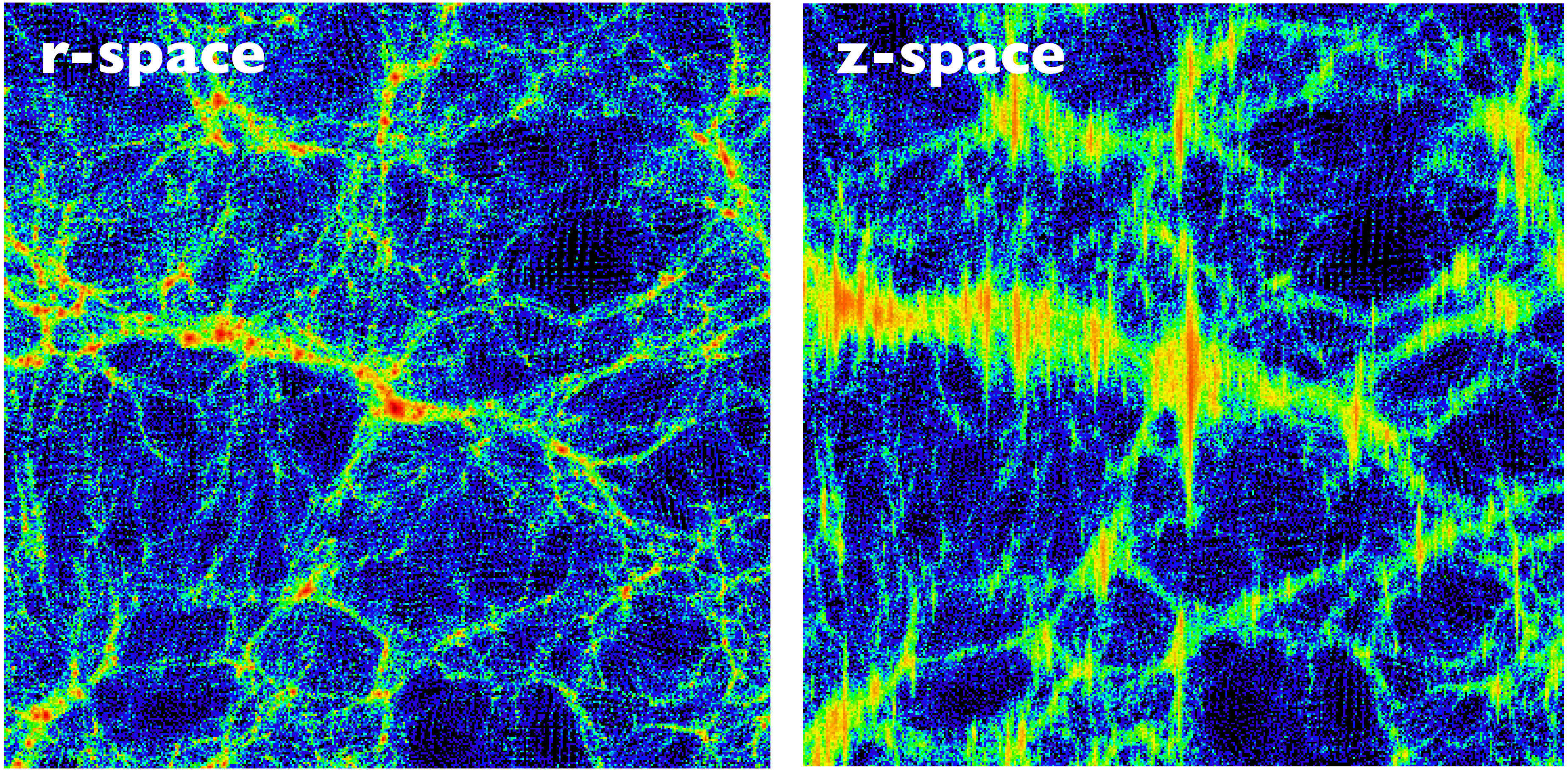
Observational effects: redshift-space & geometric distortions

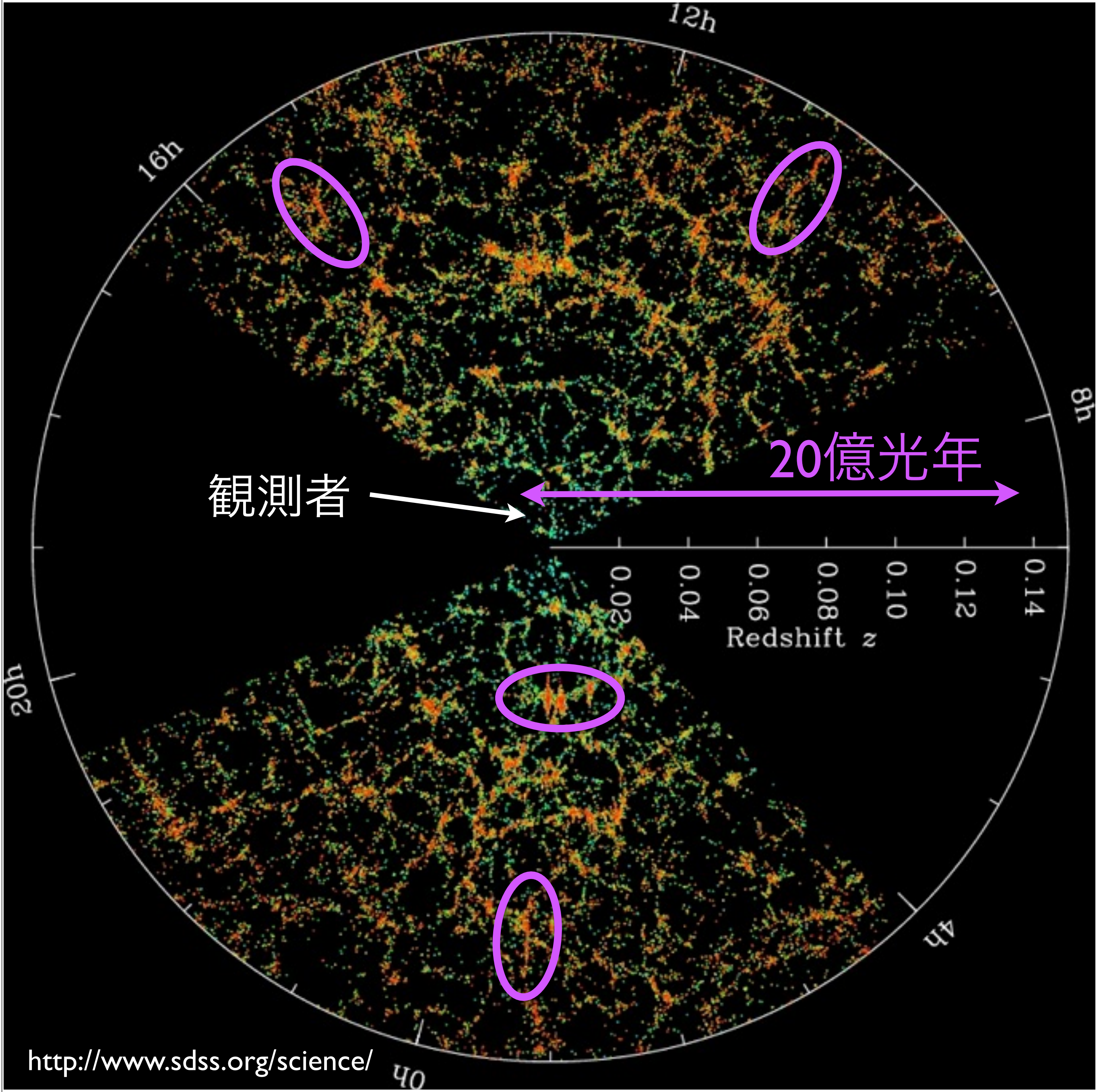
Redshift-space distortions (RSD)

Dark matter in N-body simulations (by T. Nishimichi)



~100Mpc/h ?

↑ observer's line-of-sight direction



RSD in SDSS-II main galaxies

色は銀河の年齢

青い：若い

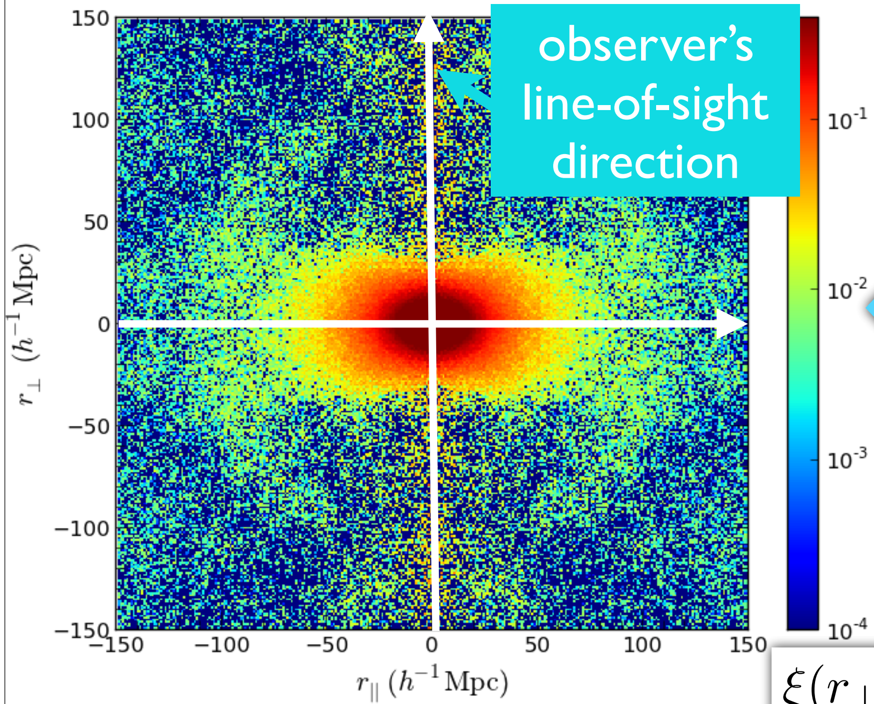
赤い：古い

Anisotropic correlation function

Anderson et al.('13)

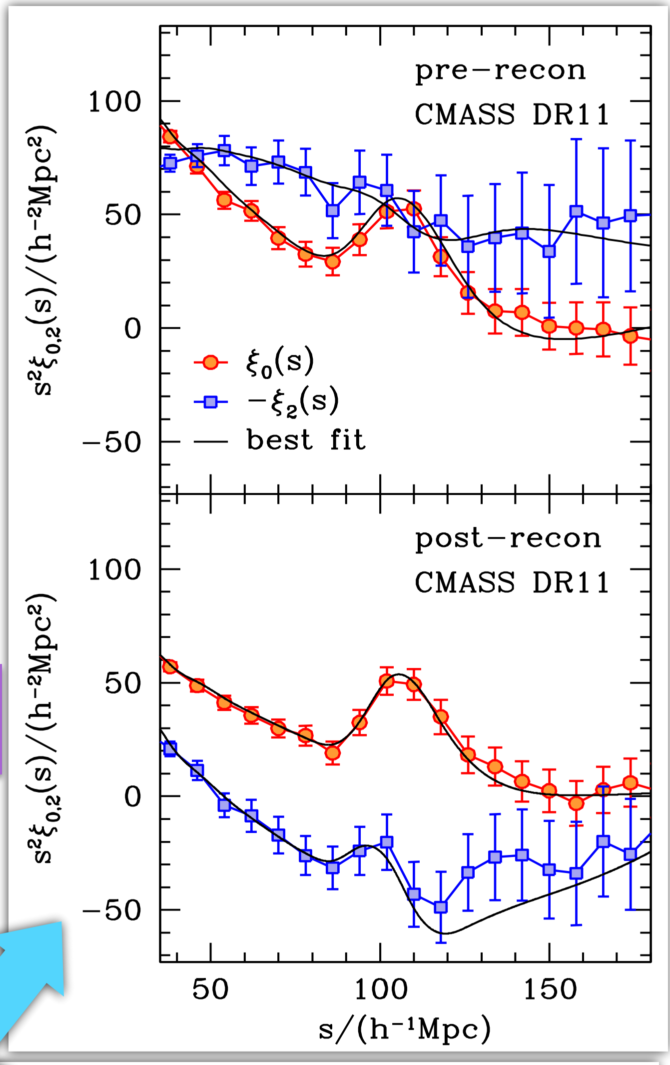
BOSS DR11, CMASS samples

700,000gals @ 0.43<z<0.7



Samushia et al.('13)

$$\xi(r_\perp, r_\parallel)$$



Multipole expansion

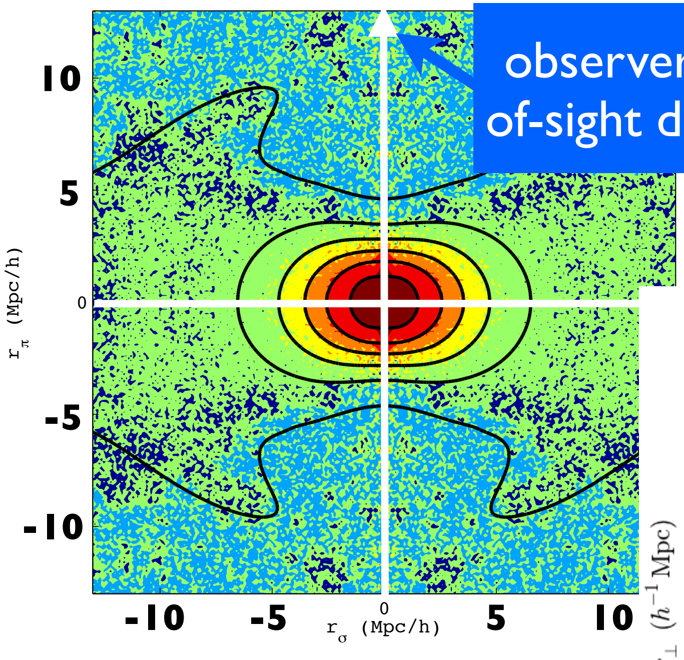
$$\xi(r_\perp, r_\parallel) = \sum_{\ell:\mathrm{even}} \xi_\ell(s)\,\mathcal{L}_\ell(r_\parallel/s)\ ;\quad s = (r_\perp^2 + r_\parallel^2)^{1/2}$$

BOSS DR9

Reid et al. ('12)

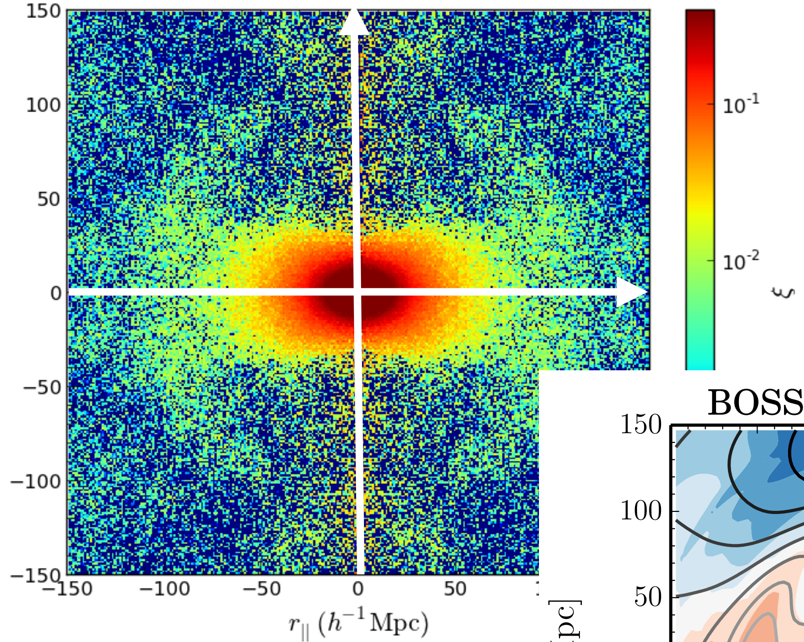
Samushia et al. ('13)

Alam et al. ('16)



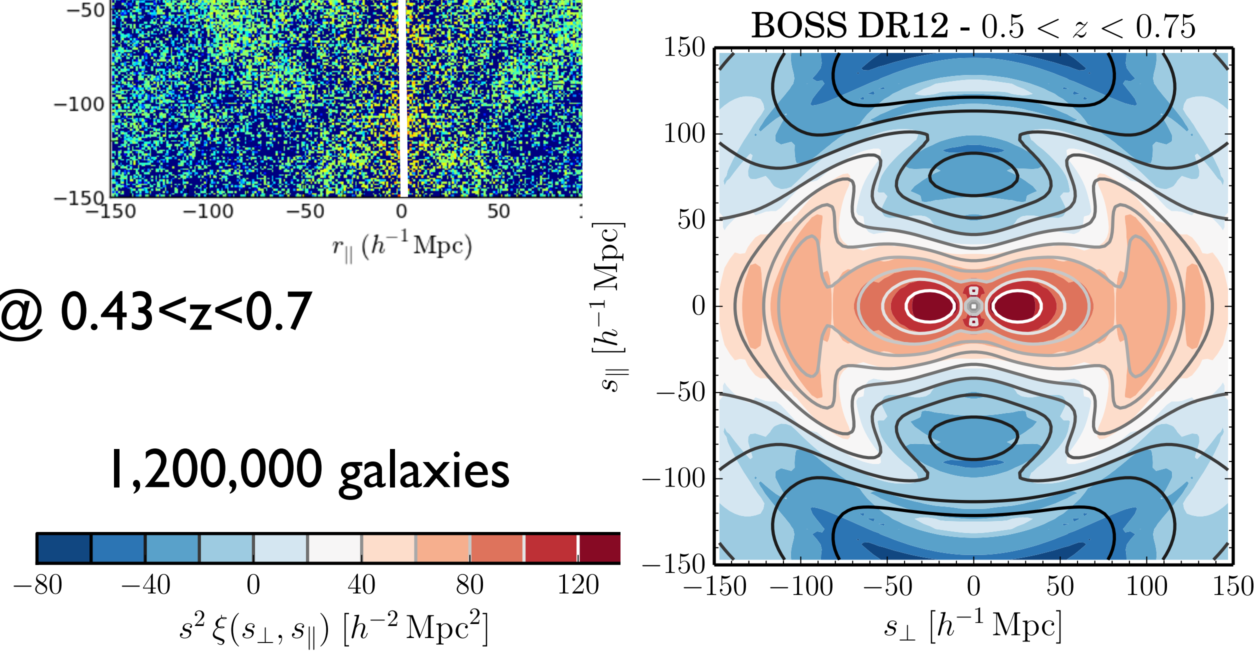
260,000gals @ 0.43<z<0.7

BOSS DR11



700,000gals @ 0.43<z<0.7

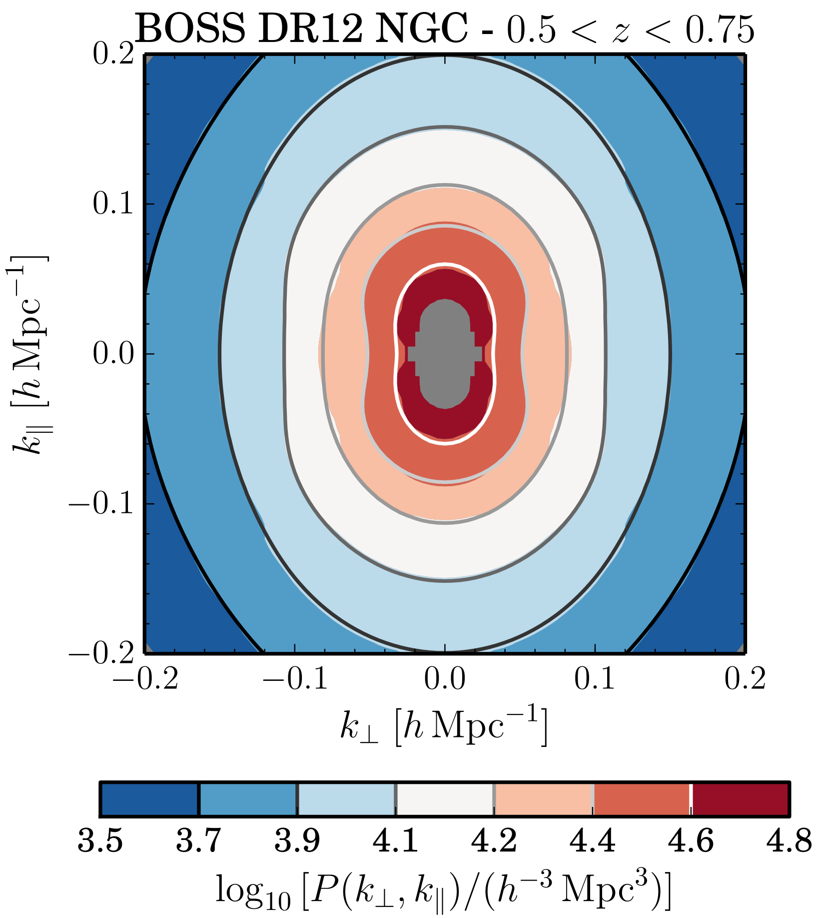
BOSS DR12

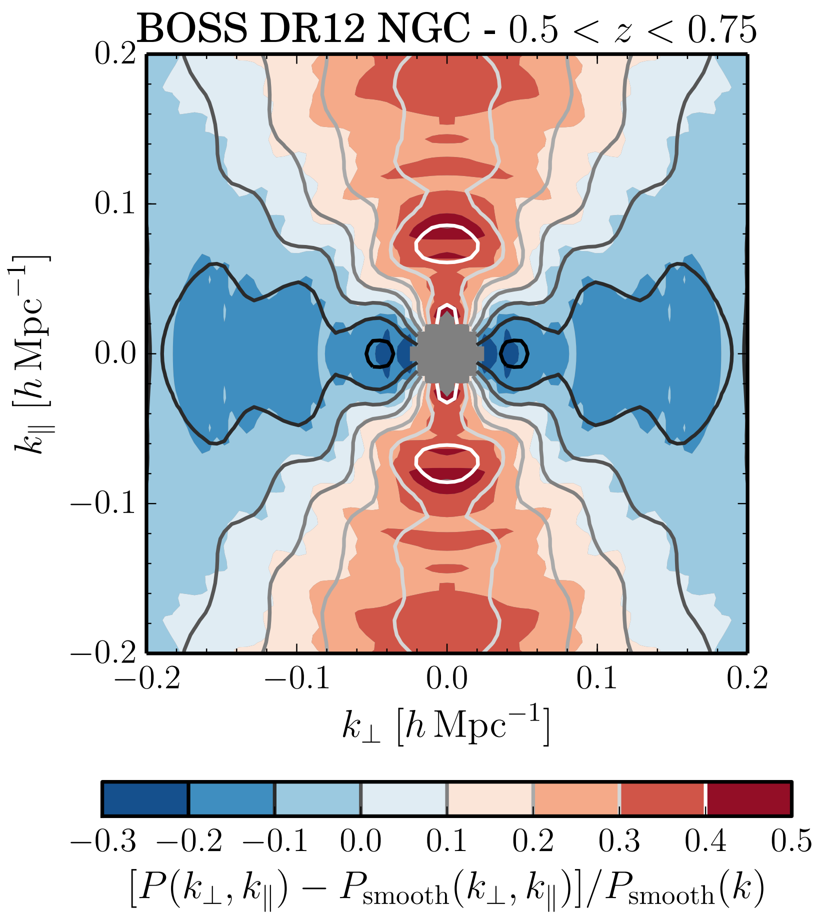


1,200,000 galaxies

Anisotropic power spectrum

BOSS DR12

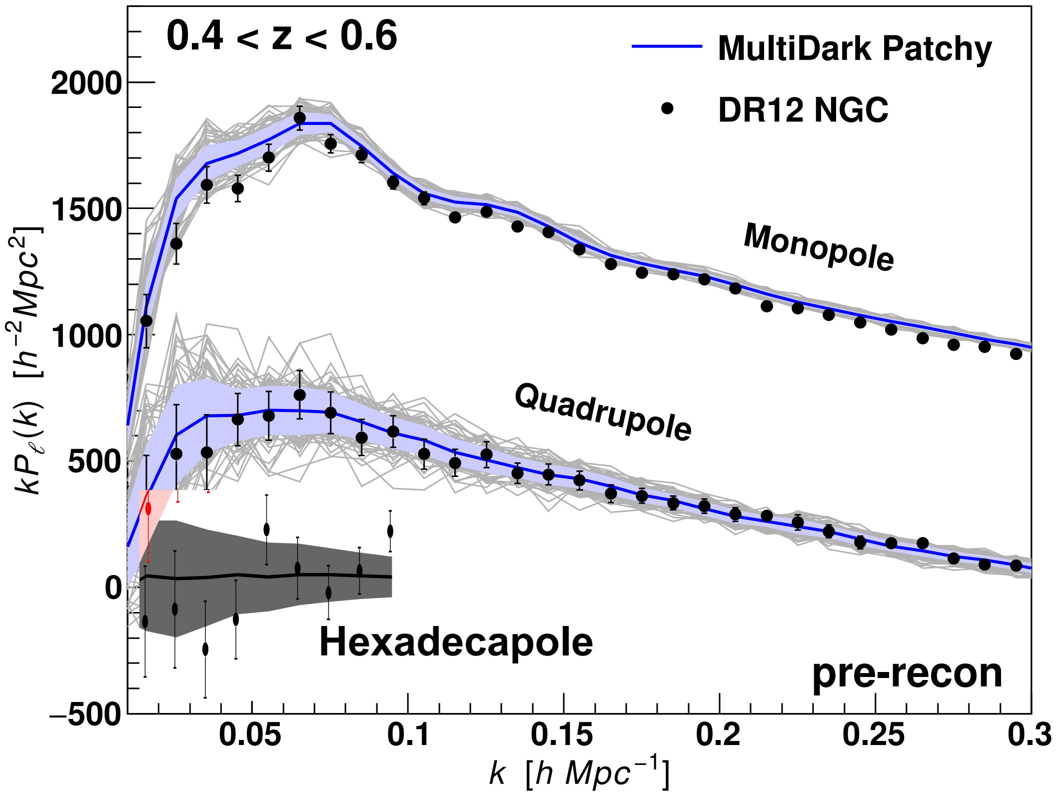




Alam et al. ('16)

Anisotropic power spectrum

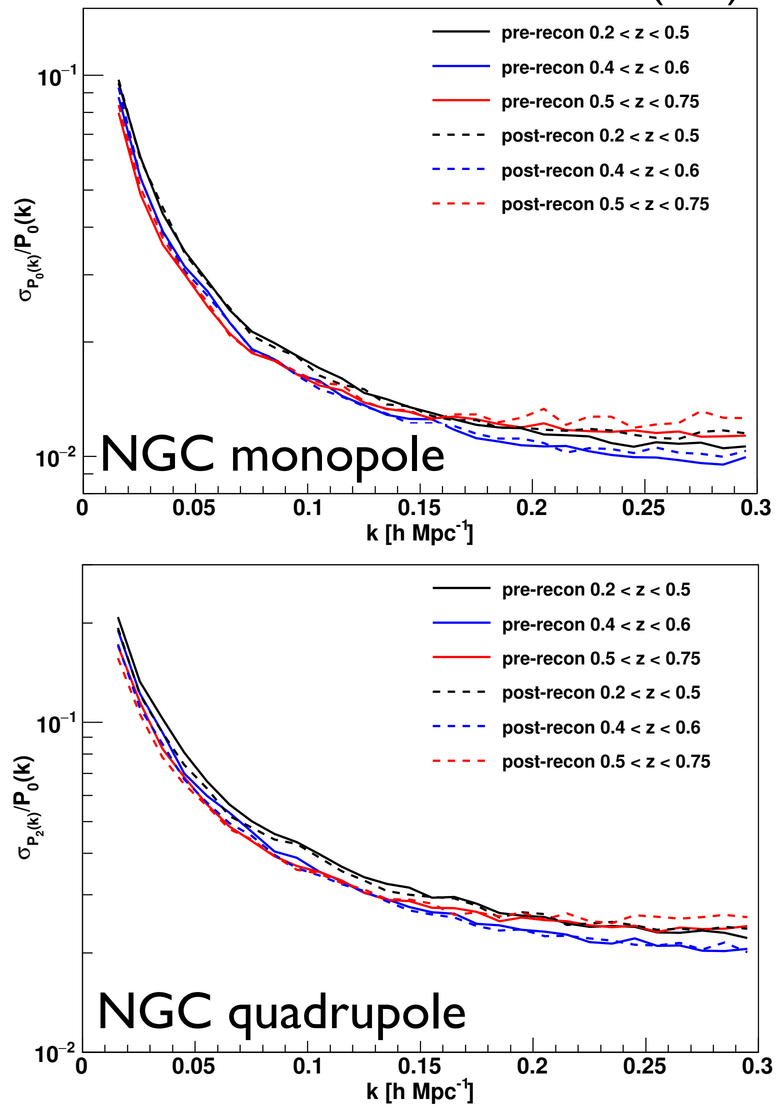
BOSS DR12



$$P(k_{\parallel}, k_{\perp}) = \sum_{\ell:\ \text{even}} P_\ell(k)\, \mathcal{P}_\ell(k_{\parallel}/k)$$

$$;\ k = (k_{\parallel}^2 + k_{\perp}^2)^{1/2}$$

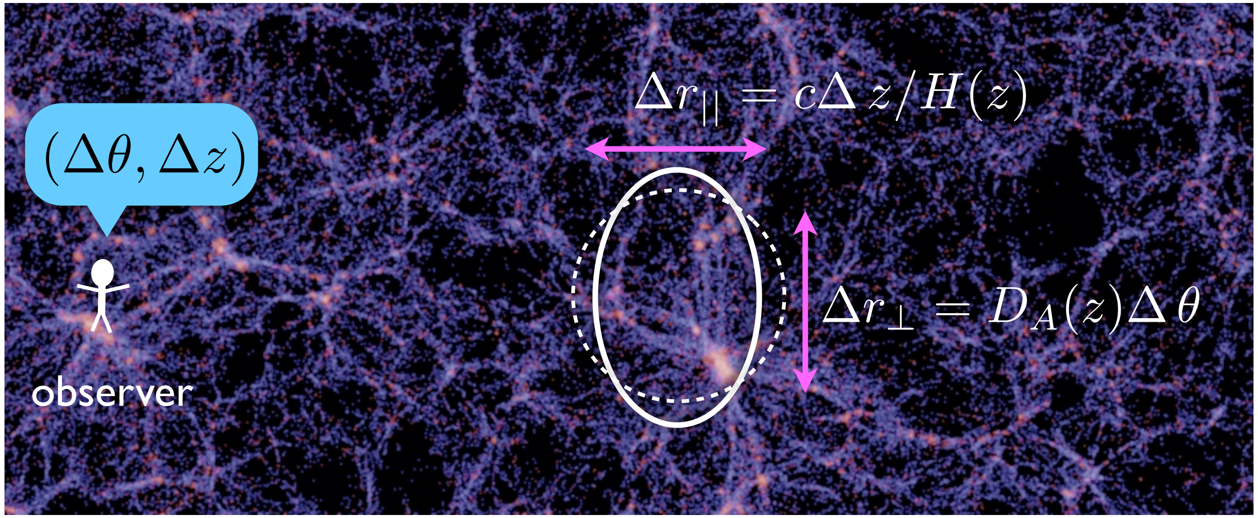
Beutler et al. ('16)



Geometric distortions

(Alcock-Paczynski effect)

Cosmological distortions caused by apparent mismatch of underlying cosmological models



⟶ can generate higher multipole moments of anisotropies

Using the standard ruler,

H(z) & **DA(z)** can be measured simultaneously

Alcock & Paczynski ('79)

Nature Vol. 281 4 October 1979

An evolution free test for non-zero cosmological constant

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The cosmological constant has recently been questioned because of difficulties in fitting the standard $\Lambda = 0$ cosmological models to observational data[1,2]. We propose here a cosmological test that is a sensitive estimator of Λ. This test is unusual in that it involves no correction for evolutionary effects. We present here the idealised conception of the method, and hint at the statistical problem that its realisation entails.

Consider a collection of test objects emitting radiation containing spectral lines (so that redshifts may be determined), which are distributed on the surface of a sphere. (Any spherically symmetric, bounded distribution will do; this idealisation is for convenience only.) Let the sphere expand with the local

where

$$\sum_{+1}(x) = \sin x, \; \sum_{-1}(x) = \sinh x \quad (5)$$

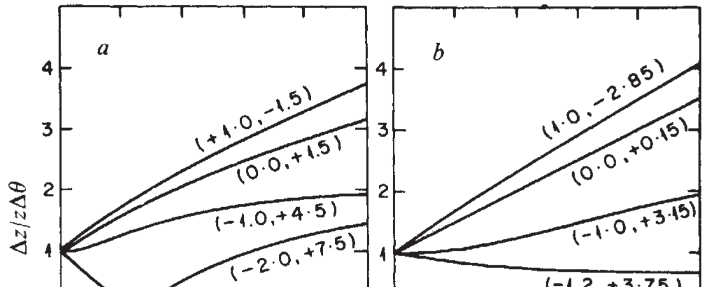
In the case $k = 0$,

$$\frac{\Delta z}{z\Delta\theta} = z^{-1}\{1 - \Omega_0 + \Omega_0(1+z)^3\}^{1/2} \int_1^{1+z} \mathrm{d}y \, \{1 - \Omega_0 + \Omega_0 y^3\}^{-1/2} \quad (6)$$

For the 'conventional' cosmologies where $\Lambda = 0$ there is the simple expression,

$$\frac{\Delta z}{z\Delta\theta} = \frac{(1+2q_0z)^{1/2}}{q_0^2 z}\{q_0z + (q_0 - 1)((1+2q_0z)^{1/2} - 1)\} \quad (7)$$

Numerical evaluation of equation (7) shows that $\Delta z/(z\Delta\theta)$ is not a powerful estimator of q_0 in the $\Lambda = 0$ case—there is only 11% variation of $\Delta z/(z\Delta\theta)$ between $q_0 = 0$ and $q_0 = 1$ at $z = 2$. However, the general expressions (4) and (6) show great variations of $\Delta z/(z\Delta\theta)$ with the parameters. This is shown in Fig. 1.

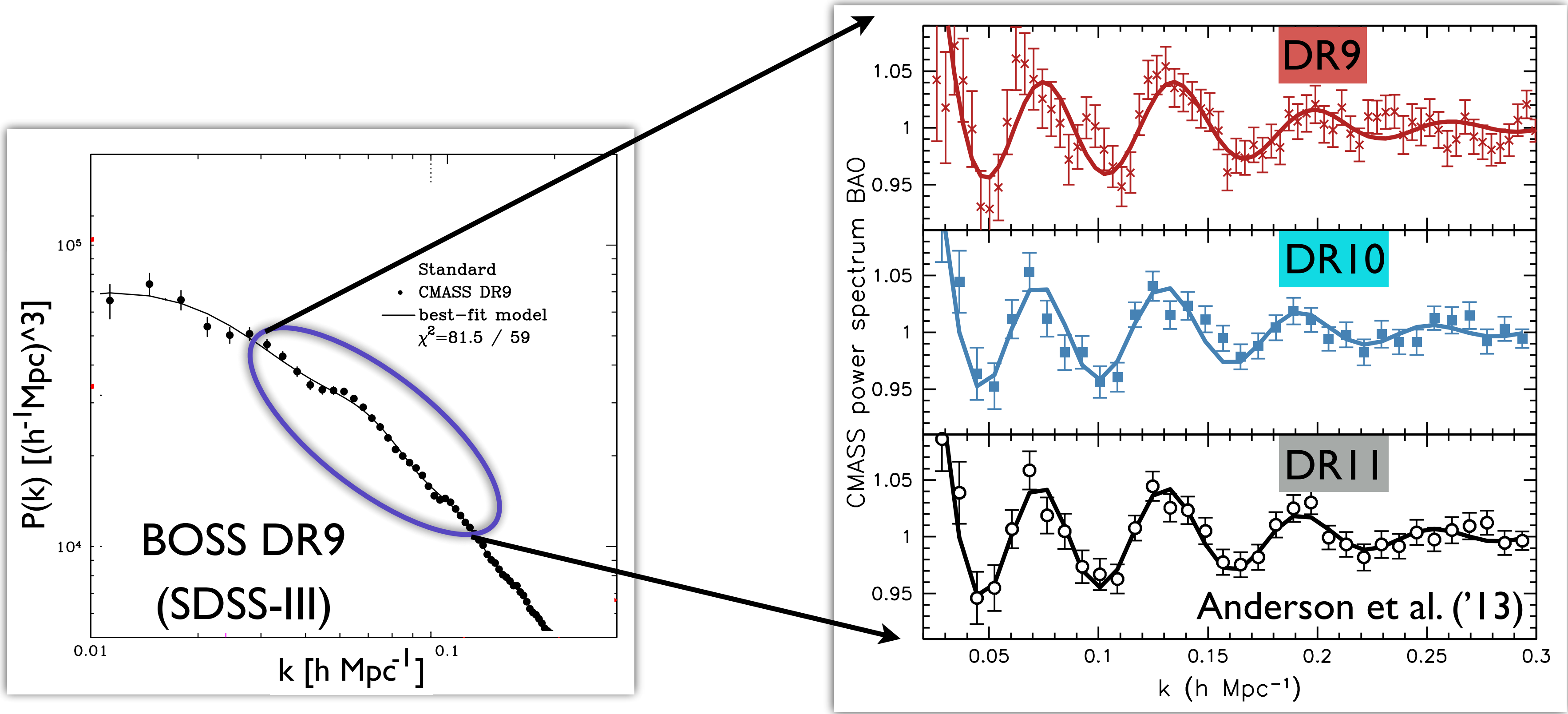


Early studies before detection of BAOs :

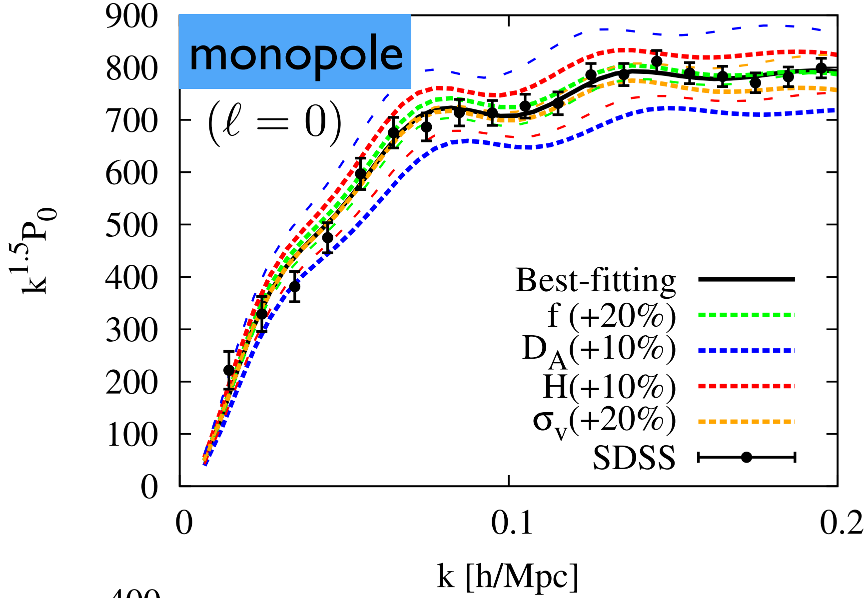
- Ryden ('95) --------- shape of void
- Ballinger, Peacock & Heavens ('96) --------- global shape of P(k) or ξ(r)
- Matsubara & Suto ('96); Magira, Jing & Suto ('98)

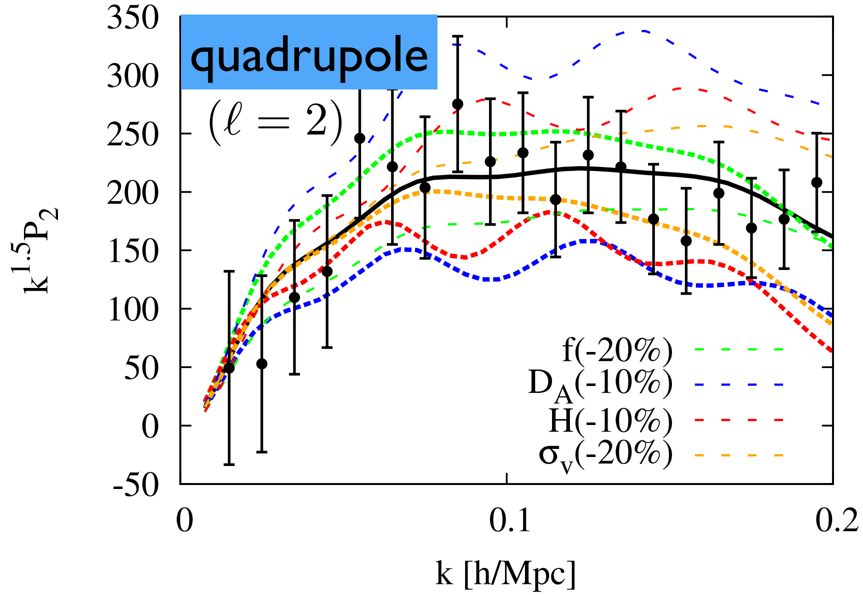
Baryon acoustic oscillations

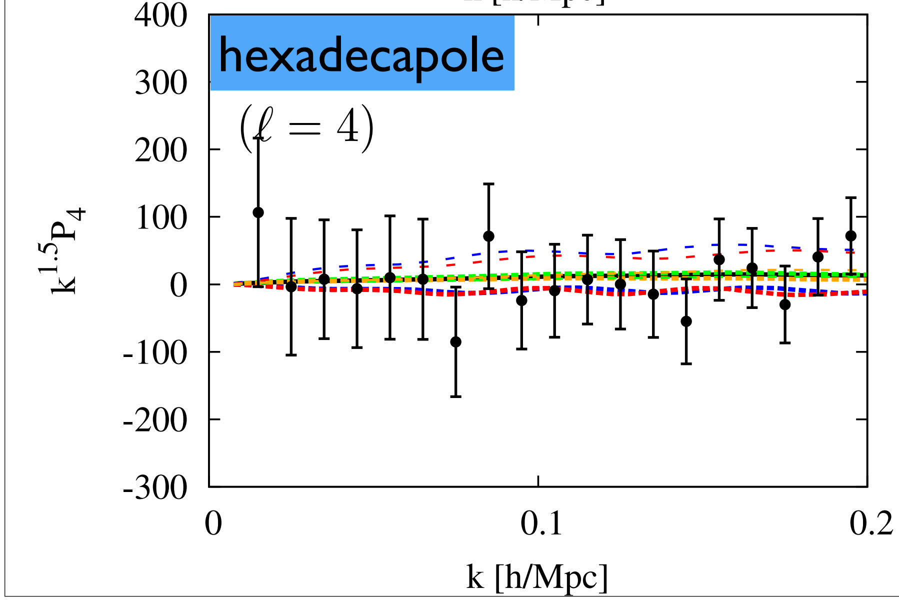
- Characteristic scale of primeval baryon-photon fluid (~150Mpc) imprinted on P(k) or ξ(r)
- Can be used as standard ruler to estimate distance to galaxies



Impact of RSD & A-P effects







Sensitivity of clustering anisotropies to D_A, H & f

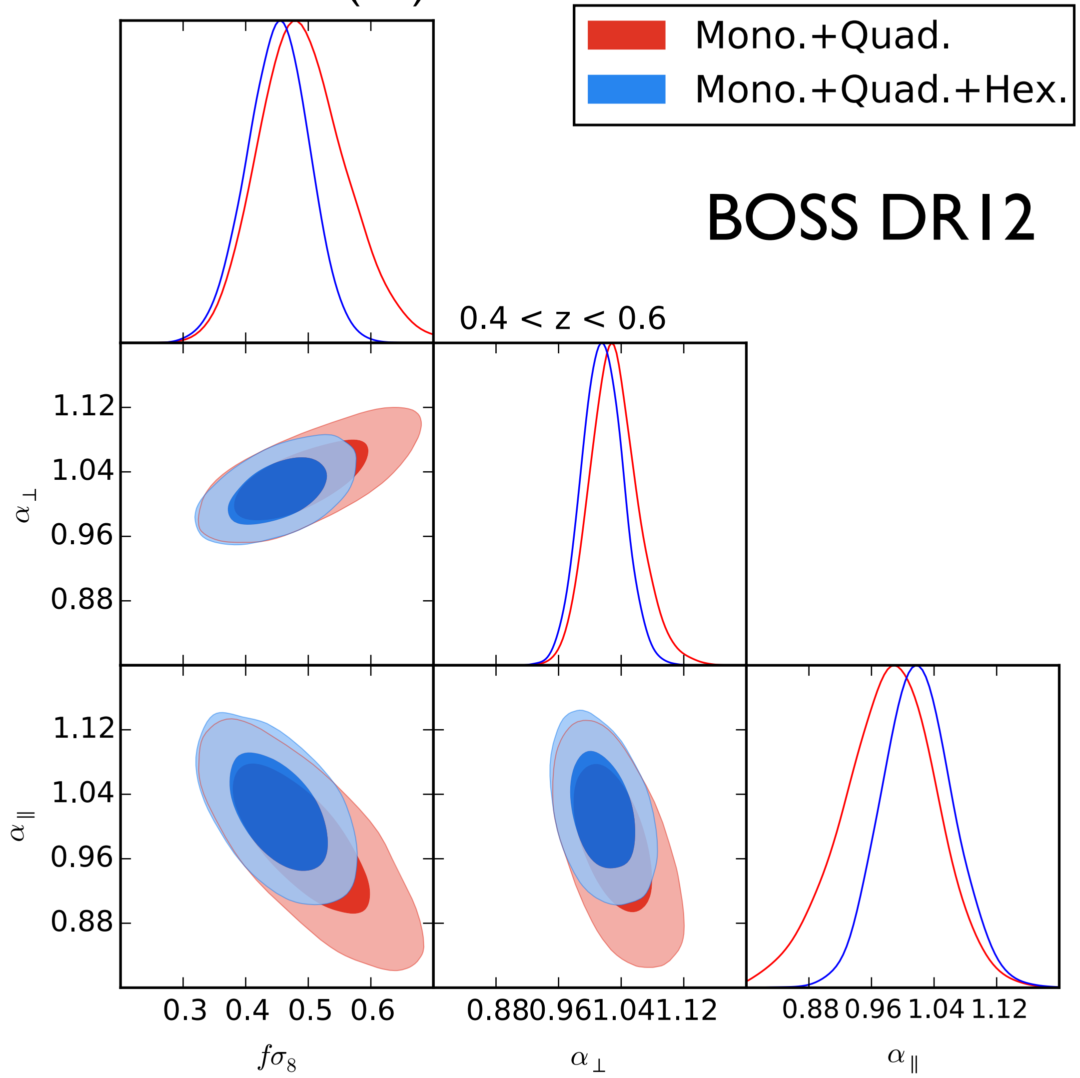
Obs. data: SDSS-II DR7 LRG

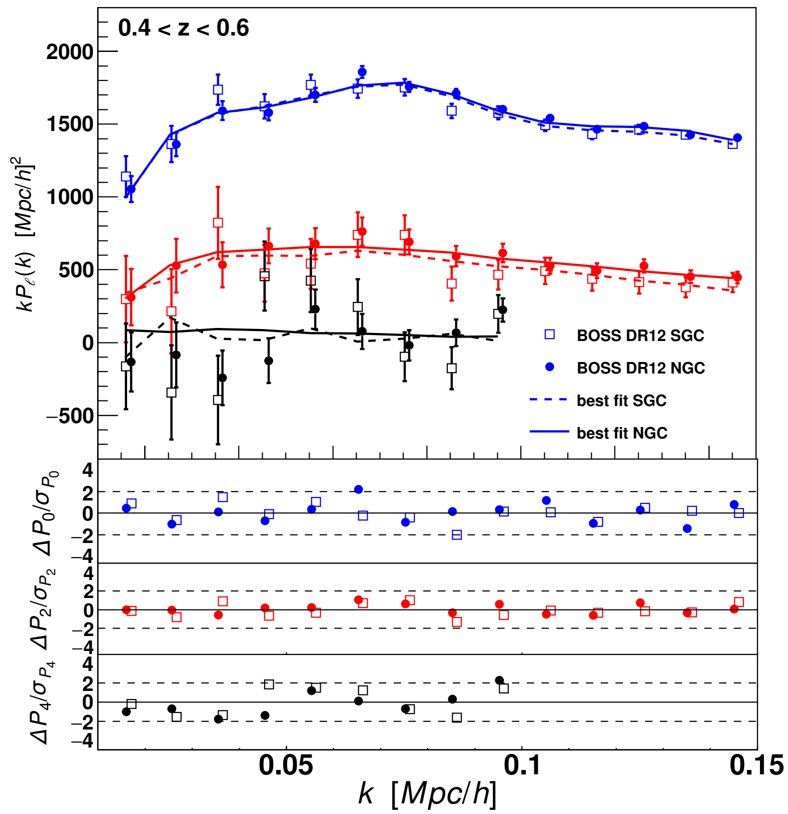
Oka et al.('13) modified

Cosmological constraints

Beutler et al. (16)

BOSS DR12





$$\alpha_\parallel = \frac{H^{\rm fid}(z) r_s^{\rm fid}(z_d)}{H(z) r_s(z_d)}$$

$$\alpha_\perp = \frac{D_A(z) r_s^{\rm fid}(z_d)}{D_A^{\rm fid}(z) r_s(z_d)}$$

Cosmological constraints