

Void galaxies

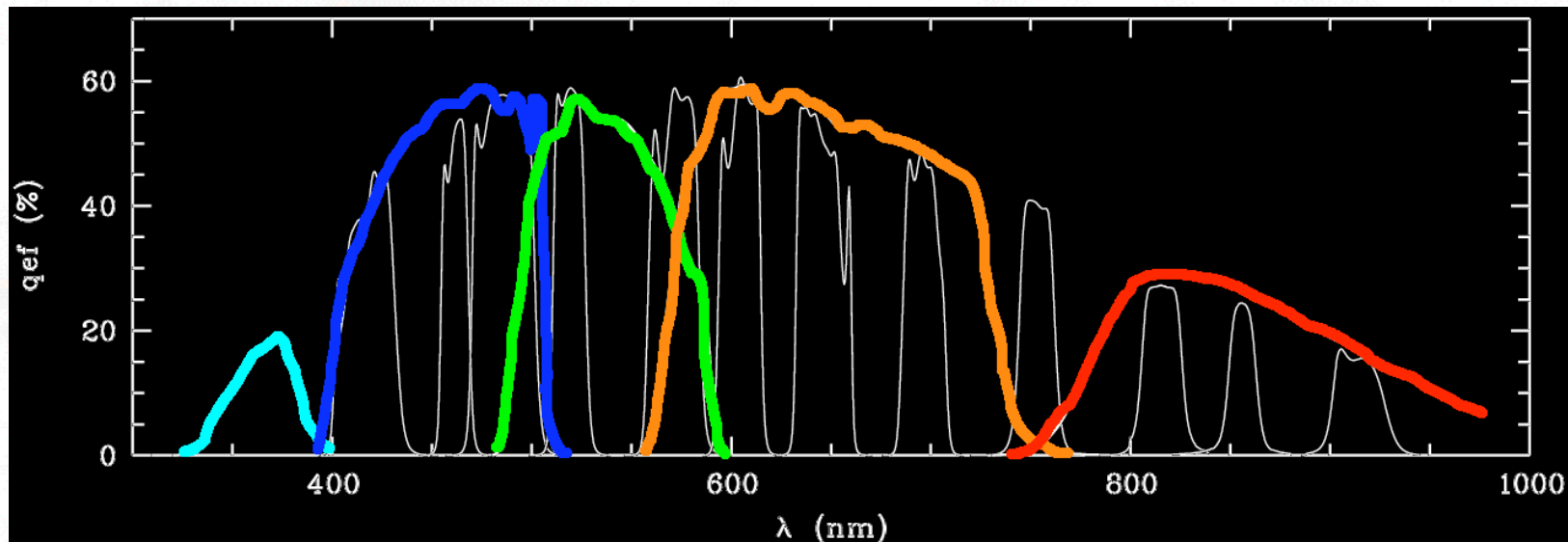
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Chris Rimes (JILA, Colorado), Marco Barden (Innsbruck)

The COMBO-17 survey

Classifying Objects by Medium-Band Observations

using 17 filters (PI: C. Wolf)



- ❖ 17 filters (5 broad-band, 12 medium-band): 40000 objects
- ❖ 4 fields with ESO/MPG Wide-Field Imager (0.5x0.5 degree):
→ CDFS, SGP, S11, A901
- ❖ Deep R-band image for lensing ($R < 25.5$) in best seeing conditions
- ❖ Photo-z's and SED classification complete to $R < 24$ ($\delta z = 0.01-0.03$)

The local galaxy density contrast in three COMBO-17 survey fields

$$\delta_g = \frac{\rho_g - \bar{\rho}_g}{\bar{\rho}_g}$$

Usually measured in spheres with a radius of $8 h^{-1}\text{Mpc}$, but in COMBO-17 $\sigma_z/(1+z)=0.02 \Rightarrow$ impossible to calculate density contrasts in small spheres

The local galaxy density contrast in three COMBO-17 survey fields

- In each field **count galaxies** in small redshift bins (e.g. bins of $\Delta z=0.02$ in steps of $\delta z=0.005$)
- Estimate **mean density** by fitting the mean of all three fields
- Correct counts for **different redshift accuracies**
- Estimate **luminosity function** for different galaxy subsamples in different environments

Influence of redshift errors on determination of δ_g

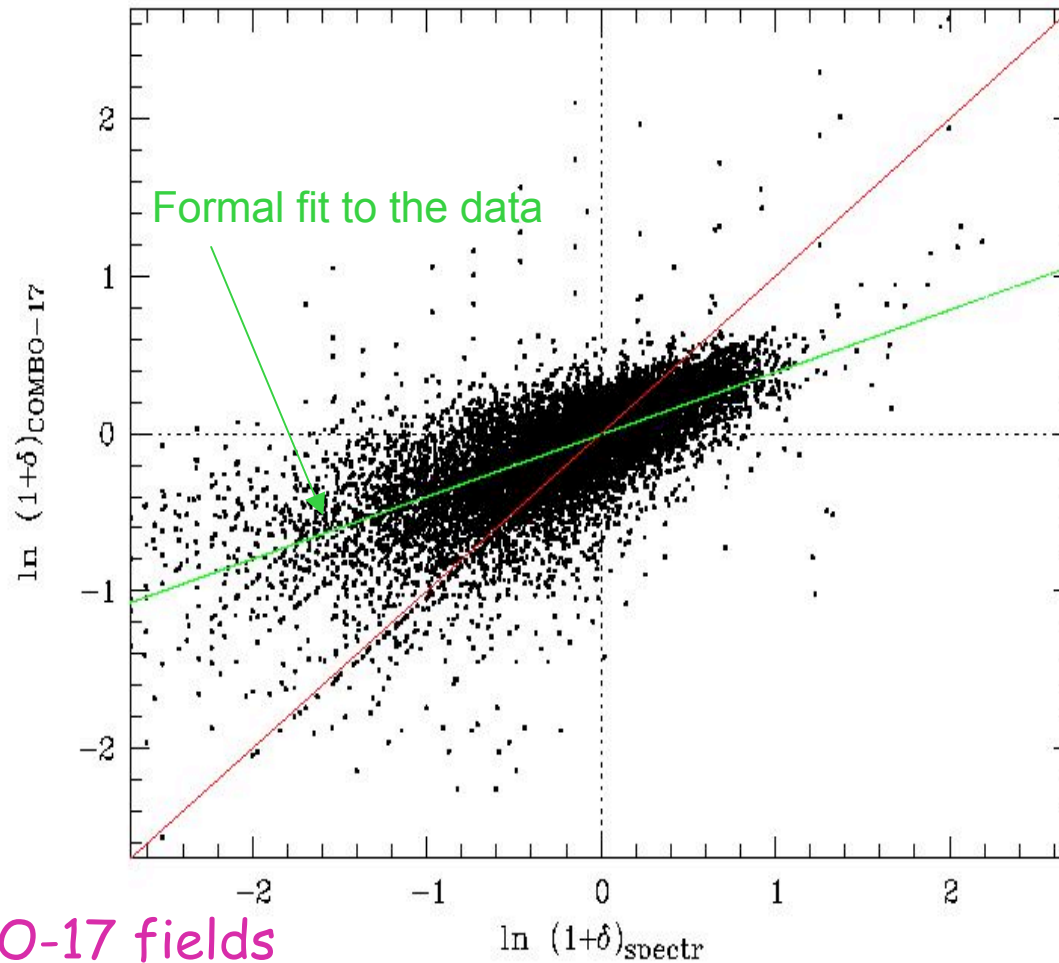
To study the influence on photometric redshift errors we use 80 mock COMBO-17 surveys.

For each of these we:

- calculate density contrast for "spectroscopic" mock sample
- assign redshift errors to each galaxy
- repeat calculation of density contrasts for photometric redshifts (by "observing" the mock)

Influence of redshift errors on determination of δ_g

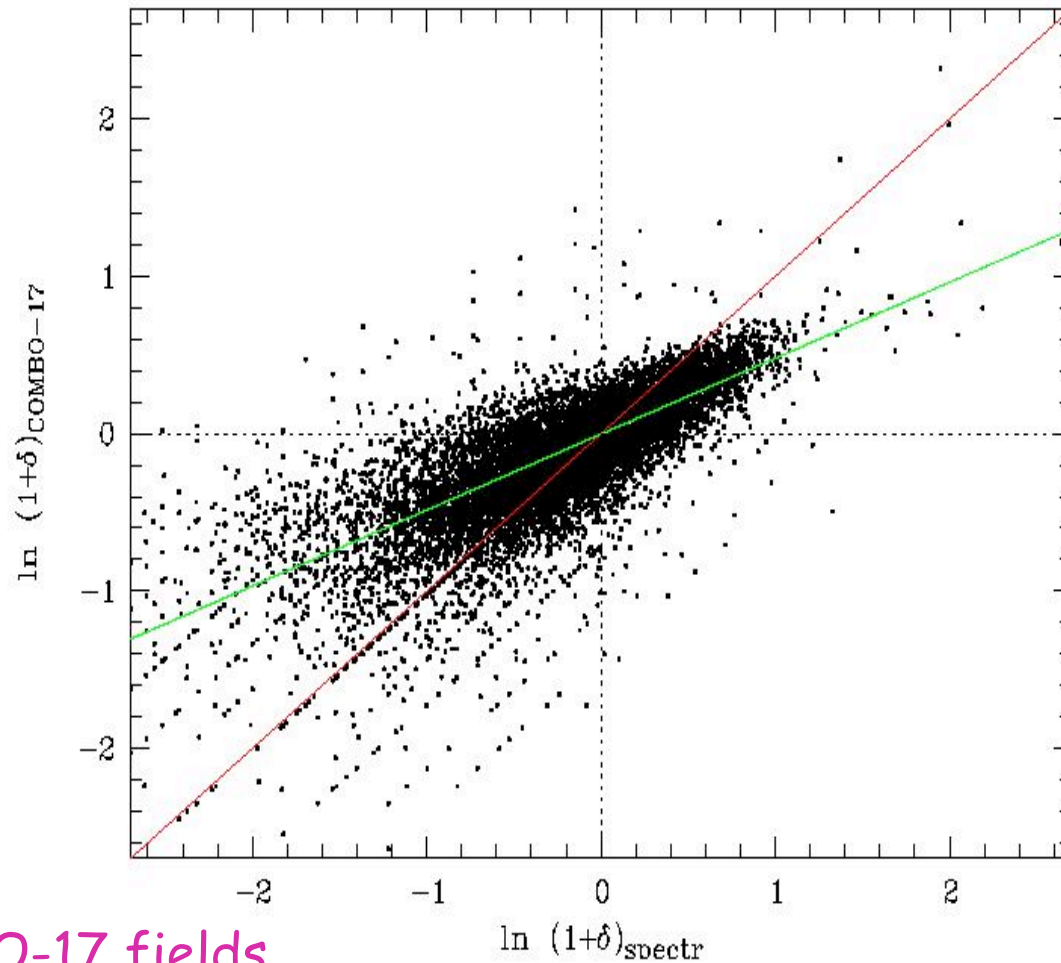
all galaxies



80 mock COMBO-17 fields

Influence of redshift errors on determination of δ_g

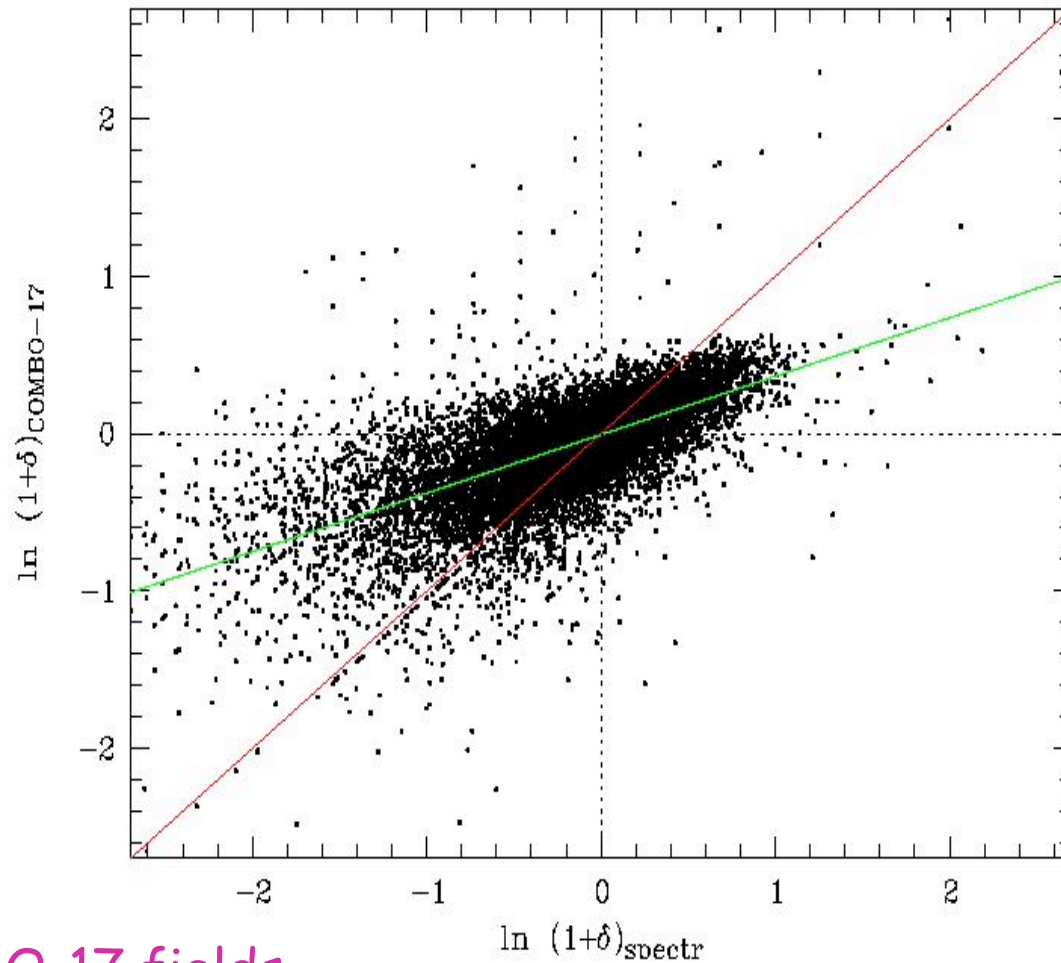
red galaxies



80 mock COMBO-17 fields

Influence of redshift errors on determination of δ_g


blue galaxies



80 mock COMBO-17 fields

Blurring red redshifts

- Redshift errors lead to suppression of signal (i.e. δ_g)
- For comparison of red and blue galaxies these need to have the same redshift error distribution

 make good redshifts worse: convolve redshift distribution of the red galaxies with blurring function

Blurring red redshifts

Blurring function can be found via the convolution theorem:

$$f(\varepsilon) = g(\varepsilon) * b(\varepsilon)$$

Here g and f are the redshift error distributions of red and blue galaxies, respectively

$$B(k) = F(k) / G(k)$$

Hence b can easily be found by dividing the Fourier transforms of f and g and transforming B back

Blurring red redshifts

$$f(\varepsilon) = \frac{1}{N_{gal}} \sum_{i=1}^{N_{gal}} \frac{1}{2\pi\sigma_i^2} \exp\left(-\frac{\varepsilon^2}{2\sigma_i^2}\right)$$

For COMBO-17 this can be approximated by a Lorentzian:

$$f(\varepsilon) = \frac{W / 2\pi}{\varepsilon^2 + \frac{W^2}{4}}$$

Blurring red redshifts

The Fourier transform of a Lorentzian is

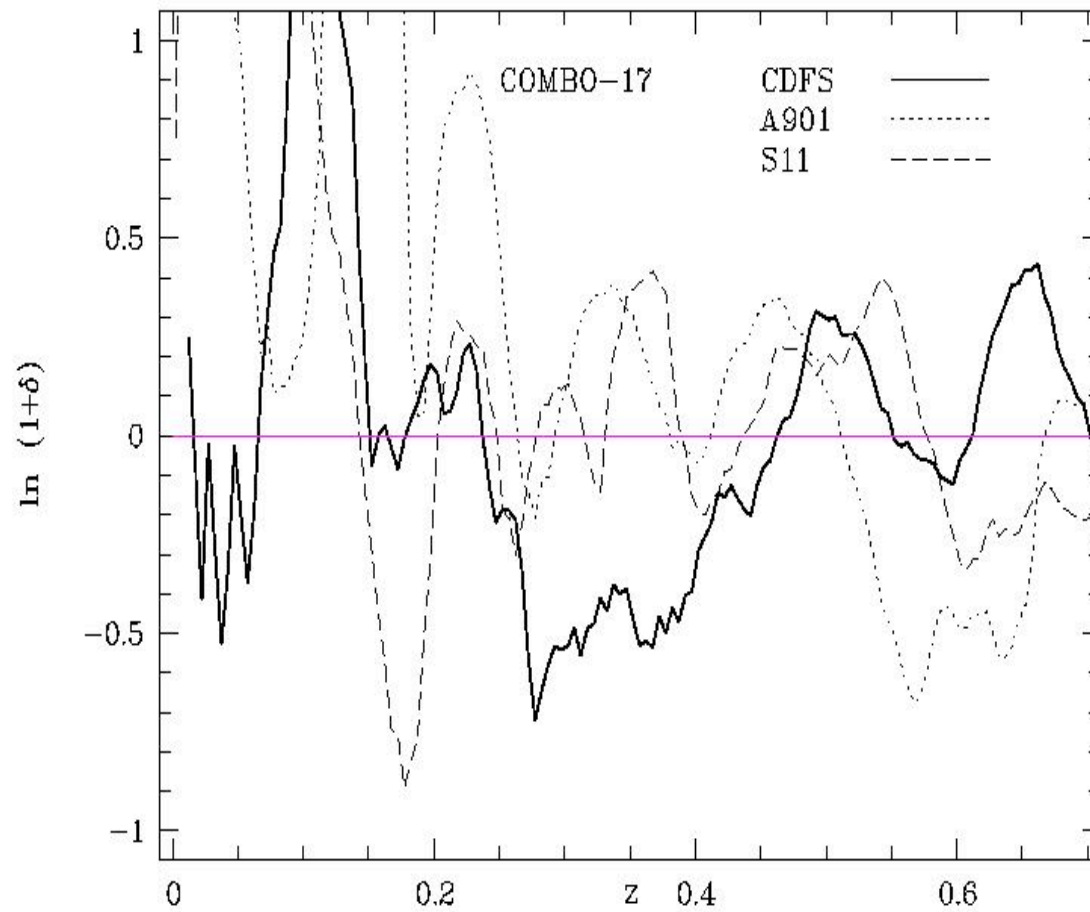
$$F(k) = \exp(-W |k| / 2)$$

So the required blurring function is

$$b(\varepsilon) = \frac{\Delta W / 2\pi}{\varepsilon^2 + \frac{(\Delta W)^2}{4}}$$

Where ΔW is the difference in width of the two populations

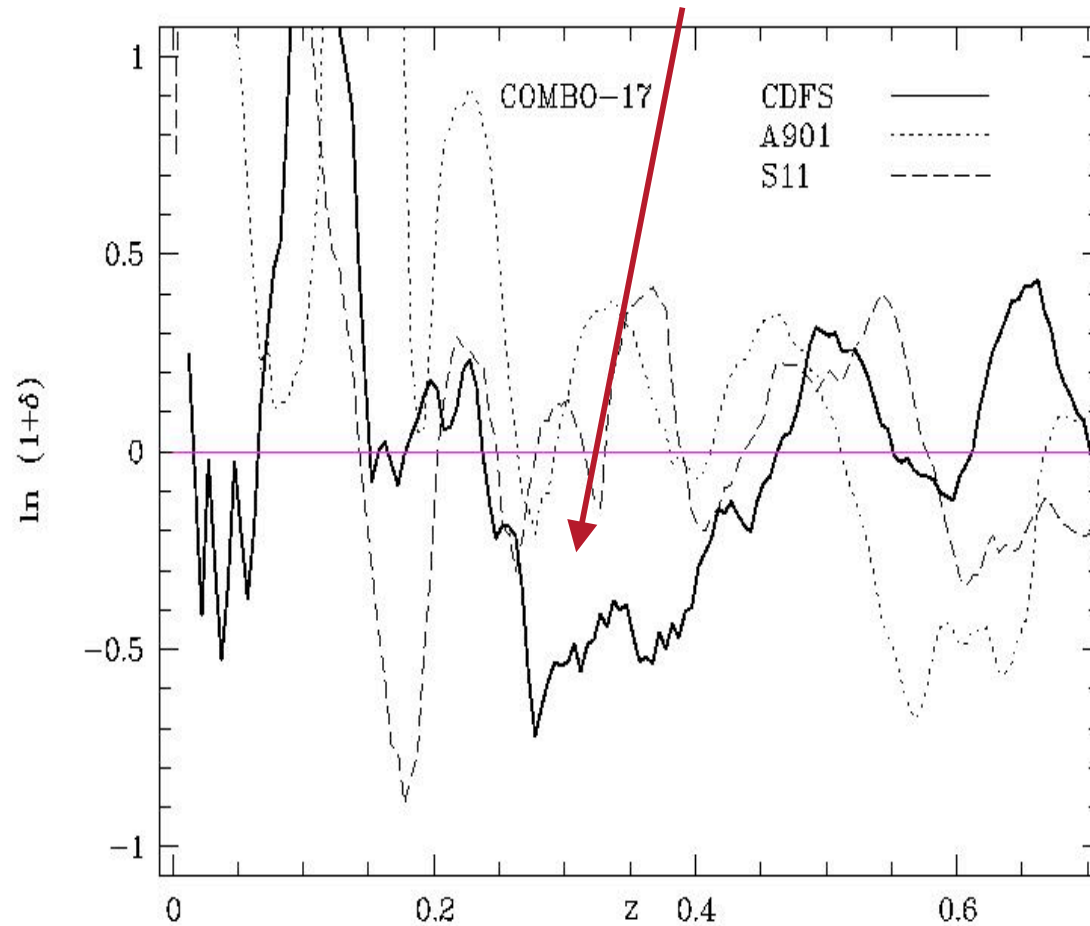
δ_g for three COMBO-17 fields



$\Delta z = 0.05$

δ_g for three COMBO-17 fields

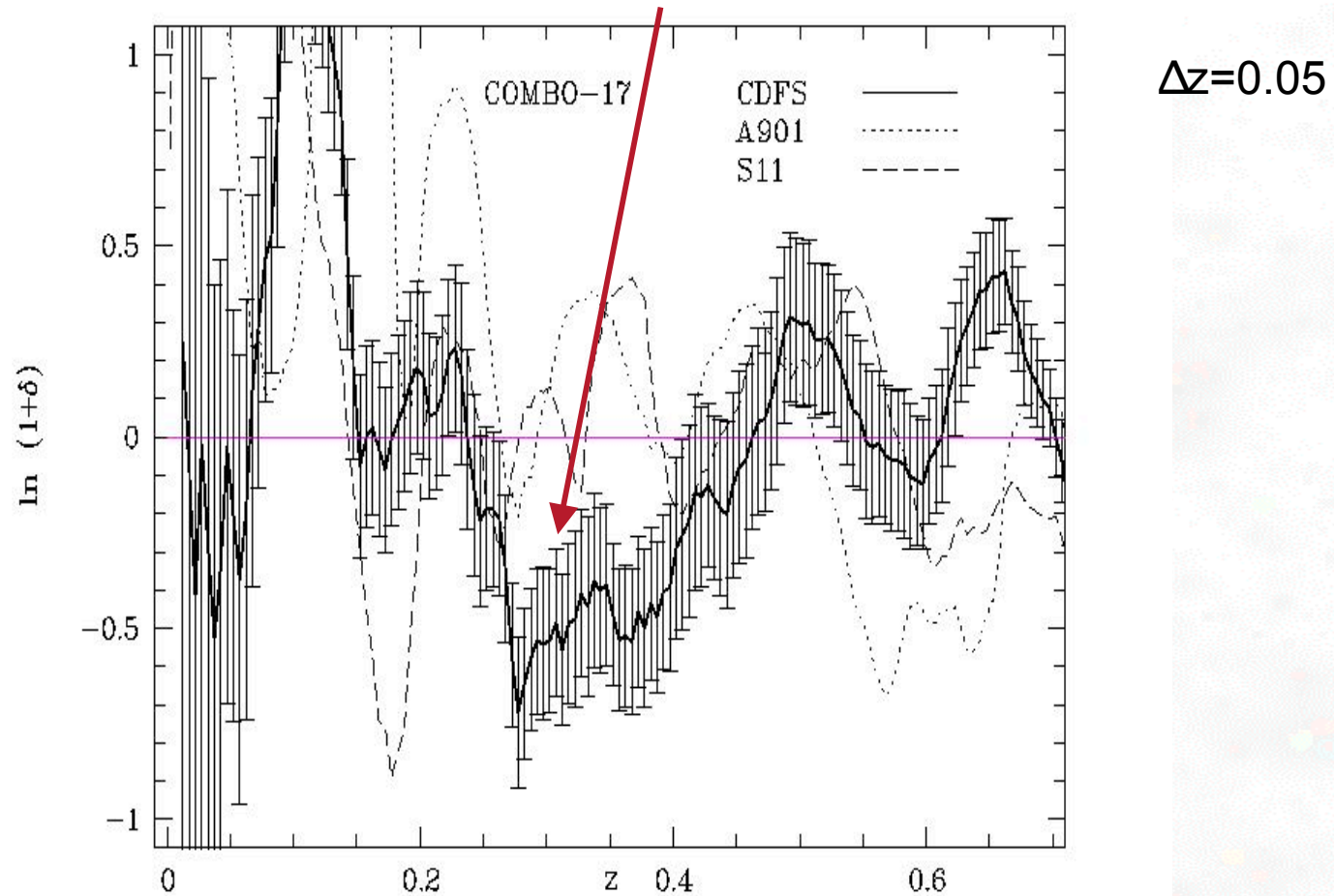
The CDFS at $0.25 < z < 0.4$: A hole in the sky!



$\Delta z = 0.05$

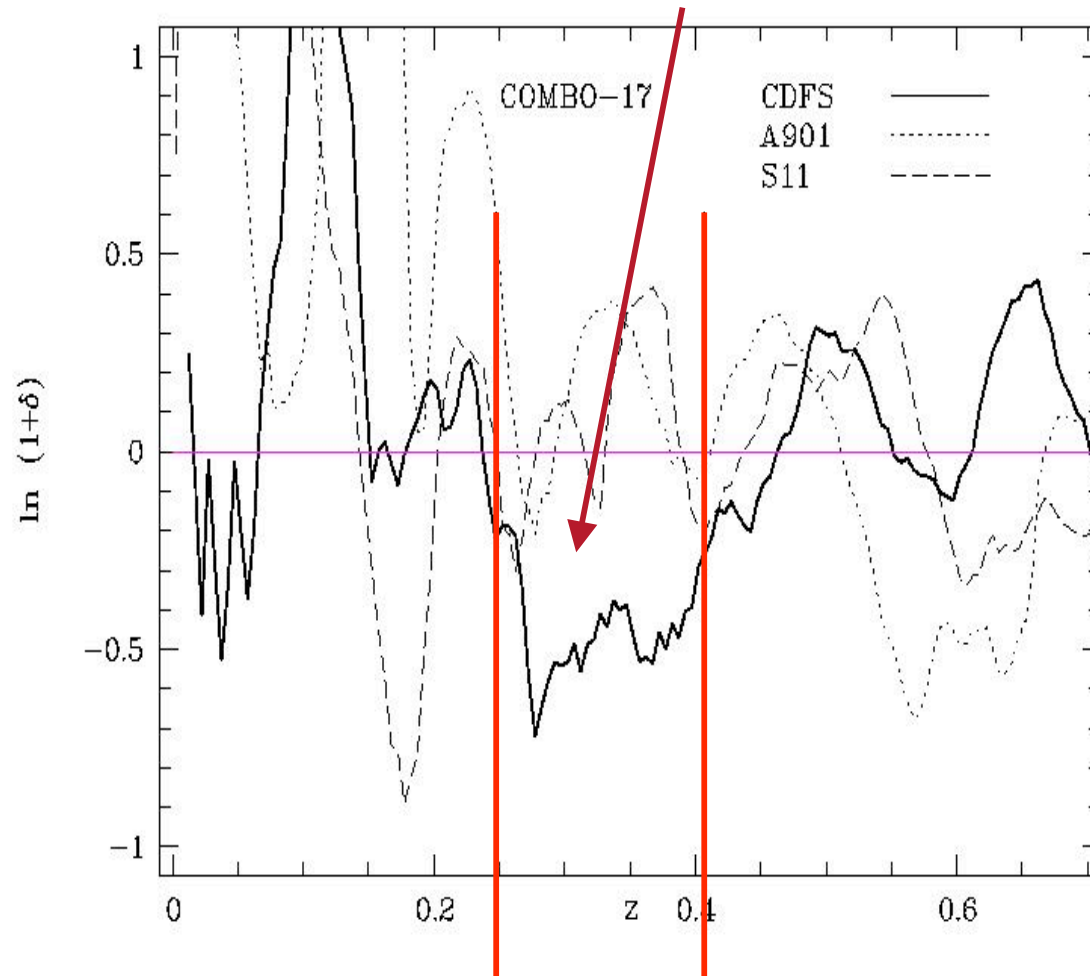
δ_g for three COMBO-17 fields

The CDFS at $0.25 < z < 0.4$: A hole in the sky!

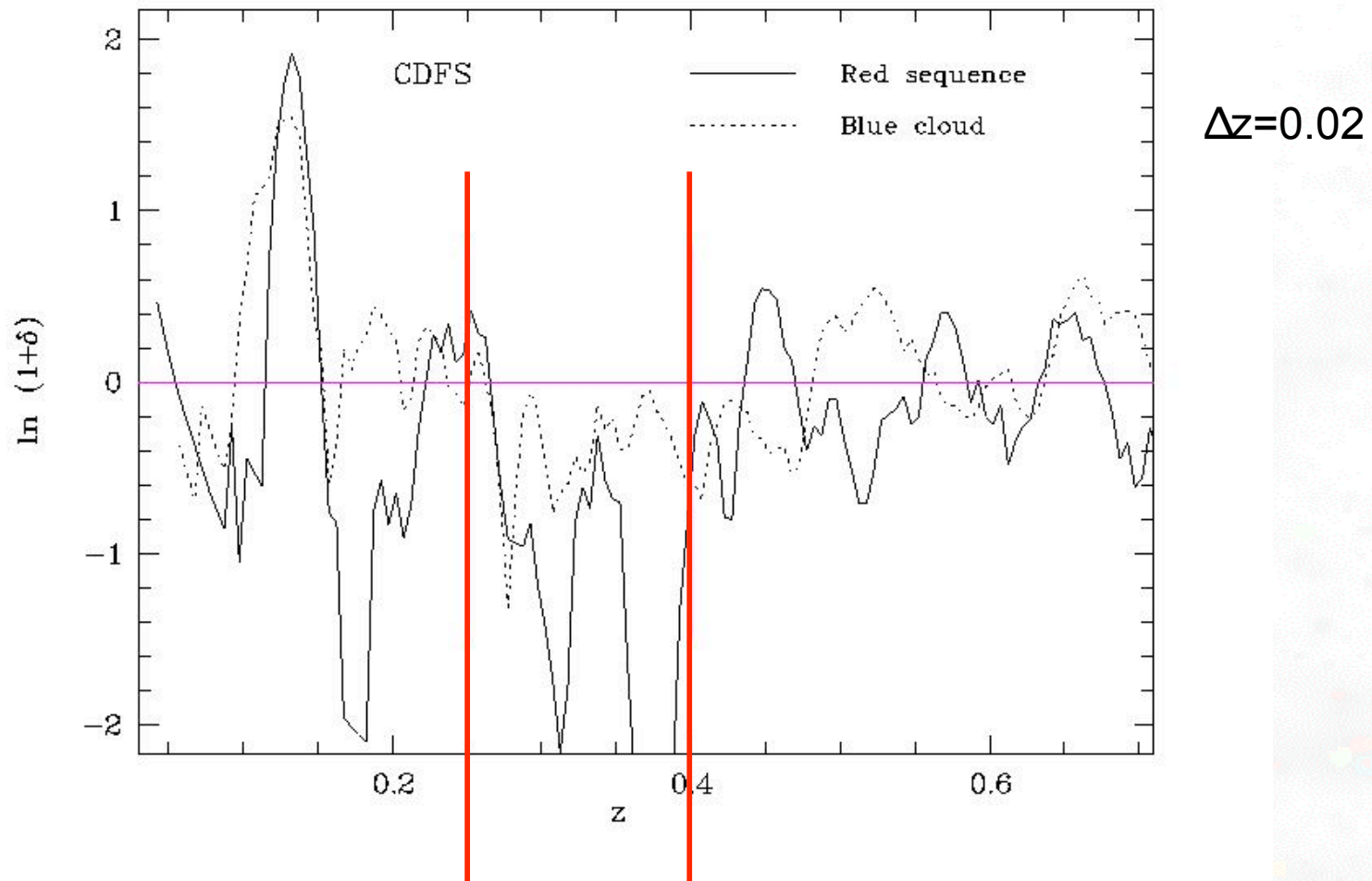


δ_g for three COMBO-17 fields

The CDFS at $0.25 < z < 0.4$: A hole in the sky!



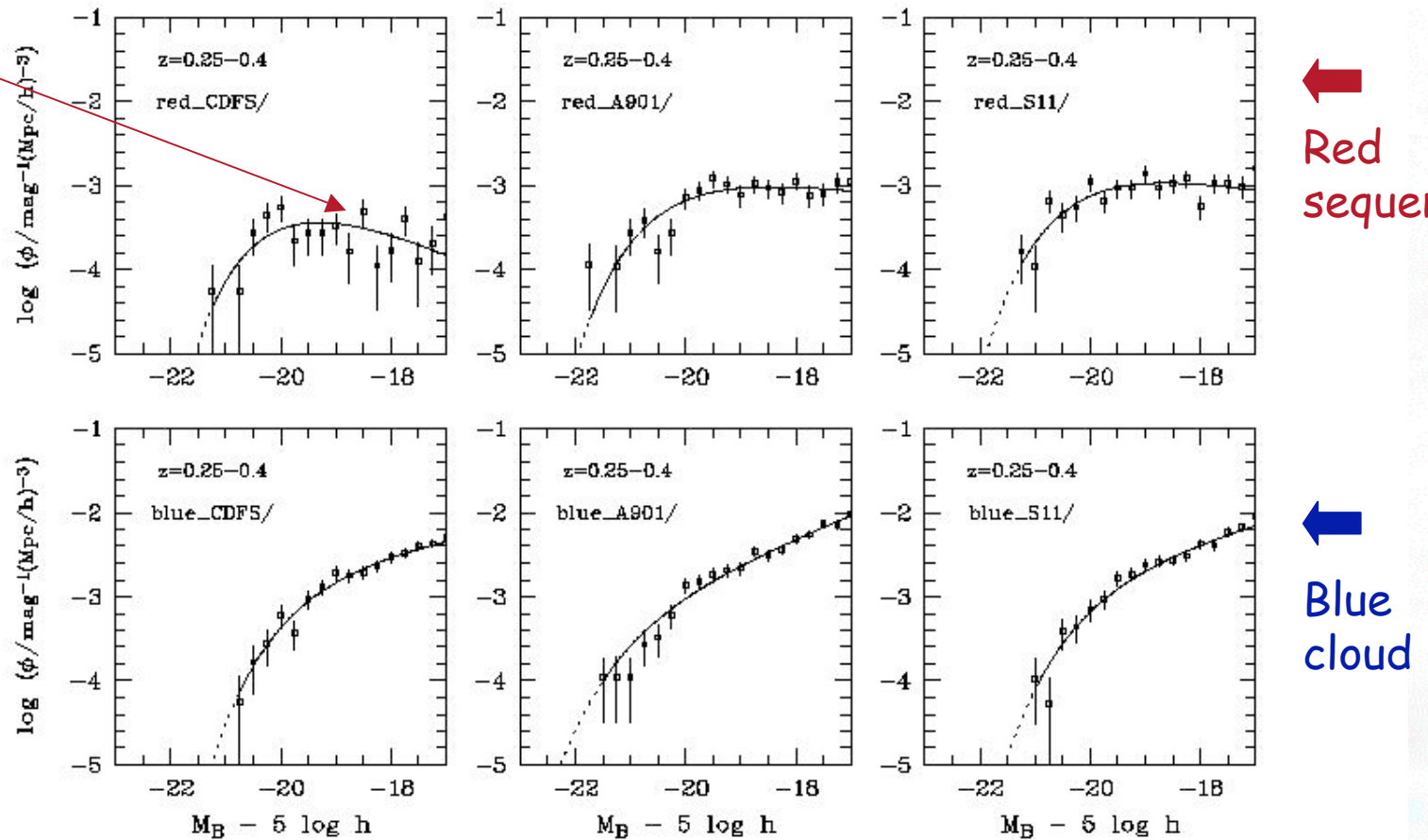
A hole in the sky in red and blue



Red sequences redshifts have been blurred in order to make them comparable to the blue cloud

The luminosity function in the three COMBO17 fields for $0.25 < z < 0.4$

Phleps et al. (2006)



Clear deficiency of faint red sequence galaxies in the underdense region!

Observational result

Using COMBO-17 at $0.25 < z < 0.4$ we observe similar general behaviour as Croton et al. (2004) do in the local universe:
underdense regions dominated by late-types, deficient of bright, early-type galaxies

But it is not clear whether the same is true at higher redshifts:
this will be one of the aims of the upcoming 'VST-16' project

Modelling void galaxies

Question: does the *global* environment effect galaxy properties as much as the *local* environment does ?

‘Global’: scales of order 10 Mpc

‘Local’: scales of order 1 Mpc

Simulating specific environments

Aim: simulate a structure for which there is lots of data:
the (core of the) Shapley supercluster with neighbouring voids using *constrained* initial conditions

We used nine constraints: 7 clusters and 2 voids

- A3558 is put at the center of the (50 Mpc) simulation box
- six more clusters were added:
A3562, A3556, A3571, A3560, A3559, A1736
- and two voids: -2σ and -3σ underdensities

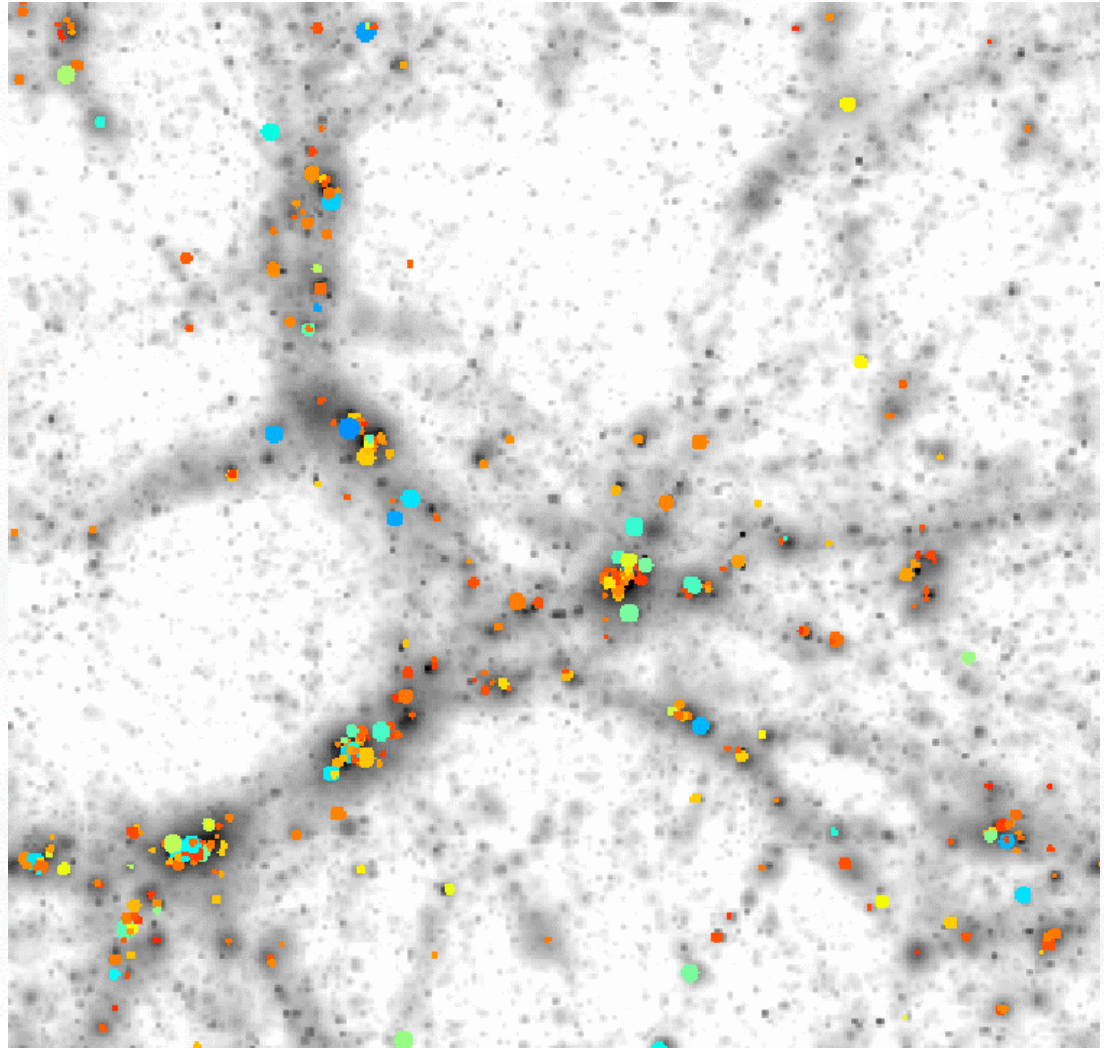
Initial conditions generated using Bertschinger's GRAFIC
N-body run by Vincenzo Antonuccio (Catania) using FLY
Galaxy formation modelling by EvK

Semi-numerical galaxy formation modelling

Ingredients:

- Cosmological model
- Halo formation and merger history
- Gas dynamics and radiative cooling
- Star formation and feedback
- Galaxy merger history
- Stellar population synthesis
- Dust modelling

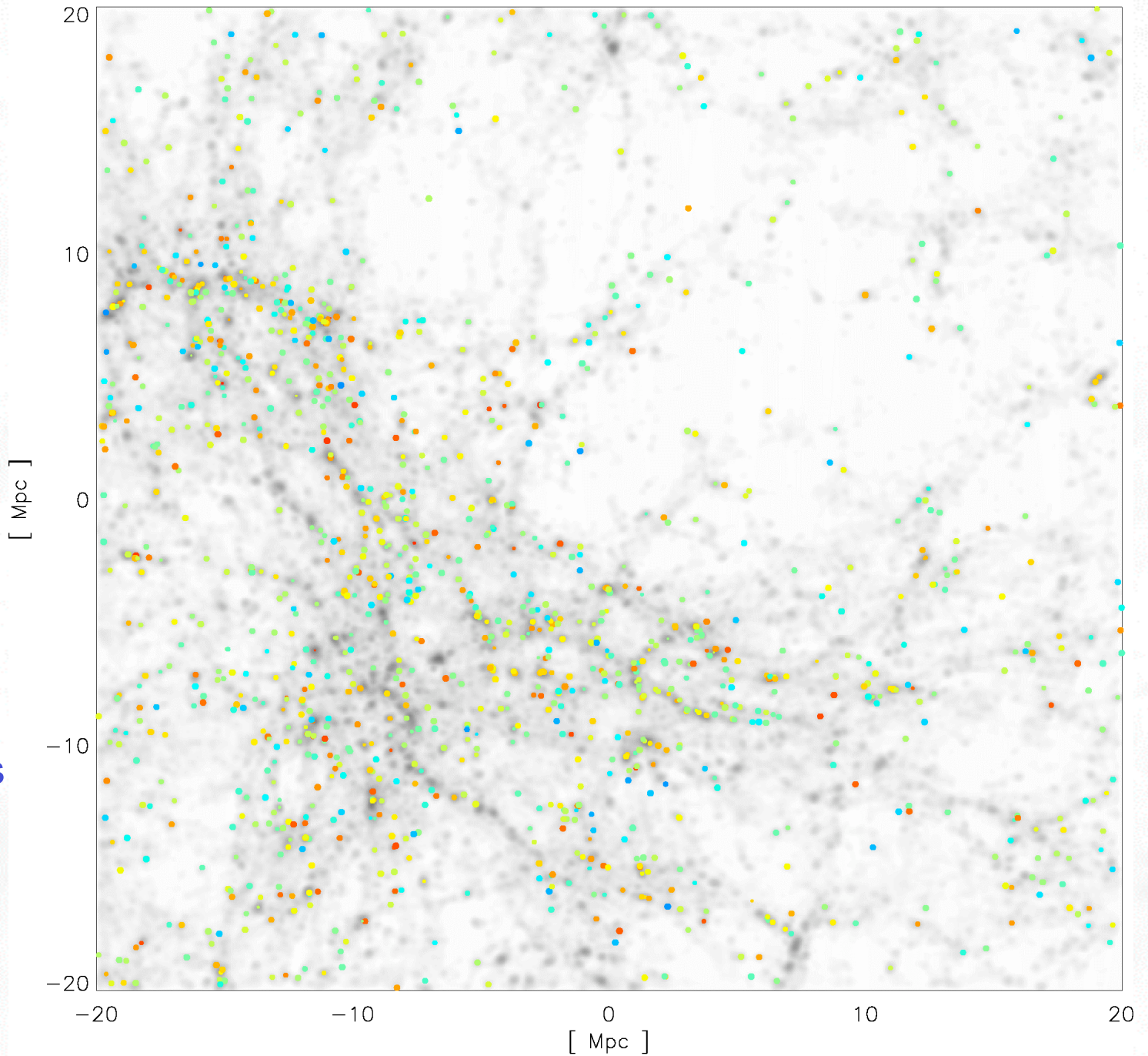
*Λ CDM model of van Kampen,
Rimes & Peacock (2006)*



Core of Shapley + 2 voids

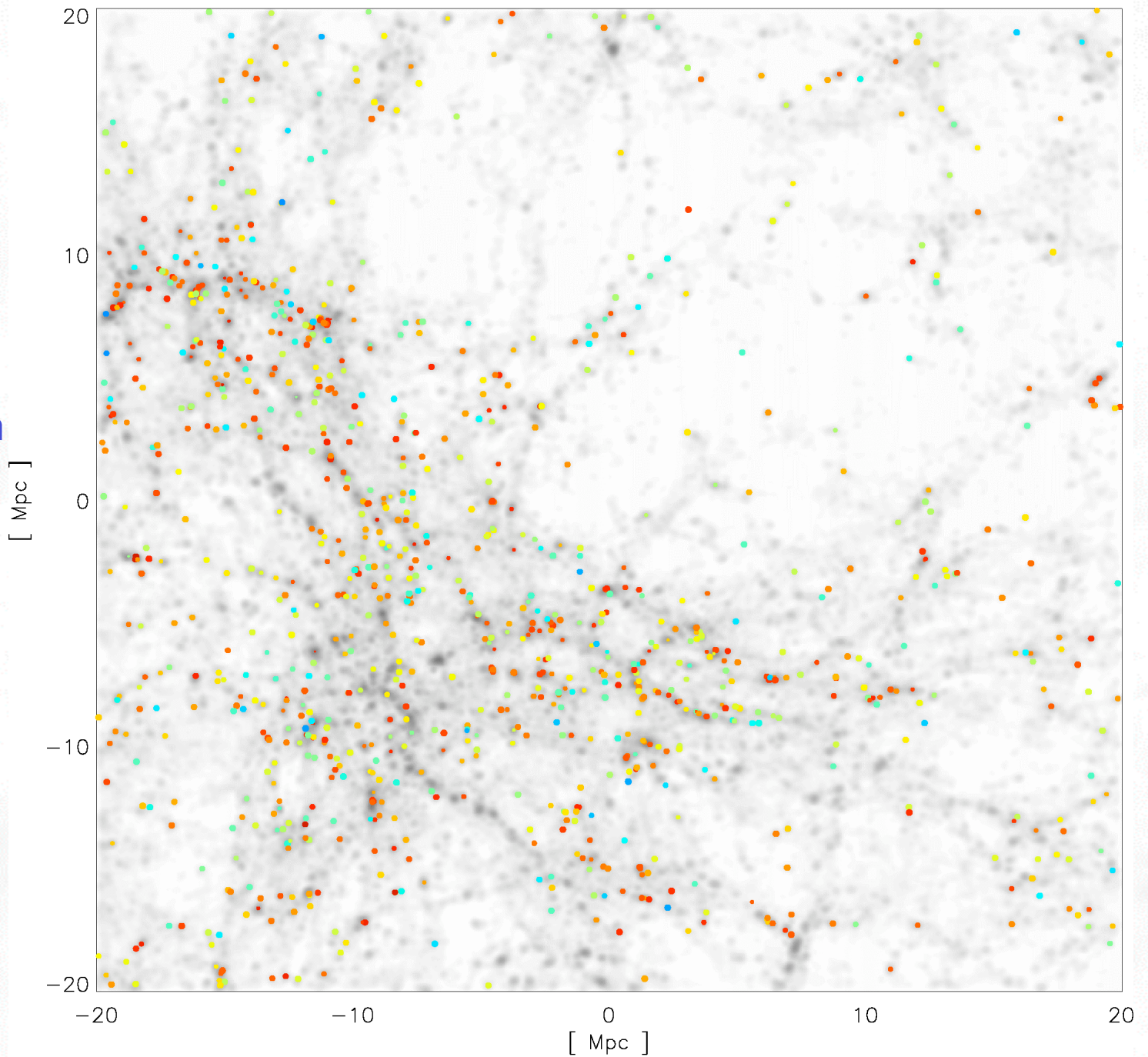
Mock using an
'environmentally
unconscious'
galaxy formation
model ('nature'
only)

AGN feedback is
not modelled yet



Core of Shapley + 2 voids

Mock using a
galaxy formation
model that
includes various
bits of *local*
environmental
physics ('nature'
and 'nurture')



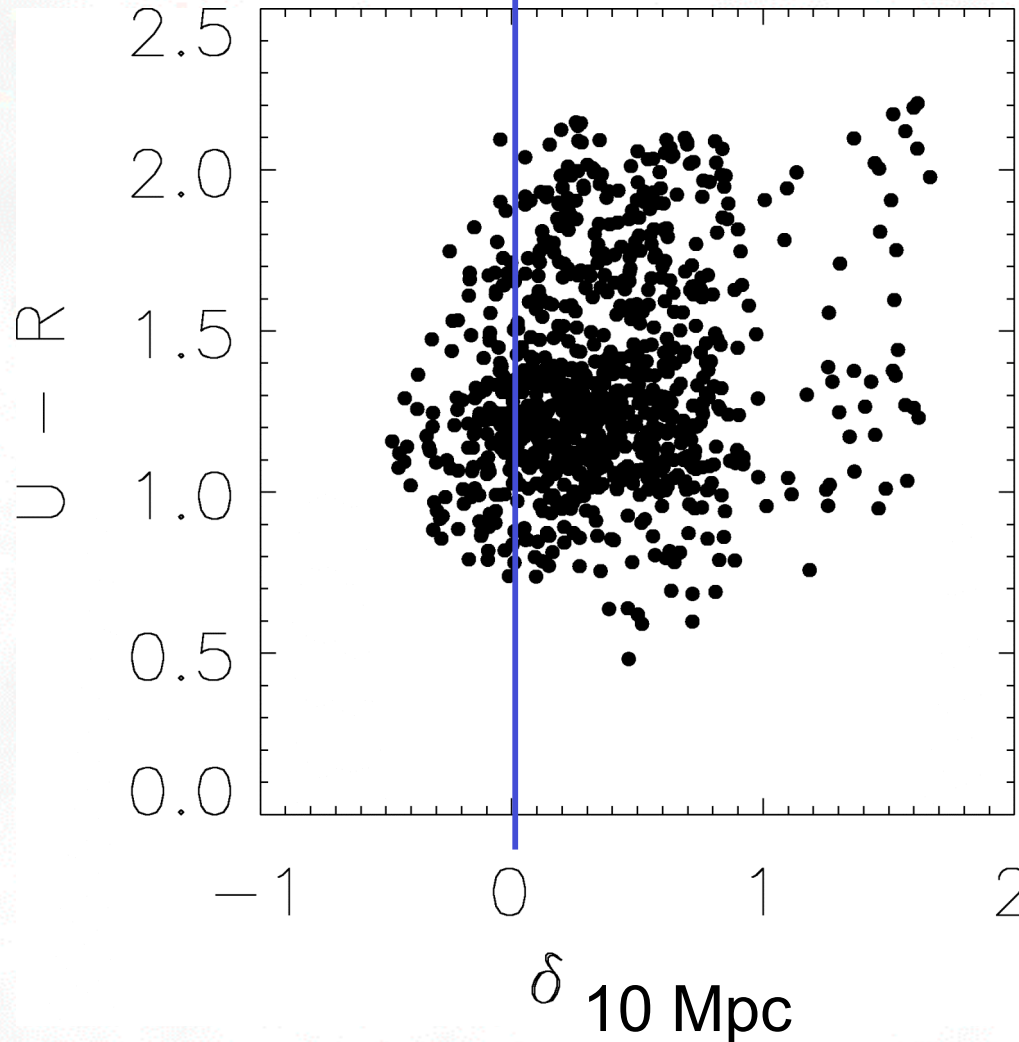
Colour - global environment relation

$M_B < -19$

Colour vs.
global density

(smoothing
scale: 10 Mpc)

Mock using an
'environmentally
unconscious' galaxy
formation model
(‘nature’ only)

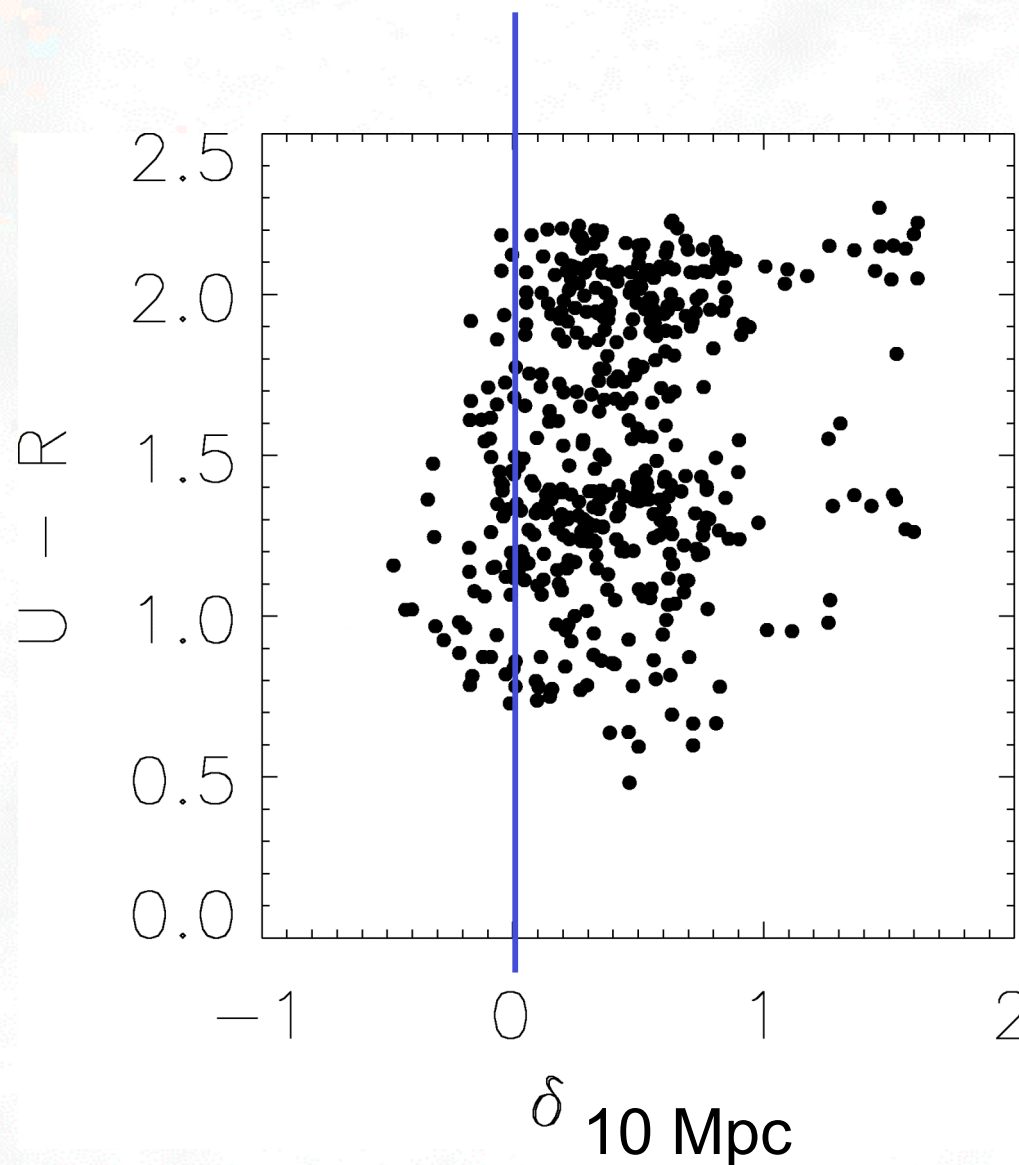


Colour - global environment relation

Colour vs.
global density

(Gaussian
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scale: 10 Mpc)

Mock using a
galaxy formation
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$M_B < -19$

Conclusions

- COMBO-17 shows that for $0.25 < z < 0.4$ the Chandra Deep Field South is underdense by a factor of two, providing a nice 'hole in the sky'
- this underdense region is mainly due to a deficiency of faint red galaxies
- galaxy formation models can reproduce this: but why ?