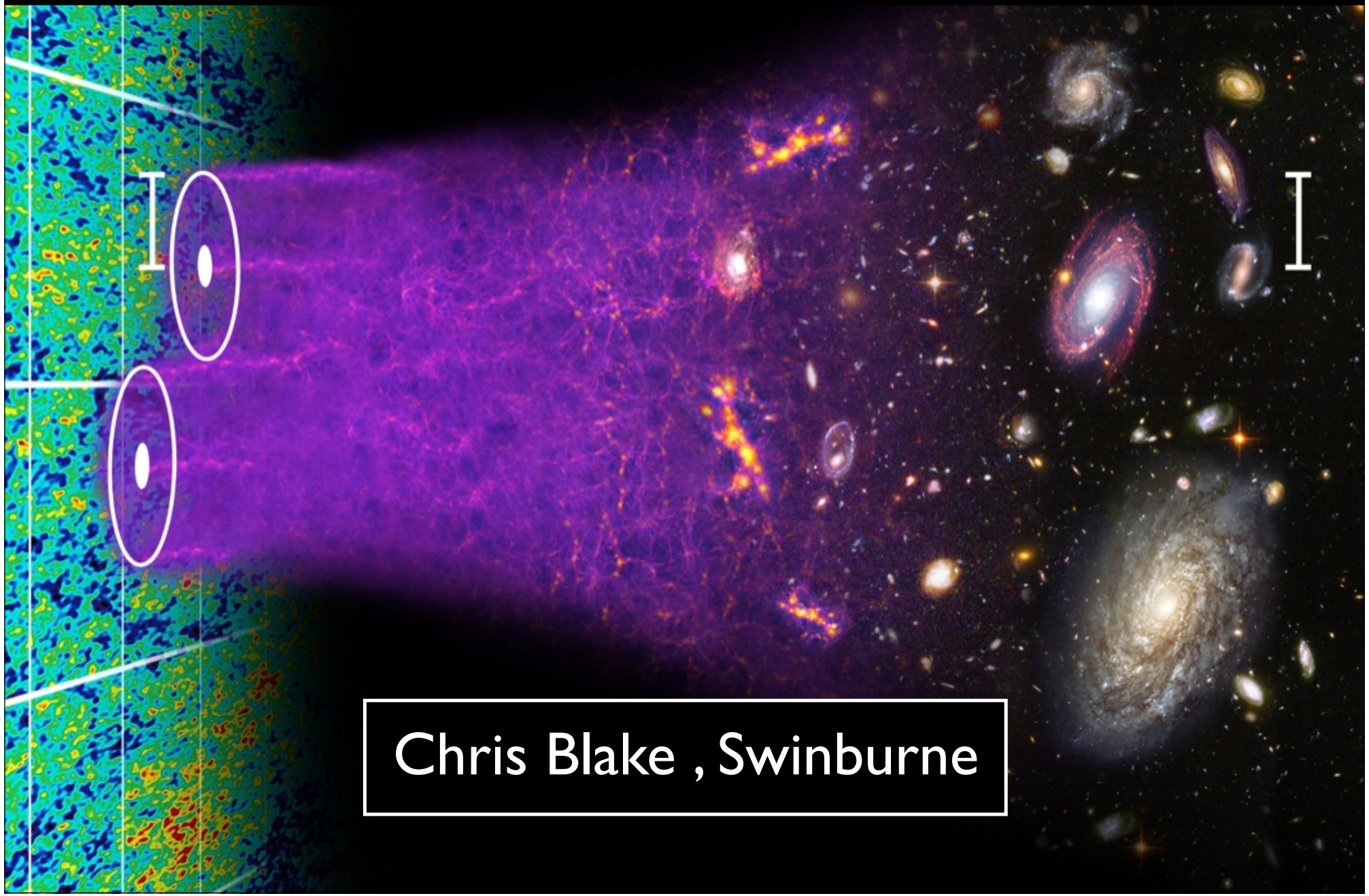
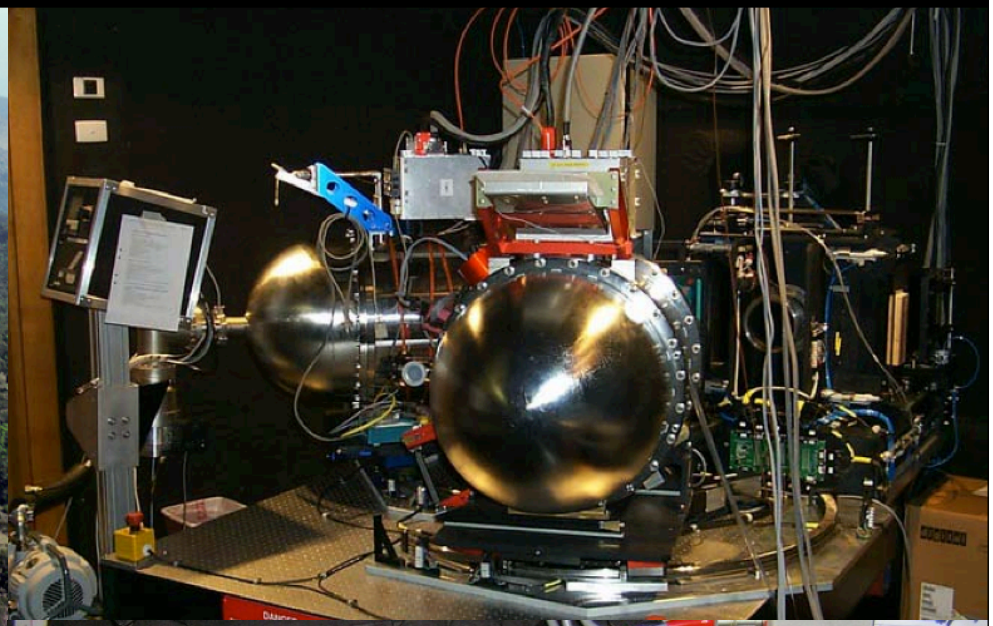
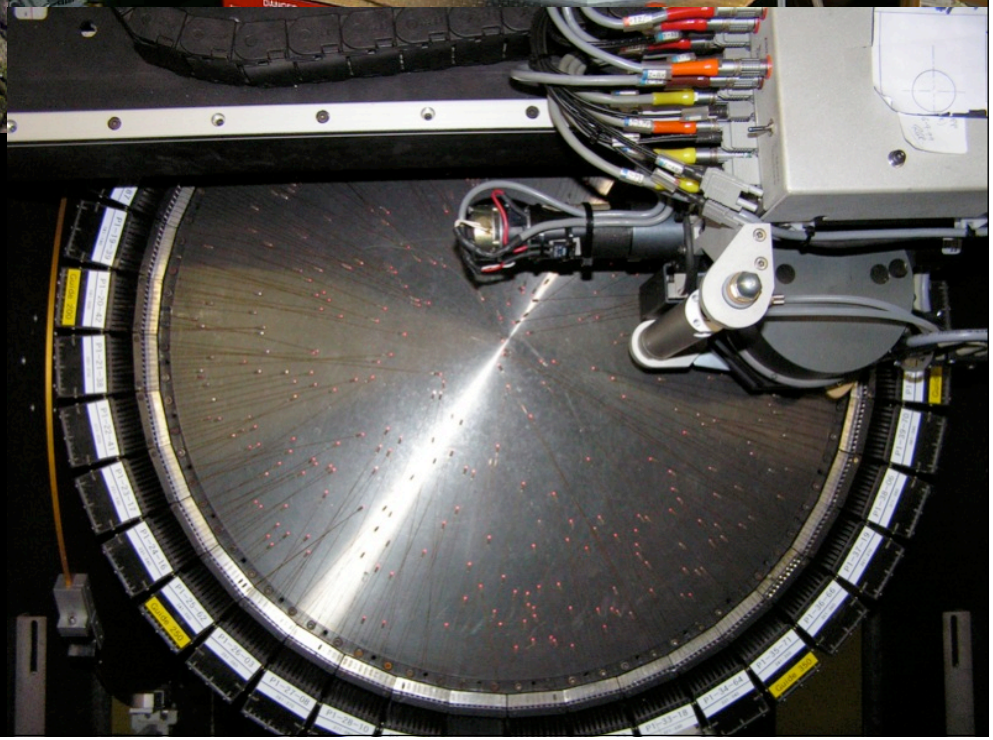
Cosmology with the WiggleZ Survey



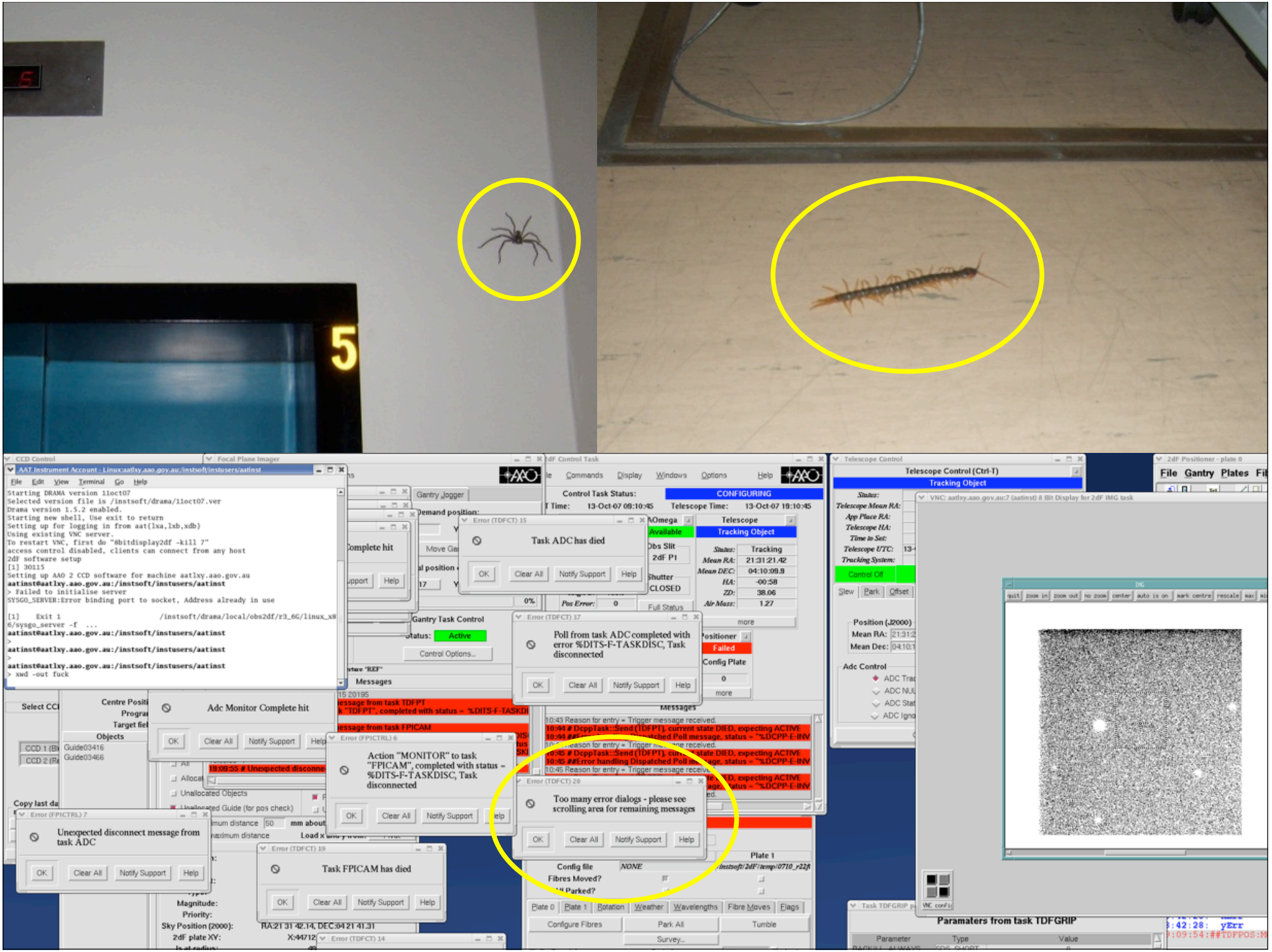
Chris Blake , Swinburne

The WiggleZ Dark Energy Survey





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


5
Task ADC has died
Poll from task ADC completed with error %DITS-F-TASKDISC, Task disconnected
Too many error dialogs - please see scrolling area for remaining messages
Adc Monitor Complete hit
Action "MONITOR" to task "FPICAM", completed with status = %DITS-F-TASKDISC, Task disconnected
Unexpected disconnect message from task ADC
Task FPICAM has died
Paramaters from task TDFGRIP

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

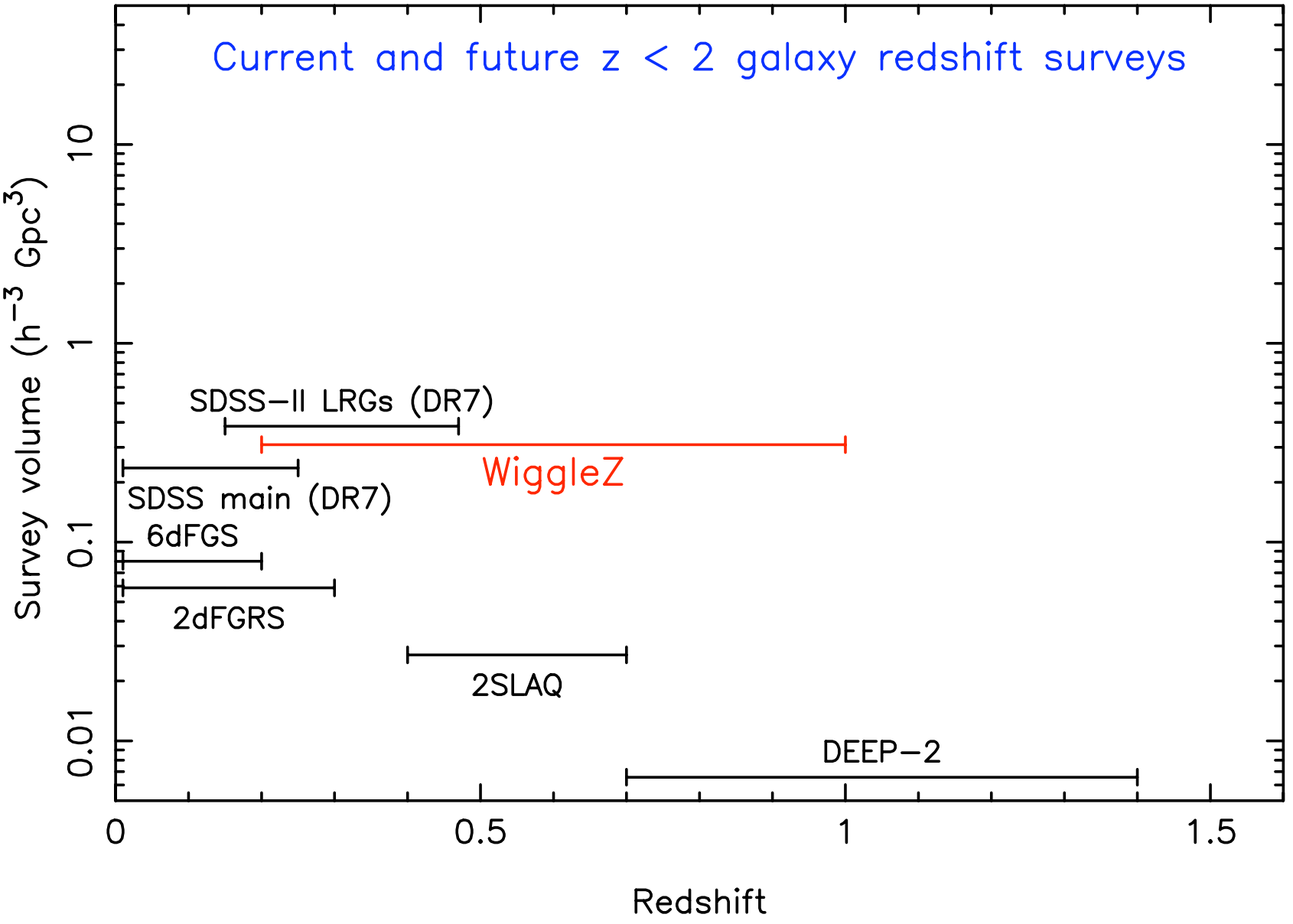
Swinburne: Chris Blake , Carlos Contreras , Felipe Marin , Greg Poole , Eyal Kazin , Jun Koda

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

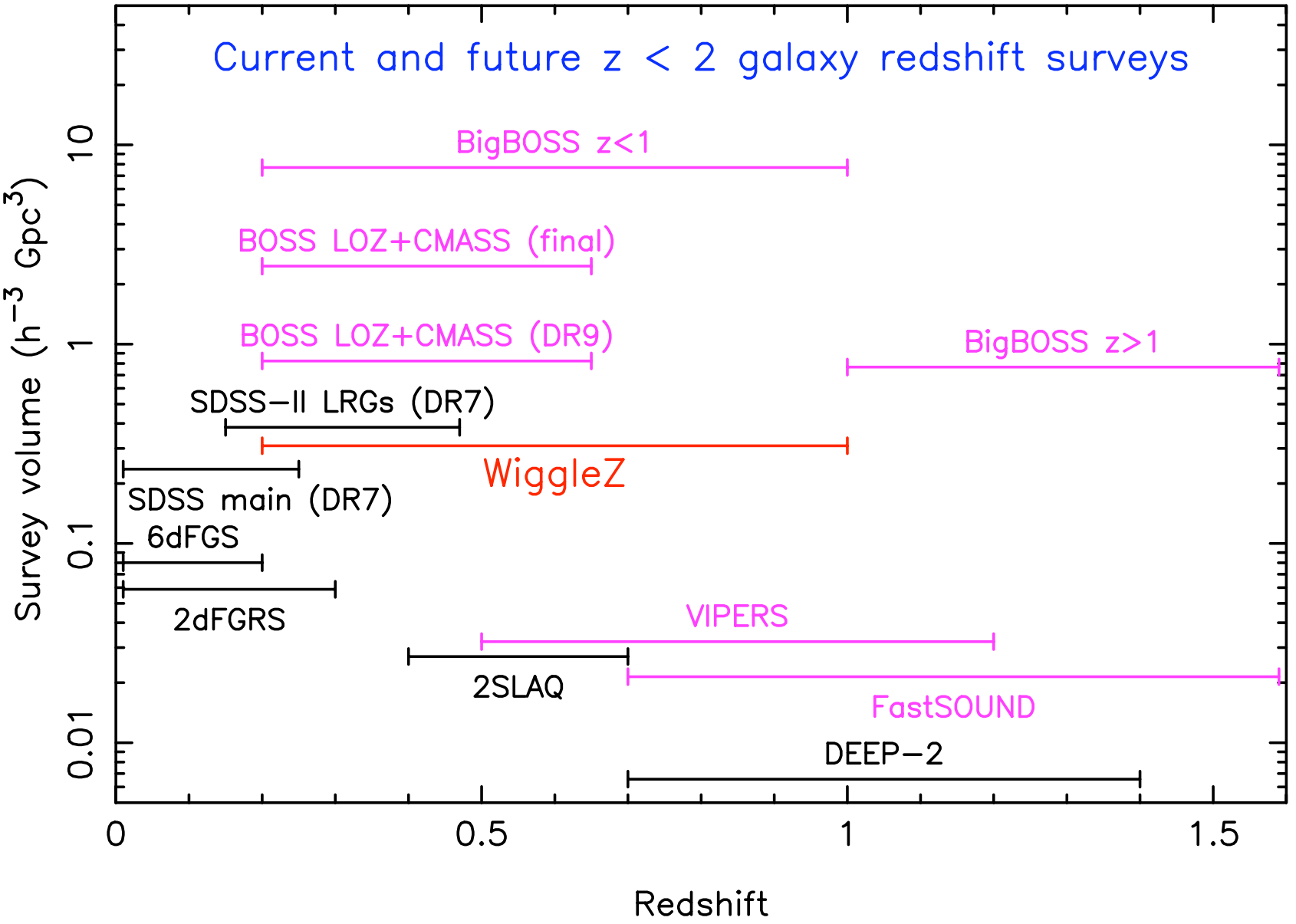
University of Western Australia: Morag Scrimgeour

DARK / Berkeley: Berian James

Survey comparison

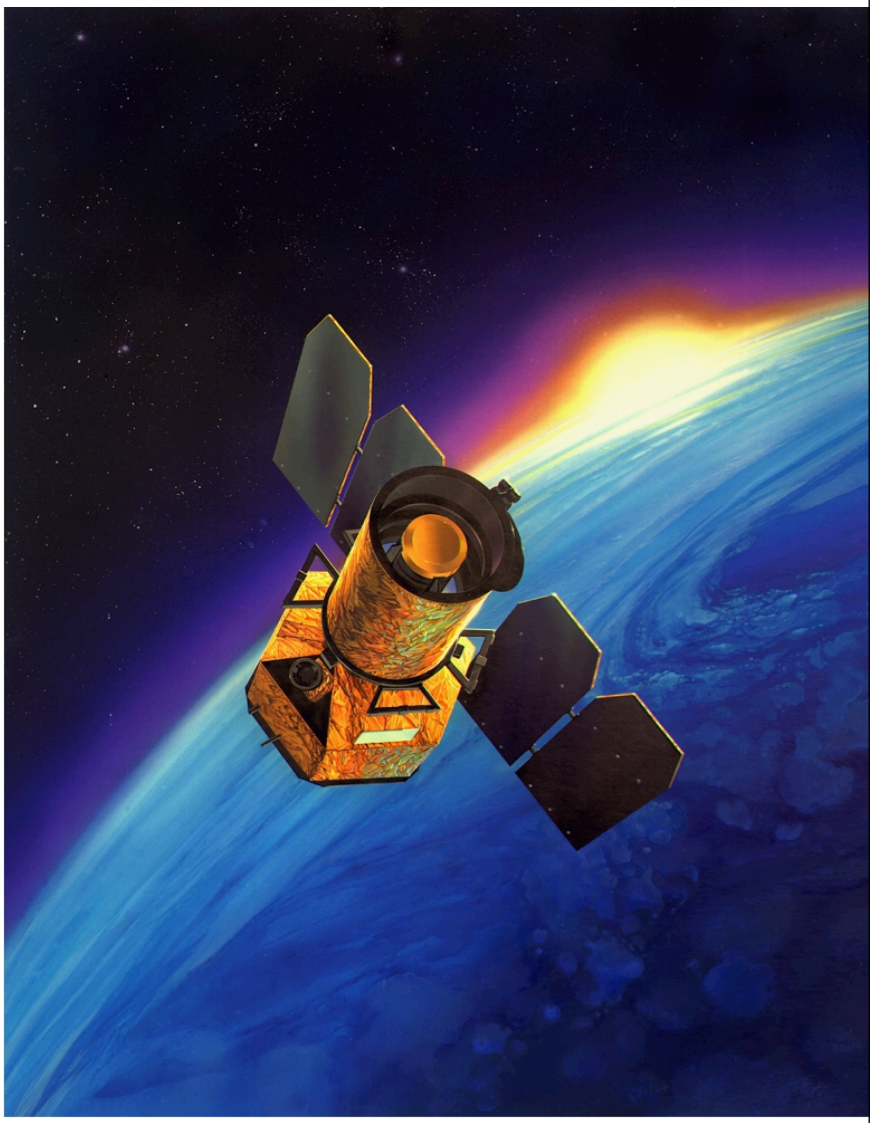


Survey comparison

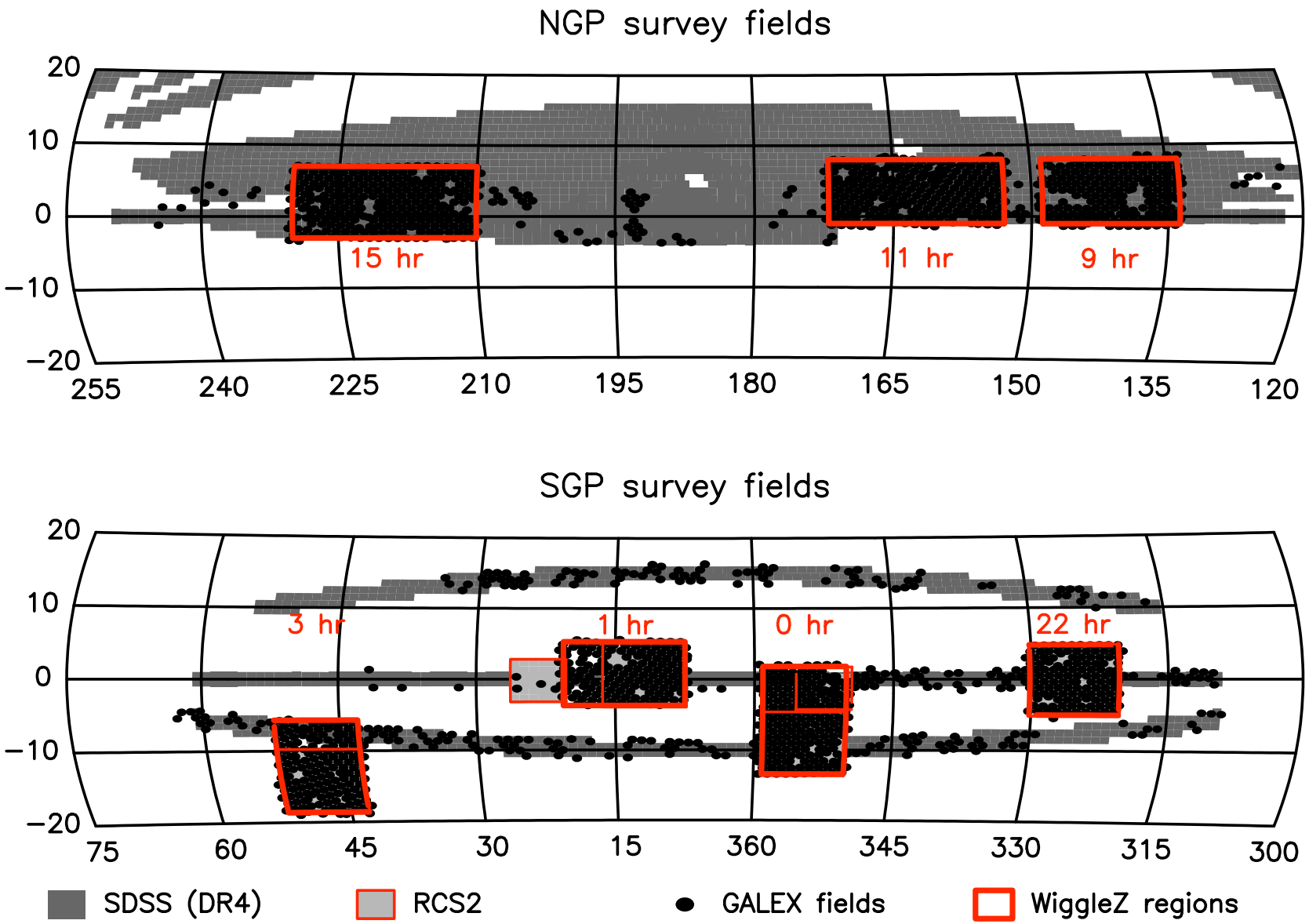


Survey design

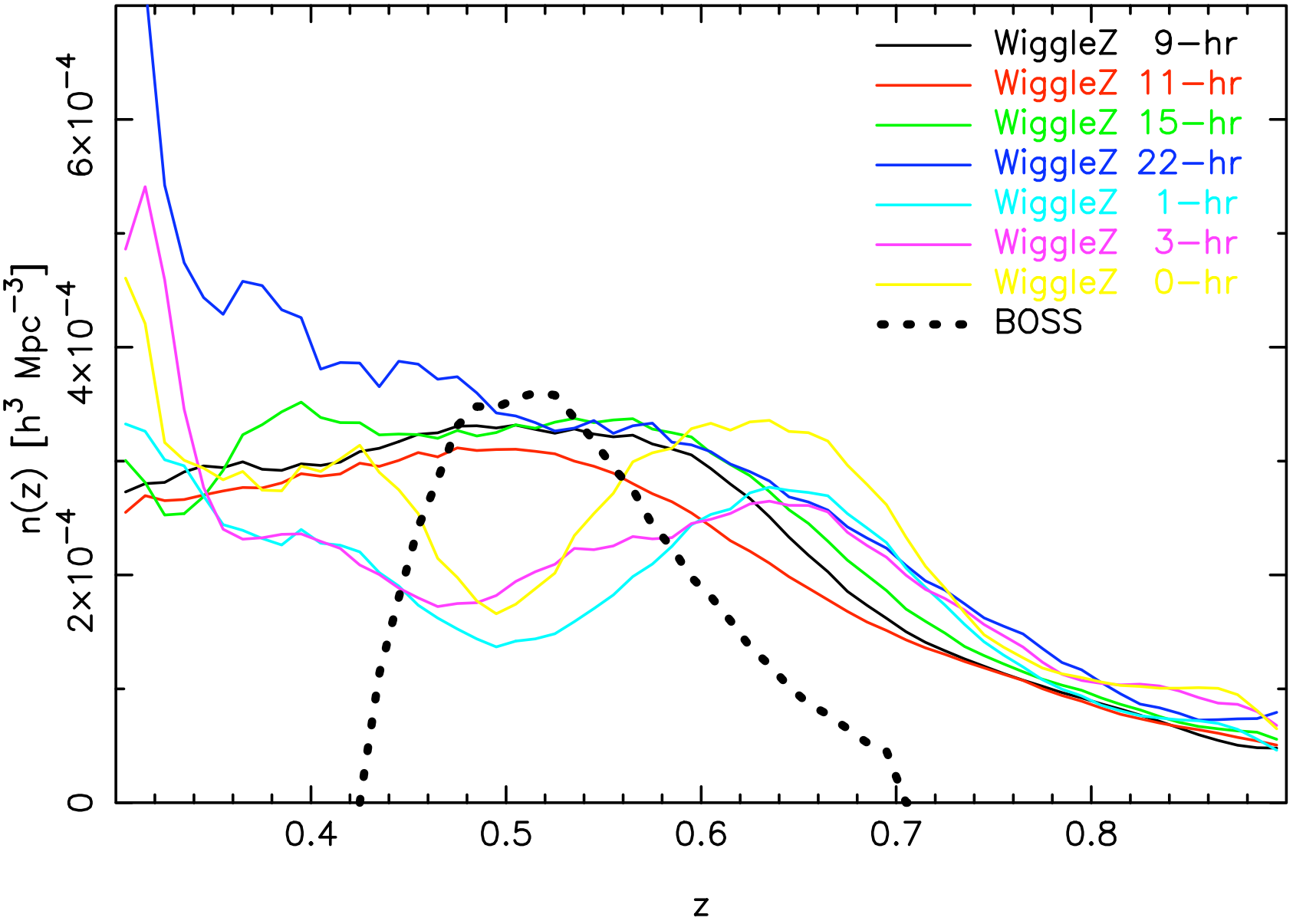
- Follow up UV-selected sources from GALEX imaging
- Colour cuts select high-redshift galaxies
- Star-forming galaxies : redshifts from emission lines, SFR 10-100 solar masses per year
- Short 1-hr exposures - maximize numbers with 70% redshift completeness



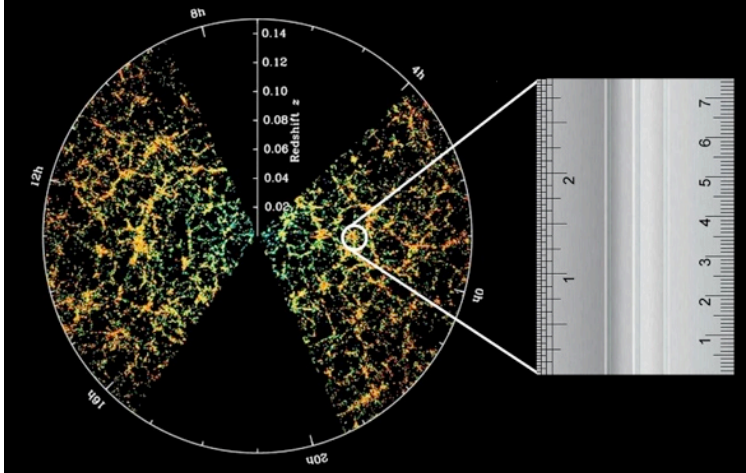
Survey design

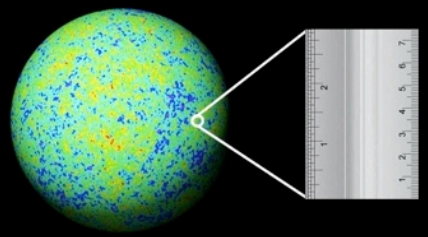


Redshift distribution

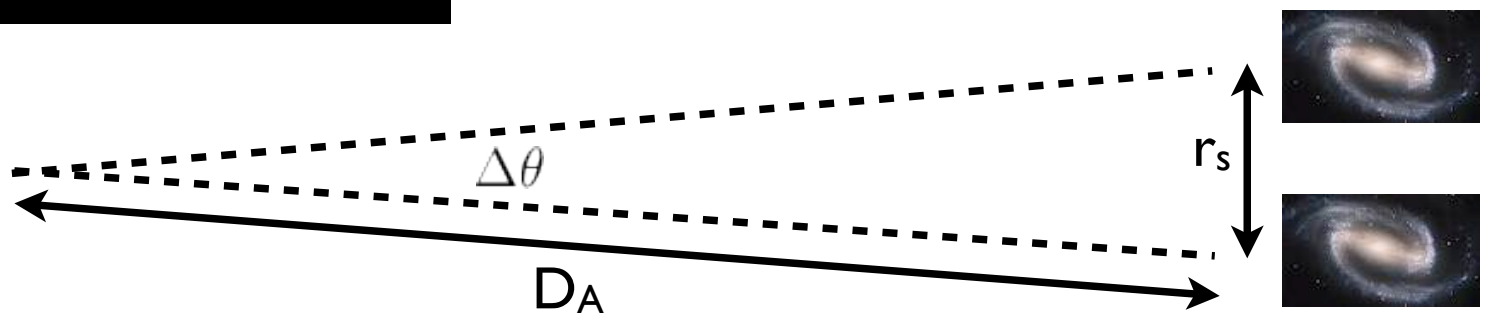


Standard ruler : baryon acoustic peak

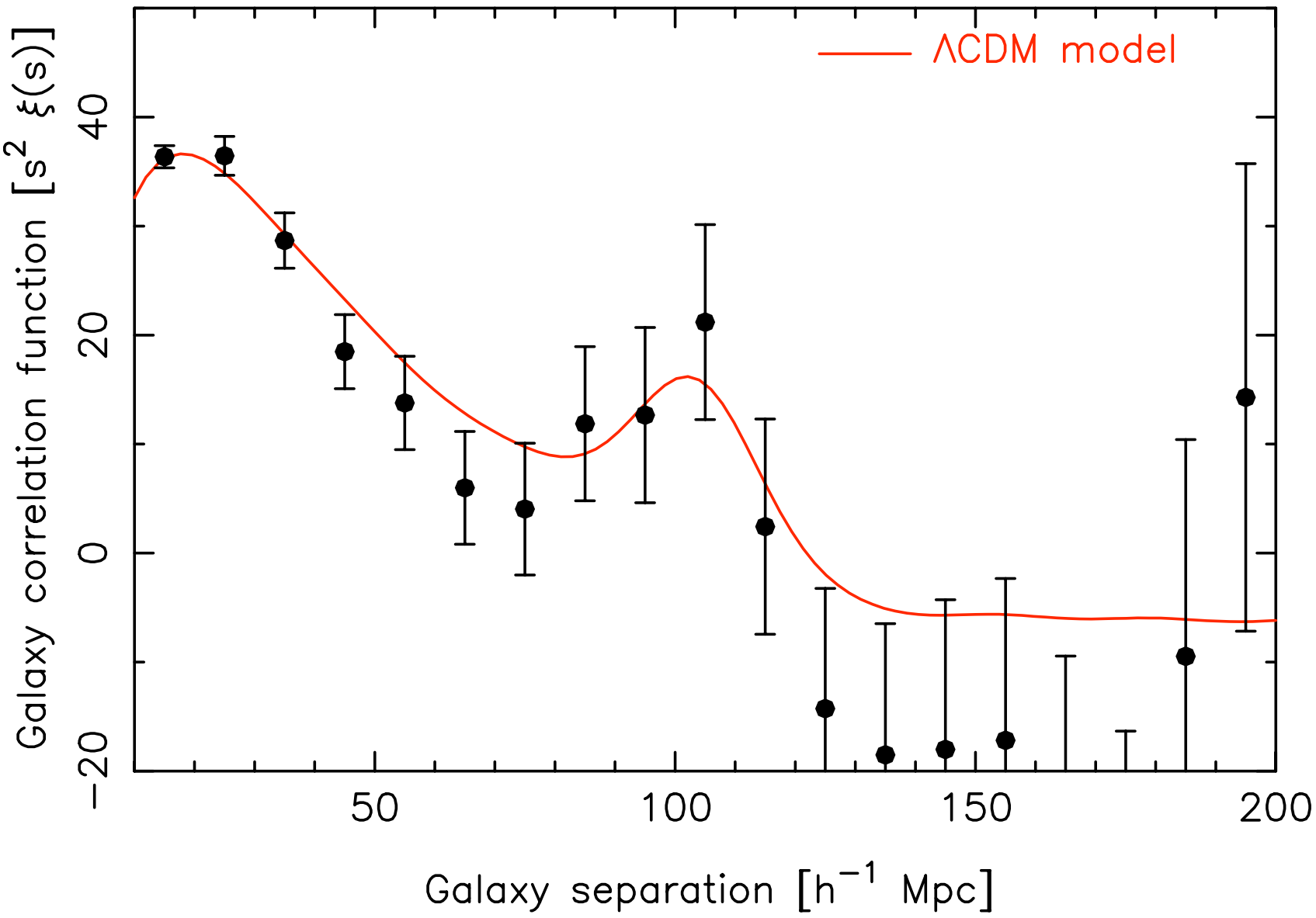




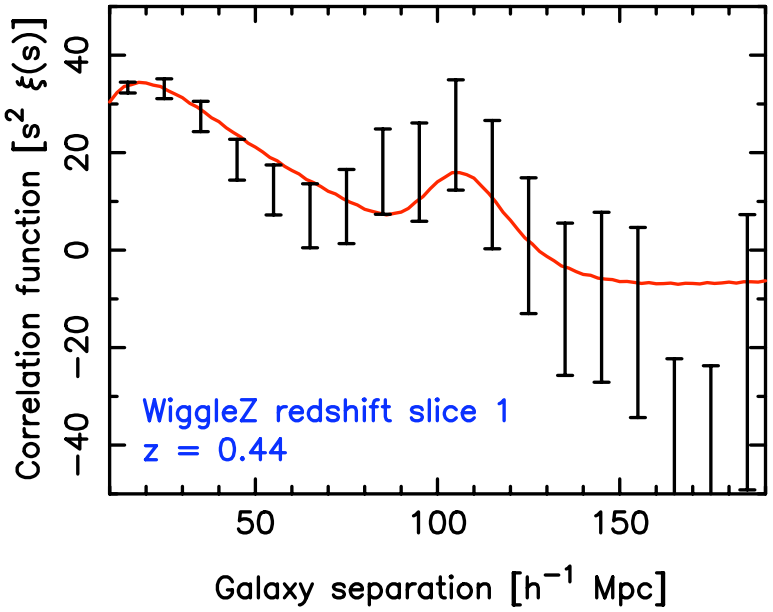
- Preferred co-moving separation of 105 h^{-1} Mpc between clumps imprinted at recombination
- We observe a preferred angular separation between galaxies at some redshift
- Allows distance determination by simple geometry

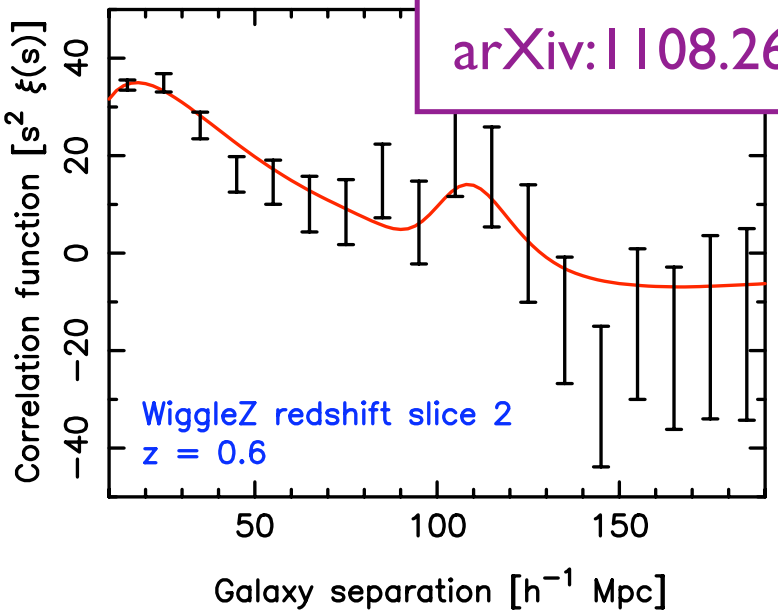


The baryon acoustic peak in WiggleZ

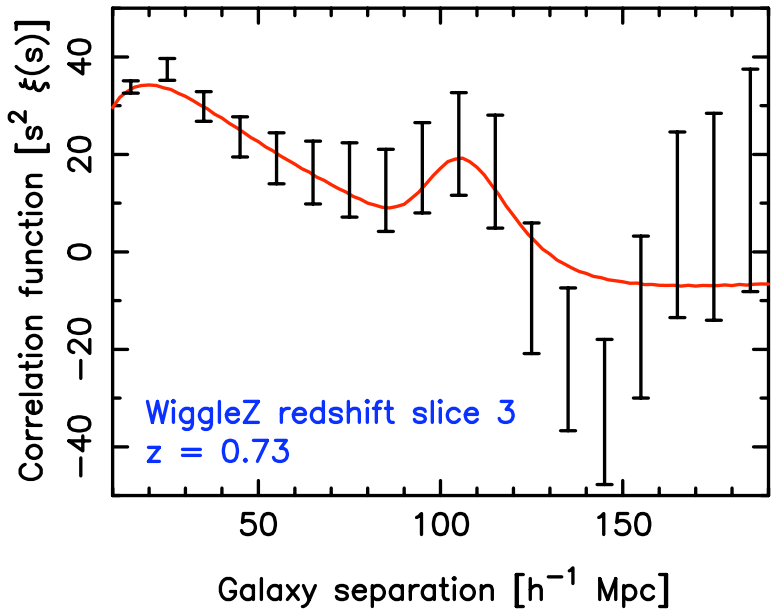


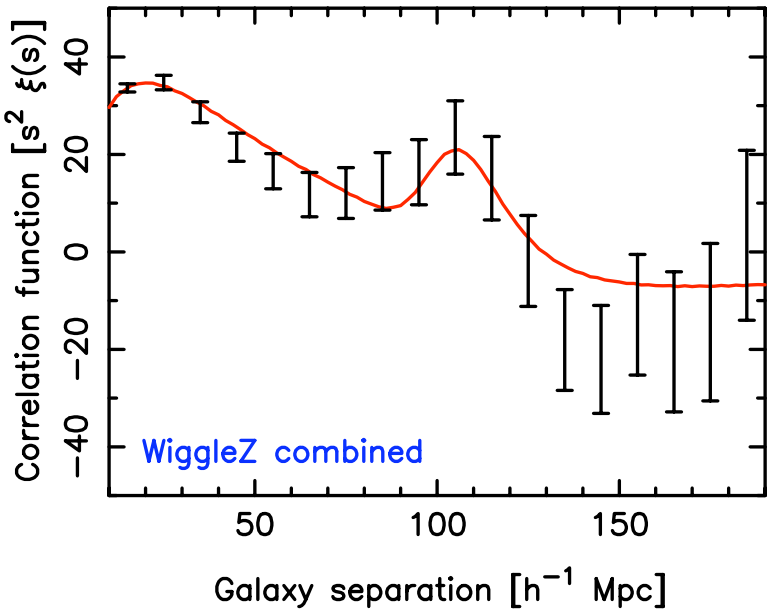
The baryon acoustic peak in WiggleZ



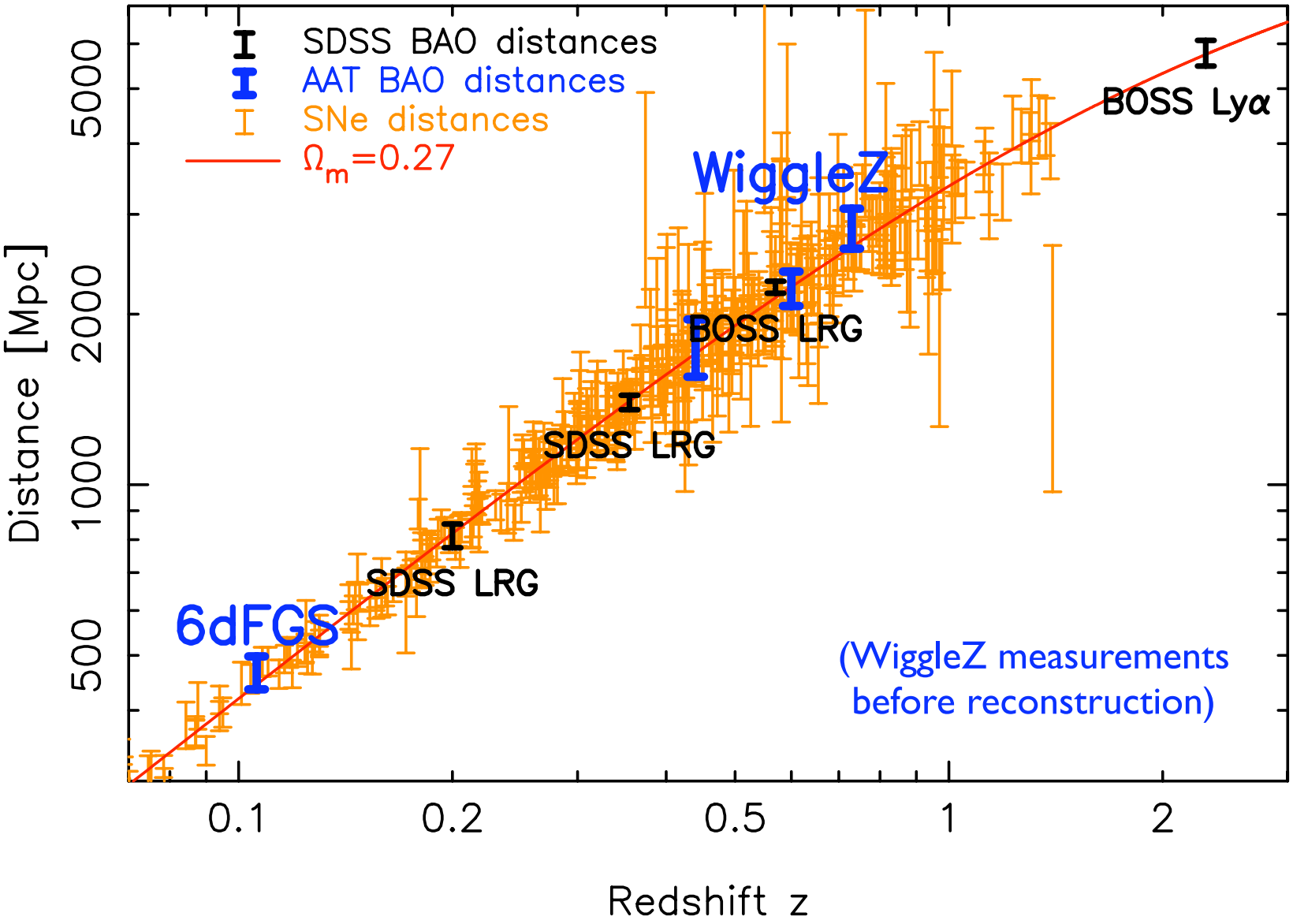


arXiv:1108.2635





BAO Hubble diagram

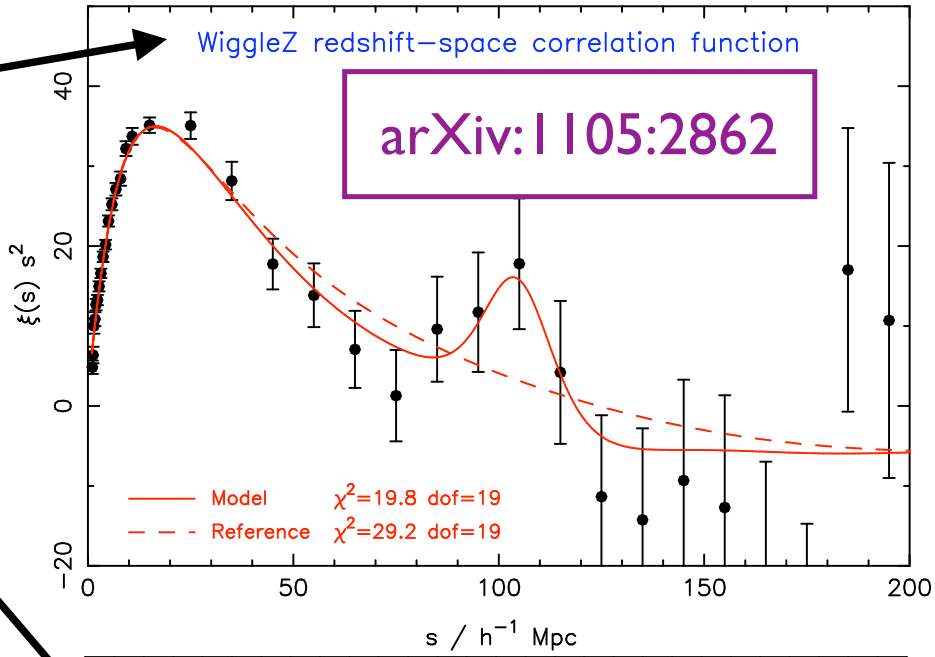


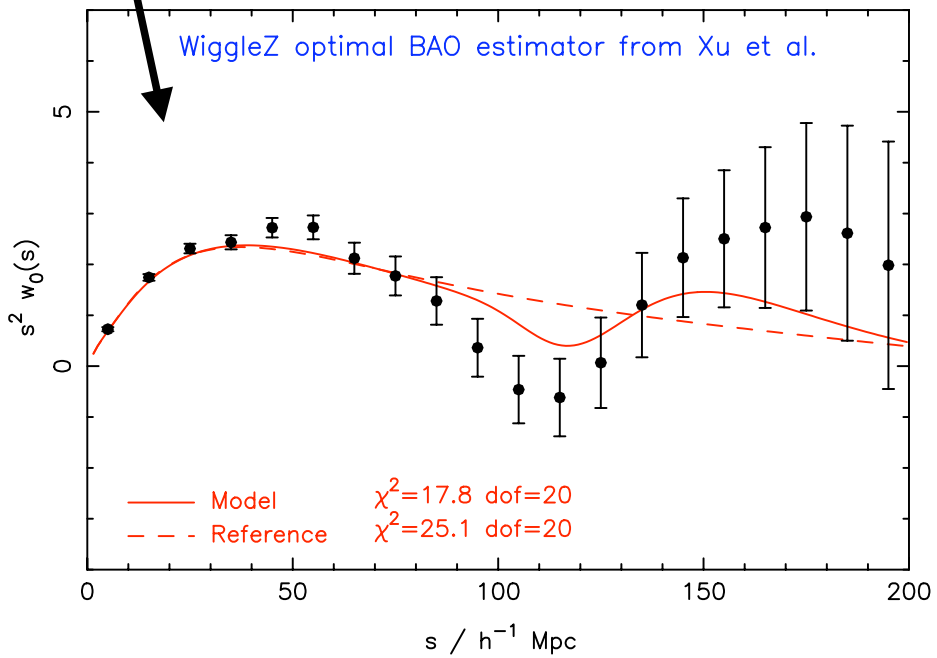
Comparison of BAO statistics in WiggleZ

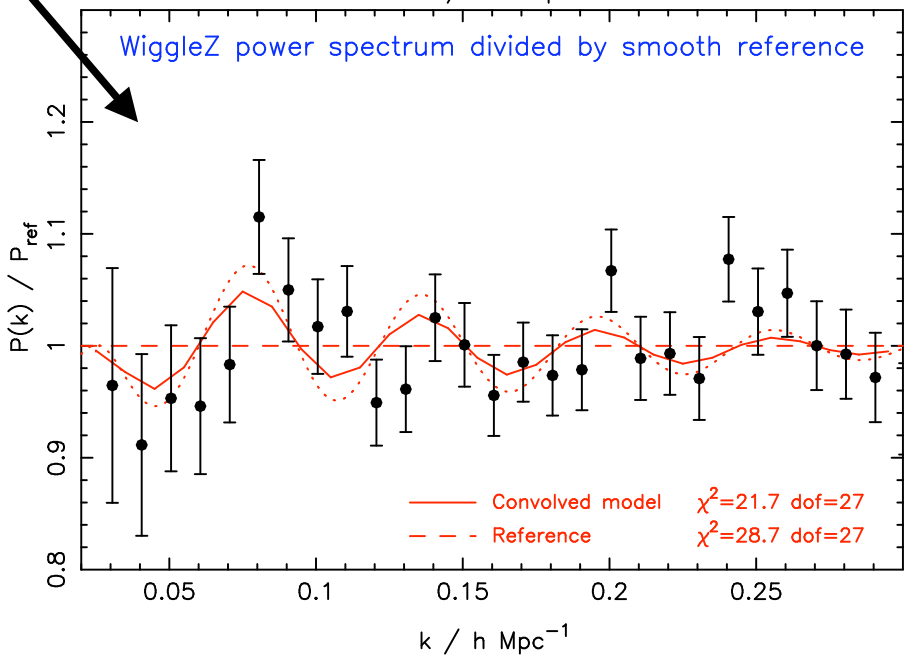
Correlation function

Power spectrum

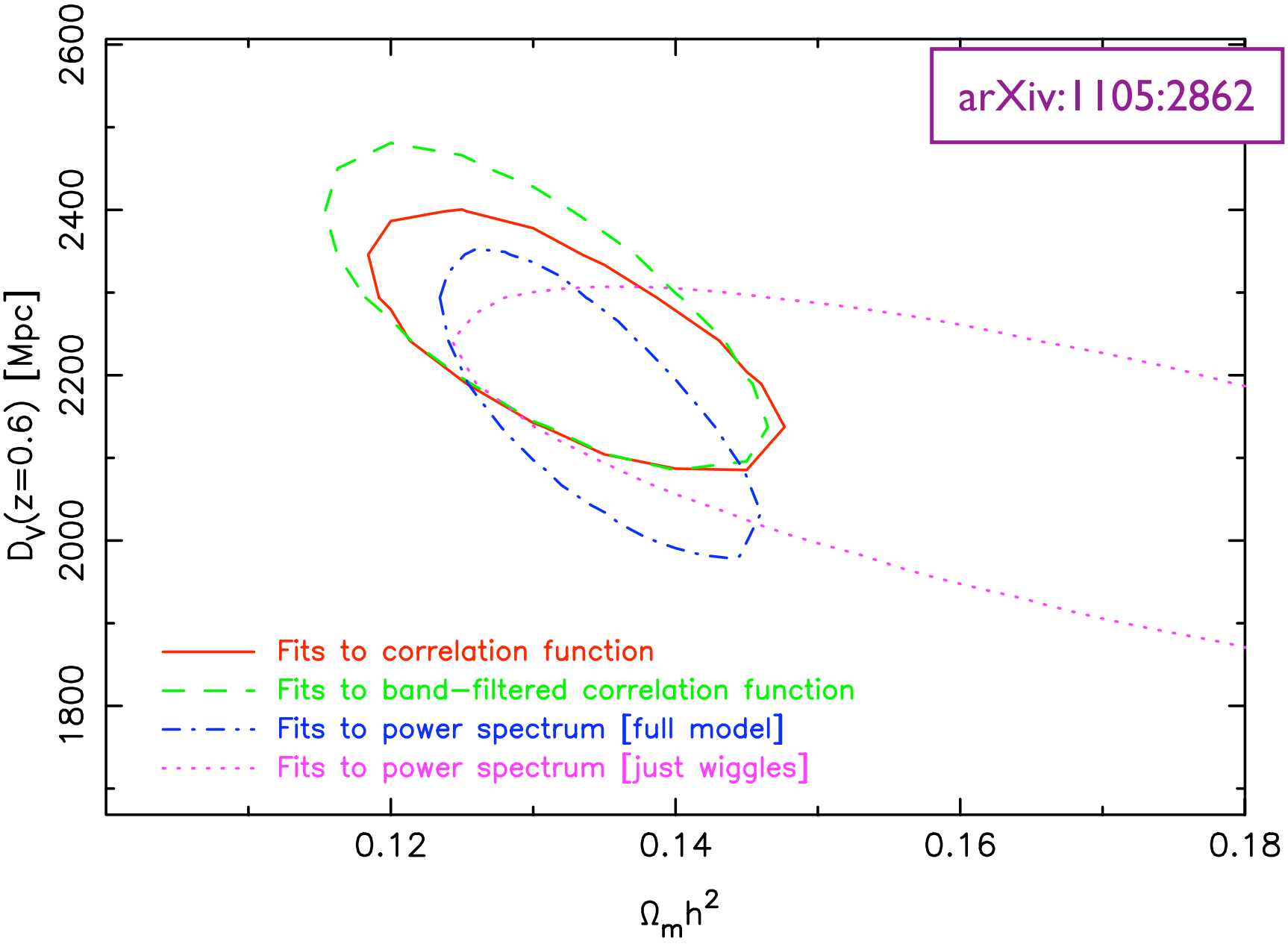
Band-filtered correlation function



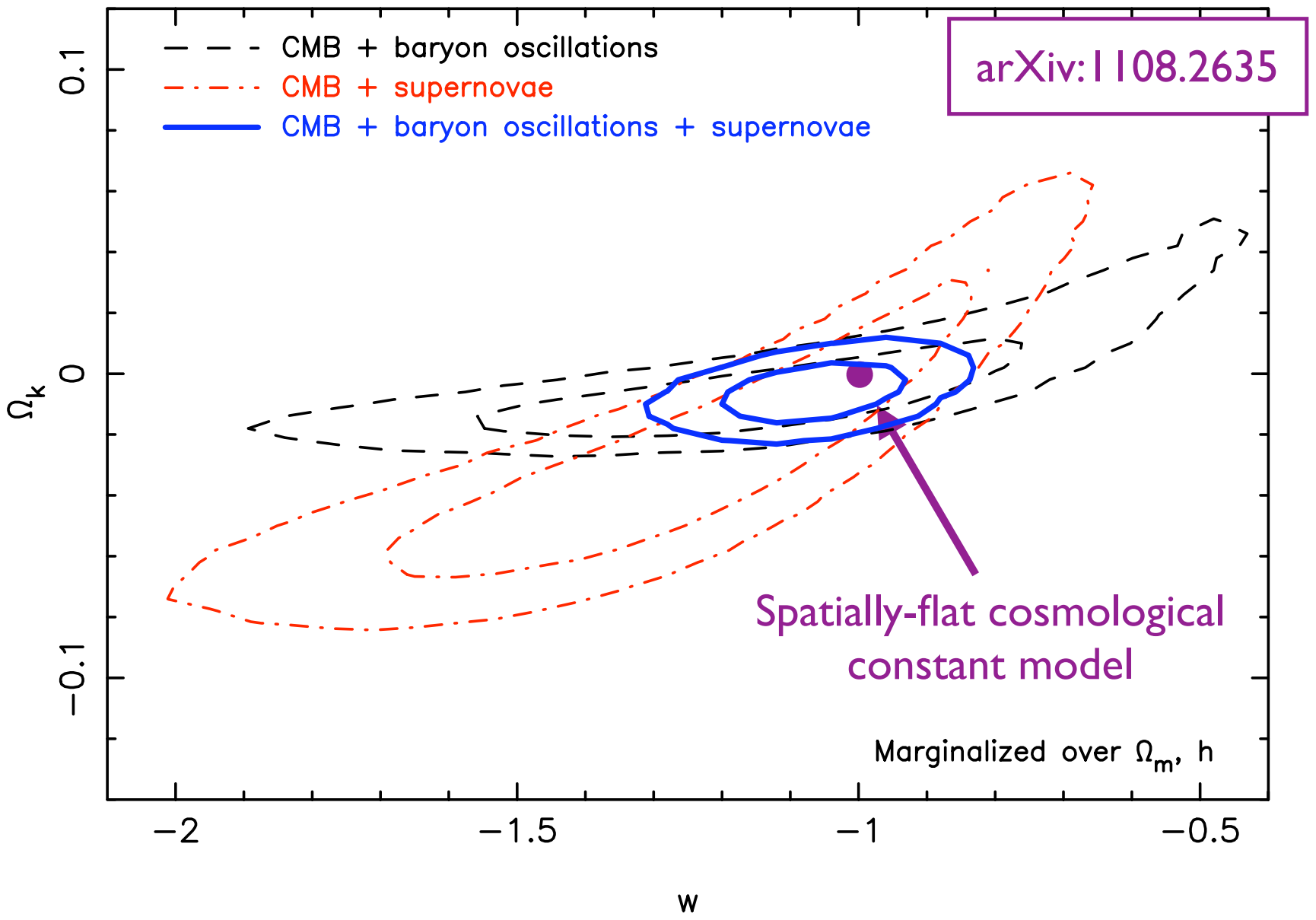




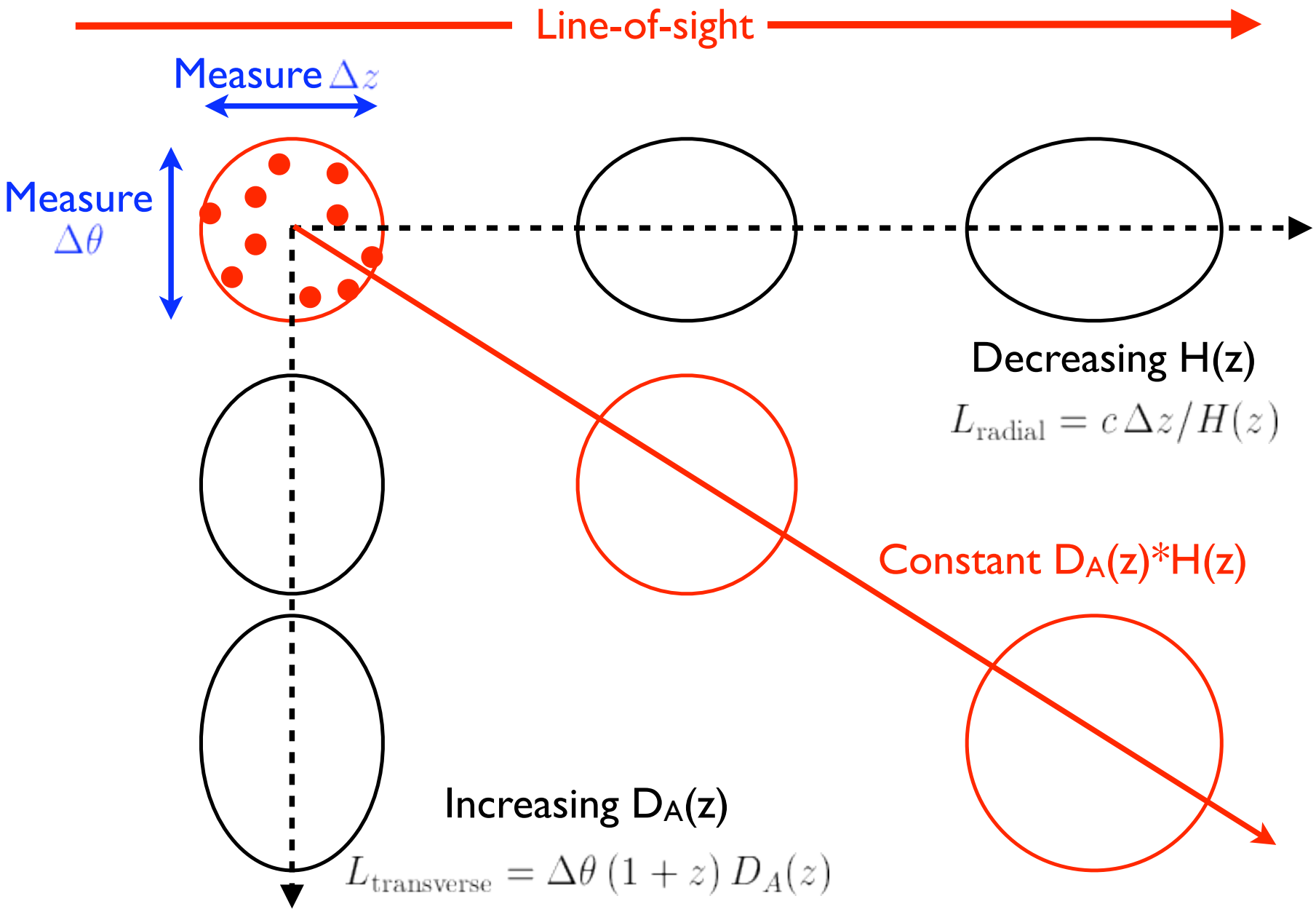
Comparison of BAO fitting techniques



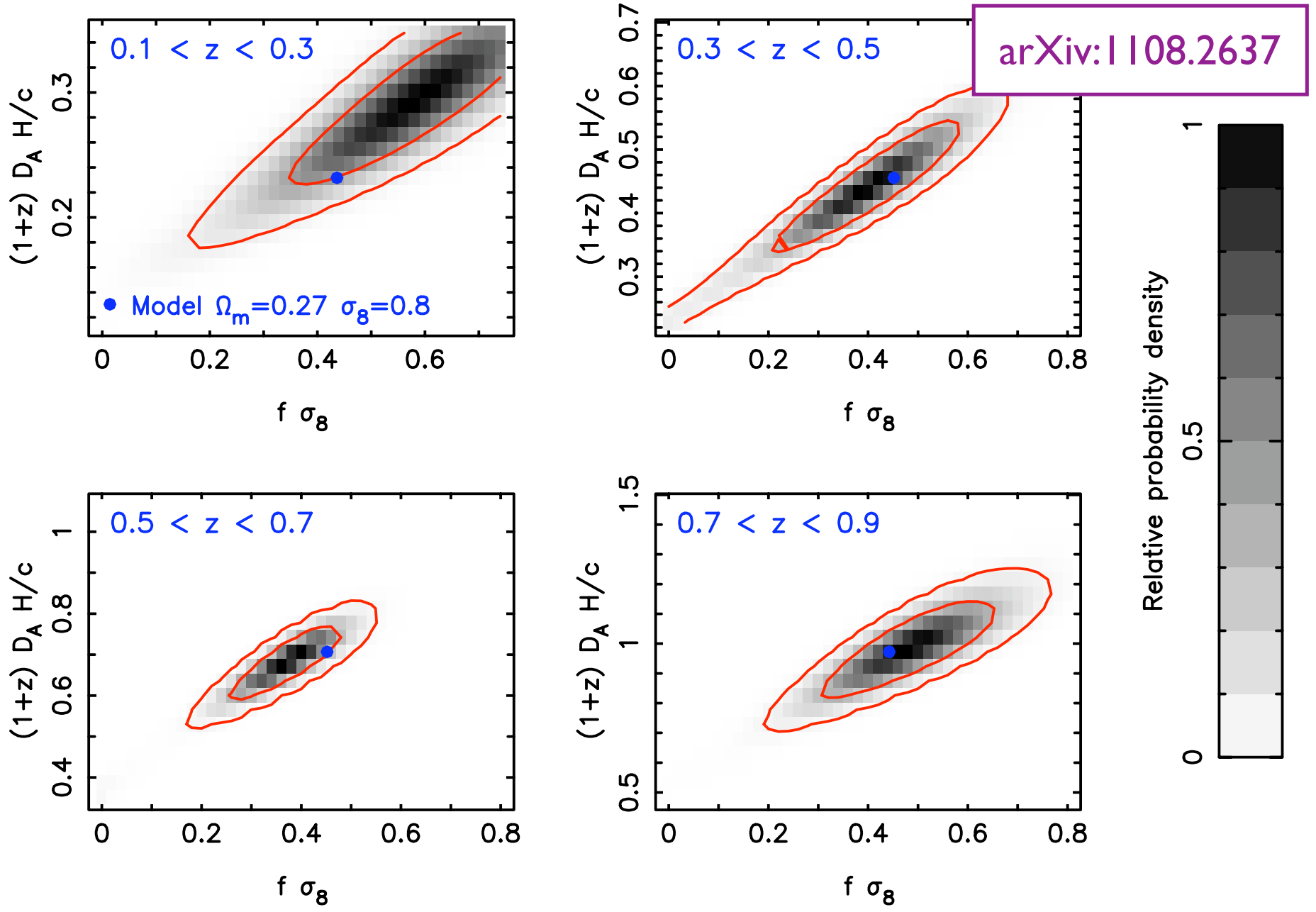
Cosmological parameter fits



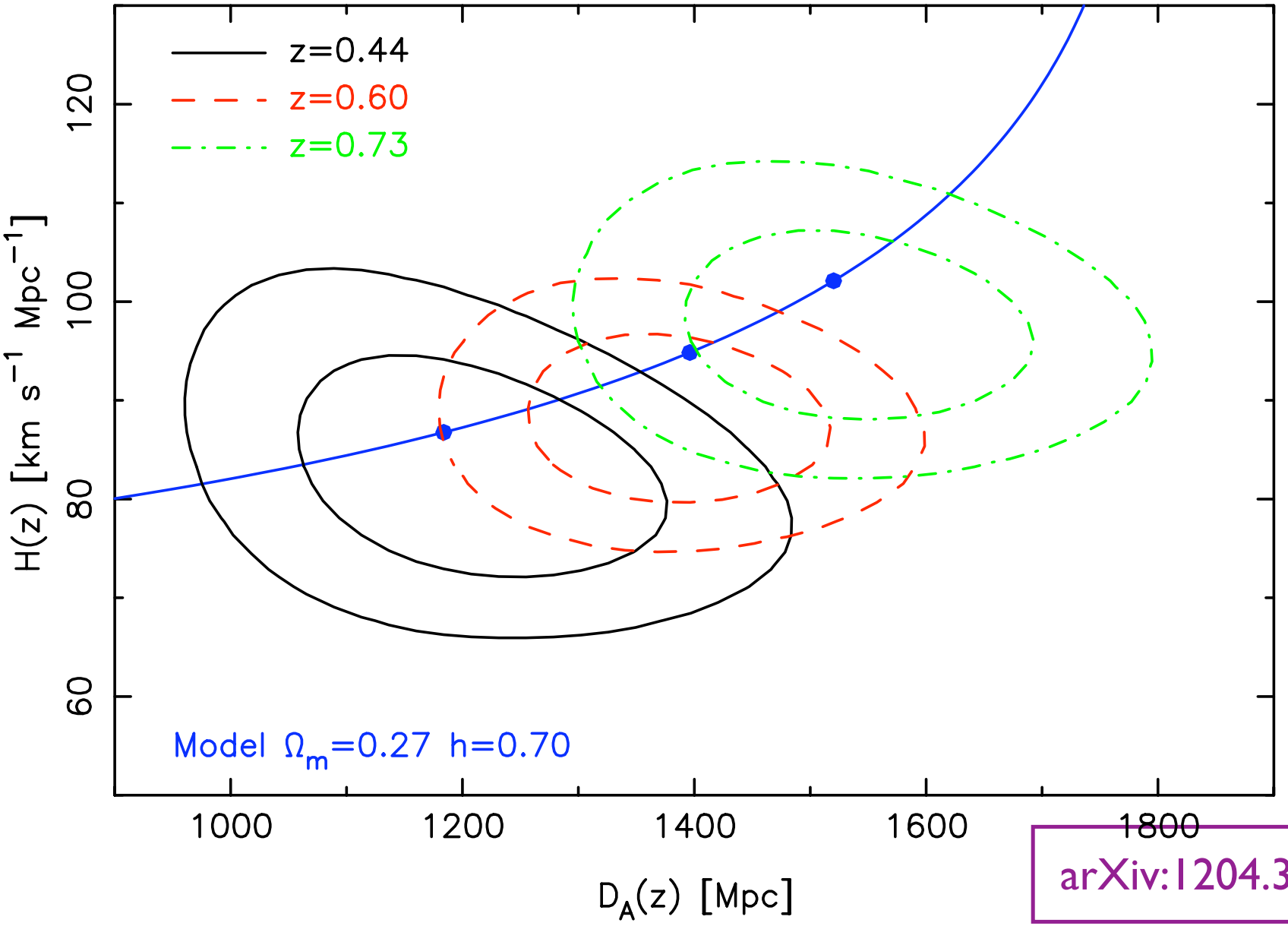
Alcock-Paczynski measurement



Alcock-Paczynski measurement

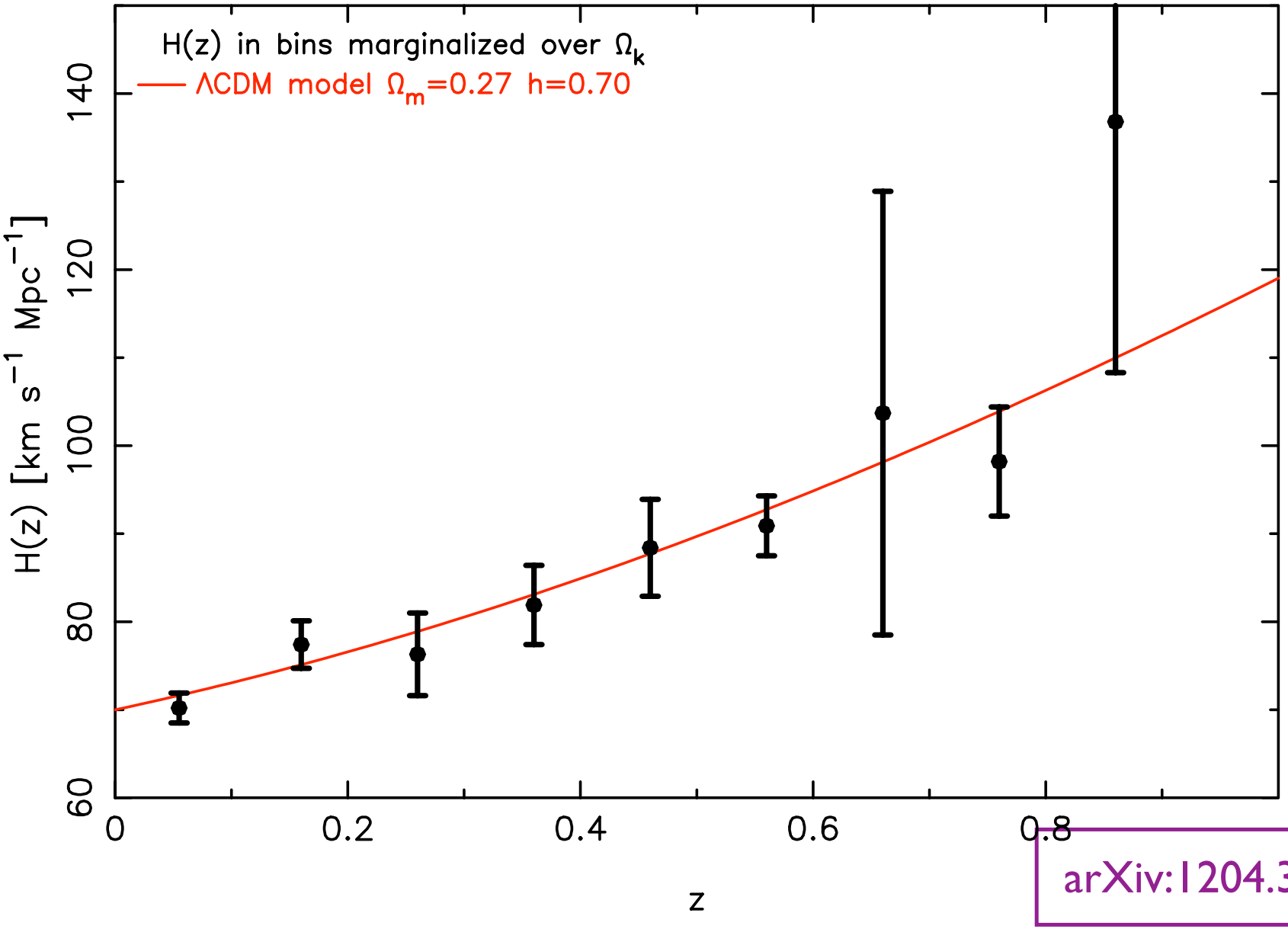


WiggleZ measurements of $D_A(z)$ and $H(z)$



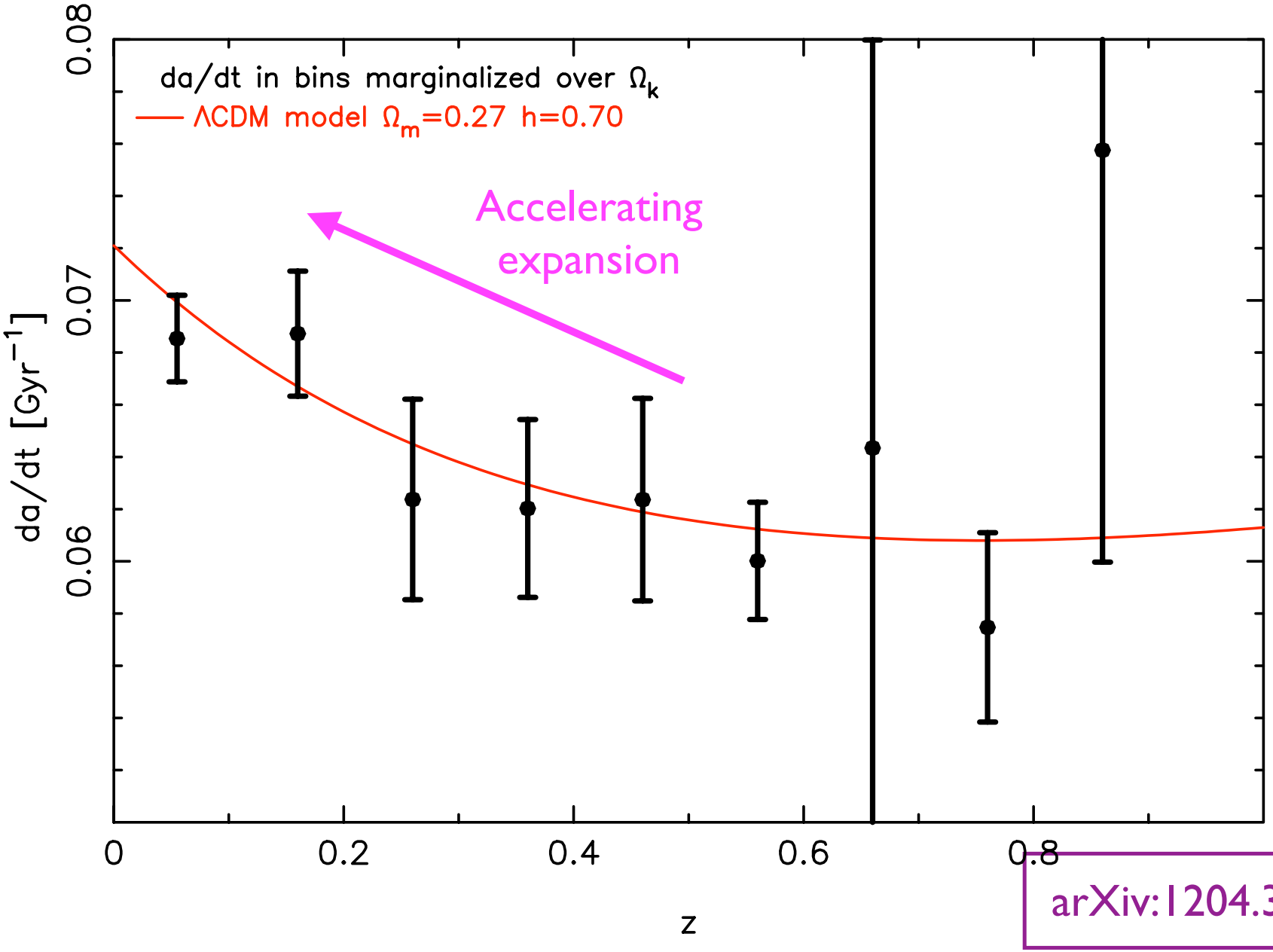
arXiv:1204.3674

Cosmic expansion history



arXiv:1204.3674

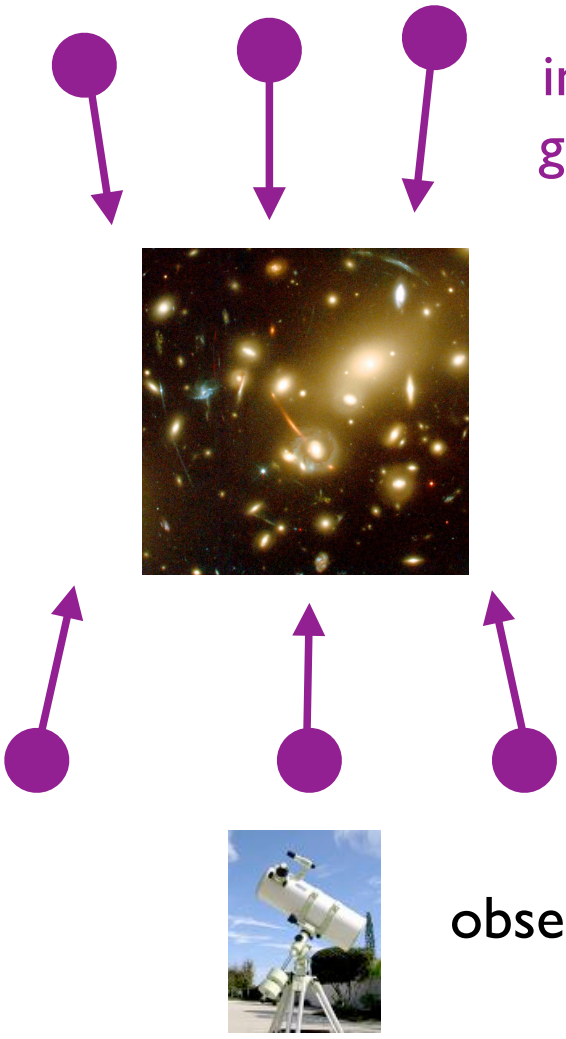
Cosmic expansion history

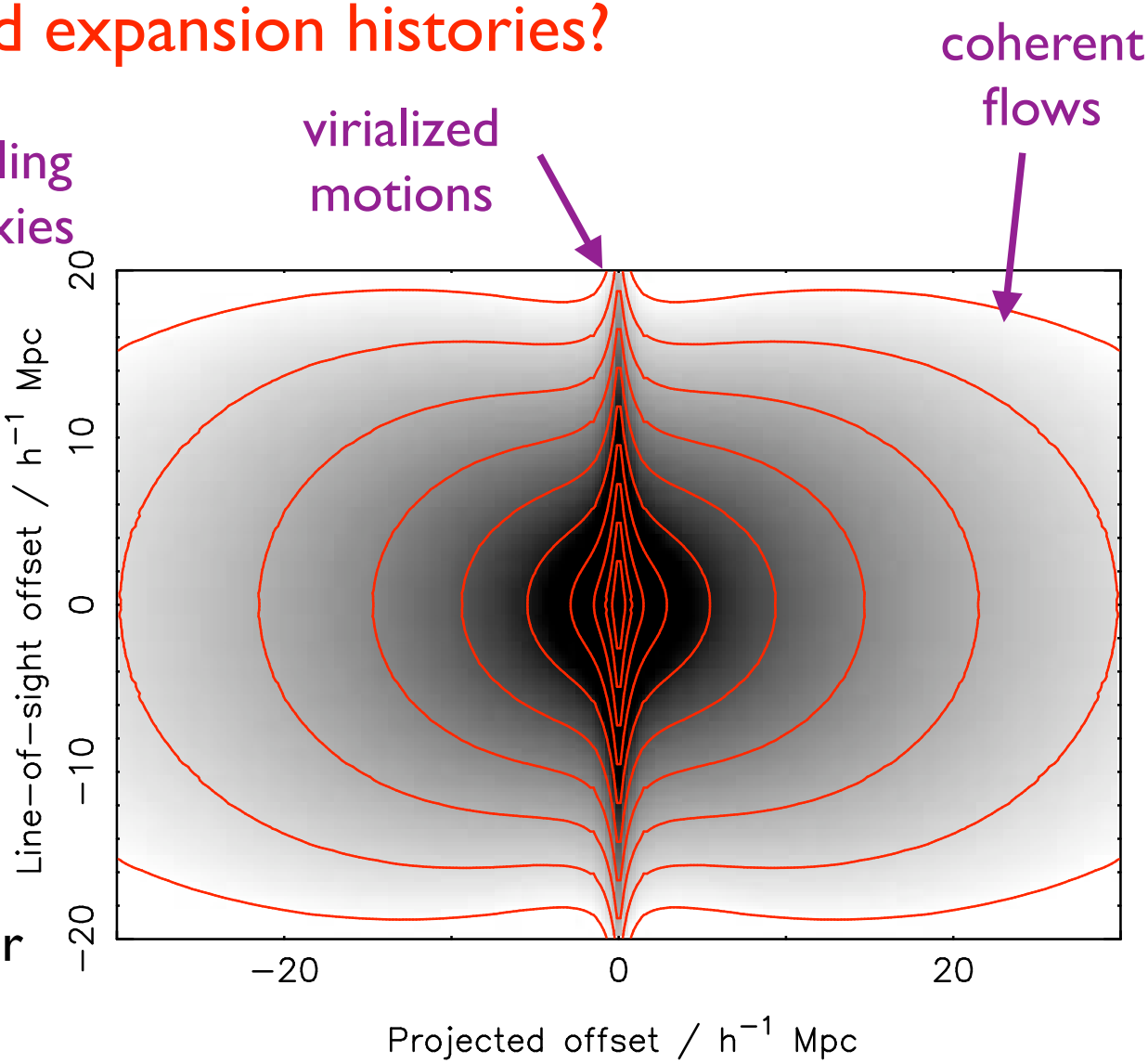


arXiv:1204.3674

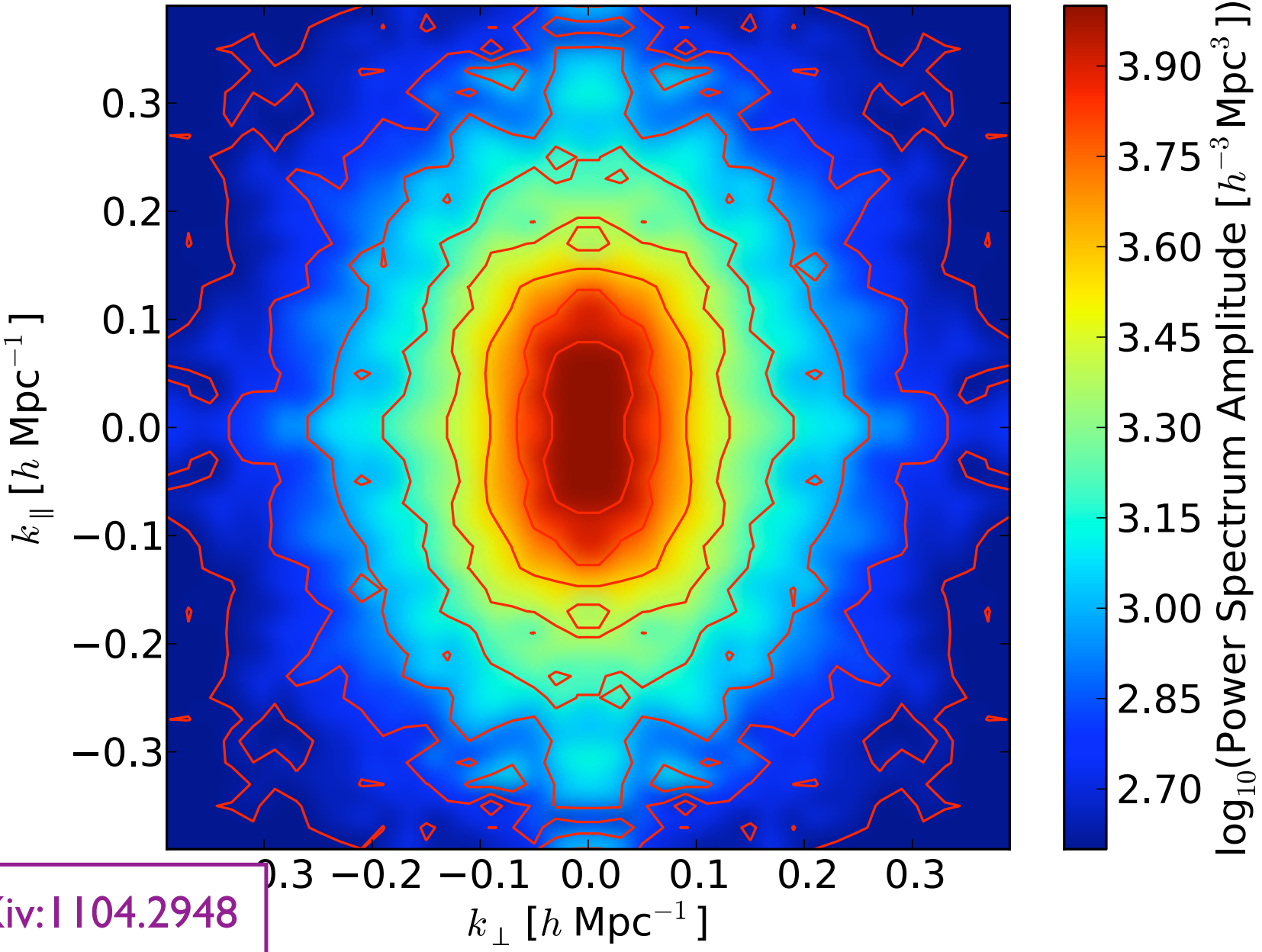
Redshift-space distortions

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



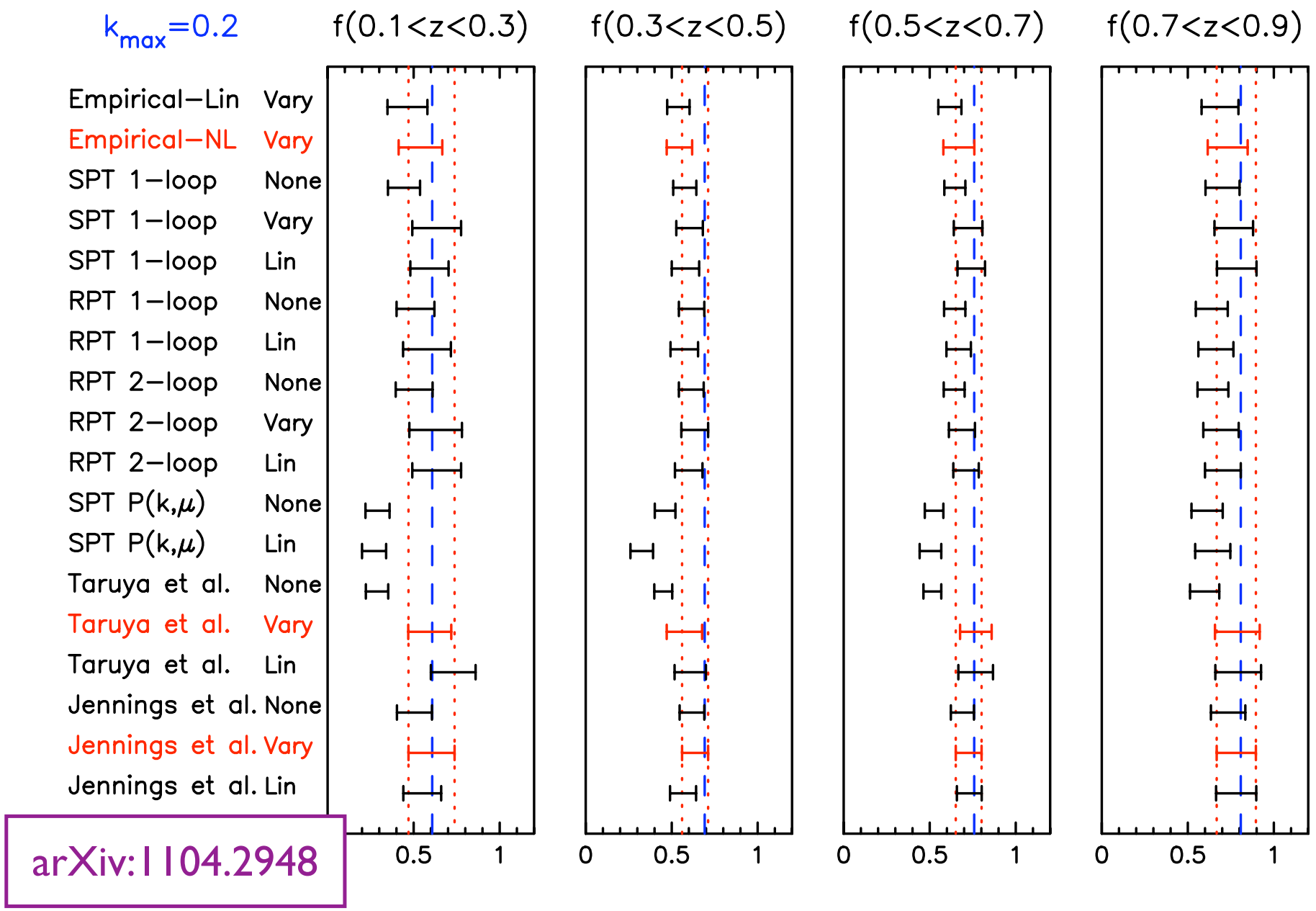


Redshift-space distortions in WiggleZ



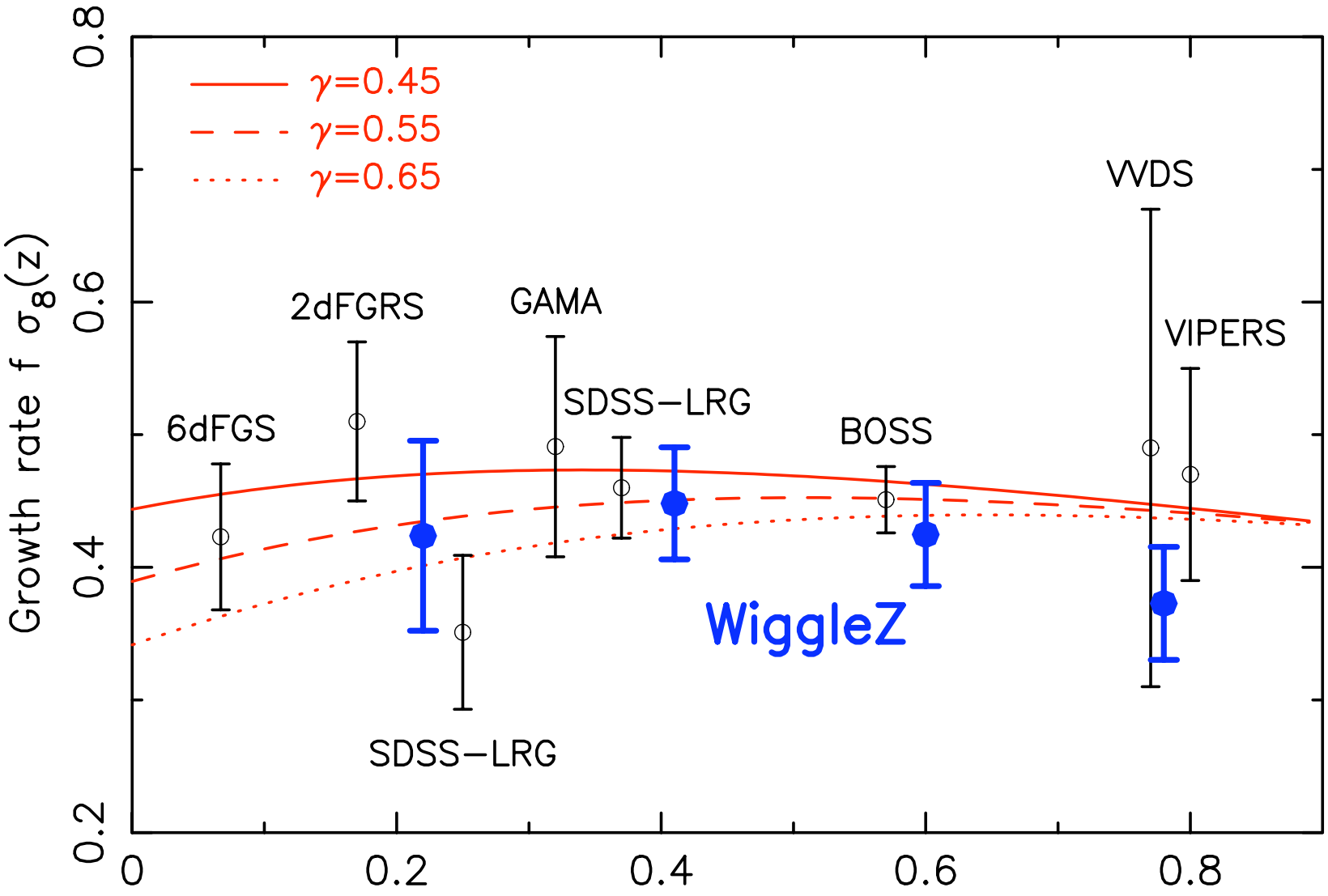
arXiv:1104.2948

Growth rate measurements from WiggleZ



arXiv:1104.2948

Growth rate measurements from WiggleZ



arXiv:1104.2948

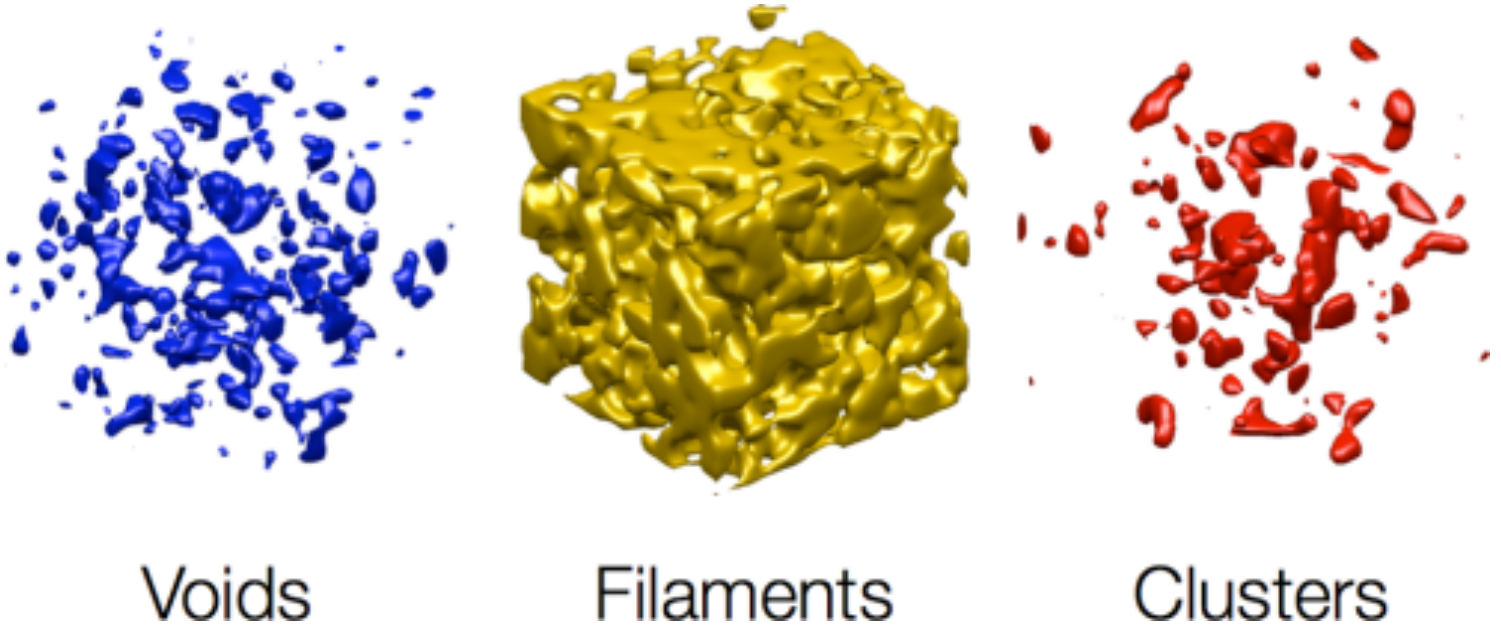
See also ...

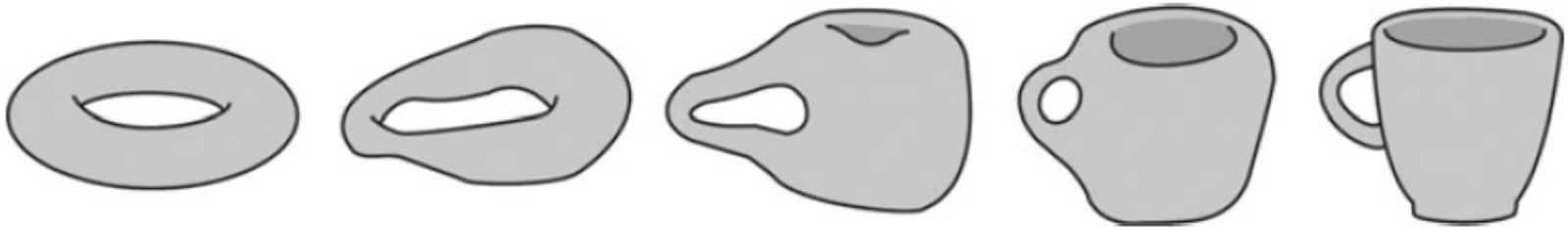
- Other WiggleZ results presented at this conference:

Neutrino mass limit	Tamara Davis talk
BAO "reconstruction"	Eyal Kazin talk
Growth from 3-pt function	Felipe Marin talk
Lensing cross-correlations	Ami Choi talk
Cosmic homogeneity	Morag Scrimgeour poster
WiggleZ-BOSS overlaps	Felipe Marin poster

Topological statistics

- Morphology of the density field (isodensity contours):

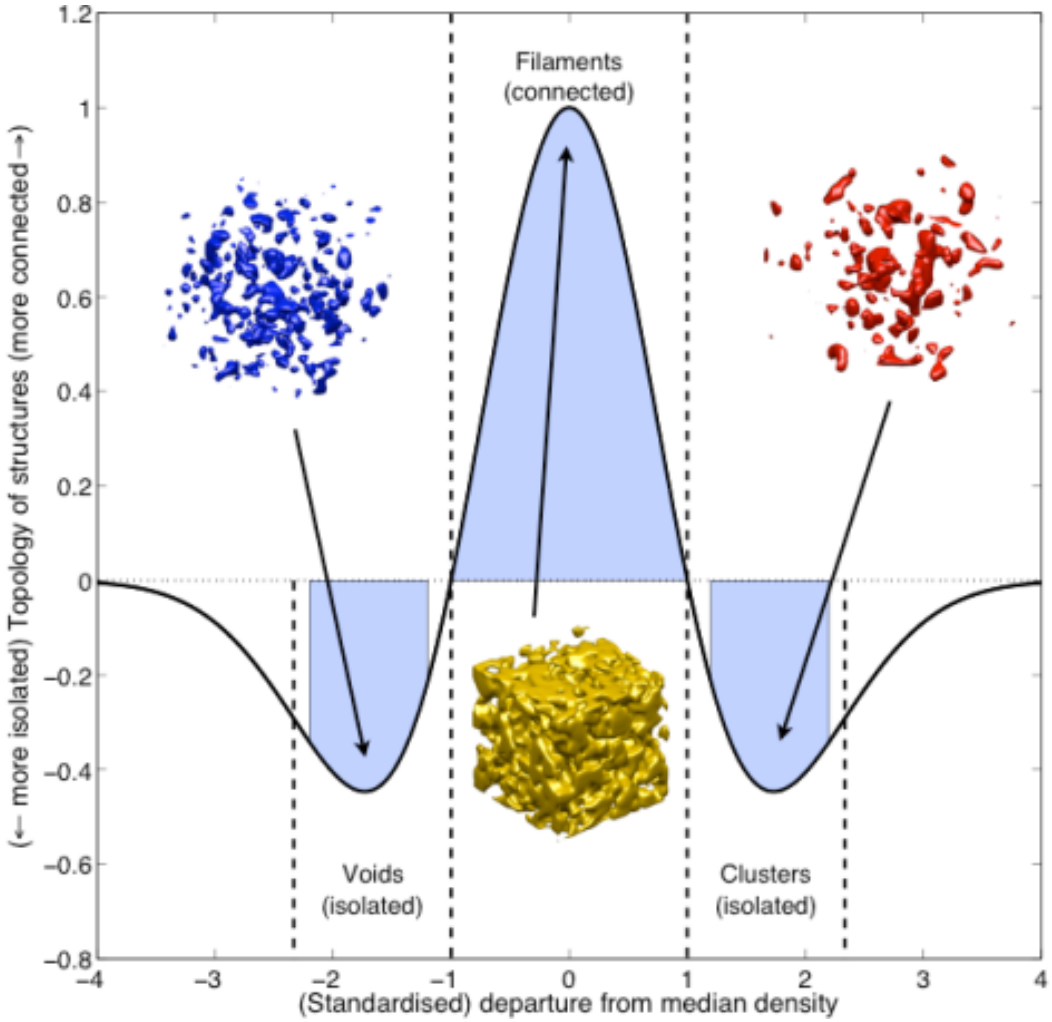




"A topologist cannot distinguish their doughnut from their coffee cup"

Topological statistics

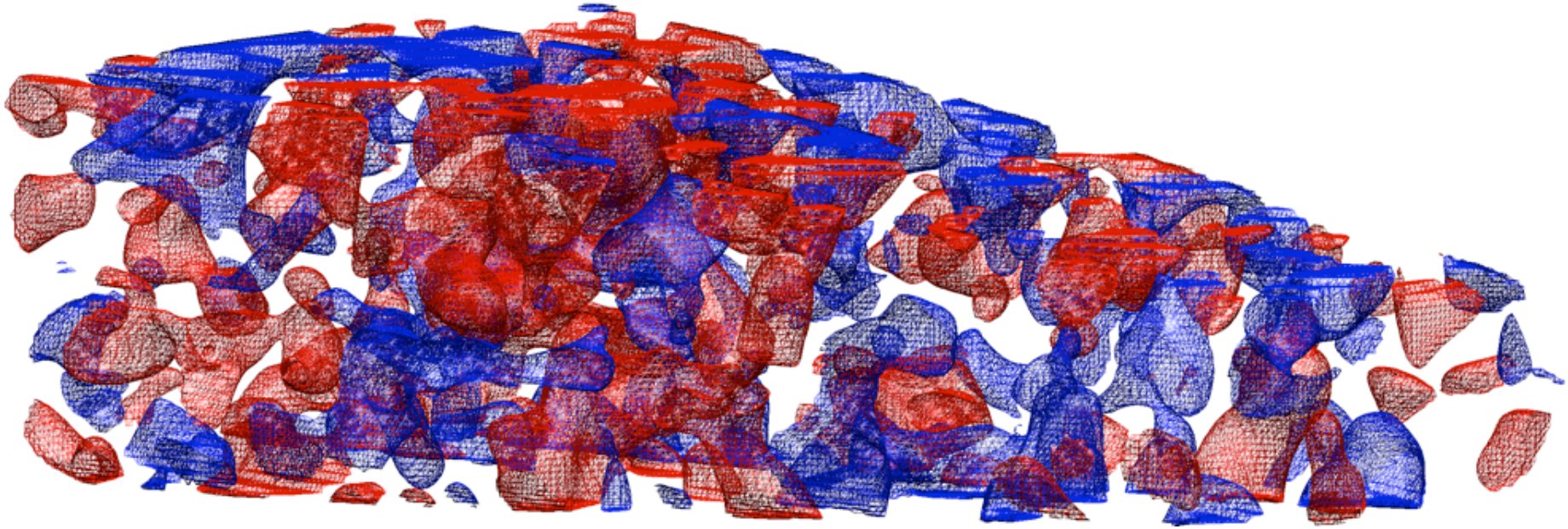
- Genus statistic (a.k.a. Euler characteristic):



Credit : Berian James

Topological statistics

- WiggleZ density field for 15-hr region:



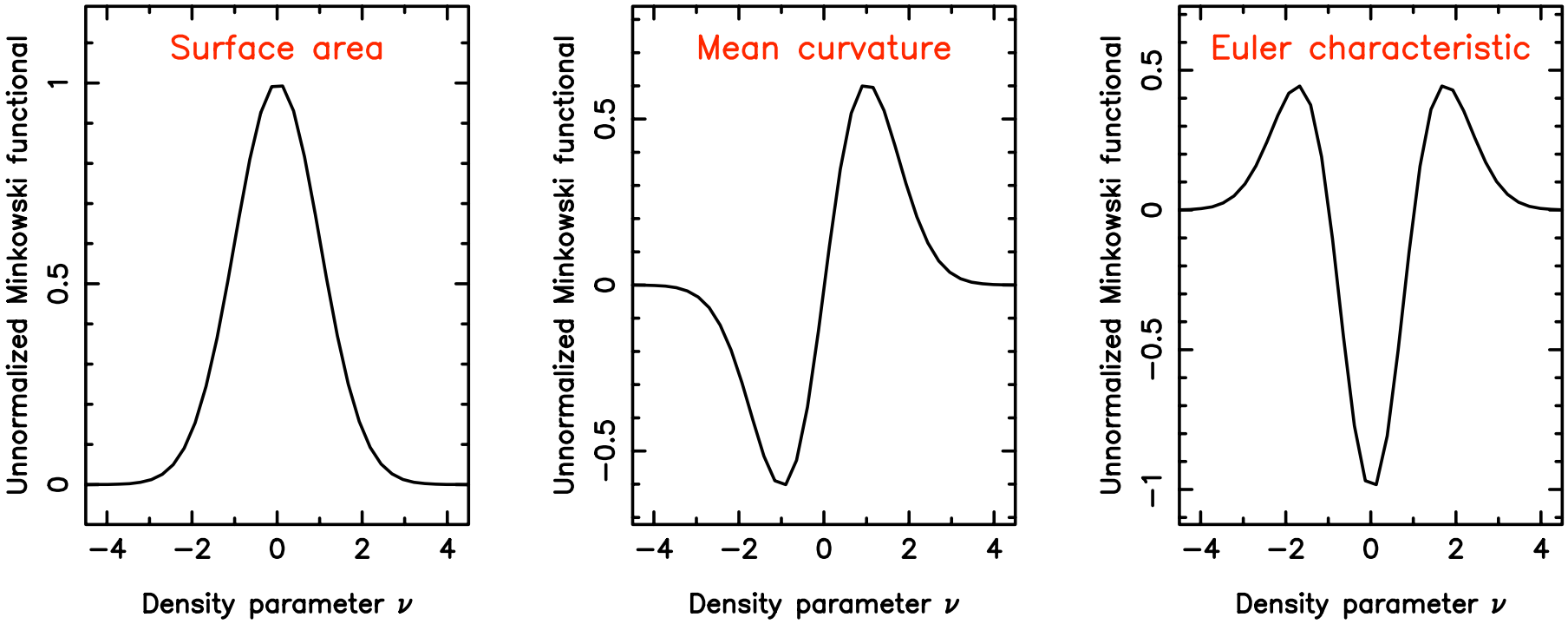
[Visualization of isodensity contours that contain the 20% highest and lowest density regions]

Credit : Berian James

Topological statistics

- Minkowski functionals give complete description

For Gaussian random field :



Topological statistics

- Analogy with number counts method

	Galaxy number counts	Topological statistics
Theory predicts ...	Luminosity function (number of galaxies per unit volume)	Minkowski functionals of Gaussian random field (topology per unit volume)
We measure ...	Galaxy count	Amount of topology
We determine ...	Volume element	Volume element
Evolution ?	Yes	No

Topological statistics

arXiv:0905.2268

LARGE-SCALE STRUCTURE OF THE UNIVERSE AS A COSMIC STANDARD RULER

CHANGBOM PARK AND YOUNG-RAE KIM
School of Physics, Korea Institute for Advanced Study, Seoul 130-722, Korea
Draft version May 14, 2009

ABSTRACT

We propose to use the large-scale structure of the universe as a cosmic standard ruler, based on the fact that the pattern of galaxy distribution should be maintained in the course of time on large scales. By examining the scale-dependence of the pattern in different redshift intervals it is possible to reconstruct the expansion history of the universe, and thus to measure the cosmological parameters governing the expansion of the universe. The features in the galaxy distribution that can be used as standard rulers include the topology of large-scale structure and the overall shapes of galaxy power

arXiv:1005.3631

Using the Topology of Large Scale Structure to constrain Dark Energy

Caroline Zunckel[1,2], J. Richard Gott III[1] and Ragnhild Lunnan[3]
[1] *Astrophysics Department, Princeton University, Peyton Hall, 4 Ivy Lane, NJ, 08544, USA*
[2] *Astrophysics and Cosmology Research Unit, University of Kwazulu-Natal, Westville, Durban 4000, South Africa*
[3] *Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge MA 02138, USA*

28 May 2010

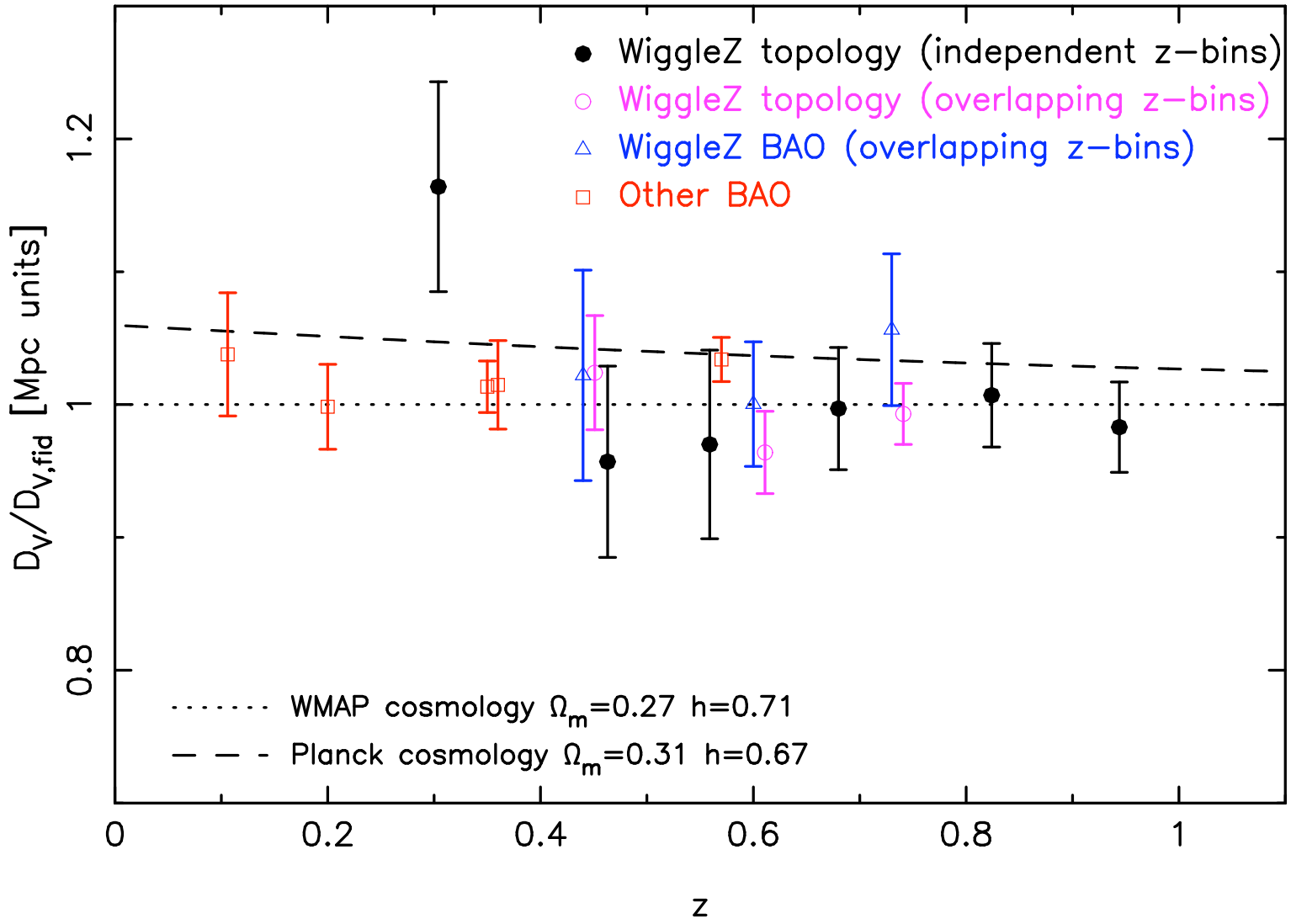
ABSTRACT
The use of standard rulers, such as the scale of the Baryonic Acoustic oscillations (BAO),

Topological statistics

- Minkowski functionals are an independent method to 2-pt statistics for quantifying large-scale structure
- They are a topological measure unchanged by any density field transformation that preserves rank-ordering (so are conserved over time in linear theory)
- We model them as a Gaussian random field (plus corrections), then the amplitudes of functionals per unit volume are predicted by power spectrum shape
- Observed amplitudes then determine volume element hence $D_V(z)$ [same quantity as measured by BAOs]

Topological statistics

- Fit distances to these amplitudes ...



Topological statistics

- Fits to WiggleZ Minkowski functionals produce distance determinations which are consistent with, and twice as precise as, fits to WiggleZ BAOs
- We obtain distance errors in the range 3-7% in 6 independent redshift slices across $0.2 < z < 1.0$
- A model power spectrum shape (although not normalization) must be assumed
- Non-linear corrections (RSD, shot noise) need more development ...

Summary of results from WiggleZ

- Baryon acoustic oscillations measure cosmic distances to z=0.8 and provide cross-check with supernovae
- Alcock-Paczynski effect allows direct measurement of the cosmic expansion [H(z)] at high redshift
- Redshift-space distortions provide accurate measurement of growth of structure to high redshift
- General Relativity + cosmological constant models have been tested in a new way and remain a good fit
- If dark energy behaves as Lambda, what is its physics?

Thank you!