



14651 - Recurrent Nova M31N 2008-12a: The surrounding 'Super-Remnant' - A signpost to Type Ia Supernova progenitors

Cycle: 24, Proposal Category: GO

(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) RX-J0045.4+4154	WFC3/UVIS	2	07-Sep-2016 17:50:13.0	yes
02	(1) RX-J0045.4+4154	WFC3/UVIS	2	07-Sep-2016 17:50:14.0	yes

<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>
03	(1) RX-J0045.4+4154	WFC3/UVIS	2	07-Sep-2016 17:50:15.0	yes
04	(1) RX-J0045.4+4154	WFC3/UVIS	2	07-Sep-2016 17:50:16.0	yes
05	(1) RX-J0045.4+4154	WFC3/UVIS	2	07-Sep-2016 17:50:17.0	yes

10 Total Orbits Used

ABSTRACT

M31N 2008-12a is the single most important nova system in the Andromeda Galaxy. With an unprecedented eight observed eruptions in just eight years, an ultra-high mass white dwarf, a high mass accretion rate, and low ejected mass, this system is now the leading pre-explosion Supernova Type Ia progenitor candidate in any galaxy. We have recently uncovered a vast elliptical nebula, centered on the erupting nova - a probable recurrent nova 'super-remnant', a relic of many thousands of past eruptions. State-of-the-art 'multi-cycle' nova eruptions models have shown that a C-O WD in a short-recurrence period nova does indeed grow towards the Chandrasekhar mass. Such models predict frequent 'He-flashes', ejecting significantly more mass at higher velocities, every 100 or so nova eruptions. We propose to utilize the unique high-spatial resolution capabilities of HST at visible wavelengths to obtain a series of deep H-alpha images to: (i) confirm the origin of the nebula; (ii) search for the signature - ripples - laid down in the super-remnant by the frequent He-flashes, hence (iii) constrain models of the remnant, allowing extrapolation to other systems, and (iv) validate long-term nova eruption models, and also (v) explore shaping mechanisms both by the nova process and surrounding ISM. Confirming this super-remnant's source as multiple recurrent nova eruptions would provide a fascinating, unexpected, but crucial signpost around Type Ia Supernovae - pointing directly to the progenitor pathway.

OBSERVING DESCRIPTION

For our observations of the remnant surrounding M31N 2008-12a we will employ the WFC3/UVIS instrument due to its superior spatial resolution capabilities and charge transfer efficiency over the ACS/WFC.

The F657N (Wide H-alpha+[NII]) filter will be used for observations of the super-remnant, and the F645N filter for continuum subtraction purposes. We plan to operate the UVIS detector in a 2k x 2k windowed mode, to reduce readout overheads. This will provide a FoV of 80" x 80", more than sufficient to contain all the flux of the ~ 36" major-axis super-remnant.

We have selected the wider F657N filter rather than the F656N (H-alpha) filter for a number of reasons. These observations are concerned with the

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spatial distribution of the gas within the super-remnant, not specifically the H I gas. With the flux from [N II] around 50% of H-alpha the wider filter will increase the remnant SNR. Additionally, M31 is approaching with a velocity of 300km/s and as such the peak of the H-alpha emission will be shifted by 6.6 Angstrom, towards the edge of the 9 Angstrom half-width F656N filter where the throughput starts to diminish significantly.

The WFC3/UVIS ETC has been used to compute SNRs for the expected H-alpha+[N II] back-ground/continuum and also the H-alpha+[NII] background+nebula signal. These results were suitably manipulated to give the following results for the pure (post-background/continuum subtraction) nebula signal. Given the extended nature of our source and the fact that we are looking for potentially small-scale and small-flux changes in nebula density/structure we require our observations to possess a relatively high SNR, i.e SNR > 20 within a discrete region.

Employing 5 HST orbits and the F657N filter gives a total integration time of 13850 s (2700 s per orbit; including relevant overheads). In these data we would detect emission from the nebula (in a 5 x 5 pixel region, above the background) with a SNR of 24. This corresponds to a flux sensitivity of ~ 5% over an angular size of just 0.75 pc (at the distance of M31). The flux sensitivity decreases to ~ 20% for a single (0.04) pixel, an angular size of 0.15pc. For the fainter centre of the super-remnant (around 1/5 of the peak flux) the 5 x 5 pixel region sensitivity will still be ~ 20%.

To maximise the SNR of the continuum subtracted images we require a similar exposure time through the similar width F645N filter - an additional 5 orbits. In total we are therefore using a total of 10 orbits, split over 5 visits, with one F657N orbit and one F645N orbit per visit. We will mitigate any CTE-losses by initiating a post-flash of 10 electrons (the SNR calculations above include such a flash).

WFC3's 3 point line dither will be implemented for each orbit within each visit. This will allow for cosmic ray rejection. In addition the dither pattern of each visit will be slightly offset from the last to allow for the creation of a finer dither pattern and as such enable the creation of higher resolution images via Drizzlepac's Astrodrizzle software. This higher resolution may be necessary in order to obtain a better understanding of the structure of the nebulosity.

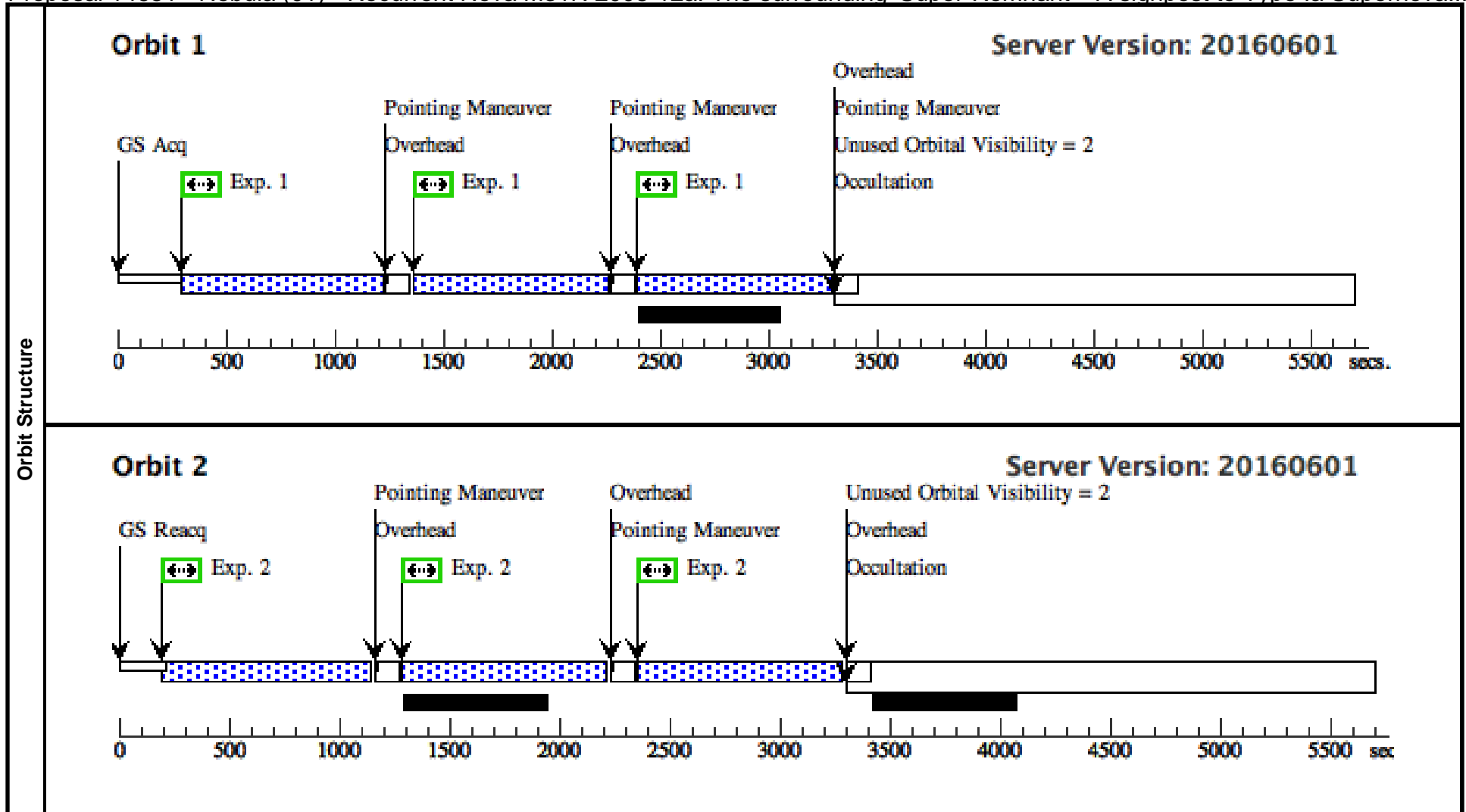
The orient of each visit must be the same or a 90 degree equivalent angle, in order to preserve the dither pattern and to minimise the effect of geometric distortion. As we are observing a "static system" we have no additional scheduling constraints.

Finally, there are no bright targets in the field that will cause any problems with the detector. Should M31N 2008-12a actually erupt during one of these observations it will only reach an apparent magnitude of 18th (across all visible bands) and won't be the brightest object in the field.

Proposal 14651 - Nebula (01) - Recurrent Nova M31N 2008-12a: The surrounding 'Super-Remnant' - A signpost to Type Ia Supernova...

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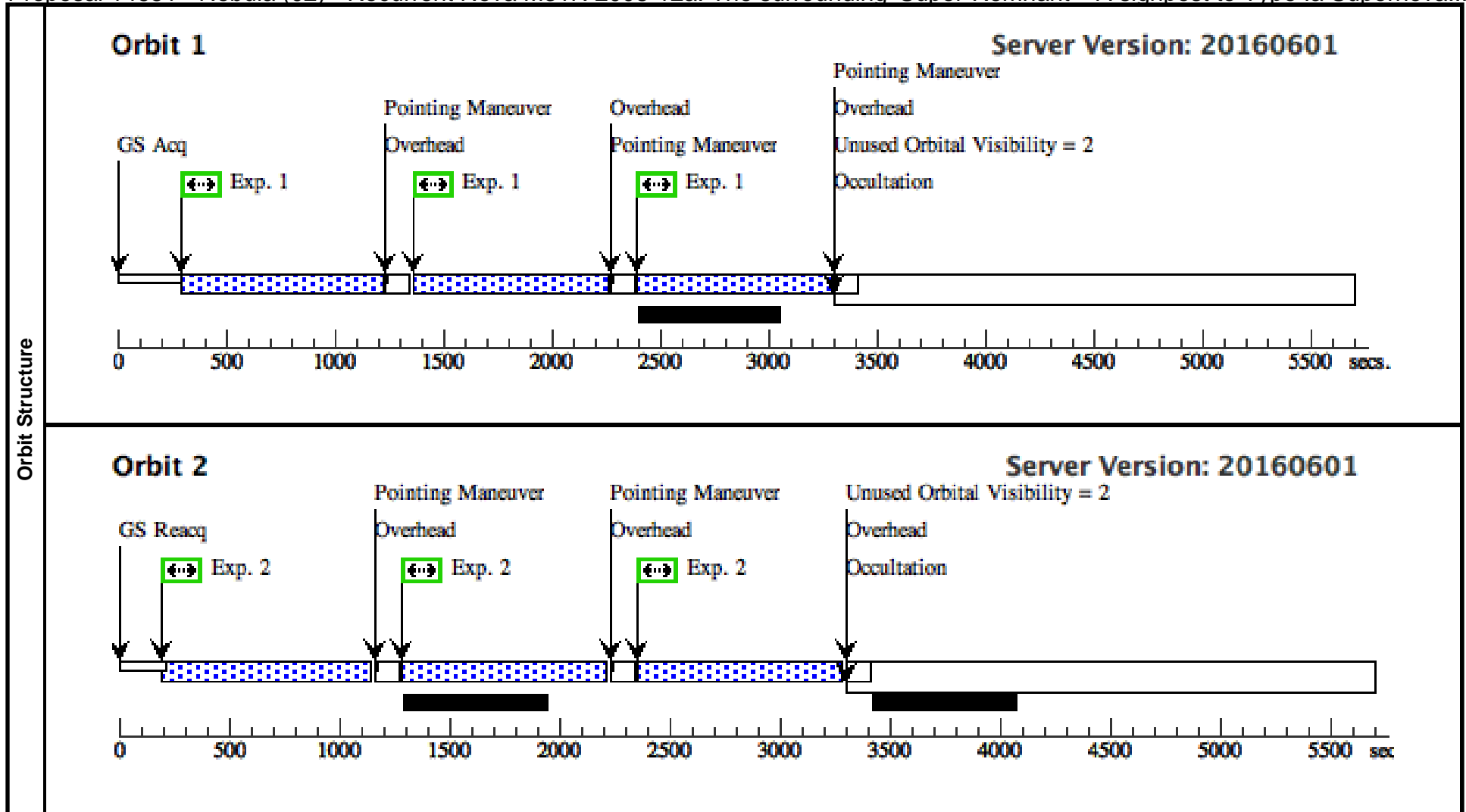
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Diagnosics										
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Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	RX-J0045.4+4154	RA: 00 45 28.8000 (11.3700000d) Dec: +41 54 10.10 (41.90281d) Equinox: J2000		V=23+/-1	Reference Frame: SIMBAD				
<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. Extended=YES</i>										
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	Halp+NI	(1) RX-J0045.4+4154 4	WFC3/UVIS, ACCUM, UVIS2-FIX	F657N	FLASH=12	POS TARG 0,0	Pattern 1, Exps 1-1 i n Nebula (01) (1)	800 Secs (2694 Secs) [==>898.0 Secs (Pattern 1)] [==>898.0 Secs (Pattern 2)] [==>898.0 Secs (Pattern 3)]	[1]
2	Continuum	(1) RX-J0045.4+4154 4	WFC3/UVIS, ACCUM, UVIS2-FIX	F645N	FLASH=12	POS TARG 0,0	Pattern 1, Exps 2-2 i n Nebula (01) (1)	800 Secs (2805 Secs) [==>935.0 Secs (Pattern 1)] [==>935.0 Secs (Pattern 2)] [==>935.0 Secs (Pattern 3)]	[2]	



Proposal 14651 - Nebula (02) - Recurrent Nova M31N 2008-12a: The surrounding 'Super-Remnant' - A signpost to Type Ia Supernova...

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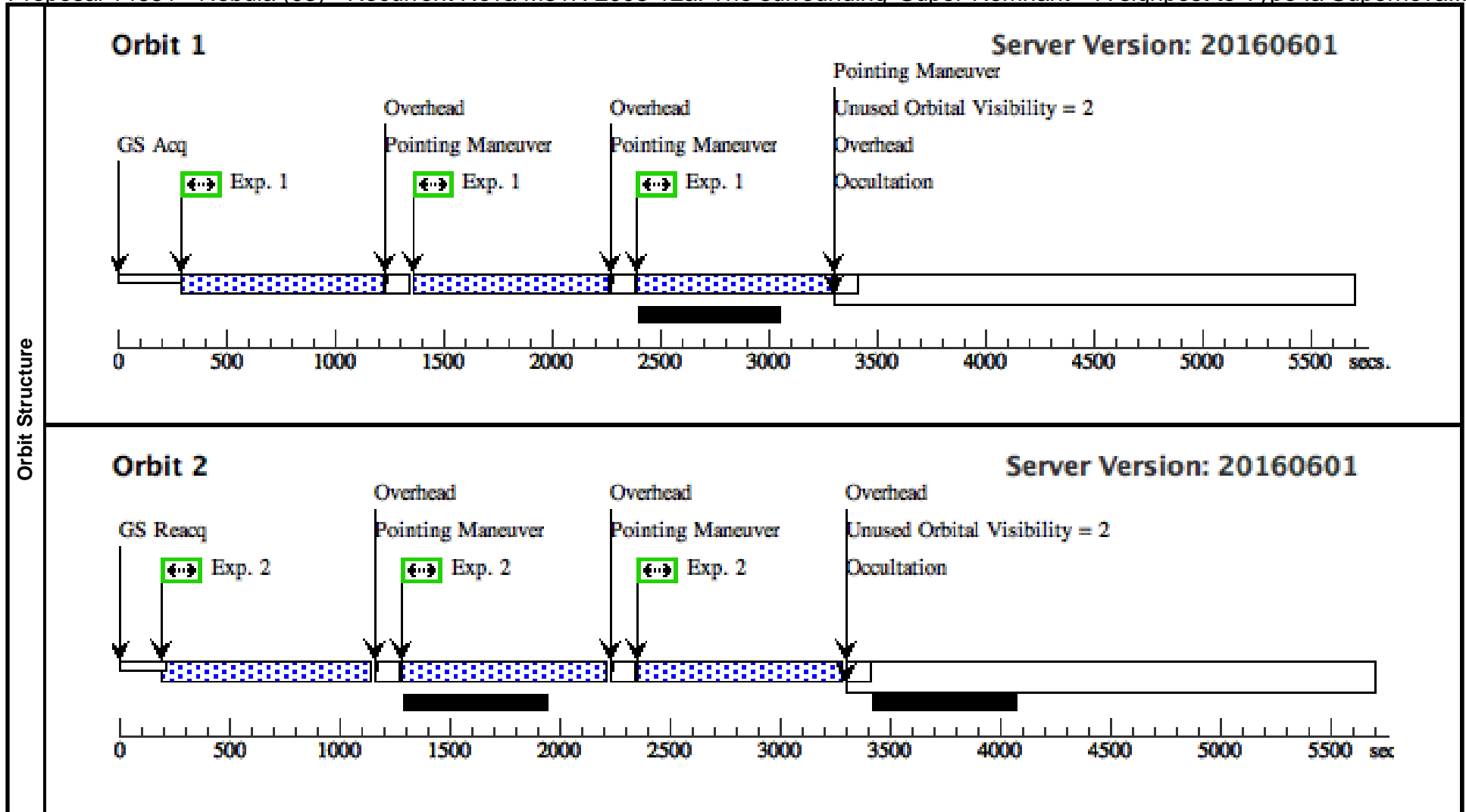
Visit	Proposal 14651, Nebula (02), implementation Diagnostic Status: Warning Scientific Instruments: WFC3/UVIS Special Requirements: SAME ORIENT AS 01									
	(Halpna+NII (02.001)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser									
Diagnosics										
Patterns	#	Primary Pattern	Secondary Pattern	Exposures						
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Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	RX-J0045.4+4154	RA: 00 45 28.8000 (11.3700000d) Dec: +41 54 10.10 (41.90281d) Equinox: J2000		V=23+/-1	Reference Frame: SIMBAD				
<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. Extended=YES</i>										
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	Halpna+NII	(1) RX-J0045.4+4154 4	WFC3/UVIS, ACCUM, UVIS2-FIX	F657N	FLASH=12	POS TARG 0.1125,0 .1125	Pattern 1, Exps 1-1 i n Nebula (02) (1)	800 Secs (2694 Secs) [==>898.0 Secs (Pattern 1)] [==>898.0 Secs (Pattern 2)] [==>898.0 Secs (Pattern 3)]	[1]
2	Continuum	(1) RX-J0045.4+4154 4	WFC3/UVIS, ACCUM, UVIS2-FIX	F645N	FLASH=12	POS TARG 0.1125,0 .1125	Pattern 1, Exps 2-2 i n Nebula (02) (1)	800 Secs (2805 Secs) [==>935.0 Secs (Pattern 1)] [==>935.0 Secs (Pattern 2)] [==>935.0 Secs (Pattern 3)]	[2]	



Proposal 14651 - Nebula (03) - Recurrent Nova M31N 2008-12a: The surrounding 'Super-Remnant' - A signpost to Type Ia Supernova...

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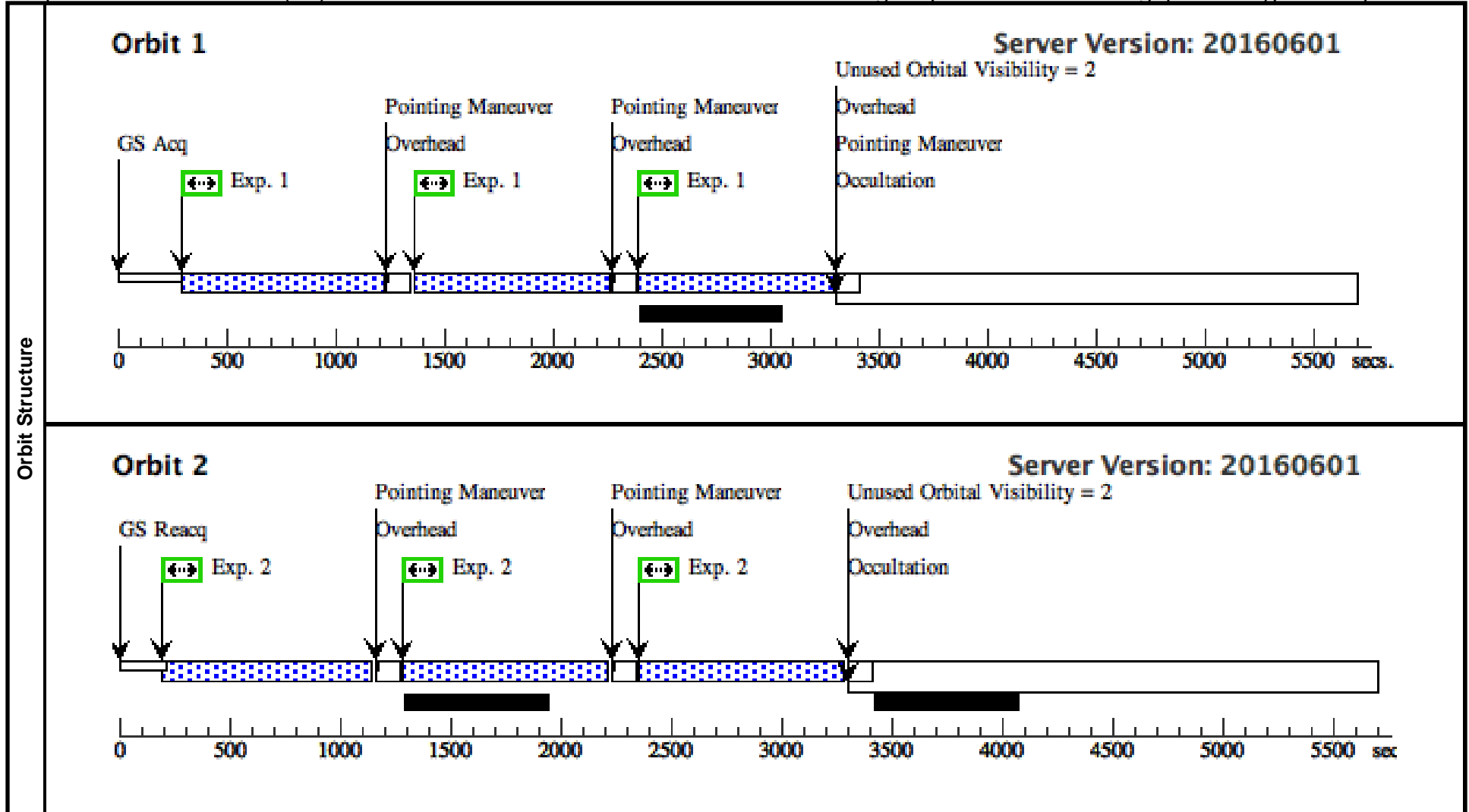
Visit	Proposal 14651, Nebula (03), implementation Diagnostic Status: Warning Scientific Instruments: WFC3/UVIS Special Requirements: SAME ORIENT AS 01									
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Diagnosics										
Patterns	#	Primary Pattern	Secondary Pattern	Exposures						
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Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	RX-J0045.4+4154	RA: 00 45 28.8000 (11.3700000d) Dec: +41 54 10.10 (41.90281d) Equinox: J2000		V=23+/-1	Reference Frame: SIMBAD				
<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. Extended=YES</i>										
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	Halpna+NII	(1) RX-J0045.4+4154 4	WFC3/UVIS, ACCUM, UVIS2-FIX	F657N	FLASH=12	POS TARG -0.1125, -0.1125	Pattern 1, Exps 1-1 in Nebula (03) (1)	800 Secs (2694 Secs) [==>898.0 Secs (Pattern 1)] [==>898.0 Secs (Pattern 2)] [==>898.0 Secs (Pattern 3)]	[1]
2	Continuum	(1) RX-J0045.4+4154 4	WFC3/UVIS, ACCUM, UVIS2-FIX	F645N	FLASH=12	POS TARG -0.1125, -0.1125	Pattern 1, Exps 2-2 in Nebula (03) (1)	800 Secs (2805 Secs) [==>935.0 Secs (Pattern 1)] [==>935.0 Secs (Pattern 2)] [==>935.0 Secs (Pattern 3)]	[2]	



Proposal 14651 - Nebula (04) - Recurrent Nova M31N 2008-12a: The surrounding 'Super-Remnant' - A signpost to Type Ia Supernova...

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Visit	Proposal 14651, Nebula (04), implementation Diagnostic Status: Warning Scientific Instruments: WFC3/UVIS Special Requirements: SAME ORIENT AS 01									
	(Halp+II (04.001)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser									
Diagnosics										
Patterns	#	Primary Pattern	Secondary Pattern	Exposures						
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Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	RX-J0045.4+4154	RA: 00 45 28.8000 (11.3700000d) Dec: +41 54 10.10 (41.90281d) Equinox: J2000		V=23+/-1	Reference Frame: SIMBAD				
<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. Extended=YES</i>										
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	Halp+II	(1) RX-J0045.4+4154 4	WFC3/UVIS, ACCUM, UVIS2-FIX	F657N	FLASH=12	POS TARG -0.1125, 0.1125	Pattern 1, Exps 1-1 i n Nebula (04) (1)	800 Secs (2694 Secs) [==>898.0 Secs (Pattern 1)] [==>898.0 Secs (Pattern 2)] [==>898.0 Secs (Pattern 3)]	[1]
2	Continuum	(1) RX-J0045.4+4154 4	WFC3/UVIS, ACCUM, UVIS2-FIX	F645N	FLASH=12	POS TARG -0.1125, 0.1125	Pattern 1, Exps 2-2 i n Nebula (04) (1)	800 Secs (2805 Secs) [==>935.0 Secs (Pattern 1)] [==>935.0 Secs (Pattern 2)] [==>935.0 Secs (Pattern 3)]	[2]	



Proposal 14651 - Nebula (05) - Recurrent Nova M31N 2008-12a: The surrounding 'Super-Remnant' - A signpost to Type Ia Supernova...

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Visit	Proposal 14651, Nebula (05), implementation Diagnostic Status: Warning Scientific Instruments: WFC3/UVIS Special Requirements: SAME ORIENT AS 01									
	(Halpna+NII (05.001)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser									
Diagnosics										
Patterns	#	Primary Pattern	Secondary Pattern	Exposures						
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Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous				
	(1)	RX-J0045.4+4154	RA: 00 45 28.8000 (11.3700000d) Dec: +41 54 10.10 (41.90281d) Equinox: J2000		V=23+/-1	Reference Frame: SIMBAD				
<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. Extended=YES</i>										
Exposures	#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
	1	Halpna+NII	(1) RX-J0045.4+4154 4	WFC3/UVIS, ACCUM, UVIS2-FIX	F657N	FLASH=12	POS TARG 0.1125,- 0.1125	Pattern 1, Exps 1-1 i n Nebula (05) (1)	800 Secs (2694 Secs) [==>898.0 Secs (Pattern 1)] [==>898.0 Secs (Pattern 2)] [==>898.0 Secs (Pattern 3)]	[1]
2	Continuum	(1) RX-J0045.4+4154 4	WFC3/UVIS, ACCUM, UVIS2-FIX	F645N	FLASH=12	POS TARG 0.1125,- 0.1125	Pattern 1, Exps 2-2 i n Nebula (05) (1)	800 Secs (2805 Secs) [==>935.0 Secs (Pattern 1)] [==>935.0 Secs (Pattern 2)] [==>935.0 Secs (Pattern 3)]	[2]	

