



17991 - Probing Magnetar Energy Input with the First Sample of Late-Time Superluminous Supernovae

Cycle: 33, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

<i>Name</i>	<i>Institution</i>
Dr. Peter Blanchard (PI) (Contact)	Harvard University
Prof. Edo Berger (CoI)	Harvard University
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Prof. Daichi Hiramatsu (CoI)	University of Florida
Dr. Harsh Kumar (CoI)	Center for Astrophysics Harvard & Smithsonian

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) SN2021AHPL	WFC3/UVIS	1	23-Mar-2026 09:00:13.0	yes
02	(2) SN2022AAWB	WFC3/UVIS	1	23-Mar-2026 09:00:13.0	yes
03	(3) SN2022LXD	WFC3/UVIS	1	23-Mar-2026 09:00:13.0	yes
04	(4) SN2022NPQ	WFC3/UVIS	1	23-Mar-2026 09:00:13.0	yes
05	(5) SN2022XGC	WFC3/UVIS	1	23-Mar-2026 09:00:14.0	yes
06	(6) SN2023AAFk	WFC3/UVIS	1	23-Mar-2026 09:00:14.0	yes
07	(7) SN2023CMX	WFC3/UVIS	1	23-Mar-2026 09:00:14.0	yes
08	(8) SN2023OUS	WFC3/UVIS	1	23-Mar-2026 09:00:14.0	yes
09	(3) SN2022LXD	WFC3/UVIS	1	23-Mar-2026 09:00:15.0	yes

9 Total Orbits Used

ABSTRACT

Since the discovery of hydrogen-poor superluminous supernovae (SLSNe) over a decade ago, research has focused on identifying the source of their enormous luminosities that can reach up to a hundred times brighter than normal supernovae. Early on, it was realized that the standard radioactive decay model that powers normal supernovae is unable to explain these events. Since then, light curve modeling of large samples, spectral modeling of both early and late-time nebular spectra, and analyses of their dwarf host galaxies have pointed towards a scenario in which the spin-down of a newly-formed magnetar central engine provides energy that is thermalized in the SN ejecta and radiated in the UV/optical. Perhaps the best evidence in favor of this model are the recent HST observations of two events at 400-1100 days after peak that match the power-law decline predicted by magnetar energy input. These observations strongly motivate new observations of a large and diverse sample to measure the distribution of power-law slopes and assess whether the diversity evident in the early light curves of SLSNe correlates with diversity at late times. We therefore propose to observe 8 new SLSNe each at three epochs spread across Cycles 32, 33, and 34 (plus one template observation of an old event). As the late-time optical light curve is highly sensitive to the thermalization of the magnetar's energy, a key goal is to compare our observations with recent radiative transfer simulations to infer properties of the magnetar wind nebulae, the region where the magnetar's energy is transferred to the ejecta. This will be the most comprehensive test to date of the magnetar model for SLSNe.

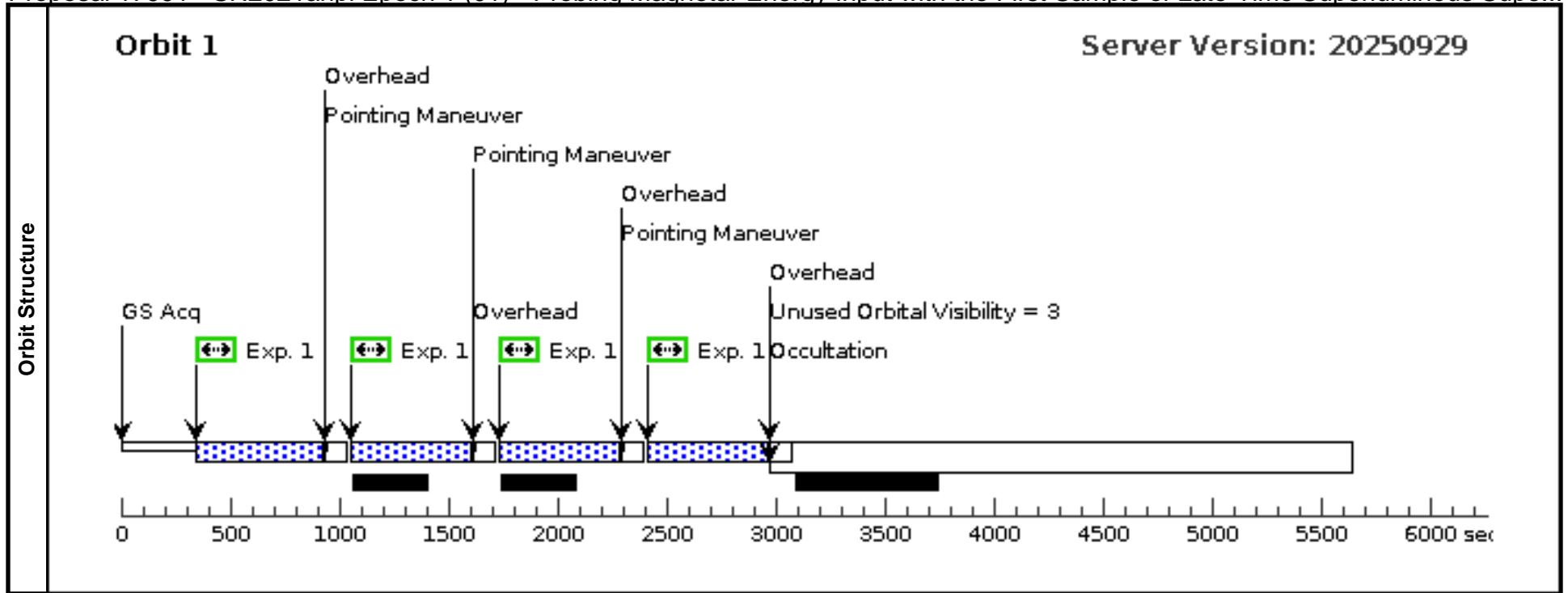
OBSERVING DESCRIPTION

In Cycle 32 we will observe 9 superluminous supernovae one time each in a single filter, 8 with WFC3/UVIS and one with ACS/WFC. Each visit will consist of a dithered observation (standard ACS or WFC3 dither pattern) in one filter lasting one orbit. We will observe 8 of these supernovae two additional times, once in Cycle 33 and a final epoch in Cycle 34.

Proposal 17991 - SN2021ahpl Epoch 1 (01) - Probing Magnetar Energy Input with the First Sample of Late-Time Superluminous Supe...

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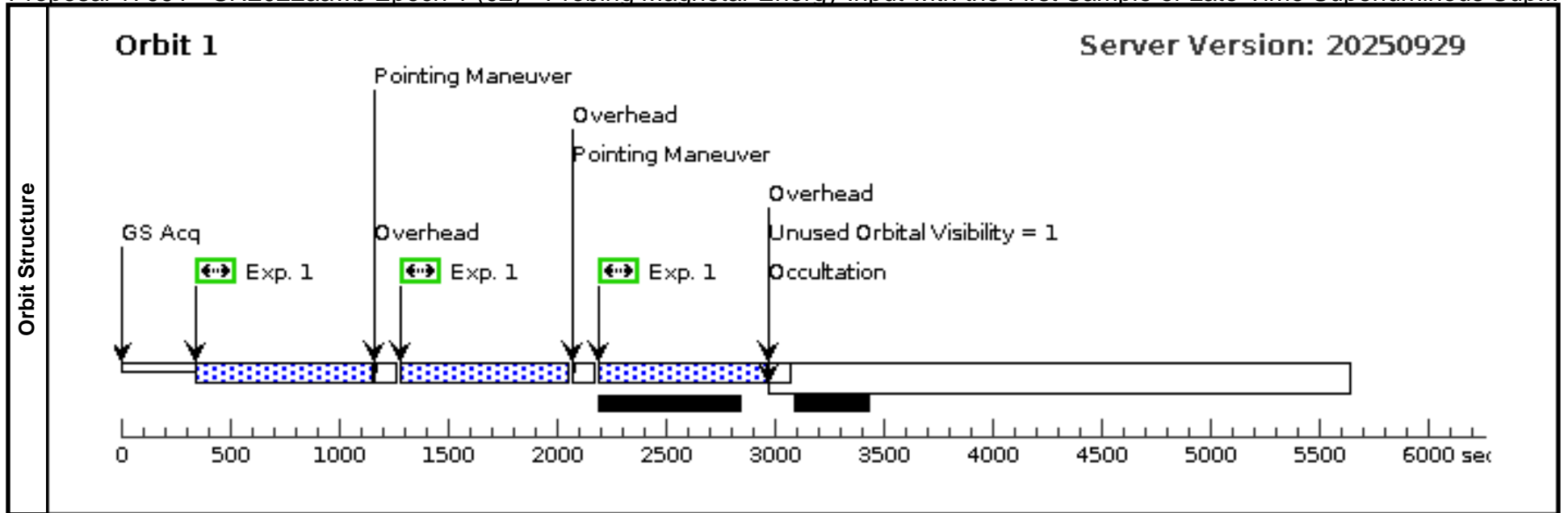
Visit	Proposal 17991, SN2021ahpl Epoch 1 (01), scheduling Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS Special Requirements: (none)										
	Patterns	#	Primary Pattern				Secondary Pattern			Exposures	
(2)		Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point 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)	SN2021AHPL	RA: 15 15 57.9400 (228.9914167d) Dec: -19 17 31.96 (-19.29221d) Equinox: J2000				V=26.0	Reference Frame: ICRS			
Comments: Category=EXT-STAR Description=[SUPERNOVA]											
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]		Orbit
	1	(1) SN2021AHPL	(1) SN2021AHPL	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F625W	FLASH=2.0		Pattern 2, Exps 1-1 in SN2021ahpl Epoch 1 (01) (2)	548 Secs (2192 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]		[1]



Proposal 17991 - SN2022aawb Epoch 1 (02) - Probing Magnetar Energy Input with the First Sample of Late-Time Superluminous Sup...

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Visit	Proposal 17991, SN2022aawb Epoch 1 (02), scheduling Diagnostic Status: Warning Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	(Exposure 1 (Pattern 3, Exps 1-1 in SN2022aawb Epoch 1 (02))) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser									
Diagnosics										
Patterns	#	Primary Pattern	Secondary Pattern			Exposures				
	(3)	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)				
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(2)	SN2022AAWB	RA: 01 44 52.3800 (26.2182500d) Dec: +23 00 43.85 (23.01218d) Equinox: J2000		V=26.0	Reference Frame: ICRS				
Comments: Category=EXT-STAR Description=[SUPERNOVA]										
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(2) SN2022AAWB	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F775W	FLASH=2.0		Pattern 3, Exps 1-1 i n SN2022aawb Epoc h 1 (02) (3)	776 Secs (2328 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)]	[1]

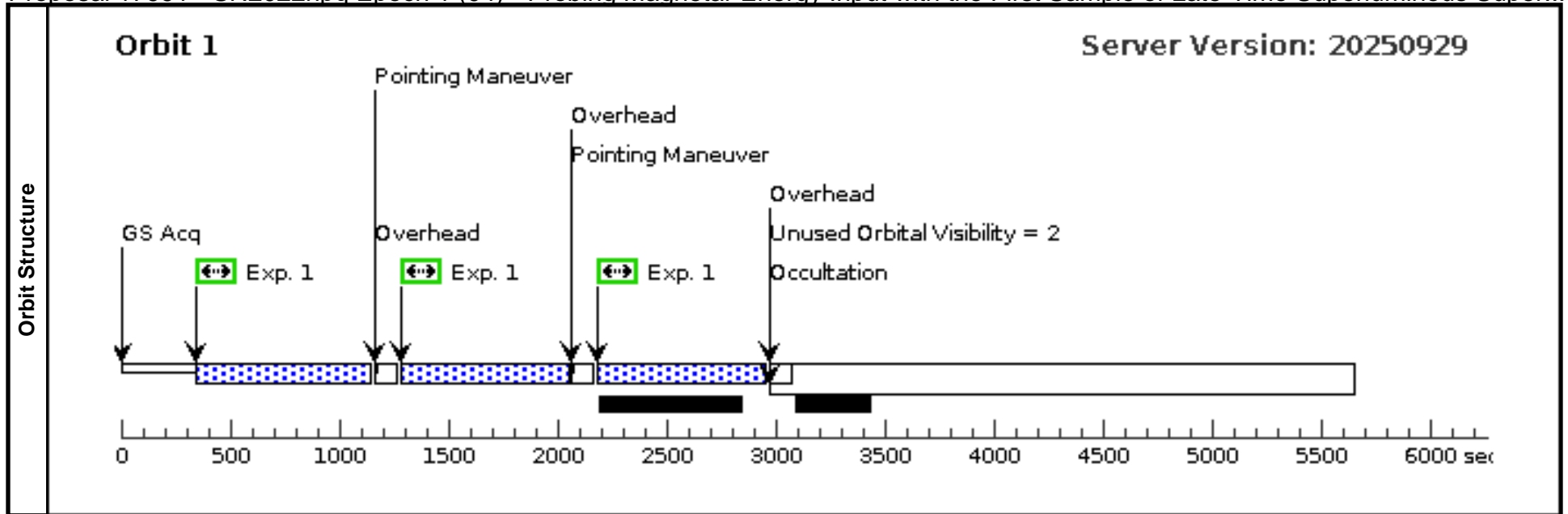


Visit	Proposal 17991, SN2022lxd Epoch 1 (03), failed Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
Patterns	#	Primary Pattern	Secondary Pattern		Exposures					
	(3)	Pattern Type=WFC3-UVIS-DITHER- LINE-3PT Purpose=DITHER Number Of Points=3 Point Spacing=0.135 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1)					
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(3)	SN2022LXD	RA: 17 36 38.6830 (264.1611792d) Dec: +61 33 18.66 (61.55518d) Equinox: J2000		V=26.0	Reference Frame: ICRS				
Comments: Category=EXT-STAR Description=[SUPERNOVA]										
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	(3) SN2022LXD		WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F850LP	FLASH=10.0		Pattern 3, Exps 1-1 i n SN2022lxd Epoch 1 (03) (3)	802 Secs (2406 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)]	[1]
Orbit Structure	Orbit 1 Server Version: 20250929									
	<p>The diagram illustrates the timeline for Orbit 1, spanning from 0 to 6000 seconds. Key events include:</p> <ul style="list-style-type: none"> GS Acq: Occurs at the beginning of the orbit. Exp. 1: Three exposures are scheduled, each marked with a green double-headed arrow icon. Pointing Maneuver Overhead: Two overhead periods are shown between the exposures. Occultation: A period where the target is obscured, occurring after the second overhead. Unused Orbital Visibility: A period at the end of the orbit where the target is visible but not observed. <p>A blue checkered bar highlights the active observation period, which ends before the occultation begins. The text "Unused Orbital Visibility = 0" is present near the occultation event.</p>									

Proposal 17991 - SN2022npq Epoch 1 (04) - Probing Magnetar Energy Input with the First Sample of Late-Time Superluminous Super...

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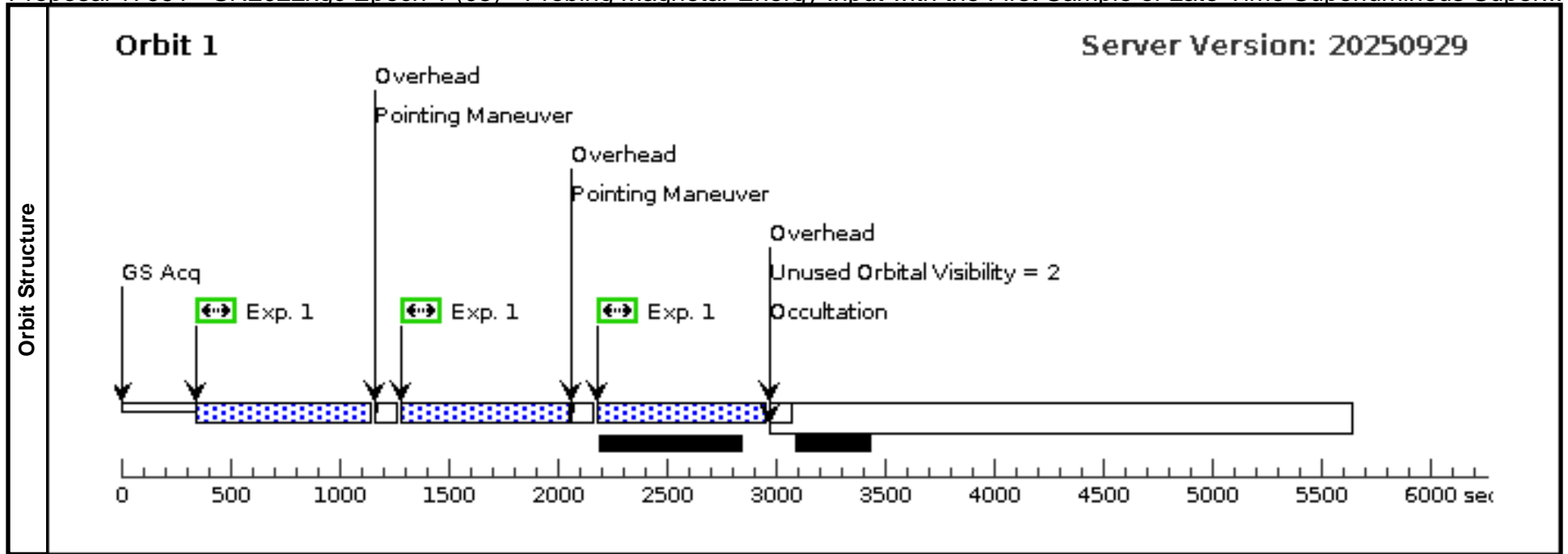
Visit	Proposal 17991, SN2022npq Epoch 1 (04), scheduling Diagnostic Status: Warning Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	(Exposure 1 (Pattern 3, Exps 1-1 in SN2022npq Epoch 1 (04))) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser									
Diagnosics										
Patterns	#	Primary Pattern	Secondary Pattern			Exposures				
	(3)	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)			
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(4)	SN2022NPQ	RA: 16 21 3.7320 (245.2655500d) Dec: +14 50 54.75 (14.84854d) Equinox: J2000		V=26.0	Reference Frame: ICRS				
Comments: Category=EXT-STAR Description=[SUPERNOVA]										
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(4) SN2022NPQ	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F775W	FLASH=2.0		Pattern 3, Exps 1-1 i n SN2022npq Epoch 1 (04) (3)	774 Secs (2322 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)]	[1]



Proposal 17991 - SN2022xgc Epoch 1 (05) - Probing Magnetar Energy Input with the First Sample of Late-Time Superluminous Super...

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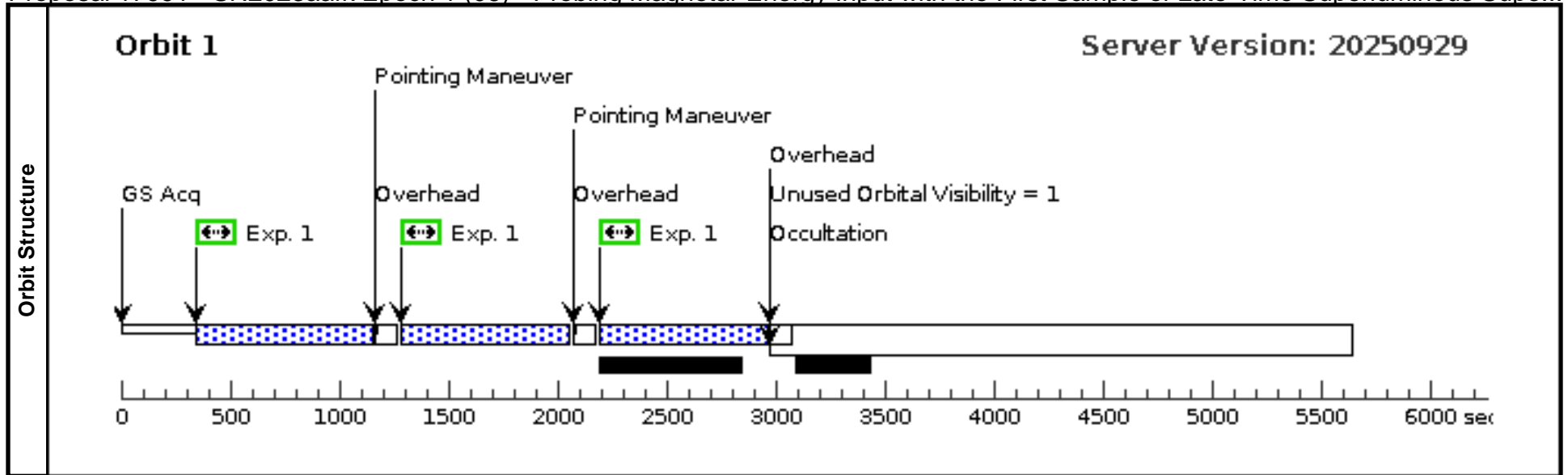
Visit	Proposal 17991, SN2022xgc Epoch 1 (05), scheduling Diagnostic Status: Warning Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	(Exposure 1 (Pattern 3, Exps 1-1 in SN2022xgc Epoch 1 (05))) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser									
Diagnosics										
Patterns	#	Primary Pattern	Secondary Pattern			Exposures				
	(3)	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)			
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(5)	SN2022XGC	RA: 07 12 41.8100 (108.1742083d) Dec: +07 18 59.95 (7.31665d) Equinox: J2000		V=26.0	Reference Frame: ICRS				
Comments: Category=EXT-STAR Description=[SUPERNOVA]										
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(5) SN2022XGC	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F775W	FLASH=2.0		Pattern 3, Exps 1-1 i n SN2022xgc Epoch 1 (05) (3)	775 Secs (2325 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)]	[1]



Proposal 17991 - SN2023aafk Epoch 1 (06) - Probing Magnetar Energy Input with the First Sample of Late-Time Superluminous Supe...

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Visit	Proposal 17991, SN2023aafk Epoch 1 (06), scheduling Diagnostic Status: Warning Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	(Exposure 1 (Pattern 3, Exps 1-1 in SN2023aafk Epoch 1 (06))) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser									
Diagnosics										
Patterns	#	Primary Pattern	Secondary Pattern			Exposures				
	(3)	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)				
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(6)	SN2023AAFK	RA: 04 30 41.6710 (67.6736292d) Dec: +02 56 42.89 (2.94525d) Equinox: J2000		V=26.0	Reference Frame: ICRS				
Comments: Category=EXT-STAR Description=[SUPERNOVA]										
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(6) SN2023AAFK	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F775W	FLASH=2.0		Pattern 3, Exps 1-1 i n SN2023aafk Epoch 1 (06) (3)	776 Secs (2328 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)]	[1]

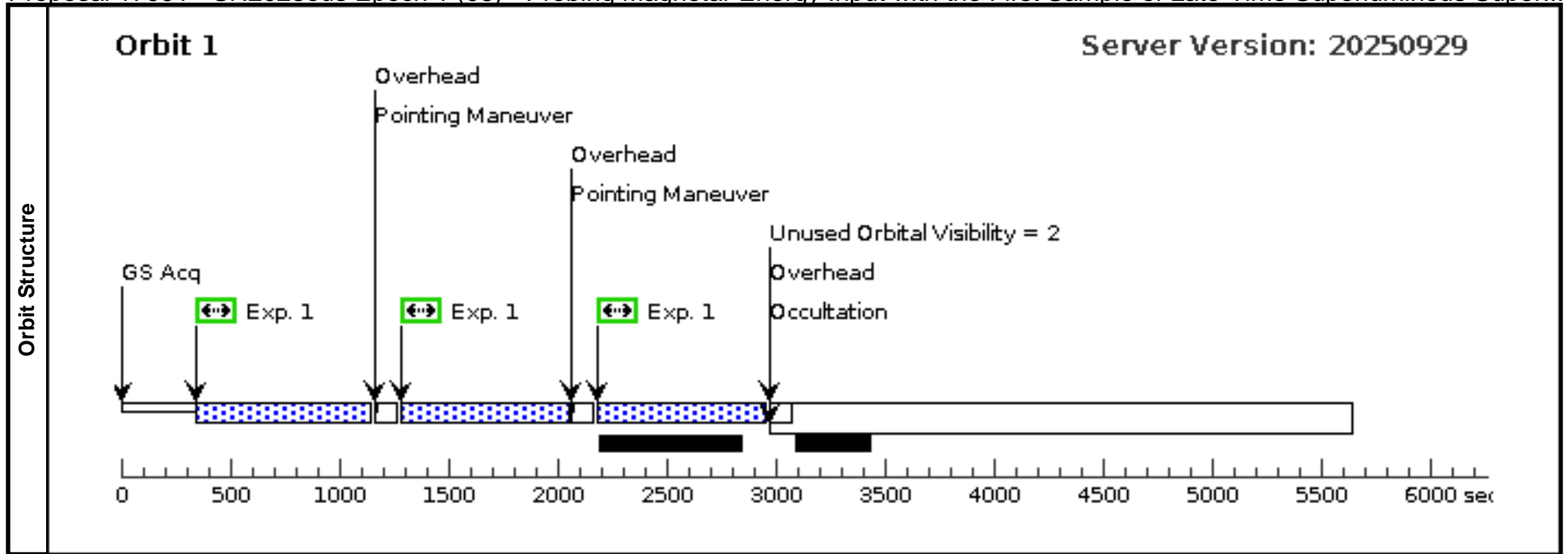


Visit	Proposal 17991, SN2023cmx Epoch 1 (07), scheduling Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	Patterns	#	Primary Pattern	Secondary Pattern	Exposures					
	(3)	Pattern Type=WFC3-UVIS-DITHER- LINE-3PT Purpose=DITHER Number Of Points=3 Point Spacing=0.135 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1)					
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(7)	SN2023CMX	RA: 07 06 54.6500 (106.7277083d) Dec: +37 58 35.54 (37.97654d) Equinox: J2000		V=26.0	Reference Frame: ICRS				
	Comments: Category=EXT-STAR Description=[SUPERNOVA]									
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	(7) SN2023CMX		WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F775W	FLASH=2.0		Pattern 3, Exps 1-1 i n SN2023cmx Epoch 1 (07) (3)	780 Secs (2340 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)]	[1]
Orbit Structure	<div style="display: flex; justify-content: space-between;"> Orbit 1 Server Version: 20250929 </div> <p>The diagram illustrates the orbit structure for Orbit 1, showing a timeline from 0 to 6000 seconds. Key events include GS Acq at 0s, three exposures (Exp. 1) at approximately 400s, 1300s, and 2200s, and a final exposure at 3000s. The timeline is divided into segments for Pointing Maneuver, Overhead, and Occultation. A shaded blue region indicates the active observation period from approximately 400s to 3000s. A black bar at the bottom indicates the occultation period from approximately 2200s to 3500s. The text 'Unused Orbital Visibility = 2' is shown at the end of the timeline.</p>									

Proposal 17991 - SN2023ous Epoch 1 (08) - Probing Magnetar Energy Input with the First Sample of Late-Time Superluminous Super...

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Visit	Proposal 17991, SN2023ous Epoch 1 (08), scheduling Diagnostic Status: Warning Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	(Exposure 1 (Pattern 3, Exps 1-1 in SN2023ous Epoch 1 (08))) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser									
Diagnosics										
Patterns	#	Primary Pattern	Secondary Pattern			Exposures				
	(3)	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)			
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(8)	SN2023OUS	RA: 04 25 50.1000 (66.4587500d) Dec: -09 09 28.08 (-9.15780d) Equinox: J2000		V=26.0	Reference Frame: ICRS				
Comments: Category=EXT-STAR Description=[SUPERNOVA]										
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1		(8) SN2023OUS	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F775W	FLASH=2.0		Pattern 3, Exps 1-1 i n SN2023ous Epoch 1 (08) (3)	775 Secs (2325 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)]	[1]



Visit	Proposal 17991, HOPR repeat of visit 3 (09) Diagnostic Status: No Diagnostics Scientific Instruments: WFC3/UVIS Special Requirements: (none)									
	Patterns	# (3)	Primary Pattern Pattern Type=WFC3-UVIS-DITHER- LINE-3PT Purpose=DITHER Number Of Points=3 Point Spacing=0.135 Line Spacing=	Secondary Pattern Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false	Exposures (1)					
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(3)	SN2022LXD	RA: 17 36 38.6830 (264.1611792d) Dec: +61 33 18.66 (61.55518d) Equinox: J2000		V=26.0	Reference Frame: ICRS				
	Comments: Category=EXT-STAR Description=[SUPERNOVA]									
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	(3) SN2022LXD		WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F850LP	FLASH=10.0		Pattern 3, Exps 1-1 i n HOPR repeat of vis it 3 (09) (3)	802 Secs (2406 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)]	[1]
Orbit Structure	<div style="display: flex; justify-content: space-between;"> Orbit 1 Server Version: 20250929 </div> <p>Pointing Maneuver Pointing Maneuver Unused Orbital Visibility = 0</p> <p>The diagram shows a timeline from 0 to 6000 seconds. Key events include: GS Acq at ~200s, three exposures of 'Exp. 1' (each preceded by an 'Overhead' period) at approximately 400s, 1300s, and 2200s. An 'Occultation' period occurs between 3000s and 3500s. A blue checkered bar at the bottom represents the active observation period, which ends at approximately 5500s. The text 'Unused Orbital Visibility = 0' is displayed above the timeline.</p>									