Void galaxies

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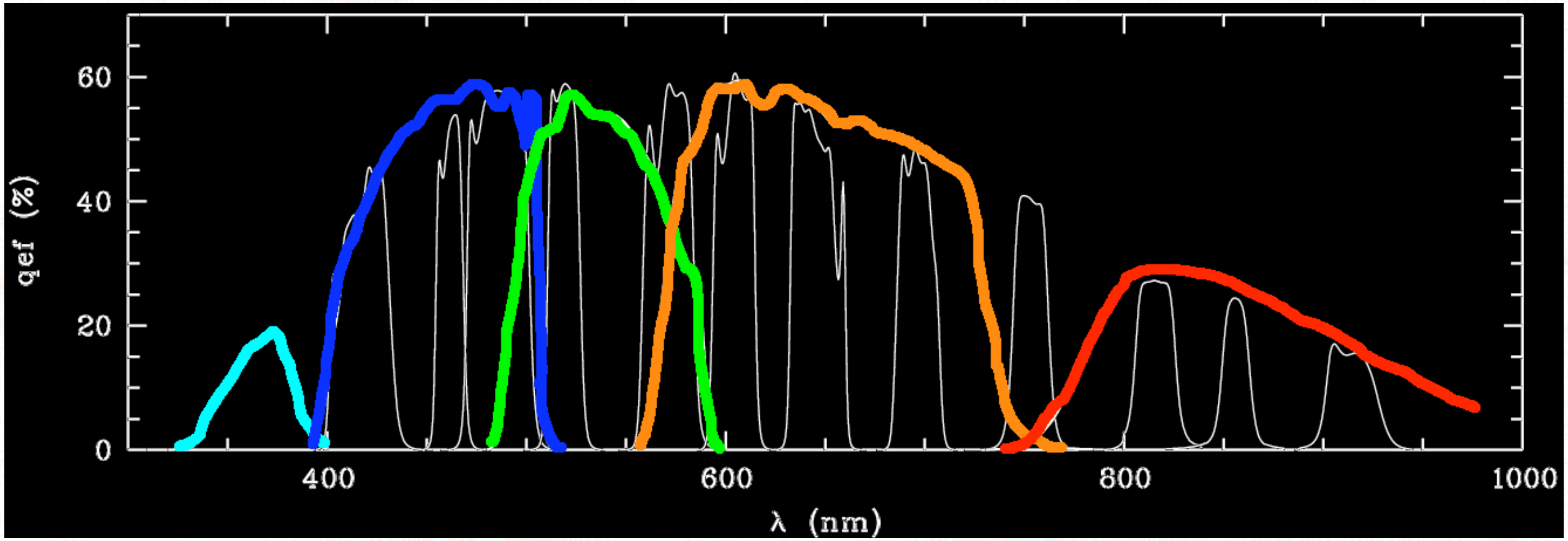
The COMBO-17 survey

Classifying **O**bjects by **M**edium-**B**and **O**bservations

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 (δz = 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}Mpc, but in COMBO-17 $\sigma_z/(1+z)=0.02$ => 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

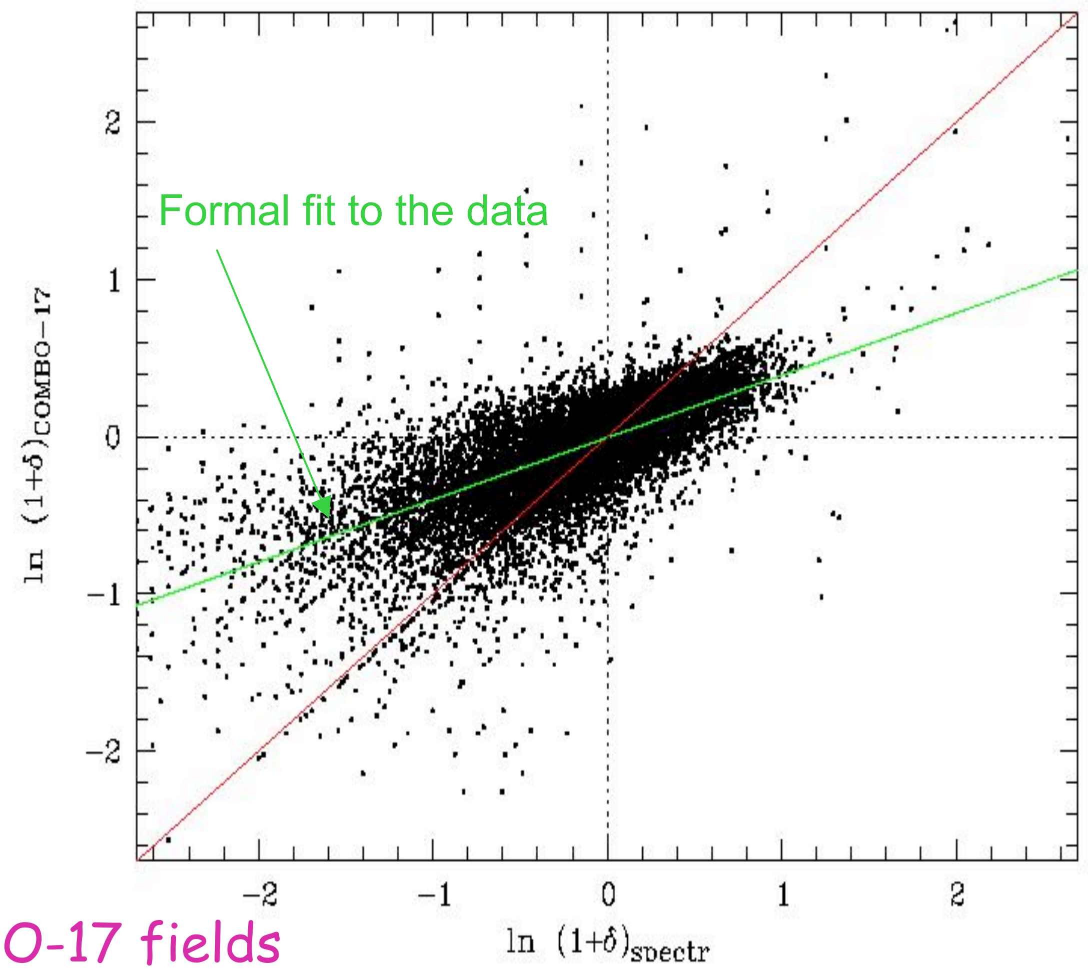
To study the influence on photometric redshift errors we use 80 mock COMBO-17 surveys.

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

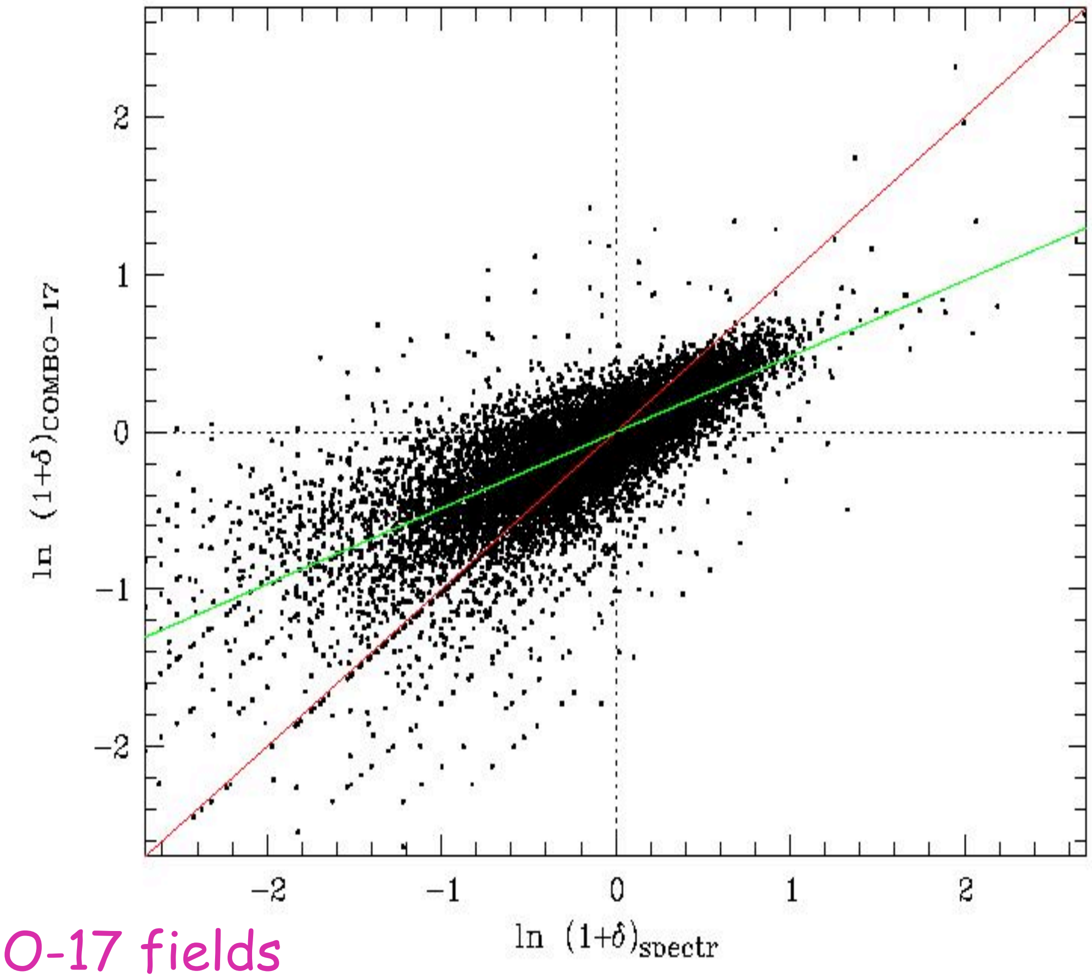
all galaxies



80 mock COMBO-17 fields

Influence of redshift errors on determination of δ_g

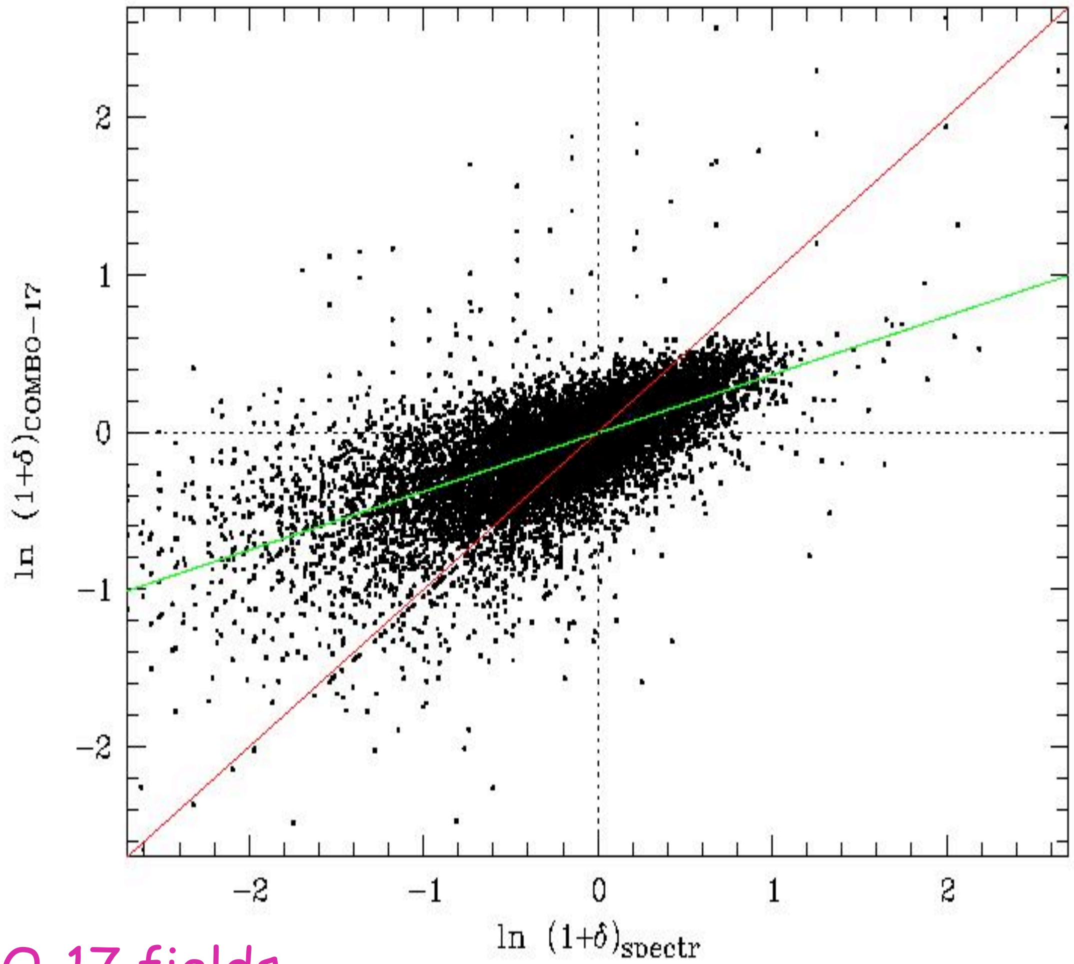
red galaxies



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

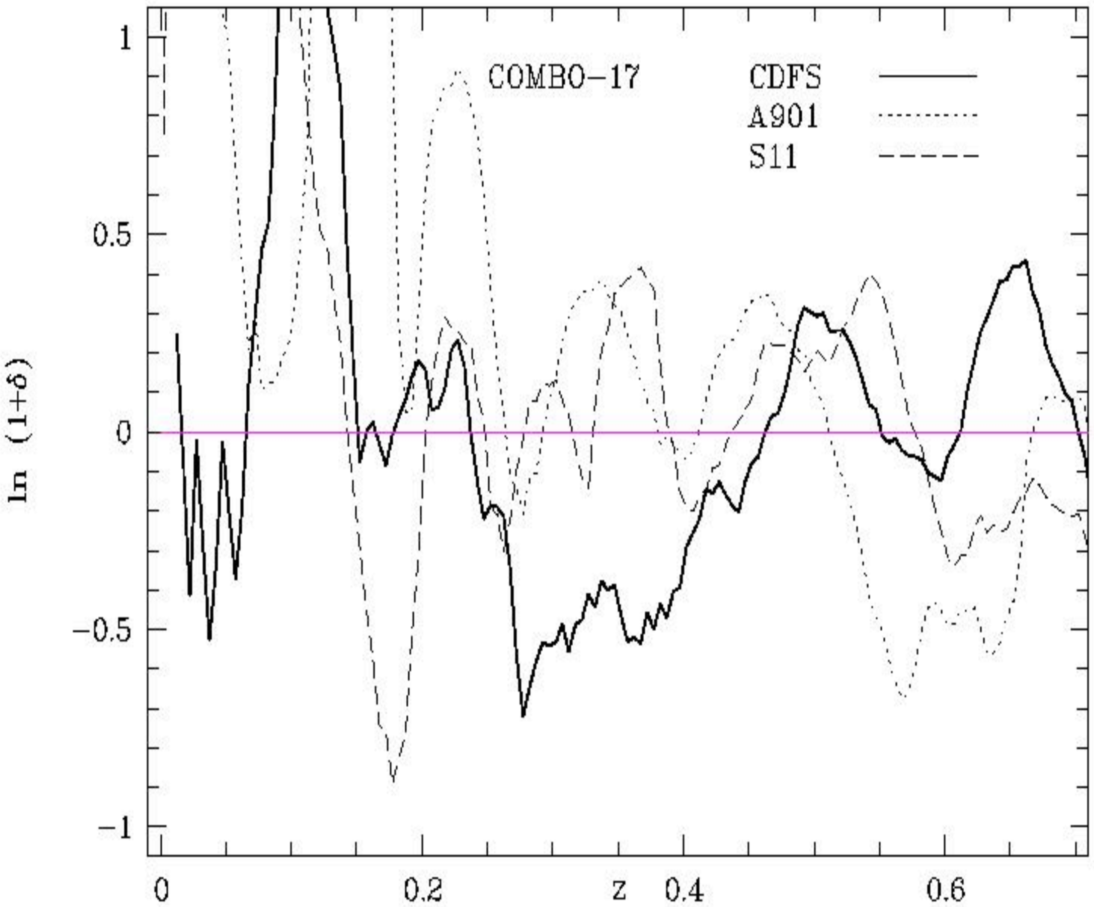
$$F(k) = \exp\left(-W\,|\,k\,|\,/\,2\right)$$

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

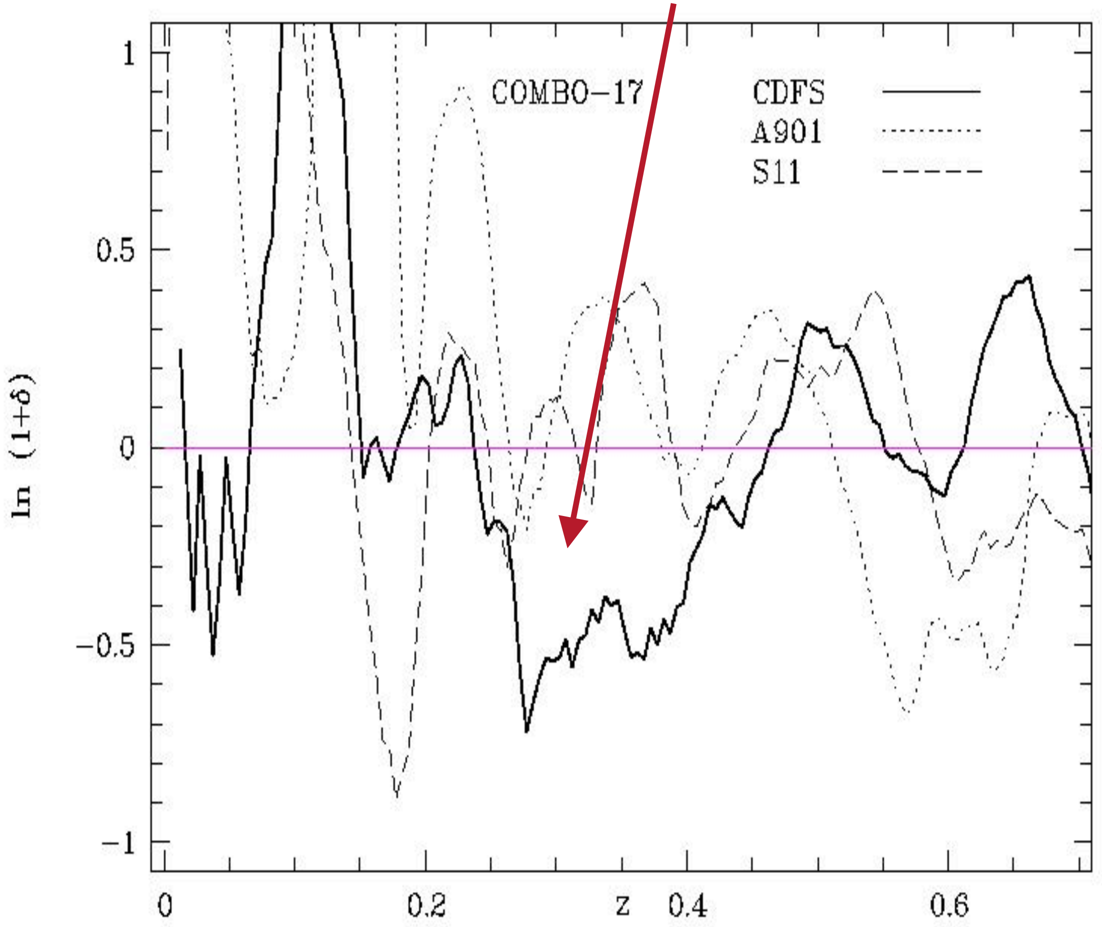
δ_g for three COMBO-17 fields



Δz=0.05

δ_g for three COMBO-17 fields

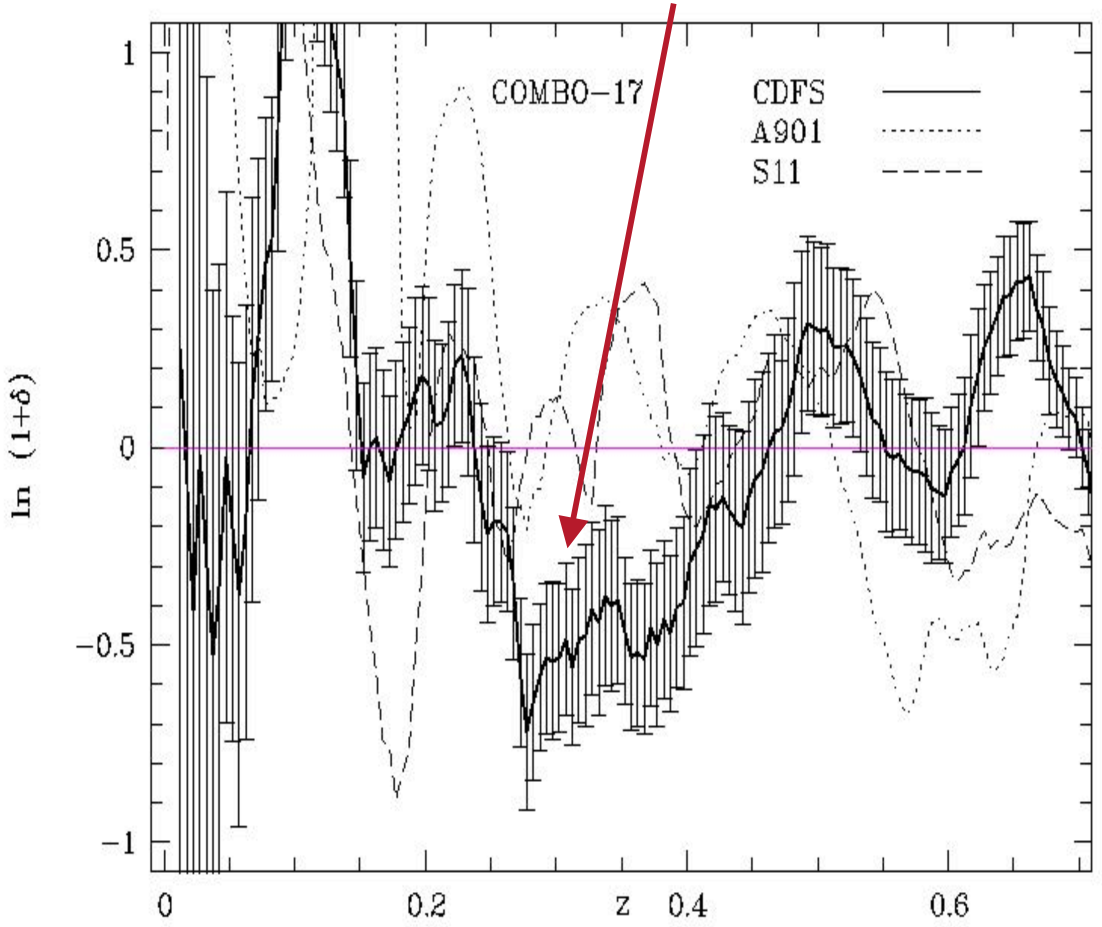
The CDFS at 0.25<z<0.4: *A* hole in the sky!



Δz=0.05

δ_g for three COMBO-17 fields

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



Δz=0.05

δ_g for three COMBO-17 fields

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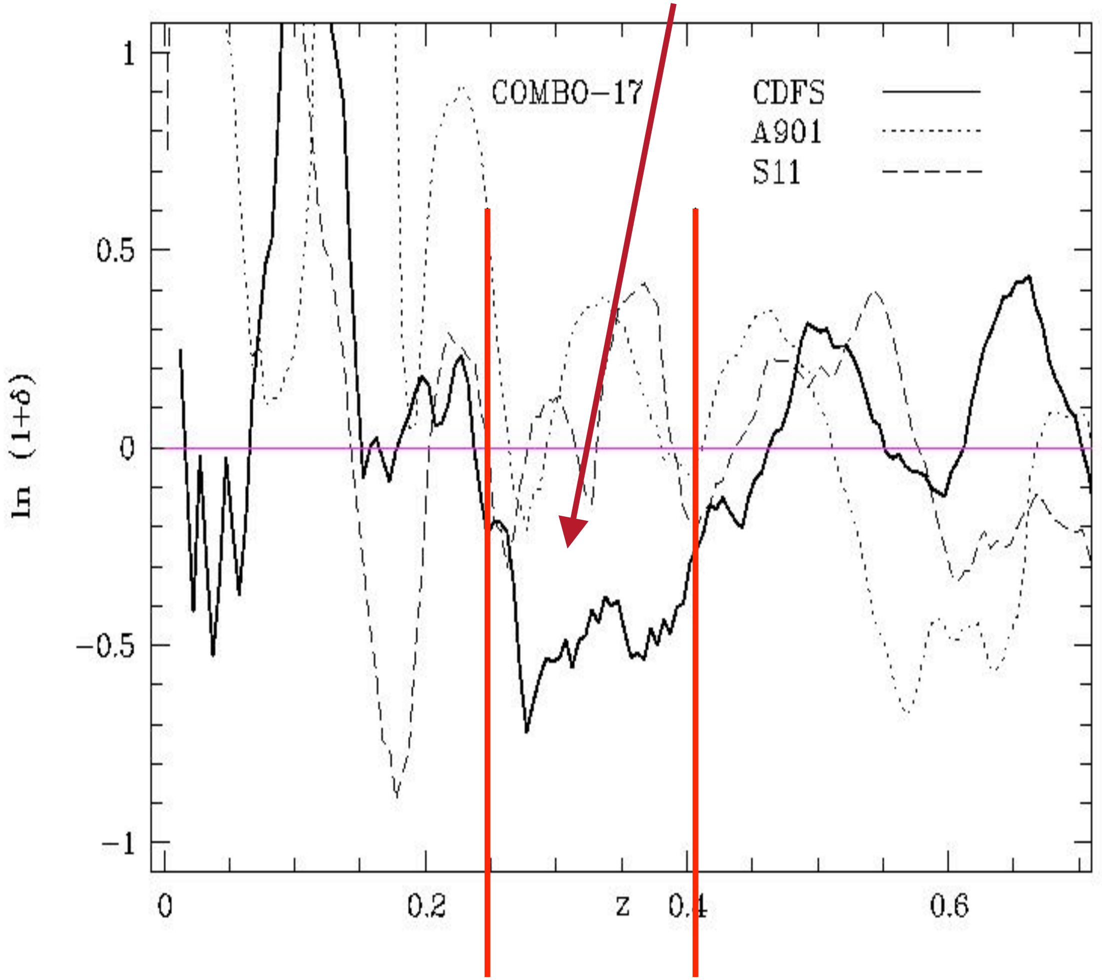
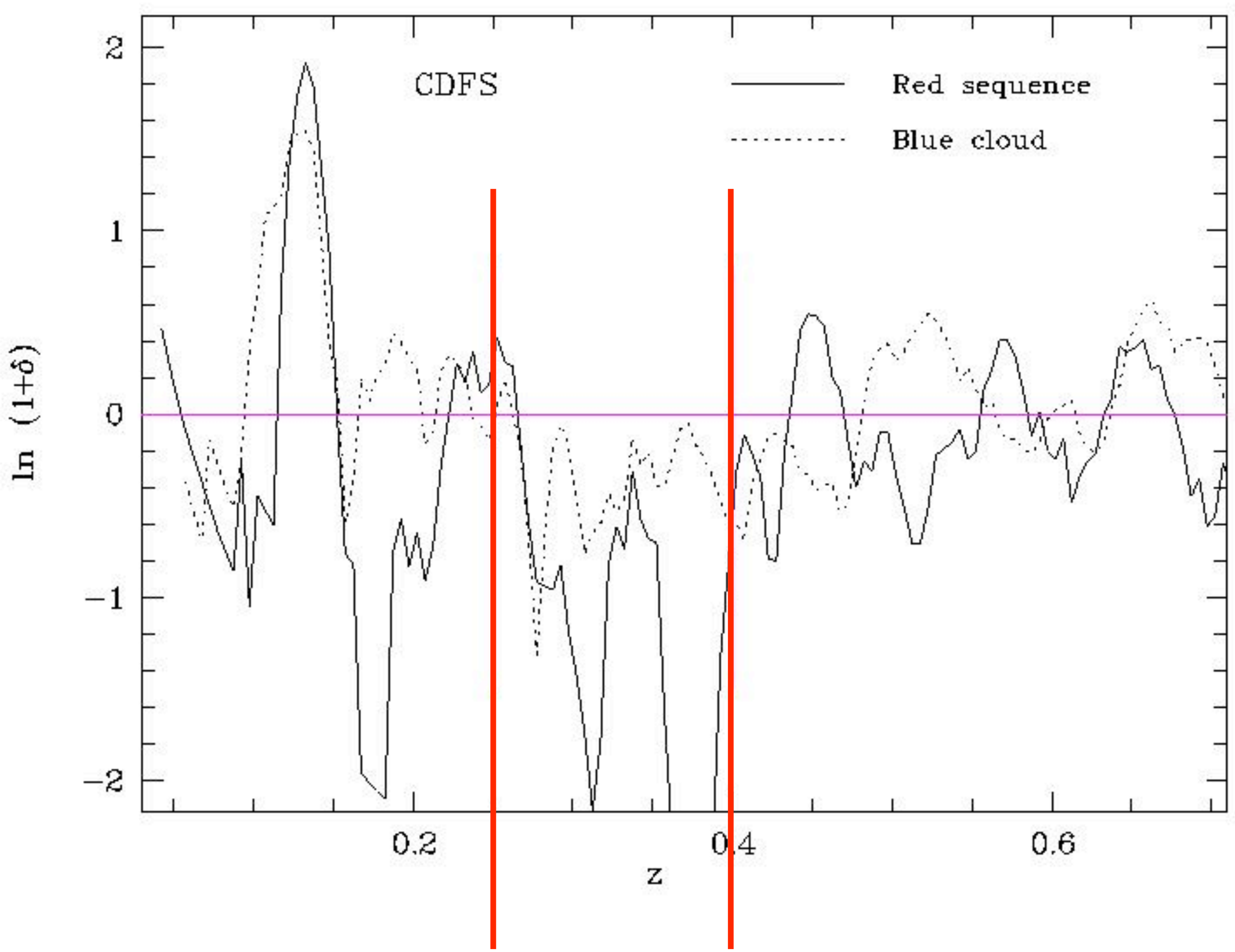


Δz=0.05

A hole in the sky in red and blue

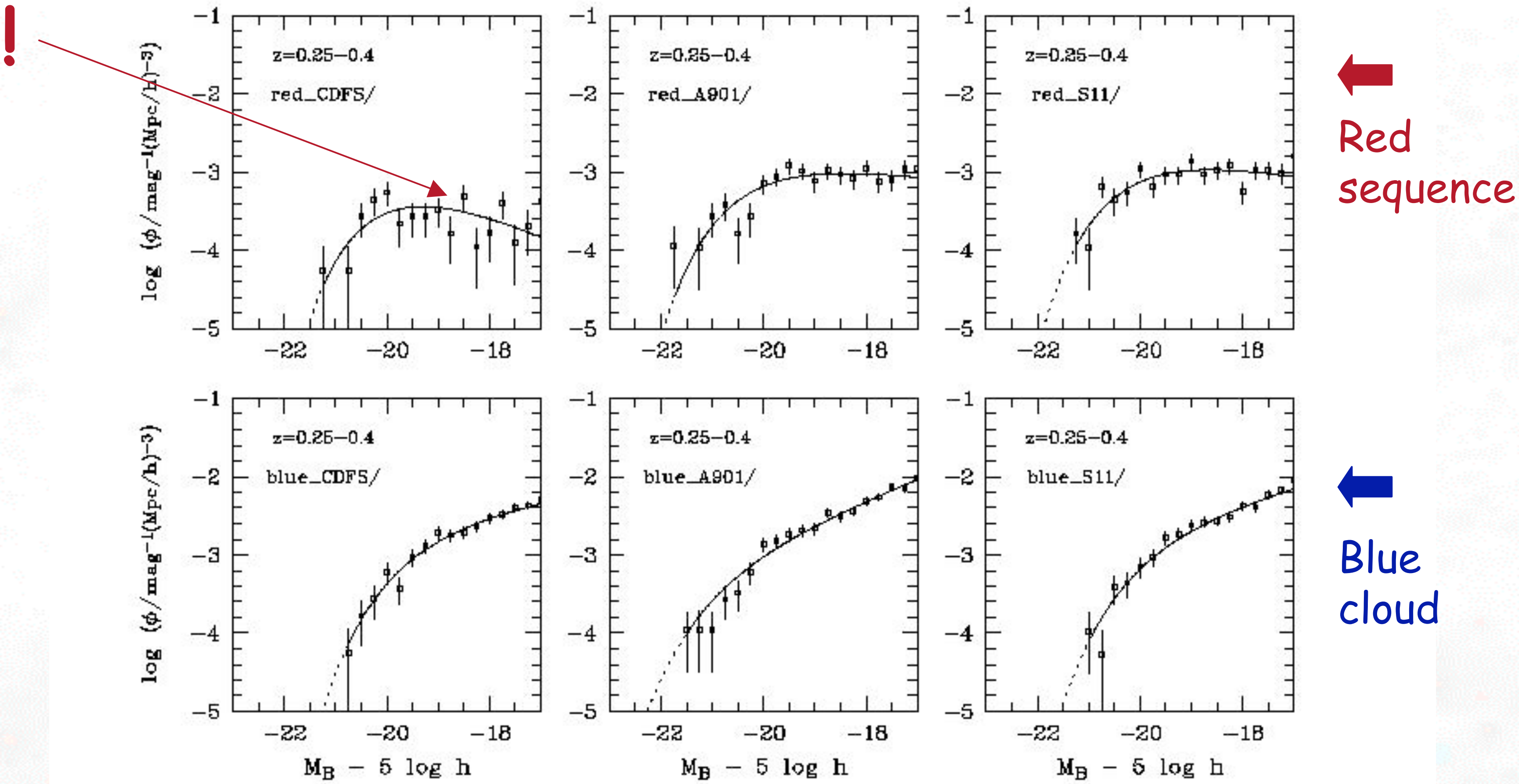


Δz=0.02

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

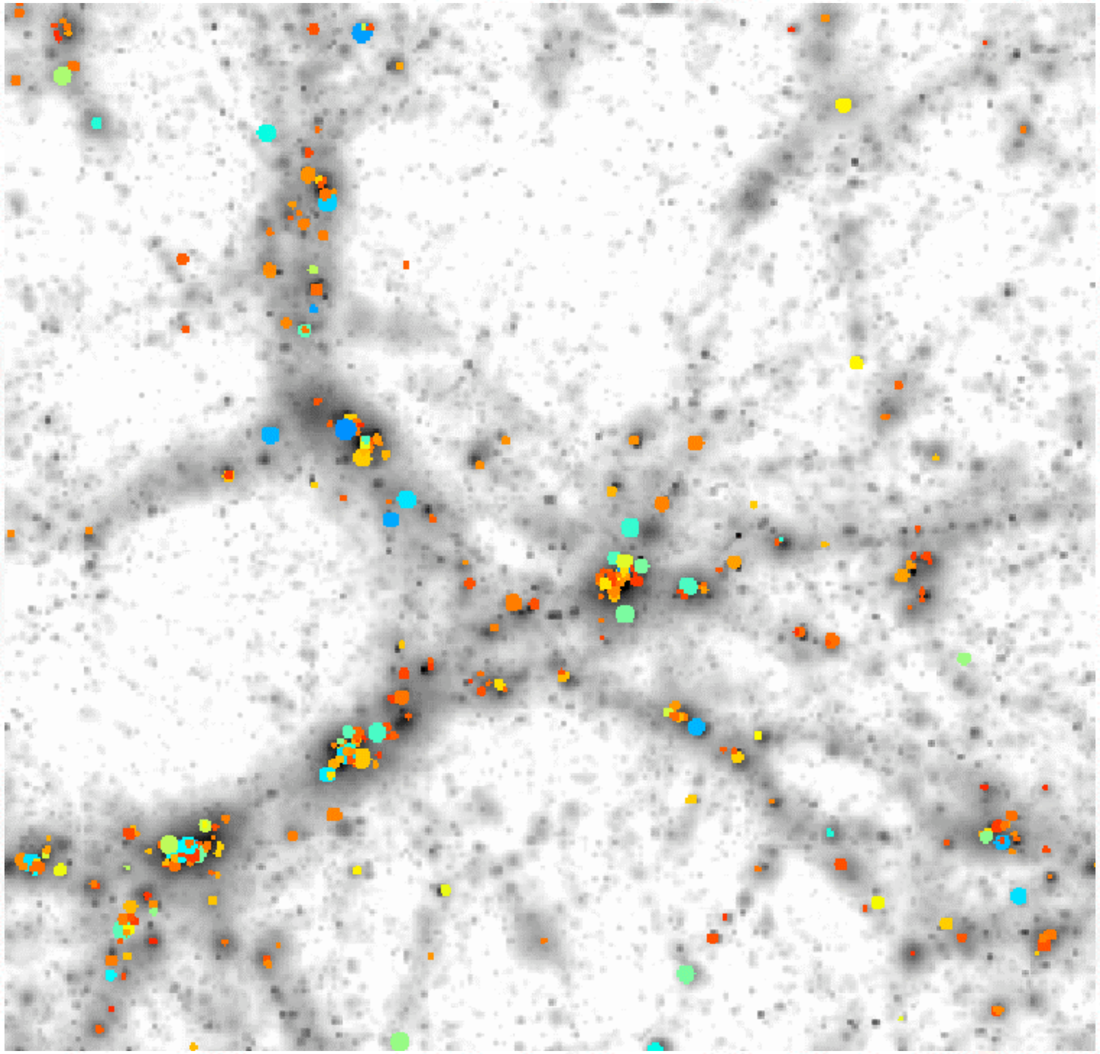
N-body run by Vincenzo Antonuccio (Catania) using FLY

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

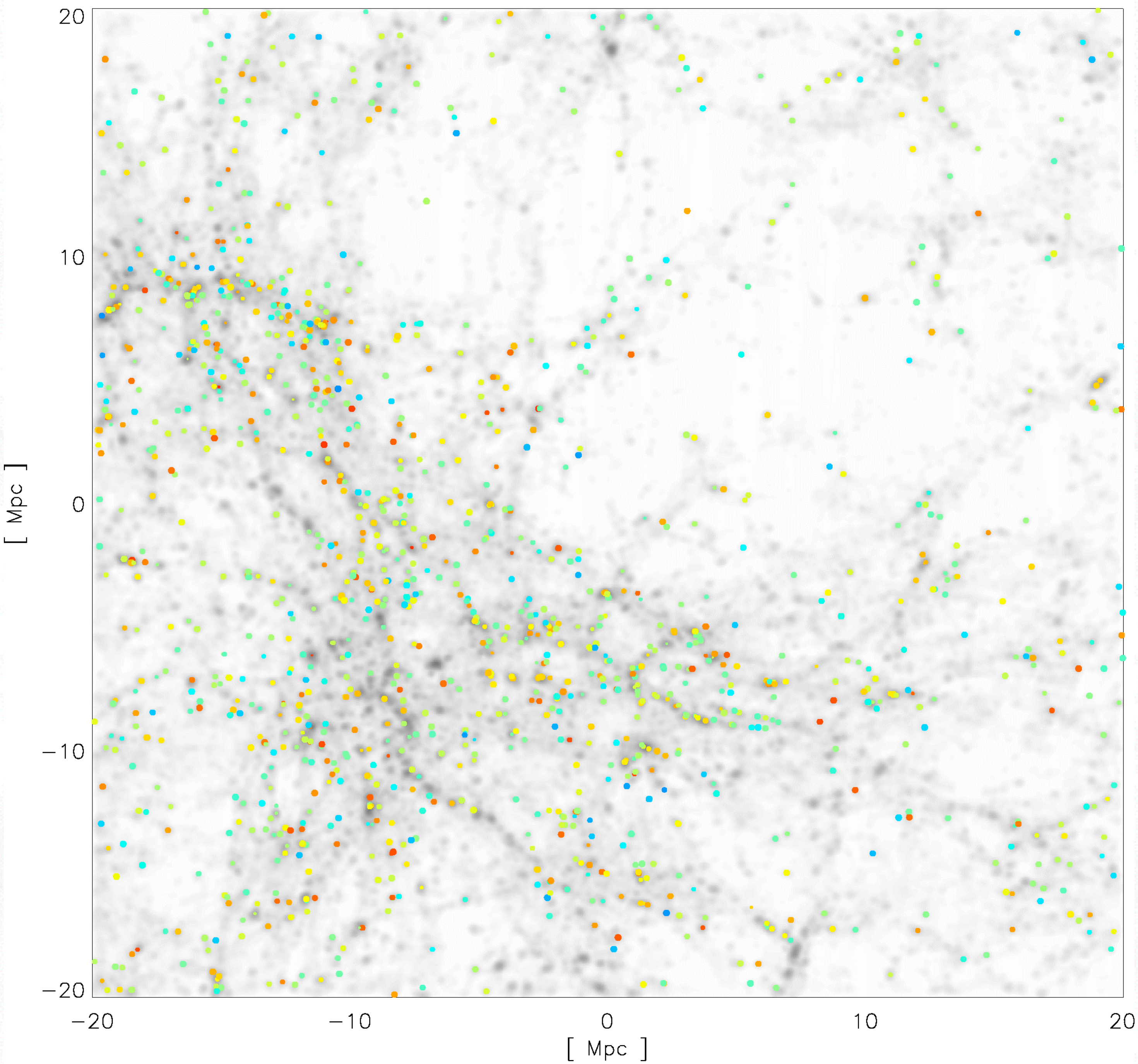


ΛCDM model of van Kampen, Rimes & Peacock (2006)

Core of Shapley + 2 voids

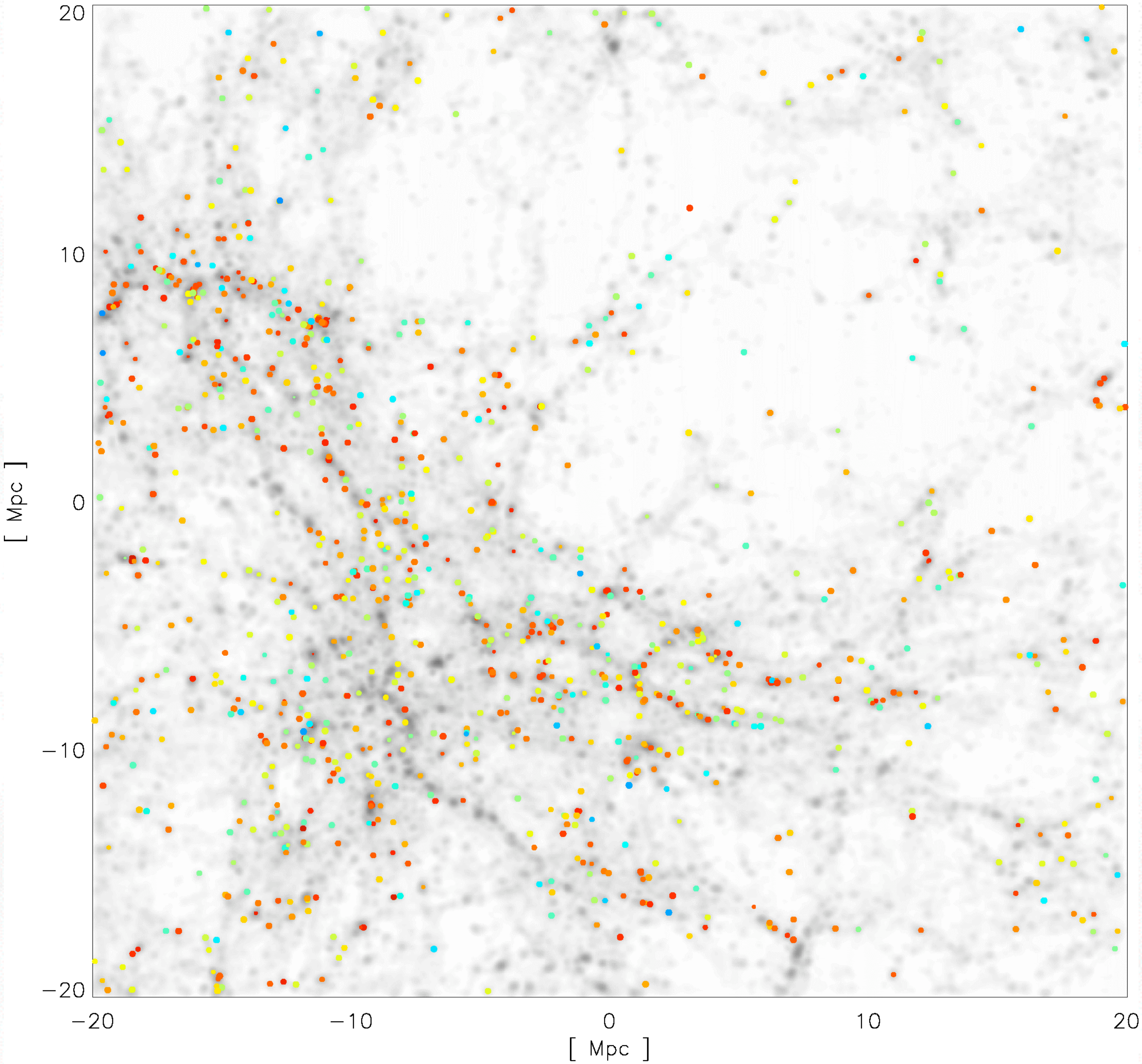
Mock using an 'environmentally unconcious' galaxy formation model ('nature' only)

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

Colour vs. global density

(smoothing scale: 10 Mpc)

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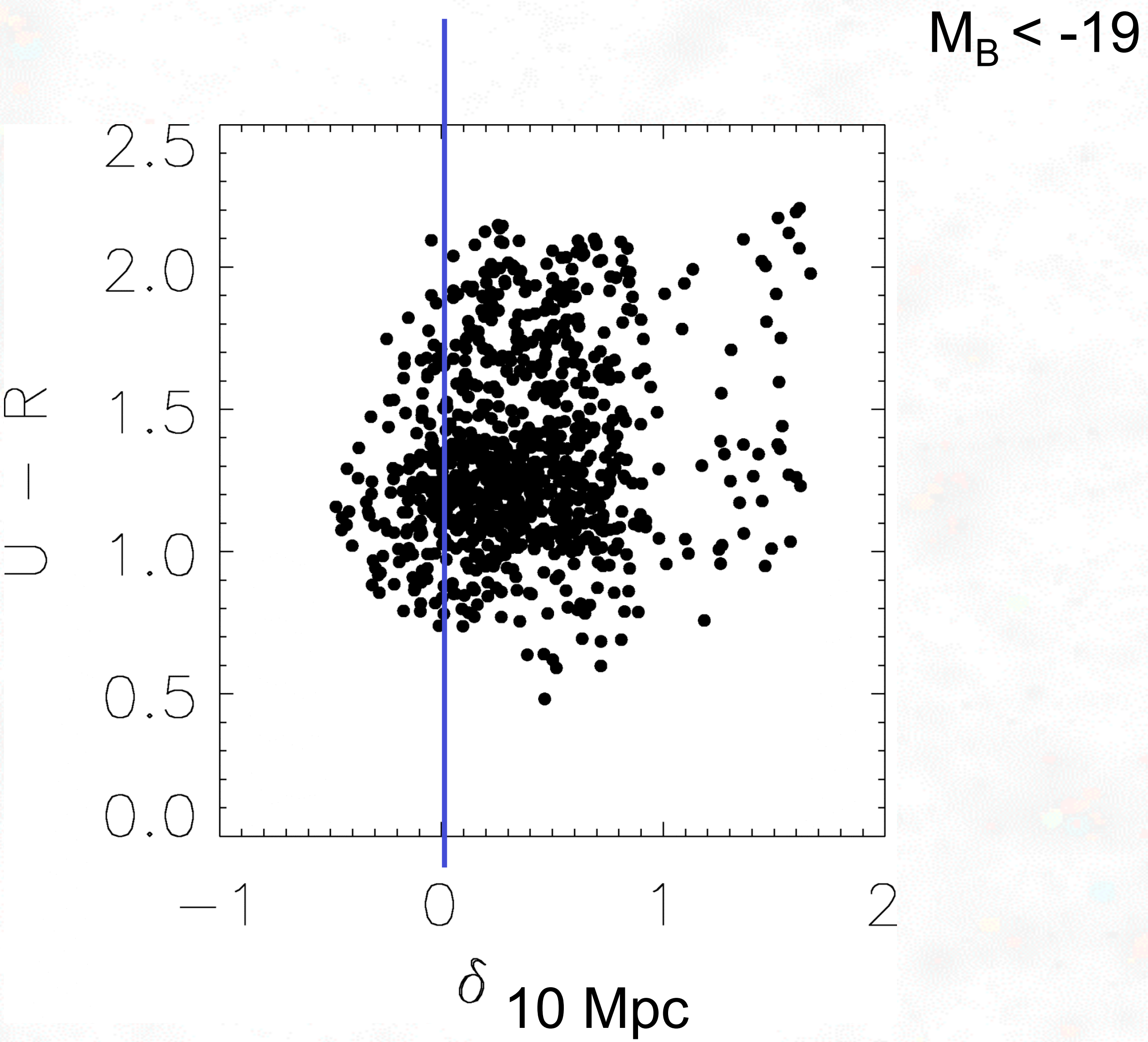


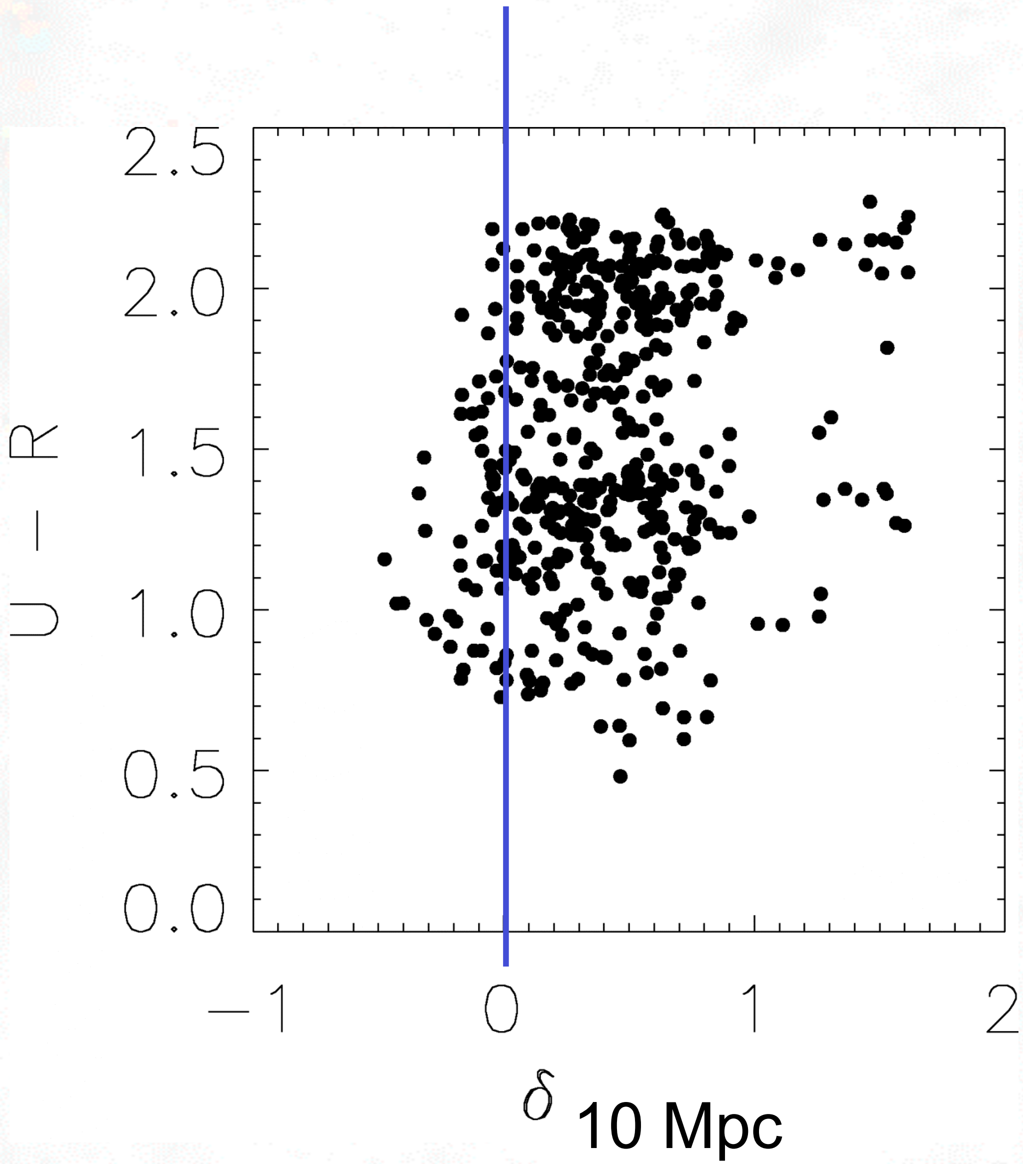
Colour - global environment relation

Colour vs. global density

(Gaussian smoothing scale: 10 Mpc)

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

$M_B < -19$



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 ?