New Constraints on the X-ray Spectral Properties of Type 1 AGN

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Motivation

- Largest sample of type 1 AGN with X-ray spectra
  Aim: Characterize the typical shape
- So far, most information from individual, bright AGN
- Despite lower S/N spectra, samples show the allowed range in properties
- Recent sample studies:
  - Bianchi et al. 2009. CAIXA, 160 AGN, XMM targets, High S/N, but biased to low z
  - Young et al. 2009. SDSS/XMM , ~300 sources used in analysis, no SE modelling
  - Mateos et al. 2010. XWAS, 500 type 1 AGN

Sample Creation

Optical Data

- SDSS DR5 quasar catalogue (Schneider et al. 2007)
- 5740 deg^2
- 77,429 quasars
- $0.08 < z < 5.41$
- FWHM > 1000 kms^{-1}

X-ray Data

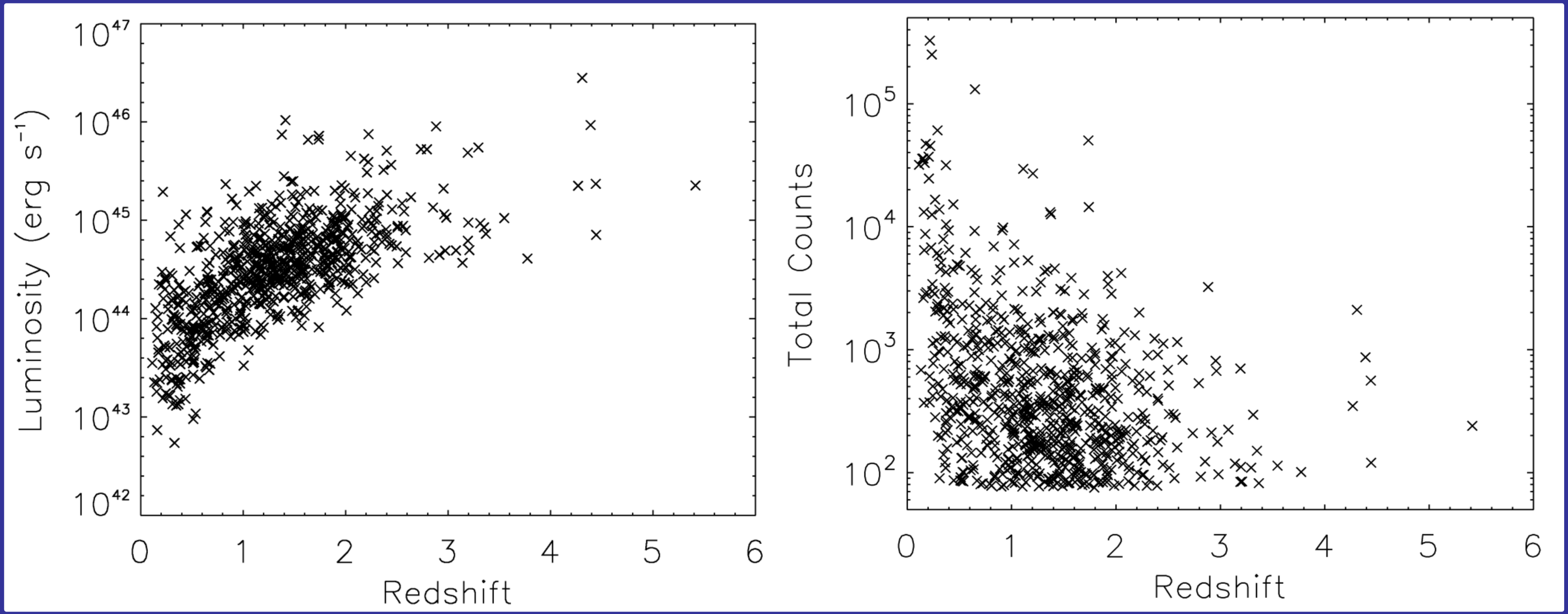
- *XMM-Newton*
- 2XMMi (Watson et al. 2009)
- 420 deg^2
- 290,000 detections → 220,000 unique sources

Cross-correlate using 10” matching radius

→ 1281 unique objects

Sample Creation

- Required >75 total counts
- → 761 sources
  - z: 0.11 – 5.41, L_x: 10^{43} – 10^{46} $ergs^{-1}$
  - CTS: ~50% > ~300 counts



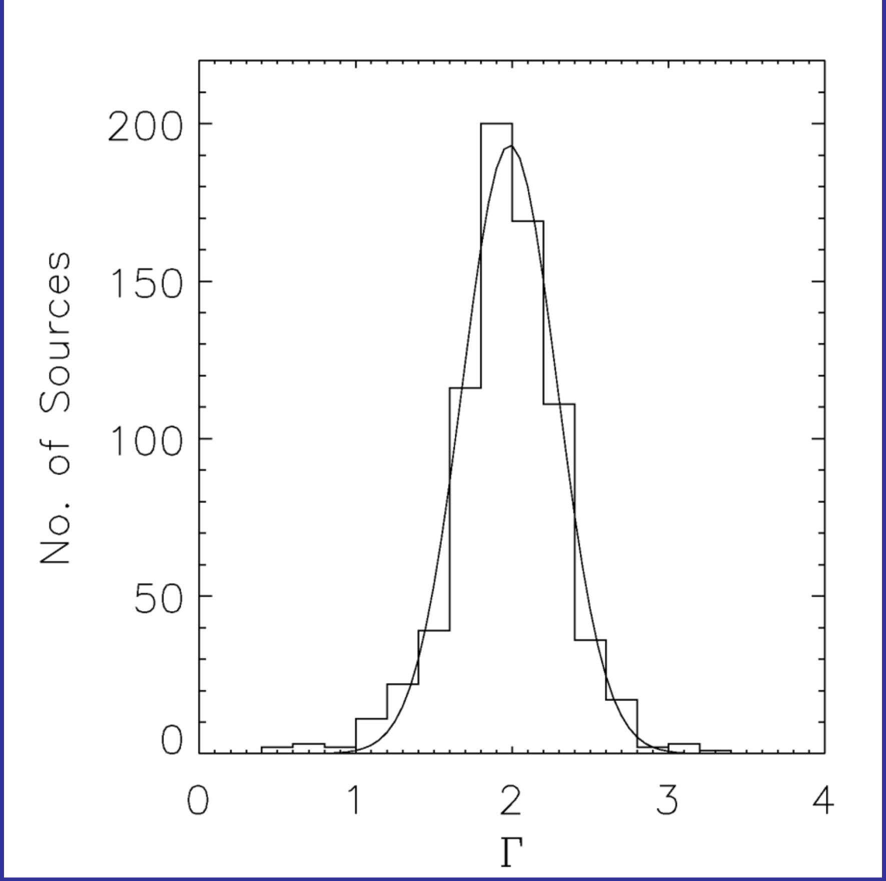
Spectral Fitting

- XSPEC, 0.5-12.0 keV
- Assume power law fit unless additional components are required by an F-test at >99% significance

Model	Number of sources best-fit with model	
Power law	672	88%
Power law + intrinsic absorption	29	4%
Power law + soft excess	55	7%
Power law + intrinsic absorption + soft excess	5	1%
	761	**100%**

Gamma Distribution

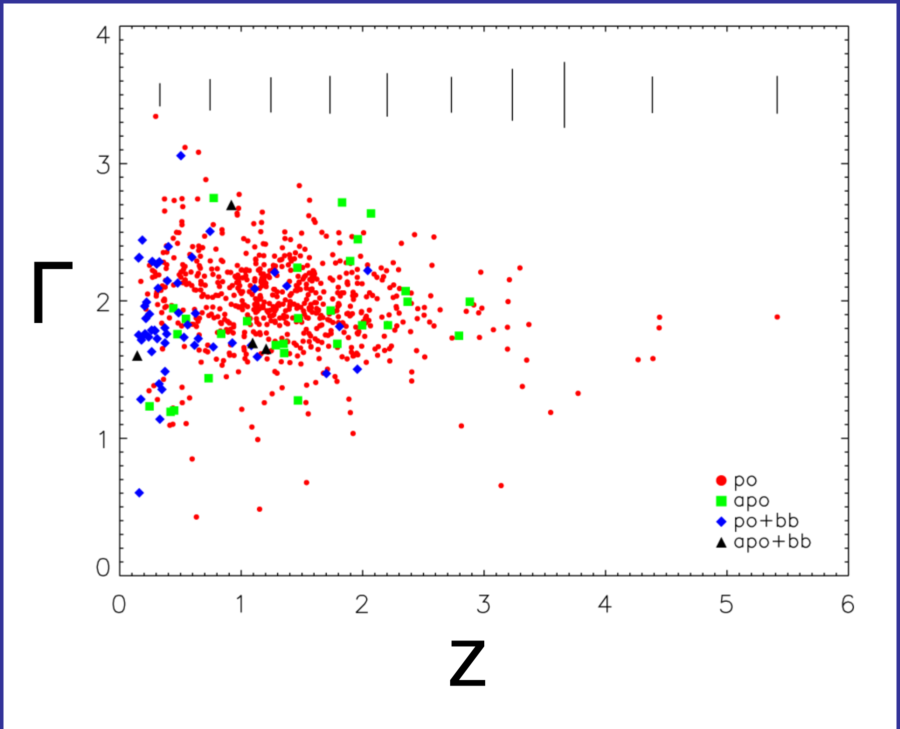
- Fit with Gaussian
  - $\langle\Gamma\rangle = 1.99 \pm 0.01$
  - $\sigma = 0.30 \pm 0.01$
  - $\Delta\Gamma = 0.13$
  - Similar to previous results
  - p = 0.34%
  - i.e. Not a good fit due to presence of extremes in wings

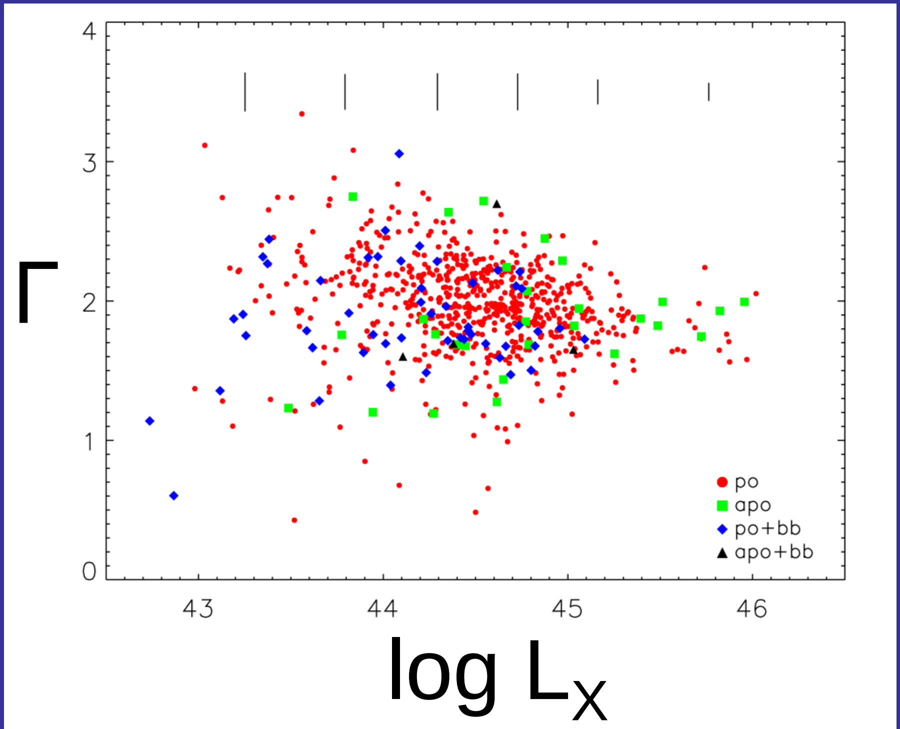


Trends of Γ with z and L_X

- Γ vs z, ~3σ
- Higher z sources have flatter Γ
- Not due to reflection

- Γ vs L_x, ~5σ
- Higher L_X sources have flatter Γ





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Γ vs Eddington Ratio

- Black Hole mass estimates from Shen et al. 2008
  - ~56,000 M_{BH} for DR5QSO
  - Virial Method
  - 79% of sample included

- Eddington Luminosity:

$$L_{Edd} = \frac{4\pi G M_{BH} m_p c}{\sigma_T} \approx 1.3 \times 10^{38} \frac{M_{BH}}{M_{Sun}} ergs^{-1}$$

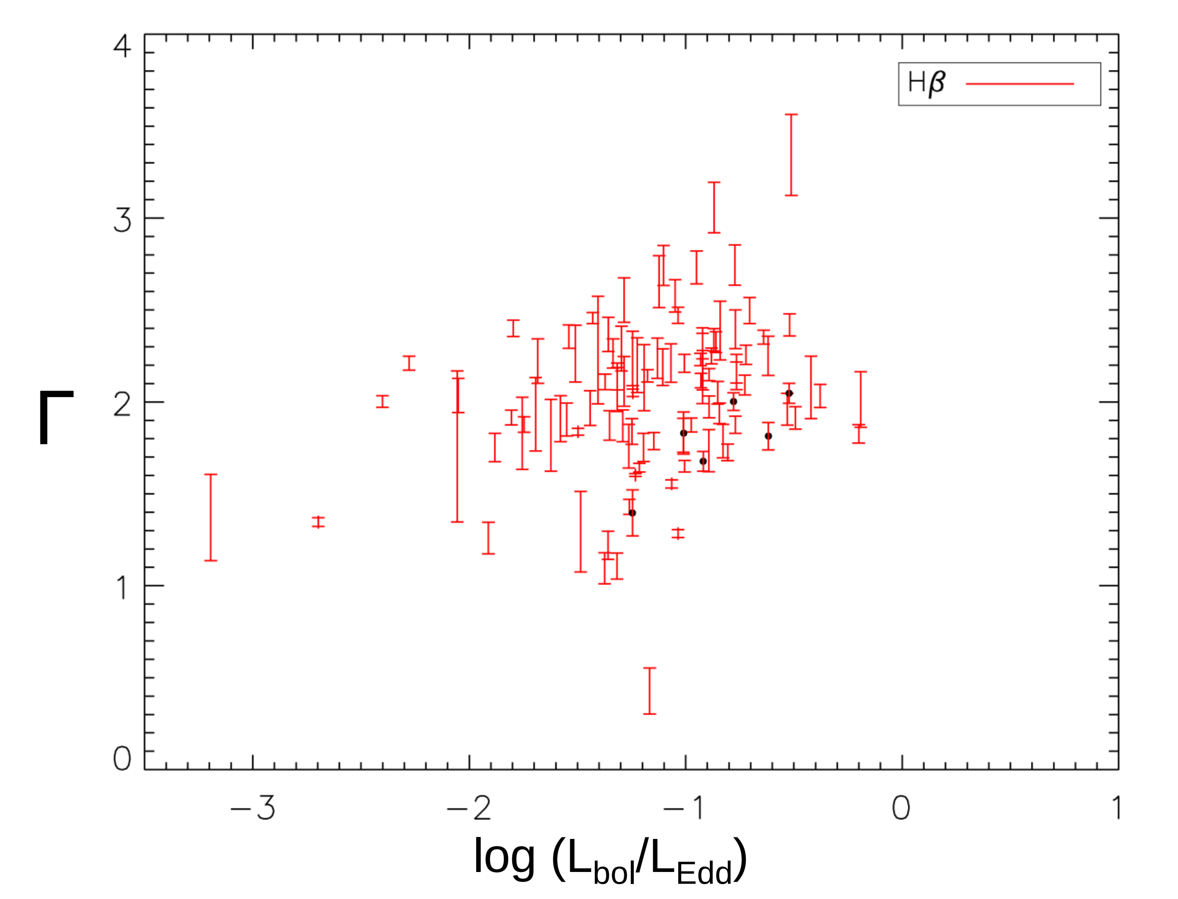
- Bolometric Luminosity: (Marconi et al. 2004)

$$\log\left(\frac{L_{bol}}{L_X}\right) = 1.54 + 0.24\ell + 0.012\ell^2 - 0.0015\ell^3$$

$$\ell = \log L_{bol} - 12$$

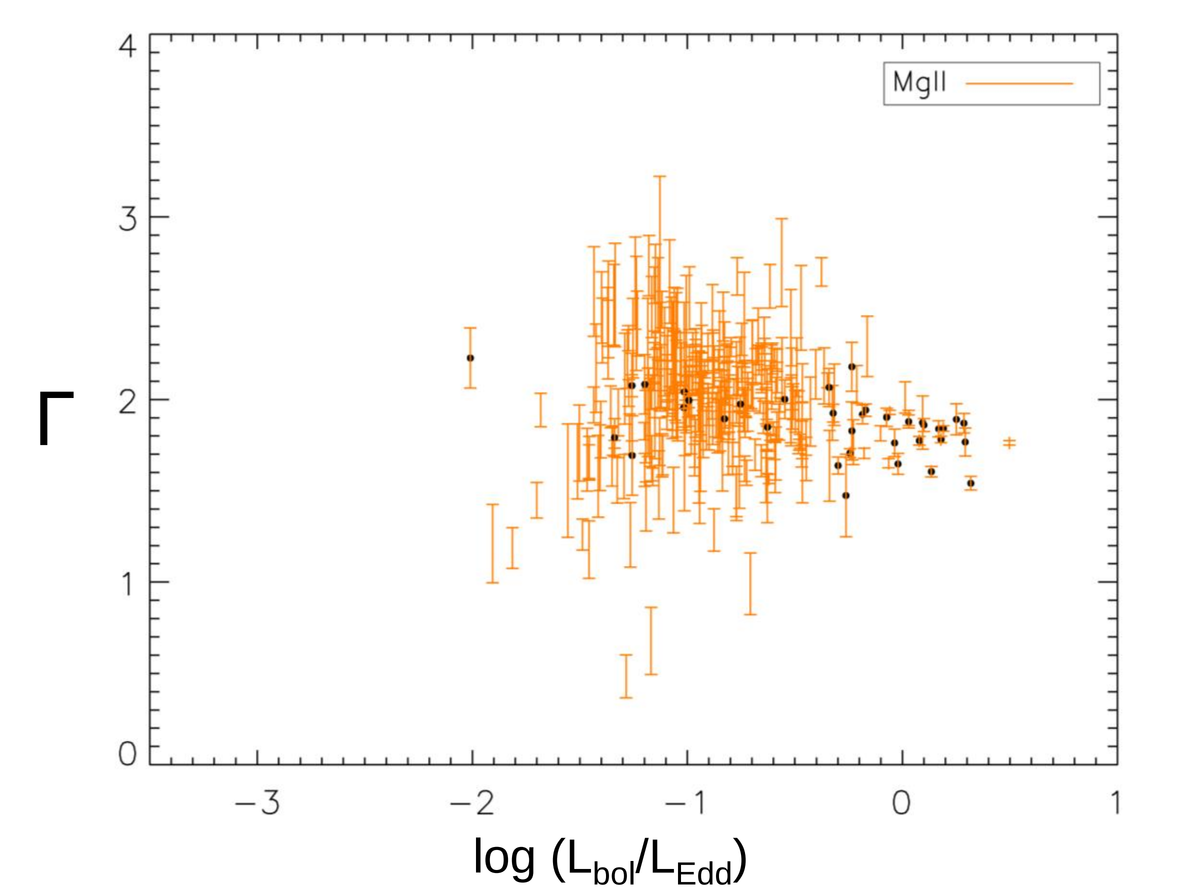
Γ vs Eddington Ratio

- Γ vs Eddington Ratio
  - Hβ, ρ = +0.26, 2.8σ



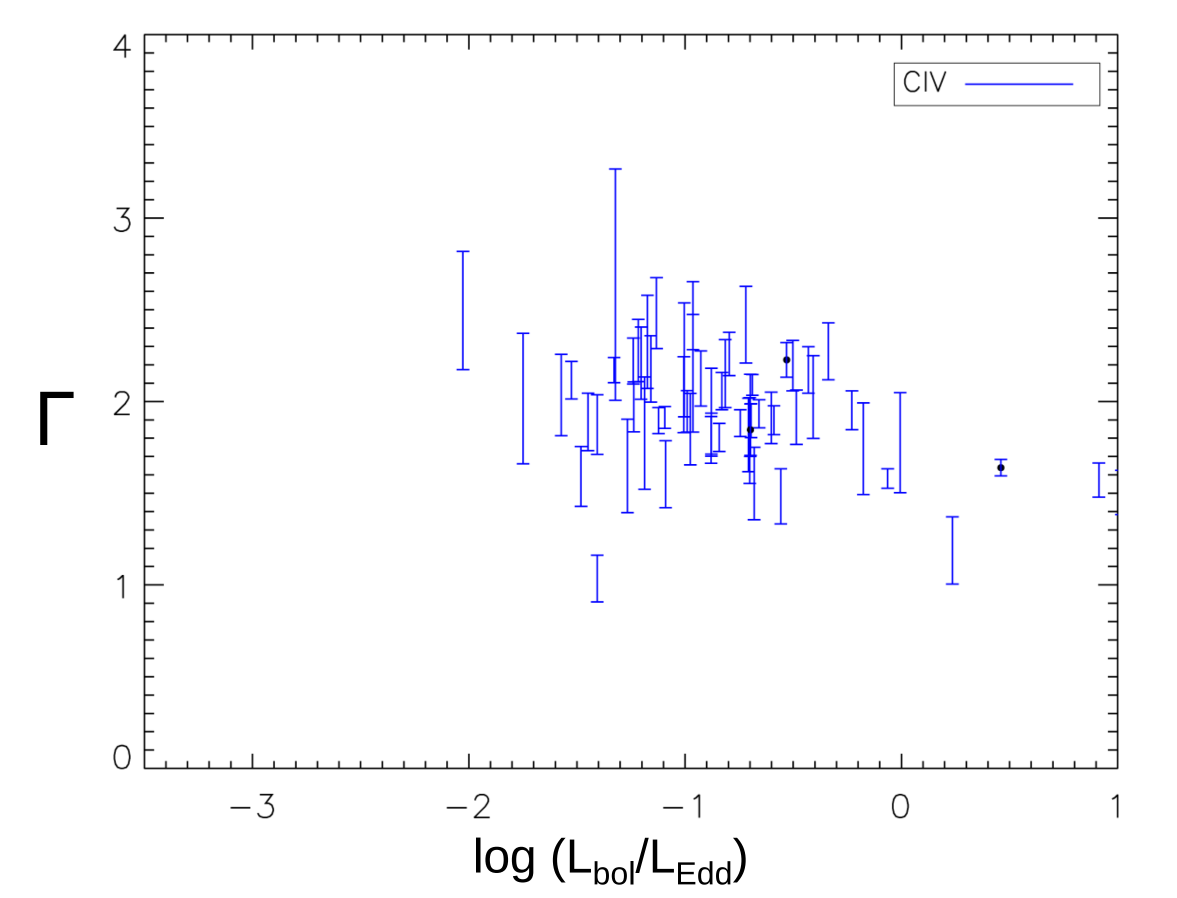
Γ vs Eddington Ratio

- Γ vs Eddington Ratio
  - MgII, no correlation



Γ vs Eddington Ratio

- Γ vs Eddington Ratio
  - CIV, ρ = -0.32, 2.9σ



Radio Properties

- Radio Loudness, $R_L = F_R / F_O$, $R_L > 10$ is radio loud

  (Kellermann et al. 1989)

  F_R = flux at 5 GHz (from FIRST – Becker et al. 1995)

  F_O = flux at 4400Å (from SDSS)

  → 552 RQQ, 75 RLQ

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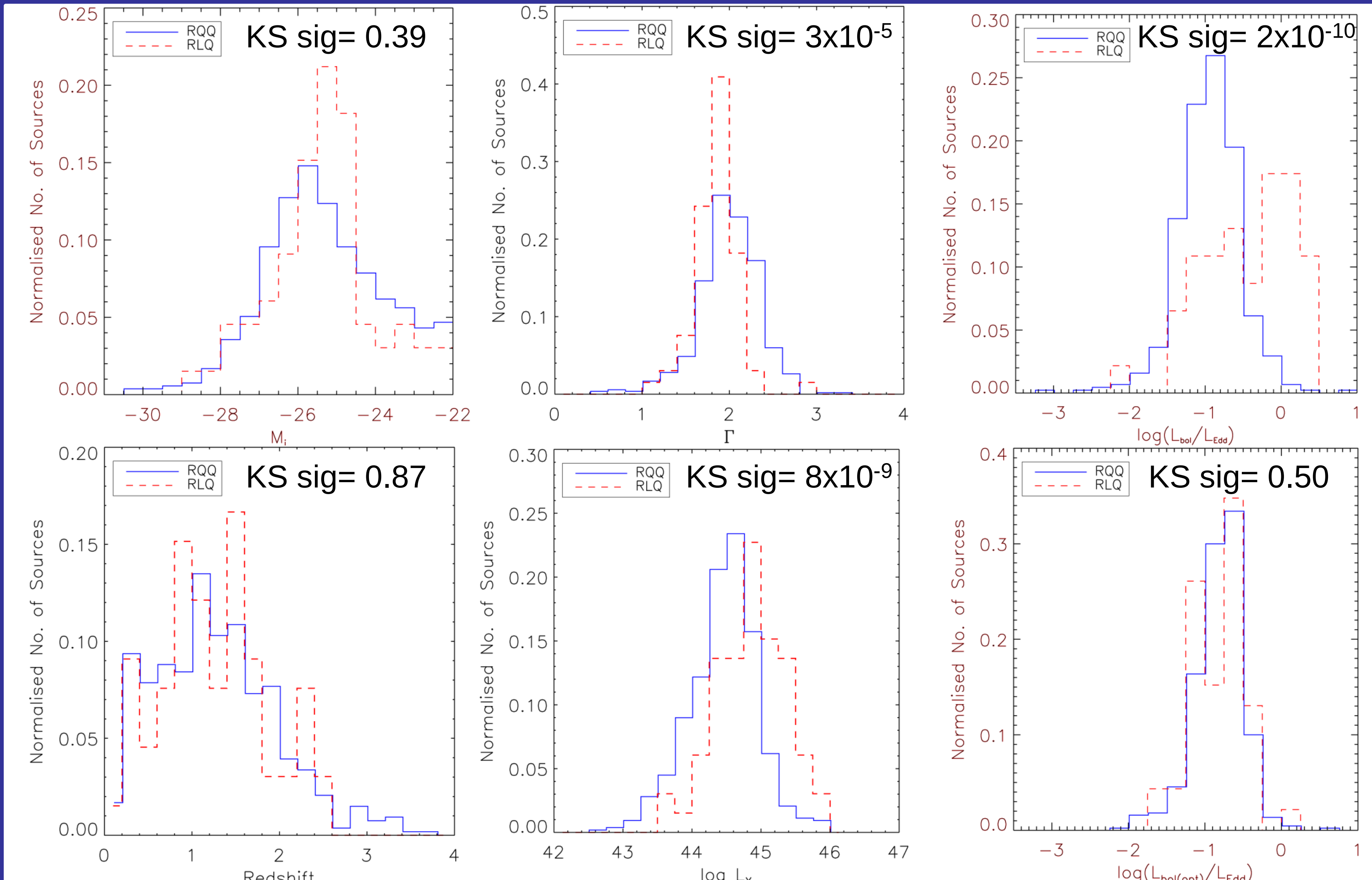
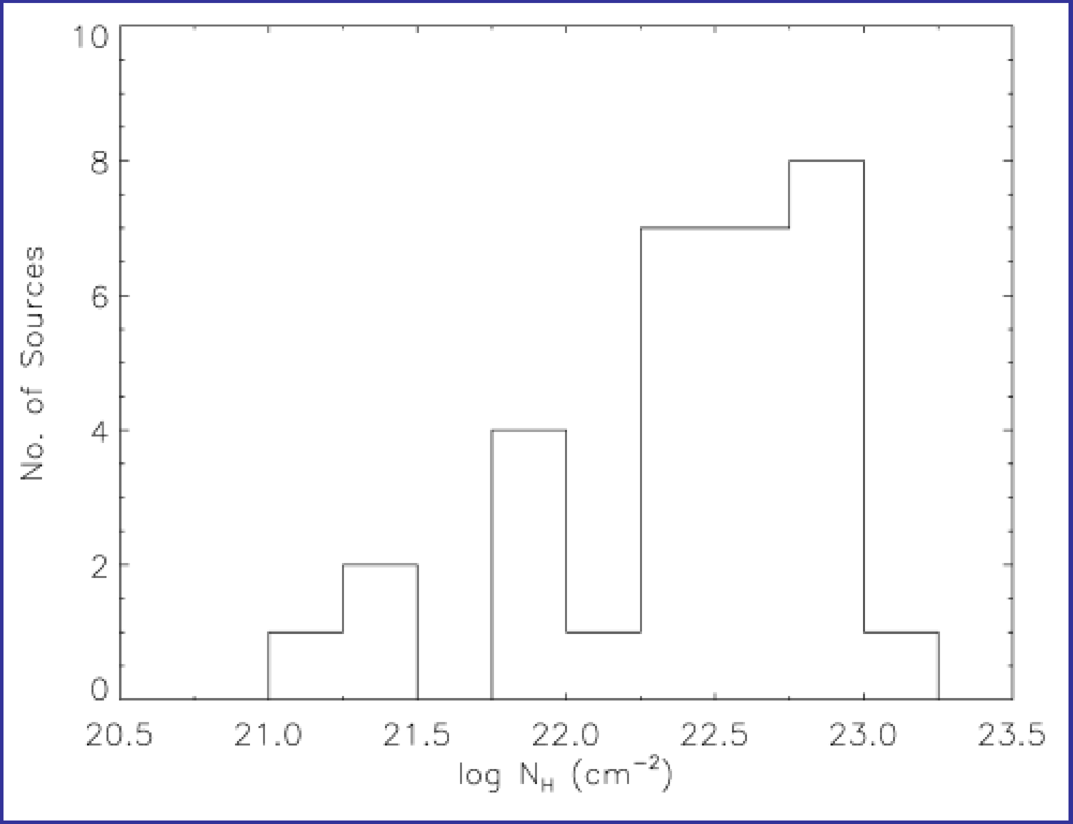
Radio Properties



Absorbed Sources

- Type 1 not expected to be absorbed (Unified Model)
- Intrinsic absorption detected in 4% sample
- N_H: 10^{21} – 10^{23} cm^{-2}



Absorbed Sources

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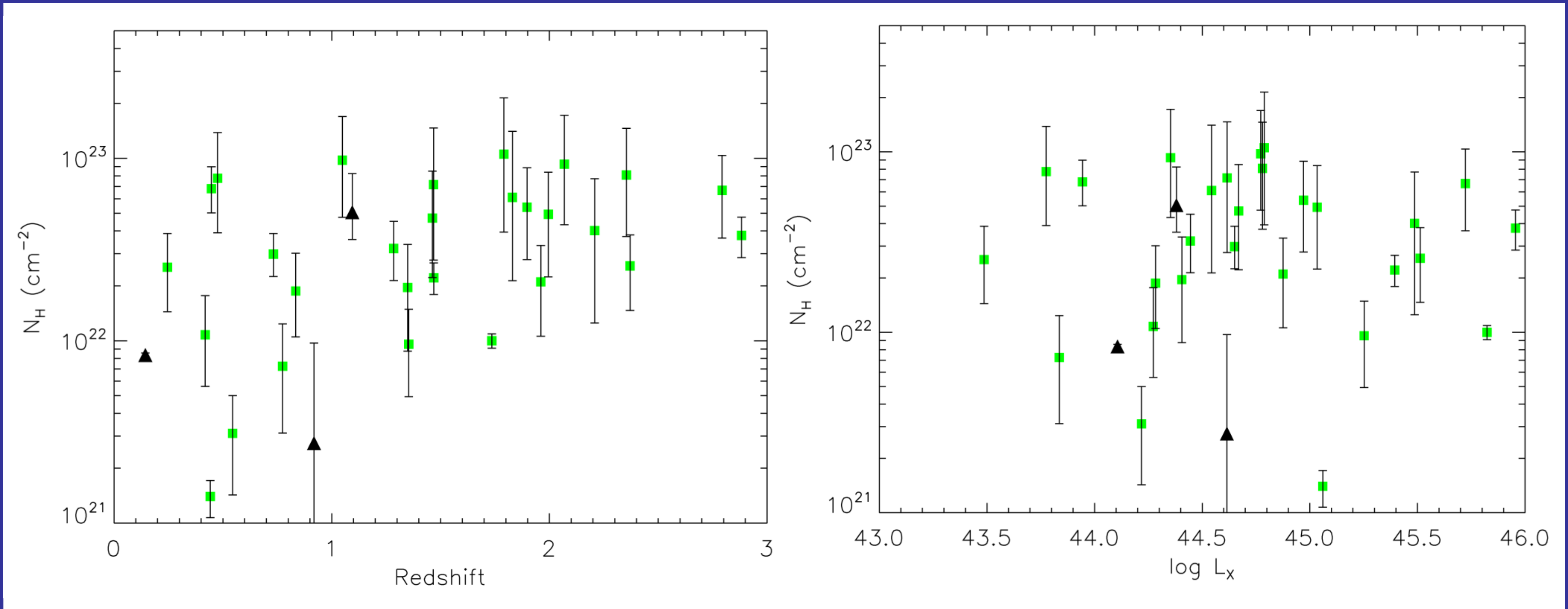
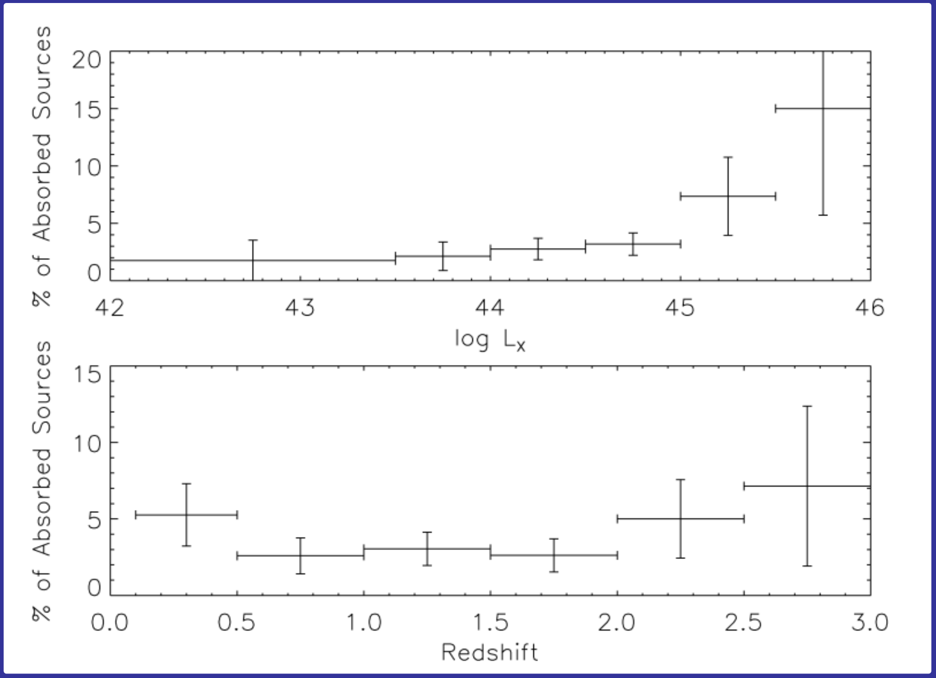
- No trend of N_H with z or L_x



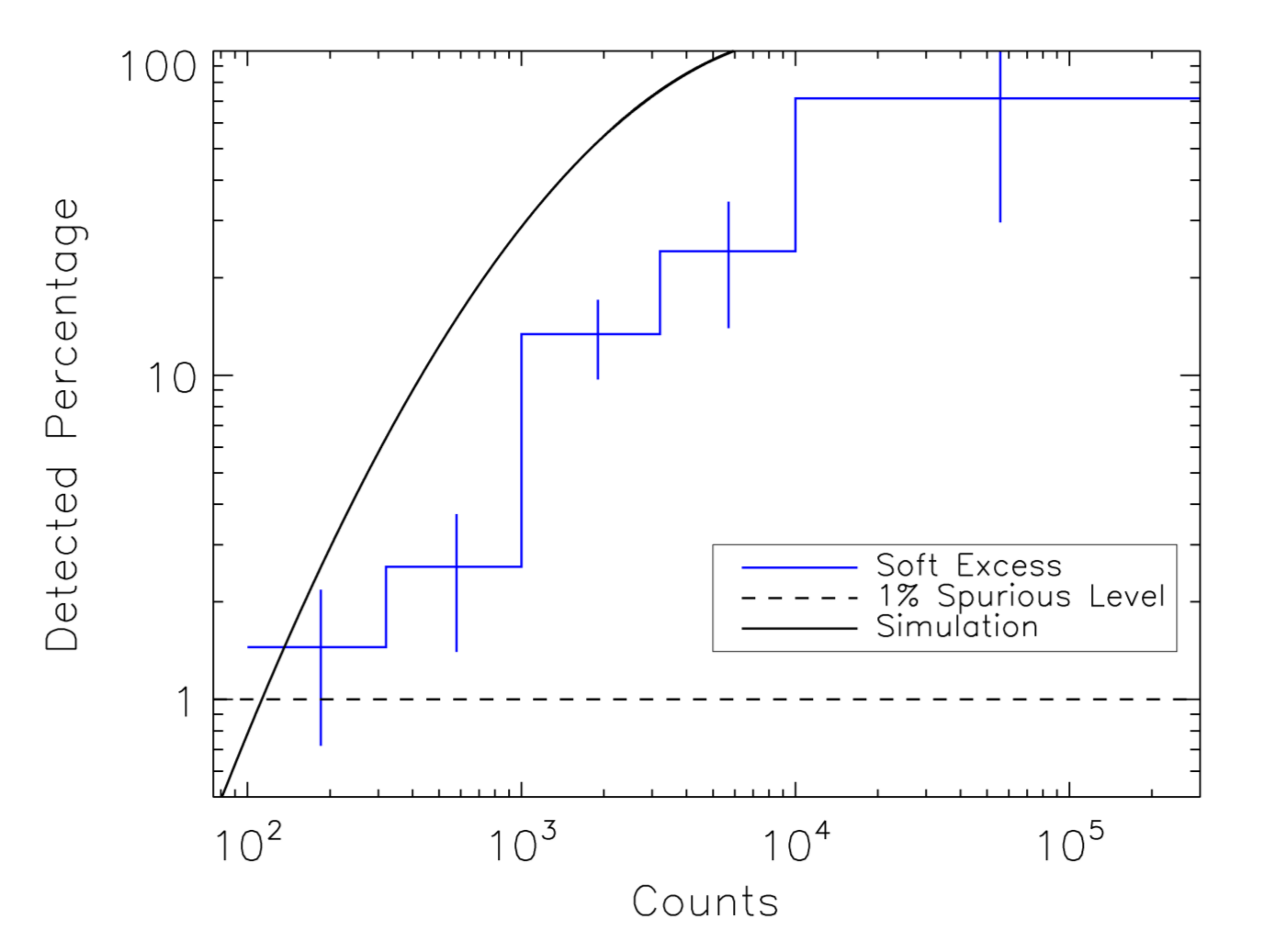
Absorbed Sources

- Type 1 not expected to be absorbed (Unified Model)
- Intrinsic absorption detected in 4% sample
- N_H: 10^{21} – 10^{23} cm^{-2}
- No trend of N_H with z or L_x
- No significant variation in the percentage of absorbed sources



Sources with a Soft Excess

- Soft Excess detected in 7% of sources



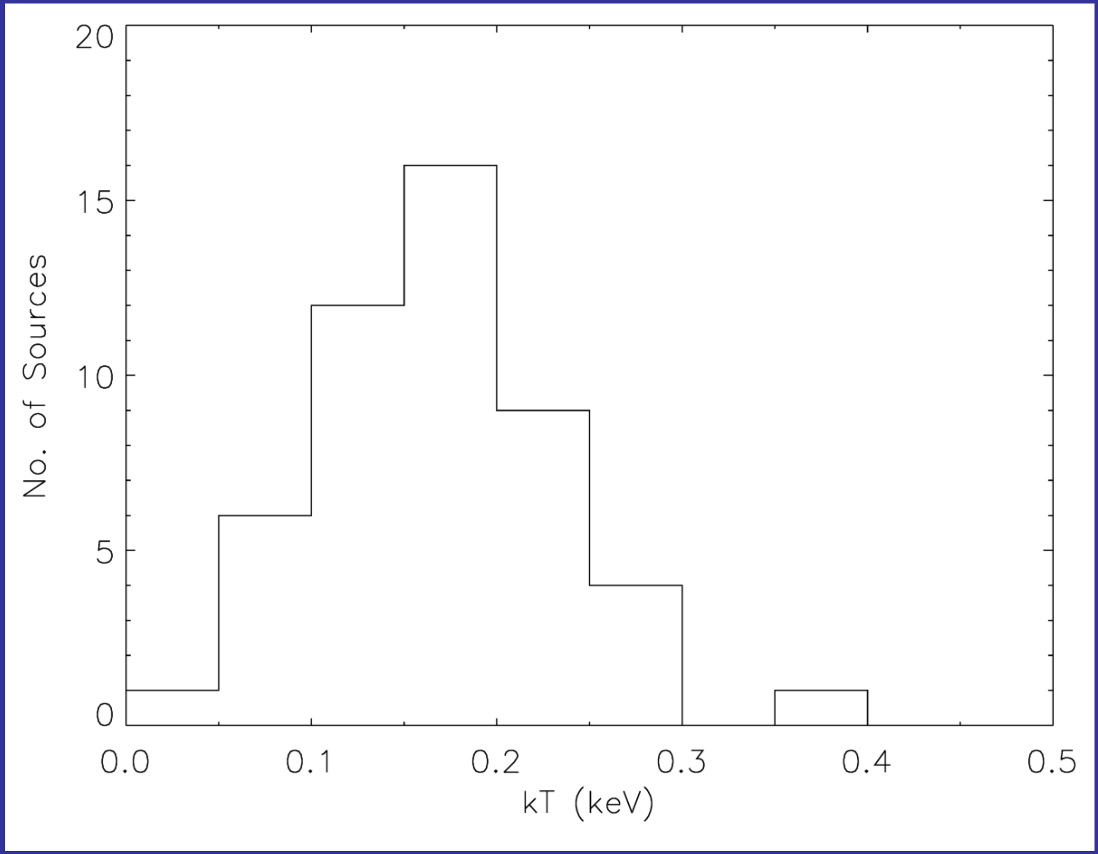
Sources with a Soft Excess

- Soft Excess detected in 7% of sources
- <kT> = 0.17 ± 0.09 keV

  68% of sources:

  0.1 - 0.25 keV

  i.e. Narrow range



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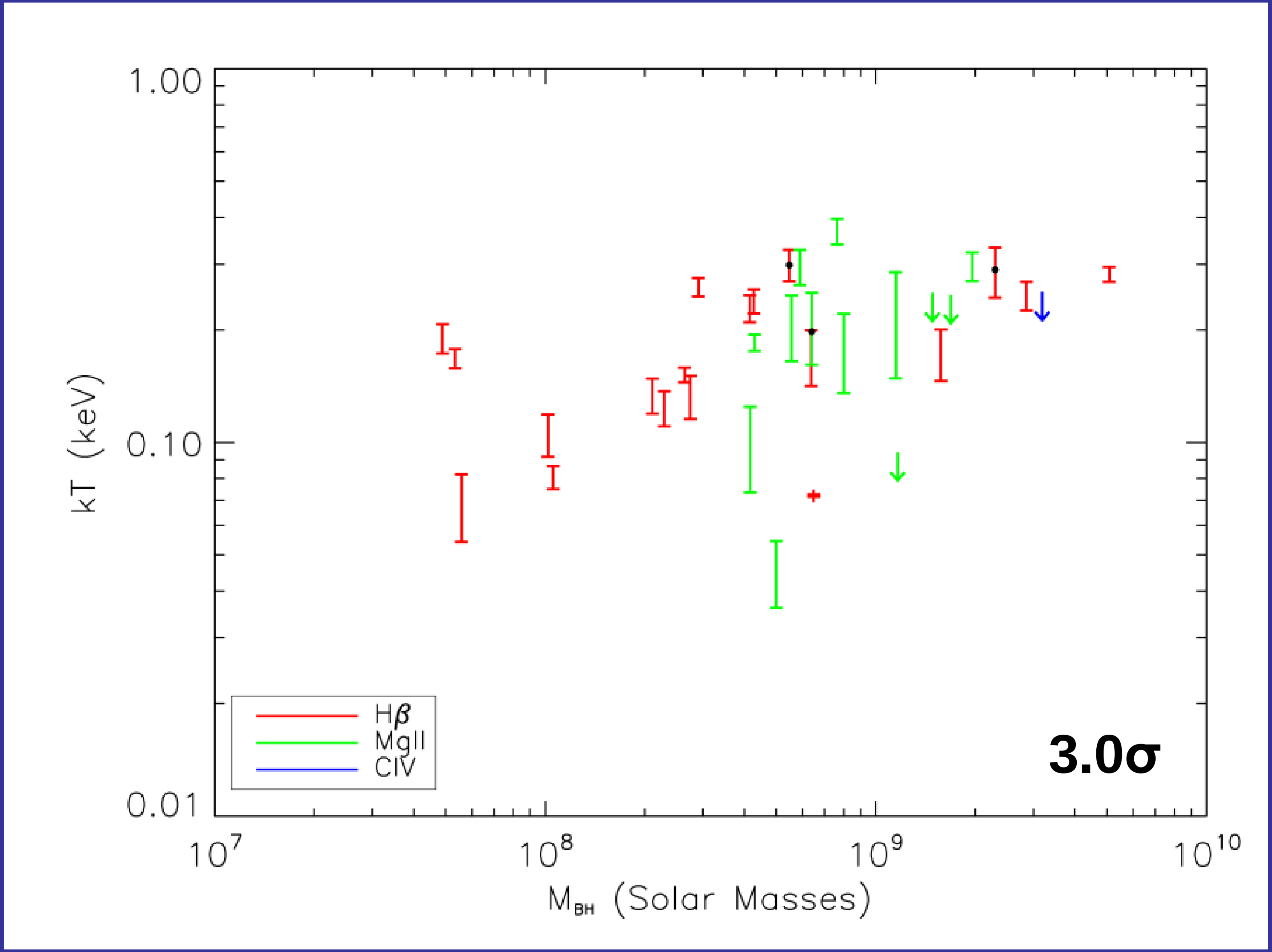

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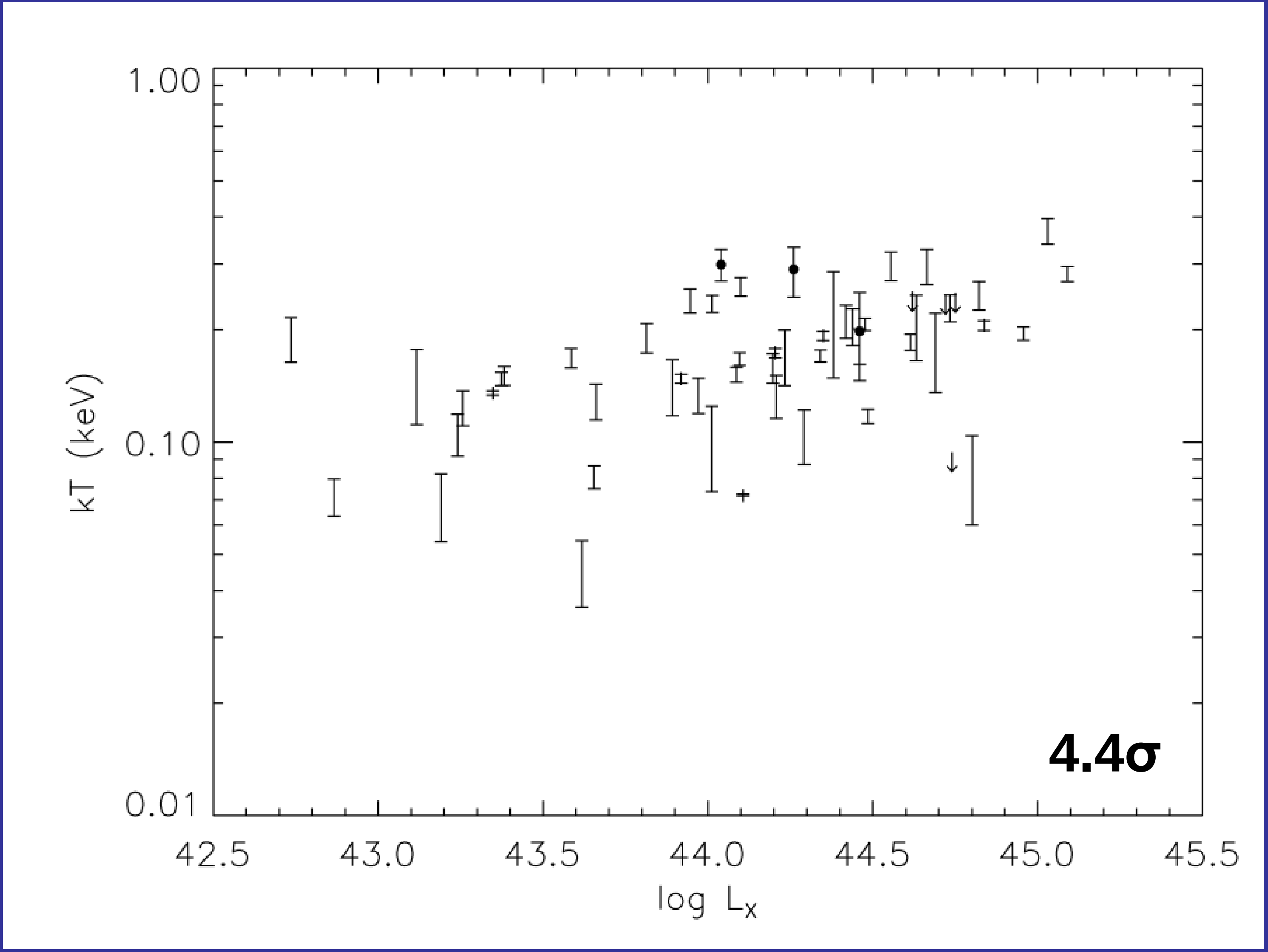

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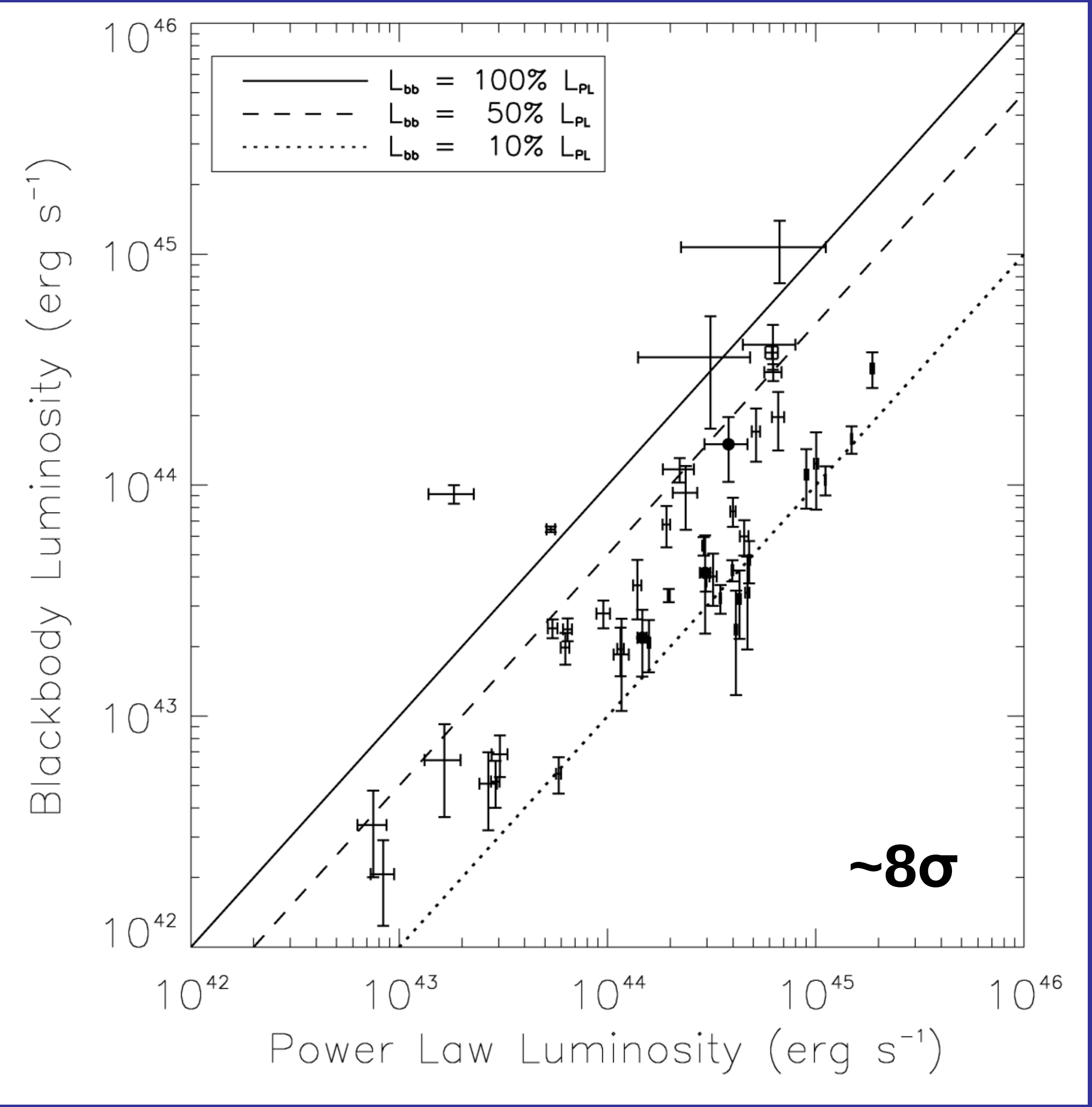

Conclusions

- Studied the X-ray spectral properties of 761 type 1 AGN
- Characterize the typical shape:
  - $\langle\Gamma\rangle = 1.99 \pm 0.01$, $\sigma = 0.30 \pm 0.01$
  - SE found in 7% with values $\langle kT\rangle = 0.2 \pm 0.1$ keV Ubiquitous?
- Surprisingly, intrinsic cold absorption found in 4% with $N_H = 10^{21} - 10^{23}$ cm^{-2}
- Trends with Γ:
  - Marginal trend between Γ and z (3σ)
  - Trend between Γ and L_X (5σ)
  - Trend between Γ and Eddington ratio depends on which broad line is used to measure the black hole mass.

- → arXiv: 1106.4904 (MNRAS accepted)