The VIMOS-VLT Deep Survey: 10 billions years of evolution of the Large Scale Structure

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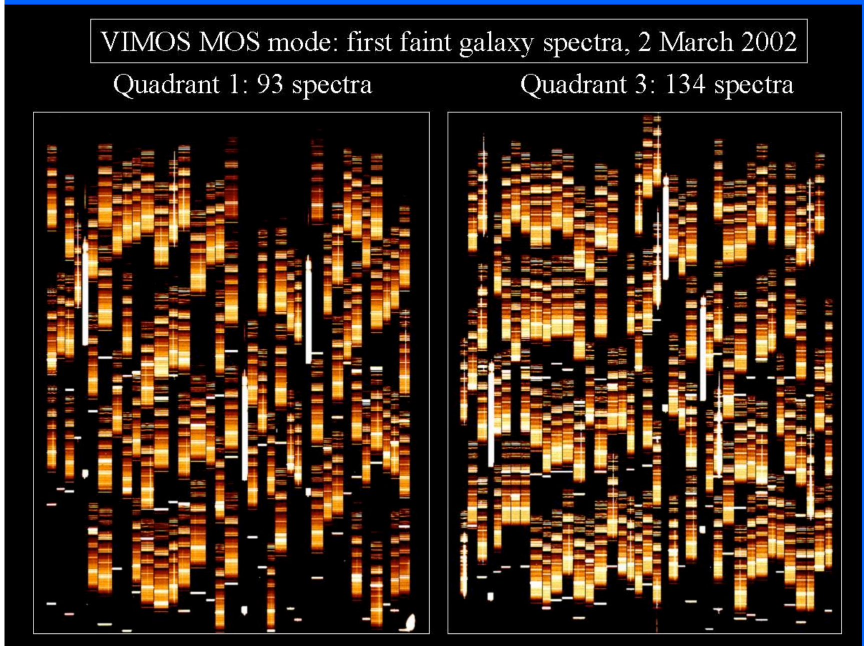
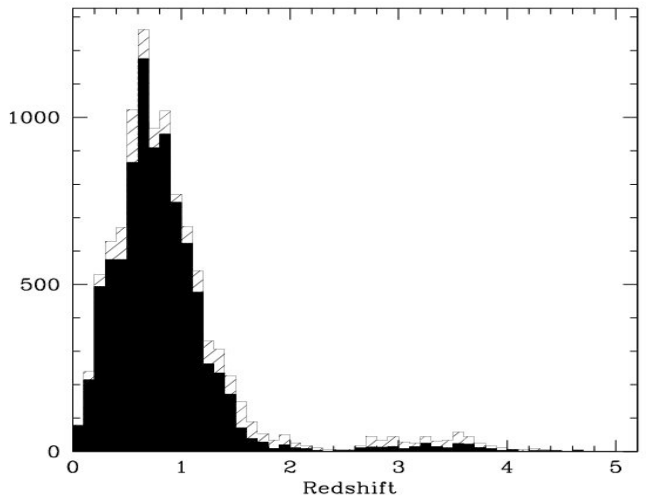
The VIMOS-VLT Deep Survey



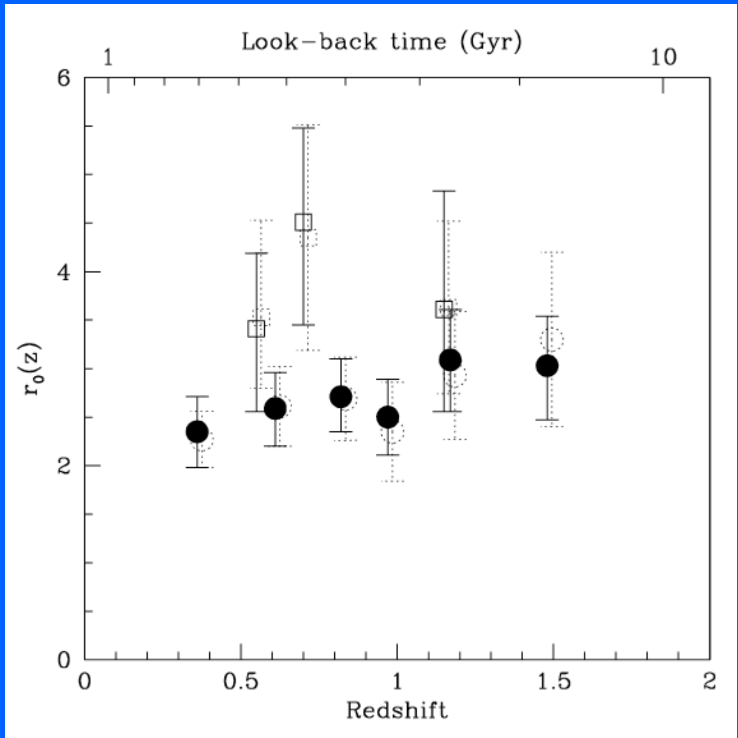
- First-epoch VVDS data:
  - 11 564 spectra from $17.5 < I_{AB} < 24$, fields 1226-04 and CDFS, area 0.61 deg^2
  - 10518 galaxies with z measured with a confidence level > 80%
  - 836 stars, 85 AGNs, 125 unidentified objects
- field coverage 25%=30%
- $0 < z < 5$
- VVDS "Ultra-Deep" up to I_{AB} =24.75 and VVDS-Wide up to I_{AB} =22.5 on-going



The data are now public:

http://cencosw.oamp.fr/EN/index.en.html

Galaxy clustering in the VVDS



$$w_p(r_p) = 2\int_0^\infty d\pi\ \xi(r_p,\pi) = 2\int_0^\infty dy\ \xi(r_p^2+y^2)^{1/2}$$

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

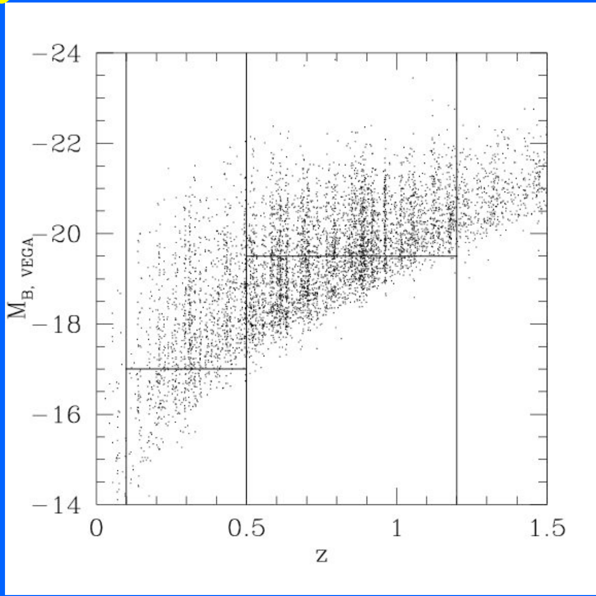
for a power-law $\xi(r)$,

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

- we compute the 2-point spatial correlation function, projected along the line of sight, $w_p(r_p)$, to measure clustering properties of galaxies
- for a power-law shape of the CF: correlation length r_0 and slope [illegible]
- for a general galaxy population: CF weakly evolving up to z~2
- which may be interpreted as a mixed effect of evolution of the LSS (stronger clustering with time) and observational bias (at higher z we see brighter and more clustered objects)
- we need some indicators to compare more alike galaxies at different redshifts

- Pollo et al., 2005 and LeFevre et al., 2005

Galaxy clustering in the VVDS: dependence on the absolute luminosity

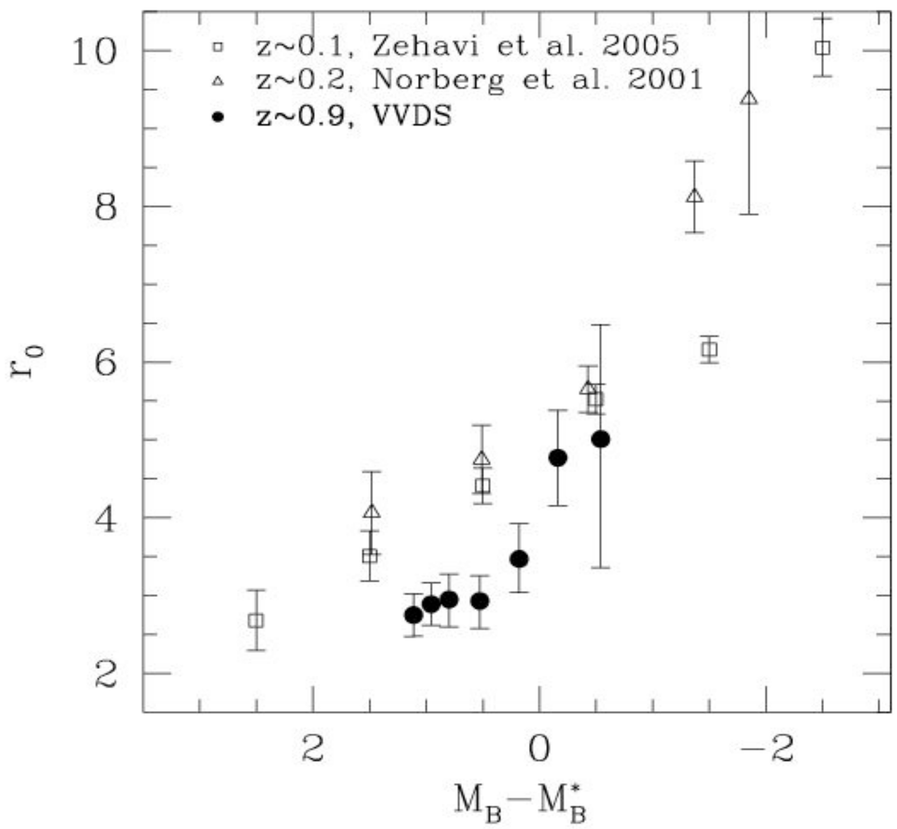


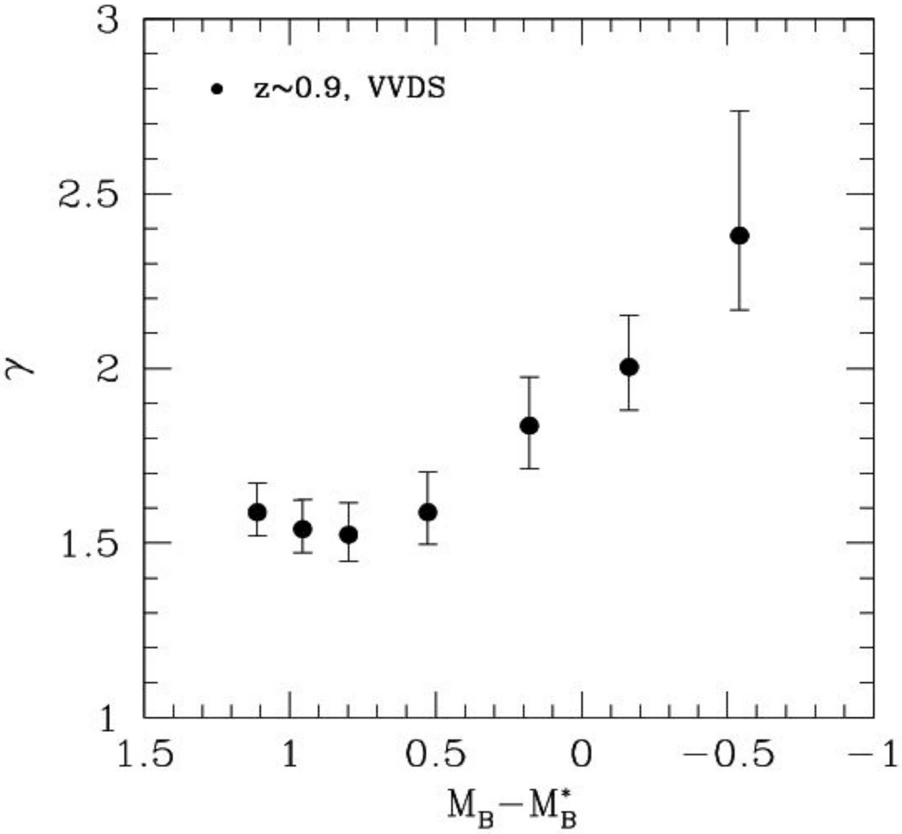
Scientific motivation:

- Currently luminous galaxies tend to be more clustered than fainter ones
- This is in a general agreement with hierarchical models of galaxy formation
- So far, we had no idea when this dependence was established and how it evolved with redshift

- VVDS-02, M_B
- 2 "wide" ranges corresponding to ~3.5 bld years, medians z~0.4 and z~0.9
- 7 luminosity ranges in each
- at z~0.9 the brightest bin at M_B > 21

- Pollo et al., 2006



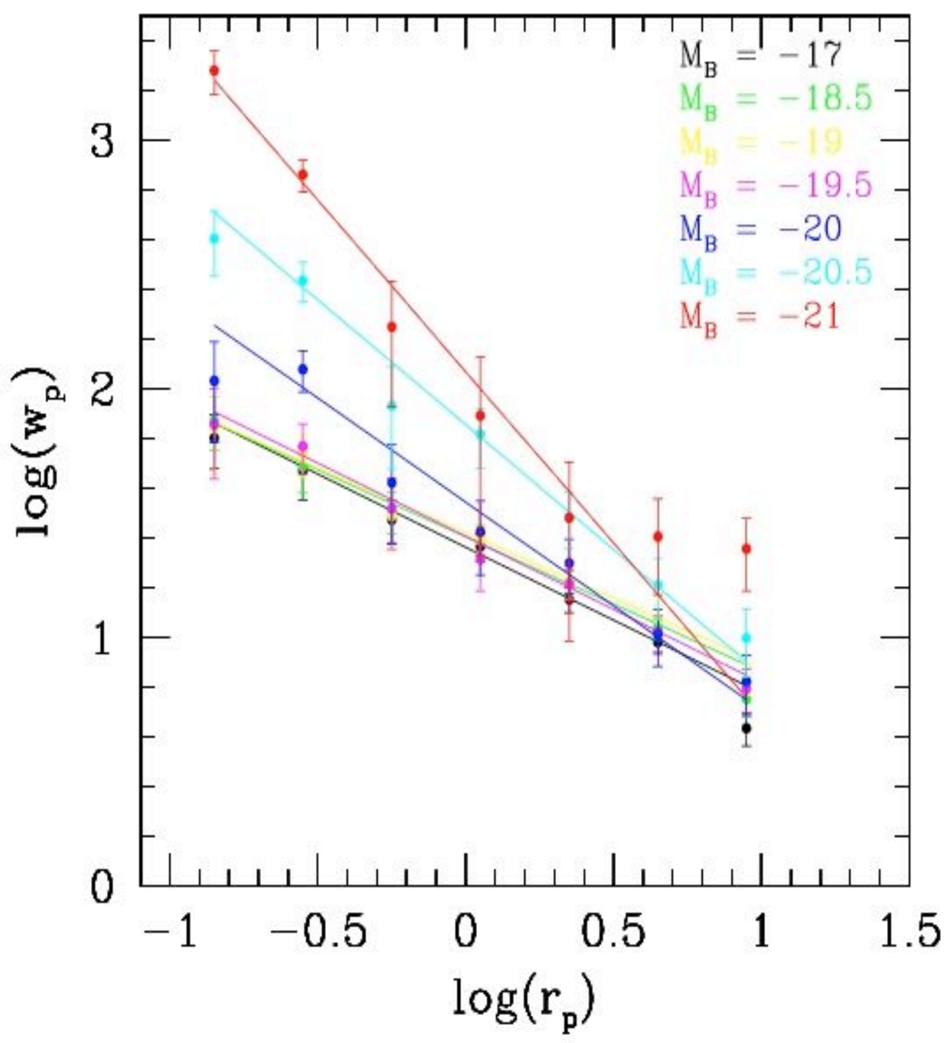


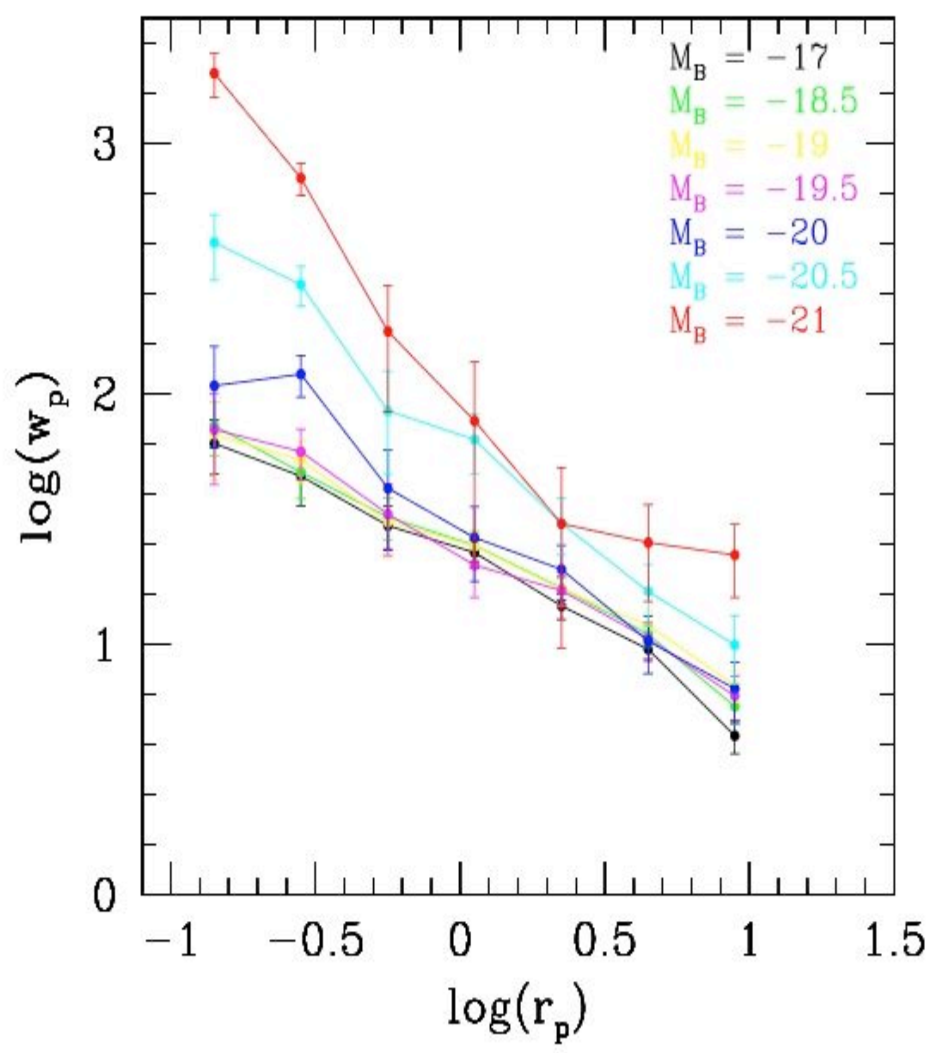
At z~0.9 r_0 rises more steeply than locally in case of galaxies brighter than M*

but at z~0.9 γ rises as well for galaxies brighter than M*, unlike at lower redshifts

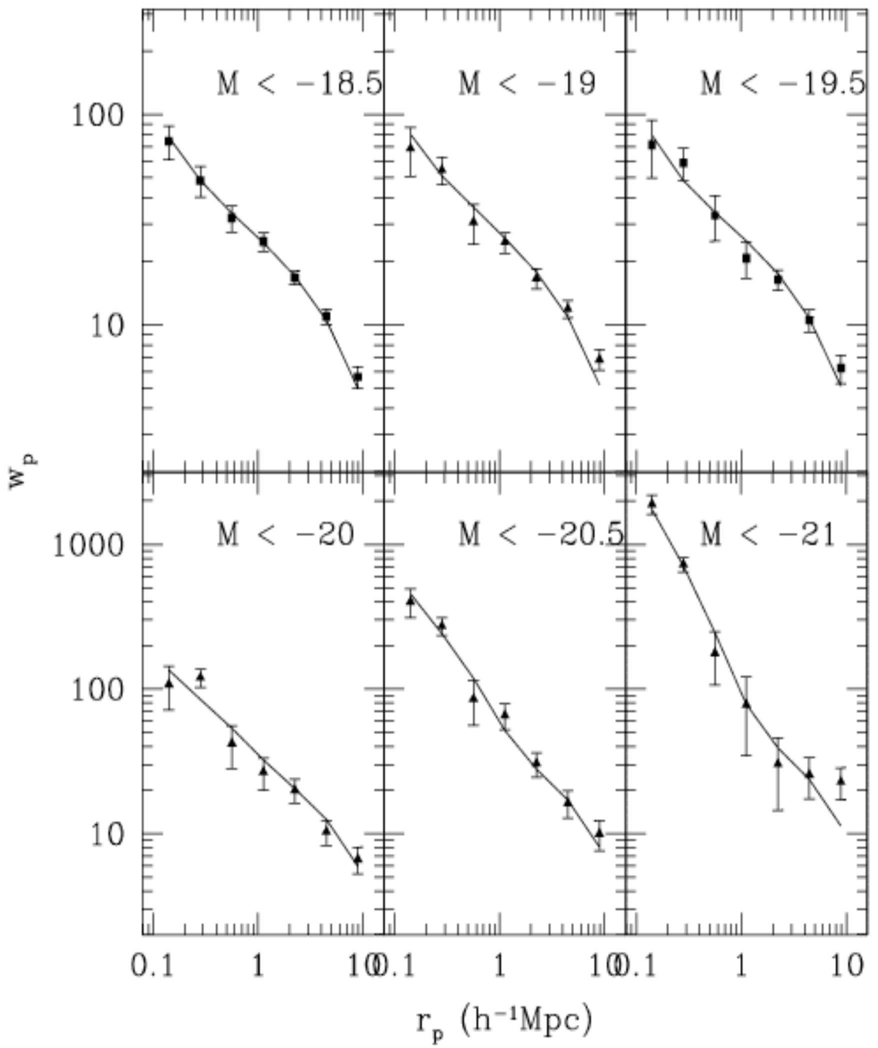
This is the first time [illegible](L) has been measured at z significantly different from 0 (see also Coil et al., 2006 for similar results from DEEP2).

CF of most luminous galaxies does not really follow a power-law fit

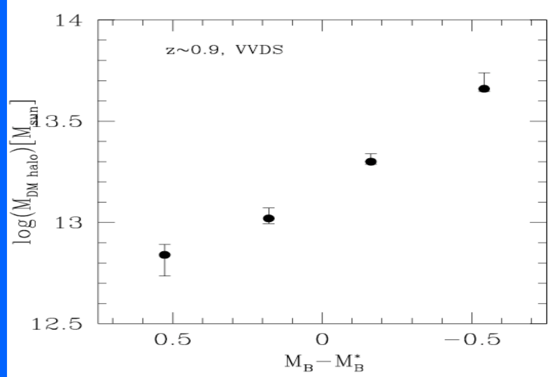


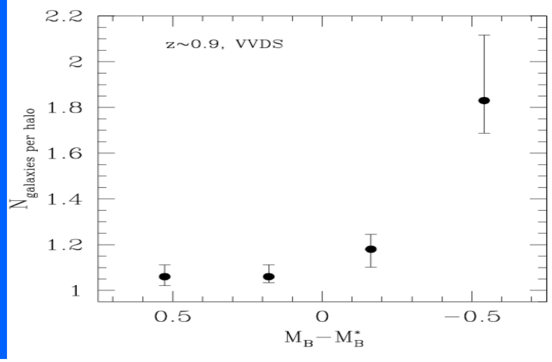


A non-power-law CF can be described in terms of the Halo Occupation Distribution Models (see also a poster of Ummi Abbas)



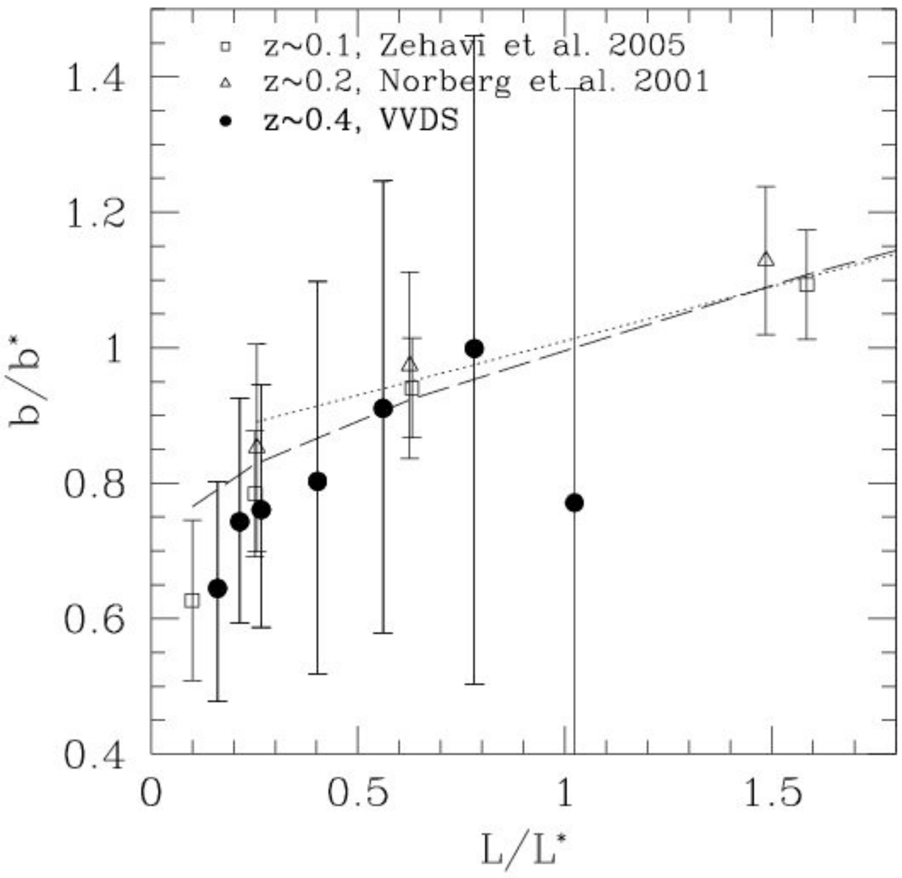
- Tinker et al. (2005) model, with $N_g(M)=1+N_{sat}=1+M/M_1 \exp(-M_{cut}/M)$ for $M>M_{min}$ and 0 otherwise
- 3 free parameters, NFW profiles, Sheth and Tormen halo clust., linear P(k), lin. bias
- And we can trace how: an average halo mass and number of satellites change with central galaxy luminosity

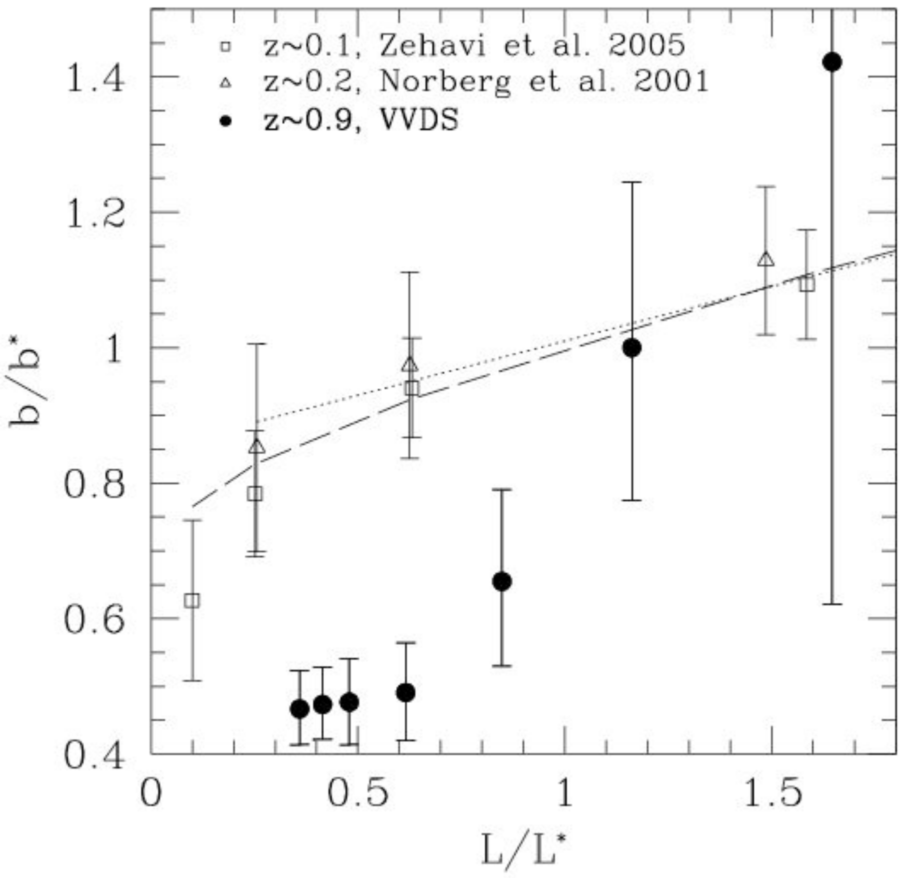




- Abbas et al., in preparation and Pollo et al., in prep.

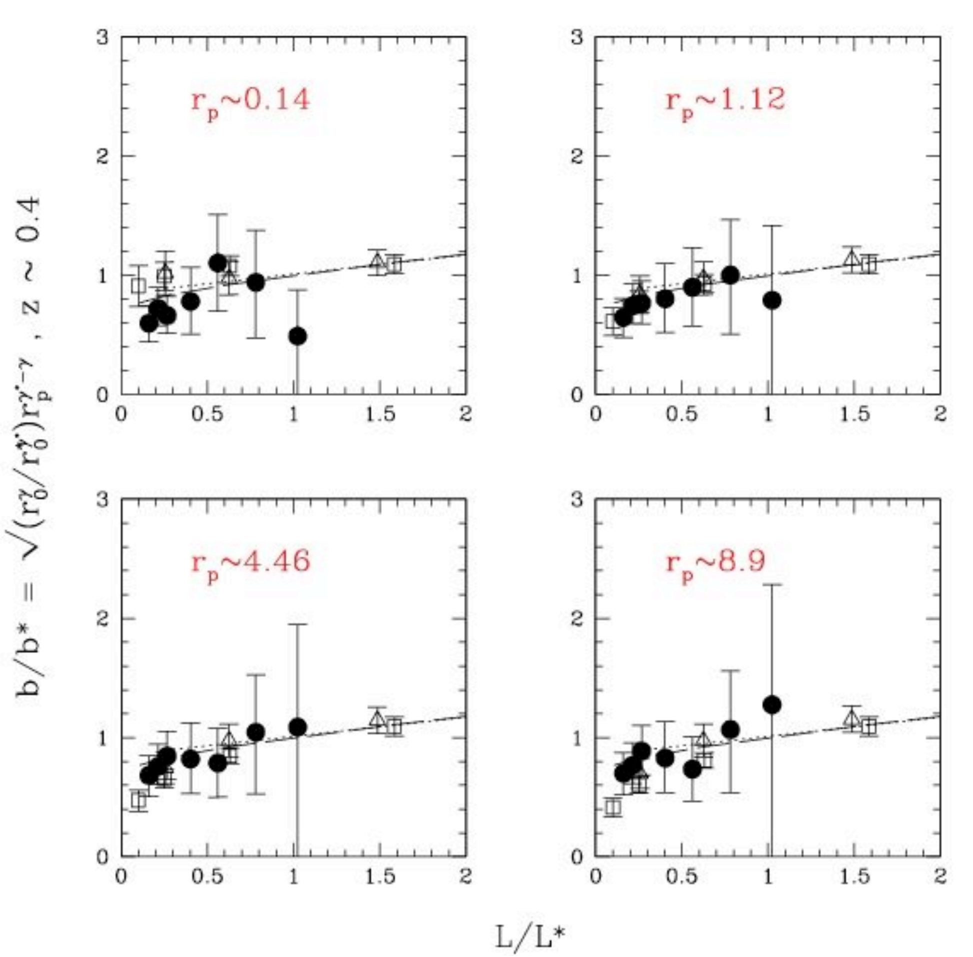
Our results have important consequences for the modelling (HOD) and analysis of bias. At 1 Mpc scale (~transition between 1-and 2-halo terms) the luminosity dependence of the relative bias with respect to M* galaxies is very different at z~0.9 than locally (suggesting a strong evolution of 1 halo term)



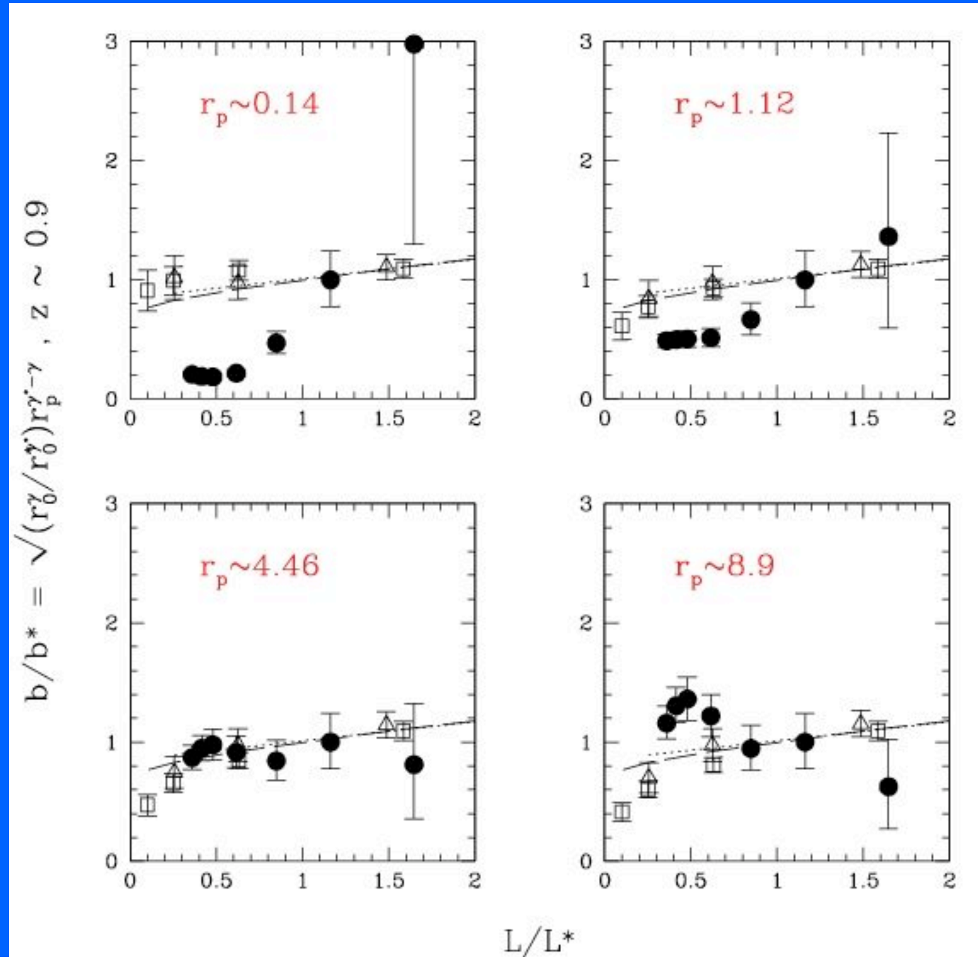


But relative bias at z~0.9 becomes also "globally" scale-dependent – does it imply a time-evolving scale dependence of halo vs DM bias as well? (bigger volumes needed to answer this question)

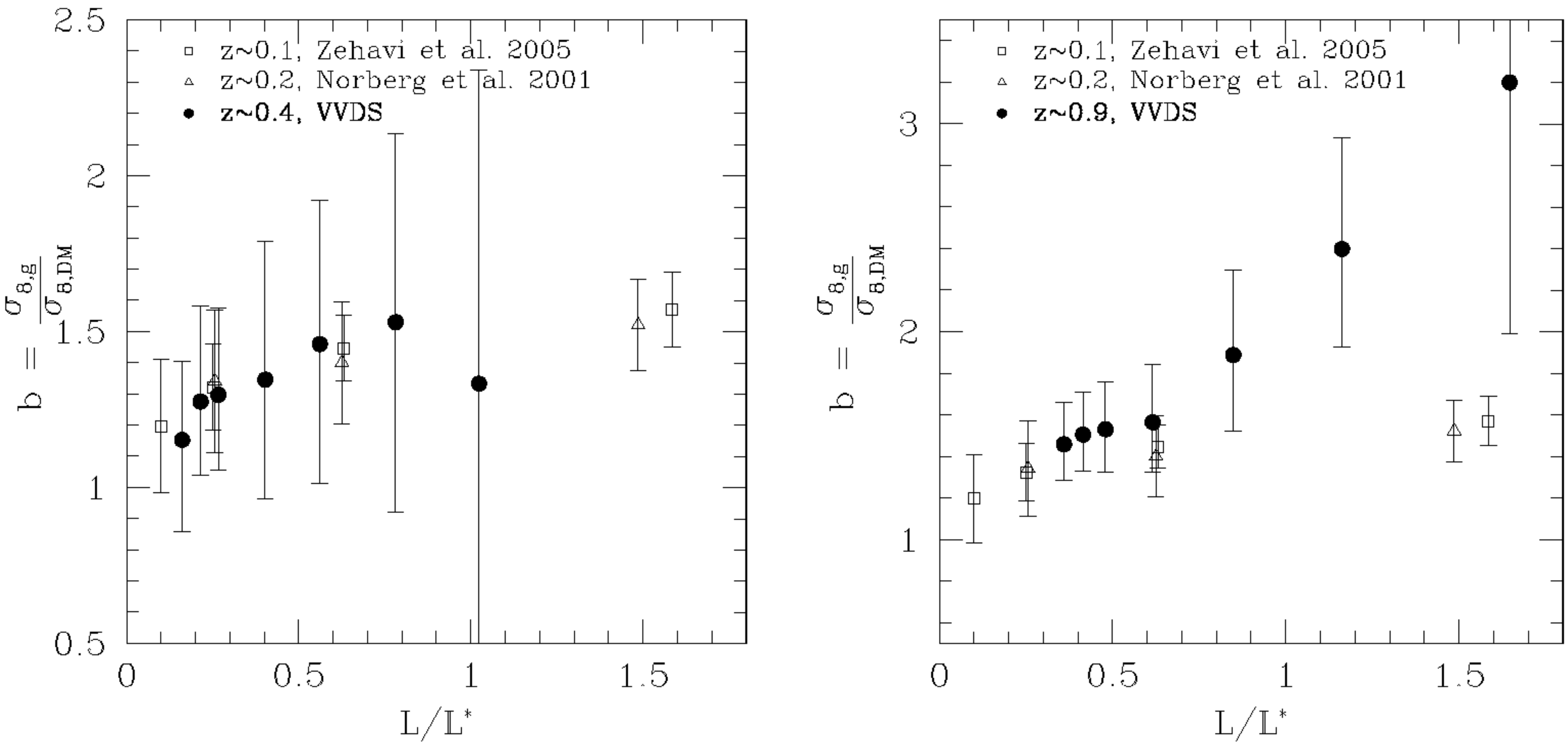
z~0.4



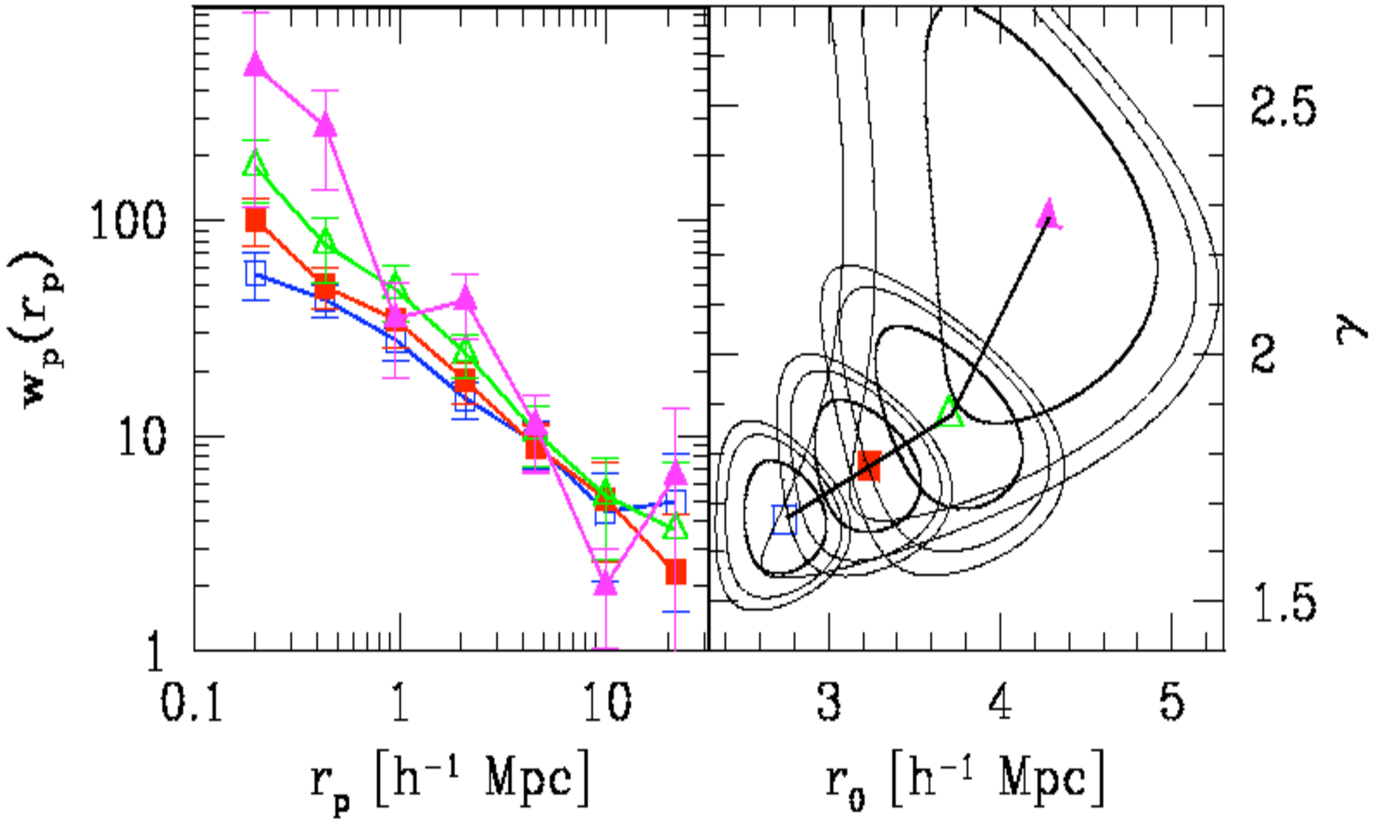
z~0.9



A linear galaxy vs DM bias, at 8 Mpc scale, seems to evolve faster for galaxies brighter than M*



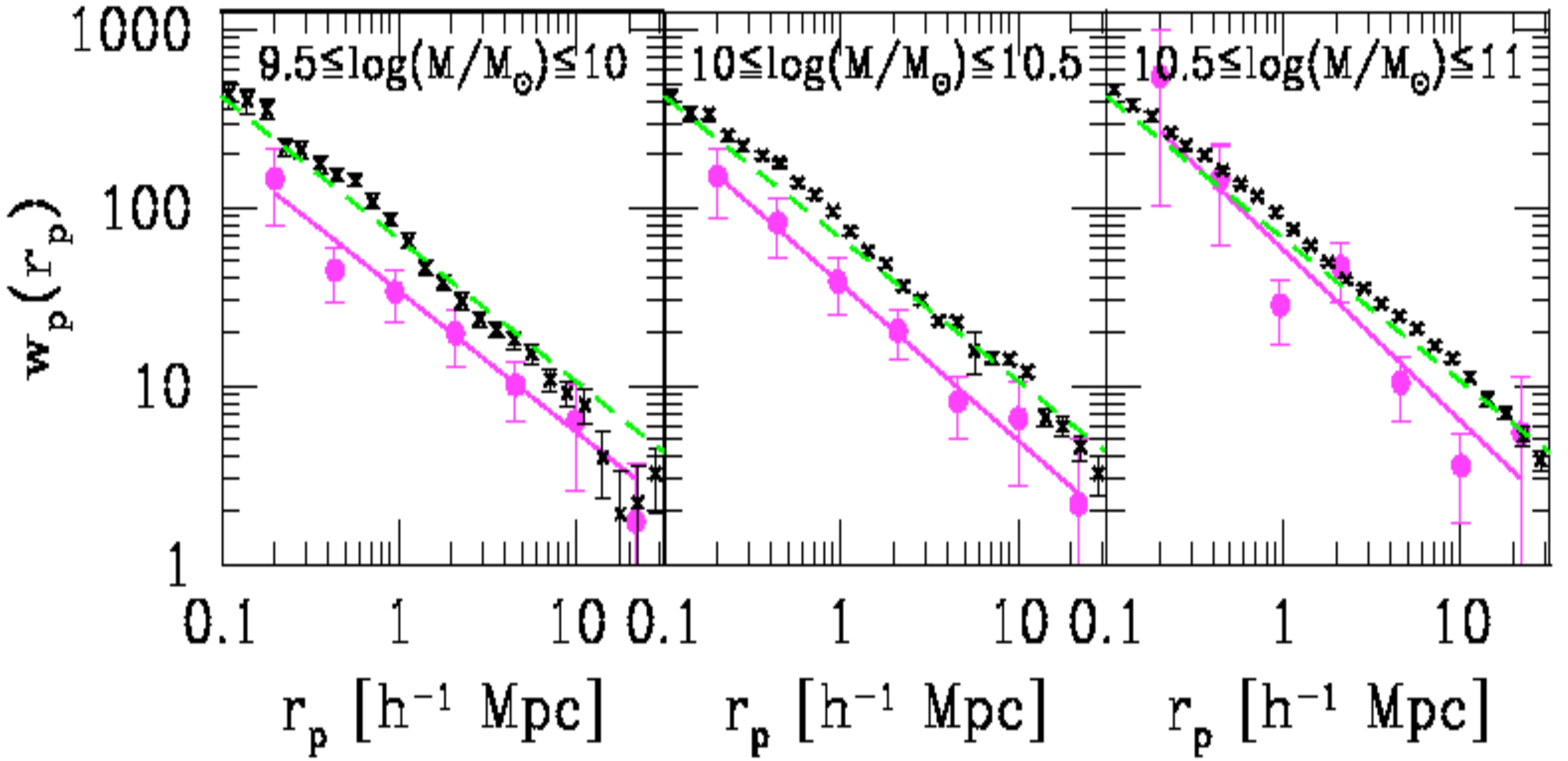
Is what we see an effect mostly related to enhanced star formation in close galaxy pairs at z~1 or something mass-related? Let's try to select galaxies according to the stellar mass they contain, which is perhaps a factor more closely related to the original dark halo mass.



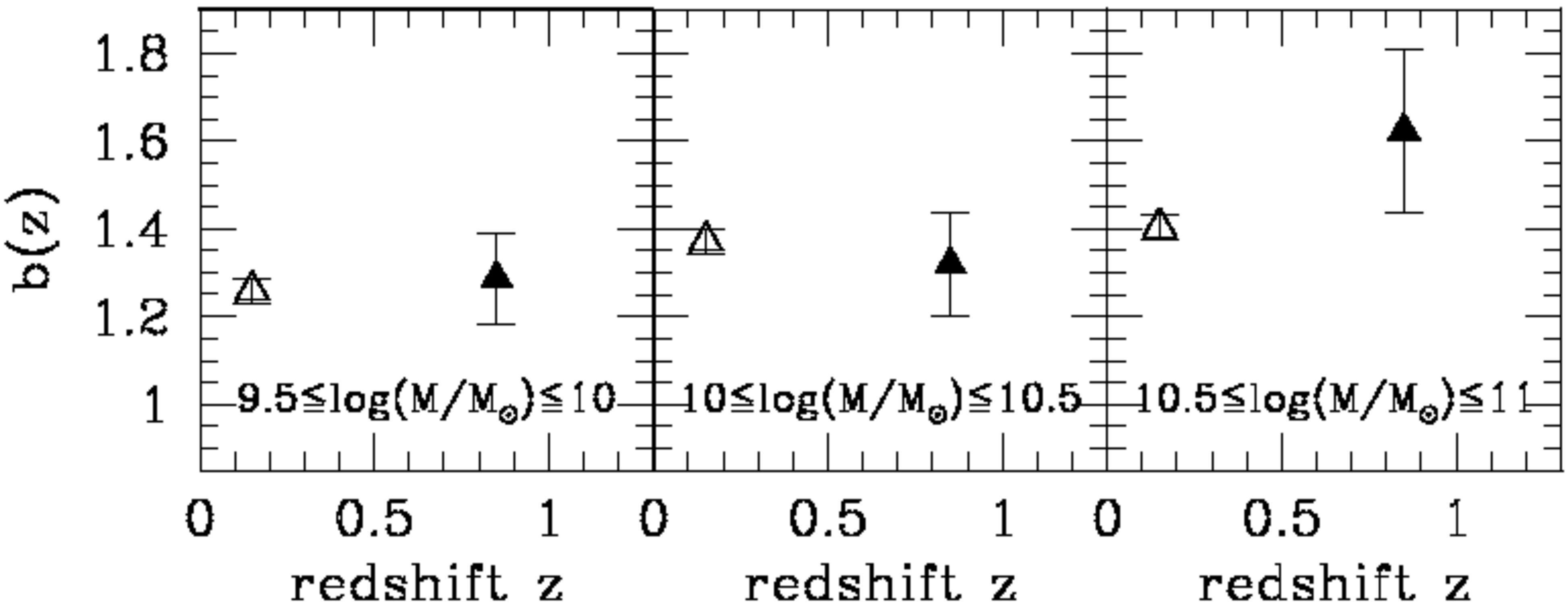
- 4 stellar masses from log($M_{\odot}$) ≥9 to 10.5 at z~0.9
- Selection effects well understood (from comparisons to Millenium simulation)
- CFs and their best-fit r_0 and γ parameters:
  - both rise for most massive galaxies. mostly at r_p <5 h^{-1} Mpc

- Meneux et al., 2007, A&A, submitted, arXiv:0706.4371

Comparison to the SDSS results (Li et al., 2006) – for the most massive galaxies $w_p(r_p)$ does not evolve

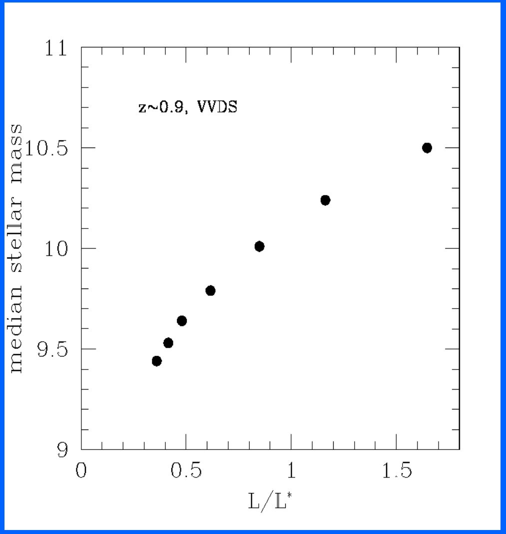


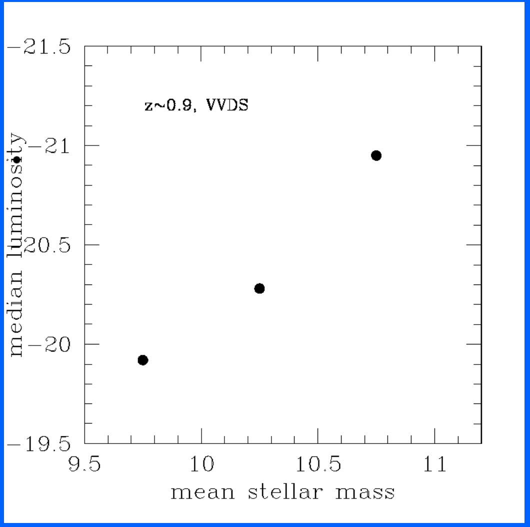
Does a galaxy bias (computed at the 8 Mpc scale) vs DM change with redshift differently for galaxies with different stellar masses?

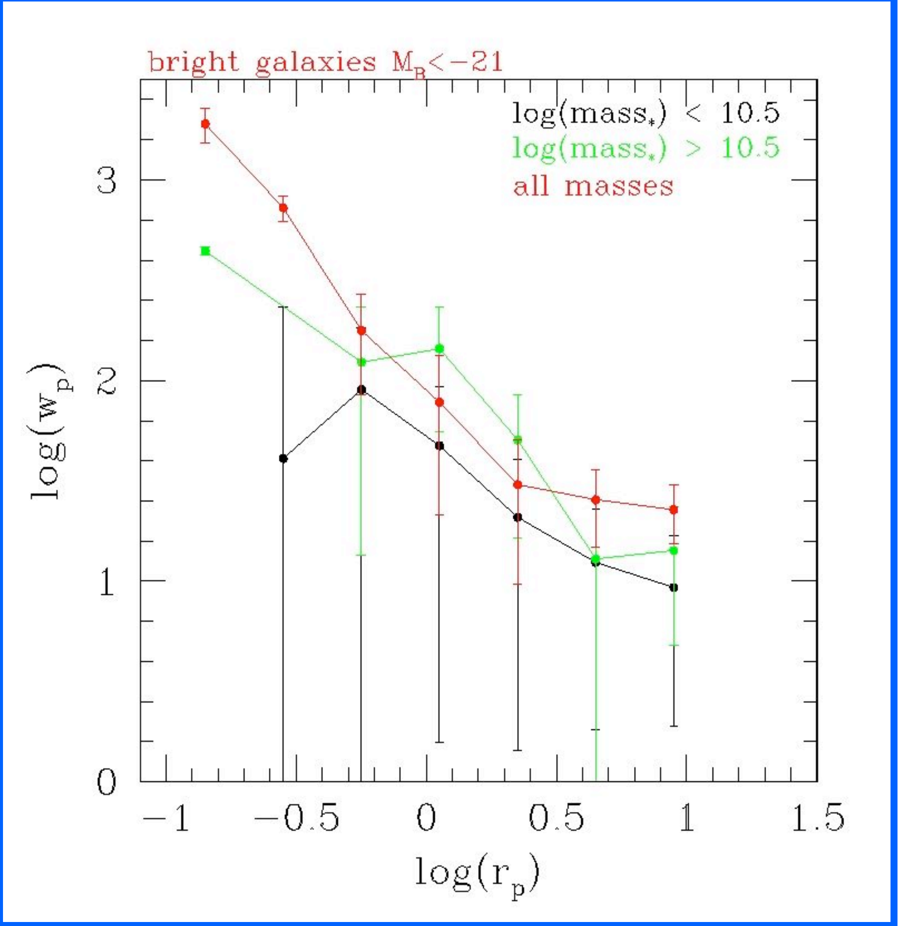


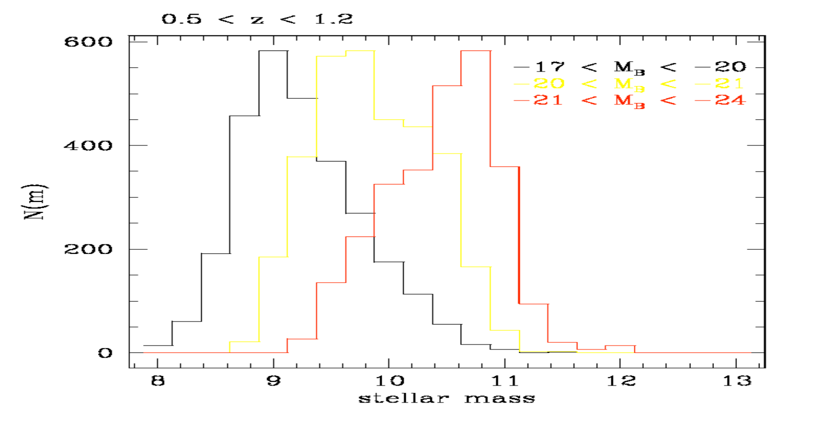
Are luminous and massive galaxies the same?

Not really: a significant fraction of bright galaxies is not so massive. The strongest clustering signal on small scales comes from bright high-low mass galaxy pairs (central halo galaxy + a satellite?) - a circumstantial evidence for a different luminosity evolution of central halo galaxies and satellites? (in progress)









Conclusions

- Dependence of galaxy clustering on their intrinsic properties: luminosities and stellar masses is different at z~1 and at the present epoch
- at z~1 r_0 AND γ rise more steeply for the brightest and most massive galaxies than locally
- ...which results from a non-power-law shape of their CF, with an upturn at scales < ~1-2 Mpc
- ...which may be nicely fitted by HOD models:
- which suggest a rise of the DM halo mass and a number of satellites with a central galaxy luminosity
- ...and has important implications for a description of an evolution of galaxy vs DM bias (possibly time-, properties- and scale-dependent)
- environmental dependence of L – M* relation at small scales?