# Expansion History of the Universe Unveiled with H II galaxies

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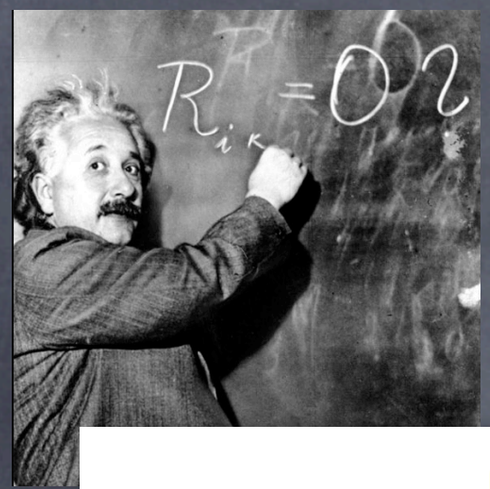
# A Picture of Our Universe

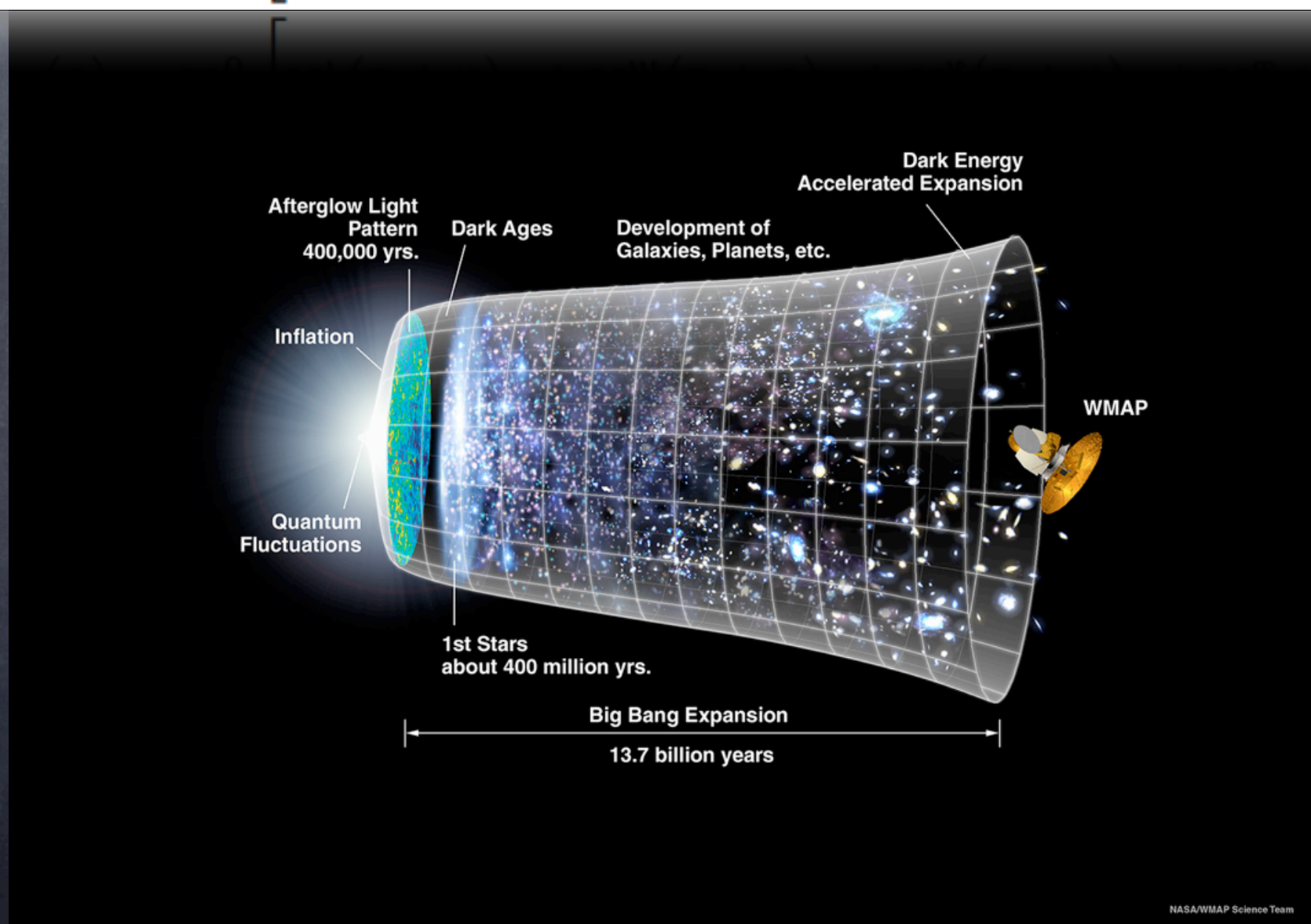


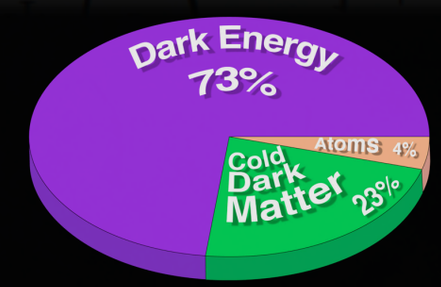
$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R + \Lambda g_{\mu\nu} = -\kappa T_{\mu\nu}$$

+

$$ds^2 = dt^2 - a^2(t)\left[\frac{dr^2}{1-kr^2} + r^2(d\theta^2 + \sin^2\theta d\phi^2)\right]$$

$$H^2(z) = H_0^2\left[\Omega_r(1+z)^4 + \Omega_m(1+z)^3 + \Omega_k(1+z)^2 + \Omega_w \exp\left(3\int_0^z \frac{1+w(x)}{1+x}dx\right)\right]$$



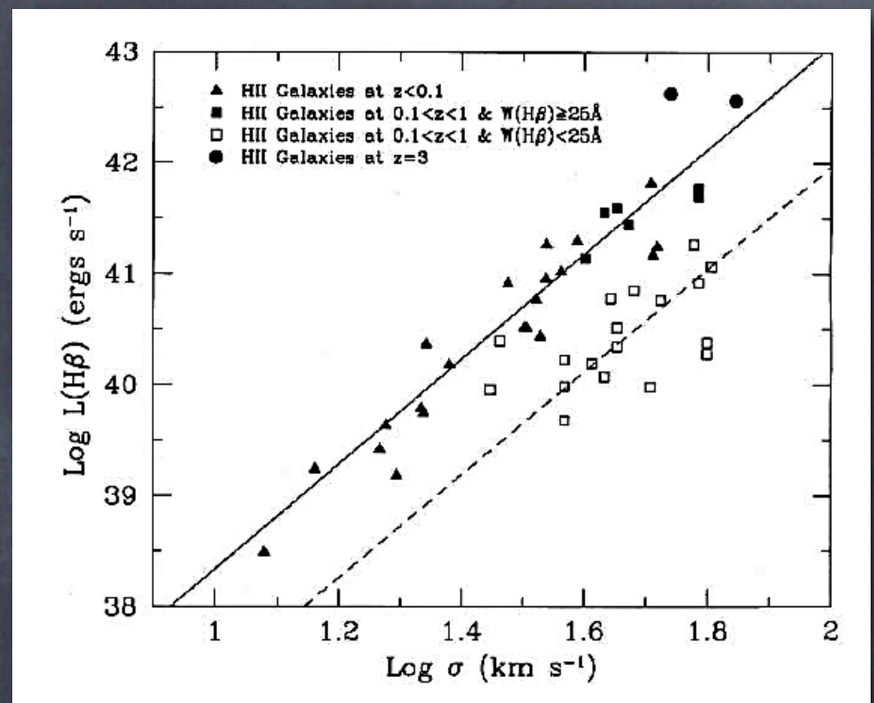




$$p_w = w(z)\rho_w$$

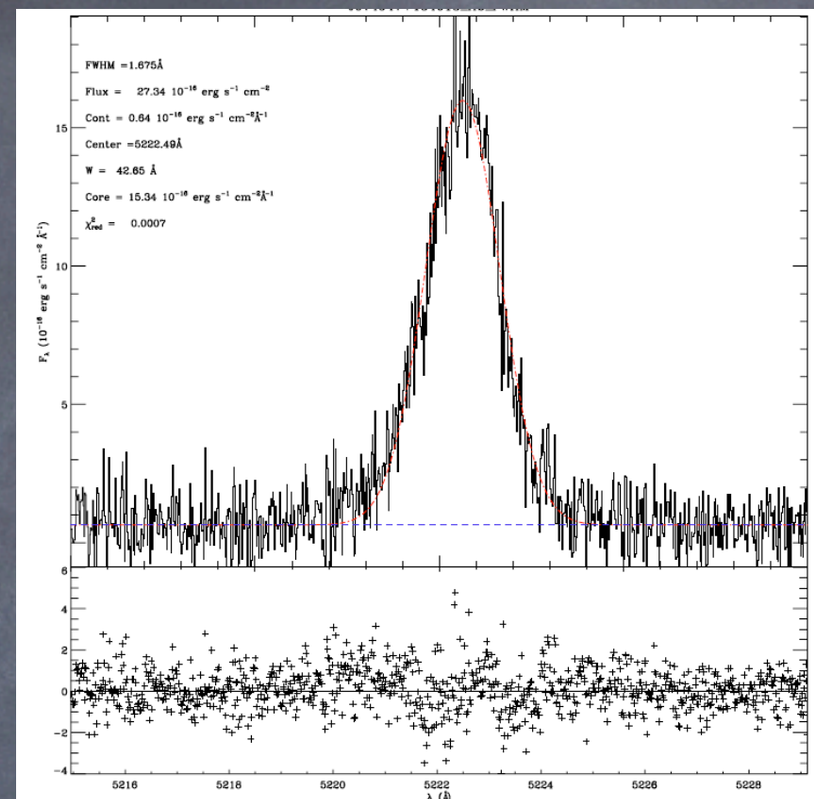
$$w(z) = w_0 + w_1 f(z)$$

$$f(z) = z/(1+z)$$

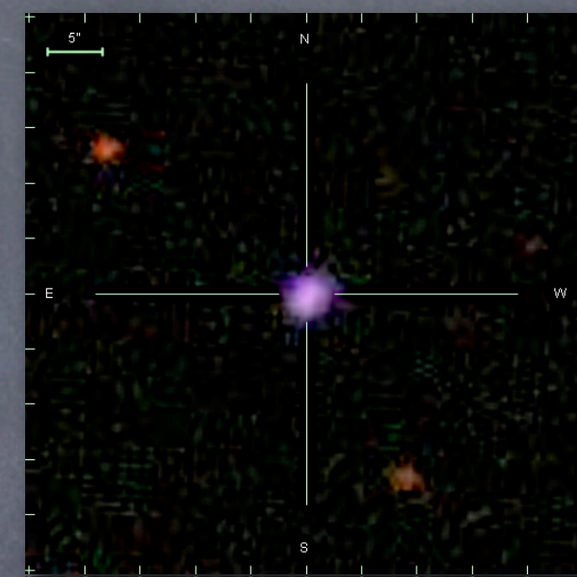
# What is an H II Galaxy?

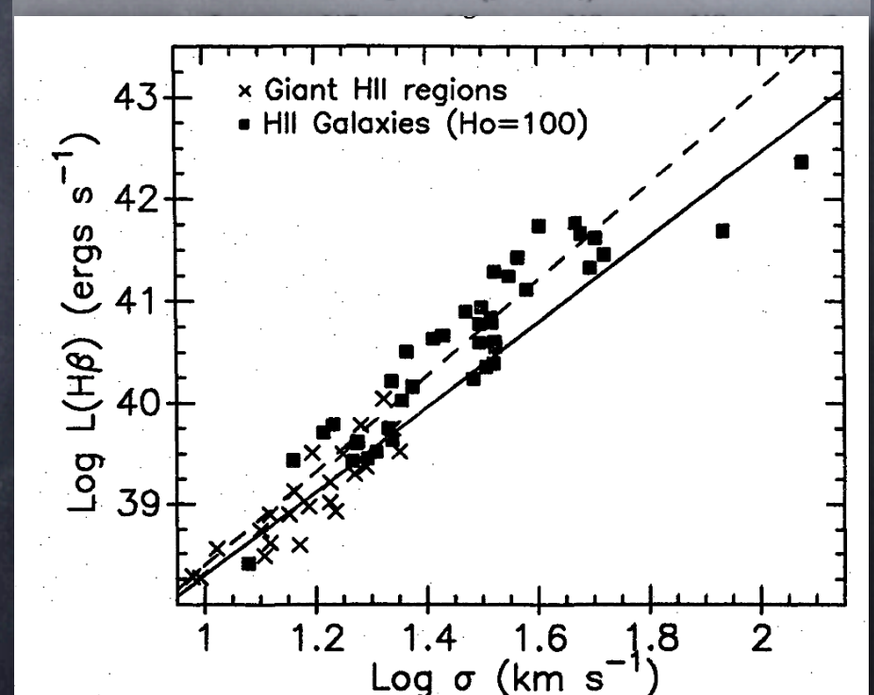



From Melnick et al. 2000

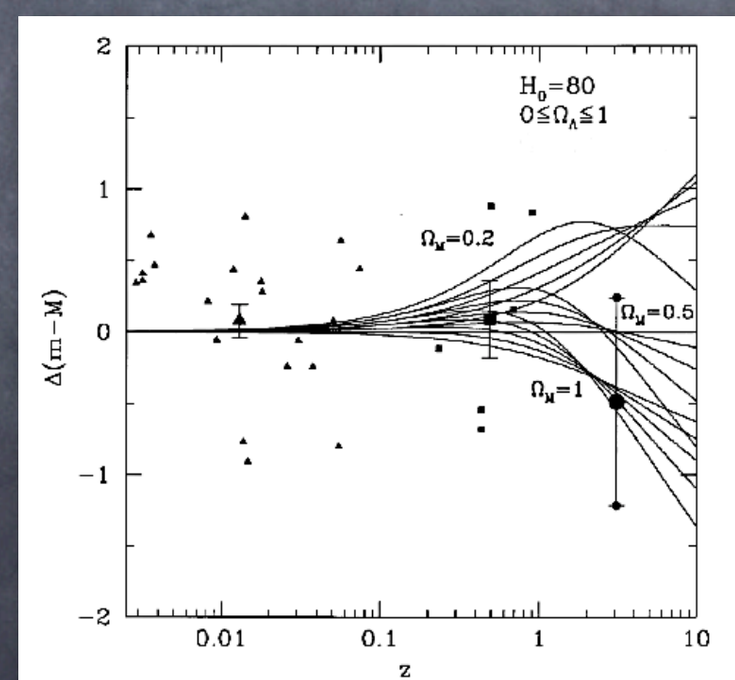



SDSS J084414.22+022621.2

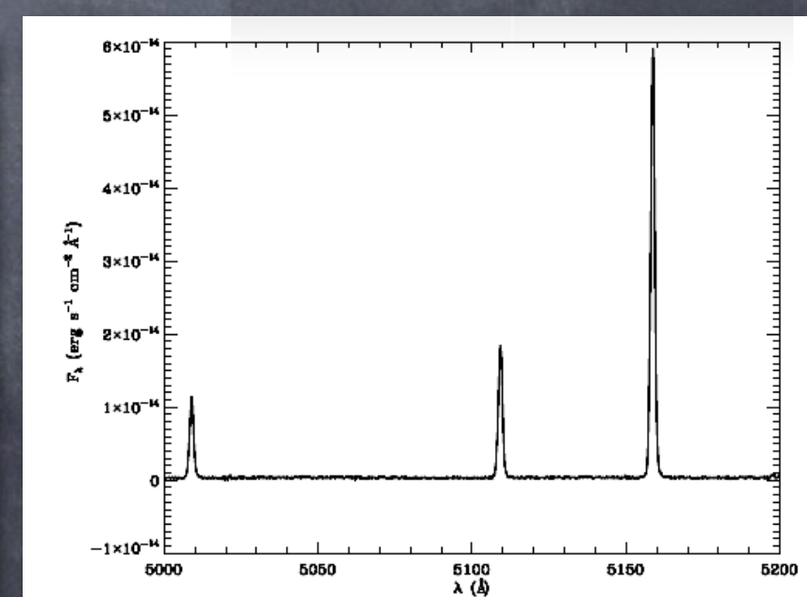


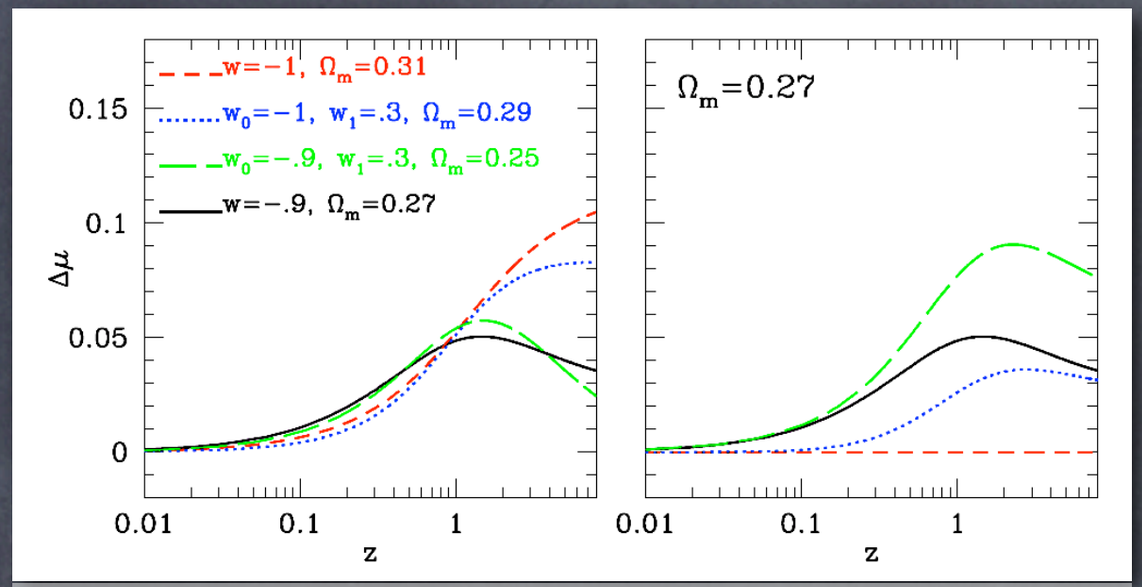

From Melnick et al. 1988



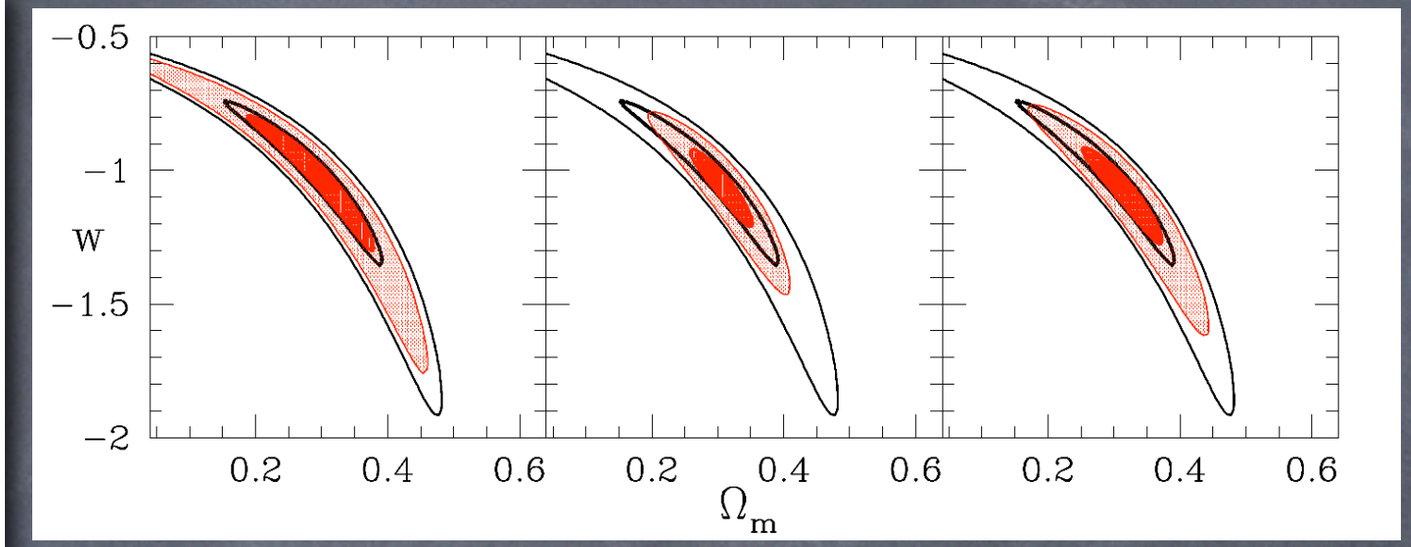

From Melnick et al. 2000



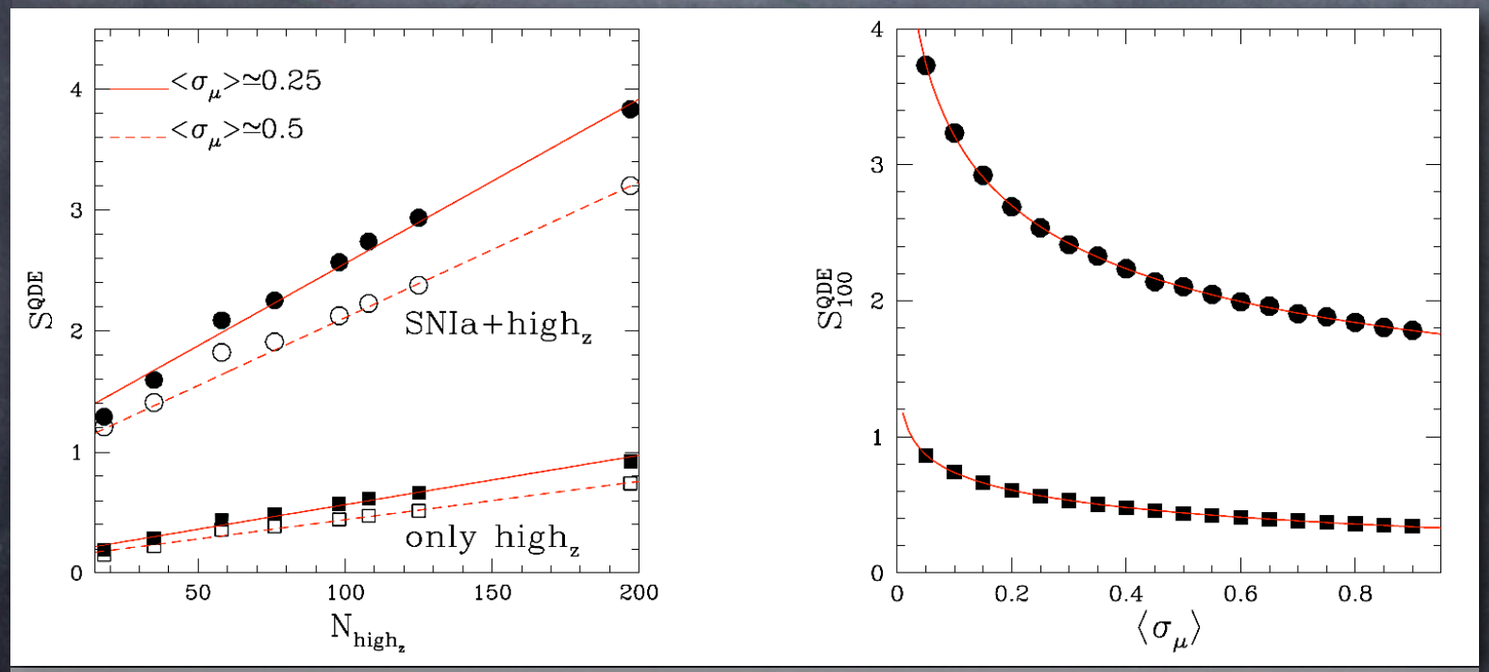
# Why H II Galaxies?



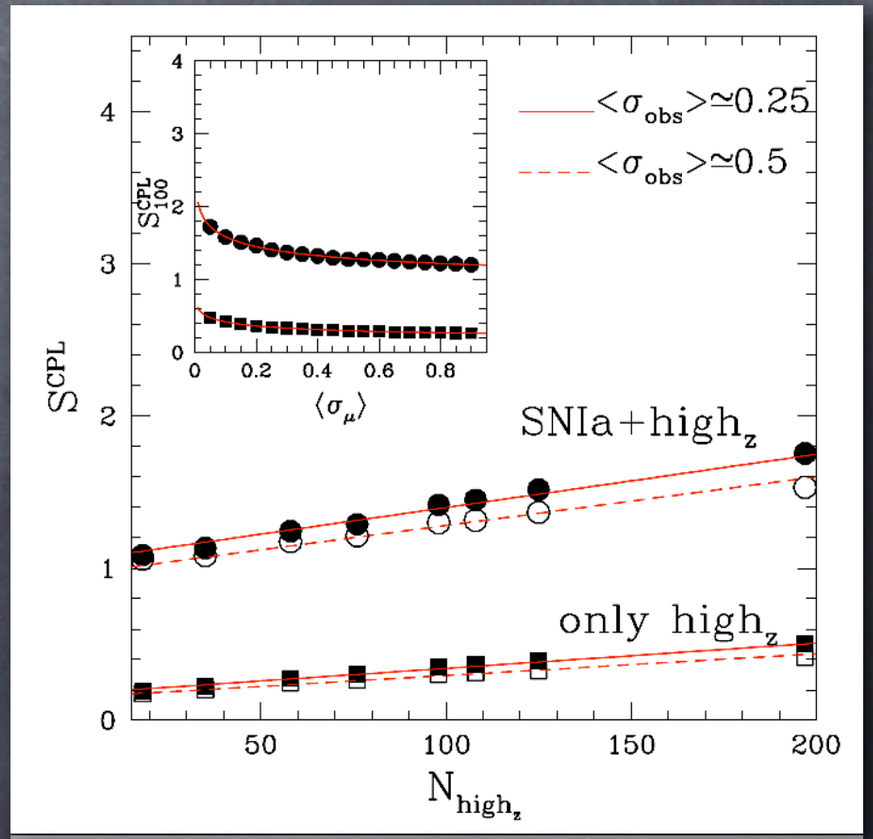

From Plionis et al. 2011




From Plionis et al. 2011

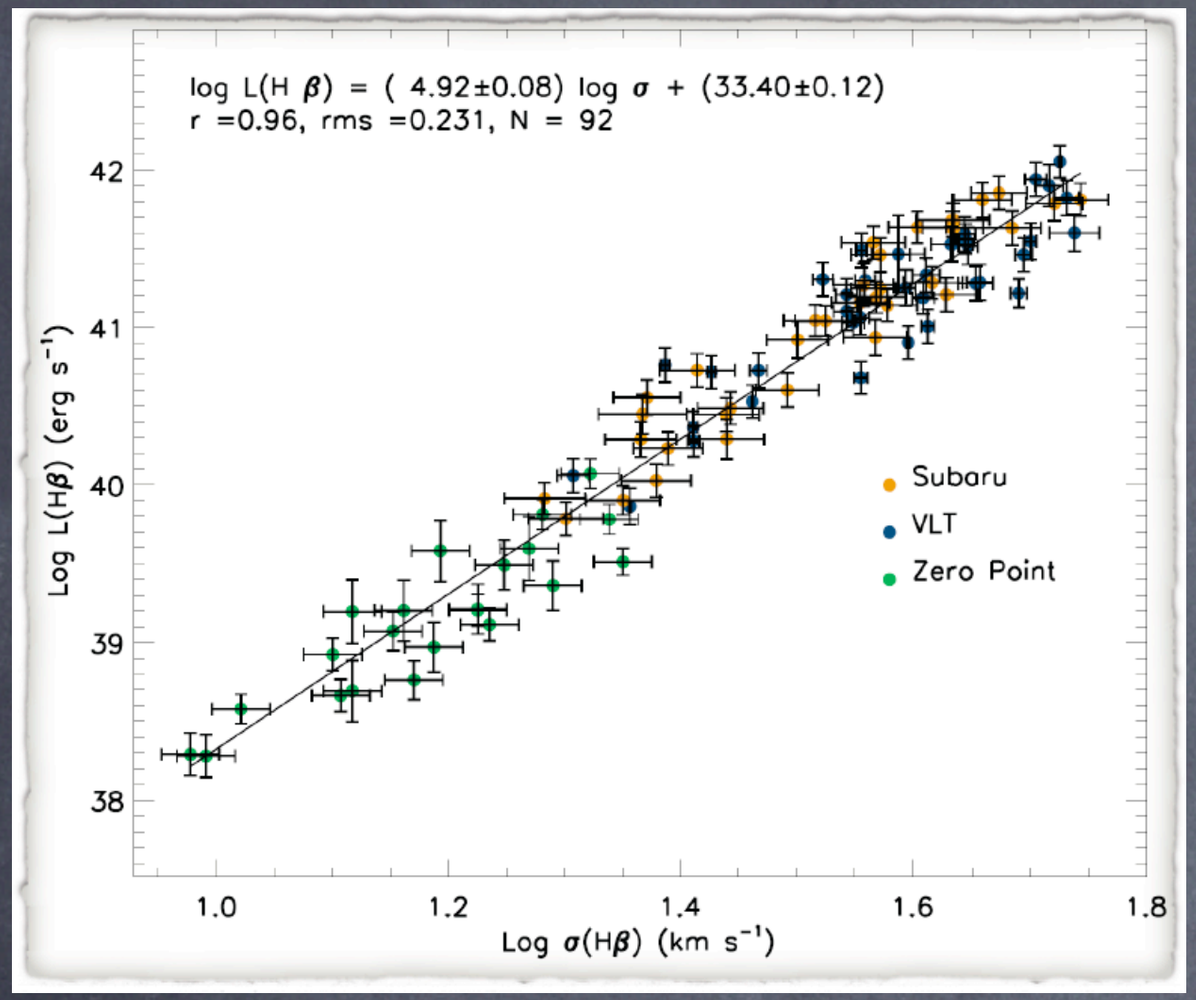


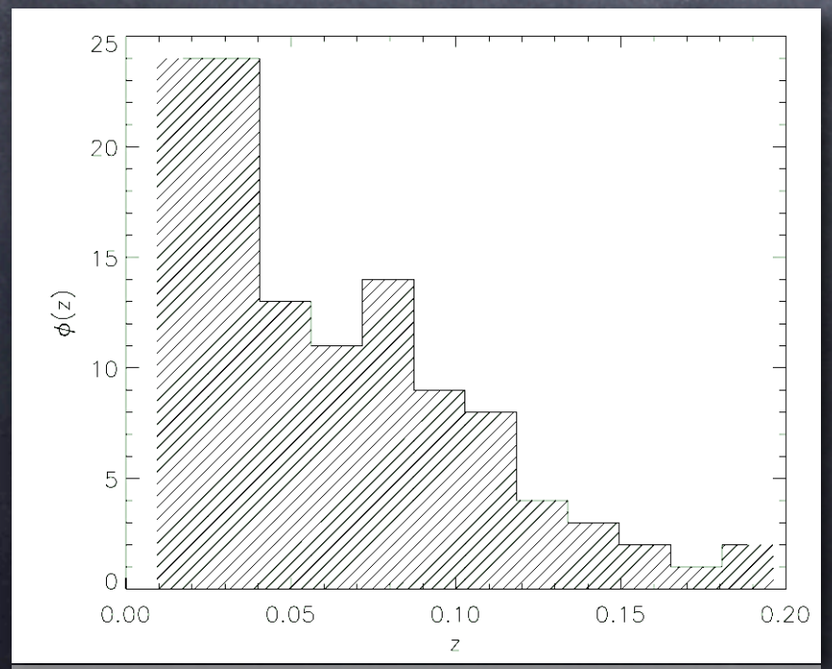

From Plionis et al. 2011

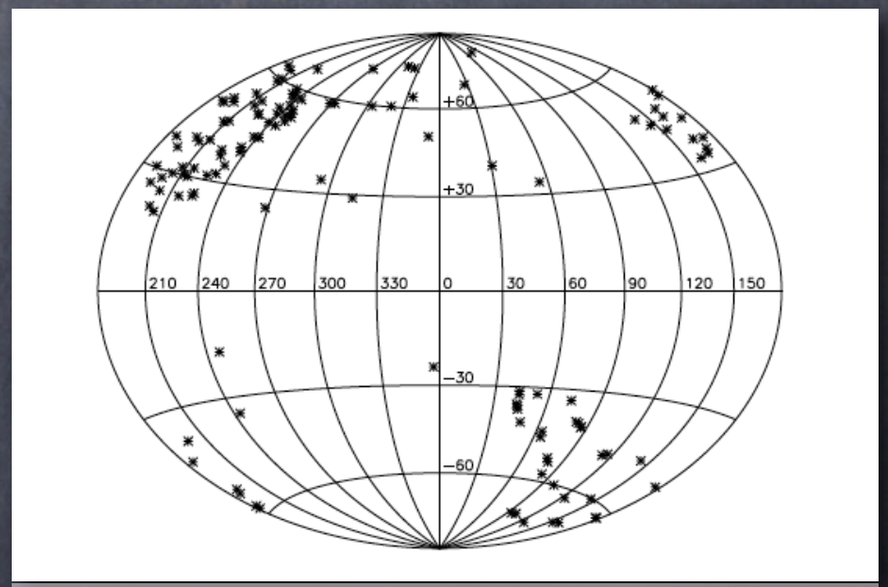



From Plionis et al. 2011

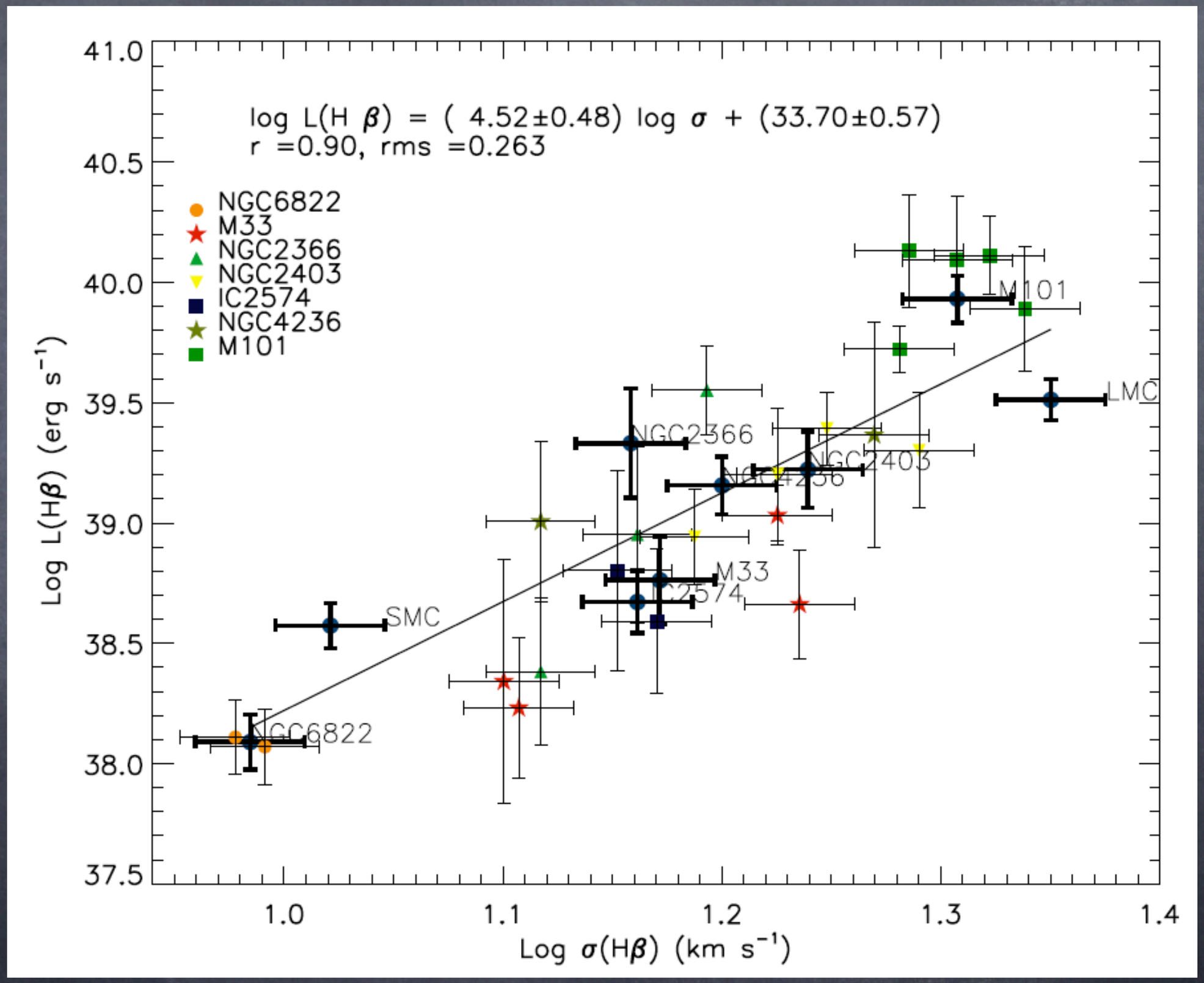
# H II Galaxies - The Local Sample



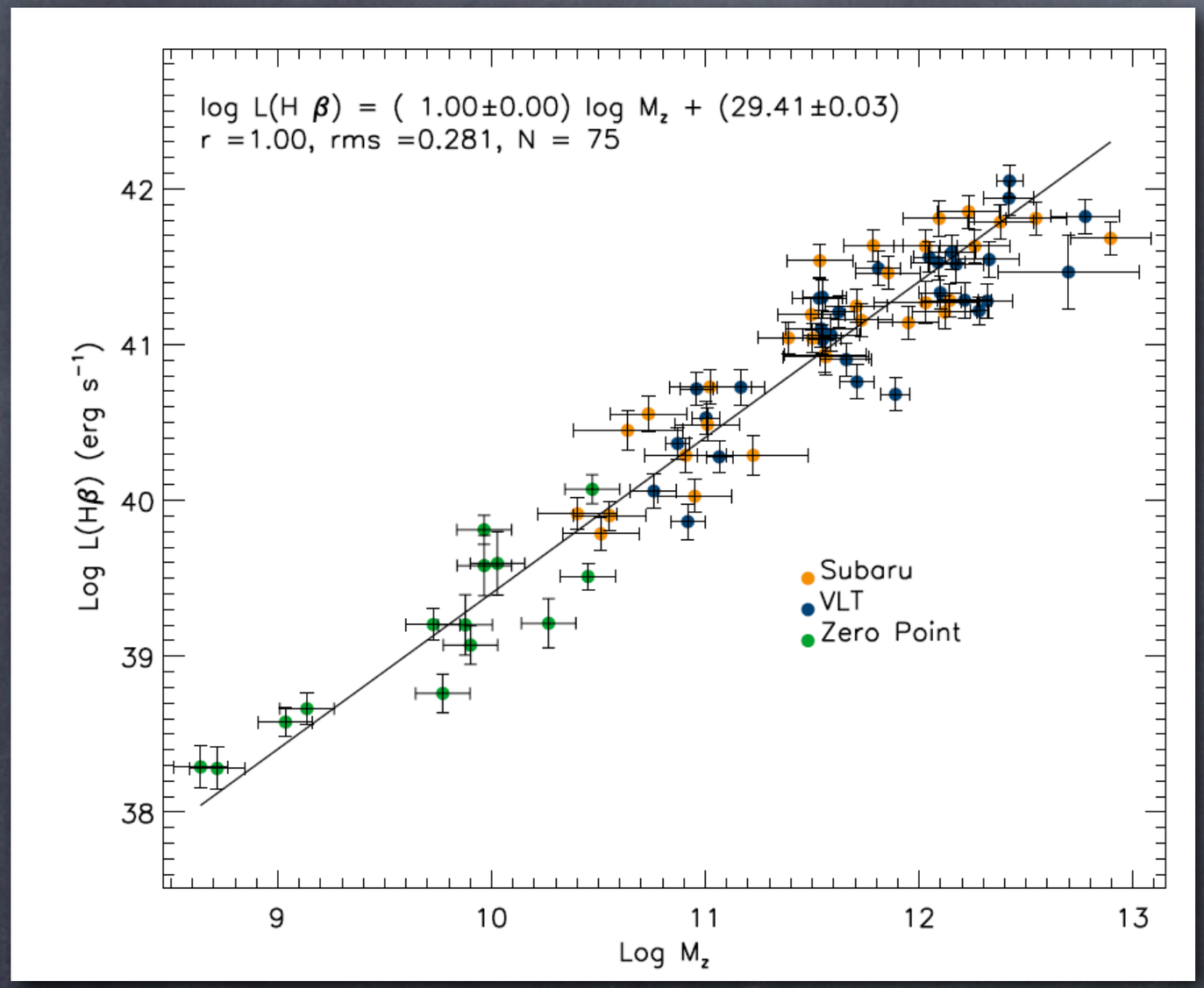


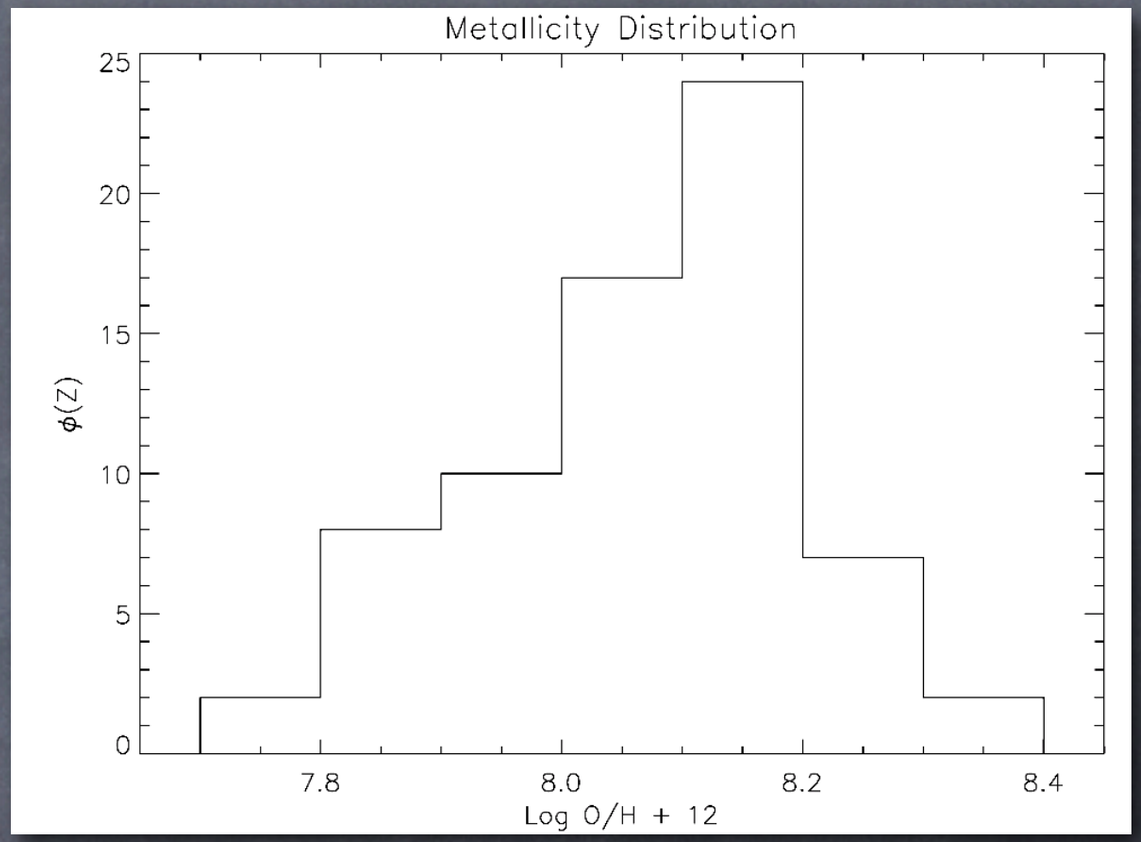


# H II Galaxies - The "Zero Point" Sample



# The Third parameter



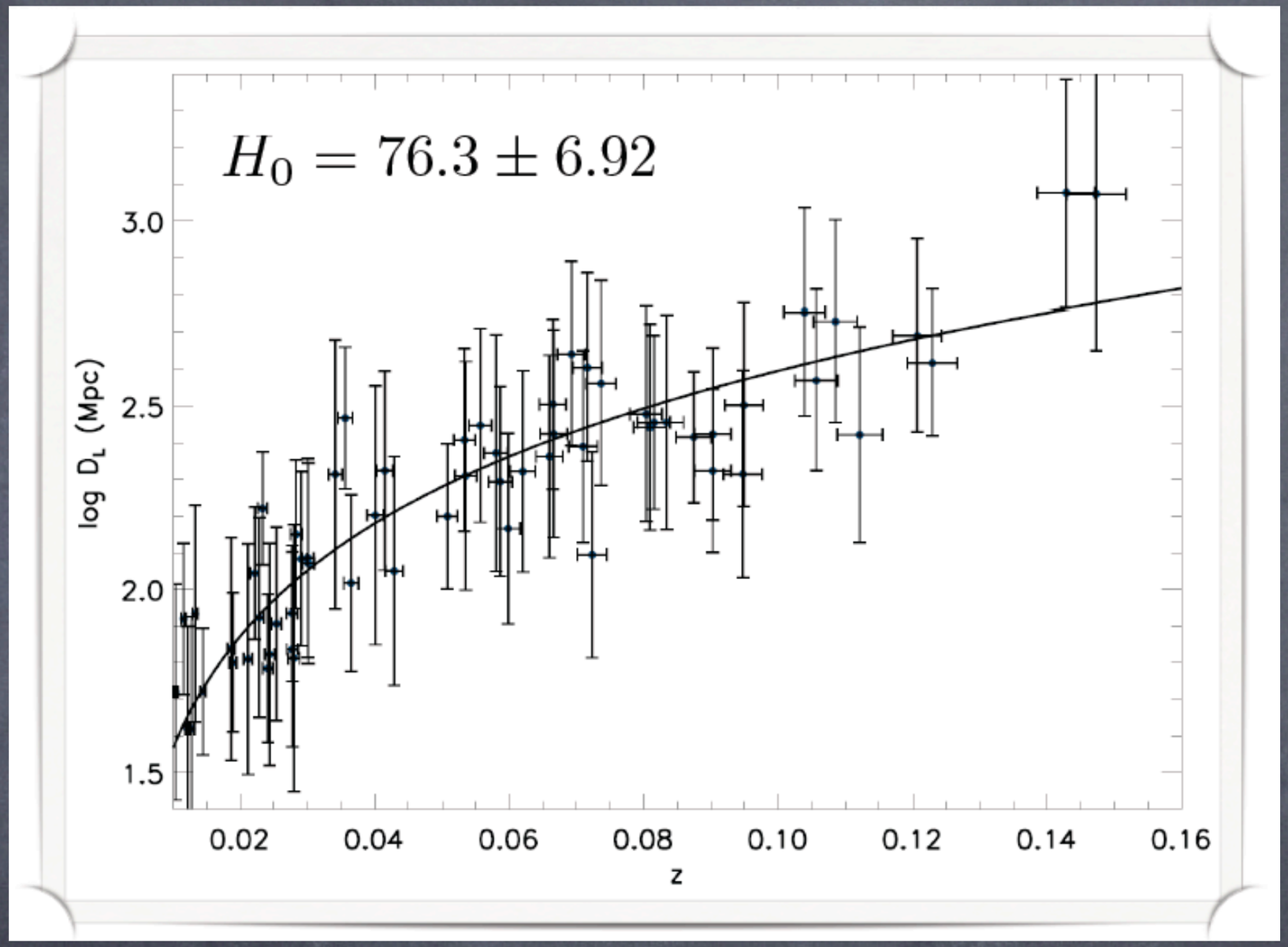




$$M_z = \frac{\sigma^5}{\mathrm{O/H}}$$

Table 1: PCA for Local Universe Sample

| Parameter | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| log L(Hβ) | 0.98 | 0.06 | -0.01 | 0.20 |
| log σ | 0.18 | 0.02 | -0.03 | -0.98 |
| log (O/H) | 0.06 | -0.99 | -0.03 | -0.01 |
| log W | 0.02 | -0.03 | 0.99 | -0.03 |
| Eigenvalues | 67.47% | 26.07% | 5.99% | 0.47% |

# The Hubble Parameter

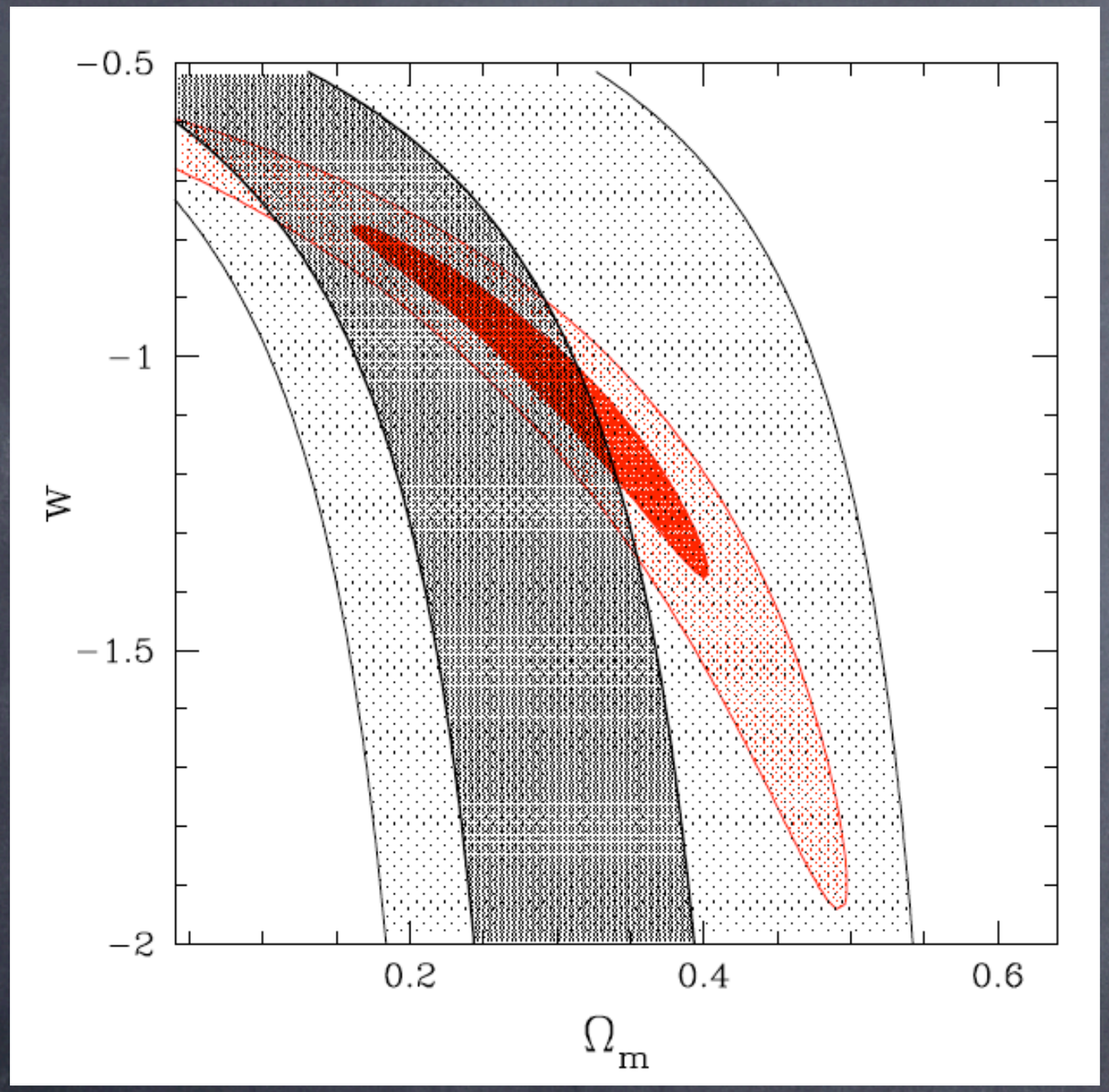



$$\log L(\mathrm{H}\beta) = \log M_z + P_0$$

$$\mu = 2.5 \log M_z - 2.5 \log f_{\mathrm{H}\beta} - A_{\mathrm{H}\beta} + Z_0$$

$Z_0$=-26.60

# Intermediate Redshift...




From Plionis et al. 2011

15 H II galaxies

Siegel et al. (2005) sample with Erb et al. (2006) corrections

$2.17 < z < 3.39$

| w | $\Omega_m$ | $\chi^2_{\rm min}$/dof |
|---|---|---|
| −1 | $0.198^{+0.051}_{-0.032}$ | 53.057/14 |
| unconstrained | $0.280^{+0.048}_{-0.038}$ | 53.849/13 |

*excluding 2 galaxies with tilted emission lines*

| w | $\Omega_m$ | $\chi^2_{\rm min}$/dof |
|---|---|---|
| −1 | $0.224^{+0.063}_{-0.038}$ | 43.119/12 |
| unconstrained | $0.310^{+0.052}_{-0.046}$ | 42.954/11 |

# Concluding Remarks

- The Cosmic Acceleration Problem is one of the most important open issues in the whole of physics.
- High redshift ($2 < z < 3.5$) Cosmological Probes are necessary in order to obtain better constraints to the Cosmological Parameters space.
- We have used H II galaxies to determine the Hubble function to low redshifts and obtained a value consistent with other determinations.
- At high redshift hundreds of H II galaxies are already catalogued while no SNe Ia is known.
- On the other hand, the same data will allow us to study the possible evolution of physical properties of H II galaxies over a wide redshift range.

# Basic References


- Plionis, M., Terlevich, R., Basilakos, S., Bresolin, F., Terlevich, E., Melnick, J., & Chávez, R. 2011, MNRAS, 416, 298
- Melnick, J., Terlevich, R., & Terlevich, E. 2000, MNRAS, 311, 629
- Melnick, J., Terlevich, R., & Moles, M. 1988, MNRAS, 235, 297