

# The tormented quiescence of the low mass X-ray binaries Centaurus X-4 and V404 Cygni



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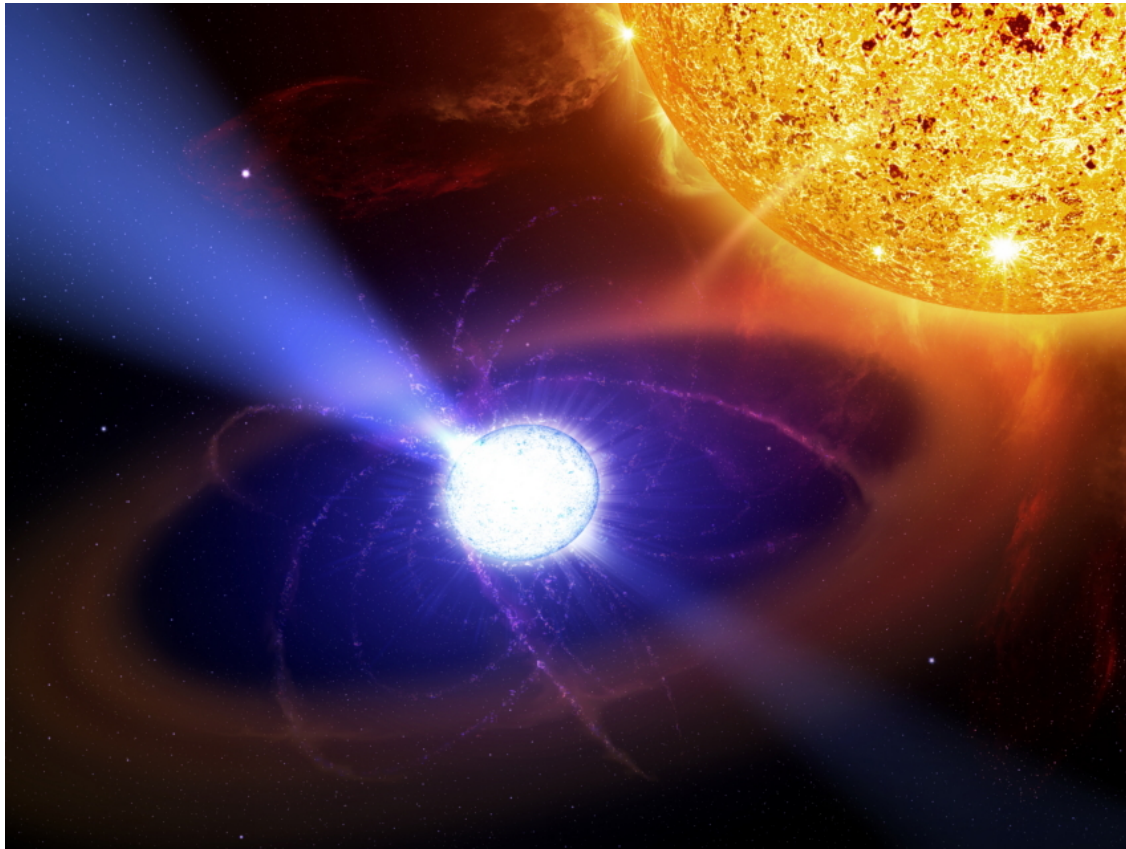
The X-ray Universe 2014  
Trinity College, Dublin, 16 June 2014

# Summary

- Why do we study Quiescent LMXB?
- The observational campaign
- Results

# Quiescent NS LMXBs

Missing clear picture of the quiescent accretion flow  
Particularly true for NS (magnetosphere and surface)



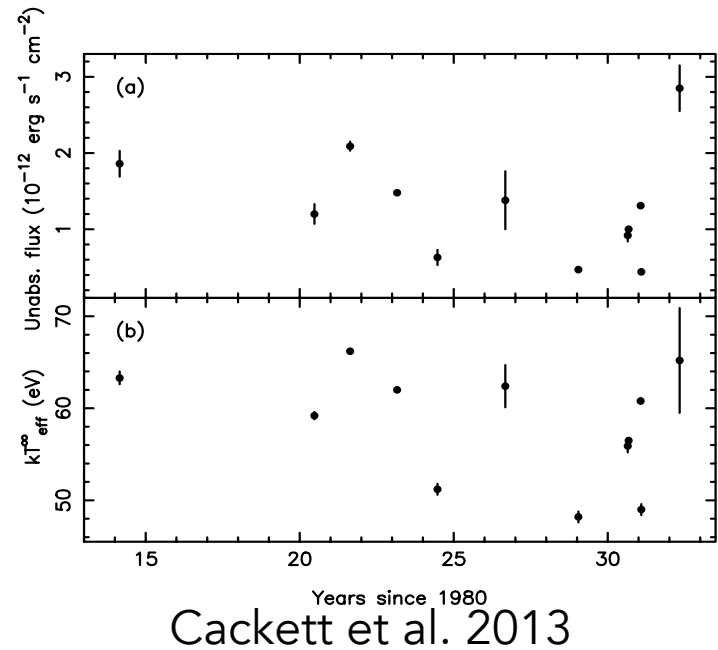
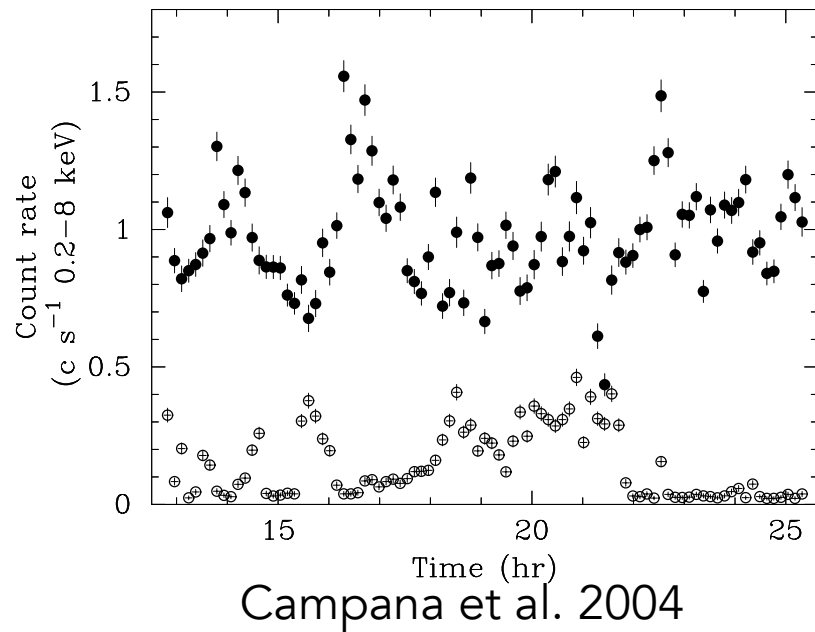
*Is matter still accreting also during quiescence?*

# Variability in Quiescence

LMXBs in quiescence are variable!

Single obs.  $\sim 40$ ks, or sparse coverage over years

## Cen X-4



*Where and how this variability is originating from?*  
*How is the quiescent emission powered?*

# Ultra Violet emission in quiescence

Companion too cold ( $\sim 5000$  K) to produce UV

UV should come from the accretion flow

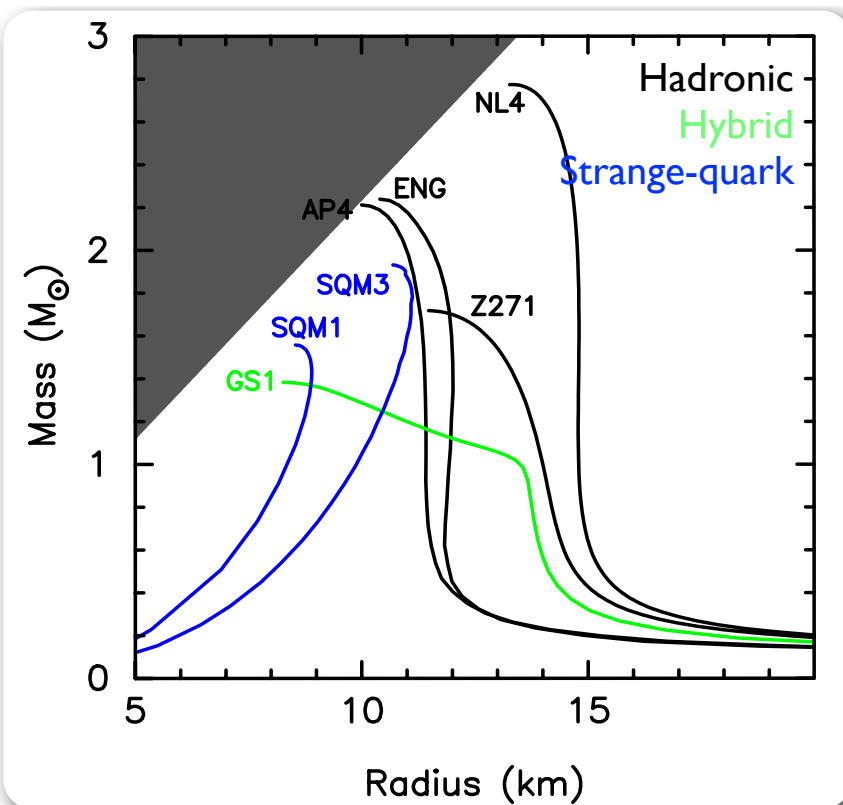
*But where exactly does the UV come from?*

- Stream impact point
- Mass accretion rate fluctuation in the disk
- Advection dominated accretion flow
- Reprocessing of the X-ray in the accretion disk

*Are the X-ray triggering the UV or viceversa?*

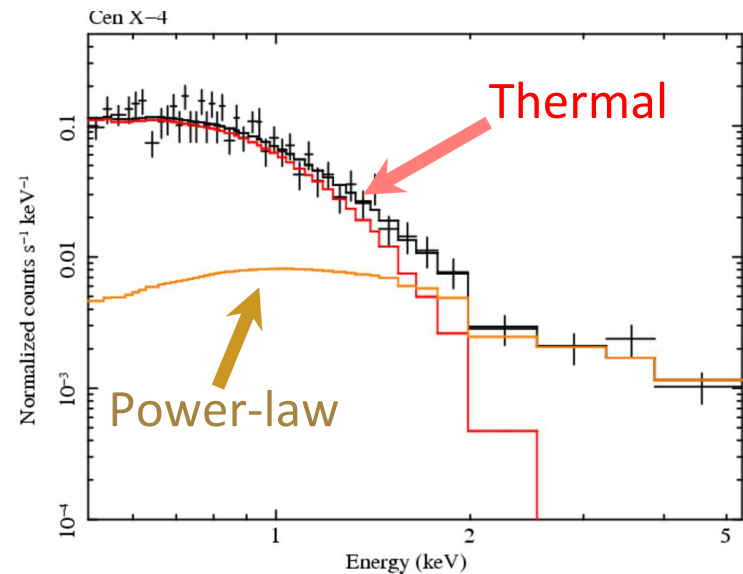
# Neutron Star Equation of State

Quiescent NS LMXB common target to measure  $R$



Credit: Ed Cackett

Measure of  $R$  can put some constrain on the EOS



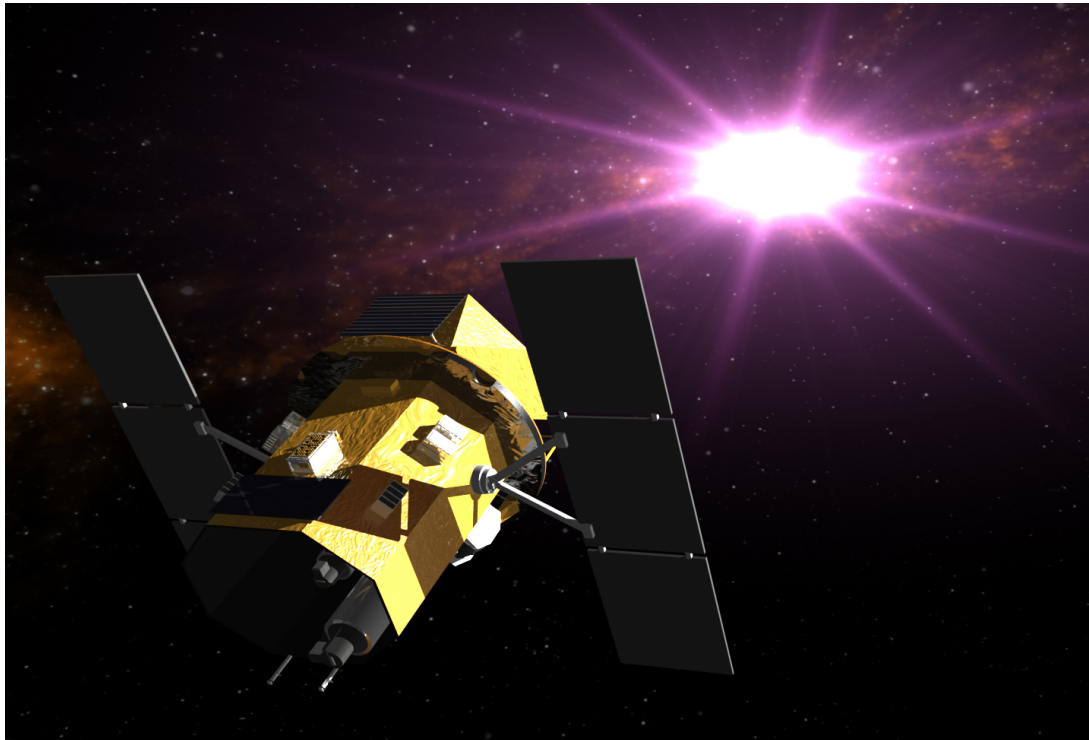
*If they are variable can we really use them to get  $R$ ?*

# How did we study qLMXB

We planned a unique study:

Long term (2 months), Multiwavelength (Optical, UV, X-ray)  
daily observations

Swift satellite



Credit: NASA's Goddard Space Flight Center.

# The sources

## 1. Centaurus X-4:

Neutron star,  $1.4 M_{\odot}$

Orbital period: 15.1 hours

Distance: 1.2 kpc

Companion: K3-7 V,  $T_{\text{eff}} = 4500 \text{ K}$ , Roche lobe filling

## 2. V404 Cygni:

Black hole,  $10 M_{\odot}$

Orbital period: 6.4 days

Distance: 2.4 kpc

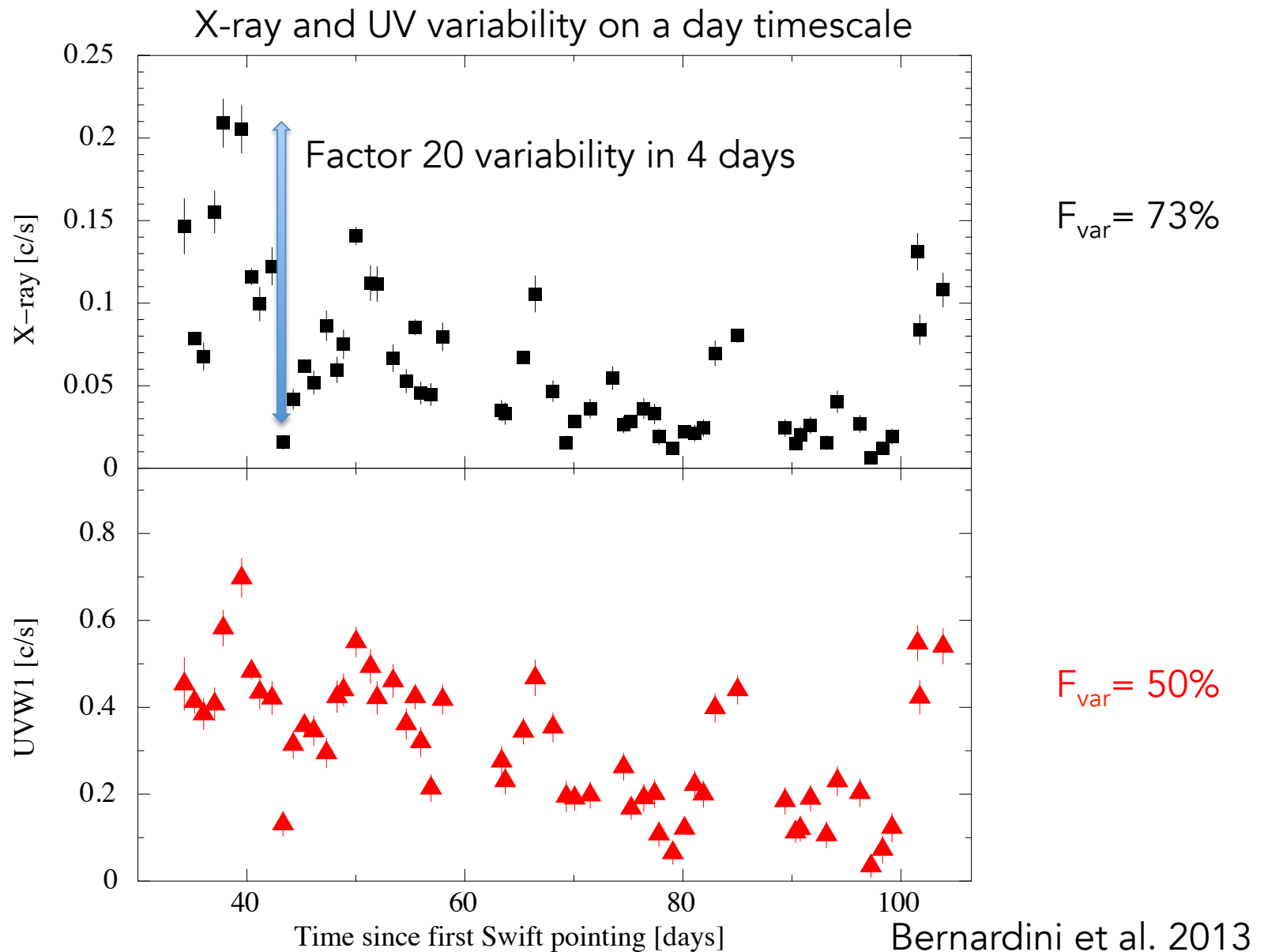
Companion: K0-1 III-V,  $T_{\text{eff}} = 4400 \text{ K}$ , Roche lobe filling

Brightest, closest, and best known qLMXBs

Perfect for quiescent studies!

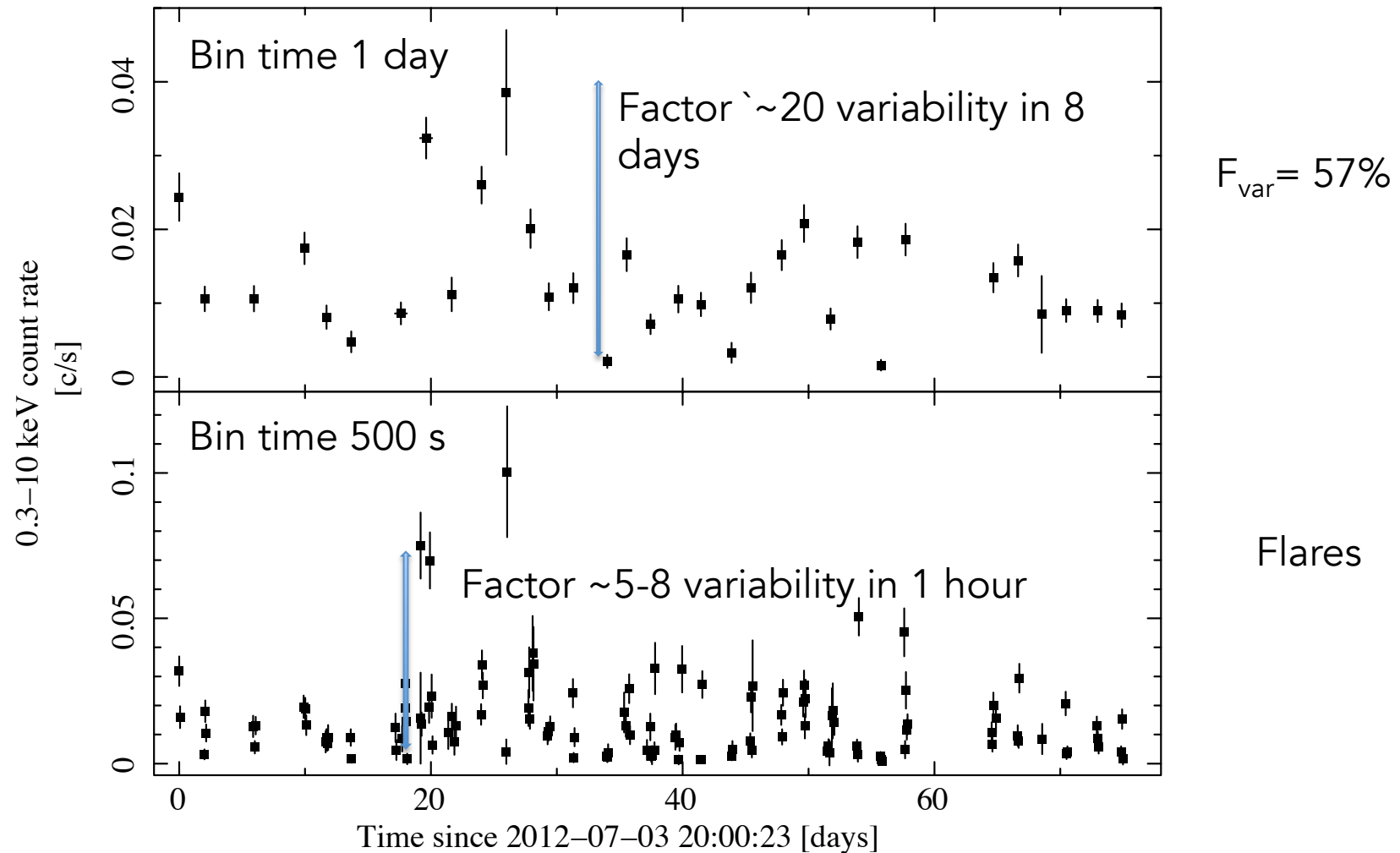


# Light curve of Cen X-4



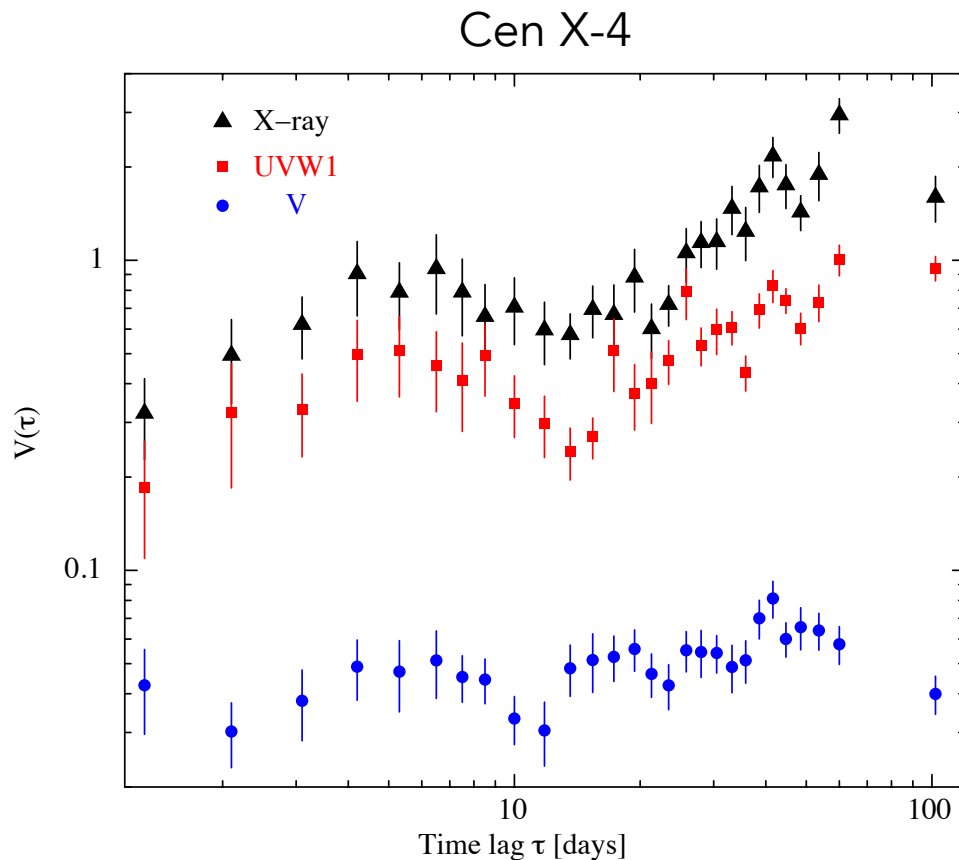
# X-ray light curve of V404 Cyg

No UV detection



# Structure function

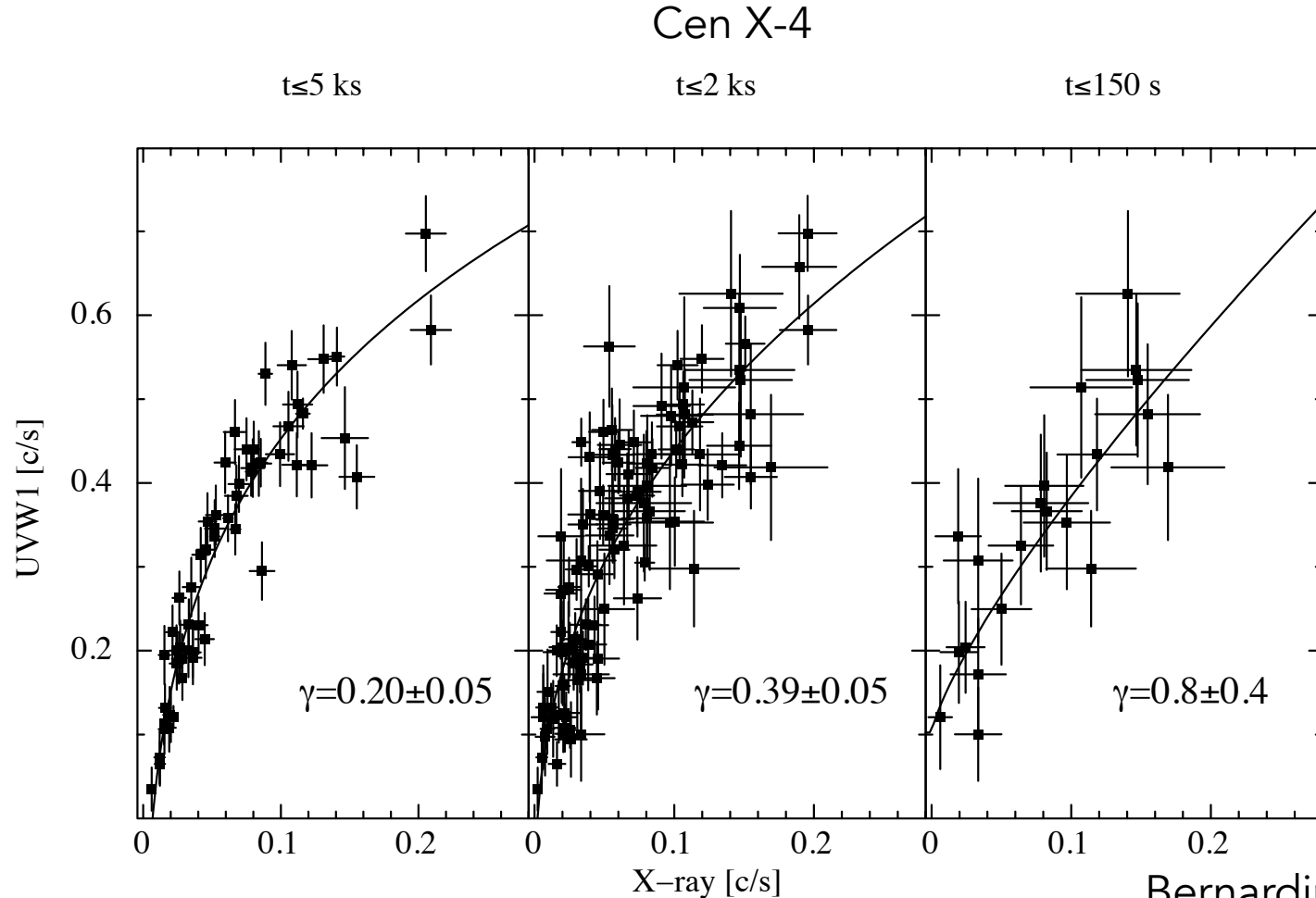
Straightforward way to measure power at given frequency for unevenly sampled data



Bernardini et al 2013

- Variability on week to months timescales
- Red noise power spectrum, typical of accreting systems

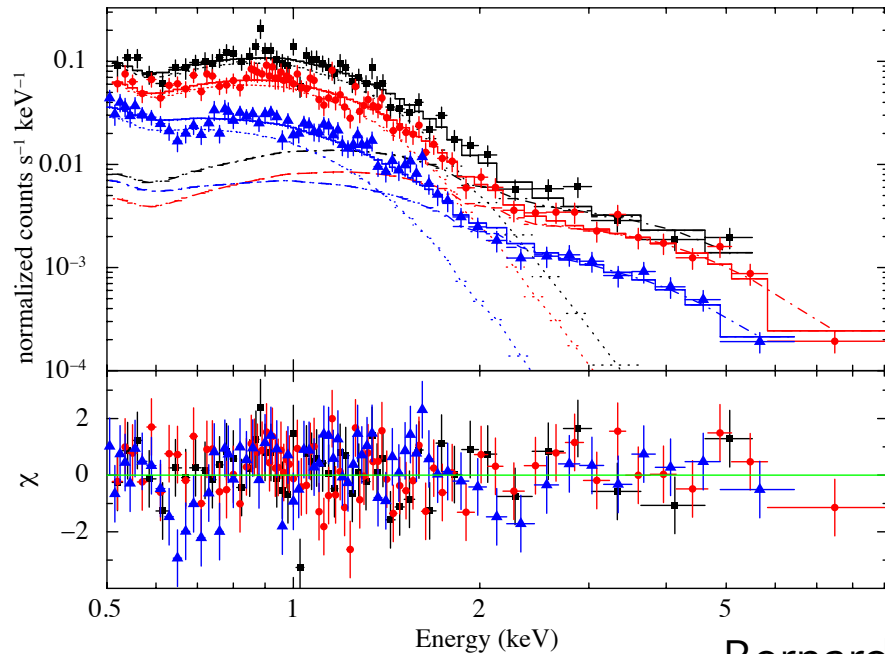
# X-ray and UV correlation



- Strong correlation down to 150 s timescale
- Reprocessing from the surface of the companion

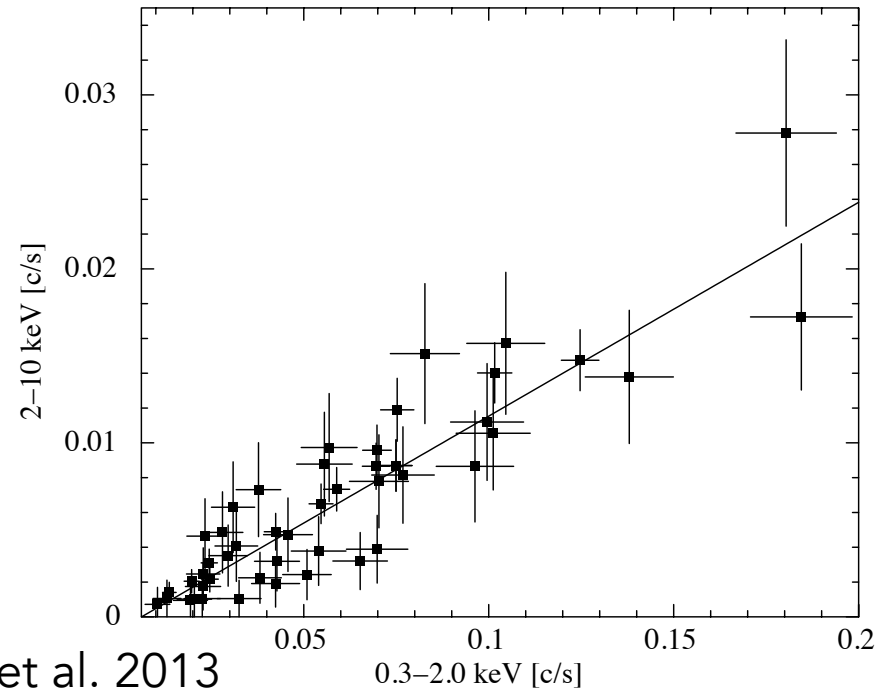
# X-ray spectrum as a function of flux

Cen X-4 Average spectra



Bernardini et al. 2013

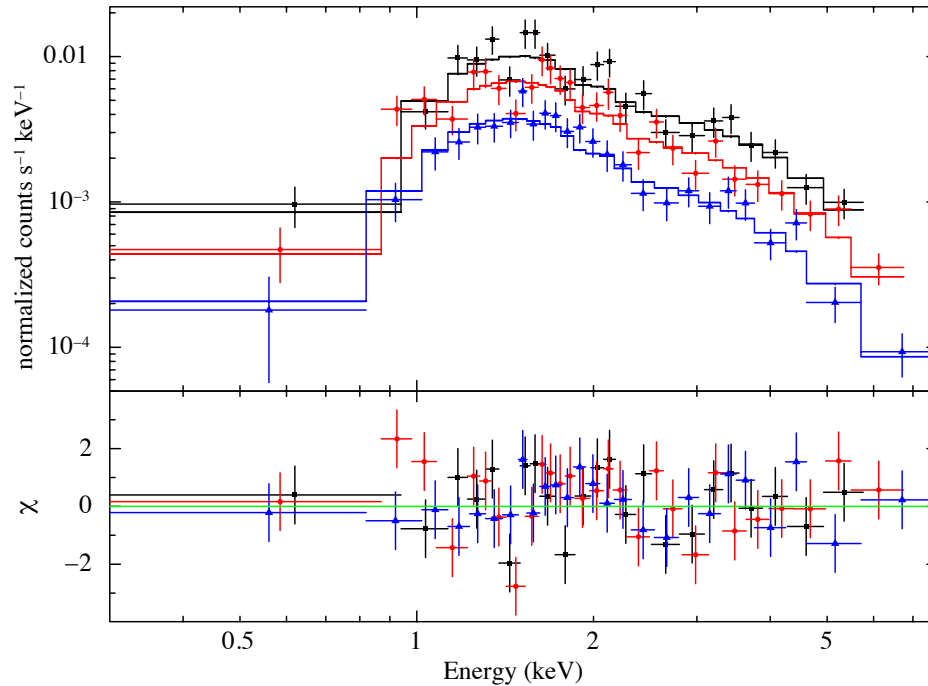
Cen X-4 count rate ratio



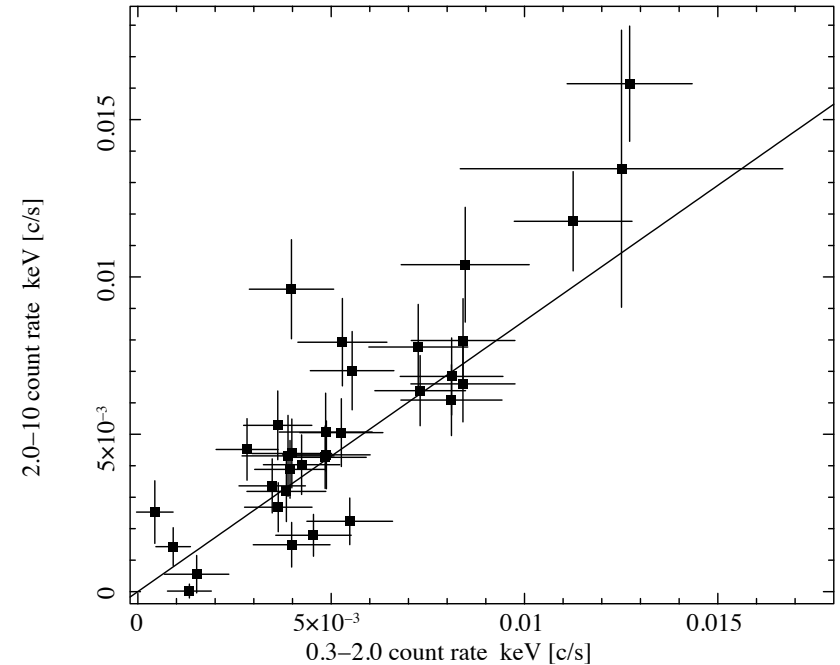
- Constant spectral shape as the flux vary, also day to day
- Neutron star H-atmosphere of  $kT=60-80$  eV,  $R=15$  km
- Power law with  $\Gamma \sim 1.4$

# X-ray spectrum as a function of flux

V404 Cyg average spectra



V404 Cyg count rate ratio



Bernardini et al. 2014

- Constant spectral shape as the flux vary, also day to day
- Power law with  $\Gamma \sim 2.1$  (softer than that of Cen X-4)

# Evidence for accretion in Cen X-4

- Highly variable light curves with several flares
- Both show variability at all timescales
- Structure function has the shape expected for a red noise power spectrum, typical of accreting systems
- We know that V404 Cyg is still accreting and they show several common properties
- Temperature of the surface is changing, likely the accreting matter is reaching and heating the surface
- Both spectral components (NS kT and power law) are changing in tandem with the flux

Bernardini et al. 2013,14

*Accretion could take place through a "dead disk"*  
*Propeller is instead disfavored*

# Accretion flow

Different power law ( $\Gamma \sim 1.4$ ,  $\Gamma \sim 2.1$ ), different mechanism

*Residual accretion for both, but different inner accretion flow*  
*V404 Cyg: Jet scenario (synchrotron emission)*

For BH and NS qLMXB in general

*BH could be Jet dominated*  
*NS likely are never Jet dominated*

For NS other mechanisms are more likely  
*ADAF plus wind*  
*Residual accretion on the magnetosphere*  
*Interaction between matter and pulsar relativistic wind*



# Some answers

- What is the nature of the inner accretion flow?  
*-Cen X-4: ADAF (hard X)+Wind (no UV), dead disk brings matter on the NS surface (soft X)*  
*-V404 Cyg: Accretion+Jet?*
- Is matter still accreting in quiescent NS LMXBs?  
*Yes for Cen X-4, likely down to the surface*
- Are the X-ray triggering the UV or viceversa?  
*X-ray are triggering the UV (for Cen X-4)*
- Where exactly does the UV emission come from?  
*Reprocessing from the companion*
- Can we really use NS qLMXBs to measure R?  
*First must check if and how they are variable*



THANKS!

*Balotelli's goal against England, 2014 Brazil World Cup*