	2	(1366522)	(1) AT2018ZR	STIS/NUV-MAMA, ACCUM, 52X0.2	G230L 2376 A				1000 Secs X 2 (2000 Secs) [==>(Copy 1)] [==>(Copy 2)]	[1]
	3	(1366522)	(1) AT2018ZR	STIS/NUV-MAMA, ACCUM, 52X0.2	G230L 2376 A			Pattern 2, Exps 3-3 in Visit 03 (2)	860 Secs X 3 (5160 Secs) [==>(Pattern 1, Copy 1)] [==>(Pattern 1, Copy 2)] [==>(Pattern 1, Copy 3)] [==>(Pattern 2, Copy 1)] [==>(Pattern 2, Copy 2)] [==>(Pattern 2, Copy 3)]	[2] [3]



Orbit Structure

Proposal 15899 - Visit 04 - Late-time UV spectroscopy of Tidal Disruption Events with HST

Tue Oct 08 19:03:23 GMT 2019

Visit	<b>Proposal 15899, Visit 04, scheduling</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: STIS/NUV-MAMA, STIS/CCD, STIS/FUV-MAMA Special Requirements: BEFORE 27-FEB-2020:00:00:00									
	Patterns	#	Primary Pattern			Secondary Pattern			Exposures	
		(2)	Pattern Type=STIS-ALONG-SLIT Purpose=DITHER Number Of Points=2 Point Spacing=0.55 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=90.0 Angle Between Sides= Center Pattern=false						(2)
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(2)	ZTF18ABXFTQM	RA: 01 07 33.6100 (16.8900417d) Dec: +23 28 34.40 (23.47622d) Equinox: J2000		V=20.5	Reference Frame: ICRS				
	<i>Comments:</i> Category=GALAXY Description=[ACCRETION DISK, NUCLEUS] Extended=NO									
Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	(1383616)	(2) ZTF18ABXFTQ M	STIS/CCD, ACQ, F28X50LP	MIRROR				60 Secs (60 Secs)	
									[==>]	[1]
	2	(1365946)	(2) ZTF18ABXFTQ M	STIS/FUV-MAMA, ACCUM, 52X0.2	G140L 1425 A			Pattern 2, Exps 2-2 i n Visit 04 (2)	850 Secs X 3 (4440 Secs)	
									[==>630.0 Secs (Pattern 1, Copy 1)] [==>630.0 Secs (Pattern 1, Copy 2)] [==>630.0 Secs (Pattern 1, Copy 3)] [==>(Pattern 2, Copy 1)] [==>(Pattern 2, Copy 2)] [==>(Pattern 2, Copy 3)]	[1]    [2]
3	(1365947)	(2) ZTF18ABXFTQ M	STIS/NUV-MAMA, ACCUM, 52X0.2	G230L 2376 A				890 Secs X 3 (2670 Secs)		
								[==>(Copy 1)] [==>(Copy 2)] [==>(Copy 3)]	[3]	

