Damped Lyman-α systems in QSOs and GRBs

-> Revealing the ISM of high-z galaxies

* The need for high-spectral resolution for GRBs

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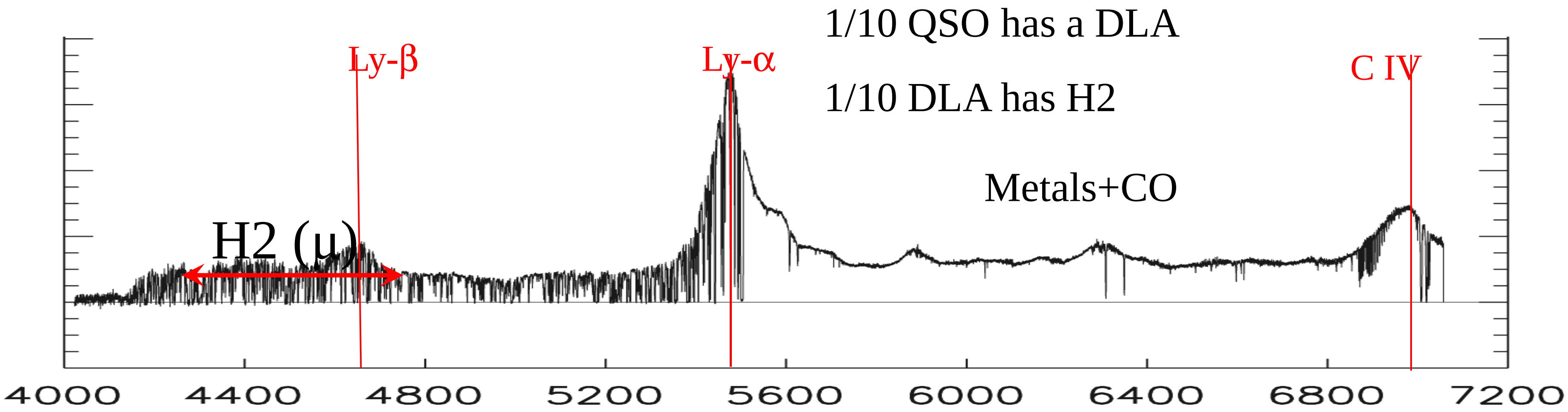
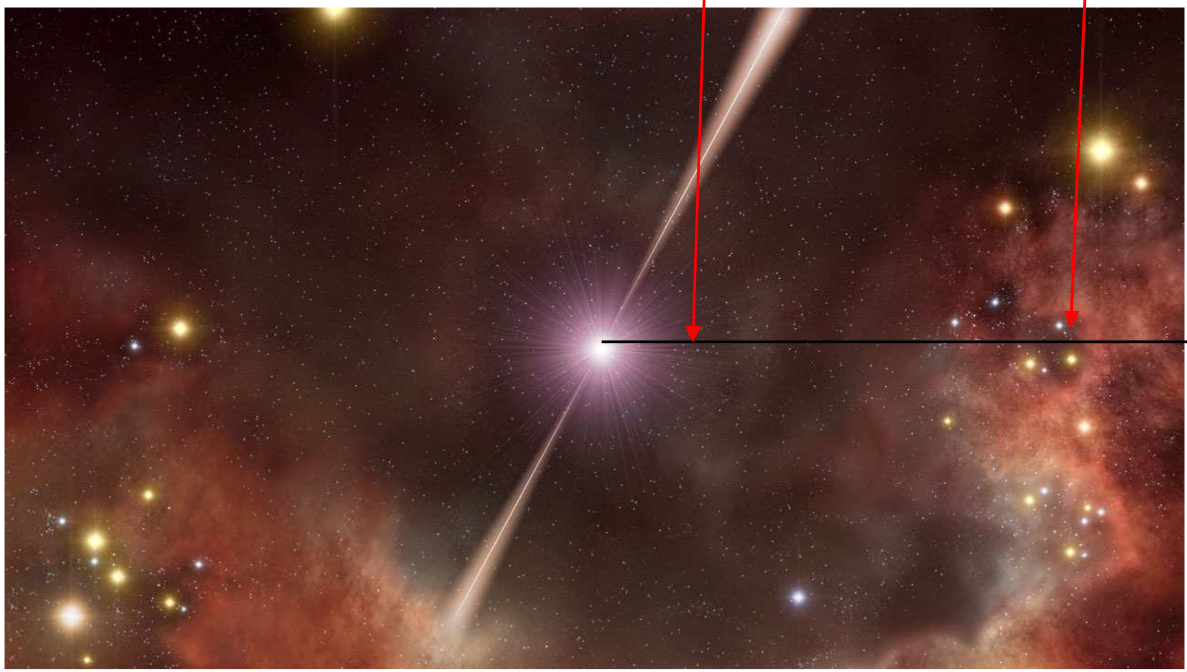


Ejecta – Wind ?

Kinematics ?

The ISM of the host galaxy:
Ionized by the GRB ?



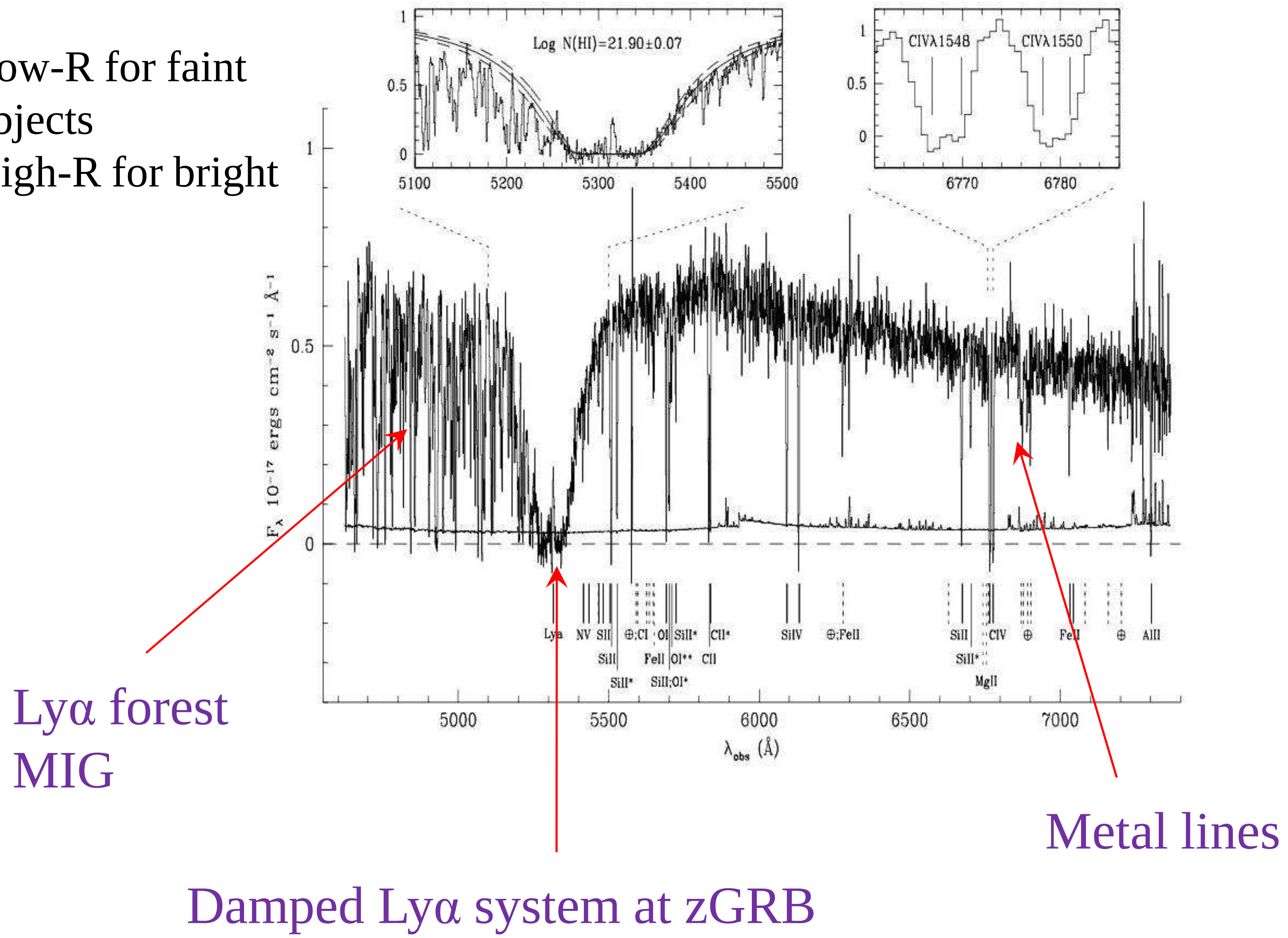
Space and

History

The OB
server

Spectroscopy (any resolution) of the afterglow

Low-R for faint objects
High-R for bright



DLAs in GRBs vs DLAs in QSOs

- No difference in the physics between QSO and GRB DLAs

  Low and medium resolution is a problem

- QSO-DLAs and GRB-DLAs do not arise in the same gas:

  -> QSO-DLAs are located in the halo and/or the disk (random los)

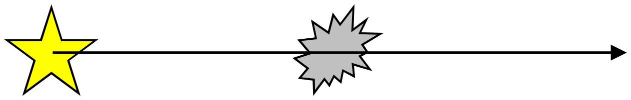
  -> GRB-DLAs are more likely to be in the disk

- GRBs : You don’t know exactly where is the gas but the galaxy is nearby

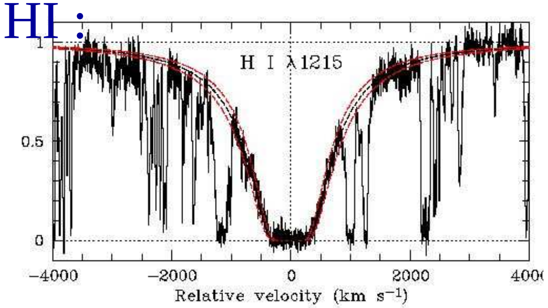
  (and you can see it)

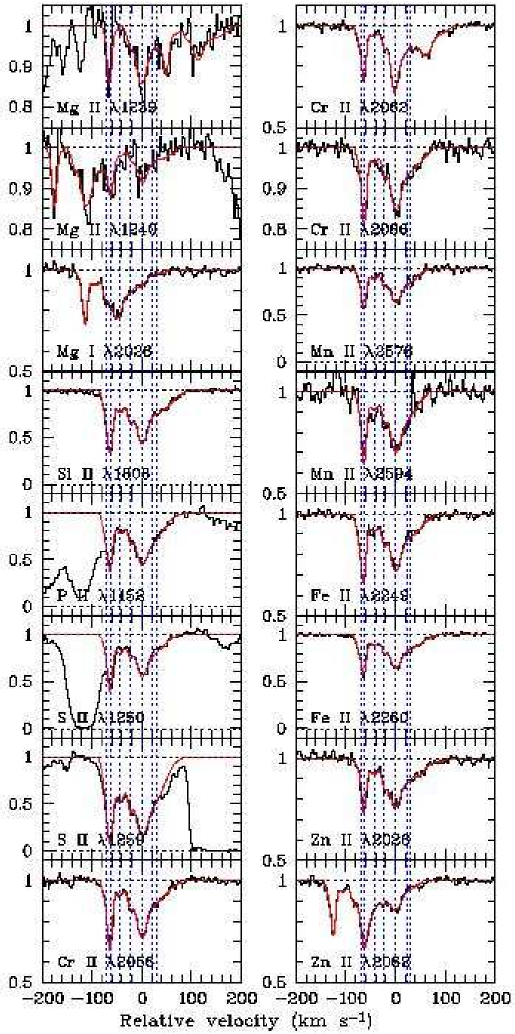
- Relate the properties of the absorption gas with that of the galaxy
- Origin of GRBs (progenitor and environment)

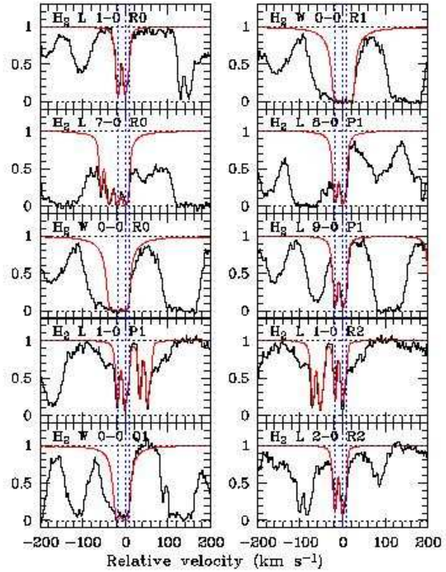
Damped Ly-α Systems



HI :







Metals :

-> Metallicities

-> Dust content

-> Kinematics

Star- Formation ?

Winds ?

Molecules H2 + CI, CI* :

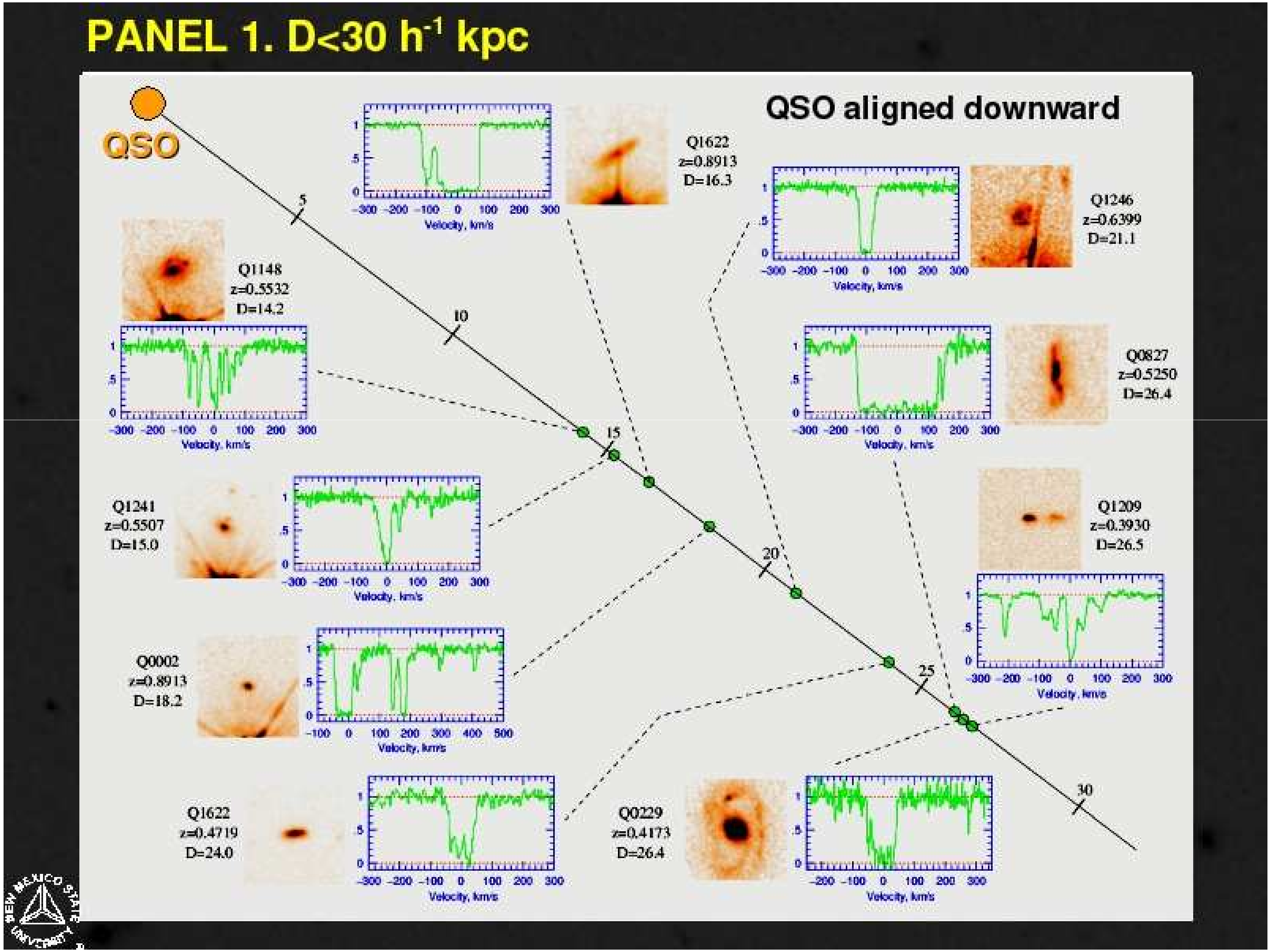
-> Density/Temperature

-> UV flux (excitation)

+ Other molecules: HD+CO

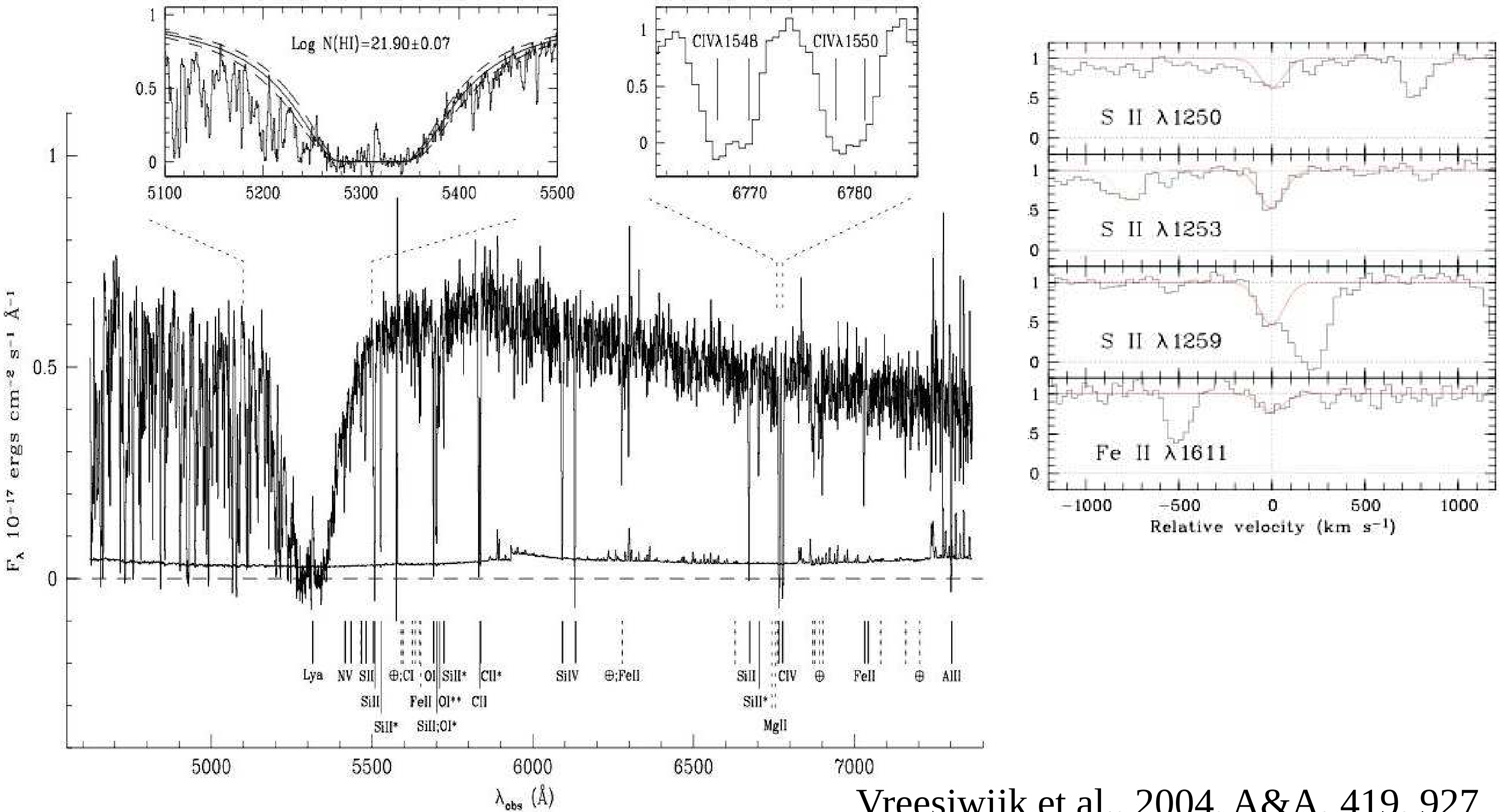
Complex profiles +
narrow lines => High Res

DLAs in QSOs : Diffuse phase -> Galactic halos



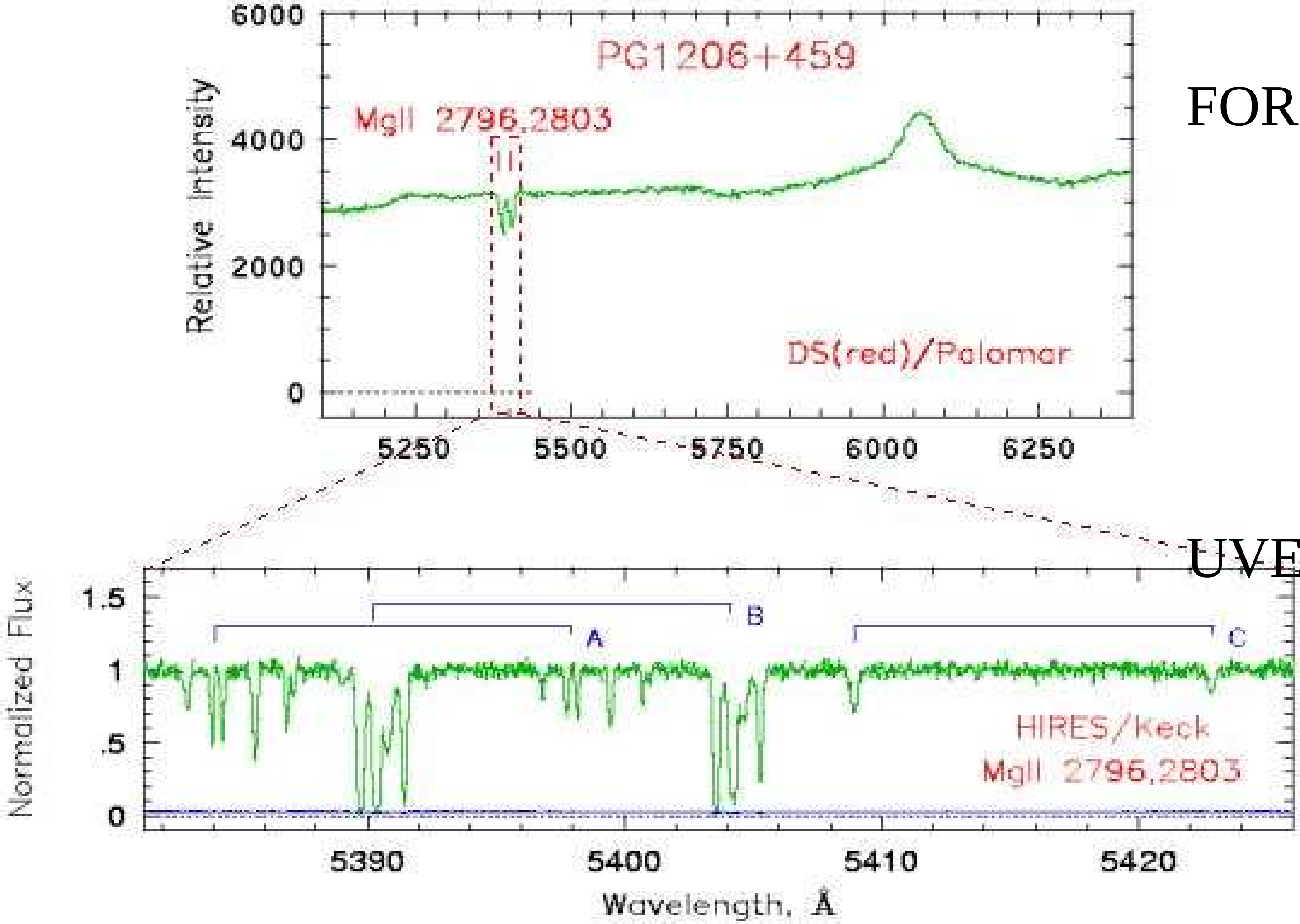
DLAs towards 030323 -> Metallicities

- logNHI=21.9   Z=-1.47 solar
- Resolution : 2100   20 times too small
- Curve of growth -> need a lot of lines both optically thin and thick



Vreesjwijk et al., 2004, A&A, 419, 927

We require high resolution spectra...



FORS

UVES

UVES R=40000 X-Shooter R=7000 … Be careful.

b small -> saturation happens for low column density
Errors can easily be as large as 2dex

-> Large number of absorption lines of the same species

bmetals < 3 km/s

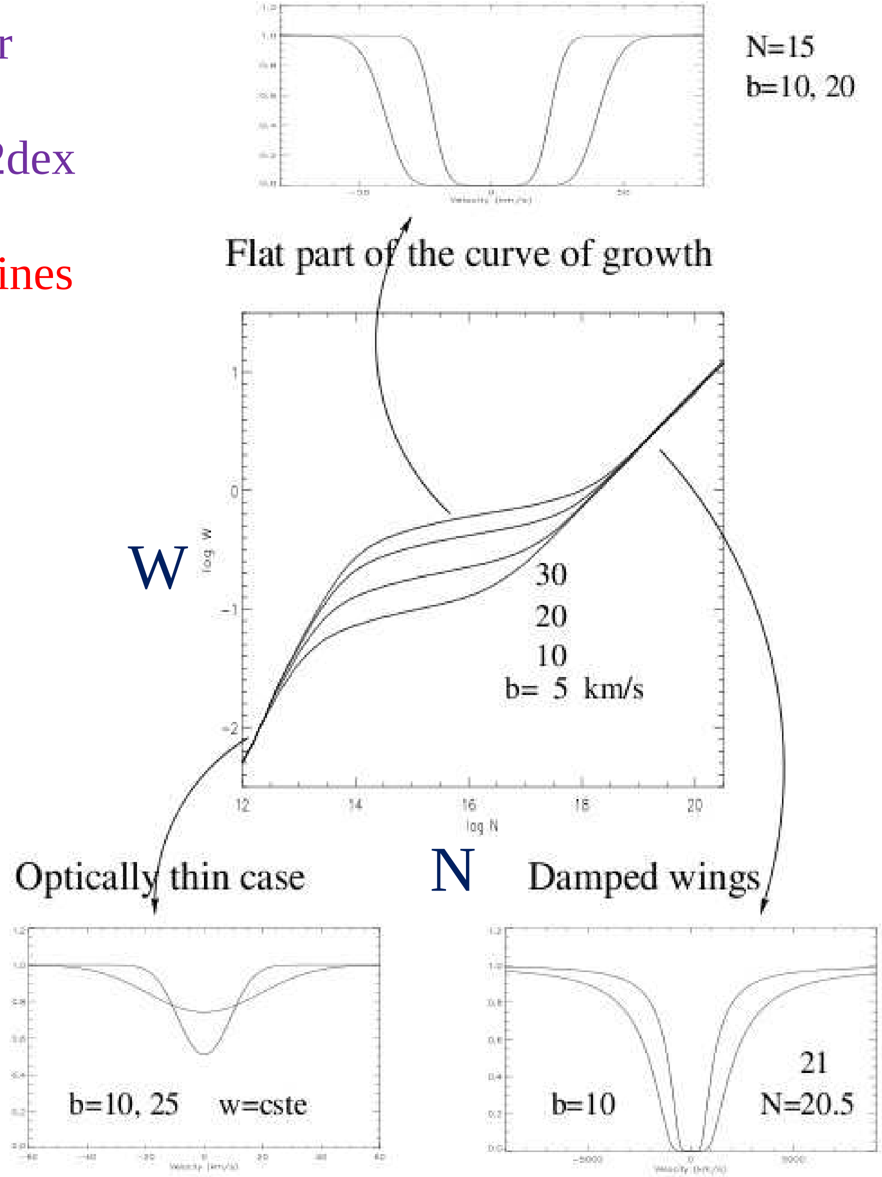
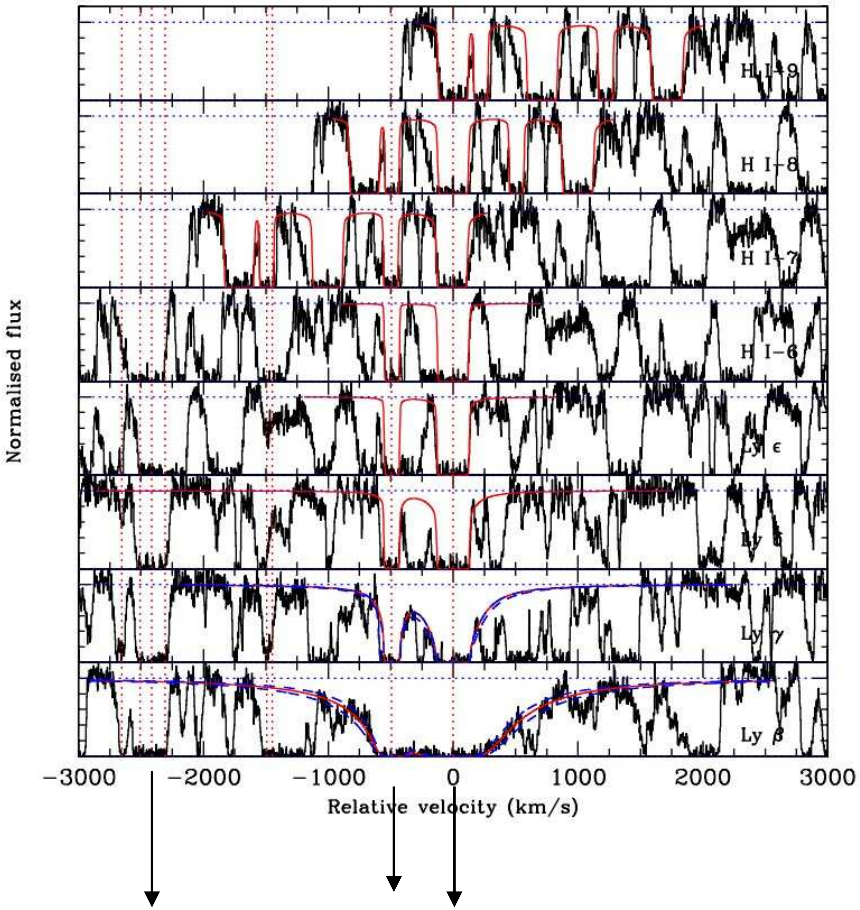
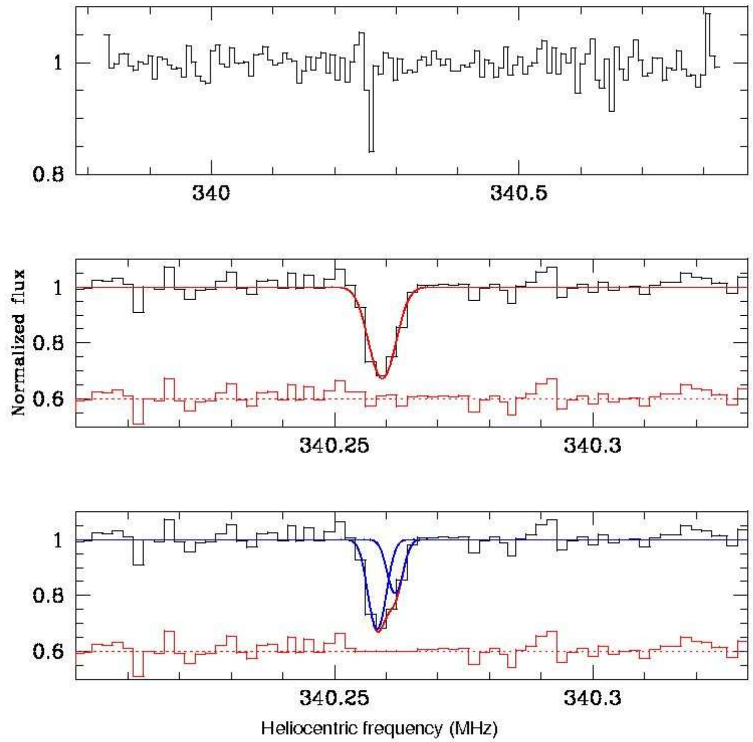


Illustration: DLAs at the redshift of the quasar (z=3.17)

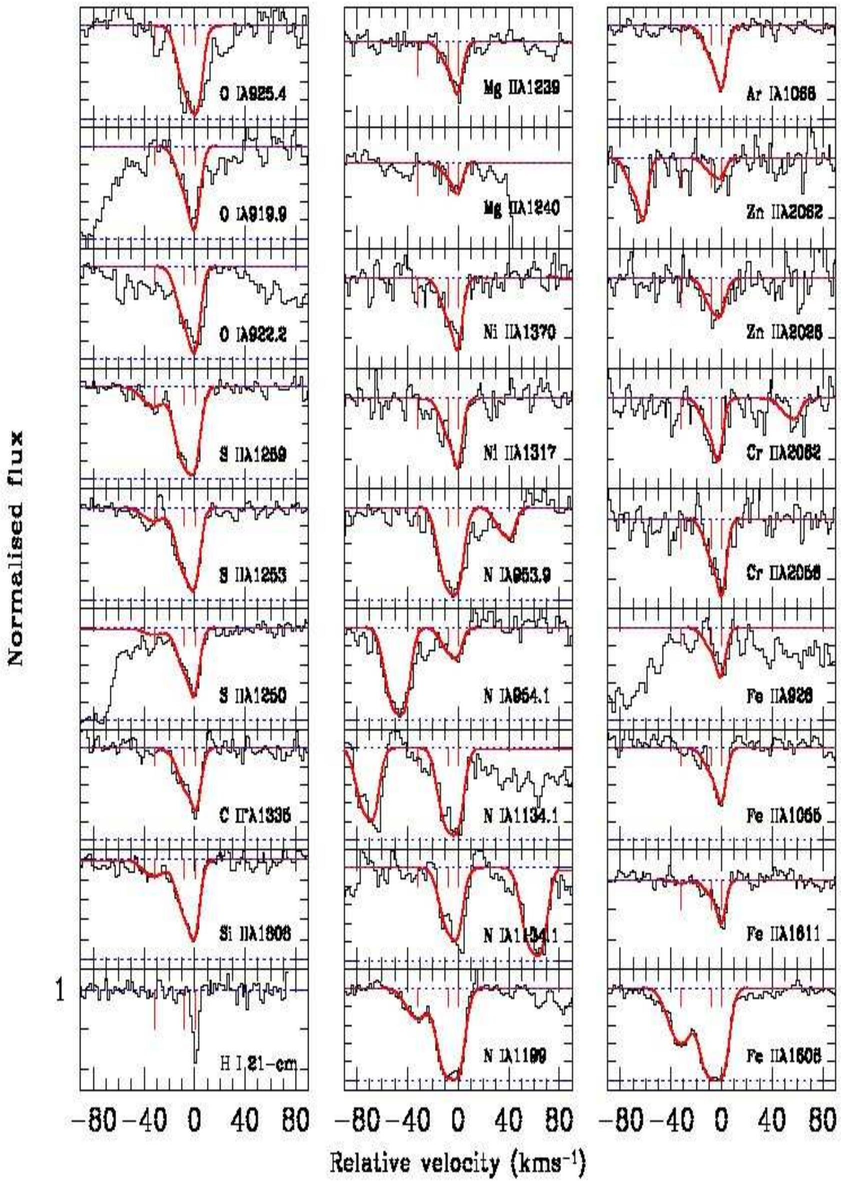


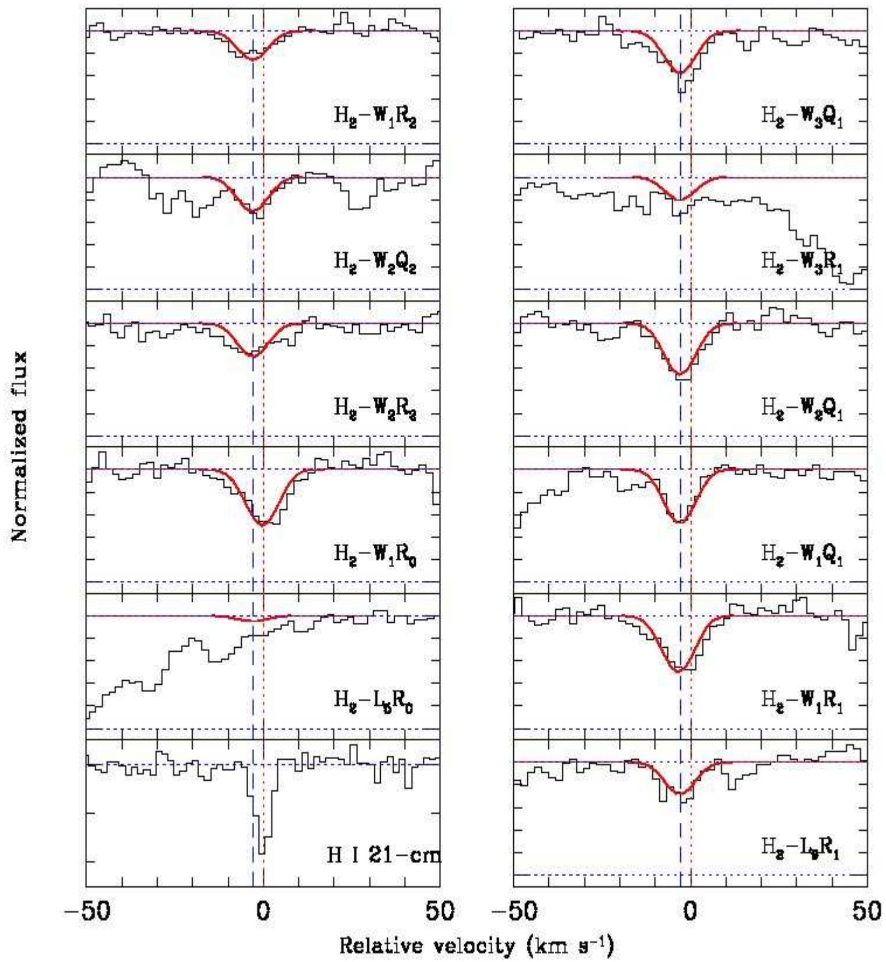
3 (sub)DLAs at the redshift of the quasar



21cm absorption (GMRT) -> GRB?

H_2 absorption





Shift between H2 and 21cm

Most of species have much broader widths

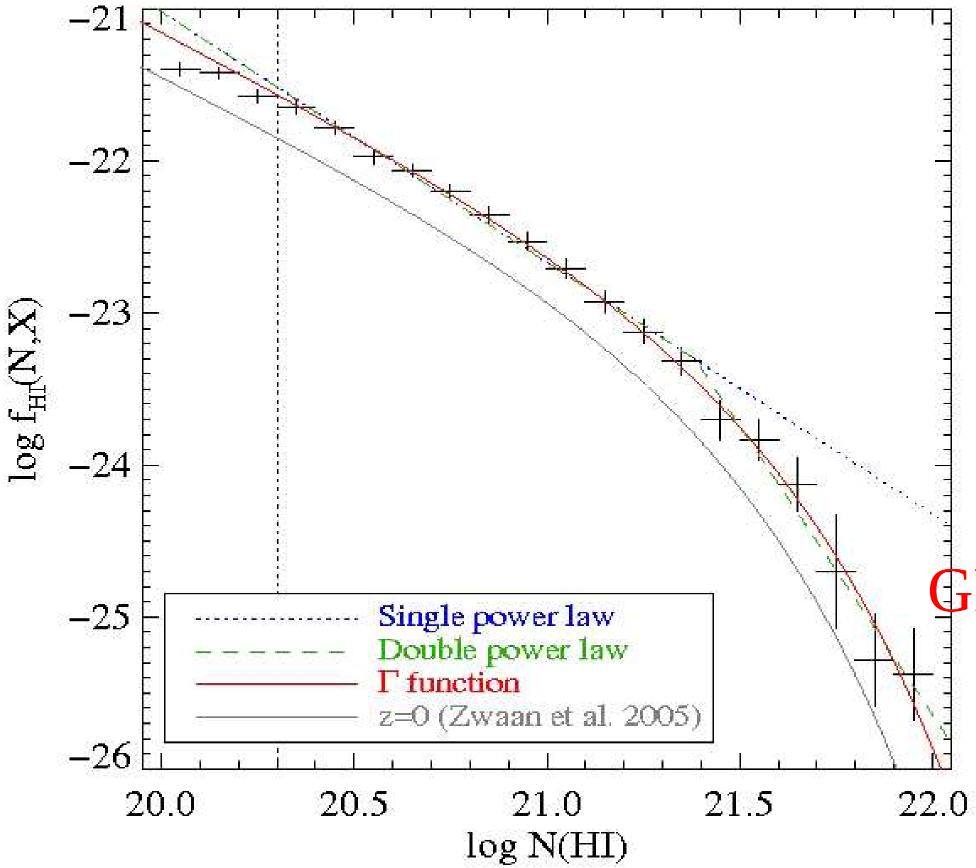
-> should be careful

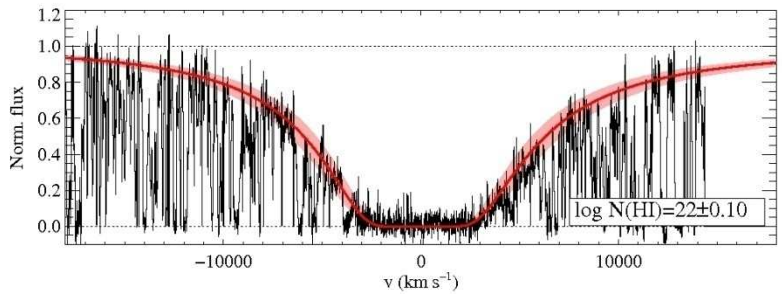
Srianand et al. 2010 , MNRAS, 405, 1888

NHI distribution function

SDSS 900 DLA Systems -> 10x more in Boss survey (2014)

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





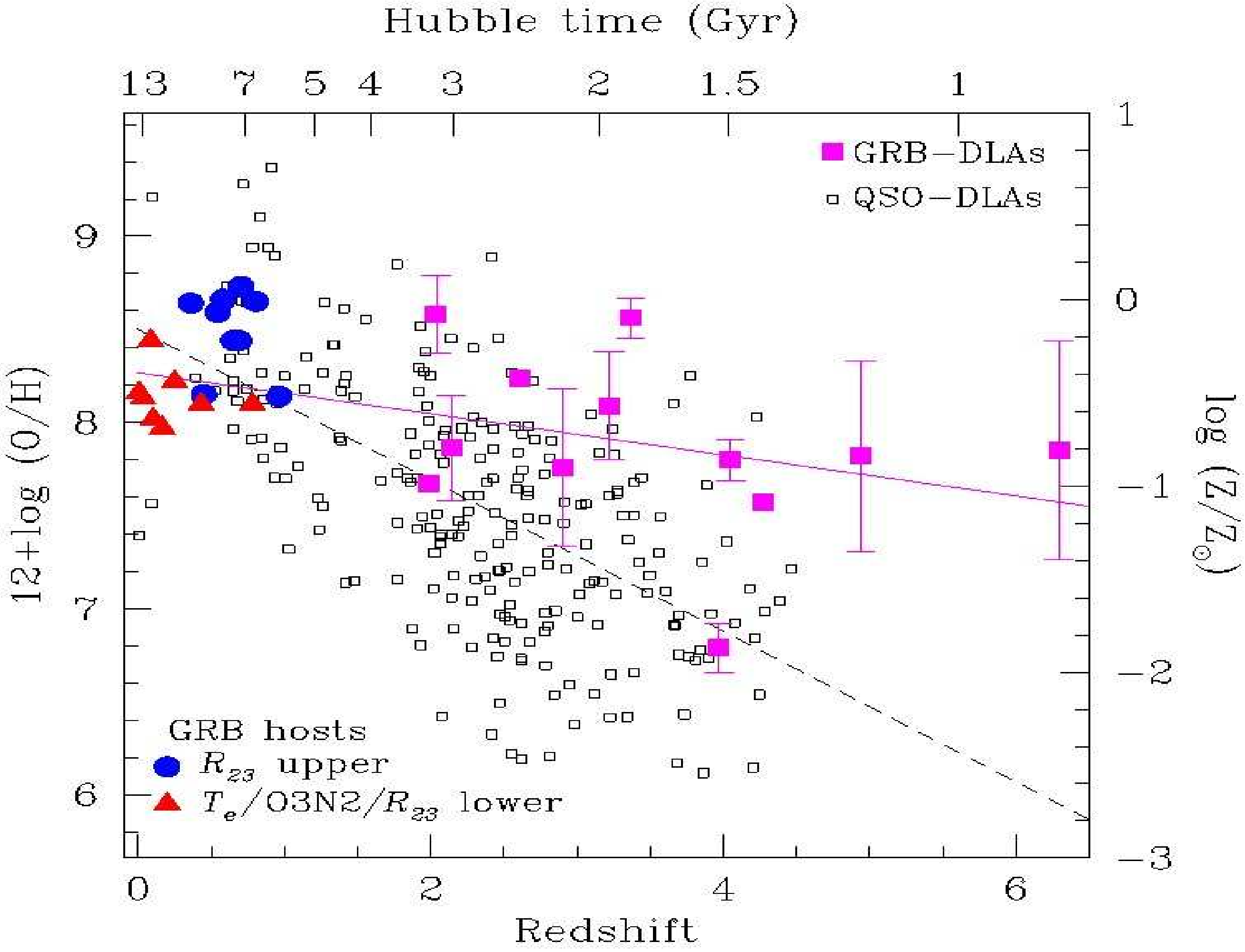
Highest column density known
logNHI = 10**22 cm-2

GRBs but some with low NHI

Similar shape at z=0 and z=2.5

Metallicity

Savaglio et al. (2007)

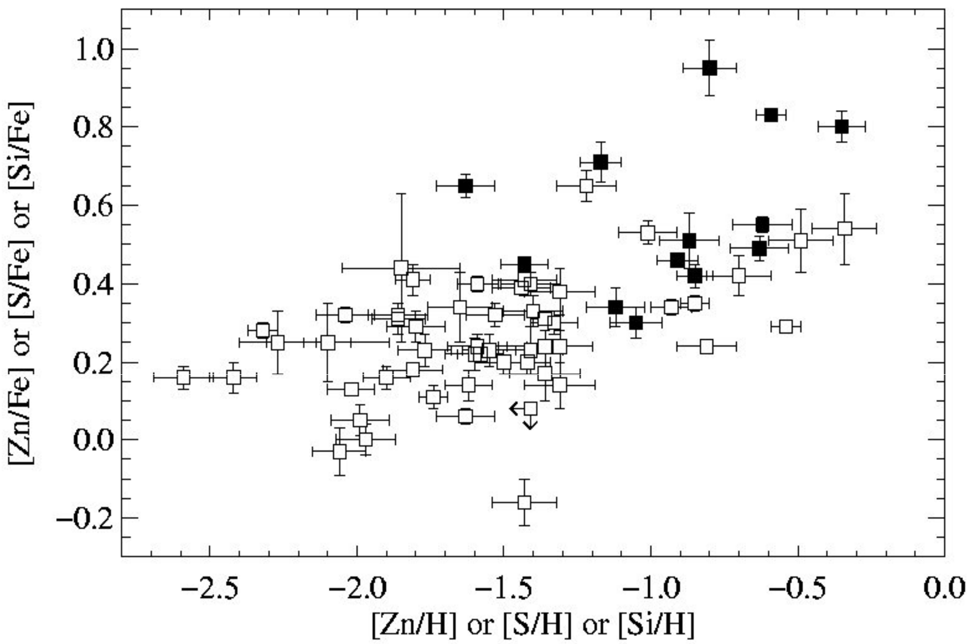


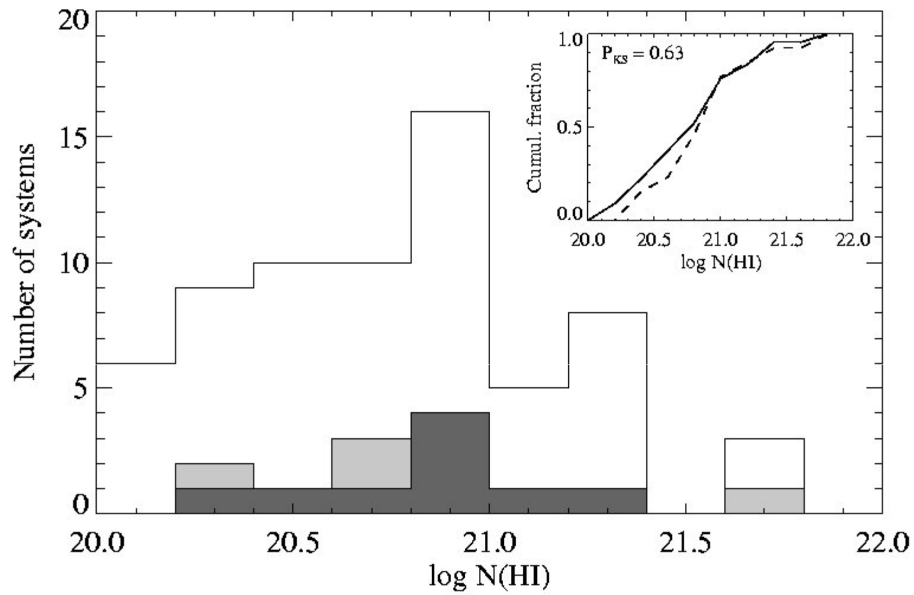
•Although there are very low-Z GRBs, most have higher metallicity

•NOT surprising: disk-gas has higher metallicities

Search for molecules in QSO-DLAs (more like GRBs)

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



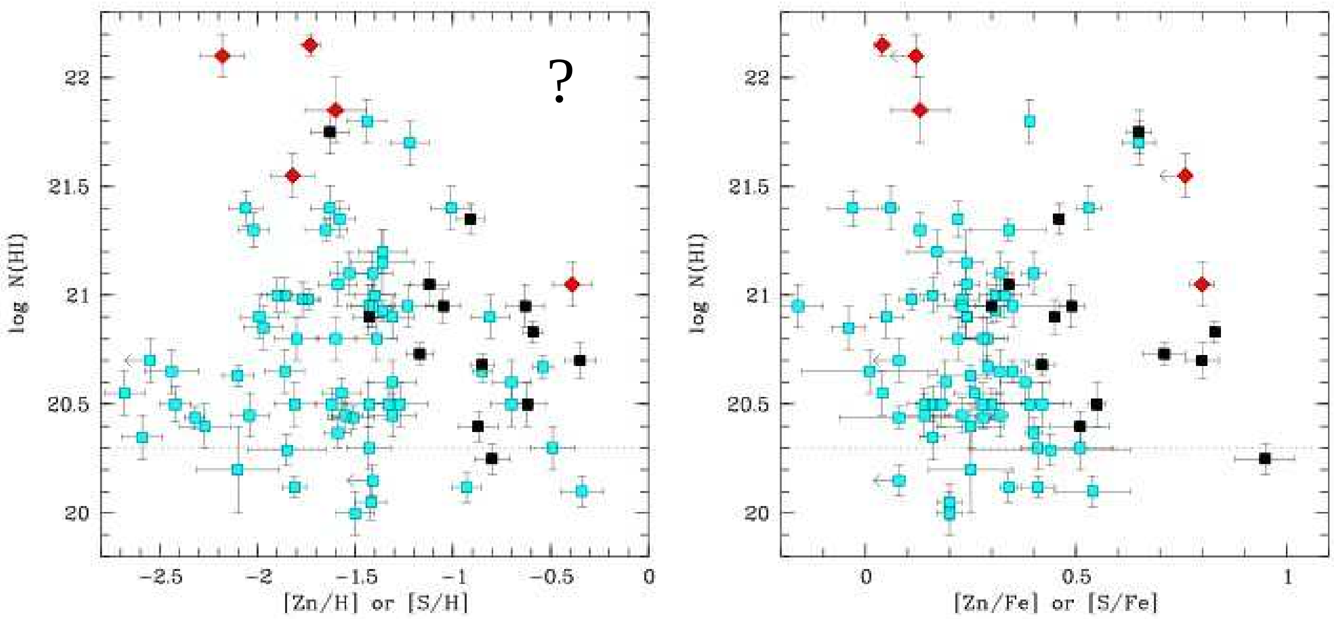


- Correlation Depletion ([Zn/Fe]) vs Metallicity ([Zn/H])

- Presence of H2 is NOT correlated with NHI

H2 GRB-DLAs

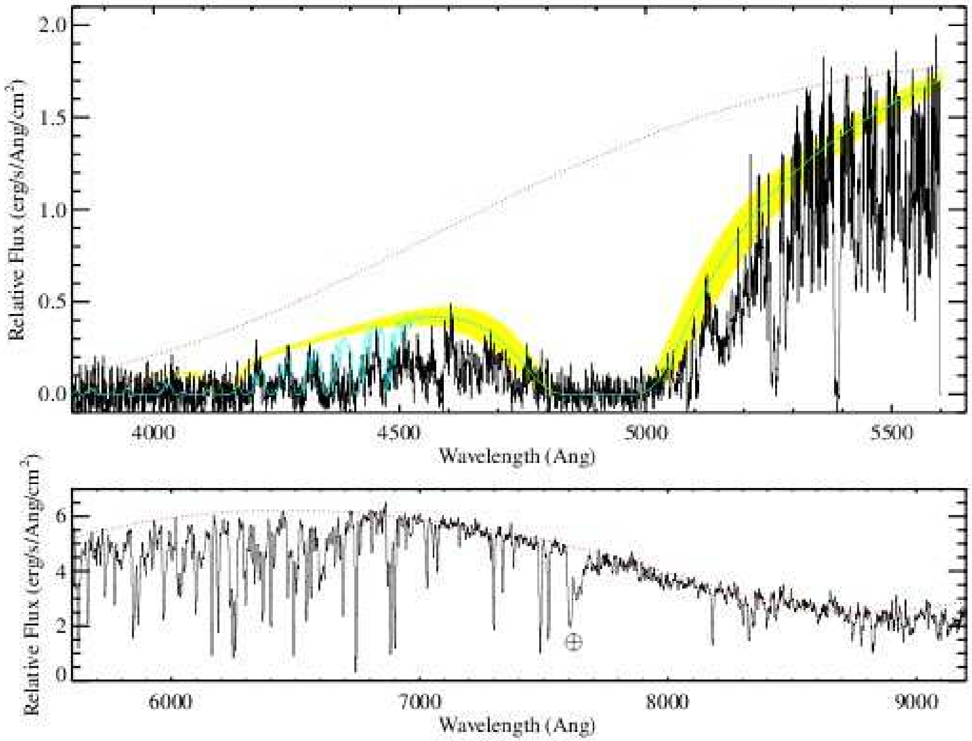
Ledoux et al., 2009, A&A, 506, 661

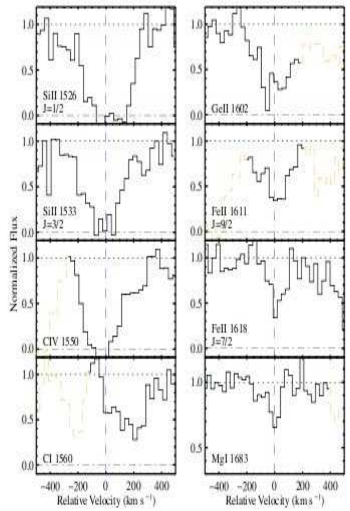


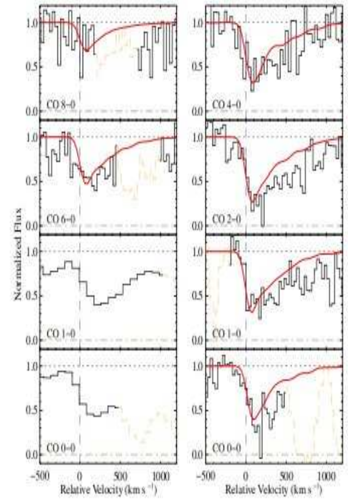
GRBs observed with UVES do not show H2 when they are expected to given metallicities and dust content => Bias against dust content (extinction)

GRBs: Unique to correlate emission and absorption

H2 and CO in GRB080607   z=3.036







Log NHI = 22.7 Estimate of NH2 : 21.2 CO: 16.5; A(1100A) = 8 mag

Res : R=2800

Tco>100 K; 10<TH2<300K

N highly uncertain

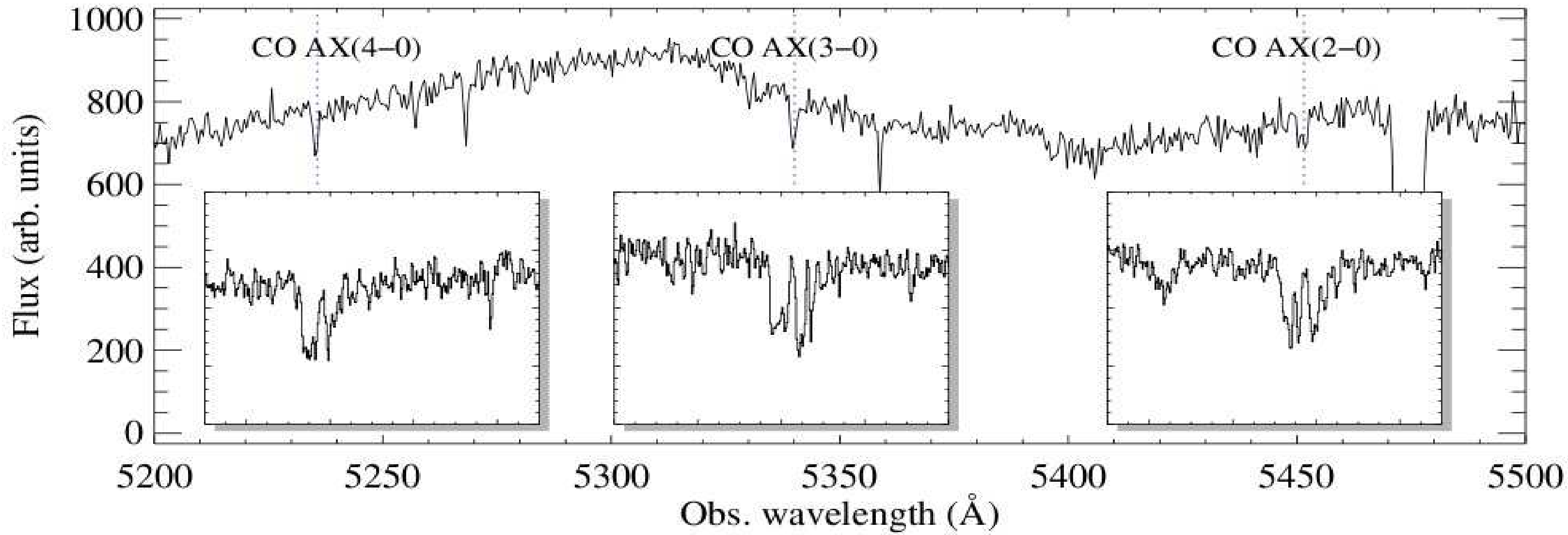
Pb here: trade-off between resolution (UVES) and extinction (X-shooter)

Complementarity

Prochaska et al., 2009, ApJ, 691, L27

X-shooter detection vs UVES analysis

X-shooter : Low res

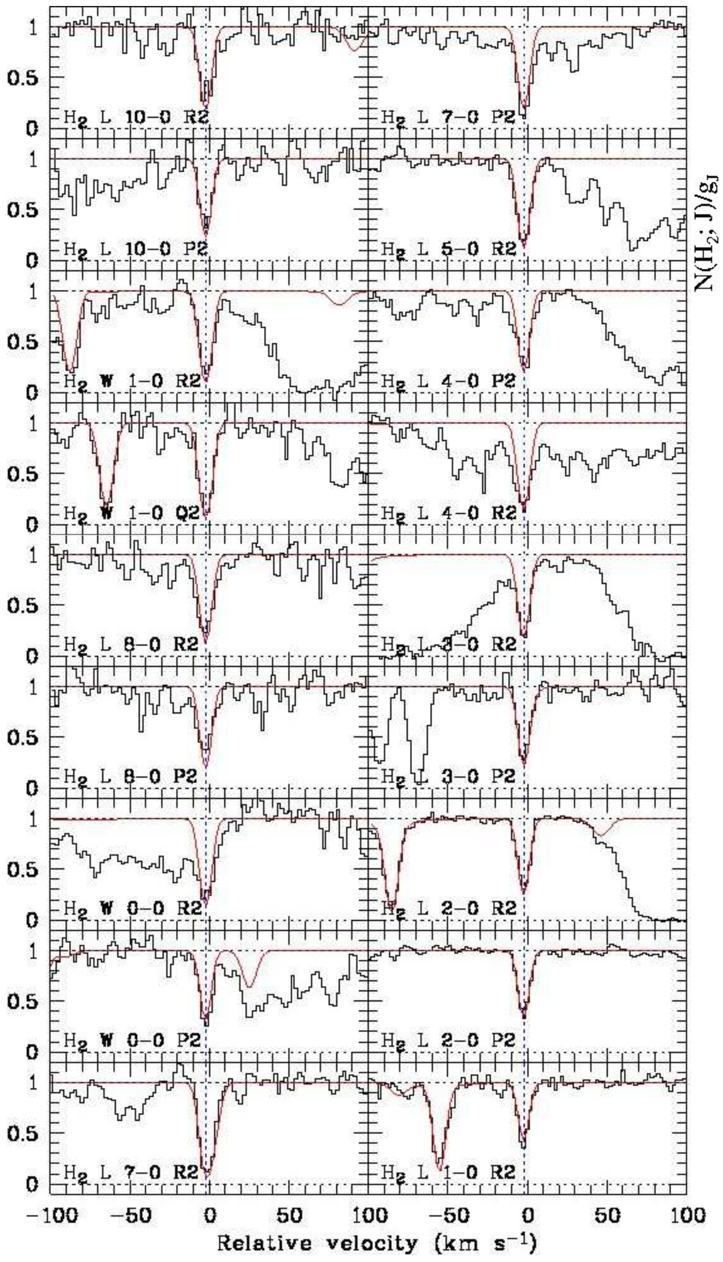


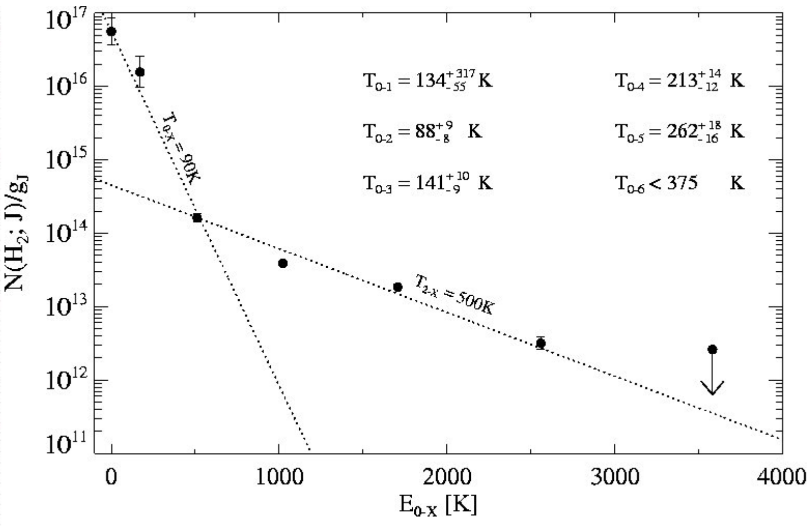
UVES : High res

High resolution data are needed to derive physical

conditions in the gas

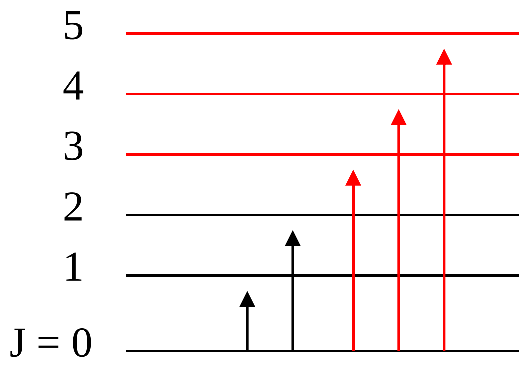
Detailed physics: Heating processes





Two temperatures

No velocity shift



Fluorescence -> UV flux

Collisions -> Tk, density

CI+ CI*

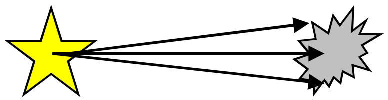
Doppler parameter increases with J

Fluorescence due to the afterglow

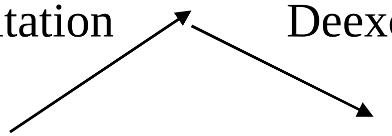
Vreeswijk et al. 2009,
A&A, 468, 83

Excitation of fine structure levels : FeII, NiII

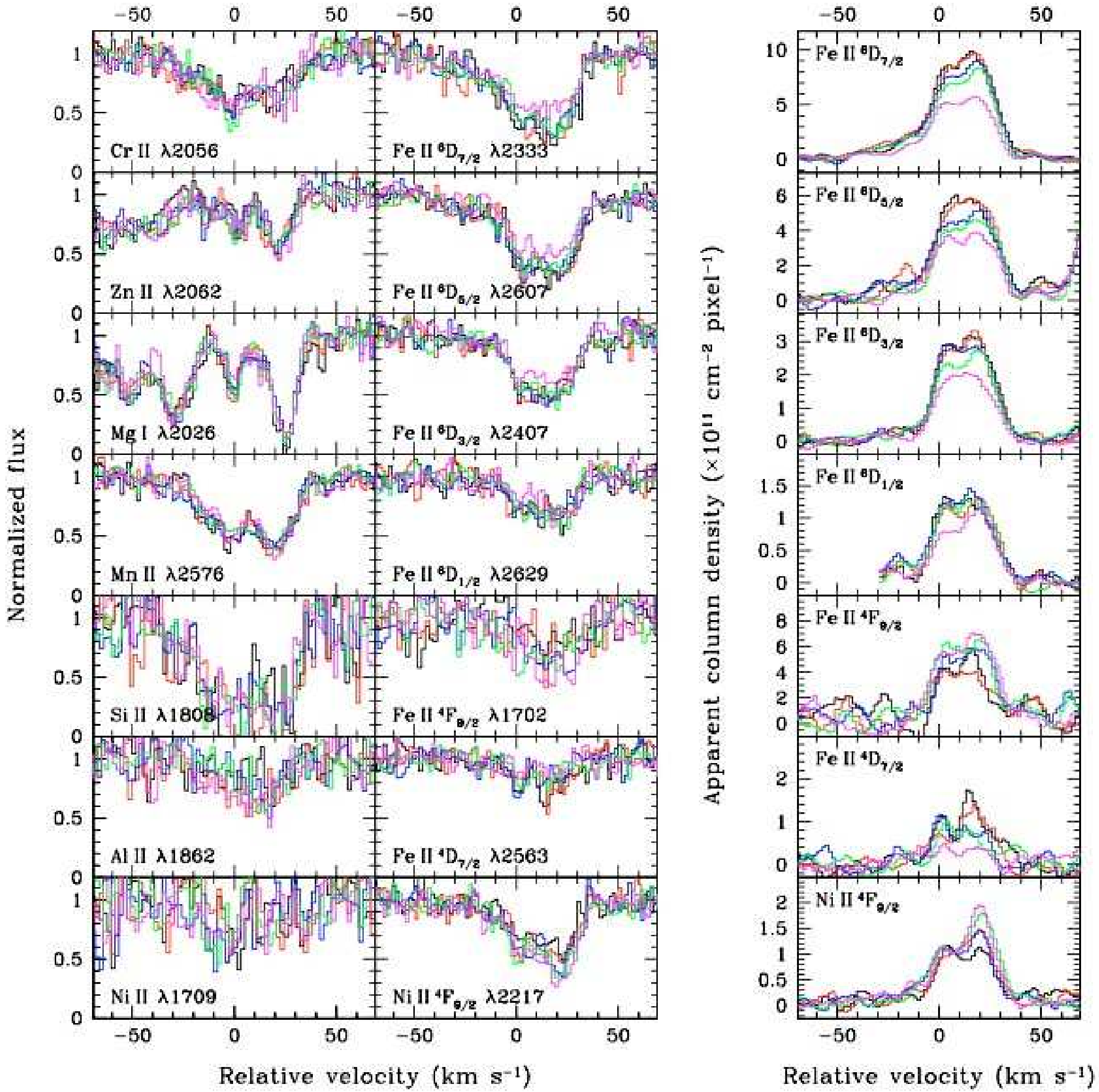
High resolution fast reaction



Excitation



Deexcitation



Fluorescence due to the afterglow

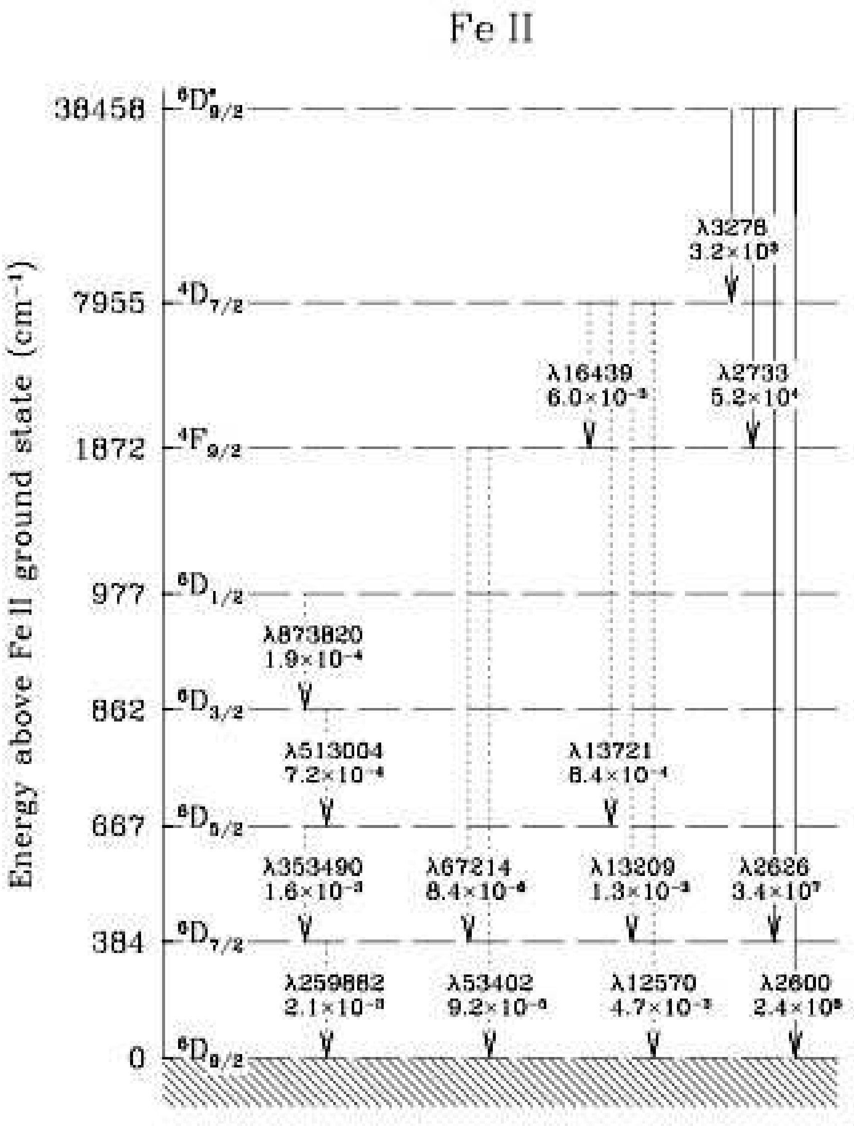
Modelling the excitation:
•Collisions
•IR radiative excitation
•UV Fluorescence

Excitation of fine structure levels :
FeII, NiII

-> Distance ~1 kpc
Seems large

MgI => d>50pc

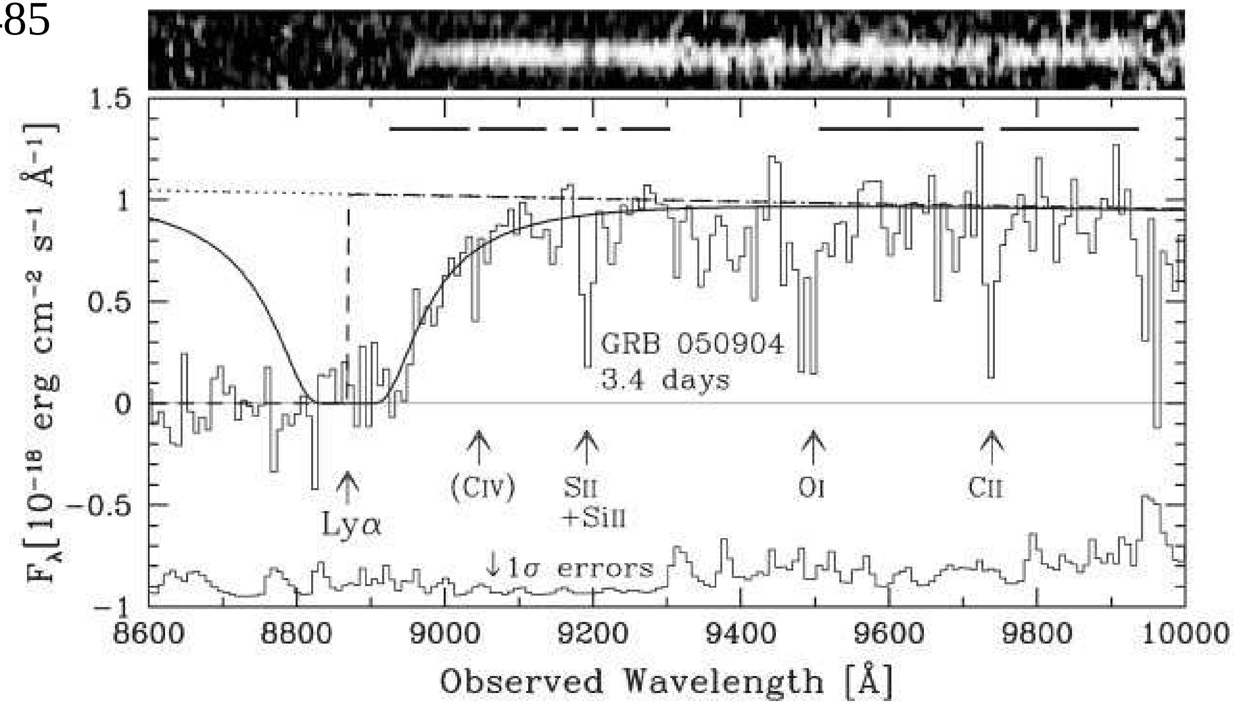
Pb with the shape of the continuum because of screening by gas you don't know



Difficult but beautiful physics

DLA from the IGM at the highest redshift

Totani et al. 2006, PASJ, 58, 485



In principal low-resolution is enough (IR).

However, metals further away in the red

Intervening (MgII) absorbers

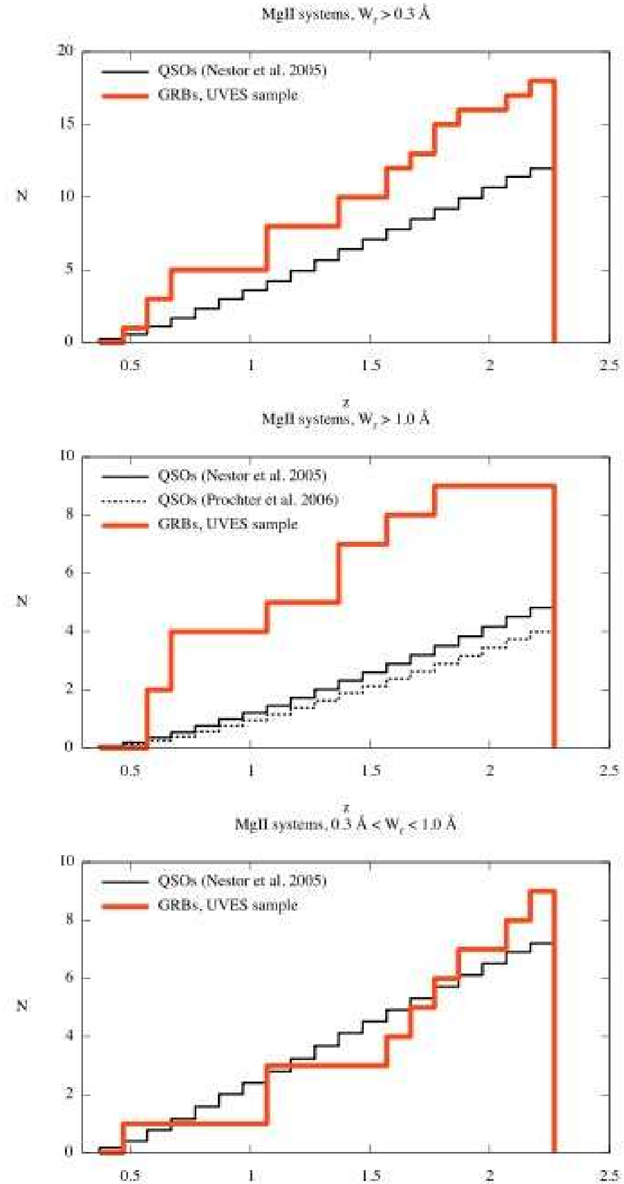
Vergani et al. 2009, A&A, 503, 771

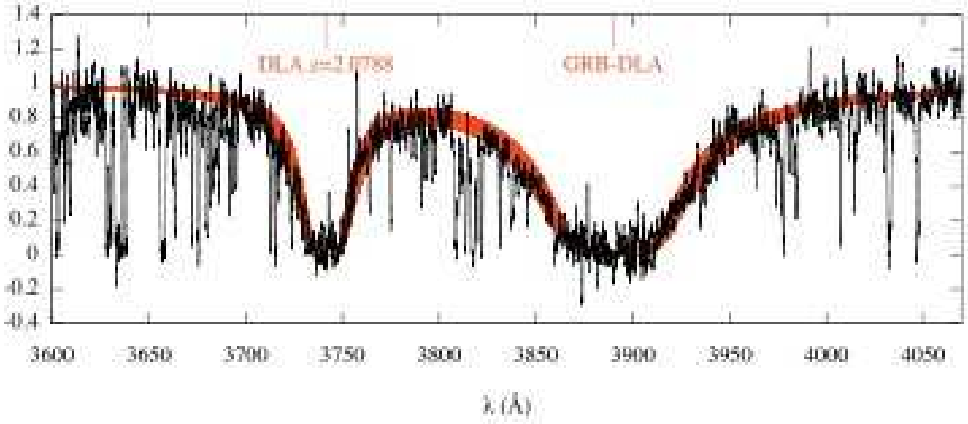
Nb of strong MgII systems is larger towards GRBs (lensing effect ?)

-> same towards BLLac (Bergeron et al. 2010)
(ejection ?)

In principal low-resolution is enough.

However, detailed study of the ejecta and/or environment





Conclusions

High resolution needed

- Physics of the ISM : Metallicities + Molecules
- Fluorescence due to the afterglow -> Flux + absorbing gas in the ejecta

- High-z : DLA from the IGM – metals at very high-z

- Low-resolution : Statistics

- For both: Relation with galaxies

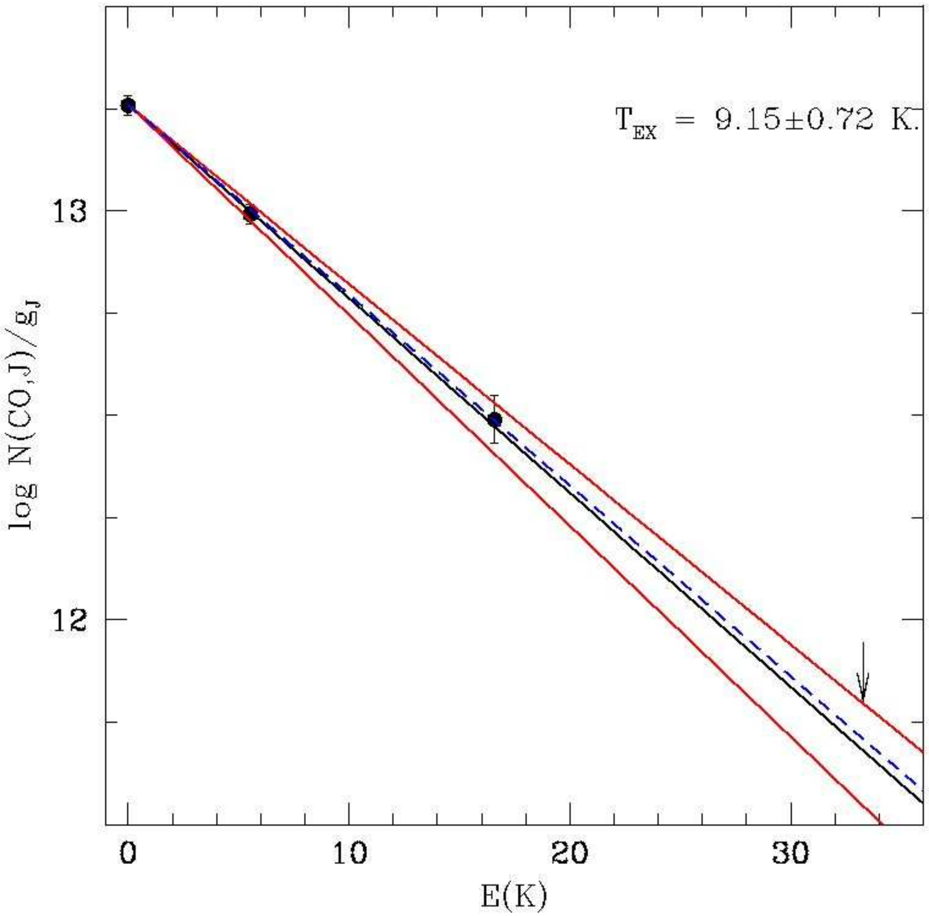
- Should not try to do galaxy evolution but stay specific to GRBs

…….. Except at very high-z…………..

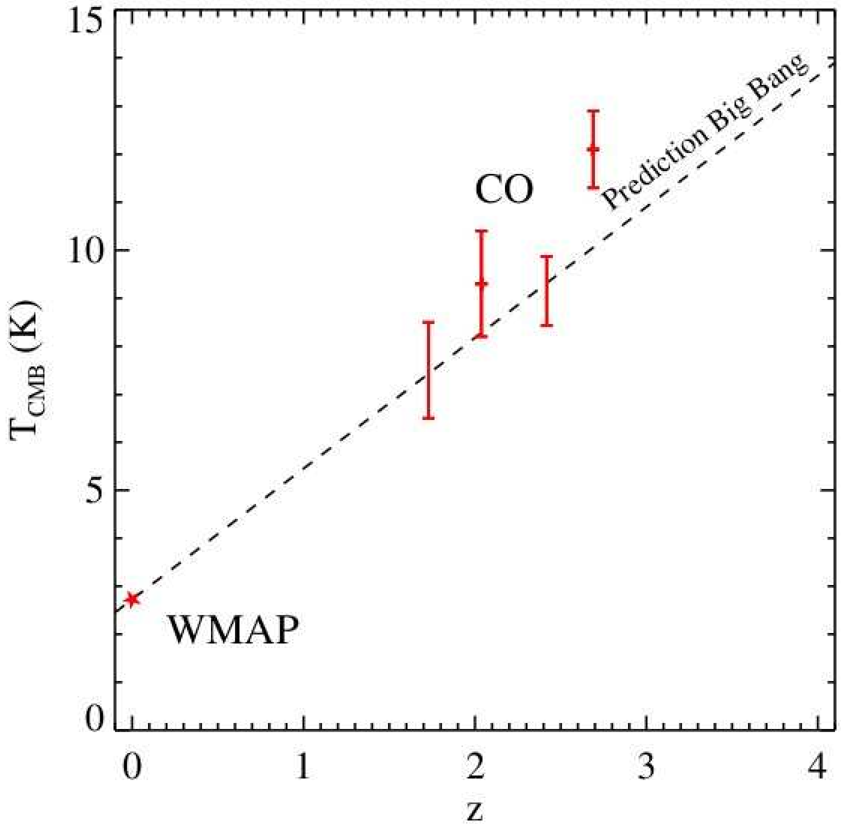
(should be ready)

Tcmb vs redshift

CO excitation temperature

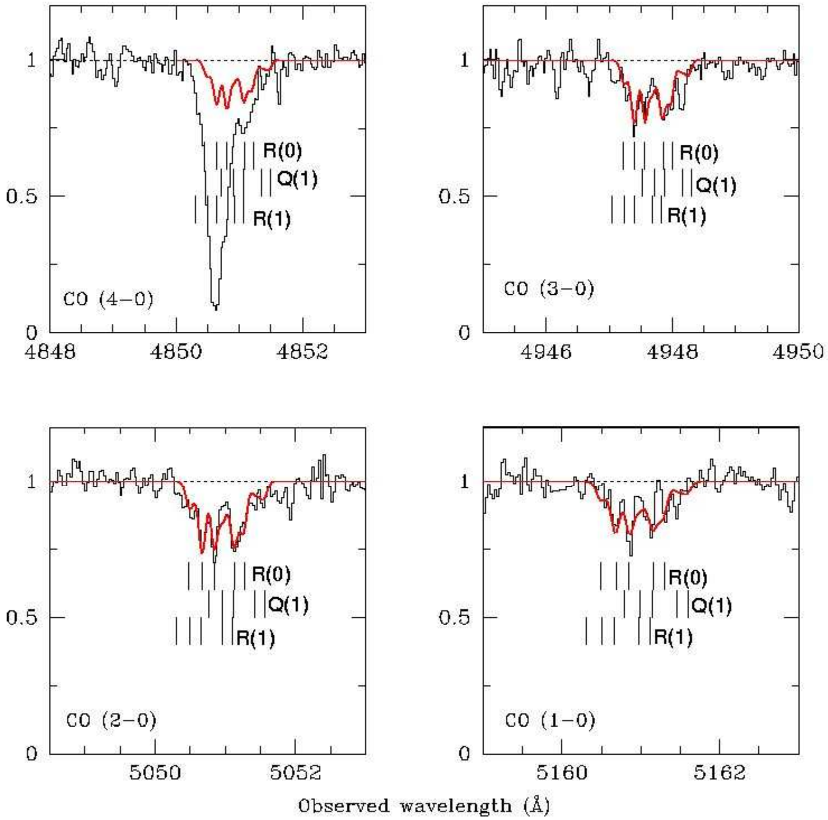


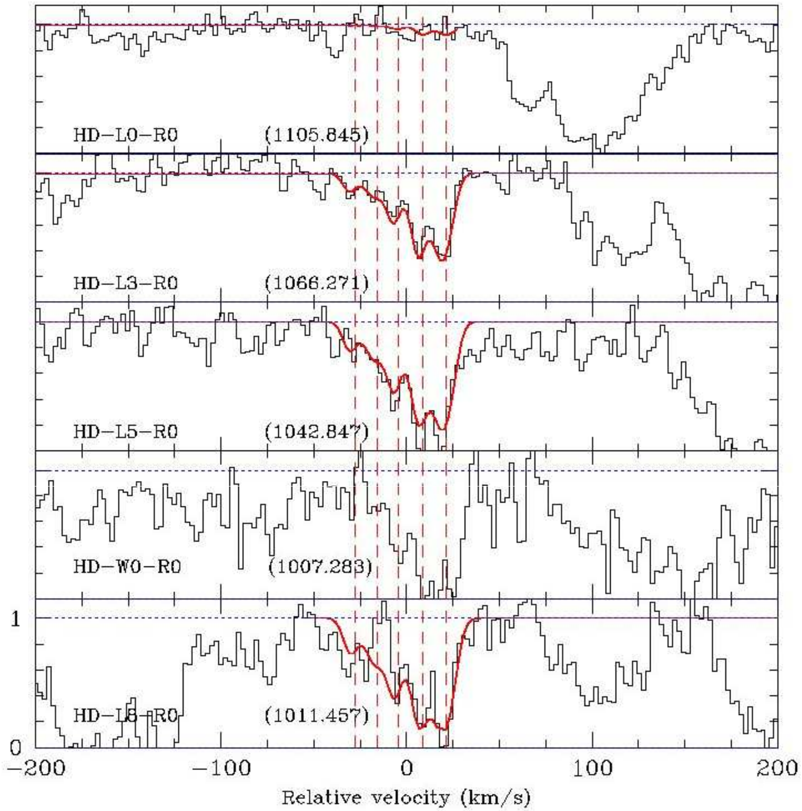
Microwave background temperature



CO and HD -> 6 detections

z=2.42 ; [S/H]=-0.07; [Fe/S]=-1.33





$CO/H2 = 3x10^{-6}$

$HD/2H2 = 1.9x10^{-5}$ (>Galactic local ISM) -> Low astration (primordial $2.8x10^{-5}$)

Srianand et al. (2008) A&A, 482, L39 - Noterdaeme et al. (2008) A&A, 491, 397

DLAs in QSOs -> Far away

Churchill et al.