Workshop on galaxy bias (Trieste, October 2013)

An “unbiased” estimate of the matter density parameter from VIPERS

Bel & Marinoni 2013, submitted

Bel, Marinoni, Granett, Guzzo, Peacock et al. (The VIPERS Team) 2013, submitted

Julien BEL
Osservatorio Astronomico di Brera (MERATE)

A work supervised by **Christian MARINONI**
Centre de Physique Théorique (MARSEILLE)

Outline

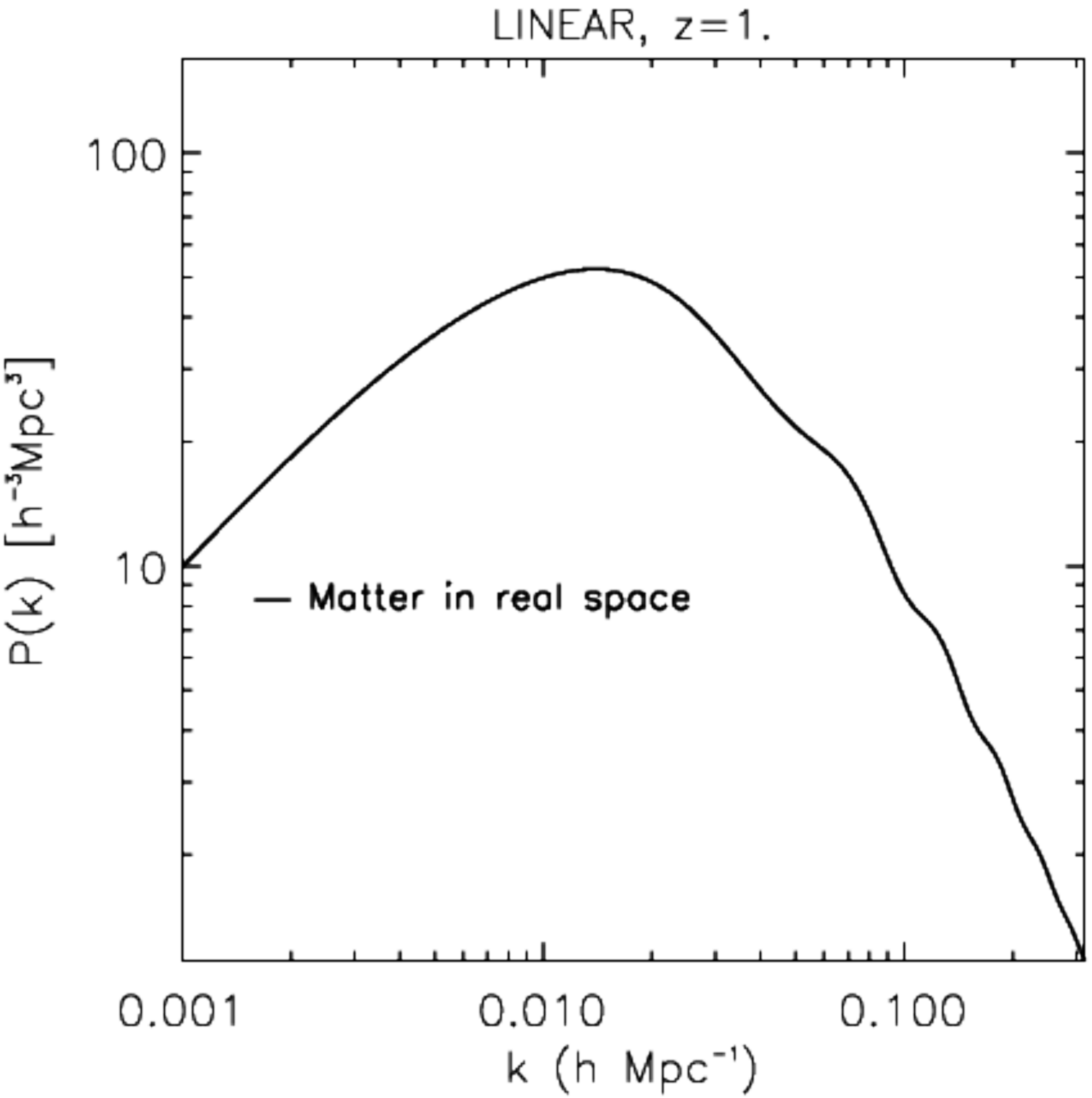
- Goal: fixing the matter power spectrum

- Tool: a new clustering statistic, the clustering ratio

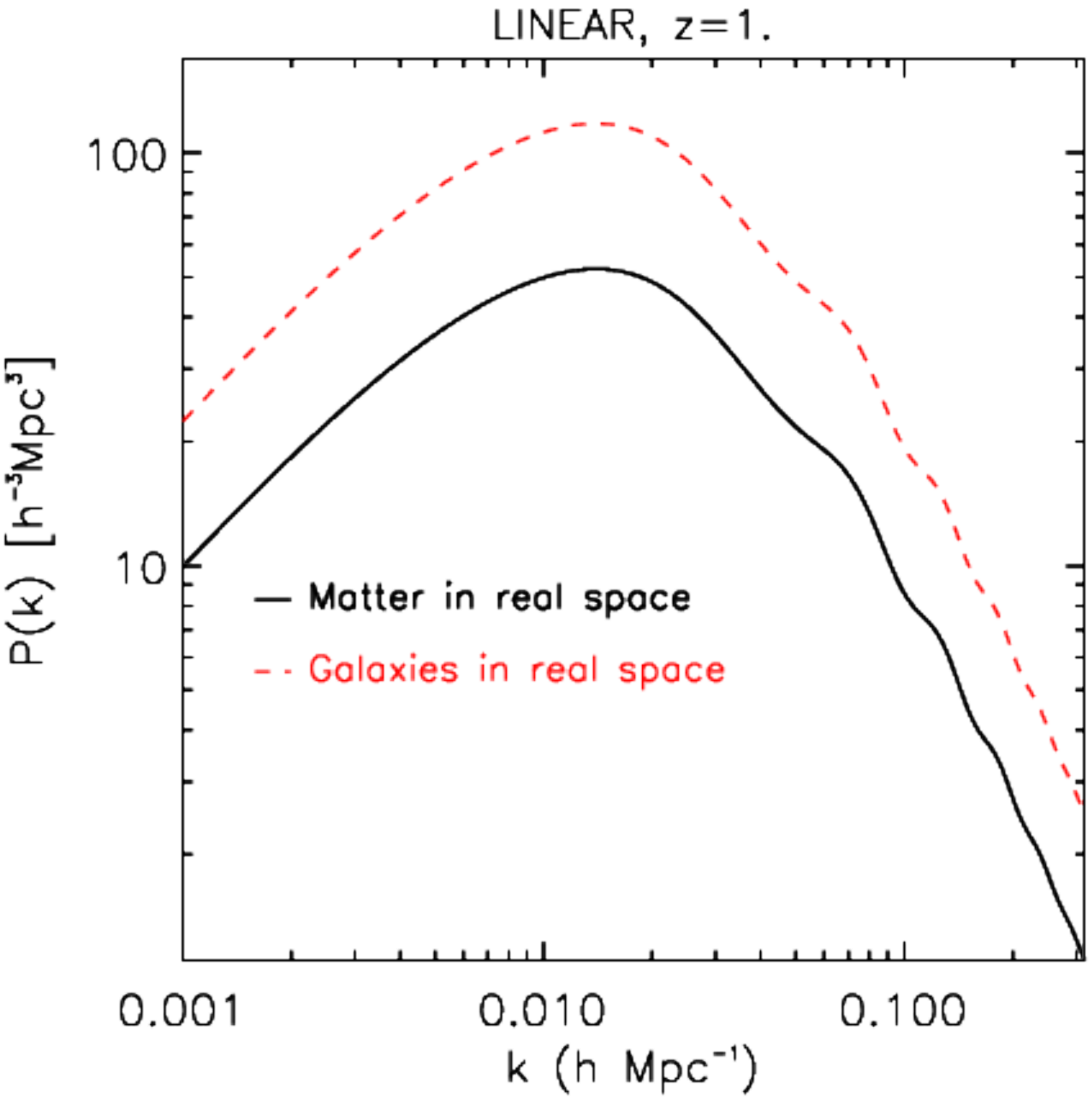
- Test: blind analysis of simulations

- Results: Omega_m from SDSS DR7 and VIPERS PDR1

The Matter power spectrum



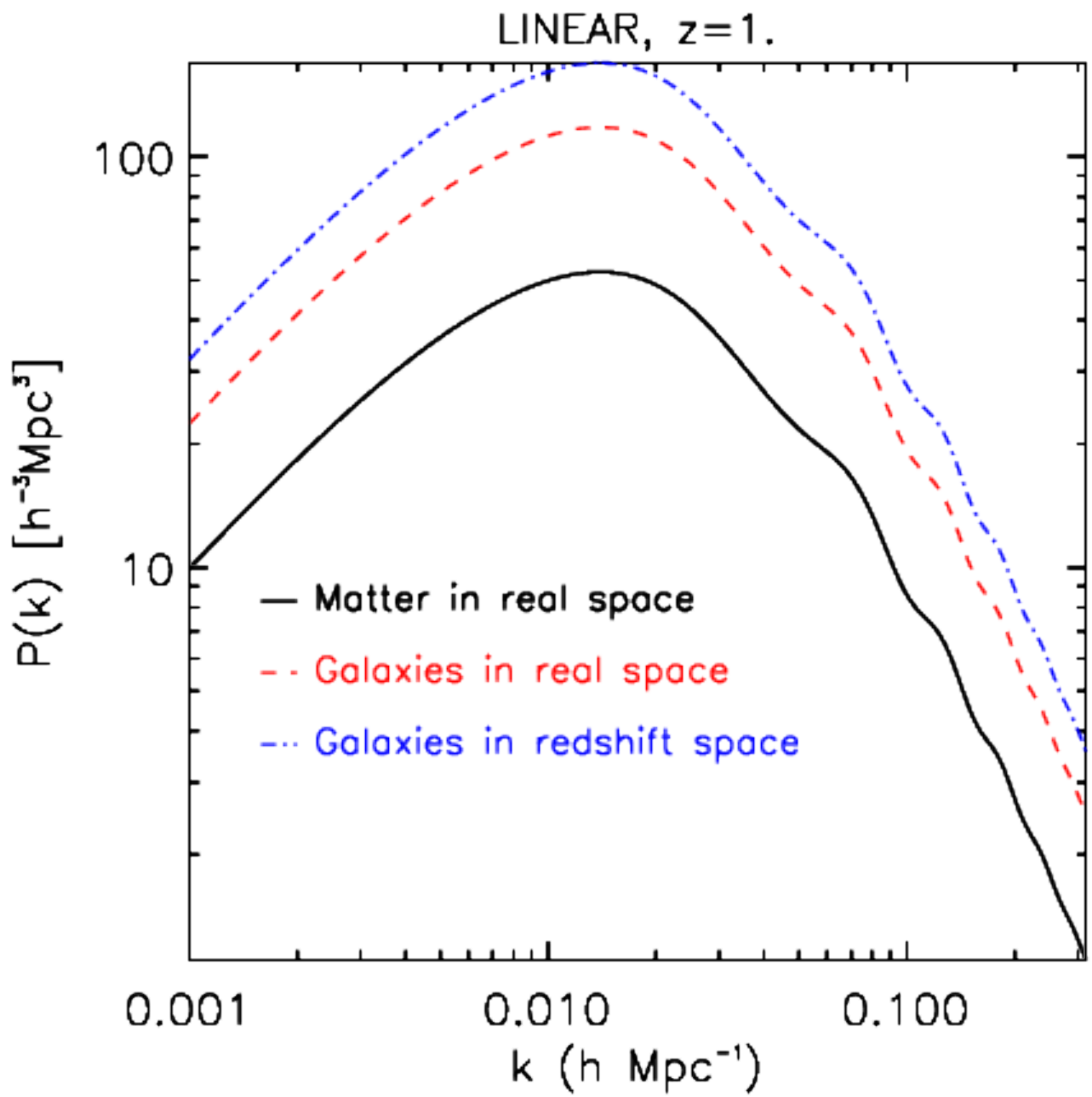
The Matter power spectrum



$$\delta_{g,R} = \sum_{i=0}^{N} \frac{b_i}{i!} \delta_R^i$$

Fry & Gaztañaga (1993)

The Matter power spectrum



$$\delta_{g,R} = \sum_{i=0}^{N} \frac{b_i}{i!} \delta_R^i$$

Fry & Gaztañaga (1993)

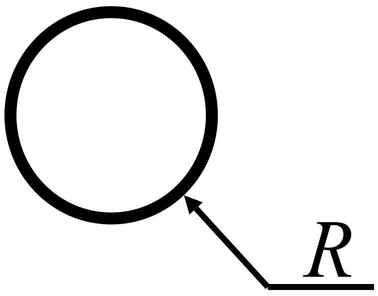
$$\delta_{g,R}{}^z = \delta_{g,R} + \mu_k{}^2 f^2 \delta_R$$

Kaiser (1987)

Statistical properties of smoothed over-densities

Variance of fluctuations in spheres:

$$\sigma^2_{g,R} = \left\langle \delta_{g,R}{}^2(\vec{x}) \right\rangle$$



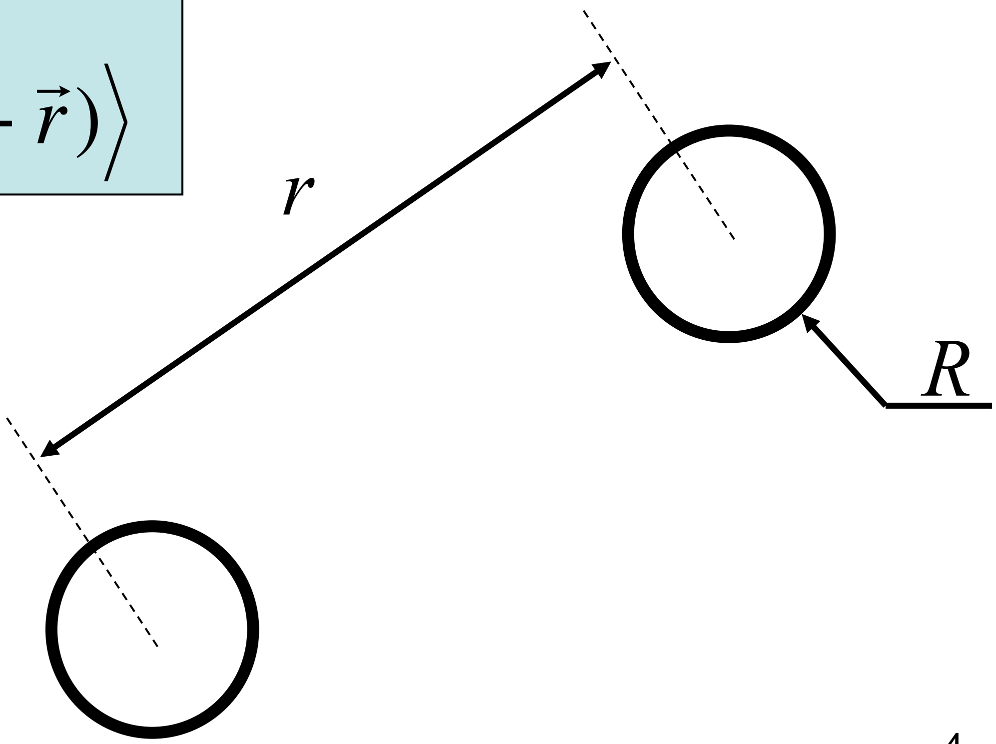
Statistical properties of smoothed over-densities

Variance of fluctuations in spheres:

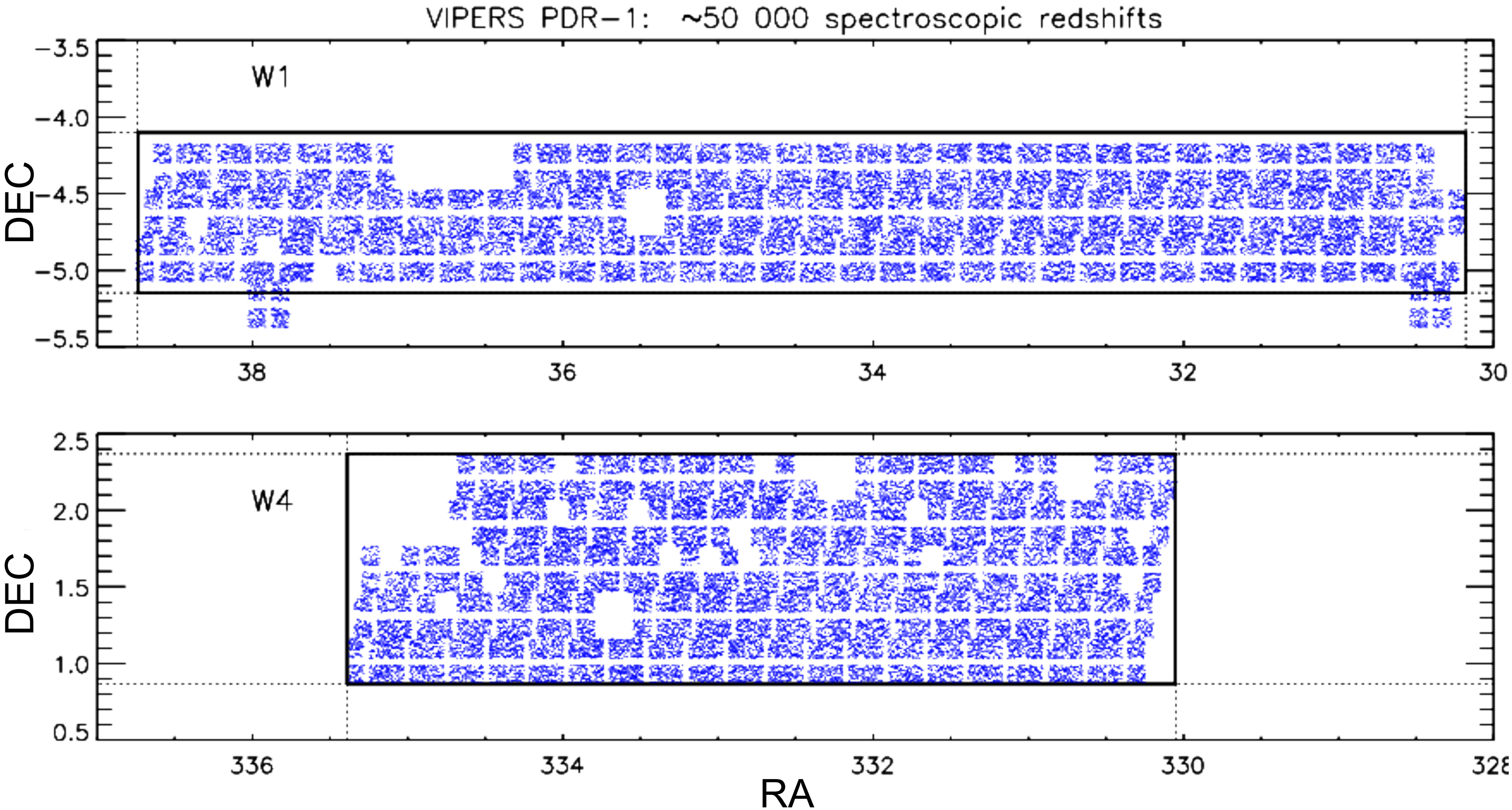
$$\sigma^2_{g,R} = \left\langle \delta_{g,R}{}^2(\vec{x}) \right\rangle$$

2-point correlation function:

$$\xi_{g,R}(r) = \left\langle \delta_{g,R}(\vec{x})\delta_{g,R}(\vec{x}+\vec{r}) \right\rangle$$

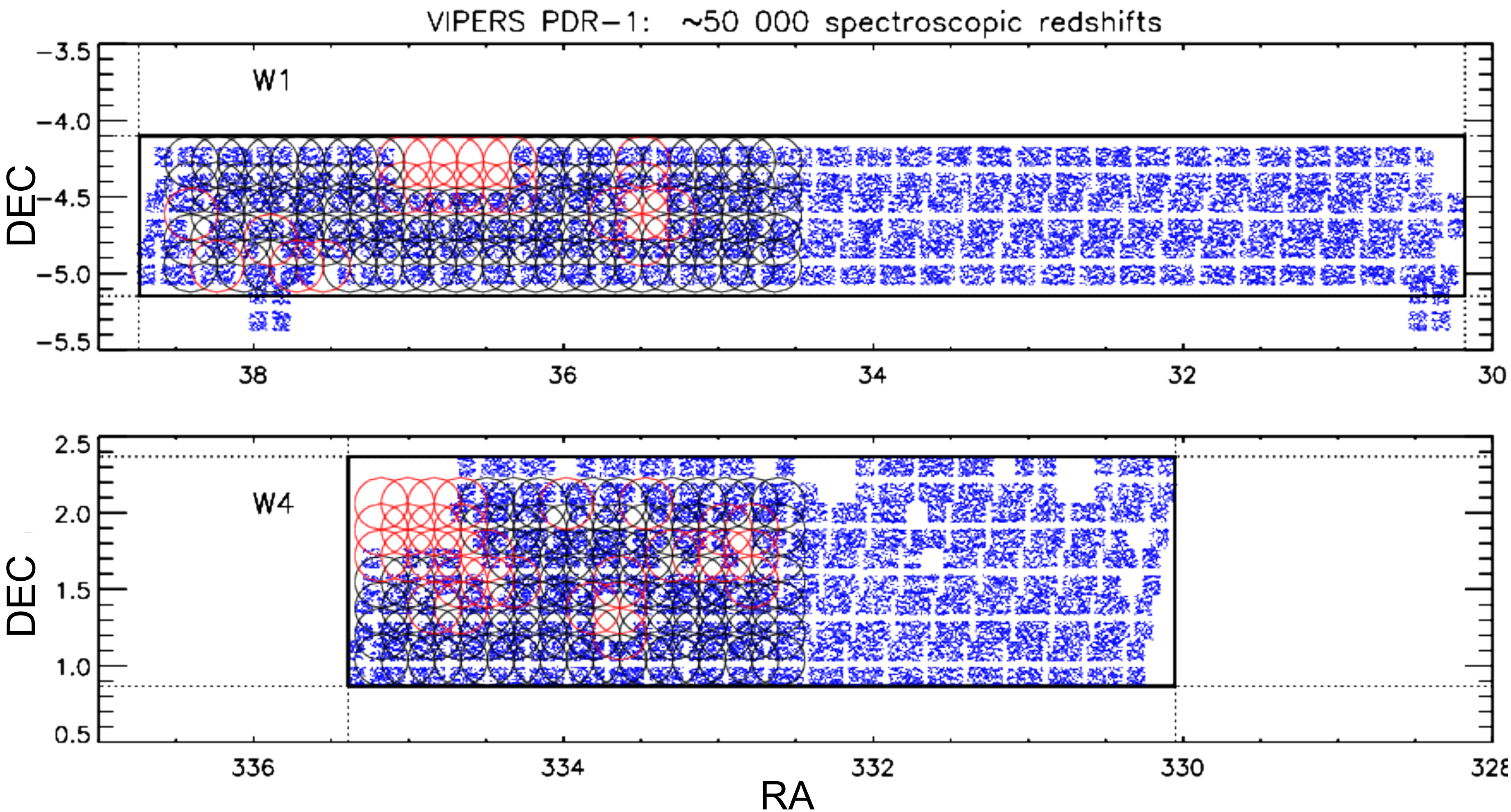


Statistical properties of smoothed over-densities



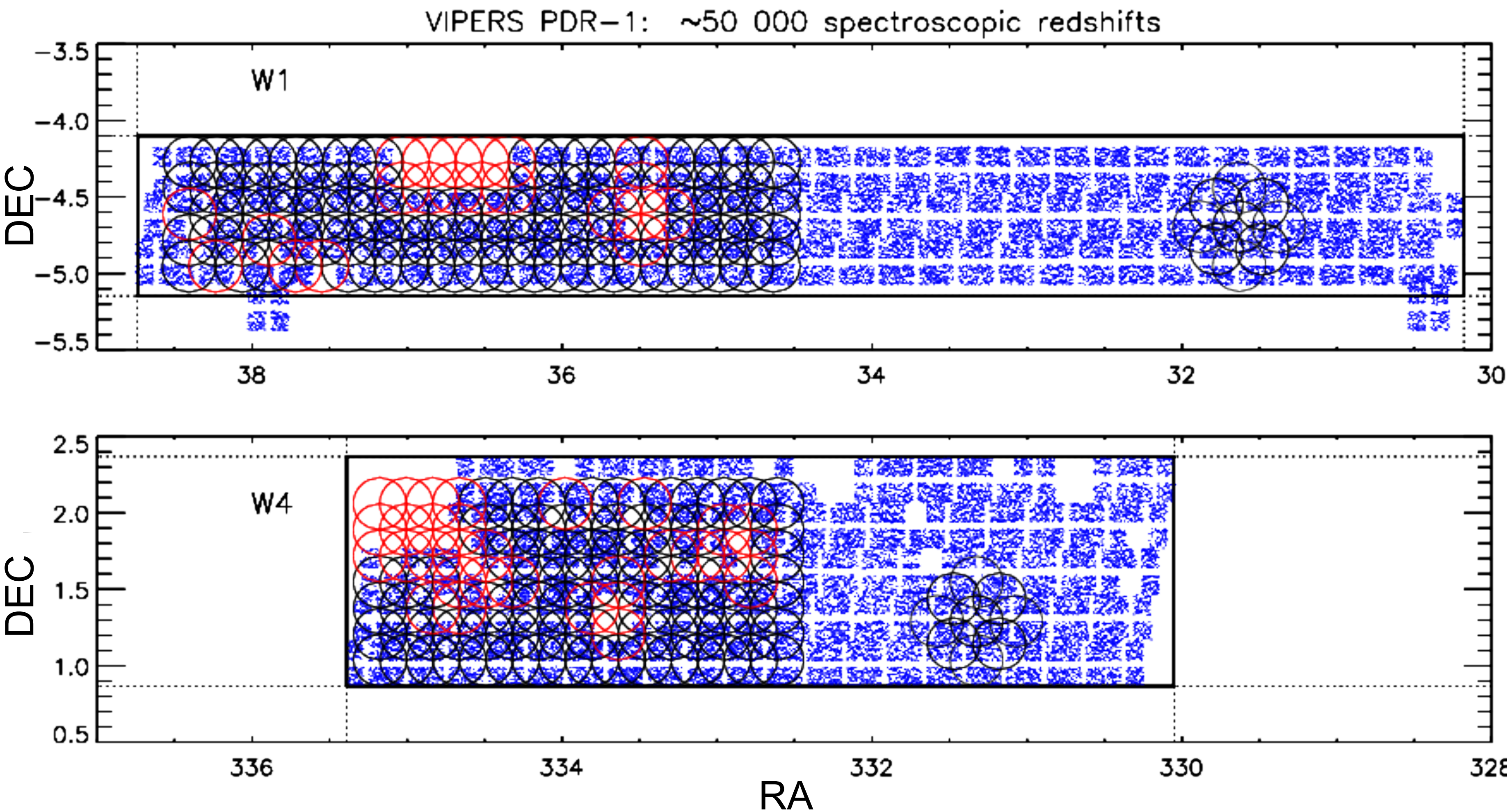
Survey description in Guzzo et al. (arXiv:1303.2623G) and data access to PDR-1 in Garilli et al. (arXiv:1310.1008G)

Statistical properties of smoothed over-densities



Survey description in Guzzo et al. (arXiv:1303.2623G) and data access to PDR-1 in Garilli et al. (arXiv:1310.1008G)

Statistical properties of smoothed over-densities



Survey description in Guzzo et al. (arXiv:1303.2623G) and data access to PDR-1 in Garilli et al. (arXiv:1310.1008G)

Statistical properties of smoothed over-densities

variance of smoothed matter field: $\sigma_R^2(z) = g^2(z).\sigma_8^2(0).F_R$

2-point correlation function of smoothed matter field: $\xi_R(r,z) = g^2(z).\sigma_8^2(0).G_R(r)$

Statistical properties of smoothed over-densities

variance of smoothed matter field: $\sigma_R^2(z) = g^2(z).\sigma_8^2(0).F_R$

2-point correlation function of smoothed matter field: $\xi_R(r,z) = g^2(z).\sigma_8^2(0).G_R(r)$

$$F_R = \frac{\int_0^{+\infty} \Delta_k W_{TH}^2(kR) d\ln k}{\int_0^{+\infty} \Delta_k W_{TH}^2(kr_8) d\ln k} \quad \text{and} \quad G_R(r) = \frac{\int_0^{+\infty} \Delta_k(z) W_{TH}^2(kR) j_0(kr) d\ln k}{\int_0^{+\infty} \Delta_k(z) W_{TH}^2(kr_8) d\ln k}$$

where $\Delta_k = 4\pi\ k^3 P(k)$ is the dimensionless power spectrum

and $W_{TH}(kR) = \frac{3}{(kR)^3}\left[\sin(kR) - kR\cos(kR)\right]$

Bel & Marinoni 2012 (MNRAS)

Statistical properties of smoothed over-densities

variance of smoothed matter field: $\sigma_R^2(z) = g^2(z).\sigma_8^2(0).F_R$

2-point correlation function of smoothed matter field: $\xi_R(r,z) = g^2(z).\sigma_8^2(0).G_R(r)$

$$F_R = \frac{\int_0^{+\infty} \Delta_k W_{TH}^2(kR)\, d\ln k}{\int_0^{+\infty} \Delta_k W_{TH}^2(kr_8)\, d\ln k}$$

and

$$G_R(r) = \frac{\int_0^{+\infty} \Delta_k(z) W_{TH}^2(kR)\, j_0(kr)\, d\ln k}{\int_0^{+\infty} \Delta_k(z) W_{TH}^2(kr_8)\, d\ln k}$$

- **Redshift evolution**
- **Non linear bias**
- **Redshift distortions**

The clustering ratio

The galaxy clustering ratio:

$$\eta_{g,R}(r) \equiv \frac{\xi_{g,R}(r)}{\sigma^2_{g,R}}$$

The matter clustering ratio:

$$\eta_R(r) = \frac{G_R(r)}{F_R}$$

$$\eta_{g,R}(r) = \eta_R(r) - \left\{ \left(S_{3,R} - C_{12,R} \right) c_2 + 1/2c_2^2 \right\} \xi_R(r) + 1/2c_2^2 \eta_R(r) \xi_R(r)$$

If second order bias coefficient satisfies to $|c_2| < 1$

$$\boxed{\eta_{g,R}(r) = \eta_R(r)}$$

Bel & Marinoni 2012 (MNRAS)

The clustering ratio

The galaxy clustering ratio:

$$\eta_{g,R}(r) \equiv \frac{\xi_{g,R}(r)}{\sigma^2_{g,R}}$$

The matter clustering ratio:

$$\eta_R(r) = \frac{G_R(r)}{F_R}$$

$$\eta_{g,R}(r) = \eta_R(r) - \left\{ \left(S_{3,R} - C_{12,R} \right) c_2 + 1/2 c_2^2 \right\} \xi_R(r) + 1/2 c_2^2 \eta_R(r) \xi_R(r)$$

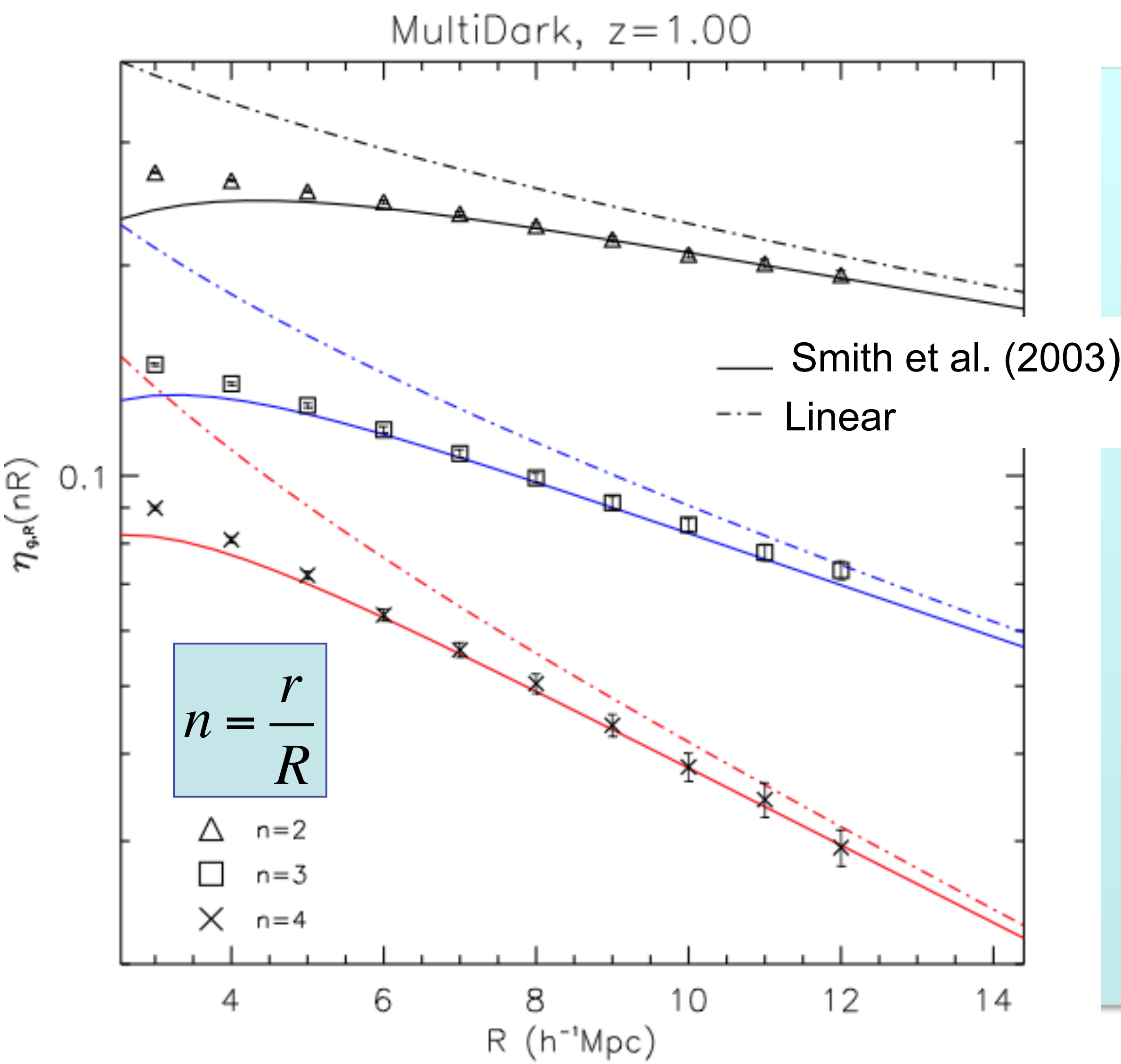
If second order bias coefficient satisfies to $|c_2| < 1$

$$\boxed{\eta_{g,R}(r) = \eta_R(r)}$$

What you see (clustering of galaxies) is what you get (clustering of matter)

Bel & Marinoni 2012 (MNRAS)

The clustering ratio in the weakly non linear regime



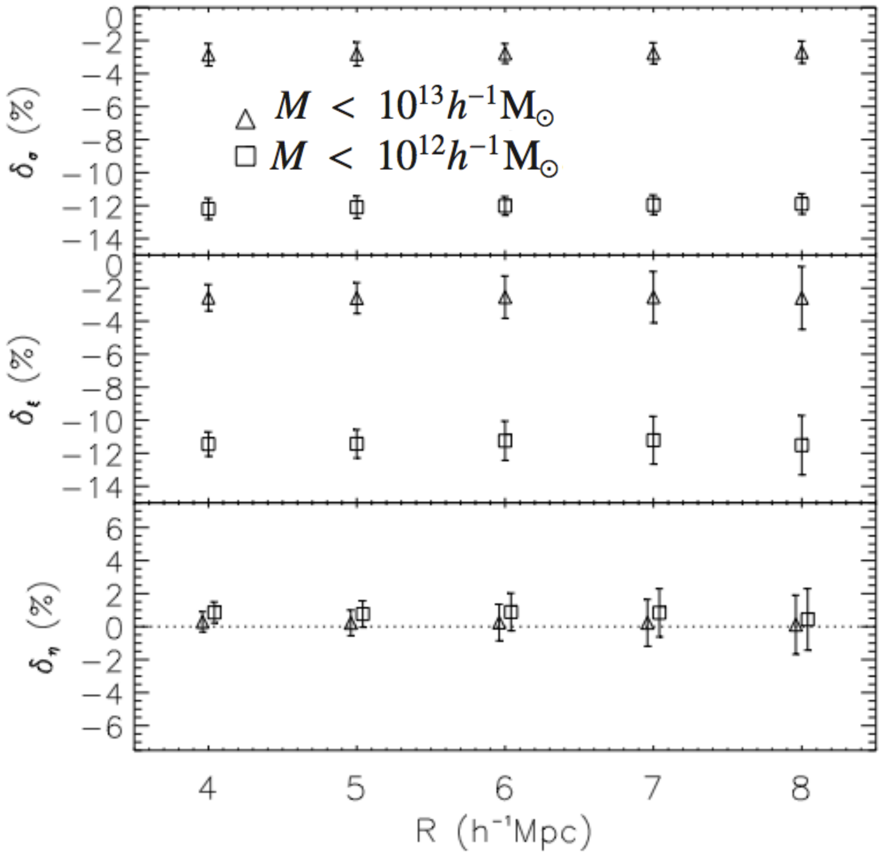
1 h^{-3} Gpc^3 comoving output at z=1 of MultiDark simulation

(Prada et al. 2012)

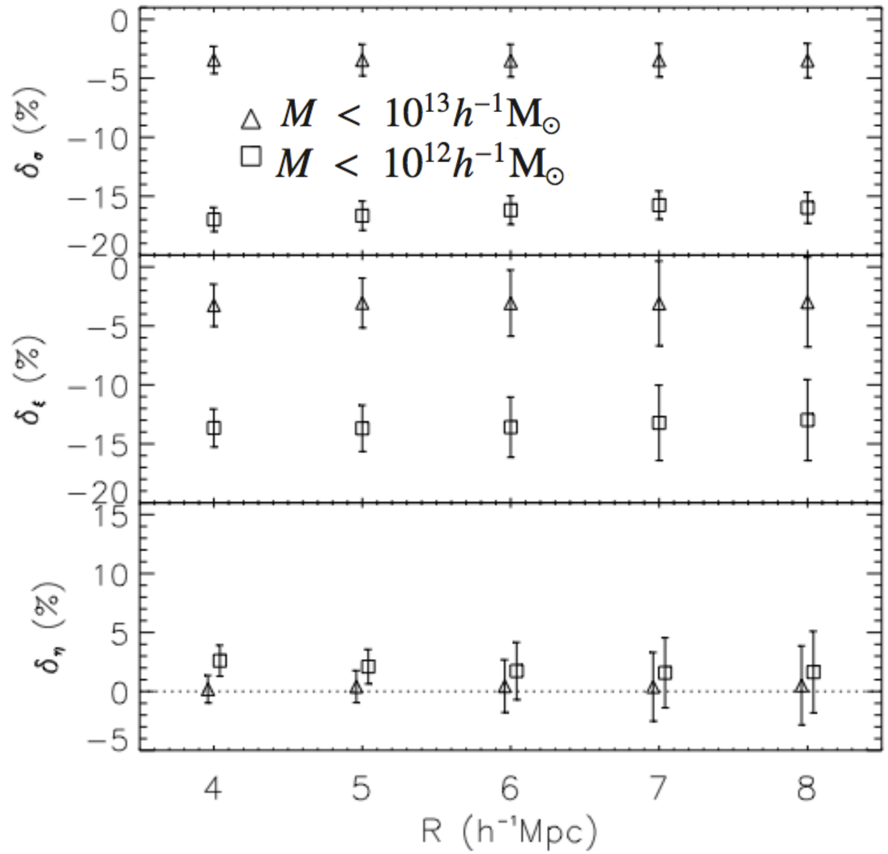
14 millions of Haloes with masses between $10^{11.5}$ h^{-1} and $10^{14.5}$ h^{-1} solar masses

The clustering ratio Vs Halo bias

Real space (comoving output):



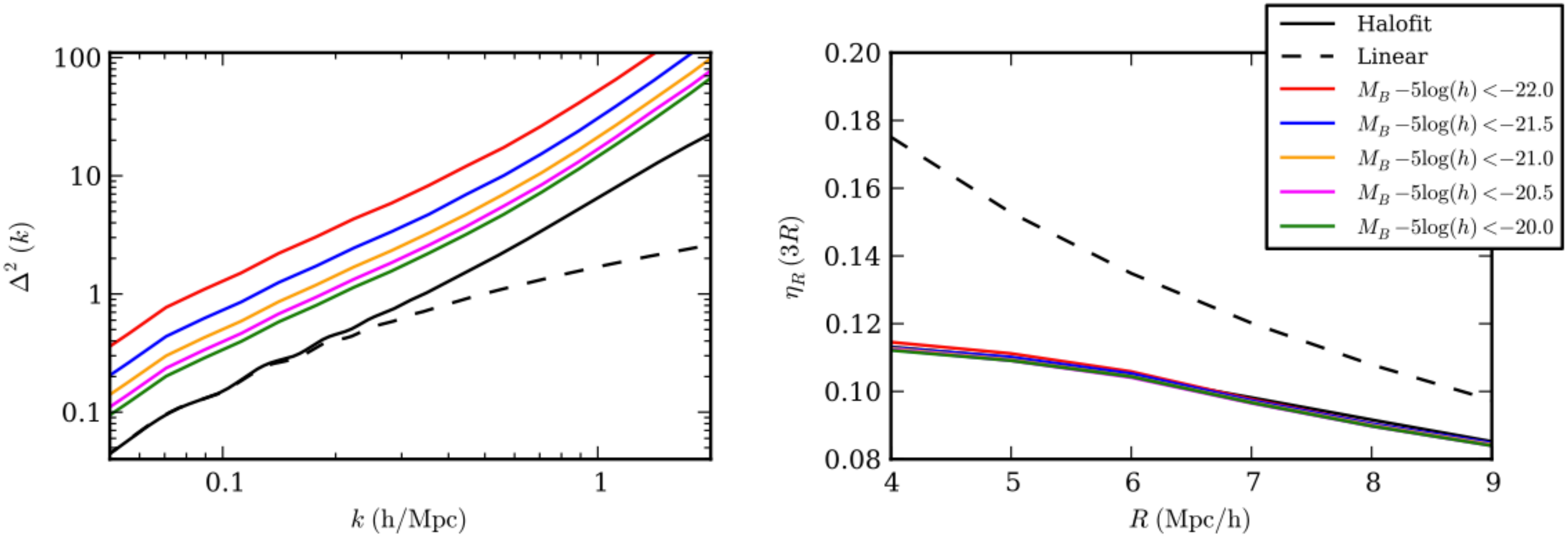
Redshift space (light cone):



$$n = \frac{r}{R} = 3$$

The clustering ratio Vs Galaxy bias

Impact of scale dependent bias:



Analysis performed on HOD galaxy mock catalogues described in de la Torre et al. (2013)

The clustering ratio as a cosmological test

The galaxy clustering ratio:

$$\eta_{g,R}(r) \equiv \frac{\xi_{g,R}(r)}{\sigma^2_{g,R}}$$

The matter clustering ratio:

$$\eta_R(r) = \frac{G_R(r)}{F_R}$$

$$\eta_{g,R}(r) = \eta_R(r) - \left\{ \left(S_{3,R} - C_{12,R} \right) c_2 + 1/2c_2^2 \right\} \xi_R(r) + 1/2c_2^2 \eta_R(r) \xi_R(r)$$

If second order bias coefficient satisfies to $|c_2| < 1$

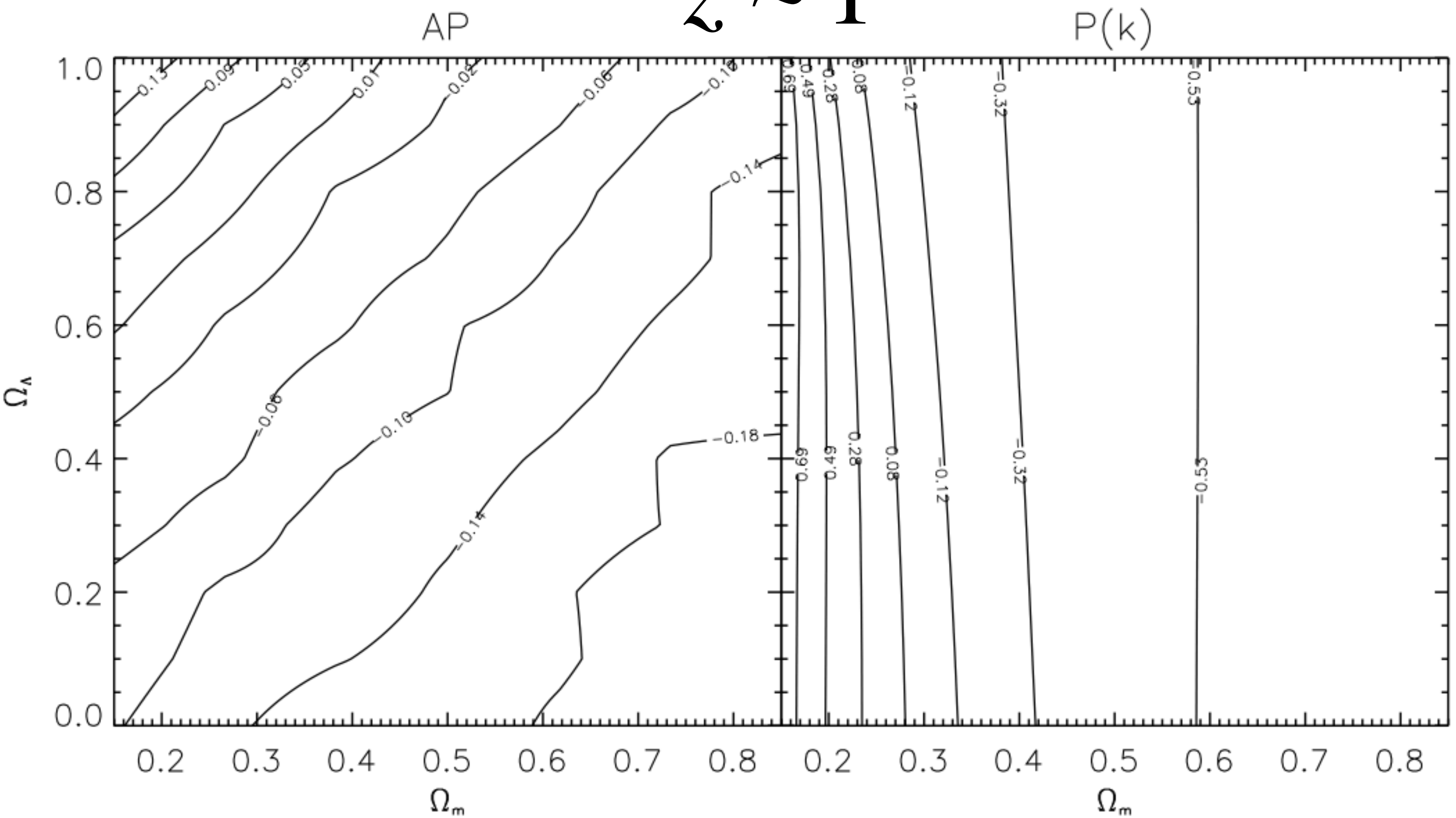
$$\boxed{\eta_{g,R}(r) = \eta_R(r)}$$

↙ Alcock-Paczynski

↘ Power spectrum

The clustering ratio as a cosmological test

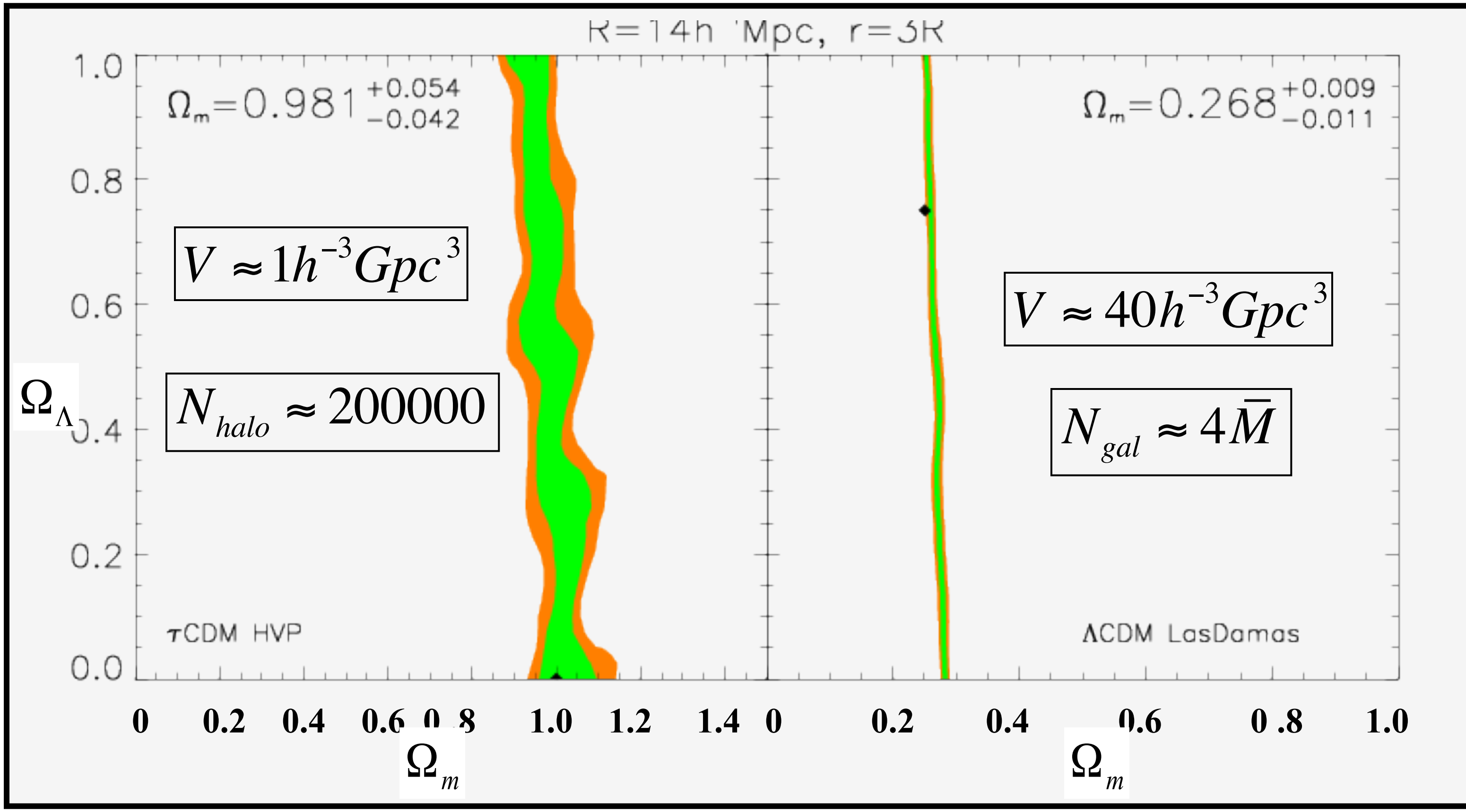
$$z \sim 1$$



$$\eta^{z}_{g,R}(r,\vec{\Omega})/\eta^{z}_{g,R}(r,\vec{\Omega}_{true})-1$$

$$\eta_{R}(r,\vec{\Omega})/\eta_{R}(r,\vec{\Omega}_{true})-1$$

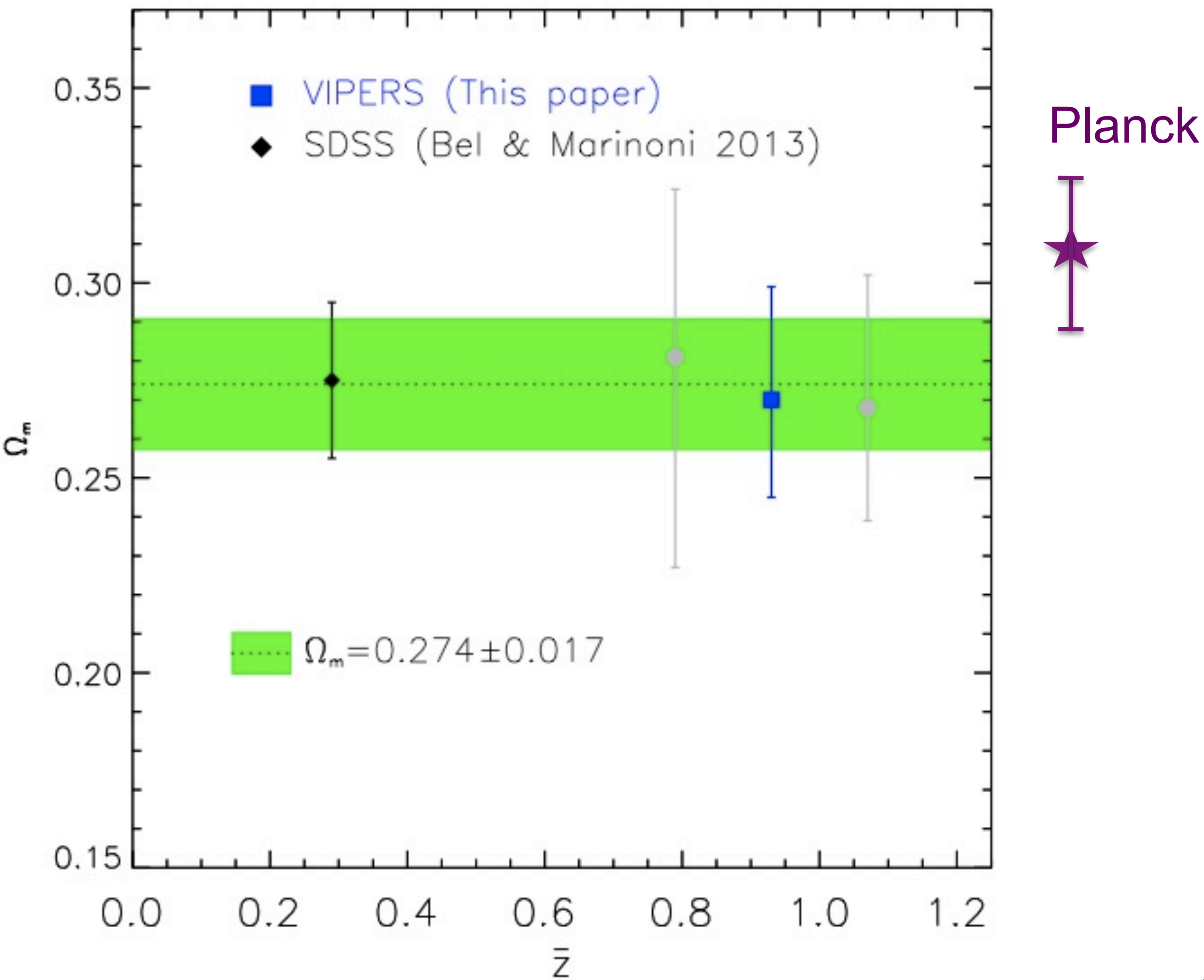
"Blind test" of N-body simulations: Figuring out the hidden cosmology



$$\begin{cases} h = & 0.21 \\ \Omega_\Lambda = & 0 \\ \Omega_m = & 1 \\ \Omega_b = & 0 \end{cases}$$

$$\begin{cases} h = & 0.70 \\ \Omega_\Lambda = & 0.75 \\ \Omega_m = & 0.25 \\ \Omega_b = & 0.04 \end{cases}$$

SDSS DR7 + VIPERS PDR1



Conclusions

• A new clustering statistic: the galaxy clustering ratio $\eta_{g,R} = \frac{\xi_{g,R}}{\sigma^2_{g,R}}$

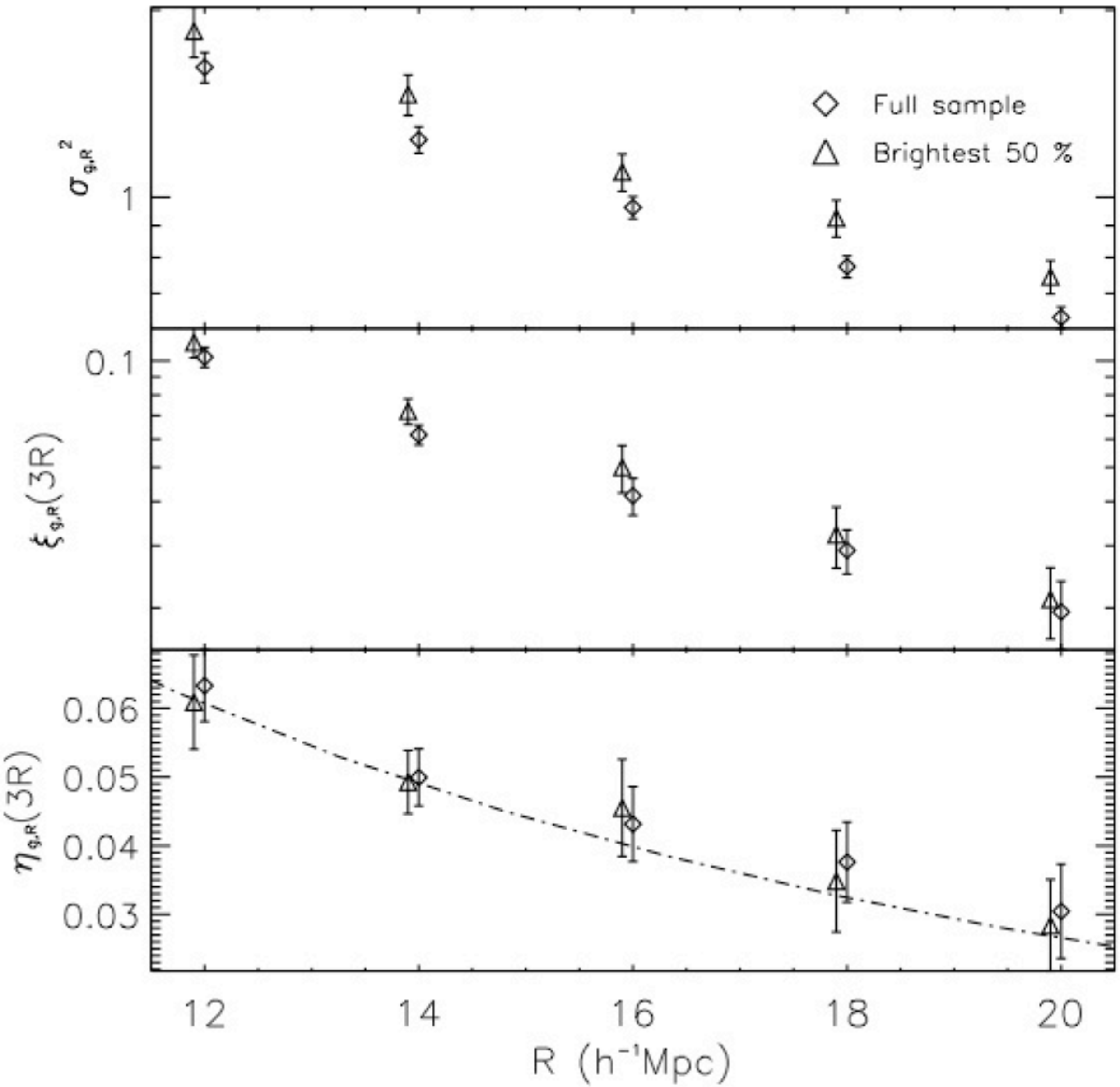
- Its amplitude is the same for galaxies and matter
- The estimator is simple (count-in-cell) and robust (blind analysis on NON LCDM cosmology)

• Assuming a flat LambdaCDM universe and combining VIPERS and SDSS measurements

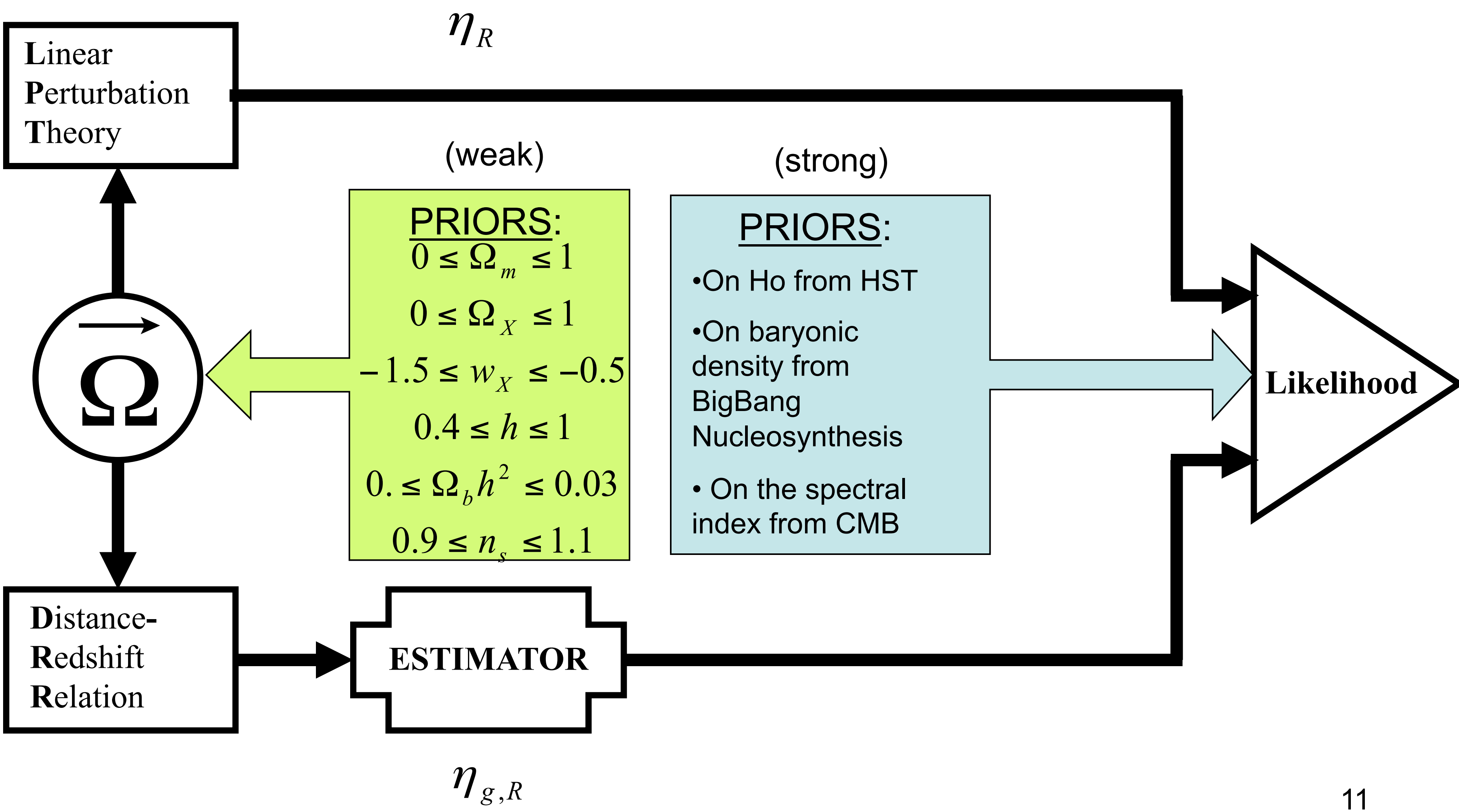
$$\Omega_m = 0.274 \pm 0.017$$

• Next: include massive neutrinos and constrain their mass

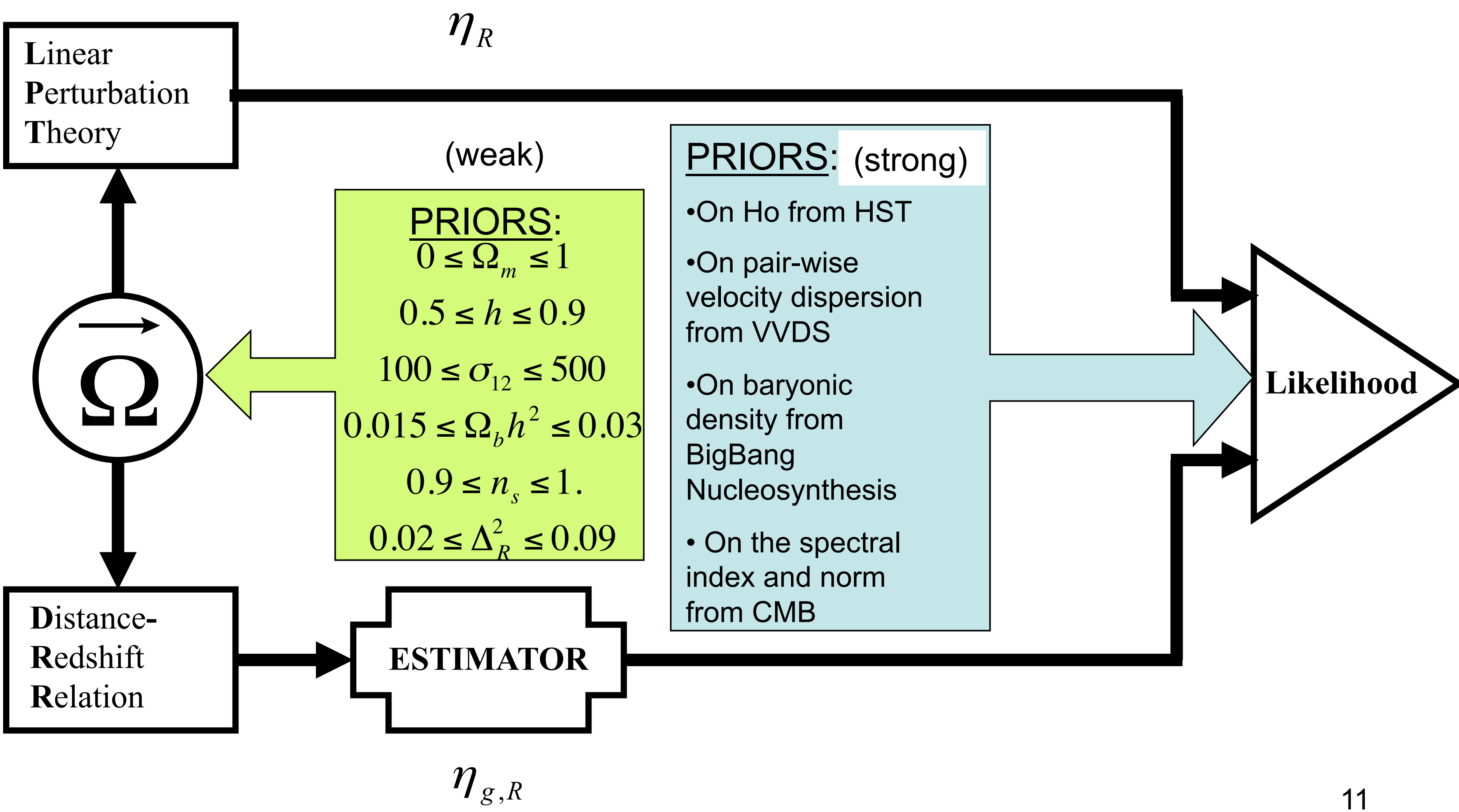
Luminosity dependence in SDSS



Application of the strategy (SDSS)



Application of the strategy (VIPERS)



Non Linear redshift space distortions

Dispersion model:

$$\tilde{\xi}(s_\perp, s_\parallel) = \int_{-\infty}^{+\infty} \mathrm{d}v f(v) \xi\left(s_\perp, s_\parallel - \frac{1+z}{H(z)} v\right)$$

where $$f(v) = \frac{1}{\sqrt{\pi}\sigma_{12}} e^{-\frac{v^2}{\sigma_{12}^2}}$$ (Gaussian)

$$\tilde{\Delta}^2_{g,NL}(k) = \Delta^2_{g,NL}(k)\mathrm{G}(k\sigma_x, \beta)$$ (Peacock & Dodds 1994)

Angle average of the power spectrum in redshift space

Non Linear Power Spectrum

RSD parameter

$$G(y, \beta) \simeq K G(y, 0).$$

Non Linear redshift space distortions

Simple theoretical prediction:

$$\tilde{\eta}_{g,R}(r,\mathbf{p}) = \tilde{\eta}_R(r,\mathbf{p}) = \frac{\int_0^{+\infty} \Delta^2_{NL}(k,\mathbf{p}) G(k\sigma_x, 0) \hat{W}^2(kR) \frac{sin(kr)}{kr} d\ln k}{\int_0^{+\infty} \Delta^2_{NL}(k,\mathbf{p}) G(k\sigma_x, 0) \hat{W}^2(kR) d\ln k}.$$

Scale dependent galaxy bias

From de la Torre & Peacock (2013):