The cold ISM at High Redshift : Molecules in DLAs

-> Census of OmegaHI from DLAs

-> Molecules in high-z DLAs

-> Future

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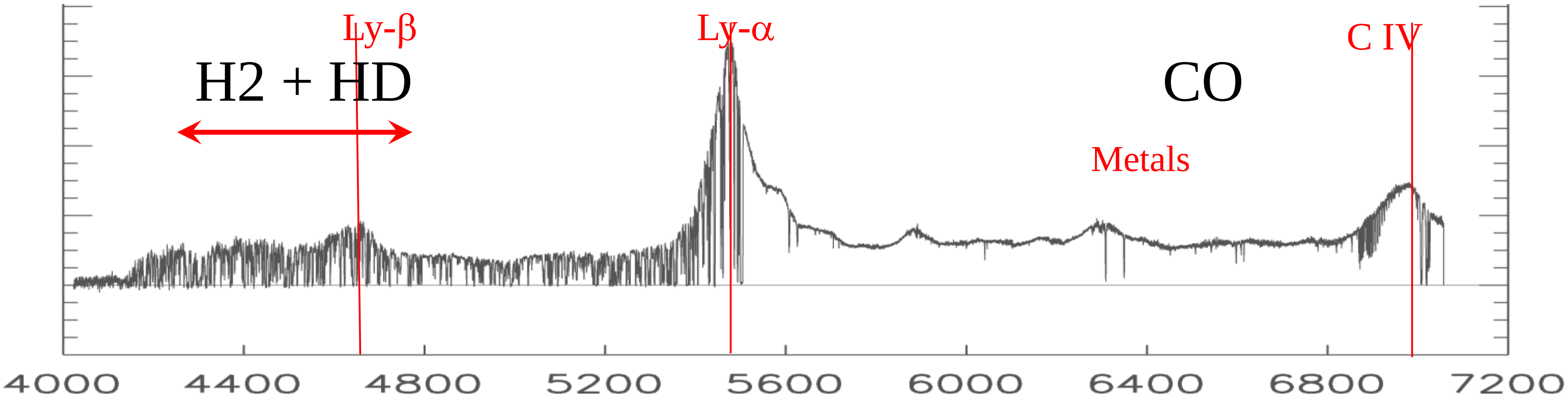
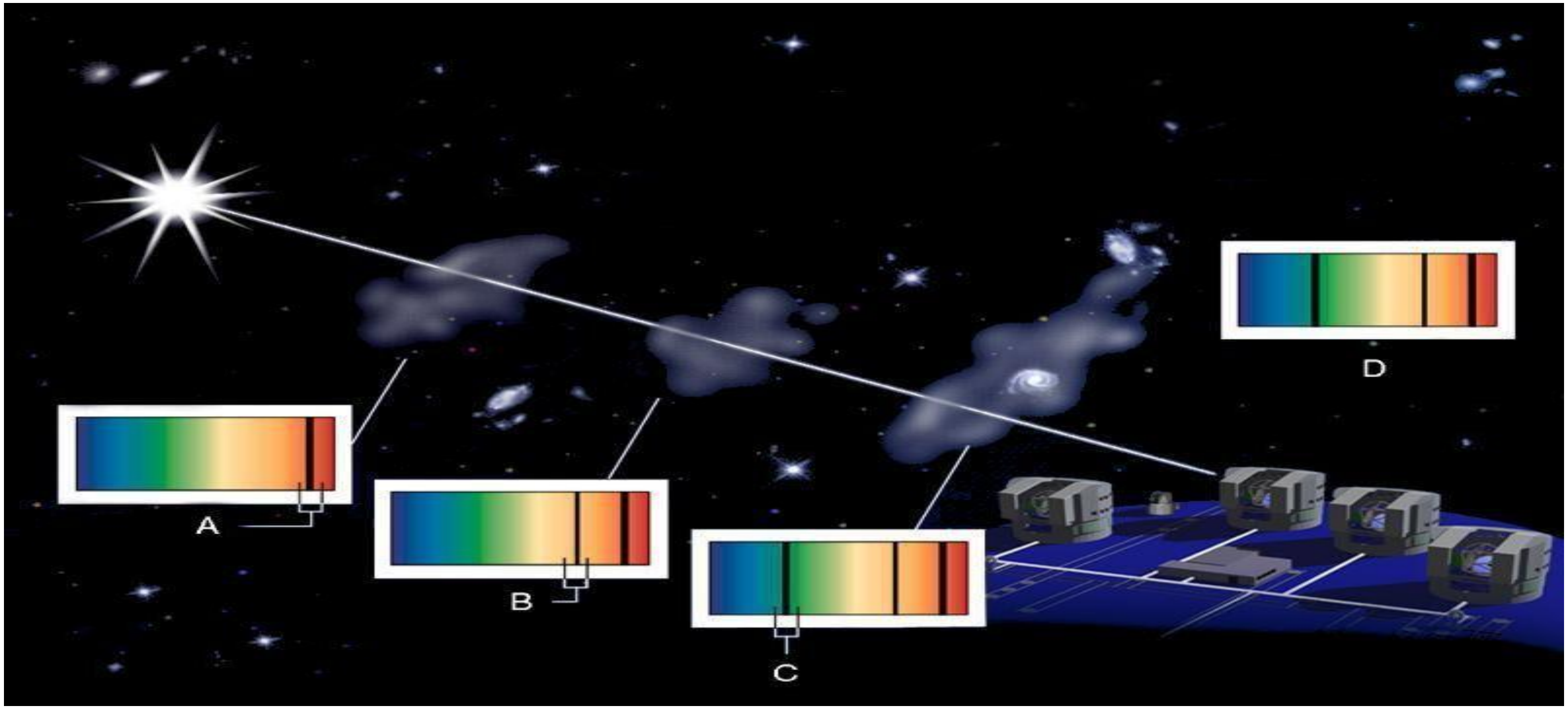
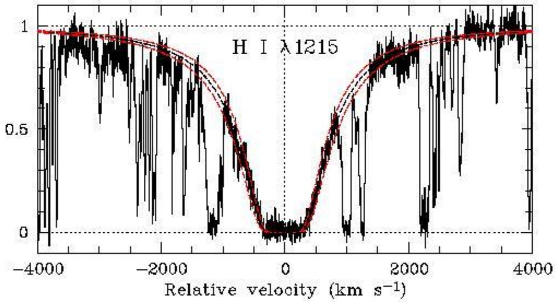
Quasar (GRB) Absorption Lines -> Diffuse IGM and dense ISM

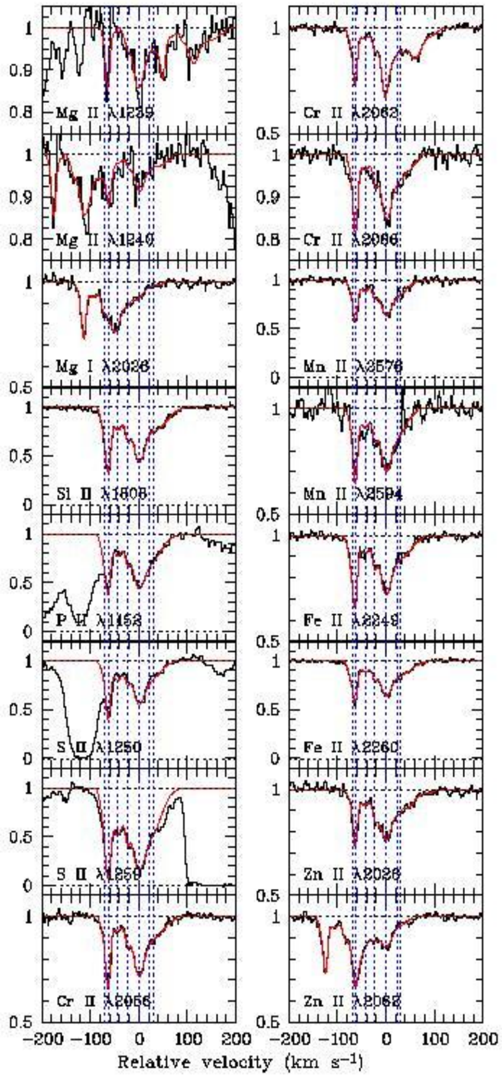


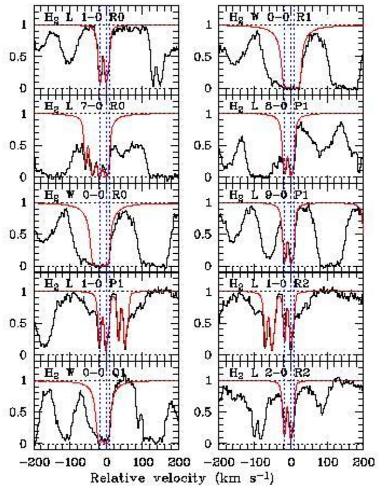


Damped Ly-α Systems

HI :







Metals :

-> Metallicities

-> Dust content

-> Kinematics

Star- Formation ?

Winds ?

Molecules H2 + CI, CI* :

-> Density/Temperature

-> UV flux (excitation)

Selection of the systems

-Search for DLAs : SDSS (DR7->BOSS)

-> derive cosmological density of HI

Ω ~ cosm density * mass

~ cosm density * cross-section * L * density

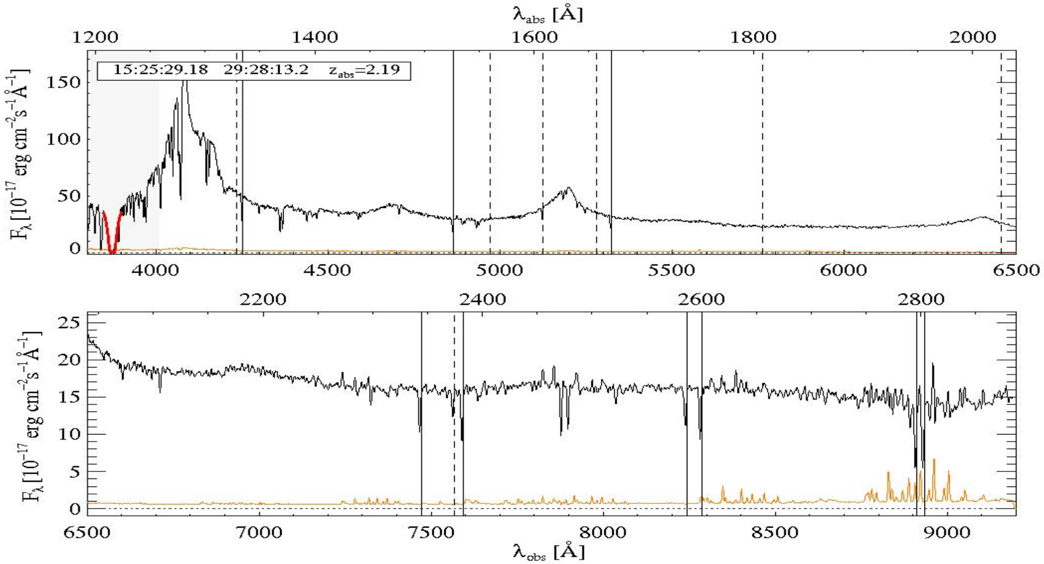
~ dn/dz * NHI

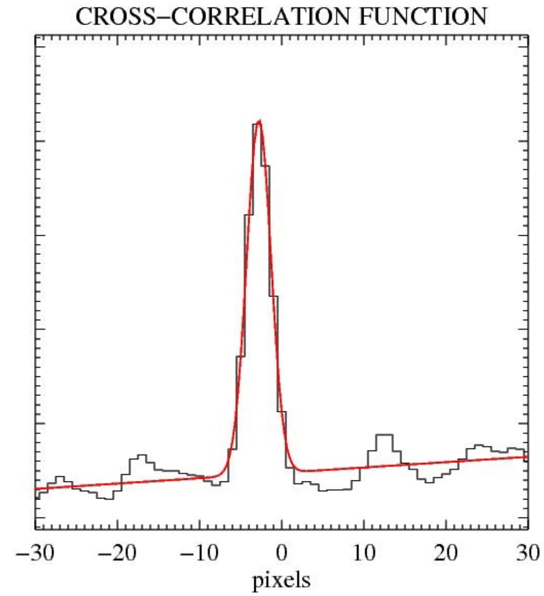
-Select systems -> search for molecules

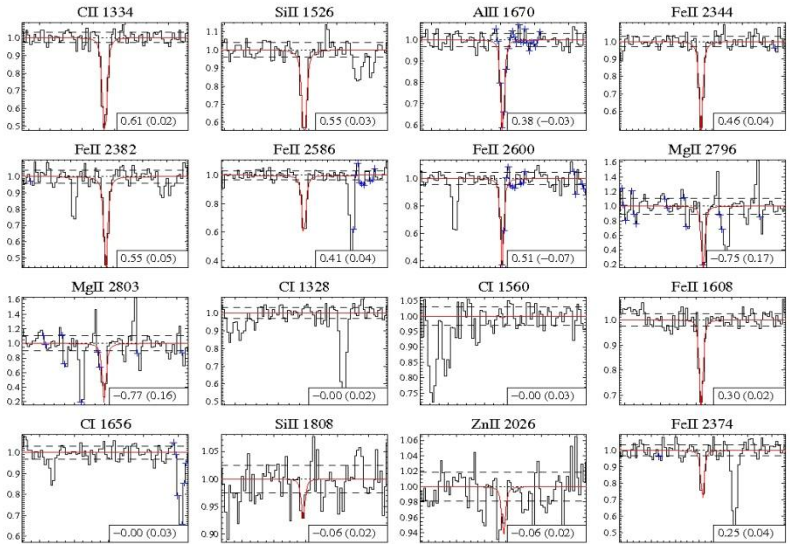
-Detailed studies

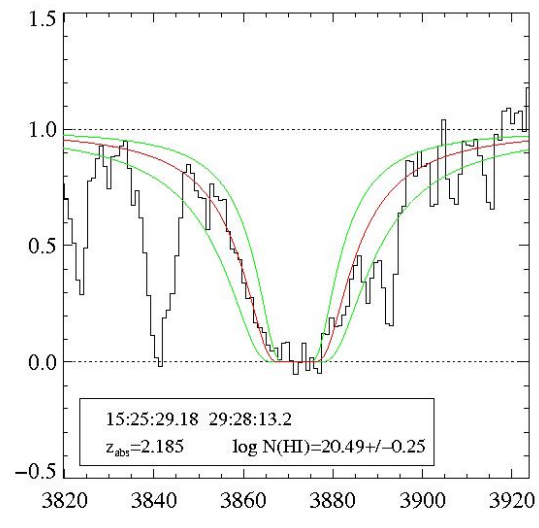
Evolution of the cosmological HI density

- Search the SDSS quasar spectra for DLAs : Fully automatic procedure



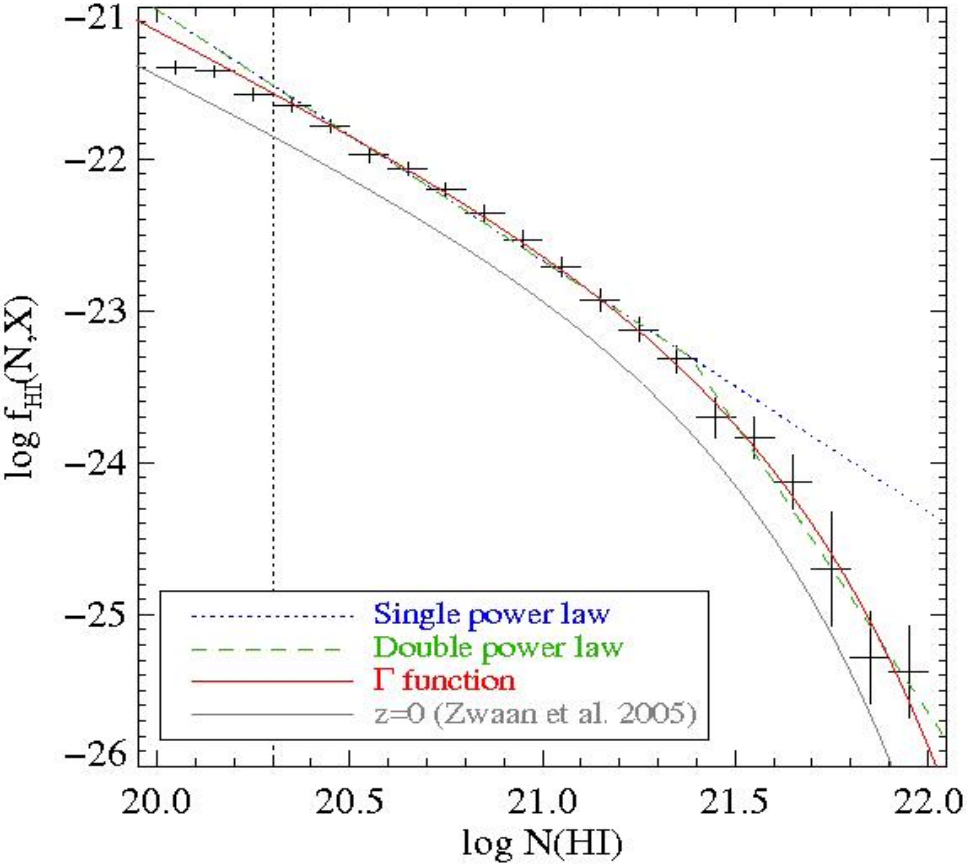




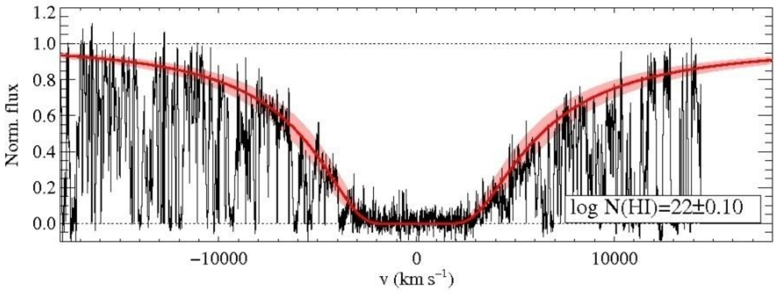


NHI distribution function

900 DLA Systems

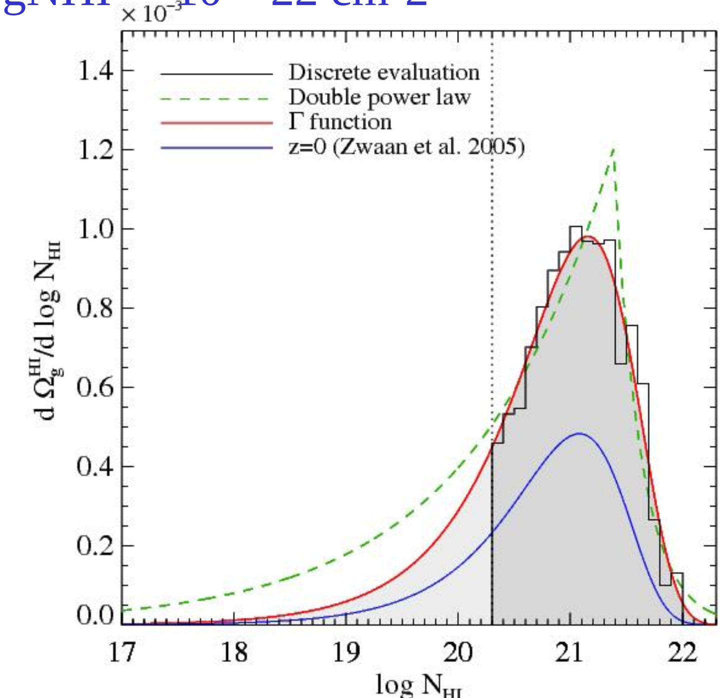


Similar shape at z=0 and z=2.5



Highest column density known

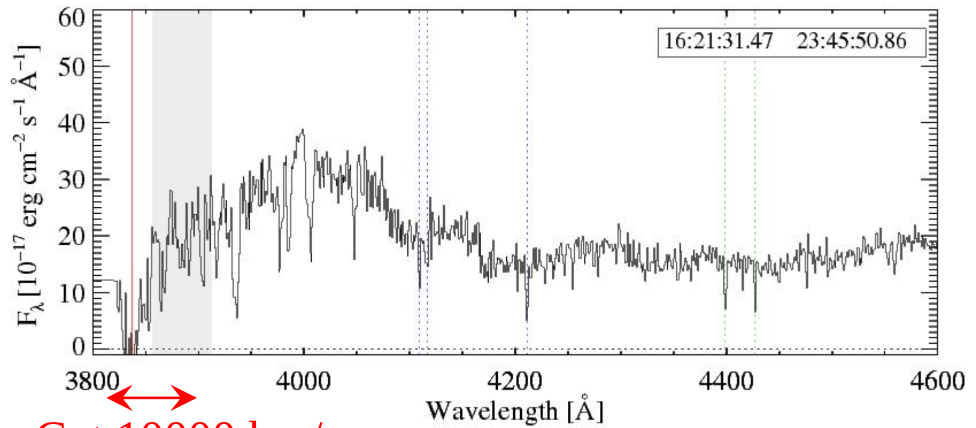
logNHI = 10**22 cm-2



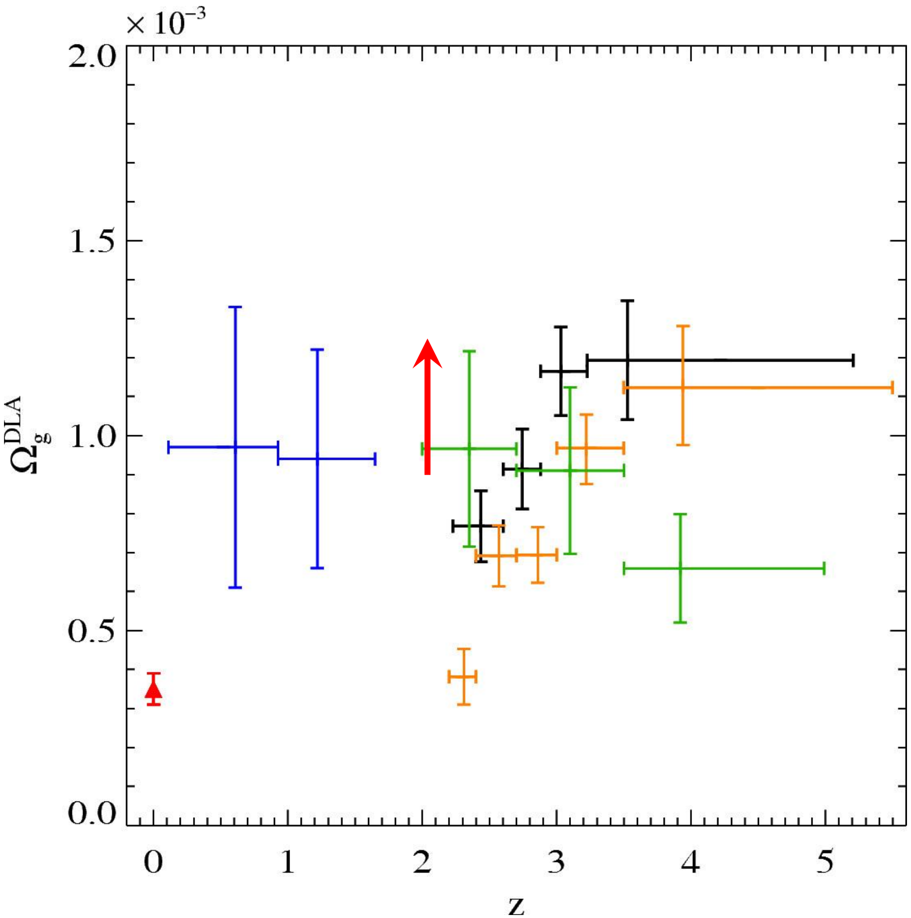
Max contribution at 21

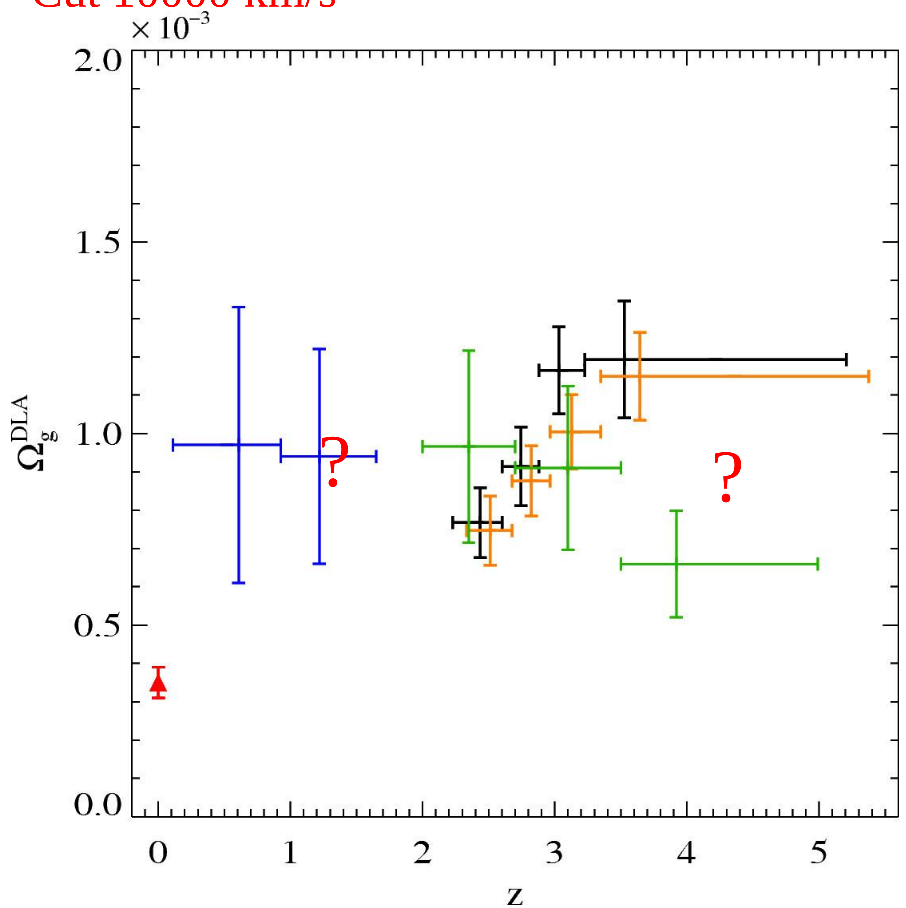
OmegaHI z evolution

The bias at z=2



Cut 10000 km/s





Noterdaeme et al. 2009, A&A, 505, 1087

Molecules: Why H_2 ?

- H_2 is ubiquitous in star-forming giant clouds and in the diffuse interstellar medium in our Galaxy
- H_2 is formed on the surface of dust-grains :What is the role of dust ?
- Excitation of H_2 in different rotational levels: Signature of the UV ambient flux + Physical properties of the gas
- Other molecules ? CO, HD
- By-products: variation of $\mu=m_e/m_p$

Two things: * Survey to learn about the H_2-bearing DLA population

* Derive selection criteria -> detailed observations

UVES survey

- 80 DLAs – sub.DLAs
- Spectral resolution R=43000; SNR>20 per pixel
- H_2 detected in 14 systems (15%)

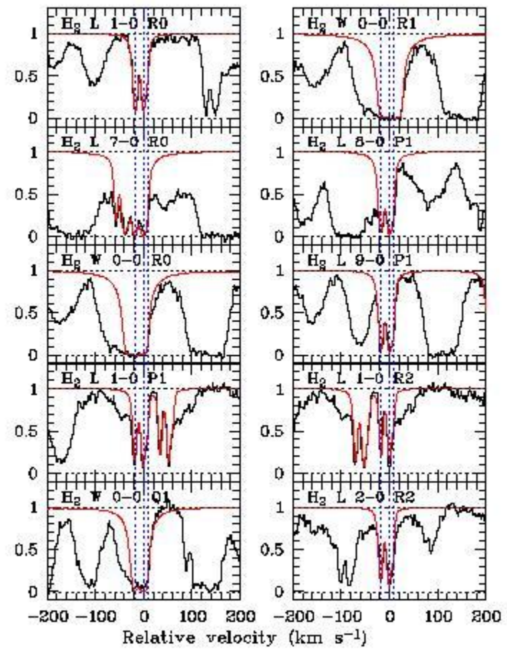
- Non detection :

  $f = 2 \times N(H_2)/(2 \times N(H_2)+N(HI)) < 10^{-5} - 10^{-7}$
- Detection threshold ~10^{14} cm^{-2} : 3h exposure time per spectrum for no detection

  -> 8h in case of detection.

  => More than 350 hours observations

  (! Old good days !)



Highest redshift

J1443+2724 z = 4.224

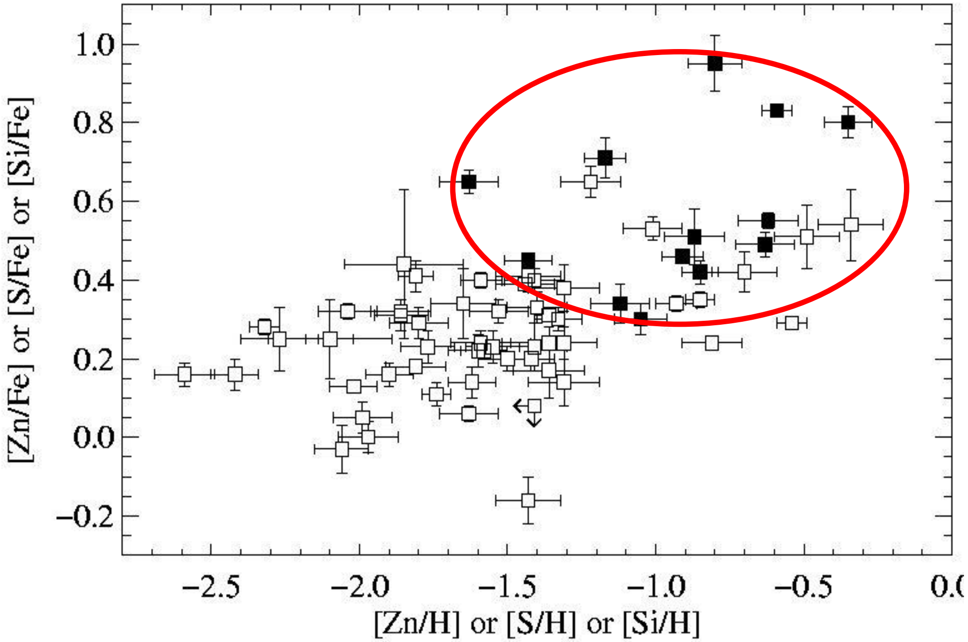
Petitjean et al. (2000), A&A, 364, L26

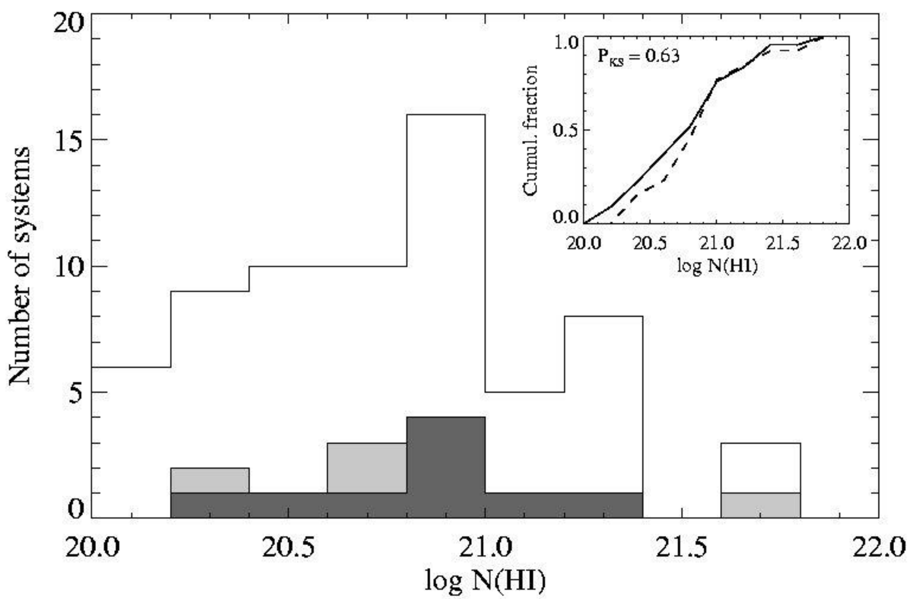
Ledoux et al. (2003), MNRAS, 346, 209

Noterdaeme et al. (2008), A&A, 481, 327

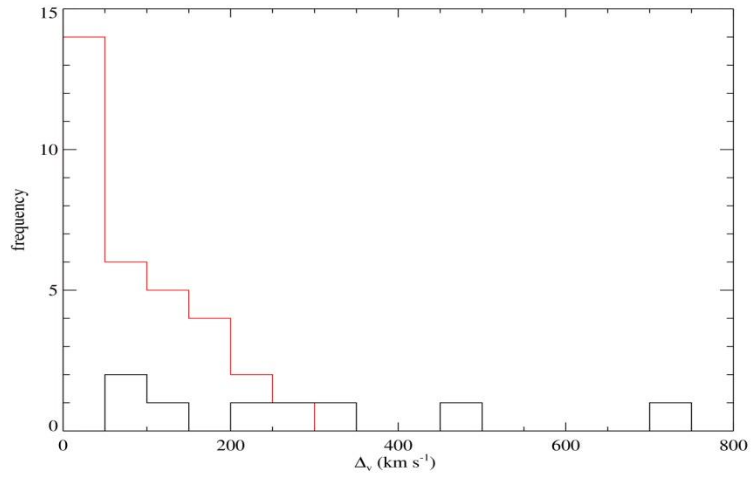
DLAs with H2: Presence of dust Not HI : 50 UVES nights

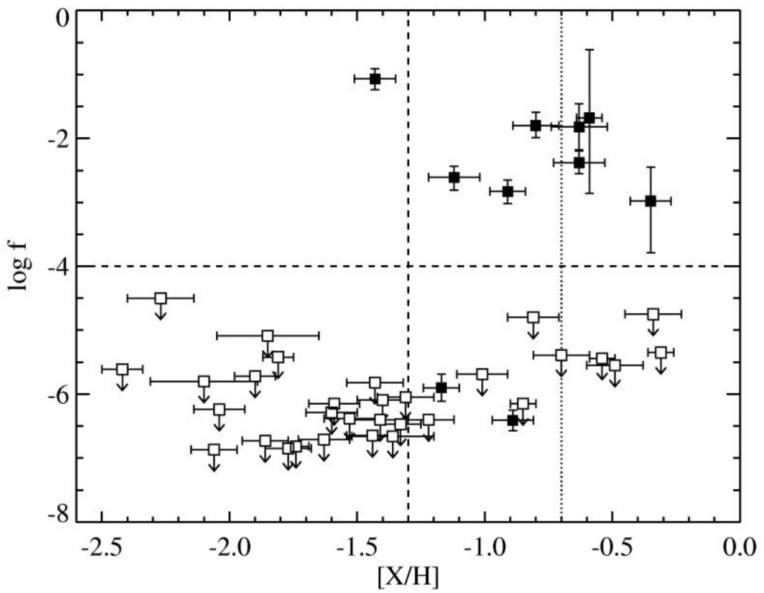
- Correlation Depletion ([Zn/Fe]) vs Metallicity ([Zn/H])
- Presence of H2 is NOT correlated with NHI





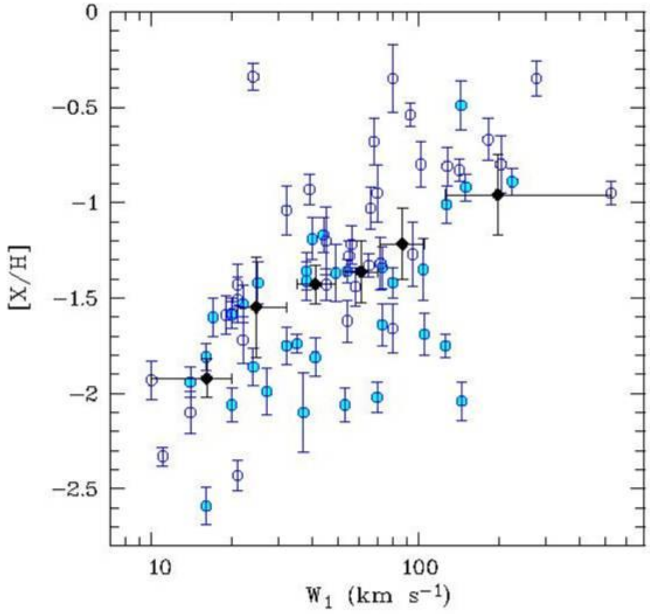
UVES survey : Noterdaeme et al. 2008, A&A, 481, 327





Presence of H2 for High metallicities

AND high velocity width



H2 = Metal Rich-large width = Massive Galaxies ?

High SFR

Ledoux et al., 2006, A&A, 457, 71

[X/H] : metallicity - W1 : Absorption Width

Search for molecules

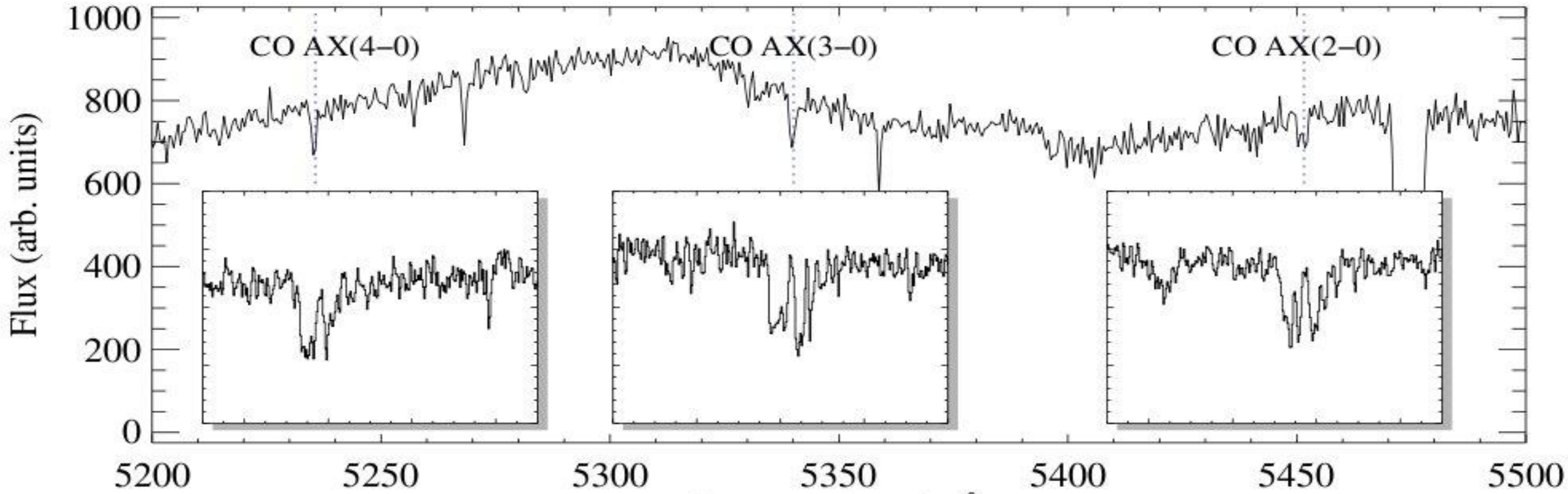
Selection H2: *** High dust content (depletion)

30% ** High metallicity

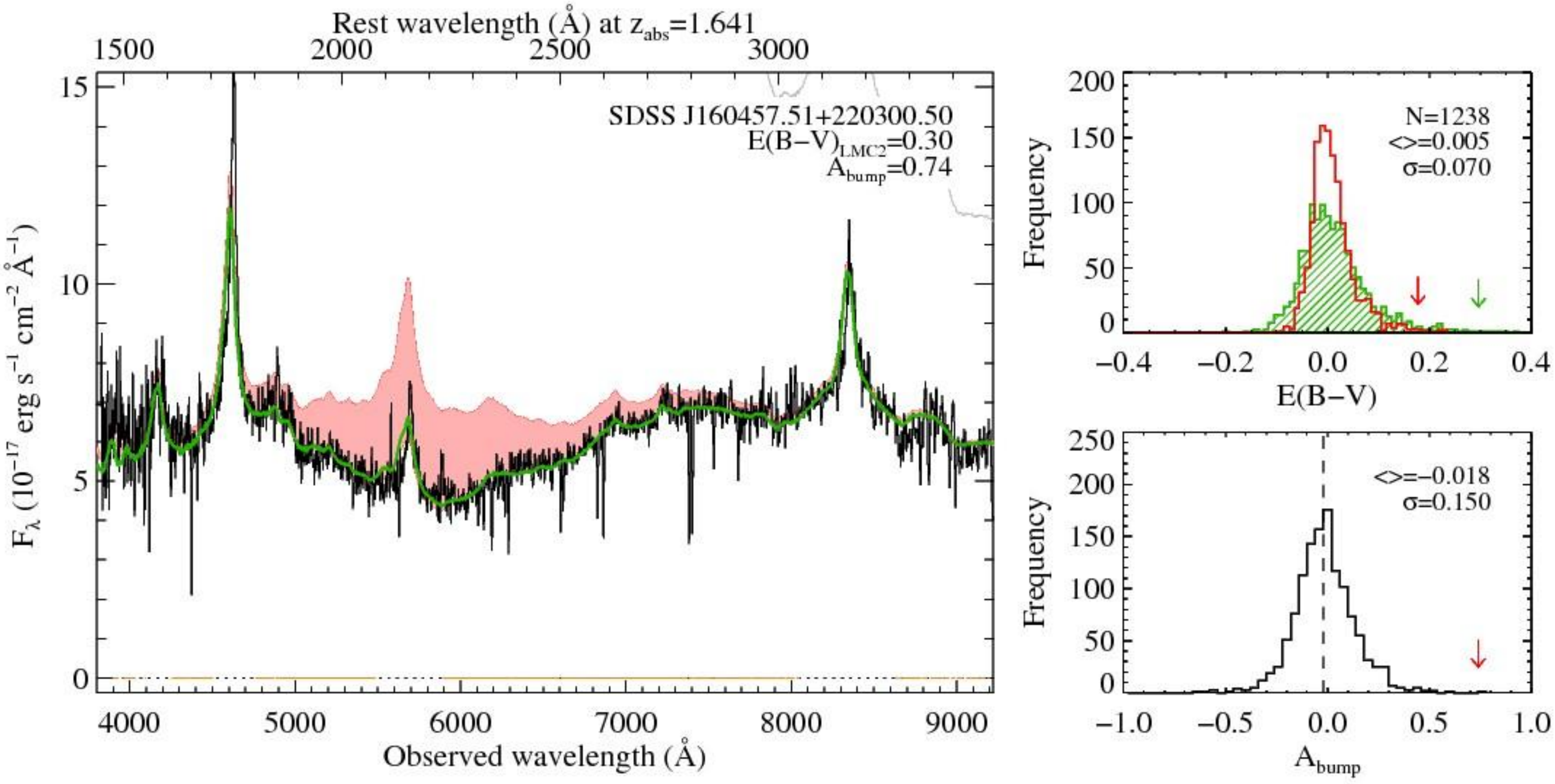
* High NHI

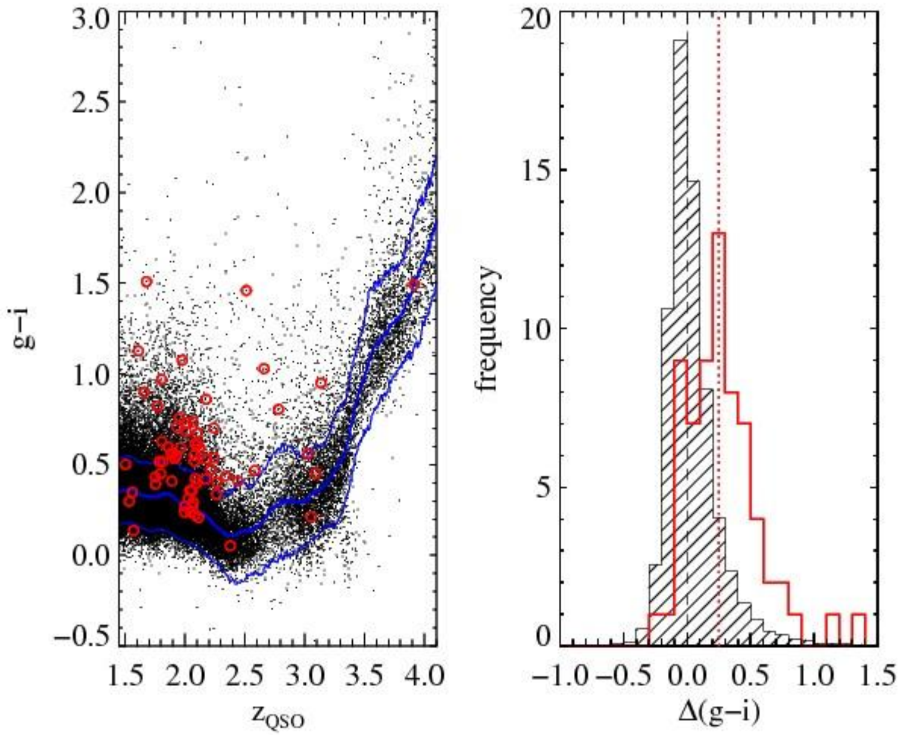
+ Presence of CI

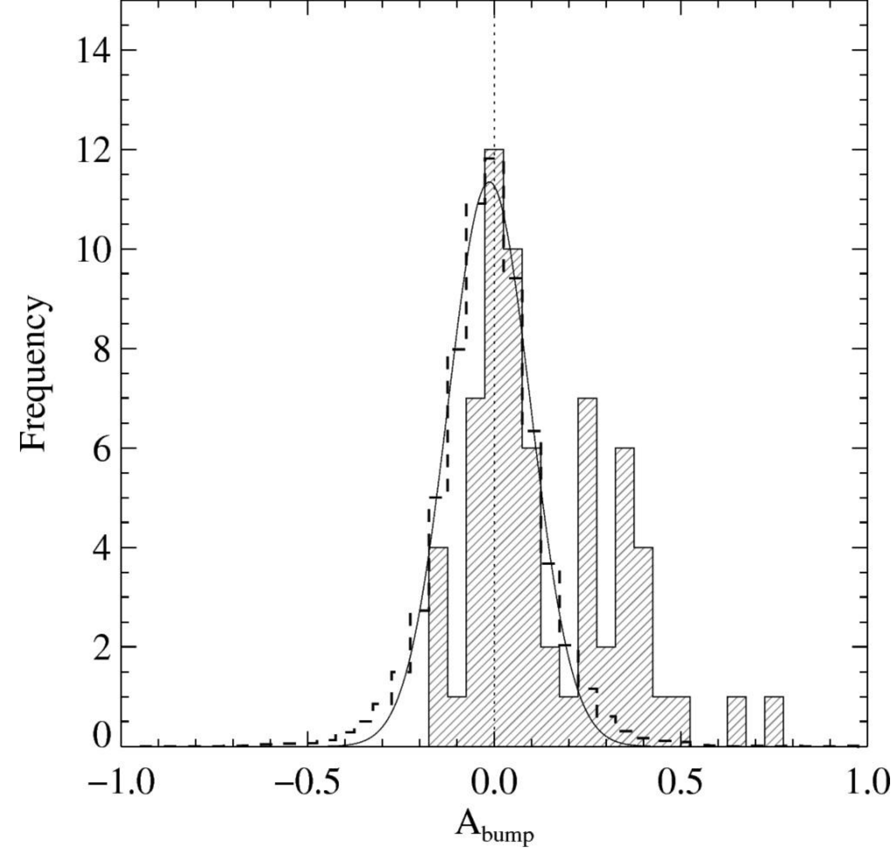
Other Molecules: CO + HD

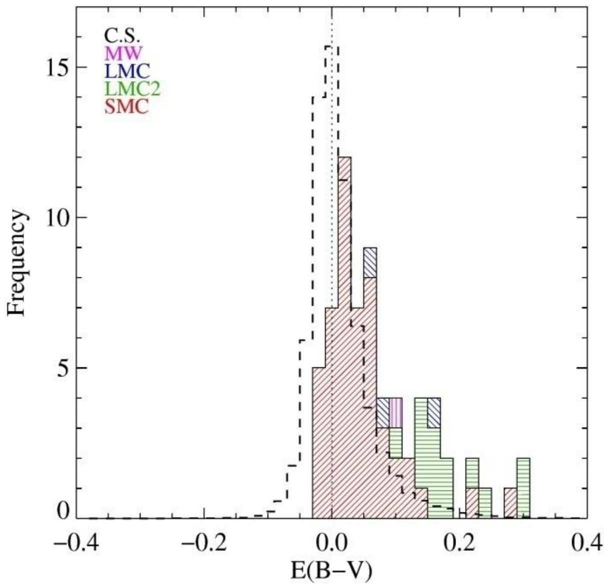


CI absorbers: Presence of dust









The CI population: (preliminary)

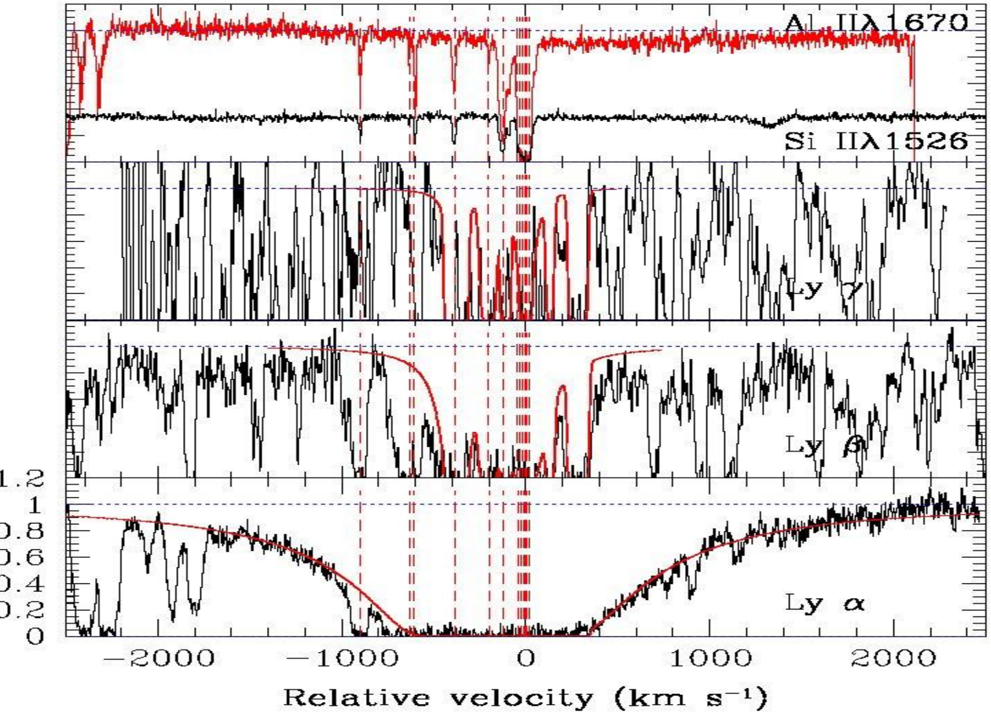
-Quasars are reddened

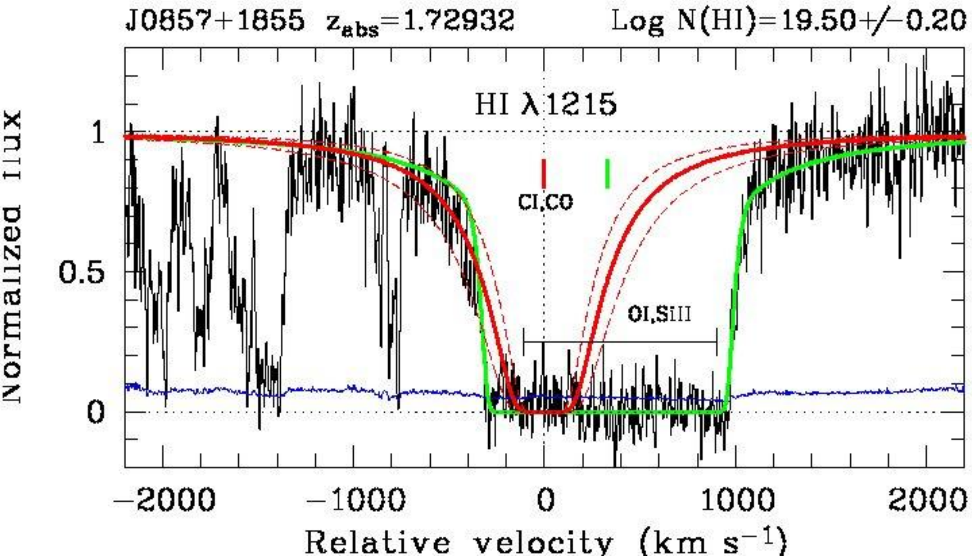
-Eb-v=0.05 => AV=0.14; 1 mag in g

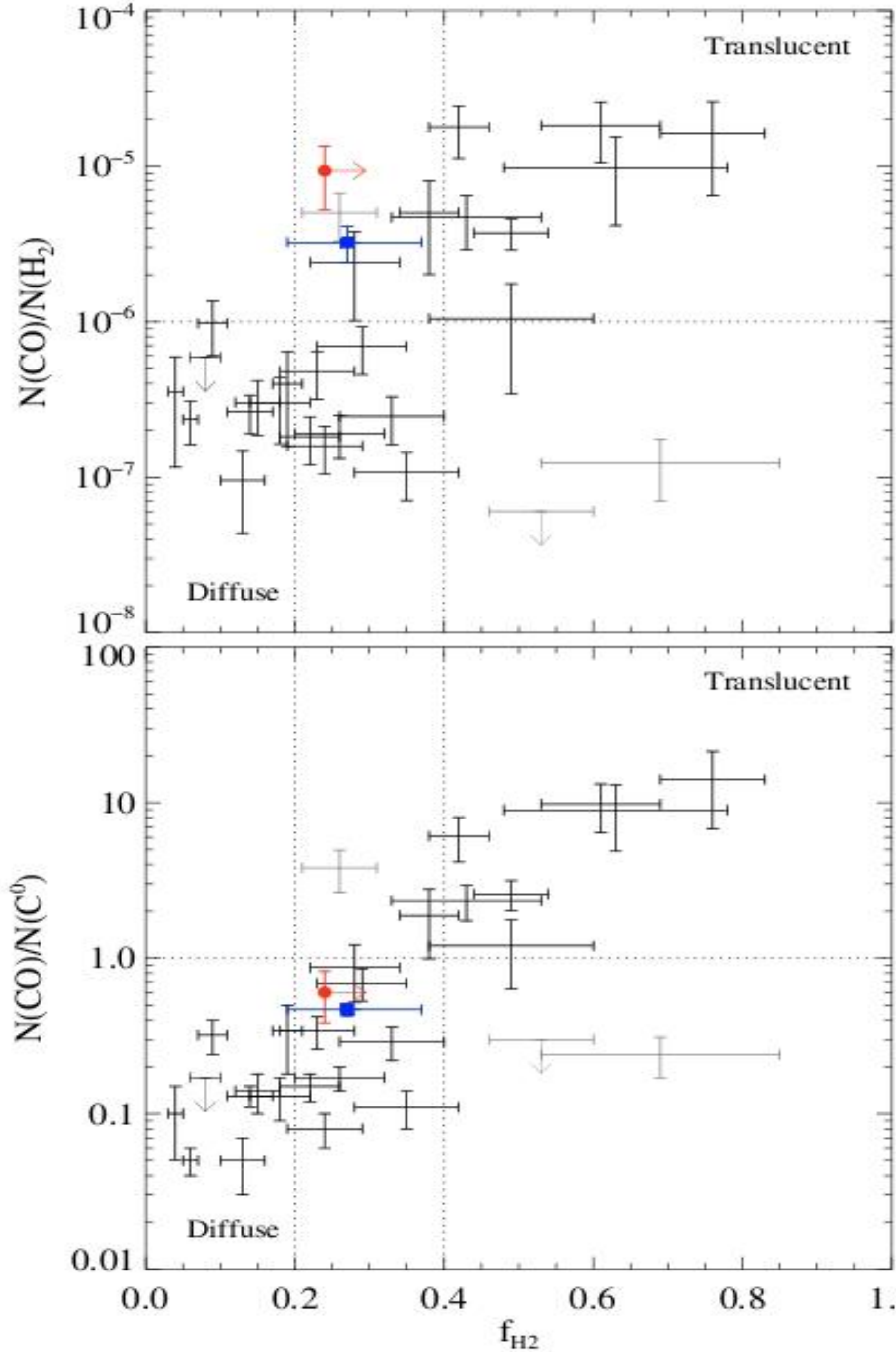
-NHI small (logNHI=20)

-We don’t see the highly reddened population

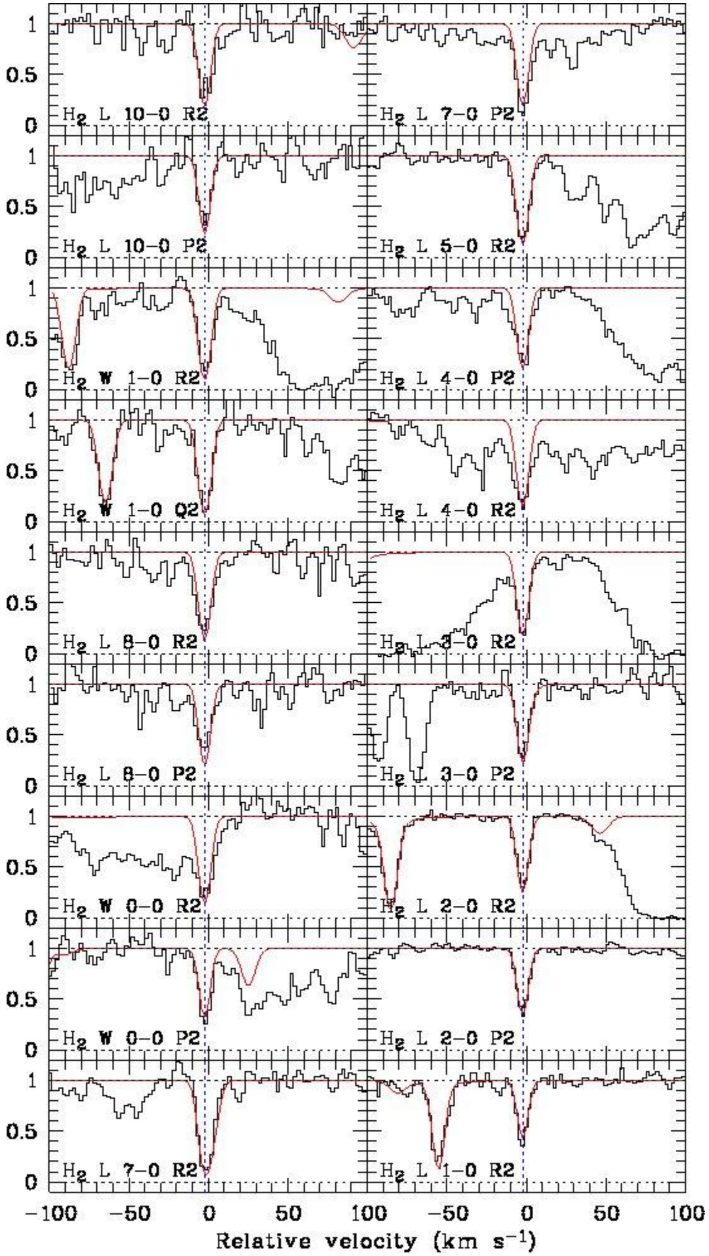
Translucent clouds

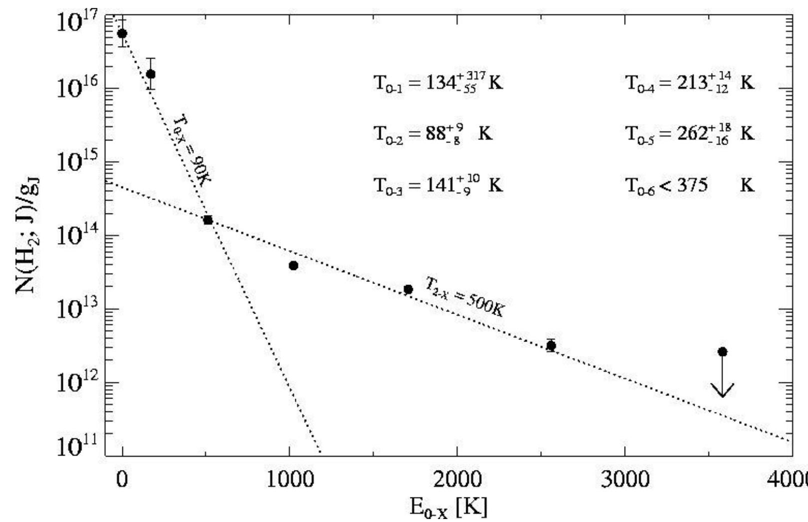






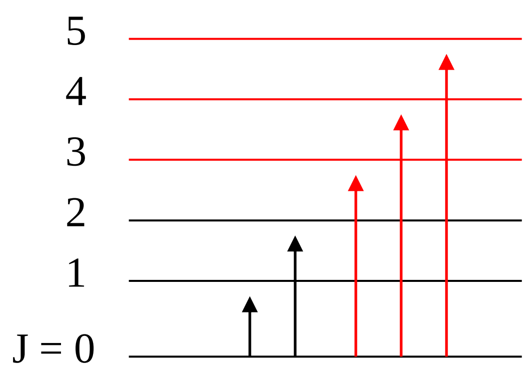
Heating processes: Molecular excitation





Two temperatures

No velocity shift



Fluorescence -> UV flux

Collisions -> Tk, density

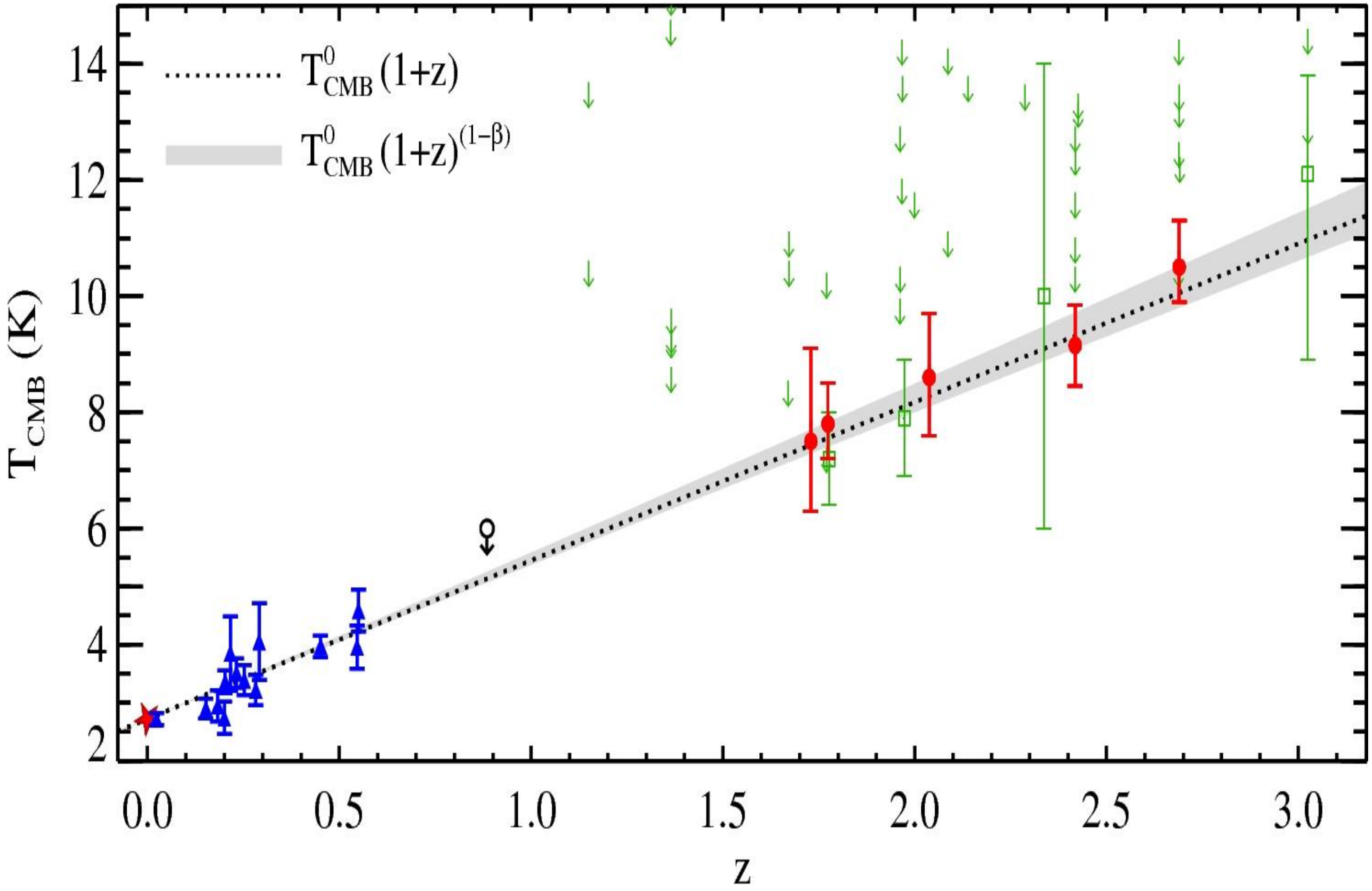
CI+ CI*

Doppler parameter increases with J

nH=100cm-3 T=100K

Same for CO

Excitation of CO: Redshift evolution of Tcmb



$\beta = 0.007 \pm 0.027$

Conclusion

-> Go deeper in the selection of quasars:

* down into the luminosity function

* detect obscured quasars

* big survey for more DLAs: BOSS -- 21cm

-> GRBs

Baryon Oscillation Spectroscopic Survey (BOSS)

Started sept 2009

Part of SDSS-III, BOSS uses redshifts of 1.6M galaxies (z~0.5)and Lyman-α forest of 0.16 M quasars (z~2.5) to determine cosmological parameters.

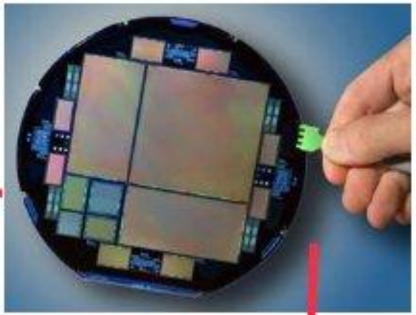
LBNL Leadership roles in BOSS:

PI: *David Schlegel*

Instrument Scientist: *Natalie Roe*

Survey Scientist: *Martin White*

SDSS telescope at Apache Point



Sloan Foundation agreed to support SDSS-III. Proposals pending at DOE and NSF. MOUs signed or in negotiations with many institutions:

Arizona	LBNL
Brazilian group	LANL
UC Irvine	MPA Garsching
UCSC	MSU
Cambridge	New Mexico State
Case Western	NYU
FNAL	OSU
Florida	Penn State
French group	Portsmouth
Heidelberg	Astrn. Inst. Princeton
Japanese group	Princeton
Johns Hopkins	Virginia
Korean Inst. Adv. Study	Wasington

Replace red CCDs on SDSS camera with w/red-sensitive LBNL/SNAP CCDs, making it possible to go to higher-z

DES: LBNL furnishes CCDs to upgrade the camera at CTIO for DES. LBNL science role: SNe and WL. Detectors for DES now in production at LBNL Microsystems Lab.

BOSS in France at IAP, APC, CEA

Chasing the quasars

* QSO target selection (from photometry) with neuronal networks:

New method -> 15 QSO/sq deg over 8000 deg : Different methods are complementary

Yeche et al., 2009, astroph/0910.3770

-> 40% success rate for z>2

•Determination of the continuum: PCA at z=3

• French Value Added Catalogue: Check identification, z, BALs and DLAs

• June13, 2011: 57,000 QSOs at z>2.15 => 150,000 => 5000 DLAs

MeerKAT Absorption Line Survey 4000 hrs to search for 21cm and OH absorbers at z<1.8.

South-Africa precursor of SKA

Array of 64x13.5m diameter off-axis gregorian dishes with wide band single pixel cryogenircreceiver.

High point sourve sensitivity and wide band coverage.

Principal Investigators

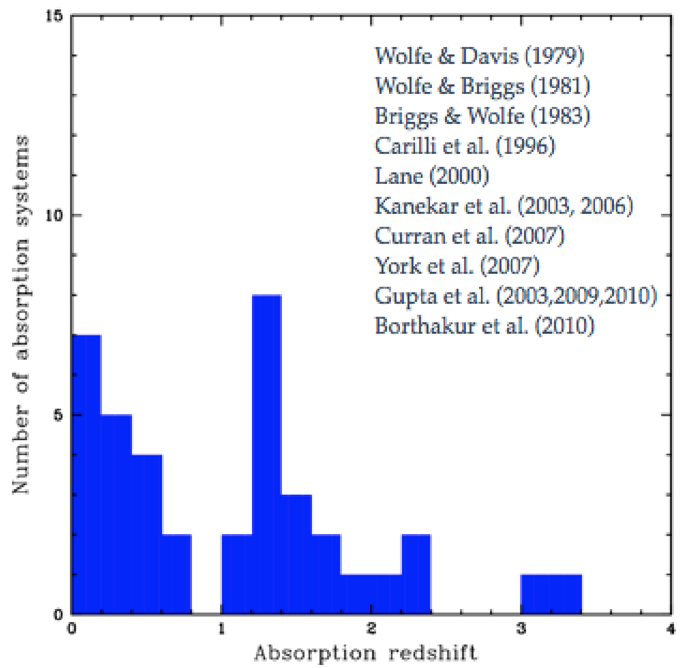
Neeraj Gupta (ASTRON, NL), Raghunathan Srianand (IUCAA, INDIA)

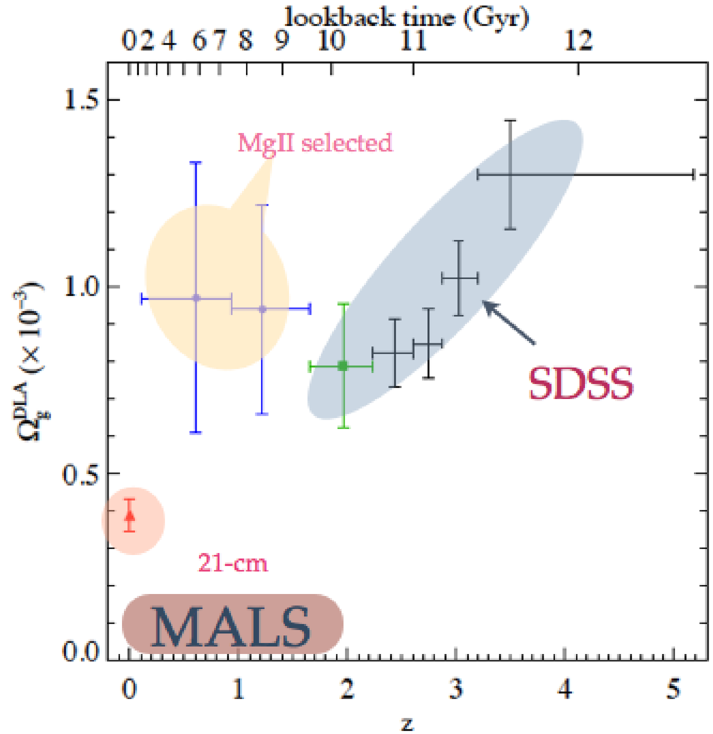
Co-Investigators (19)

Europe:	F. Combes (Observatoire de Paris), W. Baan, R. Morganti, T. Oosterloo (ASTRON), P. Petitjean (IAP), T. van der Hulst (Kapteyn)
Chile:	C. Ledoux (ESO), P. Noterdaeme (Universidad de Chile)
India:	D. Bhattacharya, A. Kembhavi (IUCAA)
S. Africa:	C. Cress, M. Jarvis (Univ. of Western Cape), K. Moodley (Univ. of KwaZulu Natal)
USA:	A. Baker (Rutgers), S. Bhatnagar, C. Carilli, E. Momjian (NRAO)
UK:	R. Beswick (Univ. of Manchester), H. Klockner (Univ. of Oxford)

Image credit: E. de Blok (http://www.ast.uct.ac.za)

Intervening 21-cm absorbers from MALS





39 absorbers known till date. Only 12 at z<0.4.

Finally, only 5 molecular absorbers known at z>0.1.

Comparable to SDSS DR7-DLA survey in redshift path.

MALS detects > 600 intervening 21-cm absorbers @ z< 1.8

MALS: Goals

1) Blind search for 21cm and OH absorbers at $z<1.8$:
   using 580- 1750 MHz frequency band(s).
2) Detect more than ~600 intervening 21-cm absorbers:
   20 times the number of absorbers known.
3) Measure the evolution of cold atomic and molecular gas at $z<1.8$:
   the z-range where most of the evolution in SFRD takes place.
4) Time variation of the fundamental constants of physics:
   using OH lines, and 21-cm and optical/UV absorption lines (SALT + VLT + ALMA).
5) Probe the magnetic field in absorbing galaxies:
   using rotation measure and Zeeman splitting.
6) Synergy with ALMA, EVLA, SALT, VLBA and VLT.

.... all the data will be public.

Conclusion

Save high resolution spectroscopy at ESO !

Thank you !