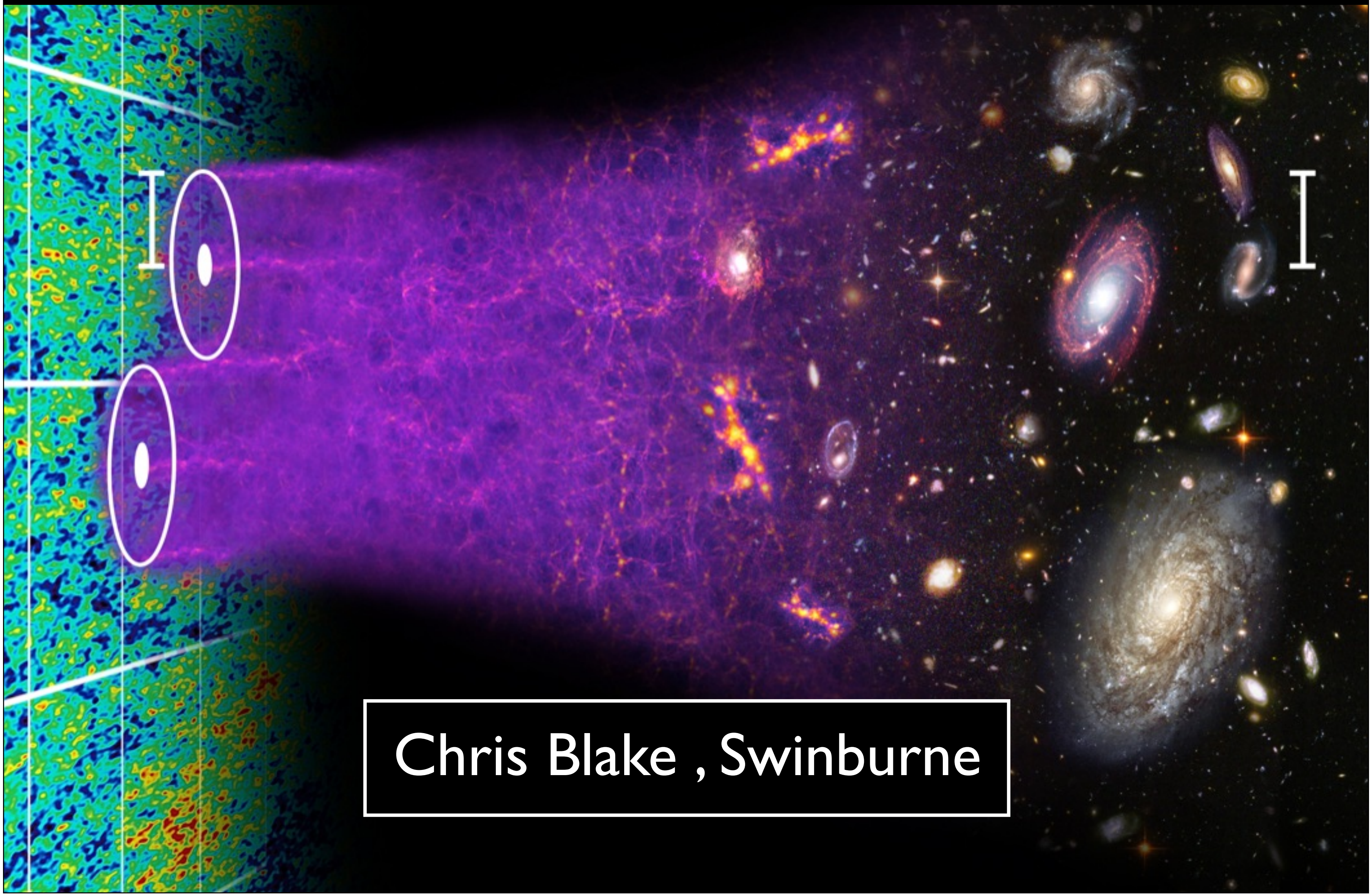
Testing cosmological models with WiggleZ



Chris Blake , Swinburne

Testing cosmological models with WiggleZ

The WiggleZ Survey Team

Swinburne : Chris Blake , Carlos Contreras , Warrick Couch , Karl Glazebrook , Tornado Li , Greg Poole , Emily Wisnioski

University of Queensland : Tamara Davis , Michael Drinkwater

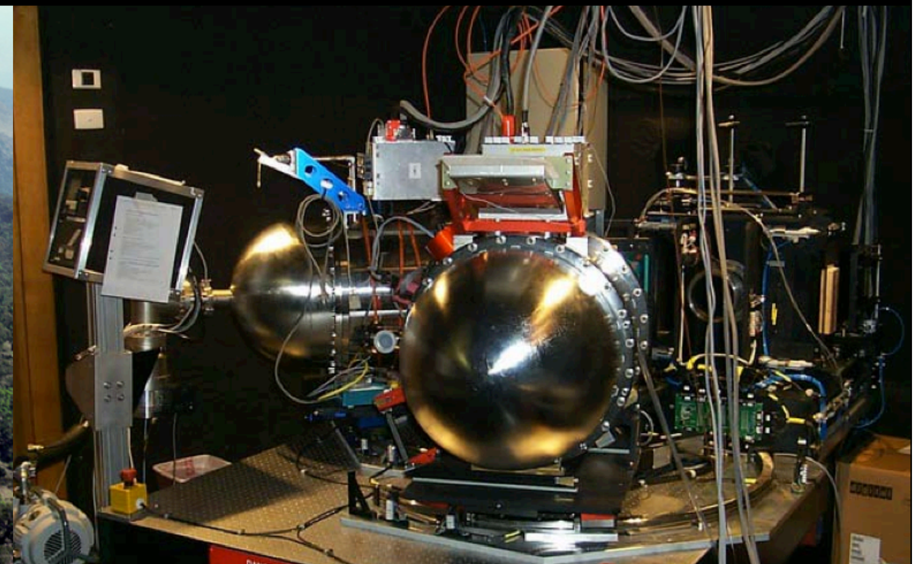
AAO : Sarah Brough , Matthew Colless , Mike Pracy , Rob Sharp

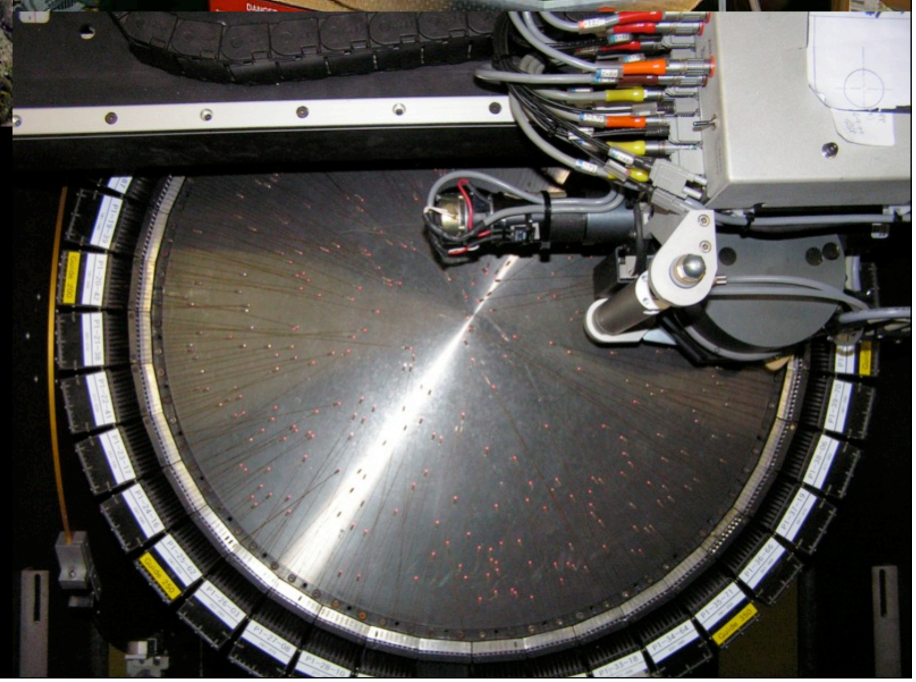
Scott Croom (U.Syd.) , Ben Jelliffe (U.Syd.) , David Woods (UBC) , Kevin Pimbblet (Monash) , Russell Jurek (ATNF)

GALEX team : Karl Forster , Barry Madore , Chris Martin , Ted Wyder

RCS2 team : David Gilbank , Mike Gladders , Howard Yee

The WiggleZ Dark Energy Survey



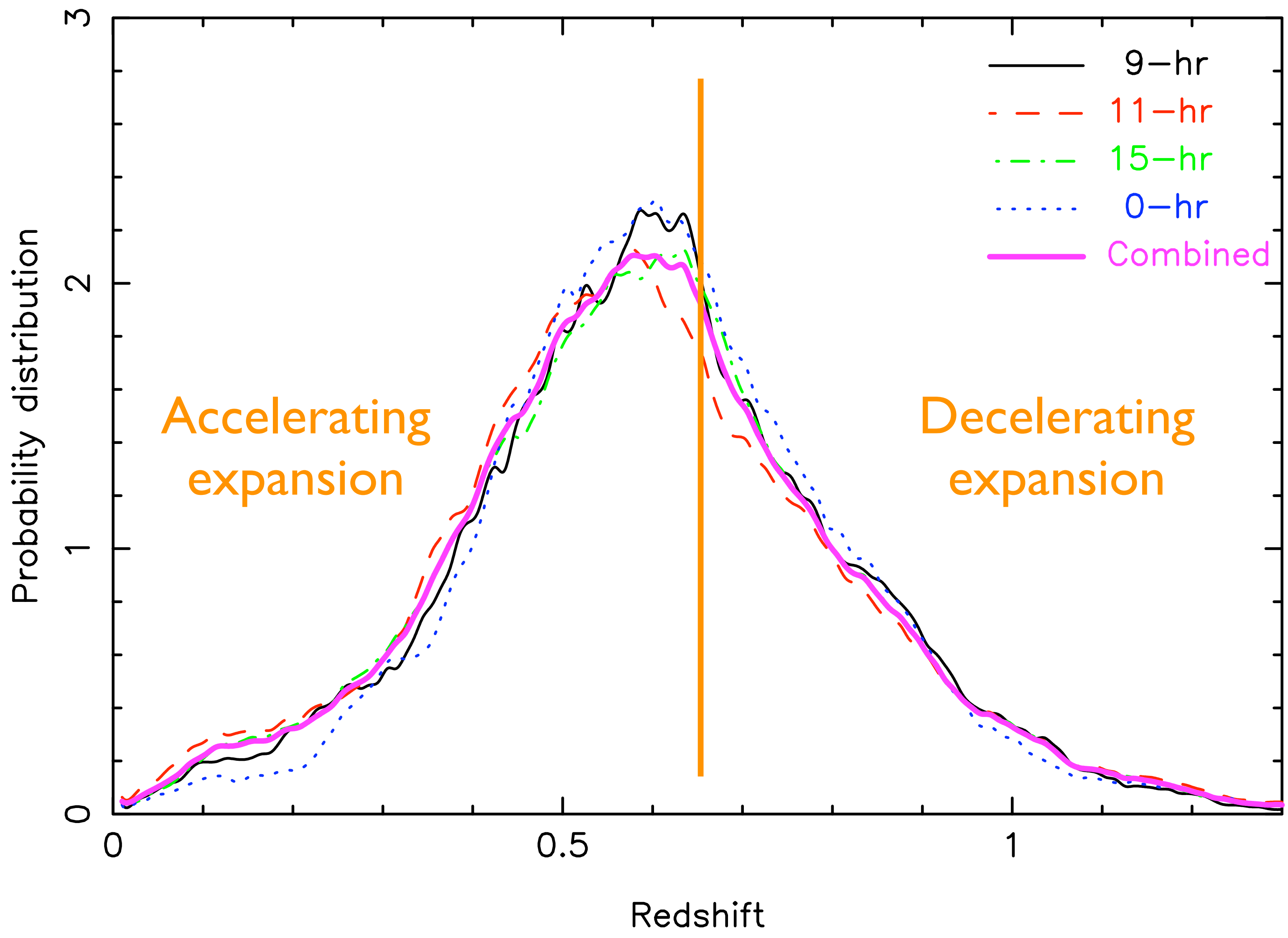


- 1000 sq deg , 0.2 < z < 1.0
- 200,000 redshifts
- blue star-forming galaxies
- 2006-2010

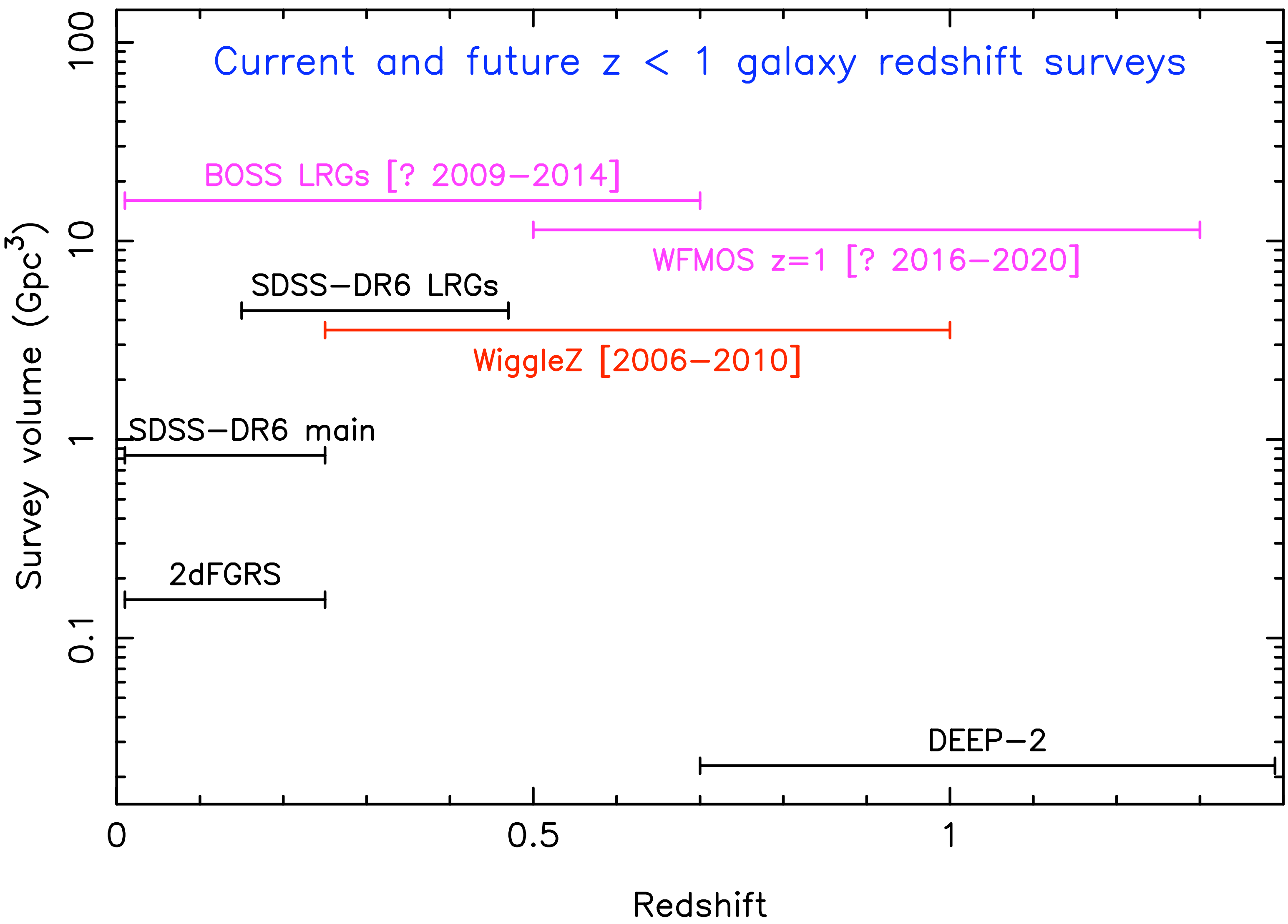
The WiggleZ Dark Energy Survey

- Map ~1 Gpc^3 of the Universe at much higher redshift than existing surveys
- Use baryon oscillations to map the distance-redshift relation to z=1 to allow systematic cross-checks with supernova measurements
- Measure growth of cosmic structure from z=1 to z=0 to test the physical nature of dark energy
- Neutrino mass , homogeneity , bispectrum , Alcock-Paczynski effect , genus , galaxy formation , ...

The WiggleZ Dark Energy Survey



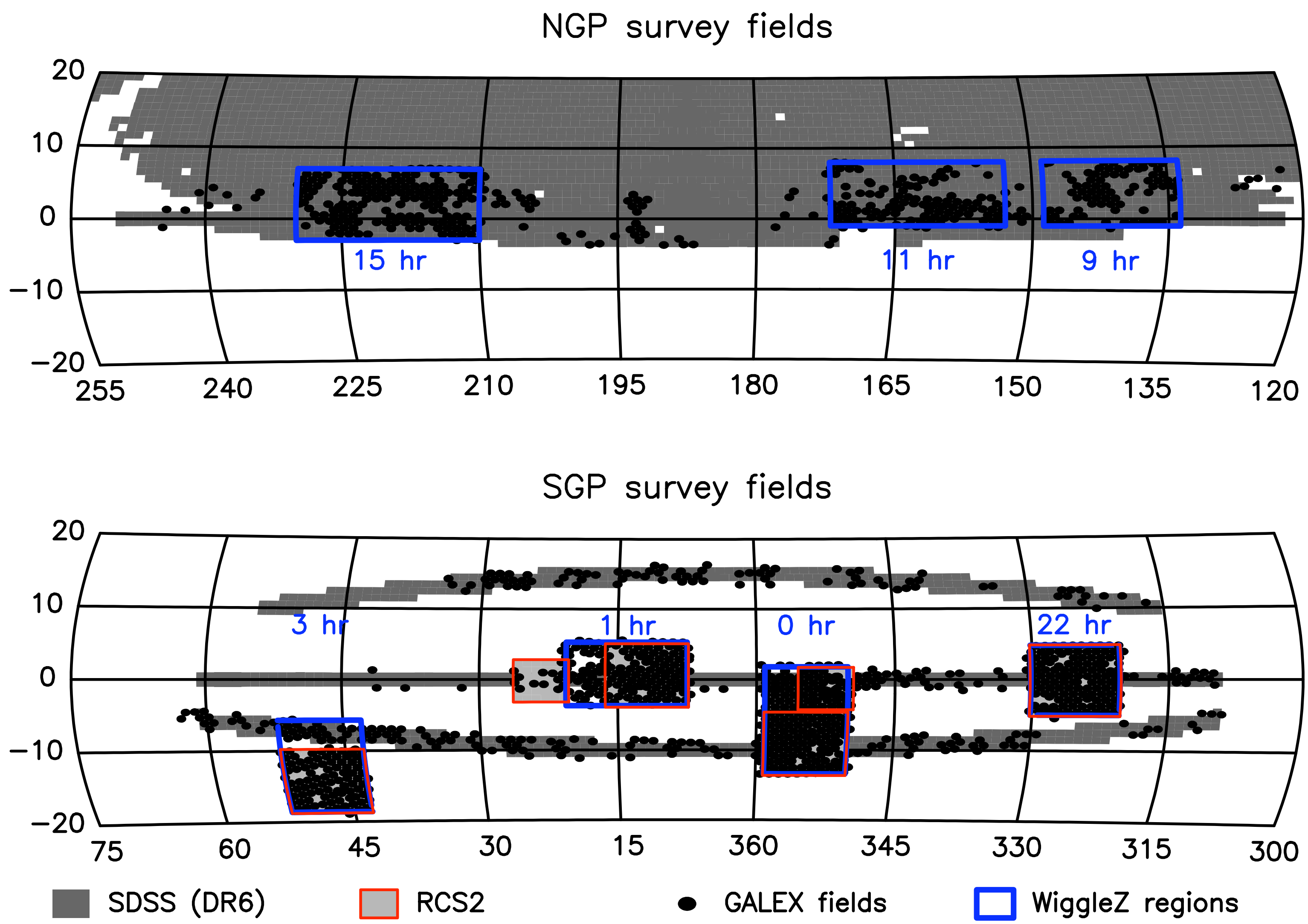
The WiggleZ Dark Energy Survey



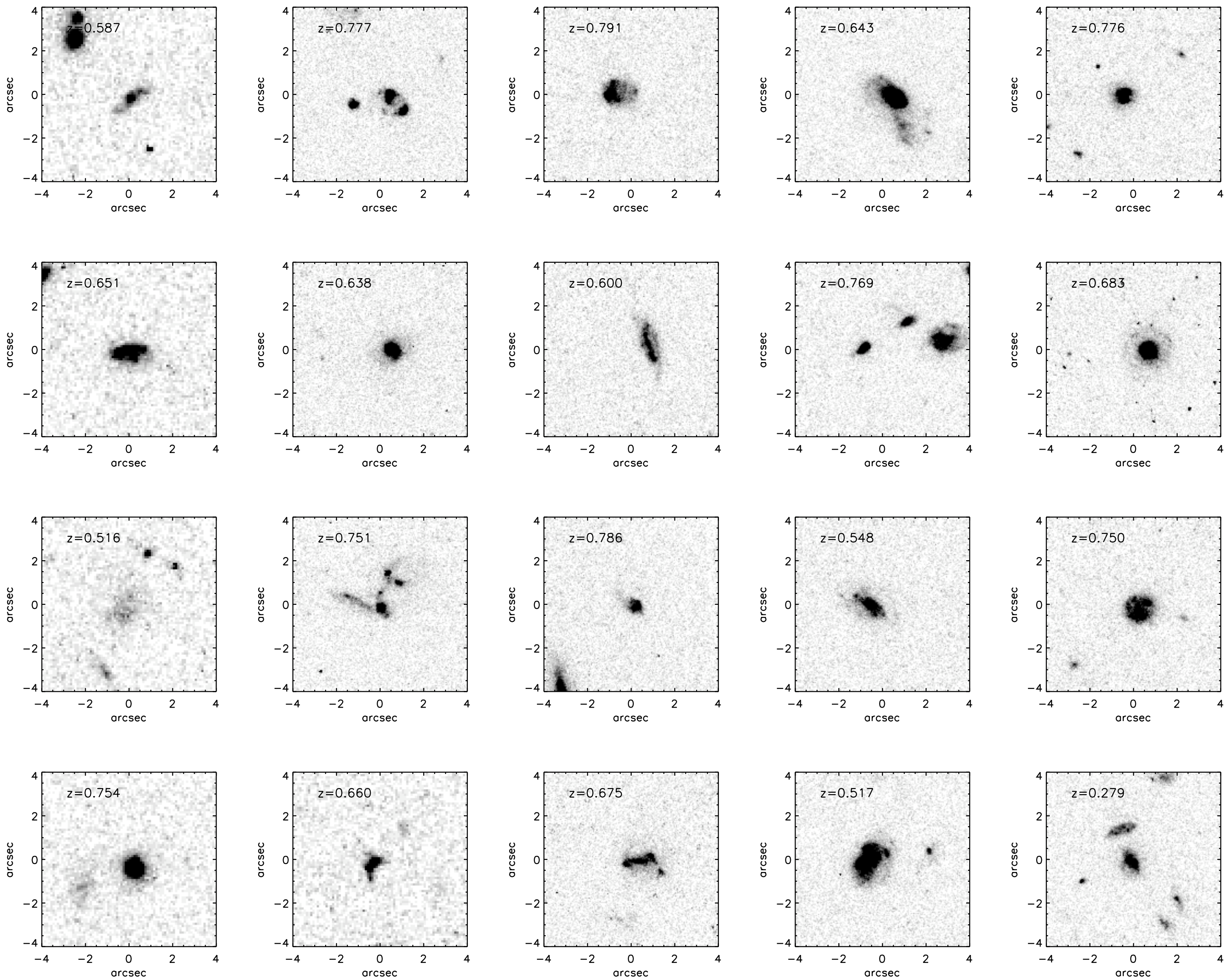
Survey design

- Follow up UV-selected sources from GALEX imaging matched with optical surveys for precise fibre position
- Colour cuts select high-redshift galaxies
- Star-forming galaxies : redshifts from emission lines, star formation rates 10-100 solar masses per year
- Very short 1-hr exposures - maximize numbers tolerating a 70% redshift completeness rate

Survey design



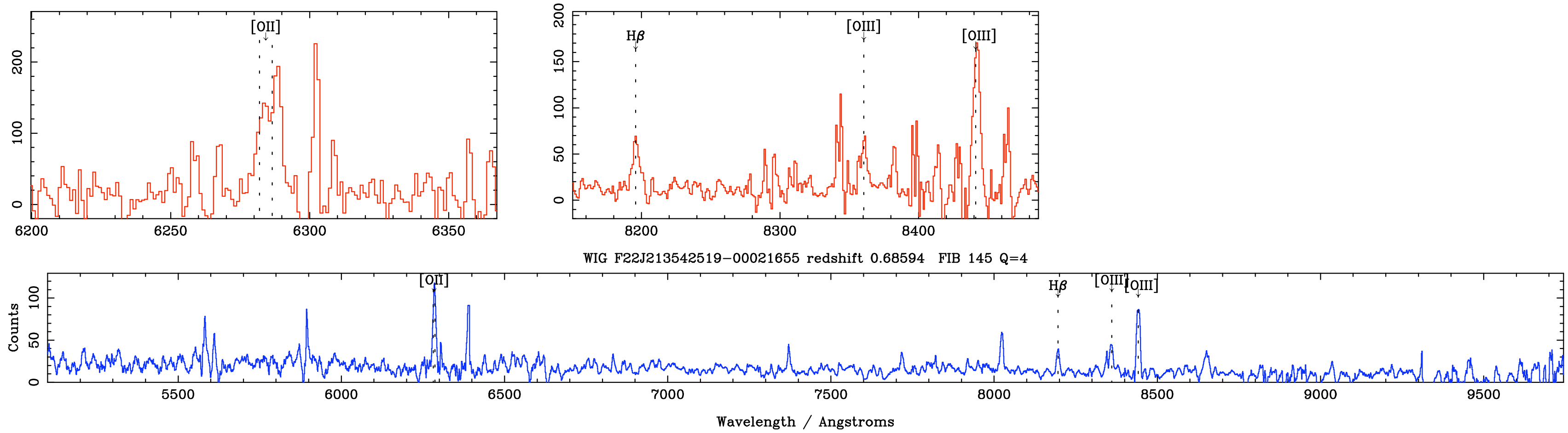
Morphologies



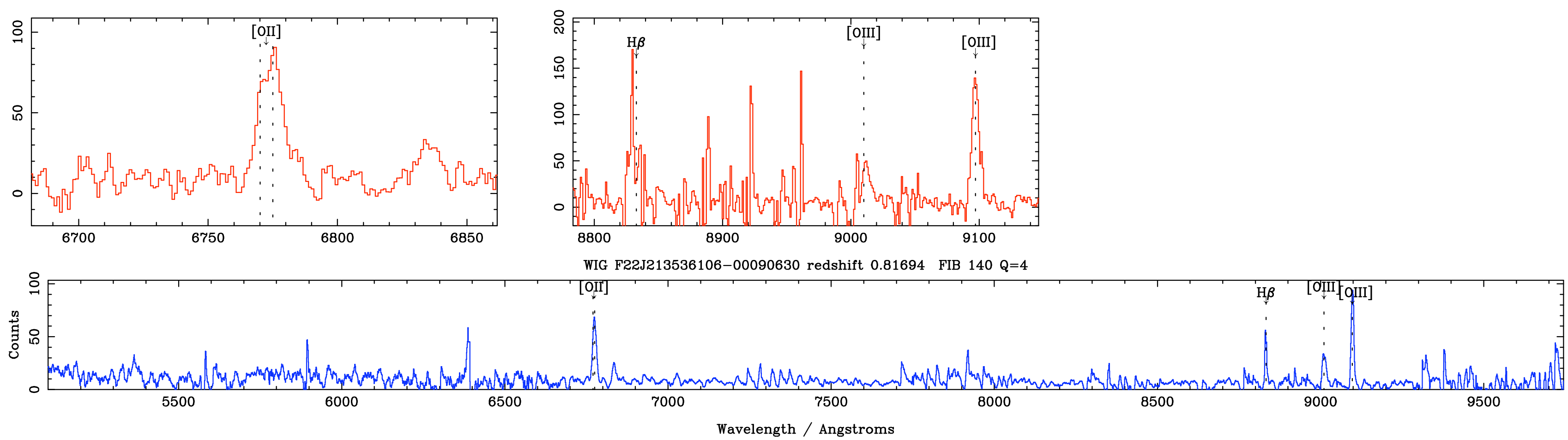
(Credit: Mike Pracy)

Spectra

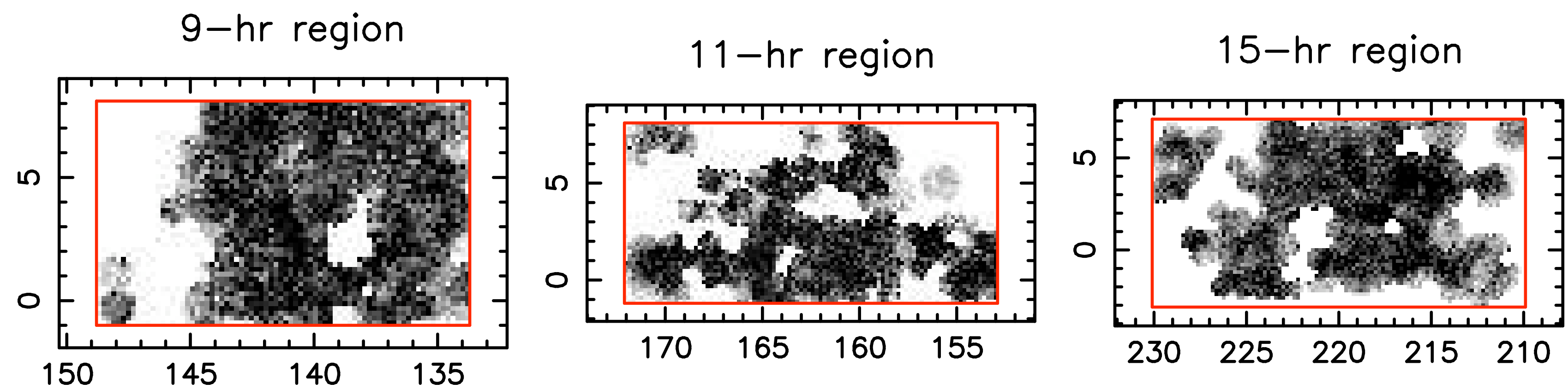
z=0.69 [OII] resolved into doublet



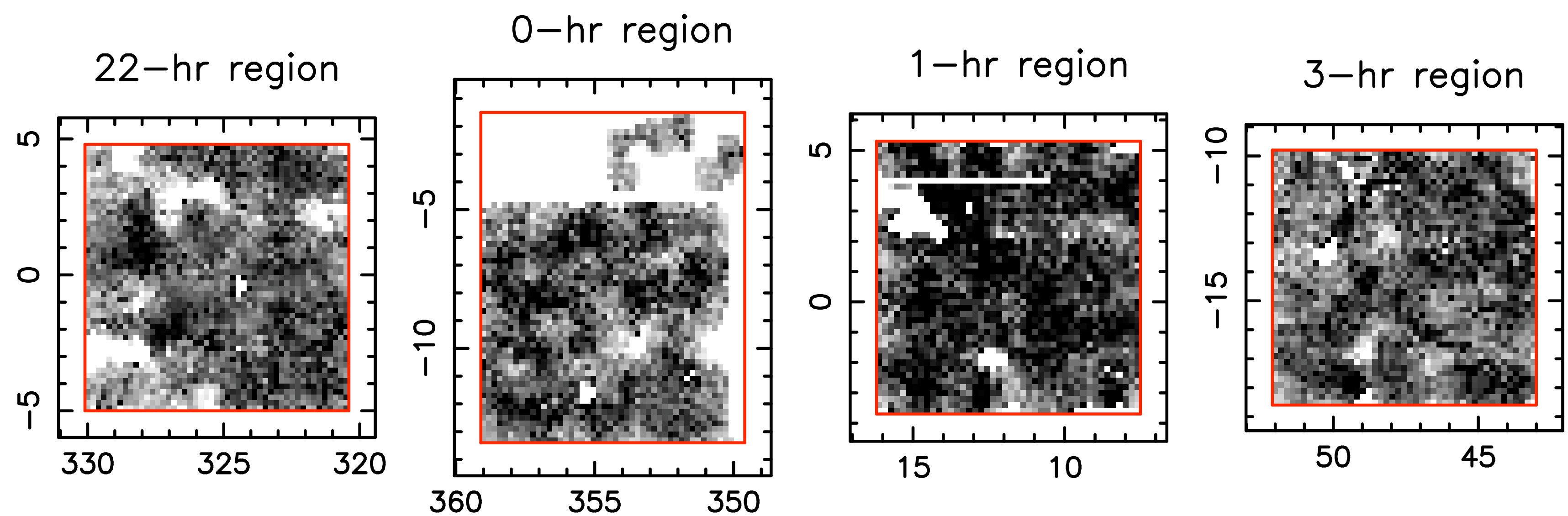
z=0.82 confirming lines detected using new dichroic



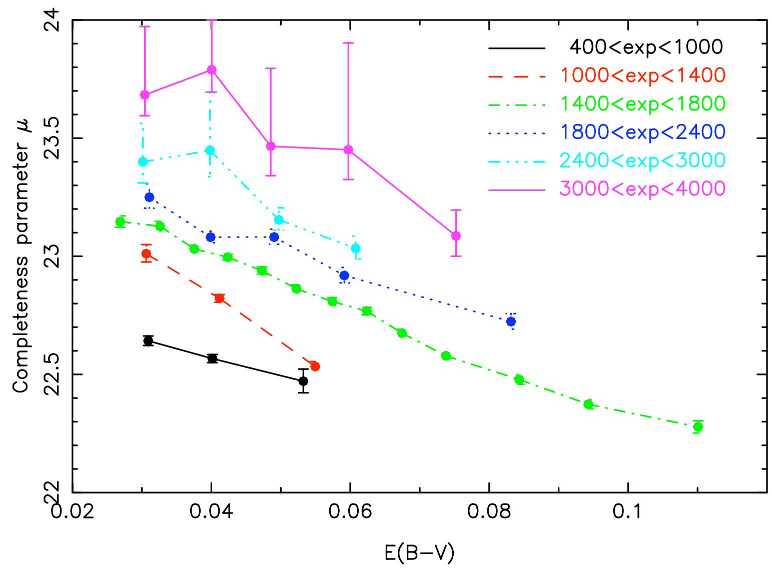
WiggleZ survey regions (Oct 09)

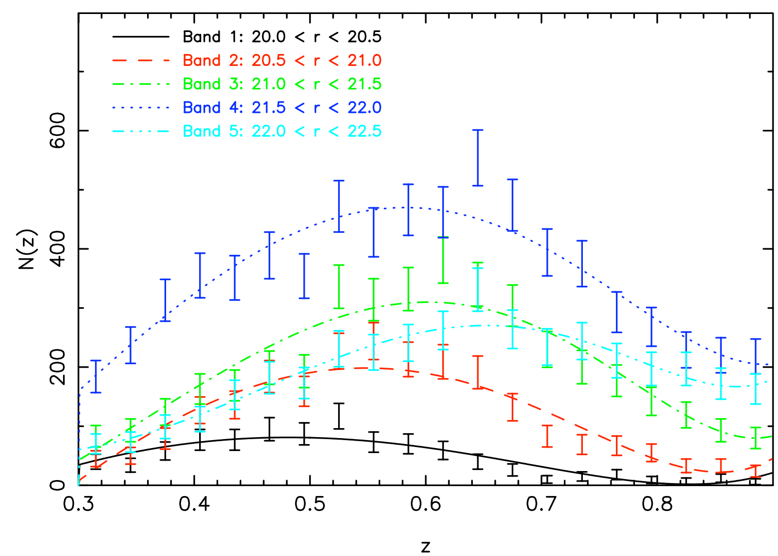


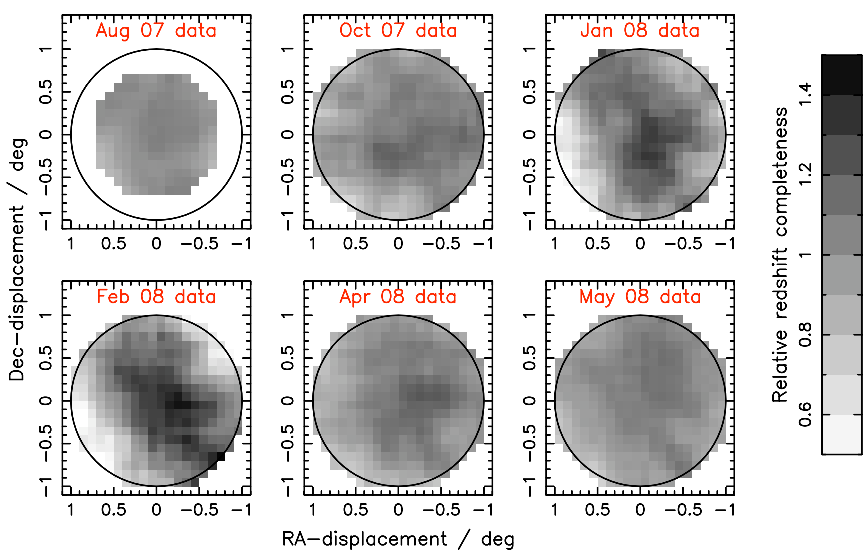
Total ~ 120,000 galaxies

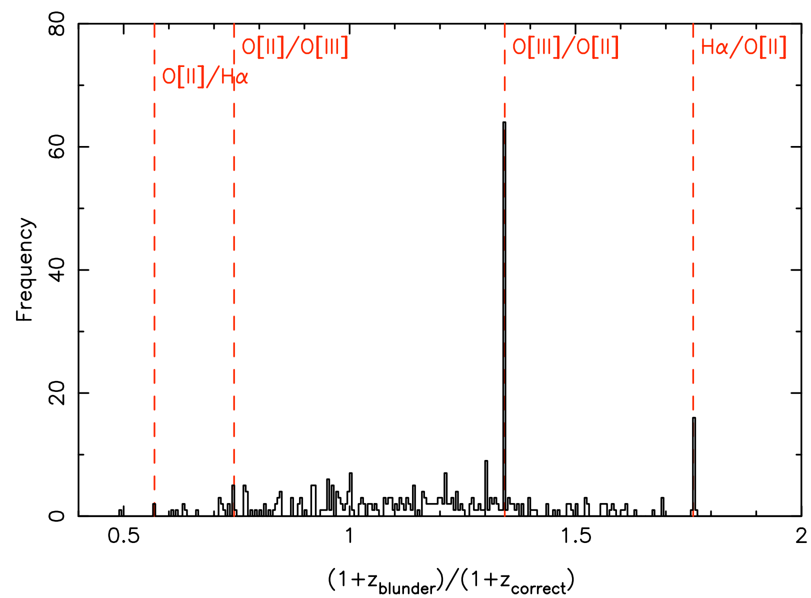


Survey selection function

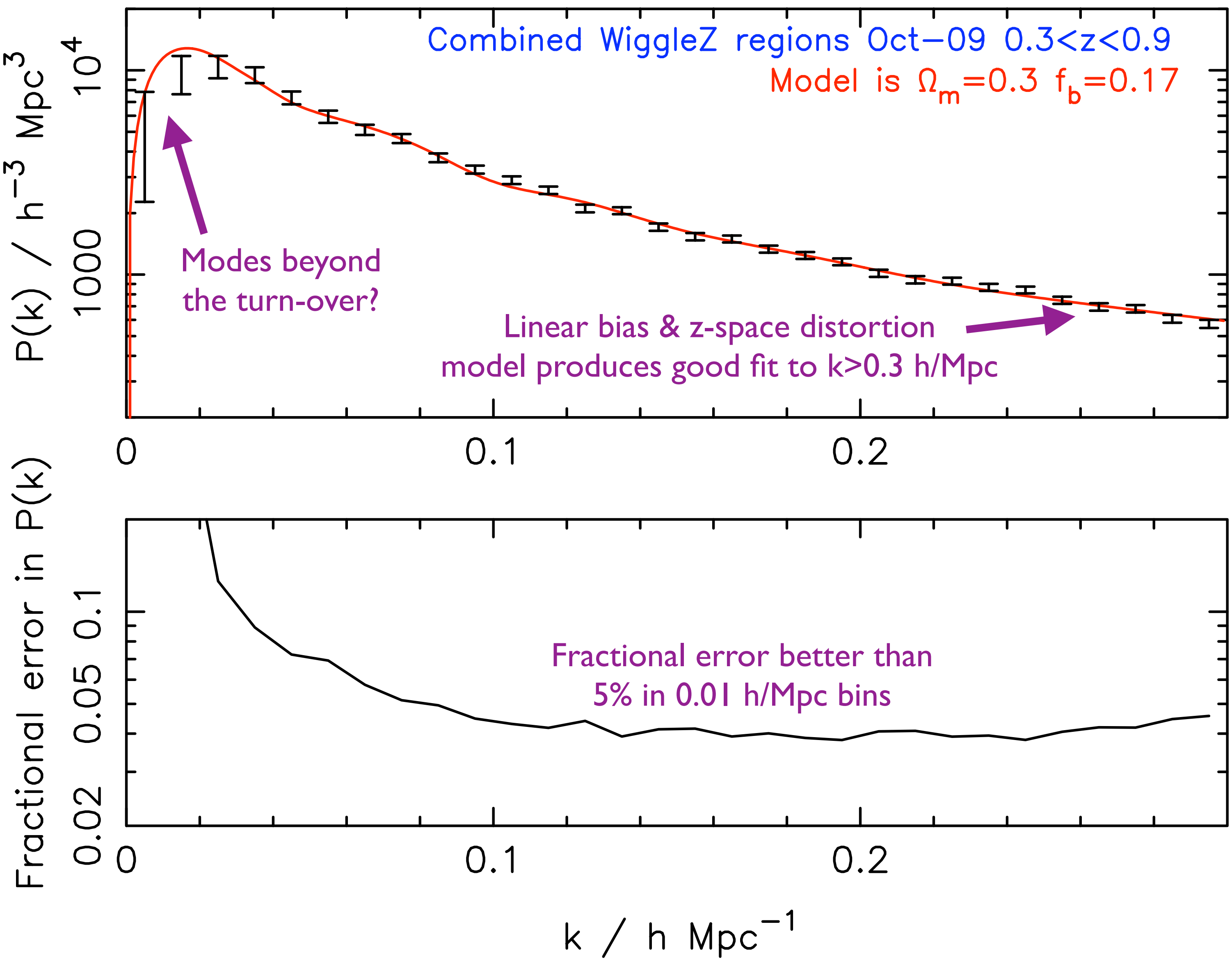




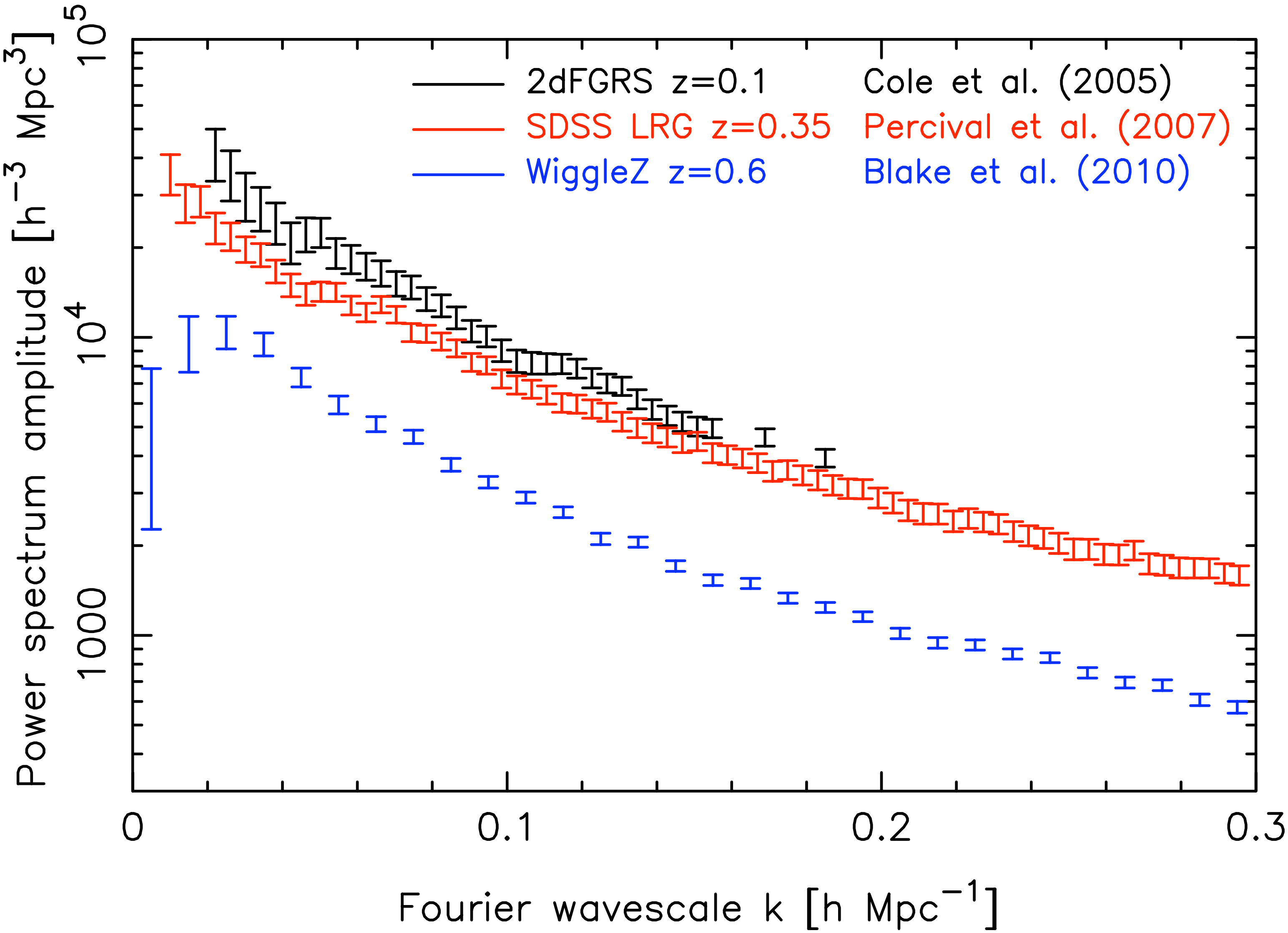




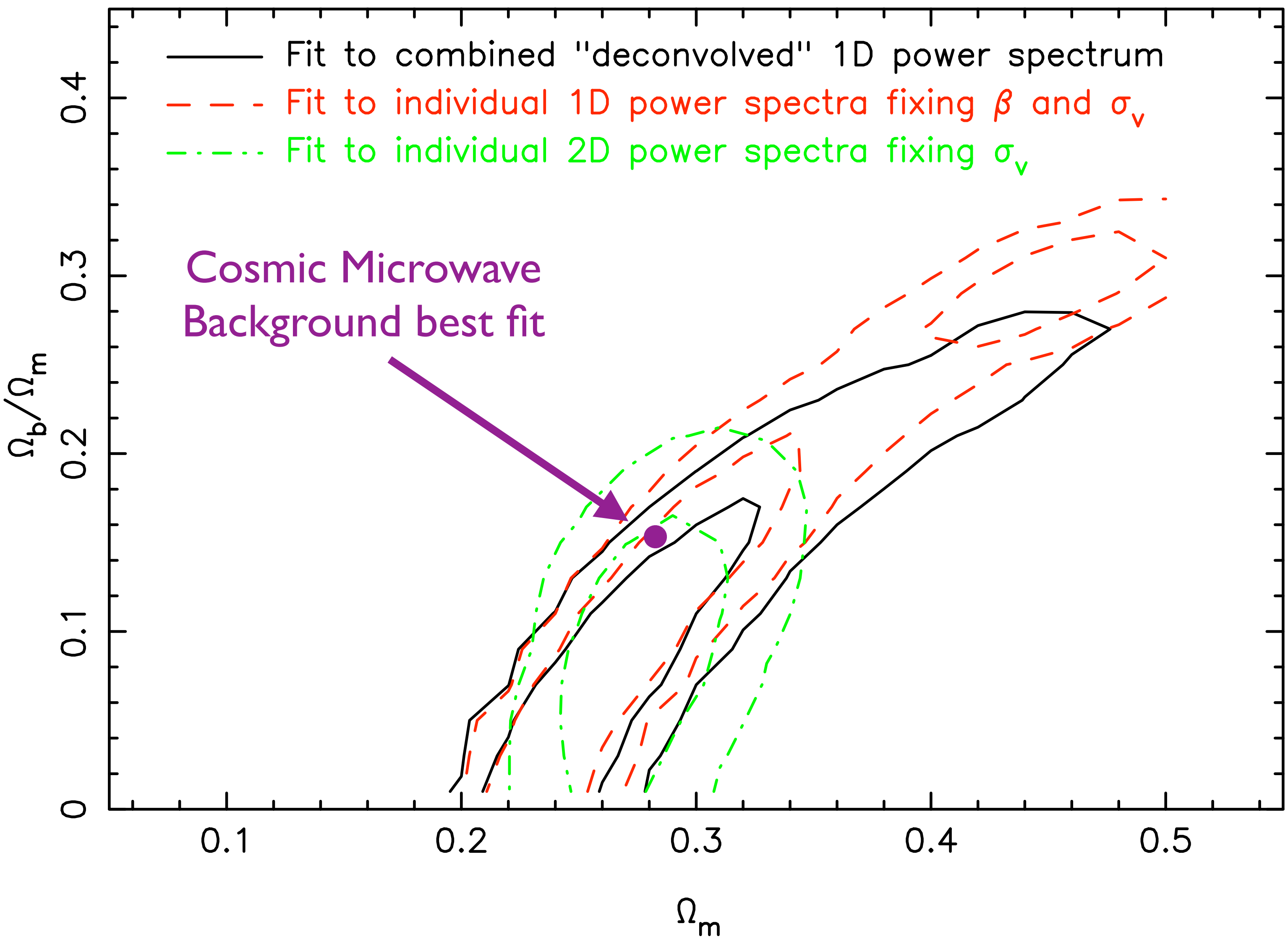
Power spectrum



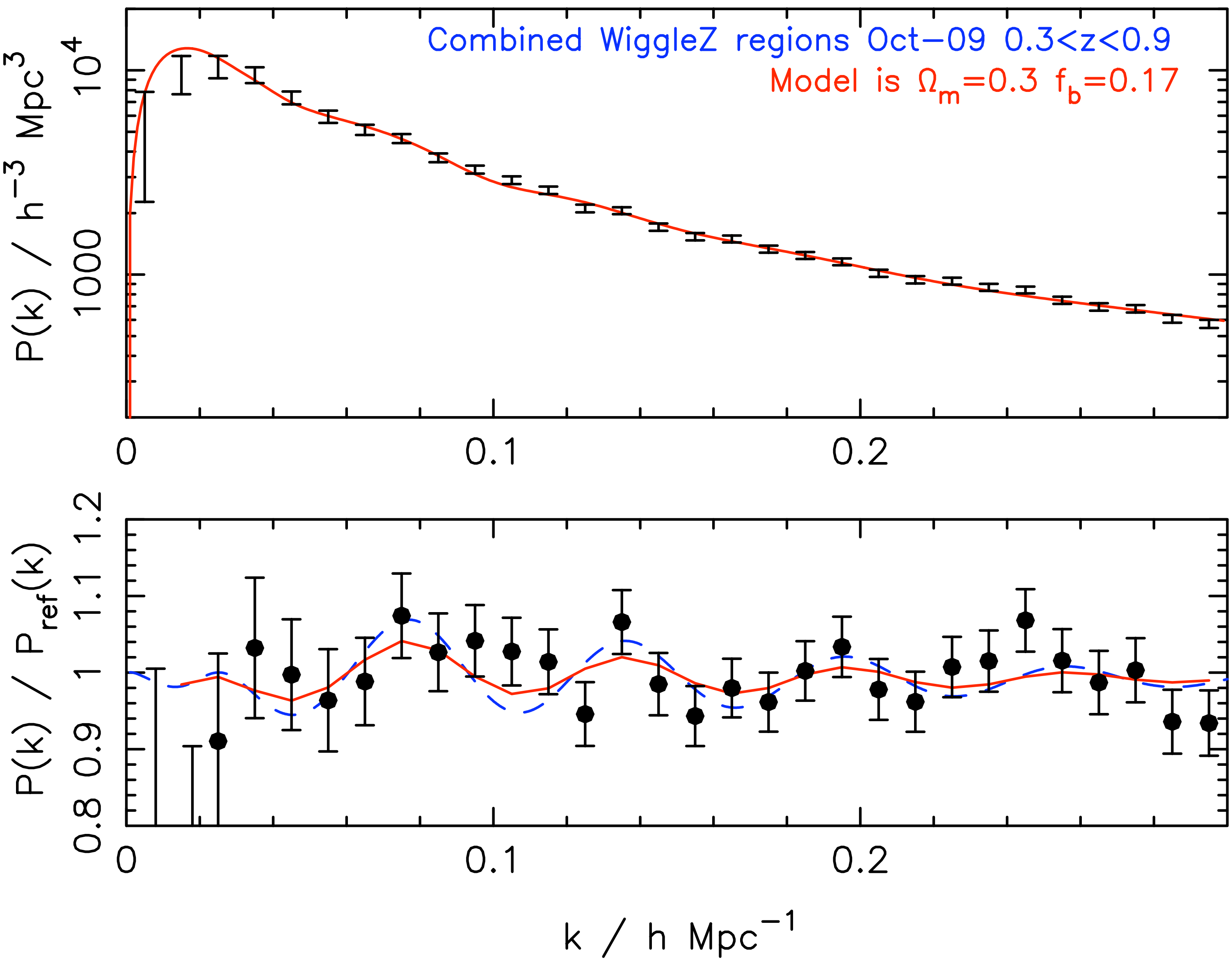
Power spectrum



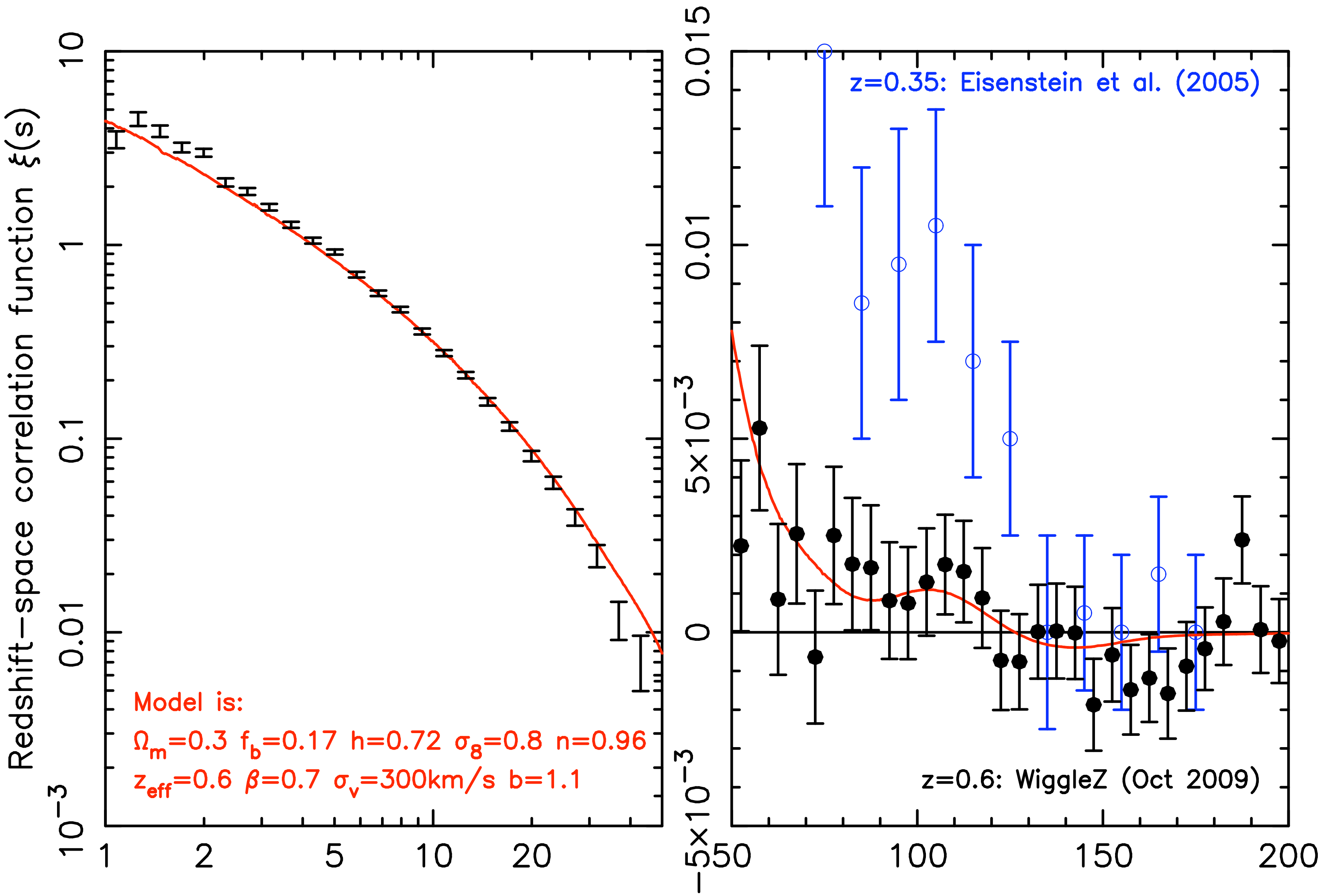
Cosmological parameter fits



Baryon oscillations?



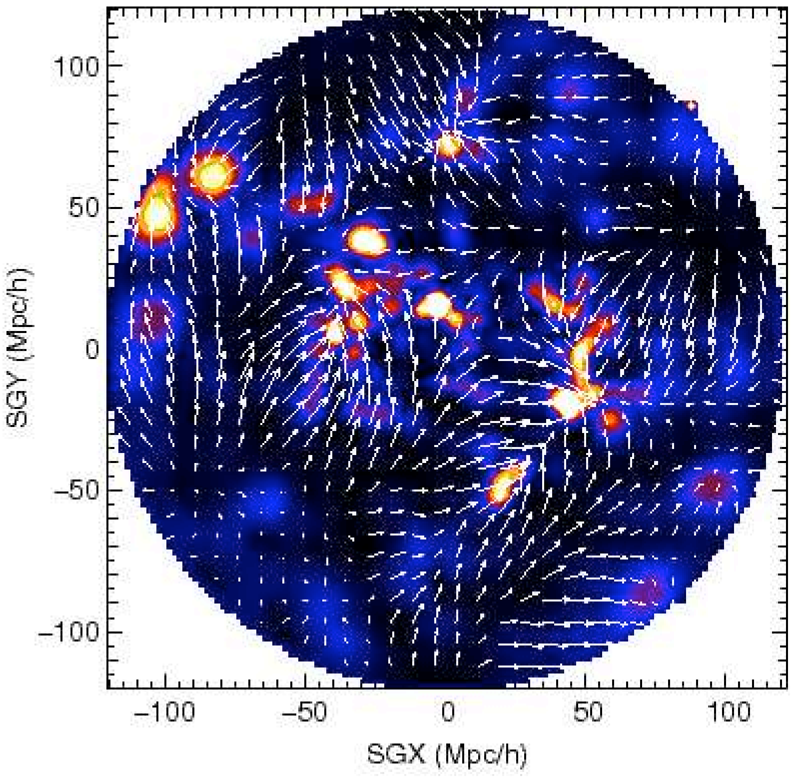
Baryon oscillations?



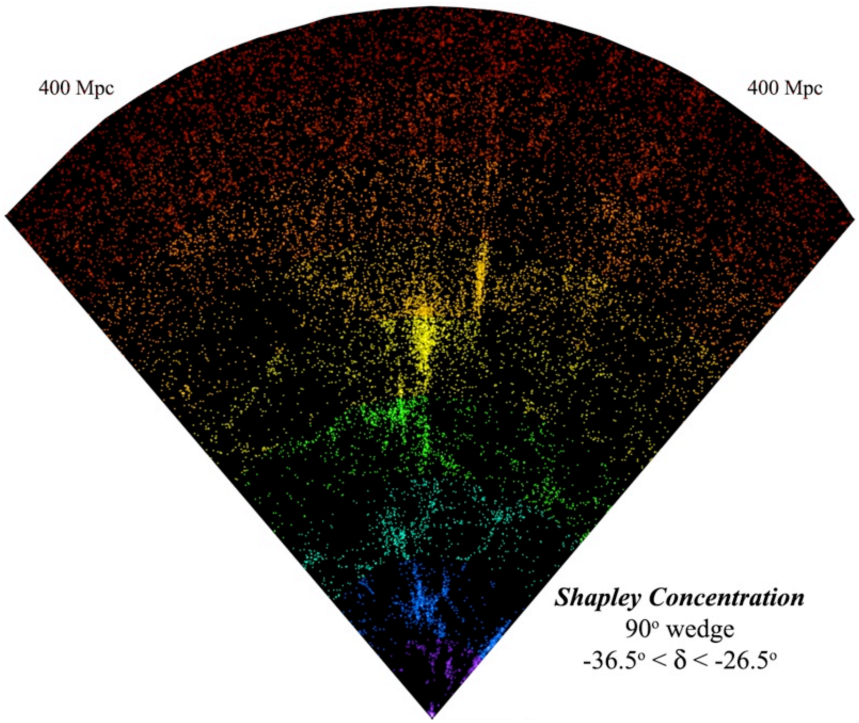
Redshift-space distortions

- Does a cosmological model produce self-consistent cosmic growth and expansion histories?

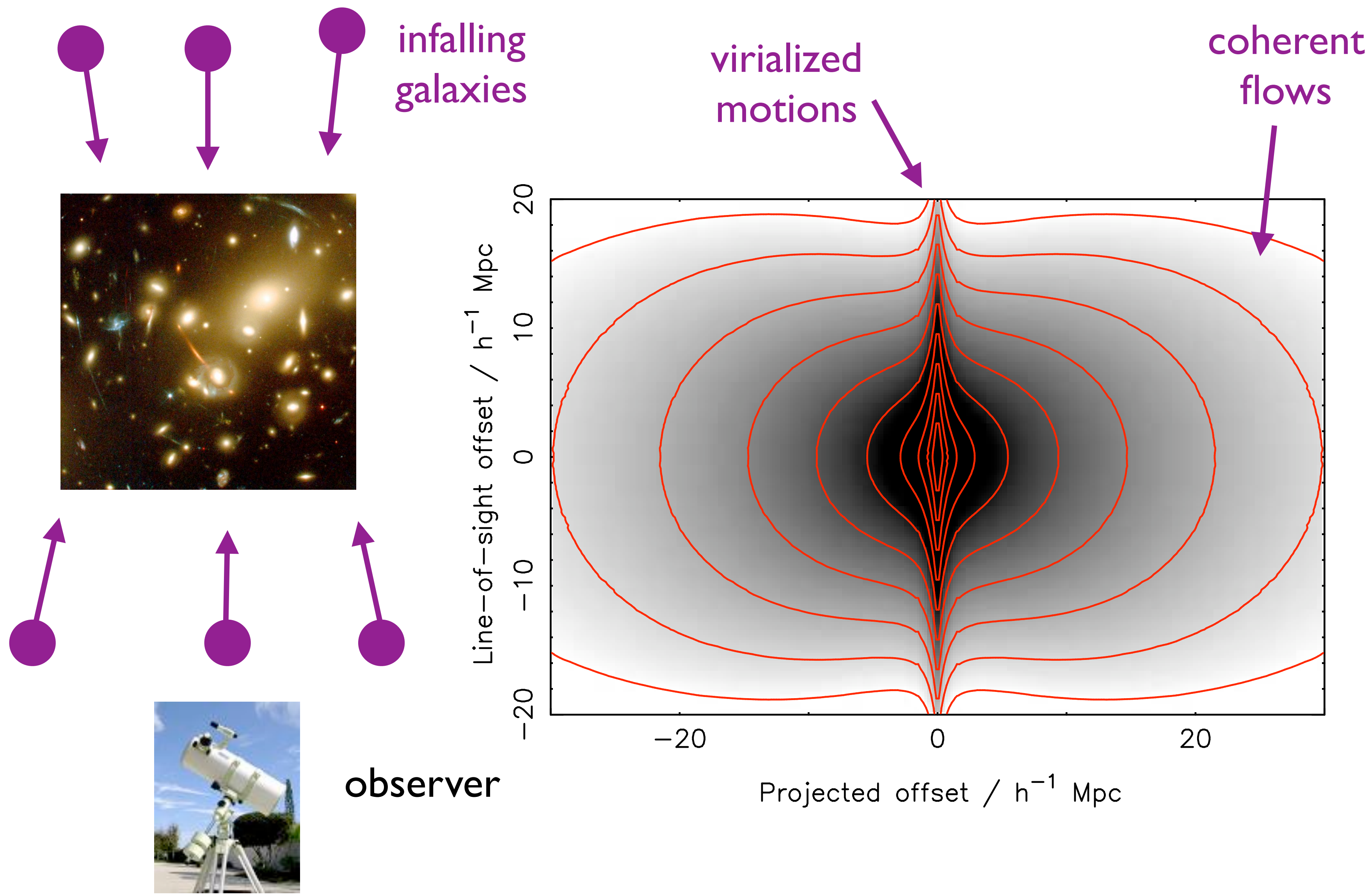
coherent flows



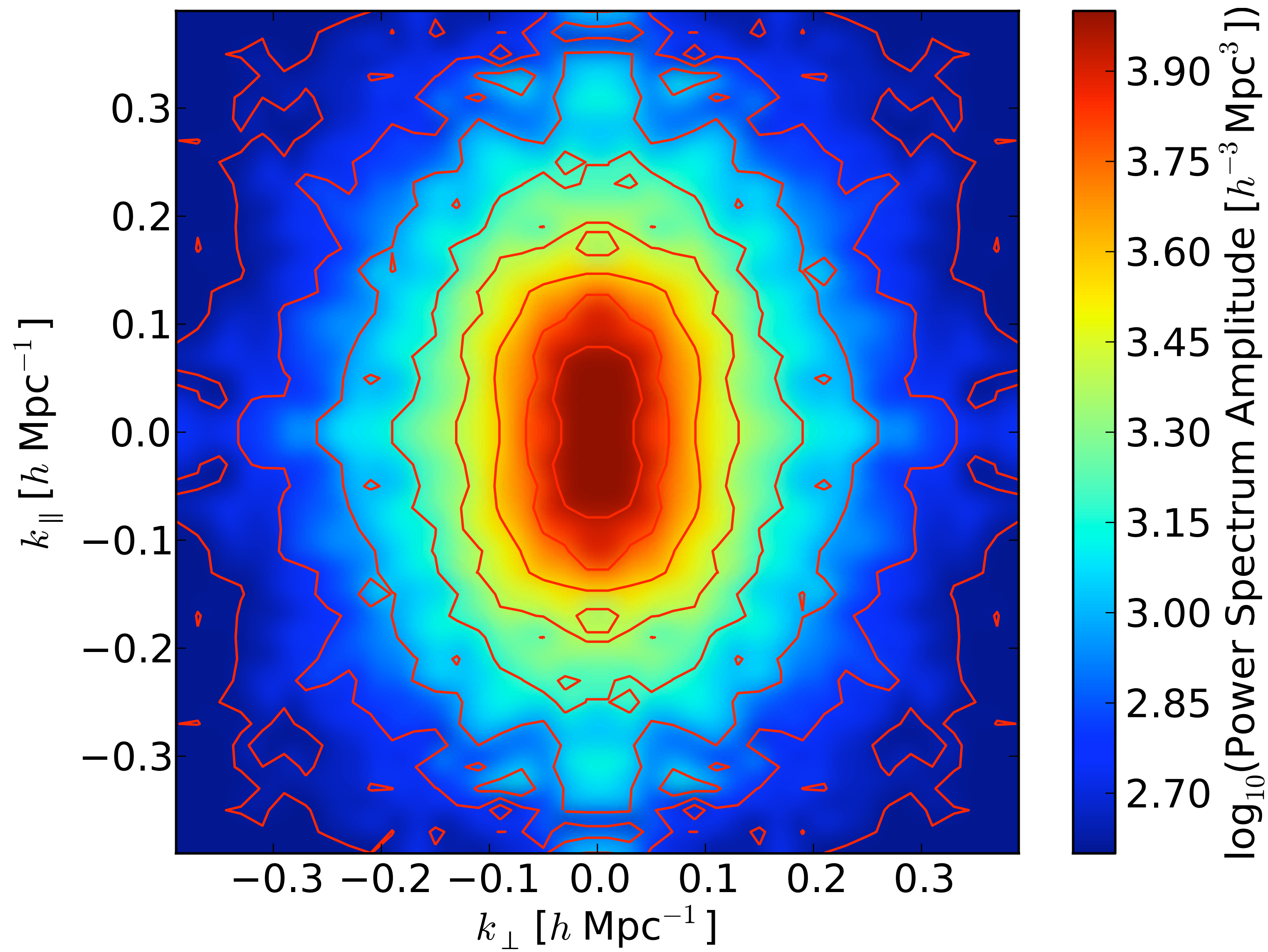
virialized motions



Redshift-space distortions



Redshift-space distortions



Redshift-space distortions theory

Amplitude of Fourier mode

Growth rate

Angle to the line-of-sight $\mu = \cos\theta$

$$\delta_s(\vec{k}) = \delta_r(\vec{k})\,(1 + f\,\mu^2)$$

Redshift-space distortions theory

Amplitude of Fourier mode

Growth rate

Angle to the line-of-sight
$\mu = \cos\theta$

$$\delta_s(\vec{k}) = \delta_r(\vec{k})\,(1 + f\,\mu^2)$$

$$\gamma \approx 6/11\ (\Lambda\mathrm{CDM})$$
$$\gamma \approx 11/16\ (\mathrm{DGP})$$

$$f = \Omega_\mathrm{m}(z)^\gamma$$

Redshift-space distortions theory

Amplitude of Fourier mode

Growth rate

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Galaxy power spectrum

Bias factor

Matter power spectrum

$$P_\mathrm{g}(k,\mu) = b^2\,P_\mathrm{m}(k)\left(1 + \frac{f}{b}\mu^2\right)^2$$

Redshift-space distortions theory

Amplitude of Fourier mode

Growth rate

Angle to the line-of-sight $\mu = \cos\theta$

$$\delta_s(\vec{k}) = \delta_r(\vec{k})\,(1 + f\,\mu^2)$$

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Galaxy power spectrum

Bias factor

Matter power spectrum

$$P_{\mathrm{g}}(k,\mu) = b^2\,P_{\mathrm{m}}(k)\left(1 + \frac{f}{b}\mu^2\right)^2$$

3 fitted parameters

Pairwise velocity dispersion

$$P(v) \propto e^{-|v|/\sigma_v}$$

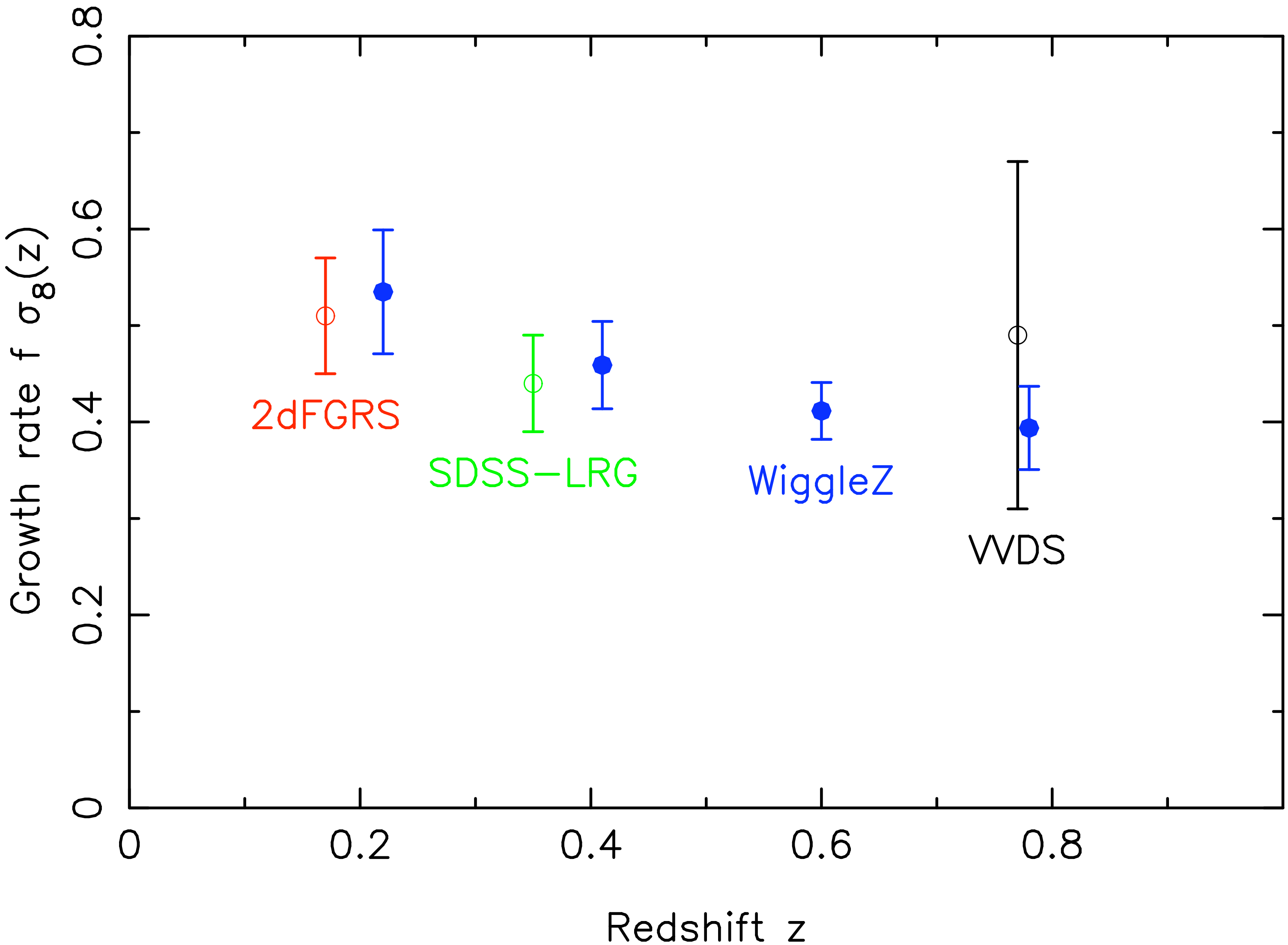
$$P_{\mathrm{g}}(k,\mu) = b^2\,P_{\mathrm{m}}(k)\frac{[1 + (f/b)\mu^2]^2}{1 + (\sigma_v H_0 k\mu)^2}$$

Redshift-space distortions theory

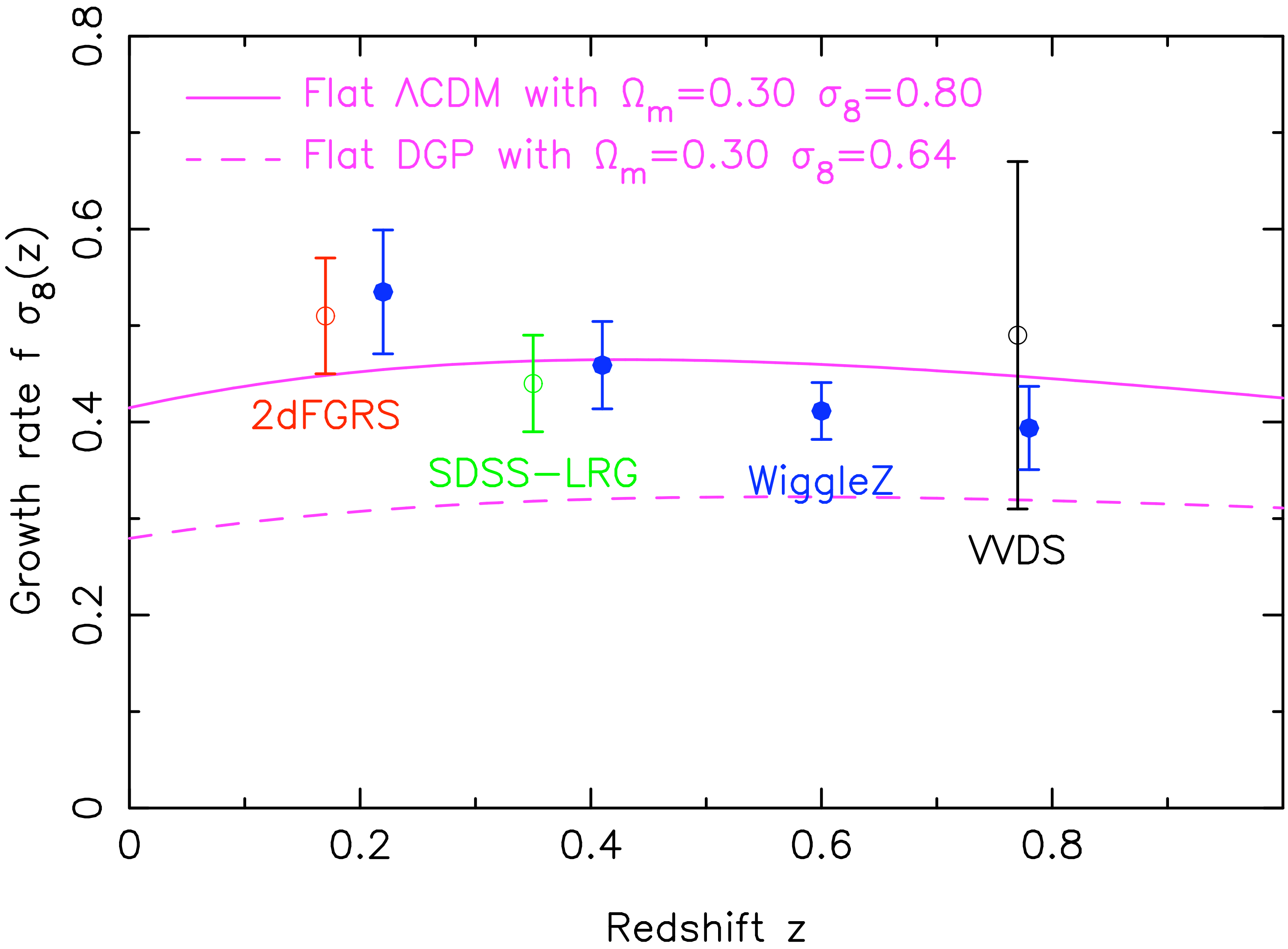
Normalization problem ...

- Galaxy bias b is degenerate with σ_8
- Observable is $f\sigma_8(z)$ not f
- CMB normalization gives us $\sigma_8(z = 1100)$

Growth of structure results



Growth of structure results



Growth of structure results

$$f = \Omega_{\mathrm{m}}(z)^{\gamma}$$

- For a ΛCDM model : $\gamma = 0.60 \pm 0.10$ [prediction 0.55]
- For a DGP model : $\gamma = 0.30 \pm 0.08$ [prediction 0.69]

Bispectrum

- Higher-order clustering statistic - measure of skewness
- Zero for Gaussian fields

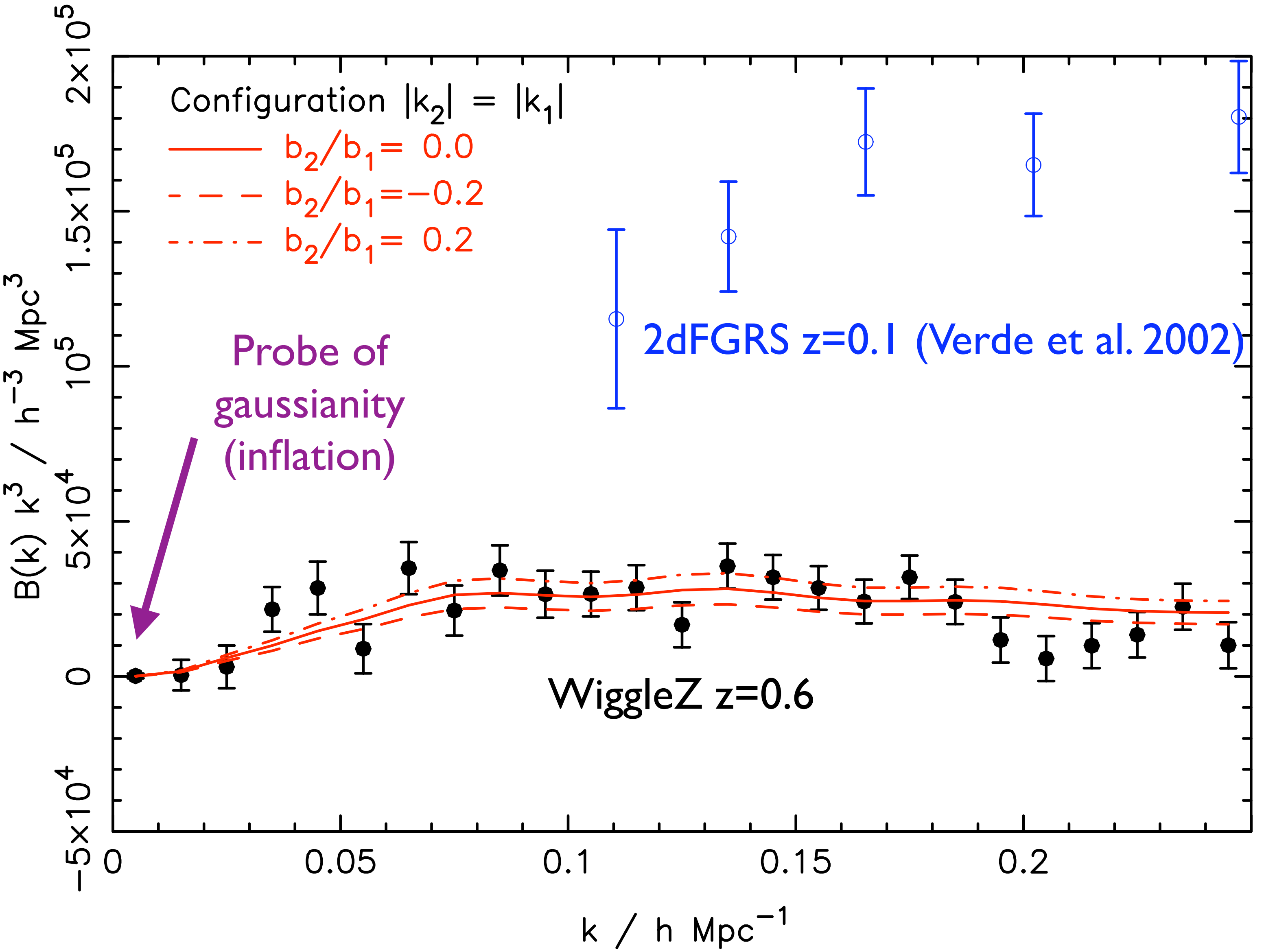
Fourier amplitudes

$$B(\vec{k_1}, \vec{k_2}, \vec{k_3}) = < \delta_{\vec{k_1}} \delta_{\vec{k_2}} \delta_{\vec{k_3}} >$$

$$\vec{k_1} + \vec{k_2} + \vec{k_3} = 0$$

$$\delta_g = b_1 \delta_m + \frac{1}{2} b_2 \delta_m^2$$

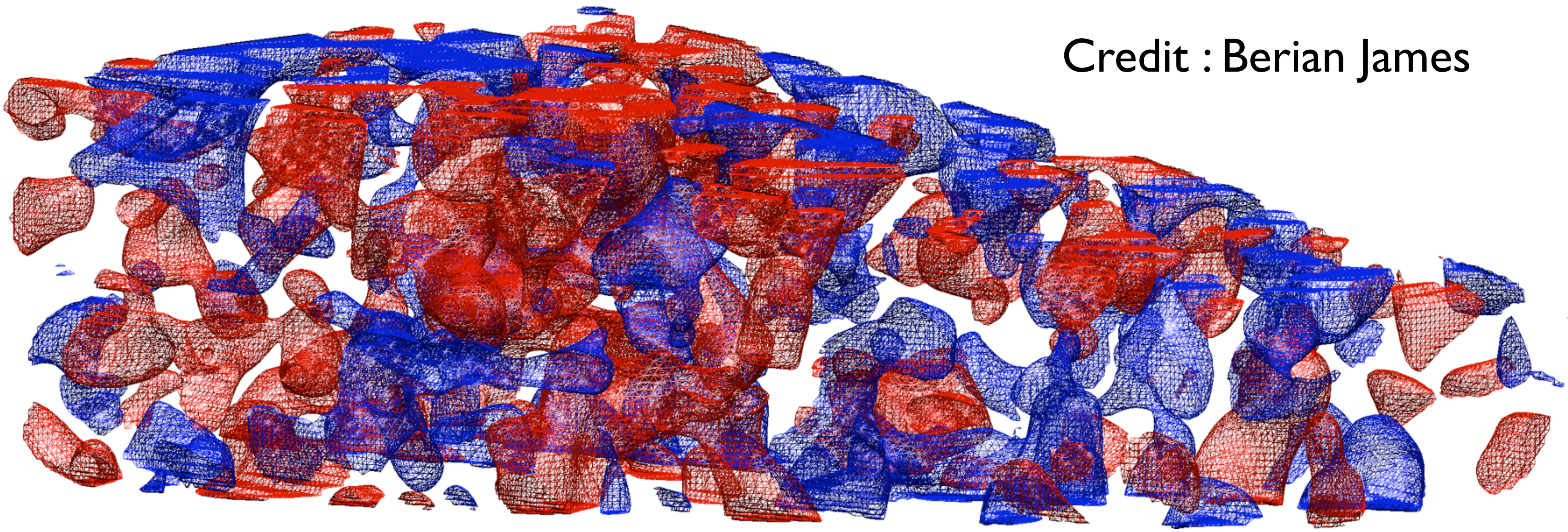
Bispectrum



Configuration |k2| = |k1|
b2/b1= 0.0
b2/b1=−0.2
b2/b1= 0.2
Probe of gaussianity (inflation)
2dFGRS z=0.1 (Verde et al. 2002)
WiggleZ z=0.6
B(k) k3 / h−3 Mpc3
k / h Mpc−1
0
0.05
0.1
0.15
0.2
−5×10^4
0
5×10^4
10^5
1.5×10^5
2×10^5

Topology of density field

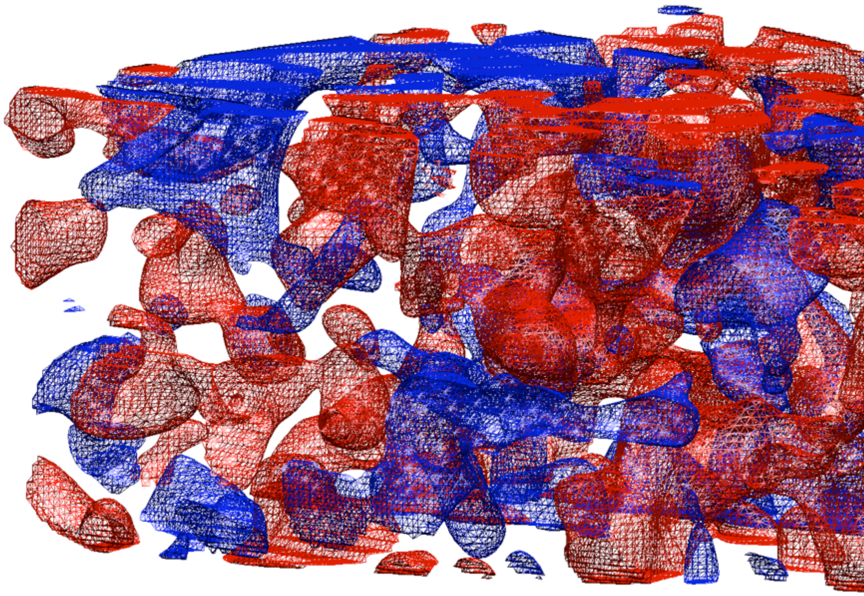
WiggleZ 15-hr region :



Credit : Berian James

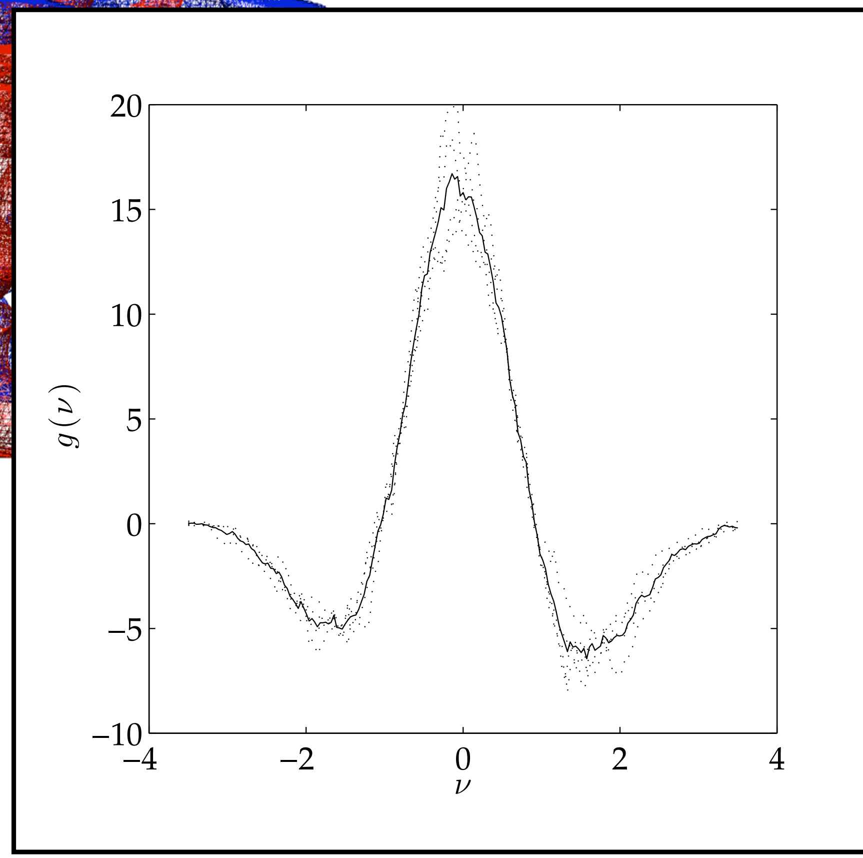
Topology of density field

WiggleZ 15-hr region :



Credit : Berian James

Measurement of the genus curve of the density field smoothed by 20 Mpc/h :



WiggleZ simulations

- Use the Swinburne supercomputer to create Gpc-scale dark matter simulations
- Mock galaxy catalogues from semi-analytic modelling and halo occupation distributions
- Crucial for interpreting our results and quantifying the errors in our clustering measurements

Conclusions

- WiggleZ power spectrum is nicely fit by theory with matter/baryon densities consistent with CMB
- Baryon oscillations currently detected at ~2-sigma significance [~3-sigma at survey end]
- WiggleZ gives most accurate growth measurement, extending previous work to higher redshift
- General relativity / cosmological constant models remain a good fit
- Many investigations currently in progress

Thank you !