



# 15863 - UV to NIR Study of the the First Robust Pulsational or Pair Instability Supernova and its Low Metallicity Environment

Cycle: 27, Proposal Category: GO

(Availability Mode: SUPPORTED)

## INVESTIGATORS

<i>Name</i>	<i>Institution</i>	<i>E-Mail</i>
<b>Sebastian Gomez (PI) (Contact)</b>	<b>Harvard University</b>	<b>sebastian.gomez@cfa.harvard.edu</b>
Prof. Edo Berger (CoI)	Harvard University	eberger@cfa.harvard.edu
Dr. Peter Blanchard (CoI)	Northwestern University	peter.blanchard@northwestern.edu
Dr. Matt Nicholl (CoI) (ESA Member)	University of Birmingham	mnicholl@star.sr.bham.ac.uk
Dr. Ashley Villar (CoI)	Columbia University in the City of New York	vav2110@columbia.edu
Locke Patton (CoI)	Smithsonian Institution Astrophysical Observatory	locke.patton@cfa.harvard.edu
Griffin Hosseinzadeh (CoI)	University of Arizona	griffin0@arizona.edu
Dr. Philip Cowperthwaite (CoI)	Carnegie Institution of Washington	pcowperthwaite@carnegiescience.edu
Prof. Ryan Chornock (CoI)	University of California - Berkeley	chornock@berkeley.edu
Daichi Hiramatsu (CoI)	Center for Astrophysics   Harvard & Smithsonian	daichi.hiramatsu@cfa.harvard.edu

## 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) SN2016IET	WFC3/IR	2	06-Jan-2022 10:00:37.0	yes
02	(1) SN2016IET	ACS/WFC WFC3/UVIS	2	06-Jan-2022 10:00:38.0	yes
52	(1) SN2016IET	WFC3/UVIS	1	06-Jan-2022 10:00:39.0	yes

5 Total Orbits Used

## **ABSTRACT**

SN2016iet is an unprecedented supernova in terms of its temporal evolution, spectra, and environment. The light curve exhibits two distinct peaks separated by 100 days, and slowly decline by only 5 mag in 2.5 years. The spectra are dominated by a blue continuum and low velocity calcium and oxygen lines with an unusually high Ca/O ratio, but lack hydrogen or helium. The SN is located at an unusually large offset (16 kpc, 5 effective radii) from a low metallicity dwarf galaxy (0.1  $Z_{\text{sun}}$ ,  $3e8 M_{\text{sun}}$ ). Modeling of the SN data indicates that it is powered by interaction of 20-85  $M_{\text{sun}}$  of ejecta with 35  $M_{\text{sun}}$  of H/He-free circumstellar material (CSM), ejected in the final decade before explosion. Thus, the progenitor's CO core shortly before explosion was 55-120  $M_{\text{sun}}$ , placing it in the regime of pulsational pair instability or pair instability explosions, further supported by the low metallicity. This is the first robust case for such an origin based directly on a large progenitor mass and low metallicity. We request observations of this unprecedented SN to achieve several goals that can only be done with HST: (i) track the SN emission at  $>1000$  days post explosion, as it fades below ground-based capabilities, to track the large-scale CSM; (ii) use NIR data to search for the first time for evidence of dust formation in H/He-poor CSM interaction; (iii) measure the UV brightness of the host galaxy to precisely determine its star formation activity and escape fraction of ionizing radiation; and (iv) search for a potential underlying galaxy at the SN position, which from existing limits will be  $<1e-3 L^*$ . This will be accomplished with 4 orbits in Cycle 27 and 3 orbits in Cycle 28.

## **OBSERVING DESCRIPTION**

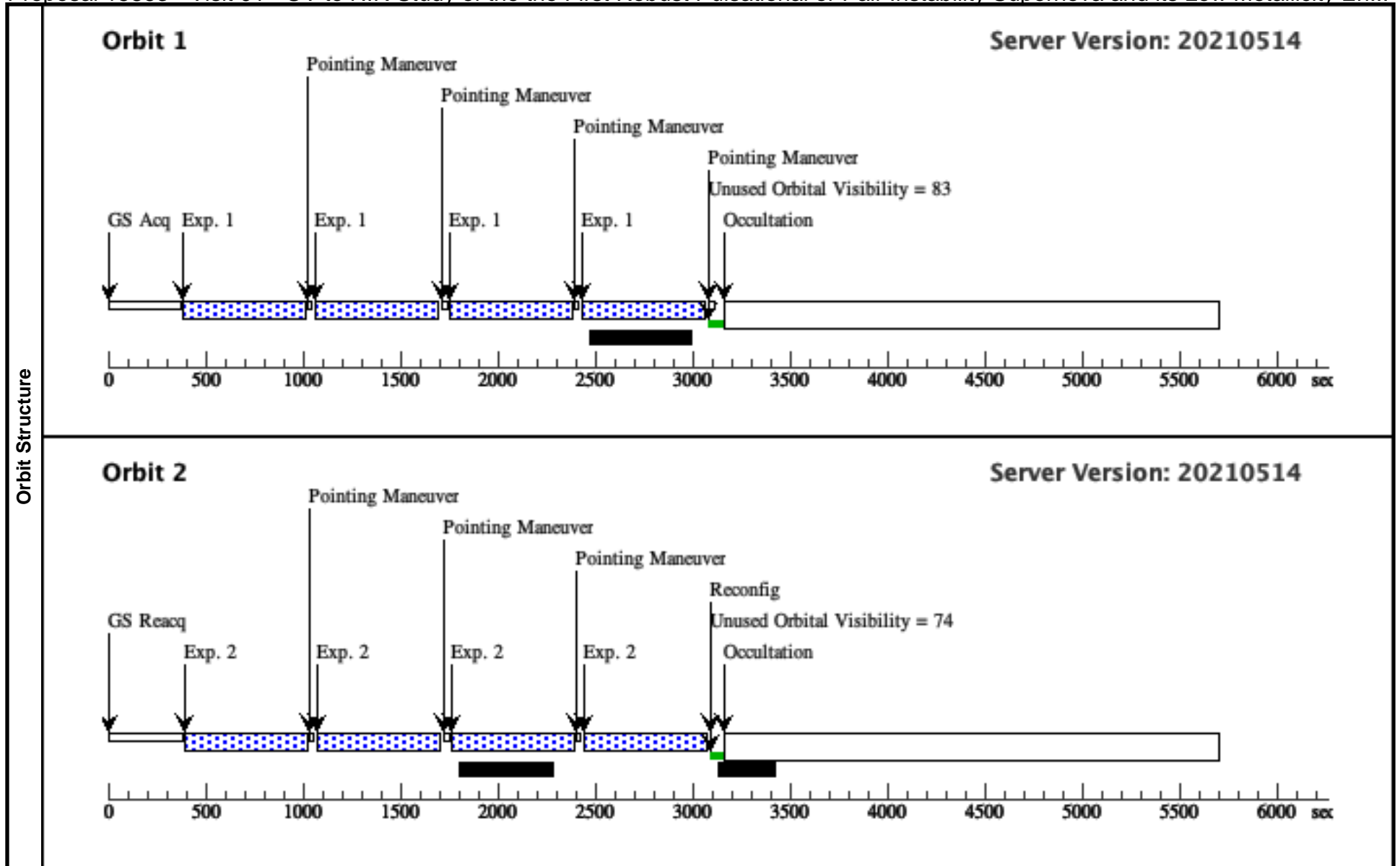
We request 4 orbits in Cycle 27 to observe SN2016iet at R.A.=12:32:33.23, decl.=+27:07:15.49 (J2000) to be observed during the early half of cycle 27, due to the fading nature of the source. The 4 orbits need not be done consecutively nor in a particular order, but they should be done within 30 days of each other. We split the 4 orbits into 2 distinct visits of 2 orbits each to aid the scheduler without increasing the overheads to much. One visit with WFC3/IR with one orbit dedicated to the F110W filter, and one orbit to the F160W filter. For the second visit one orbit should be done with ACS/WFC with the F625W filter, and a second orbit with WFC3/UVIS with the F225W filter. For each orbit we request 4 individual exposures, dithered with a box pattern. Both visits should be scheduled within 30 days of each other, due to the fading nature of the supernova.

This multi-cycle proposal has three additional orbits scheduled during Cycle 28 to obtain templates after the supernova has faded. We request these during the late half of Cycle 28. One ACS/WFC orbit with filter F625W, one WFC3/IR orbit with filter F110W, and one orbit with the F160W filter.

Proposal 15863 - Visit 01 - UV to NIR Study of the the First Robust Pulsational or Pair Instability Supernova and its Low Metallicity En...

Thu Jan 06 15:00:39 GMT 2022

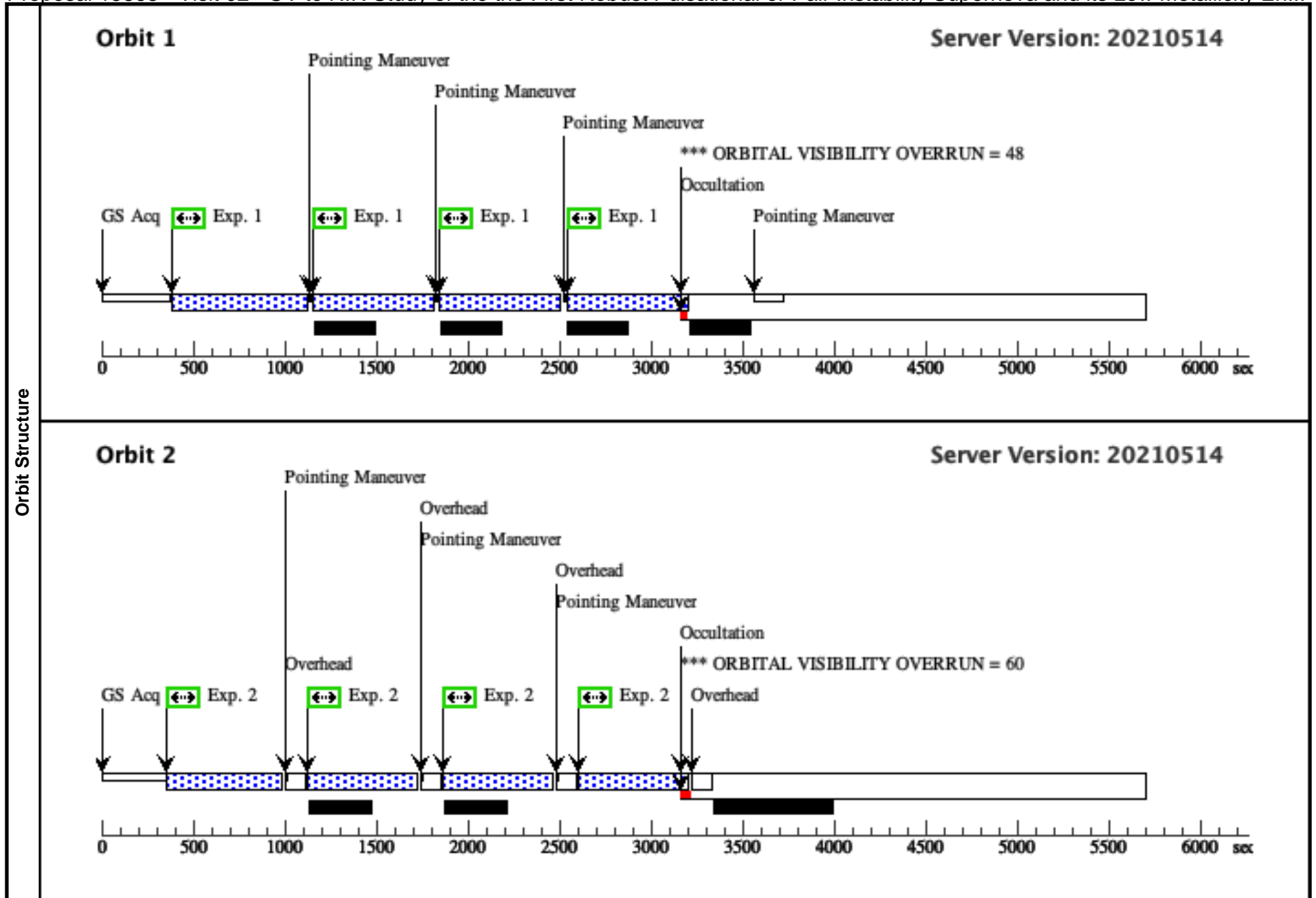
Visit	<b>Proposal 15863, Visit 01, completed</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: WFC3/IR Special Requirements: BETWEEN 07-NOV-2019:00:00:00 AND 07-MAY-2020:00:00:00: GROUP 01.02 WITHIN 30D									
	Patterns	#	Primary Pattern			Secondary Pattern			Exposures	
		(1)	Pattern Type=WFC3-IR-DITHER-BOX-UVIS Purpose=DITHER Number Of Points=4 Point Spacing=23.02 Line Spacing=35.212	Coordinate Frame=POS-TARG Pattern Orientation=0.713 Angle Between Sides=89.287 Center Pattern=true					(1), (2)	
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	SN2016IET	RA: 12 32 33.2300 (188.1384583d) Dec: +27 07 15.49 (27.12097d) Equinox: J2000		V=26.0+/-0.5	Reference Frame: ICRS				
	<i>Comments:</i> Category=STAR Description=[SUPERNOVA] Extended=NO									
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	WFC3/IR_1 10	(1) SN2016IET	WFC3/IR, MULTIACCUM, IR	F110W	NSAMP=7; SAMP-SEQ=SPAR S100	GS ACQ SCENARI O BASE1B3	Pattern 1, Exps 1-1 i n Visit 01 (1)	602.934229 Secs (2411.737 Secs)	
									[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[1]
2	WFC3/IR_1 60	(1) SN2016IET	WFC3/IR, MULTIACCUM, IR	F160W	NSAMP=7; SAMP-SEQ=SPAR S100		Pattern 1, Exps 2-2 i n Visit 01 (1)	602.934229 Secs (2411.737 Secs)		
								[==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]	[2]	



Proposal 15863 - Visit 02 - UV to NIR Study of the the First Robust Pulsational or Pair Instability Supernova and its Low Metallicity En...

Thu Jan 06 15:00:40 GMT 2022

<b>Visit</b>	<b>Proposal 15863, Visit 02, failed</b> <b>Diagnostic Status: Warning</b> Scientific Instruments: WFC3/UVIS, ACS/WFC Special Requirements: (none)									
	(Visit 02) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN (Visit 02) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN (WFC3/UVIS (02.002)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser									
<b>Diagnosics</b>										
<b>Patterns</b>	<b>#</b>	<b>Primary Pattern</b>	<b>Secondary Pattern</b>	<b>Exposures</b>						
	(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		(2)					
(3)	Pattern Type=ACS-WFC-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.262 Line Spacing=0.192	Coordinate Frame=POS-TARG Pattern Orientation=18.39 Angle Between Sides=68.14 Center Pattern=false		(1)						
<b>Fixed Targets</b>	<b>#</b>	<b>Name</b>	<b>Target Coordinates</b>	<b>Targ. Coord. Corrections</b>	<b>Fluxes</b>	<b>Miscellaneous</b>				
	(1)	SN2016IET	RA: 12 32 33.2300 (188.1384583d) Dec: +27 07 15.49 (27.12097d) Equinox: J2000		V=26.0+/-0.5	Reference Frame: ICRS				
Comments: Category=STAR Description=[SUPERNOVA] Extended=NO										
<b>Exposures</b>	<b>#</b>	<b>Label</b>	<b>Target</b>	<b>Config,Mode,Aperture</b>	<b>Spectral Els.</b>	<b>Opt. Params.</b>	<b>Special Reqs.</b>	<b>Groups</b>	<b>Exp. Time (Total)/[Actual Dur.]</b>	<b>Orbit</b>
	1	ACS	(1) SN2016IET	ACS/WFC, ACCUM, WFC2	F625W			Pattern 3, Exps 1-1 in Visit 02 (3)	534 Secs (2136 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[1]
2	WFC3/UVIS	(1) SN2016IET	WFC3/UVIS, ACCUM, UVIS2	F225W	FLASH=10	GS ACQ SCENARIO BASE1B3		Pattern 2, Exps 2-2 in Visit 02 (2)	605 Secs (2420 Secs) [=>(Pattern 1)] [=>(Pattern 2)] [=>(Pattern 3)] [=>(Pattern 4)]	[2]



Proposal 15863 - Visit 52 - UV to NIR Study of the the First Robust Pulsational or Pair Instability Supernova and its Low Metallicity En...

Thu Jan 06 15:00:40 GMT 2022

<b>Visit</b>	Proposal 15863, Visit 52, completed Diagnostic Status: Warning Scientific Instruments: WFC3/UVIS Special Requirements: (none)										
	(Visit 52) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN (WFC3/UVIS (52.001)) Warning (Form): FLASH level may be too low for this exposure or a short subexposure. See extended explanation in the diagnostic browser										
<b>Diagnosics</b>											
<b>Patterns</b>	<b>#</b>	<b>Primary Pattern</b>				<b>Secondary Pattern</b>				<b>Exposures</b>	
	(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)	
<b>Fixed Targets</b>	<b>#</b>	<b>Name</b>	<b>Target Coordinates</b>		<b>Targ. Coord. Corrections</b>		<b>Fluxes</b>		<b>Miscellaneous</b>		
	(1)	SN2016IET	RA: 12 32 33.2300 (188.1384583d) Dec: +27 07 15.49 (27.12097d) Equinox: J2000				V=26.0+/-0.5		Reference Frame: ICRS		
Comments: Category=STAR Description=[SUPERNOVA] Extended=NO											
<b>Exposures</b>	<b>#</b>	<b>Label</b>	<b>Target</b>	<b>Config,Mode,Aperture</b>	<b>Spectral Els.</b>	<b>Opt. Params.</b>	<b>Special Reqs.</b>	<b>Groups</b>	<b>Exp. Time (Total)/[Actual Dur.]</b>		<b>Orbit</b>
	1	WFC3/UVIS	(1) SN2016IET	WFC3/UVIS, ACCUM, UVIS2	F225W	FLASH=10	GS ACQ SCENARIO BASE1B3	Pattern 2, Exps 1-1 in Visit 52 (2)	605 Secs (2420 Secs) [==>(Pattern 1)] [==>(Pattern 2)] [==>(Pattern 3)] [==>(Pattern 4)]		[1]

