The X-ray absorption in GRB afterglows

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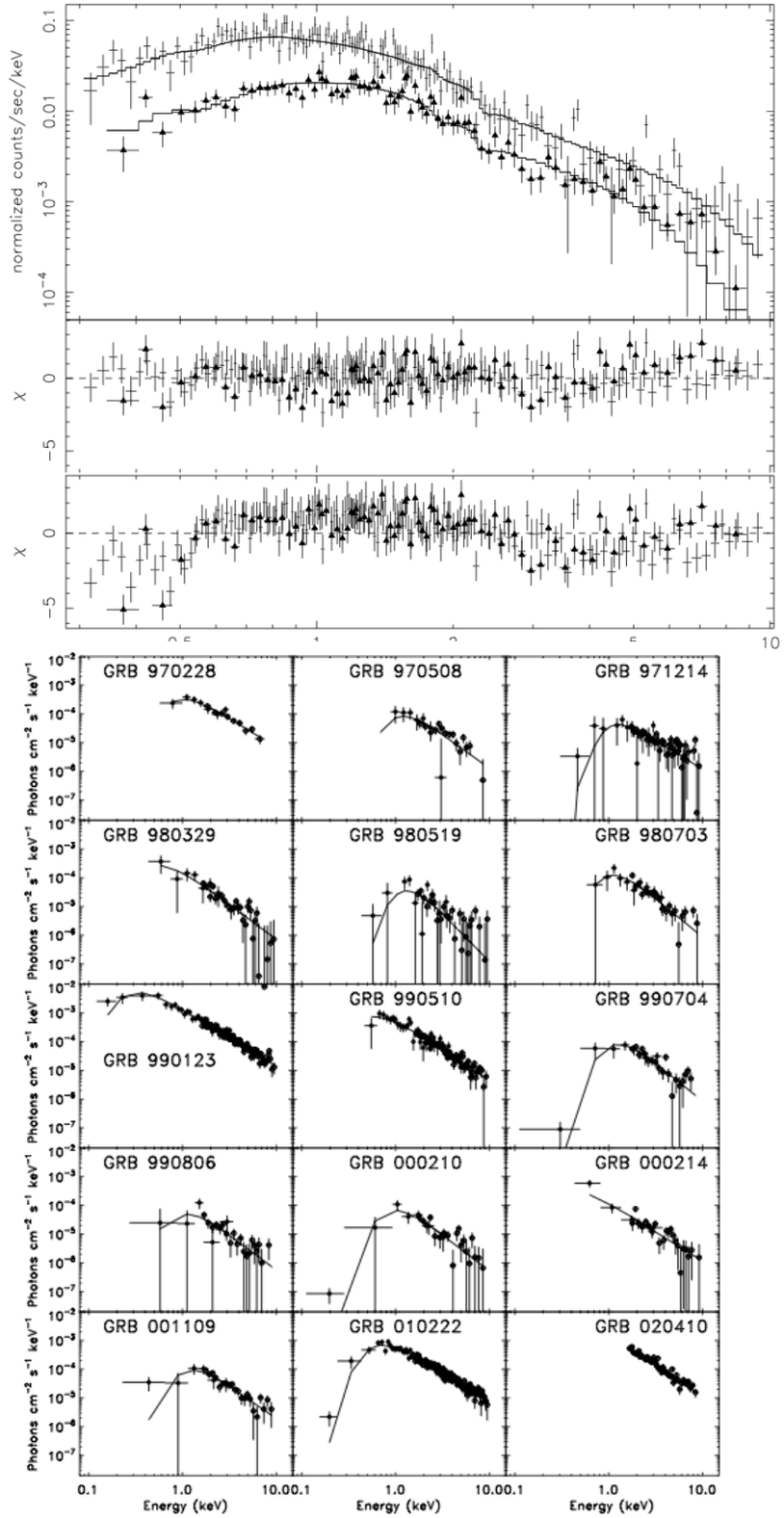
Dark Cosmology Centre

Overview

- Downturn at low energies deviating from a power-law
- Very similar to photoelectric absorption observed in the galaxy
- Fit well by photoelectric absorption by metals at host redshift
- Values well above Galactic



- Galama and Wijers, in average.; Watson et al. single afterglow; de Pasquale/Gendre/Stratta et al., Campana et al., Evans et al. samples

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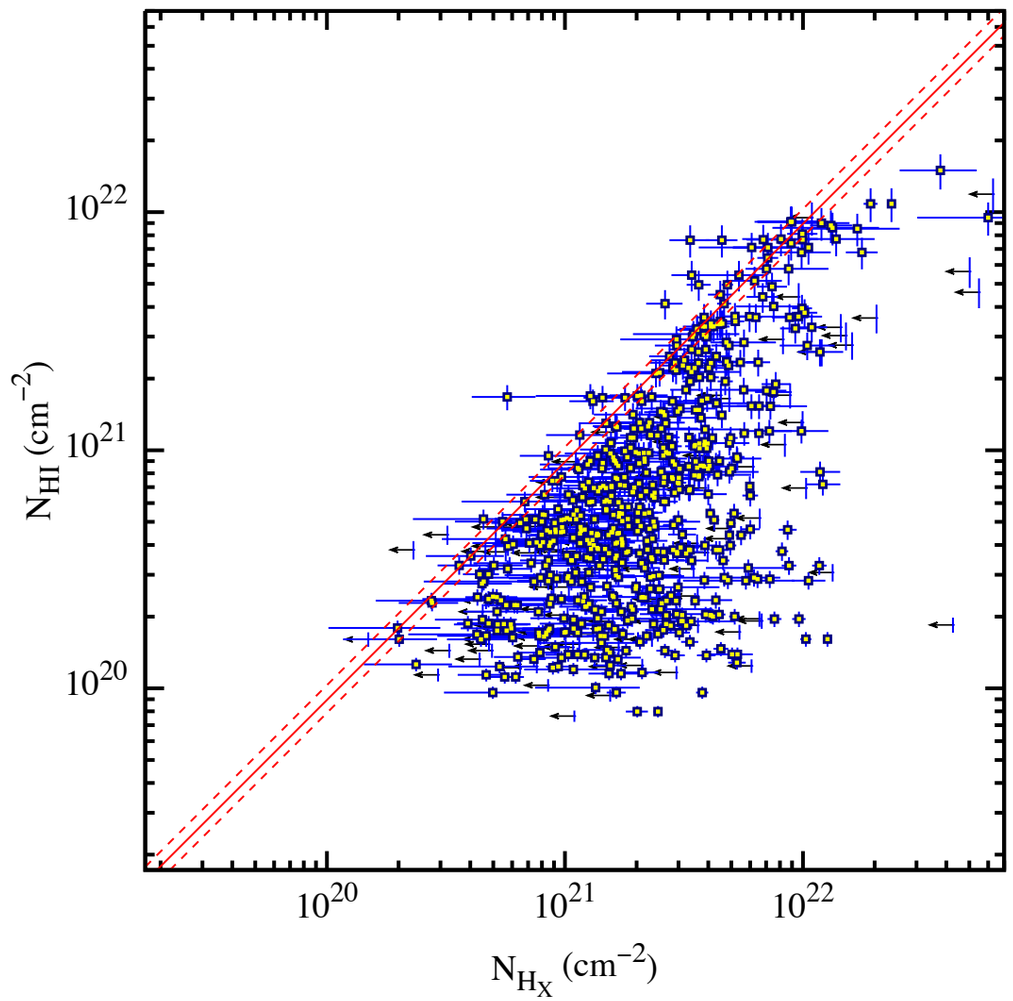

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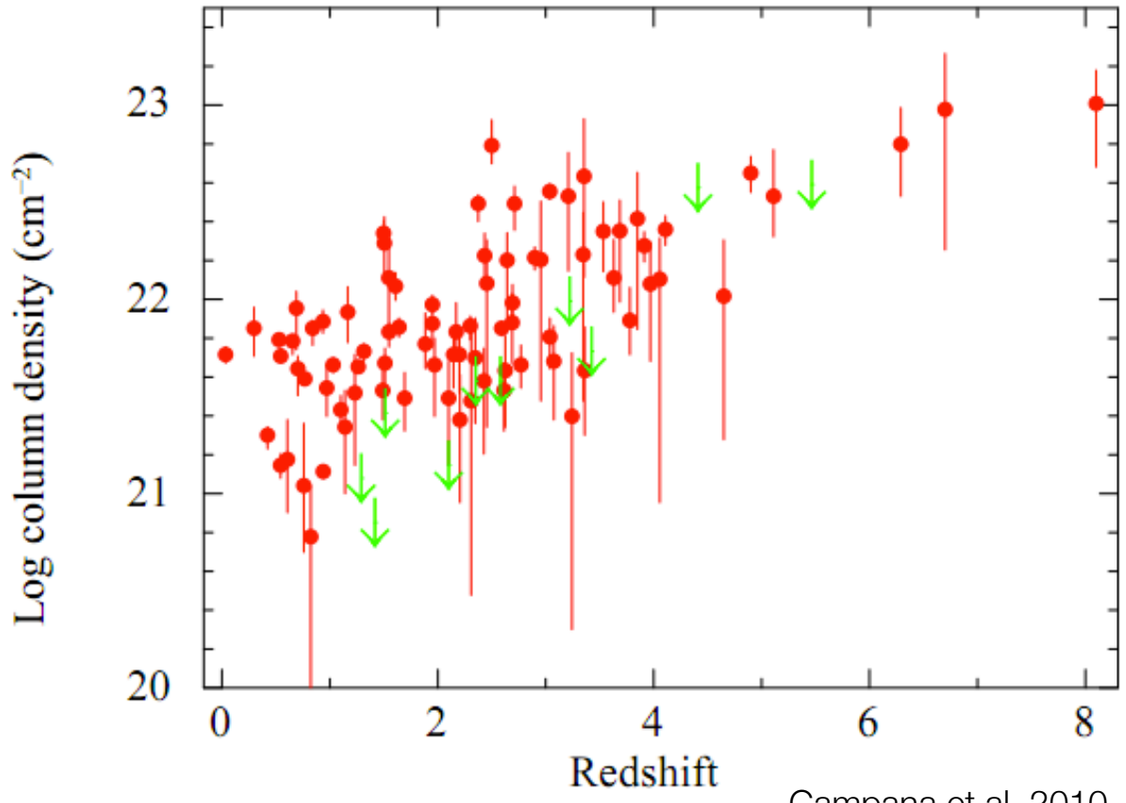
The redshift distribution

- Oddity—X-ray absorption rises with redshift. Why?
- Expect detectability threshold to rise with redshift
- But missing low redshift, high absorption GRBs



Campana et al. 2010

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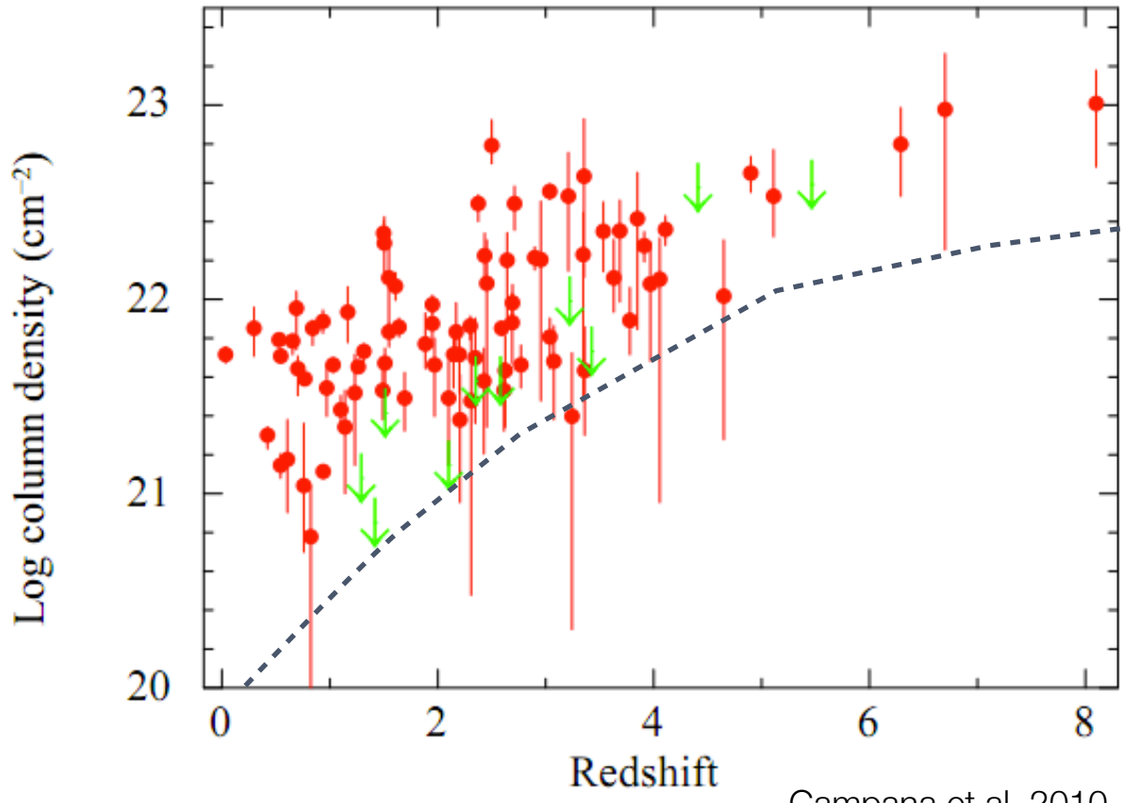

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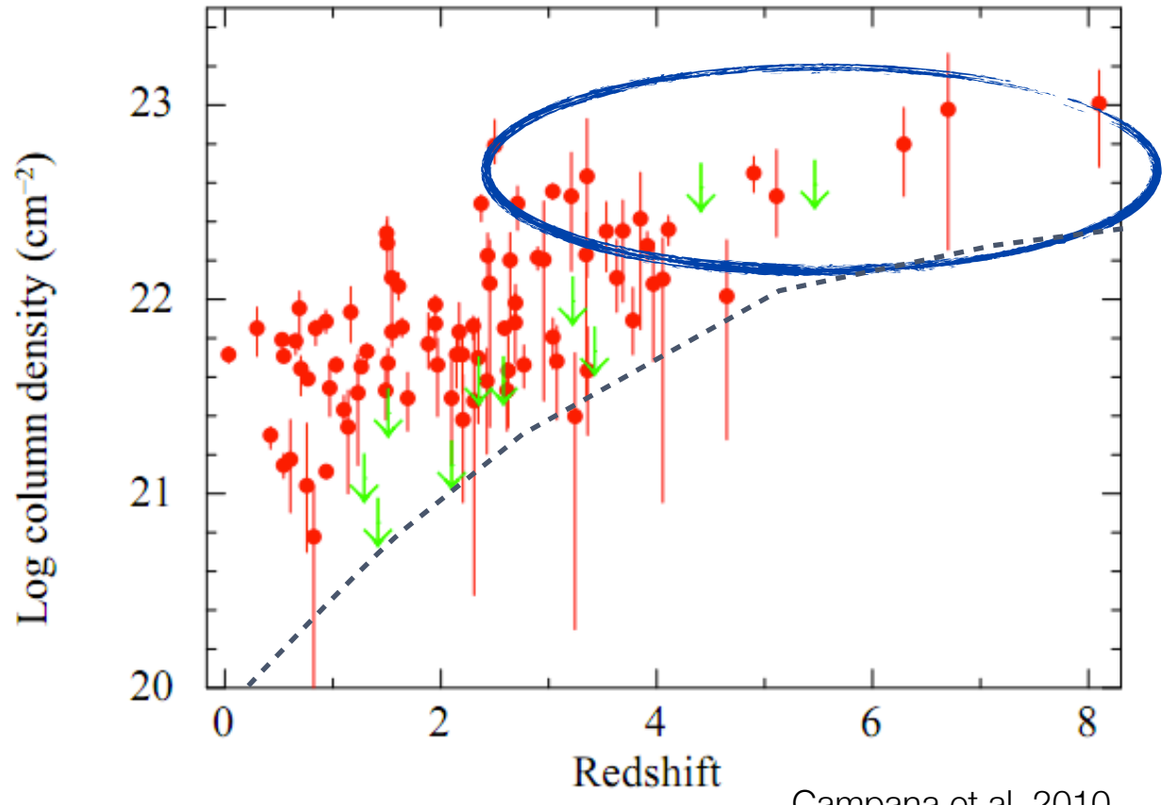

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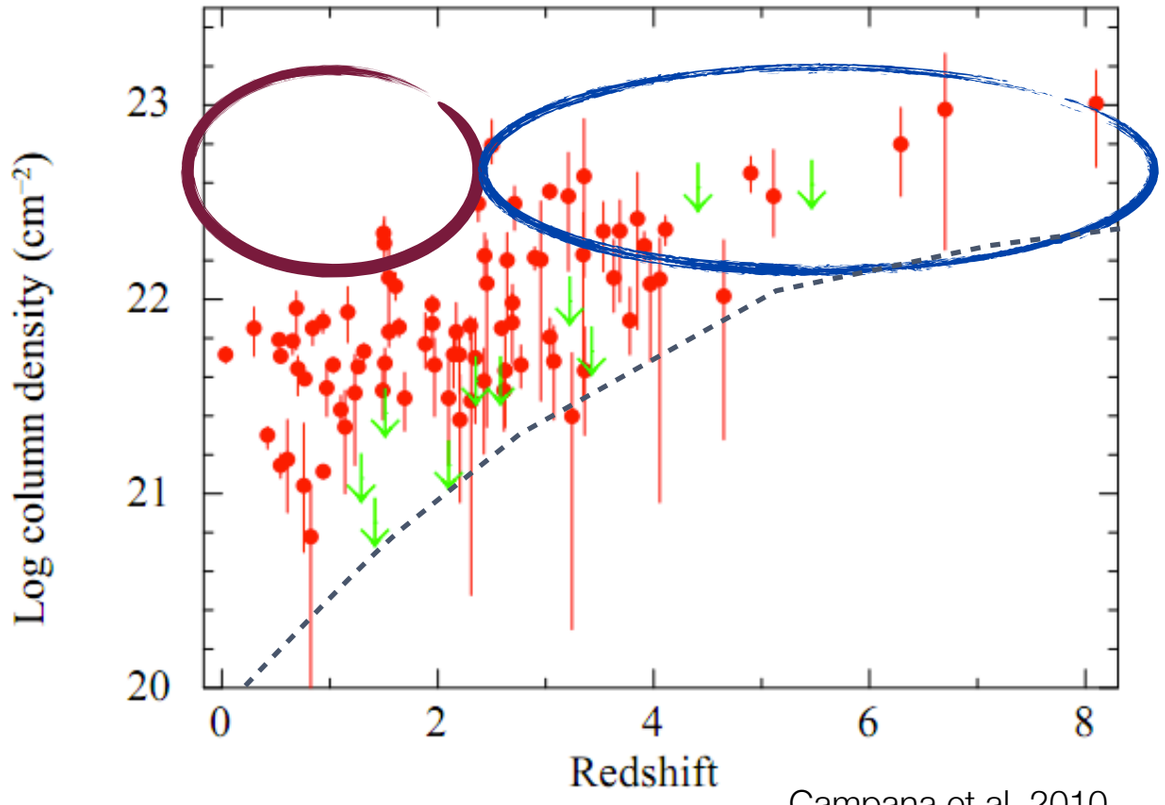

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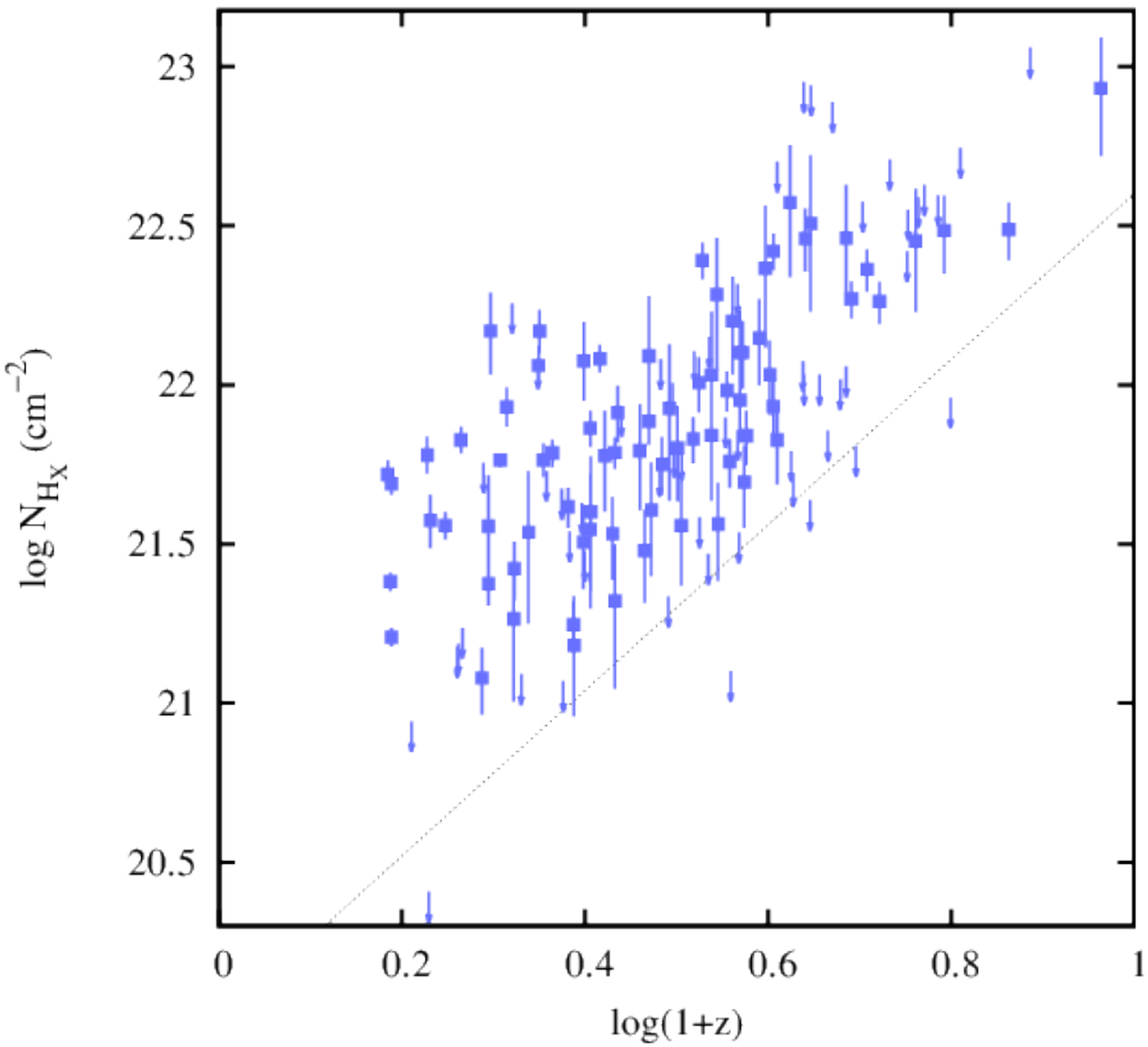
Solution: Dust bias

- X-rays unbiased by dust
- But redshifts from optical
- Bias obtaining redshifts

Watson & Jakkobson 2012



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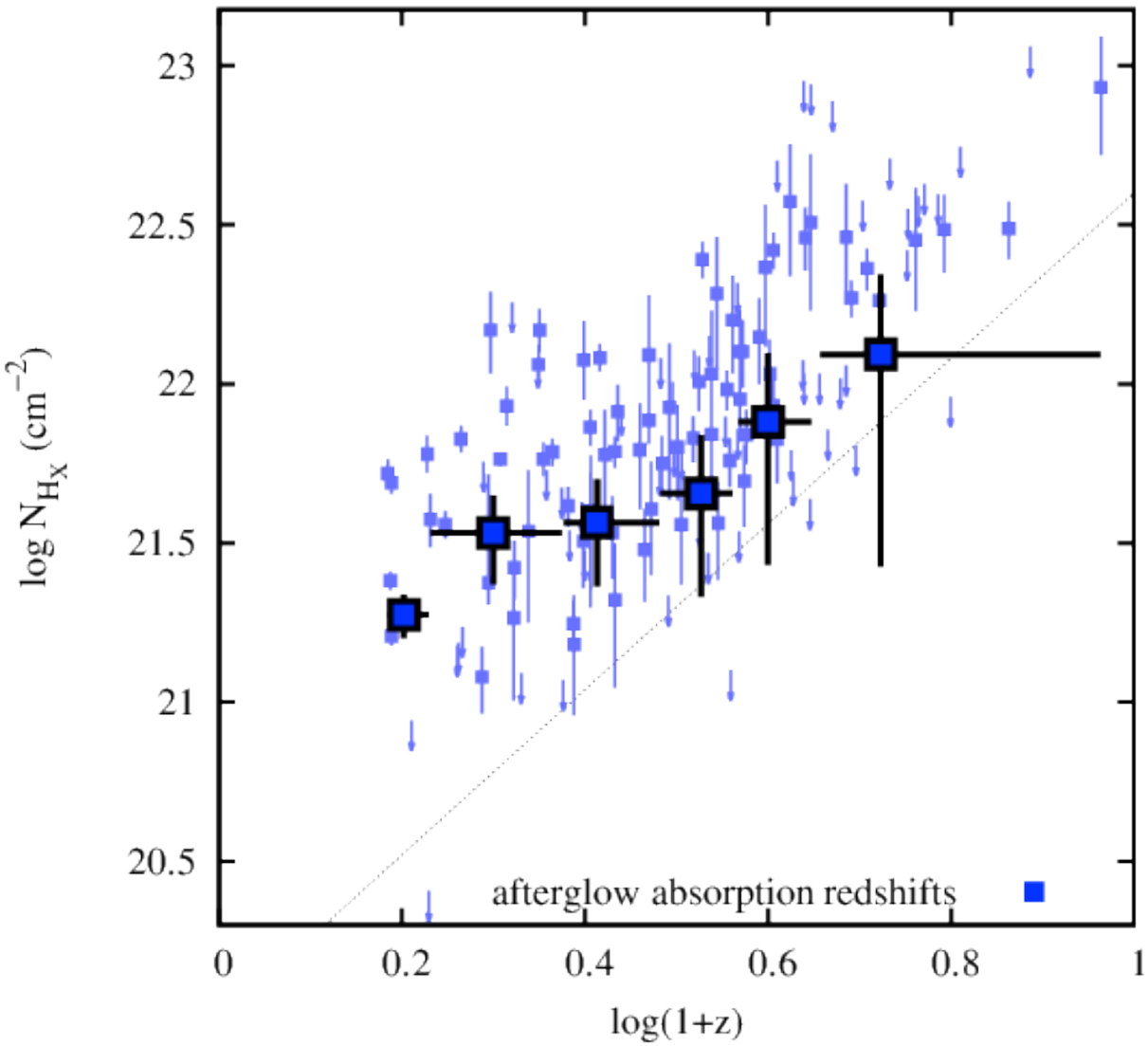

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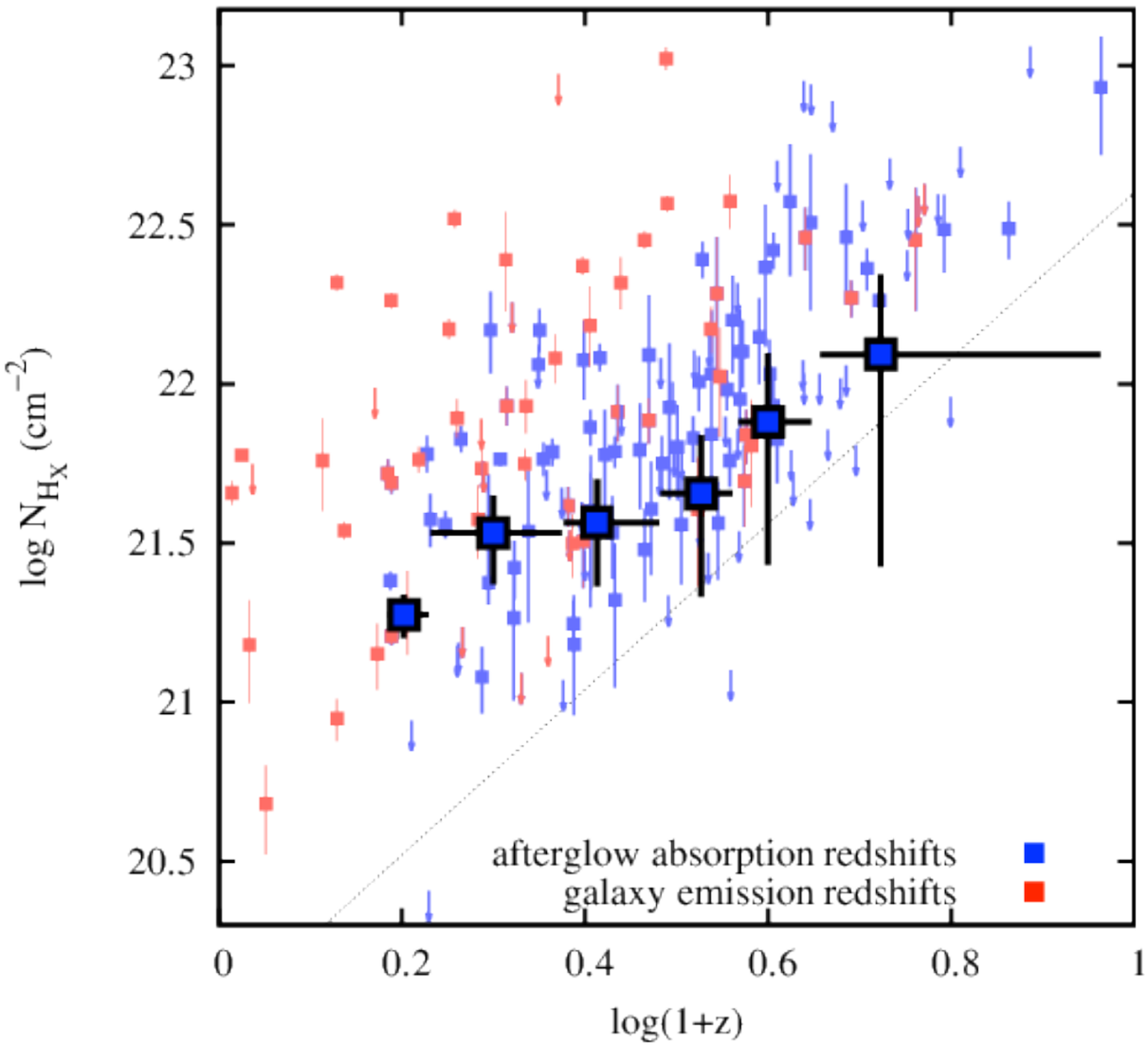

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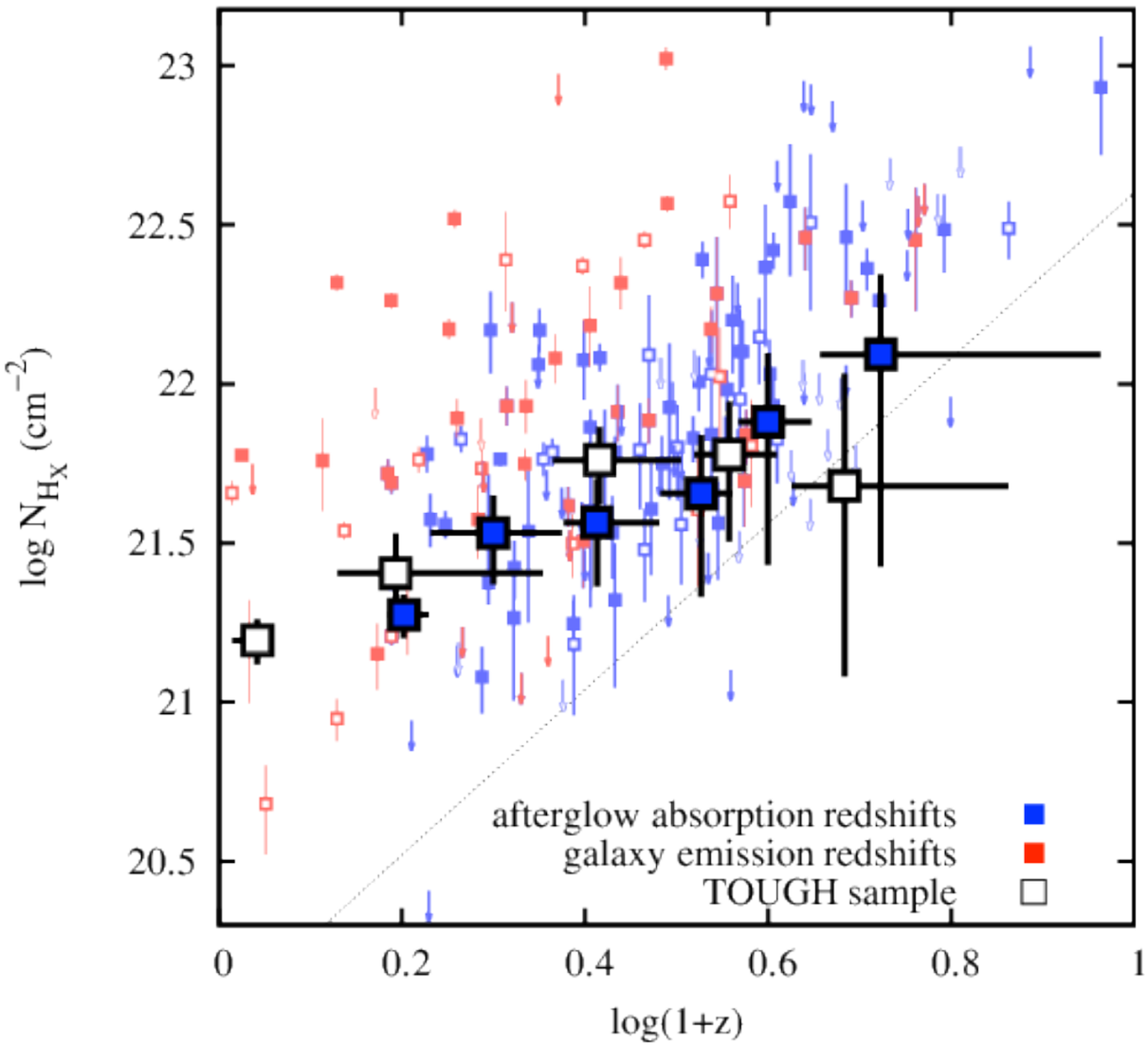

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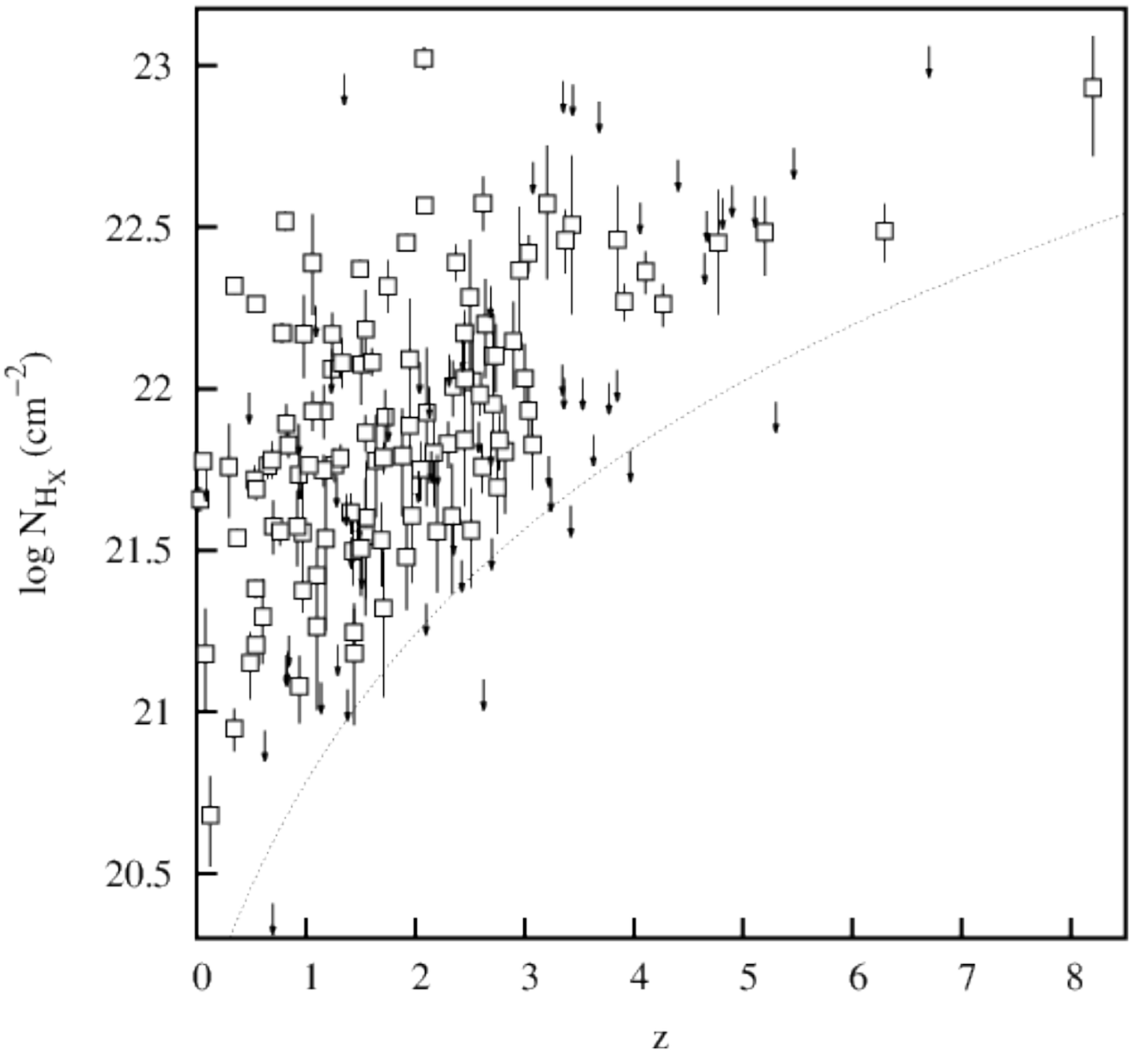

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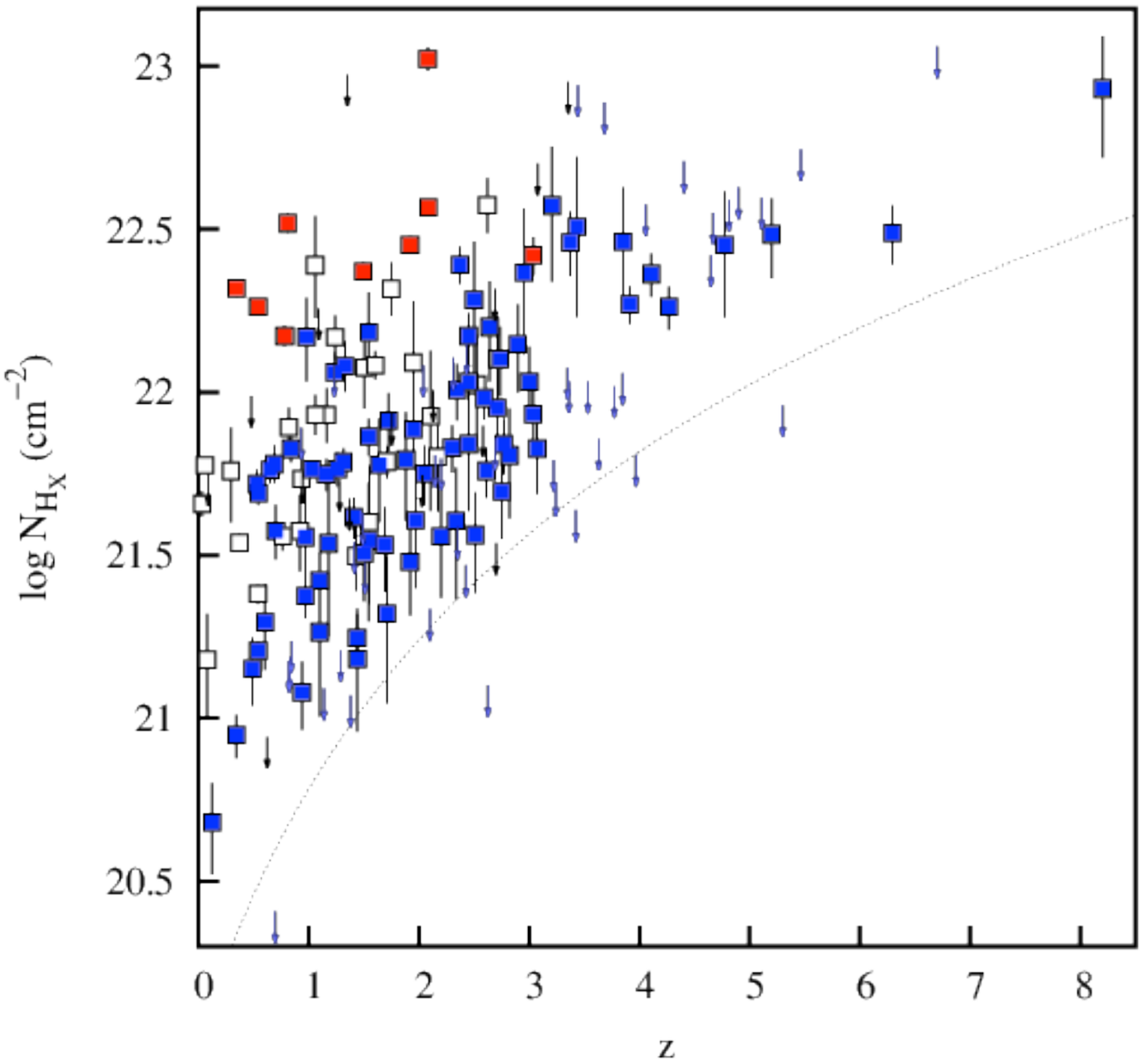

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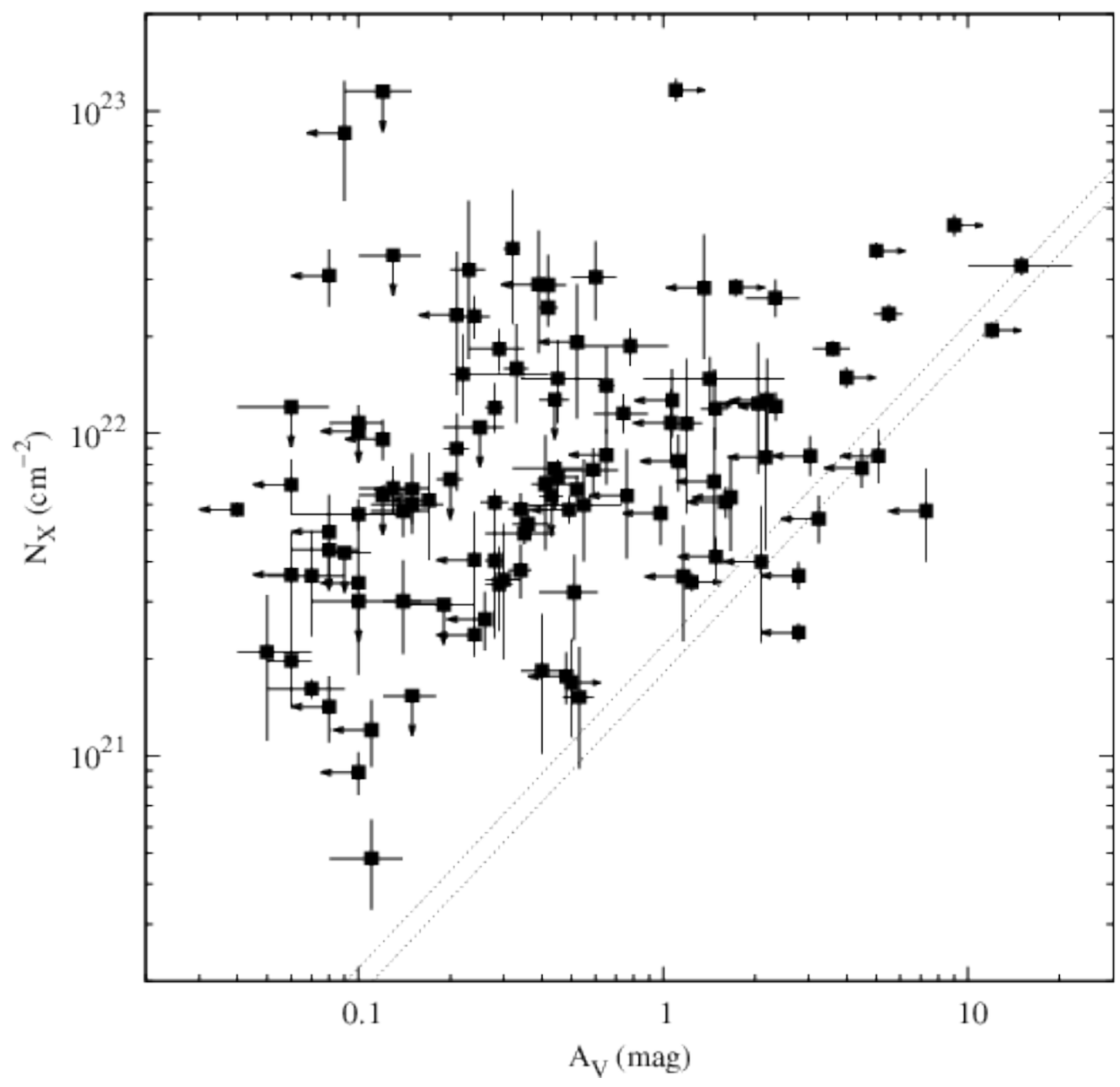
No N_{HX}-A_V correlation

- Evolving N_{HX}/A_V

Watson & Jakobssen 2012



N_{HX}-A_V correlation ?

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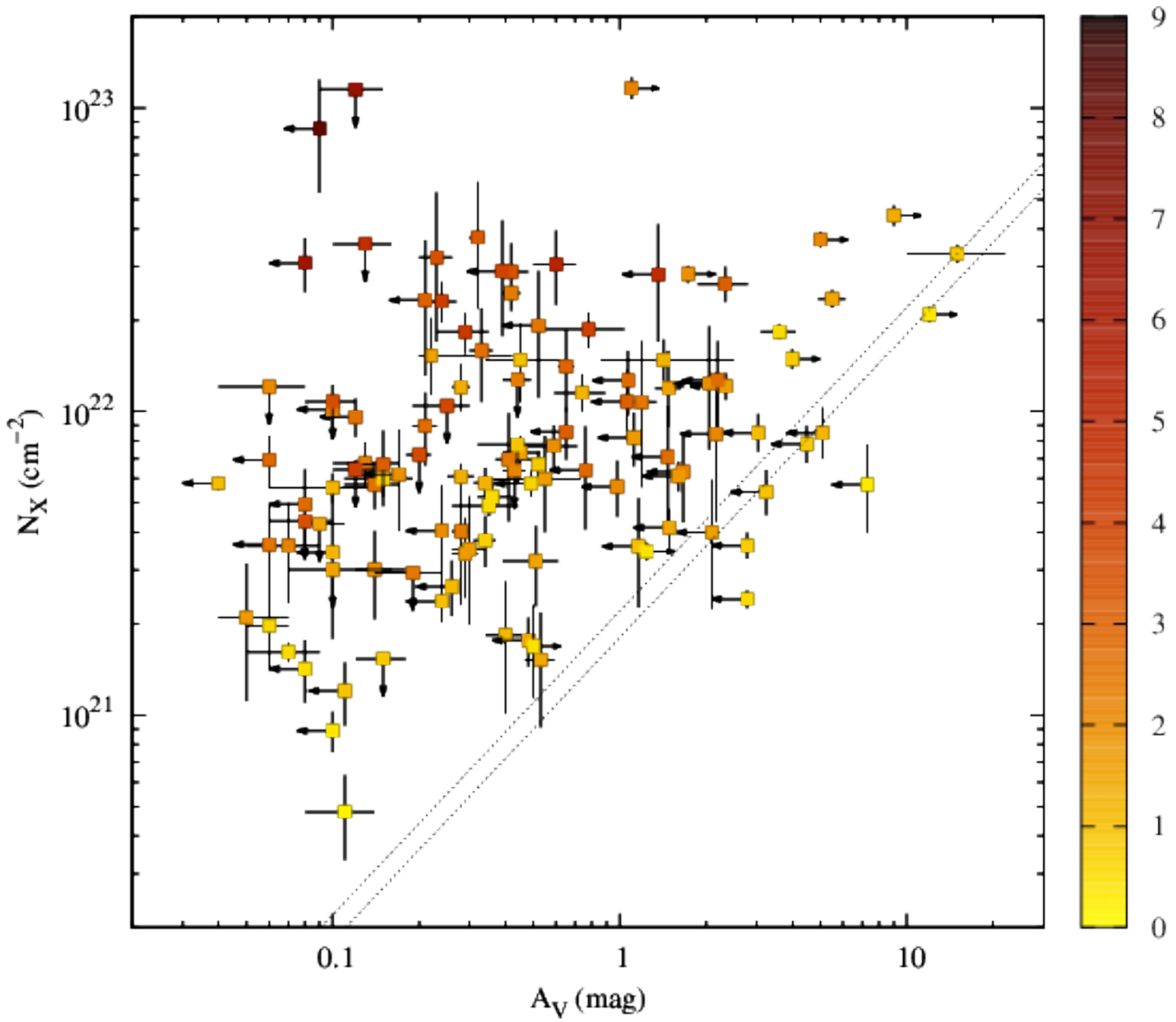

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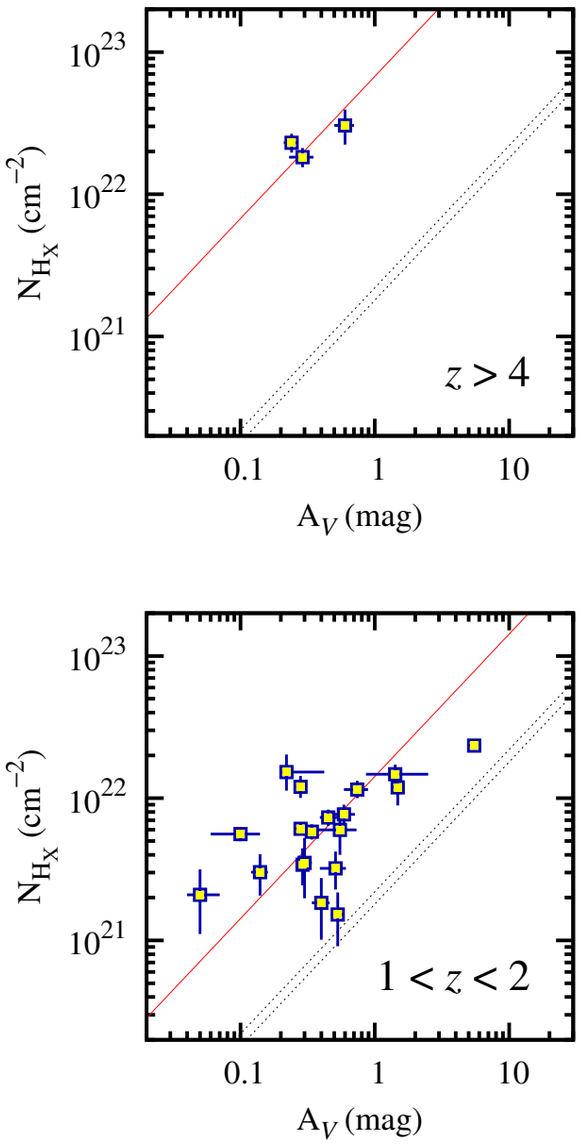
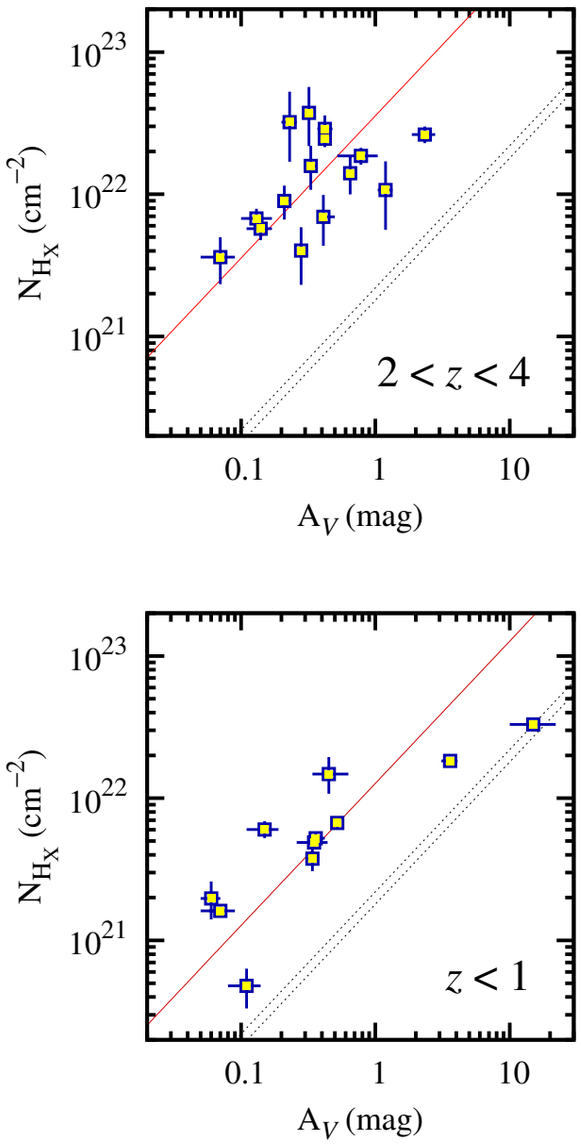
Evolving N_{HX}-A_V correlation

- Correlation between N_{HX} and A_V at $z < 1$, $1 < z < 2$, and $2 < z < 4$.
- But mean ratio rises with redshift





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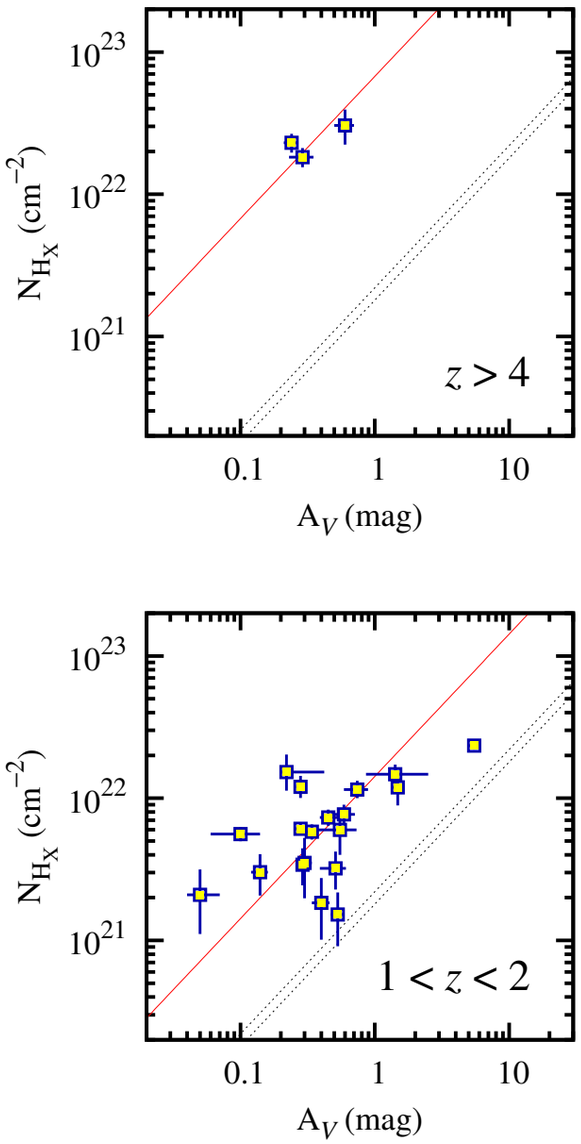

Watson et al., in prep. (incl. Jakkokson)

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(SUB-)Conclusion

- Dust produced more effectively from metals at lower redshifts? Unlikely
- Still do not understand:
  - Where is the X-ray absorption?
  - Its real column density distribution
  - Ionisation state
  - Abundances

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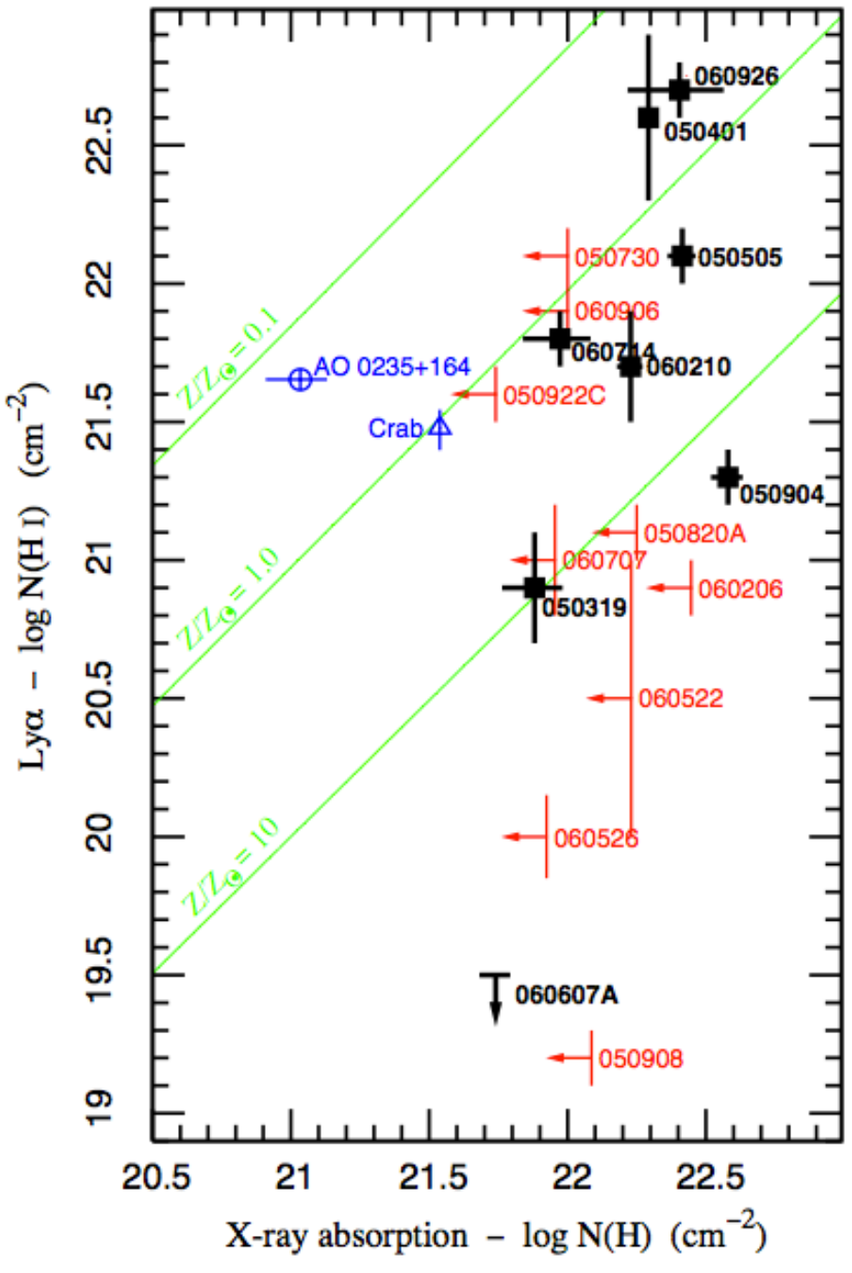
Proposals

- Molecular cloud
- Intrinsic curvature
- Underestimated Galactic
- Intervening neutral absorbers
- Warm/hot IGM



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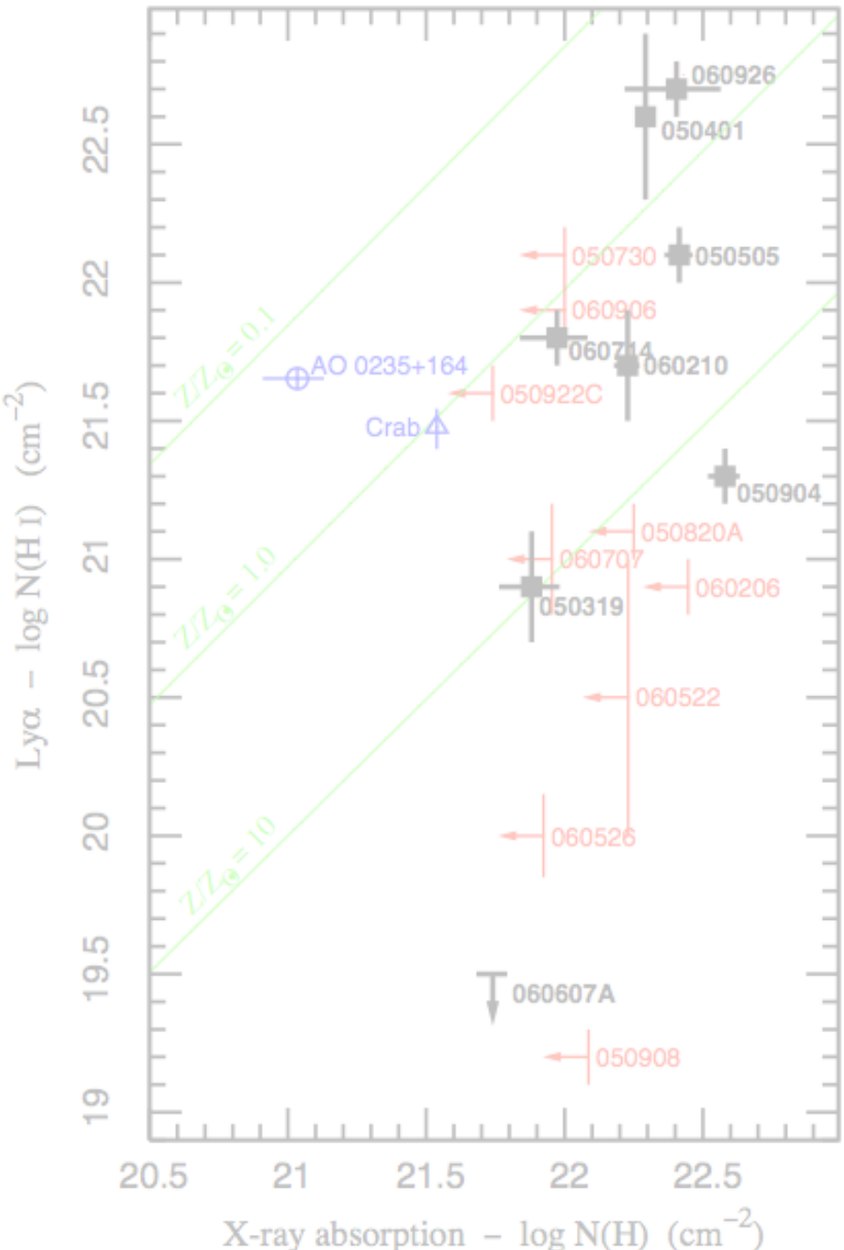

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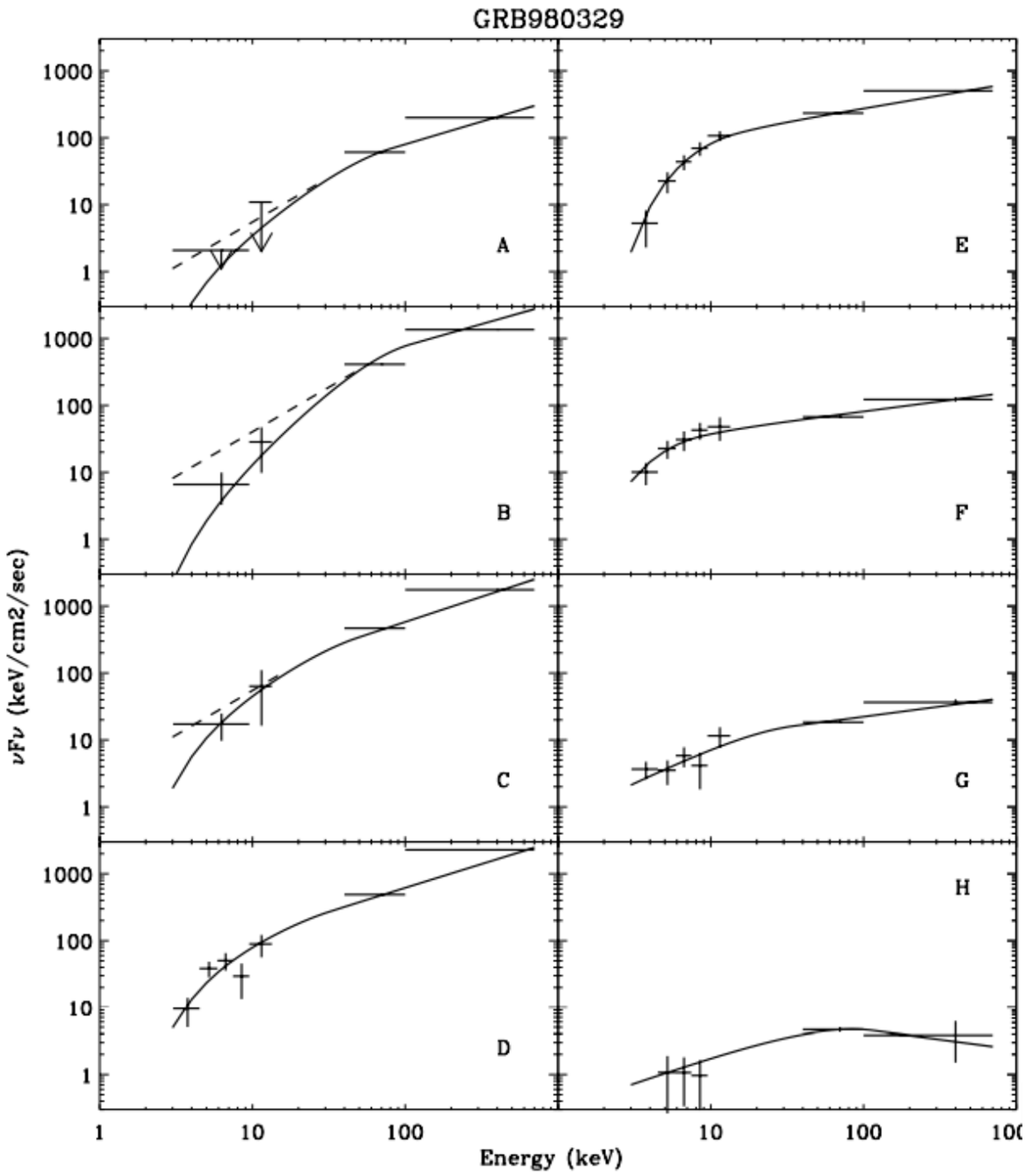
Intrinsic curvature

- Mimics absorption
- A problem in radio-loud AGN, where curvature is well-known
- But not a general solution:
  - slopes do not fit most absorbed GRBs
  - difference in slopes is usually very large
  - sometimes constant absorption in spite of varying spectral parameters



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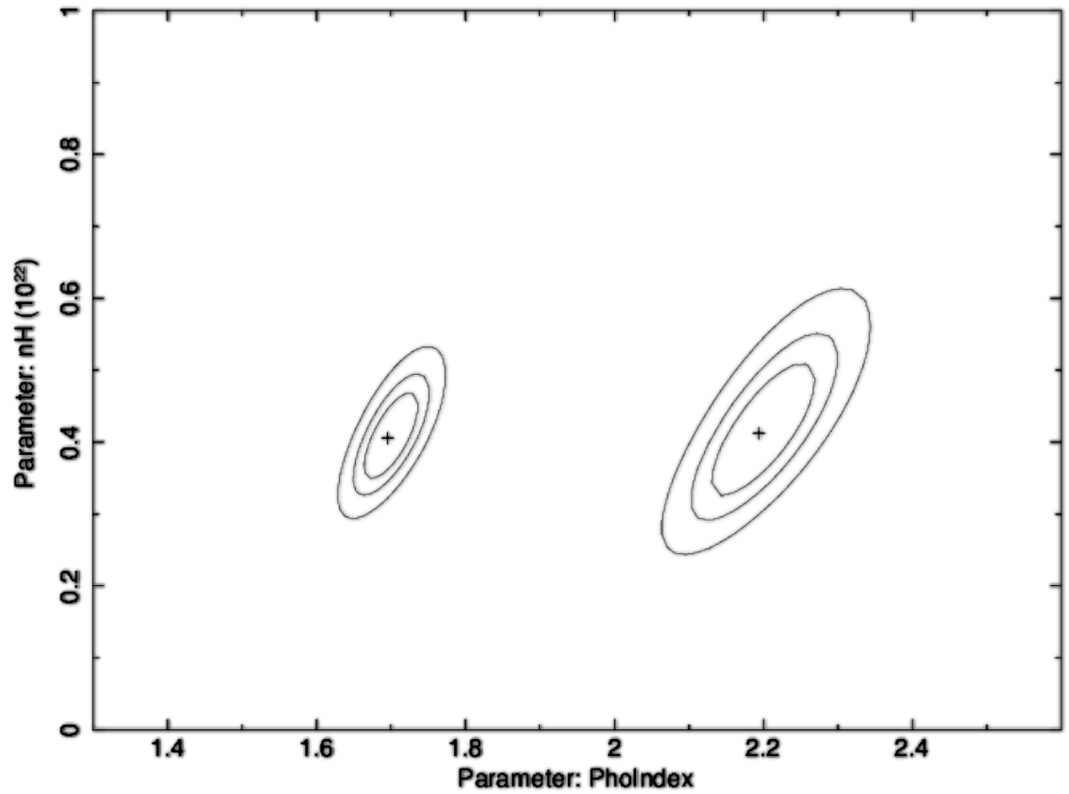

GRB 100901A

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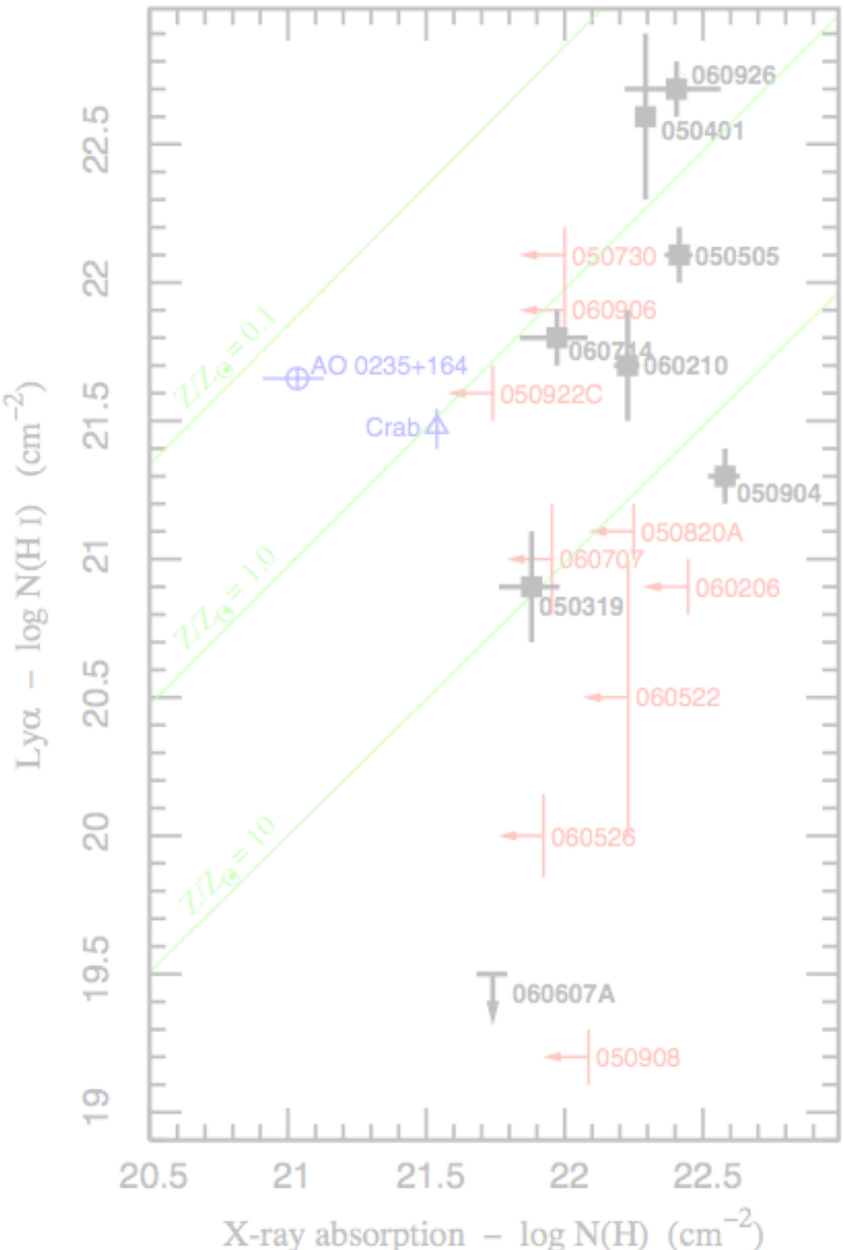

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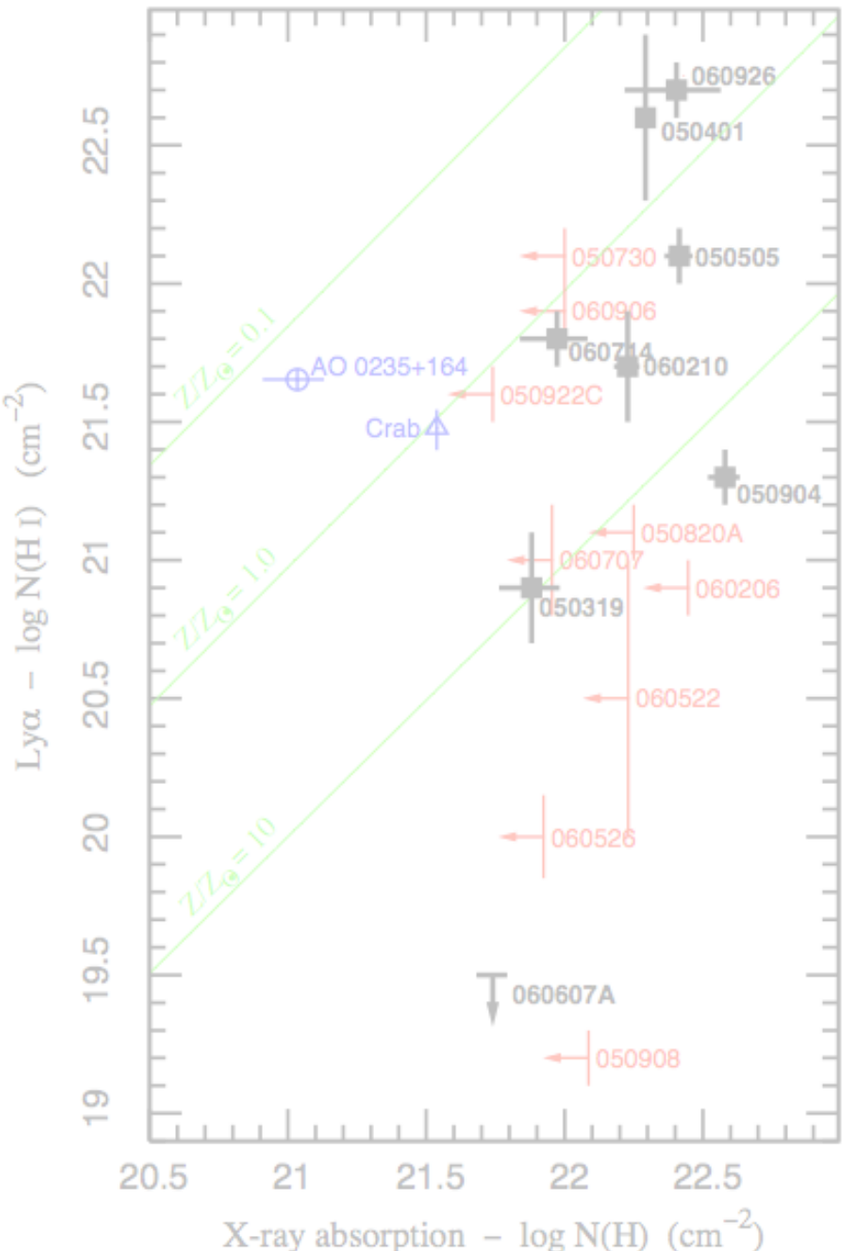

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Metals in our galaxy

- No excess seen in low-redshift blazars
- No correlation observed with Galactic column density
- No systematic difference between high-resolution pointed observations and low-resolution Galactic surveys

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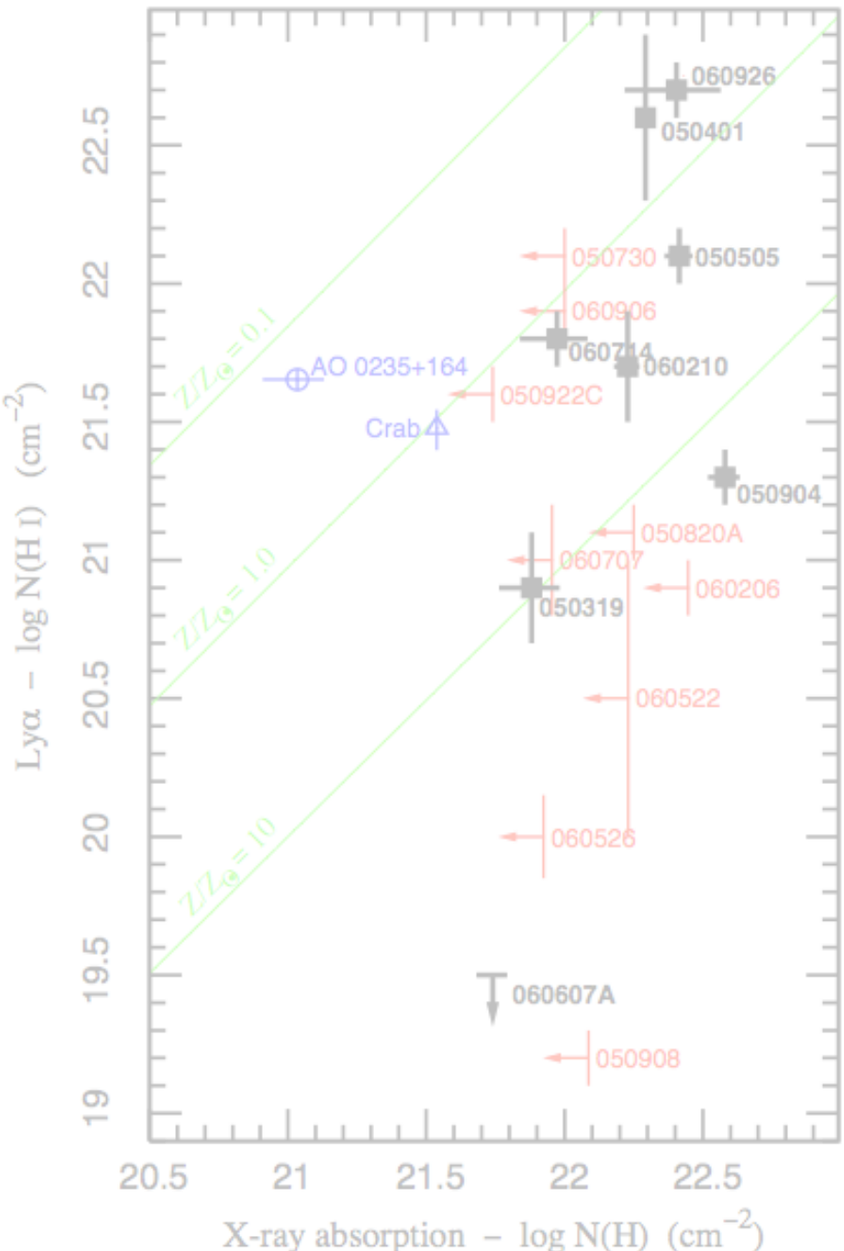

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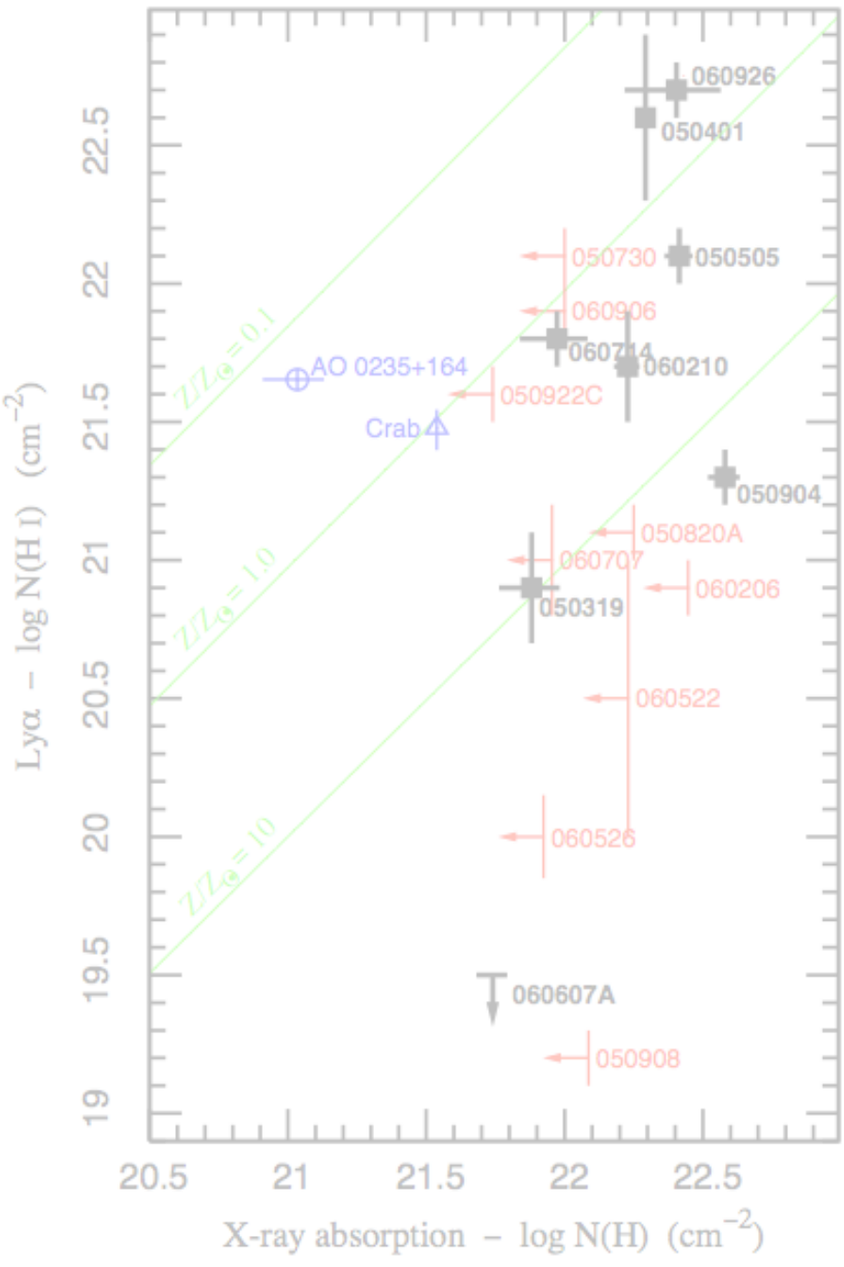

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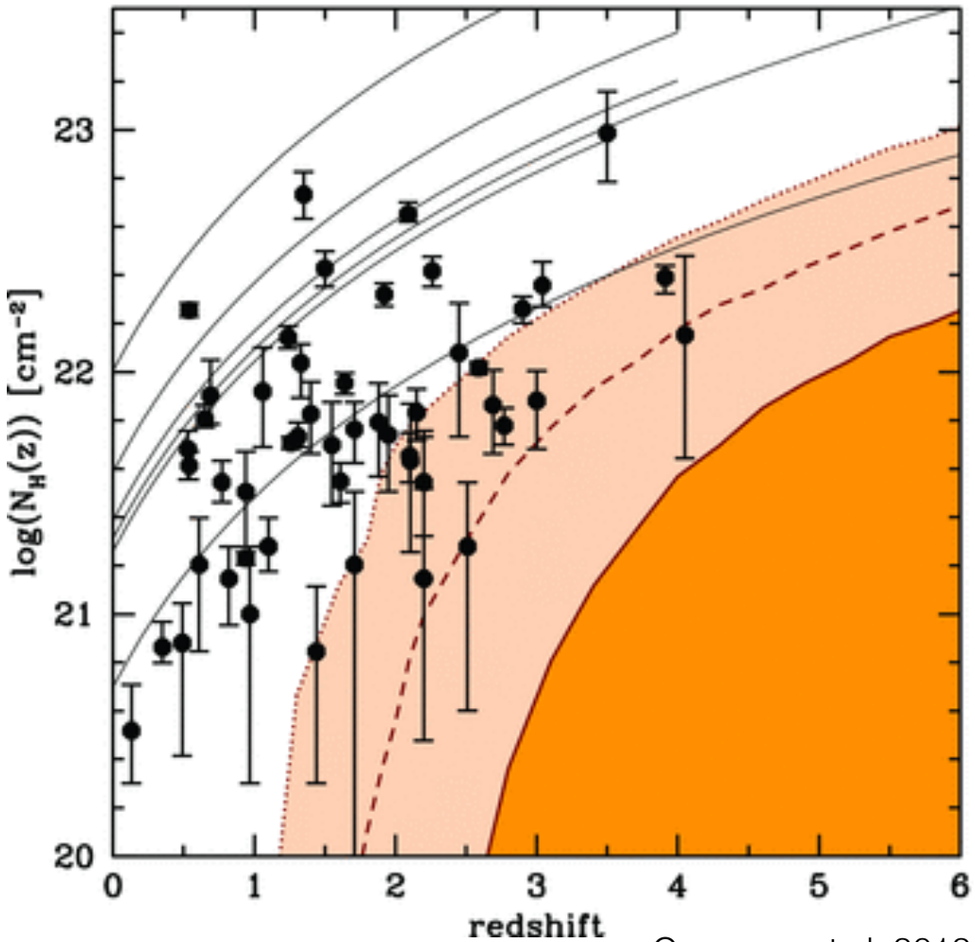
Intervening neutral absorbers

- Low-z intervening absorbers have a stronger effect at high redshift.

- GRBs show an excess of high column density MgII absorbers

- But must take into account decreasing cosmic metallicity when looking for a faster than $(1+z)^{2.5}$ increase



Campana et al. 2012

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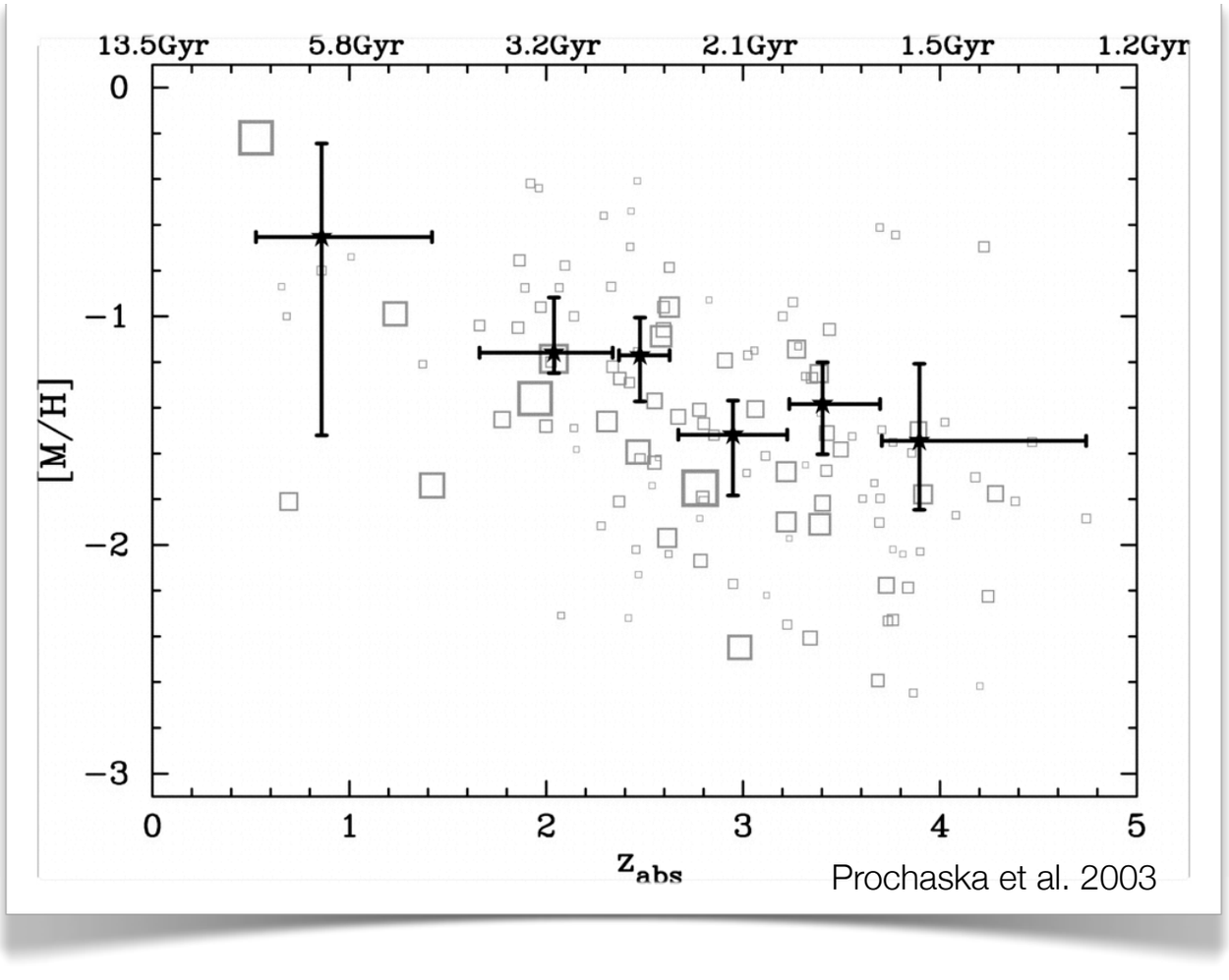

Prochaska et al. 2003

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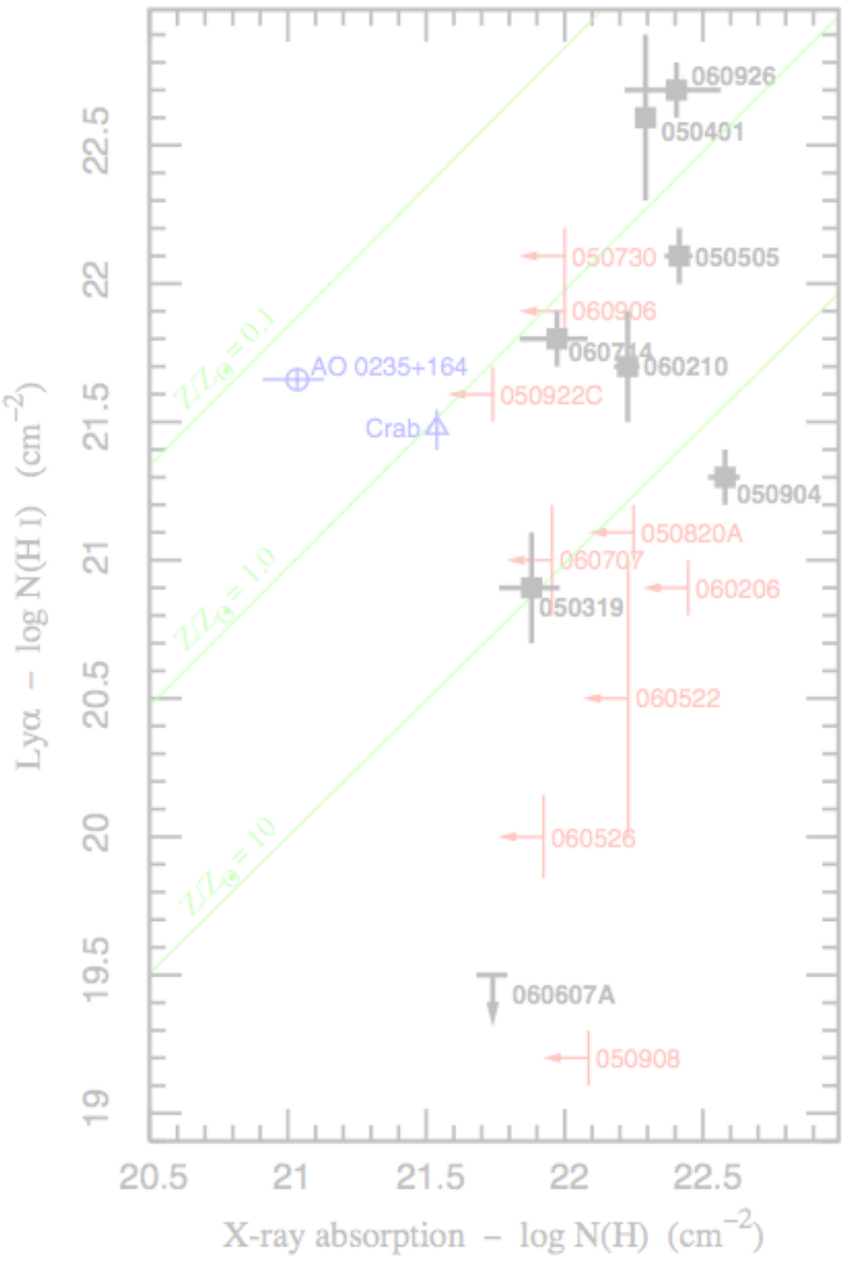

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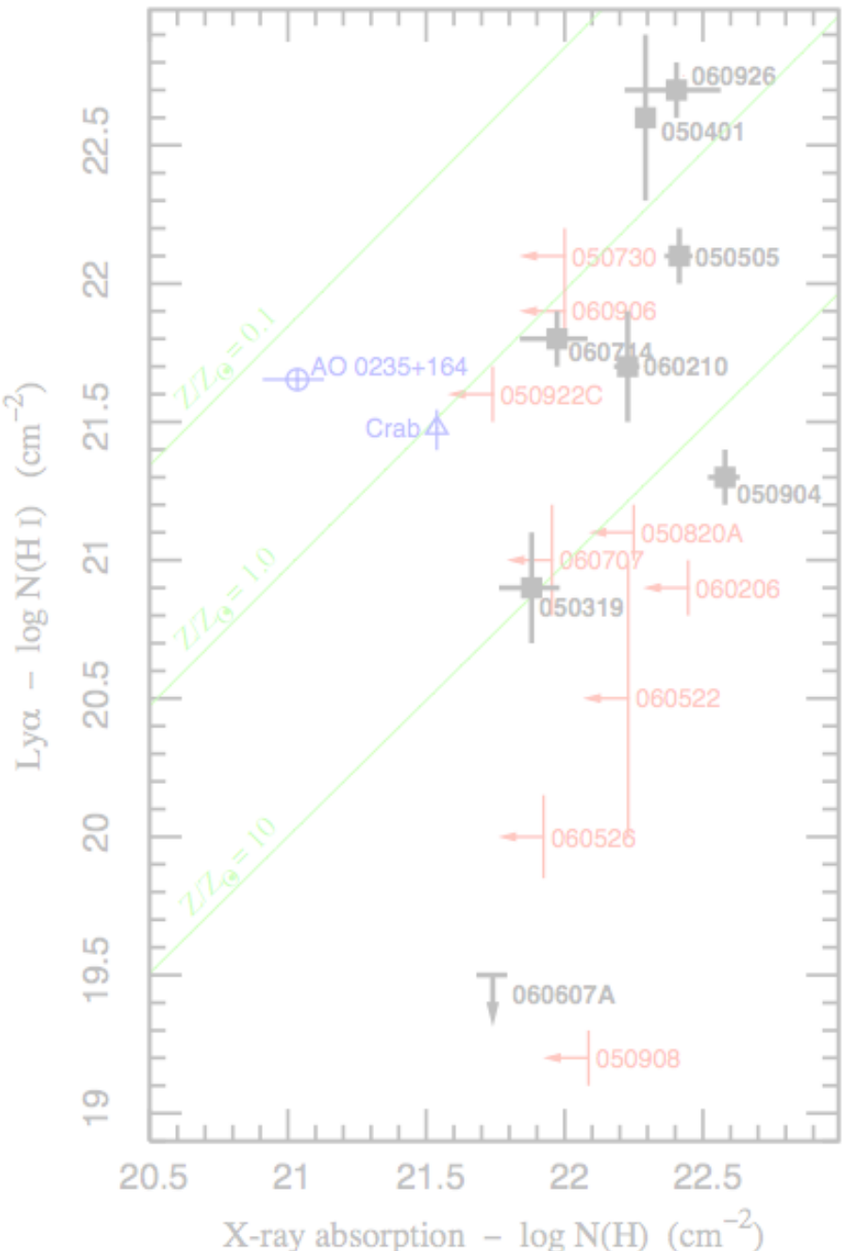
No: consistent with other surveys (dust, galactic sources)

No: Not large enough. Metallicity decreases with redshift



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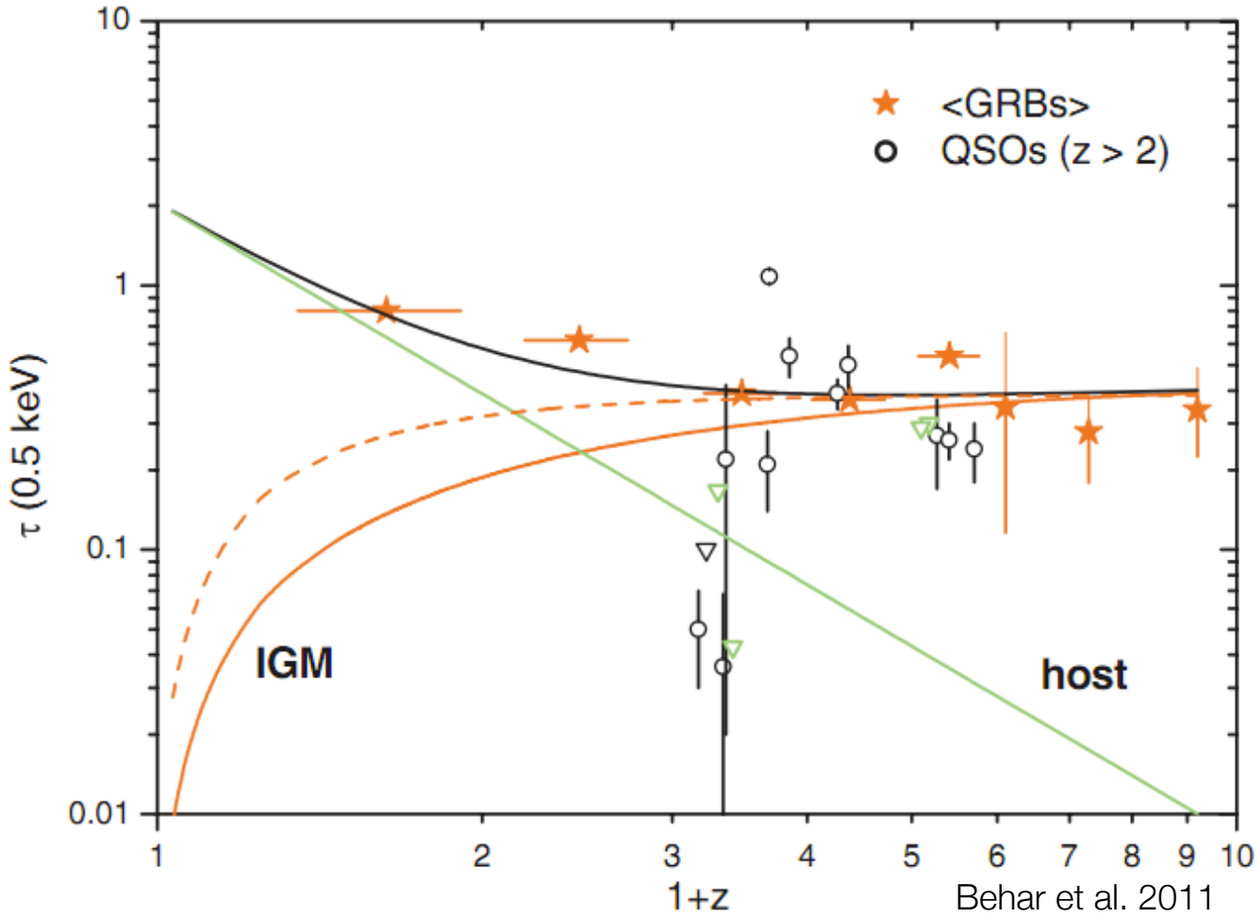
Intervening metals

- Could it be highly-ionised metals in the IGM (warm-hot intergalactic medium)?
- Individual GRBs and AGN observed with no absorption, so not universal
- Radio-quiet AGN at high redshift show no absorption— should if it was WHIM
- Radio-loud AGN sometimes seem to show absorption, but radio-loud AGN not a very good comparison, since they
  - are known to have intrinsic curvature,
  - have variable “absorption” that goes up and down,
  - show excesses at low energies as well as deficits



Behar et al. 2011

Proposals

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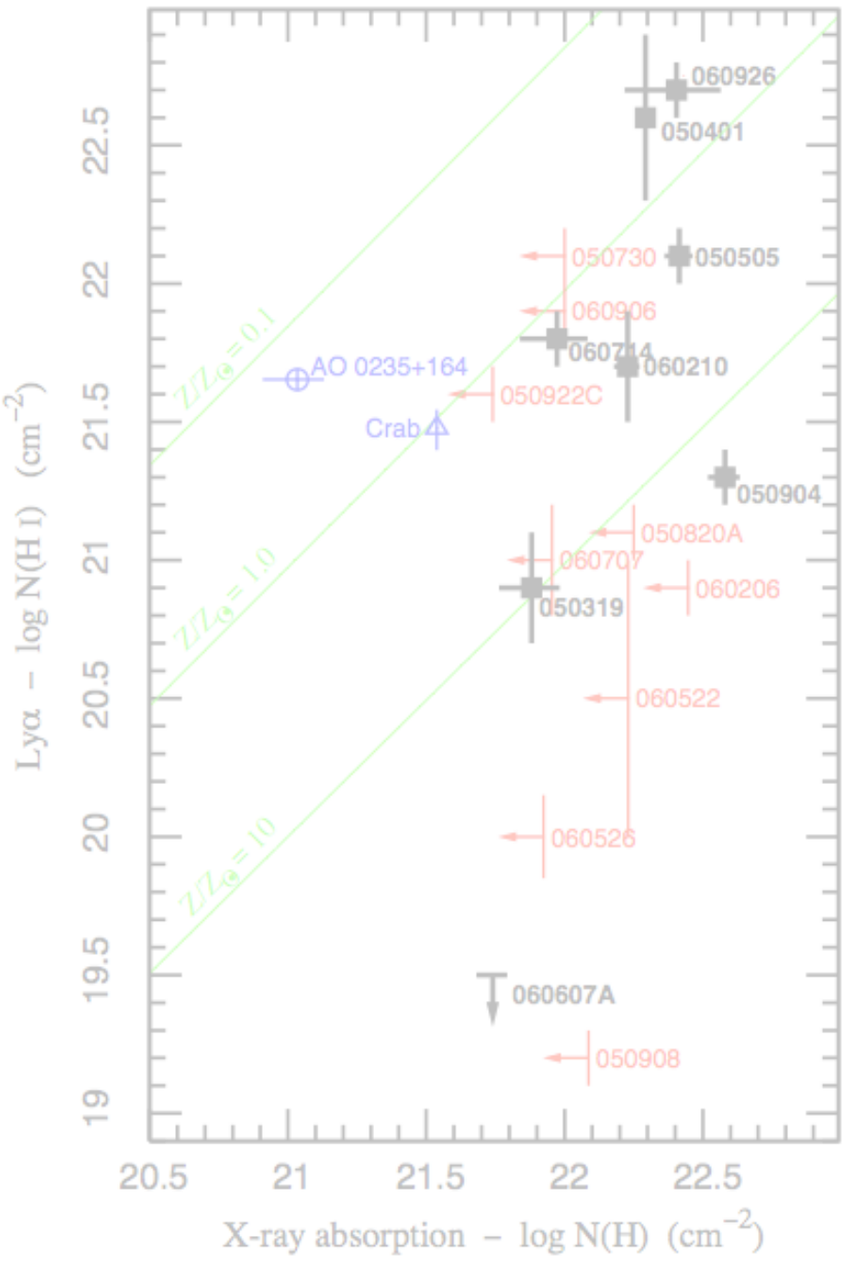

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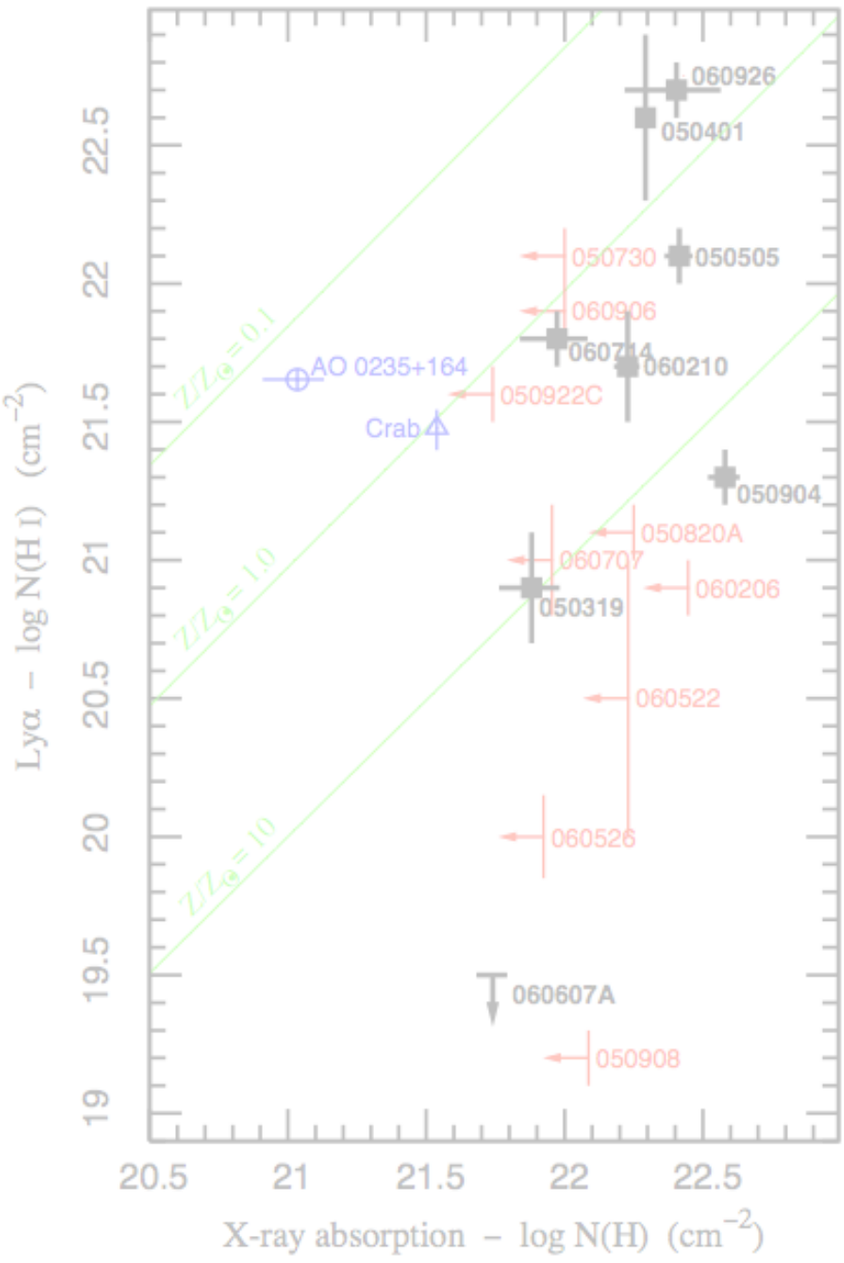

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Proposals

So what's Left?

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- ~~Underestimated Galactic~~ — No: consistent with other surveys (dust, galactic sources)
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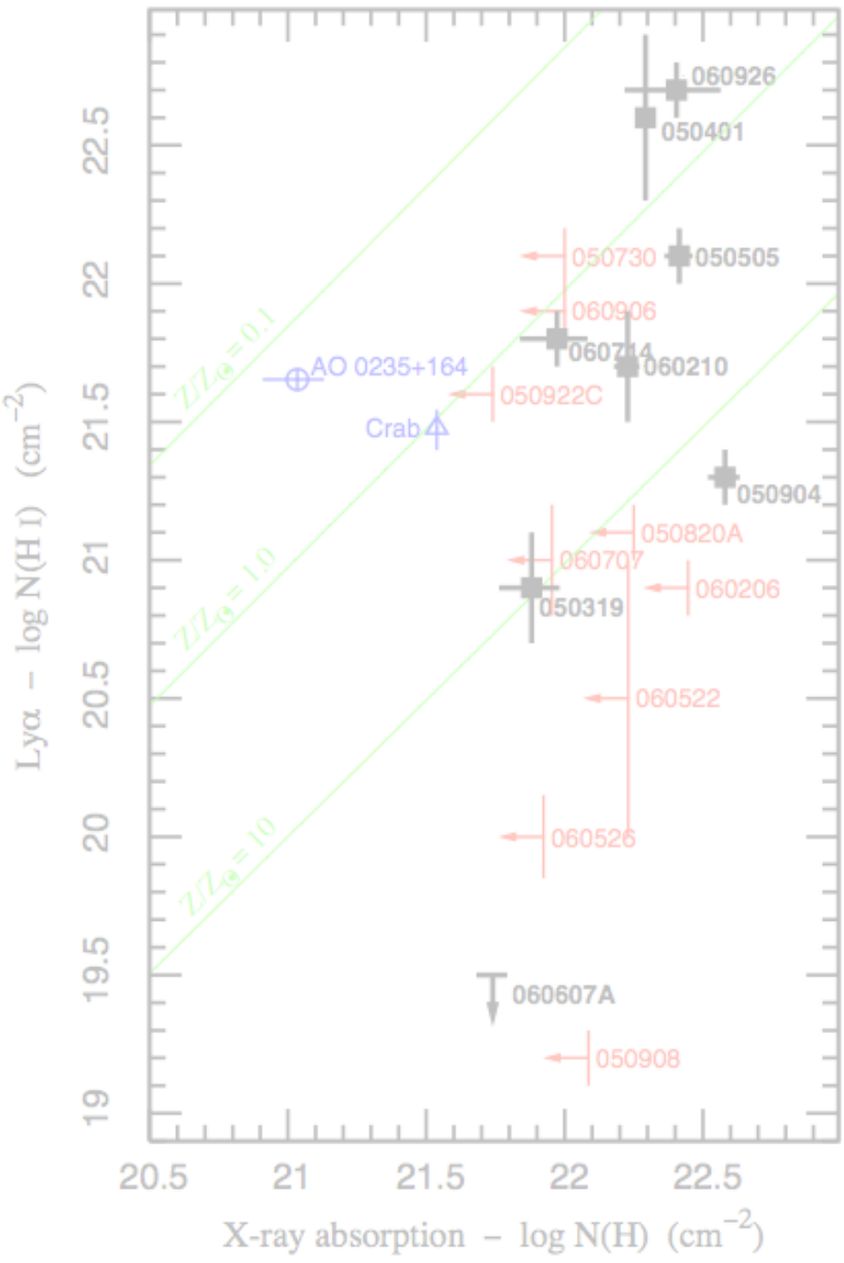

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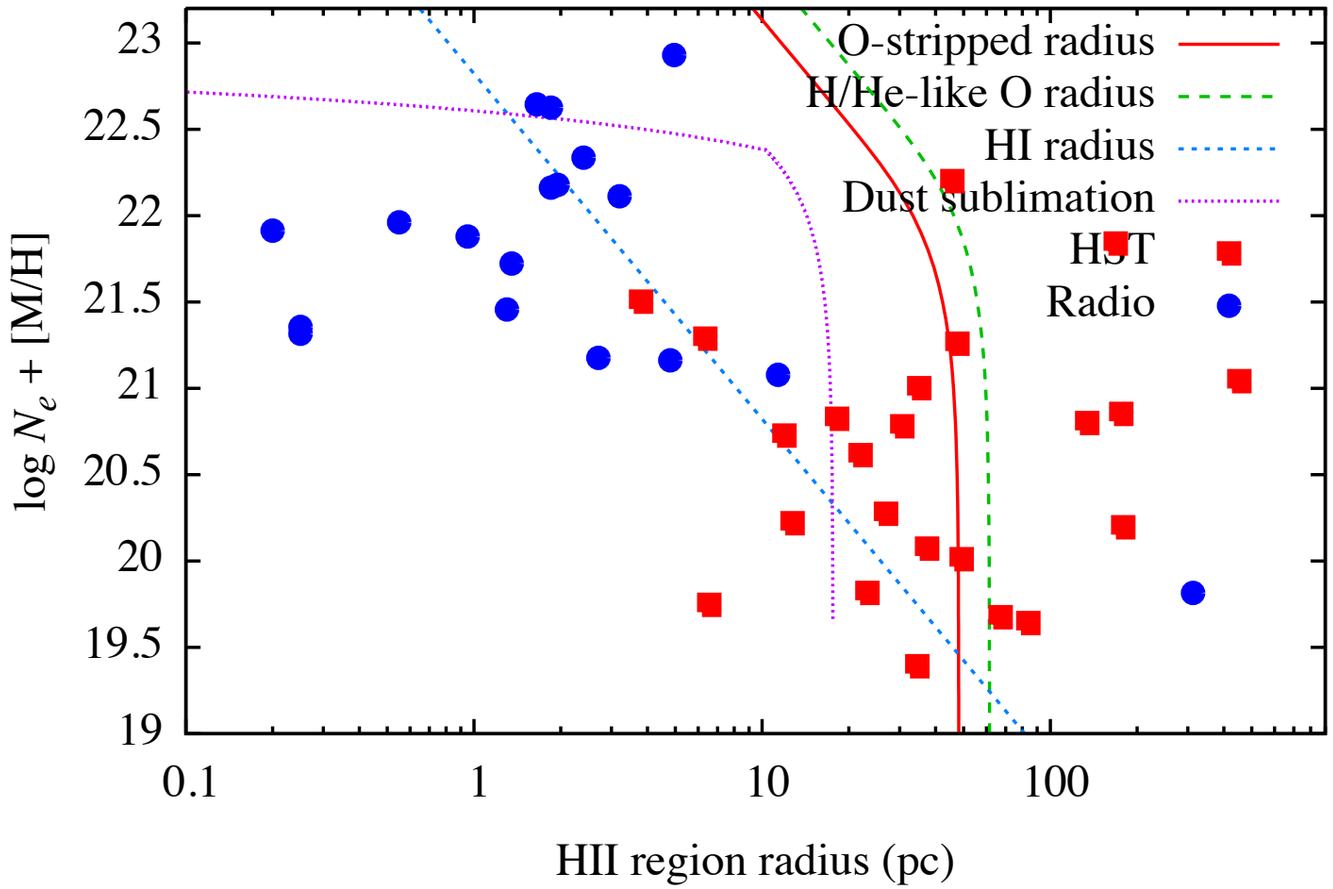
END

What's left

- HII region?
- Progenitor wind?
  - A combination of many effects?



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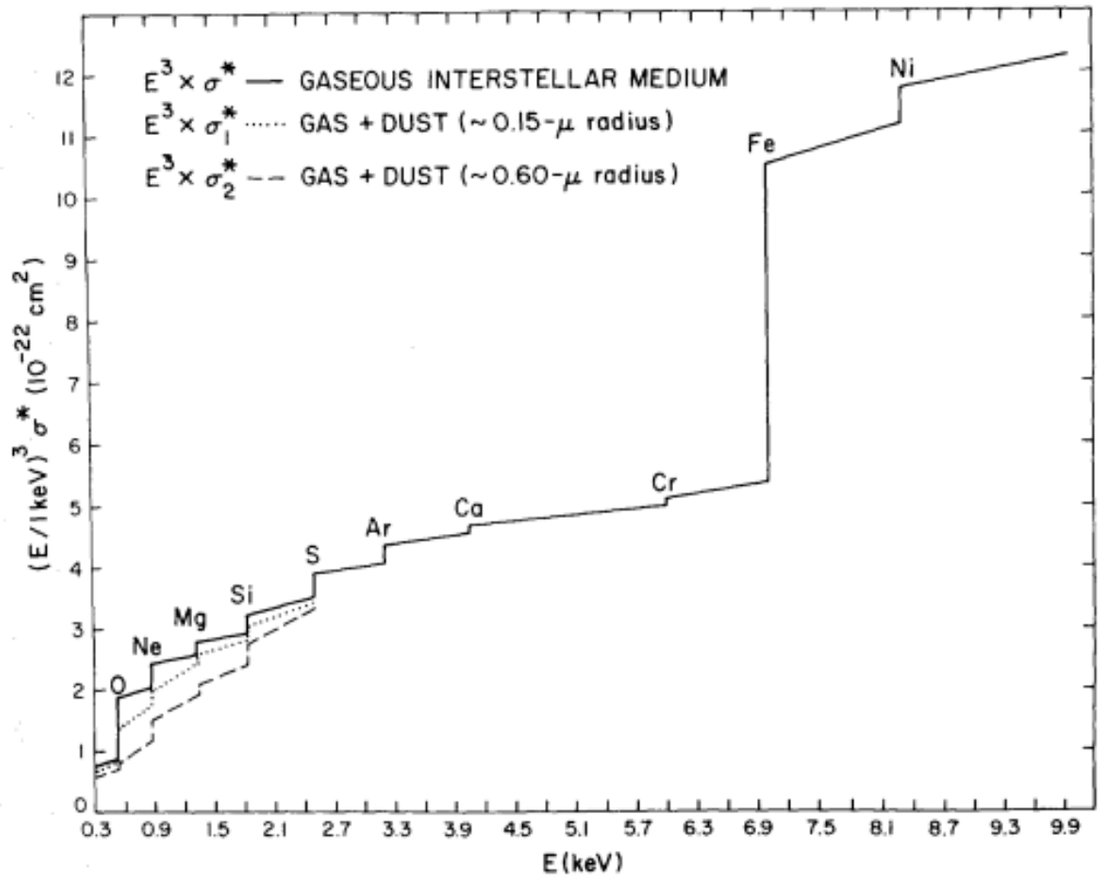
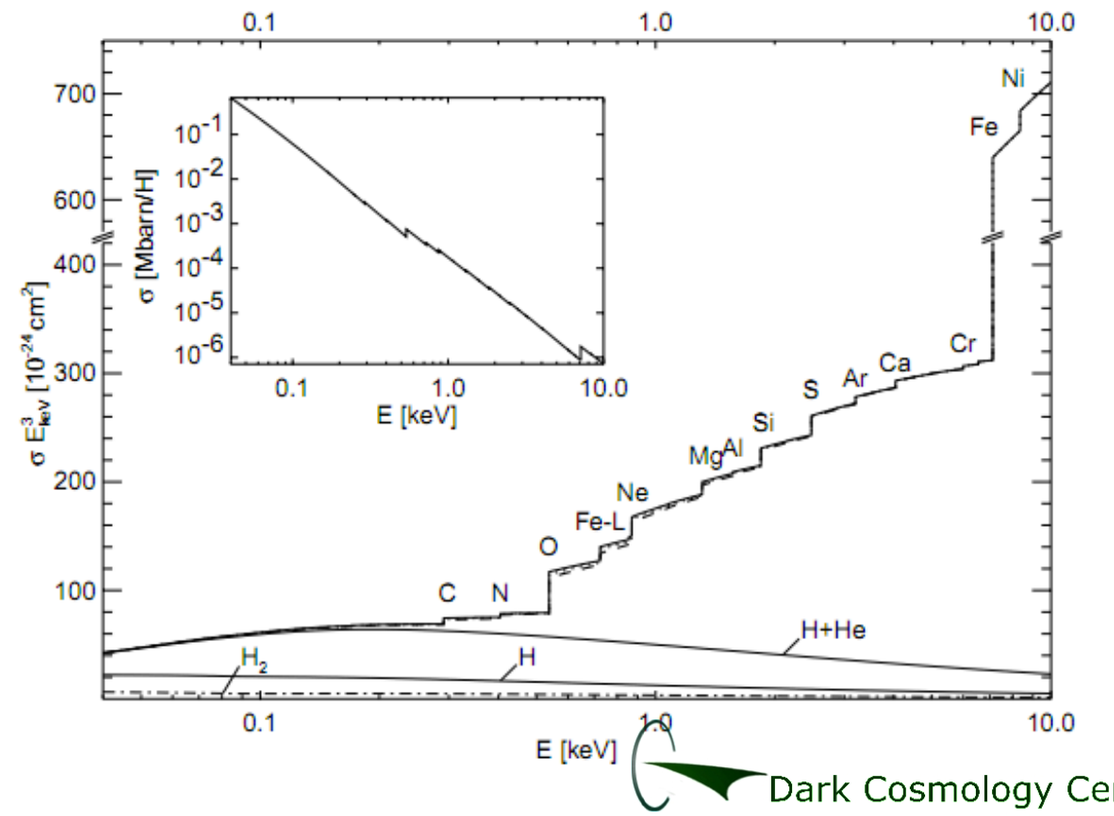
What causes the X-ray absorption?

- Photoelectric absorption
- Inner shells of metals dominate
- He, C, O, Fe, Si, S etc.
- Relatively insensitive to ionisation state or phase (i.e. in normal situations, X-rays see almost all metals)
- Use column density in hydrogen as a useful proxy, but actually, insensitive to hydrogen





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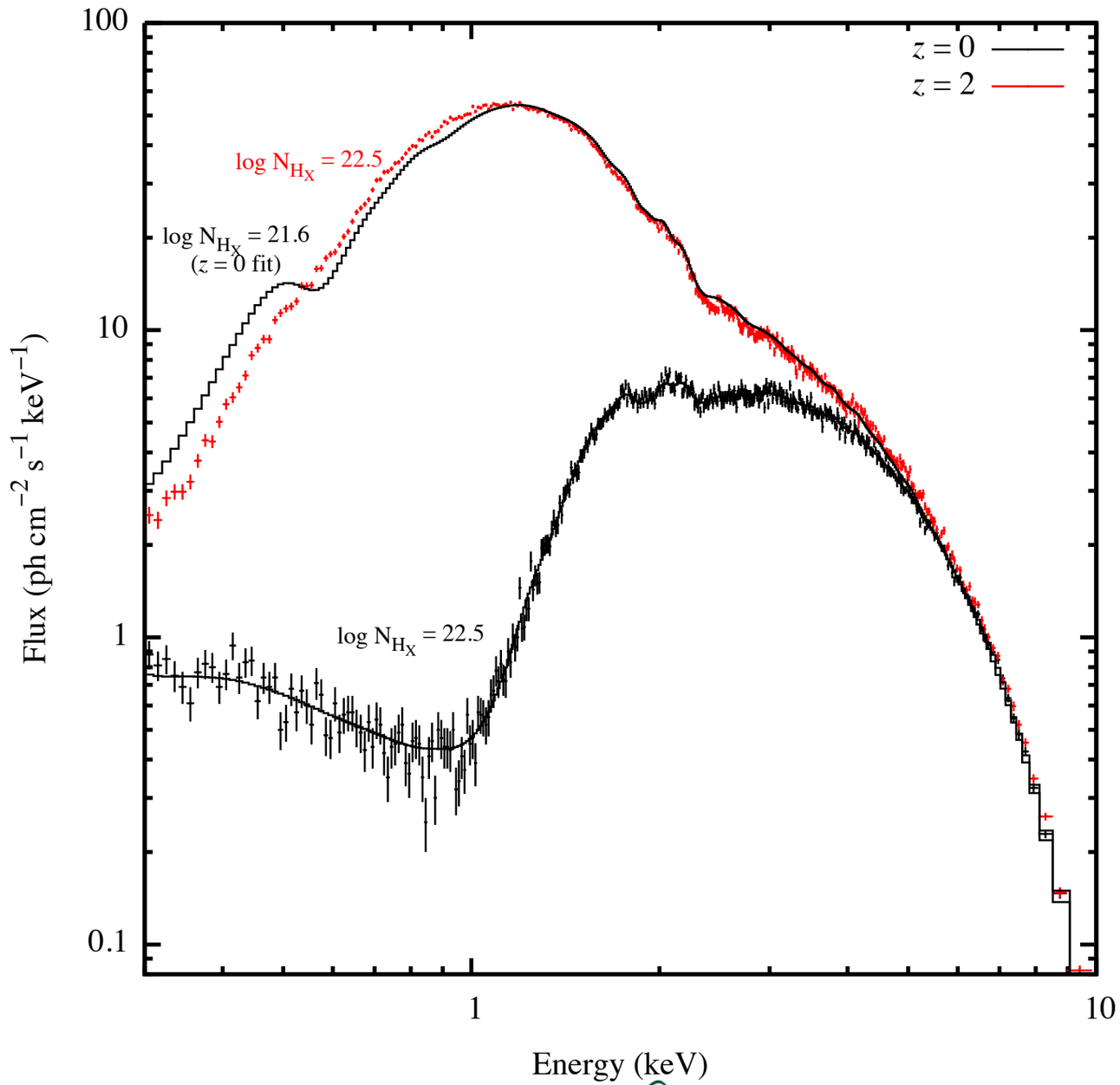
Redshift dependence

- Little redshift information in low-res X-ray spectra
- Get redshifts from optical
- But! Inferred absorption strongly redshift dependent:
- $N_{H_X}(z) \approx (1+z)^{2.5}\, N_{H_X}(0)$



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