Does super-large structures exist?

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Contents

- Hubble Ultra Deep Field preview
- Photometric redshifts
- Modeling the radial distribution of galaxies
  - Expected number fluctuations in fixed redshift bins
- Detection of super-large structures
  - HUDF survey radial distributions
  - FDF survey radial distributions
  - Expected number fluctuations
  - Where are the missing gamma ray burst redshifts?
- Tests for detection of the super-large structures
  - Gamma Ray Bursts
  - Covering sky in different directions
- References

Hubble Ultra Deep Field

Main parameters

Filter	B(F435W)	V(606)W	i(F775W)	z(F850LP)
Orbit number	56	56	144	144
Exp. number	112	112	288	288
Total exp. time (sec)	134880	135320	347110	346620
Null exp. level (AB)	25.673	26.486	25.654	24.862

Our object's catalog parameters:

- Total object count: 4125 (645 elliptical galaxy, 2175 spiral galaxy, other – irregular galaxies)
- Photometric redshift probability above 90%
- S/N ratio = 5
- Magnitude limiting: 30.31^m (z filter)

Photometric redshifts

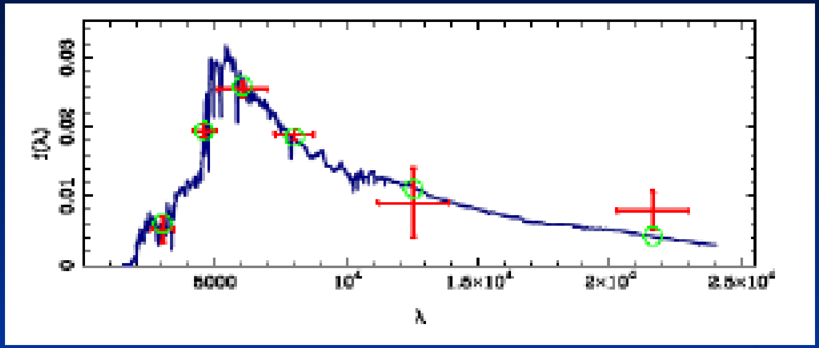
$$\chi^2(z) = \sum_{i=1}^{N} \left[\frac{F_{obs,i} - b \times F_{temp,i}(z)}{\sigma^2} \right]$$

$\sigma -$ flux deviations

$F_{temp,i}(z) -$ template flux

$F_{obs,i} -$ observed flux

i – one of the filter (b, v, i, z)



SED and observed galaxy flux in different filters

For computing photometric redshift we use HyperZ program, where we consider corrections: Calzetti reddening and “Lyman forest”.

Modeling the radial distribution of galaxies

$\delta z = 0.03(1+z)$ $\rightarrow$ $\delta z(1) = 0.06$

linear sizes and redshift intervals

Δz	0.1	0.2	0.3	0.4	0.5
Δr (Mpc)	237	474	711	1189	3214

metric distance (LCDM) :

$$r(z) = \frac{c}{H_0} \int_{\frac{1}{1+z}}^{1} \frac{dy}{y\sqrt{(\Omega_m^0 y^{-1} + \Omega_V^0 y^2)}}$$

magnitude limited galaxy distribution samples:

$$dN_{ml}(z) = Az^{\alpha} \exp\left(-\frac{z}{z_0}\right)^{\beta} dz$$

we use parameters:

H_0=72 km/c Mpc^{-1}, Ω_m=0.3, Ω_V=0.7

α, β, z_0 – free parameters, A – normalization amplitude

Steps of analysis

- construction the observed redshift distribution $\Delta Nobs(z)/\Delta z$ for several redshift bins Δz
- construction the redshift distribution $\Delta Nml(z)/\Delta z$ for magnitude limited homogeneous distribution of galaxies in considered deep field
- estimation the expected number fluctuations ΔN in fixed redshift bins Δz
- extraction inhomogeneity regions in the radial distribution of galaxies
- comparison of radial redshift distribution $dN(\alpha,\delta)(z)/dz$ for different directions (α,δ) on the sky

Expected number fluctuations in fixed redshift bins

The Poisson's noise dispersion:

$$\sigma_p^2 = \frac{\langle N^2 \rangle - \langle N \rangle^2}{\langle N \rangle^2} = \frac{1}{\langle N \rangle}$$

Expected value of «cosmic variance»:

$$\sigma_\xi^2 = \frac{1}{V^2} \int_V dV_1 \int_V dV_2 \xi(|\vec{r}_1 - \vec{r}_2|)$$

Theoretical dispersion:

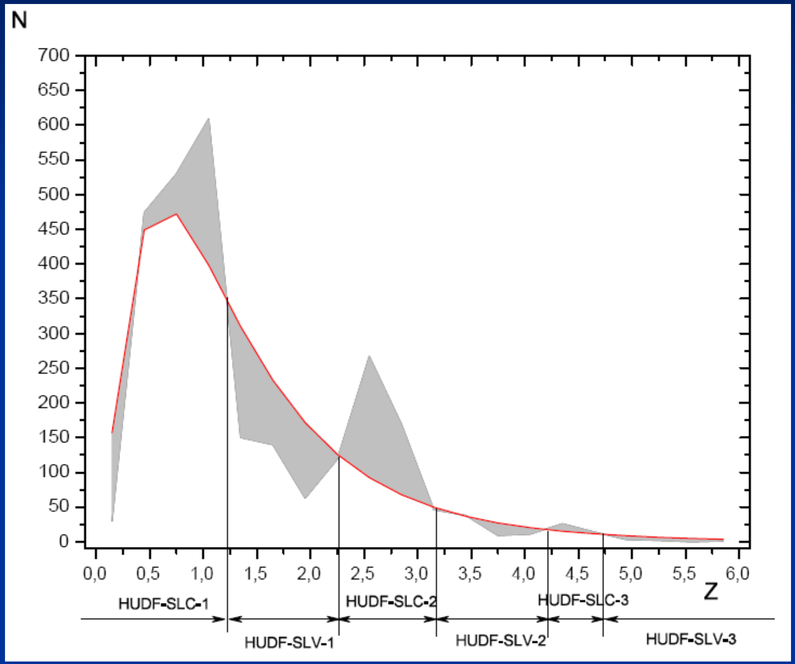
$$\sigma_{theor}^2 = \frac{J_2}{1+z} \left(\frac{r_0}{r} \right)^\gamma$$

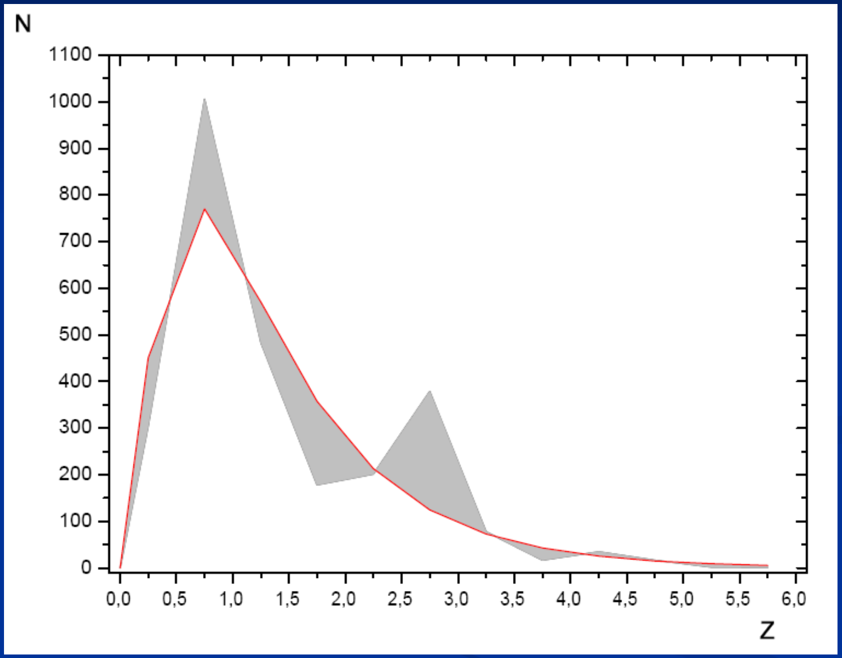
Effective radius:

$$r = r_{eff} = \left(\frac{3}{4\pi} r^2 \Delta r \Omega \right)^{\frac{1}{3}}$$

$$\sigma_{obs}(z, \Delta z) = \frac{N_{obs}(z, \Delta) - \langle N \rangle}{\langle N \rangle},$$

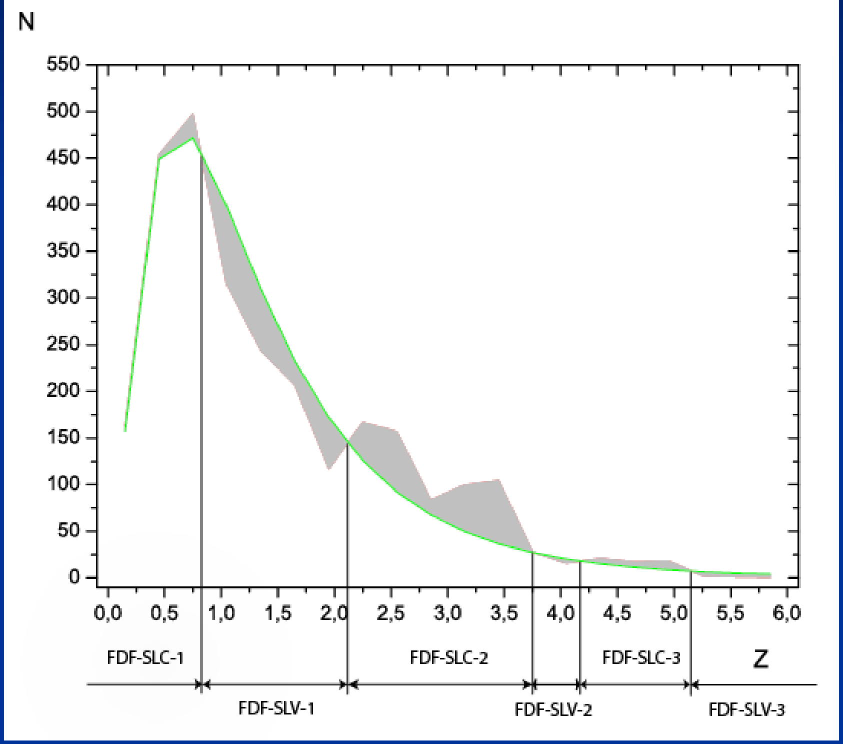
HUDF survey radial distributions



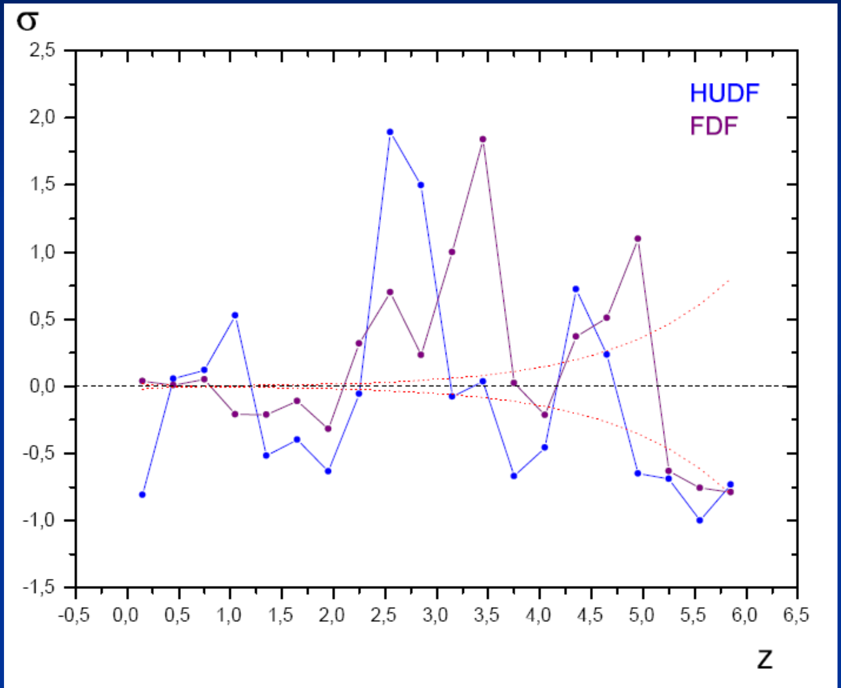


Radial distributions for bin Δz=0.3 (left) and Δz=0.5 (right)

FDF survey radial distributions



Radial distribution for bin Δz=0.3



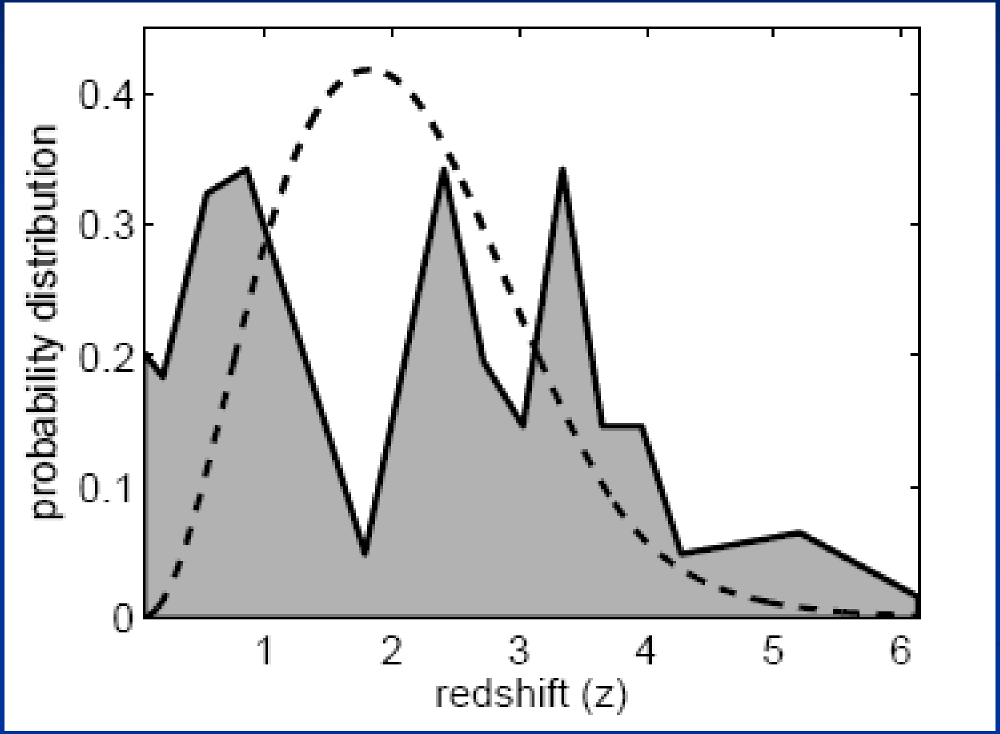
Observed deviations for bin Δz=0.3

Expected number fluctuations

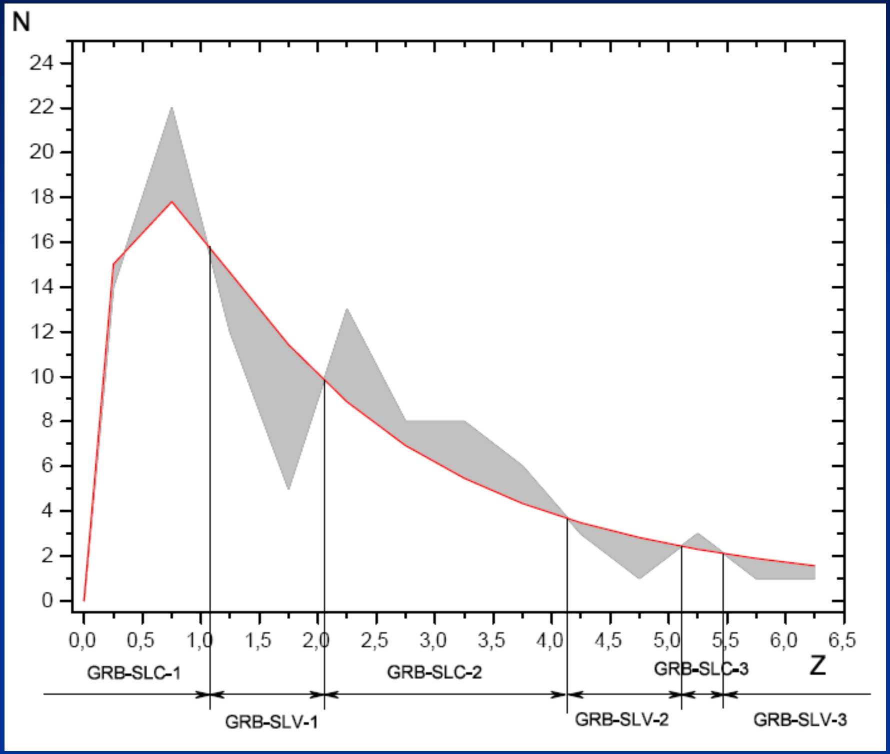
HUDF									
	$\Delta z = 0.2$			$\Delta z = 0.3$			$\Delta z = 0.5$		
z	r_{eff}	σ_P	σ_{theor}	r_{eff}	σ_P	σ_{theor}	r_{eff}	σ_P	σ_{theor}
1	6.68	0.56	0.004	7.65	0.24	0.003	8.16	0.24	0.002
2	7.72	0.39	0.009	8.91	0.12	0.006	10.47	0.09	0.004
3	7.88	0.34	0.027	9.02	0.09	0.017	10.68	0.066	0.011
4	7.67	0.31	0.078	8.76	0.074	0.05	10.53	0.055	0.031
5	7.40	0.29	0.21	8.49	0.067	0.12	10.08	0.049	0.087
FDF									
	$\Delta z = 0.2$			$\Delta z = 0.3$			$\Delta z = 0.5$		
z	r_{eff}	σ_P	σ_{theor}	r_{eff}	σ_P	σ_{theor}	r_{eff}	σ_P	σ_{theor}
1	12.81	0.31	0.004	14.7	0.07	0.003	15.71	0.07	0.002
2	15.03	0.22	0.009	17.13	0.04	0.006	20.12	0.03	0.004
3	15.12	0.19	0.027	17.33	0.03	0.017	20.55	0.02	0.011
4	14.73	0.17	0.078	16.86	0.02	0.05	20.09	0.017	0.031
5	14.22	0.16	0.21	16.35	0.02	0.12	19.41	0.015	0.087

Where are the missing gamma ray burst redshifts?

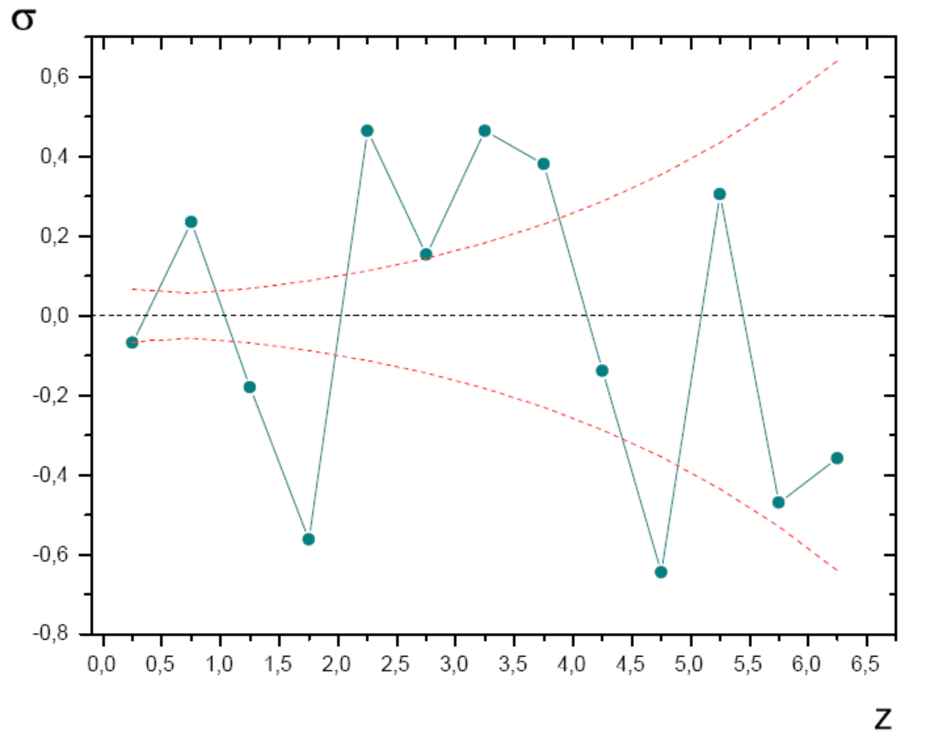
(D. M. Coward et al., 2008)



Gamma Ray Bursts



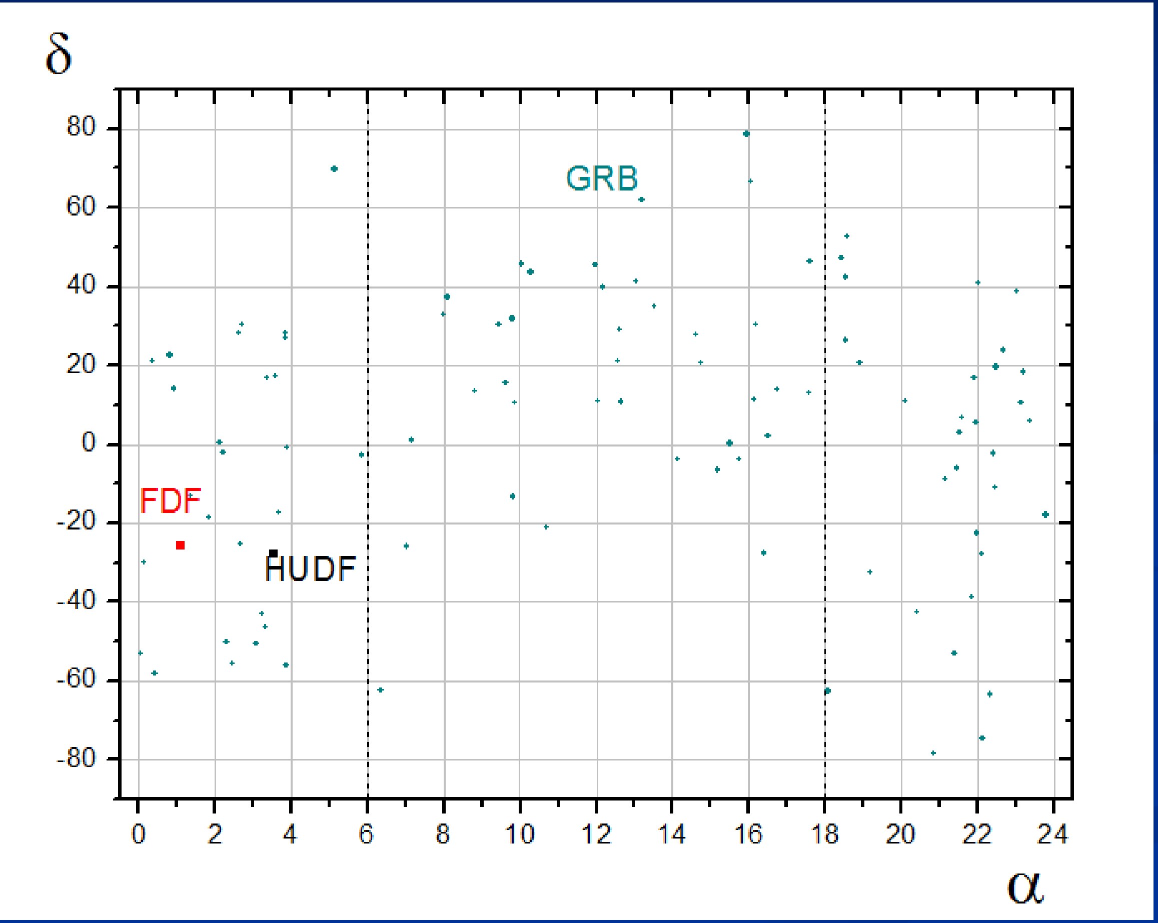
Radial distribution for Δz=0.5



Observed deviations for bin Δz=0.5

Tests for detection of the super-large structures

Covering sky in different directions



SDSS Great Wall
λ=500 Mpc

(Gott et al. 2005)

SDSS power spectrum
λ=1200 Mpc

(Padmanabhan et al. 2007)

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