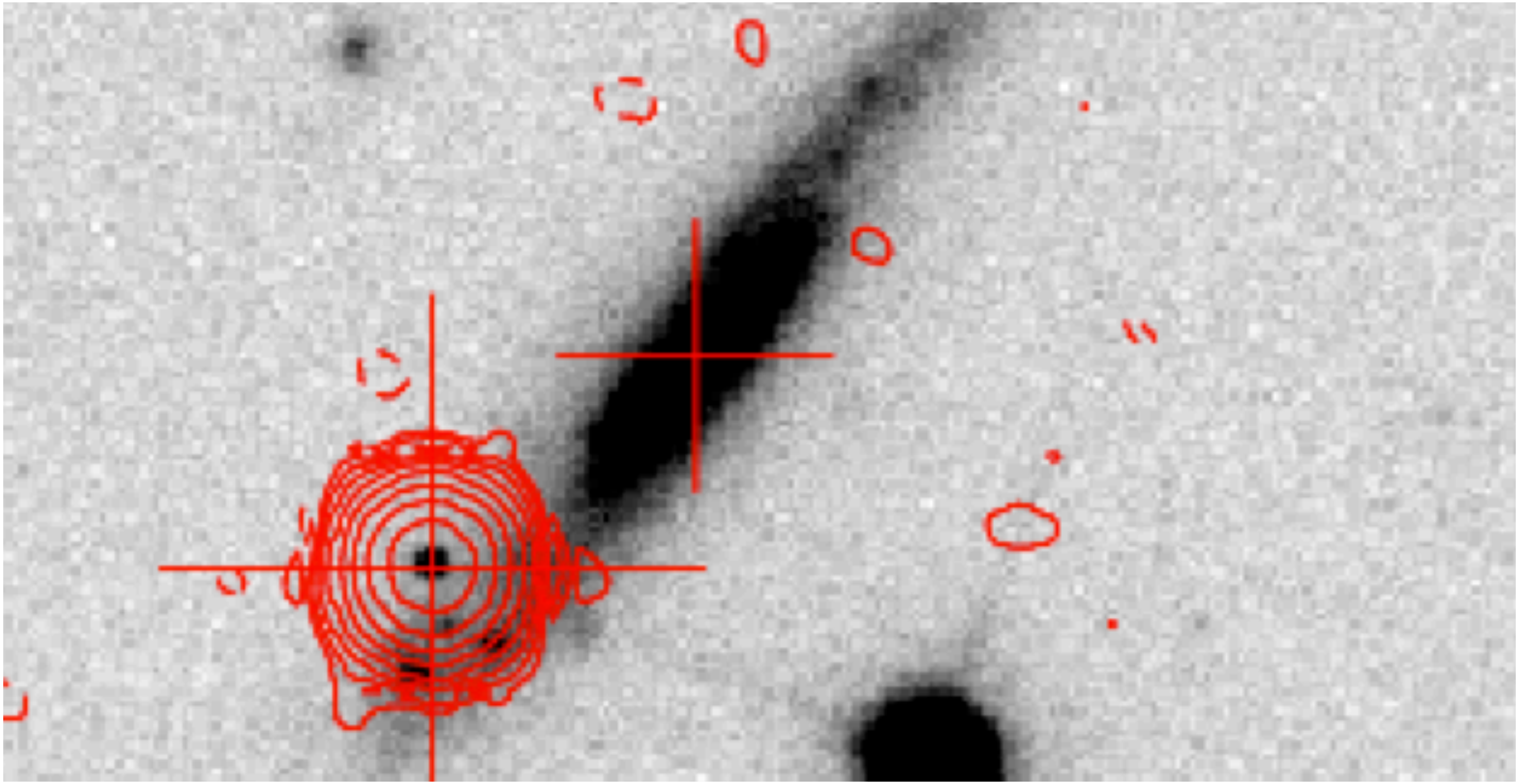

# Blind Absorption Line Surveys

## Evolution of cold gas in galaxies

Neeraj Gupta

*AAVP2011*

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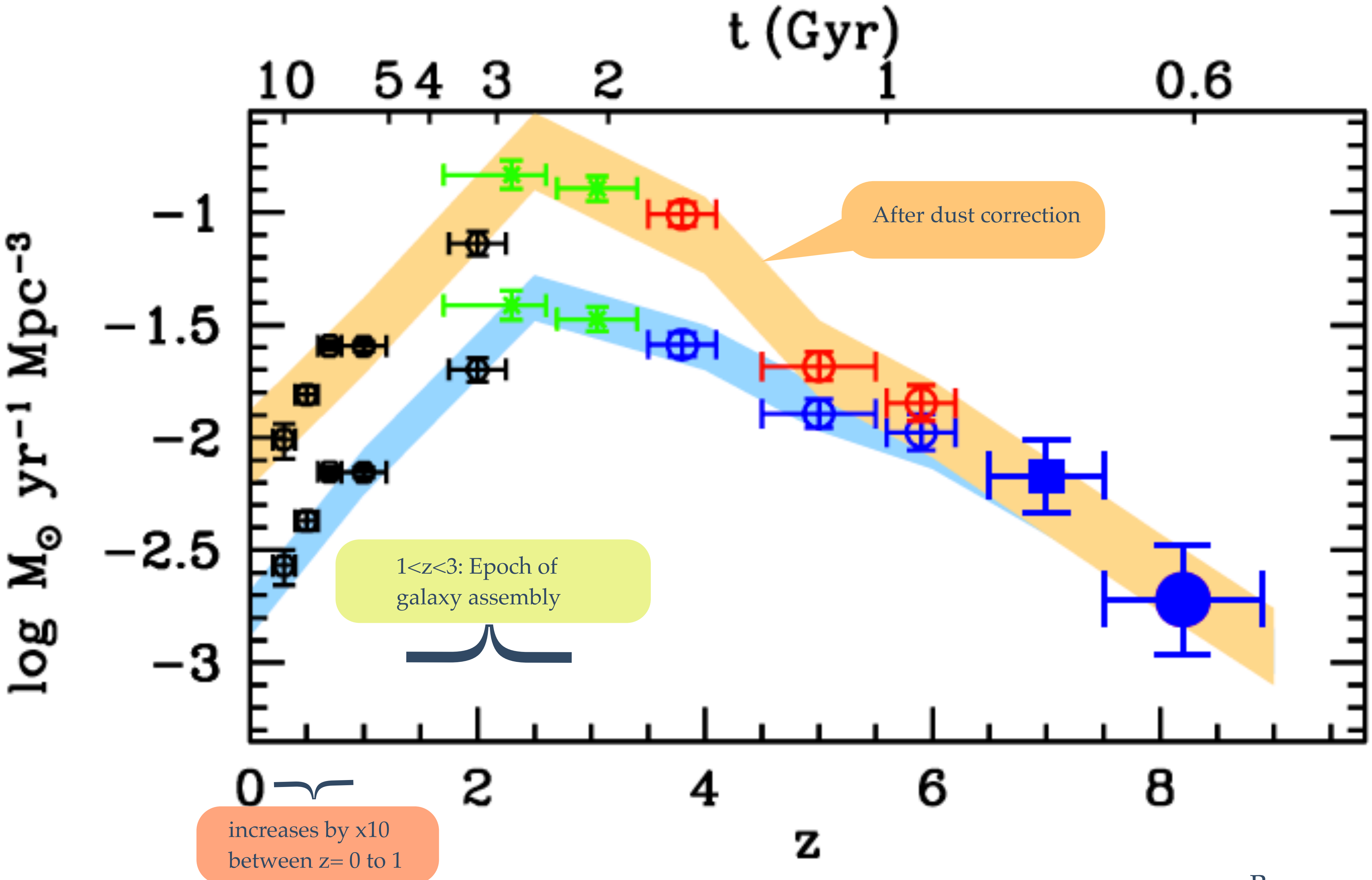
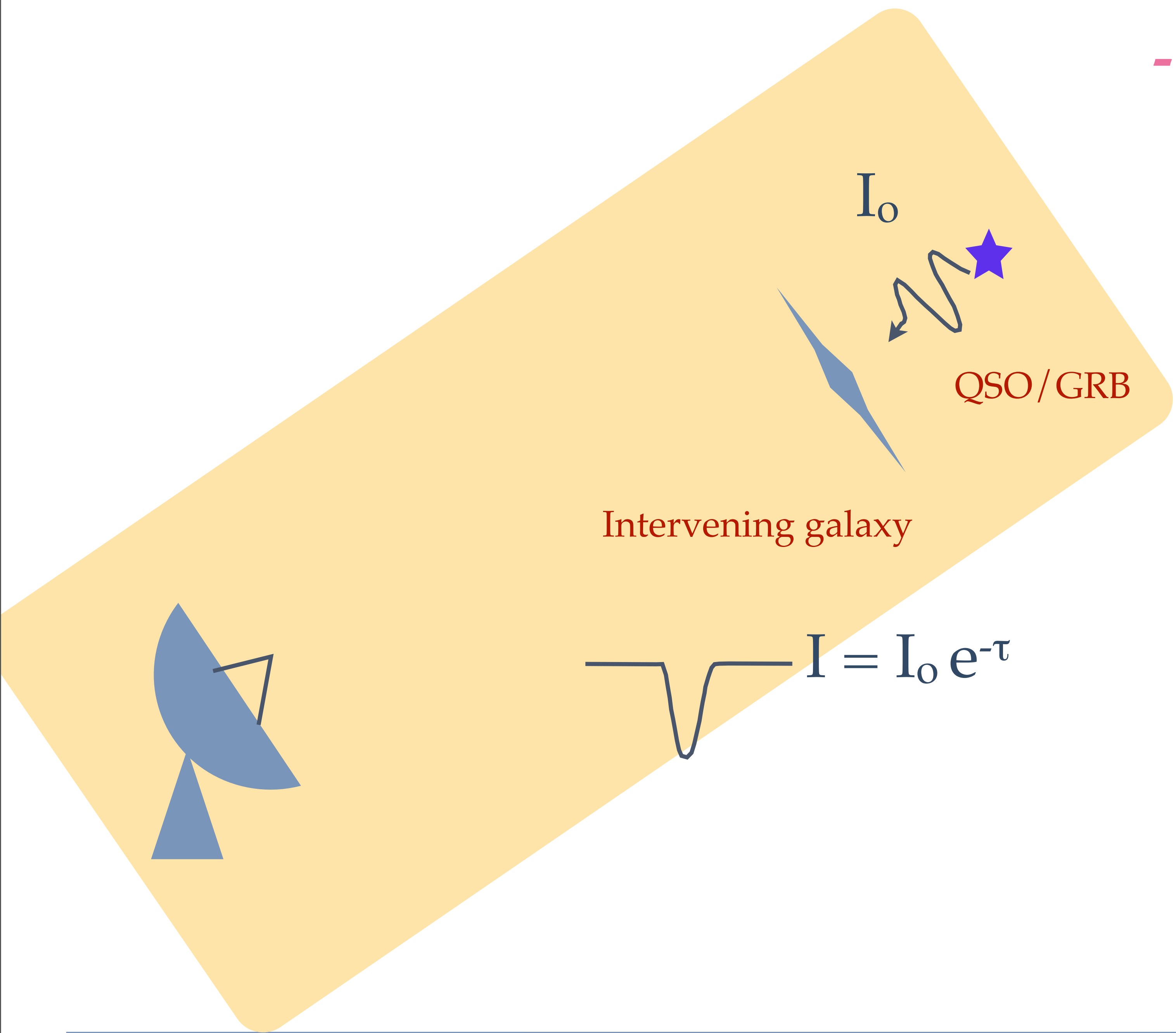
# Star formation intimately related to Cold gas



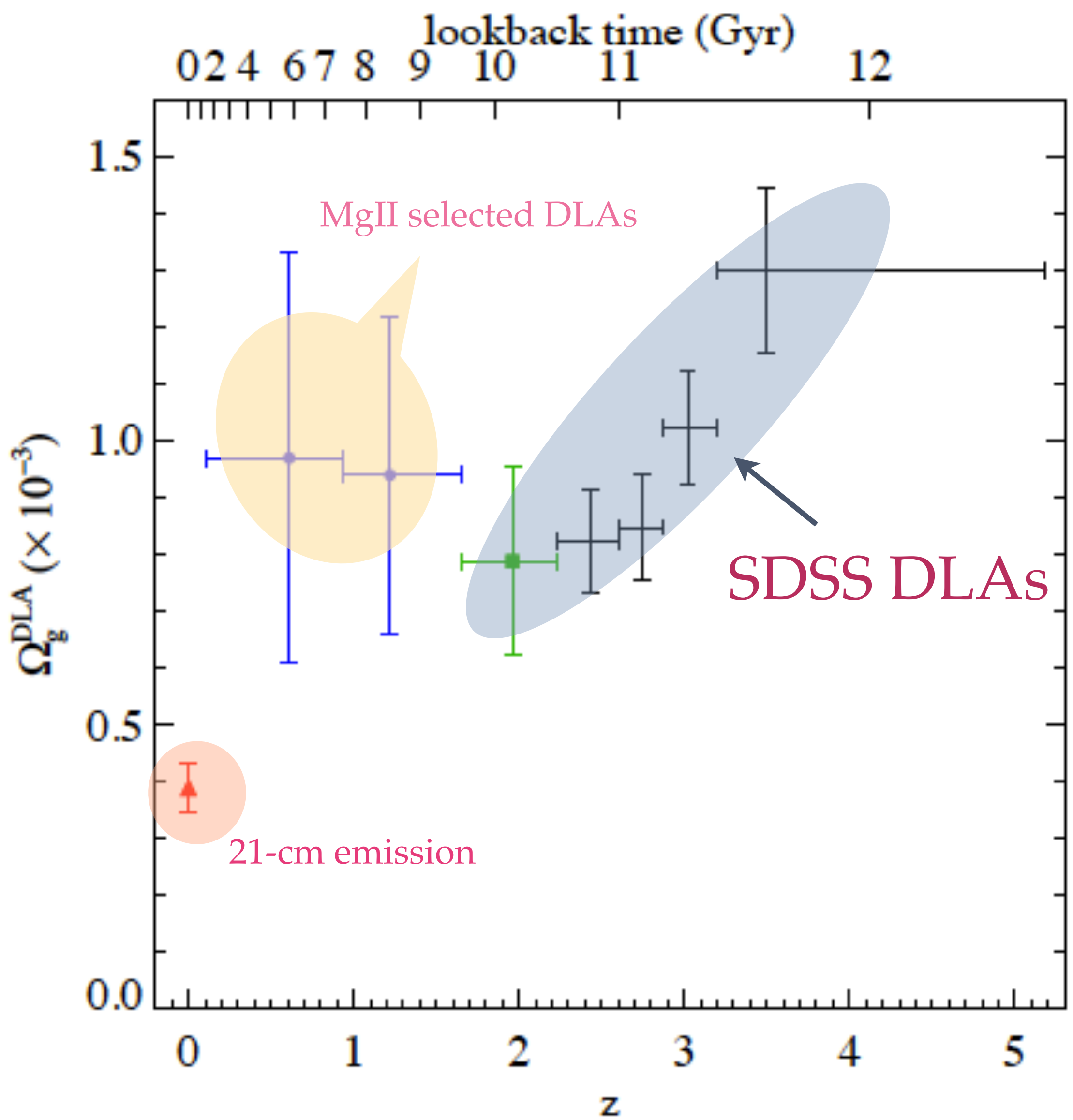

Bouwens et al. 2010

# Absorption lines as probe of cold gas




- **Luminosity unbiased**
- **Probes physics at small scales**

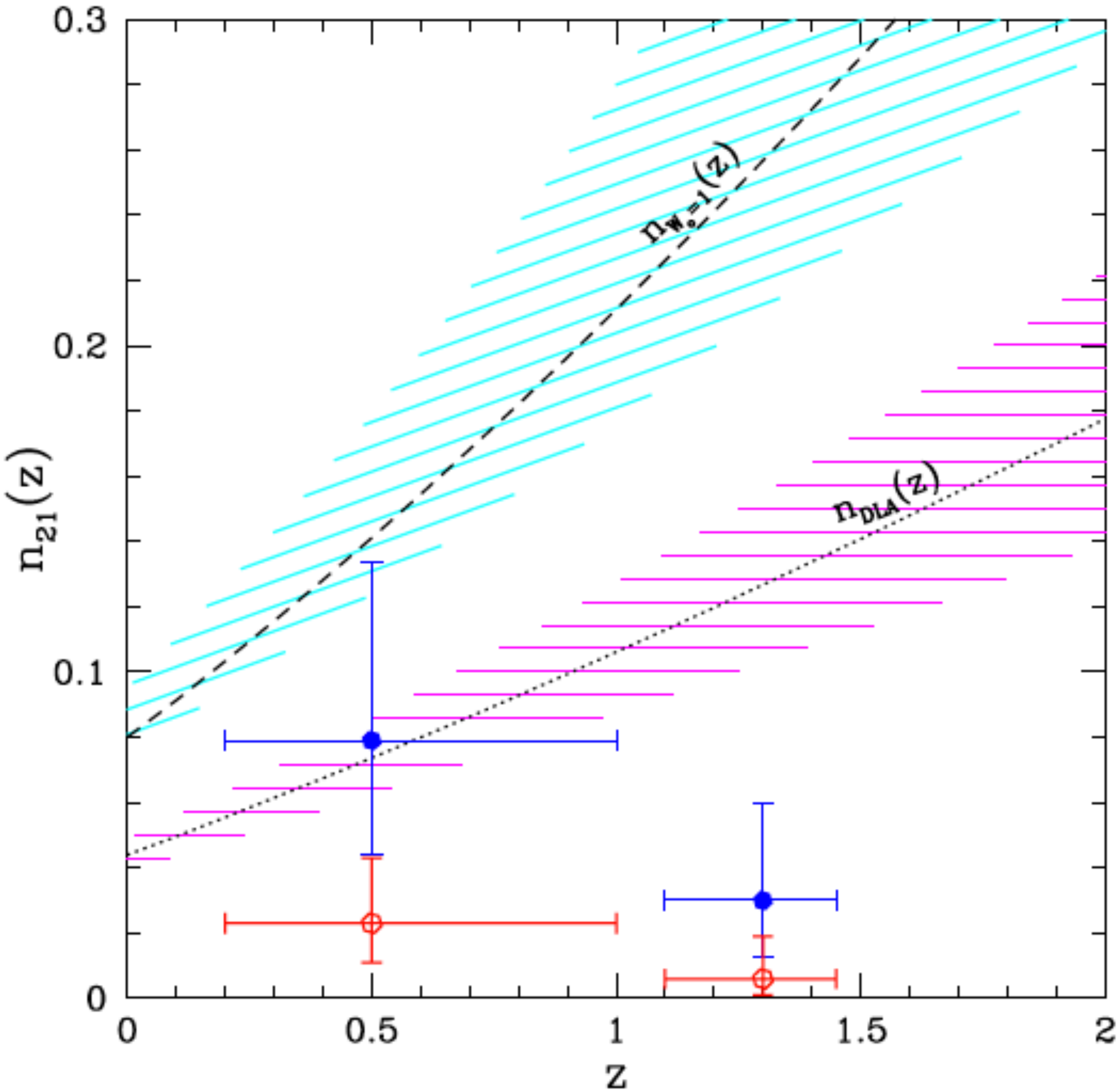
# Damped Lyman-α Absorbers (DLAs)




Thanks to SDSS, >1000 known at z>2.

Noterdaeme et al. 2009, Prochaska et al. 2009, Zwaan et al. 2005

# Number density of 21-cm absorbers




?

Gupta et al. 2009; Lane 2000



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# Constraints on constants using radio absorption lines

- HI 21cm vs UV

$$x = \frac{\alpha^2 g_p}{\mu}; \frac{\Delta x}{x} = \frac{z_{UV} - z_{21}}{1 + z_{21}}$$

Tzanavaris et al. (2007)
Kanekar et al. (2010)

- HI 21cm vs Molecular

$$y = g_p \alpha^2; \frac{\Delta y}{y} = \frac{z_{mol} - z_{21}}{1 + z_{mol}}$$

PKS1413+135 at z=0.2467
TXS0218+357 at z=0.6847
(Murphy et al. 2001;
Carilli et al. 2000;
Wiklind et al. 1997,
Varshalovich et al. 1996)

- OH 18cm vs HI 21cm

$$F = g_p (\alpha^2 \mu)^{1.57}$$

PMNJ0134-0931 at z=0.765
(Kanekar et al. 2005)
TXS0218+357 at z=0.6847
(Chengalur et al. 2003)

- OH 18cm satellite

$$G = g_p (\alpha^2 \mu)^{1.85}$$

PKS1413+135 at z=0.2467
(Kanekar et al. 2010).
Also Darling (2004) and
J0134-0931 at z=0.765.

- Ammonia

$$\frac{\Delta \mu}{\mu} = 0.289 \frac{z_{inv} - z_{rot}}{1 + z_{abs}}$$

TXS0218+357 at z=0.6847
(Murphy et al. 2008)
PKS1830-211 at z=0..8858
(Henkel et al. 2009)

**Radio absorption lines are more sensitive**

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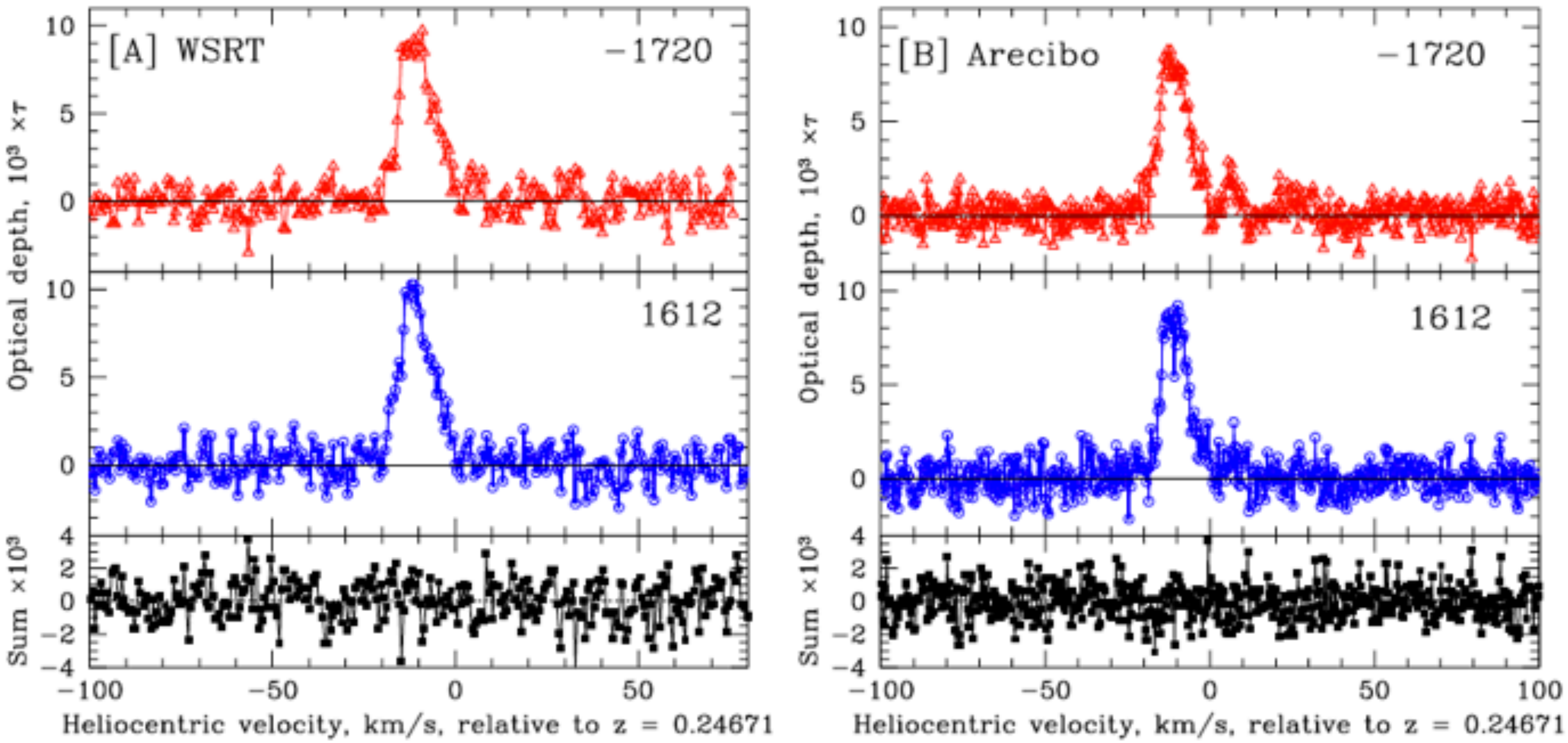


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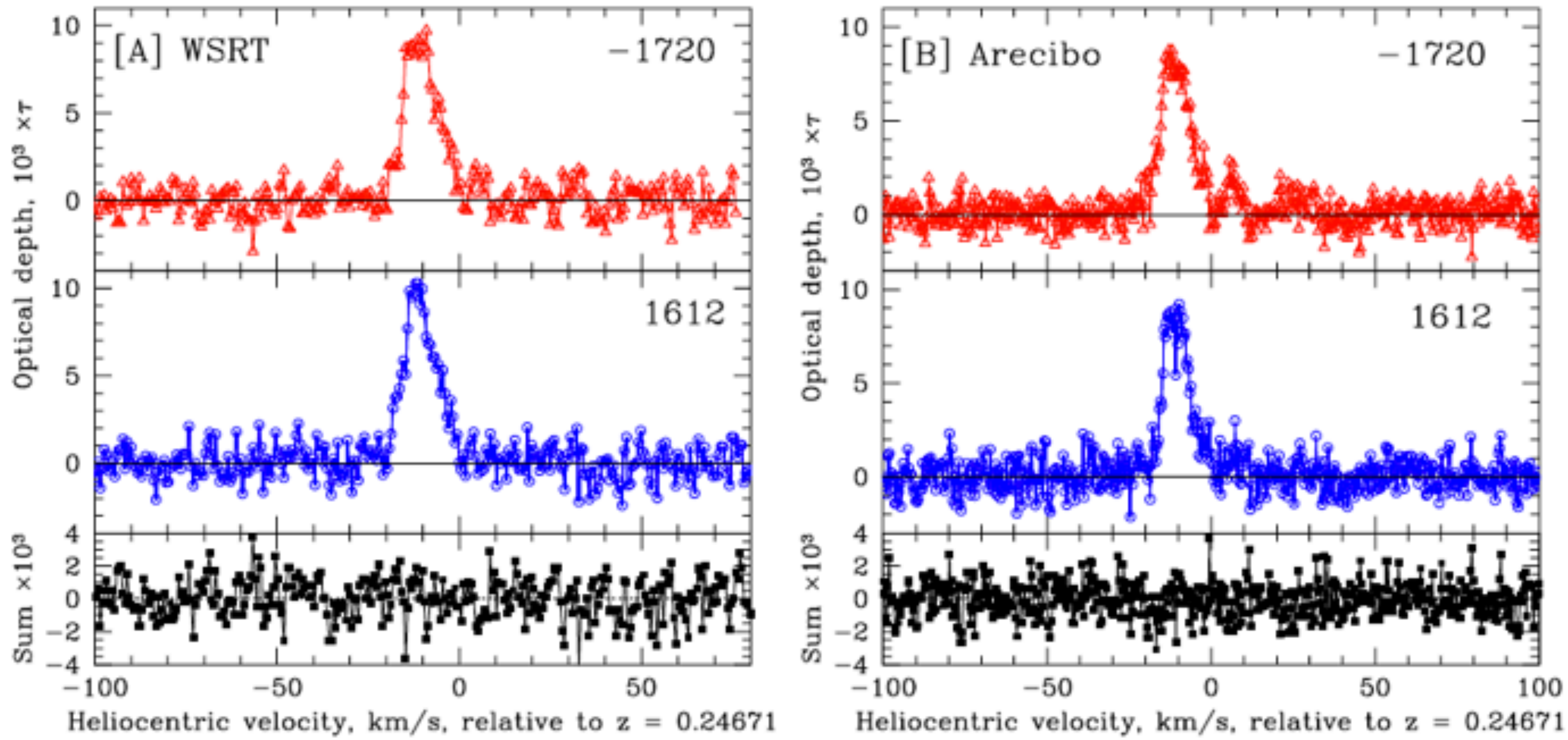


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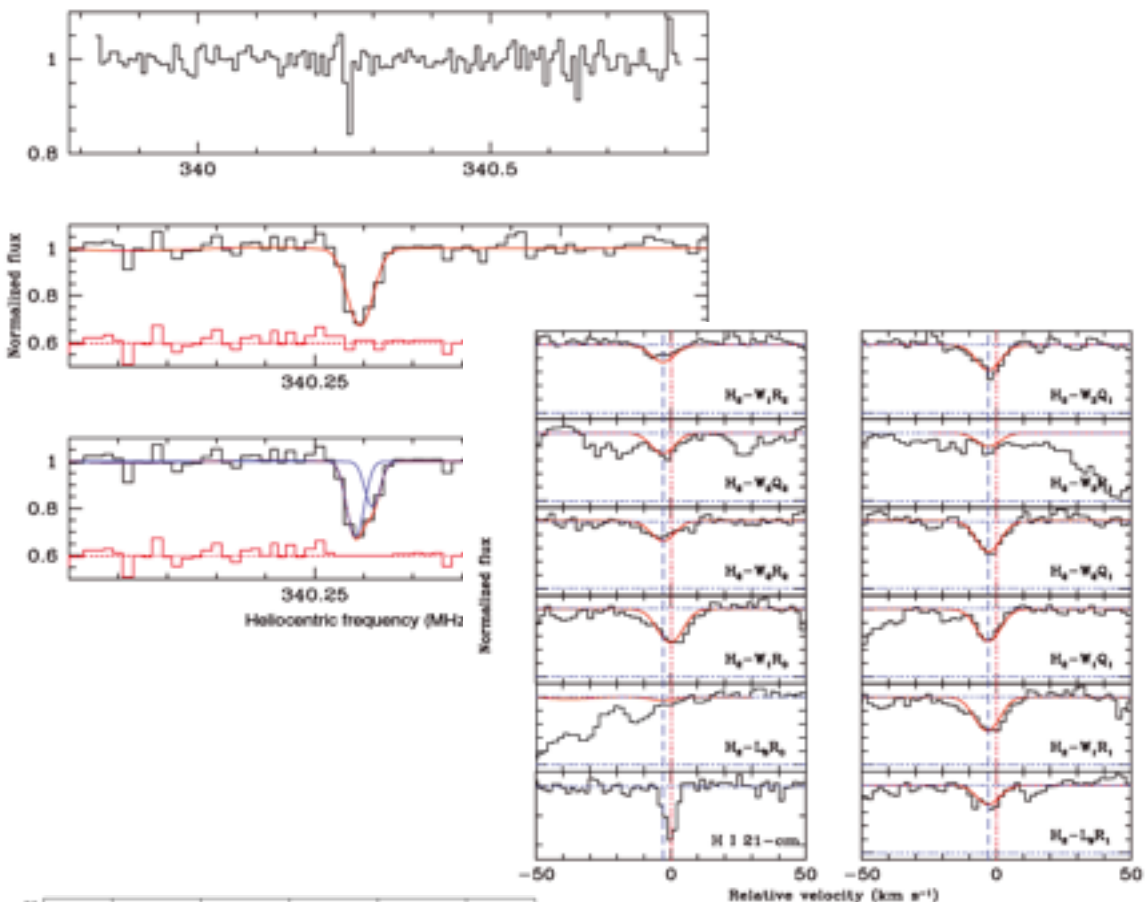
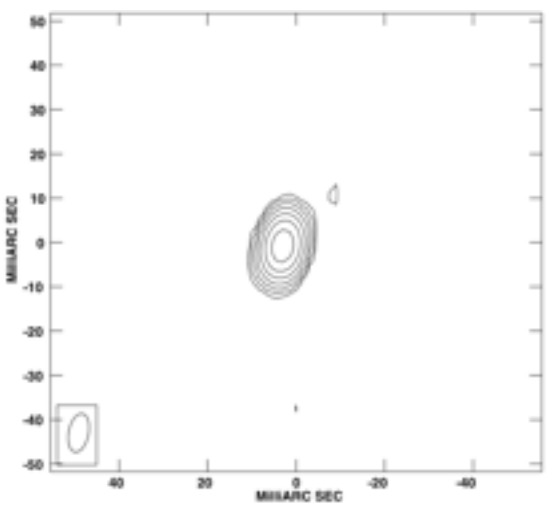
# DLA with molecular hydrogen and 21cm absorption at z=3.174




$$x = \frac{\alpha^2 g_p}{\mu}$$

$$\frac{\Delta\mu}{\mu} \leq 4.0 \times 10^{-4}$$

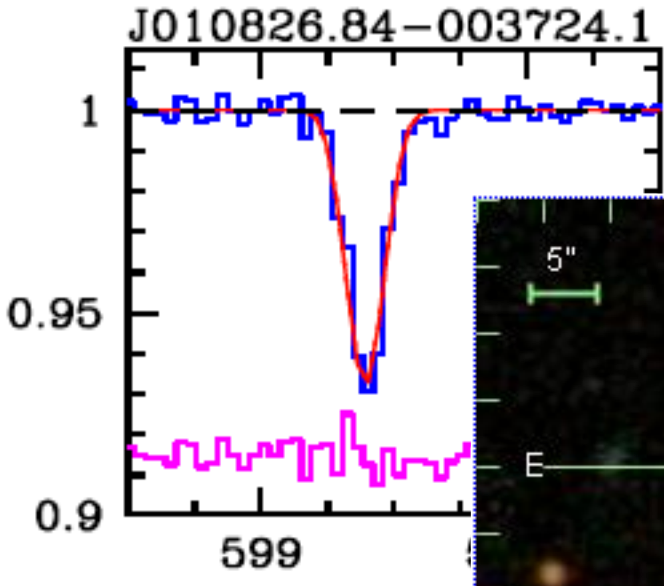
From 21cm and metal absorption lines:

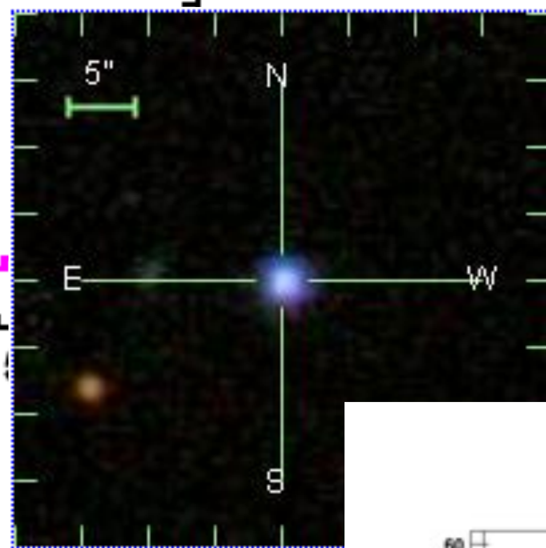
$$\frac{\Delta x}{x} = -(1.7 \pm 1.7) \times 10^{-6}$$

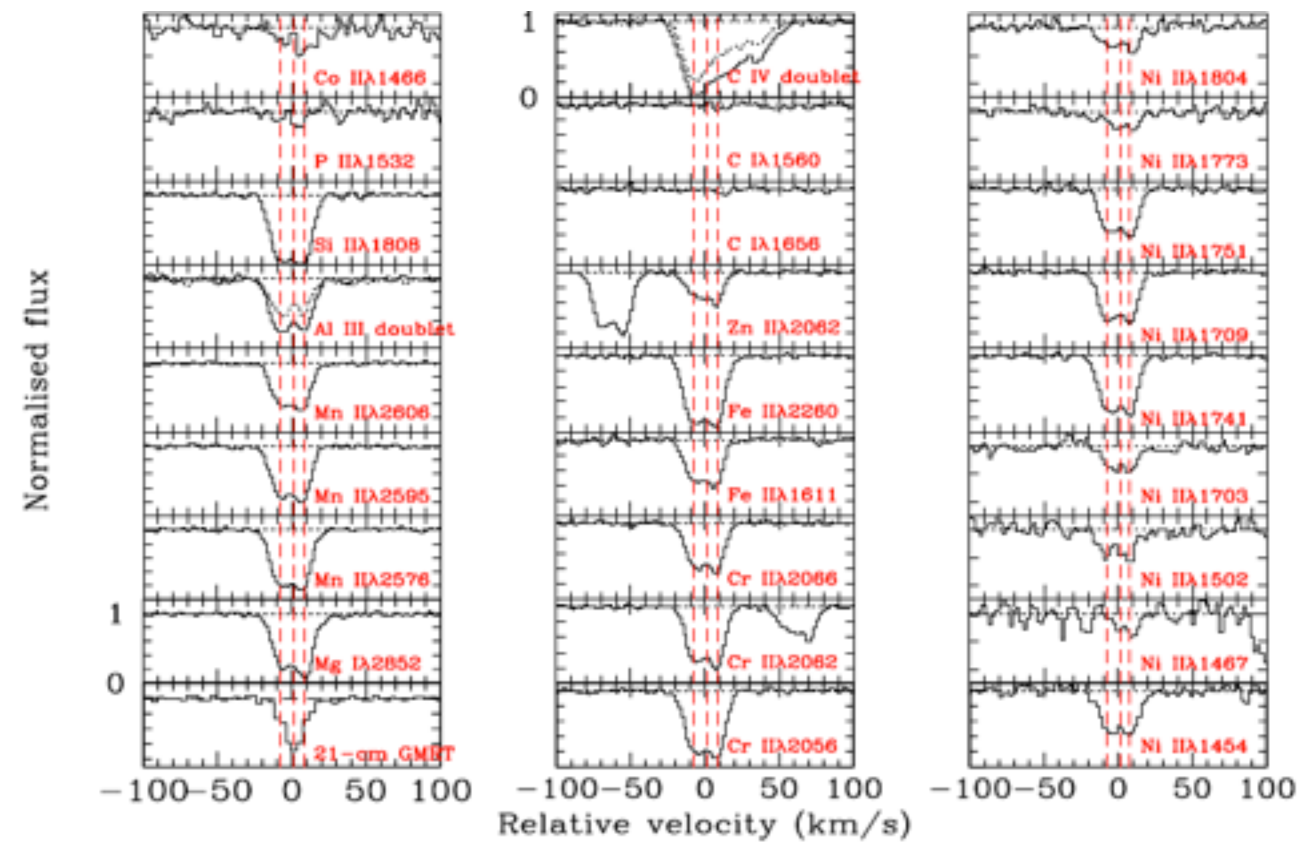
$$\frac{\Delta\mu}{\mu} = -(1.7 \pm 1.7) \times 10^{-6} \quad \text{or} \quad \frac{\Delta\alpha}{\alpha} = -(0.85 \pm 0.85) \times 10^{-6}$$

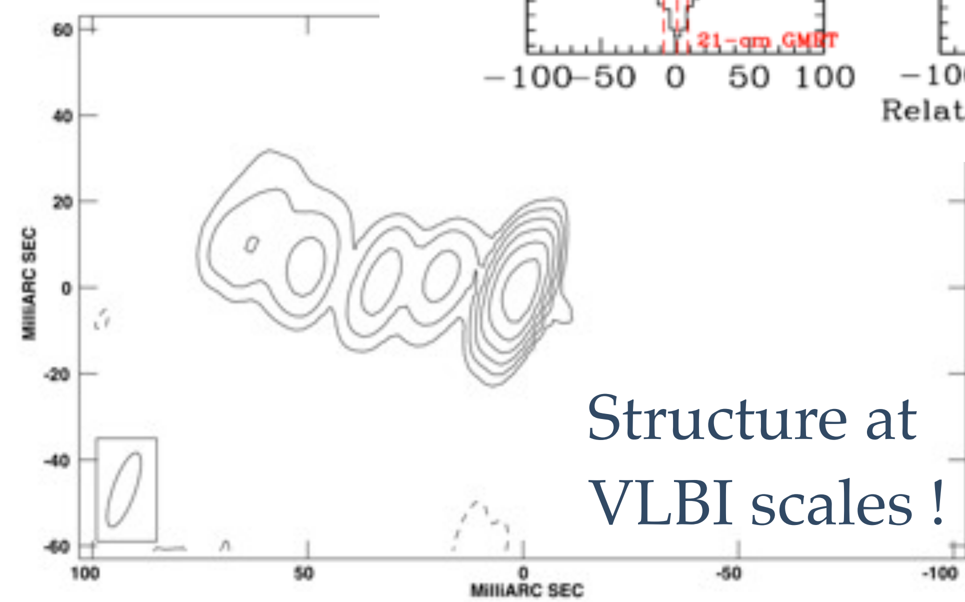
Srianand et al. 2010, MNRAS, 405, 1888

# Case of J0108-0037 (z=1.3710)



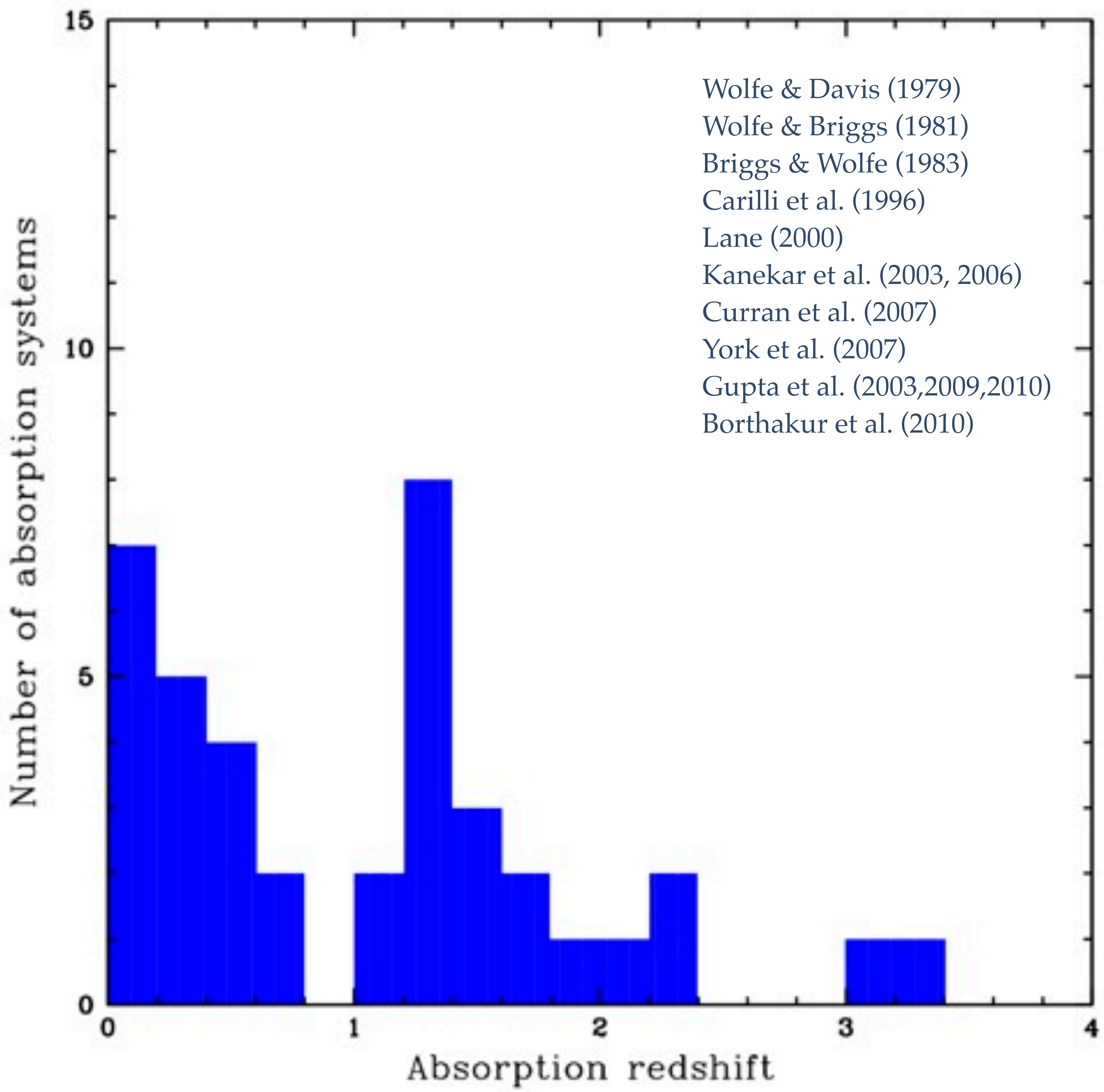




Structure at VLBI scales !

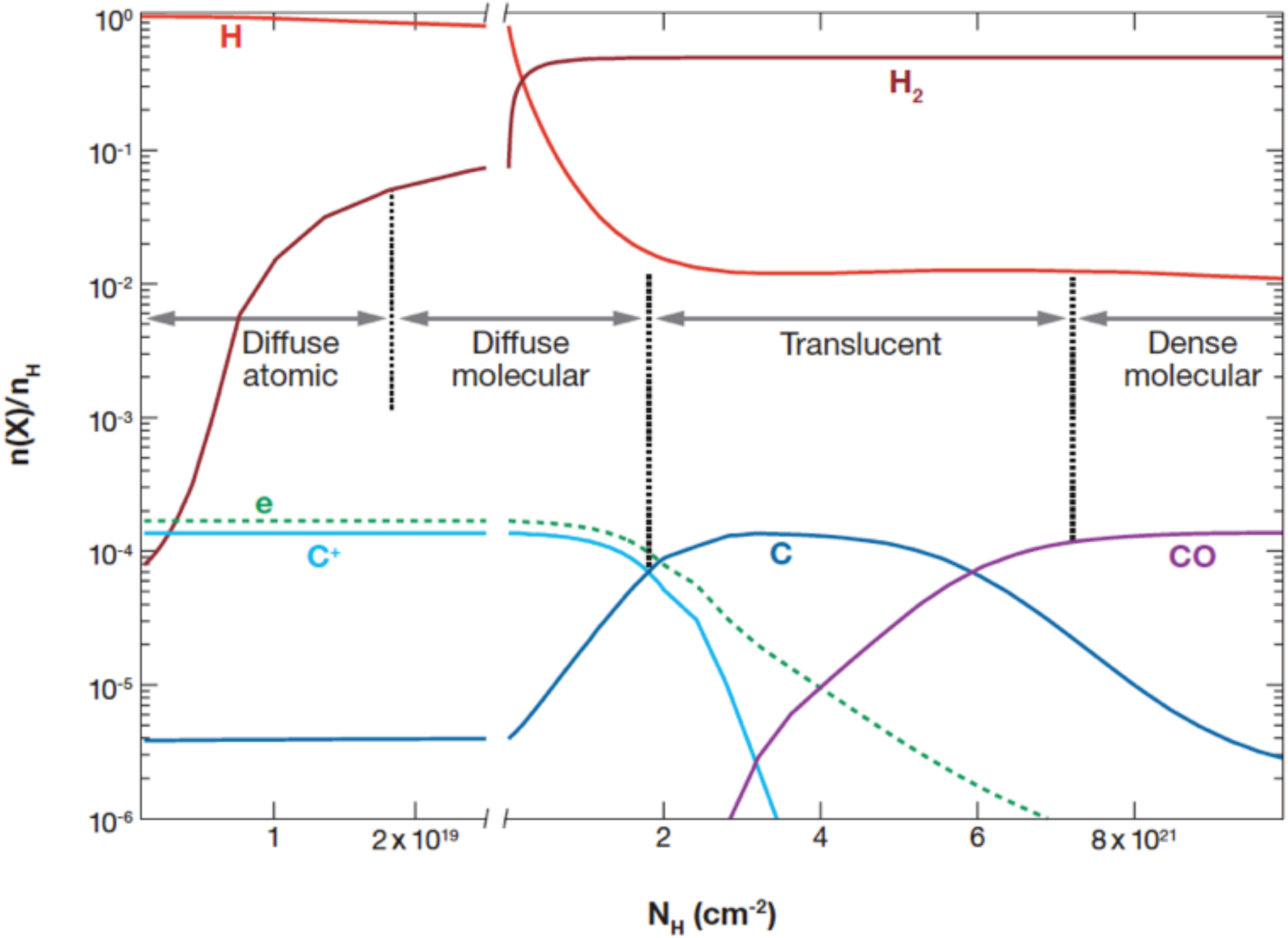
.... need to be careful (Rahmani et al. 2012).

**No clear picture on evolution of cold gas and time variation of fundamental constants**

# Intervening 21-cm absorbers




Only 5 molecular absorbers known at $z>0.1$.




Snow et al. 2006

# Blind radio absorption line surveys now possible !

# Absorption line survey speed

| | EMMA | APERTIF | ASKAP | EVLA | MeerKAT-1 |
|---|---|---|---|---|---|
| Frequency (GHz) | 0.450-1.45 | 1.0-1.7 | 0.7-1.8 | 1.0-50 | 0.9-1.75 |
| Bandwidth (GHz) | 0.5 (1.0) | 0.3 | 0.3 | 0.5 (8.0) | 0.35 |
| FoV ($deg^2$,1.4GHz) | 78 | 8 | 30 | 0.3 | 0.6 |
| $z_{max}$ for HI absorption | 2.16 | 0.42 | 1.03 | 0.42 | 0.58 |
| $S_{rms}$ (μJy, 1h, full BW) | 37 (27) | 30 | 35 | 7.6 | 14.6 |
| $S_{rms}$ (μJy, 1h, 100MHz) | 84 | 49 | 61 | 17 | 27 |
| $S_{rms}$ (mJy, 1h, 5 km/s) | 5.5 | 3.7 | 4.0 | 1.1 | 1.8 |
| A/T ($m^2$/K) | 40 | 105 | 58 | 246 | 150 |
| SSFOM $x10^4$ ($m^4/K^2/deg^2$) | 12.5 | 8.9 | 13.8 | 1.8 | 1.4 |
| $SSL(\tau < \tau_o)/N_t$ | 1 | 0.92 | 0.73 | 5.3 | 5.6 |

# Absorption line survey speed

redshift
coverage

$$\text{SurveySpeed}(\tau < \tau_o) \propto (A_e / T_{sys})^2 \text{ x } \Delta z \text{ x } N_t$$

number
of targets

sensitivity



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EMMA: ~500 21cm absorbers in ~300x5hrs

# Blind absorption line survey: Goals

1) Detect ~1000 intervening 21-cm absorbers
2) Measure the evolution of cold atomic and molecular gas
3) Time variation of the fundamental constants of physics
4) Probe the magnetic field in absorbing galaxies
5) Synergy with ALMA, ELTs, etc.

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Thank you