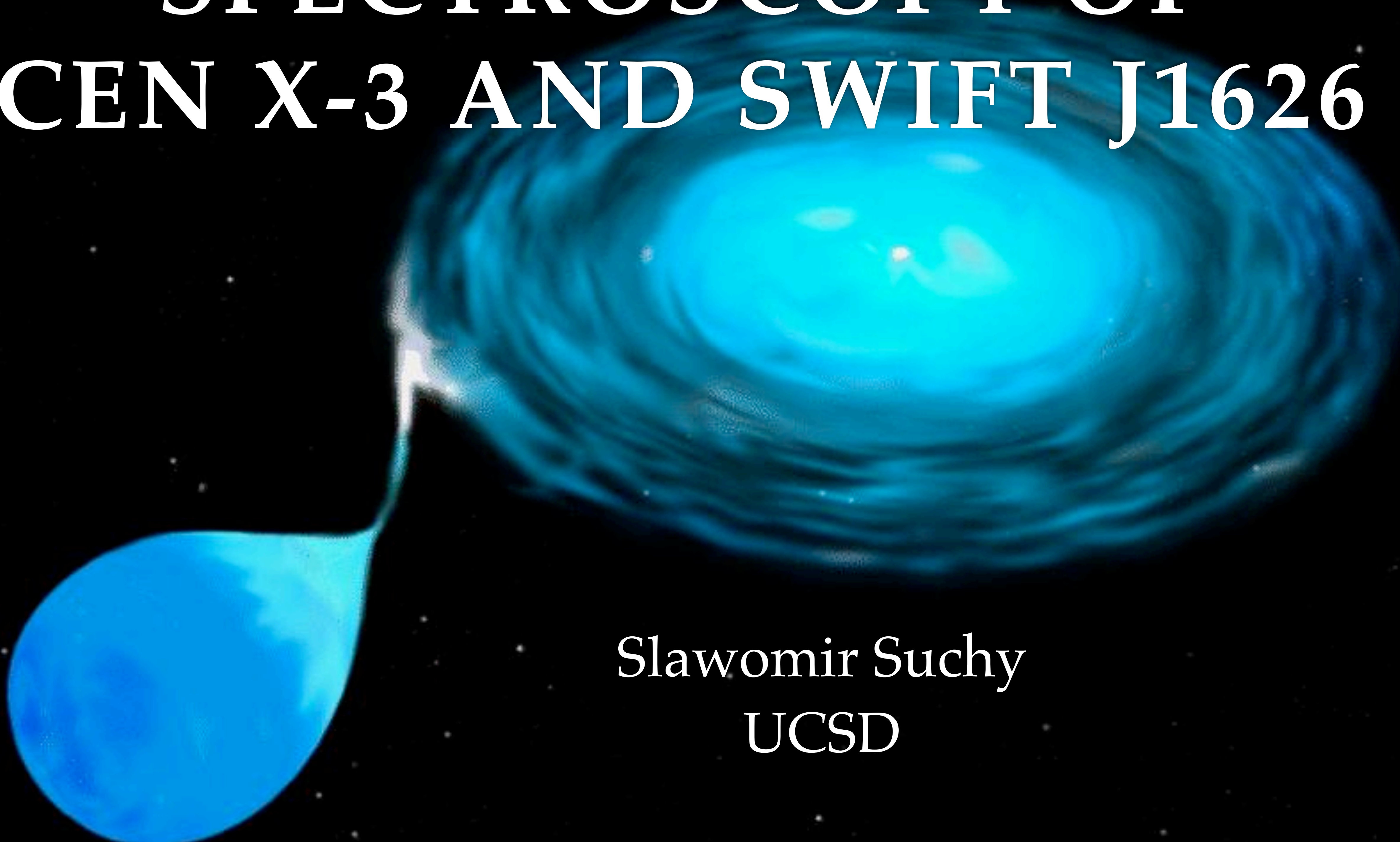
PHASE RESOLVED SPECTROSCOPY OF CEN X-3 AND SWIFT J1626



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CRSF Meeting - Tuebingen - 3/29-4/1

OUTLINE

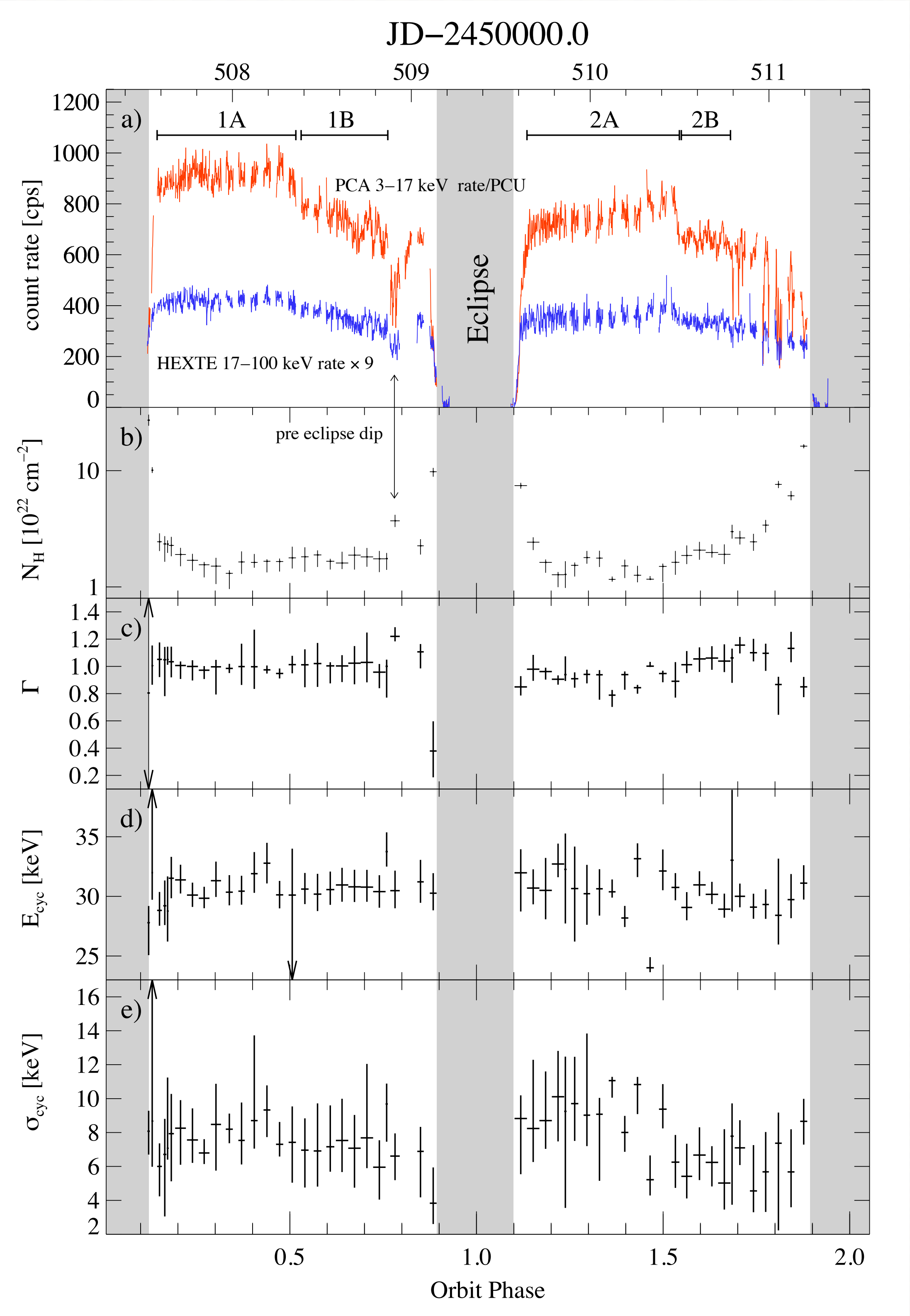
Cen X-3

(Suchy et al. 2008)

Swift J 1626.6-5156

(DeCesar et al., submitted)

CEN X-3



(Suchy et al, 2008)

HMXB discovered 1972

P_{orb} ~2.1 days

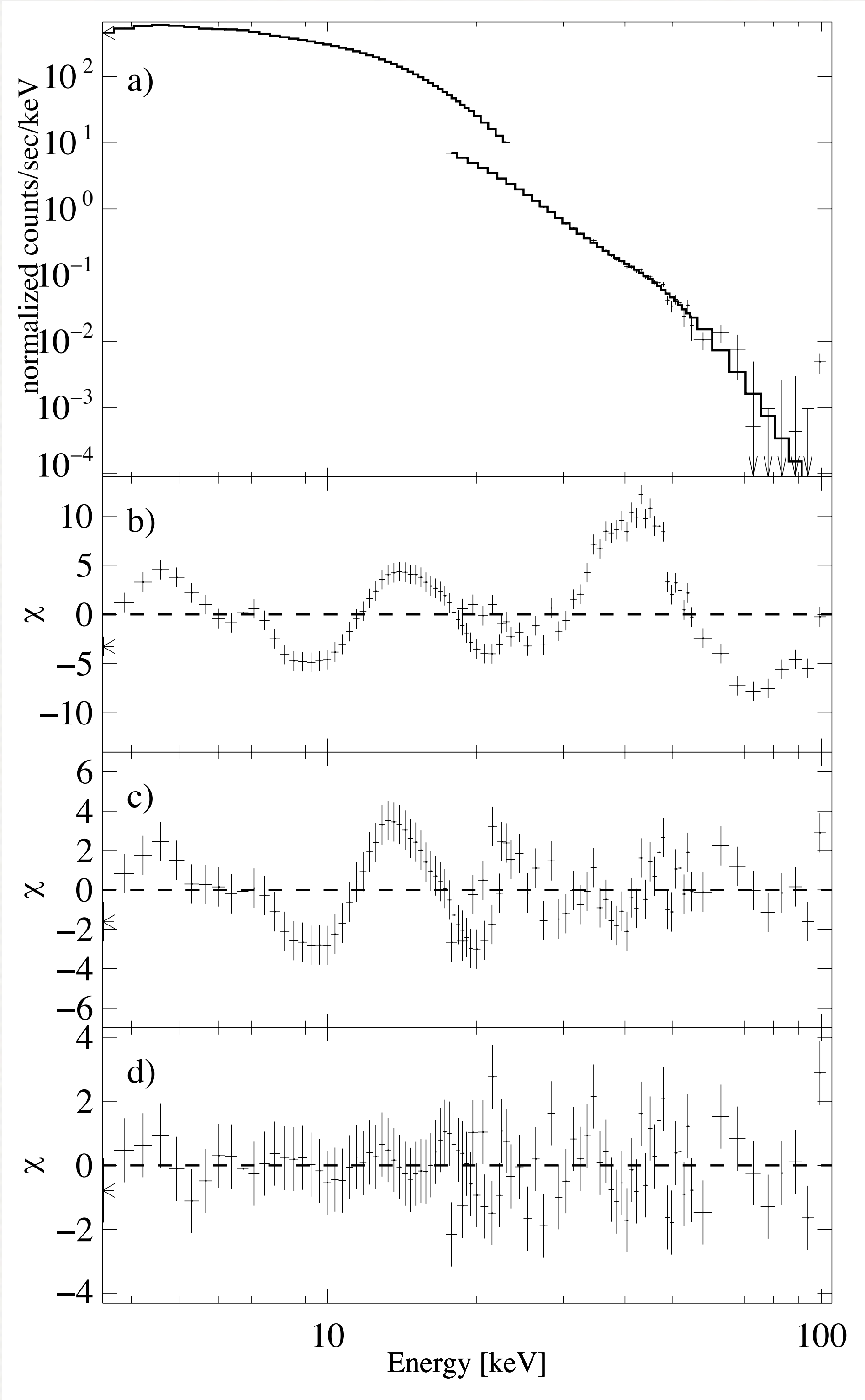
P_{spin} ~ 4.8 s

O6-8 III supergiant comp.

dist. ~8 kpc

disk or wind accretion???

SPECTRUM



(Suchy et al, 2008)

Phabs*Fdcut*power+Fe-line

N_H = 1.6 x10^{22} cm^{-2}

E_{Cut} = 11.1 keV

E_{Fold} = 7.2 keV

Γ = 0.92

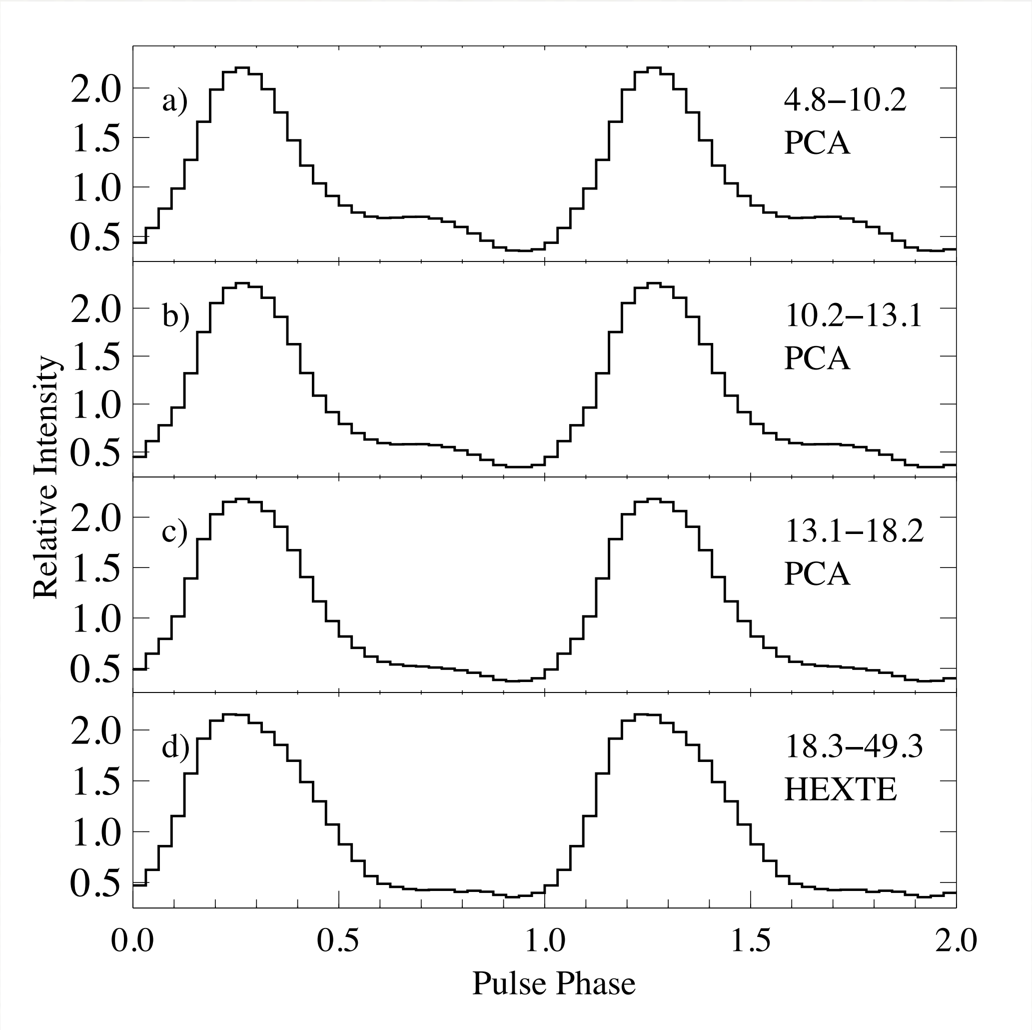
CRSF : E_{Cyc} = 30.7 keV

σ_{Cyc} = 6.4 keV

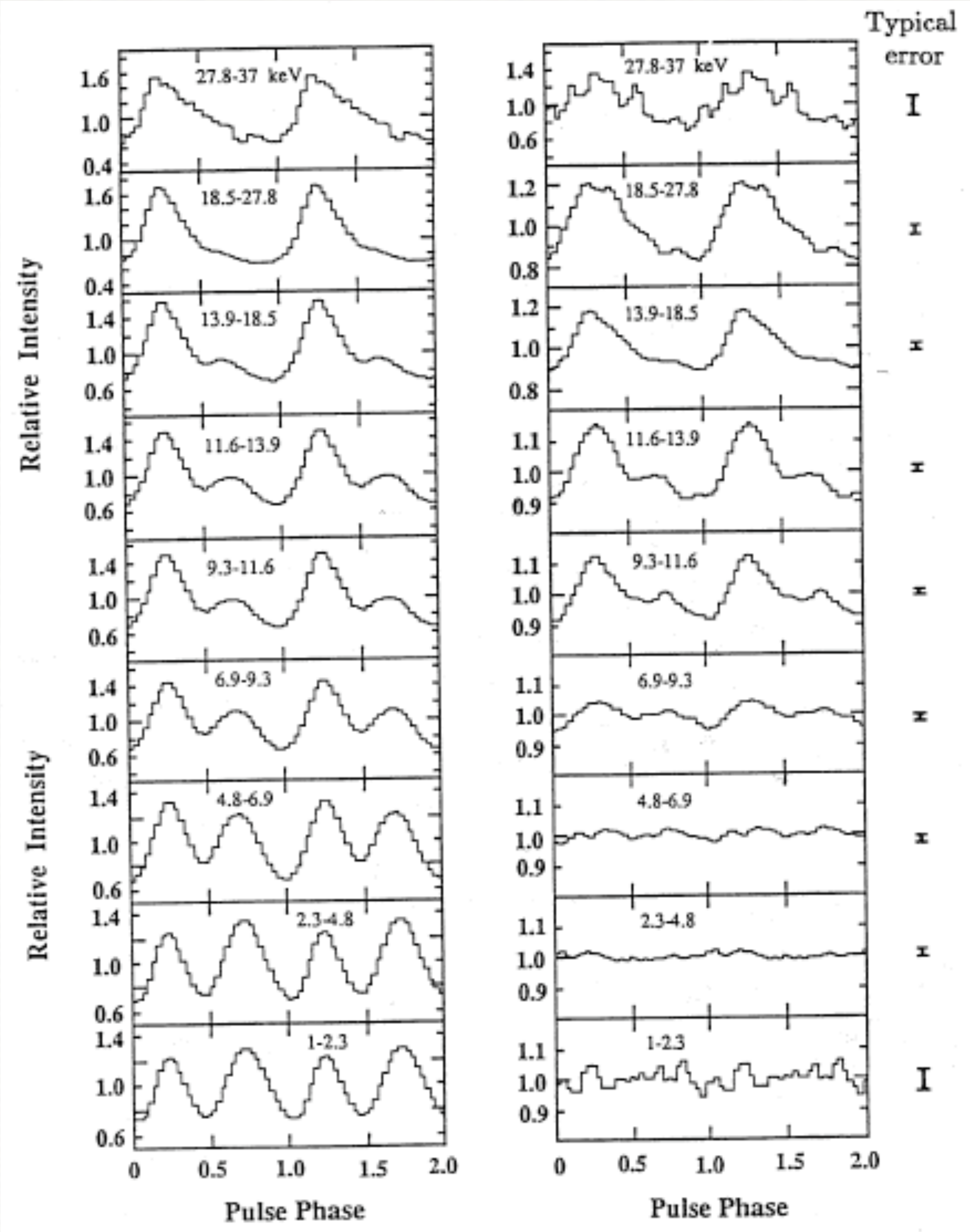
τ_{Cyc} = 0.67

13 keV feature

PULSE PROFILE

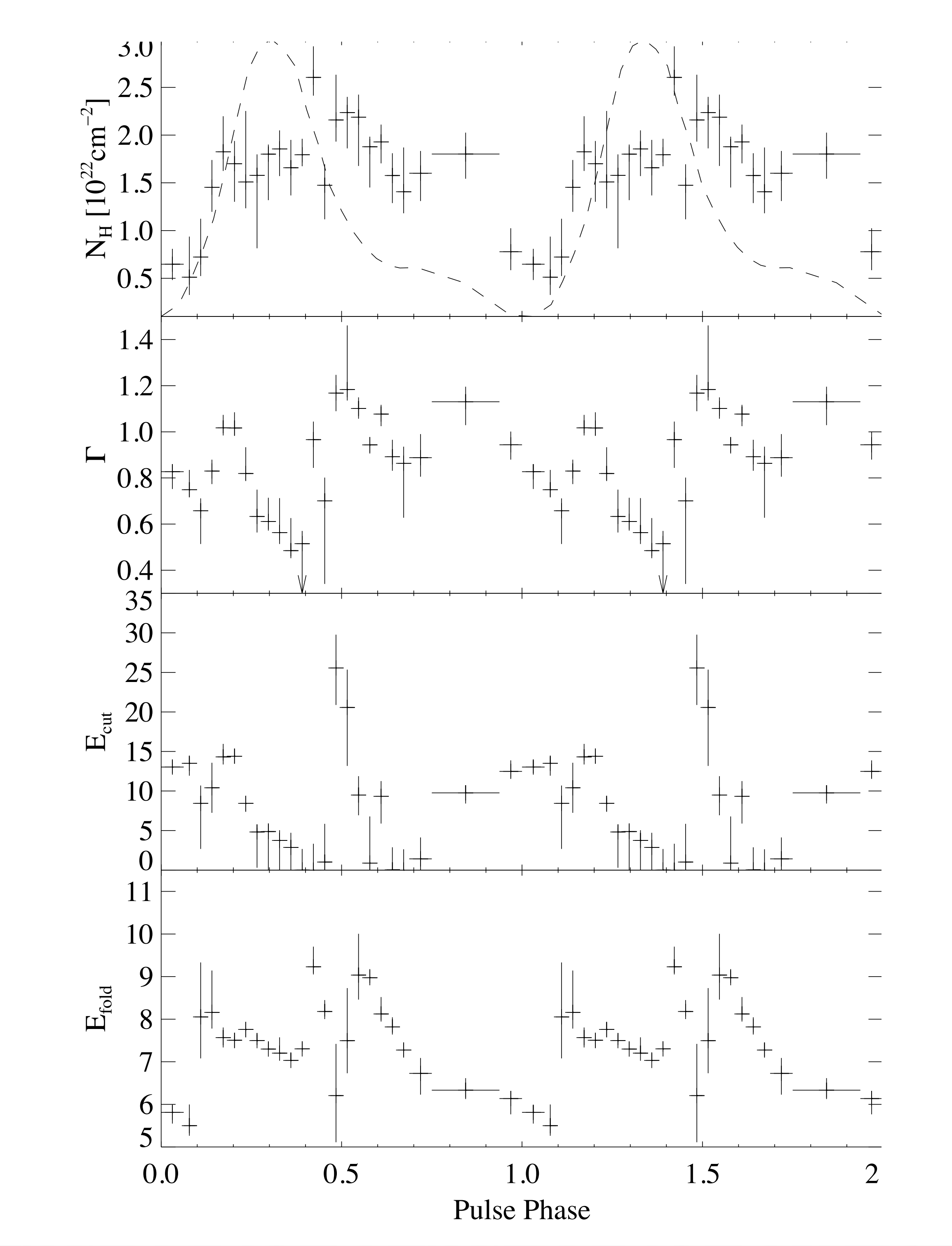


(Suchy et al, 2008)

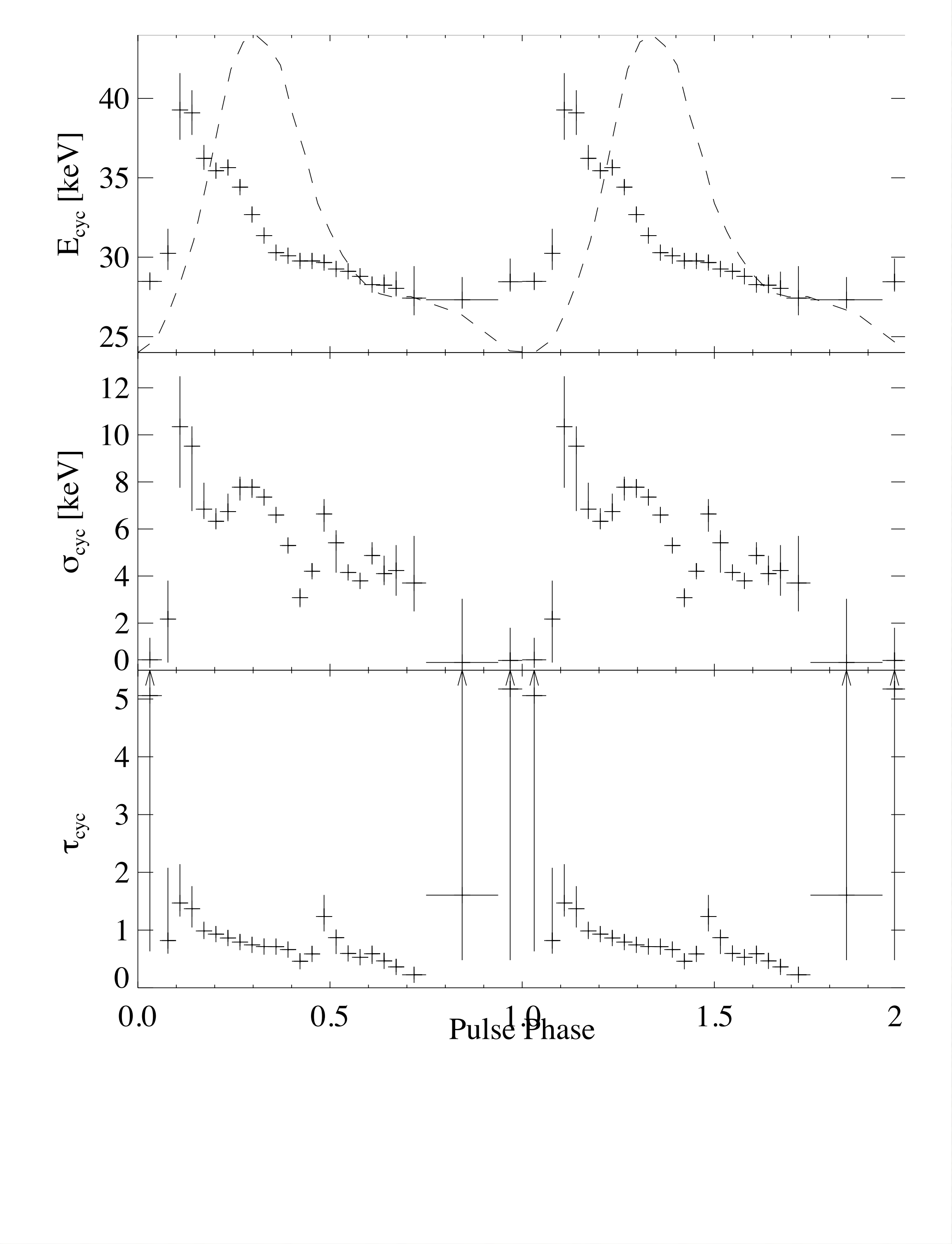


(Nagase et al, 1992)

PHASE RESOLVED SPECTRA

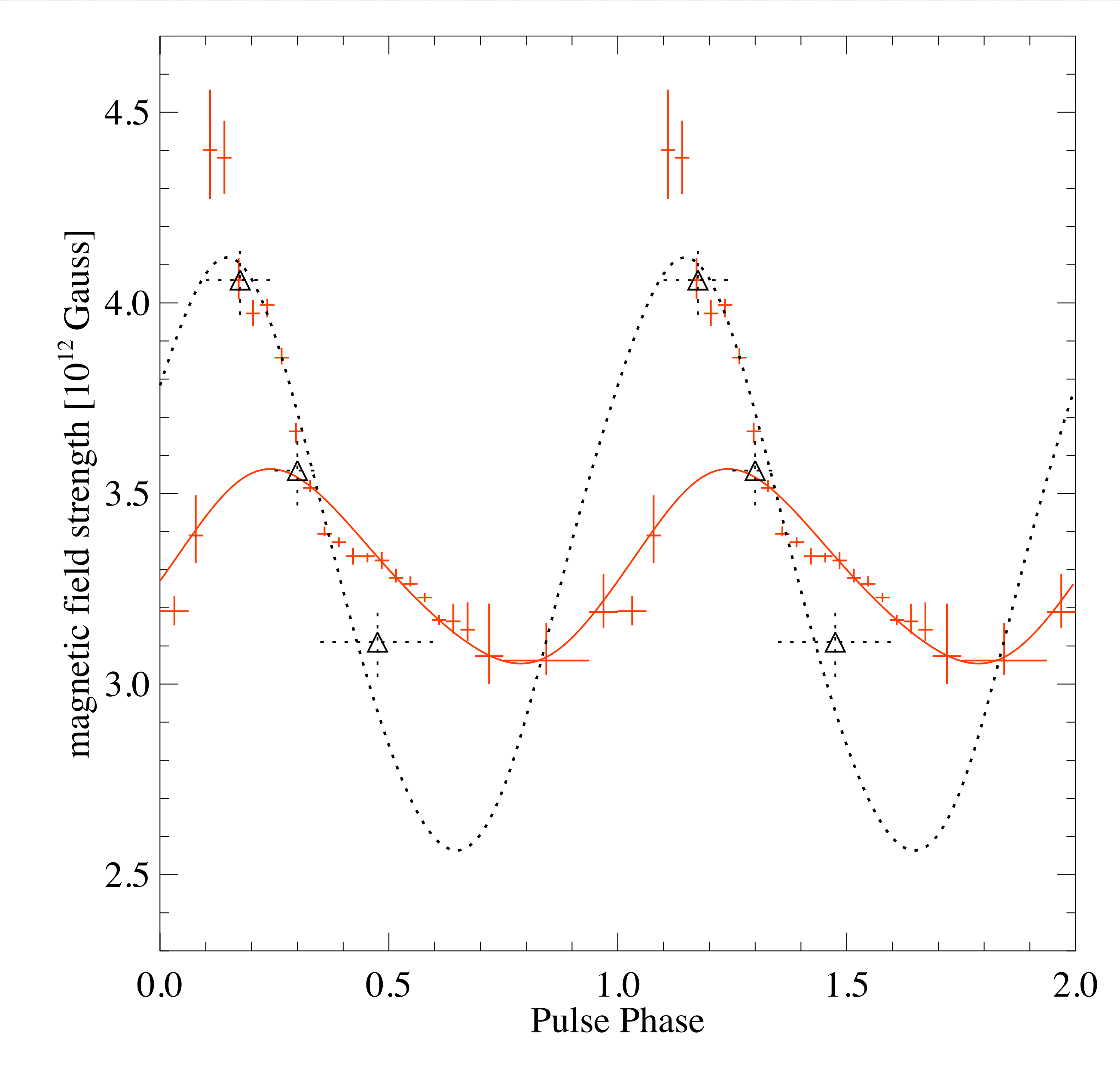


(Suchy et al, 2008)



(Suchy et al, 2008)

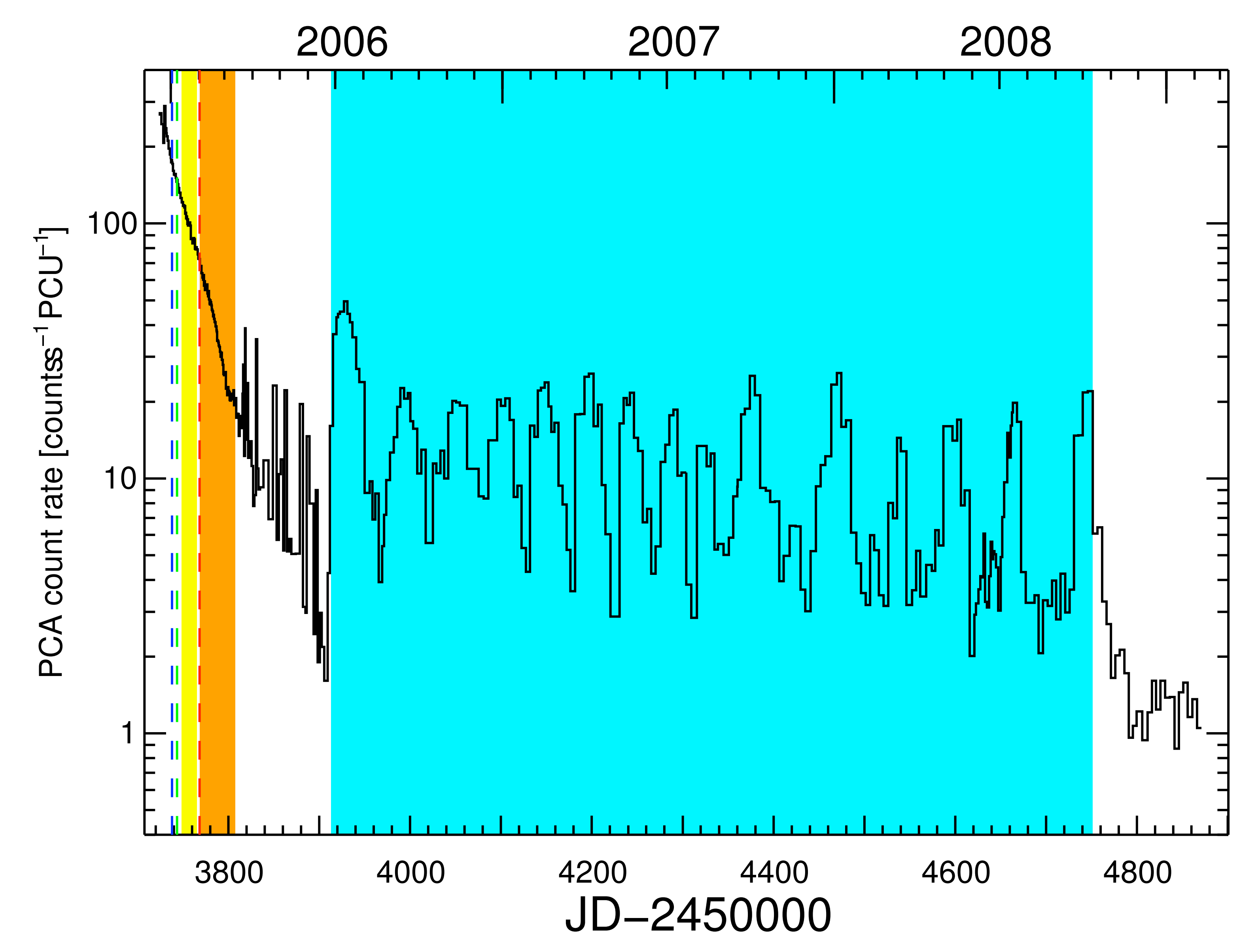
DIPOL MODELLING



comparison with BeppoSAX results (Burderi et al., 2000)

(Suchy et al, 2008)

SWIFT J1626



(DeCesar et al., submitted)

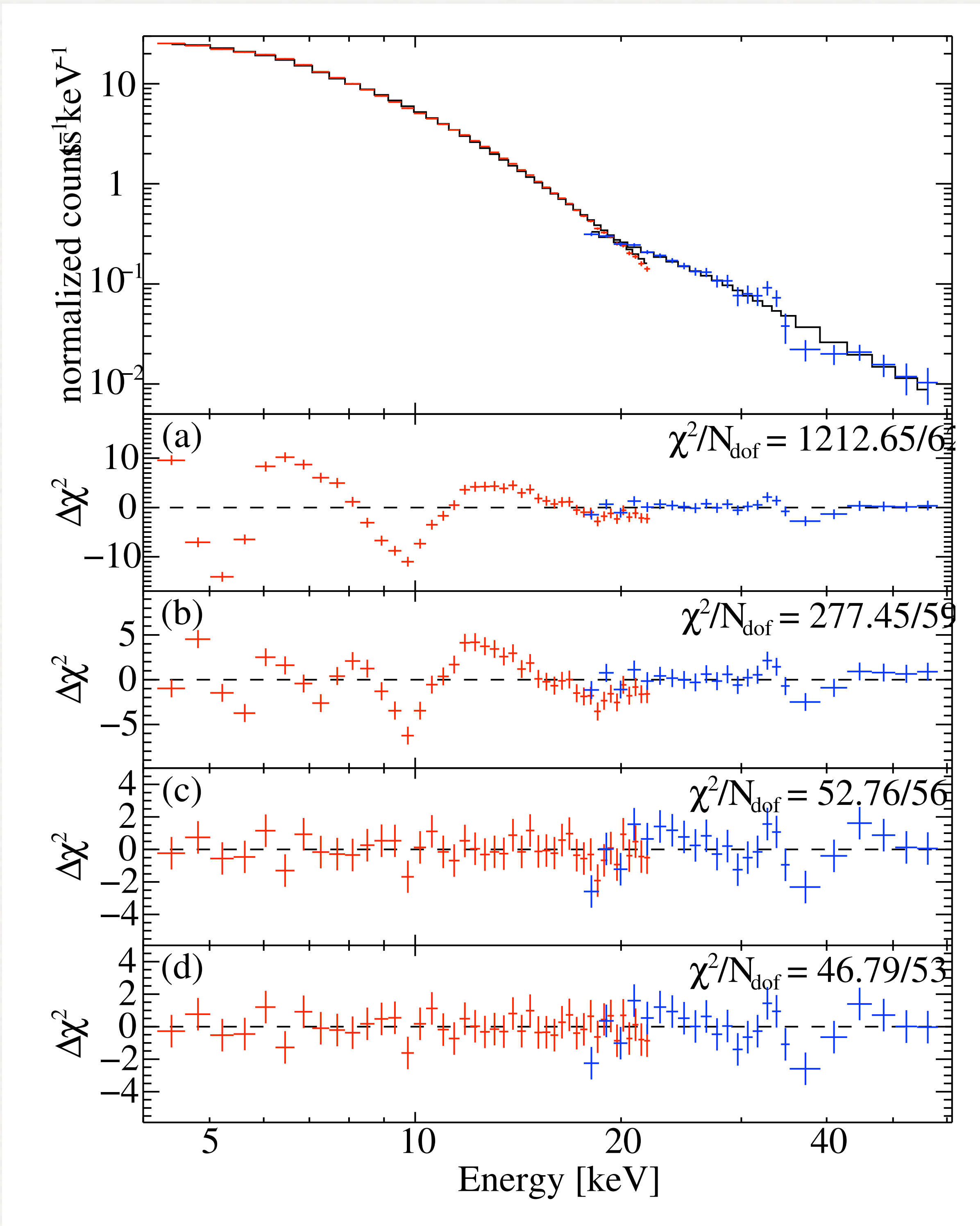
Be/X-ray Binary
Discovery Dec. 2005
Typ II outburst

P_{Orb}: ???
P_{Spin}: 15s

QPO oscillations of
47 and 72.5 days

possible P_{Orb}: 132.9 days
(Baykal et al., 2010)

SPECTRUM



(DeCesar et al., submitted)

(a) Phabs*cutoffpl

$N_H = 3.4 \times 10^{22}\ cm^{-2}$

$E_{Fold} = 10.98$ keV

$\Gamma = 1.32$

(b) additional Fe-line

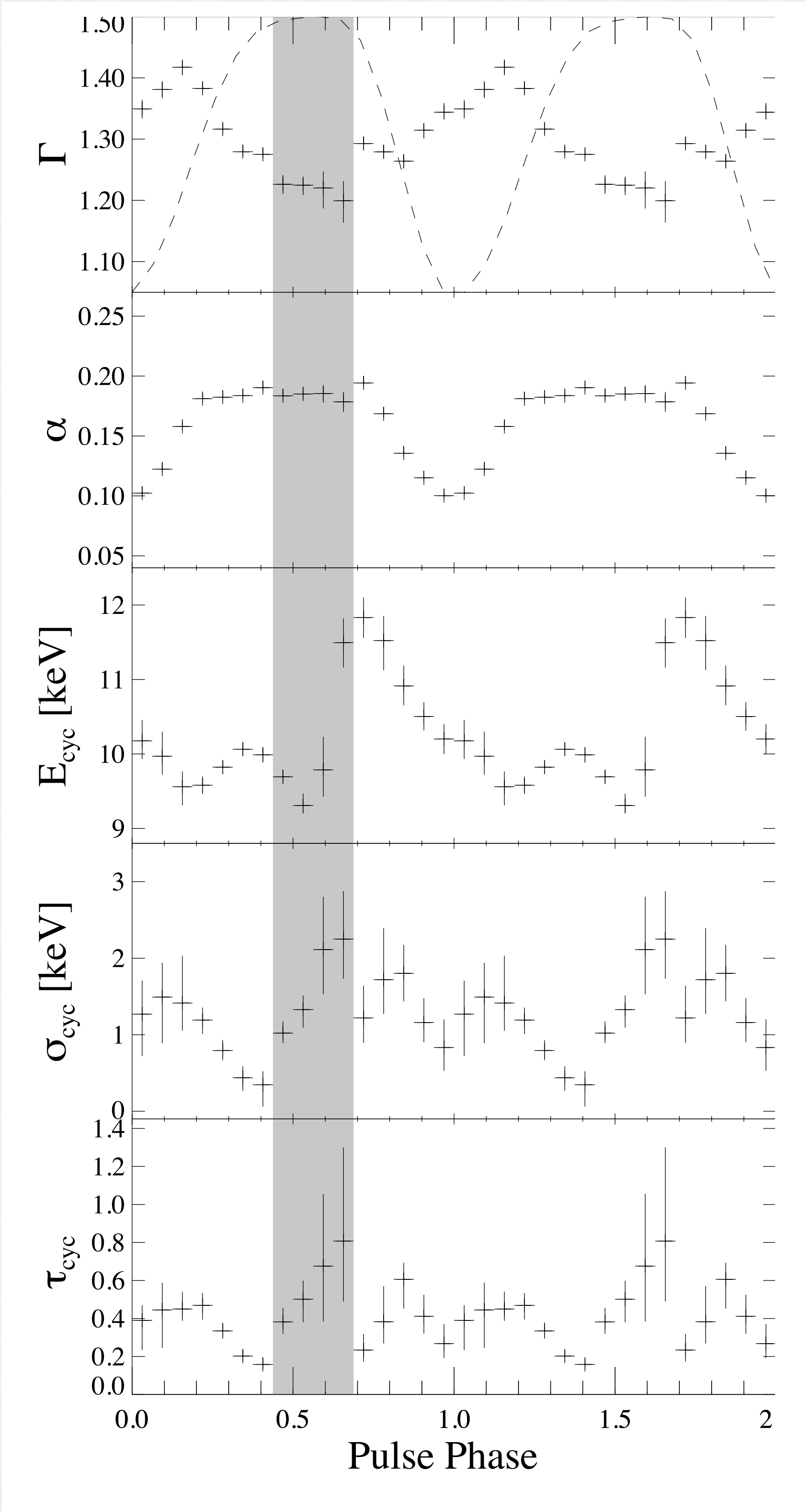
(c) CRSF : $E_{Cyc} = 9.71$ keV

$\sigma_{Cyc} = 1.27$ keV

$\tau_{Cyc} = 0.33$

(d) 2nd harmonic at ~18keV??

PHASE RESOLVED



E_{Fold} = 10.98 keV frozen

α = norm

(DeCesar et al., submitted)

TABLE 3
SPECTRAL PARAMETERS FOR PHASE RESOLVED SPECTRA FROM LO3

Phase Bin	Γ	$A_{\rm cutoff}$ $(10^{-1})^a$	$\sigma_{\rm Fe}$ (keV)	$A_{\rm Fe}$ $(10^{-3})^b$	$E_{\rm cyc,1}$ (keV)	$\sigma_{\rm cyc,1}$ (keV)	$\tau_{\rm cyc,1}$	$E_{\rm cyc,2}$ (keV)	$\sigma_{\rm cyc,2}$ (keV)	$\tau_{\rm cyc,2}$	$\chi^2_{\rm red,2}$ 41 dof	$\chi^2_{\rm red,1}$ 43 dof	$\chi^2_{\rm red,0}$ 46 dof
1	$1.34^{+0.02}_{-0.01}$	$1.02^{+0.03}_{-0.03}$	$0.3^{+0.1}_{-0.3}$	$1.02^{+0.50}_{-0.34}$	$10.2^{+0.3}_{-0.2}$	$1.3^{+0.4}_{-0.5}$	$0.4^{+0.2}_{-0.1}$	--	--	--	--	**1.34**	2.76
2	$1.38^{+0.02}_{-0.01}$	$1.22^{+0.03}_{-0.03}$	$0.3^{+0.2}_{-0.2}$	$1.15^{+0.75}_{-0.19}$	$10.0^{+0.3}_{-0.2}$	$1.6^{+0.5}_{-0.6}$	$0.5^{+0.1}_{-0.2}$	--	--	--	--	**0.98**	2.10
3	$1.42^{+0.01}_{-0.01}$	$1.57^{+0.03}_{-0.03}$	$0.3^{+0.2}_{-0.3}$	$1.32^{+0.69}_{-0.38}$	$9.6^{+0.2}_{-0.1}$	$1.4^{+0.6}_{-0.4}$	$0.5^{+0.2}_{-0.1}$	--	--	--	--	**0.93**	2.41
4	$1.38^{+0.01}_{-0.01}$	$1.81^{+0.04}_{-0.03}$	$0.0^{+0.0}_{-0.0}$	$1.10^{+0.29}_{-0.20}$	$9.6^{+0.1}_{-0.1}$	$1.2^{+0.2}_{-0.2}$	$0.5^{+0.0}_{-0.1}$	--	--	--	--	**0.68**	4.64
5	$1.32^{+0.01}_{-0.01}$	$1.82^{+0.03}_{-0.03}$	$0.0^{+0.01}_{-0.00}$	$1.15^{+0.26}_{-0.24}$	$9.8^{+0.1}_{-0.1}$	$0.8^{+0.1}_{-0.1}$	$0.3^{+0.0}_{-0.0}$	--	--	--	--	**0.96**	6.57
6	$1.28^{+0.01}_{-0.01}$	$1.83^{+0.04}_{-0.03}$	$0.8^{+0.1}_{-0.1}$	$2.75^{+0.52}_{-0.47}$	$10.0^{+0.2}_{-0.0}$	$0.4^{+0.2}_{-0.1}$	$0.2^{+0.0}_{-0.0}$	--	--	--	--	**1.69**	5.46
7	$1.28^{+0.00}_{-0.01}$	$1.90^{+0.03}_{-0.03}$	$1.0^{+0.1}_{-0.2}$	$2.96^{+0.51}_{-0.46}$	$10.0^{+0.1}_{-0.1}$	$0.3^{+0.2}_{-0.3}$	$0.2^{+0.0}_{-0.1}$	--	--	--	--	**1.41**	4.35
8	$1.23^{+0.01}_{-0.02}$	$1.84^{+0.03}_{-0.04}$	$0.0^{+0.4}_{-0.0}$	$0.62^{+0.26}_{-0.19}$	$9.7^{+0.1}_{-0.1}$	$1.0^{+0.2}_{-0.1}$	$0.4^{+0.1}_{-0.6}$	$17.5^{+0.6}_{-0.4}$	2.5	$0.8^{+0.2}_{-0.2}$	**1.24**	2.29	5.38
9	$1.22^{+0.02}_{-0.01}$	$1.85^{+0.04}_{-0.04}$	$0.0^{+0.3}_{-0.0}$	$0.74^{+0.49}_{-0.20}$	$9.3^{+0.2}_{-0.1}$	$1.3^{+0.2}_{-0.2}$	$0.5^{+1.0}_{-0.1}$	$18.4^{+0.4}_{-0.4}$	2.5	$1.0^{+0.3}_{-0.2}$	**1.05**	2.80	5.42
10	$1.22^{+0.03}_{-0.3}$	$1.85^{+0.07}_{-0.08}$	$0.4^{+0.1}_{-0.1}$	$2.28^{+1.14}_{-0.39}$	$9.8^{+0.4}_{-0.4}$	$2.1^{+0.7}_{-0.6}$	$0.7^{+0.4}_{-0.3}$	$18.7^{+0.3}_{-0.4}$	2.5	$1.3^{+0.5}_{-0.3}$	**1.33**	2.81	3.64
11	$1.20^{+0.03}_{-0.03}$	$1.78^{+0.08}_{-0.08}$	$0.4^{+0.1}_{-0.0}$	$4.32^{+1.16}_{-1.02}$	$11.5^{+0.3}_{-0.3}$	$2.2^{+0.6}_{-0.5}$	$0.8^{+0.5}_{-0.3}$	$19.1^{+0.4}_{-0.5}$	2.5	$1.5^{+0.4}_{-0.5}$	**1.17**	2.17	2.62
12	$1.29^{+0.01}_{-0.01}$	$1.94^{+0.03}_{-0.03}$	$0.4^{+0.1}_{-0.0}$	$4.40^{+0.68}_{-0.71}$	$11.8^{+0.3}_{-0.3}$	$1.2^{+0.4}_{-0.3}$	$0.2^{+0.1}_{-0.0}$	--	--	--	--	**1.43**	2.58
13	$1.28^{+0.01}_{-0.01}$	$1.68^{+0.03}_{-0.03}$	$0.4^{+0.1}_{-0.1}$	$2.44^{+0.85}_{-0.69}$	$11.5^{+0.3}_{-0.4}$	$1.7^{+0.7}_{-0.4}$	$0.4^{+0.2}_{-0.1}$	--	--	--	--	**0.89**	2.25
14	$1.26^{+0.01}_{-0.01}$	$1.35^{+0.03}_{-0.03}$	$0.3^{+0.1}_{-0.3}$	$1.13^{+0.71}_{-0.34}$	$10.9^{+0.3}_{-0.3}$	$1.8^{+0.4}_{-0.4}$	$0.6^{+0.2}_{-0.1}$	--	--	--	--	**1.03**	3.66
15	$1.31^{+0.01}_{-0.01}$	$1.15^{+0.02}_{-0.03}$	$0.3^{+0.2}_{-0.2}$	$1.18^{+0.45}_{-0.27}$	$10.5^{+0.2}_{-0.2}$	$1.2^{+0.3}_{-0.3}$	$0.4^{+0.1}_{-0.1}$	--	--	--	--	**1.02**	3.49
16	$1.34^{+0.02}_{-0.01}$	$1.00^{+0.03}_{-0.02}$	$0.3^{+0.2}_{-0.1}$	$1.31^{+0.46}_{-0.34}$	$10.2^{+0.2}_{-0.2}$	$0.8^{+0.4}_{-0.3}$	$0.3^{+0.1}_{-0.1}$	--	--	--	--	**0.99**	2.38

NOTE. — α and β are respectively the normalization constants of the cut-off power law and Gaussian iron emission line; $E_{\rm cyc,1}$, $\sigma_{\rm cyc,1}$, and $\tau_{\rm cyc,1}$ the energy, width, and Gaussian optical depth of the first CRSF; $E_{\rm cyc,1}$, $\sigma_{\rm cyc,1}$, and $\tau_{\rm cyc,1}$ the same parameters for the second CRSF; $\chi_{\rm red,0}$, $\chi_{\rm red,1}$, and $\chi_{\rm red,2}$ the reduced χ^2 values for fits with no CRSF, one (the fundamental) CRSF, and both CRSFs. [a]Units are 10^{-1} photons keV^{-1} cm^{-2} at 1 keV. [b]Units are 10^{-3} total photons cm^{-2} s^{-1} in the line.

(DeCesar et al., submitted)

SUMMARY

Phase resolved spectroscopy can emphasize features, that are smeared out otherwise

Further studies can help to understand the physics at the line forming region

FOLLOW UP

Cen X-3: Using a Suzaku observation of 1 Orbit for a comparison in a different state

Swift J1626: Commenting on the received referee report

ALL SOURCES

(**bold** sources show signifiant CRSF variations)

Swiftj J1626-51	**10?,18**	**Coburn et al. (2006), DeCesar et al. (subm.)**
4U 0115+63	**14,24,36,48,62**	**Wheaton et al.(1979, HEAO-1), Heindl et al. (1999, RXTE)**
		Santangelo et al.(1999,SAX)
4U 1907+09	**18,38**	**Cusumano et al.(1998,SAX)**
4U 1538-52	20	Clark et al. (1990, Ginga)
Vela X-1	**24?,52**	**Kendziorra et al(1992,Mir-Hexe), Kreykenbohm et al.(2002,RXTE)**
V 0332+53	**27**	**Makishima & Ohashi (1990,Ginga)**
Cep X-4	28	Mihara et al. (1991,Ginga)
Cen X-3	**29**	**Santangelo et al. (1998 SAX), Heindl&Chakrabarty (1999, RXTE)**
X Per	**29**	**Coburn et al. (2001, RXTE)**
-MX 0656-072	35	Heindl et al. (2003,RXTE)
XTE J1946+274	36	Heindl et al. (2001, RXTE)
-OAO 1657-415	36?	Orlandini et al. (1999, SAX)
-4U 1626-67	37	Orlandini et al. (1998, SAX), Heindl & Chakrabarty (1999, RXTE)
GX 301-2	**37**	**Mihara (1995, Ginga)**
Her X-1	**41**	**Trümper et al. (1998, Ballon-HEXE)**
A0535+26	**50,110**	**Kendziorra et al. (1992, 1994, HEXE), Maisack et al. (1997, CGRO)**
LMC X-4	100?	Barbera et al. (2001, SAX)