17842 - Expanding shocks and the emergence of the compact object in Supernova 1987A

Cycle: 32, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*
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Prof. Robert P. Kirshner (CoI) (AdminUSPI)	Harvard University
Mr. Peter Challis (CoI)	Harvard University
Dr. Roger A. Chevalier (CoI)	The University of Virginia
Prof. Kevin France (CoI)	University of Colorado at Boulder
Prof. Kevin Heng (CoI) (ESA Member)	Ludwig Maximilian Universitat of Munich
Dr. Stephen S. Lawrence (CoI)	Hofstra University
Prof. Peter Lundqvist (CoI) (ESA Member)	Stockholm University
Dr. Seppo Mattila (CoI) (ESA Member)	University of Turku
Dr. Bruno Leibundgut (CoI) (ESA Member)	European Southern Observatory - Germany
Dr. Nicholas B. Suntzeff (CoI)	Texas A & M University
Dr. Jesper Sollerman (CoI) (ESA Member)	Stockholm University
Dr. Mikako Matsuura (CoI) (ESA Member)	Cardiff University
Dr. Sophie ROSU (CoI) (ESA Member)	Royal Institute of Technology
Dr. Jason Spyromilio (CoI) (ESA Member)	European Southern Observatory - Germany
Dr. Tea Temim (CoI)	Princeton University
Dr. Alec S. Hirschauer (CoI)	Space Telescope Science Institute
Dr. Patrick Kavanagh (CoI) (ESA Member)	

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) SN-1987A	WFC3/UVIS	3	13-Aug-2024 08:00:17.0	yes
02	(1) SN-1987A	WFC3/UVIS	2	13-Aug-2024 08:00:18.0	yes

5 Total Orbits Used

ABSTRACT

By a fortunate turn of events, SN 1987A, the brightest supernova (SN) since 1604, exploded just a few years before the launch of HST. This has allowed HST to monitor the evolution from the very beginning as the SN evolves into a remnant, proving astronomers with a unique laboratory for SN physics. The most recent observations show major changes in the interaction with the iconic triple-ring nebula of circumstellar material. The dense, inner ejecta are just starting to crash into the equatorial ring, while the shocks further out in the system are gradually revealing the mass-loss history of the progenitor star. Furthermore, JWST has recently detected the first clear electromagnetic signal from the compact object created in the explosion, though its properties are yet to be determined. We request imaging in narrow and broad filters over the next three cycles, as well as a COS spectrum in Cycle 31, to study the shock interaction and compact object. The observations will be used to determine the conditions in the shock region, the properties of the circumstellar medium, and constrain the main competing scenarios for the compact object. Annual observations are needed to track the rapid evolution of the shocks and the emerging emission from the compact object. Taken together, this will allow the properties of the progenitor and compact object to be connected for the first time. The HST observations are also indispensable for interpreting other multiwavelength observations of SN 1987A.

OBSERVING DESCRIPTION

The requested observervations include 6 orbits with WFC3/UVIS and 11 orbits with COS.

WFC3 Imaging:

We request imaging in F625W, F502N, F657N and F763M in cycle 31. The first three filters are needed to measure the propagation of all the shock components and connect to the previous monitoring, while F763M will be used to search for signs of the compact object.

To obtain a similar S/N as the previous observations, considering the fading of the system, we require one orbit each for F625W and F657N, and two

orbits for F502N. The most interesting line from the compact object in the F763M filter is the [Ar III] 7753 line. Model predictions give a typical luminosity ~0.1* the [Ar II] 6.99 um luminosity, which results in a flux of 9 * 10^-17 erg cm^-2 s^-1. With a FWHM of 200 km s^-1, this results in a S/N ~14 in 6000 s. We therefore request two orbits with F763M to search for the compact object.

Since 2003, all ACS and WFC3 imaging have used a fixed dither strategy to improve the spatial resolution, which will be repeated for consistency.

COS spectrum:
We will observe SN 1987A using central wavelength settings of the G130M (1291, 1318) and G160M (1600, 1611, 1623) gratings, which ensures continuous wavelength coverage at relatively constant S/N, and effectively performs a focal plane split to minimize fixed pattern noise. The 1318 setting for G130M is needed to provide continuous wavelength coverage across the full G130M spectral region and to compare with previous epochs of COS
data. The limited spatial resolution of COS (about 1" in a 2.5" aperture) leaves some spatialspectral ambiguity in the deep spectral data. However, different emission components can be separated based on different line widths and Doppler shifts. While STIS would provide spatial information, its lower sensitivity makes it unsuitable for our objectives. We require a similar S/N as in the COS spectrum from 2017 (Fig. 7) to model the shocked emission from the ring and search for possible new lines from the compact object.

Assuming that the UV flux from the ring has faded by 30% since 2017 (as in the optical), we require 3.5 orbits with G130M and 7 orbits with G160M. Combining these, and including extra time to account for the overheads introduced in Cycle 30 by the extra wavelength calibration at LP6, we require 11 orbits for the COS observations. We have run the Bright Object Tools and no bright object violations are detected. This, combined with the offset acquisition, makes the observations safe to execute.

Visit

Proposal 17842, Visit 01, implementation Tue Aug 13 12:00:19 GMT 2024

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: ORIENT 78D TO 82 D; ORIENT 168D TO 172 D; ORIENT 258D TO 262 D; ORIENT 348D TO 352 D; BETWEEN 10-MAY-2025:00:00:00 AND 15-OCT-2025:00:00:00; SEQ 01,02 WITHIN 14 D

Comments: The orienation constraints are set to make sure that the diffraction spikes from "Star 3" (Fig. 1 of the proposal) do not overlap with the emission from the SN.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	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		(1-3)

Fixed Targets

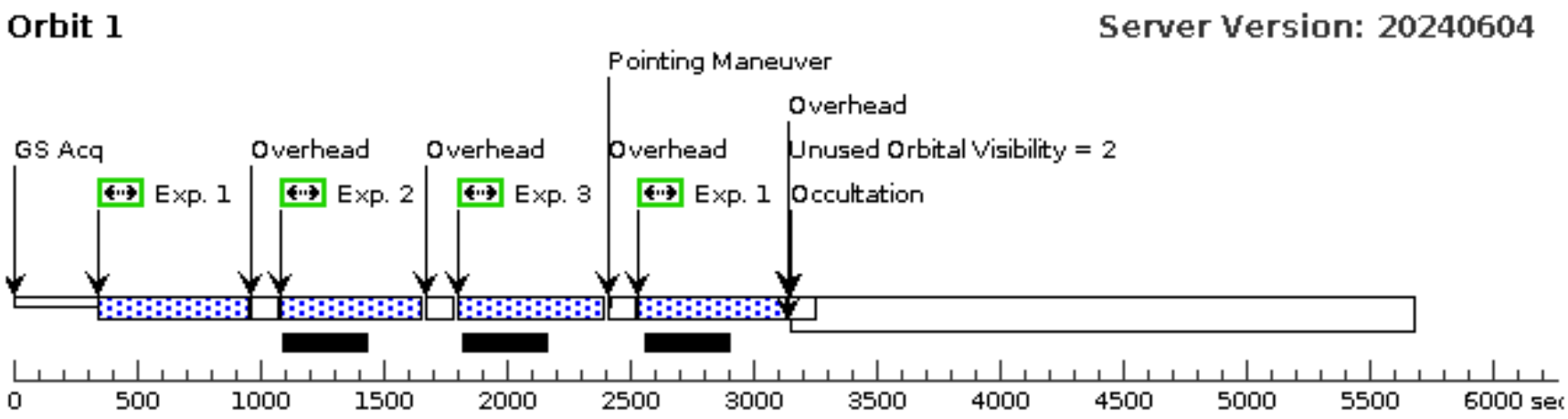
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	SN-1987A	RA: 05 35 28.0200 (83.8667500d) Dec: -69 16 11.07 (-69.26974d) Equinox: J2000	Epoch of Position: 2015.5	V=22	Reference Frame: SIMBAD

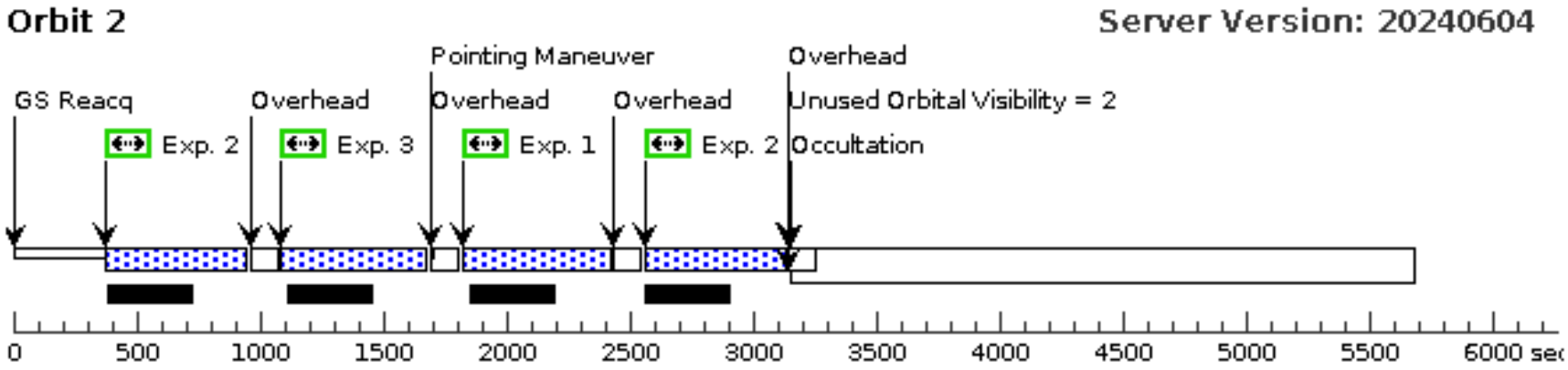
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=EXT-MEDIUM
Description=[SNR]

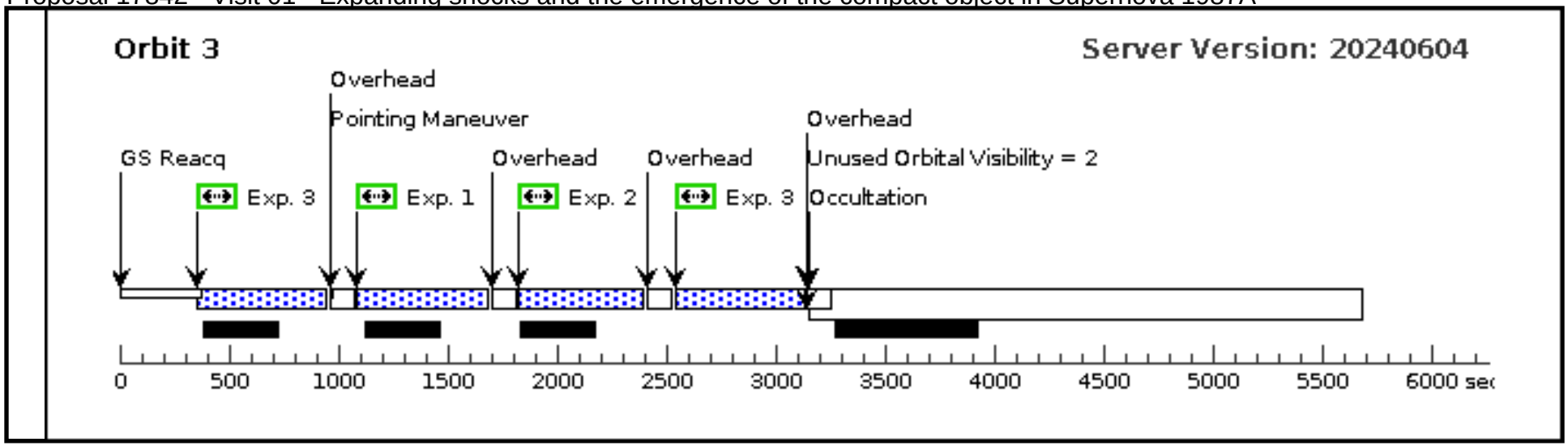
Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) SN-1987A	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F502N	CR-SPLIT=NO; FLASH=16		Pattern 1, Exps 1-3 in Visit 01 (1)	576 Secs (2304 Secs)	
								[==>(Pattern 1)]	***[1]***
								[==>(Pattern 2)]	
								[==>(Pattern 3)]	***[2]***
								[==>(Pattern 4)]	***[3]***
2		(1) SN-1987A	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F502N	CR-SPLIT=NO; FLASH=16		Pattern 1, Exps 1-3 in Visit 01 (1)	576 Secs (2304 Secs)	
								[==>(Pattern 1)]	***[1]***
								[==>(Pattern 2)]	***[2]***
								[==>(Pattern 3)]	
								[==>(Pattern 4)]	***[3]***
3		(1) SN-1987A	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F657N	CR-SPLIT=NO; FLASH=15		Pattern 1, Exps 1-3 in Visit 01 (1)	576 Secs (2304 Secs)	
								[==>(Pattern 1)]	***[1]***
								[==>(Pattern 2)]	***[2]***
								[==>(Pattern 3)]	***[3]***
								[==>(Pattern 4)]	

Orbit Structure



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Overhead
Pointing Maneuver
Overhead
Overhead
Overhead
Unused Orbital Visibility = 2
GS Reacq
Exp. 3
Exp. 1
Exp. 2
Exp. 3
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000 sec

Visit

Proposal 17842, Visit 02, implementation Tue Aug 13 12:00:19 GMT 2024

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: ORIENT 78D TO 82 D; ORIENT 168D TO 172 D; ORIENT 258D TO 262 D; ORIENT 348D TO 352 D; BETWEEN 10-MAY-2025:00:00:00 AND 15-OCT-2025:00:00:00

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Category=EXT-MEDIUM
Description=[SNR]

Exposures

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1		(1) SN-1987A	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F438W	CR-SPLIT=NO; FLASH=12		Pattern 1, Exps 1-2 in Visit 02 (1)	570 Secs (2280 Secs)	
								[==>(Pattern 1)] *[==>(Pattern 2)]*	***[1]***
								[==>(Pattern 3)] *[==>(Pattern 4)]*	***[2]***
2		(1) SN-1987A	WFC3/UVIS, ACCUM, UVIS2-C1K1C-CTE	F625W	CR-SPLIT=NO; FLASH=5		Pattern 1, Exps 1-2 in Visit 02 (1)	565 Secs (2260 Secs)	
								[==>(Pattern 1)] *[==>(Pattern 2)]*	***[1]***
								[==>(Pattern 3)] *[==>(Pattern 4)]*	***[2]***

Orbit Structure