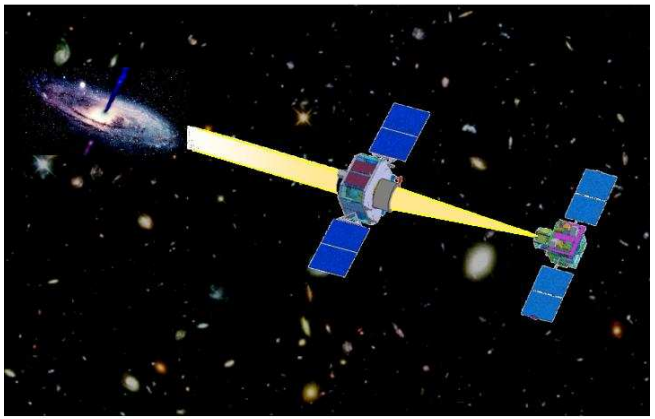
Transient X-ray binaries in quiescence with Simbol-X



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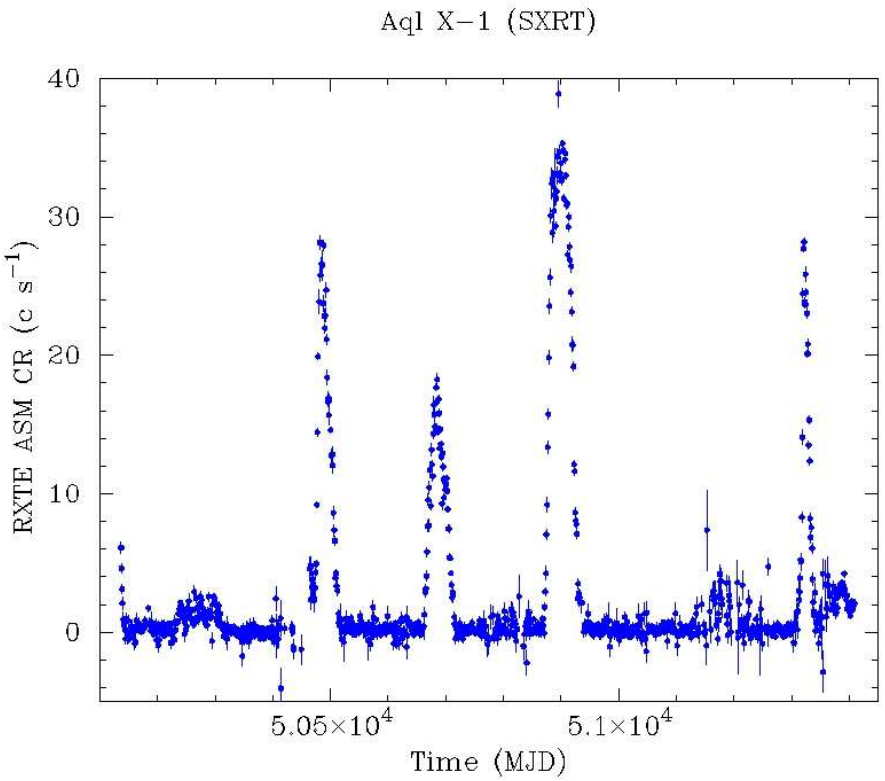
Paris, March 2004

What are X-ray binary transients?



RXTE/ASM light curve

- Binary systems
- BH and NS primaries
- Low mass companions
- Roche lobe overflow
- Coherent pulsations (!)

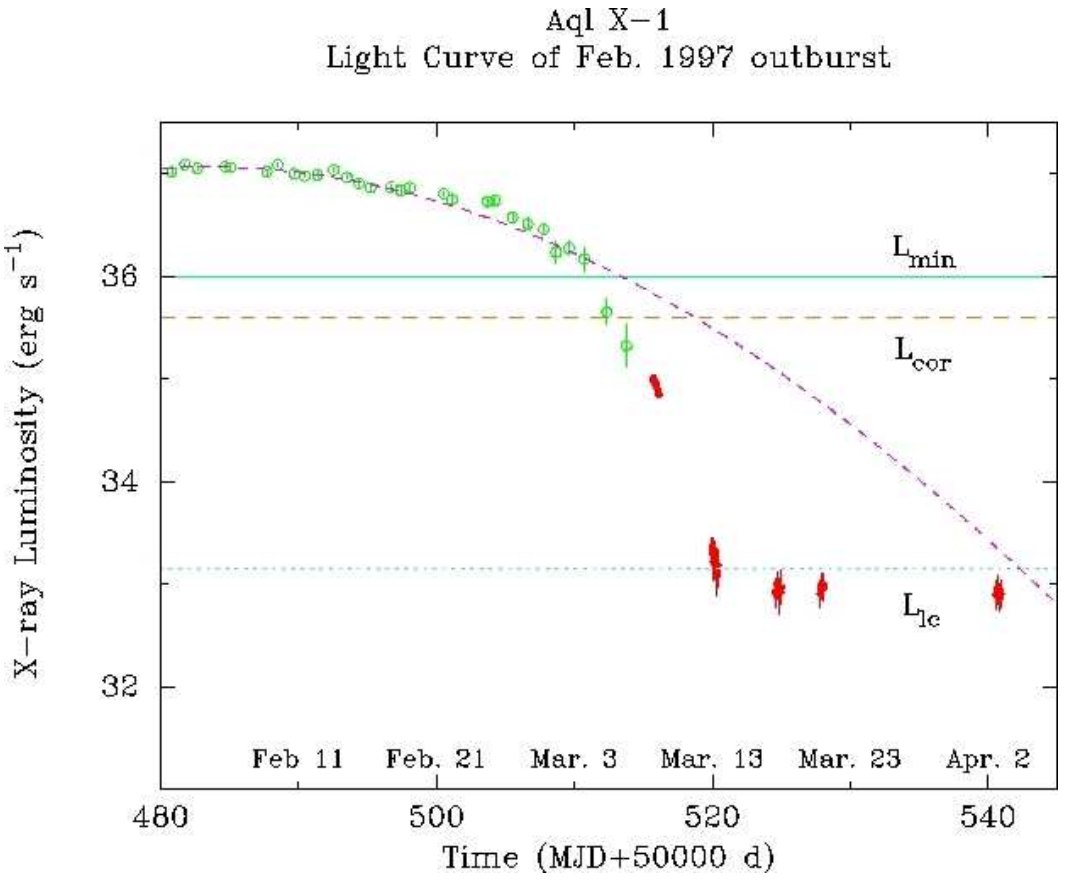
Why study transient sources?

Transient sources vary their luminosity over several orders of magnitude

They probe different accretion regimes onto compact objects, not encompassed by persistent sources

Allow us to study the physics of the emission mechanism in quiescence and infer neutron star parameters

From outburst to quiescence



Campana et al. 1998

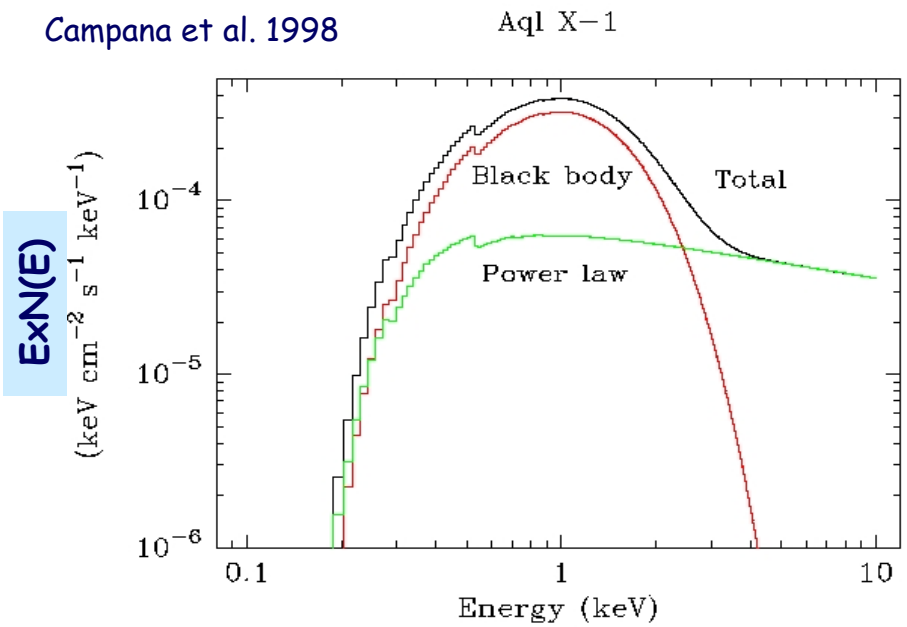
FAST !

e-folding time changing from ~20 d to ~1 d at transition

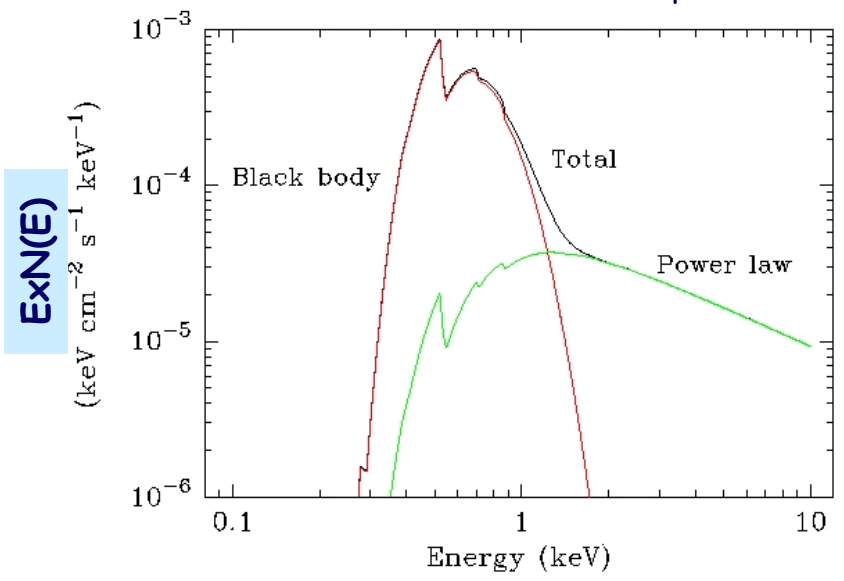
BeppoSAX data

NS transients in quiescence

Campana et al. 1998



Campana et al. 2000



Canonical spectrum:

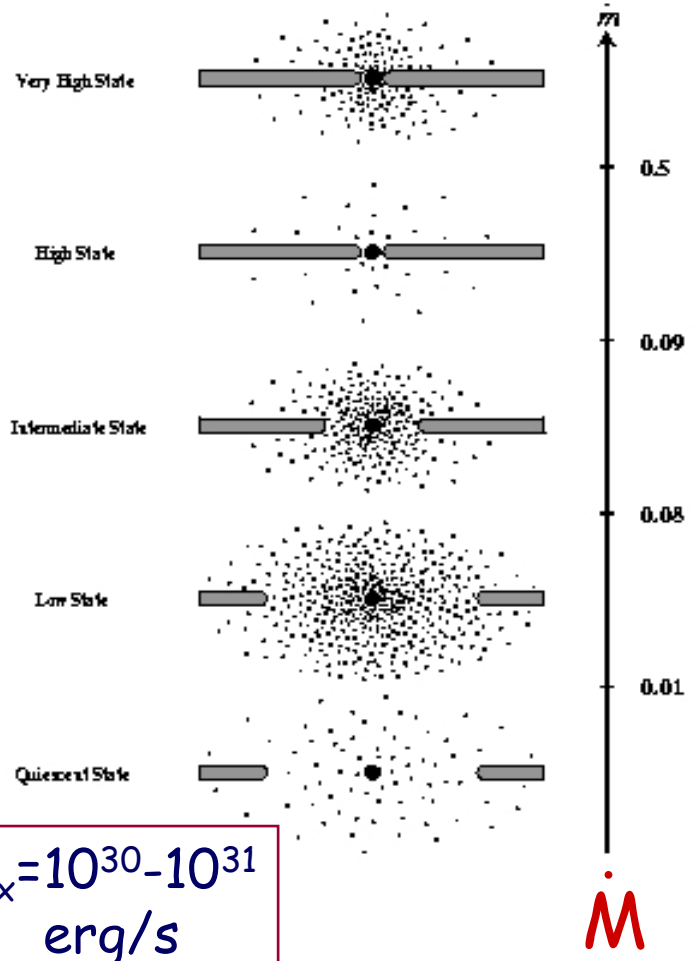
- Soft component (NS atmosphere, kT~0.1-0.3 keV; ≥50% of the flux)
- Hard component (Power law, photon index Γ~1-2; ≤50% of the flux) (Not always present!)

L_x=10^{32}-10^{33} erg/s

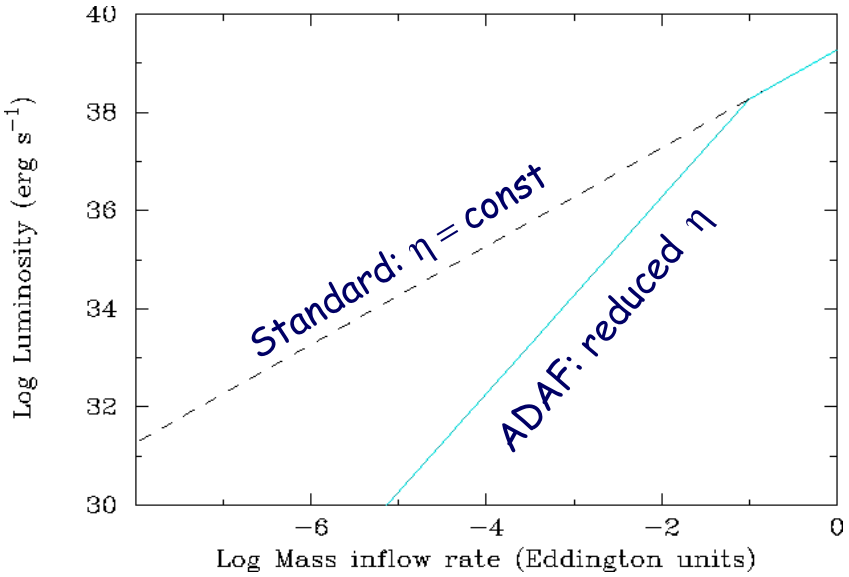
ADAF/CDAF/ADIOS models

Narayan et al. 1997

$L = \eta \dot{M} c^2$ (η: mass to radiation conversion efficiency)



$L_x = 10^{30}$-10^{31} erg/s



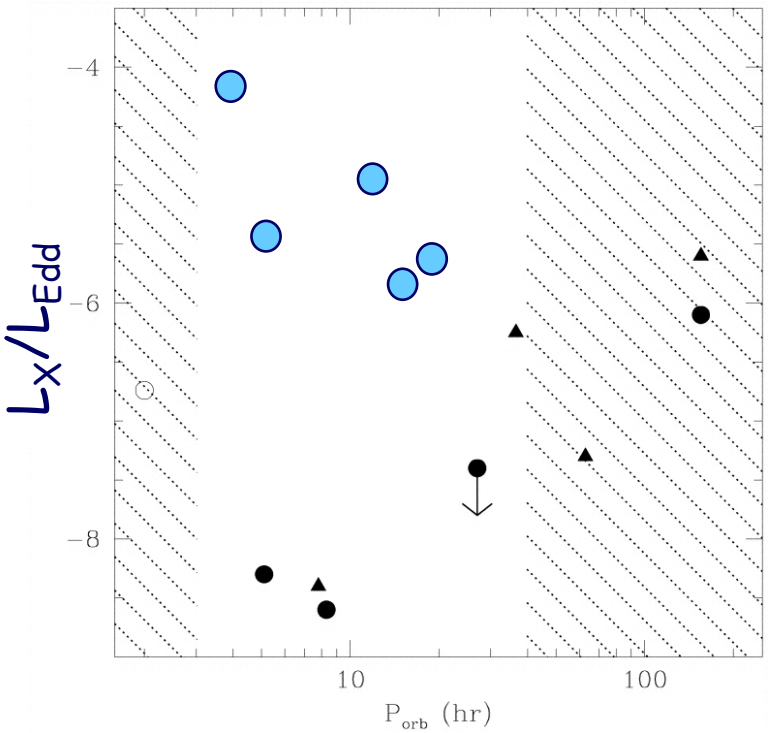
For low rates, increasing fraction of energy stored in accretion flow:

-In BHCs the energy is `lost' in the horizon: reduced efficiency η

-In NSs the energy is released at the star surface: standard efficiency η

Quiescent state of NS and BHC transients

	NS	BHC
X-ray luminosity	10^{32}-10^{33} erg s^{-1}	10^{30}-10^{31} erg s^{-1}
X-ray spectra	BB+Power law	Power law



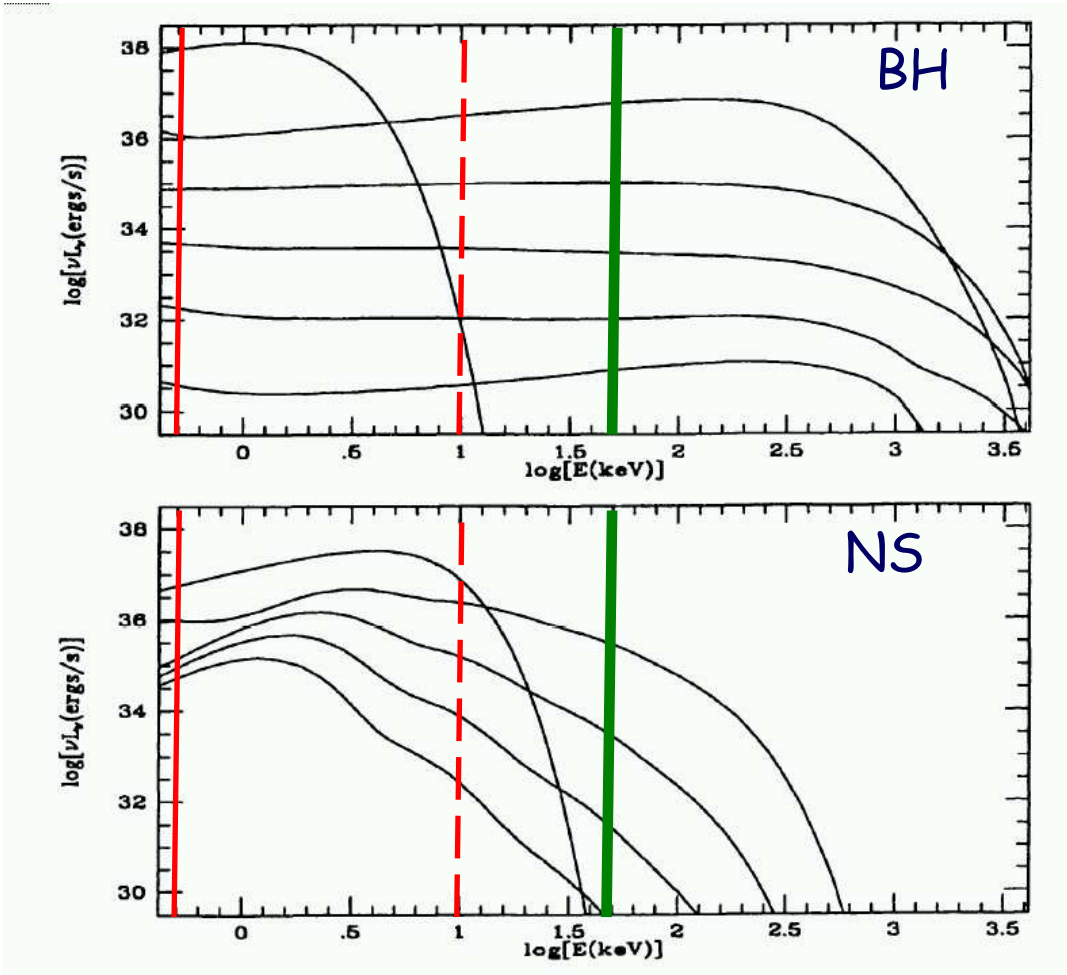
Models for NS (and BHC) in quiescence

- Accretion (advection-dominated, convection-dominated, outflows, etc.)
- Neutron star cooling
- Regimes connected to the presence of a magnetic neutron star (propeller, radio pulsar)

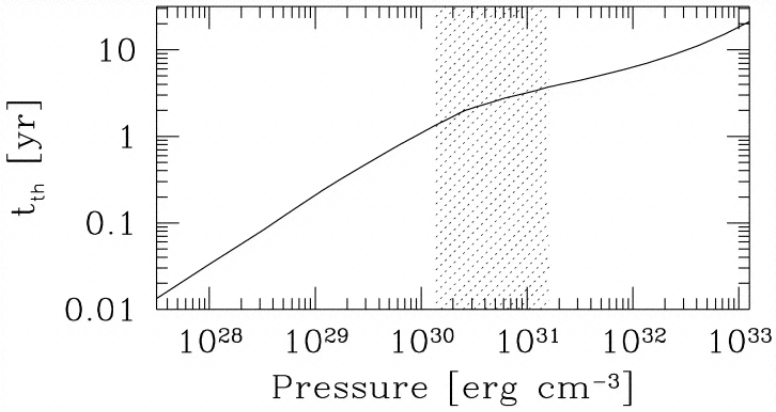
ADAF spectra for quiescent SXRTs

- In agreement with the non-changing spectrum of BH at (varying) low luminosities
- Need for another (soft) component to explain the quiescent spectrum of NS

Yi et al. 1996



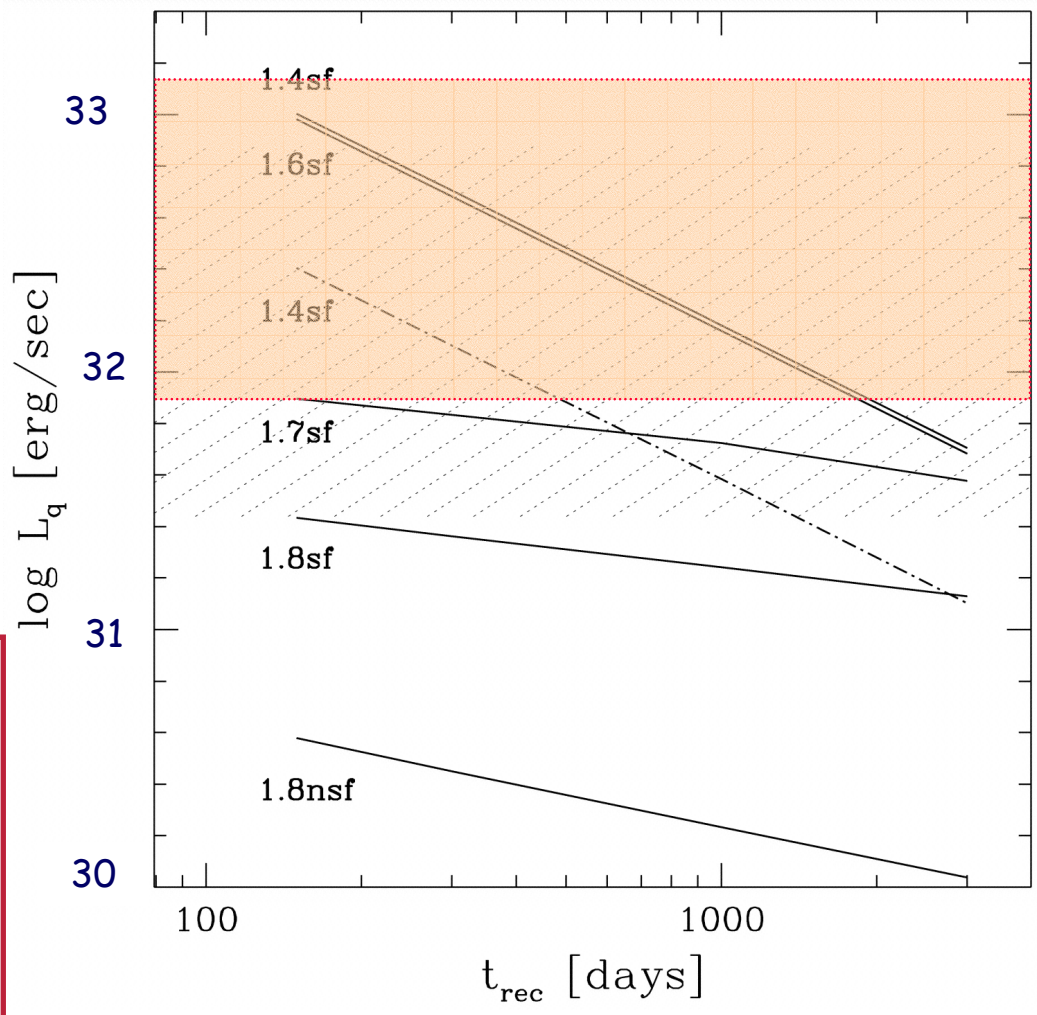
Cooling of the heated NS



Brown et al. 1998;
Campana et al. 1998;
Rutledge et al. 1999

Constant Luminosity

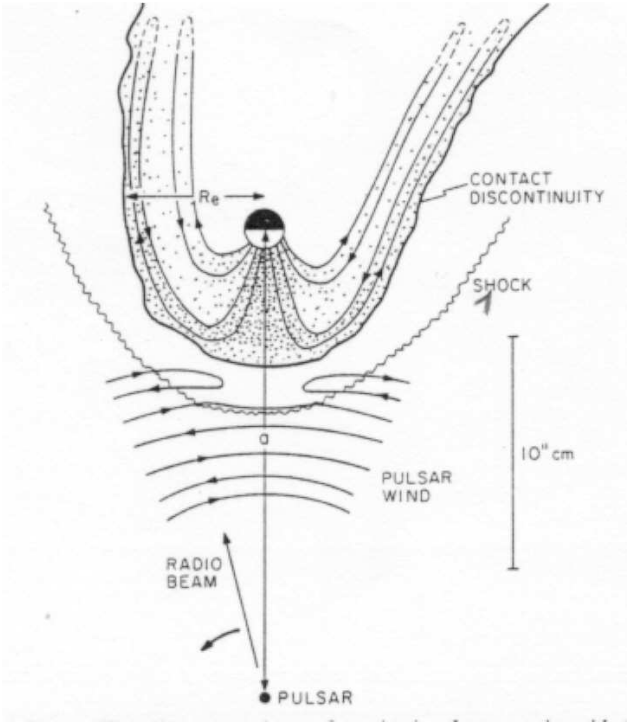
Colpi et al. 2001



Can account for the soft component: it is consistent with NS radius (10-15 km). Prospects to derive NS radius in well known distance sources (e.g. globular clusters)

Shock emission mechanism

- interaction of relativistic pulsar wind with matter outflow from companion star
- plerionic-like high energy shock emission: extended power law spectrum
- analogy with X-ray emission of PSR1259-63 close to periastron: power law slope of ~1.5-2; efficiency ε ~ 0.01-0.10 of the spin-down luminosity



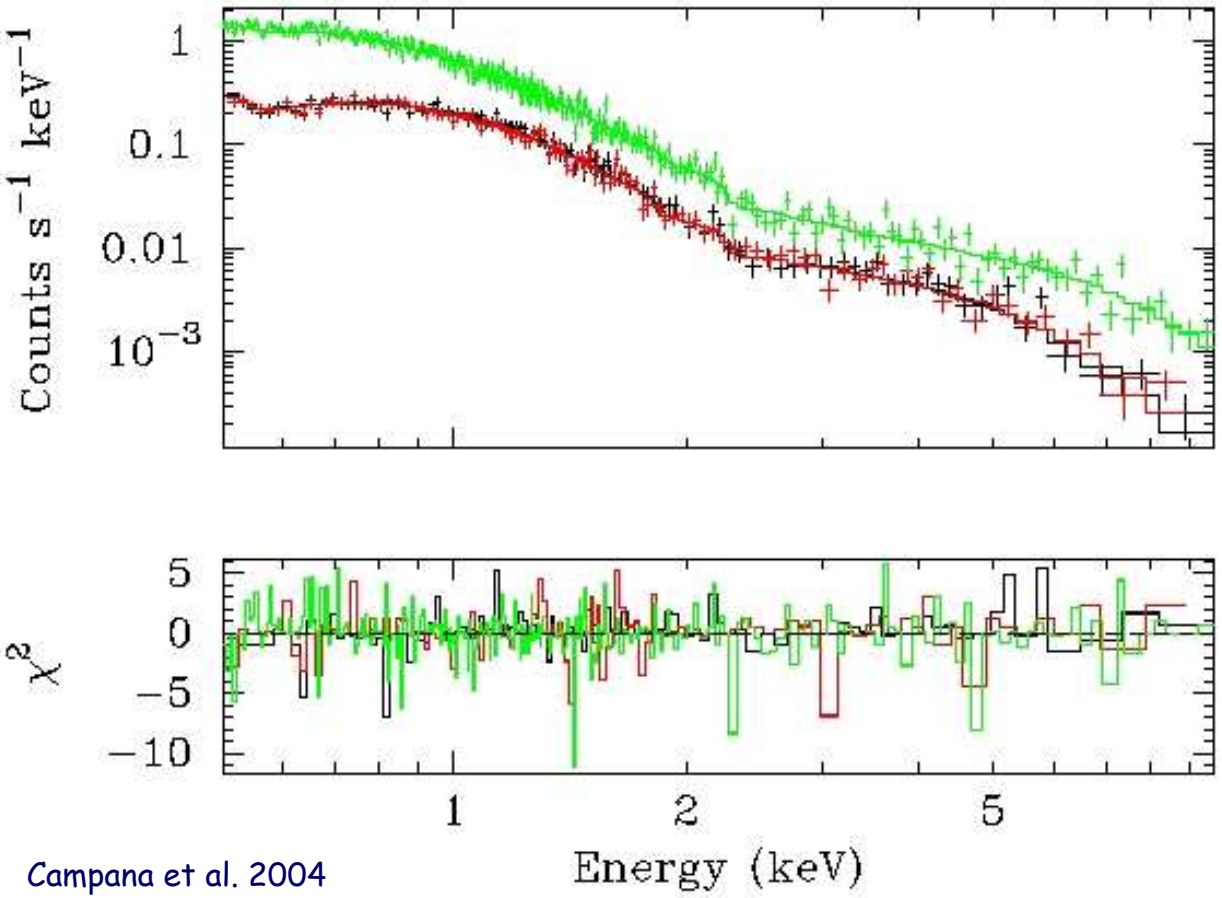
Can account for the luminosity and the spectrum of the hard power law tail

Tavani & Arons 1997

Phinney et al. 1998

State of the art of X-ray observations of quiescent NS & BHC

Cen X-4



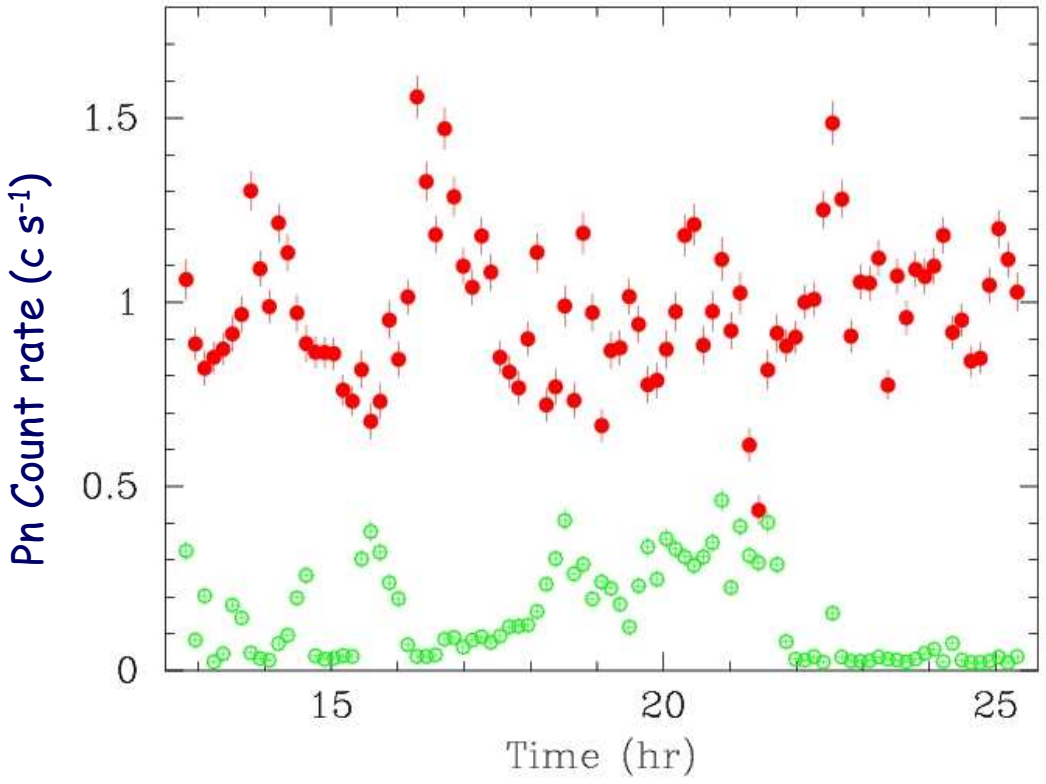
Campana et al. 2004

NS atmosphere +

Power law tail

N_H	8.3±3.5x 10^{20} cm^{-2}
kT	85±3 eV
Γ	1.56±0.09
χ^2_{red}	1.07 (518)

Variability in Cen X-4

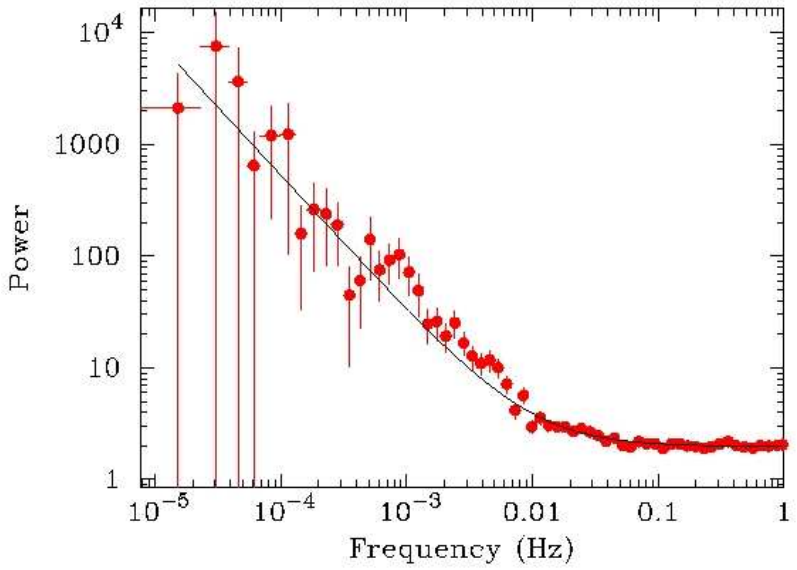


Flare-like events

(also observed in the optical) Zurita et al. 2003

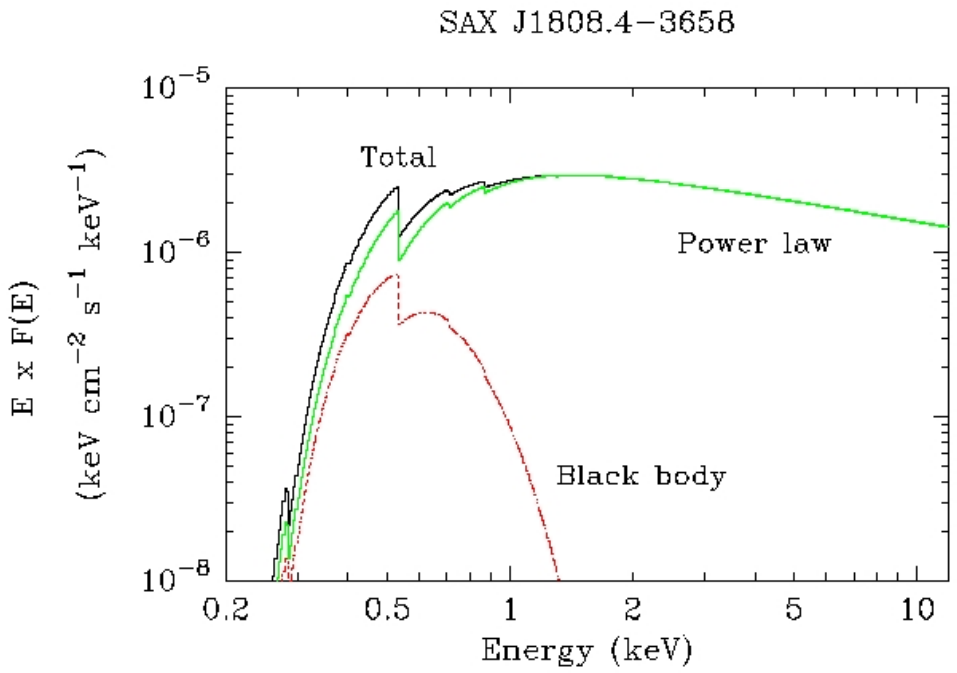
Variability r.m.s. 45±7%

Rutledge et al. 2003



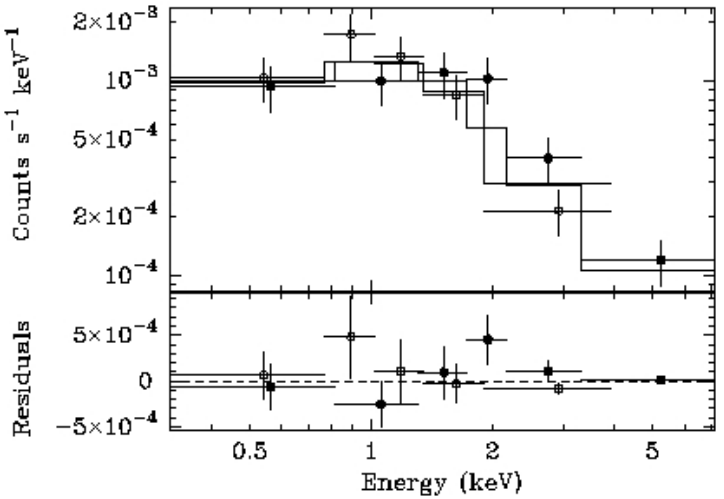
SAX J1808.4-3658 in quiescence

Campana et al. 2002



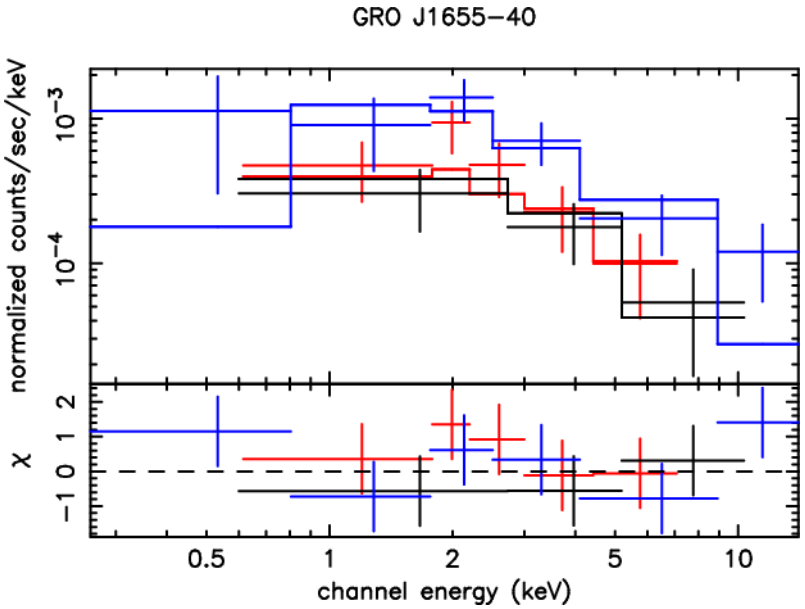
NS atmosphere model can account less than 10% of the total flux and it is not required by the fit

XMM-Newton data



GRO J1655-40 in quiescence

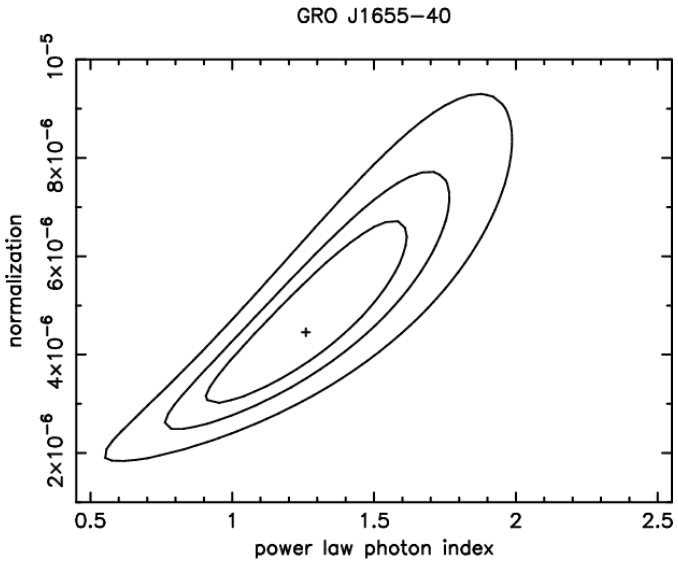
Hameury et al. 2002



XMM-Newton data

Power law spectrum with $\Gamma \cong 1.5$

0.5-10 Flux = 5×10^{-14} erg cm^{-2} s^{-1}

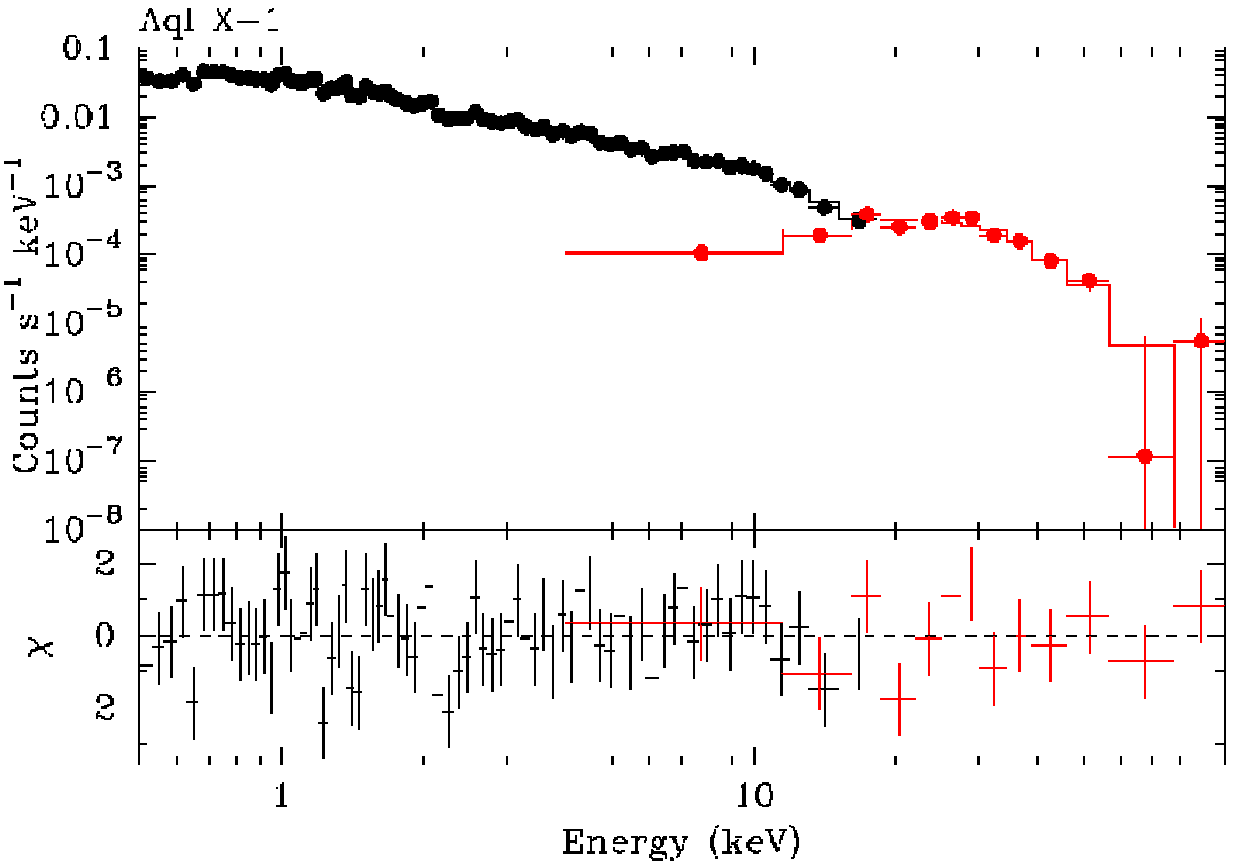


Simulated simbol-X spectra

NS transient in quiescence

50 ks

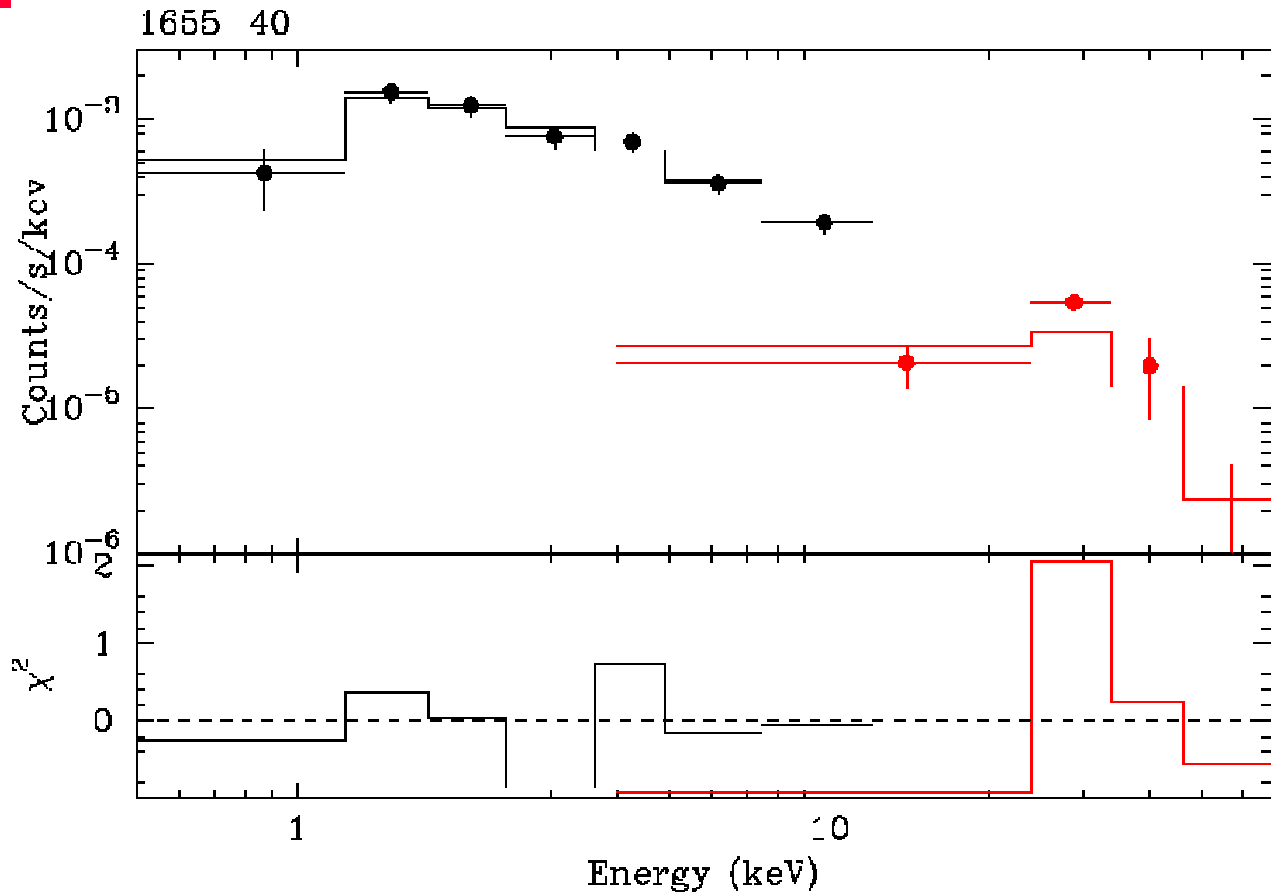
Diagnostic of the power law tail



Simulated simbol-X spectra (2)

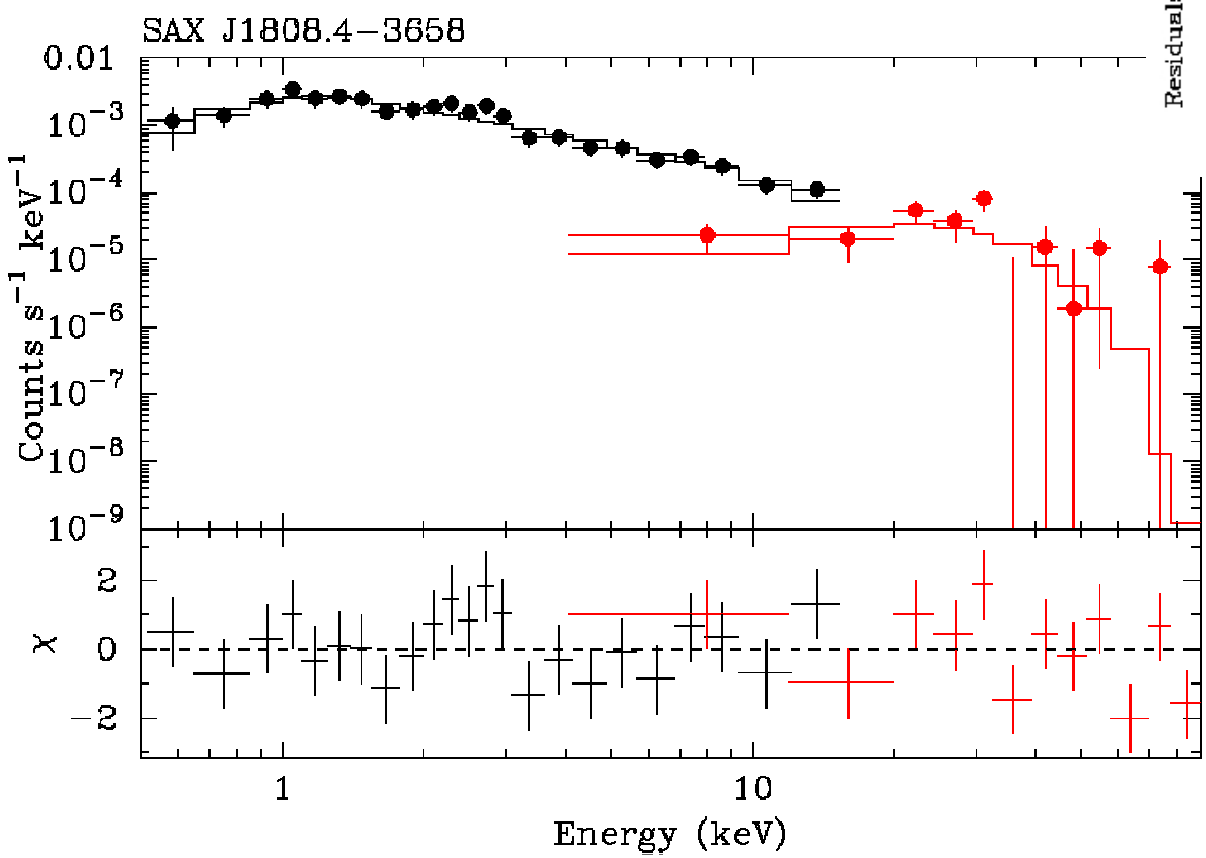
50 ks

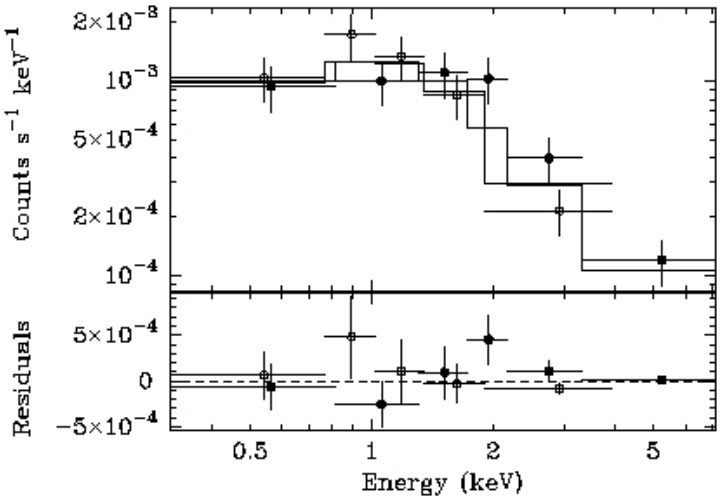
BHC in quiescence



Simbol-X on the 'holy graal' X-ray pulsar SAX J1808.4-3658

50 ks





XMM

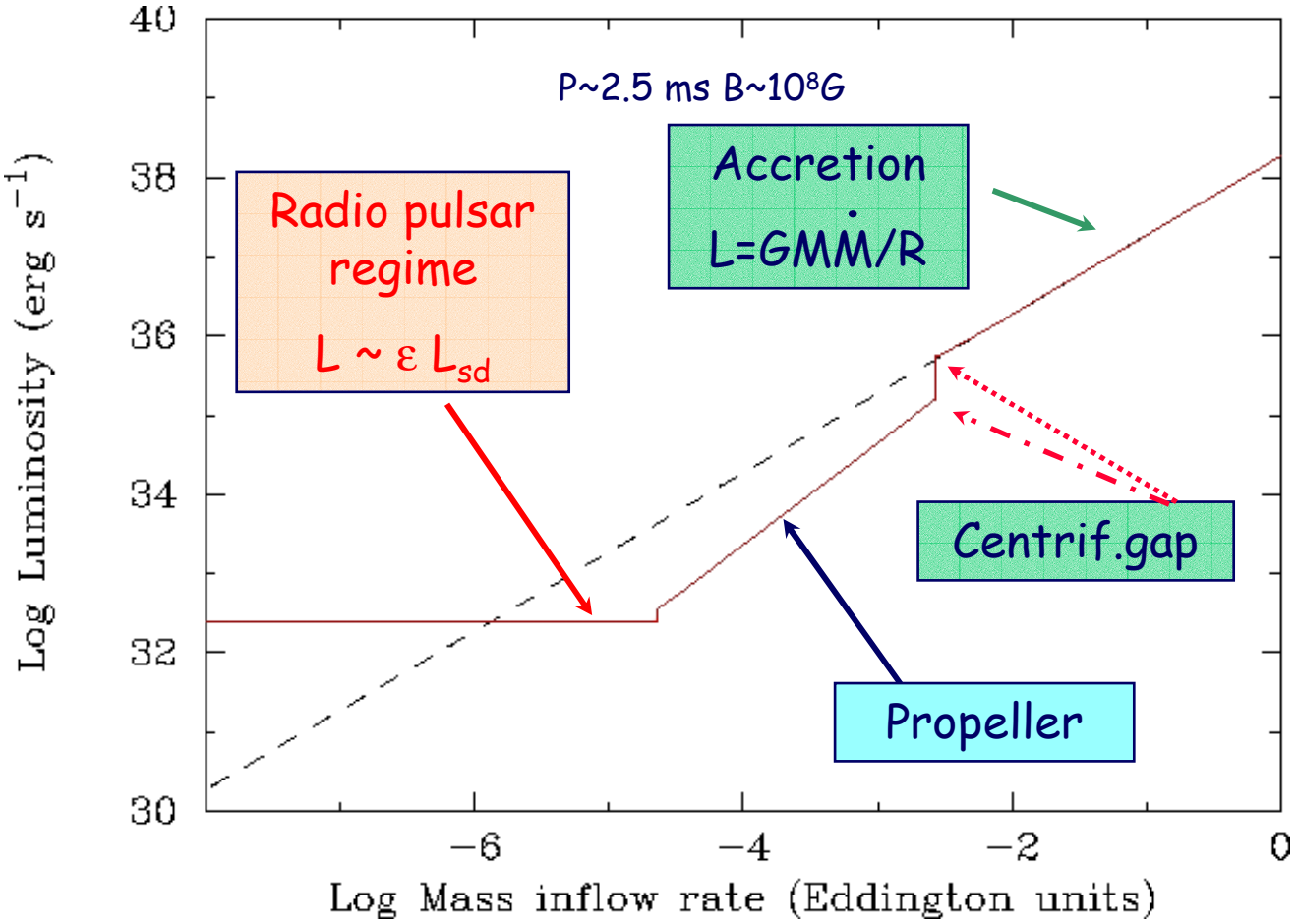
In 100 ks provides a 3 sigma detection of a pulsed signal of 3% amplitude (in outburst it is 4-6%)

Summary

- Different mechanisms for explaining the quiescent emission of NS & BH XRTs (**physics**, not encompassed by persistent sources)

- Simbol-X is the first observatory able to disclosed the high energy part of the spectrum at very faint luminosities, making possible a thorough test of the emission mechanisms

Mass-energy conversion efficiency in NS



(Campana et al. 1998,
Campana & Stella 2000)