Measuring Galaxy Bias at z~1 from Counts in Cells.

Enzo Branchini

ROMA TRE
UNIVERSITÀ DEGLI STUDI

Cinzia di Porto
Julien Bel
Federico Marulli
Sylvain de la Torre
and the VIPERS Team

Galaxy Bias: Non-linear, (Non)-local, (Non)-Gaussian
ICTP
10 October 2013

Layout of the Talk

- Dataset: VIPERS PDR-1
- Goal: Nonlinear Bias
- Method: PDF from counts in cells
- Tests: Mock Catalogs
- (Preliminary) Results

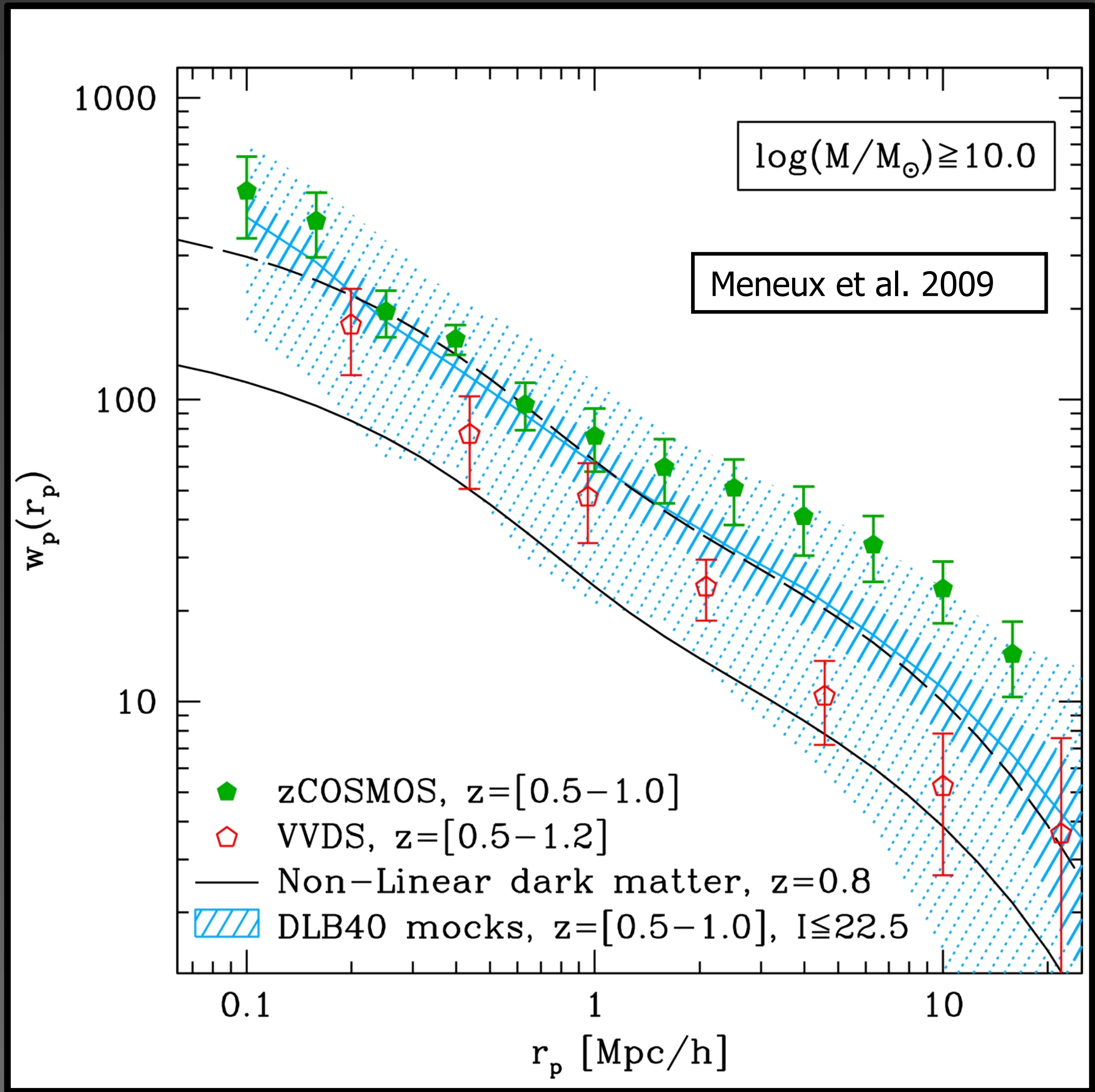
VIPERS

VIMOS PUBLIC EXTRAGALACTIC REDSHIFT SURVEY

VIPERS design goals

- Aim at z=0.5-1.2 range
- Maximize volume (minimize cosmic variance) and statistics
- Maximize sampling ($n \sim 10^{-2}$ gal h^3 Mpc^{-3}, comparable to 2dFGRS and SDSS in the local Universe)
- Cosmology driven, but assure also broad legacy return (clusters, galaxy evolution, environment, AGN, …)

At these redshifts: small volumes, strong variance



VIPERS in a nut-shell

- ~24 deg^2 over W1 and W4 CFHTLS wide fields (~16 + 8)
- I_{AB}<22.5, LR Red grism, 45 min exp.
- z>0.5 color-color pre-selection
- 288 VIMOS pointings
- 440.5 VLT hours
- **~100,000 redshifts, >40% sampling**
- **Density and volume comparable to 2dFGRS, but at z~0.8**

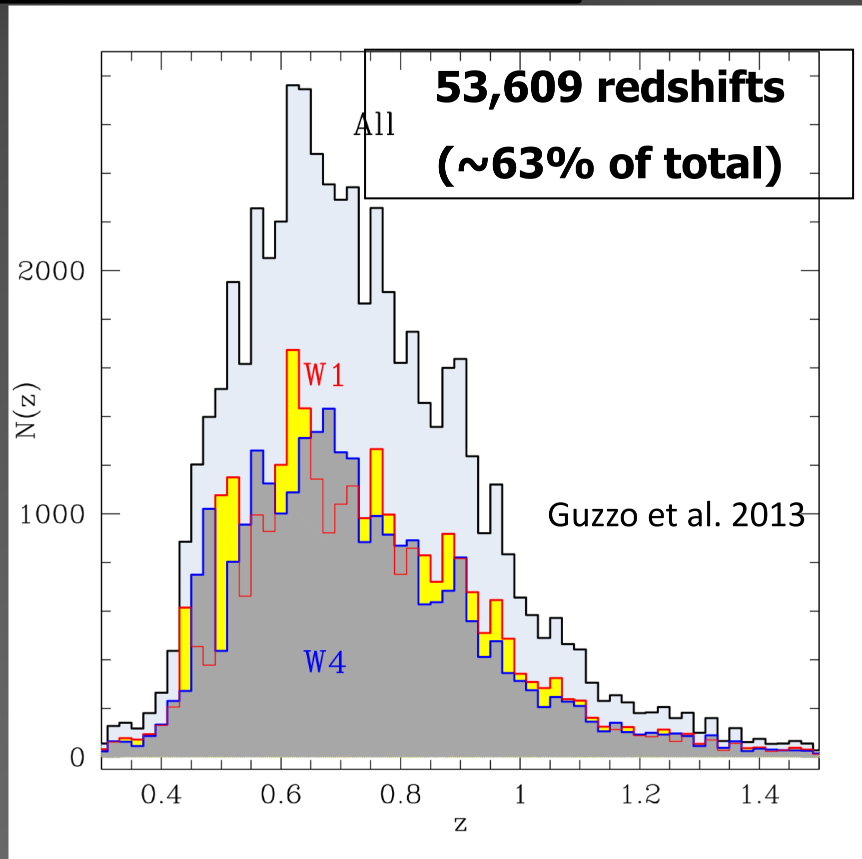
VIPERS Public Data Release 1 (PDR-1)

Data observed prior to Spring 2012: public release October 4th 2013

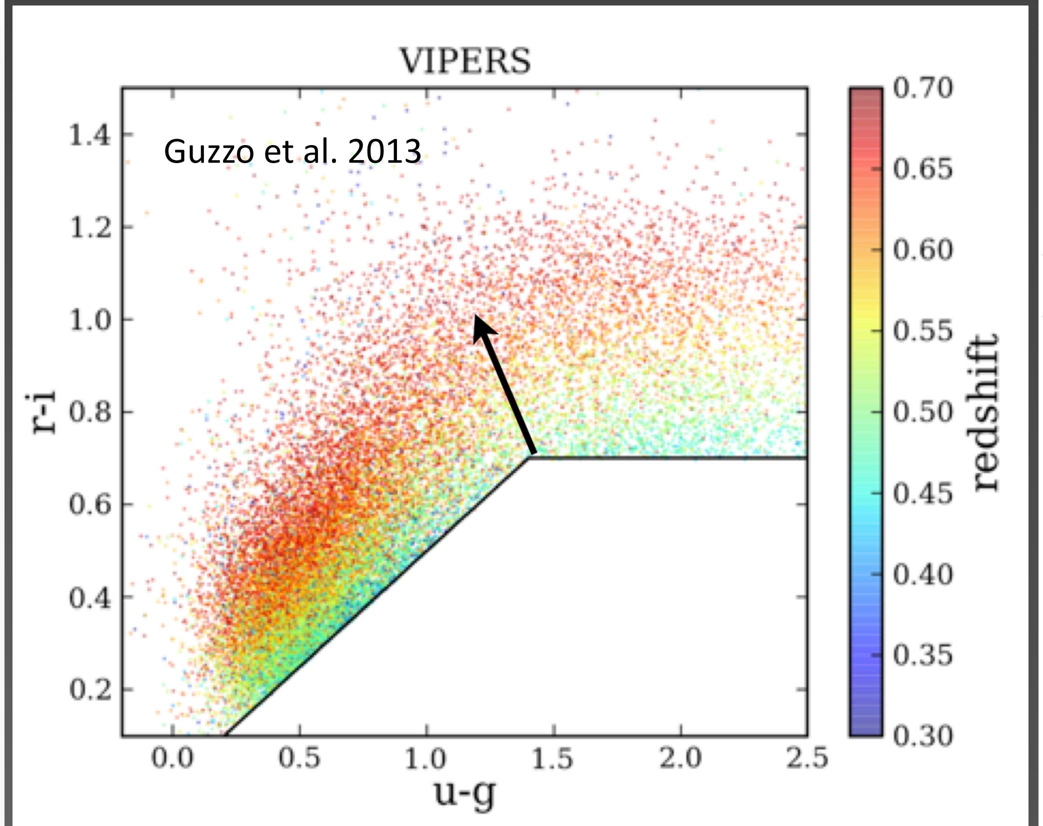
SURVEY STATUS AS OF 12/07/2012

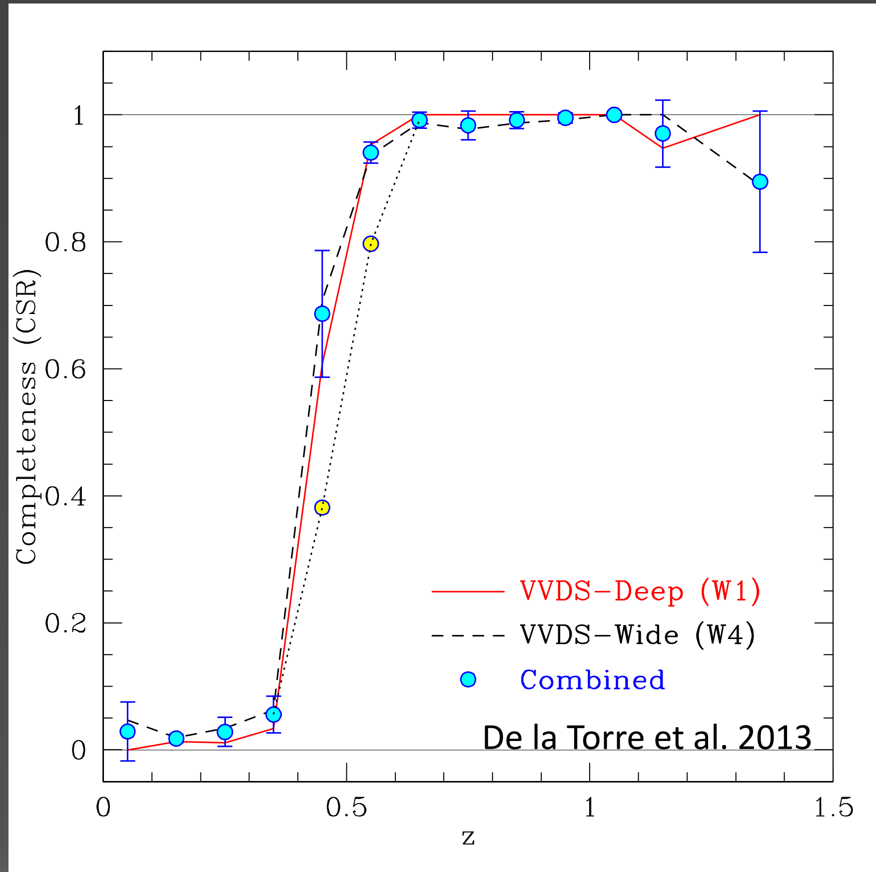
EFFECTIVE TARGETS	MEASURED REDSHIFTS	STELLAR CONTAMINATION	COVERED AREA
59013	55359	1750 (3.2 %)	63.6 %

- **193 VIMOS pointings, out of 288**
- W4 fully covered
- Major science papers based on V3.0 catalogue out in March 2013
- Public release of this same data set in September 2013
- Expected completion: 2014

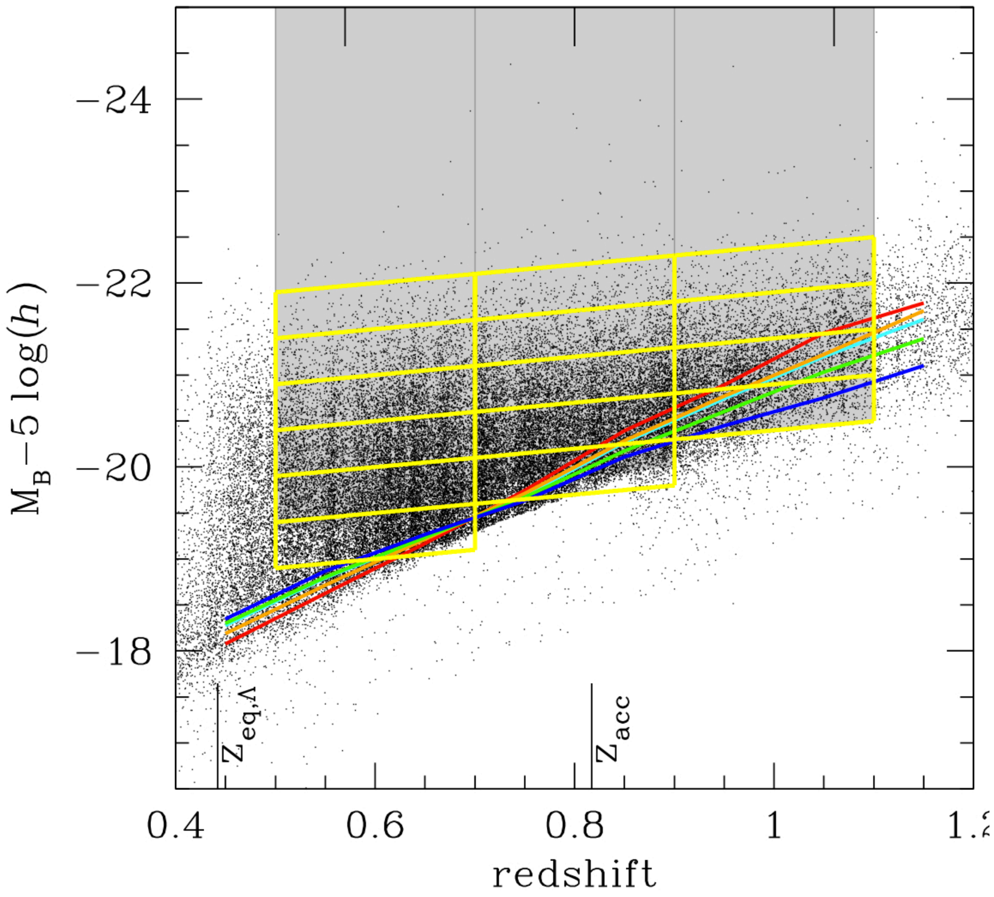


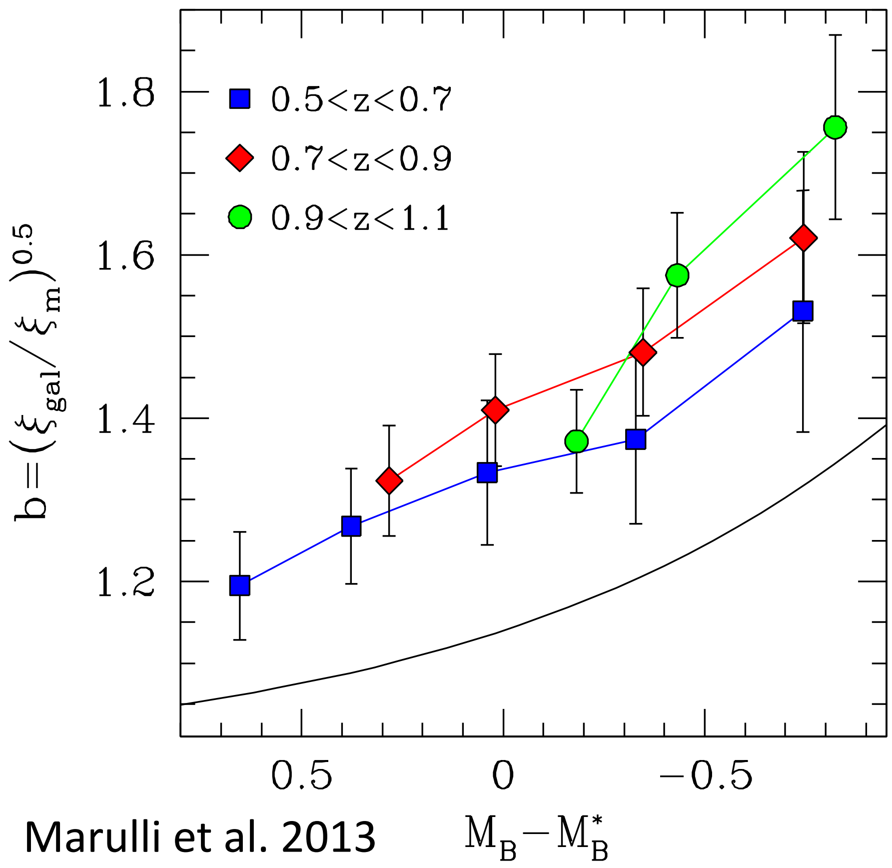
VIPERS COLOR-COLOR SELECTION: BENEFITING OF A GOOD MULTI-BAND PARENT SAMPLE TO ISOLATE z>0.5 GALAXIES





Linear bias from 2-point statistics (1-10 Mpc range)





Marulli et al. 2013

Galaxy bias from counts in cells

(Lahav & Dekel 1999, Sigad EB Dekel 2000)

If galaxy bias is a **local** process then it is completely characterized by the conditional probability $P(\delta_g|\delta)$. From which one can form the mean biasing function:

$$b(\delta_m)\delta_m \equiv \langle \delta_g | \delta_m \rangle = \int P(\delta_g|\delta_m)\delta_g d\delta_g$$

Its nontrivial second order moments

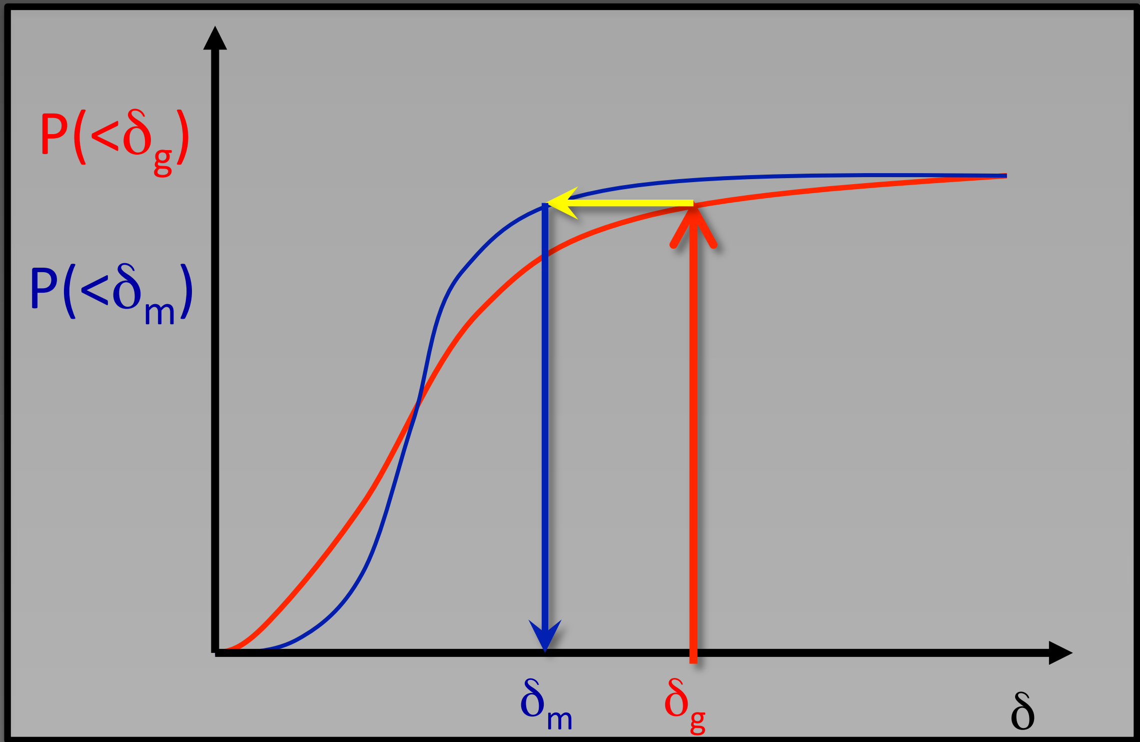
$$\hat{b} = \frac{\langle b(\delta_m)\delta_m^2 \rangle}{\sigma_m^2}; \quad \tilde{b} = \frac{\langle b^2(\delta_m)\delta_m^2 \rangle}{\sigma_m^2}$$

And the biasing scatter or stochasticity

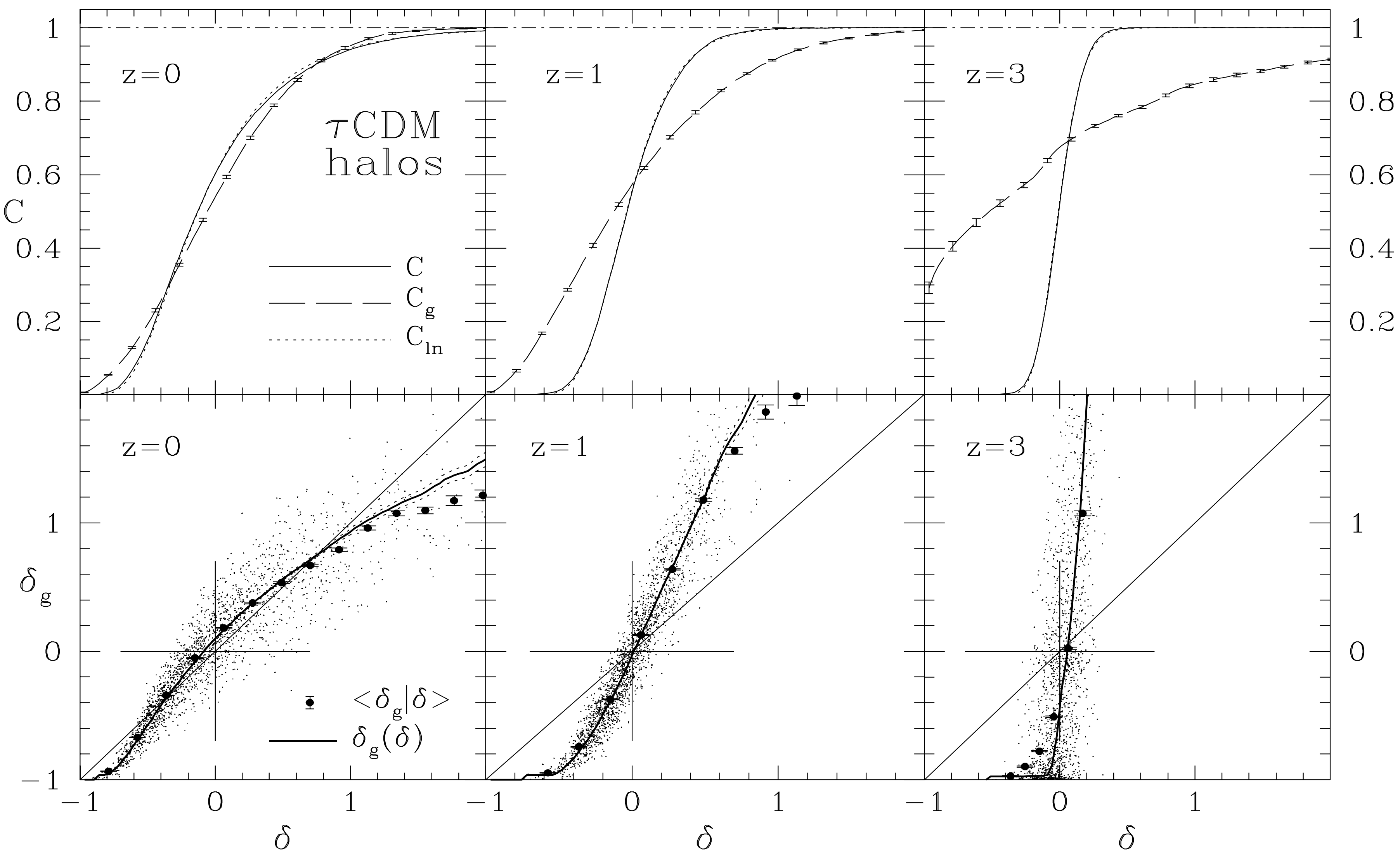
$$\sigma_b^2(\delta) = \frac{\langle \varepsilon^2 | \delta \rangle}{\sigma_m^2}; \quad \varepsilon = \delta_g - \langle \delta_g | \delta \rangle$$

A practical estimator of galaxy bias

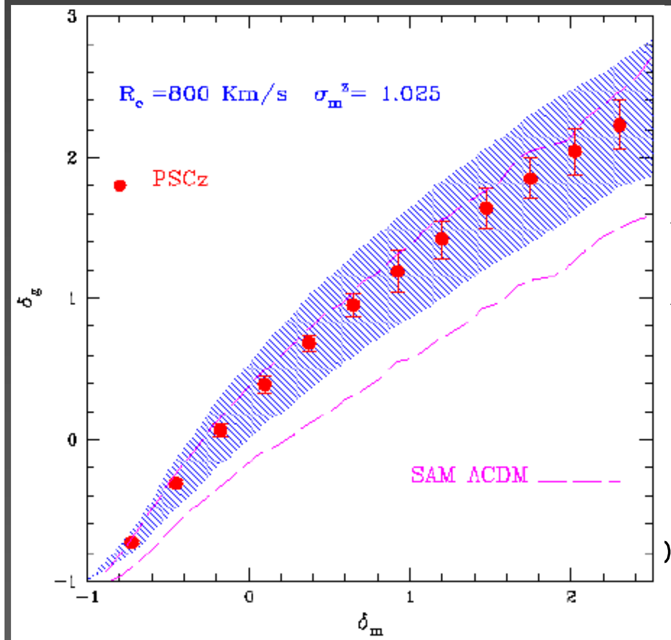
If the bias is **deterministic** (if stochasticity can be ignored) then the ranking of density fluctuations in mass and galaxy is preserved and the mean basing function can be estimated from the 1-point probability functions of mass and galaxies.



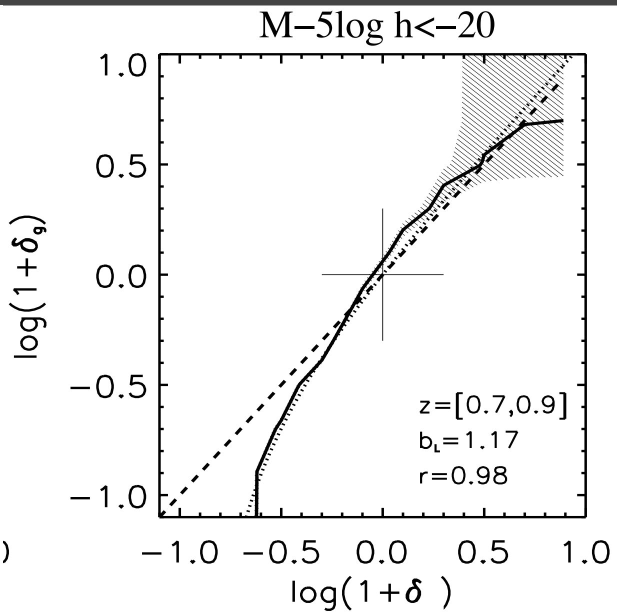
Sigad, EB & Dekel 2000



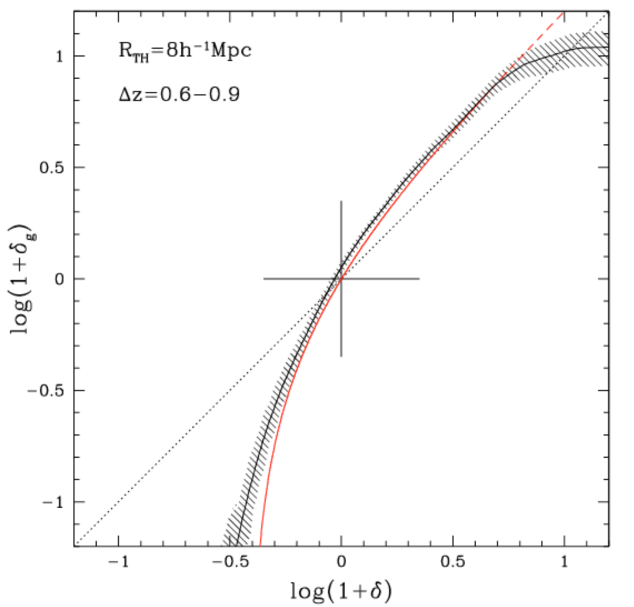
This is a powerful method to assess deviations from linearity as the ratio $\tilde{b}/\hat{b}$ is almost independent on the *rms* amplitude of the mass fluctuations (whereas the second order moments linearly depends on σ_m)



IRAS PSCz galaxies
(E.B. 2001)



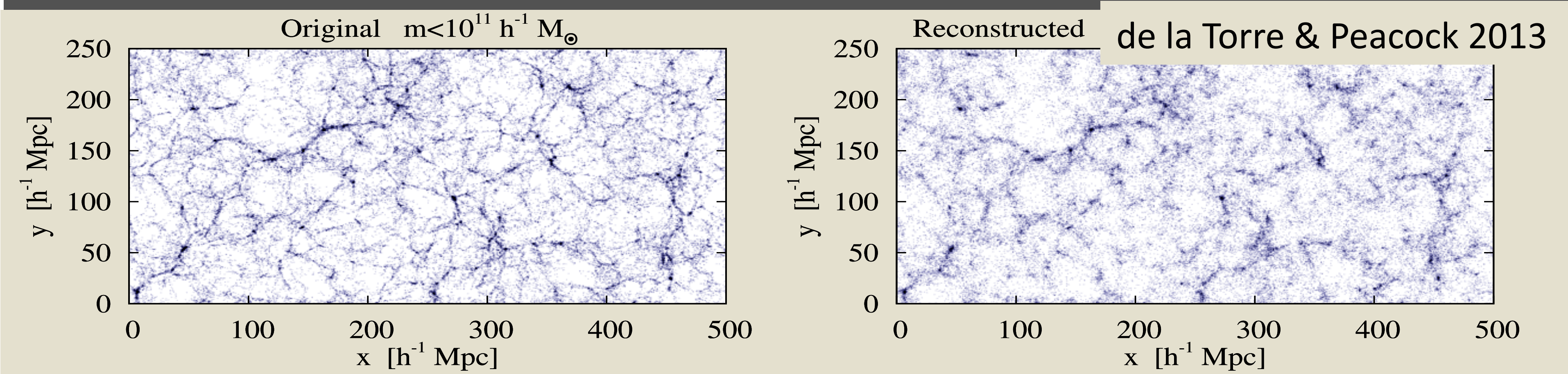
VVDS Deep Field
(Marinoni et al. 2005)



zCOSMOS galaxies
(Kovac et al. 2011)

Improving the Estimator

Need for a better estimator, especially if one is interested in small scales where shot noise is large.
Improvement should be adequate to the dataset and quantified using mock galaxy catalogs.
It is desirable to use different types of mock galaxies (e.g. SAM vs. HOD)

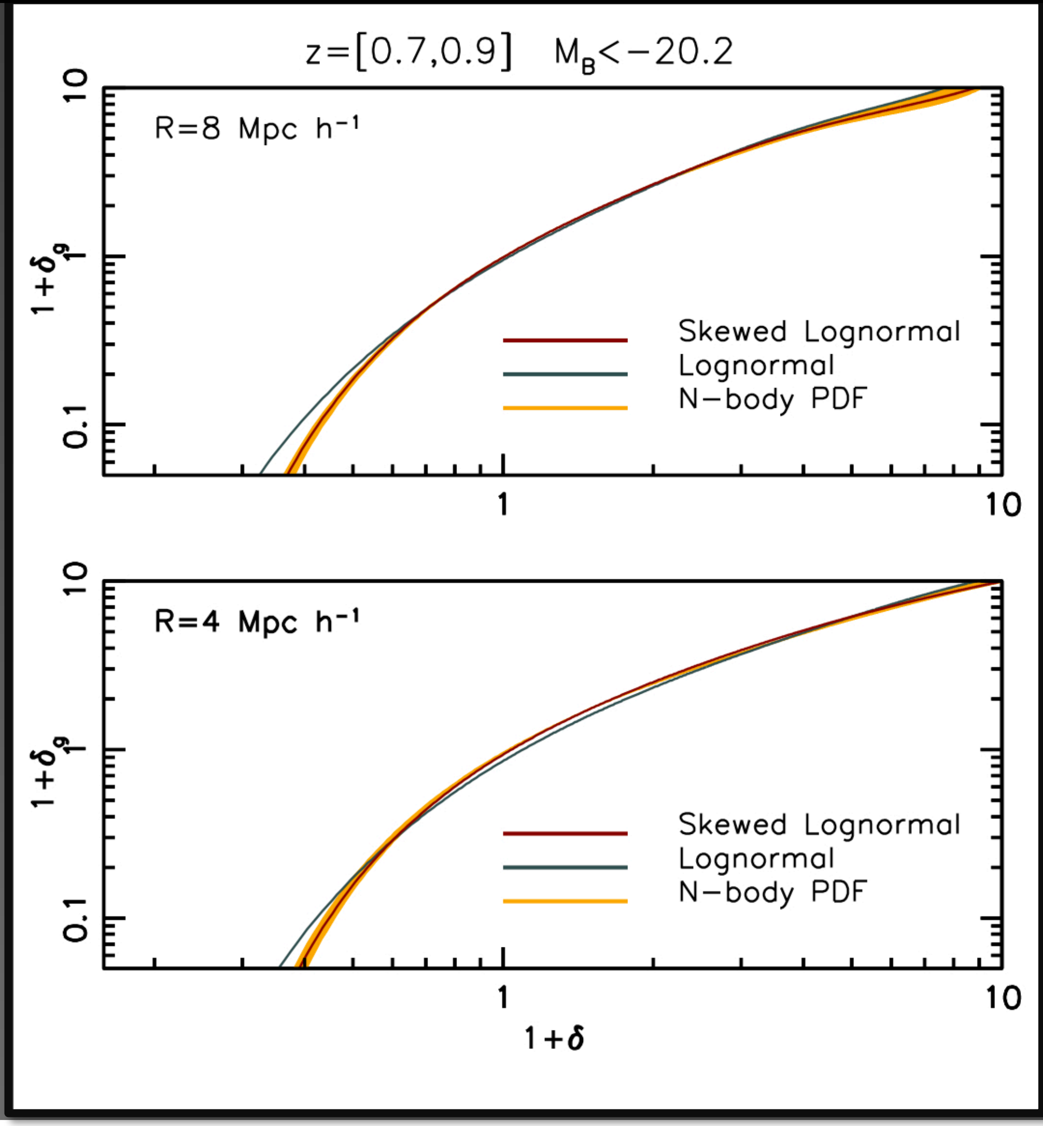


de la Torre & Peacock 2013

N.B. all tests / error analyses have beep performed using mocks mimicking Volume-limited, luminosity complete VIPERS sub-samples

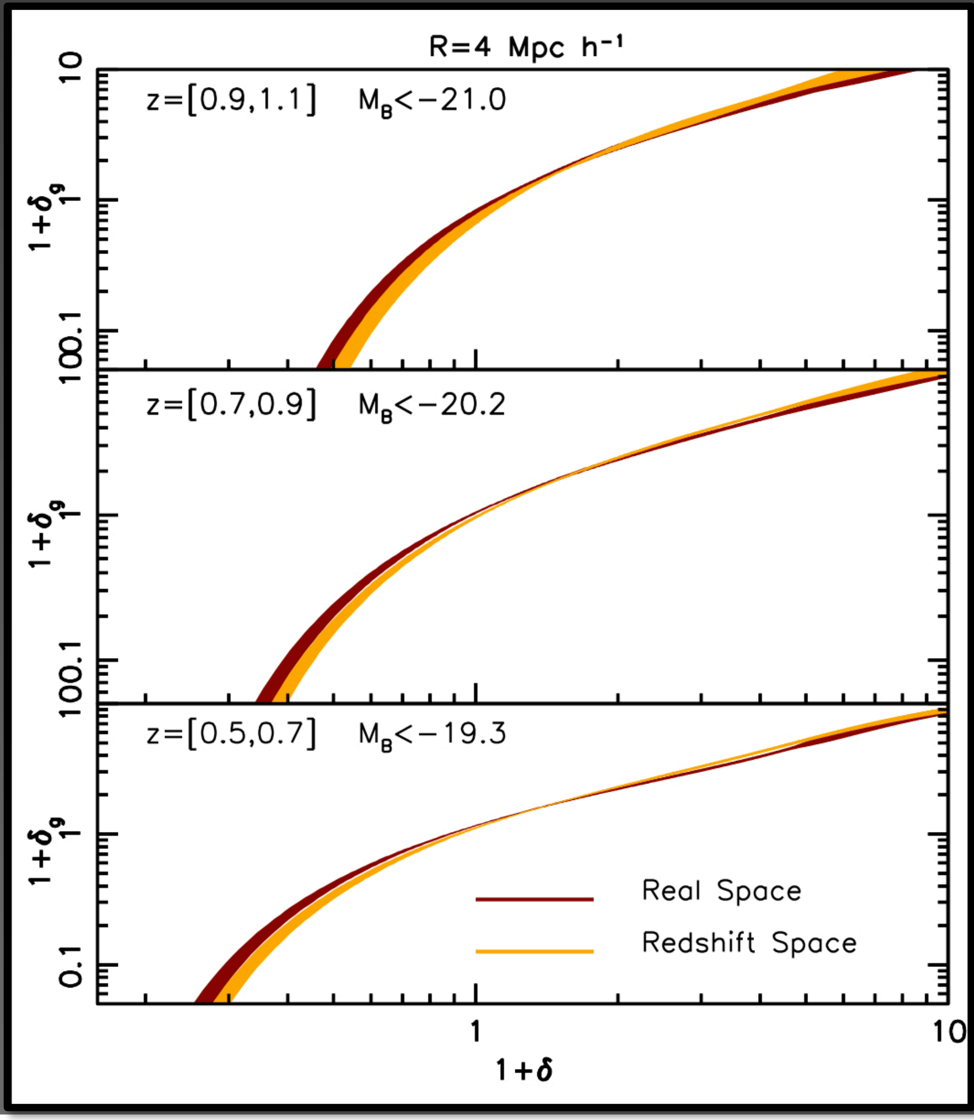
Estimator issues: mass PDF

So far all practical applications have assumed a lognormal model for the mass PDF.



Estimator issues: z-distortions

Galaxy PDF is measured in redshift space while we are interested in the real-space bias galaxy bias.



Estimator issues: shot noise

A large fraction of stochasticity is contributed by discrete sampling. Galaxy PDF is related to the probability of counts in cells through

$$P_N = \int_{-1}^{\infty} P(\delta_g) P(N_g|\delta_g) d\delta_g; \quad P(N|\delta) = \frac{[\langle N\rangle(1+\delta)]^N e^{-\langle N\rangle(1+\delta)}}{N!}$$

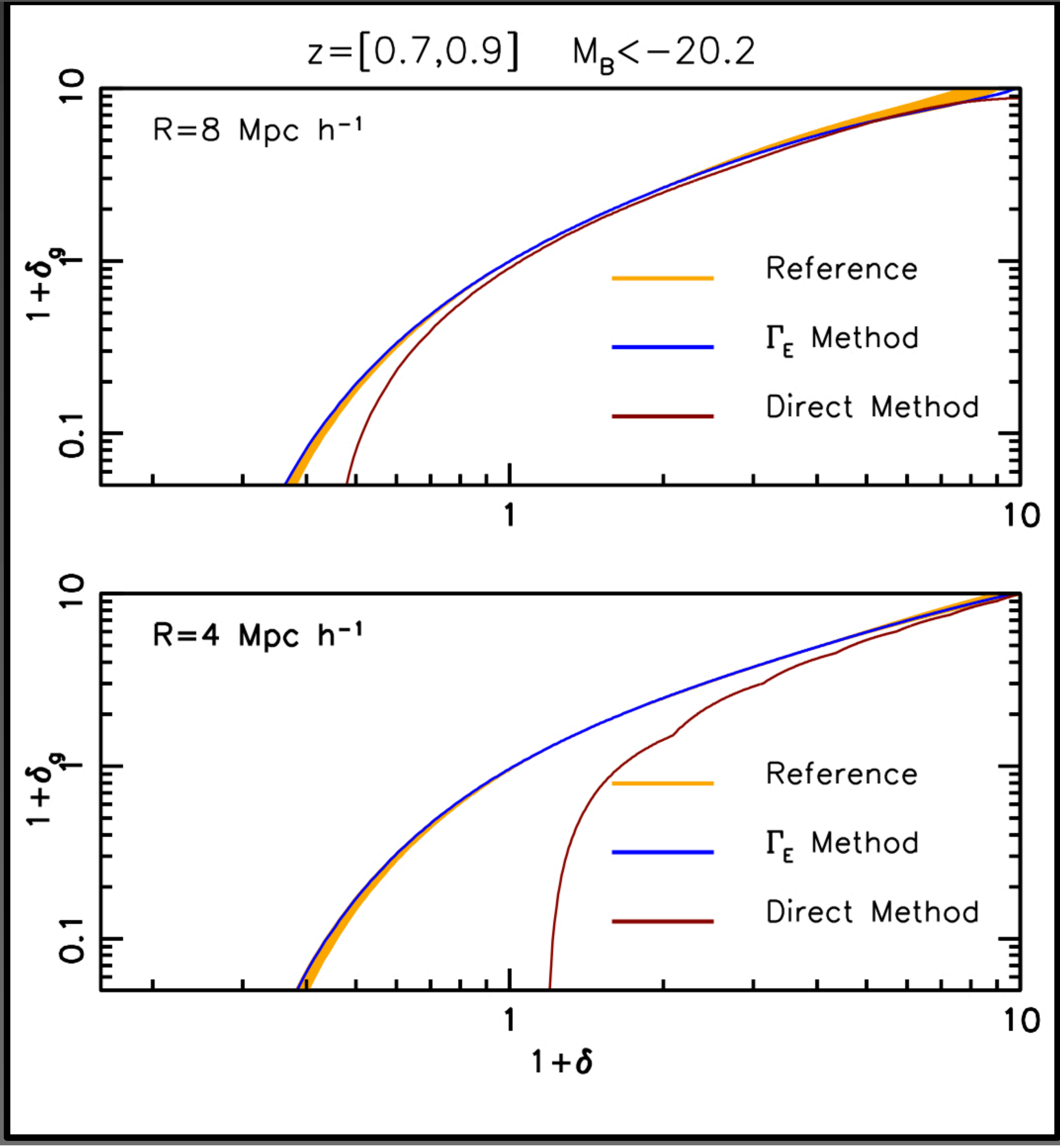
Note: the Poisson hypothesis is often adopted (and will also be used in this talk) but in principle one can use any other kernel.

Various techniques have been proposed to reconstruct $P(\delta_g)$ from $P(N_g)$

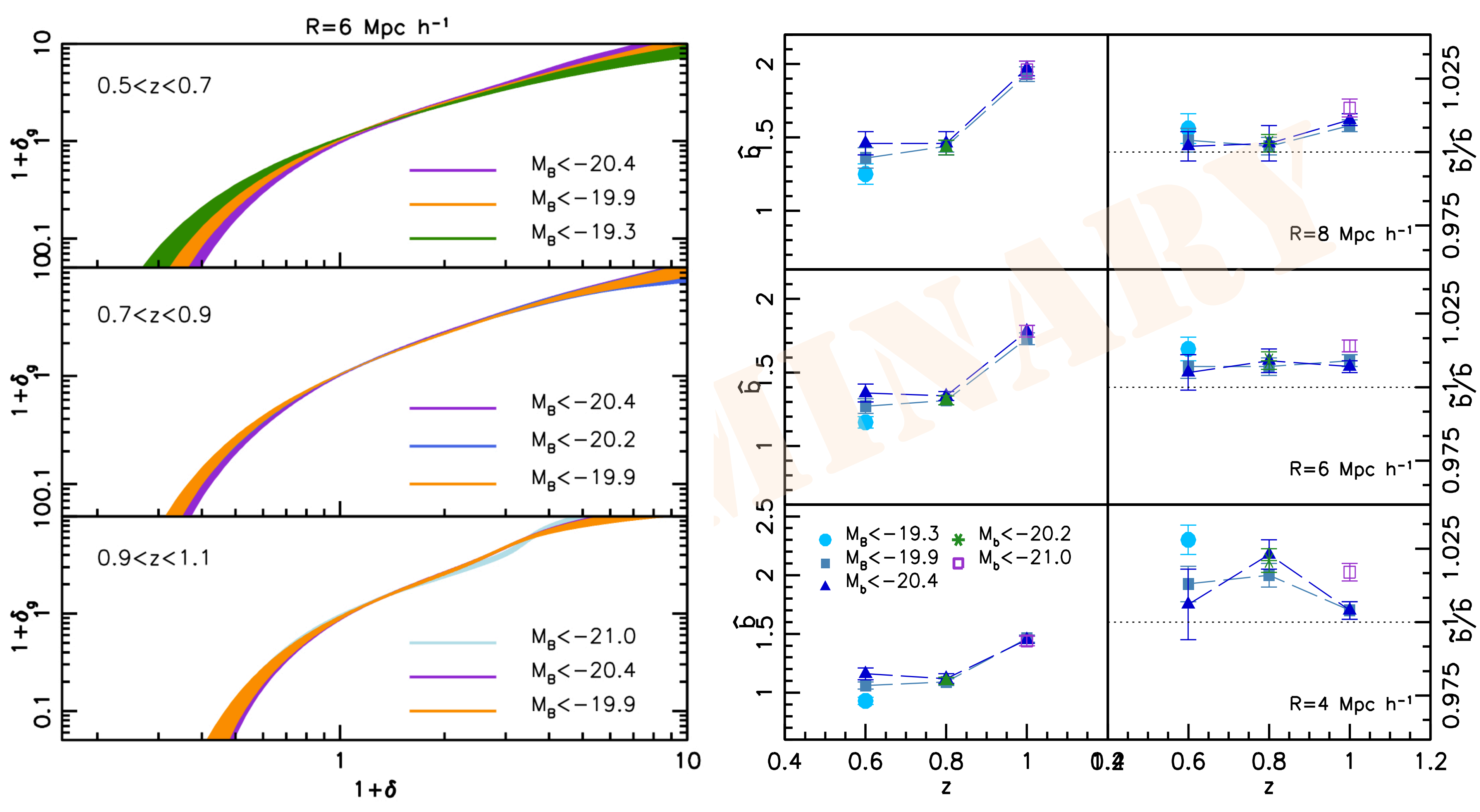
1. The iterative Richardson-Lucy deconvolution (Szapudi & Pan 2004)
2. Skewed-lognormal fit to $P(\delta_g)$ (Szapudi & Pan 2004)
3. Γ-expansion for $P(\delta_g)$ using the factorial moments of the counts (Bel et al. 2013)

With the sampling rate considered here ($\langle N\rangle > 0.5$) these methods give similar results. Here we use method #3.

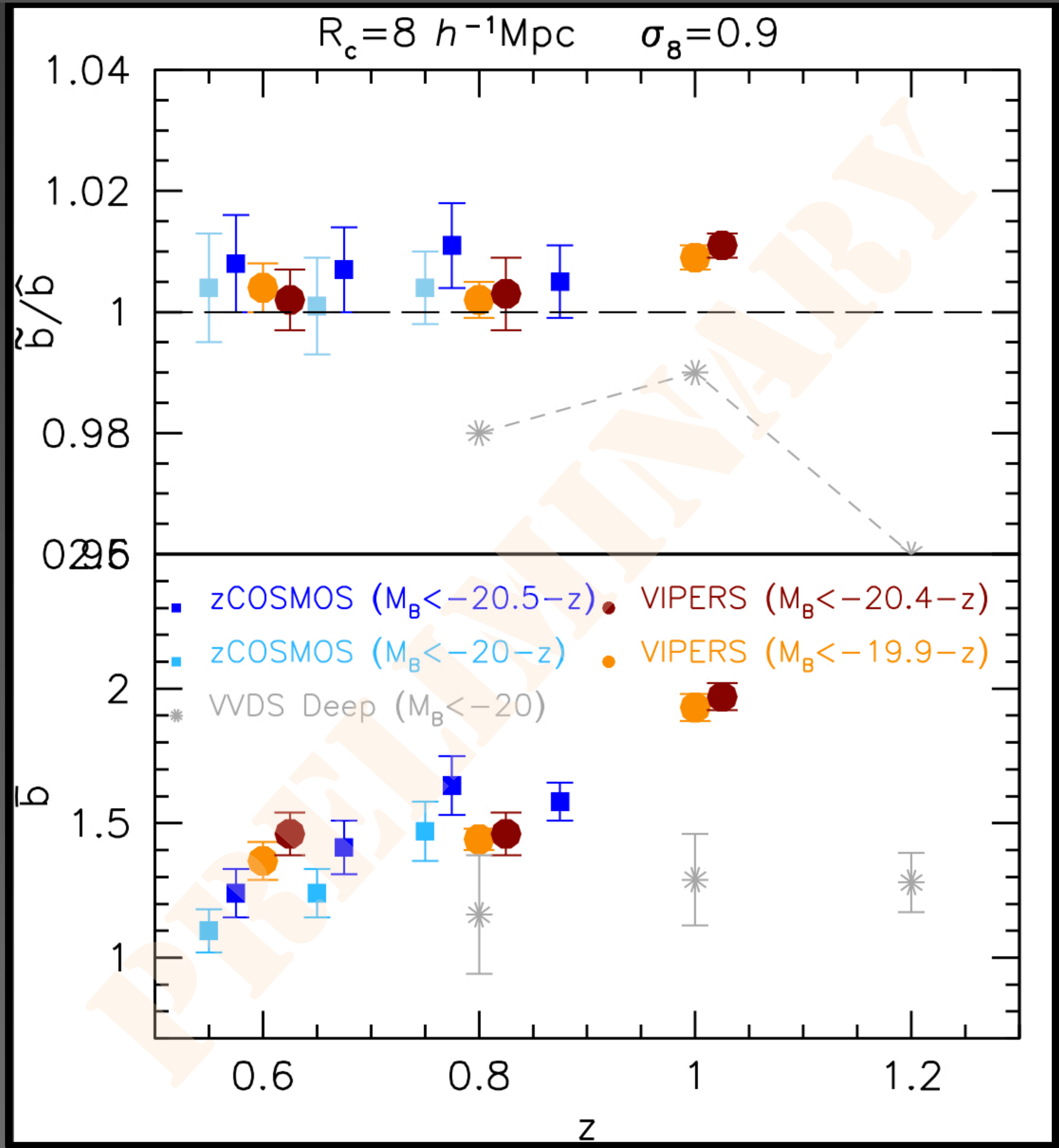
Estimator issues: shot noise



RESULTS: M- R- and z-dependence



Reconstructing the mean biasing function and its 2nd order moments: comparison with previous results



Tentative Conclusions

- A new estimate of nonlinear galaxy bias at z~1
- Nonlinearity detected.
- Previous inconsistencies (VVDS vs. zCOSMOS) due to limited volumes.
- Method used seems adequate for the VIPERS sample…
- …and could be (easily ?) improved.