Galaxy clustering as a function of stellar mass at $z\sim1$

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&
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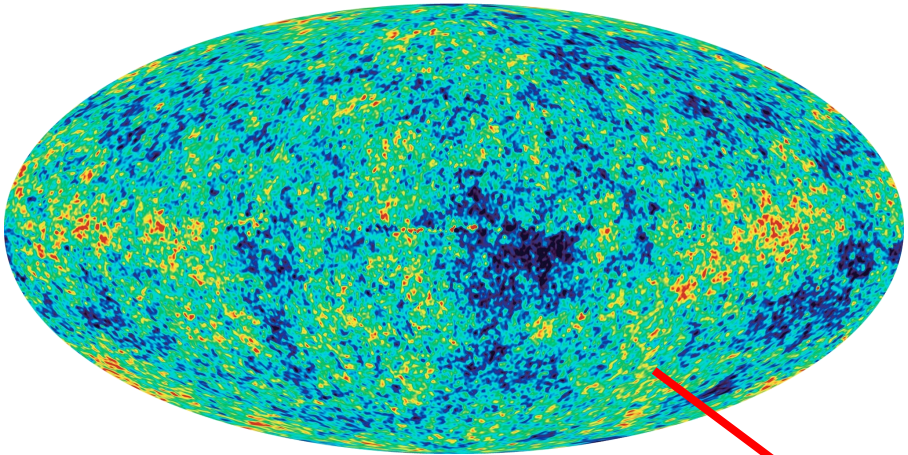
Astro-Siesta **June 14, 2007**

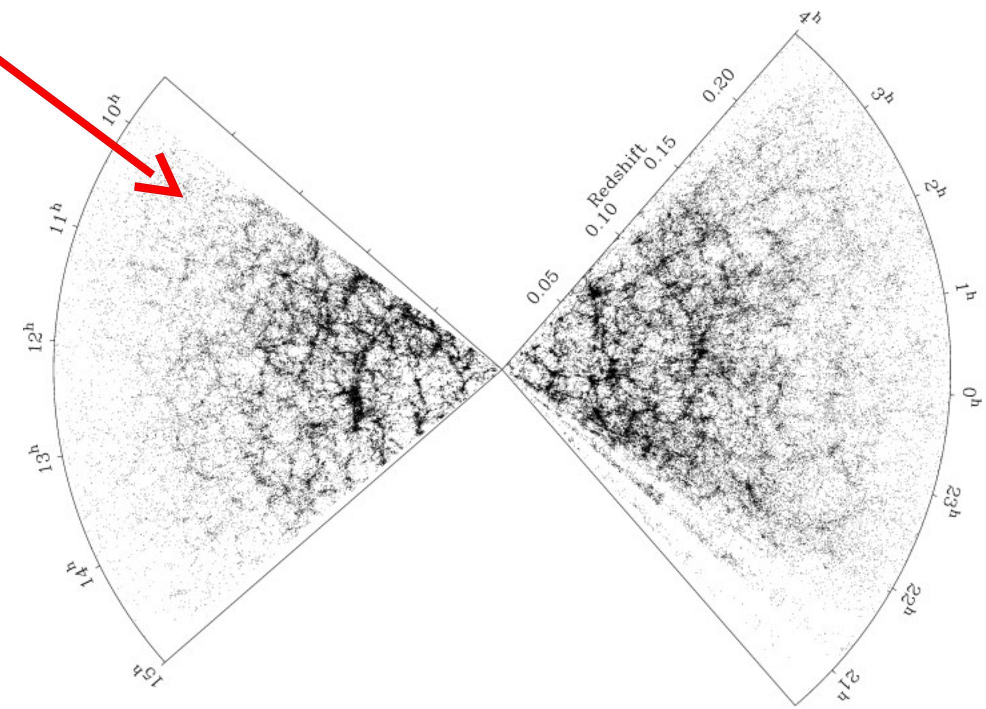


Spergel et al., 2006, WMAP

?

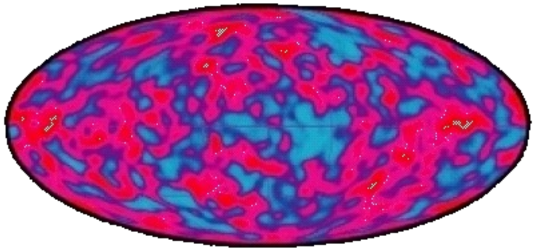
Ω_m, Λ, H_0, …

- Understand the physical mechanism of the large-scale structure formation
- Bring constraints to cosmological model

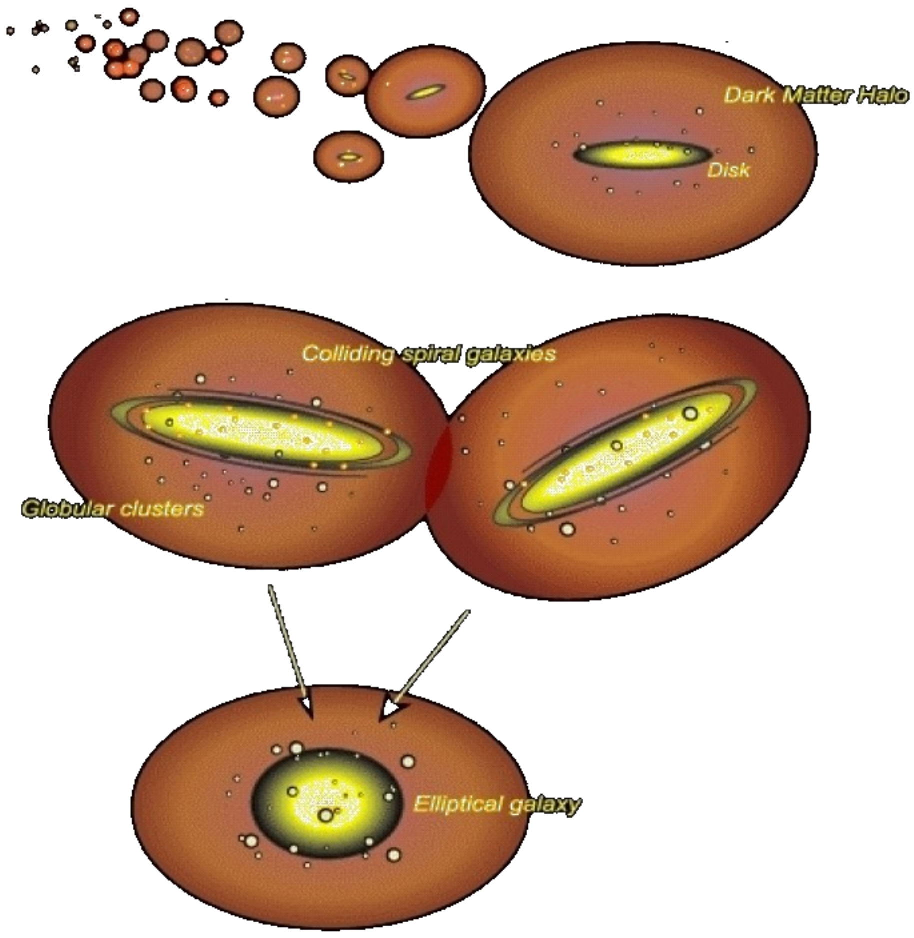


Colless et al., 2001, 2dFGRS

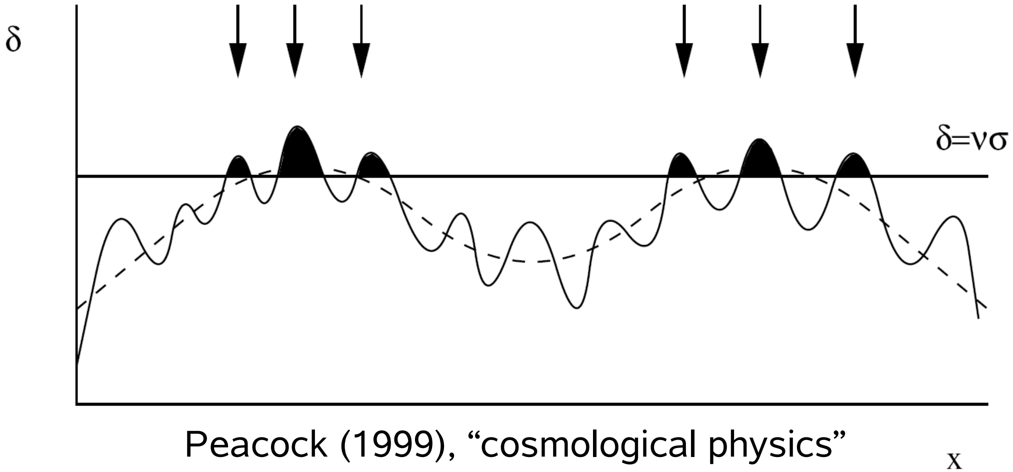
Cosmological scenario



- Hierarchical model

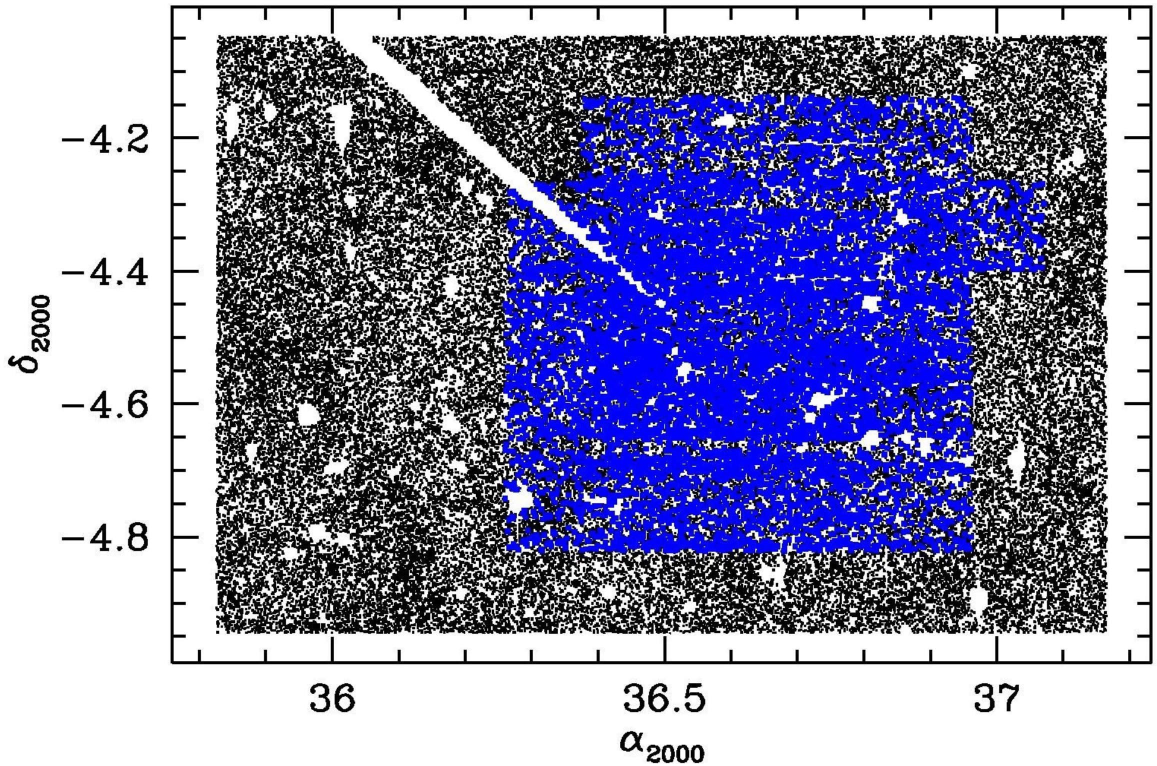


- Biased distribution of galaxies



Peacock (1999), “cosmological physics”

The Deep Field VVDS-02h



First epoch data

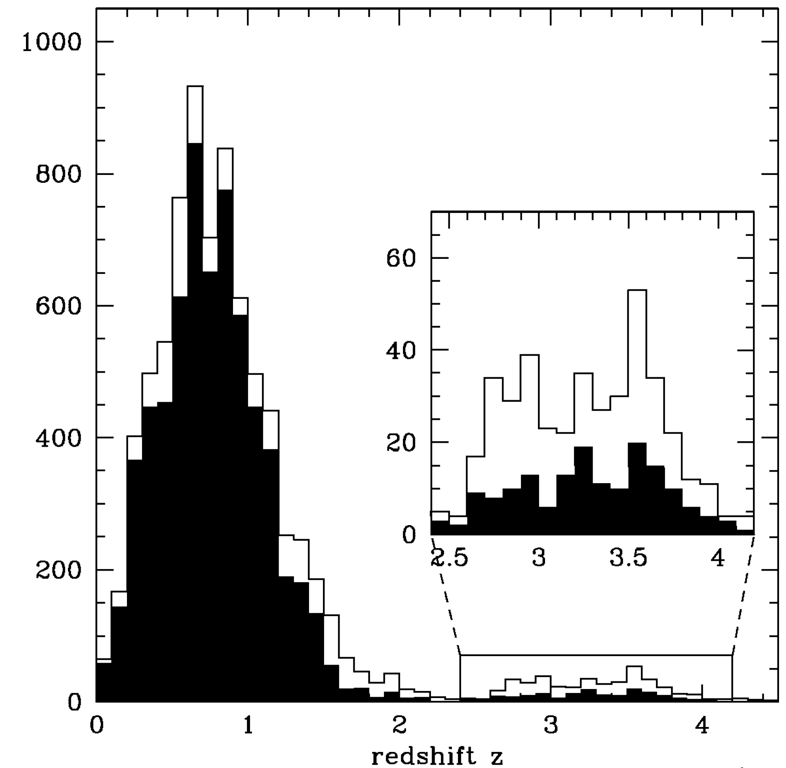
0.7x0.7 deg^2

$17.5 \leq I_{AB} \leq 24$

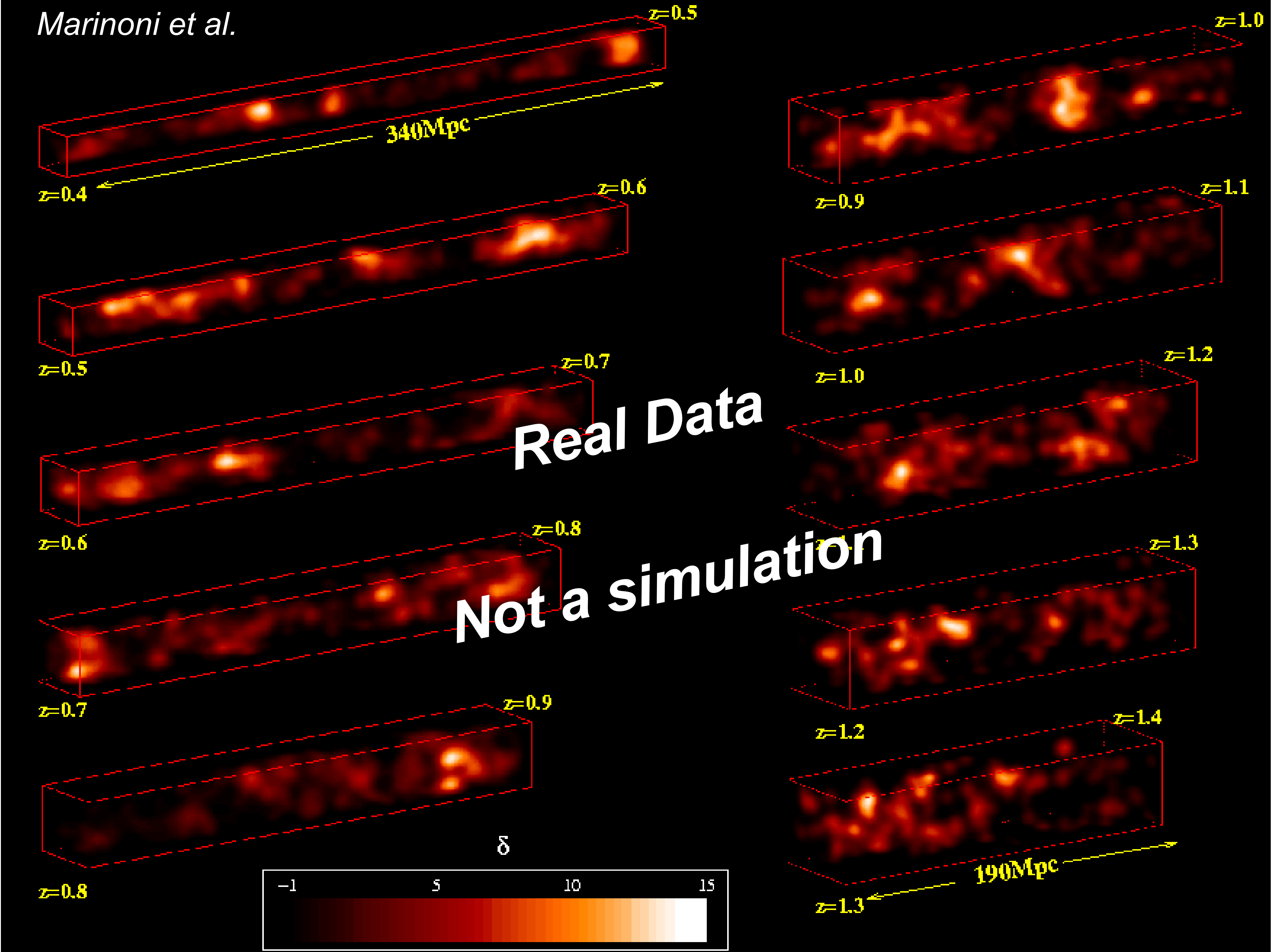
~11000 redshifts (first epoch data)

Sampling rate ~35%

High redshift tail up to z~5



Le Fèvre et al. (2005)


Marinoni et al.
Real Data
Not a simulation
z=0.4
340Mpc
z=0.5
z=0.5
z=0.6
z=0.6
z=0.7
z=0.7
z=0.8
z=0.8
z=0.9
z=0.9
z=1.0
z=1.0
z=1.1
z=1.2
z=1.2
z=1.3
z=1.3
z=1.4
190Mpc
δ
−1
5
10
15

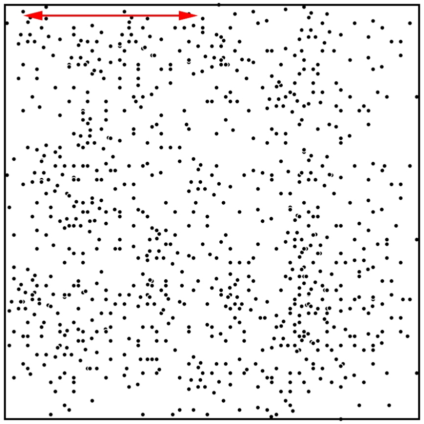
The two-point correlation function:
a classical tool to quantify clustering

Excess probability over random of finding one galaxy “near” another galaxy

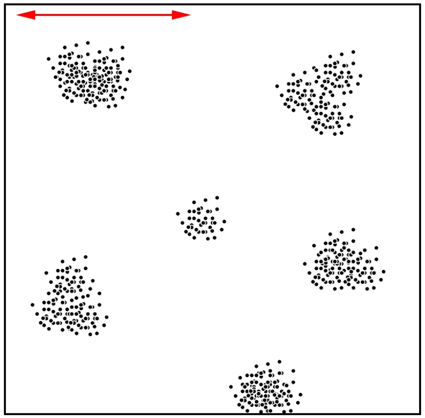
$$\delta P = \rho_0^2 \left(1 + \xi(r_{12})\right) \delta V_1 \delta V_2$$

where δP is the probability of finding a second object near an object at r

$$\xi(r) = \left(\frac{r}{r_0}\right)^{-\gamma}$$

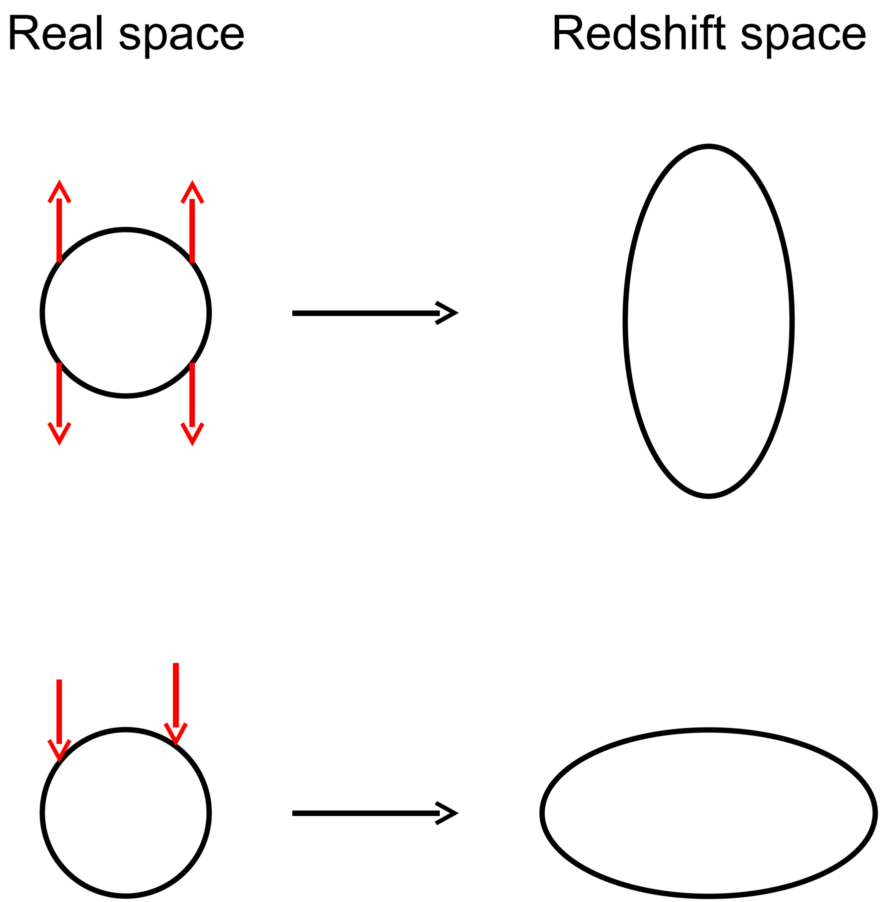


small r_0



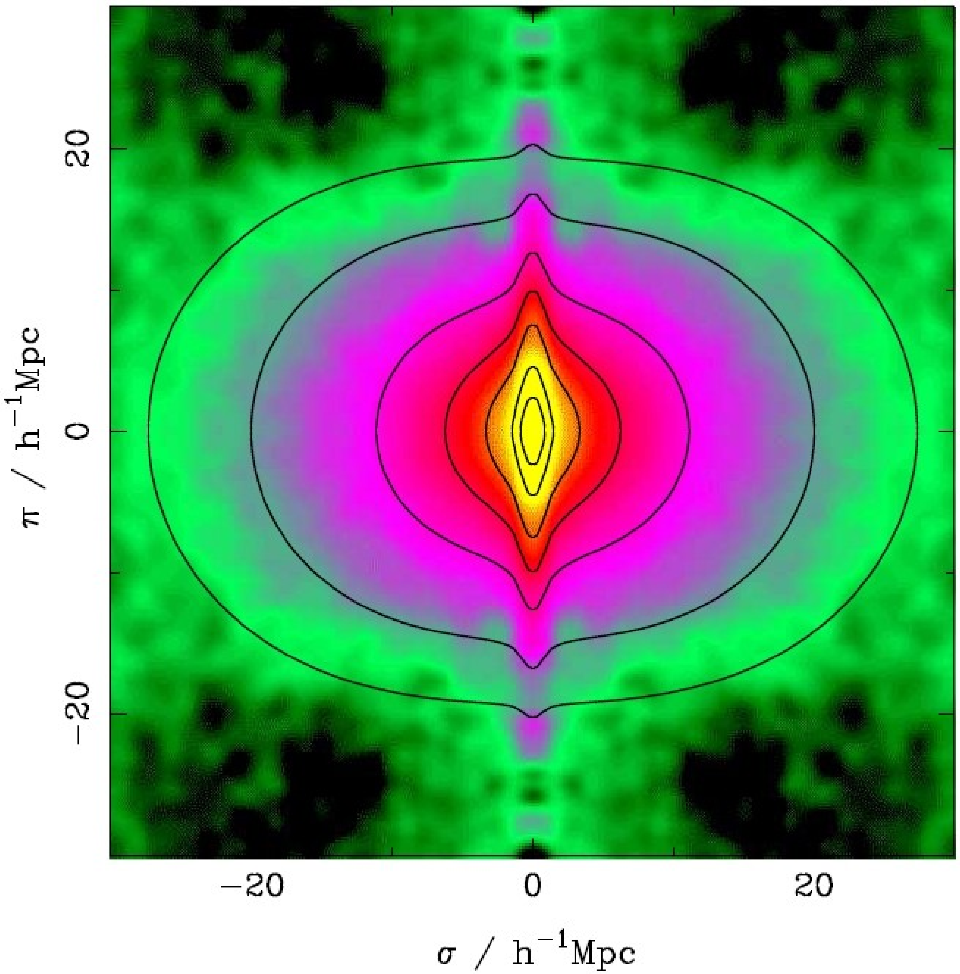
large r_0

Distorsions in the redshift space



- *Finger-of-God* on small scale (peculiar velocities)
- Coherent infall of galaxies on large scale (Kaiser, 1987)

The projected correlation function $w_p(r_p)$



Peacock et al., 2001 (2dFGRS)

Summing along the line-of-sight to recover the real-space correlation function (Davis & Peebles, 1983)

$$
\begin{aligned}
w_p(r_p) &= 2\int_0^\infty \xi(r_p,\pi)\,d\pi \\
&= 2\int_0^\infty \xi\left[\left(r_p^2+y^2\right)^{1/2}\right]dy
\end{aligned}
$$

With the assumption that $\xi(r)$ is a power-law,

$$
w_p(r_p) = r_p\left(\frac{r_0}{r_p}\right)^\gamma \times \frac{\Gamma\left(\frac{1}{2}\right)\Gamma\left(\frac{\gamma-1}{2}\right)}{\Gamma\left(\frac{\gamma}{2}\right)}
$$

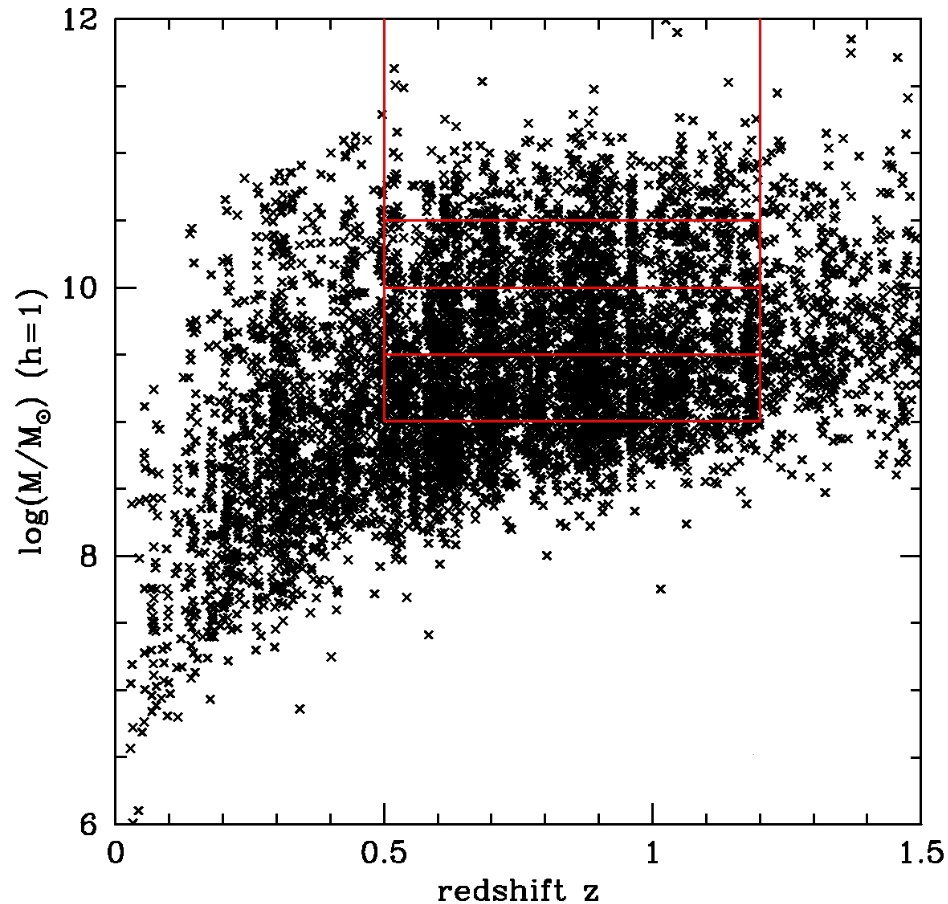
Stellar masses of VVDS data

Stellar mass from SED fitting of Bruzual&Charlot (2003) using apparent magnitude and spectroscopic redshift

see Pozzetti et al. (astro-ph/0704.1600)

z=[0.5-1.2]: 3218 galaxies with log(M)>9

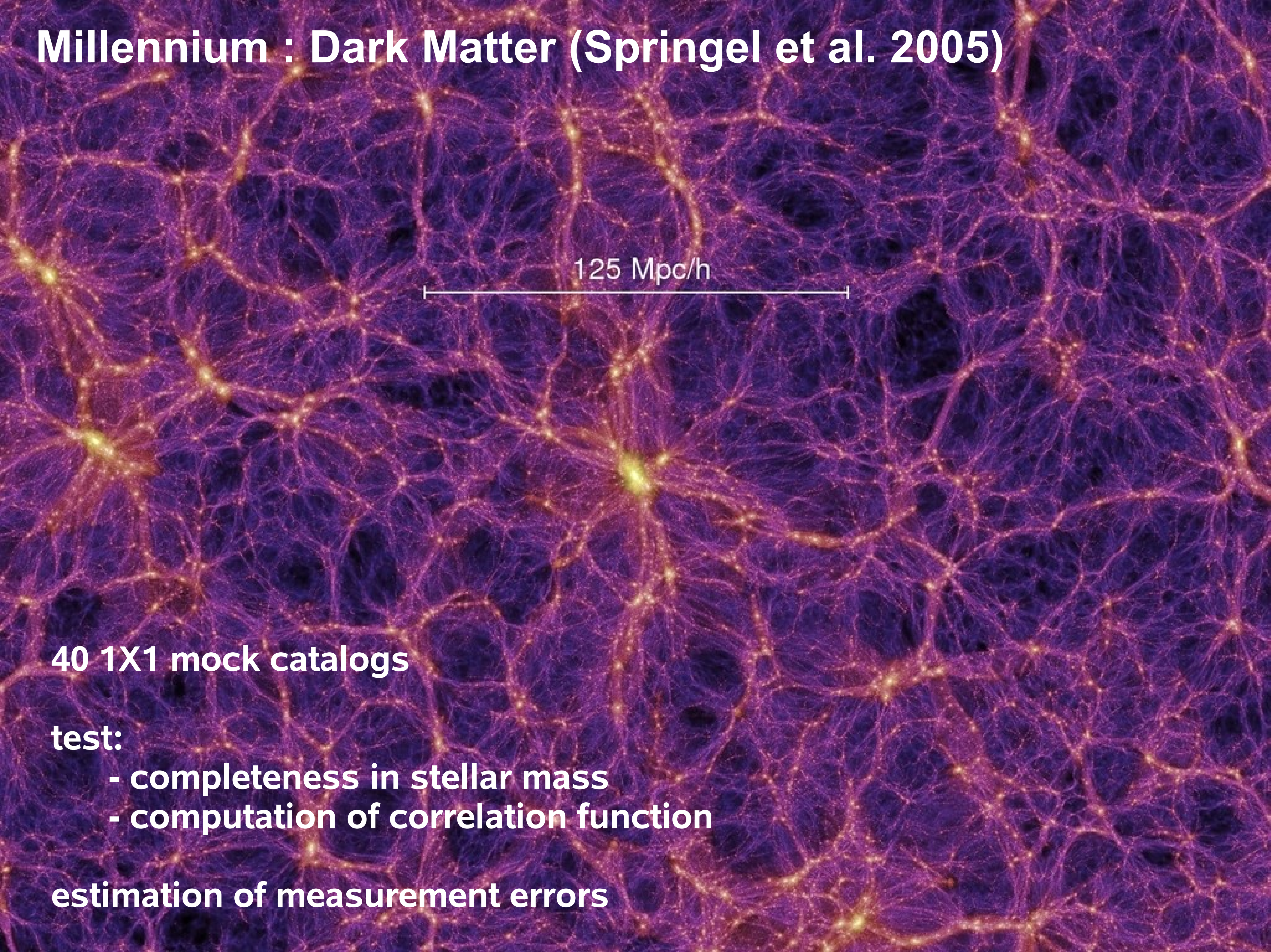
<z> = 0.85



VVDS : a flux limited survey ...
Which fraction of galaxies do we miss ?

Mass completeness estimated from VVDS data : log(M)~9.6

Millennium : Dark Matter (Springel et al. 2005)

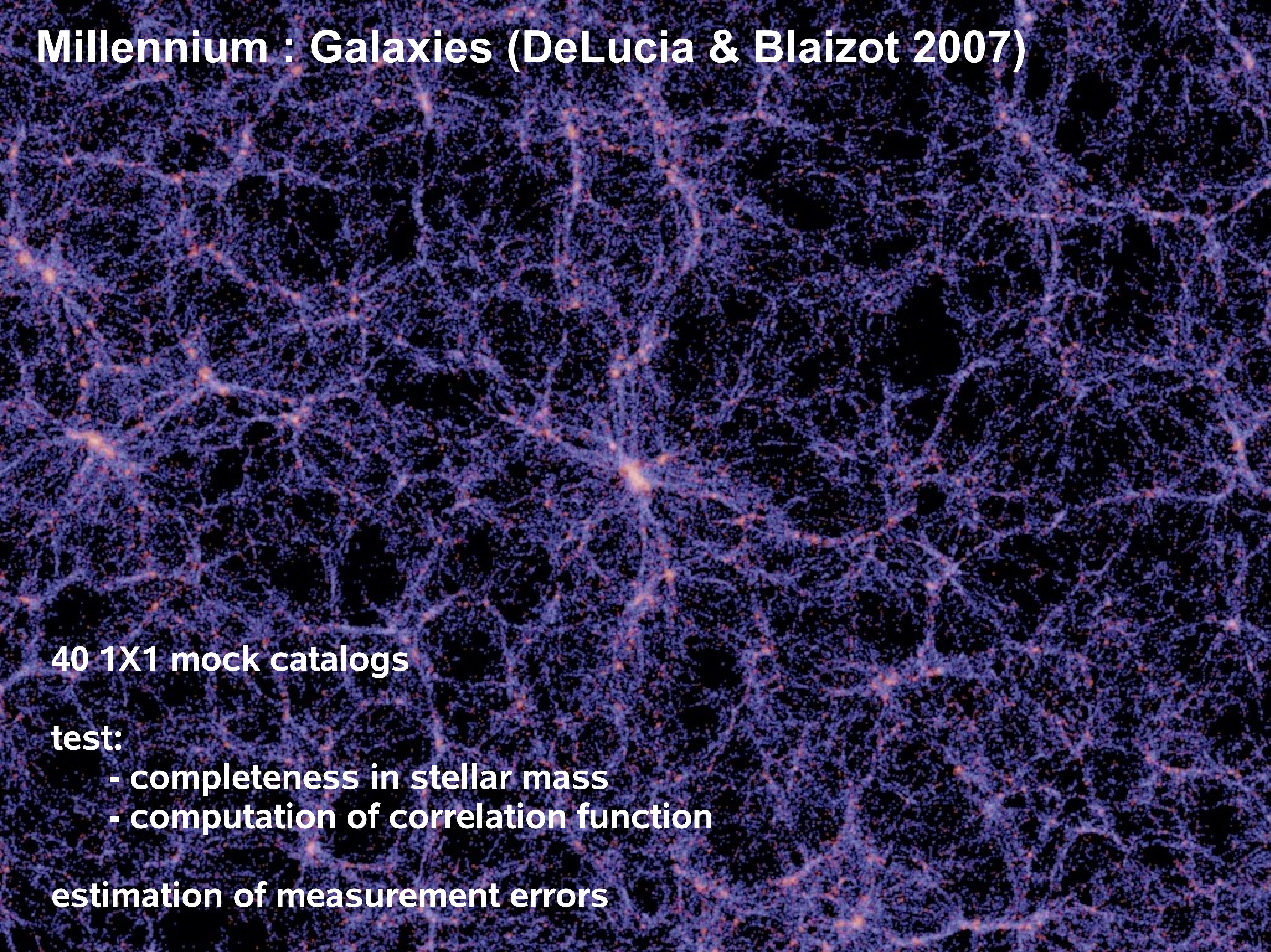


40 1X1 mock catalogs

test:

- completeness in stellar mass
- computation of correlation function

estimation of measurement errors


Millennium : Galaxies (DeLucia & Blaizot 2007)
40 1X1 mock catalogs
test:
- completeness in stellar mass
- computation of correlation function
estimation of measurement errors

Stellar mass completeness from mock catalogs

First series of **40 mock catalogs**:
- complete in redshift up to z~1.7
- contains all galaxies irrespective to their apparent magnitude or stellar mass

Completeness =
Fraction of galaxies, in a given redshift range, in a given stellar mass range, for which $17.5 \leq I_{AB} \leq 24$

z=0.5-1.2

$log(M/M_{\odot})$	C
9.0 – 9.5	0.37
9.5 – 10.0	0.70
10.0 – 10.5	0.93
10.5 – 11.0	0.99
≥ 9.0	0.56
≥ 9.5	0.79
≥ 10.0	0.94
≥ 10.5	1.00

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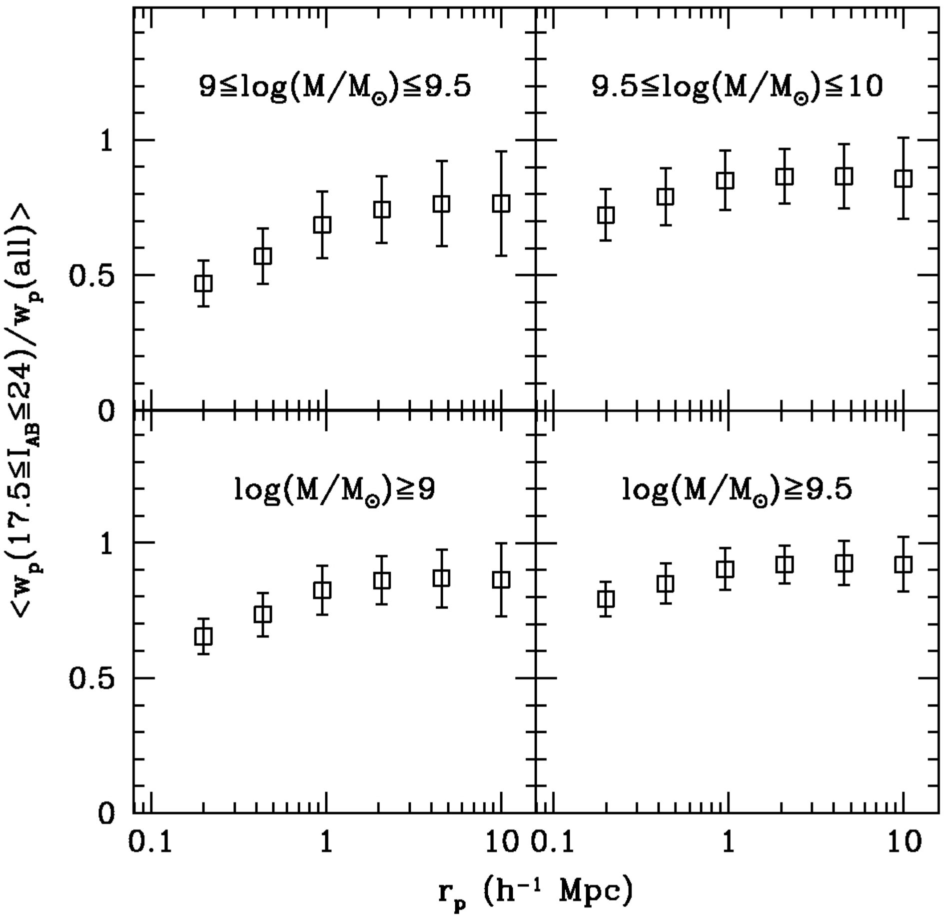
$\geq$ 10.5	1.00

Incompleteness effect on clustering properties

4 critical cases

Computation of $w_p(r_p)$
- for samples complete in stellar mass
- for subsample defined by $17.5 \leq I_{AB} \leq 24$



- w_p underestimated by a factor ~2 on small scales in [9-9.5]
- ratio quite flat above 1Mpc/h

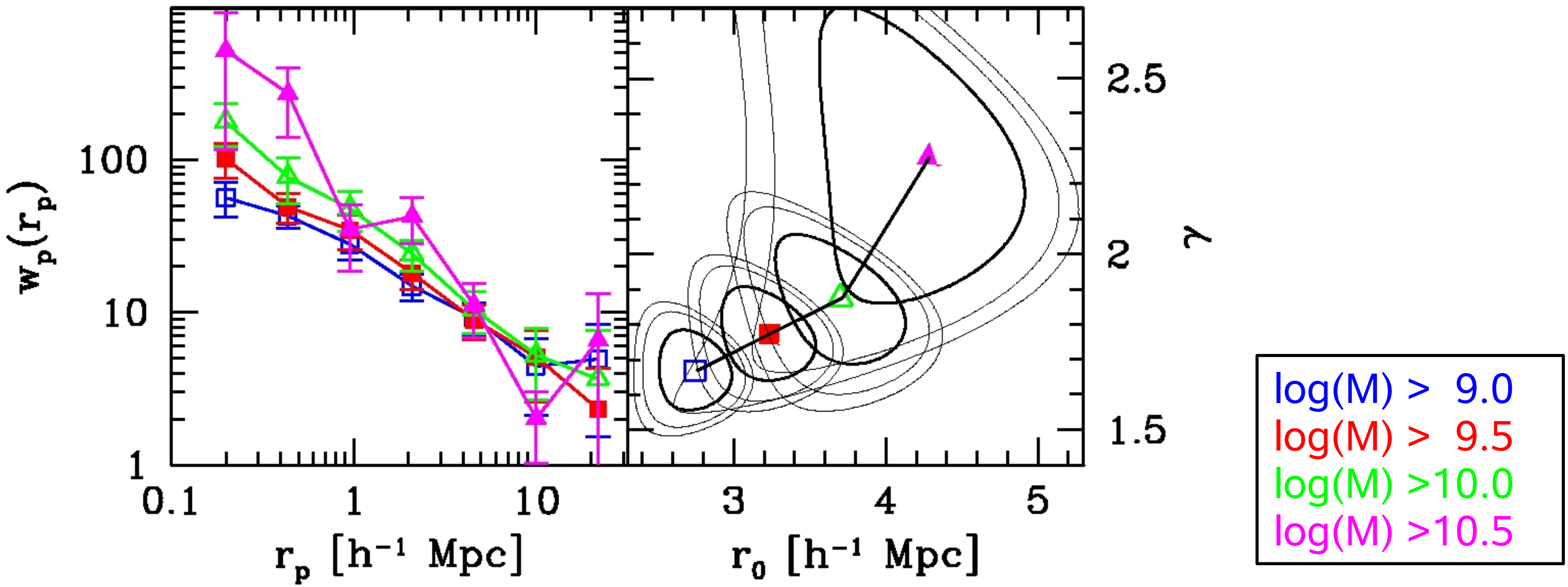
Effect on r_0 and γ :

$log(M/M_\odot)$	mean relative error r_0	γ
9.0 – 9.5	0.25	0.07
9.5 – 10.0	0.11	0.03
≥ 9.0	0.13	0.05
≥ 9.5	0.06	0.03

Projected correlation function $w_p(r_p)$ with VVDS data

Galaxy samples selected in the redshift bin z=[0.5-1.2]

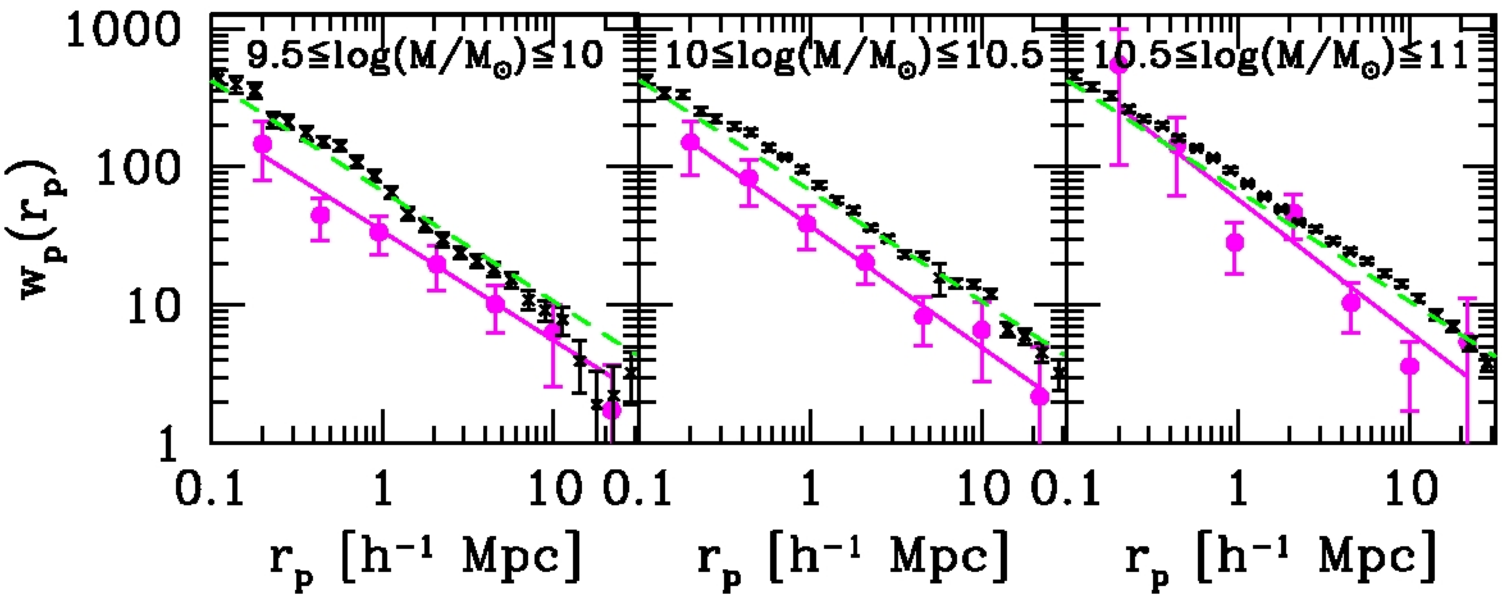
Clear trend of the clustering amplitude and slope with stellar mass



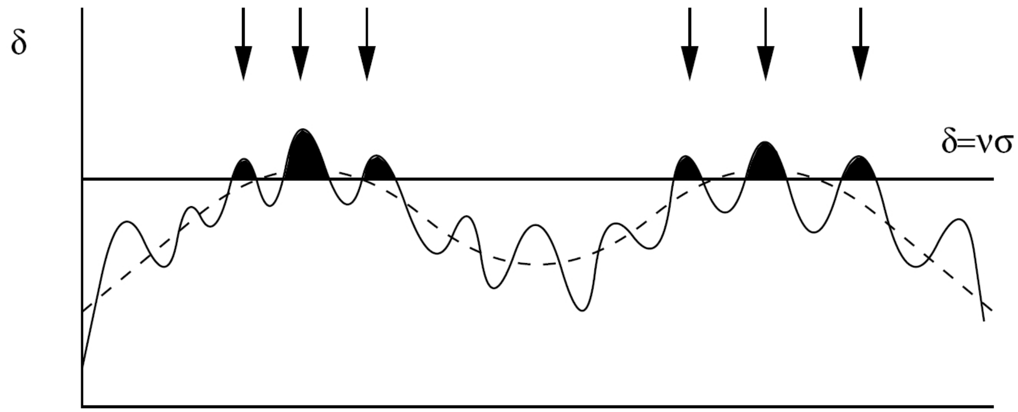
Comparison to Local Universe

Evolution of amplitude and slope of $w_p(r_p)$:

- with stellar mass at z~0.9 (VVDS, magenta points)
  and z~0.15 (SDSS, Li et al. 2006, black points)
- with redshift in a given stellar mass range
- stronger evolution for small stellar mass galaxies



Biased distribution of galaxies



Peacock (1999), “cosmological physics”

Galaxies are expected to form in the highest peak of the matter density field (Kaiser 1984)

Distribution of galaxies is biased with respect to the mass

$$b = \frac{\sigma_{8,g}}{\sigma_{8,m}}$$

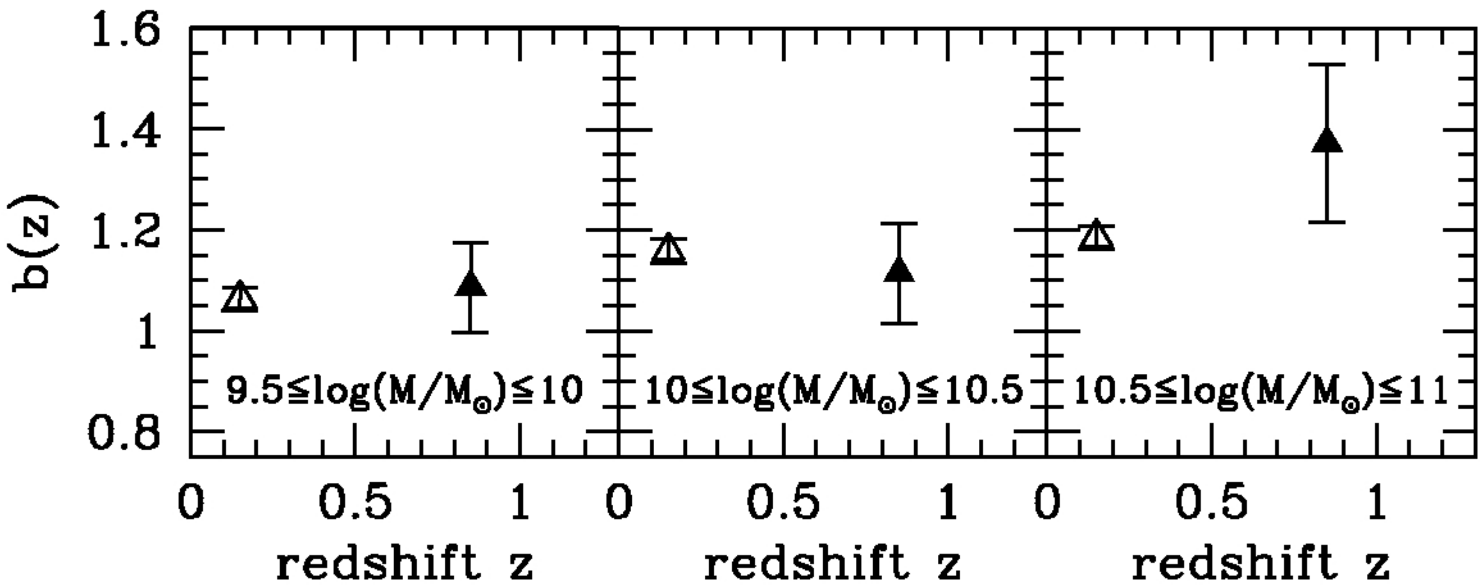
$\sigma_{8,g}$ ← Estimated from r0 and γ

$\sigma_{8,m}$ ← Model assumed

Bias evolution as a function of stellar mass

- no evolution with redshift for log(M)<10.5 and b~1.1
- evolution from b~1.4 (z~0.85) to b~1.2 (z~1.15)

- densest regions stop forming new galaxies
- galaxy formation moved from high peak to low peak of the matter density field
- distribution of massive galaxies is less biased with time



Summary

- More massive galaxies are more clustered than low mass galaxies at z~1
- Evolution of amplitude and shape of wp with redshift for log(M)<10.5
- w_p is roughly the same at z~0.8 and z~0.1 for log(M)>10.5

- As a consequence, strong evolution of the bias of massive galaxies with z
- This implies that massive galaxies do not form any more in highest peak of the matter density field. With time, their distribution is less biased