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A XMM-Newton study of the Fe K band variability in the 22 brightest-unabsorbed AGN

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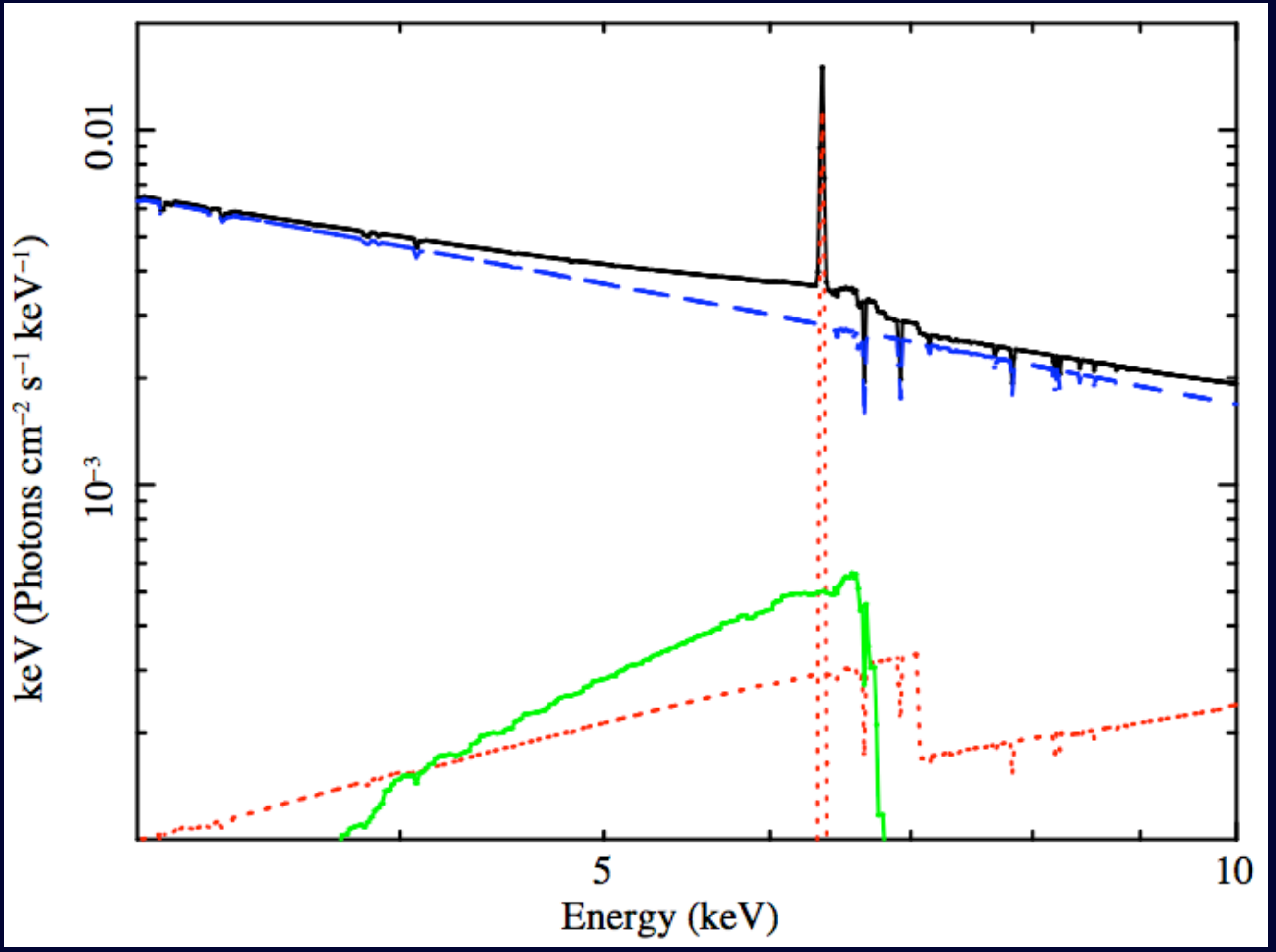
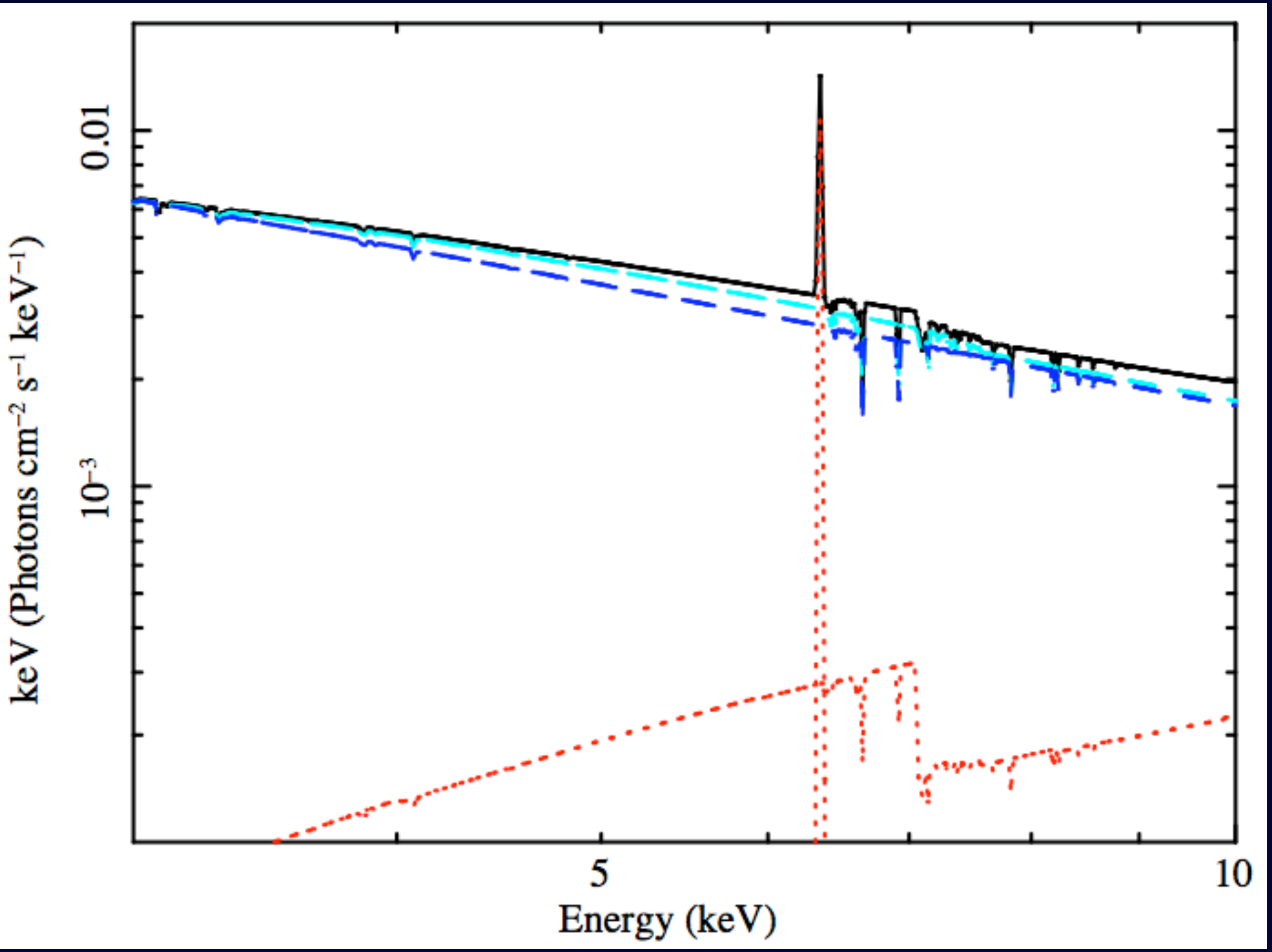
thanks to: G. Miniutti, P. Uttley, L. Gallo, B. De Marco, M. Cappi, A. Fabian, and the FERO collaboration

Typical 3-10 keV spectrum of Seyfert 1



Tanaka et al. 1995;
Fabian et al. 2002;
Guainazzi et al. 2006;
Nandra et al. 2007

Typical 3-10 keV spectrum of Seyfert 1



Reeves et al. 2004; Done et al. 2007; Miller et al. 2008

An ionised partially covering absorber may produce a spectral curvature in the 3-10 keV band resembling a broad Fe K line

Mean spectra degenerate!
⇒ spectral variability

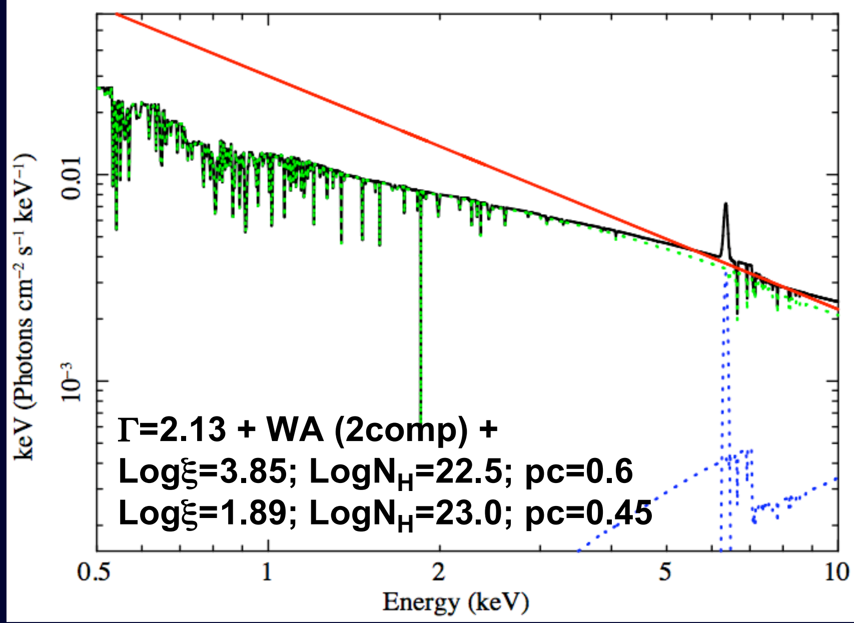
The variability tools:

Root Mean Square variability or Fvar
"model and calibration independent"
Vaugan et al. 2003; Ponti et al. 2004;Markowitz & Edelson 2004

$$RMS = \sqrt{\frac{S(E)^2 - <\sigma_{err}^2>}{<X(E)>^2}}$$

Total rms
"model independent"
~ fourier resolved spectroscopy
Revnivtsev et al. 1999; Papadakis et al. 2005; 2007 Arevalo et al. 2008

$$Trms = \sqrt{\frac{S(E)^2 - <\sigma_{err}^2>}{\Delta E * arf^2}}$$

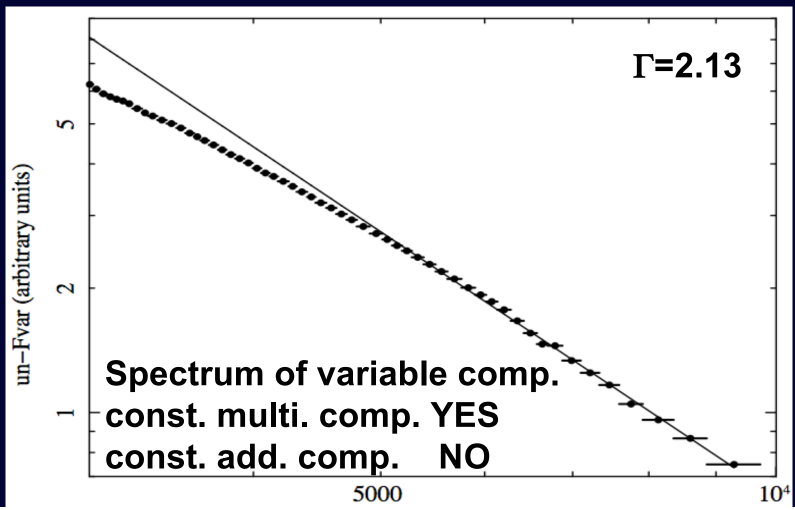


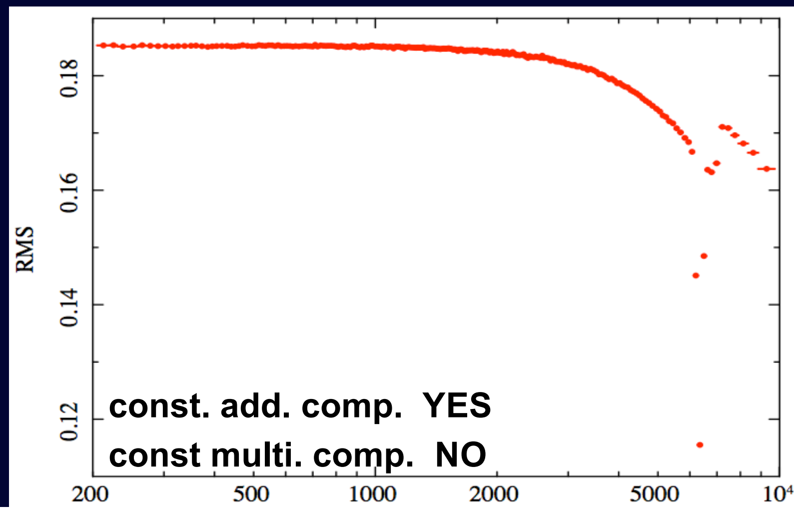
Similar to Miller et al. 2008

Source spectrum:
$F(E,t) = A(E) * [B(E,t) + C(E)]$
$B(E,t) = K(t) * E^{-\alpha}$

Total rms spectrum:
$T(E,t) = A(E) * E^{-\alpha} * P_k$

If $B(E,t) = K(t) * E^{-\alpha}$
⇒ Same spectral index
⇒ Same absorption
⇒ No constant component





The sample of type AGNs:

The brightest unabsorbed

($N_H < 1.5 \times 10^{22}$ cm^{-2})

AGNs from the RXTE Slew Survey

(Revnivtev et al. 2004)

Subsample of Guainazzi et al. 2006

⇒ $Flux_{2-10\ keV} \geq 1.5 \times 10^{-11}$ erg s^{-1} cm^{-2}

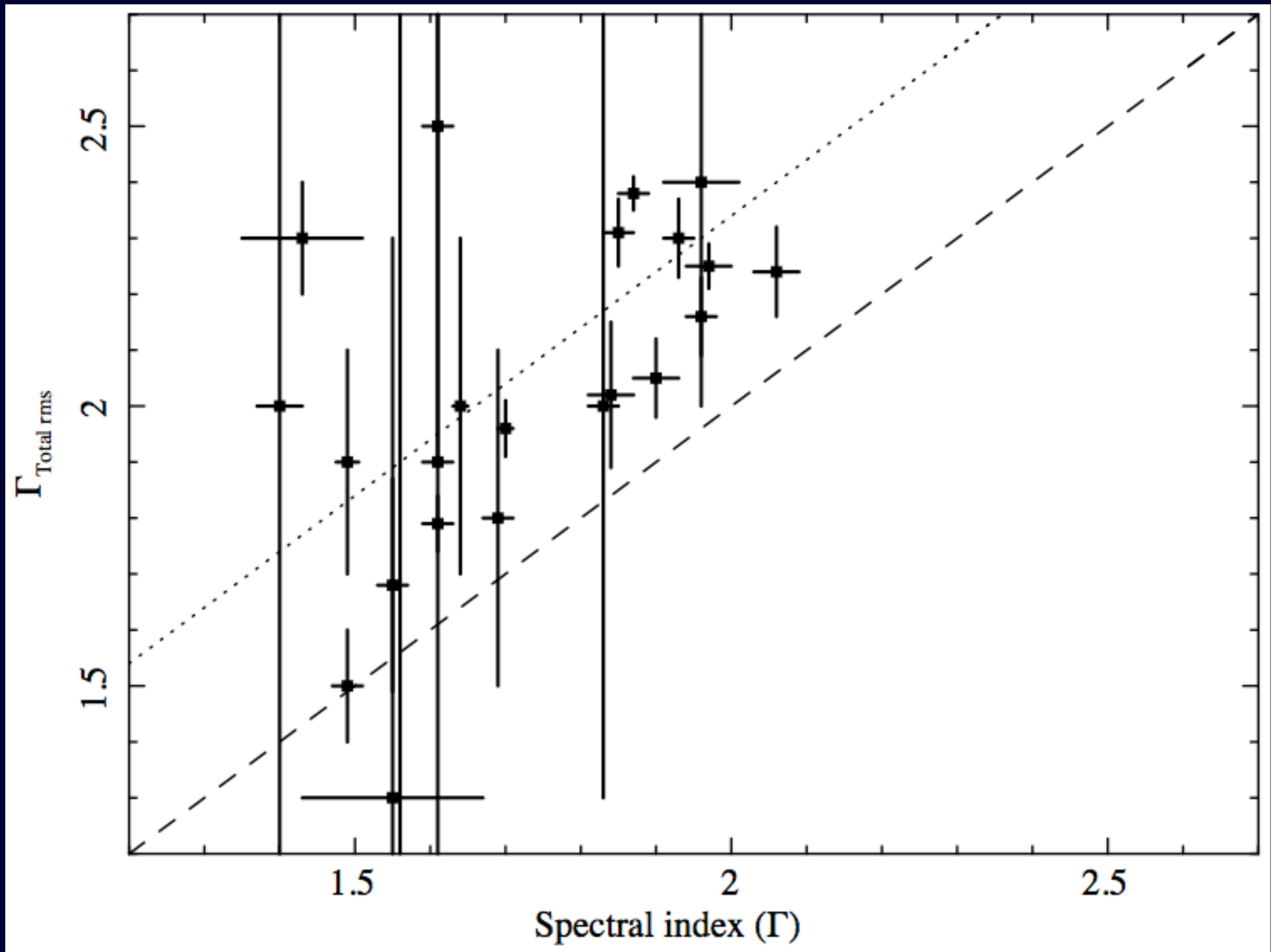
⇒ 22 sources

⇒ 44 XMM-Newton EPIC-pn observation > 30 ks

~ 3.2 Ms of data

SOURCE	z	rate c/s 3-8 keV	Type	exp. ks
IC4329A	0.0161	7.29	S1	113
MCG-5-23-16	0.0085	6.46	S2	110
NGC3783	0.0097	4.90	S1	286
NGC5548	0.0170	3.58	S1	80
NGC3516	0.0088	3.21	S1	354
MRK509	0.0344	3.12	S1	242
MCG-6-30-15	0.0077	3.08	S1	416
MCG+8-11-11	0.0205	2.36	S1	37
H0557-385	0.0339	2.33	S1	73
NGC7314	0.0048	2.16	S2	43
AKN120	0.0323	2.14	S1	102
MRK279	0.0305	2.13	S1	158
MR2251-178	0.0640	2.10	RQQ	63
NGC3227	0.0039	2.10	S1	135
IRAS05078+1626	0.0179	2.08	S1	57
MRK590	0.0264	1.95	S1	60
MRK766	0.0129	1.77	NLS1	618
NGC7469	0.0164	1.69	S1	162
MGC-2-58-22	0.0469	1.61	S1	-
NGC526A	0.0191	1.61	S2	39
NGC4051	0.0024	1.49	NLS1	148
ESO141-G055	0.0360	1.37	S1	-

The 3-10 keV continuum

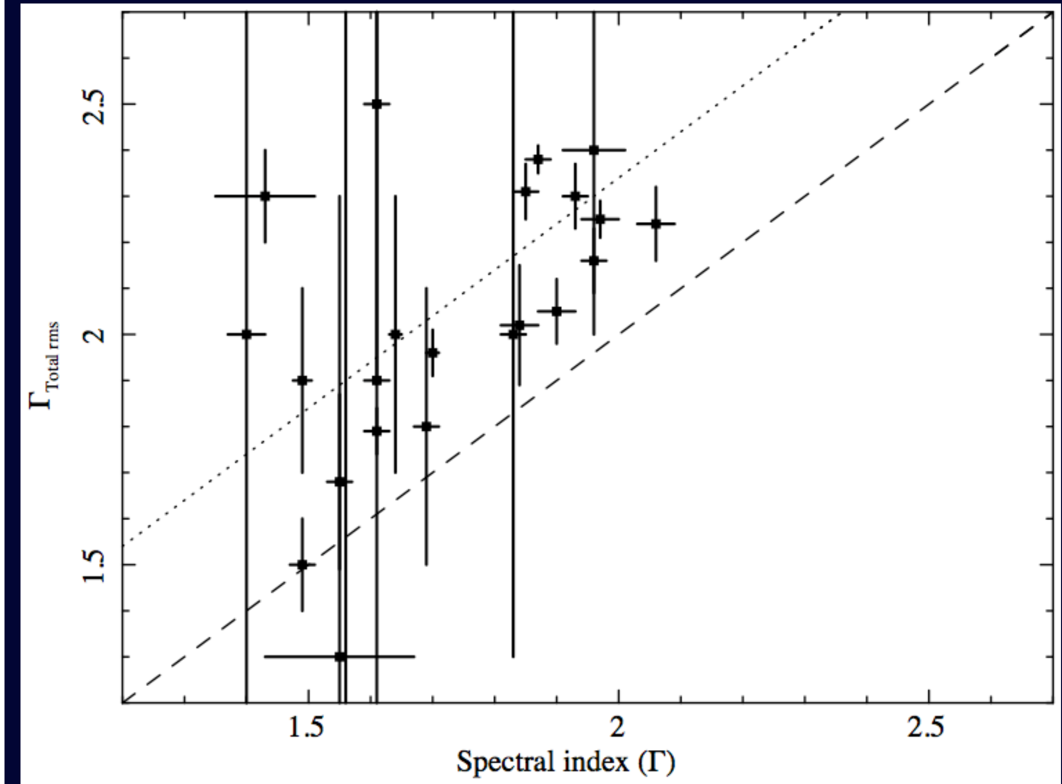


$\Gamma_{\text{Total rms}} > \Gamma_{\text{mean spectrum}}$

$\Rightarrow \Gamma_{\text{mean spectrum}}$ **increases with flux**

Zdziarski et al. 1999; 2003; Markowitz et al. 2001

The 3-10 keV continuum

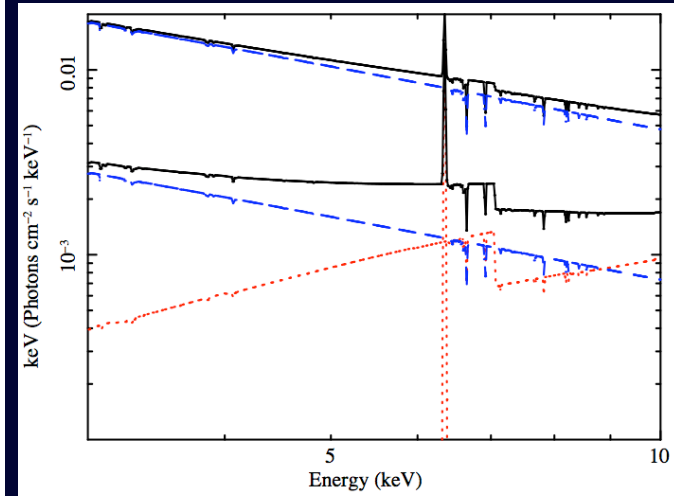


McHardy et al. 1998; Shih et al. 2002
Fabian et al. 2002

Two components - Reflection:

F(E,t) = A(E) * [B(E,t) + C(E)]

B(E,t) = K(t) * $E^{-\alpha}$



$\alpha = \Gamma_{Trms}$

Γ_{Trms}-Γ_{mean}=0.34

$\Rightarrow$R ~ 3

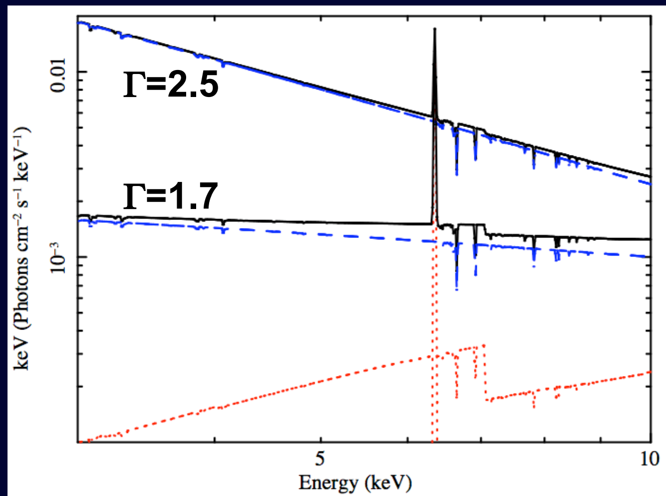
(R=1 $\Delta\Gamma$=0.1-0.15)

Trms - power law

Γ_{Trms} - constant with flux

Pivoting power law :

Pivot point at 20 keV

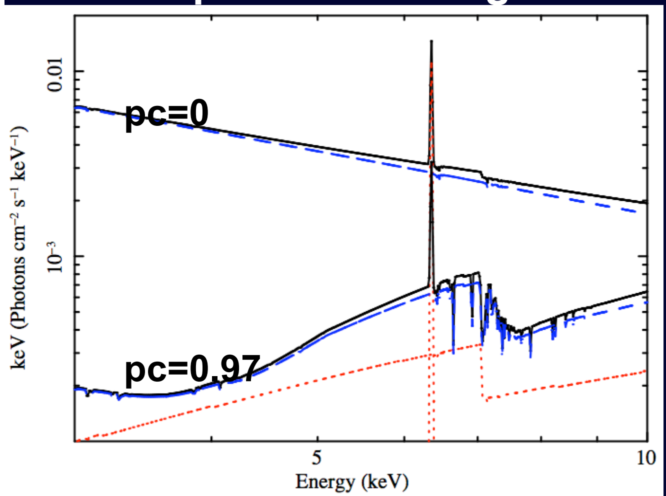


Haardt et al. 1993; 1997; Poutanen et al. 1999; Zdziarski et al. 2003

Trms - power law

Γ_{Trms} - correlated with flux

Variable partial covering - Absorption :



Boller et al. 2002; Reeves et al. 2004; Done et al. 2007; Miller et al. 2008

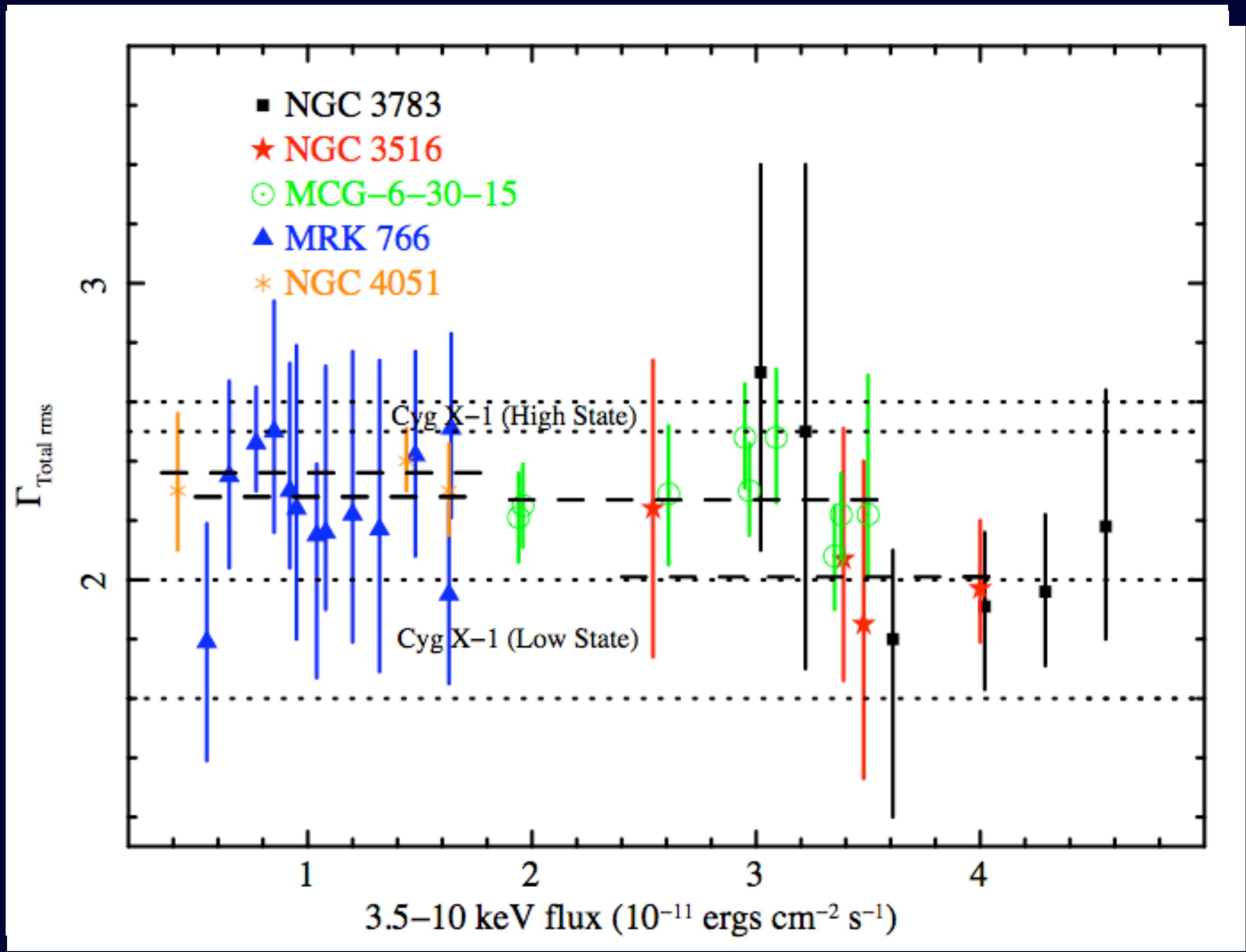
$n_H = 10^{24}$ cm^{-2}

$Log(\xi) = 1.9$

Trms - random shape

Γ_{Trms} - correlated with flux

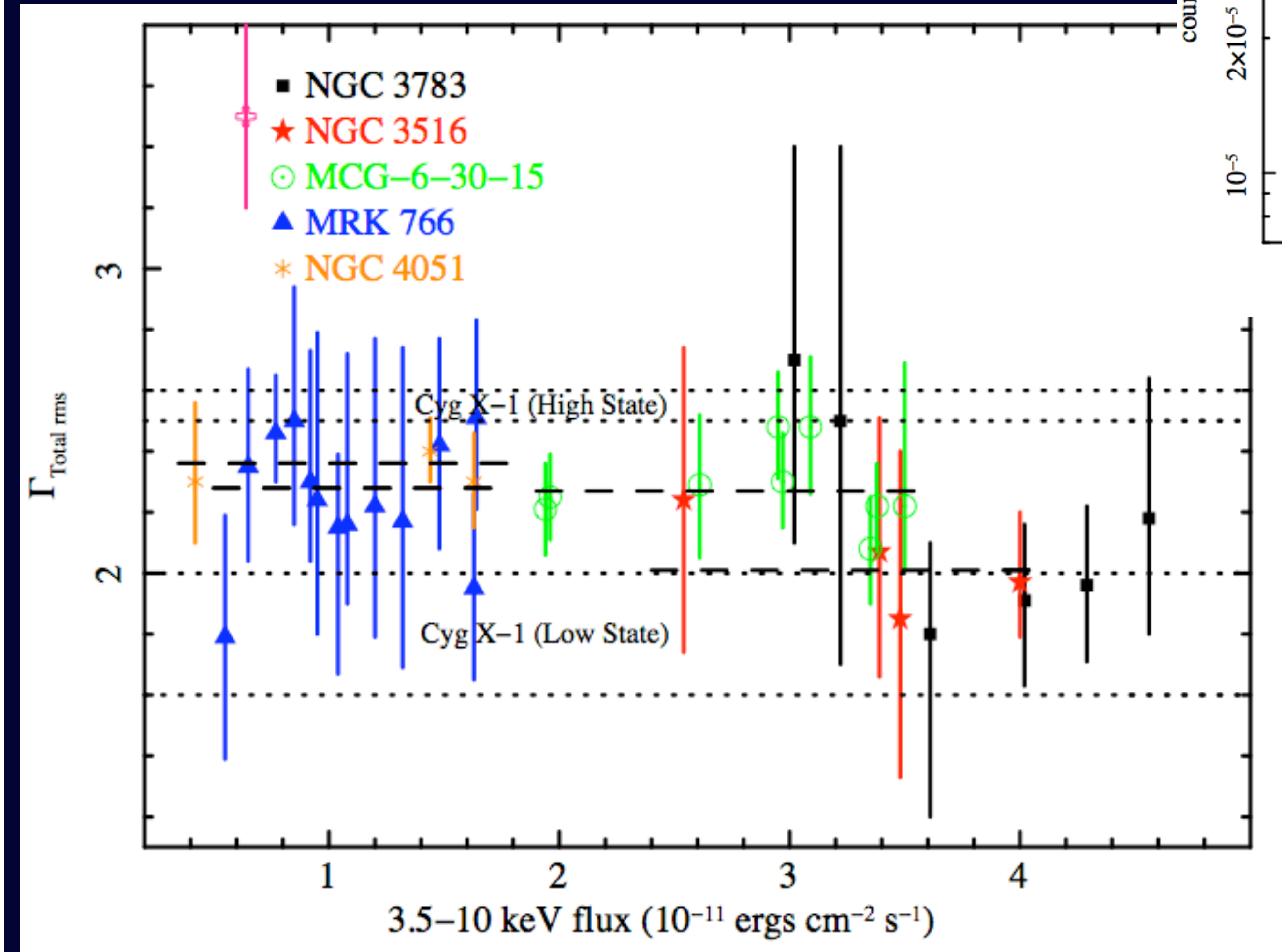
The 3-10 keV continuum: flux dependence

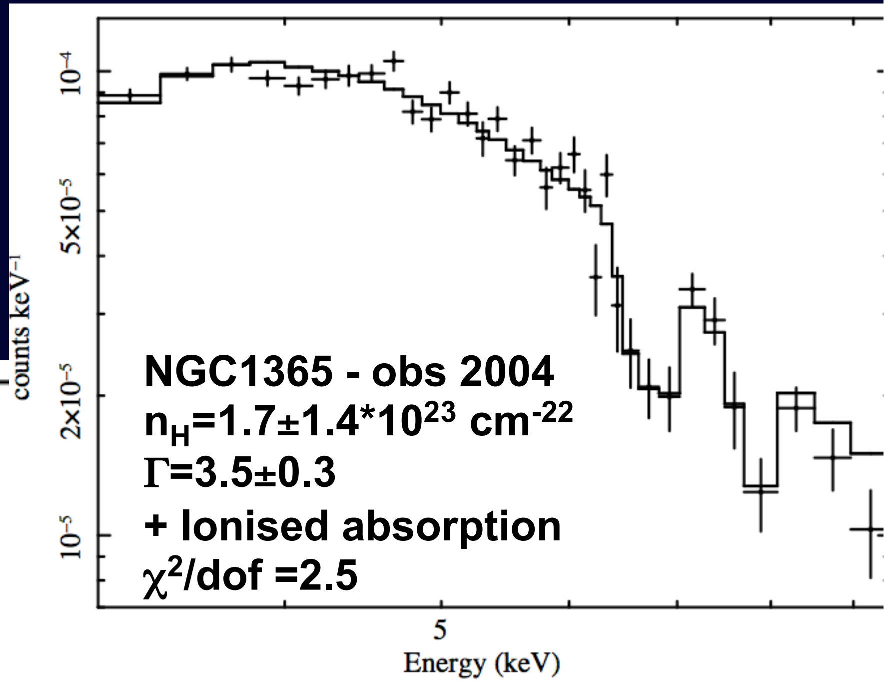


The major variability ⇒ steep (Γ~1.8-2.6) power law varying mainly in normalisation

Papadakis et al. 2007
Gilfanov et al. 2000;
Revnivtev et al. 1999

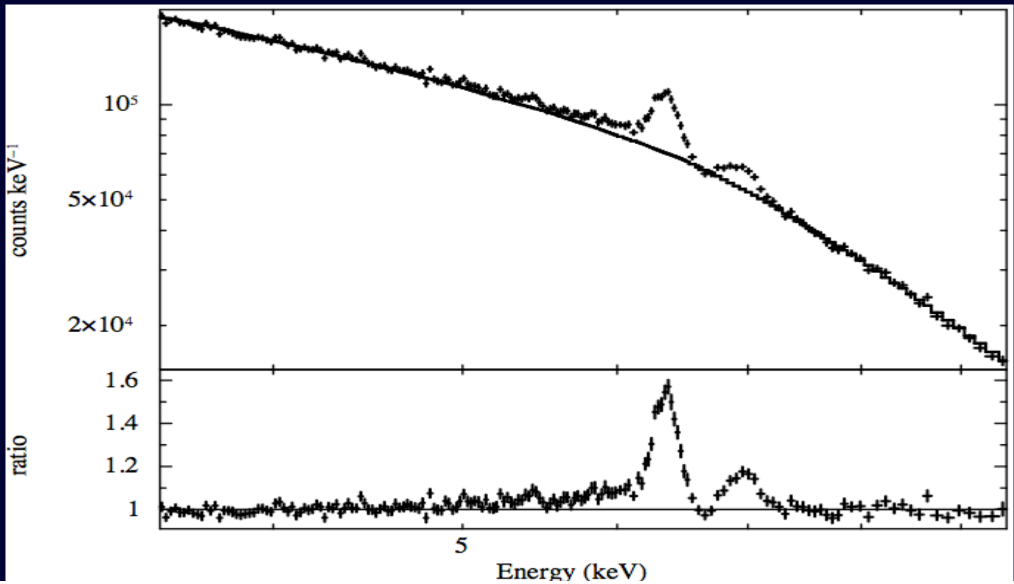
The 3-10 keV continuum: Variable Absorption



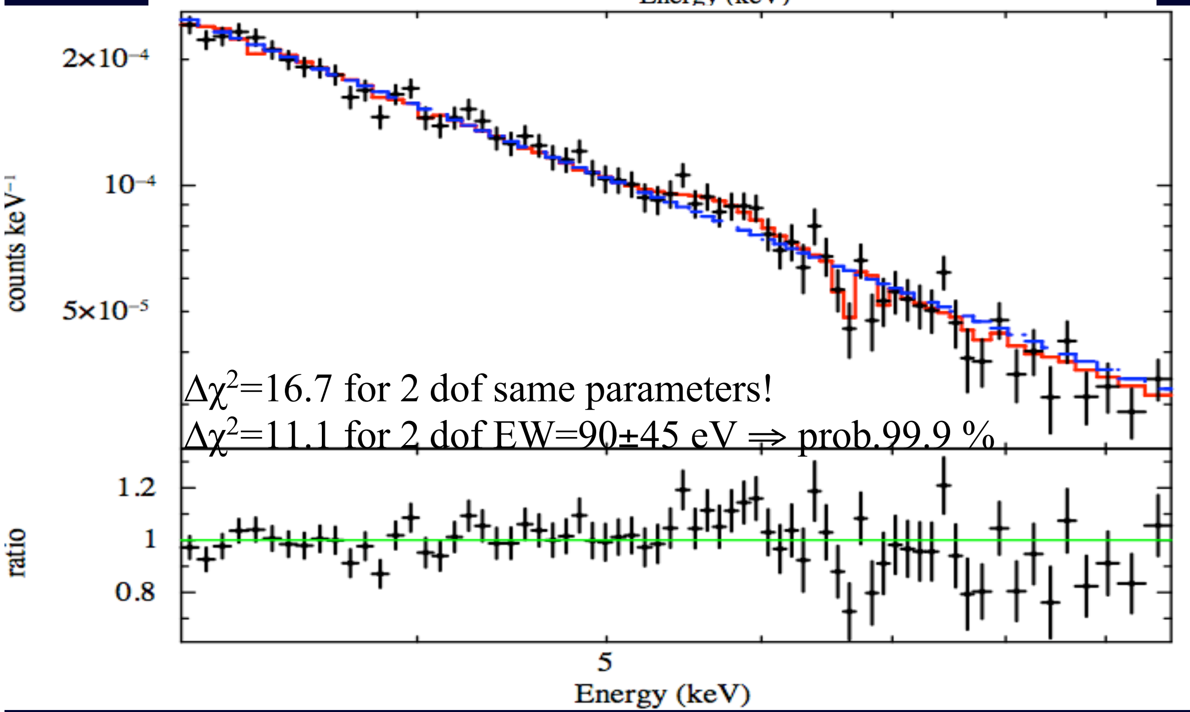


Papadakis et al. 2007;
Gilfanov et al. 2000;
Revnivtev et al. 1999;

Detailed study of the line variability: The case of NGC 3783



i) FeKα+β (EW~110±8 eV);
ii) Fe XXVI (EW~17±5 eV);
iii) Absorption at 6.67 (EW=17±5 eV); FeXXV;
iv) Excess redward of FeKα;
⇒ diskline (EW~58±12 eV)
⇒ absorption + Compton shoulder



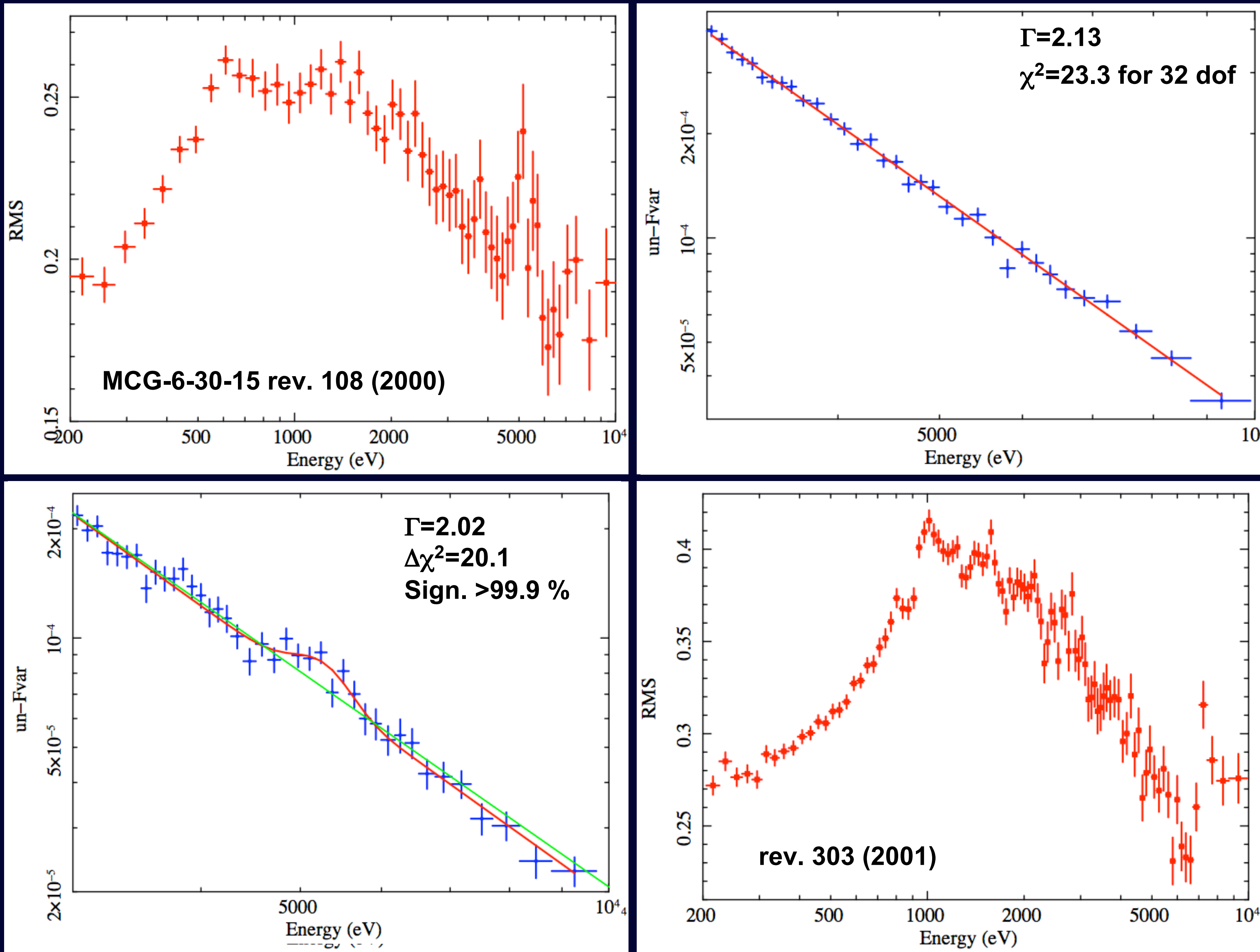
FeKα+β ⇒ constant
Fe XXVI emission ⇒ constant
Absorption FeXXV ⇒ constant

Excess variable! (prob. 99.9 %)
⇒ broad line from the disk
⇒ absorption + Compton shoulder excluded!

Tombesi et al. 2008; Poster by De Marco et al.

MCG-6-30-15: the variability of the Fe K line

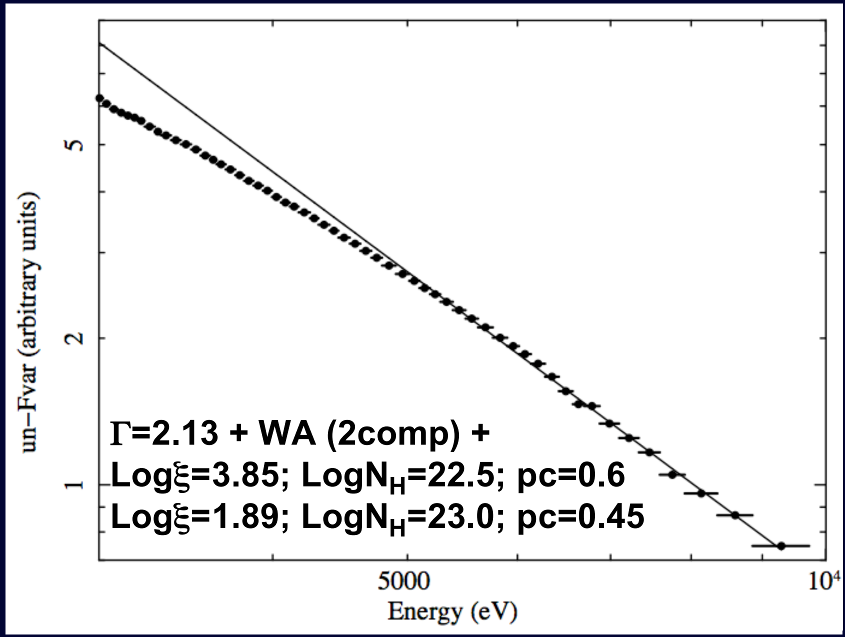
Revnivtsev et al. 1999; consistent with Papadakis et al. 2005

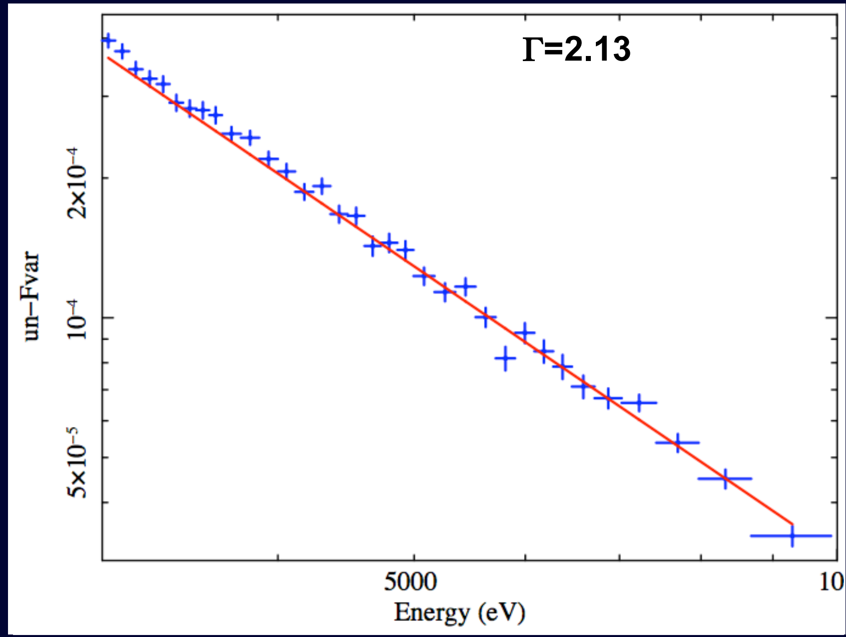


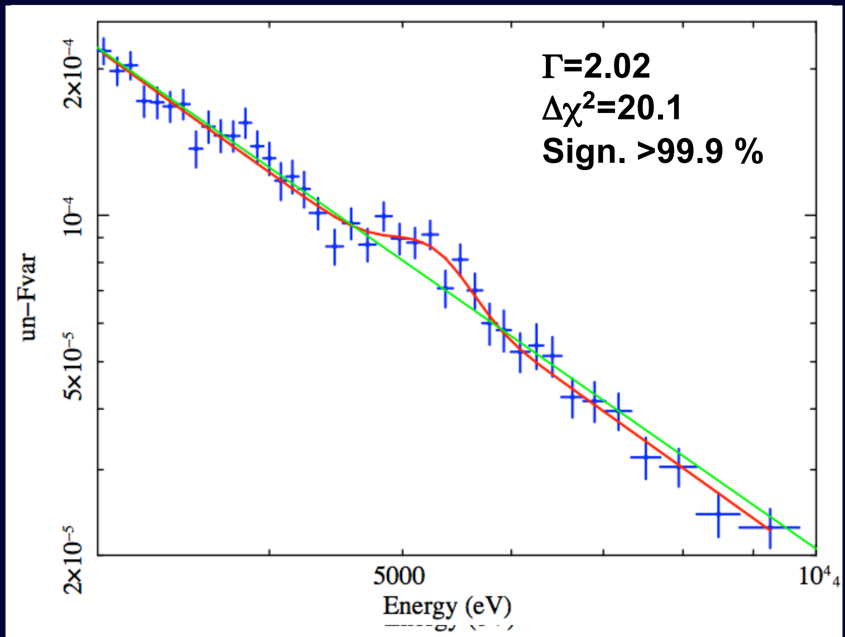
see Ponti et al. 2004, Vaughan et al. 2004; Reynolds et al. 2004

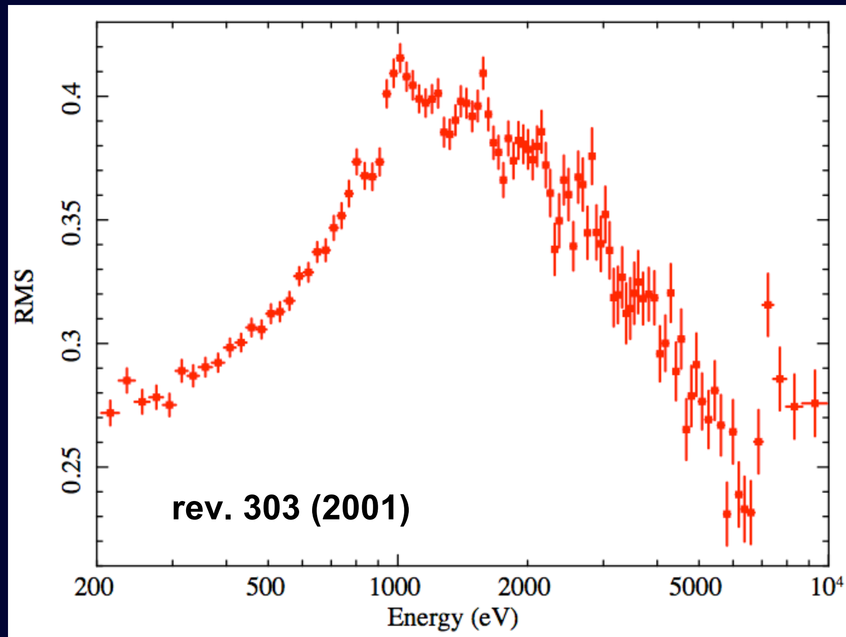
MCG-6-30-15: the variability of the Fe K line

Revnivtsev et al. 1999; consistent with Papadakis et al. 2005





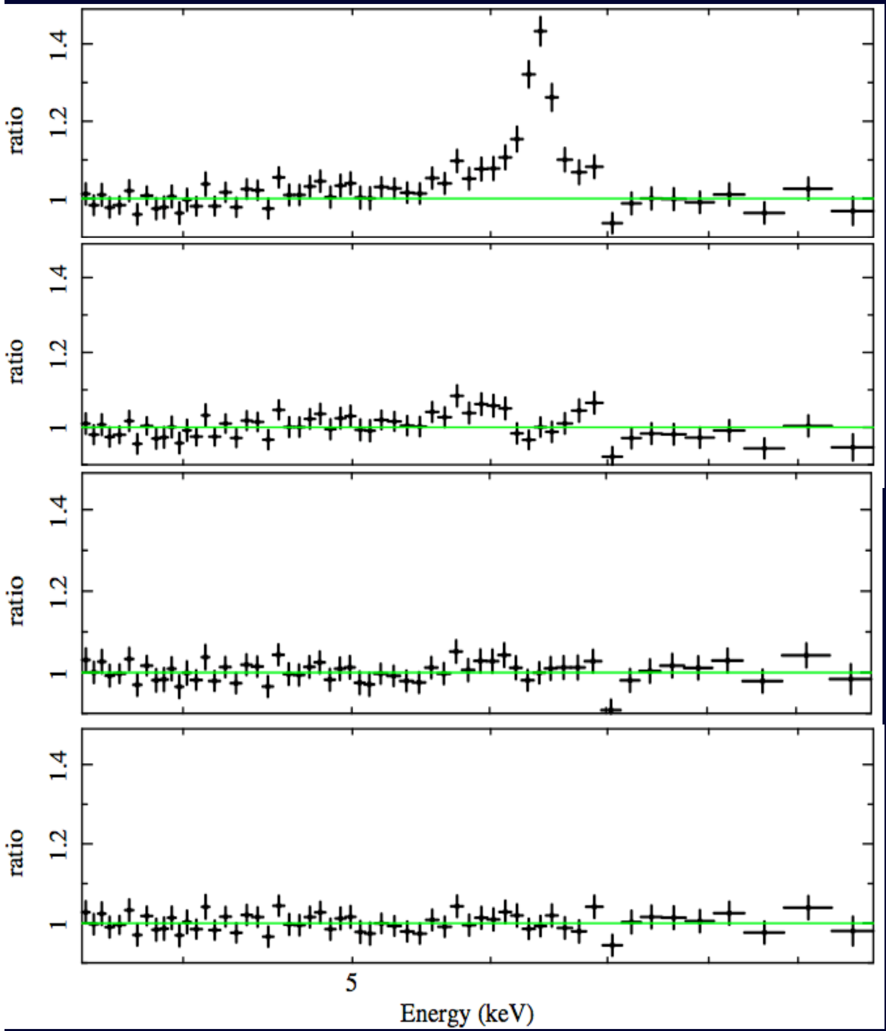




see Ponti et al. 2004, Vaughan et al. 2004; Reynolds et al. 2004

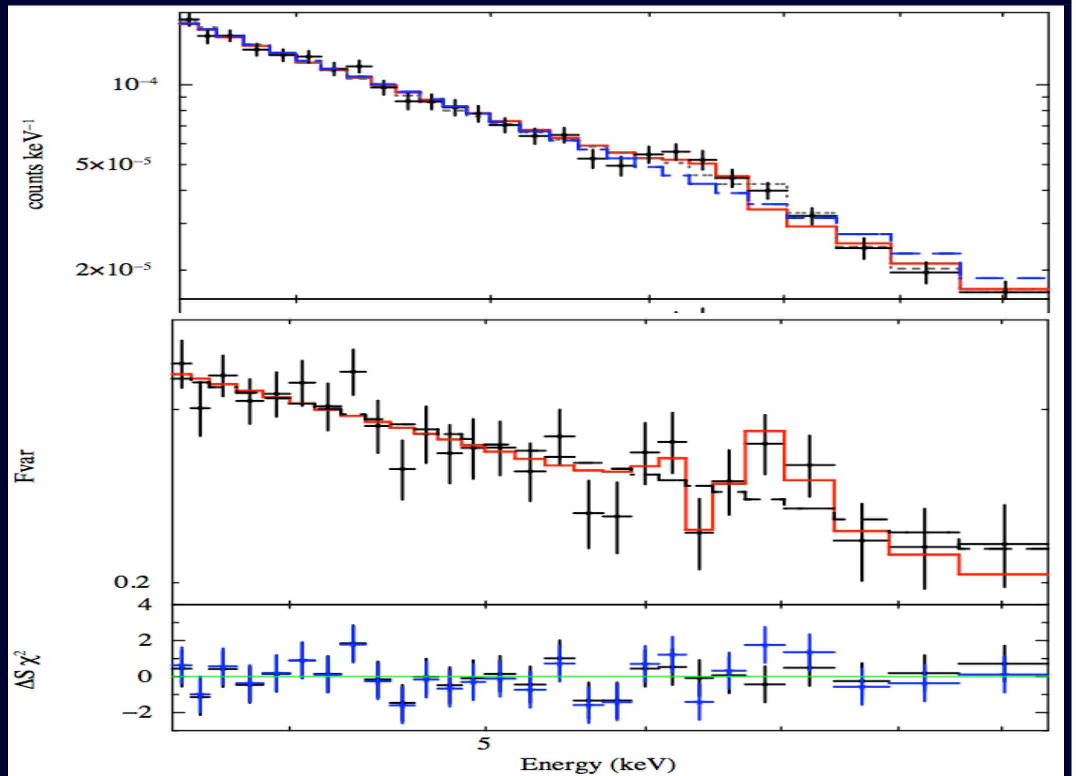
Detailed study of the line variability: The case of NGC 4051

i) FeKα+β (EW~76±17 eV);
ii) Broad excess in the FeKα band;
⇒ absorption partially covering the source
⇒ diskline (EW~180±45 eV)



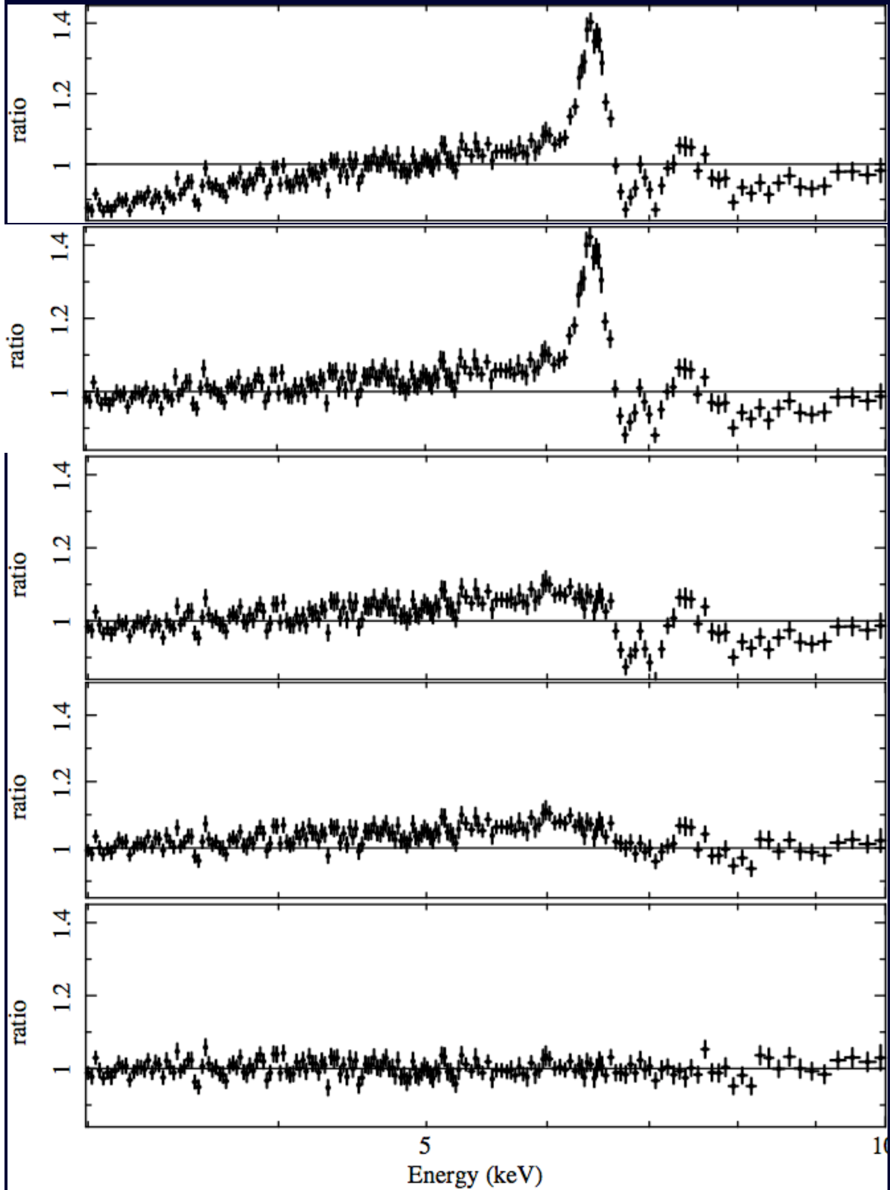
Significant excess of variability at the broad Fe K energy
Constant partial covering absorber ⇒ no
Better fitted with a broad variable Fe K line

Narrow FeKα ⇒ constant

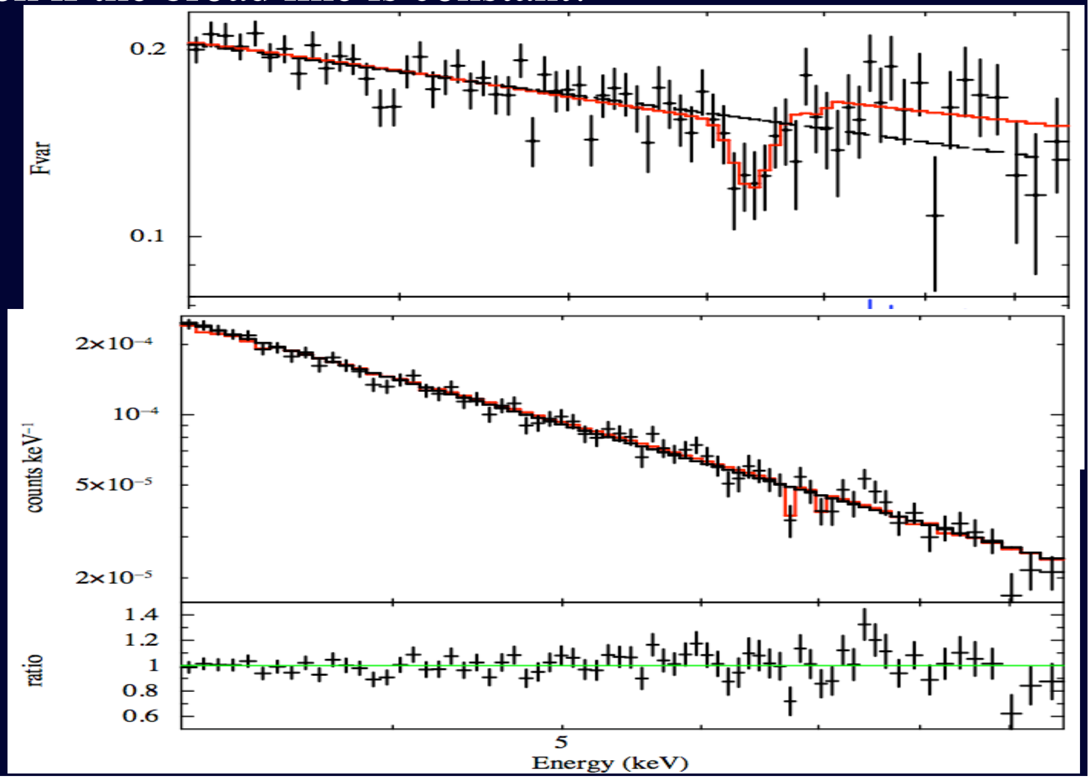


Detailed study of the line variability: The case of NGC 3516

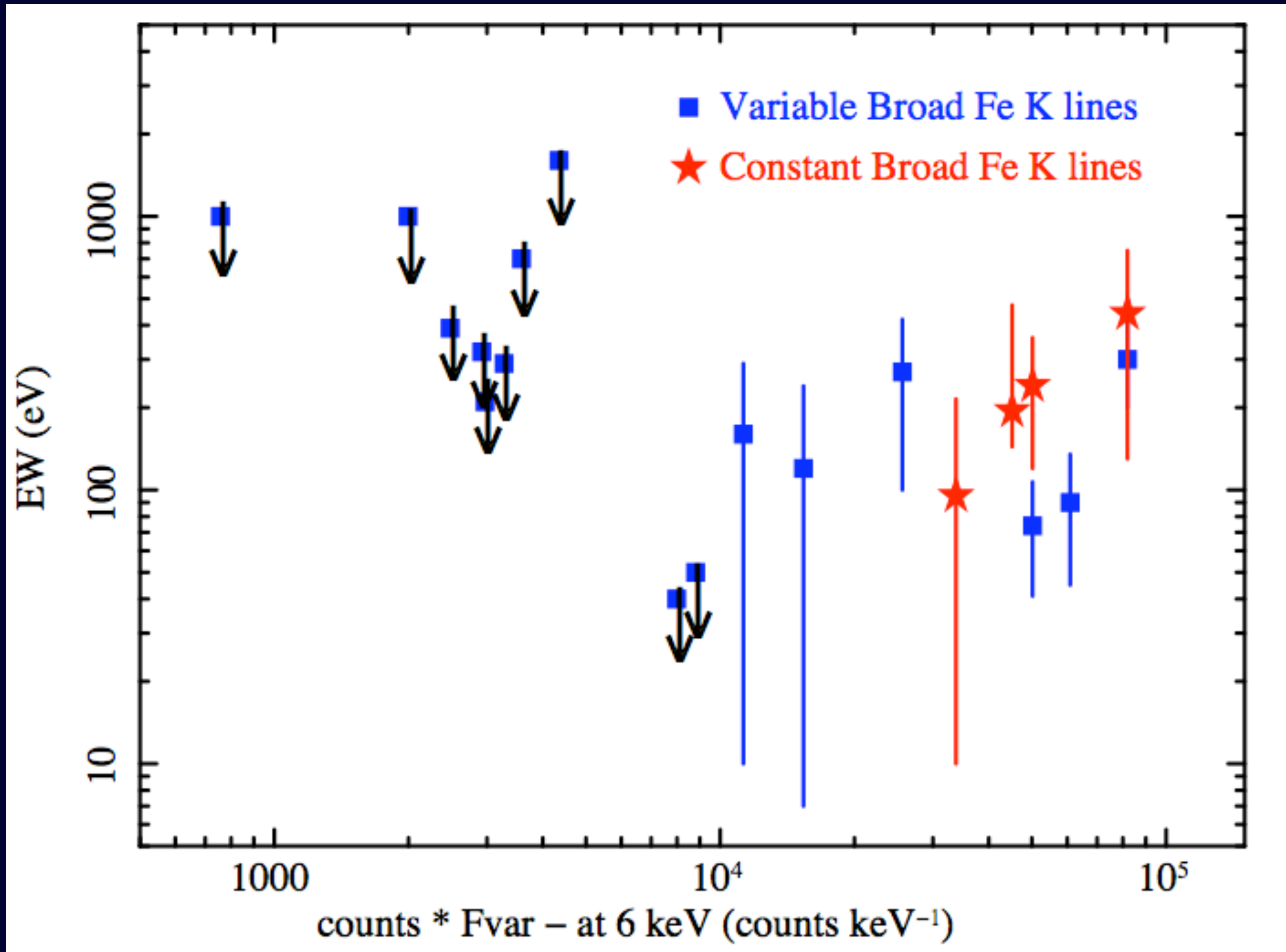
i) WA absorption strong even in the 3-10 keV band;
ii) FeKα+β (EW~92±22 eV);
iii) High ionization absorption FeXXV, FeXXVI;
iv) Excess redward of FeKα;
⇒ diskline (EW~248±70 eV)
⇒ absorption partially covering the source



Narrow FeKα+β ⇒ constant
Highly ionized component ⇒ constant
No further absorption in the variability spectrum
⇒ no partial covering!
⇒ ok if the broad line is constant!



The Fe K line: broad component



Summary:

3-10 keV CONTINUUM:

The 3-10 keV Total rms spectrum ⇒ PL shape, without signatures of partial covering absorption
A constant ionized partial covering or variations such as in NGC1365 are excluded

⇒ total rms is the same in sources where partial covering may/is-not present

Main spectral variations due to PL varying in normalisation

Fe K BAND VARIABILITY:

8 sources the statistics/variability allows to probe the variability of the Fe K band (~20-40 eV)
In all the 8 cases the variability behaviour confirm the presence of broad Fe K lines

- **In NGC 3783, NGC 4051, IC4329A the broad line is variable and correlated with continuum**
- **in NGC 3516, MCG-5-23-16 the broad line is constant**
- **in Mrk 766 the red wing of the broad is constant, the blue peak variable**

The red tail of the Fe K line of MCG-6-30-15 shows a significant excess of variability in one over 4 XMM-Newton observations

Theoretical models can explain this behaviour (I.e. ligh bending…)