



Swift Cataclysmic Variables and Novae

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Swift nova-CV group



Cataclysmic Variables



CVs consist of a white dwarf accreting from a binary companion

They have a rich temporal phenomenology

- Multiple periods if WD is magnetic or oscillating
- Outbursts due to:
 - accretion events = dwarf novae
 - thermonuclear runaway reaction on WD = novae

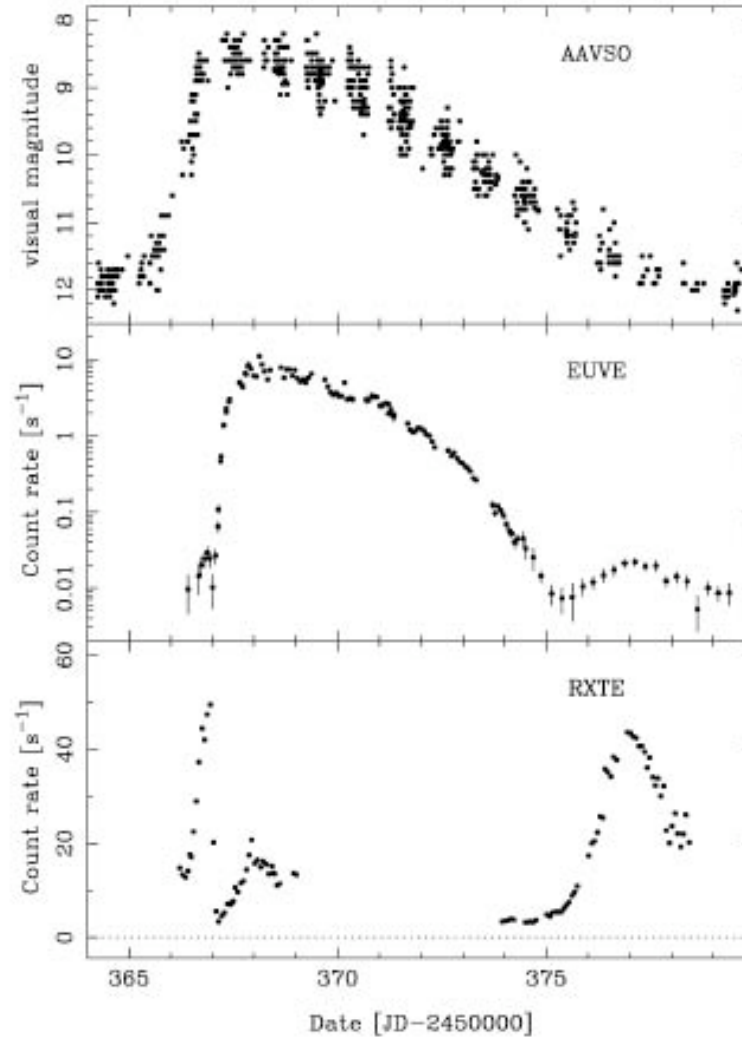


1 – Observation of non-magnetic CV through outburst

Expectation from model:

- Rising hard X-ray flux as accretion rate rises
- Hard X-ray flux suppressed as WD-disk boundary layer become optically thick
- Resumption of hard X-ray flux as boundary layer becomes optically thin
- Decline of hard flux as accretion rate continues to decline to quiescence
- Only archetypal object SS Cyg has been observed sufficiently to see this

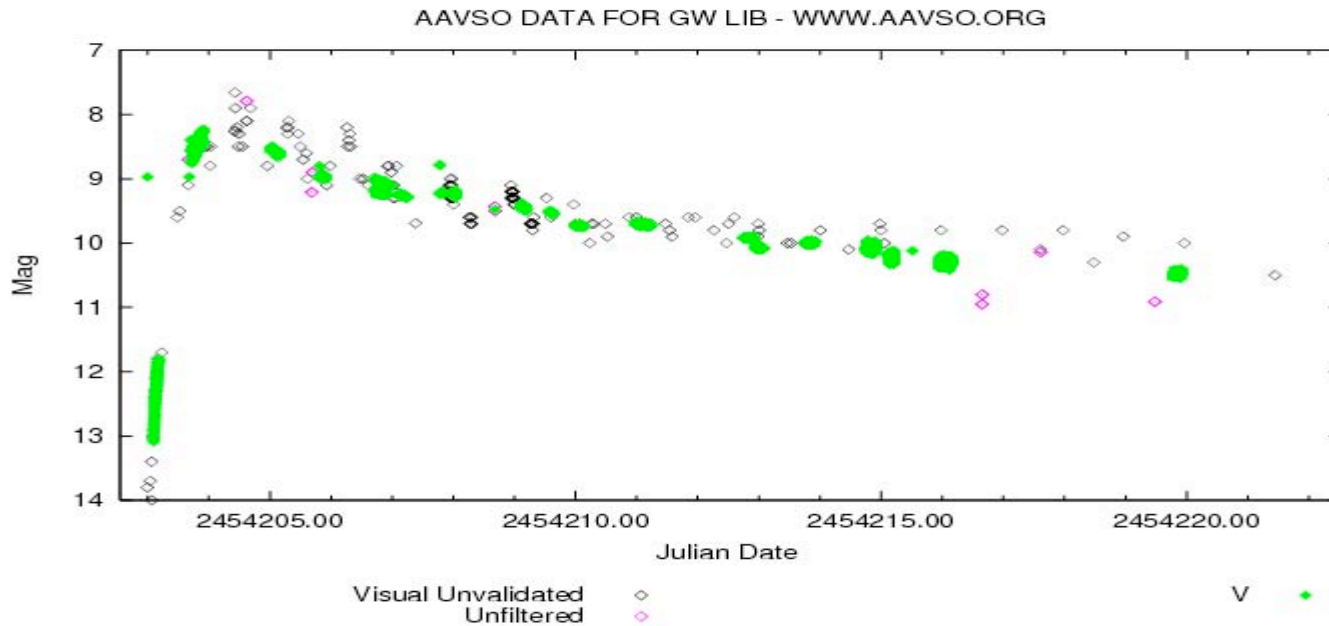
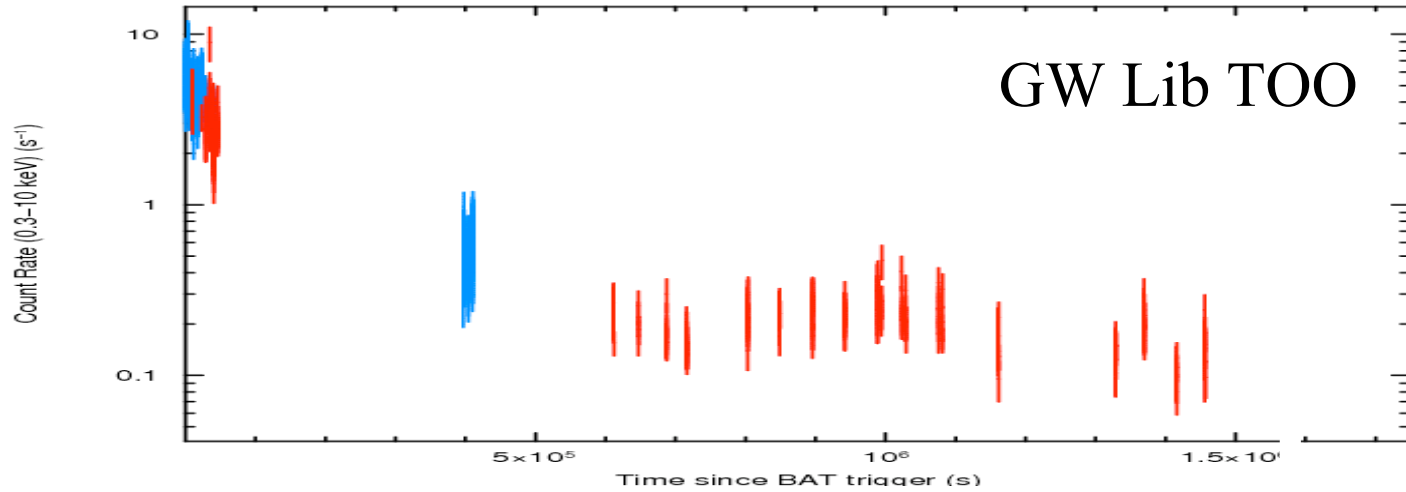
SS Cyg



Wheatley et al 03



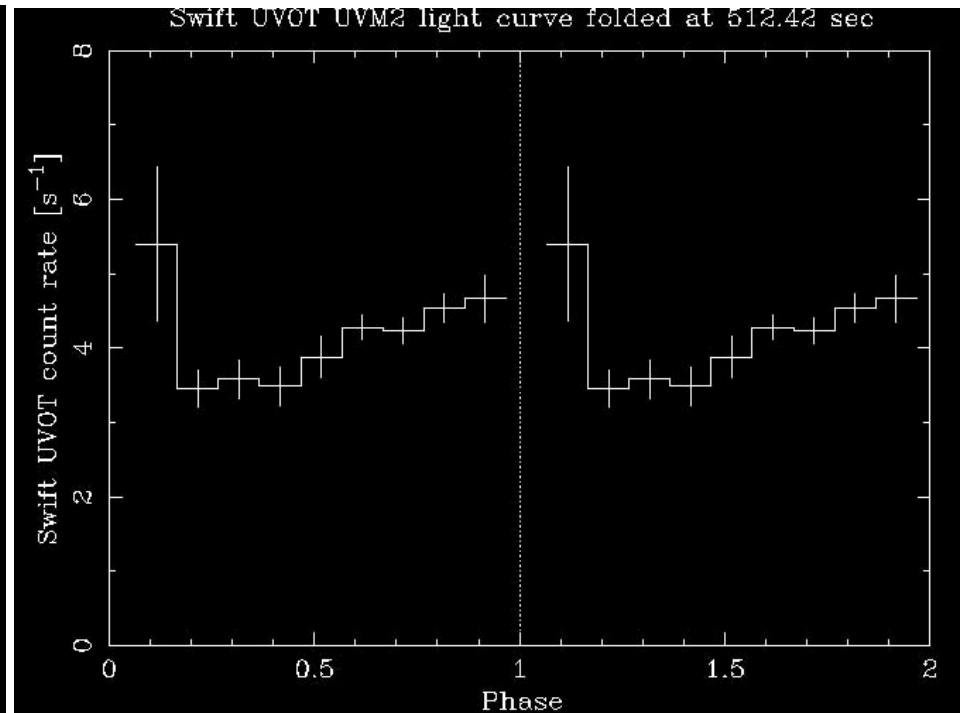
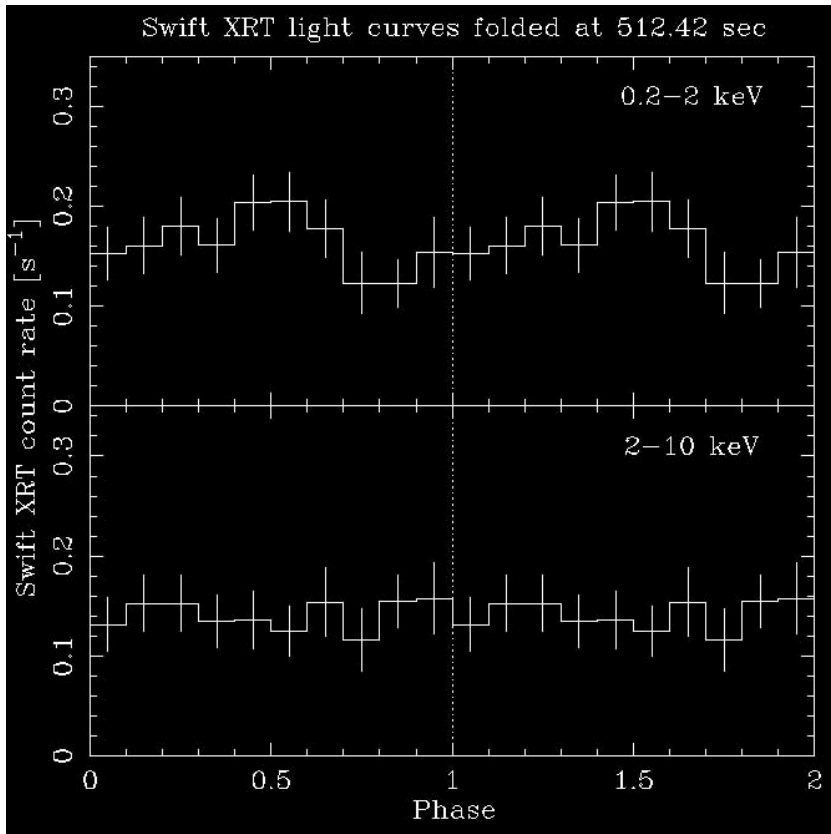
Non-magnetic CV through outburst





2 – classification of magnetic CV

- New BAT source
- Located by XRT
- Associated 2MASS object suggested CV classification
- 512 sec optical period discovered
- X-ray confirmation of optical period in XRT & UVOT data
- 5.5 hr optical period discovered
- Hence Intermediate Polar classification complete



Wheatley et al ATel 765

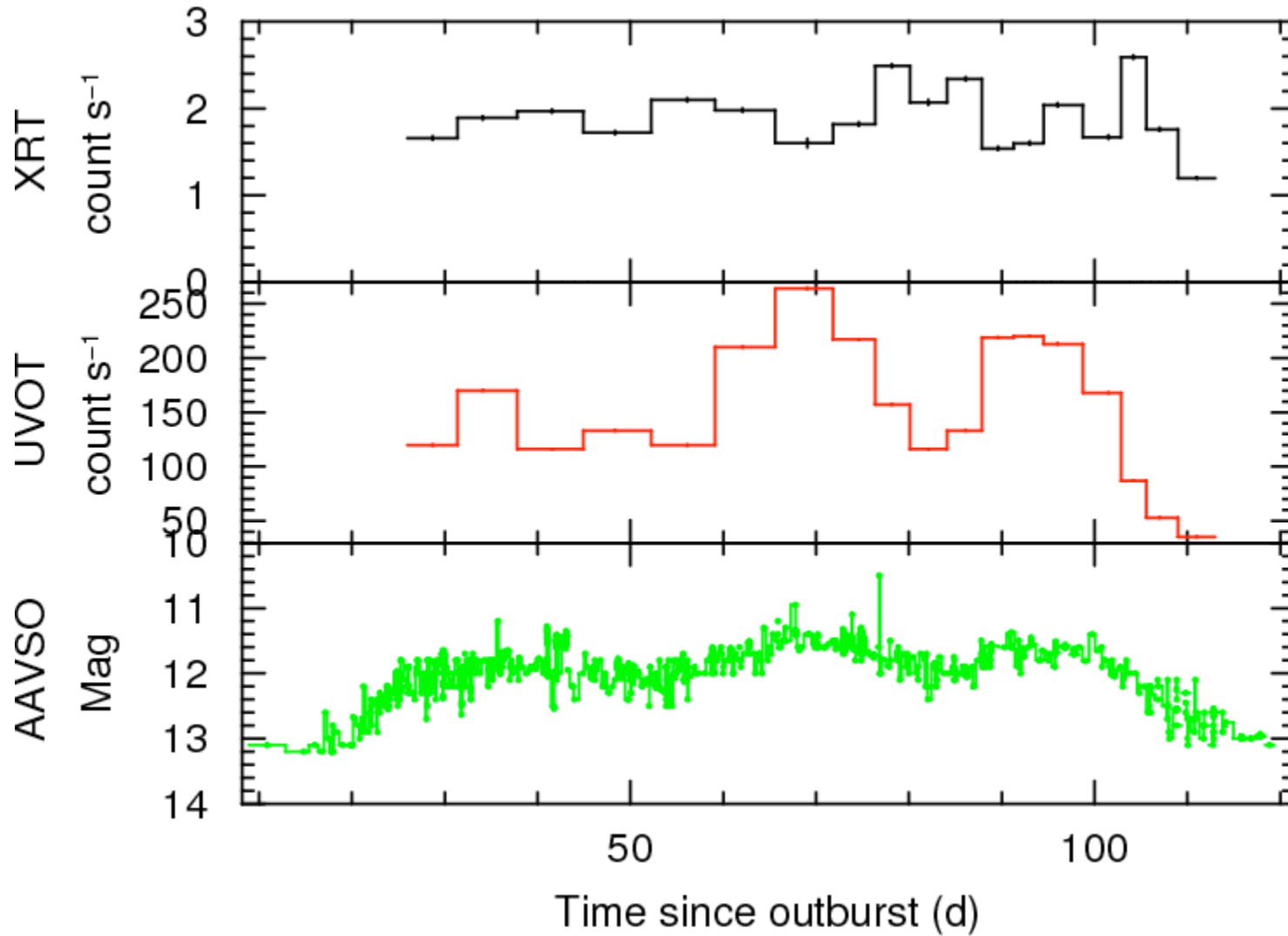
- Swift hard X-ray source (Ajello et al ATel 697)
- Optical 512 sec and 5.5 hr periods
- XRT 512 sec period in soft X-rays due to varying NH confirms intermediate polar classification

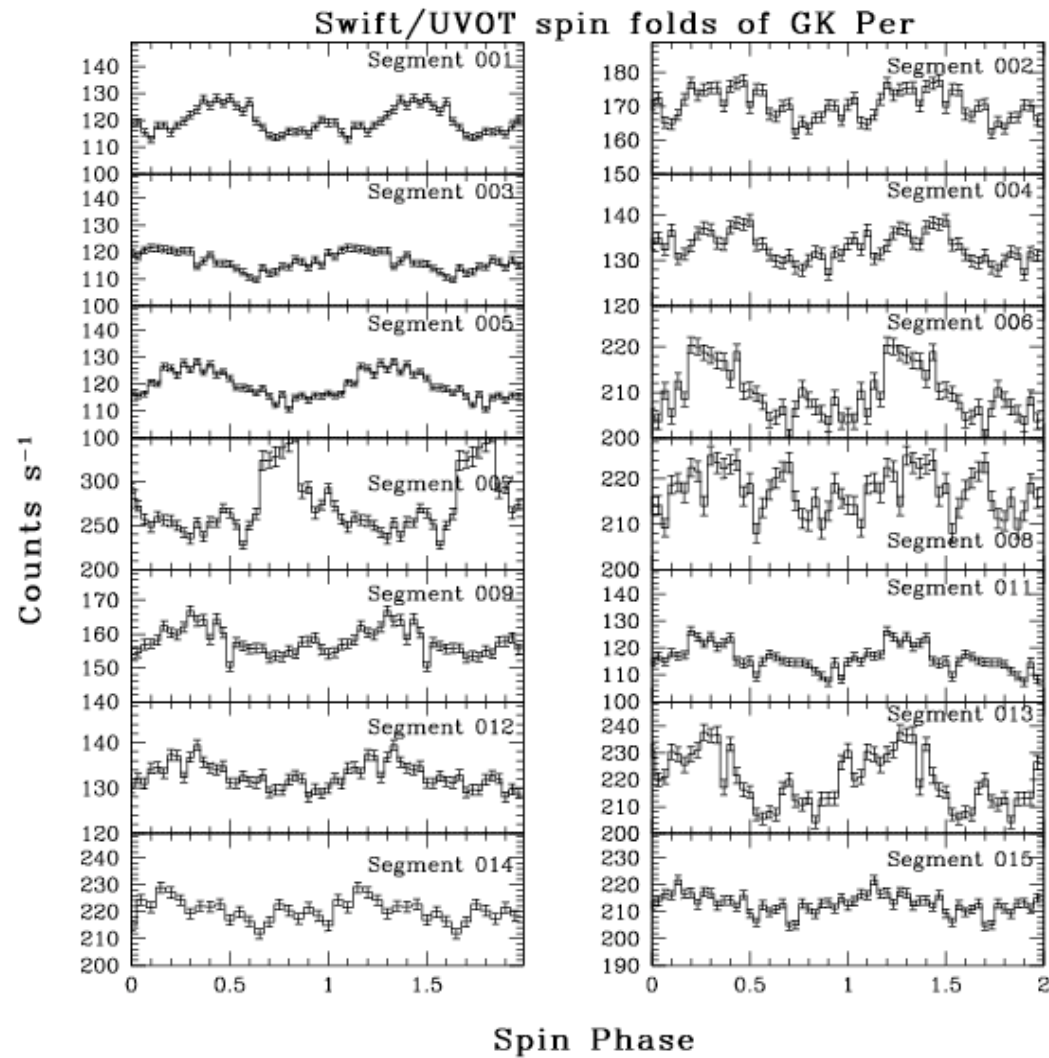


3 – A magnetic CV in outburst

- GK Per is an ex-nova with a 2-day orbit
- Hence has a large accretion disk
- 351 sec X-ray period due to spinning white dwarf
- Shows dwarf nova-like outbursts, unlike most intermediate polars
- Can monitor accretion geometry under changing accretion rate
- Outburst ended late last month

(Evans and Beardmore)







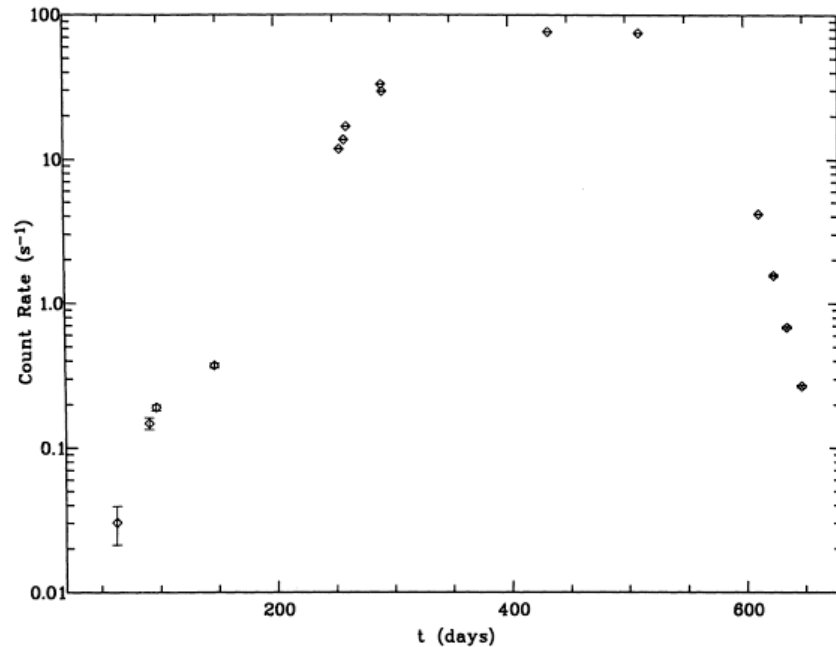
4 – Novae

X-ray observations so far have been highly sporadic – need to establish patterns of behaviour

Expectations for X-ray emission:

- Short-lived hot envelope at ignition (not seen)
- Nova wind shocks (internal or external)
- Super-soft emission from nuclear burning WD
- Post-explosion re-establishment of accretion
- Compton degradation of Na^{22} gamma-rays (not seen)

Swift nova group collaborates in obtaining observations



Krautter et al 1996

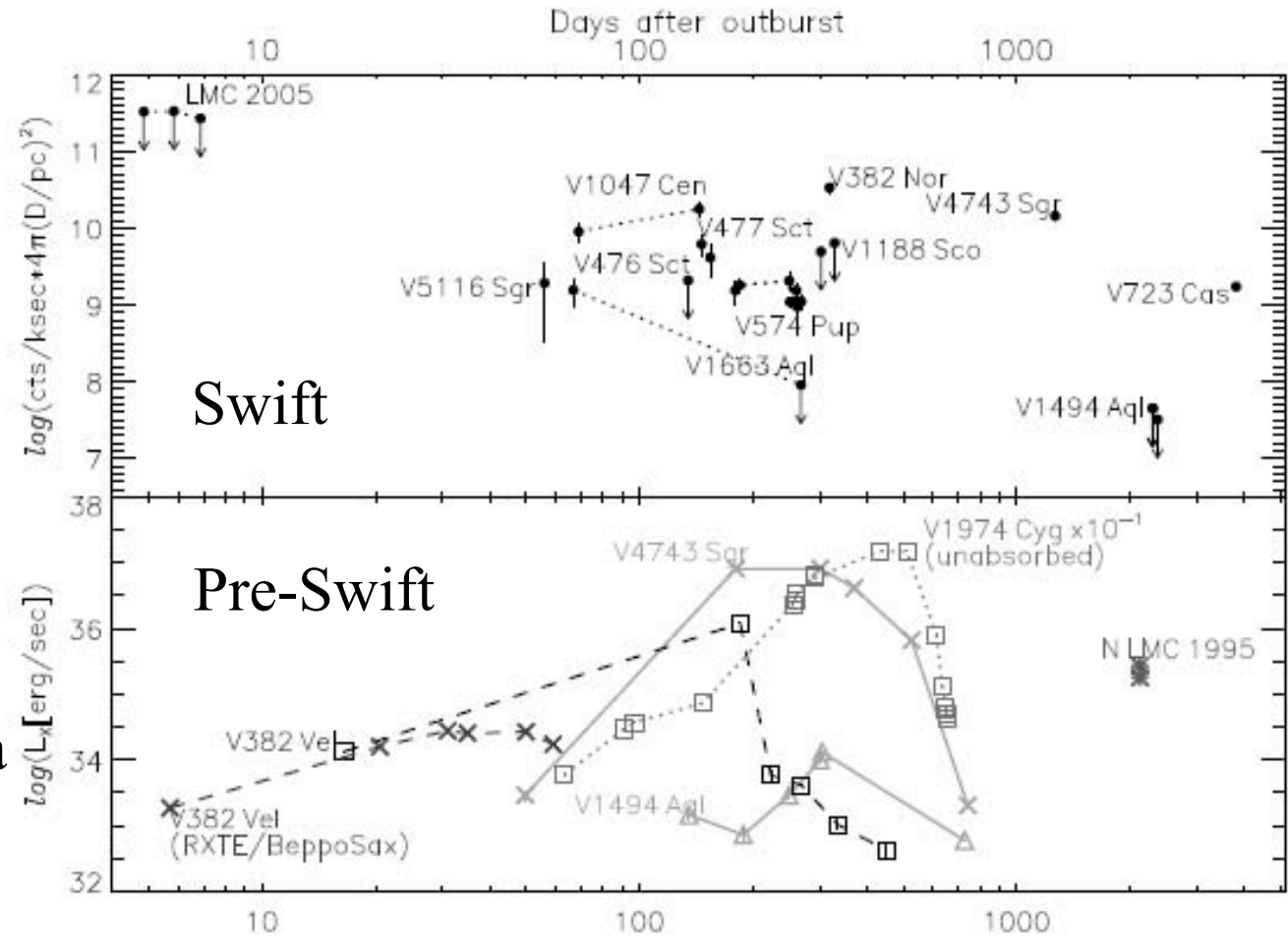
Nova Cyg 1992 (V1974 Cyg)

- Rosat PSPC
- 18 observations
- SSS lasts ~400 days

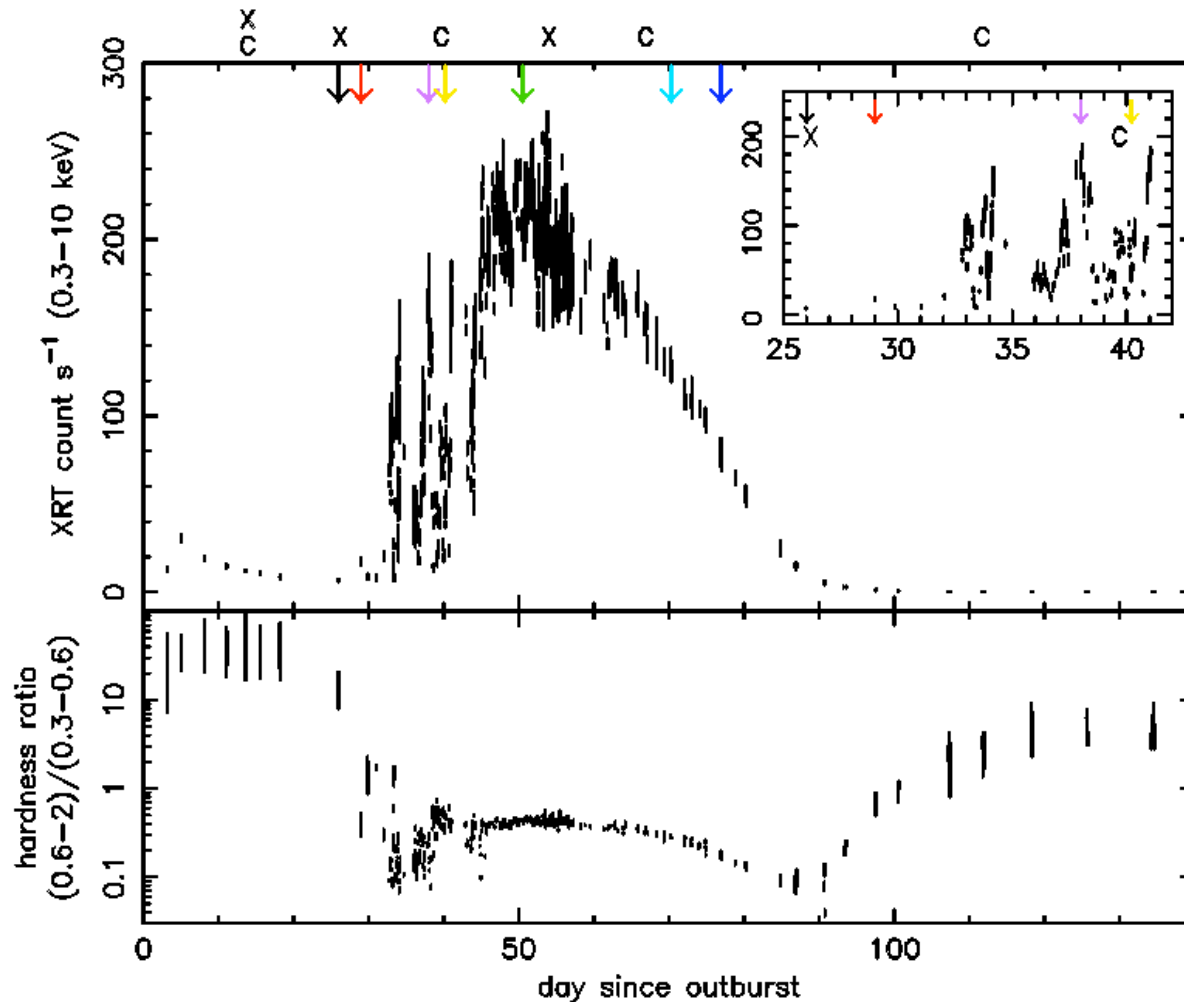
- Duration of SSS phase generally unknown – important constraint on WD mass

1st Swift nova paper has 12 novae

Swift is building a more complete sample than was previously available

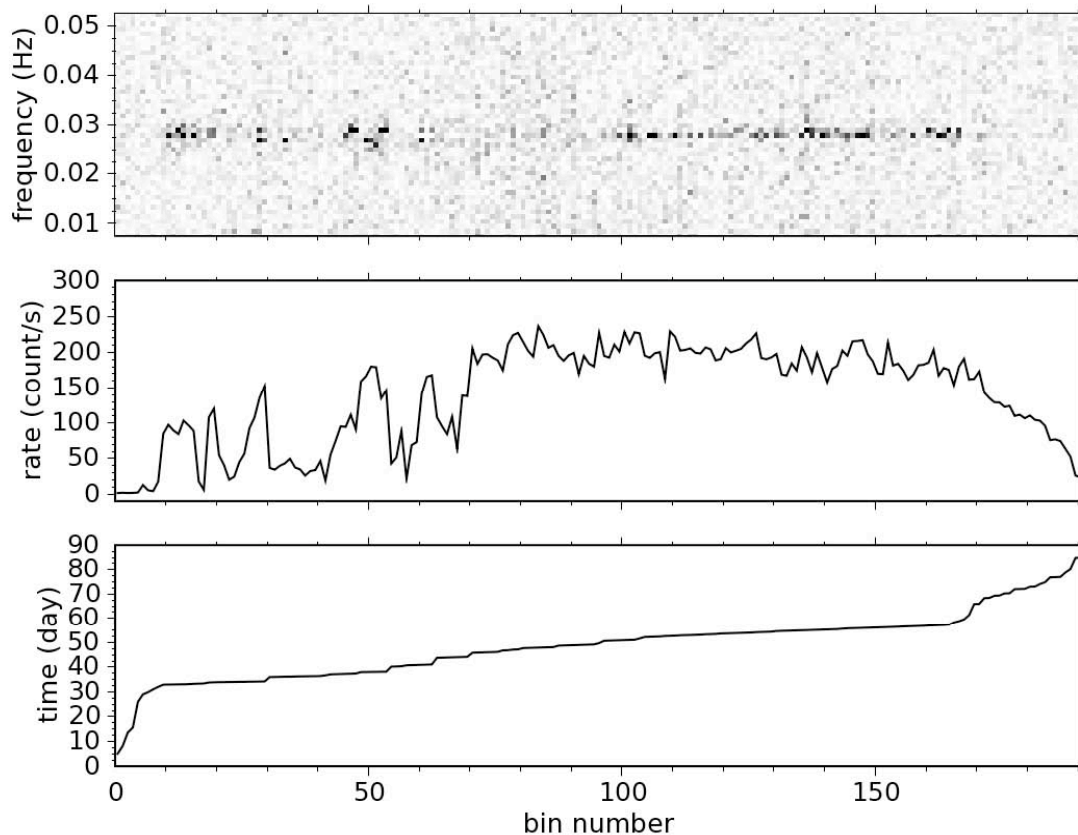


Ness et al 07



Swift XRT
0.3-10 keV light
curve shows:

- Cooling hot gas emerging from red giant wind
- Noisy onset of super-soft phase, which lasts ~64 day in total
- Very short SSS phase → WD near Chand limit



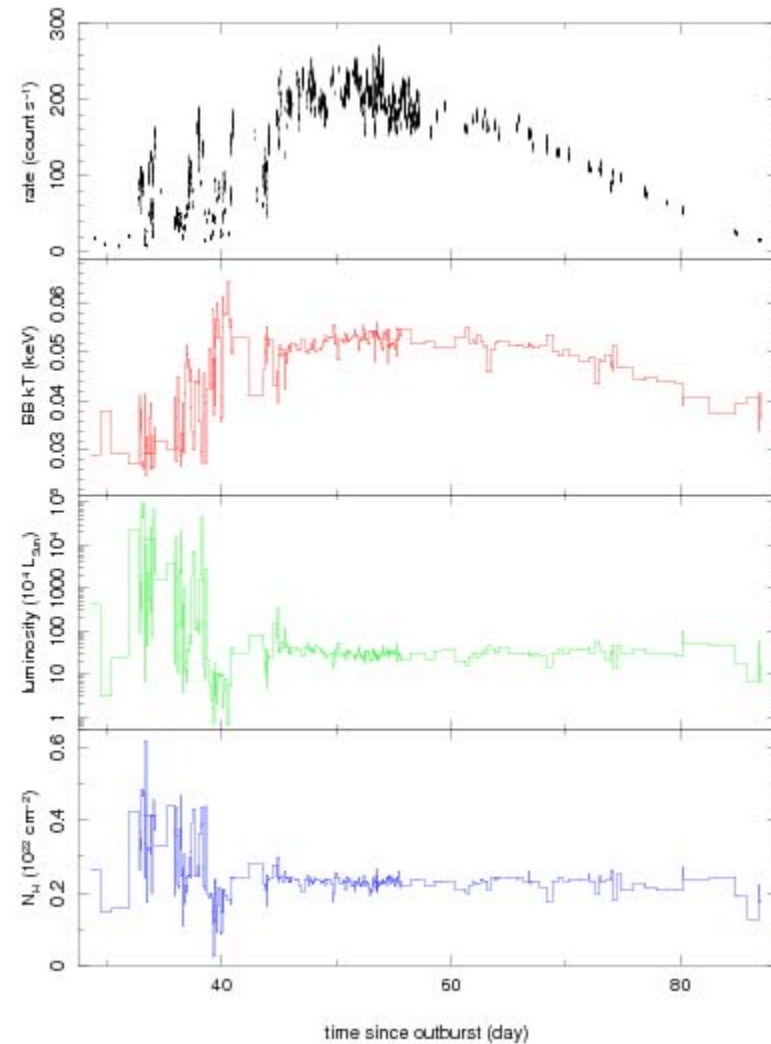
~35 sec modulation
mostly present
when SSS is bright

Fastest period seen
in a nova so far –
possible nuclear
burning instability?

Preliminary high temporal density spectral fits

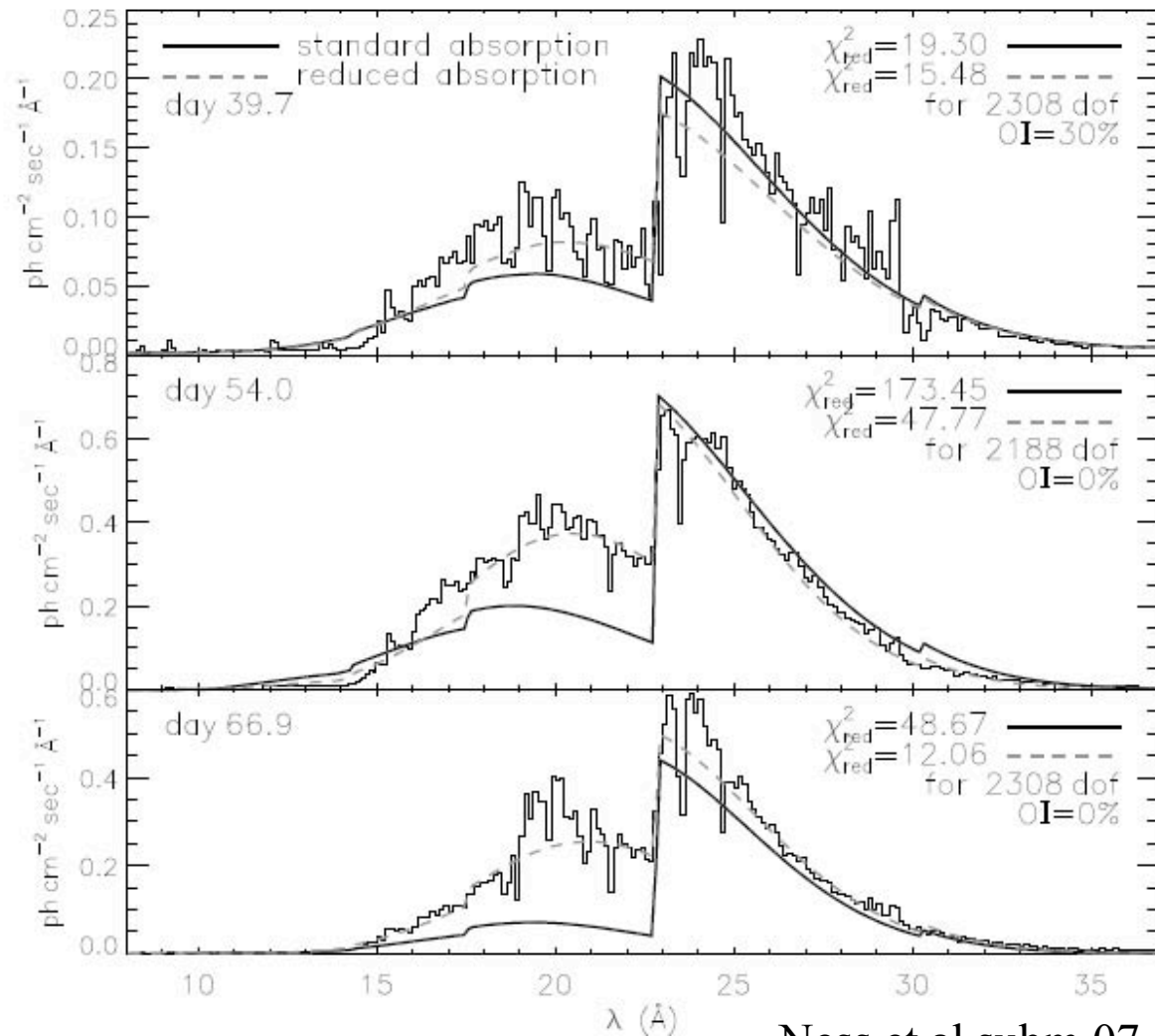
Blackbody cooling clear during late SSS phase

All parameters uncertain at SSS onset due to highly variable absorption in nova ejecta



3 epoch Chandra
grating spectra
suggest reduced
Oxygen in absorber

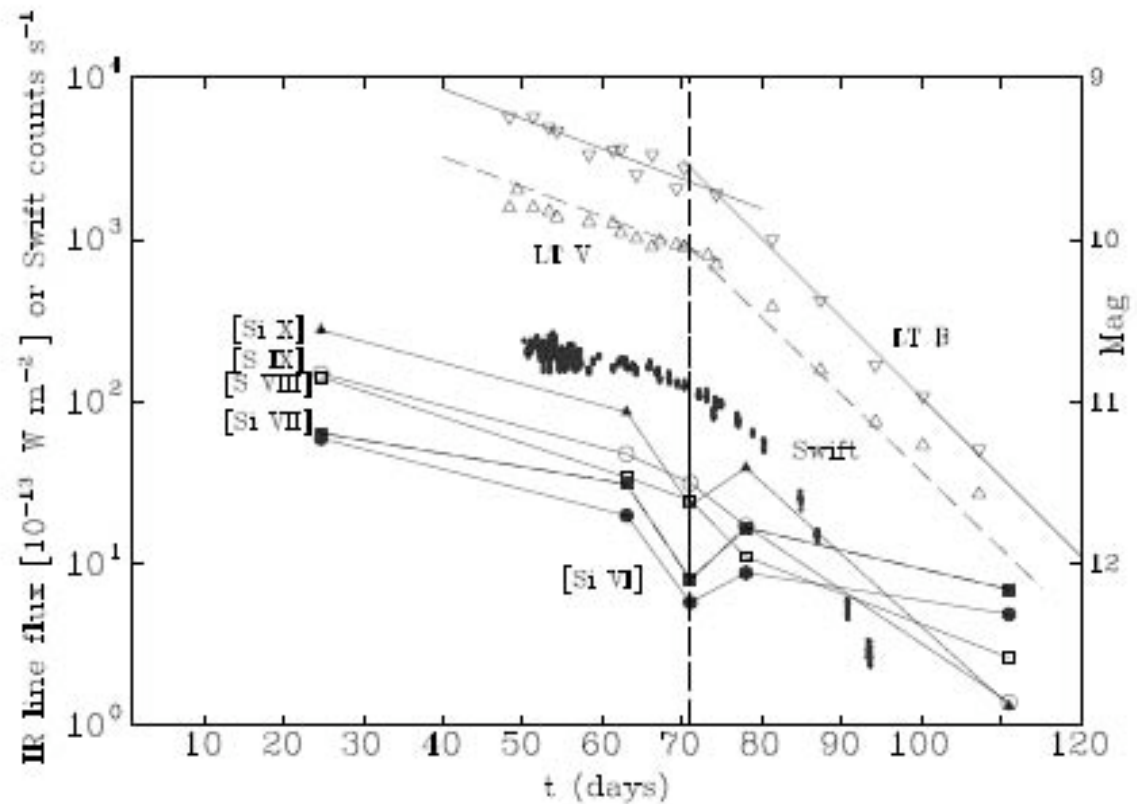
Model atmosphere
modelling now
starting



Ness et al subm 07

Spitzer emission lines
 $\rightarrow T \sim 1.5 \text{ \& } 9 \times 10^5 \text{ K}$
 (consistent with XRT)

Line flux drop at 70 days coincides with optical ‘knee’, around time of shock breakout from red giant wind - no simple explanation

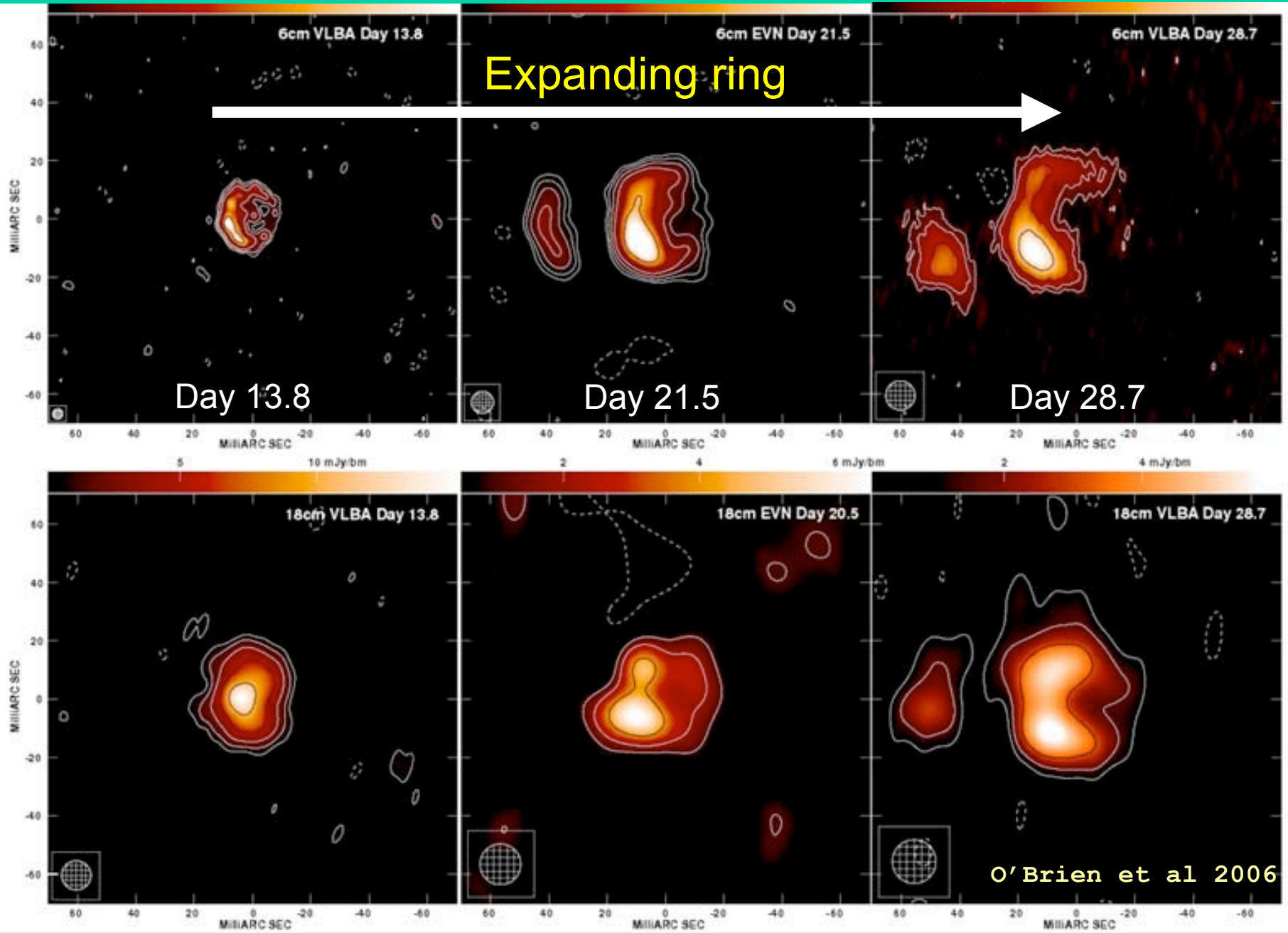


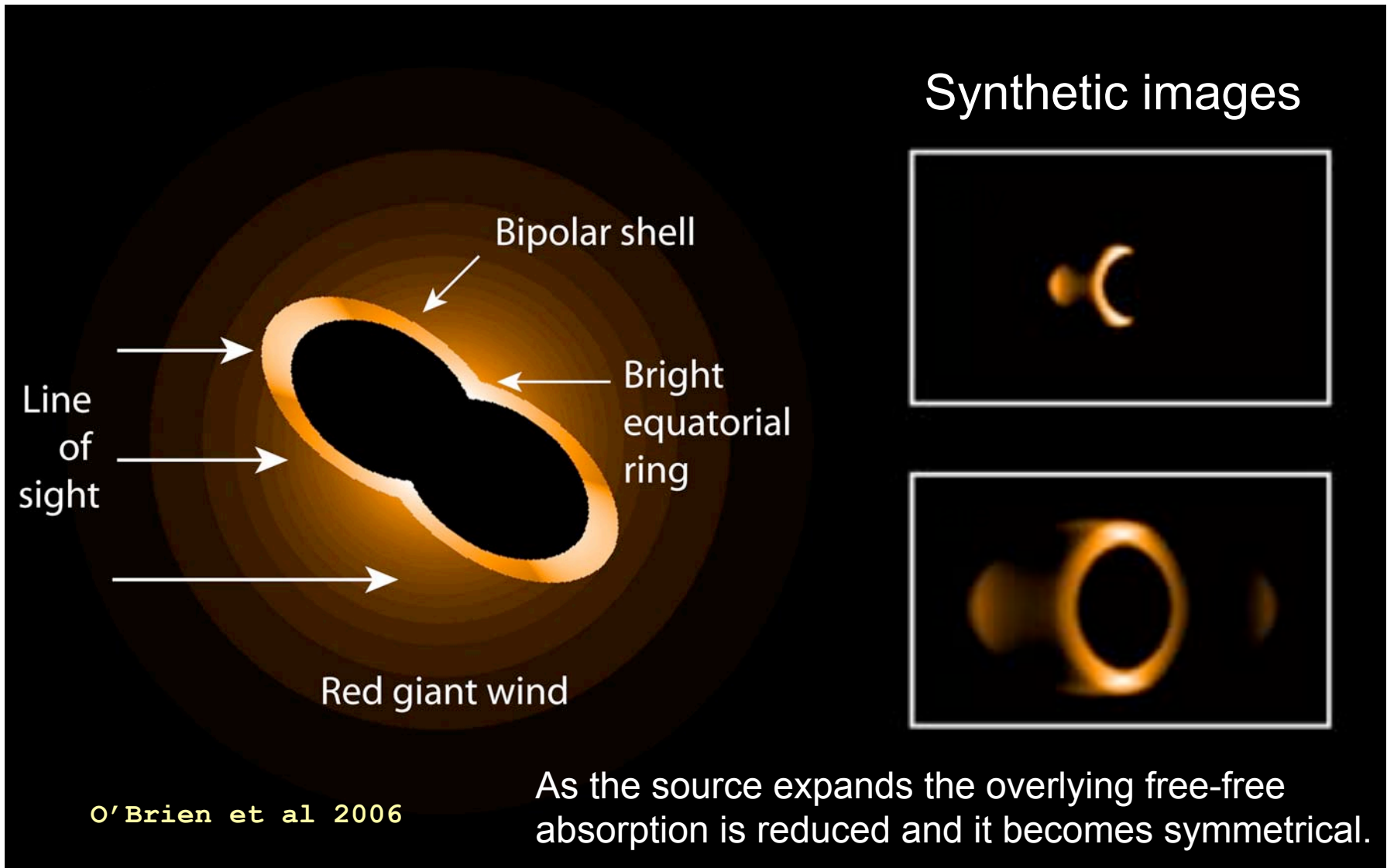
Evans et al subm 07

VLBA

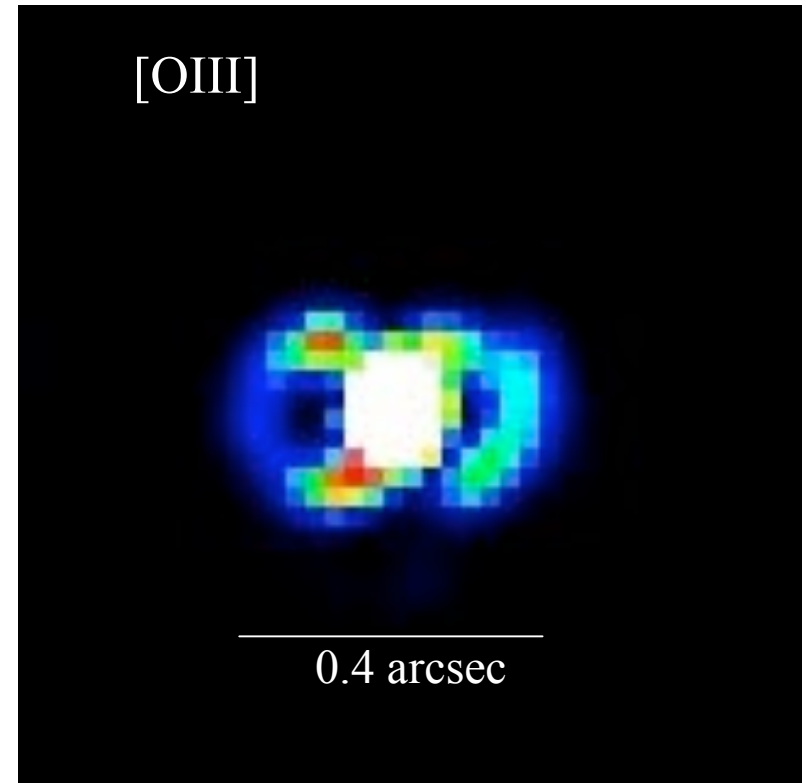
EVN

VLBA

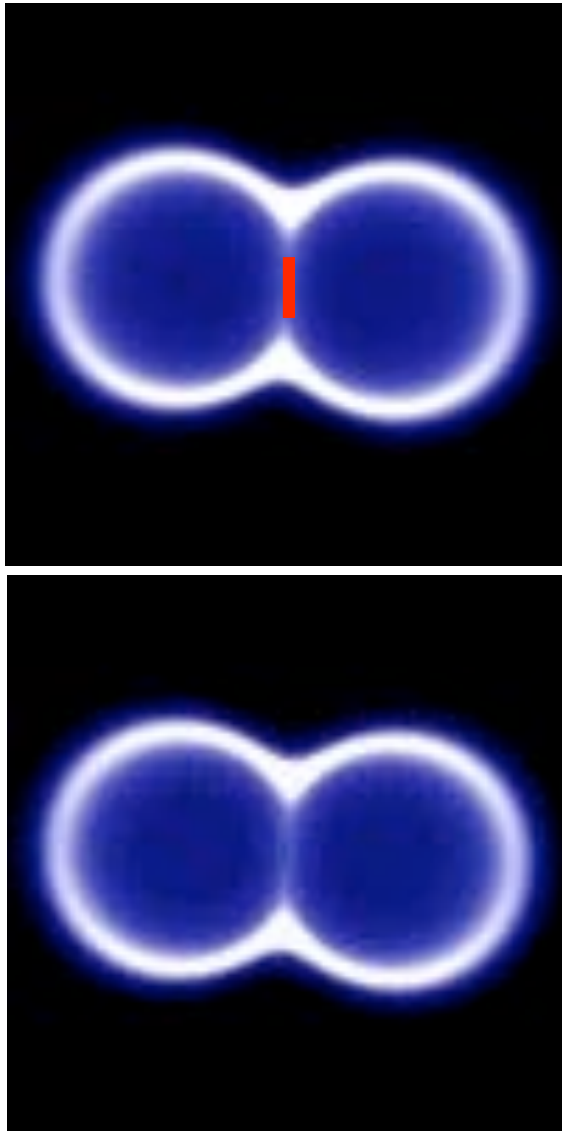




- HST ACS/HRC DDT, $t = 155\text{d}$
- 2 orbits, [OIII]5007, Ha, [NeV]3426
- Extended structure detected in [OIII] and [NeV] (+possibly Ha)
- Elongated structure ~ 380 mas, E-W, comparable with constant velocity of expansion of outer radio lobes
- $v \sim 3400$ km/s (in plane of sky)



Bode et al subm 07



- O'Brien et al. suggested VLBI evolution modelled by bipolar structure
- Here, “peanut” with axial ratio 3:1 consistent with $v = \text{constant}$ (major axis), deceleration (minor) *cf.* radio
- $i = 35^\circ \rightarrow$ binary orbital plane in “waist”; $v_{\text{ej}} = 5900 \pm 1200 \text{ km/s}$
- Consistent (first order) model of geometry

(Bode et al. 2007, ApJ, submitted)



“RS Ophiuchi (2006) and the Recurrent Nova Phenomenon II”

Conference

12 – 14 June 2007

University of Keele, UK

<http://www.astro.keele.ac.uk/rsoph/>



Galactic nova strategy –

- $V_{\max} < \sim 8$ to ensure possible X-ray detection and other follow-up
- Short observation as soon as possible
- Monitor if detected, otherwise observe again at 3 mags below max
- For low extinction novae monitor for SS phase onset (weekly for fast novae, monthly for slow novae)
- For SS novae measure duration of SS phase for WD mass

Magellanic Cloud novae have lower metallicity and extinction, meriting less stringent V_{\max} selection



Swift is a near-ideal rapid-reaction, multi-wavelength facility

Swift is making a very significant impact in this area

- Nova properties
- Accreting systems under varying accretion rate

Large Swift programs can bring in the contribution of other facilities

Such programs need exploratory TOOs to motivate them

Desiderata:

- Grism calibration
- Annular photometry for bright UVOT sources
- Continuation of current TOO regime