The cold gas in the interstellar medium of high-z galaxies

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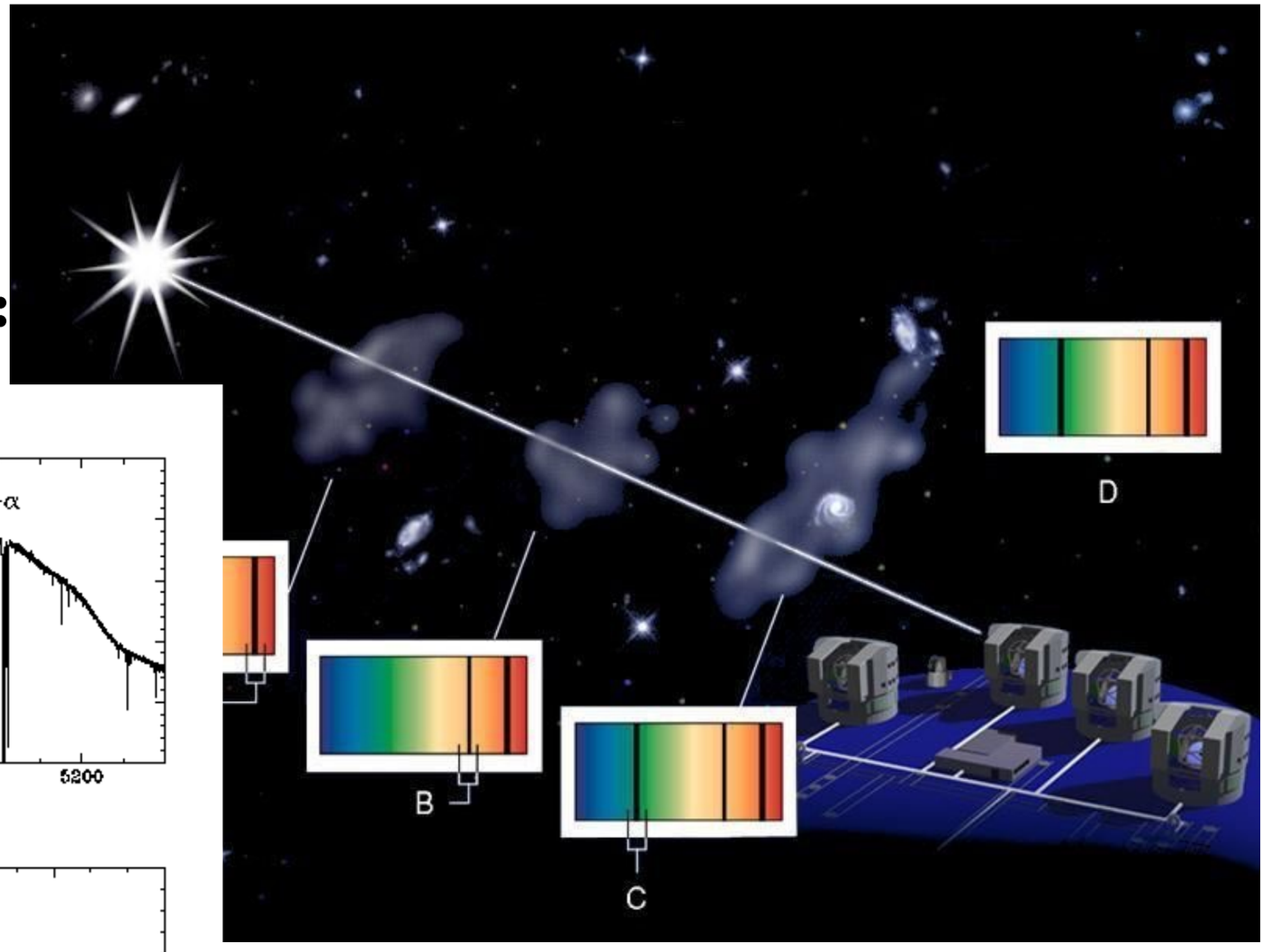
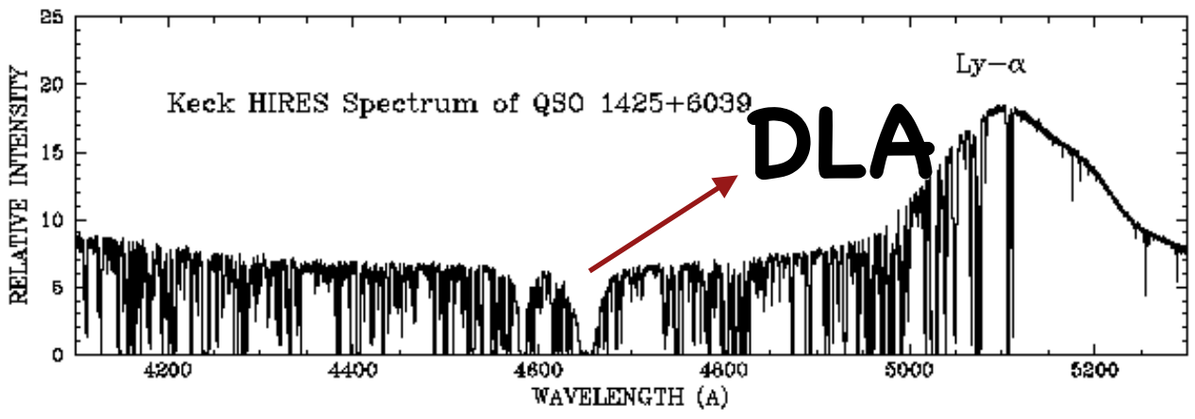
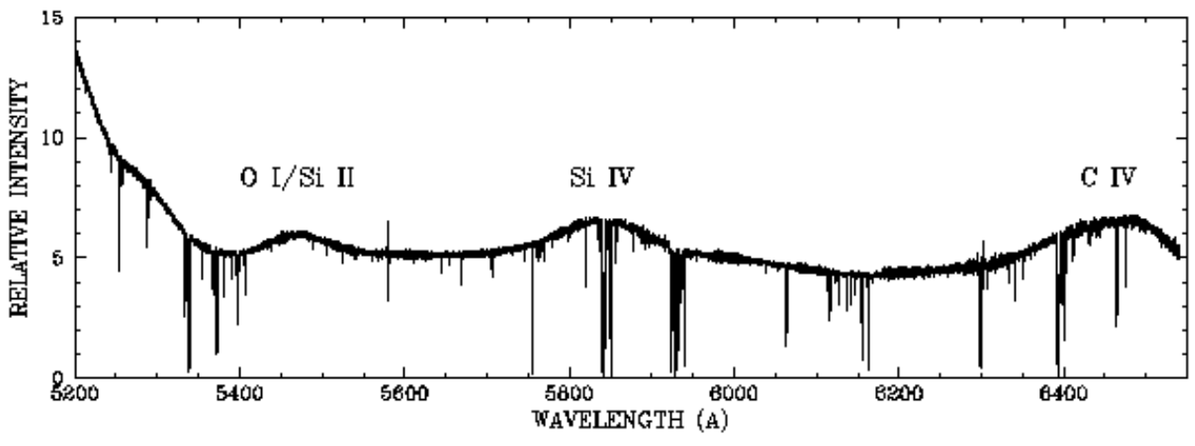
Absorption Lines

- **Intrinsic Absorption lines:** Provide information of the quasar and the host galaxy
- **Intervening Absorption lines:**







Why cold gas?

- Stars are formed in cold, shielded gas, which is dusty and molecular rich.

- In order to understand the evolution of star-formation, we also need to study the evolution of cold gas.

- The neutral gas, as probed by most DLAs is found to be very diffuse.

- Much more difficult to observe cold gas which normally lies in the disk of galaxies —- a tracer is needed,

Why CI?

- New tracer —CI, which is directly connected to cold gas
- Indeed, CI only survives in shielded gas. The ionization energy of CI (11.26 ev) is below the neutral hydrogen ionization energy (13.6 ev).
- Since there are very few samples using CI as the tracer of cold gas in the previous studies, therefore a large database is needed.

Sample

- Large database **SDSS –DR7 (Agazajian et al. 2009)**,
- Redshift range 1.5 < z_abs < 3.1
- A complete sample of 66 CI absorbers are selected from 41696 QSOs which is described in Ledoux et al. 2015 (A&A,580,8).

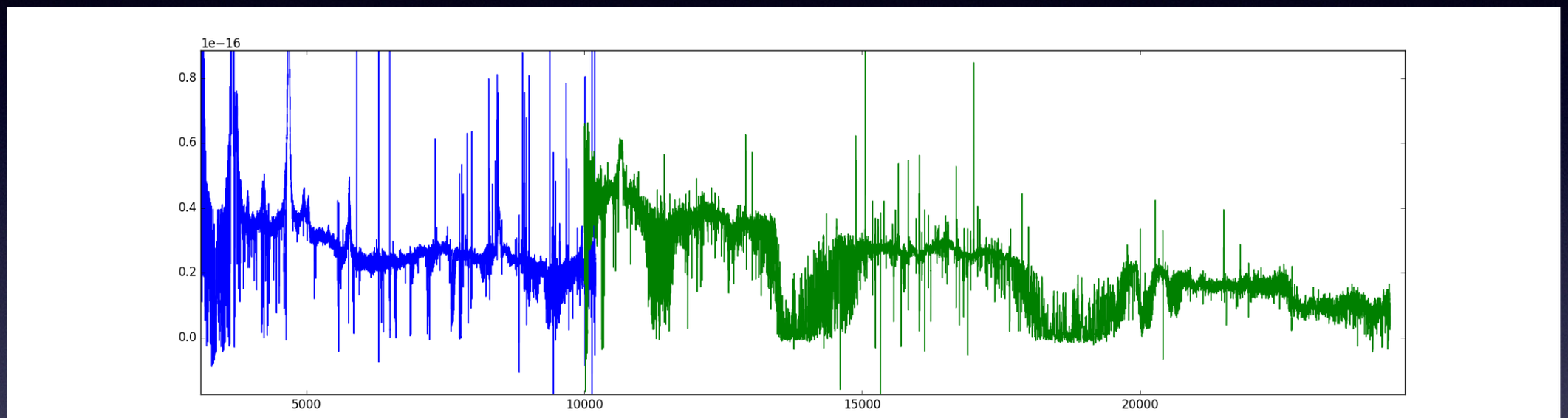
Subsample

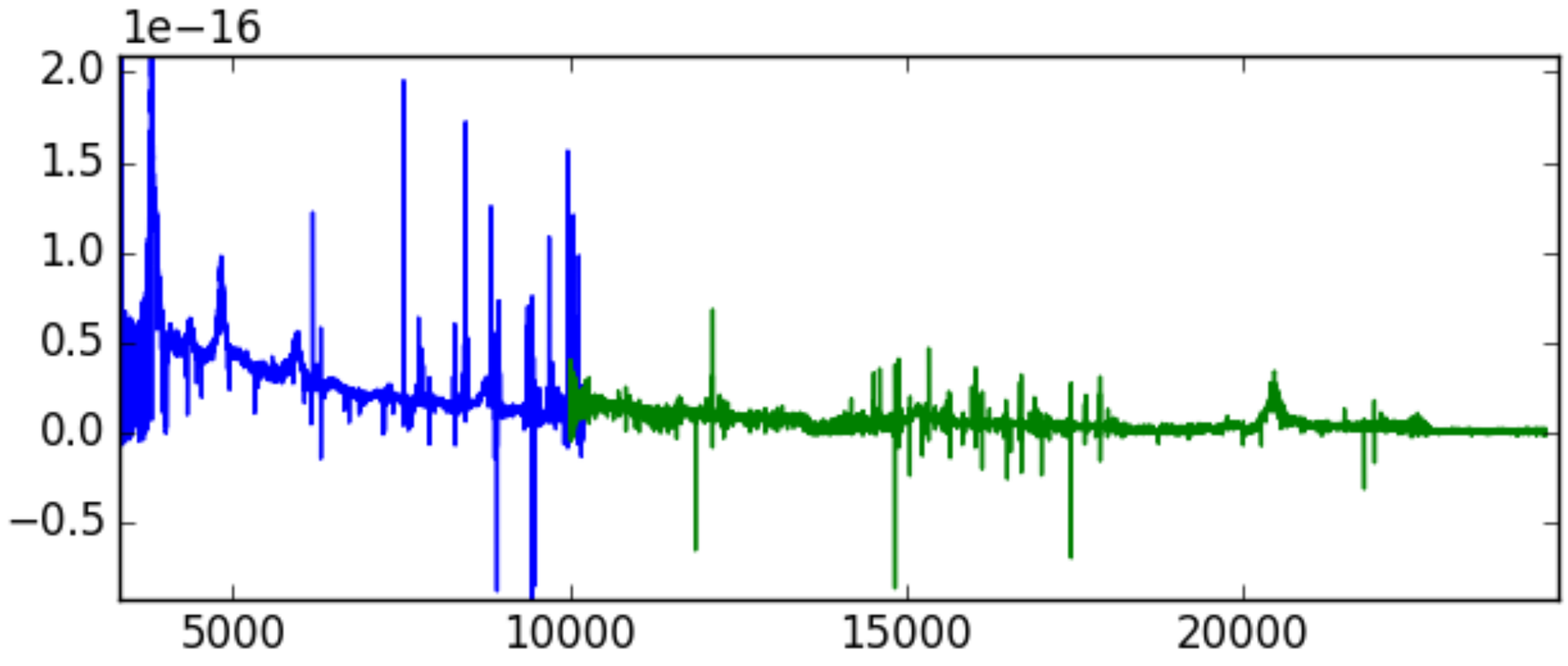
- We re-observed 17 QSOs using VLT-Xshooter.

- VLT-Xshooter is a multi-wavelength (3000-20000 Å) medium resolution spectrograph which has three arms covering the UVB(3000-5595 Å), VIS (5595- 10240 Å) and NIR (10240-24800 Å) wavelength ranges.

Why the subsample is interesting

- NaI and CaII detections in the NIR wavelength range, which are not extensively studied for high-z galaxies





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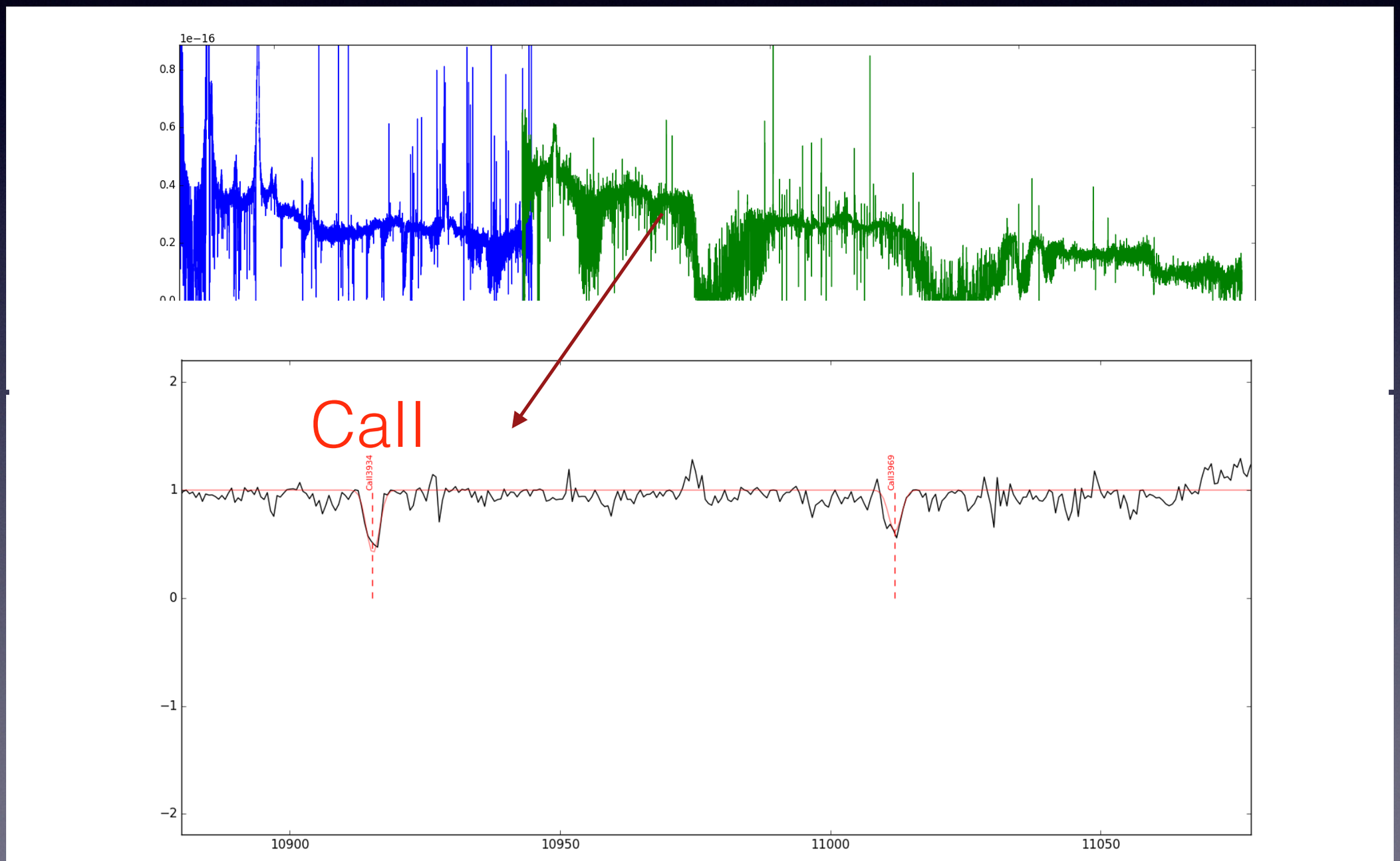

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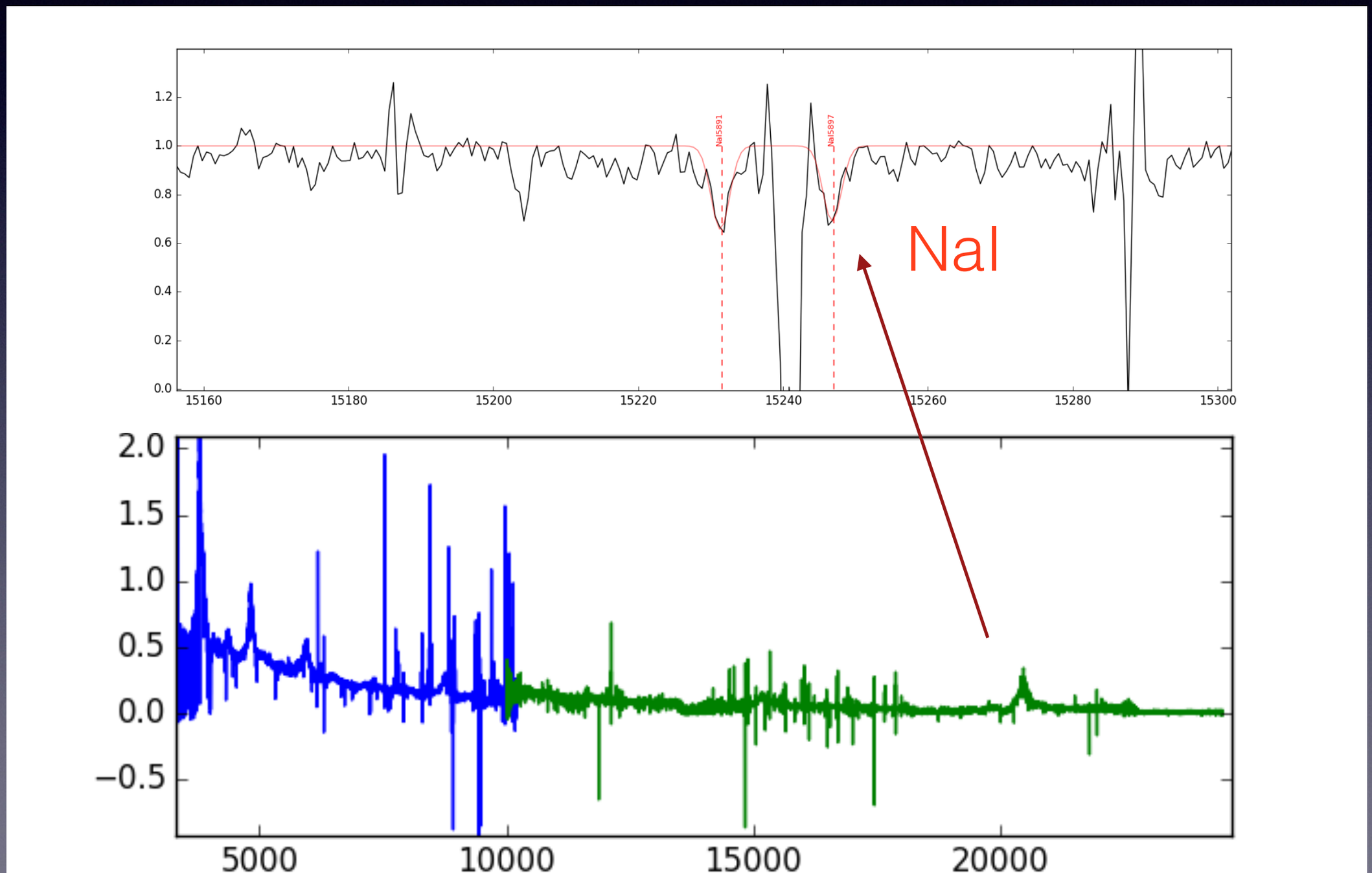
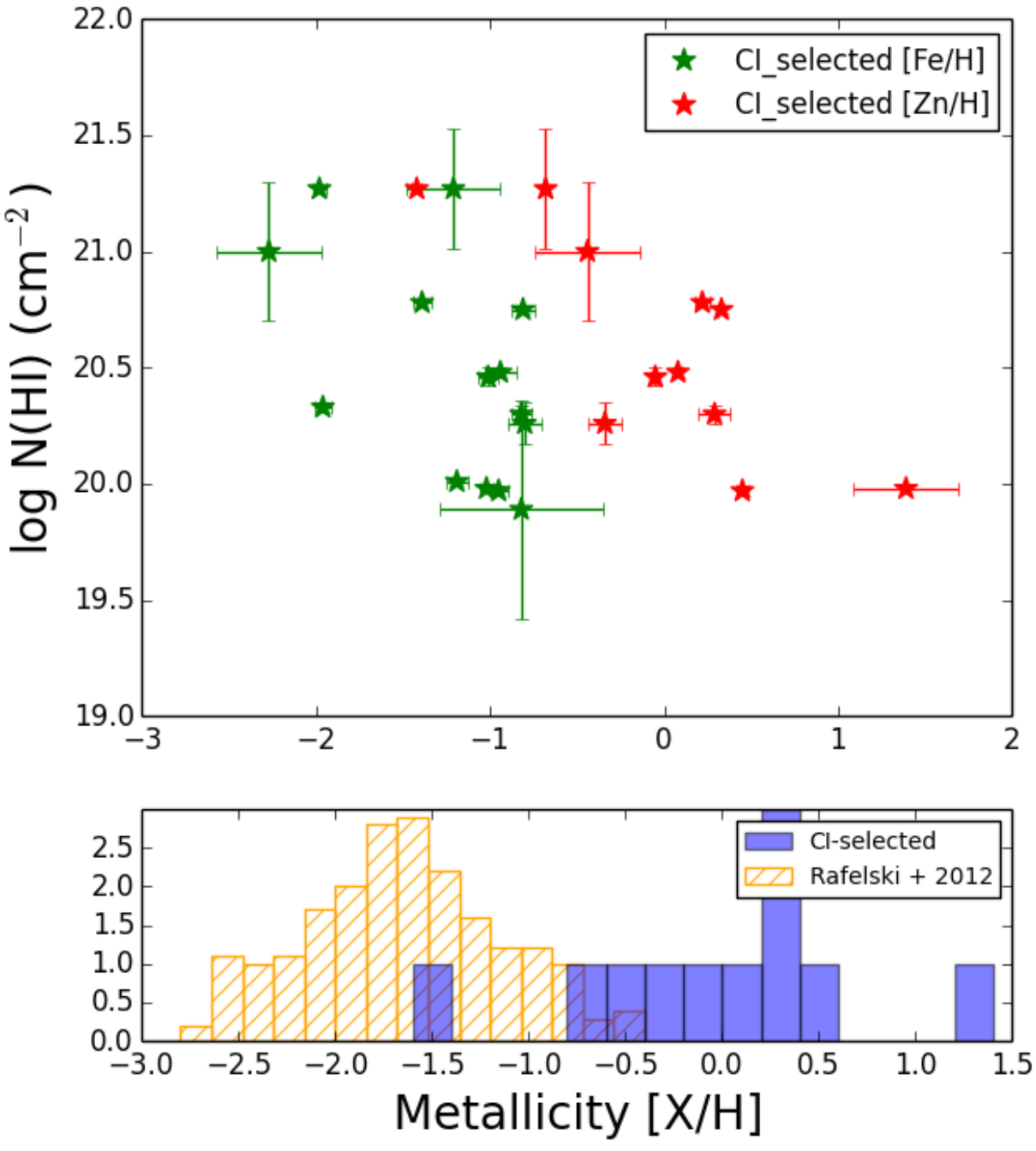


Results

Metallicity

upper panel :
red stars: CI-selected [Zn/H]
green stars: CI-selected [Fe/H]

lower panel:
Metallicity distribution function
orange histogram: Metallicity distribution in Rafelski+ 2012
blue histogram: CI-selected metallicity

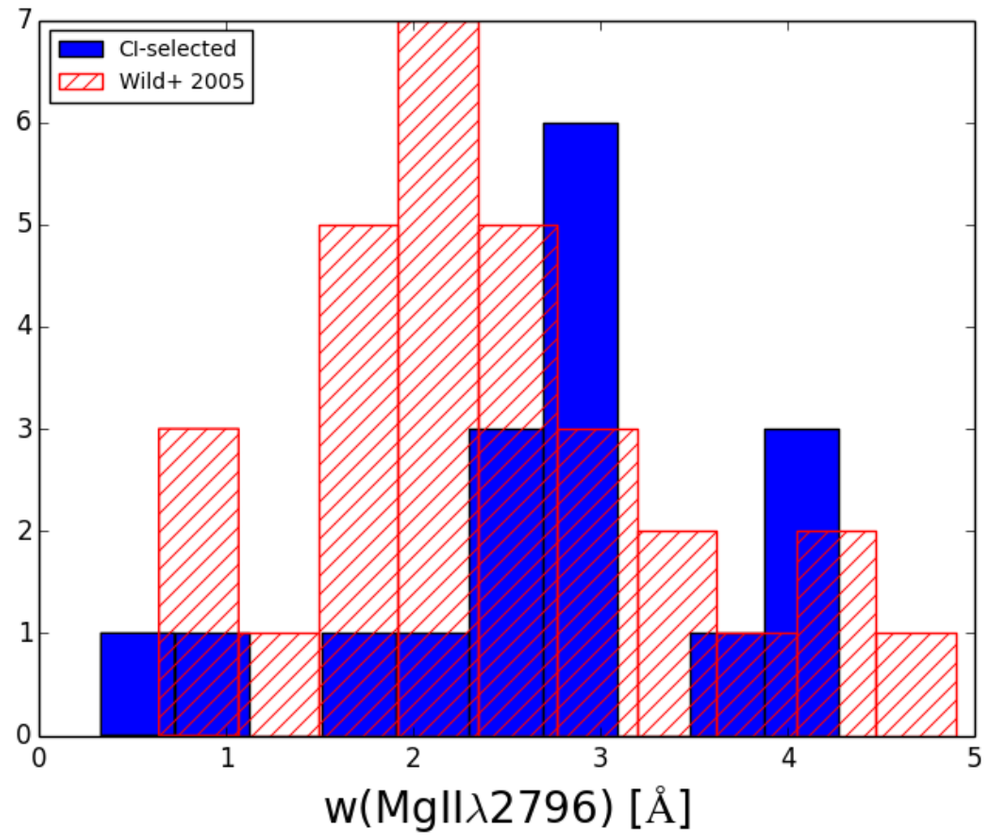


S.Zou et al. 2017 (in prep)

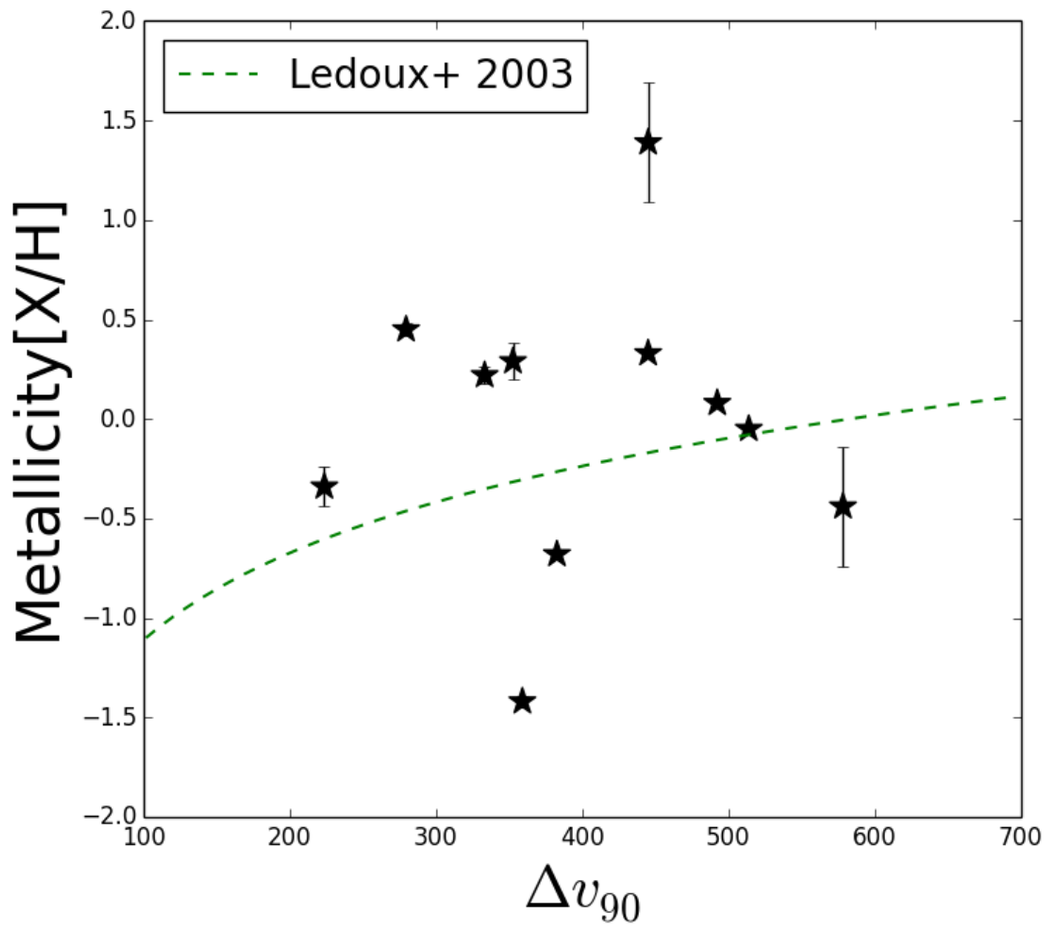
Results

MgII

Red histogram: Wild et al. 2005
0.84 < z_abs <1.3



Green dashed line:[X/H] - v90 relation for DLAs at 1.7<z<2.32
Ledoux et al. 2003



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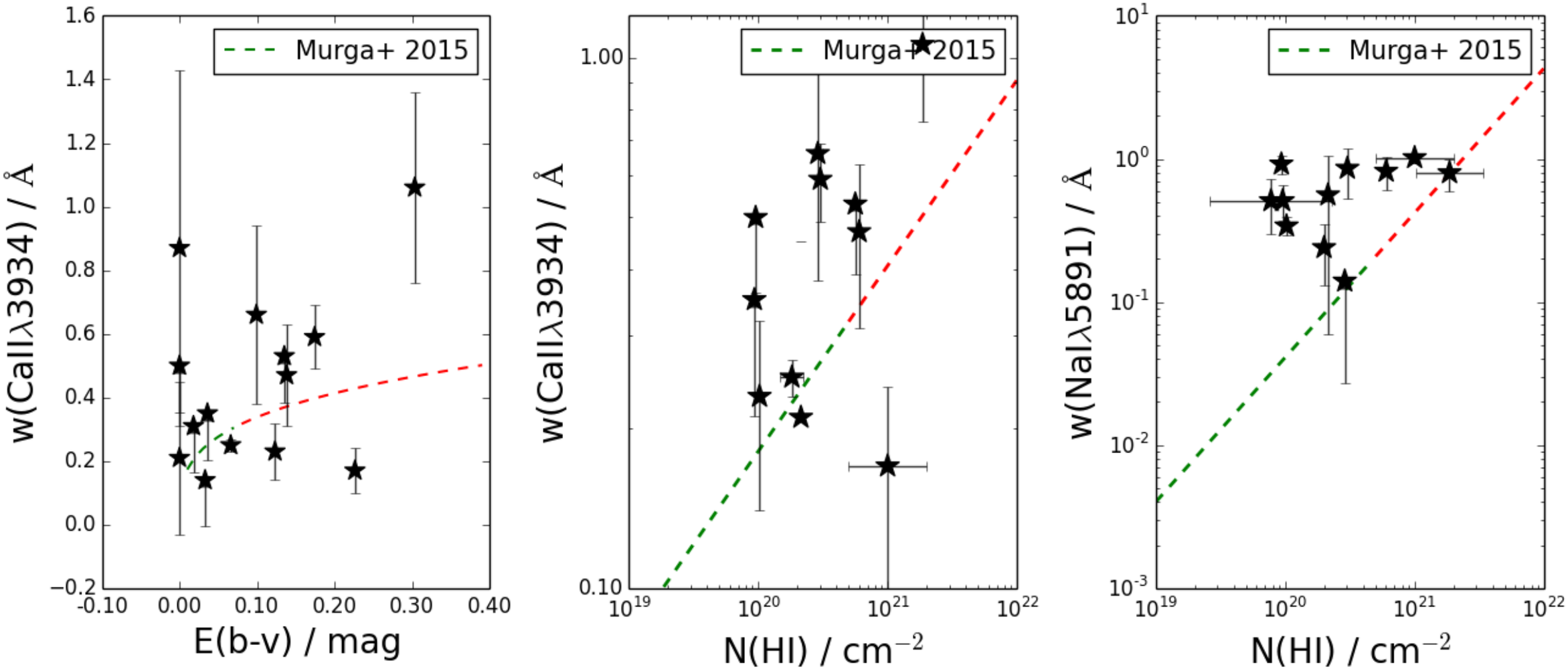
Results

NaI and CaII



Green line: Murga+ 2015, CaII and NaI study at local universe

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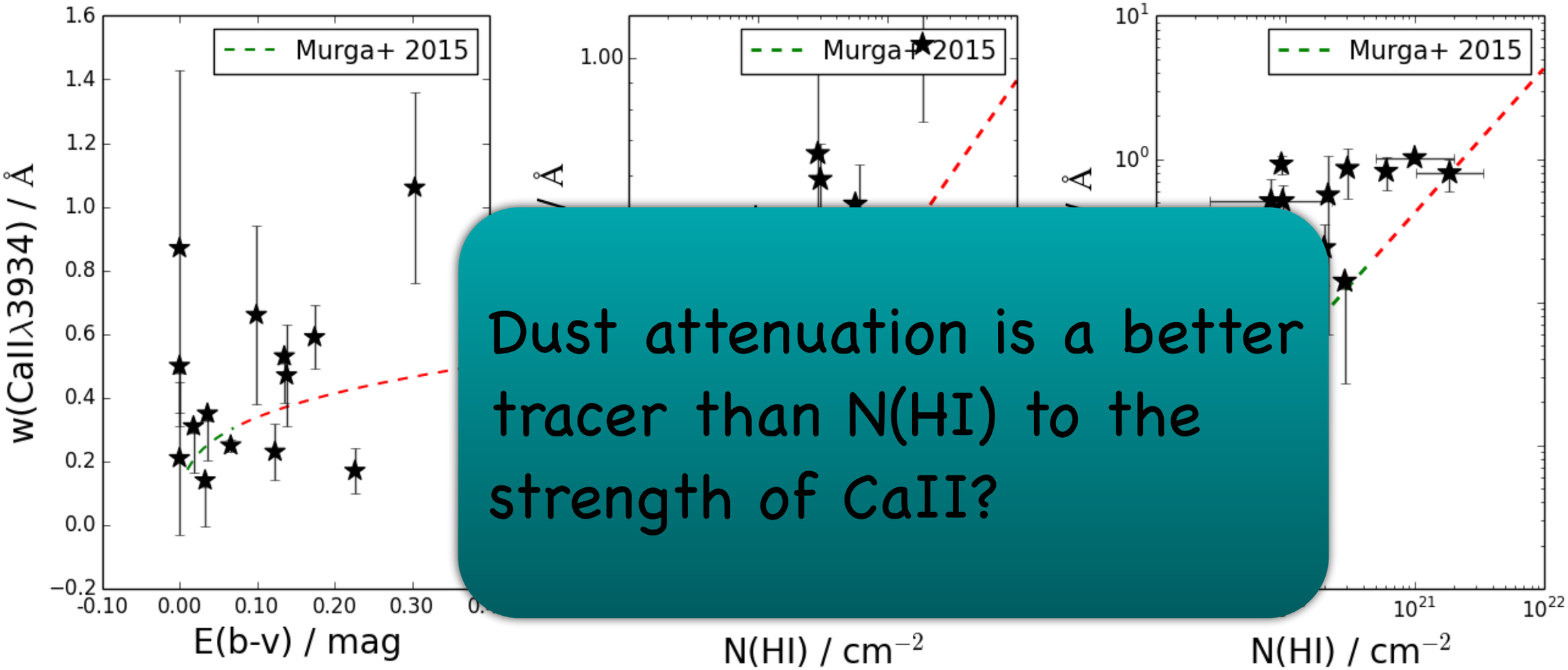
Results

NaI and CaII



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Dust attenuation

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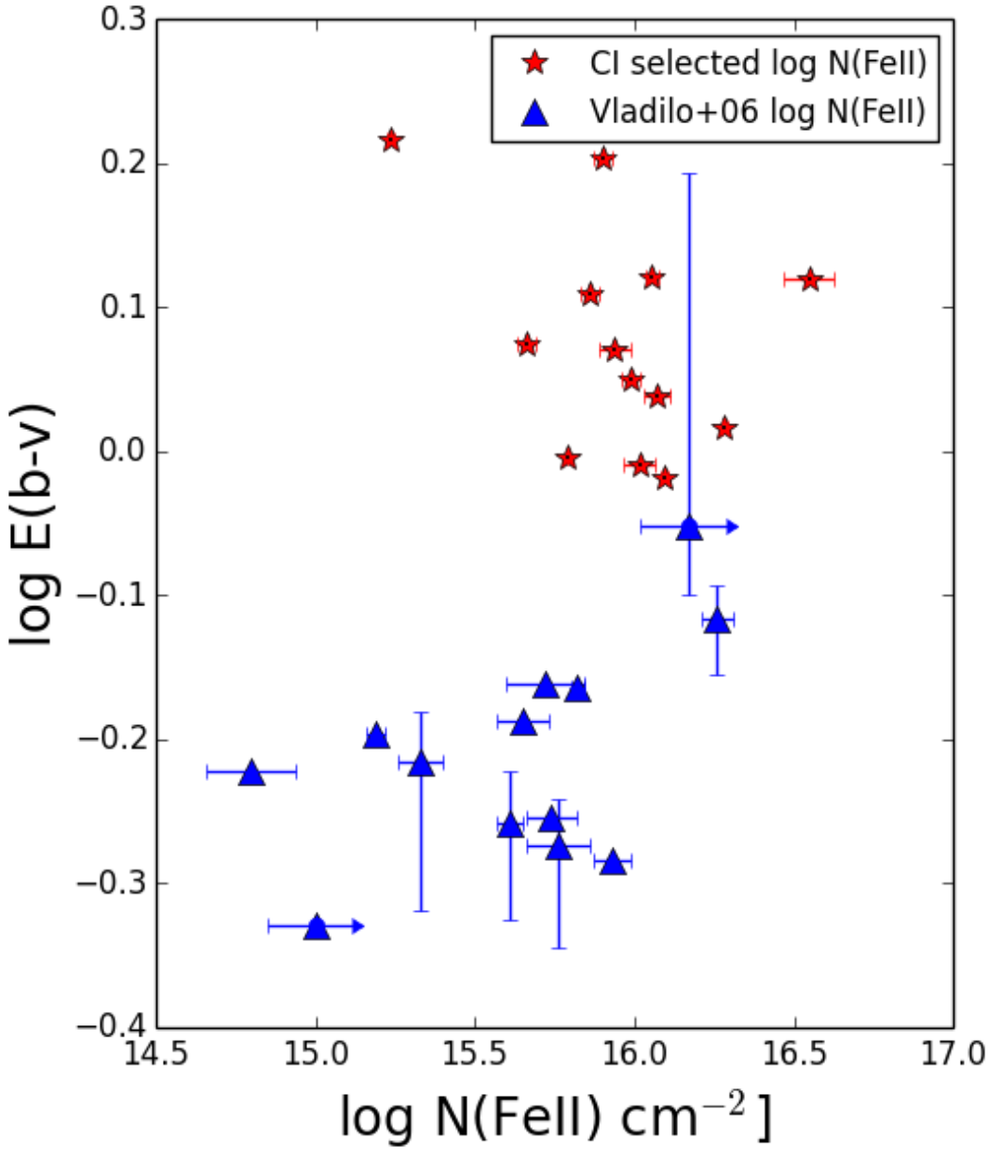
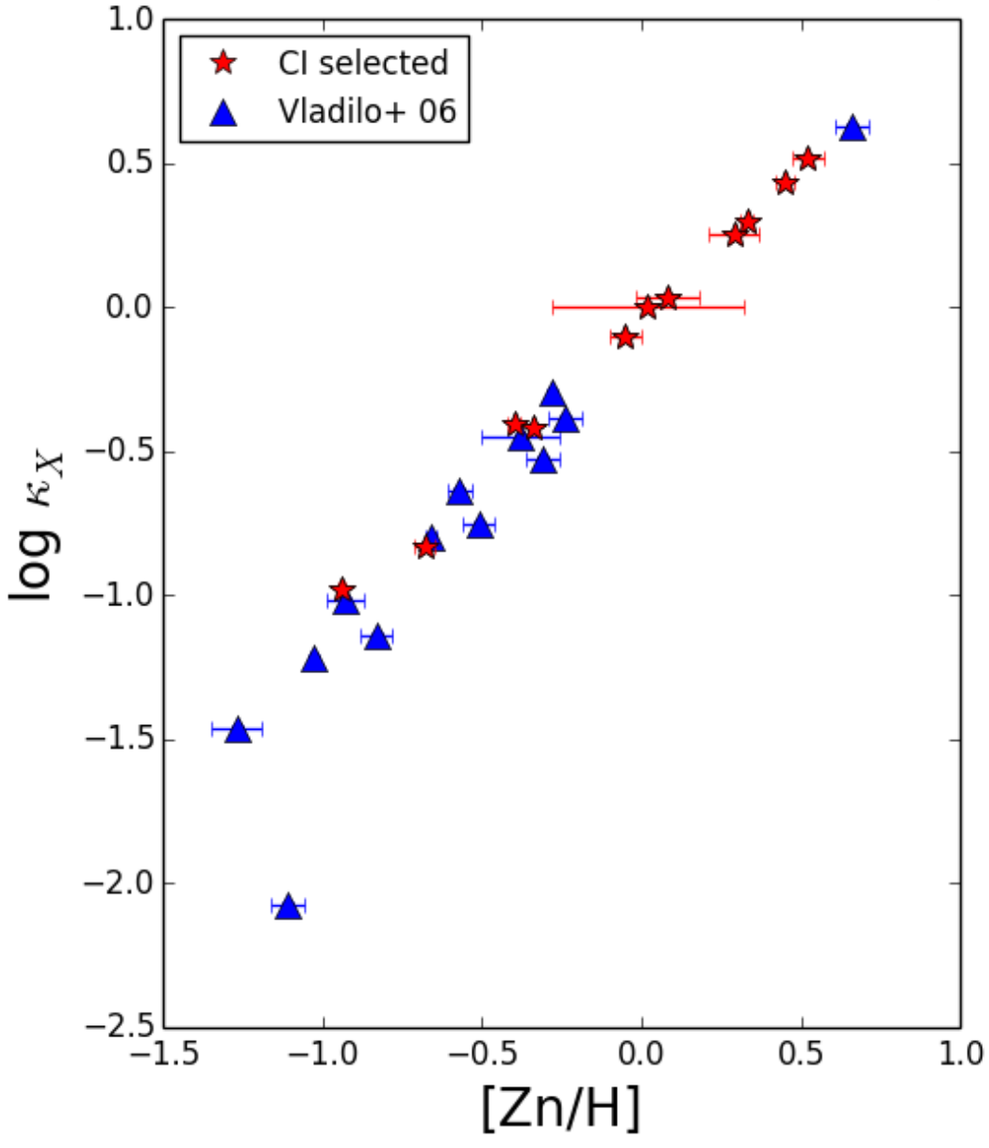


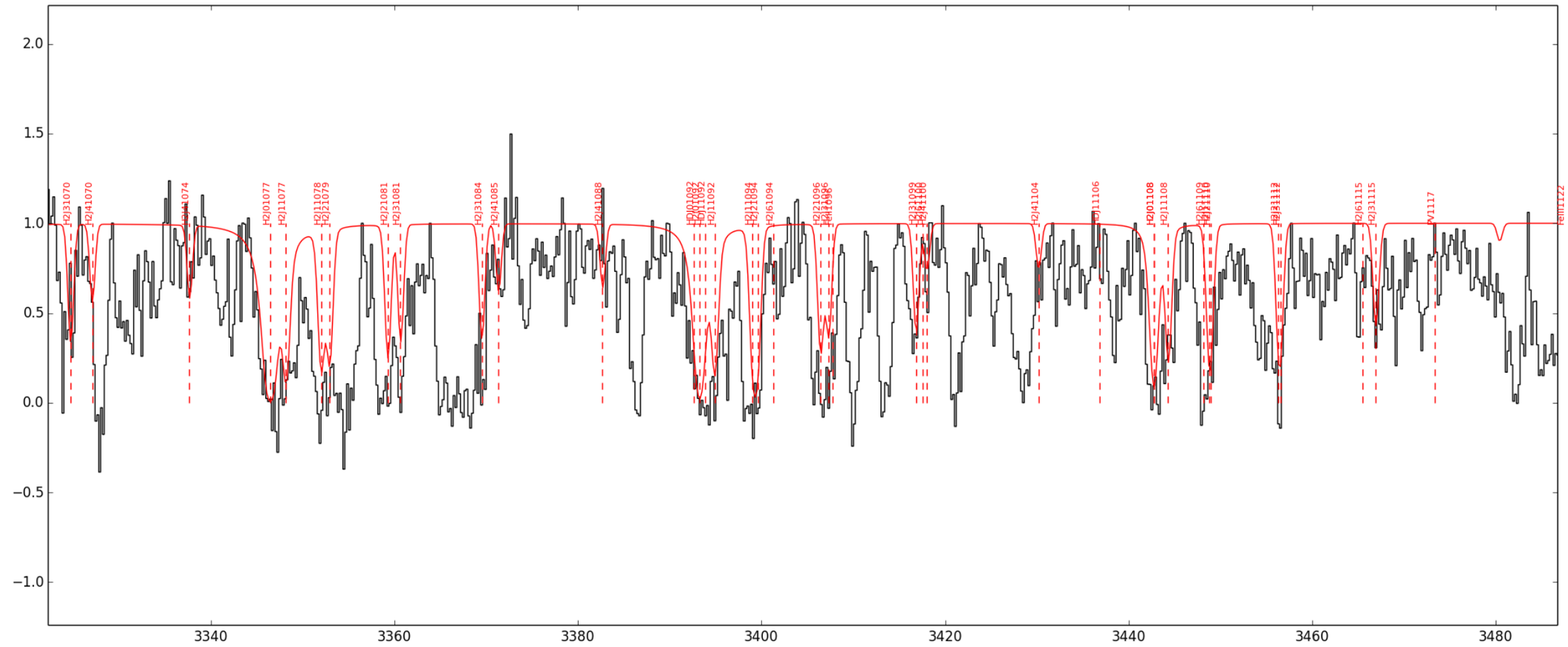


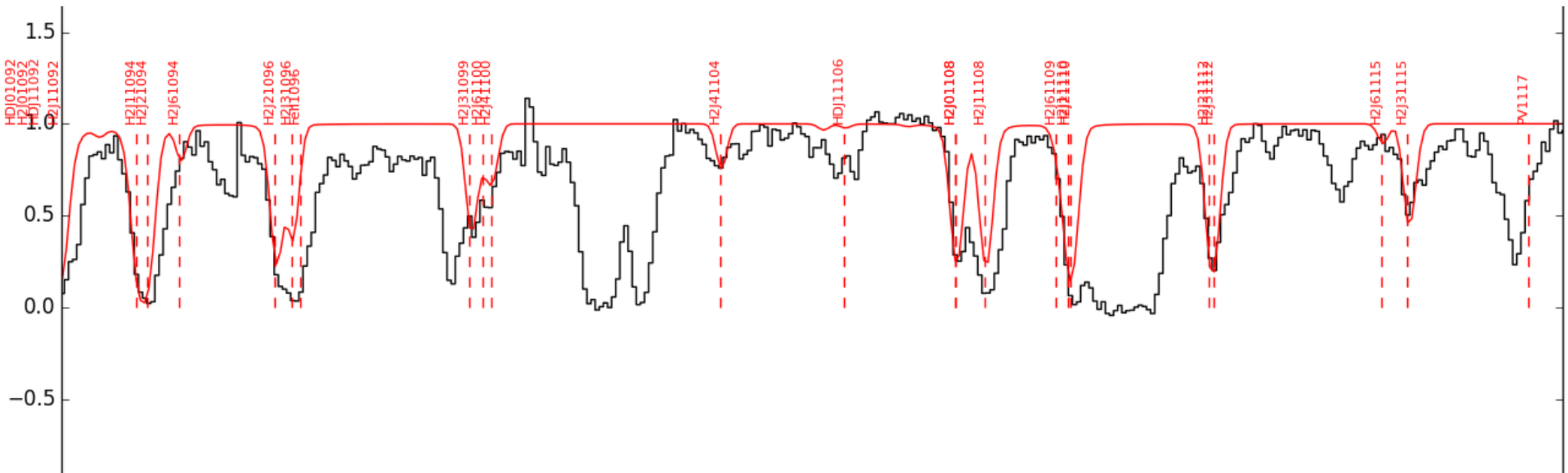
red: FeII in the dust of CI-selected sample

blue: FeII in the dust in Vladilo et al. 2006

H2 detections

P.Noterdaeme et al. 2017 (in prep)





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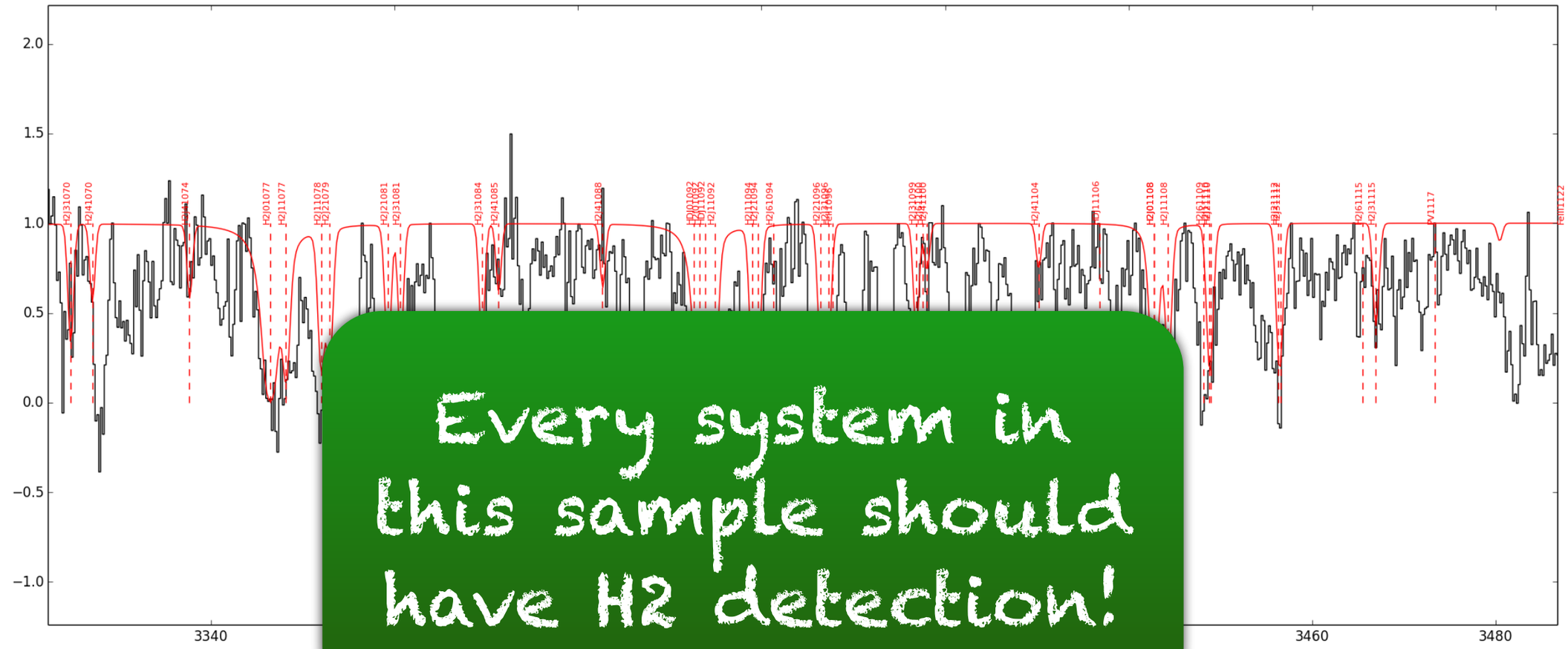
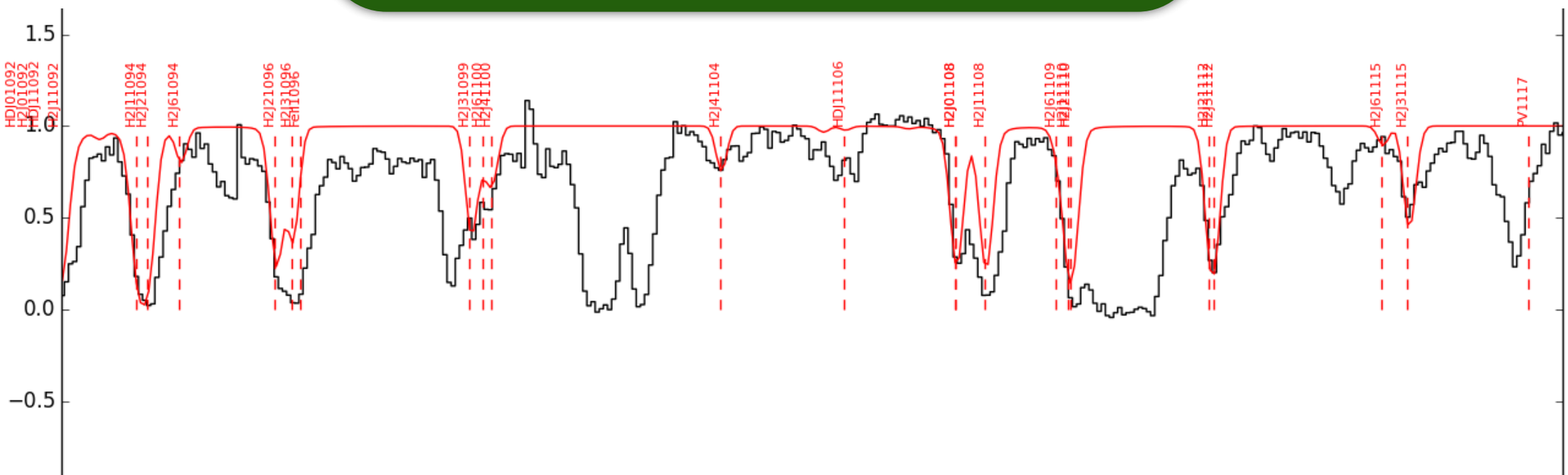


Every system in this sample should have H2 detection!



Summary

- The best way to probe the physical properties of molecular phase in galaxies is to detect the tracers of the cold gas in absorption.

- The metallicity of the CI-selected systems are close to solar, which is higher than the normal DLA metallicities. Therefore more comparisons with survey in the local universe are needed.

- The kinematics width of MgII are larger than that for DLAs, around 400 km/s.

- We detected 9/17 CaII H&K doublets and 10/17 NaID lines, the preliminary result shows dust attenuation has strong correlation with w(CaII) than N(HI).

- The dust content is high in the CI-selected sample, H2 should be detected in every system in this sample.