Swift Observations of Classical and Recurrent Novae

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On behalf of the Swift Nova-CV Group

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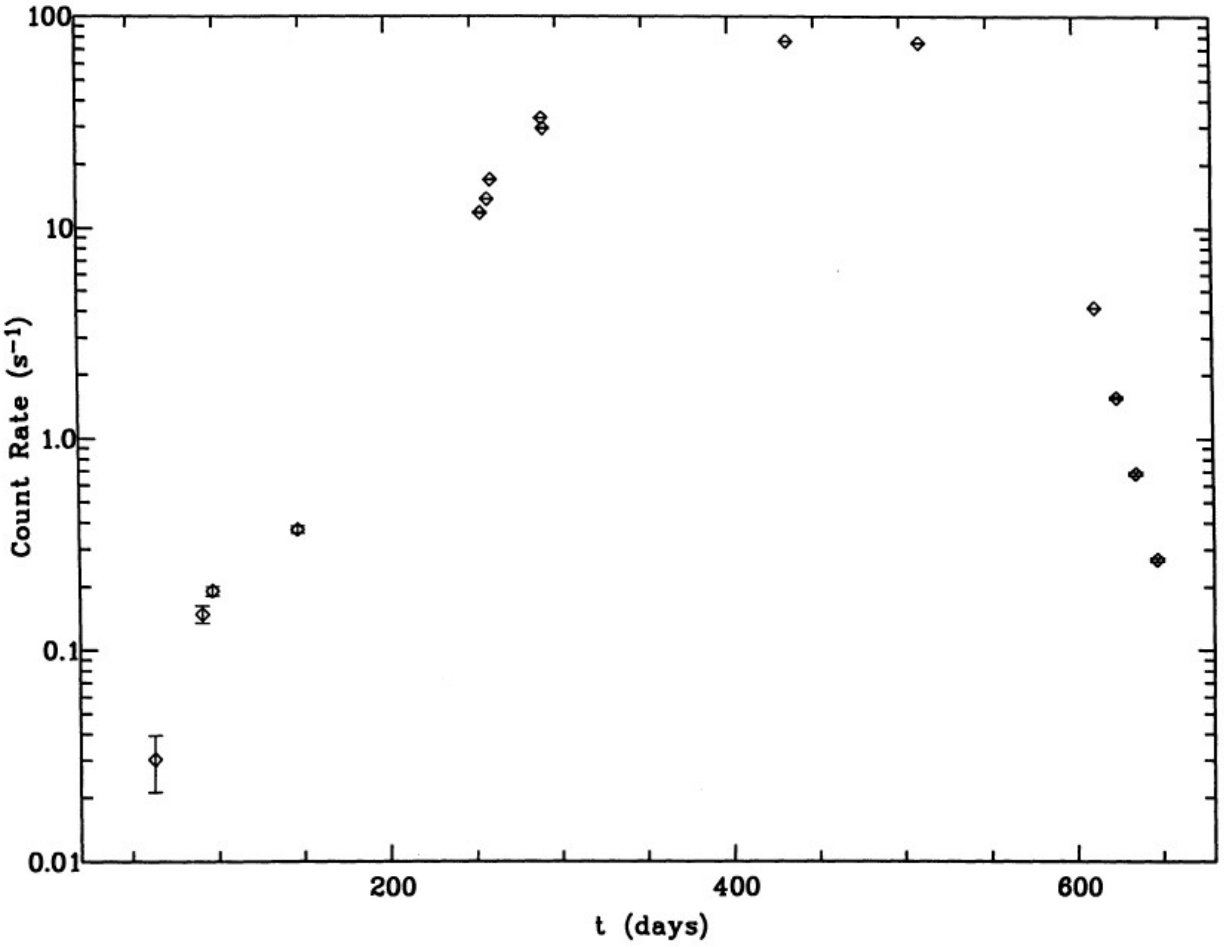
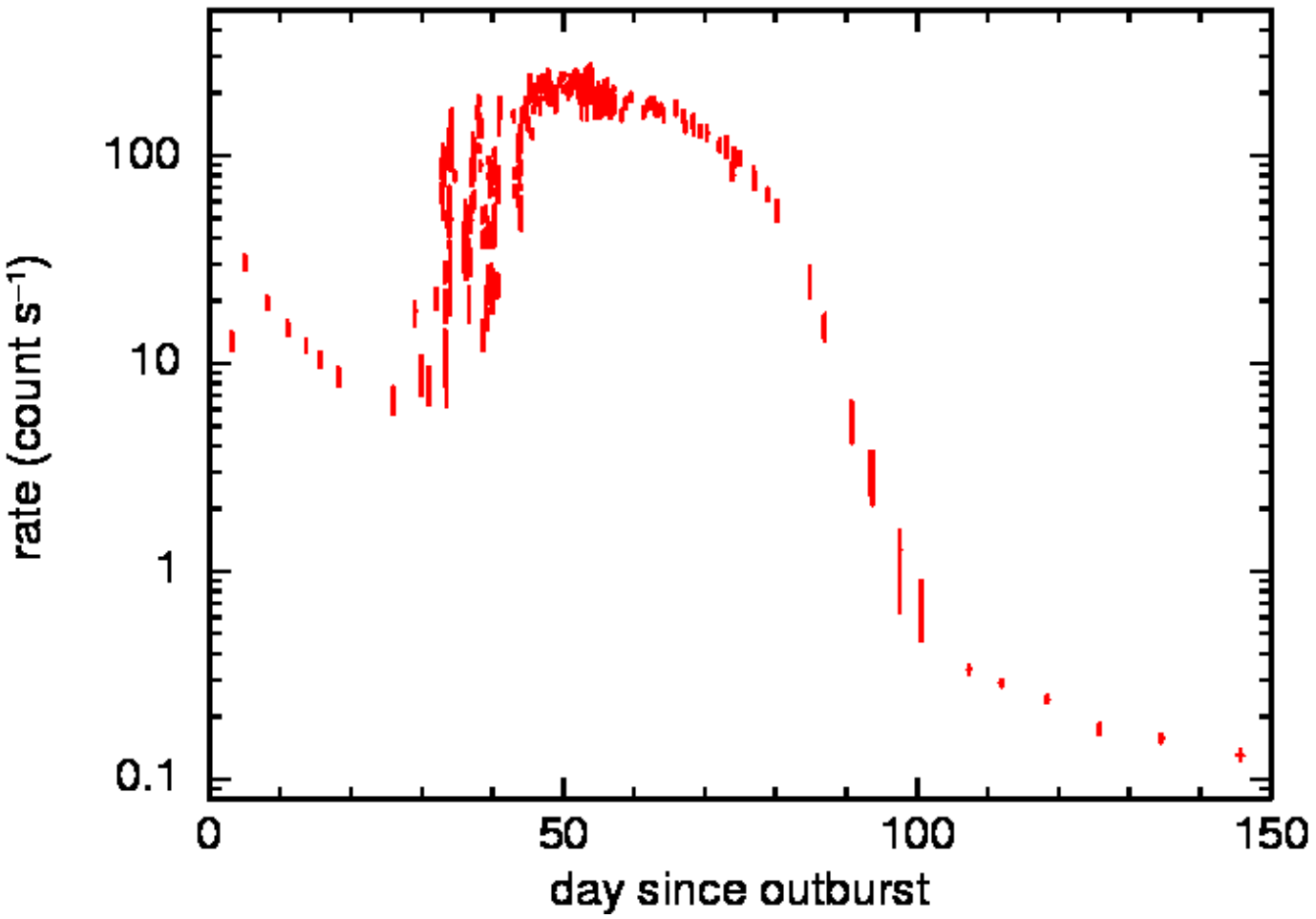
That was then...



V1974 Cyg
Krautter et al. (1996)

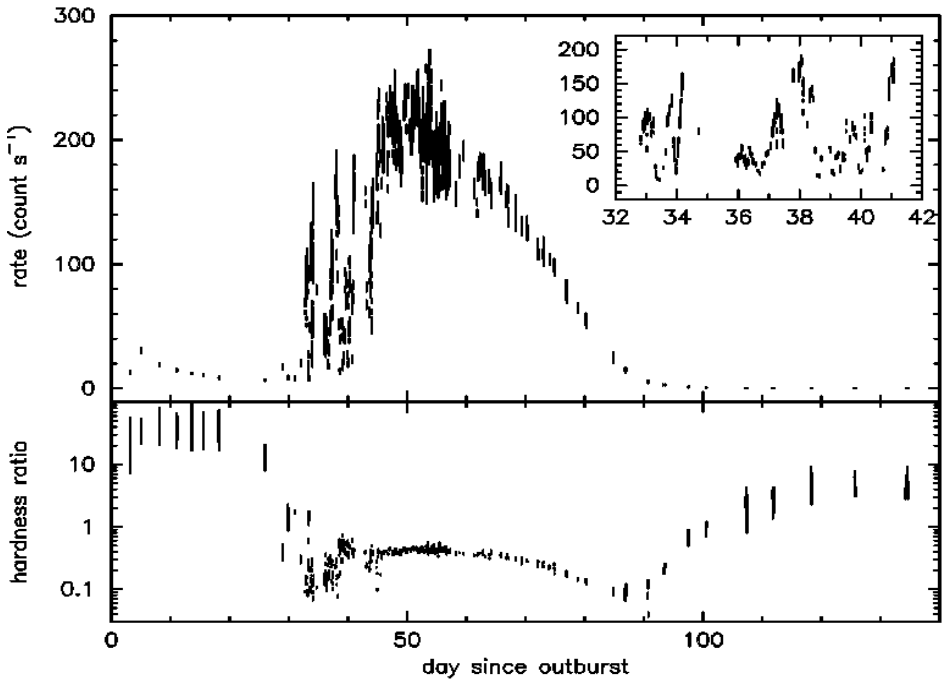
This is now!

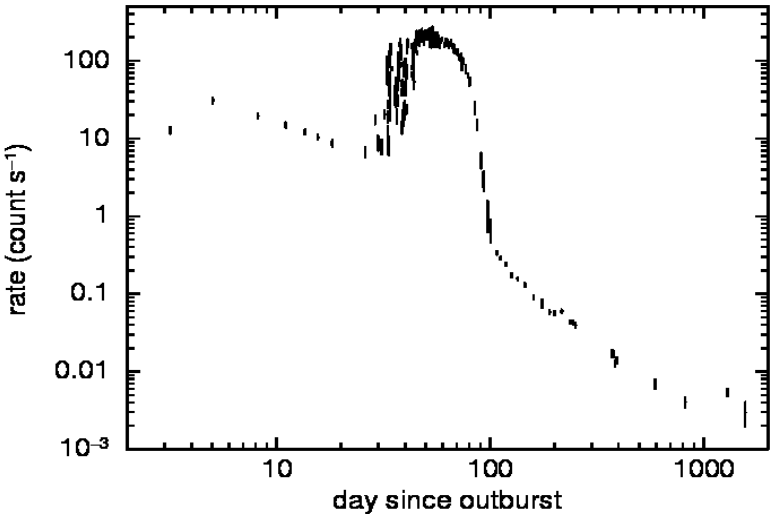


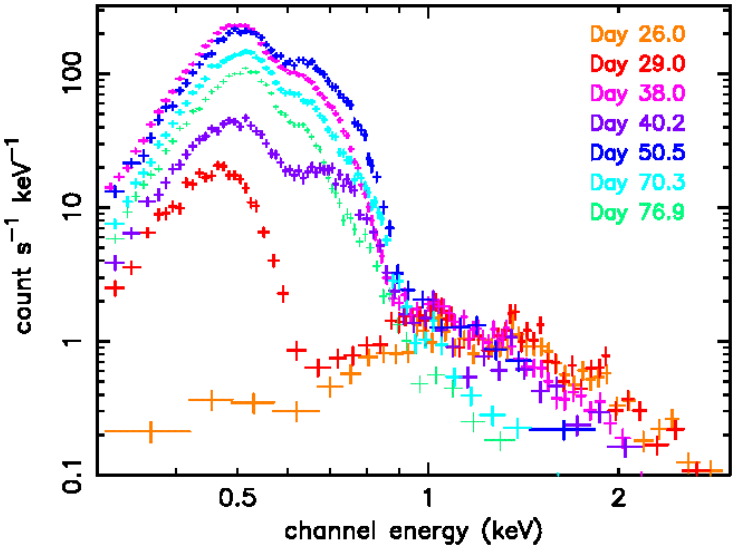
RS Oph

Osborne et al. (2011)

RS Oph





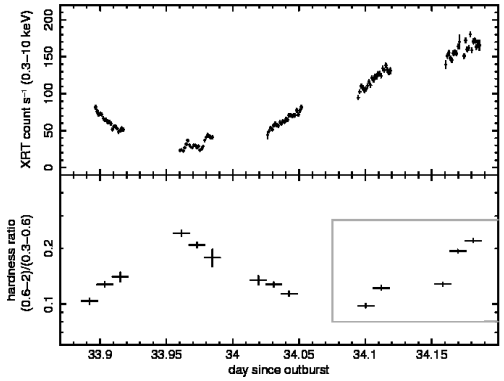


HR = (0.6-2 keV)/(0.3-0.6 keV)

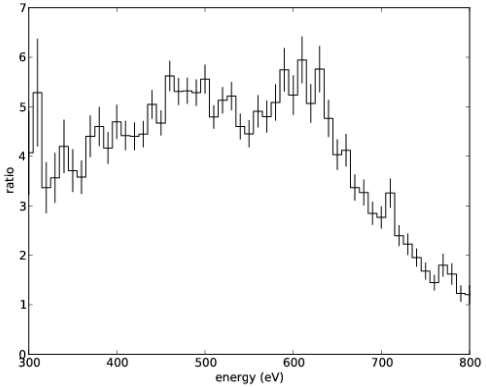
See Osborne et al., 2011, ApJ, 727, 124 for more details

RS Oph: more detail - 1

- Start of lc: optically thin plasma
  - Decline described by evolution of shocks as ejecta interact with RG wind.
- Supersoft emission detected shortly before day 30.
  - Mainly continuum emission with superimposed lines → hot WD atmosphere
- Extreme variability began at same time
  - Example: CR decreased by > order of magnitude in 12 hours
  - Usually softer when brighter, but not quite that simple...



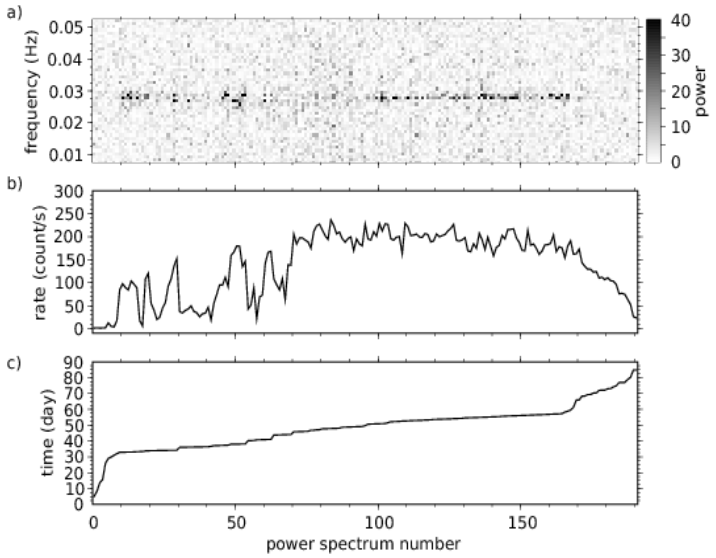
Ratioing peak and trough spectra show that simple variations in N_H (ionisation or clumpiness) or photospheric radius cannot be the only cause. Changing temperature (hotter when brighter)?

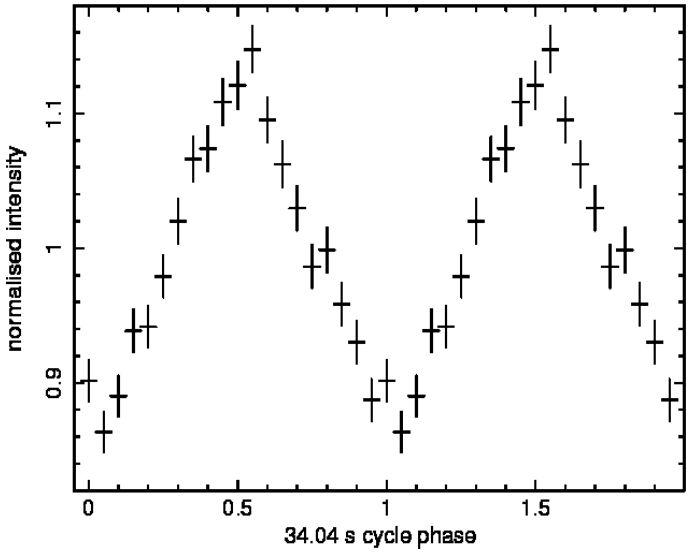


- After day 60, CR and BB kT start to decline.
- During the ~const CR phase, the luminosity is around L_{Edd}
  - Consistent with a high WD mass, as might be expected for a RN.

RS Oph: more detail - 2

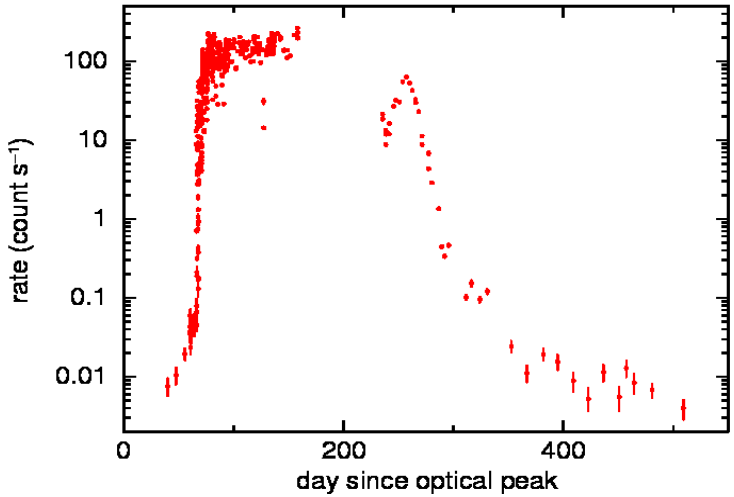
- 35s quasi-periodic oscillation. Also seen in XMM data.
  - Could be epsilon-mechanism: increased nuclear energy generation is followed by expansion, leading to a reduction in generation rate and hence a contraction etc. etc.
  - Should only last as long as nuclear burning is active
  - Lum. too high for it to be accretion related or IP mechanism
  - ~35s period is seen in KT Eri as well (also a RN)



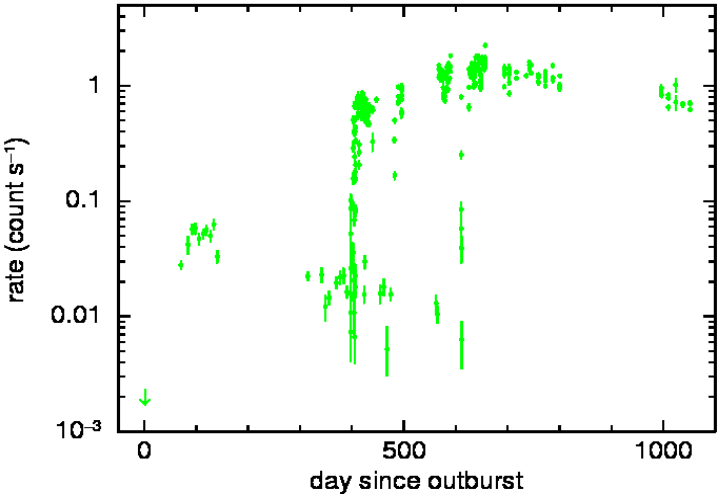


High-amplitude X-ray variability

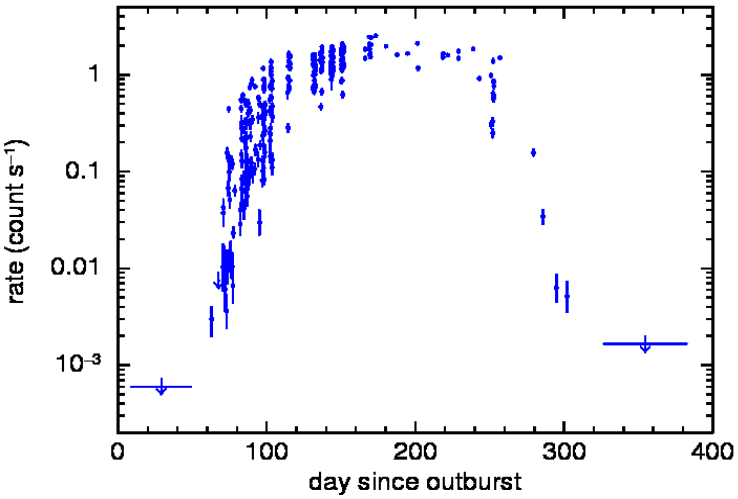
KT Eri



V458 Vul



Nova LMC 2009a



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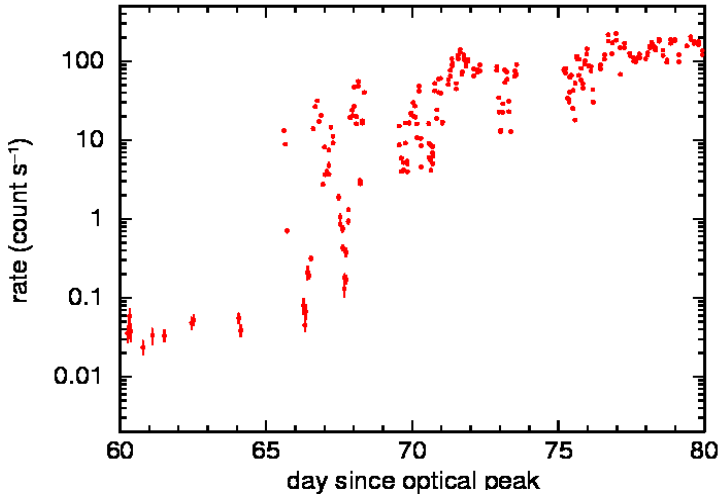
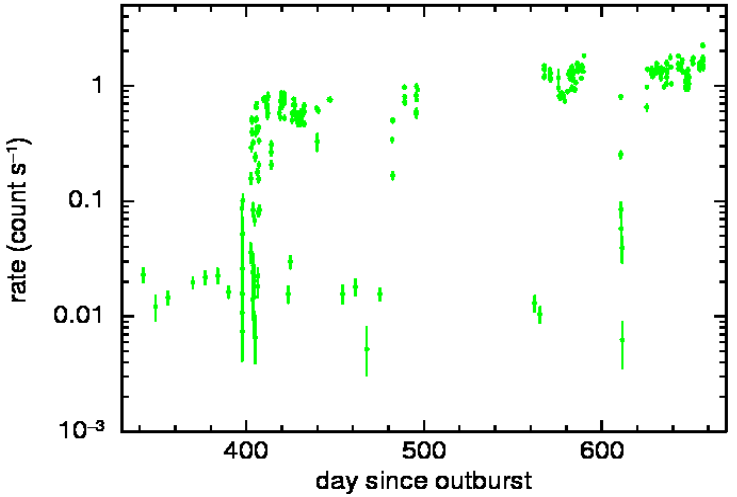
High-amplitude X-ray variability - zoom

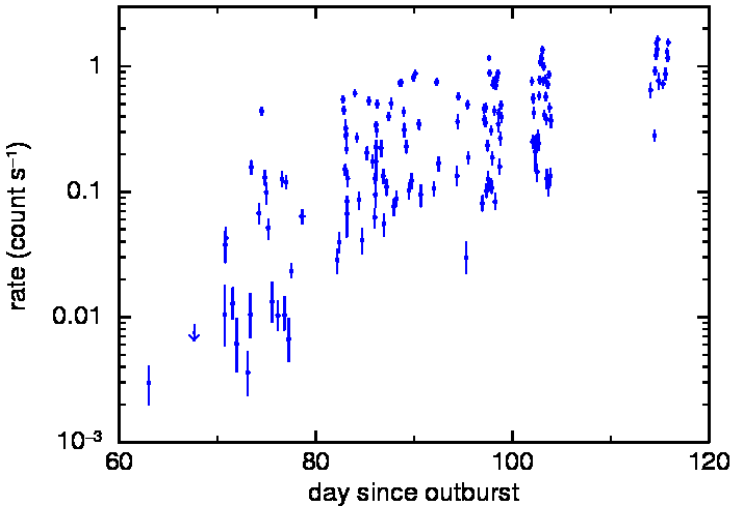
KT Eri



V458 Vul



Nova LMC 2009a



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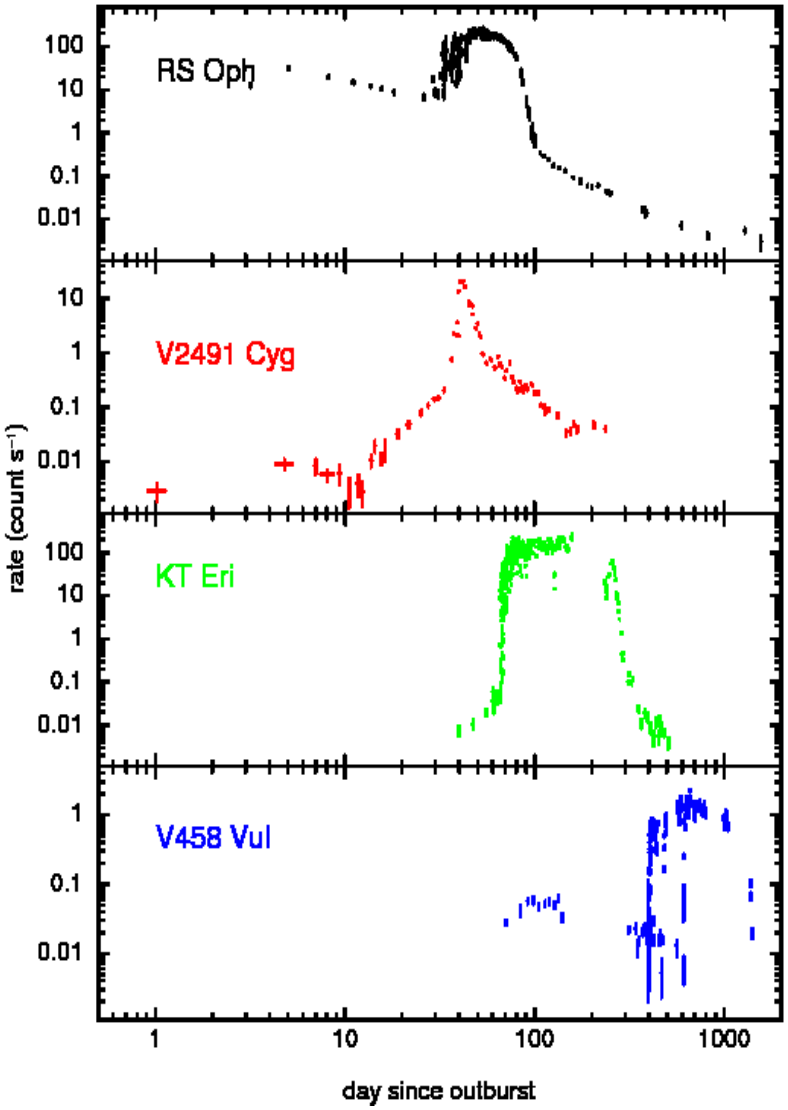
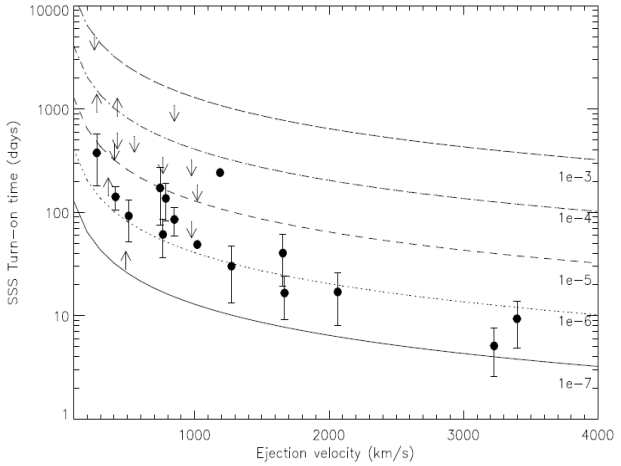
Identification of SSS turn-on and -off



This shows Swift XRT count rate light-curves for four novae with a super-soft phase for which the start and stop times can be identified.

The turn-on time provides information about the mass of the ejected shell. Generally, the quicker the start of the SSS, the smaller the mass ejected, though velocity is also important.



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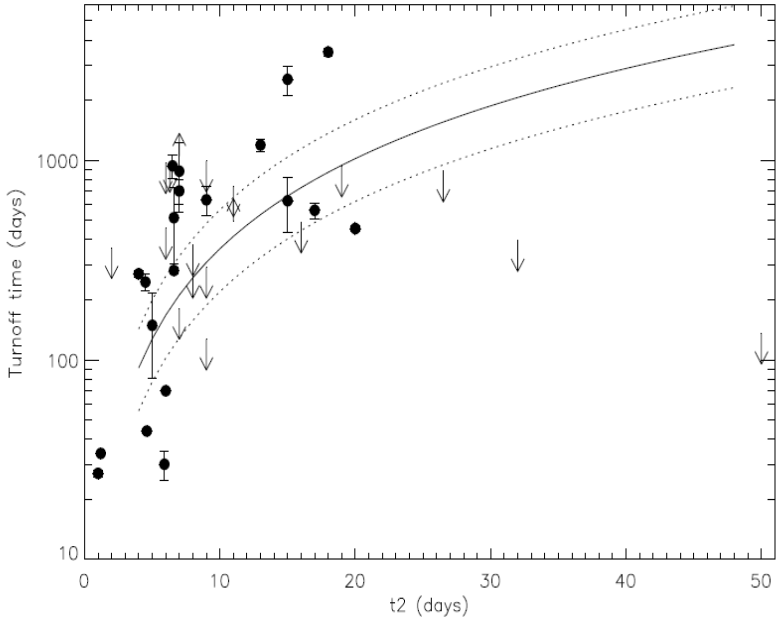
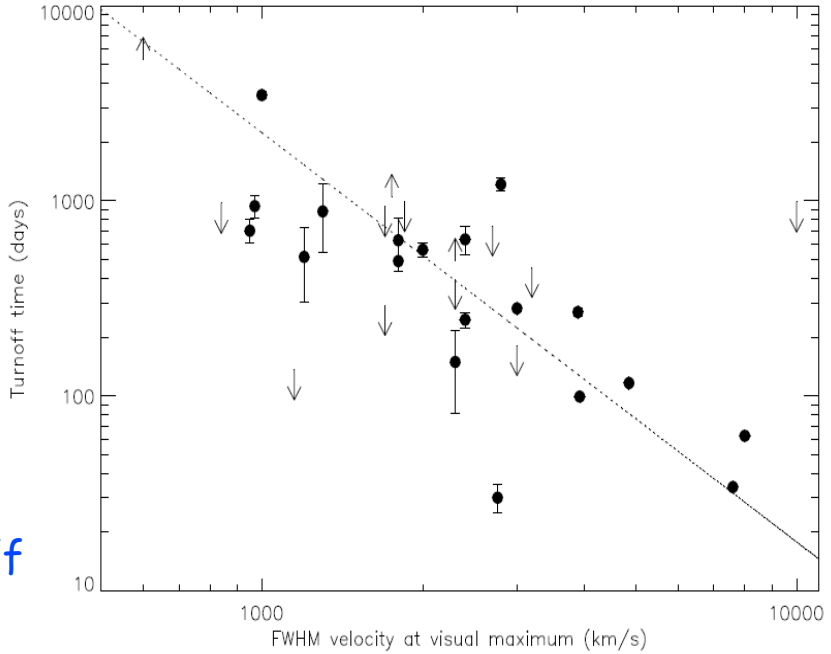


←
Turn-off time against t_2, with Hachisu & Kato (2010) relationship over-plotted.

→
Turn-off time against FWHM with the relationship from Greiner et al. (2003)



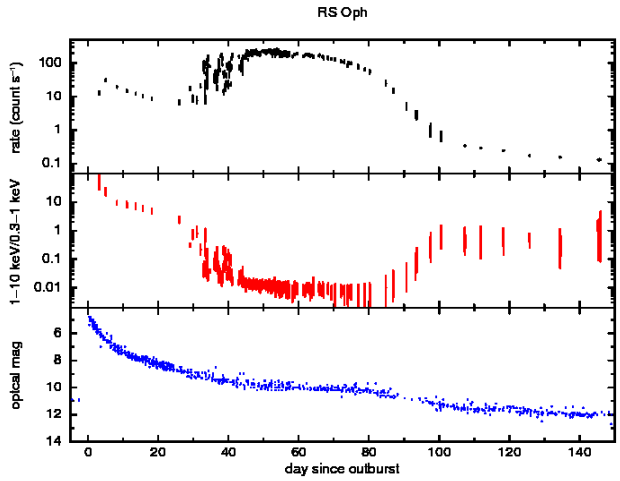
Most Galactic novae detected have turned off in < 3 yr.

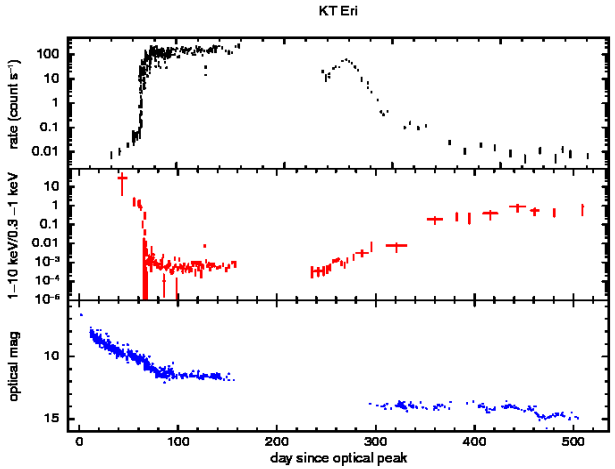
SSS and optical plateaux

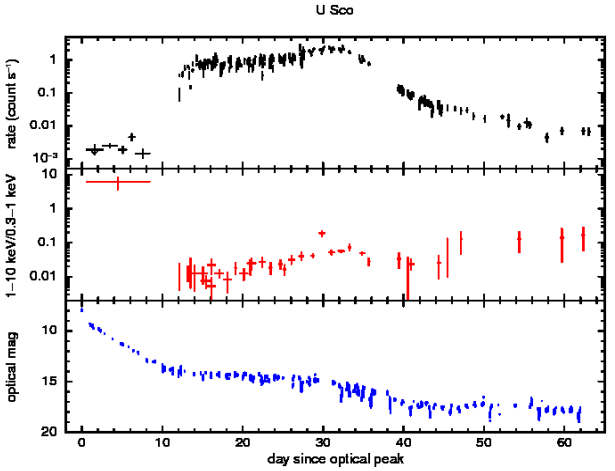
RNe often show a plateau in their visible light, which is speculated to arise from the reradiation of the SSS emission from an accretion disc (Hachisu et al. 2008). The plateau doesn't appear to be affected by the system inclination, though.

Examples:

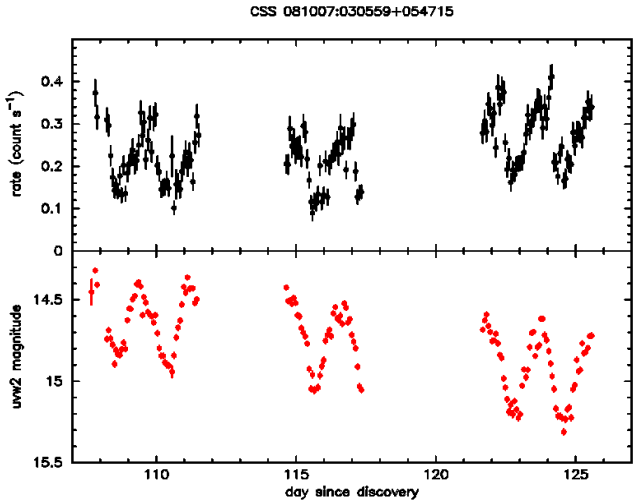
- RS Oph (i = 39°)
- U Sco (i = 83°)
- KT Eri – shows start of plateau, but source went behind the Sun before end
- LMC 2009a – possibly, but insufficient optical data to be sure



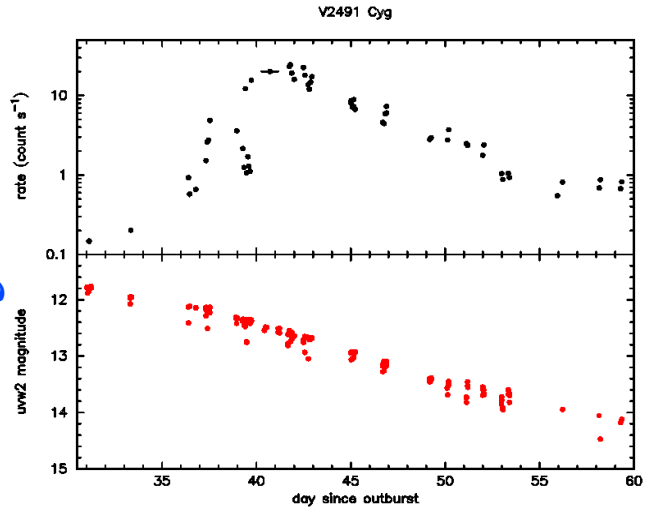




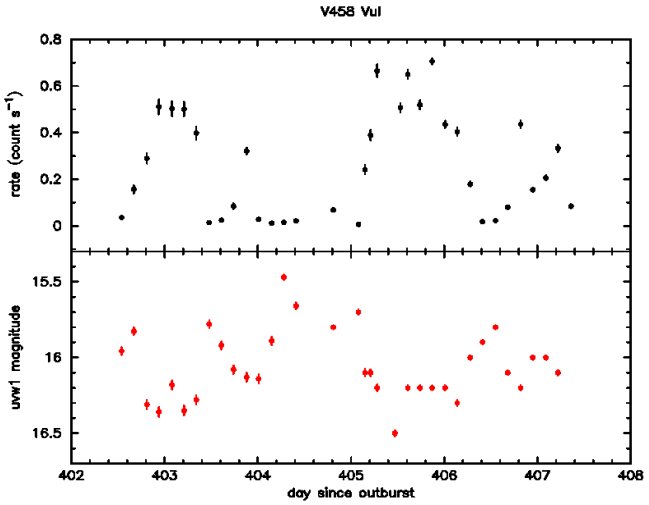
X-ray and UV variability



Anti-phase: temperature variations? (Increase in mass accretion rate causes photosphere to expand...)

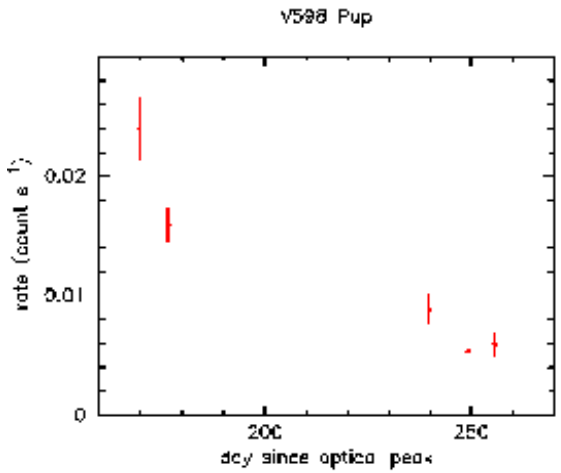


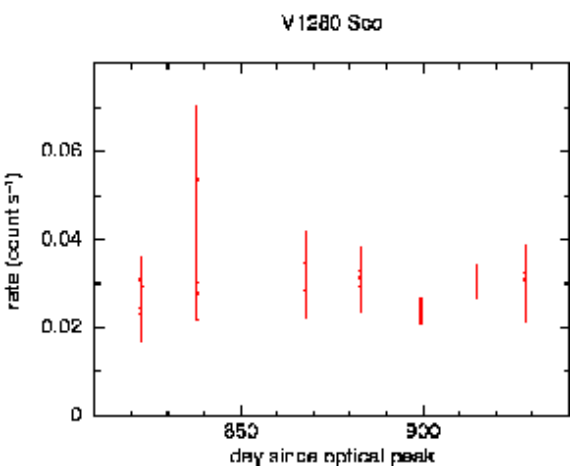
In phase: obscuration in a high-inclination system?

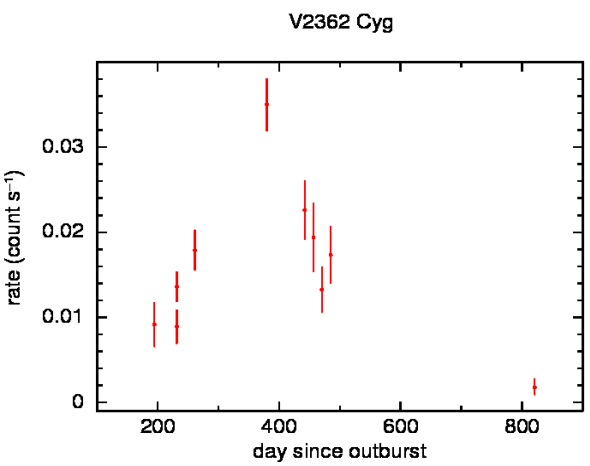


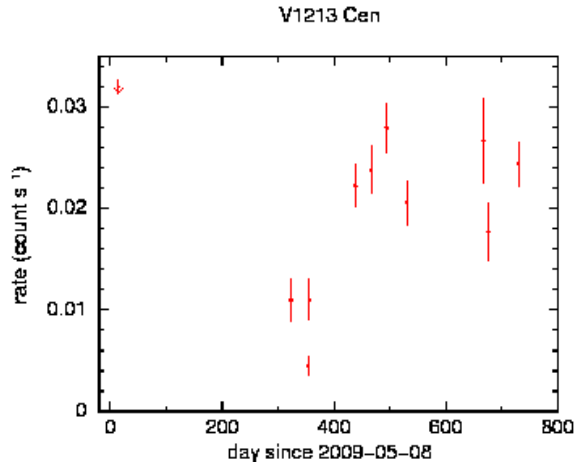
No correlation: different emitting regions for X-ray and UV?

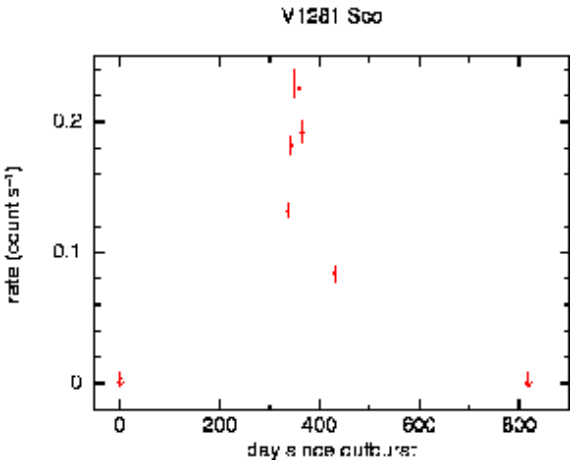
Other Swift-observed novae

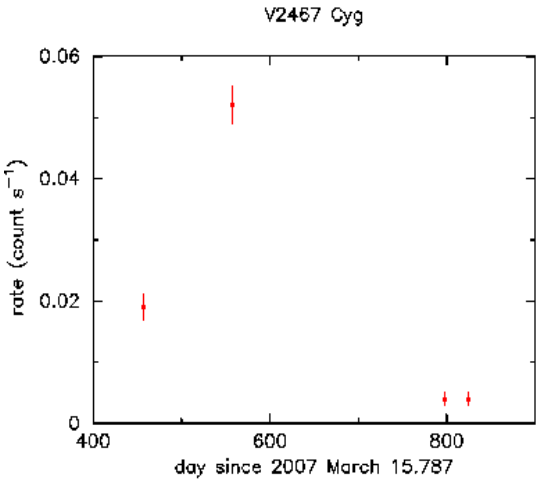












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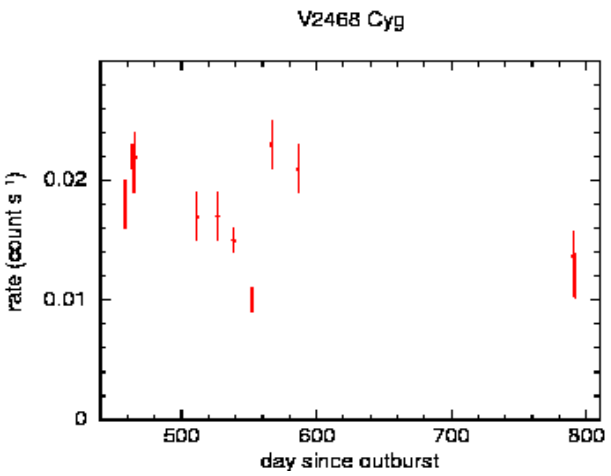
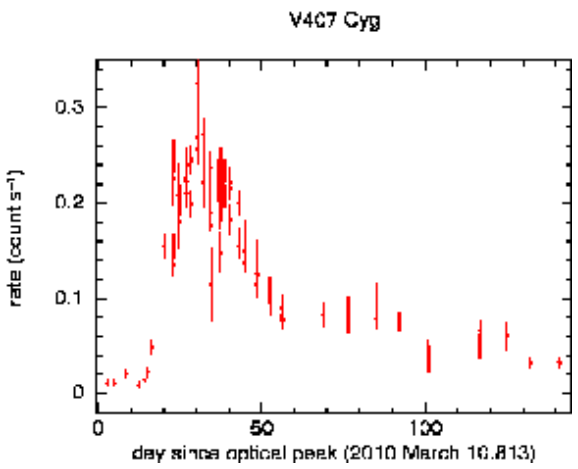
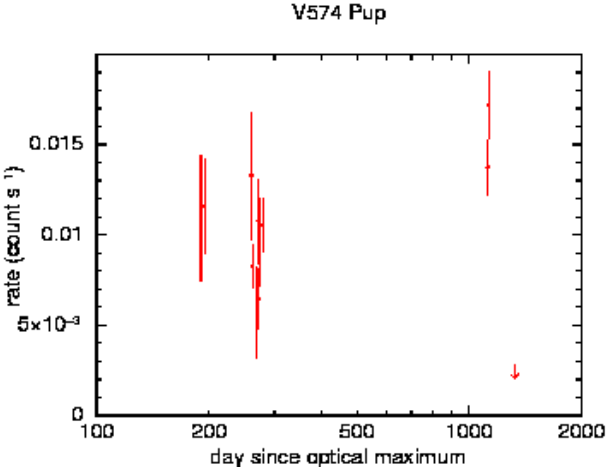
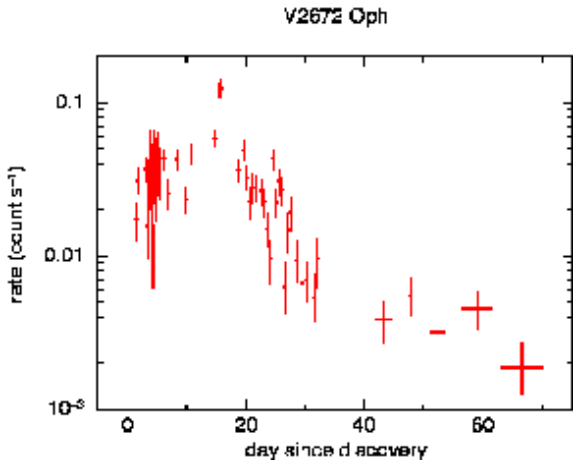
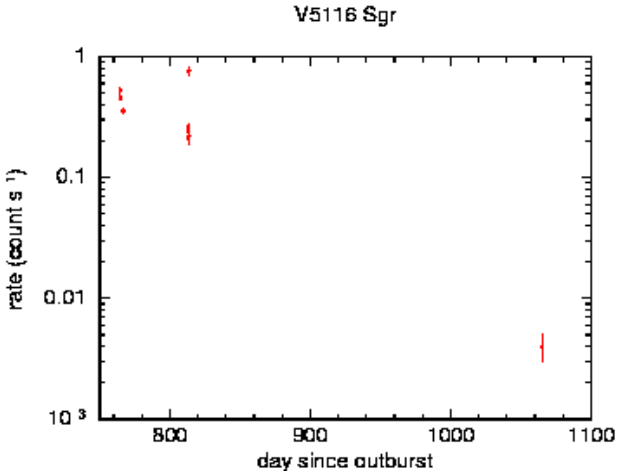
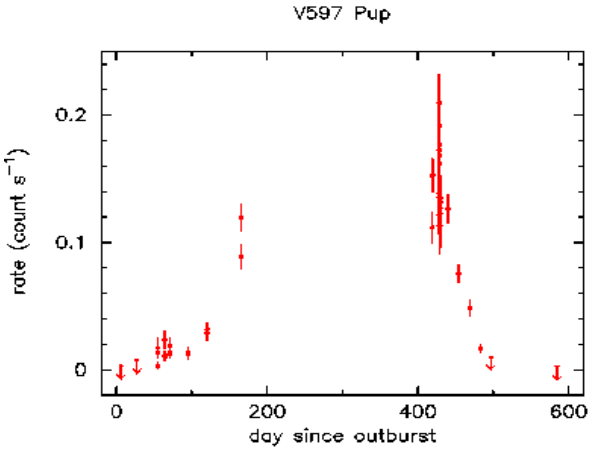




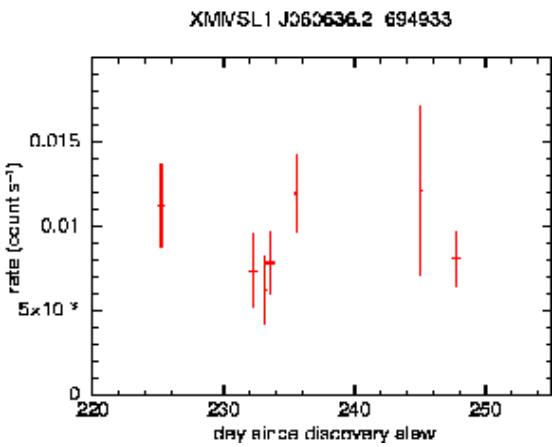


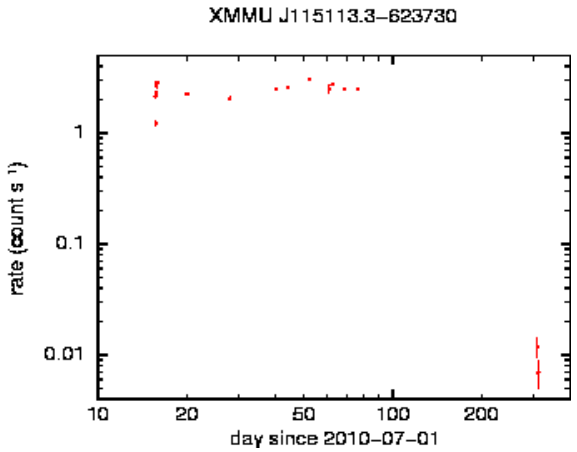


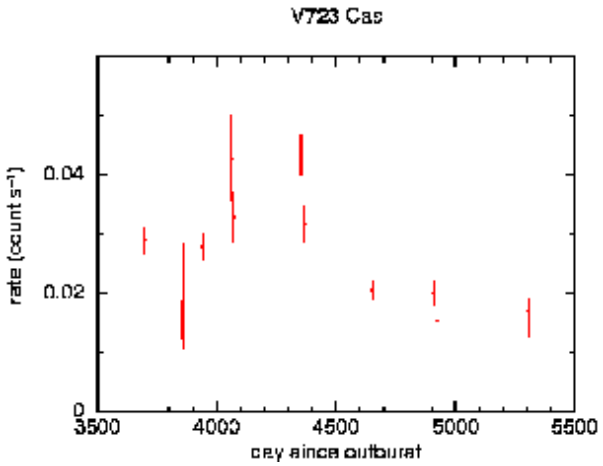




Other Swift-observed novae







Swift papers from the Nova-CV group

Swift X-ray Observations of Classical Novae II: The Supersoft Source Sample, Schwarz er al., 2011, ApJ, submitted
Swift Observations of the 2006 Outburst of the Recurrent Nova RS Ophiuchi. III. X-ray Spectral Modelling, Vaytet et al., 2011, ApJ, in press (arXiv:1106.2824)
XMM-Newton X-ray and UV observations of the fast nova V2491 Cyg during the supersoft source phase, Ness et al., 2011, ApJ, 733, 70
The spectroscopic evolution of the symbiotic-like recurrent nova V407 Cygni during its 2010 outburst. I. The shock and its evolution, Shore et al., 2011, A&A, 27, A98
The Supersoft X-ray Phase of Nova RS Ophiuchi 2006, Osborne et al., 2011, ApJ, 727, 124
Swift observations of the X-ray and UV evolution of V2491 Cyg (Nova Cyg 2008 No. 2), Page et al., 2010, MNRAS, 401, 121
X-ray and UV observations of nova V598 Puppis between 147 and 255 days after outburst, Page et al., 2009, A&A, 507, 923
Optical and X-ray Observations of M31N 2007-12b: An Extragalactic Recurrent Nova with a Detected Progenitor?, Bode et al., 2009, ApJ, 705, 1056
Pre-nova X-ray observations of V2491 Cygni (Nova Cyg 2008b), Ibarra et al., 2009, A&A, 497, L5
Swift X-ray and UV monitoring of the Classical Nova V458 Vul (Nova Vul 2007), Ness et al., 2009, AJ, 137, 4160
X-Ray Spectroscopic Diagnosis of a Wind-Collimated Blast Wave and Metal-Rich Ejecta from the 2006 Explosion of RS Ophiuchi, Drake et al., 2009, ApJ, 691, 418
Nova V2362 Cygni (Nova Cygni 2006): Spitzer, Swift, and Ground-Based Spectral Evolution, Lynch et al., 2008, AJ, 136, 1815
Novae as a Class of Transient X-Ray Sources, Mukai, Orio & Della Valle, 2008, ApJ, 677, 1248
V723 CASSIOPEIA: Still on in X-Rays a Bright Super Soft Source 12 Years after Outburst, Ness et al., 2008, AJ, 135, 1328
V5116 Sagittarii, an Eclipsing Supersoft Postoutburst Nova?, Sala, Hernanz, Ferri & Greiner, 2008, ApJ, 675, 93
Swift Observations of the 2006 Outburst of the Recurrent Nova RS Ophiuchi. II. One-dimensional Hydrodynamical Models of Wind-driven Shocks, Vaytet, O'Brien & Bode, 2007, ApJ, 665, 654
Swift X-Ray Observations of Classical Novae, Ness et al., 2007, ApJ, 663, 505
Swift Observations of the 2006 Outburst of the Recurrent Nova RS Ophiuchi. I. Early X-Ray Emission from the Shocked Ejecta and Red Giant Wind, Bode et al., 2006, ApJ, 652, 629