A hard X-ray view of the soft-excess in AGN

The X-ray Universe 2017, Rome

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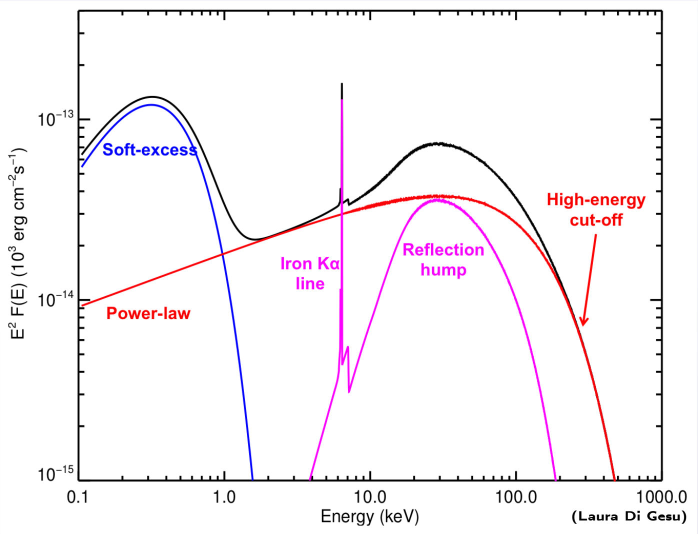
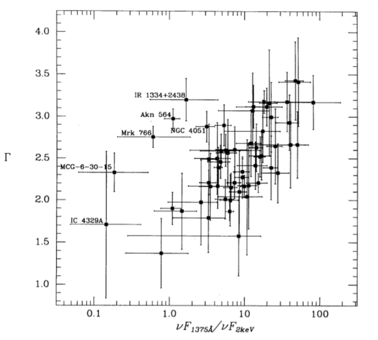
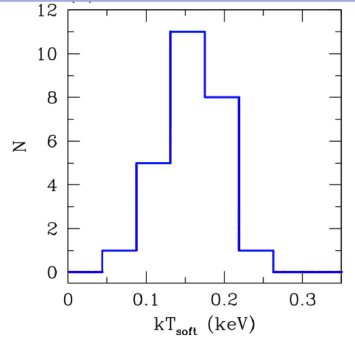
The X-ray emission of AGN



Warm Comptonization

- UV disk photons up-scattered by a warm Comptonizing corona
- (+) Model applied successfully in many objects ; Similarities between spectral shapes and variability of optical/UV and soft X-ray emissions
- (—) Soft-excess almost constant, same temperature T_{soft} that does not vary with M_{BH} or with T_{disk}

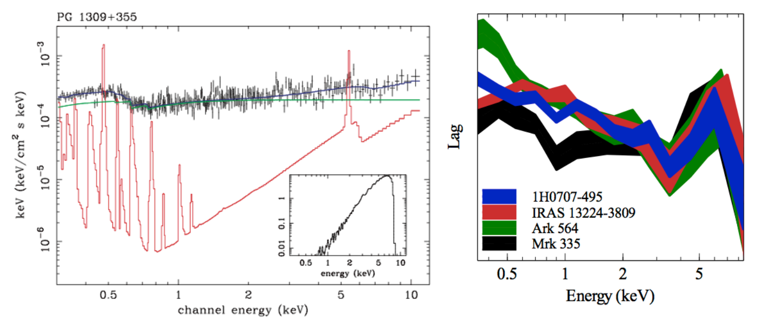




(Walter & Fink 93 ; Gierlinski & Done 04)

Blurred ionized reflection

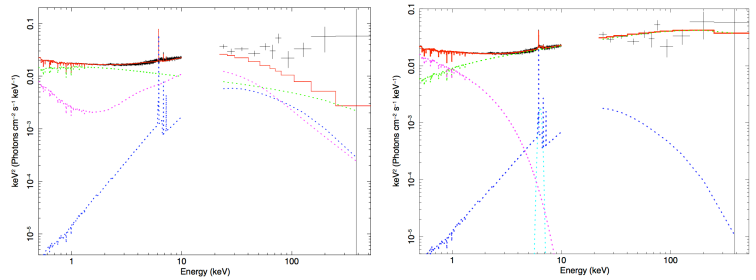
- Emission lines produced in the inner part of the ionized disk blurred by the proximity of the SMBH by strong Doppler and relativistic effects
- (+) Atomic transitions ; Applied successfully in many objects ; Detection of broad iron lines ; Iron and soft X-ray time-lags
- (—) Extreme parameters needed (maximum spin, steep emissivity) ; Soft lags measured only on short timescales (e.g. Gardner & Done 2014)



(Crummy+06 ; Kara+13)

A hard X-ray view of the soft-excess in AGN (Boissay+16)

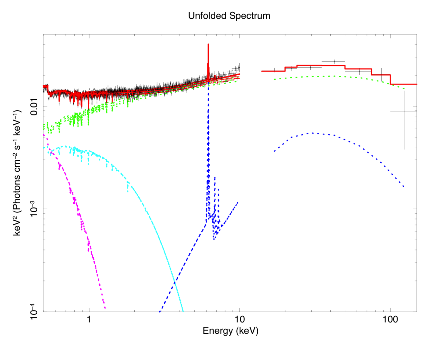
- **Aim** : Determine the origin of the soft-excess using hard X-rays, model-independent analysis
- **Method** : Study the differences at hard X-rays between AGN with different soft-excess strengths (statistical study)
- **Principle** :
  - If the soft-excess is due to **blurred ionized reflection** → **stronger reflection hump expected in objects with stronger soft excess**
  - If the soft-excess is due to **Comptonization** → **no difference** expected



(Boissay+14)

Sample and spectral fitting (Boissay+16)

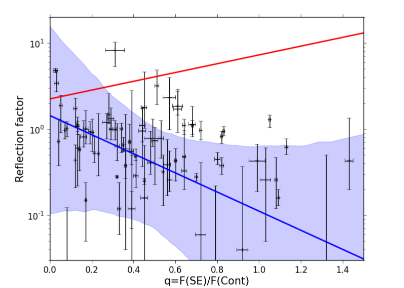
- **102 sources** from Swift BAT 70-Month Hard X-ray Survey catalog (Seyfert 1s)
- **BAT** and **XMM-Newton** obs.
- **Spectral fitting** :
  - cut-off power-law continuum
  - neutral reflection
  - soft-excess : 2 Bremsstrahlung
  - cold/warm absorption
- 80% with SE, including 37% lowly absorbed
- **Definition SE strength** : $q = F^{Brems.}_{0.5-2keV} / F^{Cont.}_{0.5-2keV}$



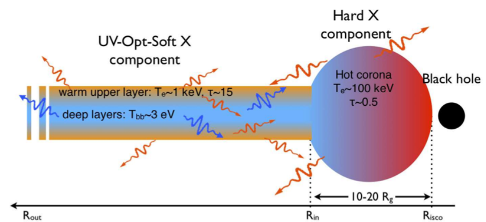
(Boissay+16)

Comparison between simulations and data (Boissay+16)

- **Simulations** blurred ionized reflection : R-q **correlation**
- **Data** : **opposite trend**
- **Against ionized-reflection**
- **Warm Comptonization** : larger covering of AD by plasma at $T_e \sim 1$ keV $\Rightarrow q \nearrow$ and high $\xi \rightarrow$ featureless reflection $\rightarrow R \searrow$



(Boissay+16)

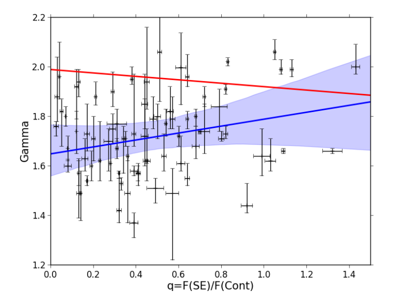


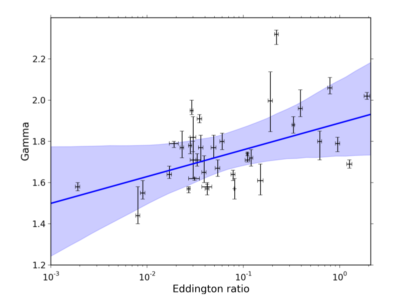
(Mrk 509 : Petrucci+13)

Evolution of the photon index **(Boissay+16)**

- Correlation Γ–q $\rightarrow$ link SE and cooling of the hot corona
- Correlation Γ–λ_{Edd} $\rightarrow$ link accretion disk and hot corona
- Possible correlation q–λ_{Edd} $\rightarrow$ link accretion disk and SE

$\rightarrow$ **Correlations compatible with warm Comptonization model** (e.g. Mrk 509)

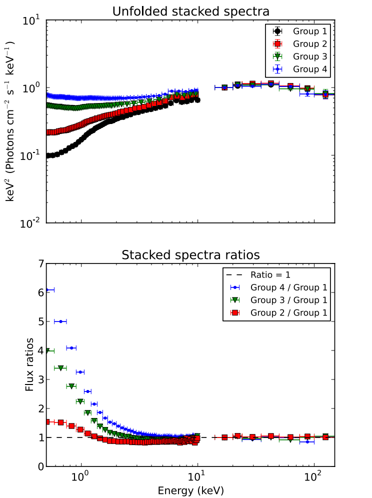




(Boissay+16)

Stacking of spectra (Boissay+16)

- **Stacking** of BAT and XMM-Newton spectra
- **4 groups of SE strengths**
- SEDs and ratios of stacked spectra
- For different SE strengths, no difference in the hard energy band : **no link between reflection and soft-excess**
- **For increasing SE strengths, steeper spectra**
- ⇒ Confirmation of results found for individual spectra



(Boissay+16)

Conclusion of this work

Published in A&A in 2016
by Dr. Rozenn Boissay, Dr. Claudio Ricci and Prof. Stéphane Paltani

- **Statistical model-independent** analysis
  $\Rightarrow$ **no link between reflection and SE** (disfavors blurred ionized reflection)
  $\Rightarrow$ **links between SE, hot corona and accretion disk** (favors warm Comptonization)

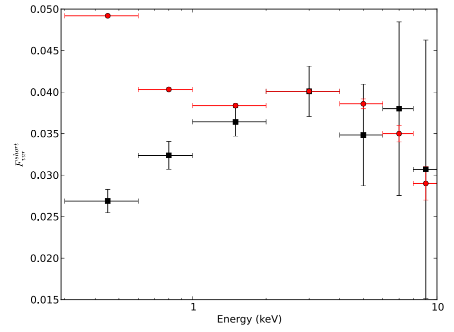
- **Both mechanisms** may be at work in all objects, but dominance of one over the other, depending on physical conditions and time scales

Ongoing project

Sy1s **simultaneous NuSTAR and Chandra/XMM-Newton** obs.

- Similar analysis as in our previous work : **the hard x-ray view of the SE** (e.g. relation R vs SE)
- **Broad-band spectral analysis** :
  - **Different models for the SE**
  - **Absorption** : Chandra gratings and XMM/RGS
  - Recent physical models for **continuum and hard X-ray reflection**
  - **Establish the nature of the soft excess for groups of similar objects** (e.g. λ_{Edd}, M_{BH}) thanks to the distribution of characteristic parameters

- **Timing analysis** :
  - **Variability** (diff. time scales) : example **Mrk 509** (Boissay+14)
  - **Time lags** (diff. time scales)



(Boissay+14)

Thank you !