

# A NEW POPULATION OF X-RAY WEAK QUASARS

**Elisabeta Lusso**

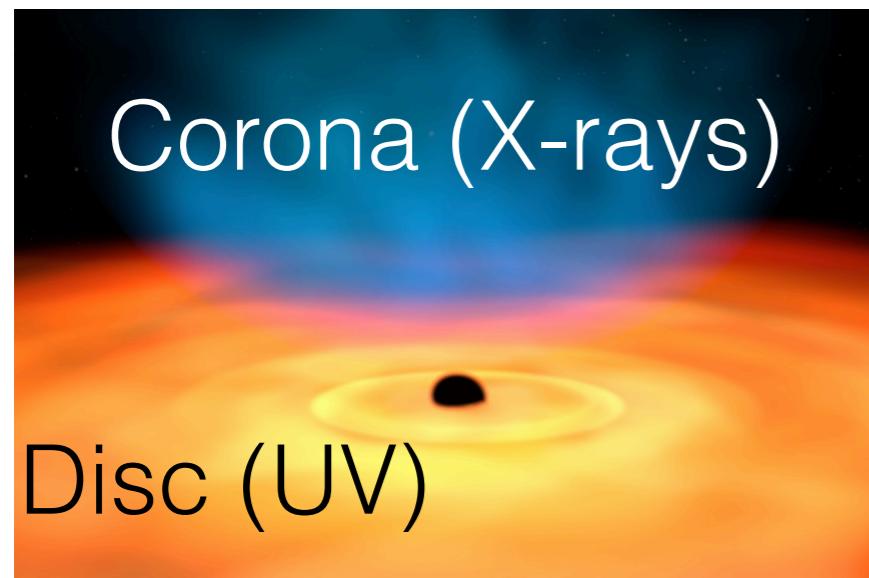
Junior Research Fellow-CoFund

**G. Risaliti (Uni. of Florence-INAF),  
E. Nardini (INAF Arcetri), S. Bisogni (INAF Arcetri/Harvard CfA)**

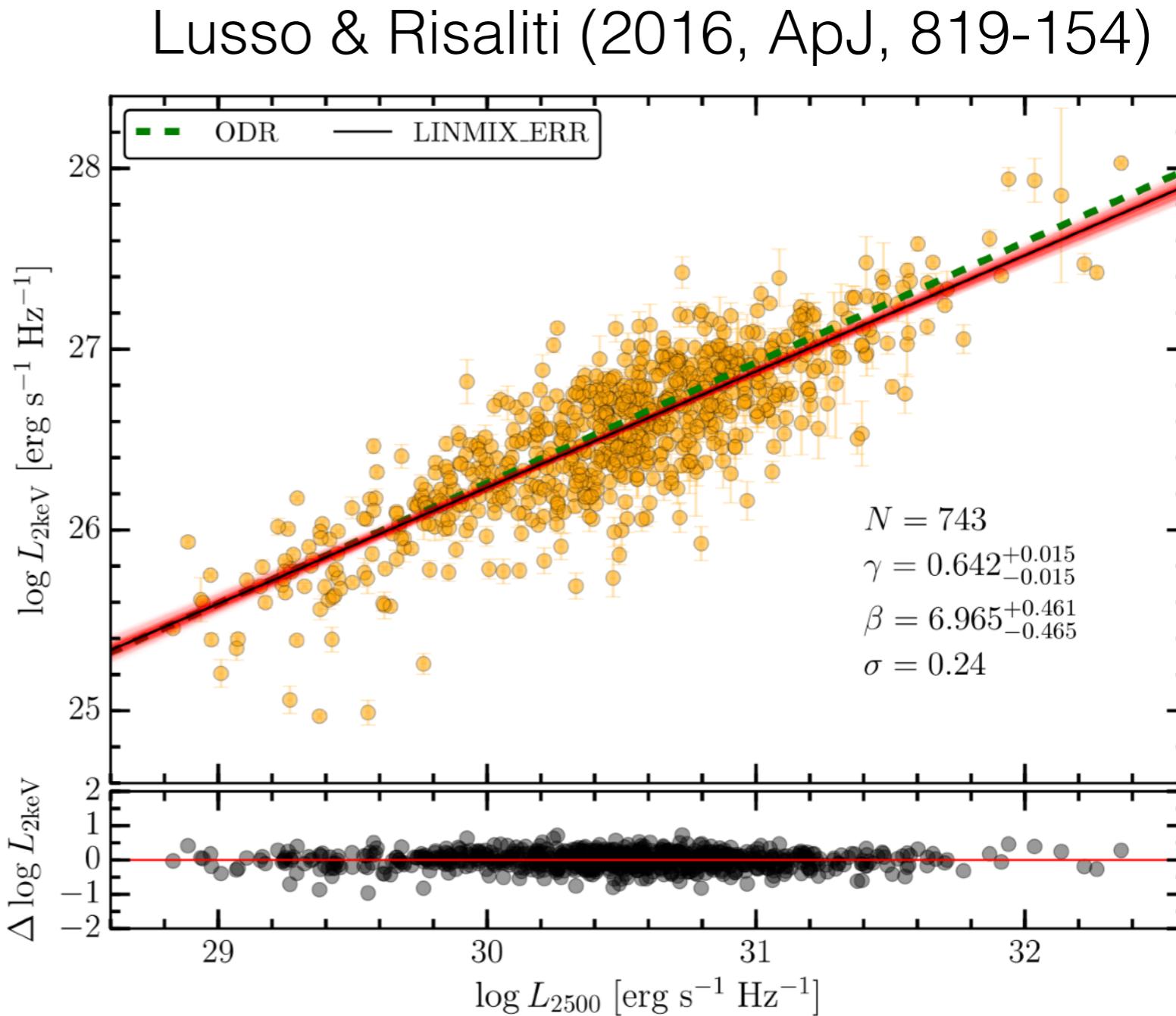
*Exploring the Hot and Energetic Universe*

Palermo, 24-27 September, 2018

# The (tight) X-ray/UV non-linear relation



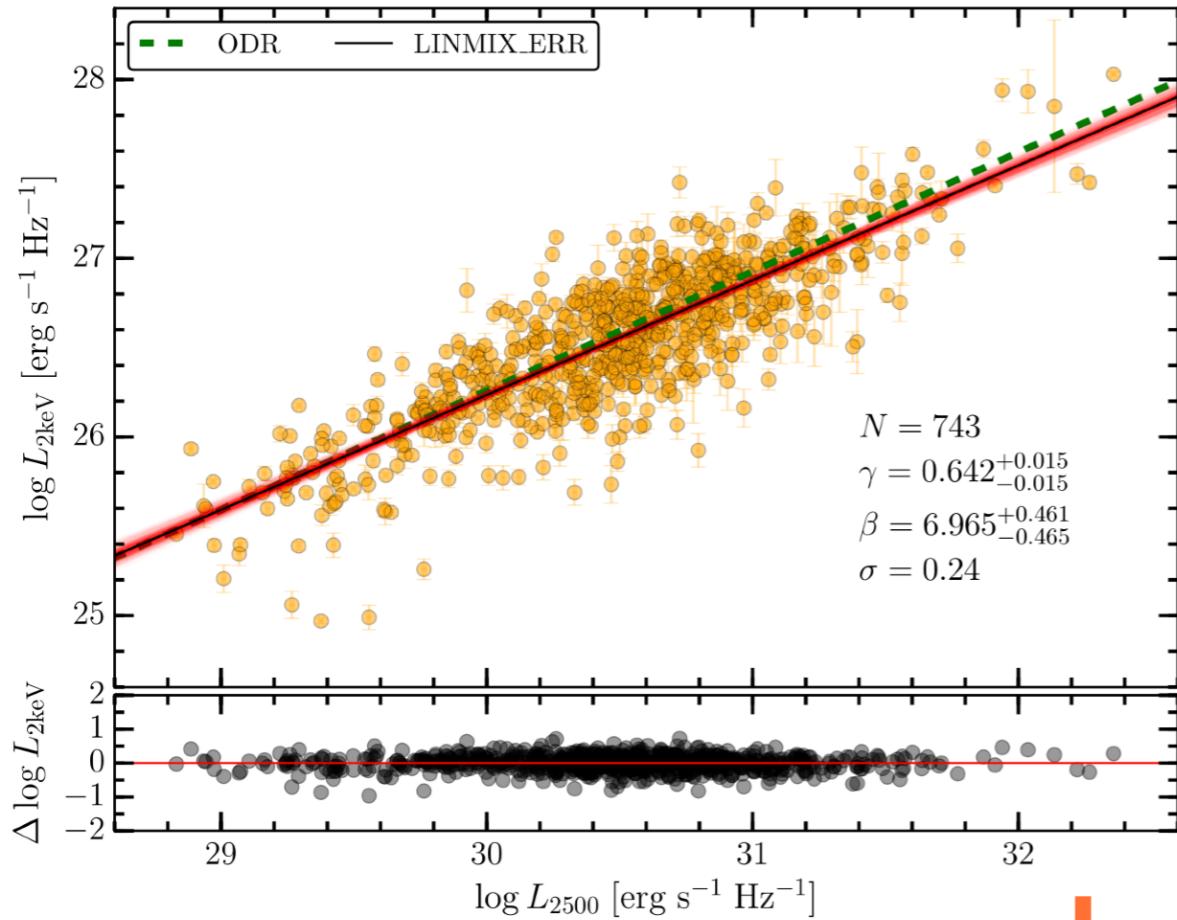
$\text{Log } L_{\text{X}} \sim 0.6 \text{ log } L_{\text{UV}} + 7$   
 $\sigma = 0.24 \text{ dex!}$



# Cosmology with quasars

## The distance modulus

Lusso & Risaliti (2016, ApJ, 819-154)

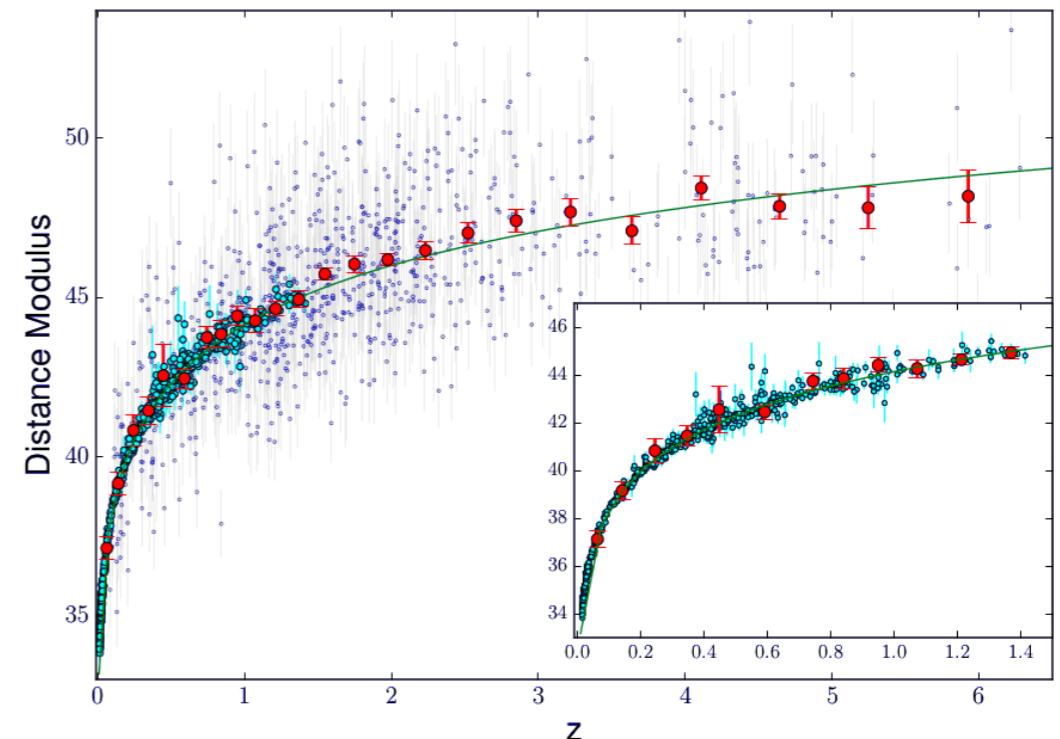


*Standardise the quasar emission*

$$\begin{aligned} \log(F_X) &= \Phi(F_{\text{UV}}, D_L) \\ &= \beta' + \gamma \log(F_{\text{UV}}) + 2(\gamma - 1)\log(D_L) \\ &\quad D_L(z, \Omega_M, \Omega_\Lambda) \end{aligned}$$

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

Risaliti & Lusso (2015, ApJ, 815-33)

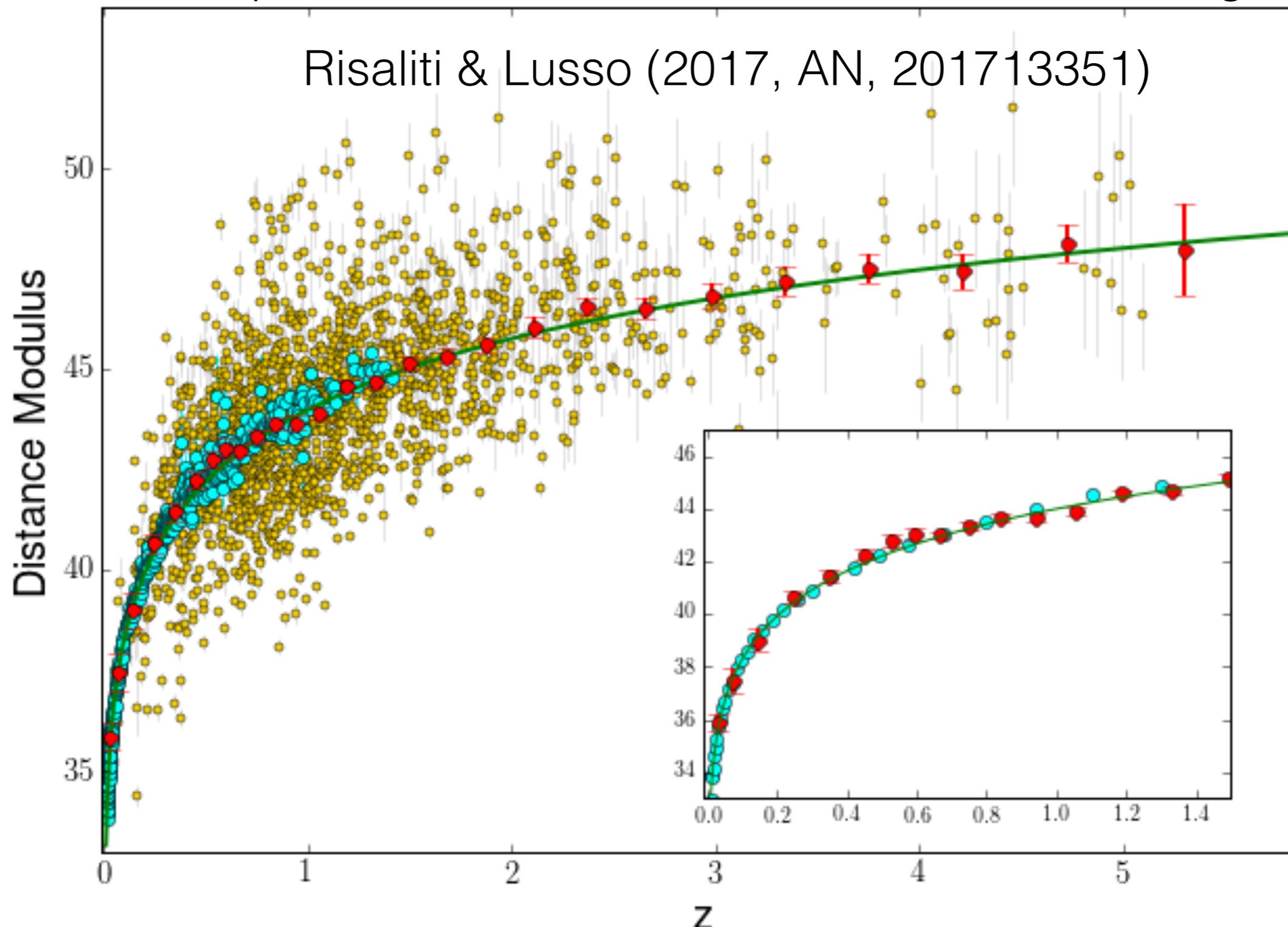


The  $L_X$ - $L_{\text{UV}}$  non-linear relation as a way to measure quasar distances

# Cosmology with quasars

## The Quasars Hubble Diagram

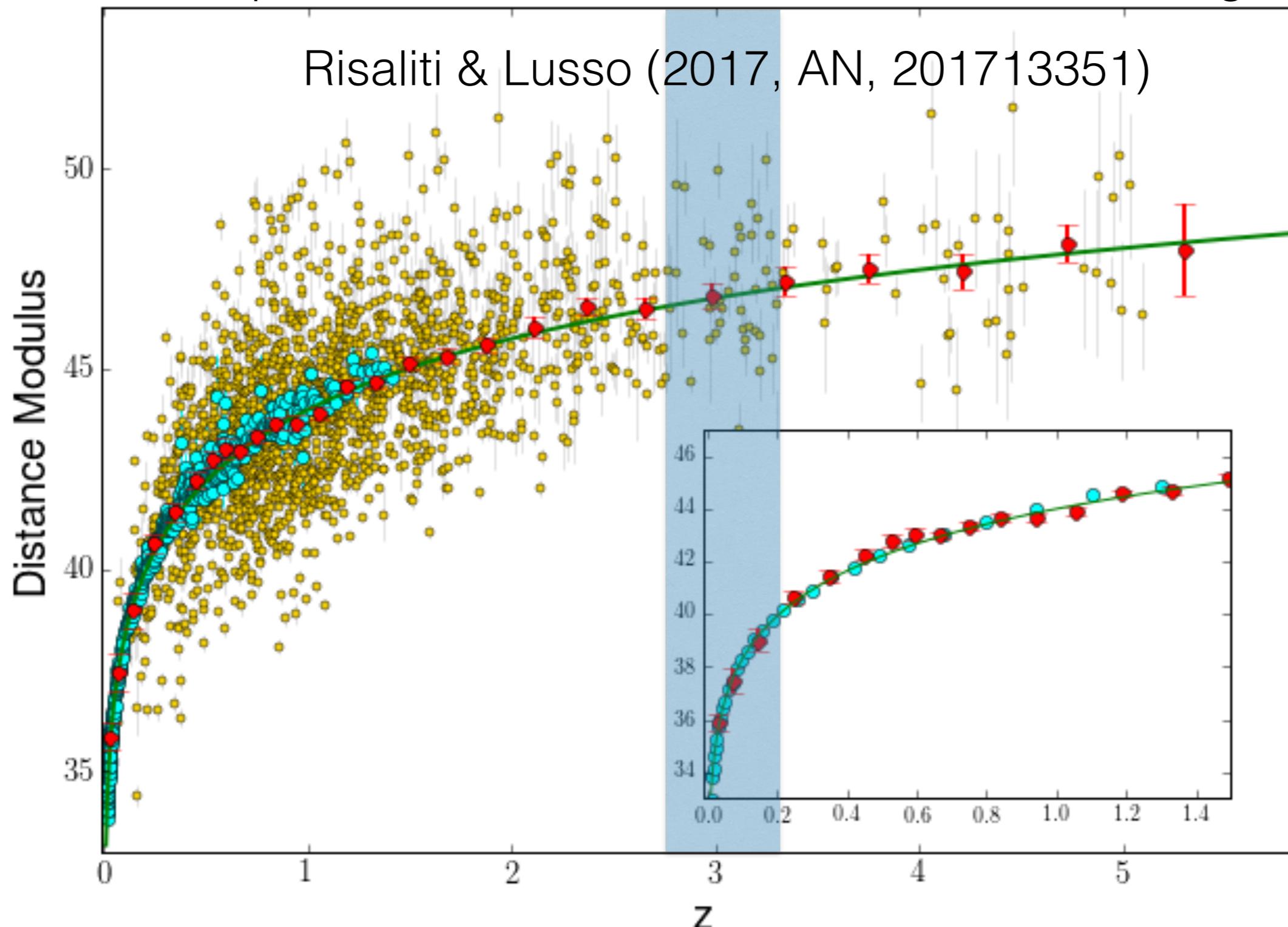
~2000 quasars SDSS-DR7/DR12+3XMM-DR6 catalogue



# Cosmology with quasars

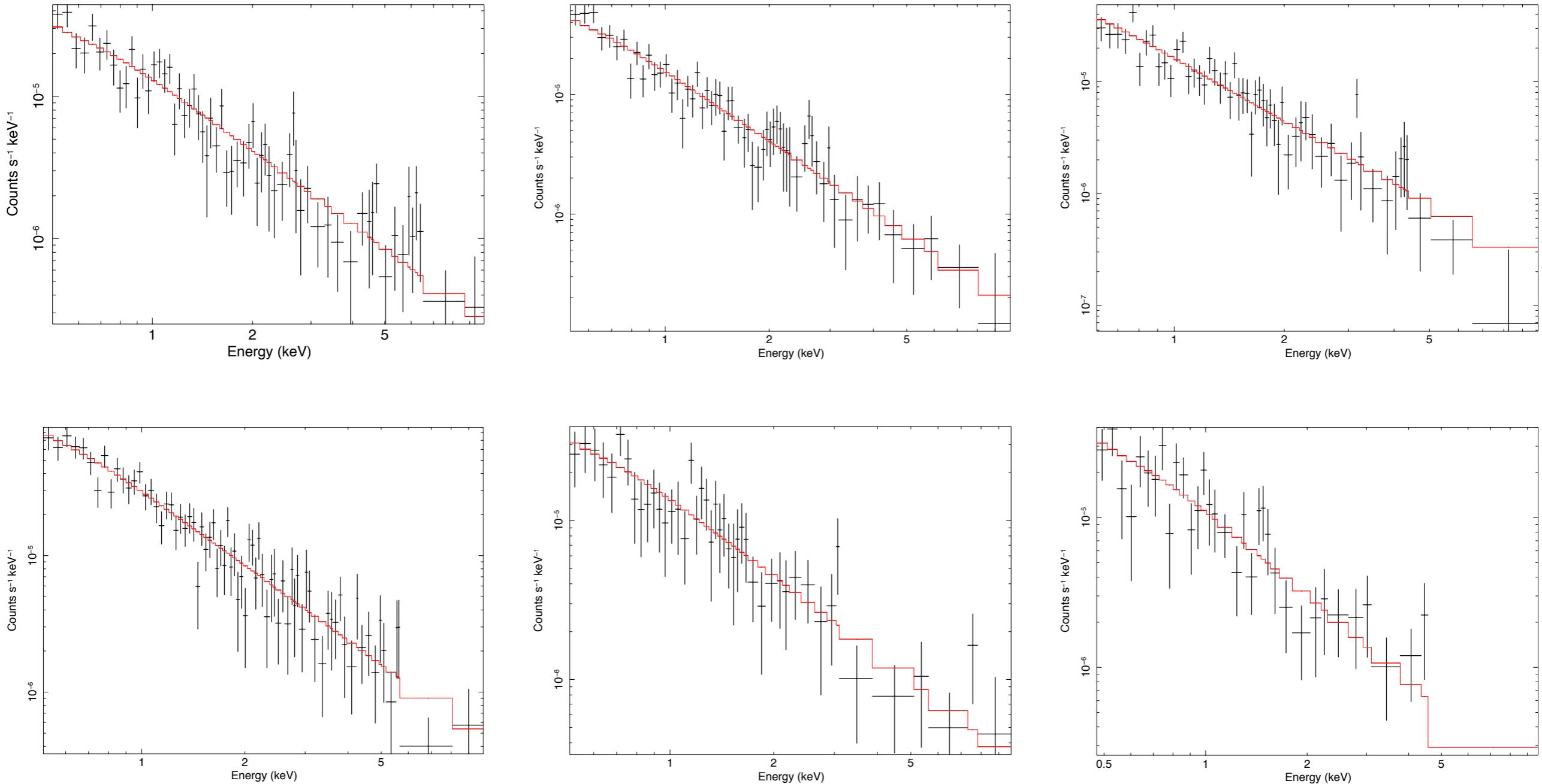
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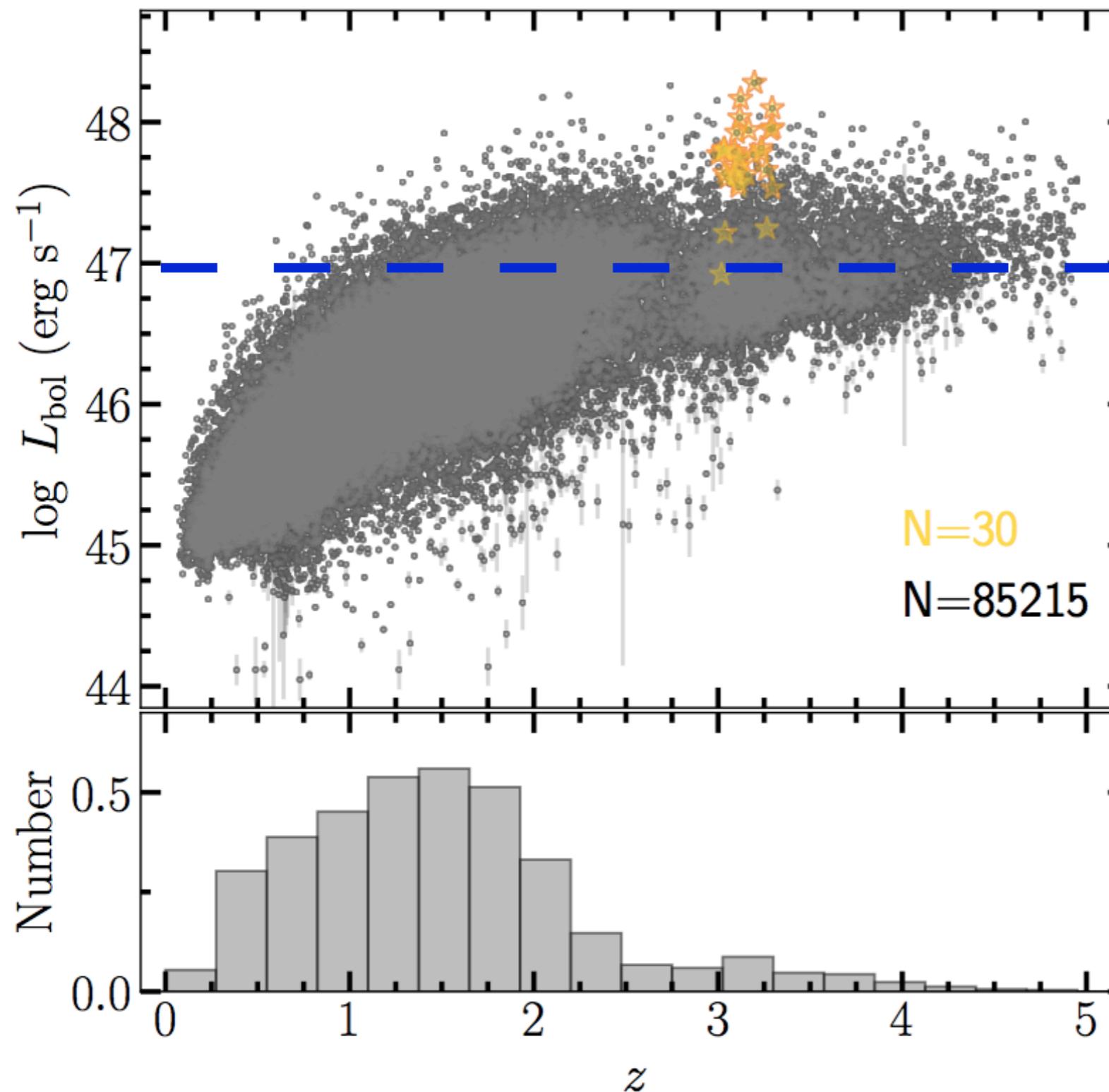


# The XMM-Newton program on z~3 quasars

~1Ms AO-16 (co-I, PI: Risaliti): 30 non-jetted SDSS quasars  
@z=3-3.3 observed for 25-35 ks



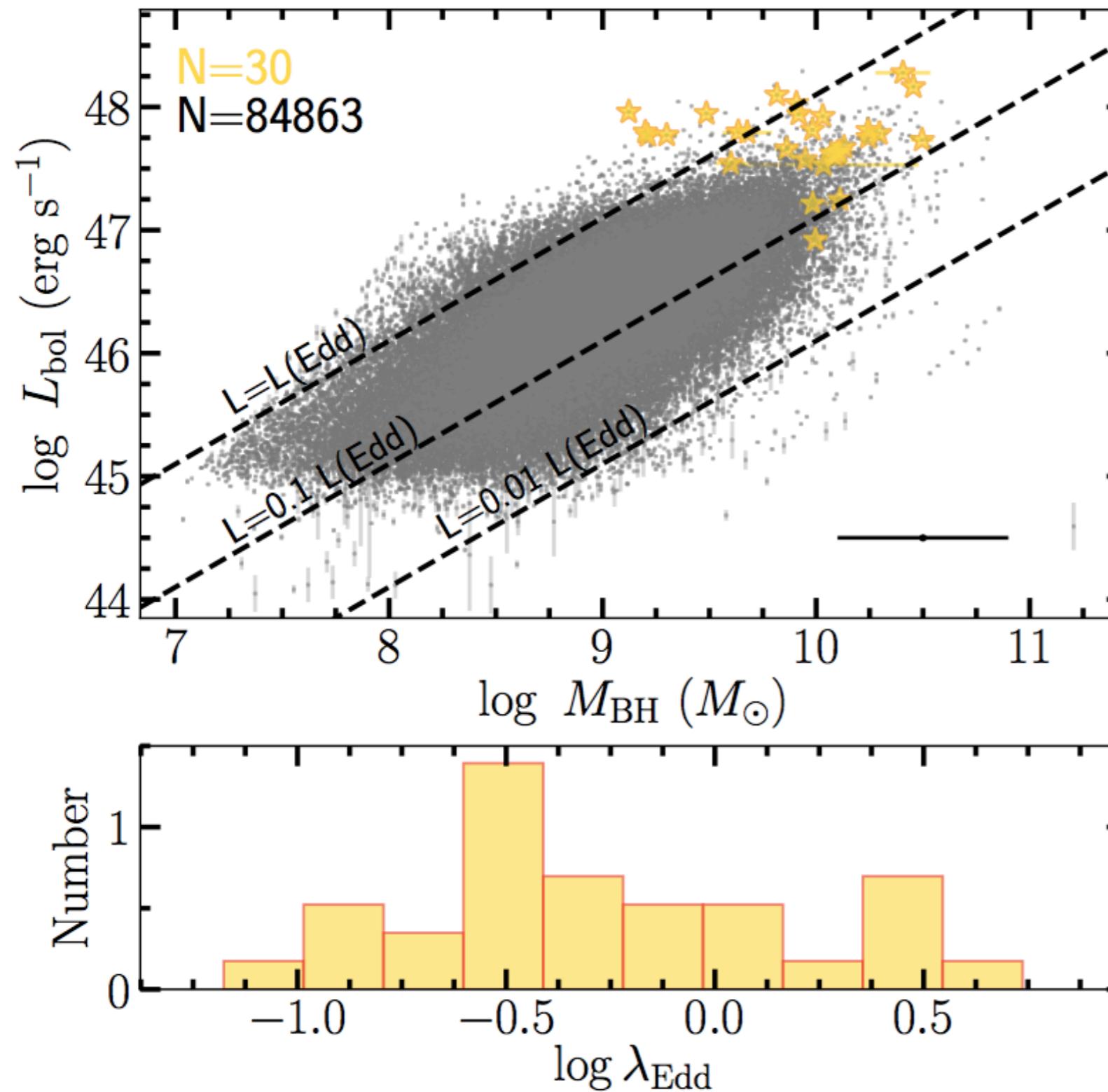
# The XMM-Newton program on $z \sim 3$ quasars



Main sample SDSS-DR7  
(105,783 AGN)  
85,215 AGN:  
NO BAL, jetted,  
dust reddened objects

1.  $L_{\text{BOL}} > 10^{47} \text{ erg/s}$
2.  $3 < z < 3.3$
3. No previous X-ray observations

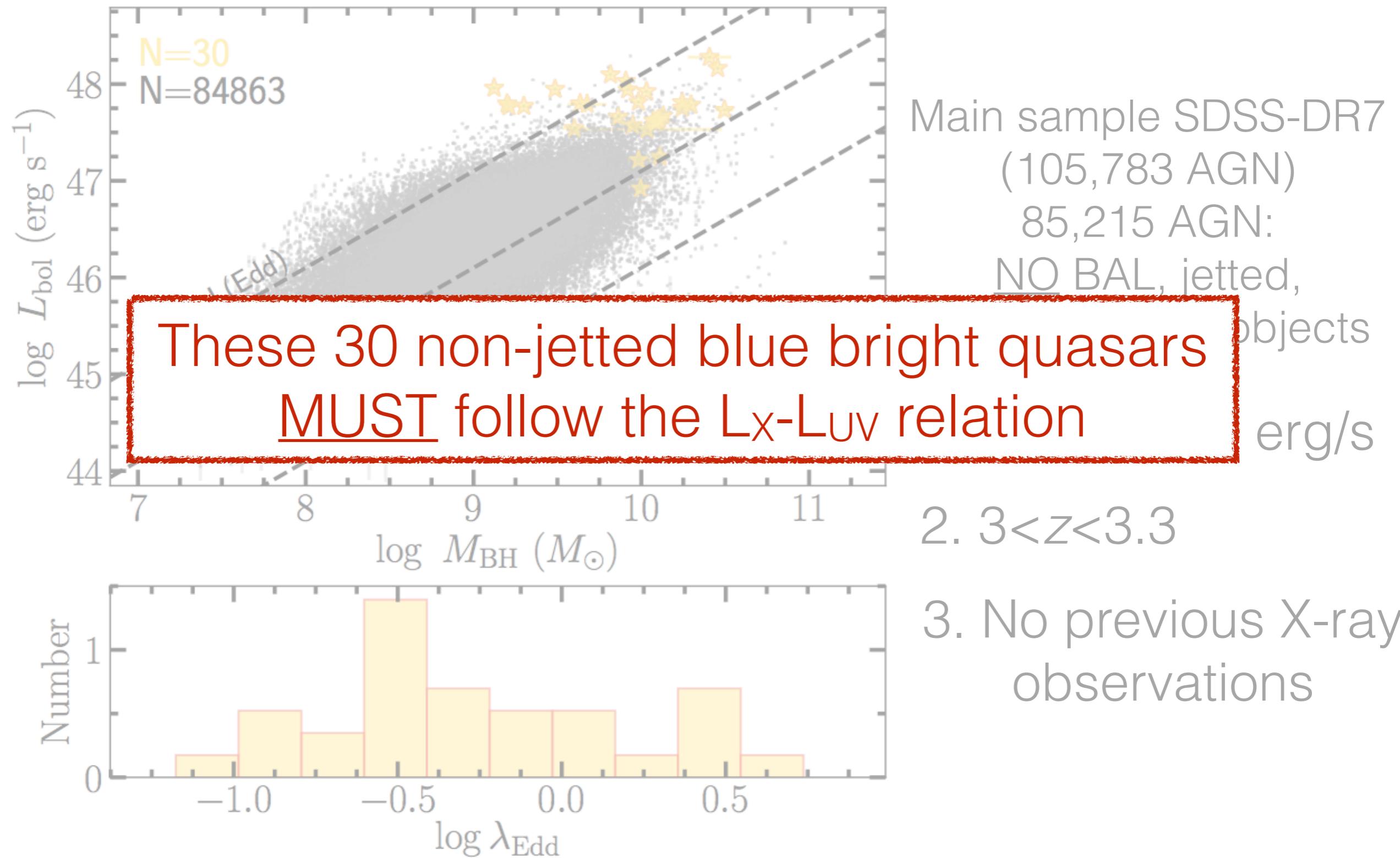
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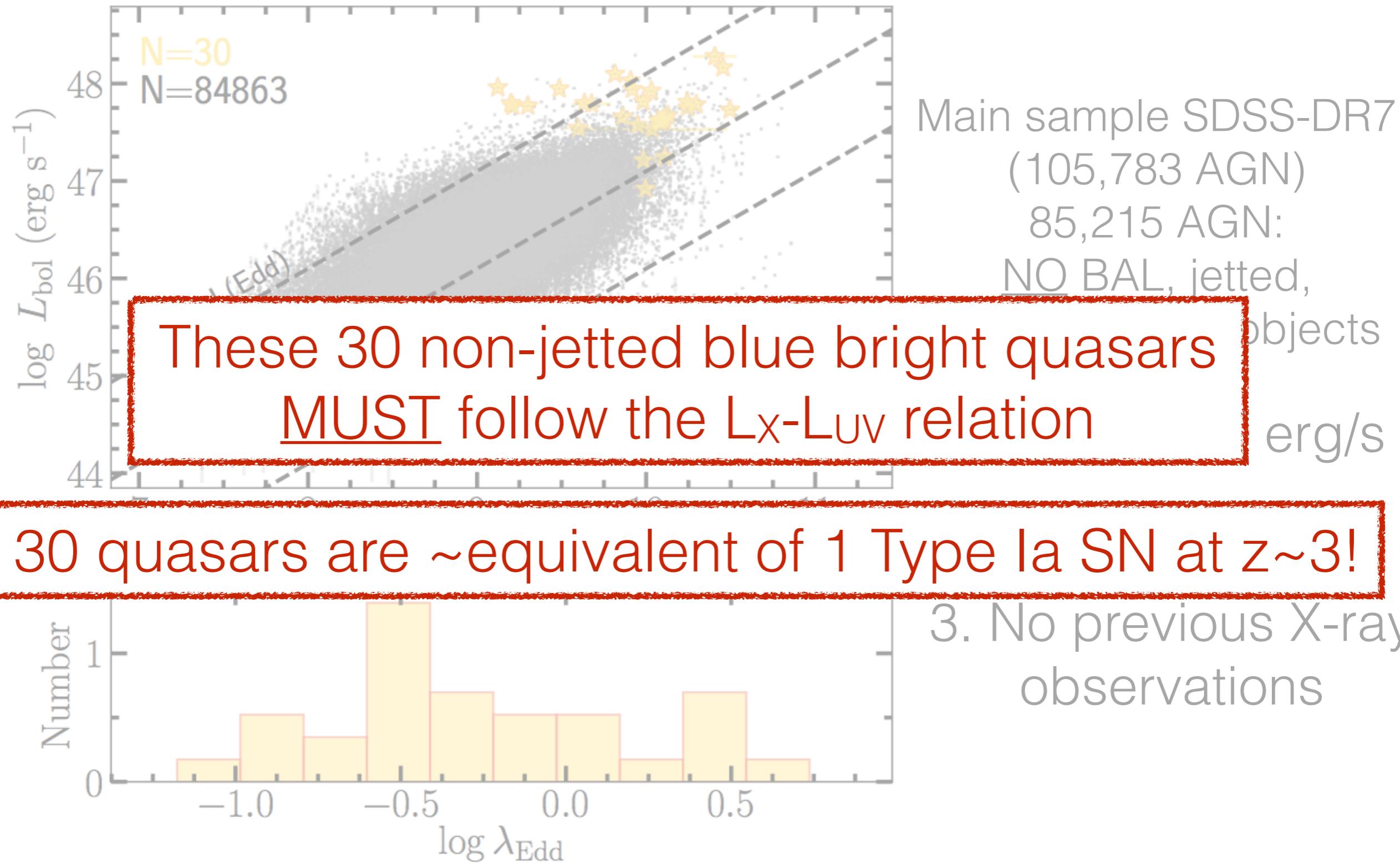
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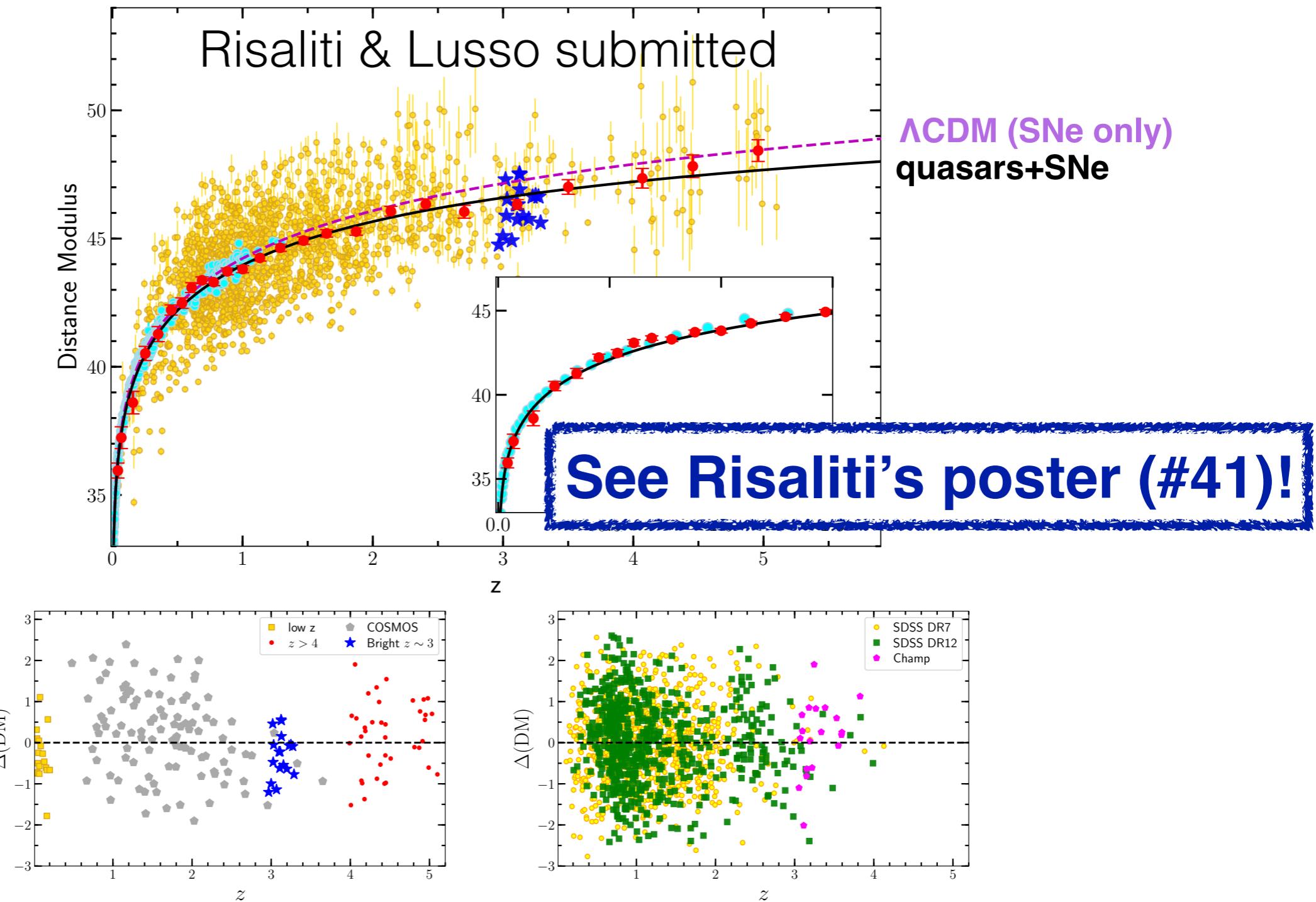
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# Cosmology with quasars

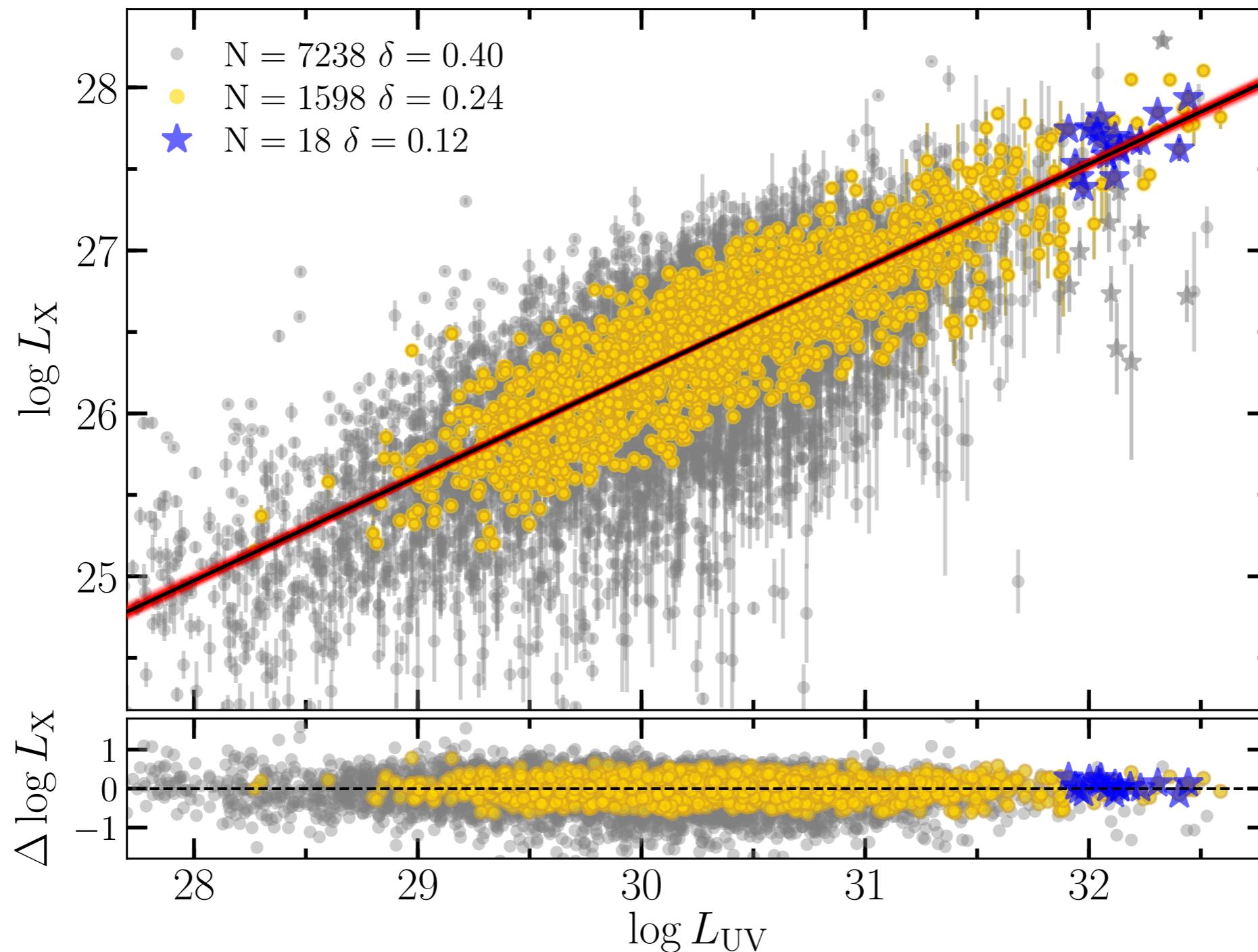
## The new! Quasars Hubble Diagram

~1600 quasars: SDSS+3XMM+XMMLP+archive/literature



# The new quasar sample @z~3

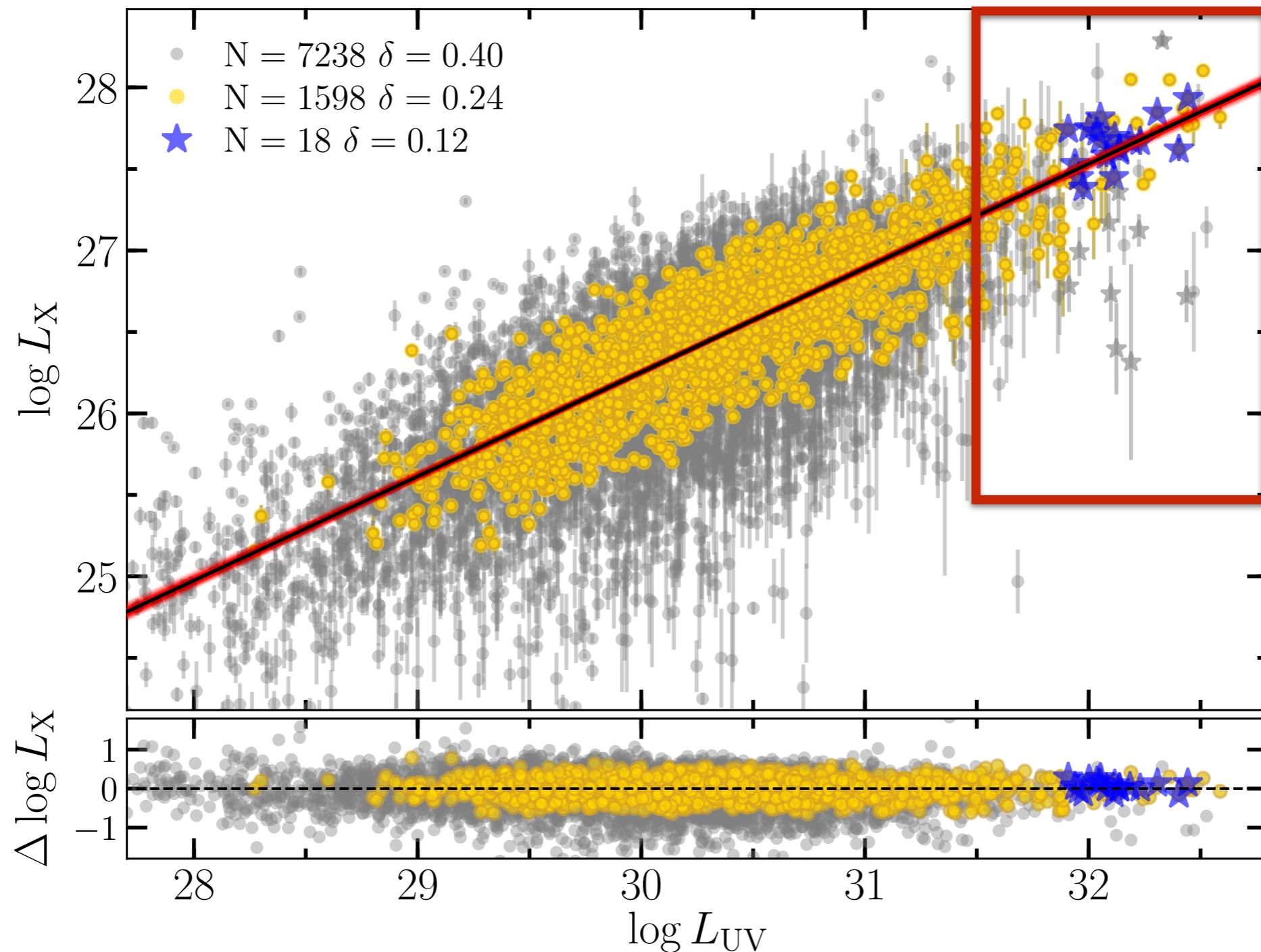
## L<sub>X</sub>-L<sub>UV</sub>



Risaliti & Lusso submitted

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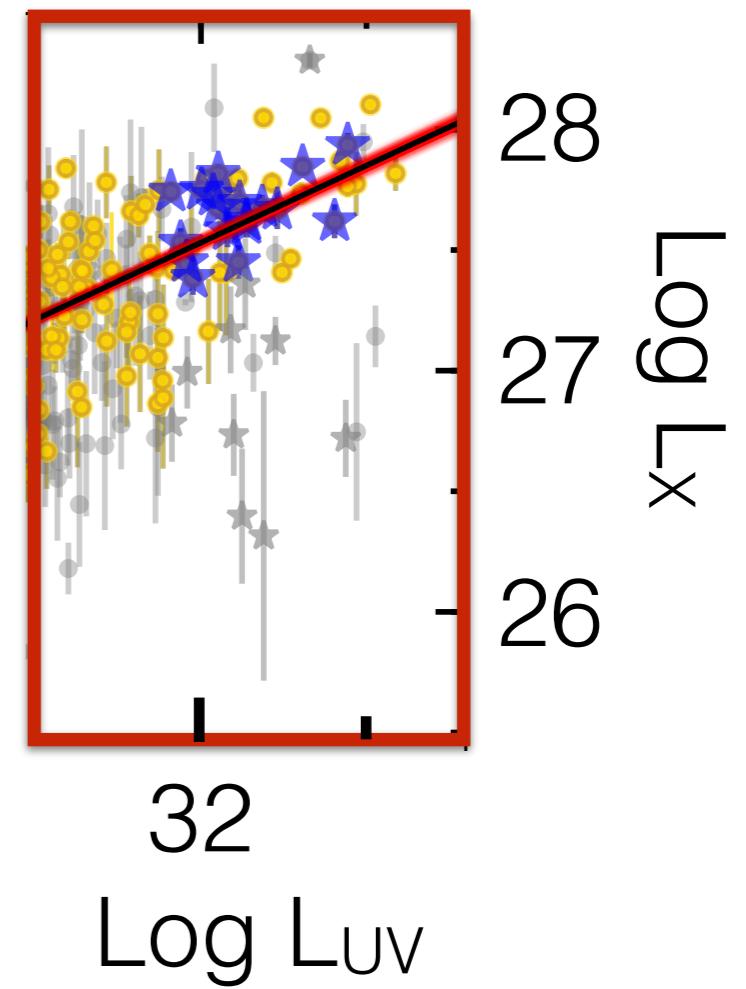
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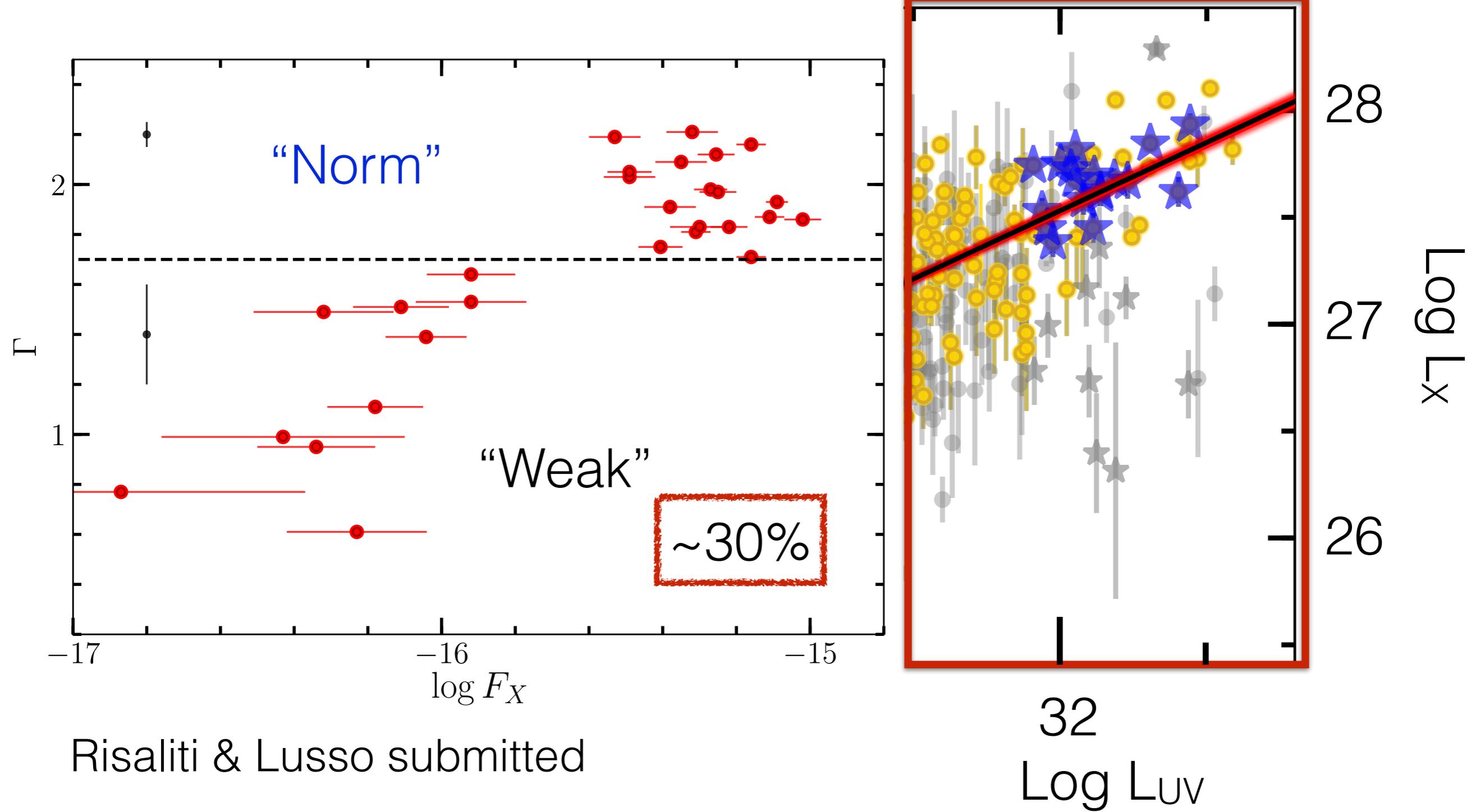
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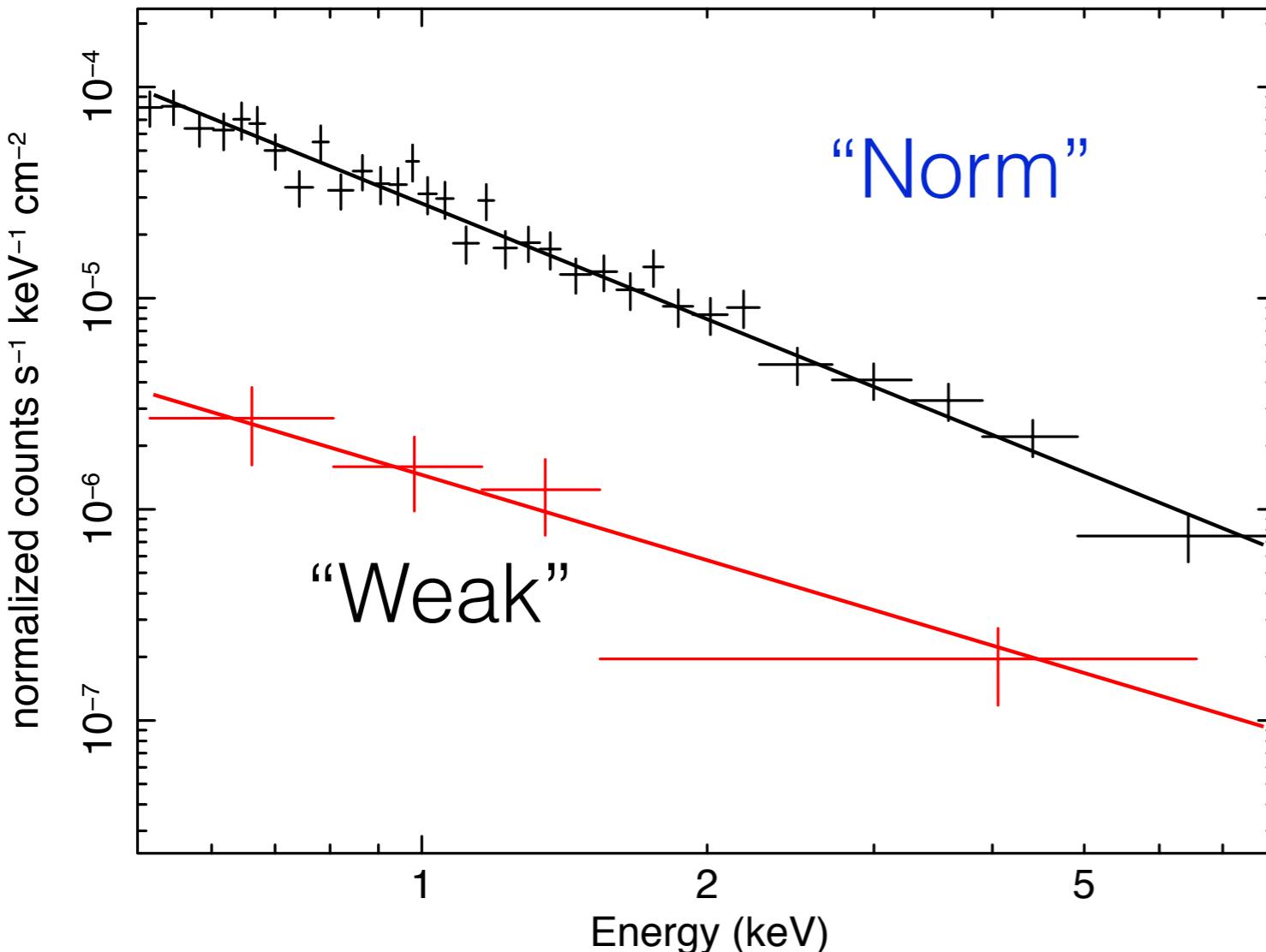


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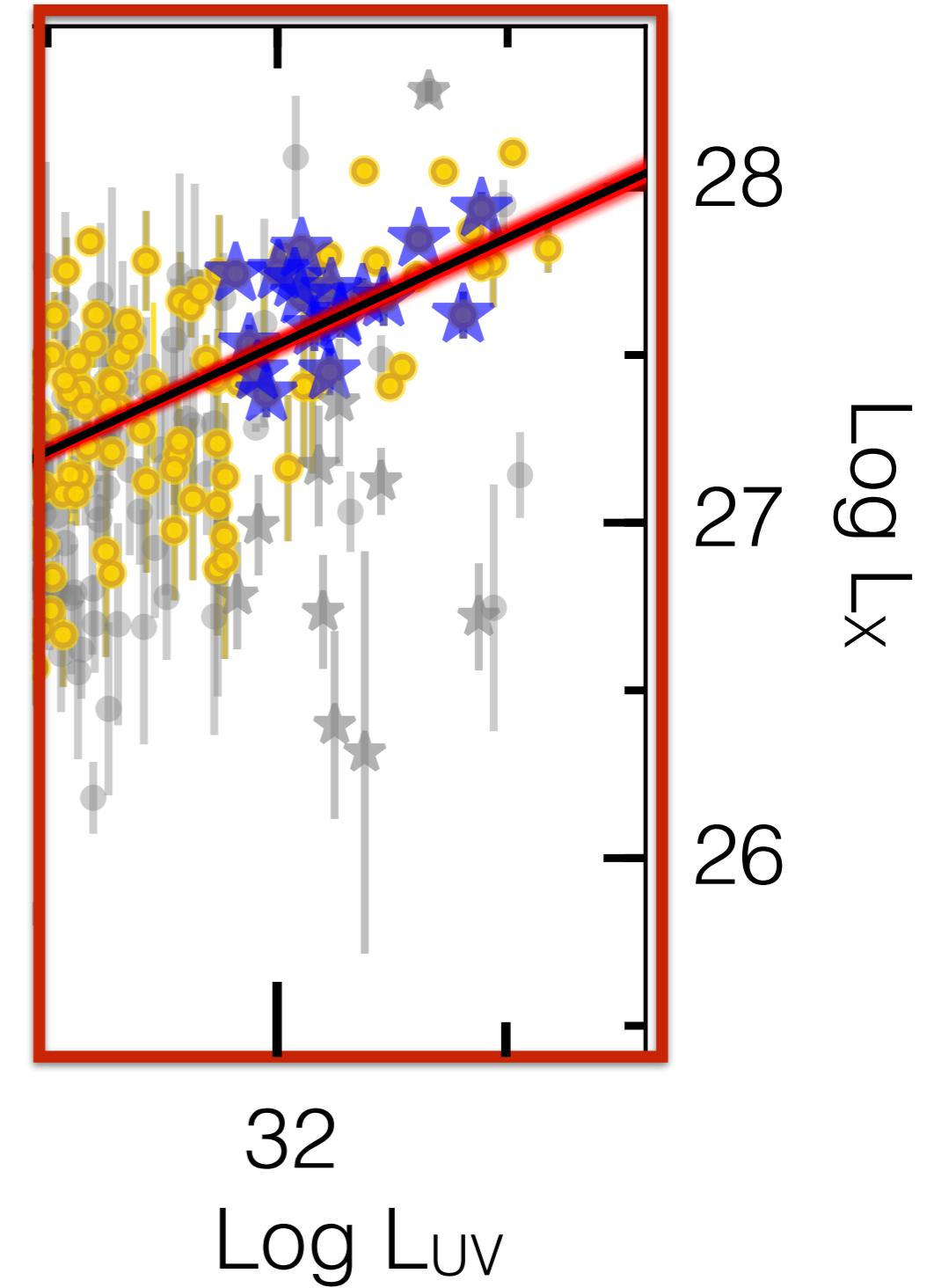
# The new quasar sample @ $z \sim 3$



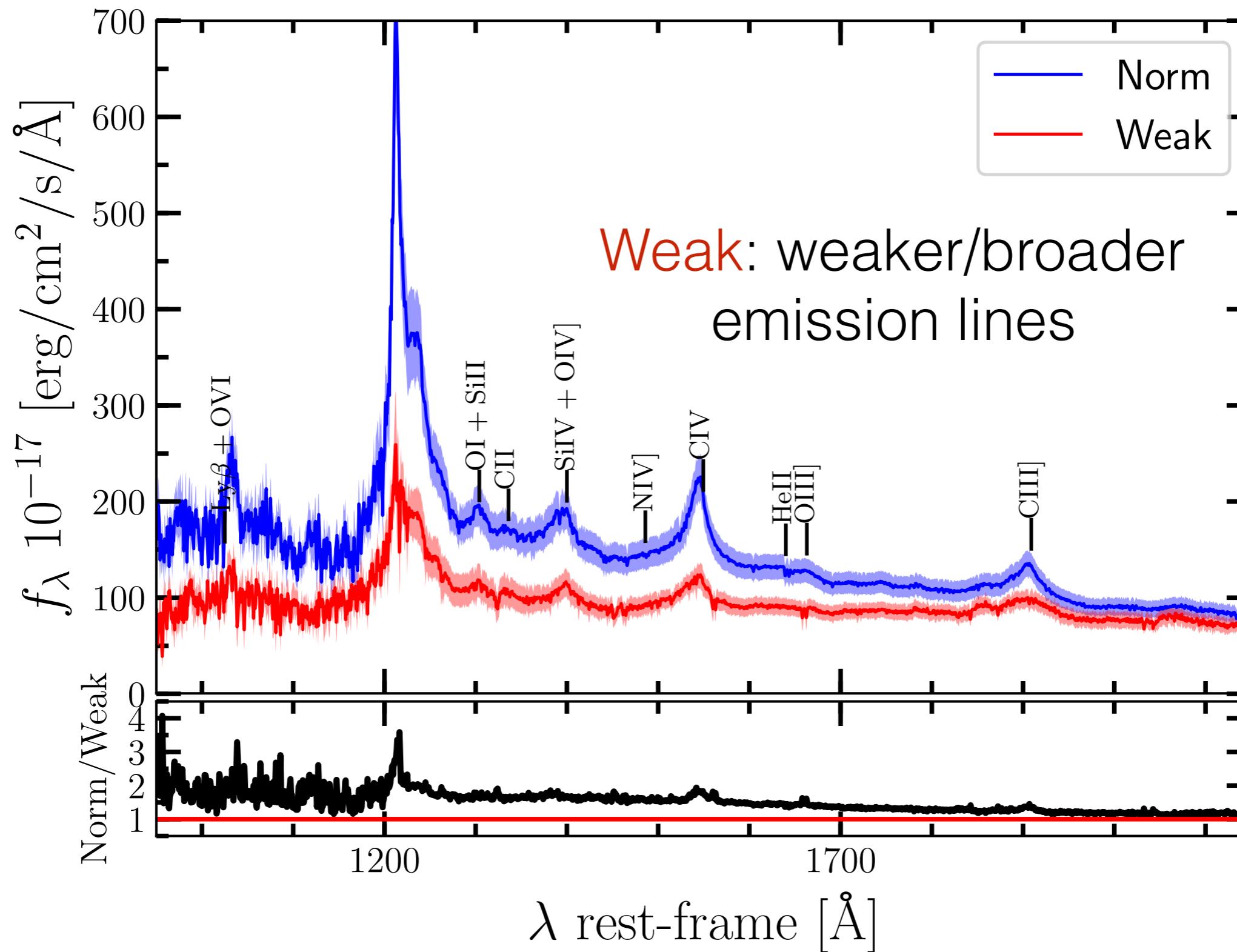
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Nardini E., et al. in prep

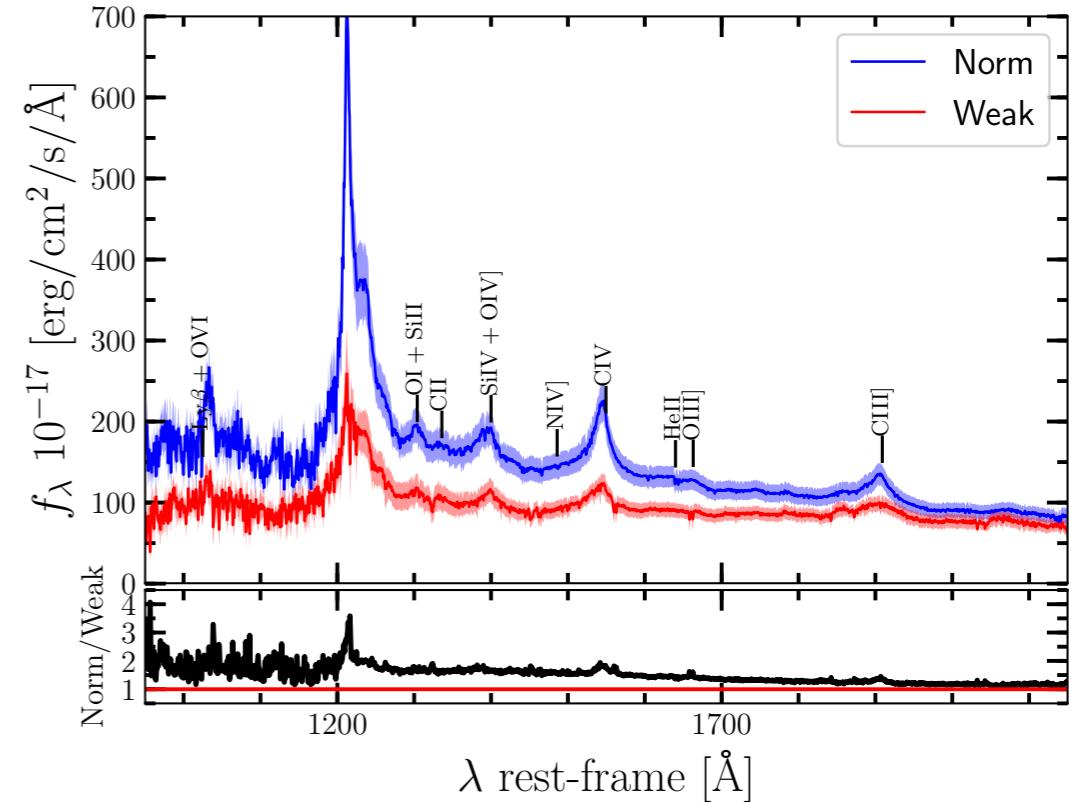


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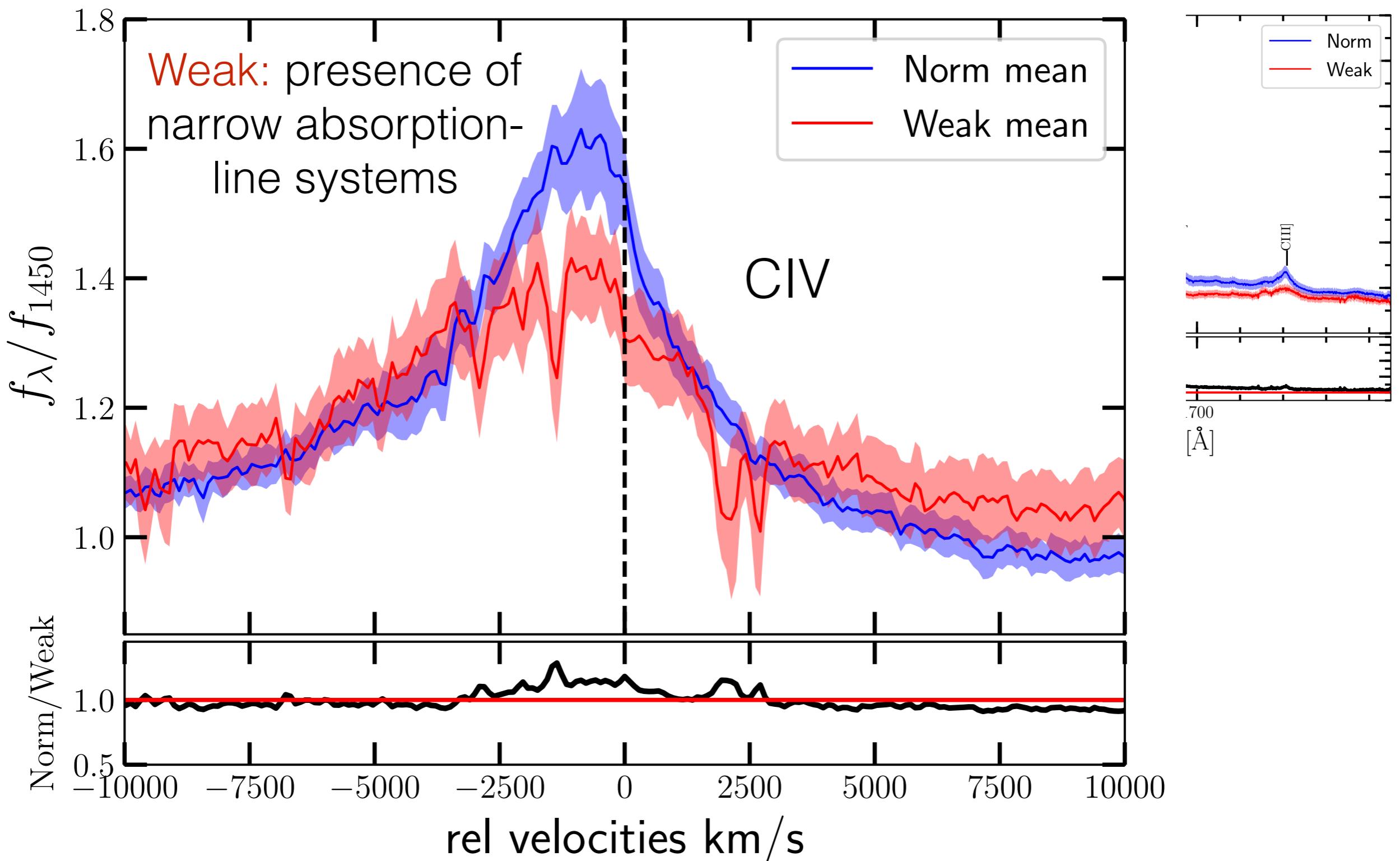
Lusso E., et al. in prep

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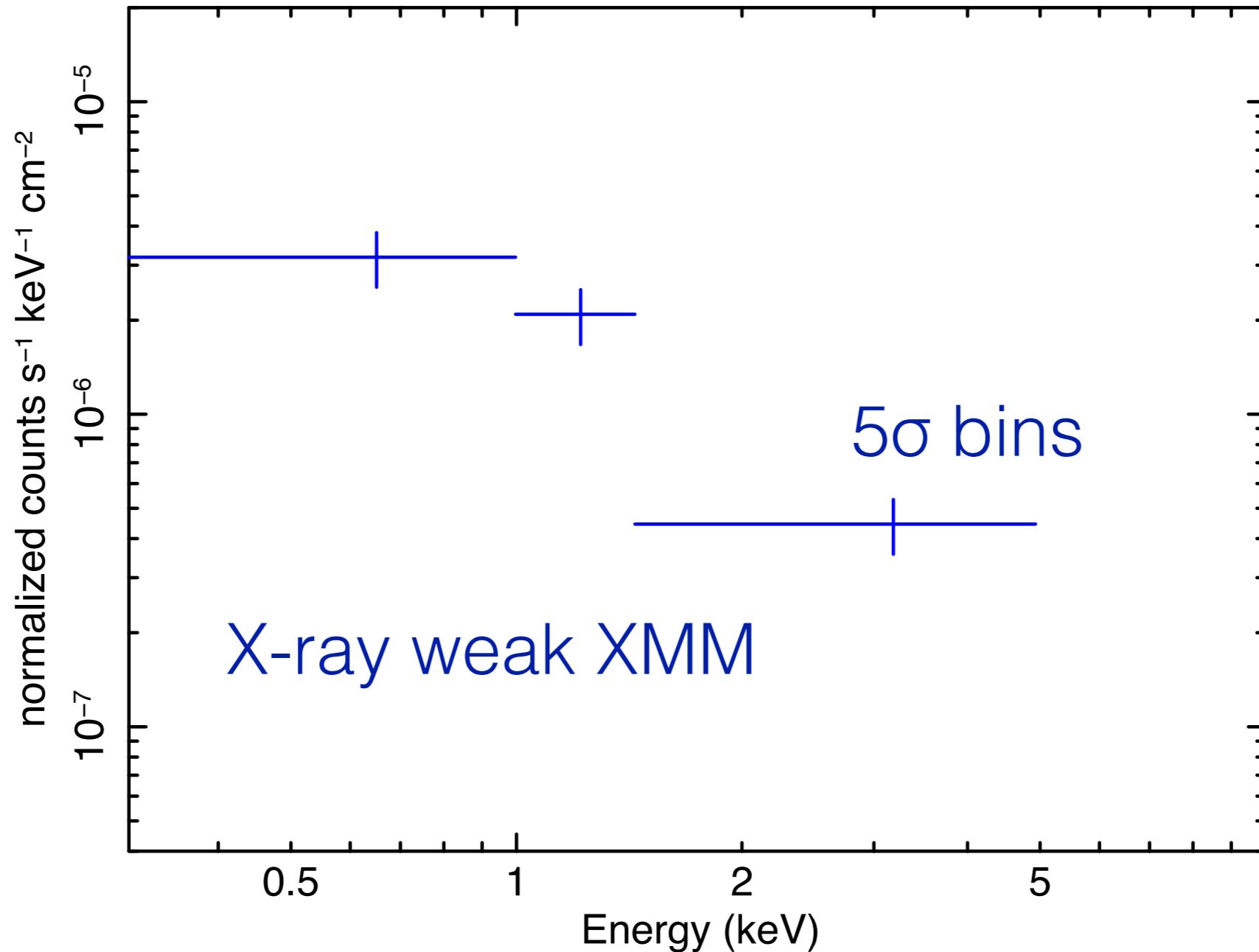
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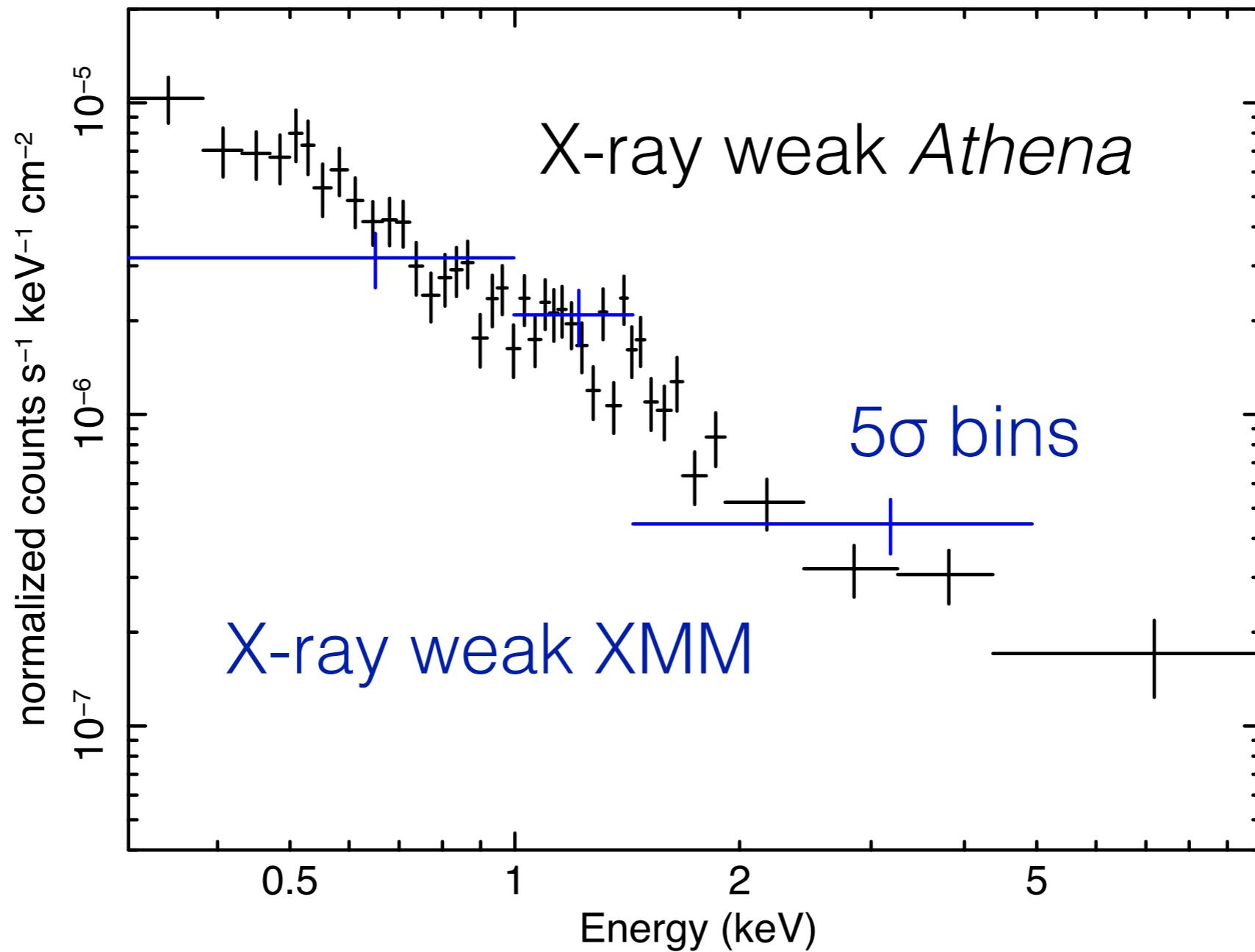
# X-ray weak quasars with *Athena*

J120144.36+011611.6 @z=3.236, 40ks, 218 net counts  
EPIC 0.3-8 keV (123 net counts PN only)



# X-ray weak quasars with *Athena*

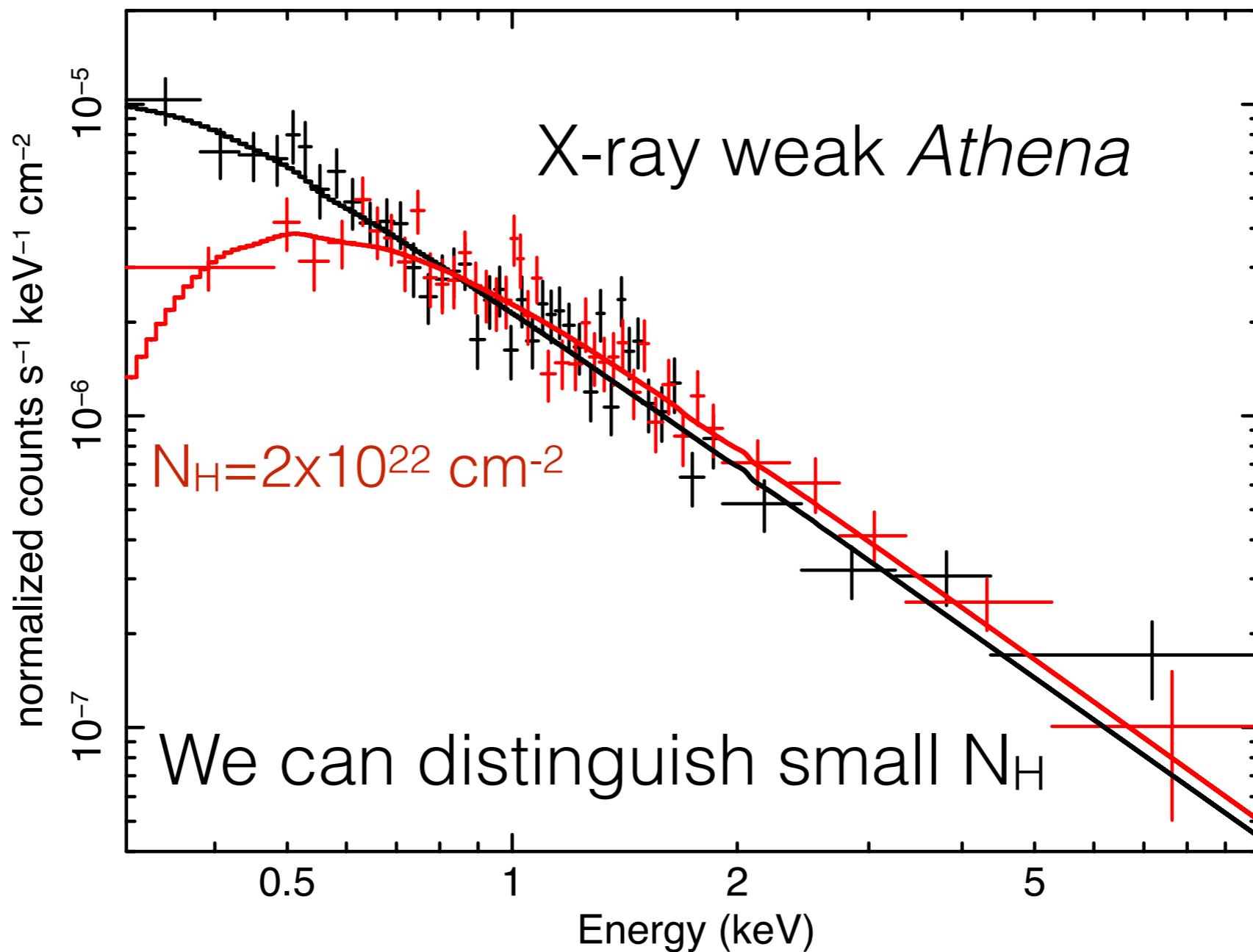
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30ks, >1000 net counts WFI 0.3-8 keV

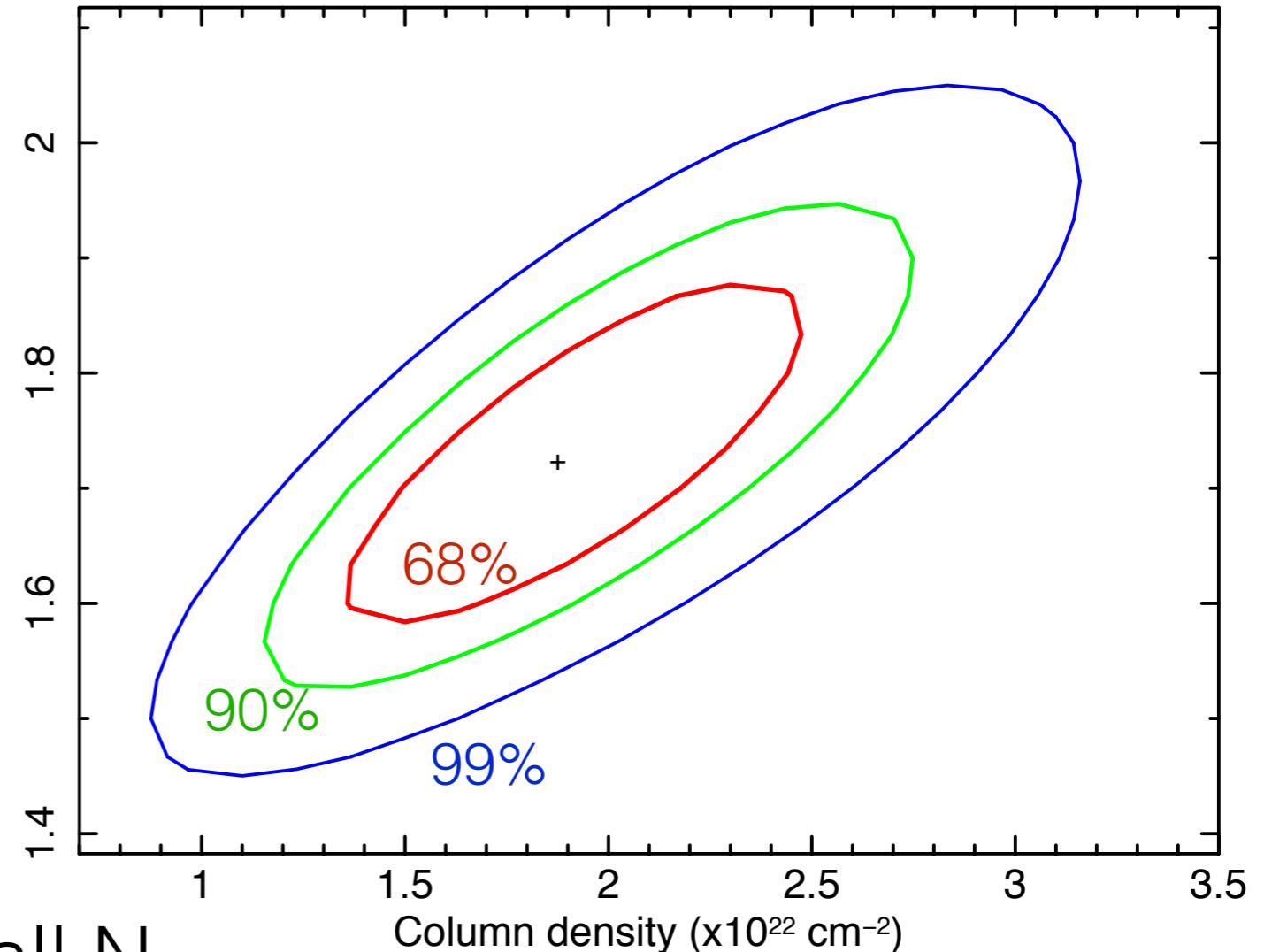
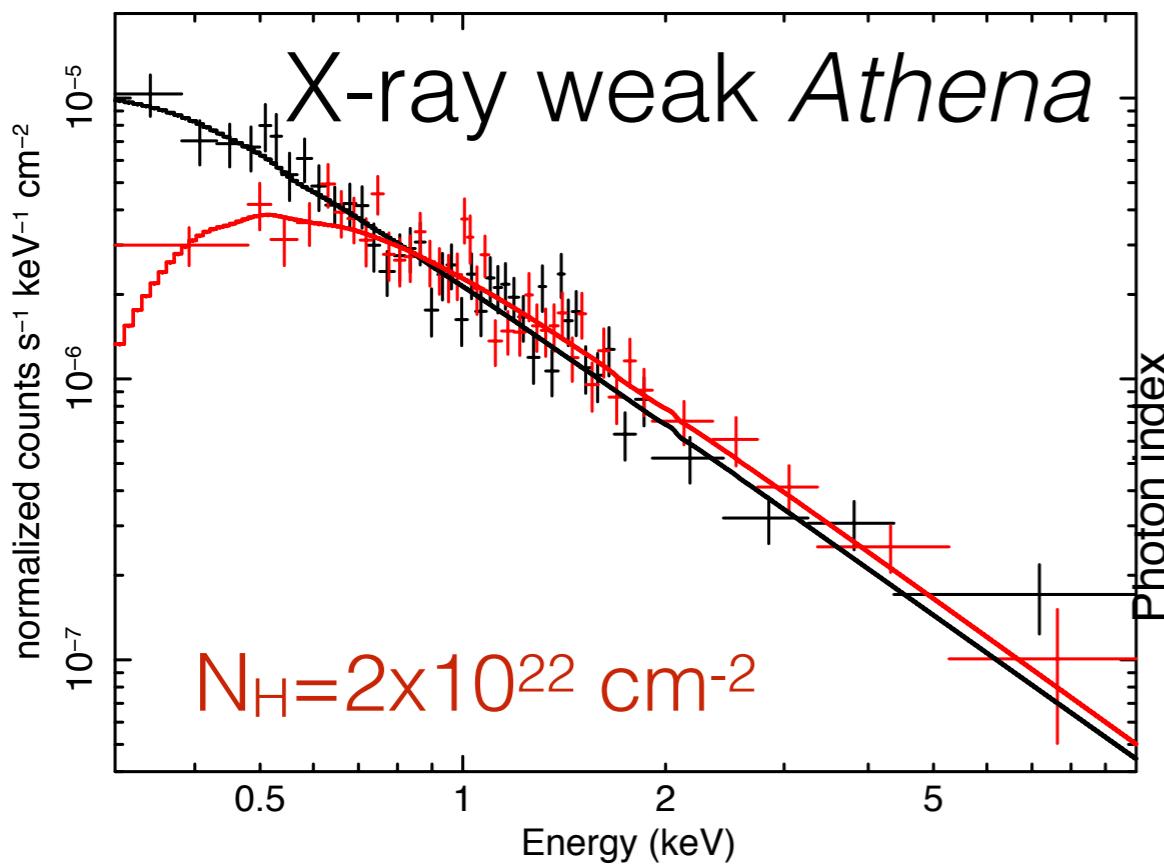
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30ks, >1000 net counts WFI 0.3-8 keV



We can distinguish small  $N_{\text{H}}$

# X-ray weak quasars with *Athena*

Based on SDSS DR7 (9380 deg<sup>2</sup>)

$3 < z < 3.3 \text{ & } L_{\text{bol}} > 10^{47} \text{ erg/s}$  (1140 quasars): ~1 quasar/8 deg<sup>2</sup> -> 12 WFI fields

$3 < z < 3.3 \text{ & } L_{\text{bol}} > 10^{46} \text{ erg/s}$  (2860 quasars): ~1 quasar/3 deg<sup>2</sup> -> 5 WFI fields

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1 Ms with *Athena* (~3ks each, e.g. XMM: 30 quasars ~30ks each)

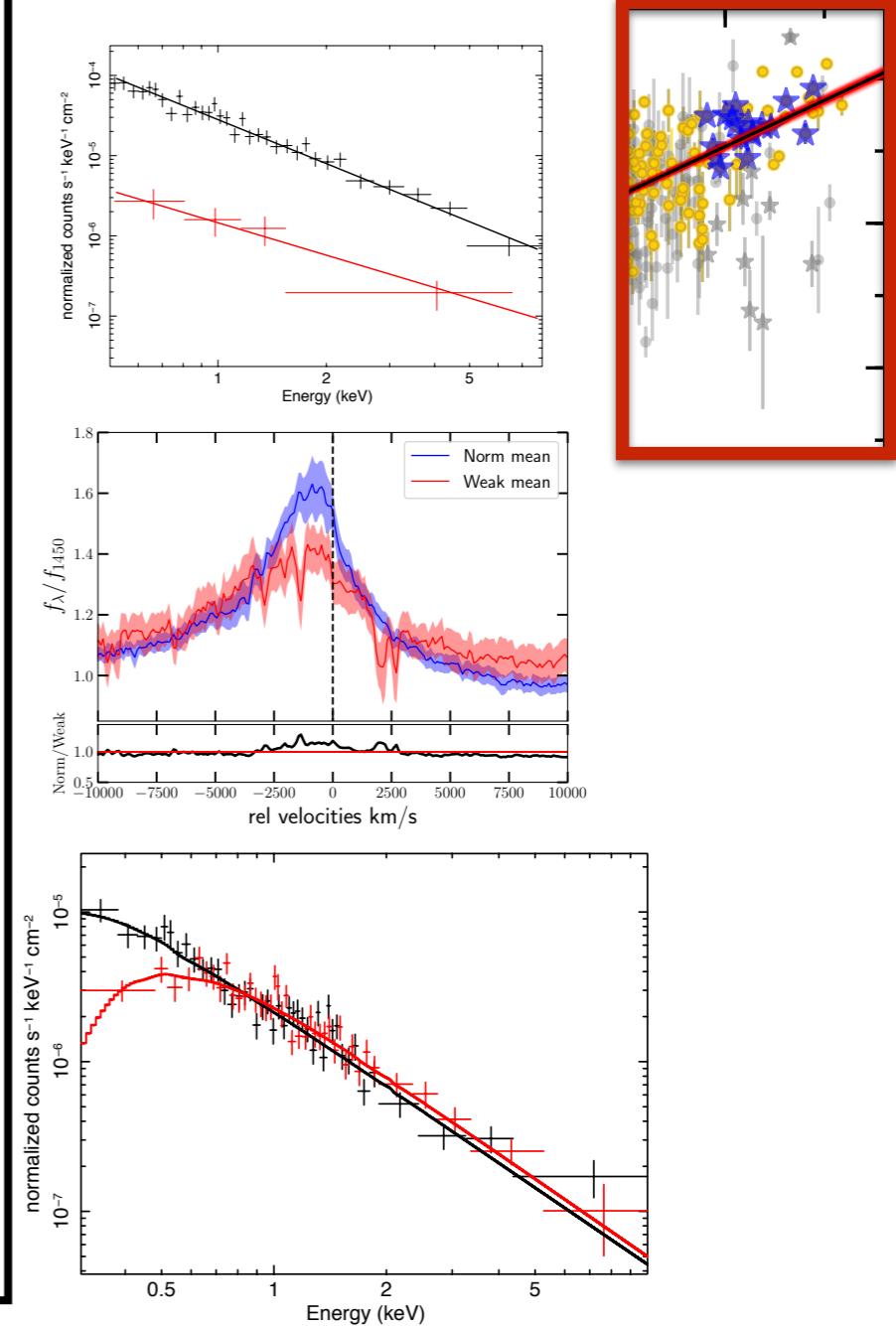
$3 < z < 3.3 \text{ and } L_{\text{bol}} > 10^{47} \text{ erg/s}$ : ~200 normal quasars with spectra +  
~100 X-ray weak, detected.

$3 < z < 3.3 \text{ and } L_{\text{bol}} > 10^{46} \text{ erg/s}$ : ~300 quasars (X-ray weak fraction?)

# To summarise

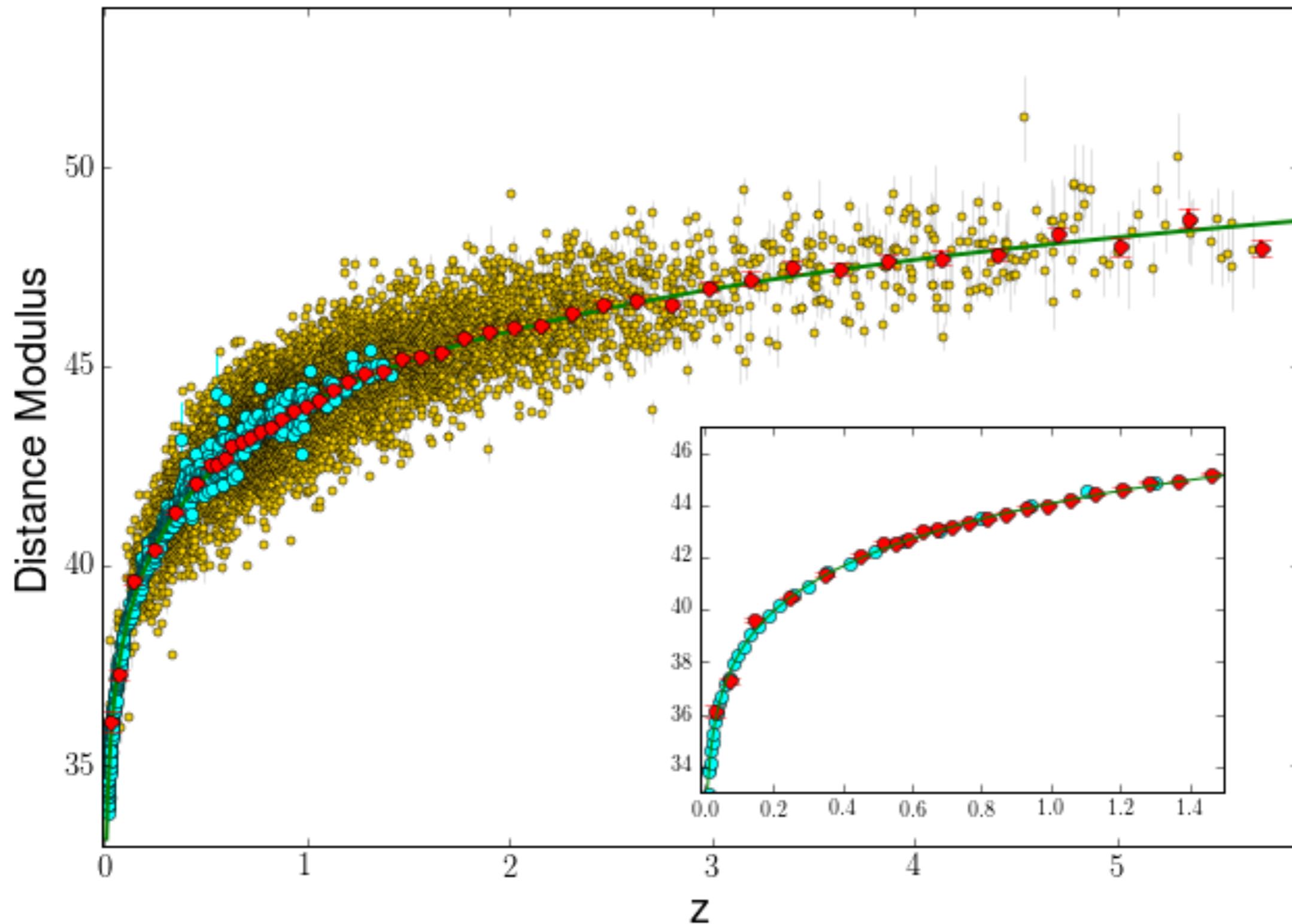
~1Ms XMM VLP: 30 non-jetted SDSS quasars @z=3-3.3

1. ~30% of the z~3 blue quasar sample shows *intrinsically* weak X-ray spectra
2. X-ray weak quasars show broader/weaker emission lines and narrow absorption line systems
3. Athena will definitely pinpoint low level of absorption and quantify the X-ray weak fraction at low  $L_{bol}$  ( $\sim 10^{46} \text{ erg/s}$ )



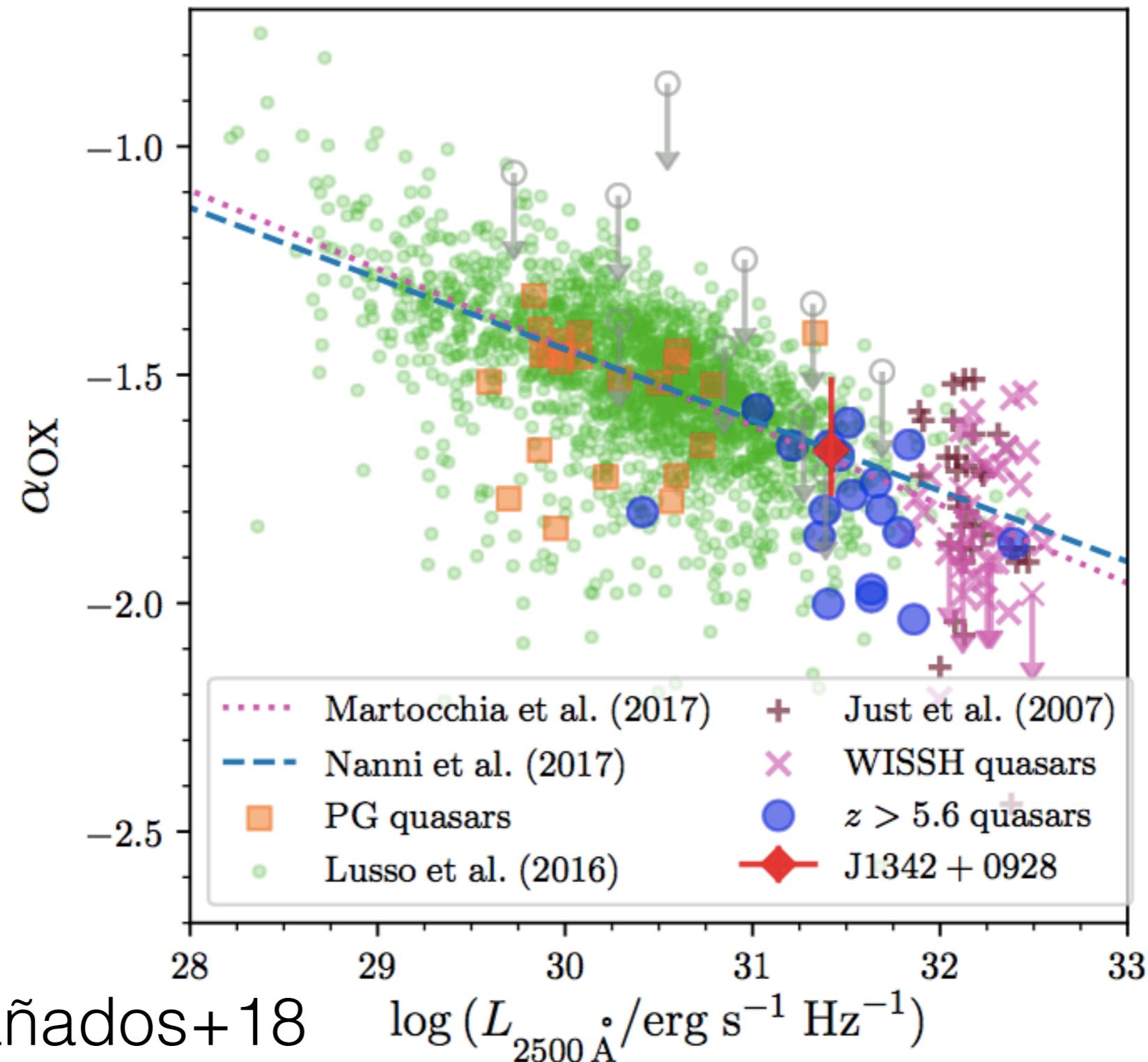


# Quasar Hubble Diagram with Athena



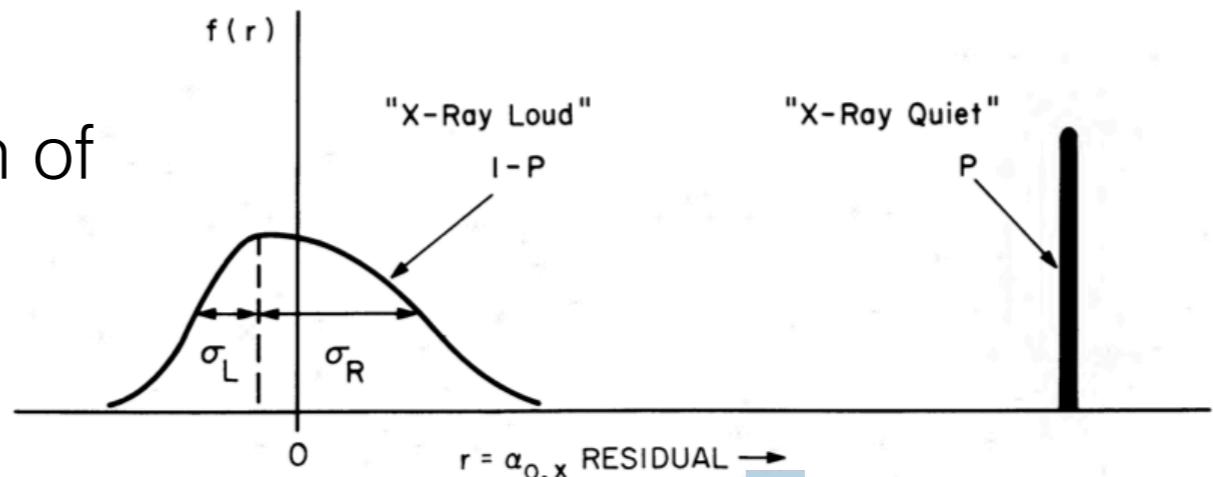
# The $\alpha_{\text{OX}}$ - $L_{\text{UV}}$ relation at high redshifts

ULAS J1342+0928 @7.54

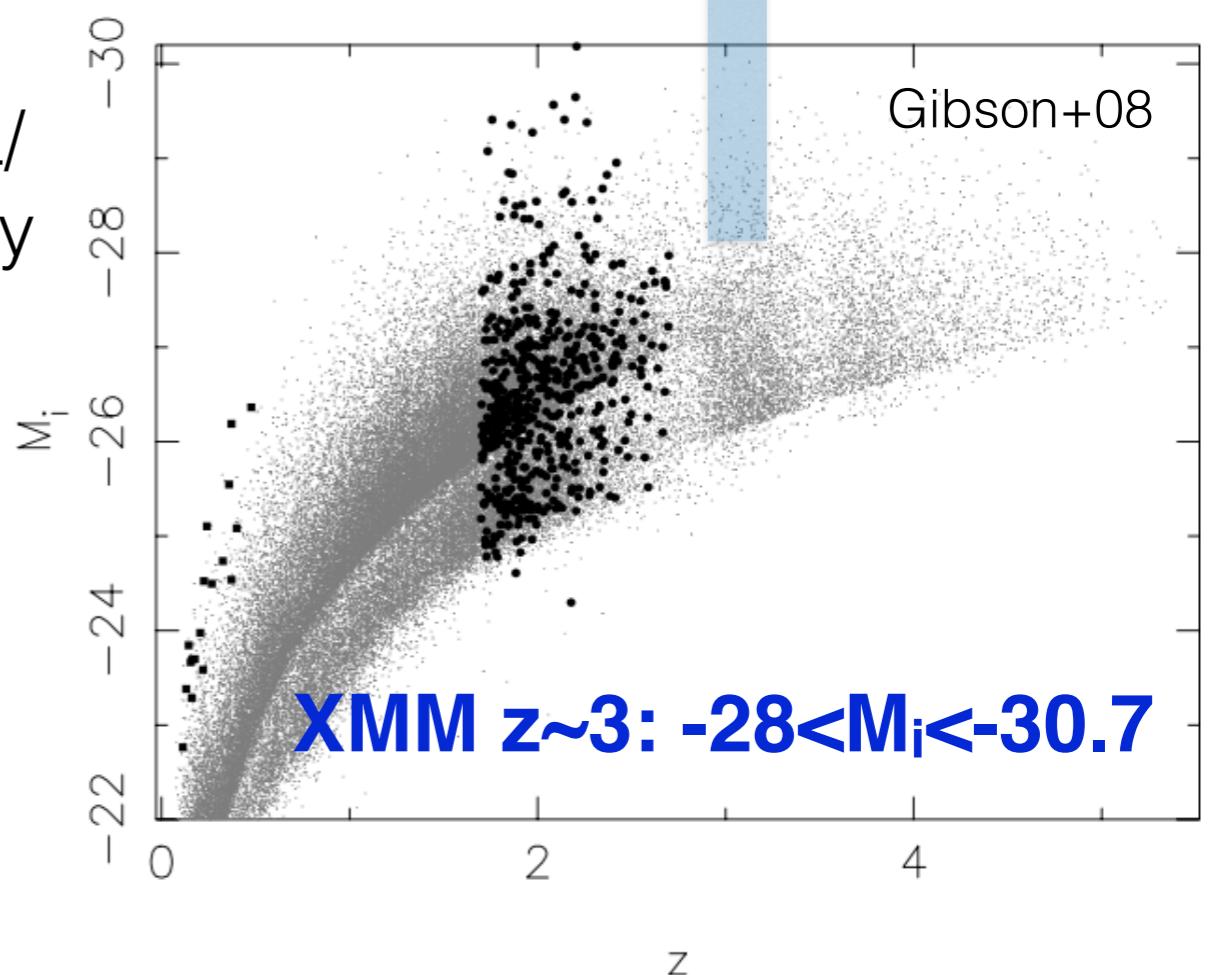


# X-ray weak quasar fraction (incomplete list of previous studies)

Avni & Tananbaum (1986): <8%, fraction of X-ray weak considered as a separated population from *typical* quasars.

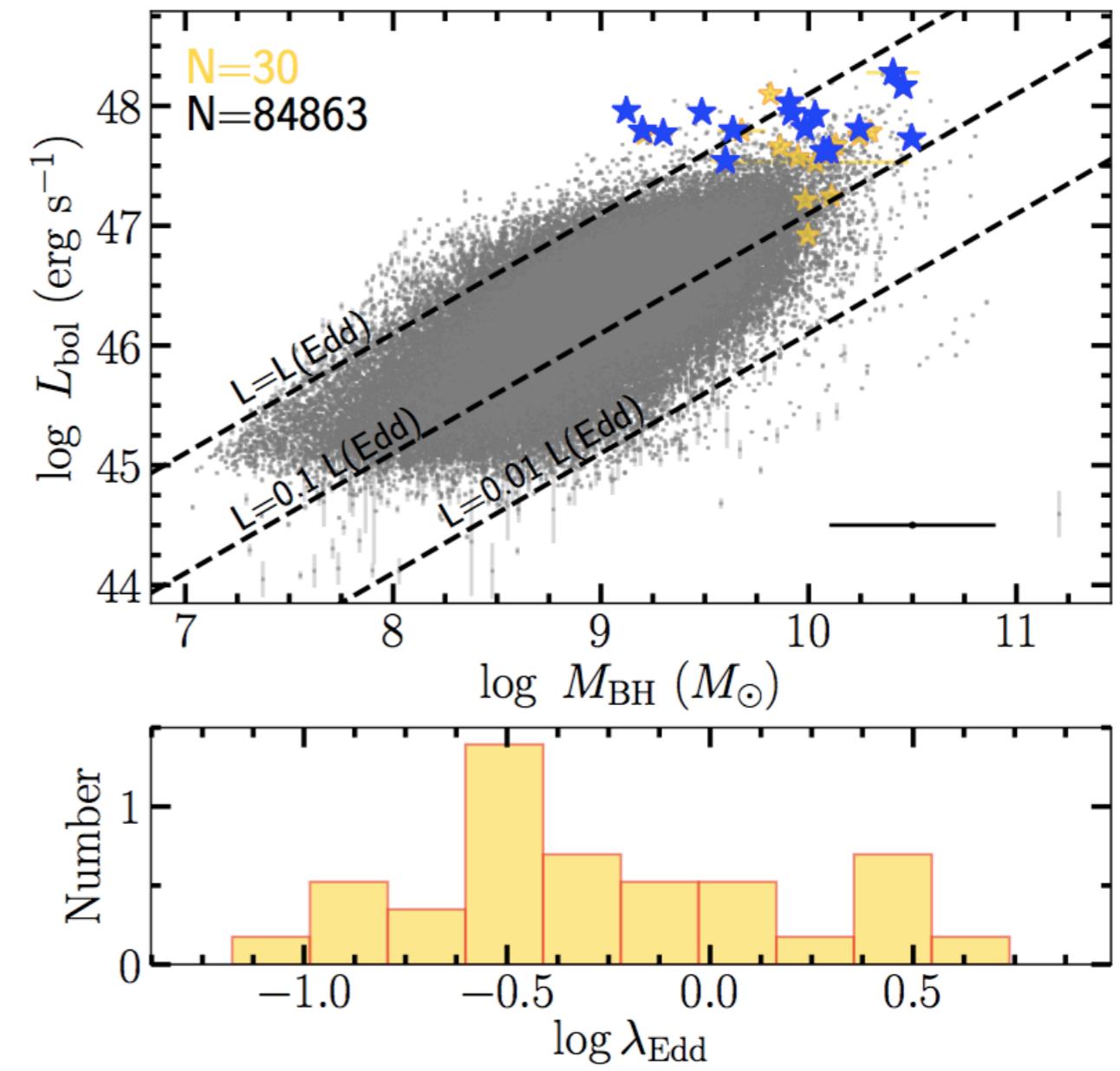
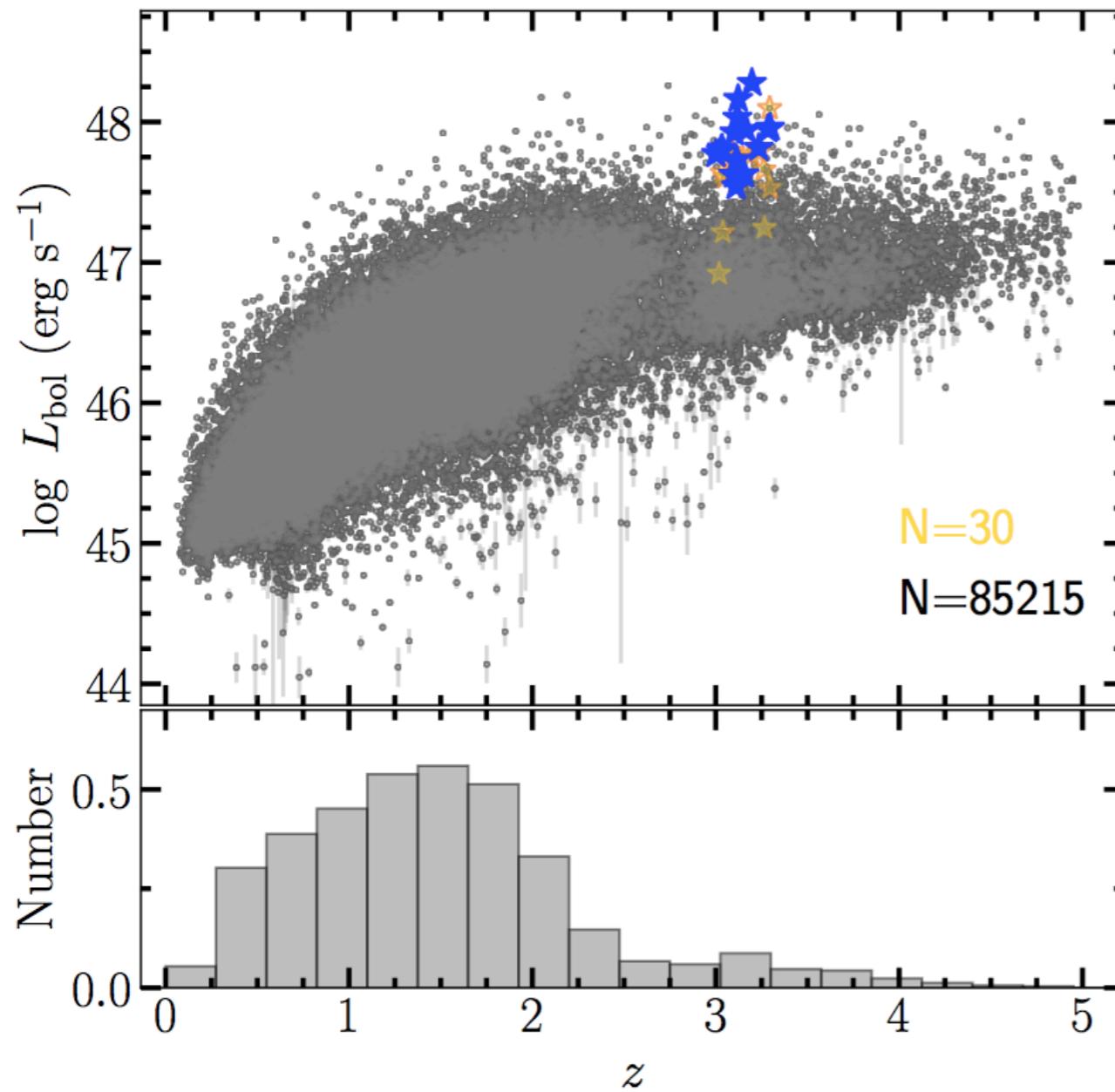


Gibson et al. (2008): <2% SDSS non-BAL/jetted quasars are relatively X-ray weak by (even) a factor of 10.



See also: Leighly et al. (2007, PHL1811);  
Shemmer et al. (2009); Wu et al. (2011, 2012);  
Luo et al. (2015)

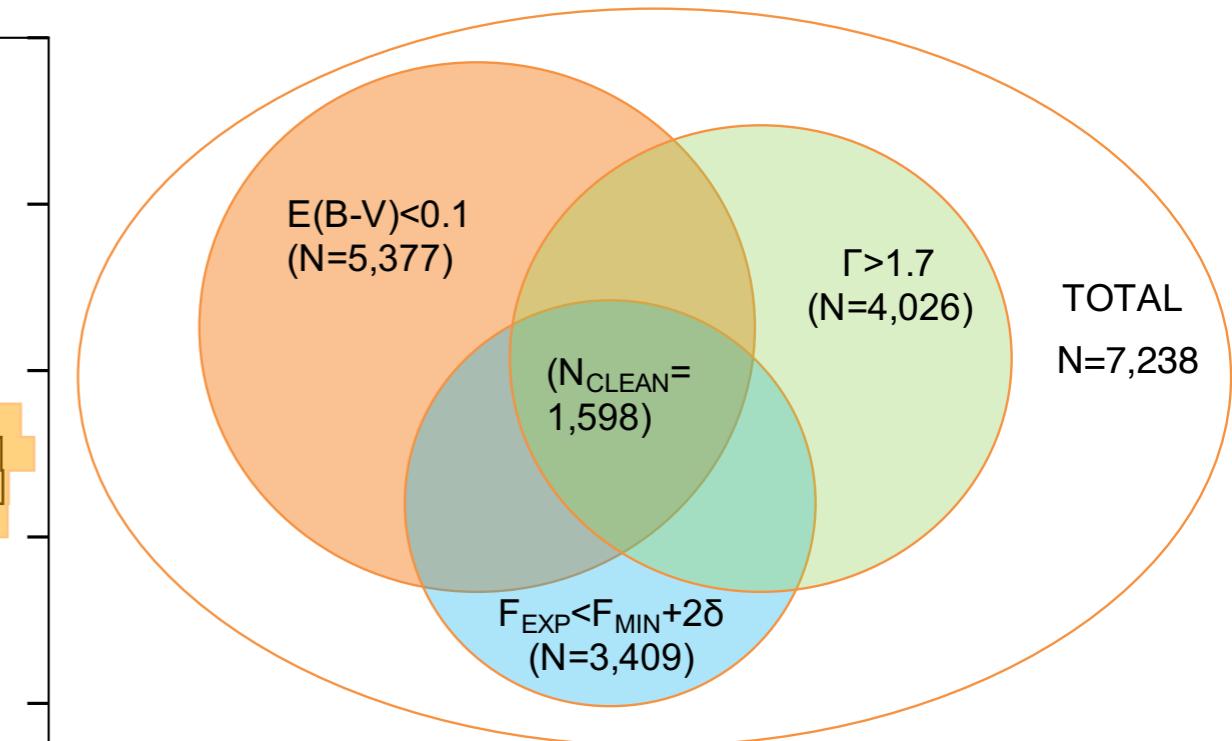
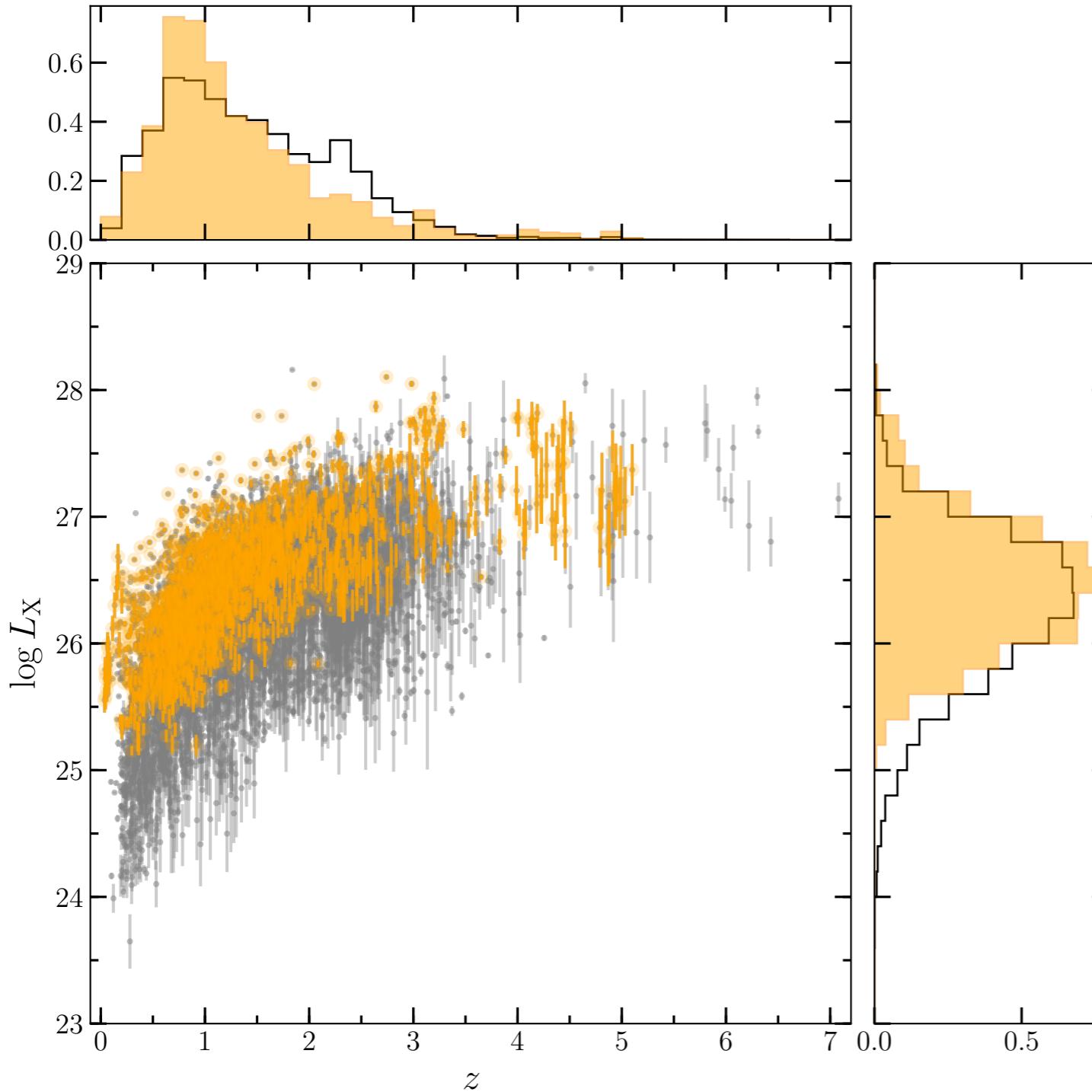
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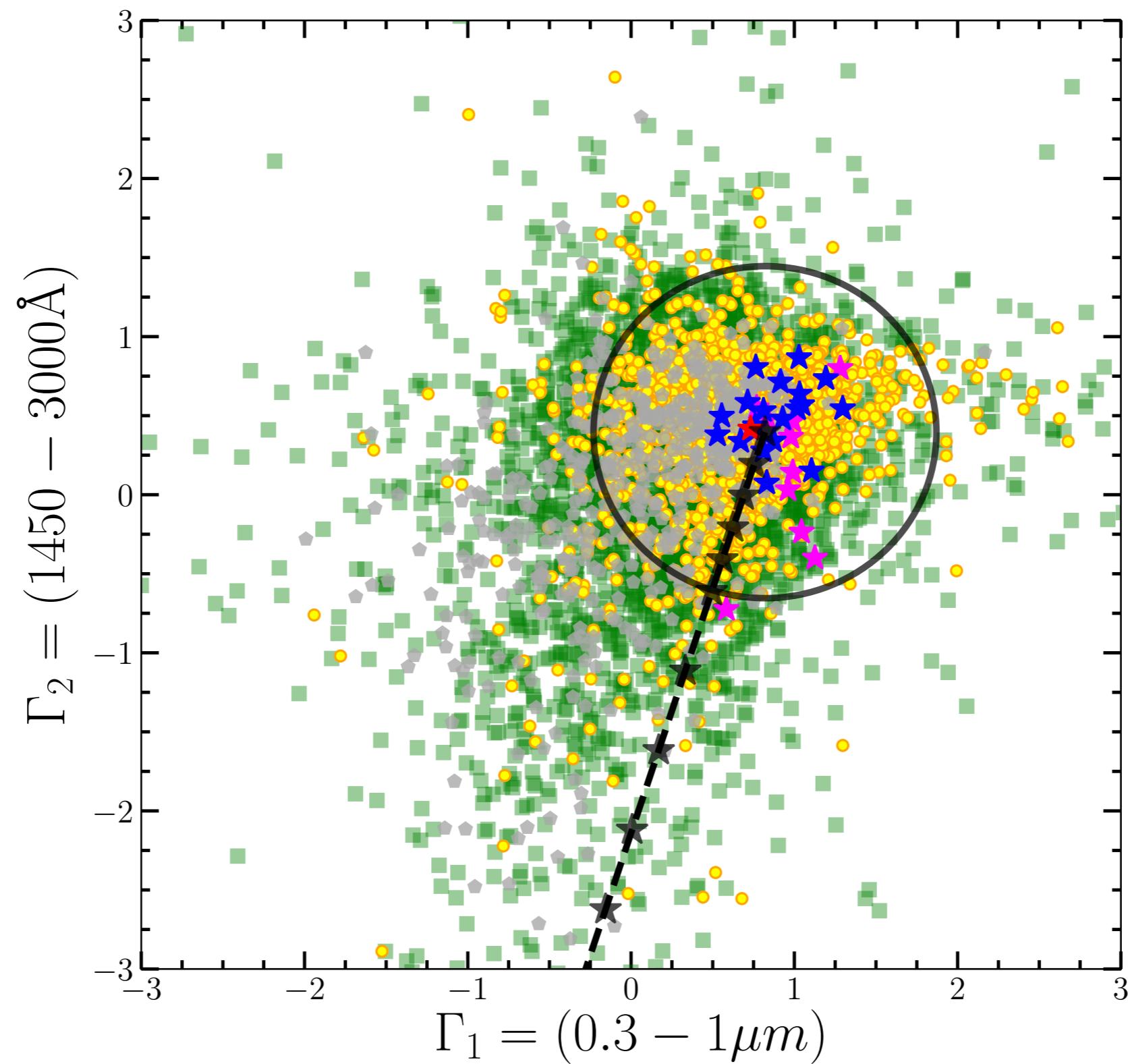
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~1600 quasars: SDSS+3XMM+XMMLP+archive/literature

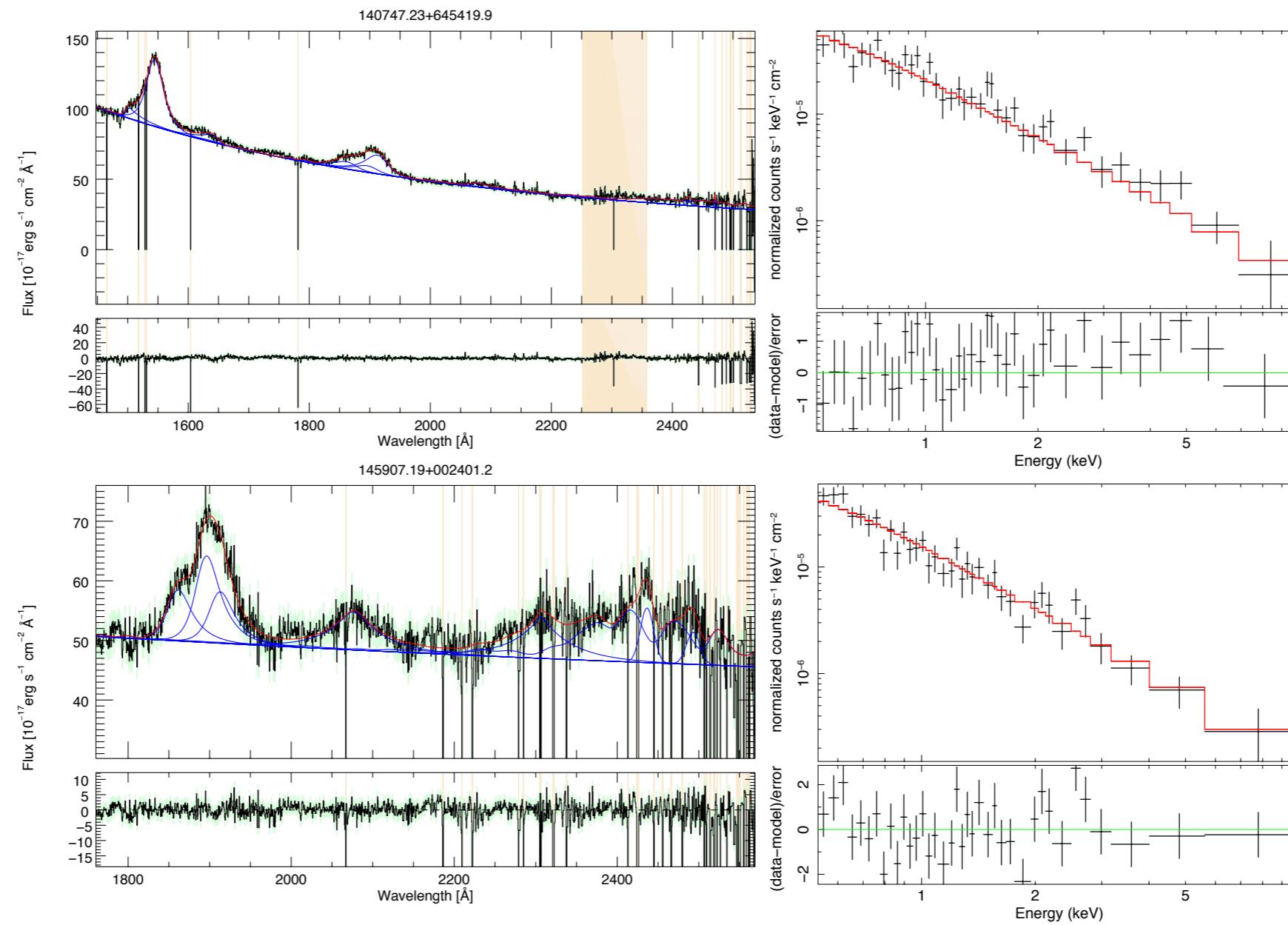


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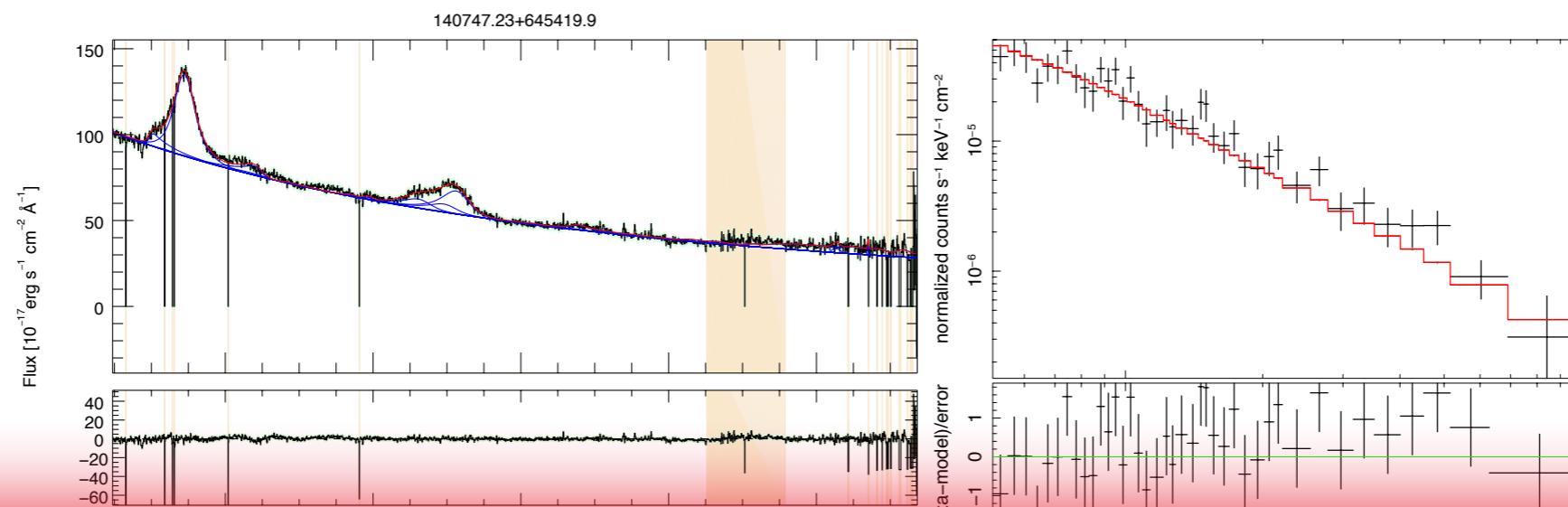
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30 quasars are ~equivalent of 1 Type Ia SN at z~3!

