

The Distribution of Metals in the Intergalactic Medium

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JS et al. 2003, ApJ, in press (astro-ph/0306469)

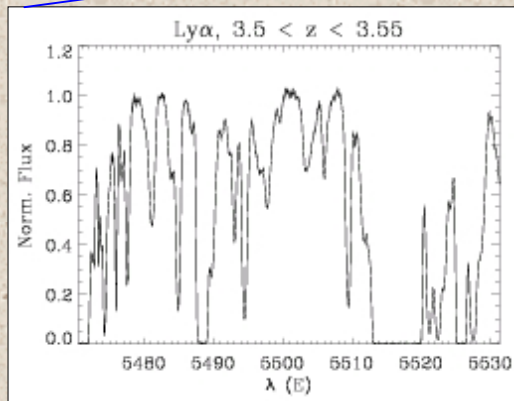
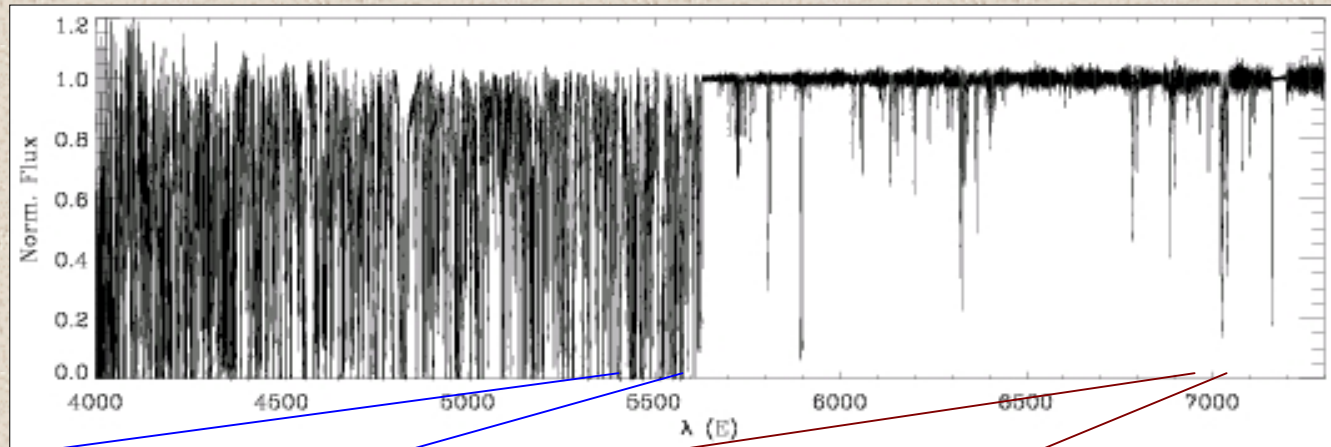
Collaborators

- Anthony Aguirre
- Tae-Sun Kim
- Tom Theuns
- Michael Rauch
- Wal Sargent

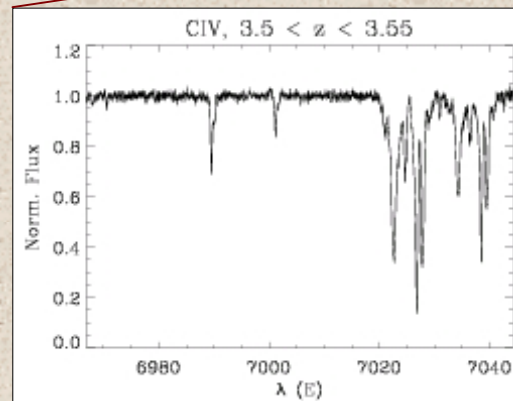
Why do we care about IG metals?

- Learn about feedback from star formation (galactic winds)
- Fossil record of past star formation (e.g., Pop III)
- Metals are important coolants

A QSO absorption spectrum



HI 1216



CIV 1548, 1551

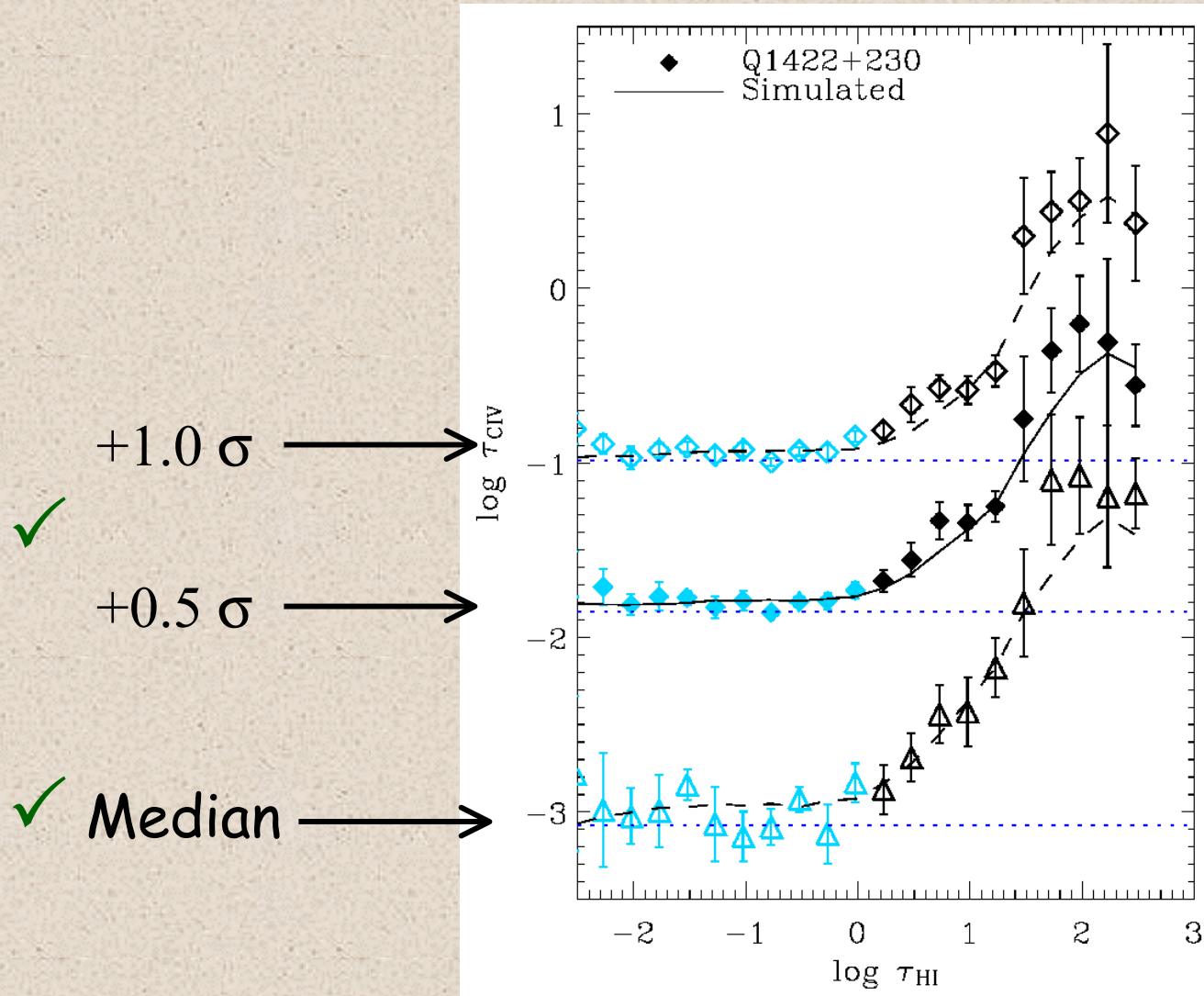
Q1422+230

$z_{\text{em}} = 3.62$

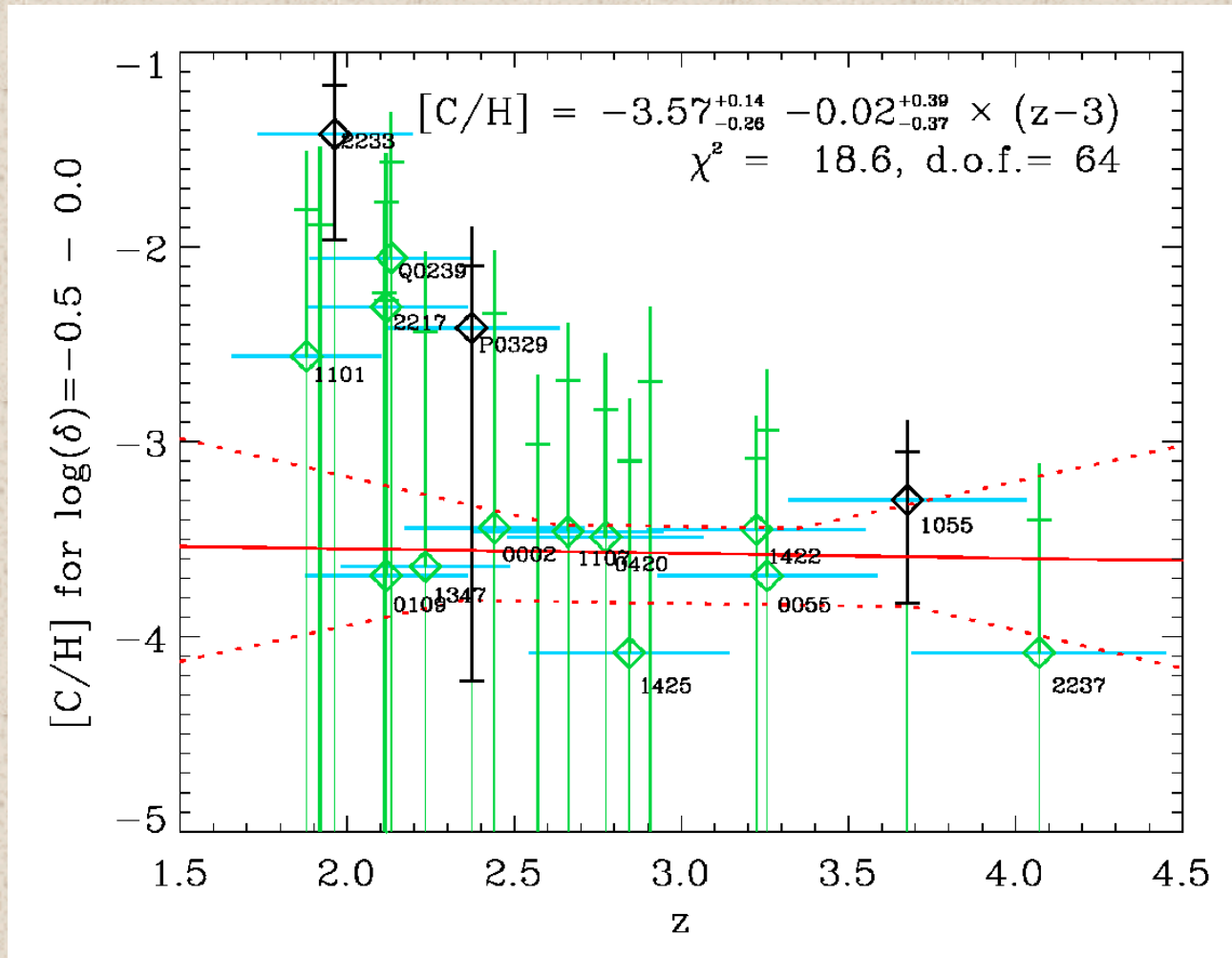
Questions

- Are metals generally present at $\delta \sim < 1$?
- How does Z vary with δ ?
- How does Z vary with z ?
- How much scatter is there in $Z(\delta, z)$?
- Does the scatter depend on δ or z ?
- Are the observed metal absorbers photoionized?

Pixel statistics

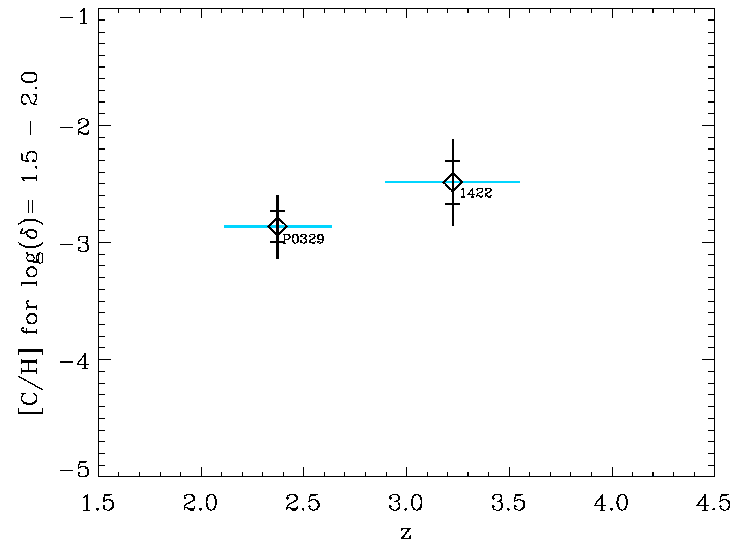
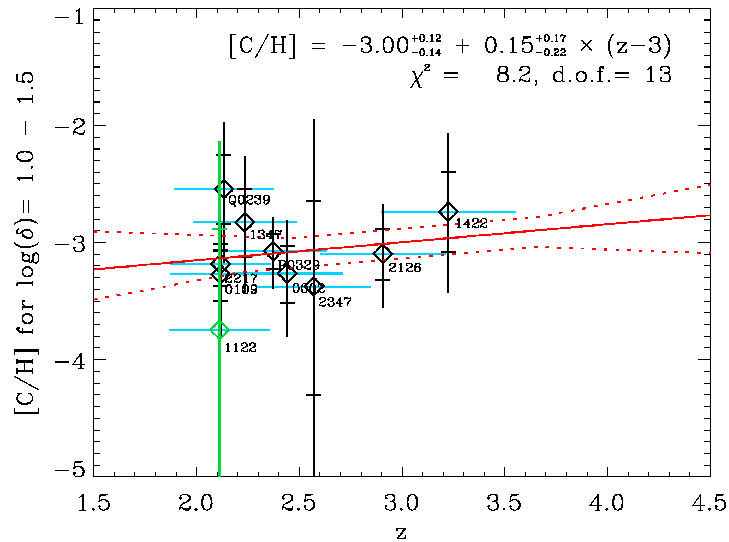
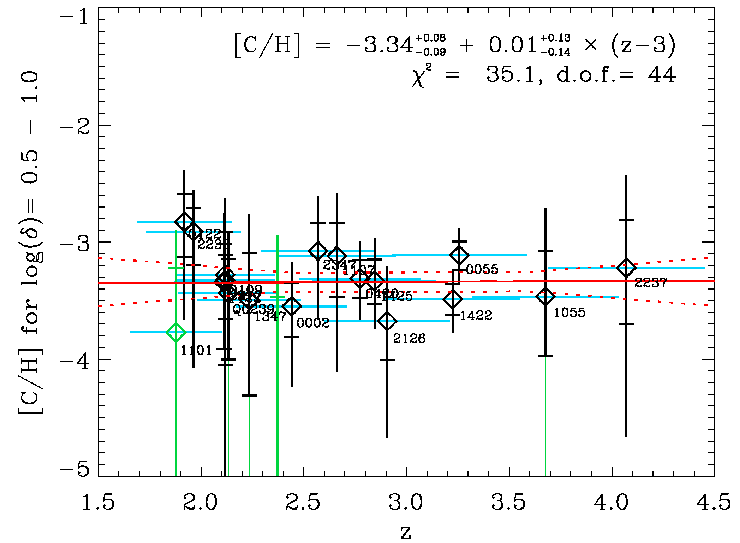
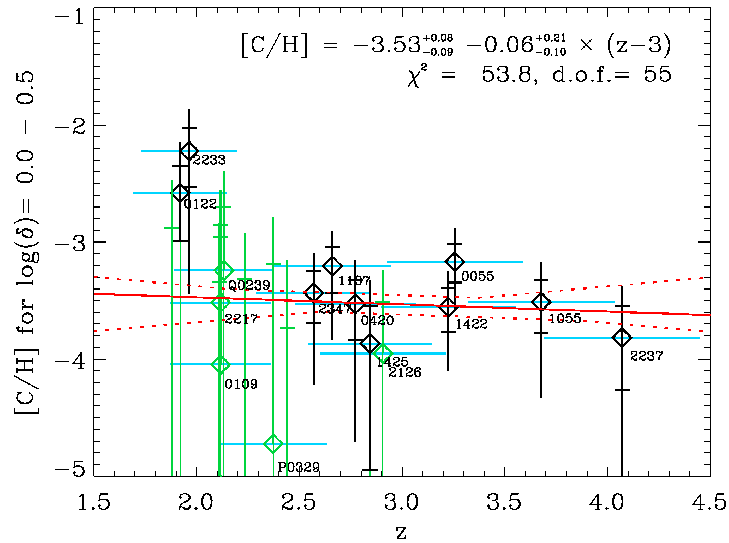


Metallicity of underdense gas

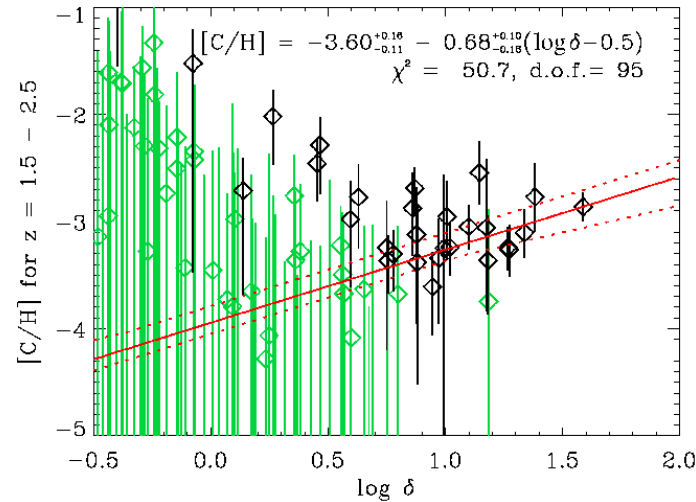


2.4 σ detection (i.e., 99.2% CL)

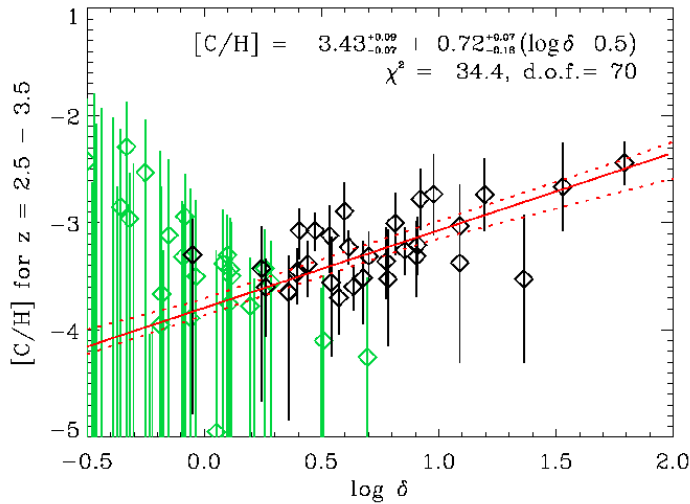
Metallicity of overdense gas



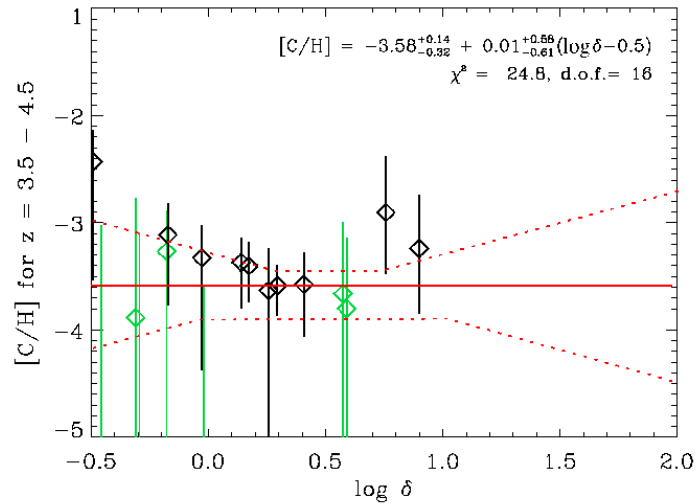
Metallicity binned in redshift



$z = 2$

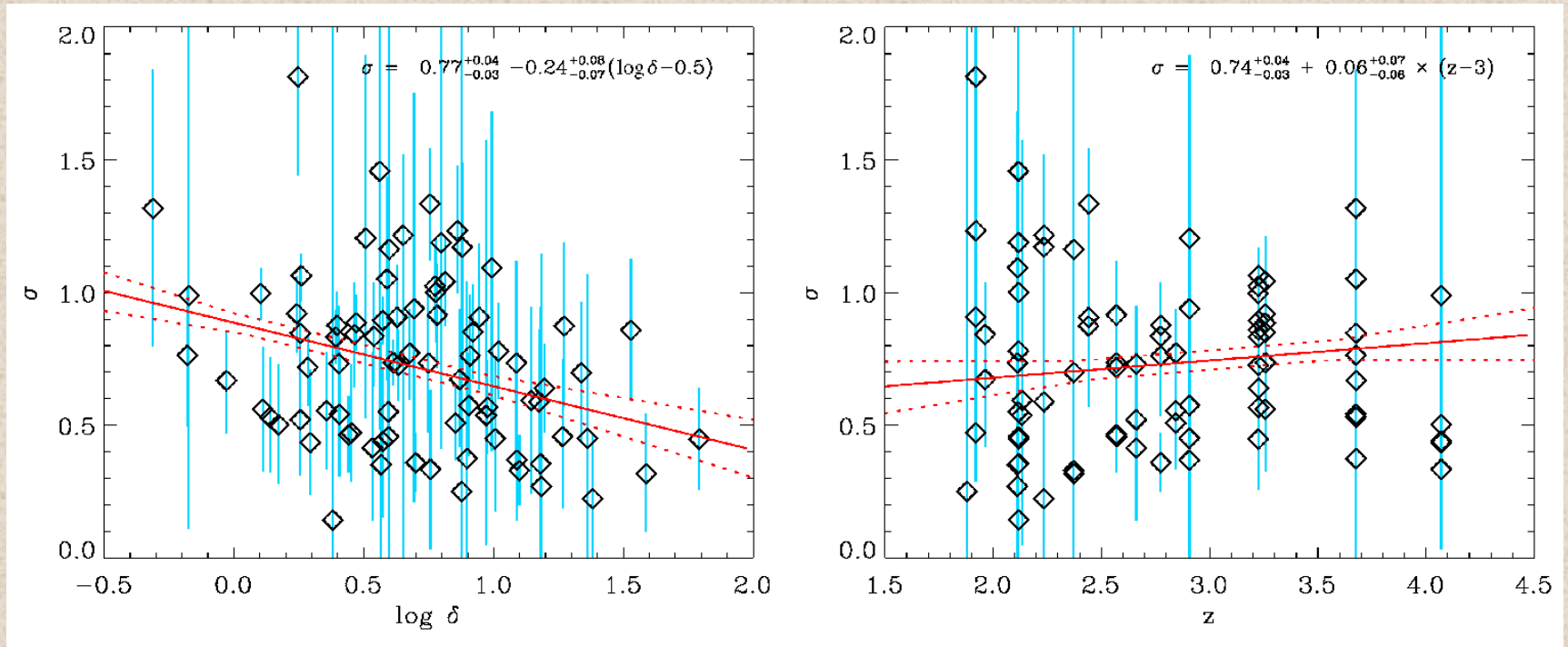


$z = 3$



$z = 4$

Measuring the scatter

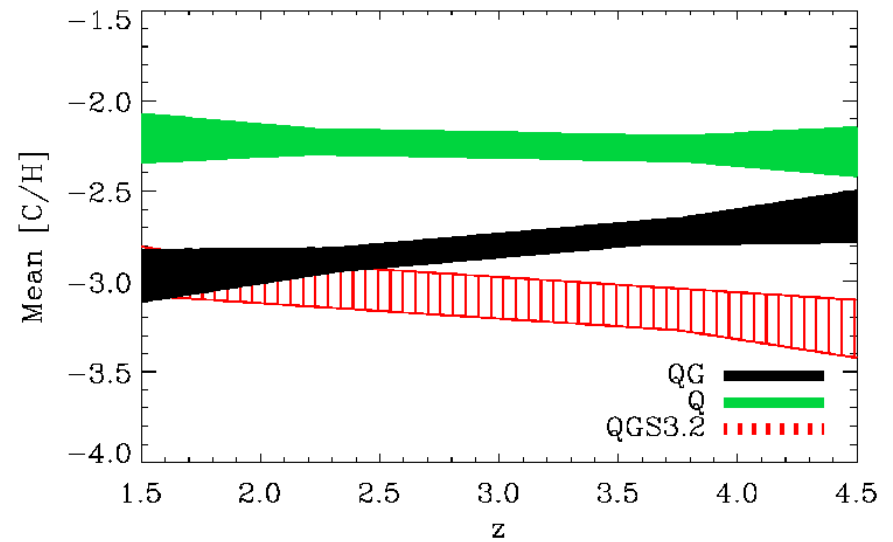
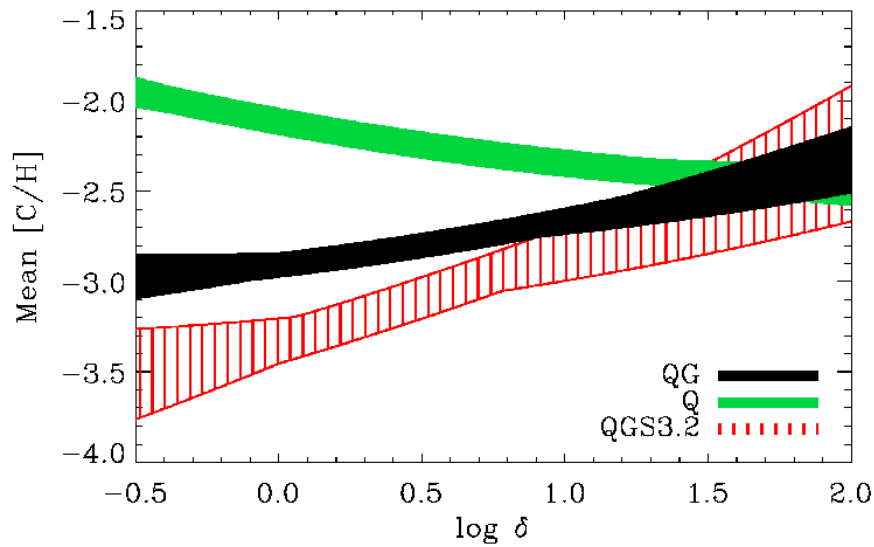


Varying the UV background

Mean metallicity

$z = 3$

$\log \delta = 0.5$



Conclusions

- No evidence for evolution from $z=4$ to $z=2$, except for $\delta < 10$ if UV background was very soft at $z > 3.2$
- Strong evidence for an increase of the median metallicity with overdensity
- Metallicity at $\delta=1$: Median ~ -3.5 , mean ~ -2.9 (higher if background is harder)
- Scatter (independent of UV background):
 - Metal distribution is lognormal for fixed density
 - $\sigma(\log Z) \sim 0.9$ dex at $\delta=1$
 - strong evidence for a decrease in scatter with overdensity
 - no evidence for evolution
- Carbon is present in underdense gas (median abundance is nonzero at $>99\%$ confidence)
- Pure quasar background is too hard
- CIII/CIV ratio implies CIV absorbers are warm (photoionization temperatures), but there could be additional metals in hot gas.