On the possible break in the metallicity evolution of DLAs at z~5

Marc Rafelski

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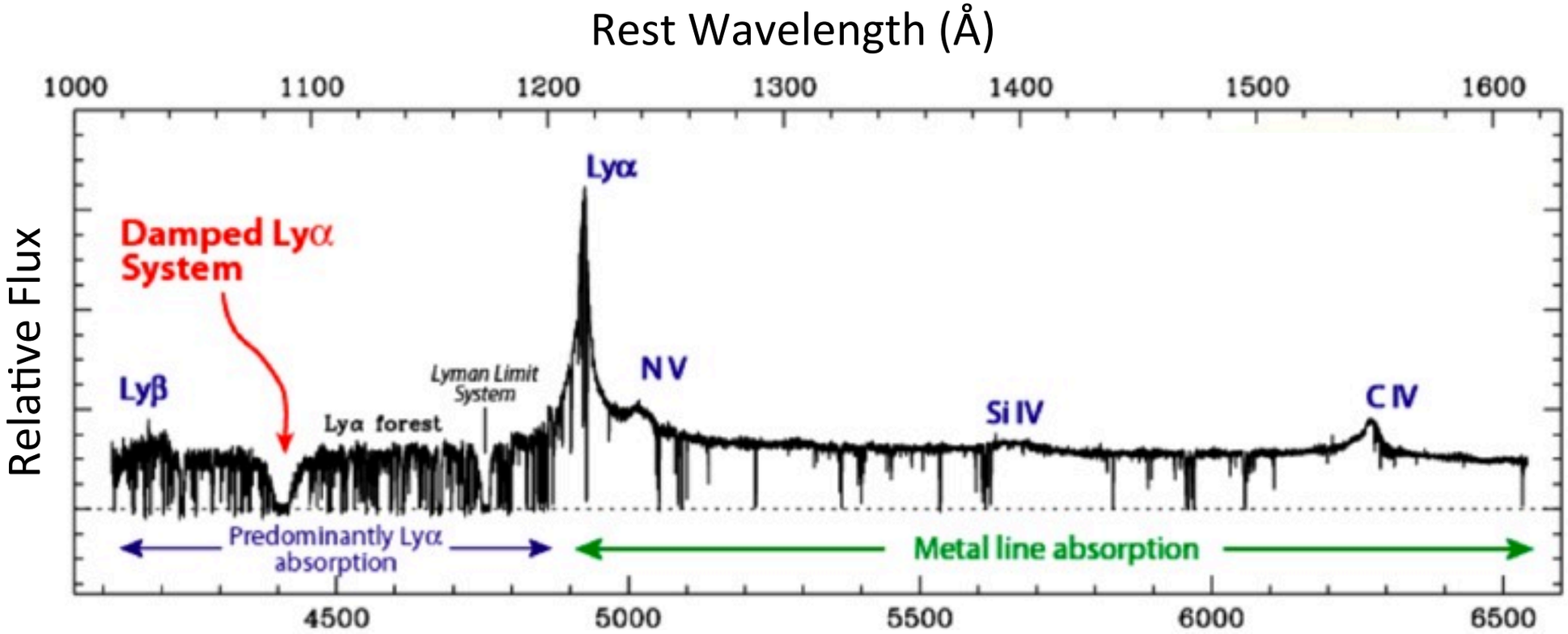
Collaborators:
- Arthur Wolfe
- Marcel Neeleman
- J. Xavier Prochaska
- Michele Fumagalli
- Harry Teplitz

Properties of Damped Lyman Alpha Systems



- Definition of Damped Lyα System (DLA): $N(HI) \geq 2\times10^{20}$ cm^{-2}
- Distinguishing characteristics of DLAs :
  - (1) Gas is Neutral
  - (2) Metallicity is low: [M/H]=-1.5
  - (3) Molecular fraction is low: $f_{H2}\sim10^{-5}$
- DLAs dominate the neutral-gas content of the Universe out to z~4.5
- DLAs cover 1/3 of the sky at z=[2.5,3.5]

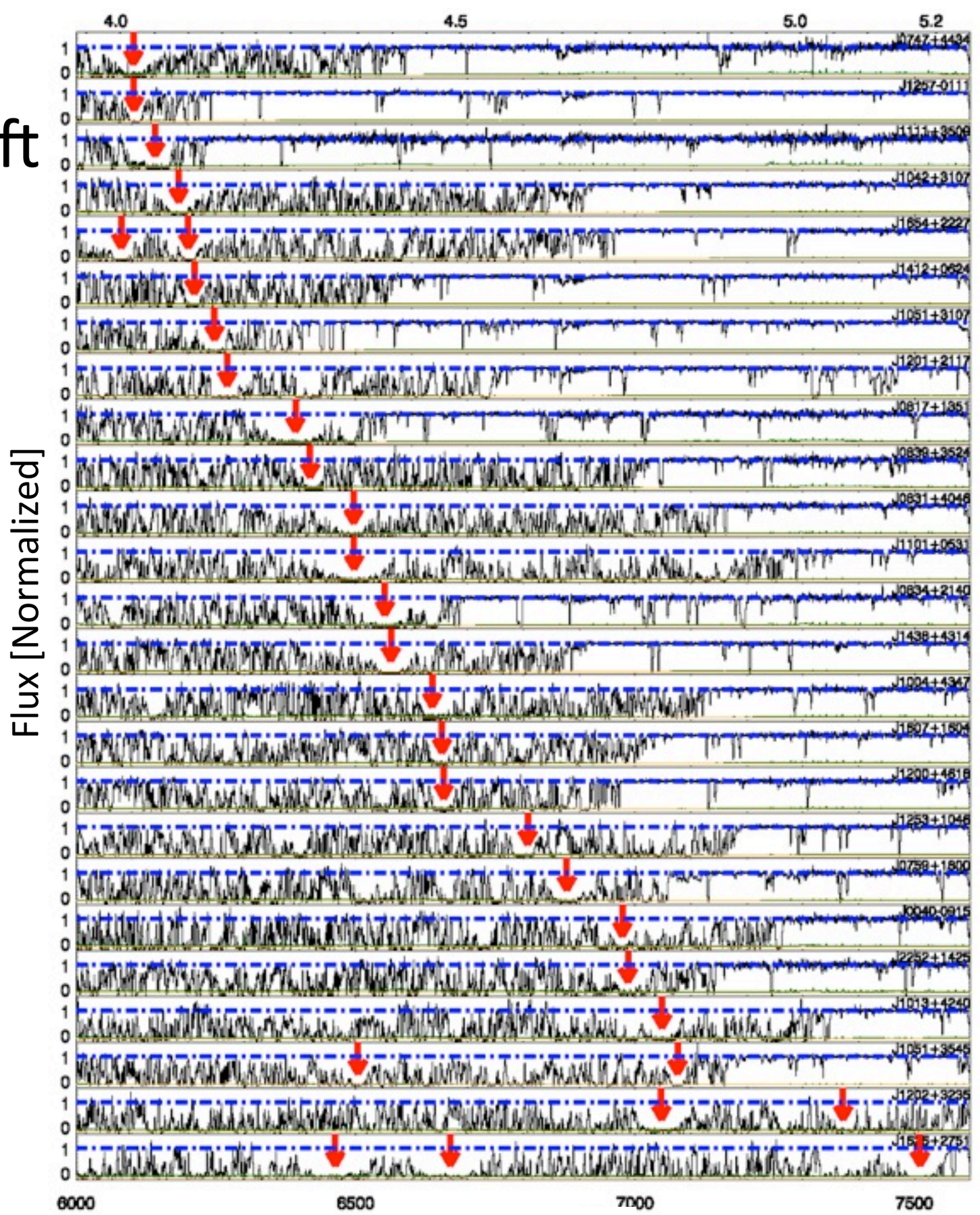
Wolfe et al. 2005

Survey for high redshift DLAs using ESI with HIRES followup

ESI: R~10,000 (~40km/s)
HIRES: R~50,000 (~6km/s)

Observed 50 QSO's with 70 DLAs

46 SDSS 'candidate' z>4 DLAs

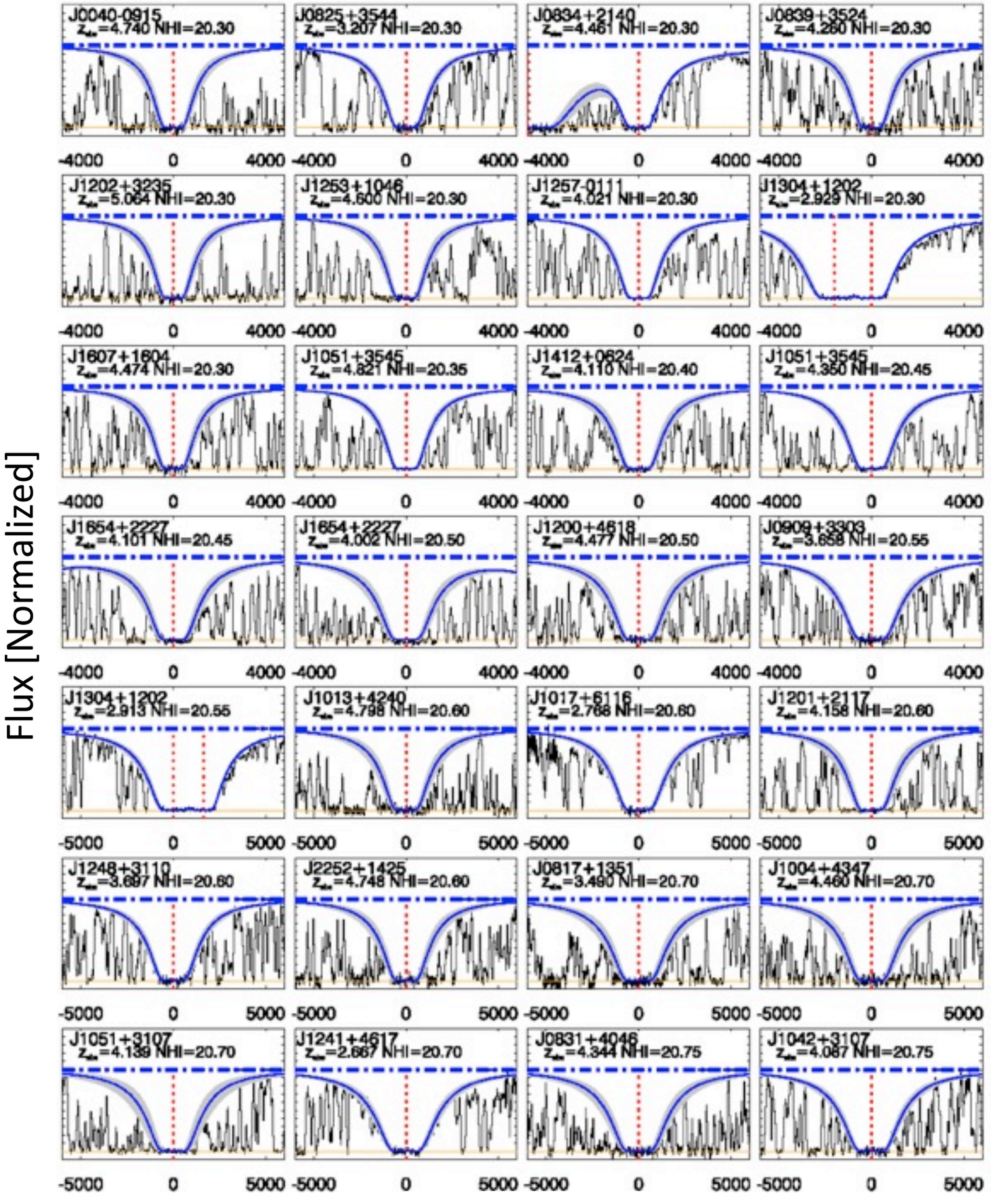


Rafelski et al. 2012

Voigt profile fits for N_{HI}

18 confirmed $2.4 < z < 4$

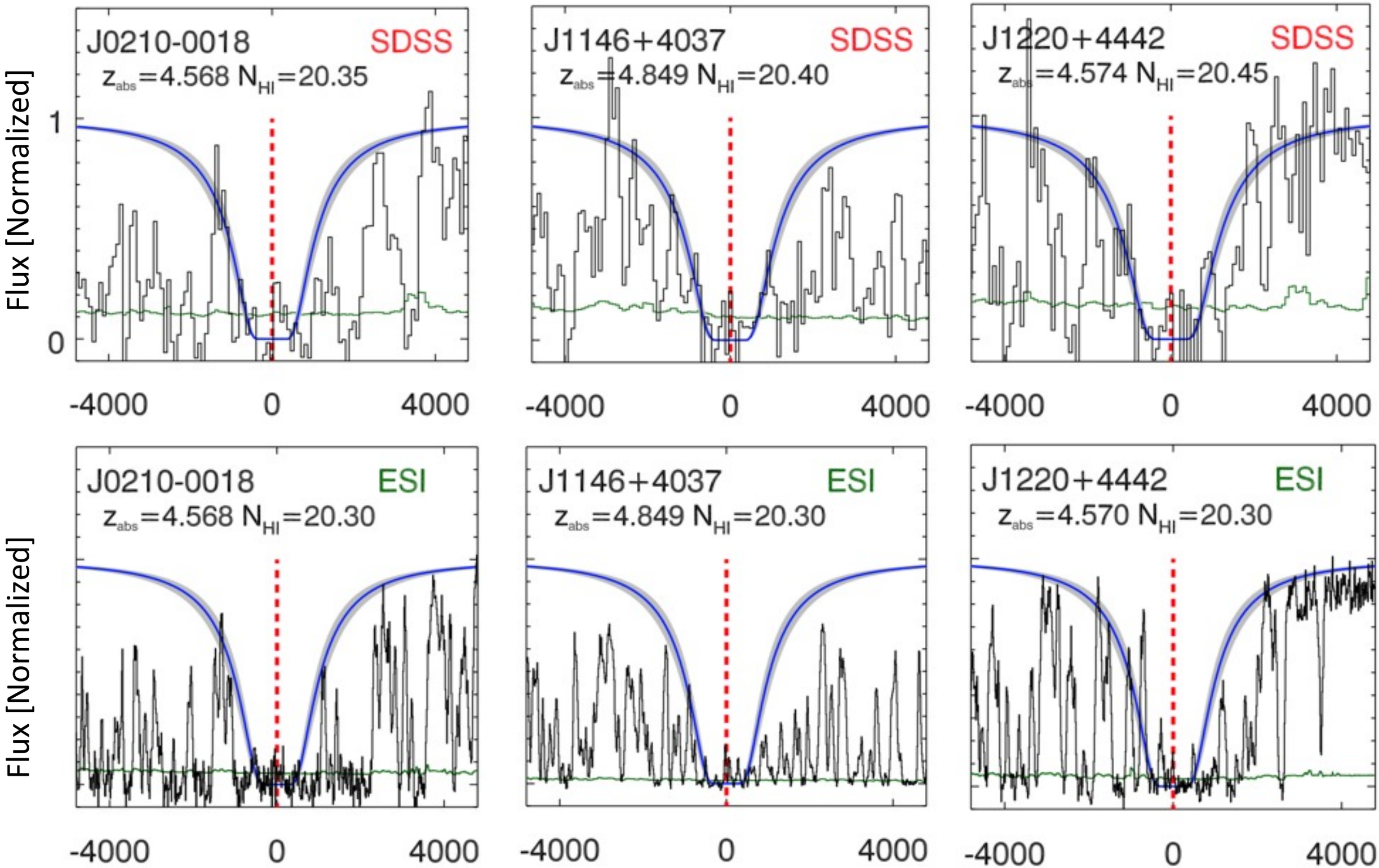
32 confirmed $z > 4$



More false candidates at higher redshift

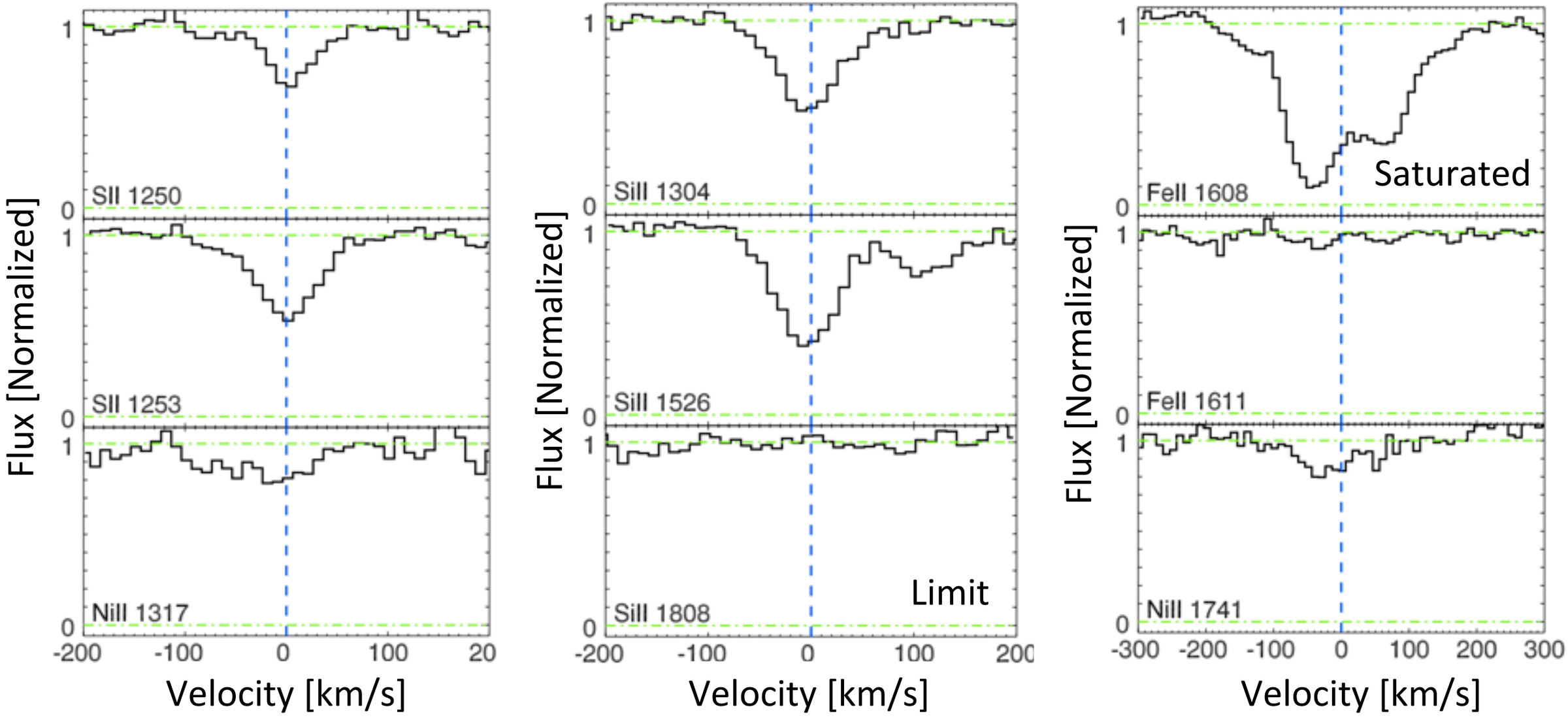
Rafelski et al. 2012

Example Catastrophic Failures from SDSS



Rafelski et al. 2012

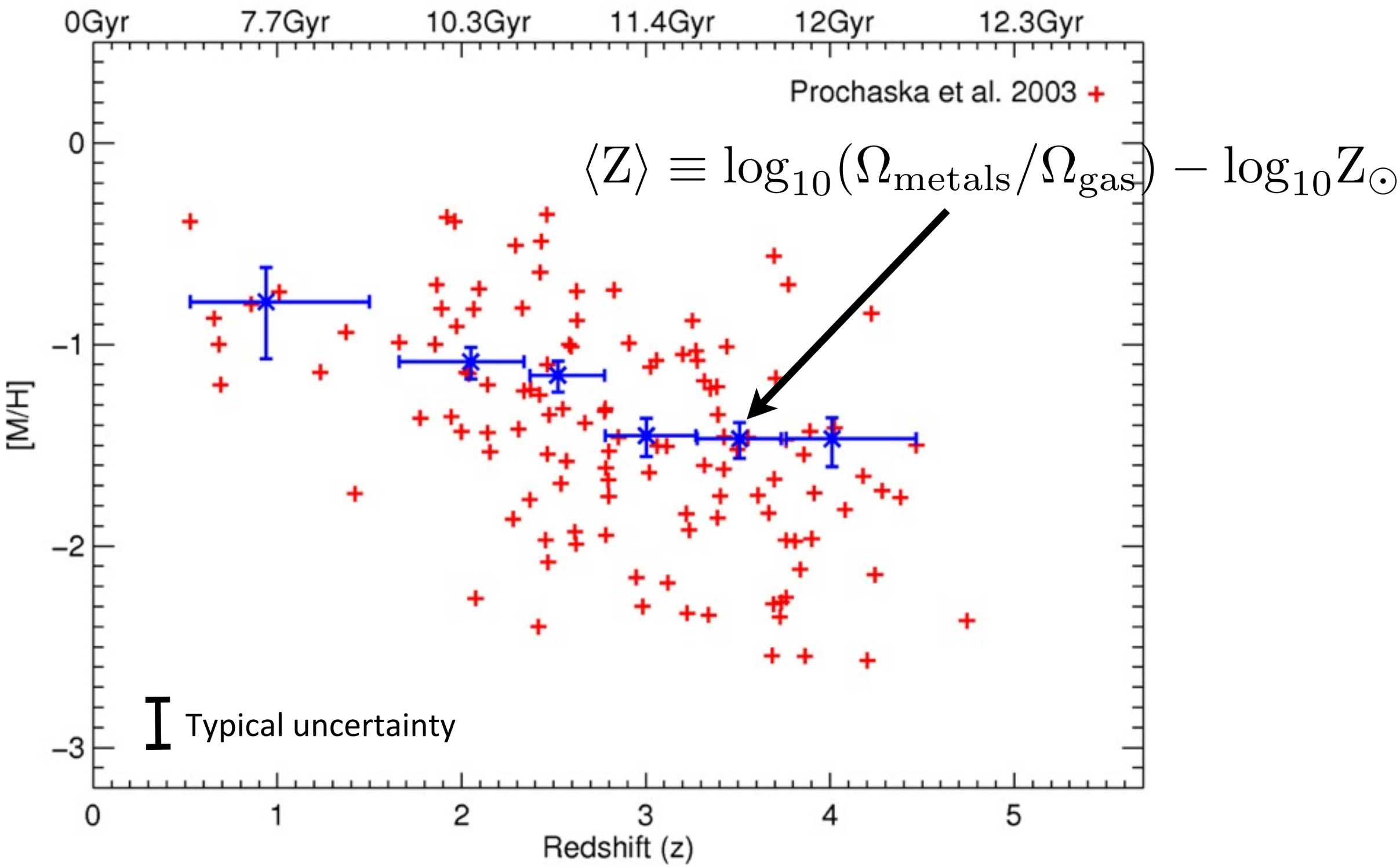
Example ESI Metal Line Velocity Profiles



Metallicity: $[\mathrm{M/H}] = \log_{10}(N_M/N_H)_{\mathrm{DLA}} - \log_{10}(N_M/N_H)_{\odot}$

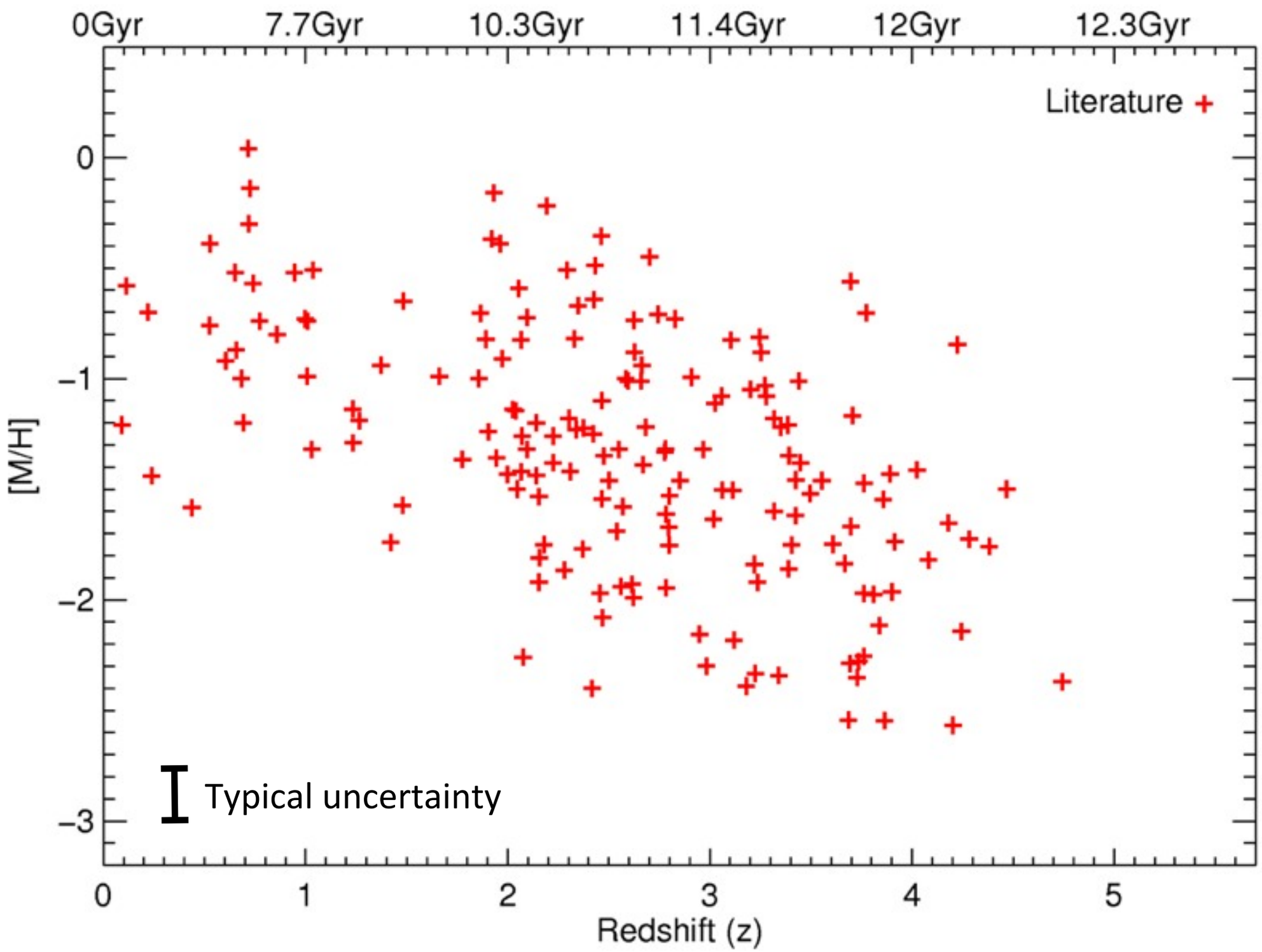
Generally, we use S II and/or Si II for metallicity measurements

Metal Abundances versus redshift (2003 sample)

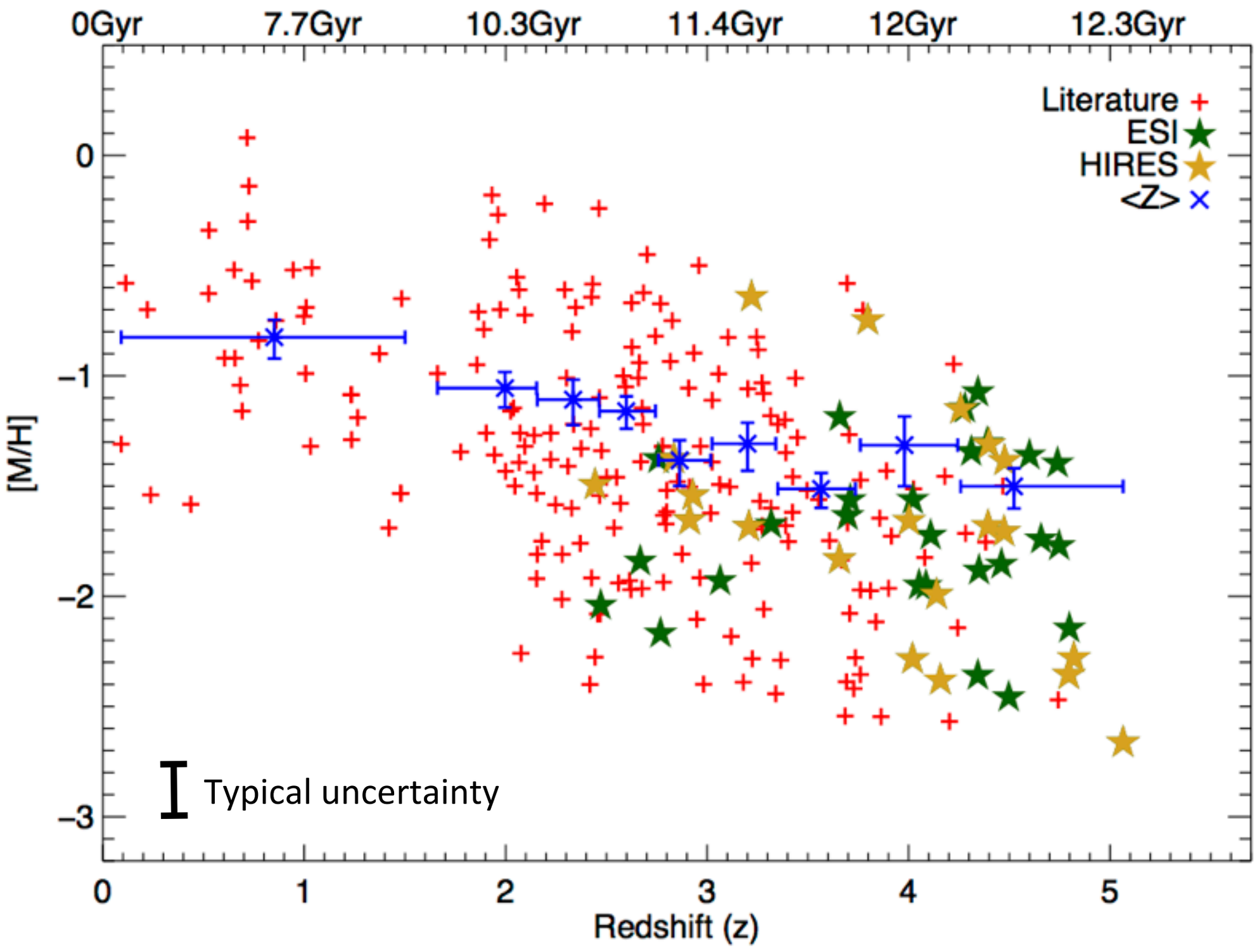


Prochaska et al. 2003

Metal Abundances versus redshift with literature through 2012

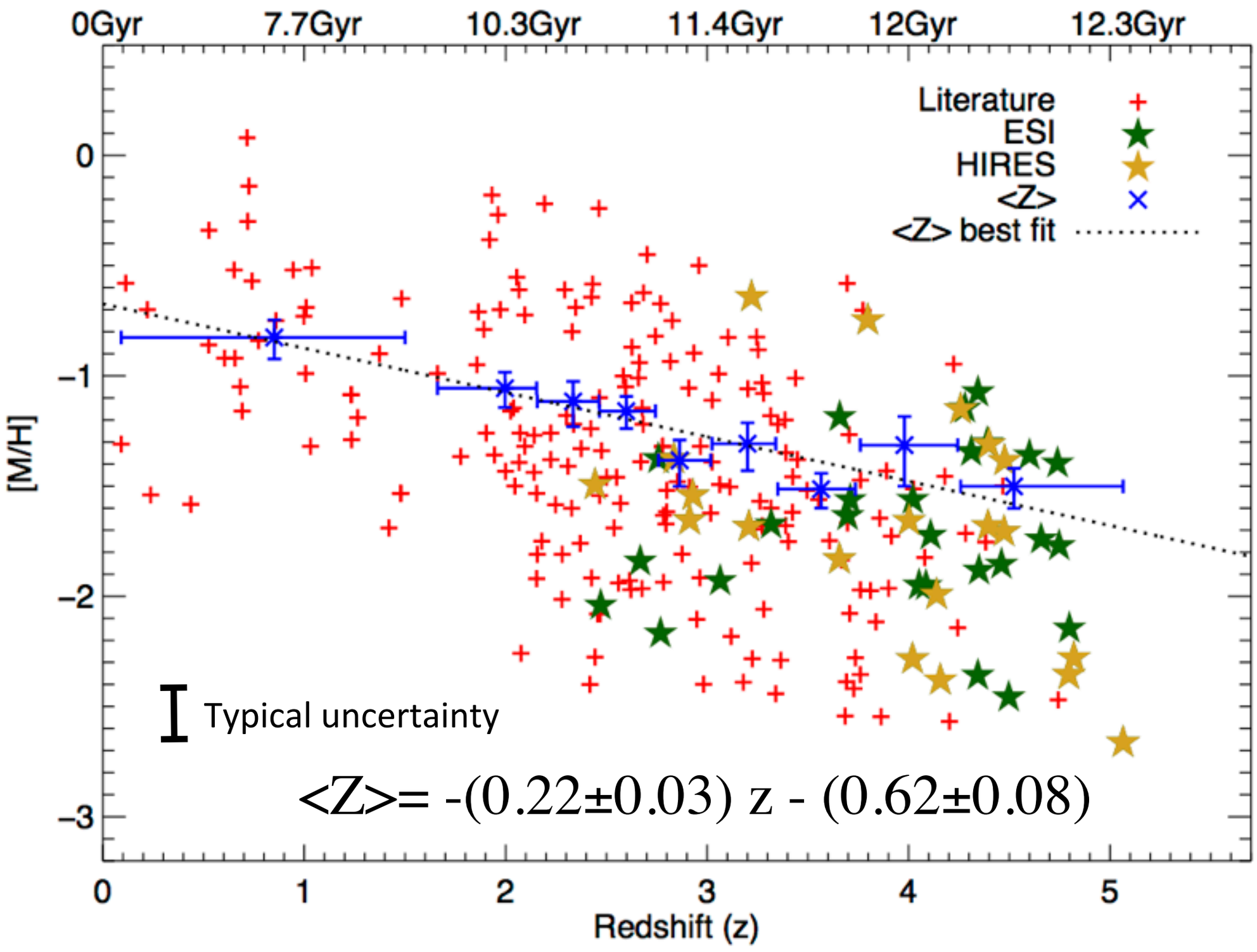


Metal Abundances versus redshift from Rafelski et al. 2012



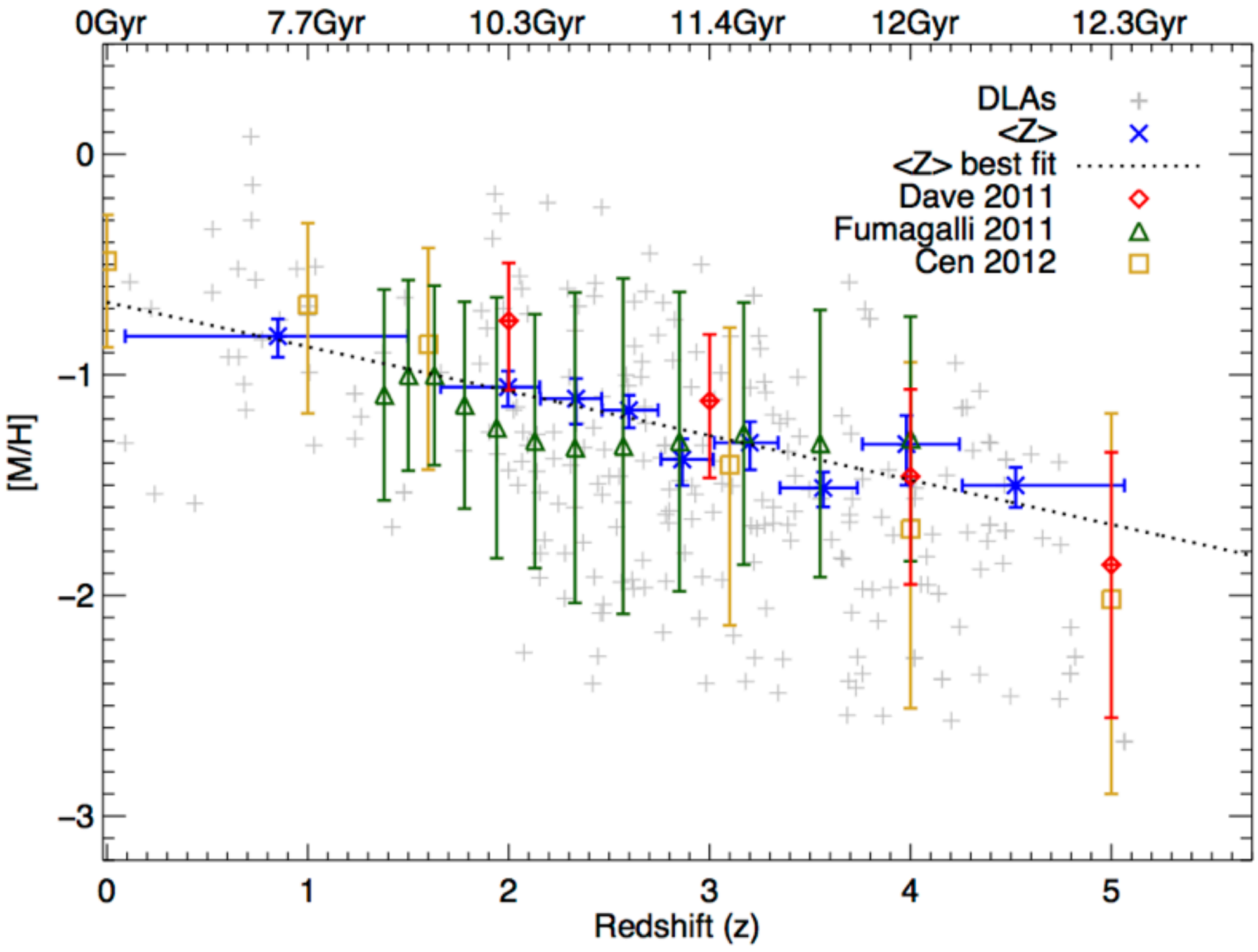
Rafelski et al. 2012

Metal Abundance versus redshift fit from Rafelski et al. 2012



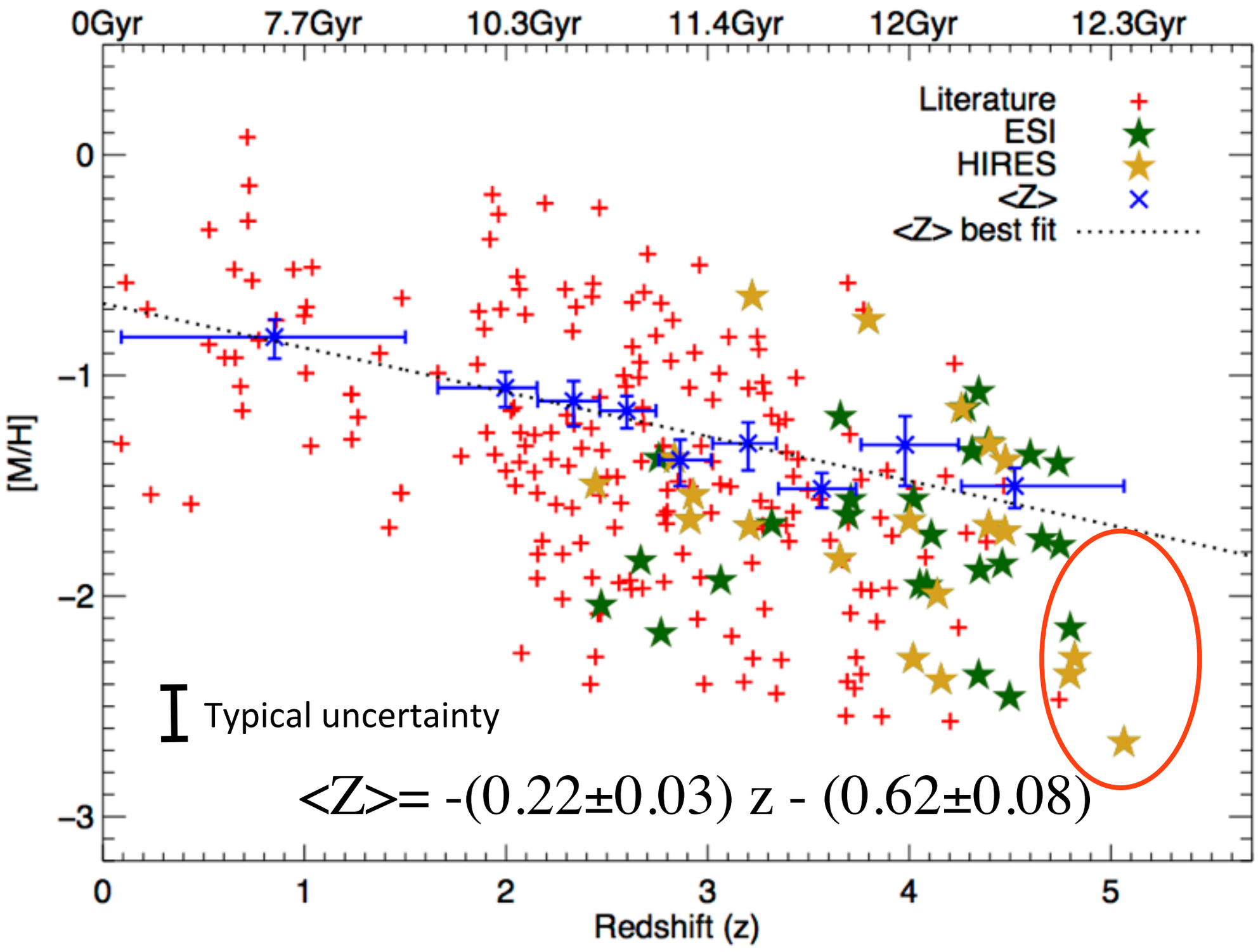
Rafelski et al. 2012

Metal Abundances Compared to Simulations



Rafelski et al. 2012

Metal Abundances versus redshift from Rafelski et al. 2012



Rafelski et al. 2012

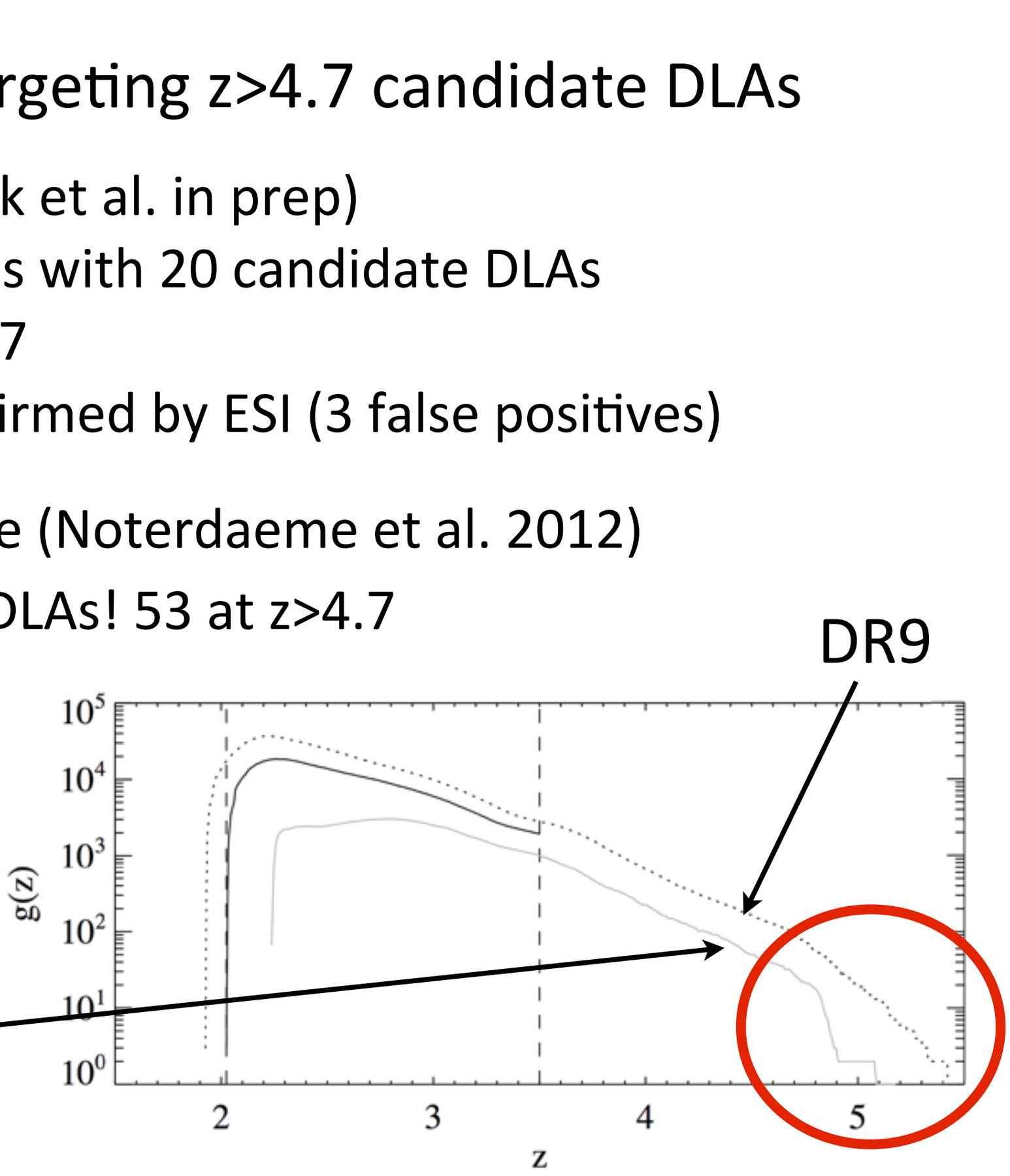
New Survey targeting z>4.7 candidate DLAs

- GMOS sample (Worseck et al. in prep)
  - We observed 14 QSOs with 20 candidate DLAs
  - 12 candidates at z>4.7
  - 9/12 z>4.7 DLAs confirmed by ESI (3 false positives)

- BOSS - SDSS DR9 sample (Noterdaeme et al. 2012)

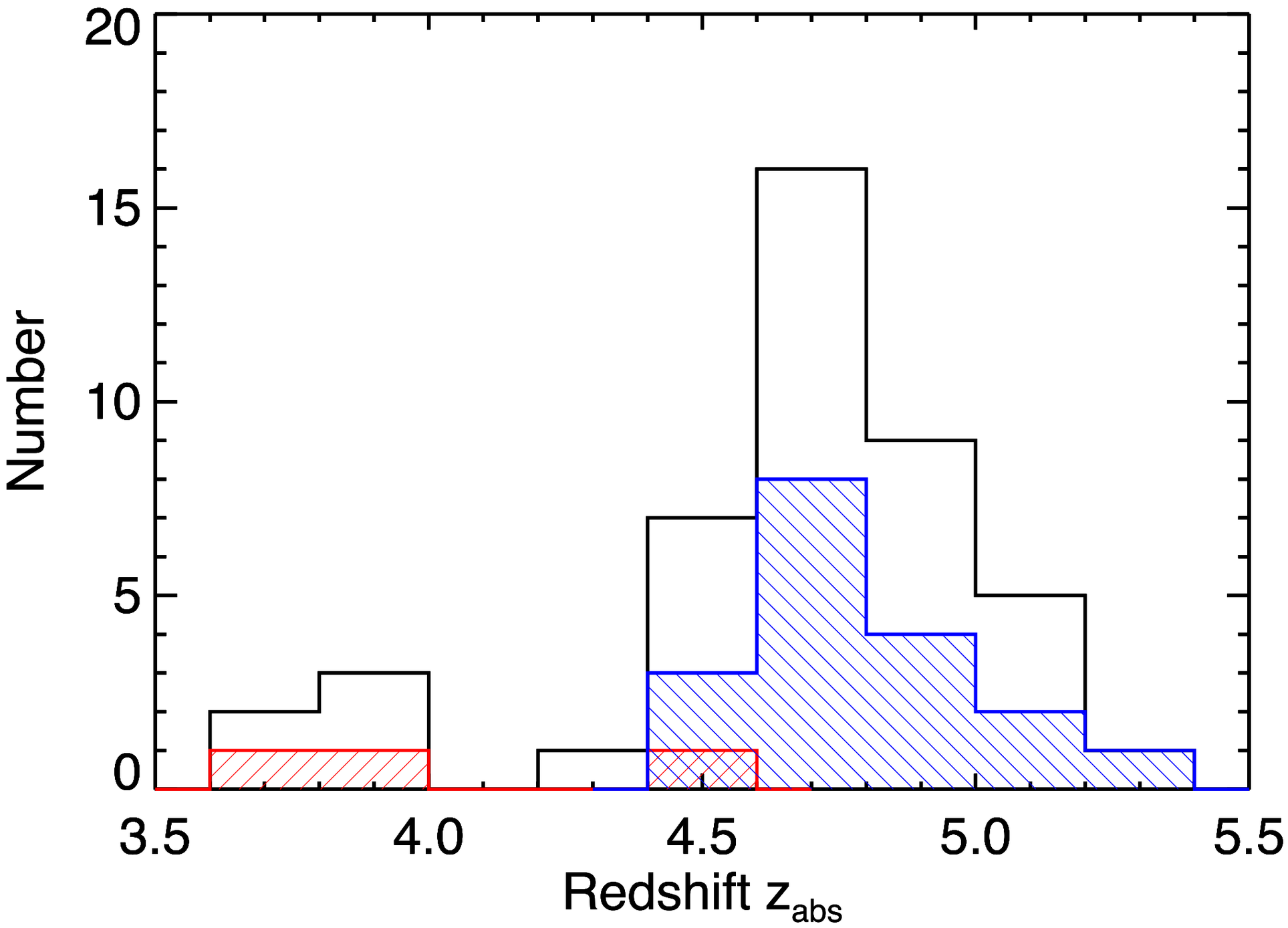
6,839 DLAs! 53 at z>4.7

- Observed 15 QSOs with 43 candidate DLAs
- 24 at z>4.7



Noterdaeme et al. 2012

The BOSS SDSS DR9 DLAs



43 candidates

17 candidates

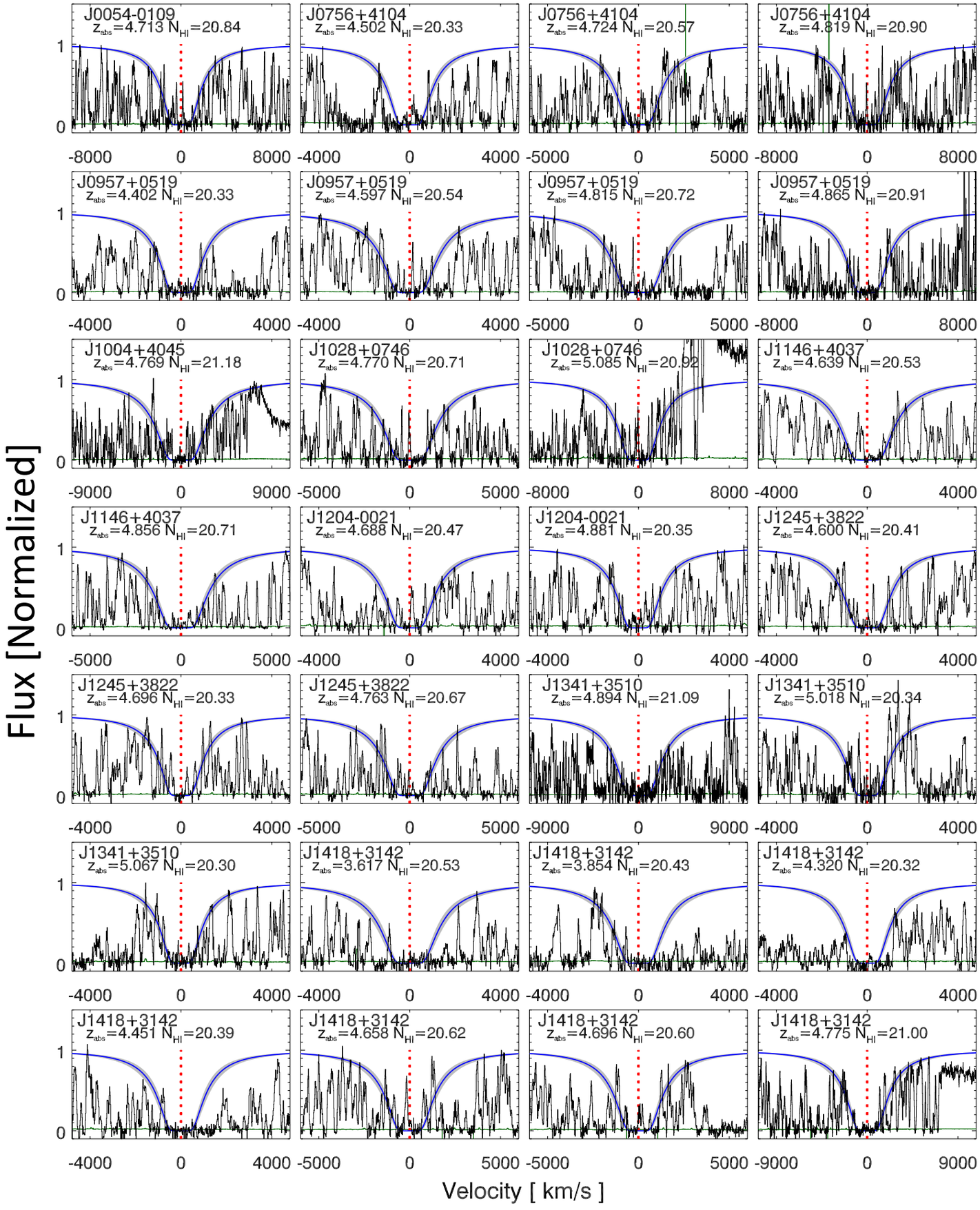
13 z>4.7

3 confirmed with ESI

Example BOSS DLA False Positives

Most are Catastrophic Failures

0 / 24 observed candidate DLAs at z>4.7 from Noterdaeme et al. 2012 are real

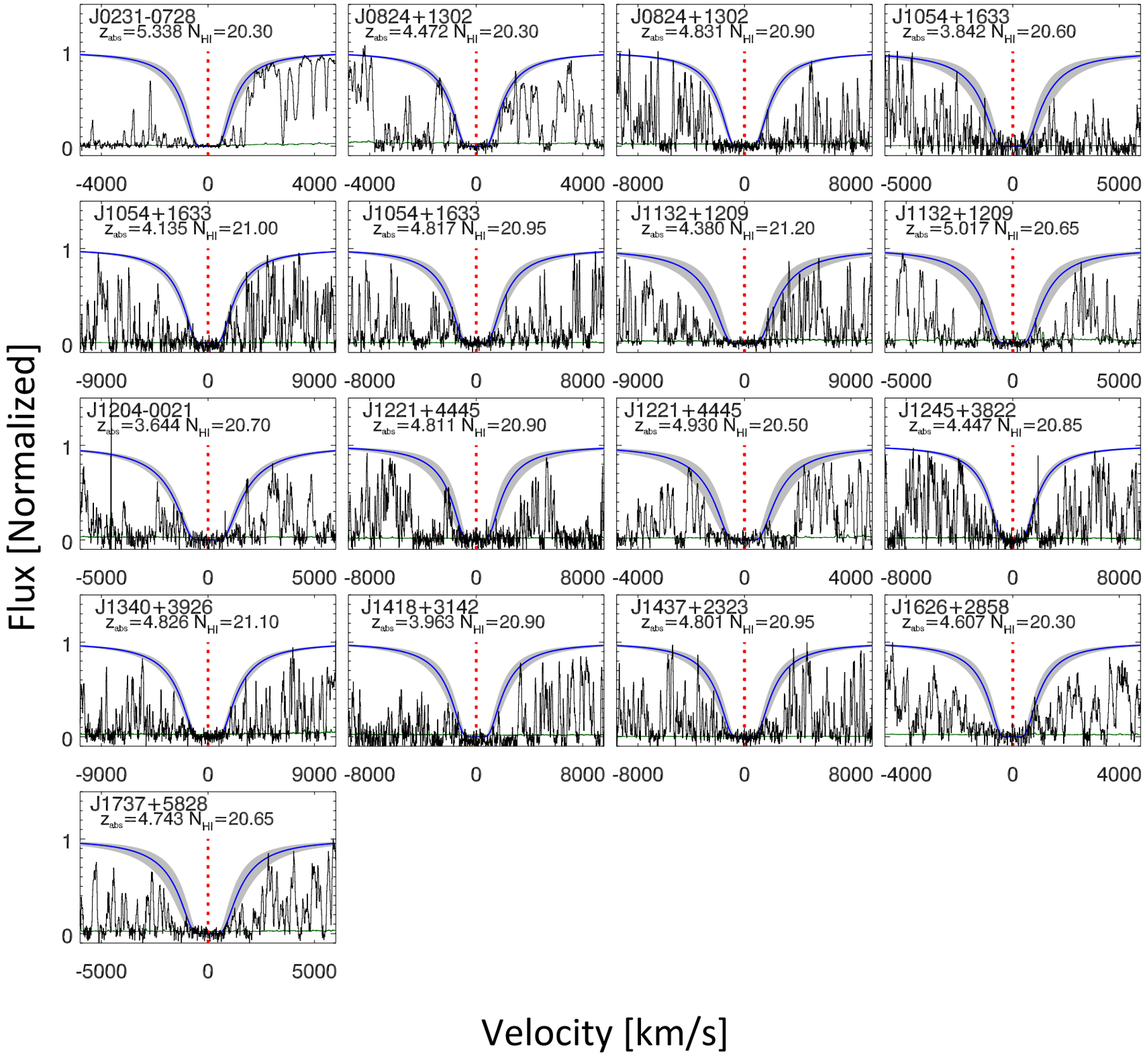


Voigt profile fits for new confirmed DLAs

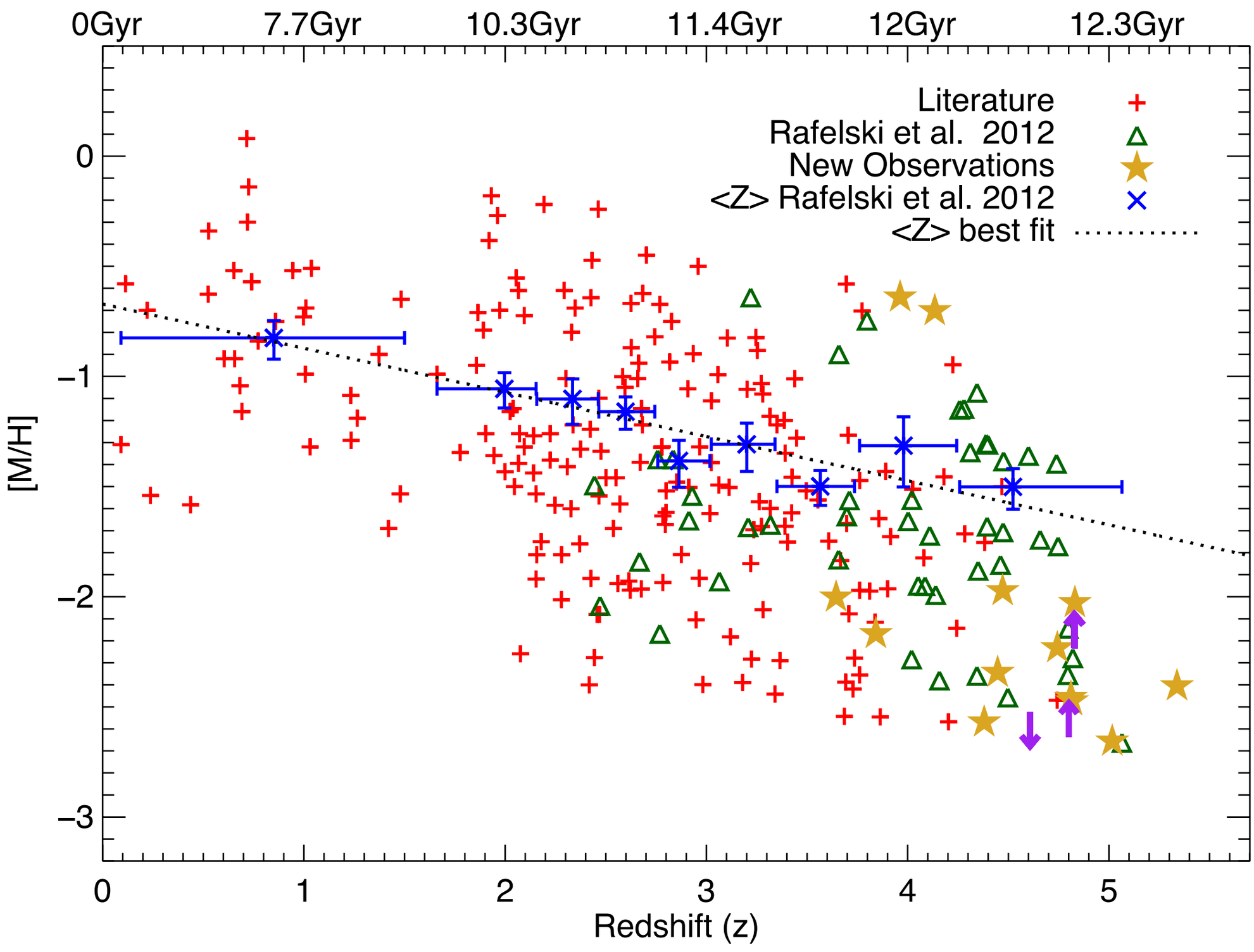
17 new confirmed DLAs with ESI

9 new z>4.7 DLAs

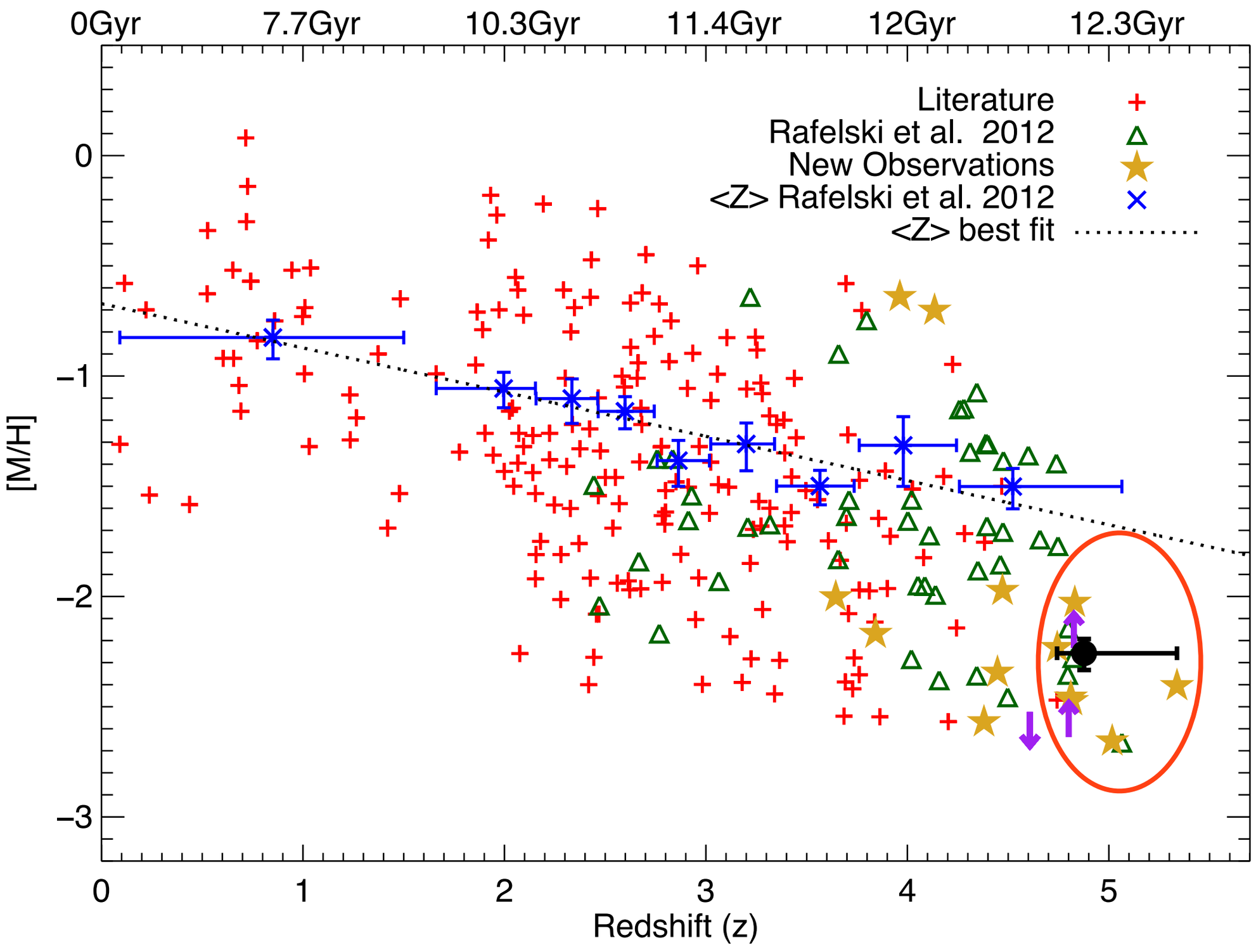
+ 8 other DLAs



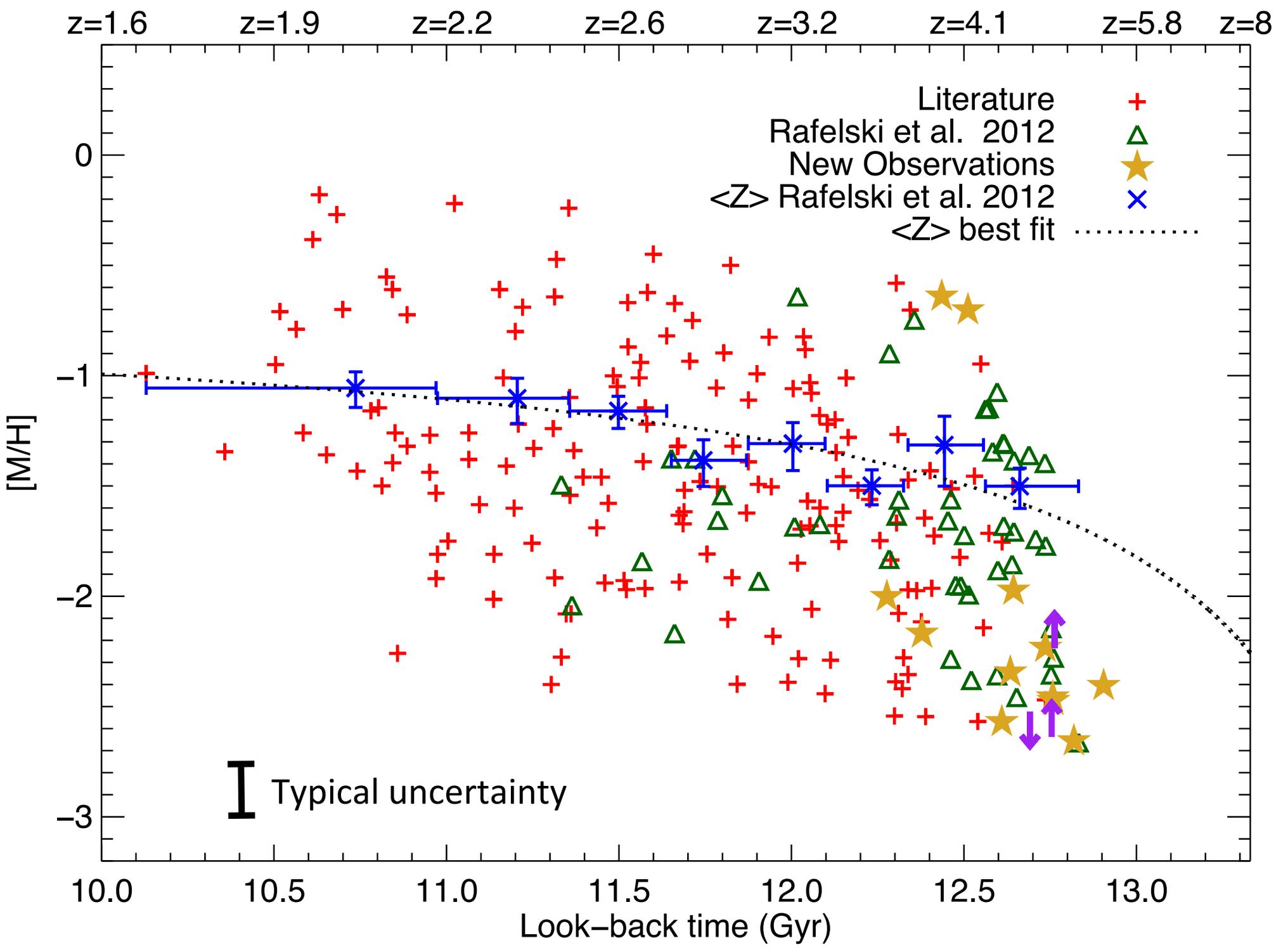
New Metal Abundances using ESI and FIRE



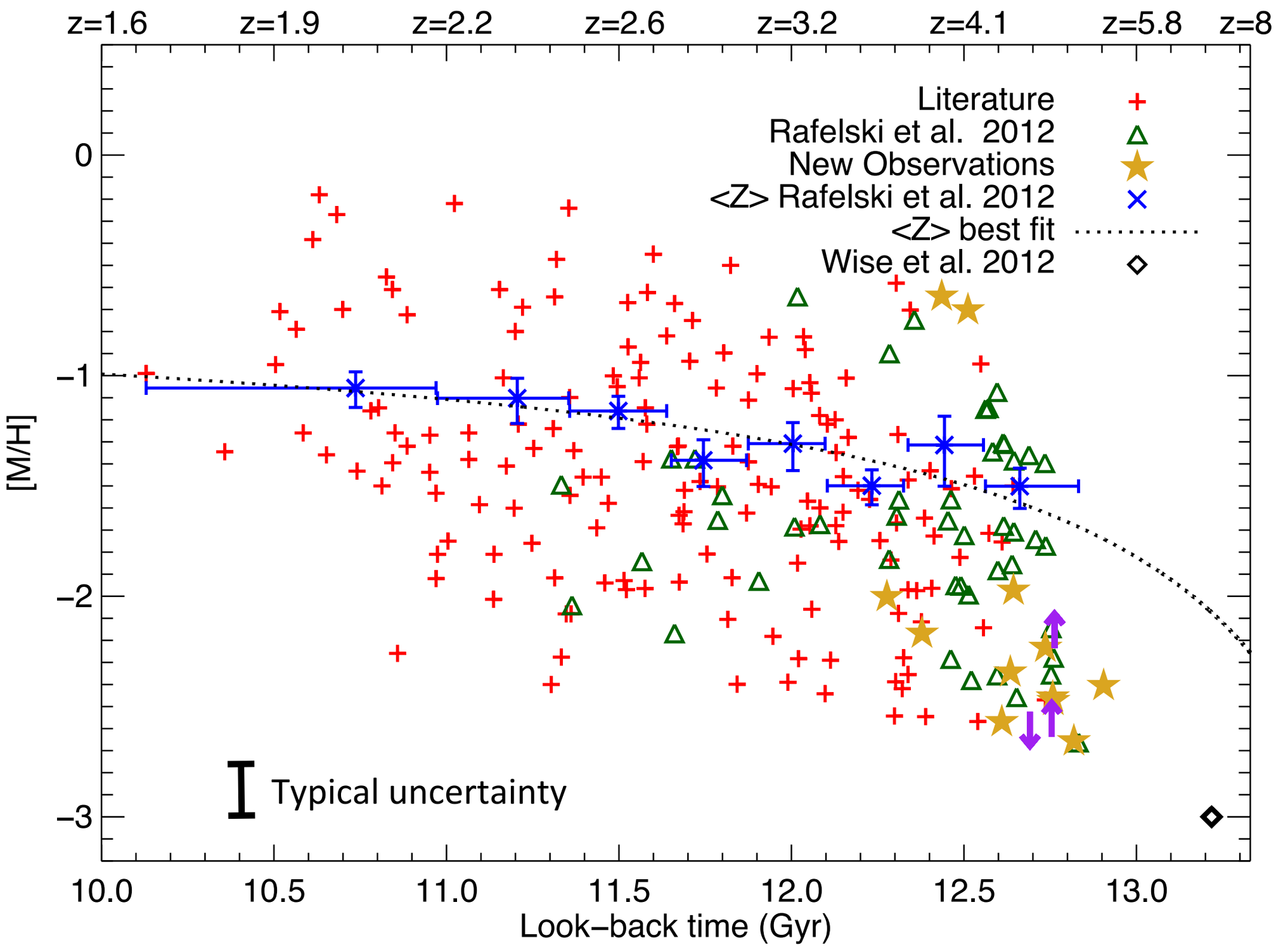
Metal abundance break at z>4.7



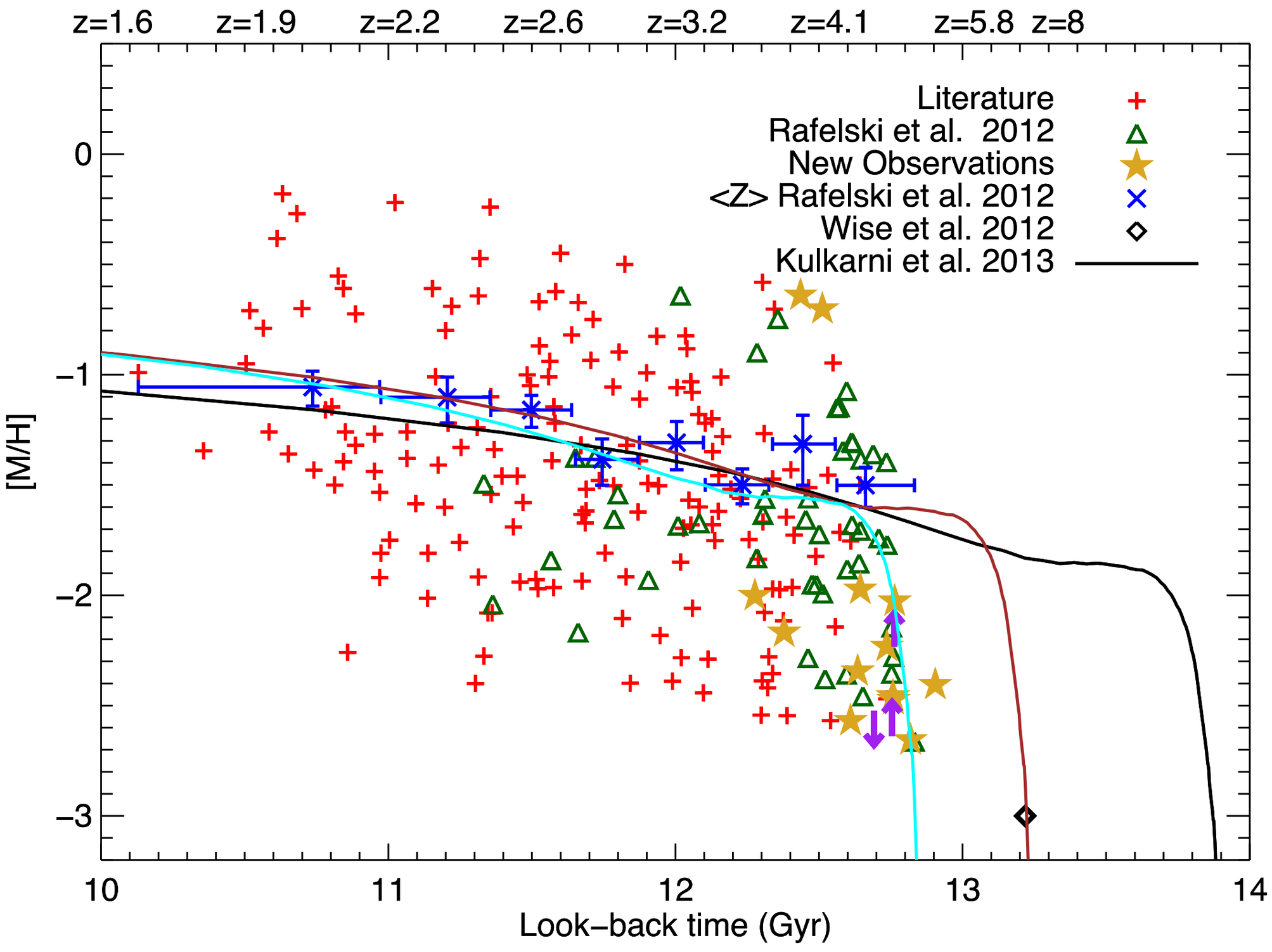
Metal Abundance versus look-back time



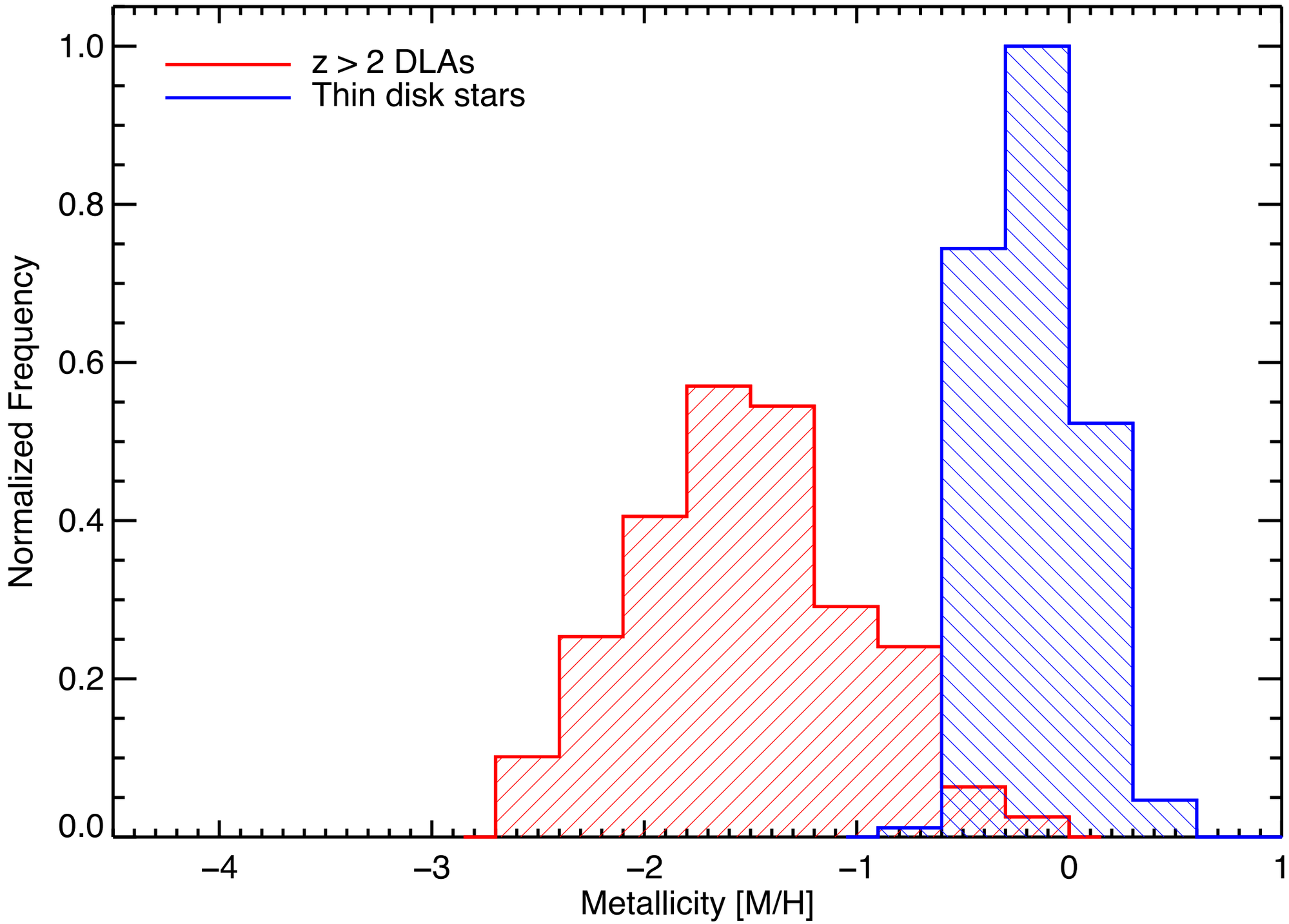
Comparison to Wise et al. 2012 simulation with Pop III stars



Comparison to ISM model including Pop III stars

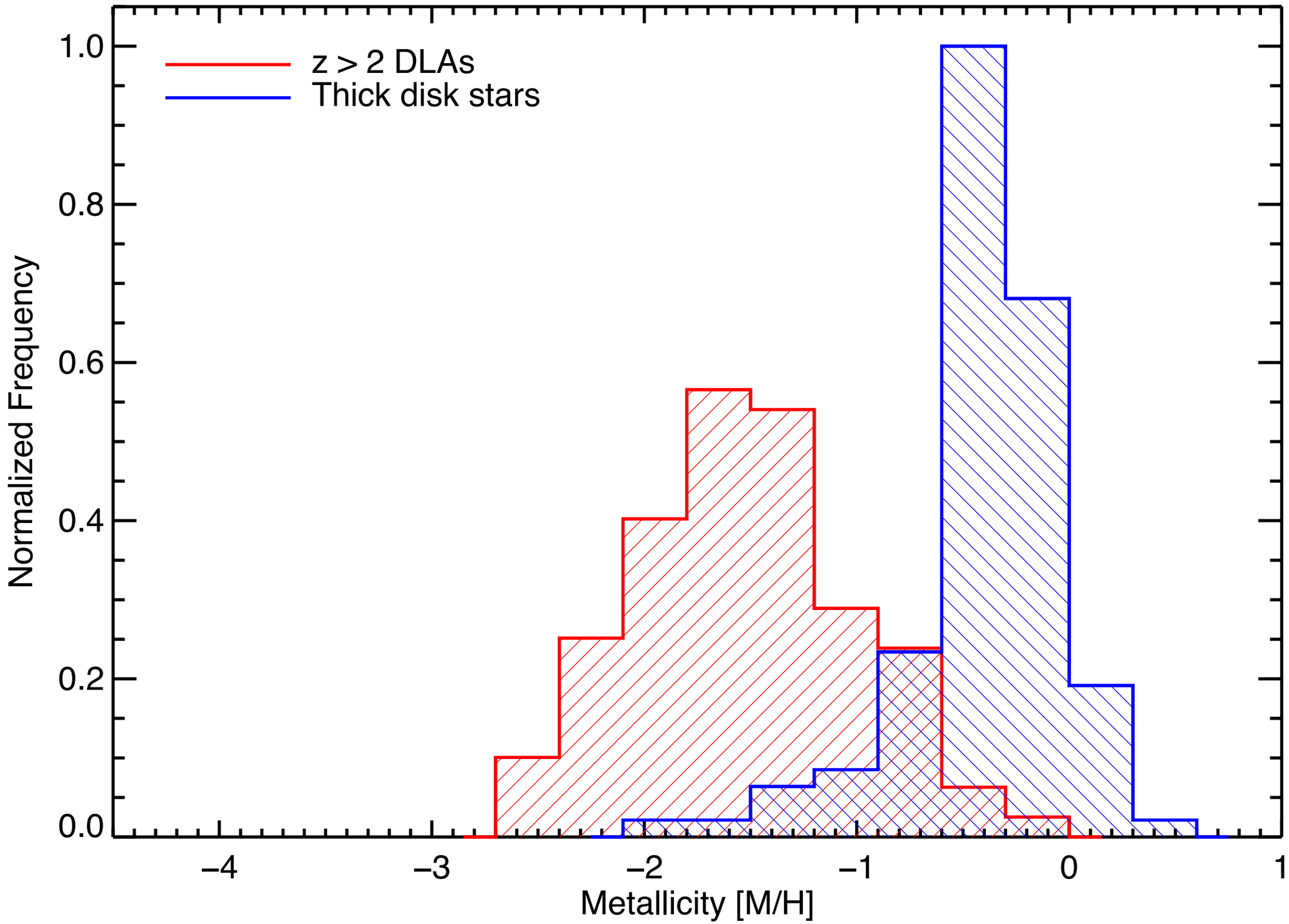


Thin disk metallicity comparison with DLAs



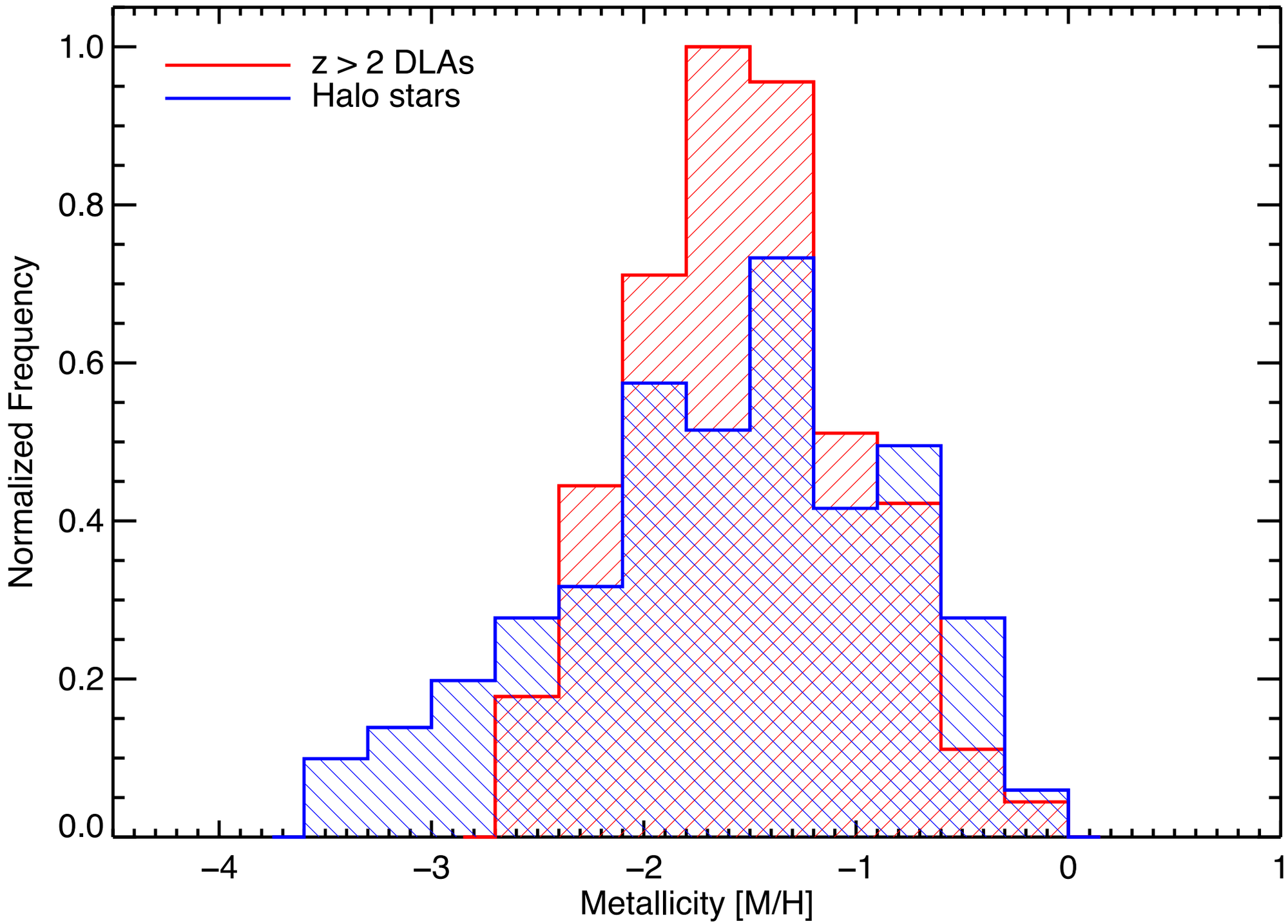
Rafelski et al. 2012

Thick disk metallicity comparison with DLAs



Rafelski et al. 2012

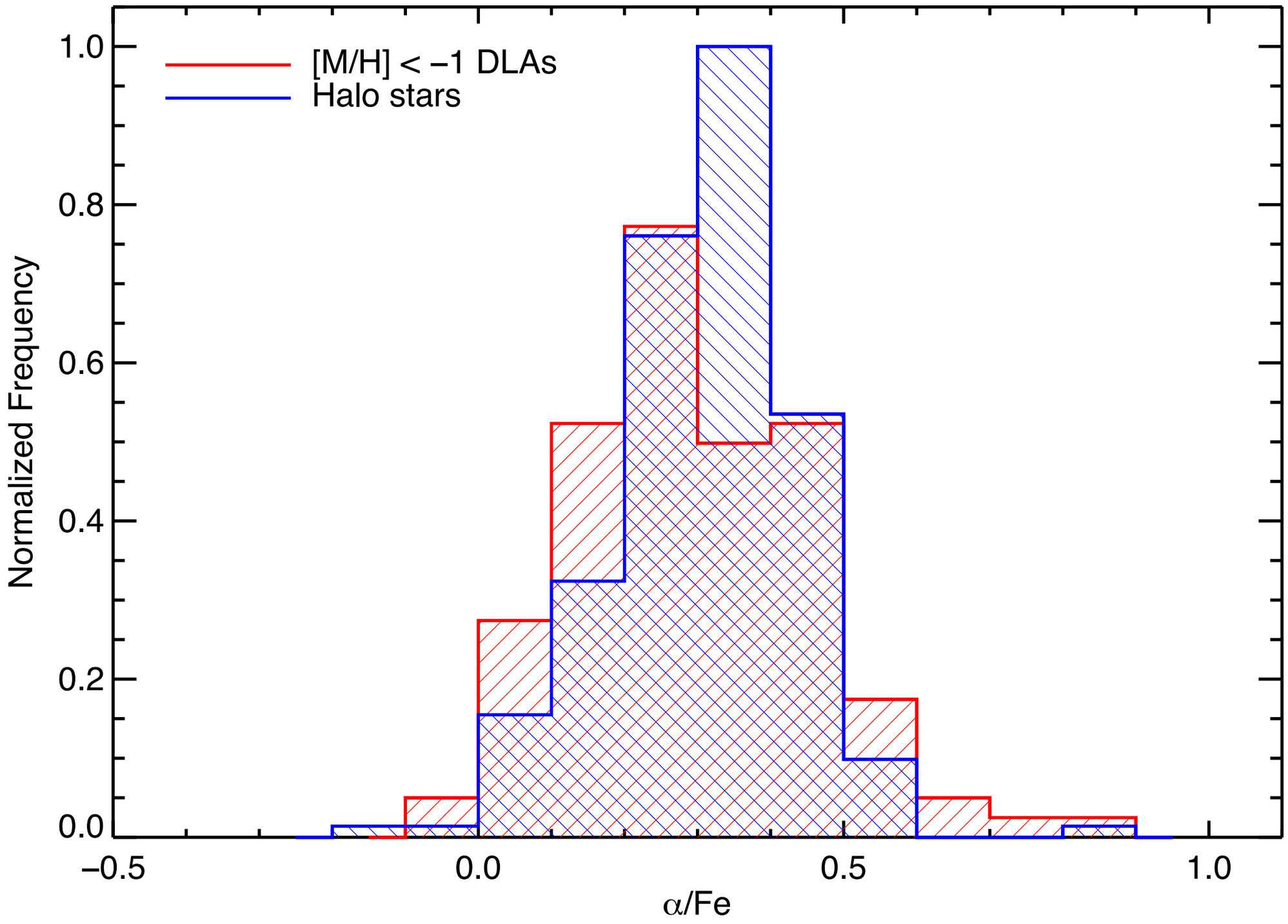
Halo metallicity comparison with DLAs



Consistent with being drawn from the same parent population

Rafelski et al. 2012

Halo chemistry comparison with DLAs



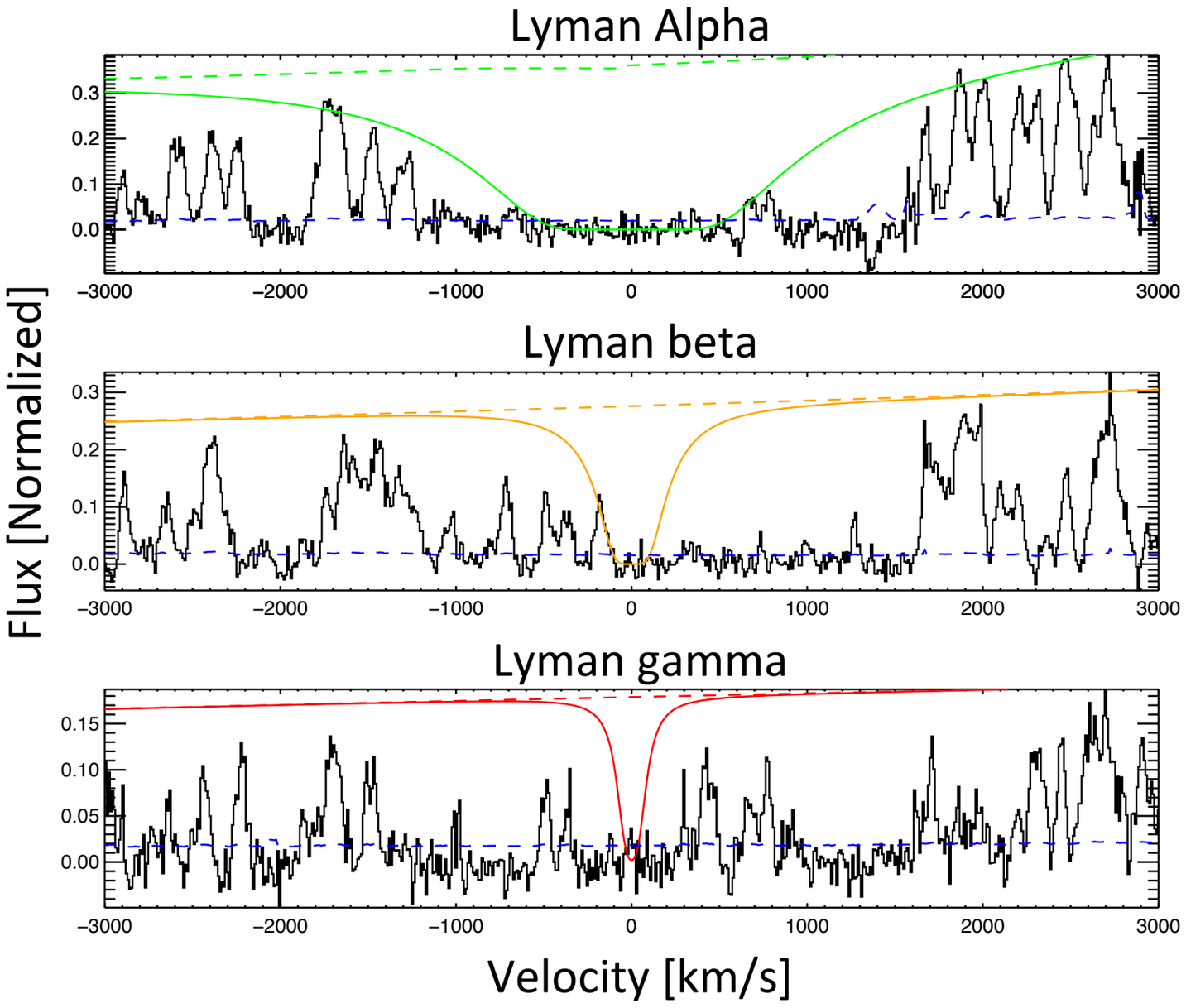
Consistent with being drawn from the same parent population

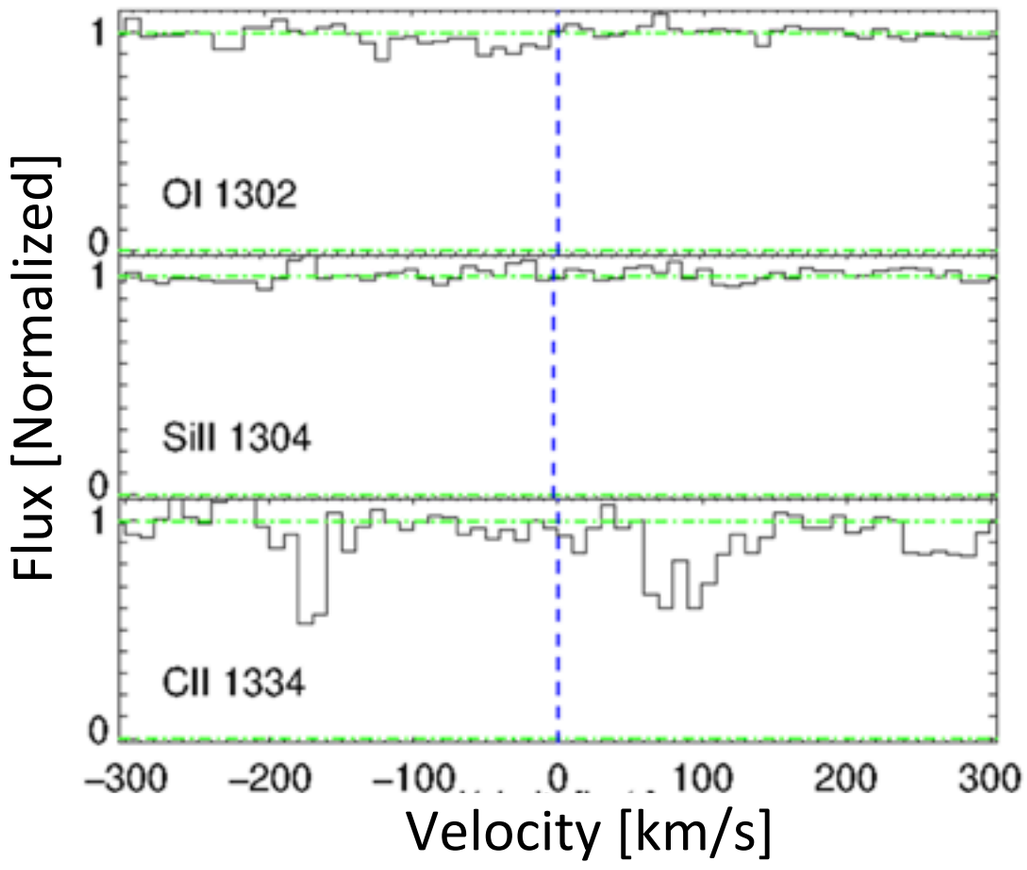
Rafelski et al. 2012

Potential DLA with No Metal Lines?

N_{HI} ~20.5

[M/H] < -3.4?





Summary

- Survey of high redshift HI rich galaxies (DLAs)
  - Higher frequency of false positives with SDSS data z>4
  - GMOS survey very helpful in finding new z>4.7 DLAs
  - BOSS DLA paper candidates unreliable at z>4.5

- Measured the metallicity evolution of neutral-gas out to z~5
  - Find a break in metallicity evolution at z>4.7
    - New population of DLAs due to lower background radiation Field?
    - Transition from Pair Instability SN to Type II SN?

- Alpha enhancement measured in DLAs
  - Distribution consistent with halo stars forming out of DLA gas
  - Will follow up with FIRE to get alpha enhancement and hopefully other abundance ratios at z>4.7

- Potential DLA with no metal lines? Intriguing possibility.