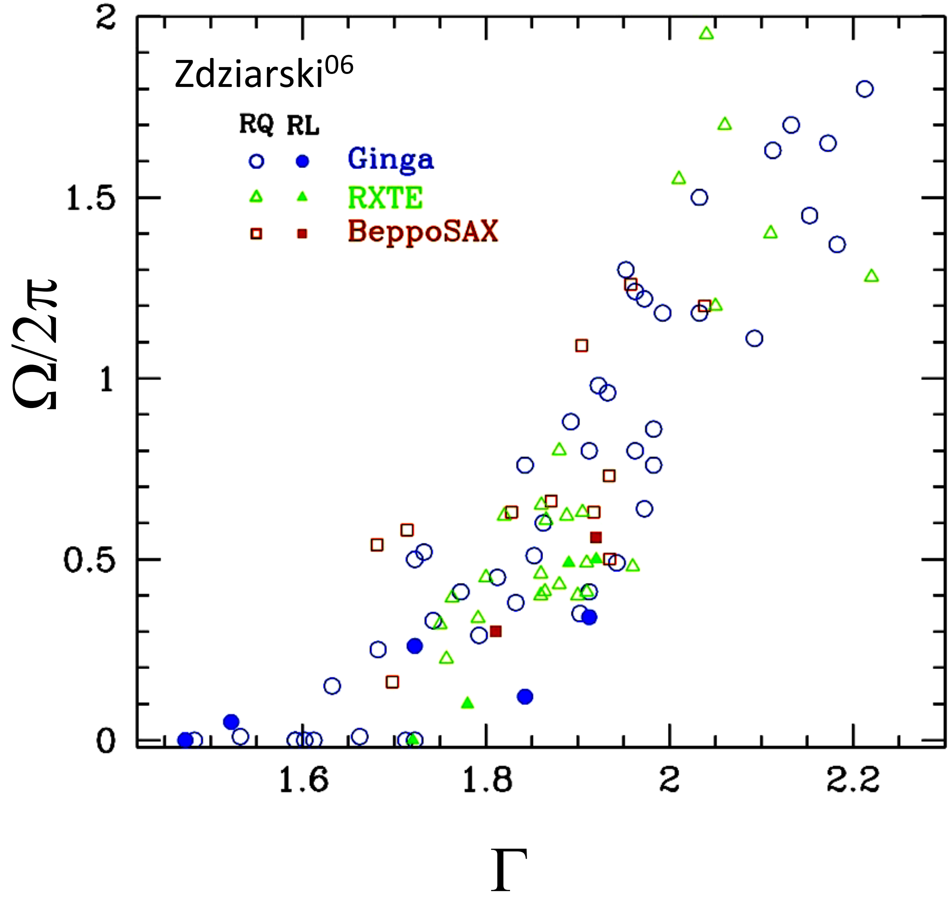
Explaining the global X-ray Baldwin effect with XMM-Newton

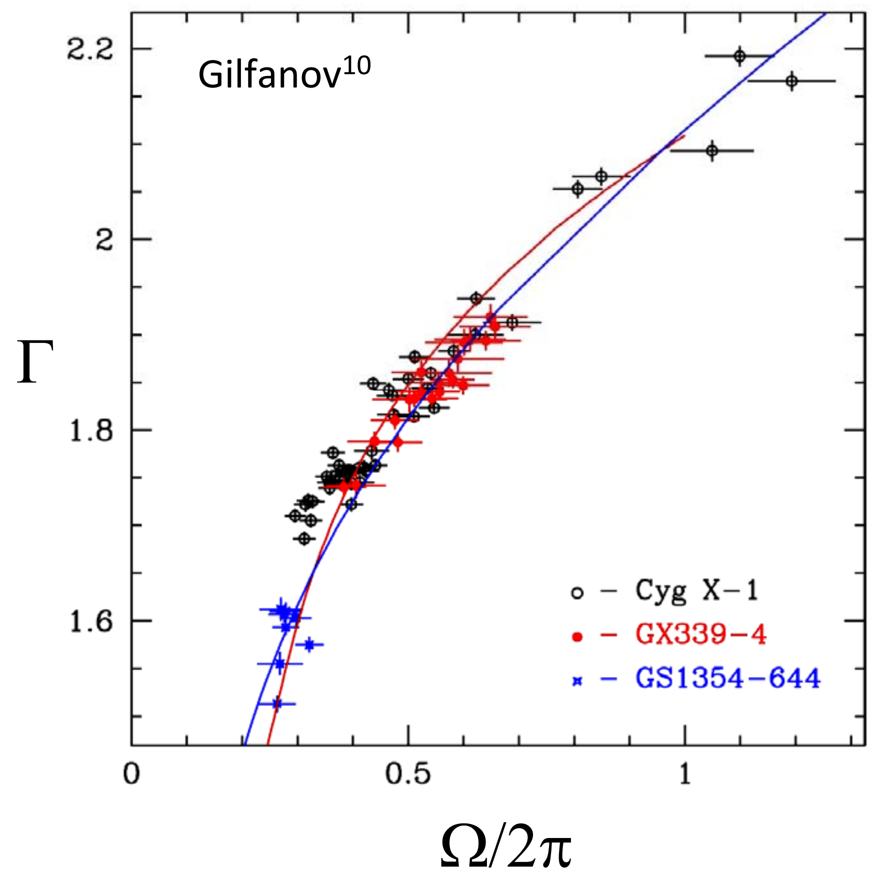
Thomas Boller
Max-Planck-Institut für extraterrestrische Physik Garching
Germany

The strong correlation between the intrinsic spectral slope Γ in X-rays and the amount of Compton reflection $\Omega/2\pi$

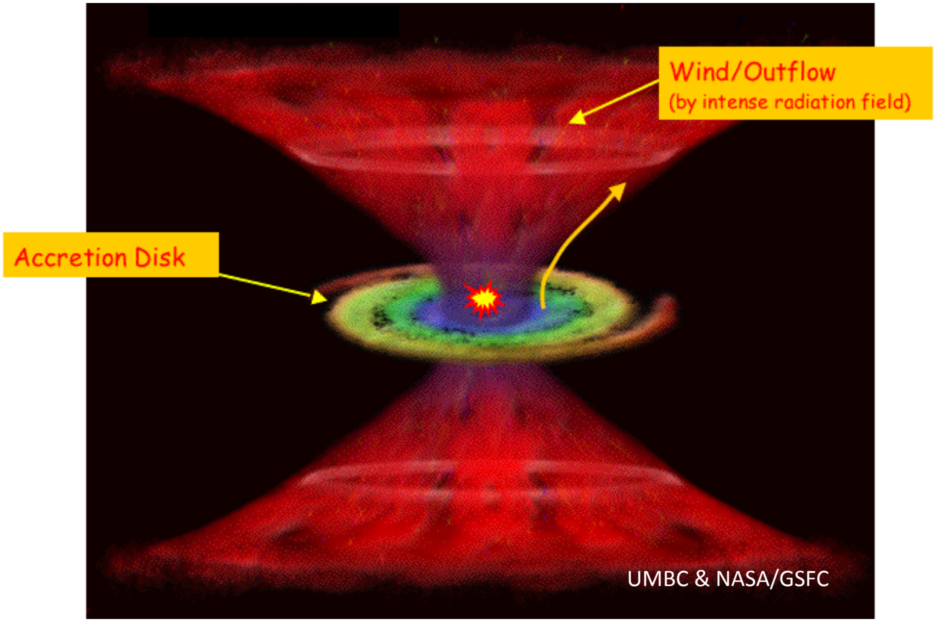
AGN

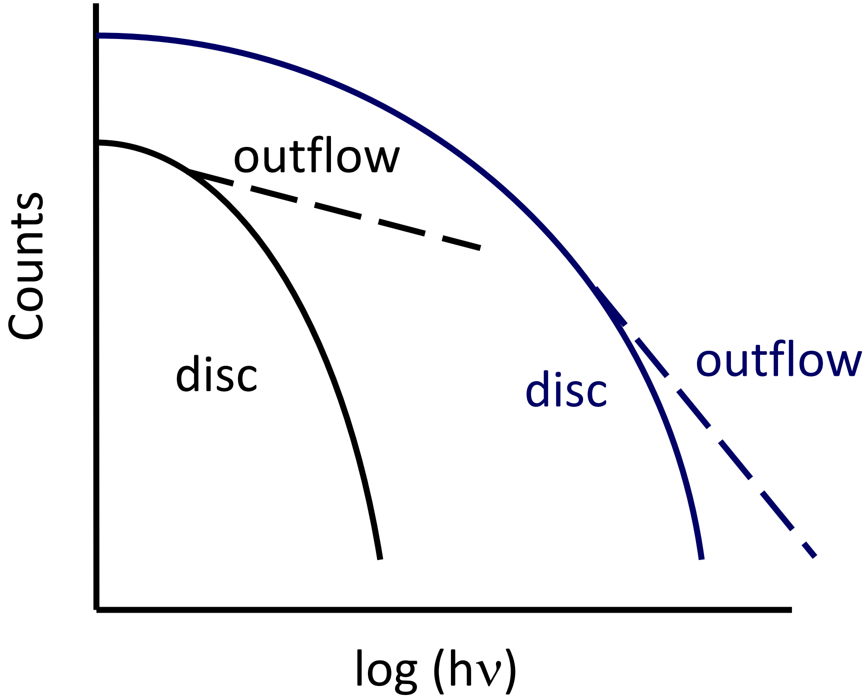


Galactic black hole binaries



The $\Omega/2\pi$ - Γ correlation is explained by Comptonization of AGN accretion disc photons

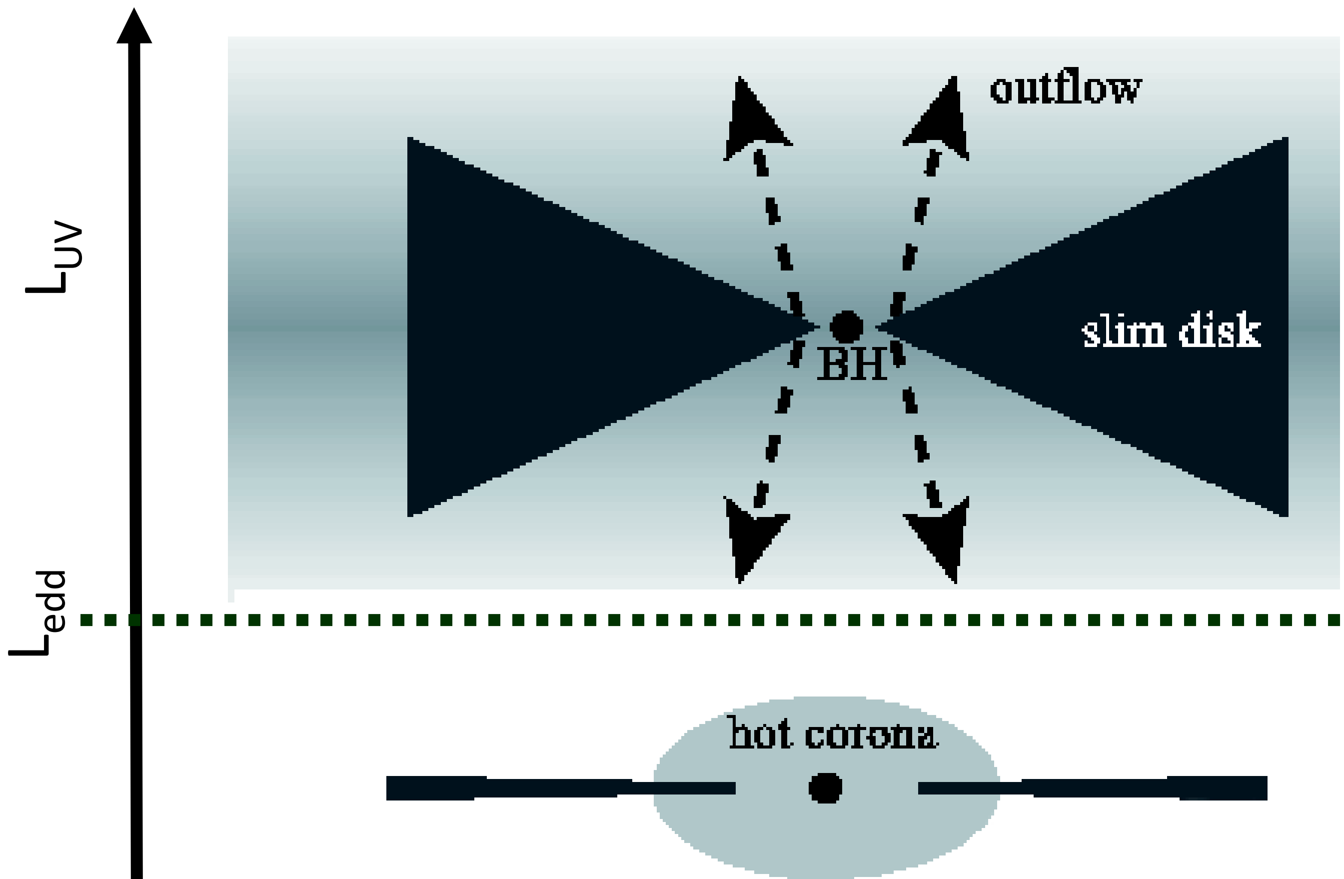




the larger the solid angle $\Omega/2\pi$ subtended by the reflector and the stronger the luminosity L_{UV} of soft photons is:

- the greater is the cooling by seed photons incident on the plasma
- the lower is the plasma electron temperature $\Theta = kT_e/mc^2$
- the steeper are the X-ray photon indices Γ
- the weaker is the X-ray luminosity L_X
- the lower are the α_{ox} values

Accretion states and Comptonizing coronal parameters



- Super-Eddington
- radiation driven outflows with $\tau >> 1$
- cool corona
- photon trapping

- weak and steep Comptonized X-ray emission

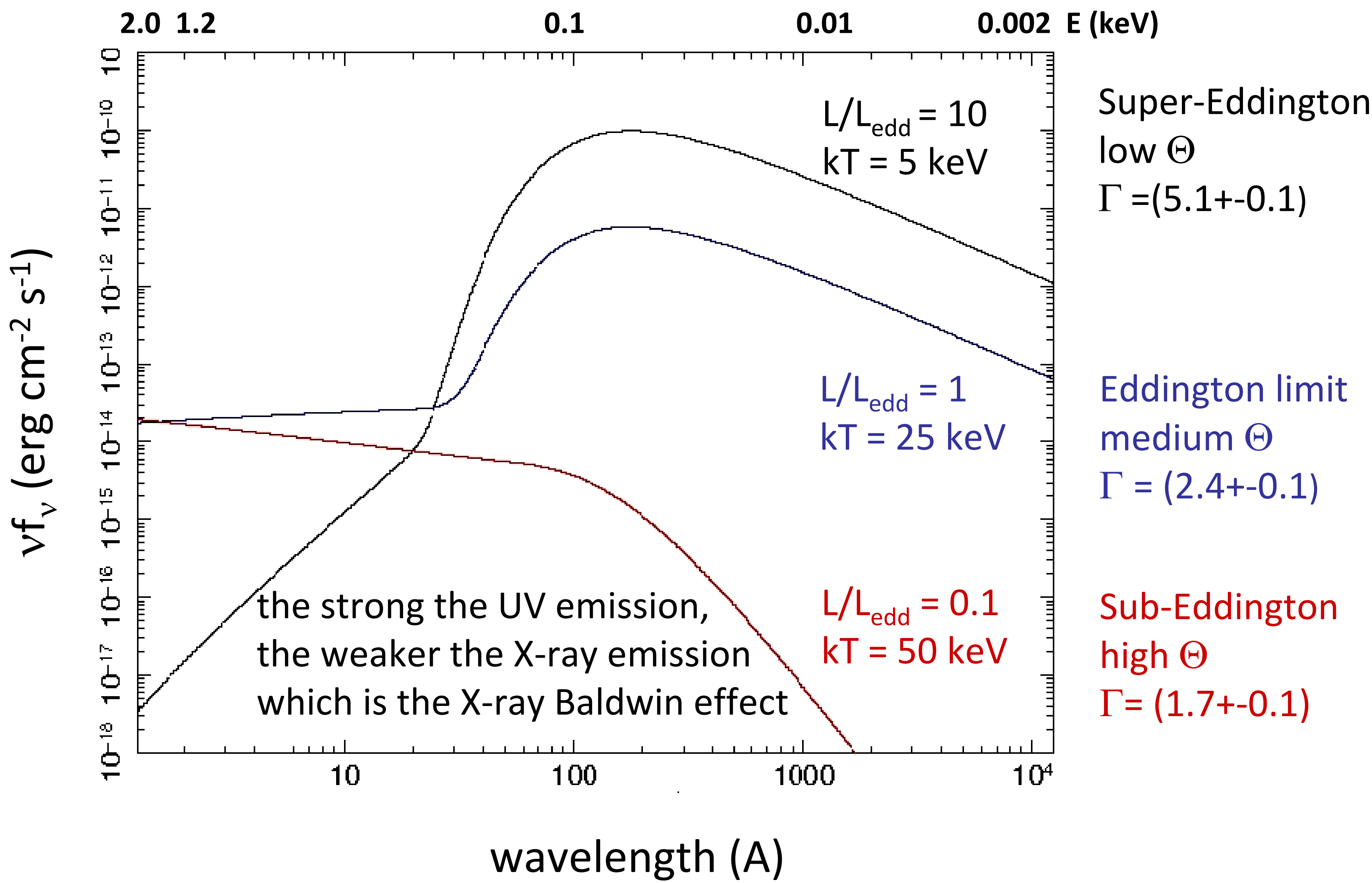
- standard disk
- sub-Eddington
- hot corona

- strong and flat Comptonized X-ray emission

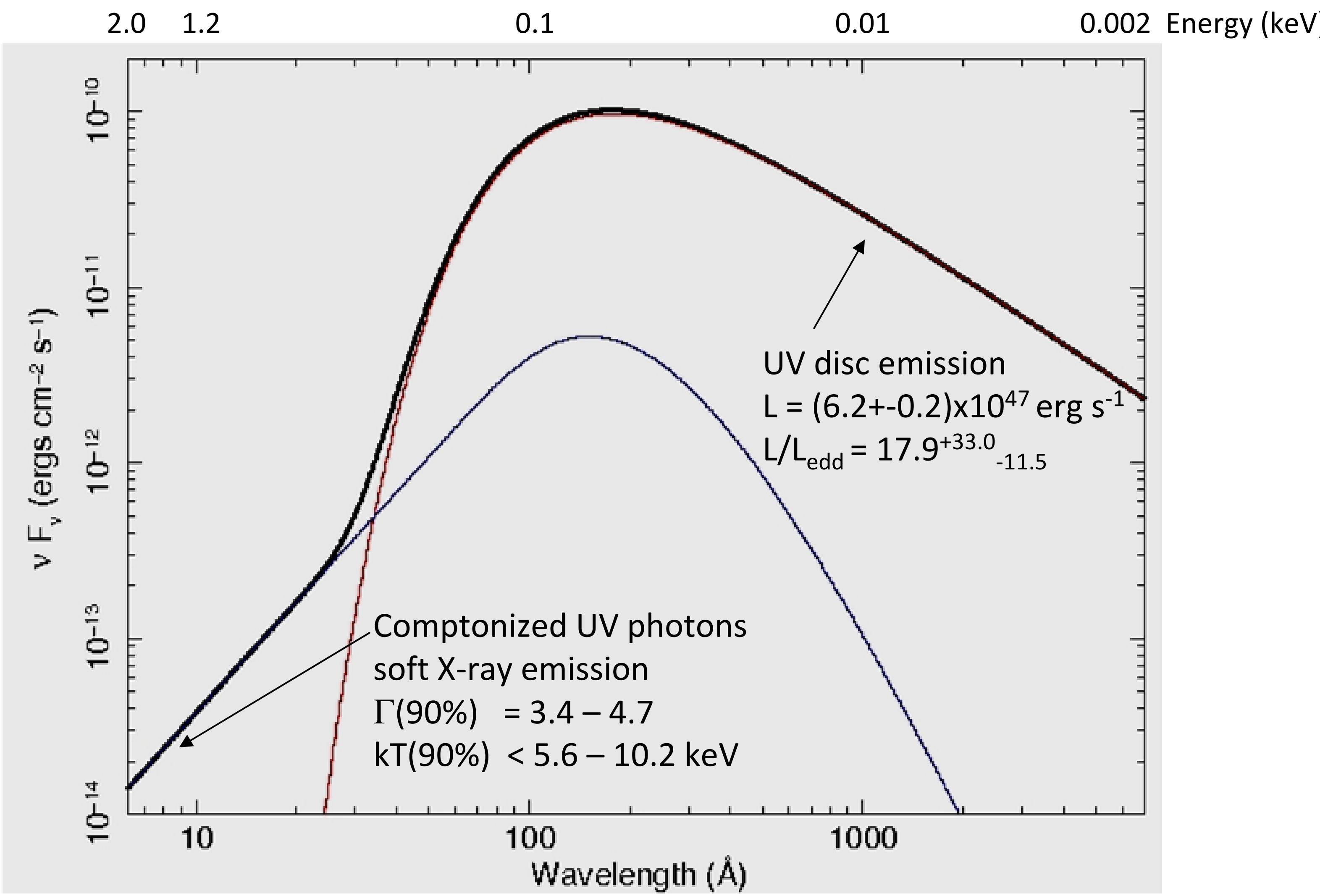
$$\Gamma = \ln \tau \,/\, \ln (1 + 4\Theta)$$

$$L_{corona} = f(\Theta, \tau)$$

XMM-Newton simulations of AGN accretion states and Comptonized plasma parameters

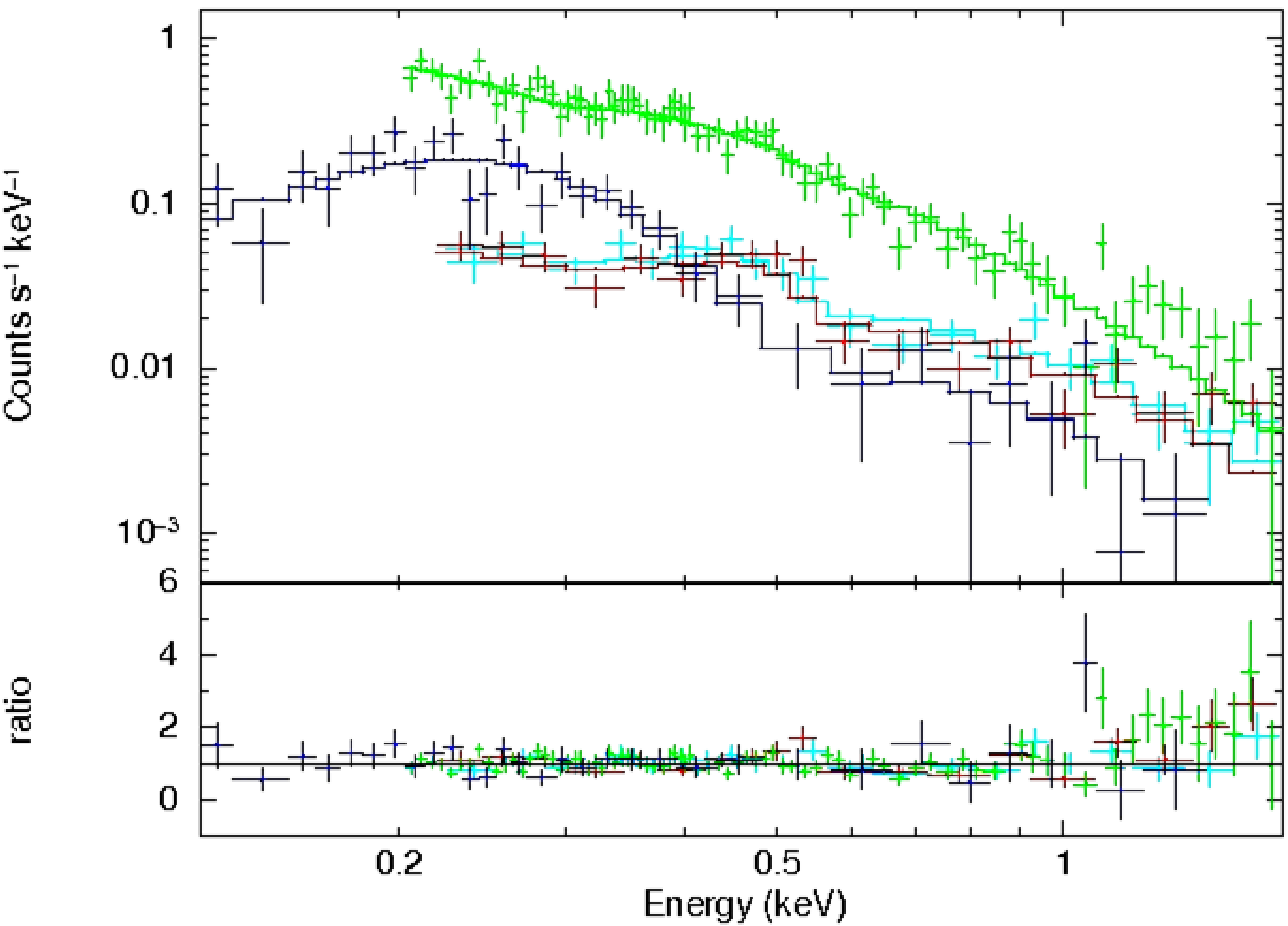


LBQS 0102-2713 as an extreme for AGN accretion states and Comptonized plasma parameters



LBQS exhibits one of the steepest soft photon indices

joint fit to the XMM-Newton and ROSAT data



observed photon index

	Γ(90%)
M1	**3.4-4.0**
M2	**3.5-4.0**
PN	**3.8-4.3**
ROSAT	**3.7-4.7**

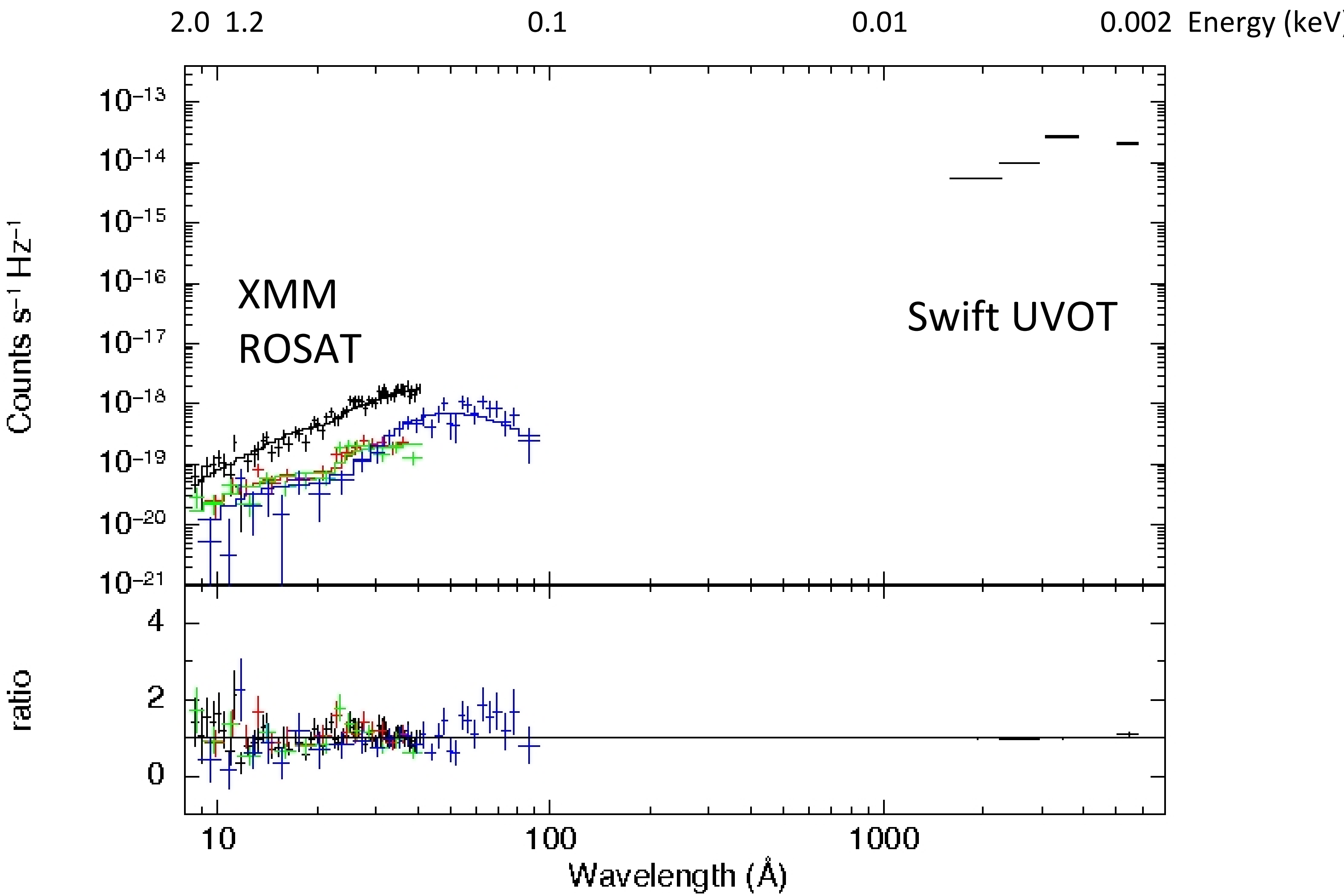
mean value

2.3 with large scatter

ROSAT	Walter, Fink[93]
Chandra	Green[08]
SDSS, PSS	Vignali[03]
	Brandt, Just[07]
	Shemmer[04]
	Strateva[07]

LBQS 0102-2713: XMM-Newton, Swift, ROSAT data

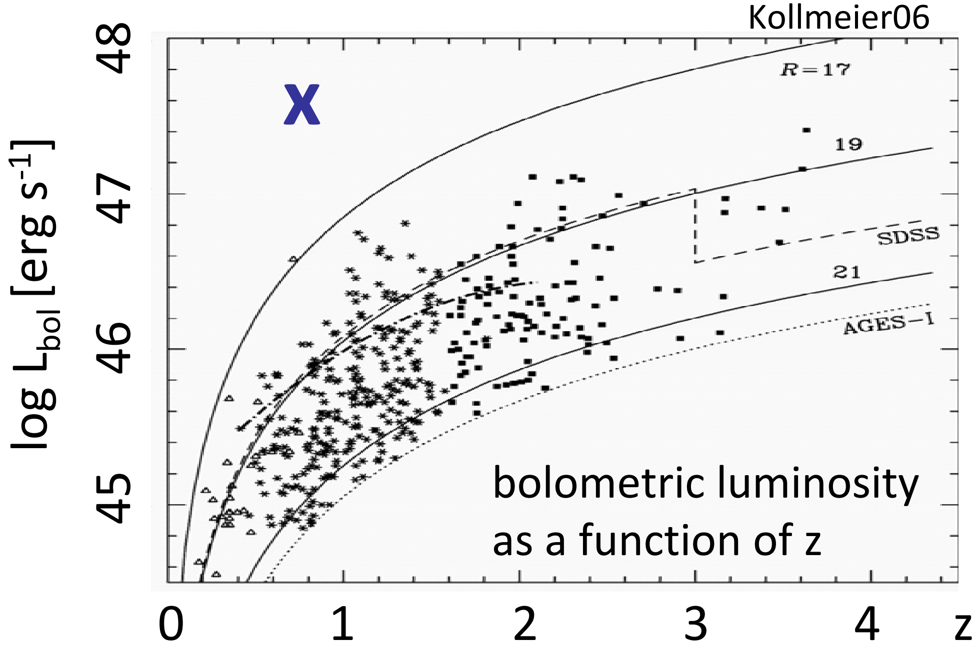
accretion disc spectrum + local Comptonized emission



LBQS 0102-2713: Luminosity, Mass and Eddington ratio

LUMINOSITY:
$L = (6.2 \pm 0.2) \times 10^{47}$ erg s^{-1}

the most luminous quasar in the local universe ?

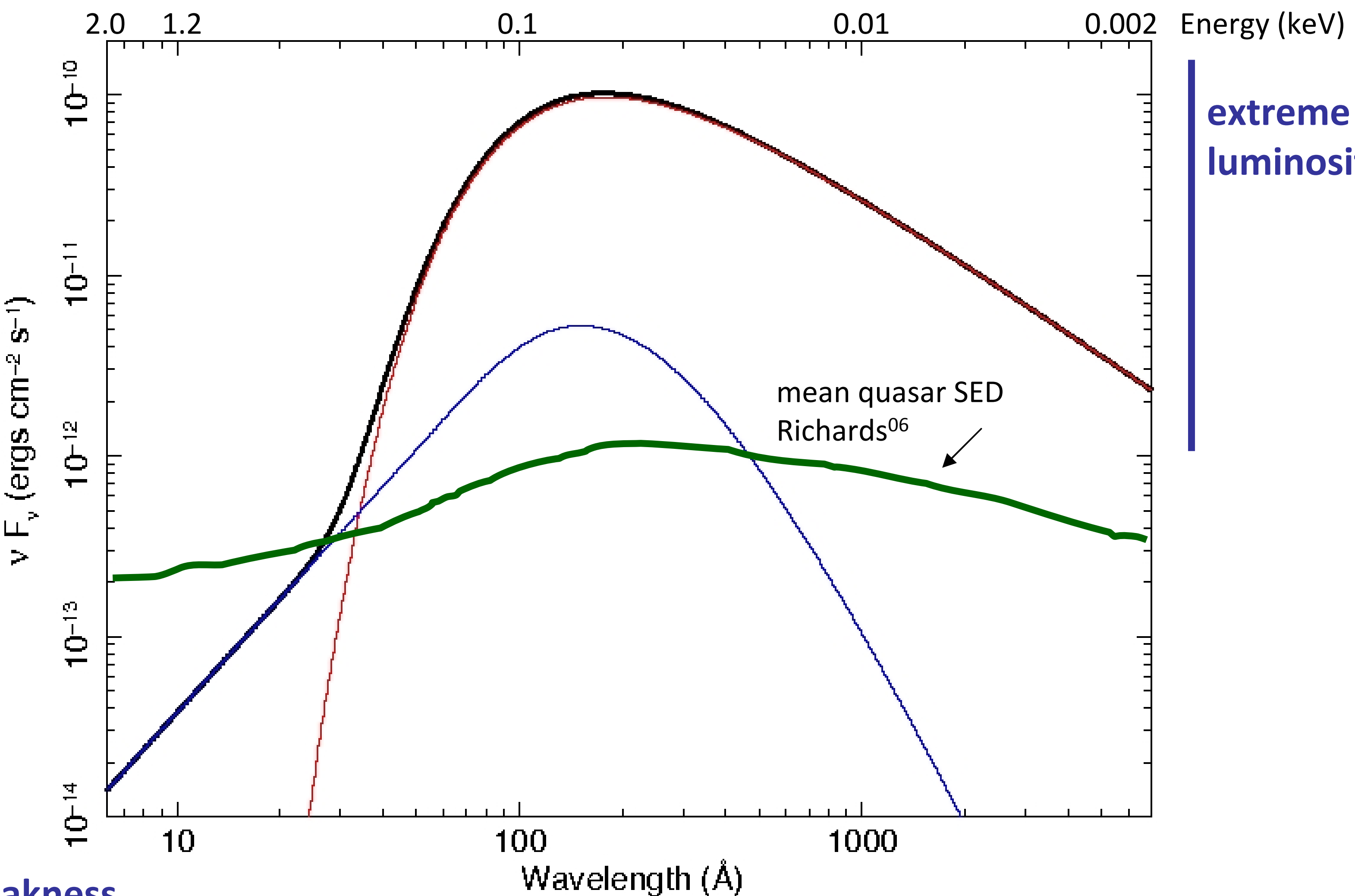


MASS:
$M = (2.5^{+4.3}_{-1.6}) \times 10^{8}\ M_{sun}$

EDDINGTON RATIO:
$L/L_{edd} = 17.9^{+33.0}_{-11.5}$

one of the highest Eddington ratios measured so far

LBQS 0102-2713: Comparision with mean quasar SED

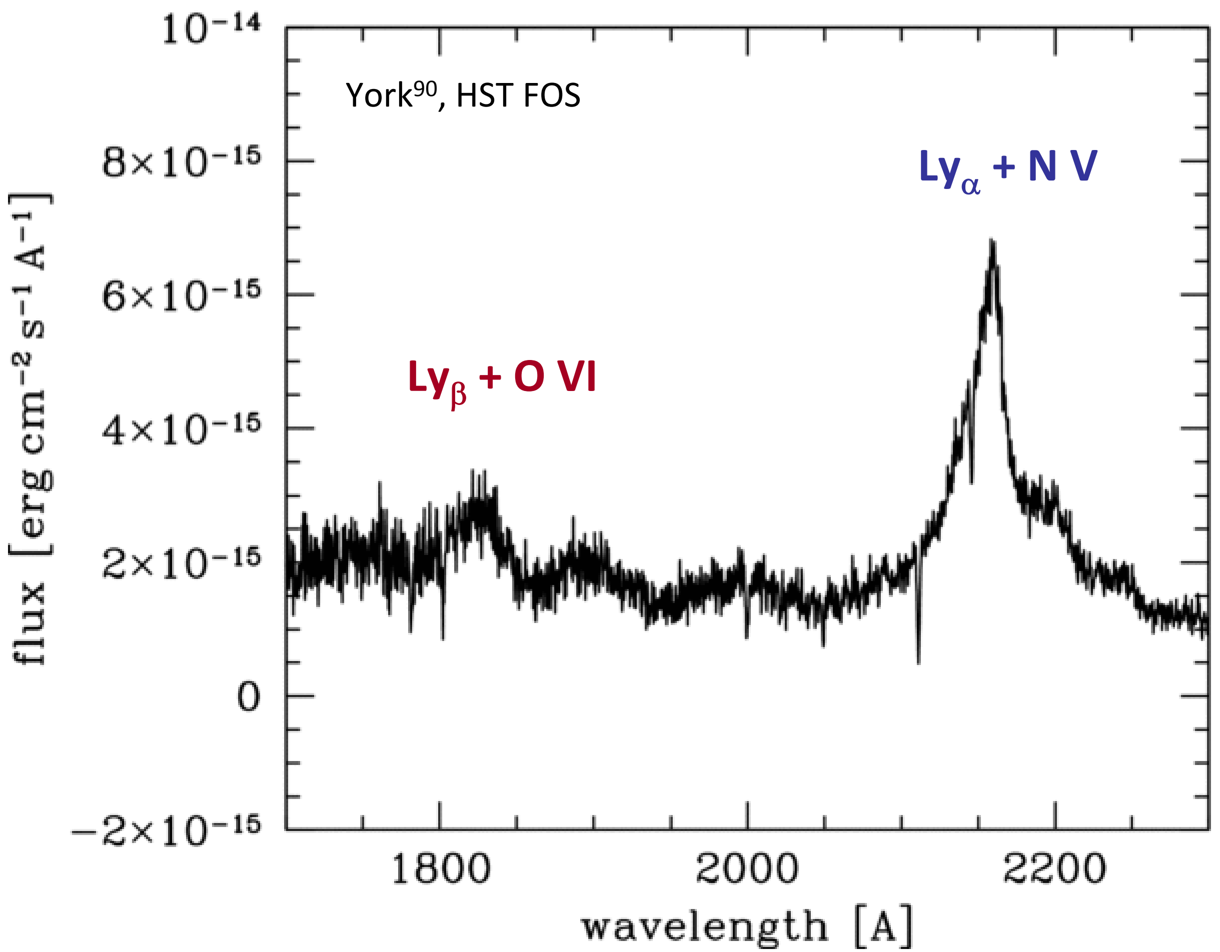


extreme UV luminosity

X-ray weakness

- **low plasma temperature**
- **steep Γ**

The UV line emission is comparable to quasar composits and LBQS is NOT intrinsically X-ray weak



rest frame EW values

Ly_β + O VI = 12 A measured

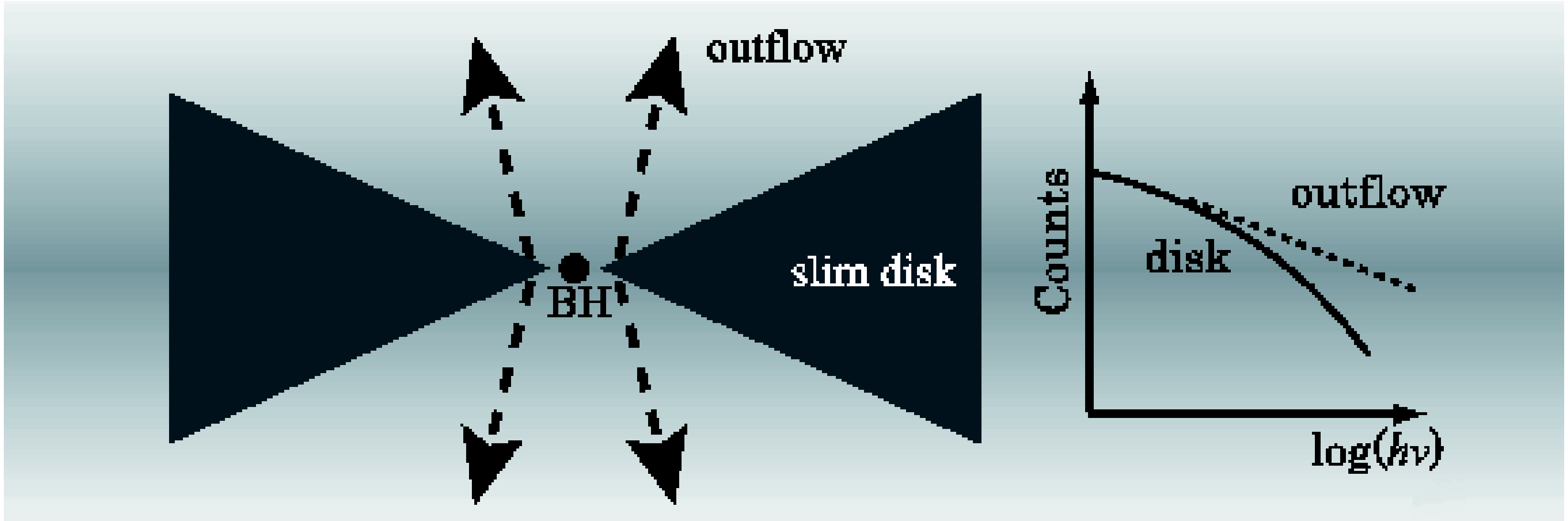
quasar composits
Brotherton 11 A
Zheng 16 A
Vanden Berk 9 A

Ly_α + N V = 70 A measured

quasar composits
Brotherton 87 A
Zheng 102 A
Vanden Berk 94 A

the X-ray weakness is explained by the Comptonization of accretion disc photons

LBQS 0102-2713: Super-Eddington accretion and an extremely cool corona



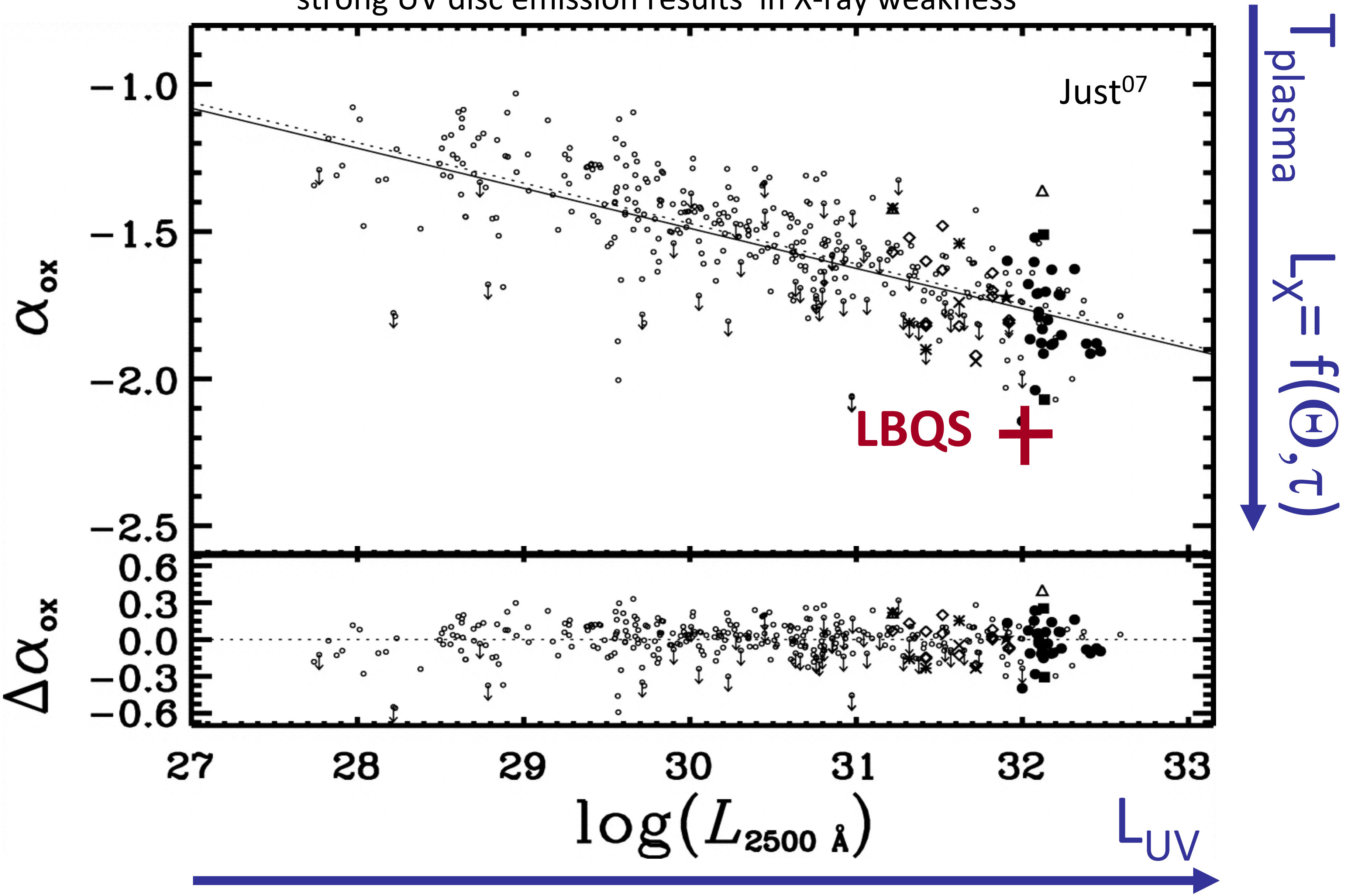
Super-Eddington accretion produce radiation-driven outflows with significant Thomson depth t >> 1 (e.g. Abramowicz88, Kawashima09), and such outflows Compton up-scatter photons, making the hard emission component

the **steep** soft X-ray photon indices Γ translate in Compton y parameters ranging between y = (0.05 and 0.08)

as $y = 4\,\Theta \times \tau$ and assuming a lower limit for τ of 1, the upper limit for $\Theta = kT_e/mc^2$ ranges between 0.01 and 0.02, corresponding to **low electron temperatures ranging between 5.6 and 10.2 keV**

An qualitative explanation for the global X-ray Baldwin effect

strong UV disc emission results in X-ray weakness



Summary

the larger the solid angle $\Omega/2\pi$ subtended by the reflector and the stronger the luminosity L_{UV} of soft photons is:

- the larger is the radiation-driven outflow (feedback)
- the greater is the cooling by seed photons incident on the plasma
- the lower is the plasma electron temperature $\Theta = kT_e/mc^2$
- the steeper are the X-ray photon indices $\Gamma = \ln \tau / \ln (1 + 4\Theta)$
- the weaker is the X-ray luminosity $L_X = f(\Theta,\tau)$
- the lower are the α_{ox} values

which generally explains the global X-ray Baldwin effect