THE L_X-L_{UV} RELATION IN QUASARS AND THE ENDLESS WONDERS OF THE DISC-CORONA INTERACTION

E. Lusso, E. Nardini, C. Niccolai, M. Rałowski,
G. Risaliti, A. Sacchi, A. Shenstlova, B. Trefoloni

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AGN XVI – Brindisi – 19/06/2026

IN THIS TALK

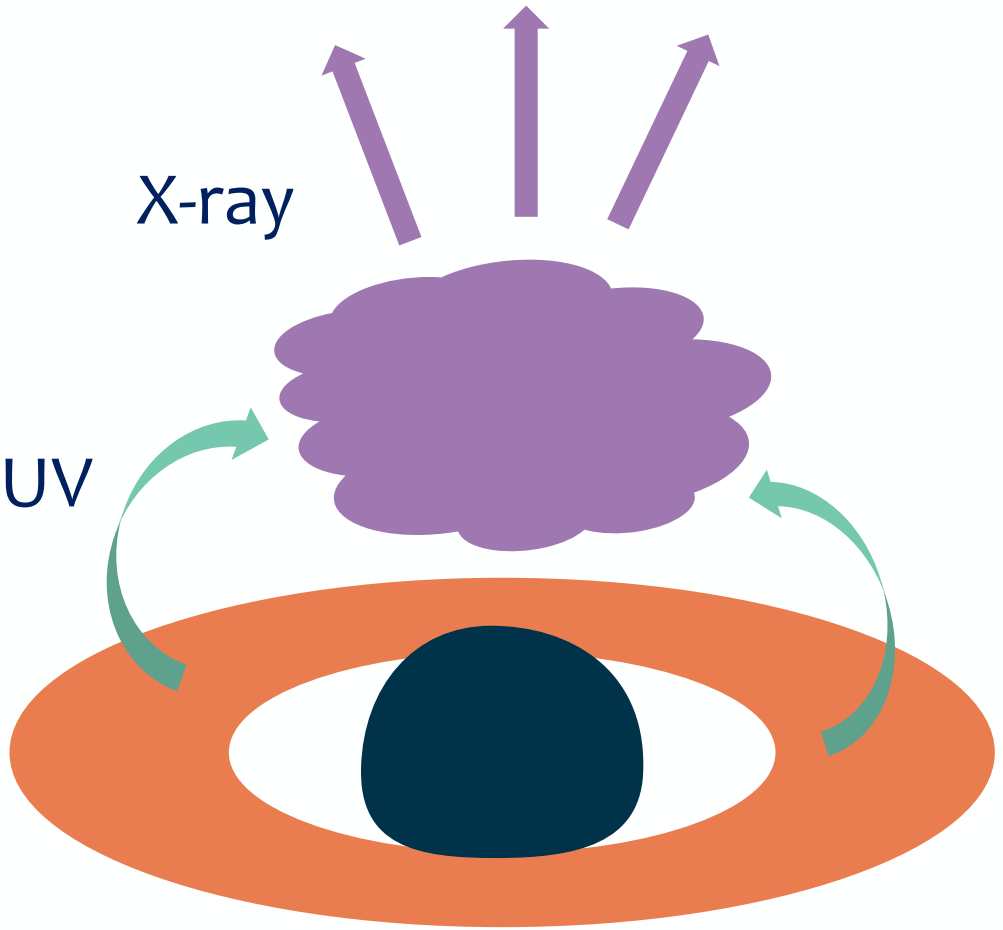
If you care about cosmology:

a new homogeneous sample (Risaliti+26b) to convince you the relation is solid

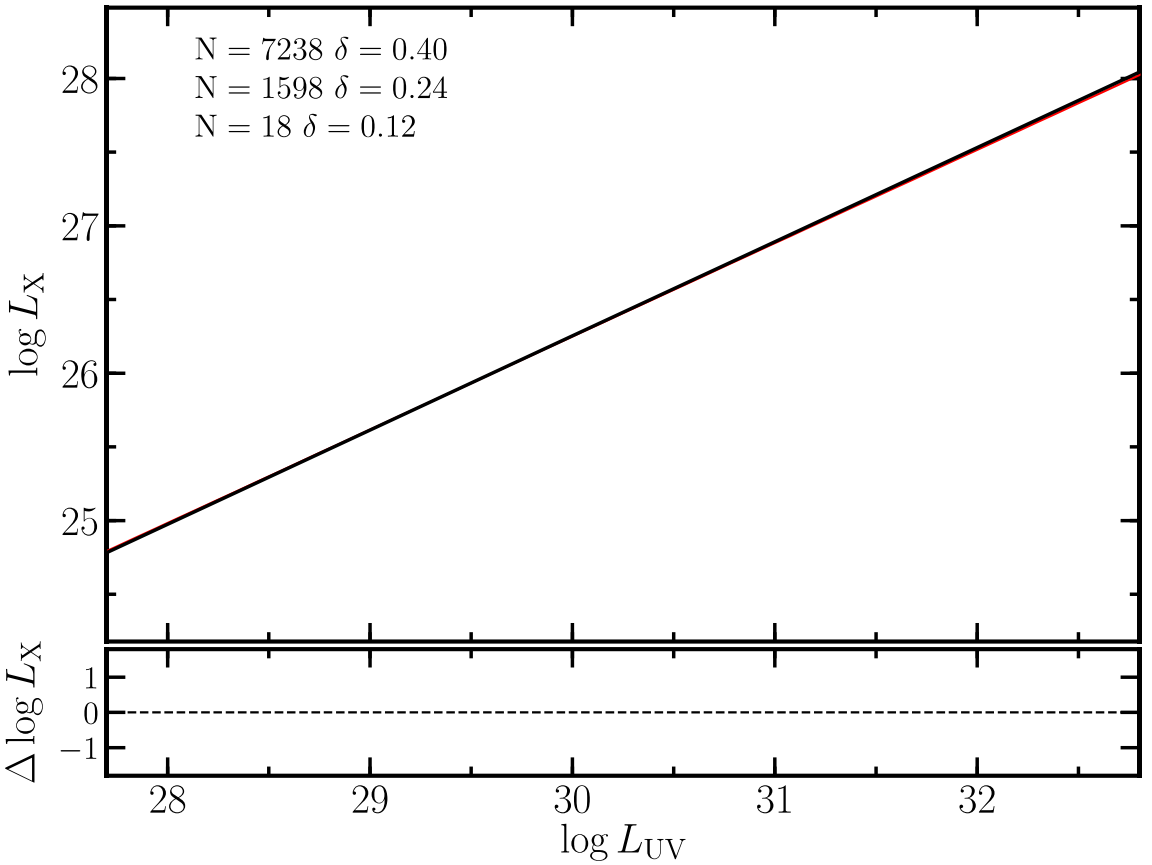
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If you are bored with the L_X-L_{UV} relation:

a new work on the Γ-λ_{Edd} relation



THE L_X-L_{UV} RELATION



Risaliti&Lusso19

$$\log(L_X) = \gamma \log(L_{UV}) + \beta$$

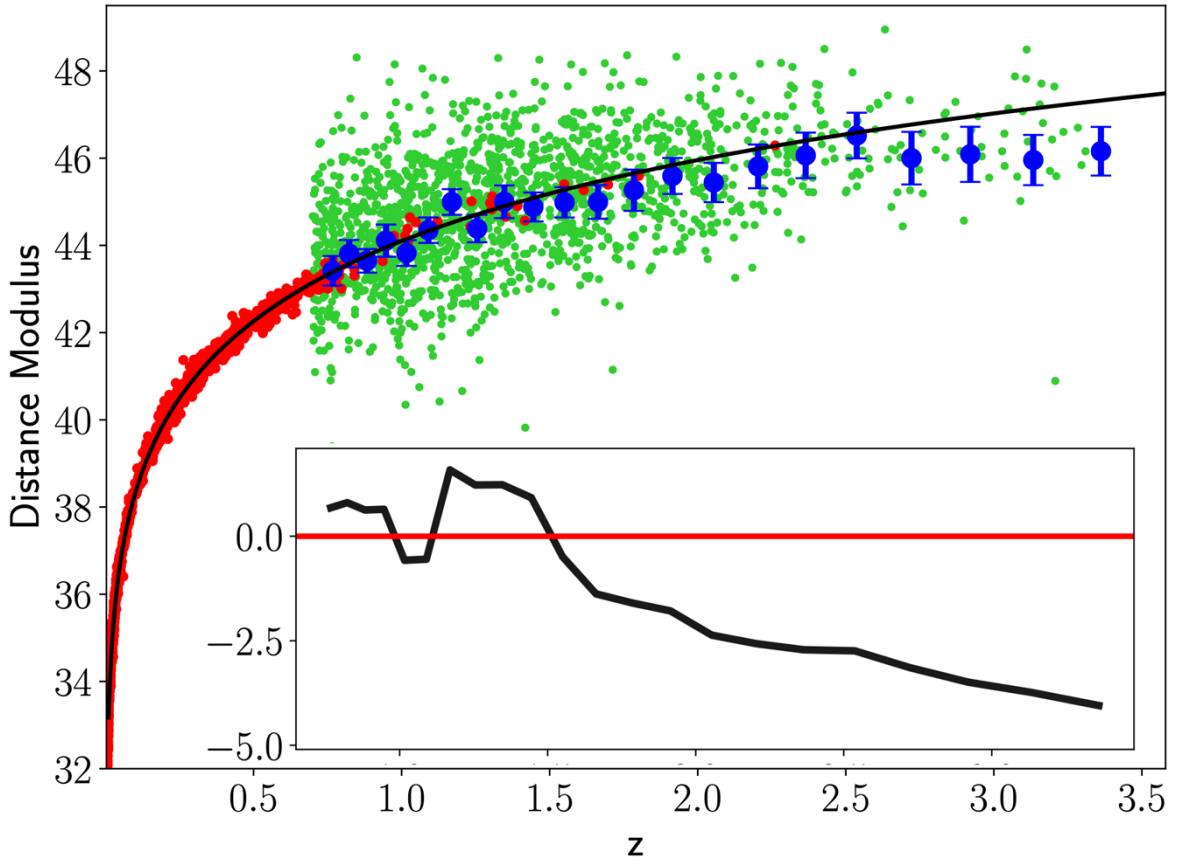
$$f_X = \frac{L_X}{4\pi D L^2} \qquad f_{UV} = \frac{L_{UV}}{4\pi D L^2}$$

$$\log(D_L) = \frac{1}{2 - 2\gamma}(\log(f_X) - \gamma \log(f_{UV})) + \beta'$$

Tension with ΛCDM!

See Beta Lusso's talk from yesterday ☺

THE L_X-L_{UV} RELATION



Risaliti&Lusso19

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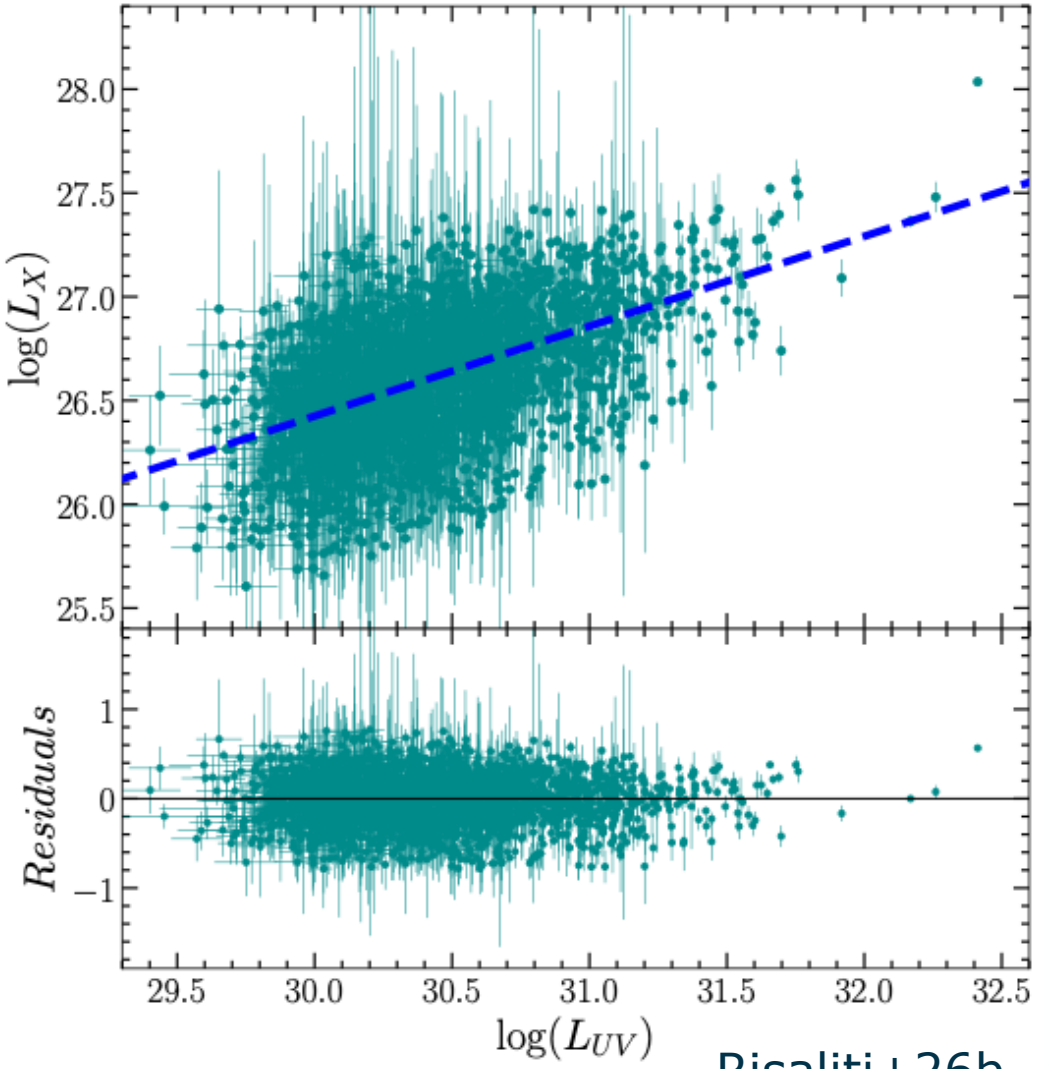
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SAMPLE SELECTION

SDSS DR16 (Wu&Shen 2022)
+
4XMM–DR14 (Webb 2020)

L_X-L_{UV} in one redshift bin: dispersion is very high, ~0.4 dex



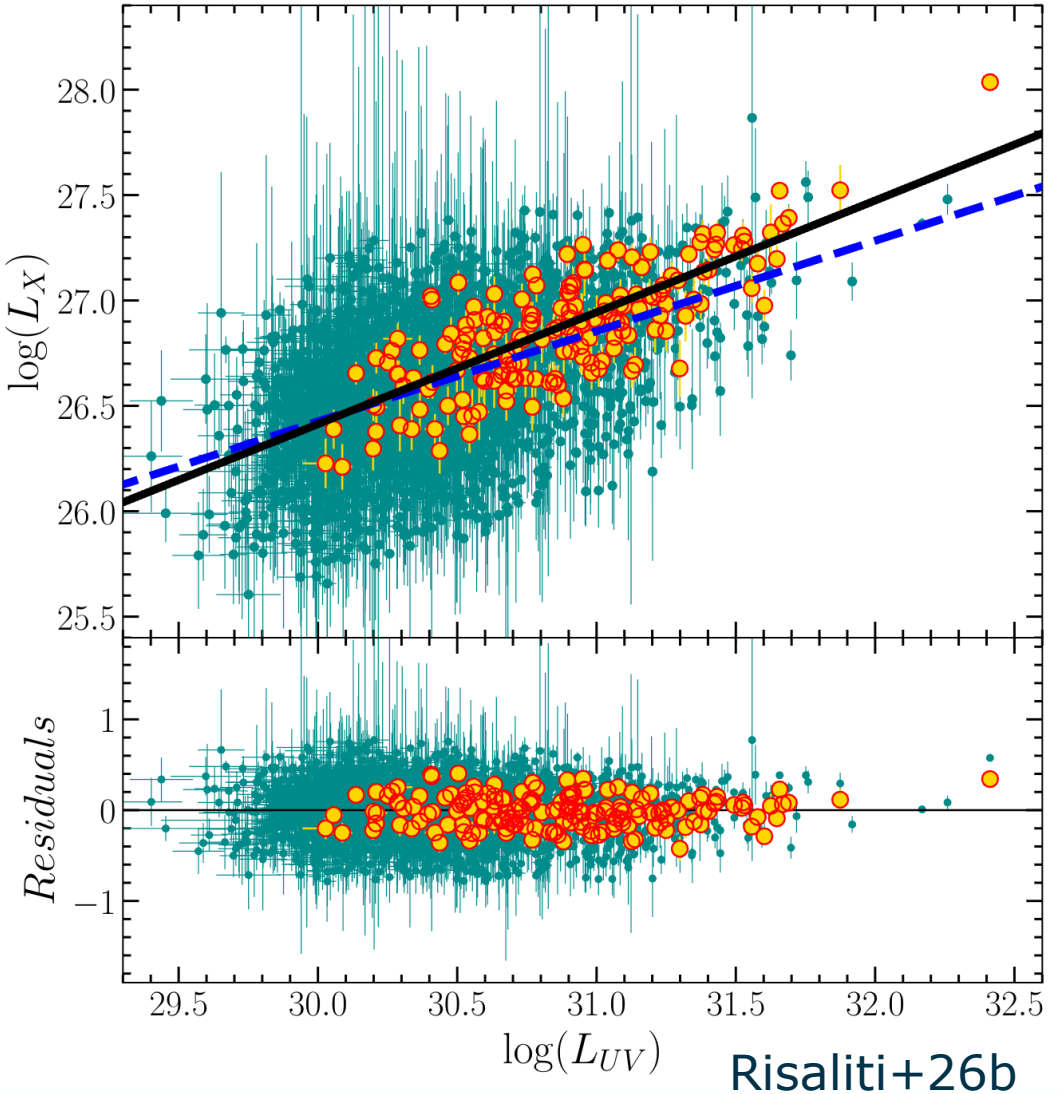
Risaliti+26b

SAMPLE SELECTION

SDSS DR16 (Wu&Shen 2022)
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4XMM–DR14 (Webb 2020)

L_X-L_{UV} in one redshift bin: dispersion is very high, ~0.4 dex

When we clean the sample we get ~0.15 dex! [Lusso+20 sample: 0.20 dex]



Risaliti+26b

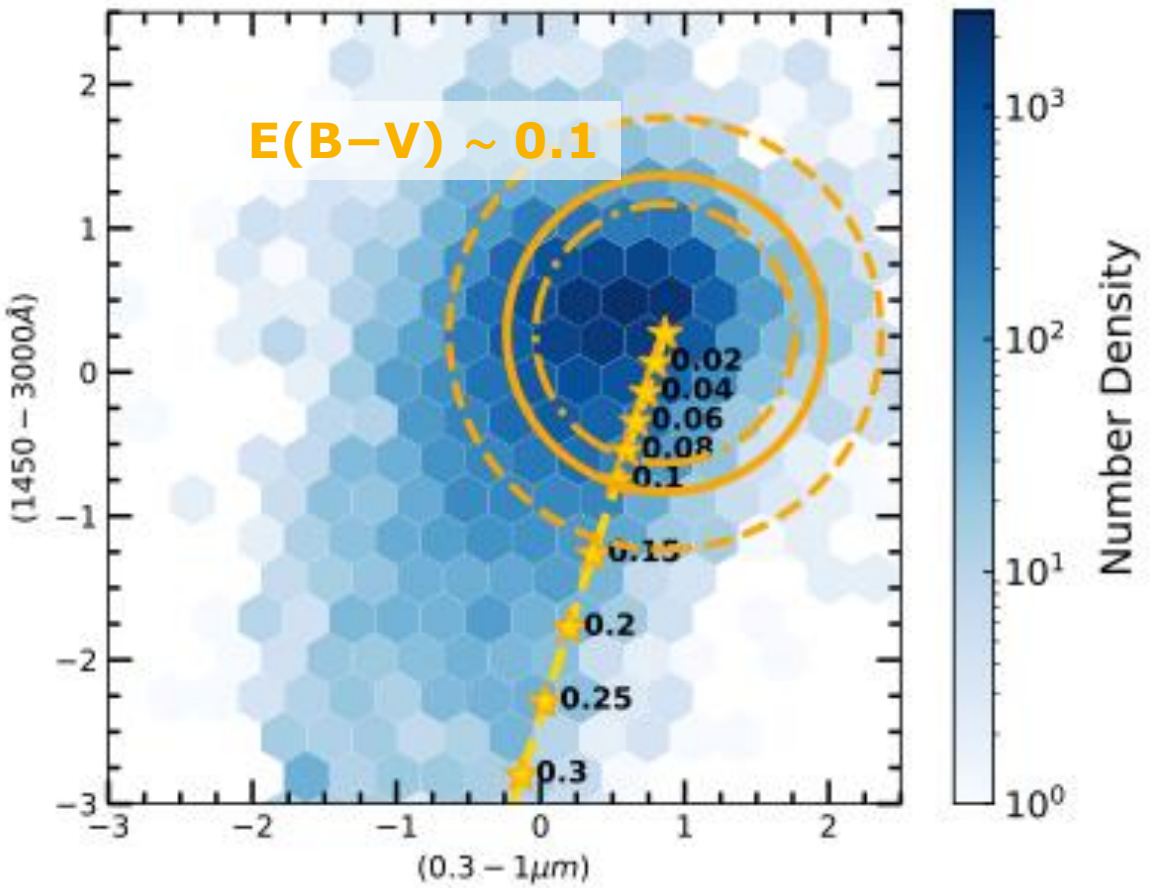
SAMPLE SELECTION

1) Remove Broad Absorption Lines &
   Radio-loud objects

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2) Remove objects with reddened UV colors (dust reddening and/or host galaxy contamination)
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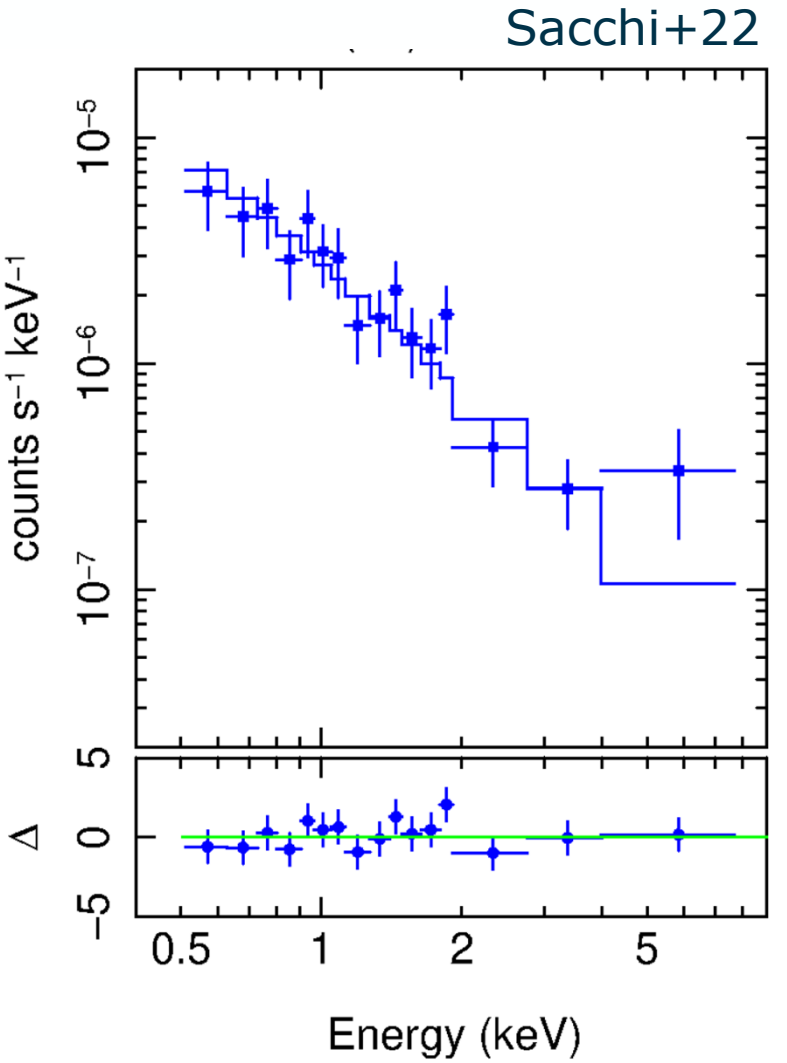
Risaliti+26b

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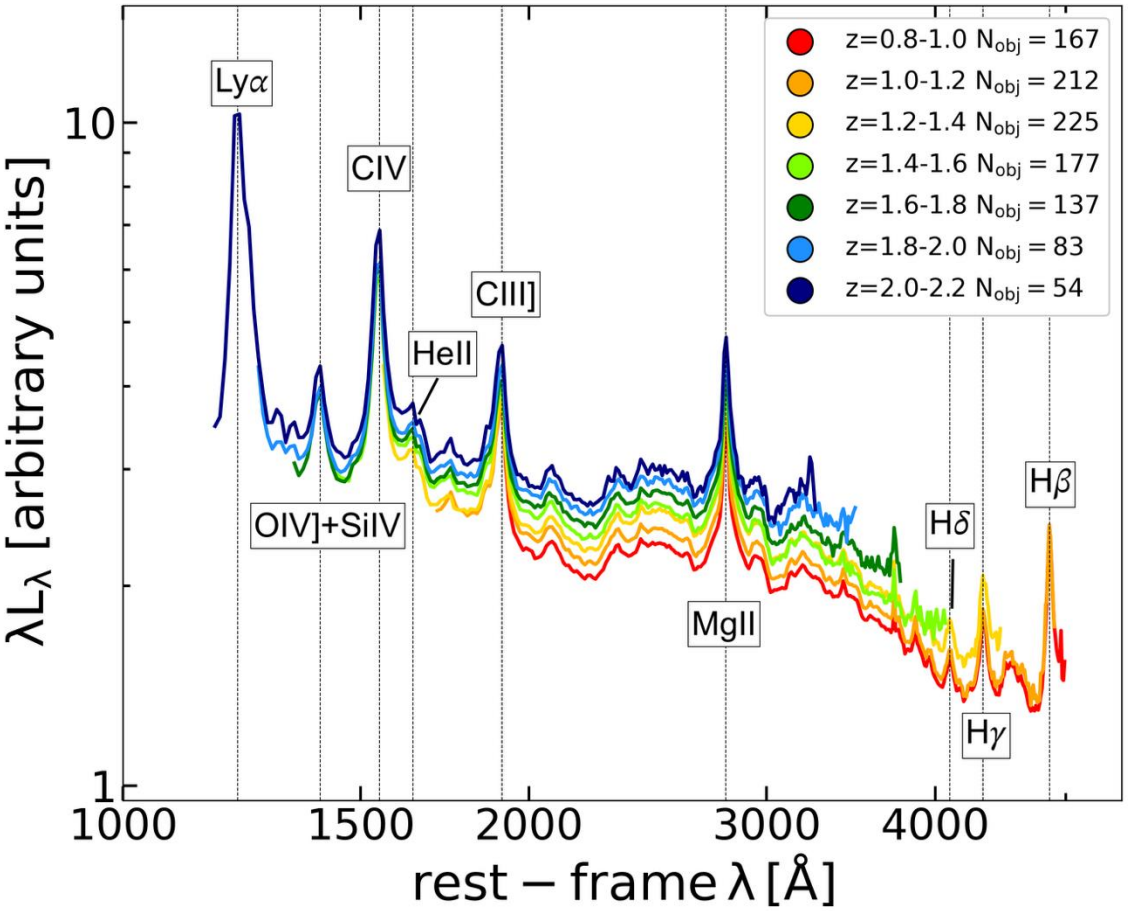
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all the objects all look the same!
(See also Trefoloni+24)

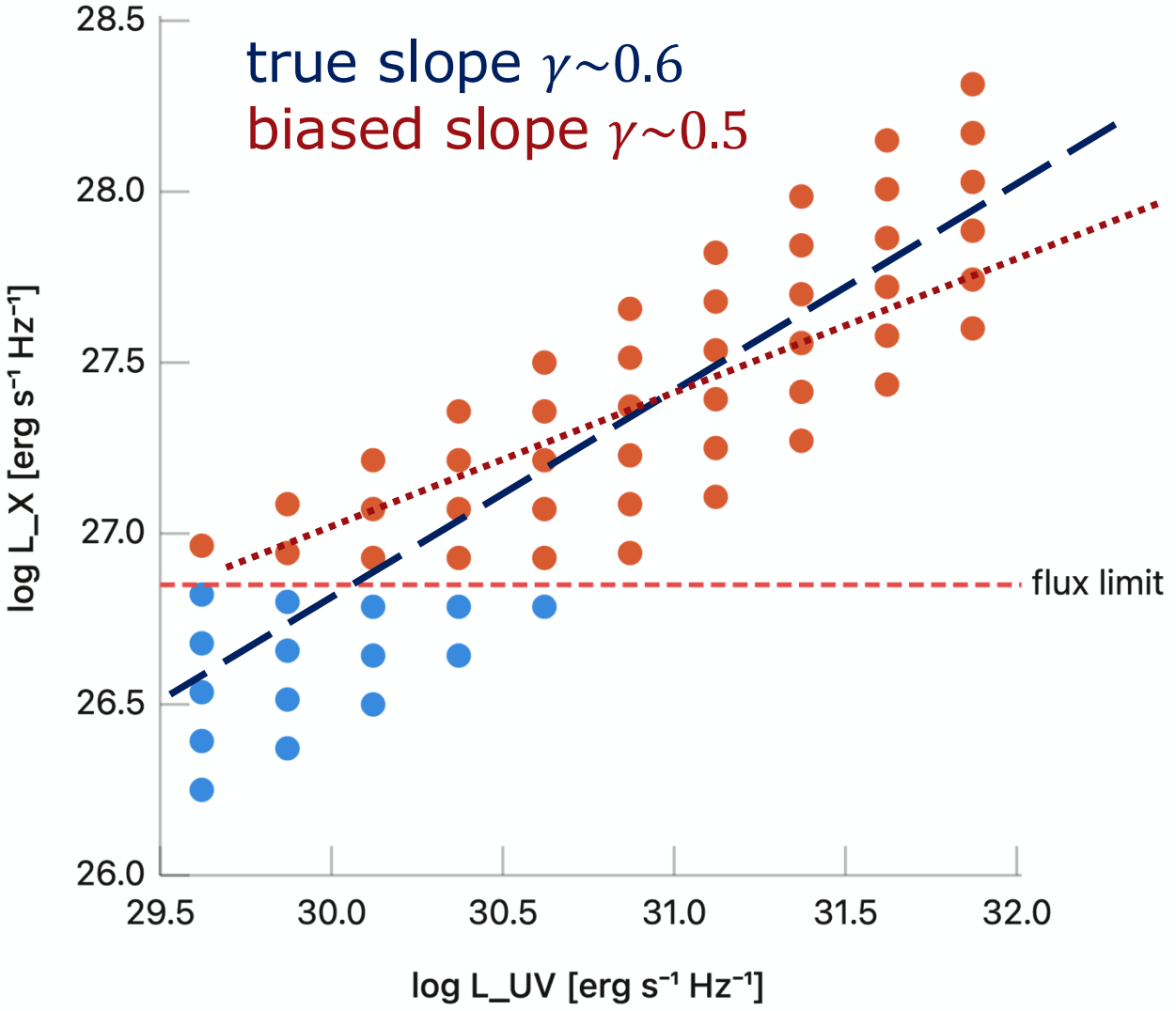


Risaliti+26b

SAMPLE SELECTION – EDDINGTON BIAS

Due to X-ray variability and the relation scatter, we detect objects close to the flux limit only when they are in a positive fluctuation state

This **flattens** the slope

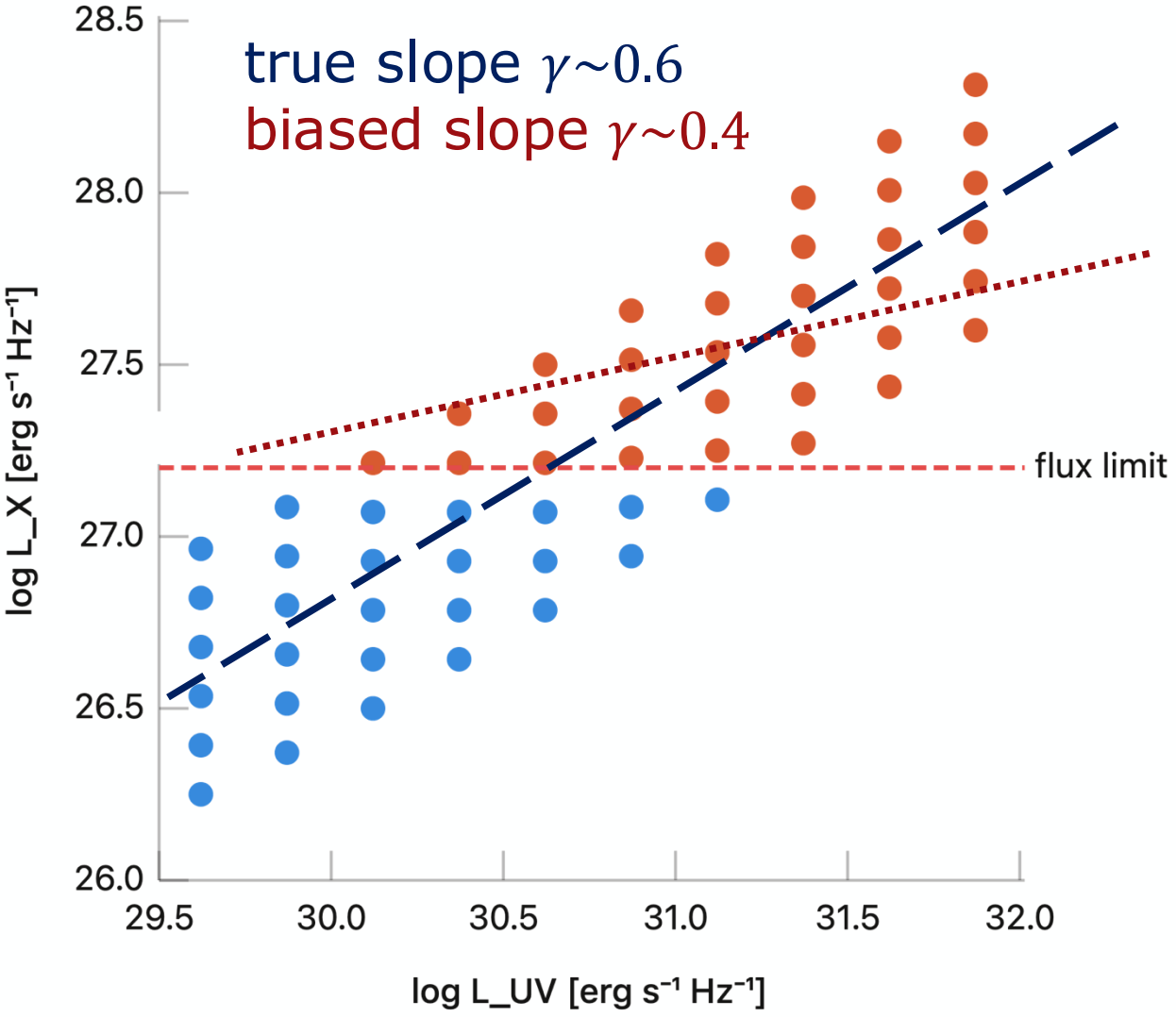


SAMPLE SELECTION – EDDINGTON BIAS

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The effect worsens with redshift as the flux limit gets higher



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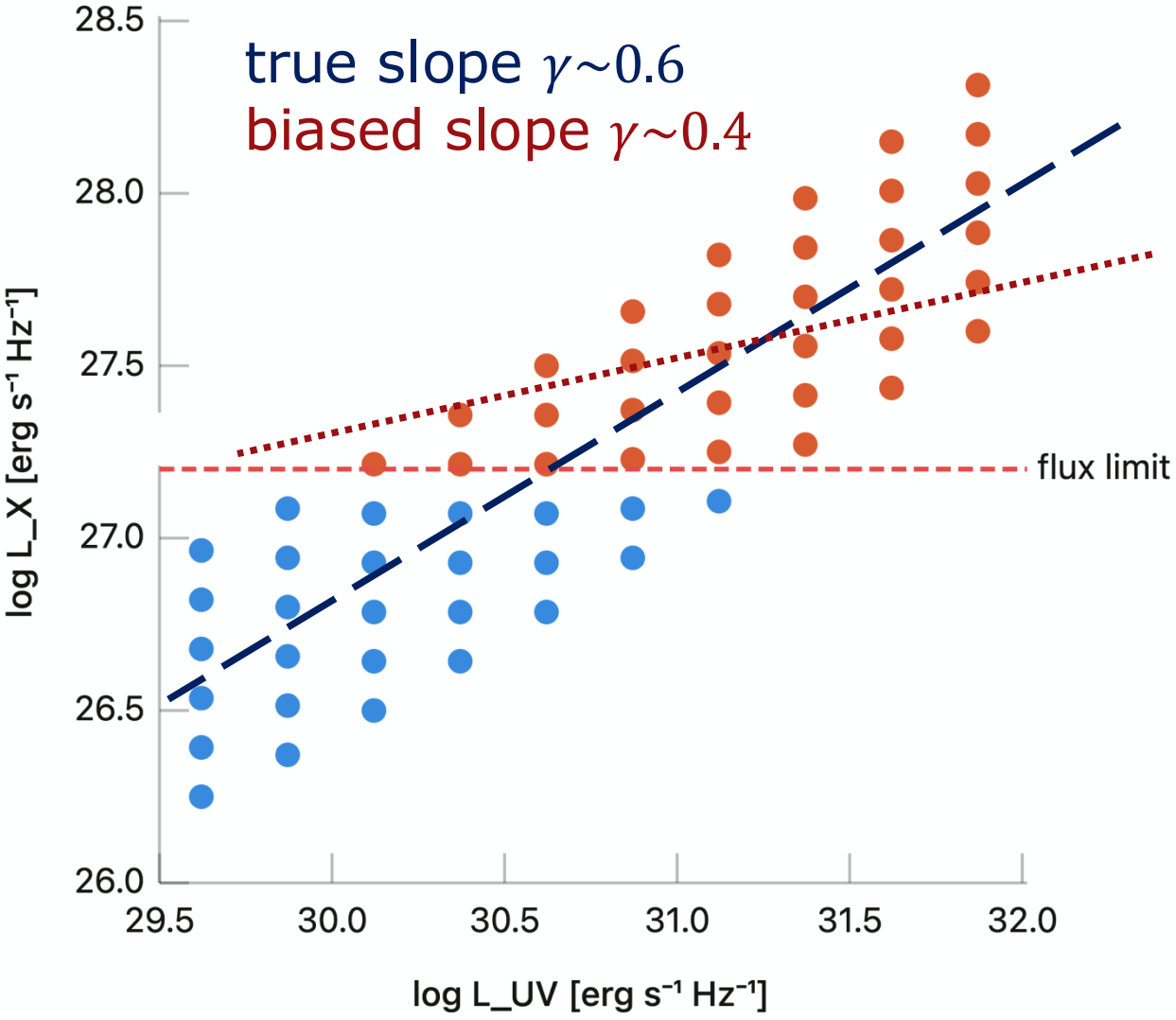
Due to X-ray variability and the relation scatter, we detect objects close to the flux limit only when they are in a positive fluctuation state

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The effect worsens with redshift as the flux limit gets higher

We only keep observations where the X-ray would flux have been detected even during a low-flux state

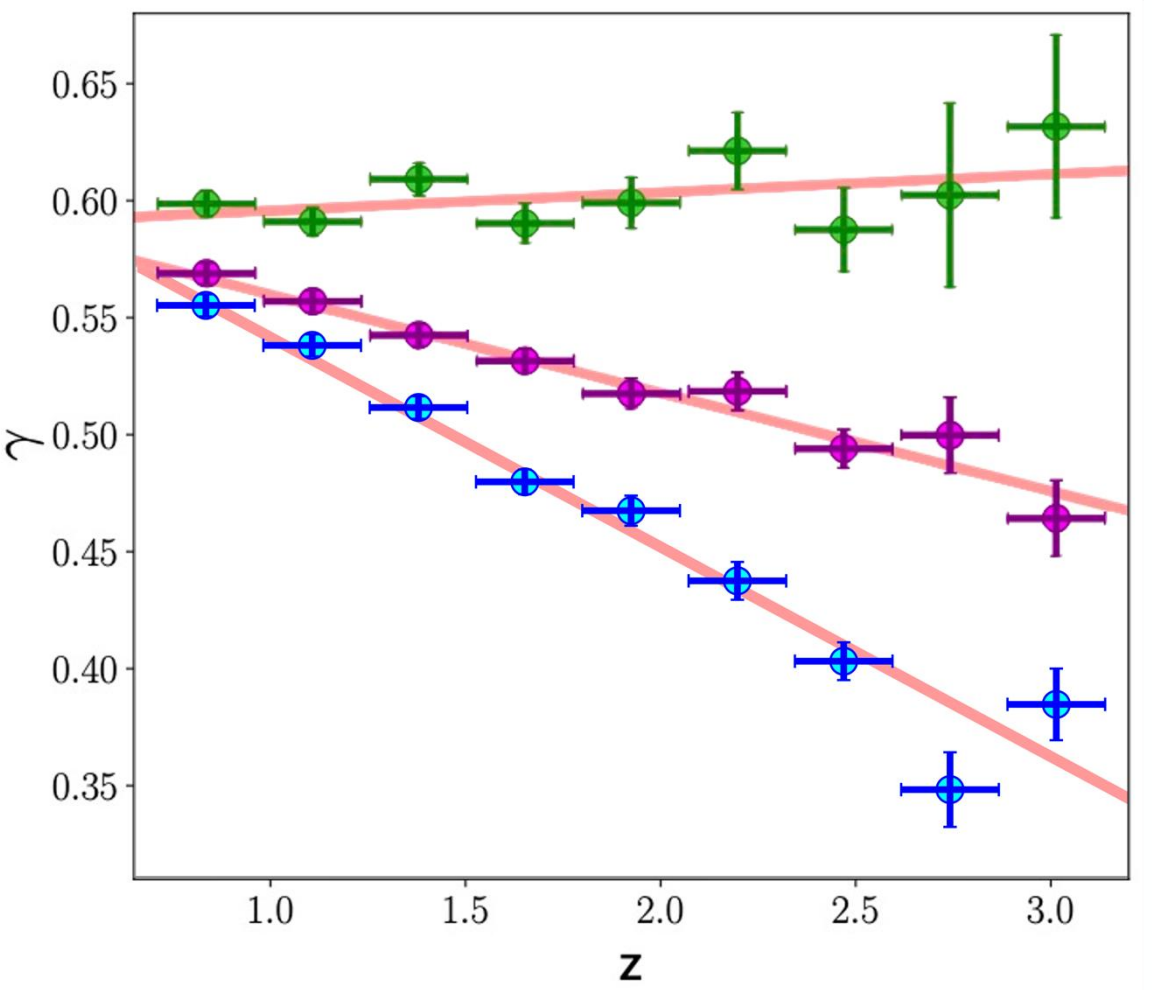
$\log(F_{X,min}) < \log(F_{X,exp}) - K$ → 3σ



SAMPLE SELECTION – EDDINGTON BIAS

Mock sample with slope γ=0.6

no correction ⟶ trend with z
not enough correction ⟶ trend with z
full correction ⟶ we recover the injected constant slope



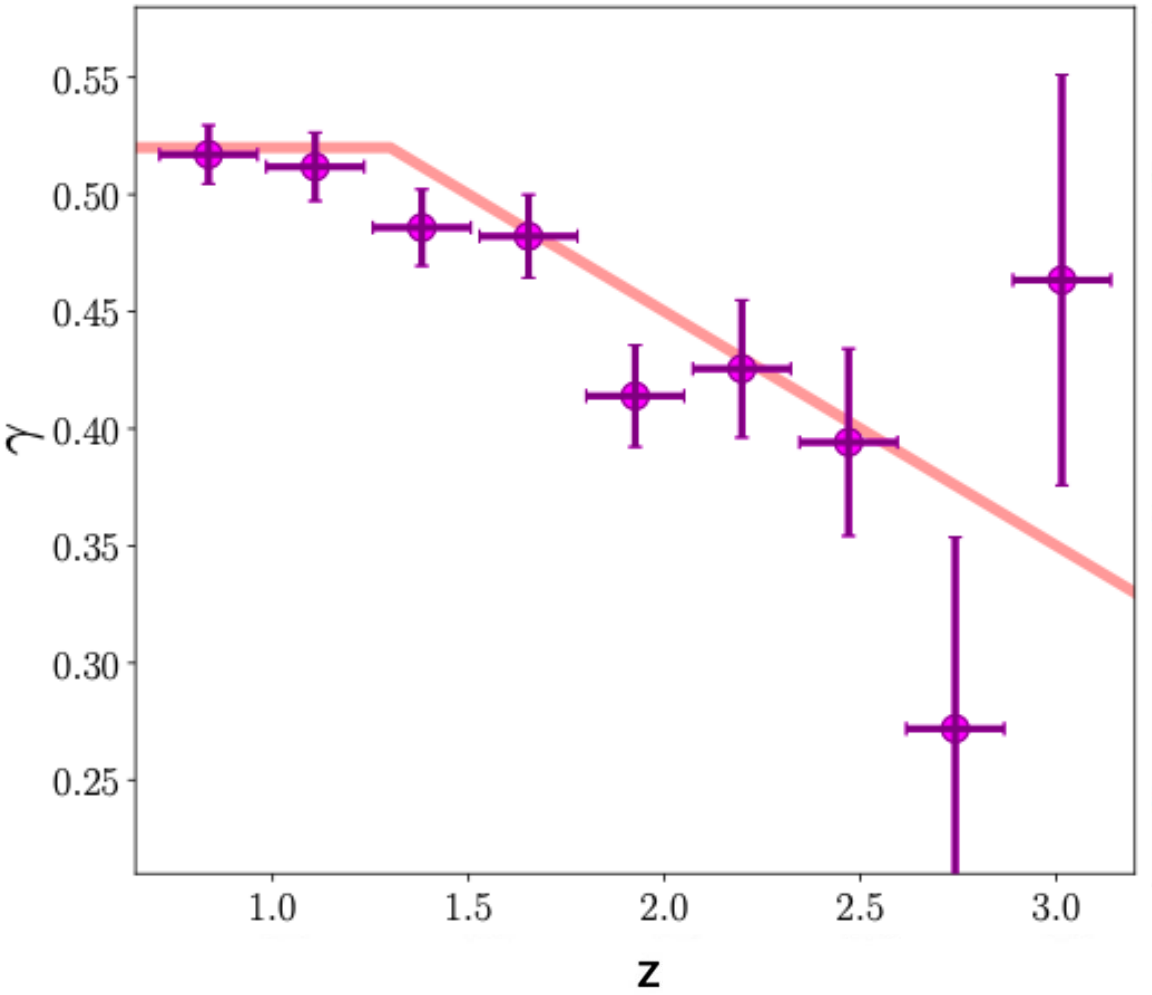
Risaliti+26b

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Complementary test: if the truth was a slope that evolves with z, we would recover it!



Risaliti+26b

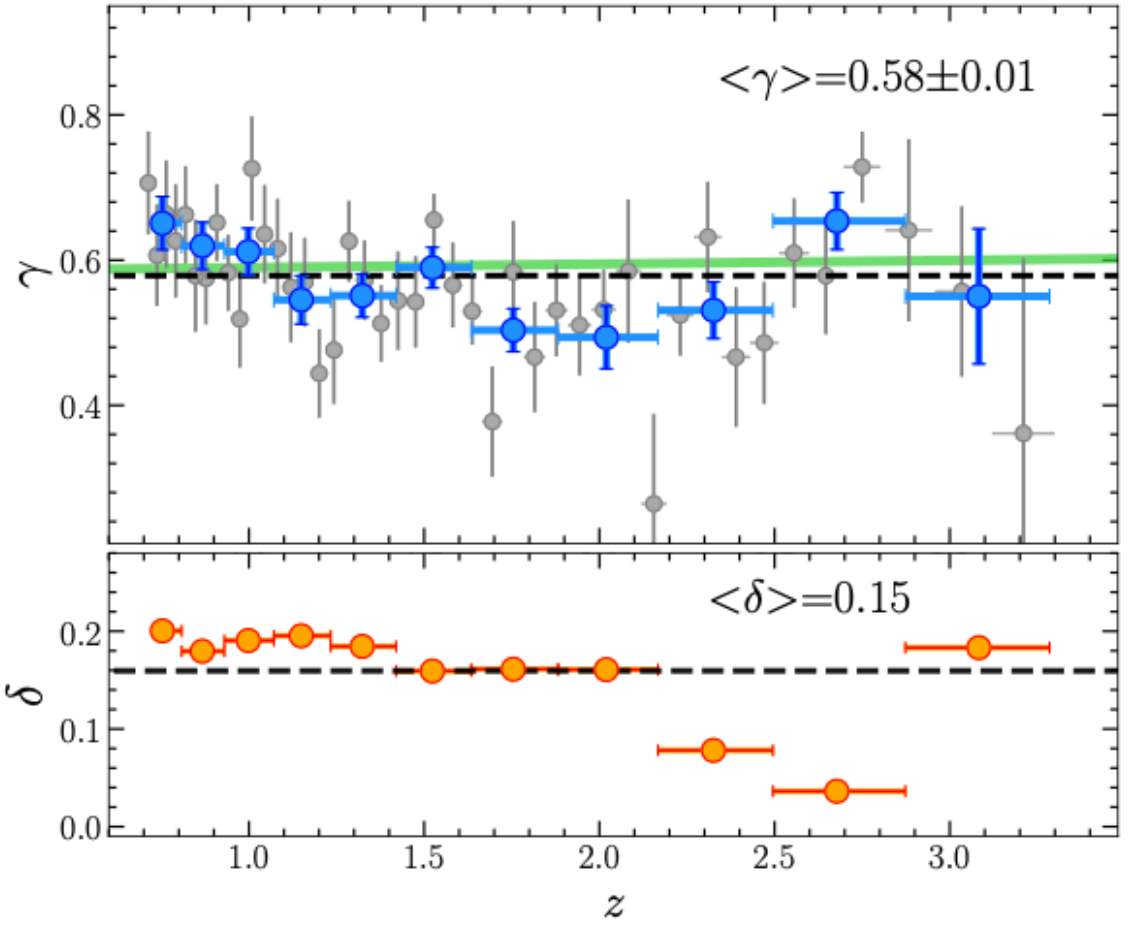
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When we look at the real data, we see no redshift evolution

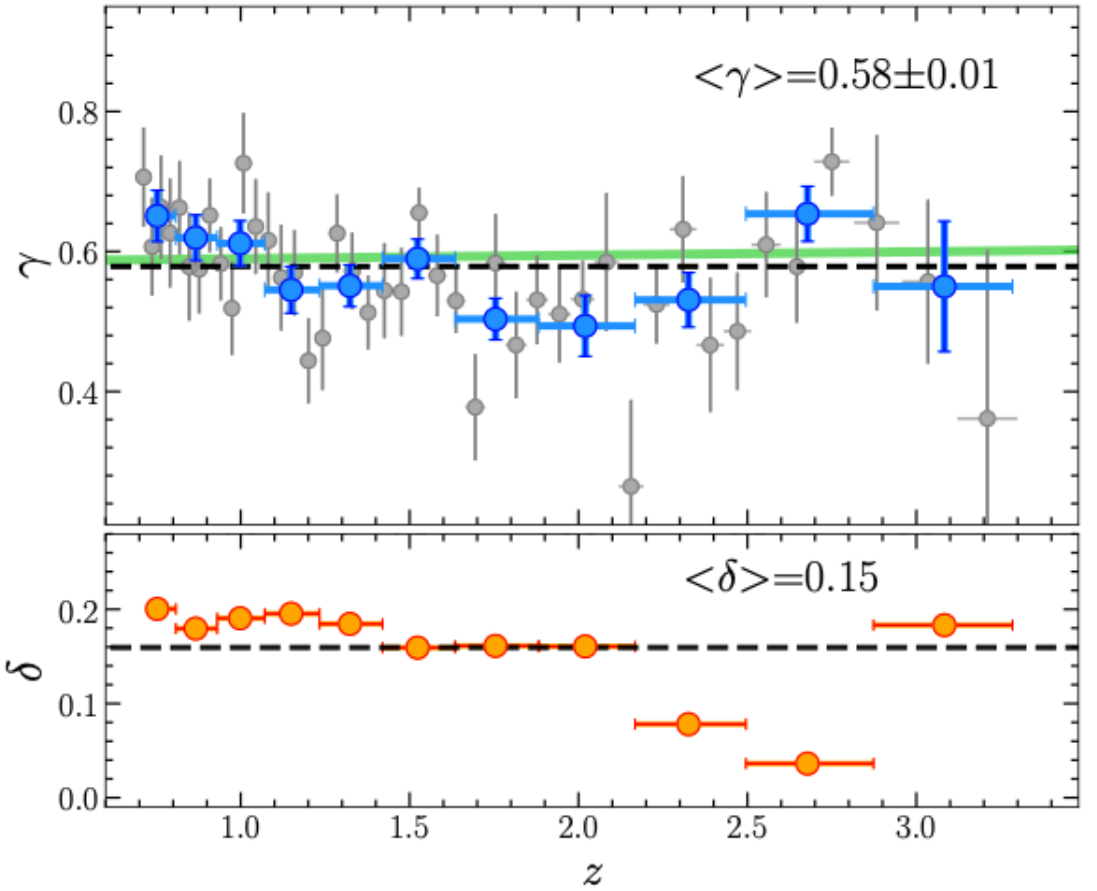


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SAMPLE SELECTION – RECAP

- Constant slope with z
- Dispersion ~0.15 dex
  - The intrinsic scatter must be <0.05 dex (see **Signorini+24**)
- A new way to use quasars to measure distances (Dutra+25) gives cosmological results that are consistent with the L_X-L_{UV} ones (see Lusso's talk from yesterday)

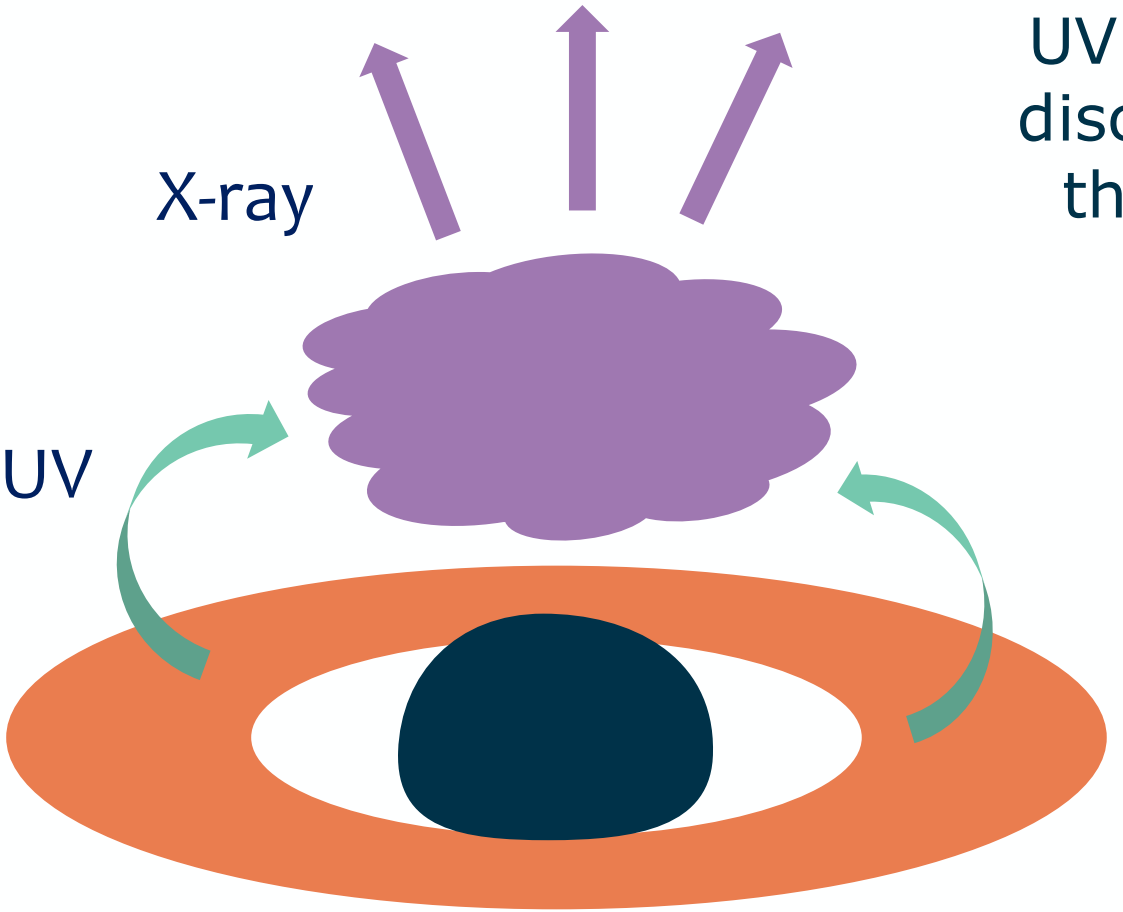
- The sample is public!
- A bigger sample that extends at high redshift is on the way



Risaliti+26b

DISC-CORONA INTERACTION

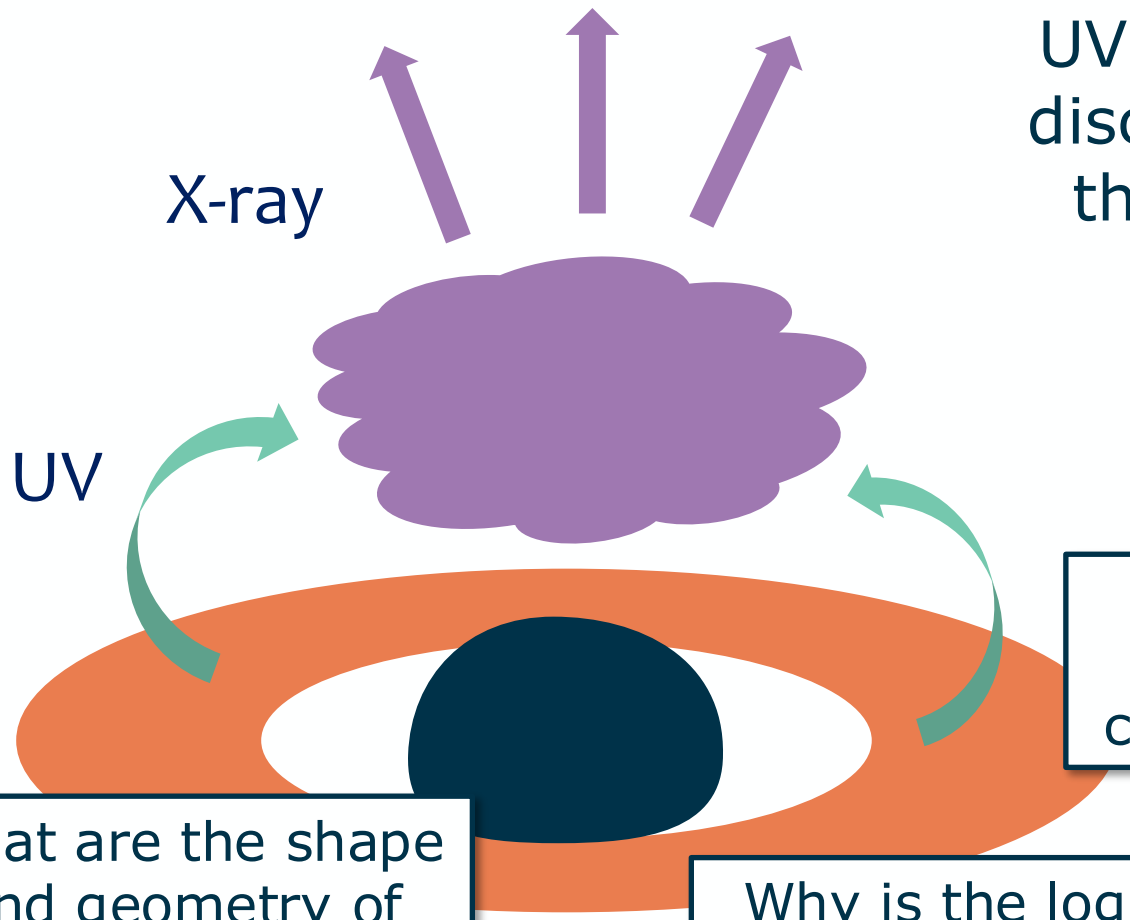
A refueling process constantly brings energy from the disc to the corona



UV photons from the disc are the seeds for the X-ray emission

DISC-CORONA

A refueling process constantly brings energy from the disc to the corona



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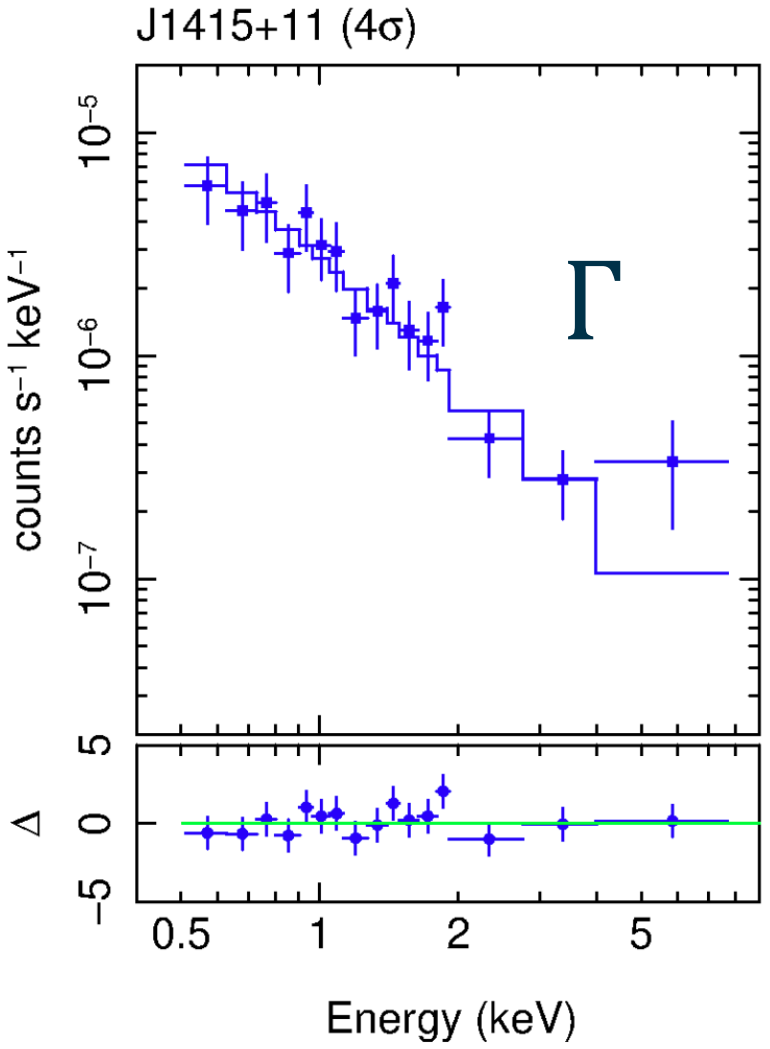
How does this energy transfer happen?

What are the shape and geometry of the corona?

How do the corona properties change with changes in the accretion?

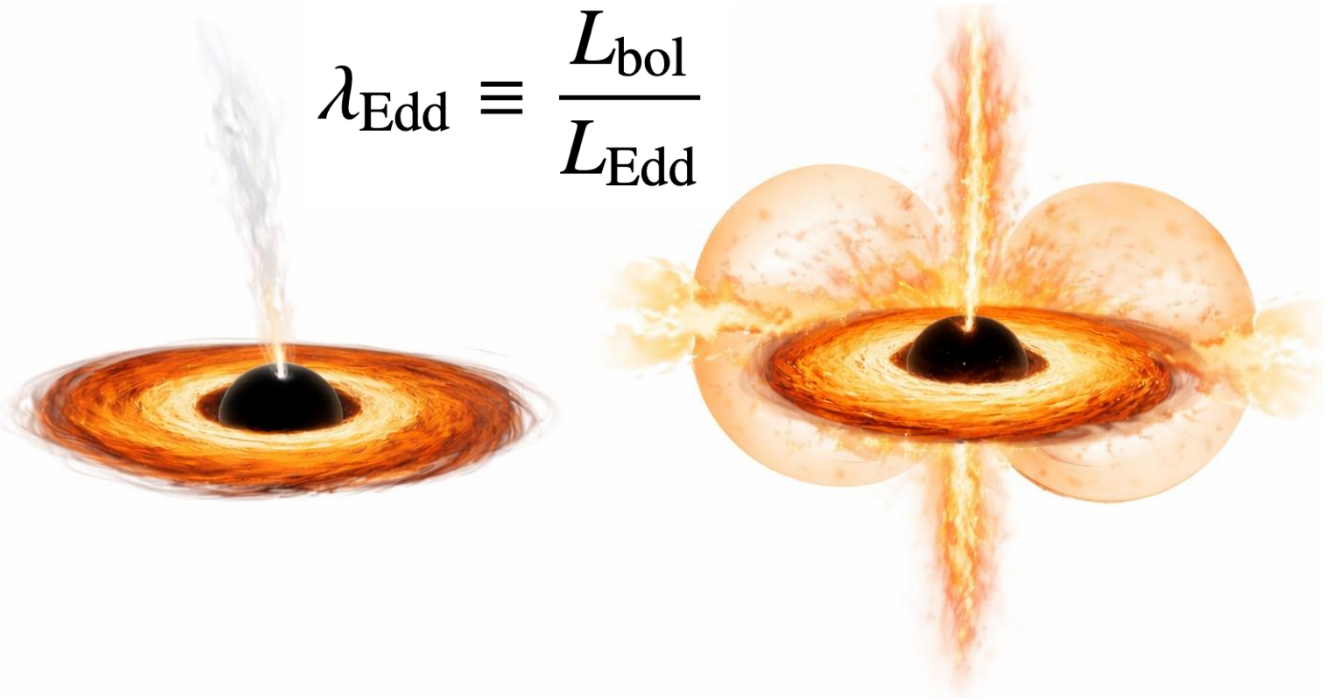
Why is the $\log(L_X)$-$\log(_{UV})$ relation so tight?

THE Γ-λ_{Edd} RELATION



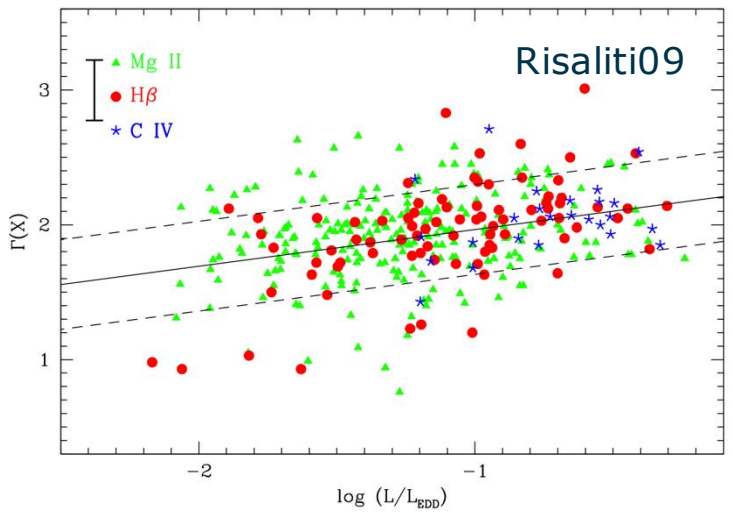
$\propto$

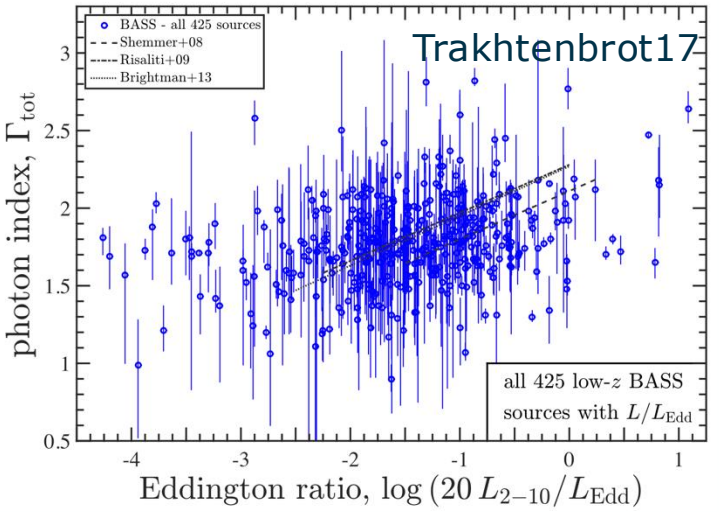
$$\lambda_{Edd} \equiv \frac{L_{bol}}{L_{Edd}}$$

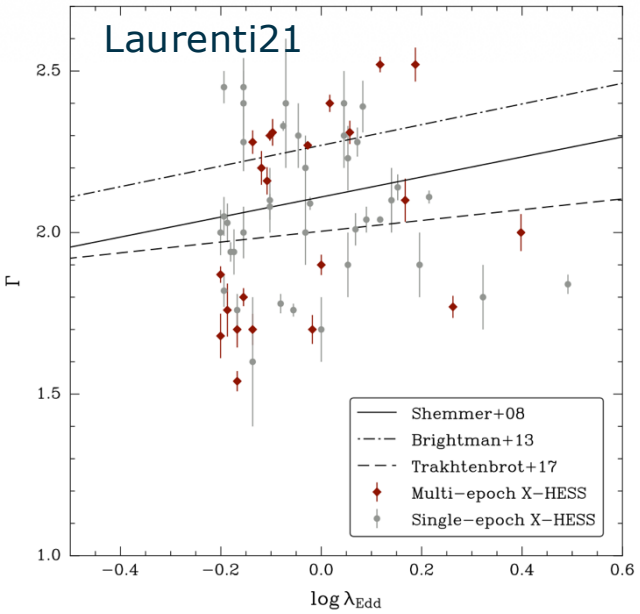


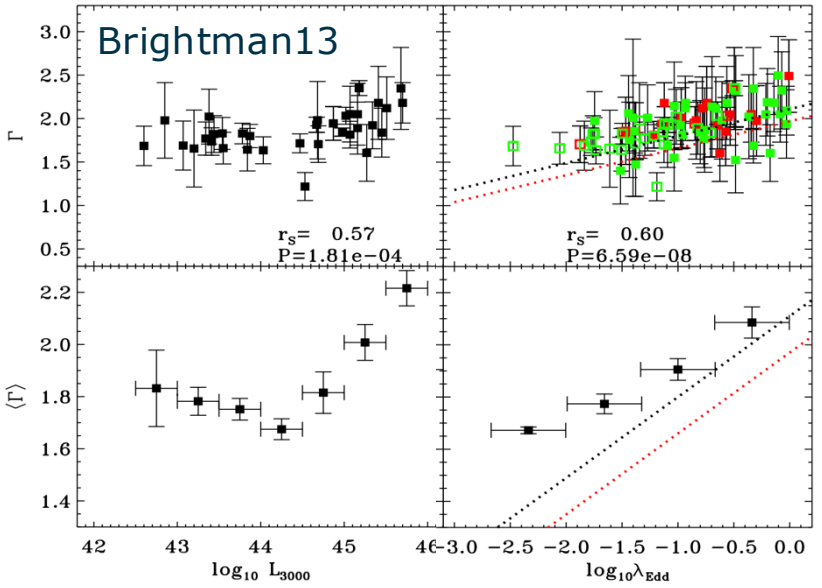
Standard picture: more energetic UV photons from the disc cool down the Corona, producing a steeper spectrum

THE Γ-λ_{Edd} RELATION



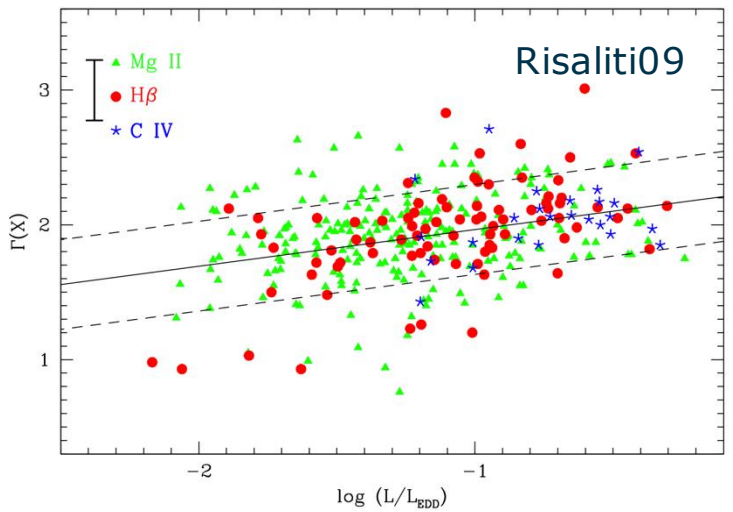


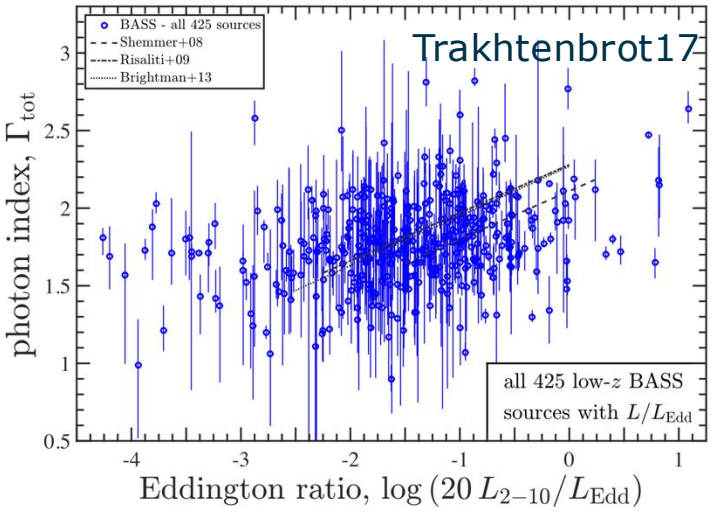


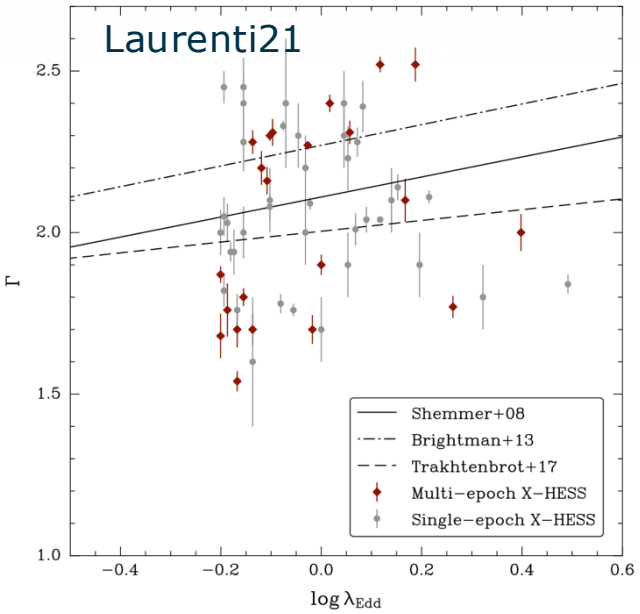


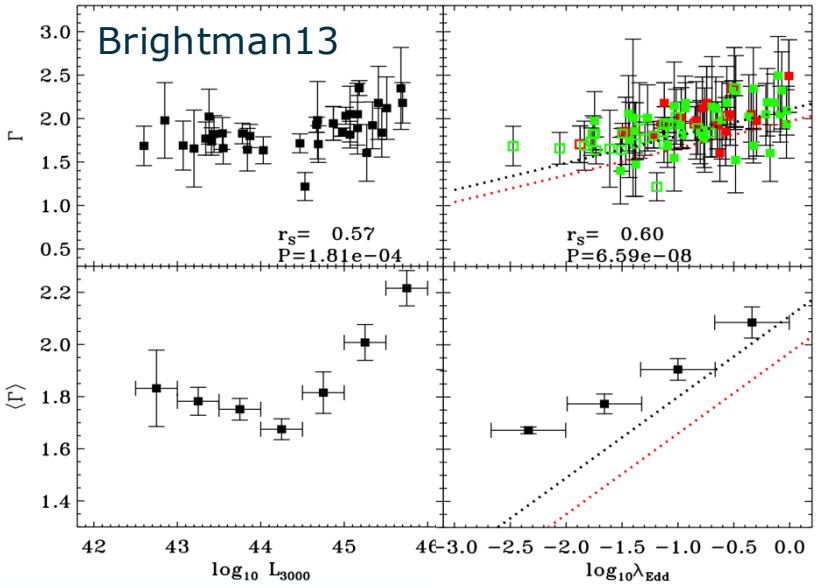
- Slopes from ~0.2 to ~0.6
- Different results for different λ_{Edd} recipes and sample selections
- Some question the existence of the relation entirely (Kamraj+22)
- Alternative physical explanations (e.g. Yang+15)

THE Γ-λ_{Edd} RELATION





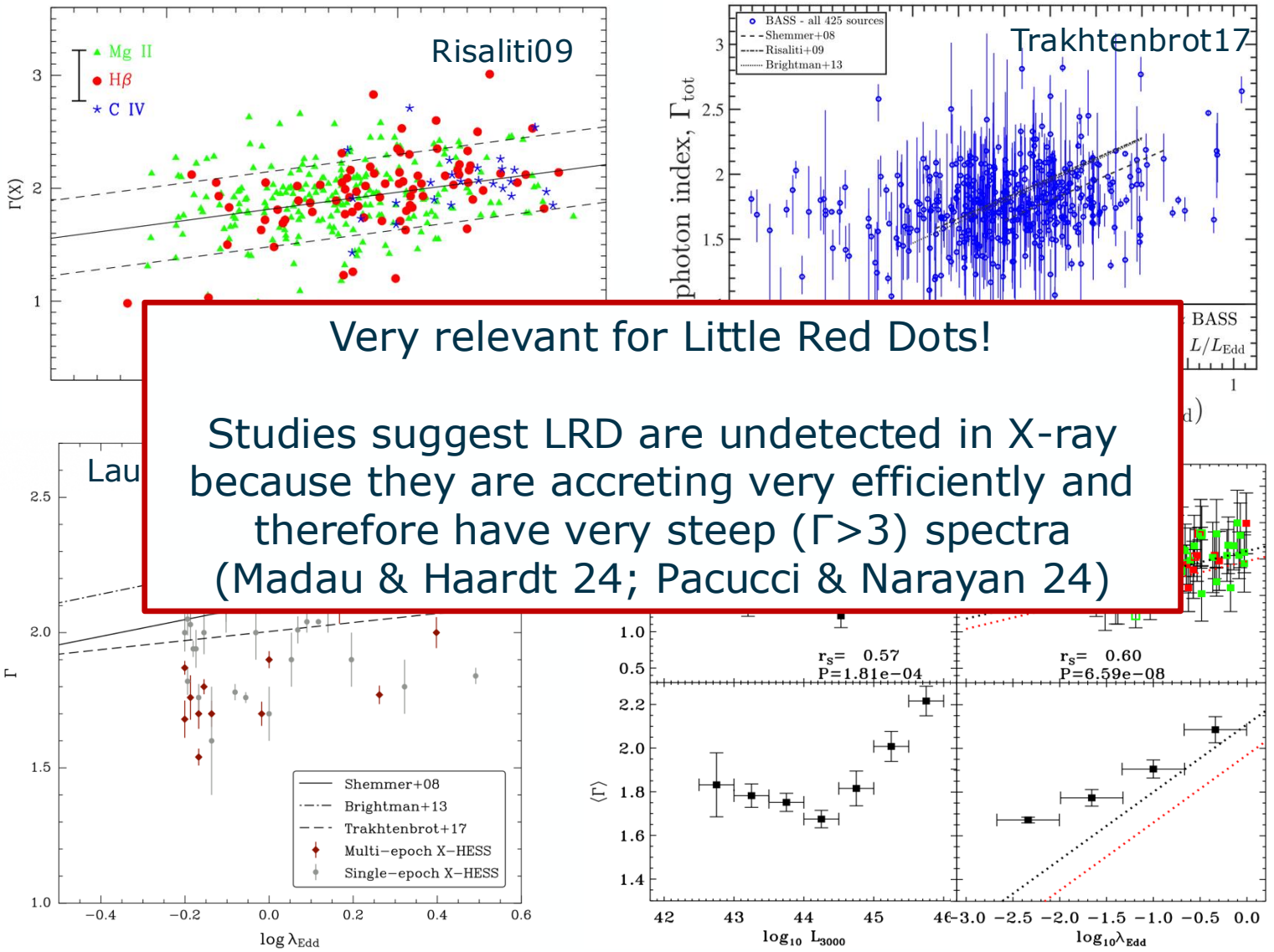




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Our goal: to test the Γ-λ_{Edd} relation on the biggest uniform sample possible

THE Γ-λ_{Edd} RELATION



Very relevant for Little Red Dots!

Studies suggest LRD are undetected in X-ray because they are accreting very efficiently and therefore have very steep (Γ>3) spectra (Madau & Haardt 24; Pacucci & Narayan 24)

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SAMPLE SELECTION



SDSS DR16Q
+
XMM-Newton serendipitous sources catalogue
=
25548 objects

Cleaning criteria:

- remove reddened objects using optical colours
- remove BAL
- remove radio-loud
- require SNR>1 in each XMM band
- require Γ-$\Delta\Gamma$ >1.5 to avoid obscuration
- require well-defined SMBH mass measurement

5805 objects

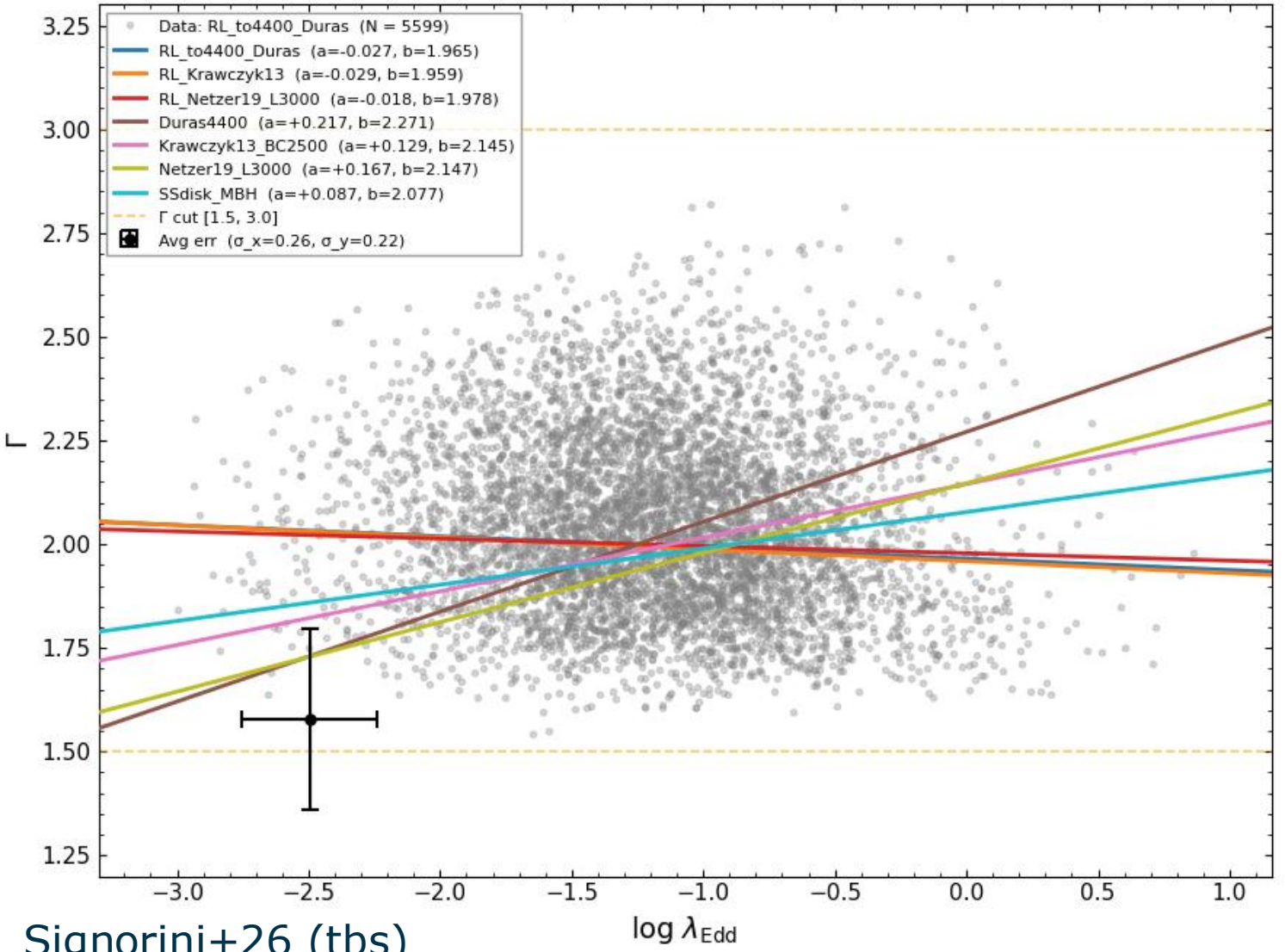
MEASURING λ_{Edd}

different recipes:
Lusso+12, Krowczyk+13,
Netzer+19, Duras+20…

$$\lambda_{\rm Edd} \equiv \frac{L_{\rm bol}}{L_{\rm Edd}} = \frac{L_{\rm bol}}{1.26 \times 10^{38}\,(M_{\rm BH}/M_{\odot})\,{\rm erg\ s^{-1}}}$$

Single Epoch
(Hβ, MGII, CIV)
from Wu&Shen22

THE Γ-λ_{Edd} RELATION - RESULTS



Signorini+26 (tbs)

Hβ
0.06±0.01 to 0.23±0.02

MGII
-0.11±0.01 to 0.22±0.02

CIV
-0.12±0.01 to -0.03±0.01

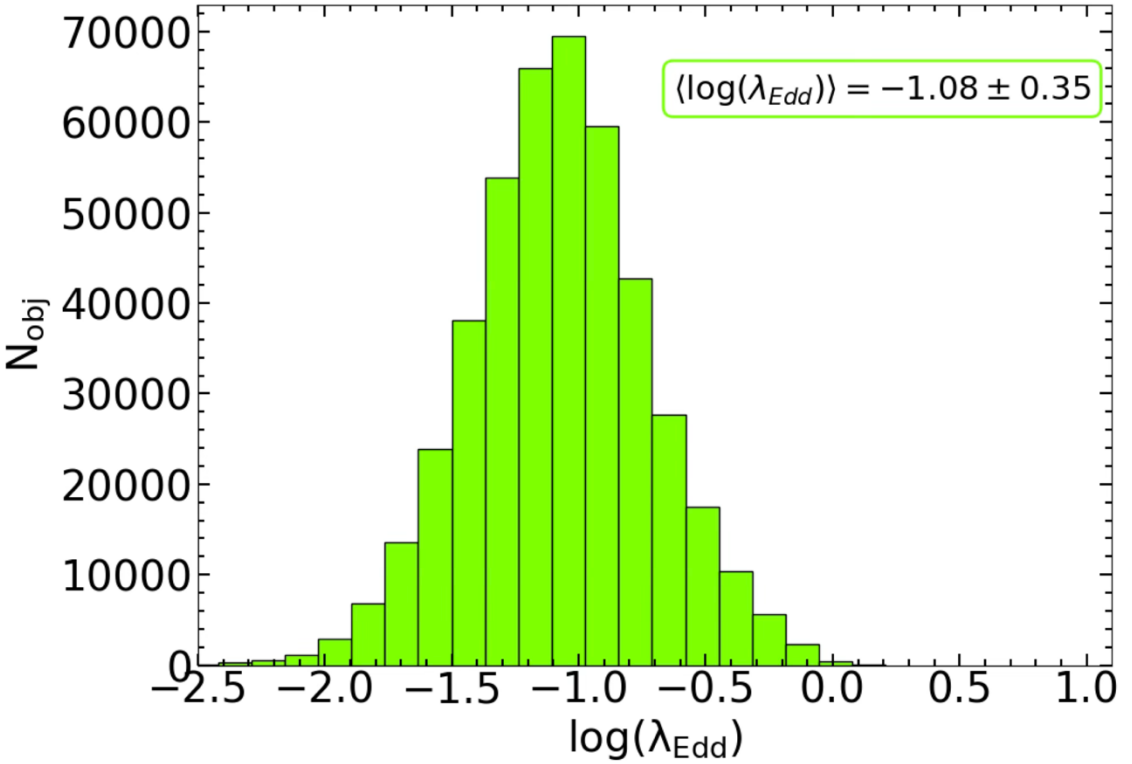
- **Different results for different SMBH masses and L_{bol}**
- **Always flatter than the ~0.3 from the literature**

EDDINGTON RATIO DISTRIBUTION

Risaliti, Trefoloni & Salvati 2026 (arXiv 2601.19412)

There is no room for an intrinsic dispersion in λ_{Edd} higher than ~0.2 dex

Most SDSS quasars likely populate a tiny λ_{EDD} rage, so a relation can be easily washed out!



See Bartolomeo Trefoloni's talk from yesterday ☺

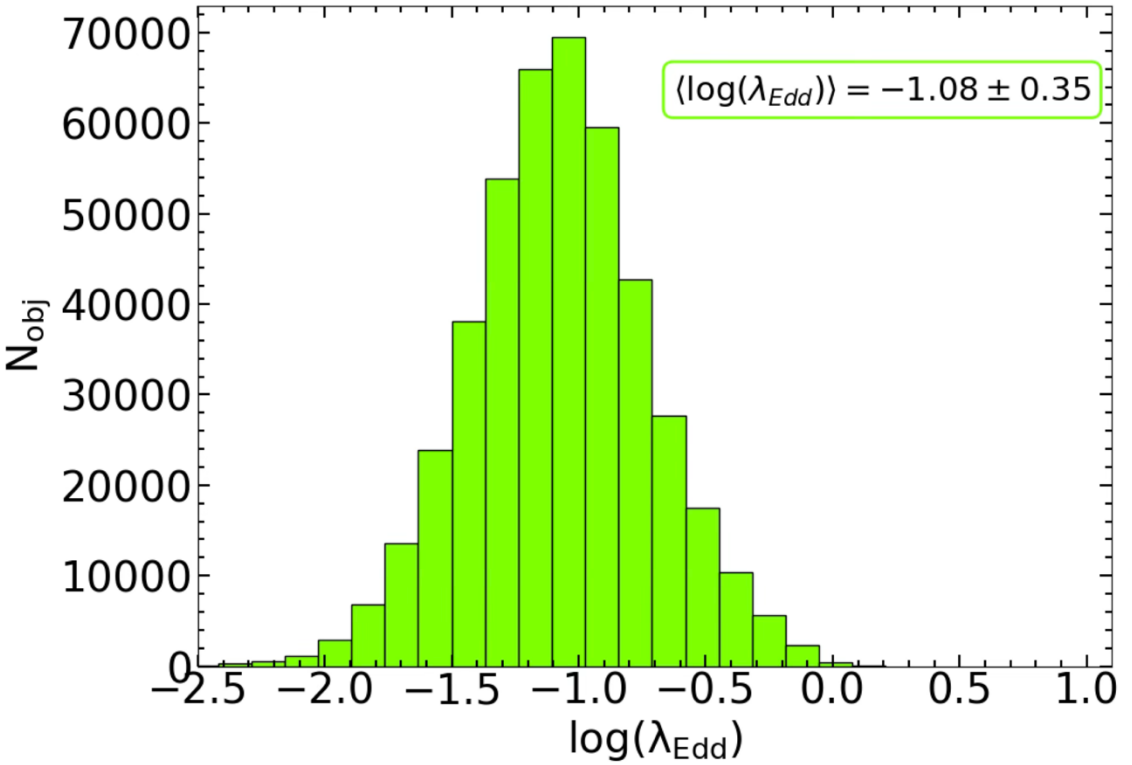
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…so are we doomed?



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MULTIPLE OBSERVATIONS

1900 objects in the sample have multiple XMM-Newton observations

If we look at an object and it varies in luminosity, the mass is constant, therefore the change can be attributed to a change in λ_{EDD}

fit Γ-L_X and then translate the slope to a Γ-λ_{EDD} relation

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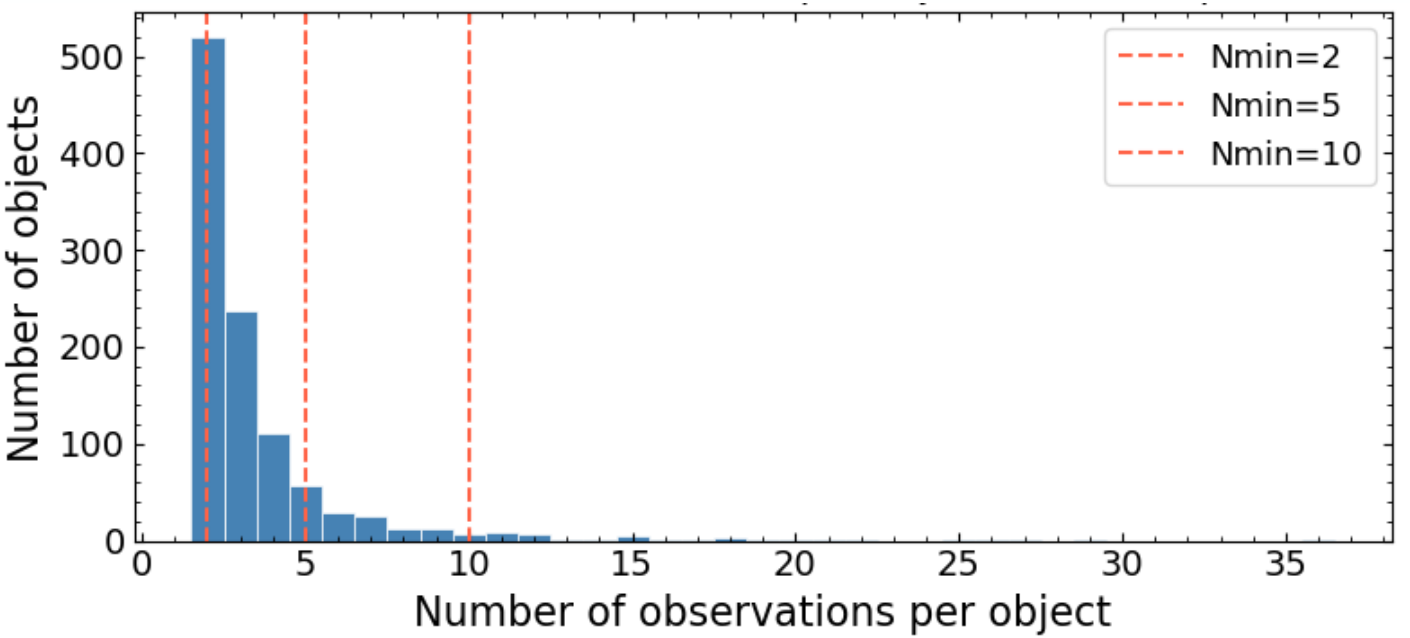
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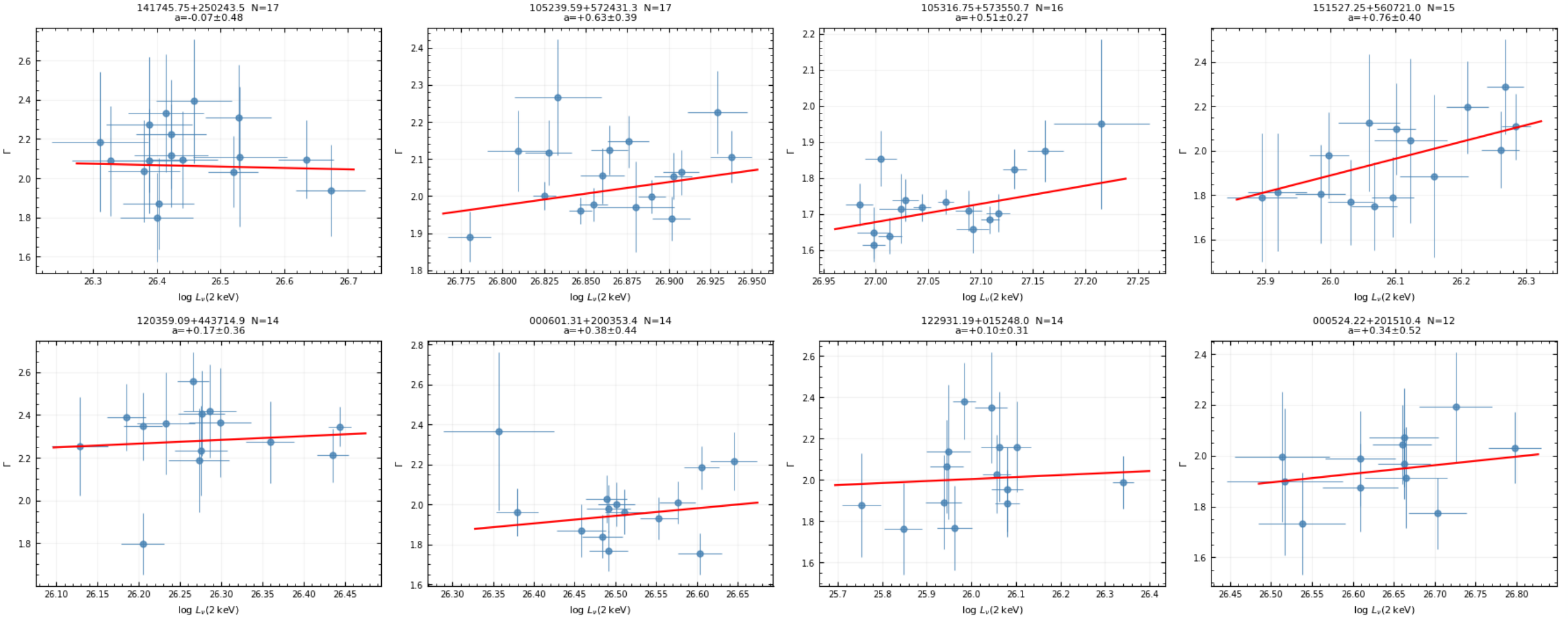
Caveats:
- Variability is stochastic
- Observations not homogenously spaced in time

We require:
- Std(L_X)/median(err_L_X) >1

1046 objects



MULTIPLE OBSERVATIONS



Signorini+26 (tbs)

MULTIPLE OBSERVATIONS

The object-to-object difference is significant
(different times, different numbers of observations, different uncertainties on Γ values)

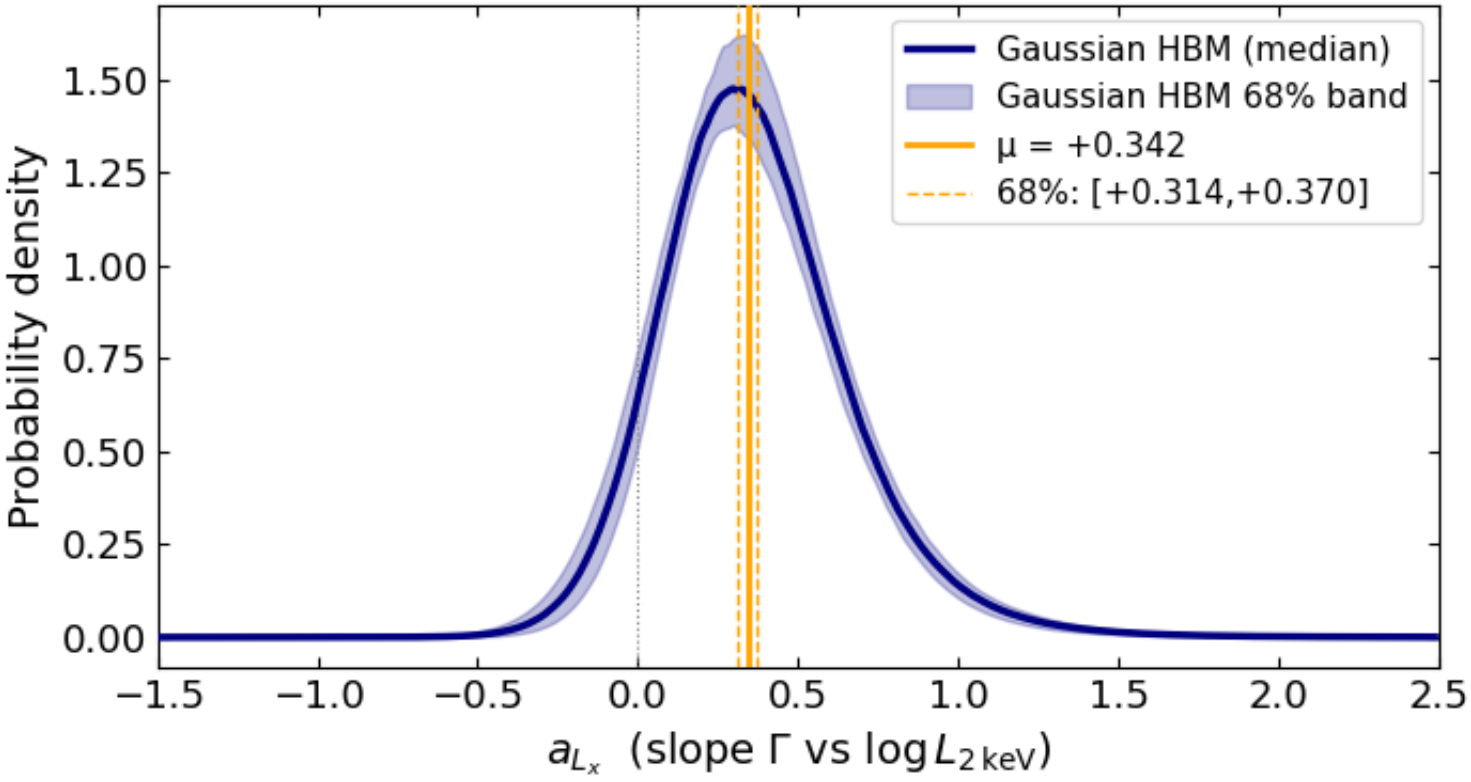
We stack the posterior distributions for the slope value a_{LX} using *PosteriorStacker* (Baronchelli, Nandra & Buchner 2020)

Signorini+26 (tbs)

$$\Gamma = a_{LX} * \log(L_{2keV}) + b$$

$$a_{LX} = 0.37 \pm 0.03$$

$$\sigma \sim 0.22$$

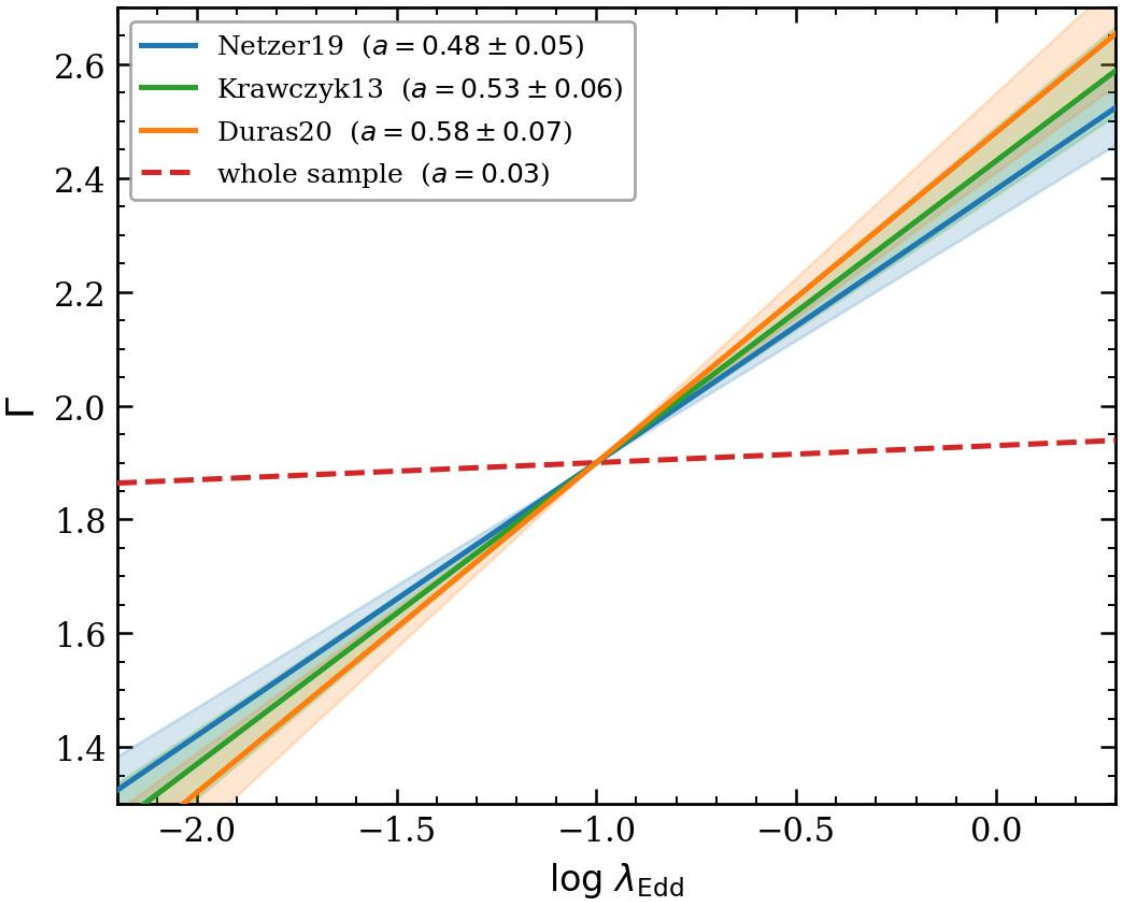


MULTIPLE OBSERVATIONS

We can now translate the a_{LX} to the $a_{\lambda EDD}$:

- use the $\log(L_X)$ - $\log(L_{UV})$ relation to derive $\log(L_{2500A})$ [Lusso+20]
- choose a recipe to go from monochromatic to bolometric luminosity

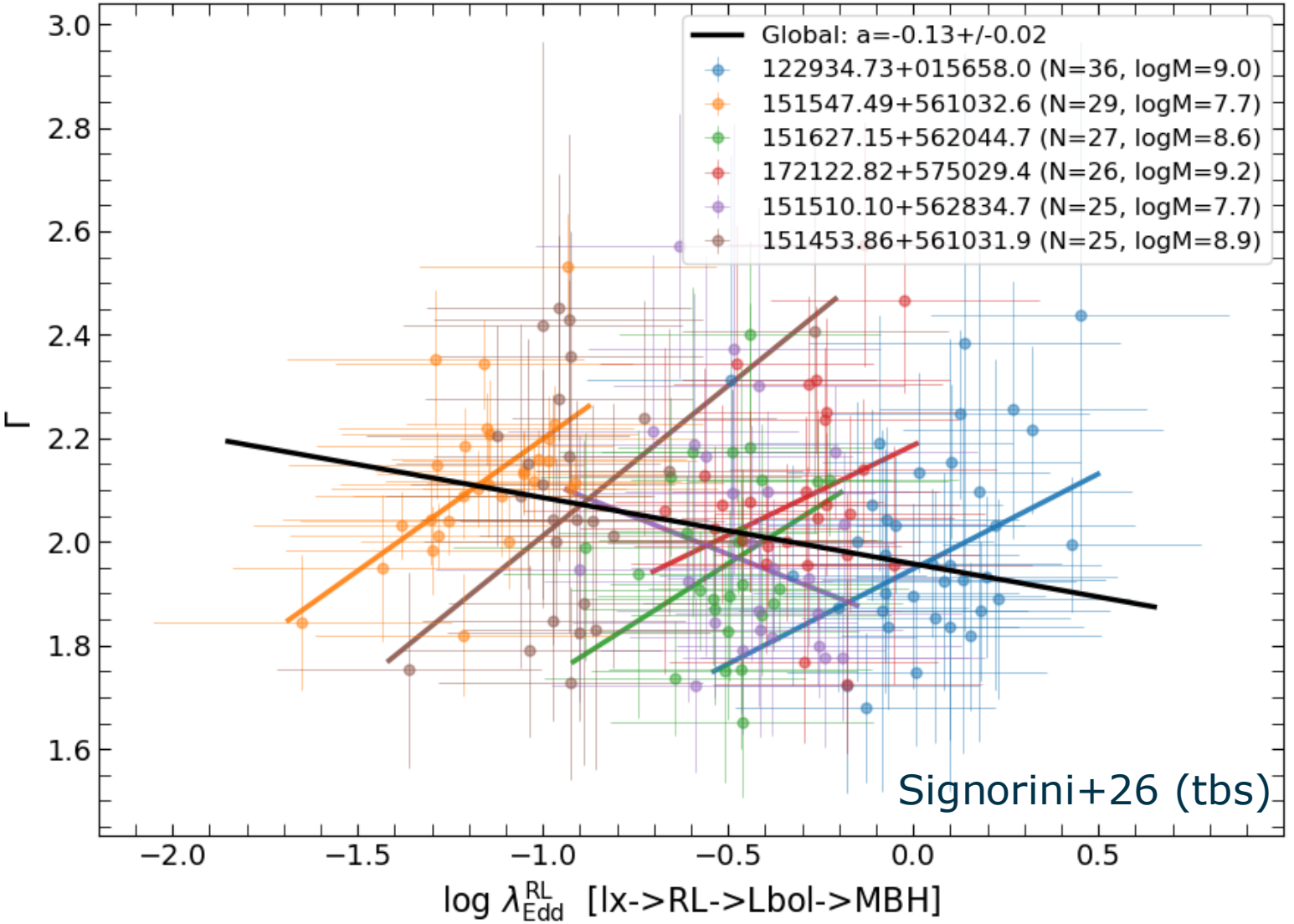
For different K_{bol}, the values go from
$a_{\lambda EDD} = 0.48 \pm 0.05$ to **$a_{\lambda EDD} = 0.58 \pm 0.07$**



Signorini+26 (tbs)

MULTIPLE OBSERVATIONS

Multiple objects together in the Γ-λ_{Edd} plane: dividing by M_{BH} shifts objects so that the resulting slope goes from positive to negative



CONCLUSIONS

I

- We build a clean, homogeneous sample to study the L_X-L_{UV} relation
- We check our methodology against the Eddington ratio using mock samples
- The slope γ is constant with the redhisft and dispersion ~0.15 dex
- Dutra+25 shows consistent cosmological results
- A bigger sample with high-z objects is on the way

II

- We start from the same homogeneous sample to study the the Γ-λ_{Edd} relation
- In the whole sample, we find slopes that are almost flat and that change with different M_{BH} and L_{bol} choices
- Using X-ray variability we remove the M_{BH} scatter and get a strong signal $a_{\lambda EDD}$ ~0.5

THANK YOU!

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