

Cygnus X-1 as seen by *RXTE*: on the edge (of transition)

Katja Pottschmidt

CRESST & UMBC & NASA-GSFC

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S. Kreykenbohm geb. Fritz (prev. IAAT), M. Hanke (prev. FAU),
S. B. Markoff (UvA), S. Heinz (UW-Madison), M. Klein-Wolt (S[&]T Corp),
R. P. Fender (USouthampton), J. Rodriguez (CEA Saclay), I. Kreykenbohm (FAU),
S. Suchy (IAAT), W. A. Heindl (prev. UCSD), D. M. Smith (UCSC),
R. A. Remillard (MIT), R. E. Rothschild (UCSD), R. Staubert (IAAT)

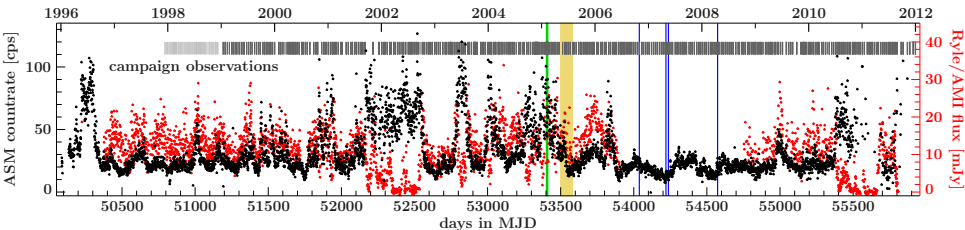
16 Years of Discovery with RXTE, GSFC, March 29 & 30, 2012



UMBC



Legacy – Long Term Flux Evolution: **ASM** & *Ryle/AMI*



05/1996-08/1996 soft state
 09/1996-06/1998: stable hard state
 07/1998-05/2006: many flares
 06/2006-05/2009: stable hard state
 06/2009ff: many flares

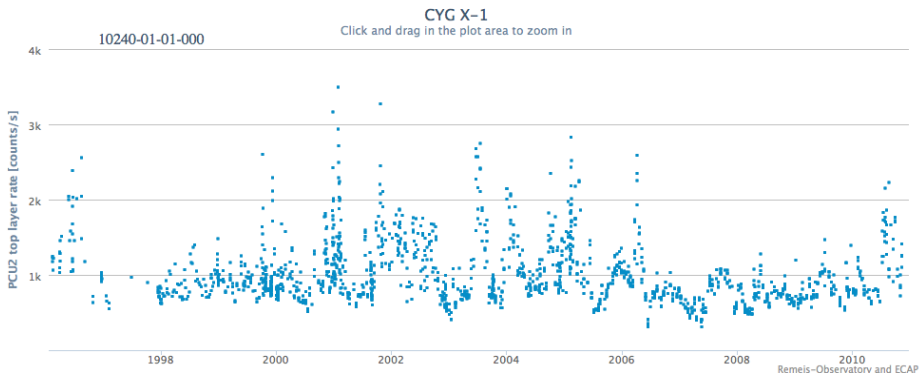
(Quasi-)Simultaneous observations:
Suzaku [Nowak+11],
Chandra [Hanke11:thesis],
INTEGRAL [Pottschmidt+03],
XMM [Duro+11],
Spitzer [Rahoui+11], and more

For multi-instrument campaigns see talk by Mike Nowak and poster by Victoria Grinberg, here: **focus on *RXTE* and radio monitoring.**

Many thanks to Evan Smith and Divya Pereira for everything!

Legacy – Long Term Flux Evolution: PCA

<http://crux.sternwarte.uni-erlangen.de/~wilms/rxte/>
 coming soon: *RXTE* in HEAVEN(S):
<http://www.isdc.unige.ch/heavens/>

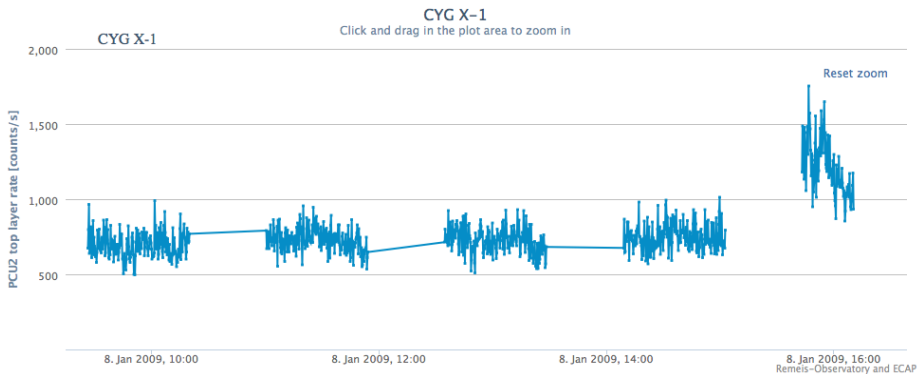


CYG X-1

Observation		Object	ObsID	Source rate
Start	End			[counts/s]
50125.08346	50125.39867	CYG X-1	10240-01-01-000	1248.09
50125.39867	50125.41890	CYG X-1	10240-01-01-00	1180.08

Legacy – Long Term Flux Evolution: PCA

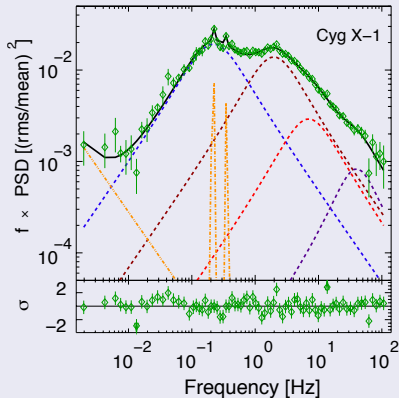
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CYG X-1

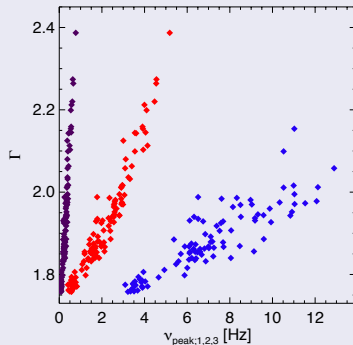
Observation		Object	ObsID	Source rate
Start	End			[counts/s]
54833.39307	54833.62867	CYG X-1	94121-01-01-00	712.04
54833.65384	54833.68492	CYG X-1	94121-01-01-01	1194.06

Hard State Power Spectra: Disk-Corona Connection



Pottschmidt et al. (2003) 1998-2001

Hard/Trans. State: Decomposition into **broad Lorentzians** possible.
First example by Nowak (2001).

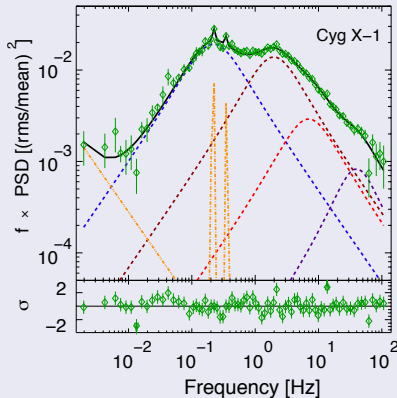


Pottschmidt et al. (2003) 1998-2001

Oscill. region shrinks with softening
(Shaposhnikov & Titarchuk, 2007).

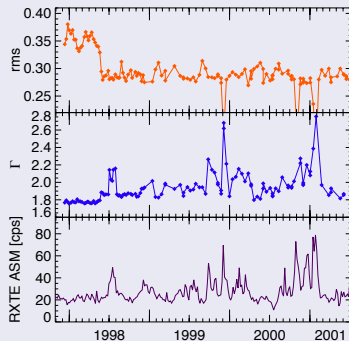
"Two hard states": O-star activity
(Gies et al., 2003)?

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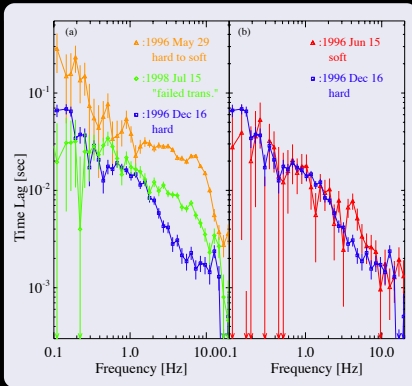


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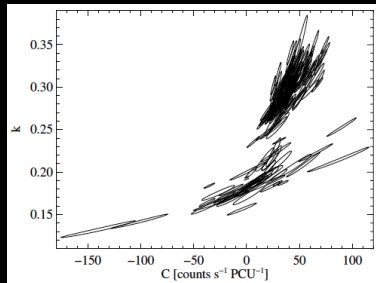
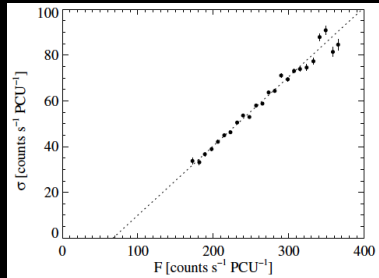
Time Lags & RMS-Flux: Accretion Rate Fluctuations



Pottschmidt et al. (2000) 1996-1998

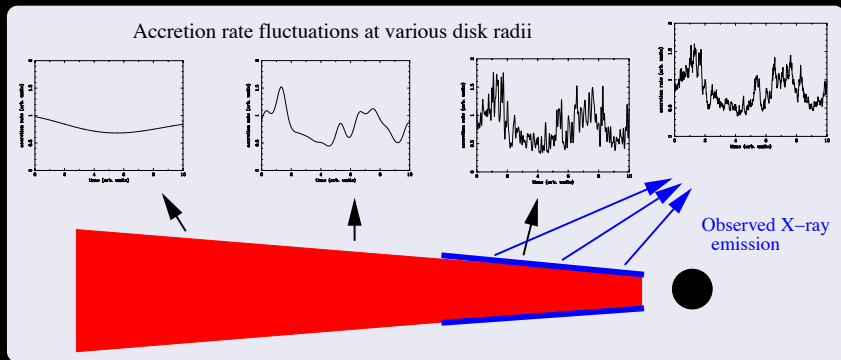
Hard/Soft State: **Harder emission lags** (Miyamoto et al., 1988)
 Trans. State: **Enhanced lag**.

RMS-flux correlation, first example by Uttley and McHardy (2001).



Glæssner et al. (2004a) 1996-2002

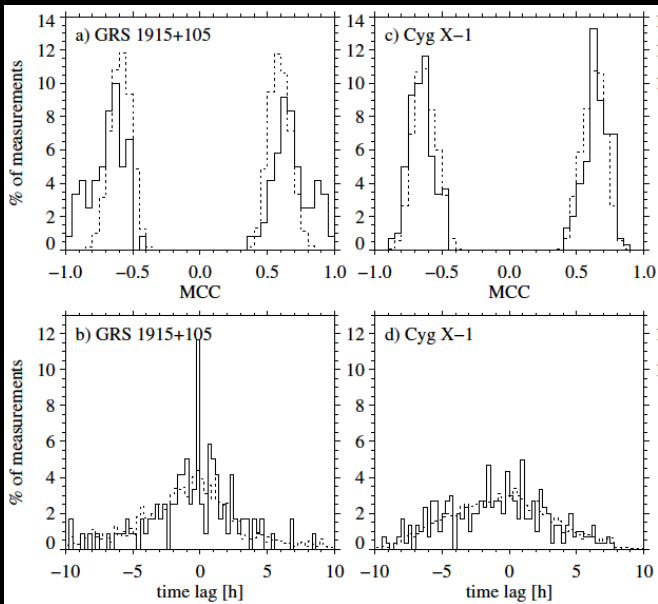
Time Lags & RMS-Flux: Accretion Rate Fluctuations



Courtesy Phil Uttley.

Flicker noise with radius dependent time scale in disk (Lyubarskii, 1997):
 Can explain RMS-flux correlation (Uttley and McHardy, 2001) and lags at < 3 keV (Uttley et al., 2011). Lags at higher energies require an additional corona/jet component (Kotov et al., 2001; Reig et al., 2003).

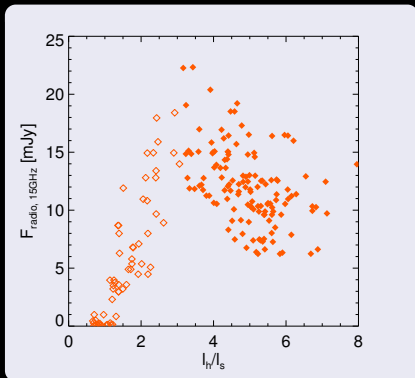
No XR Short Term Correlation: Disk-Jet Connection?



1999-2003

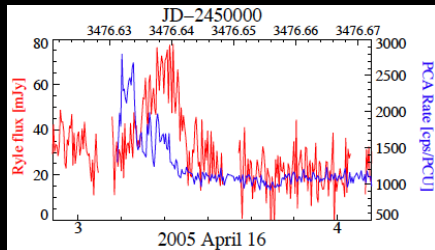
Glennier et al. (2004b)

The Transitional State: Disk-Jet Connection!



Wilms et al. (2006, 2007) 1999-2004/5

Long term: **Radio flaring** during transitional states.



Wilms et al. (2007)

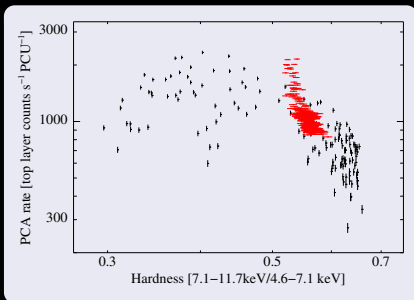
The only short term correlation event.

Lag of ~7 min:

Expanding synchrotron “blobs”?

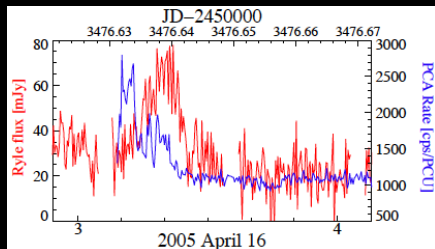
Confirmed with radio imaging (Miller-Jones et al., 2006).

The Transitional State: Disk-Jet Connection!



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Wilms et al. (2007)

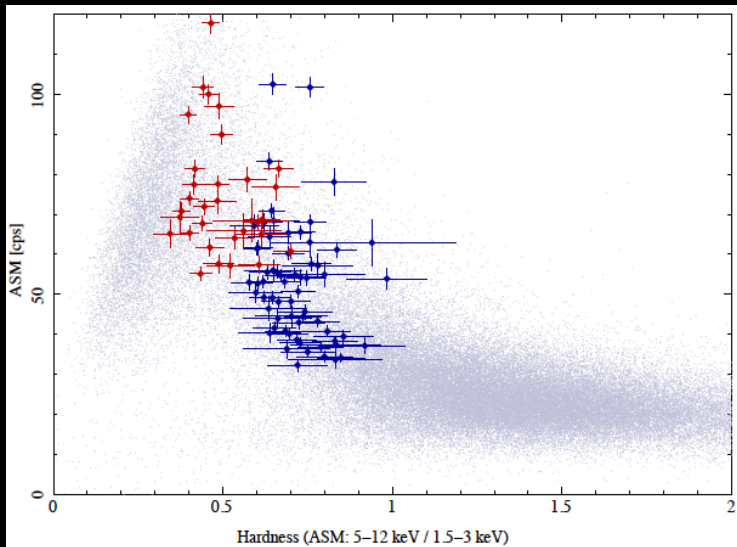
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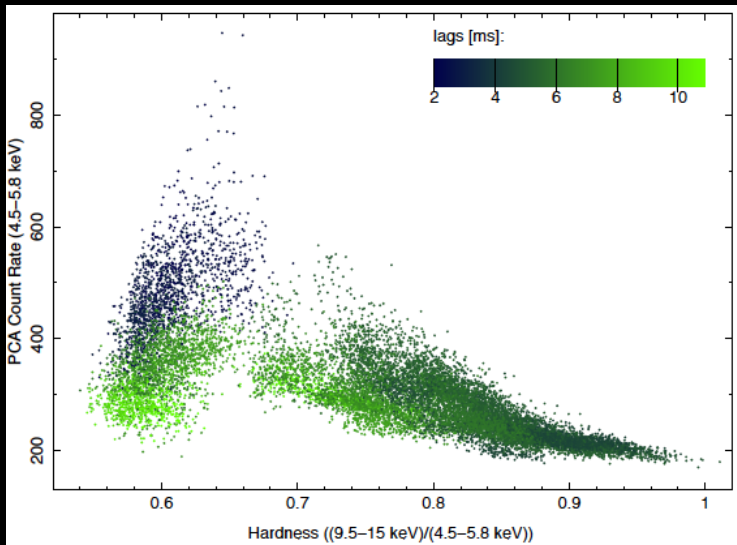
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HIMS \Rightarrow SIMS in under 2.5 hours

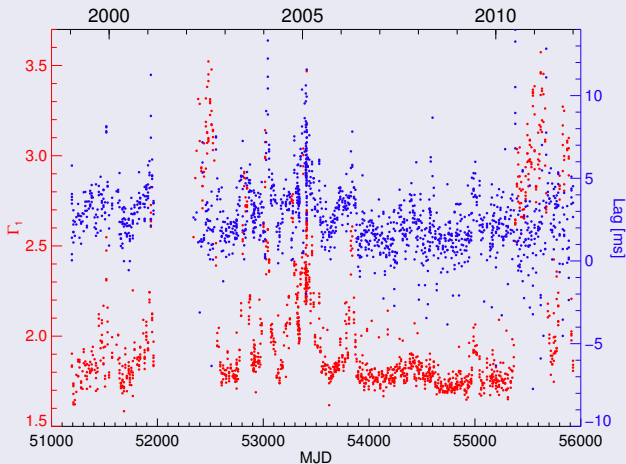


HIMS \Rightarrow SIMS in under 2.5 hours

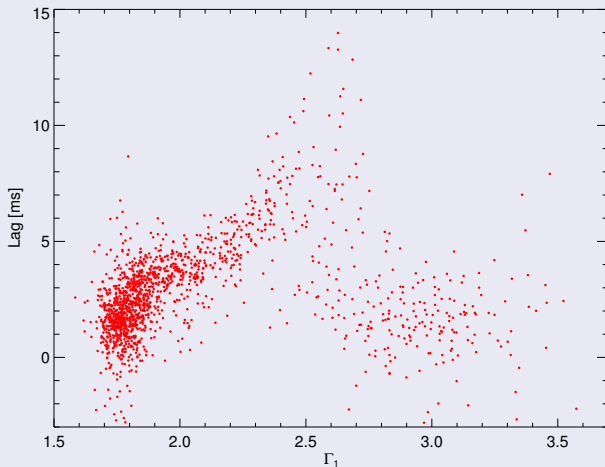
Böck et al. (2011)

within 10 d in 2005 February

The Complete Picture or “We are not done yet”



The Complete Picture or “We are not done yet”



Cyg X-1 Monitoring Papers

Temporal evolution of X-ray lags in Cygnus X-1: **Pottschmidt**, K., Wilms, J., Nowak, M. A., Heindl, W. A., Smith, D. M., Staubert, R., **2000**, A&A 357, L17

Long term variability of Cygnus X-1. I. X-ray spectral-temporal correlations in the hard state: **Pottschmidt**, K., Wilms, J., Nowak, M. A., Pooley, G. G., Gleissner, T., Heindl, W. A., Smith, D. M., Remillard, R., Staubert, R., **2003**, A&A 407, 1039

Long term variability of Cyg X-1. II. The rms-flux relation: **Gleissner**, T., Wilms, J., Pottschmidt, K., Uttley, P., Nowak, M. A., Staubert, R., **2004**, A&A 414, 1091

Long term variability of Cygnus X-1. III. Radio-X-ray correlations: **Gleissner**, T., Wilms, J., Pooley, G. G., Nowak, M. A., Pottschmidt, K., Markoff, S., Heinz, S., Klein-Wolt, M., Fender, R. P., Staubert, R., **2004**, A&A 425, 1061

Long term variability of Cygnus X-1. IV. Spectral evolution 1999-2004: **Wilms**, J., Nowak, M. A., Pottschmidt, K., Pooley, G. G., Fritz, S., **2006**, A&A 447, 245

Correlated Radio-X-Ray Variability of Galactic Black Holes: A Radio-X-Ray Flare in Cygnus X-1: **Wilms**, J., Pottschmidt, K., Pooley, G. G., Markoff, S., Nowak, M. A., Kreykenbohm, I., Rothschild, R. E., **2007**, ApJ 663, L97

Spectro-timing analysis of Cygnus X-1 during a fast state transition: **Böck**, M., Grinberg, V., Pottschmidt, K., Hanke, M., Nowak, M. A., Markoff, S. B., Uttley, P., Rodriguez, J., Pooley, G. G., Suchy, S., Rothschild, R. E., Wilms, J., **2011**, A&A 533, 8

Grinberg, V.; et al., **2012**, in prep.

+ example phenomenology & modeling, multi-instrument, other groups, ...