The puzzling observables of accreting neutron stars

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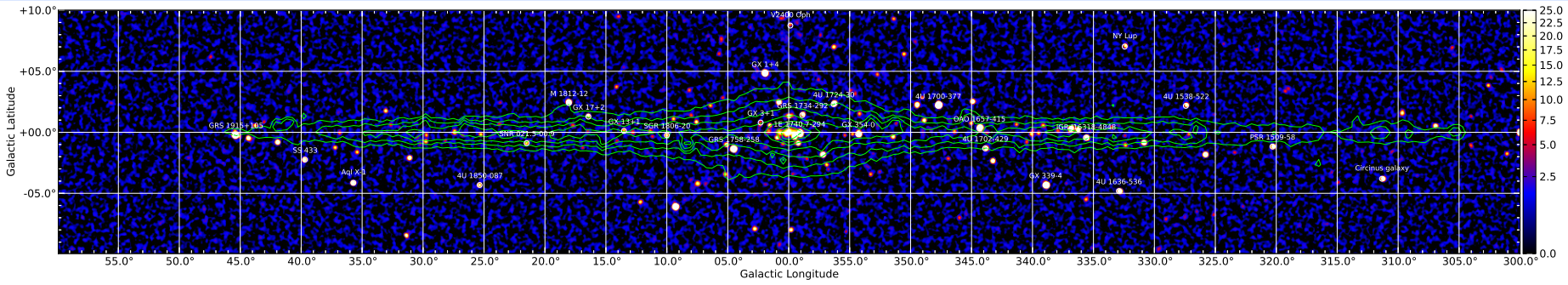
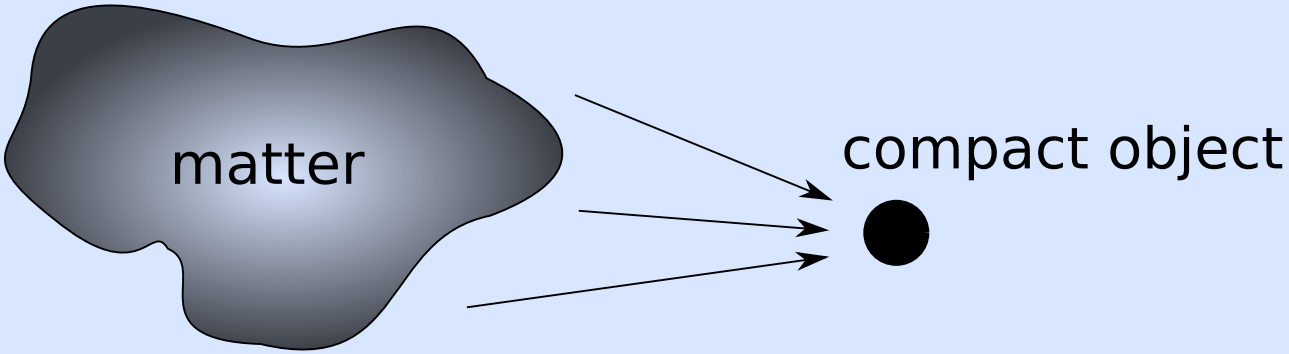
NATURWISSENSCHAFTLICHE FAKULTÄT

ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

INTEGRAL-IBIS 9-year survey

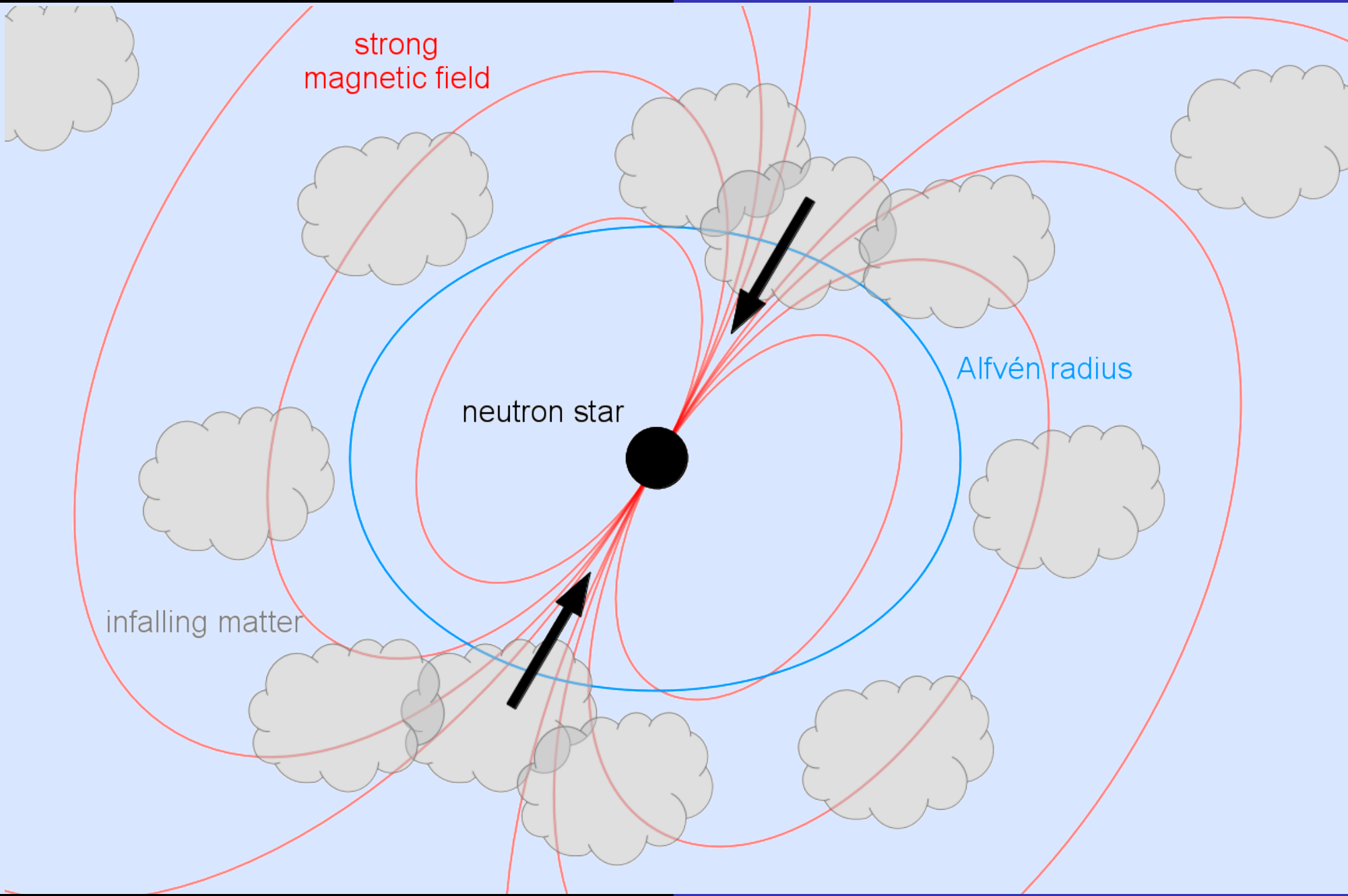


X-rays are produced by mass accretion:



- white dwarf
- black hole
- neutron star

Known since ∼40 years... (see, e.g., Pingle & Rees 1972)


strong
magnetic field
neutron star
Alfvén radius
infalling matter

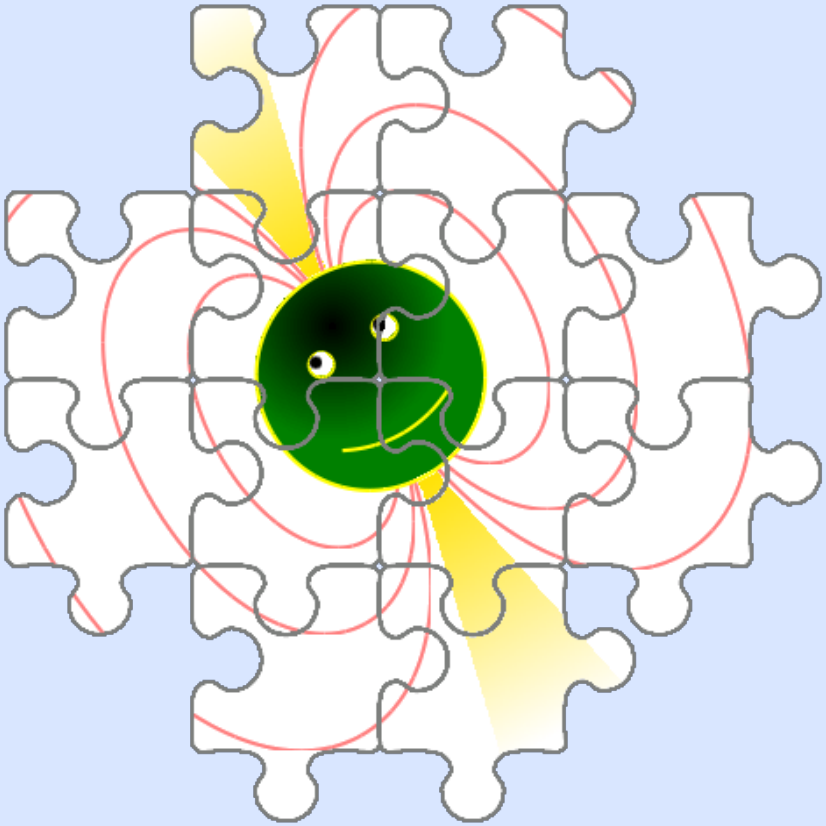
strong
magnetic field

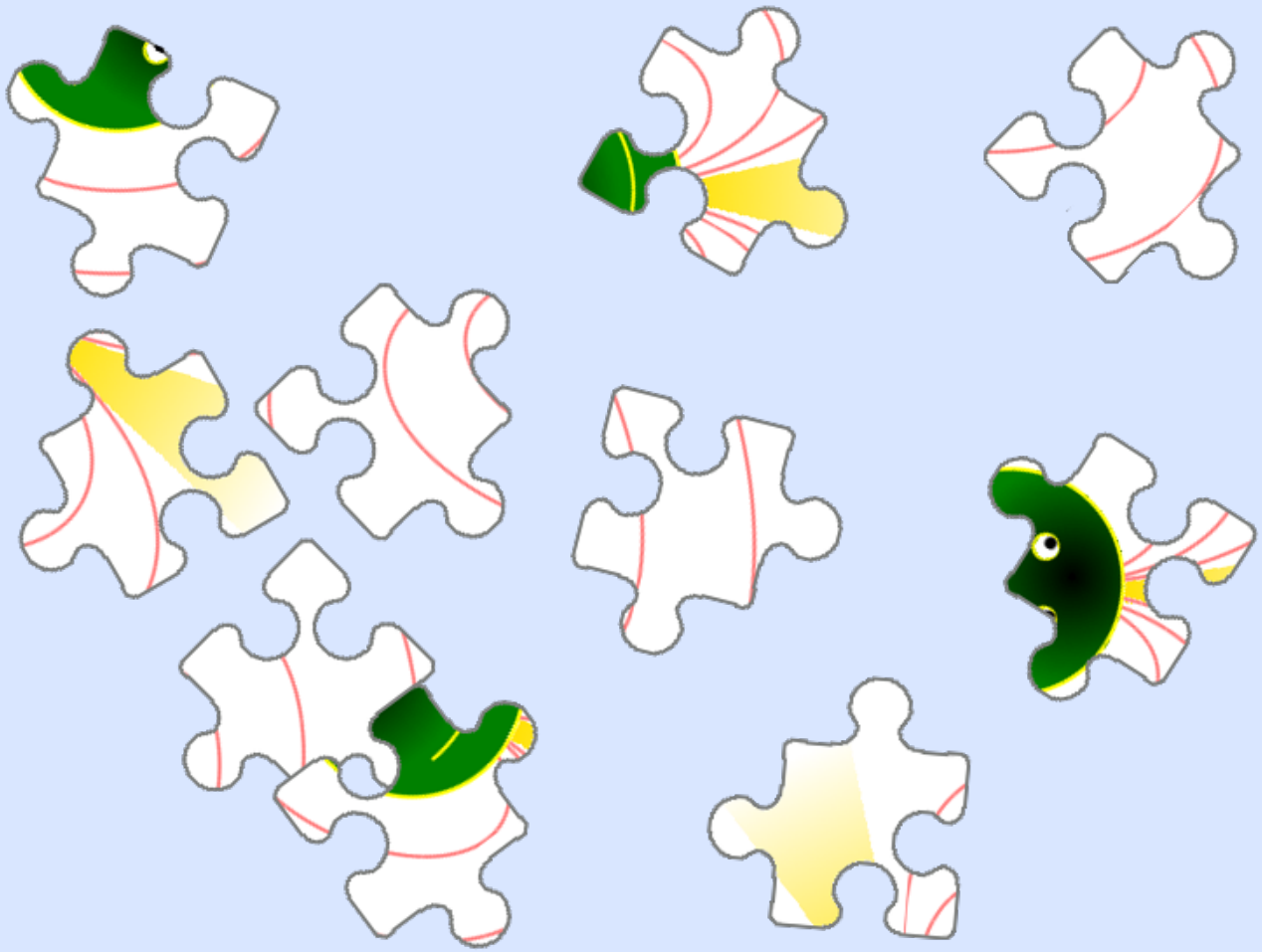
X-ray observables

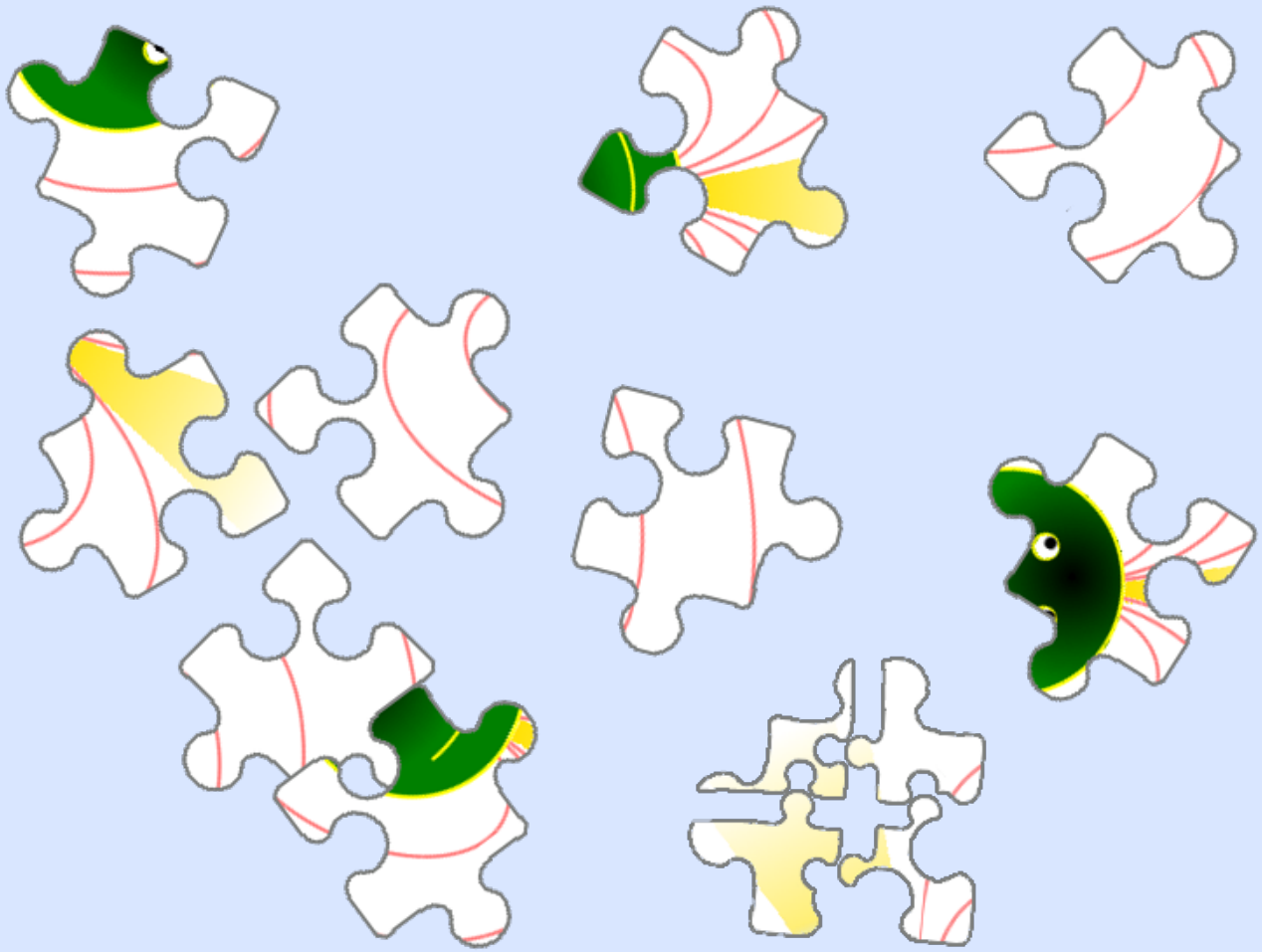
- pulsations (lighthouse effect)
- bremsstrahlung continuum

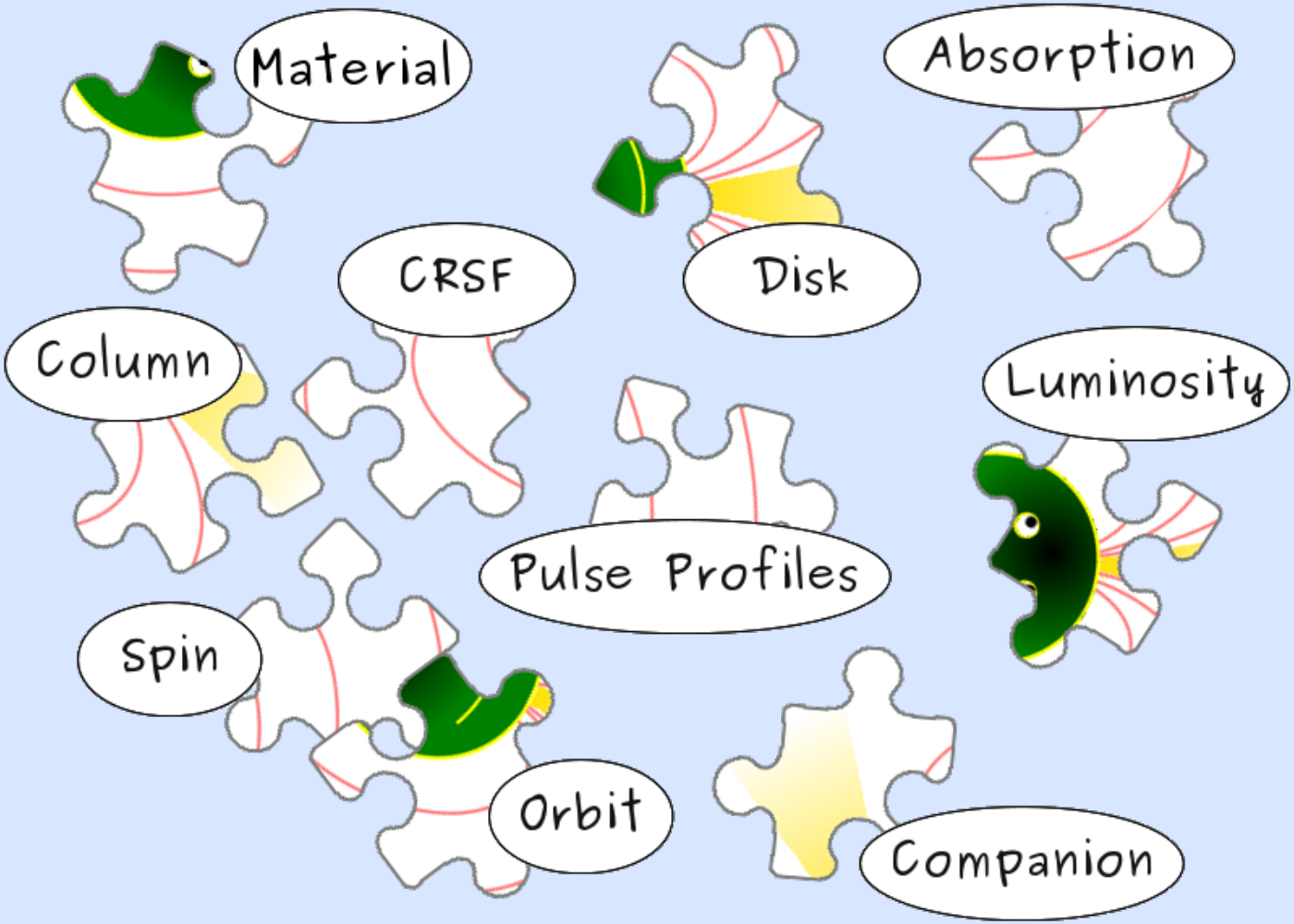
ron star

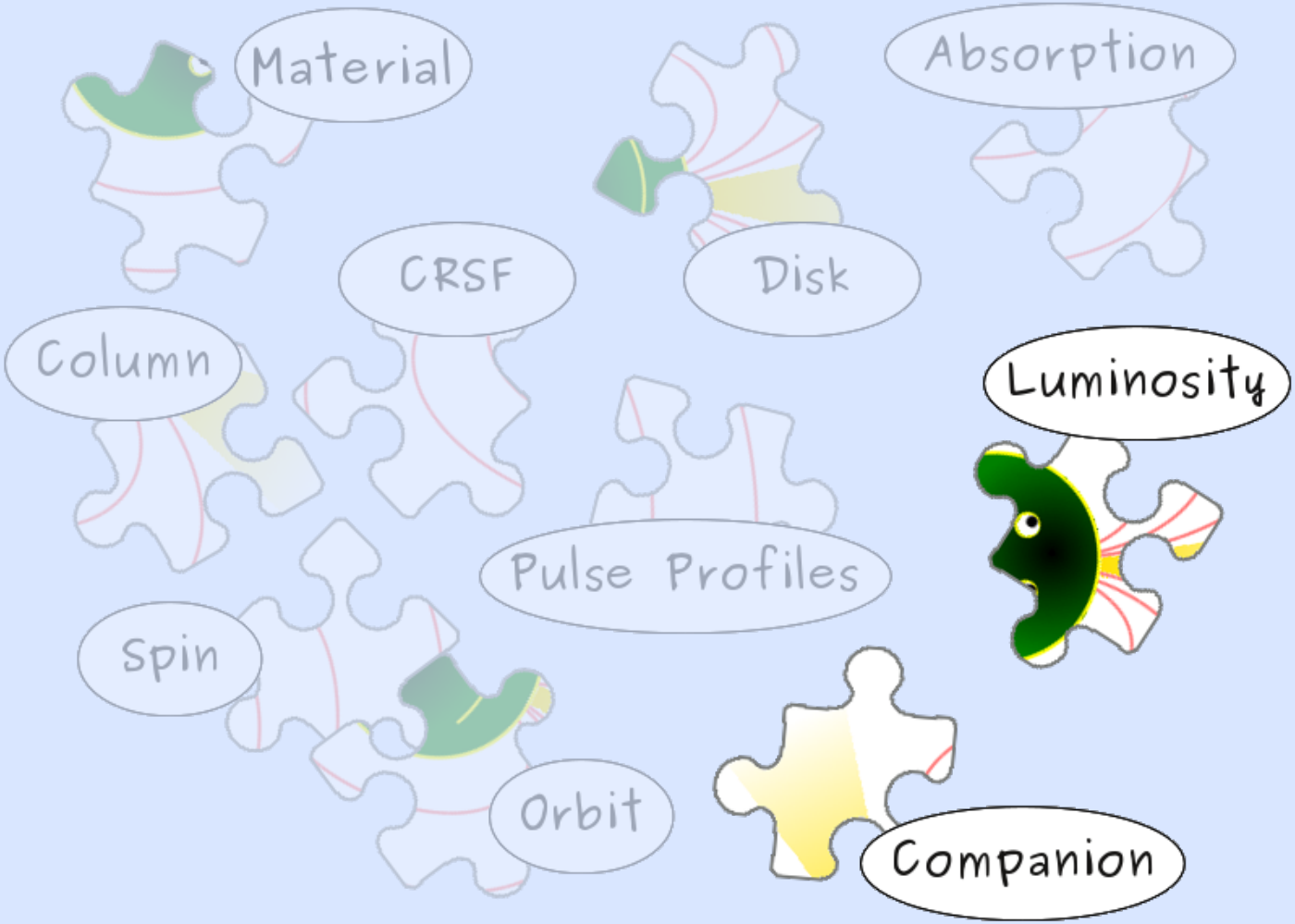
Alfvén radius








Material
Absorption
Disk
CRSF
Column
Luminosity
Pulse Profiles
Spin
Orbit
Companion


Material
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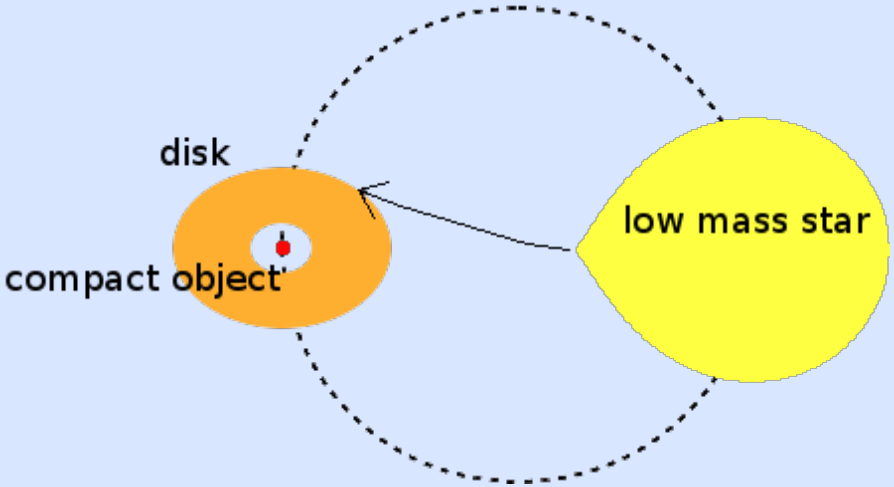
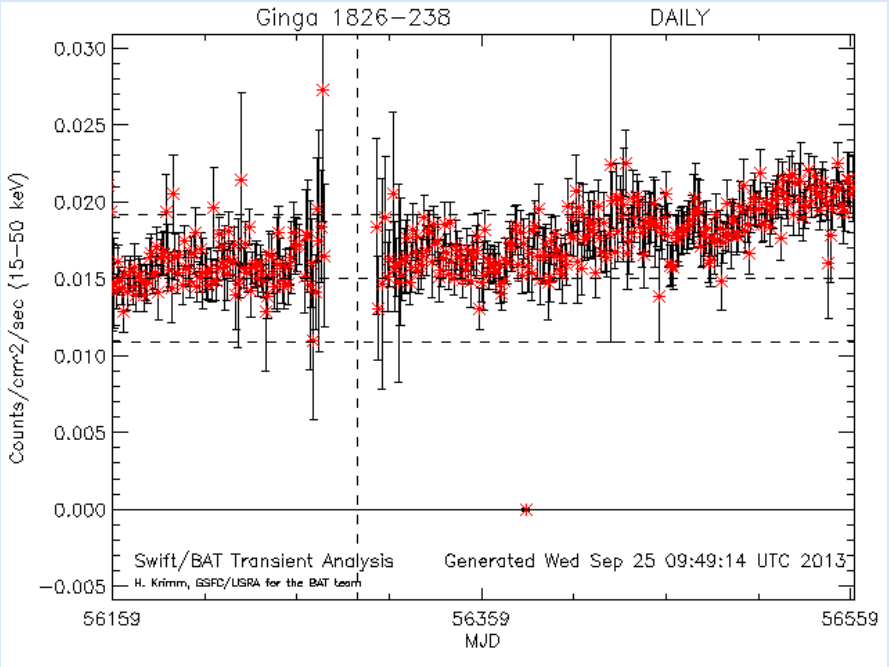
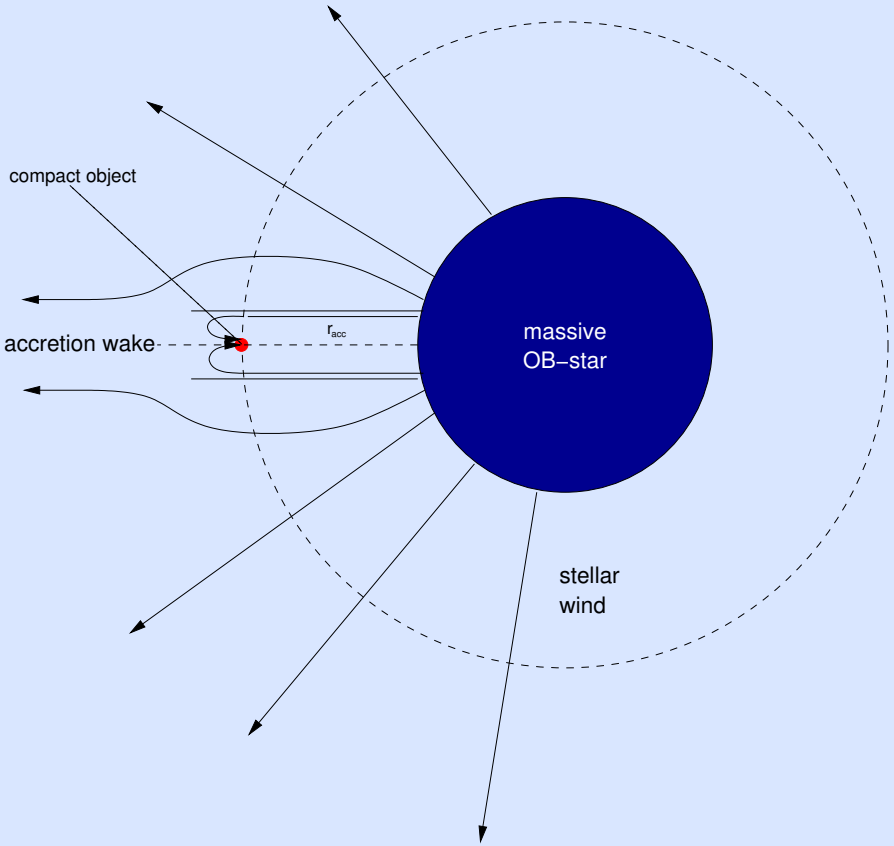
Disk-accretion

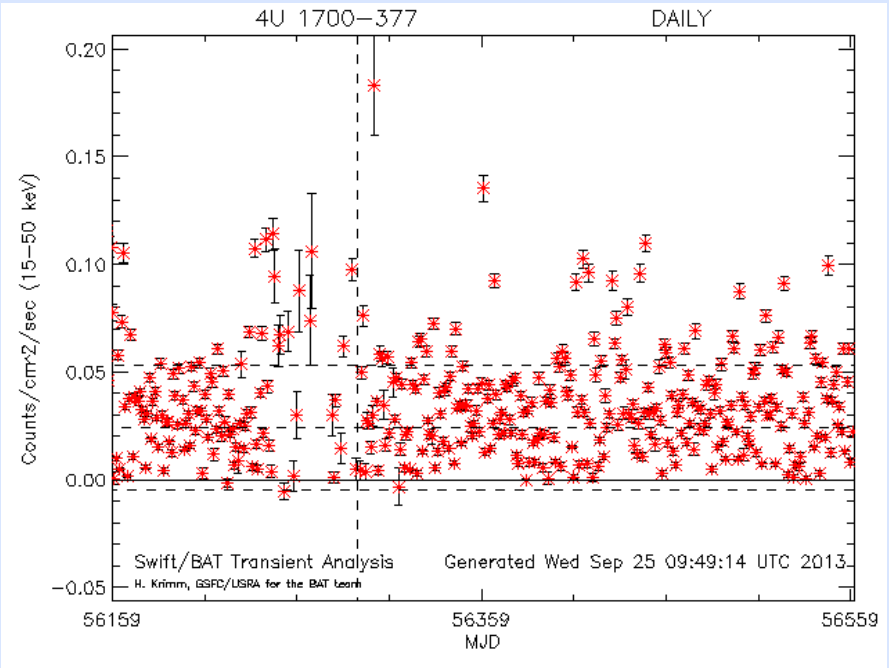




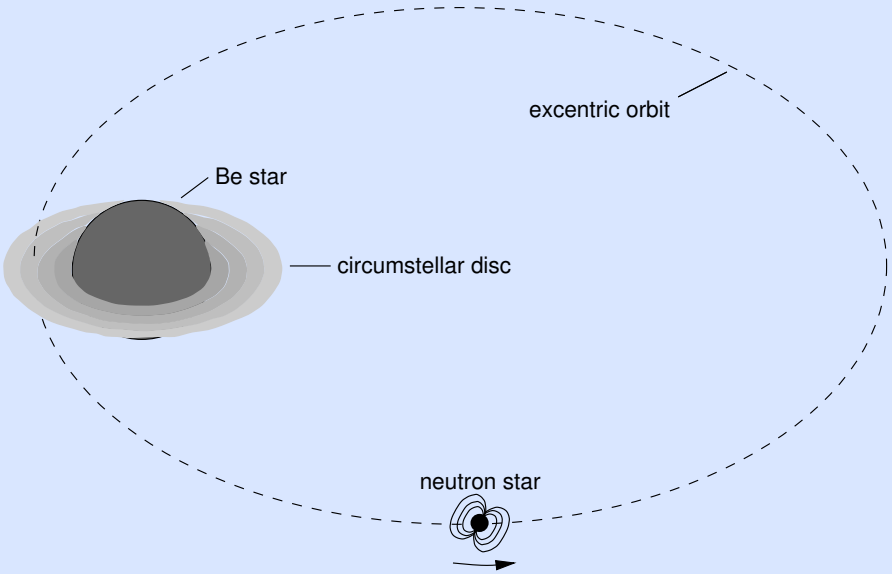
Wind-accretion



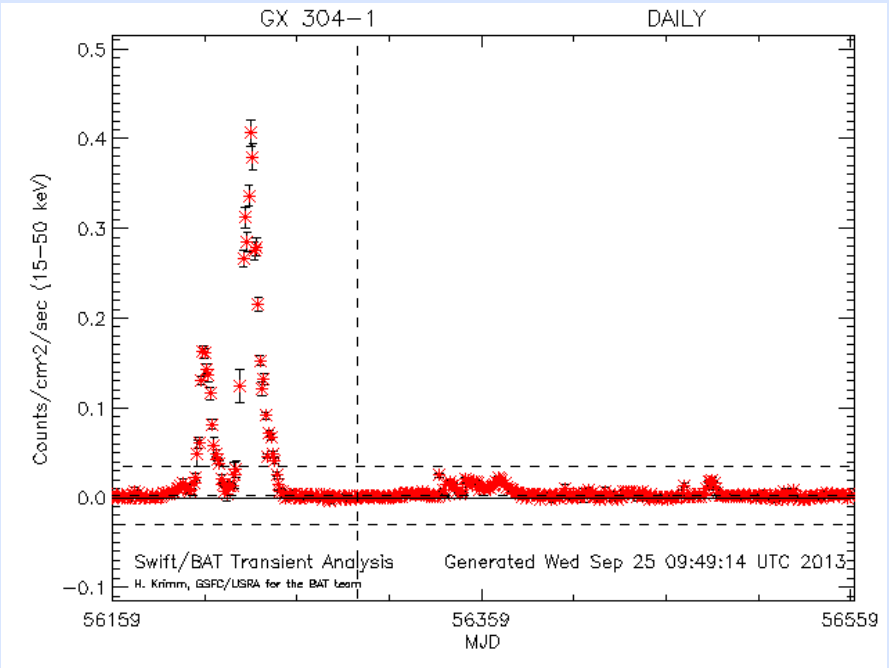
Kreykenbohm (2004) after Bondi & Hoyle (1944)



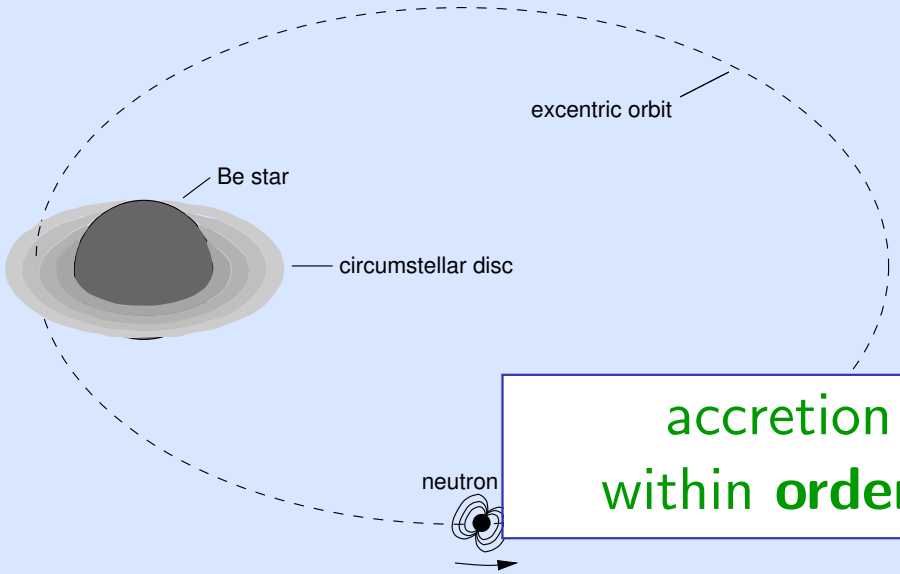
Be-mechanism



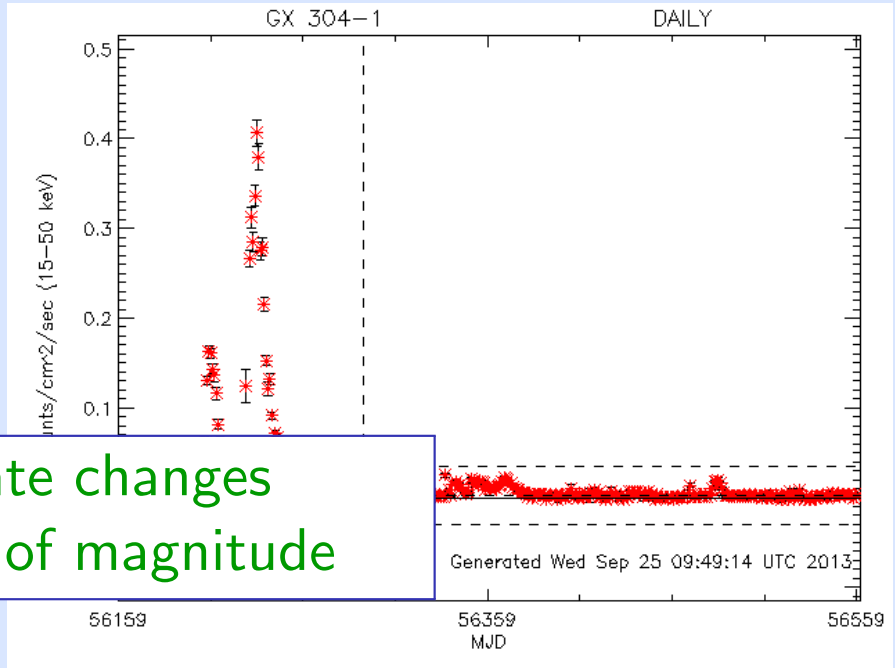
Kretschmar (1996)



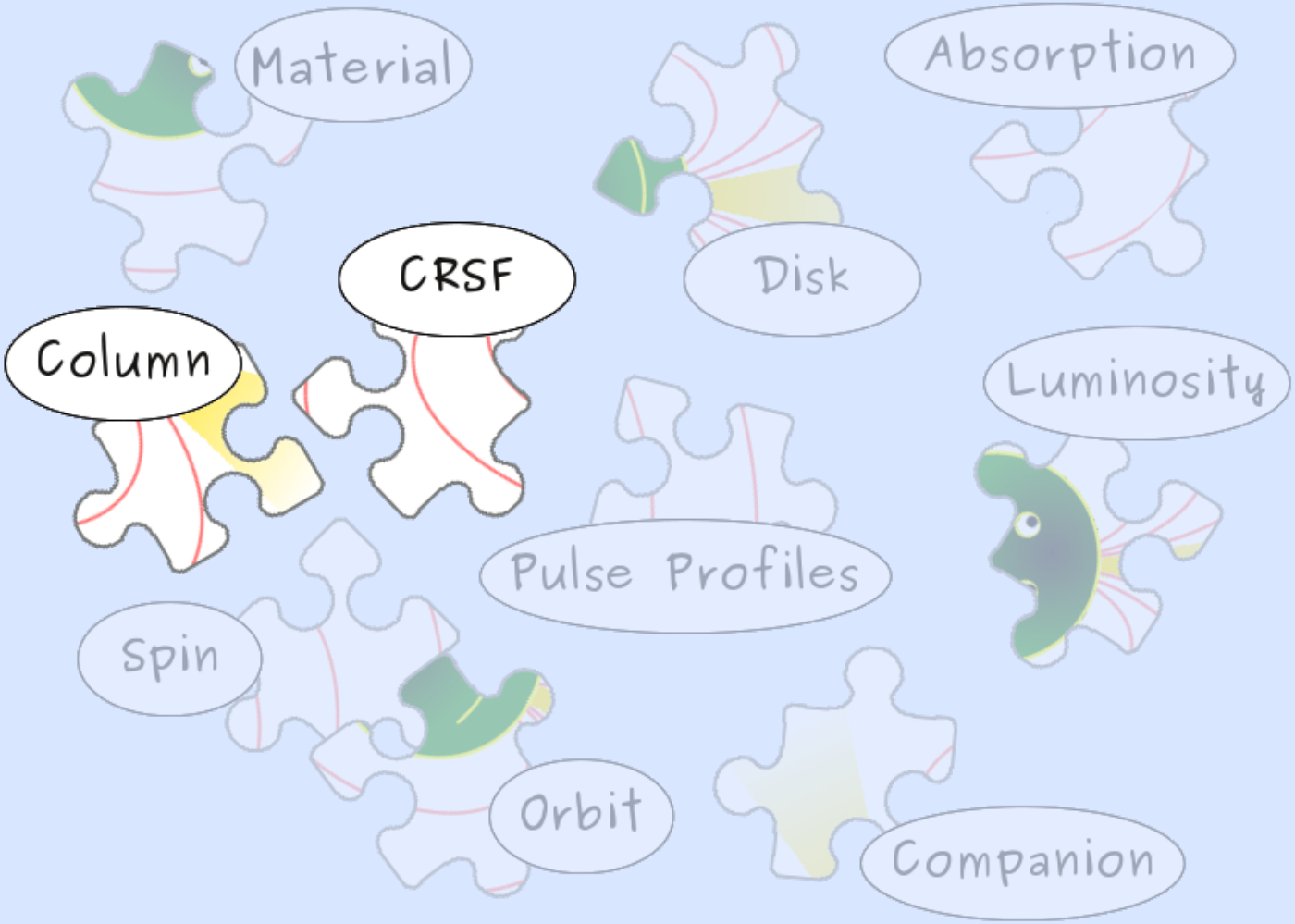
Be-mechanism

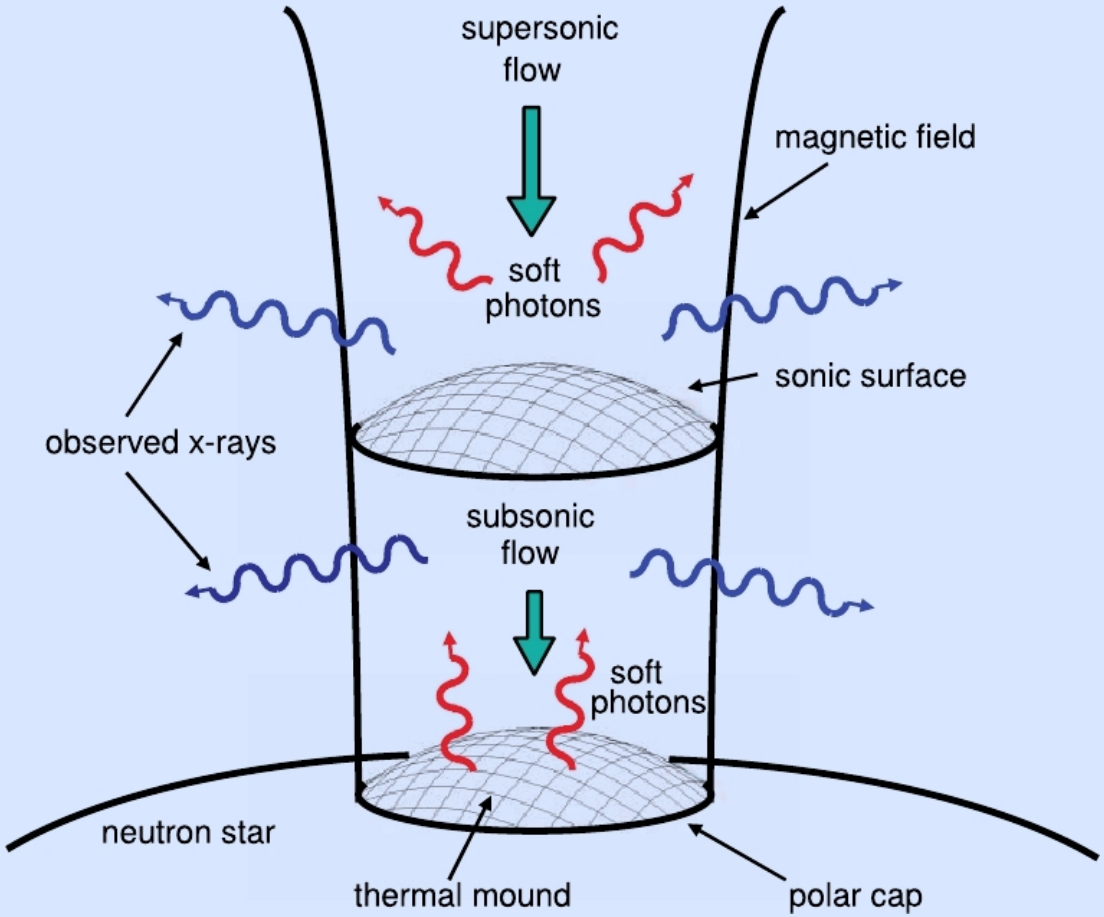


Kretschmar (1996)



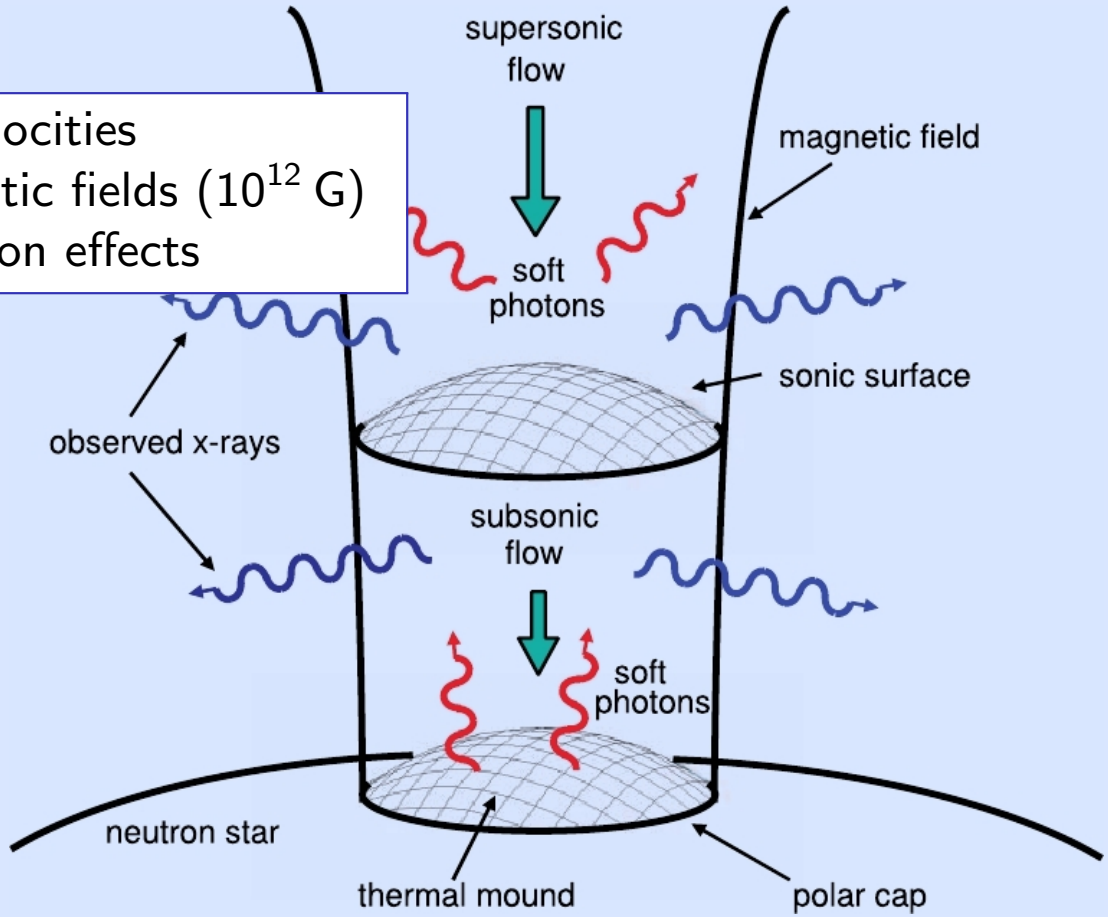
accretion rate changes
within **orders** of magnitude


Material
Absorption
Disk
CRSF
Column
Luminosity
Pulse Profiles
Spin
Orbit
Companion

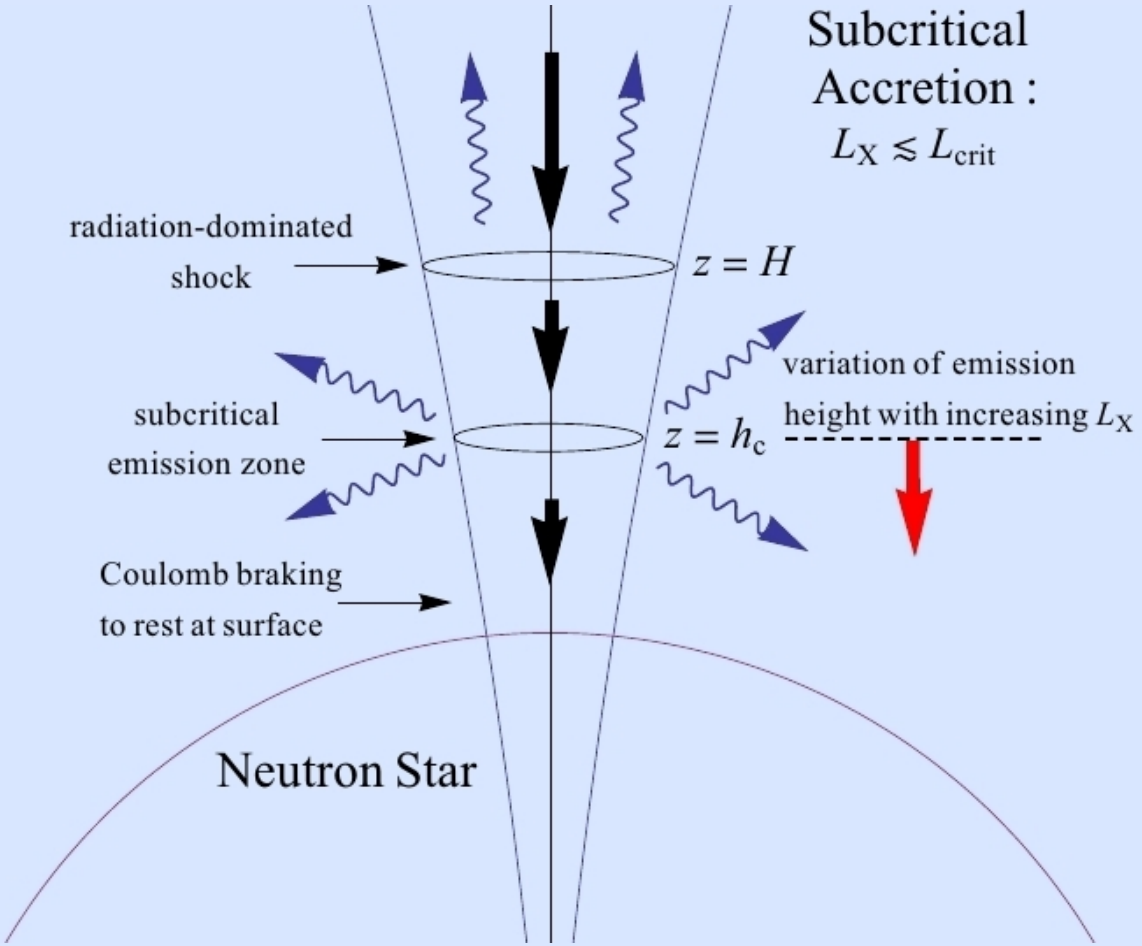


Becker & Wolff (2007)

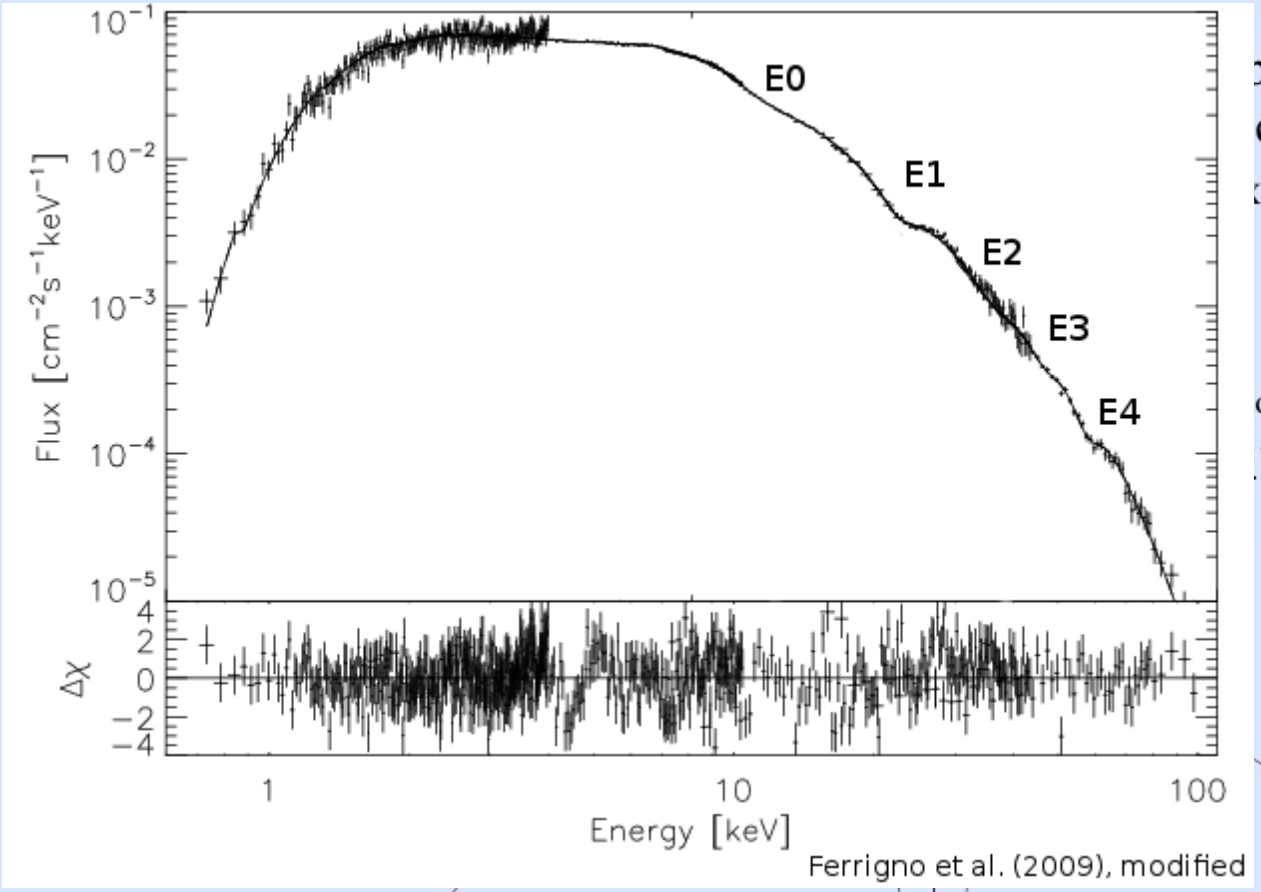
relativistic velocities
strong magnetic fields (10^{12} G)
Comptonization effects



Becker & Wolff (2007)



Becker et al. (2012)

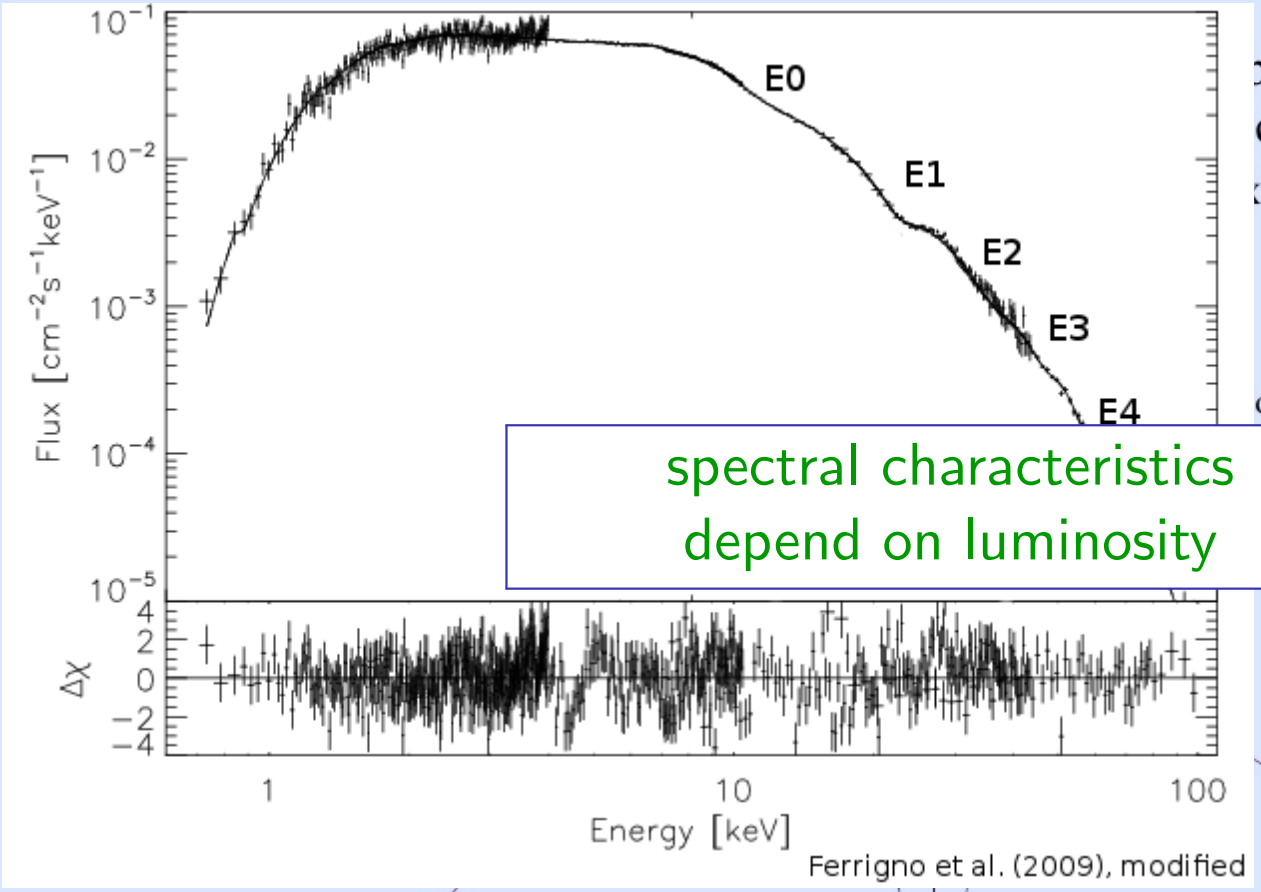


Ferrigno et al. (2009), modified

ocritical
cretion :
$\lesssim L_{\rm crit}$

on of emission
with increasing $L_{\rm X}$

Becker et al. (2012)



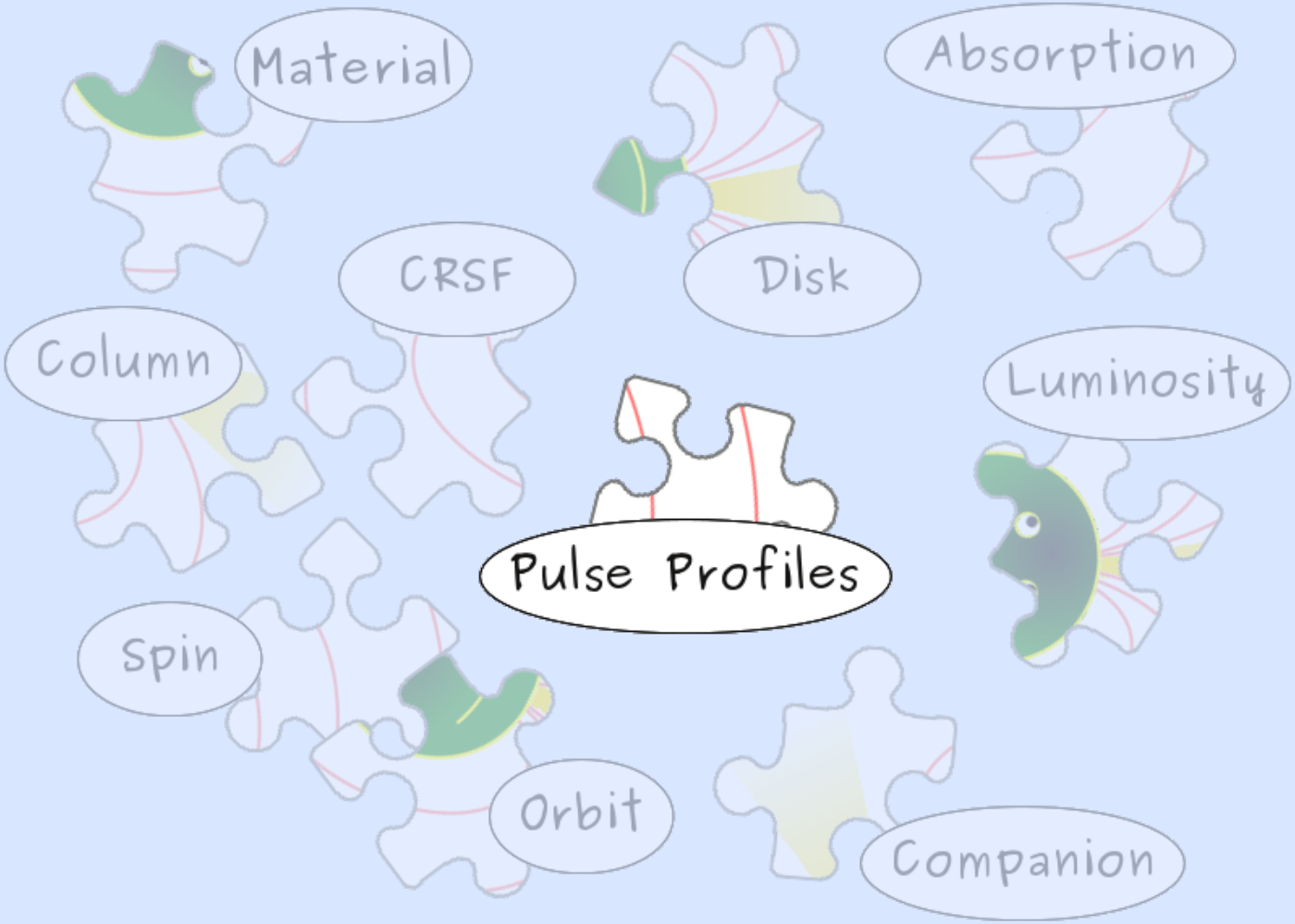
Ferrigno et al. (2009), modified

spectral characteristics
depend on luminosity

...critical
...cretion :
$\dot{x} \lesssim L_{\rm crit}$

...on of emission
...asing $L_{\rm X}$

Becker et al. (2012)


Material
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CRSF
Column
Luminosity
Pulse Profiles
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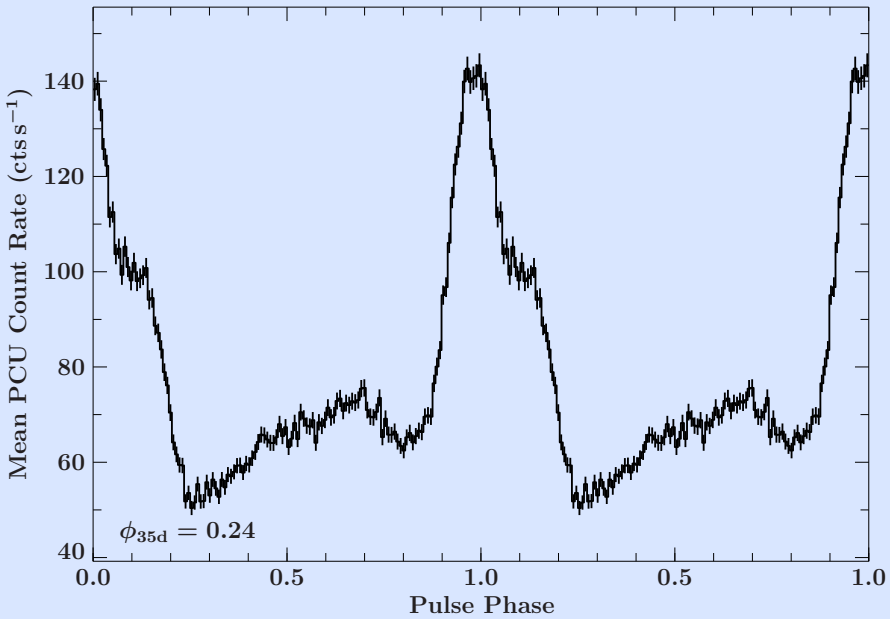
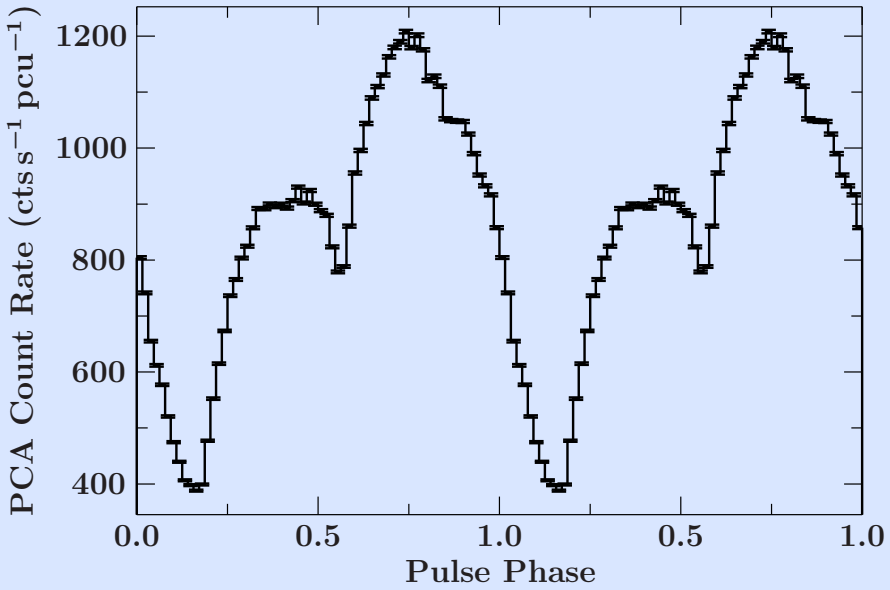
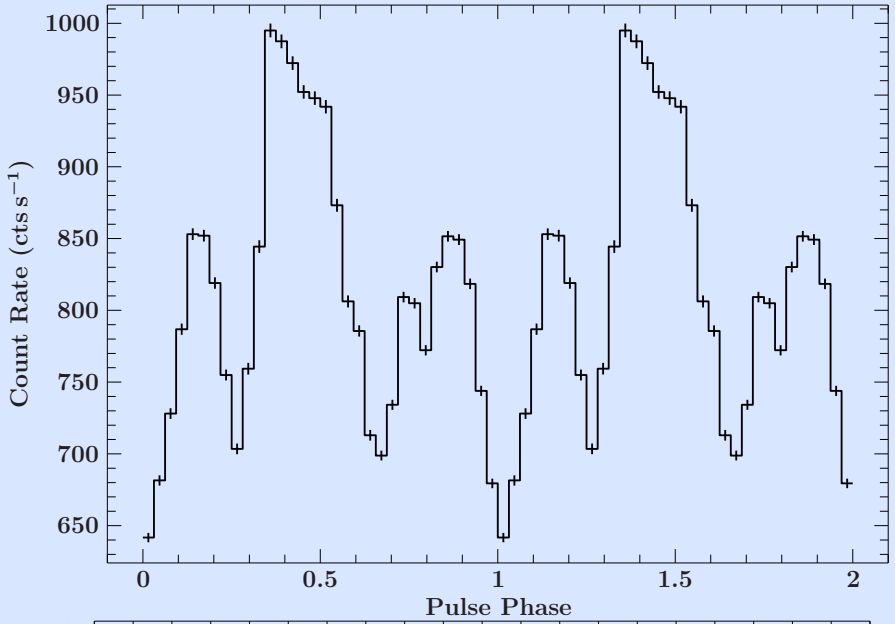
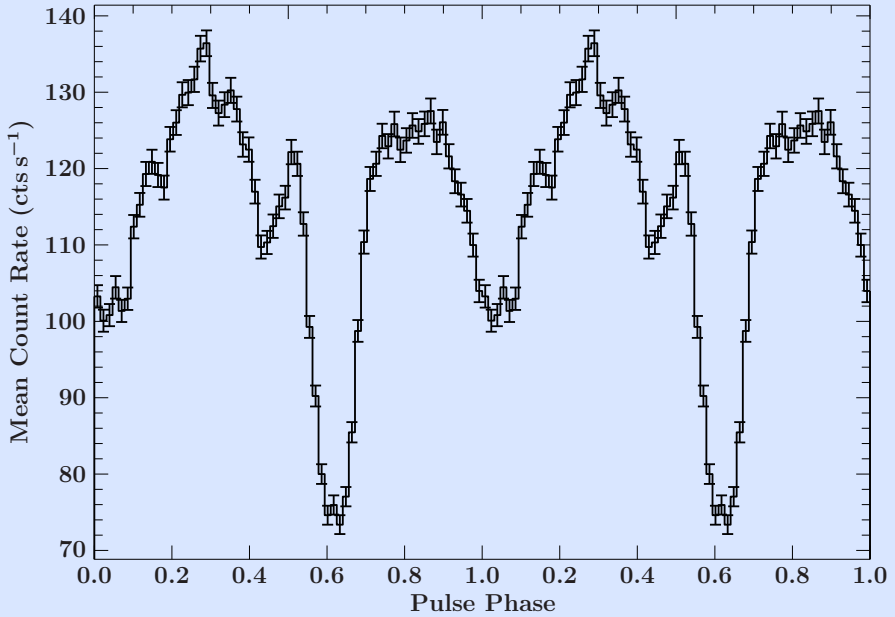
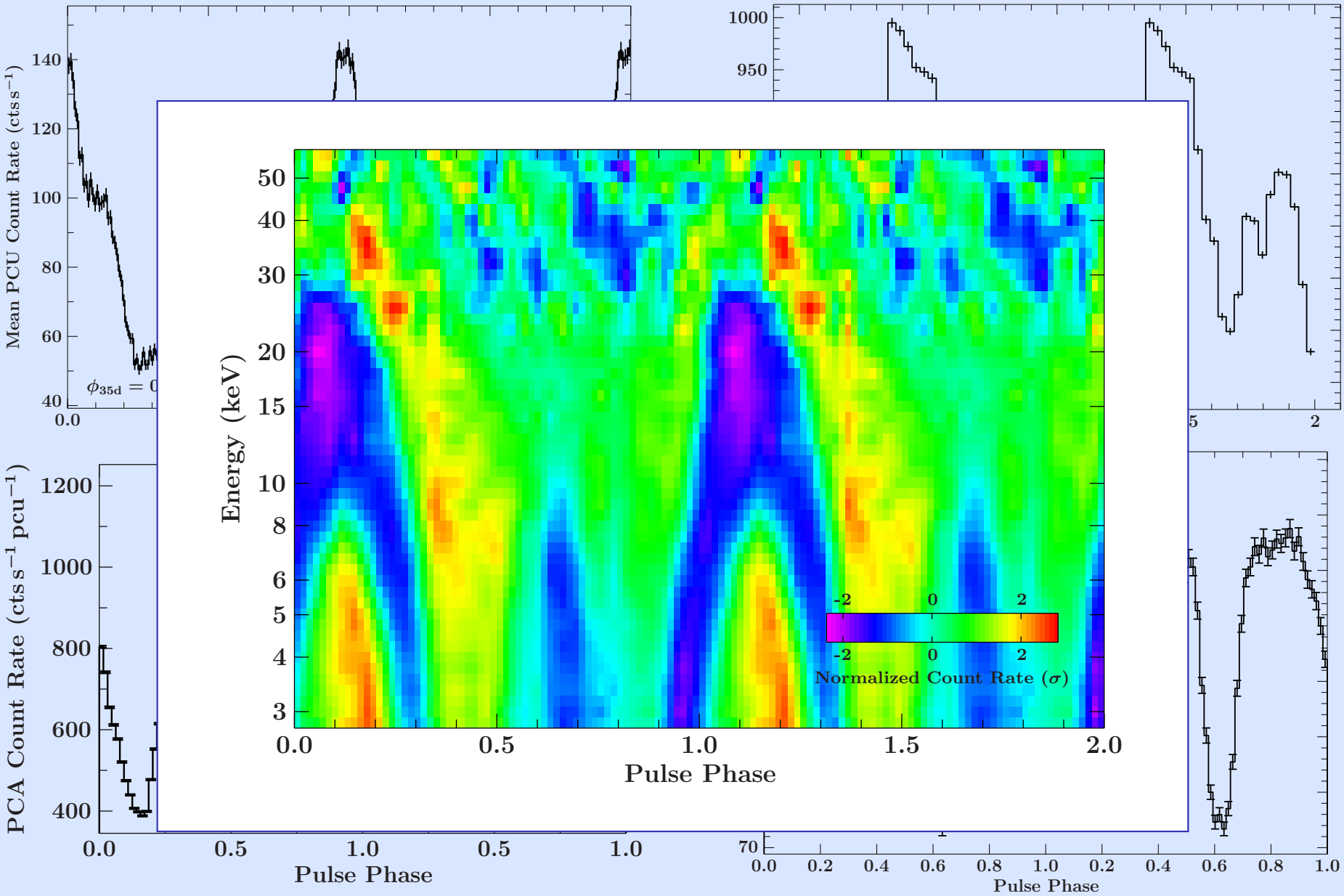
Orbit
Companion

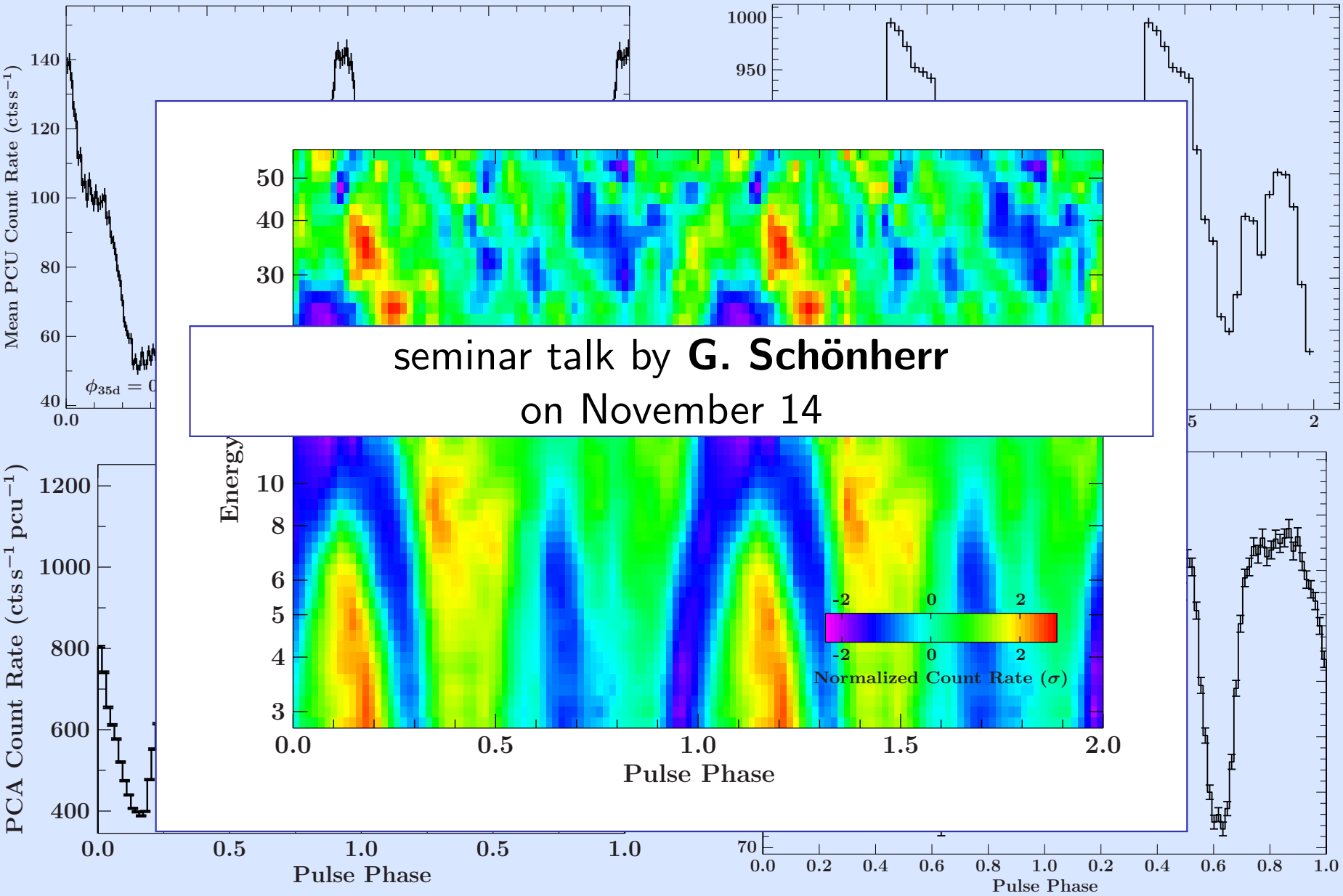

Mean PCU Count Rate (cts s^{-1})
$\phi_{35d} = 0.24$
Pulse Phase


PCA Count Rate (cts s^{-1} pcu^{-1})
Pulse Phase

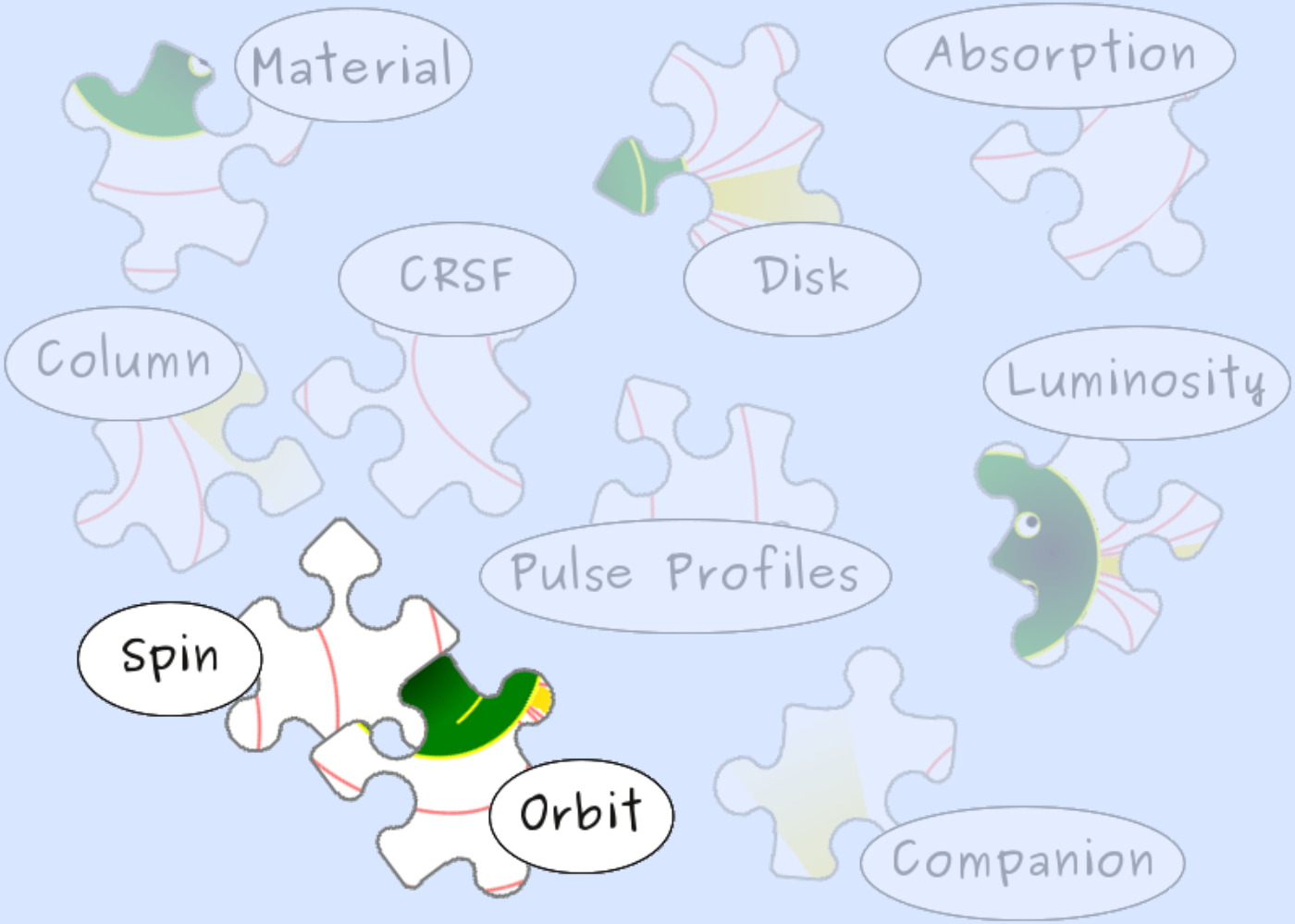

Count Rate (cts s^{-1})
Pulse Phase


Mean Count Rate (cts s^{-1})
Pulse Phase


Mean PCU Count Rate (cts s^{-1})
$\phi_{35d} = 0$
PCA Count Rate (cts s^{-1} pcu^{-1})
Pulse Phase
Energy (keV)
Normalized Count Rate (σ)



seminar talk by **G. Schönherr**
on November 14


Material
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Orbit
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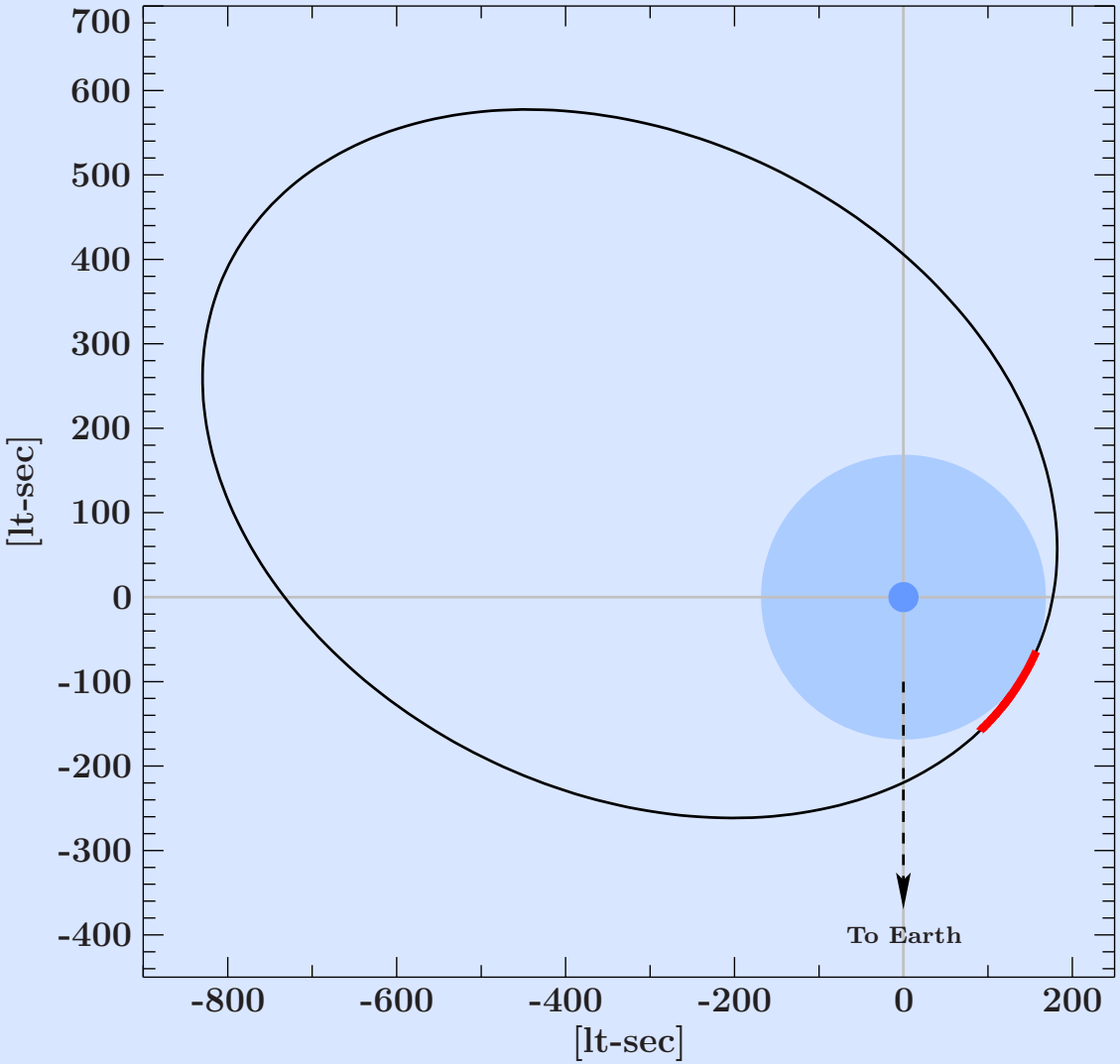


GRO J1008–57

- $R_\star = 7\,\mathrm{R}_\odot$
- $R_{\mathrm{disk}} = 52\,\mathrm{R}_\odot$ (?)

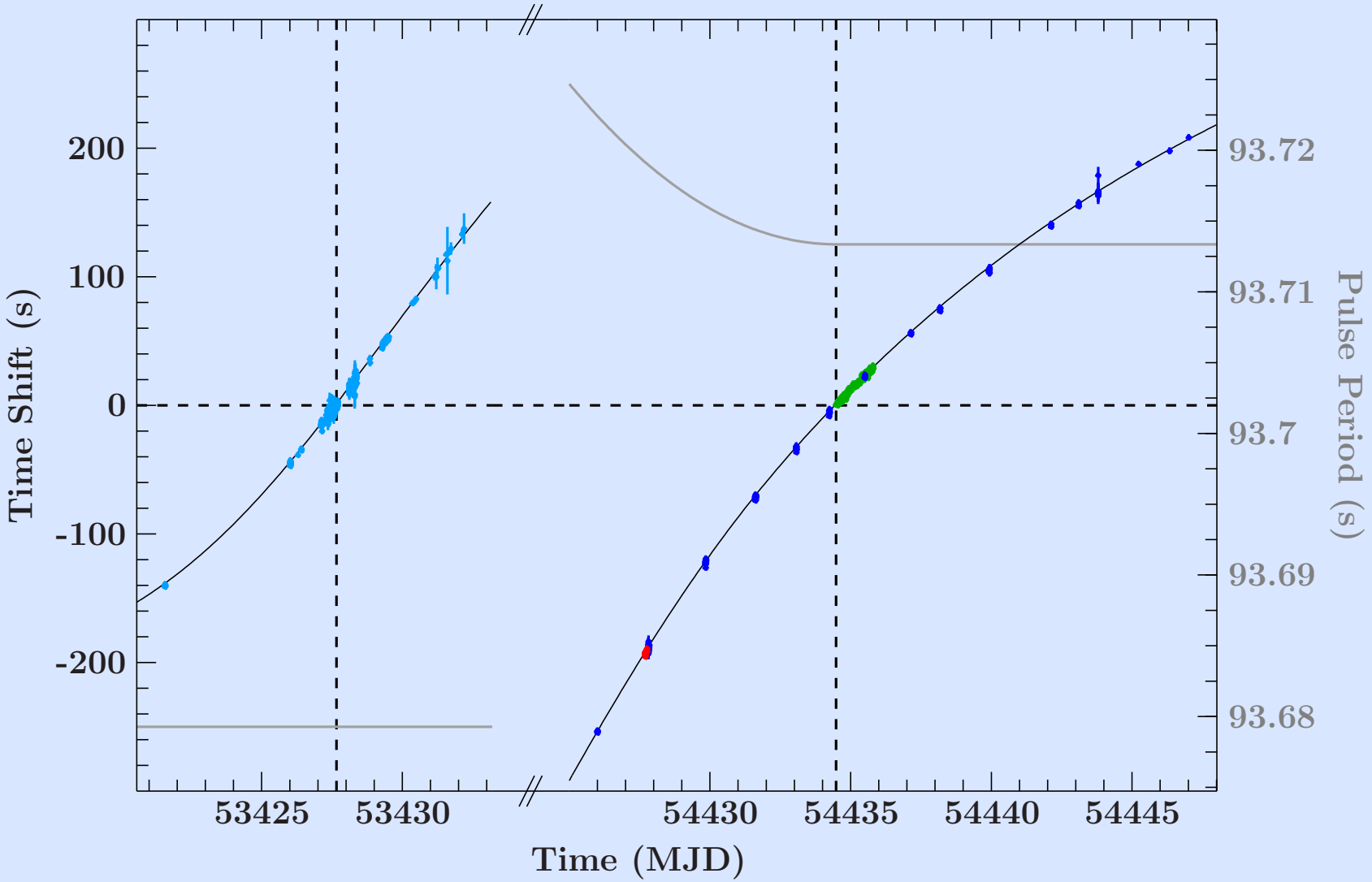
Coe et. al (2007)

- $P_{\mathrm{orb}} = 249.48\,\mathrm{d}$
- $\phi_{\mathrm{outburst}} = -0.03$

Kühnel et. al (2013)

Outbursts in 2005 and 2007

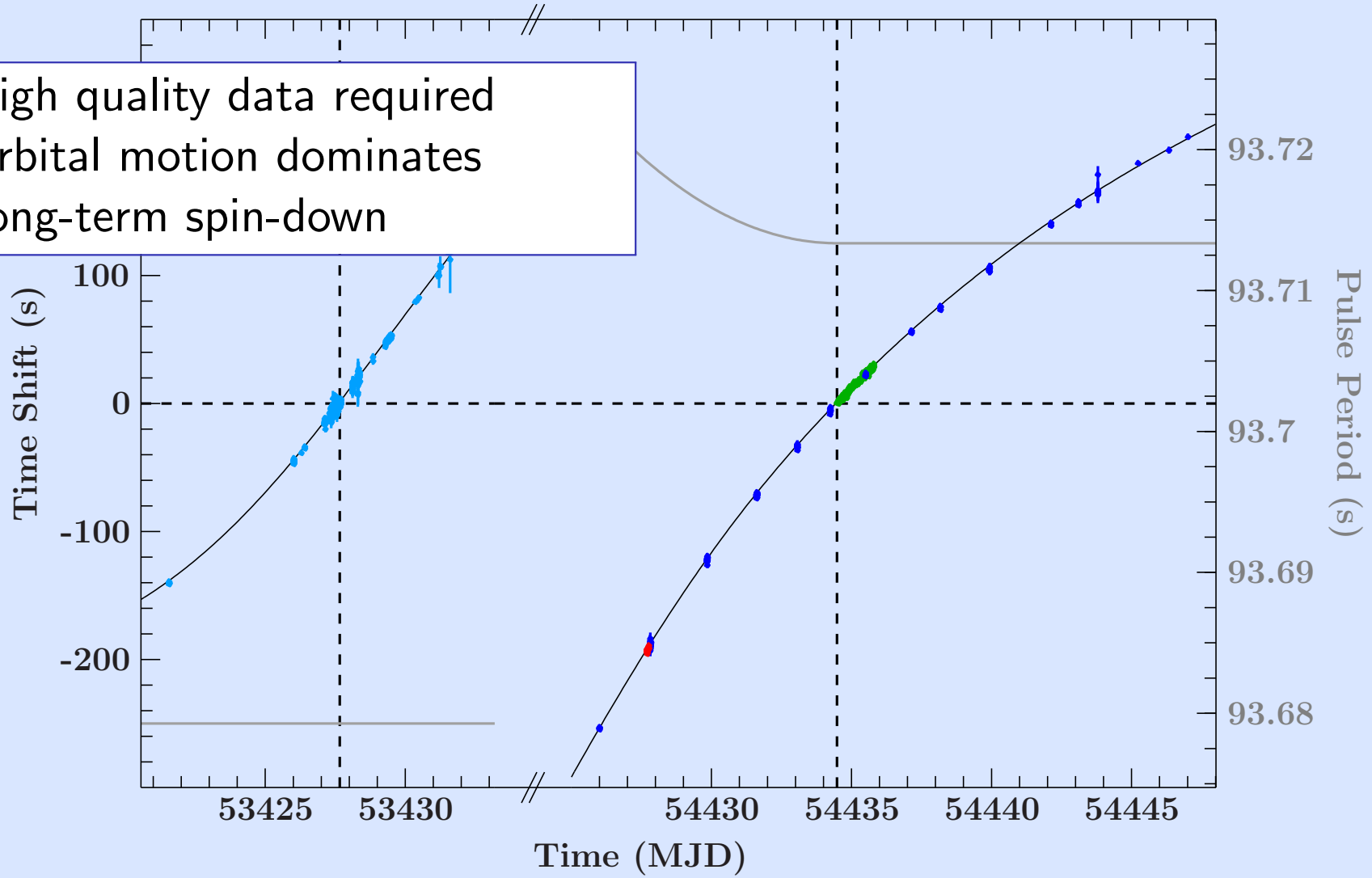
RXTE, *Suzaku* and *Swift*



Outbursts in 2005 and 2007

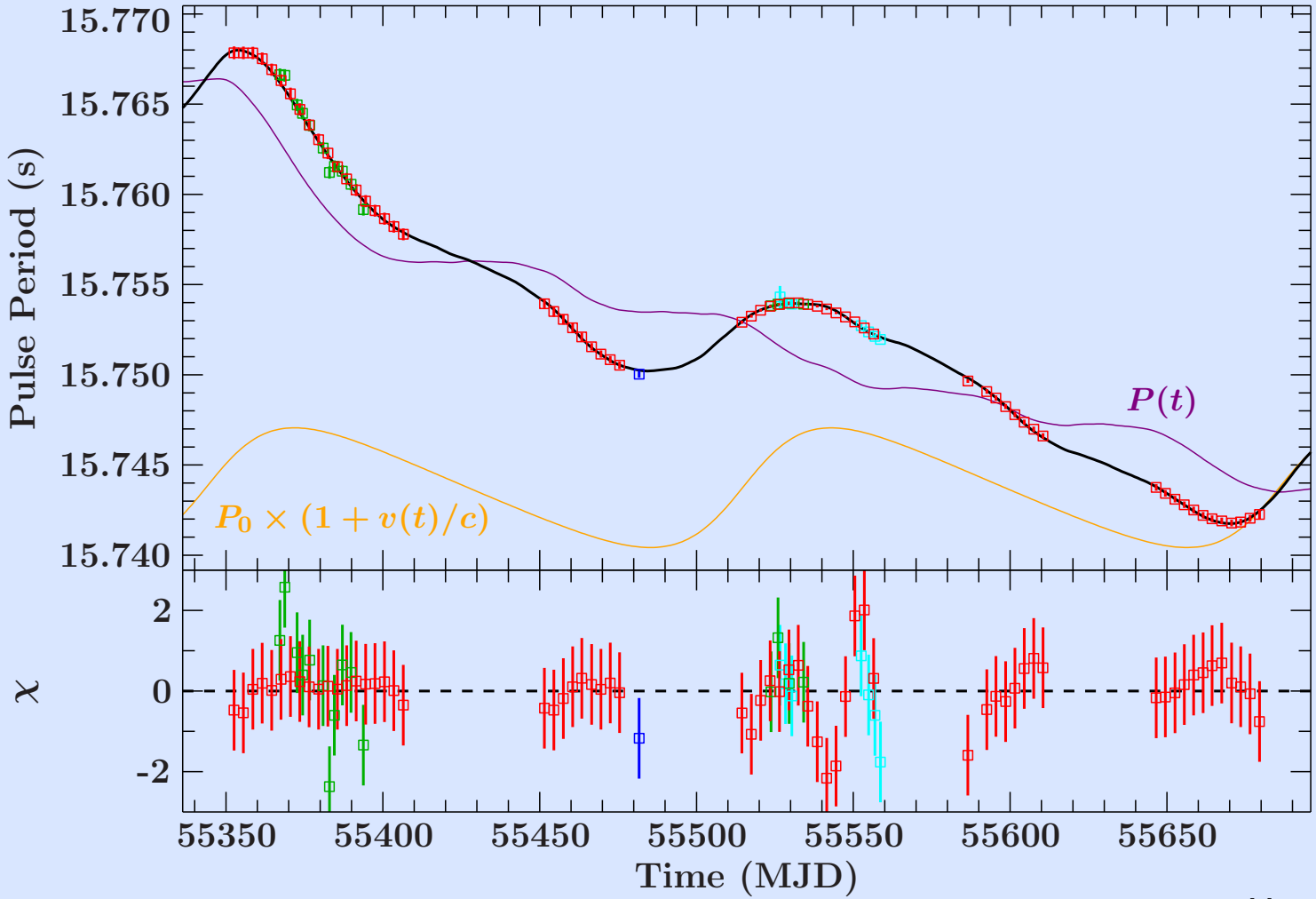
RXTE, *Suzaku* and *Swift*

high quality data required
orbital motion dominates
long-term spin-down



XTE J1946+274

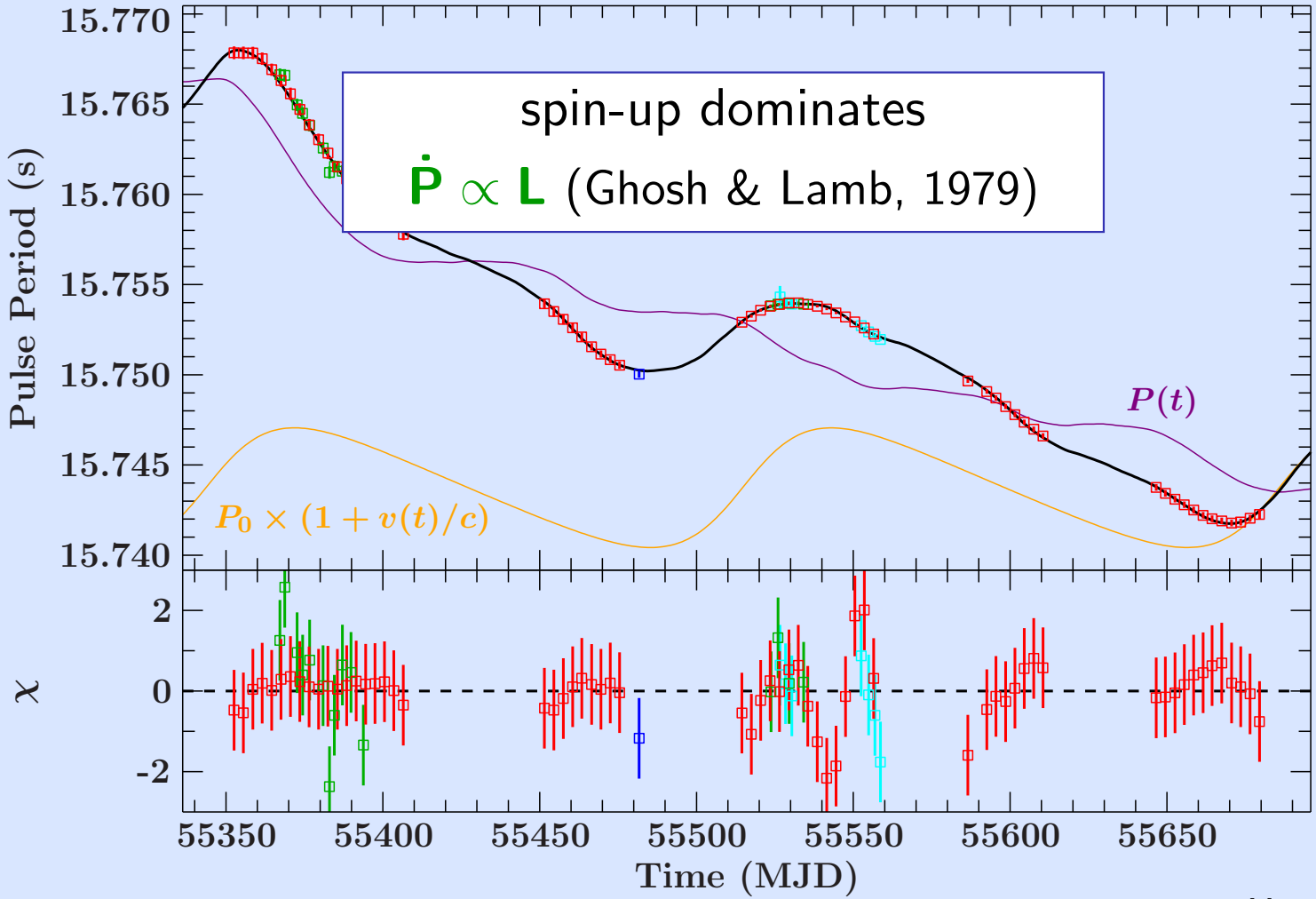
Fermi-GBM, *RXTE*, *Suzaku*, and *Swift*



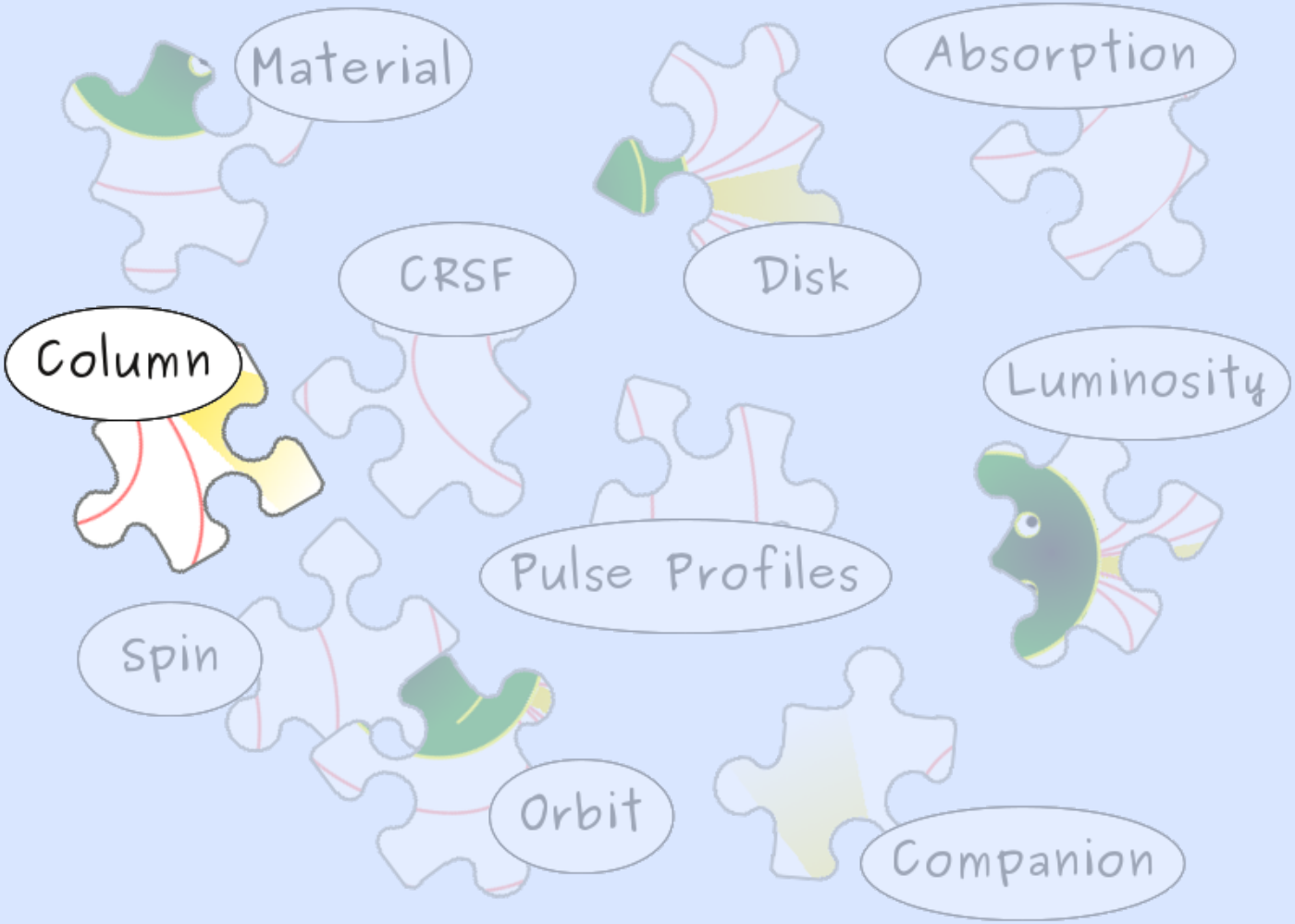
Marcu et al. (in prep.)

XTE J1946+274

Fermi-GBM, *RXTE*, *Suzaku*, and *Swift*

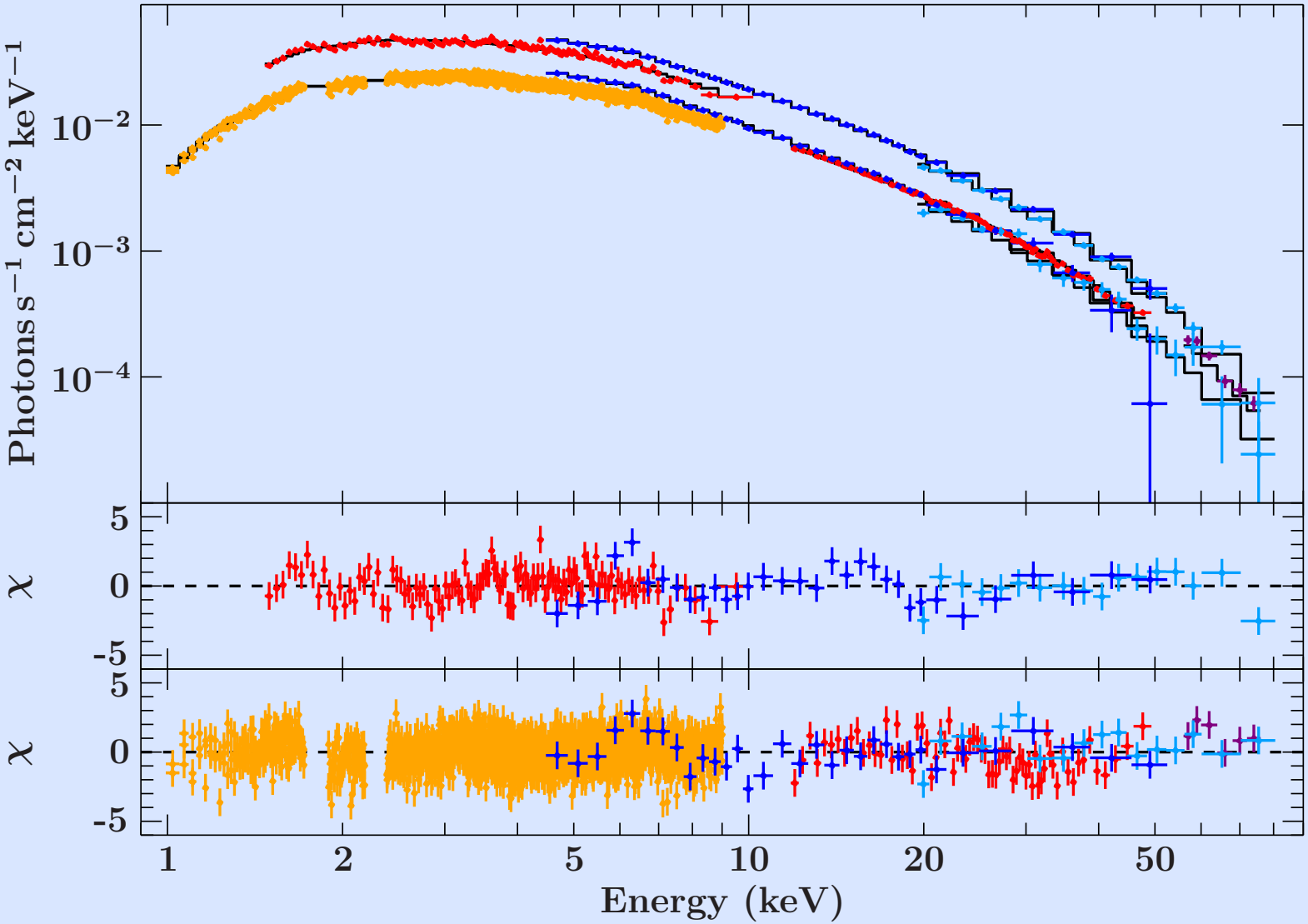


Marcu et al. (in prep.)


Material
Absorption
CRSF
Disk
Column
Luminosity
Pulse Profiles
Spin
Orbit
Companion

GRO J1008–57

Simultaneous fit of *Swift* + *RXTE* and *Suzaku* + *RXTE* spectra



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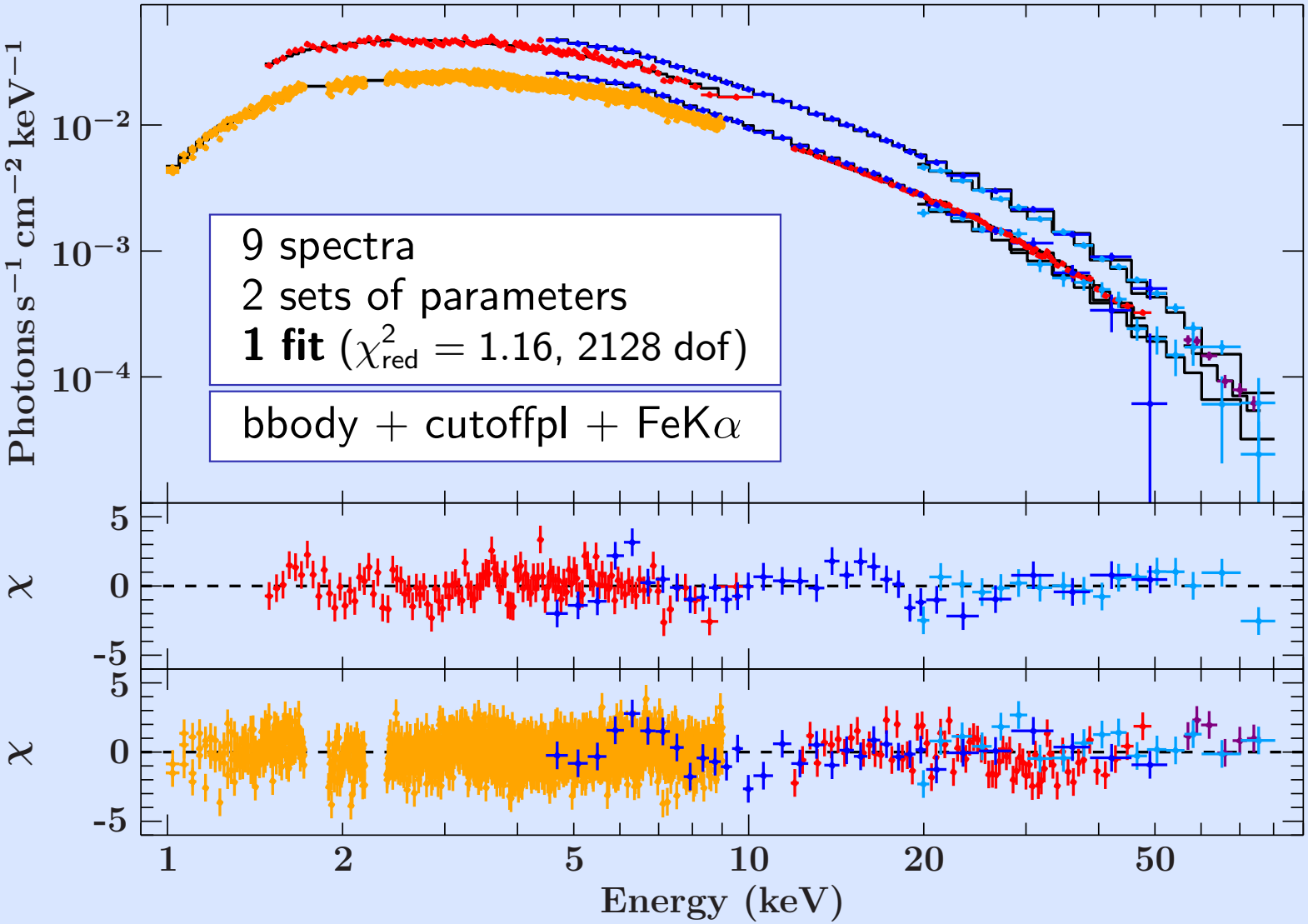

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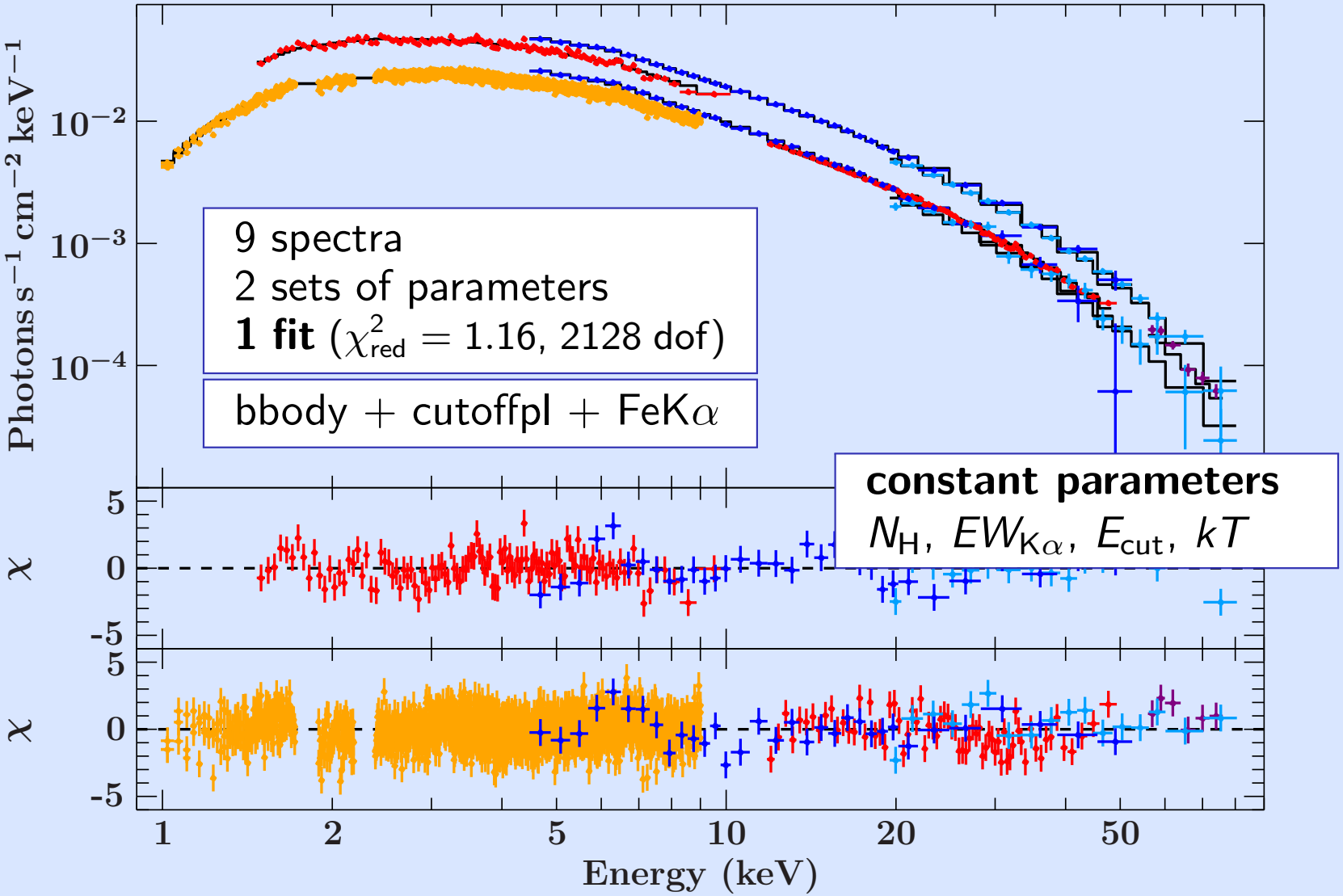
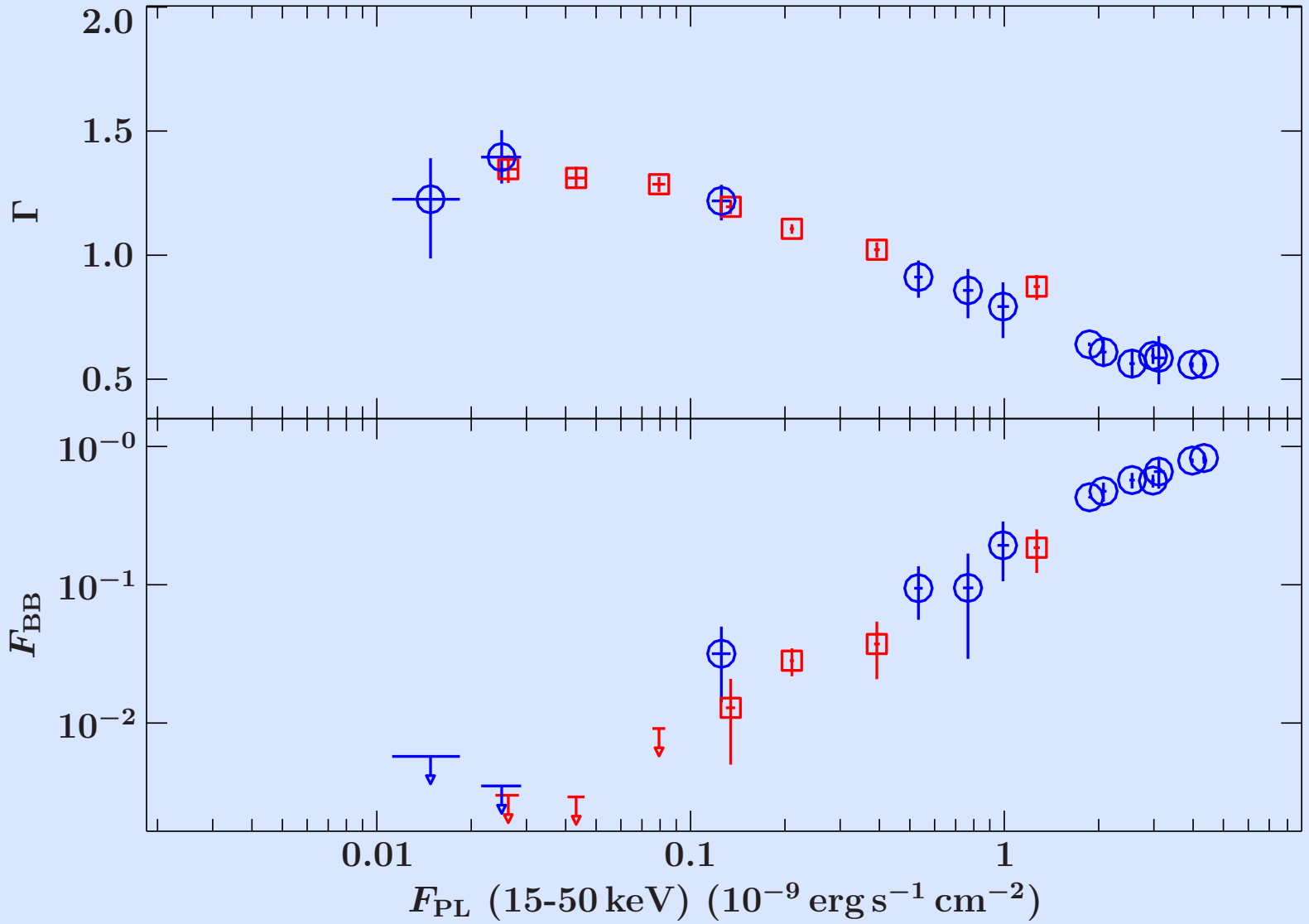
Simultaneous fit of *Swift* + *RXTE* and *Suzaku* + *RXTE* spectra



All spectra from 2005 and 2007



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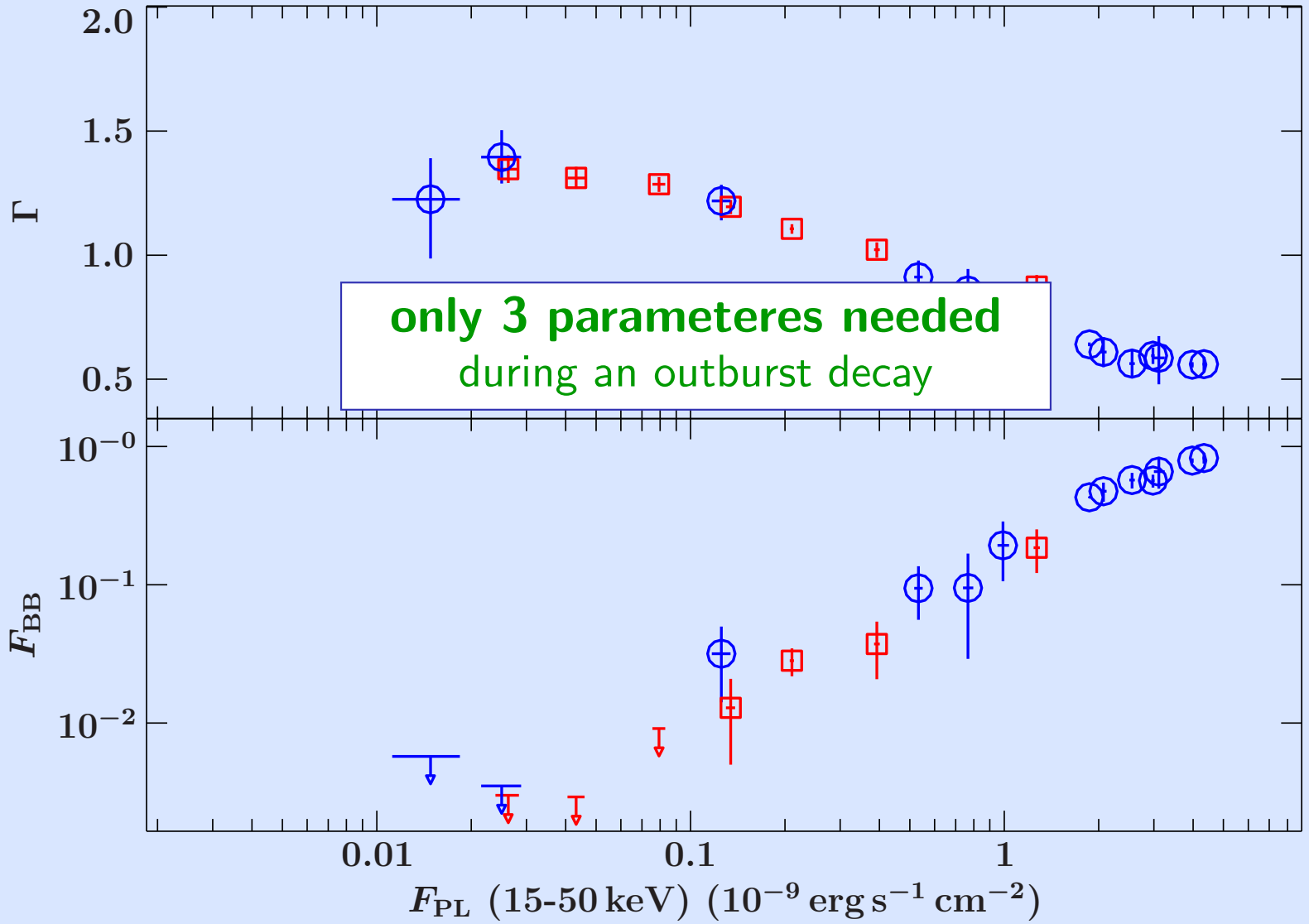
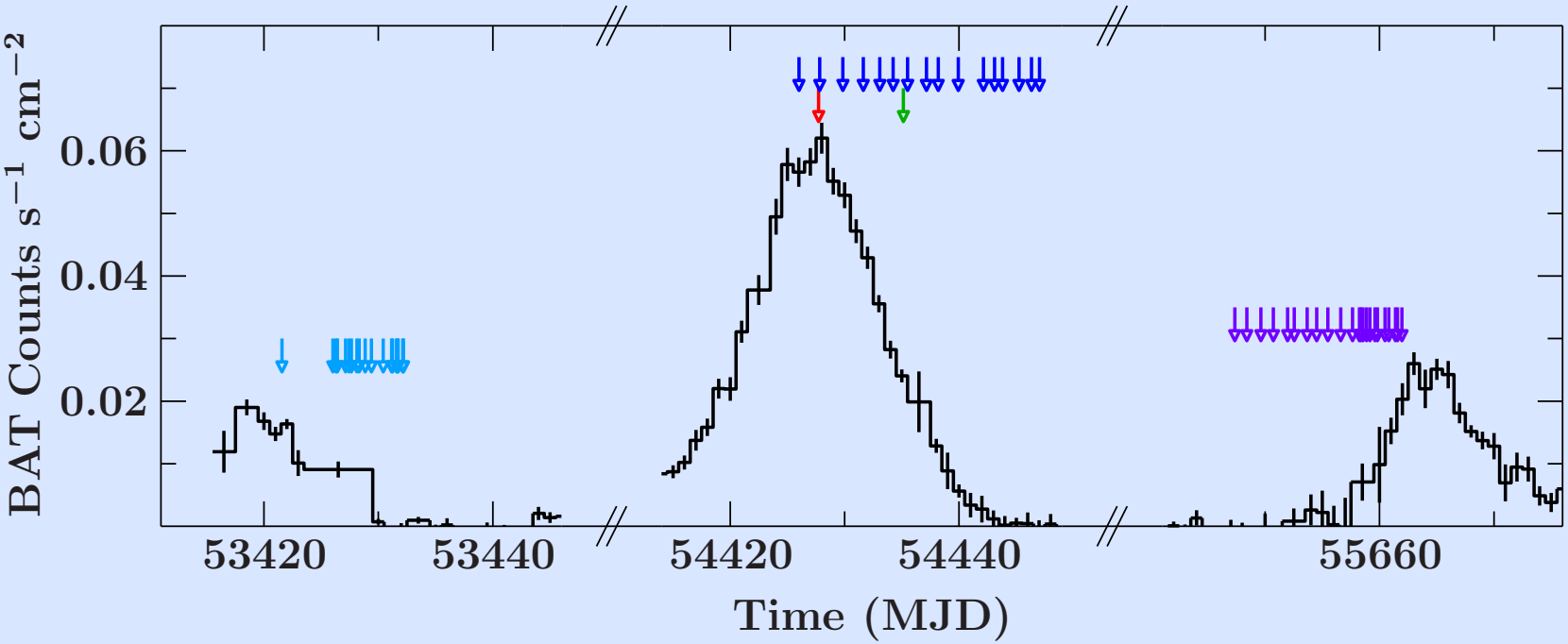


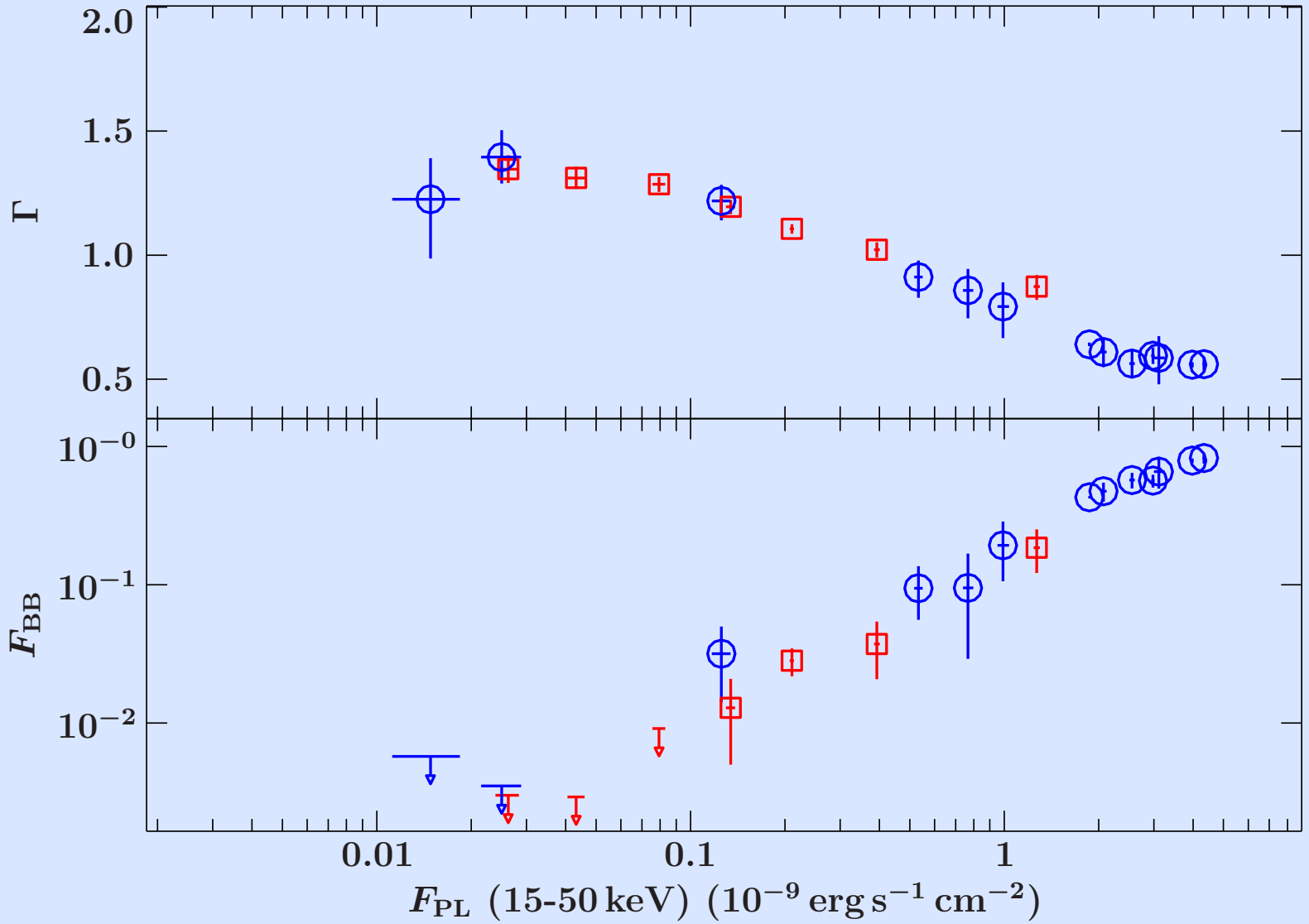
Outbursts in 2005, 2007, and 2011

monitored by *RXTE*, *Suzaku* and *Swift*

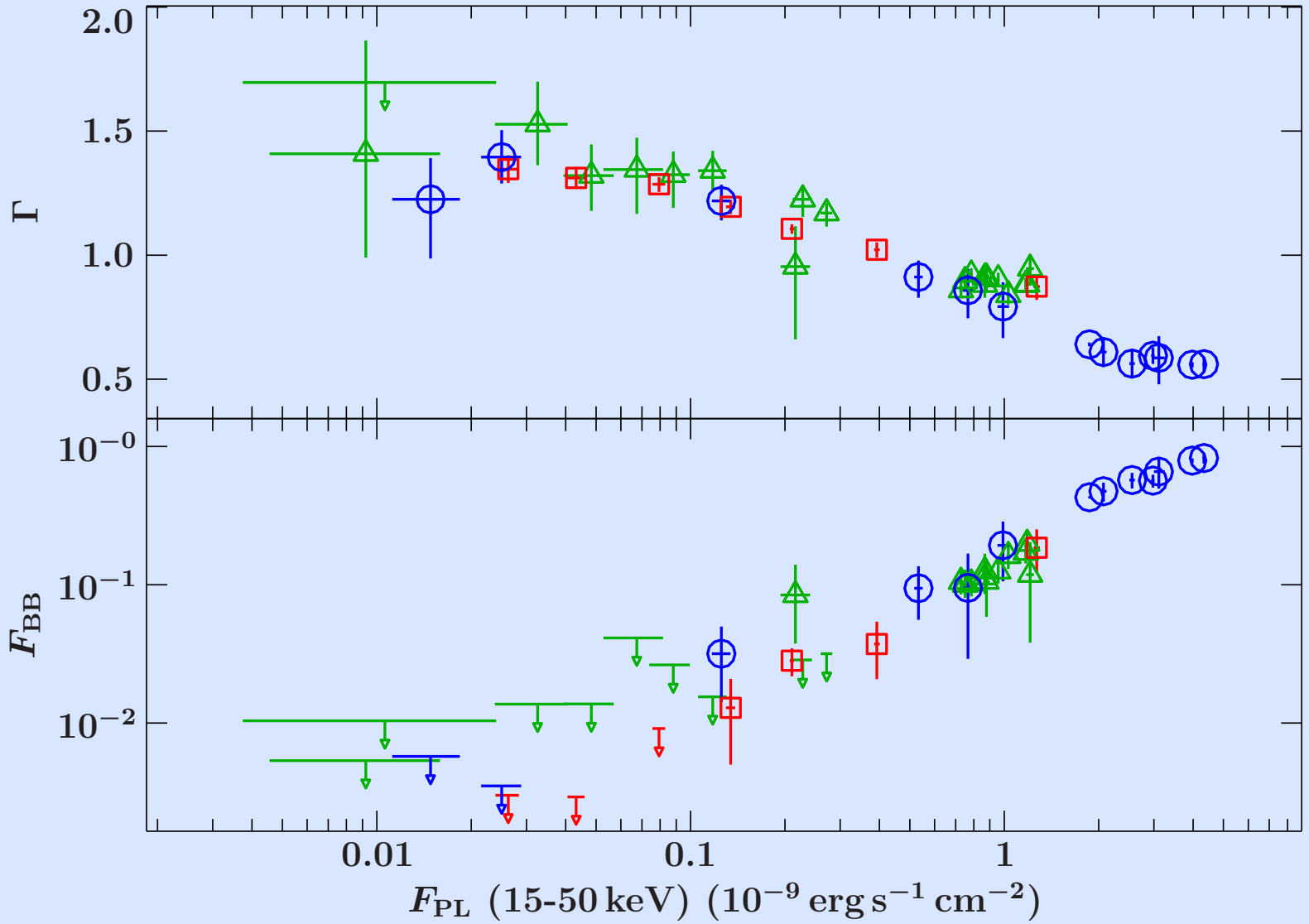
- outbursts are predictable
  → scheduled observations during the **rise of an outburst**



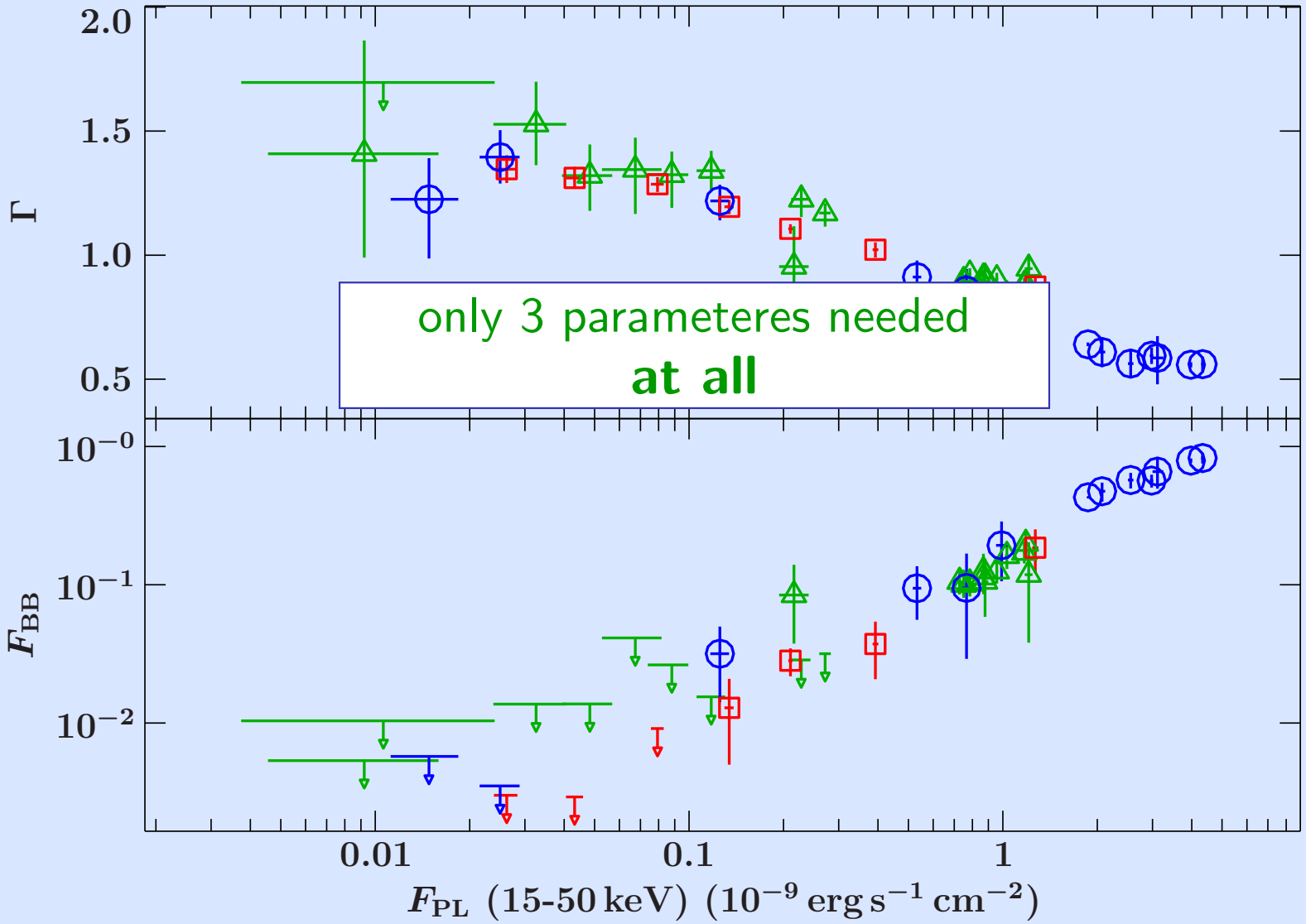
All spectra from 2005, 2007, and 2011



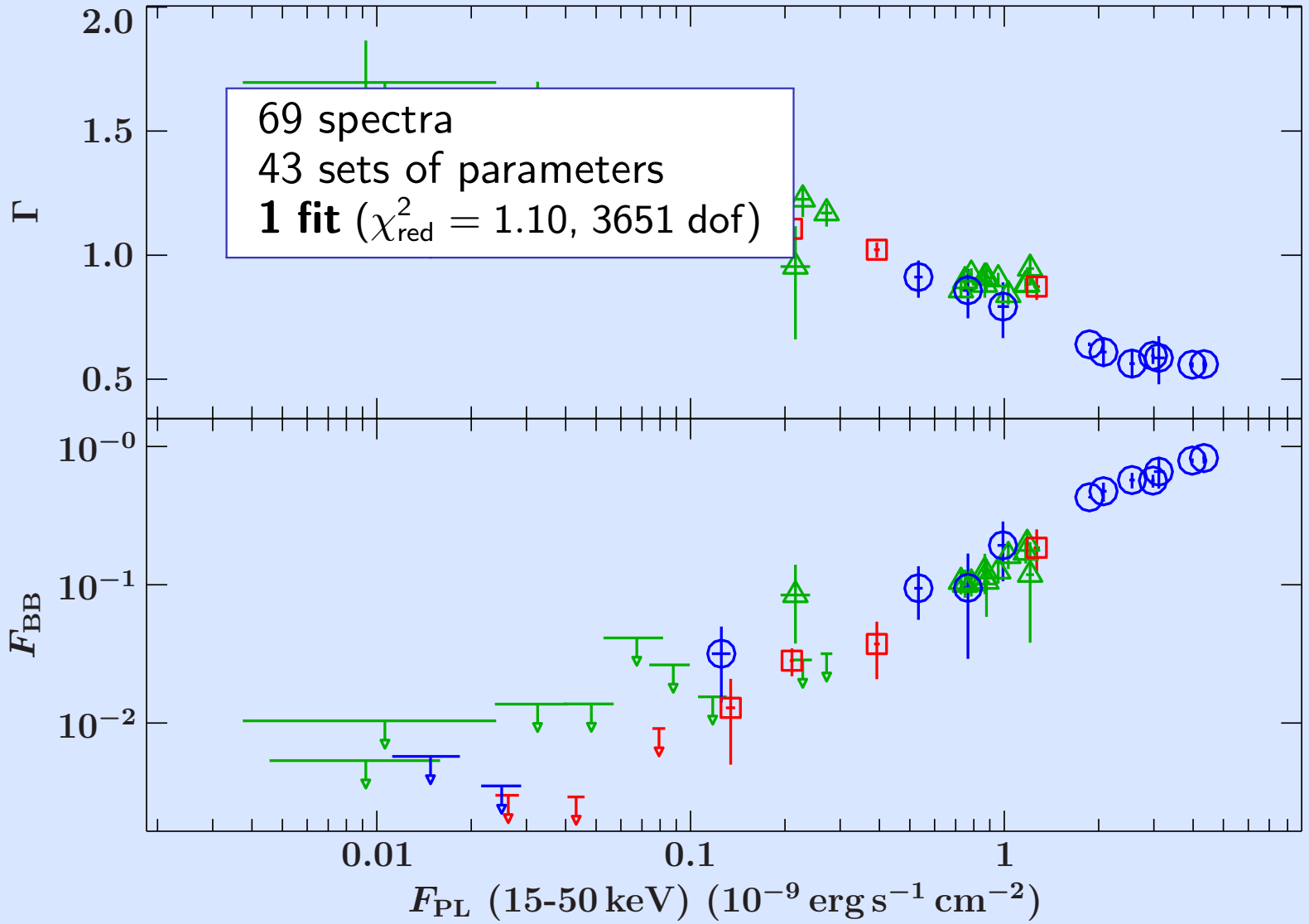
All spectra from 2005, 2007, and 2011



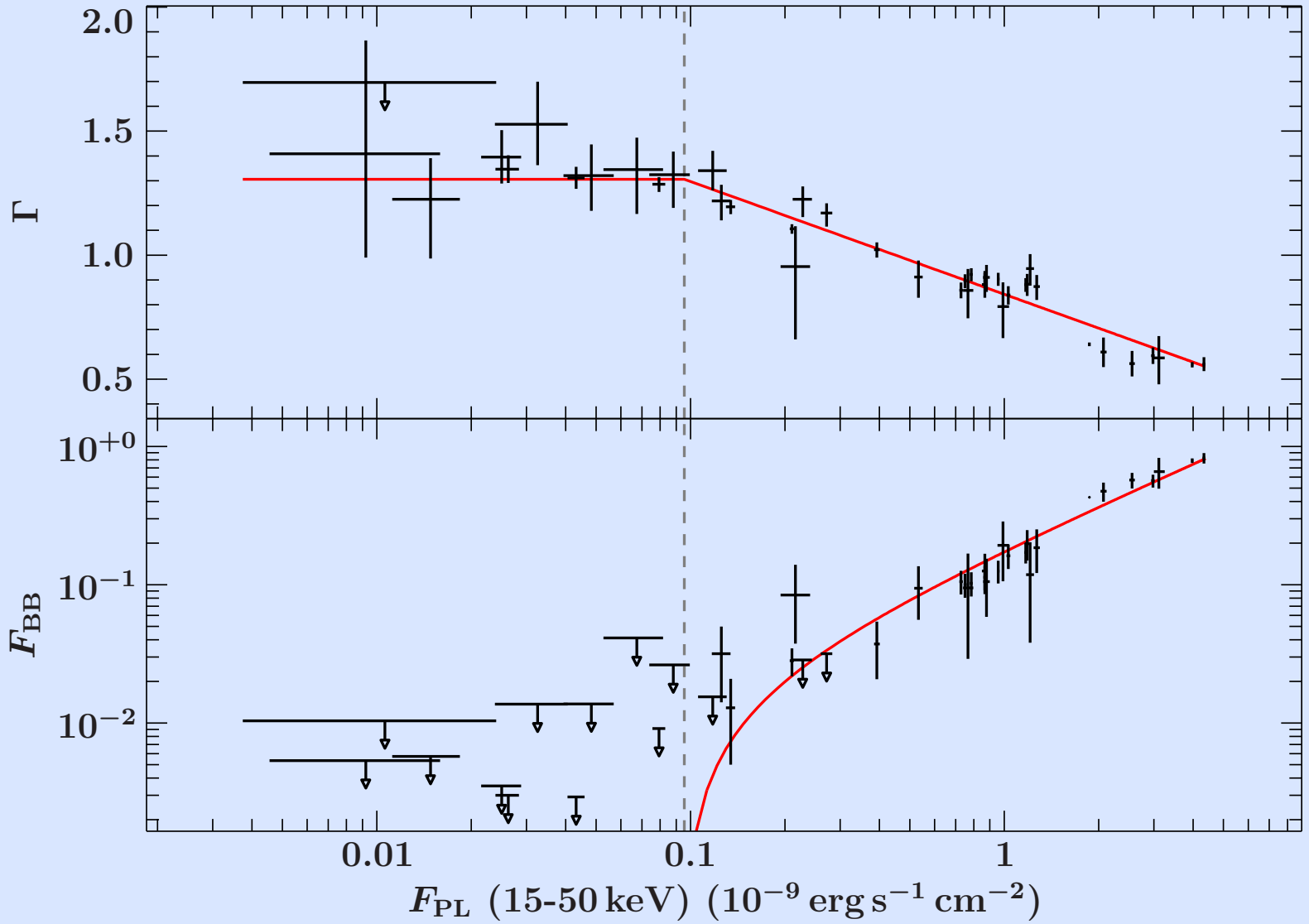
All spectra from 2005, 2007, and 2011



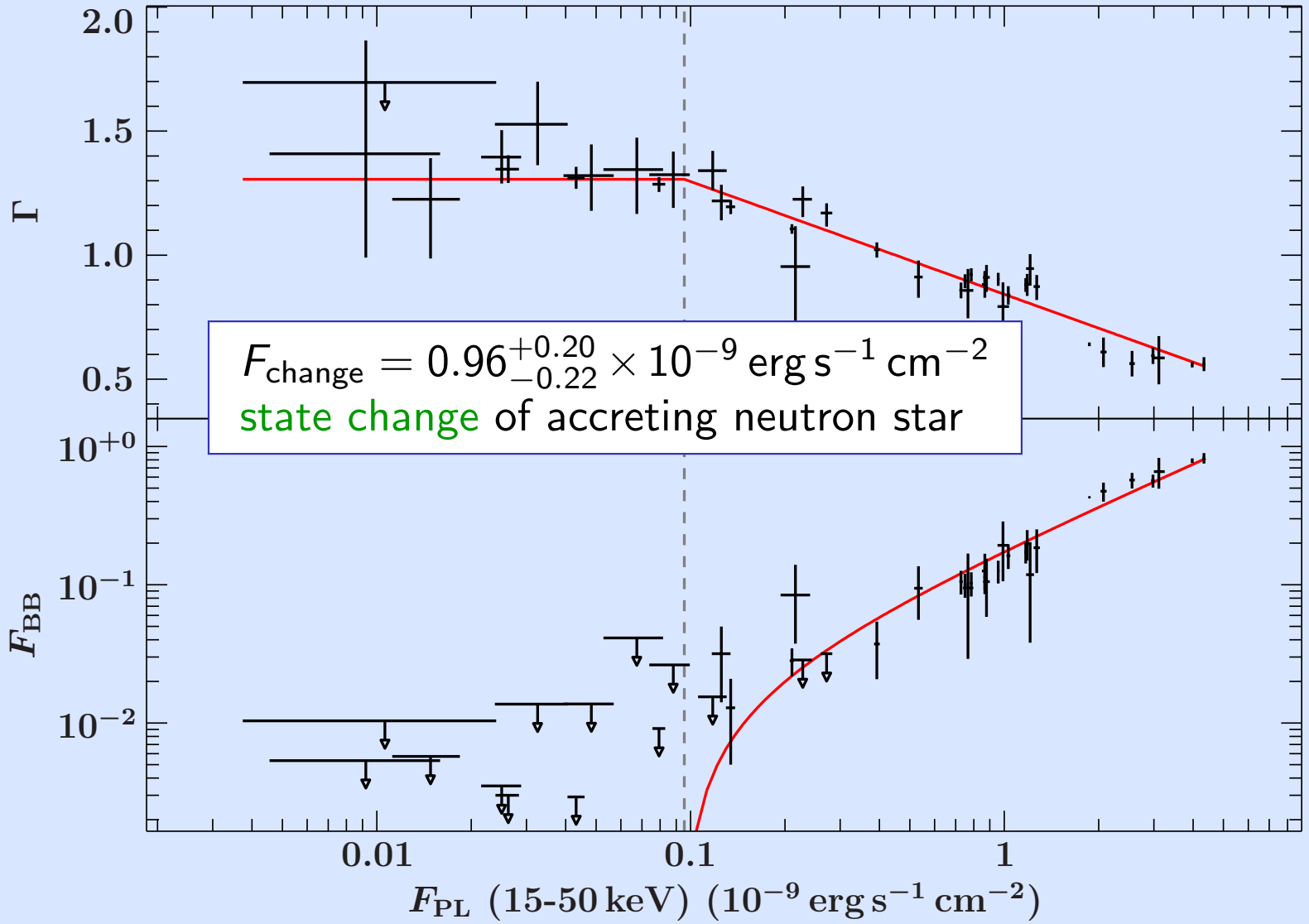
All spectra from 2005, 2007, and 2011



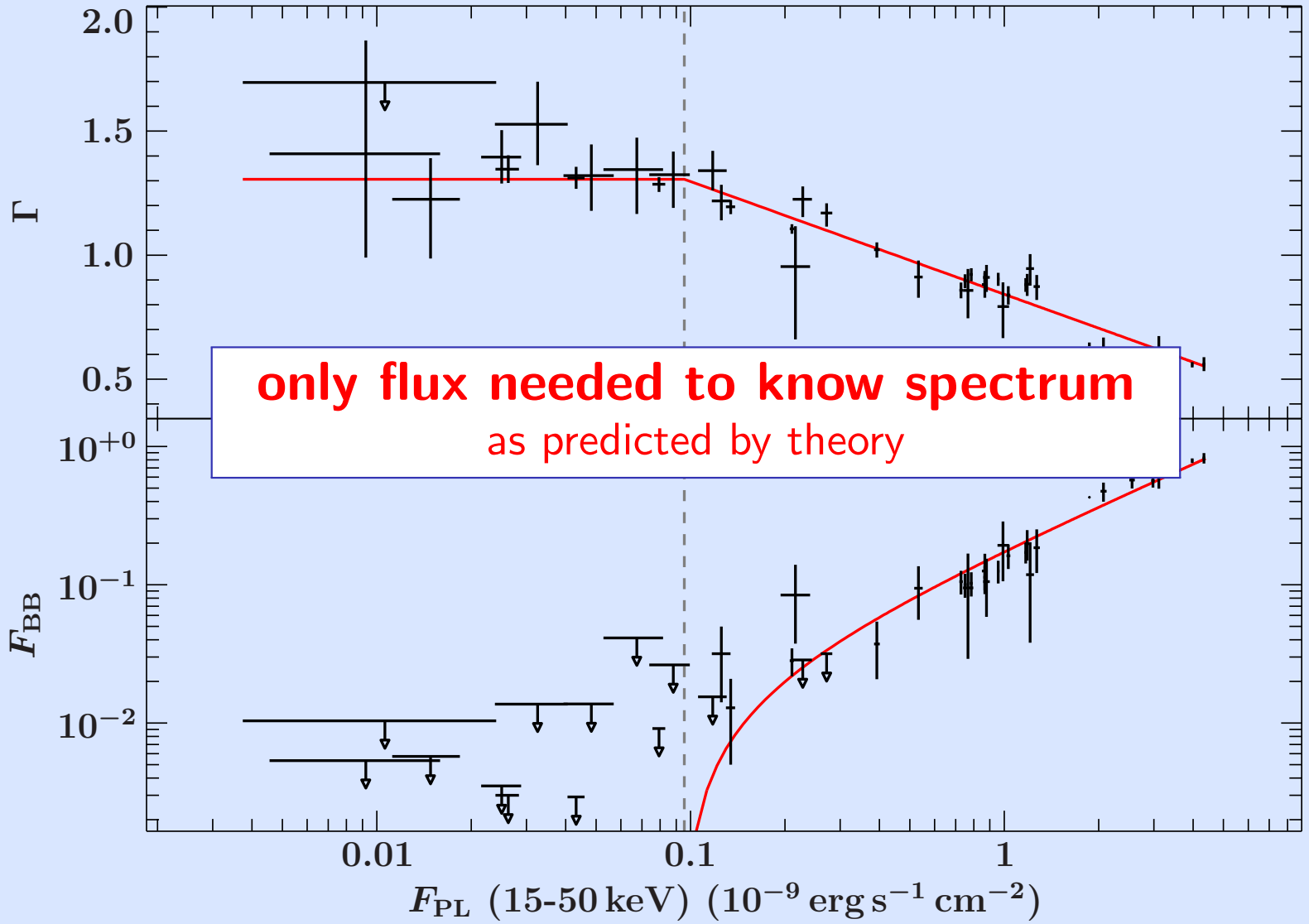
Fitting parameter correlations



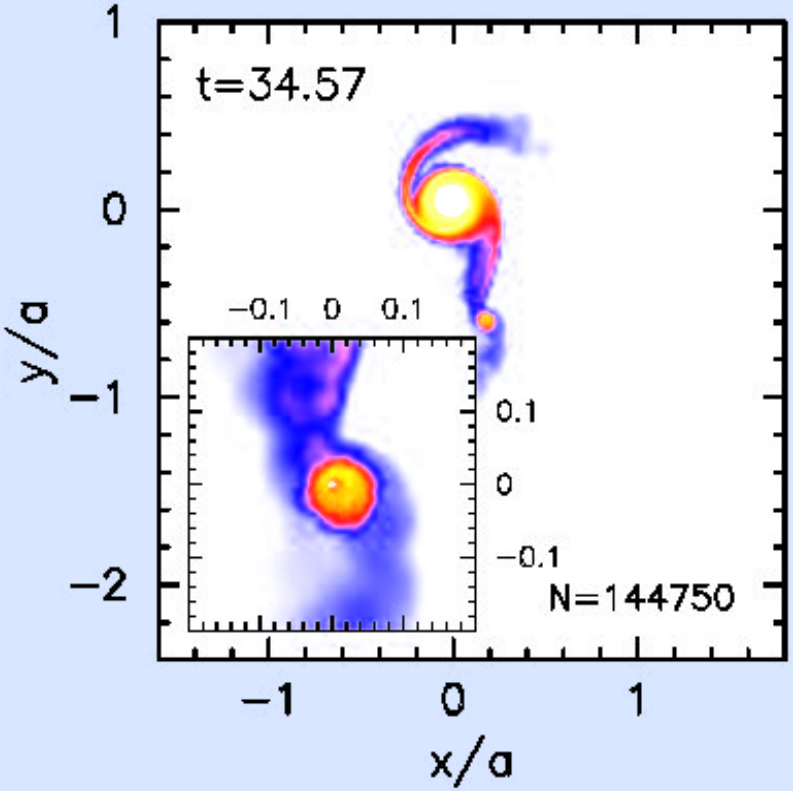
Fitting parameter correlations



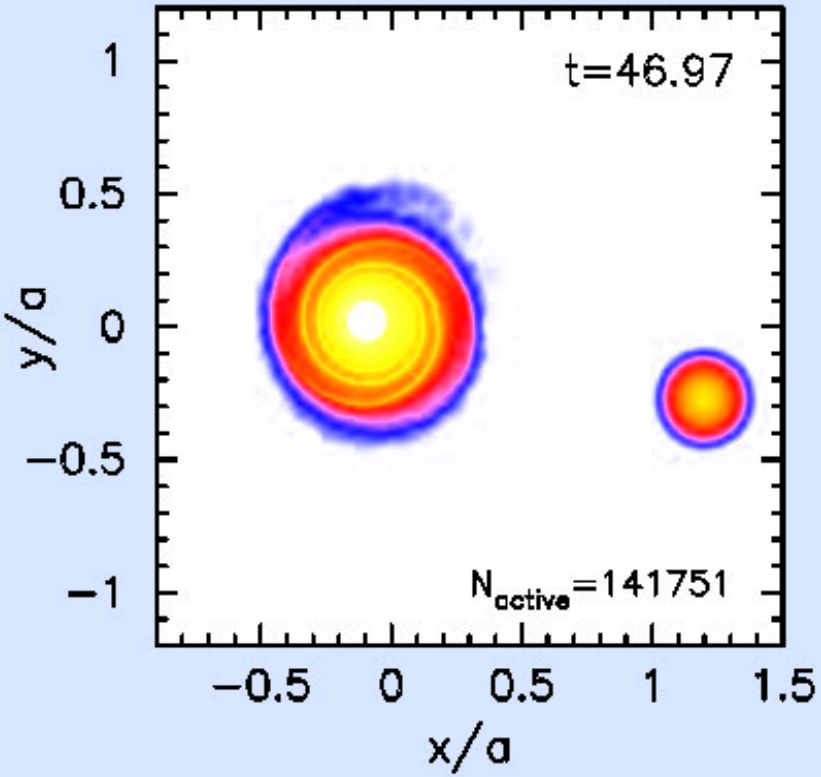
Fitting parameter correlations



BeXRB outburst lightcurves



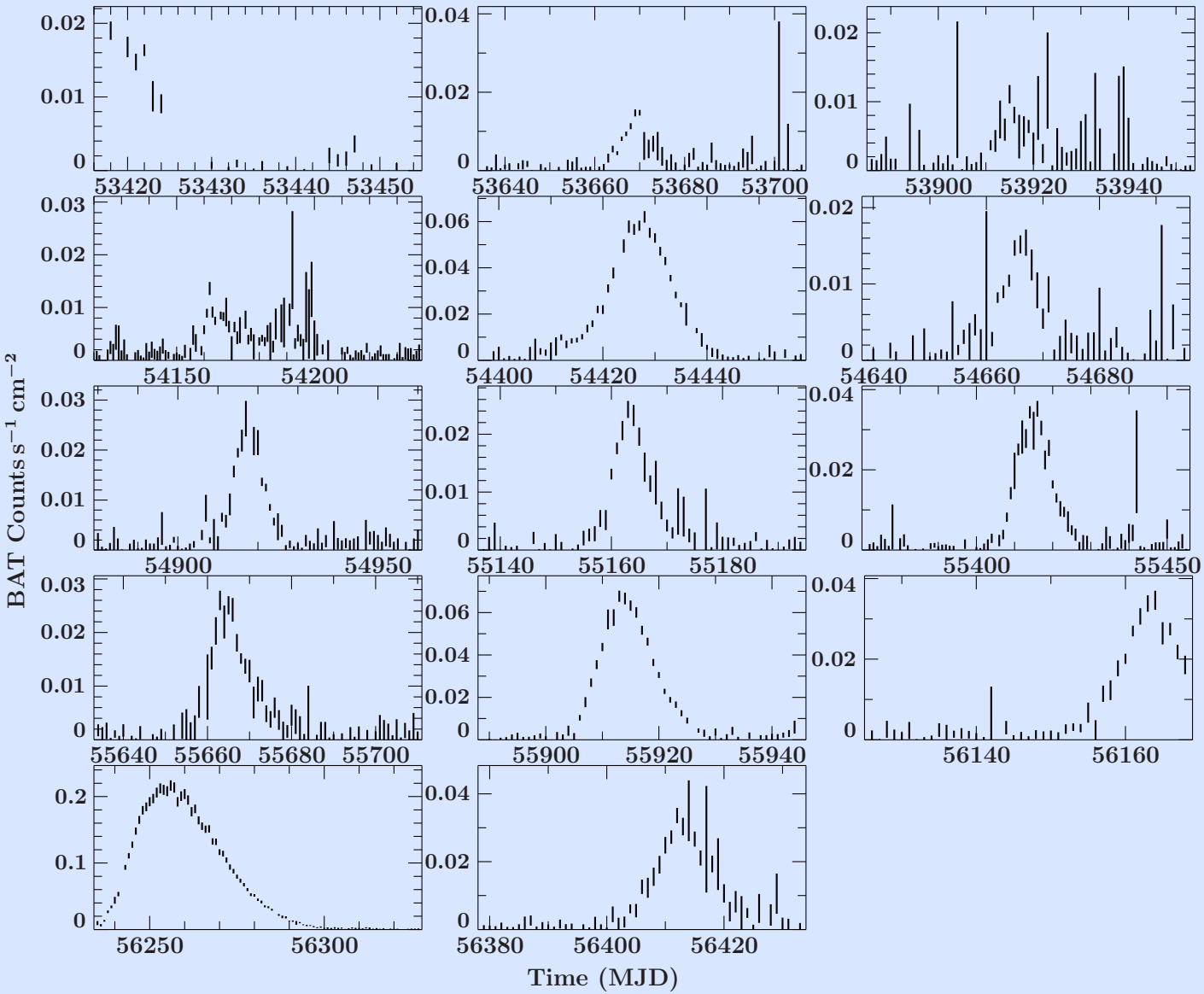
type I



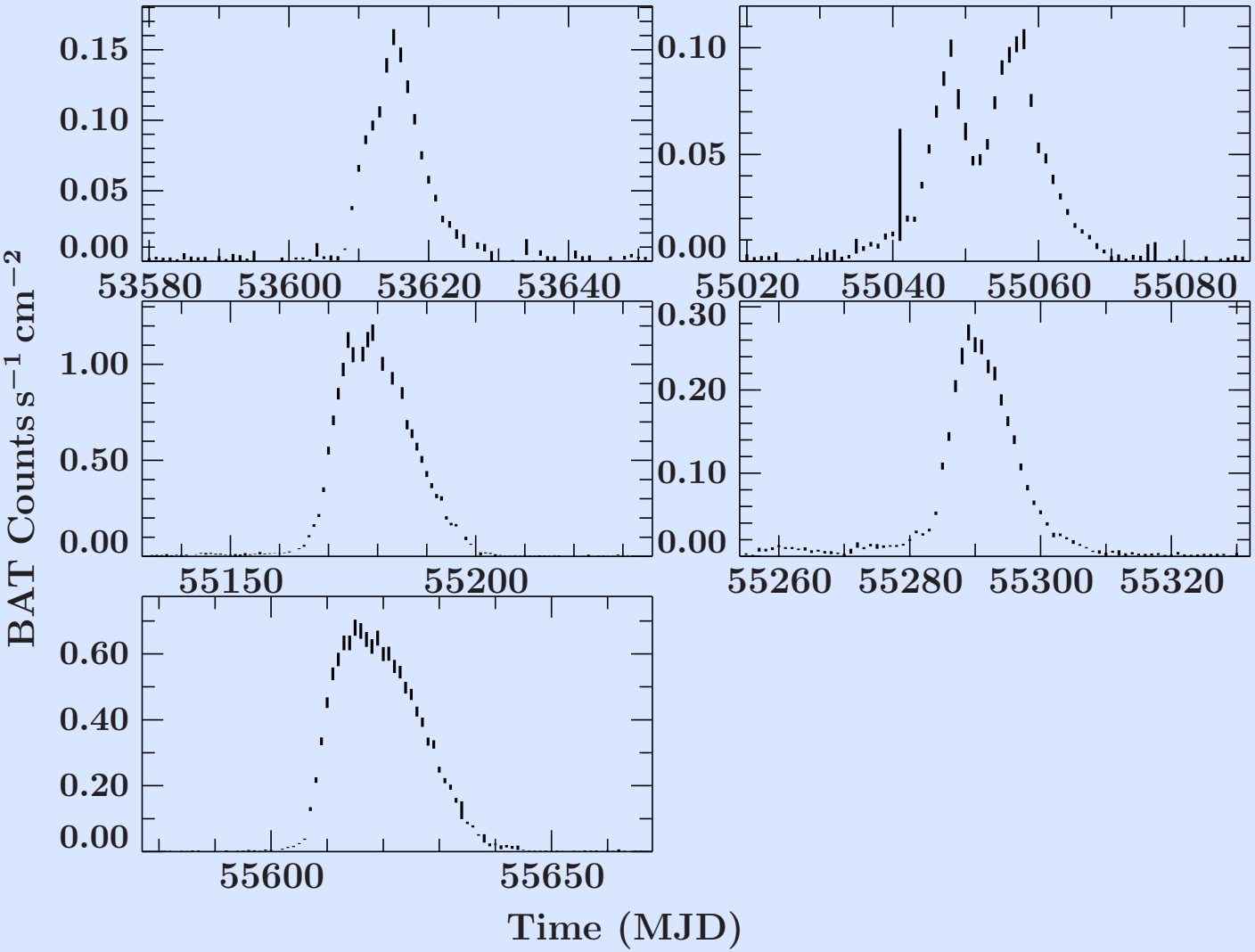
type II

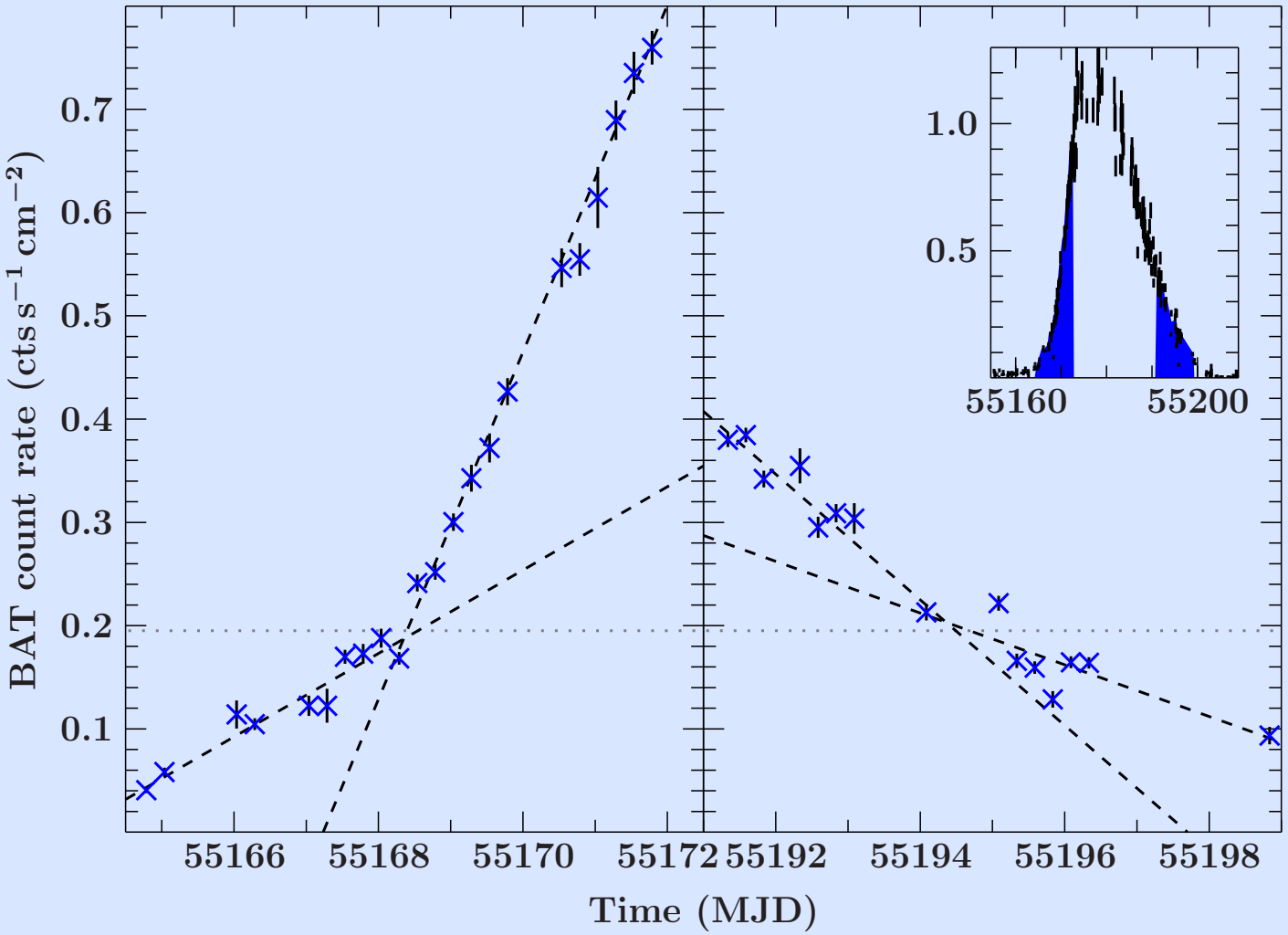
Okazaki et al. (2012)

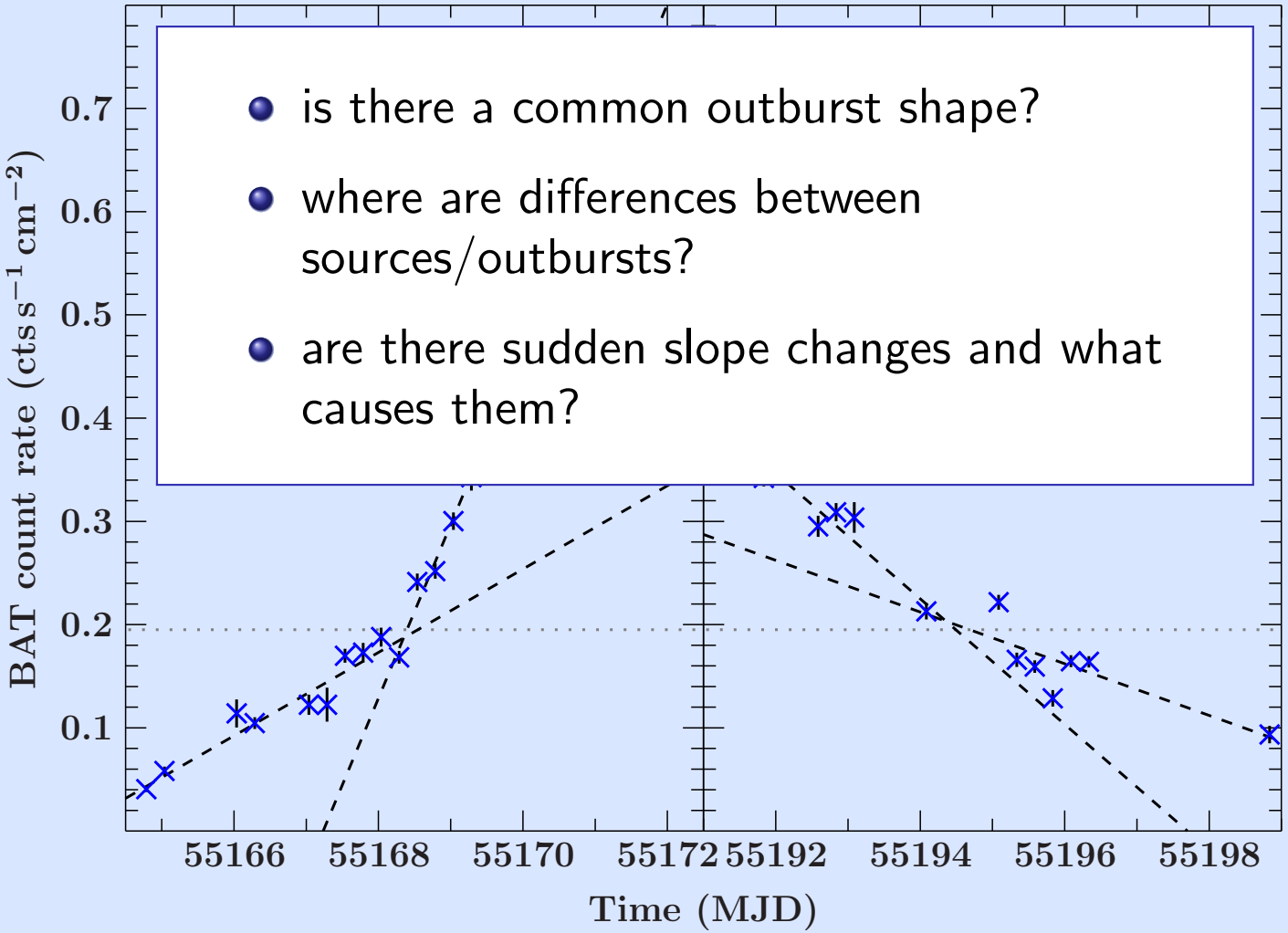
GRO J1008–57 (type I)



A 0535+262 (type II) (?)




BAT count rate (cts s^{-1} cm^{-2})
0.7
0.6
0.5
0.4
0.3
0.2
0.1
55166
55168
55170
55172
55192
55194
55196
55198
Time (MJD)
1.0
0.5
55160
55200


is there a common outburst shape?
where are differences between sources/outbursts?
are there sudden slope changes and what causes them?
BAT count rate (cts s^{-1} cm^{-2})
0.7
0.6
0.5
0.4
0.3
0.2
0.1
55166
55168
55170
55172
55192
55194
55196
55198
Time (MJD)