

ESAC seminar 14-11-18

The complex X-ray spectrum and
variability of the AGN 1E0754.6+392

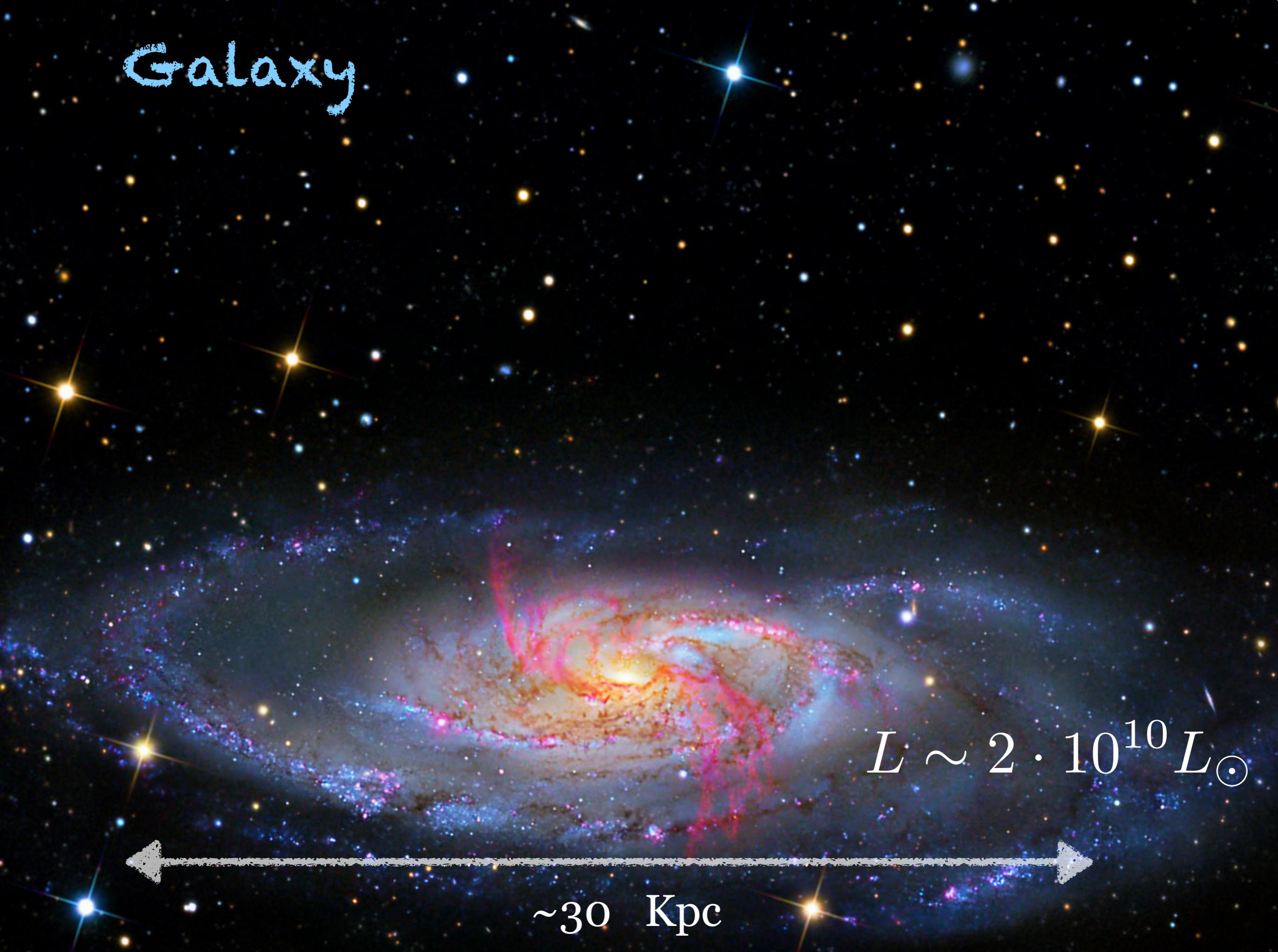
Riccardo Middei

S. Bianchi, A. Marinucci, G. Miniutti,
R. Serafinelli, F. Tombesi, F. Ursini, F. Vagnetti

Galaxy

$$L \sim 2 \cdot 10^{10} L_{\odot}$$

~ 30 Kpc



Galaxy

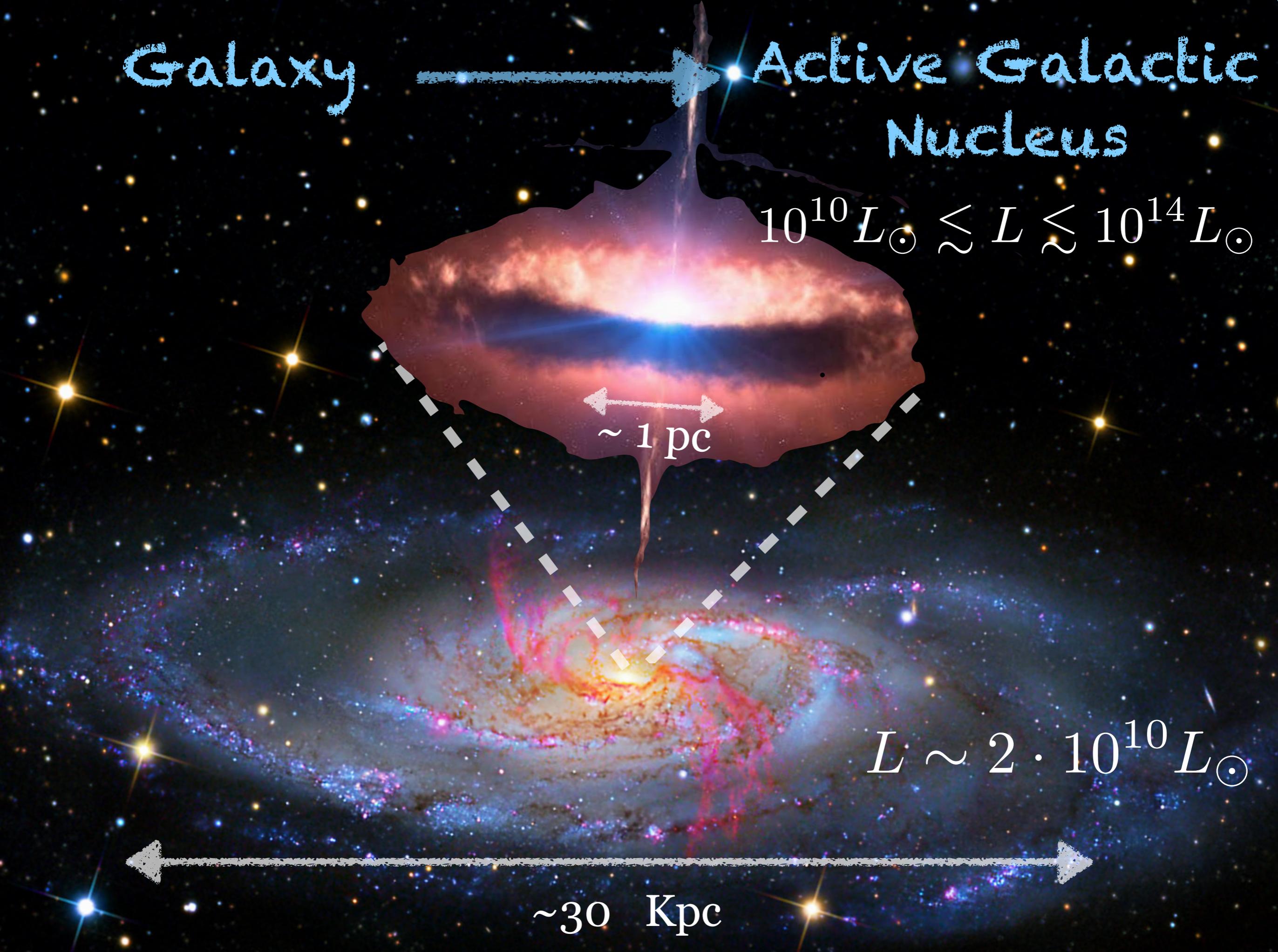
Active Galactic
Nucleus

$$10^{10} L_{\odot} \lesssim L \lesssim 10^{14} L_{\odot}$$

~ 1 pc

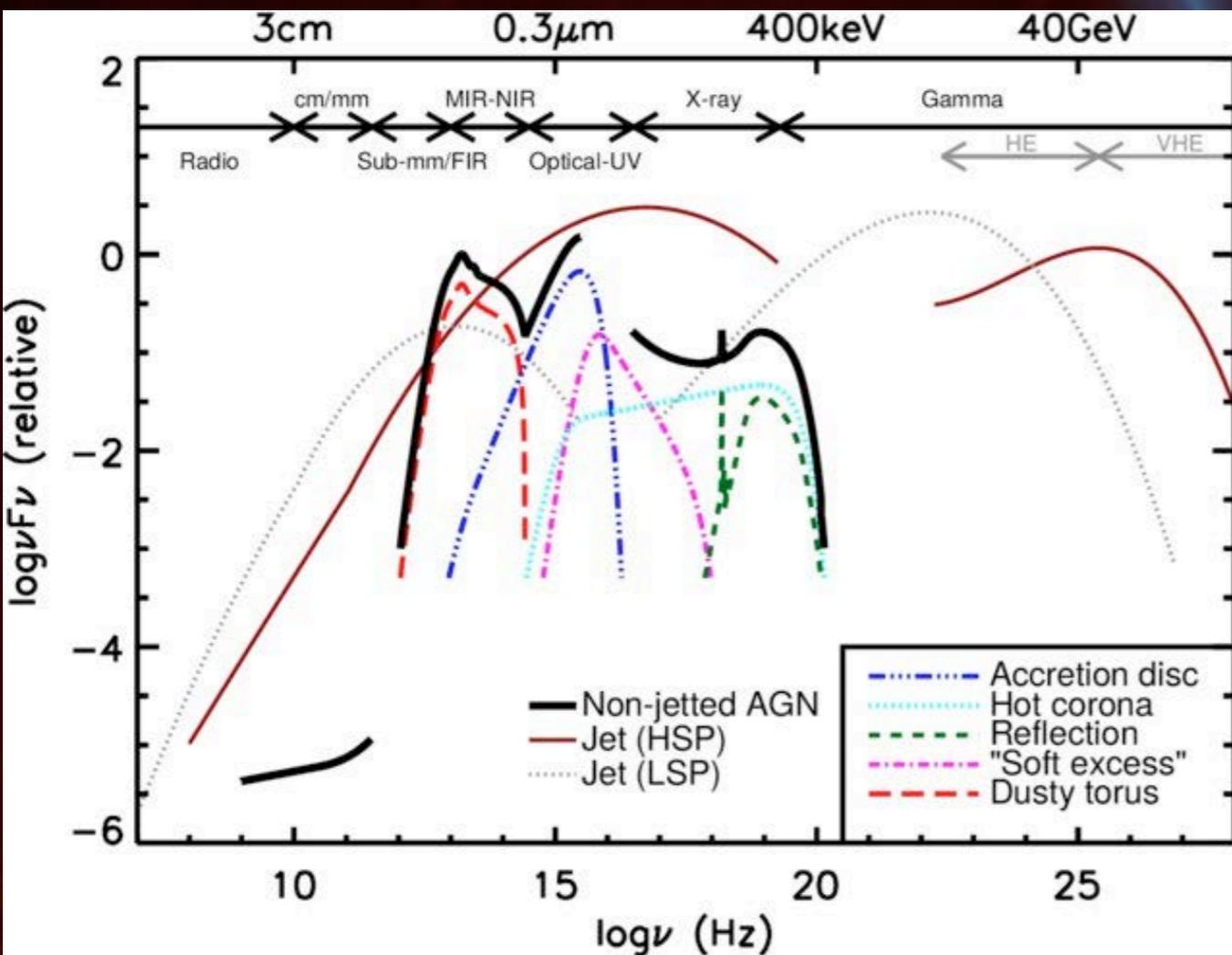
$$L \sim 2 \cdot 10^{10} L_{\odot}$$

~ 30 Kpc



IR

Broadband emission



X-ray

UV

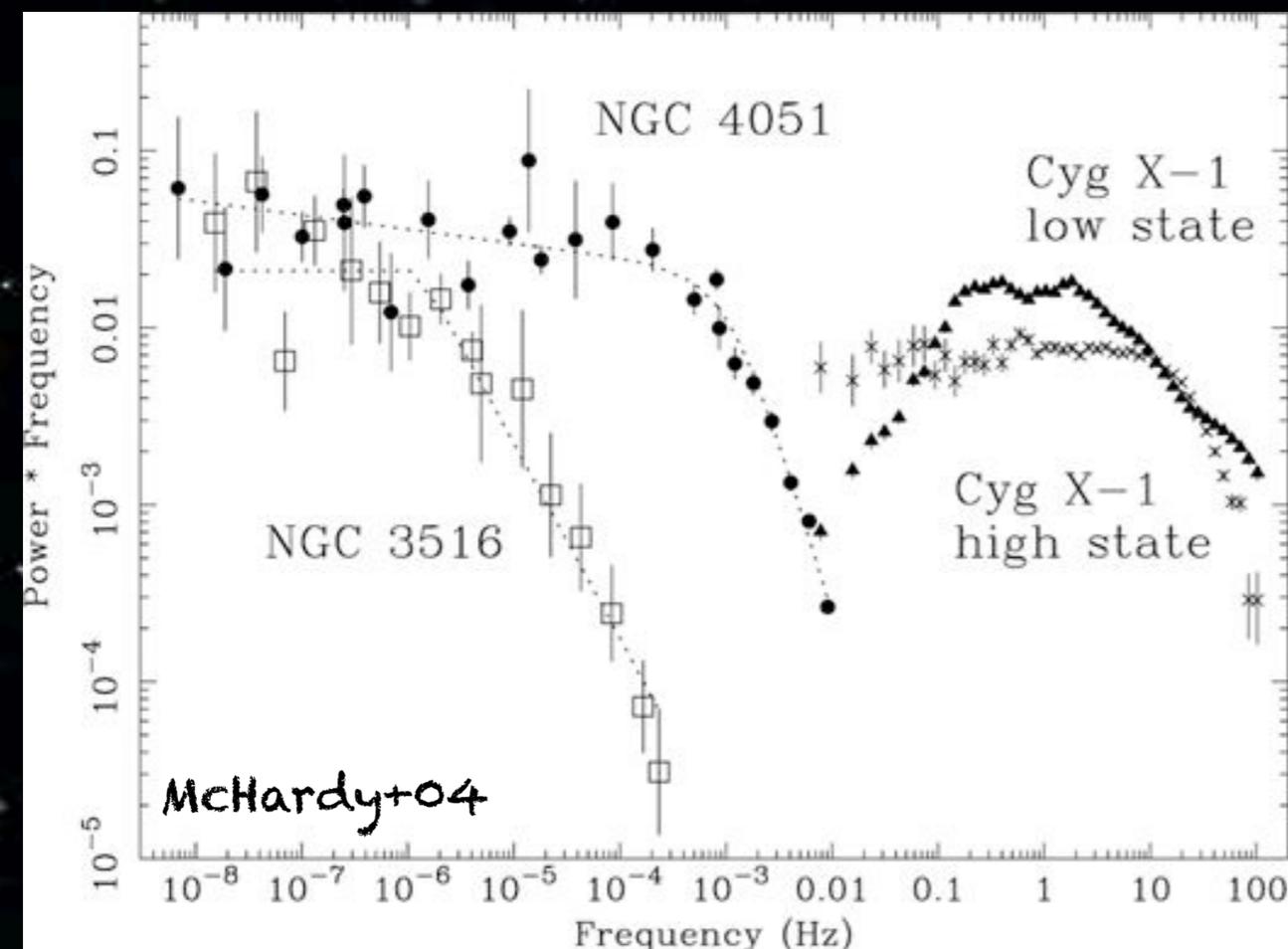
Optical

broadband variability

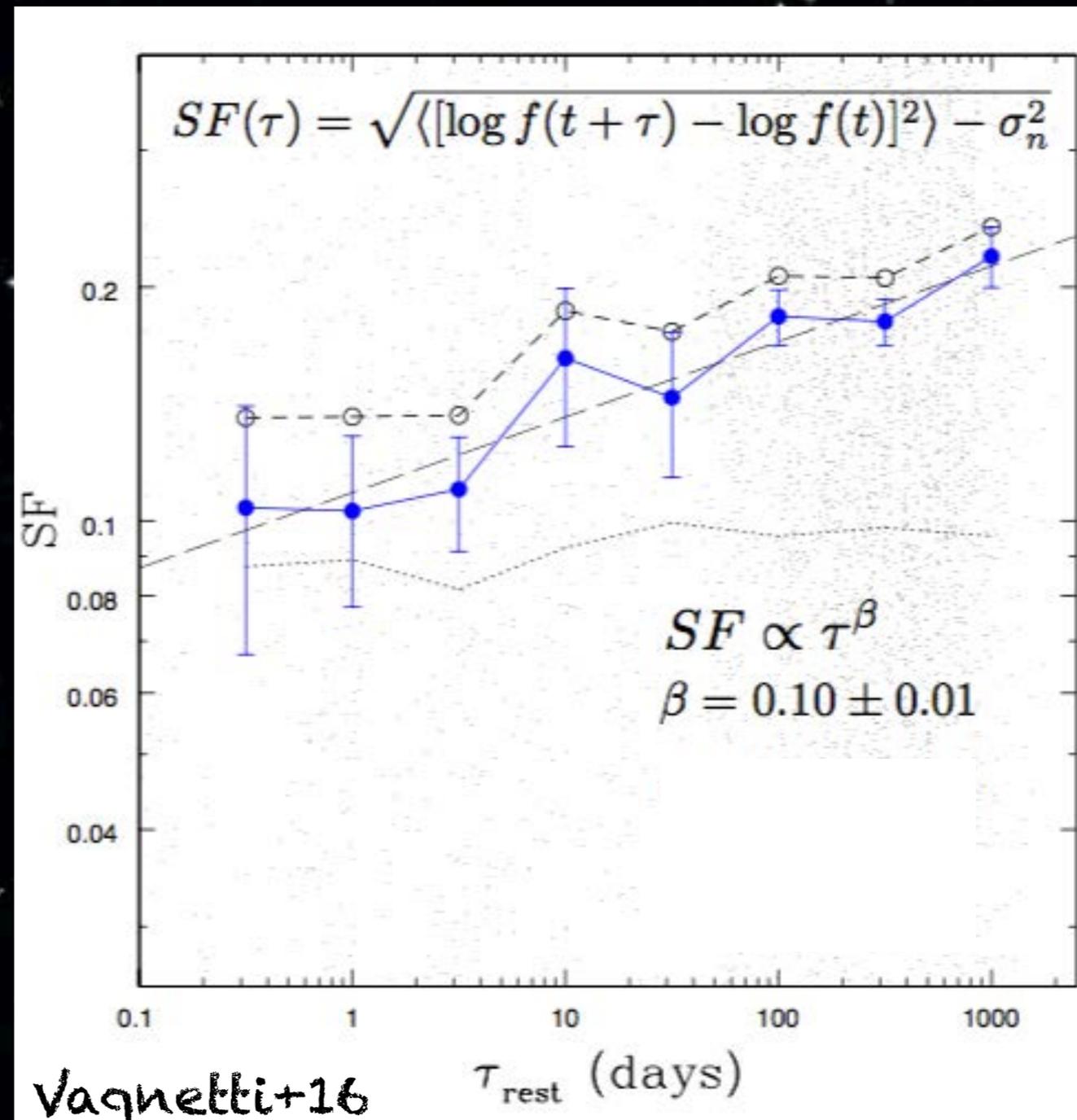
in X-rays

hours

years



see also Papadakis+04, Ponti+12



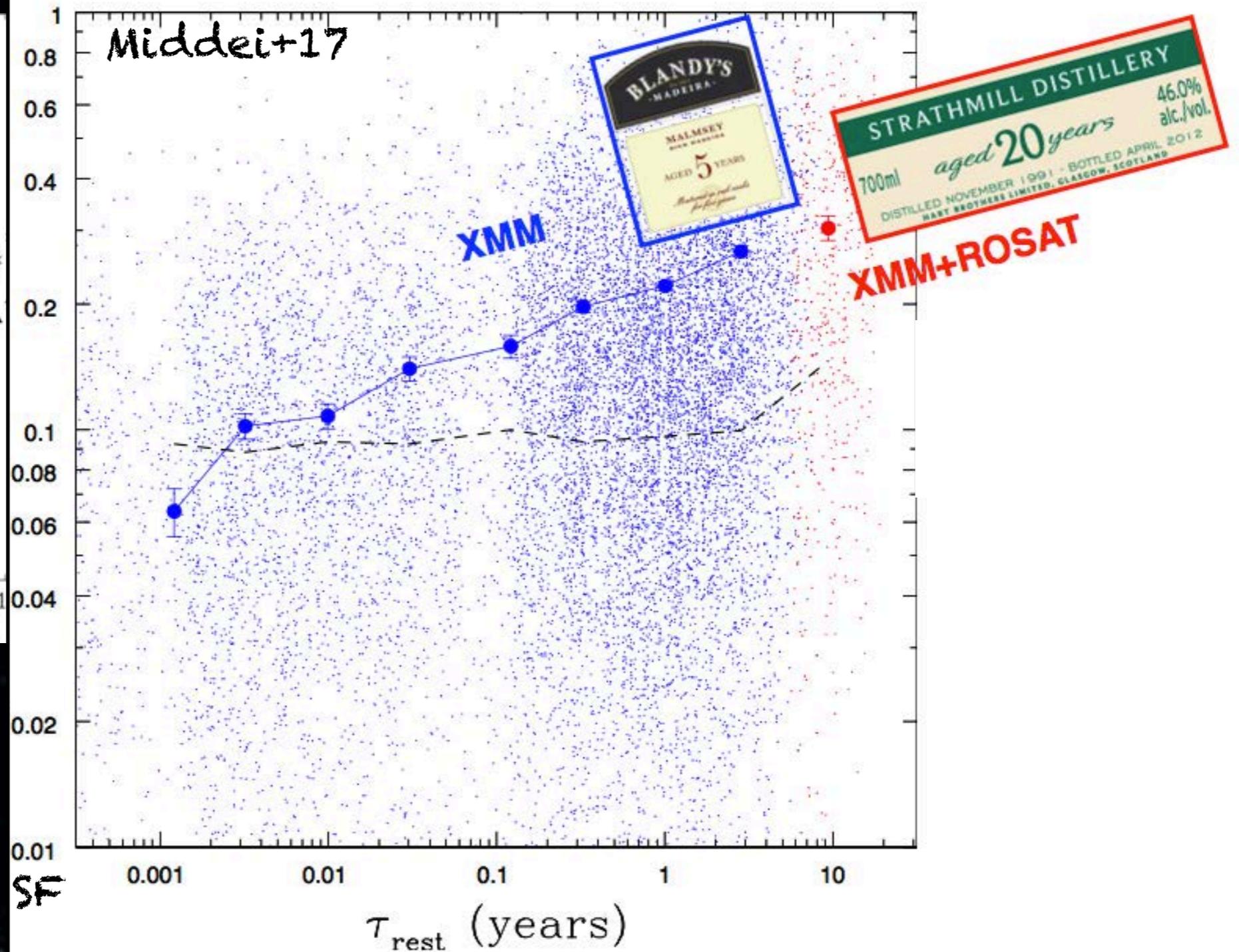
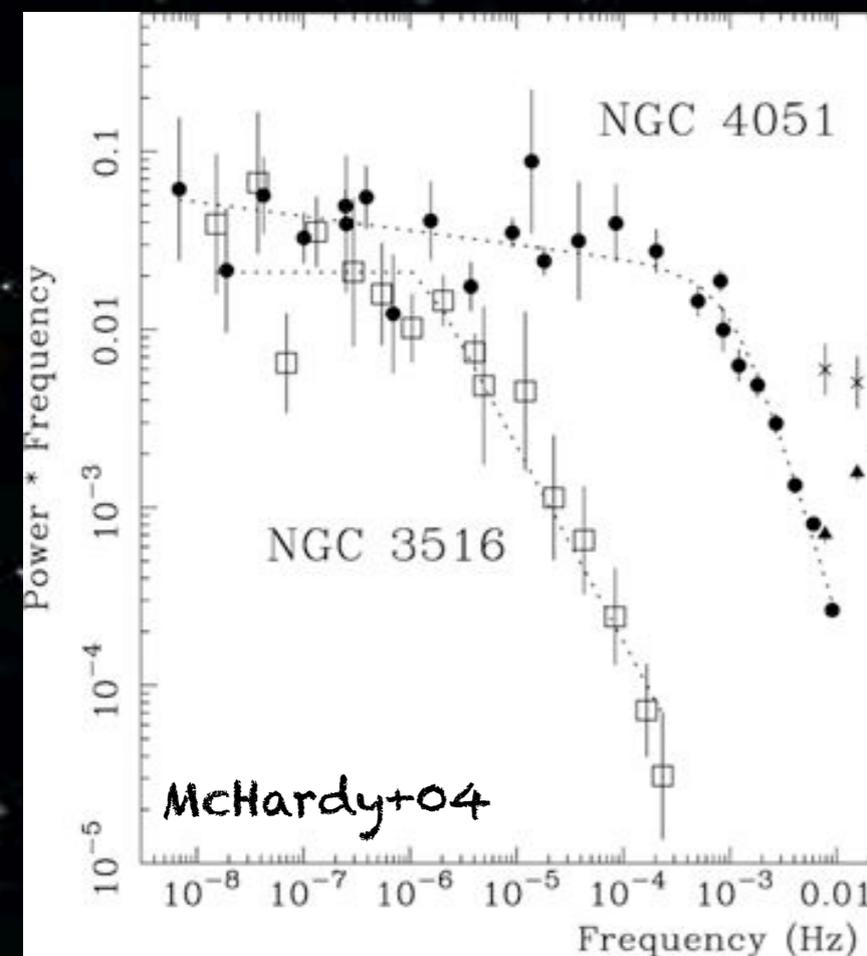
see also Paolillo+17, Gallo+18

broadband Variability

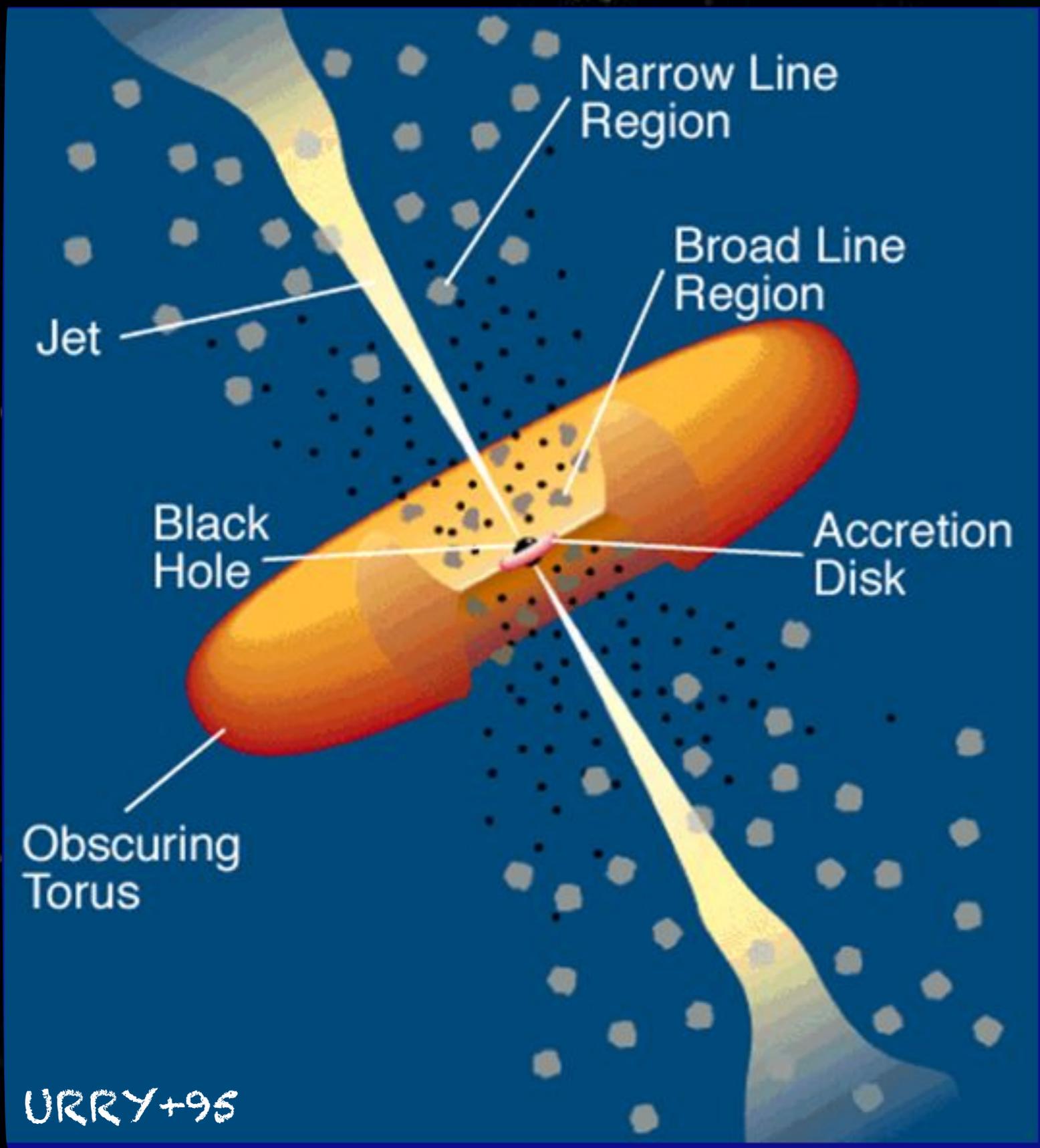
hours

in X-rays
years

decades



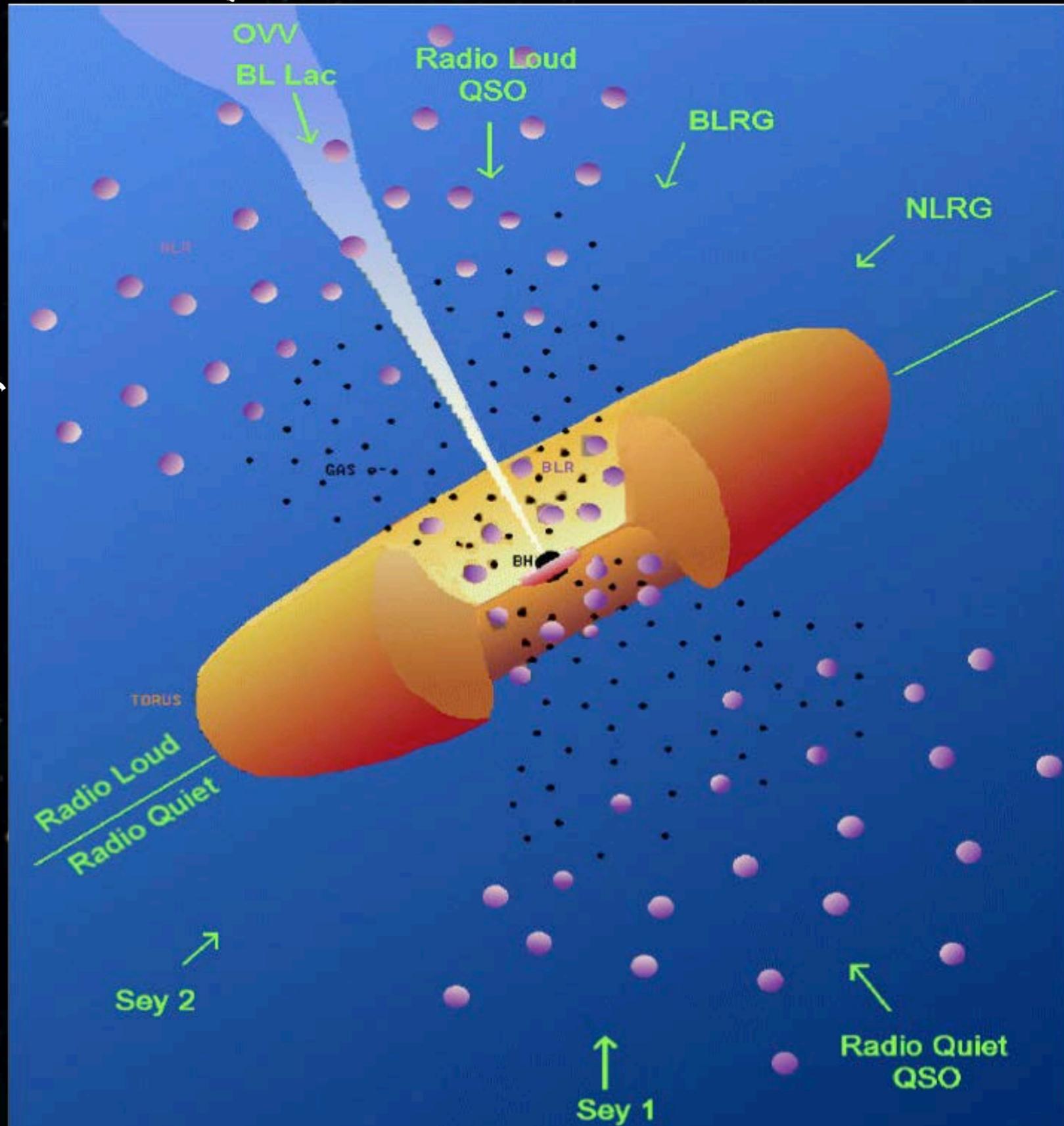
hints of a composite nature



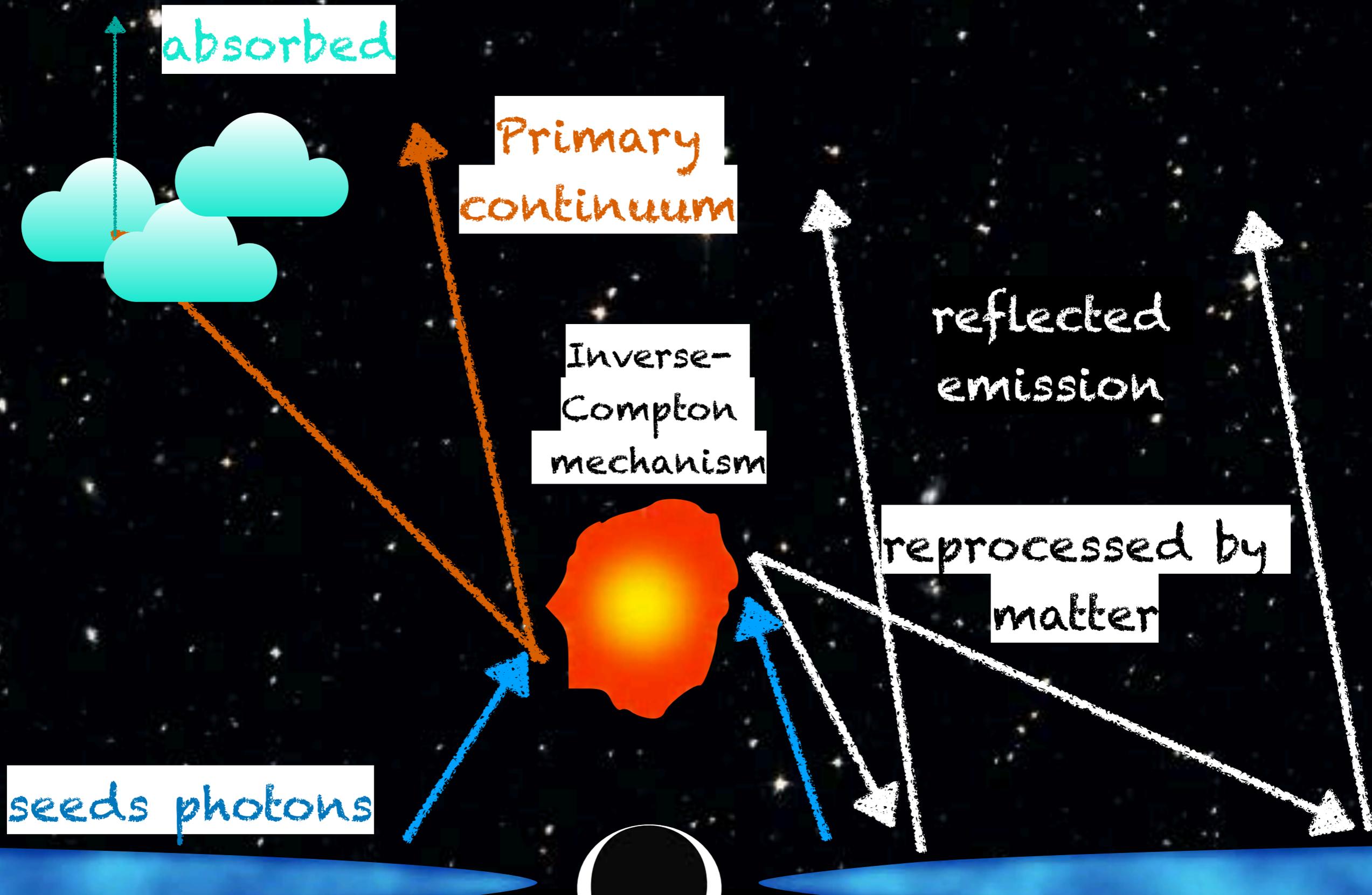
various
actors in
building
the AGN
SED

hints of a composite nature

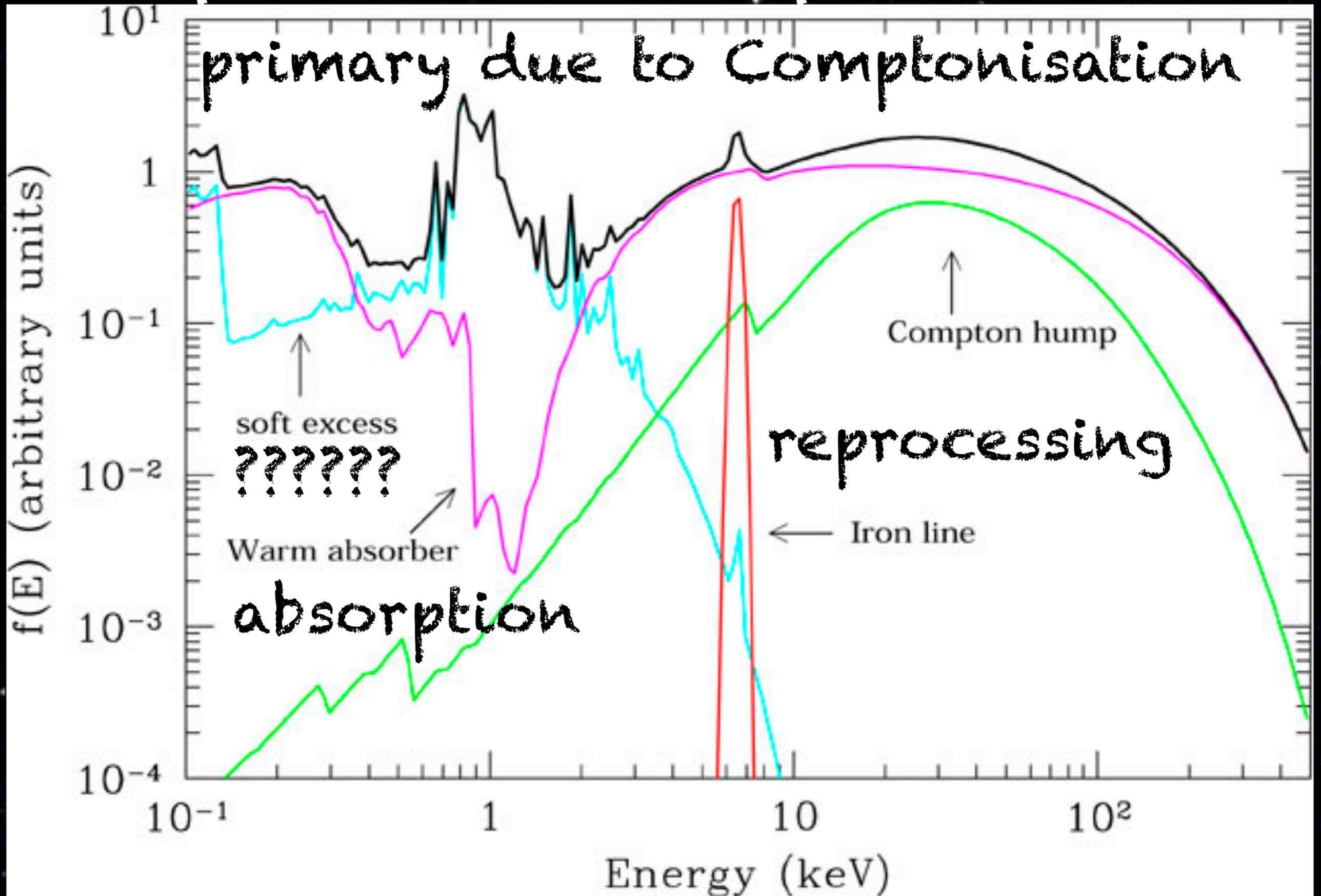
differences in
the
SED due to
observational
issues



X-raying the central engine!



Spectral components



The primary continuum

Which is the
coronal optical
depth?
what about its
temperature?
and the coronal
geometry?

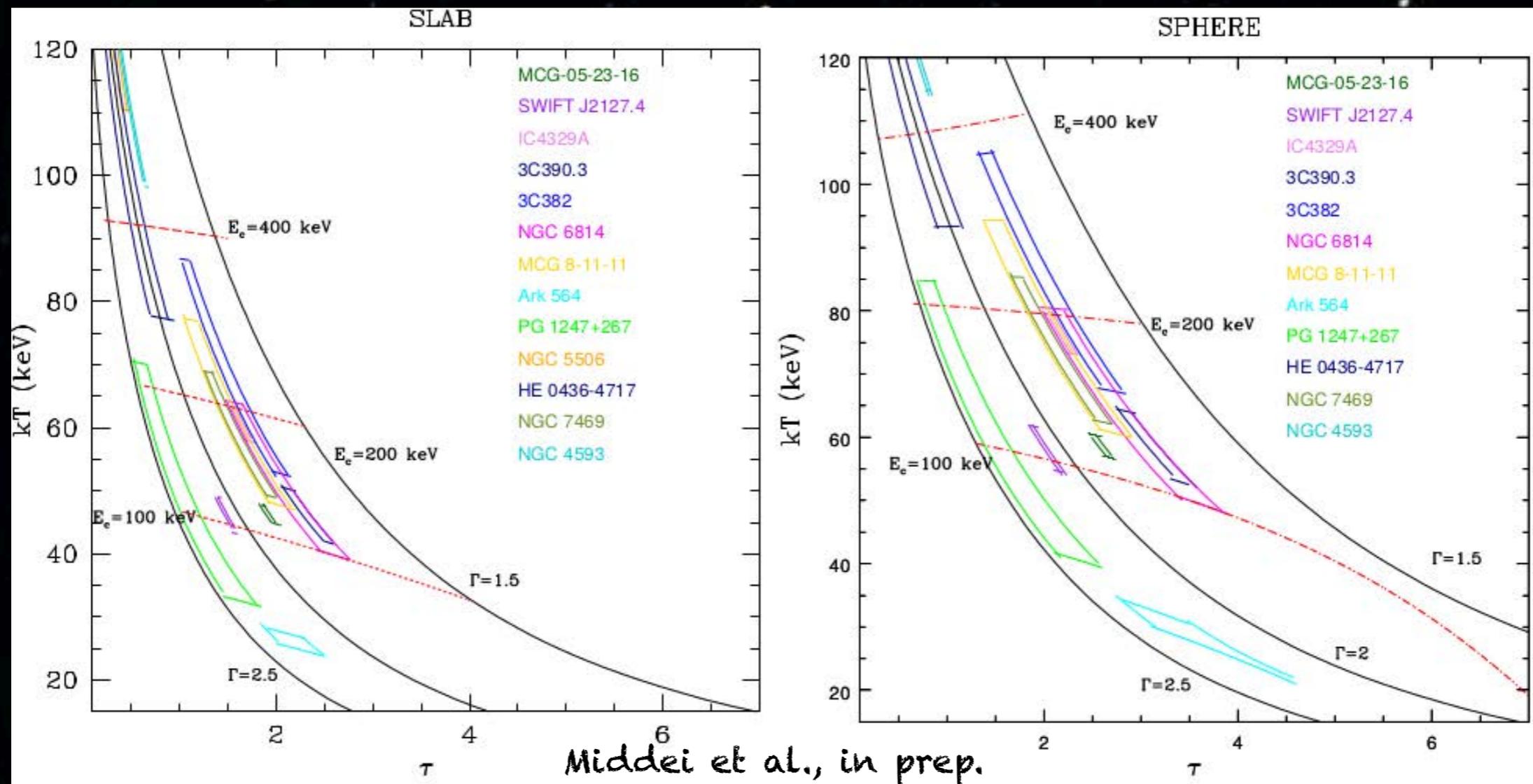


see e.g. Haardt+91,93,94,97

The primary continuum due to inverse-Compton of seed photons into an hot medium

information on coronal opacity and temperature,

see also Beloborodov+99, Petrucci+00,01, Fabian+15,17, Malzac+17



The soft-excess:

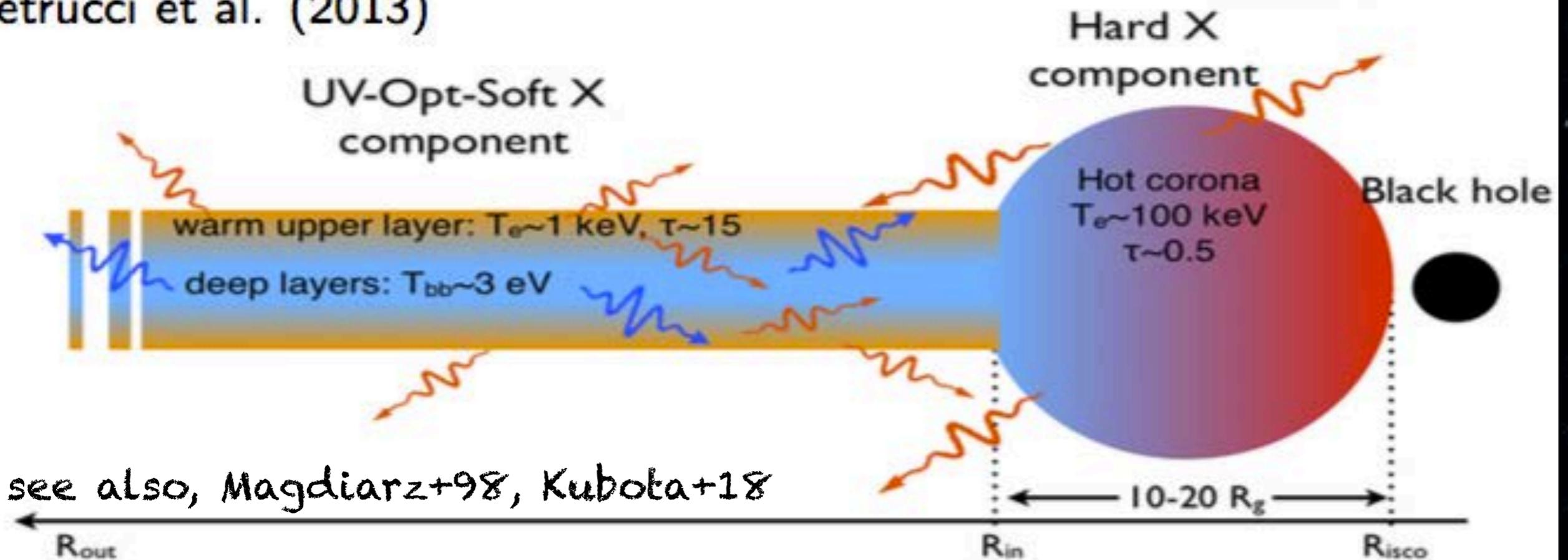
Line blurring?

(see e.g. Crummy+06; Bonson+15)

or

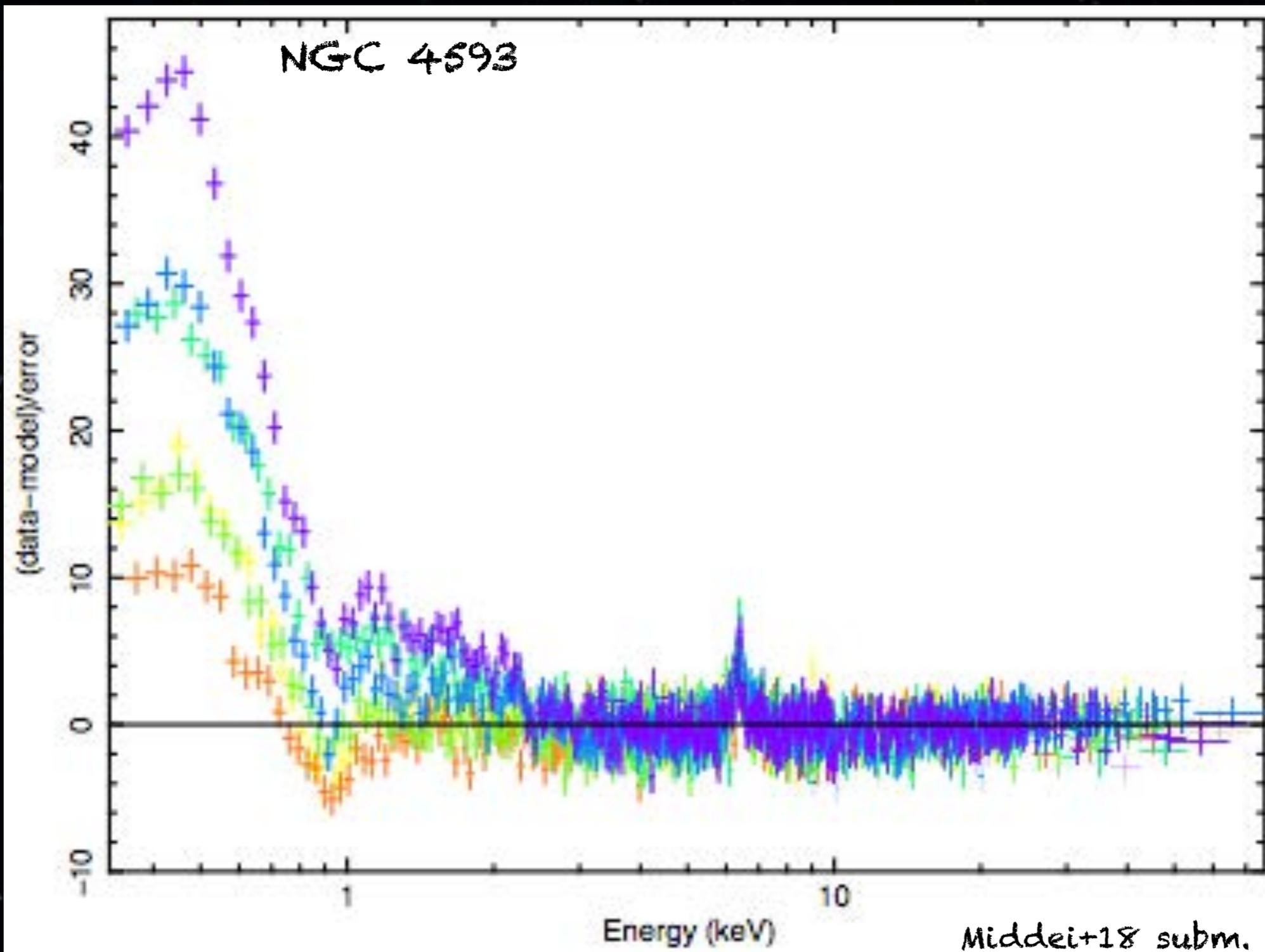
two.-coronae?

Petrucci et al. (2013)

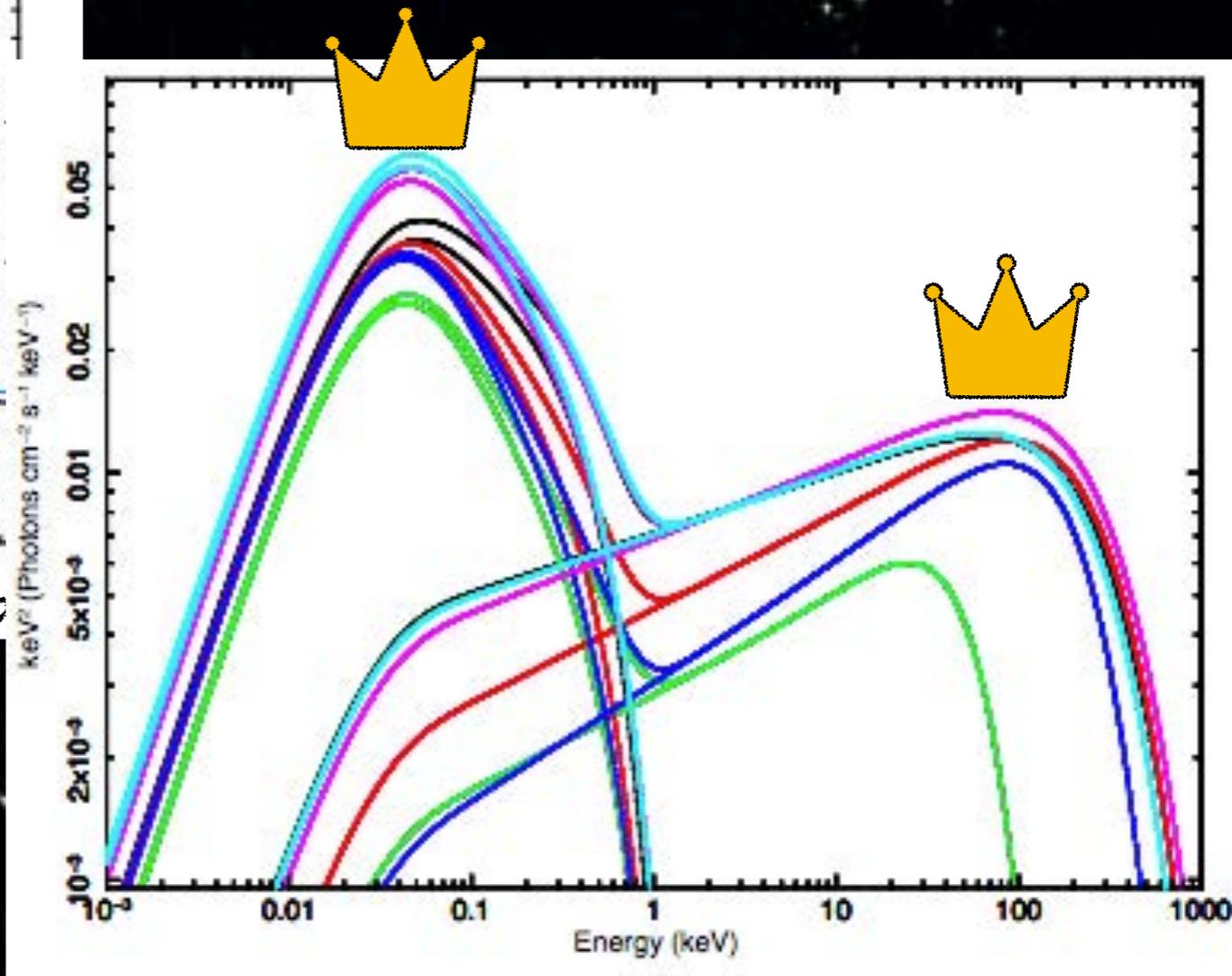
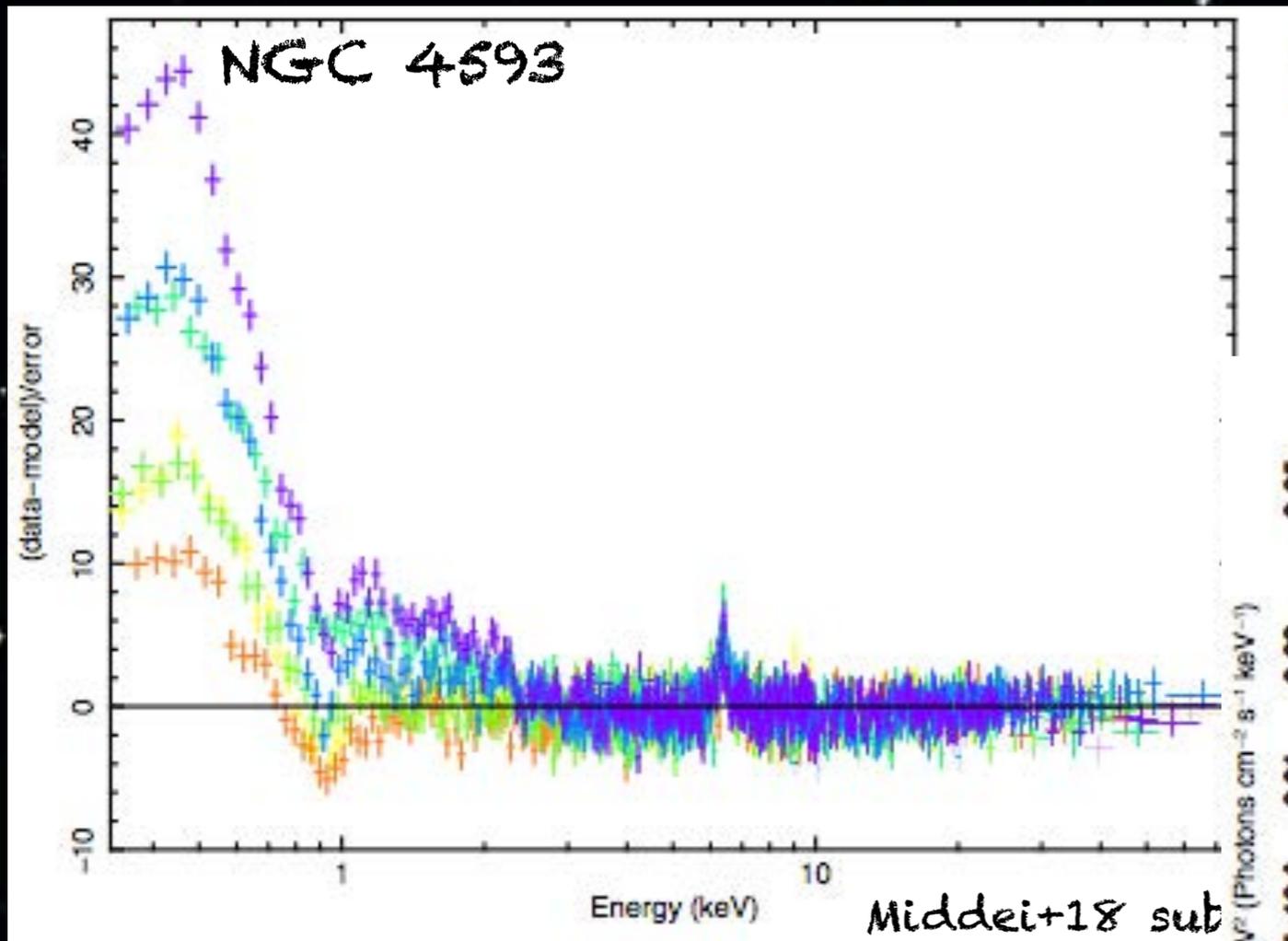


see also, Magdziarz+98, Kubota+18

The soft-excess:



The soft-excess:

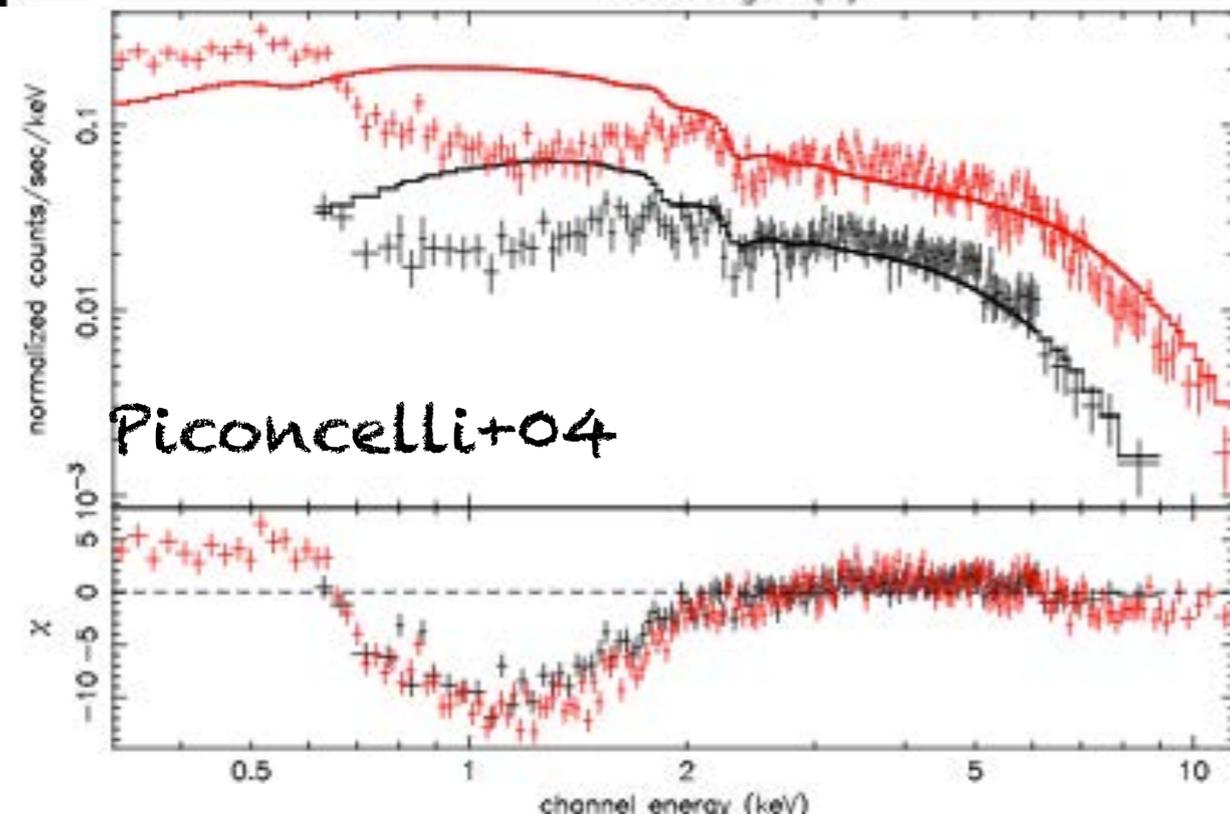
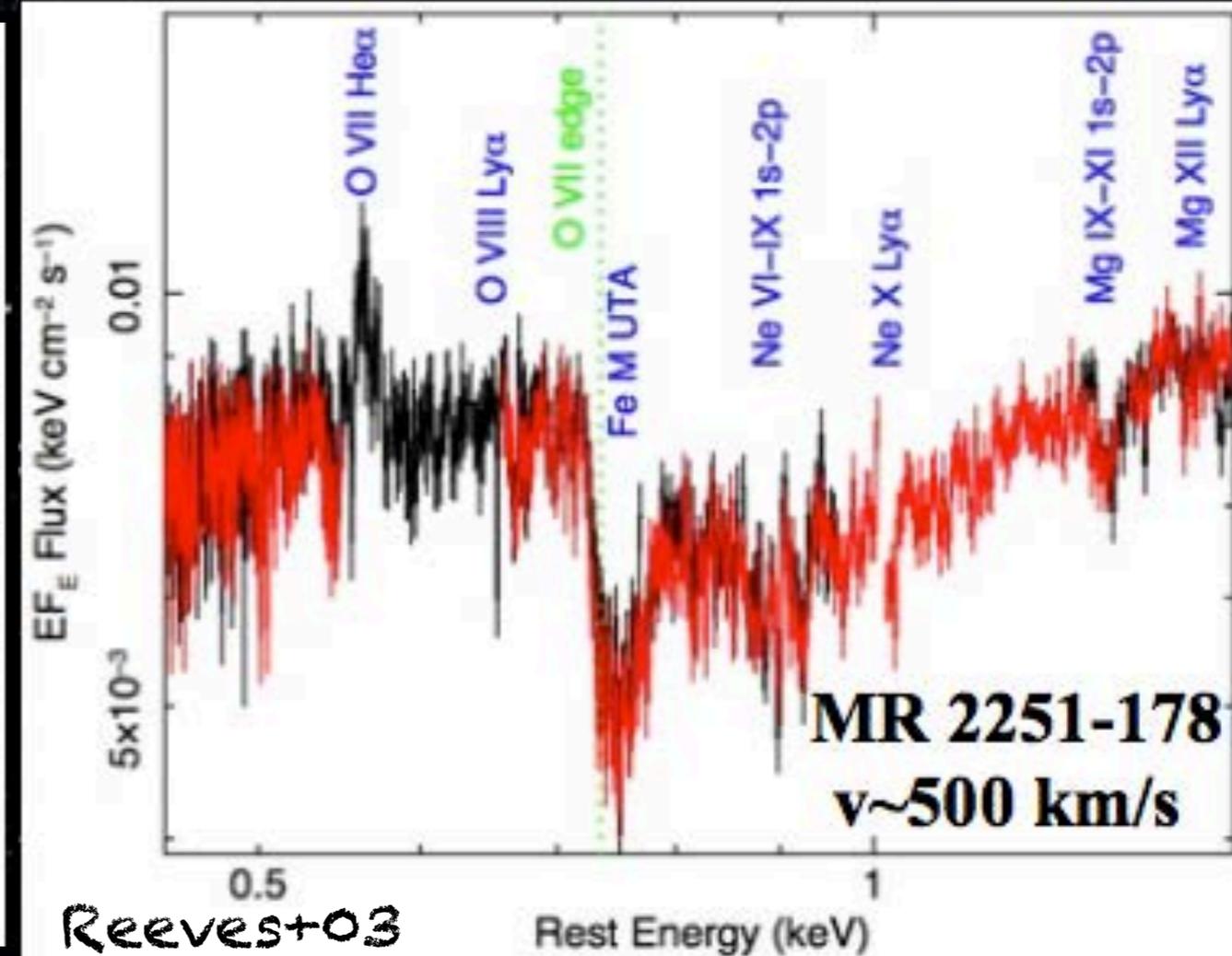
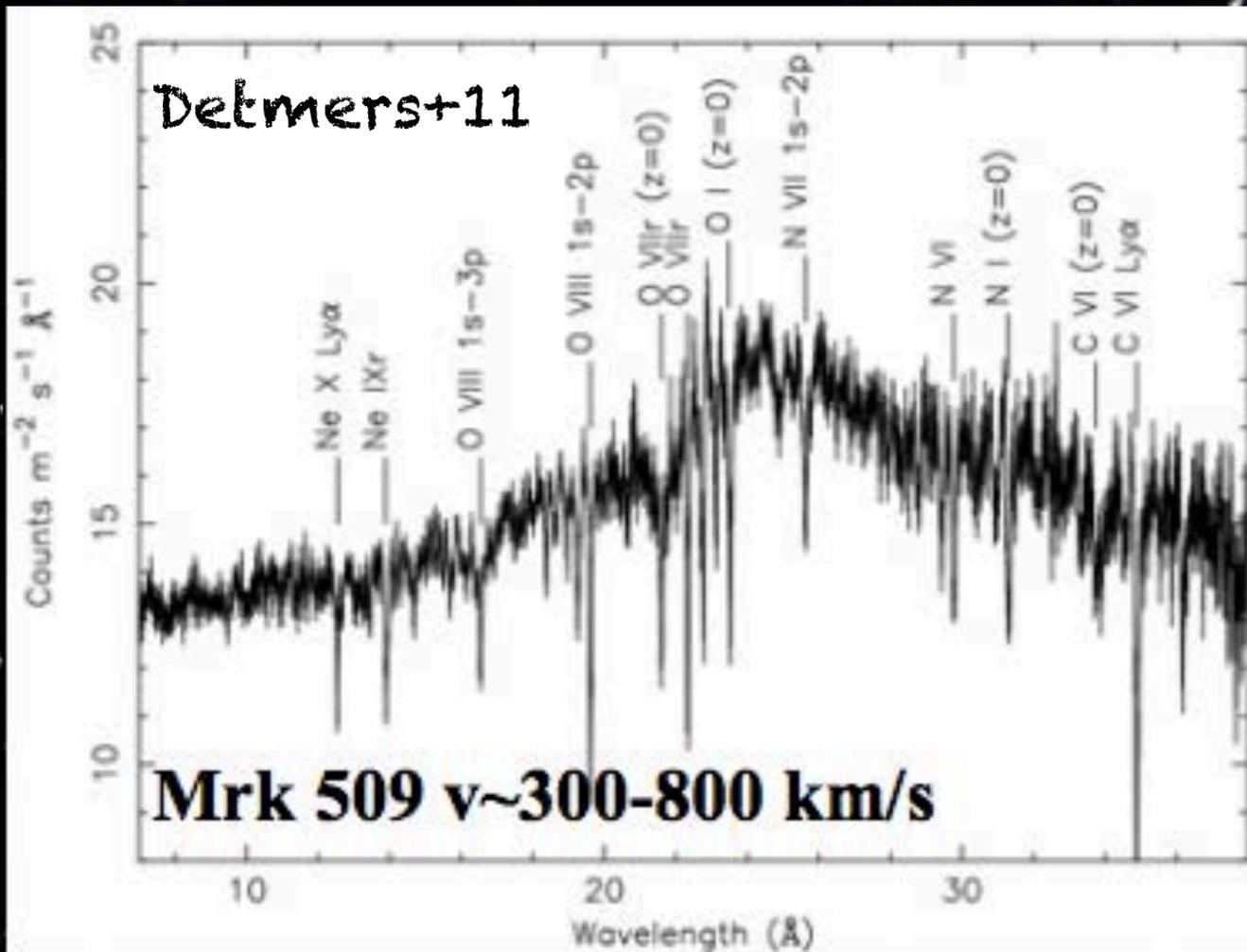


see also McHardy+18

X-ray/UV/optical variability of NGC 4593 with Swift: reprocessing of X-rays by an extended reprocessor

See also Petrucci+18, Porquet+18 for Ark120
Middei+18 for NGC 7469, Ursini+18 for 3c382

Warm Absorption



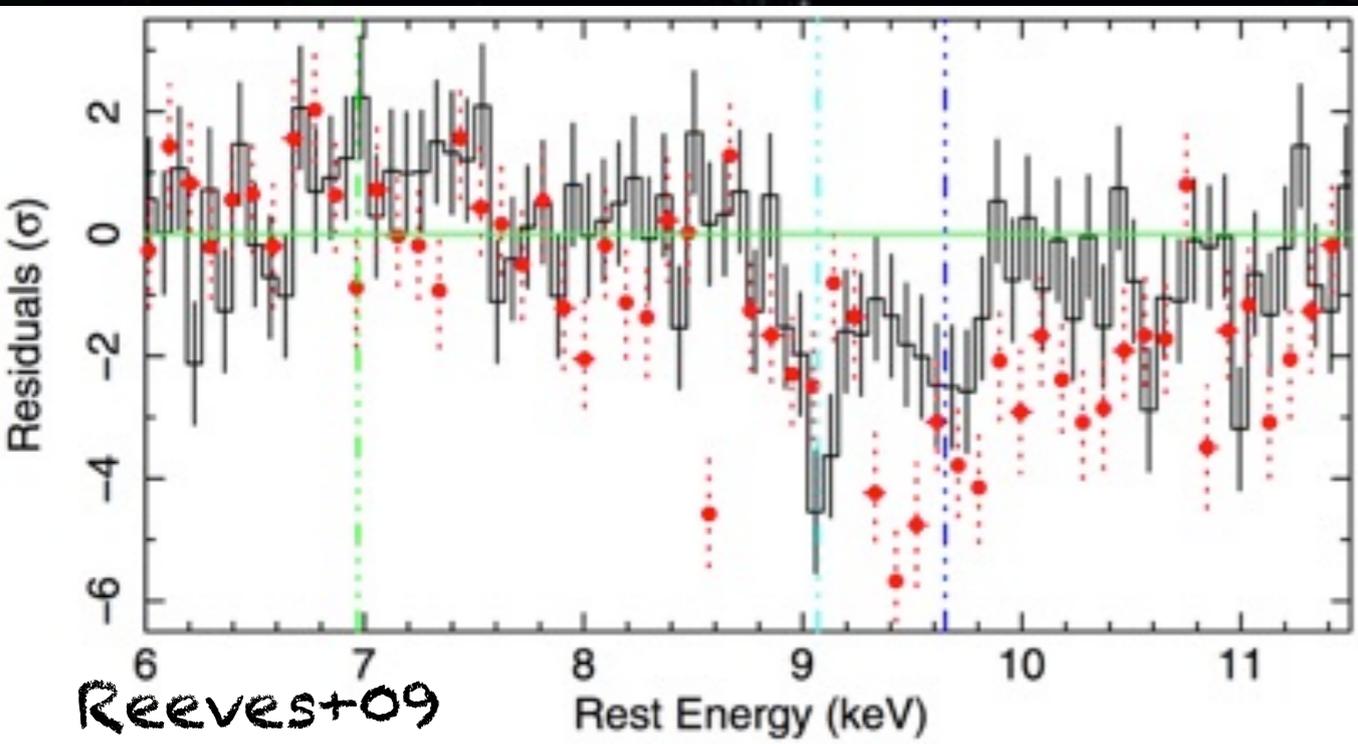
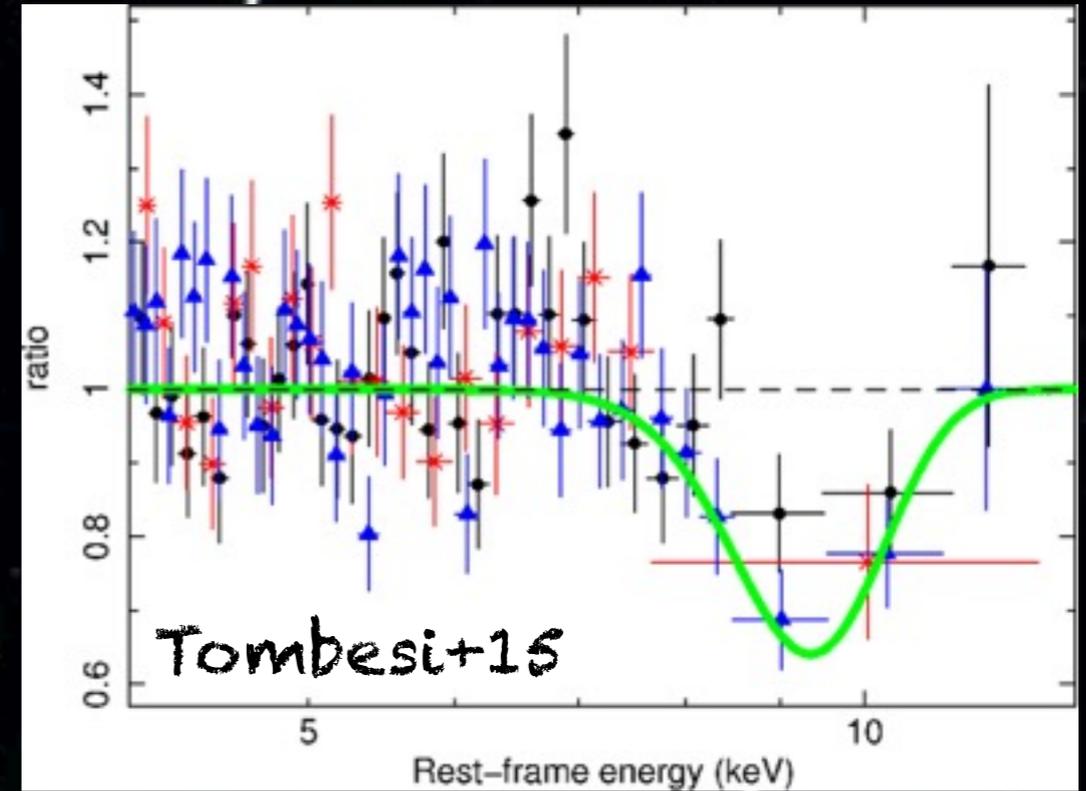
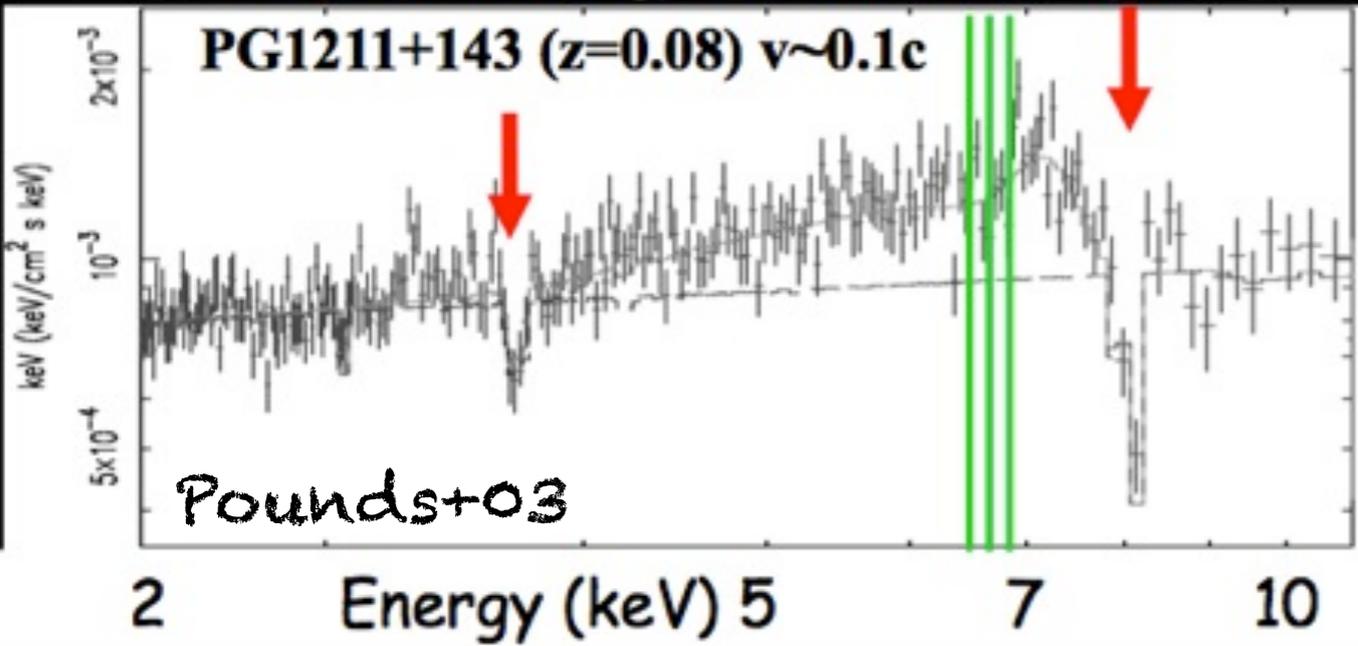
~50% of Seyfert 1

- Outflows velocity 10^2-3 km/s
- Wide range of Ionization states
- Column density $10^{20-22} \text{ cm}^{-2}$
- Location: disk, torus or NLR?

Ultra Fast Outflows (UFOs)

- Present in 30-40% of X-ray samples
- Outflow velocity $\sim 0.1-0.3c$
- Mass outflow rate $\sim 0.01-1 M_{\odot} \text{ yr}^{-1}$
- Observed in the Fe K band
as blue shifted absorption
lines by highly ionized Iron

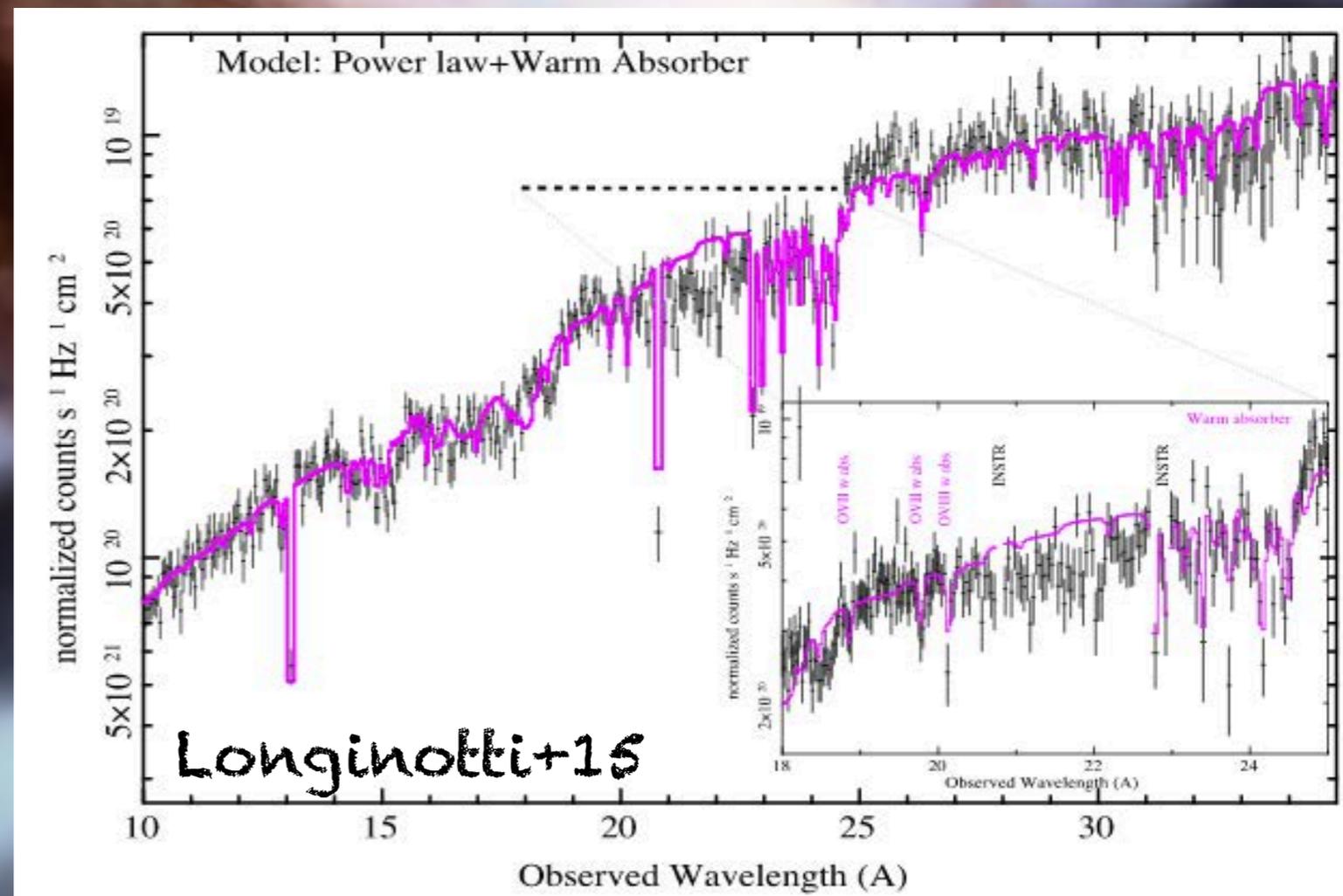
Ultra Fast Outflows (UFOs)



X-ray absorption
spectroscopy
of critical importance

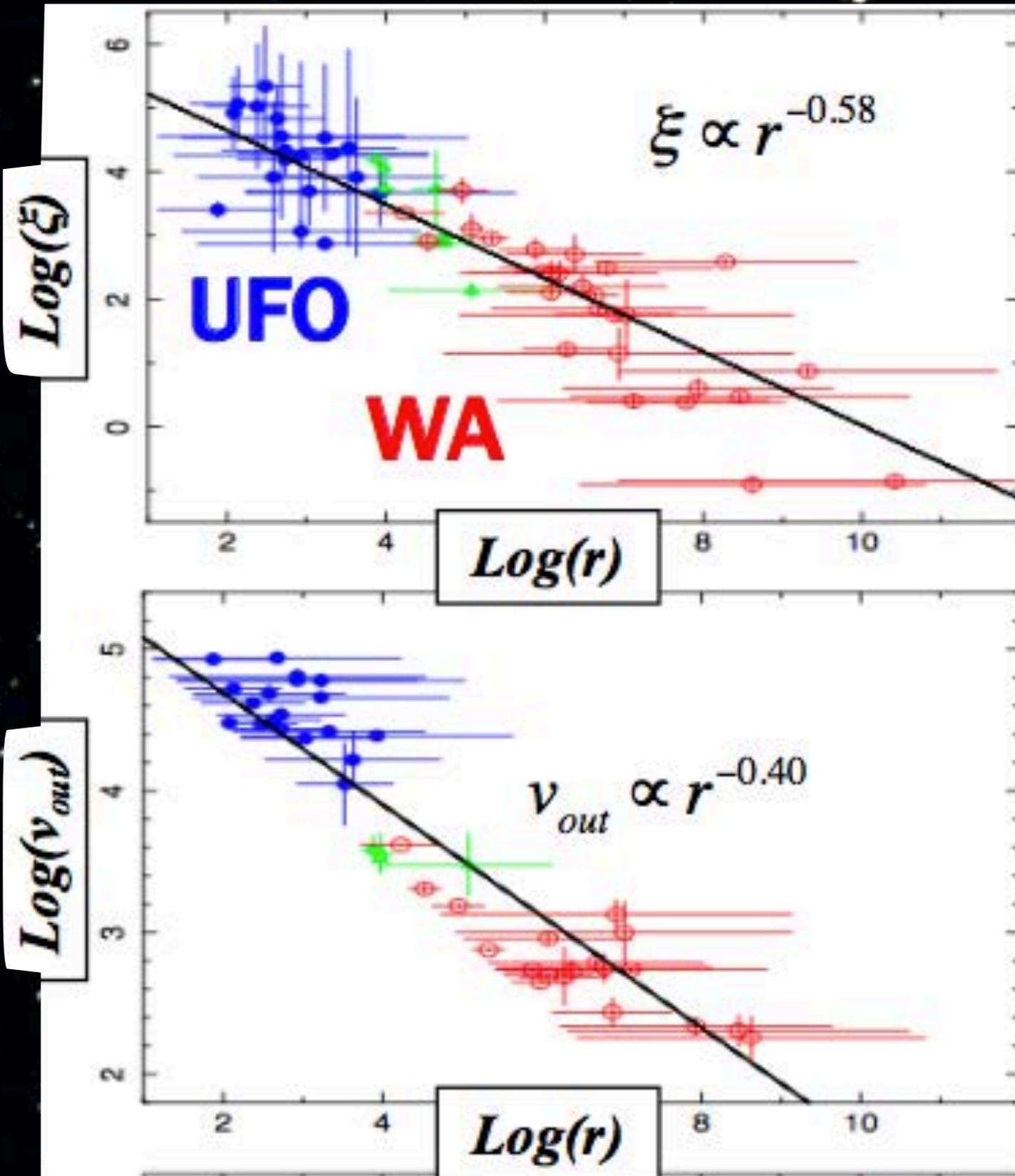
see also Parker+18

Ultra Fast Outflows (UFOs) also at high resolution



Properties from systematic studies

(Tombesi et al. 2010, 11,13; Gofford et al. 2013)



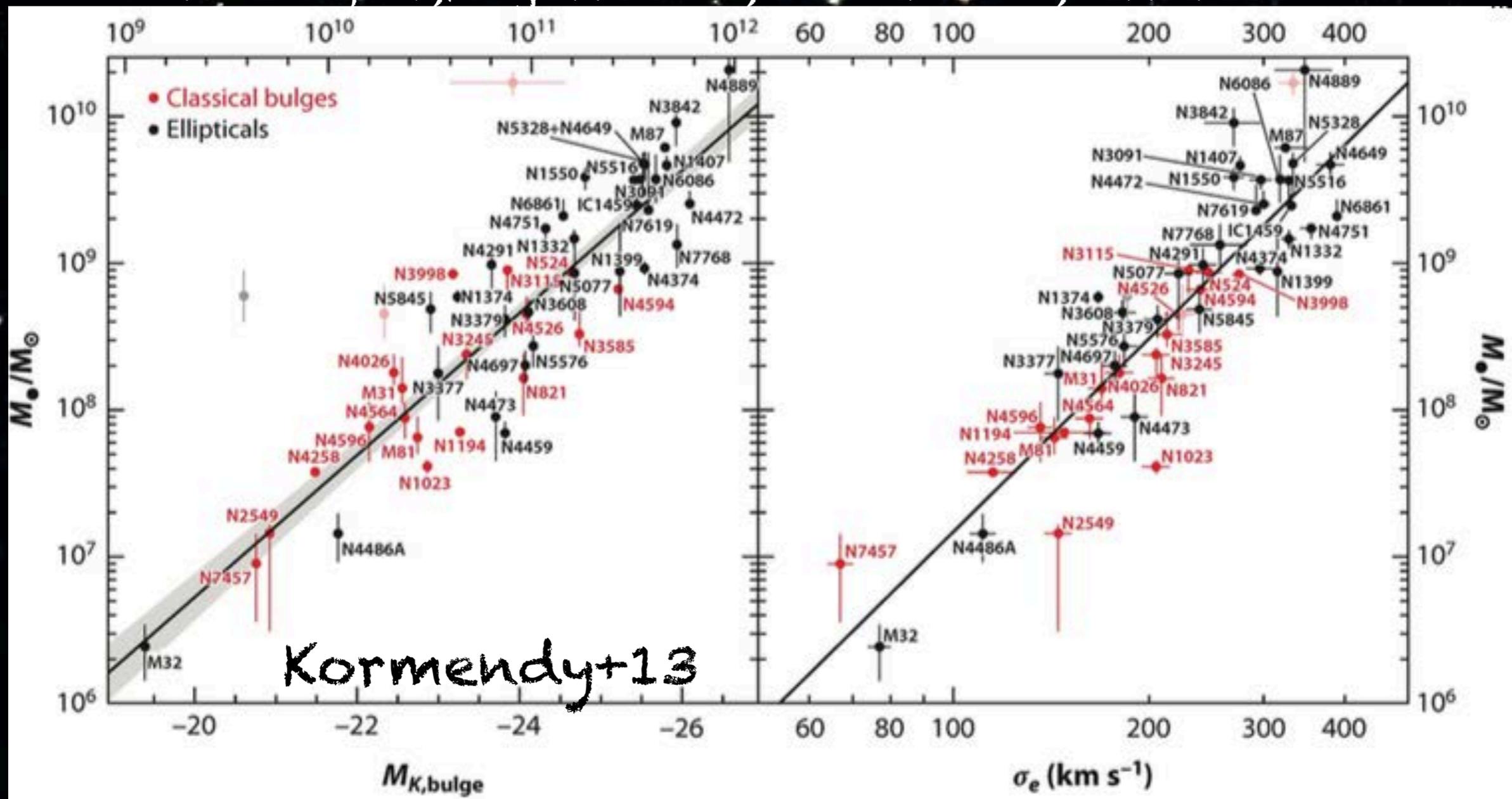
UFOs → outflows → host



A deep link between BH and host galaxy

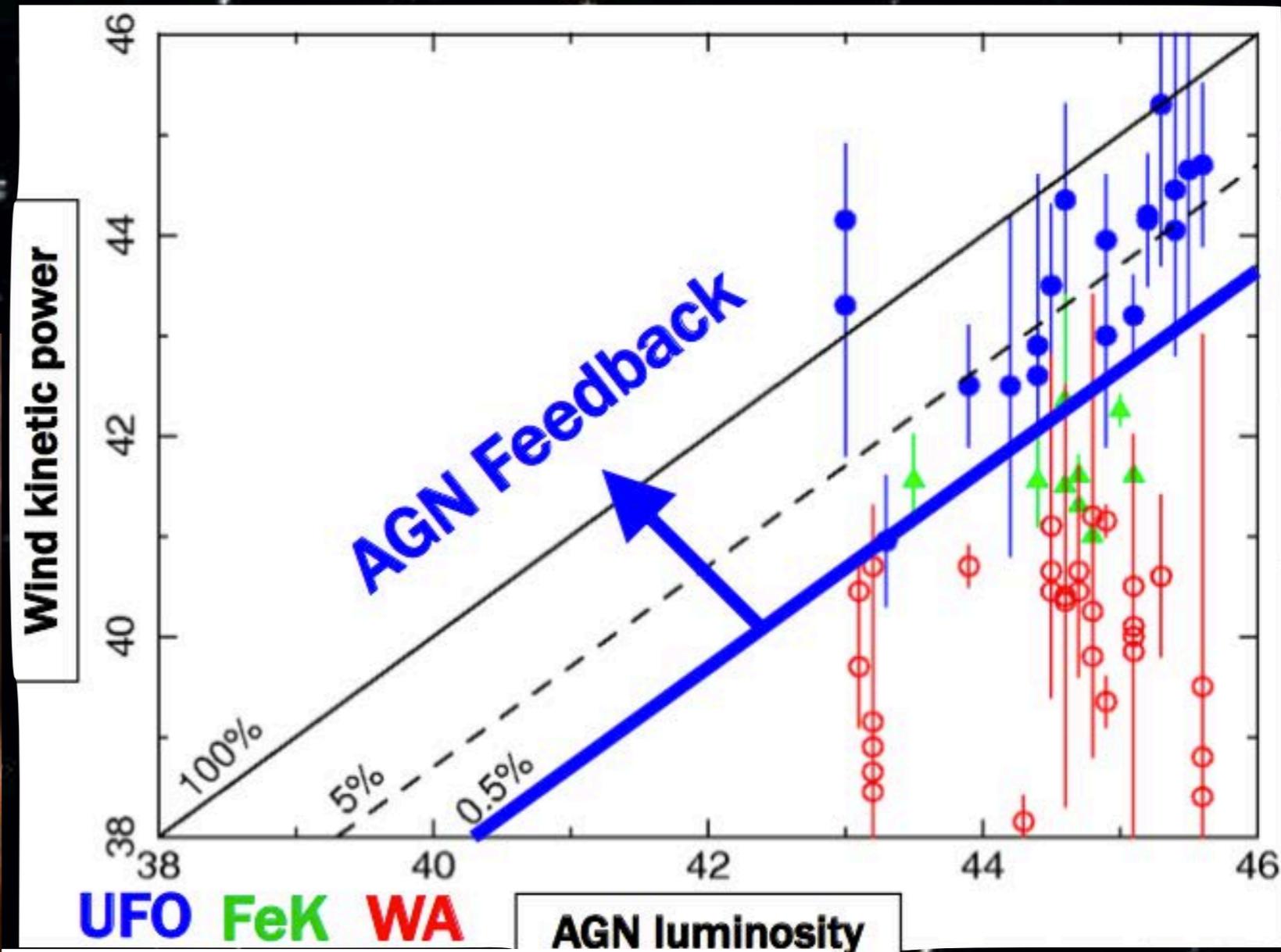
Long time quest:

Kormendy+95, Moqorrian98, Gebhardt+00, Ferrarese+00



see also De Nicola+18

Feedback due to AGN winds?



The outflow can act on the host galaxy

If it is 0.5-5% of the AGN luminosity,

then AGN feedback can regulate the growth of the galaxy and the growth of the central black hole as well

see also Di Matteo+05; Hopkins+10

The complex X-ray
spectrum and
variability of the AGN
1E 0754.6+392

Brightest AGN in the NuSTAR
serendipitous catalog

$\log L_{10-40 \text{ keV}} = 44 \text{ erg s}^{-1}$

Lansbury+17

preliminary

1E0754.6+392

INFO

NLS1 at $z=0.096$, Enya+02

$\log L_{\text{Bol}}/L_{\text{Edd}}=-0.85$

$\log L_{\text{Bol}}=45.4 \text{ erg s}^{-1}$, Bertou+15

$\log M_{\text{BH}}/M_{\odot}=8.15$, Bertou+15

$\log M_{\text{BH}}/M_{\odot}=8.0$, Sergeev+07

PASSPORT

PASSPORT

1E0754.6+392 ID

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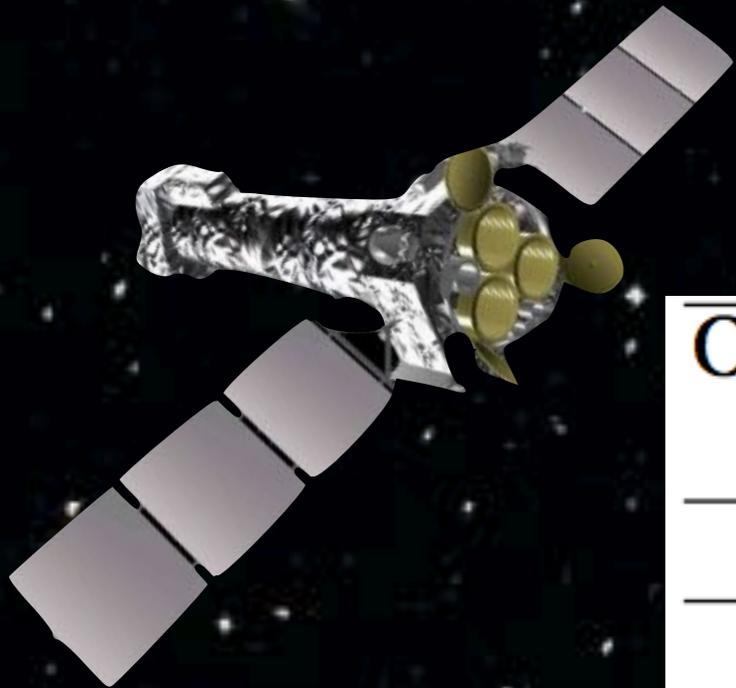
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$\log M_{\text{BH}}/M_{\odot}=8.0$, Sergeev+07

Observations Log

Obs.	Satellite	Obs. ID	Net exp. (ks)	Start-date yyyy-mm-dd
1	<i>XMM-Newton</i>	0305990101	13.5	2006-04-18
2	<i>XMM-Newton</i>	0406740101	14.7	2006-10-22



1E0754.6+392 ID

NLS1 at $z=0.096$, Enya+02

$\log L_{\text{bol}}/L_{\text{Edd}}=-0.85$, Berton+15

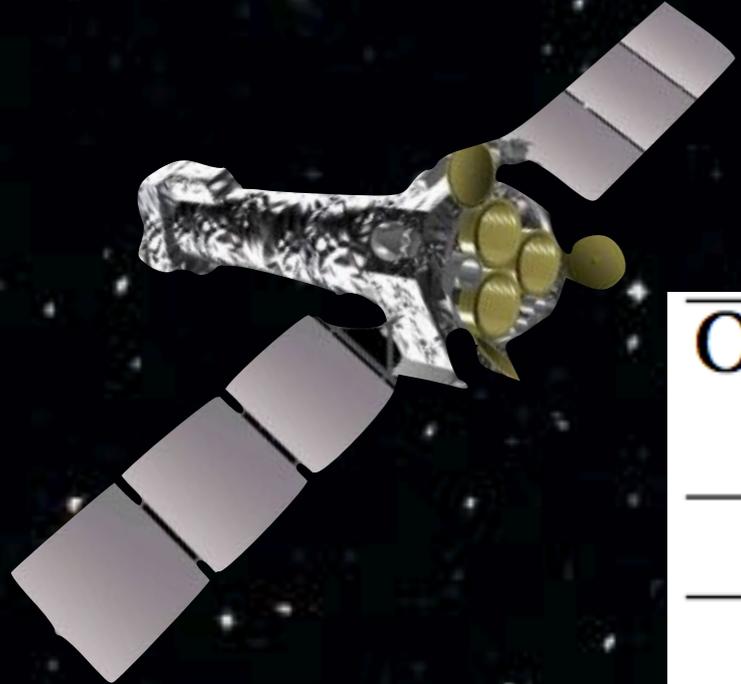
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$\log M_{\text{BH}}/M_{\odot}=8.15$, Berton+15

$\log M_{\text{BH}}/M_{\odot}=8.0$, Sergeev+07

Two short
observations!

Observations Log



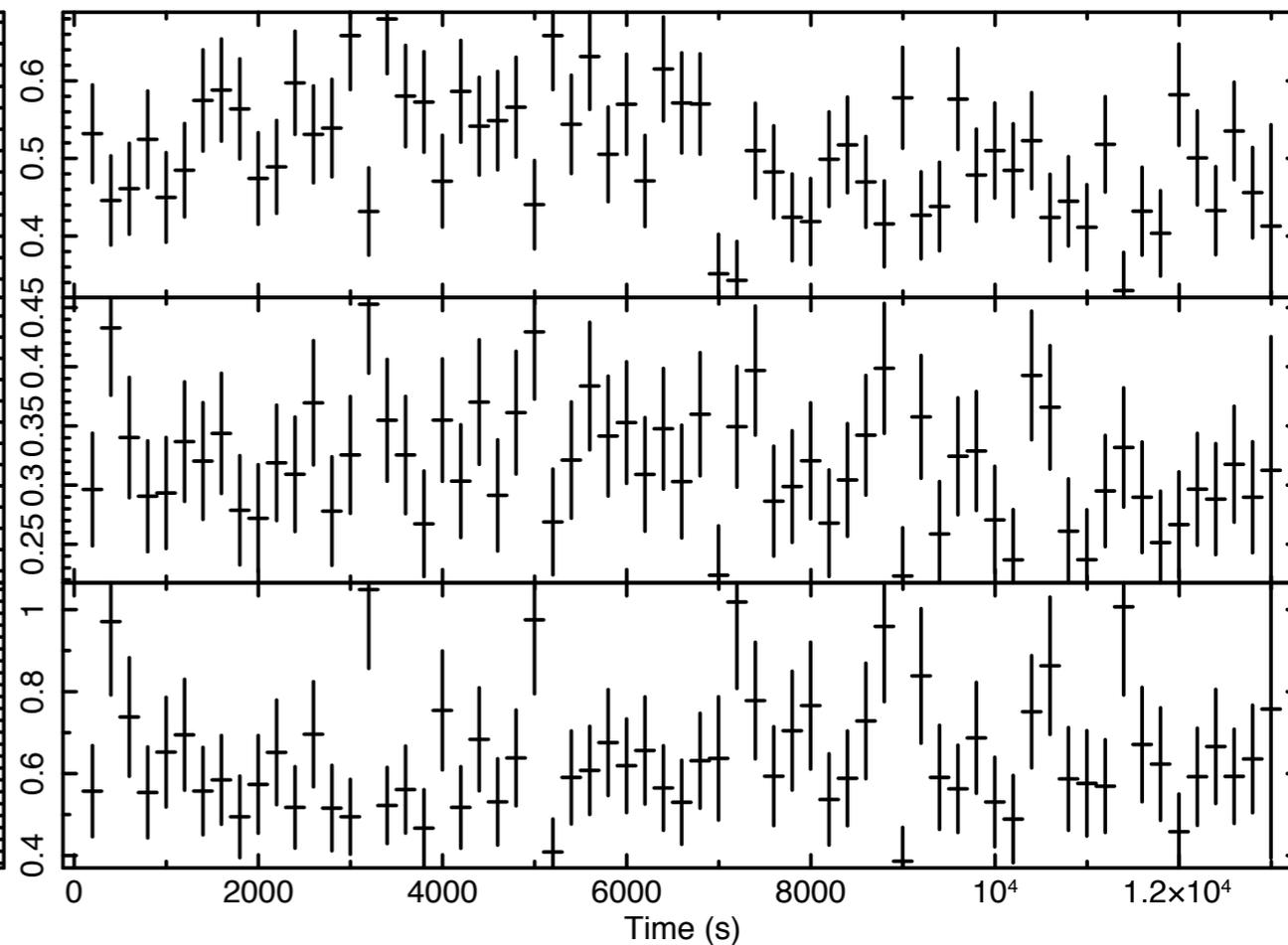
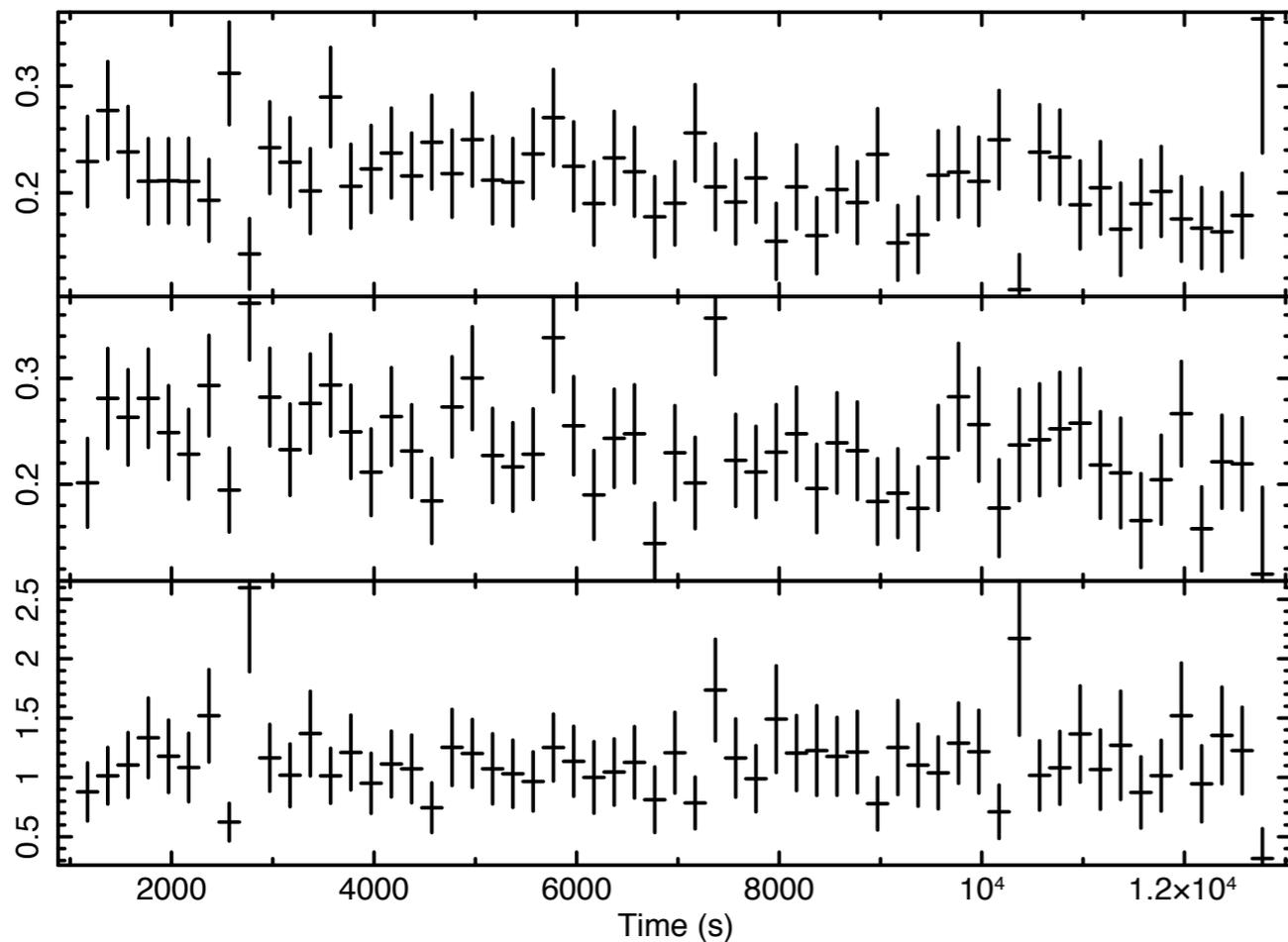
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1E0754.6+392, temporal properties

obs1

obs2

ratio 2-10 keV 0.3-2 keV

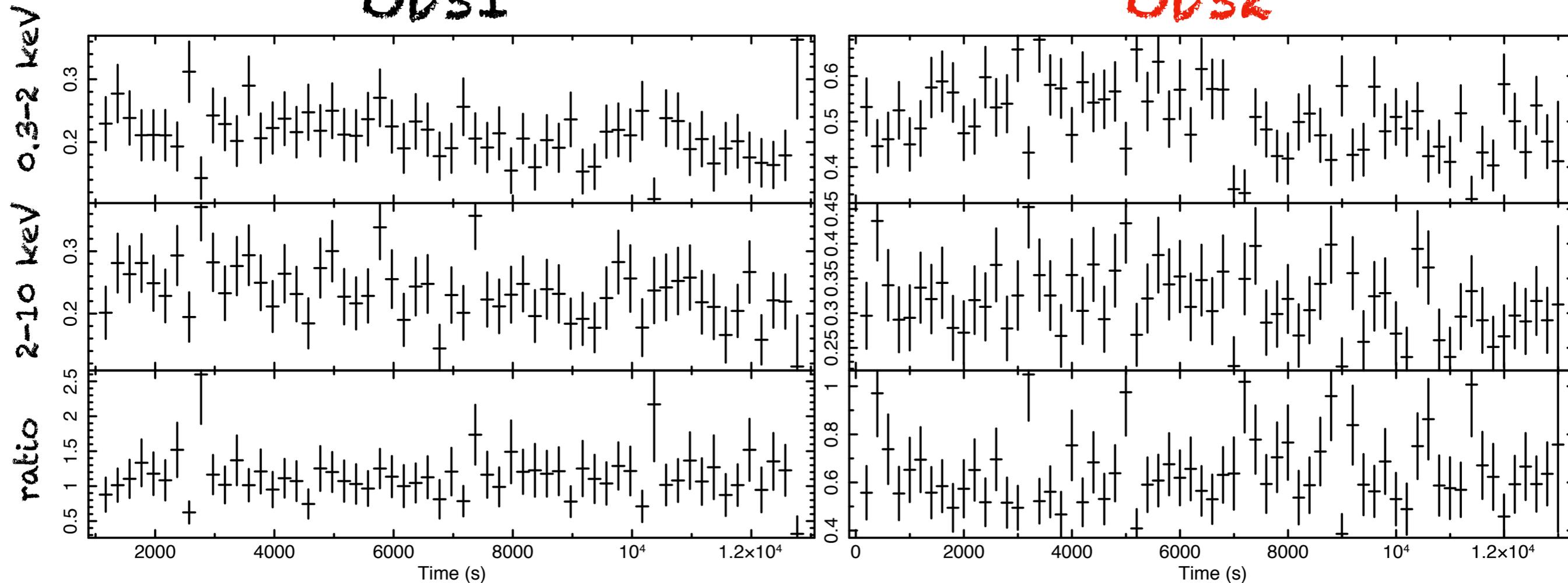


Flux_{0.3-2} = 3.4e-13 erg/cm²/s Flux₂₋₁₀ = 2.1e-12 erg/cm²/s
Flux_{0.3-2} = 7.9e-13 erg/cm²/s Flux₂₋₁₀ = 2.6e-12 erg/cm²/s

1E0754.6+392, temporal properties

obs1

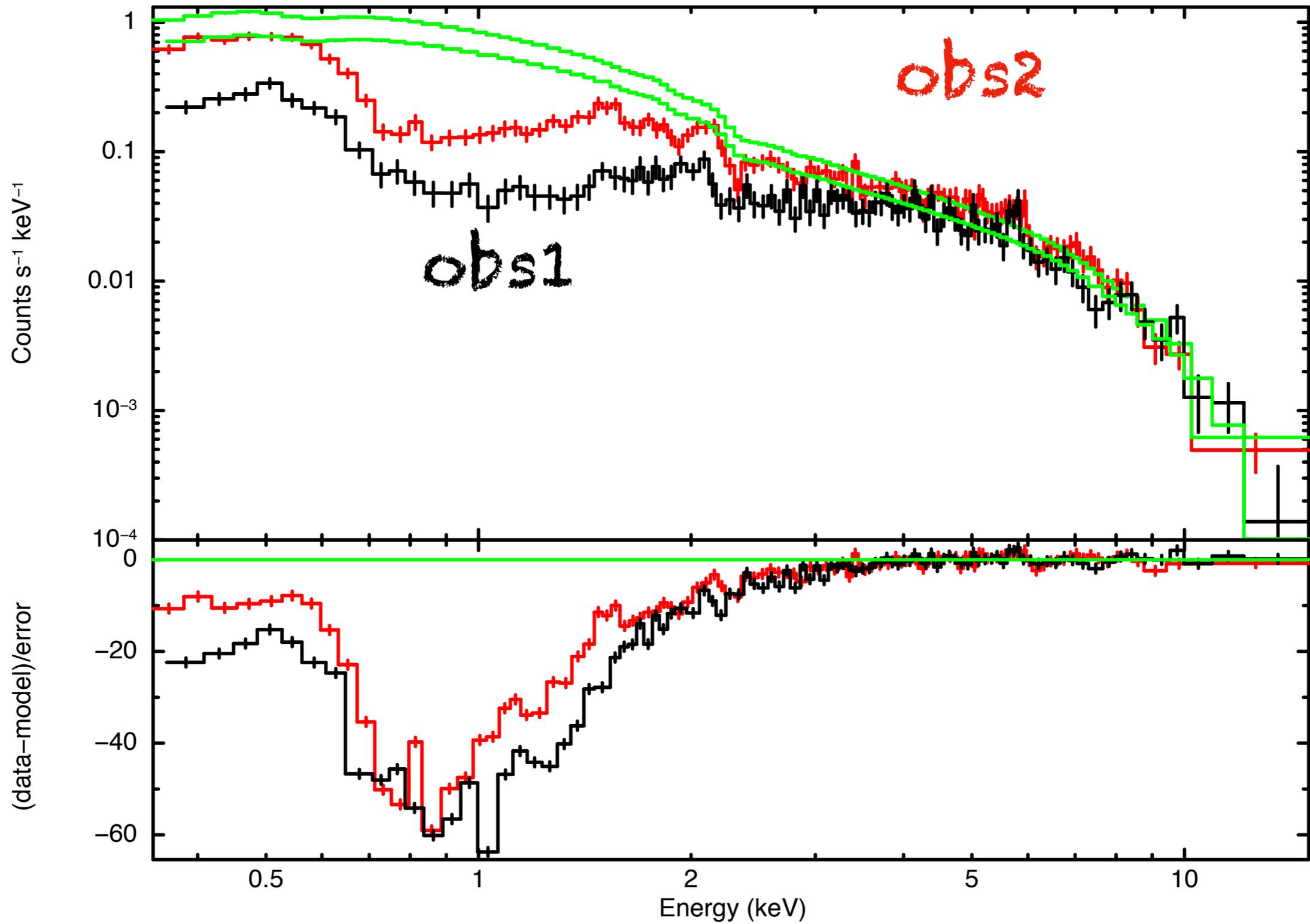
obs2



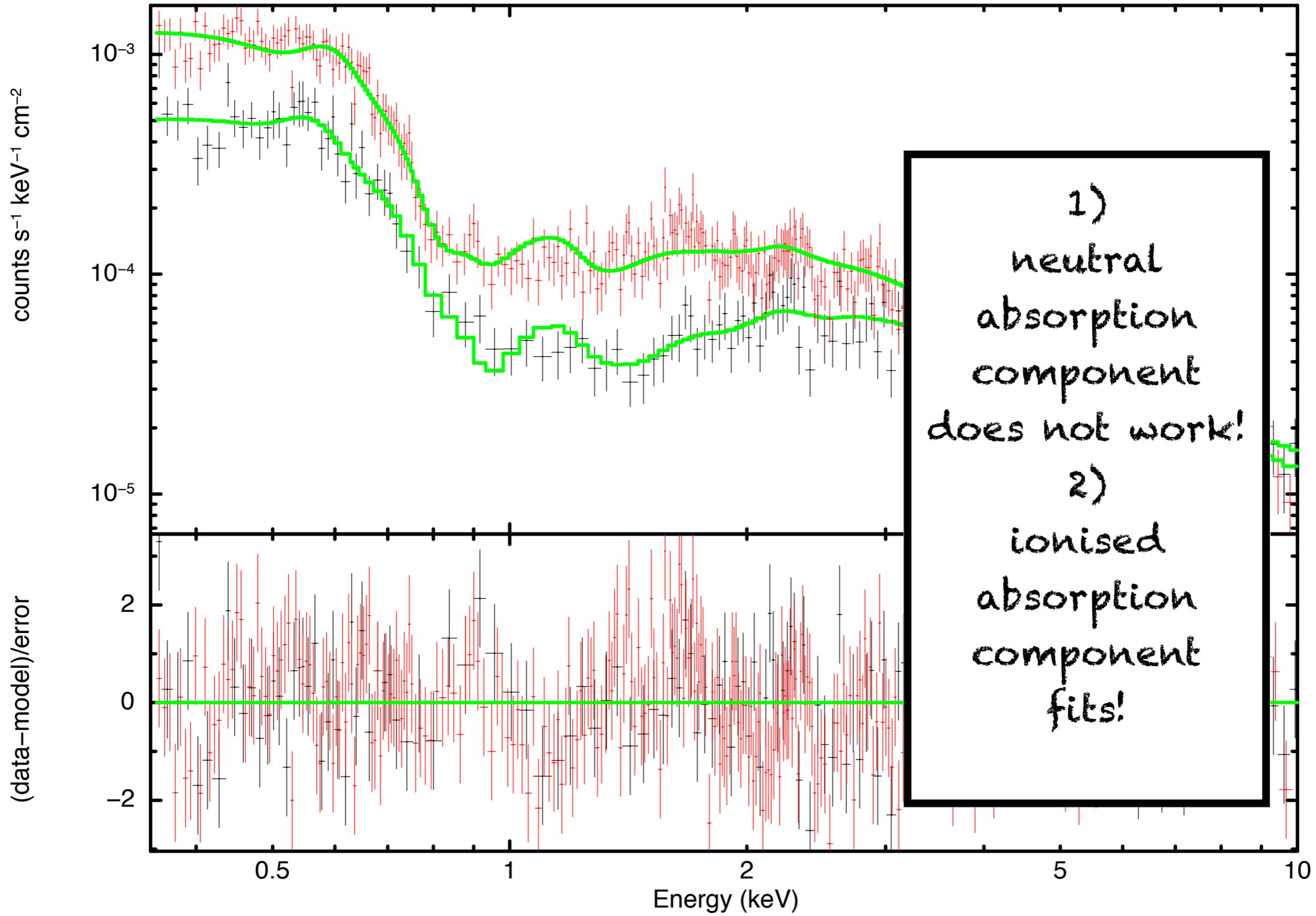
no variability within observations
months variability

Flux_{0.3-2} = $3.4e-13$ erg/cm²/s Flux₂₋₁₀ = $2.1e-12$ erg/cm²/s
Flux_{0.3-2} = $7.9e-13$ erg/cm²/s Flux₂₋₁₀ = $2.6e-12$ erg/cm²/s

More than a simple power-law



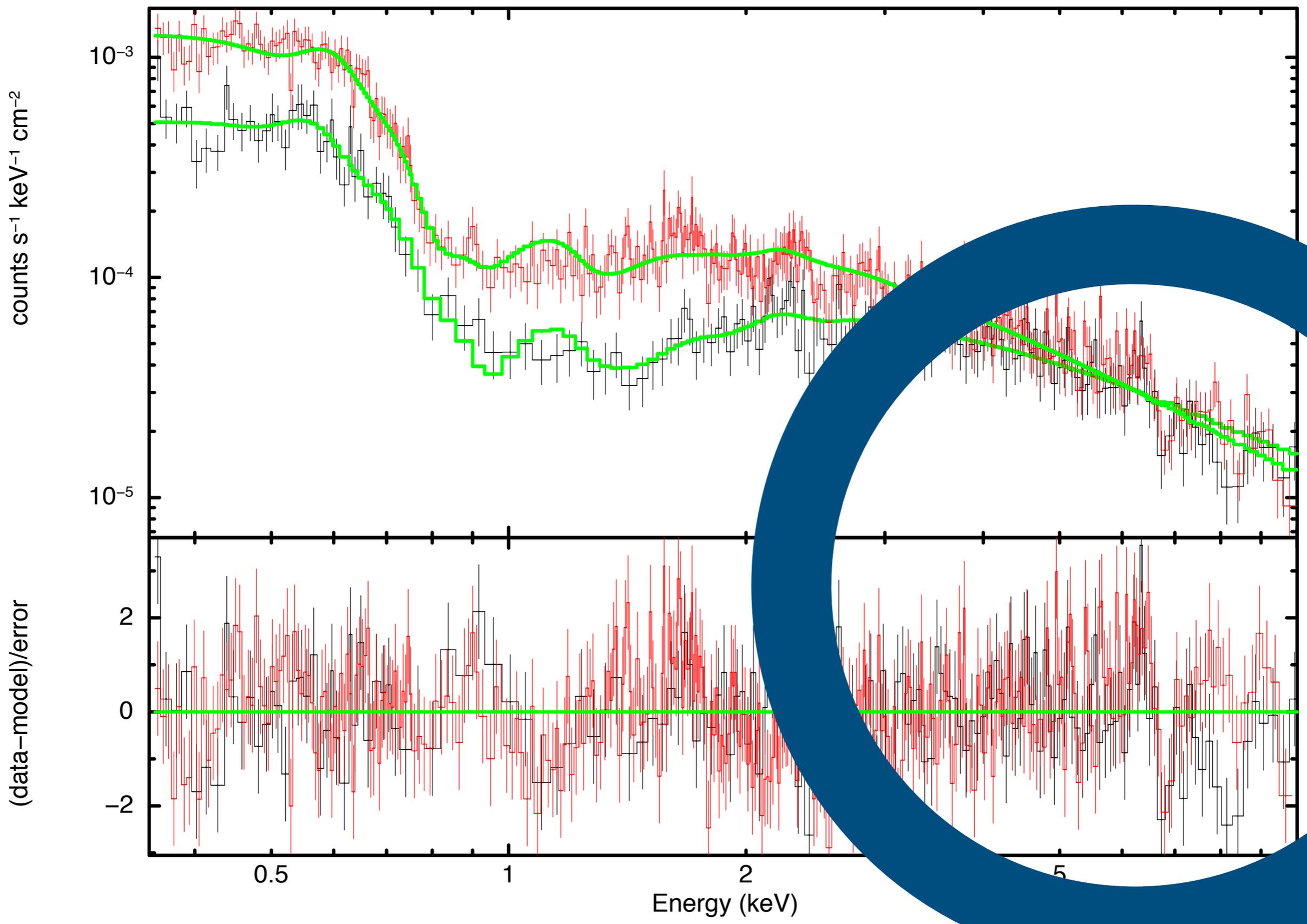
Much more than a simple power-law



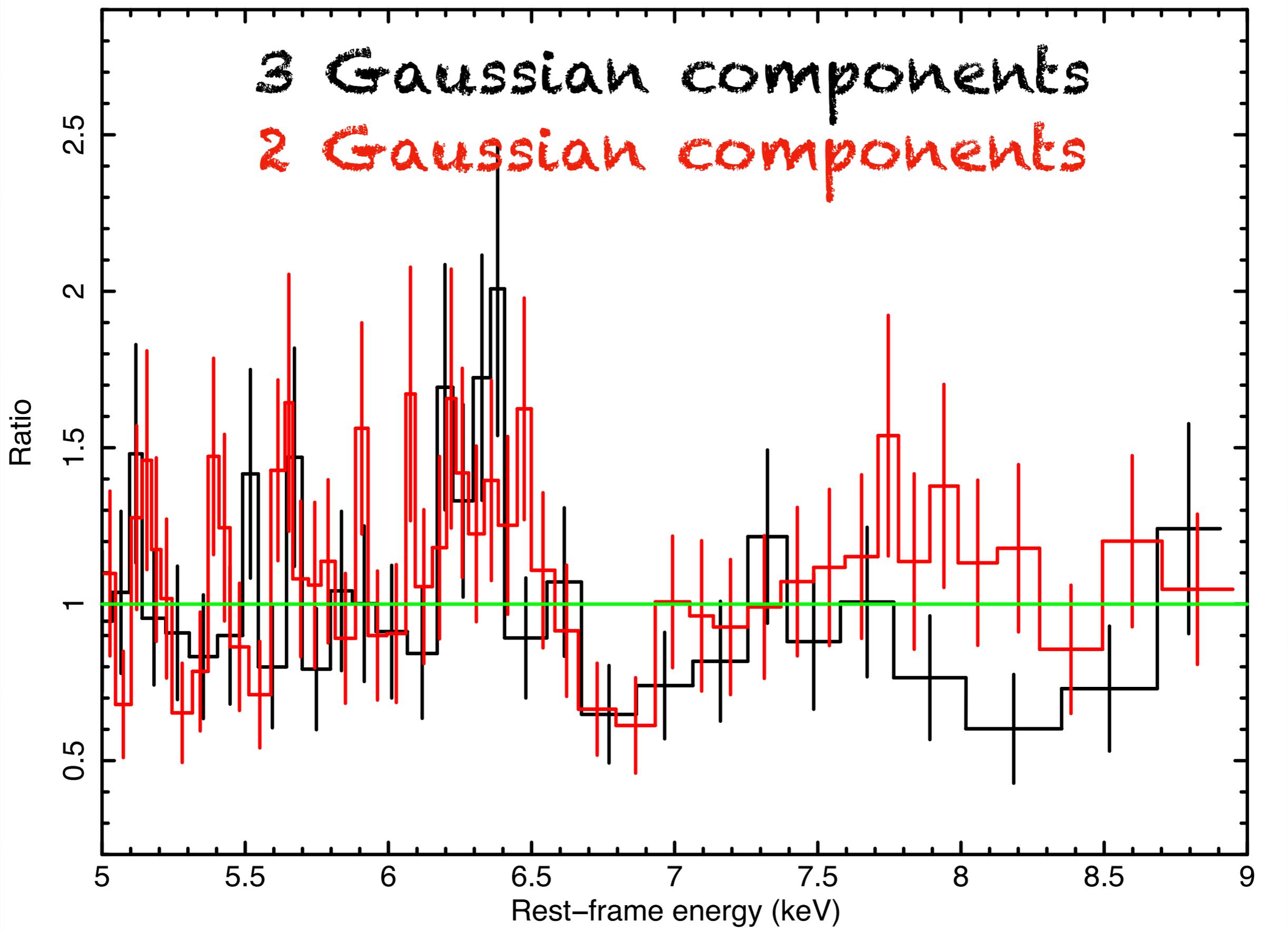
1)
neutral
absorption
component
does not work!

2)
ionised
absorption
component
fits!

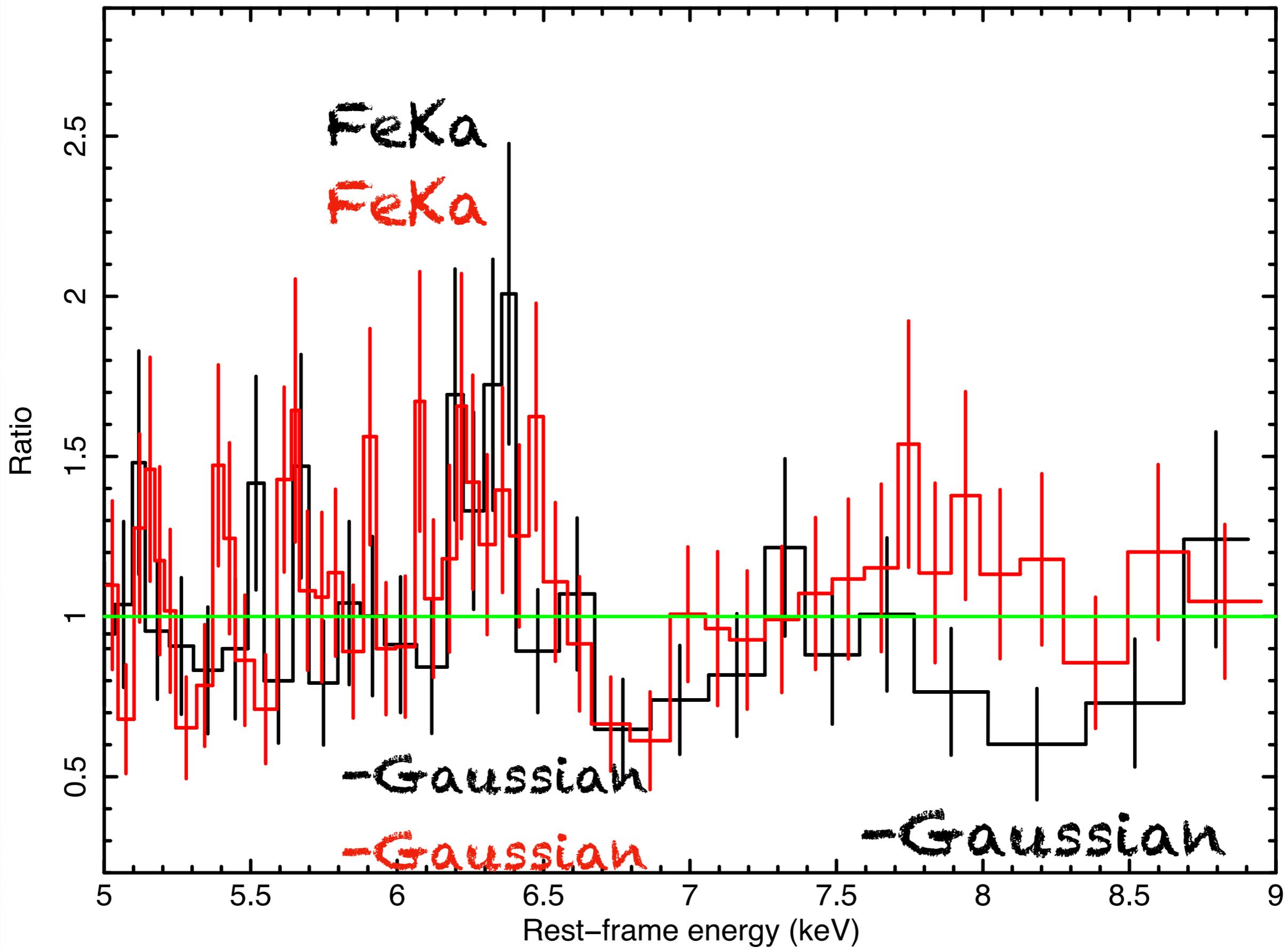
Much more than a simple power-law



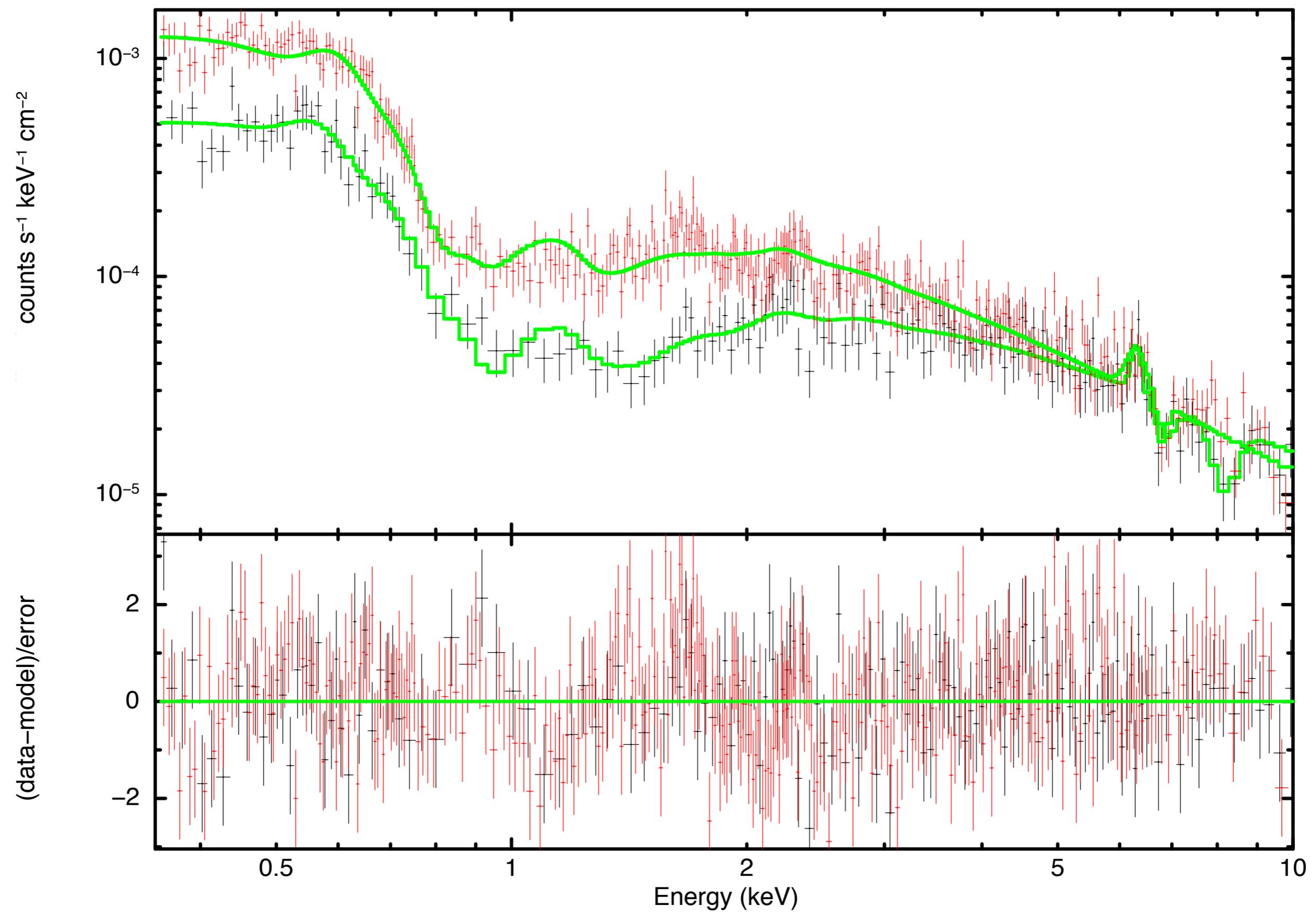
Much more than a simple power-law



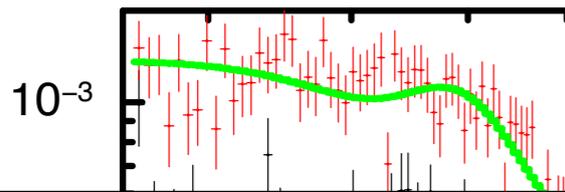
Much more than a simple power-law



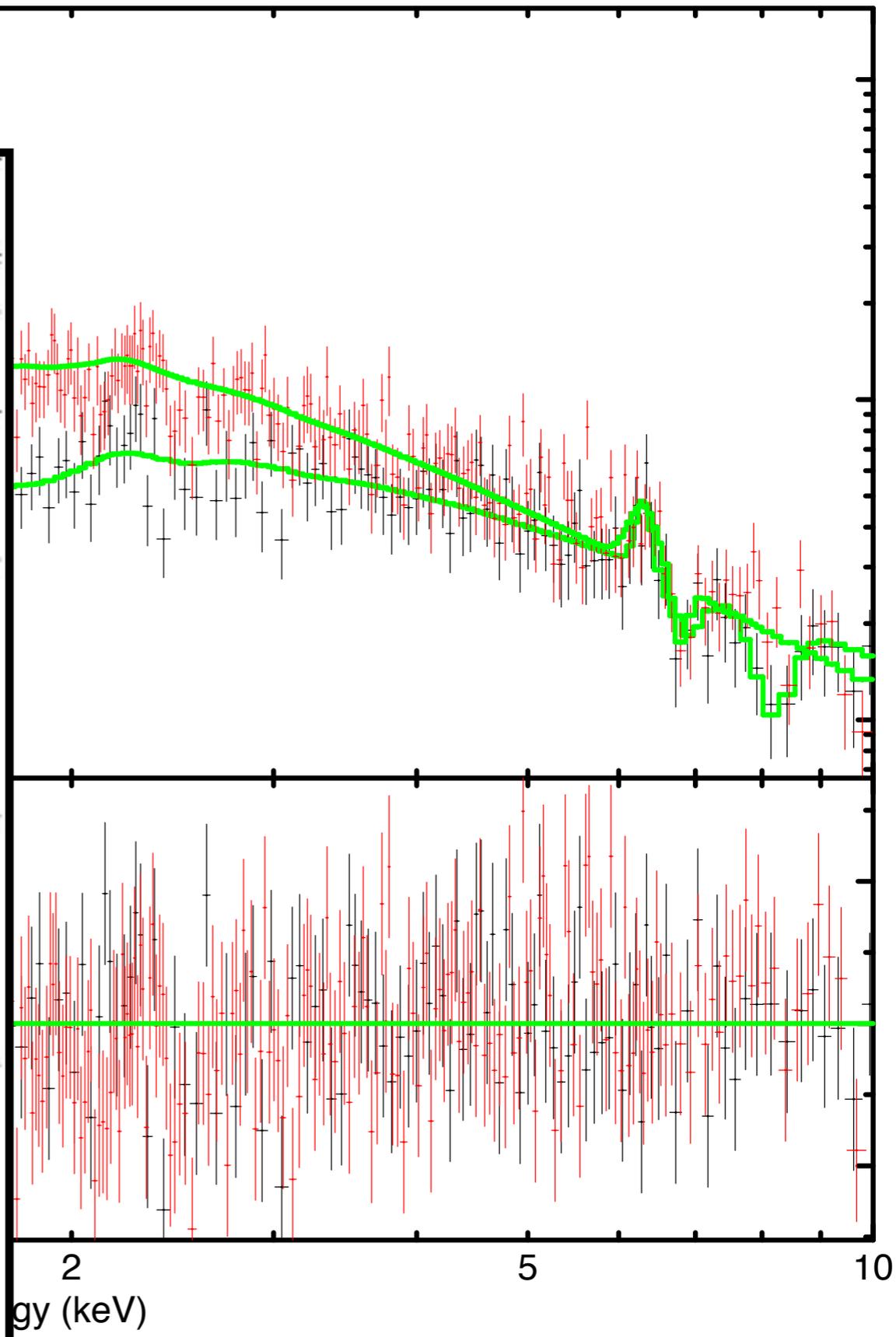
Much more than a simple power-law



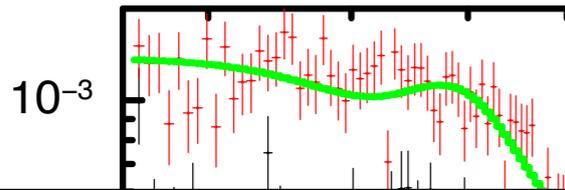
best-fit parameters



Model	Parameter	Obs. 1	Obs. 2
phabs	N_{H}^{\dagger}	0.0474	0.0474
power-law	Γ	1.54 ± 0.04	1.89 ± 0.01
	Norm	$(5.4 \pm 0.3) \times 10^{-4}$	$(1.0 \pm 0.2) \times 10^{-3}$
xstar 1	N_{H}	6.9 ± 0.5	3.5 ± 0.2
	$\log \xi$	$1.92^{+0.02}_{-0.02}$	1.67 ± 0.03
	z^{\dagger}	0.096	-
zgauss	E (keV)	$6.30^{+0.2}_{-0.05}$	6.36 ± 0.08
	σ (eV)	<80	240^{+230}_{-100}
	z^{\dagger}	0.096	-
	Norm	$(5.8 \pm 1.8) \times 10^{-6}$	$(7.8 \pm 2.2) \times 10^{-6}$
	Eq.W (eV)	160^{+20}_{-80}	180^{+80}_{-40}
zgauss	E (keV)	6.85 ± 0.12	6.79 ± 0.06
	σ (eV)	<430	<180
	z^{\dagger}	0.096	-
	Norm	$(-3.6^{+1.9}_{-3.1}) \times 10^{-6}$	$(-5.1 \pm 1.2) \times 10^{-6}$
	Eq.W (eV)	-110^{+70}_{-60}	-130 ± 30
zgauss	E (keV)	8.15 ± 0.12	-
	σ (eV)	250^{+160}_{-130}	-
	z^{\dagger}	0.096	-
	Norm	$(-7.7 \pm 3.3) \times 10^{-6}$	-
	Eq.W (eV)	-310^{+120}_{-100}	-



best-fit parameters

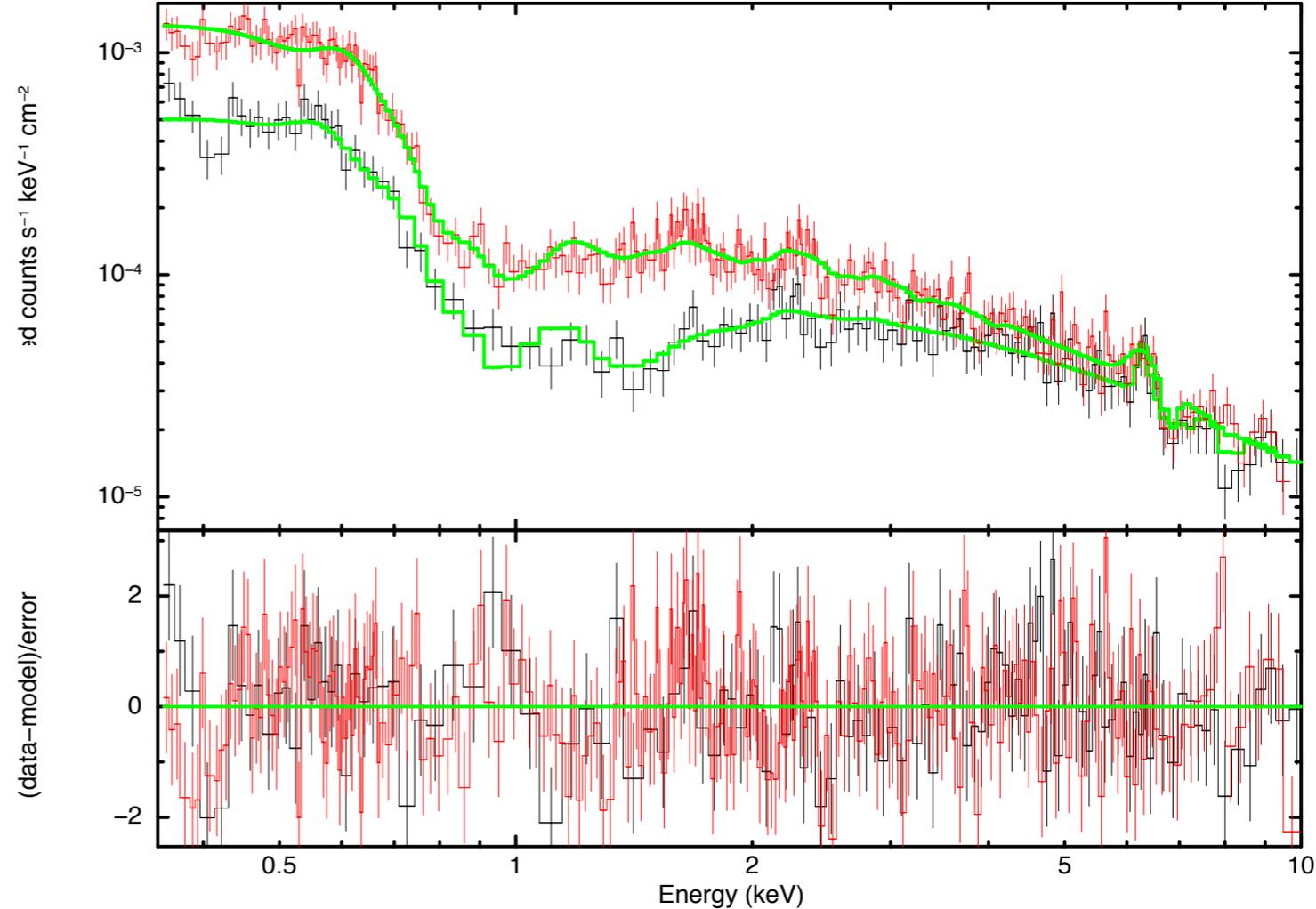


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	$z\ddagger$	0.096	-
	Norm	$(-7.7 \pm 3.3) \times 10^{-6}$	-
	Eq.W (eV)	-310^{+120}_{-100}	-

- warm-absorber displays a variable ξ and N_H
- spectral slope strongly varies
- Fe Kalpha narrow (obs1)/broad(obs1)
- Fe XXV lowly blue-shifted
- Fe XXVI highly blue-shifted



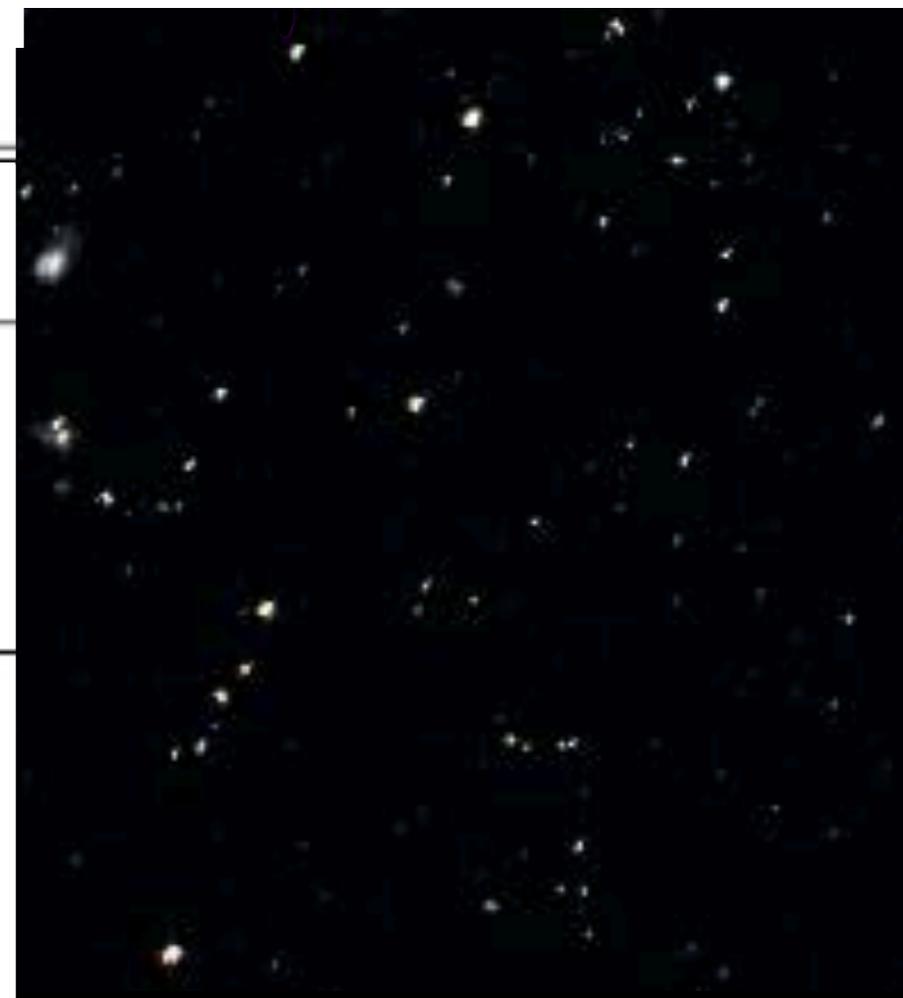
best-fit
parameters
using
XSTAR tables



obs1

obs2

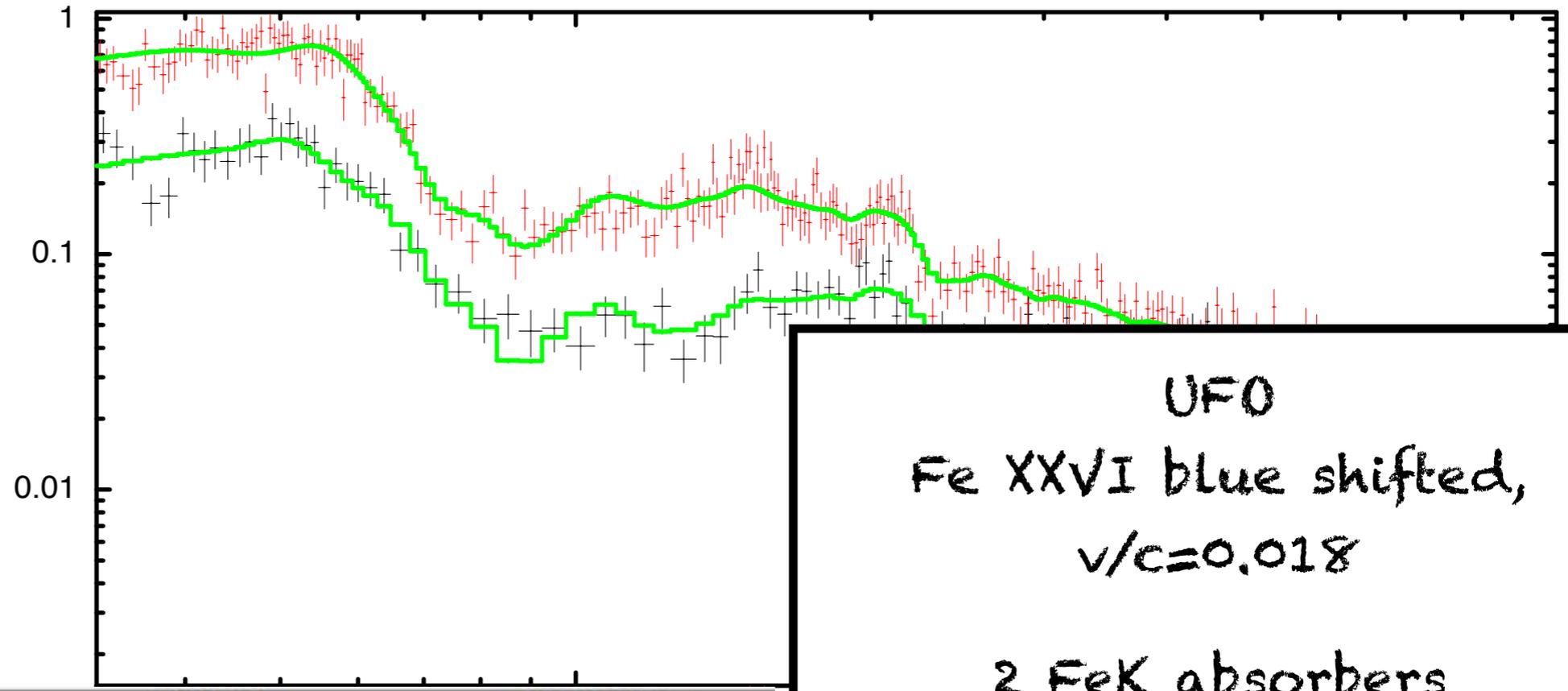
xstar (FeK α) (Fe XXV)	N_H (cm $^{-2}$)	$(9.9^{+2.7}_{-6.4}) \times 10^{22}$	$(1.4^{+0.2}_{-0.2}) \times 10^{23}$
	$\log \xi$	3.4 ± 0.2	2.9 ± 0.1
	z_{obs}	$(5.7 \pm 0.9) \times 10^{-2}$	$(5.3^{+0.4}_{-0.6}) \times 10^{-2}$
	v_{out}/c	0.037 ± 0.008	0.042 ± 0.005
xstar (UFO) (Fe XXVI)	N_H (cm $^{-2}$)	$(1.0^{+0.2}_{-0.4}) \times 10^{24}$	-
	$\log \xi$	$4.0^{+0.3}_{-0.1}$	-
	z_{obs}	$(-6.2^{+1.4}_{-1.6}) \times 10^{-2}$	-
	v_{out}/c	0.18 ± 0.02	-



best-fit parameters using XSTAR

tables

free zWA →
 Delta C = 7 for 2
 d.o.f. less
 i.e. 2 sigma
 (~96.8% prob.)



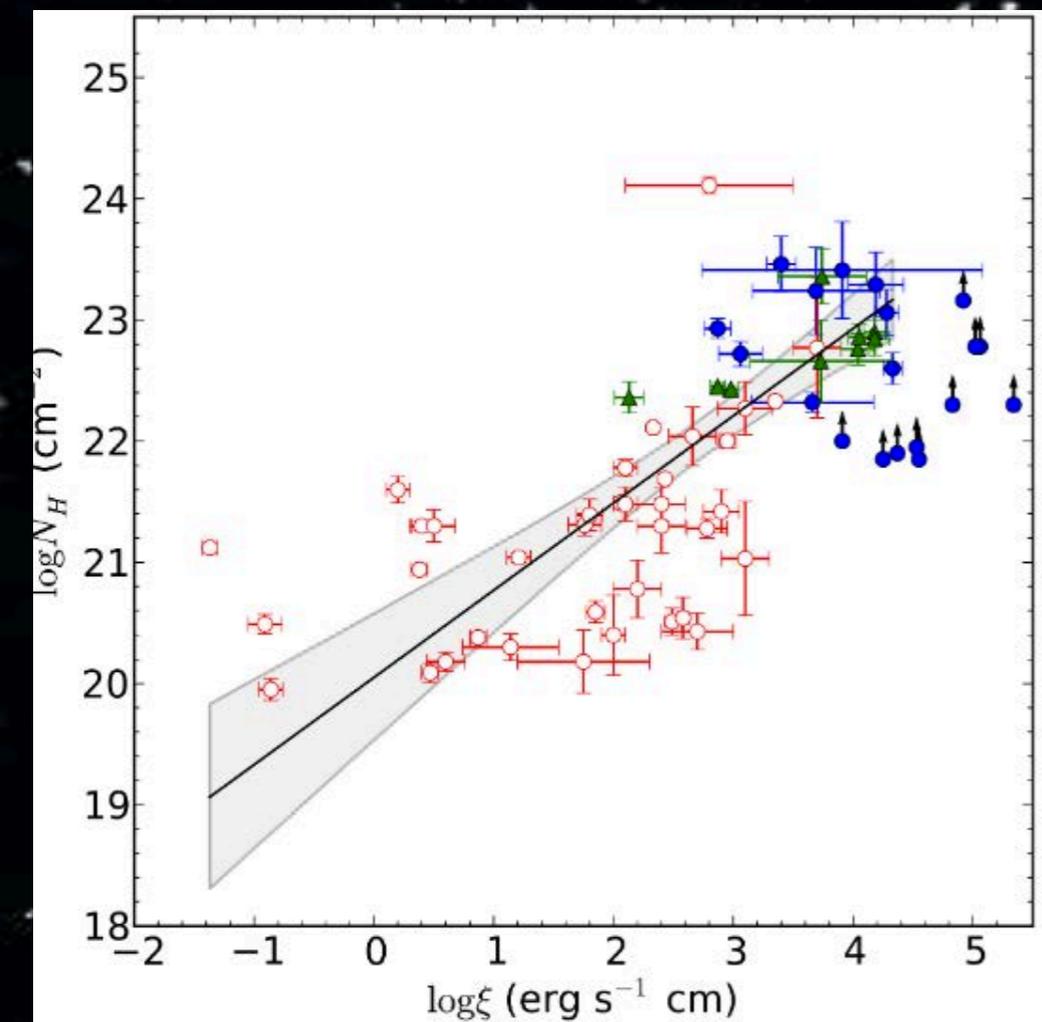
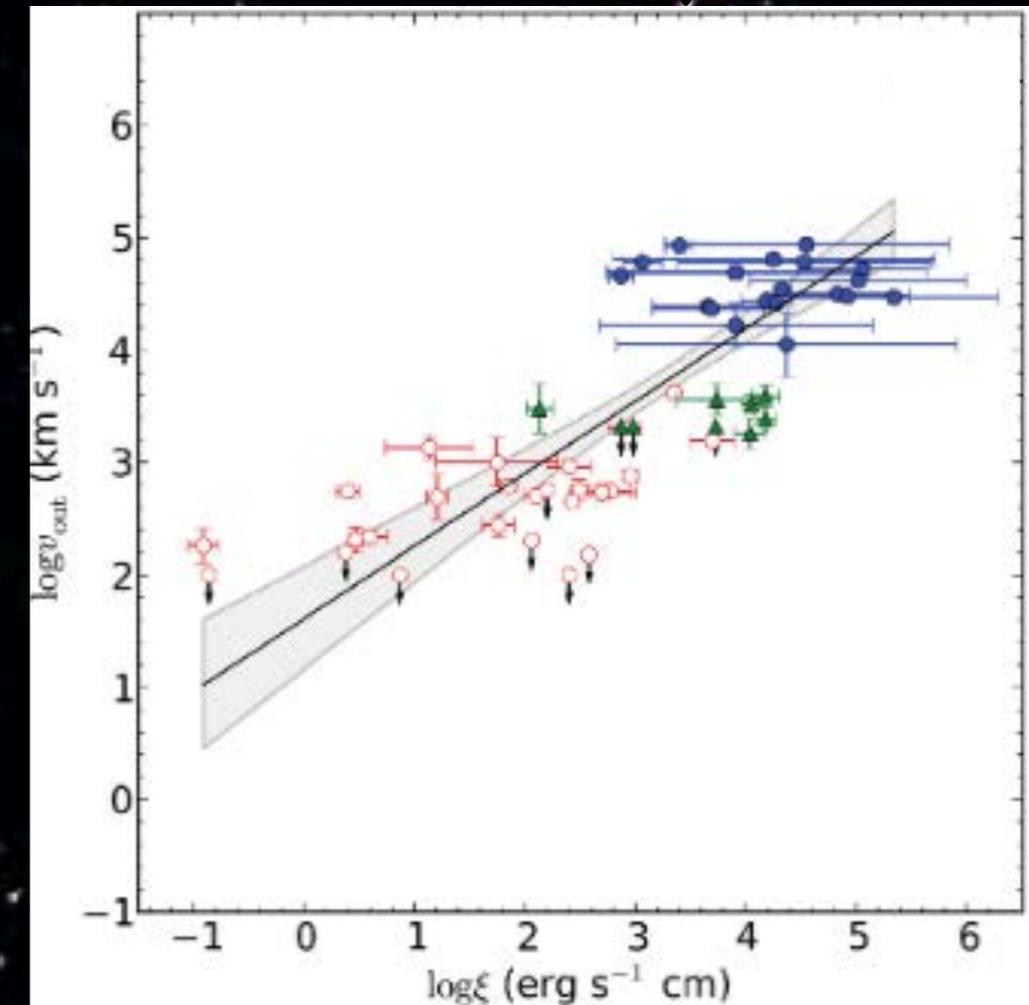
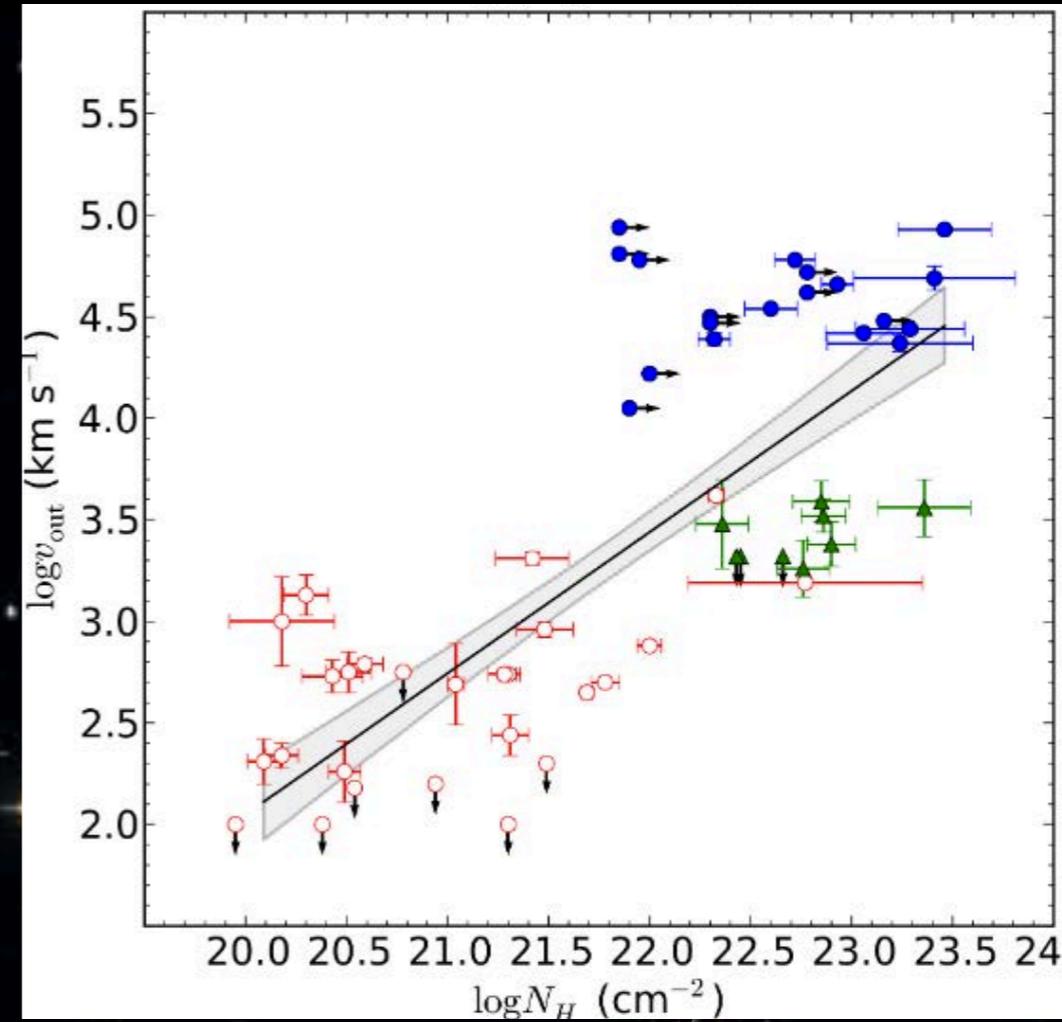
UFO
 Fe XXVI blue shifted,
 $v/c = 0.018$

2 FeK absorbers
 consistent column density
 (but not ξ !)
 likely outflowing

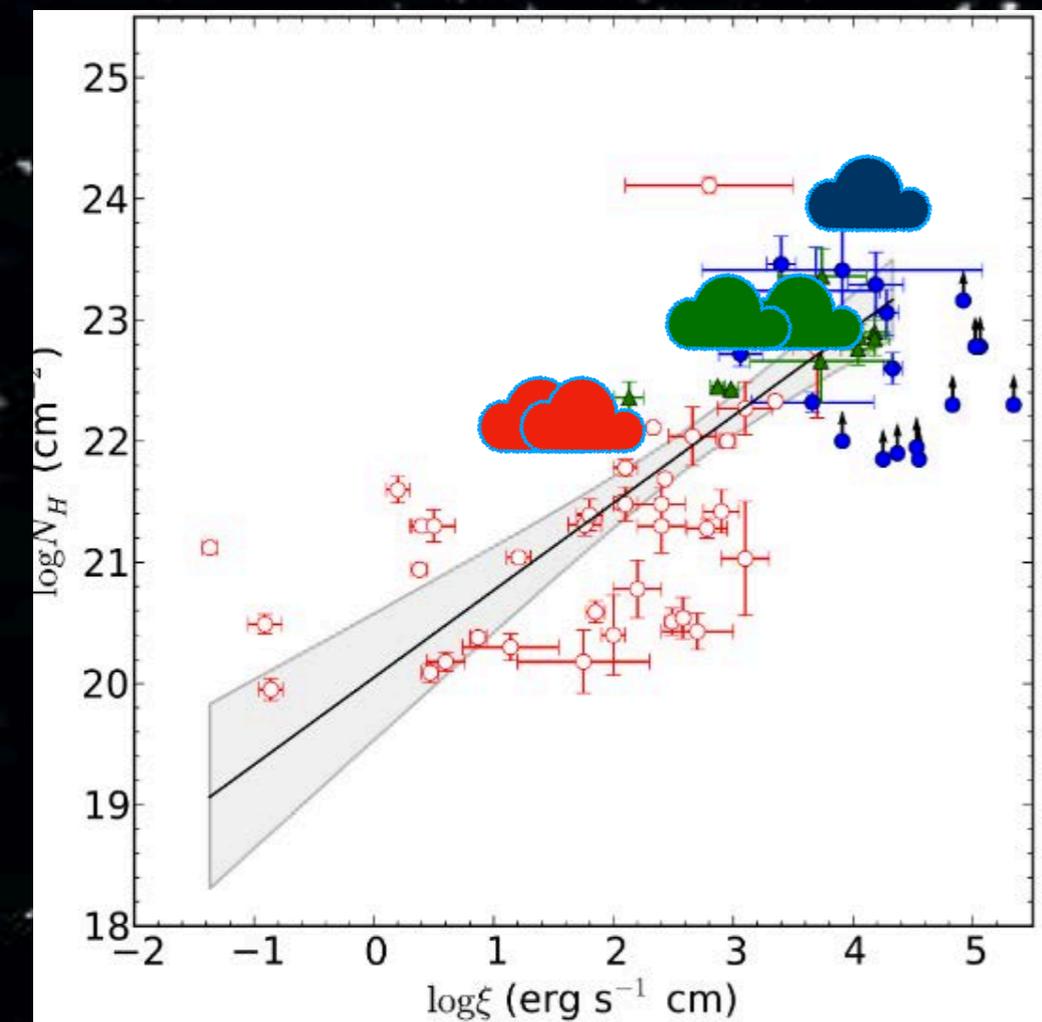
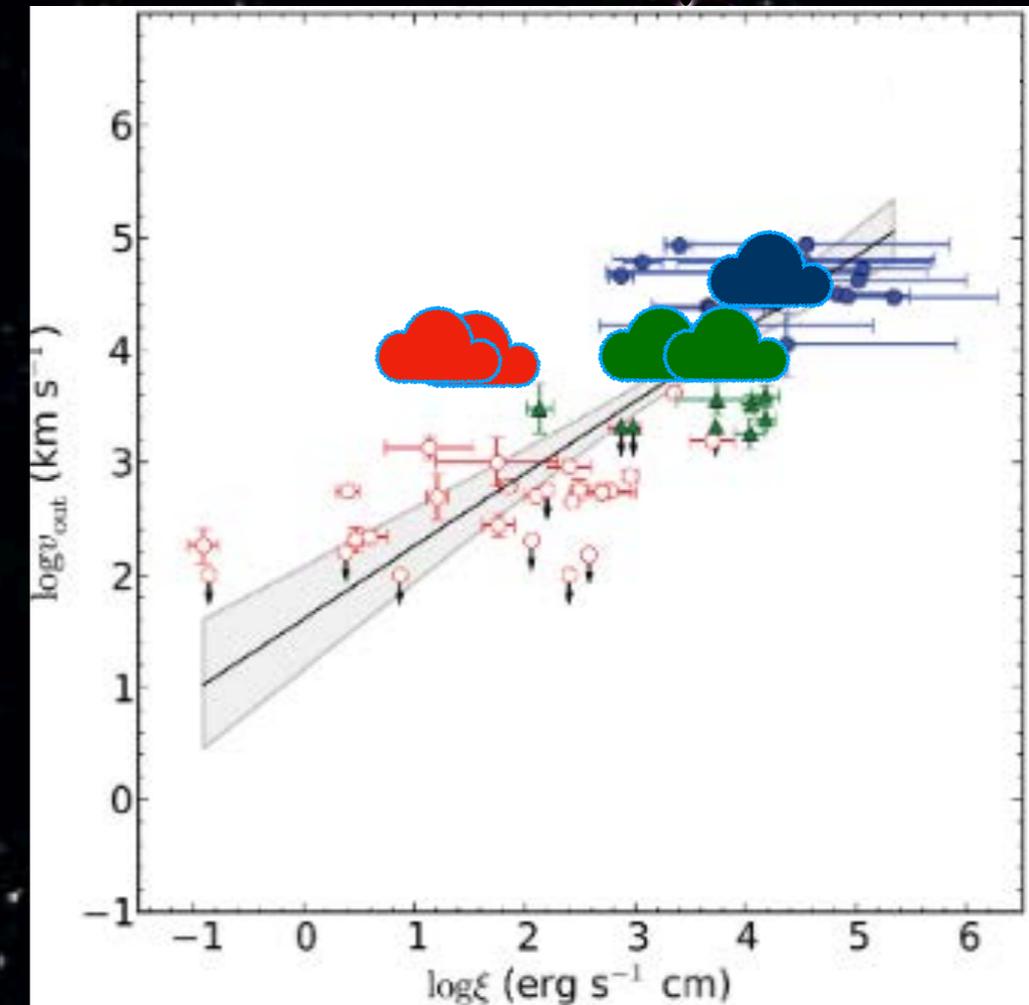
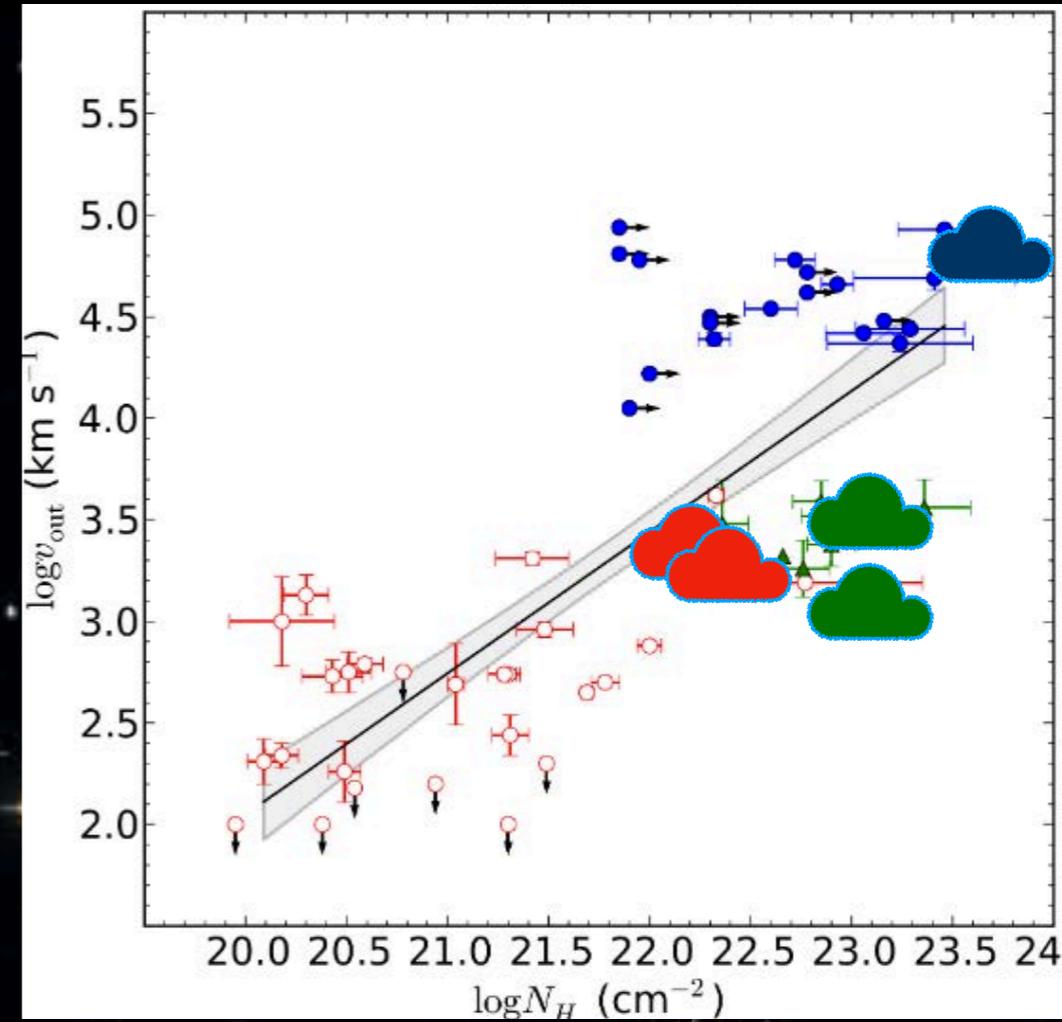
outflowing WA?

Model	Parameter	Obs. 1	Obs. 2
xstar (WA)	Z_{obs}	$(6.8 \pm 1) \times 10^{-2}$	$(6.6 \pm 1.0) \times 10^{-2}$
	v_{out}/c	0.036 ± 0.010	0.038 ± 0.010
xstar (FeK α) (Fe XXV)	$N_{\text{H}} (\text{cm}^{-2})$	$(9.9^{+2.7}_{-6.4}) \times 10^{22}$	$(1.4^{+0.2}_{-0.2}) \times 10^{23}$
	$\log \xi$	3.4 ± 0.2	2.9 ± 0.1
	Z_{obs}	$(5.7 \pm 0.9) \times 10^{-2}$	$(5.3^{+0.4}_{-0.6}) \times 10^{-2}$
	v_{out}/c	0.037 ± 0.008	0.042 ± 0.005
xstar (UFO) (Fe XXVI)	$N_{\text{H}} (\text{cm}^{-2})$	$(1.0^{+0.2}_{-0.4}) \times 10^{24}$	-
	$\log \xi$	$4.0^{+0.3}_{-0.1}$	-
	Z_{obs}	$(-6.2^{+1.4}_{-1.6}) \times 10^{-2}$	-
	v_{out}/c	0.18 ± 0.02	-

Comparing with other absorbers



Comparing with other absorbers

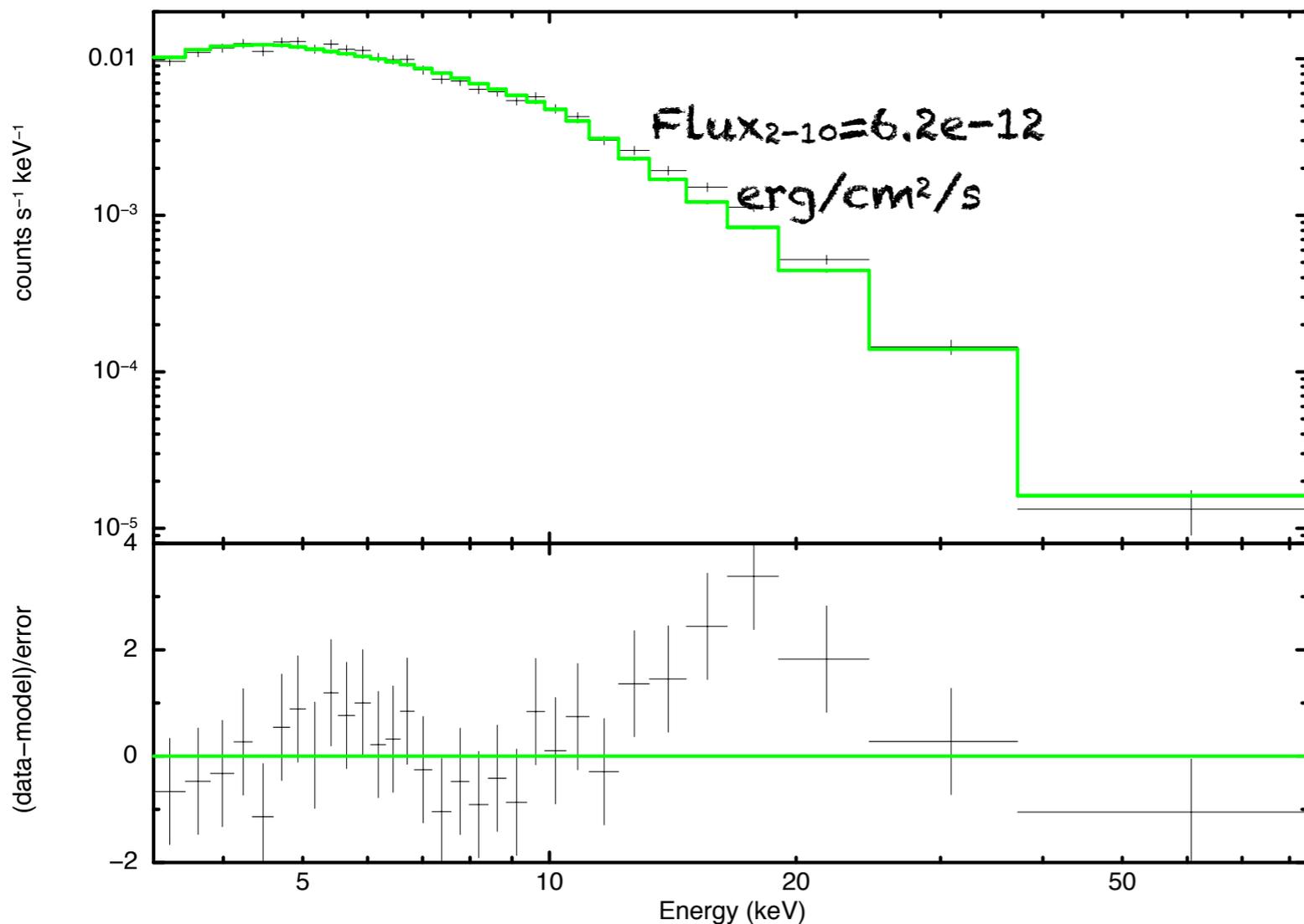


To do...

refine Xstar spectral fitting

Computing the energetics of the outflow in 1E 0754.6

A 40 ks NuSTAR observation
about 8 years later XMM-Newton



Information on
the hot
Comptonisation
component,
reprocessed emission

conclusions

1E 0756 displayed complex absorption spectra

flux and spectral variations observed on months timescales

Variable FeK α , narrow in obs1 broad in obs2

UFO with $v/c \sim 0.018$

(3sigma confidence level) detection in 1 out of 2 observations

Fe K α absorbers likely in outflow ($v/c = 0.03 - 0.04$)

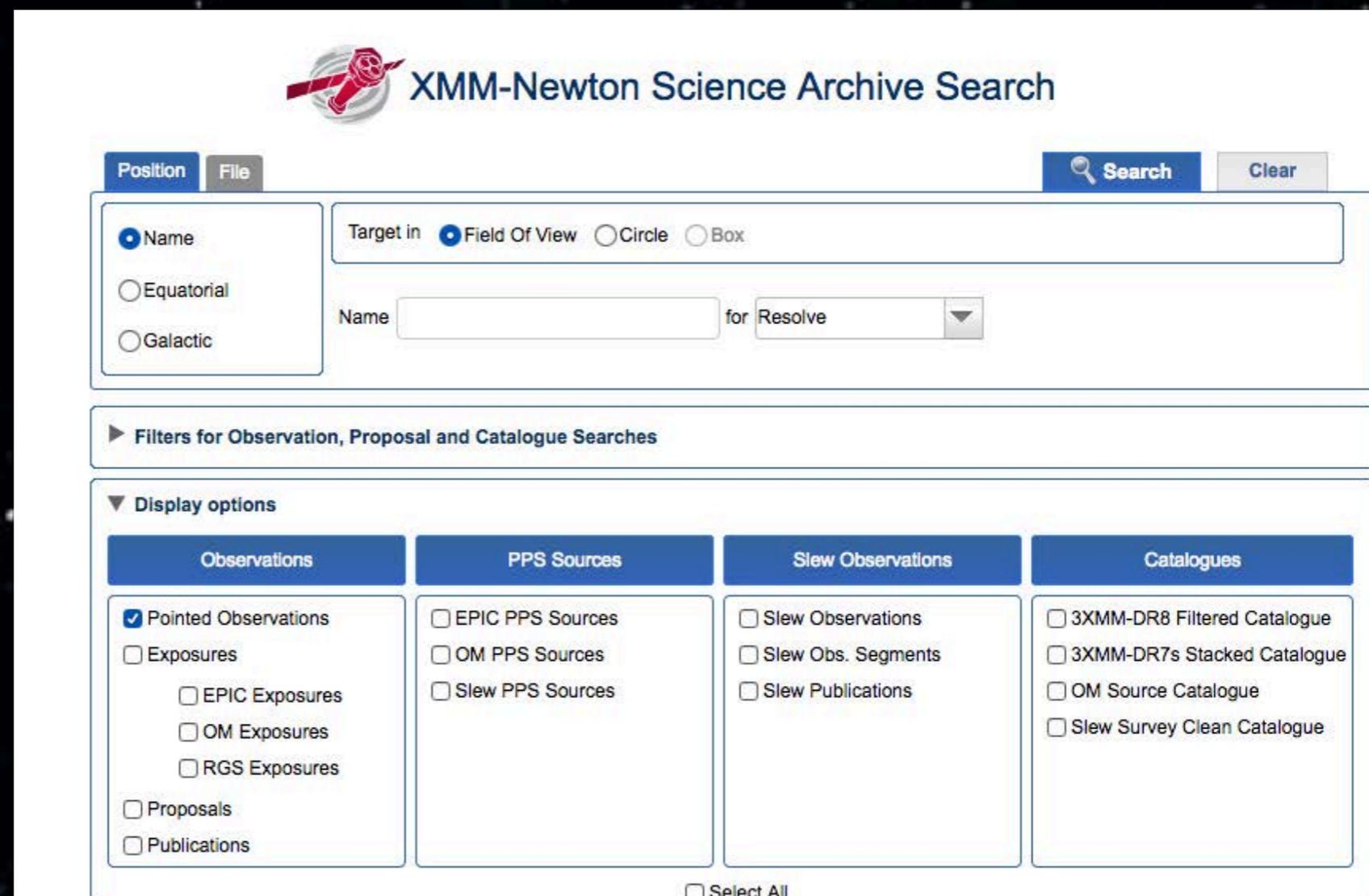
WAs (in outflow?) with variable column density and
ionisation parameter

Longer observations are needed

Proposal A018...fingers crossed.

Thank you for the
attention

P.S.
After ~18
years XMM-
Newton
archive is still
rich of poorly
known
sources.



The image shows the XMM-Newton Science Archive Search interface. At the top, there is a logo of the XMM-Newton satellite and the title "XMM-Newton Science Archive Search". Below the title, there are two tabs: "Position" (selected) and "File". To the right of the tabs are "Search" and "Clear" buttons. The main search area contains a "Name" field with radio buttons for "Name", "Equatorial", and "Galactic". The "Name" radio button is selected. To the right of the "Name" field is a "Target in" section with radio buttons for "Field Of View", "Circle", and "Box". The "Field Of View" radio button is selected. Below the "Name" field is a "Name" input field followed by "for" and a "Resolve" dropdown menu. Below the search area is a section titled "Filters for Observation, Proposal and Catalogue Searches". Underneath this is a "Display options" section with four columns: "Observations", "PPS Sources", "Slew Observations", and "Catalogues". Each column contains a list of search options with checkboxes. In the "Observations" column, "Pointed Observations" is checked. In the "PPS Sources" column, "EPIC PPS Sources", "OM PPS Sources", and "Slew PPS Sources" are listed. In the "Slew Observations" column, "Slew Observations", "Slew Obs. Segments", and "Slew Publications" are listed. In the "Catalogues" column, "3XMM-DR8 Filtered Catalogue", "3XMM-DR7s Stacked Catalogue", "OM Source Catalogue", and "Slew Survey Clean Catalogue" are listed. At the bottom of the "Display options" section, there is a "Select All" checkbox.