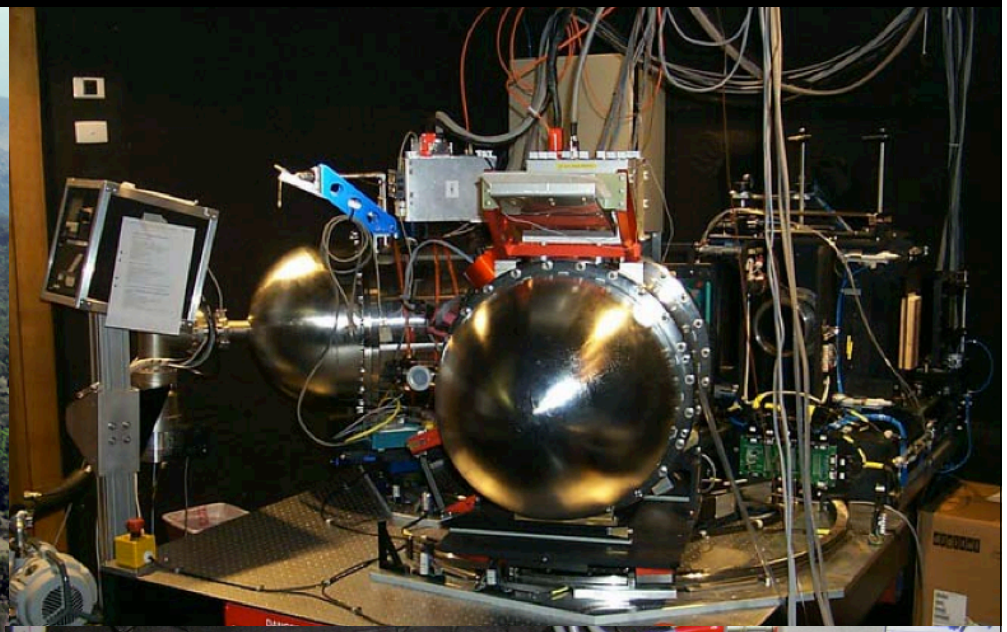
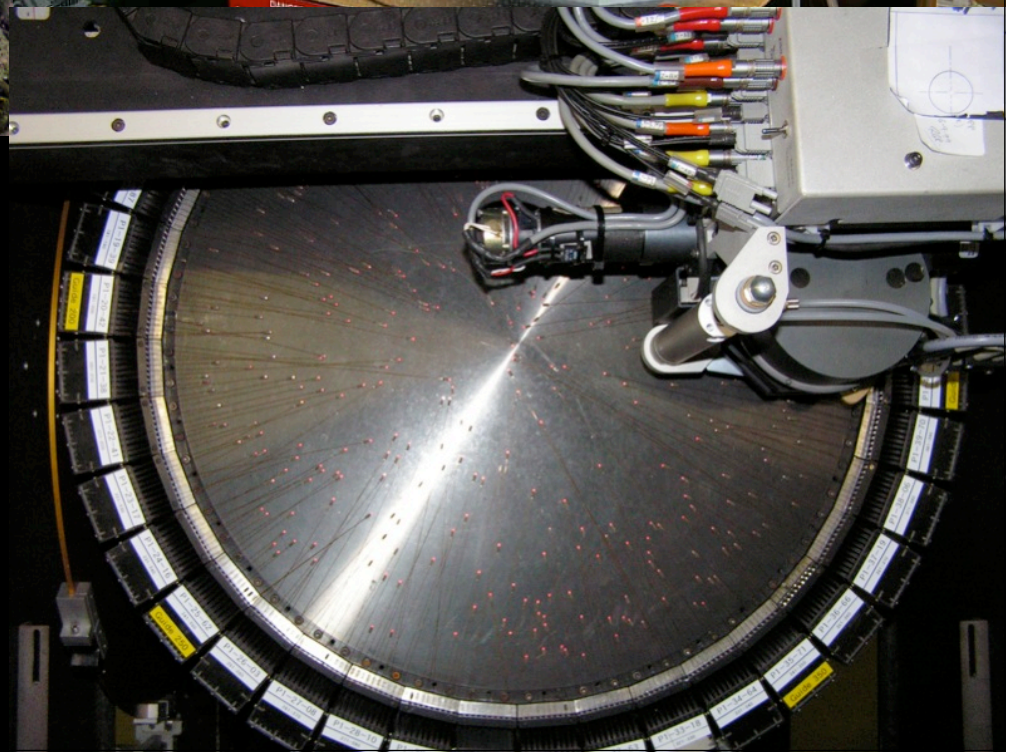
The WiggleZ Dark Energy Survey

- Large-scale structure survey covering SDSS-like volumes over a range of higher redshifts to z=1
- Test the cosmological model in three ways :
- (1) Use the baryon acoustic peak as a standard ruler to measure cosmic distances to z=1
- (2) Map the growth rate of structure to z=1
- (3) Use Alcock-Paczynski distortions to measure a non-parametric expansion history
- Cross-check evidence for dark energy from SNe

The WiggleZ Dark Energy Survey





- 1000 sq deg , $0.2 < z < 1.0$
- 200,000 redshifts
- blue star-forming galaxies
- Aug 2006 - Jan 2011

The WiggleZ Survey (observational) Team

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

University of Queensland : Tamara Davis , Michael Drinkwater

Sarah Brough (AAO) , Matthew Colless (AAO) , Scott Croom (U.Syd.) , Ben Jelliffe (U.Syd.) , Russell Jurek (ATNF) , Kevin Pimbblet (Monash) , Mike Pracy (UNSW) , Rob Sharp (ANU) , David Woods (UBC)

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

RCS2 team : David Gilbank , Mike Gladders , Howard Yee

The WiggleZ Survey (cosmology analysis) Team

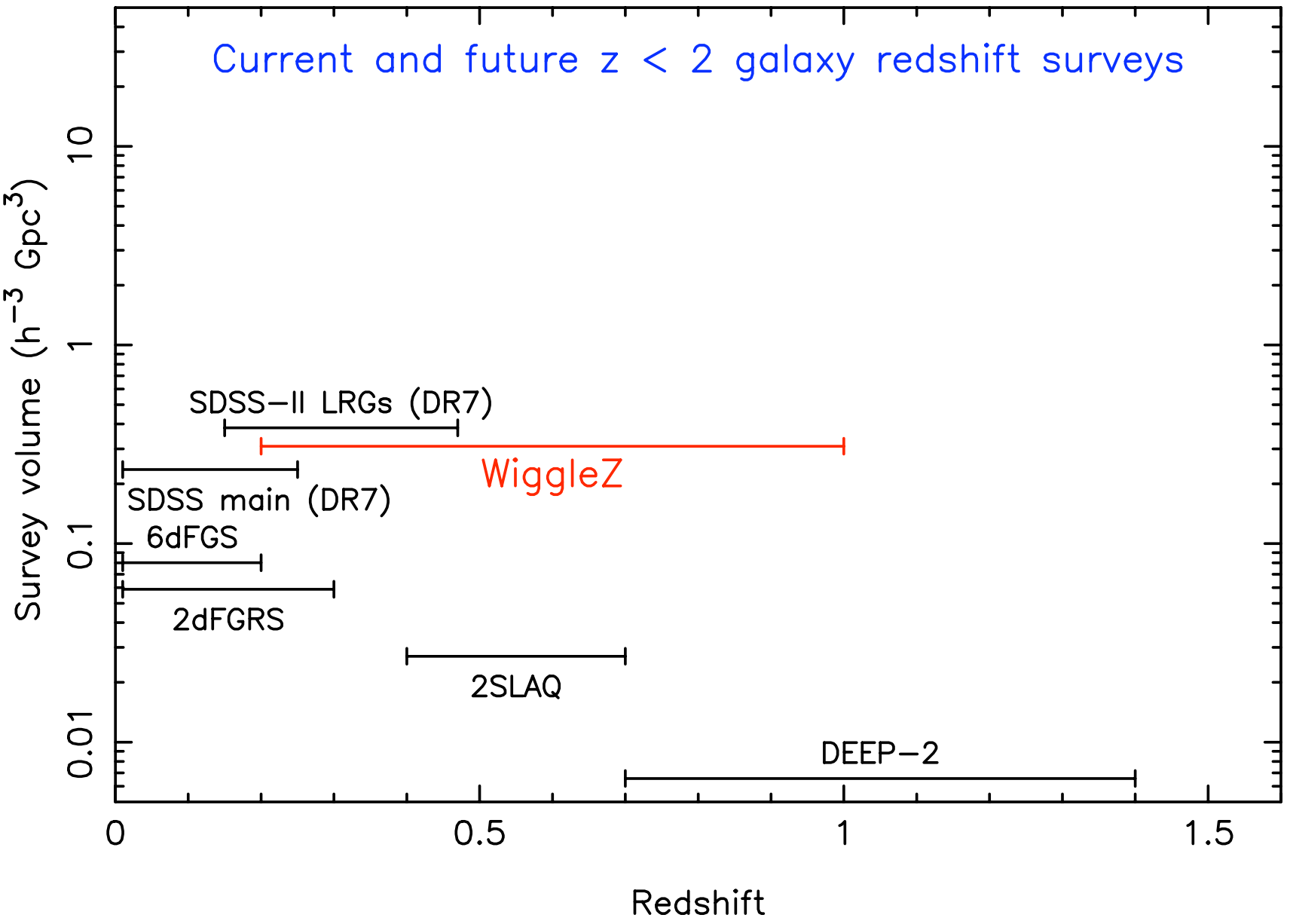
Swinburne: Chris Blake , Carlos Contreras , Felipe Marin , Greg Poole

U. of Queensland: Tamara Davis , David Parkinson , Signe Riemer-Sorensen

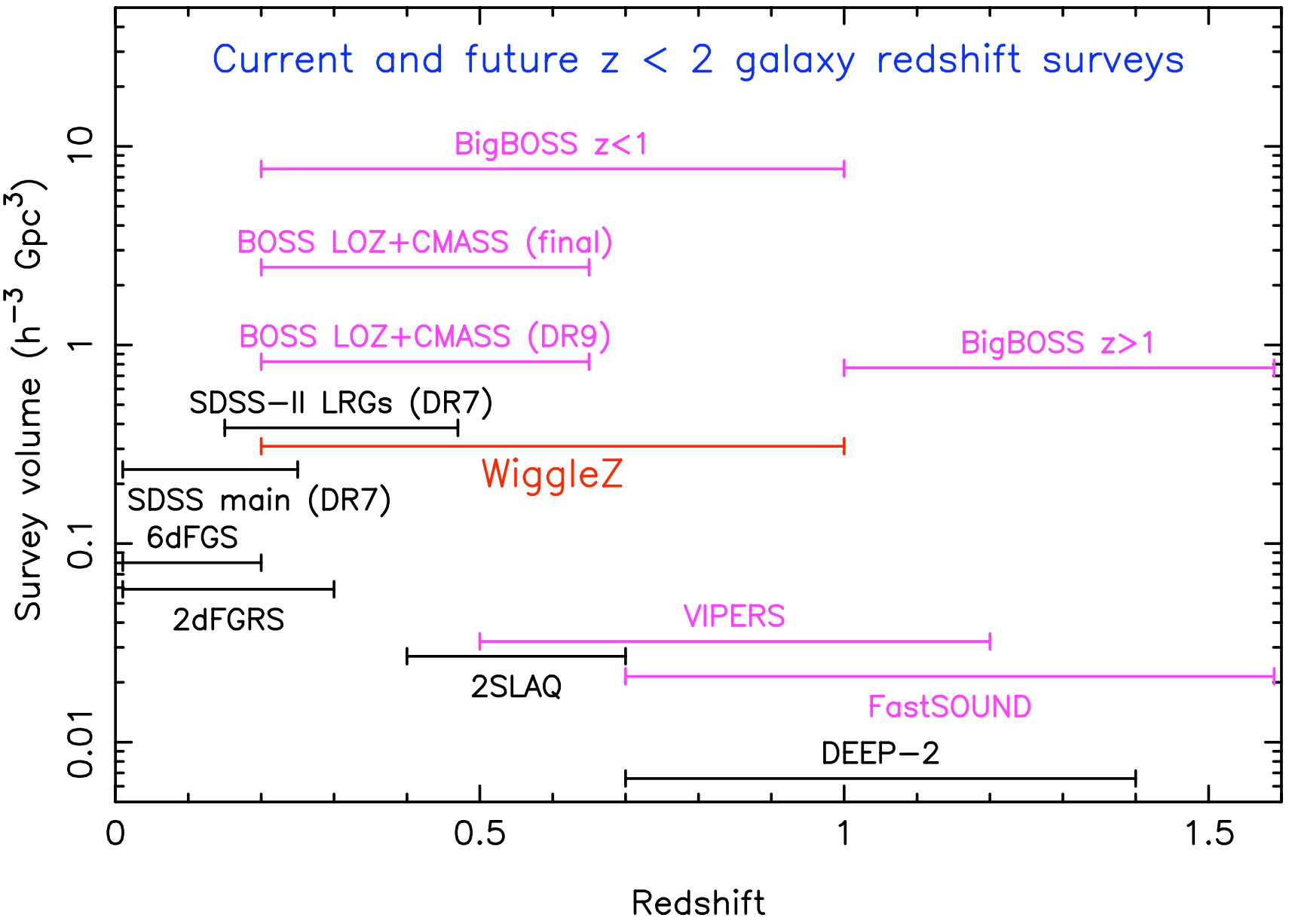
University of Western Australia: Morag Scrimgeour

DARK / Berkeley: Berian James

Survey comparison

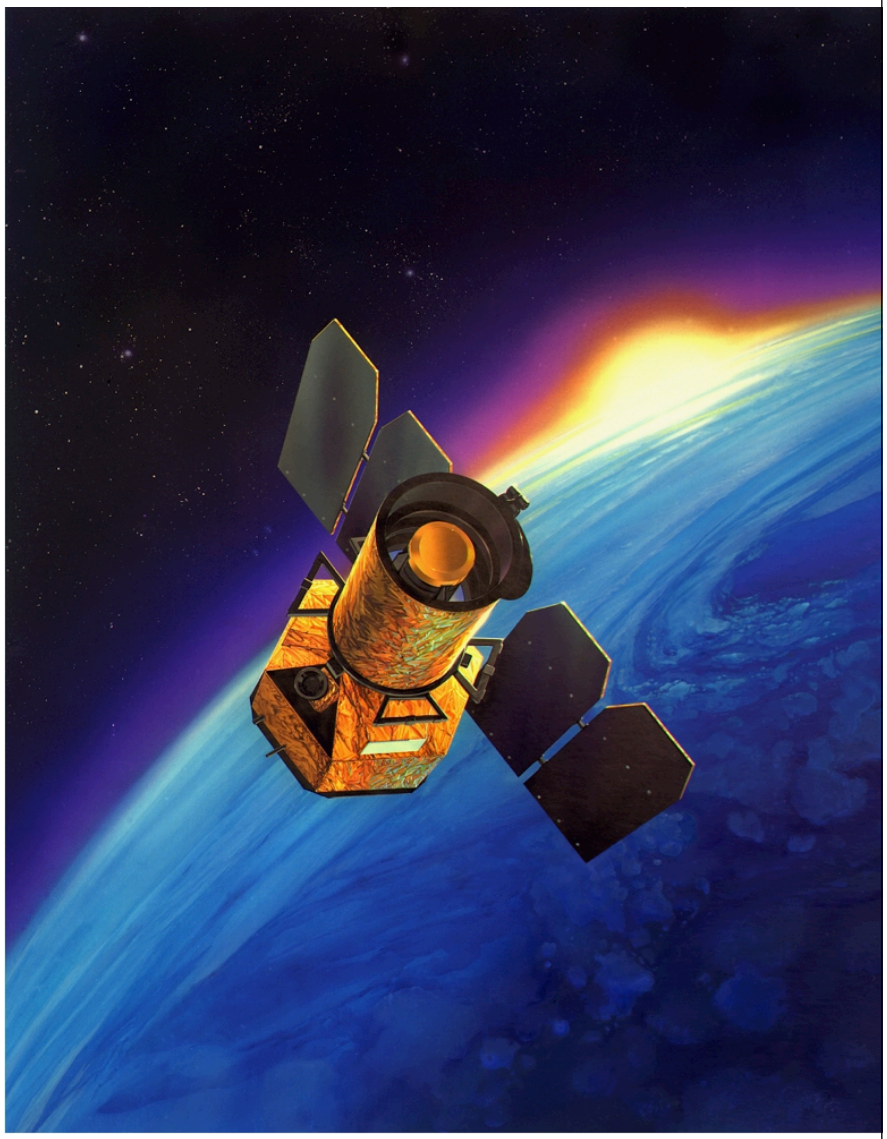


Survey comparison

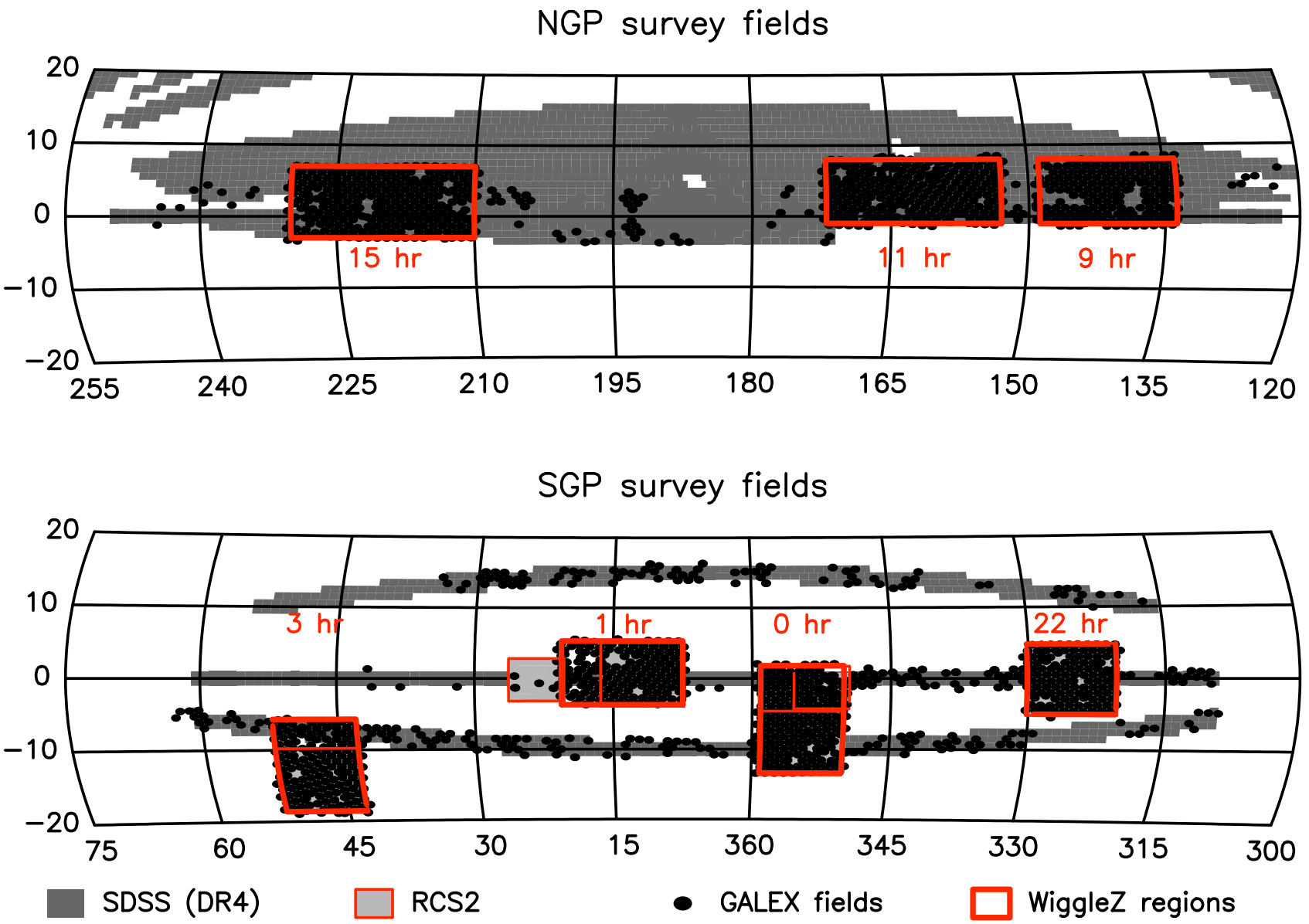


Survey design

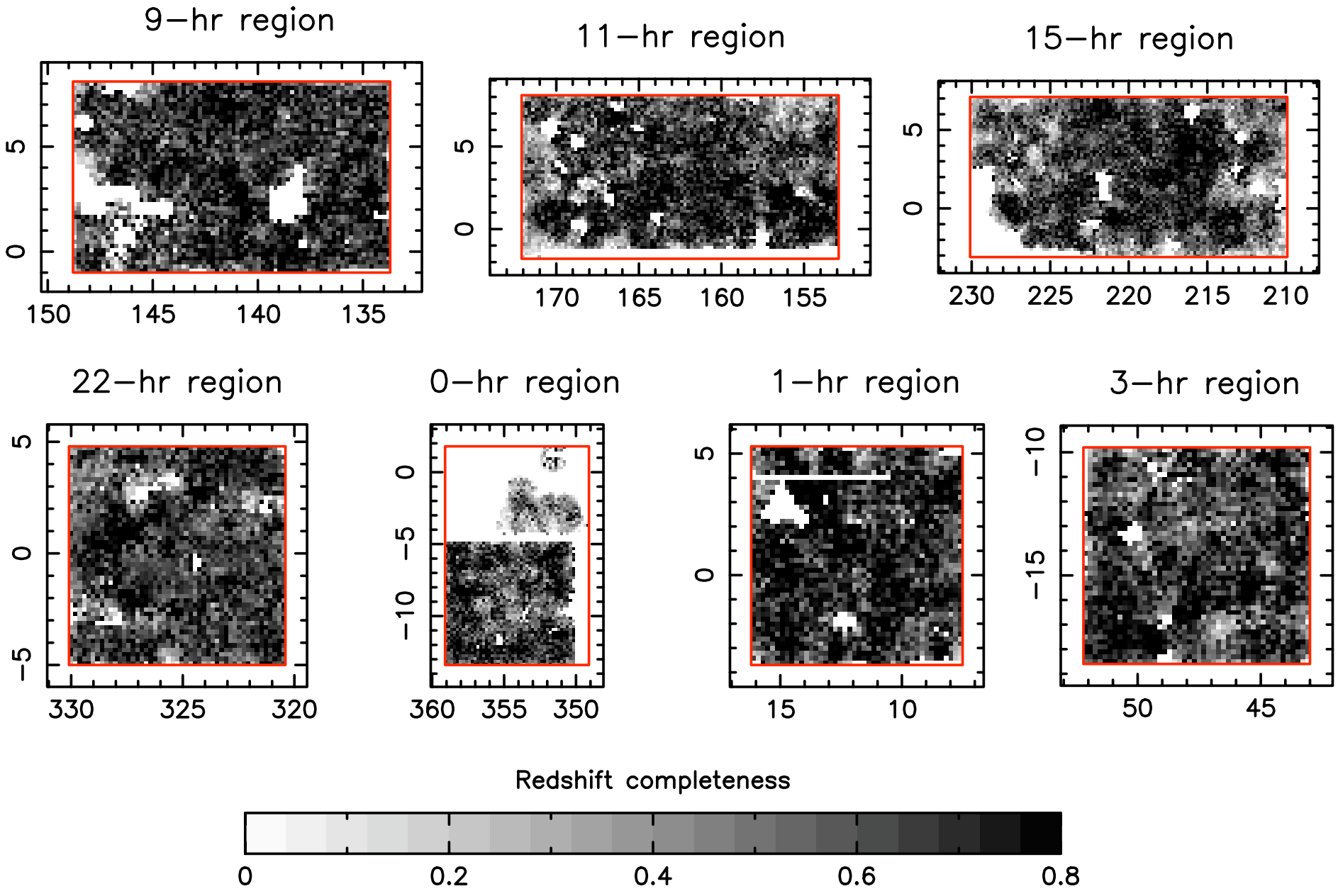
- Follow up UV-selected sources from GALEX imaging
- Colour cuts select high-redshift galaxies
- Star-forming galaxies : redshifts from emission lines, SFR 10-100 solar masses per year
- Short 1-hr exposures - maximize numbers with 70% redshift completeness



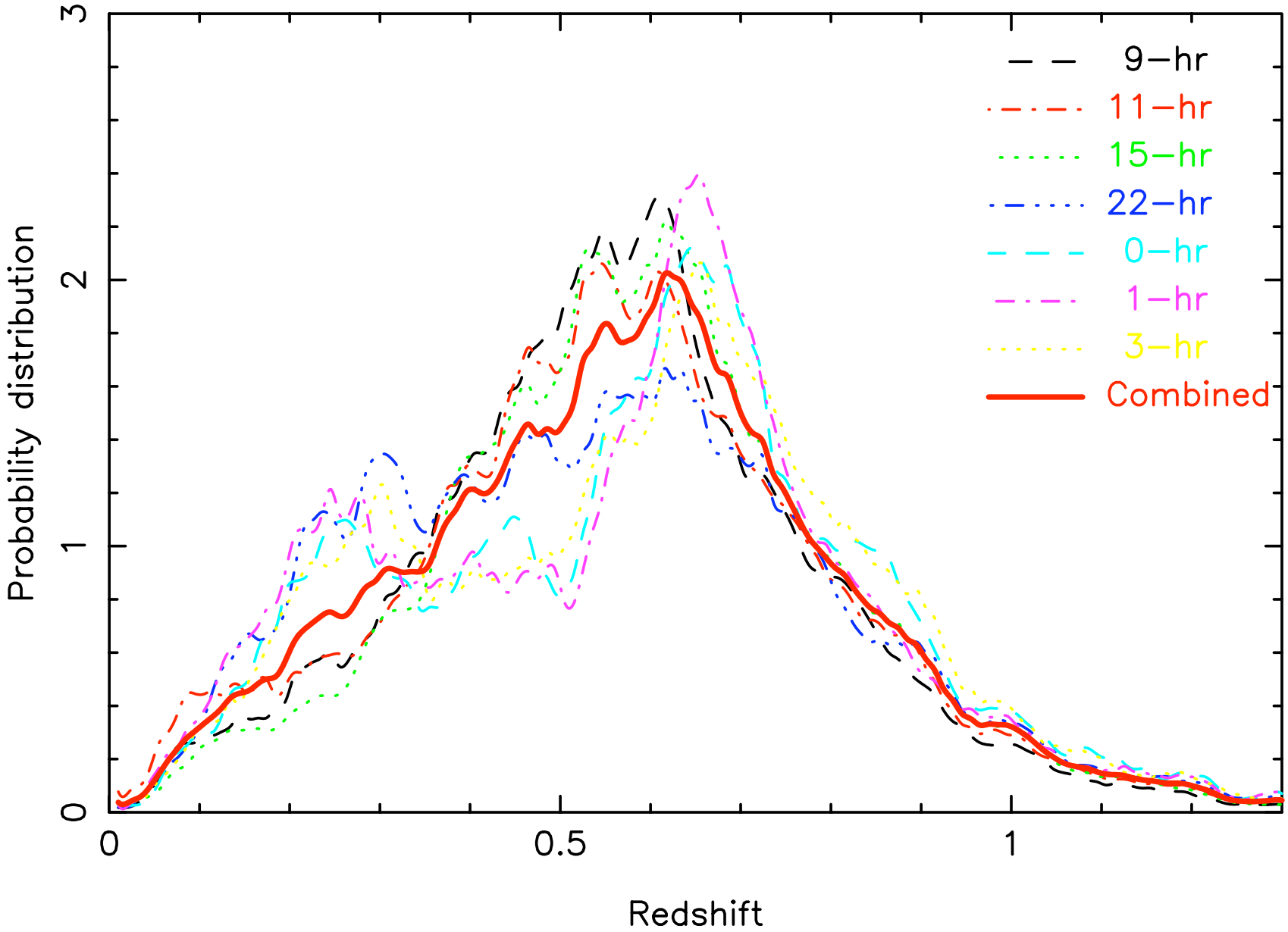
Survey design



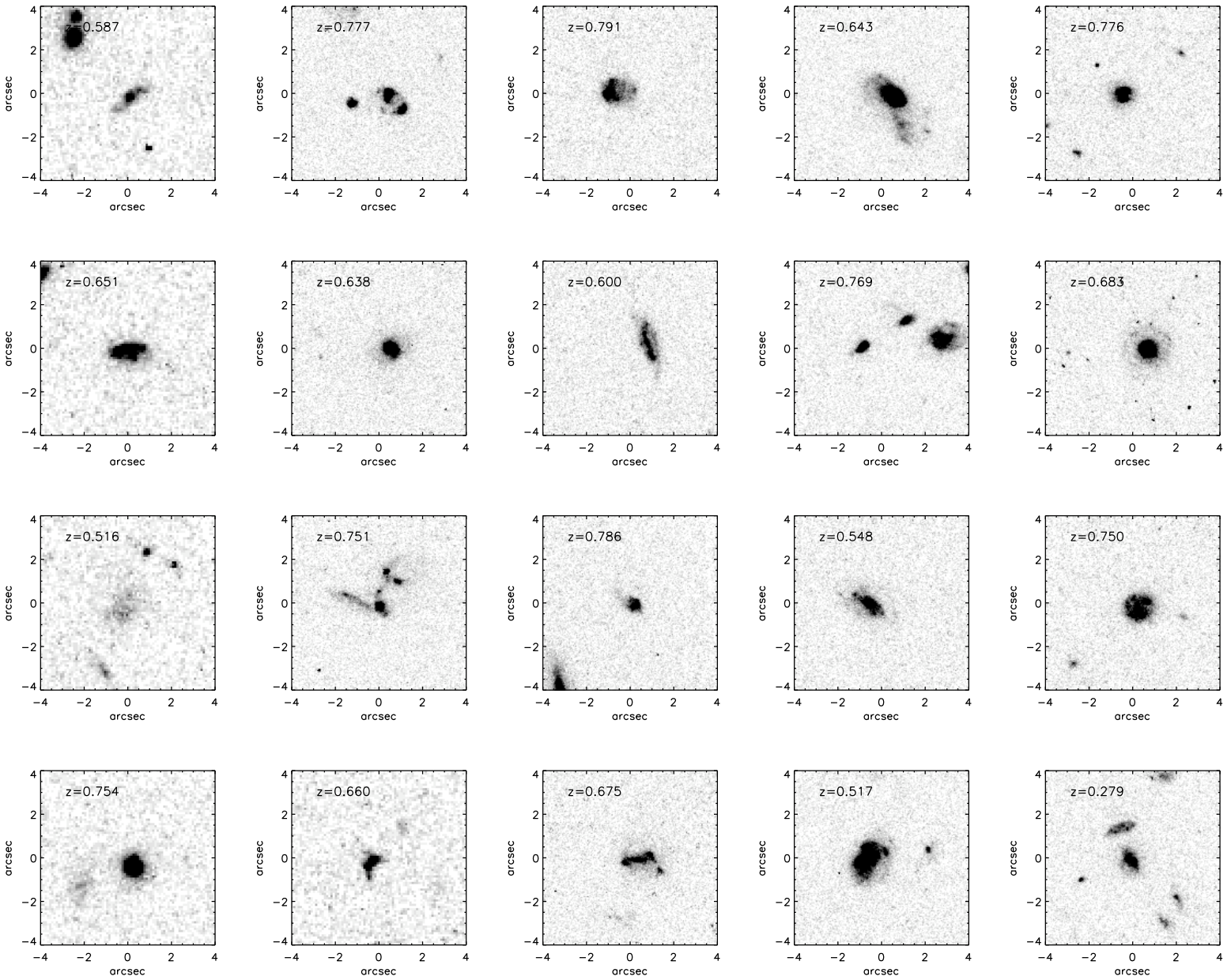
Survey design



Redshift distribution

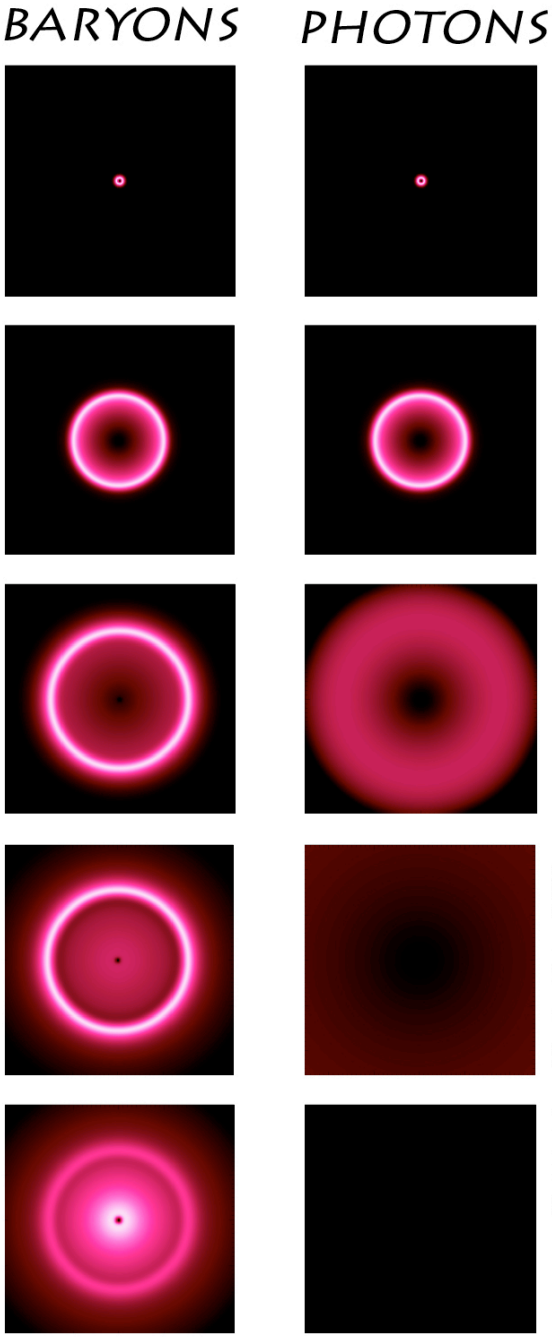


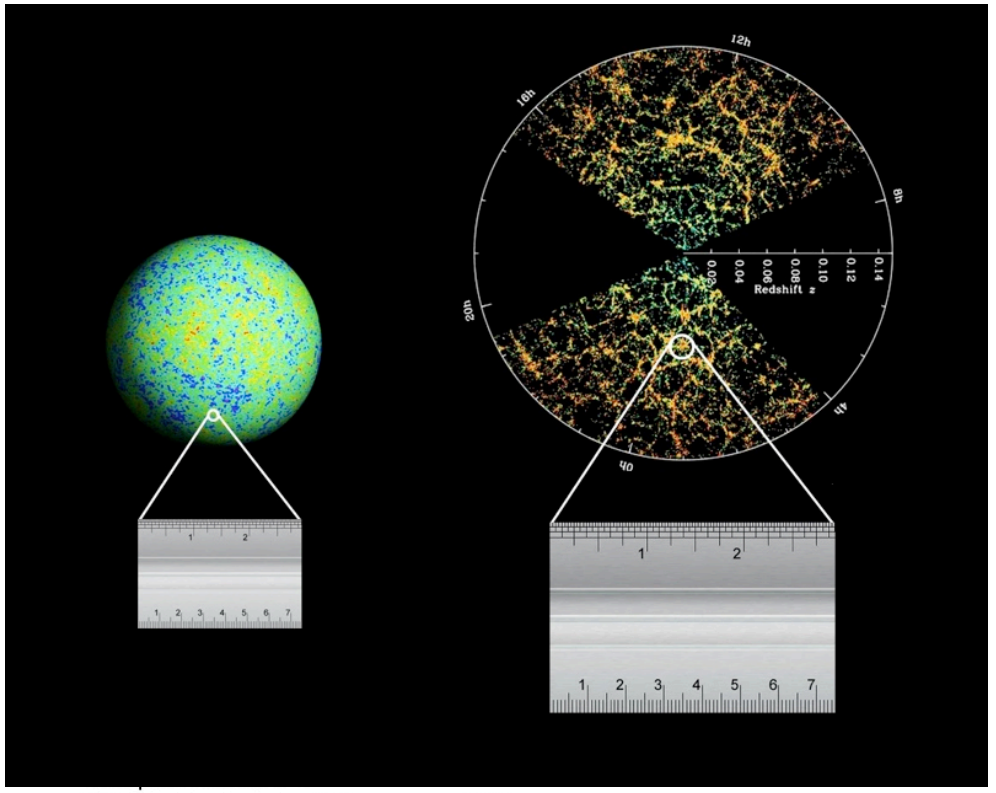
Galaxy targets

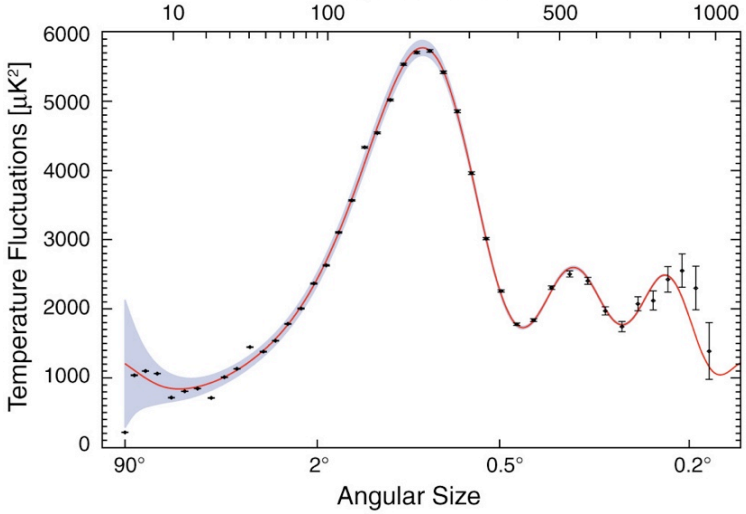


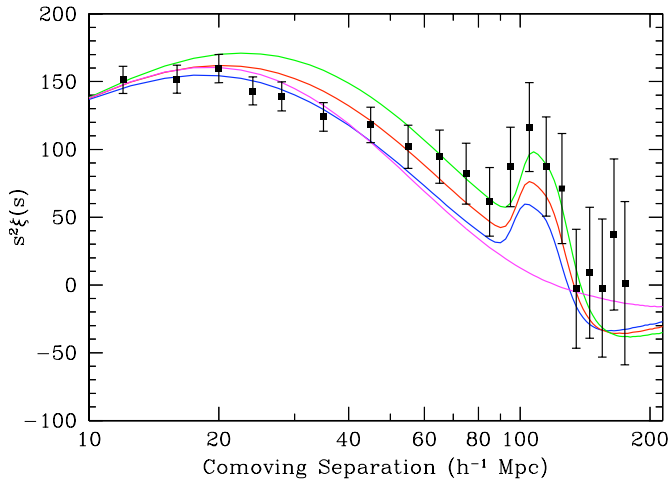
(Credit: Mike Pracy)

The baryon acoustic peak

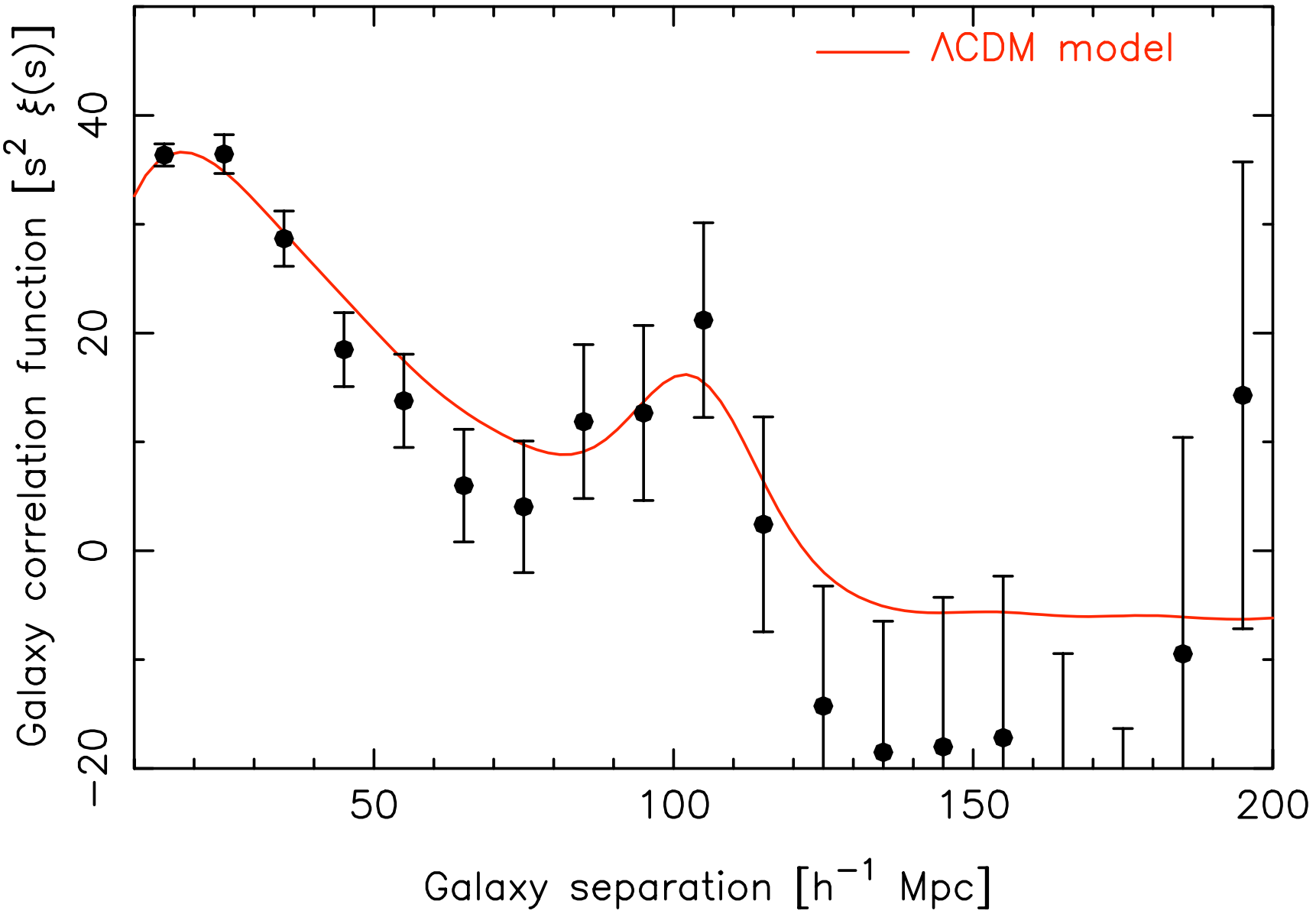




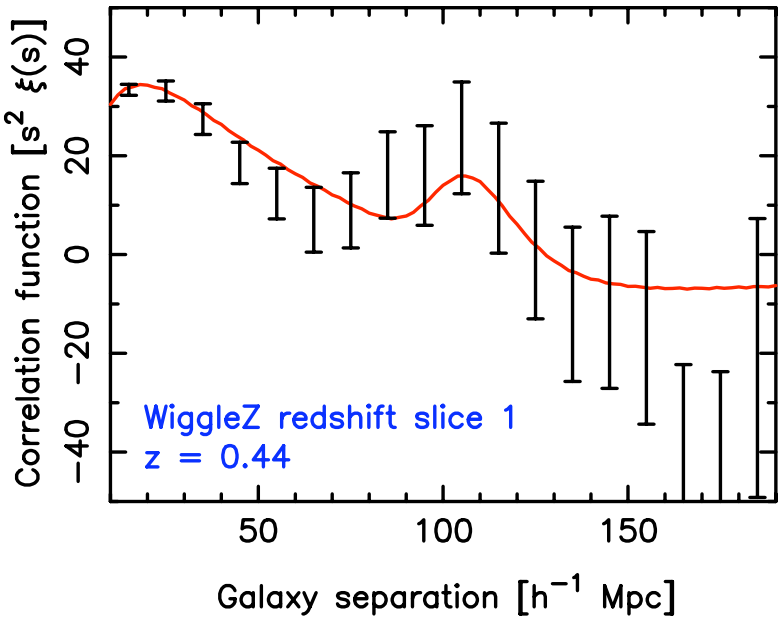


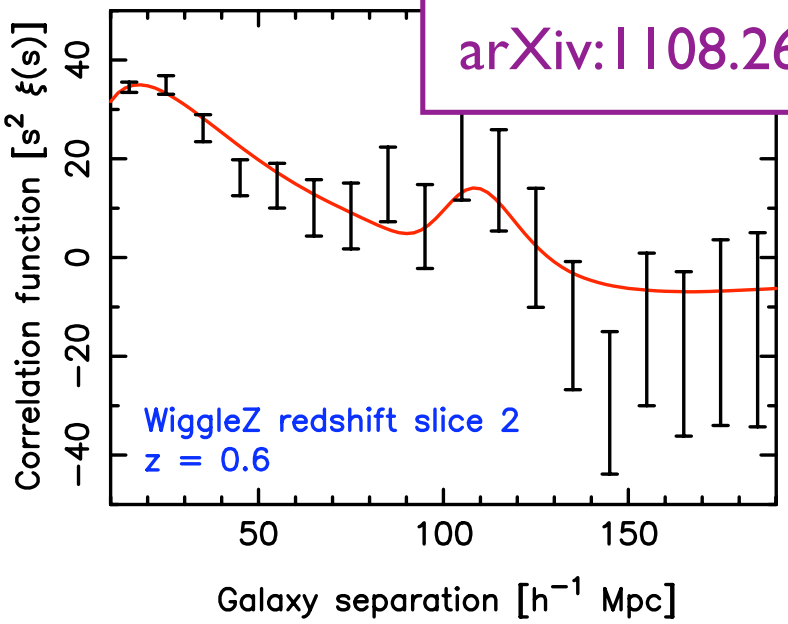


The baryon acoustic peak in WiggleZ

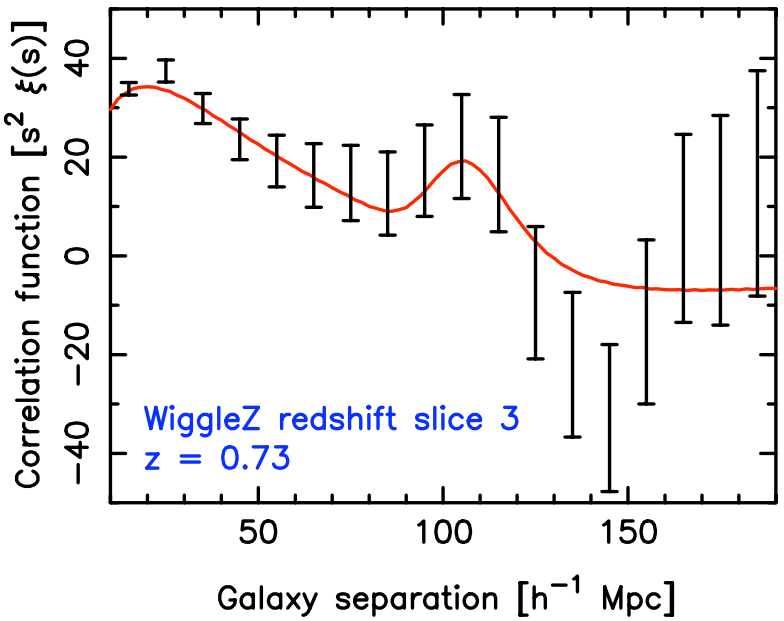


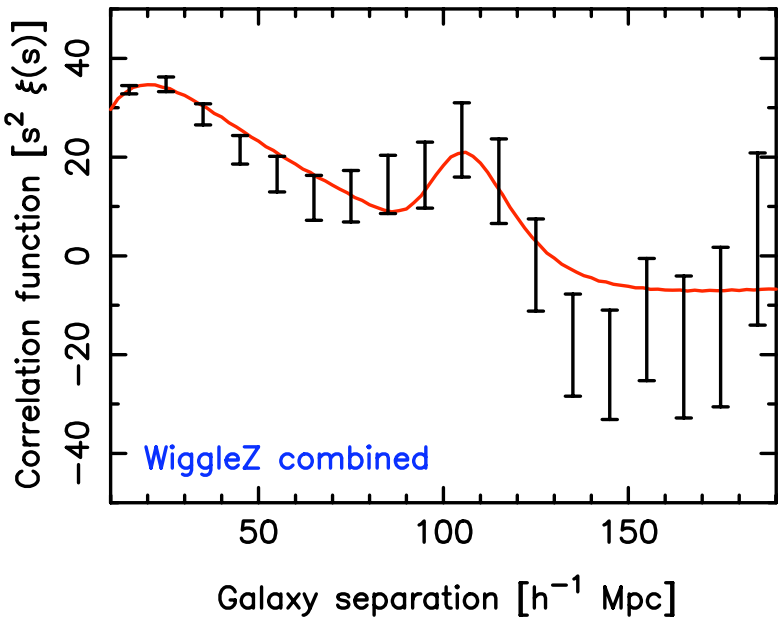
The baryon acoustic peak in WiggleZ



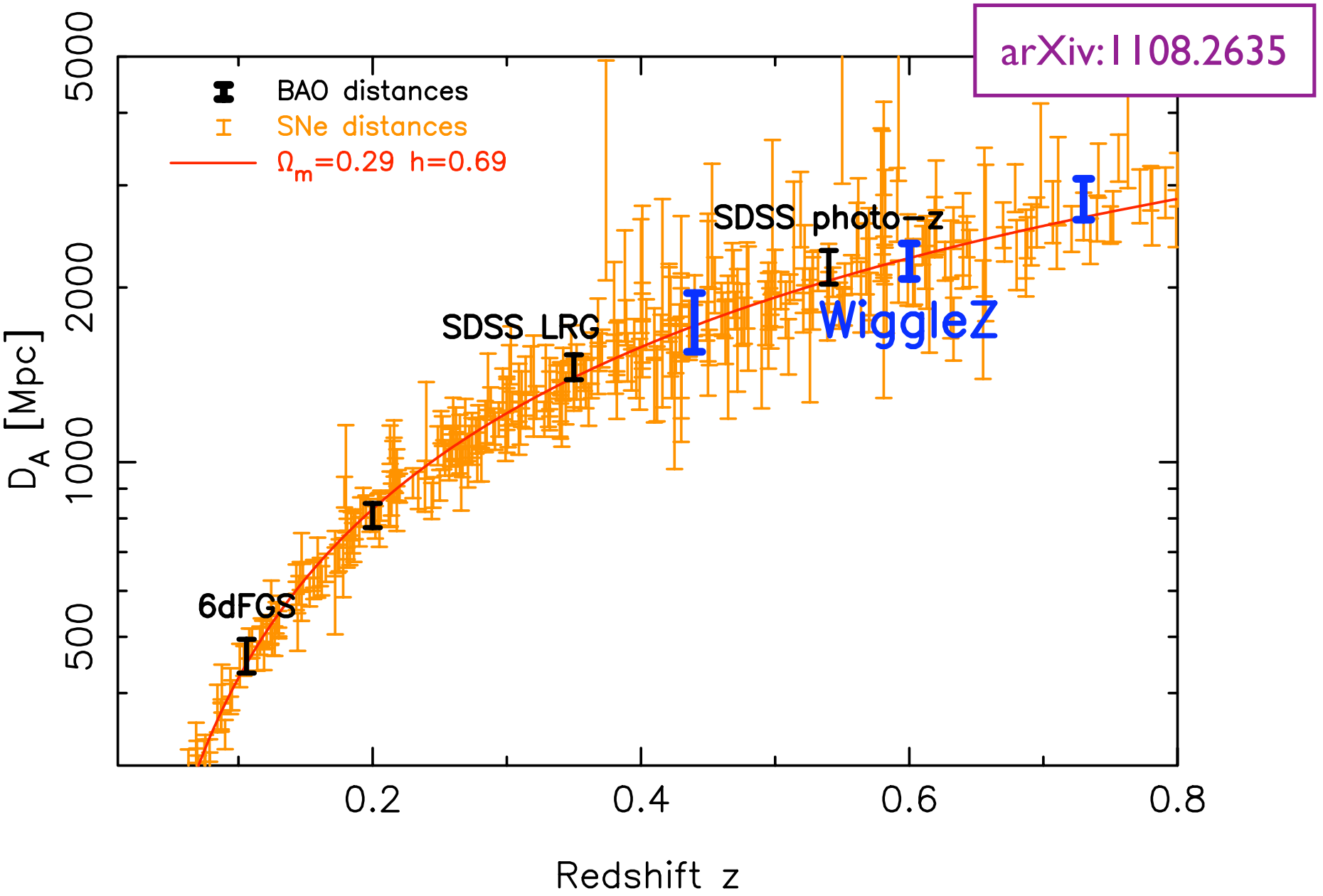


arXiv:1108.2635

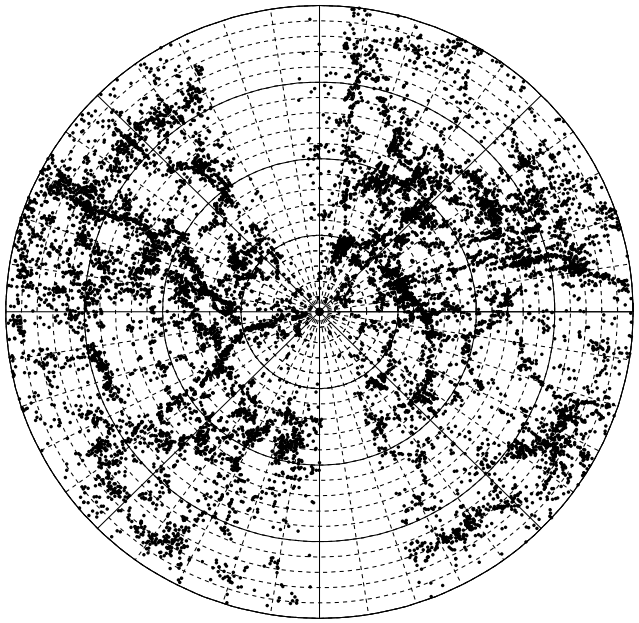




BAO Hubble diagram



The 6-degree Field Galaxy Survey

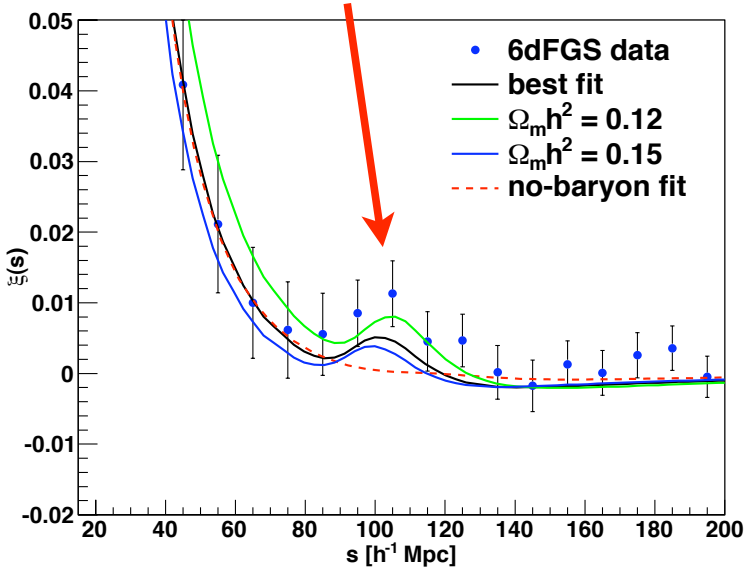


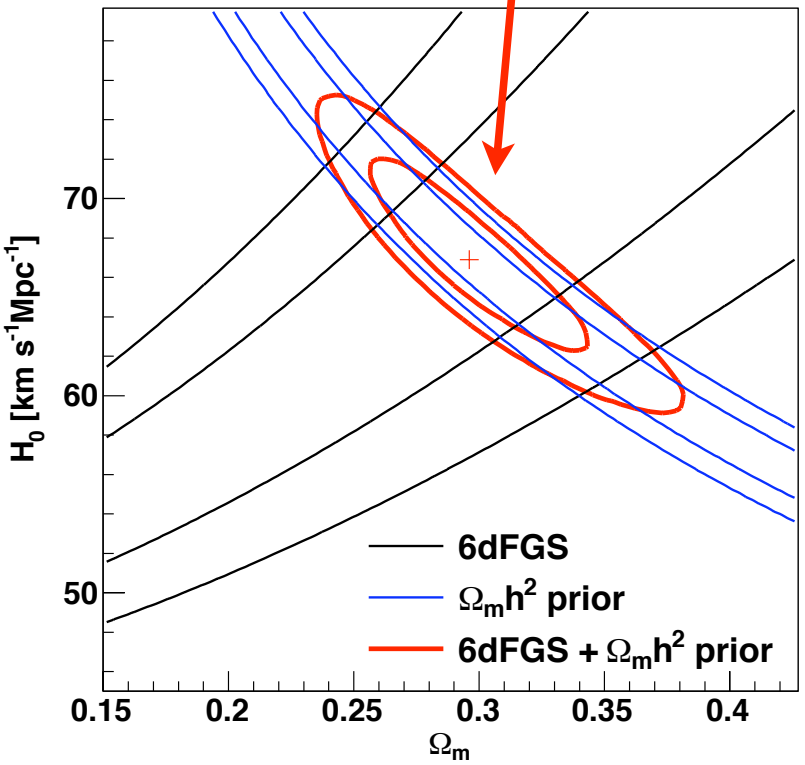
Measurement of baryon acoustic peak in local Universe

See paper by Florian Beutler !

$H_0 = 67.0 +/- 3.2$ km s^{-1} Mpc^{-1}

D(z=0.1) = 456 +/- 27 Mpc



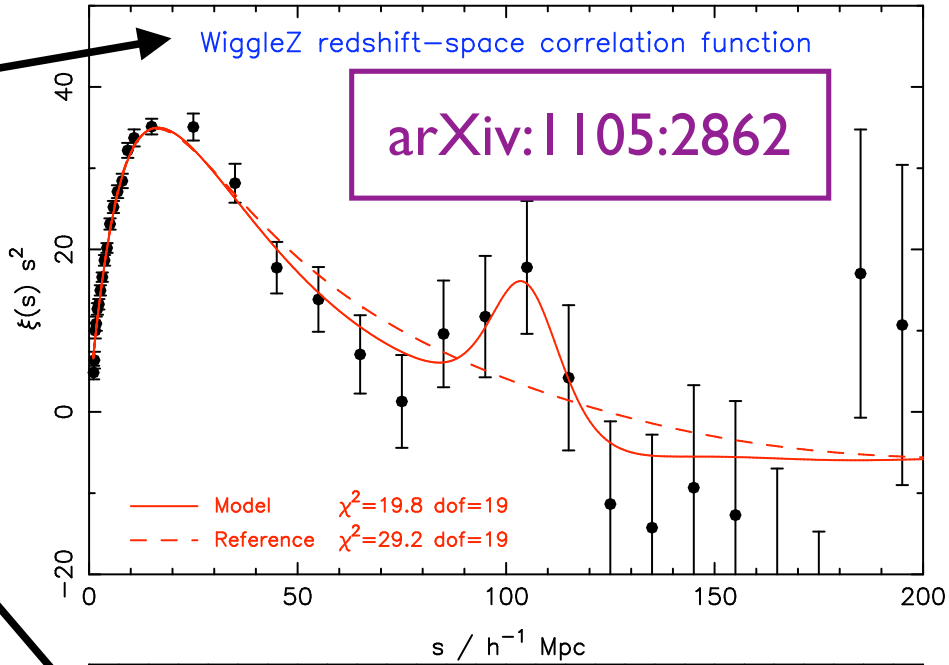


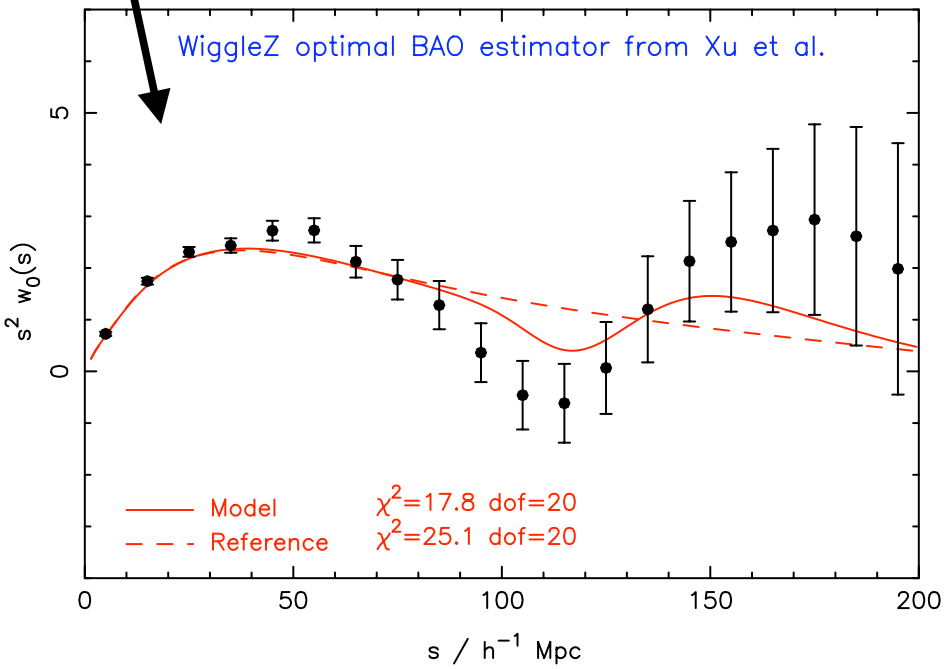
Comparison of BAO statistics in WiggleZ

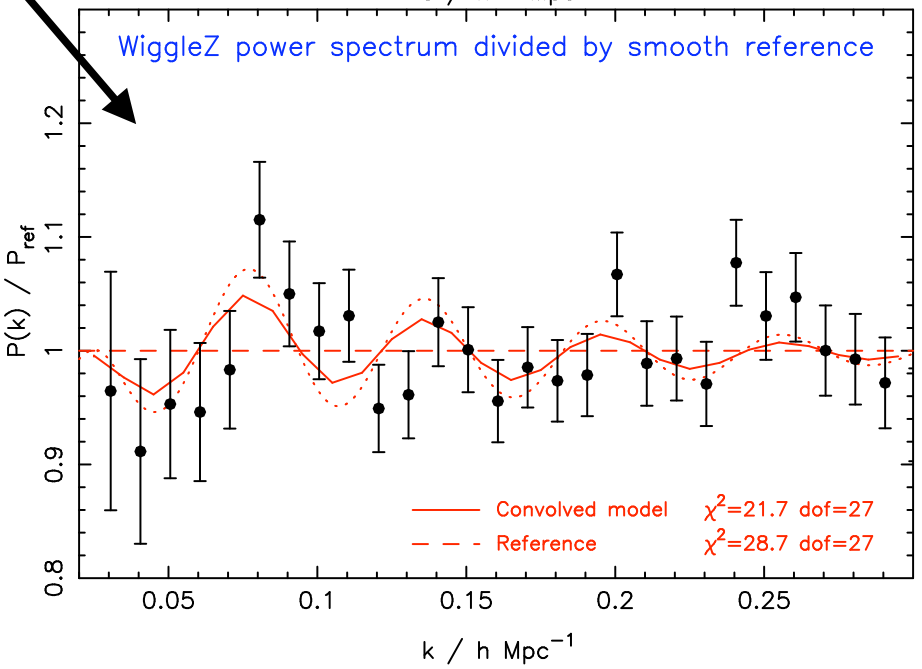
Correlation function

Power spectrum

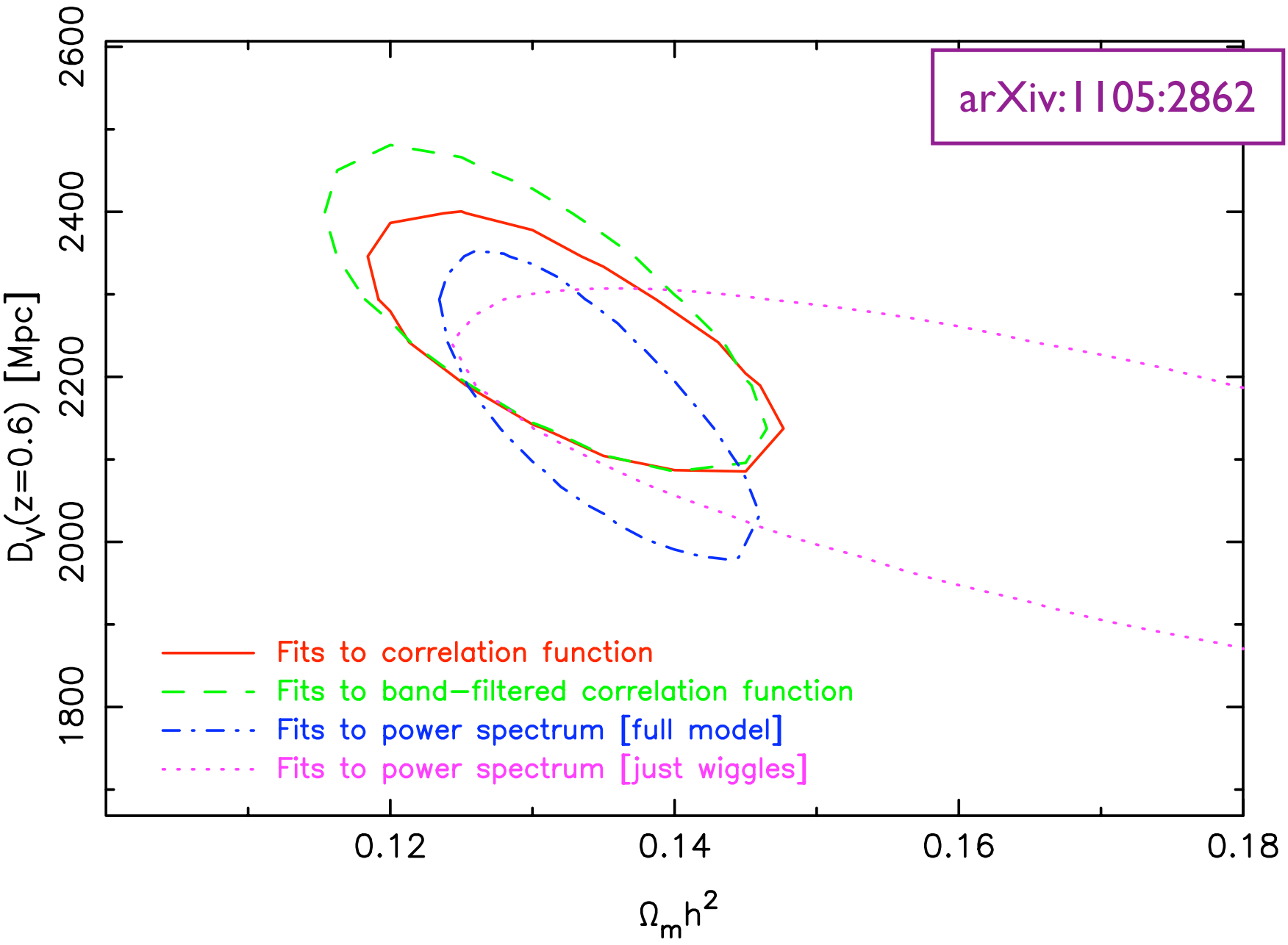
Band-filtered correlation function



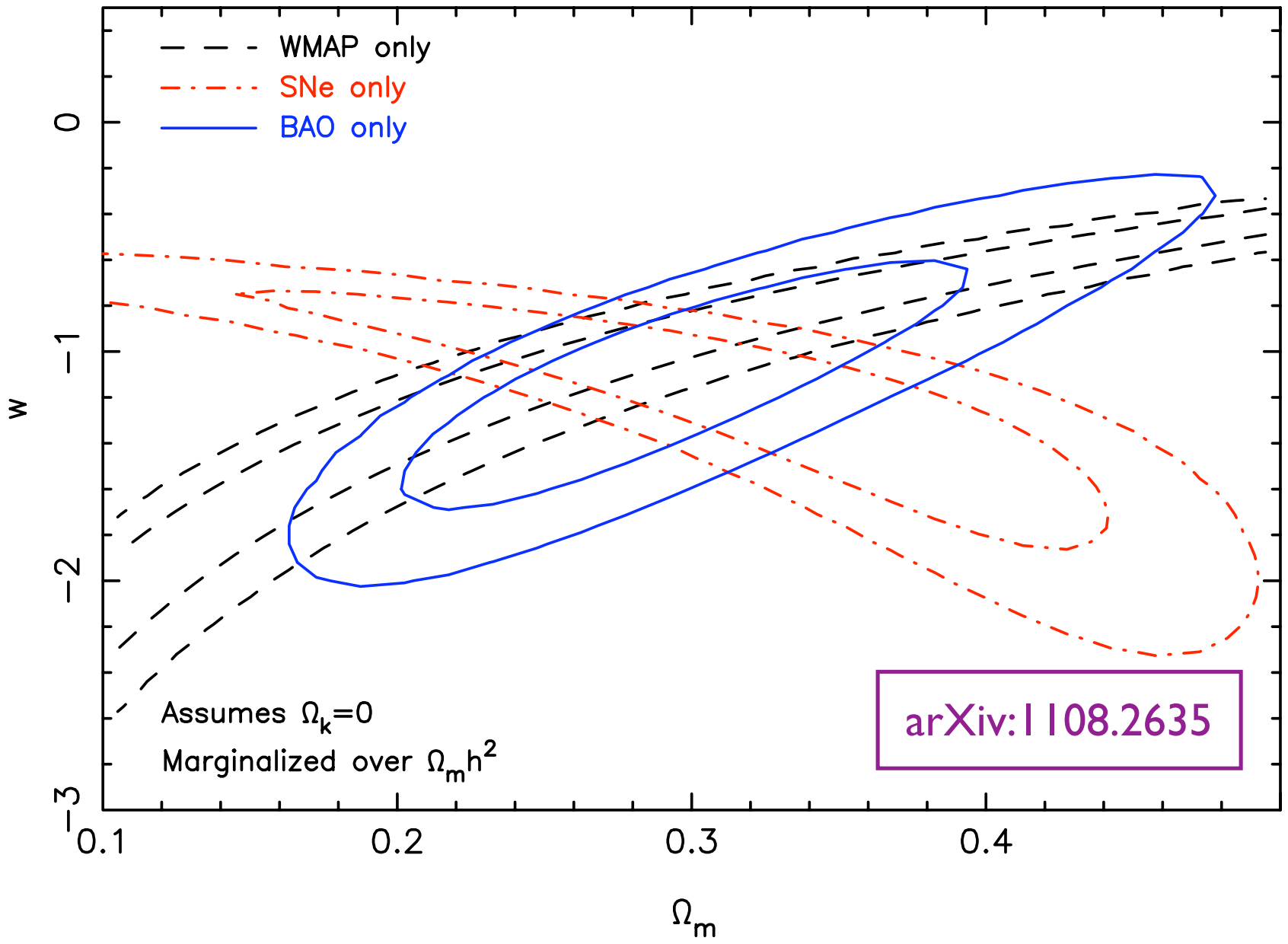




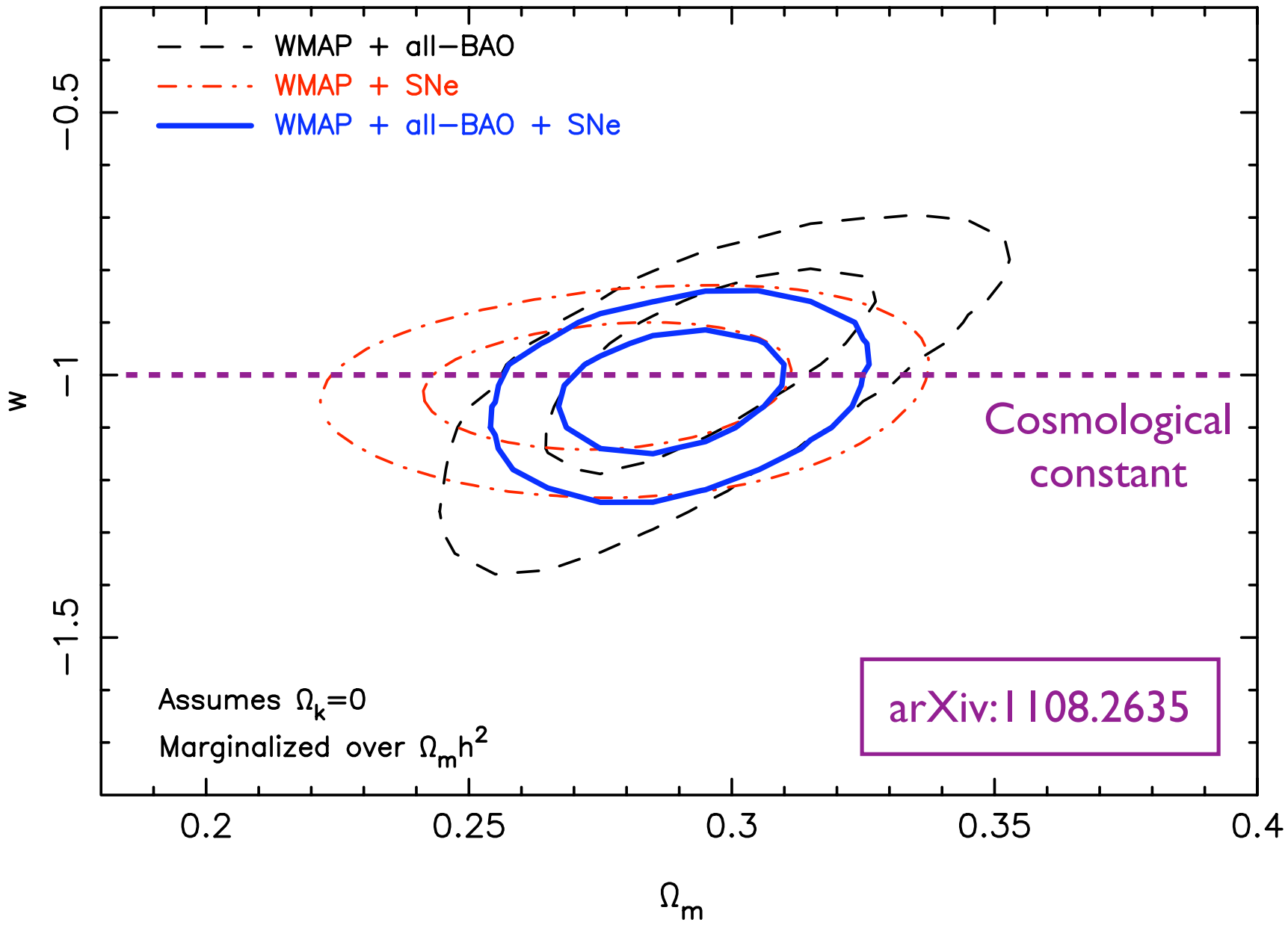
Comparison of BAO fitting techniques



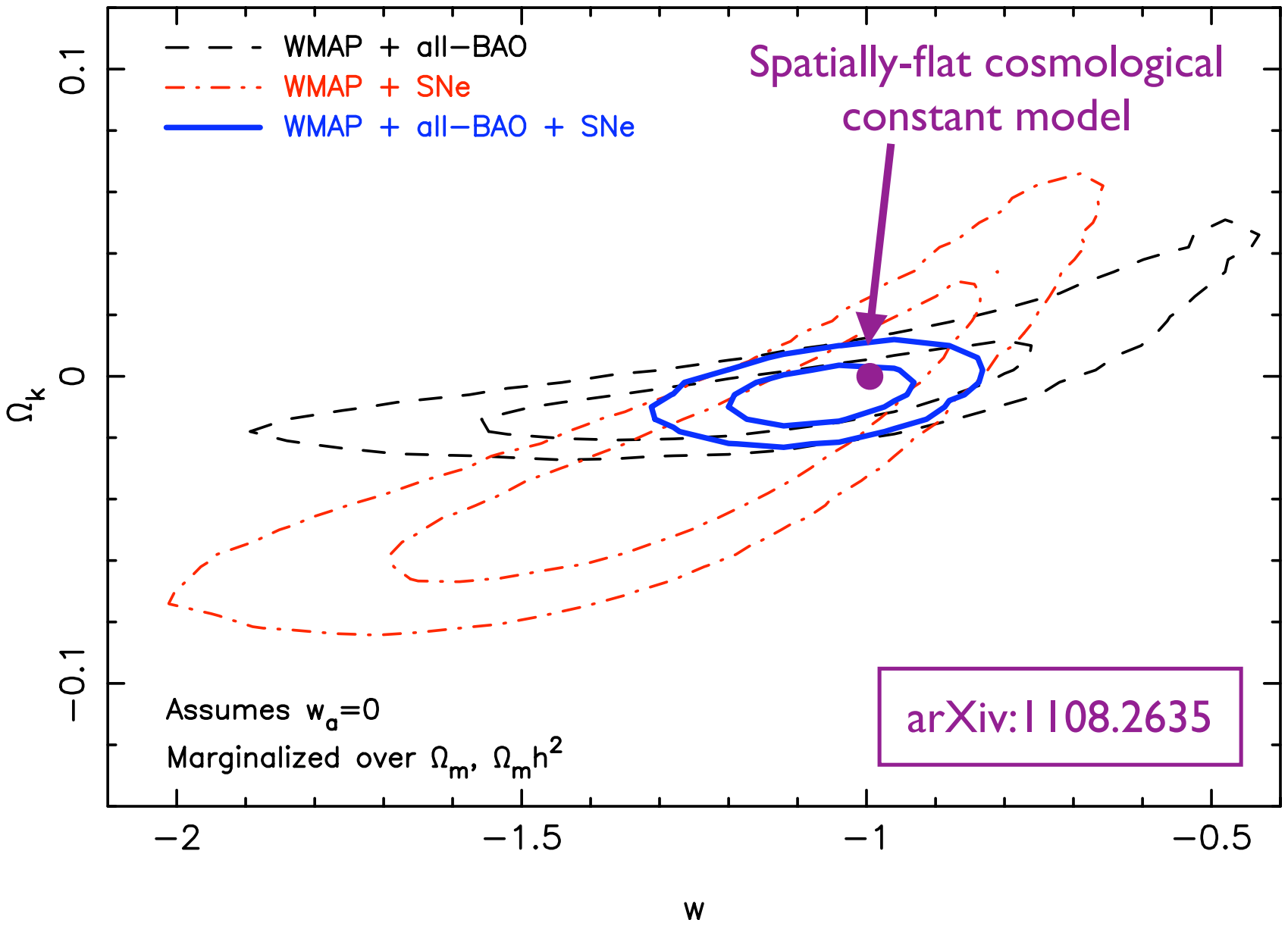
Cosmological parameter fits



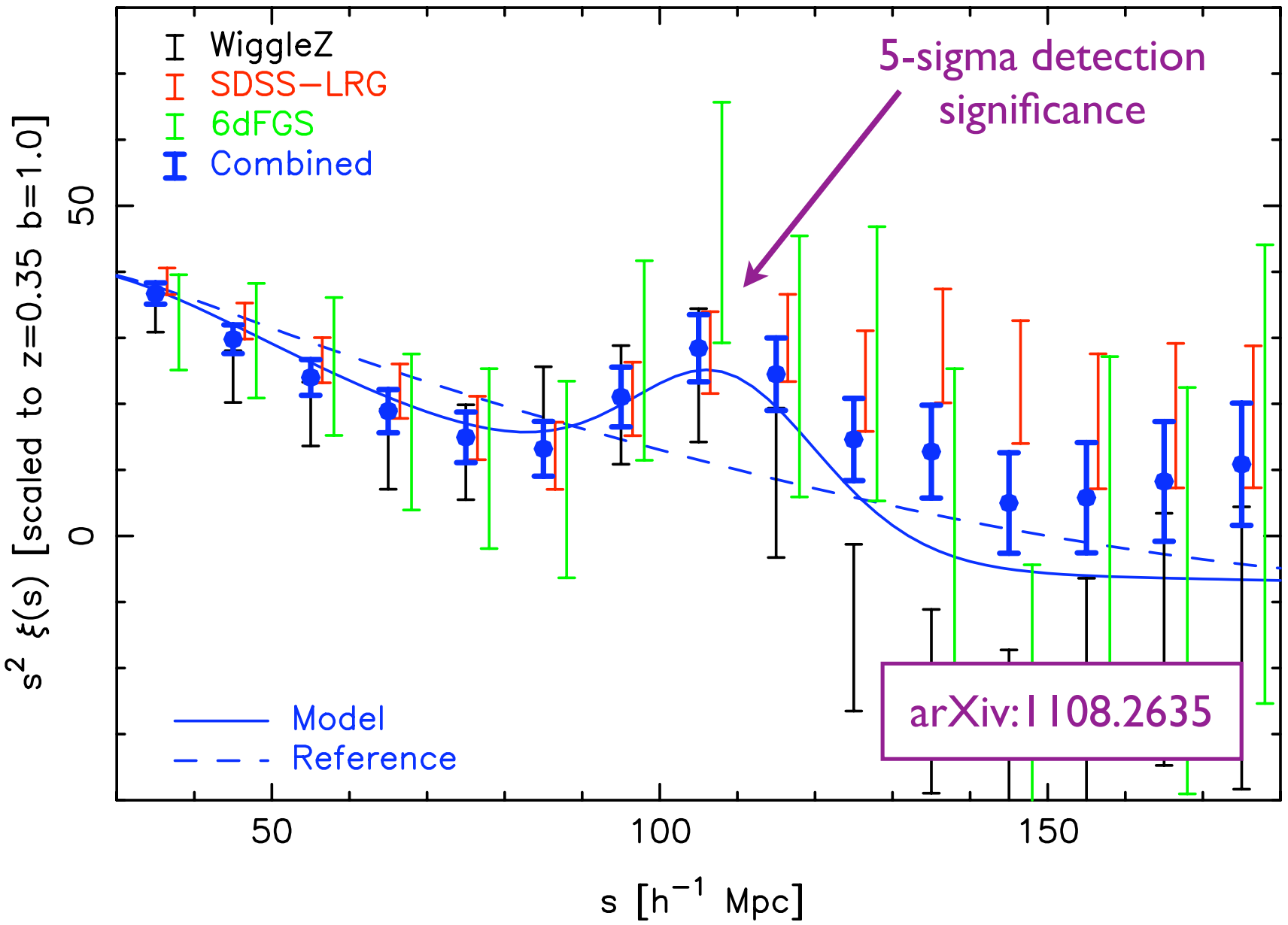
Cosmological parameter fits



Cosmological parameter fits



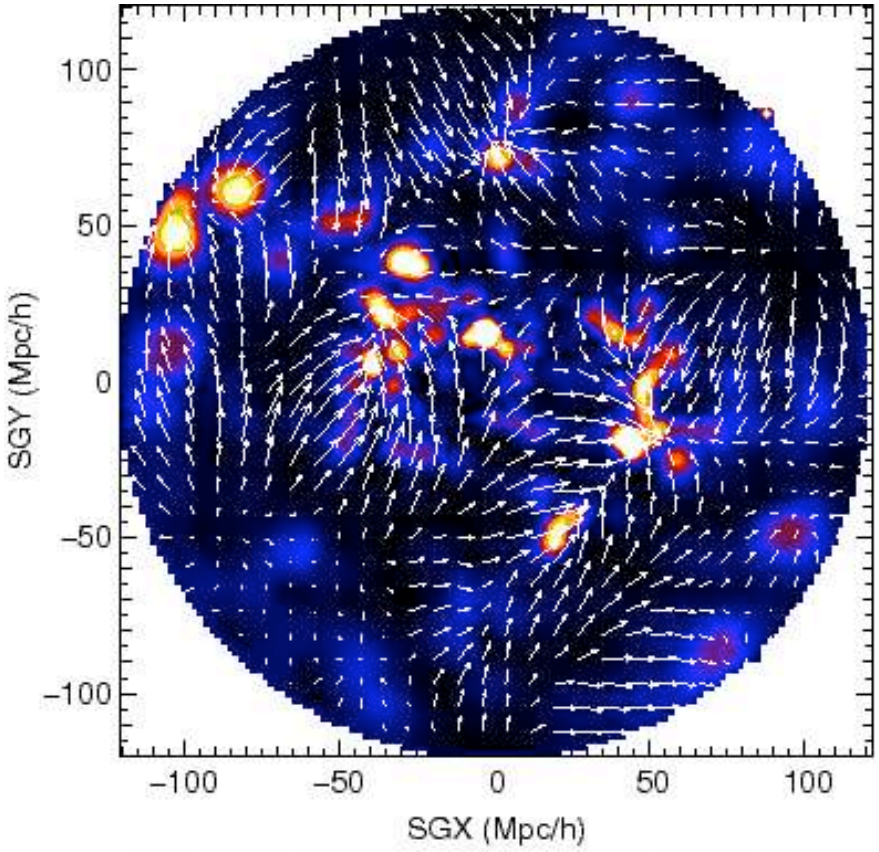
Stacking the BAO measurements!



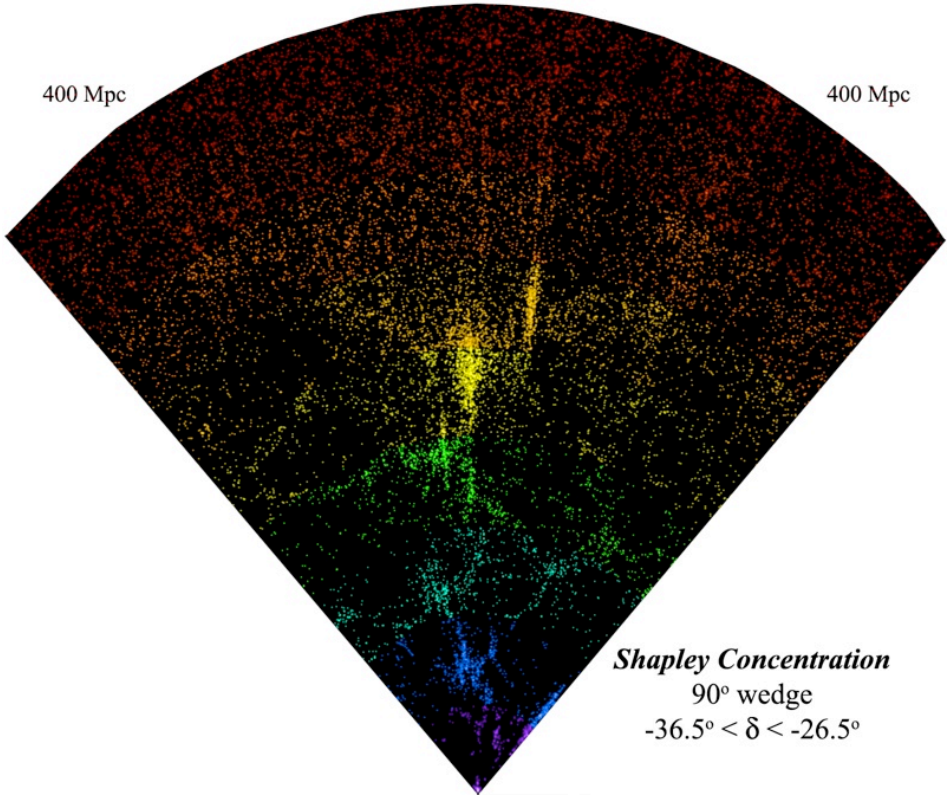
Redshift-space distortions

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

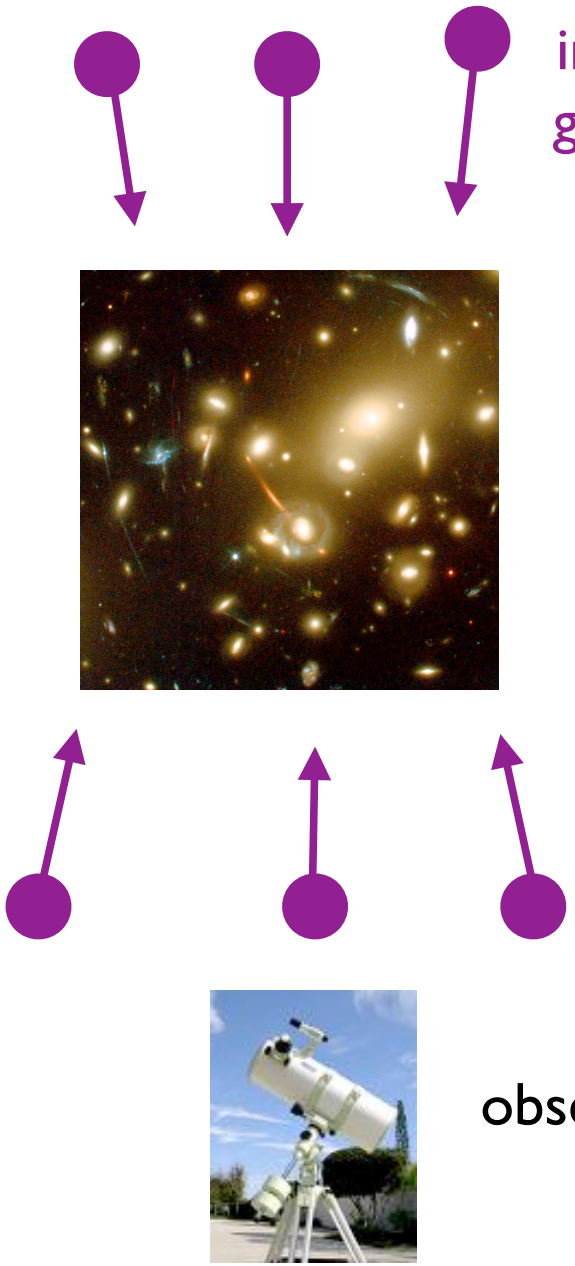
coherent flows

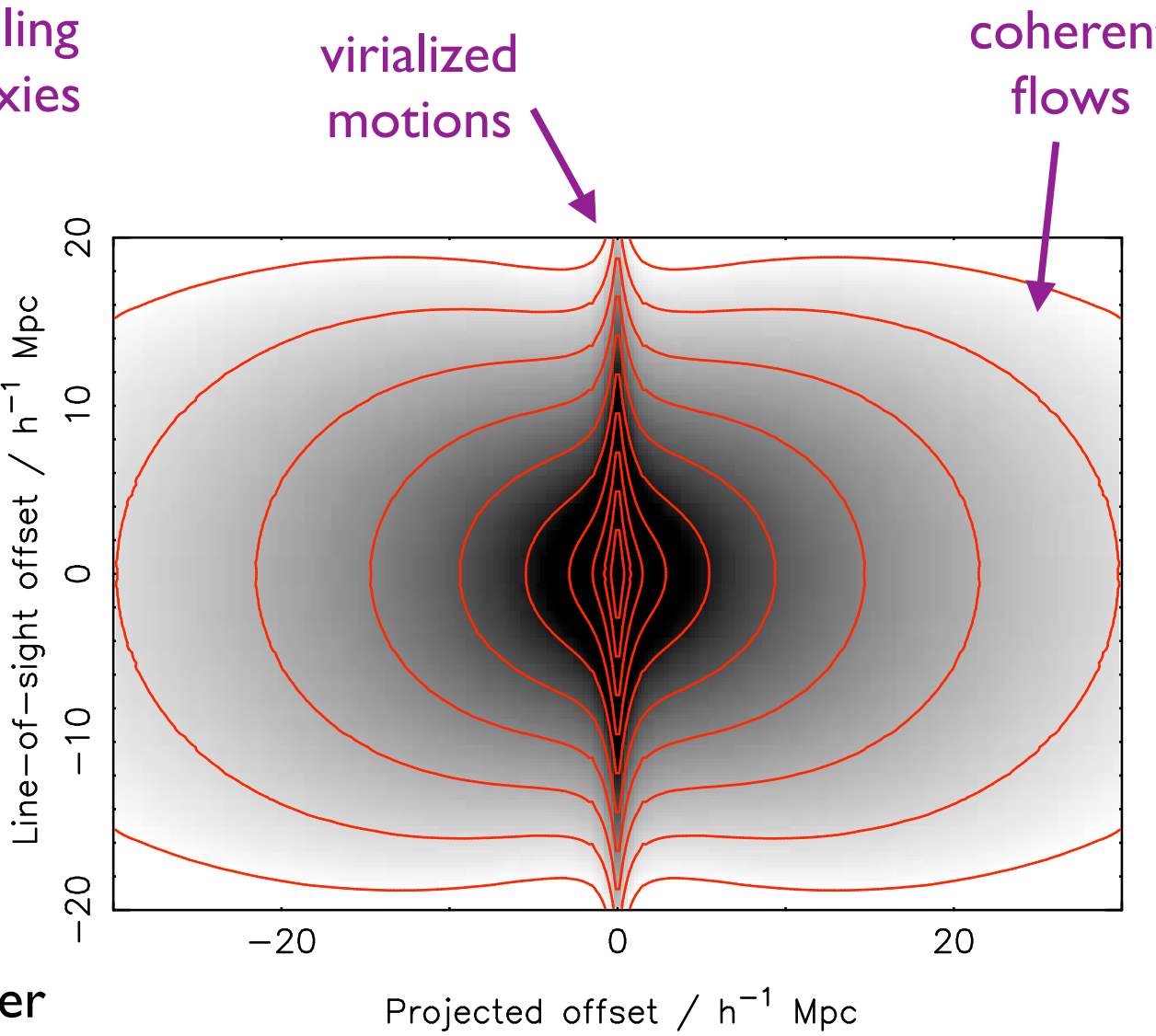


virialized motions

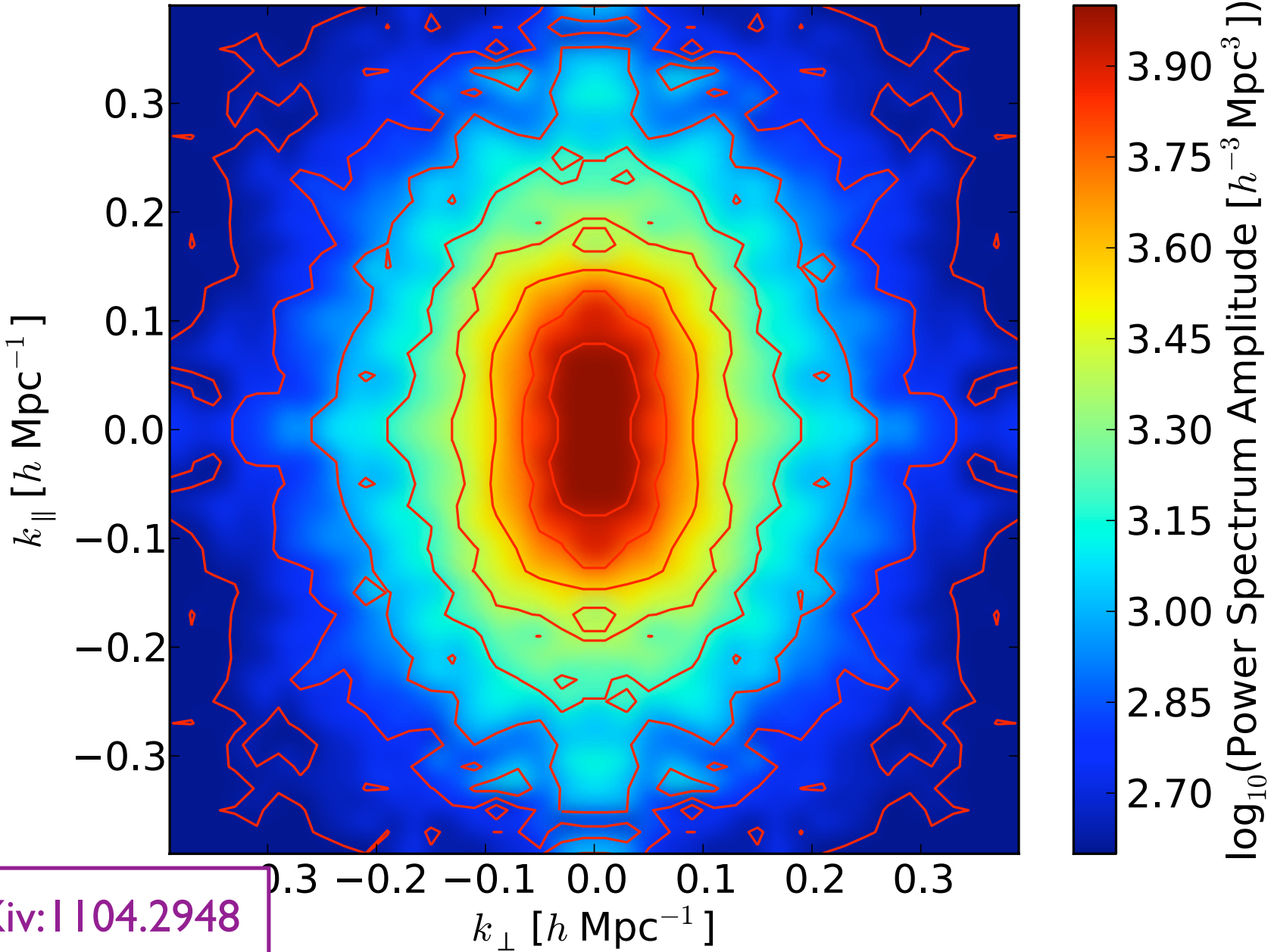


Redshift-space distortions



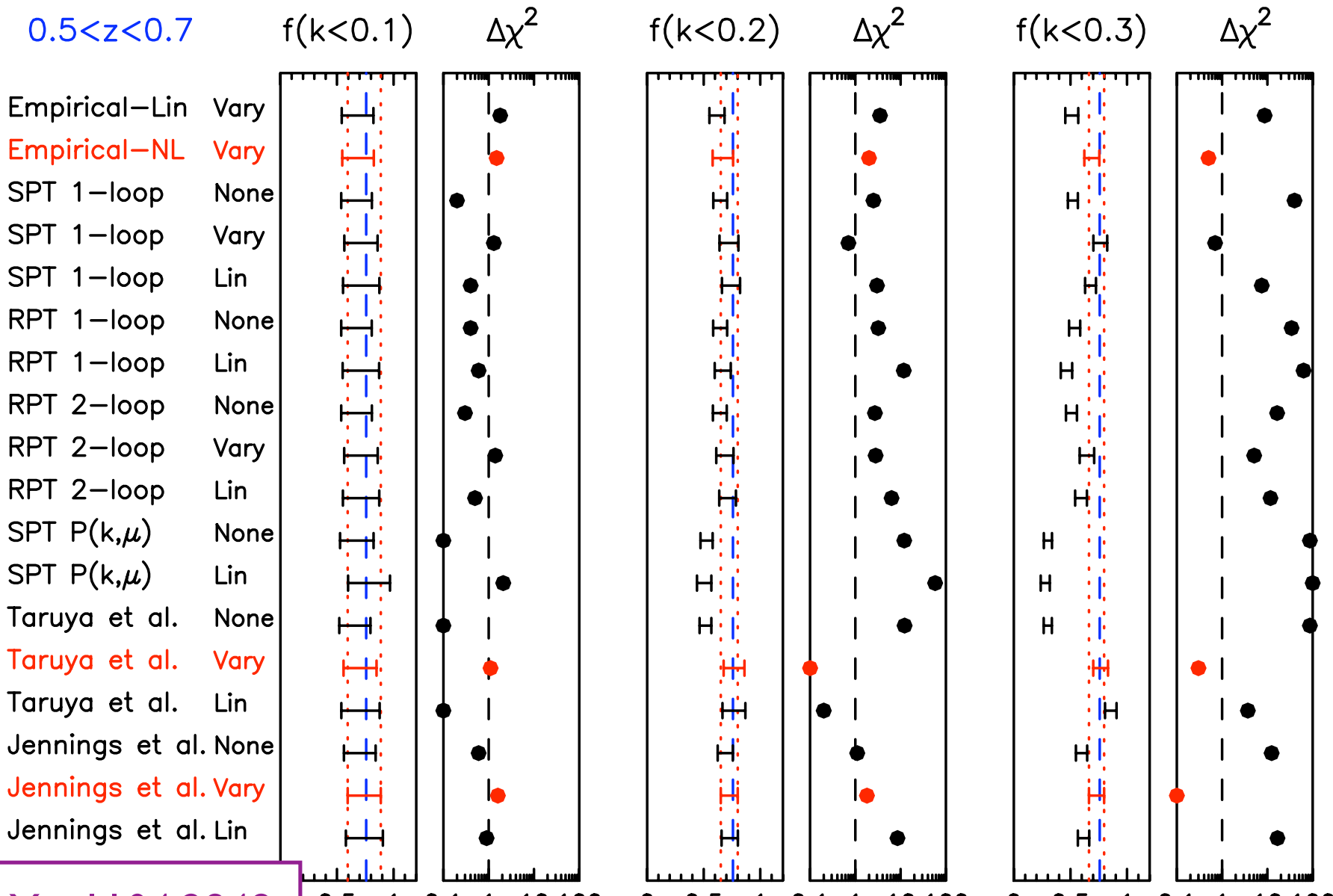


Redshift-space distortions in WiggleZ



arXiv:1104.2948

Growth rate measurements from WiggleZ



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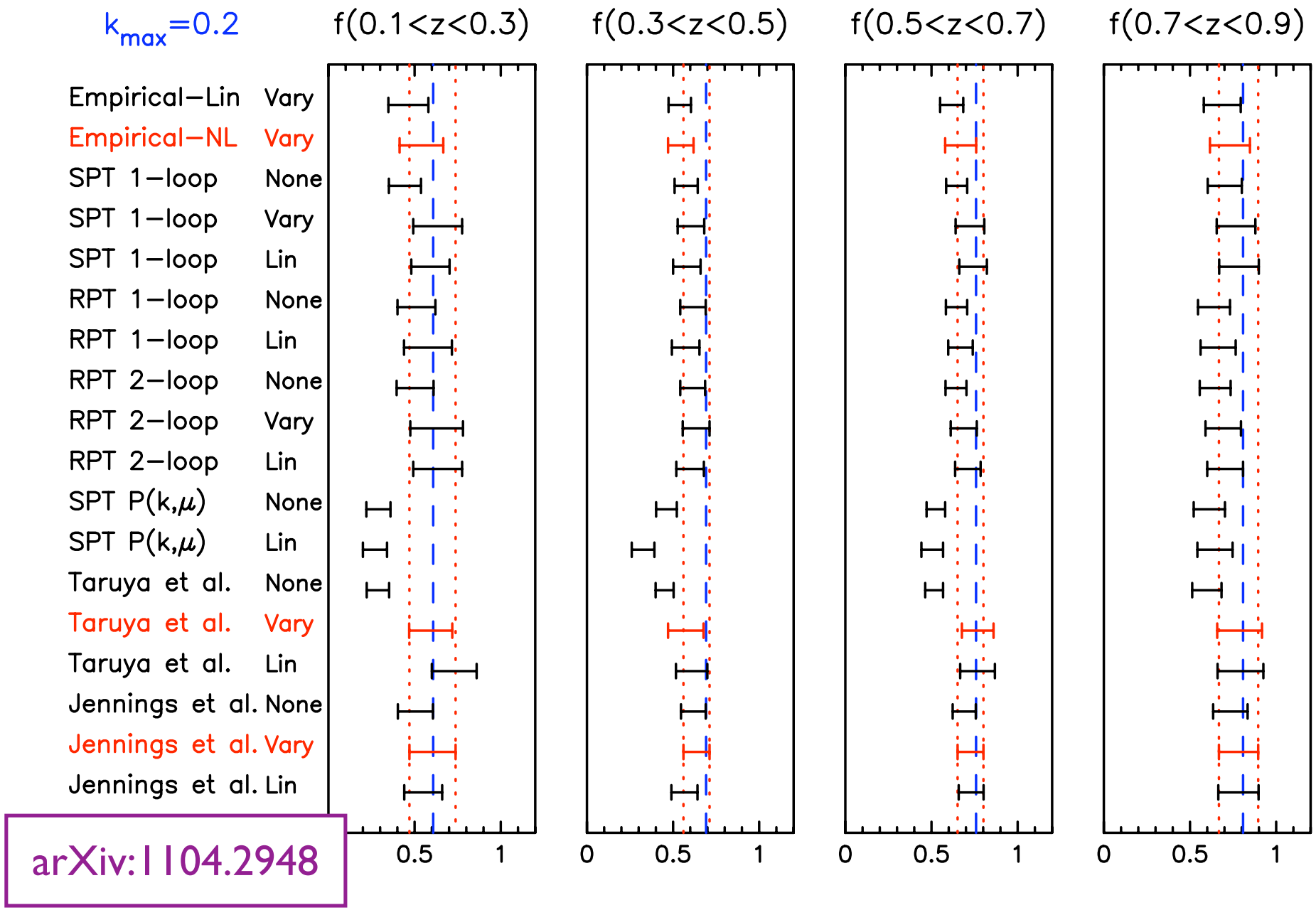

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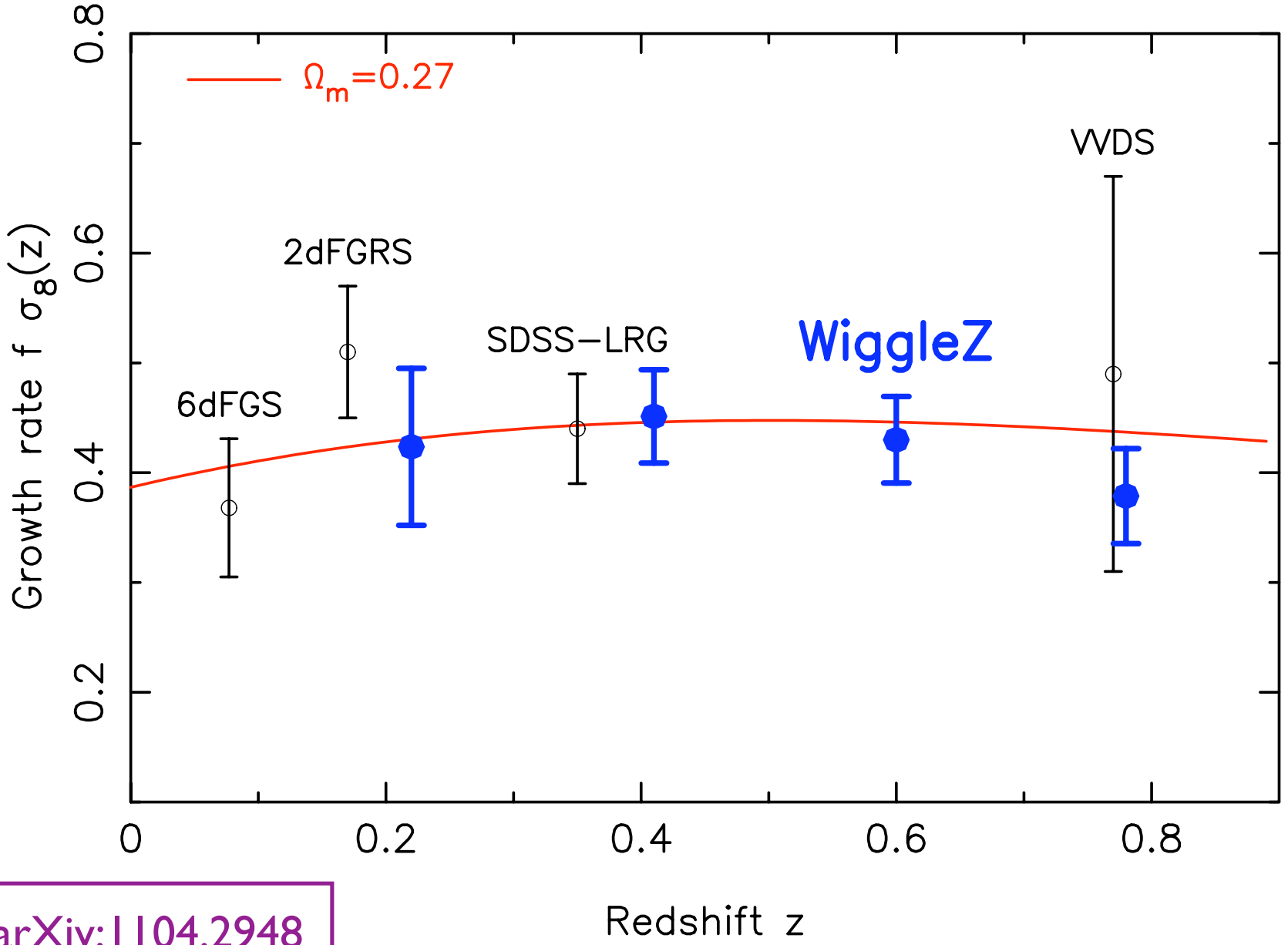


arXiv:1104.2948

Density and velocity power spectra in WiggleZ

Exploit the different angular dependences ...

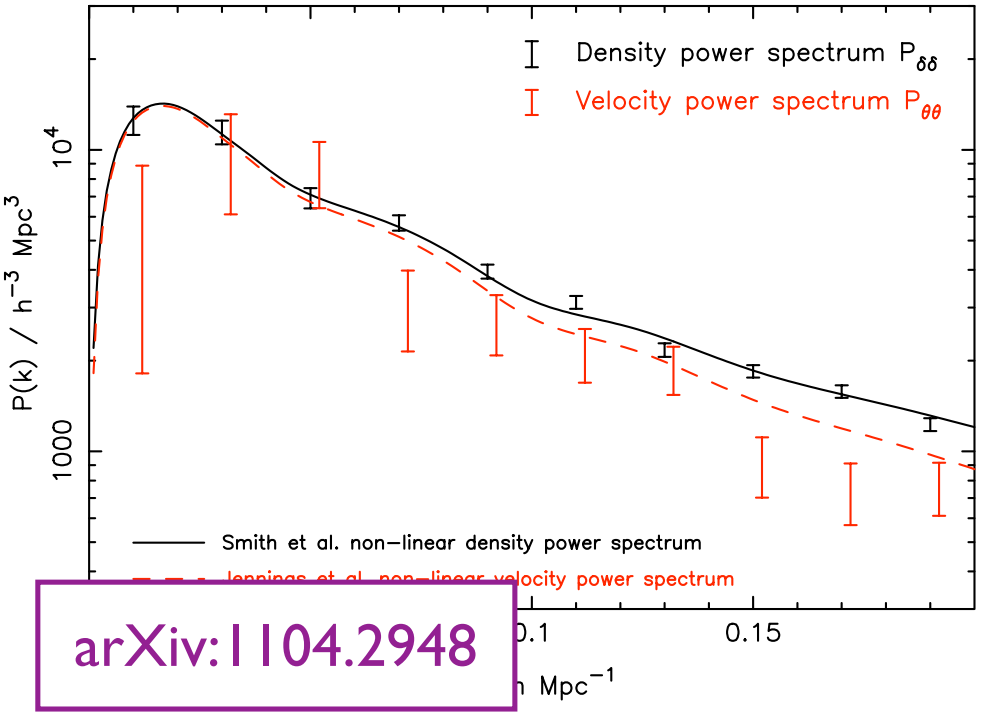
$$P_g(k,\mu) = b^2 P_{\delta\delta}(k) - 2\mu^2 br P_{\delta\theta}(k) + \mu^4 P_{\theta\theta}(k)$$

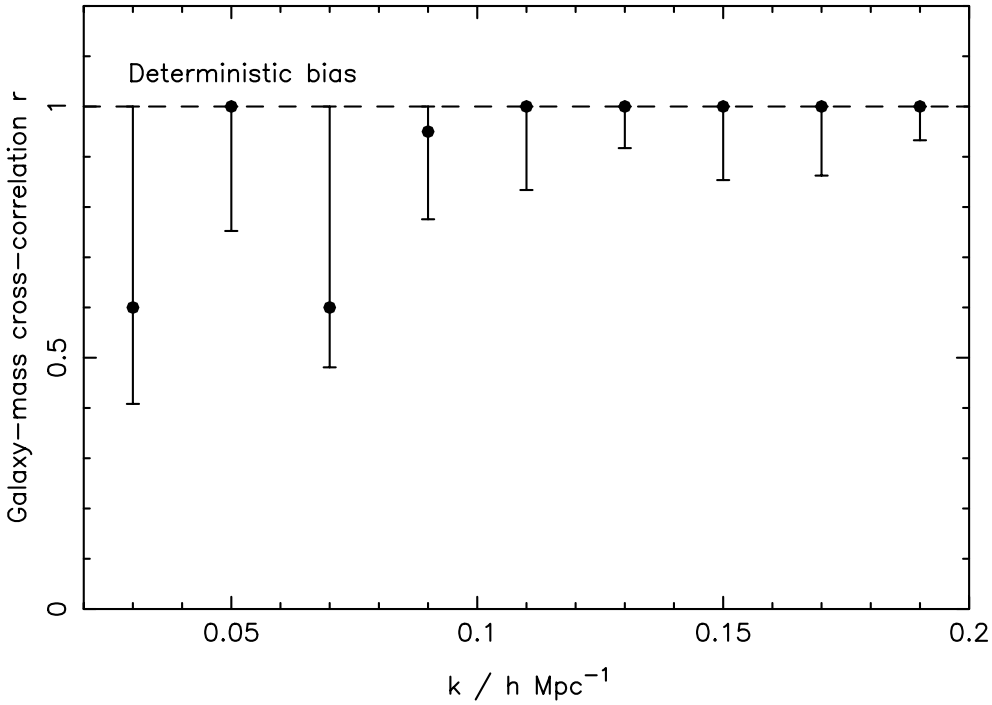
Determine velocity power spectrum:

$$r = 1, P_{\delta\theta} = -\sqrt{P_{\delta\delta} P_{\theta\theta}}$$

Determine stochastic bias:

$$f = f_{\Lambda CDM}, r = <\delta_g \delta> / \sqrt{<\delta_g^2><\delta^2>}$$

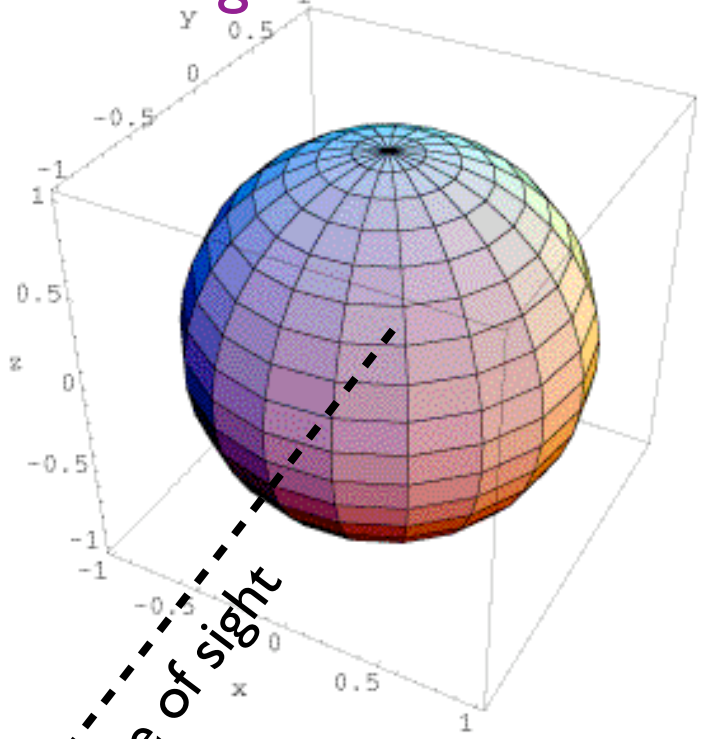




arXiv:1104.2948

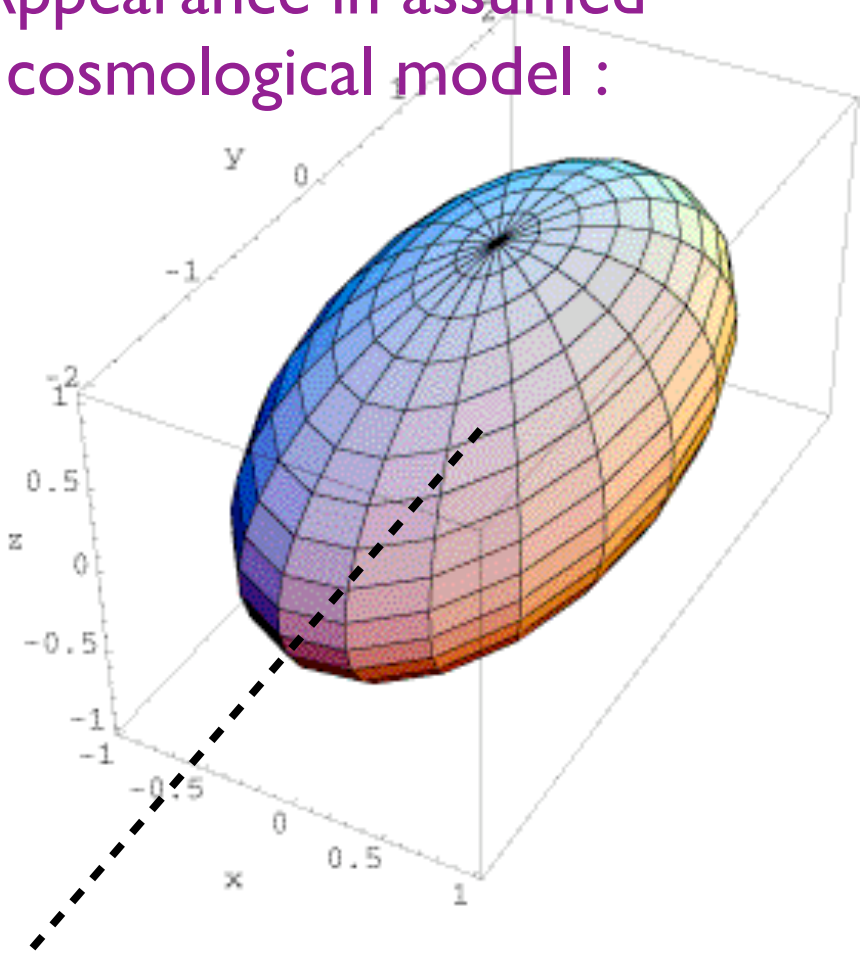
Alcock-Paczynski measurement

True appearance of cluster of galaxies :



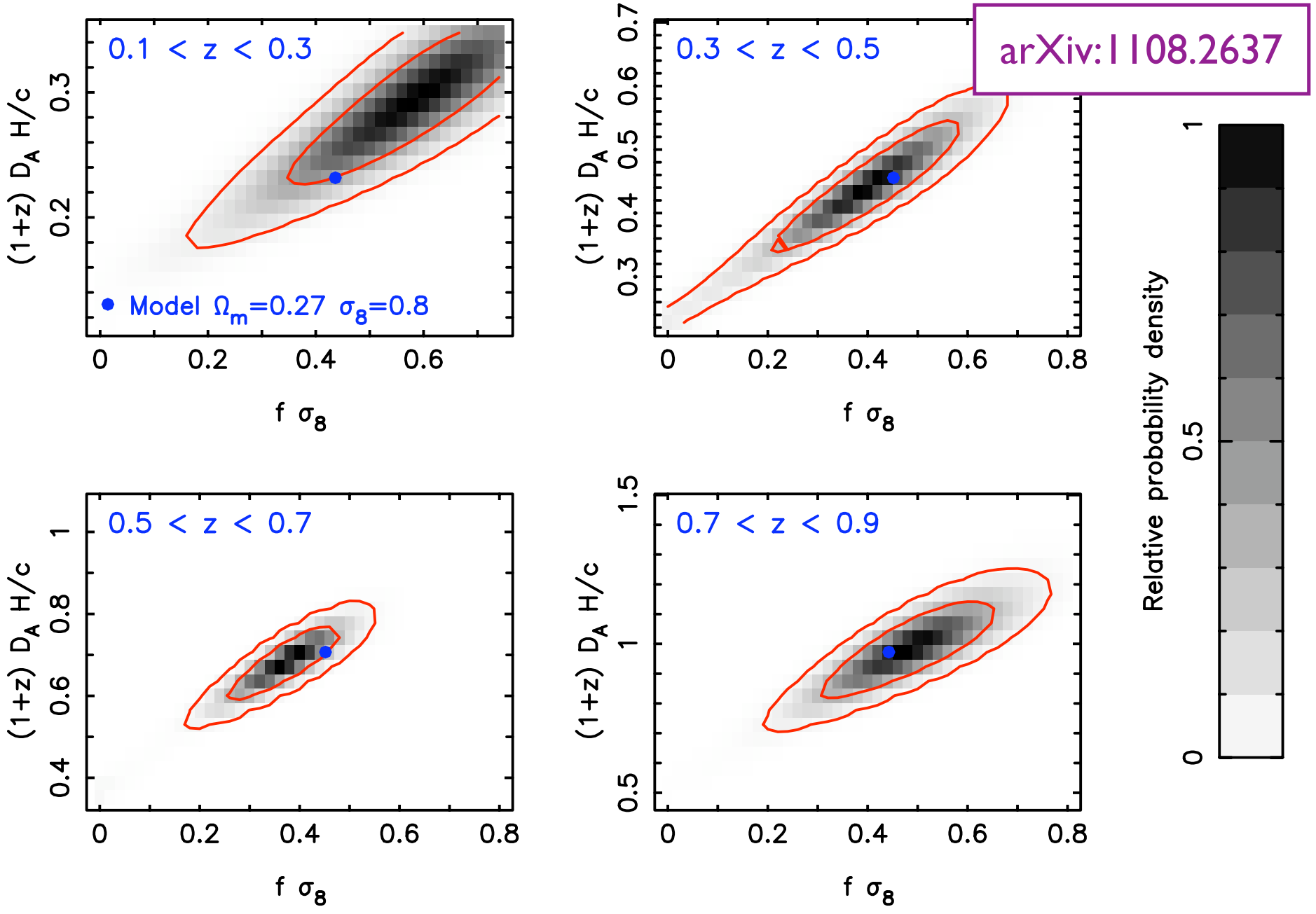
Observer's line of sight

Appearance in assumed cosmological model :

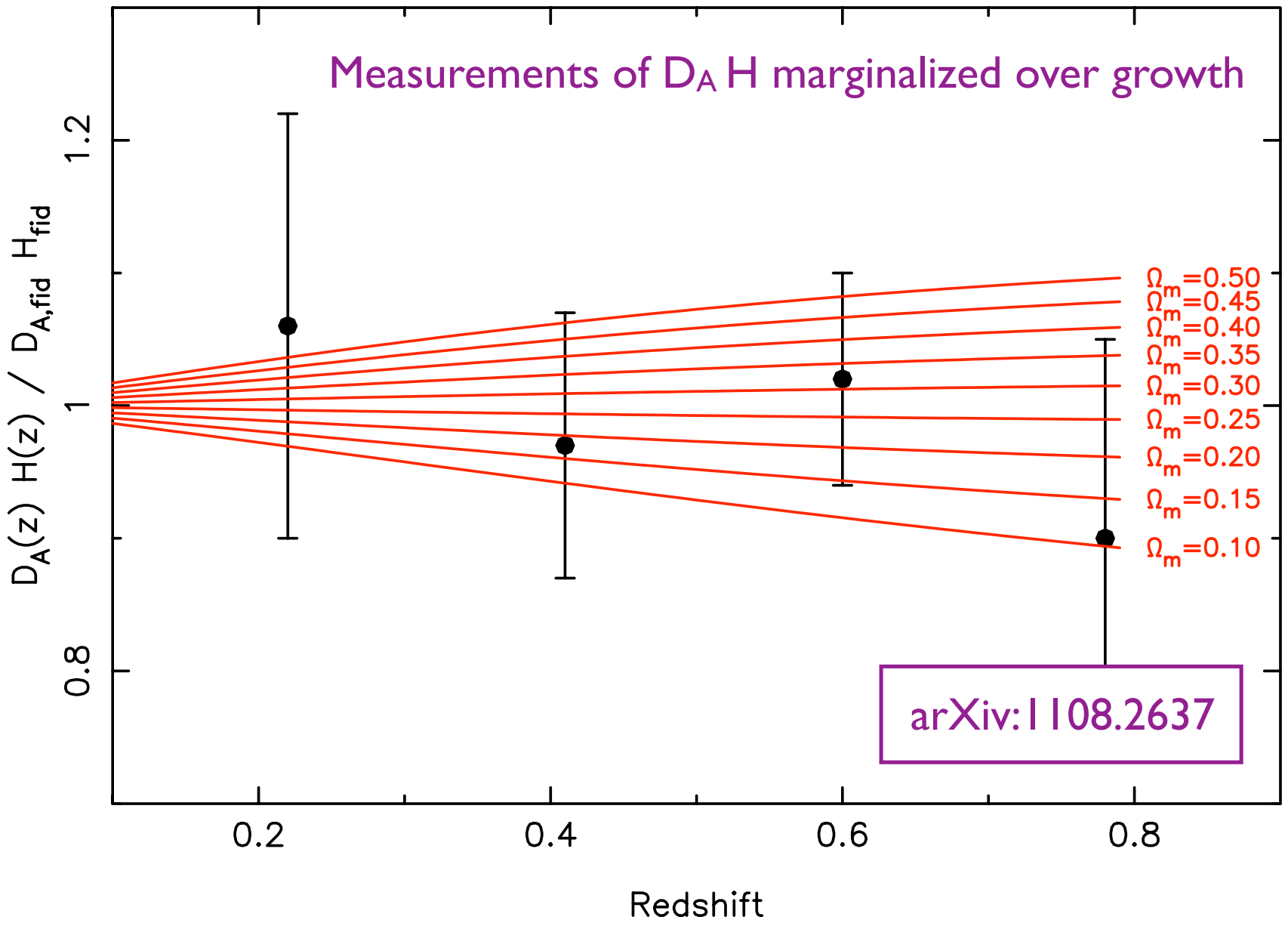


$$\text{Apparent angular size} = (1+z)\, D_A(z)\, \Delta\theta$$
$$\text{Apparent radial size} = [c/H(z)]\, \Delta z$$

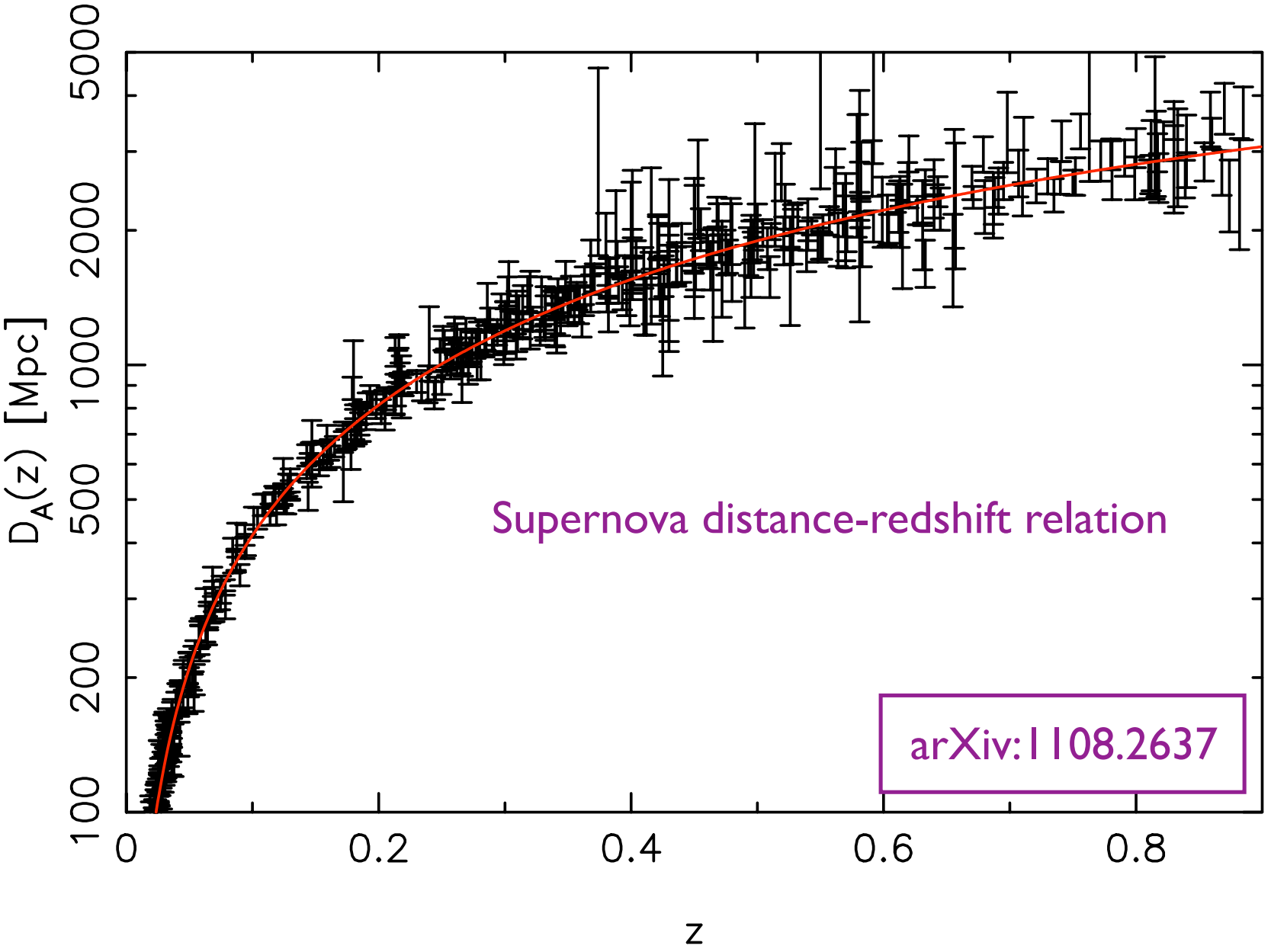
Alcock-Paczynski measurement in WiggleZ



Alcock-Paczynski measurement in WiggleZ



Alcock-Paczynski measurement in WiggleZ

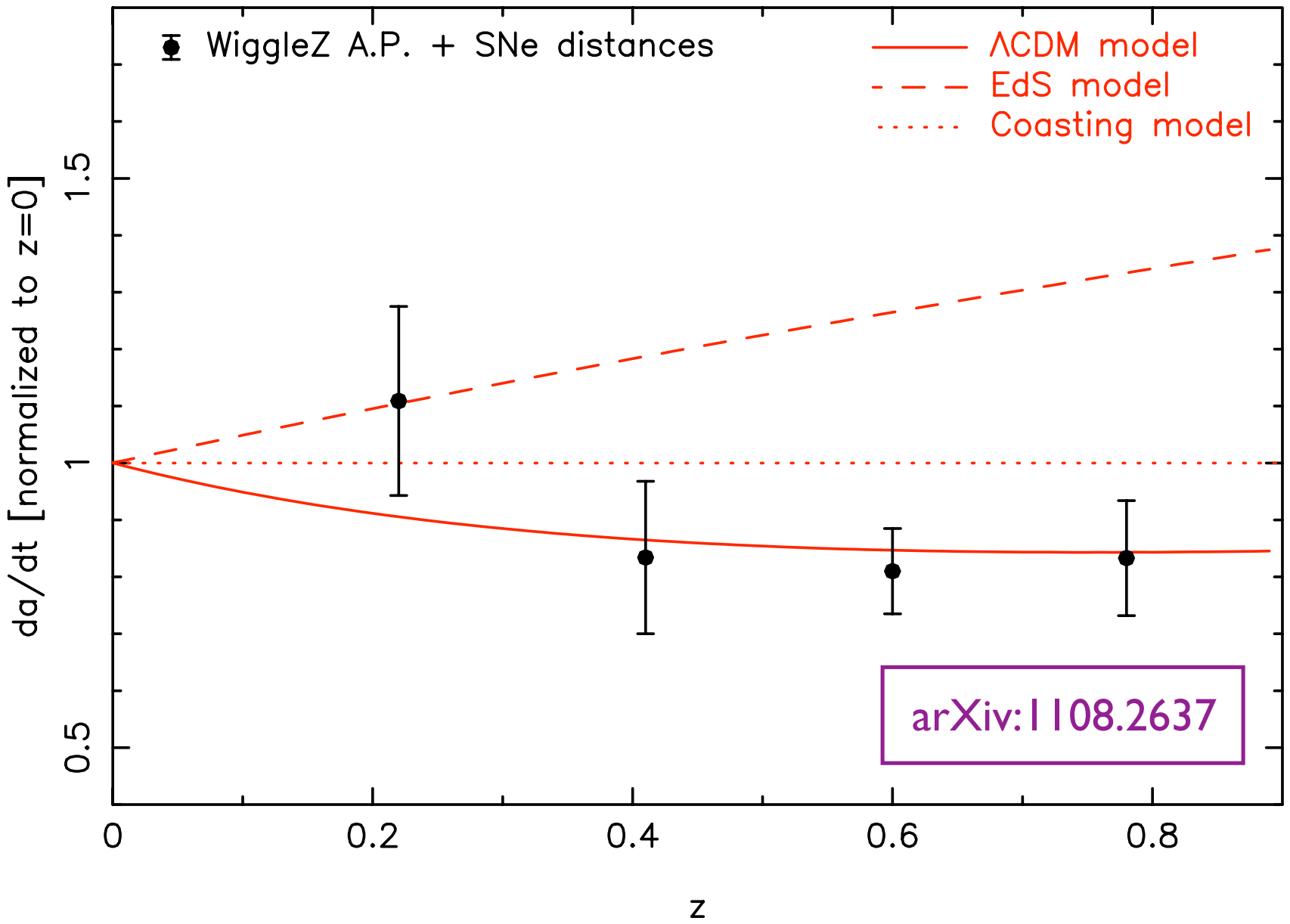


Model-independent cosmic acceleration

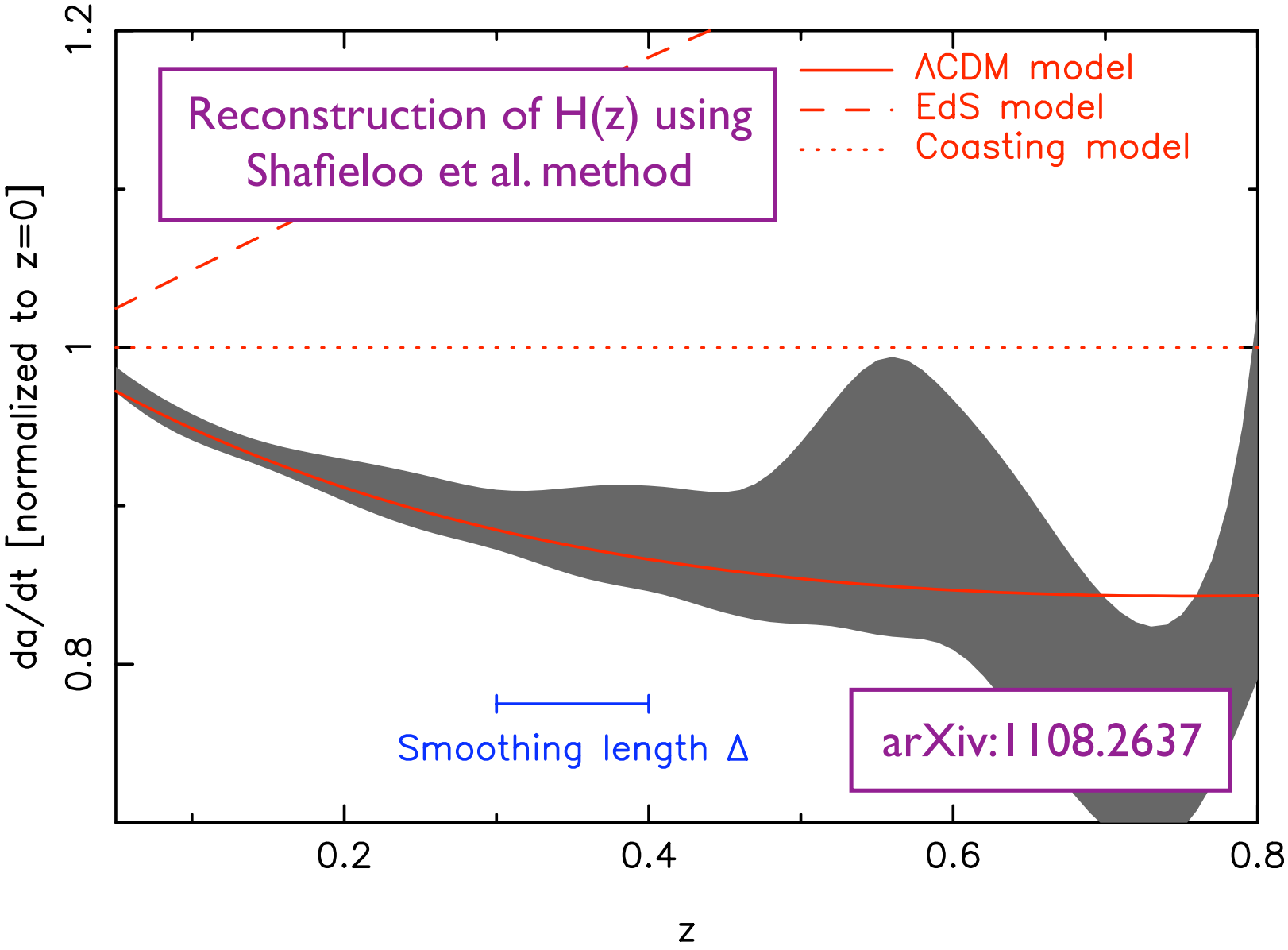
- With current data, the accelerating expansion can only be established by assuming a cosmological model
- But, the importance of dark energy lies in the fact that we don't know what this model should be!
- Can we demonstrate the acceleration model-independently or non-parametrically?
- Need to measure the Hubble parameter as a function of redshift :

$$\dot{a} = \frac{H(z)}{1+z}$$

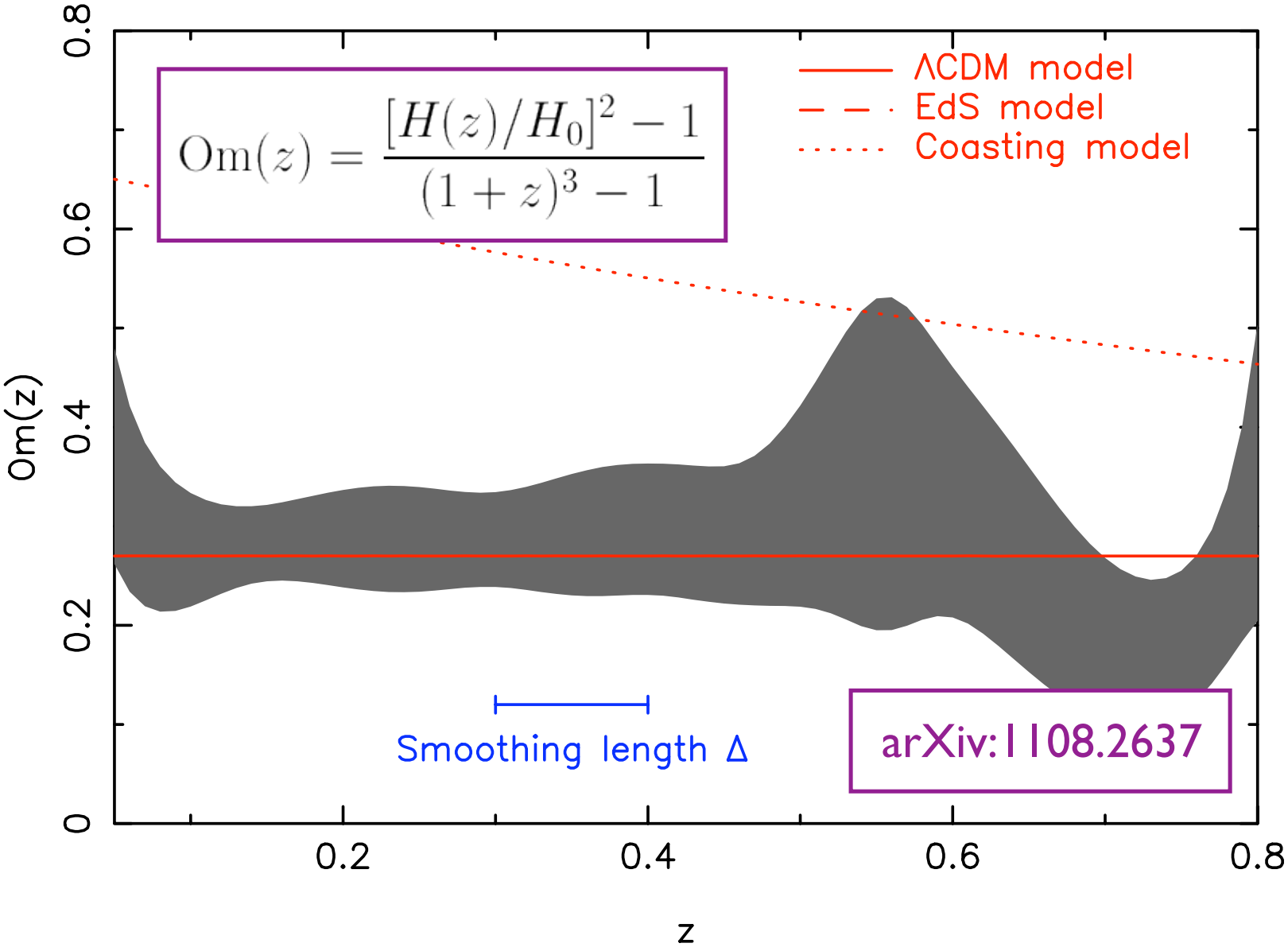
Non-parametric expansion history



Non-parametric expansion history



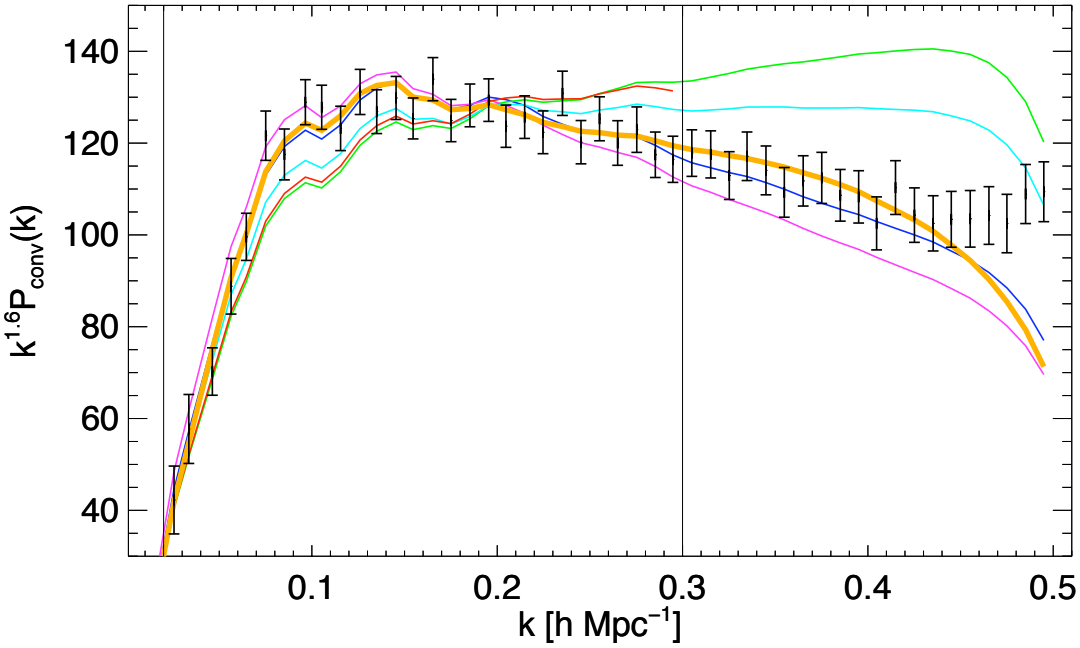
Non-parametric expansion history



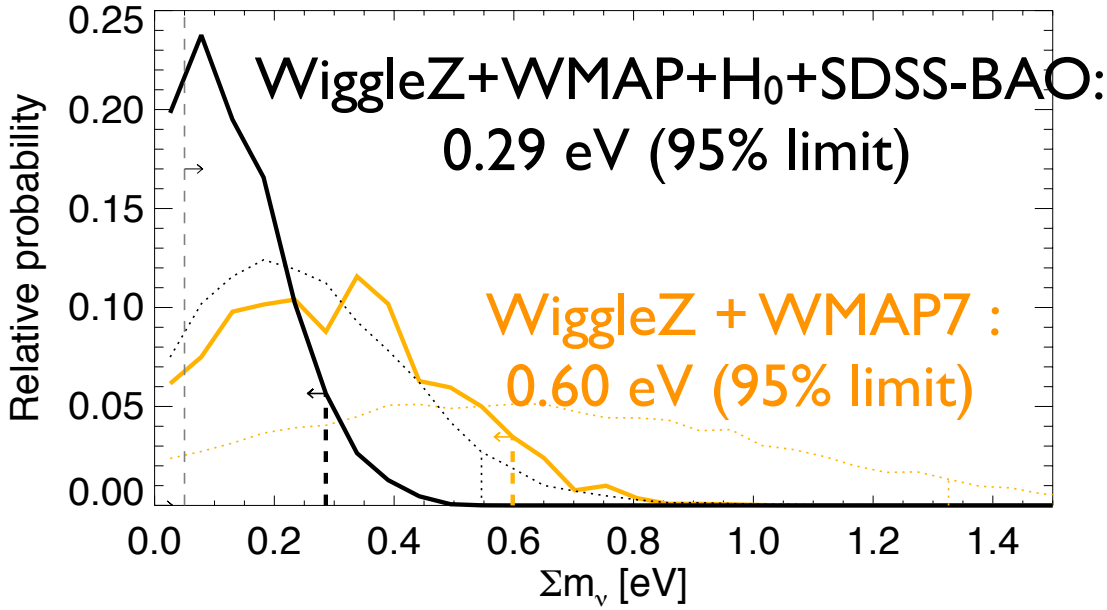
Neutrino mass limit from WiggleZ P(k)

Riemer-Sorensen et al.
arXiv:1112.4940

Combined WiggleZ power spectrum dataset compared to various models :



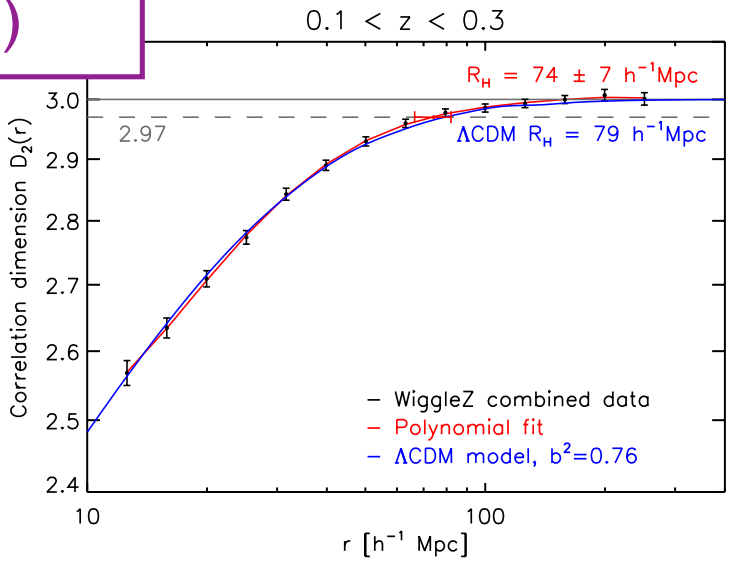
Probability histogram for the sum of neutrino masses :

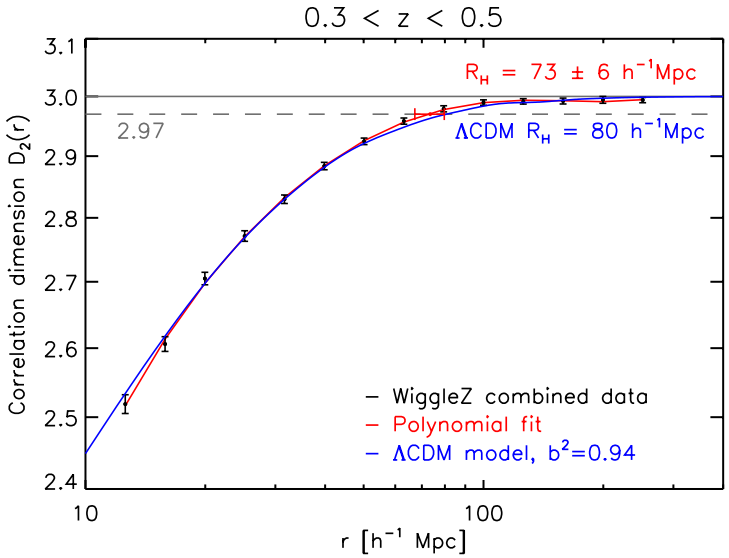


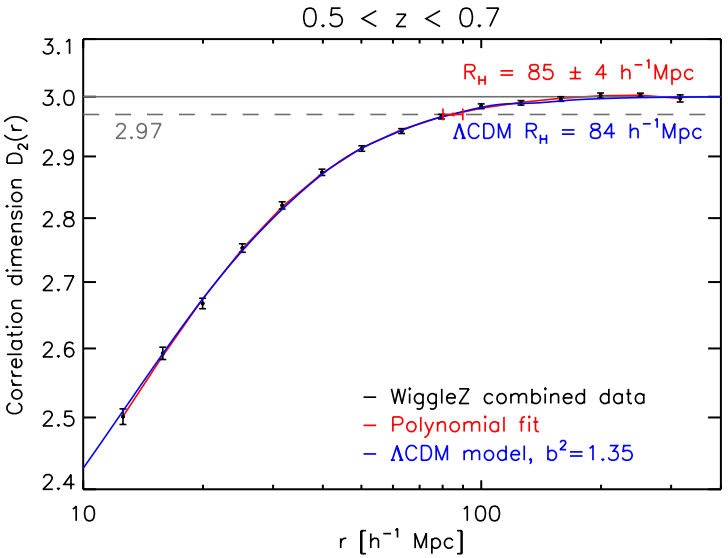
Transition to cosmic homogeneity

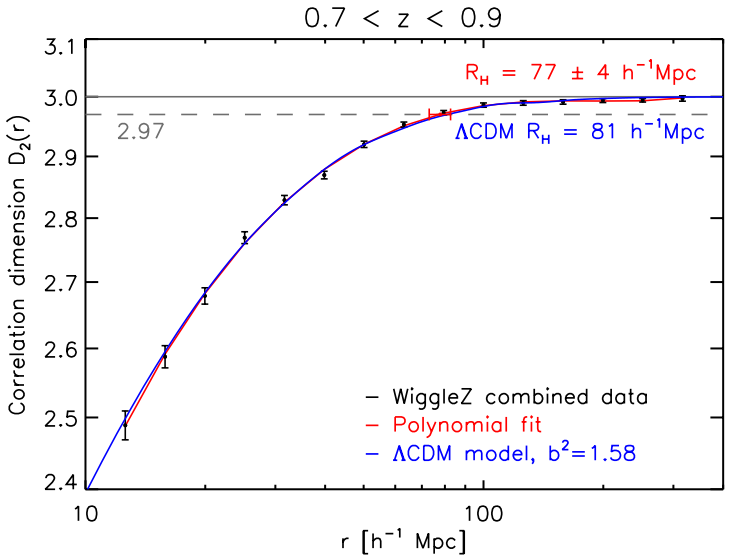
Scrimgeour et al. (submitted)

Measurement of the correlation dimension $N(<r) \sim r^D$









Other analyses in progress ...

- Cosmo-MC module for P(k) and data release
- Limits on modified gravity theories
- Higher-order clustering (non-Gaussianity , skewness)
- BAO reconstruction and 2D fitting for $D_A(z)$ / $H(z)$
- Clusters and voids
- Cosmic topology (genus)
- Turnover in power spectrum (early-universe physics)

Summary of results from WiggleZ

- Baryon acoustic peak detected at ~3-sigma significance and measures cosmic distances to z=0.8
- WiggleZ gives most accurate growth measurement, extending previous work to higher redshift
- Alcock-Paczynski effect allows direct reconstruction of H(z) at high redshift
- G.R. + Lambda models remain a good fit
- If dark energy behaves as Lambda, what is its physics?