Star formation in damped Lyα selected galaxies

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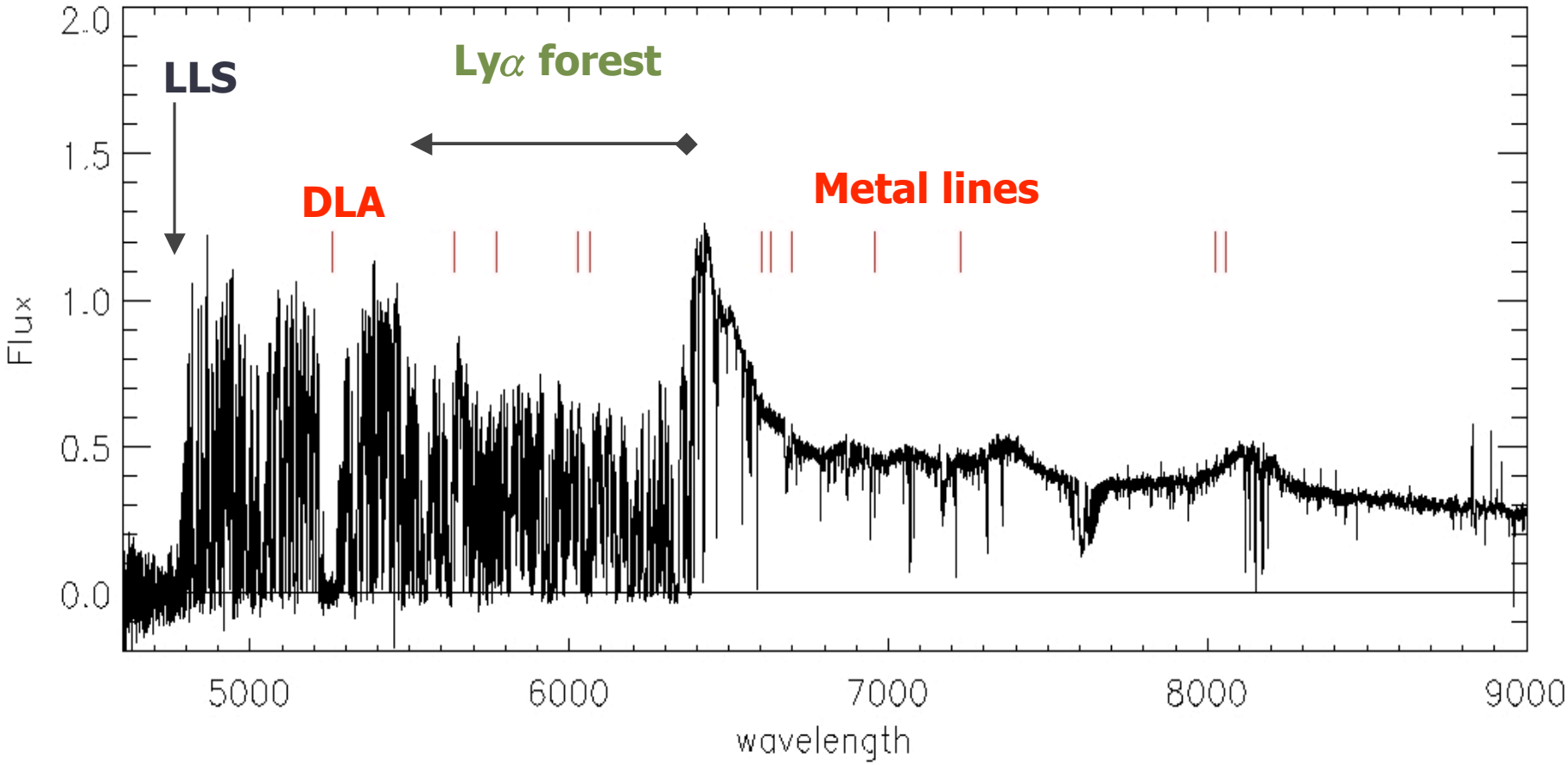
Fellow since Oct. 05

Quasar absorption lines

Lyα forest : $N(\mathrm{H\ I}) < 10^{17}$ cm^{-2}

LLS : $10^{17} < N(\mathrm{H\ I}) < 2\mathrm{x}10^{20}$ cm^{-2}

DLA : $N(\mathrm{H\ I}) > 2\mathrm{x}10^{20}$ cm^{-2}



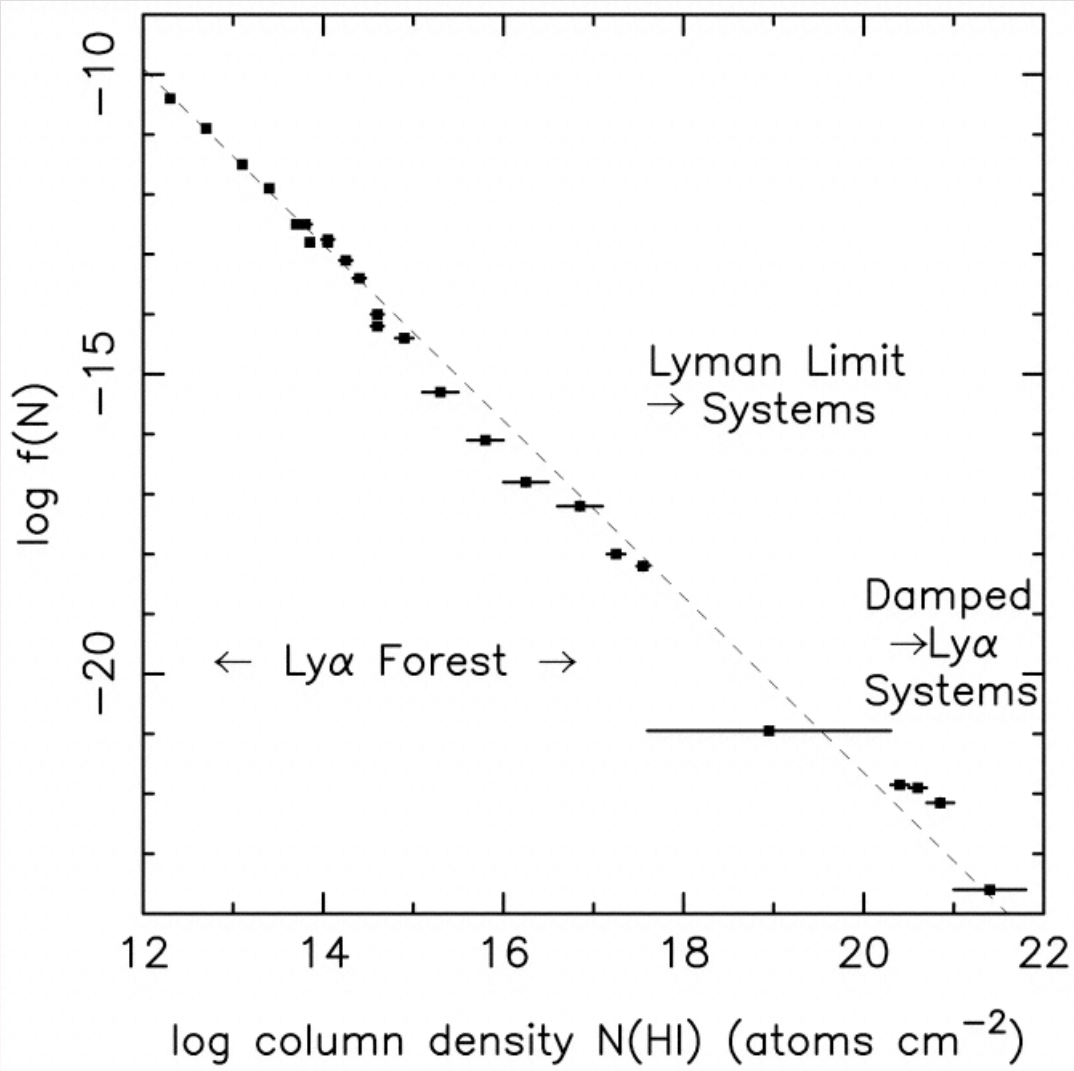
Number densities

$$\frac{dn}{dN} \propto N^{-\beta}$$

β =1.5 :
most mass is contained in high *N* systems (80% in DLAs)

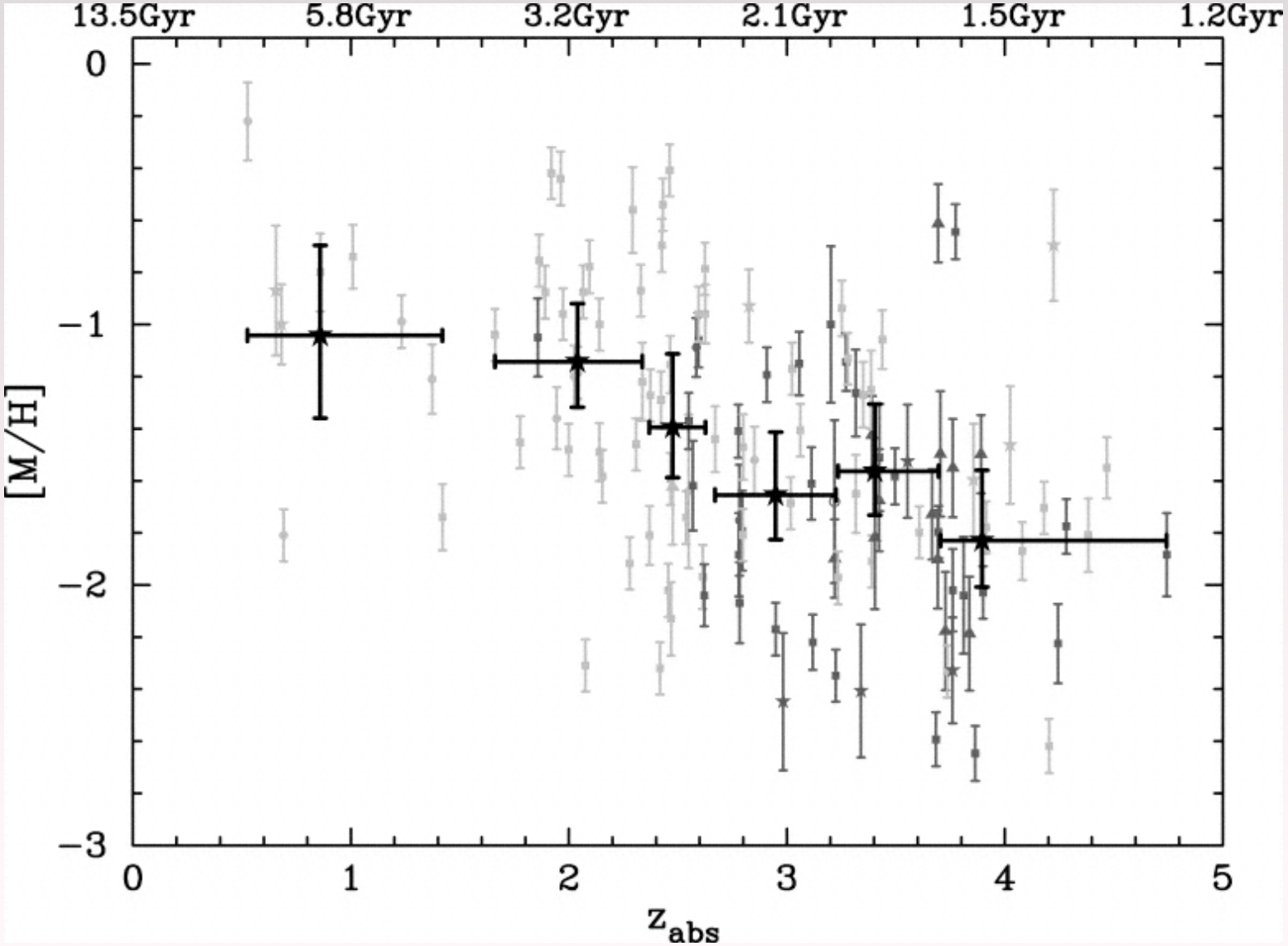
neutral gas only!

much more gas in the ionized IGM @ z~3



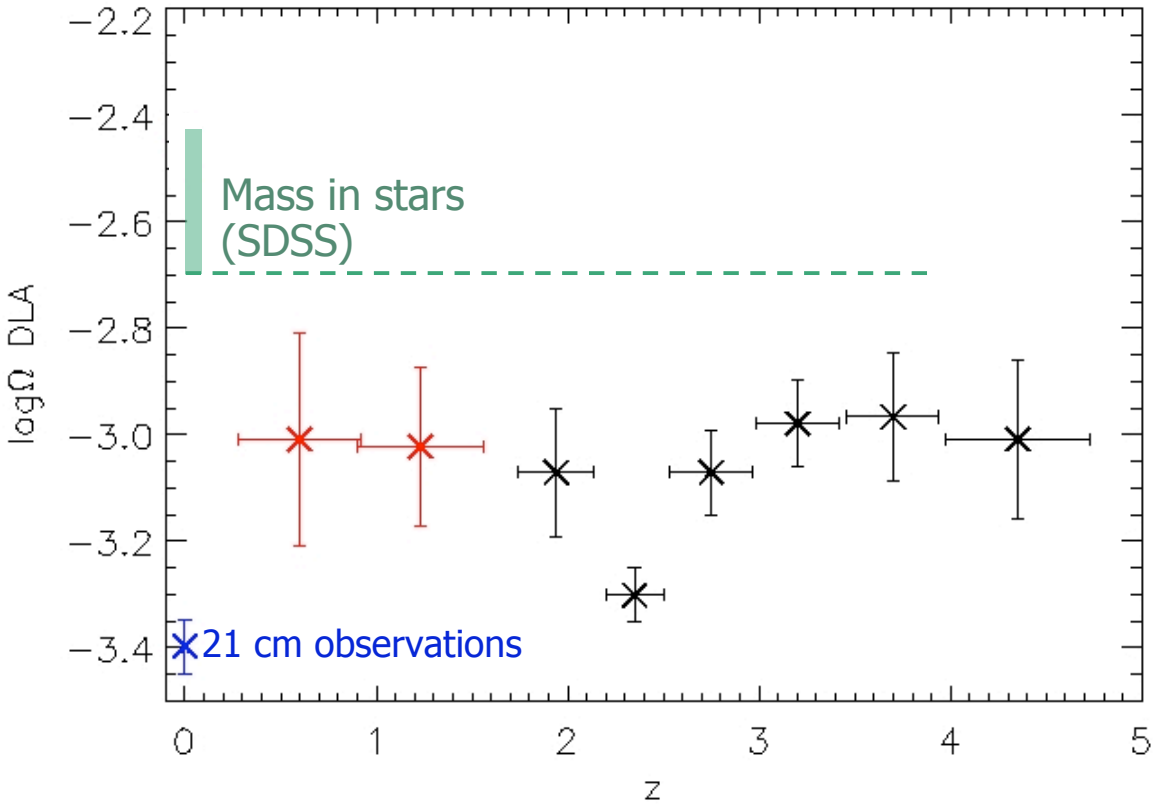
Petitjean et al. 1993

DLA metallicities



Prochaska et al. 2003

Neutral gas density Ω_{DLA}



$$\Omega_g = \frac{H_0 m_H \mu}{c\rho_{crit}} \int Nf(N,z)dN$$

- evolution with z ?
- $\Omega_{DLA} \rightarrow \Omega_{stars}$?
- DLAs are reservoirs for galaxy formation?

Rao et al. 2006
Prochaska et al. 2005
Zwaan et al. 2005

What we know about DLAs:

- N(H I) as galaxy disks
- Metal enriched – star formation has taken place
  [M/H] between halo and disk stars
  Slow evolution
- Reservoirs for star formation

What we don't know:

- Do they form stars?
- In what type of galaxies do DLAs reside - disks/dwarfs?

Purpose of the IFS survey

- What types of galaxies harbor DLAs?
  - Large disks or small dwarfs?
  - Understand proto-galaxies
- DLA galaxies present an alternative selection to flux limited surveys
- Emission lines from the DLA galaxies -> SFR
- Impact parameters -> sizes

Main parts:

1. Low redshift (z < 1): optical emission lines
2. High redshift (z > 2): Lyman-α emission

The IFS survey for emission lines

IFS advantages:

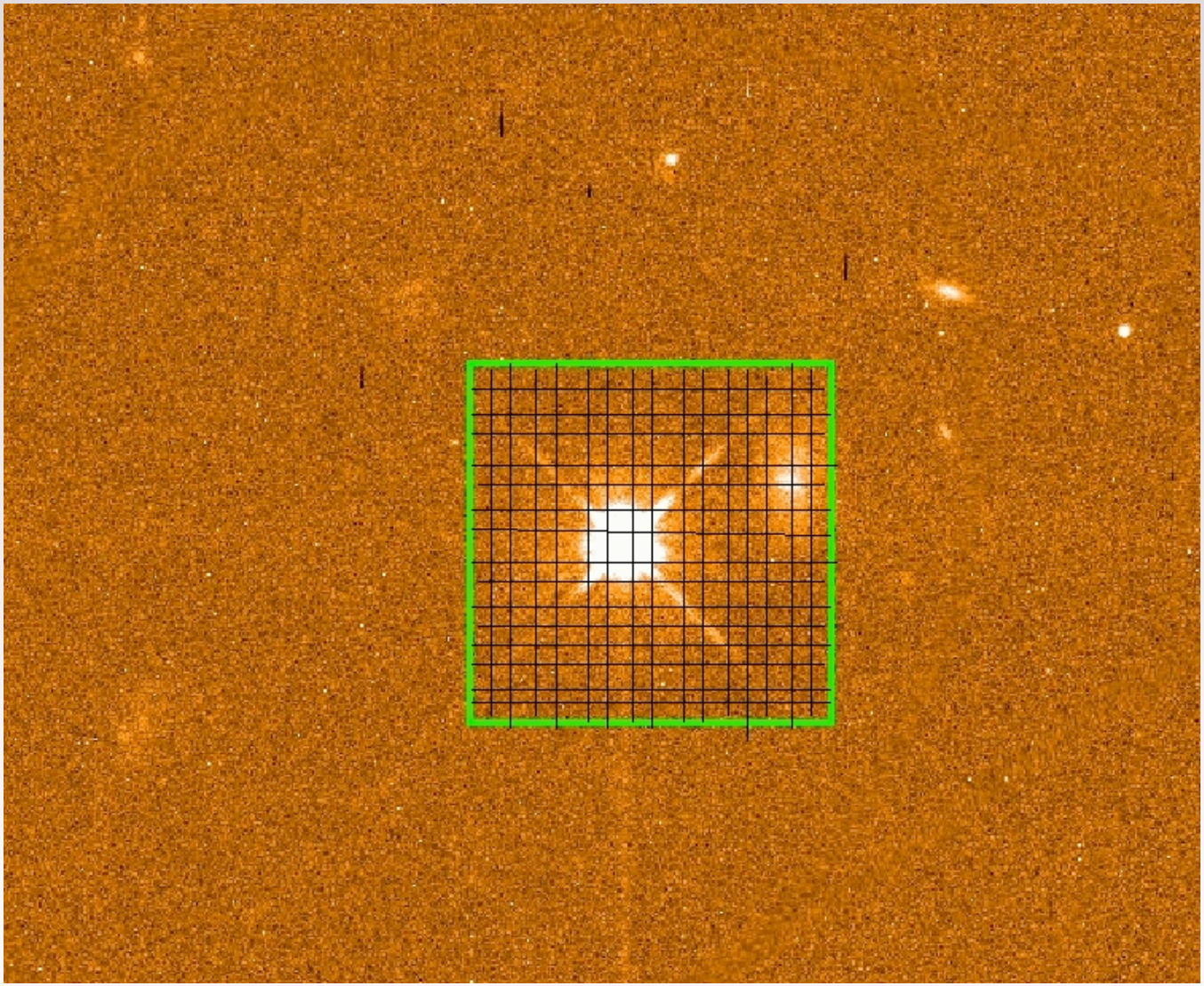
- Imaging and spectroscopy simultaneously
- No slit-losses
- Search for emission lines at unknown spatial location.

Data (2003-2007) (high-z project):

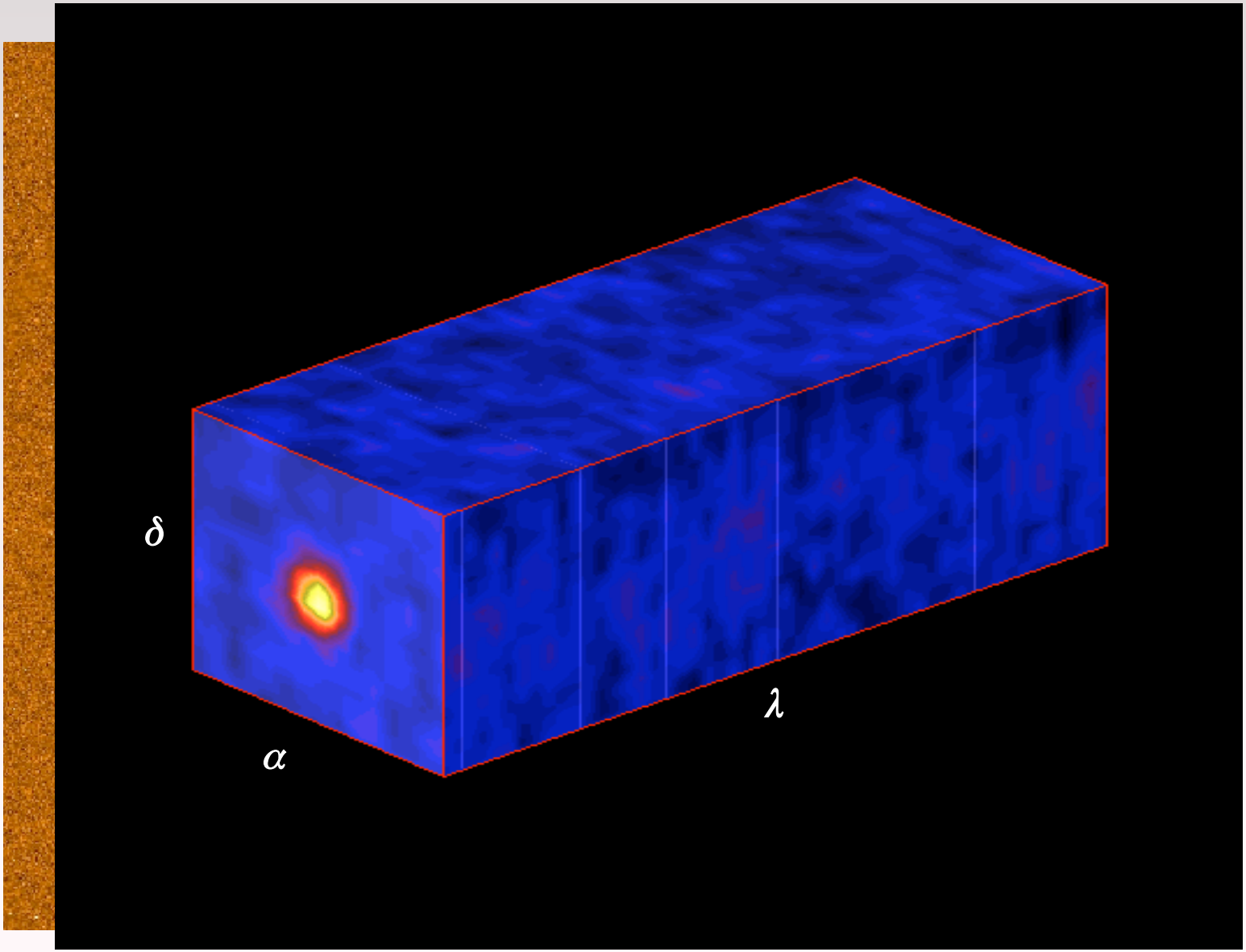
- VIMOS (VLT) - 10 DLAs
- FLAMES -ARGUS (VLT) - 1 DLA
- GMOS (Gemini) - 3 DLAs
- PMAS (4m Calar Alto) - 21 DLAs
- Osiris - Keck (Dec 2007)
- Total 35 systems with IFUs

Collaborators: Andy Bunker, Hsiao-Wen Chen, Cedric Ledoux, Sebastian Lopez, Philipp Richter, Art Wolfe, Mirka Dessauges-Zavadsky, Jason Prochaska

Method: which galaxy is the absorber?

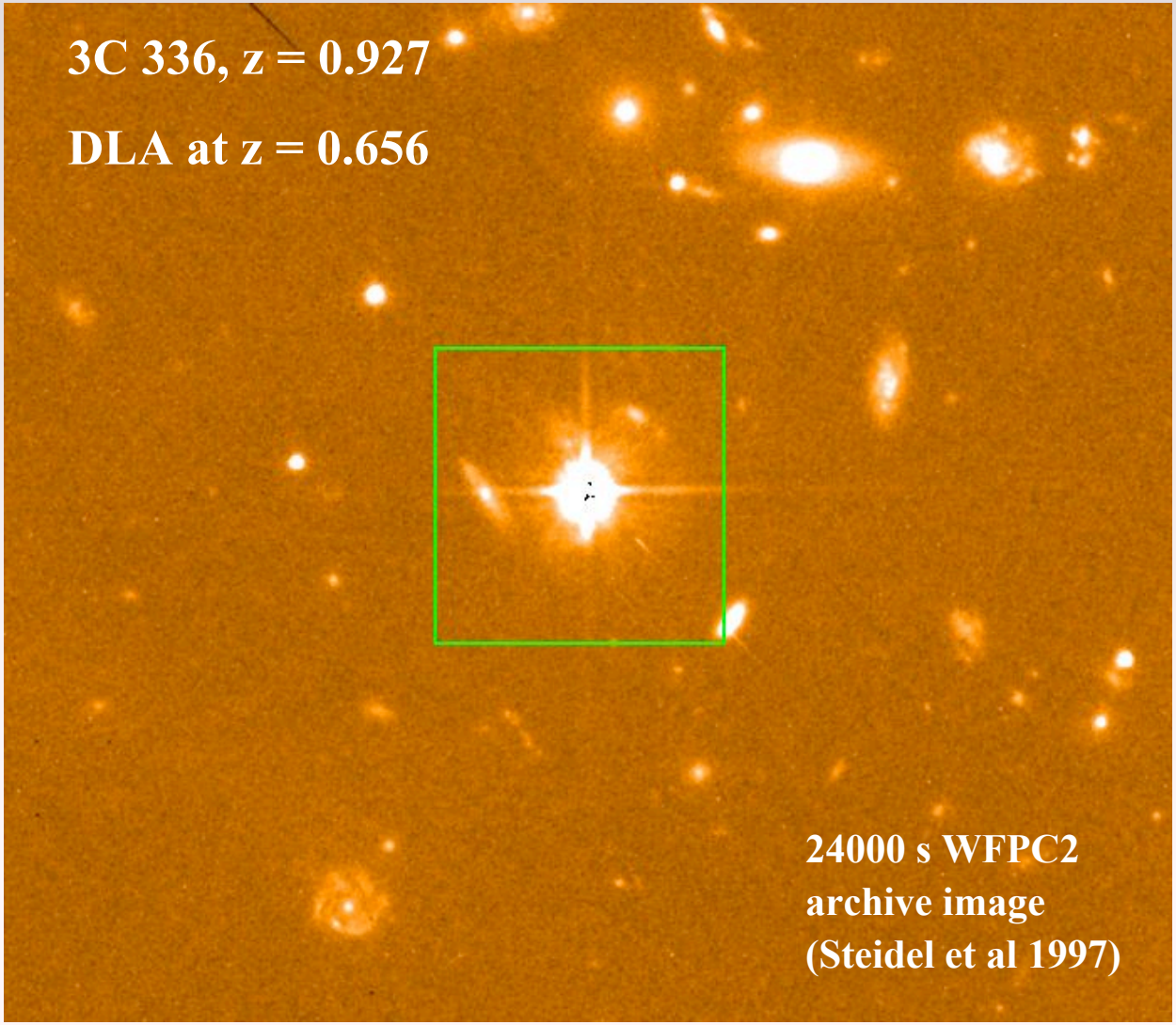


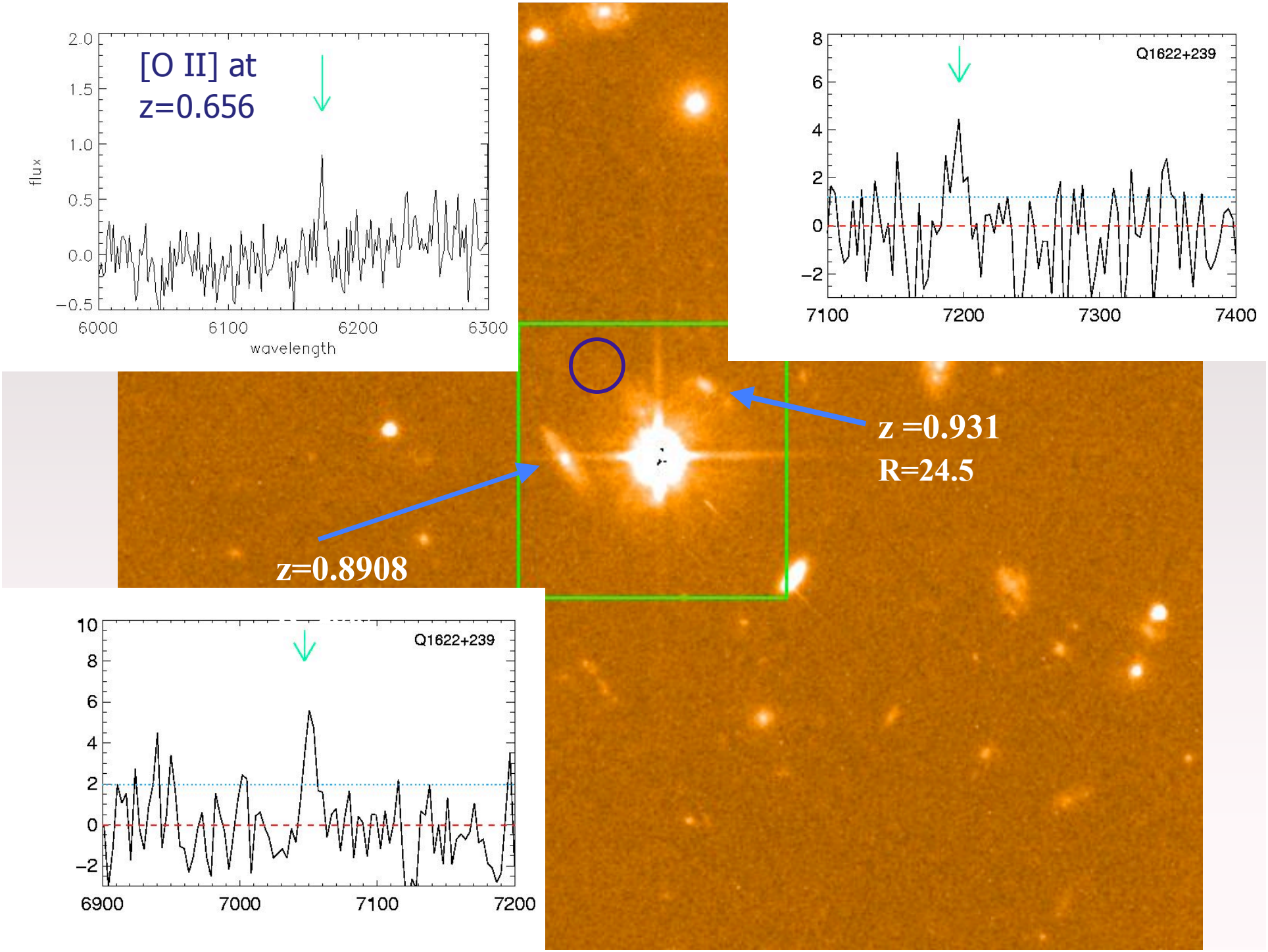
Method



Previous low-z studies:

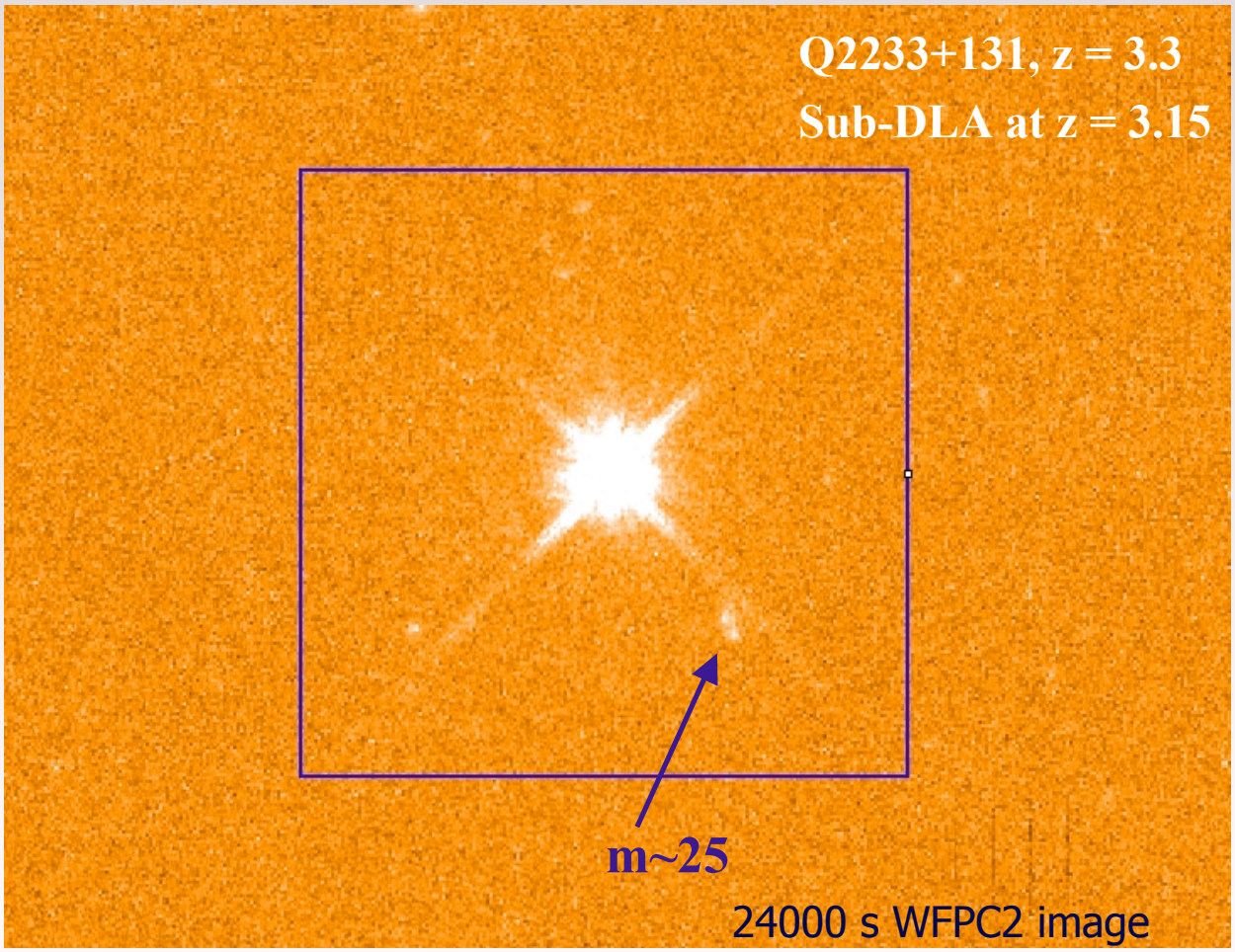
At z<1 : ~30 known DLA systems – 14 confirmed DLA galaxies




[O II] at
z=0.656
flux
wavelength
2.0
1.5
1.0
0.5
0.0
−0.5
6000
6100
6200
6300
Q1622+239
8
6
4
2
0
−2
7100
7200
7300
7400
z =0.931
R=24.5
z=0.8908
Q1622+239
10
8
6
4
2
0
−2
6900
7000
7100
7200

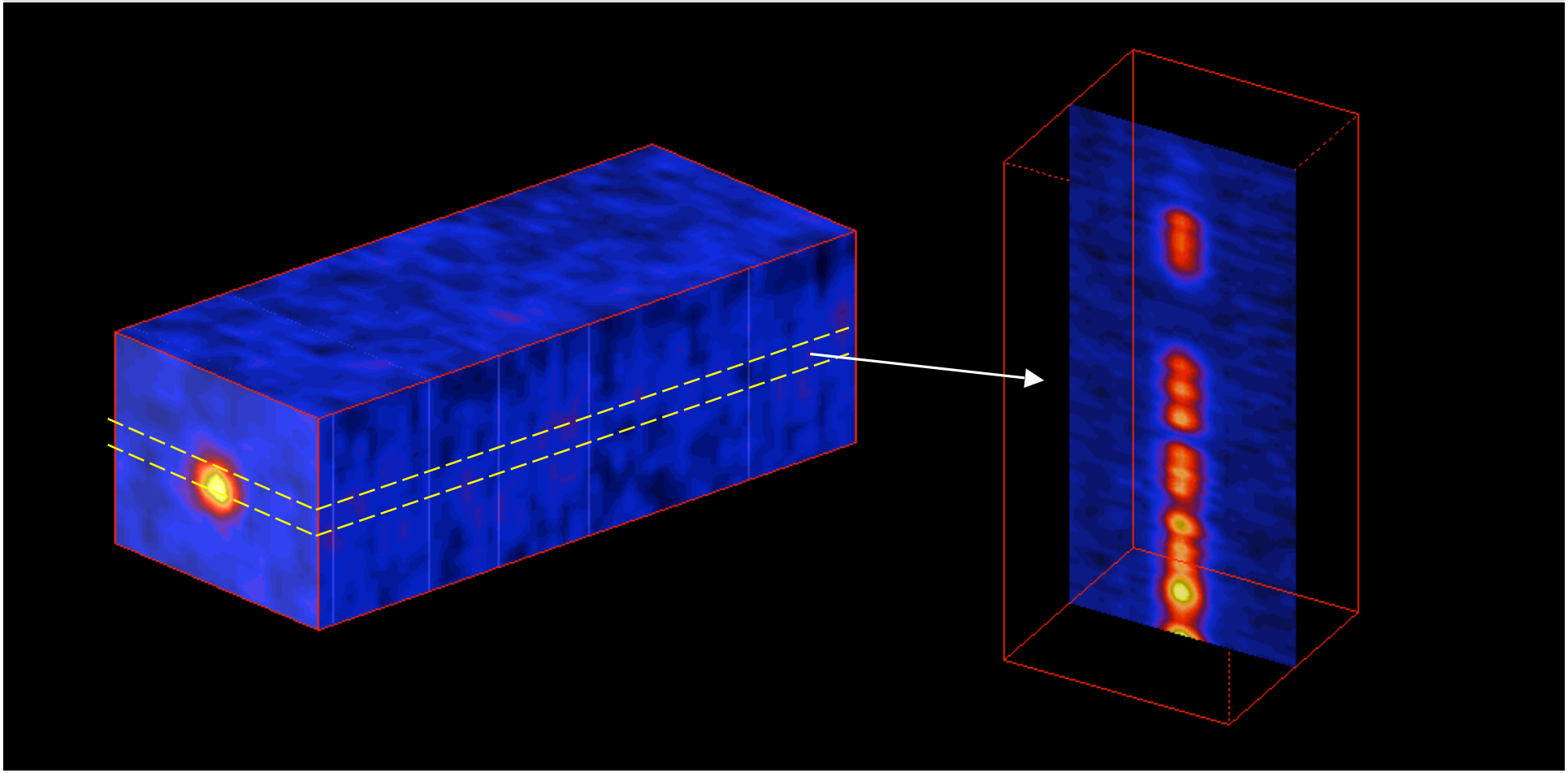
DLAs at high redshifts (z>2)

~1000 DLA systems known – 3 intervening confirmed DLA galaxies

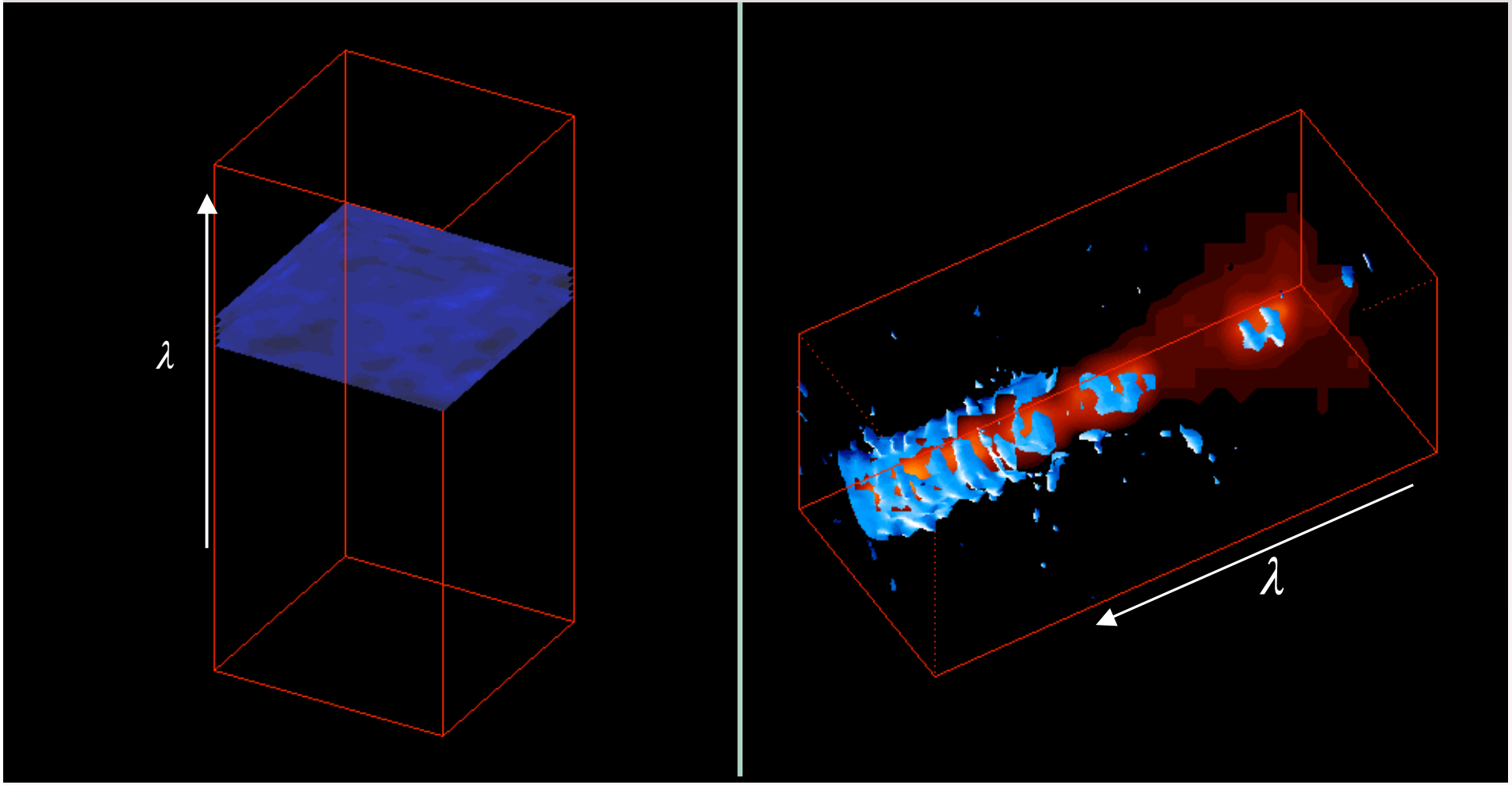


Djorgovski et al 1996 (Keck spectrum)
Christensen et al. 2004 (PMAS-IFU @ 4m telescope)

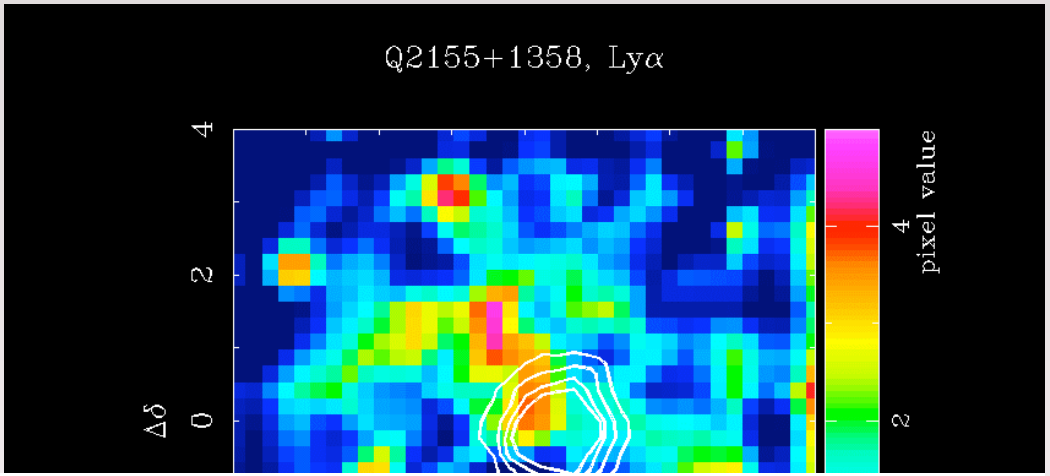
Visualisation – long slits

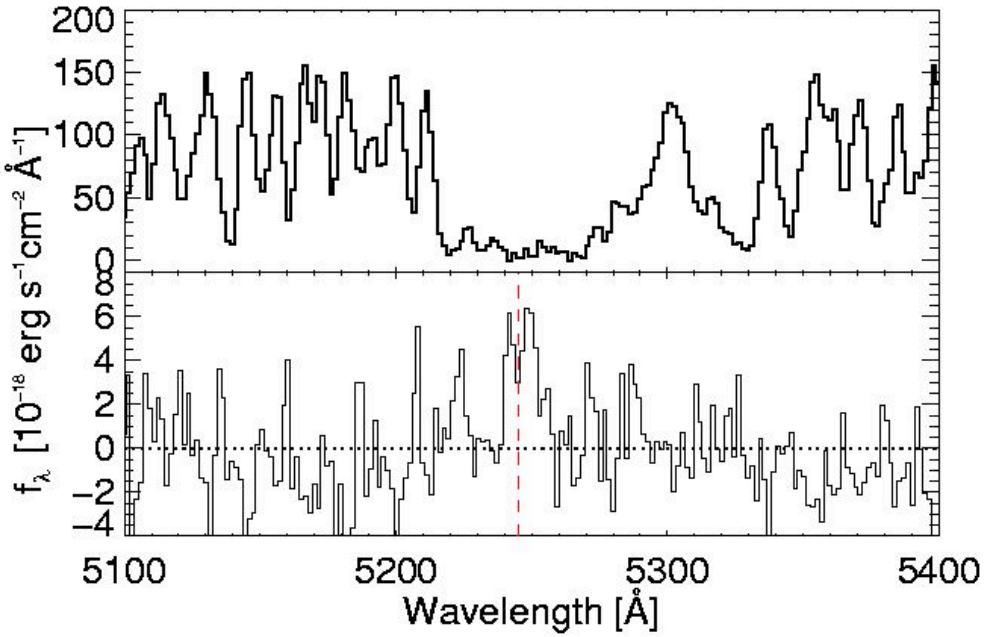


Visualisation – narrow bands - cubes



Candidate DLA galaxies

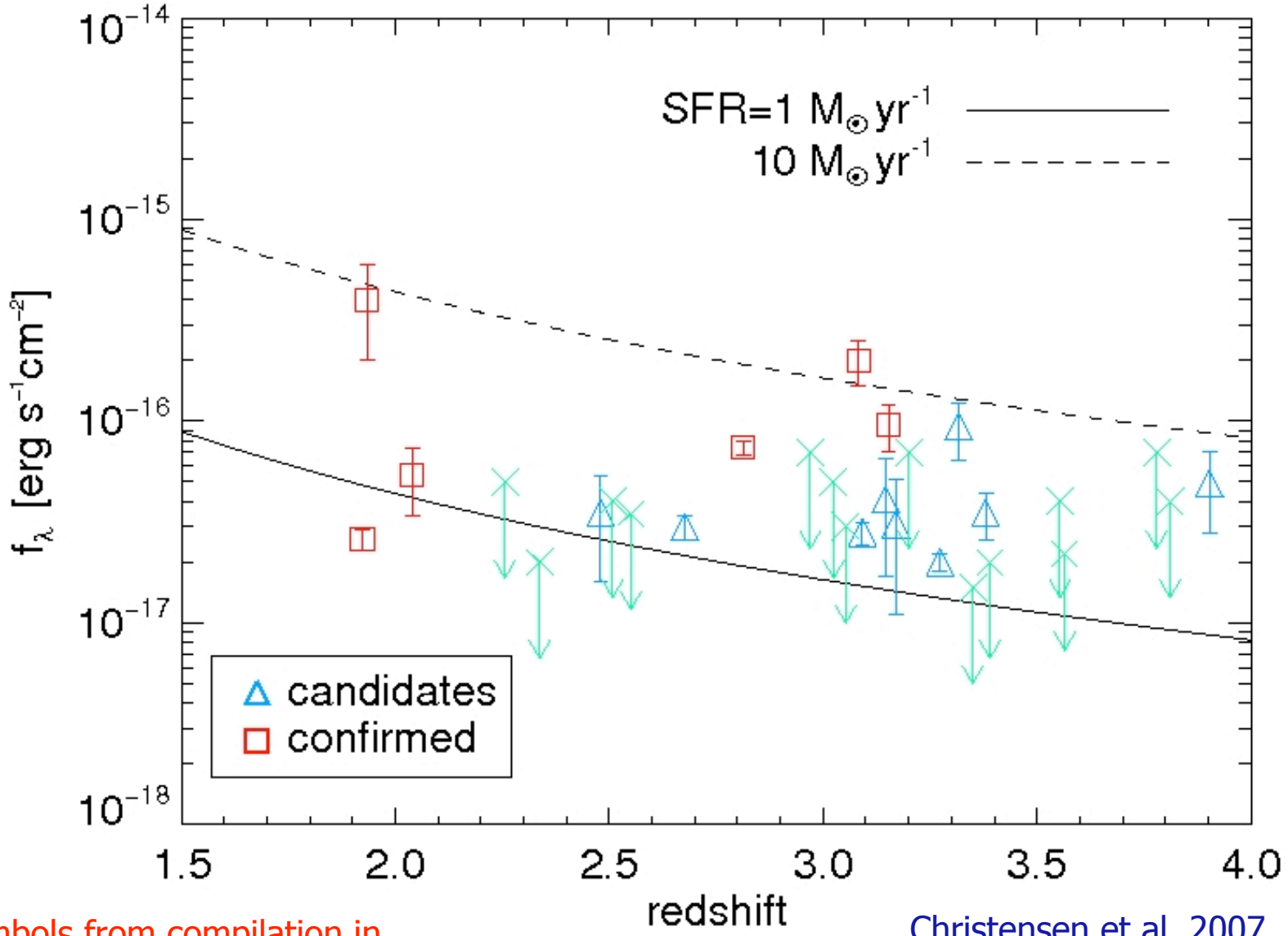




High-z IFU DLA survey

- 35 DLAs
- 9 good candidates found – but only detected at the 3-4 σ levels
- Line fluxes:
  2 - 8 x 10^{-17}erg cm^{-2} s^{-1}
- Impact parameters from 1 - 3” (10 - 30 kpc)

DLA galaxy; **SFR** ; Impact parameters ; masses

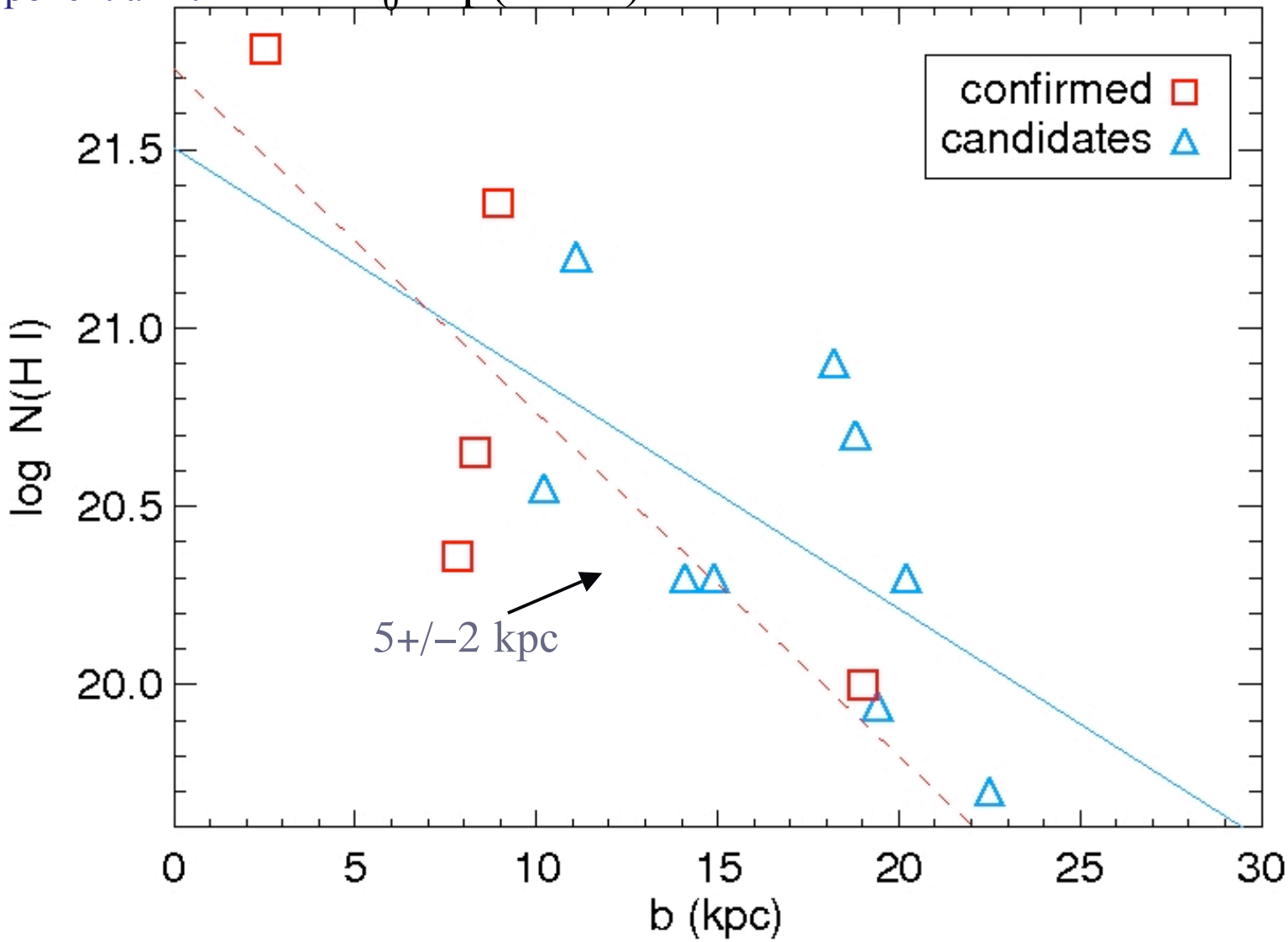


Red symbols from compilation in Moeller et al. 2002

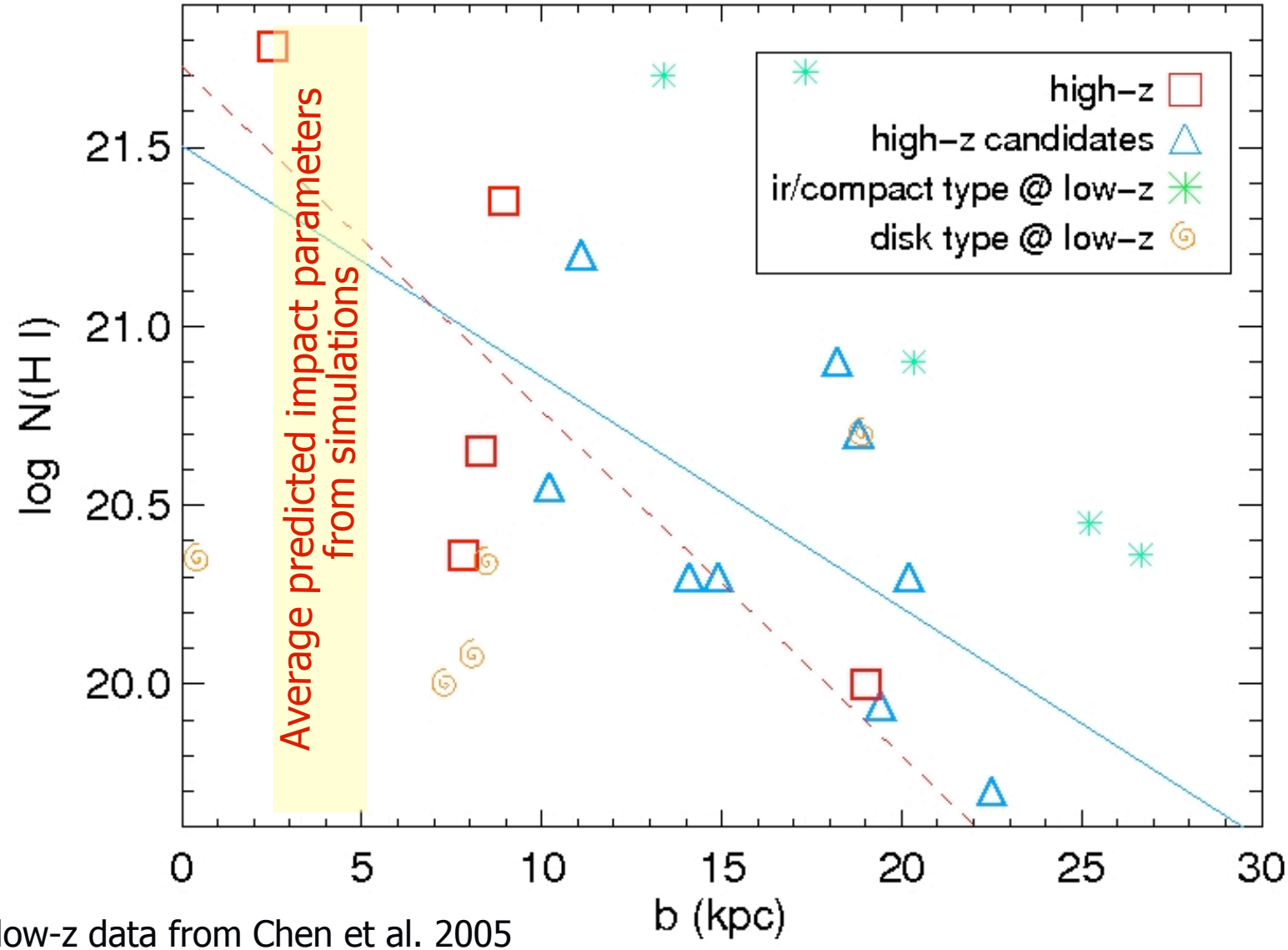
Christensen et al. 2007

DLA galaxy; SFR ; **Impact parameters** ; masses; gradients

Exponential fit $N \propto N_0 \exp(-r/h)$

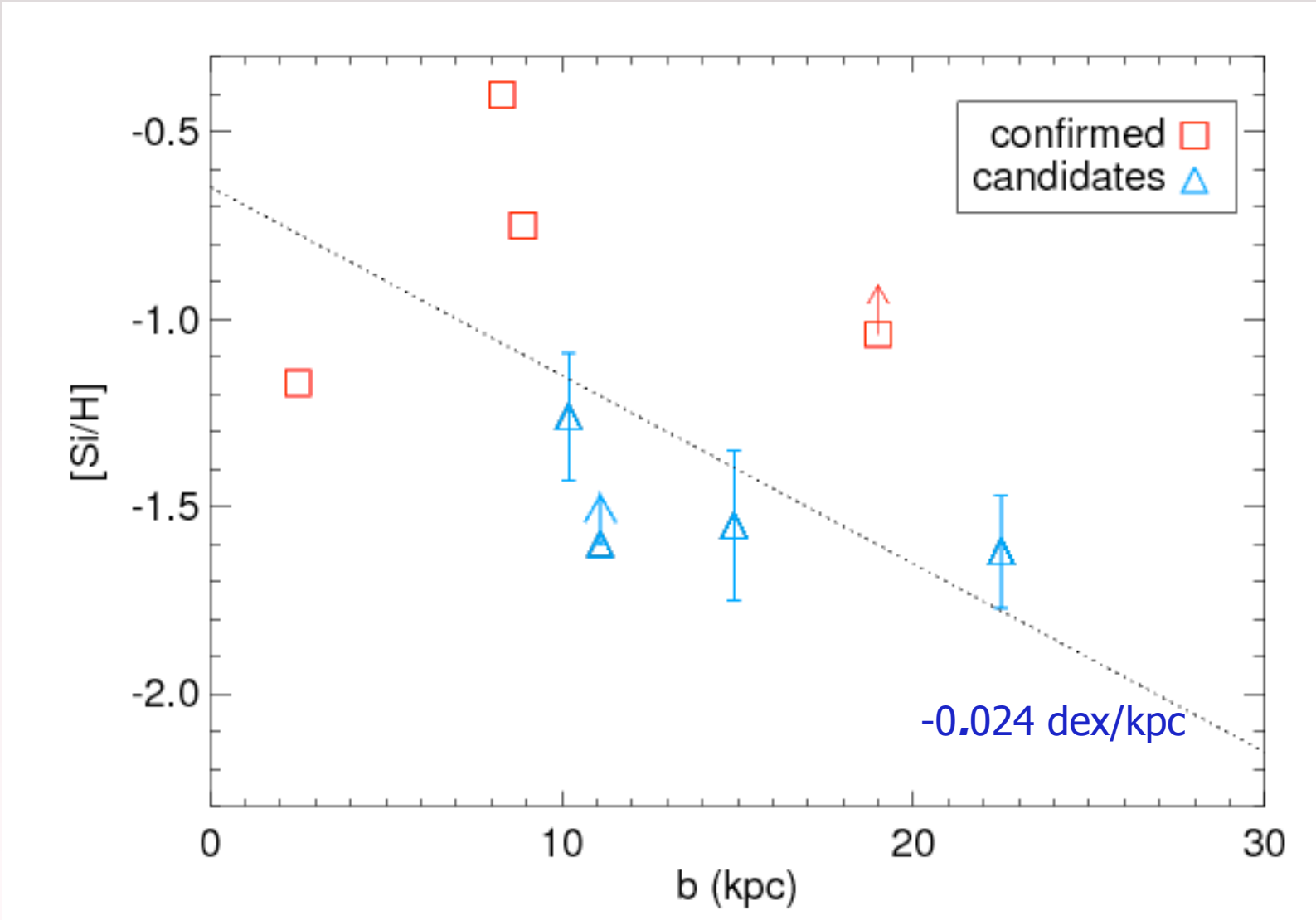


DLA galaxy; SFR ; **Impact parameters** ; masses; gradients



+low-z data from Chen et al. 2005

DLA galaxy; SFR ; Impact parameters ; masses **; gradients**



$$M = \int 2\pi r 10^{21.7} \exp(-r/5)\, dr$$

$$\approx 2 \times 10^{9} M_{\odot}$$

Neutral gas only - similar to the MW gas mass

Numerical simulations by Nagamine et al. 2004 :
$M^*/M_{gas}=3$ at $z=3$

$M(\text{DLA gal}) = 10^{10} M_{\odot}$ ~10% M(MW)

Survey done at detection limit for current IFUs

Implications

- Selects large gas disk galaxies:

  biased selection (although not on luminosity)

- Large impact parameters:

  biases DLA M/H to lower metallicities

  but can explain higher GRB-DLA abundances

- Trace star forming galaxies?

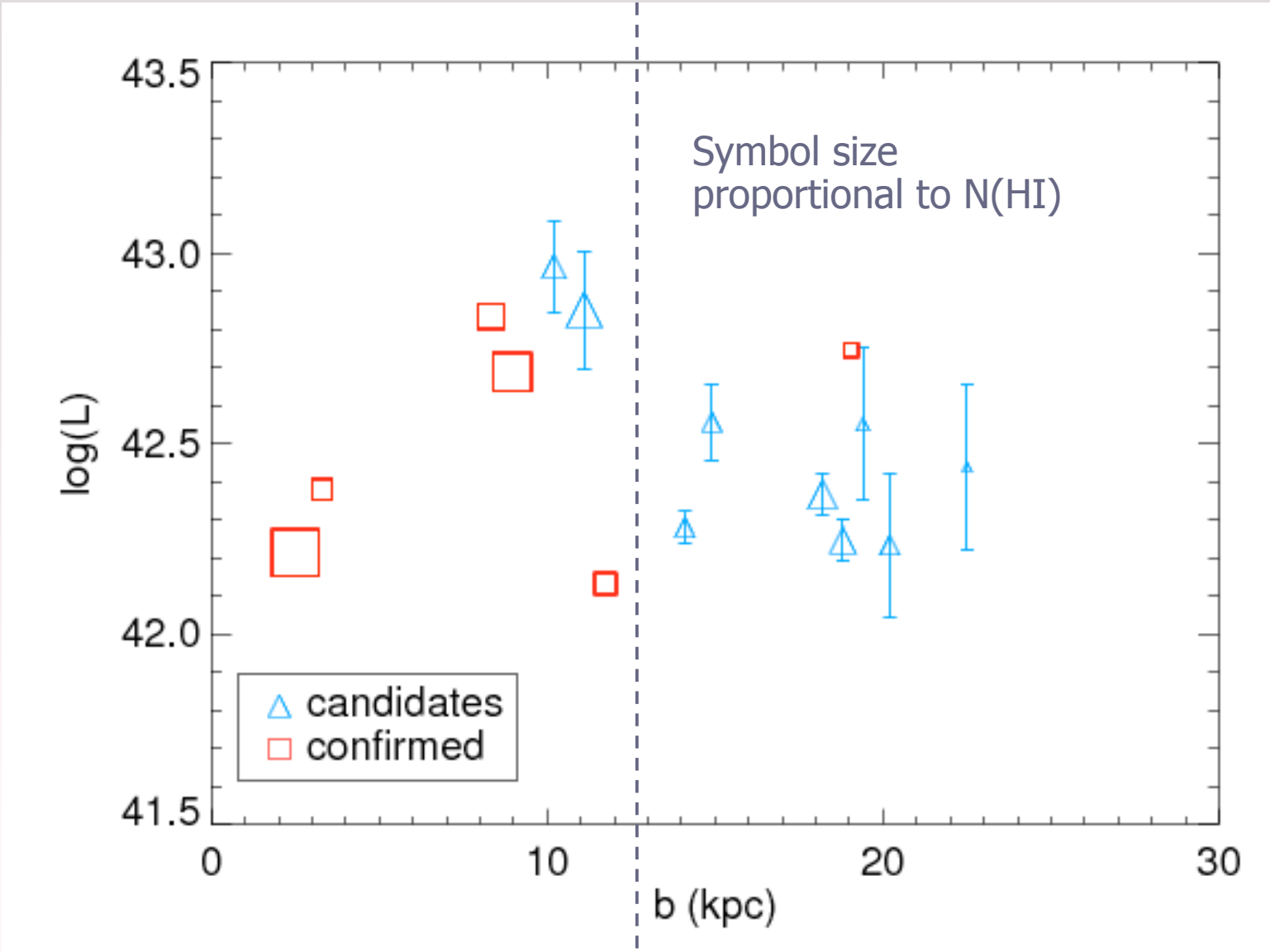
  not starbursts!

  do DLAs just remain reservoirs?

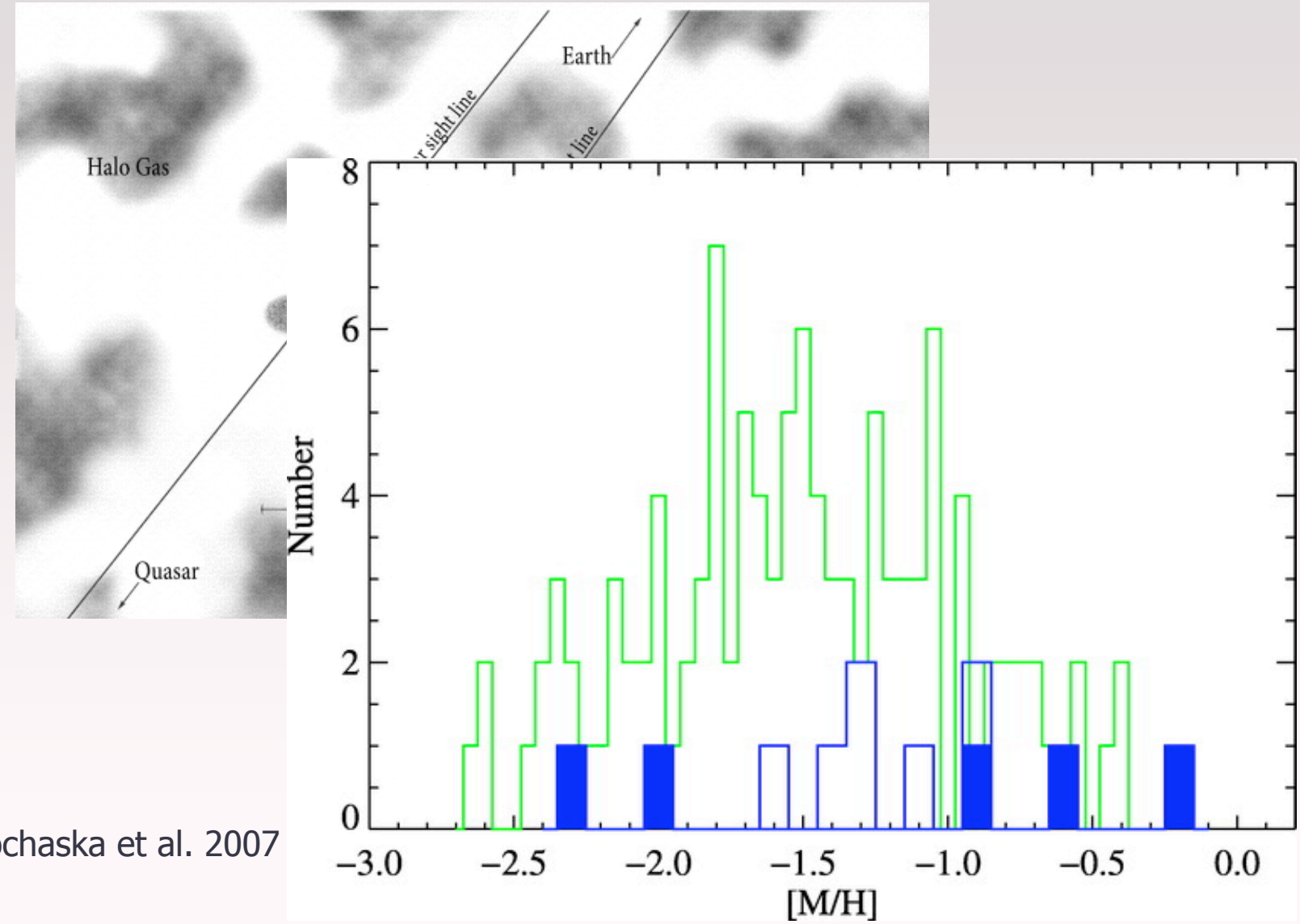
Summary

1. IFS able to identify faint emission lines
   - Independent confirmations are needed
   - Lyα properties similar to known DLA galaxies
2. Impact parameters indicate large disks
   - both at high and low-z
   - DLA galaxies could reside in groups
3. DLA disks could be massive (gas), but not necessarily belong to massive (stars), luminous, high SFR galaxies

DLA galaxy - or companion galaxy selection?



Impact parameter effects



From Prochaska et al. 2007