RS Oph:
A new look at the evolution of 2006 outburst in X-rays

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Overview

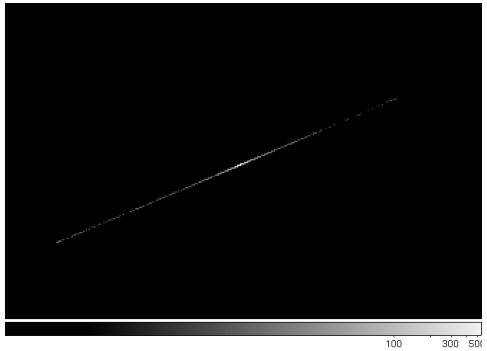
RS Oph

- symbiotic recurrent nova
  (outbursts every ~ 20 years)
- last outburst in year 2006
- P = 456 days, i ≈ 50°
- near-Chandrasekhar-mass white dwarf + red giant

Swift space observatory

Burst Alert Telescope (BAT): 15 - 150 keV

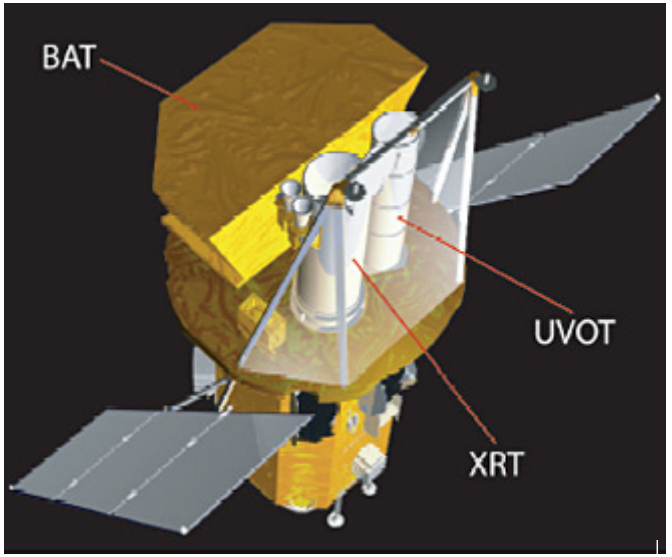
X-ray Telescope (XRT): 0.3 - 10 keV

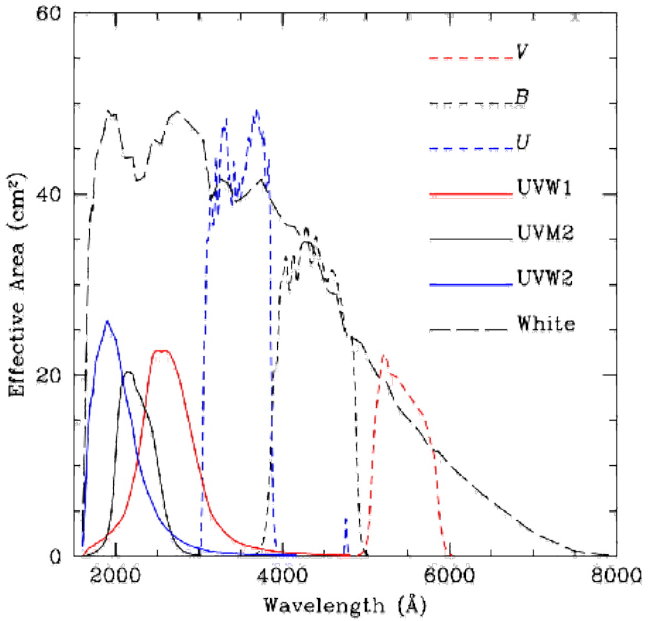


Windowed Timing mode [WT]

Photon Counting mode [PC]

UV/Optical Telescope (UVOT): 170 - 600 nm





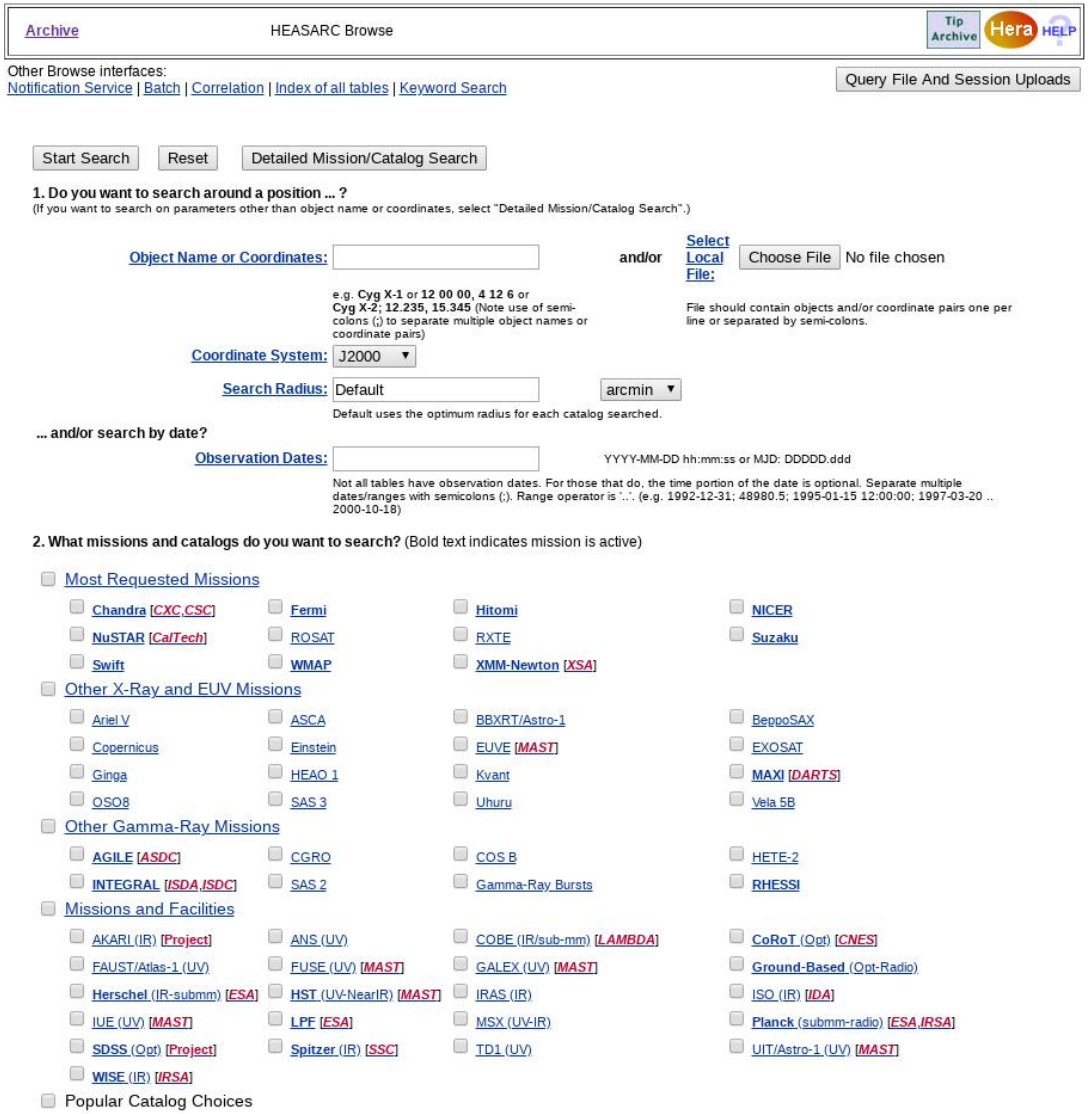
HEASARC

https://heasarc.gsfc.nasa.gov/cgi-bin/W3Browse/w3browse.pl

~120 simultaneous XRT & UVOT observations of RS Oph during and after the outburst in 2006

- tool to build Swift-XRT light curve or spectrum:

http://www.swift.ac.uk/user_objects/

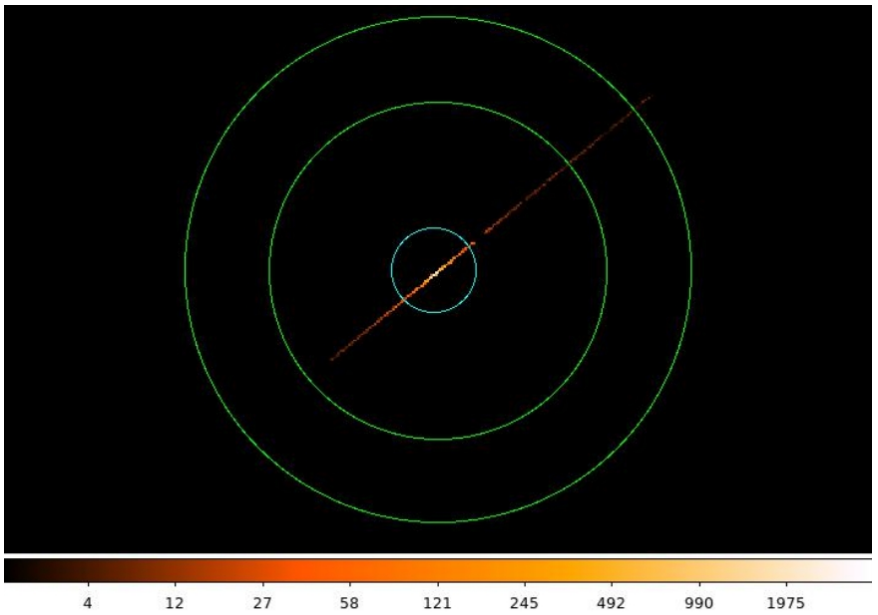


Data reduction and analysis

HEASoft:

https://heasarc.gsfc.nasa.gov/docs/software/heasoft

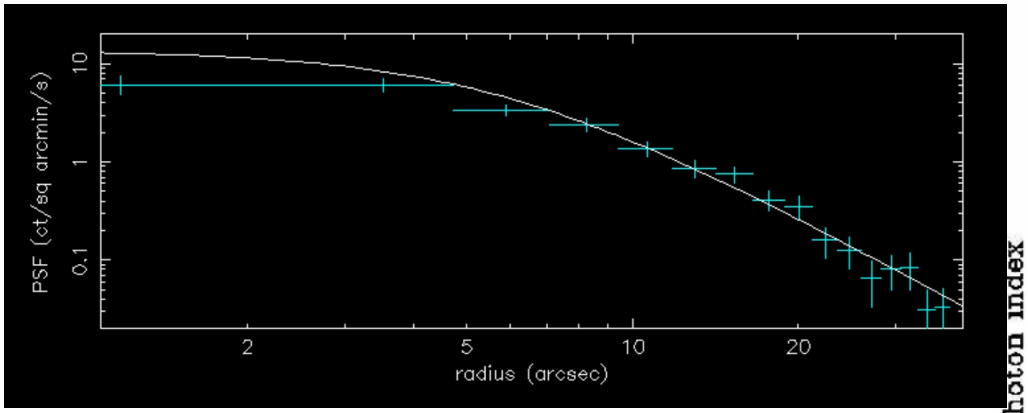
- produce cleaned event-list
- correct for the pile-up
- define source and background region
- extract spectrum
- build ancillary response file
- link all necessary files
- spectral analysis (Xspec)

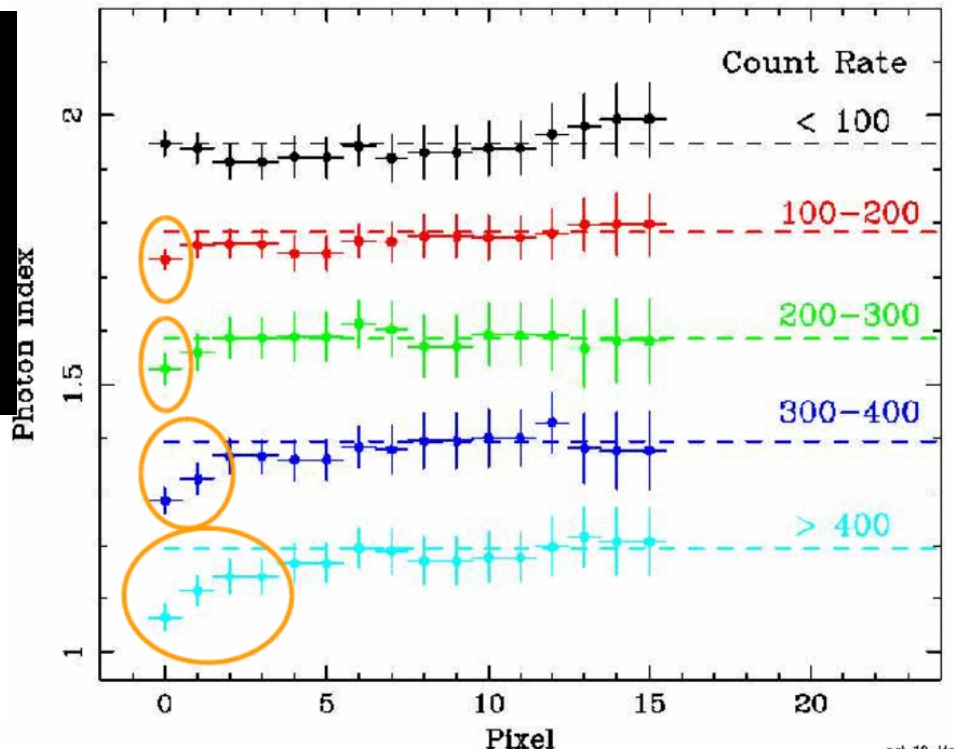


Pile-up

- one or more photon hit the same pixel at the same time

- pile-up can occur for **count rate above**: 0.5 c/s for PC, 100 c/s for WT



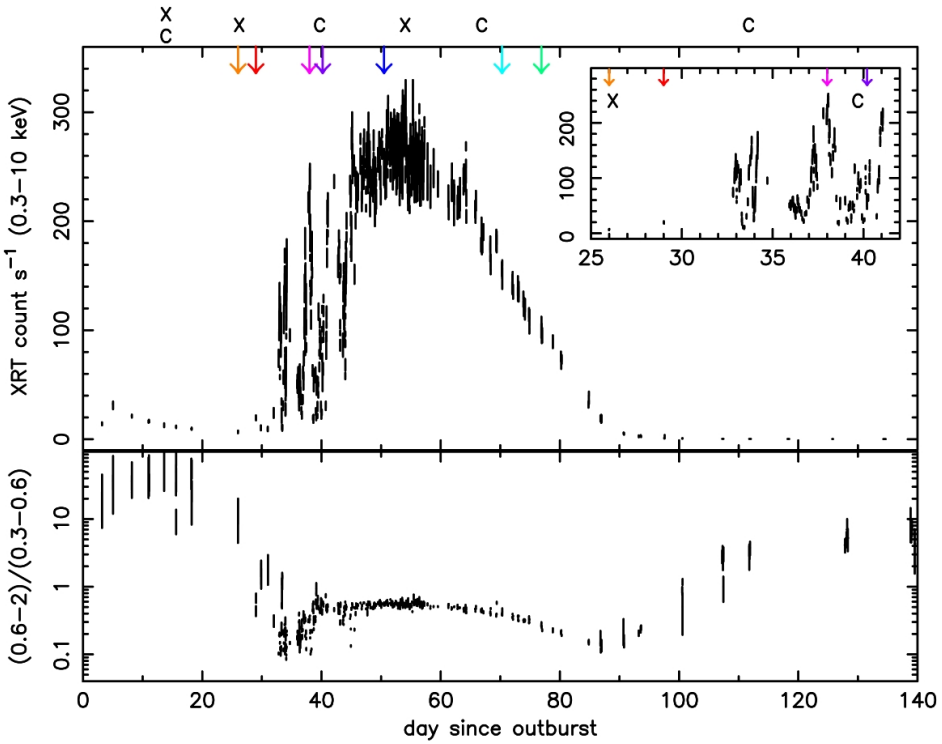


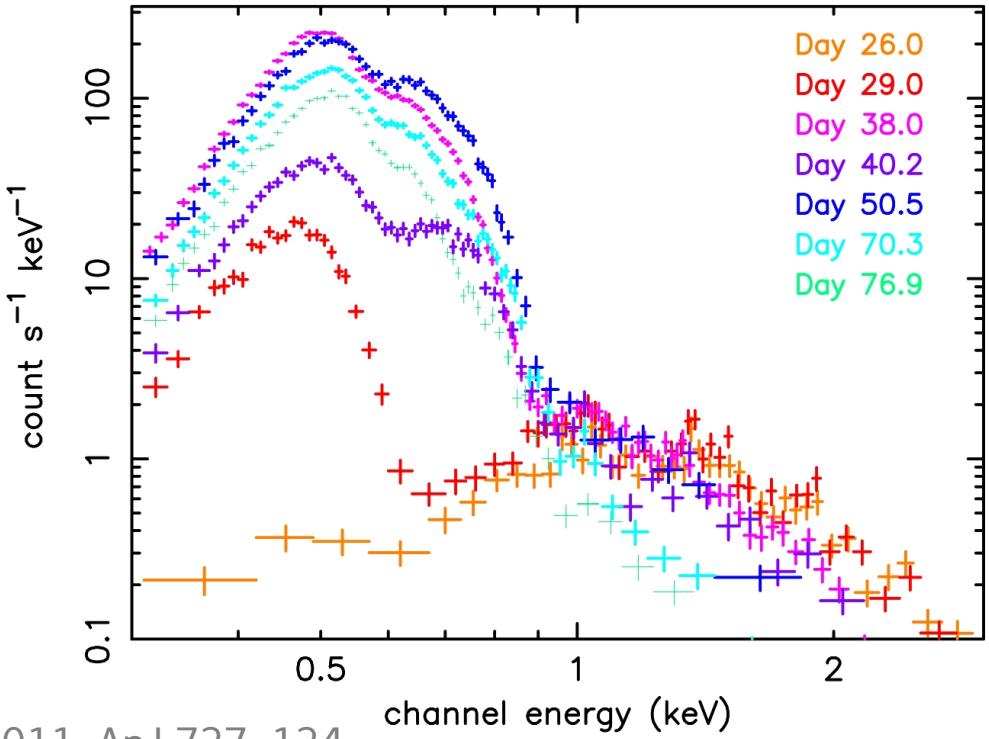
- point spread function fitted by the King function:

$$PSF(r) = [\ 1 + (r/r_c)^2\ ]^{-\beta}$$

RS Oph 2006 outburst

- February 12 at a magnitude of 4.5
- hard phase + variable SSS phase + stable SSS phase + hard phase toward quiescence



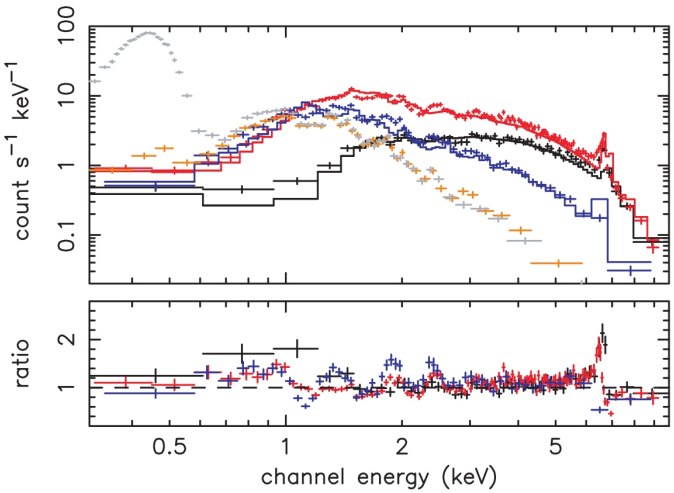


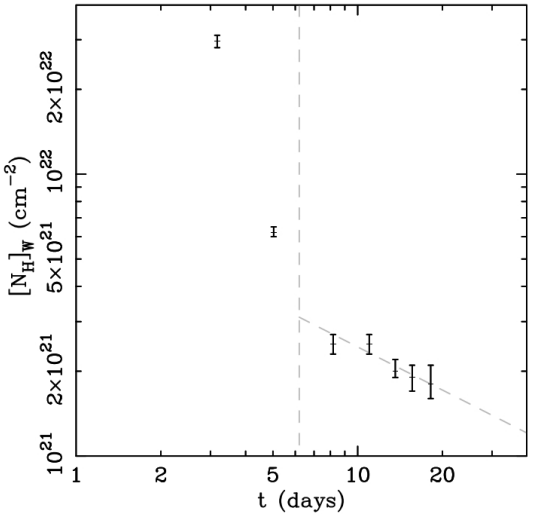
Osborne et al. 2011, ApJ 727, 124

Initial hard phase

Bode et al. 2006, ApJ 652, 629

– high-velocity ejecta from WD interact with preexisting red giant wind
--→ creation of **shocks**





- model: **thermal emission from optically thin plasma (SHOCKS)** – MEKAL model x **absorption (ISM + RG wind)**
- N_H: profile as expected for a red giant wind ahead of the shock

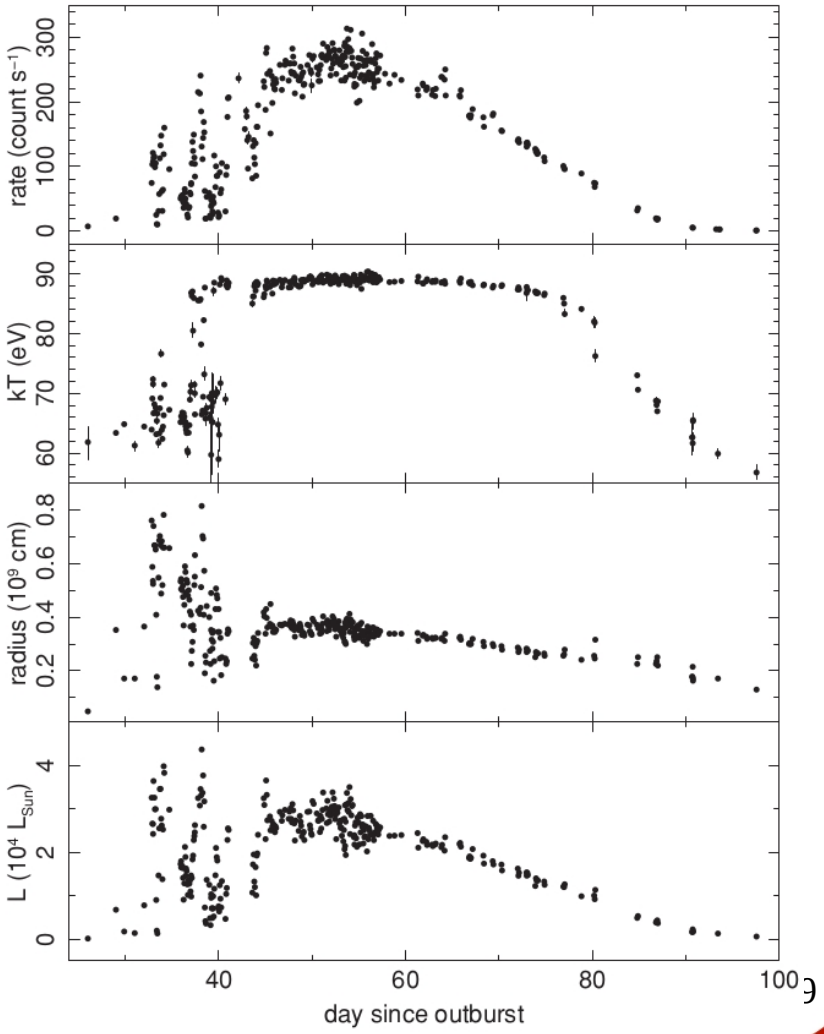
Supersoft source (SSS) phase

Osborne et al. 2011, ApJ 727, 124

- model:(**plasma (T_1)** – APEC model
  + plasma (T_2) – APEC model
  + hot WD atmosphere – Rauch 2003)
  x absorption (ISM + unshocked RG wind)

- N_H: $N_{H,\,wind} = 7.5 \times 10^{21} t^{-0.5} cm^{-2}$
  (Bode et al. 2006)

  – X-ray spectra during SSS phase dominated by radiation from the **unveiled WD surface** due to the ongoing **nuclear fusion**
  – reestablished accretion **ruled out** as the origin of SSS component

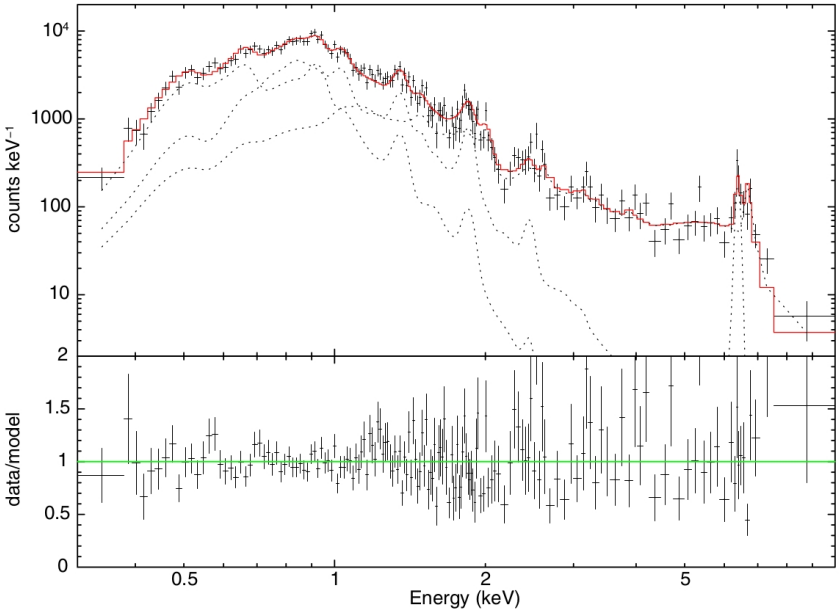


Quiescence

Nelson et al. 2011, ApJ 737, 7

- two-component plasma model:
  --→ **shocked nova ejecta**
  --→ **accretion disk boundary layer**

- to reproduce the continuum above 2 keV:
  --→ **partially covering absorber**
  $f \times exp[-n_H \sigma(E)] + (1-f)$



- model:(**plasma (T_1)** – VAPEC model
  + plasma (T_2) – VAPEC model
  + partially covering abs. x (plasma (T_3) + Fe line))
  x absorption (ISM + unshocked RG wind)

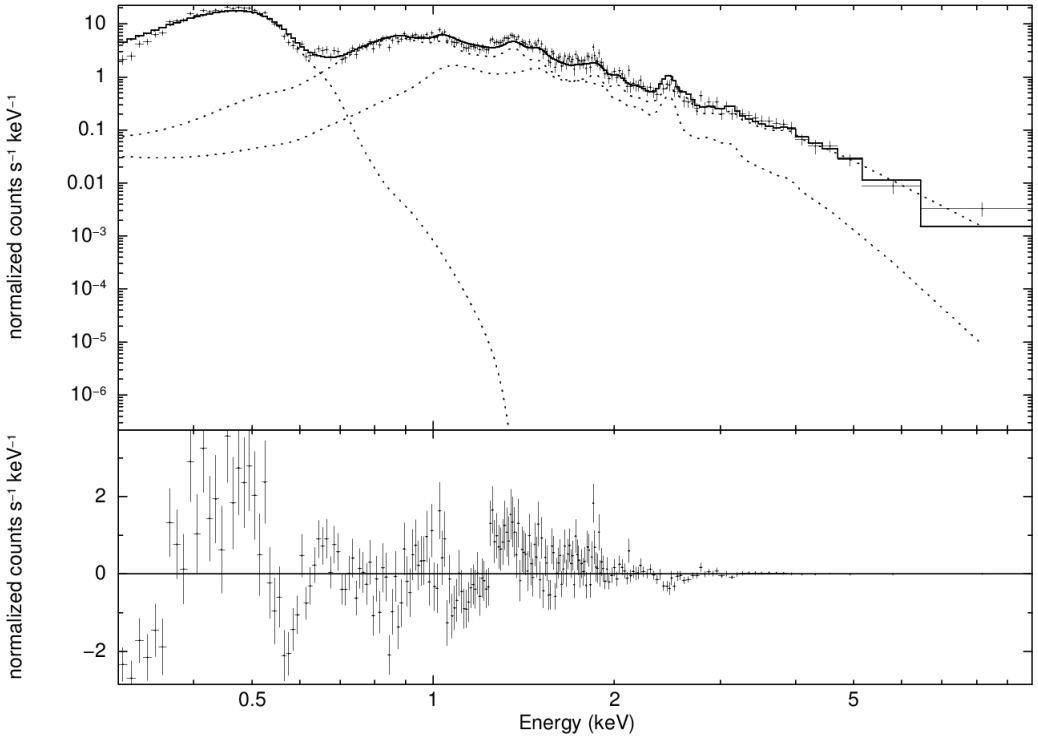
- N_H: $N_{H,\,total} = 2.4 \times 10^{21}$ cm^{-2}
  $N_{H,\,part.\,cov.} = 1.3 \times 10^{24}$ cm^{-2}

Modelling Swift XRT spectra

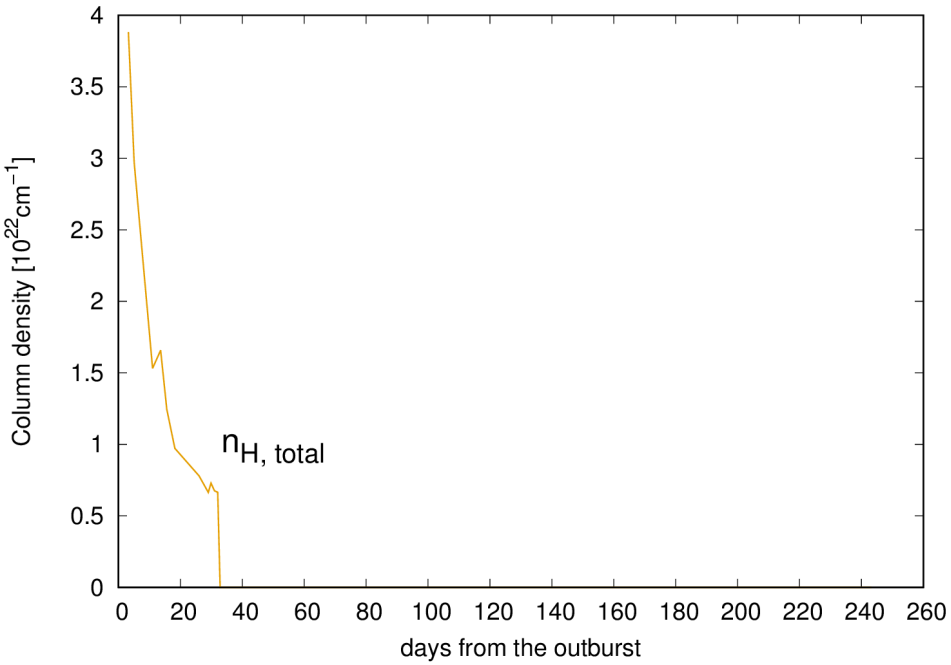
- model:(**abs.** (unshocked RG wind) **x plasma (T_1)** – VAPEC model
  + partially covering abs. x (plasma (T_2) + hot WD atmosphere))
  x absorption (ISM)

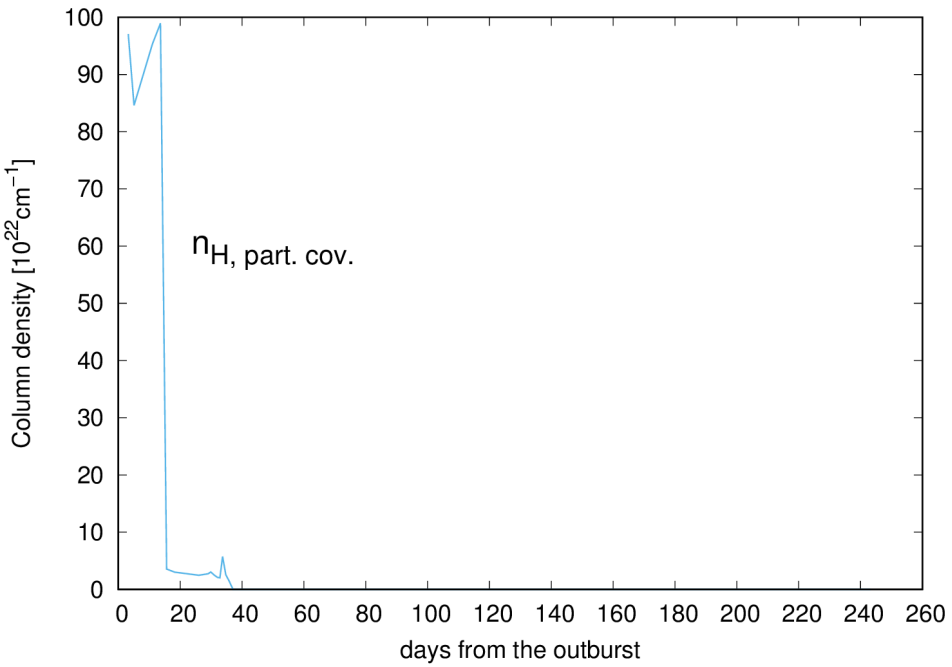
- N_H: $N_{H,\,total}$ - *free parameter*
  $N_{H,\,part.\,cov.}$ - *free parameter*

- abundances:
  - Wilms et al. 2000 (**ISM**)
  - Ness 2007 (**shock**)
  - Ness 2009 (**shock**)
  - Pavlenko 2008 (**RG wind**)

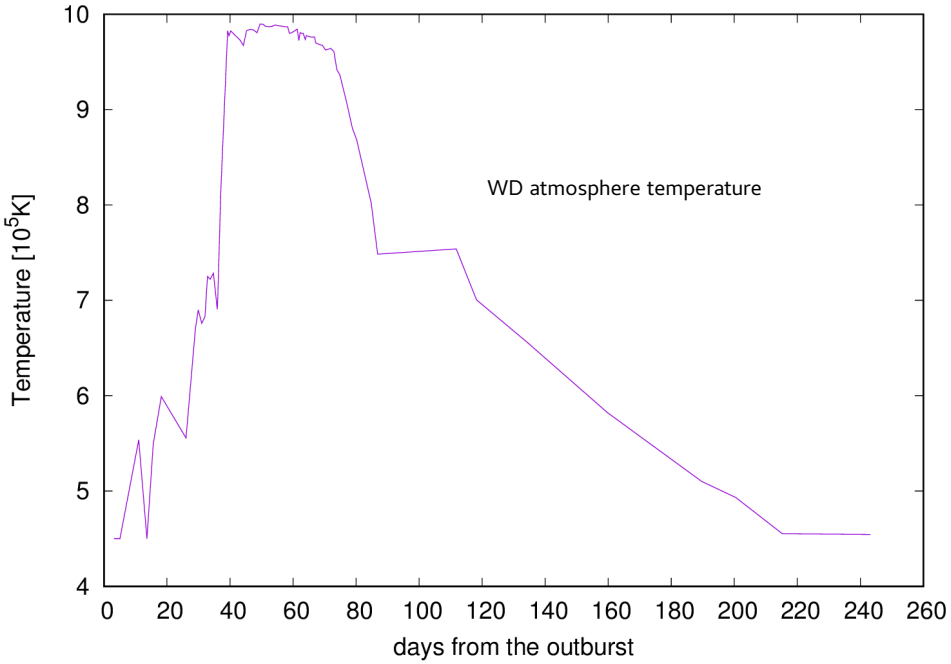


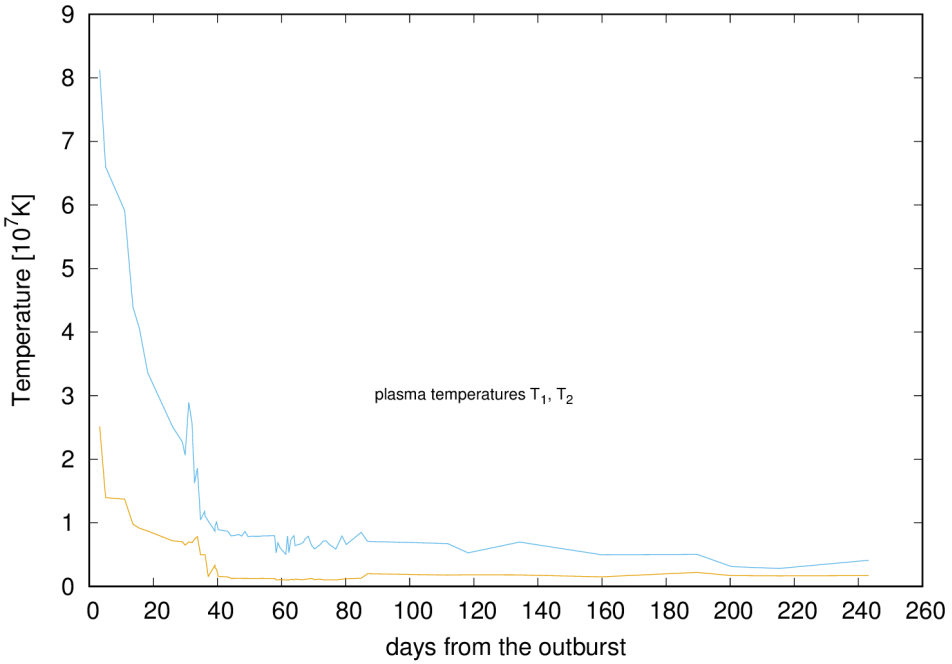
Column densities





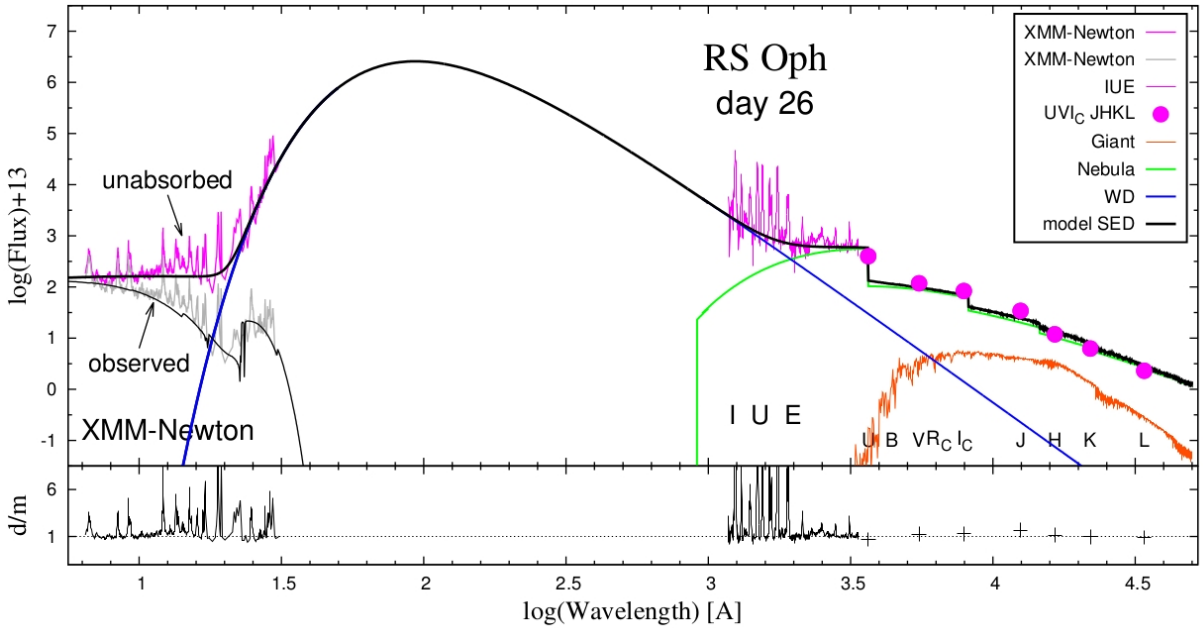
Temperatures





Future outlook

- extend the dataset by simultaneous **UVOT** observations
- compare with existing multiwavelength (**supersoft X-rays – IR)** models
- **luminosity problem**: Eddington vs highly super-Eddington (~ $65L_{Edd}$)



Skopal 2015, New Astr. 36, 139

Conclusions

- our model is consistent with the WD atmosphere as a source of the supersoft radiation during the supersoft phase of the 2006 outburst

- need of the multiwavelength studies to resolve the luminosity problem

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Thank you for attention!