The XMM-Newton view of the cooling NS EXO 0748-676

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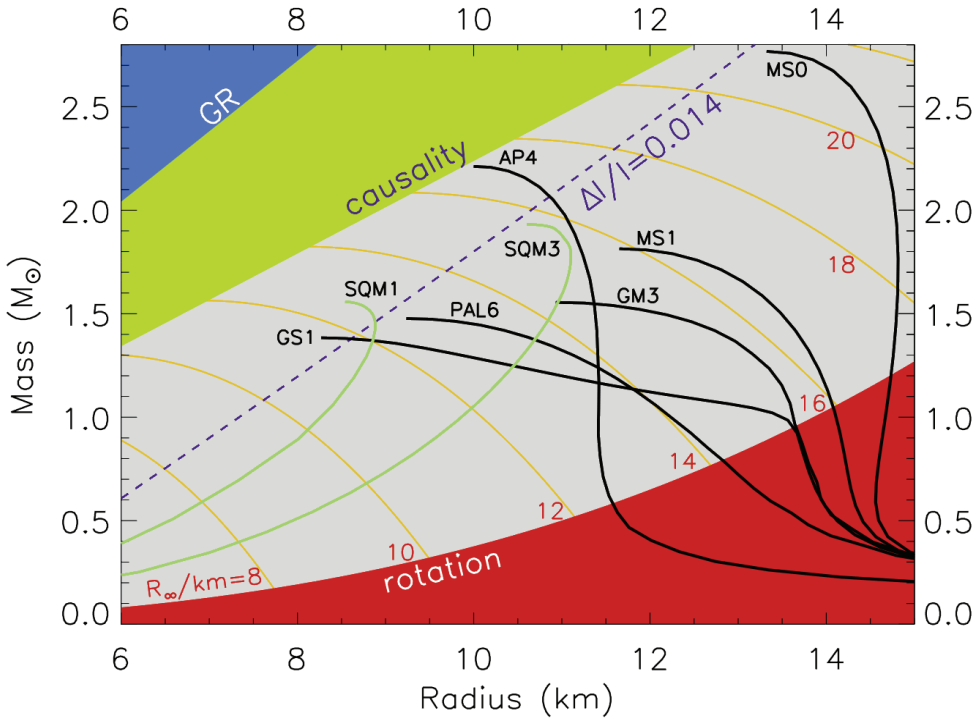
Equation of State of nuclear matter

EoS reasonably well known for outer parts of a neutron star but unconstrained for the high density core

The idea that neutron stars may contain exotic forms of matter makes them of prime interest for physics in general

Different EoS predict different maximum masses and mass-radius relationships



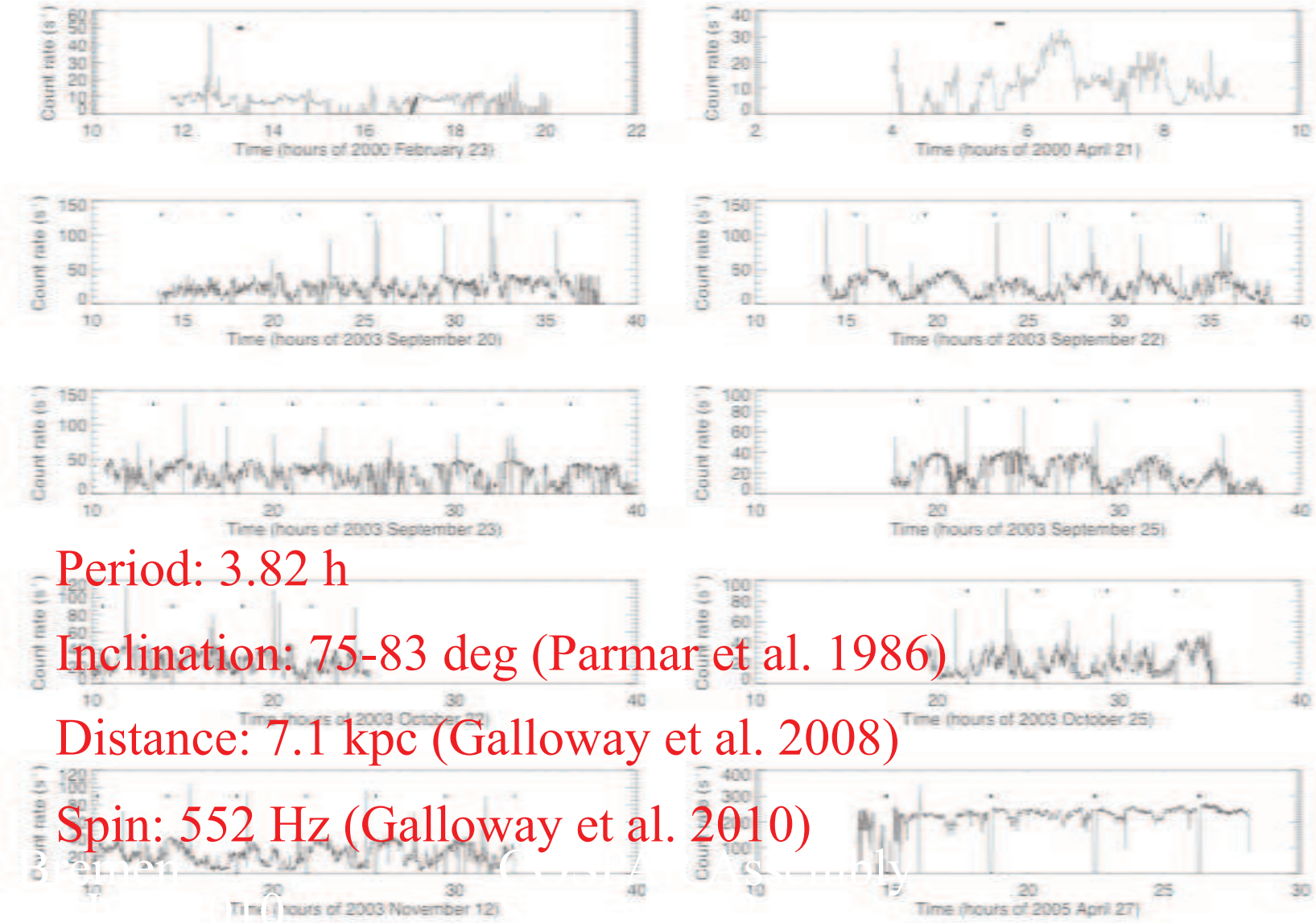
Lattimer & Prakash 2007

XMM-Newton observations of cooling NSs

XMM-Newton has an effective area of > 4650 cm^2 at 1 keV

- Use the RGS spectrum to constrain the interstellar extinction
- Study the cooling curve of the NS crust
- Determine contours for the M/R of the NS

EXO 0748-676



Period: 3.82 h

Inclination: 75-83 deg (Parmar et al. 1986)

Distance: 7.1 kpc (Galloway et al. 2008)

Spin: 552 Hz (Galloway et al. 2010)

EXO 0748-676

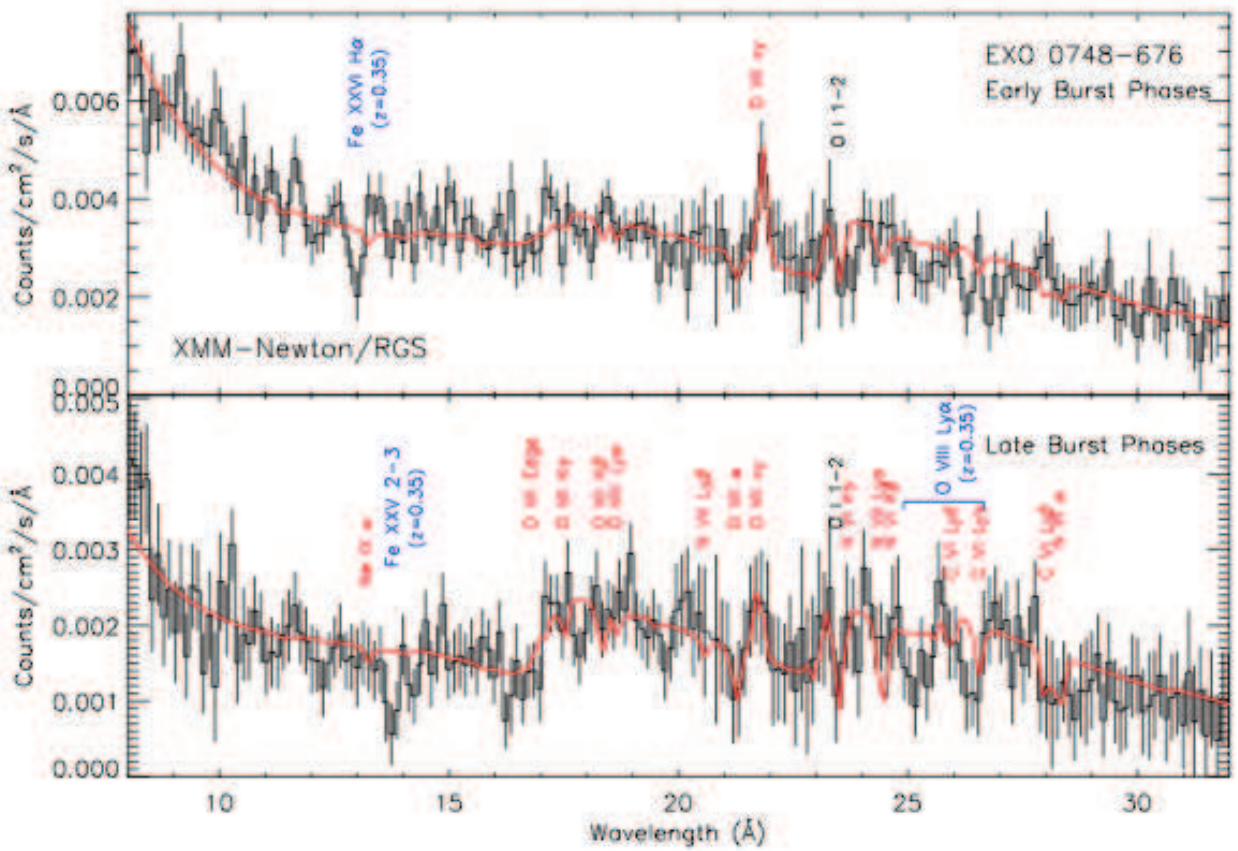
28 bursts

$z=0.35 \pm 0.01$

$M/R = 0.152\ M_{sun}/km$

$\Rightarrow M > 1.82\ M_{sun}$
$\Rightarrow R > 12$ km

(Ozel 2006)



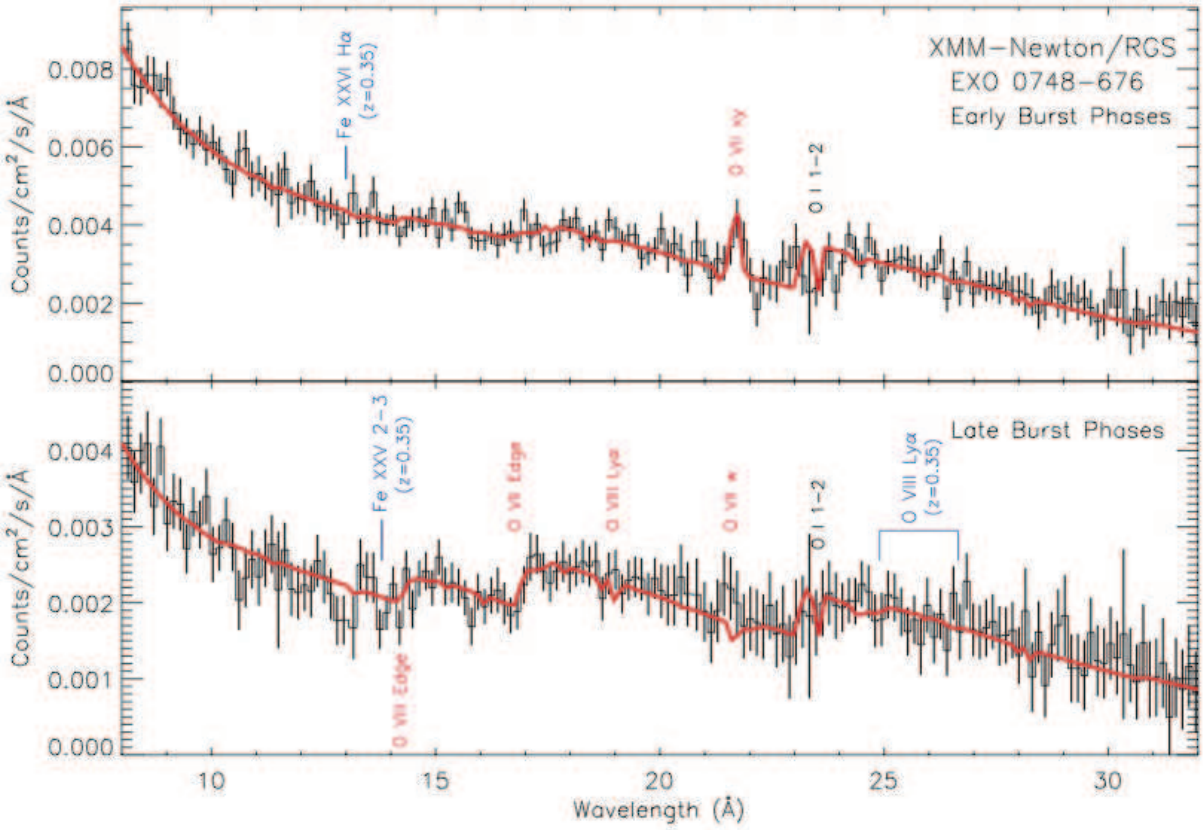
Cottam et al. 2002

EXO 0748-676

67 bursts

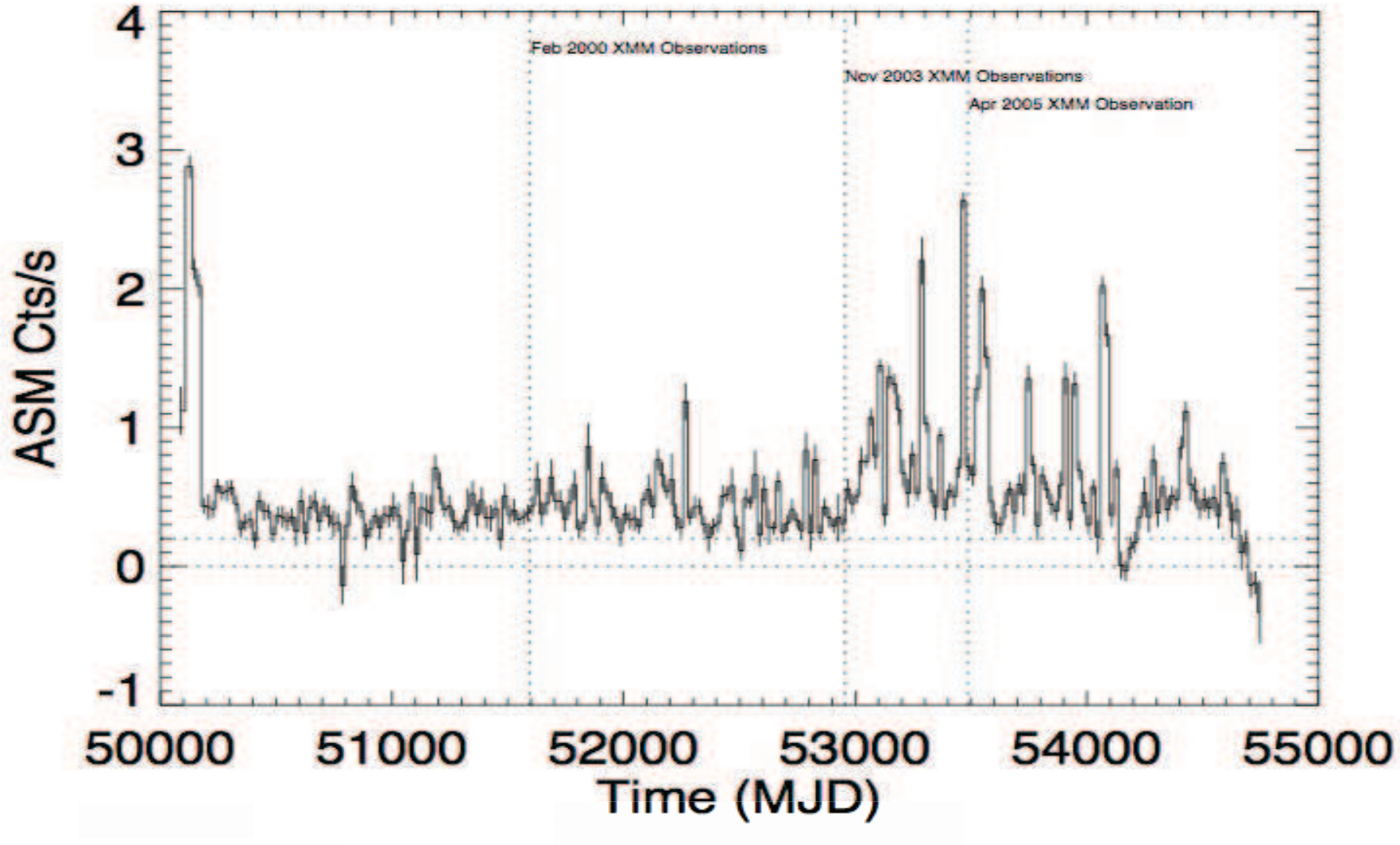
No gravitationally redshifted lines

Change of conditions in the photosphere (e.g. ions fully stripped in early phases of the burst)?

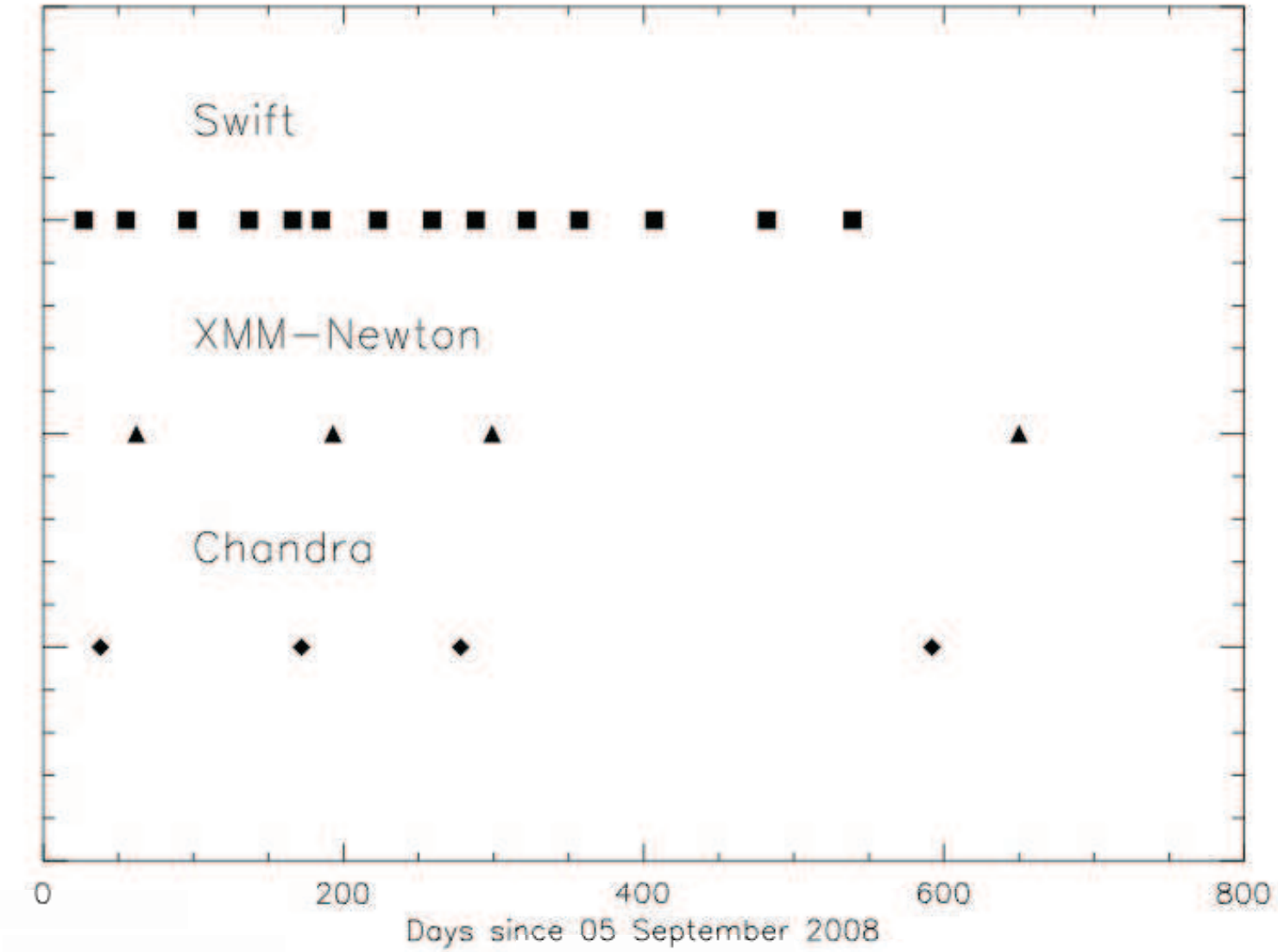


Cottam et al. 2008

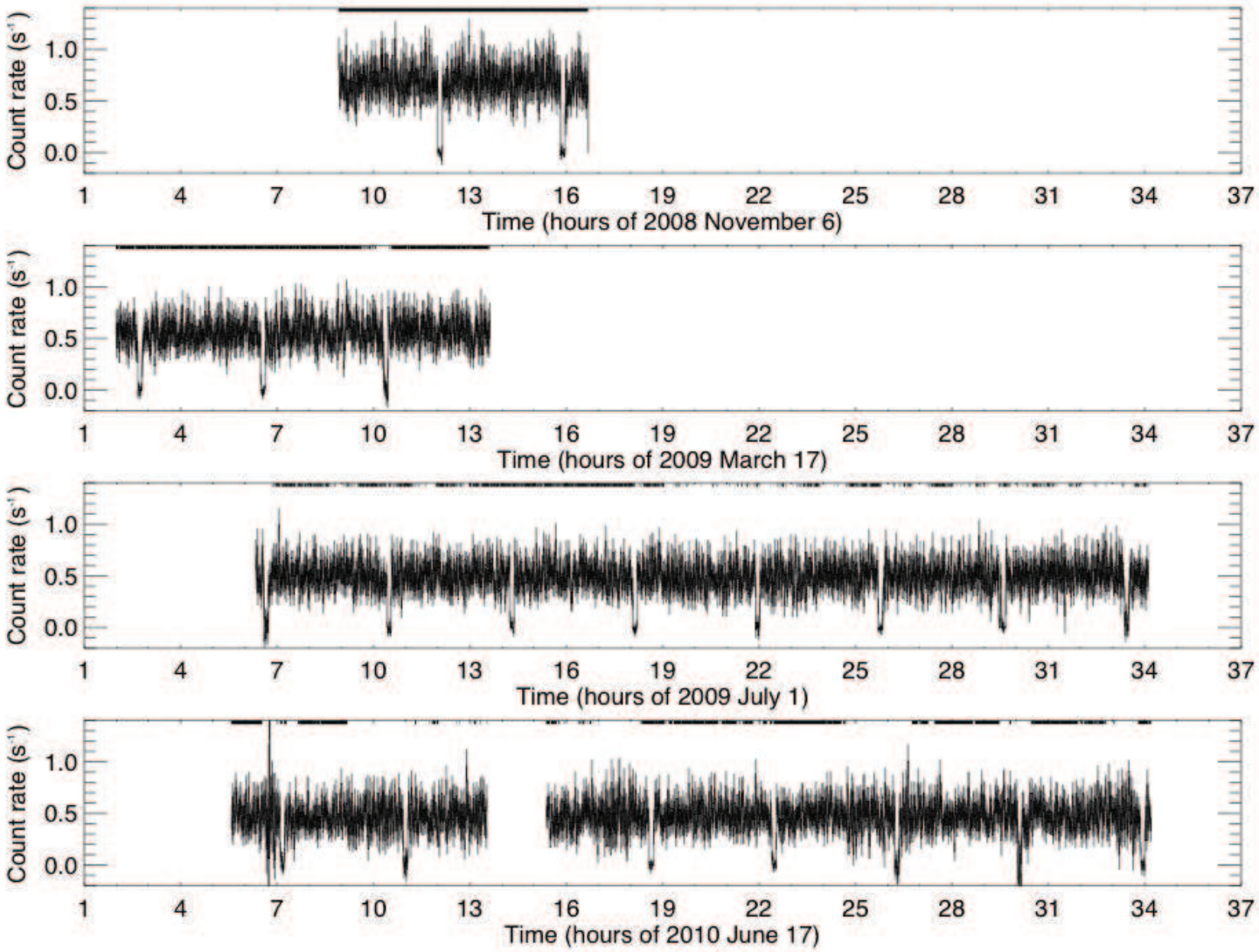
The cease of accretion



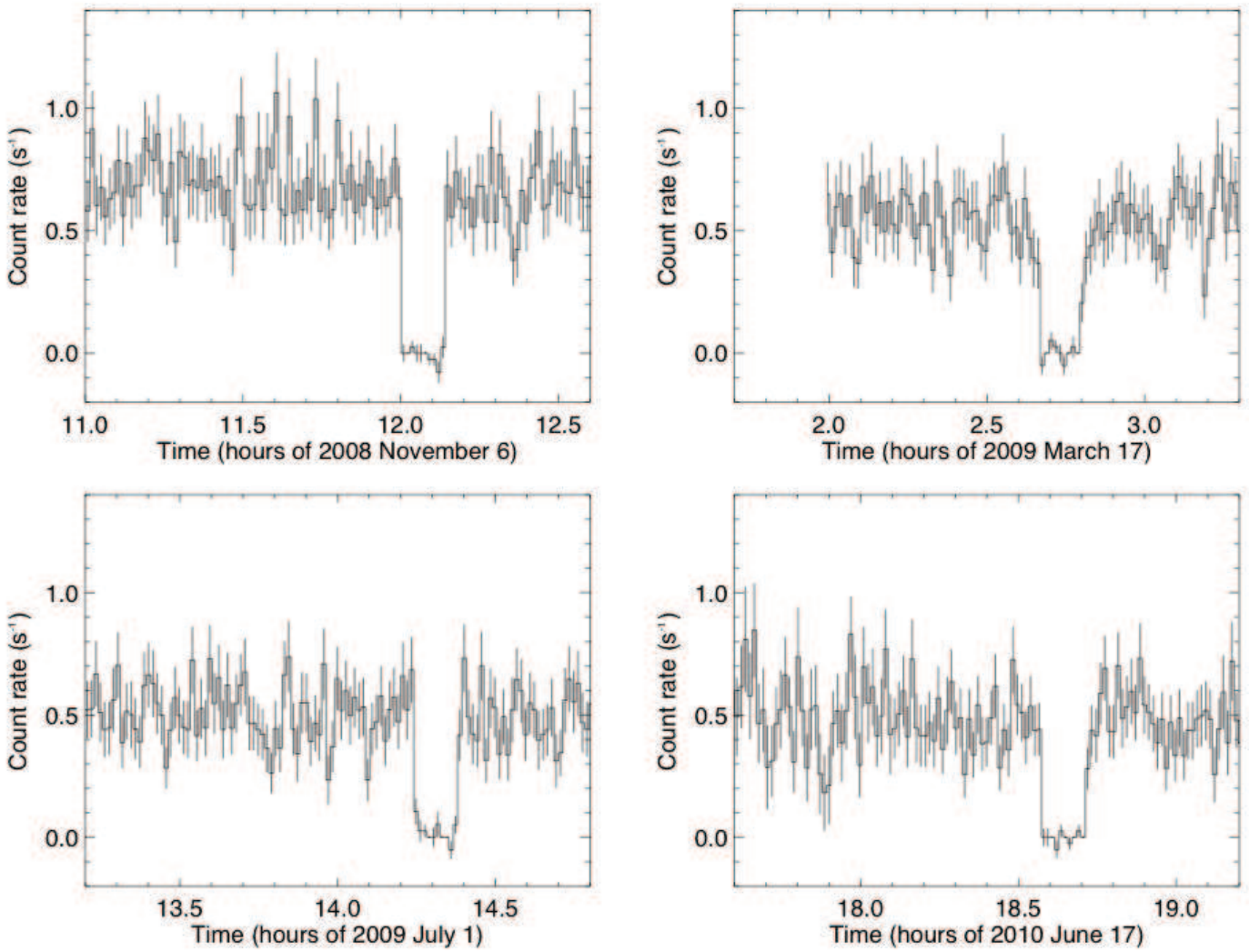
Alert to all soft-band X-ray observatories



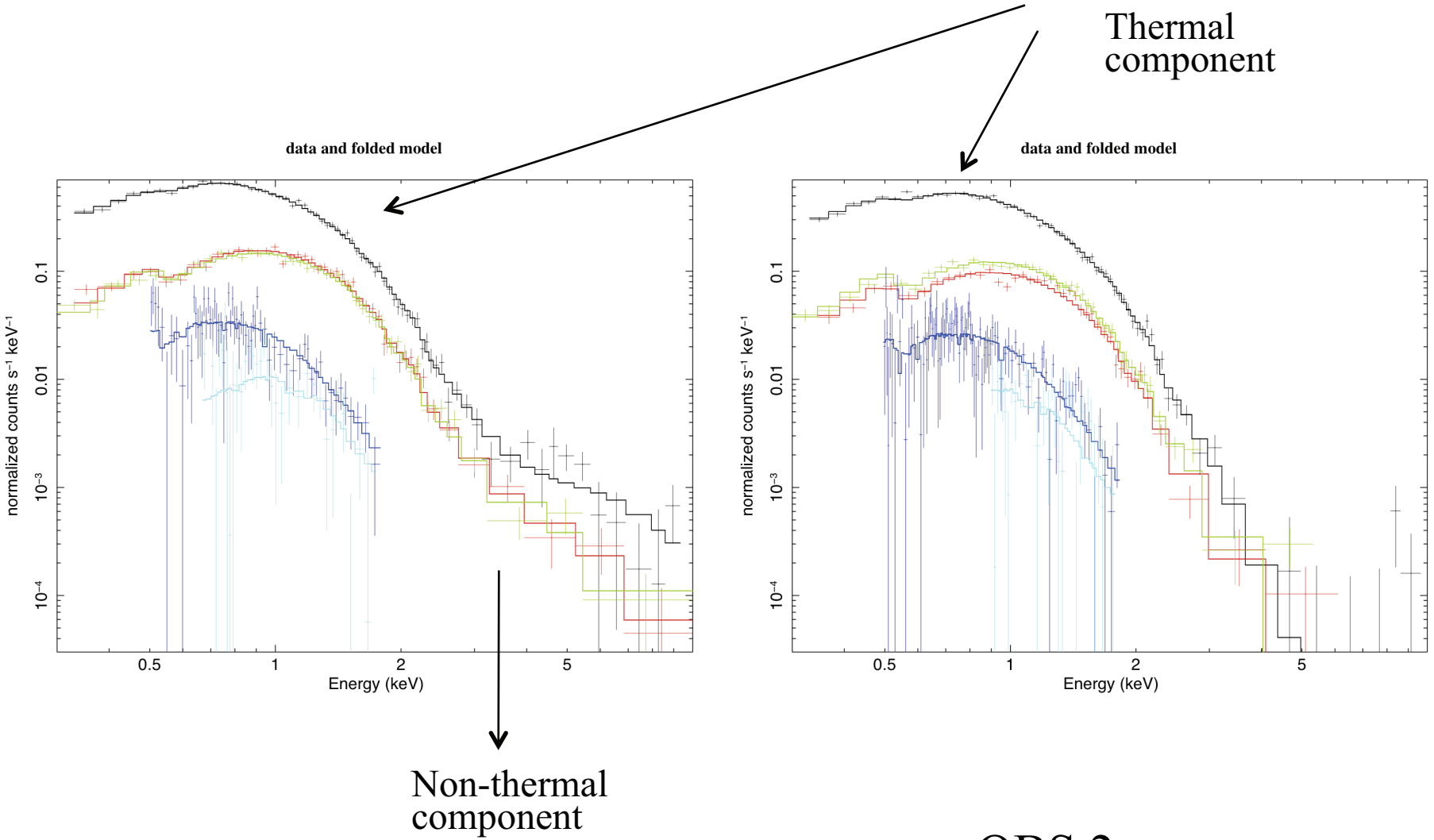
XMM-Newton observations



XMM-Newton observations



XMM-Newton observations

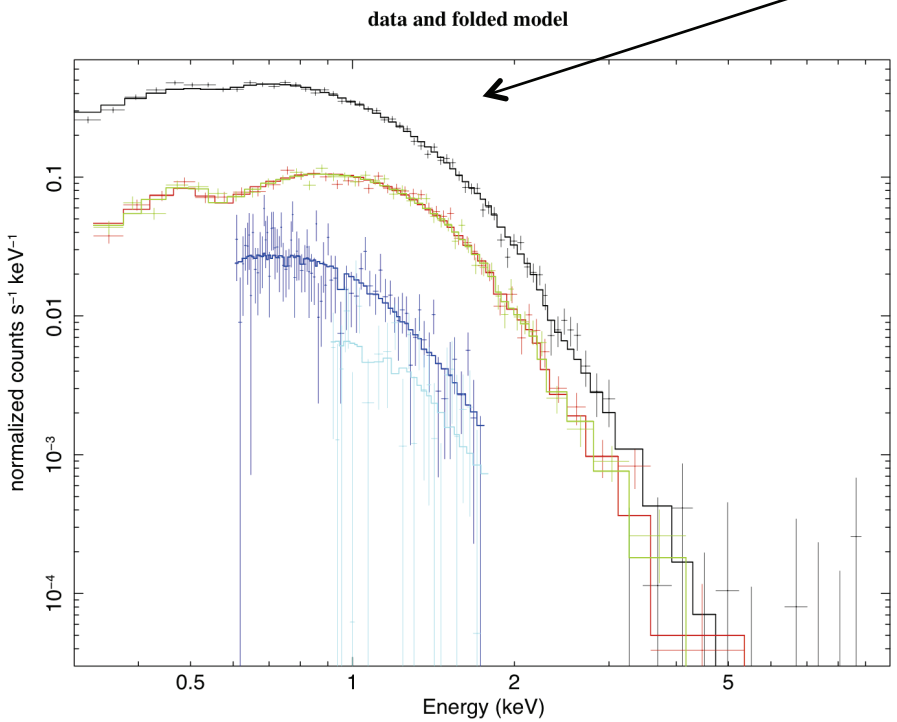


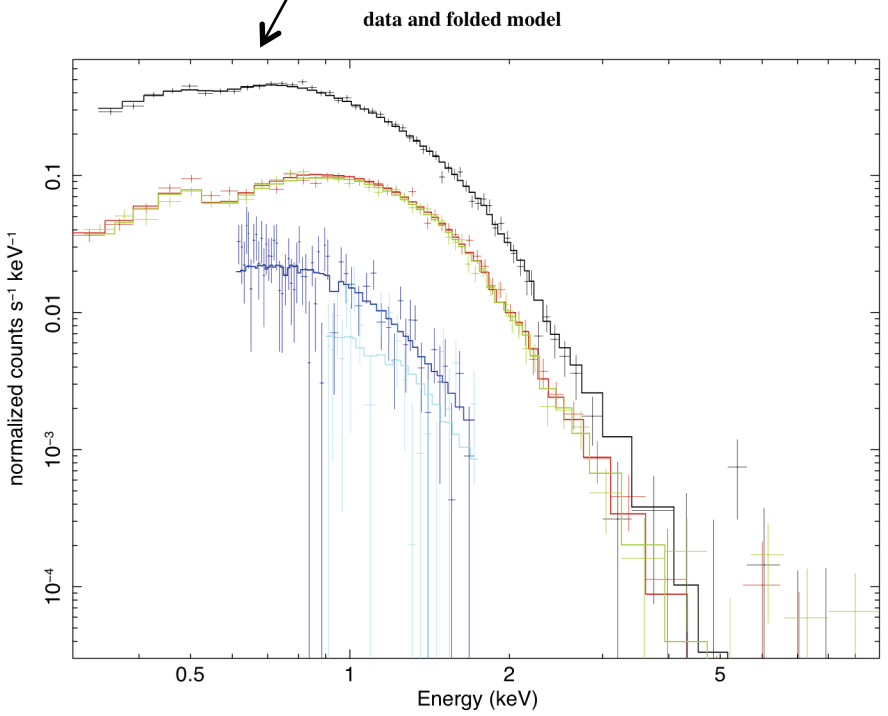
OBS 1

OBS 2

XMM-Newton observations

Thermal component





OBS 3

OBS 4

XMM-Newton observations

Model:

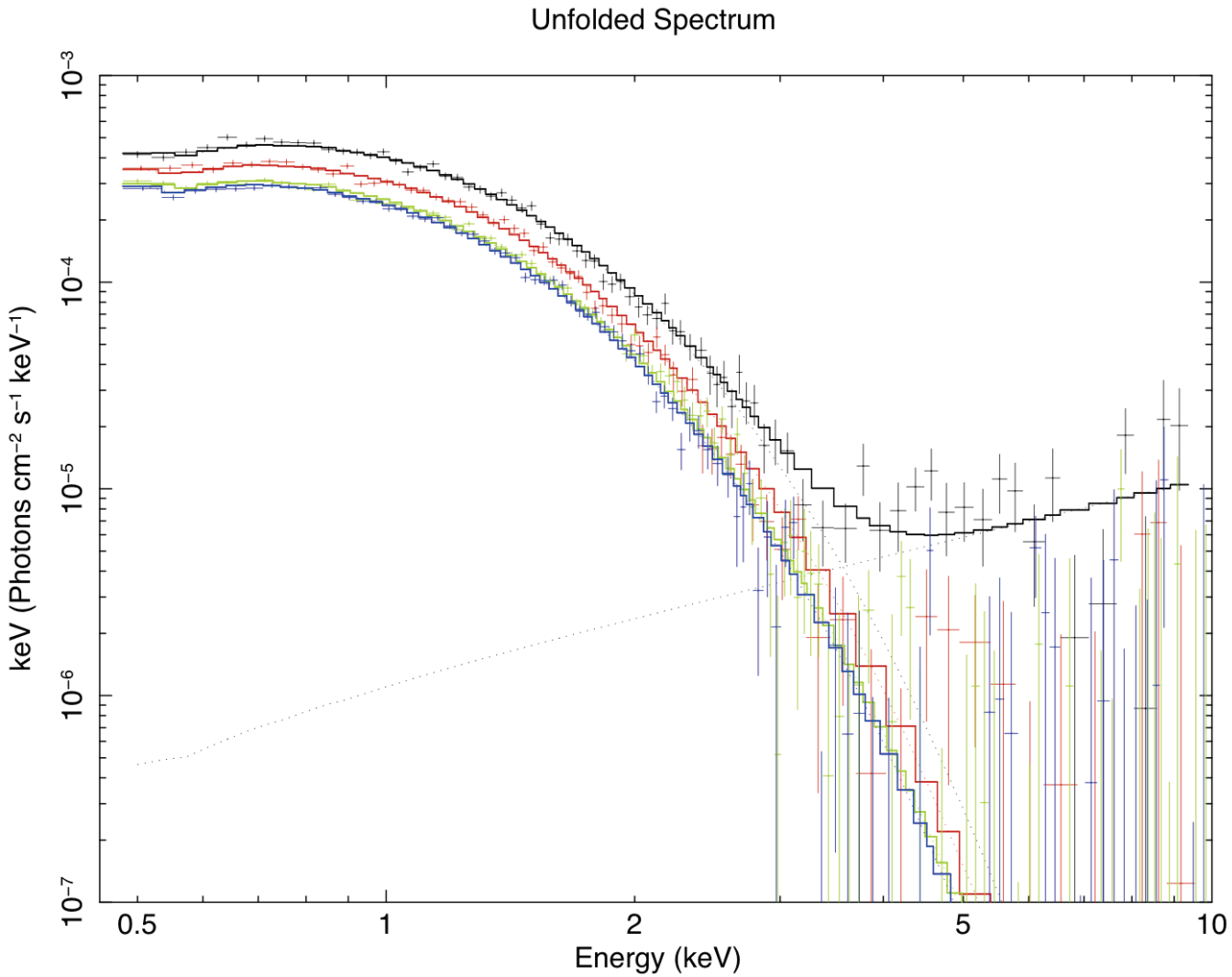
Thermal component (0.3-2 keV): NS atmosphere model (nsatmos, Heinke et al. 2006)

nsatmos (M_{NS}, R_{NS}, $distance_{NS}$, $temperature_{NS}$, normalisation)

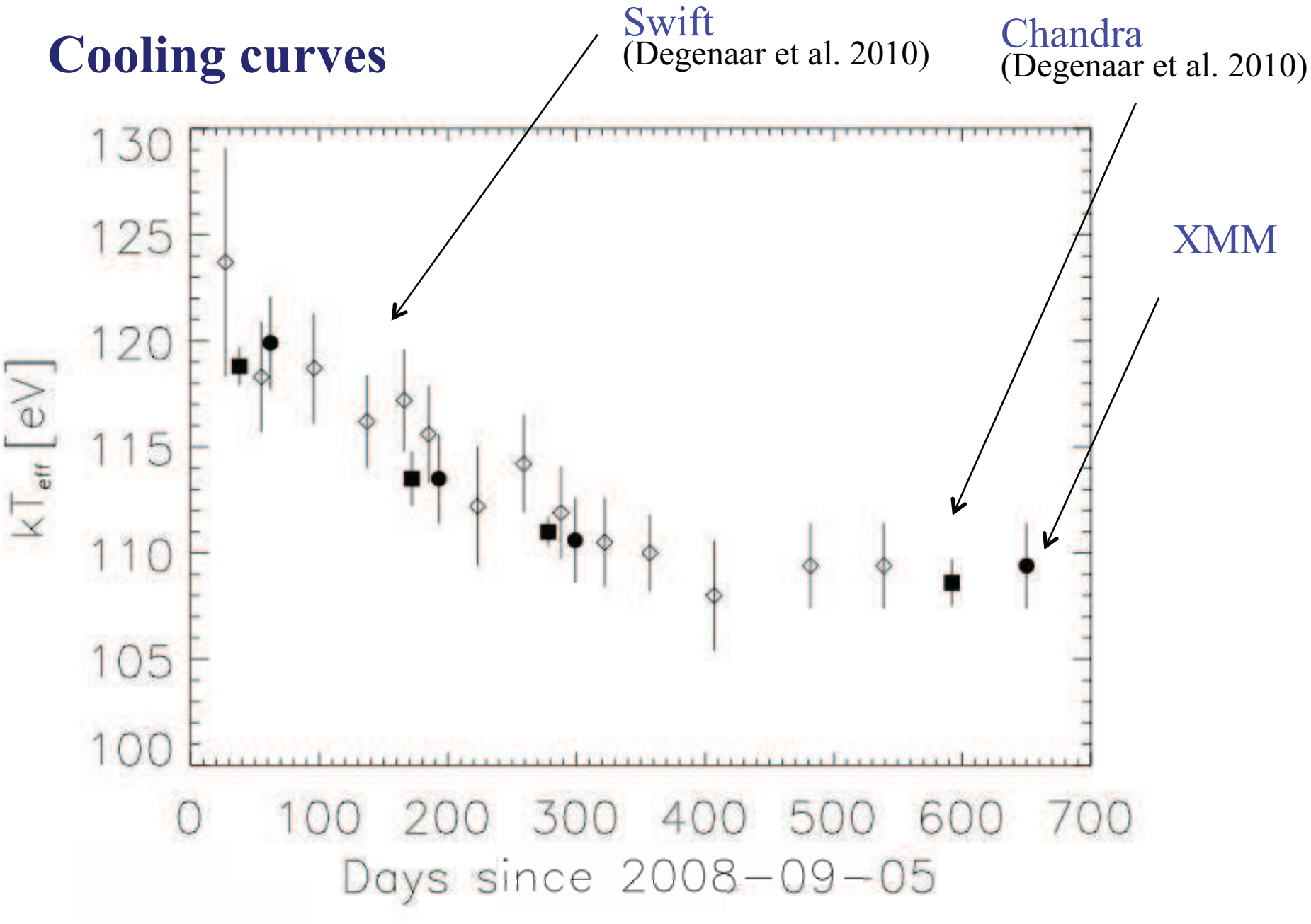
Non-thermal component (> 2 keV): power law

Model: tbabs*(nsatmos+po)

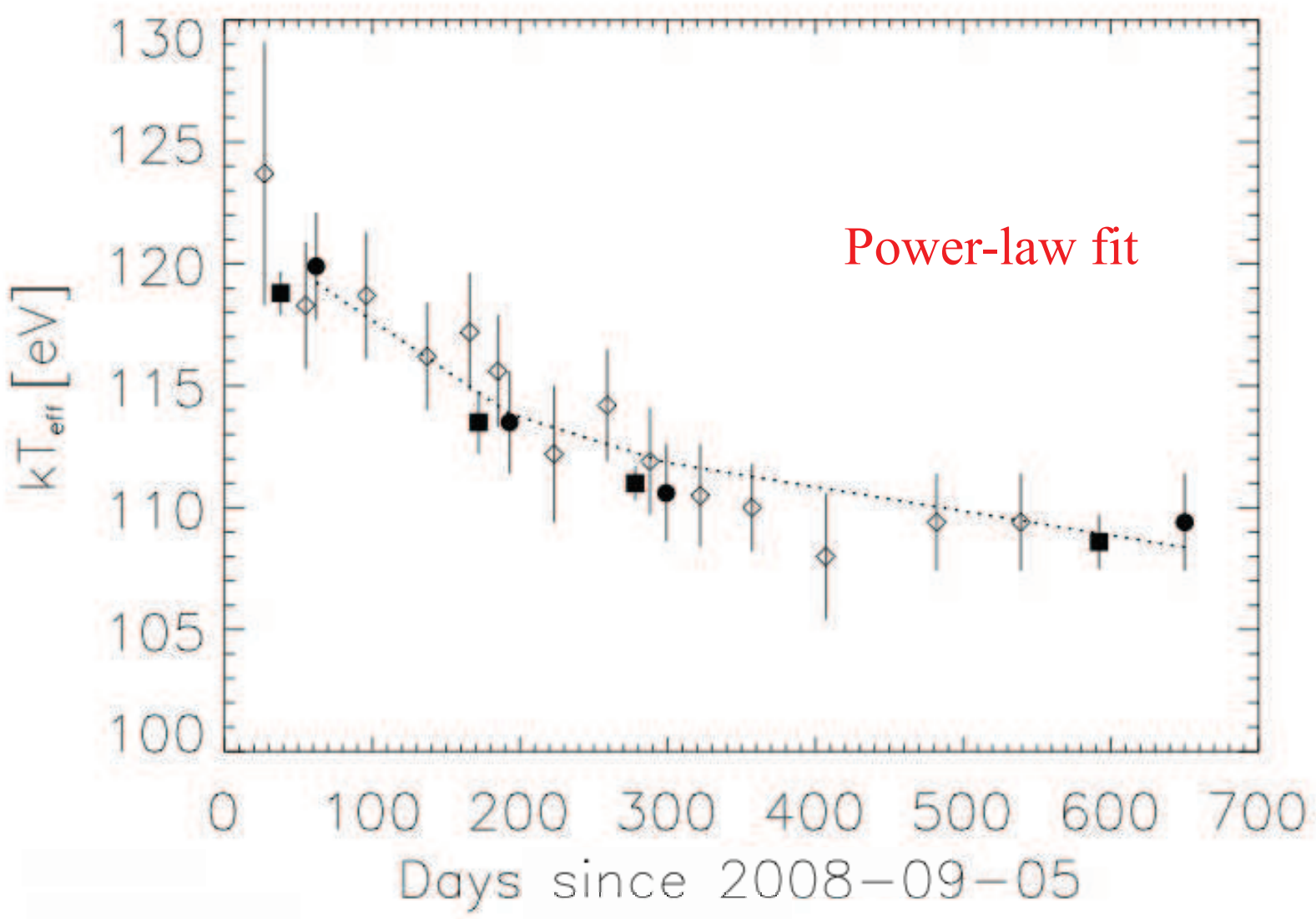
EPIC persistent spectra



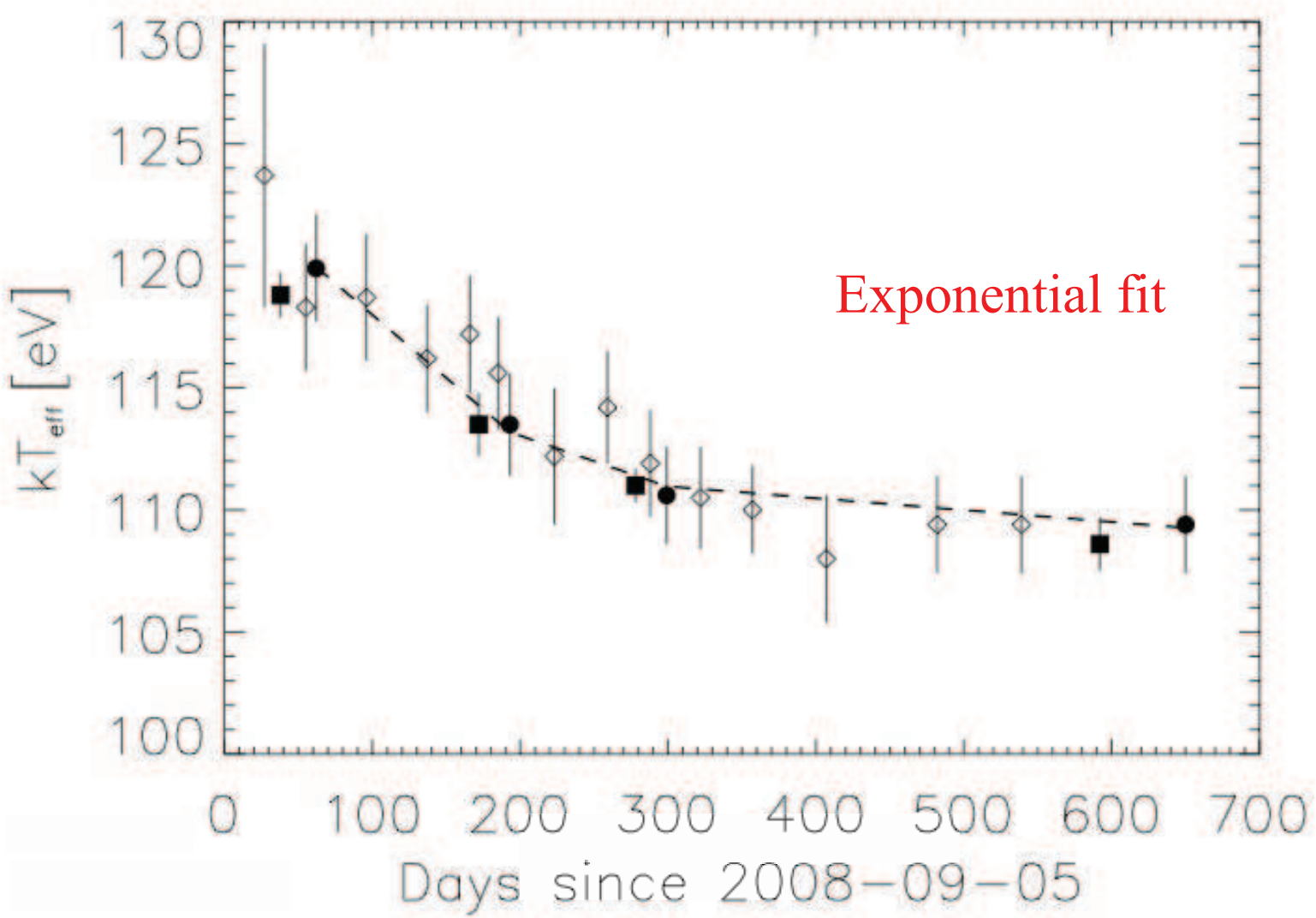
Cooling curves



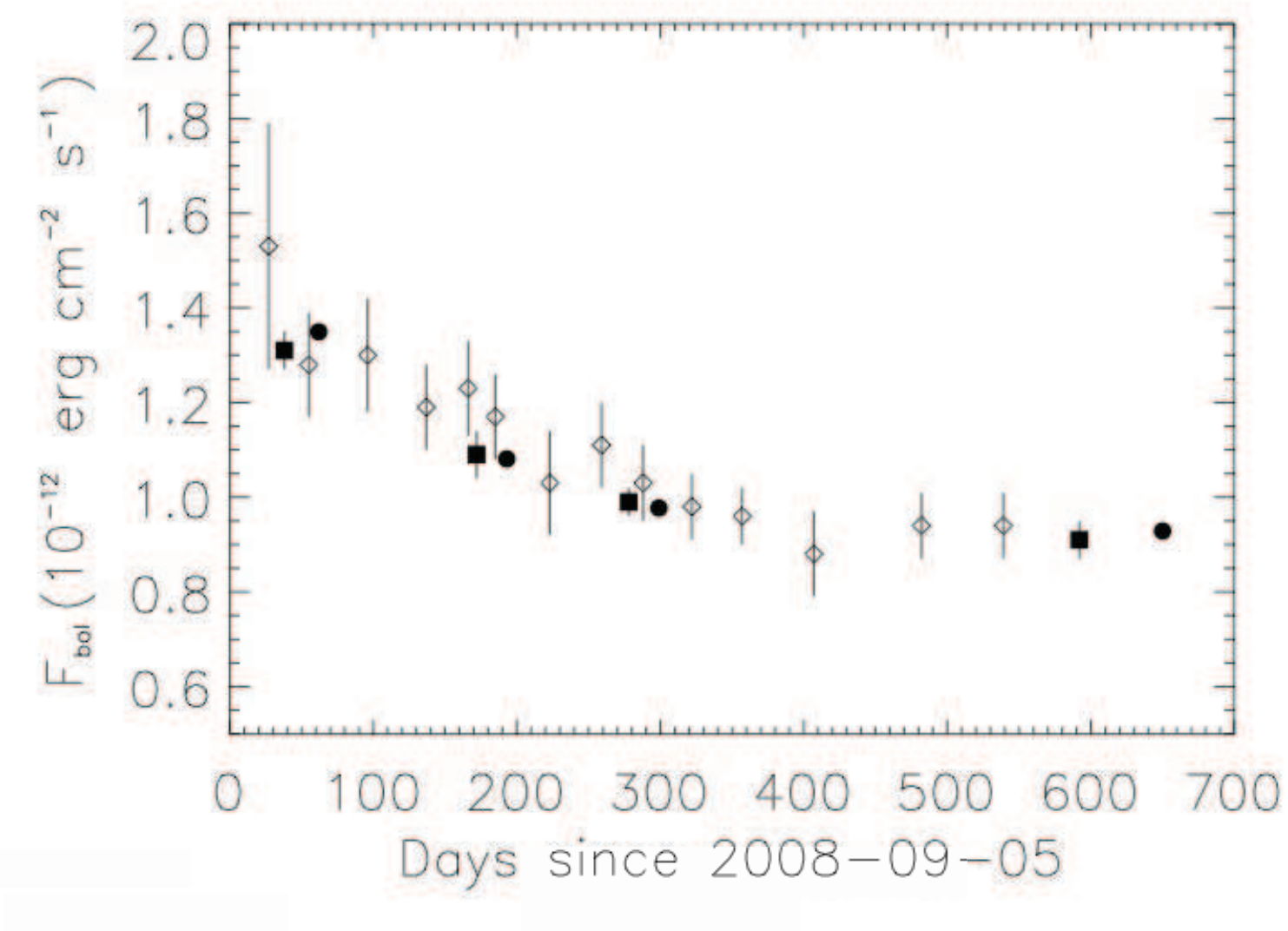
Cooling curves



Cooling curves

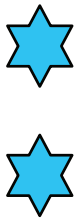


Cooling curves

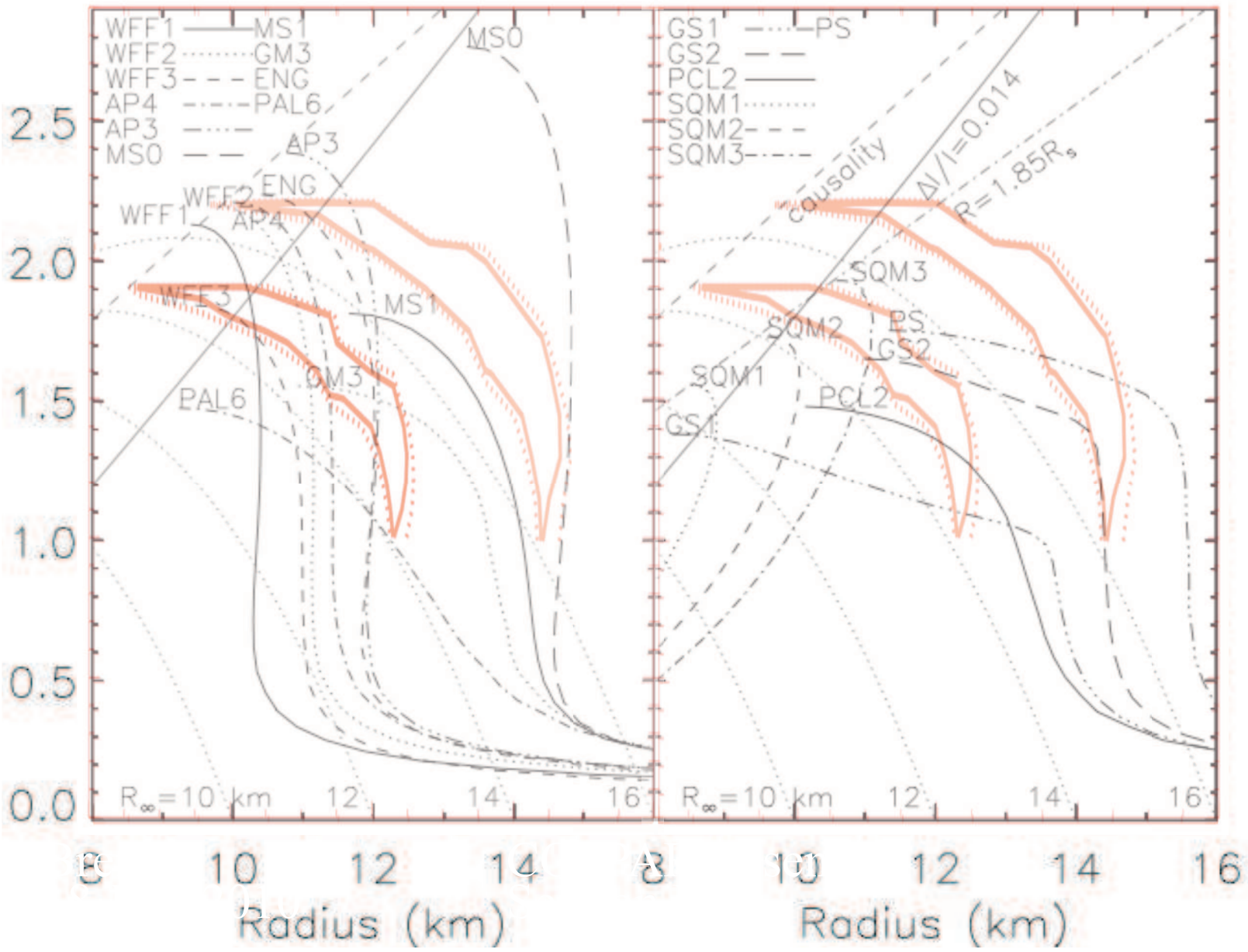


Cooling curves

	Decay time [days]	Index PO	Temperature [eV]	Bolometric luminosity [10^{33} erg/s]	Time after end of outburst [days]
KS 1731-260 (Cackett et al. 2010)	418 ± 70	-0.12 ± 0.1* (no break)	63 ± 2	0.35	2974
MXB 1659-298 (Cackett et al. 2008)	465 ± 25	(break?)	54 ± 2	0.21	2386
XTE J1701-462 (Fridriksson et al. 2010)	120 ± 25	-0.07 ± 0.04 (broken po)	125 ± 0.9	5.4	800
EXO 0748-676	133 ± 88 (C: 192 ± 10)	-0.04 ± 0.01	109 ± 2	5.6	650



M/R constraints



Conclusions

-Residual accretion is not detected after day 60 in the XMM observations (in contrast to Chandra observations)

- XMM-Newton cooling curves are consistent with a relatively hot, medium-mass NS, cooling by standard mechanisms

- More observations needed to determine if the decay proceeds as a (broken) power-law or as an exponential law

- Very stringent constraints to the M/R limits are being set: if the NS has indeed a medium-mass, the M/R contours indicate that the distance may be overestimated