The Be/X-ray binary A0535+26 in 2009/2010

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CRSF Meeting
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1. The Be-X-ray binary A0535+26
2. Double-peaked normal outburst 2009
3. Giant outburst in 2009
4. New activity in March 2010

Outline

A 0535+26

Neutron Star

- $R \sim 10 - 14\,\mathrm{km}$, $M \sim 1.4\,\mathrm{M}_\odot$
- $P_{\mathrm{spin}} \sim 103\,\mathrm{s}$
- $B \sim 4 \times 10^{12}\,\mathrm{G}$

Ariel, Rosenberg et al. 1975

Optical companion HDE 245770 (O9.7IIIe)

- $14\,\mathrm{M}_\odot$, $14\,\mathrm{R}_\odot$, $1.41 \times 10^5\,\mathrm{L}_\odot$
- $T_{\mathrm{eff}} = 26000\,\mathrm{K}$

$P_{orb} = 111\,\mathrm{days}$, $e = 0.47$, $d \sim 2\,\mathrm{kpc}$

Transient source

- Type II ("giant") outbursts
  $L_X > 10^{37}\,\mathrm{erg\,s^{-1}}$
- Type I ("normal") outbursts
  $L_X \sim 10^{36-37}\,\mathrm{erg\,s^{-1}}$
- quiescence states
  $L_X \lesssim 10^{36}\,\mathrm{erg\,s^{-1}}$

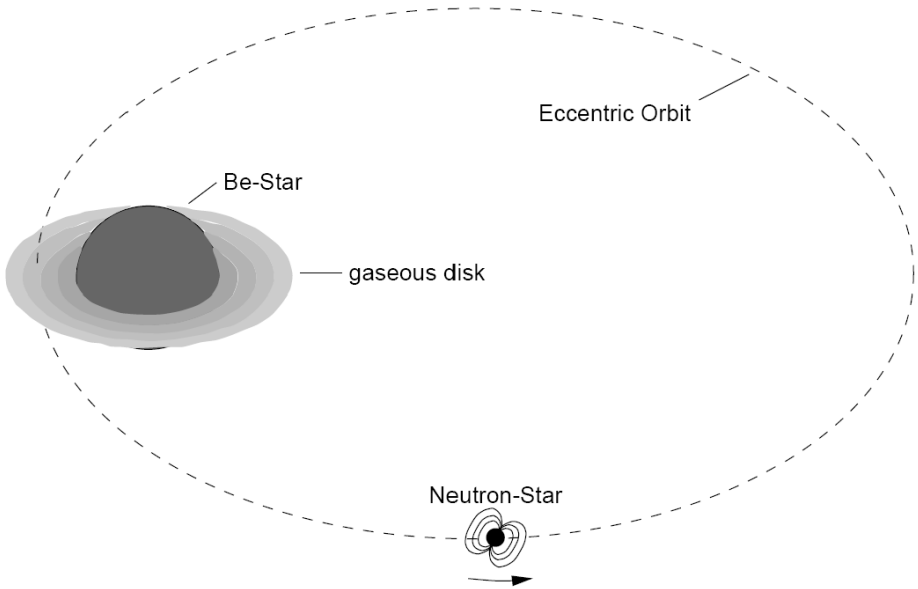

Figure: Kretschmar, 1996

A 0535+26

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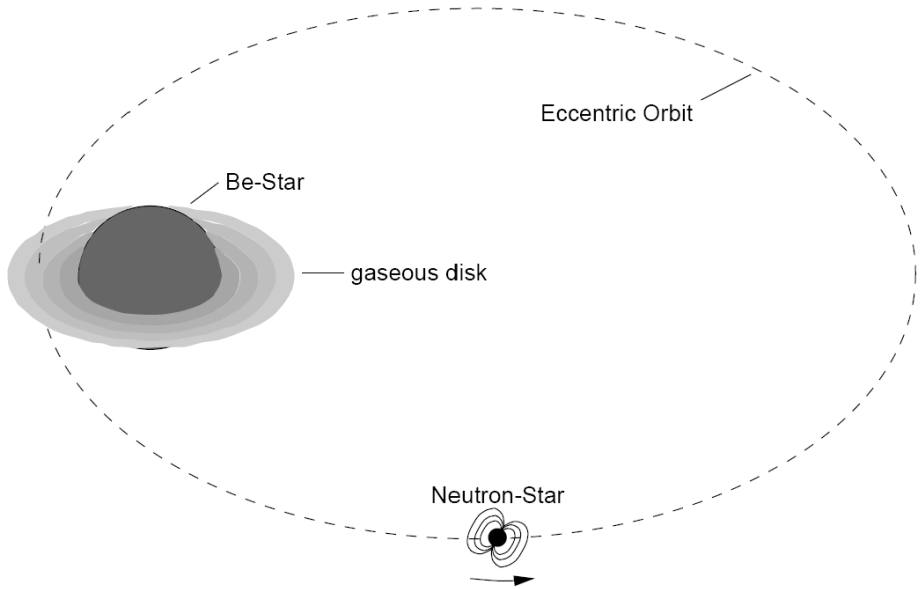
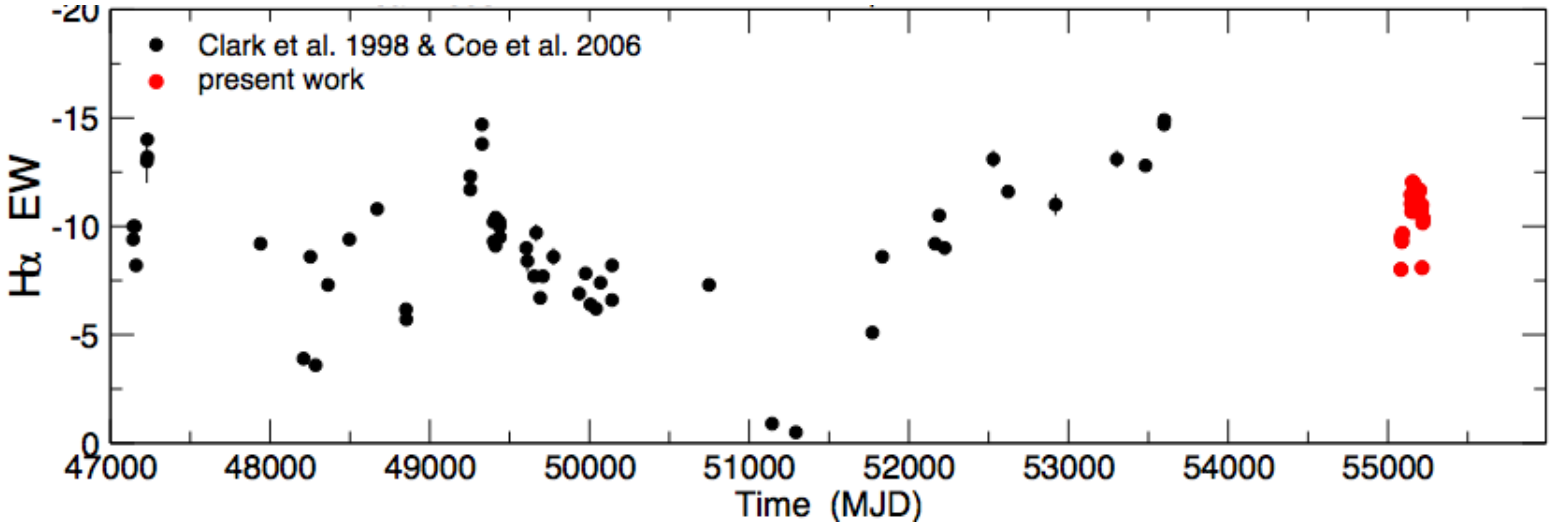
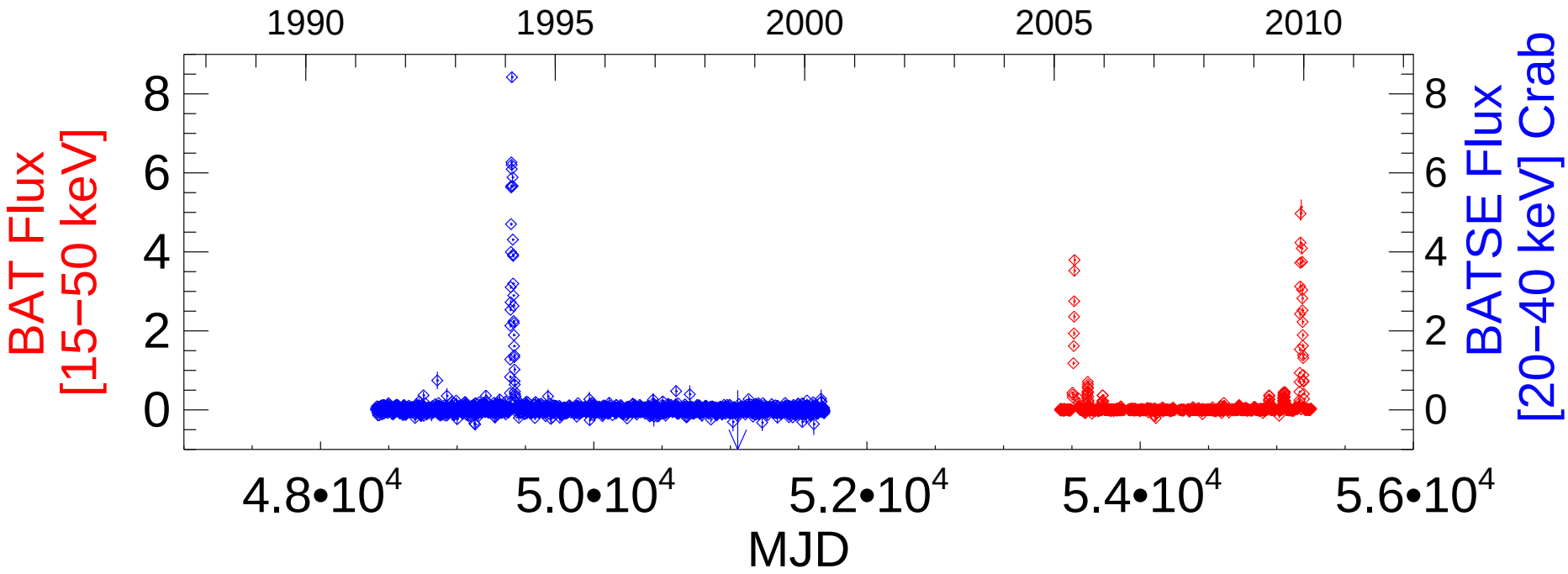


Figure: Kretschmar, 1996

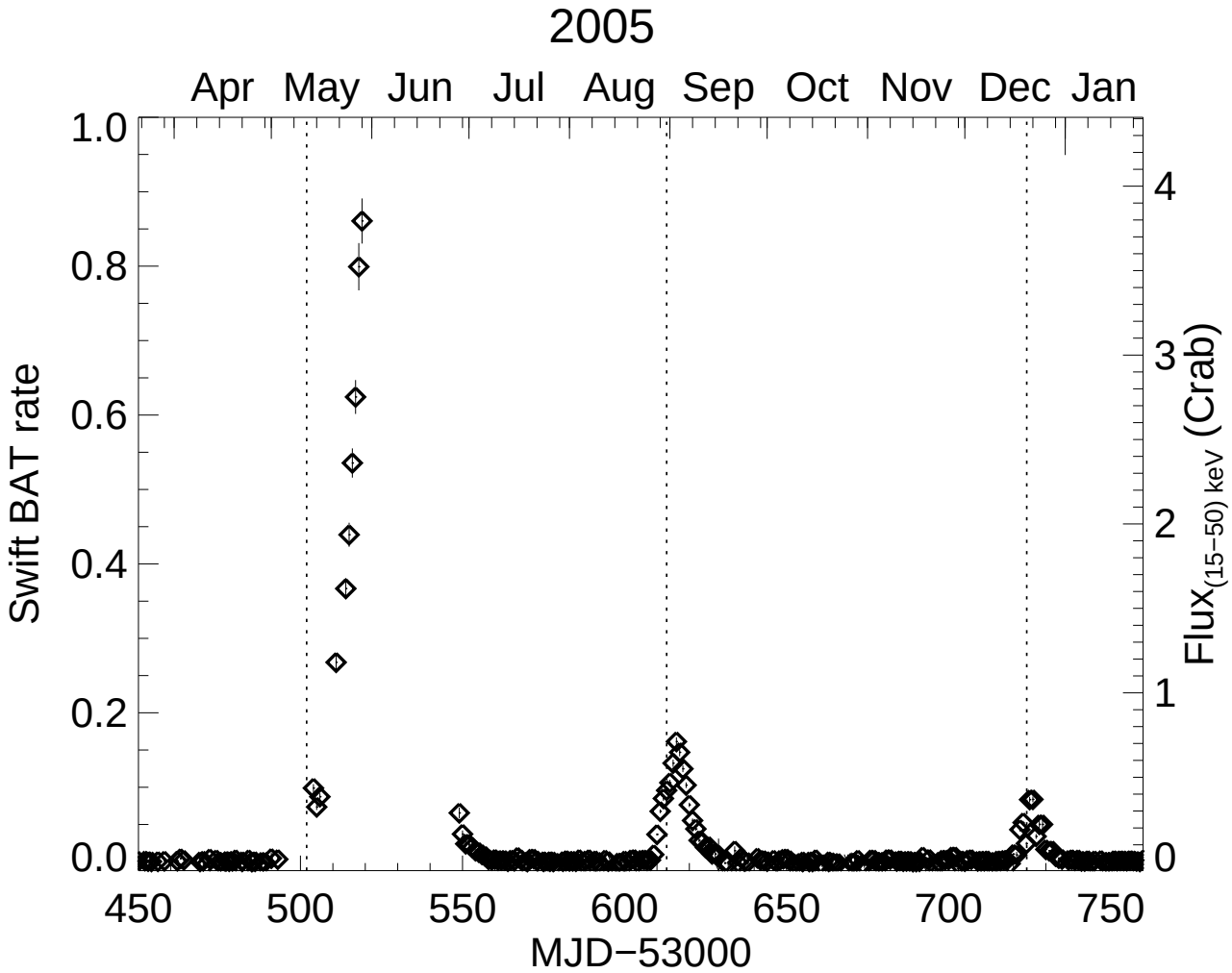
Optical and X-ray long term behavior

Camero et al. 2010 (Liverpool Telescope)



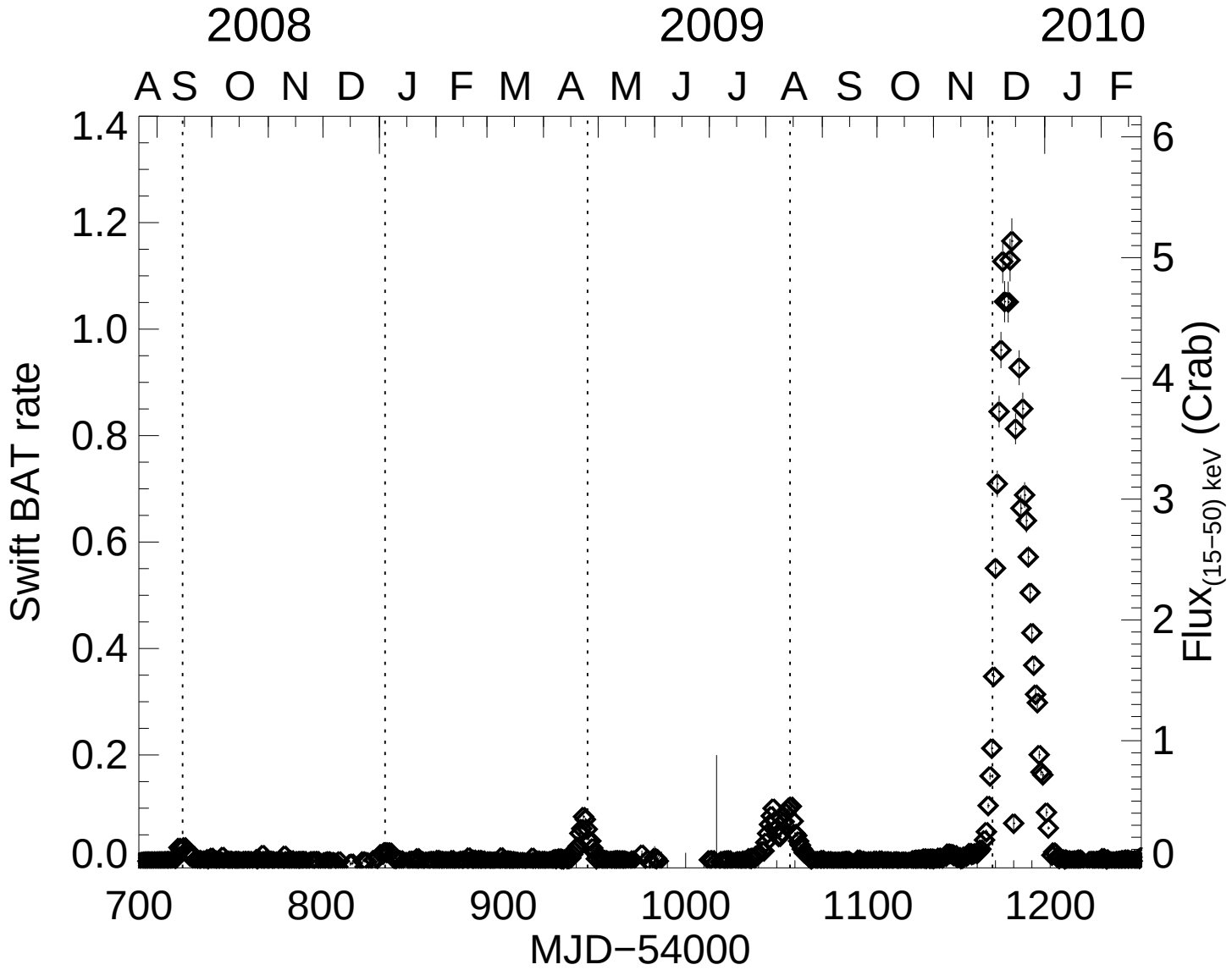


Giant and normal outbursts in 2005

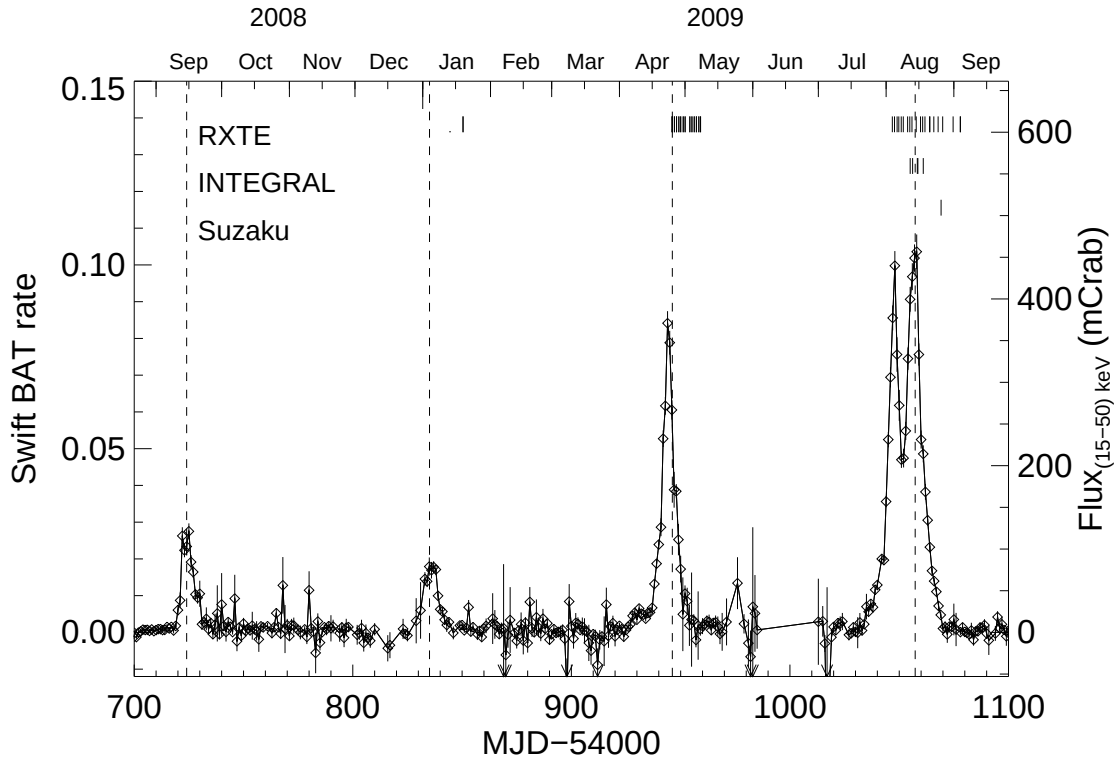


Caballero et al. 2007, 2008, Postnov et al. 2008

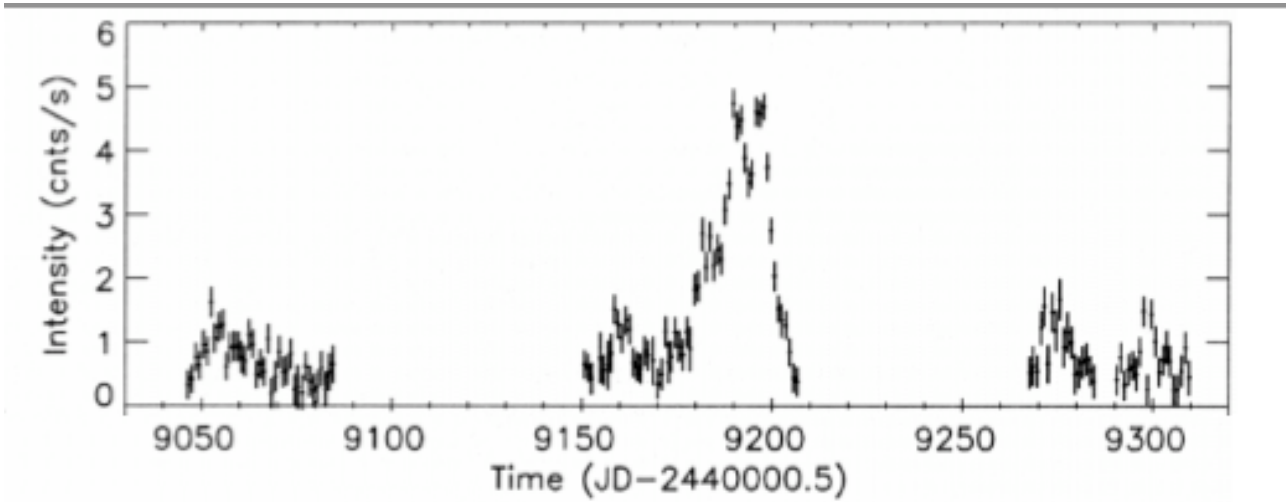
New giant outburst in 2009...



...preceded by normal outbursts

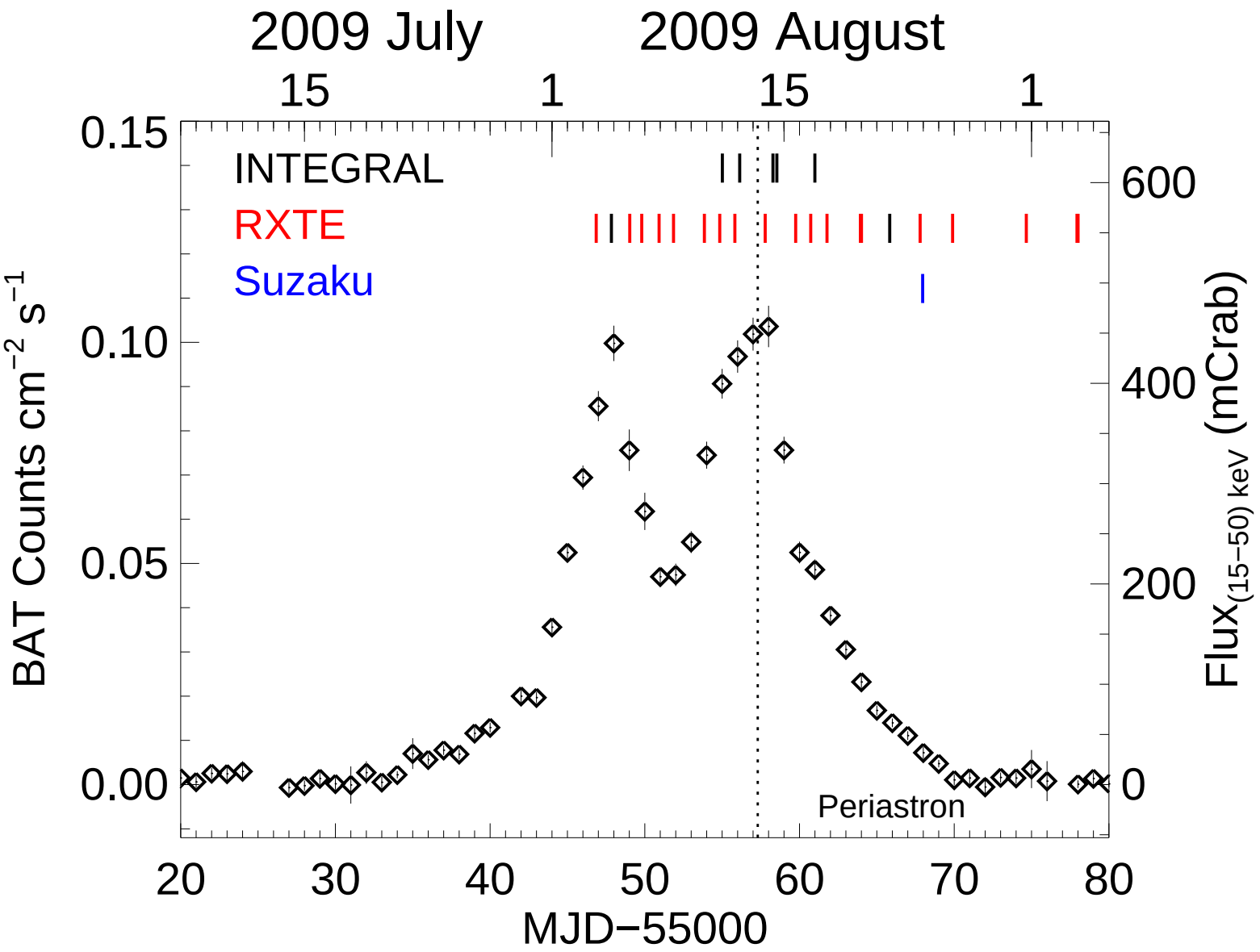


Similar to 1994 behavior before giant outburst
(Finger 1994)



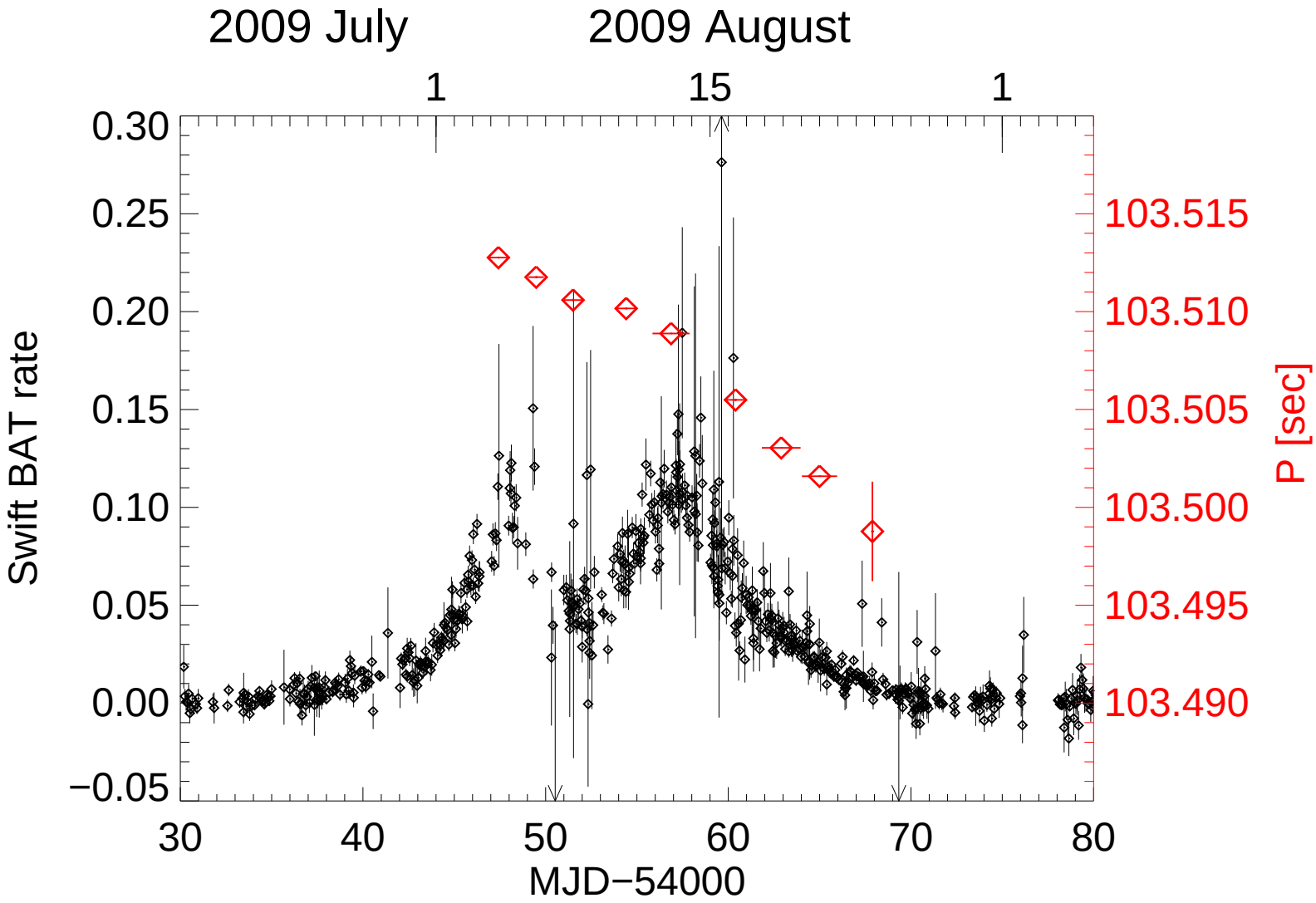
Outline

Normal double-peaked outburst 2009

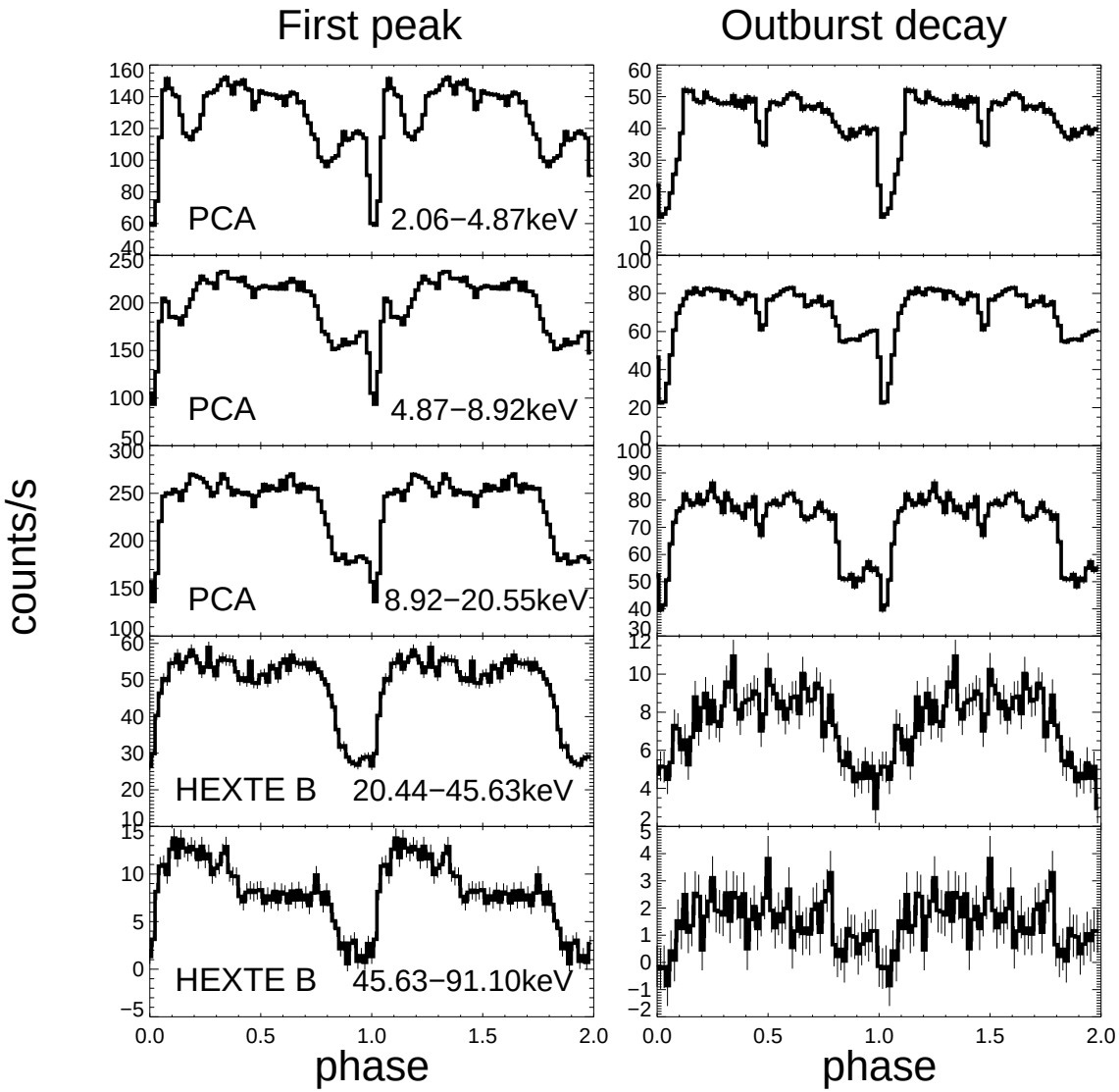


Double-peaked outburst 2009 - Pulse period

Pulse period evolution, spin-up measured (preliminary)
From 5 first measurements, $\dot{P} = 0.5 \pm 0.04 \times 10^{-8}$ s/s (MDJ 55046.9)

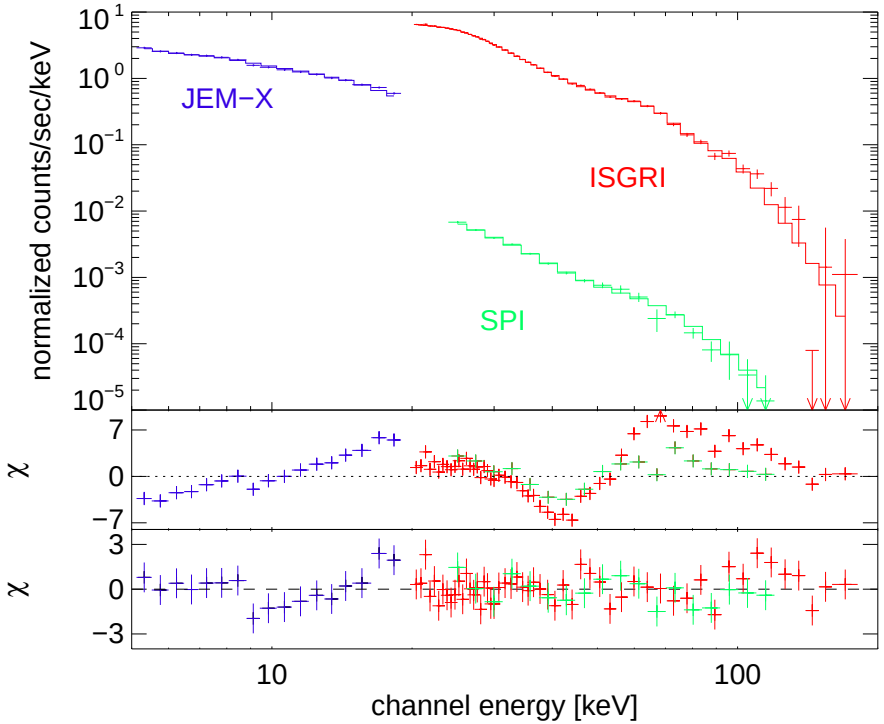


Double-peaked outburst 2009 - RXTE pulse profiles

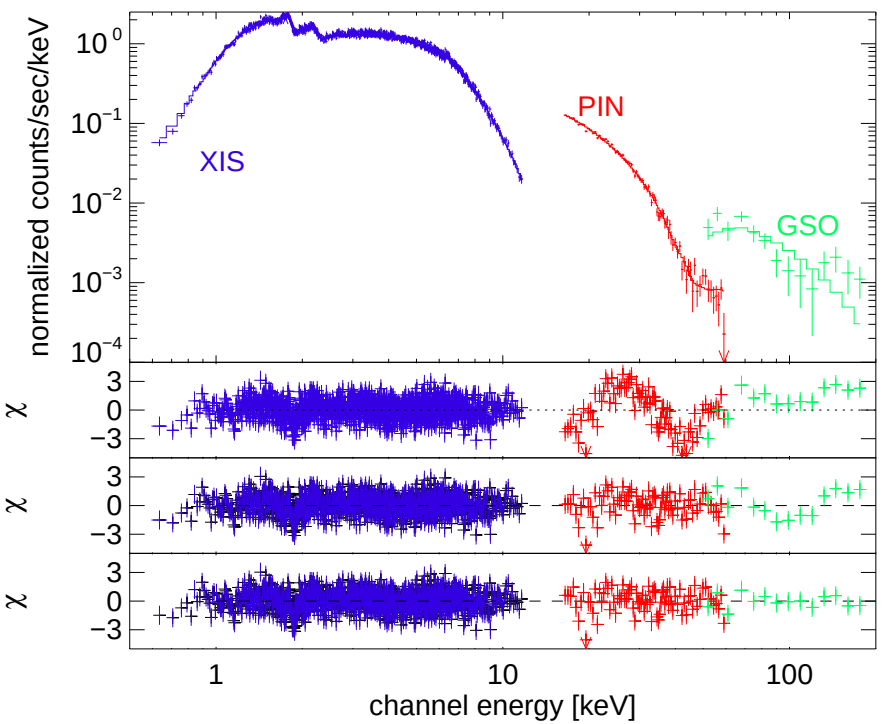


Double-peaked outburst 2009 - Cyclotron line

INTEGRAL



Suzaku



$E_{\mathrm{cyc},1} = 46.1^{+0.3}_{-0.3}$ keV (MJD 55055)

RXTE:

$E_{\mathrm{cyc},1} = 44.7 \pm 0.5$ keV (MJD 55055)

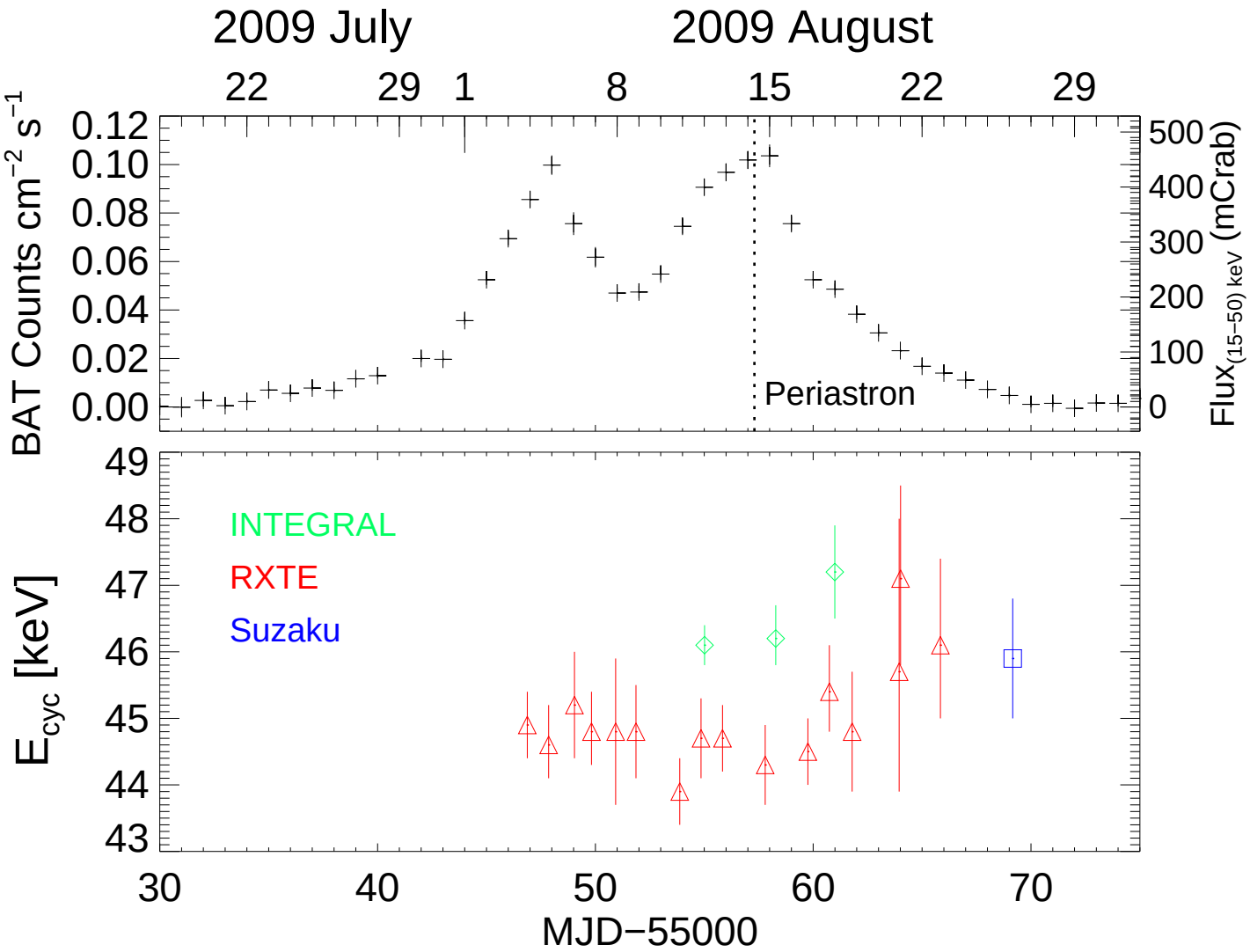
$E_{\mathrm{cyc},1} = 45.9^{+0.5}_{-0.9}$ keV (MJD 55069)

$E_{\mathrm{cyc},2} = 104^{+7}_{-5}$ keV

$kT = 1.324^{+0.003}_{-0.002}$ keV

$N_{\mathrm{H}} = 0.696 \pm 0.019 \times 10^{22}\mathrm{cm}^{-2}$

Double-peaked outburst 2009 - Cyclotron line



Double-peaked outburst 2009 - Conclusions

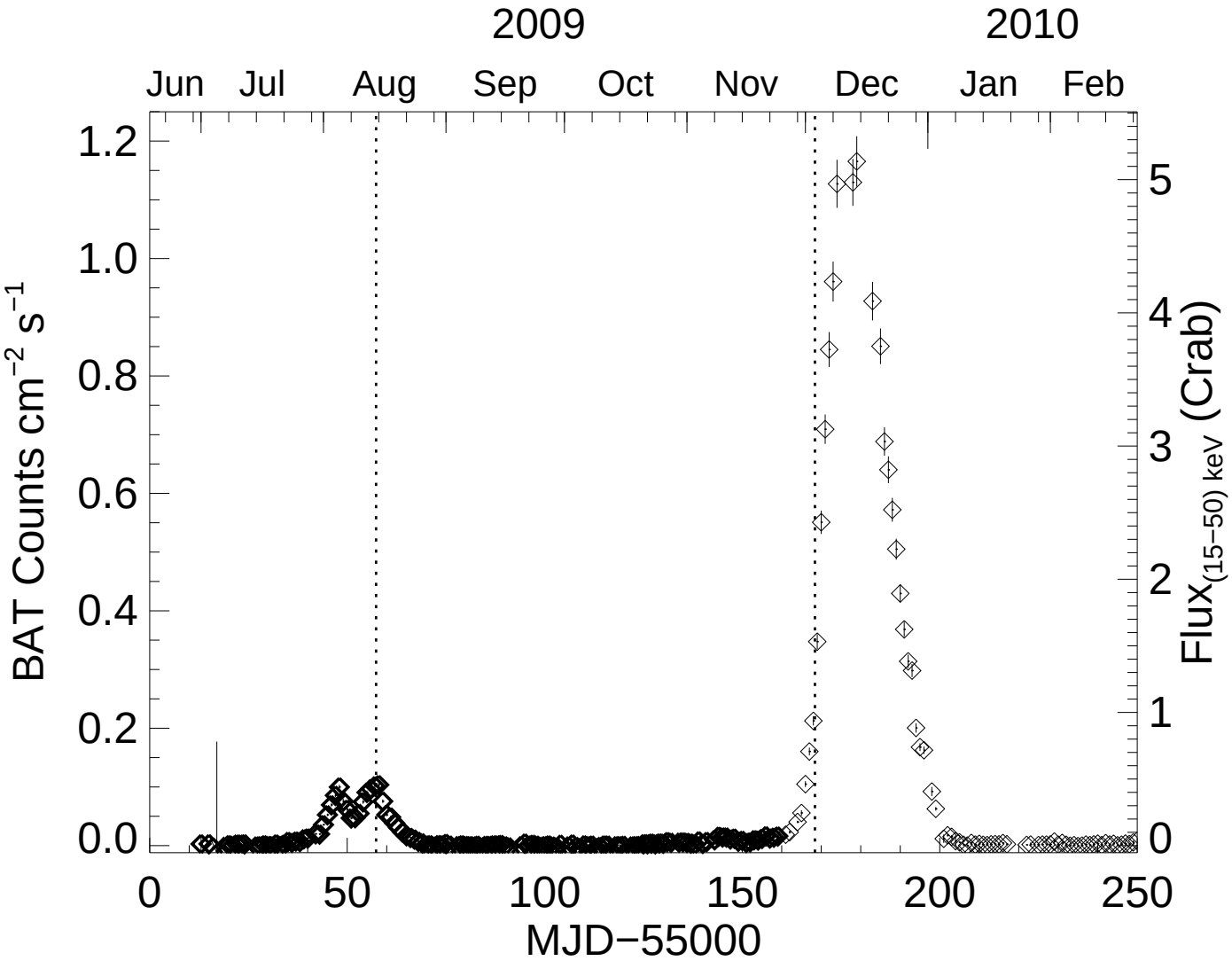
- Ecyc evolution: mainly constant, increase at low luminosity
- Presence of accretion disk (spin-up)
- Energy dependent pulse profiles, cyclotron line evolution, very similar to past 2005 outburst
- But very peculiar double-peaked light curve, why???

Caballero et al. 2010, in preparation

Outline

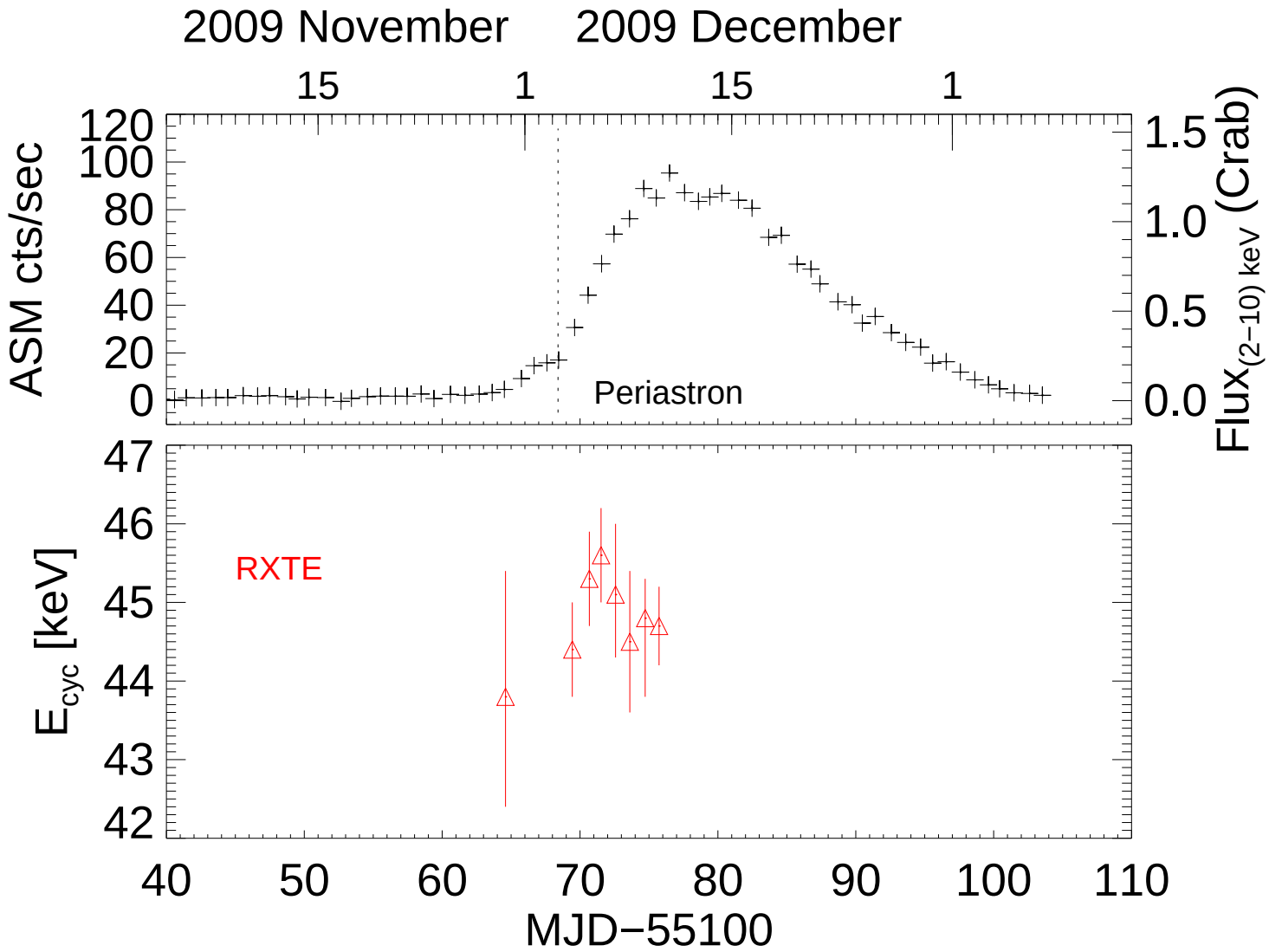
Giant 2009

Only RXTE observations (INTEGRAL and Suzaku Sun constraints).
Unfortunatelly HEXTE B stopped rocking in the outburst's peak...



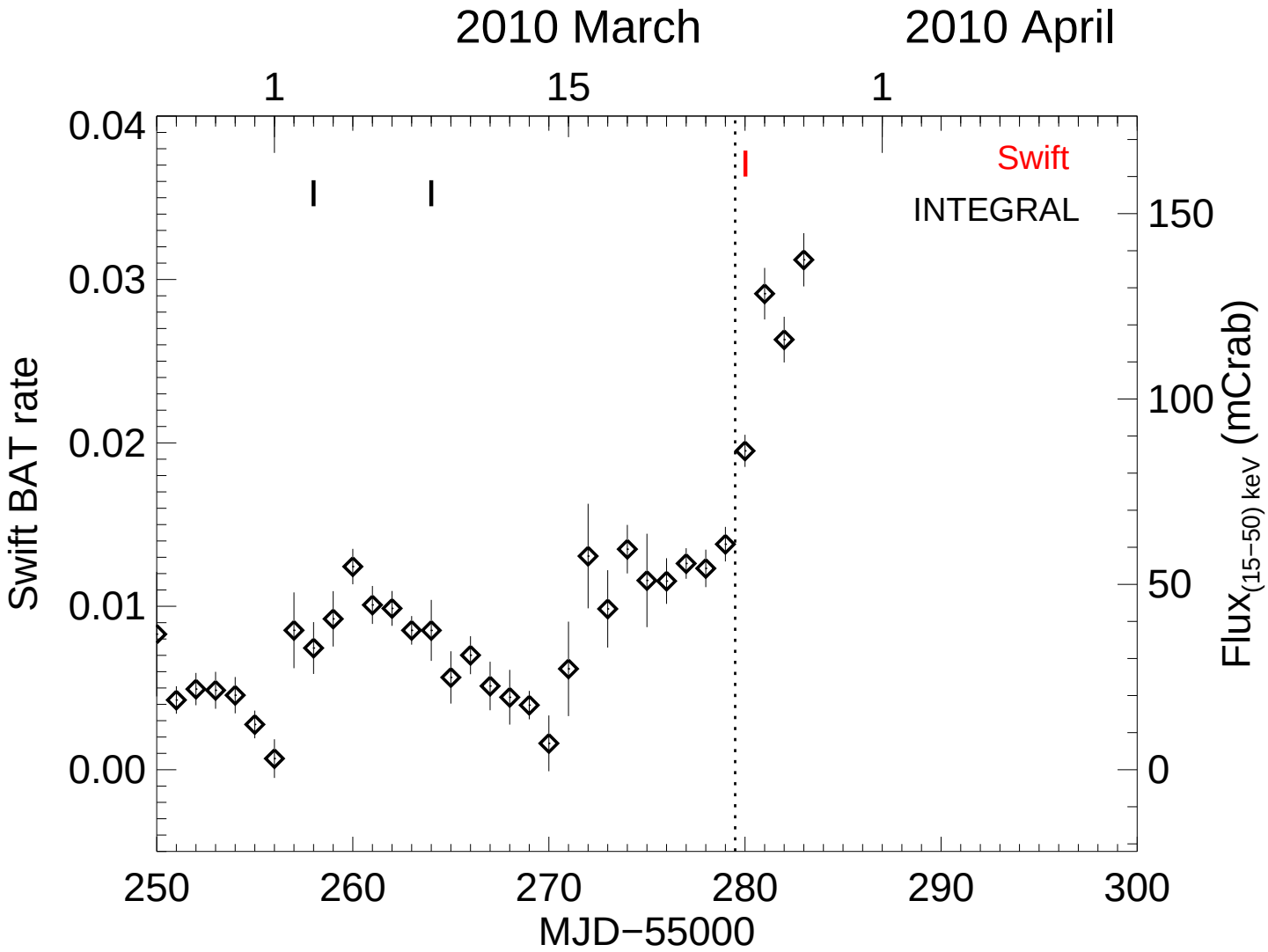
Giant outburst 2009: Cyclotron line

HEXTE B background modeling to be done



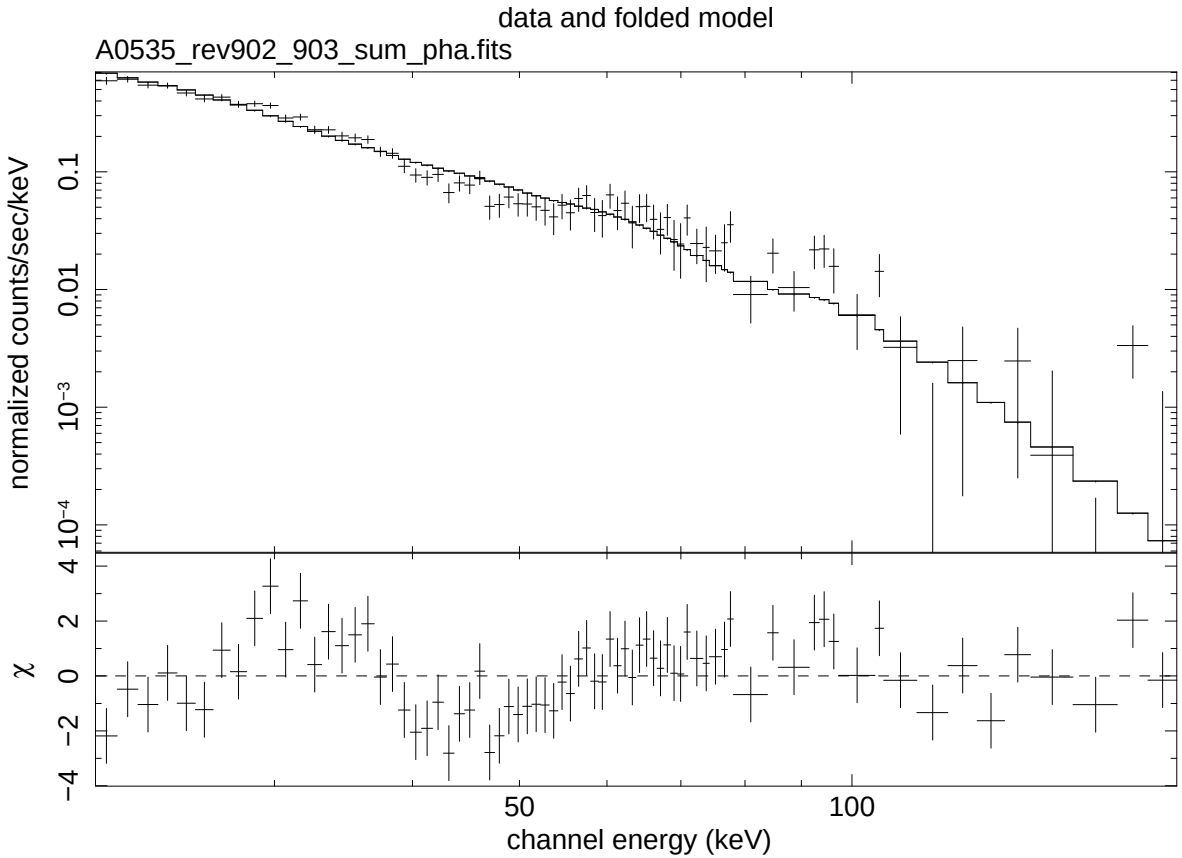
Outline

New activity in March 2010



New activity in March 2010

- INTEGRAL observed a brigthening 3 weeks before periastron, $\sim$32.4 mCrab [20-100 keV]
- First cyclotron line measurement outside of an outburst: E=47.8+1.7/-1.4 keV



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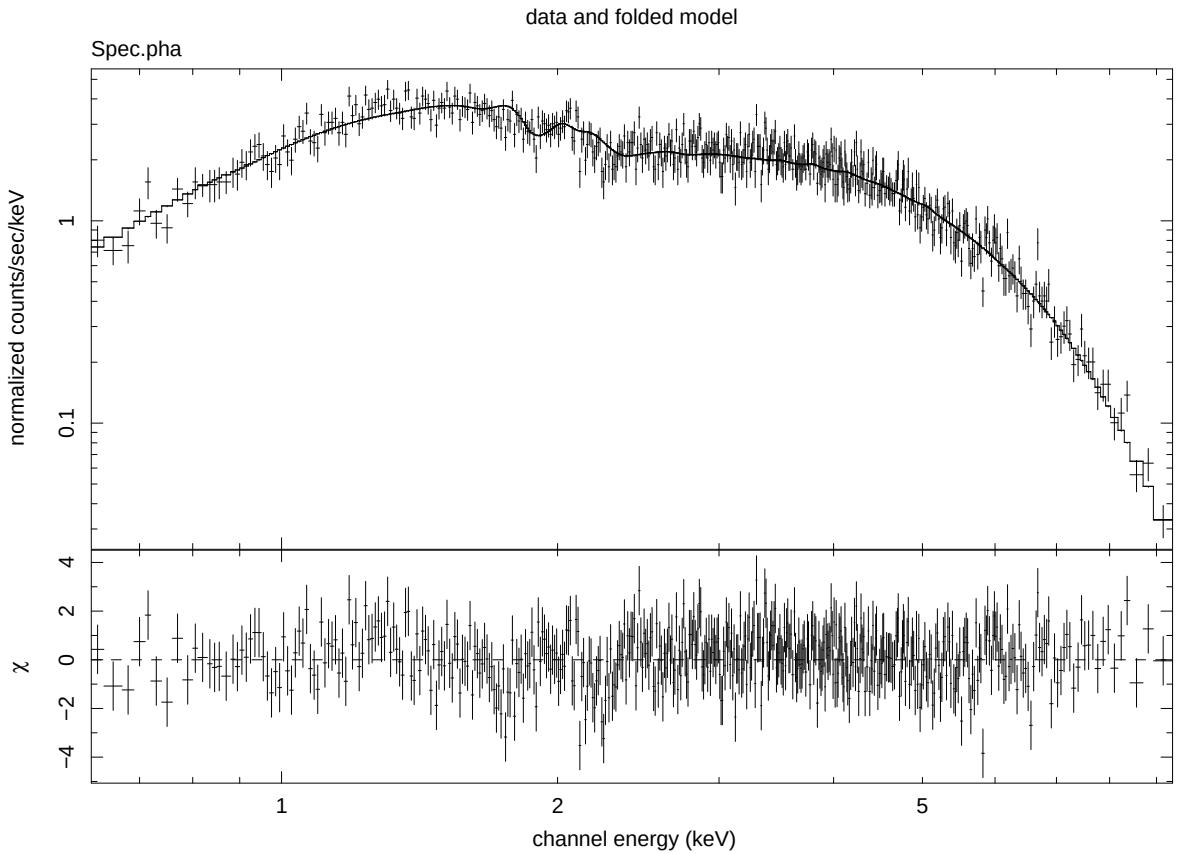
New activity in March 2010

Swift XRT - first results:

Absorbed powerlaw + black body

kT=1.4 $\pm$ 0.1keV, $N_{\rm H} = 0.409^{+0.14}_{-0.10}{\rm cm}^{-2}$

(consistent with Suzaku decay 2009 double-peaked outburst)



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New activity in March 2010

- Ongoing work. Swift observations ongoing
- INTEGRAL, RXTE and Suzaku TOO observations if the outburst goes on?