17087 - The final word: Documenting the Final Days of the Nearby Type Ia Supernova 2011fe

Cycle: 30, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

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VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) SN-2011FE-UVIS ANY	ACS/WFC WFC3/UVIS	3	09-Feb-2023 11:00:15.0	yes

3 Total Orbits Used

ABSTRACT

Even though SNe Ia are crucial to cosmological studies as distance indicators, the exact nature of these systems remains theoretically ambiguous and observationally elusive. However, there is a new hope. The very late-time light curves of SNe Ia harbor important clues to the natures of their progenitor systems. First, the ejecta from the SN will shock heat a non-degenerate companion, leaving it luminous and visible at very late times after the SN has faded. Second, due to nucleosynthetic effects during the explosion, different explosion models are predicted to produce vastly differing amounts of 57Co and 55Fe. 57Co and 55Fe dominate the power of the very late time light curves of SNe Ia after >1050 days after the initial explosion. As the brightest SN Ia in 50 years, SN 2011fe offers a prime opportunity to follow a SN Ia to such late epochs. Multiple groups have used late-time HST observations to measure the bolometric luminosity, determine the ratio of these isotopes, and thus discriminate between progenitor models. However, the current measurements are degenerate between a 55Fe-powered light curve and the presence of a shock-heated companion at

~2400 days. Thus adding a significant caveat to any conclusions that can be drawn. Here we propose to break that degeneracy with a single ~4200-day F555W observation, nearly 4 times later than any other SN Ia has been observed. SN 2011fe is likely to remain the best-studied normal SN Ia of our generation and if these observations are not made while Hubble is operational, we will lose this opportunity.

OBSERVING DESCRIPTION

The very late-time spectra of SNe Ia predominantly consists of line emission over a very broad range of wavelengths longwards of the UV (where there is little emission). We selected the F555W (V) filter for WFC3/UVIS because it is the most efficient filter used in the 2400 day epoch to obtain the depth required to test if SN 2011fe has faded. We considered using a long-pass filter such as F350LP, but we rejected this idea for three reasons: 1) the depth gains are minimal, 2) this choice could potentially lead to added confusion because there is no direct earlier-time observation to compare to, and 3) there is an increased risk of crowding affecting deep observations at longer wavelengths.

We estimated the number of orbits and exposure times needed for our program using the estimated magnitude of the Shappee et al. (2013) shock-heated model (F555W = 28.3 mag) and the recommendations in the HST Primer. We require a SNR of 4 to ensure that any non-detection is significantly below the expected magnitude which would affect the 55Fe mass determination by more than its errorbars. We then used the exposure time calculator to estimate the length of our required observations. The exposure time calculation includes both the date and coordinates to ensure that our estimated times are accurate and that the correct contribution of zodiacal light is accounted for. We find that observations carried out between Jan and June 2023 require significantly less time (by 1-2 orbits) due to decreased zodiacal light. Our request time frame is a balance between zodiacal light and scheduling flexibility. Thus we request 3 orbits for this proposal.

We attempted to create the 6 point dither as described in:
http://documents.stsci.edu/hst/HST_overview/documents/DrizzlePac/AppendixC3.html
for the 6 exposures spread across 3 orbits. Additionally, we place SN2011fe close to the edge of the chip to reduce the effect of charge transfer losses and the uncertainty with thier corrections.

Finally, because there is still a large and ongoing interest in SN 2011fe, we will waive our 1 year proprietary period and make the data immediately public.

Parallel Observations: As the closest face-on Milky Way analogue, M101 is an important nearby galaxy for many reasons. For example, Shara et al. 2013 have compiled a catalog of 10,000 Wolf-Rayet stars using extensive HST WFC3 He II optical narrow-band imaging. There are also F435W/F555W/F814W/F658N(Halpha) mosaics covering most of the galaxy (GO 9490, 9492, 9720). Furthermore, others have performed a study of Cepheids using archival ACS data that provides the distance which is commonly used for SN 2011fe (Shappee & Stanek 2011). As a result, M101 is an key galaxy for the recent 1% determination of the Hubble Constant Riess et al. (2021). We include ACS in parallel mode to broaden the archival data base. We have used APT and Aladin to confirm it is possible to place the ACS detector (given the roll restrictions created by the timing of the observations) on M101.

Visit

Proposal 17087, Eighth Epoch (01), implementation Thu Feb 09 16:00:16 GMT 2023

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS, ACS/WFC

Special Requirements: ORIENT 205D TO 230 D; BETWEEN 01-JAN-2023:00:00:00 AND 01-JUN-2023:00:00:00

Comments: 13 orbits were not schedulable together, so we had to split the epoch into at least two visits. However, only up to 6 orbits are schedulable together, so we had to schedule three visits.

Patterns

#	Primary Pattern		Secondary Pattern		Exposures
(1)	Pattern Type=LINE	Coordinate Frame=POS-TARG	Pattern Type=LINE	Coordinate Frame=POS-TARG	(1-3)
	Purpose=DITHER	Pattern Orientation=46.84	Purpose=DITHER	Pattern Orientation=0.0	
	Number Of Points=3	Angle Between Sides=	Number Of Points=2	Angle Between Sides=	
	Point Spacing=0.135	Center Pattern=false	Point Spacing=0.0198	Center Pattern=false	
	Line Spacing=		Line Spacing=		

Fixed Targets

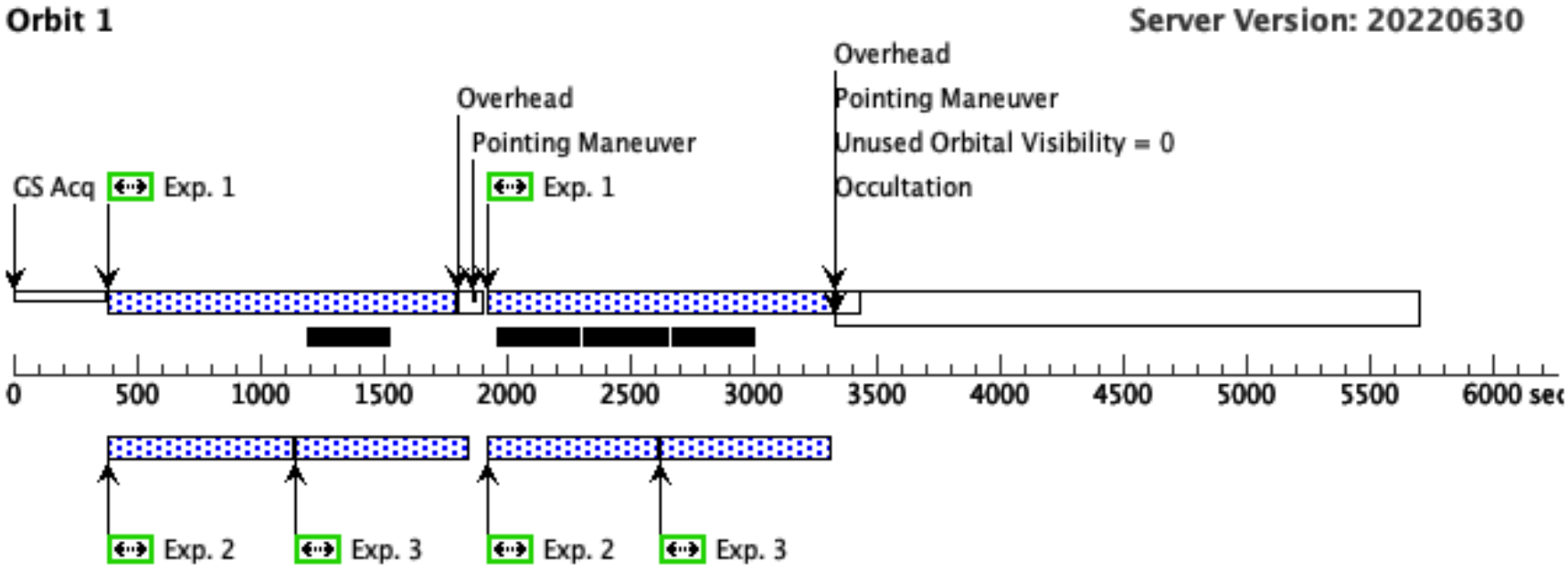
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	SN-2011FE-UVIS	RA: 14 03 5.7400 (210.7739167d) Dec: +54 16 25.24 (54.27368d) Equinox: J2000		V=28.3+/-1.0	Reference Frame: SIMBAD

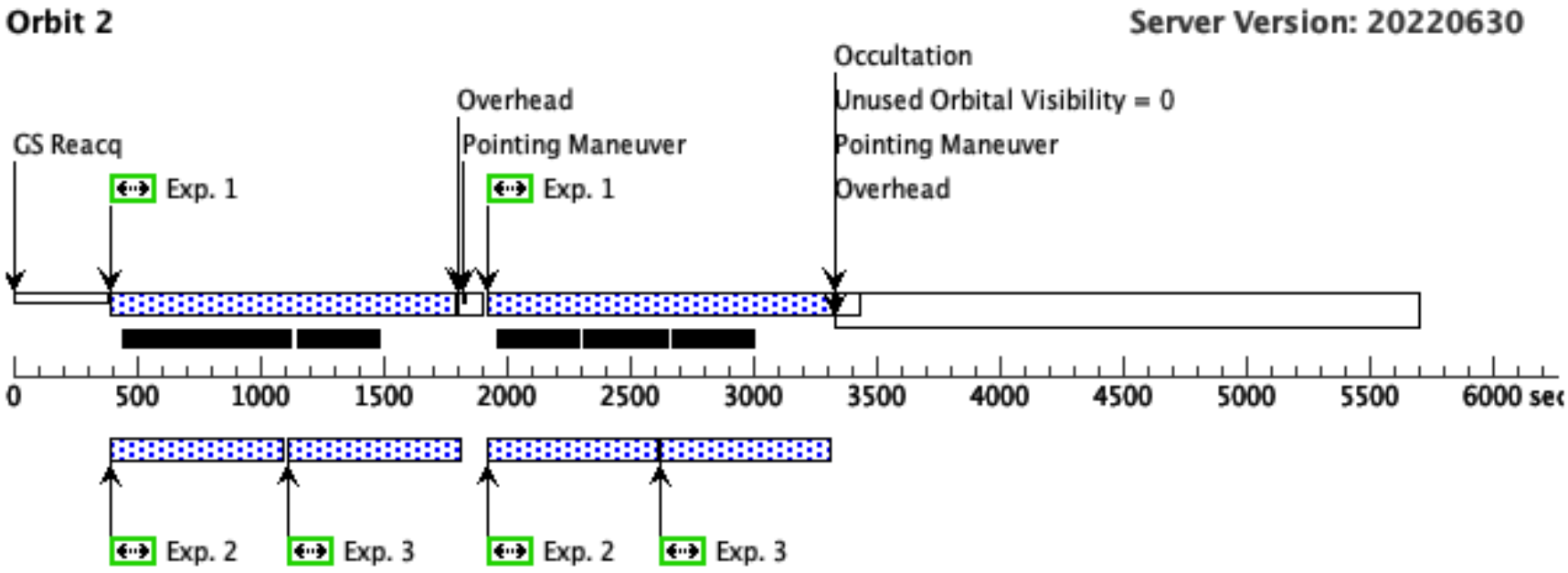
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=EXT-STAR
Description=[SUPERNOVA TYPE IA]

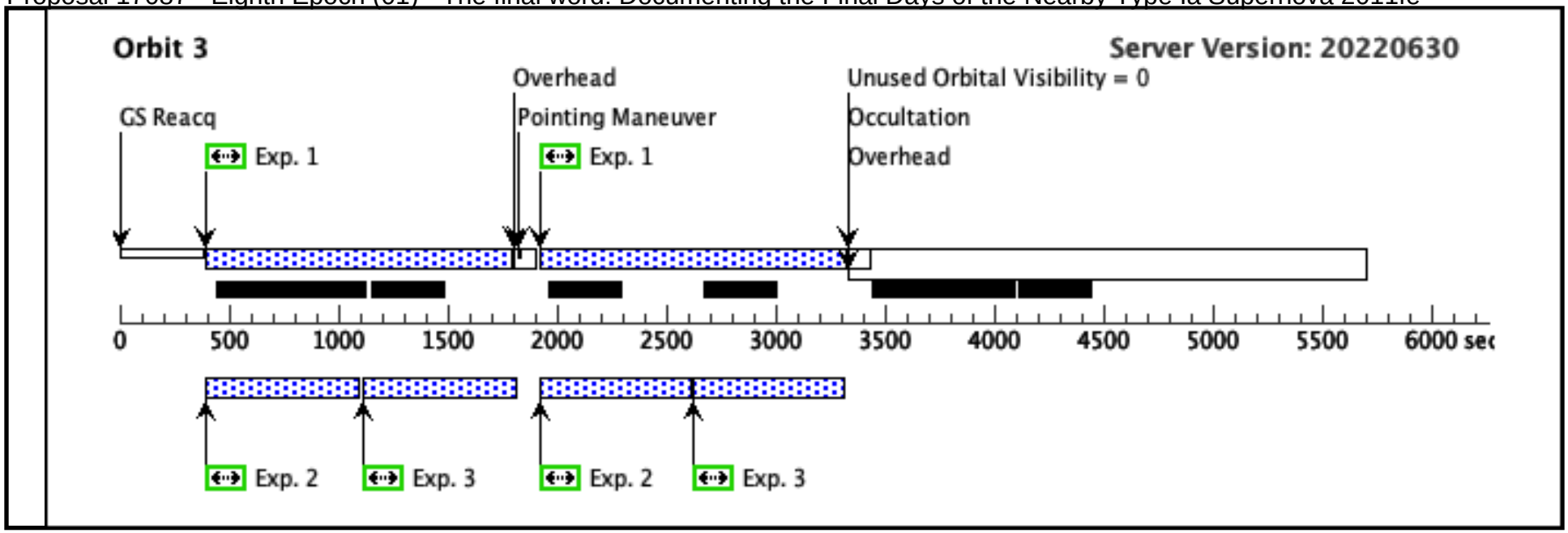
Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	WFC3_F555W	(1) SN-2011FE-UVIS	WFC3/UVIS, ACCUM, UVIS2-C512C-CTE	F555W		GS ACQ SCENARIO BASE1B3	Pattern 1, Exps 1-3 in Eighth Epoch (01) (1) Prime + Parallel Group 1-3 in Pattern 1, Exps 1-3 in Eighth Epoch (01)	1400 Secs (8380 Secs)	
								[==>1378.0 Secs (Pattern 1,1)] *[==>(Pattern 1,2)]*	***[1]***
								[==>(Pattern 2,1)] *[==>1401.0 Secs (Pattern 2,2)]*	***[2]***
								[==>(Pattern 3,1)] *[==>1401.0 Secs (Pattern 3,2)]*	***[3]***
2	ACS_F555W	ANY	ACS/WFC, ACCUM, WFC	F555W			Pattern 1, Exps 1-3 in Eighth Epoch (01) (1) Prime + Parallel Group 1-3 in Pattern 1, Exps 1-3 in Eighth Epoch (01)	410 Secs (3195 Secs)	
								[==>540.0 Secs (Pattern 1,1)] *[==>525.0 Secs (Pattern 1,2)]*	***[1]***
								[==>540.0 Secs (Pattern 2,1)] *[==>525.0 Secs (Pattern 2,2)]*	***[2]***
								[==>540.0 Secs (Pattern 3,1)] *[==>525.0 Secs (Pattern 3,2)]*	***[3]***
3	ACS_F814W	ANY	ACS/WFC, ACCUM, WFC	F814W			Pattern 1, Exps 1-3 in Eighth Epoch (01) (1) Prime + Parallel Group 1-3 in Pattern 1, Exps 1-3 in Eighth Epoch (01)	410 Secs (3195 Secs)	
								[==>540.0 Secs (Pattern 1,1)] *[==>525.0 Secs (Pattern 1,2)]*	***[1]***
								[==>540.0 Secs (Pattern 2,1)] *[==>525.0 Secs (Pattern 2,2)]*	***[2]***
								[==>540.0 Secs (Pattern 3,1)] *[==>525.0 Secs (Pattern 3,2)]*	***[3]***

Orbit Structure



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Exp. 1
Overhead
Pointing Maneuver
Exp. 1
Unused Orbital Visibility = 0
Occultation
Overhead
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2500
3000
3500
4000
4500
5000
5500
6000 sec
Exp. 2
Exp. 3
Exp. 2
Exp. 3