Constraining cosmic growth combining WiggleZ & BOSS surveys

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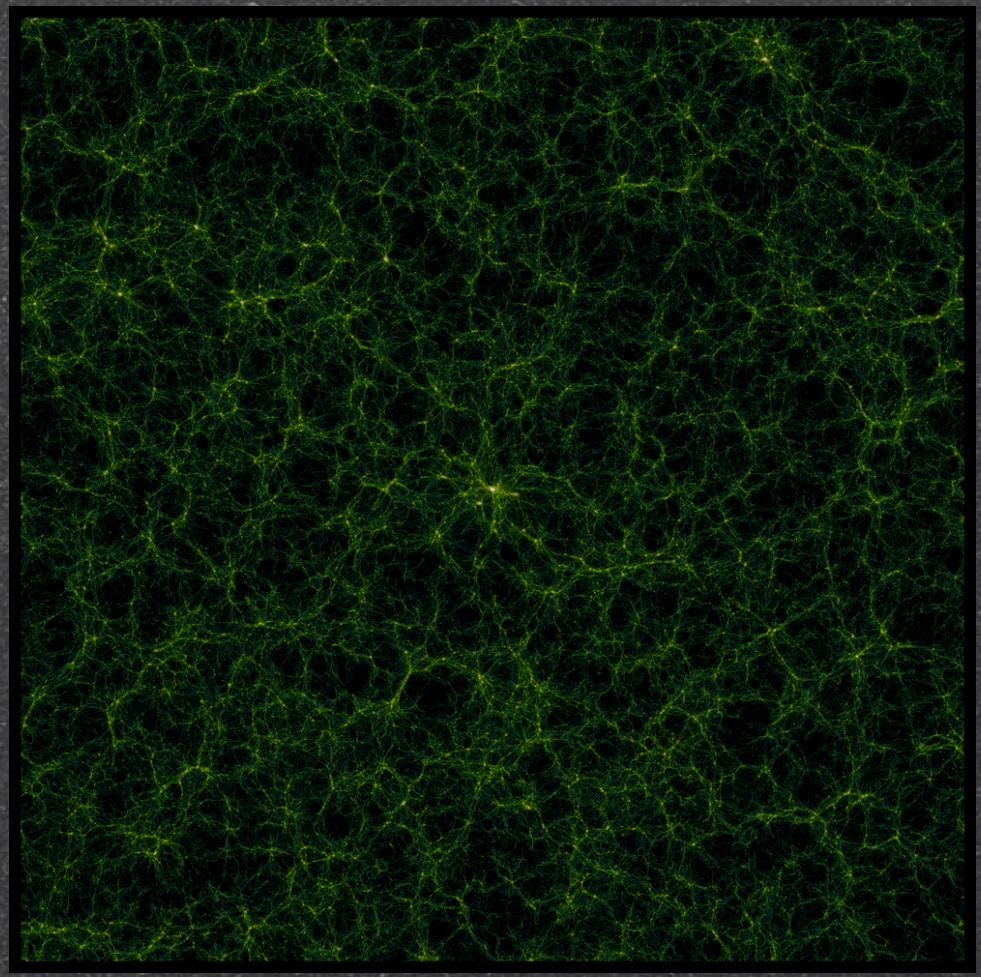
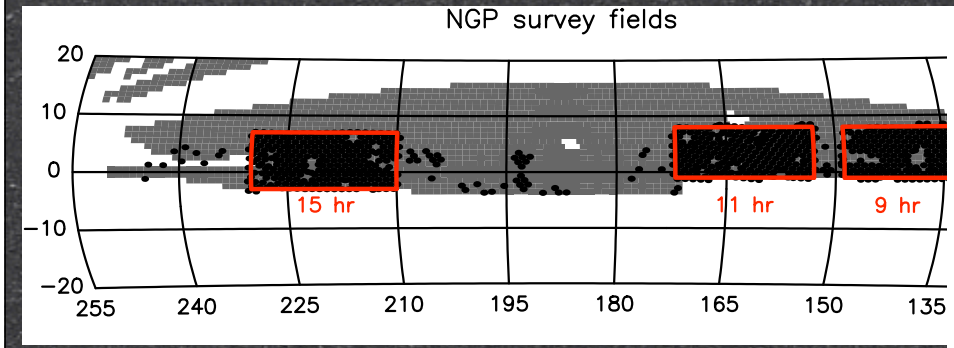
Galaxy surveys: dynamical probes of cosmology

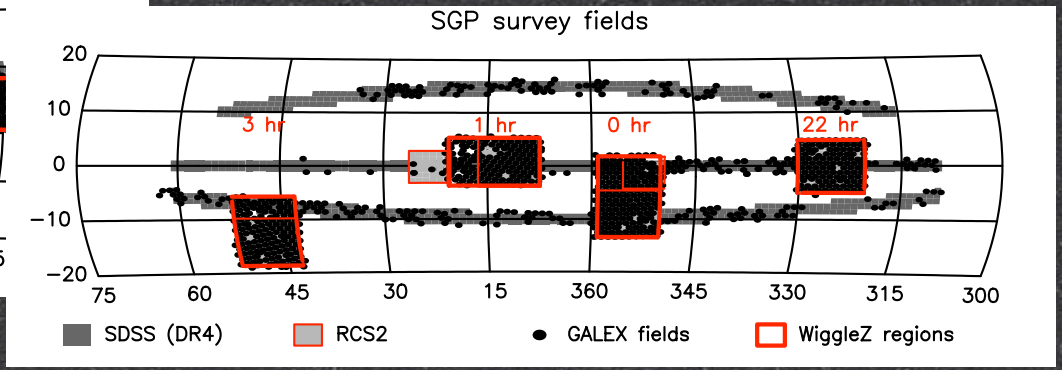
- Primordial conditions still imprinted
- Gravity and dark matter main drivers
- Large scales: $\delta_m(k,a) = G(a,H,\Omega_i)\delta_m(k,a_0)$



The WiggleZ Galaxy Survey

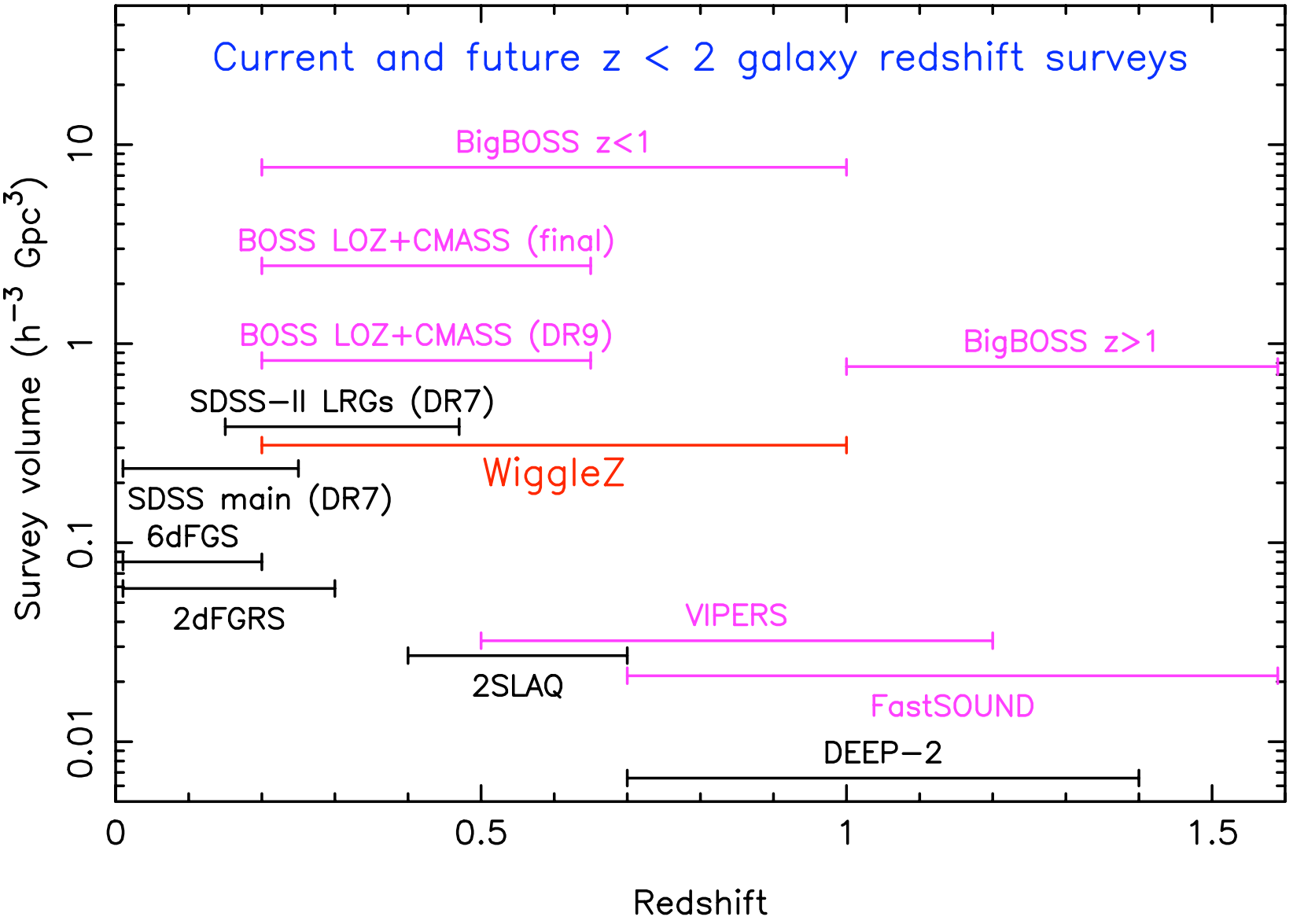
- 1000 sq deg from AAT
- 8/2006-01/2011 - Spectroscopic redshifts with AAO Multi-spectrograph
- Follow up UV-selected sources from GALEX
- Color cuts to select high-z emission-type galaxies - short exposures
- Overlap with SDSS, RCS2 fields
- 200k+ galaxies 0.1<z<1





Chris Blake

current landscape



Chris Blake

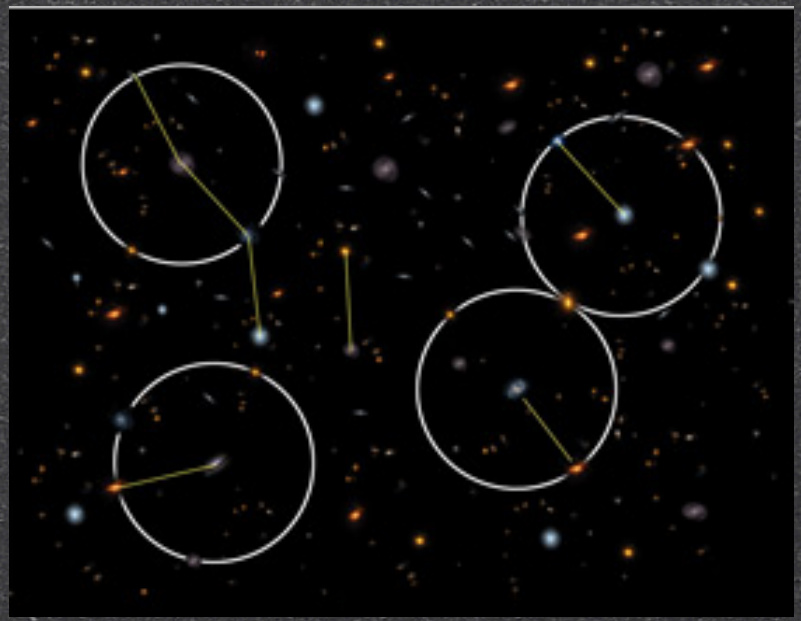
How we extract info from WiggleZ?

- assume statistical homogeneity and isotropy
- overdensity of galaxies

$$\delta_{gal} = \frac{n_{gal}(x) - \bar{n}_{gal}}{\bar{n}_{gal}}, \langle \delta_{gal}(x) \rangle = 0$$

- Use clustering statistics:
  - Two-point correlation function (2PCF) - configuration space

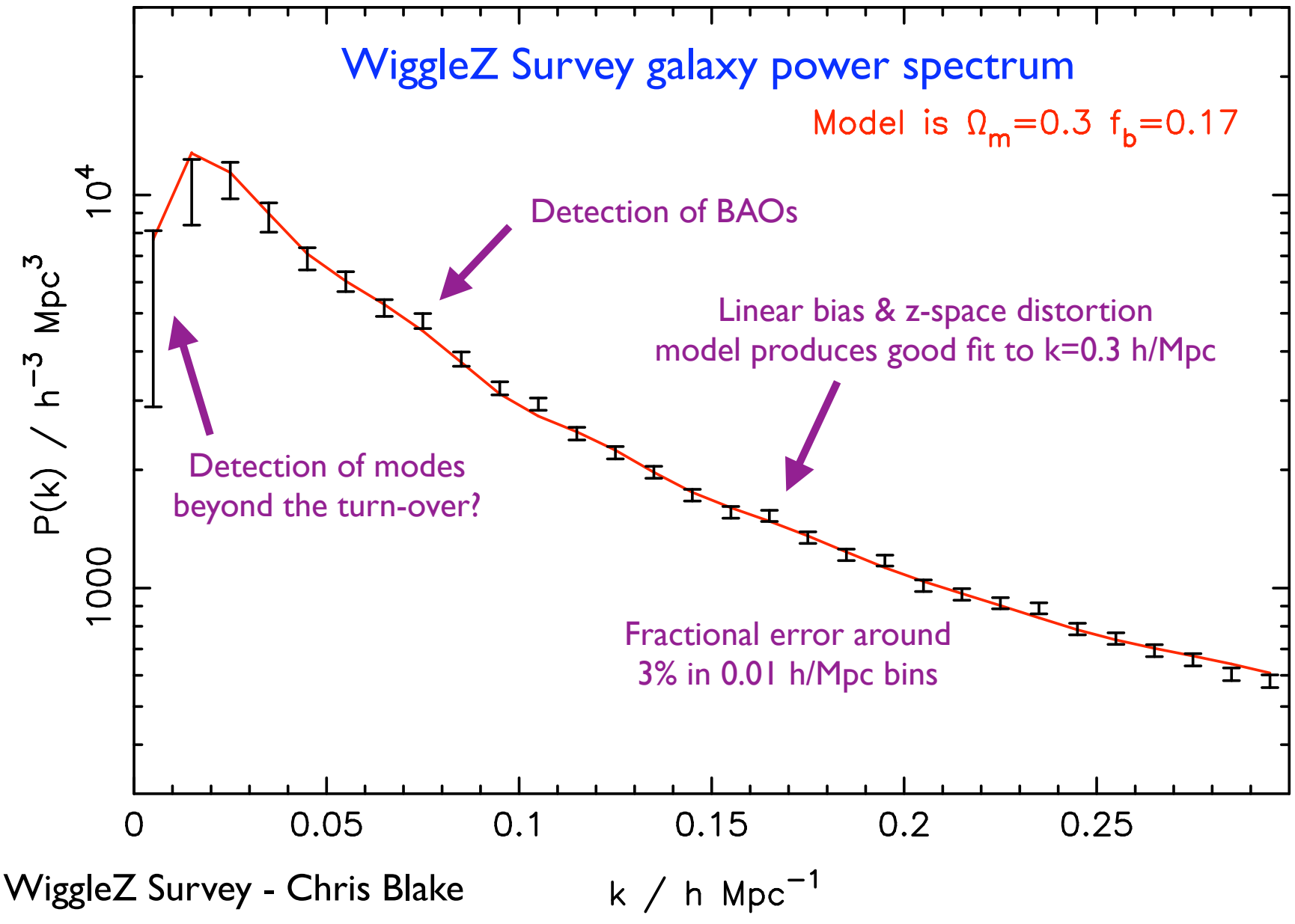
$$\xi(r) = \langle \delta_{gal}(x) \delta_{gal}(x+r) \rangle \approx \frac{DD - 2DR + RR}{RR}$$



http://www.pdl.cmu.edu

  - Power Spectrum - Fourier space

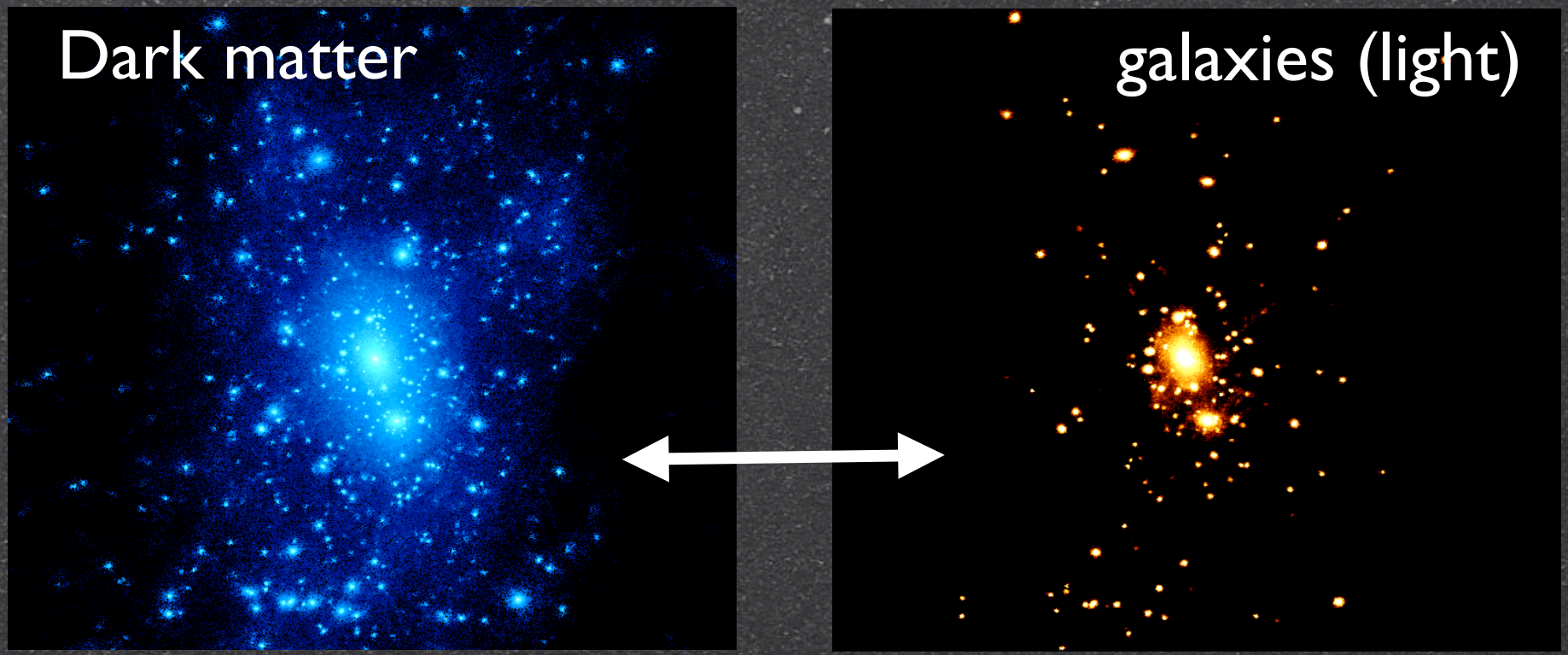
$$P(k) = \langle \delta(k) \delta(k^*) \rangle >, \xi(r) = \frac{1}{2\pi^2} \int P(k) j_0(kr) k^2 dk$$


WiggleZ Survey galaxy power spectrum
Model is Ω_m=0.3 f_b=0.17
Detection of BAOs
Linear bias & z-space distortion
model produces good fit to k=0.3 h/Mpc
Detection of modes
beyond the turn-over?
Fractional error around
3% in 0.01 h/Mpc bins
P(k) / h^{-3} Mpc^3
10^4
1000
0
0.05
0.1
0.15
0.2
0.25
k / h Mpc^{-1}
WiggleZ Survey - Chris Blake

First Challenge: Galaxy bias

- Galaxies form in dark matter halos
  - peaks of matter distribution
  - Correlation between halo mass & galaxy luminosity
  - simple model

$$\delta_g = b\delta_m \Rightarrow \xi_g = b^2\xi_m$$

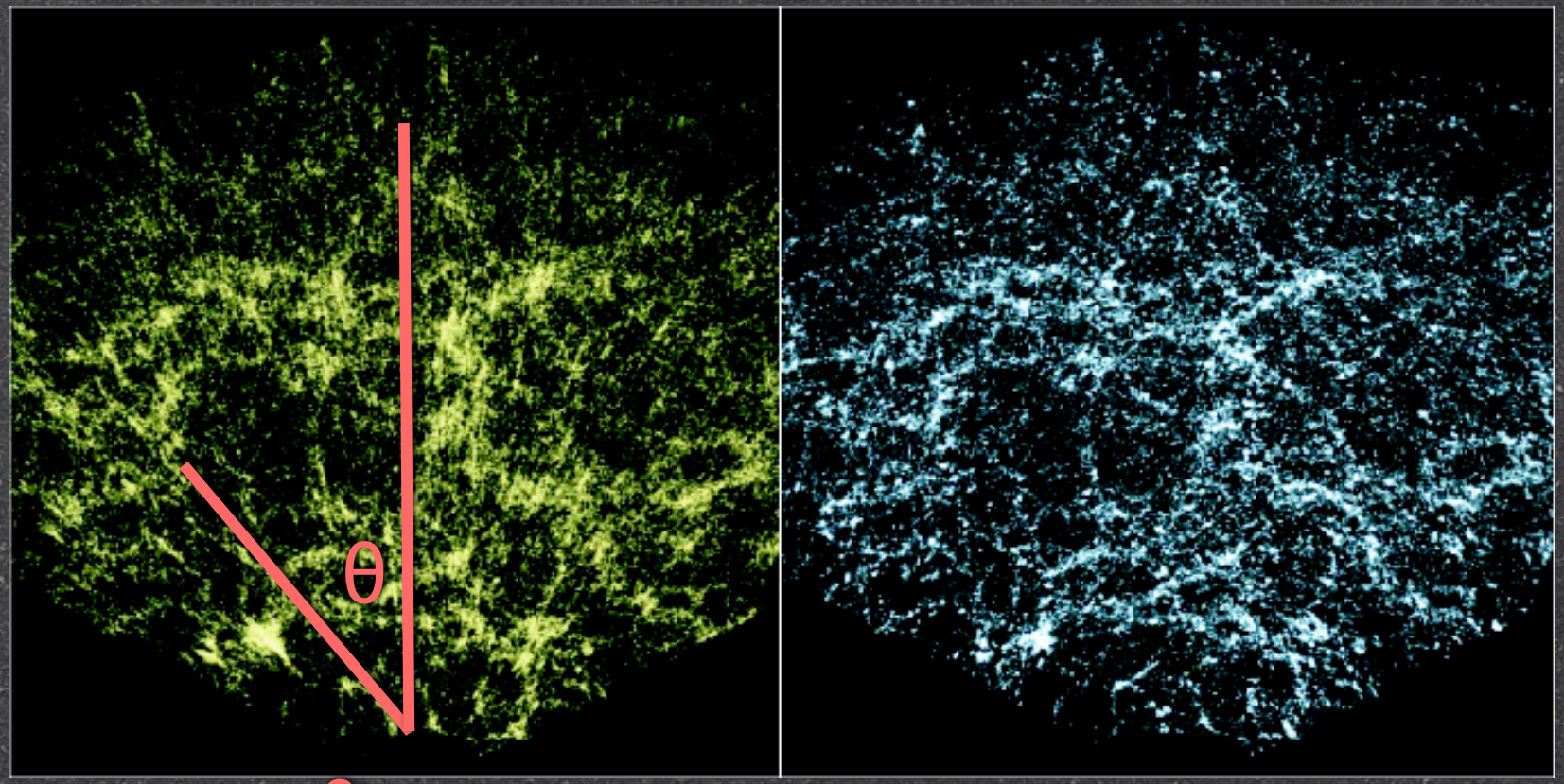


Redshift-space distortions

$$\mathbf{s} = \mathbf{r} + \frac{(1+z)\mathbf{v}\cdot\hat{r}}{H(z)}\hat{r}$$ + Linearized e.o.m =

$$\nabla \cdot \mathbf{v} = -f\delta_m$$

$$\delta_g^s(\mathbf{k}) = (b + f\mu^2)\delta_m^r(\mathbf{k}),$$

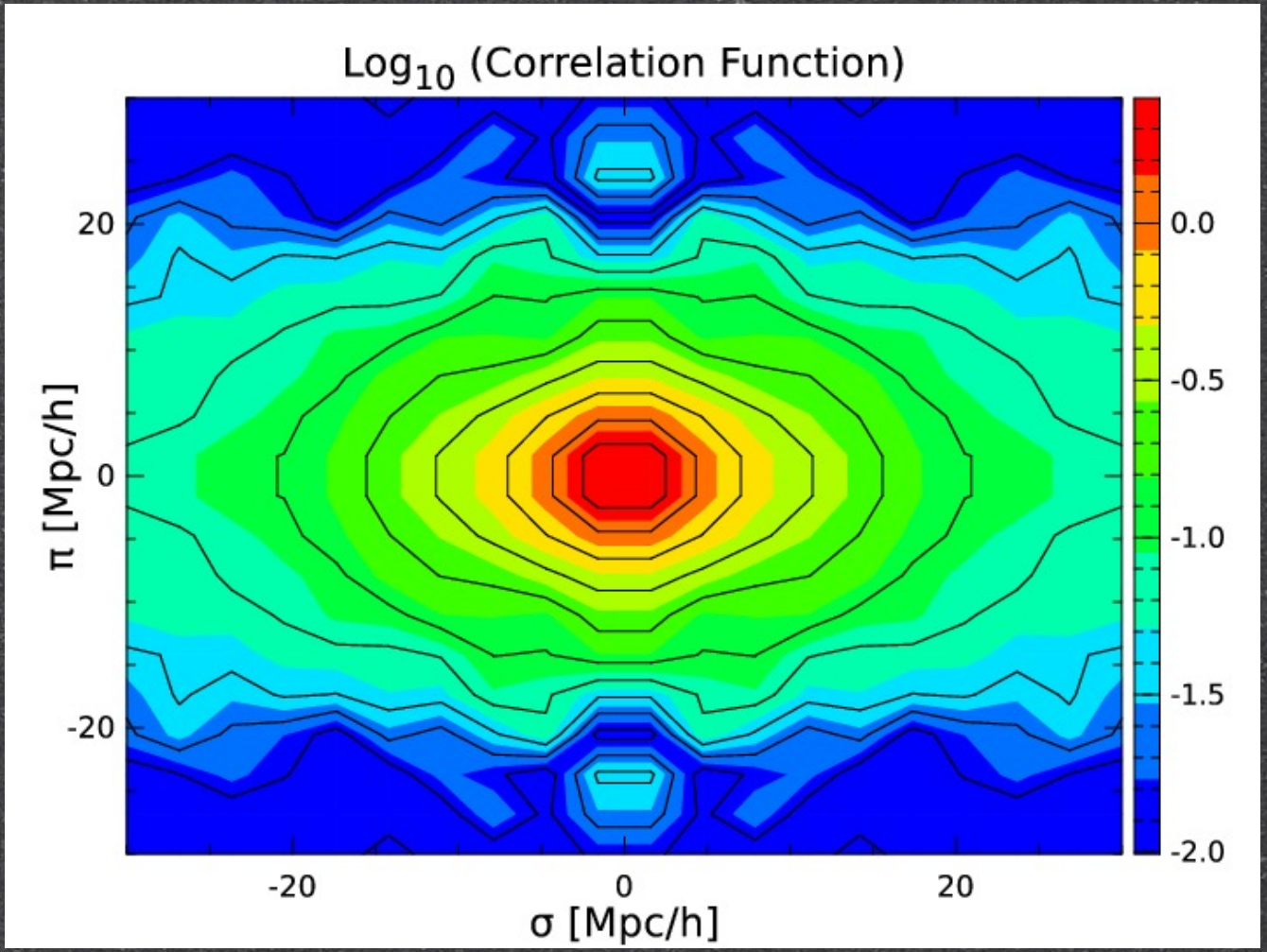


credit:M SubbaRao

μ=cos θ

$$f(z) \equiv \frac{d\ln G(a)}{d\ln a} \approx \Omega_m^{0.55}$$

Model WiggleZ 2-D ξ and P(k)

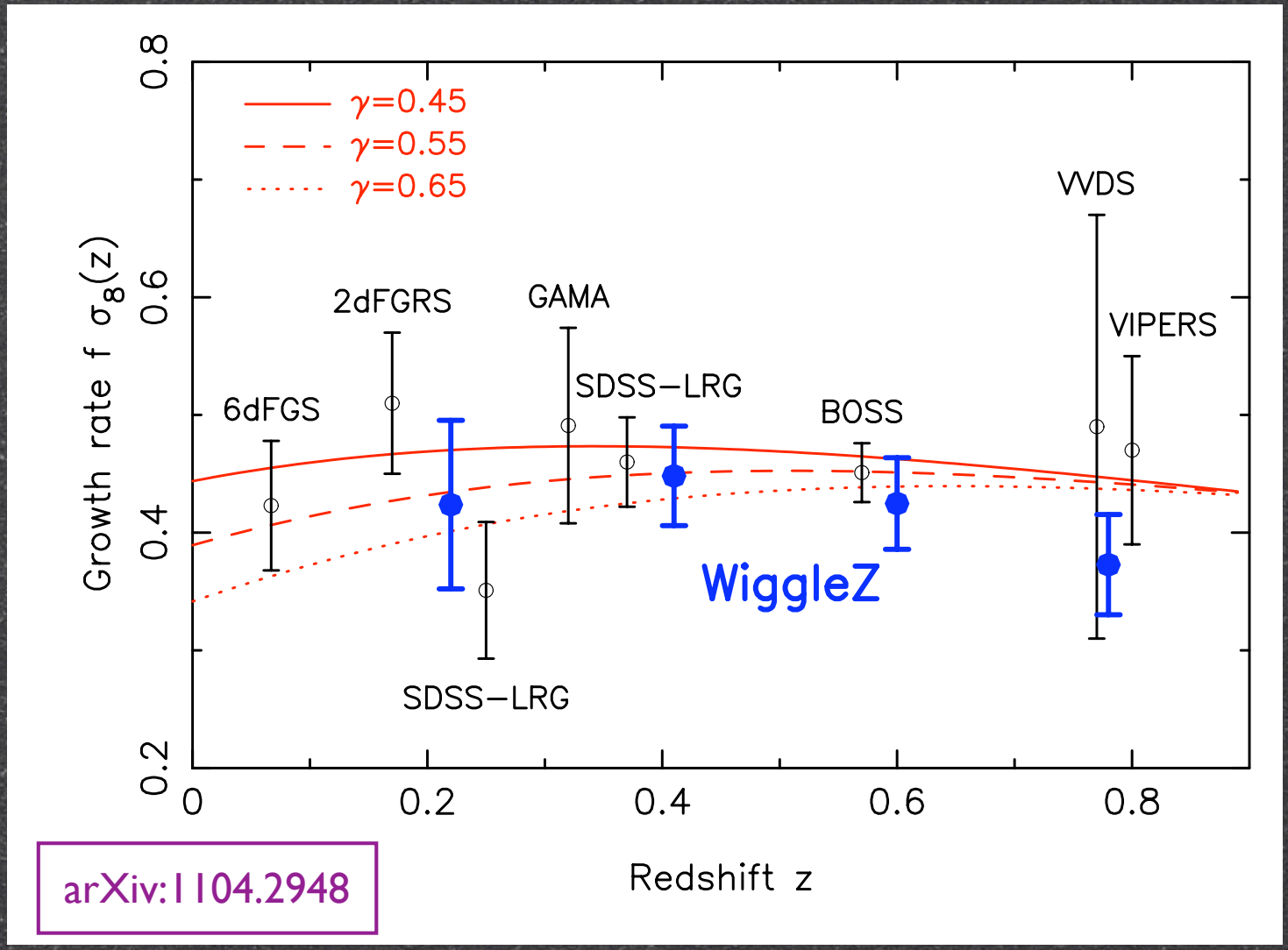


WiggleZ: Blake+ 2011, Contreras+ 2013

$$P_g^s(k,\mu) = \frac{(b + f\mu^2)^2 P_m^r(k)}{1 + [k\mu\sigma_v(1+z)/H(z)]^2}$$

Growth constraints gravity

$$f(z) \approx \Omega_m(z)^{\gamma}$$



credit: C Blake

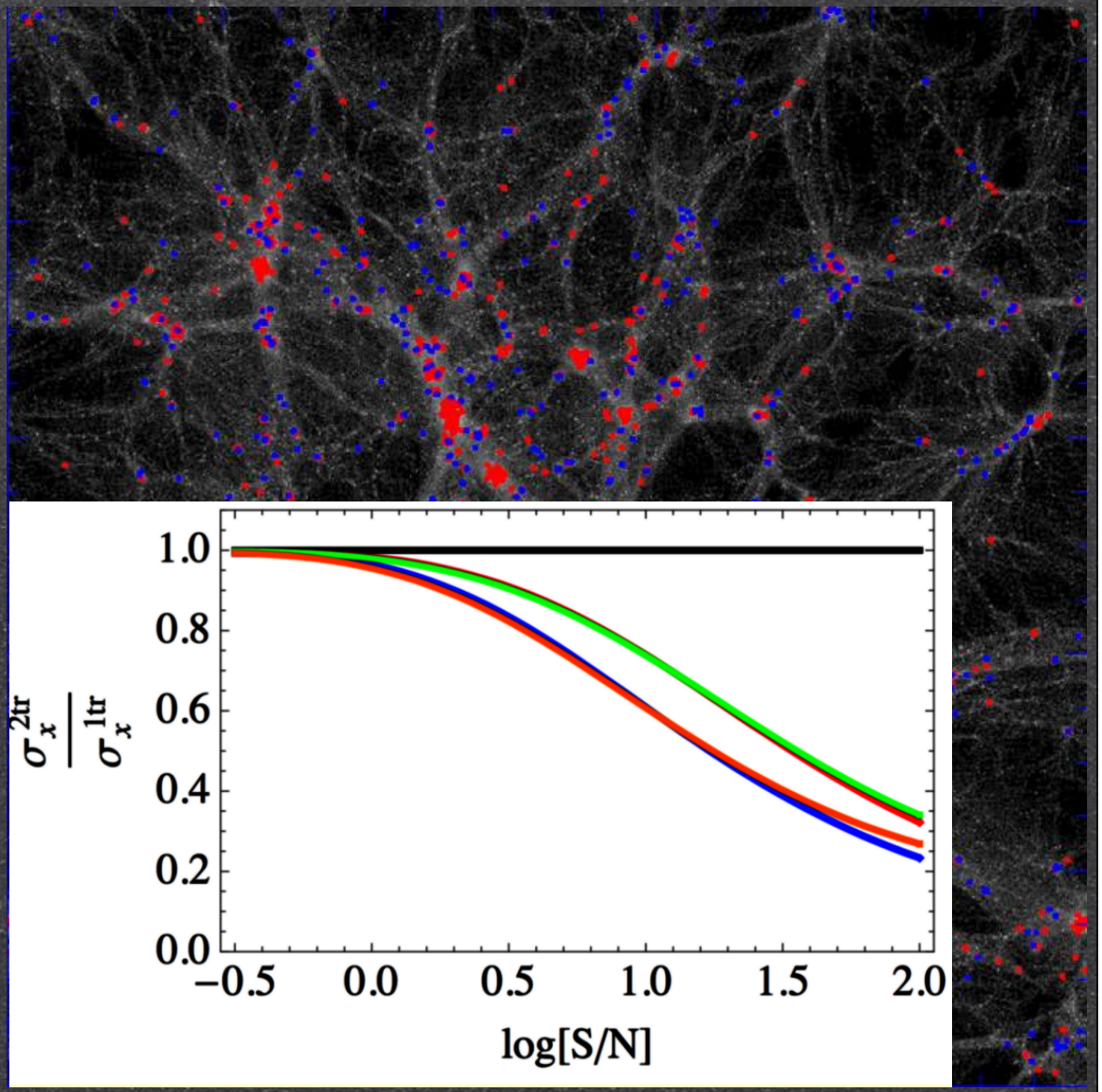
arXiv:1104.2948

But all these measurements are independent of each other!

is there a gain to measure in overlapping volumes?

Multiple Tracers

- Galaxies are not perfect tracers
  - Different bias
  - Stochasticity in bias
  - Shot noise
- MTs allow us to estimate systematics
- Shared cosmic variance! If S/N>>1 and on large scales, we can get rid of cosmic variance error (McDonald & Seljak '09, Gil-Marin+ '12)
- Blake+13: 10% improvement in GAMA - needs volume & density



Gil-Marin+ 2012

credit: X Kang

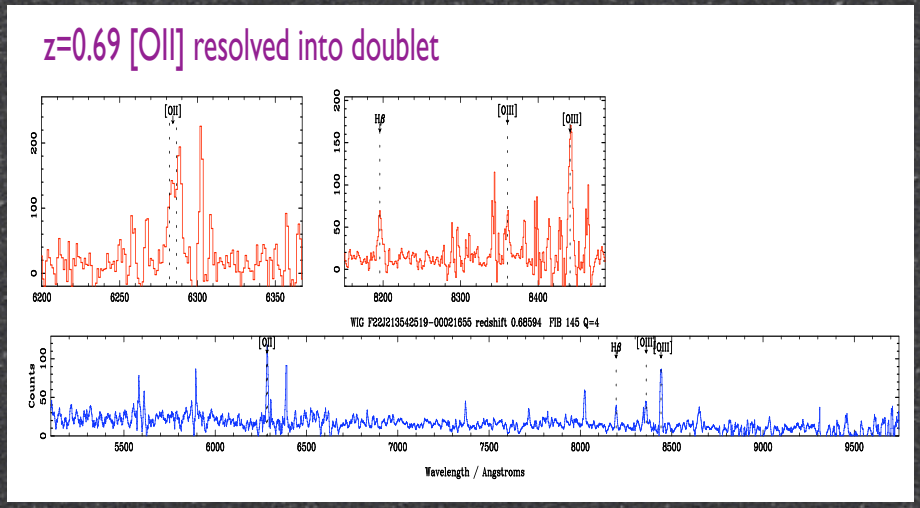
Our case

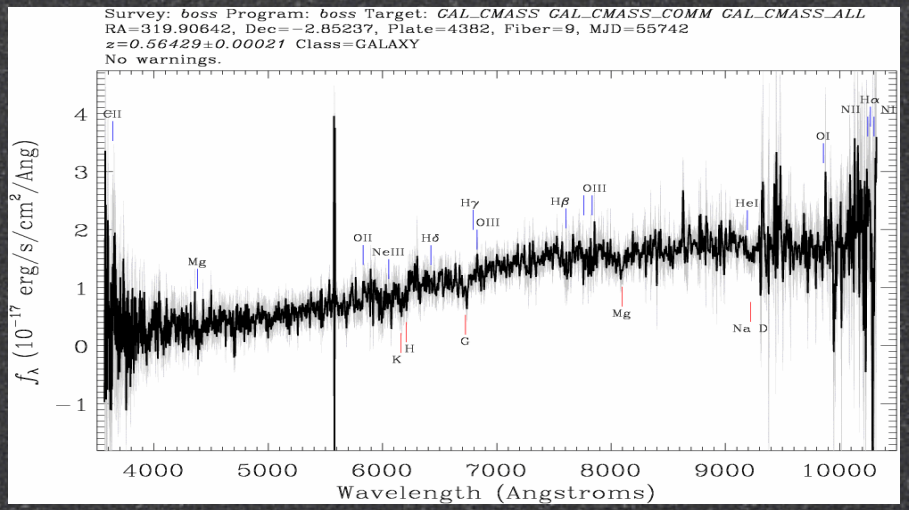
WiggleZ

- 1,000 sq deg from AAT
- Blue, emission line galaxies
- populate filaments
- 200,000 galaxies 0.2<z<1
- n ~ 2.5x10-4 (Mpc/h)-3
- b ~ 1 @ z~0.6

BOSS-DR10

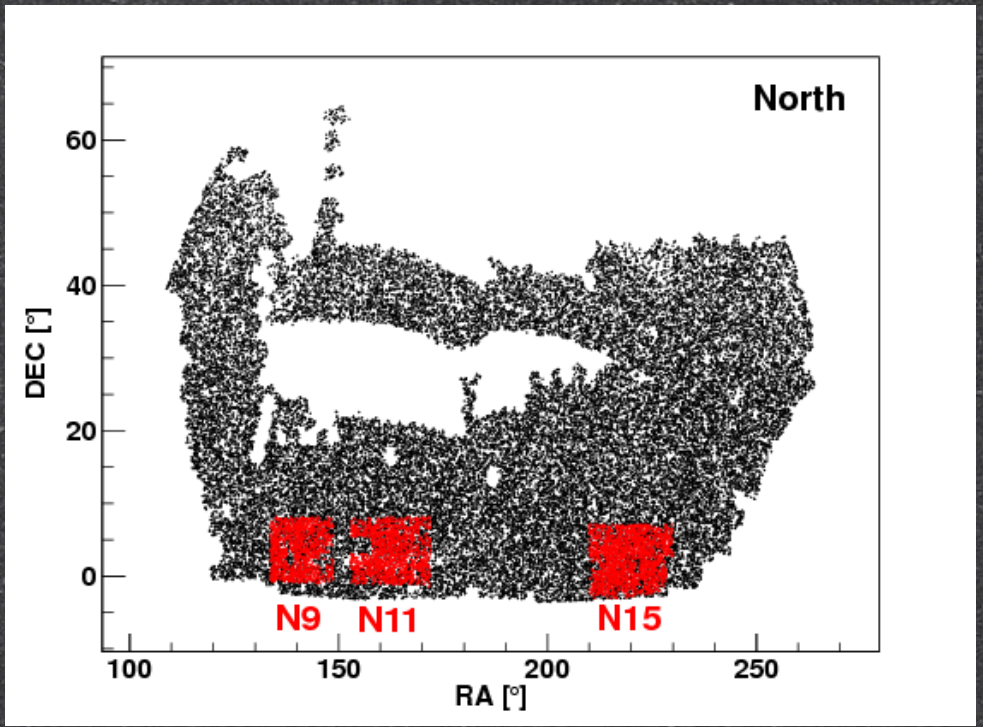
- 15,000 sq deg
- Luminous red(der) galaxies
- populate clusters
- 550,000 galaxies 0.45<z<0.7
- n ~ 2.5x10-4 (Mpc/h)-3
- b ~ 2 @ z~0.6

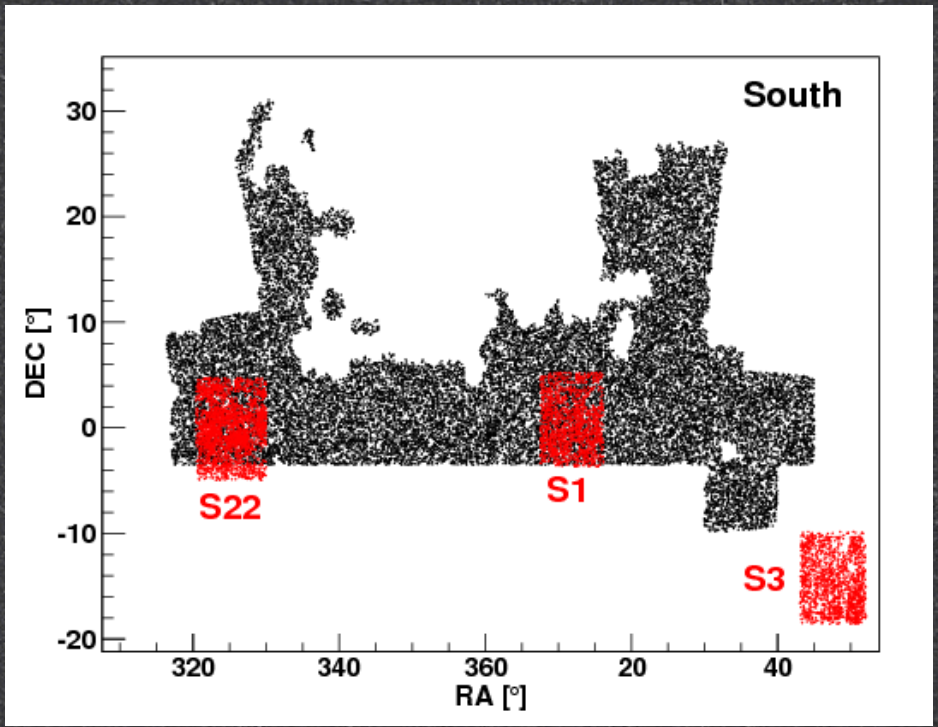




BOSS-WiggleZ overlap

- 0.43<z<0.7 x 560 sq deg ~ 0.2 (Gpc/h)3
- 68,900 WiggleZ galaxies
- 45,802 CMASSS DR10 galaxies
- No galaxy belonging to both (i.e. not counting twice)!

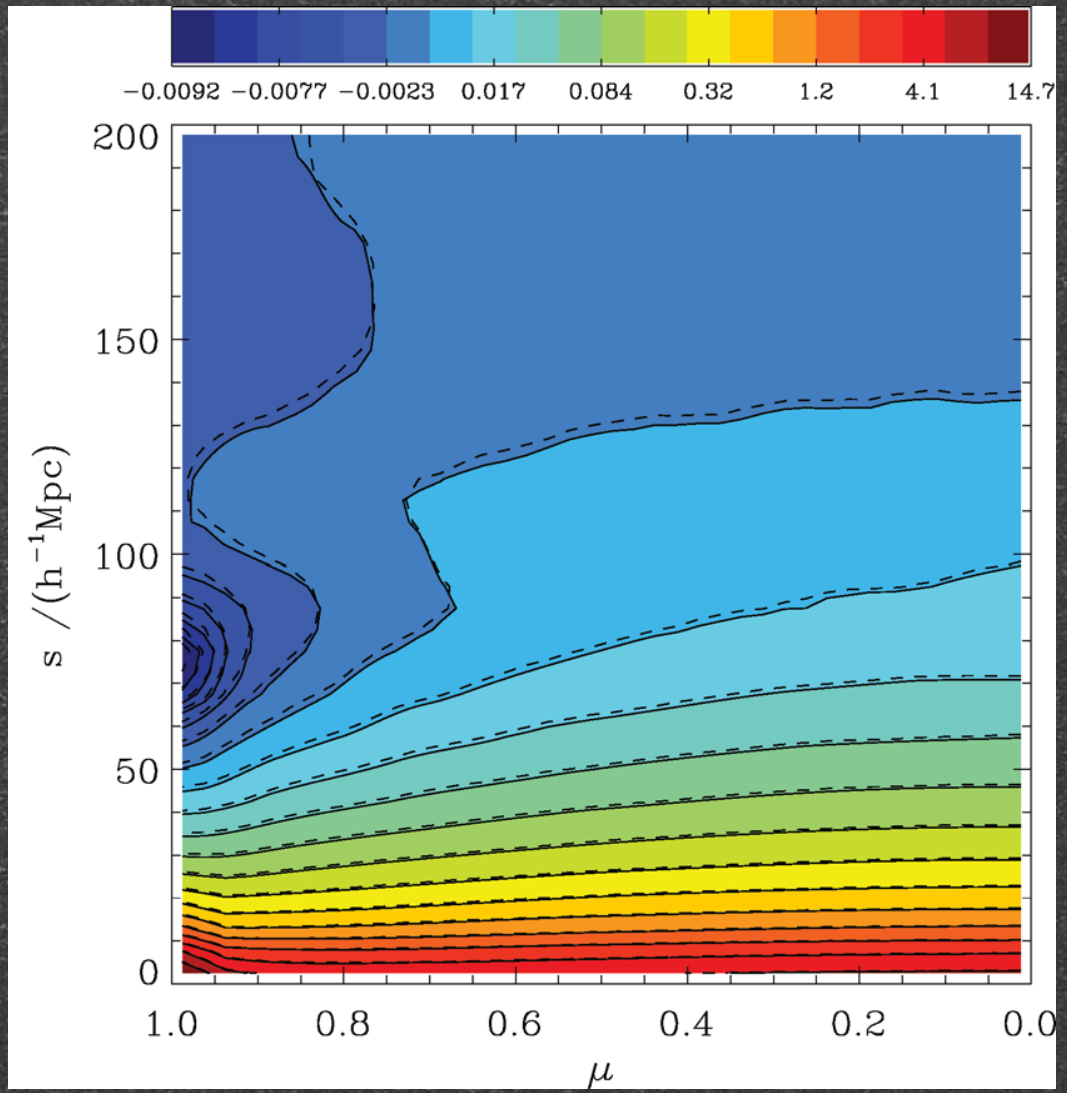




credit:F Beutler, C Blake

we measure...

$$\xi_{\rm auto}(s,\mu) = \frac{wDD(s,\mu) - 2wDR(s,\mu) + wRR(s,\mu)}{wRR(s,\mu)},$$



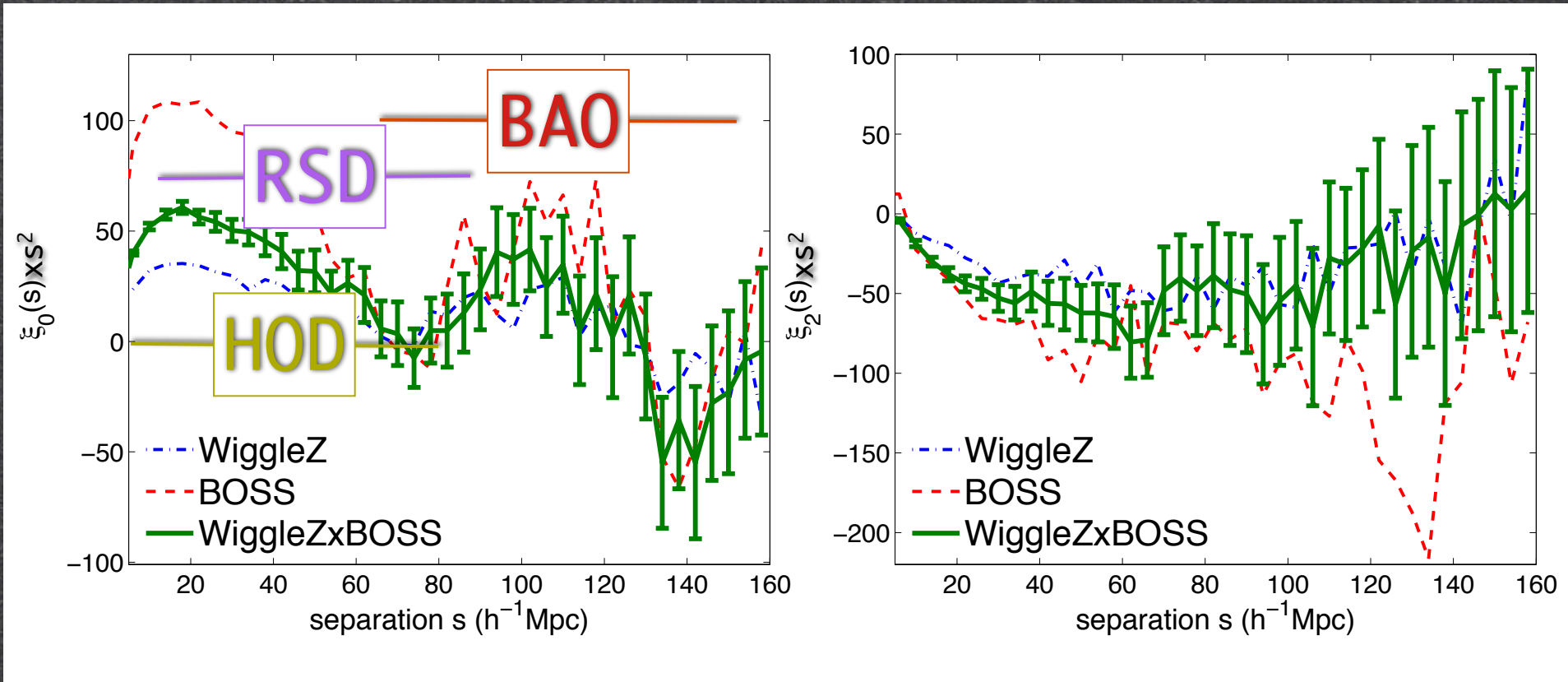
Kazin+ 2013

Auto- and cross-2PCF multipoles

- Monopole & Quadrupole (compress info)

$$\xi_l = \frac{2l+1}{2} \int_{-1}^{1} \xi(s,\mu) L_l(\mu) d\mu,$$

- What can you learn from these?



our method

- For auto-2PCF in redshift space

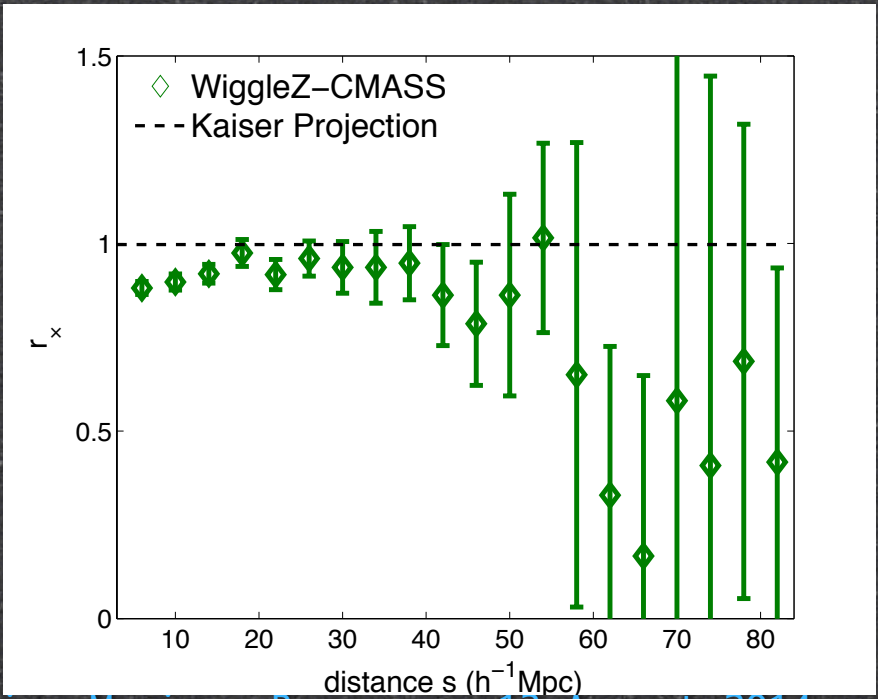
large-scale: Kaiser effect

$$P_{\rm a}^{s}(k,\mu) = \frac{b^2 P_{\delta\delta}(k) + 2\mu^2 f b P_{\delta\theta}(k) + \mu^4 f^2 P_{\theta\theta}(k)}{1 + [k\mu\sigma_v(1+z)/H(z)]^2}$$

small-scale: Fingers of God

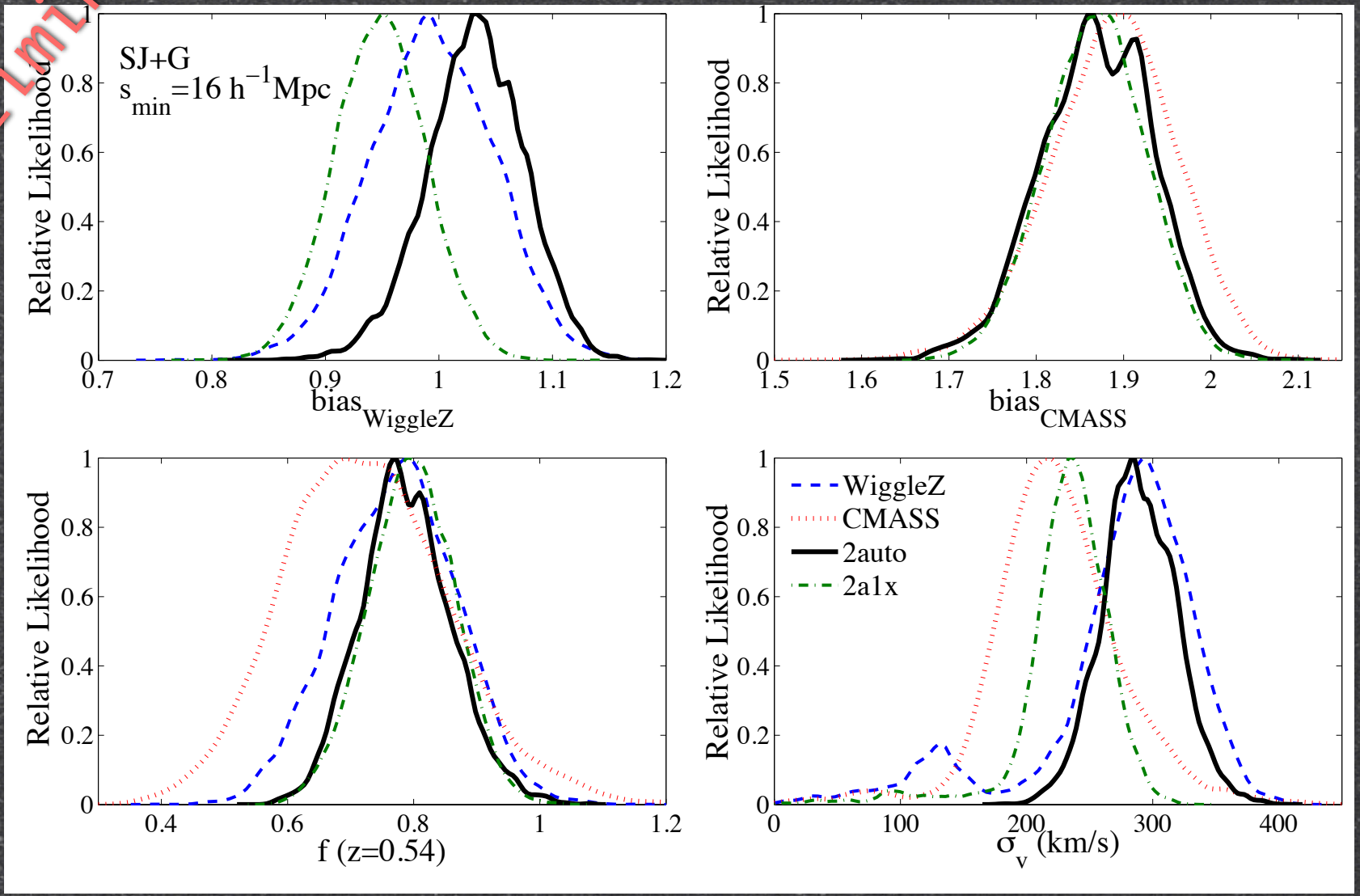
- Fit for $b_{\rm WiggleZ}$, $b_{\rm CMASS}$, f, σv

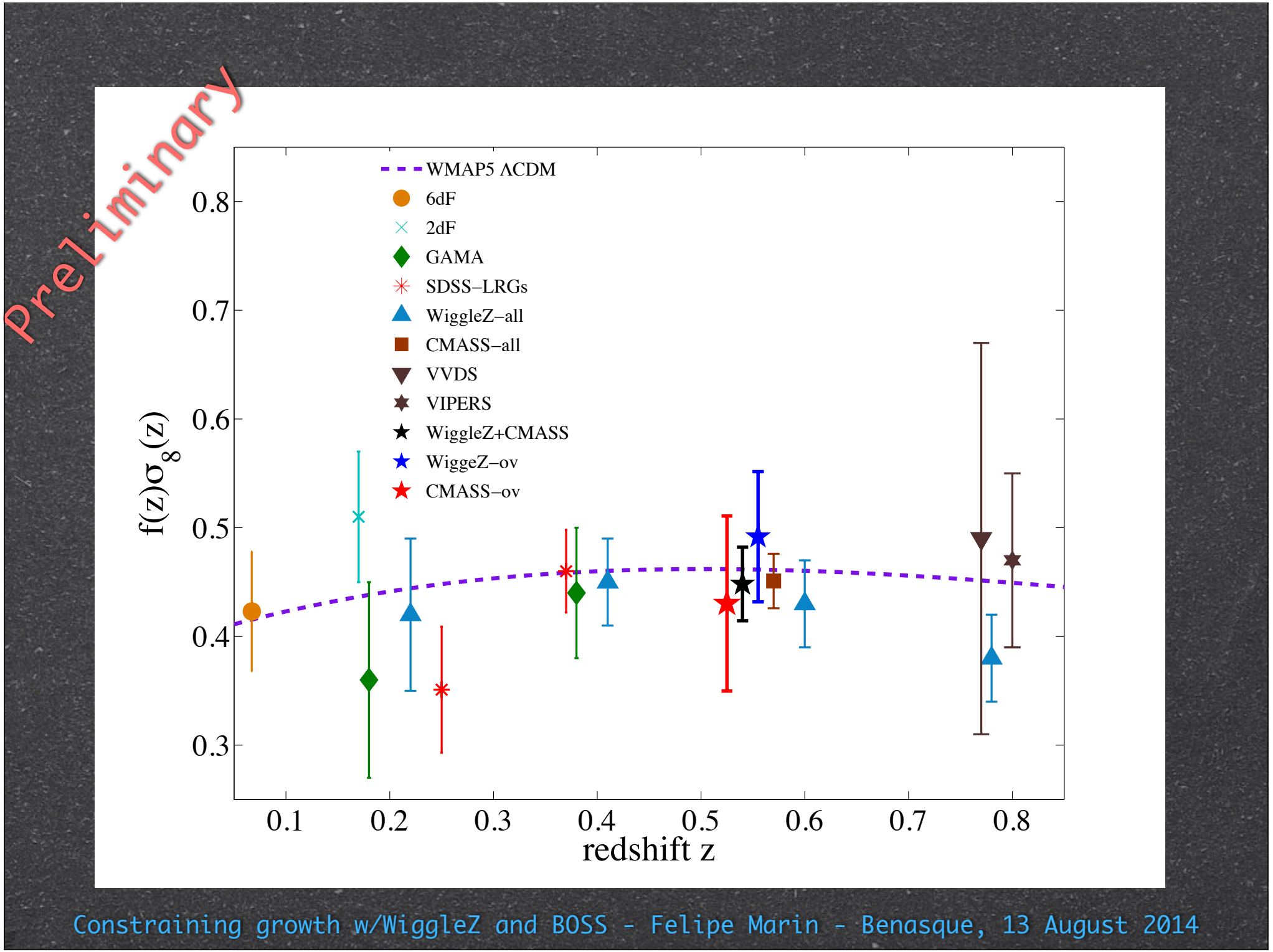
- Use common covariance: Jack-knife errors



4-parameter MCMC

Preliminary




Preliminary
WMAP5 ΛCDM
6dF
2dF
GAMA
SDSS–LRGs
WiggleZ–all
CMASS–all
VVDS
VIPERS
WiggleZ+CMASS
WiggeZ–ov
CMASS–ov
f(z)σ8(z)
redshift z
0.3
0.4
0.5
0.6
0.7
0.8
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

Summary

- Studying clustering of different galaxy types in an overlapping volume has several advantages:
  - study bias and RSD systematics
  - lower shot noise in measurements
  - avoid cosmic variance
- We measure 2D-2PCF of WiggleZ and BOSS galaxies and improve on measurements of the growth rate - consistent with LCDM predictions
- Future work: test more RSD models, add WiZcolas Covariance Matrix. Can we constraint other gravity models? Stay tuned!

gracias!