RX J0136.9-3510 and the Spectral State of Super Eddington Accretion Flows

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Presented at:
JENAM held at the University of Hertfordshire
20th April, 2009

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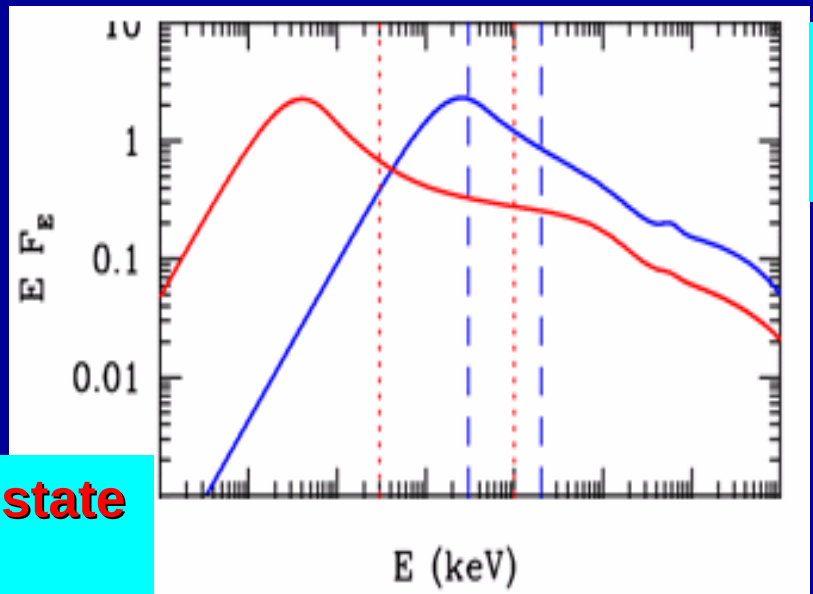
Spectral state similarity between AGN and Black Hole Binaries

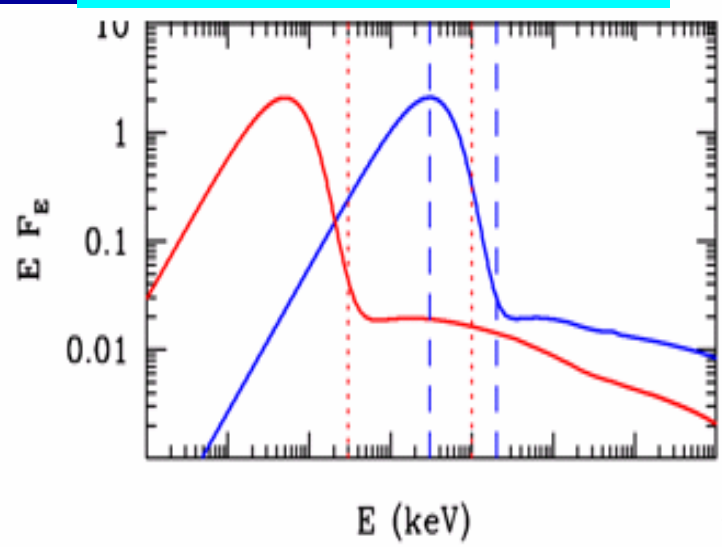


Very high state

=⟩ NLS1

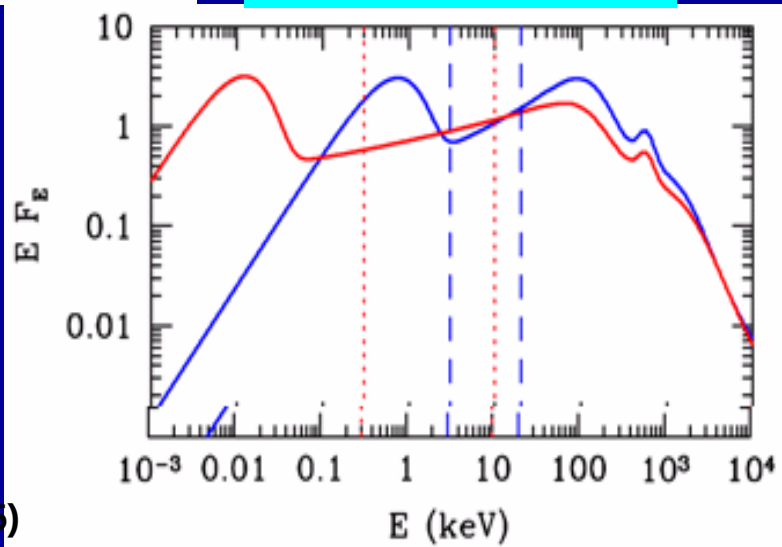
Disk dominated state

=⟩ QSO



Low/hard state

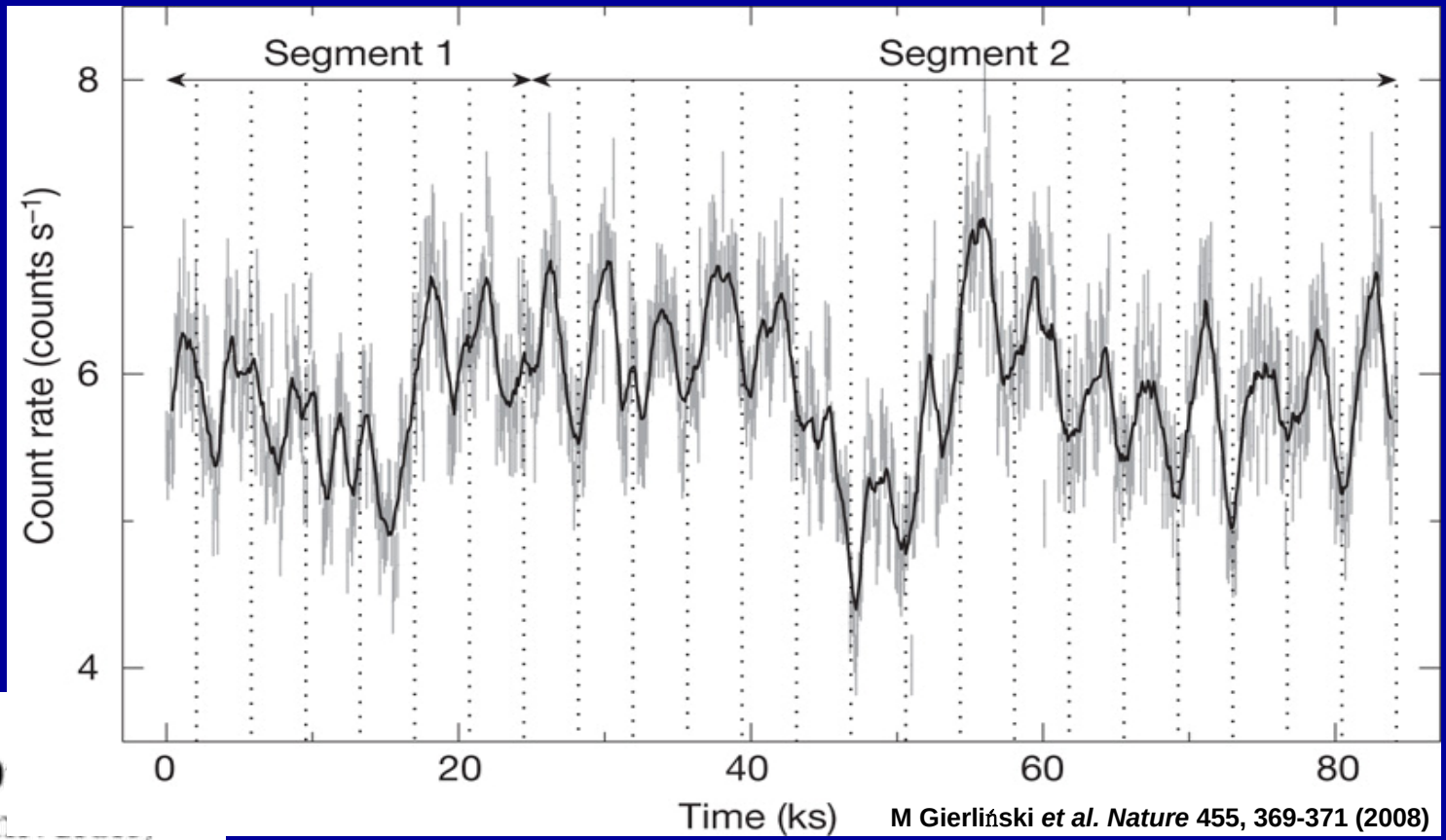
=⟩ LINERS



(Done & Gierlinski 2005)

Comparison with the NLS1 RE 1034+396 (1st "convincing" AGN QPO !)

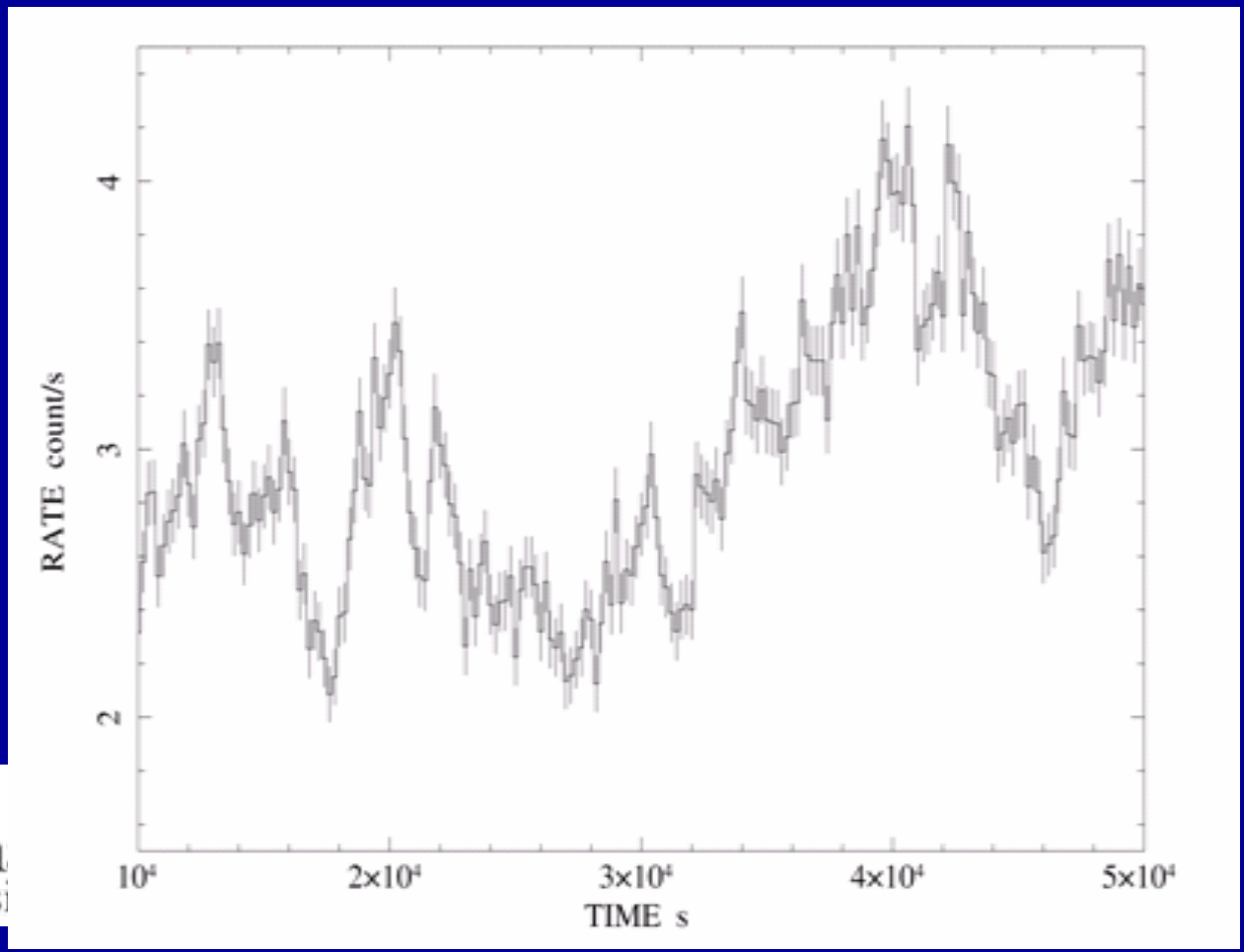
- Most extreme mass accretion rates?
- BHB counterpart: e.g. micro-quasar
- GRS 1915+105



M Gierliński *et al. Nature* 455, 369-371 (2008)

The XMM X-ray observation of RX J0136.9-3510

RMS fractional variation: 0.13 ±0.007



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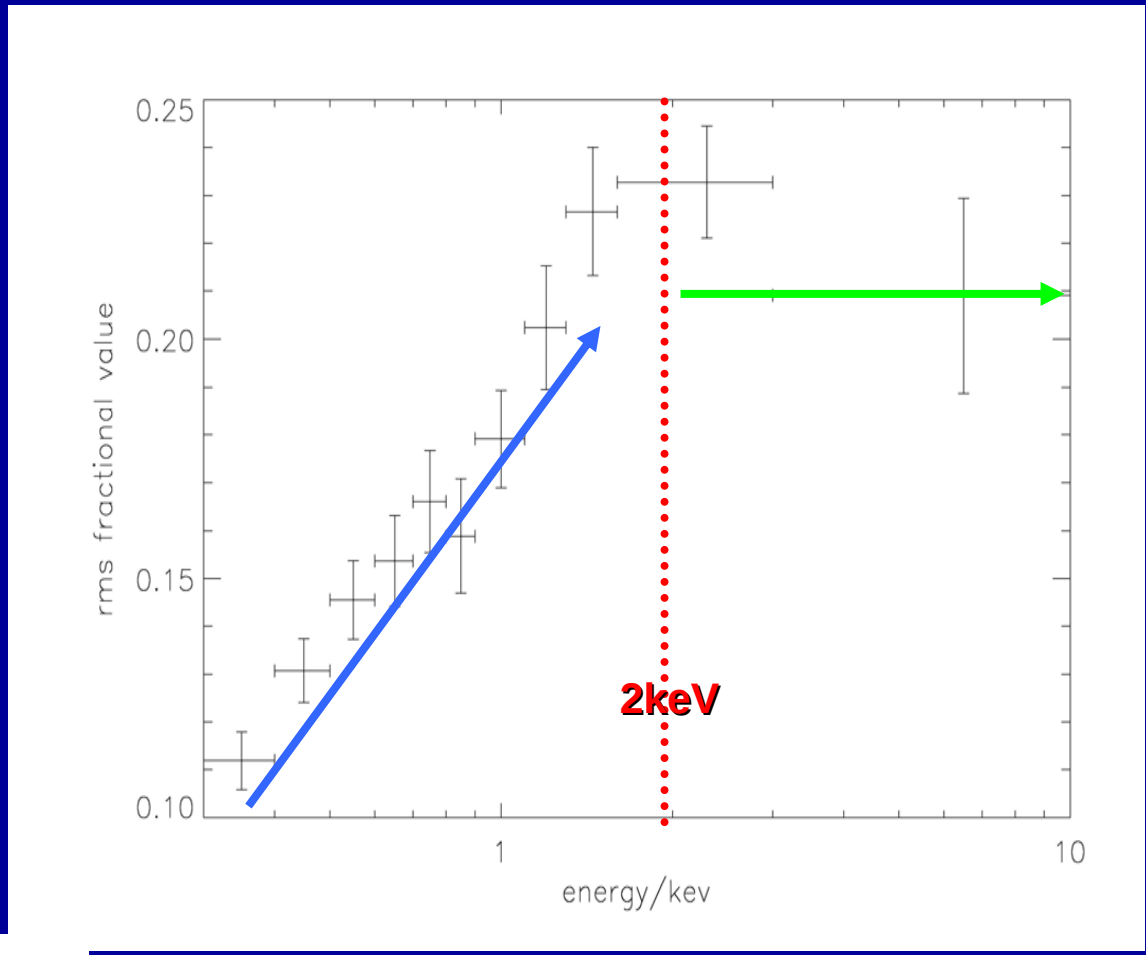
X-ray variability

RMS fractional variation: 0.13 ±0.007



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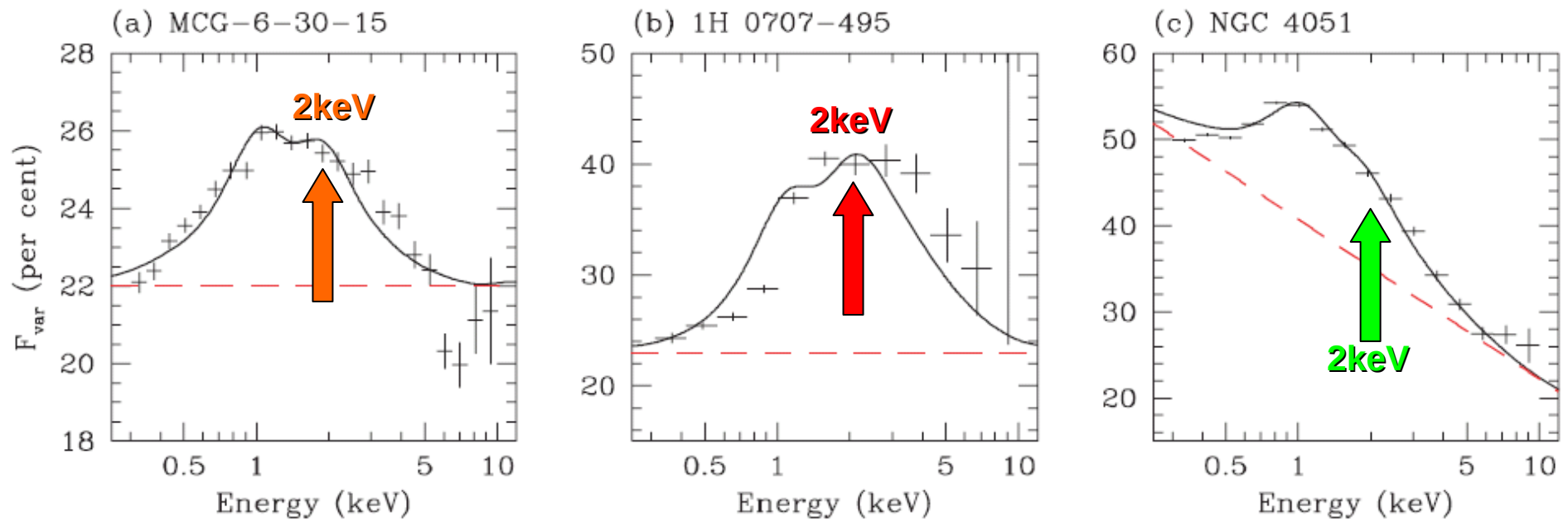
rms spectra of other NLS1s



(Gierlinski & Done 2006)

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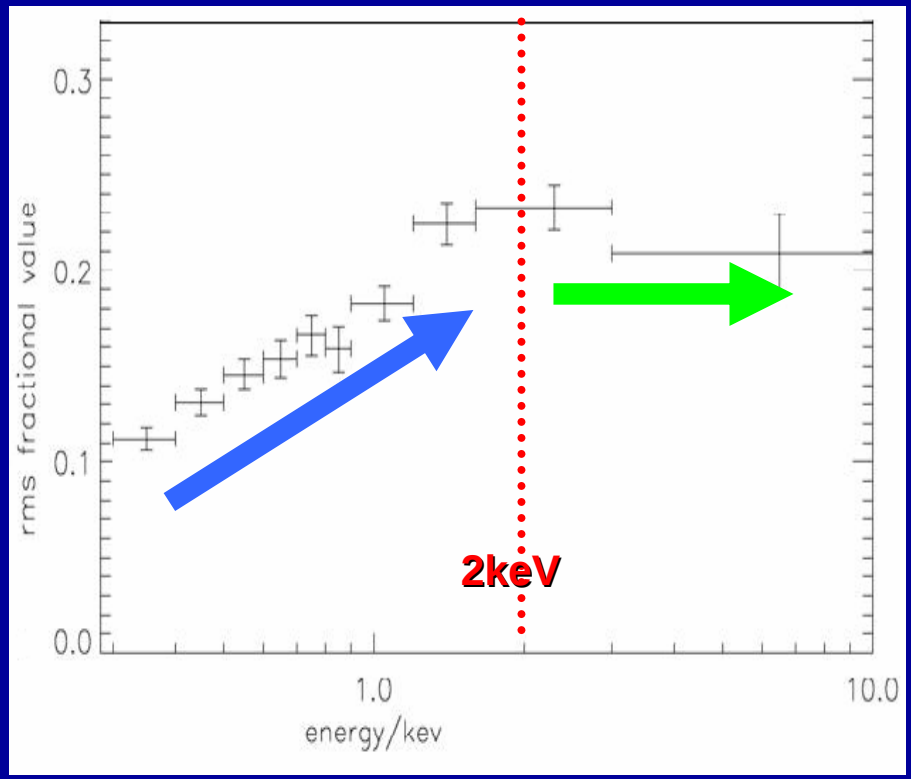
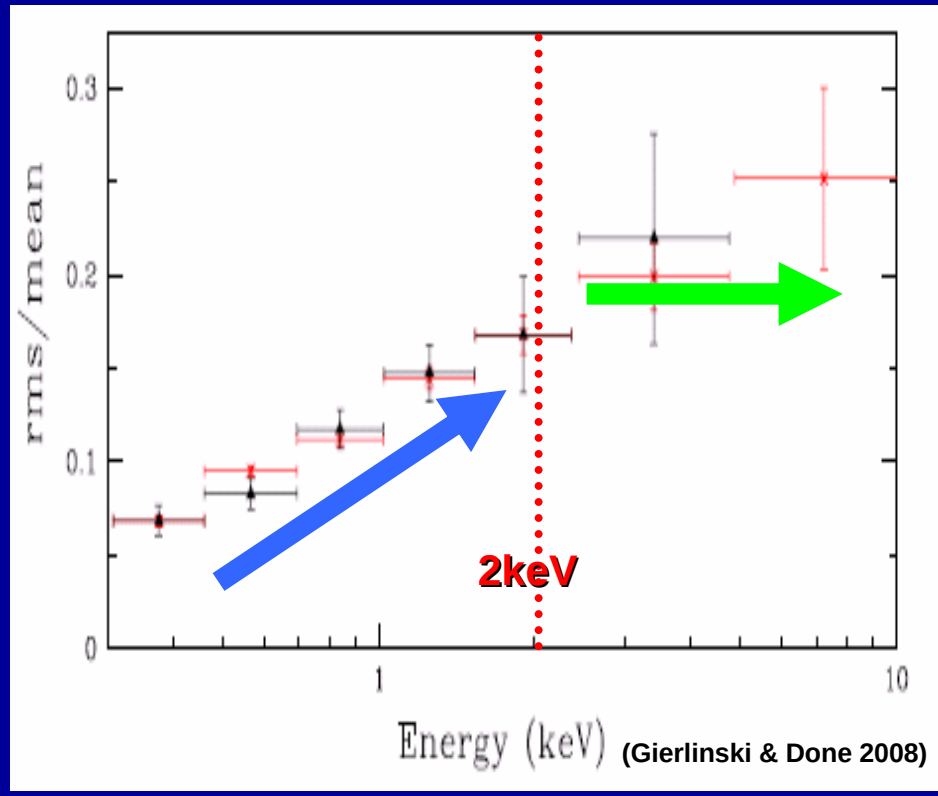
rms spectral similarity between RX J0136.9-3510 and RE J1034+396

RX J0136.9-3510



RE J1034+396



(Gierlinski & Done 2008)

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rms spectral similarity between RX J0136.9-3510 and RE J1034+396

- Both sources' rms spectra are quite different from those commonly seen in other NLS1s.
- Basic shape: the fractional variability **rises steeply up to ~2keV**, and then **flattens towards higher energy**

So what does the SED tell us?

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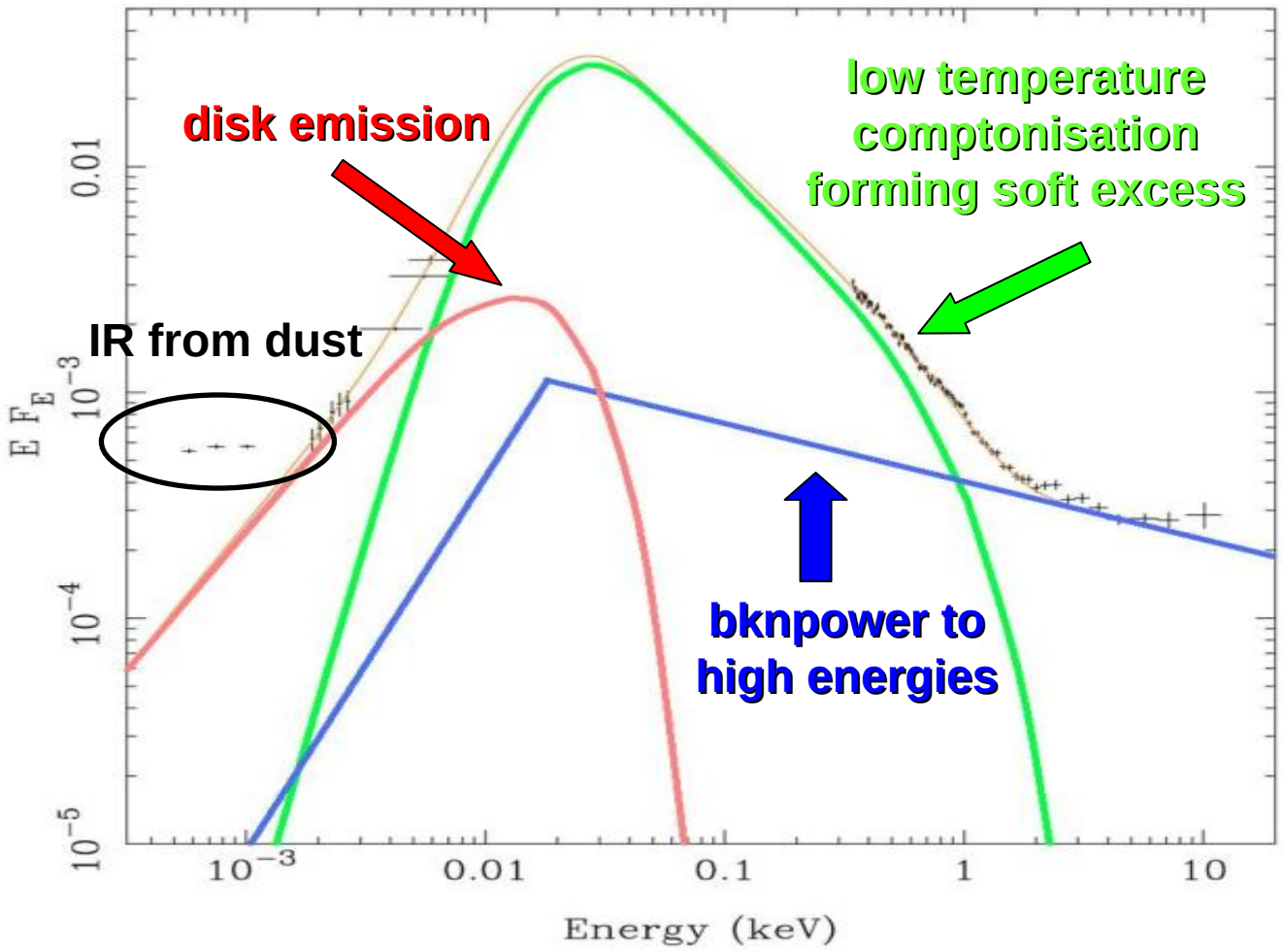
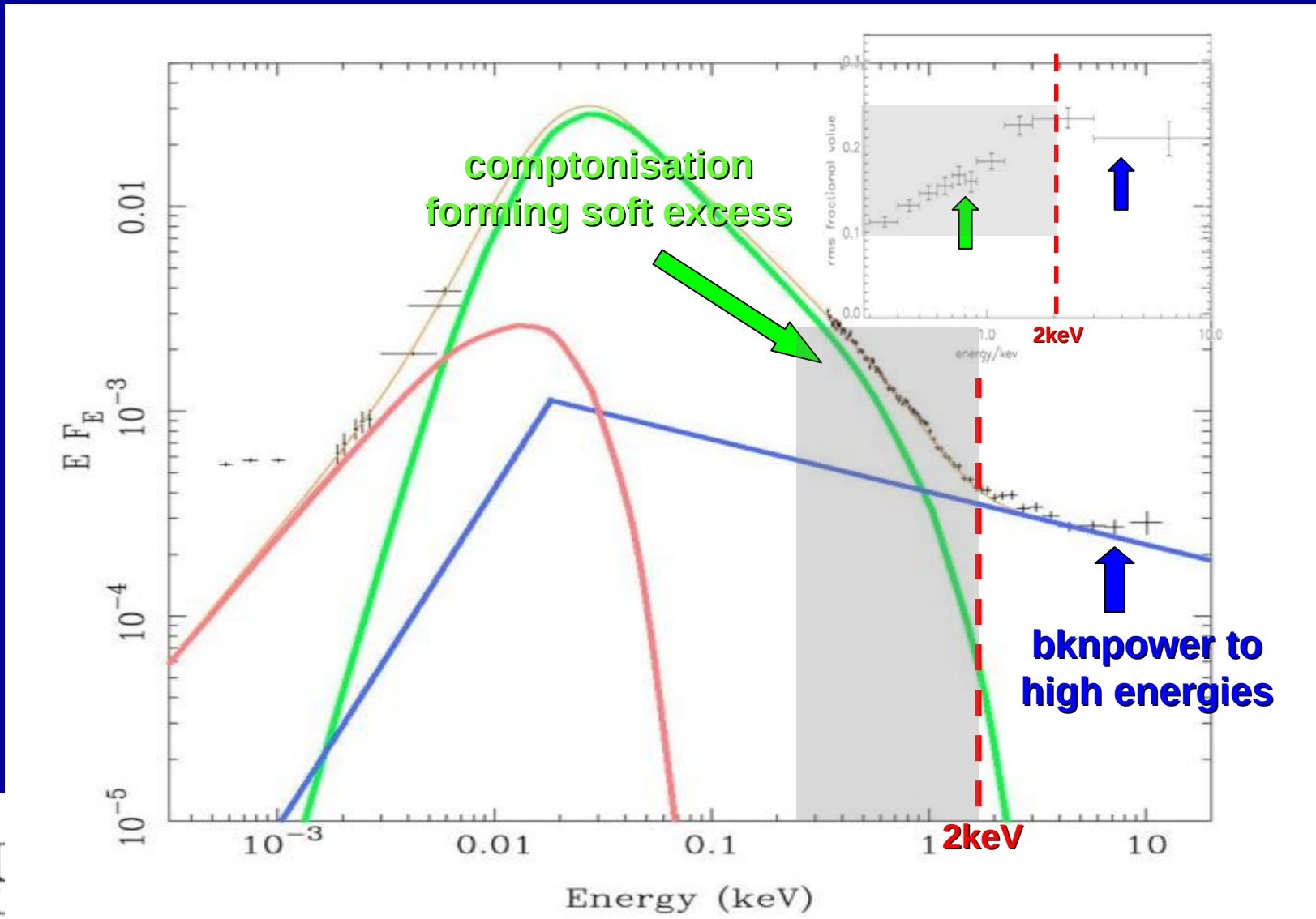
Broadband SED modeling of RX J0136.9-3510

$L_{bol} = 2.7 \times 10^{46}$ erg/s



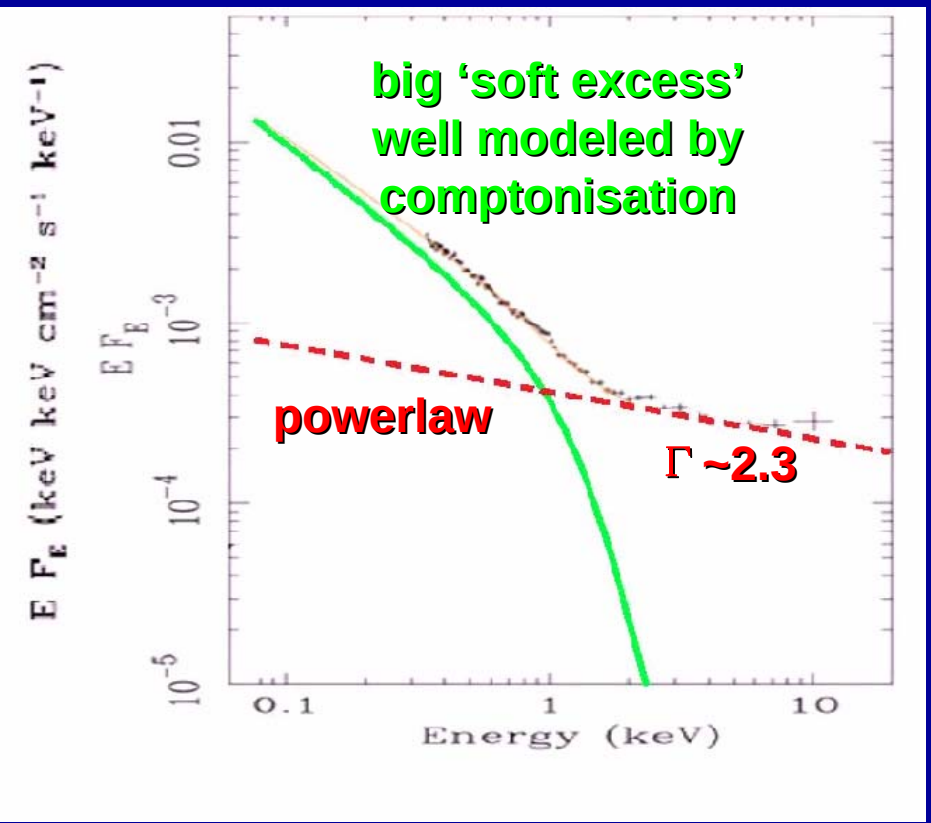
SED model components and their separate variability



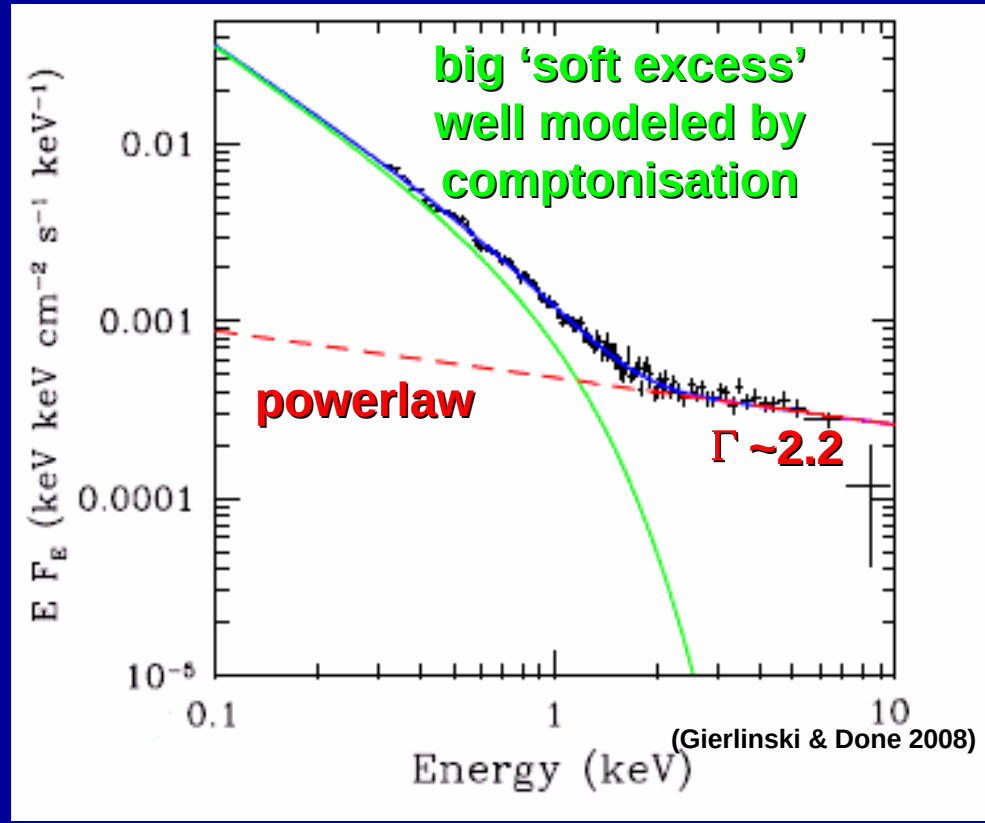
X-ray spectral similarity
between RX J0136.9-3510 and RE J1034+396

'broken powerlaw'+ 'comptonisation' + 'diskpn'

RX J0136.9-3510



RE J1034+396



(Gierlinski & Done 2008)

Black hole mass estimation

- We use the following equation to estimate the object's BH mass:

$$M_{BH} = 4.817 \times [\frac{\lambda L_{\lambda}(5100\mathring{A})}{10^{44} ergs^{-1}}]^{0.7} FWHM^2$$

(Woo & Urry 2002)

Comparing this method with reverberation mapping for a sample of AGN , the rms difference is a factor ~3

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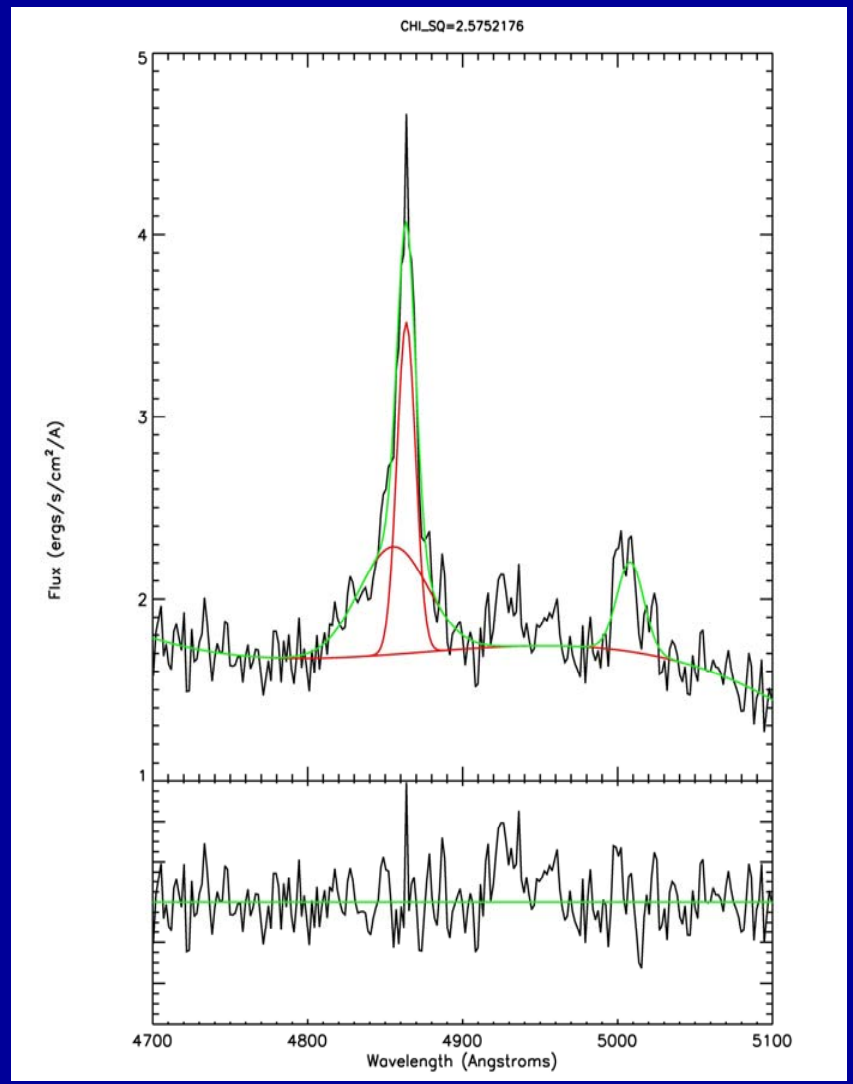
Black hole mass estimated from the Hβ emission line width

- Ghosh et. al. 2004 FWHM=2354km/s
- 4.1×10^{7} Msun L/Ledd=4.2
- Our fit with two Gaussians FWHM=3200km/s
- 7.9×10^{7} Msun L/Ledd=2.7



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BH mass and Eddington ratio Comparison

- RX J0136.9-3510:
  4.1×10^{7} Msun; Edd_ratio: 4.2
  or: 7.9×10^{7}Msun; Edd_ratio: 2.7
- RE J1034+396:
  ~ 2×10^{6} Msun; Edd_ratio: ~2 (comp)
- Although their BH masses differ a lot, both of them **have super-Eddington accretion flows**

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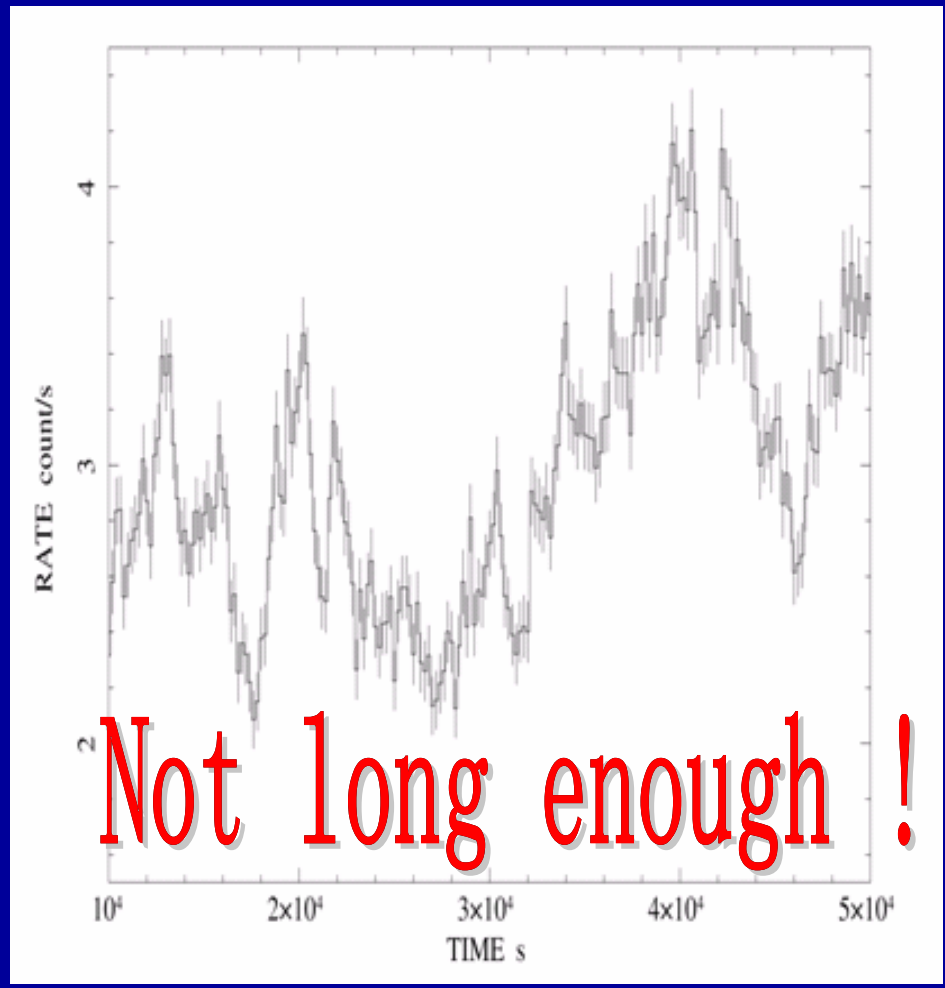
Search for a QPO in RX J0136.9-3510

- No clear periodic signals were found in the light curve
- If QPO period scales with BH

  T=(10 to 50)×3730s

  ~10^5s



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Summary and Conclusions

- There are **strong similarities** between RX J0136.9-3510 and RE J1034+396.
- They have the same **rms spectral shape**, which is very rare among NLS1s.
- Same **broad band spectrum** dominated by soft excess, from **a low temperature, optically thick** Comptonisation mechanism.
- Both exhibit **super-Eddington accretion**.

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Summary and Conclusions

- RX J0136.9-3510 and RE J1034+396 may represent a sub-class of the **most extreme mass accretion rates.**
- **BH binary counterparts** could be micro-quasars e.g. **GRS 1915+105.**
- Perhaps also the Ultra-luminous X-ray sources, (binaries found in some galaxies).

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Thank you for listening

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