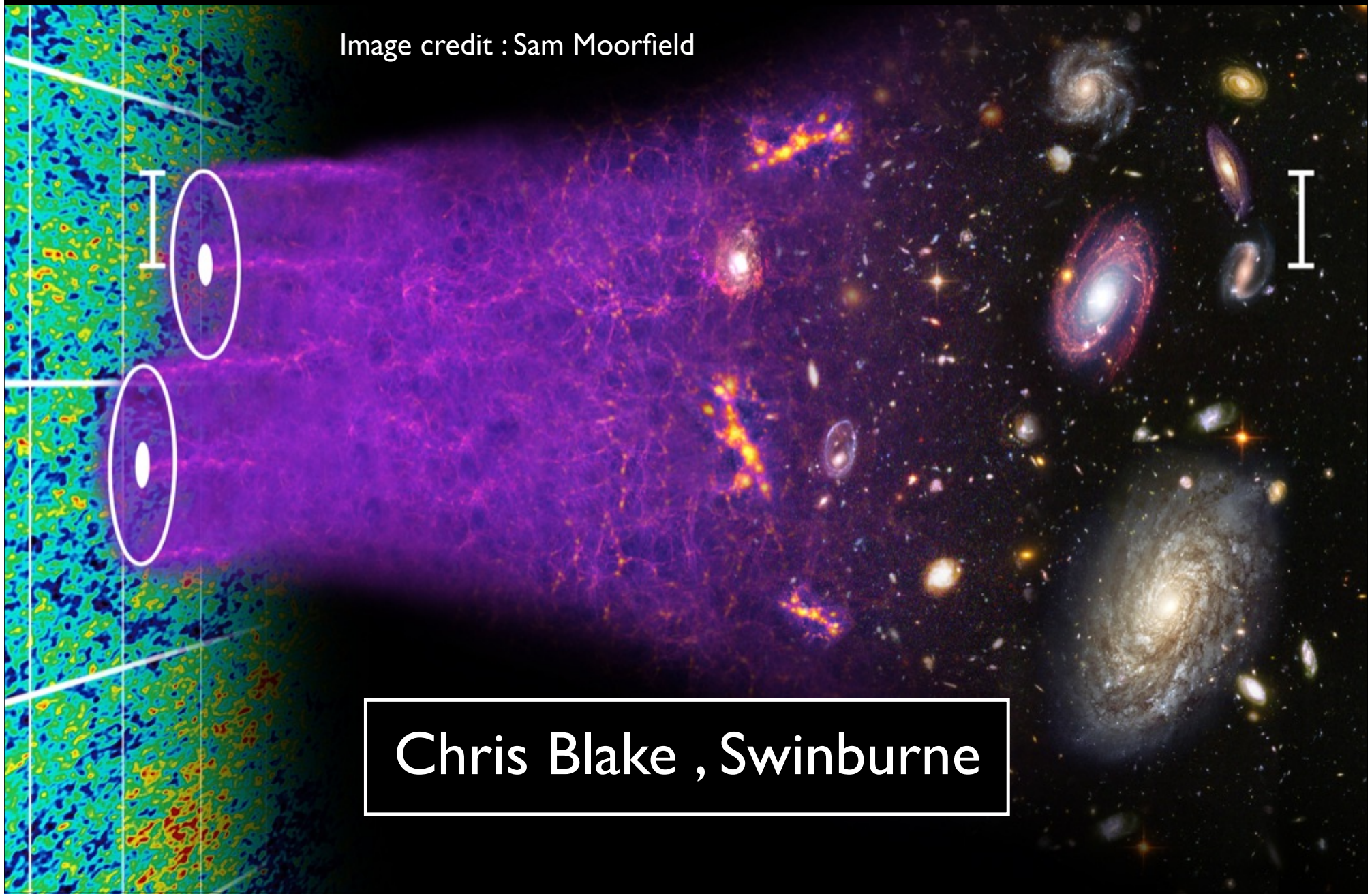
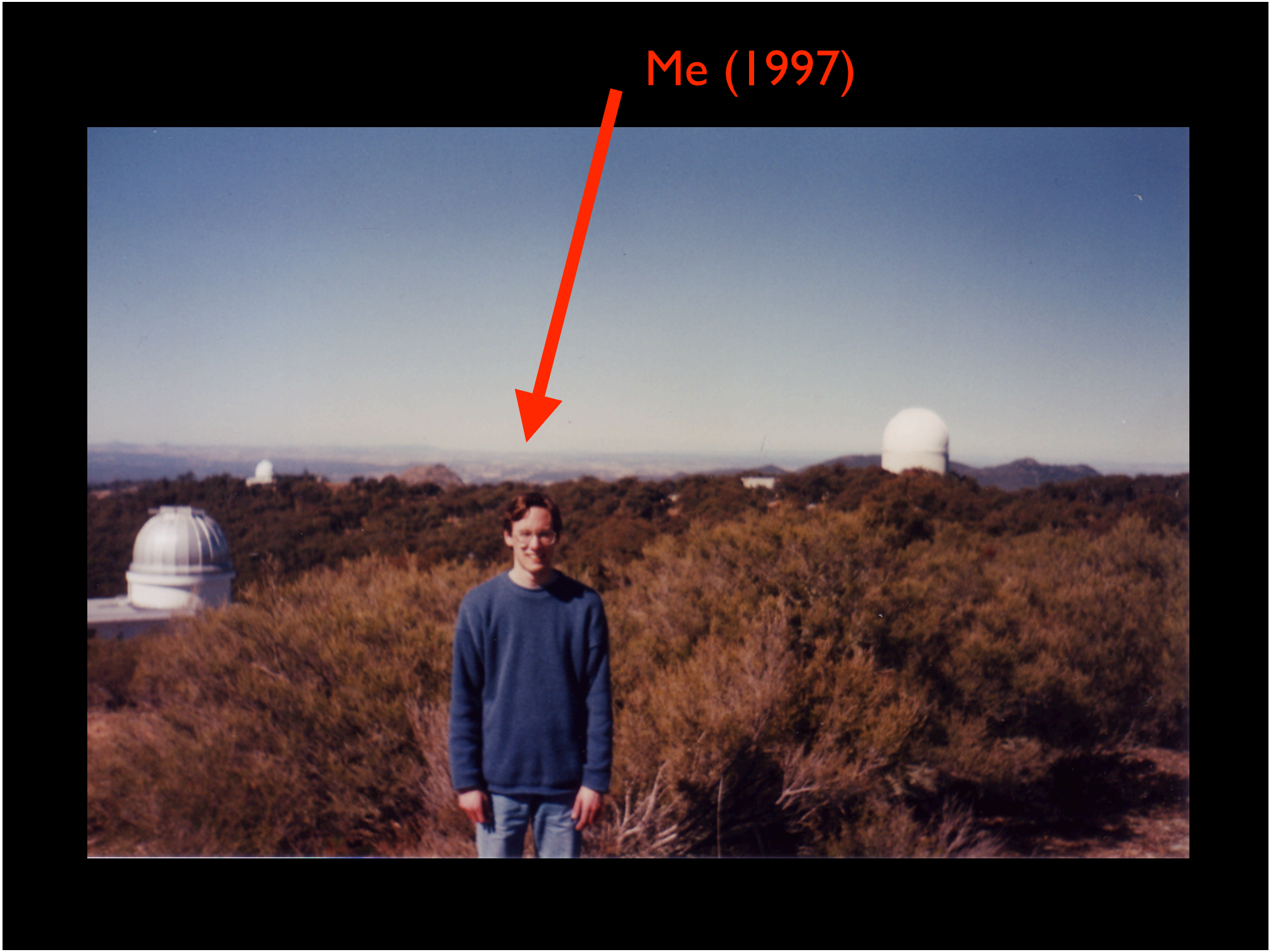
Cosmology with the WiggleZ Survey

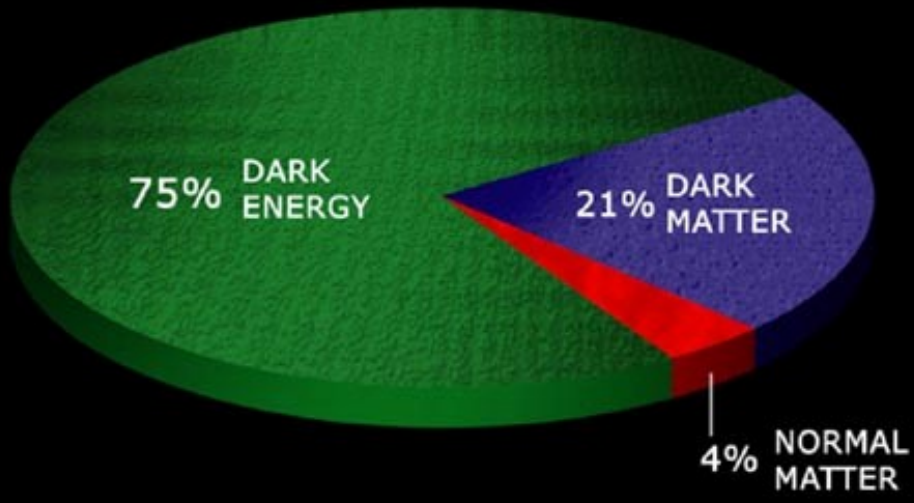


Chris Blake , Swinburne


Me (1997)

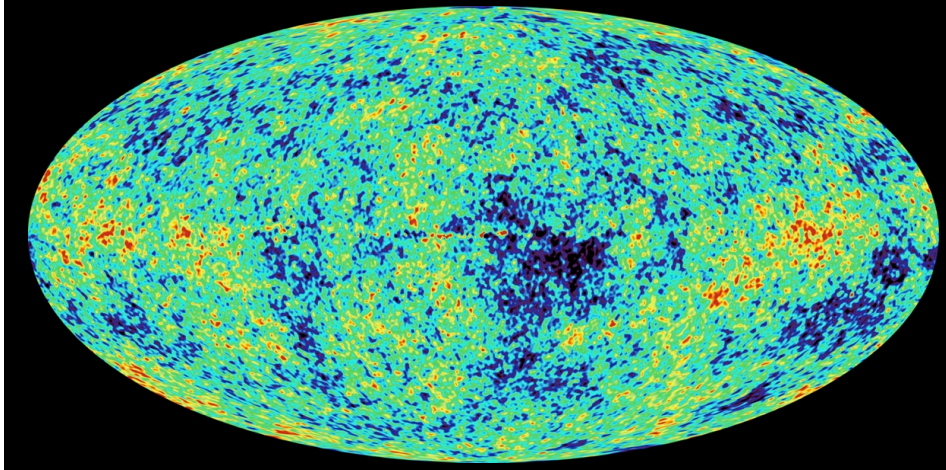
Me (2010)

What does a cosmologist do?



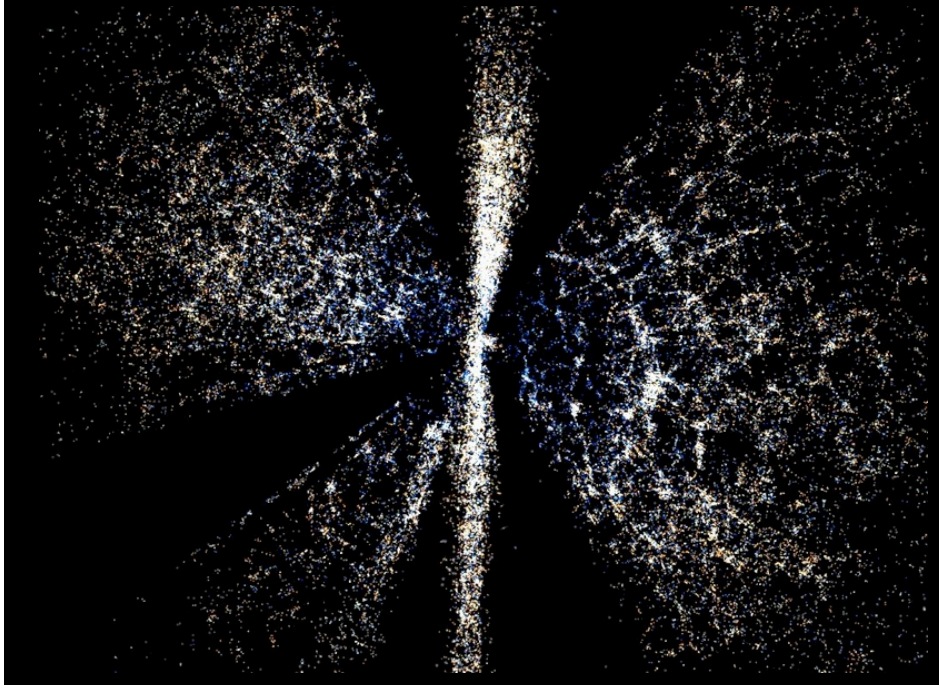
Cosmologist's tools

Cosmic microwave background

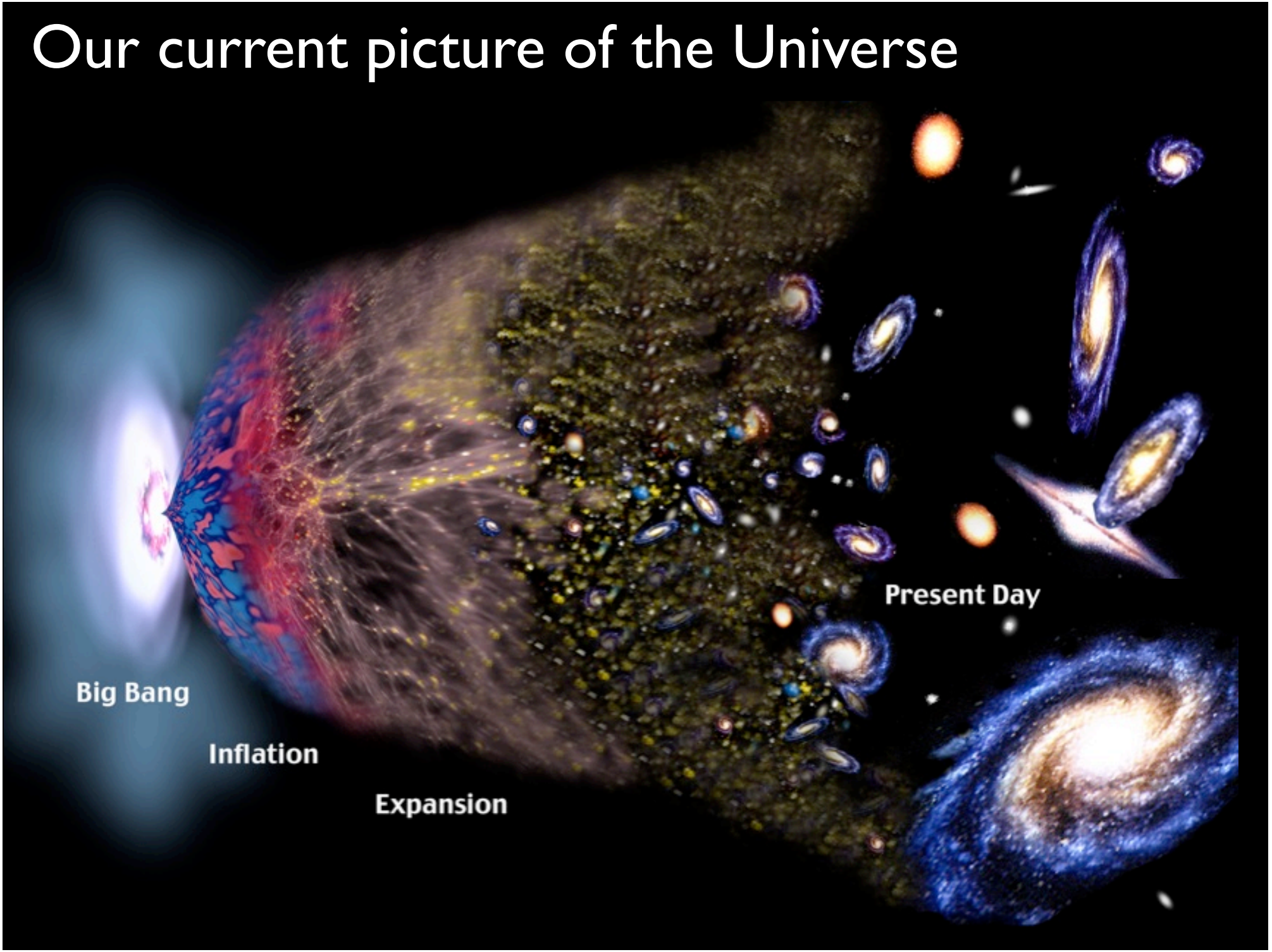


Supernovae

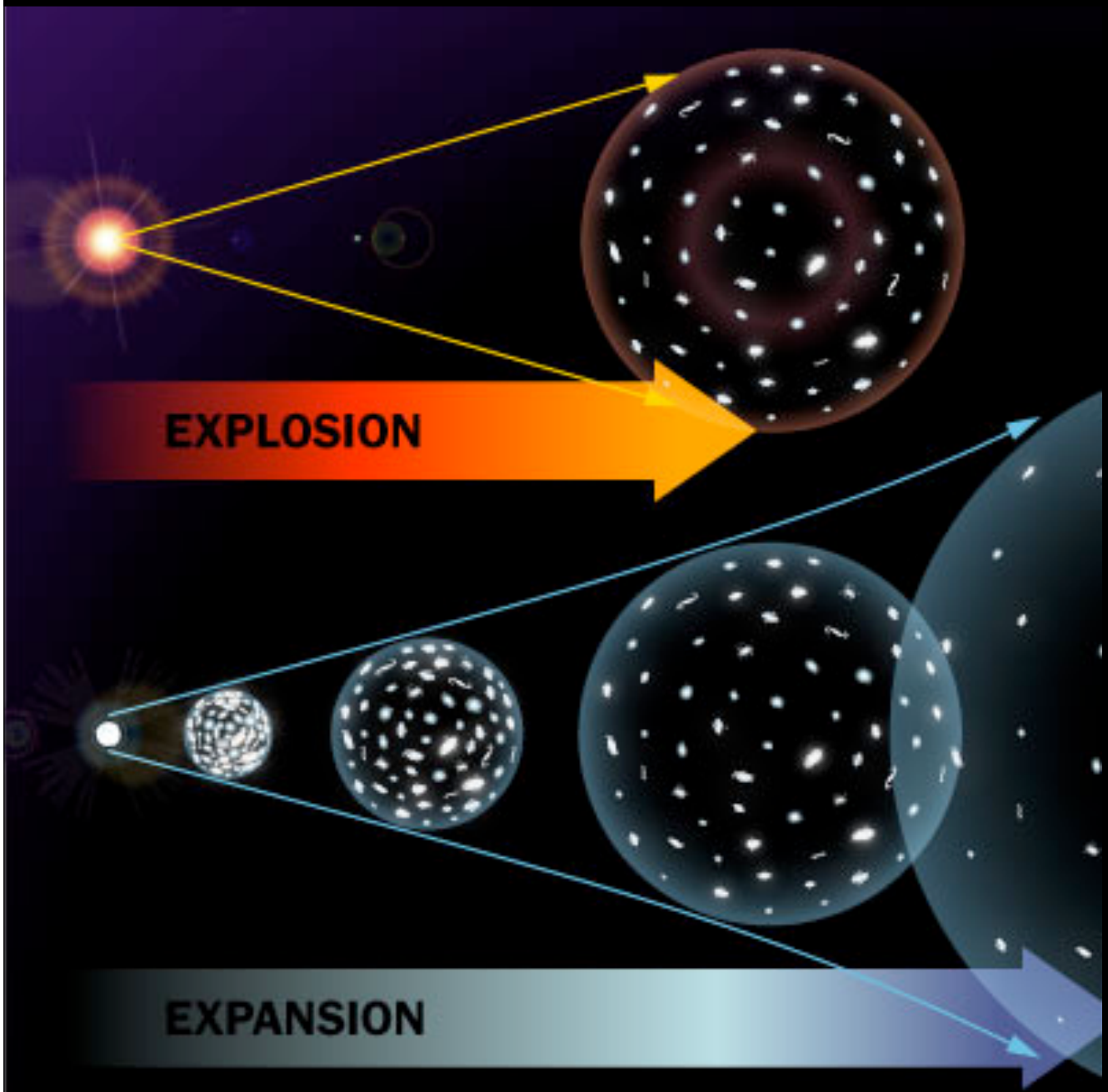
Galaxy surveys



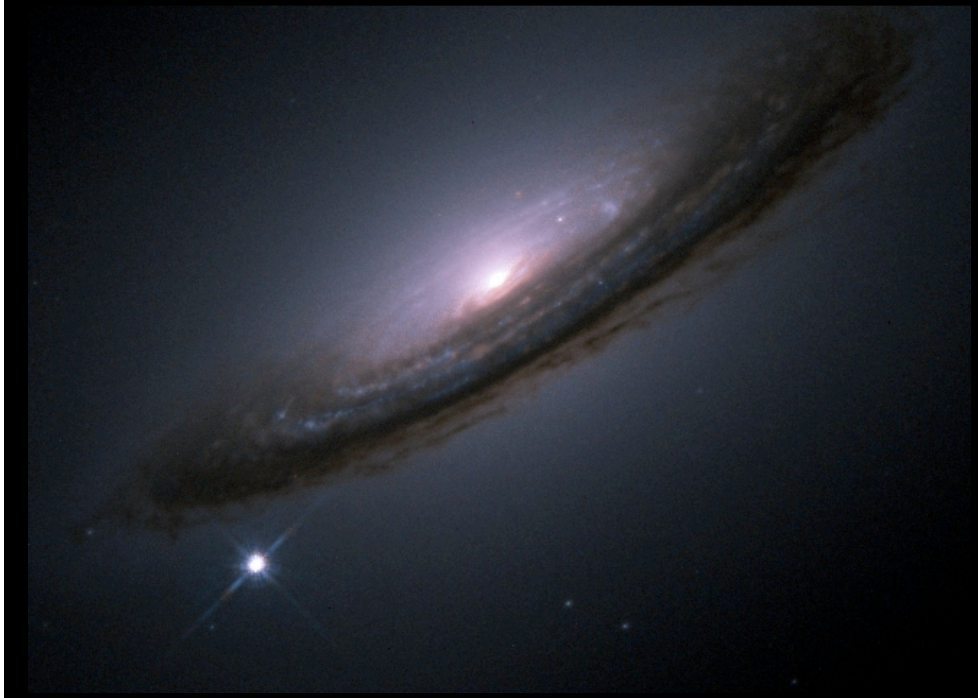
Our current picture of the Universe

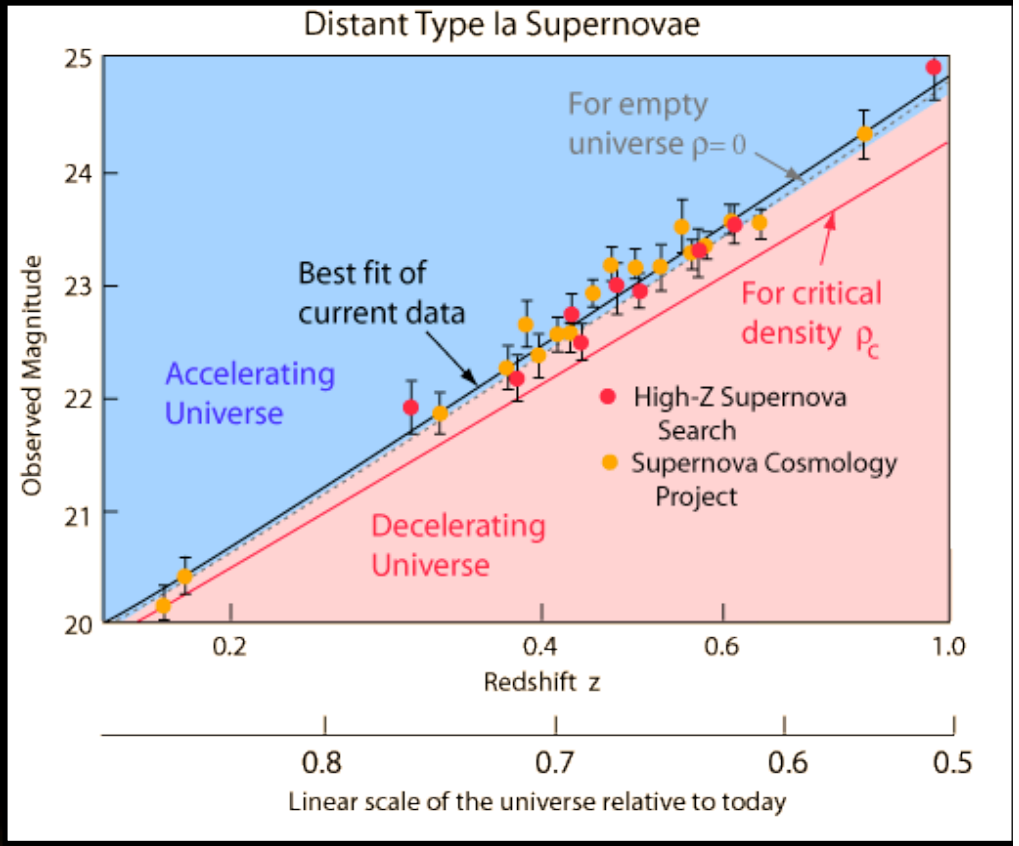


The Universe is expanding ...

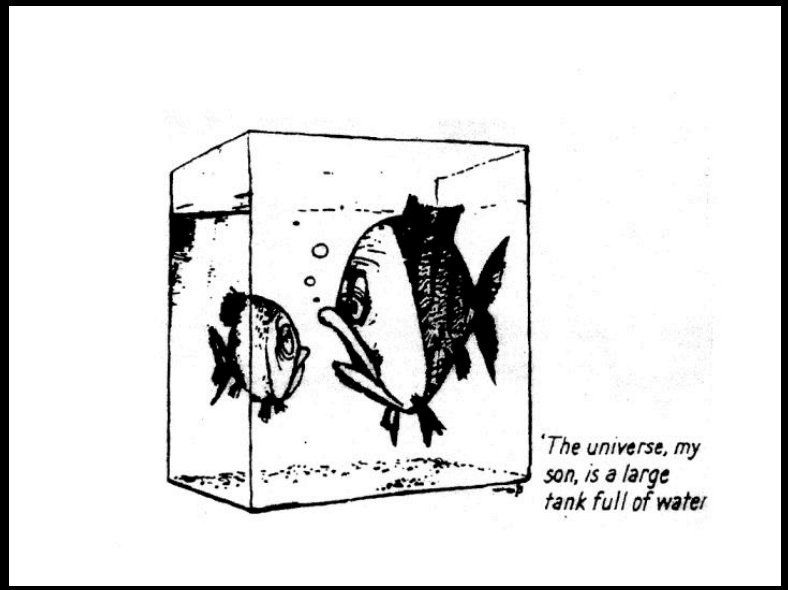


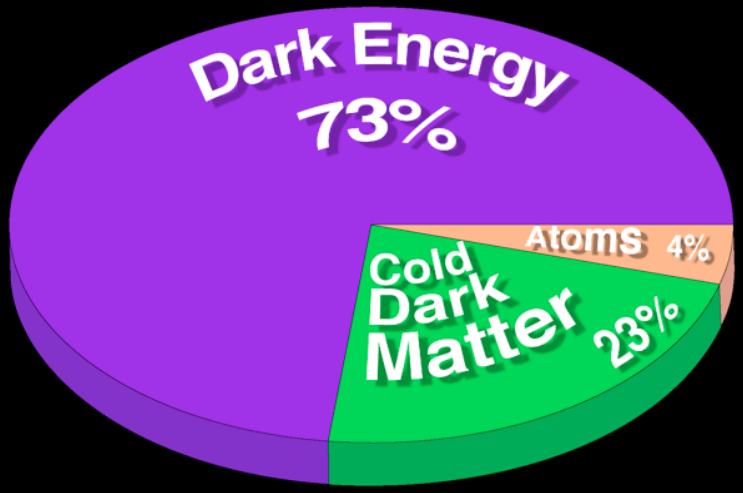
... and the expansion is speeding up ! ...

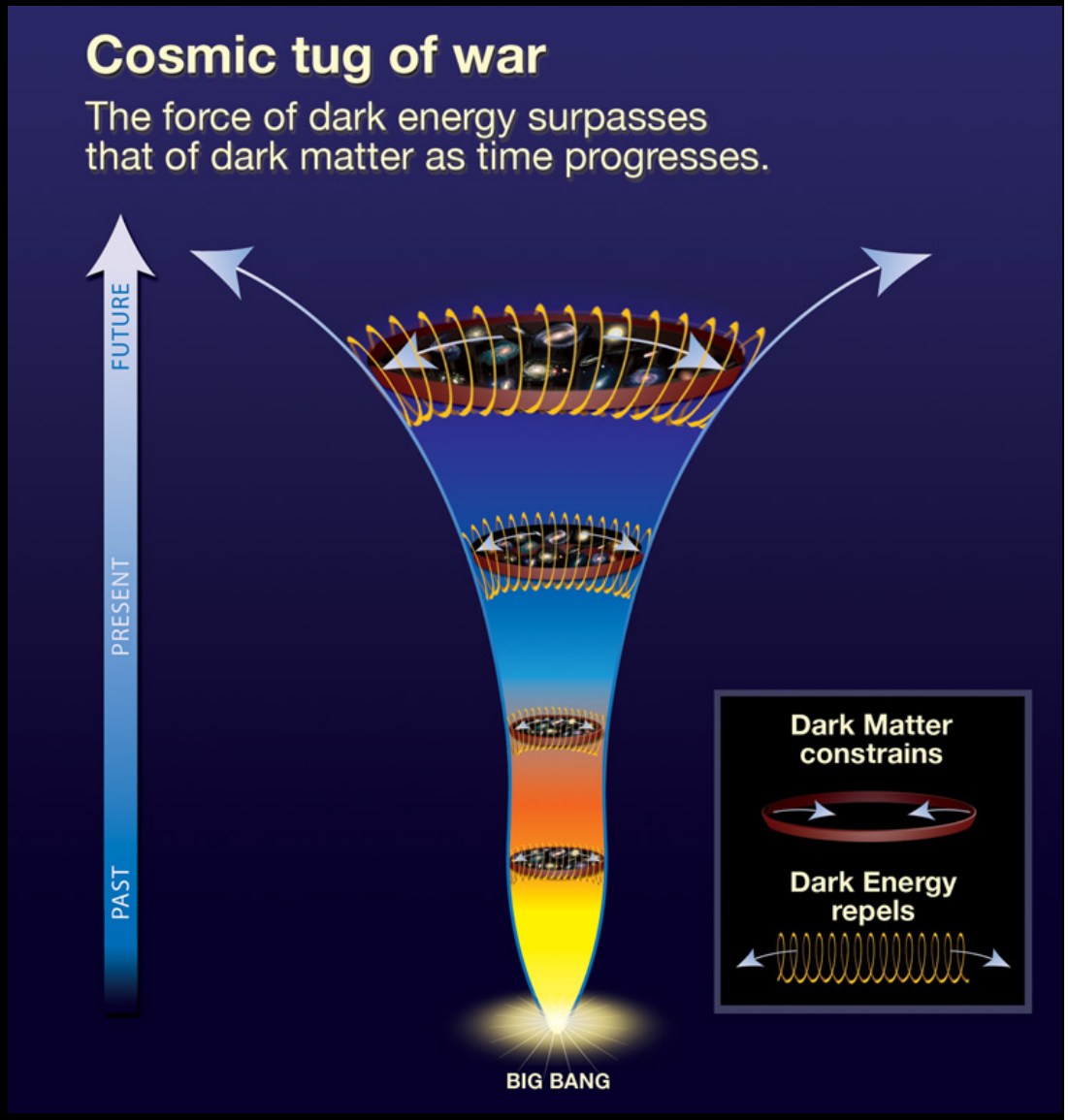




Our current model of cosmology

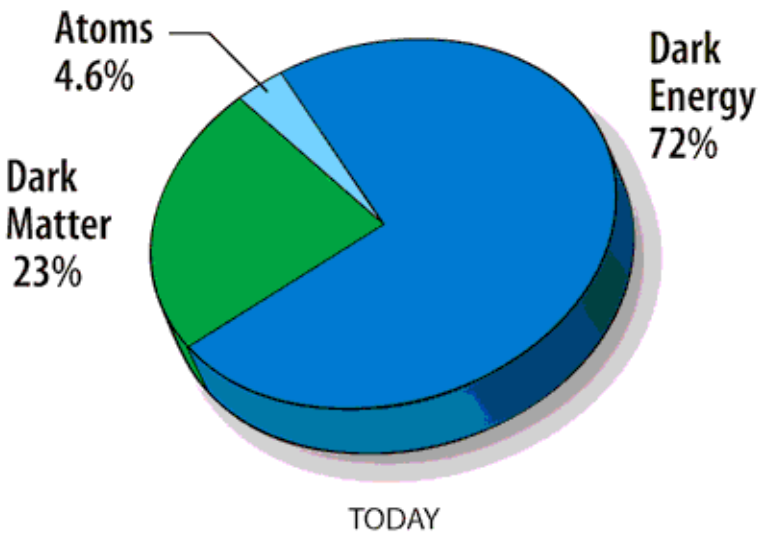


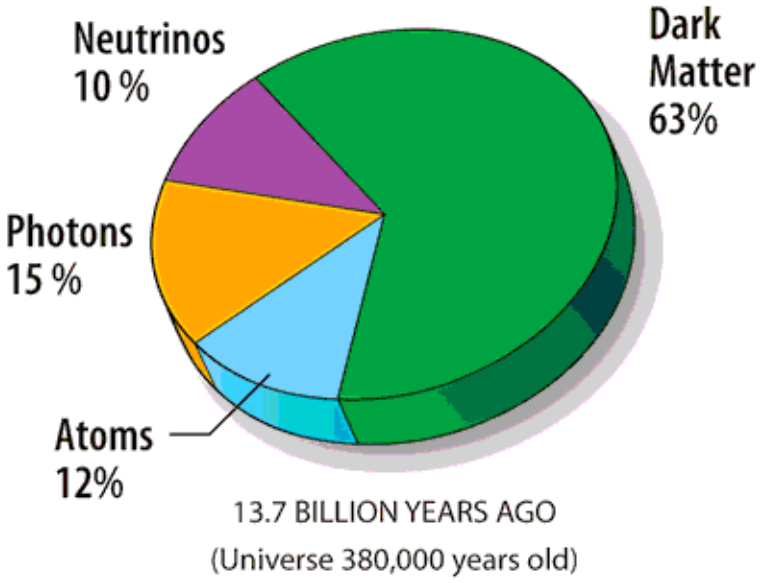




Dark energy : what do we know?

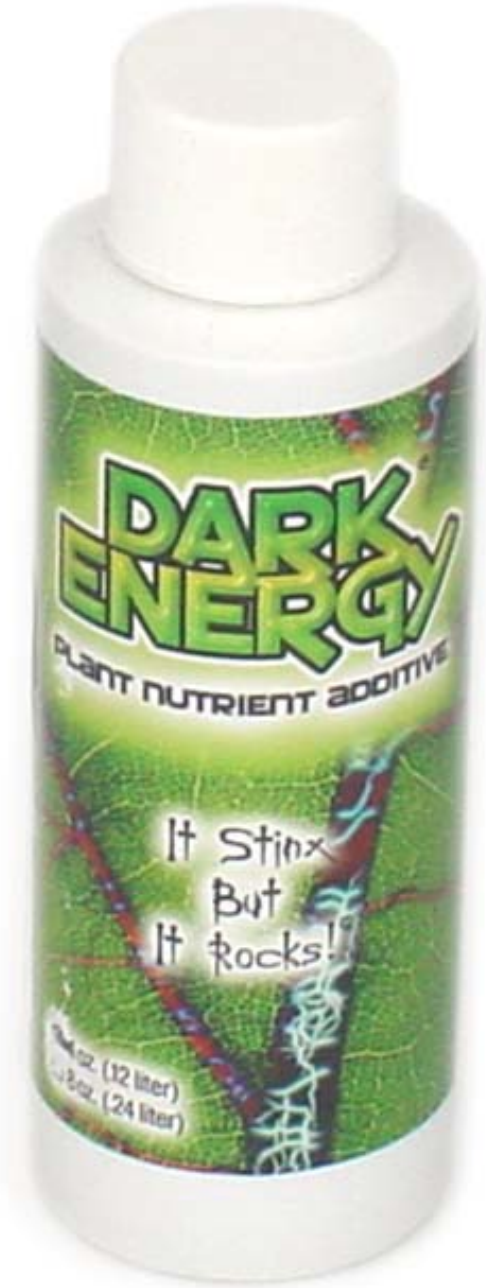
- Dark energy smoothly fills space with a roughly constant energy density
- Dark energy dominates the Universe today but is insignificant at high redshift
- Dark energy propels the cosmos into a phase of accelerating expansion





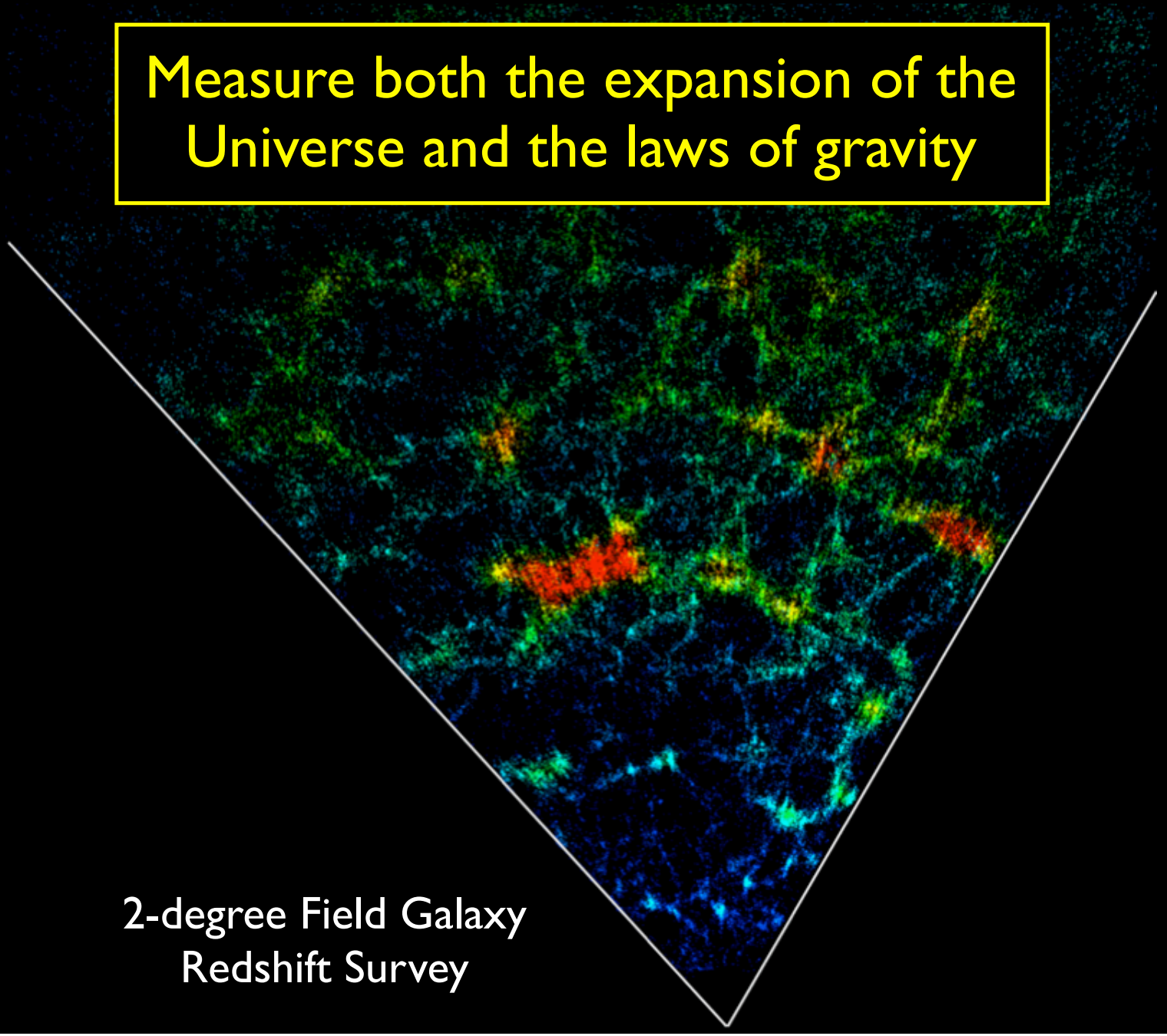
Dark energy : what don't we know?

- Physically, is it a manifestation of gravity or matter-energy?
- Why now? - why does dark energy become important billions of years after the Big Bang?
- If dark energy is vacuum energy, how can we explain its magnitude?
- How are our observations of dark energy affected by inhomogeneity?



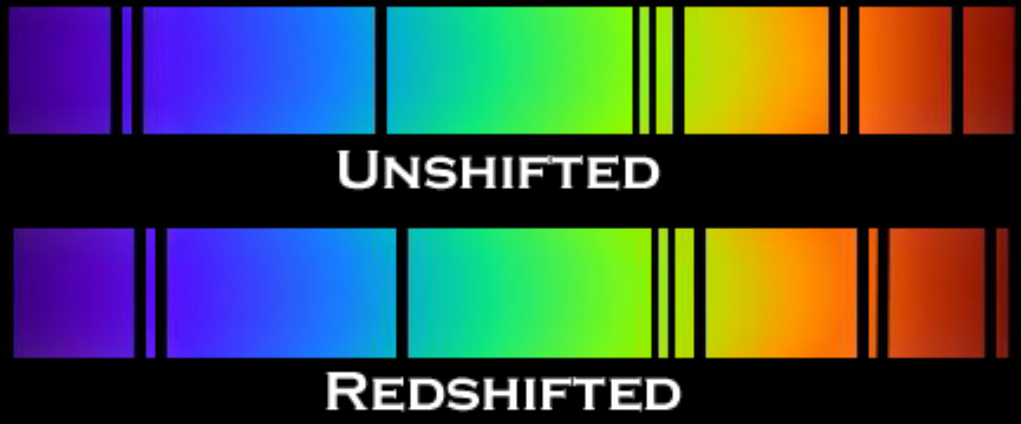
A powerful tool : galaxy redshift surveys

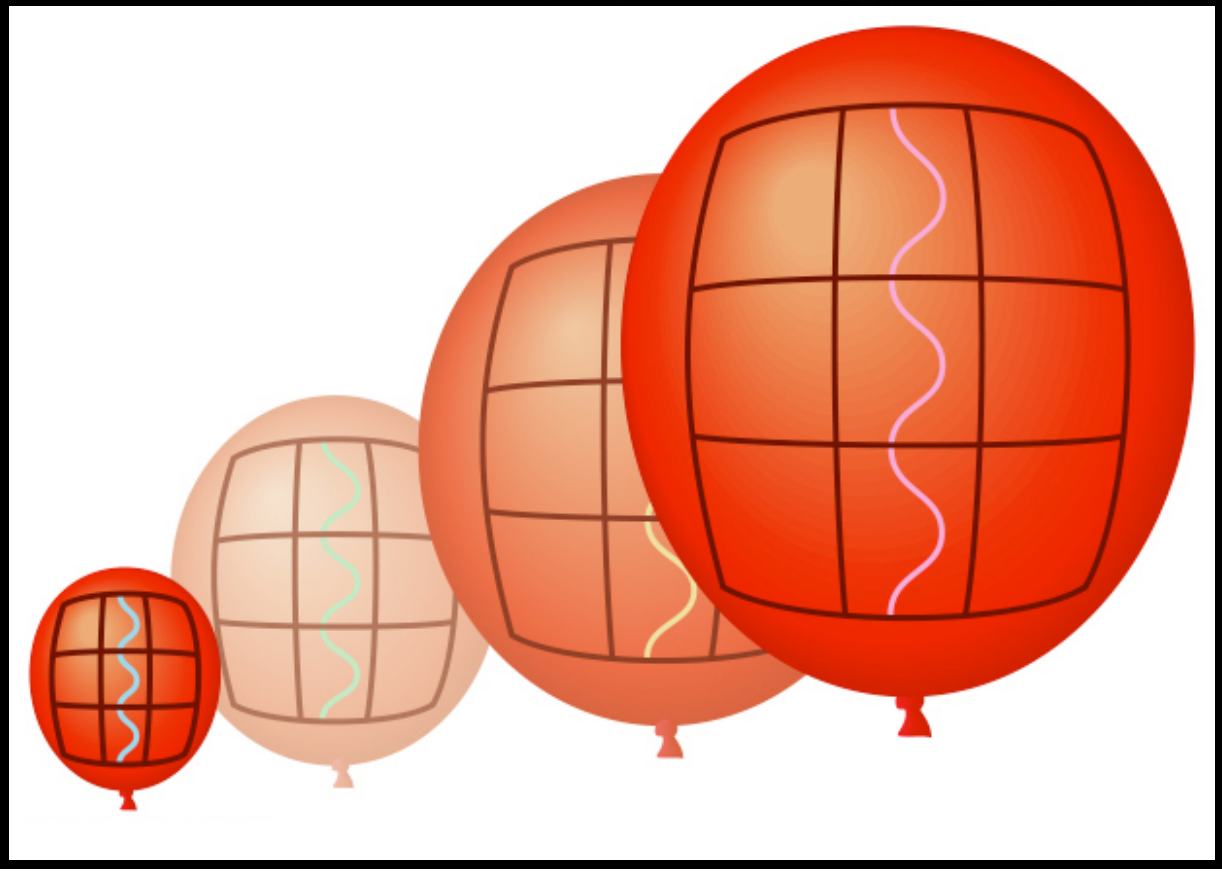
Measure both the expansion of the Universe and the laws of gravity



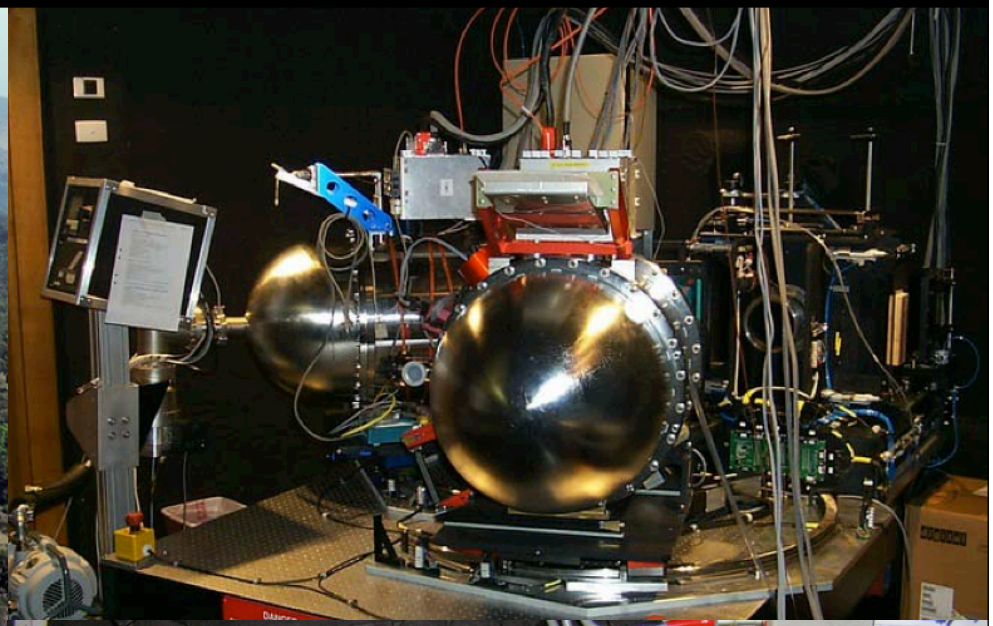
2-degree Field Galaxy Redshift Survey

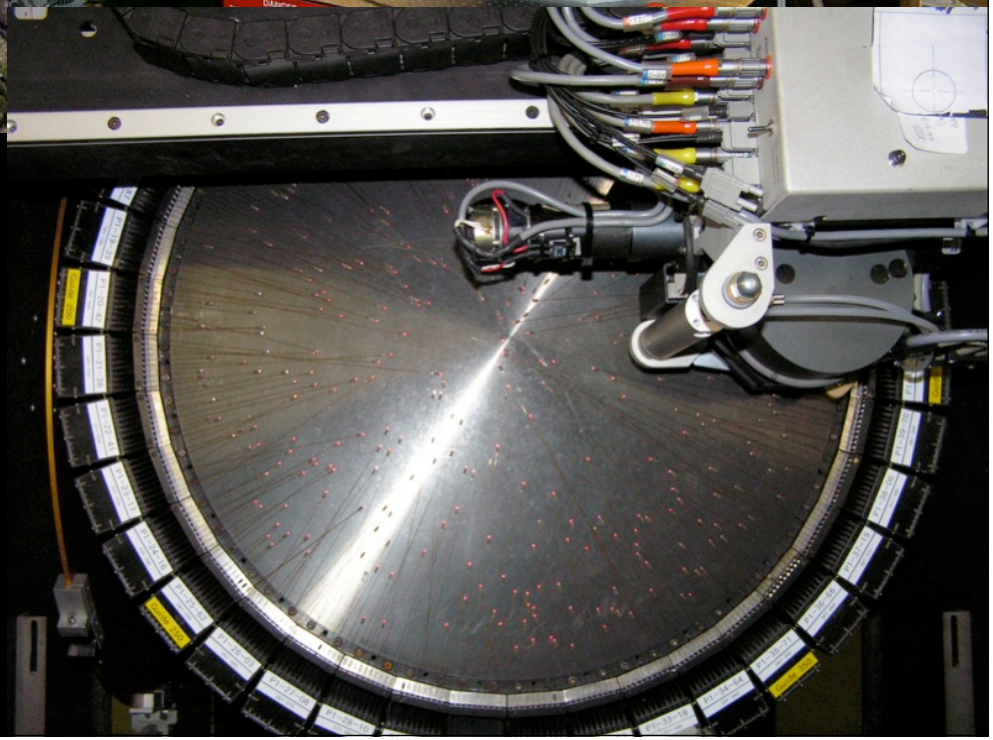
Cosmological redshift





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

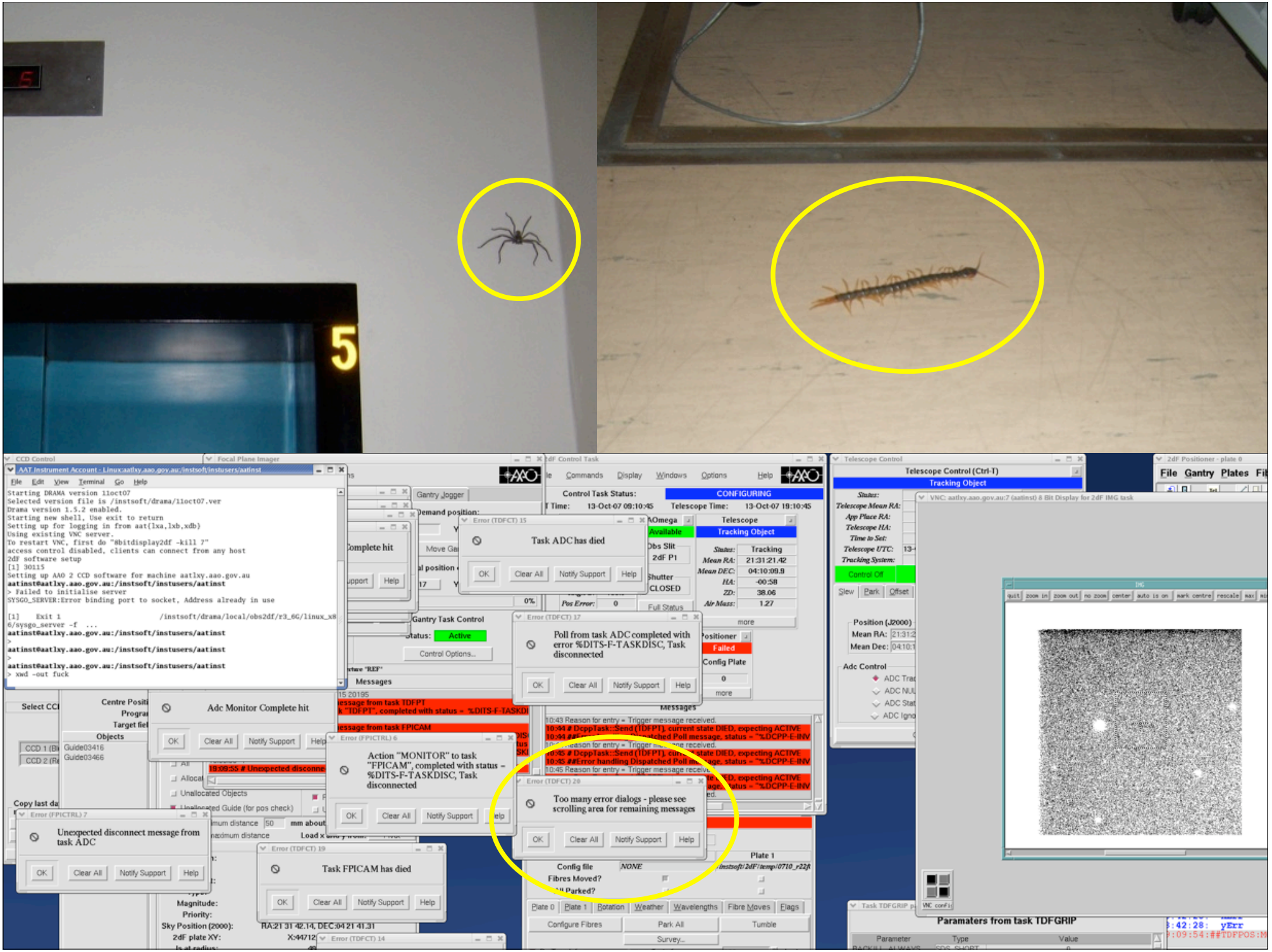
Swinburne : Chris Blake , Carlos Contreras , Warrick Couch , Darren Croton , Karl Glazebrook , Tornado Li , Greg Poole , Emily Wisnioski

University of Queensland : Tamara Davis , Michael Drinkwater

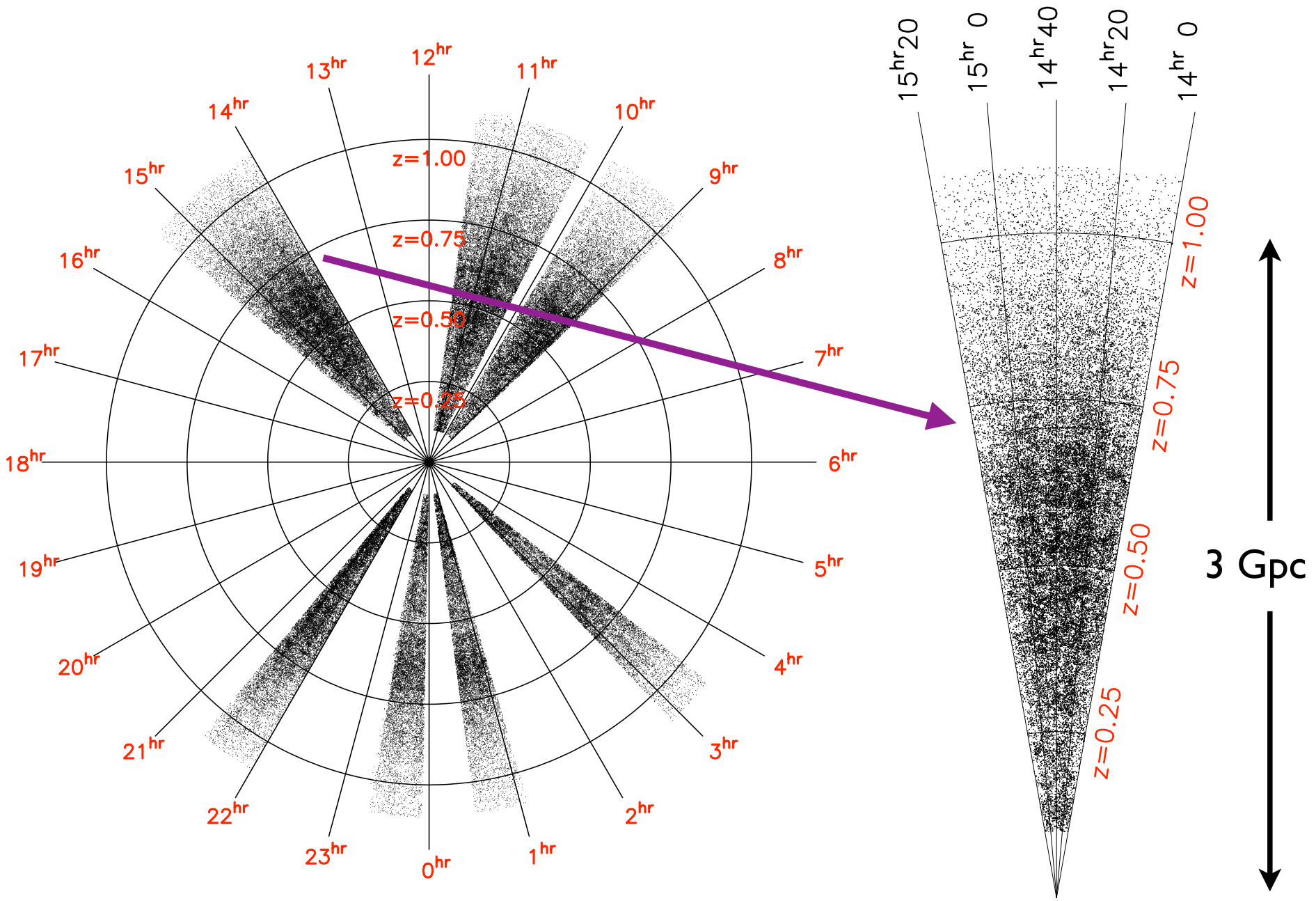
Sarah Brough (AAO) , Matthew Colless (ANU) , Scott Croom (U.Syd.) , Ben Jelliffe (U.Syd.) , Russell Jurek (ATNF) , Kevin Pimbblet (Monash) , Mike Pracy (U.Syd) , Rob Sharp (ANU) , David Woods (UBC)

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

RCS2 team : David Gilbank , Mike Gladders , Howard Yee

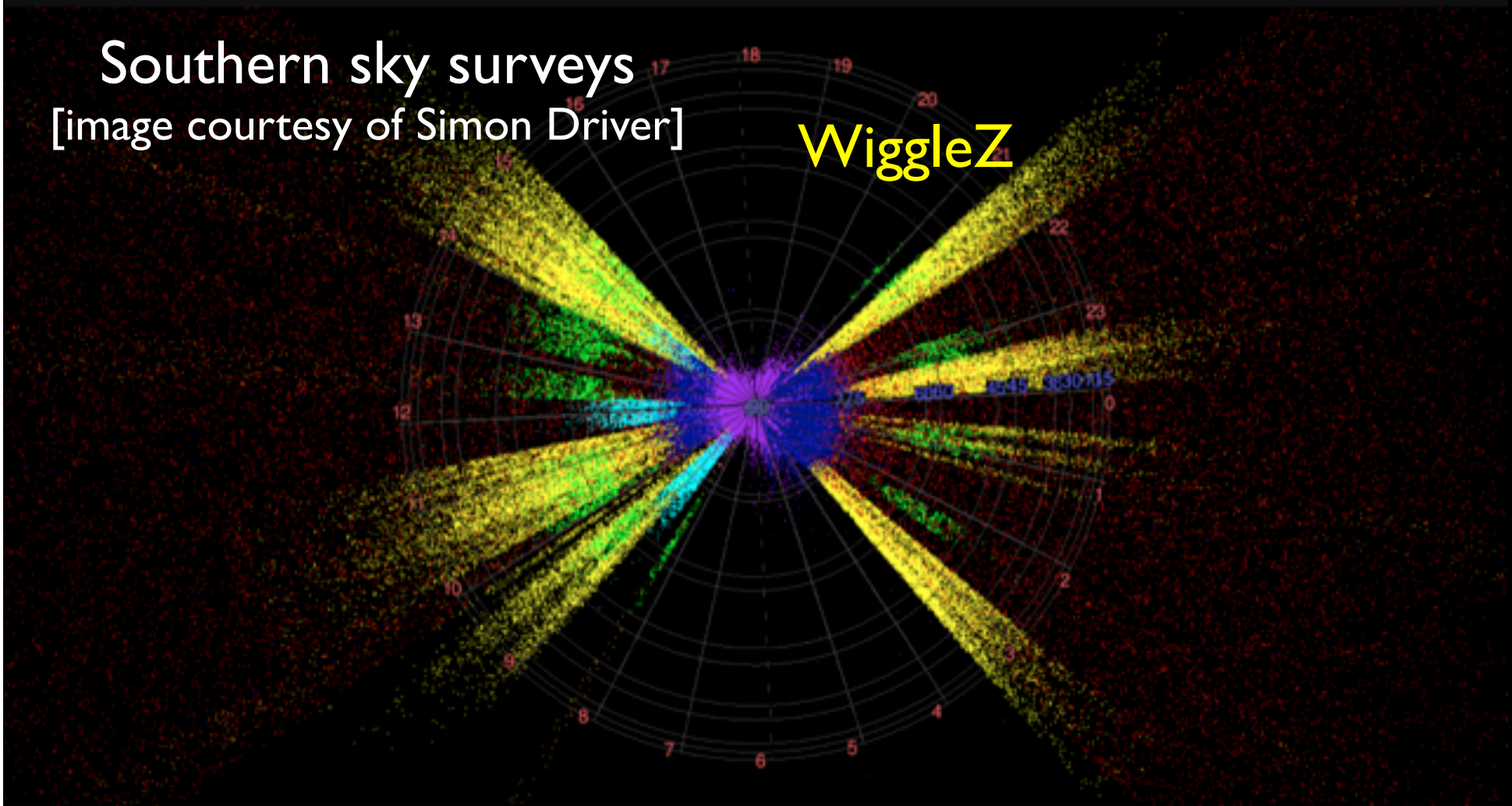

5
Task ADC has died
Poll from task ADC completed with error %DITS-F-TASKDISC, Task disconnected
Too many error dialogs - please see scrolling area for remaining messages
Adc Monitor Complete hit
Action "MONITOR" to task "FPICAM", completed with status = %DITS-F-TASKDISC, Task disconnected
Unexpected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

The WiggleZ Dark Energy Survey



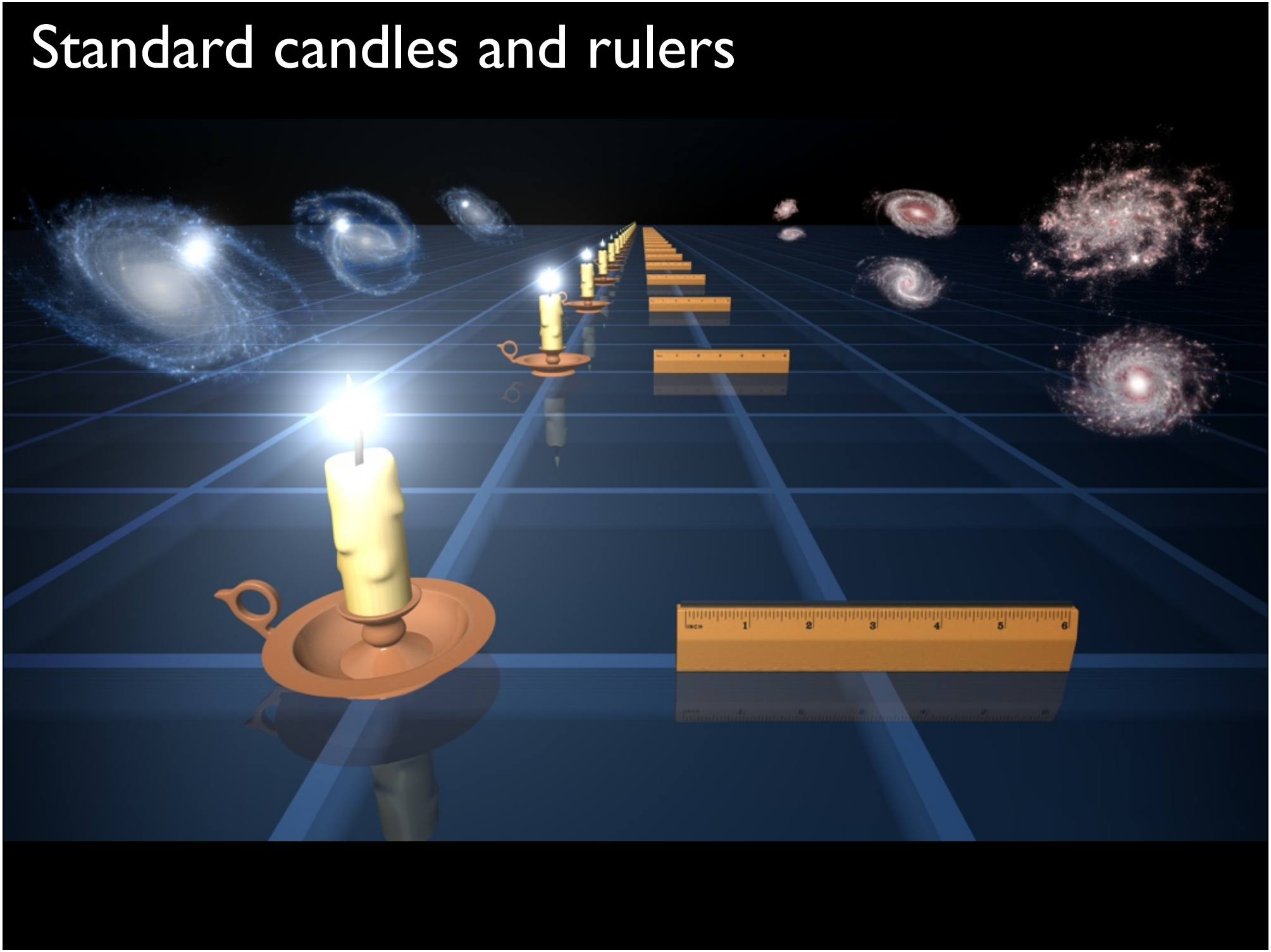
The WiggleZ Dark Energy Survey

Southern sky surveys
[image courtesy of Simon Driver]

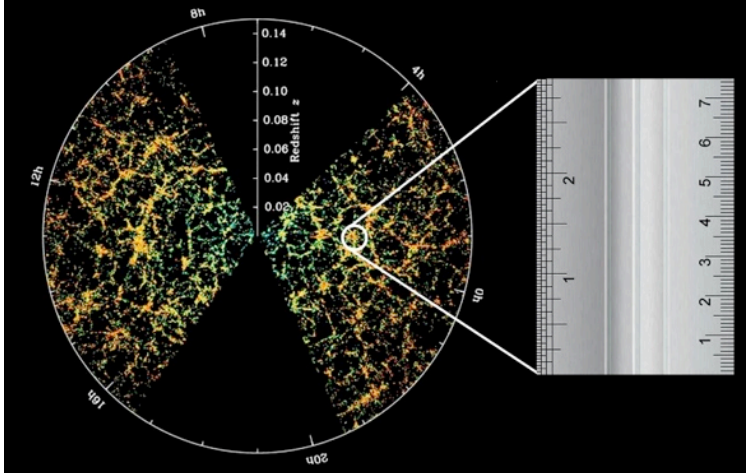


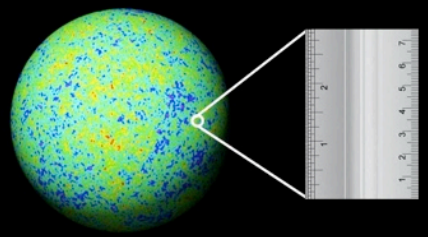
6dFGS (purple), 2dFGRS (blue), MGC (navy), GAMA (cyan), 2SLAQ-LRG (green), WiggleZ (yellow), 2SLAQ-QSO (orange), 2QZ (red); the celestial sphere is at z=1.

Standard candles and rulers

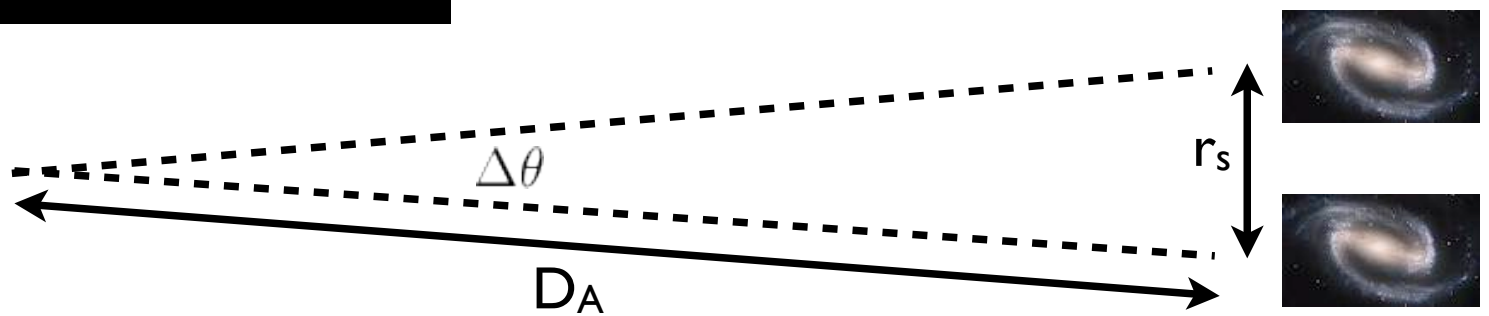


Standard ruler : baryon acoustic peak

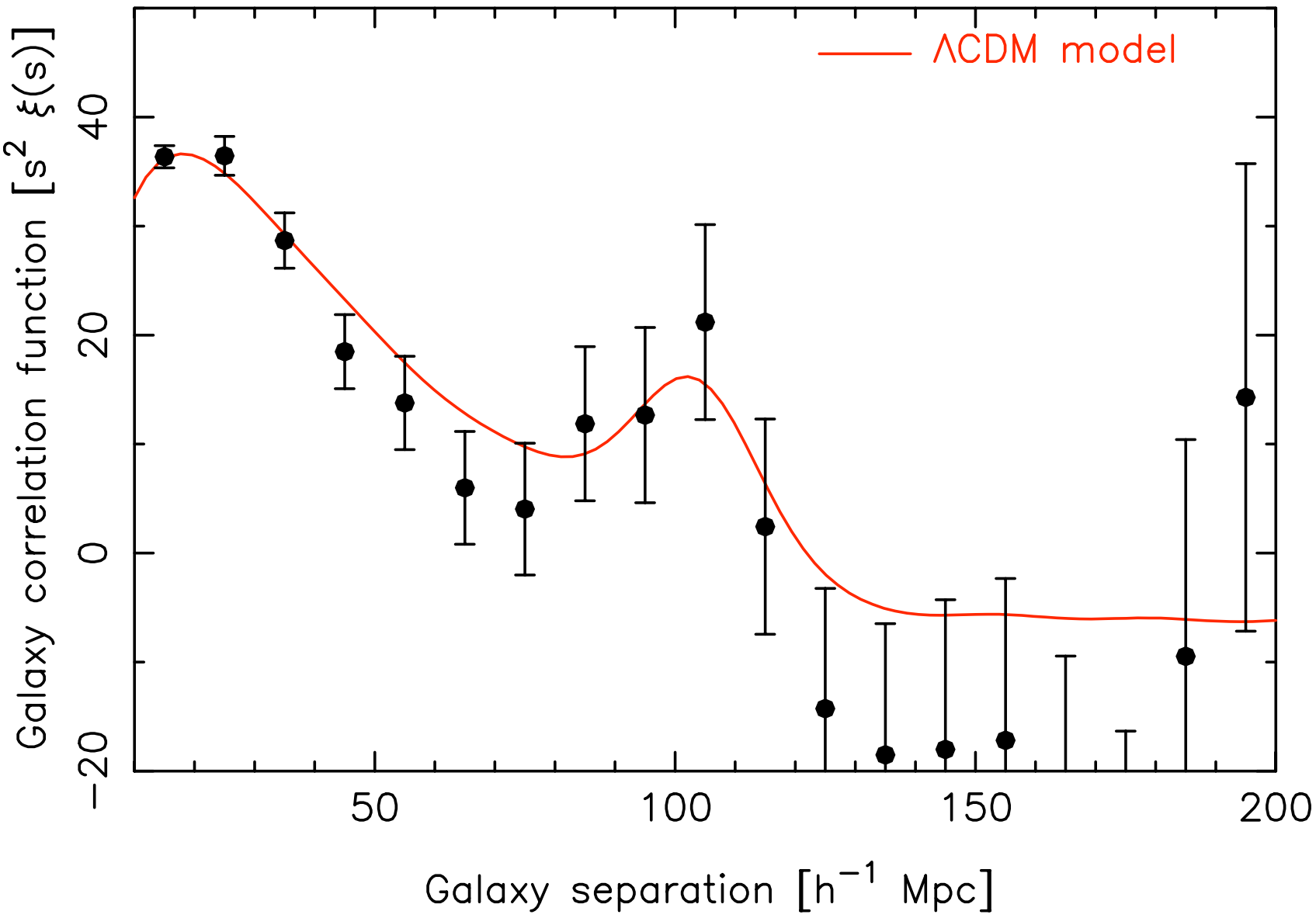




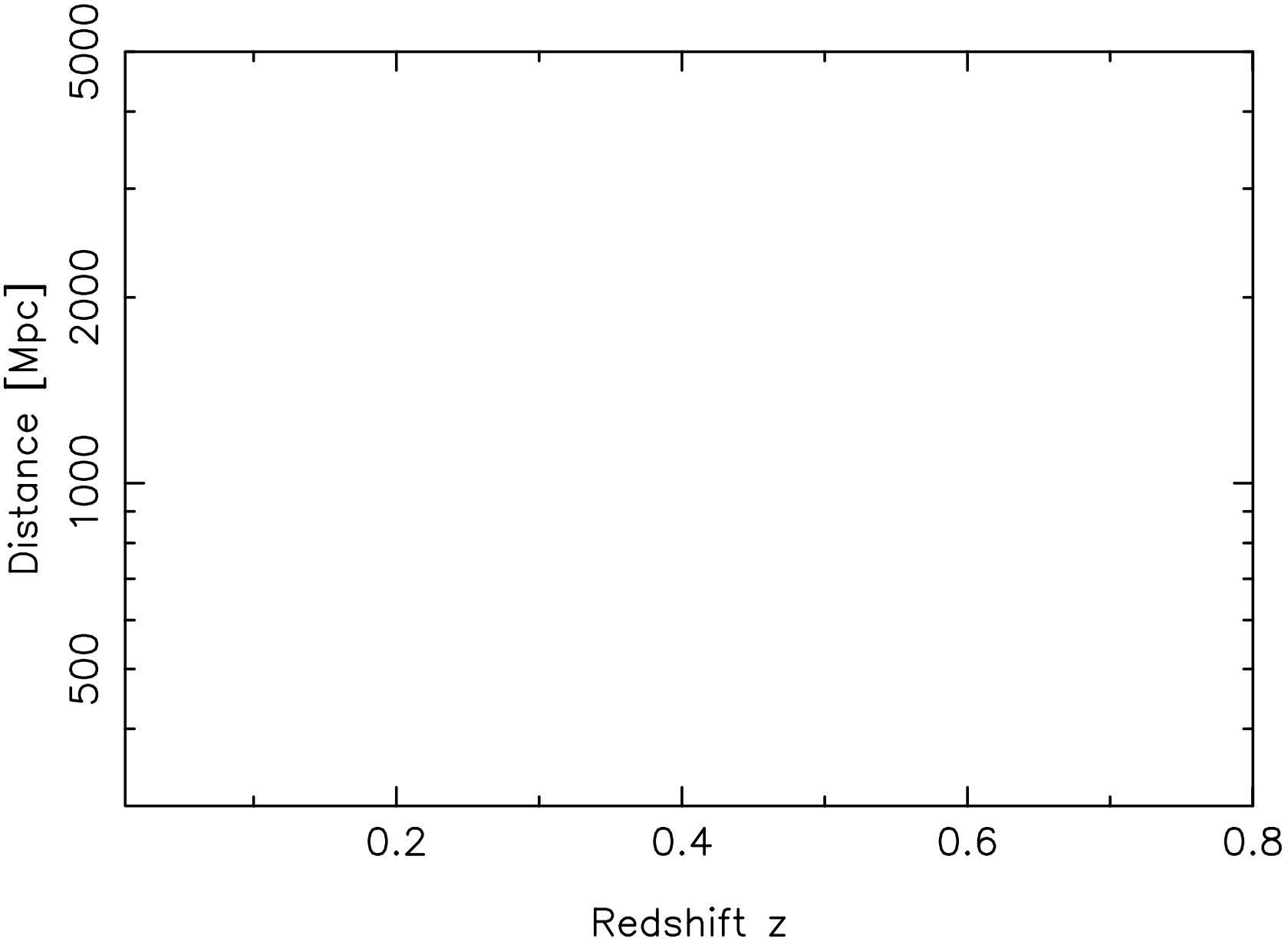
- Preferred co-moving separation of 105 h^{-1} Mpc between clumps imprinted at recombination
- We observe a preferred angular separation between galaxies at some redshift
- Allows distance determination by simple geometry



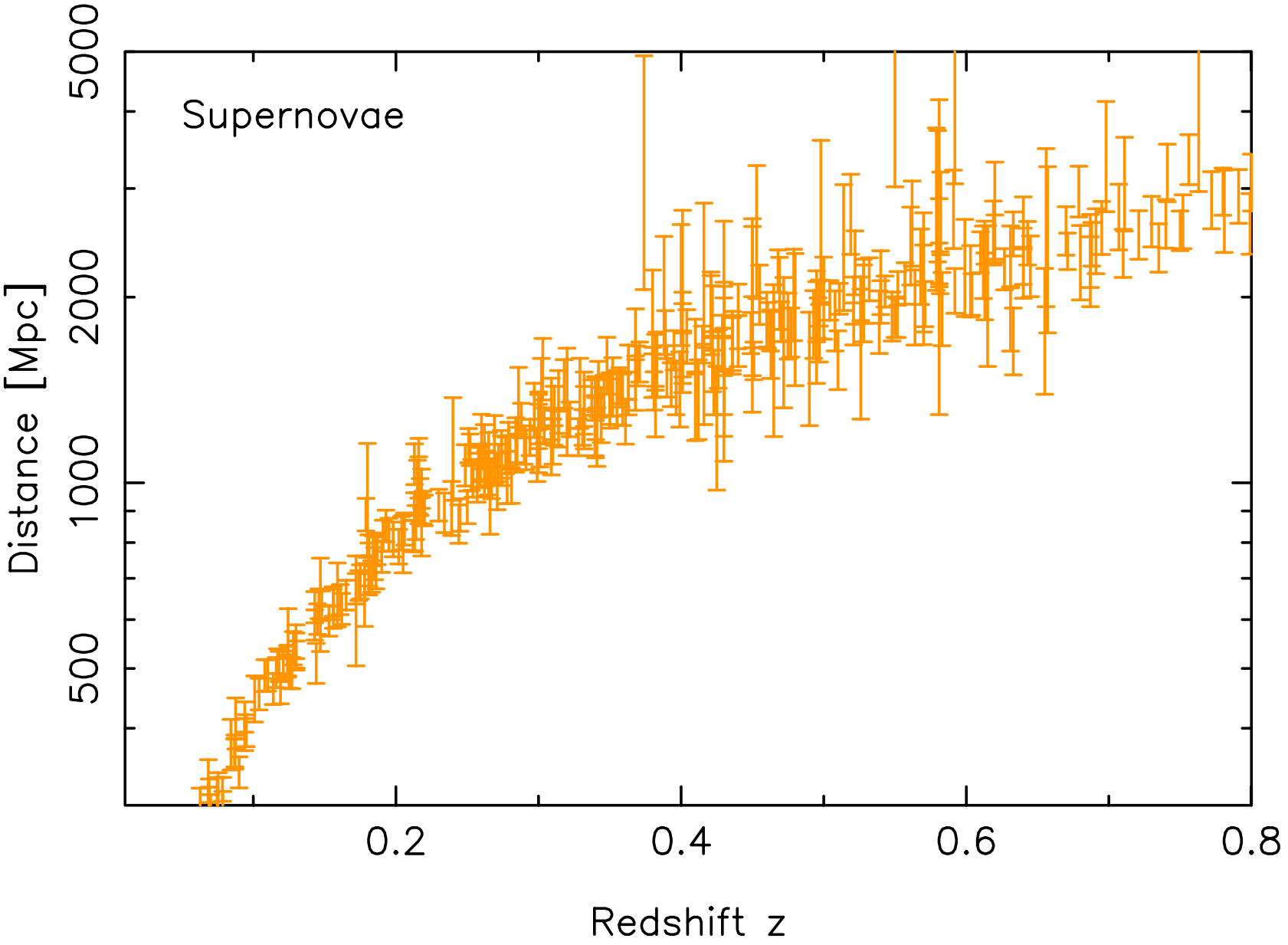
The baryon acoustic peak in WiggleZ



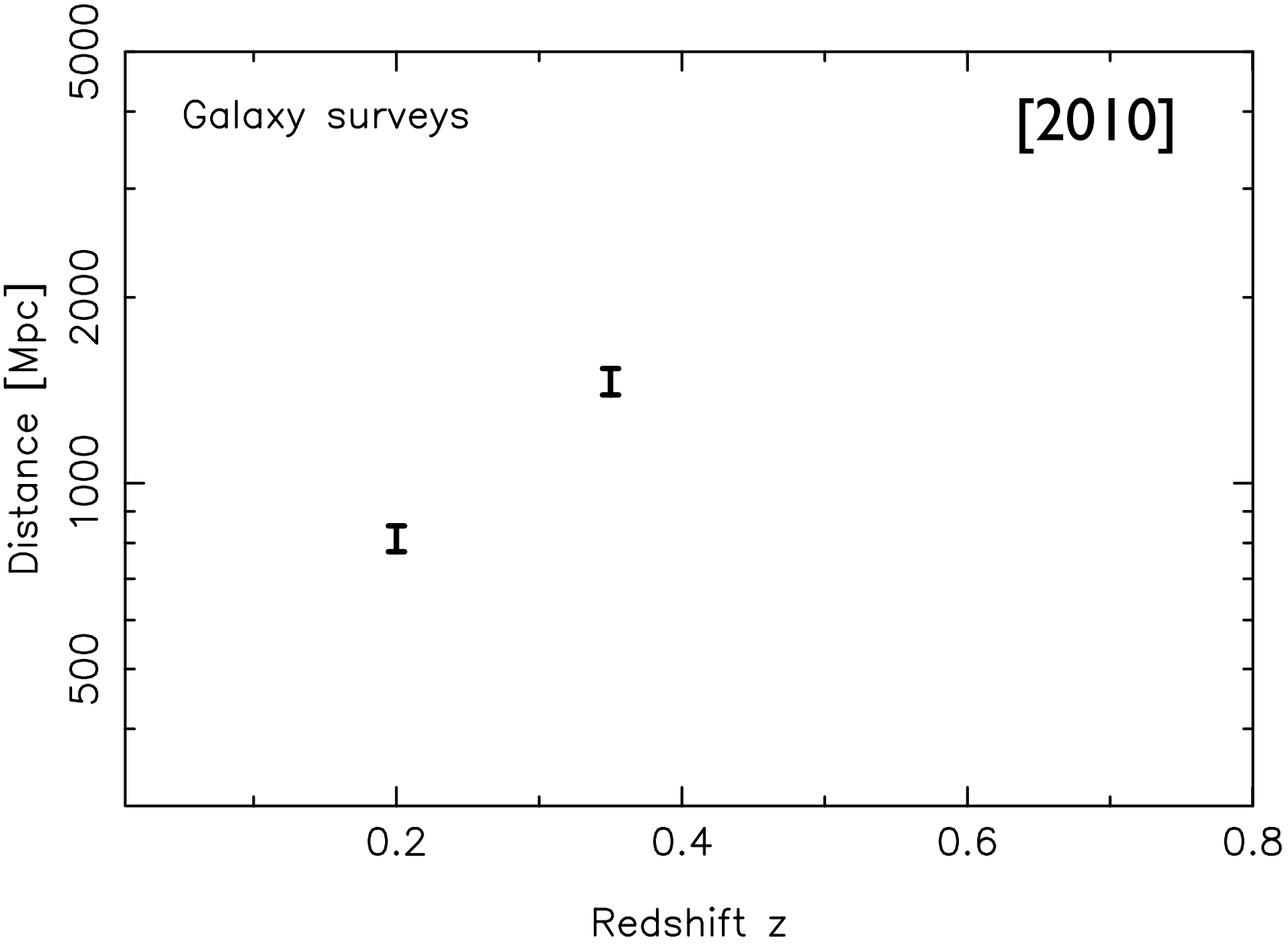
Distance-redshift relation



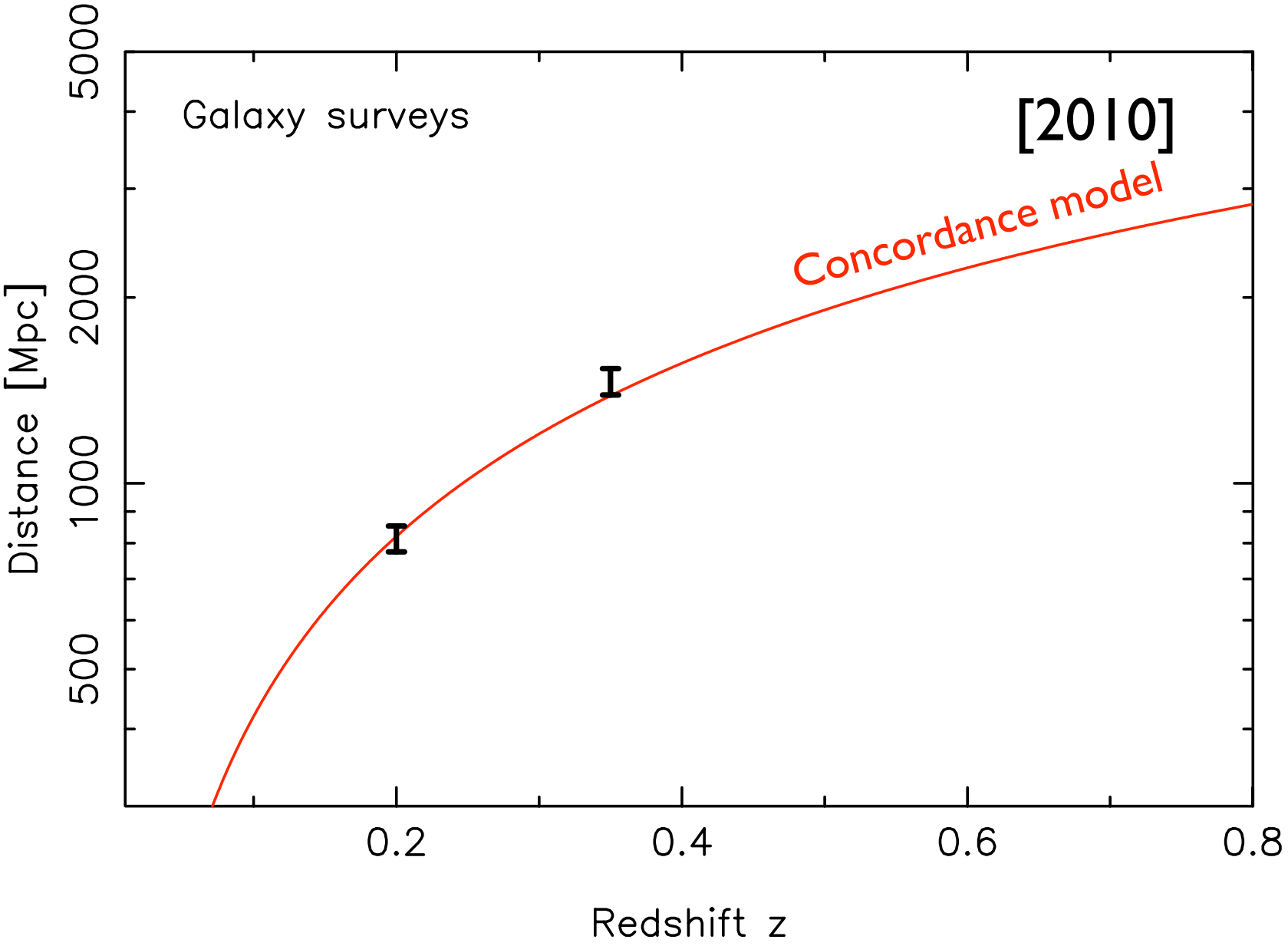
Distance-redshift relation



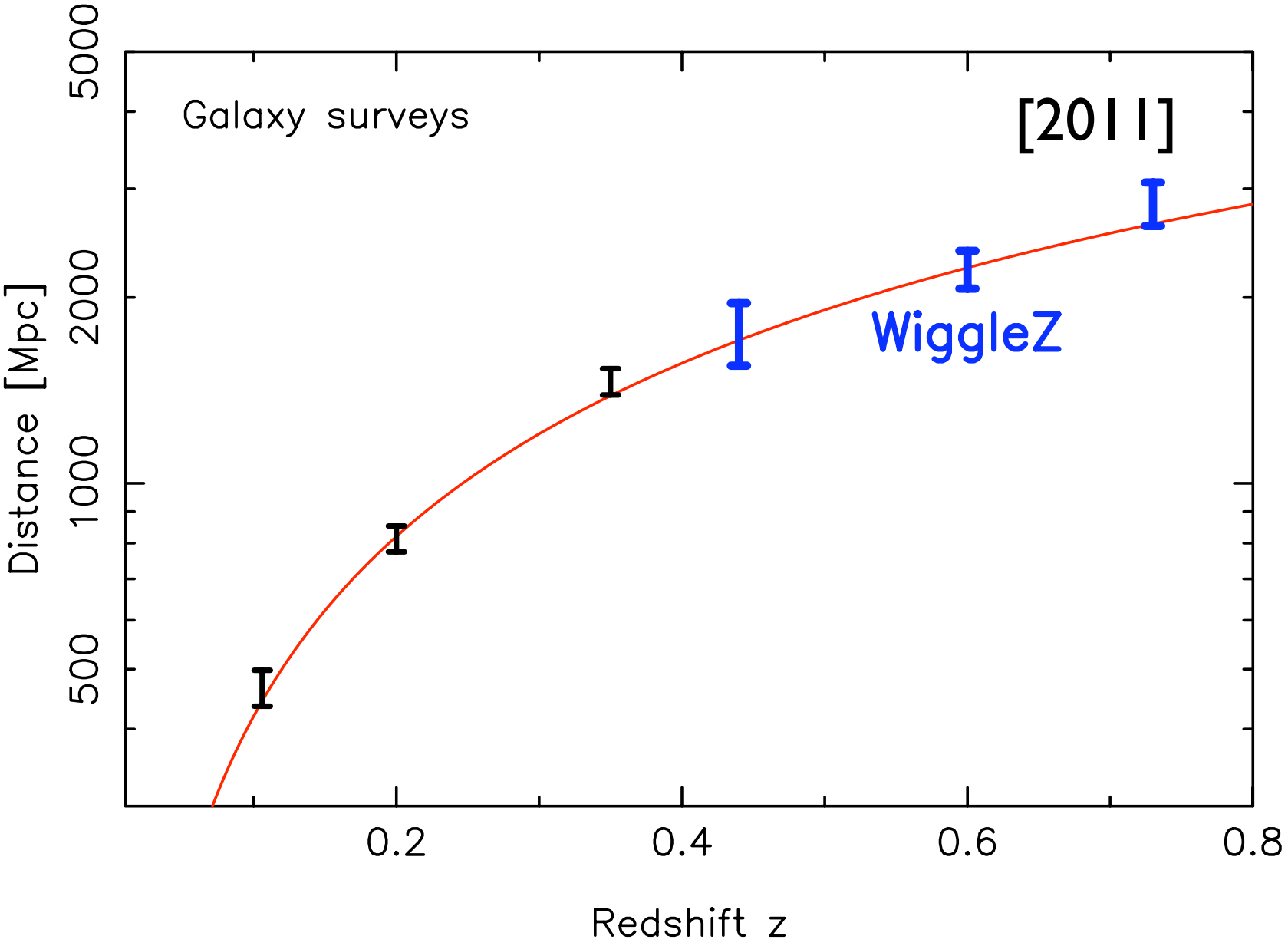
Distance-redshift relation



Distance-redshift relation



Distance-redshift relation



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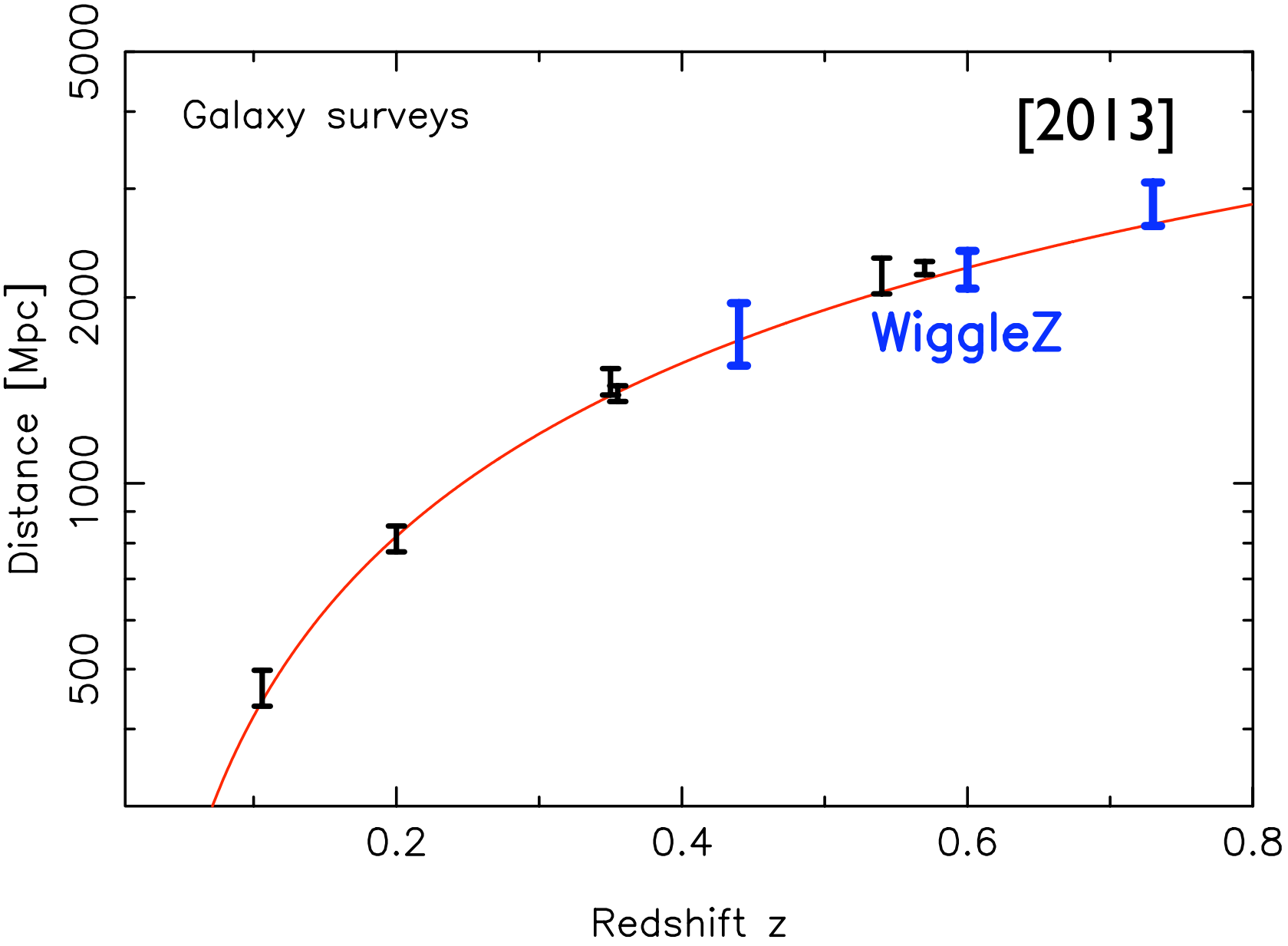
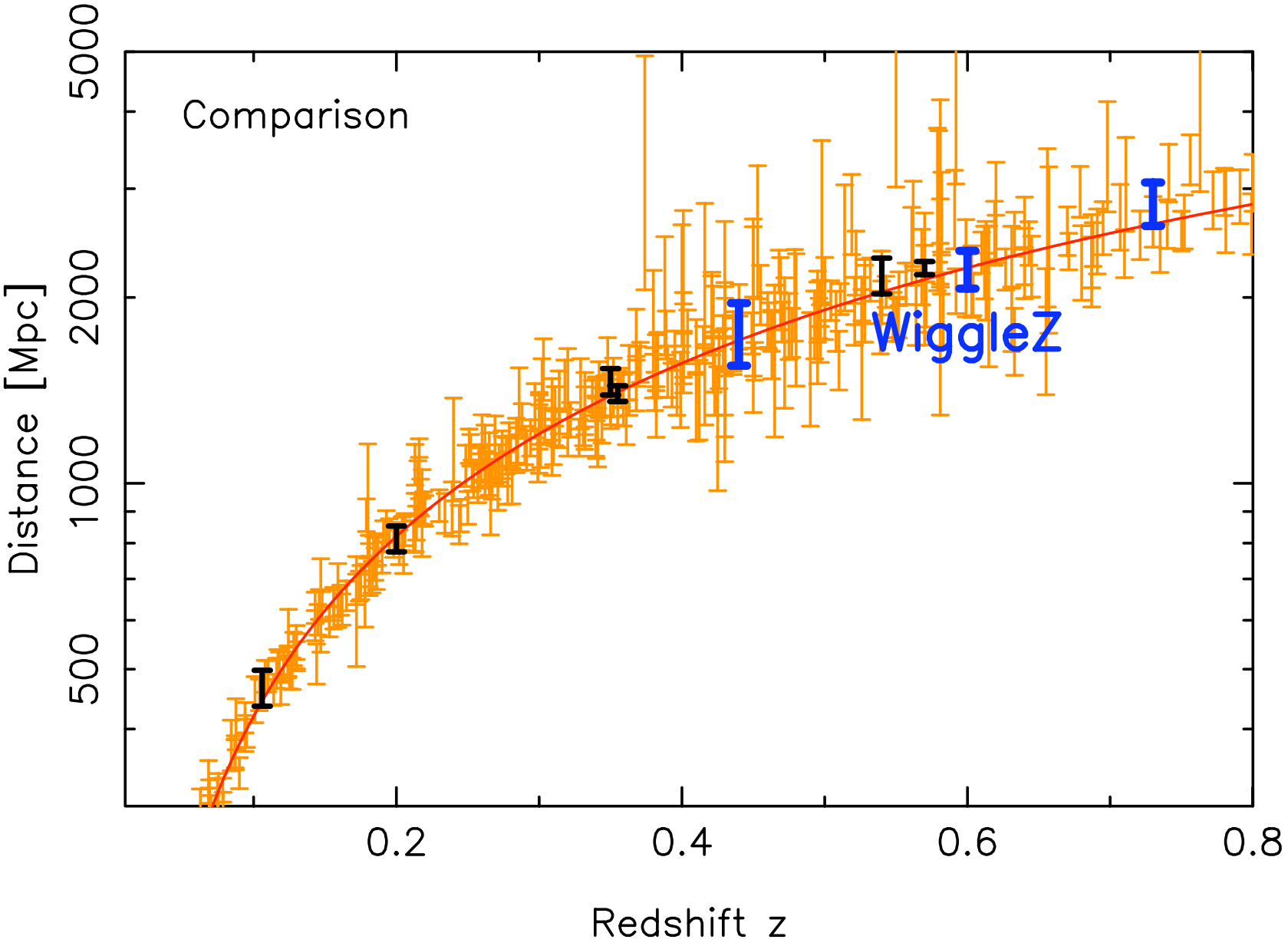
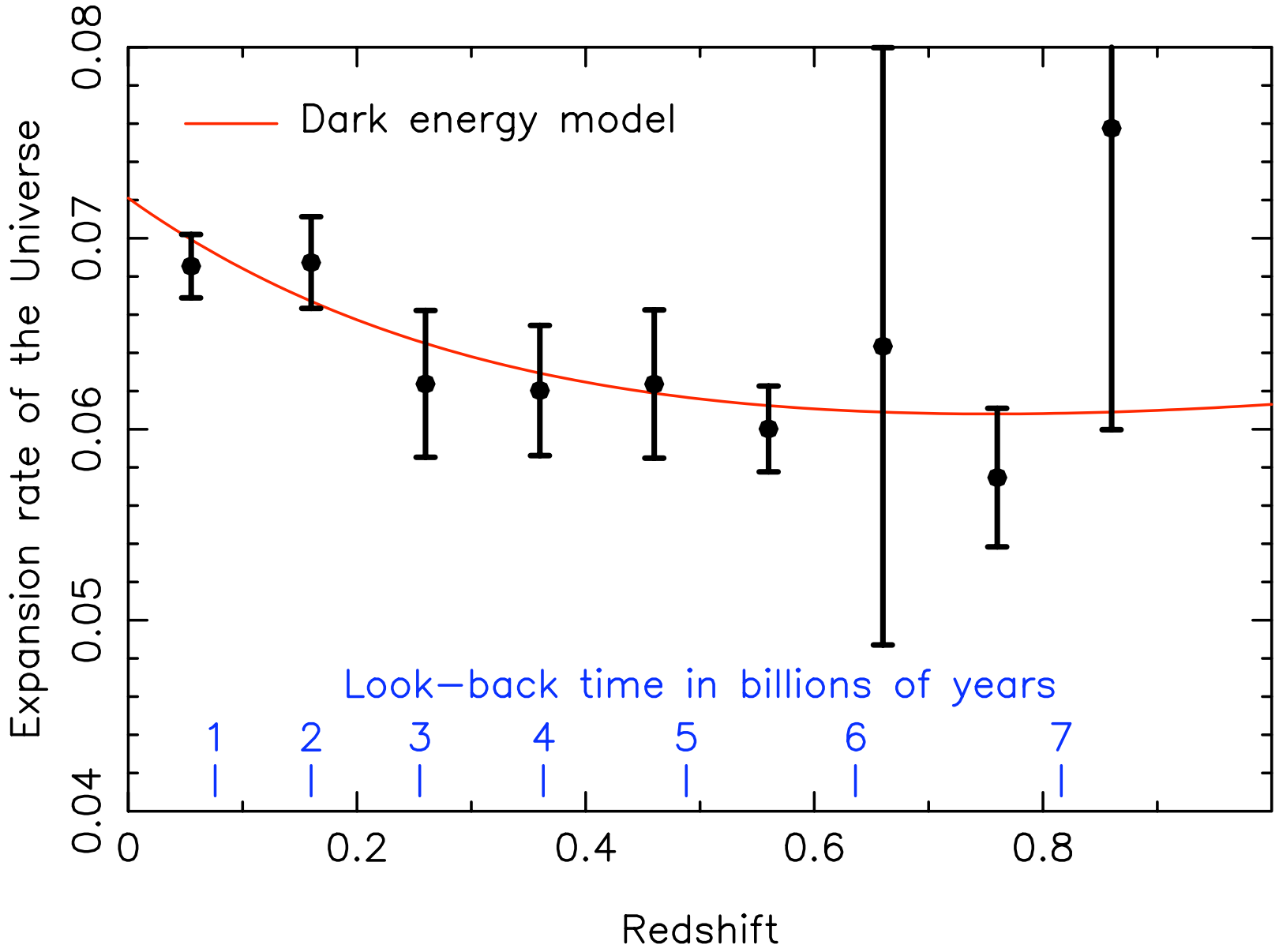


Distance-redshift relation



Our result : new evidence for dark energy



Dark energy : the "w" parameter

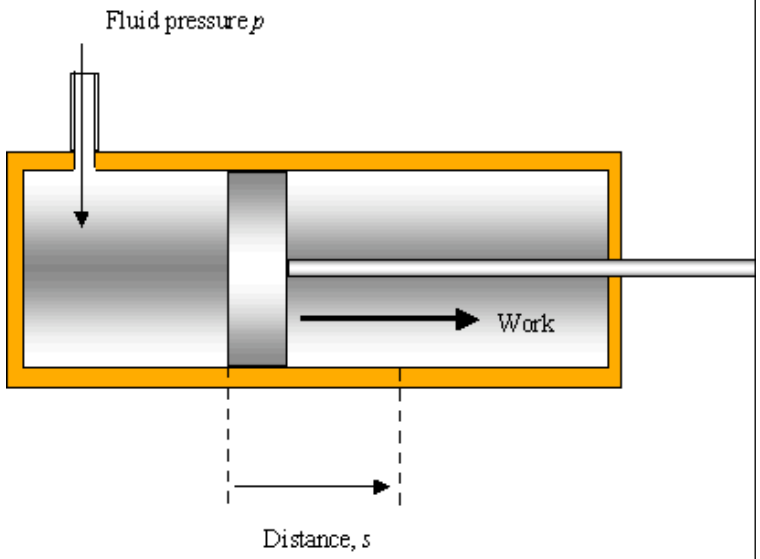
Key values ...

Matter : $w = 0$

Radiation : $w = 1/3$

Cosmological constant : $w = -1$

Accelerating fluid : $w < -1/3$



Physics of dark energy ...

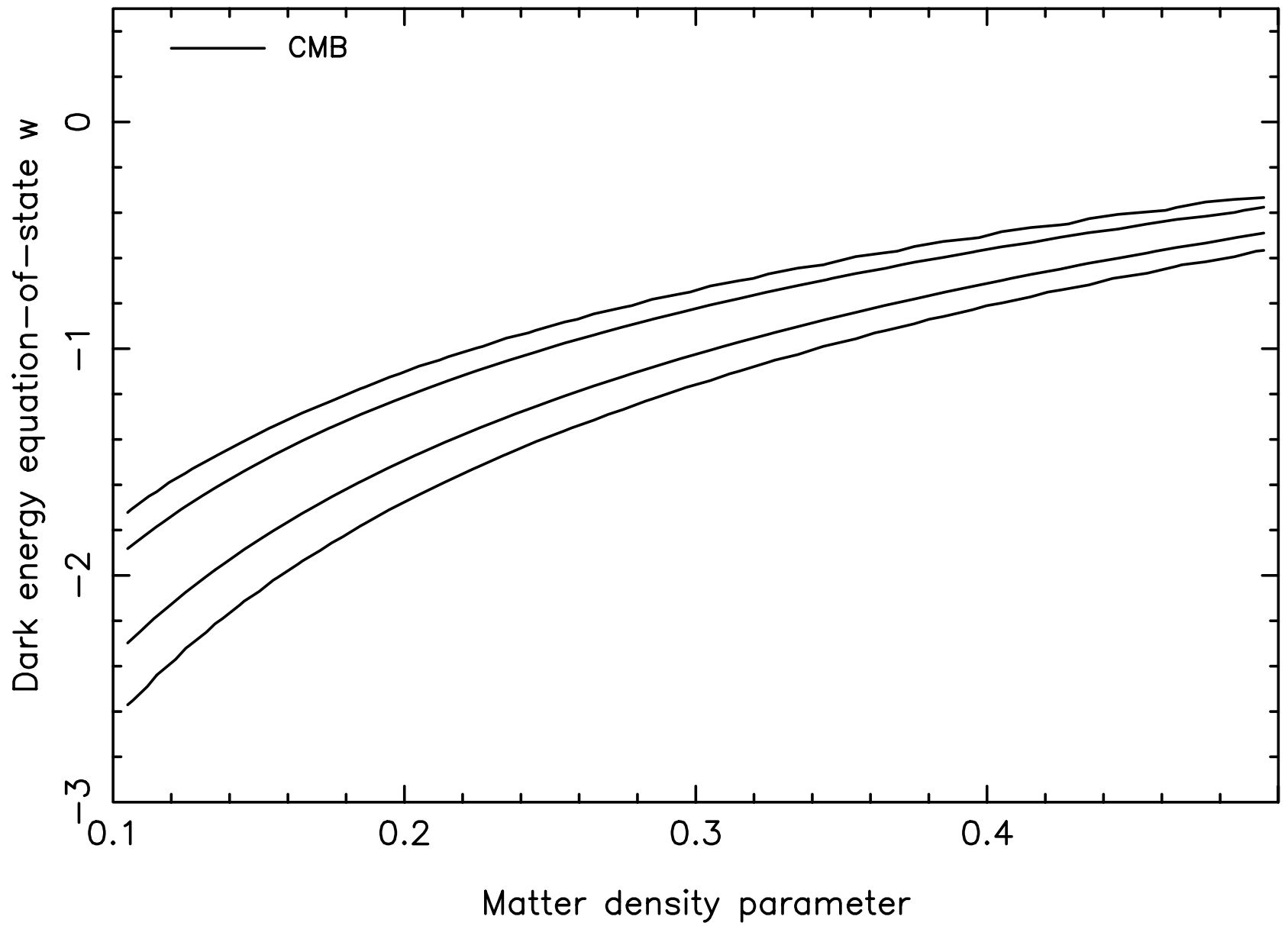
Equation of state : $P = w\,\rho$

Conservation of energy : $dE = d(\rho\, a^3) = -p\, d(a^3)$

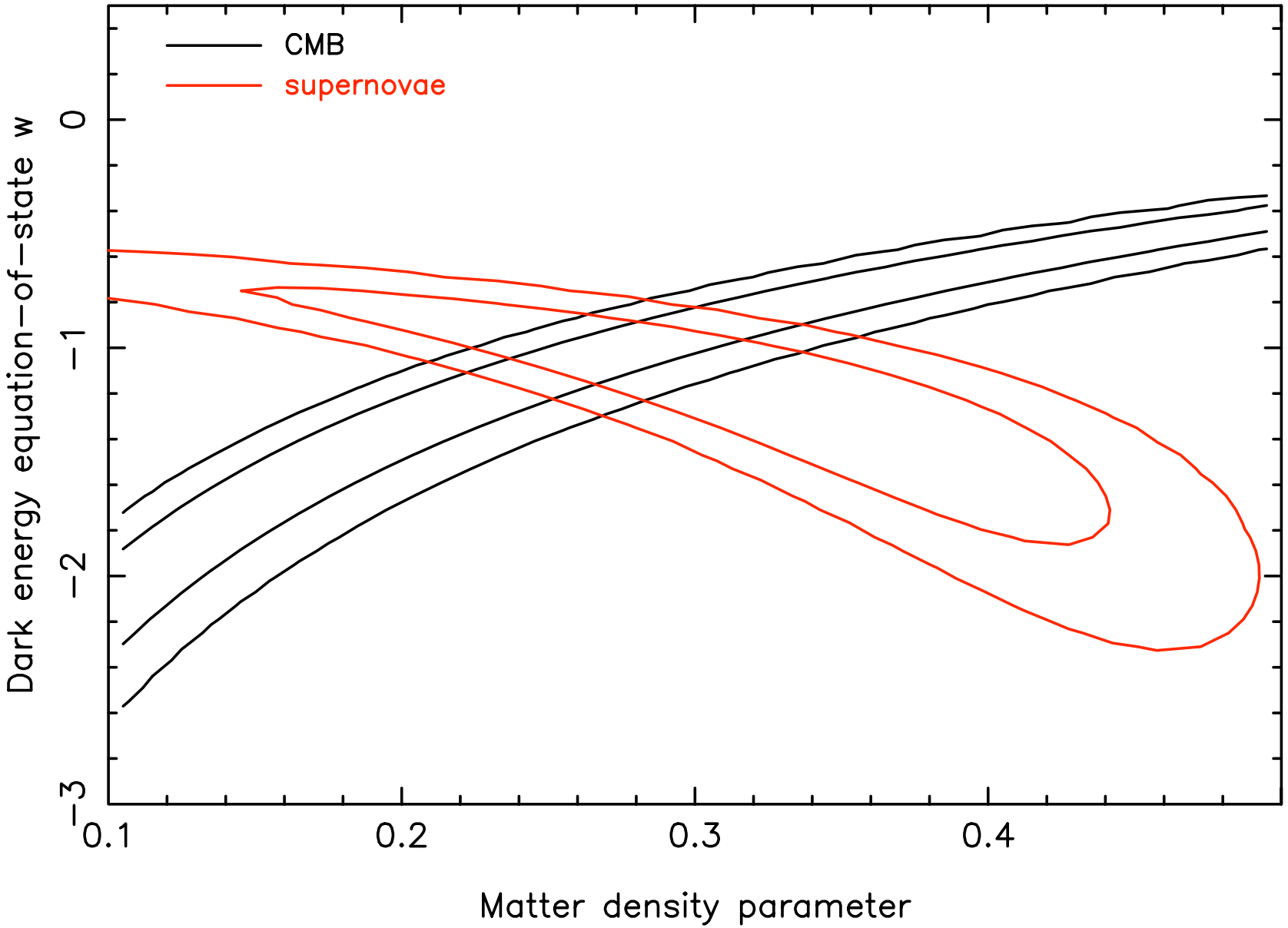
Re-arranging : $\rho \propto a^{-3(1+w)}$

Friedmann equation : $da/dt \propto a^{-(1+3w)/2}$

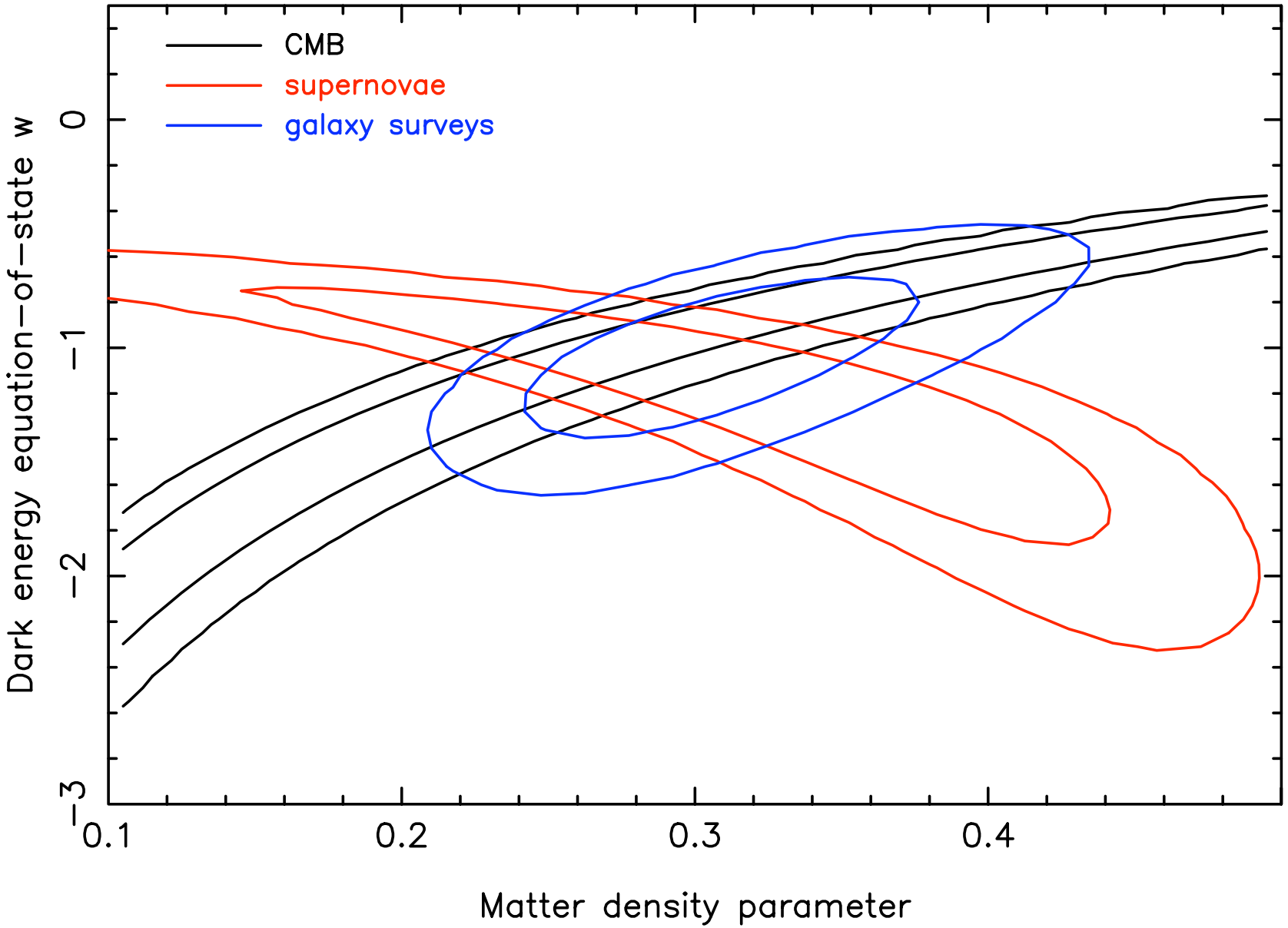
Cosmological data working together



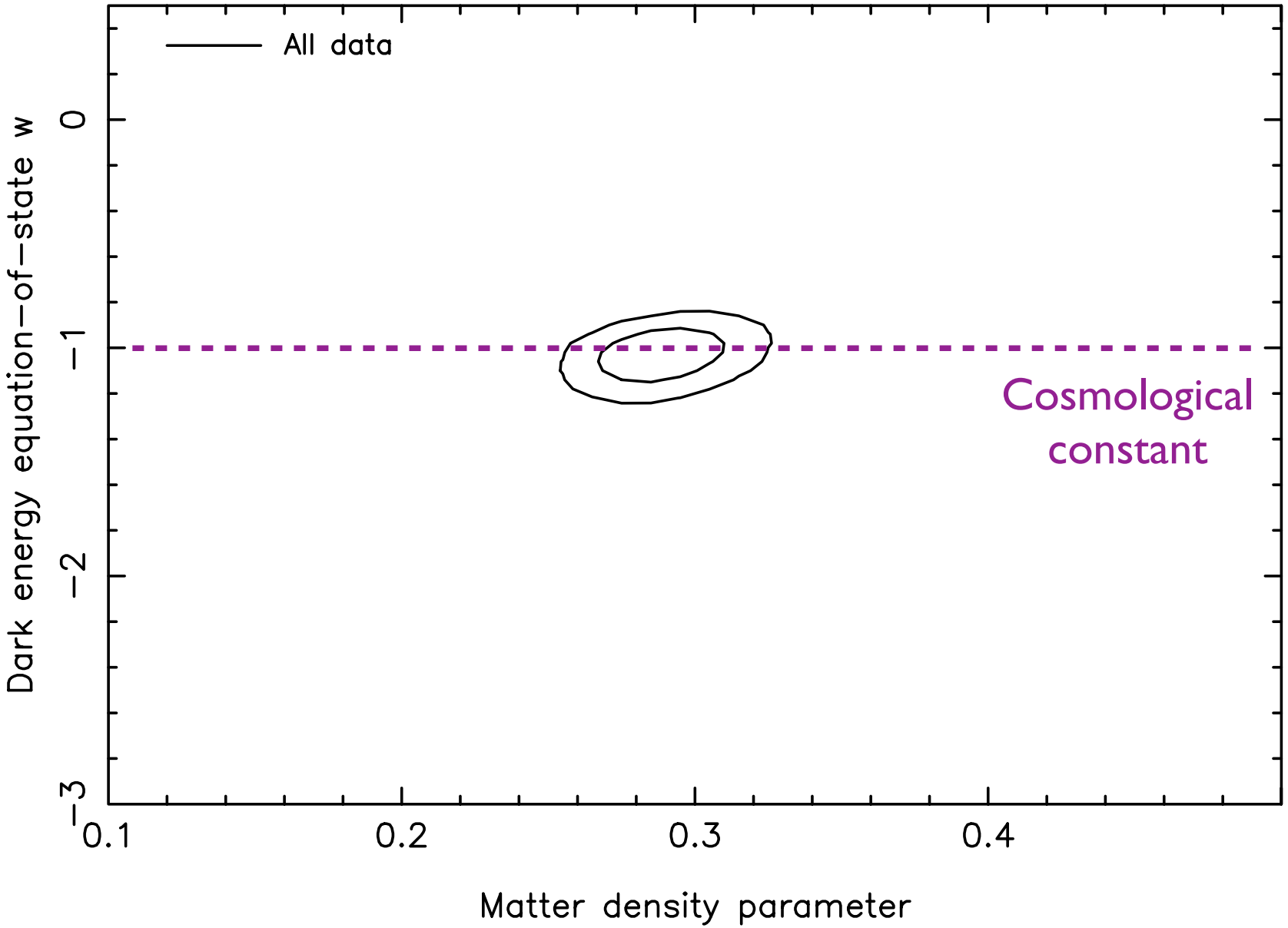
Cosmological data working together



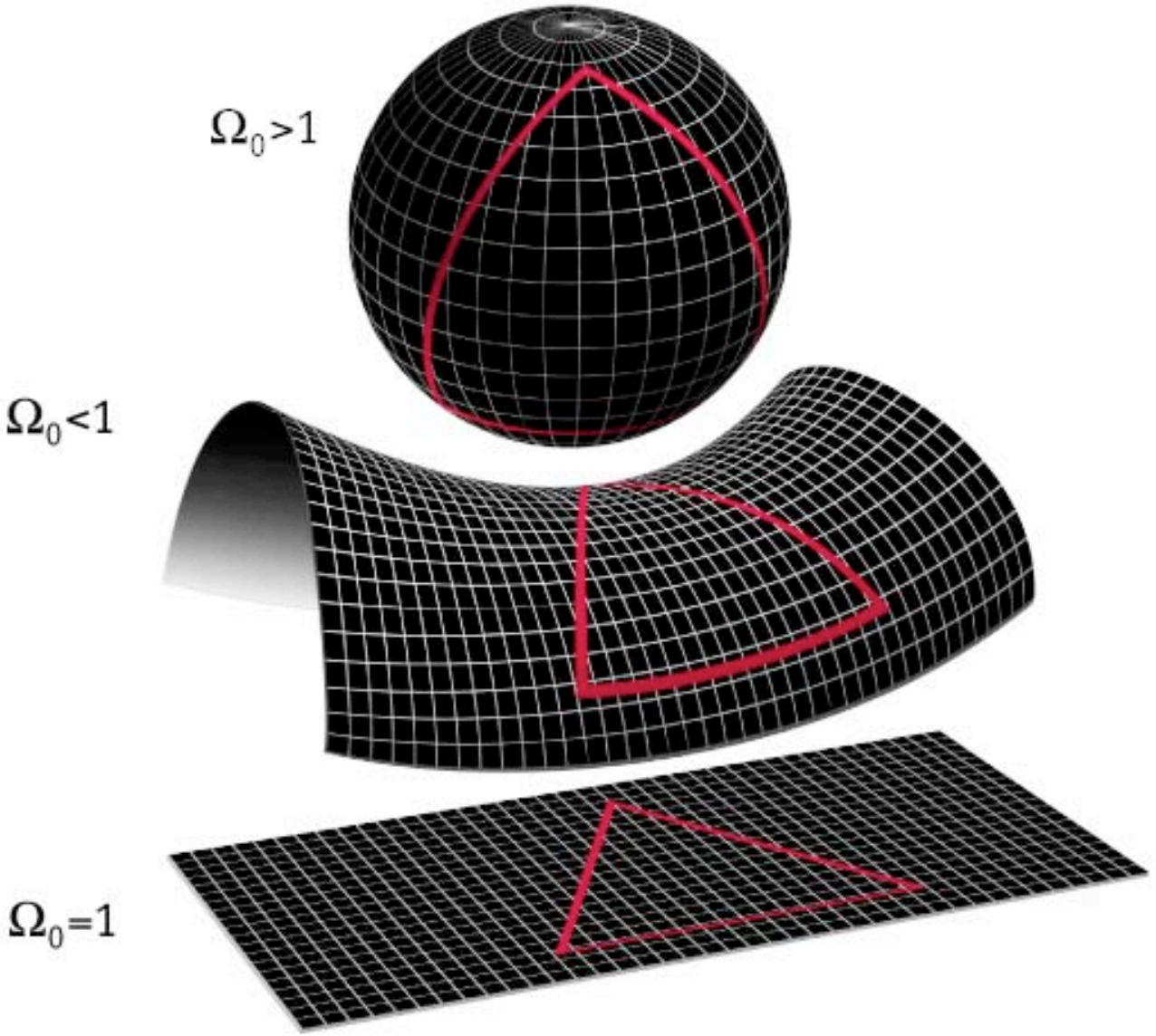
Cosmological data working together



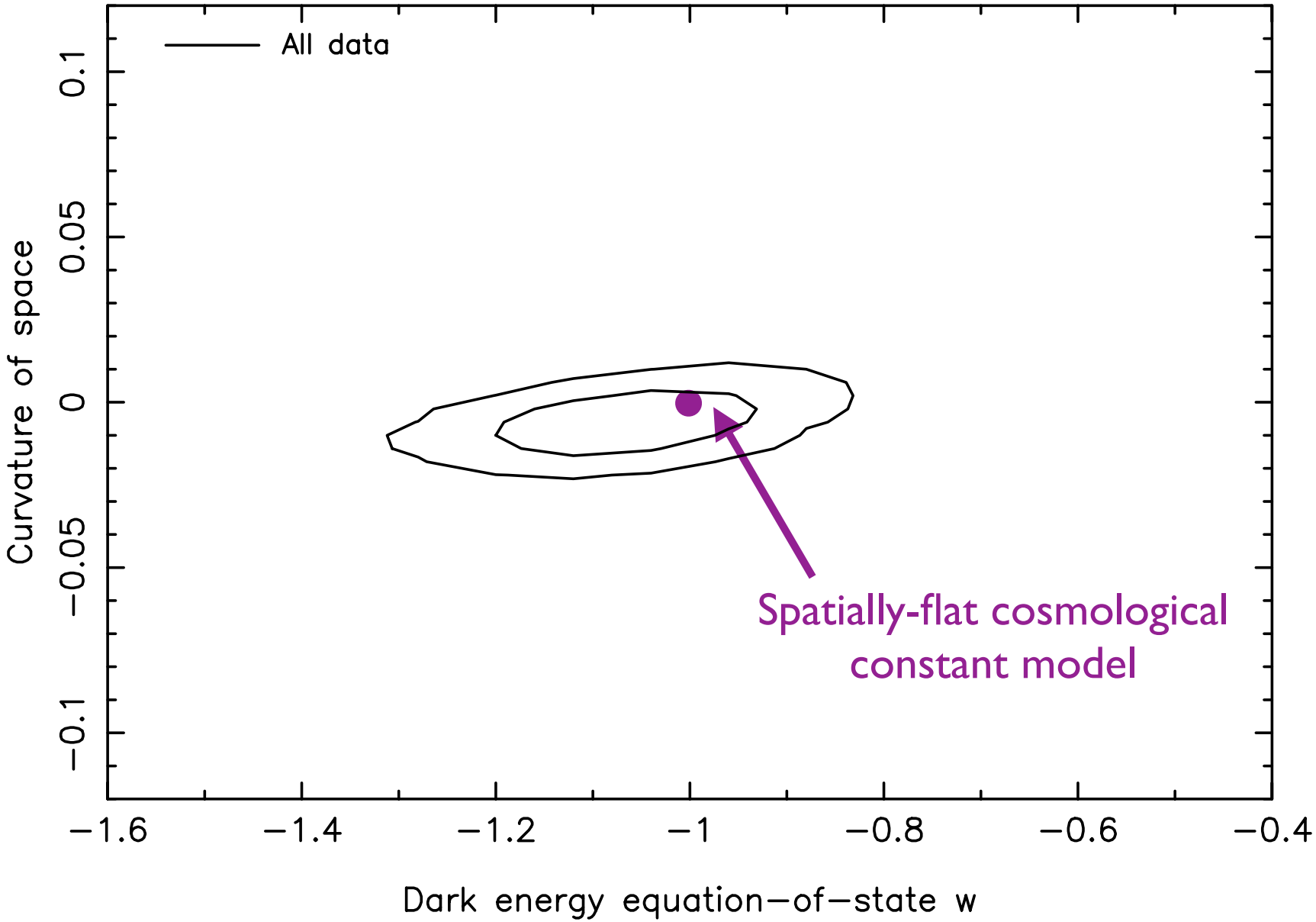
Cosmological data working together



Curvature of space



Curvature of space



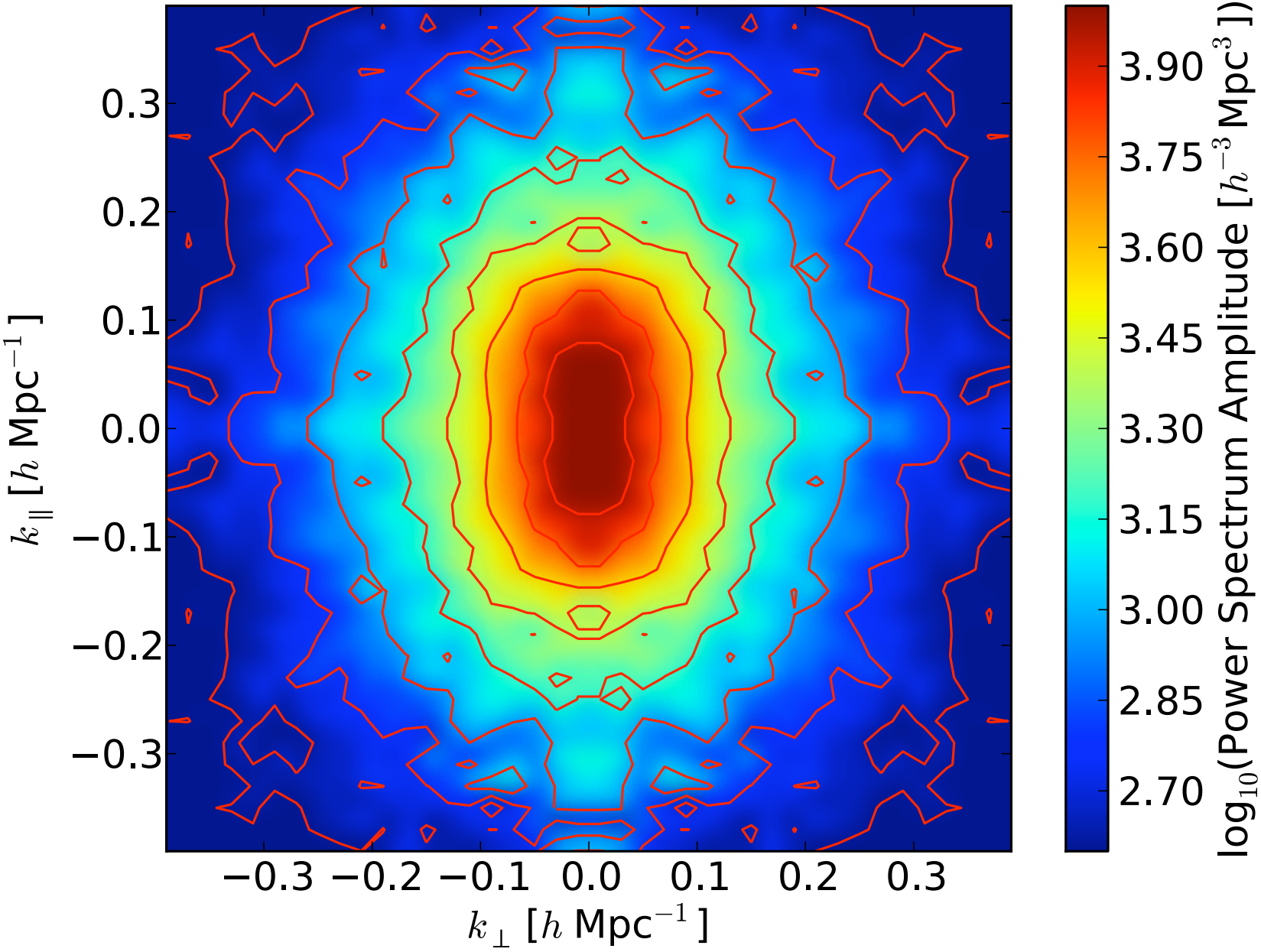
Galaxy flows

observer

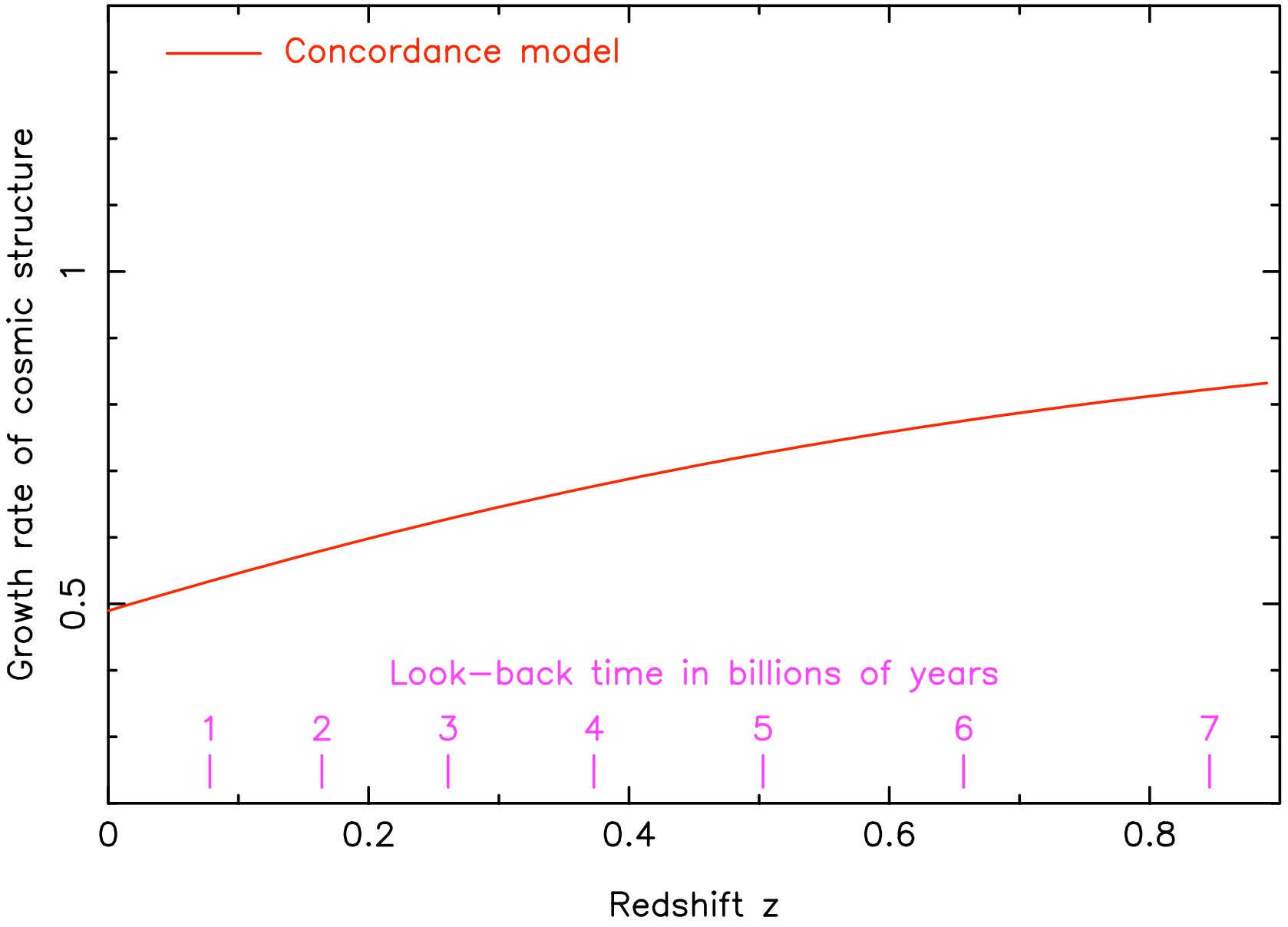
Extra redshifts

Extra blueshifts

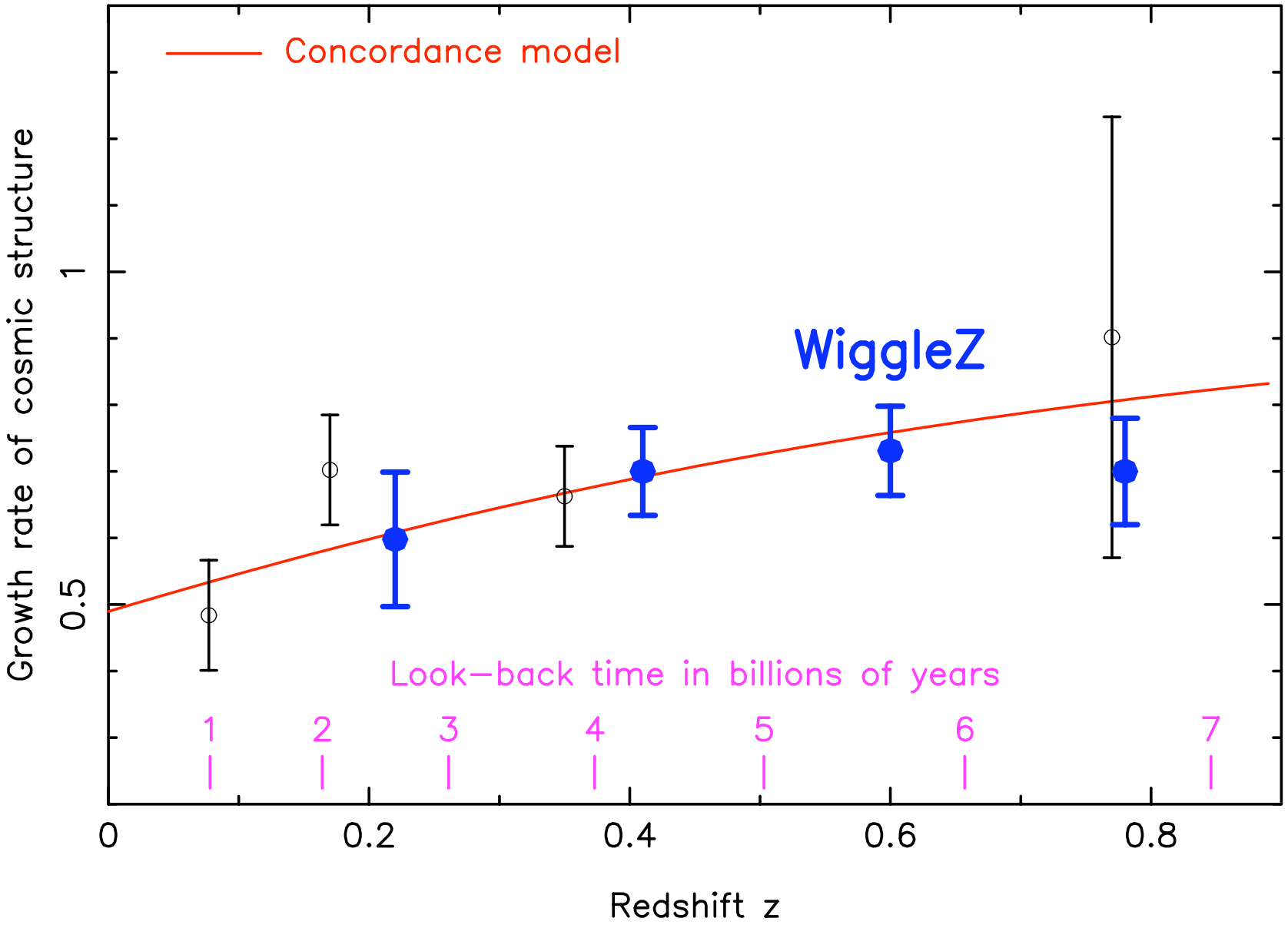
Galaxy flows in WiggleZ



Galaxy flows in WiggleZ



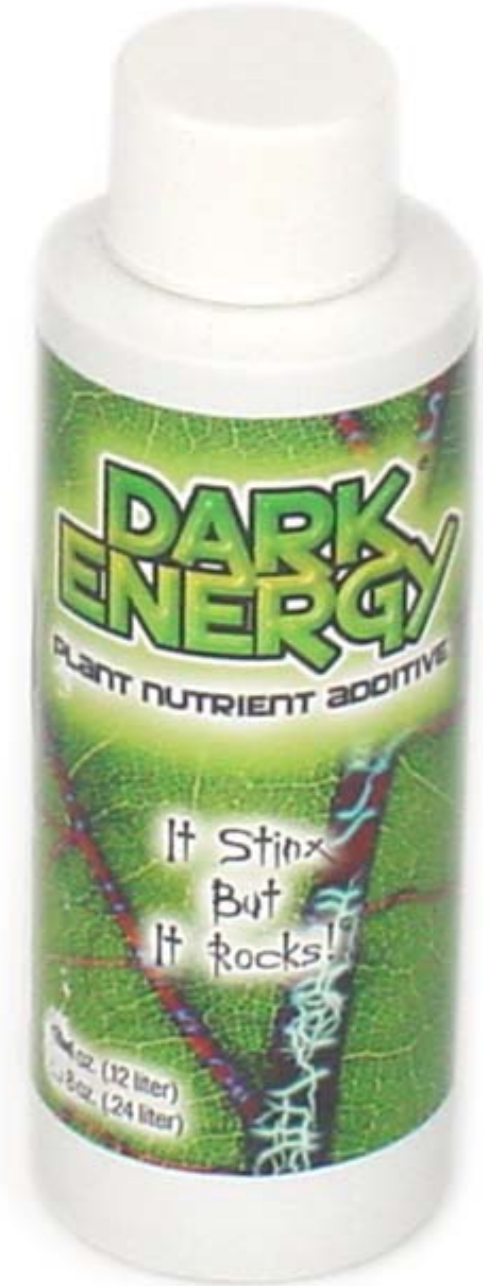
Galaxy flows in WiggleZ



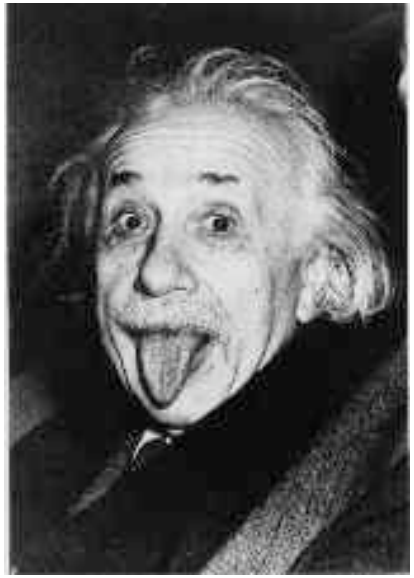
Summary of results from WiggleZ

- Large galaxy surveys offer a powerful means to test the cosmological model
- Baryon acoustic oscillations measure cosmic distances to z=0.8 and provide cross-check with supernovae
- Galaxy flows 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?

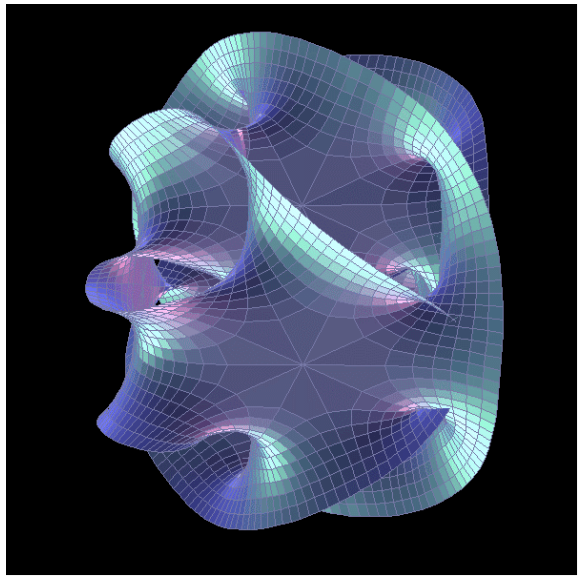
In that case , what is dark energy?



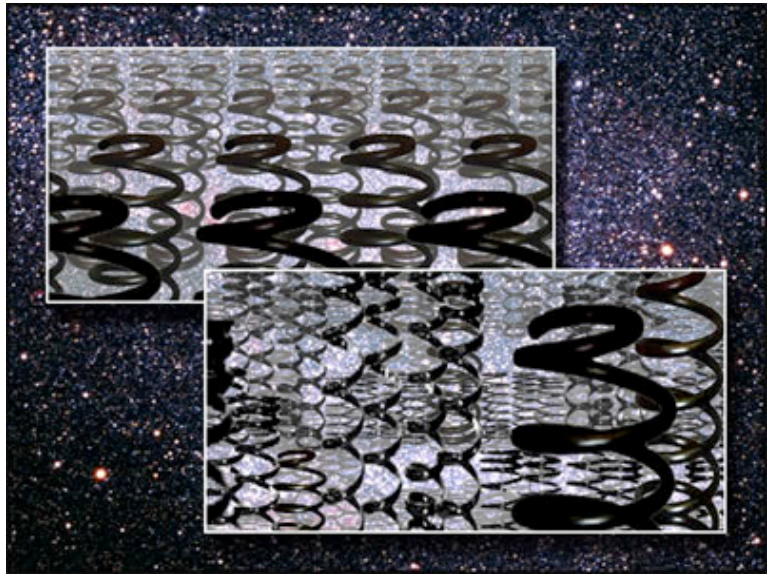
New laws of gravity?



Extra dimensions?



New cosmic materials?



Thank you!