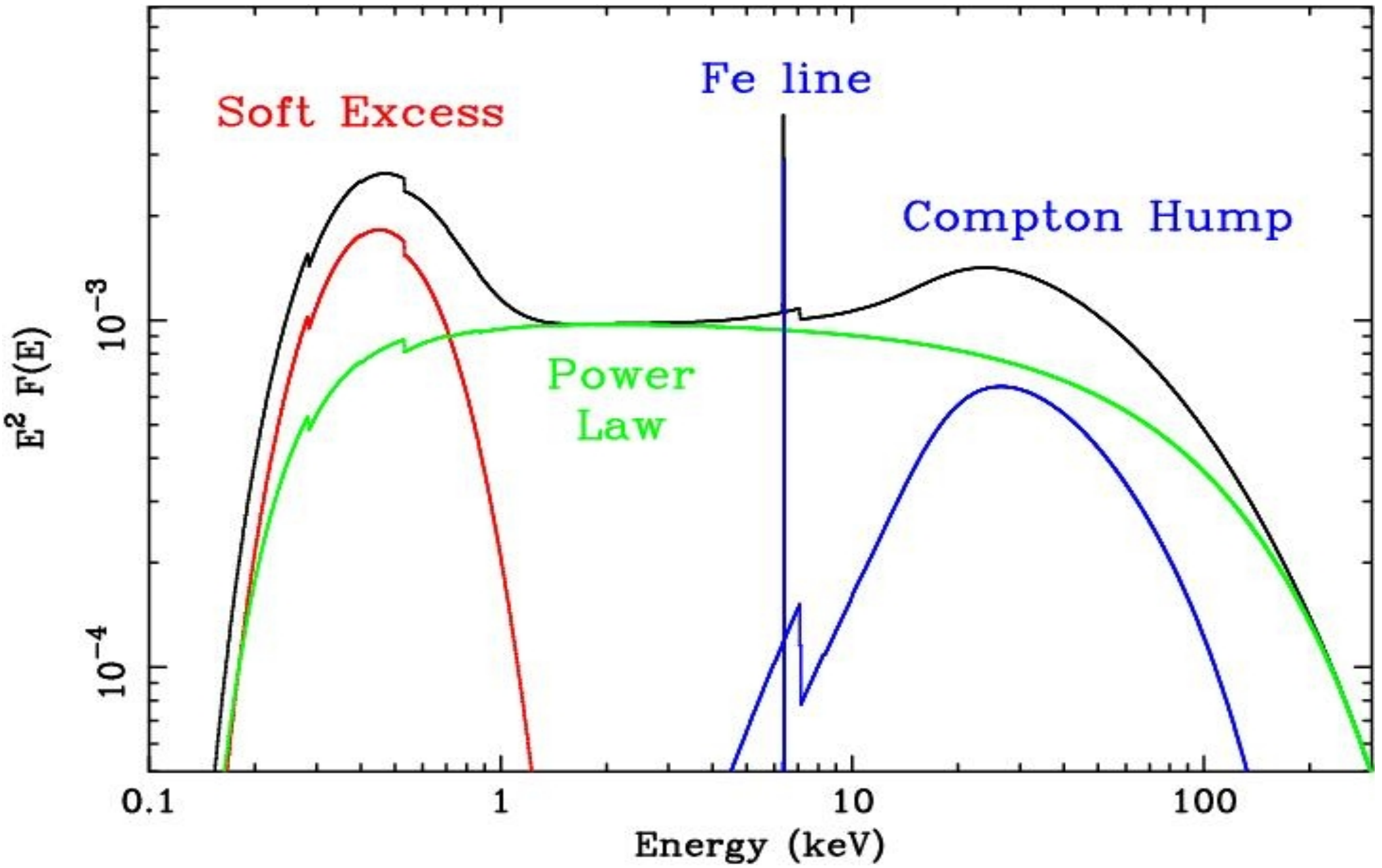
Is the light bending effect at work in the core of NGC 4051 and IRAS 13224-3809?

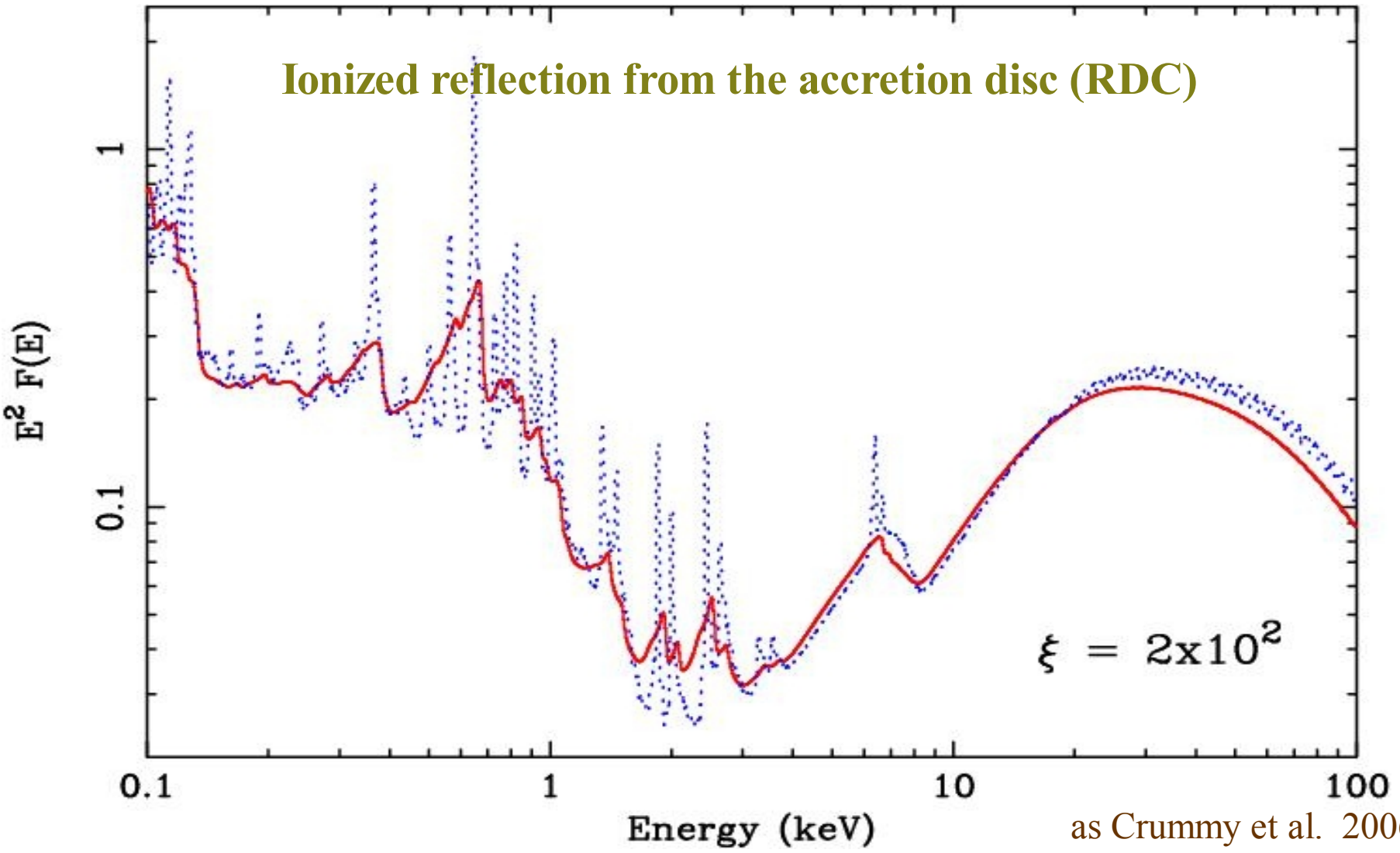
Gabriele Ponti
Phd student at Bologna University
Istituto INAF/IASF-BO

G. Miniutti, A.C. Fabian and M. Cappi

The typical X-ray spectrum of a Seyfert galaxy



The typical X-ray spectrum of a Seyfert galaxy: a new interpretation



as Crummy et al. 2006

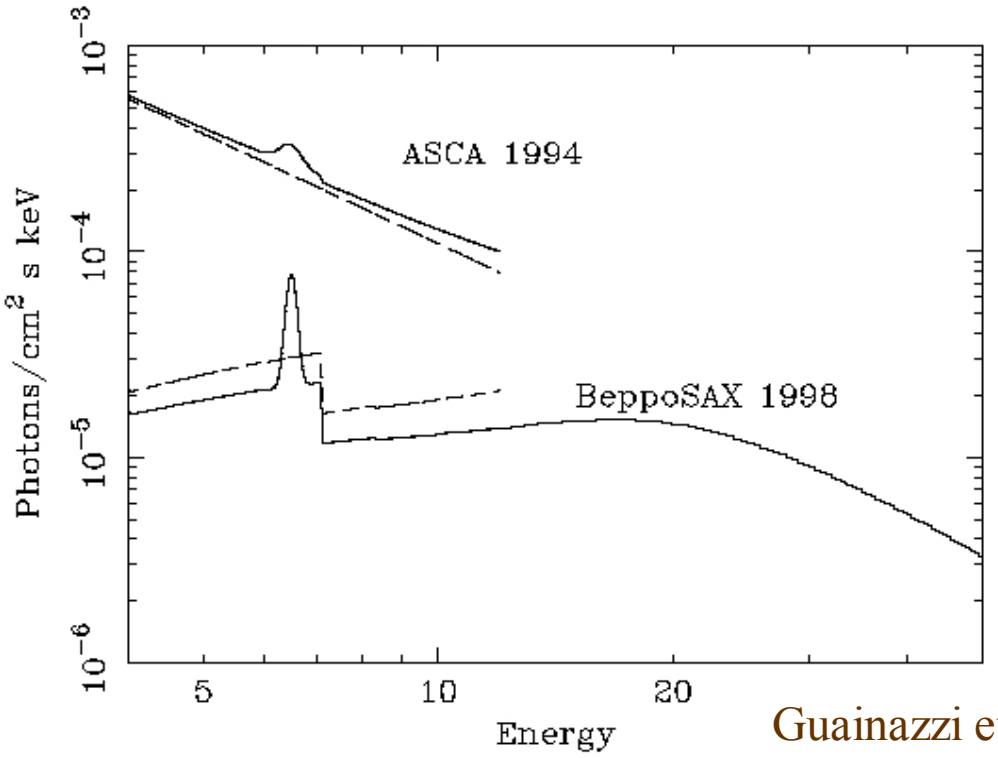
ionized reflection from the disc (RDC) could explain the soft excess

⇒ origin of the soft excess no more black body

To disentangle the different decompositions ⇒ detailed spectral variability

NGC 4051

- Narrow Line Seyfert 1
- z=0.002336
- $L_{[2\text{-}10\ keV]} \cong$ few $\times 10^{41}$ erg s^{-1}
- $M_{BH} \cong 3\text{–}5 \times 10^5\ M_{Sun}$



Guainazzi et al. 1998

★ ⇒ **source switched off** ⇒ leaving **residual reflection**

★ $Flux_{2\text{-}10\ keV} = 1.26 \times 10^{-12}$ erg cm^{-2} s^{-1}

2 XMM-Newton observations:

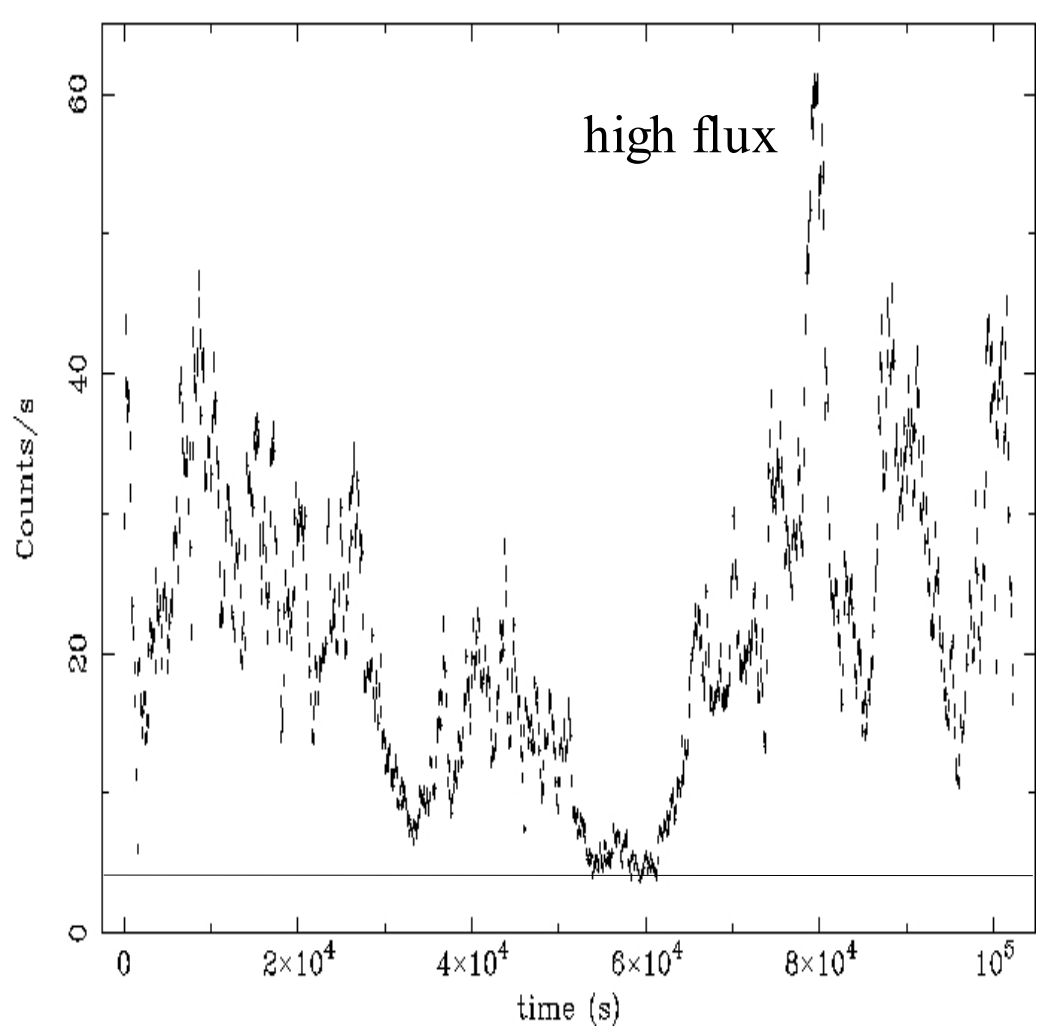
2001-05-16 rev. 263 $flux_{2\text{-}10\ keV} = 2.3 \times 10^{-11}$ erg cm^{-2} s^{-1}

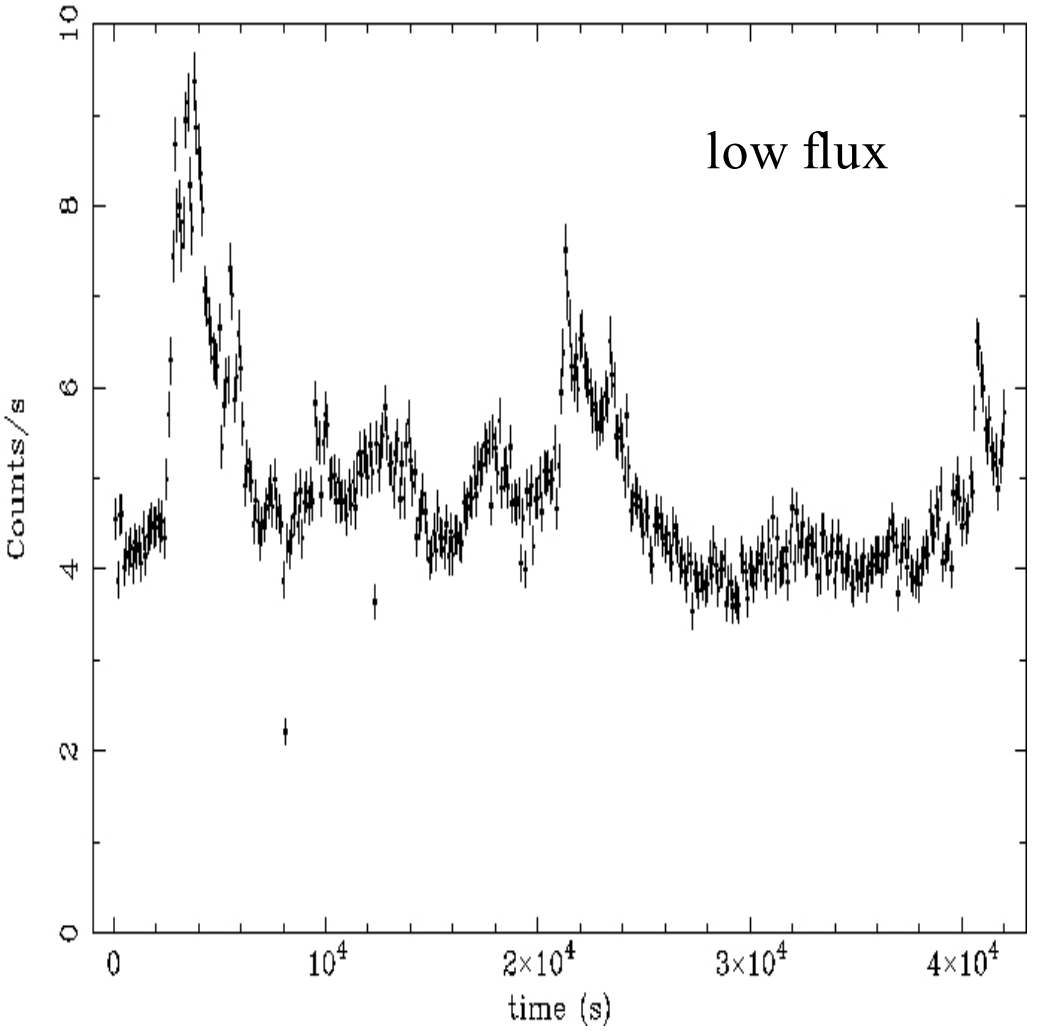
2002-11-22 rev. 541 $flux_{2\text{-}10\ keV} = 0.58 \times 10^{-11}$ erg cm^{-2} s^{-1}

Pounds et al. 2004; Uttley et al. 2004; Feňovčík et al. sub. Krongold et al. sub. BB for Soft Excess

Ponti et al. 2006 ⇒ detailed time resolved spectral variability

Light curves



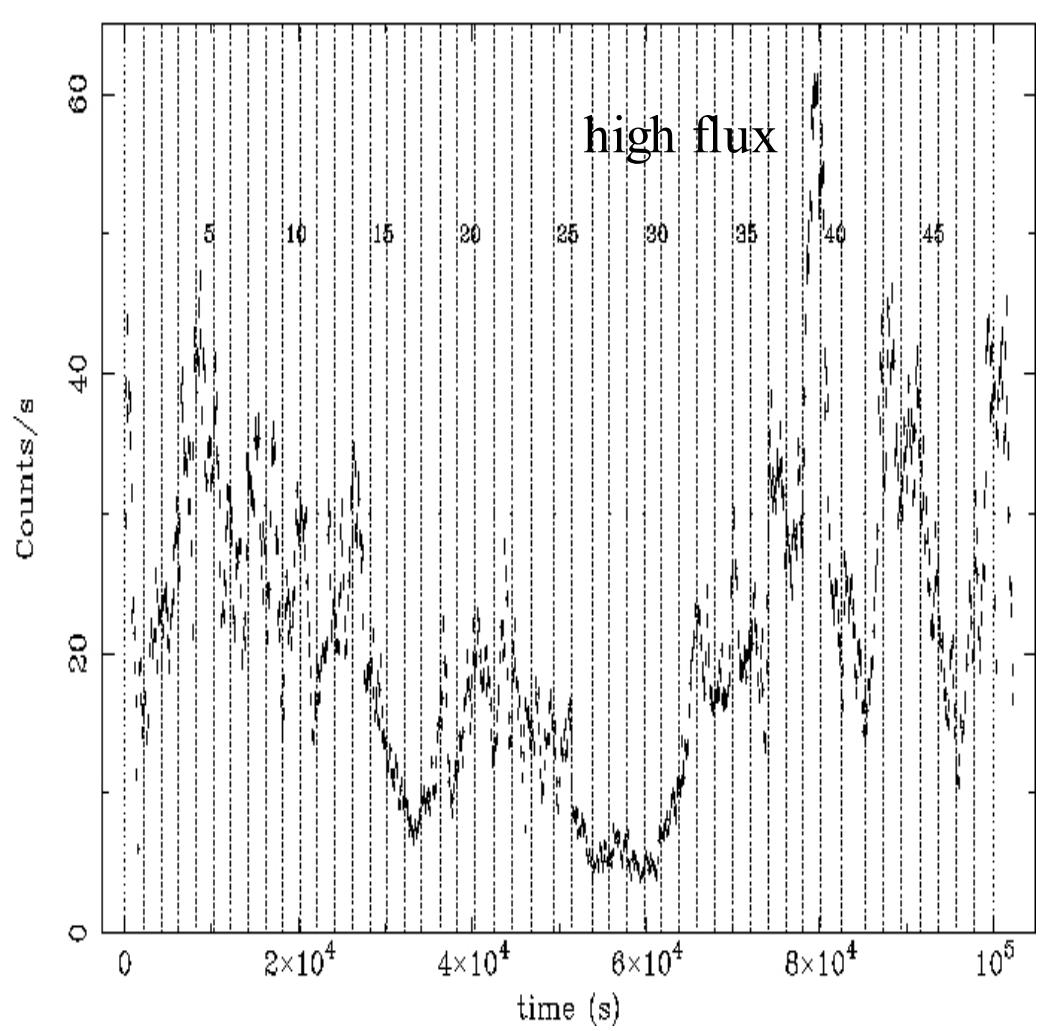


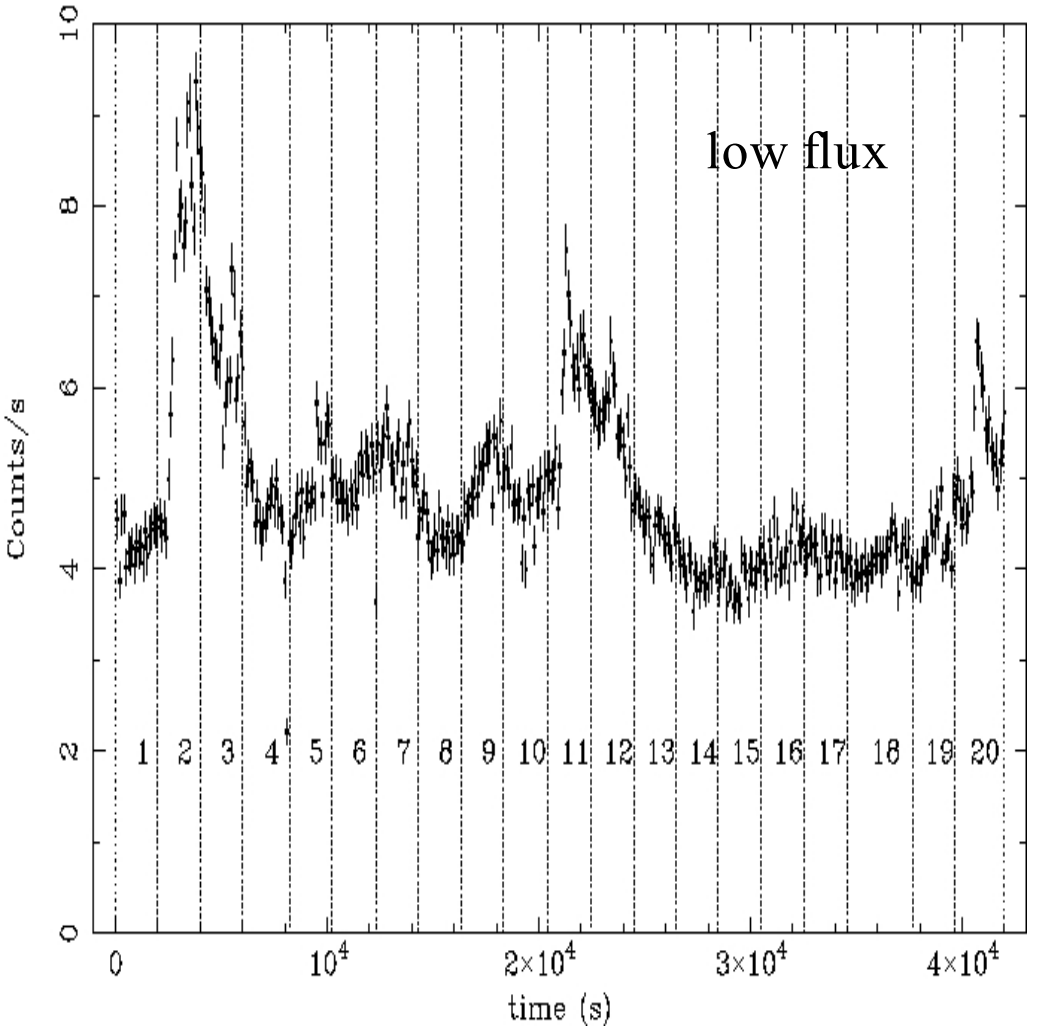
★ΔF~3 in 1000 s

Pounds et al. 2004

★ Mean spectrum study loses information

Light curves





★**ΔF~3 in 1000 s**

Ponti et al. 2006

★**Mean spectrum study loses information**

⇒ Time resolved spectral analysis in ~2 ks long periods.

⇒ **Test if models are valid in every moment**

Constant components in NGC 4051

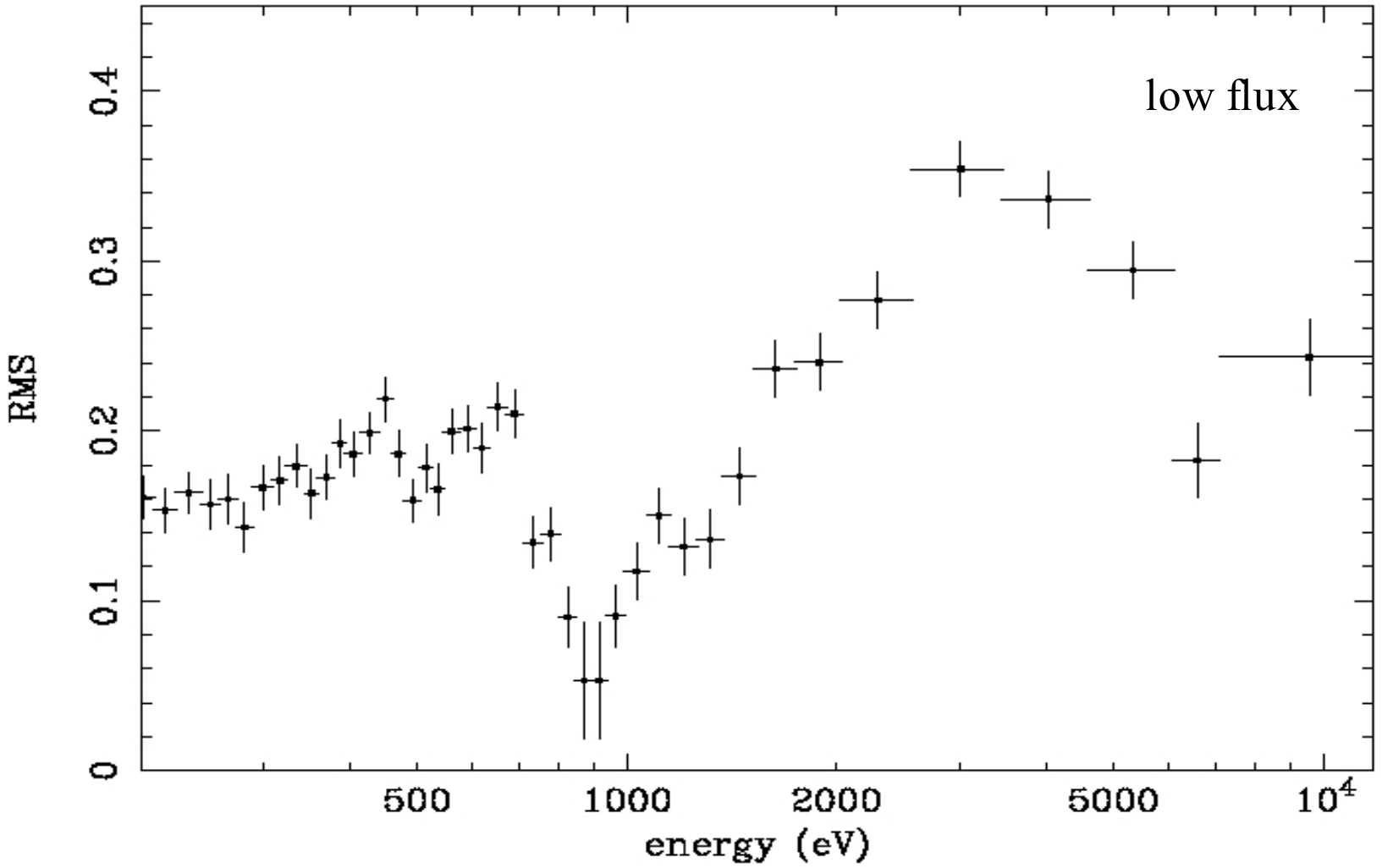


Photo-ionized gas

- **At 0.9-1 keV:**
  Ne IX + Oxygen Recombination Continuum + Fe L complex
- **Lower energy:**
  OVII and OVIII

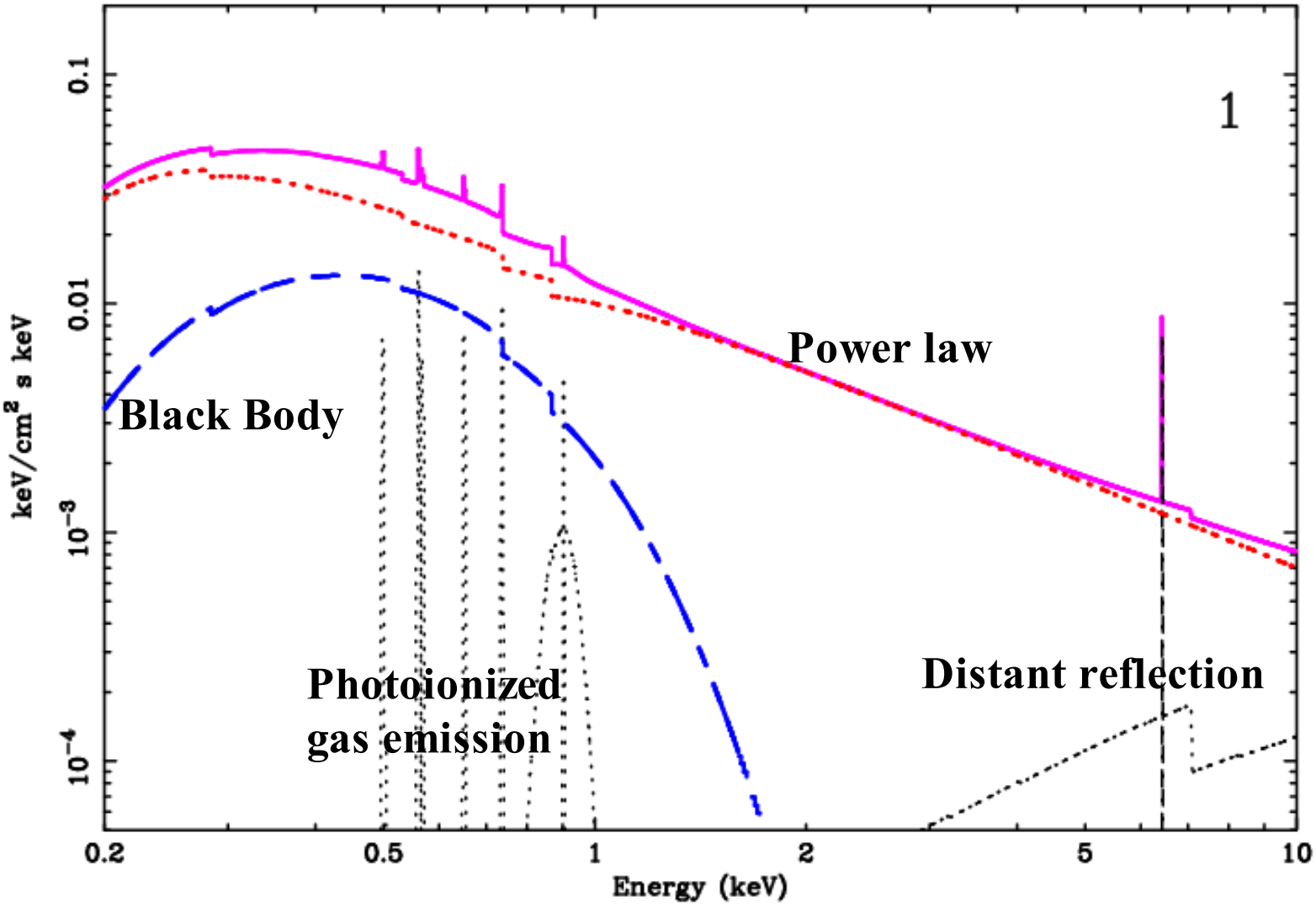
Pounds et al. 2004

Constant Reflection

- **Narrow Fe k line is consistent with previous observations EW 700 eV**

Guainazzi et al. 1998

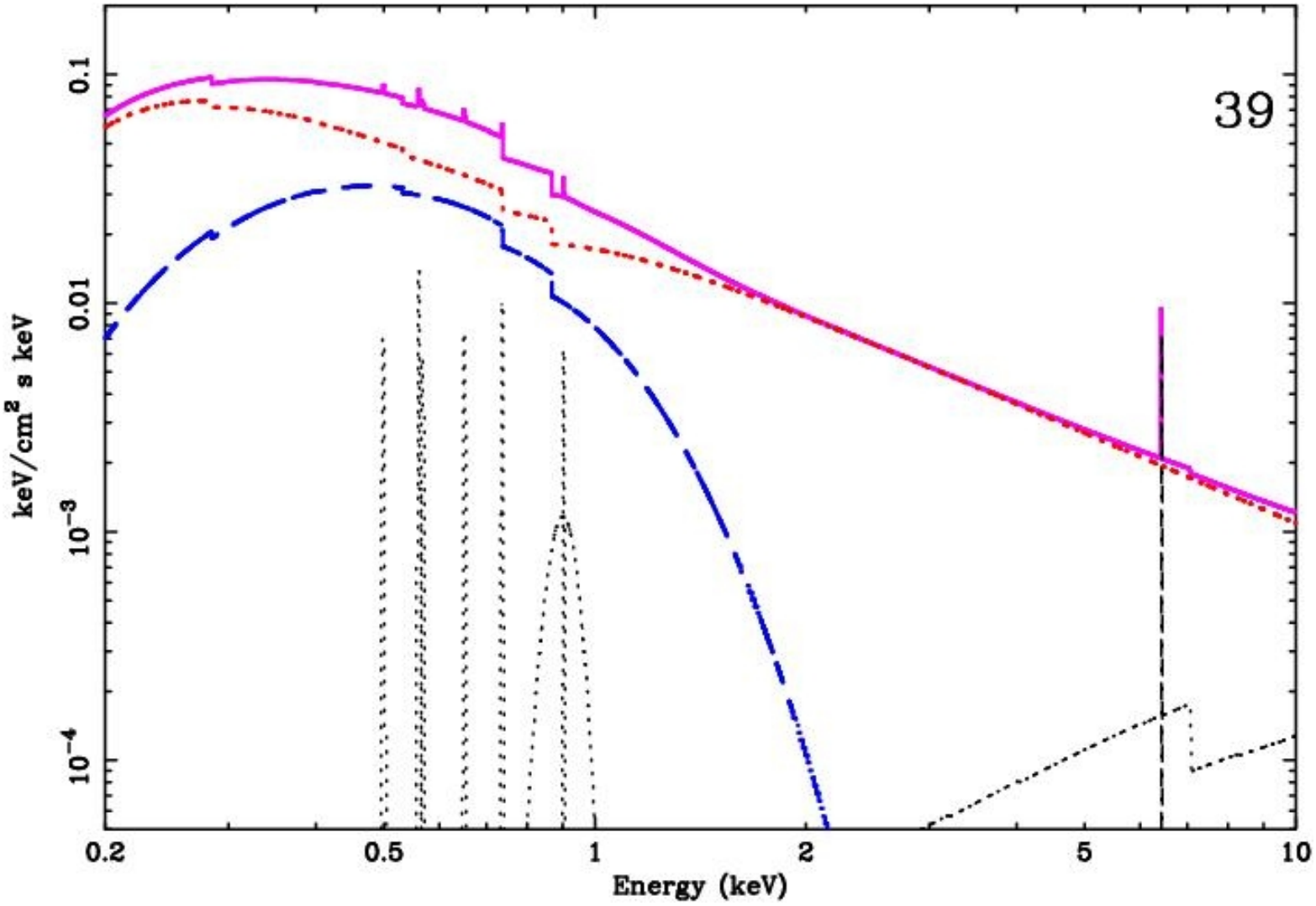
Time resolved spectral variability: “classical picture”



Free parameters: T_{BB} A_{BB} A_{Pl} Γ_{Pl} τ_{E1} τ_{E2}

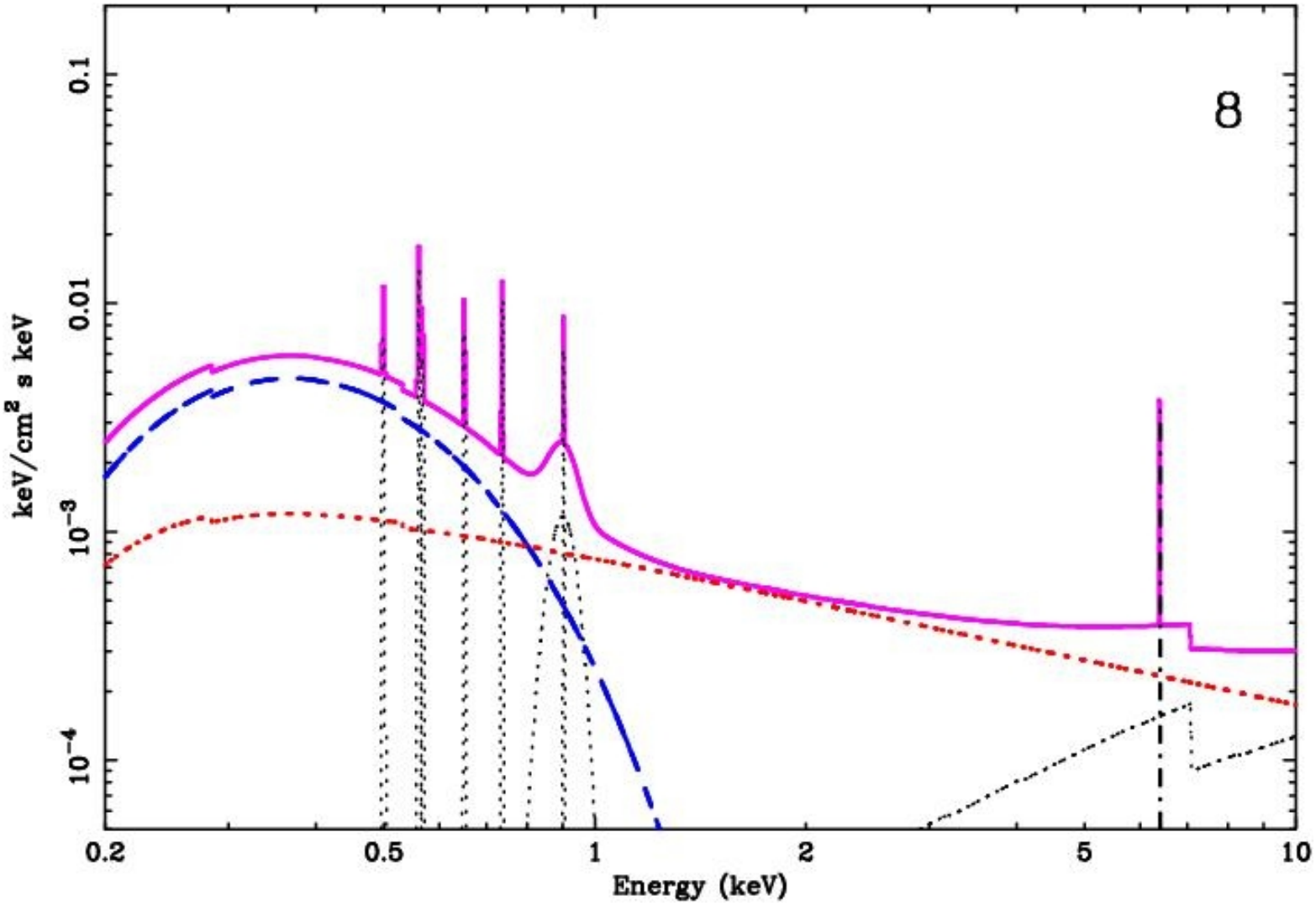
Time resolved spectral variability: “classical picture”

high flux ~ Seyfert 1 – like spectrum

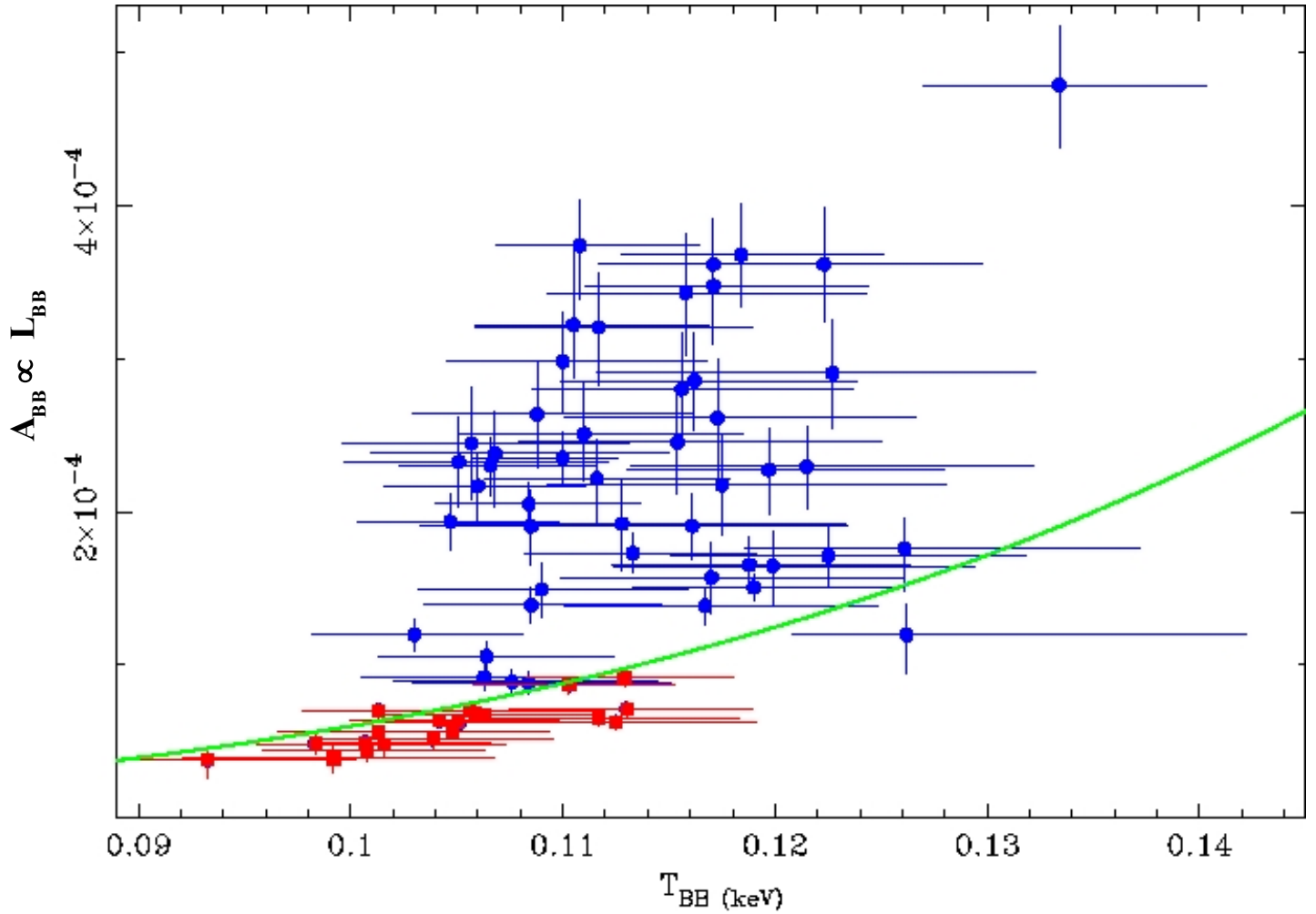


Time resolved spectral variability: “classical picture”

low flux~ Seyfert 2 – like spectrum



Time resolved spectral variability: "classical picture"



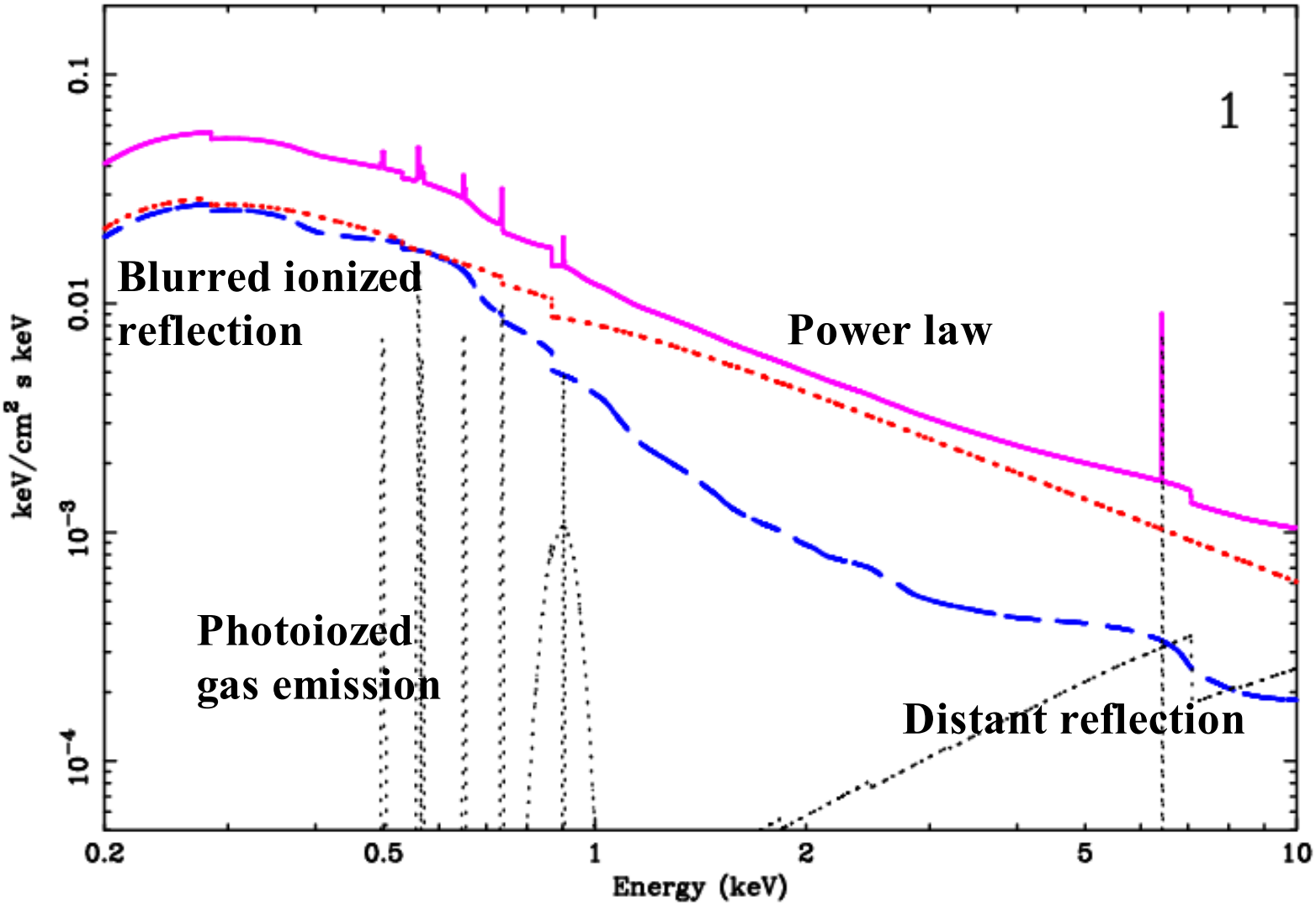
T_{BB} is the same of all PG quasars that have M_{BH} up to 10^5 times higher

Data do not follow the BB relation $L_{BB} \propto T_{BB}^4$ Gierlinski & Done 04; Piconcelli et al. 05; Crummy et al. 06

T_{BB} consistent with constant

$\Rightarrow$ Soft excess tied to atomic process (ionized reflection)?

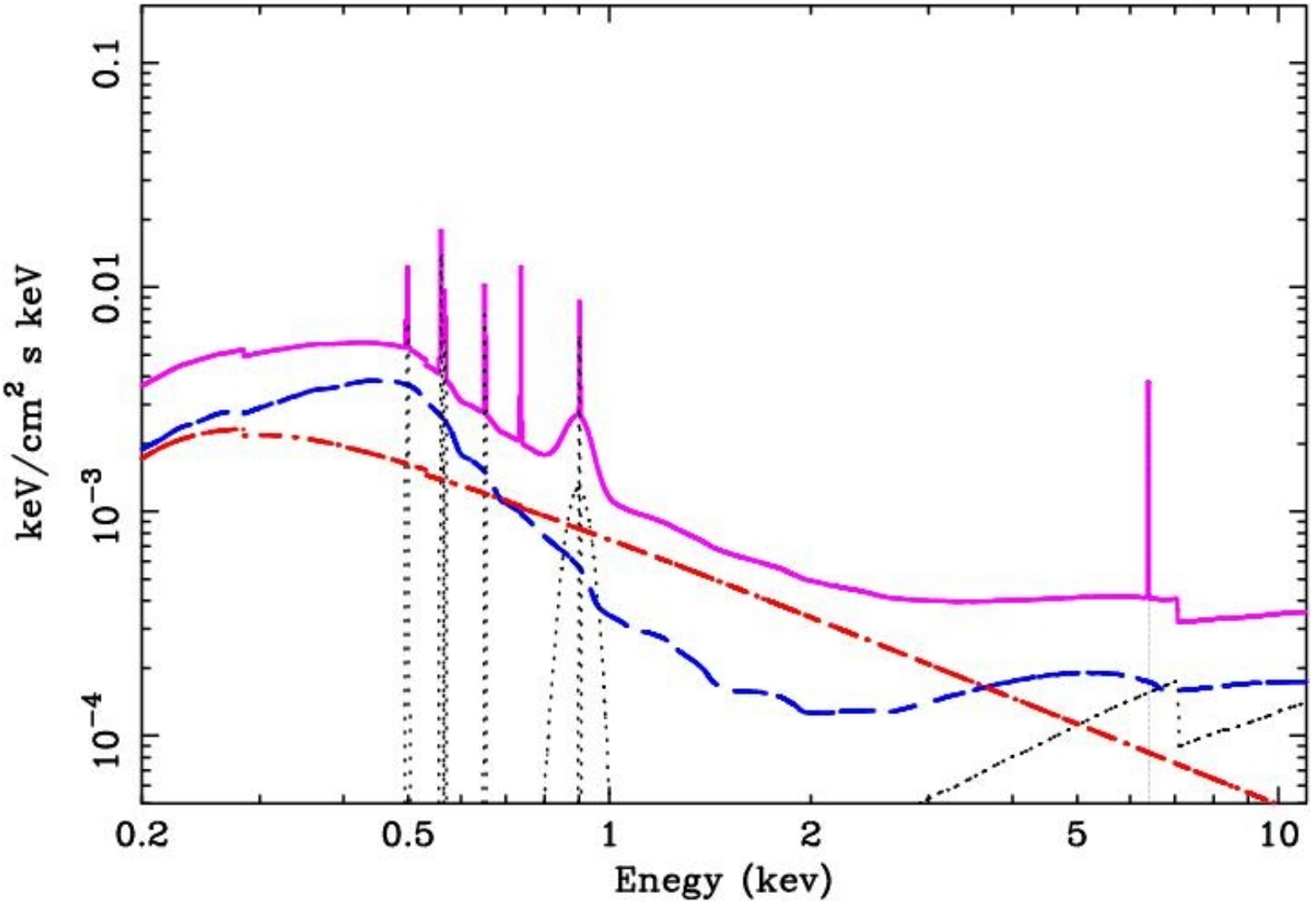
Time resolved spectral variability: Two component model



Free parameters: $\alpha_{discemissivity}$ ξ_{Refl} A_{Refl} A_{Pl} τ_{E1} τ_{E2}

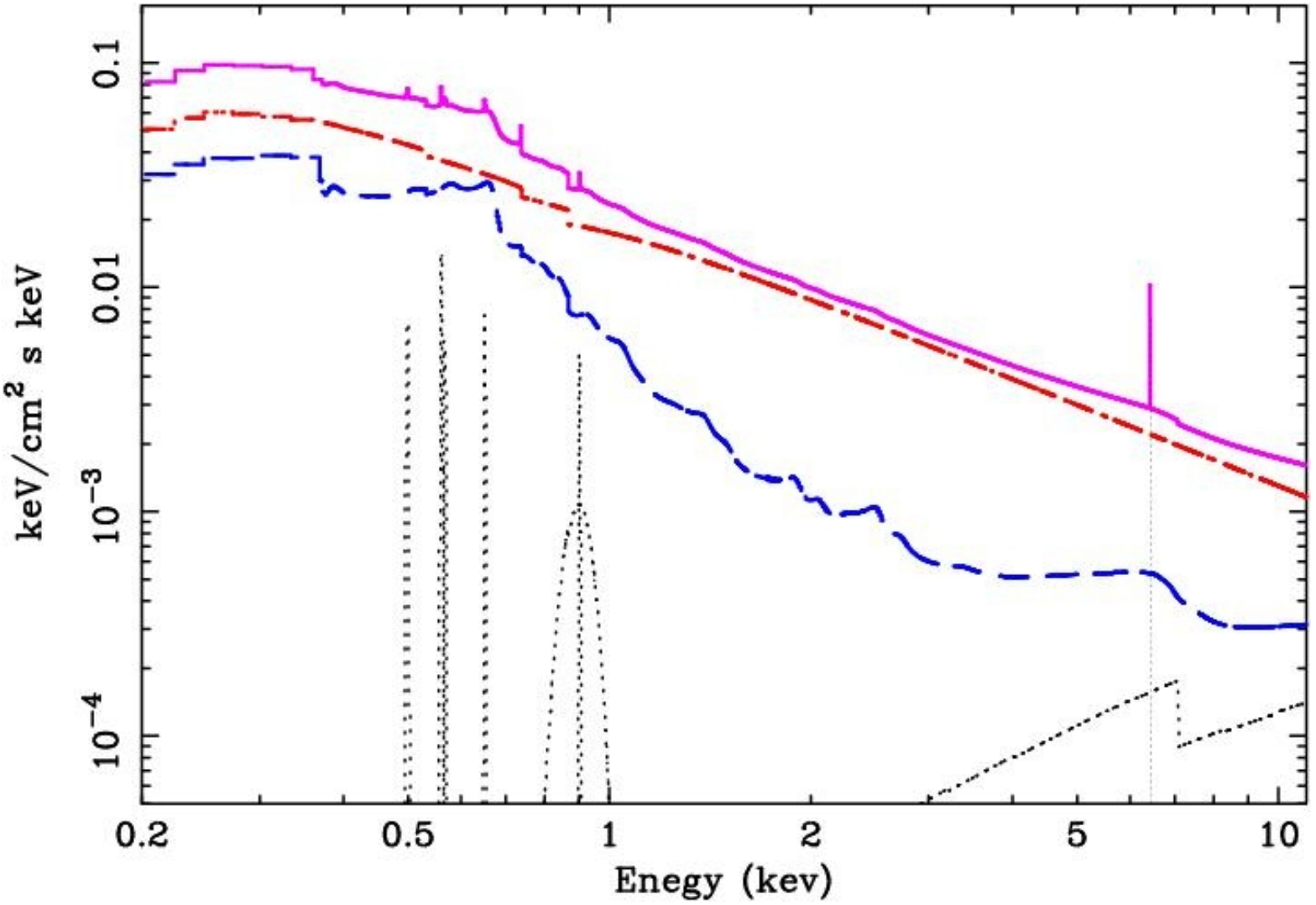
Time resolved spectral variability: Two component model

low flux

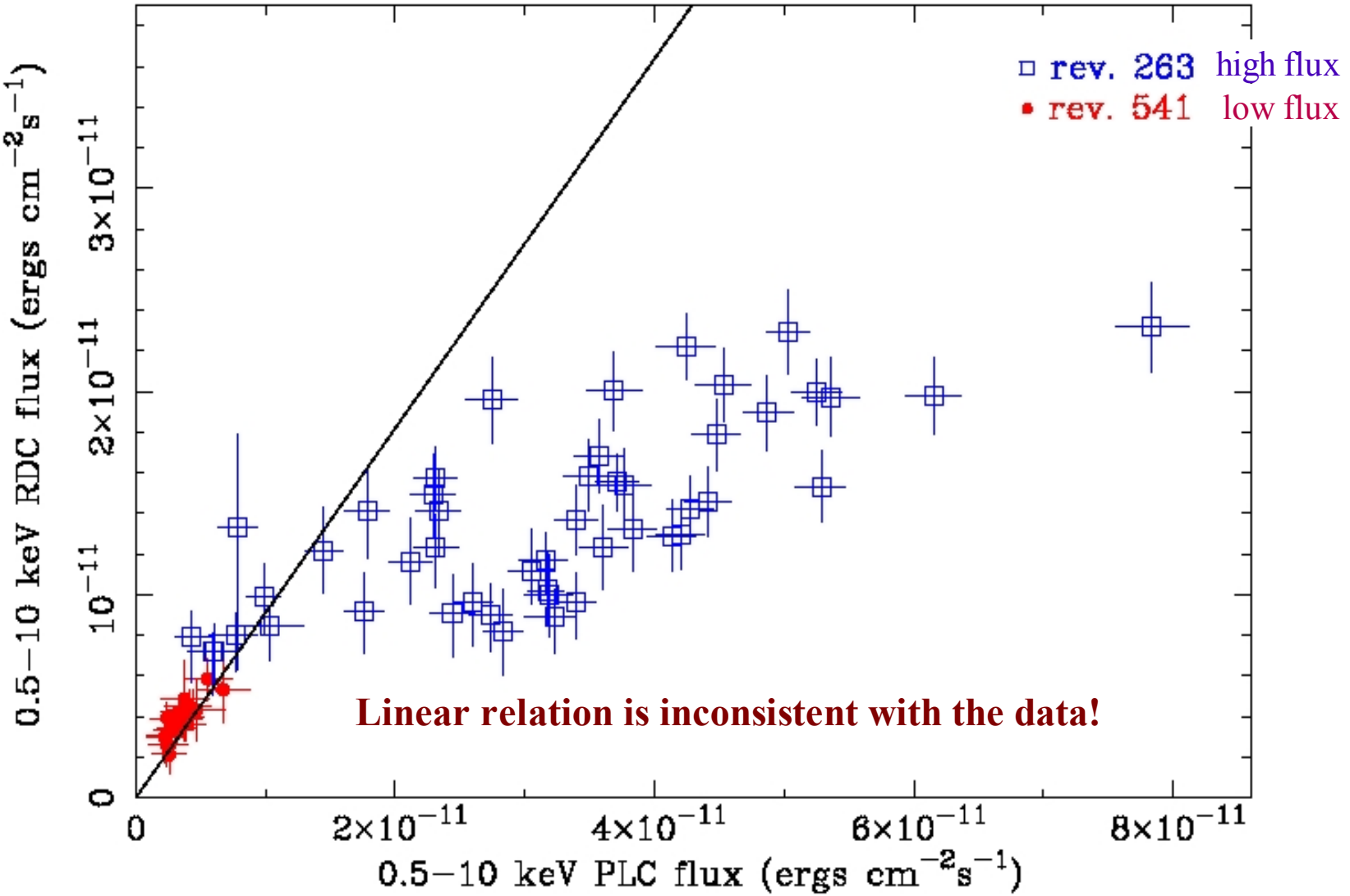


Time resolved spectral variability: Two component model

high flux



Two component model

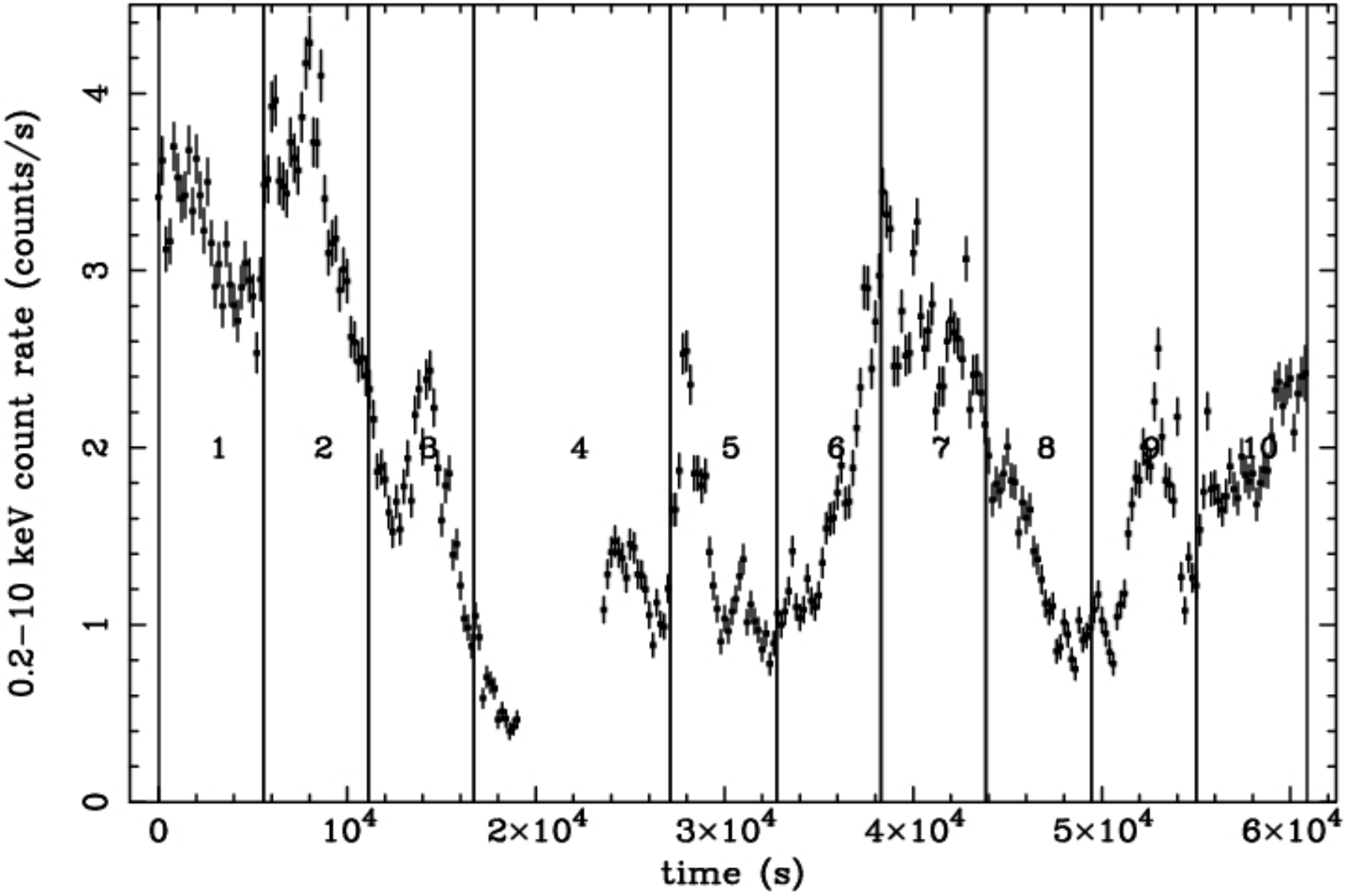


- The reflection explains the observed constancy of the soft excess "temperature" and its similarity to PG quasars
- The observed relation is predicted by the light bending model Miniutti and Fabian 2004

NGC 4051 ⇒ height X-ray source < 10-20 r_g

IRAS 13224-3809: Another light bending dominated source?

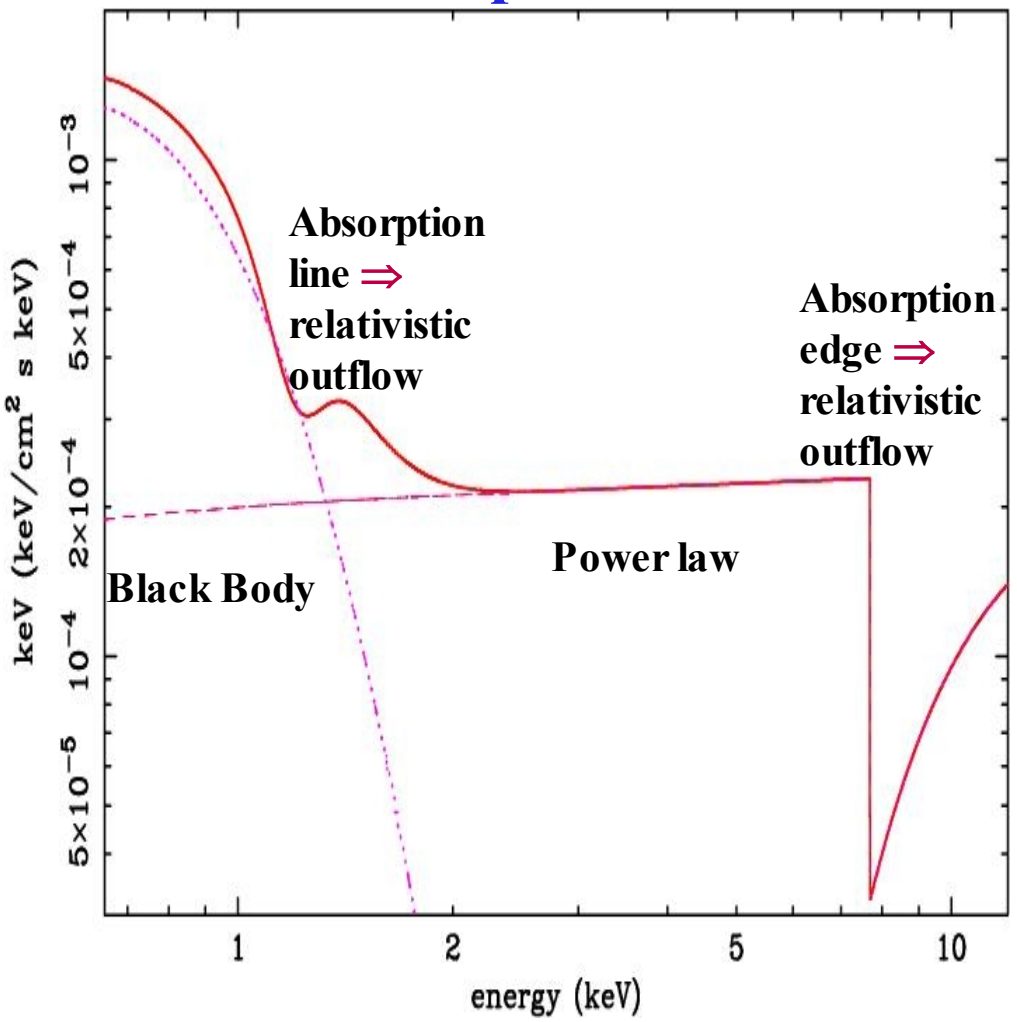
- Narrow Line Seyfert 1
- z=0.0667



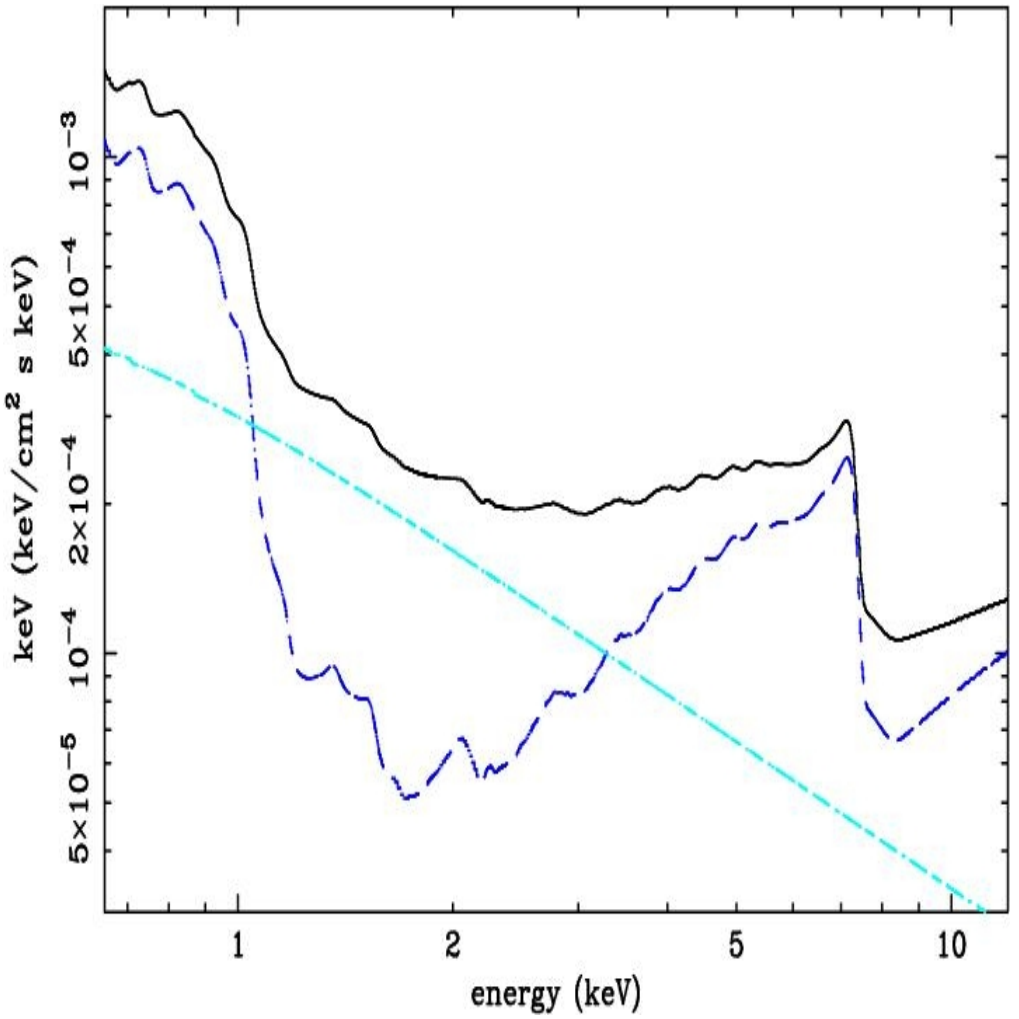
Boller et al. 2003

Best fit model:

absorption



reflection



The relativistic outflow of one component is not consistent with the other!

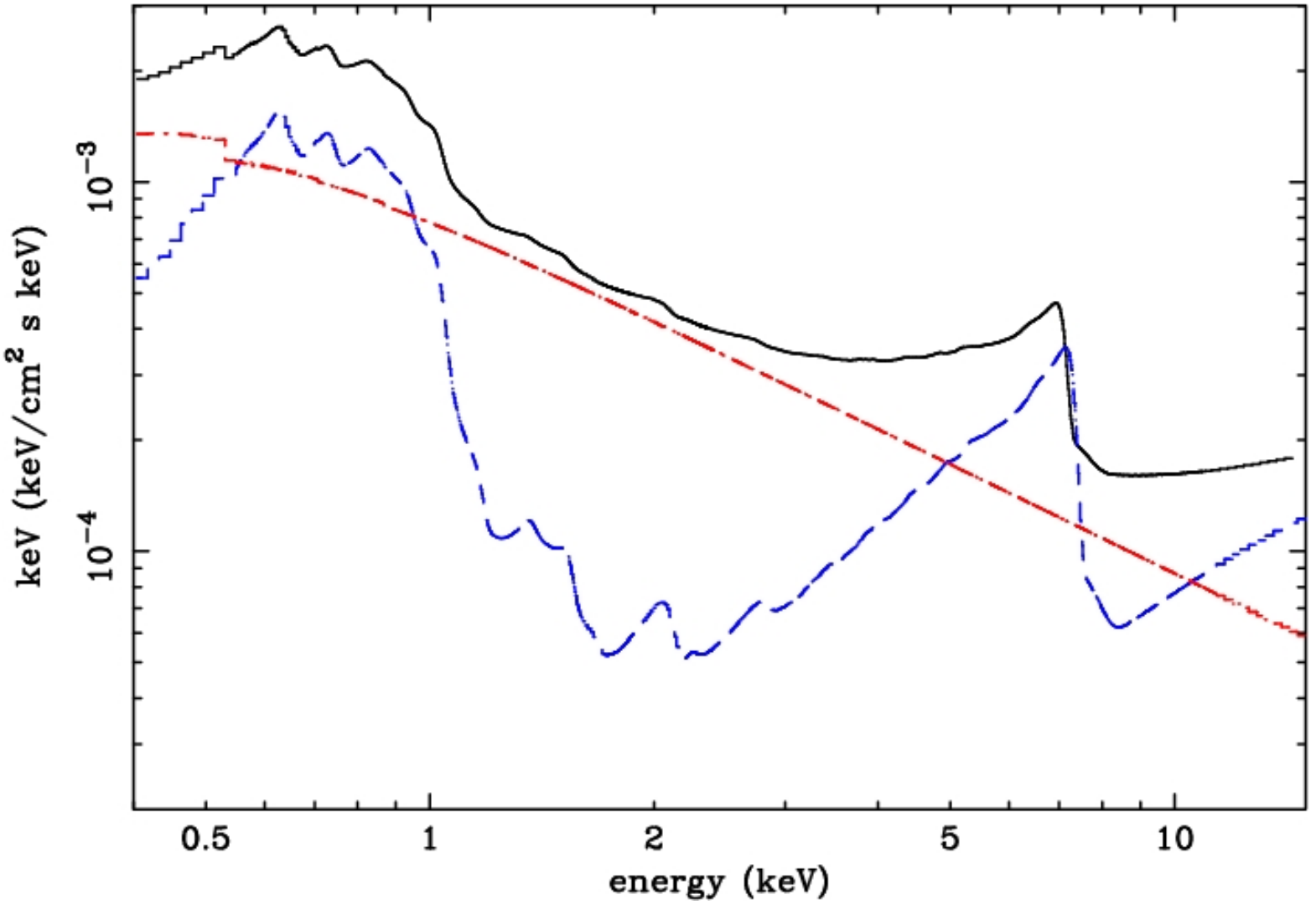
The absorption at low energy occurs at the junction between BB and power law

The sharpness of the edge ⇒ neutral (but close!?) material

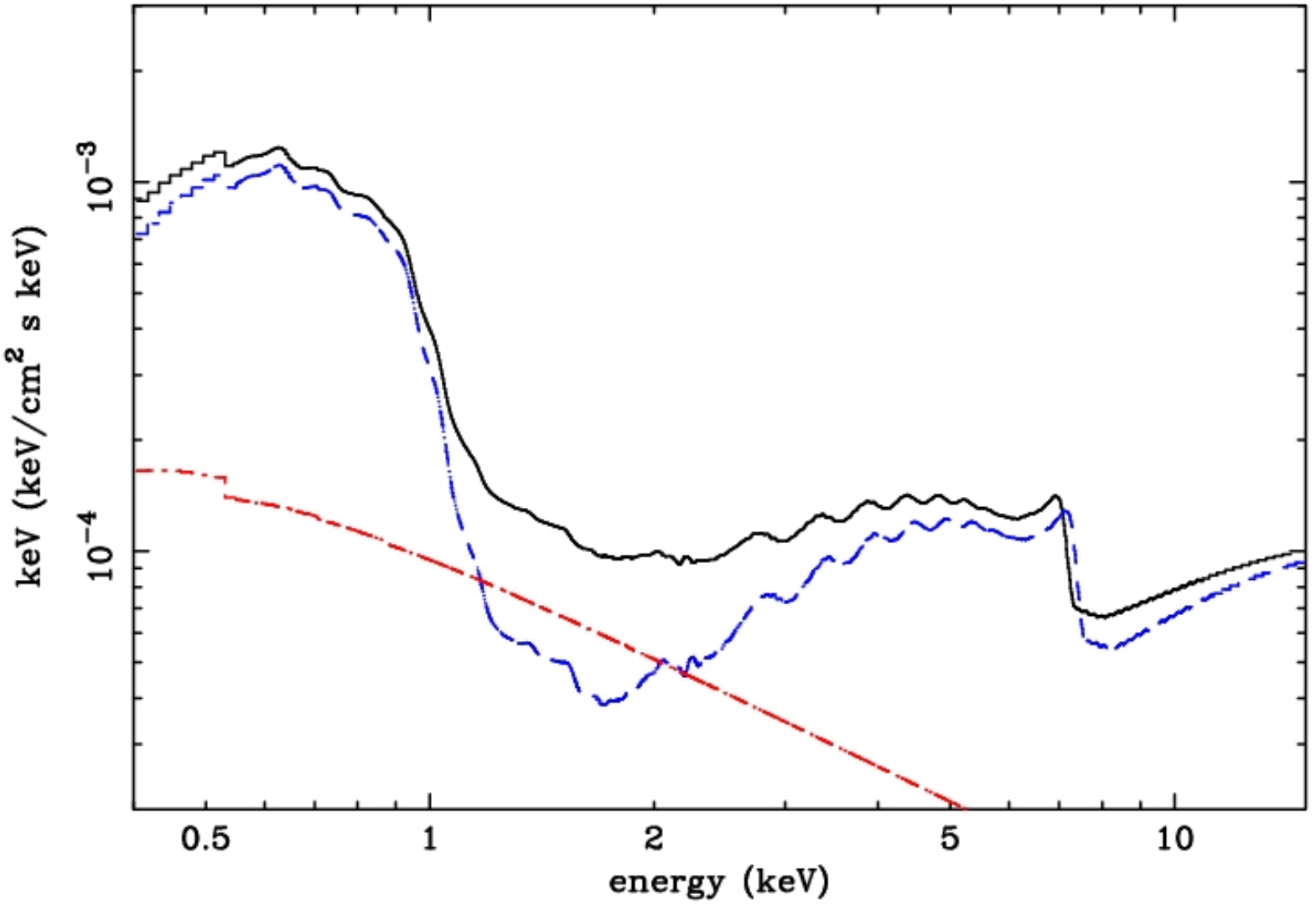
☆ With the two component model there is no need of relativistic outflowing absorption

☆ All the spectral features are due to just two broad band components

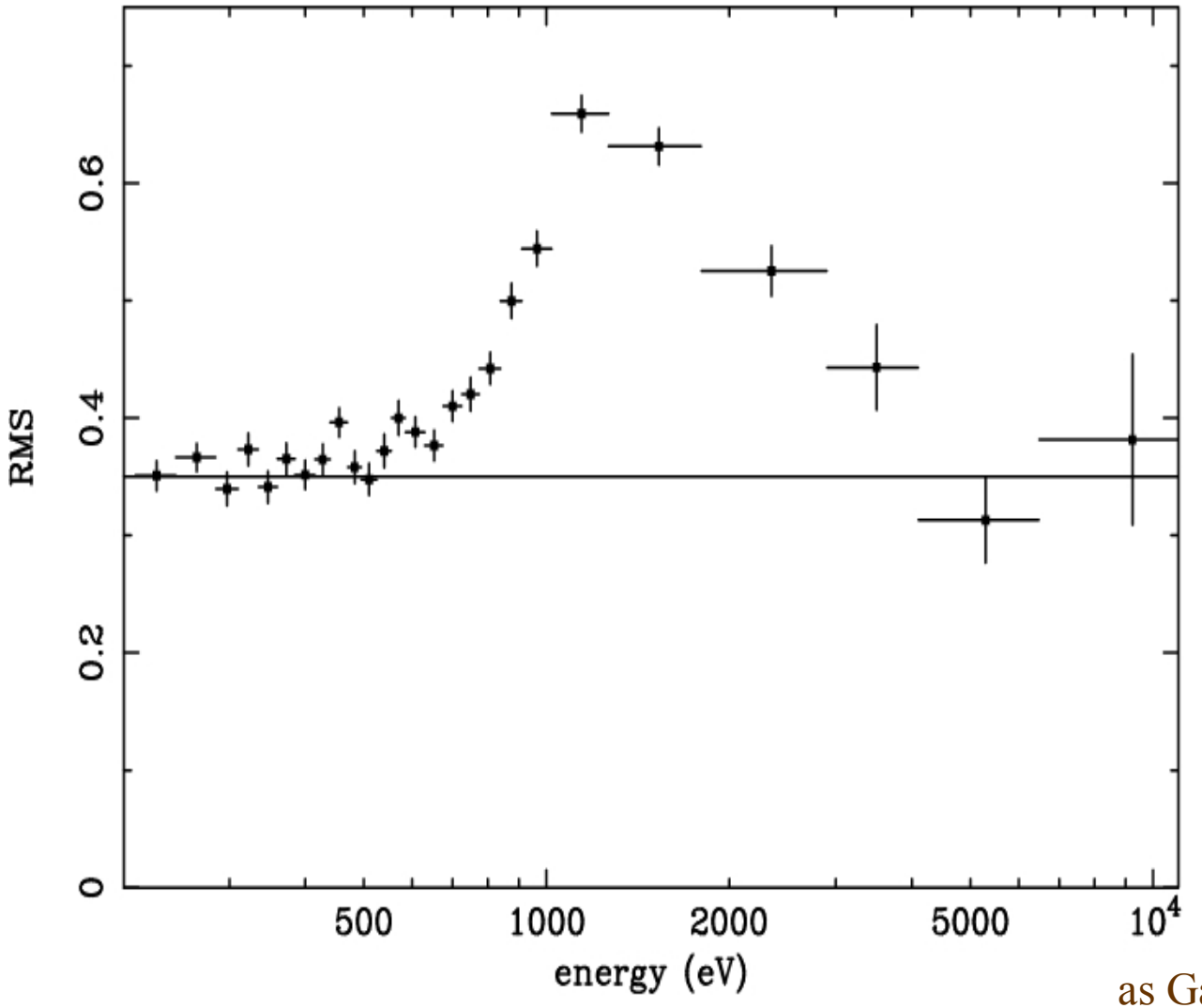
Time resolved spectral variability: The new interpretation



Time resolved spectral variability: The new interpretation



Model independent tools: RMS Spectra

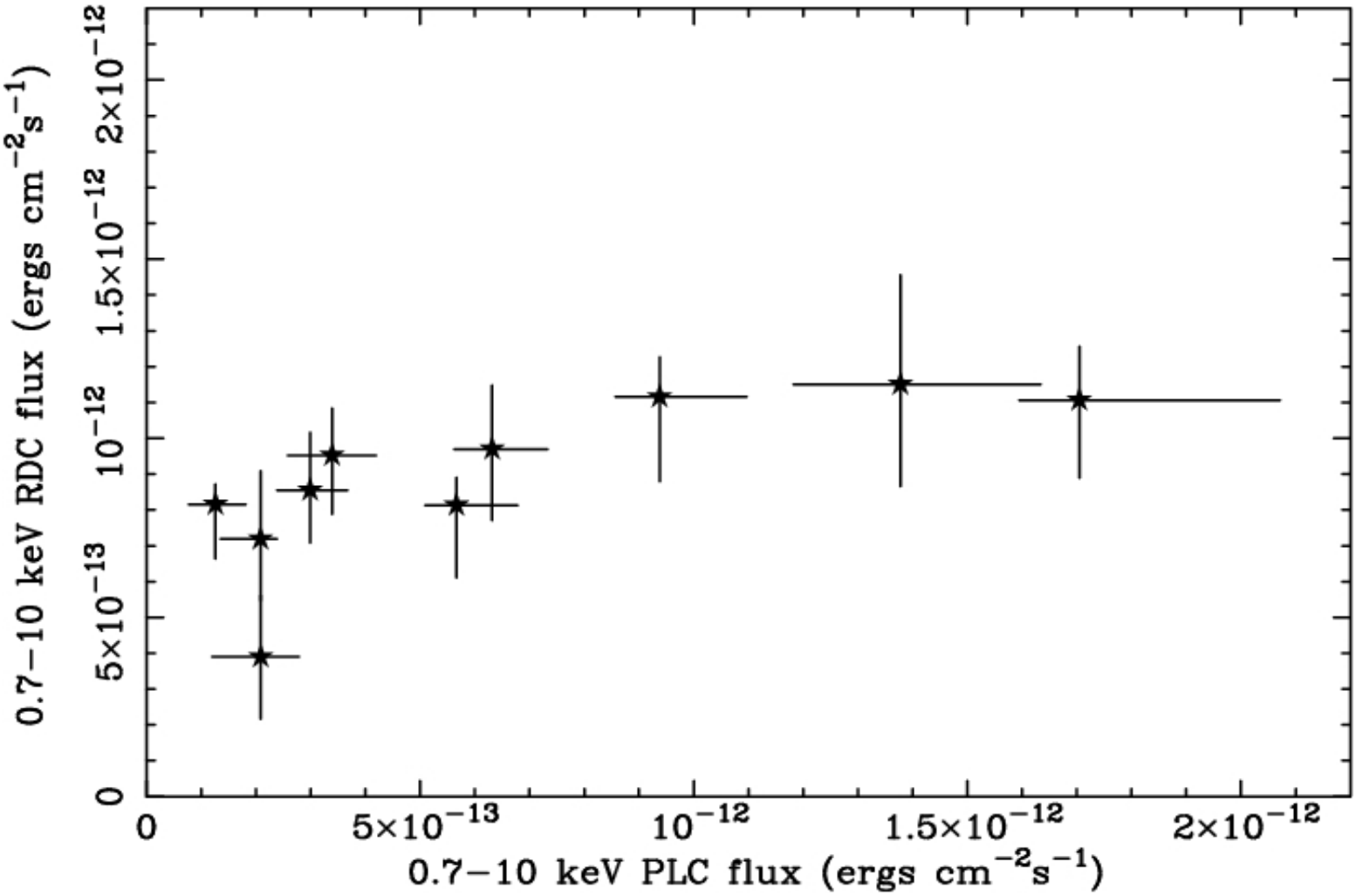


as Gallo et al. 2004

Possible explanations:

- **pivoting power law + less variable black body**
- **two component model**

Two component model



- The RDC is correlated with the PLC at low flux and saturates at medium-high flux
- The observed relation is predicted by the light bending model Miniutti and Fabian 2004
- The reflection explain the soft excess and the other spectral features

Conclusions

- **The XMM-Newton data of NGC 4051 and IRAS 13224-3809 are in agreement with the light bending model**
  - relation flux PLC vs flux RDC
  - constancy of T_{BB} and Gamma flux

- **These imply that the nuclear emission comes from a few gravitational radii ($h < 10\text{-}20\ r_g$) and Kerr black hole**

- **The soft excess emission and variability is consistent with being due to relativistic ionized reflection**