# Comparing gas in **galaxies** and **DLAs**

Martin Zwaan (ESO)

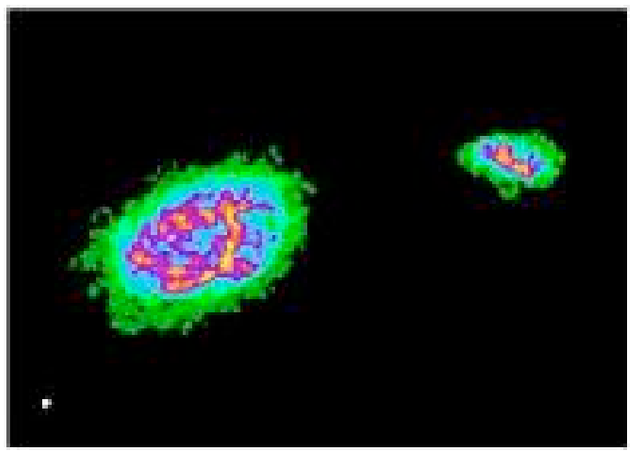
# HI at **high** and **low *z***

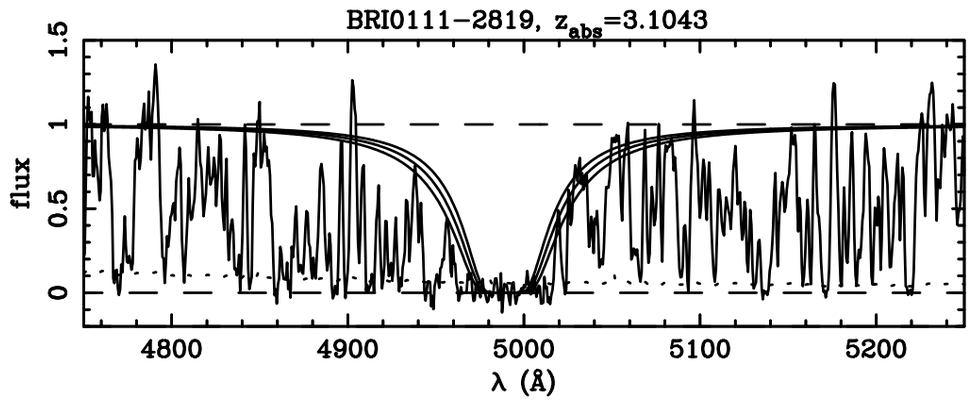
**low redshift**

- 21-cm
- emission
- 21-cm emission weak: limited to local Universe
- 3D data cube
- study of galaxy easy

**high redshift**

- Lyα
- absorption
- only limited by brightness of background QSO
- only info along sightline to QSO
- study of host galaxy hard





# local HI: The **HI mass function**

- measured from blind 21-cm surveys:
  - **AHISS**: HI strip Survey *(Zwaan et al 1997)*
  - **AS**: Arecibo Slice *(Spitzak & Schneider 1998)*
  - **ADBS**: Arecibo Dual Beam Survey *(Rosenberg & Schneider 2000)*
  - **HIPASS**: HI Parkes All Sky Survey *(Zwaan, Meyer et al 2003/2004/2005)*
  - **ALFALFA**: Arecibo Legacy Fast ALFA Survey *(Giovanelli et al 2005)*

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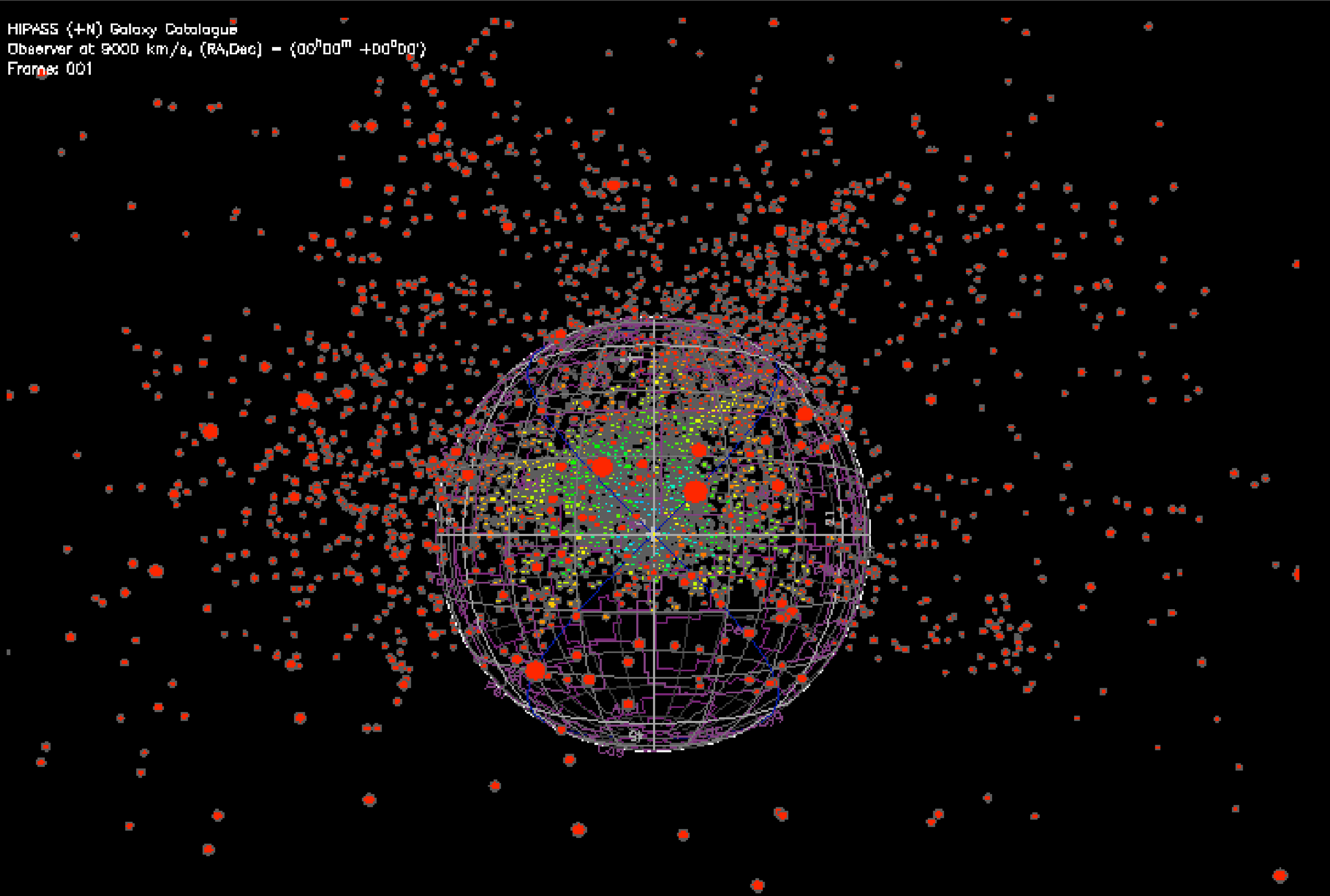
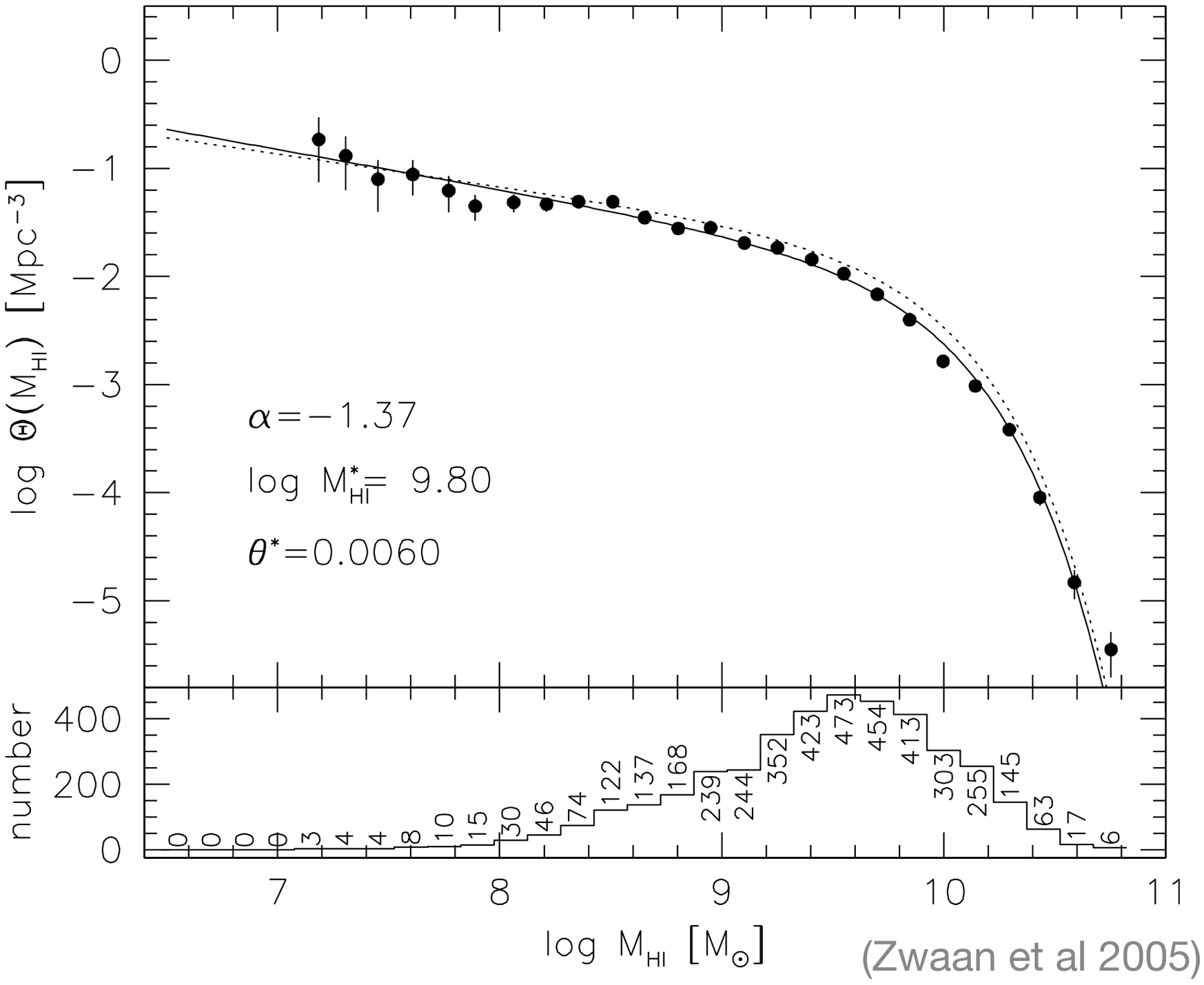
Blind survey covering whole southern sky up to dec=+25°.
5300 detections




Animation nhicat-DVD-111a by Mark Calabretta, 2006

# The **HI mass function**




(Zwaan et al 2005)

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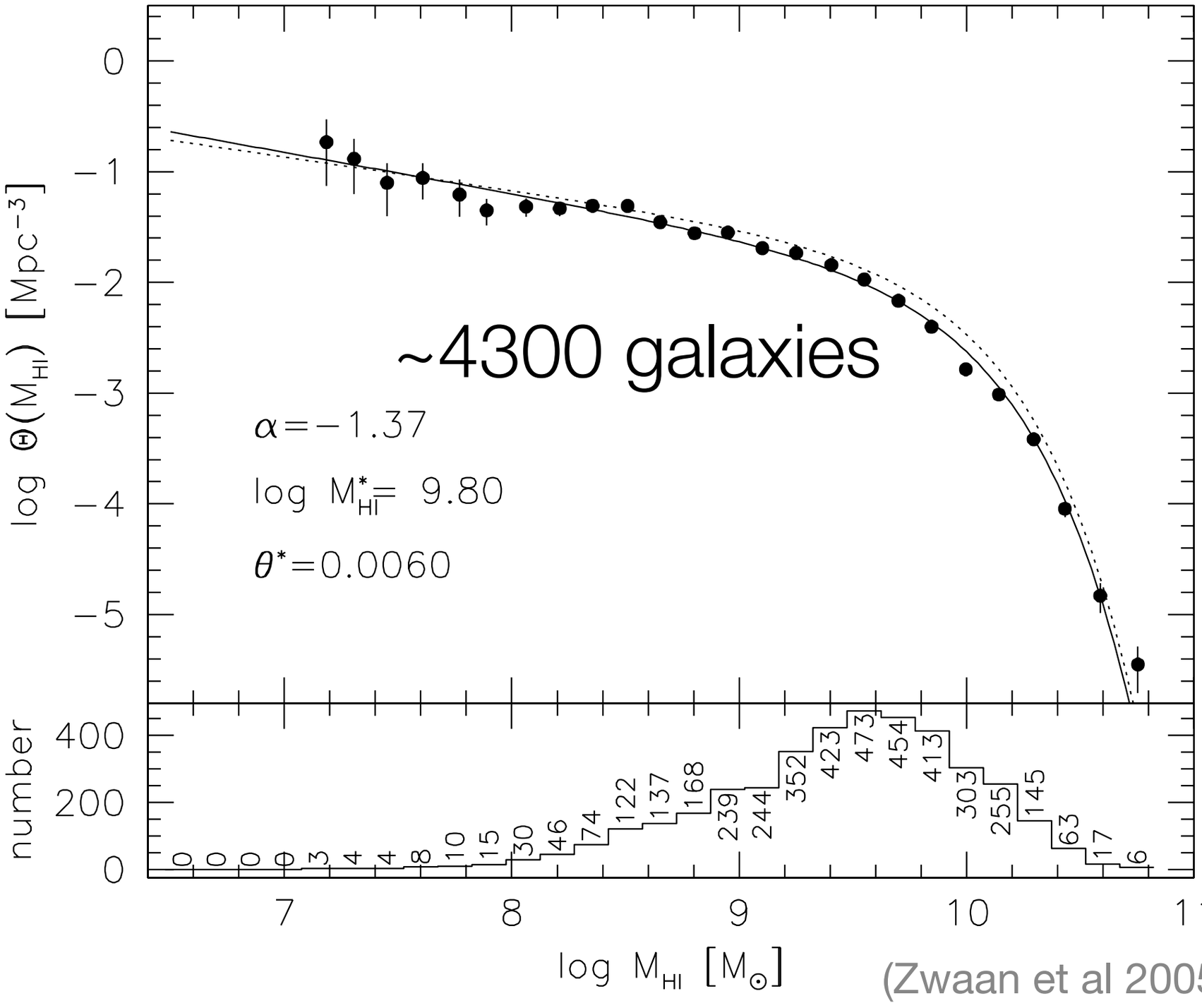


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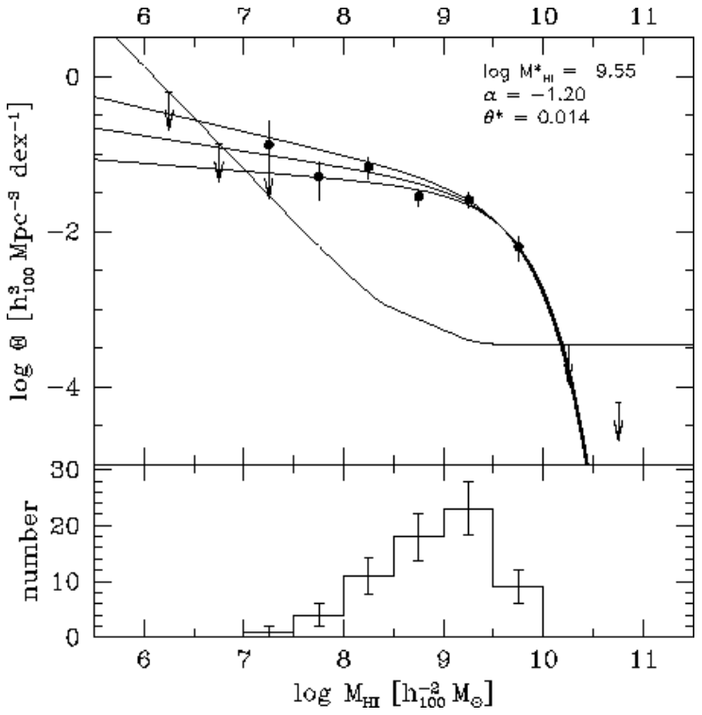


AHISS
(Zwaan et al 1997)

~66 galaxies

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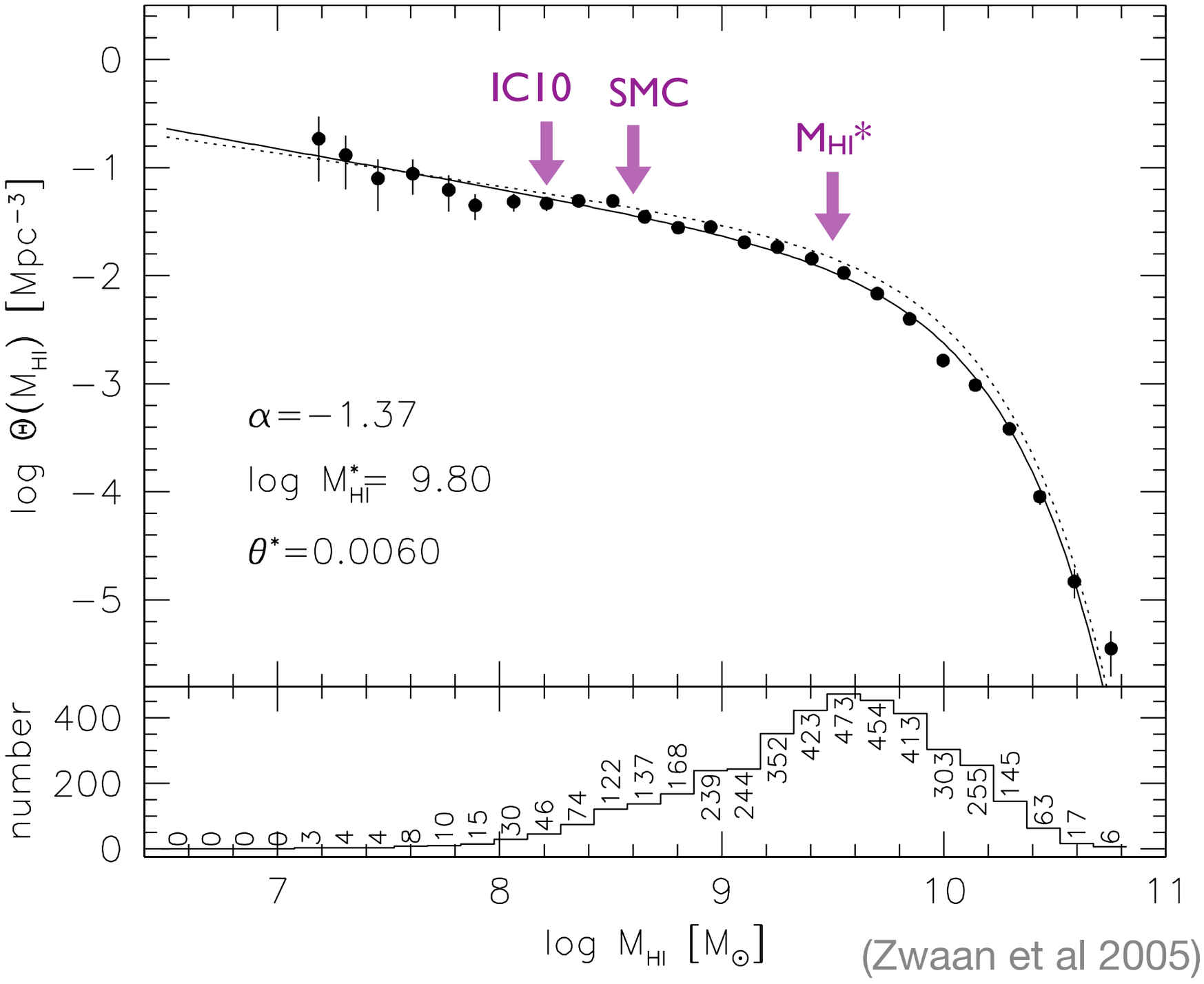


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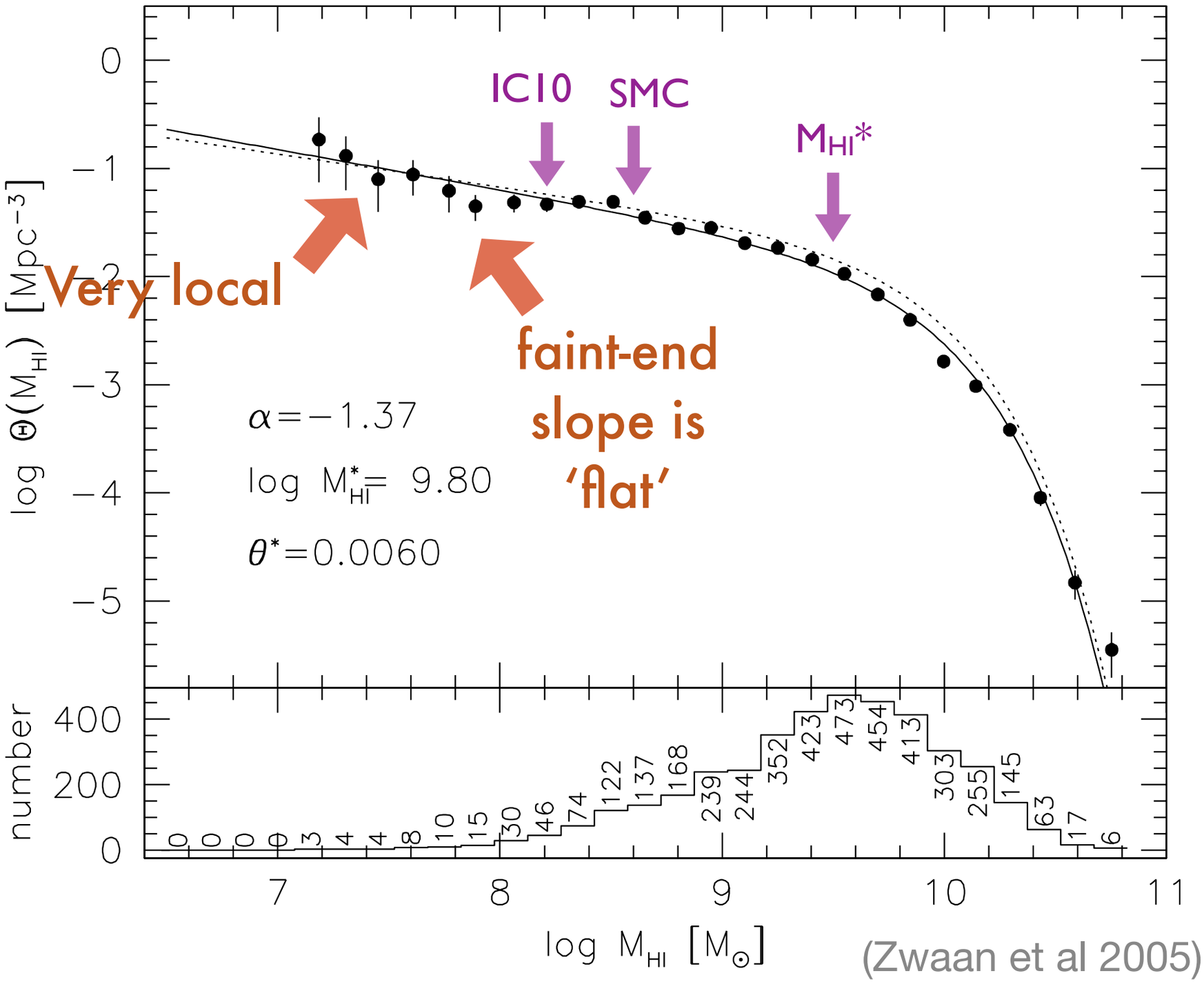


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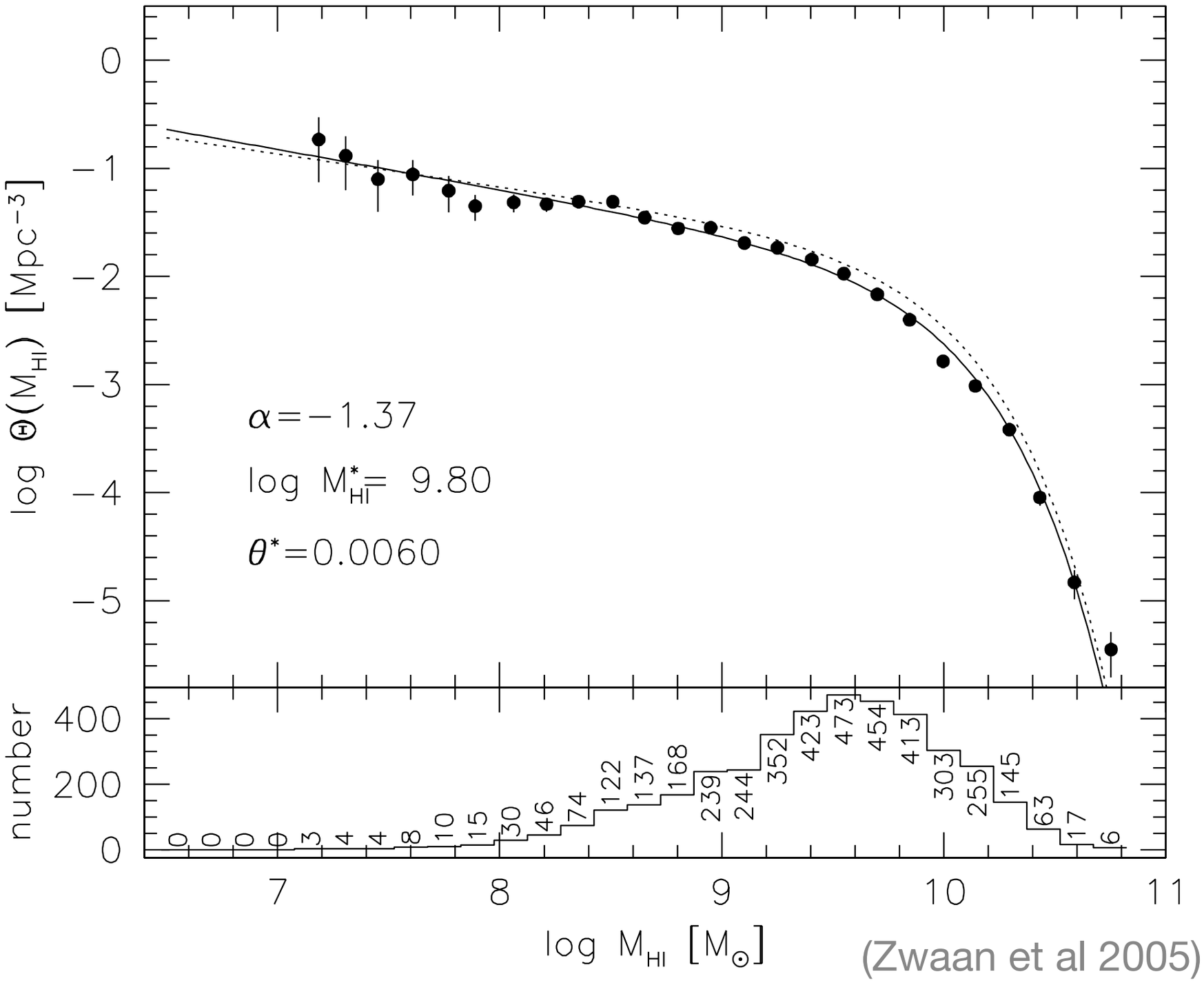


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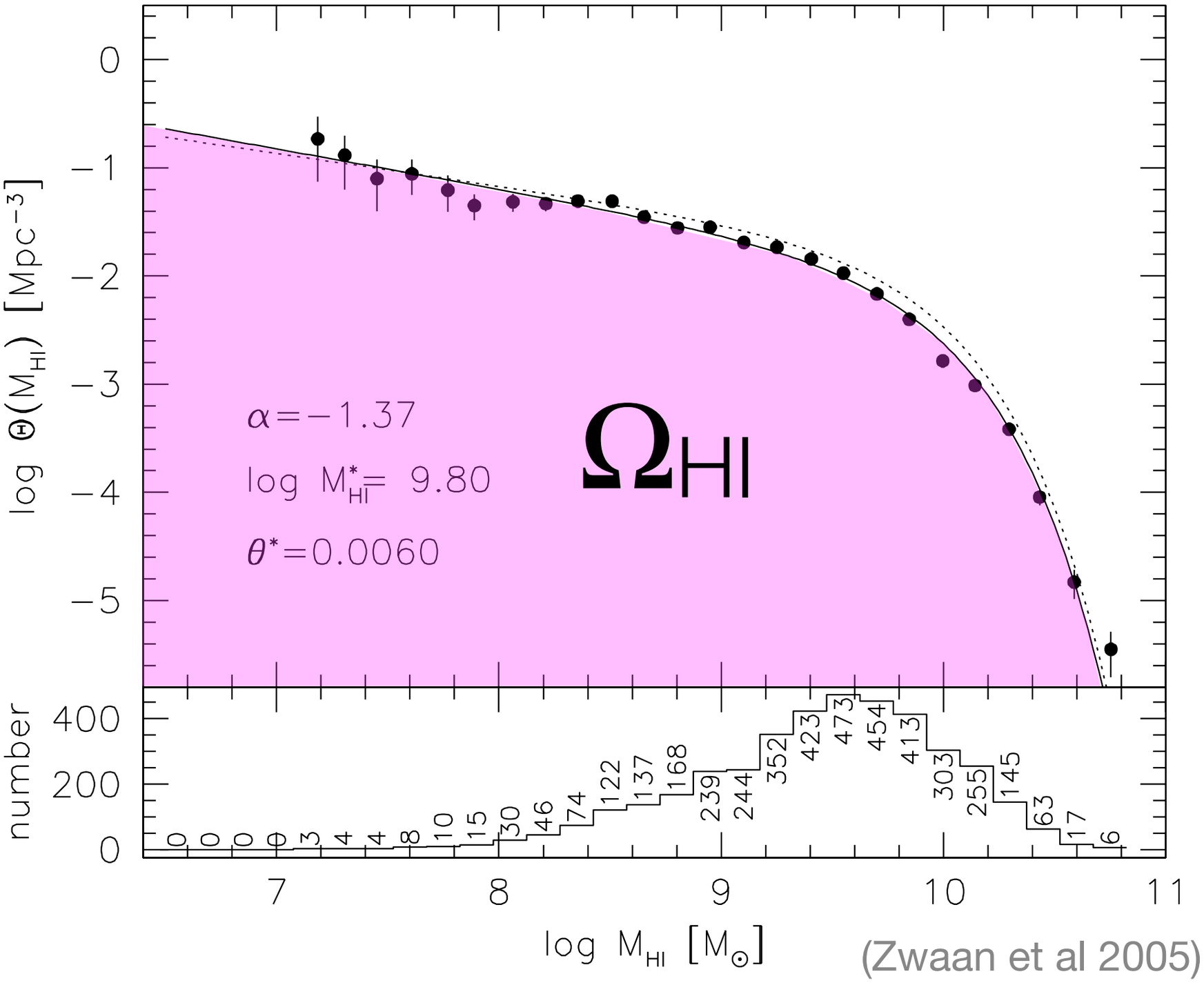


(Zwaan et al 2005)

# local HI: results from **blind surveys**

- The universe seen in 21-cm is similar to that seen in the optical
- No large population of dark or very LSB galaxies
- $\Omega_{HI}$ dominated by L* galaxies

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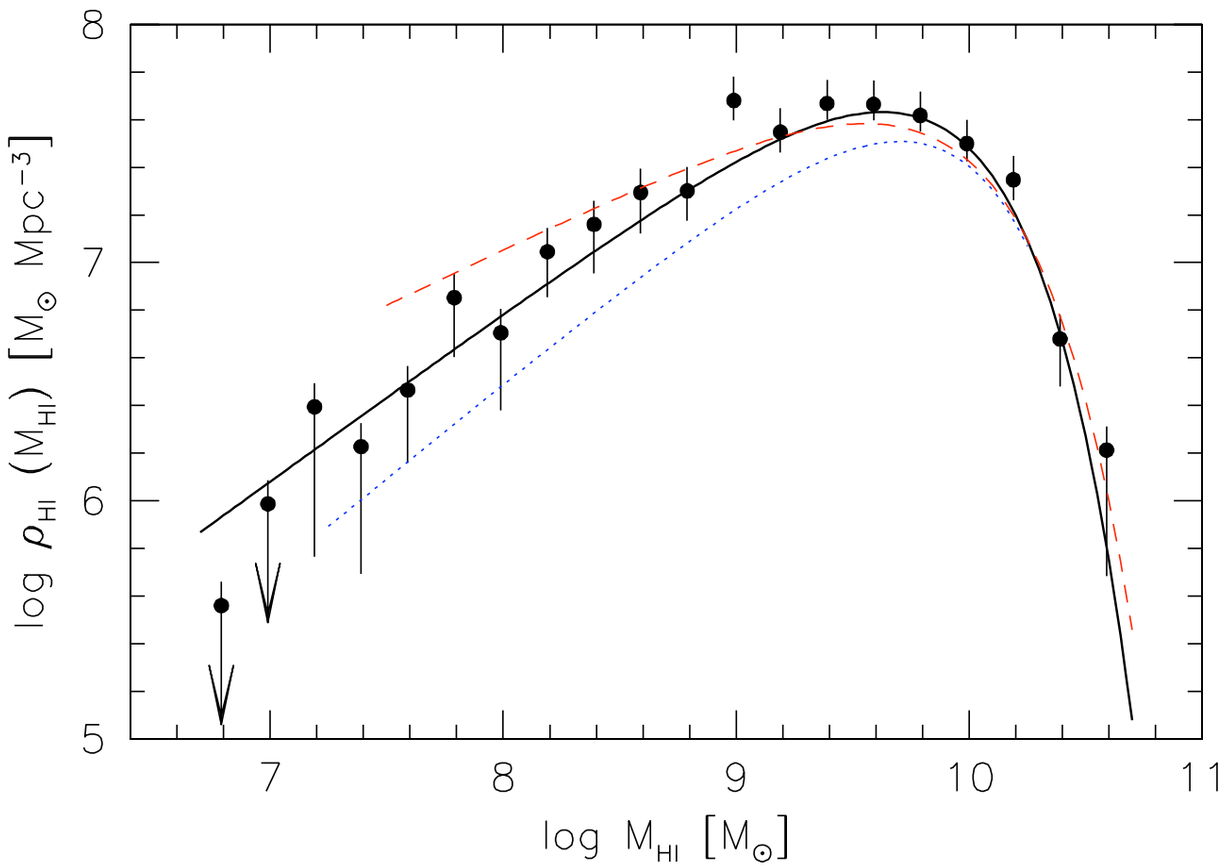
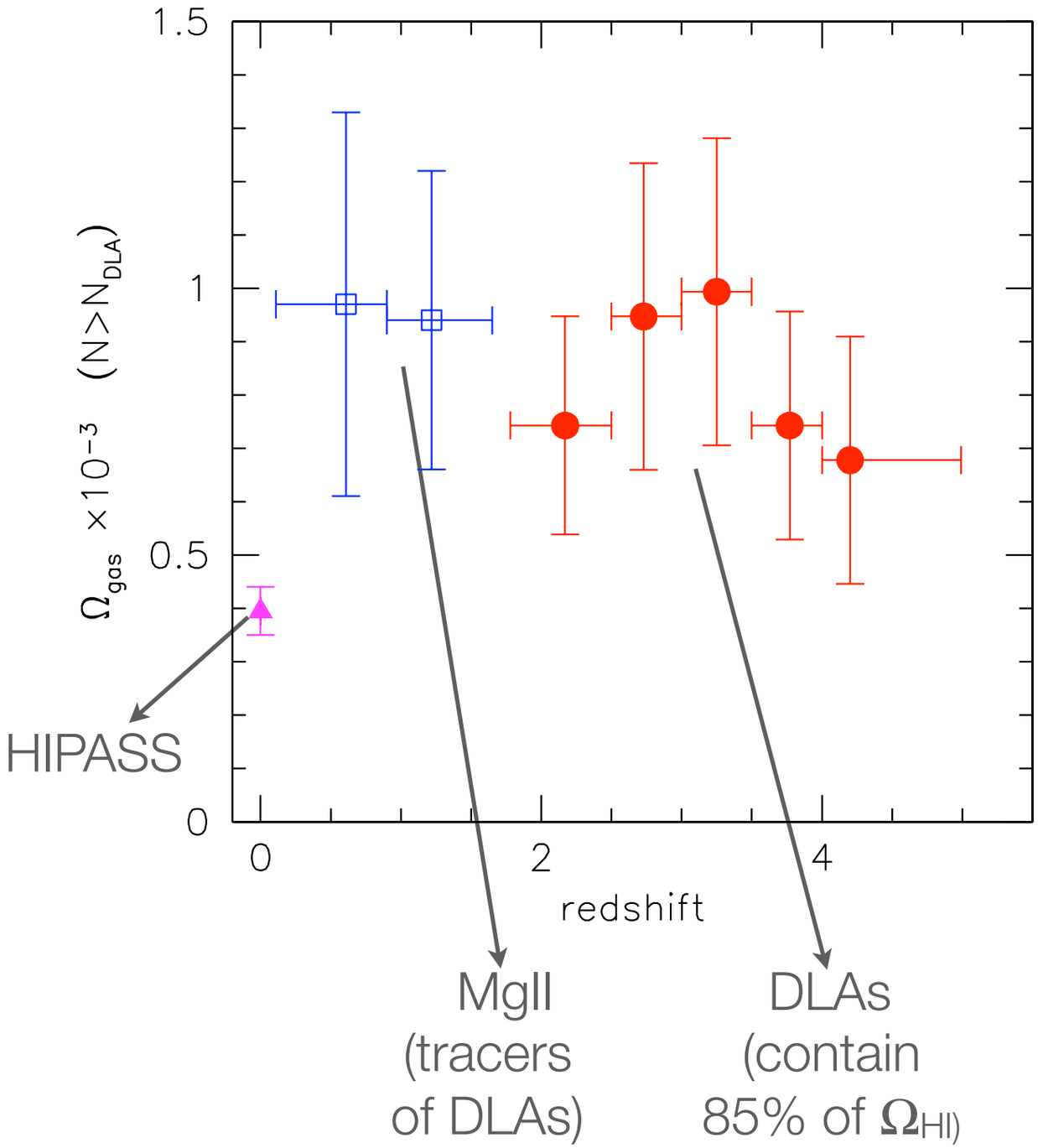


# Cosmic HI mass density **evolves slowly**



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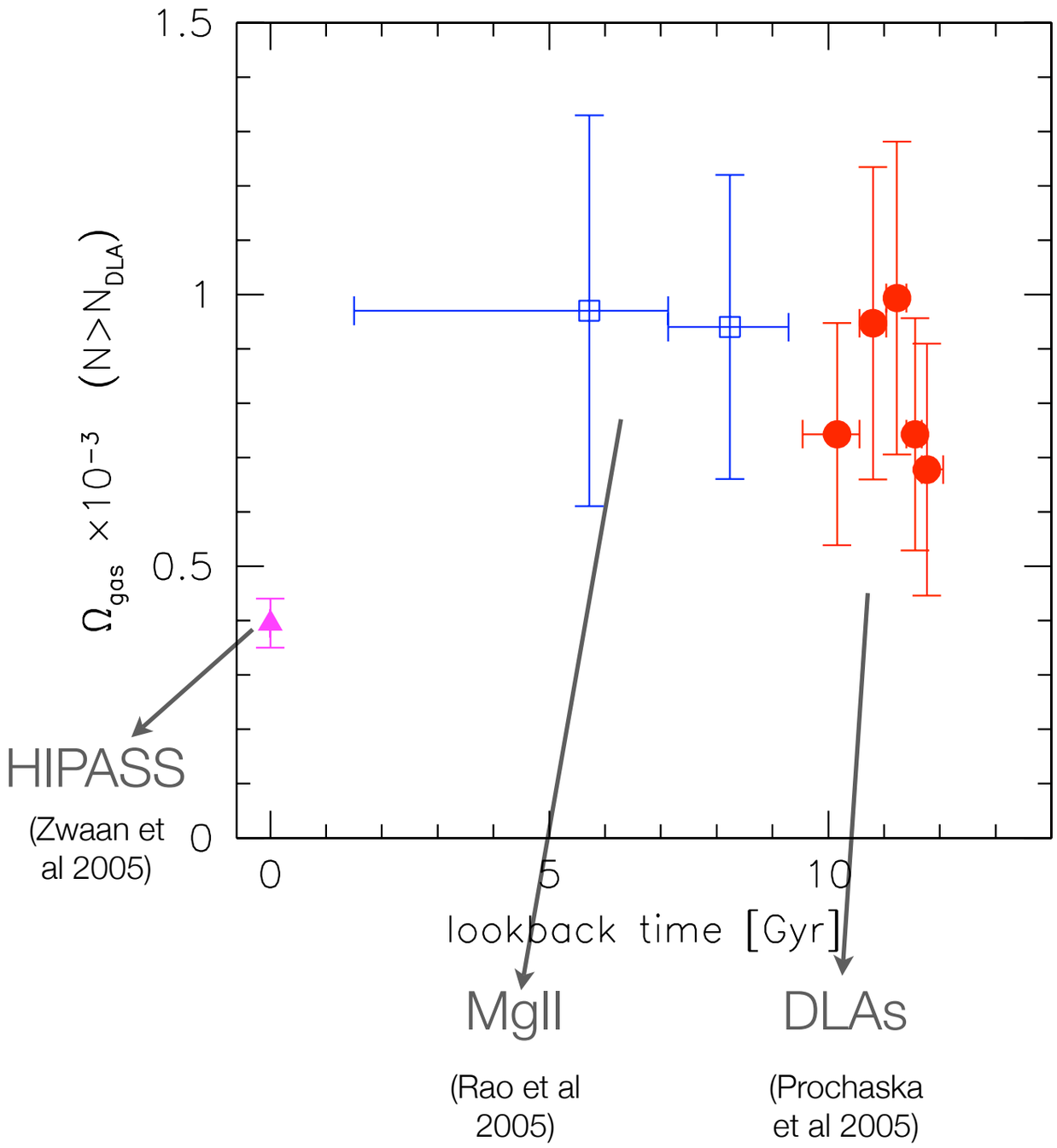

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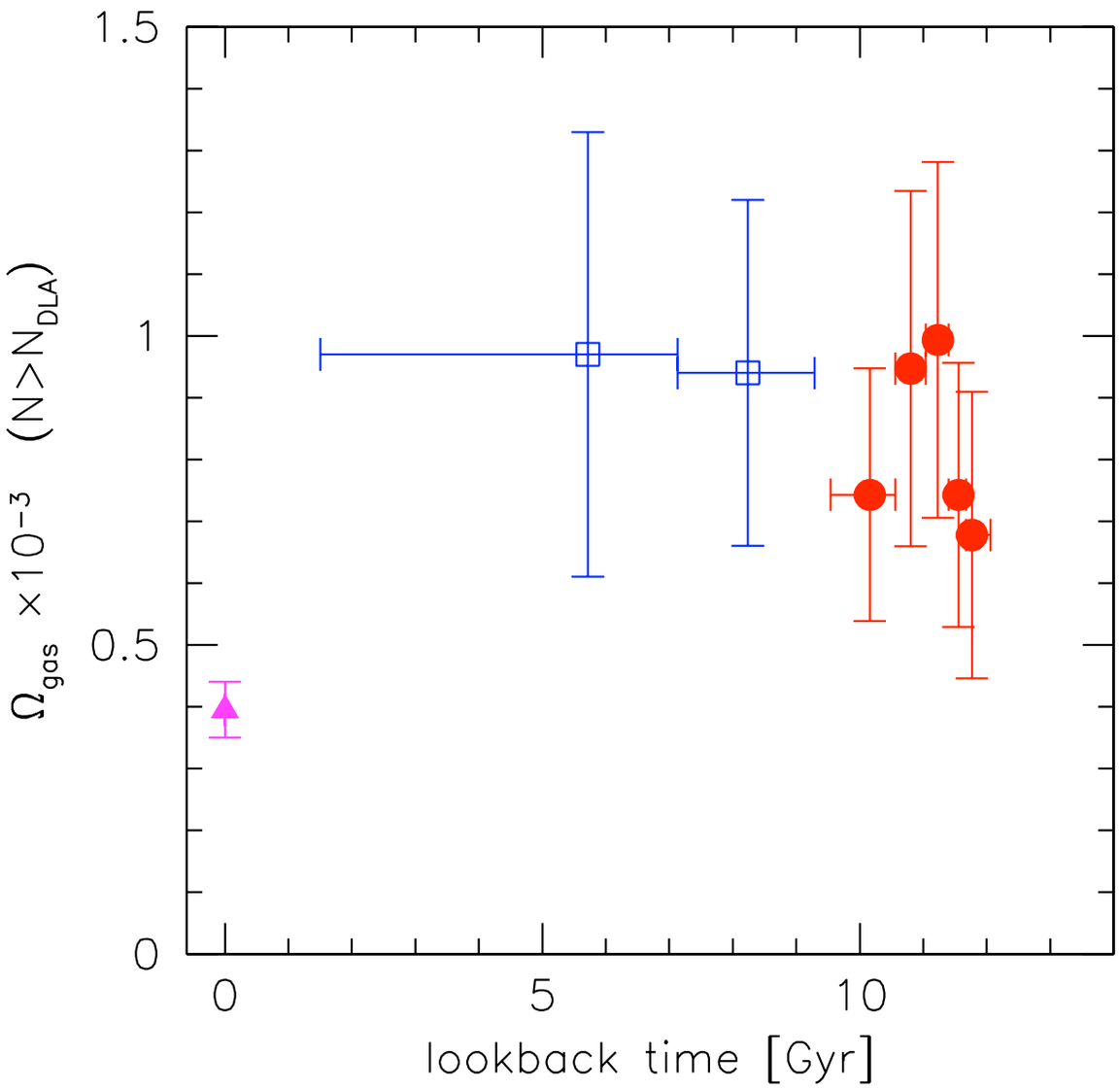

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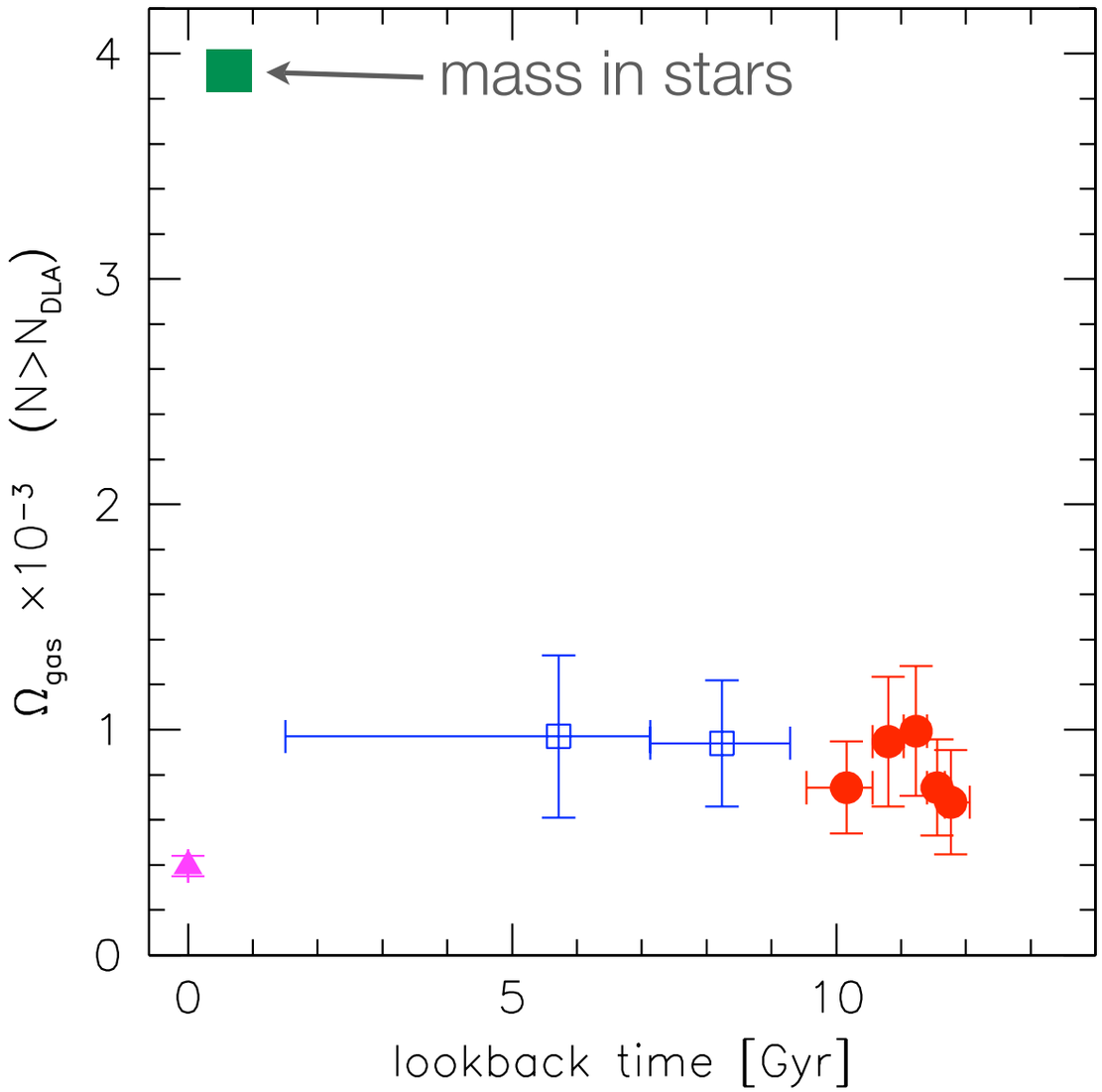


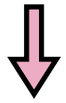
# What can we learn from **local galaxies** to understand **DLAs**?

Treat local galaxies as if they were DLAs and calculate “DLA statistics”.

# QSO absorption line statistics from local galaxies:

redshift number
density of absorbers

space density
of galaxies



$$dN/dz = c/H_0 \times \mathrm{Area(HI)} \times \mathbf{\Phi}$$

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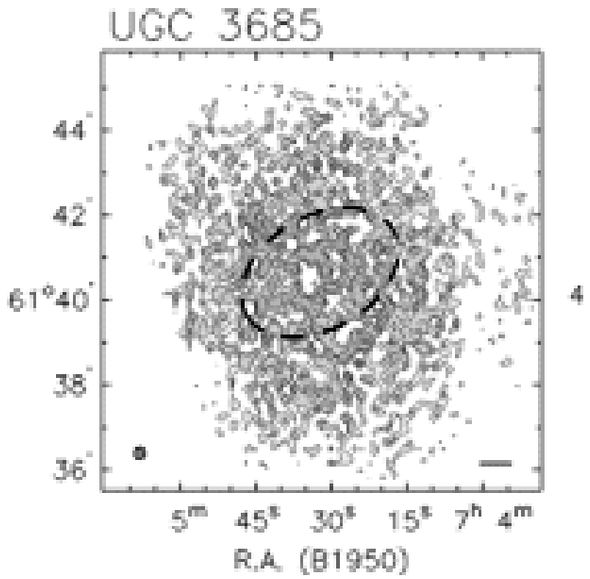
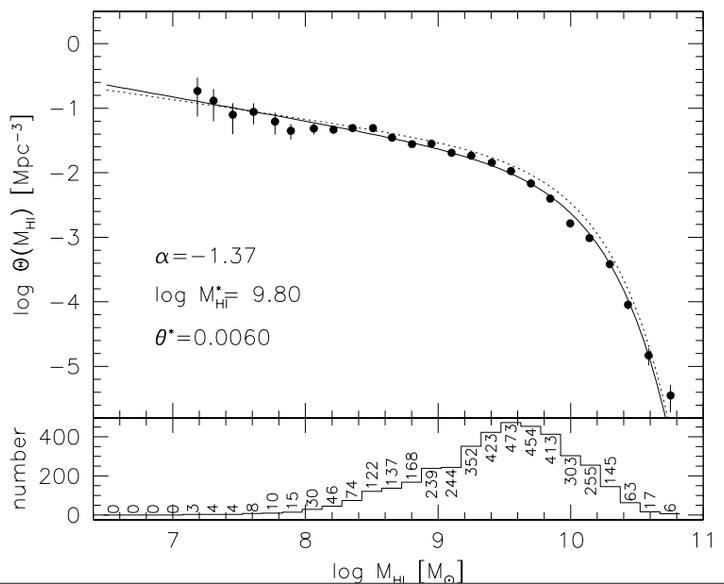
HI imaging




HI mass function



# DLA measurements to explain:

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- f(N)
- dN/dz
- DLA galaxy properties
- impact parameters
- metallicities
- abundance of molecules
- kinematics

# z=0 surveys used for comparison with DLAs

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**WHISP**:
WSRT HI maps of 350 galaxies
Resolution: 15”
*(van der Hulst et al)*

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# z=0 surveys used for comparison with DLAs

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140,000 ‘DLAs’

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800,000 ‘DLAs’

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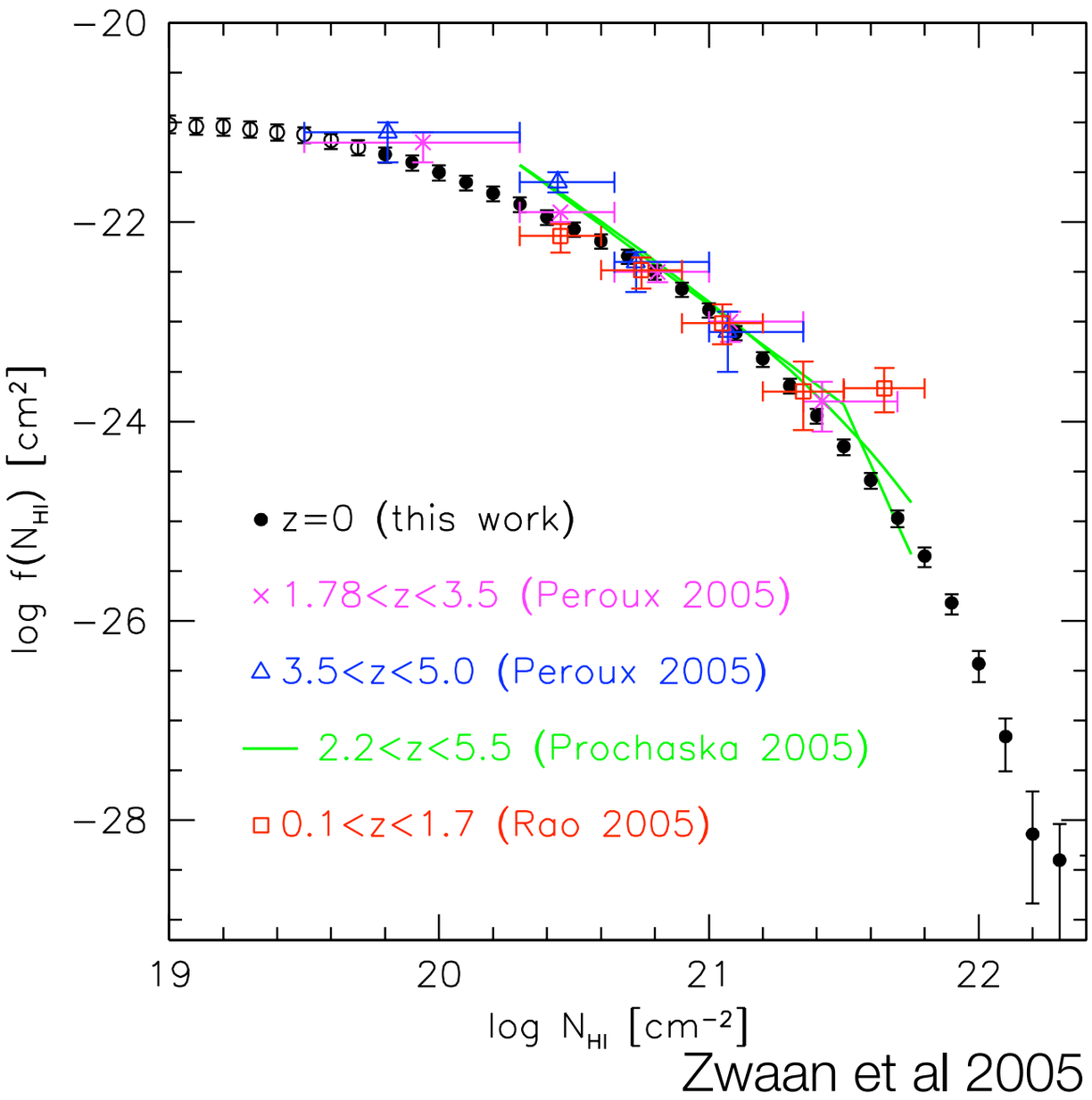
# HI column density distribution **evolves slowly**




Zwaan et al 2005

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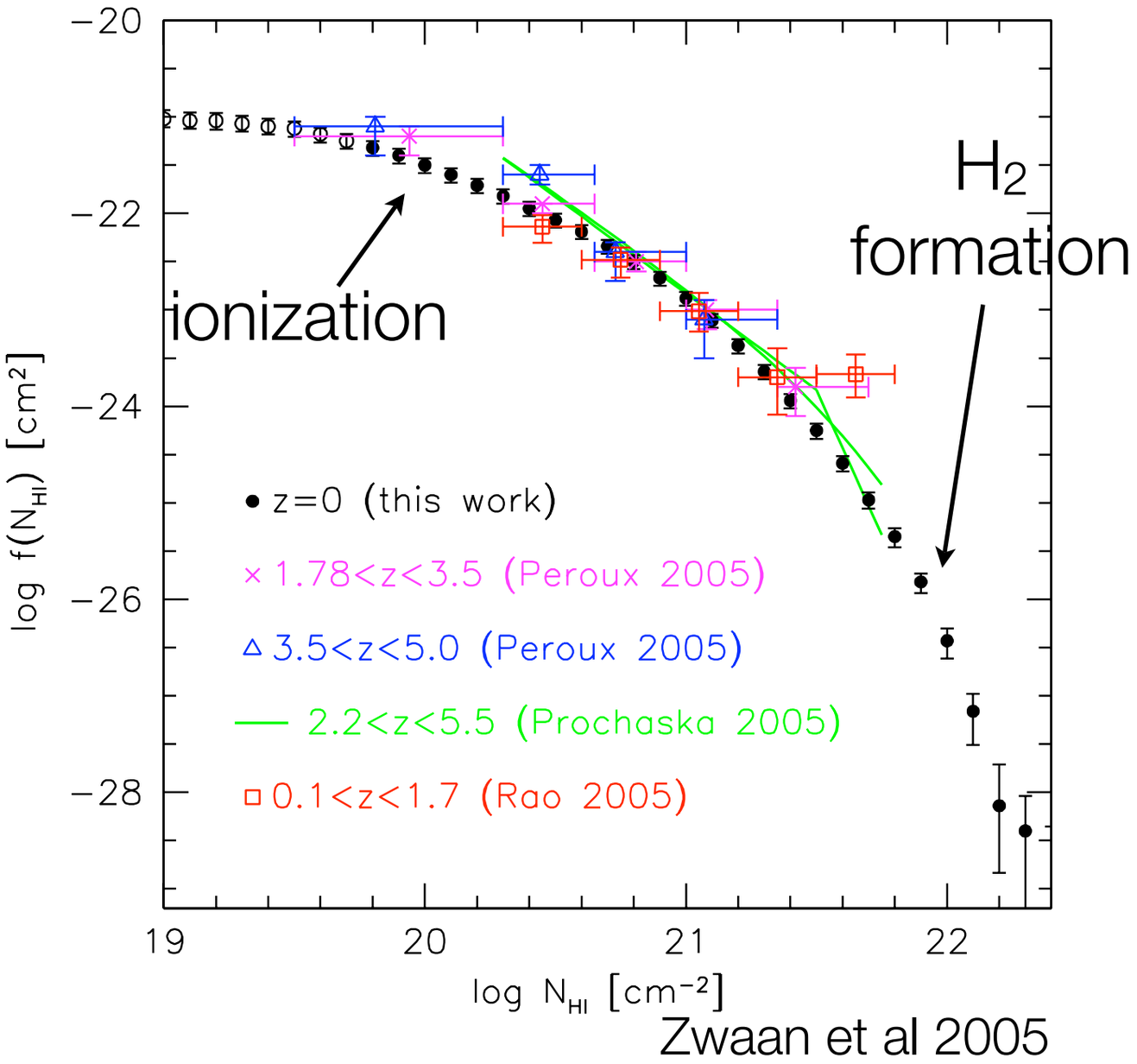
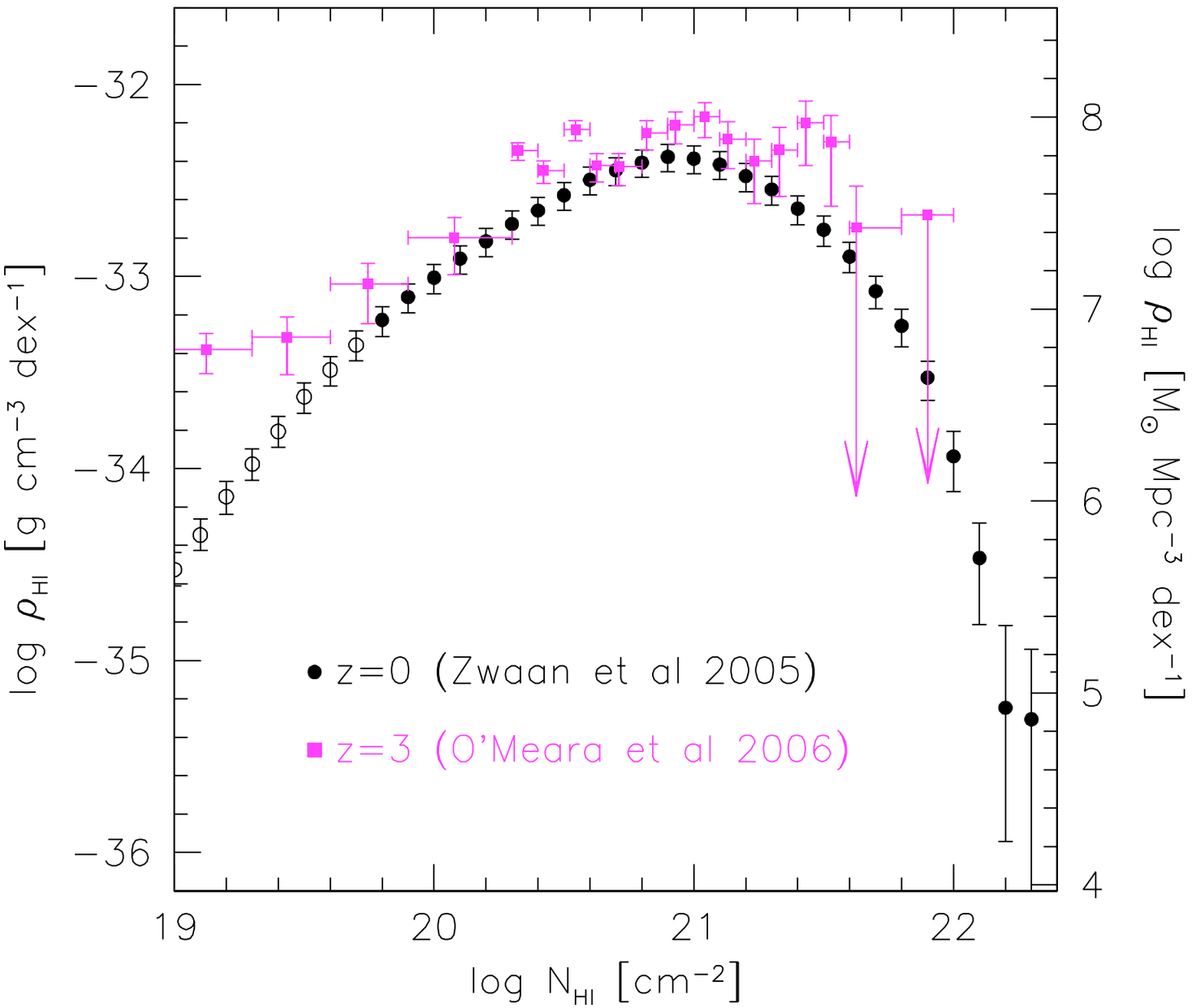



Zwaan et al 2005

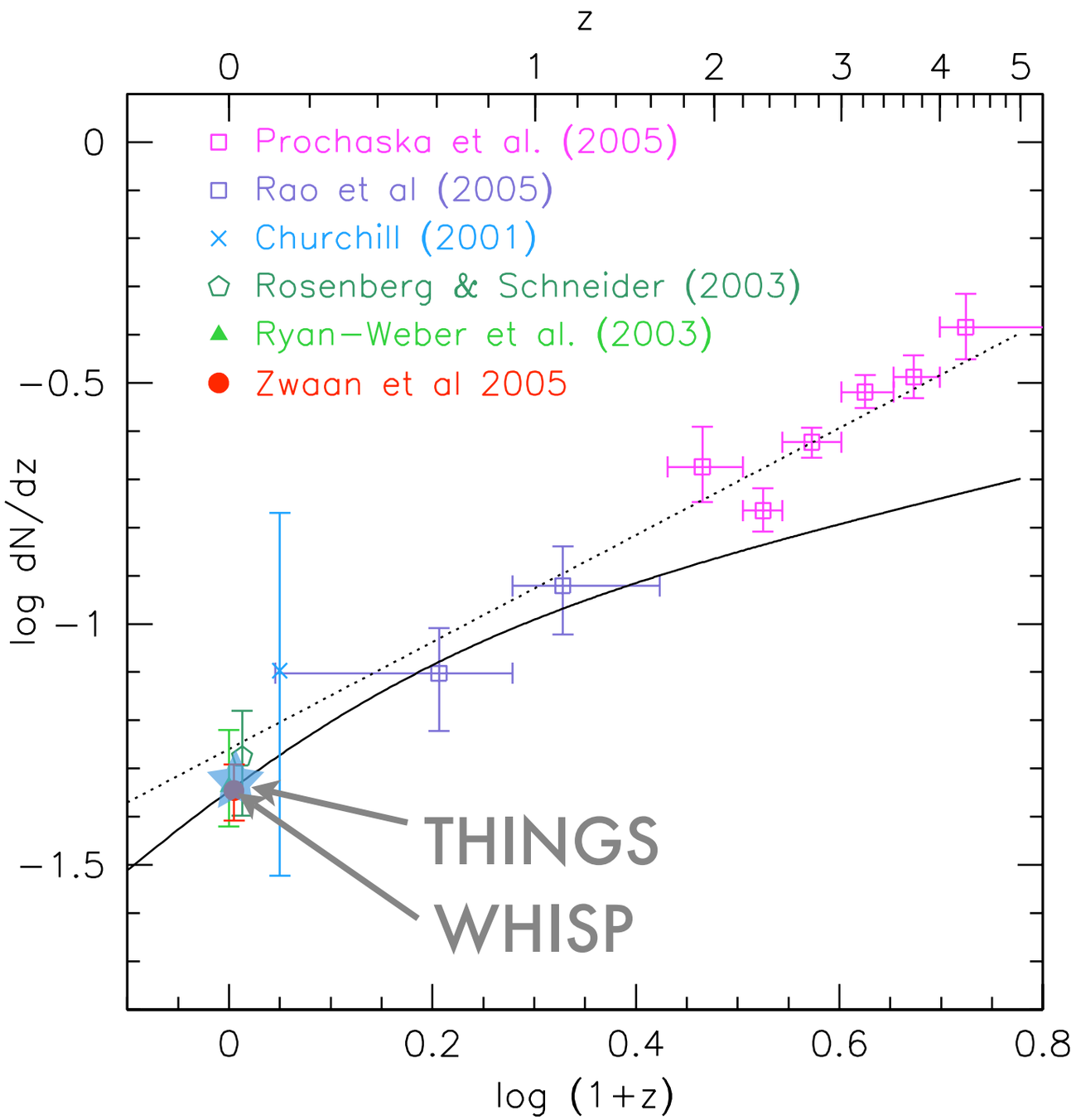
- Shape of f(N) is constant in time
- HI distribution in galaxies at $z$=3 similar to that today?
- Star formation laws similar at higher z?

# HI column density distribution **evolves slowly**



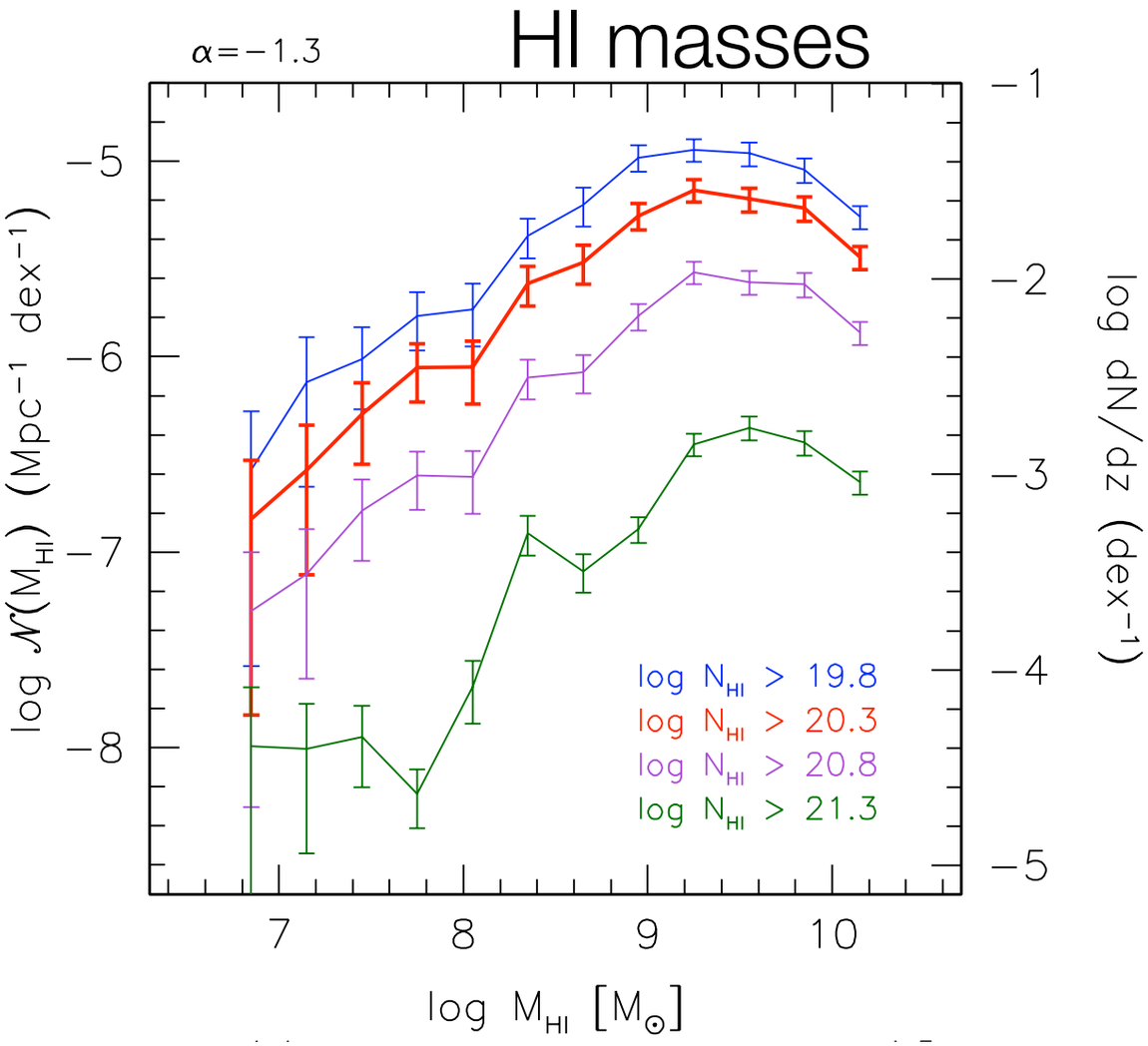

- Most of the HI atoms in column densities around $10^{21}$ cm$^{-2}$

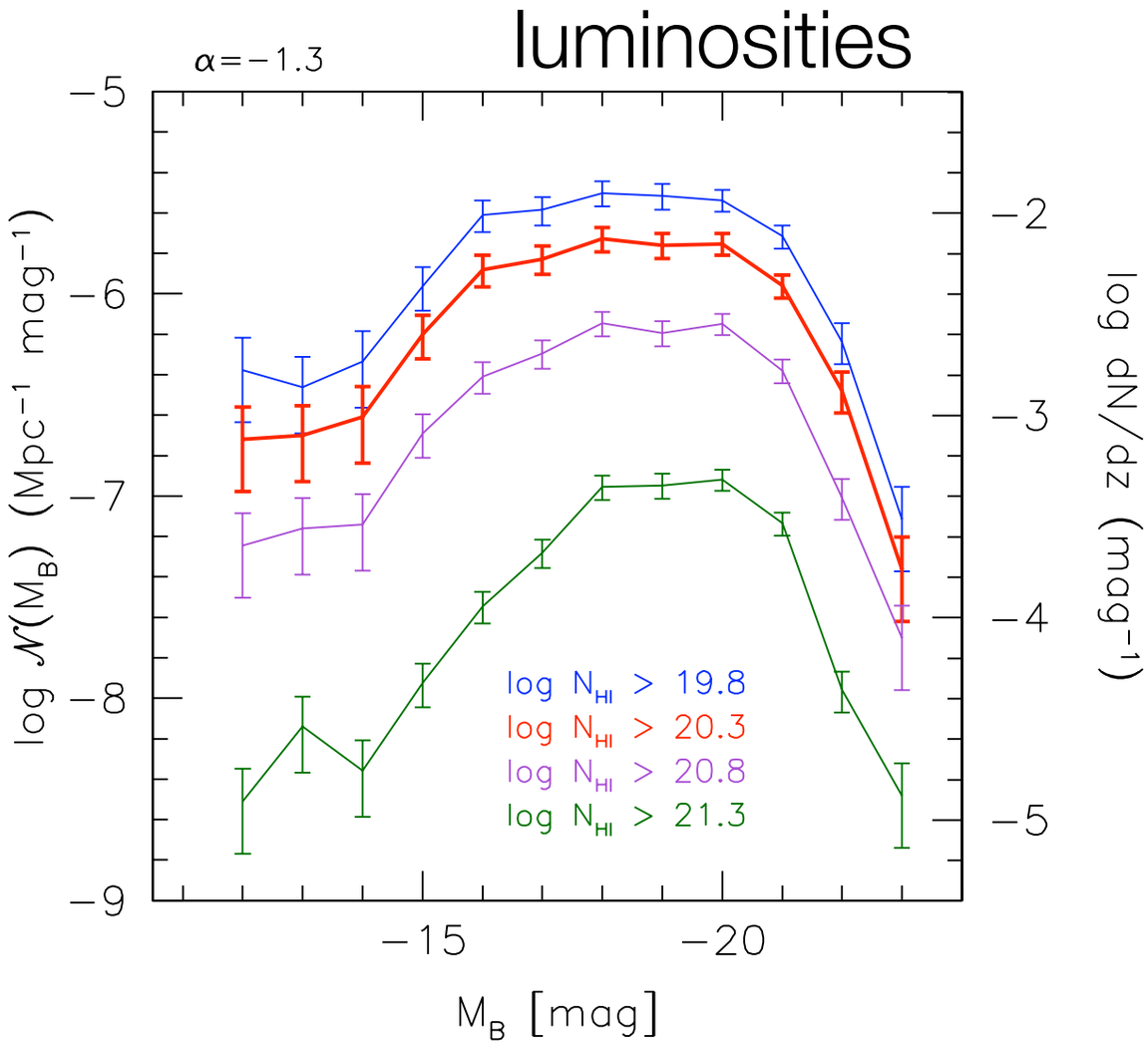
# Local galaxies can explain **incidence rate**




- Local galaxies explain dN/dz of DLAs at z<1.5

# Local galaxies can explain **DLA galaxy properties**

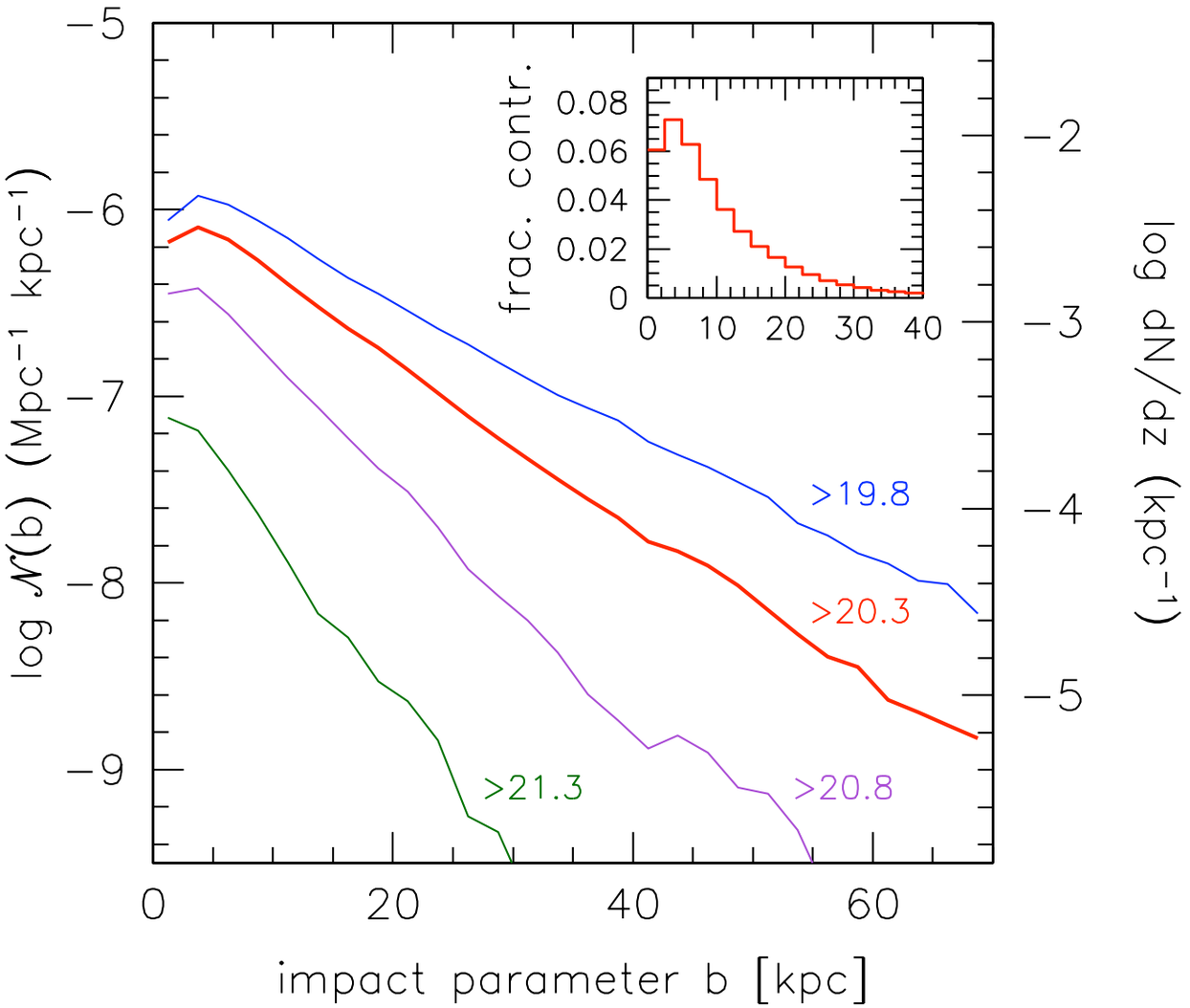



- our analysis: 80% of DLA hosts in sub L* (35% in L< L*/10)

- from z<1 DLA surveys: 75% of DLA hosts in sub L* (15% in L< L*/10)

# Local galaxies can explain **DLA impact parameters**




from our analysis: median b: 7.8 kpc
from literature: median b: 8.3 kpc

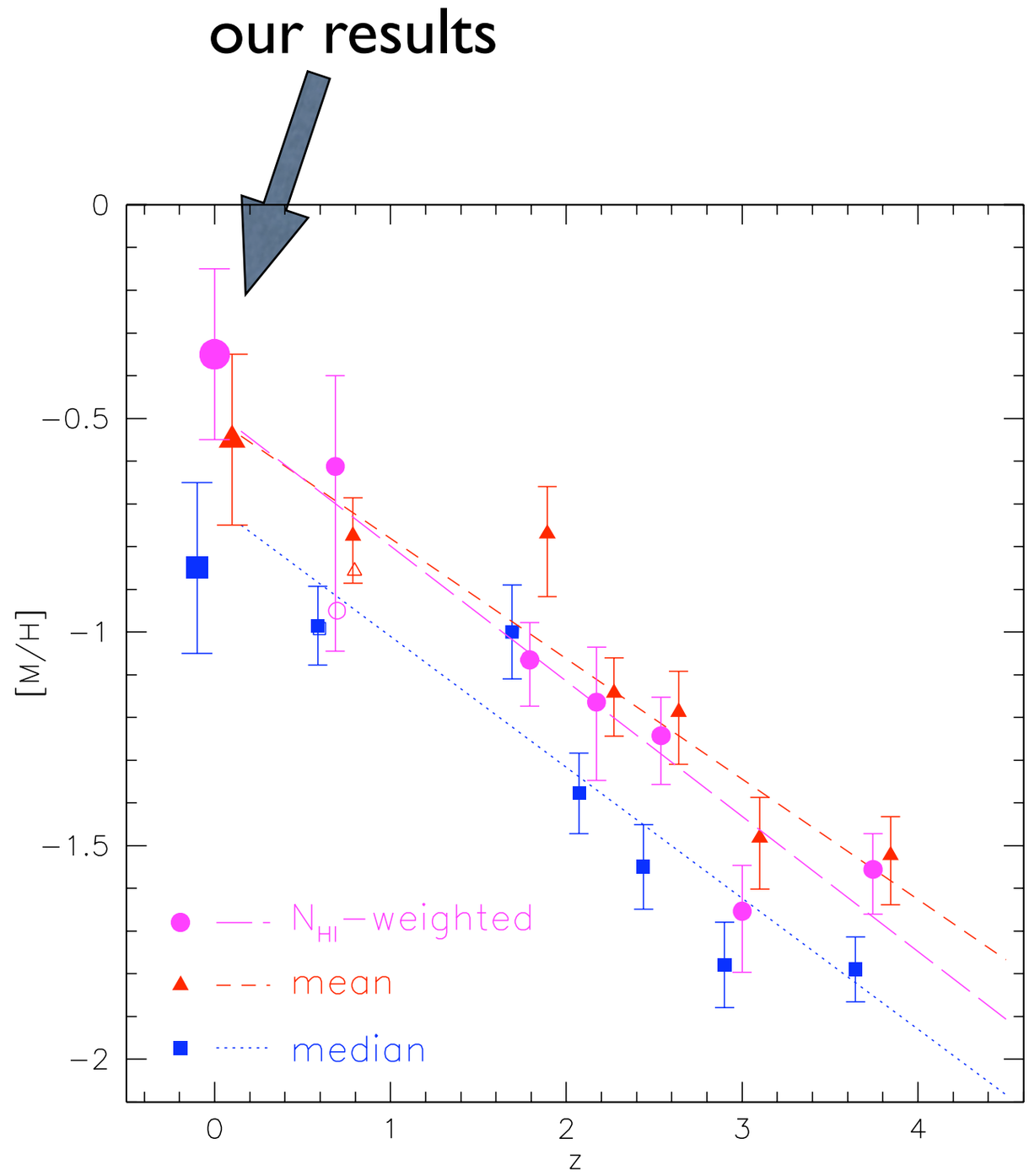
implication for DLA host galaxies:
34% should have b<1” at z=0.5
46% should have b<1” at z=1

# Local galaxies can explain **DLA metallicities**

Metallicity distribution asuming:

- Z-L relation (Garnett 2002)
- Z-gradients (Vila-Costas & Edmunds 1992, Ferguson et al 1998)

- Agreement in metallicities between local galaxies and DLAs



# What about the **molecules**?

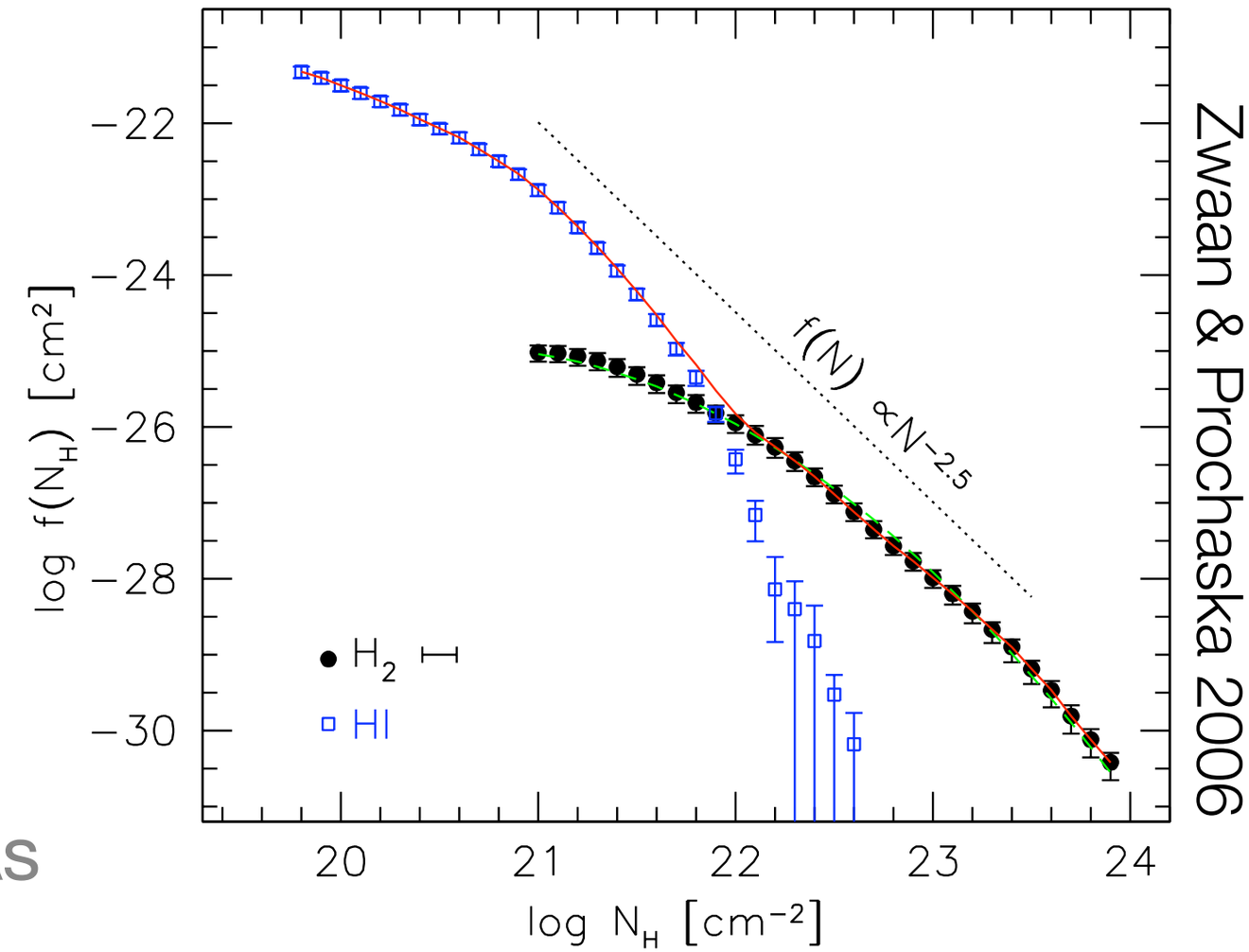
- DLAs contain the **reservoir for star formation**
- Star formation occurs in molecular clouds

→ DLAs **should contain molecules**

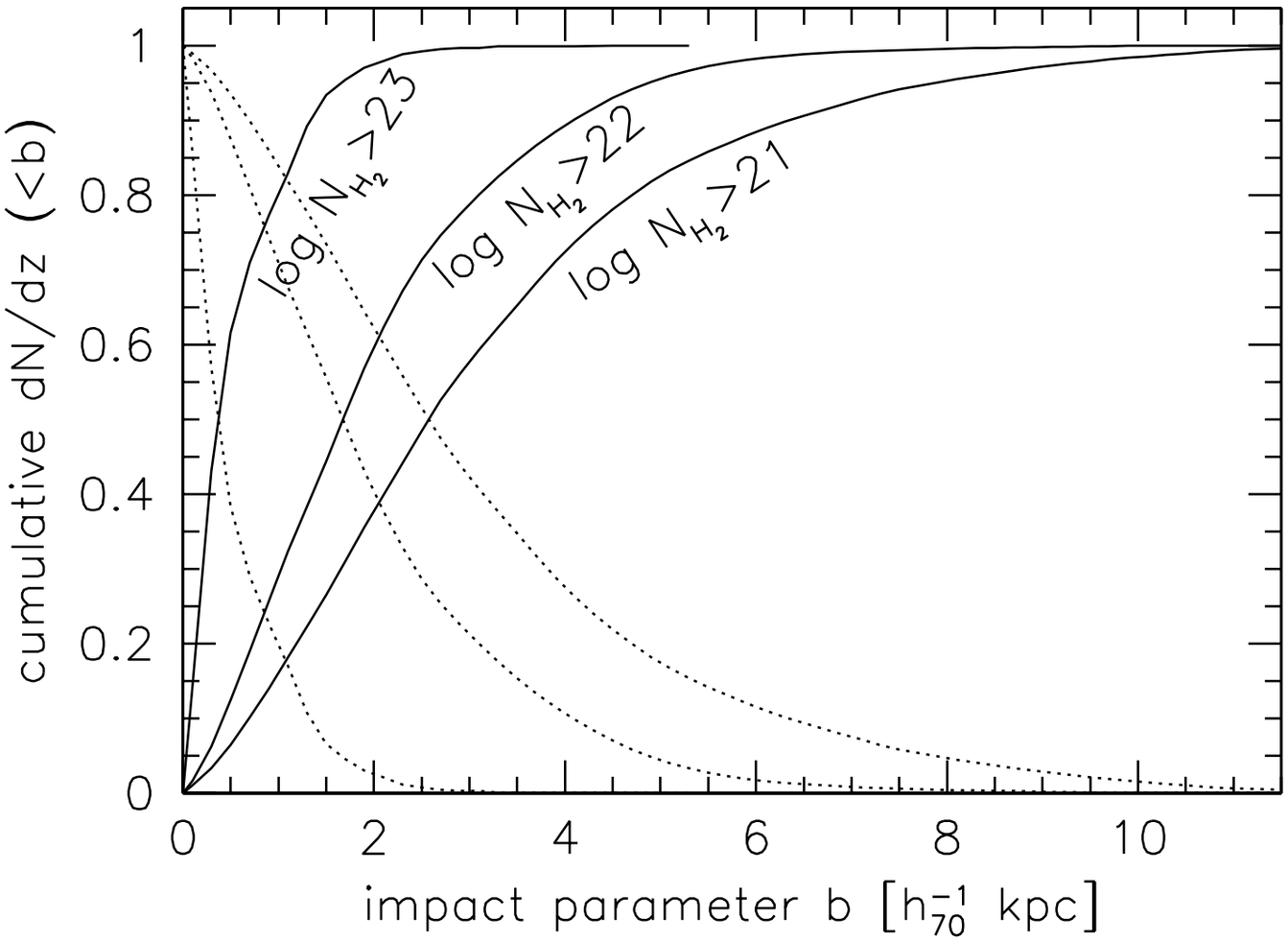
- surveys for millimetre molecular absorption have been **unsuccessful** (Curran et al 2004, Wiklind & Combes,...)
- optical/UV surveys for $H_2$ have **low success rate** and find very **low $H_2$ fractions** ($10^{-3}$ - $10^{-2}$) (e.g., Ledoux et al 2003)

# f(N) for **molecular** gas

- Use CO maps from BIMA-SONG (Helfer et al 2003) to derive f($N_{H2}$)
- dN/dz ($N_{H2}>10^{21}$) = $3\times10^{-4}$
- >100 times lower than that for HI in DLAs
- ➡ molecular surveys in DLAs unsuccessful



# Molecules are at **small impact parameters**




- 90% of $H_2$ mass within impact parameters of 6.5 kpc

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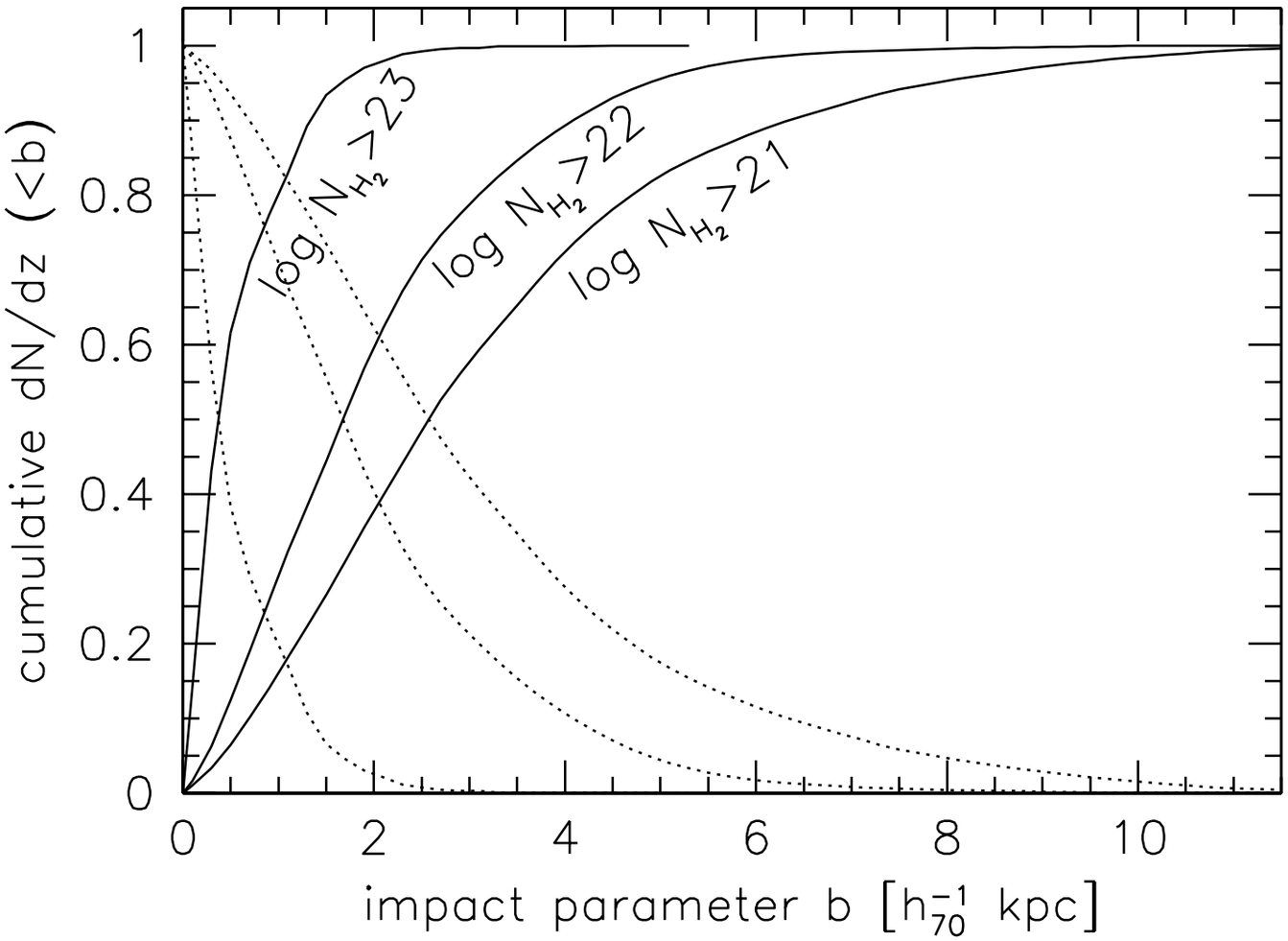
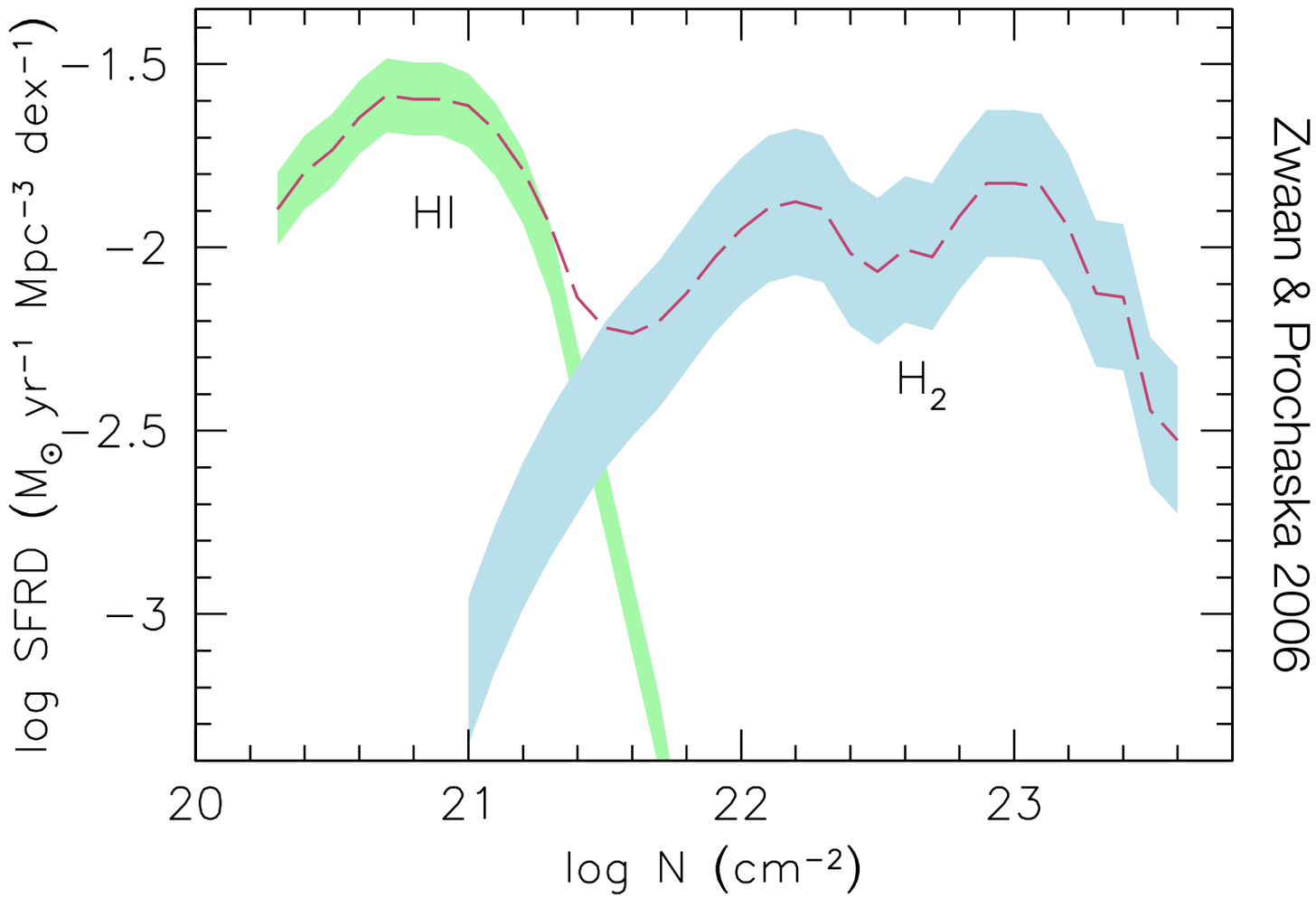



- 90% of $H_2$ mass within impact parameters of 6.5 kpc

GBT program looking for OH in systems with small impact parameters (Zwaan, Peroux, Murphy, Zych, Curran, Liske, Bouche): No detections...

# Implications for cosmic **SFR density**

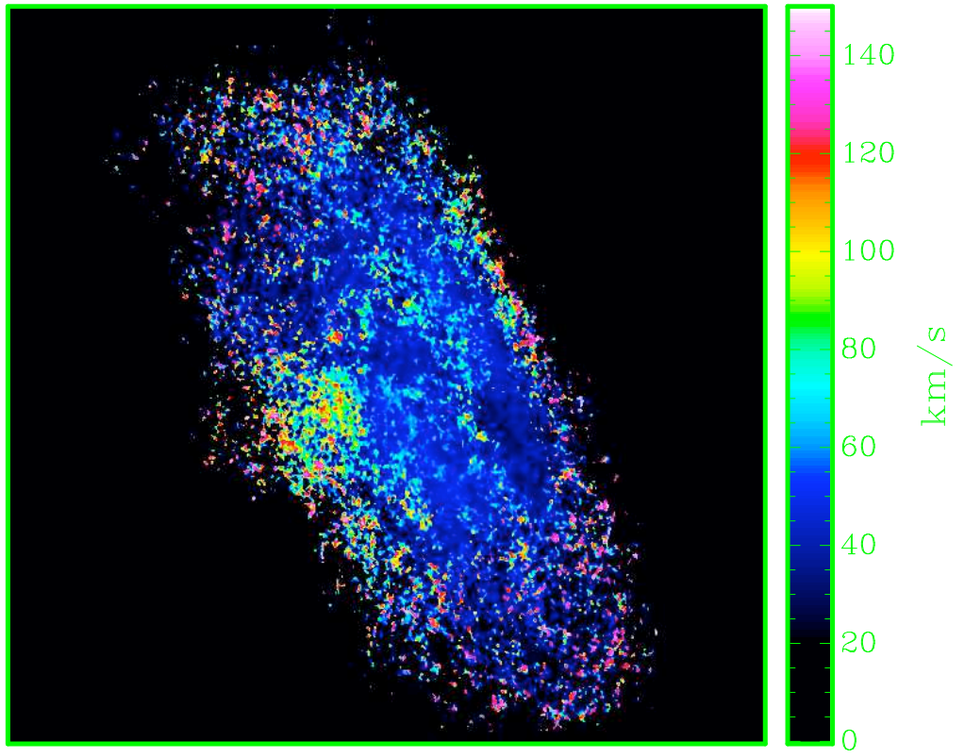
SFRD as function of HI and $H_2$ (at z=0):




Even though $H_2$ has very small cross section, it contributes significantly to $\Omega_{gas}$ and the SFRD

# Can local galaxies explain **DLA kinematics?**

- Velocity spread of DLA characterized by $\Delta V_{90}$ of low-ions: $Fe^{+}$, $Si^{+}$, $Ni^{+}$
- Calculate $\Delta V_{90}$ maps from THINGS data:
- Not the same spatial resolution for DLAs galaxies...
- Is THINGS a fair sample?



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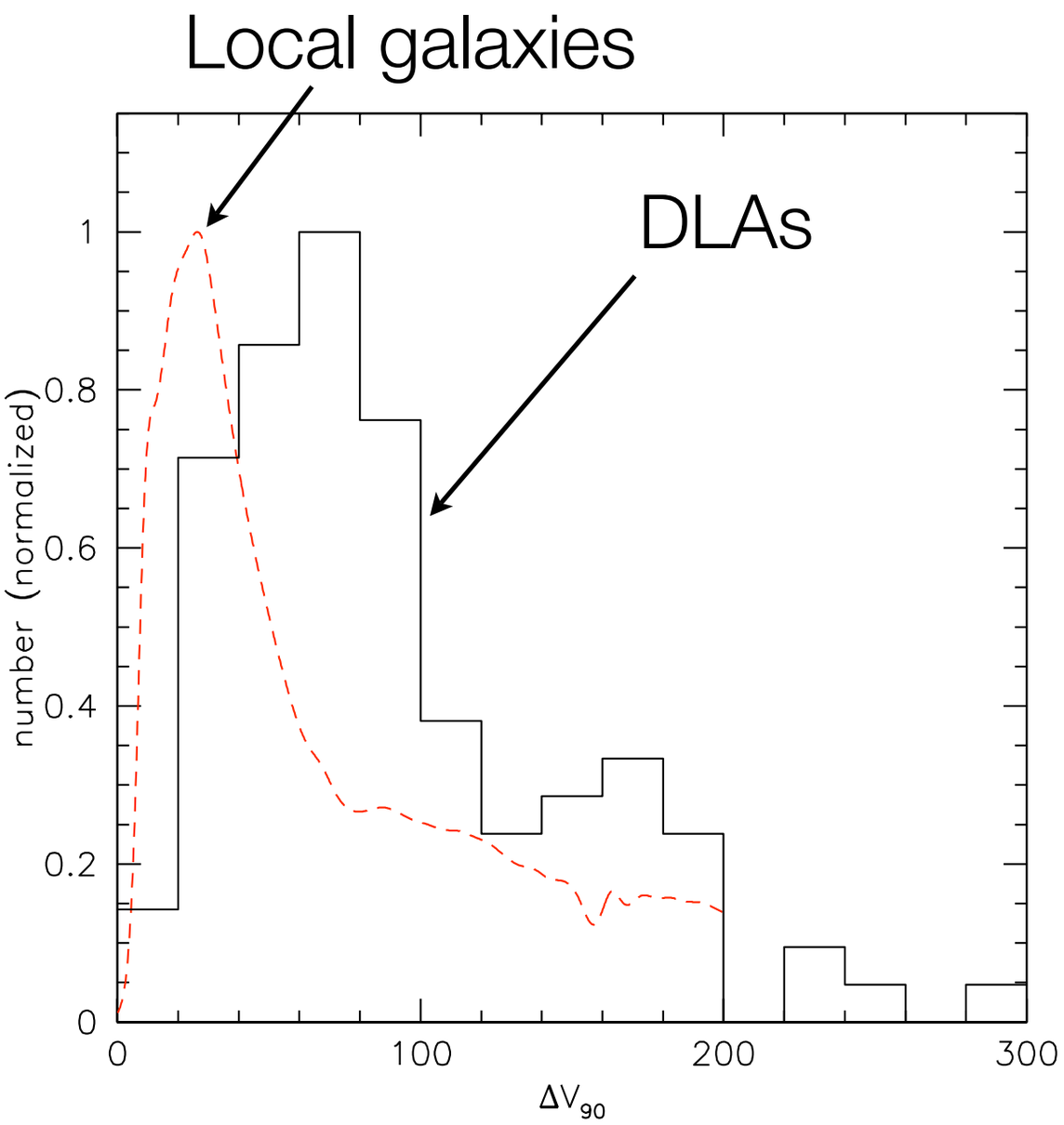


- At higher z larger contribution from:
- Superwinds? (see also Schaye 2001, Nulsen et al 1998, Bouche et al 2007)
- Mergers? (tidal tales etc)

# Conclusions

- Most HI atoms in L* galaxies and around log $N_{HI}$=21
- Local galaxies explain most low z DLA properties
- We understand why we don't see $H_2$ in DLAs... but it's there
- SF probably associated with this high $N_H$ gas
- High *z* DLA kinematics cannot be explained with disks