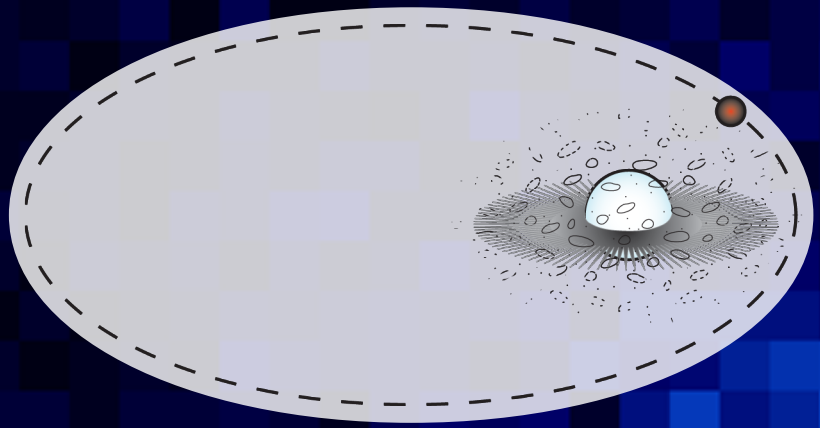
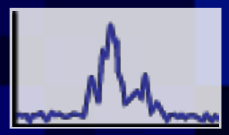
Suzaku Observations of Supergiant X-ray Binaries

Arash Bodaghee SSL - UC Berkeley

High-Mass X-ray Binaries

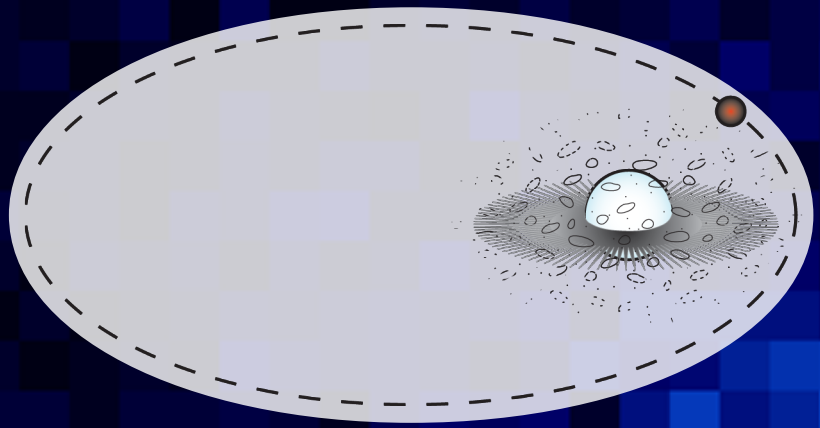
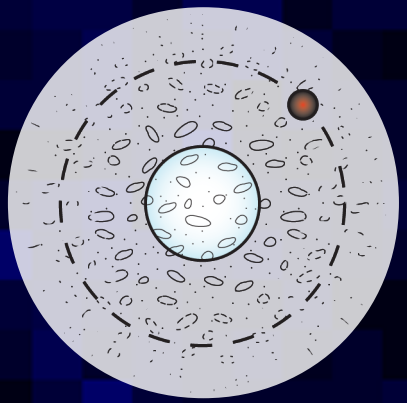
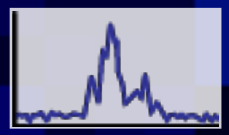
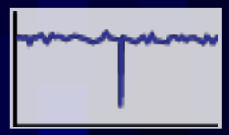
BEXB
Be X-ray Binary



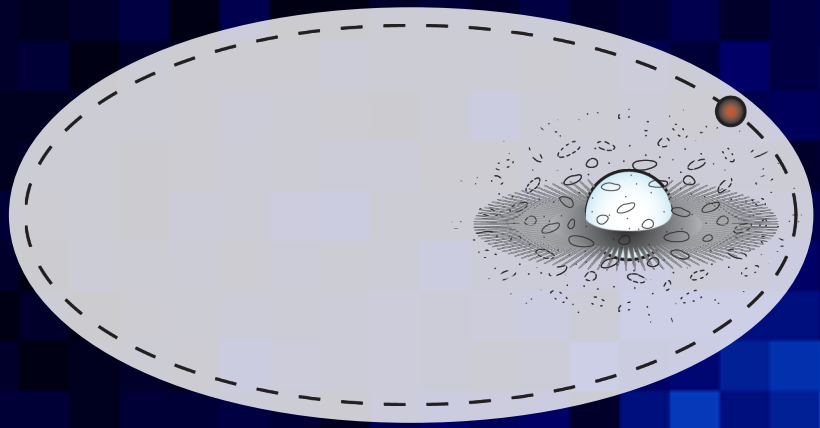
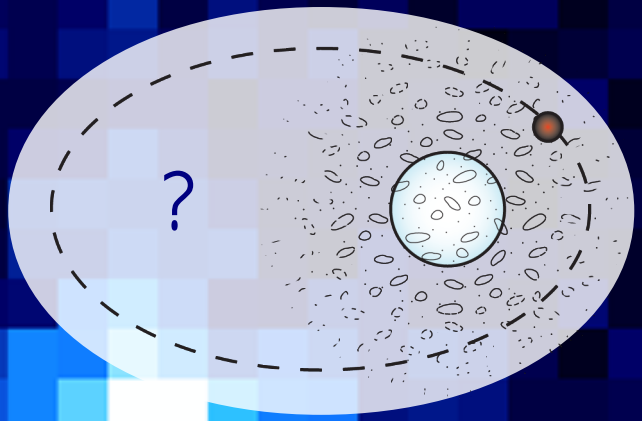
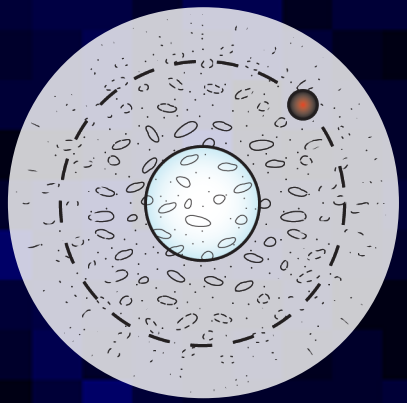
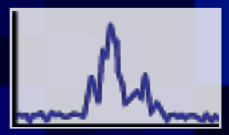
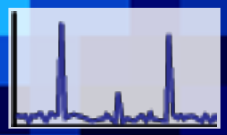
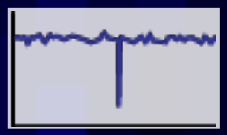


light curve	
X-ray luminosity (erg s^{-1})	10^{31}—10^{35}
on-timescale	days/weeks
off-timescale	months/years
spin period (s)	1—1000
orbital period (d)	10—1000
prototype	V 0332+53

High-Mass X-ray Binaries

	BEXB Be X-ray Binary	SGXB Supergiant X-ray Binary
		
light curve		
X-ray luminosity (erg s^{-1})	10^{31}—10^{35}	10^{35}—10^{37}
on-timescale	days/weeks	quasi-continuously
off-timescale	months/years	minutes
spin period (s)	1—1000	100—5000
orbital period (d)	10—1000	1—50
prototype	V 0332+53	Vela X-1

High-Mass X-ray Binaries

	BEXB Be X-ray Binary	SFXT Supergiant Fast X-ray Transient	SGXB Supergiant X-ray Binary
			
light curve			
X-ray luminosity (erg s^{-1})	10^{31}—10^{35}	10^{32}—10^{36}	10^{35}—10^{37}
on-timescale	days/weeks	hours/days	quasi-continuously
off-timescale	months/years	weeks/months	minutes
spin period (s)	1—1000	10—500	100—5000
orbital period (d)	10—1000	10—200	1—50
prototype	V 0332+53	XTE J1739–302	Vela X-1

High-Mass X-ray Binaries

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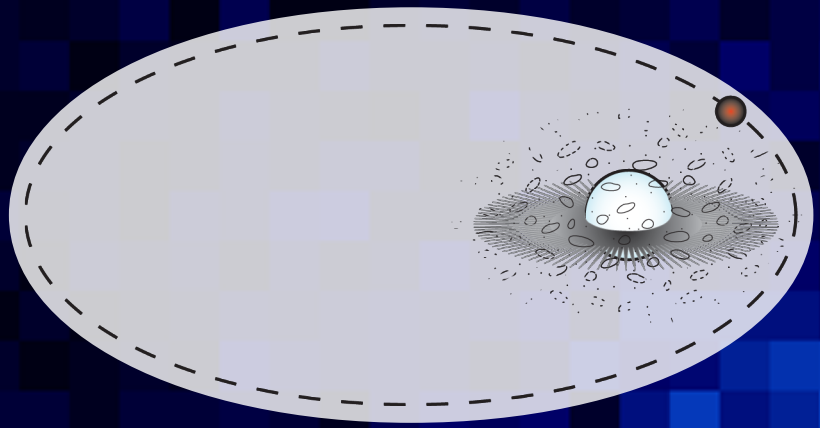
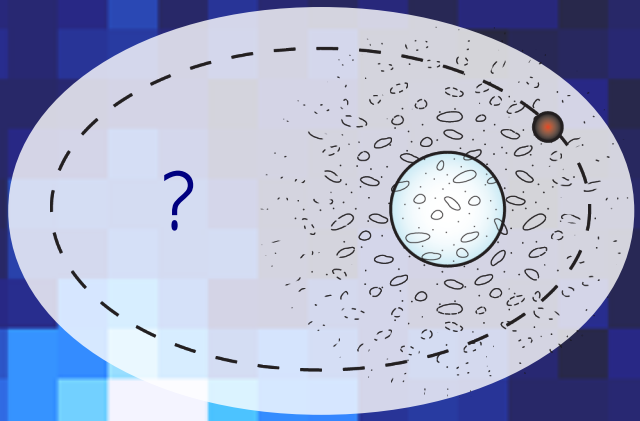
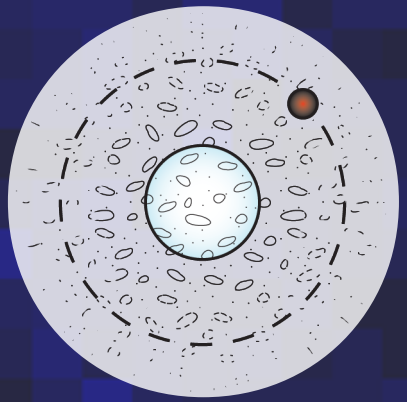
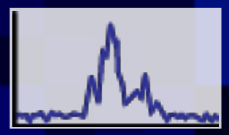
			
light curve			
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spin period (s)	1—1000	10—500	100—5000
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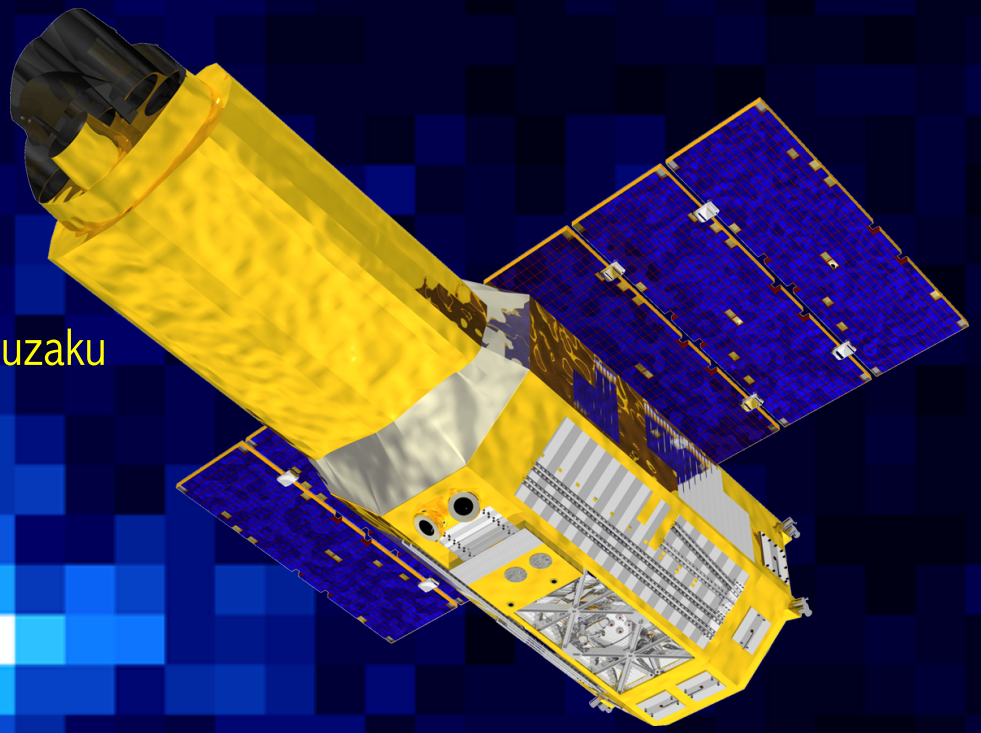
Suzaku observations of SGXBs/SFXTs



nearly a dozen new SGXBs/SFXTs have been observed by Suzaku

these are in addition to the “classical” systems:
4U 1907+09: Rivers et al. 2010; talk by K. Pottschmidt
4U 2206+54: Finger et al. 2010
AX J1841.0–0536: poster by K. Kawabata
Cyg X-1: Makishima et al. 2008; Nowak et al. 2011; talks by S. Yamada and S. Torii
GX 301–2: talk by K. Pottschmidt
LMC X-4: Hung et al. 2010
LS 5039: Kishishita et al. 2009; Takahashi et al. 2009; Yamaguchi et al. 2010
SFXT flaring mechanisms: poster by S. Sasano
Vela X-1: poster by H. Odaka

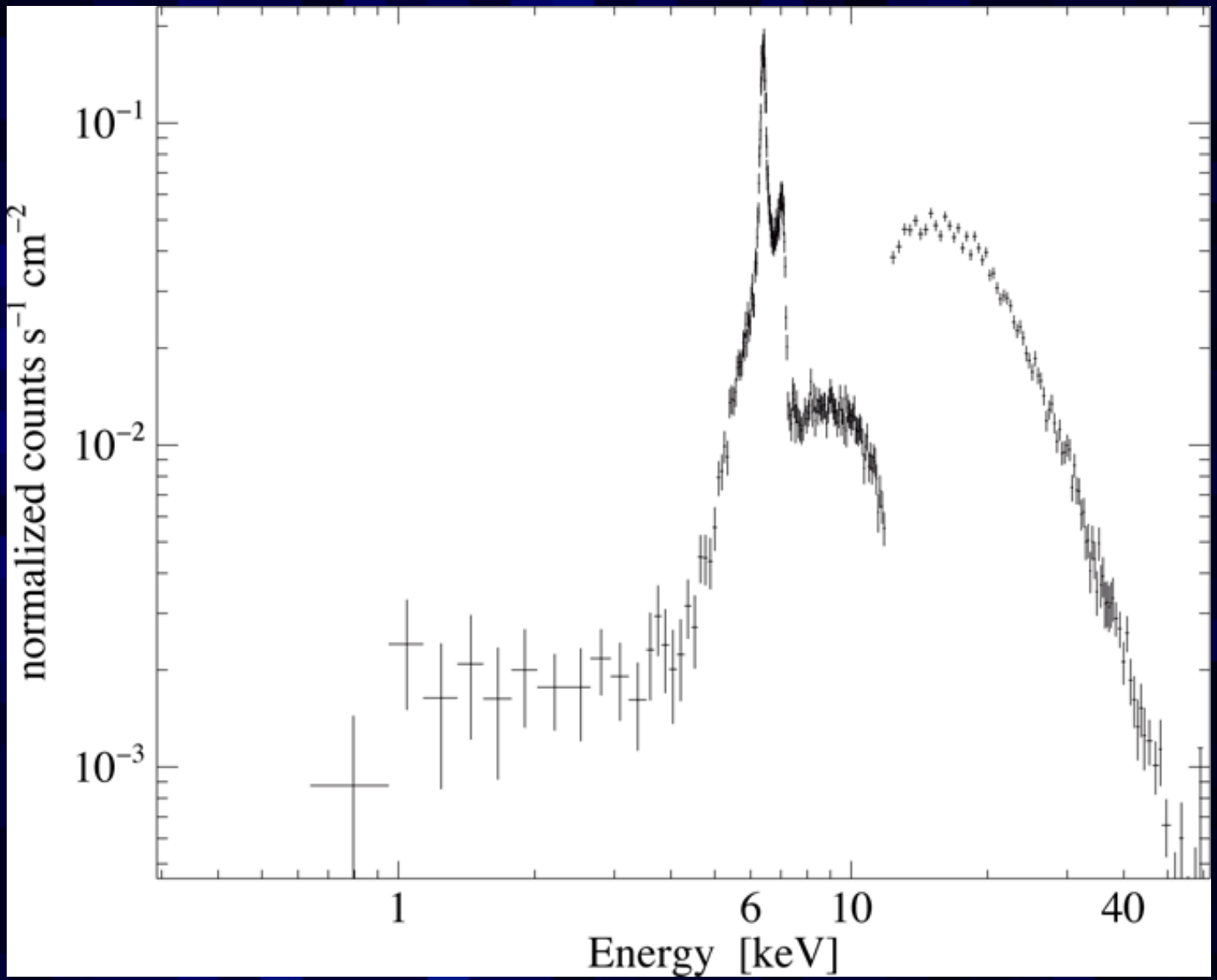
Suzaku broadband observation of IGR J16318−4848

probable NS
orbiting SG B[e]
d ~ 1.6 kpc
absorbed SGXB

97 ks Suzaku obs.

huge absorption (>10^{24} cm^{-2})

Barragàn et al. 2009



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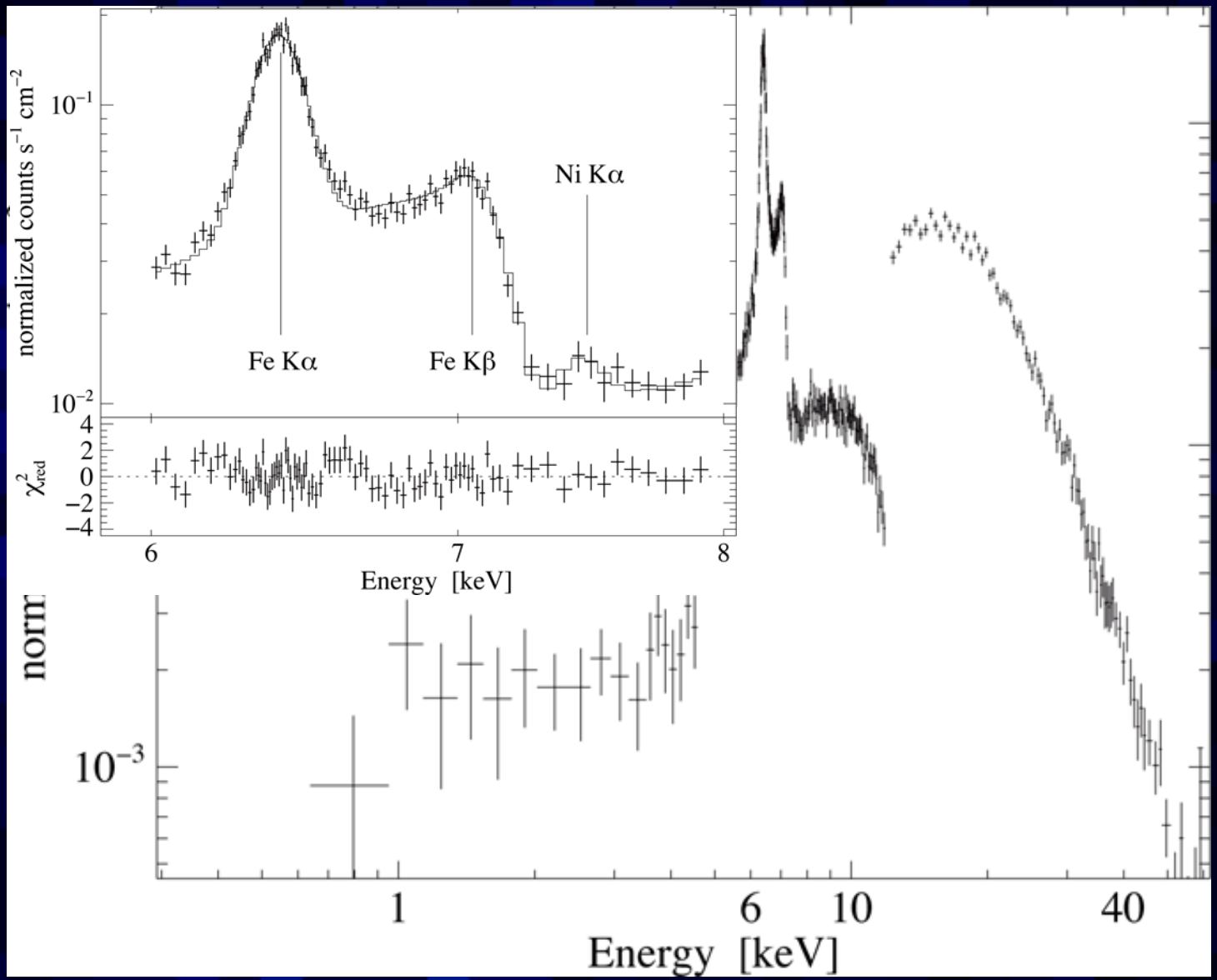
d ~ 1.6 kpc
absorbed SGXB

97 ks Suzaku obs.

huge absorption (>10^{24} cm^{-2})
iron line complex

Barragàn et al. 2009



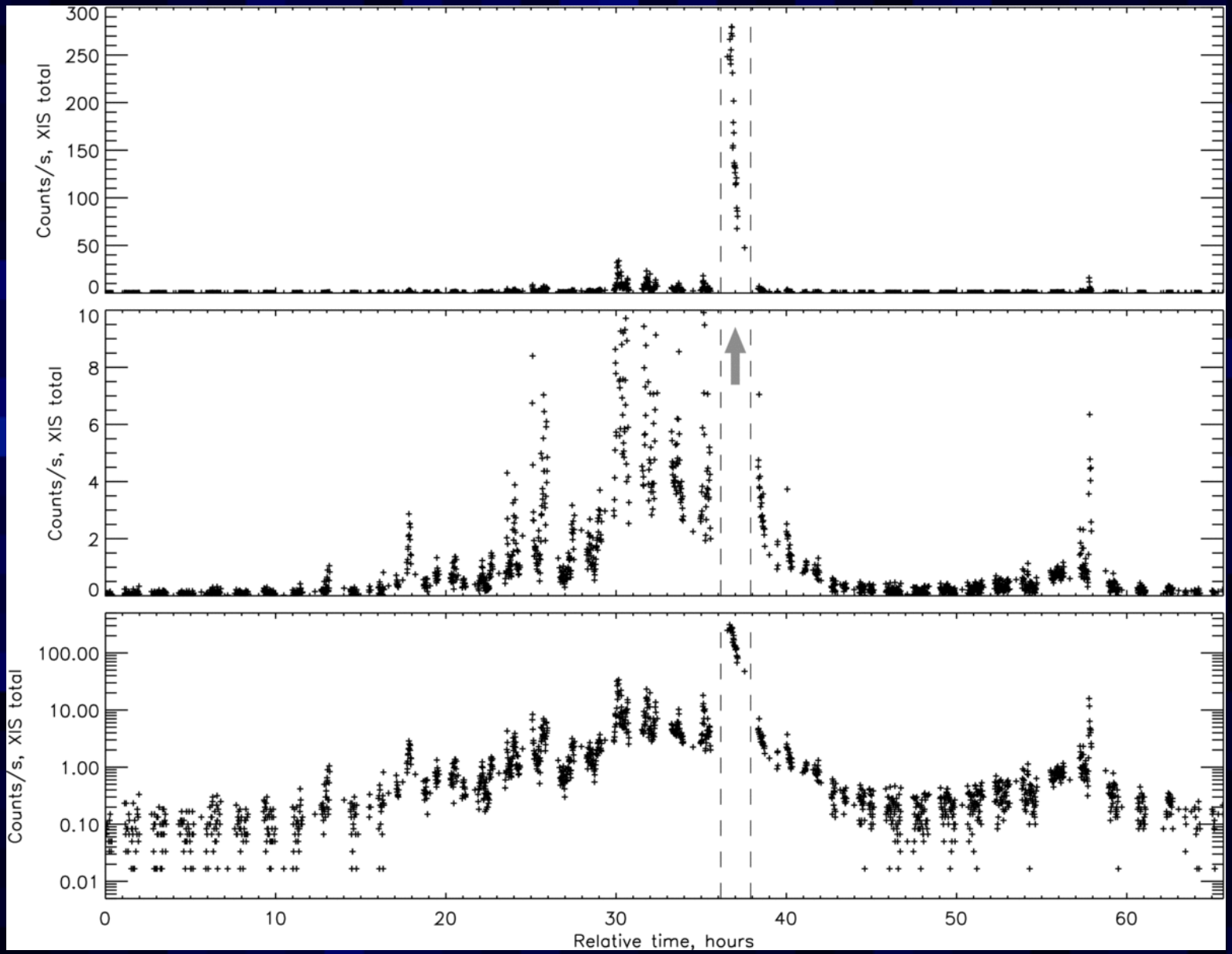
Suzaku sees clumpy winds around IGR J17544−2619

probable NS
orbiting O9Ib SG
P_{orb} = 4.9 d
d ~ 3.6 kpc
SFXT archetype

240 ks Suzaku obs.

10^{-13}—10^{-9} ergs/cm^2/s

Rampy et al. 2009



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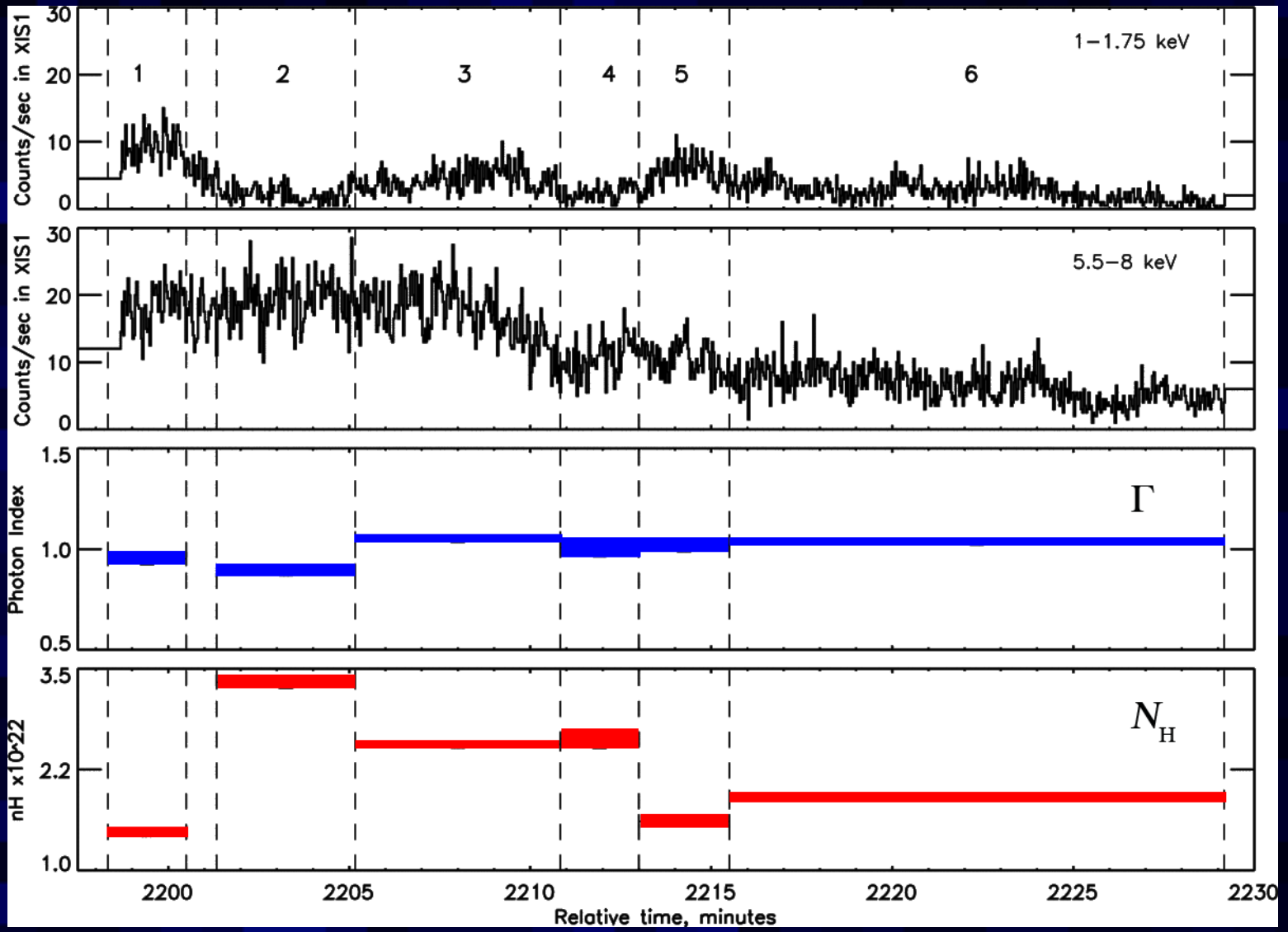
10^{-13}—10^{-9} ergs/cm^2/s

spectrum hardens w/ L
variable absorption

Rampy et al. 2009



Suzaku observes four obscured SGXBs/SFXTs

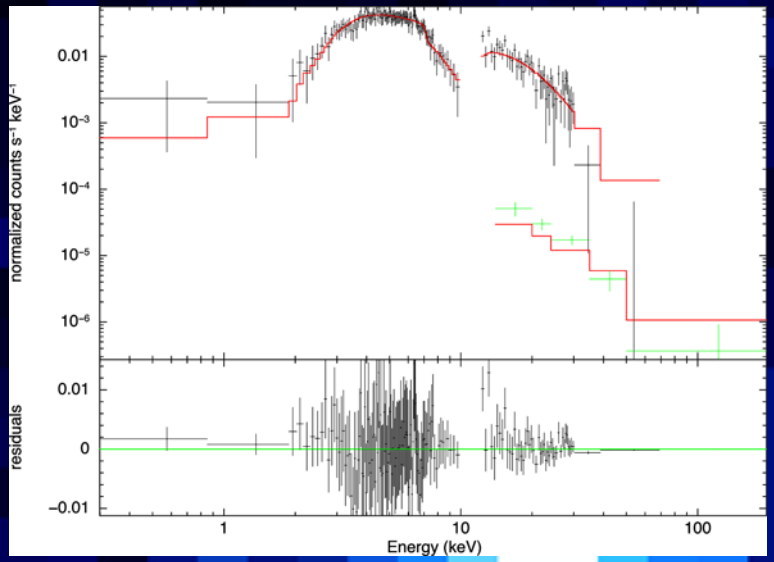
high absorption
($>10^{23}$ cm^{-2})

stringent iron line
u.l. for all four

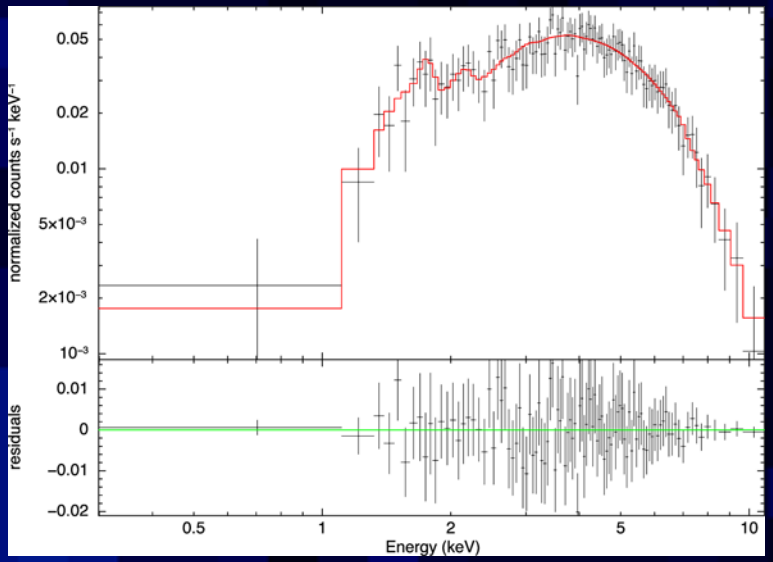
P_{spin} = 1056 s in
Swift J2000.6+3210

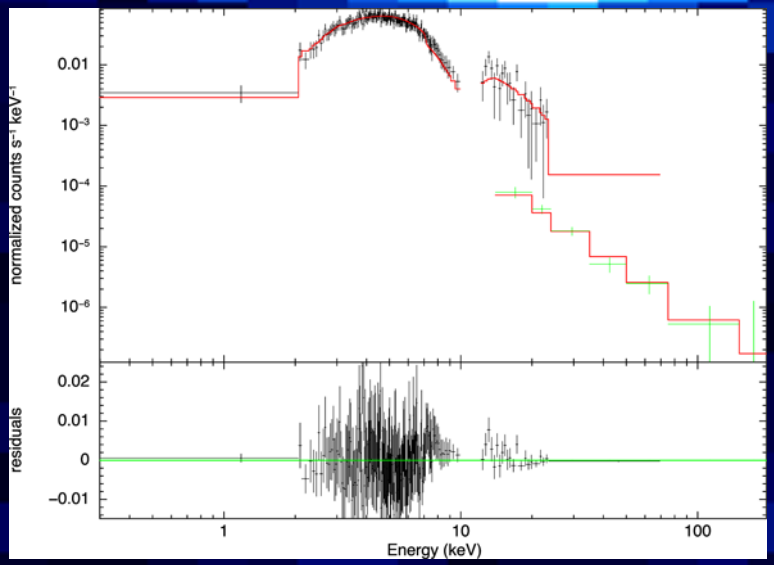
Morris et al. 2009

IGR J16195–4945

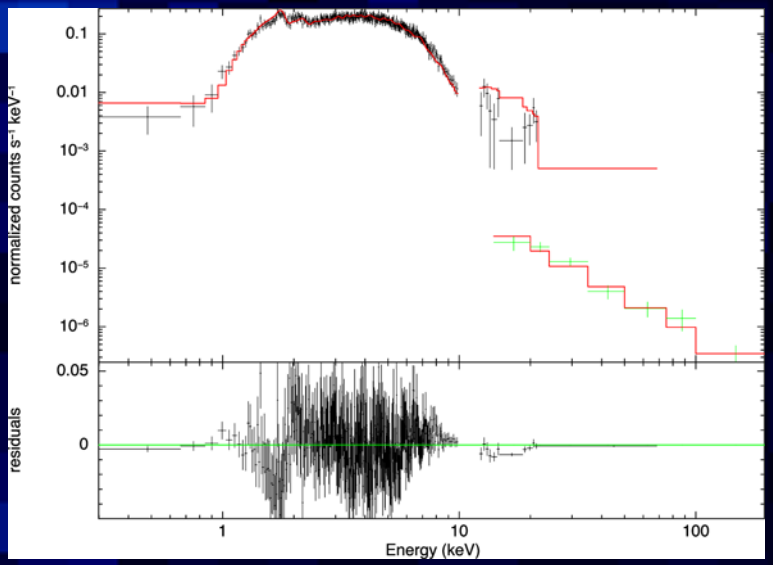


IGR J16465–4507





IGR J16493–4348



Swift J2000.6+3210

Suzaku spots IGR J08408–4503 in a low-activity state

probable NS
orbiting O8.5Ib SG
d ~ 3 kpc
P_{orb} = 35 d ?
SFXT

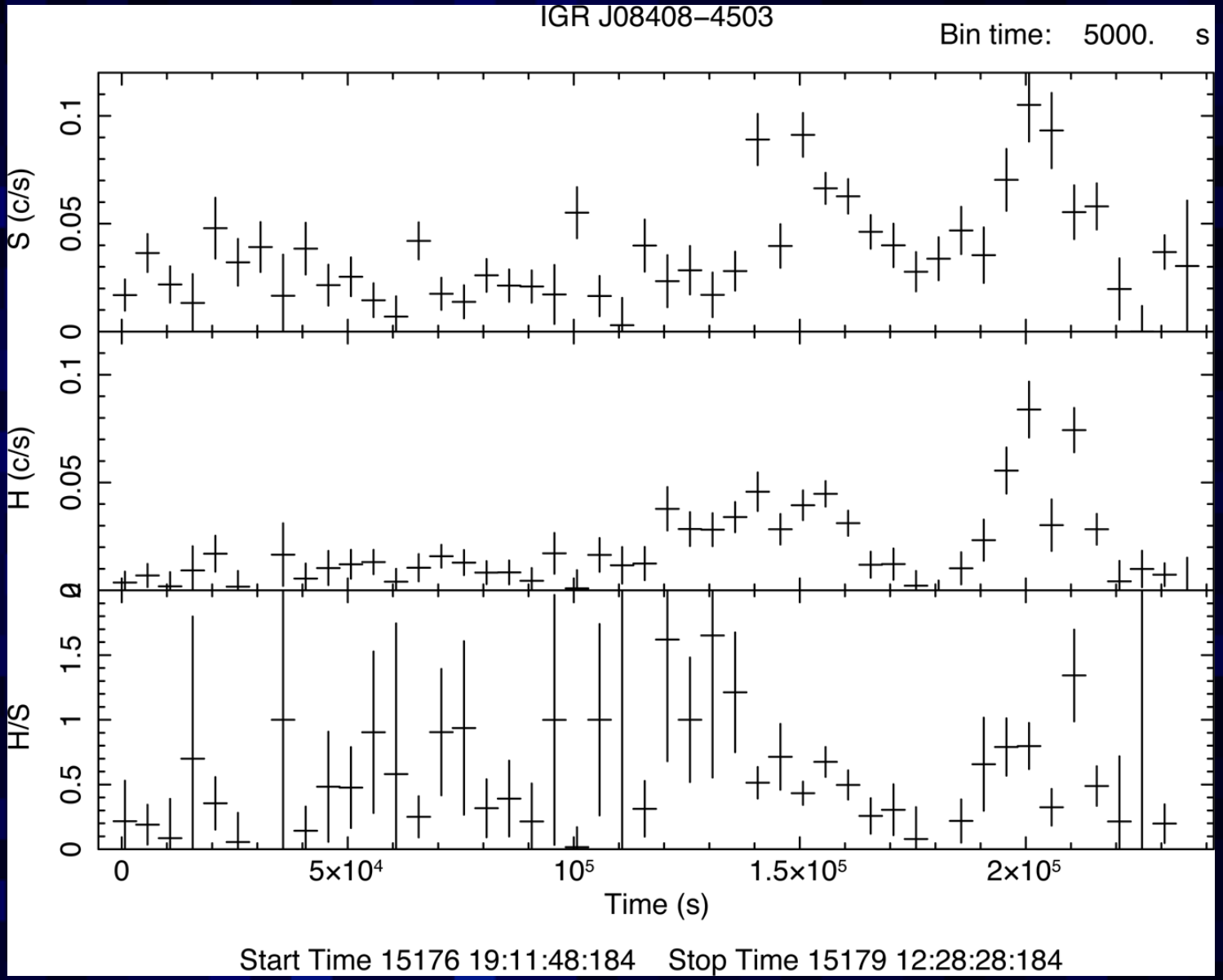
67 ks Suzaku obs.

$L = 4 \times 10^{32}$ ergs/s
(0.5—10 keV)

$L < 6 \times 10^{33}$ ergs/s
(15—40 keV)

signs of accretion even
at such low luminosities

Sidoli et al. 2010



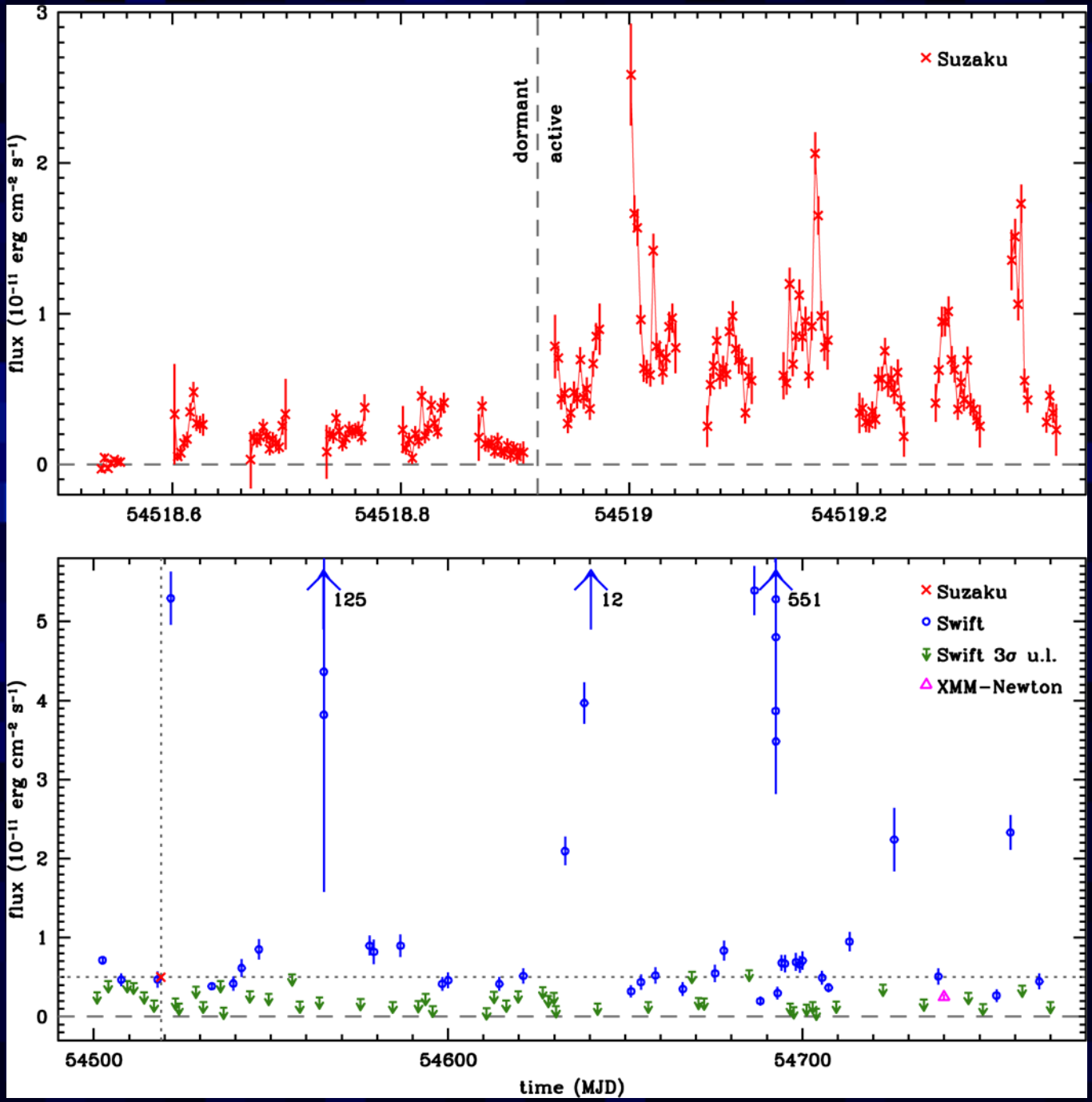
Suzaku sees micro flares from IGR J17391−3021

probable NS
orbiting SG
d ~ 2.7 kpc
SFXT archetype

37 ks Suzaku obs.

low-intensity state
punctuated by micro flares
(most common state)

Bodaghee et al. 2011



Suzaku sees micro flares from IGR J17391−3021

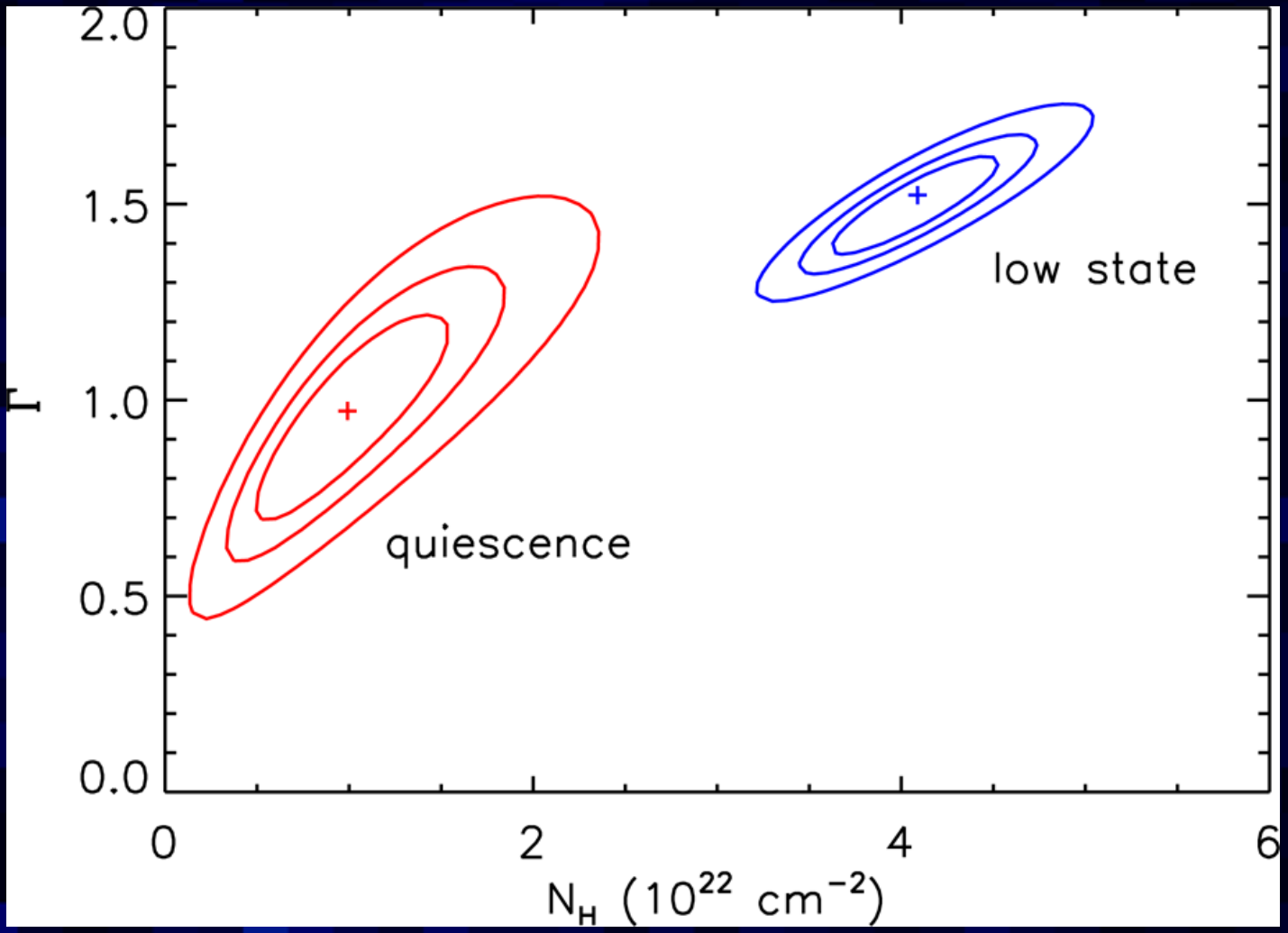
probable NS
orbiting SG
d ~ 2.7 kpc
SFXT archetype

37 ks Suzaku obs.

low-intensity state
punctuated by micro flares
(most common state)

variable absorption (×2—10)
(accretion of obscuring clumps)

Bodaghee et al. 2011



epoch	N_H (10^{22} cm^{-2})	Γ	$^{unabs}L_{0.5-10\ keV}$ (erg s^{-1})
quiescence	1.0±0.6	1.0±0.3	1×10^{33}
low state	4.1±0.5	1.5±0.1	7×10^{33}

Suzaku broadband Spectrum of IGR J16207–5129

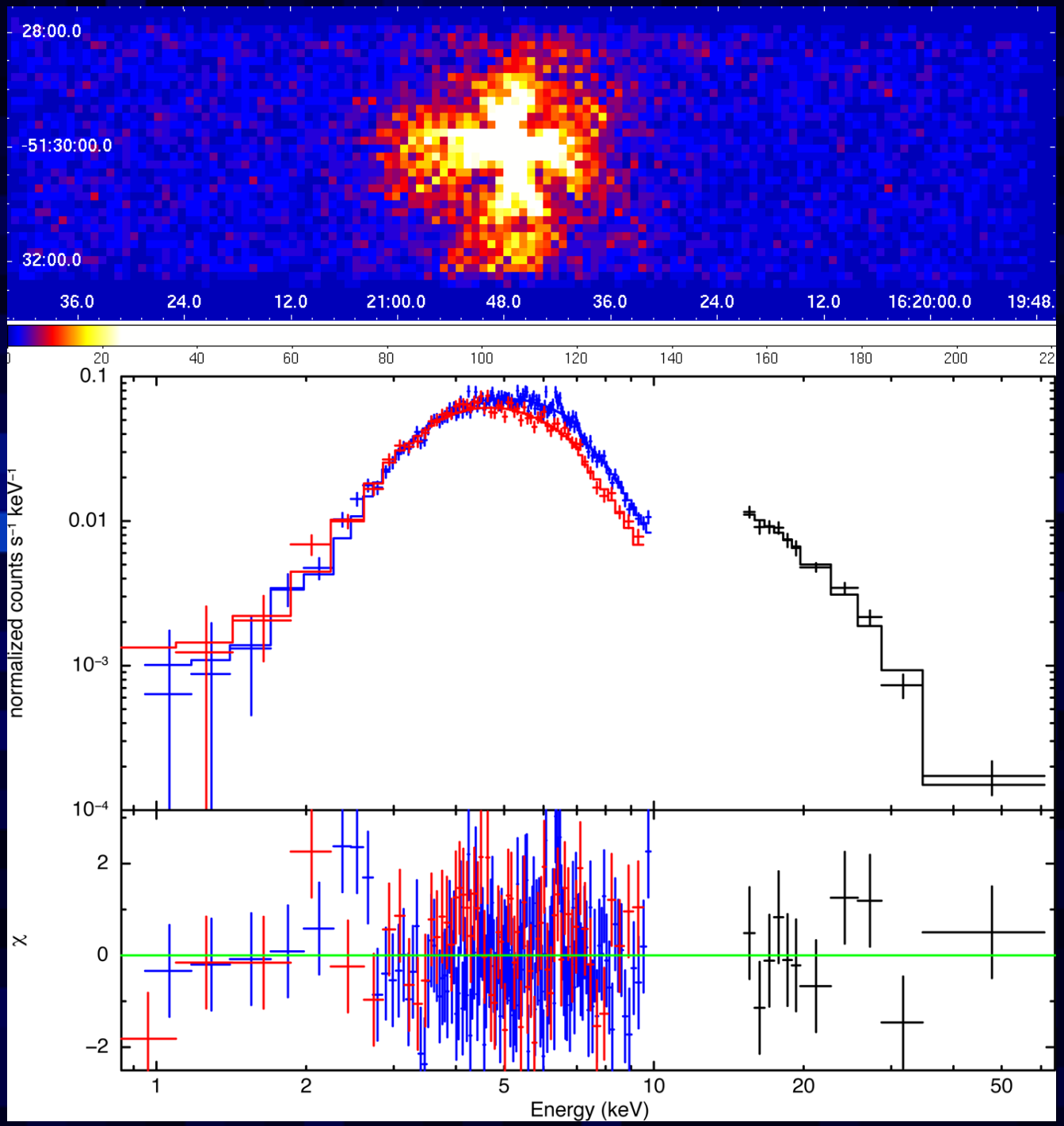
probable NS
orbiting OB SG
d ~ 6 kpc
absorbed SGXB

80 ks Suzaku obs.

high absorption (>10^{23} cm^{-2})
iron line
E_{cut} established: ~19 keV
(typical of wind-fed XRP)

E_{cut} from XIS/HXD fits of others:
IGR J16318–4848: ~20 keV (B09)
IGR J16493–4348: ~18 keV (M09)
IGR J17544–2619: ~11 keV (R09)

Bodaghee et al. 2010



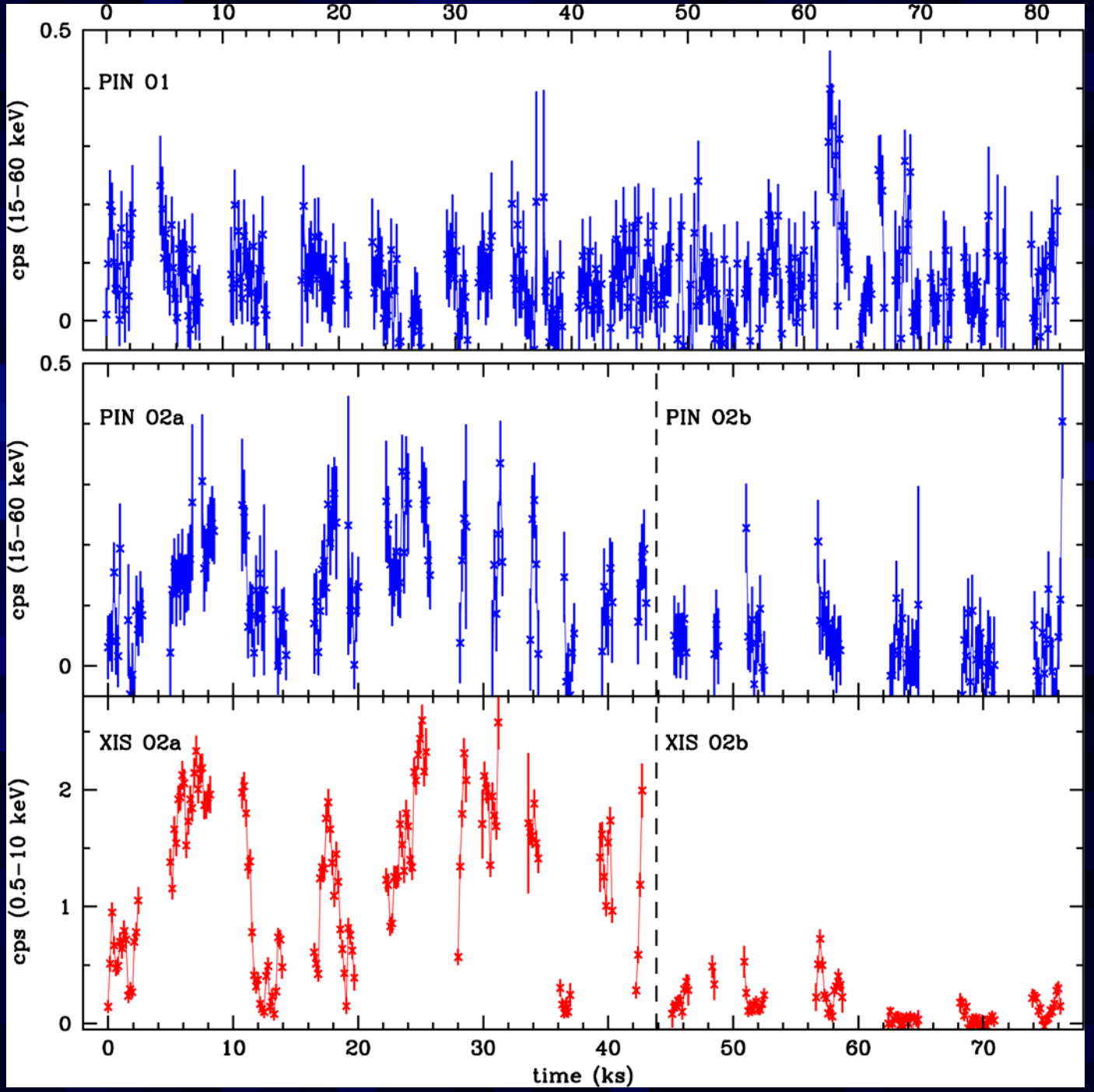
Did Suzaku capture IGR J16207−5129 in eclipse?

probable NS
orbiting OB SG
d ~ 6 kpc
absorbed SGXB

80 ks Suzaku obs.

eclipse?
$F_{min} = 4 \times 10^{-12}$ erg/cm^2/s
(>12 ks: lower/longer than XMM)

Bodaghee et al. 2010



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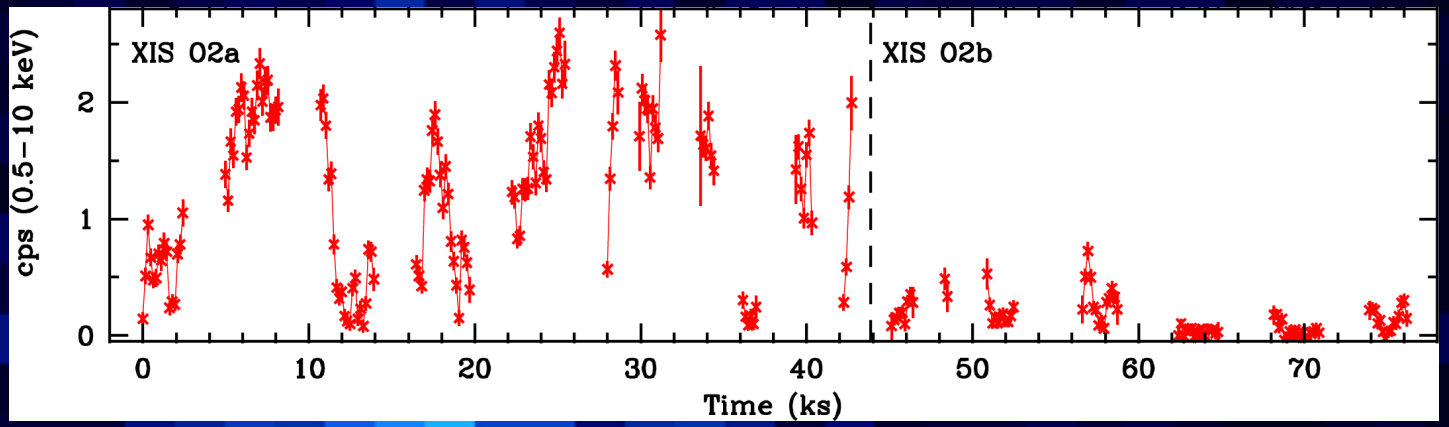
80 ks Suzaku obs.

eclipse?
$F_{min} = 4\times10^{-12}$ erg/cm^2/s
(>12 ks: lower/longer than XMM)

N_H does not vary
(i.e. not an occulting clump;
and not photo-ionization)



epoch	N_H (10^{22} cm^{-2})	Γ	$^{unabs}L_{0.5-10\ keV}$ (erg s^{-1})
02a	19±1	1.3±0.1	2×10^{35}
02b	19±5	1.5±0.4	6×10^{34}

Bodaghee et al. 2010

Did Suzaku capture IGR J16207−5129 in eclipse?

probable NS
orbiting OB SG
d ~ 6 kpc
absorbed SGXB

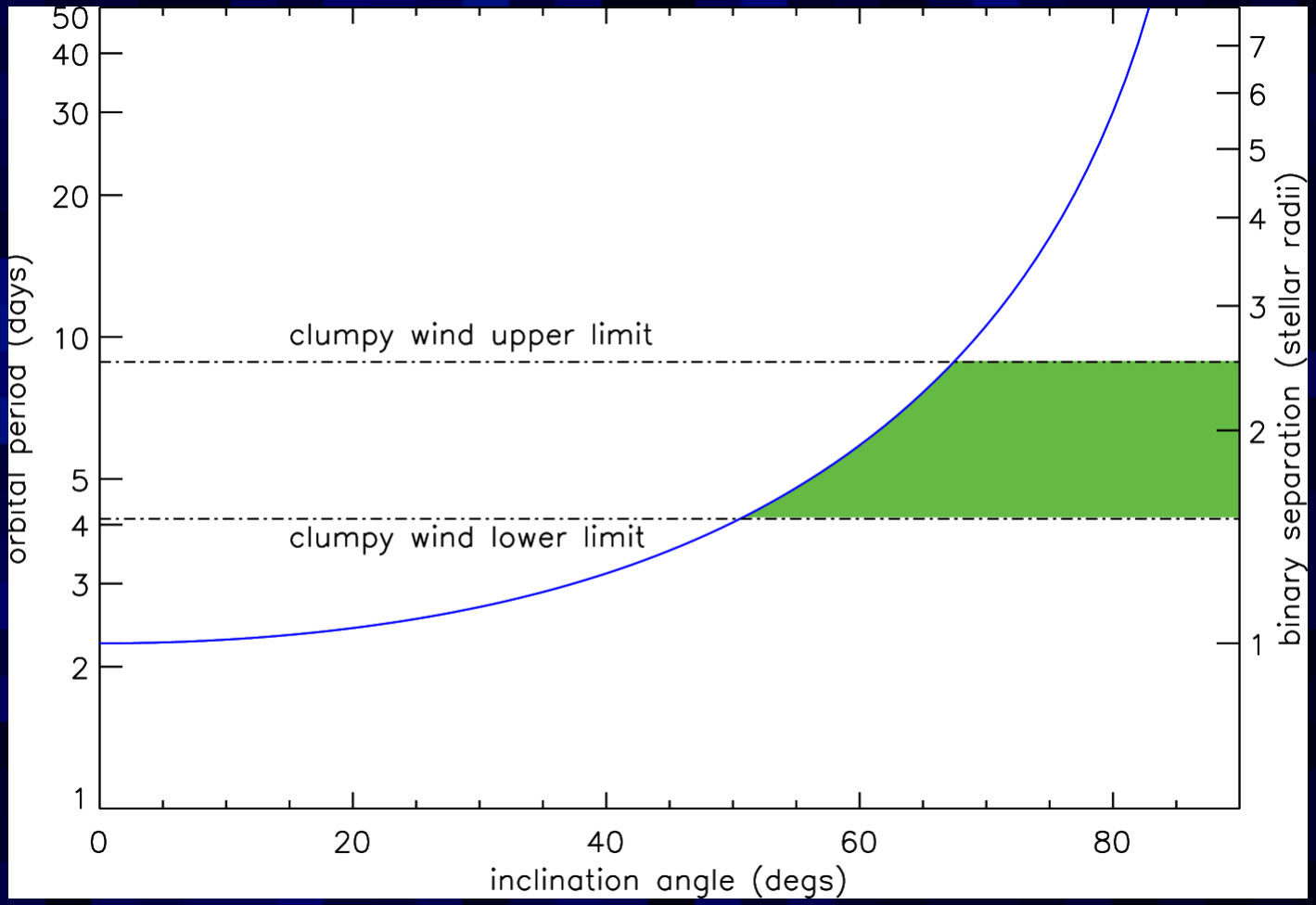
80 ks Suzaku obs.

eclipse?
$F_{min} = 4 \times 10^{-12}$ erg/cm^2/s
(>12 ks: lower/longer than XMM)

N_H does not vary
(i.e. not an occulting clump;
and not photo-ionization)

$P_{orb} = 4$—9 d
$i > 55^{o}$

Bodaghee et al. 2010

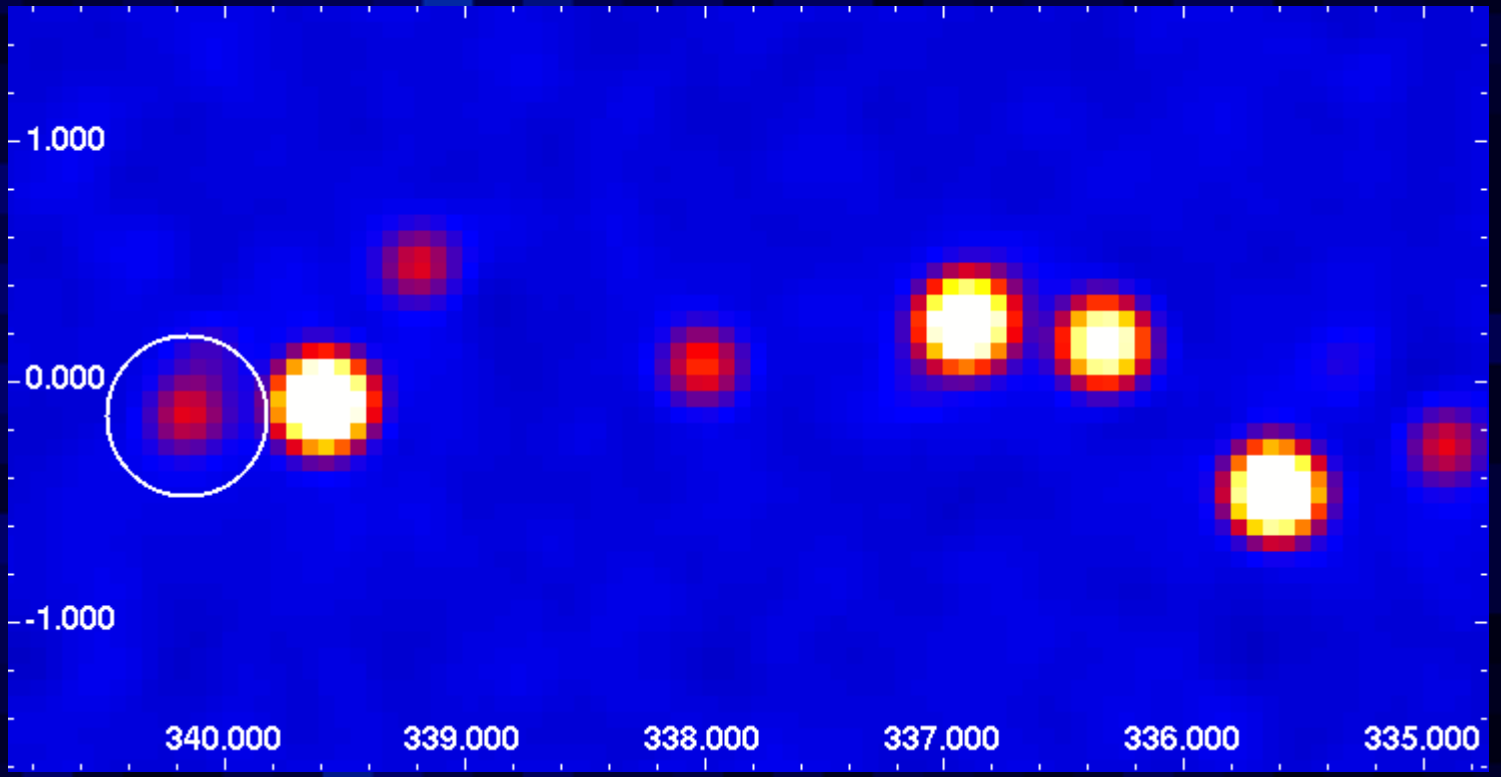


Suzaku will observe an orbit of IGR J16479–4514

probable NS
orbiting O9.5Iab SG
d ~ 3 kpc
P_{orb} = 3.3 d
high activity cycle
SFXT (intermediate?)

150 ks Suzaku obs.
at various phases
including eclipse

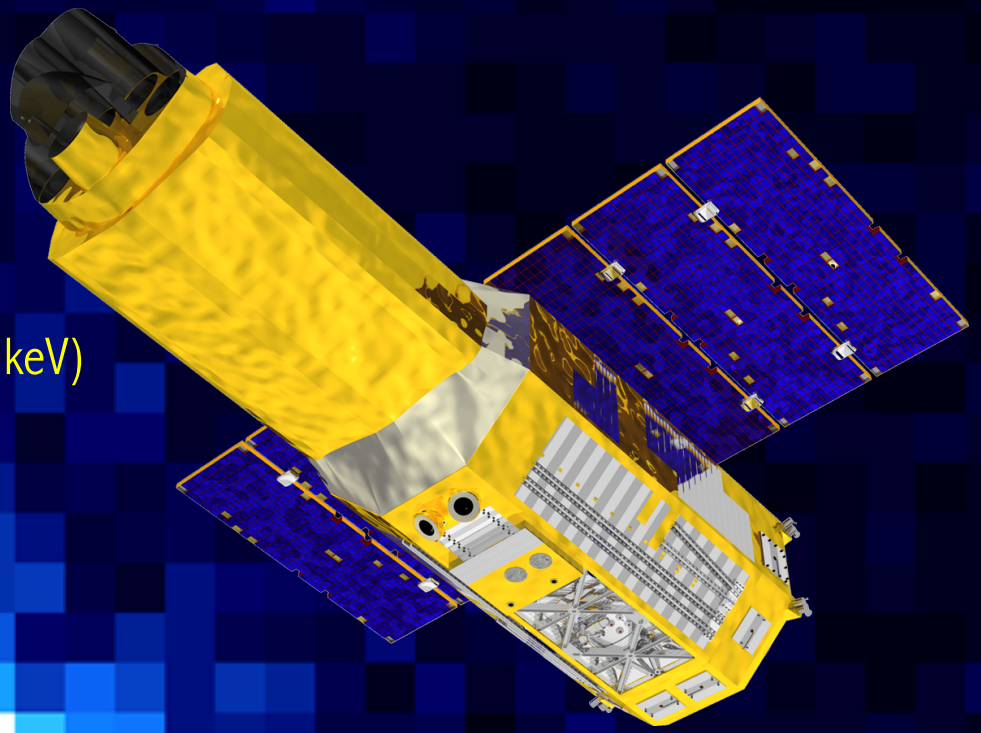
objectives:
1) test SFXT emission models
2) establish nature of CO
3) probe its environment



INTEGRAL 18—40 keV
(courtesy: R. Krivonos)

(circa 8-9/2011 or 2-3/2012: PPI Sidoli; PI Bodaghee)

Conclusions & Perspectives



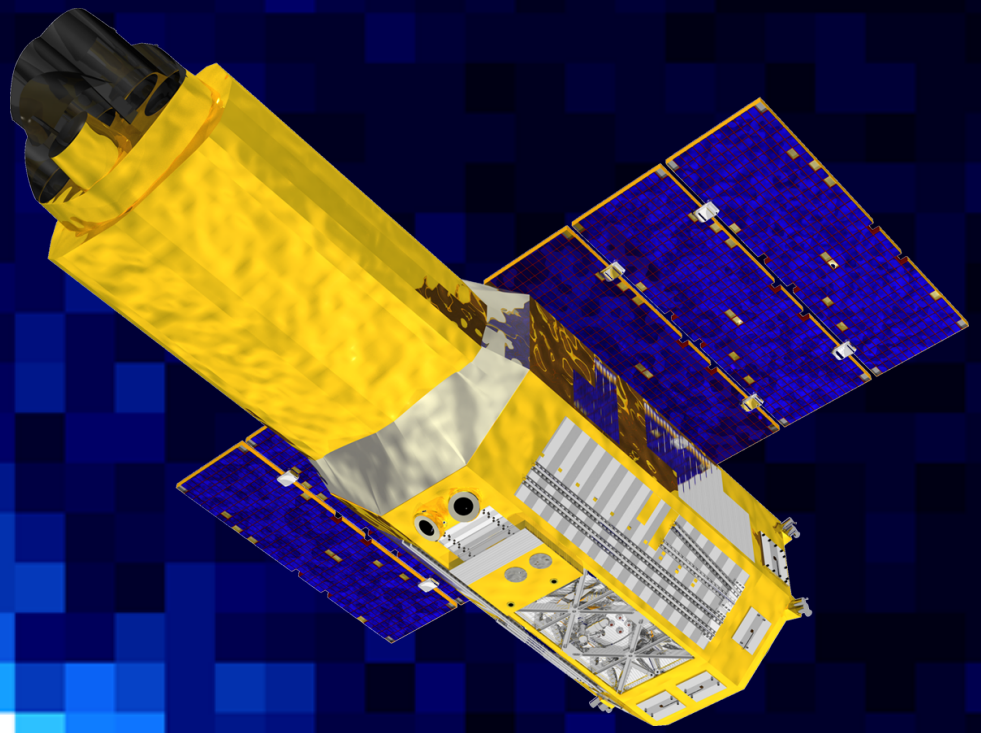
Suzaku's sensitivity and broad X-ray bandpass (0.5—100 keV) makes it well-suited for follow-up studies of SGXBs/SFXTs:

spectral evolution (N_H, Γ) during quiescence, low-activity states, and outbursts

establish E_{cut} and possibly detect cyclotron absorption lines (c.f. talk by K. Pottschmidt)

find P_{spin} for long-period pulsars

Conclusions & Perspectives



our upcoming orbital analysis of IGR J16479–4514
will help shed light on SFXT emission mechanisms and the SFXT-SGXB connection

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J.A. Tomsick (SSL - UC Berkeley); J. Rodriguez (CEA - Saclay);
K. Pottschmidt (UMBC & NASA - GSFC); J. Wilms (Uni. Erlangen); P. Romano (INAF - Palermo)