

# MICE

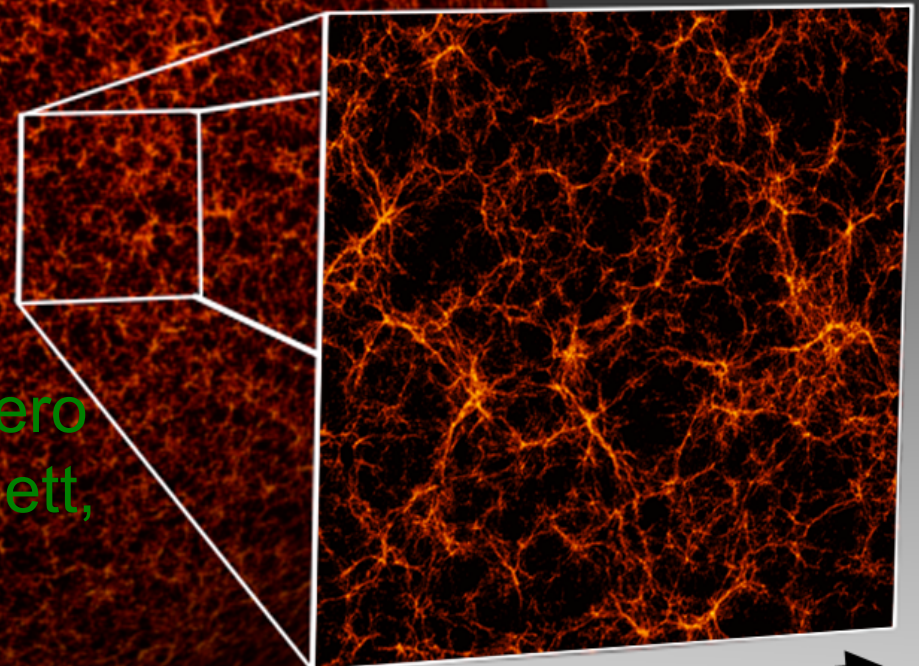
Cosmological Simulations @  
Marenostrum Supercomputer  
using 4000 processors

## MICE simulations a tool for cosmological surveys

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[www.ice.cat/mice](http://www.ice.cat/mice)



1000 Million Light Years

# MICE

Marenostrum Institut  
de Ciències de l'Espai  
Simulations

# MICE simulations

[www.ice.cat/mice](http://www.ice.cat/mice)



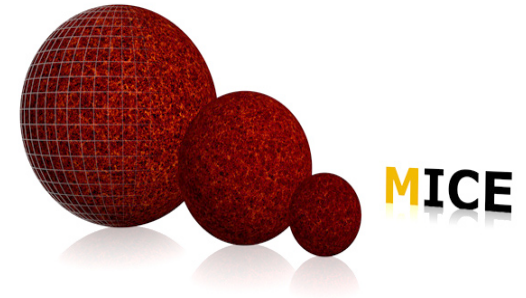
## Cosmological surveys

- Probe large volumes: wide area & z range
- determine tracers (galaxies) positions (redshifts)
- determine the expansion rate and growth of structure

## MICE simulations

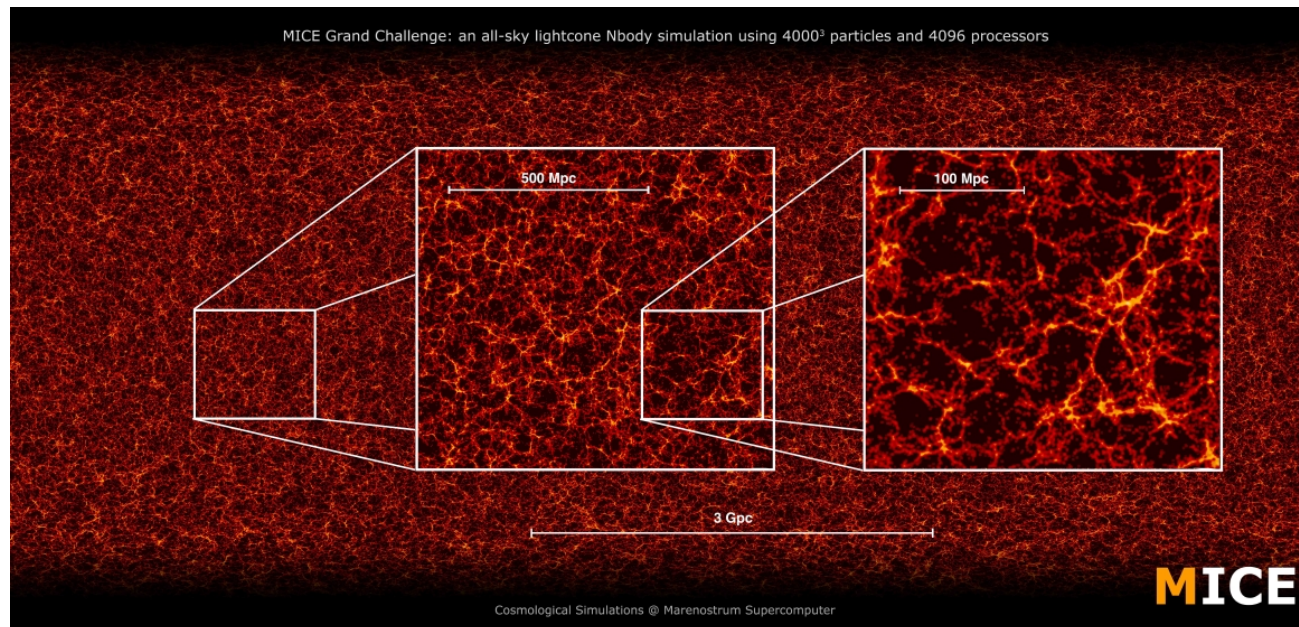
- Provide mocks for cosmological surveys: DES, PAU, Euclid, DESI
- help plan and optimize surveys
- analyze and exploit cosmological data
- understand errors and covariances





## Simulation process

- Generate large dark matter simulation
- Produce lightcones
- All-sky lensing maps
- generate halo catalogues
- produce galaxy catalogues



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# MICE simulations

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## Products

- Comoving and lightcone outputs
  - dark matter
  - halo catalogues
  - lensing catalogues
  - galaxy catalogues

## Properties

- Clustering
- Lensing
- Galaxy properties



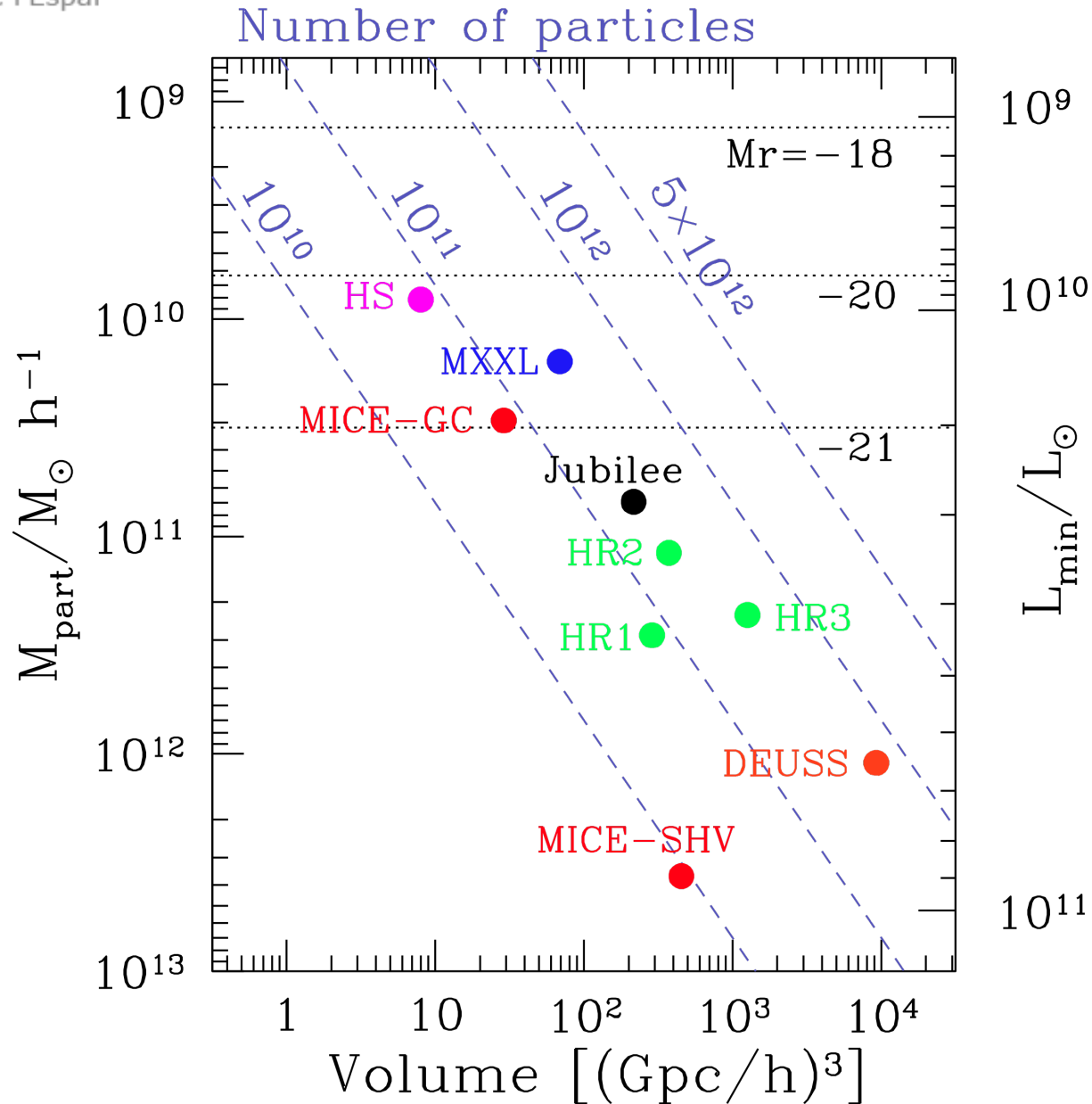
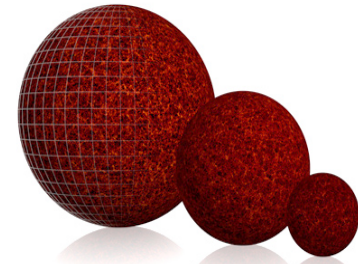
# MICE MICE galaxy catalogue

Marenostrum Institut  
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Simulations



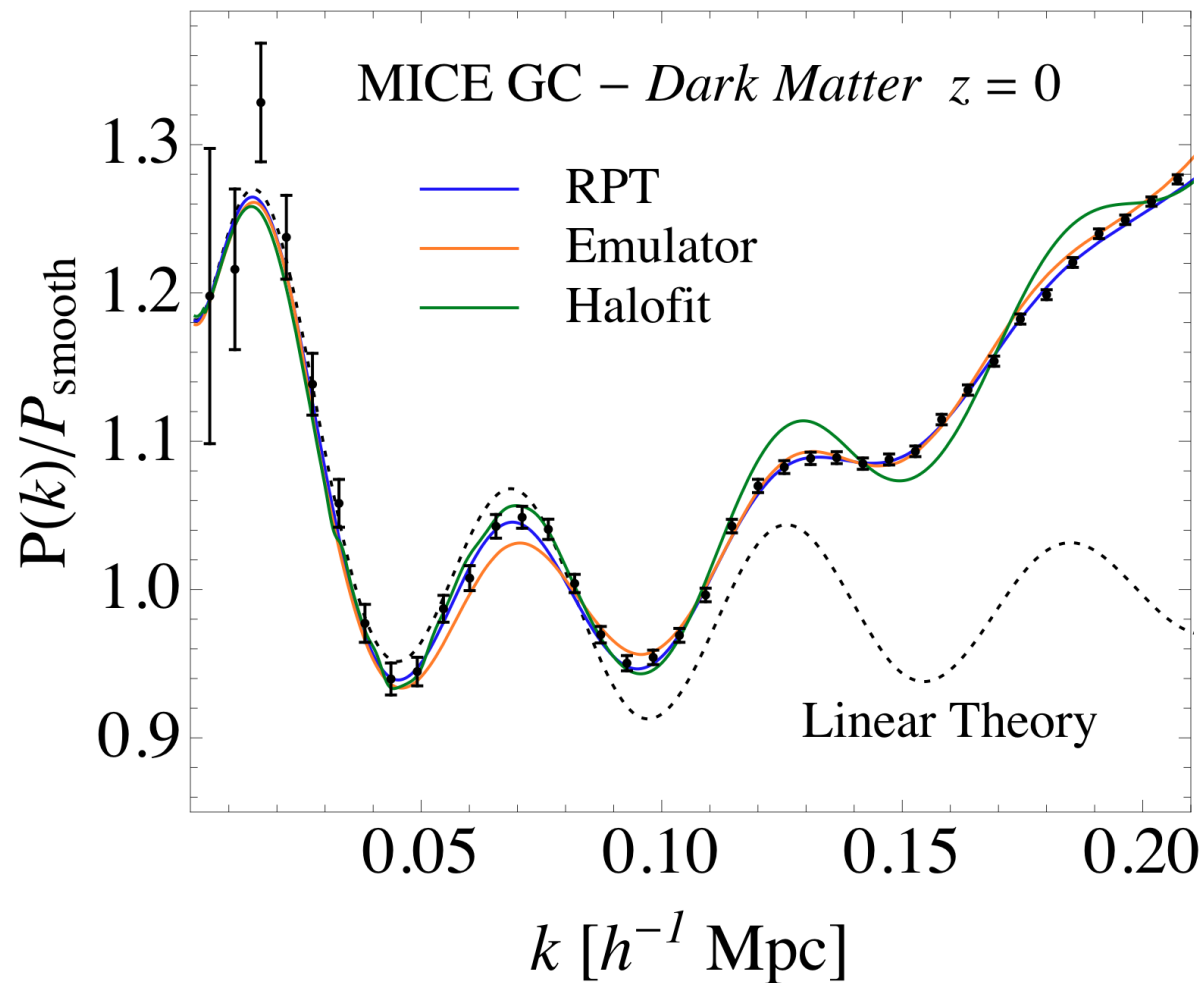
- Run at BSC Marenostrum
- Uses MICE Grand Challenge simulation:  $4096^3 = 70$  billion particles, 3 Gpc/h box,  $m_p = 3 \times 10^{10} M_\odot$
- Lightcone without repetition to  $z=1.4$
- FoF halos with  $b=0.2$  (1.2 billion,  $n_{\text{part}} \geq 10$ )
- All-sky lensing maps
- 1 octant (5000 deg<sup>2</sup>) filled with HOD+SHAM galaxies
- Apply lensing properties to all galaxies

Box Size (Mpc/h)	Number of Particles	Particle Mass ( $\times 10^{10}$ Msun/h)	PMGrid size	Initial conditions	Initial redshift	$l_{\text{soft}}$ (kpc/h)	MaxSize Timestep
3072	$4096^3$	2,927	$4096^3$	ZA	100	50	0,02

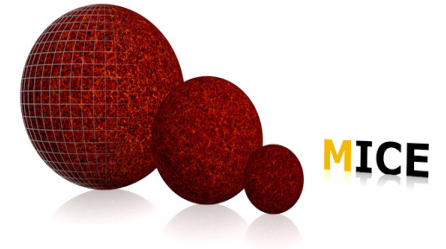




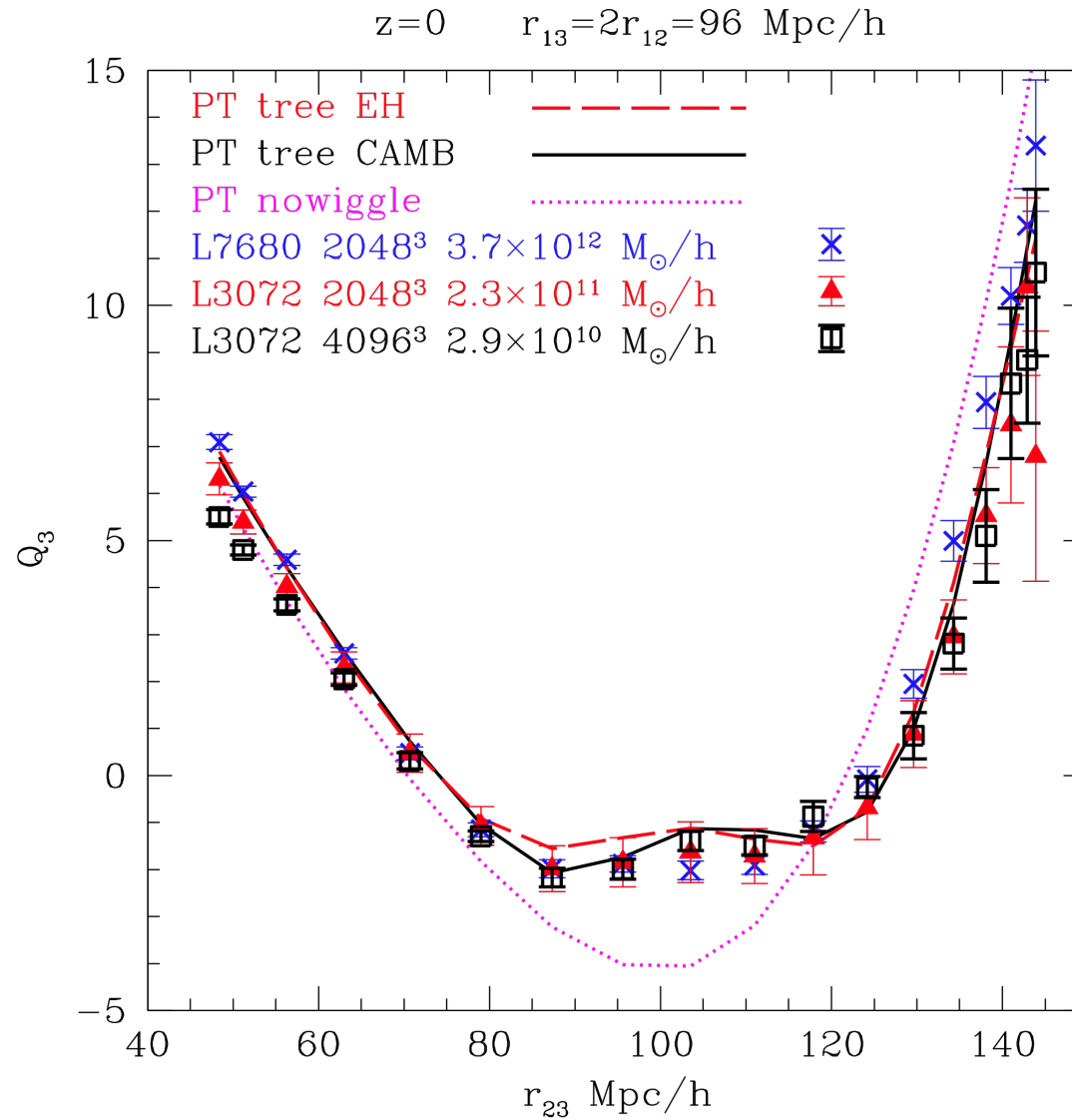
## Dark Matter

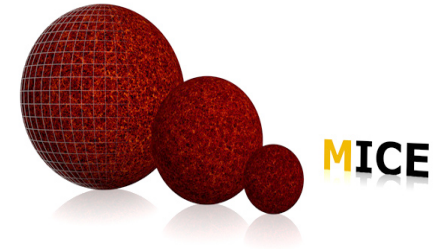






## Dark Matter

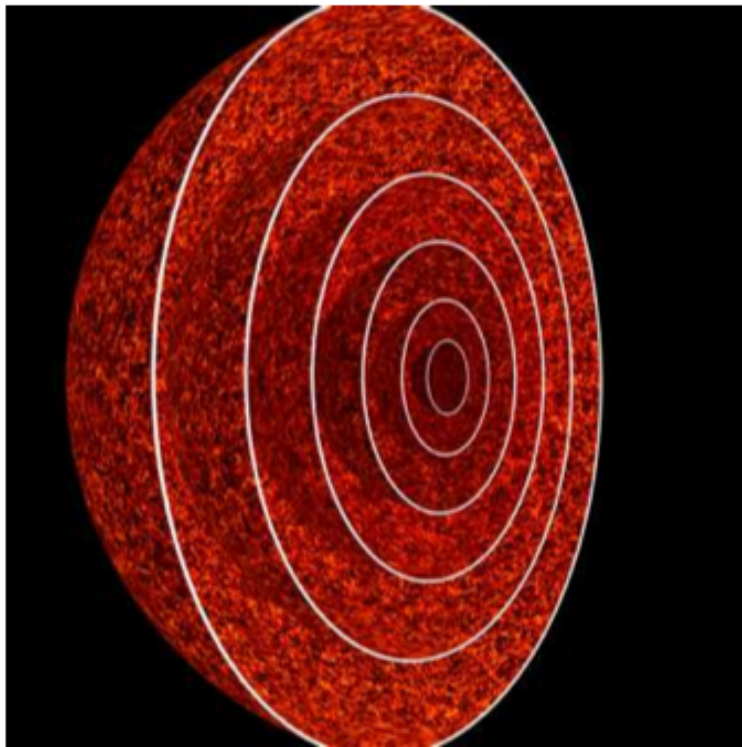




## All sky lensing maps

*“The onion universe: all sky light-cone simulations in spherical shells ”*

Fosalba et al, MNRAS, **391**, 435 (2008)



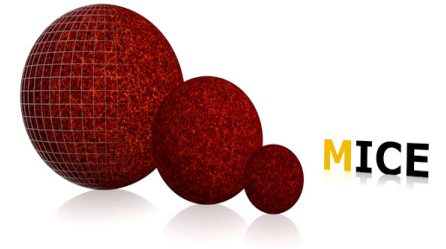
- Split data in thin shells
- Interplate into (healpix) pixels
- Combine to produce convergence maps

$$\kappa(\theta) = \frac{3H_0^2\Omega_m}{2c^2} \int dr \delta(r, \theta) \frac{(r_s - r)r}{r_s a}$$

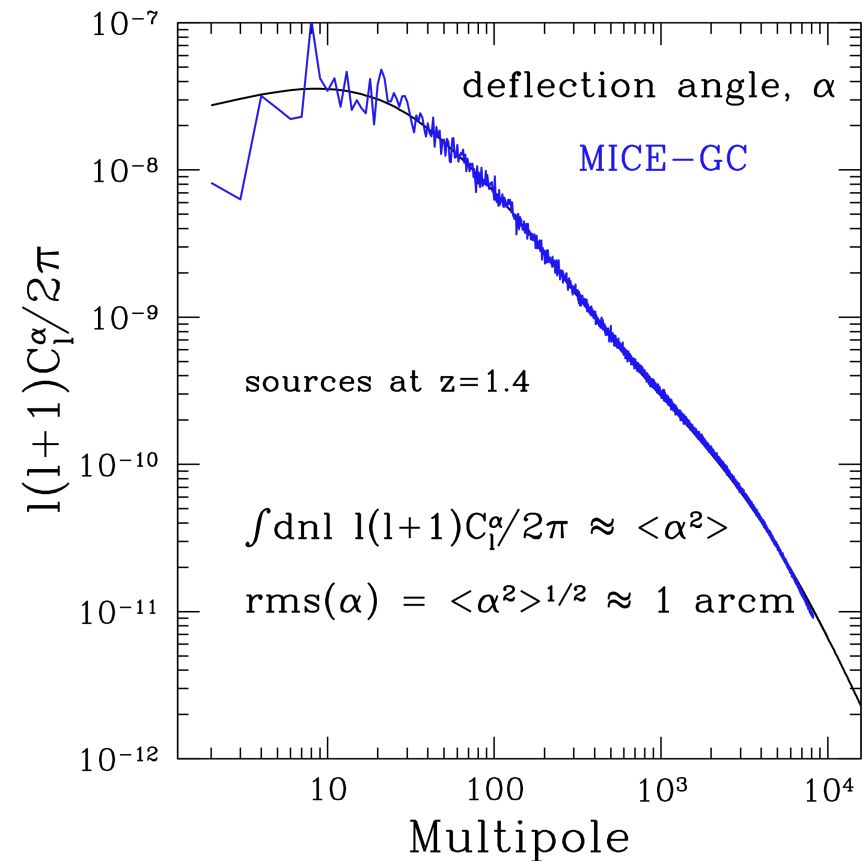
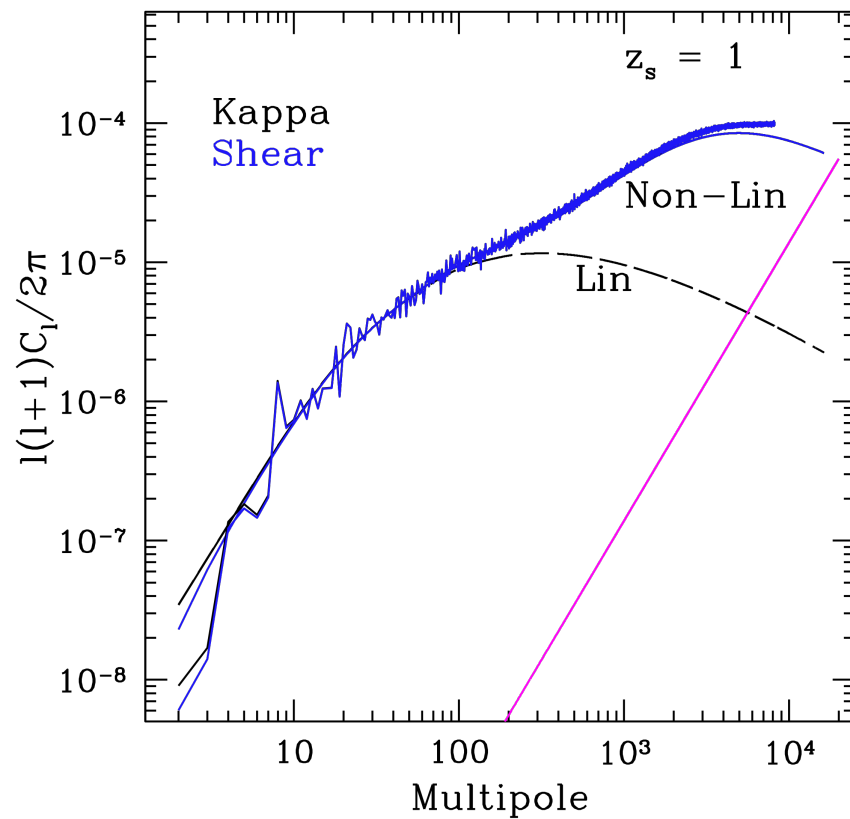


$$\kappa(i) = \frac{3H_0^2\Omega_m}{2c^2} \sum_j \delta(i, j) \frac{(r_s - r_j)r_j}{r_s a_j} dr_j$$

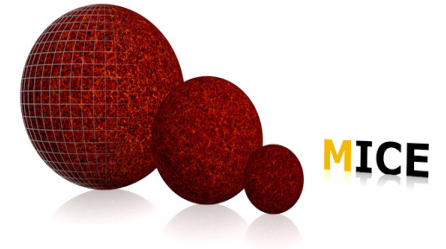
- From this it is possible to obtain other lensing observables, e.g. shear, magnification, flexion, etc *in the Born approximation*



## All sky lensing maps

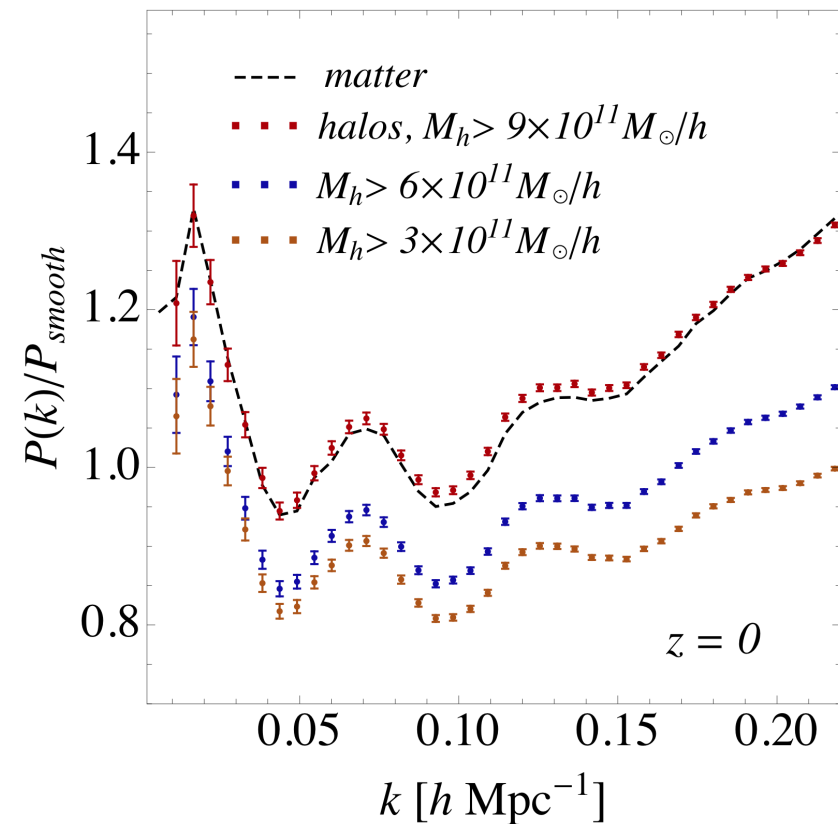
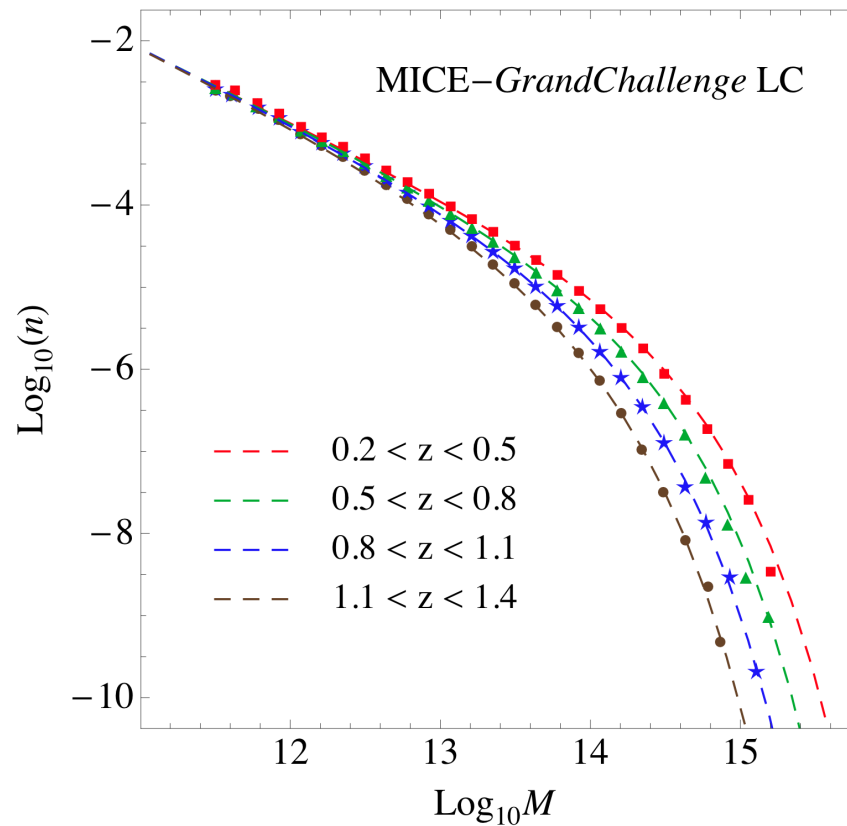






## Halo catalogue

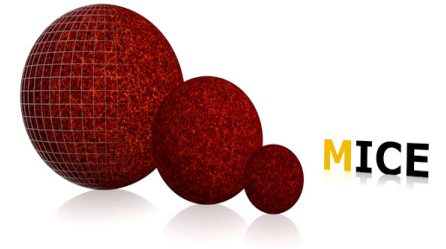
- Select halos with FoF  $b=0.2$ ; Crocce et al 2010



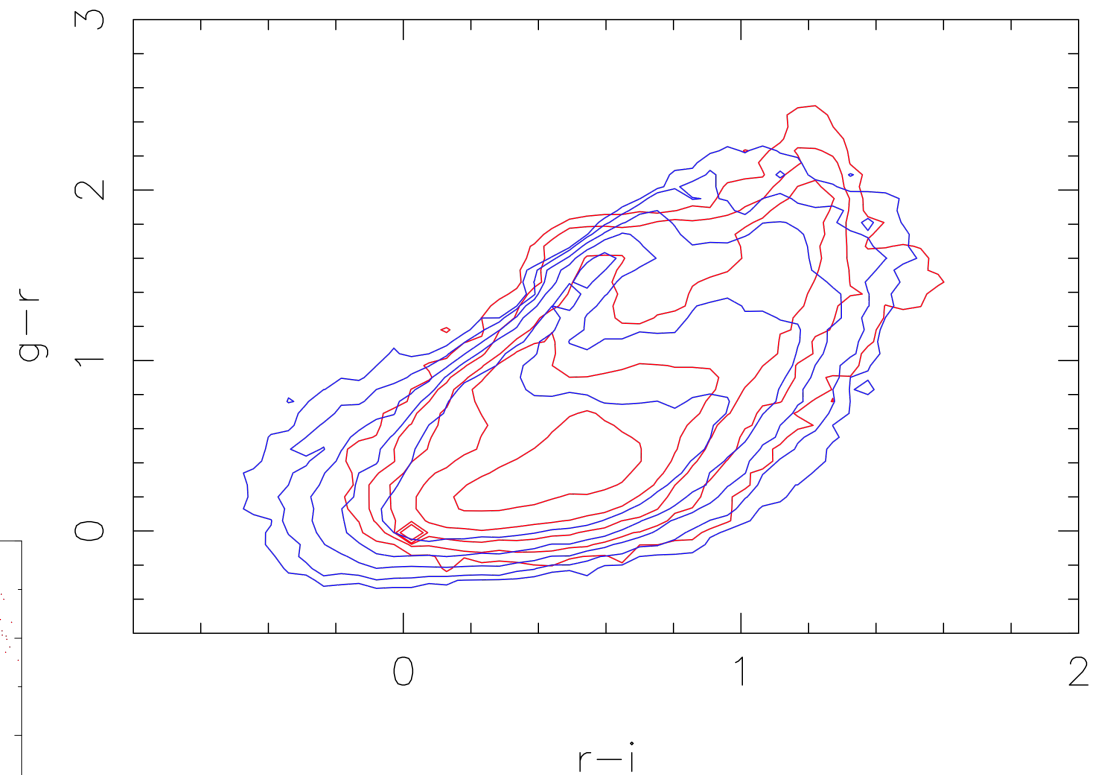
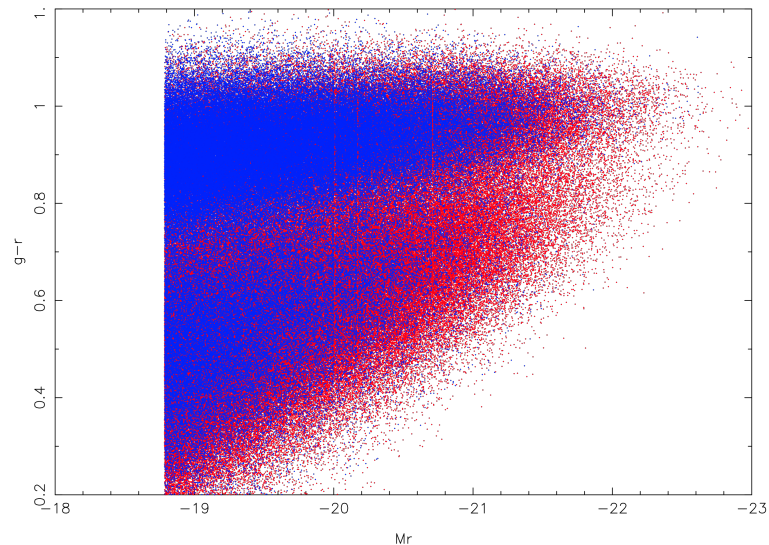
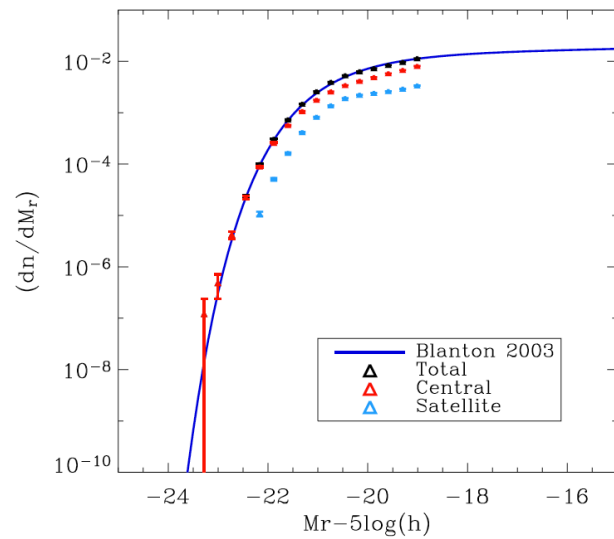


## Galaxy Catalogues

- Build mock galaxy catalogues from N-body halos using HOD & SHAM prescriptions
- Generate: positions, luminosities, colours, SEDs and lensing
- Start at  $z=0$  where constraints more stringent
- Constraints
  - luminosity function
  - colour-magnitude diagram
  - clustering as a function of luminosity and colour
- Implement recipes to higher redshifts



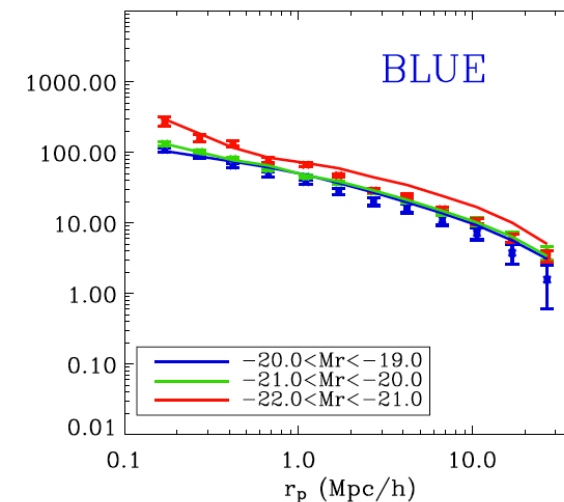
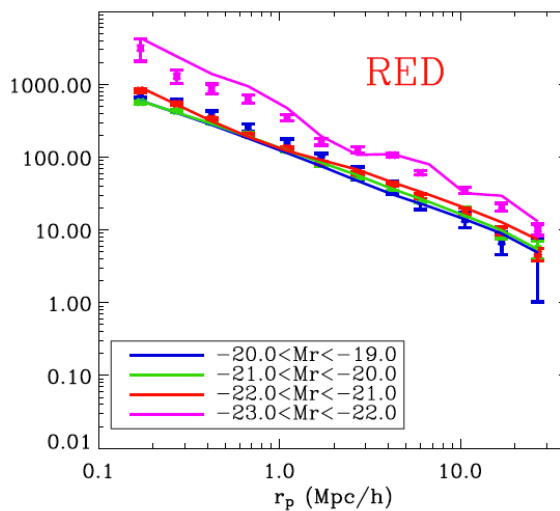
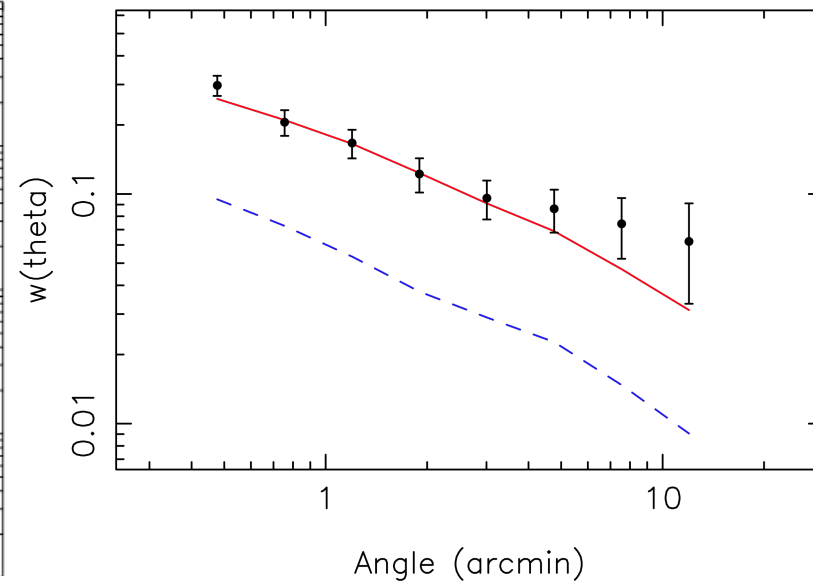
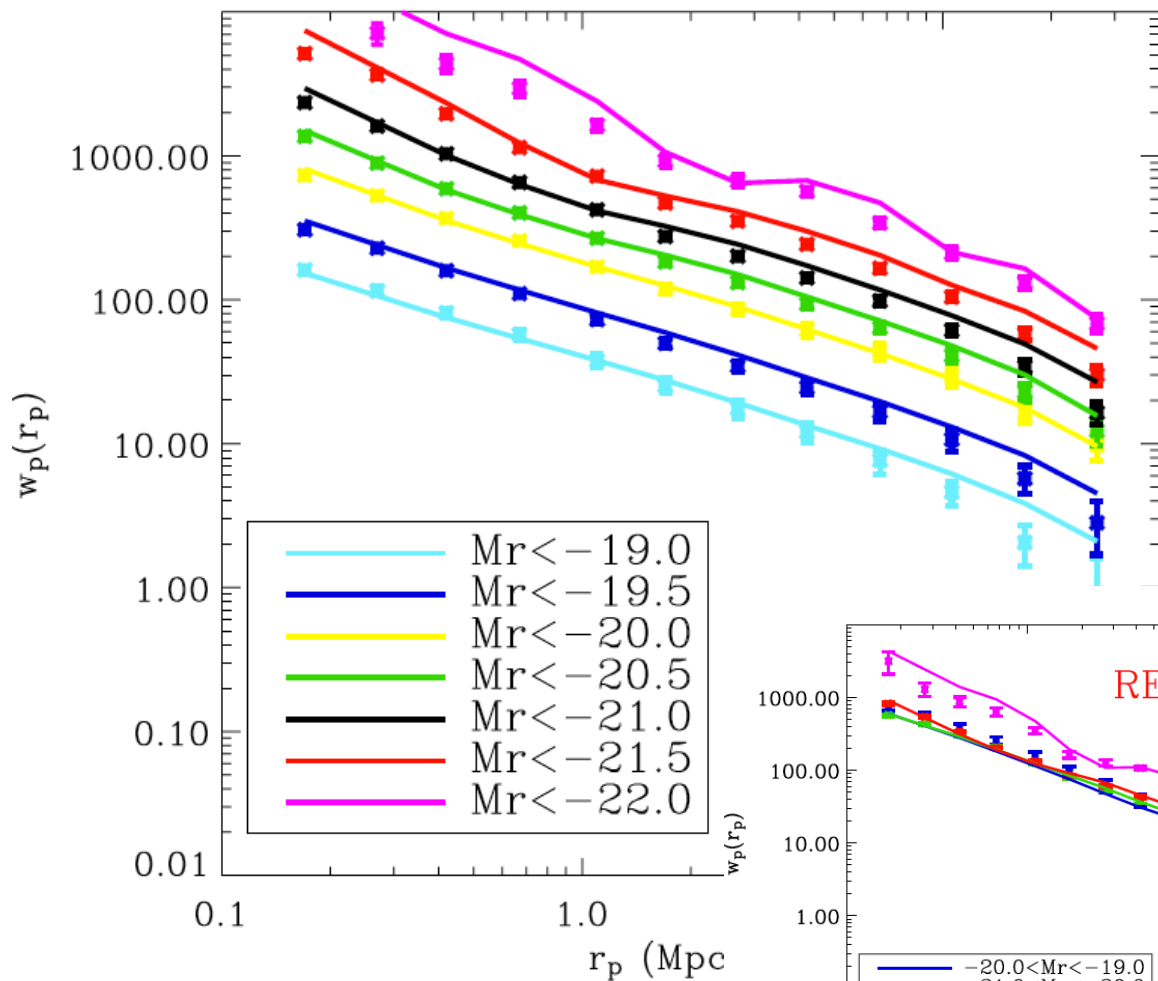
## Galaxy catalogue: photometric properties





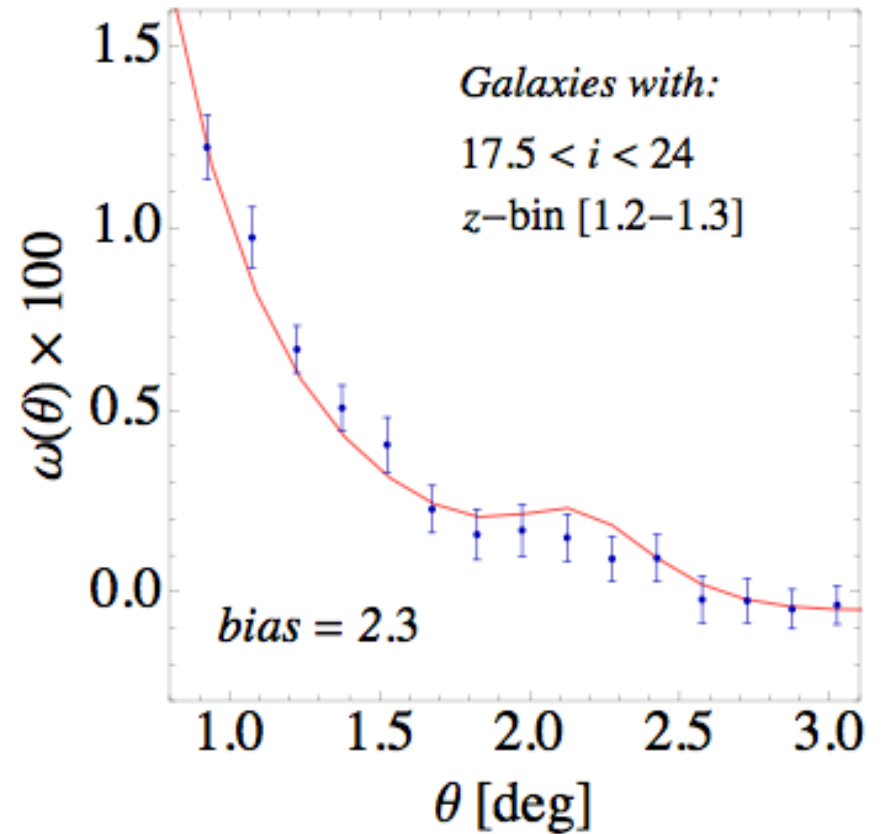
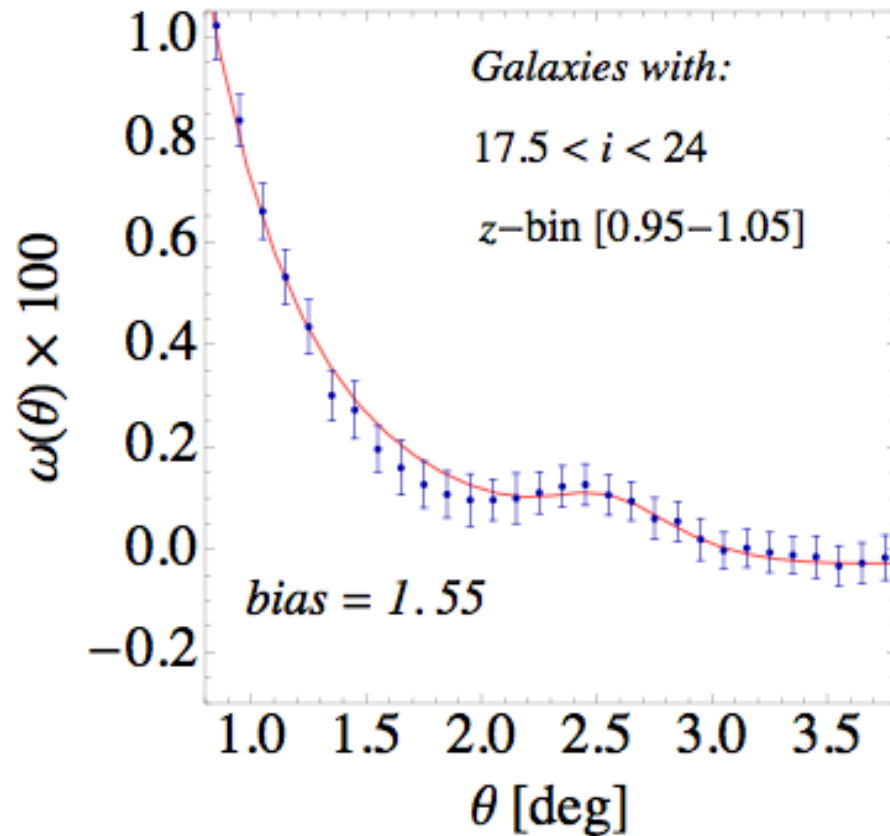


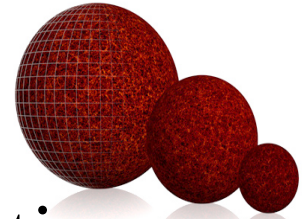
## Galaxy Catalogue: clustering





## Galaxy catalogues: clustering

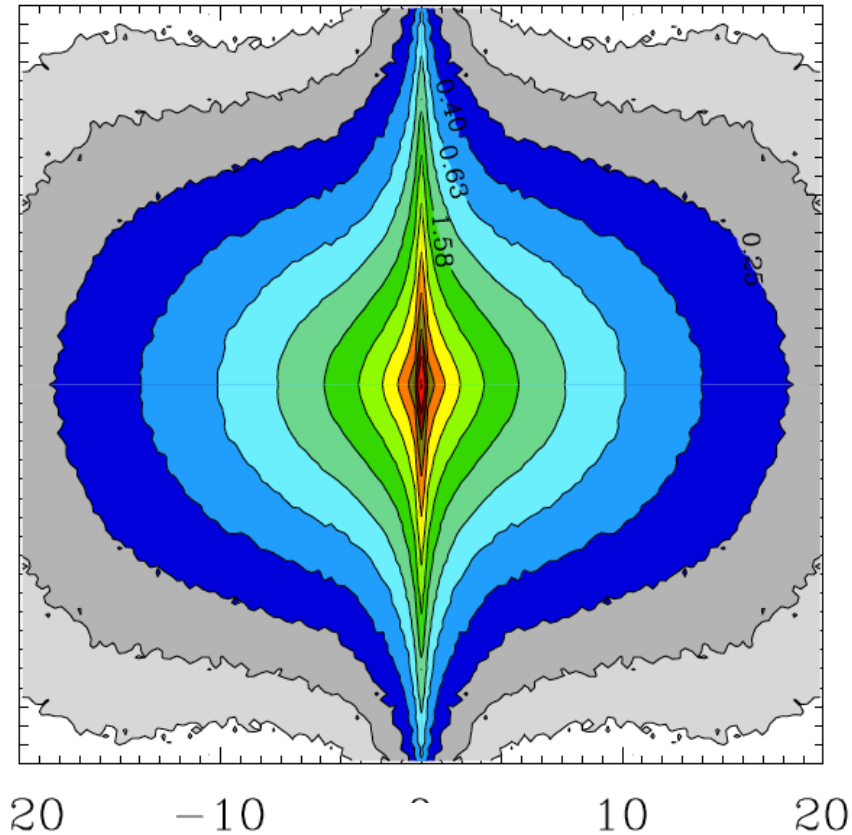
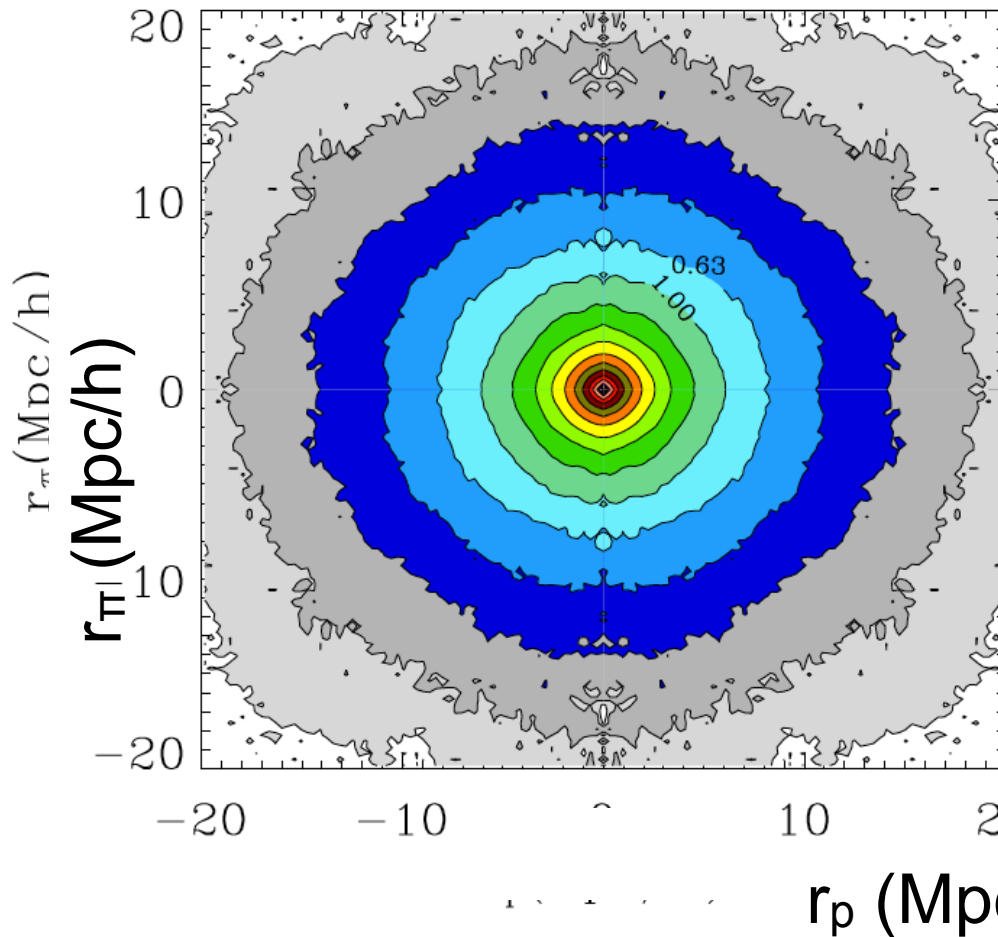




## Galaxy Catalogue: Redshift Space Distortions

real space

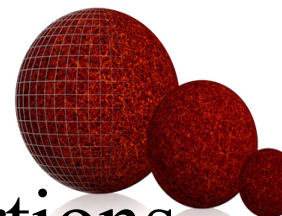
redshift space



$M_r < -19.0$

$L_{\text{BOX}} = 307.2 \text{ Mpc/h}$



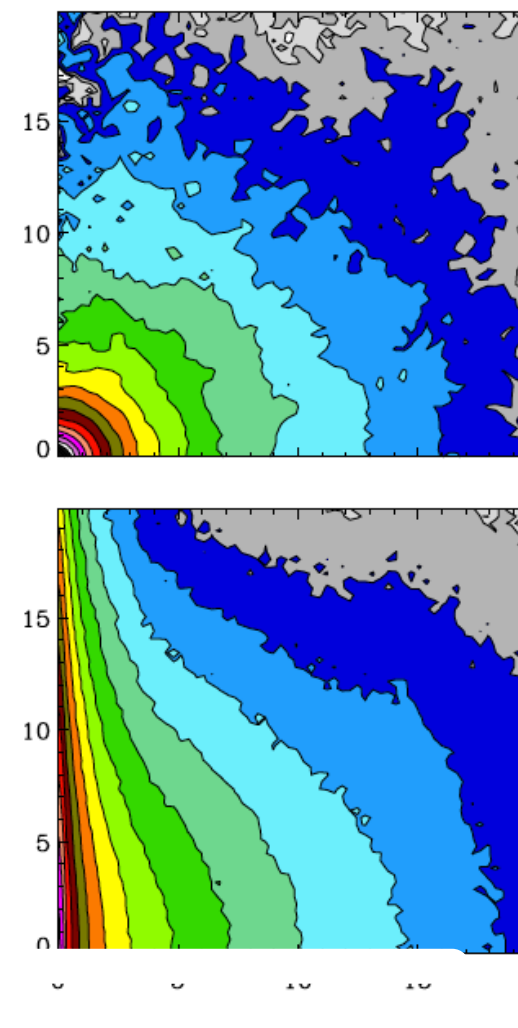
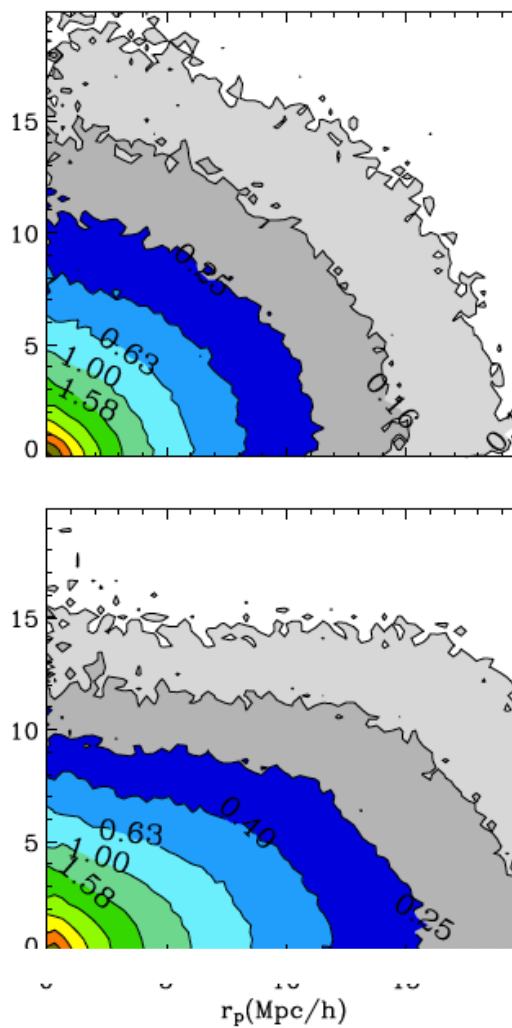
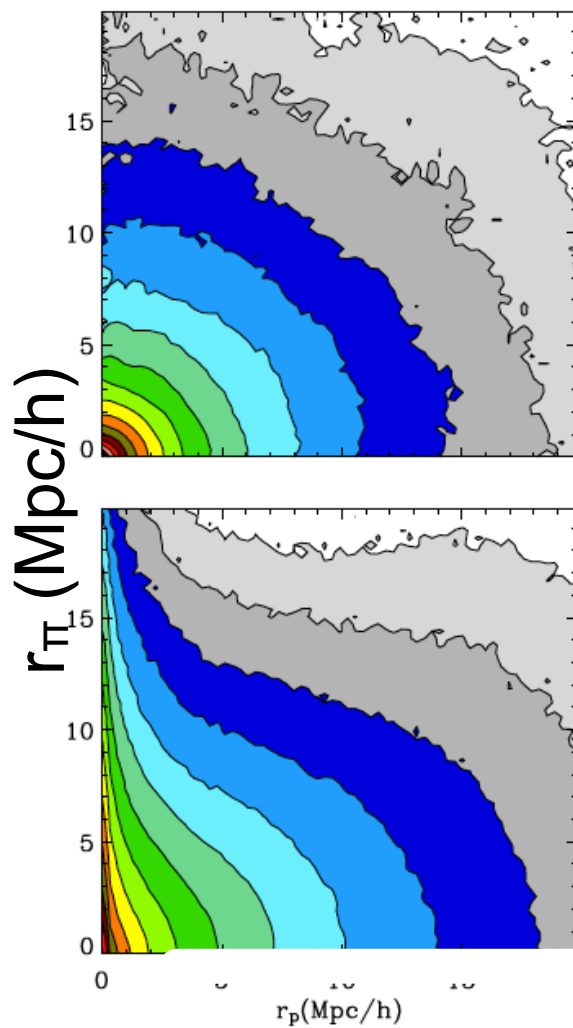


## Galaxy Catalogue: Redshift Space Distortions

TOTAL

CENTRAL

SATELLITE

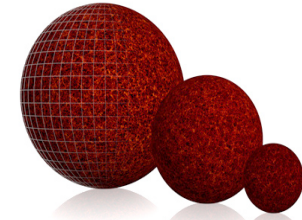


real space

redshift space

$r_p$  (Mpc/h)

$M_r < -19.0$   $L_{\text{BOX}} = 307.2$  Mpc/h



## Galaxy Catalogue: Redshift Space Distortions

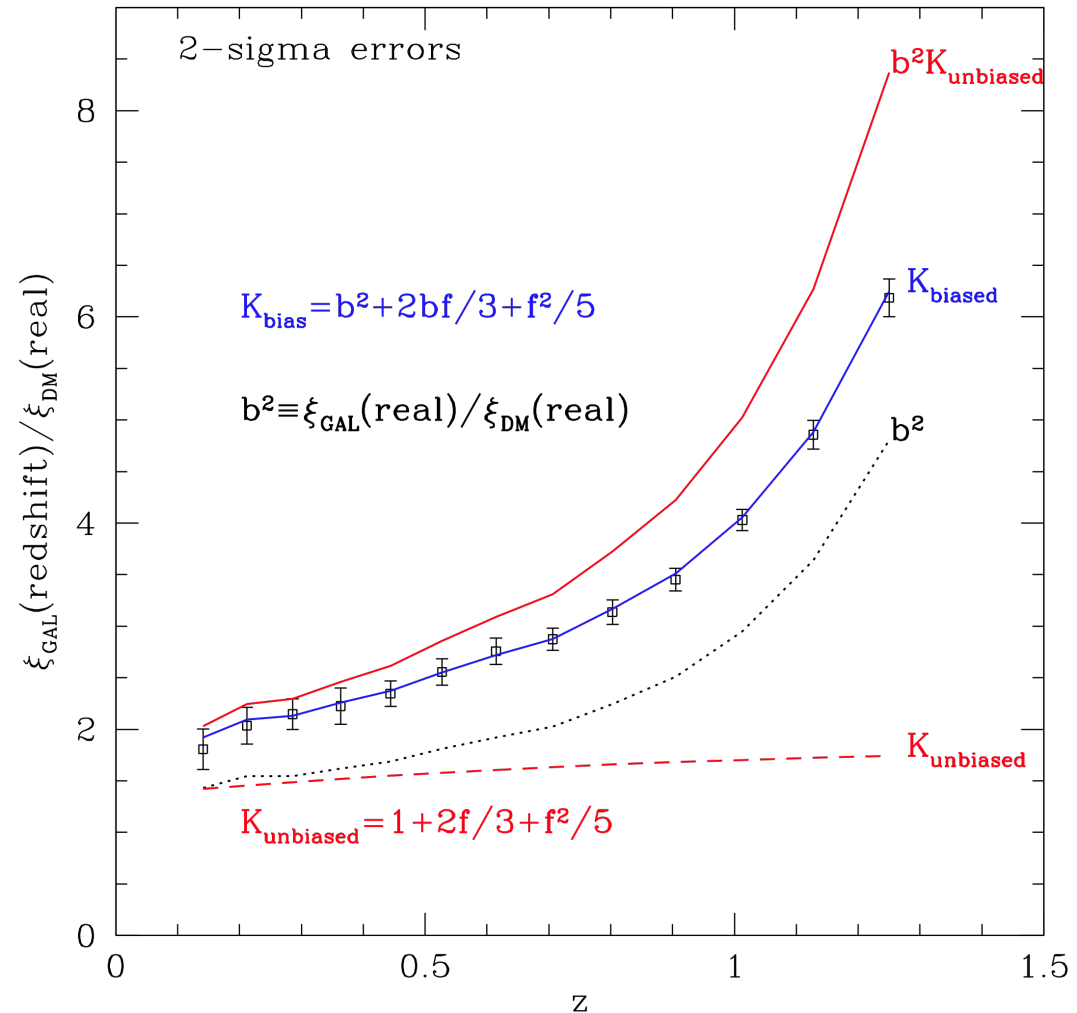
gal.reds.v0.2r24 vs DM

$$\delta_G(k, \mu) = (b + f\mu^2)\delta_m(k)$$

$$P_{\delta\delta}(k, \mu) = \langle \delta_G^2(k) \rangle = (b + f\mu^2)^2 P(k)$$

$$\xi_{\delta\delta} = K(z) \xi_{mm}$$

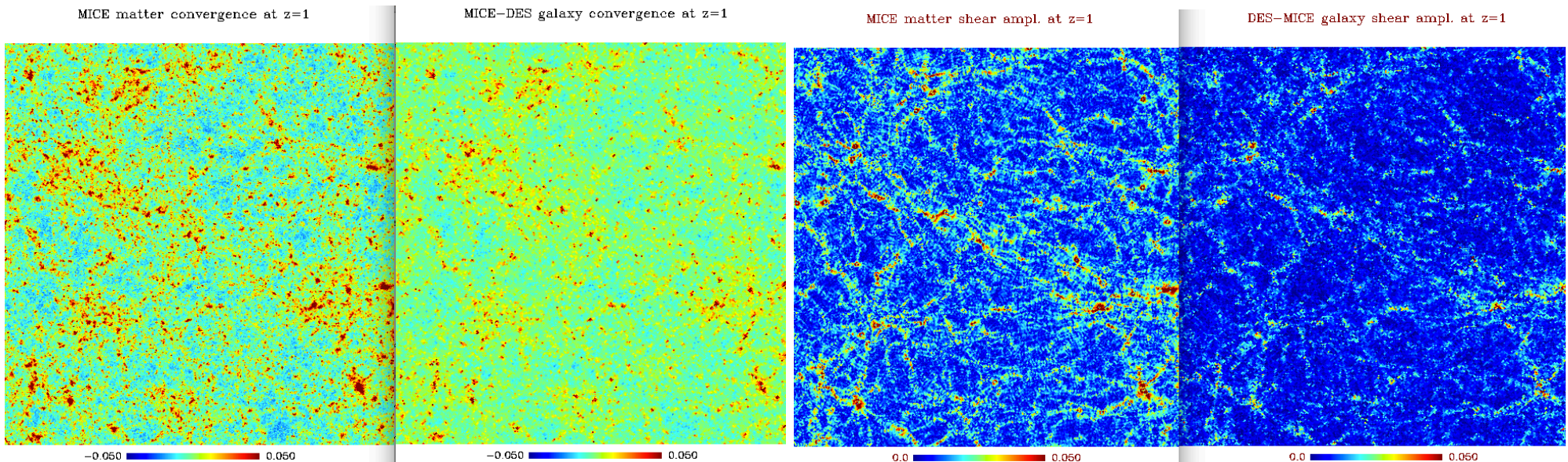
$$K(z) \equiv b(z)^2 + \frac{2}{3}b(z)f(z) + \frac{1}{5}f(z)^2b(z)^2$$





## Galaxy catalogue: lensing

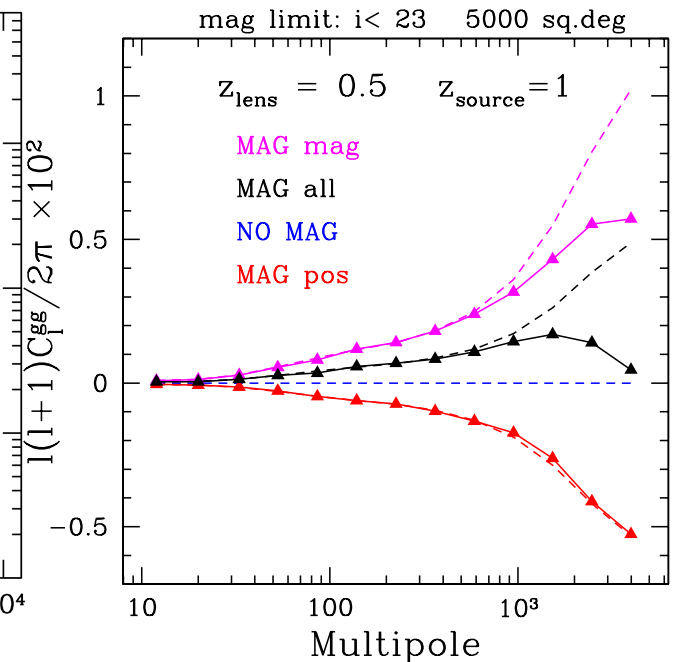
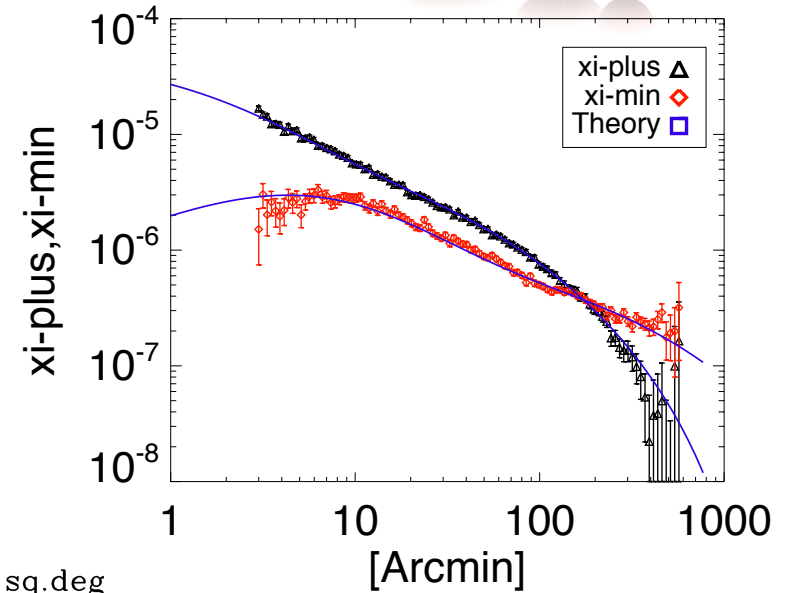
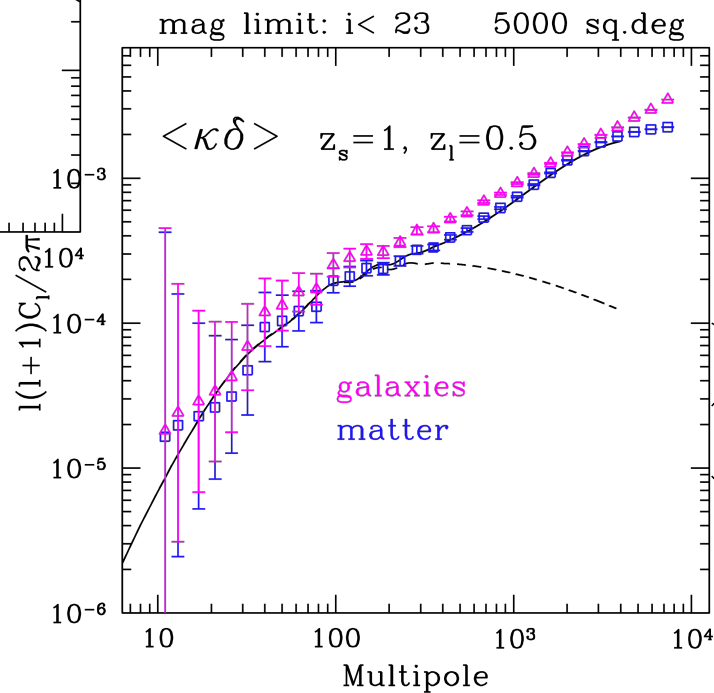
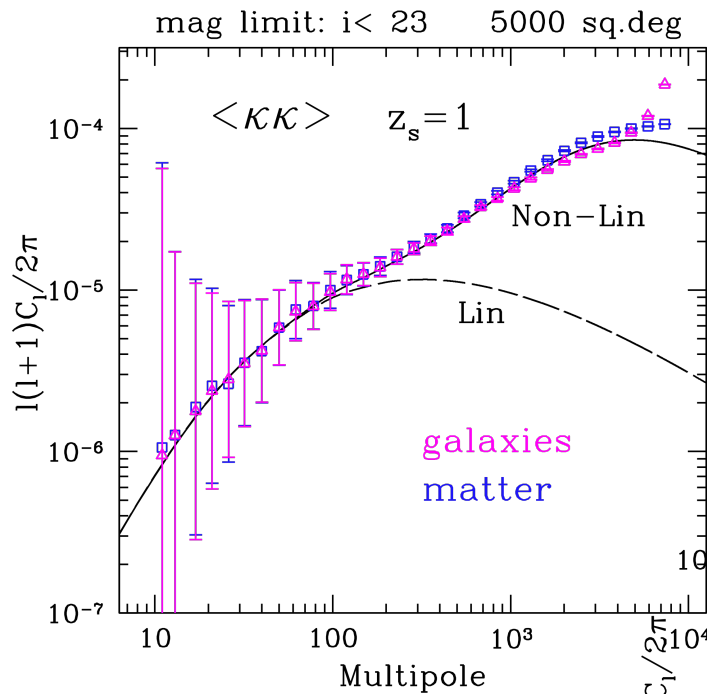
- All-sky convergence maps computed in 3D in the LC
- Compute shear in this 3D grid
- Assign convergence and shear to galaxies







## Galaxy catalogue: lensing





## Galaxy catalogue

- Constructed from large N-body simulation with HOD +SHAM recipes
- lensing information (convergence, shear and displacements) for all galaxies
- galaxy clustering
- galaxy properties (SEDs)
- useful for large cosmological surveys; DB distribution

## Developments

- improve incompleteness
- improve SEDs: add emission lines & AGN