The energy dependence of the X-ray PSDs in AGN

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ΕΠΙΧΕΙΡΗΣΙΑΚΟ ΠΡΟΓΡΑΜΜΑ
ΕΚΠΑΙΔΕΥΣΗ ΚΑΙ ΔΙΑ ΒΙΟΥ ΜΑΘΗΣΗ
επένδυση στην κοινωνία της γνώσης
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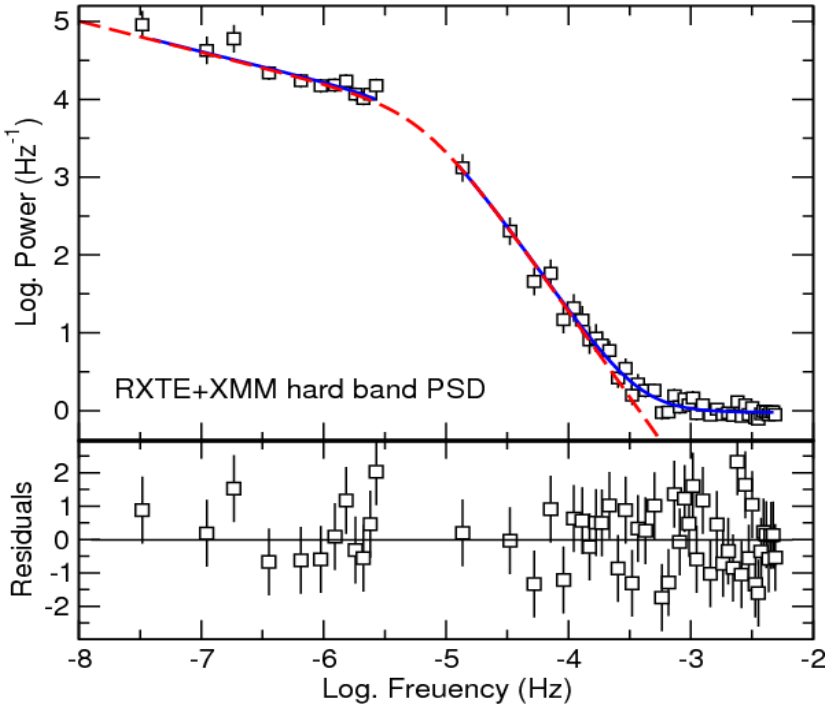
Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

1. Introduction

There has been a significant progress in our knowledge of the X-ray variability properties of AGN the last few years.

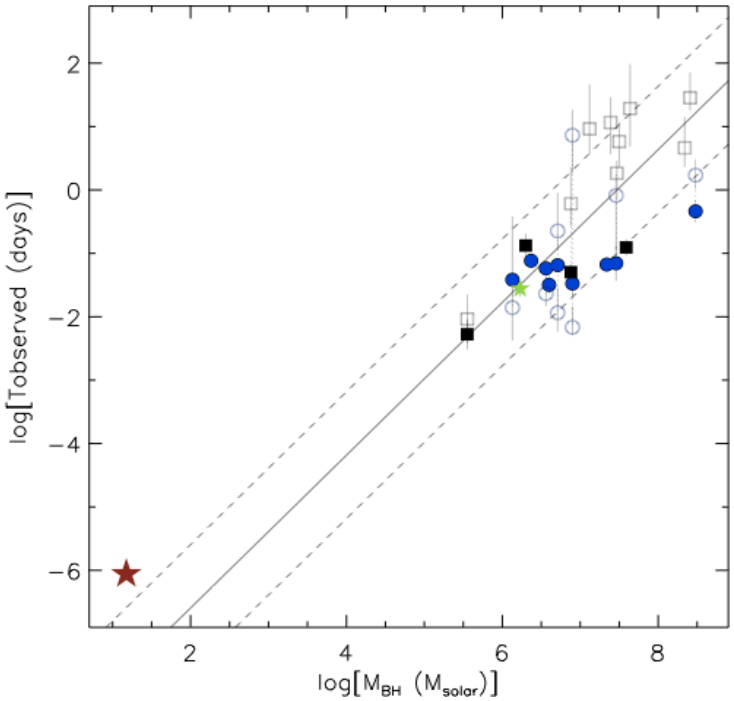
We have discovered high-frequency "breaks" in the PSDs (ν_{br})



PKS0558-504 (Papadakis et al, 2009)

The characteristic "break" time scale, T_{br}, scales linearly with BH mass:

$$T_{br}(\text{days}) \sim 0.02 (M_{BH}/10^6\ M_\odot)$$



(González-Martín & Vaughan, 2012)

T_{br} may also depend on accretion rate (McHardy et al 2006), but this is an open issue yet.

PSD studies in the past have focused mainly in two energy bands: ~0.5-2 keV ("soft band") and ~2-10 keV ("hard" band).

We know that:

"soft band" PSD slope > "hard band" PSD slope

But, so far, *there has not been a systematic study of the energy dependence of the PSDs in AGN*.

How does ν_{br} change with energy?

How does α_{hf} change with energy?

How does the PSD amplitude change with energy?

2. The sample

I chose objects which are X-ray bright, highly variable, and have been observed extensively by XMM:

Name	Net exposure (ksec)
MCG -6-30-15	434.1
IRAS 13224-3809	564.6
Ark 564	572
NGC 4051	622.7
Mrk 766	648.9
1H0707-495	1160

3) The method.

A) I produced light curves in 5 energy bands:

0.3-0.5	0.5-0.9	0.9-1.5	1.5-4	4-10 keV

Average energy of the photons detected in these bands:

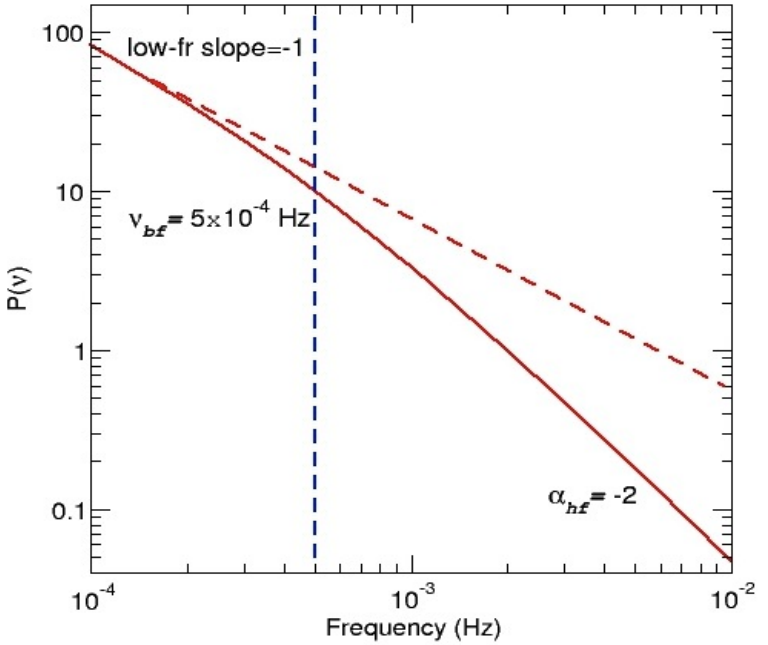
~0.4 keV	~0.7 keV	~1.2 keV	~2.5 keV	~6 keV
	×2	×3	×4	×15

B) I estimated the PSD in the frequency band: 10^{-4} – 10^{-2} Hz.

C) I fitted the PSDs in each band with a "bending power-law" model:

$$P(\nu) = \frac{N}{\nu\left[1+\left(\frac{\nu}{\nu_{bf}}\right)^{(\alpha_{hf}-1)}\right]}$$

Free parameters: *N*, α_{hf} and ν_{bf}.



I fitted the PSDs twice:

1) α_{hf}-tied, ν_{bf} variable (Model 1)

2) ν_{bf}-tied, α_{hf} variable (Model 2)

Model 1

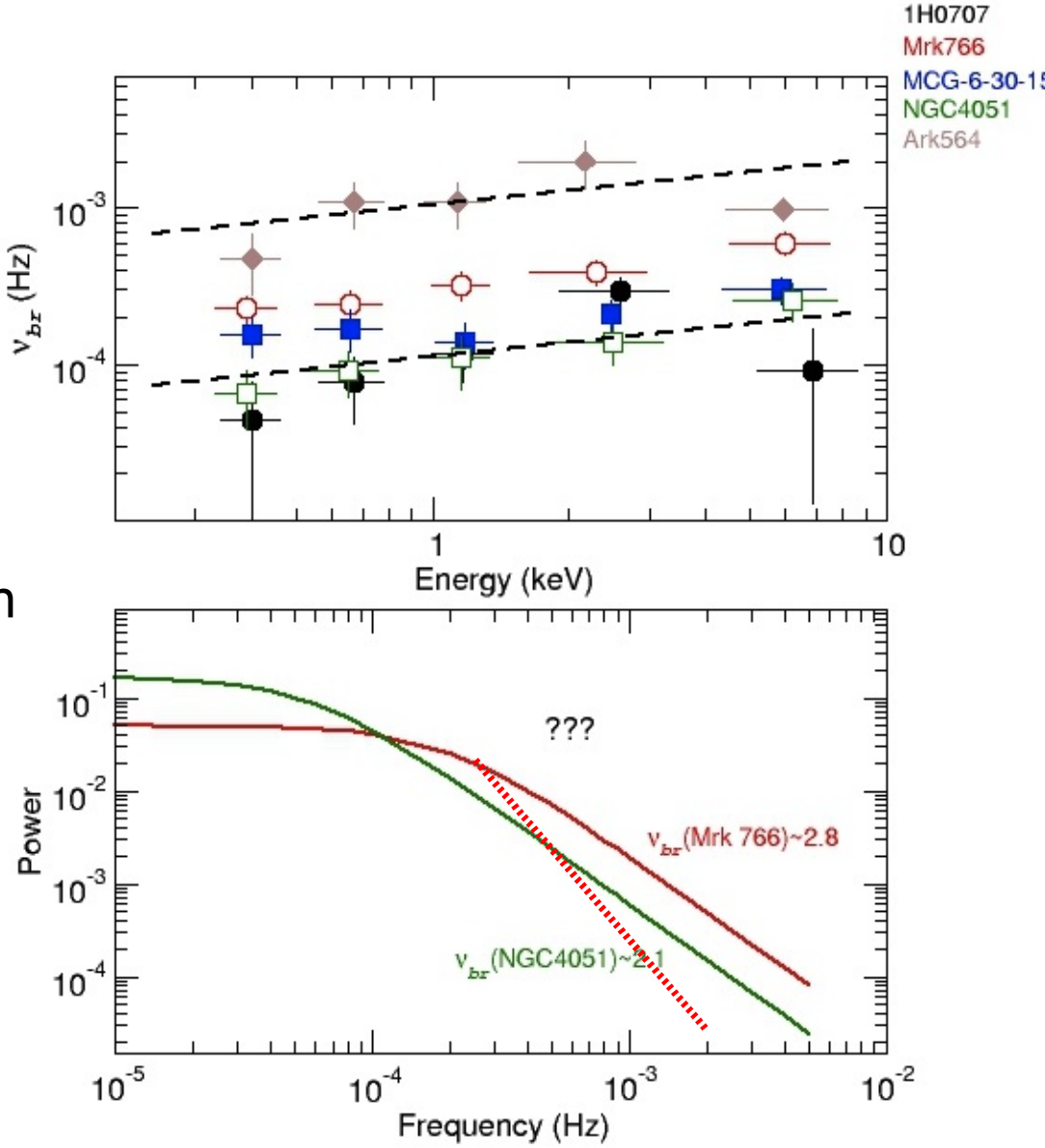
Quality of fits is ok.

$$\nu_{br} \propto E^{1/3}$$

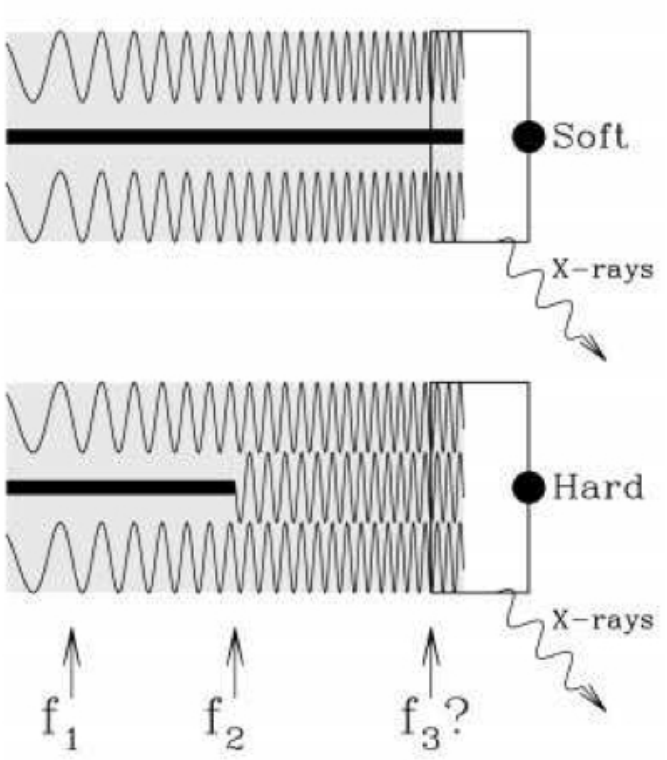
Consistent with "propagating fluctuations (within the corona)" models (in fact this result can constrain emissivity profiles)

but

High-freq slope is NOT the same in all objects.



So, to my opinion, this picture:



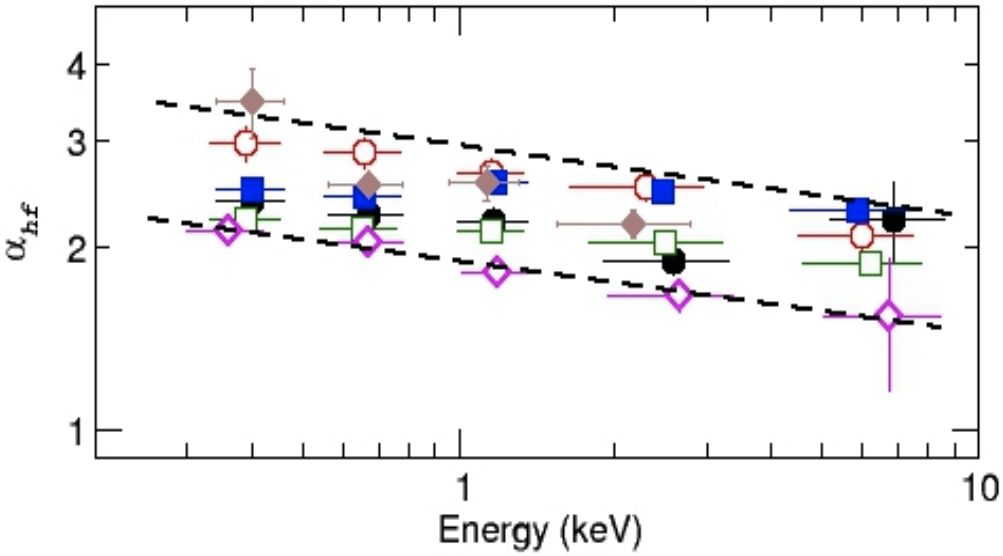
(Churazov etal 2001)

is **NOT** the correct one for these bright AGN.

Model 2

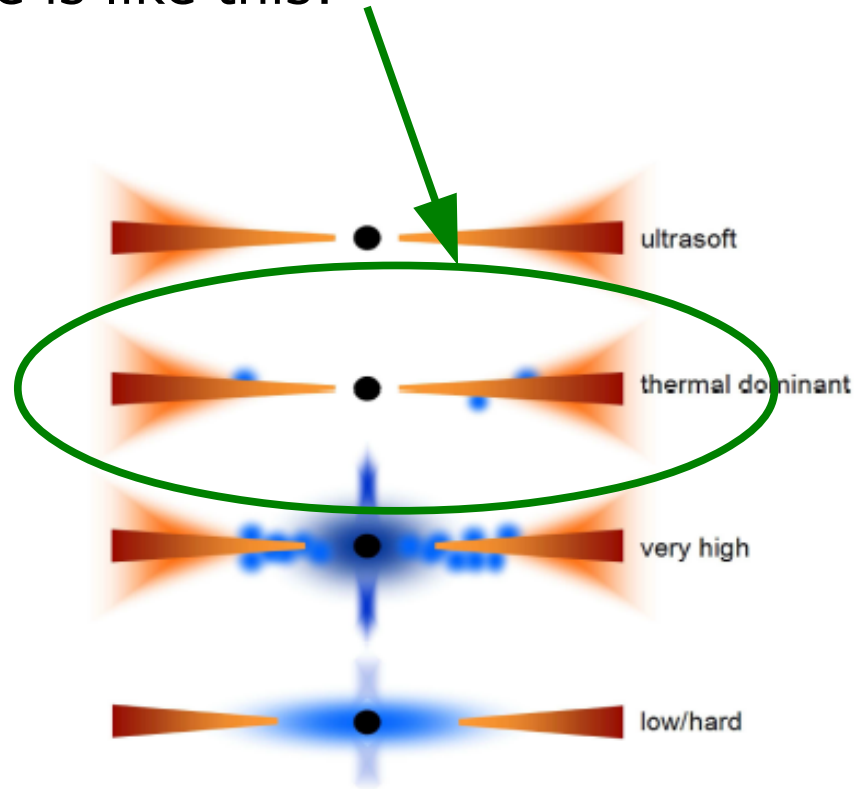
Quality of fits is ok
(better than Model 1 in 2 cases)

$$\alpha_{hf} \propto E^{-0.1}$$



This result rules out models where the
the X-ray source is non-variable
and the observed variability is attributed to
absorption variations only

So, to my opinion, the picture is like this:



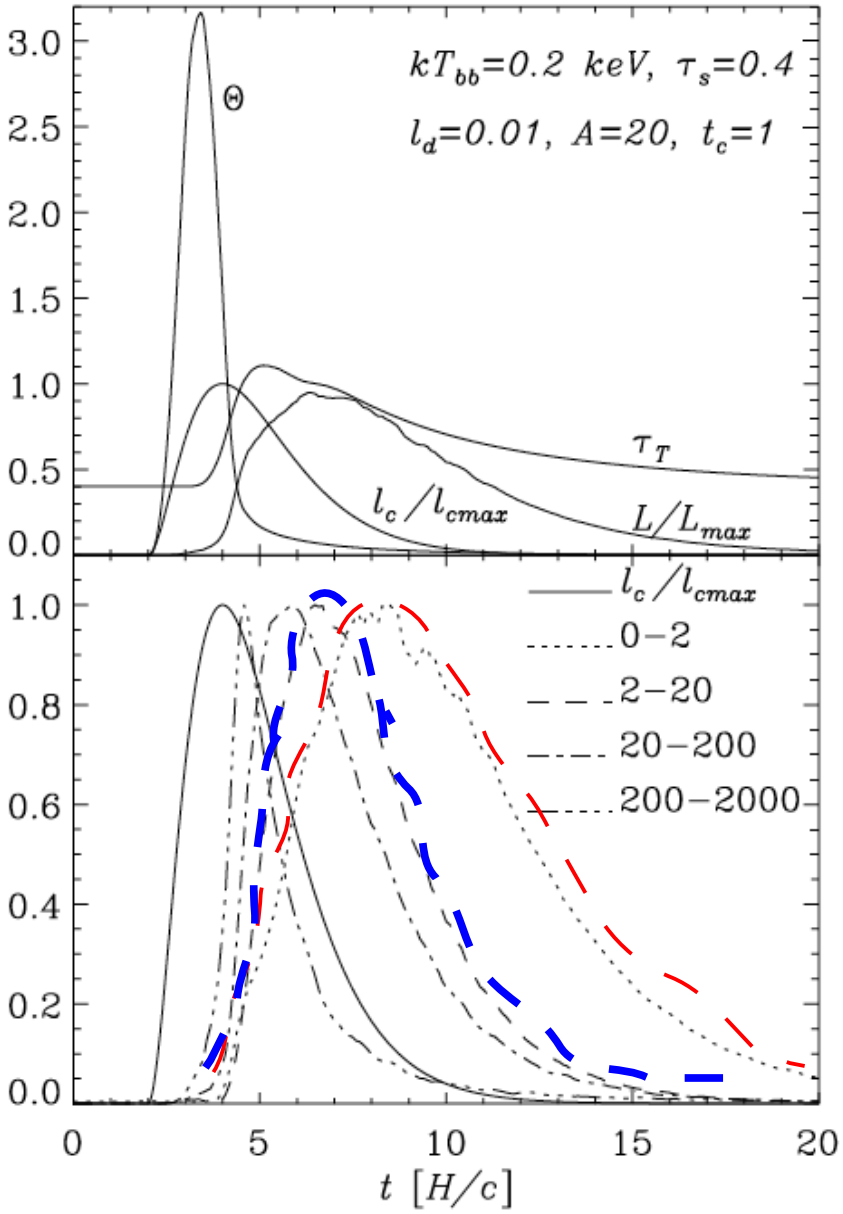
Done et al, 2007

And the PSD hardening could tell us something about the "active regions".

Malzac & Jourdain 2000

Study of the energy dependent X-ray variability in the case of flares which are due to a violent *heating* of the corona, when the perturbation time scale is of the order of a few corona light crossing times.

The soft X-ray band flares are *wider* than those in the harder band (2-20 keV).



4. Summary

How does ν_{br} change with energy?

- ✔ It does not depend on energy.
- ✔ One can determine break frequencies using full band light curves.

How does α_{hf} change with energy?

It flattens with increasing energy: $\alpha_{hf} \propto E^{-0.1}$

Detailed study of dynamic X-ray "coronae" is necessary to understand better the X-ray variability properties of bright Seyferts.

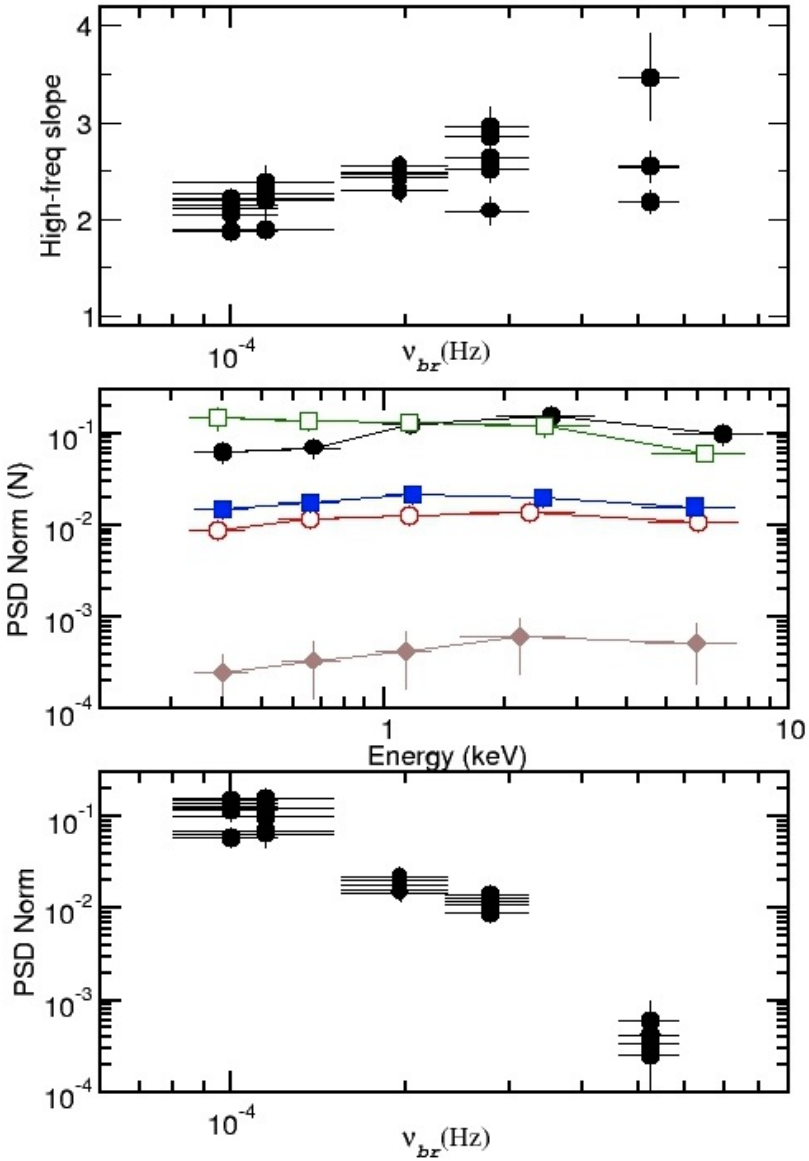
Need to understand:

a) why α_{hf} is not the same in all objects, and why does it appear to scale with ν_{bf}?

b) Why is PSD norm *not* the same in all objects?

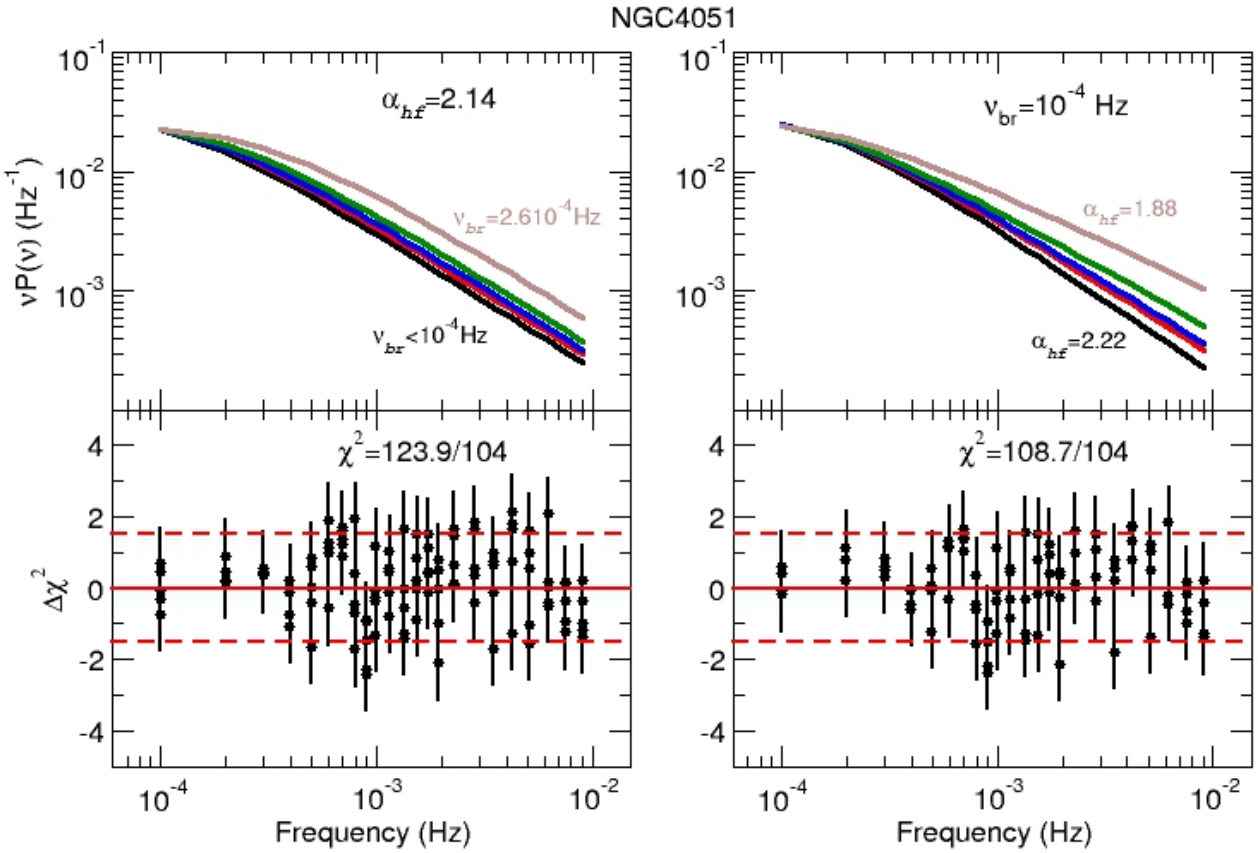
and...

c) Why does PSDamp anti-correlate with ν_{bf}?



Model 1

Model 2



Model 1

Model 2