DAMPED LYMAN-ALPHA SYSTEMS

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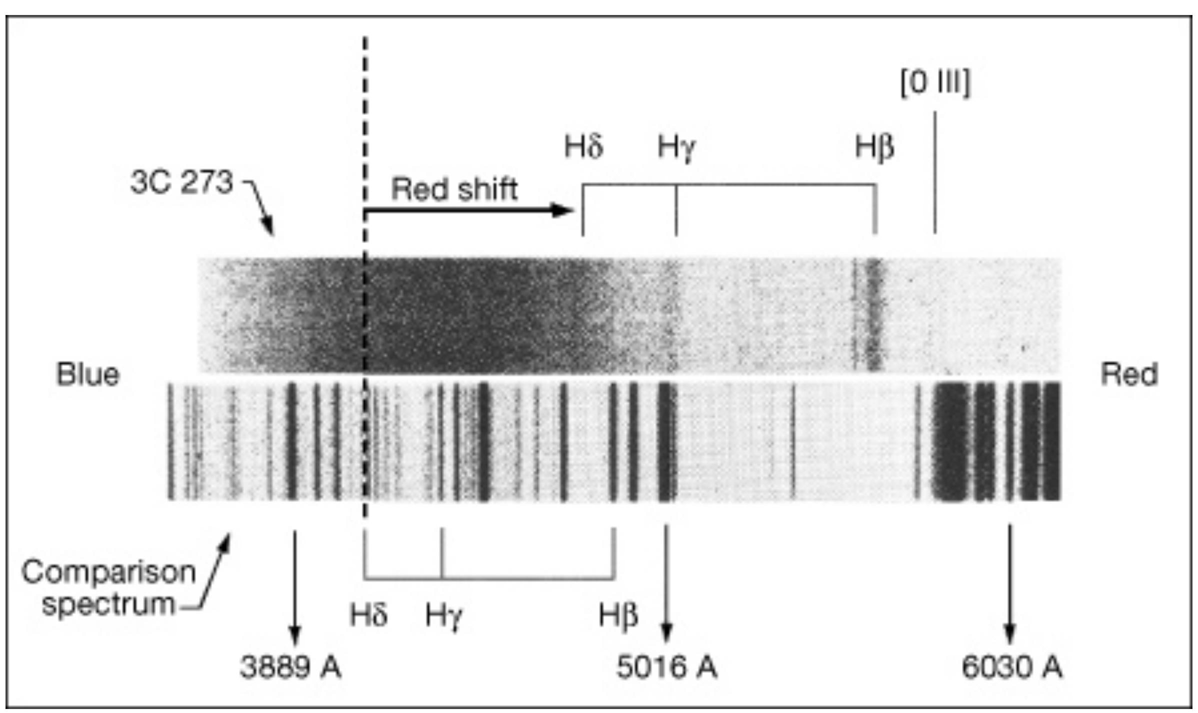
QUASI-STELLAR OBJECTS

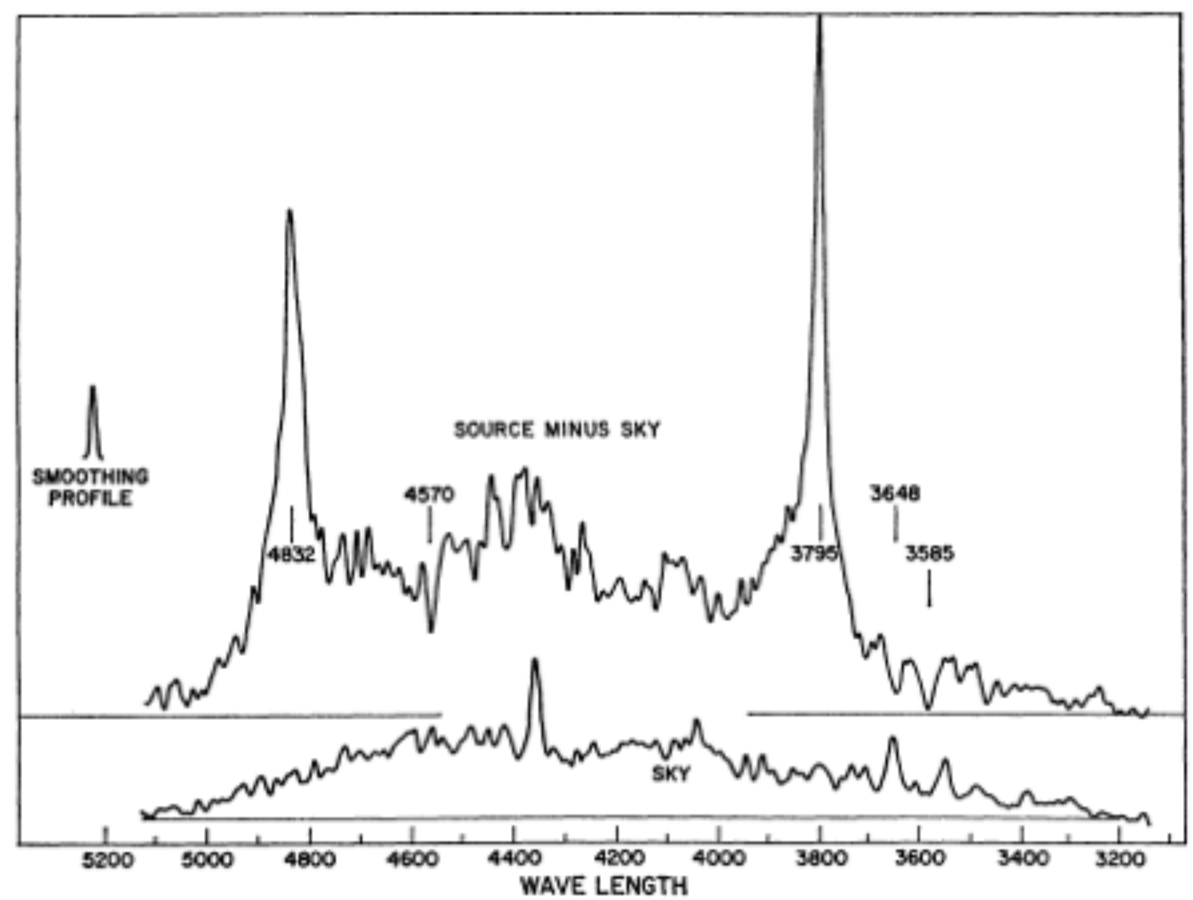
- QSOs discovered in the late 1950's and early 1960
- Optical spectra was difficult to interpret
- High redshift scenario was initially opposed because of the energies that have to be involved
- Today, we think that quasars have cosmological origin with the power source originating from an accretion disc powering a massive black hole (a case of AGN)



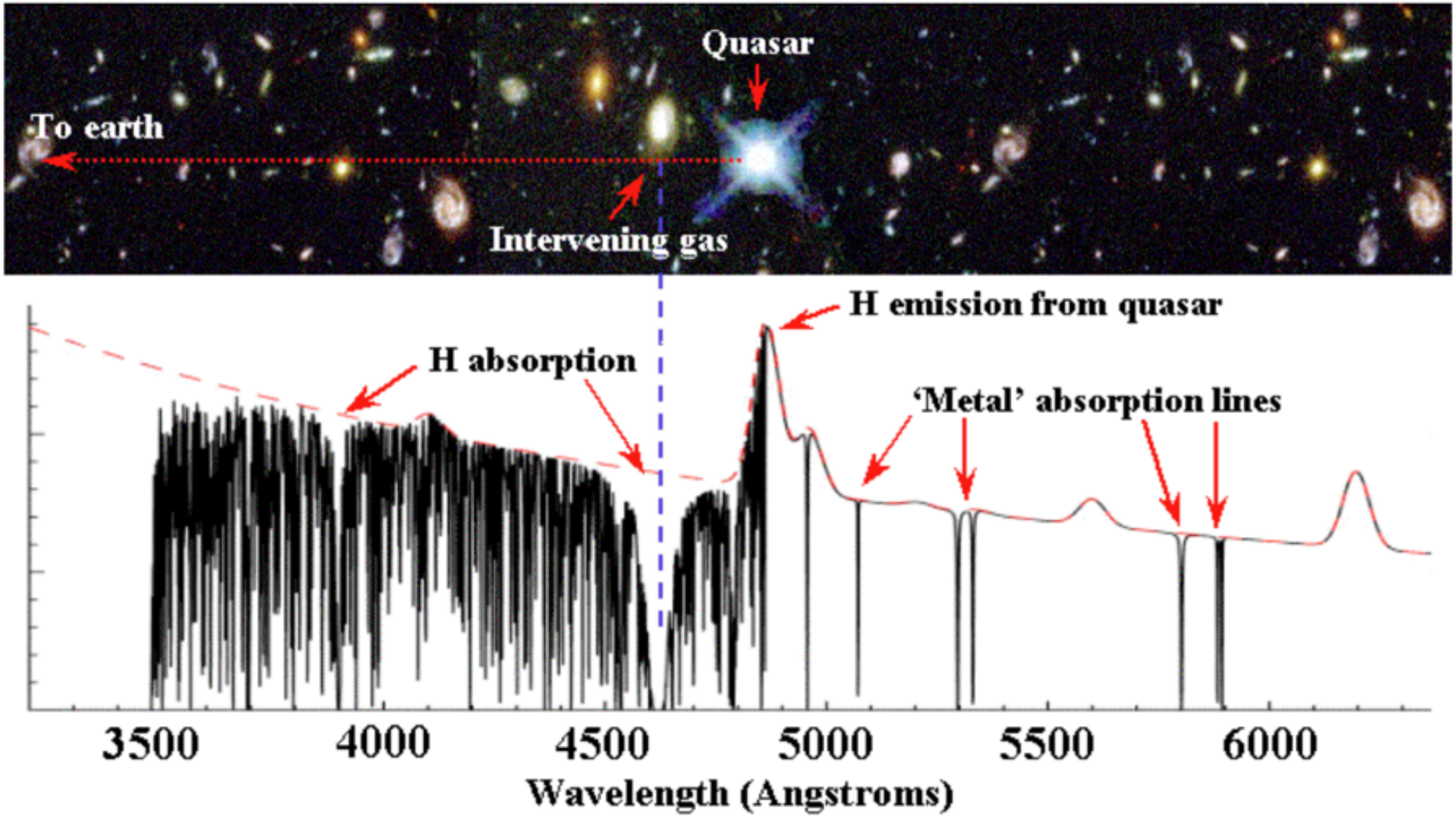
No. 1, 1966 LETTERS TO THE EDITOR 369

ON THE ABSORPTION SPECTRUM OF 1116+12

We have analyzed two spectrograms of the quasi-stellar radio source 1116+12. Schmidt (1966) has derived a redshift of 2.118 from emission lines at 3795 and 4827 Å which were identified as Ly-α λ 1216 and C IV λ 1549, respectively. We have found on both plates wide absorption features at 3585 and 4570 Å. These absorption features are tentatively identified as Ly-α and C IV, respectively, with a redshift of 1.949. In this Letter we describe briefly the techniques and results of our analysis and, following Bahcall and Salpeter (1965, 1966), some implications of our tentative identifications.

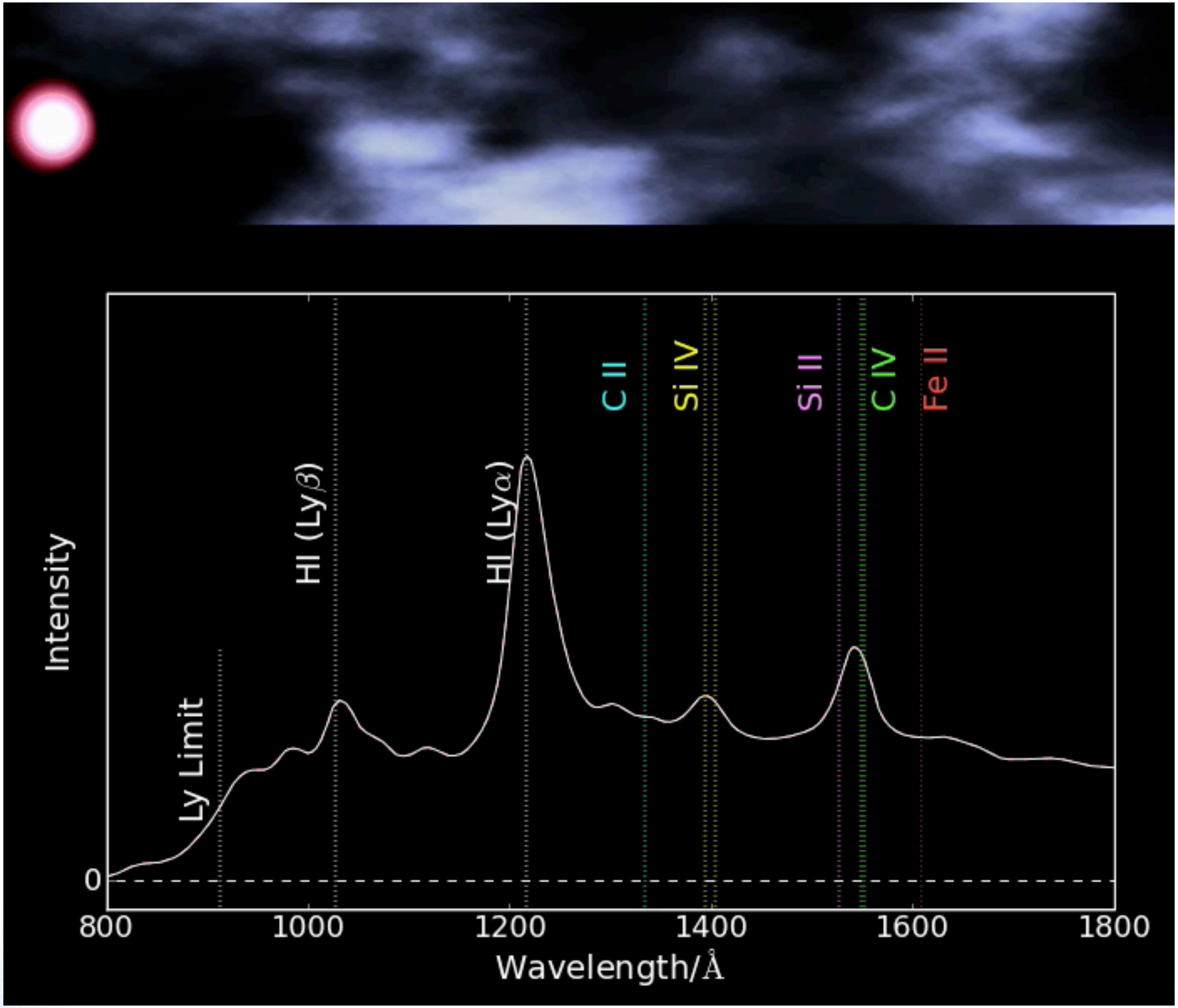


QSO SPECTRA



Quasar
To earth
Intervening gas
H emission from quasar
H absorption
'Metal' absorption lines
3500
4000
4500
5000
5500
6000
Wavelength (Angstroms)

QSO SPECTRA



Intensity
Ly Limit
HI (Lyβ)
HI (Lyα)
C II
Si IV
Si II
C IV
Fe II
0
800
1000
1200
1400
1600
1800
Wavelength/Å

ABSORPTION SYSTEMS

Absorber	Log N(HI)	Signature	What is it?
Lyα forest	11 - 17.5 cm^{-2}	Lyα 1216 A	IGM
CIV system	> 14 cm^{-2} ?	CIV 1548 A	IGM/galaxy
MgII system	> 17 cm^{-2}	Mg II 2796 A	Galaxy halo
Lyman limit systems	> 17.5 cm^{-2}	Lyman limit at 912 A	Galaxy halo
Sub-DLA	19 - 20.3 cm^{-2}	Weak Lyα damping wings	Halo?Massive galaxy?
DLA	> 20.3 cm^{-2}	Lyα damping wings	Galaxy
CaII system	> 19 cm^{-2} ?	CaII 3935 A	High density gas?

ABSORPTION LINES

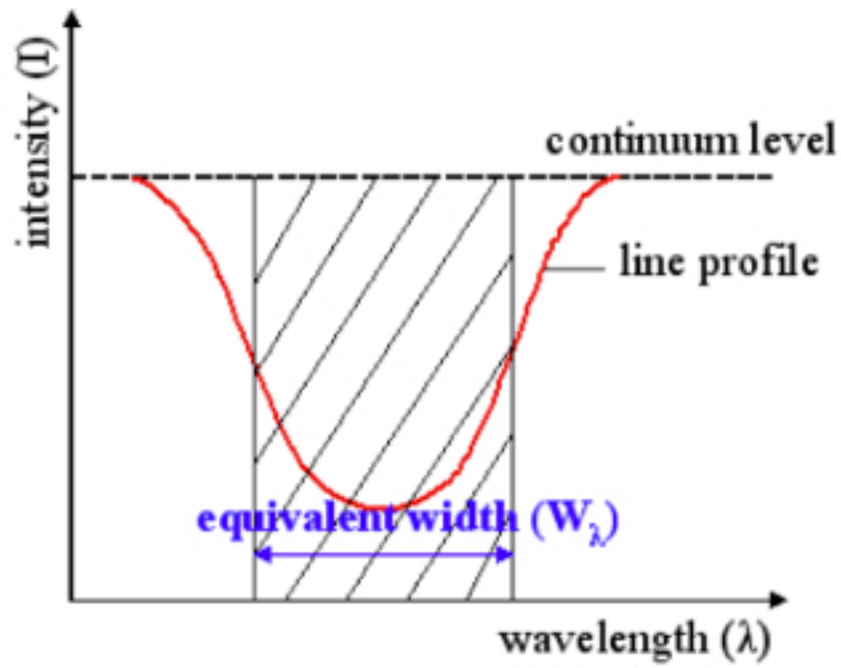
$$I(\nu) = I_0(\nu)e^{-\tau}$$

Voigt profile

$$\tau(\nu) = N\sigma(\nu)$$

$$EW = \int \frac{I_0 - I_\lambda d\lambda}{I_0}$$

$$Ew_{obs} = Ew_{rest} \times (1+z)$$



$$\tau(\lambda) = \frac{\sqrt{\pi}e^2}{m_e c}\frac{Nf\lambda}{b}H(a,u) = 1.497 \times 10^{-15}\frac{N(\mathrm{cm}^{-2})f\lambda(\mathrm{\AA})}{b(\mathrm{kms}^{-1})}H(a,u)$$

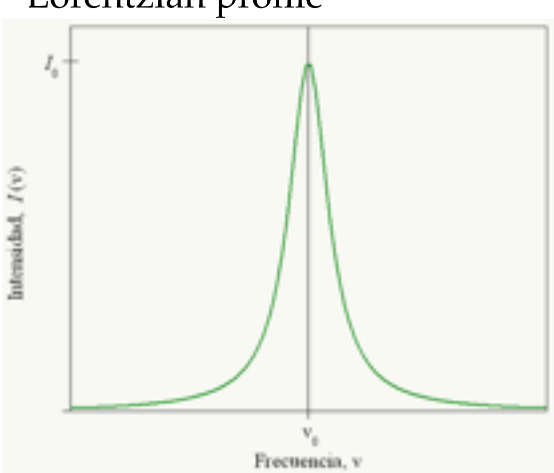
$$P(v) = \frac{1}{b\sqrt{\pi}}e^{-(v/b)^2} \qquad b = \sqrt{2}\sigma = \frac{FWHM}{2\sqrt{ln2}}$$

$$b = \sqrt{b^2_{thermal} + b^2_{turbulent}} = \sqrt{\frac{2kT}{m} + +b^2_{turbulent}}$$

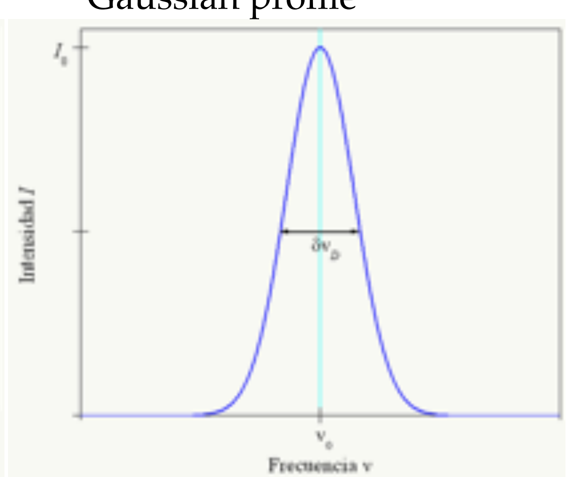
$$H(a,u) = \frac{a}{\pi}\int_{-\infty}^{+\infty}\frac{e^{-y^2}dy}{(u-y)^2 + a^2}$$

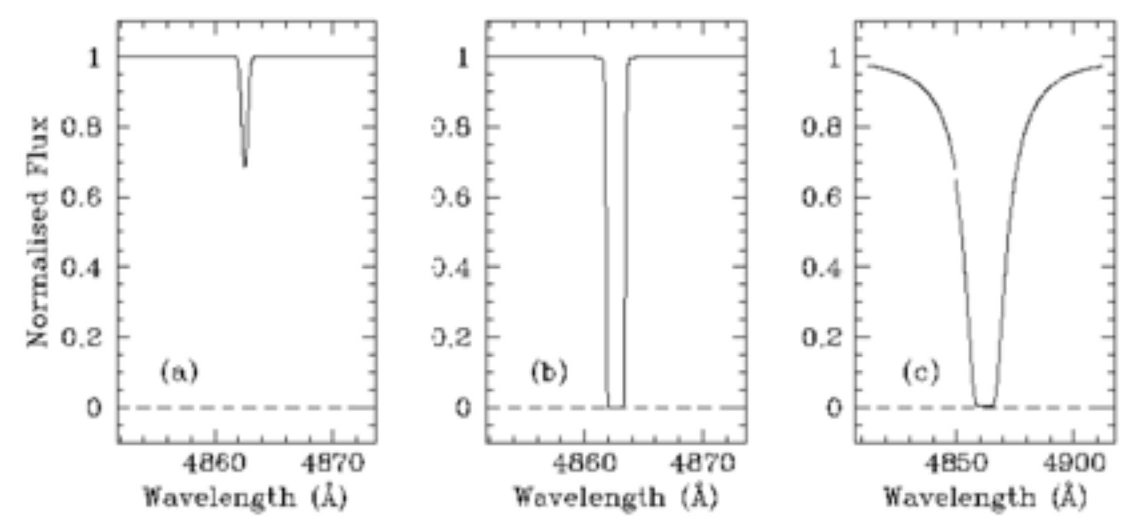
$$\Delta\nu = \frac{b\nu_0}{c}; \qquad a = \frac{\Gamma}{4\pi\Delta\nu}; \qquad u = \frac{c(\nu - \nu_0)}{\nu_0 b}; \qquad y = v/b$$

Lorentzian profile



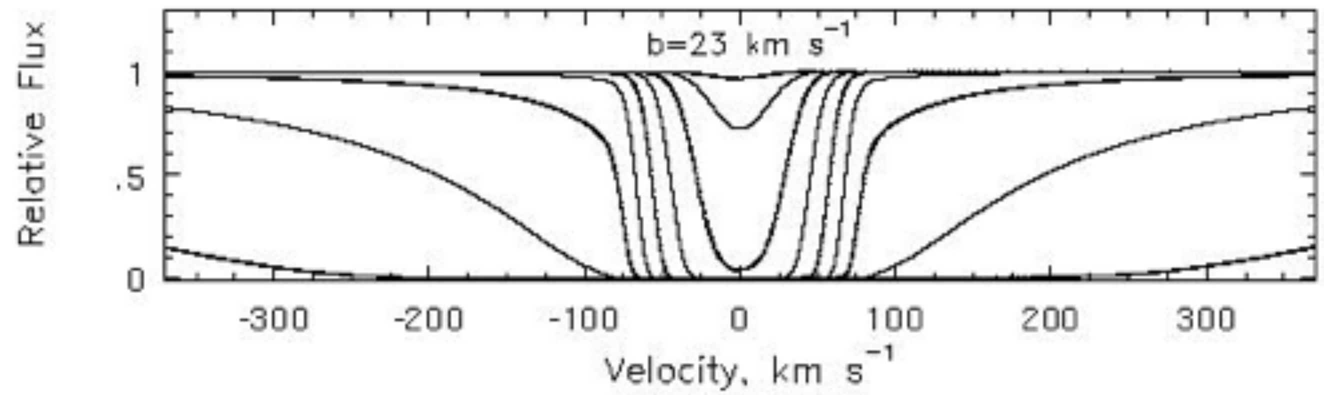
Gaussian profile





ABSORPTION LINES

$$W = \int (1 - exp[-N\sigma(\nu)])d\nu$$

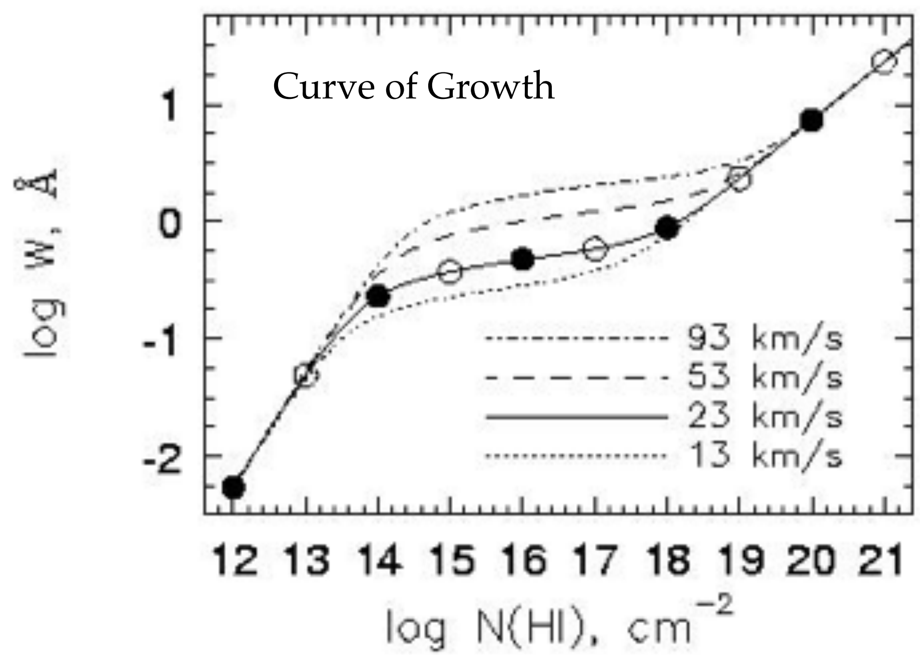


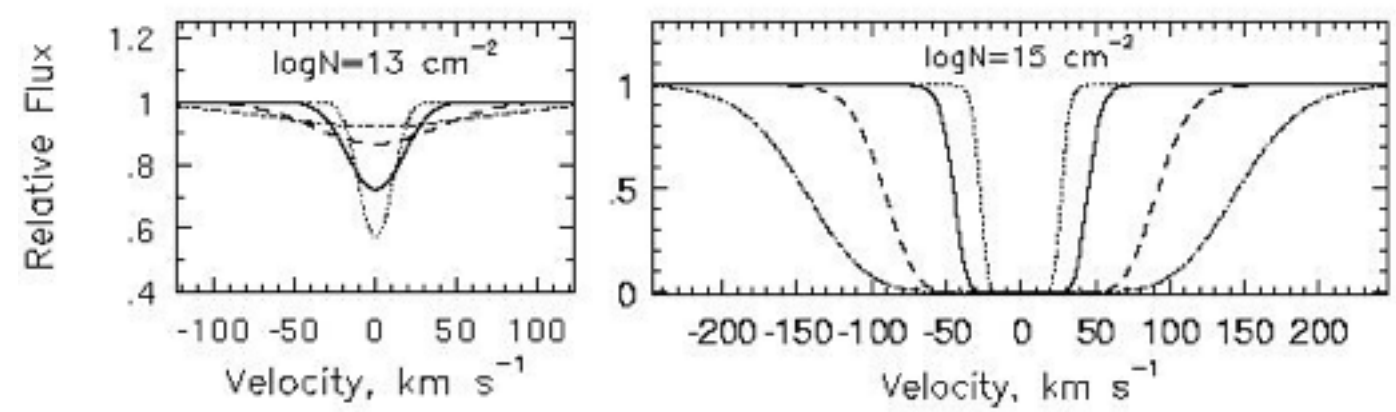
$\tau(\nu) = N\sigma(\nu) << 1$

$$W(\lambda) = \frac{\pi e^2 \lambda_0}{m_e c^2} N\lambda_0 f$$

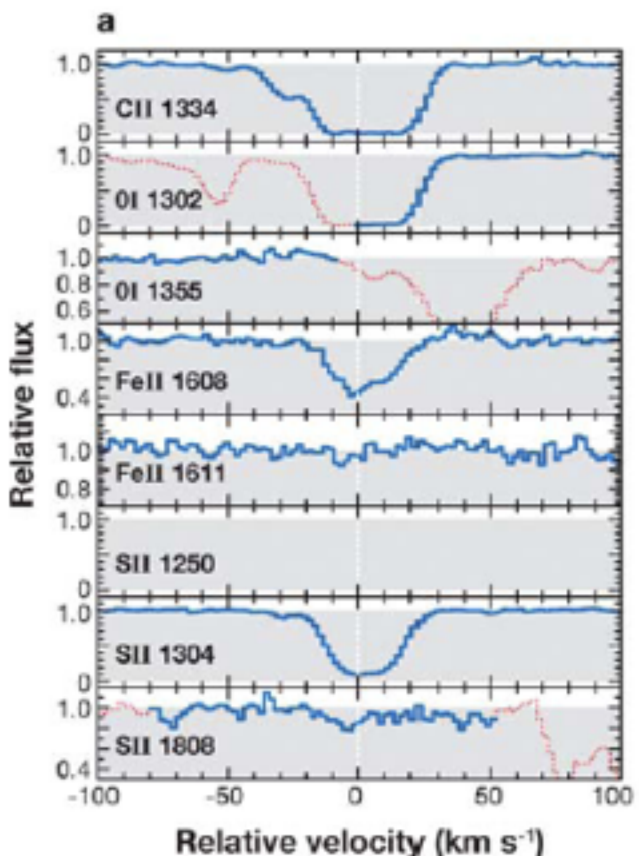
$$W(\lambda) \sim \frac{2b\lambda_0}{c}\sqrt{\ln\left(\frac{\pi^{0.5} e^2 N\lambda_0 f}{m_e c b}\right)}$$

$$W(\lambda) \sim \frac{\lambda_0^{1.5}}{c}\sqrt{\frac{e^2}{m_e c} N\lambda_0 f \Gamma}$$

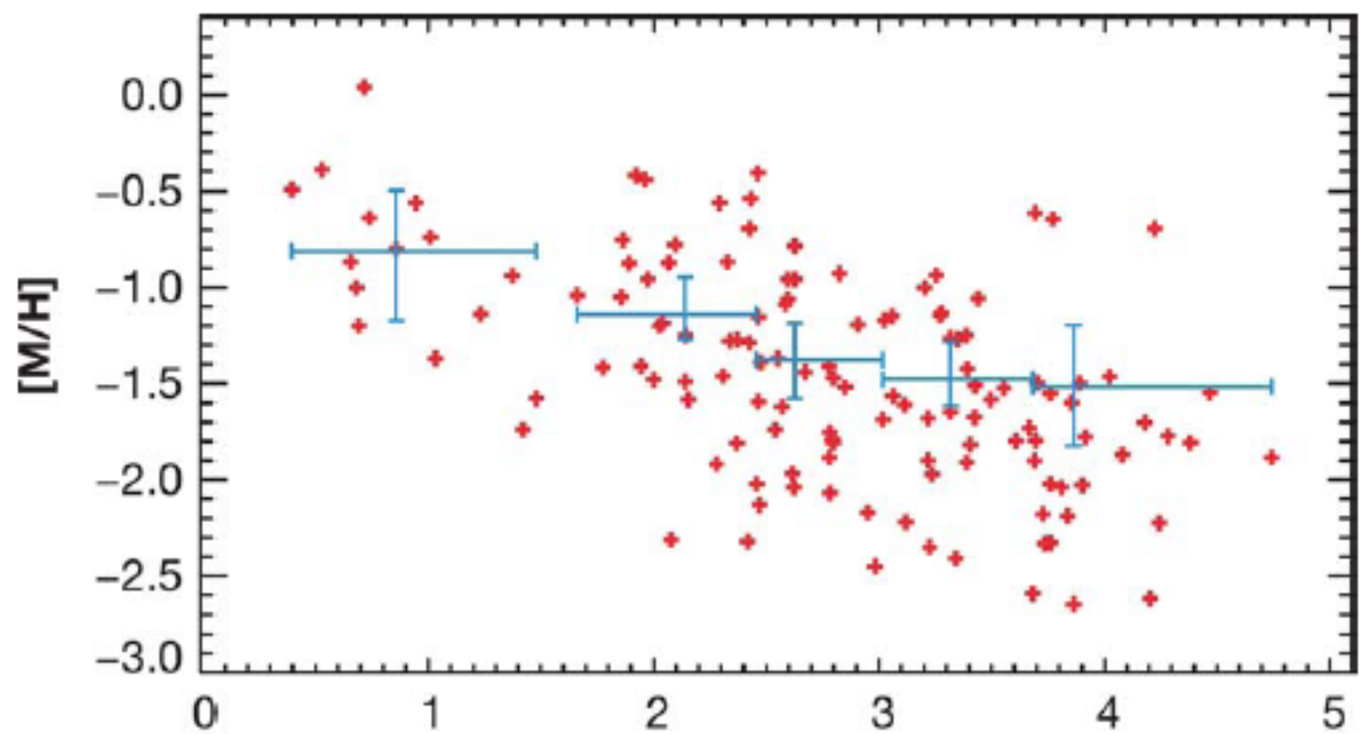




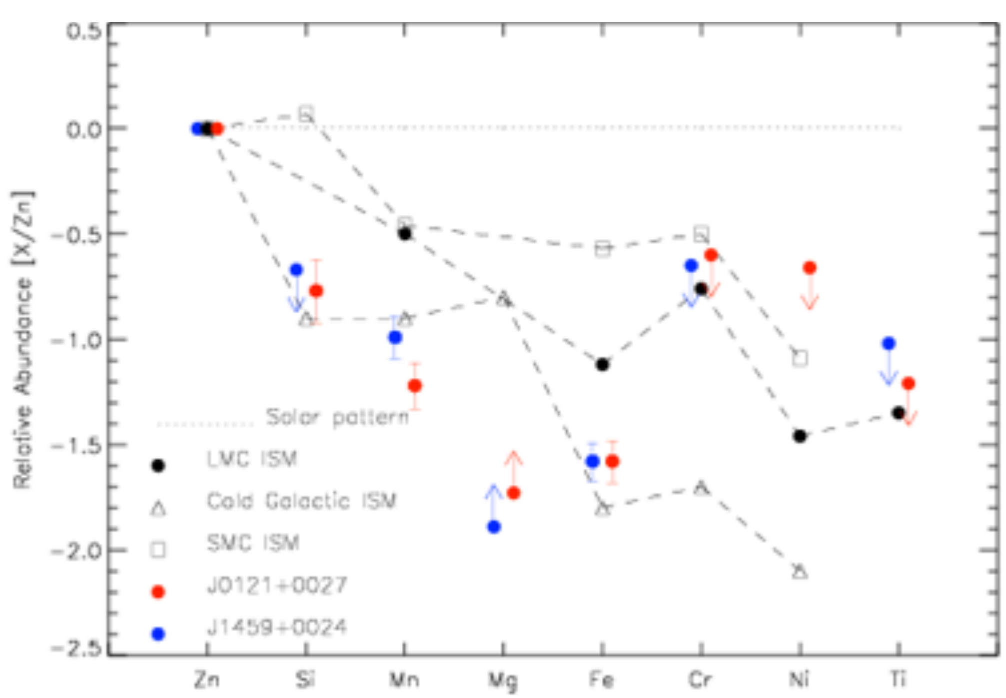
ABSORPTION LINES

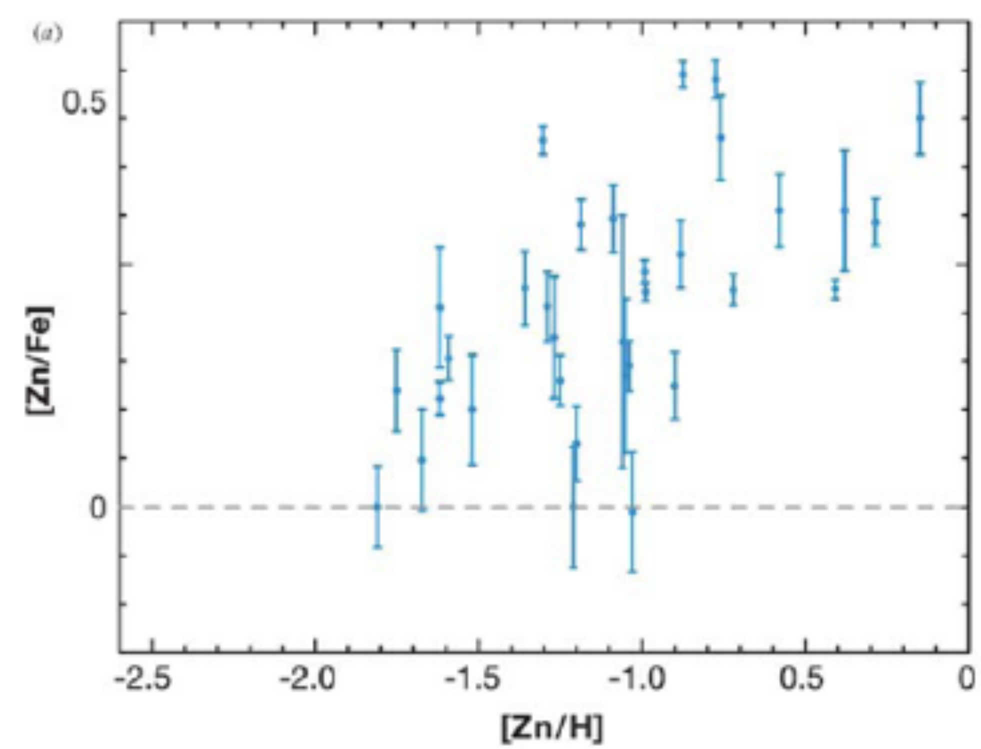


$$\langle Z \rangle = \log_{10}\left[\frac{\sum_{i=1}^{n} 10^{[\mathrm{M/H}]_i} N_i}{\sum_{i=1}^{n} N_i}\right] - \log_{10}(\mathrm{M/H})_{\odot}$$



$$\kappa = 10^{[\mathrm{Y/H}]_{\mathrm{int}}}(10^{[\mathrm{X/Y}]_{\mathrm{int}}} - 10^{[\mathrm{X/Y}]_{\mathrm{gas}}})$$

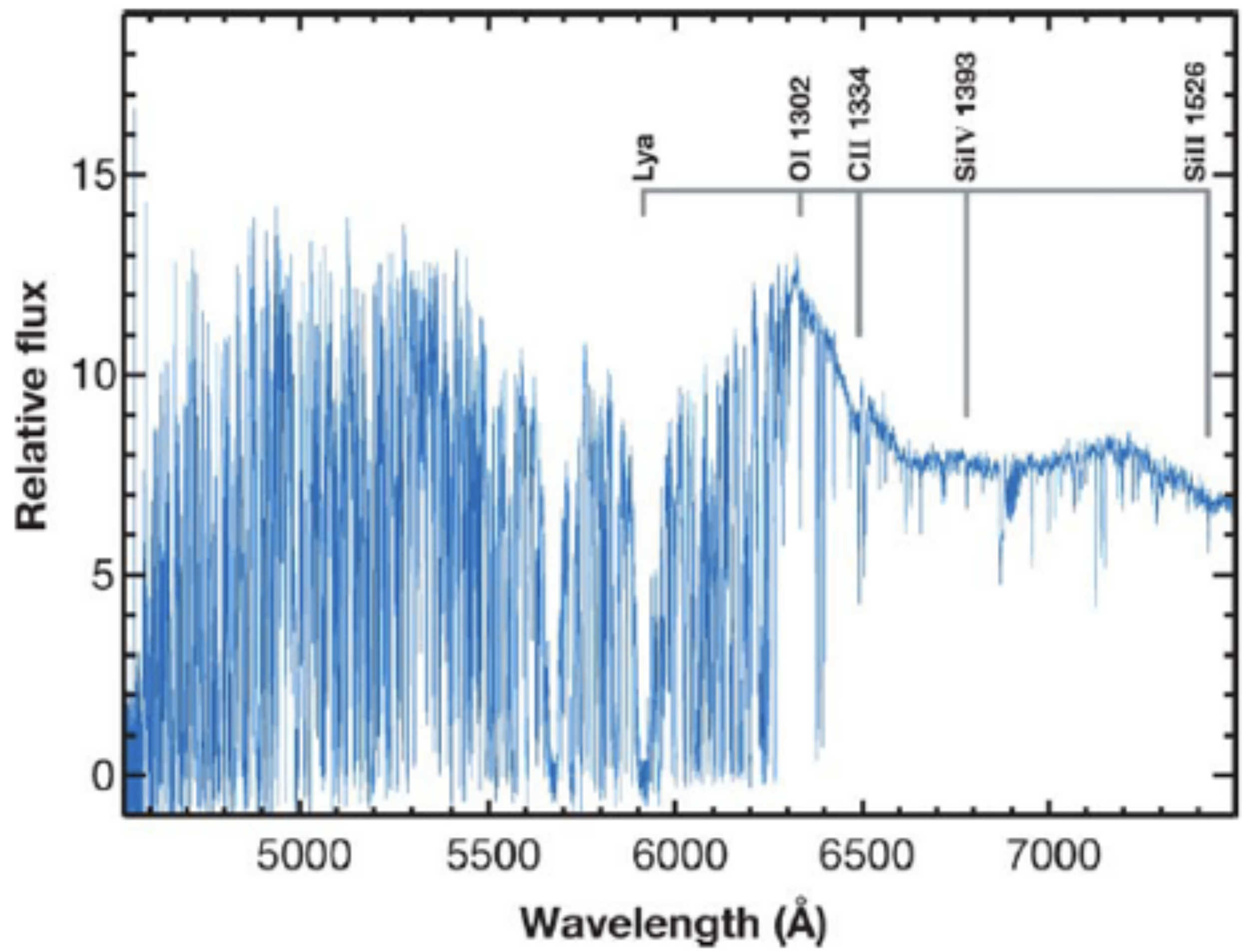


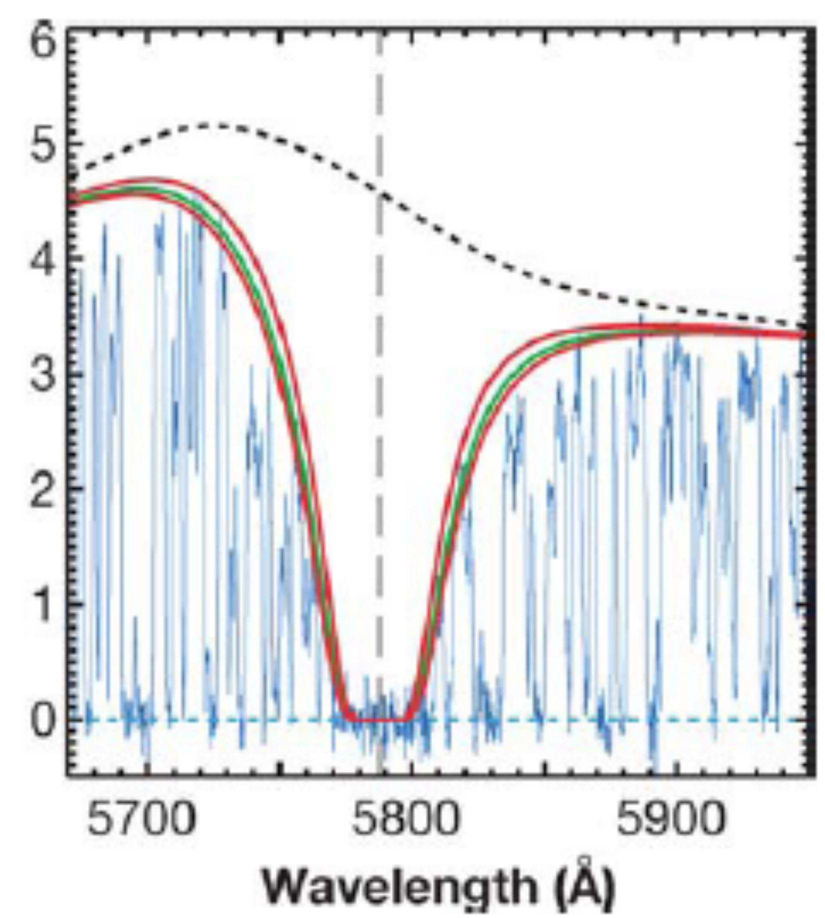


DAMPED LYMAN ALPHA SYSTEMS

- DLA: N > 2 * 10
- subDLA: N > 10
- LLS: N > 10
- Ly-a forrest: N < 10

- Hydrogen mainly neutral (precursors of molecular clouds, stars' birthplace)
- Used to trace the chemical evolution along the history of the universe





DLAS: THE DISTRIBUTION FUNCTION F(X,N)

$$f(N, X) \equiv (c/H_0) n_{co}(N, X) A(N, X),$$

$$f_{\rm H\,I}(N, X) dN\, dX$$

Number of DLAs in the intervals (N, N+dN) and (X, X+dX)

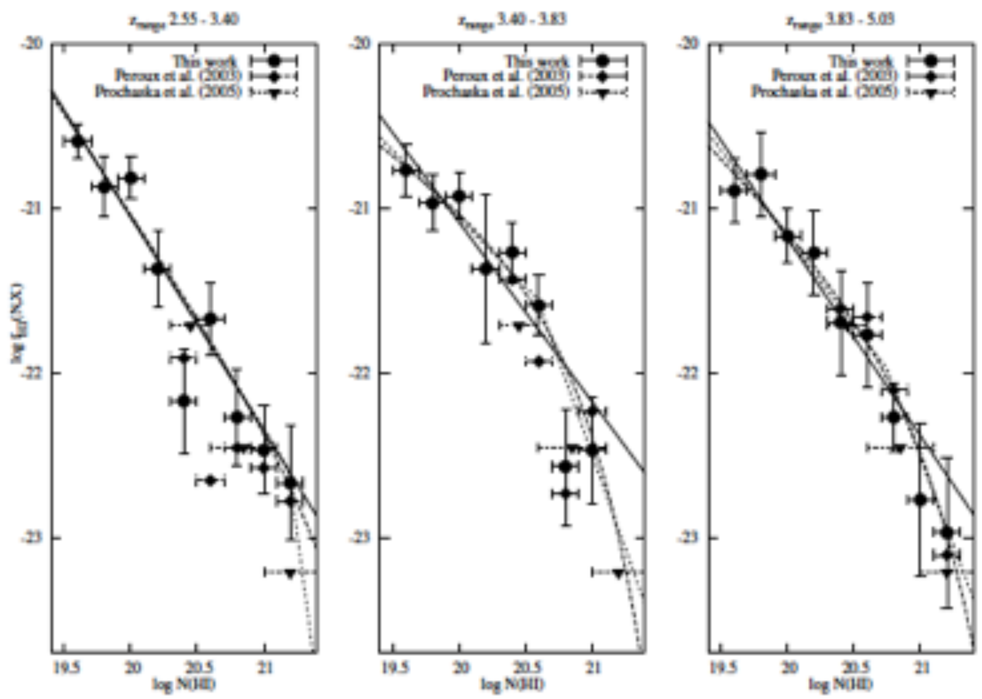
$$dX \equiv \frac{H_0}{H(z)} (1+z)^2\, dz \qquad H(z) = H_0 \left[\Omega_{\rm m}(1+z)^3 + \Omega_\Lambda\right]^{1/2}$$

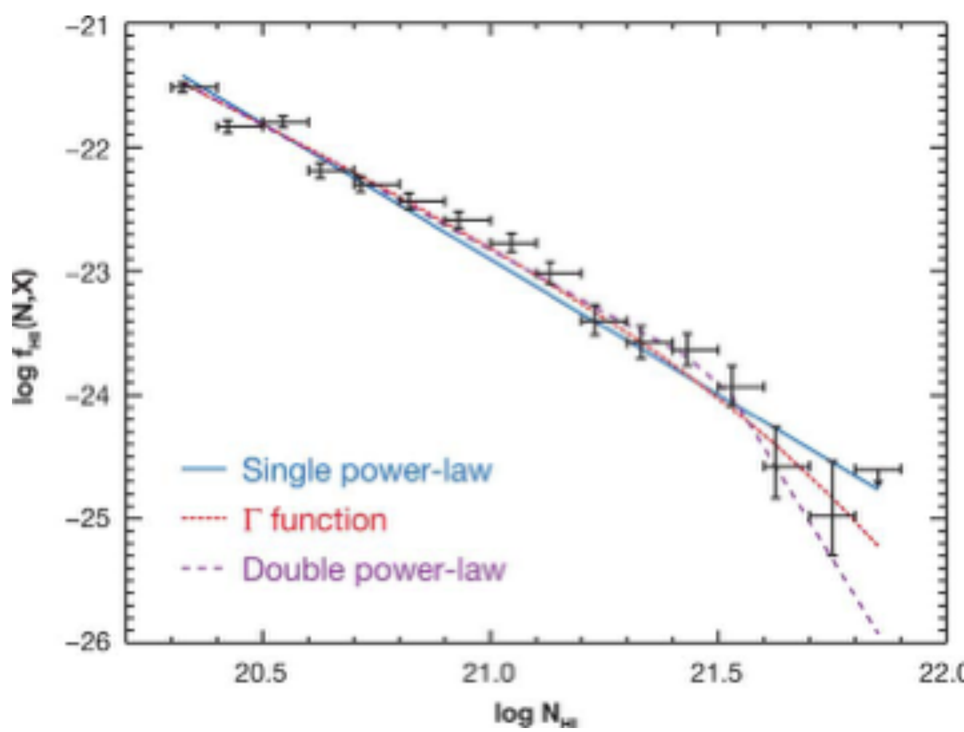
$$f_{\rm HI}(N, z) {\rm d}N{\rm d}X = \frac{m}{\Delta N \sum_{i=1}^{n} \Delta X_i} {\rm d}N{\rm d}X$$

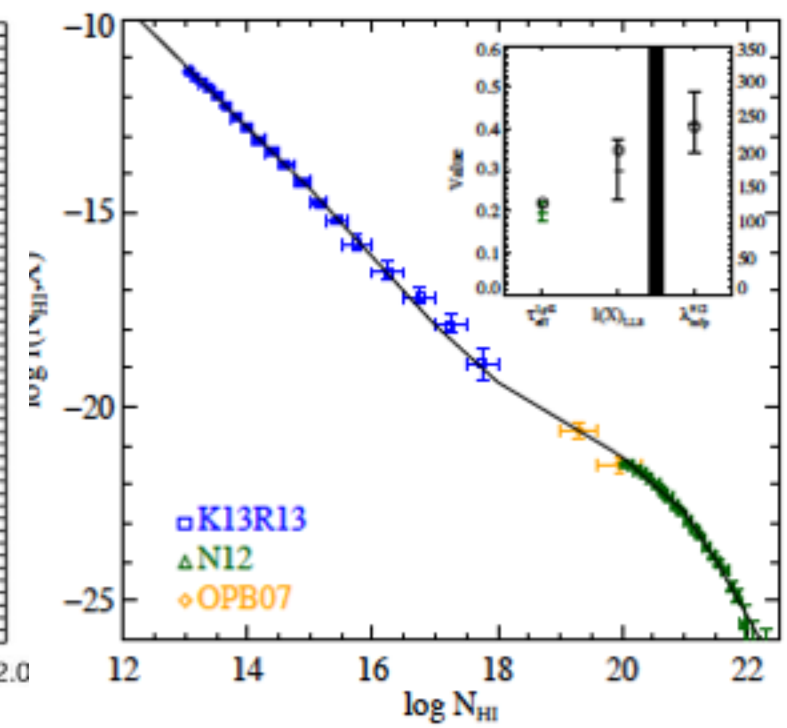
$$f_{\rm H\,I}(N, X) = k_1 N^{\alpha_1}$$

$$f_{\rm H\,I}(N, X) = k_3 \left(\frac{N}{N_d}\right)^{\beta}, \text{ where } \beta = \begin{cases} \alpha_3 & N < N_d \\ \alpha_4 & N \geq N_d \end{cases}$$

$$f_{\rm H\,I}(N, X) = k_2 \left(\frac{N}{N_\gamma}\right)^{\alpha_2} \exp\left(\frac{-N}{N_\gamma}\right)$$





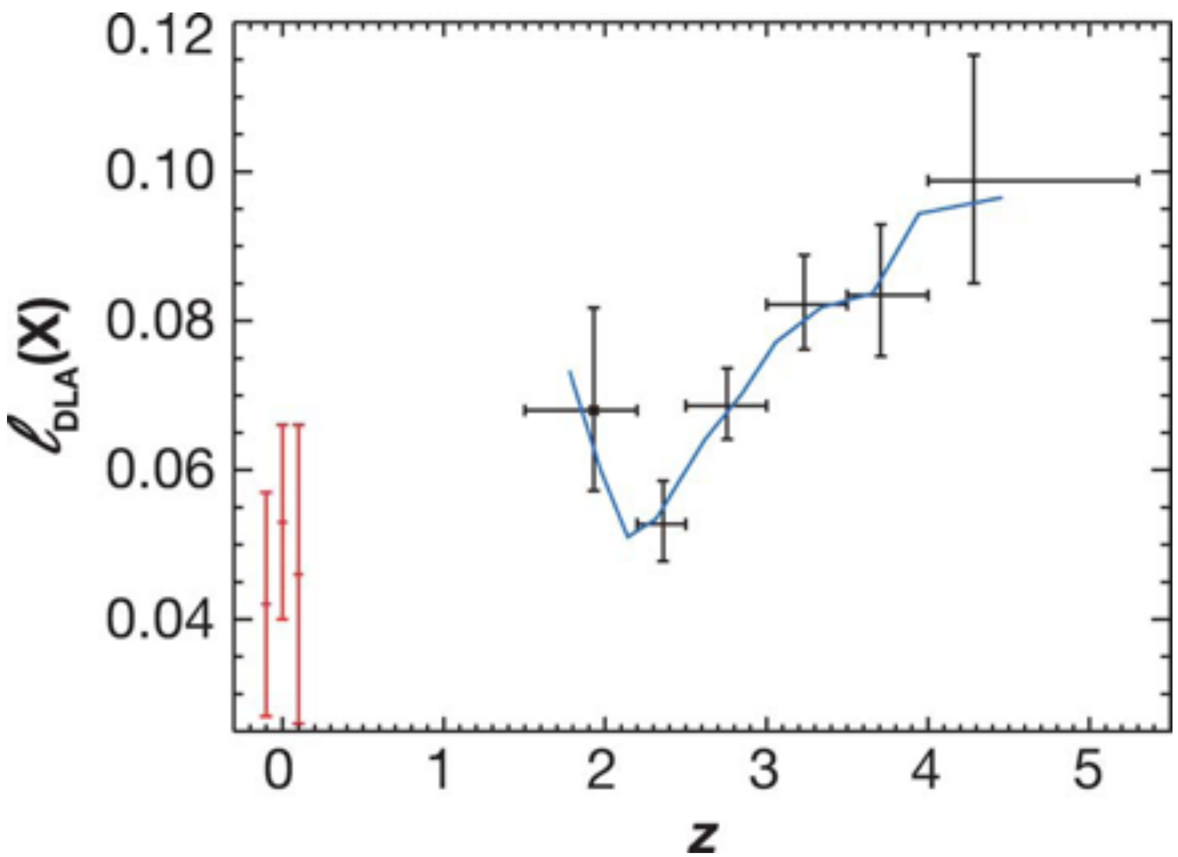


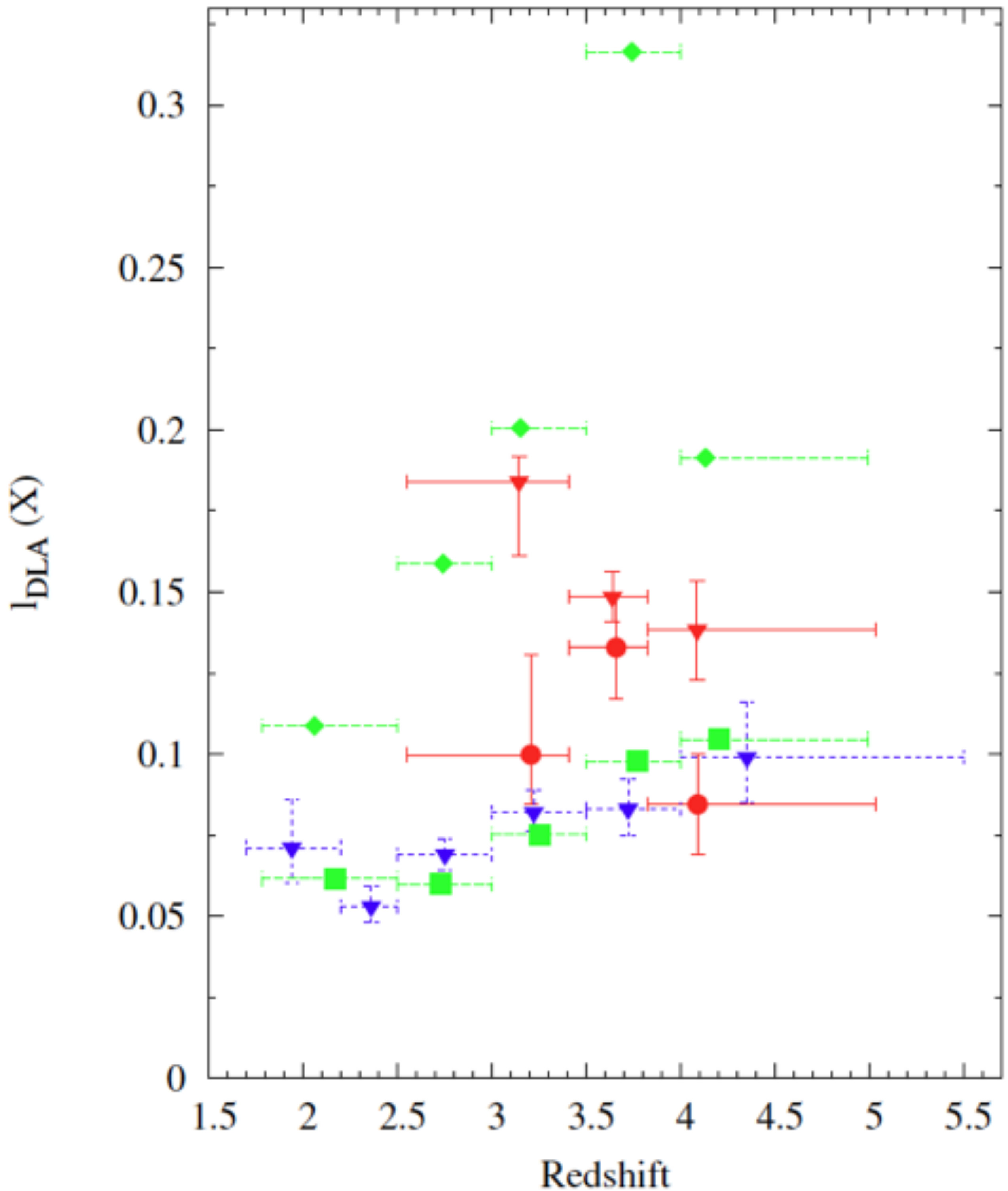
DLAS: THE LINE DENSITY OF SYSTEMS (ℓ_{DLA})

$$\ell_{DLA}(X)\,dX = \int_{N_{th}}^{\infty} f_{HI}(N, X)\,dN\,dX$$

$$\ell_{DLA}(X) = (c/H_0)\,n_{DLA}(X)\,A(X)$$

$$\ell_{DLA}(X) = m_{DLA}/\Delta X$$

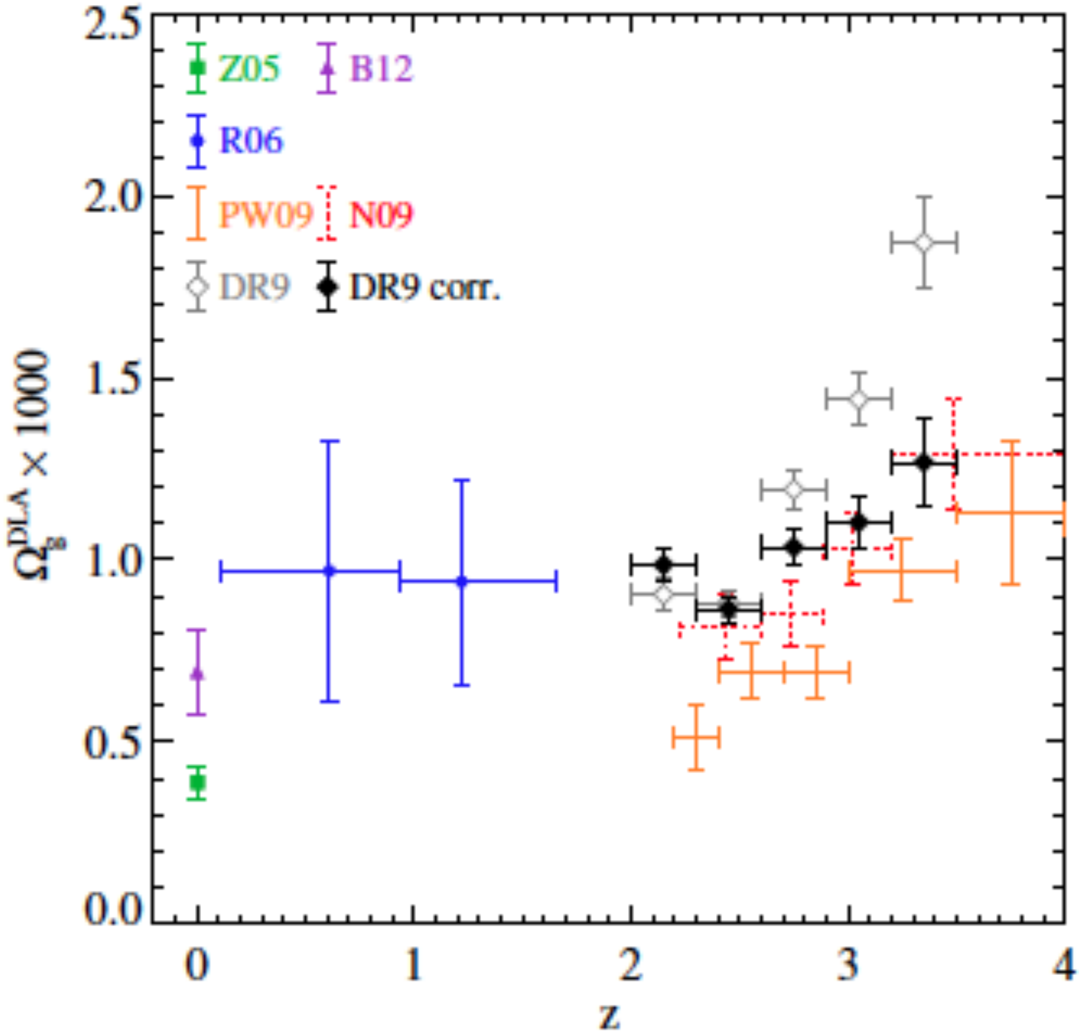


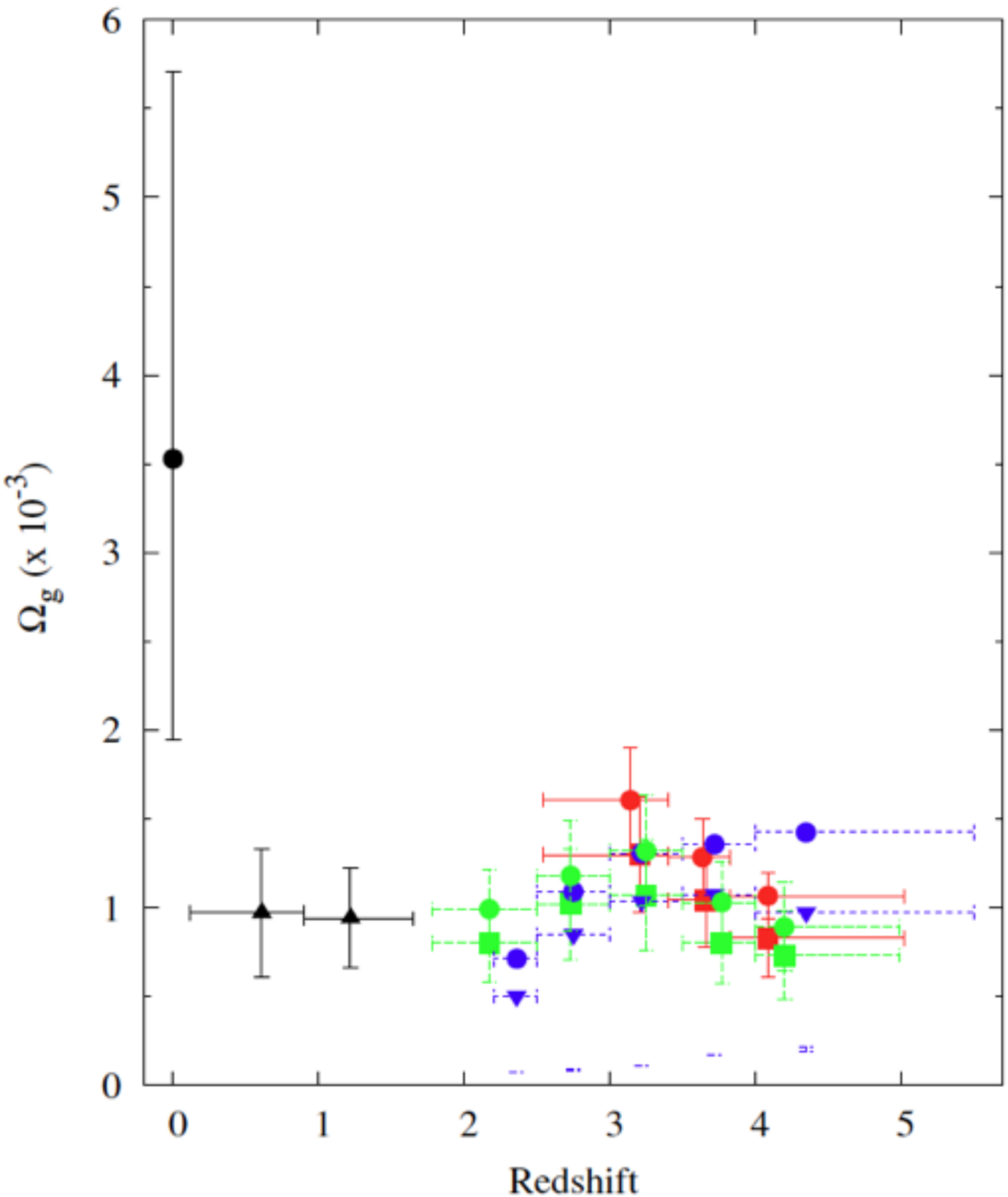


DLAS: HI CONTENT AND EVOLUTION (Ω_G)

$$\Omega_g = \frac{H_0}{c} \frac{\mu m_H}{\rho_{crit}} \int_{N_{min}}^{N_{max}} dN N f(N, X)$$

$$\Omega_g(X) = \frac{H_0}{c} \frac{\mu m_H}{\rho_{crit}} \frac{\sum_{i=1}^{n} N_i}{\Delta X}$$





DLA SURVEYS: HISTORICAL PERSPECTIVE

THE ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES, 61:249–304, 1986 June

DAMPED LYMAN-ALPHA ABSORPTION BY DISK GALAXIES WITH LARGE REDSHIFTS.
I. THE LICK SURVEY

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HARDING E. SMITH AND ROSS D. COHEN
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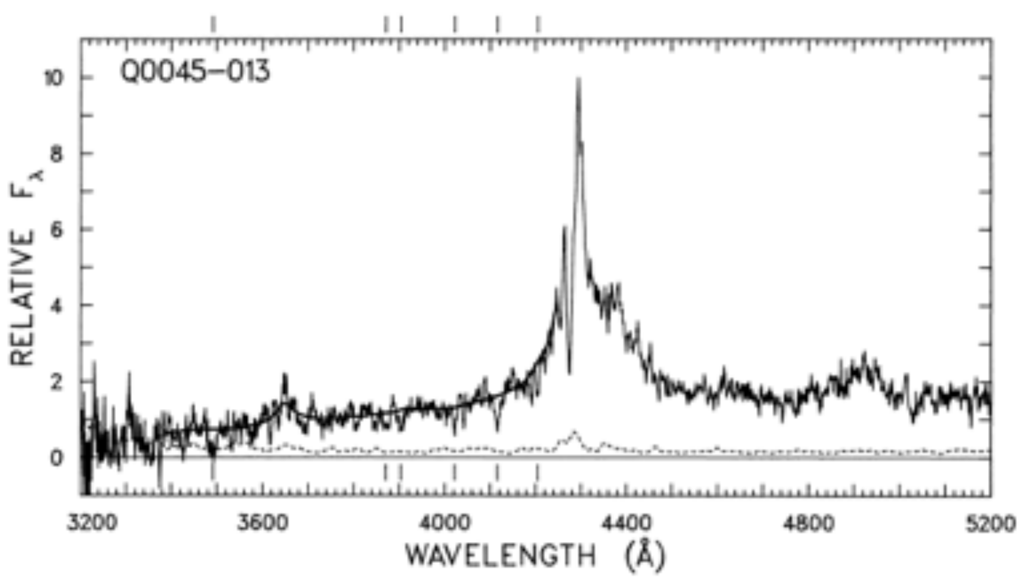
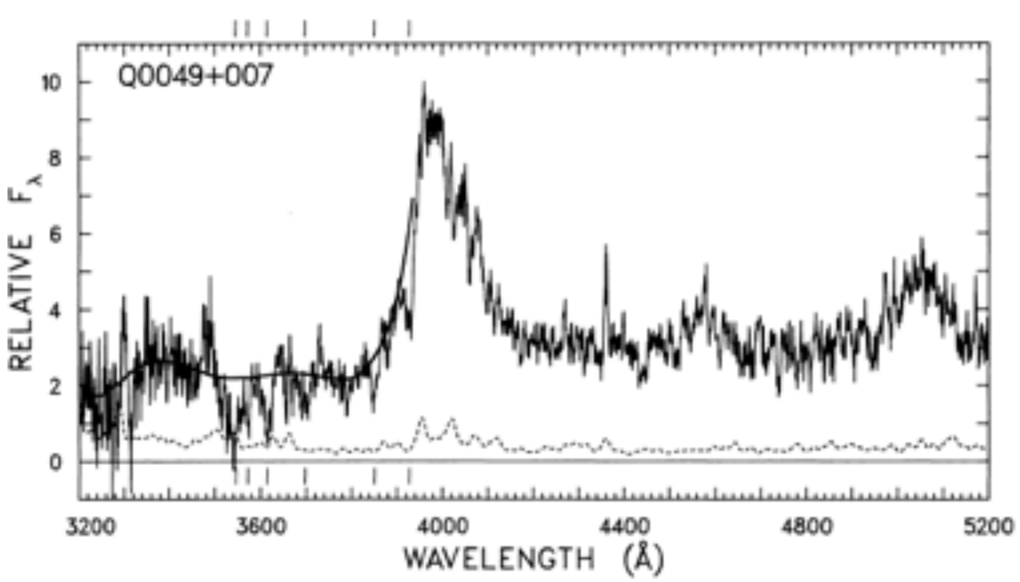
Received 1985 August 1; accepted 1985 December 2





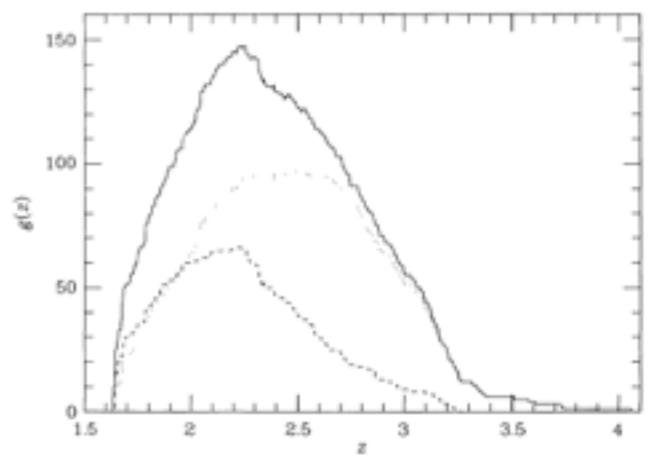
- Sample: 68 QSOs
  - Motivated by the discovery of 21cm absorption in 2 of the 3 DLAs known at the date (Wolfe et al, 1981)
  - Low resolution (Δ
  - Criteria: V ≤ 18.5, z
  - Search for HI disks: N(HI) > 1.8 × 10
    (from radio observations of spiral galaxies)
    ⇨ EW > 5
  - 47 features detected (DW are clearly detected in 15 cases and in 11 cases DW are ruled out)

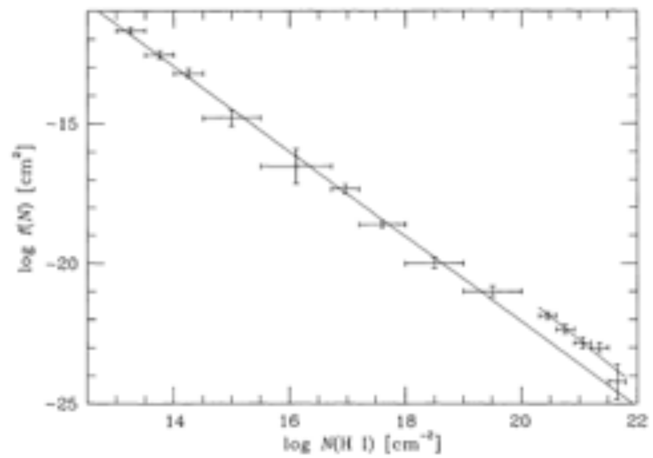
DLA SURVEYS: HISTORICAL PERSPECTIVE

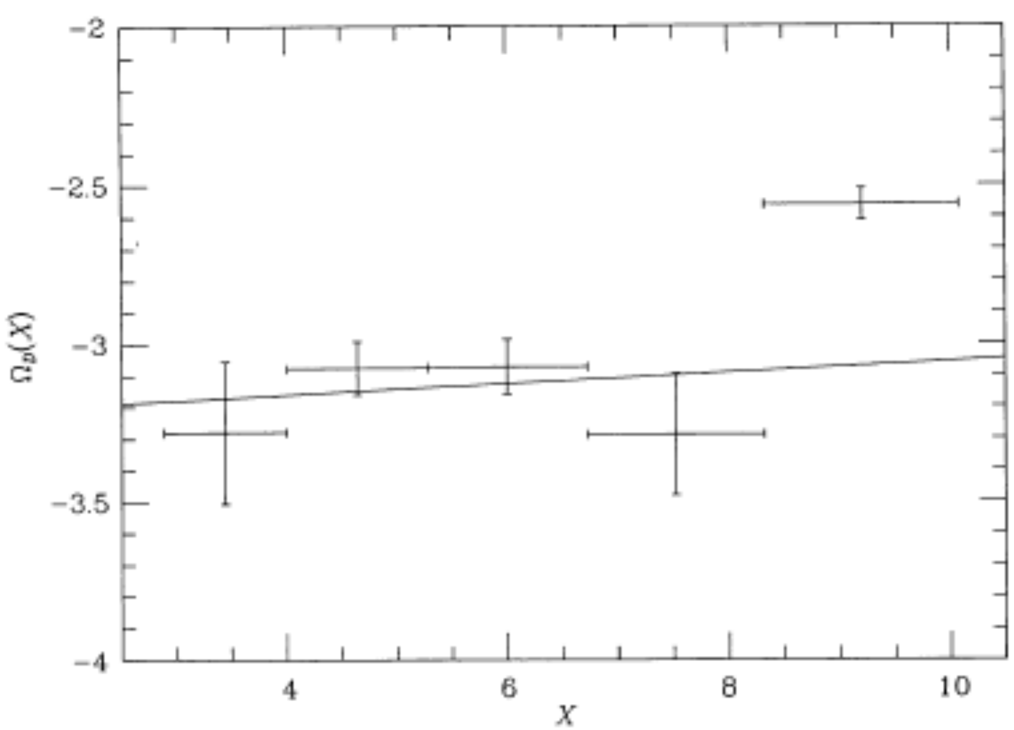
THE ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES, 77:1–57, 1991 September

A NEW SPECTROSCOPIC SURVEY FOR DAMPED Lyα ABSORPTION LINES FROM HIGH-REDSHIFT GALAXIES[1]

KENNETH M. LANZETTA[2], ARTHUR M. WOLFE[3], DAVID A. TURNSHEK[4], LIMIN LU[3,4], RICHARD G. MCMAHON[2], AND CYRIL HAZARD[4]
Received 1990 August 6; accepted 1991 March 5







Sample: 57 (+literature) QSOs

- Low resolution (Δ
- Goals: 1) Sample large enough for statistical purposes
  2) z_{em} > Wolfe et al. (1986)
  3) Identify DLAs toward bright radio sources
- Statistical DLA sample: 125 candidates
- DLAs are not only HI disks in spiral galaxies
- Local star mass density comparable to DLA HI density at z ~2.5 ⇨ Tracers of the material available for star formation

$$n(z) = n_0(1+z)^\gamma$$

NUMBER DENSITY DISTRIBUTION PARAMETERS

Sample	N_0	γ
D1 ...	0.035 ± 0.007	1.2 ± 1.7
D2 ...	0.163 ± 0.026	0.3 ± 1.4

$$f(N) = BN^{-\beta}$$

H I COLUMN DENSITY DISTRIBUTION PARAMETERS

Sample	log B	β
D1 ...	13.63 ± 0.09	1.73 ± 0.29
D2 ...	12.33 ± 0.07	1.67 ± 0.19

$$\langle \Omega_D \rangle = \begin{cases} 0.71 \pm 0.05 \times 10^{-3}\, h^{-1} & (q_0 = 0) \\ 1.31 \pm 0.09 \times 10^{-3}\, h^{-1} & (q_0 = 0.5) \end{cases}$$

$$\langle \Omega_D \rangle = \begin{cases} 0.79 \pm 0.14 \times 10^{-3}\, h^{-1} & (q_0 = 0) \\ 1.45 \pm 0.25 \times 10^{-3}\, h^{-1} & (q_0 = 0.5) \end{cases}$$

$$\langle n(z) \rangle = 0.16 \pm 0.03$$

$$\langle n(z) \rangle = 0.25 \pm 0.04$$

DLA SURVEYS: HISTORICAL PERSPECTIVE

The Astrophysical Journal, 440:435–457, 1995 February 20

THE *IUE* SURVEY FOR DAMPED LYMAN-α AND LYMAN-LIMIT ABSORPTION SYSTEMS: EVOLUTION OF THE GASEOUS CONTENT OF THE UNIVERSE

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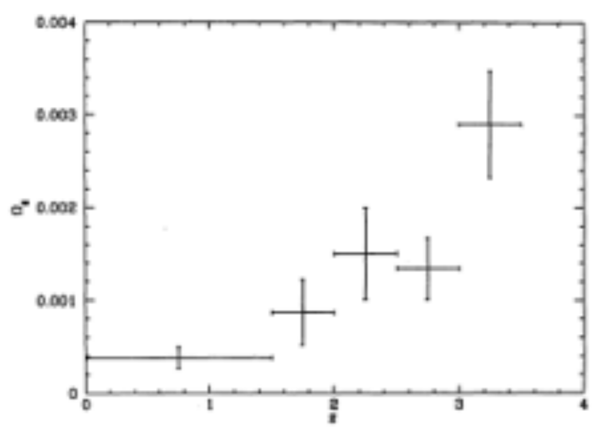
Received 1993 April 15; accepted 1994 September 2

Damped Lyα Redshift and Absorption Distance Paths

Data Set	Δz	ΔX (q_0 = 0)	ΔX (q_0 = 0.5)
Ultraviolet survey	48.5	74.8	59.6
Optical survey	154.3	524.1	283.9
Ultraviolet plus optical surveys	202.8	598.9	343.4



The Astrophysical Journal, 454:698–725, 1995 December 1

THE LARGE BRIGHT QSO SURVEY FOR DAMPED Lyα ABSORPTION SYSTEMS[1]

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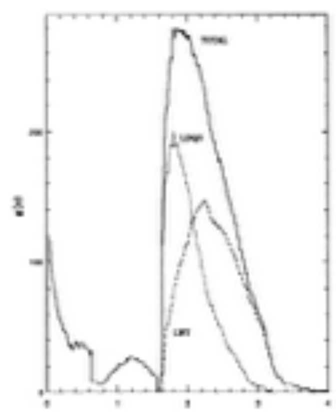
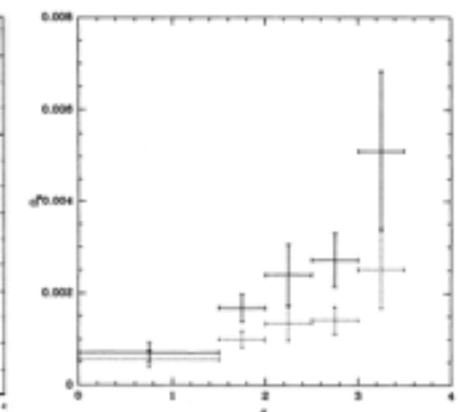
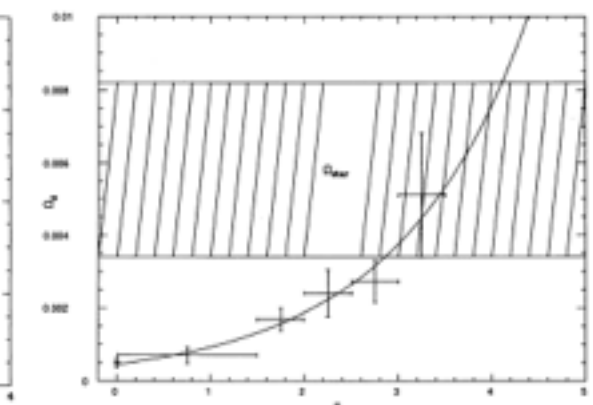
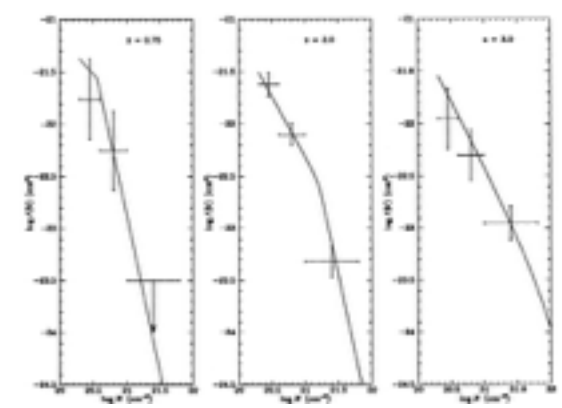
Received 1995 March 16; accepted 1995 June 14









- Sample: 260 (+literature) QSOs
  - Low resolution (Δ
  - First low-z survey (0.008 ≤ z ≤ 1.55)
  - Closed box assumption is incorrect

- Sample: 228 (+literature) QSOs
  - Low resolution (Δ
  - High N systems decrease when z decreases
  - Density evolution due to gas consumption by star formation

MODERN DLA SURVEYS AND IDENTIFICATIONS

- Low redshift
  - Zwaan et al. (2005)
  - Rao et al. (2006)
- Intermediate redshift
  - Ellison et al. (2001)
  - Prochaska et al. (2004, 2005)
  - Noterdaeme et al. (2009, 2012)
- SubDLAs
  - Peroux et al. (2005)
  - O'Meara et al. (2007)
  - Zafar et al. (2013)
- High redshift
  - Storrie-Lombardi et al. (1996)
  - Storrie-Lombardi & Wolfe (2000)
  - Peroux et al. (2001, 2003)
  - Guimaraes et al. (2009)
  - Sánchez-Ramírez et al. (2014, in prep.)

MODERN SURVEYS AND IDENTIFICATIONS

THE ASTROPHYSICAL JOURNAL, 468:121–138, 1996 September 1

APM $Z \geq 4$ QSO SURVEY: SPECTRA AND INTERVENING ABSORPTION SYSTEMS

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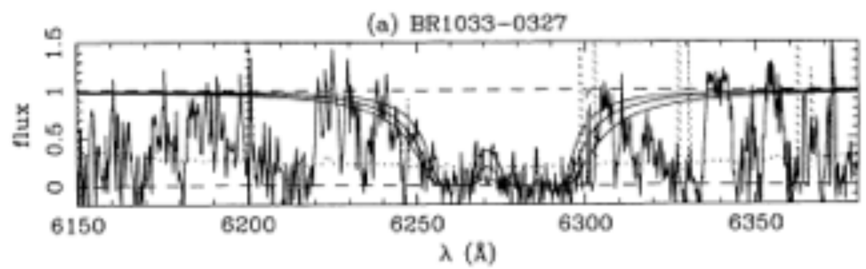

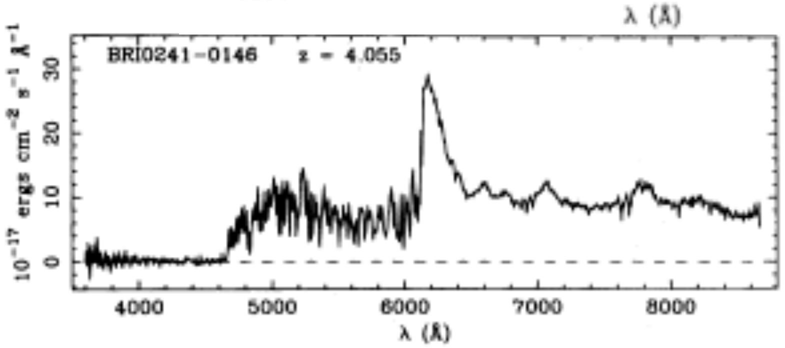

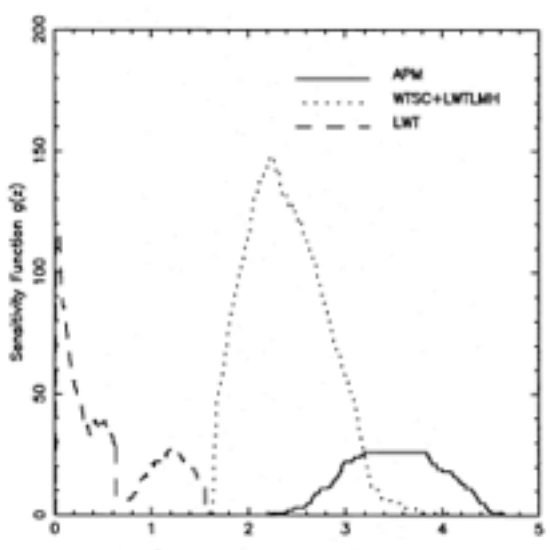

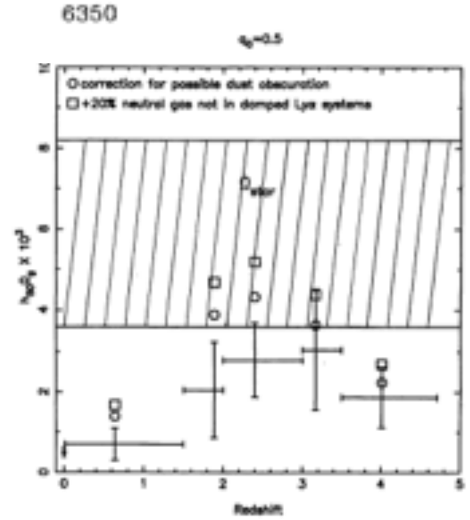

THE ASTROPHYSICAL JOURNAL, 543:552–576, 2000 November 10

SURVEYS FOR $z > 3$ DAMPED Lyα ABSORPTION SYSTEMS: THE EVOLUTION OF NEUTRAL GAS[1]

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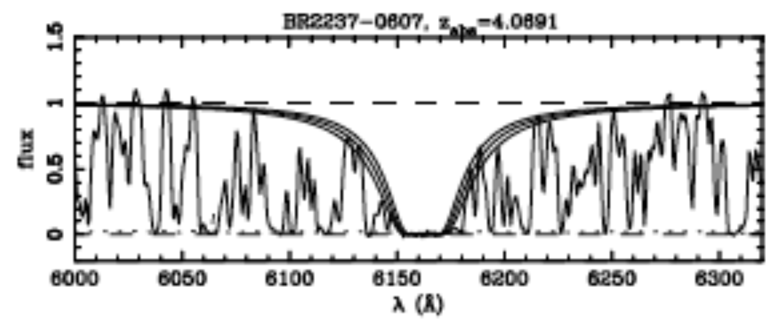
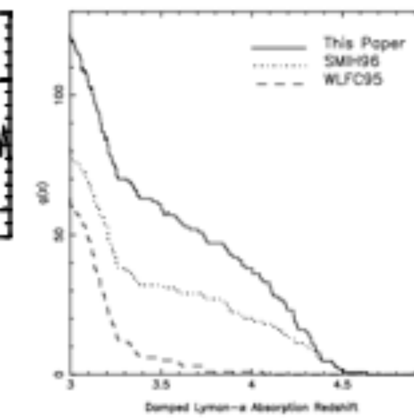
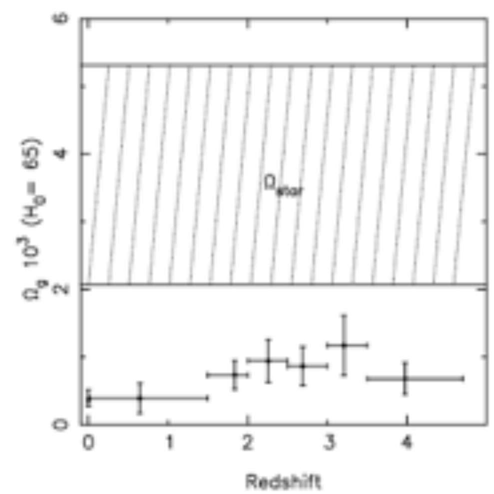
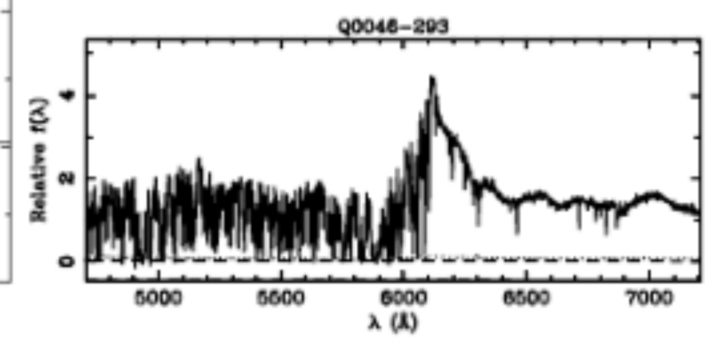
Received 2000 March 2; accepted 2000 June 12









- Sample: 26 (+literature) QSOs
  - Intermediate resolution (Δ
  - First high-z survey ($2.8 \leq z \leq 4.4$)
- Sample: 40 (+literature) QSOs
  - Intermediate resolution (Δ
  - High-z survey ($3.2 \leq z \leq 4.694$)
  - $\Omega_\star$

MODERN SURVEYS AND IDENTIFICATIONS

THE ASTRONOMICAL JOURNAL, 121:1799–1820, 2001 April

ABSORPTION SYSTEMS IN THE SPECTRA OF 66 $z \gtrsim 4$ QUASARS

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LISA J. STORRIE-LOMBARDI
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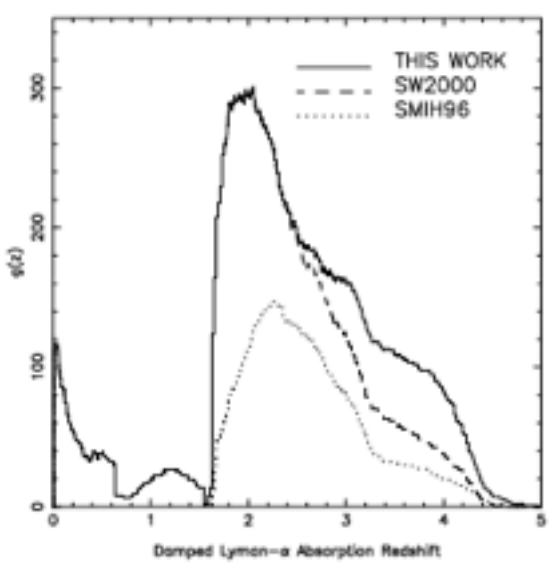
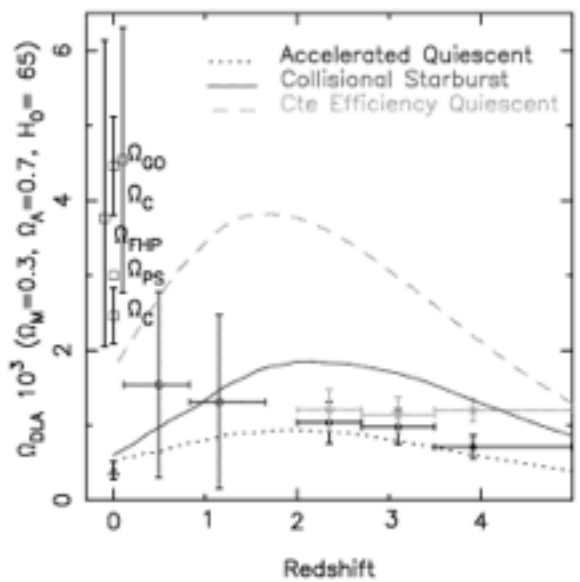
AND
ISOBEL M. HOOK
Institute for Astronomy, Royal Observatory, Blackford Hill, Edinburgh EH9 3HJ, England, UK
Received 2000 November 27; accepted 2001 January 9





- Sample: 66 (+literature) QSOs
  - Intermediate resolution (Δ
  - EW method

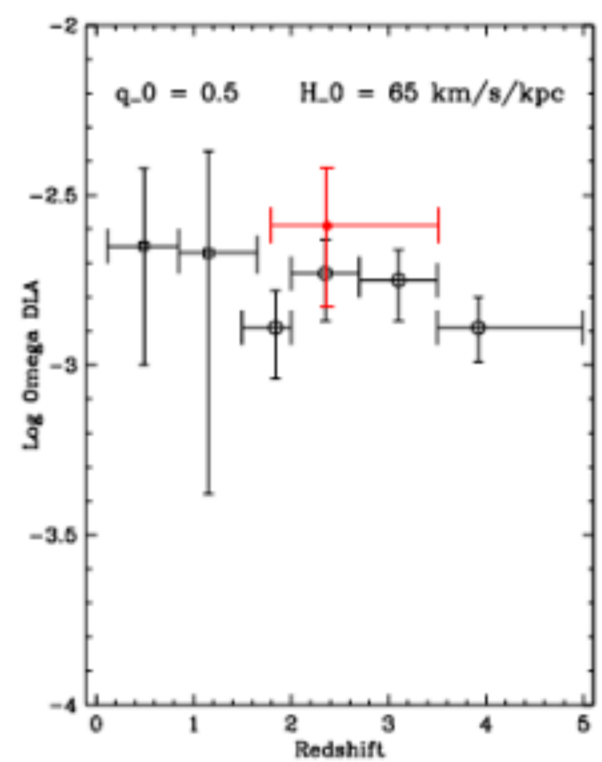
A&A 379, 393–406 (2001)
DOI: 10.1051/0004-6361:20011281

Astronomy & Astrophysics

The CORALS survey I: New estimates of the number density and gas content of damped Lyman alpha systems free from dust bias*,**

S. L. Ellison[1], L. Yan[2], I. M. Hook[3], M. Pettini[4], J. V. Wall[5], and P. Shaver[6]

- Sample: 66 (+literature) QSOs
  - Intermediate resolution (Δ
  - No dust bias in DLA samples



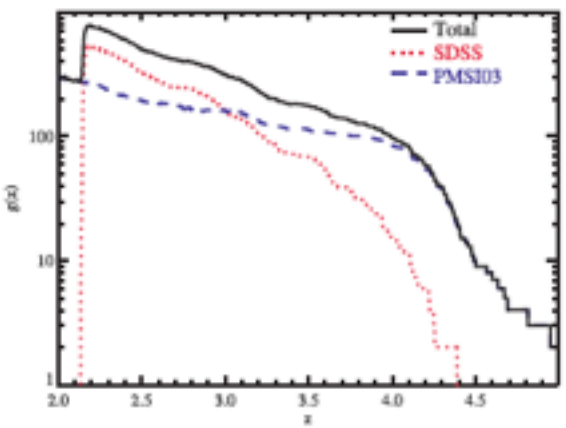
MODERN SURVEYS AND IDENTIFICATIONS

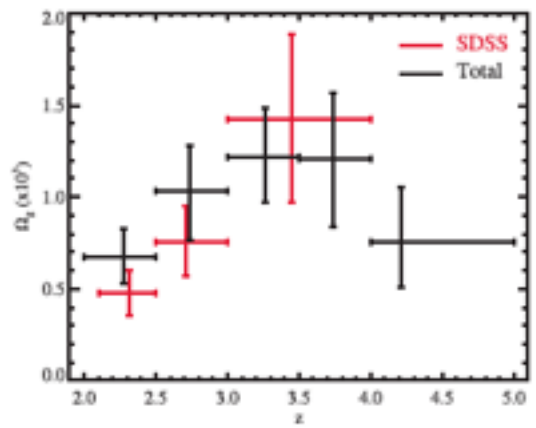
Publications of the Astronomical Society of the Pacific, 116:622–633, 2004 July

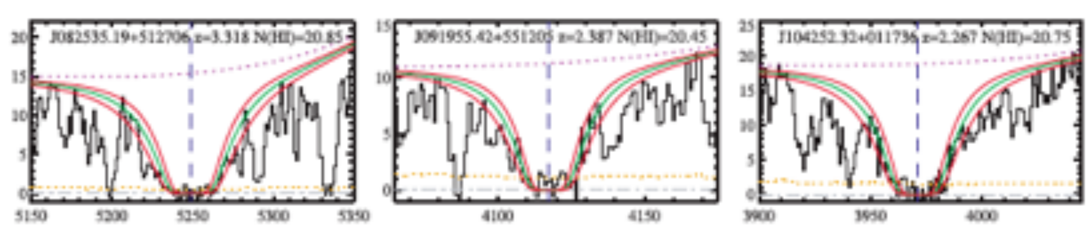
The Sloan Digital Sky Survey Damped Lyα Survey: Data Release 1

Jason X. Prochaska and Stephane Herbert-Fort
UCO/Lick Observatory, University of California, 1156 High Street, Santa Cruz, CA 95064; xavier@ucolick.org, shf@ucolick.org

Received 2004 March 17; accepted 2004 April 20; published 2004 June 8







The Astrophysical Journal, 635:123–142, 2005 December 10

THE SDSS DAMPED Lyα SURVEY: DATA RELEASE 3

Jason X. Prochaska and Stéphane Herbert-Fort
Department of Astronomy and Astrophysics, UCO/Lick Observatory; University of California, 1156 High Street, Santa Cruz, CA 95064; xavier@ucolick.org, shf@ucolick.org
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Arthur M. Wolfe
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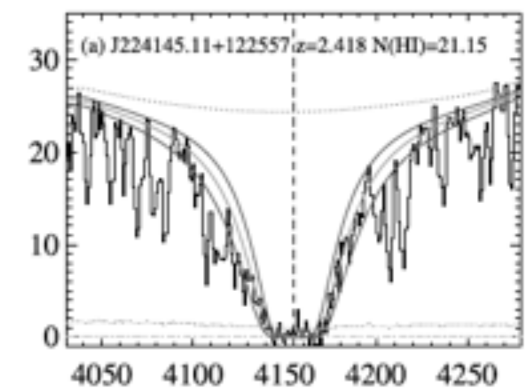
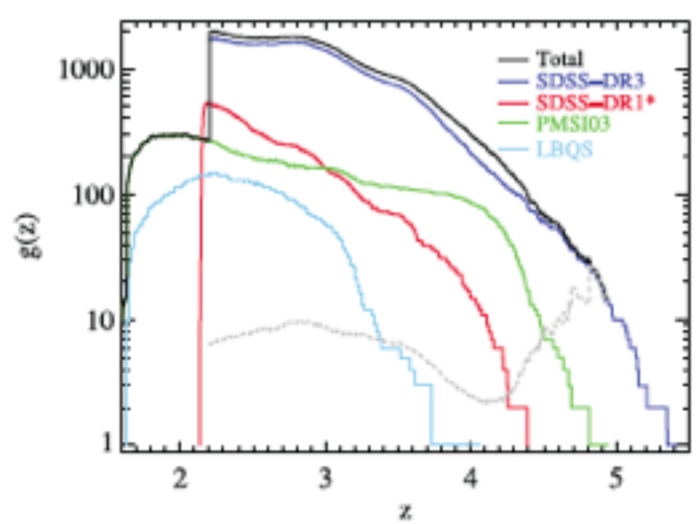
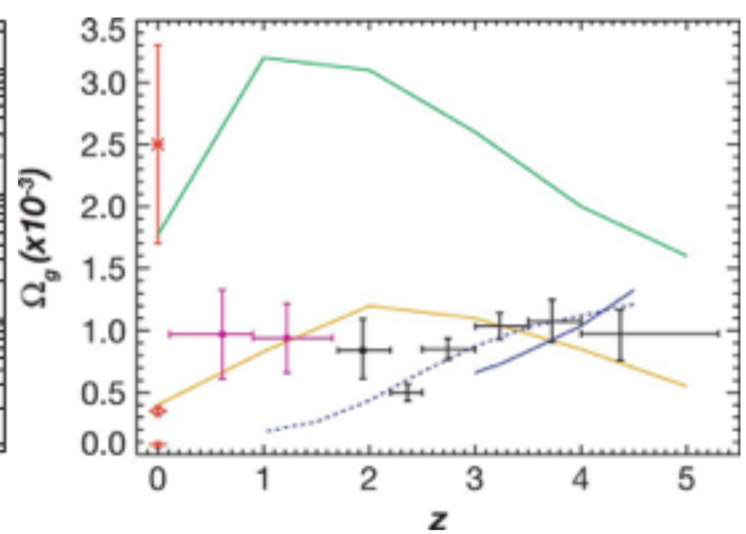
Received 2005 February 19; accepted 2005 August 15







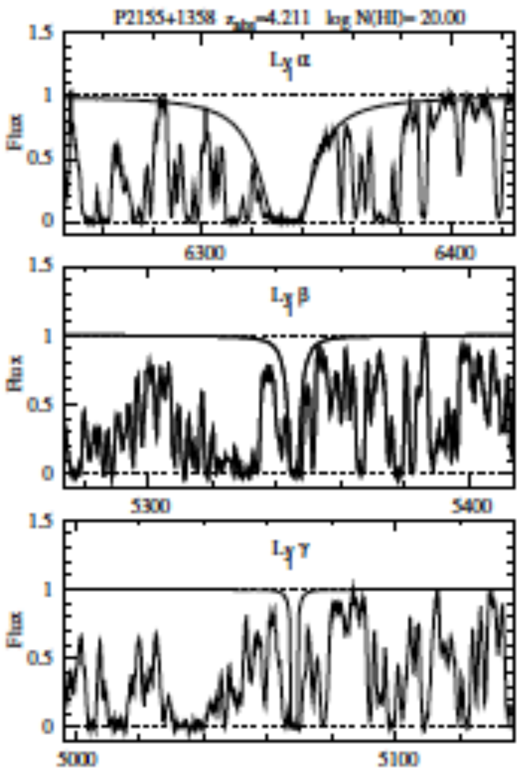
MODERN SURVEYS AND IDENTIFICATIONS

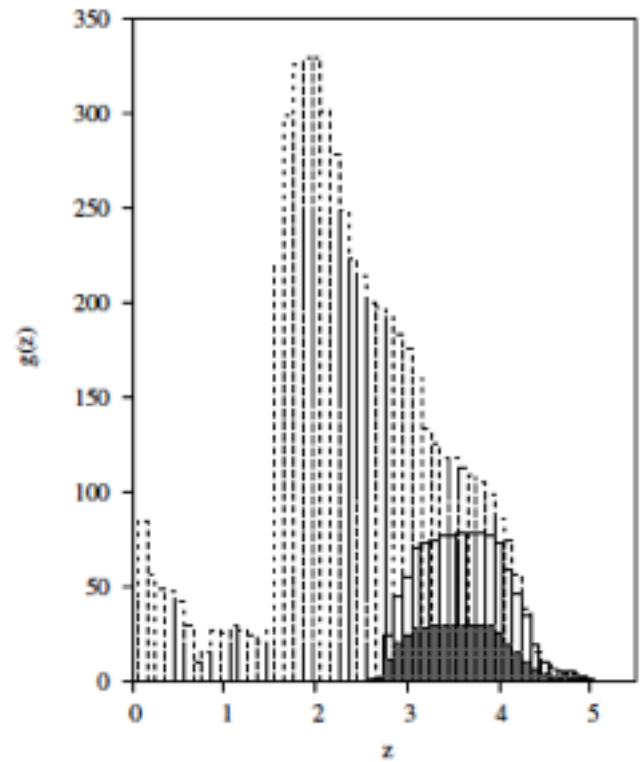
A&A 508, 133–140 (2009)
DOI: 10.1051/0004-6361/200811541

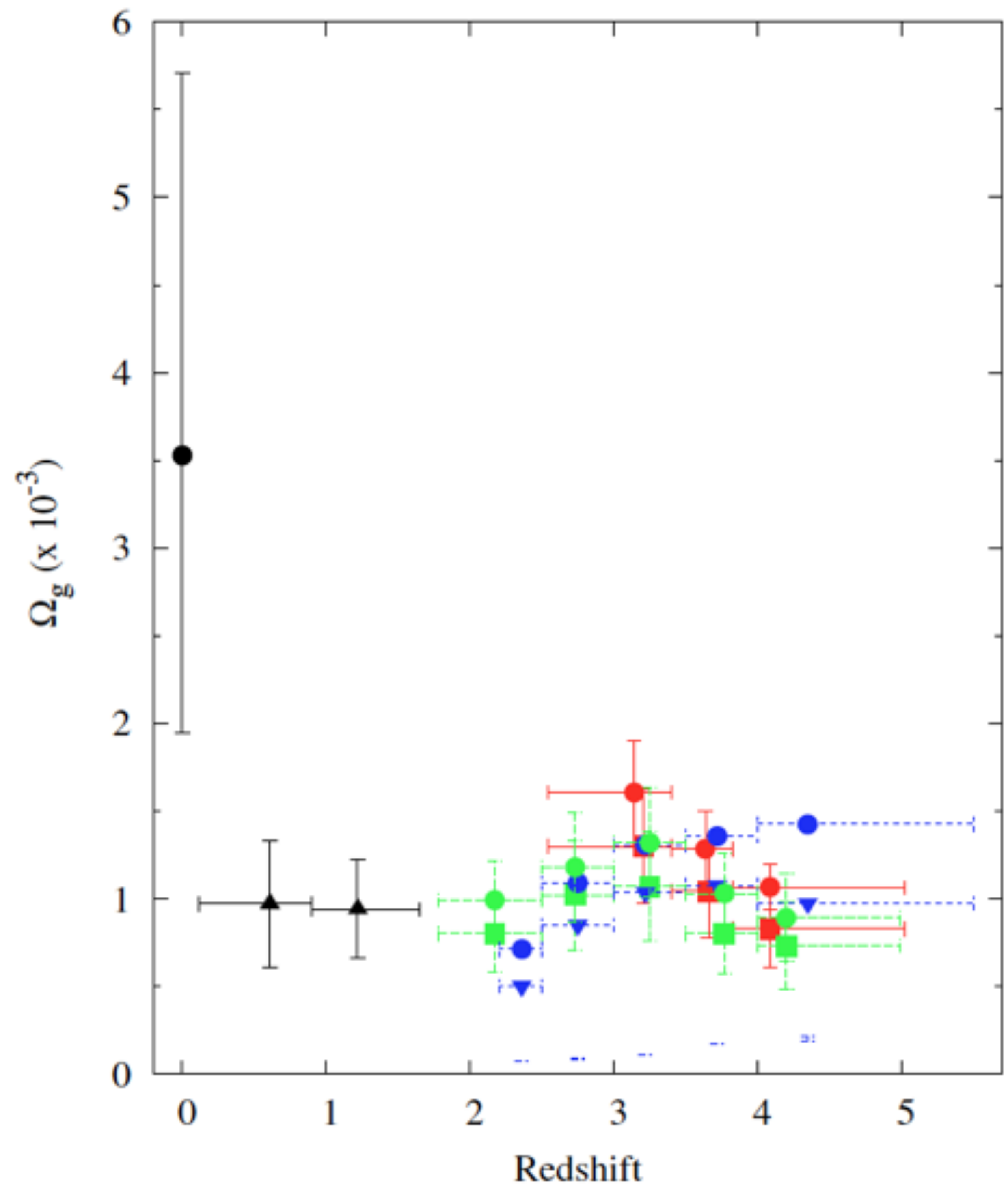
Astronomy & Astrophysics

Damped and sub-damped Lyman-α absorbers in $z > 4$ QSOs★,★★

R. Guimarães[1], P. Petitjean[2], R. R. de Carvalho[3], S. G. Djorgovski[4], P. Noterdaeme[5], S. Castro[6], P. C. da R. Poppe[1], and A. Aghaee[7,8]







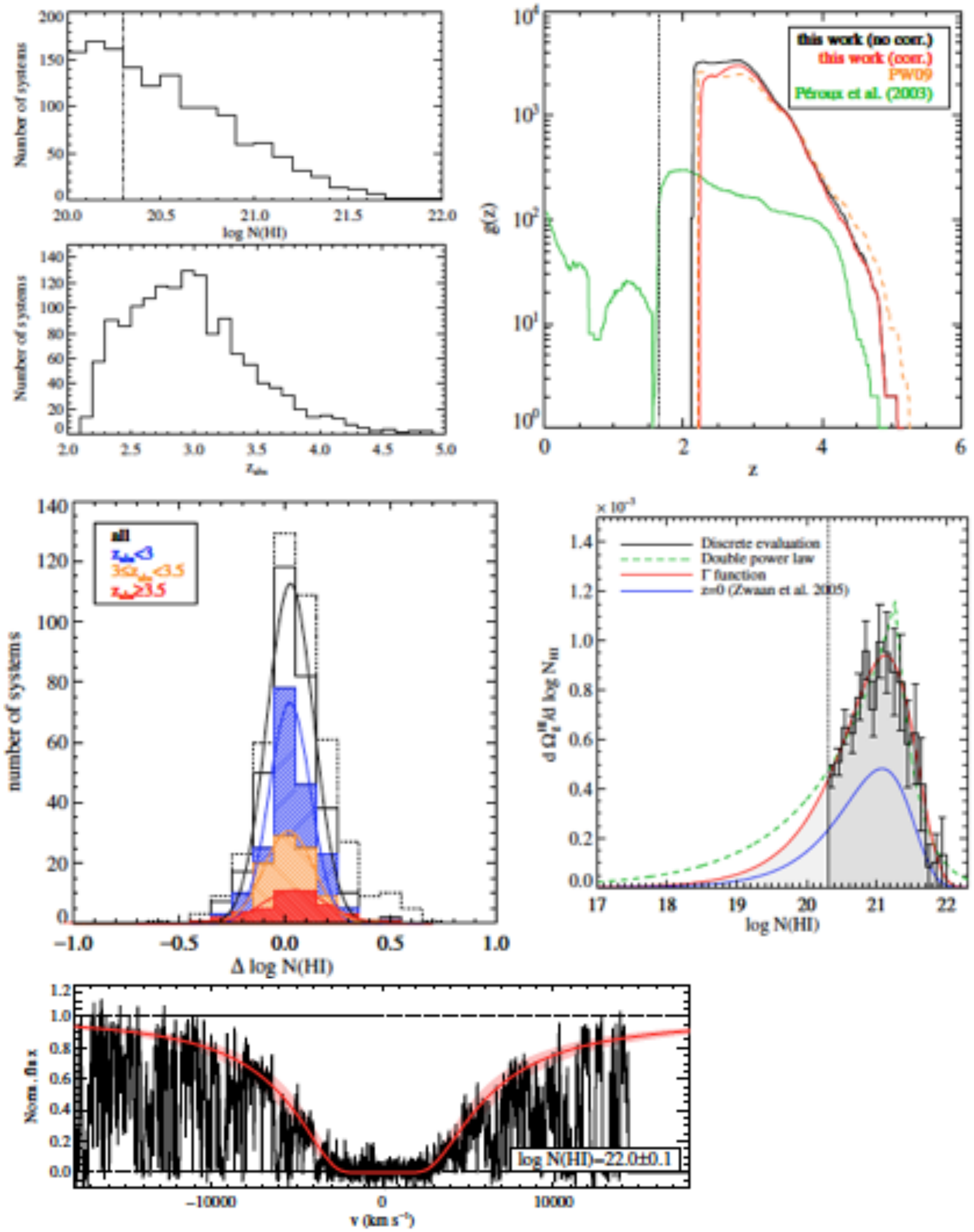
MODERN SURVEYS AND IDENTIFICATIONS

A&A 505, 1087–1098 (2009)
DOI: 10.1051/0004-6361/200912768

Astronomy & Astrophysics

Evolution of the cosmological mass density of neutral gas from Sloan Digital Sky Survey II – Data Release 7⋆

P. Noterdaeme[1,2], P. Petitjean[2], C. Ledoux[3], and R. Srianand[1]



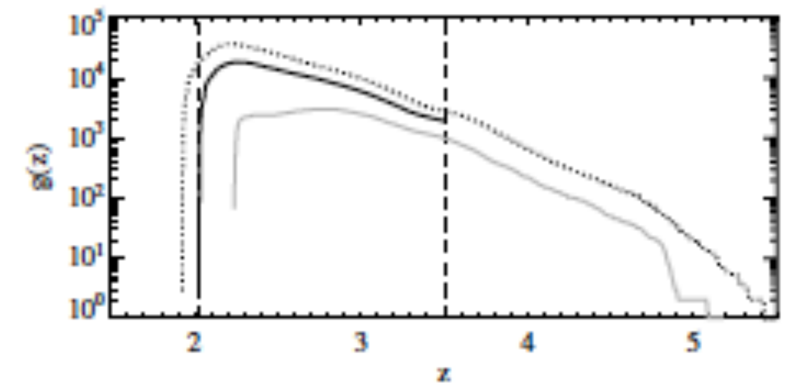
A&A 547, L1 (2012)
DOI: 10.1051/0004-6361/201220259

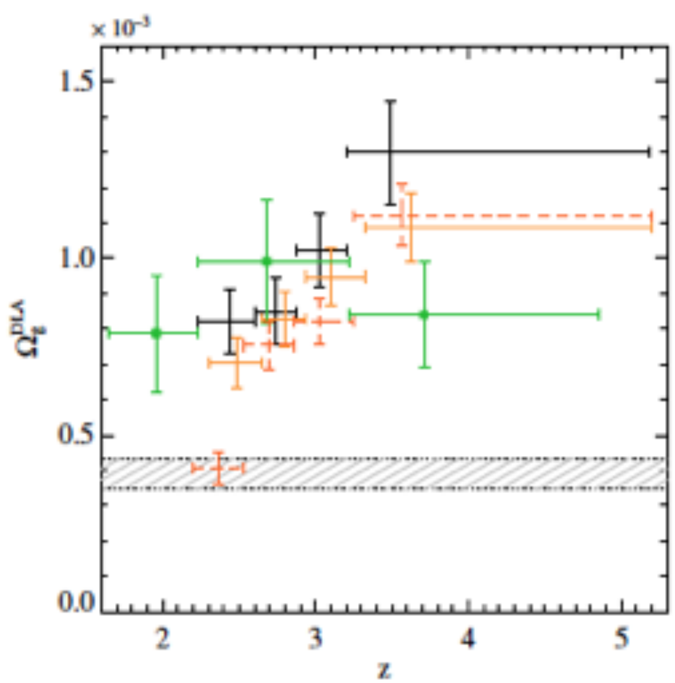
Astronomy & Astrophysics

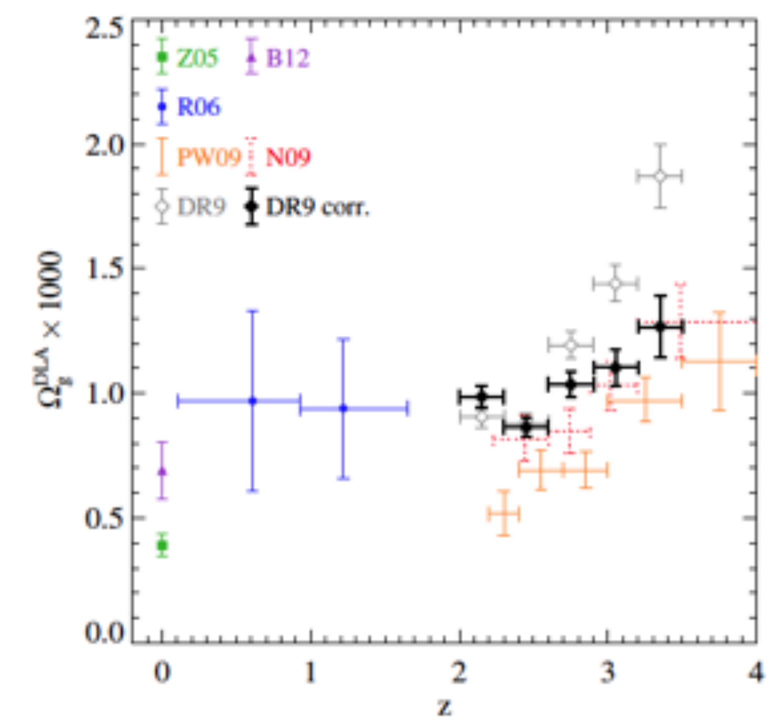
Letter to the Editor

Column density distribution and cosmological mass density of neutral gas: Sloan Digital Sky Survey-III Data Release 9⋆

P. Noterdaeme[1], P. Petitjean[1], W. C. Carithers[2], I. Pâris[3], A. Font-Ribera[2,4], S. Bailey[2], E. Aubourg[5], D. Bizyaev[6], G. Ebelke[6], H. Finley[1], J. Ge[7], E. Malanushenko[6], V. Malanushenko[6], J. Miralda-Escudé[8], A. D. Myers[9], D. Oravetz[6], K. Pan[6], M. M. Pieri[10], N. P. Ross[2], D. P. Schneider[11,12], A. Simmons[6], and D. G. York[13,14]







SUBDAMPED LYMAN ALPHA SYSTEMS

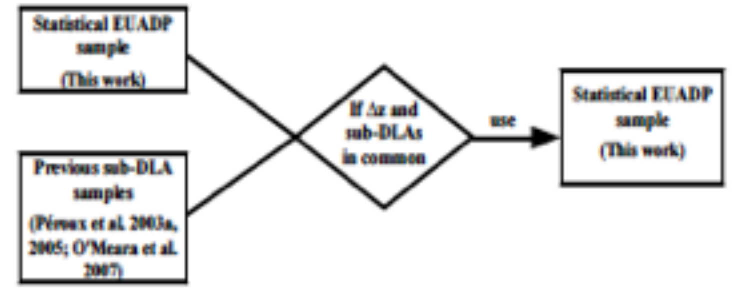
A&A 556, A141 (2013)
DOI: 10.1051/0004-6361/201321154

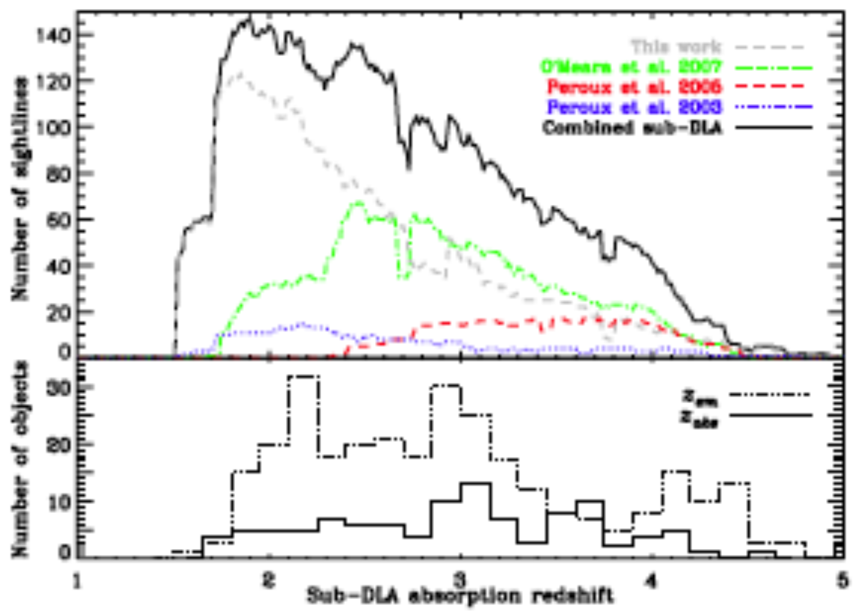
Astronomy & Astrophysics

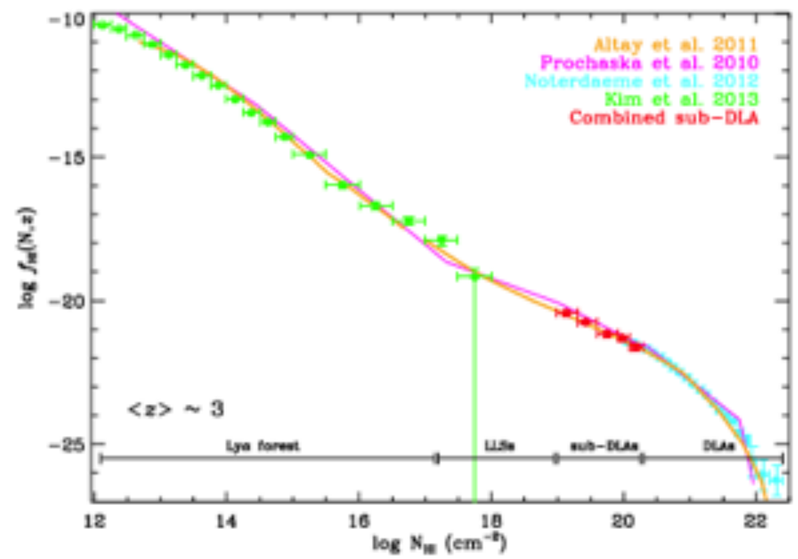
The ESO UVES advanced data products quasar sample

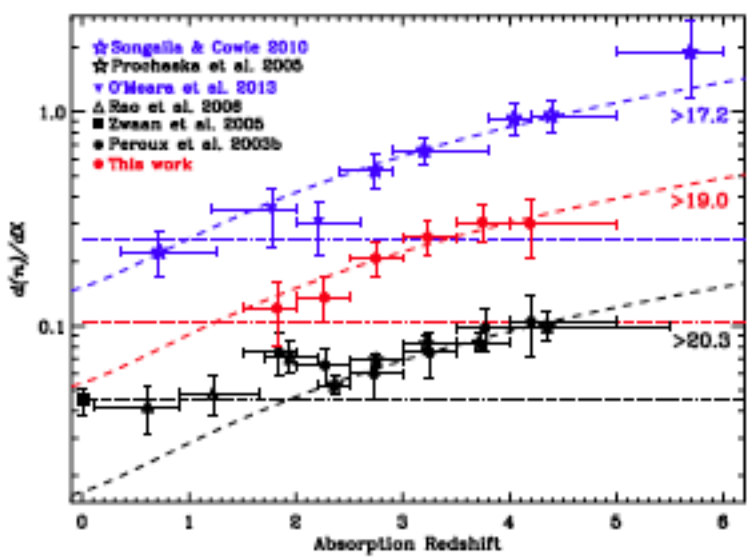
II. Cosmological evolution of the neutral gas mass density*

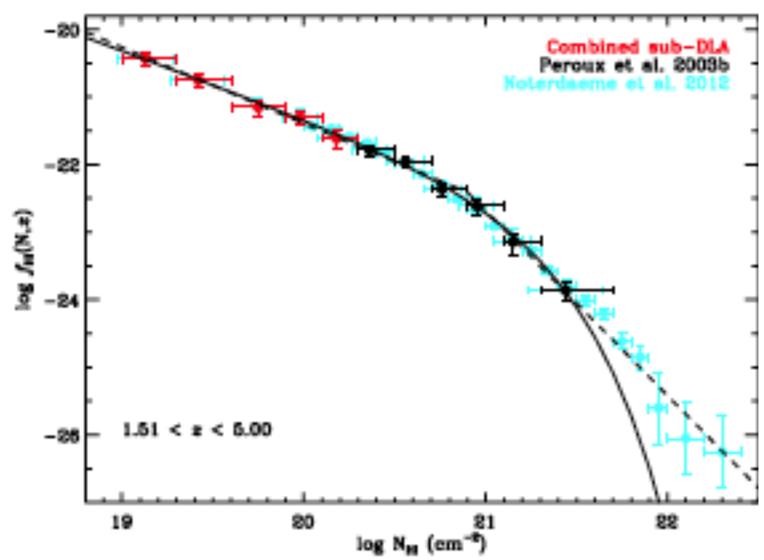
T. Zafar[1], C. Péroux[1], A. Popping[2], B. Milliard[1], J.-M. Deharveng[1], and S. Frank[1,3]

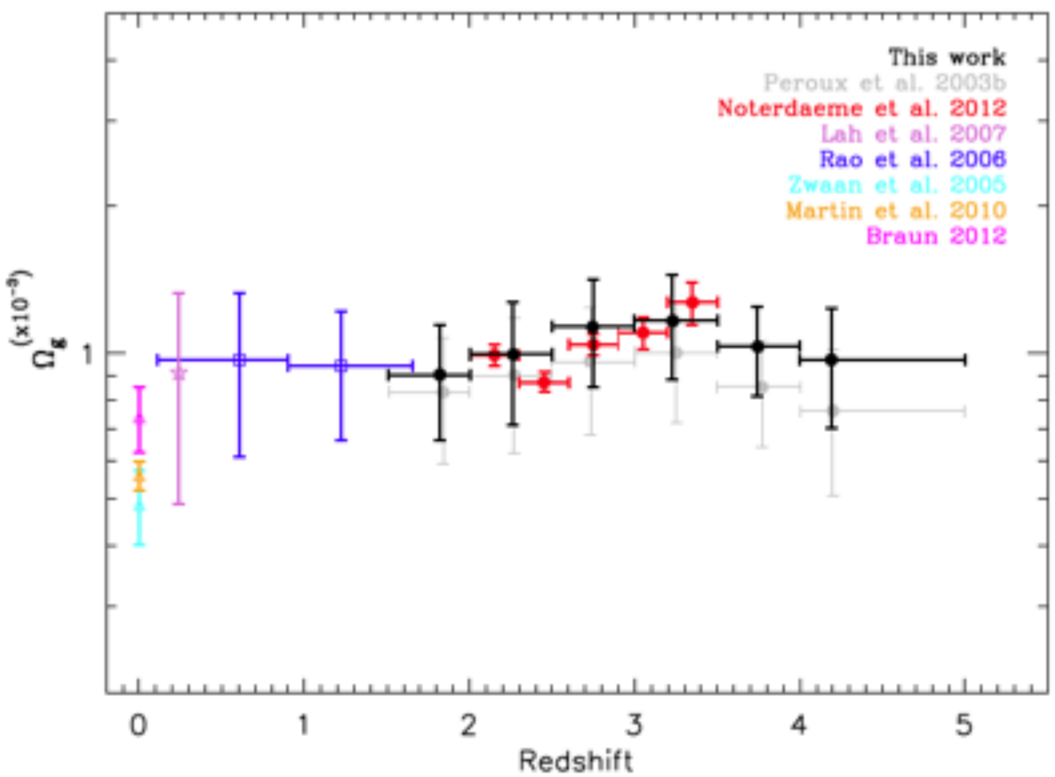








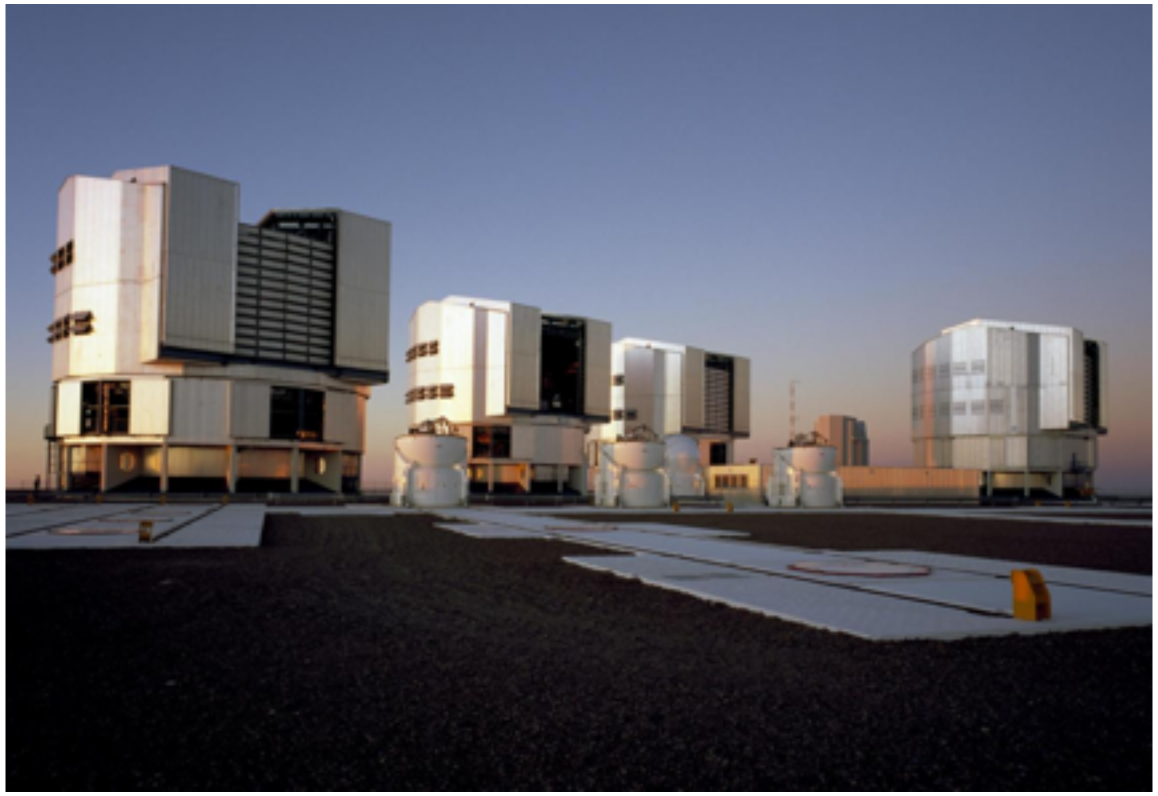


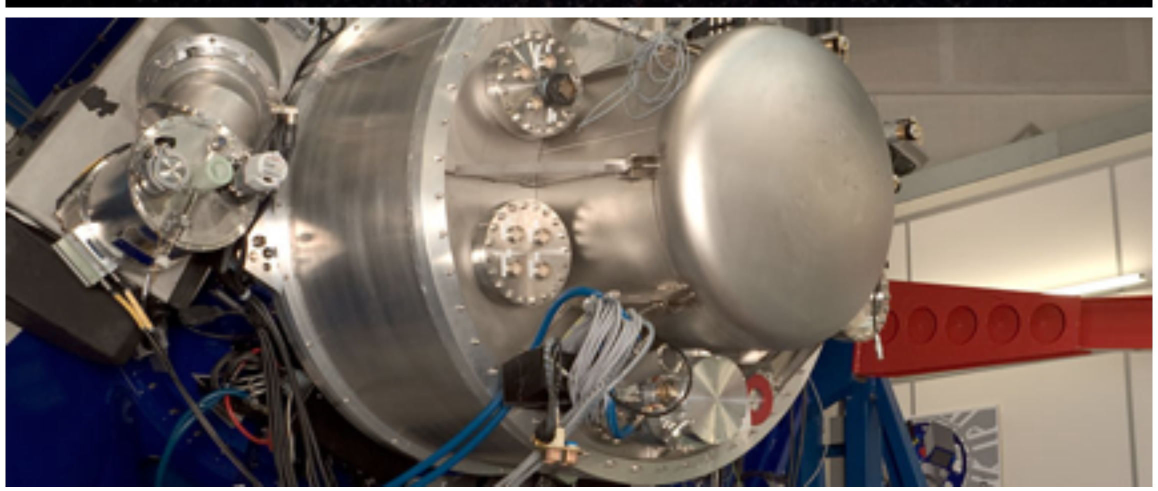


QUASARS AND THEIR ABSORPTION LINES: A LEGACY SURVEY OF THE HIGH REDSHIFT UNIVERSE

X-shooter Large Programme

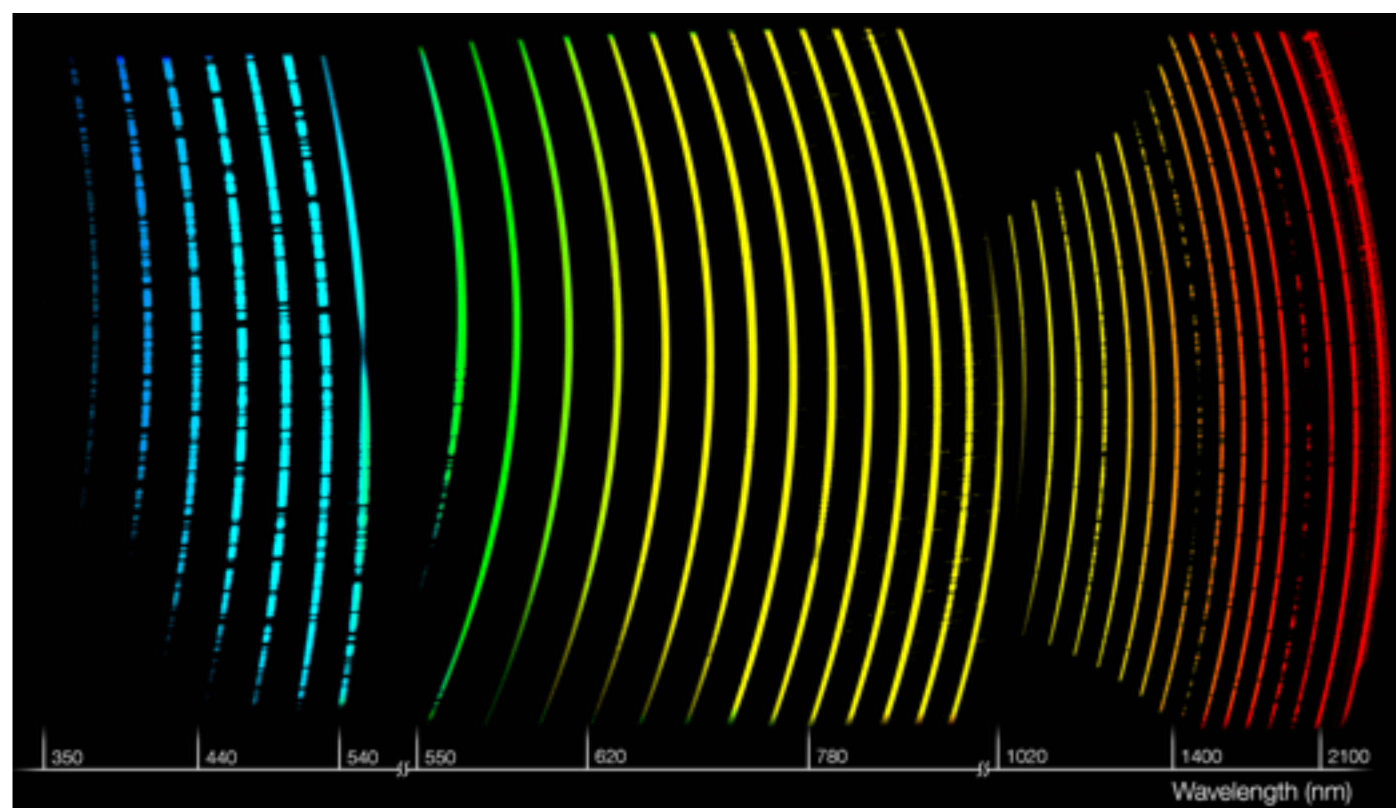
http://adlibitum.oat.ts.astro.it/dodorico/Xshooter_LP/Abstract.html





X-Shooter, VLT (UT3), Paranal Observatory, Chile

- UVB: 3000-5600
- VIS: 5500-10200
- NIR: 10200-24800



QUASARS AND THEIR ABSORPTION LINES: A LEGACY SURVEY OF THE HIGH REDSHIFT UNIVERSE

X-shooter Large Programme http://adlibitum.oat.ts.astro.it/dodorico/Xshooter_LP/Abstract.html

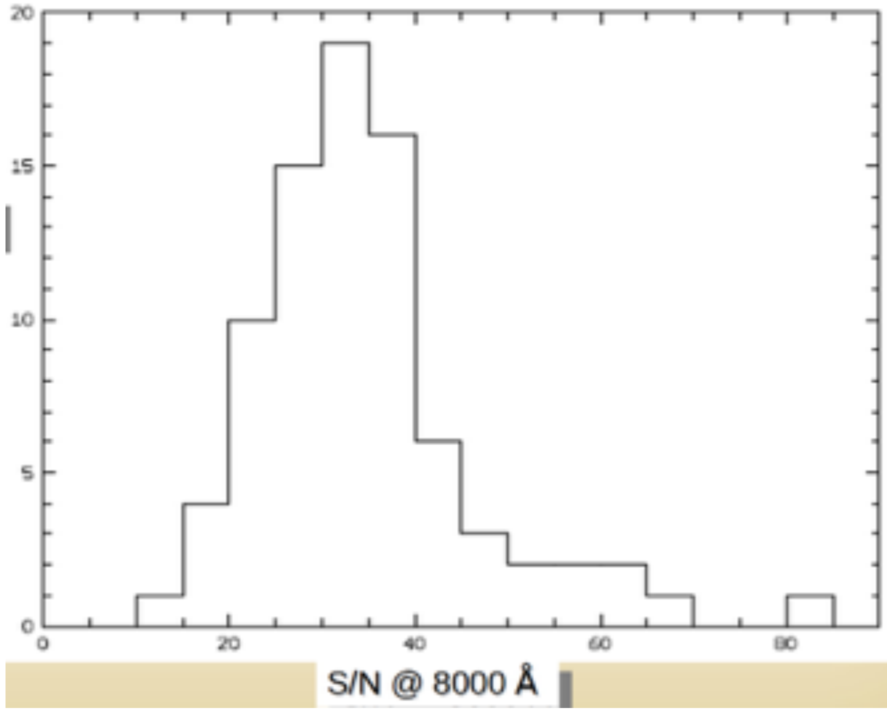
The aim of this LP is to assemble a legacy dataset of 100 z > 3.5 QSO spectra observed with X-shooter at the ESO VLT.

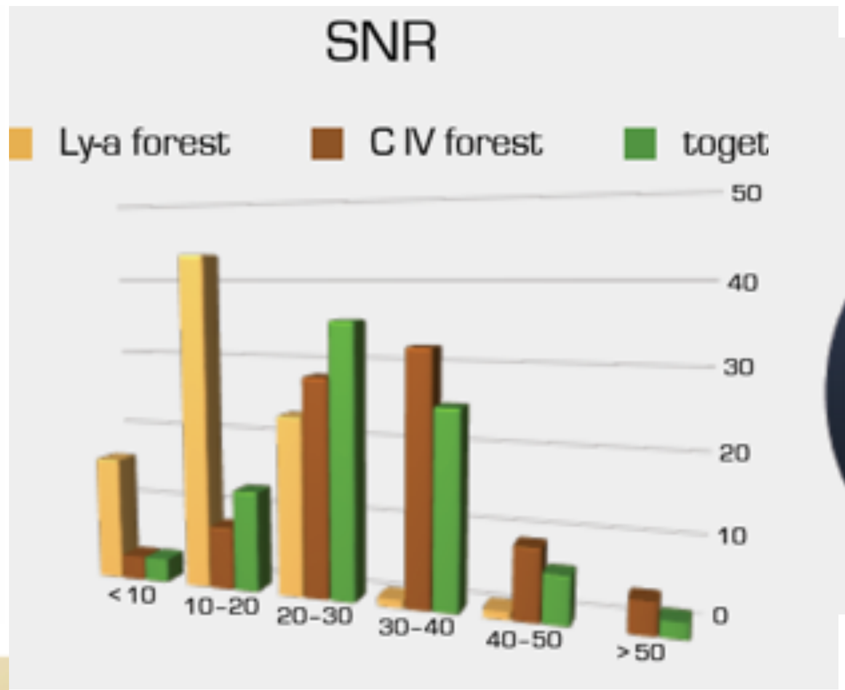
No	Object name	Redshift	Mag	High Res	Status
1	SDSS J101347.29+065015.6	3.79	APM_R=18.4, r=18.9	N	OBS
2	SDSS J101818.45+054822.8	3.52	APM_R=18.1,r=18.8	N	OBS
3	SDSS J102040.62+092254.2	3.64	APM_R=18.0,r=18.4	N	OBS
4	SDSS J102456.61+181908.7	3.53	APM_R=17.9	N	OBS
5	SDSS J103221.11+092748.9	3.99	APM_R=17.9, r=18.8	N	OBS
6	BR 1033-0327	4.51	APM_R=18.5	N	
7	SDSS J103446.54+110214.5	4.27	APM_R=18.2, r=18.9	N	
8	SDSS J103732.38+070426.2	4.10	APM_R=18.3,r=18.5	N	
9	SDSS J103730.33+213531.3	3.63	APM_R=17.7	N	
10	SDSS J104234.01+195718.6	3.64	APM_R=18.1	N	
11	SDSS J105434.17+021551.9	3.97	APM_R=18.0, r=18.8	N	OBS
12	SDSS J105705.37+191042.8	4.10	APM_R=17.9, r=18.7	N	OBS
13	SDSS J105858.38+124554.9	4.33	APM_R=17.6, V=18	N	
14	SDSS J110352.73+100403.1	3.61	APM_R=18.6,r=18.7	N	
15	SDSS J111008.61+024458.0	4.12	APM_R=17.6,r=18.3	N	OBS
16	SDSS J110855.47+120953.3	3.67	APM_R=18.4,r=18.6	Y	
17	SDSS J111701.89+131115.4	3.62	APM_R=18.3,r=18.4	N	
18	SDSS J112617.40-012632.6	3.61	APM_R=18.7,r=18.9	N	OBS
19	SDSS J112634.28-012436.9	3.74	APM_R=18.5, r=19.0	N	TBR
20	SDSS J113536.40+084218.9	3.83	APM_R=18.3,r=18.3	N	
21	[HB89] 1159+123	3.51	APM_R=17.3,r=17.4	Y	OBS
22	SDSS J120210.08-005425.4	3.59	APM_R=18.5	N	OBS
23	SDSS J124837.31+130440.9	3.72	APM_R=18.1,r=18.6	N	OBS
24	SDSS J124957.23-015928.8	3.63	APM_R=17.5,r=17.6	Y	TBR
25	SDSS J130452.57+023924.8	3.65	APM_R=18.6,r=18.4	N	OBS
26	SDSS J131242.87+084105.1	3.74	APM_R=18.4,r=18.6	N	OBS
27	2MASS J1320299-052335	3.70	APM_R=17.8	Y	OBS
28	SDSS J132346.05+140517.6	4.04	APM_R=18.6, r=19.0	N	OBS
29	BR J1330-2522	3.95	APM_R=18.5	Y	OBS
30	SDSS J133254.51+005250.6	3.51	APM_R=18.4,r=18.3	Y	TBR
31	SDSS J135247.98+130311.5	3.70	APM_R=18.4,r=18.2	N	TBR
32	SDSS J133653.44+024338.1	3.80	APM_R=18.6,r=18.7	N	OBS
33	SDSS J1401+0244	4.44	APM_R=18.4, r=19.0	N	OBS
34	PKS B1418-064	3.689	R=18.5	Y	OBS
35	SDSS J141608.39+181144.0	3.59	APM_R=18.2	N	OBS
36	SDSS J144250.12+092001.5	3.53	APM_R=17.2,r=17.5	N	OBS
37	SDSS J1445 +0958	3.5203	r=17.9	Y	OBS
38	SDSS J160328.88+041949.0	3.66	APM_R=18.0,r=18.1	N	TBR
39	SDSS J161756.18+061103.5	3.56	APM_R=18.3	N	OBS
40	SDSS J152436.08+212309.1	3.61	APM_R=17.3	N	TBR
41	SDSS J154237.71+095558.8	3.99	APM_R=18.2, r=18.9	N	OBS
42	SDSS J155255.03+100538.3	3.73	APM_R=18.6, r=18.9	N	TBR
43	SDSS J1621-0042	3.70	APM_R=17.7,r=17.3	Y	TBR
44	SDSS J163319.63+141142.0	4.33	APM_R=18.7,r=19.0	Y	OBS
45	CGRaBS J1658-0739	3.74	R=18.7	N	TBR
46	PSS J1723+2243	4.52	R=18.2	N	OBS
47	BR 2212-1626	3.99	APM_R=18.1	Y	TBR
48	2MASSi J2239536-055219	4.56	APM_R=18.3	Y	OBS
49	BR 2248-1242	4.16	APM_R=18.6	N	OBS
50	PSS J2344+0342	4.24	APM_R=18.2	Y	TBR
51	BR 2213-6729	4.47	APM_R=18.6	Y	OBS
52	BR J2349-3712	4.21	APM_R=18.7	N	OBS
53	[HB89] 0000-263	4.01	NED=18.?	Y	OBS
54	BR J0006-6208	4.46	NED=18.3,R=19.3	Y	OBS
55	BR J0030-5129	4.17	R=18.6	N	OBS
56	PSS J0034+1639	4.29	R_APM=18.0	N	OBS
57	SDSS J004219.74-102009.4	3.88	APM_R=18.2,r=18.7	N	OBS
58	BR 0035-25(BRI J0048-2442)	4.15	NED=18.9	N	OBS
59	[HB89] 0053-284	3.62	NED=18.3	N	OBS
60	[HB89] 0055-269	3.66	NED=17.1	Y	OBS
61	PMN J0100-2708	3.52	R=18.7	N	OBS
62	BRI J0113-2803	4.30	R=18.7	N	OBS
63	PSS J0117+1552	4.24	V=18.6	N	OBS
64	PSS J0121+0347	4.13	R=18.3, V=17.9	Y	OBS
65	SDSS J0124+0044	3.84	APM_R=17.5?,r=17.9	Y	OBS
66	PSS J0132+1341	4.16	R_APM=18.5	N	OBS
67	PSS J0133+0400	4.15	R_APM=18.3	Y	OBS
68	BRI J0137-4224	3.97	NED=18.46	Y	OBS
69	SDSS J015339.60-001104.8	4.19	APM_R=18.0,r=18.9	N	OBS
70	PSS J0211+1107	3.98	APM_R=18.2	N	OBS
71	PMN J0214-0518	3.99	APM_R=18.4	N	OBS
72	BR J0234-1806	4.31	NED=18.8	N	OBS
73	BRI 0241-0146	4.05	APM_R=17.8	Y	OBS
74	BR 0245-0608	4.24	NED=18.6	Y	OBS
75	PSS J0248+1802	4.42	APM_R=17.7	Y	OBS
76	SDSS J025518.57+004847.4	4.01	APM_R=18.3,r=19.0	Y	OBS
77	BR J0307-4945	4.72	NED=18.8	Y	OBS
78	BR J0311-1722	4.04	APM_R=17.7	N	OBS
79	BR 0401-1711	4.23	NED=18.7	Y	OBS
80	BR J0415-4357	4.07	NED=18.8	N	OBS
81	BR 0424-2209	4.32	NED=17.9, no APM	Y	OBS
82	BR 0523-3345	4.41	APM_R=18.4	N	OBS
83	BR J0529-3552	4.17	APM_R=18.3	N	OBS
84	BR J0529-3526	4.41	NED=18.9	N	OBS
85	BR J0714-6455	4.46	APM_R=18.3	N	OBS
86	SDSS J074711.15+273903.3	4.17	APM_R=17.2,r=18.5	Y	OBS
87	SDSS J075552.41+134551.1	3.67	APM_R=18.8,r=18.6	N	TBR
88	SDSS J080050.27+192058.9	3.96	APM_R=18.3, r=20.0	N	
89	SDSS J081855.78+095848.0	3.67	APM_R=17.7,r=17.9	N	OBS
90	SDSS J083322.50+095941.2	3.75	APM_R=18.5,r=18.8	N	OBS
91	SDSS J083510.92+065052.8	3.99	APM_R=18.0,r=18.5	N	OBS
92	SDSS J083941.45+031817.0	4.25	APM_R=17.9, r=18.9	N	OBS
93	SDSS J092041.76+072544.0	3.64	APM_R=18.5,r=18.6	N	
94	SDSS J093556.91+002255.6	3.75	APM_R=17.8,r=18.7	N	OBS
95	SDSS J093714.48+082858.6	3.70	APM_R=18.2,r=18.7	N	
96	BRI 0952-0115	4.43	NED=18.7	Y	
97	SDSS J095937.11+131215.4	4.06	APM_R=16.9	N	
98	SDSS J105340.75+010335.6	3.65	APM_R=19.1,r=18.5	N	OBS
99	BRI 1108-0747	3.92	APM_R=18.8, NED=18.1	Y	OBS
100	SDSS J133150.69+101529.4	3.85	APM_R=18.8,r=18.6	N	OBS

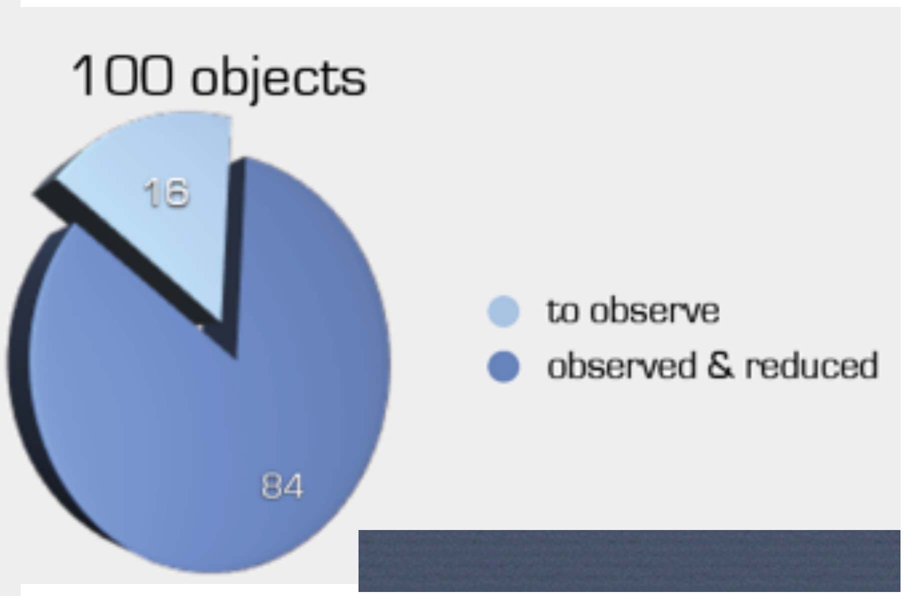
QUASARS AND THEIR ABSORPTION LINES: A LEGACY SURVEY OF THE HIGH REDSHIFT UNIVERSE

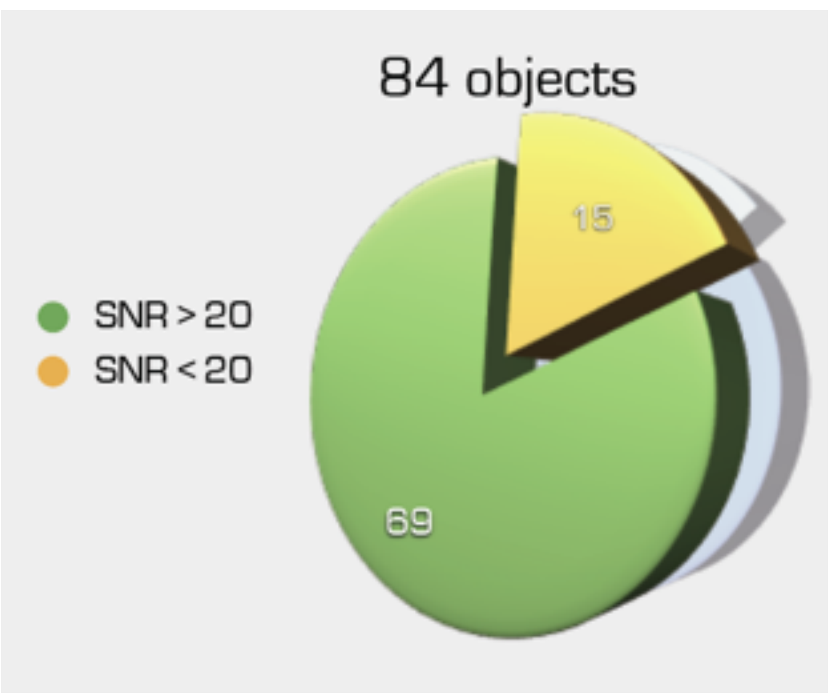
X-shooter Large Programme http://adlibitum.oat.ts.astro.it/dodorico/Xshooter_LP/Abstract.html

The aim of this LP is to assemble a legacy dataset of 100 z > 3.5 QSO spectra observed with X-shooter at the ESO VLT.



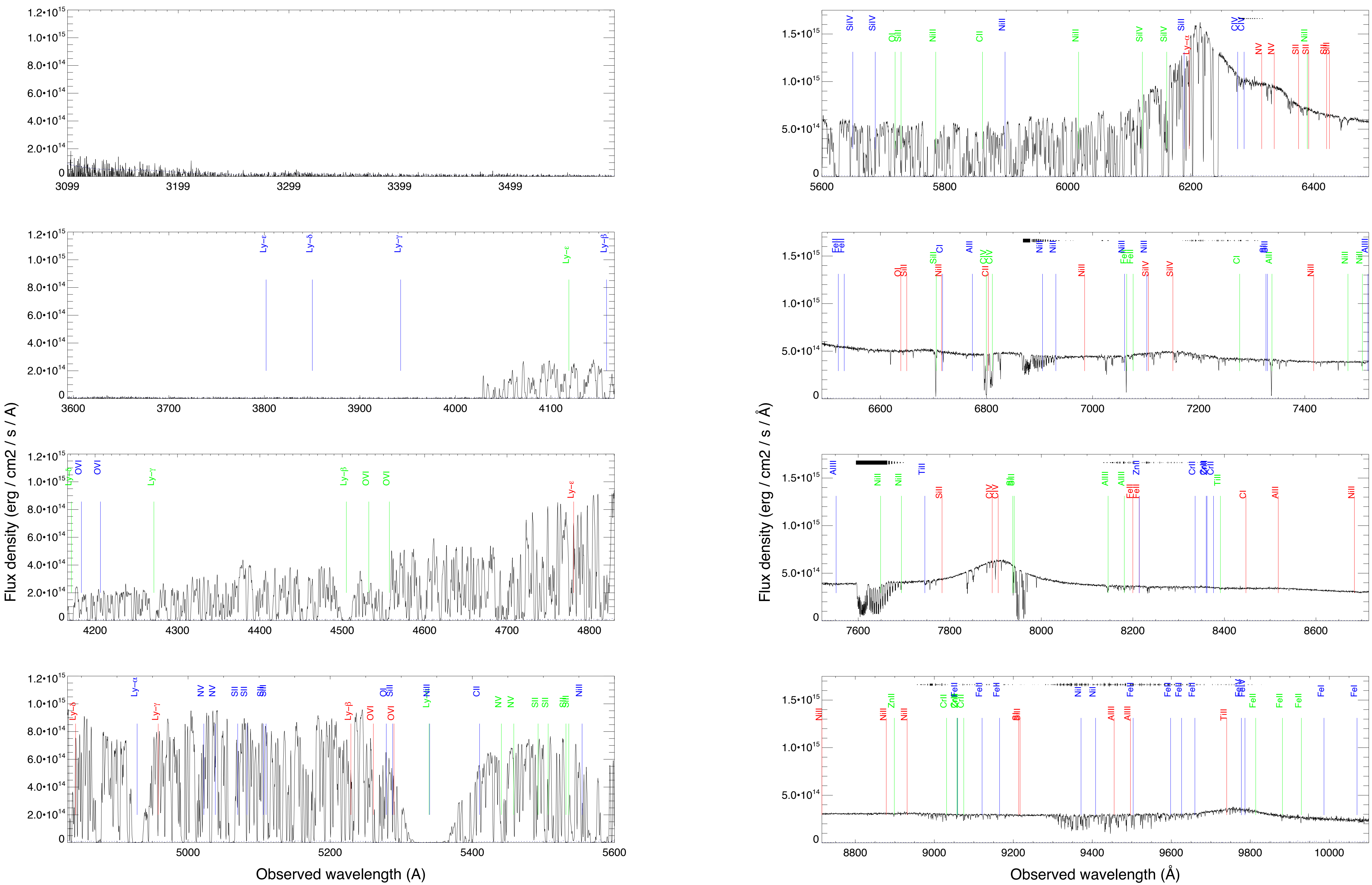




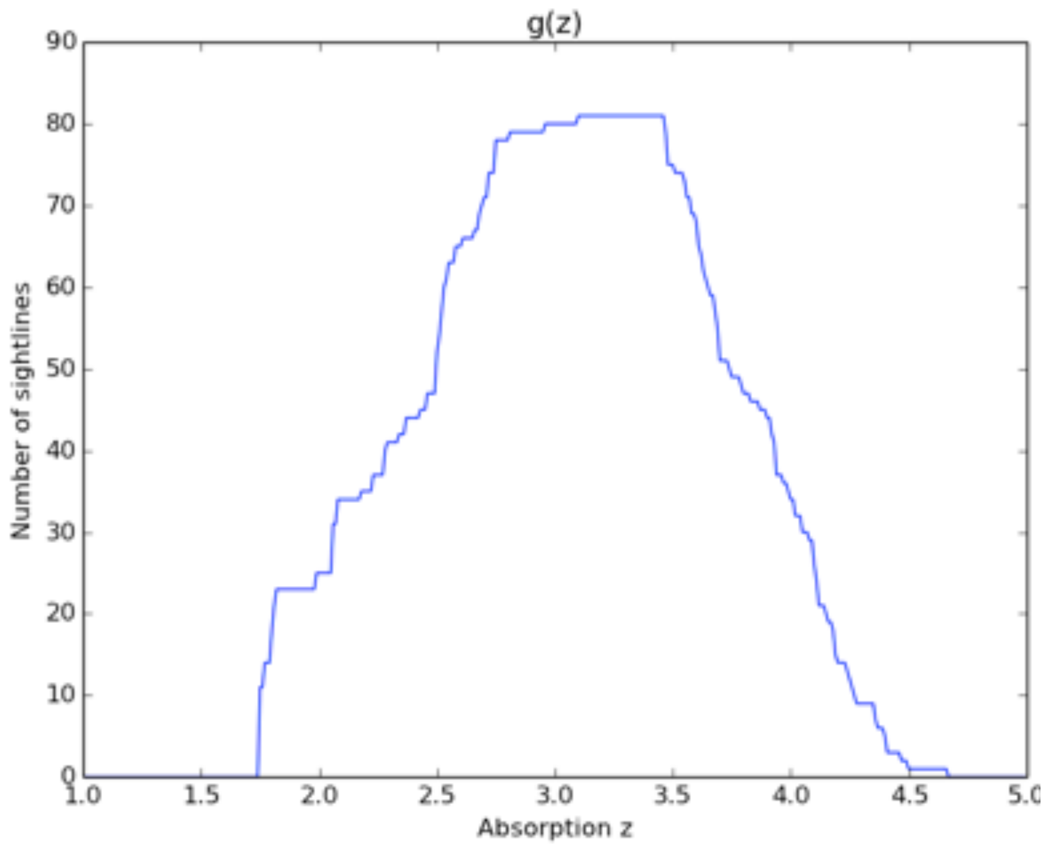


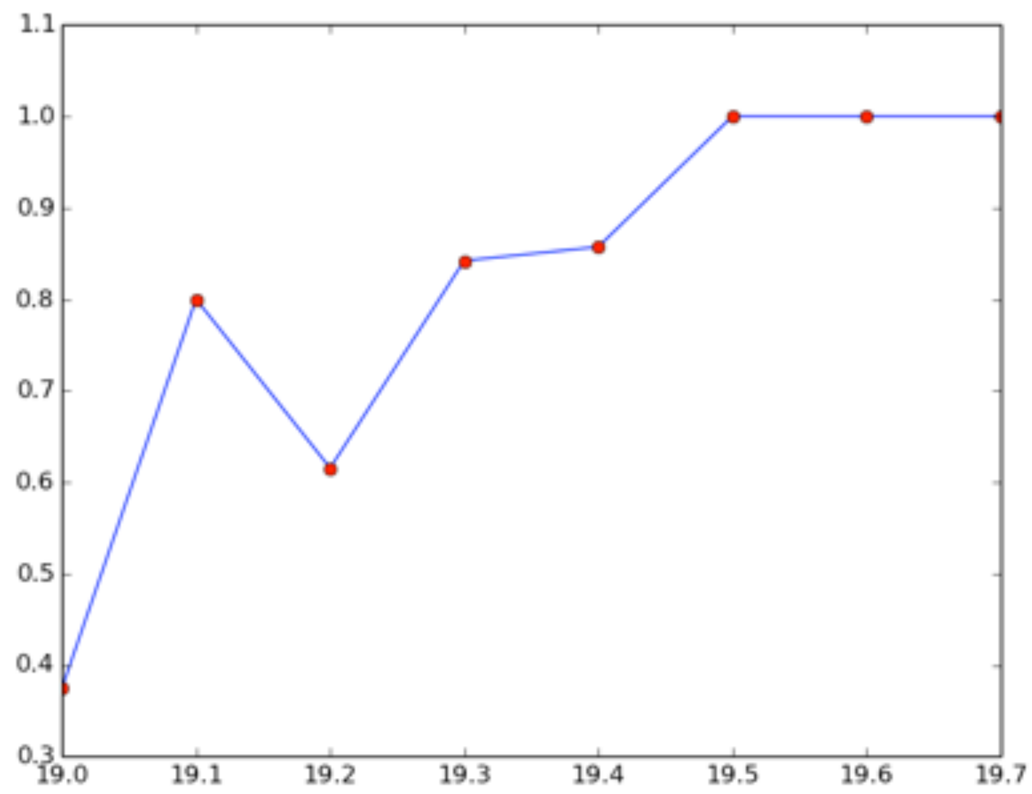
- Pipeline based on George Becker's code
- Developed some scripts do the job automatically (homogeneous reduction)
- Velocity bins ⇨ UVB: 20 km/s VIS: 11 km/s NIR: 19 km/s
- ~3 pix per resolution element

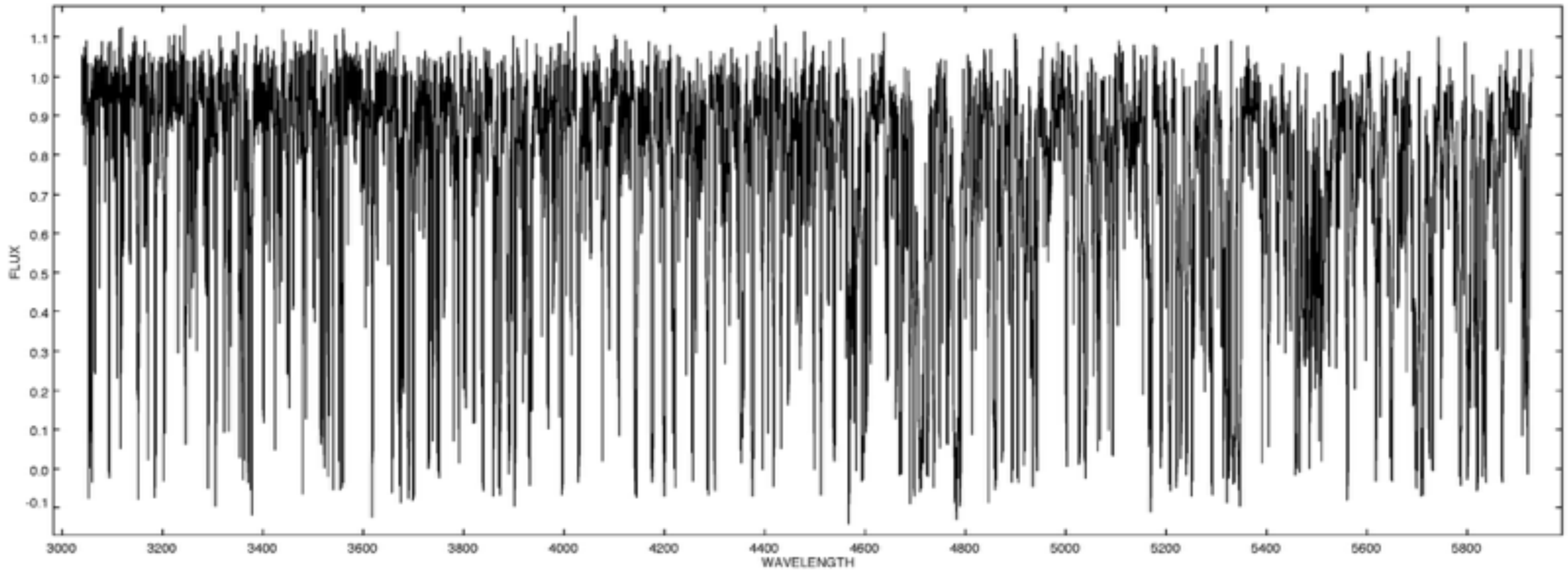
QSO X-SHOOTER LP: DLA SURVEY



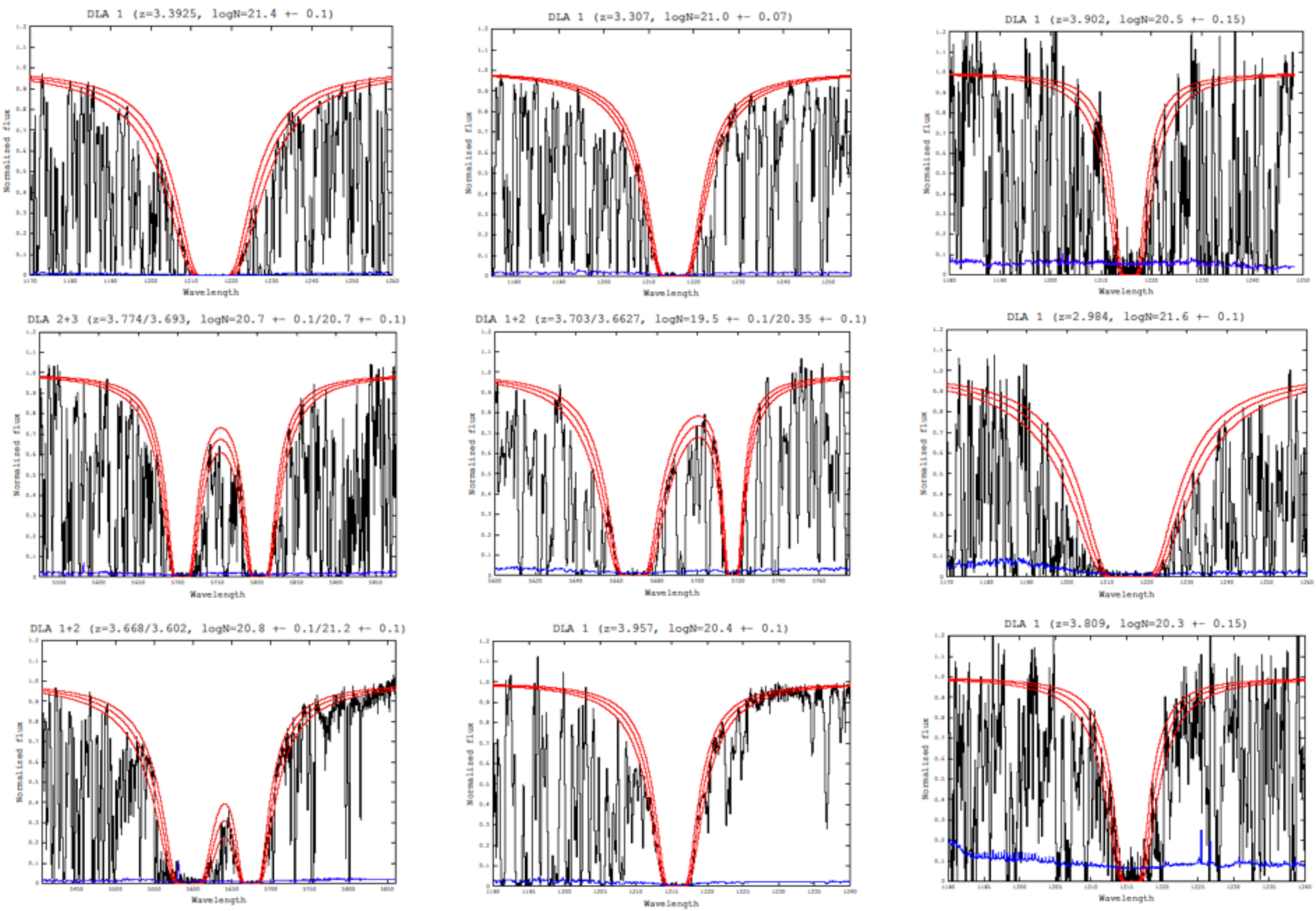
QSO X-SHOOTER LP: DLA SURVEY





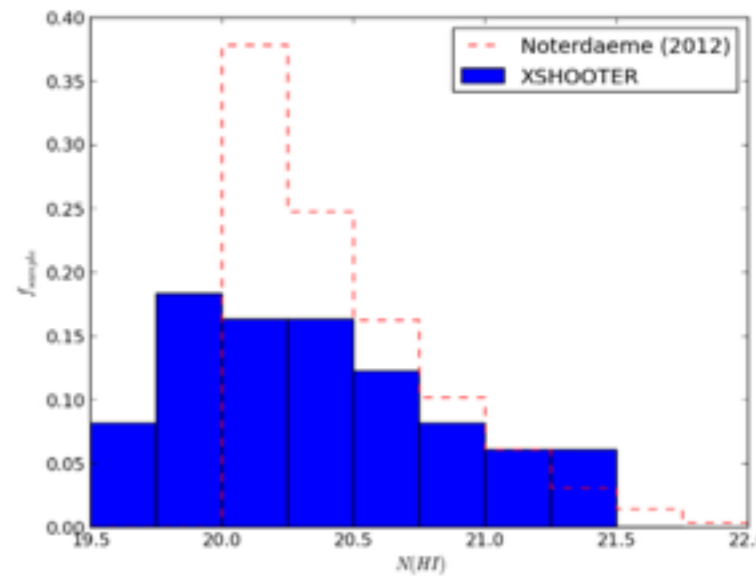


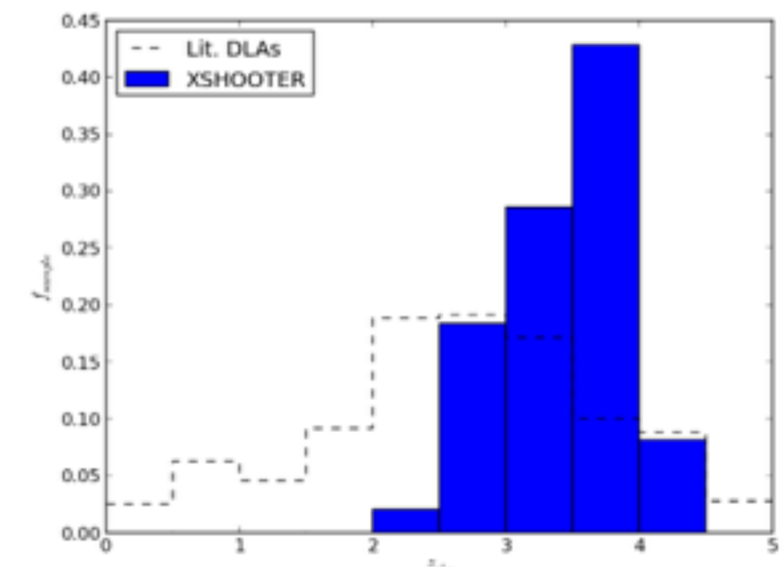
QSO X-SHOOTER LP: DLA SURVEY

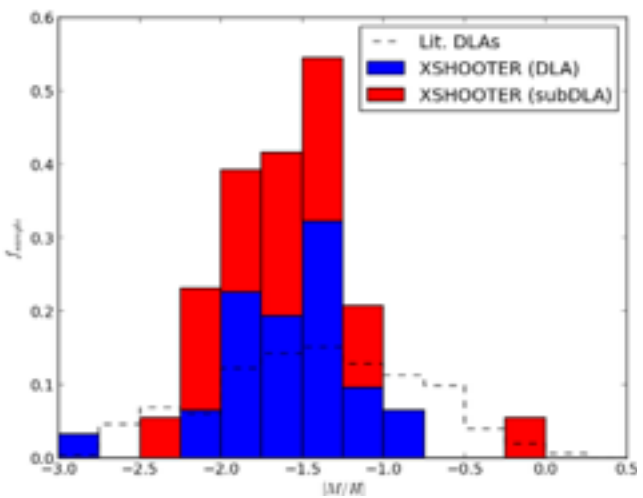


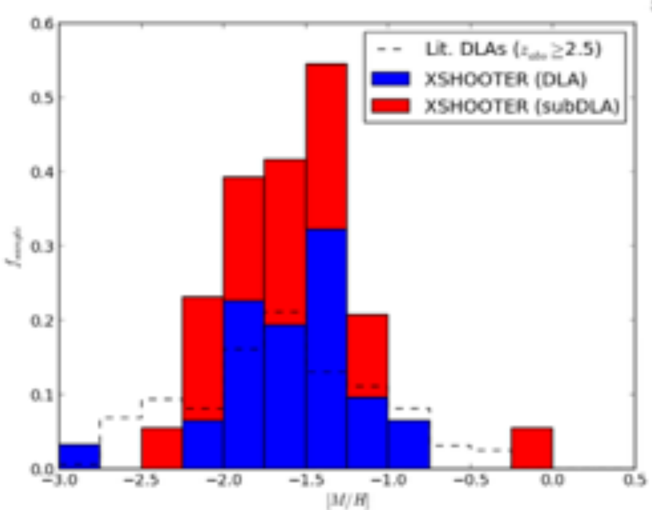
QSO X-SHOOTER LP: DLA SURVEY

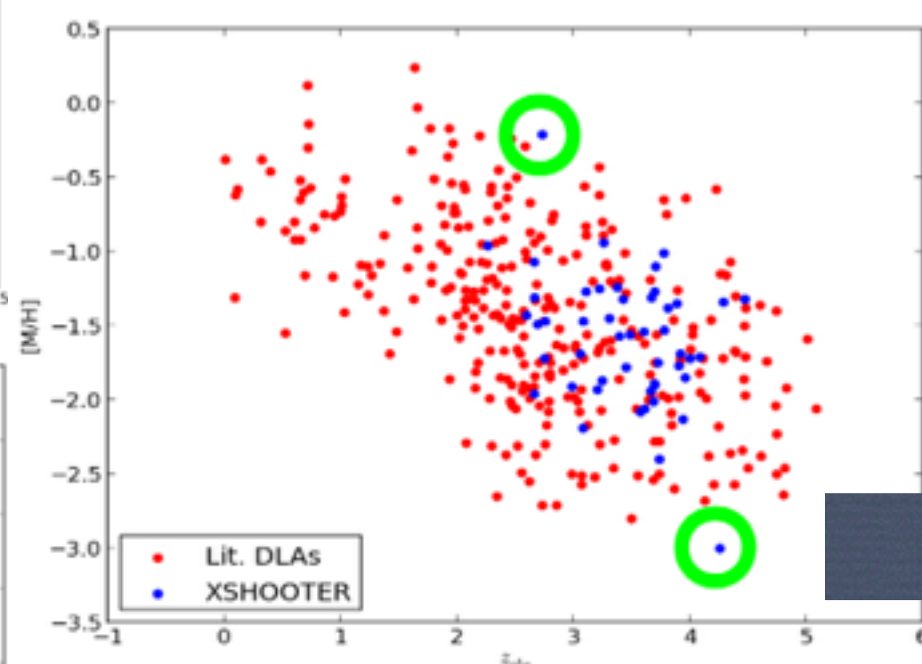
- 31 DLAs
  - 5 proximate DLAs
  - 13 multiple DLA systems
- 18 subDLAs

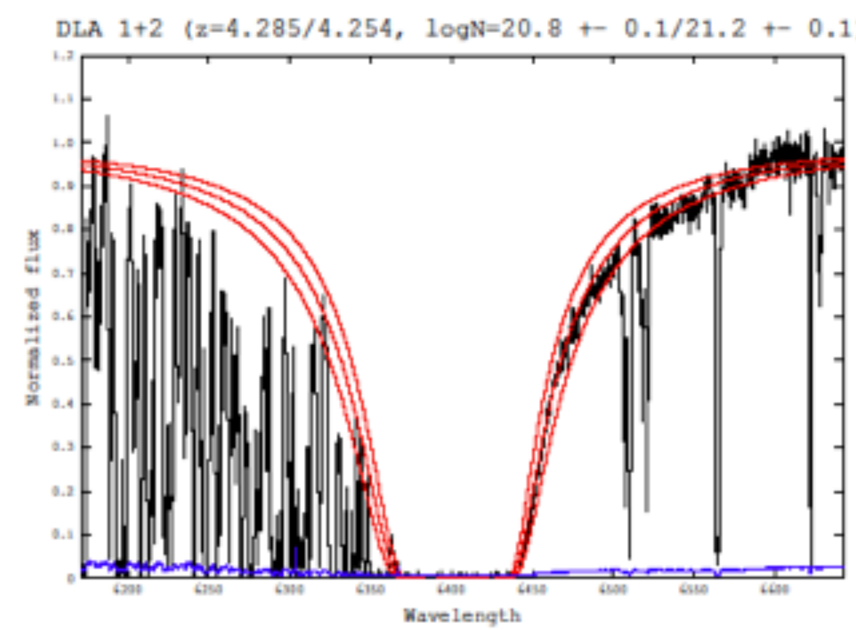






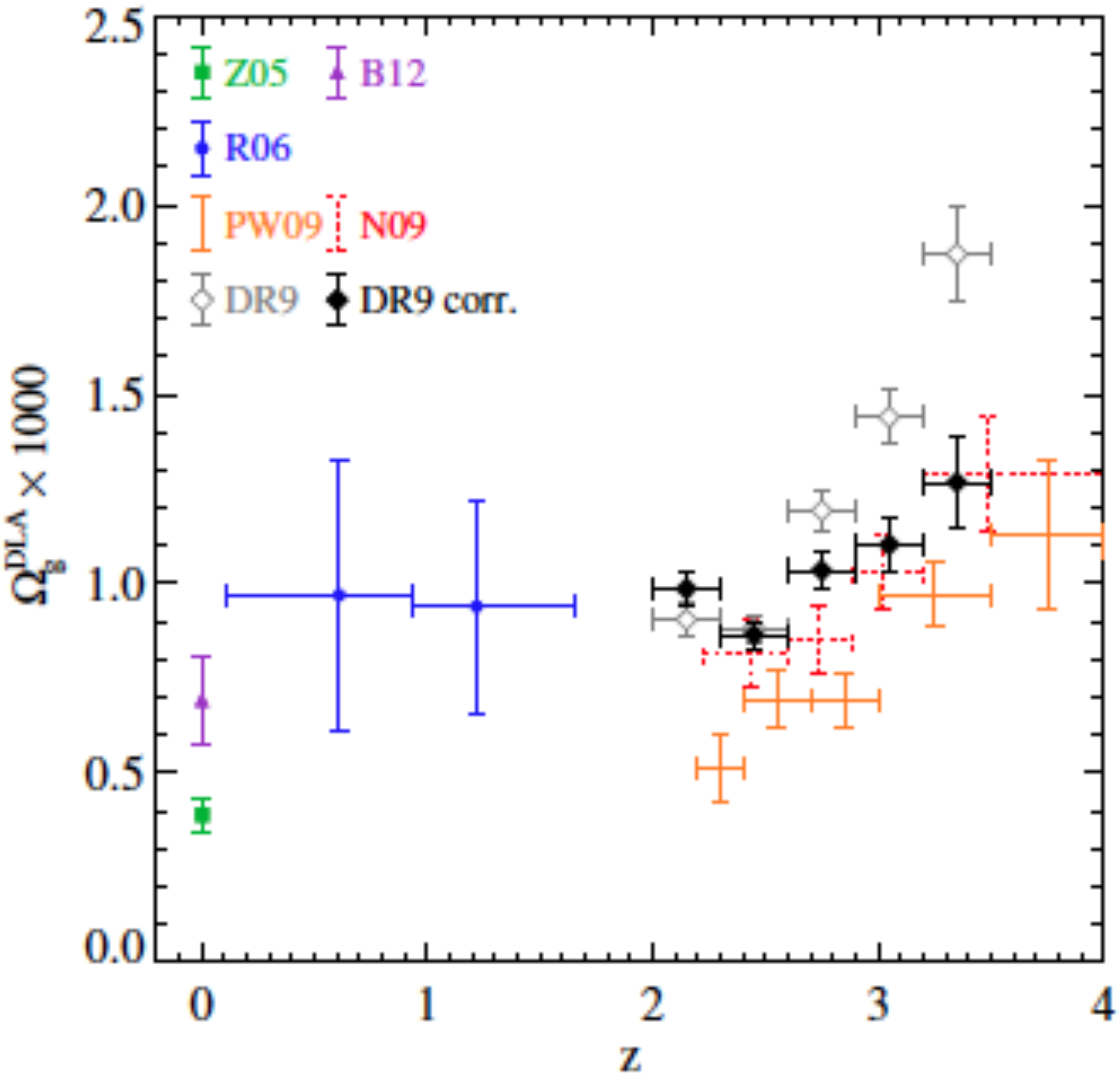






- Z_{abs}=4.28 and 4.25
- V_{PDLA}=454 and 2226 km s^{-1}
- N(H I)=20.8 and 21.2
- For 21.2 system:
  - N(Fe II)=13.5; [Fe/H]=-3.3
  - N(C II)>14.3; [C/H]>-3.3
  - N(O I)>14.7; [O/H]>-4.13
  - N(Si II)=13.8; [Si/H]=-3.0

QSO X-SHOOTER LP: DLA SURVEY




GRACIAS!!!!