# Connecting Galaxies and Dark Matter:

## *The Conditional Mass Function*

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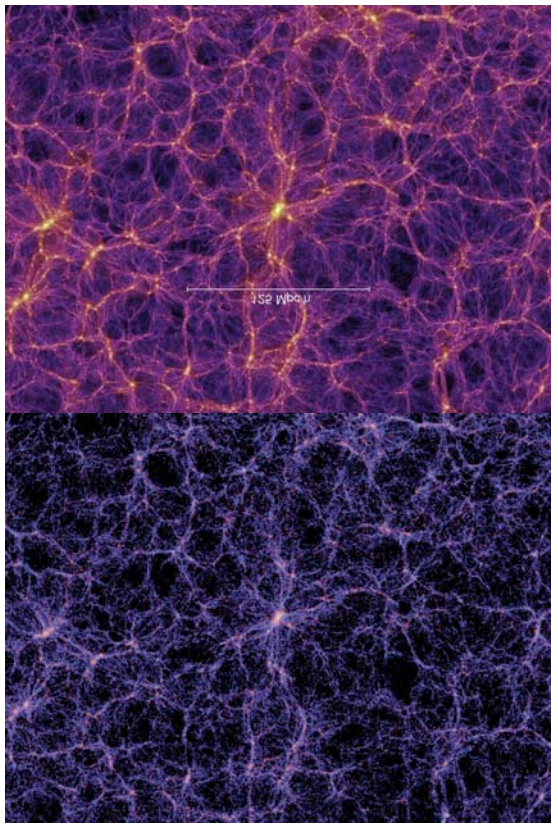
# Motivation and Techniques

## Why study connection between Galaxies and Dark Matter?

- **To constrain the physics of Galaxy Formation**
  - Cooling
  - Star formation
  - Merging
  - Feedback processes (AGN, SN)
- **To constrain Cosmological Parameters**



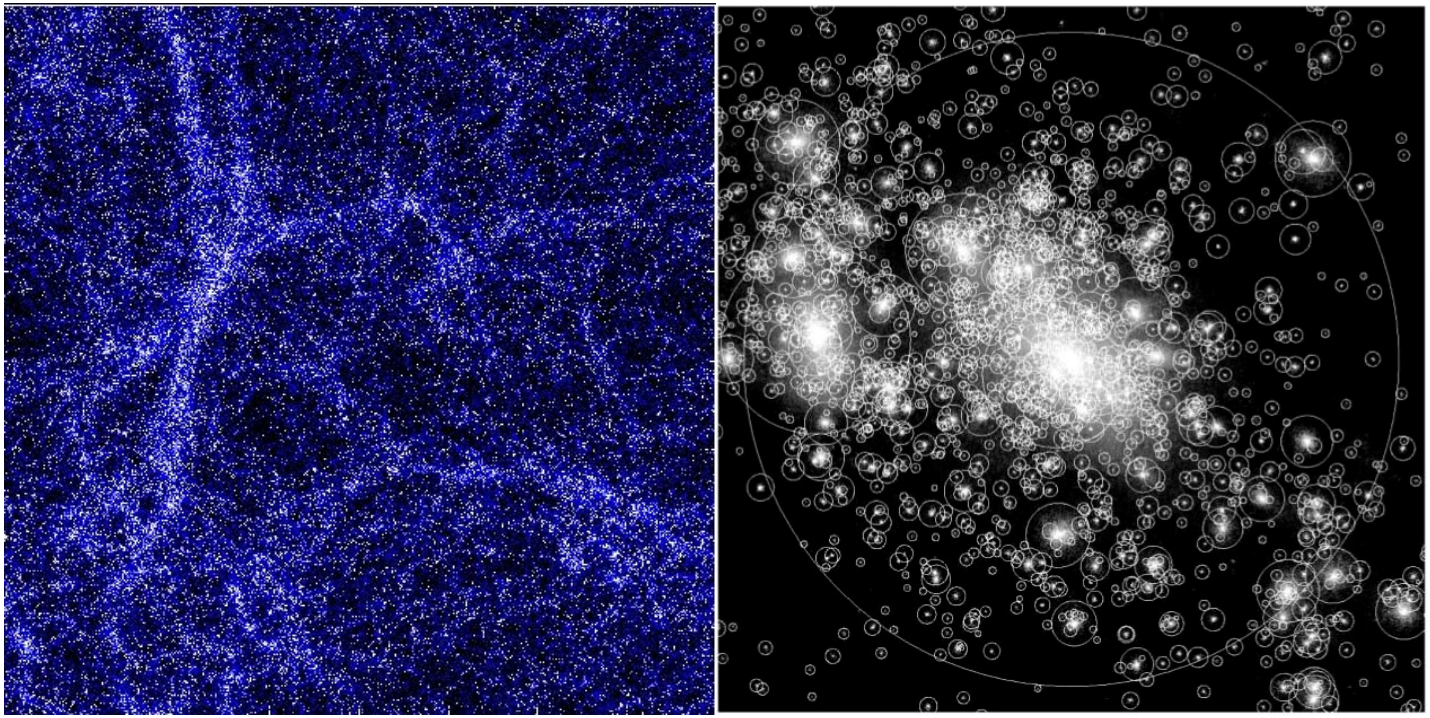
## How to Constrain this Connection?

- **Stellar mass dependent Clustering**
- **Galaxy Group Catalogues**

# Halo Identification

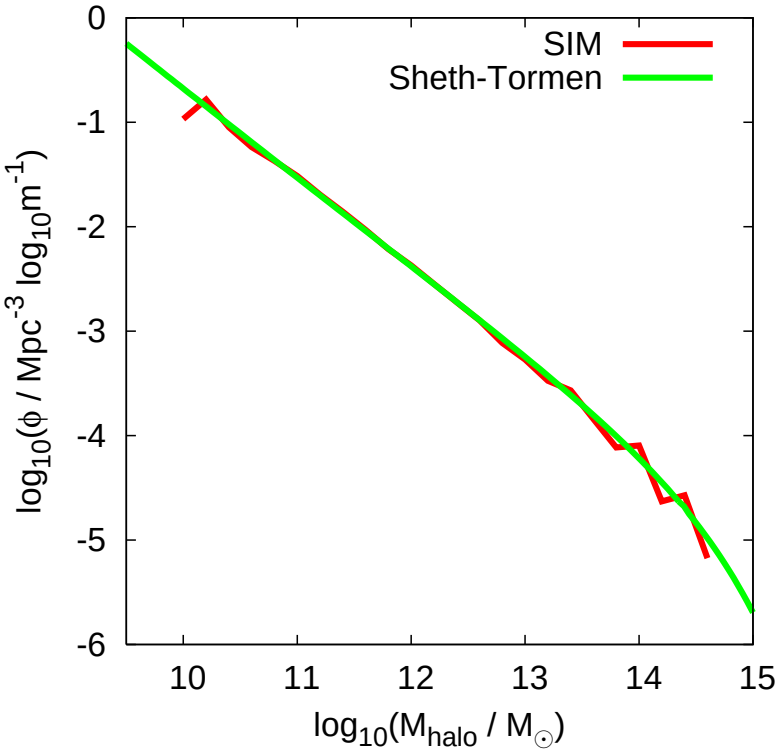
- Starting point: Dark Matter only simulation in a $80h^{-1}$ box
- Identify halos and subhalos with bound density maxima algorithm (BDM)
- Halo whose center is located in larger halo is called subhalo

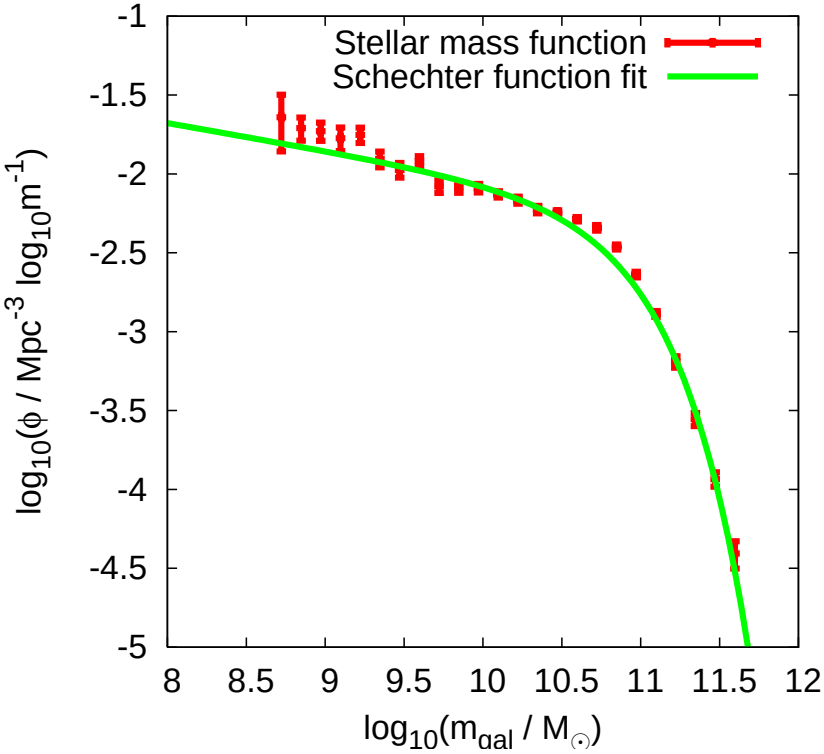
$h = 0.7$
$\Omega_m = 0.3$
$\Omega_\Lambda = 0.3$
$\sigma_8 = 0.9$
$n = 1.0$



# Mass functions

- Mass function gives number of objects of a certain mass per volume




- Linear stellar mass to halo mass ratio ?

  → No. Too many low mass and high mass halos

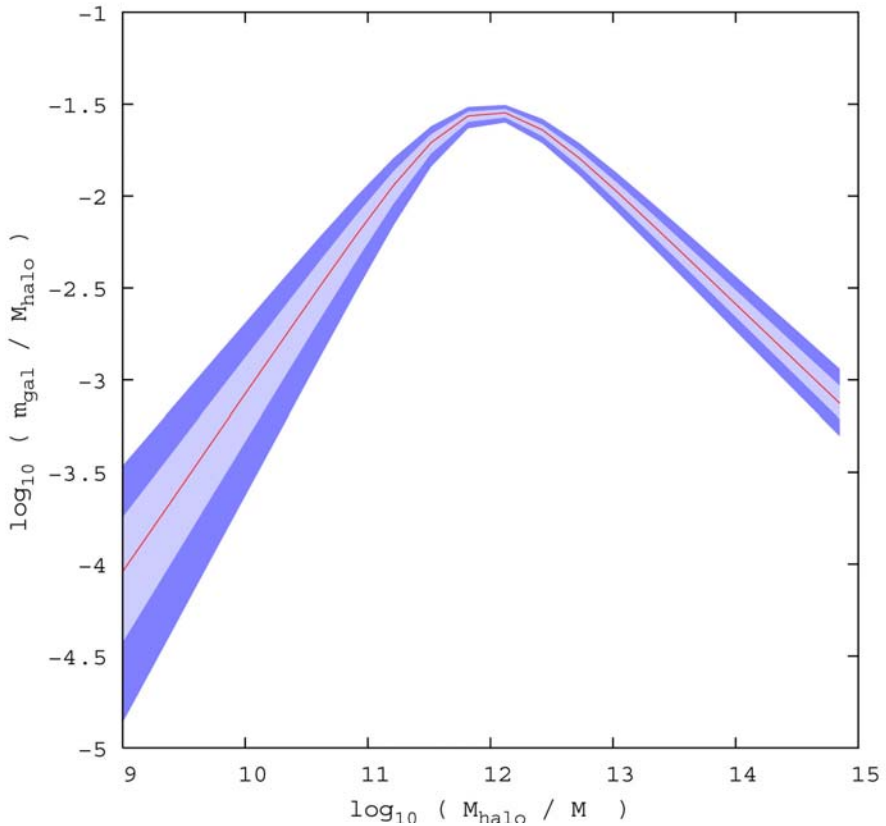
# Map: halo mass to stellar mass

- Need a ratio which is low for low and high halo masses
- Parameterization:

$$M_h \rightarrow m_g(M_h)$$

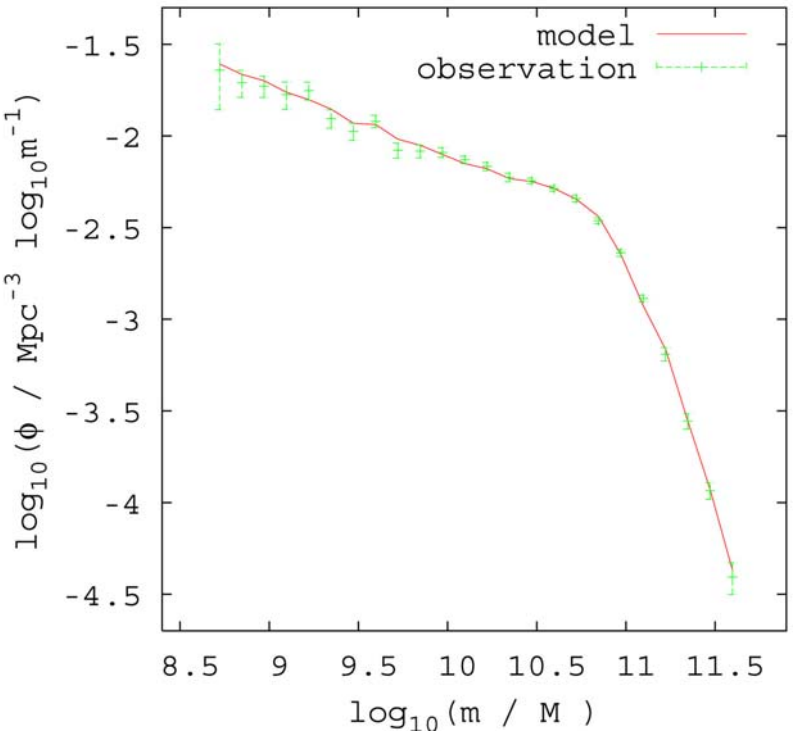
$$m_g(M_h) = 2 \cdot \left(\frac{m}{M}\right)_0 \cdot M_h \cdot \left[\left(\frac{M_h}{M_1}\right)^{-\beta} + \left(\frac{M_h}{M_1}\right)^{\gamma}\right]^{-1}$$

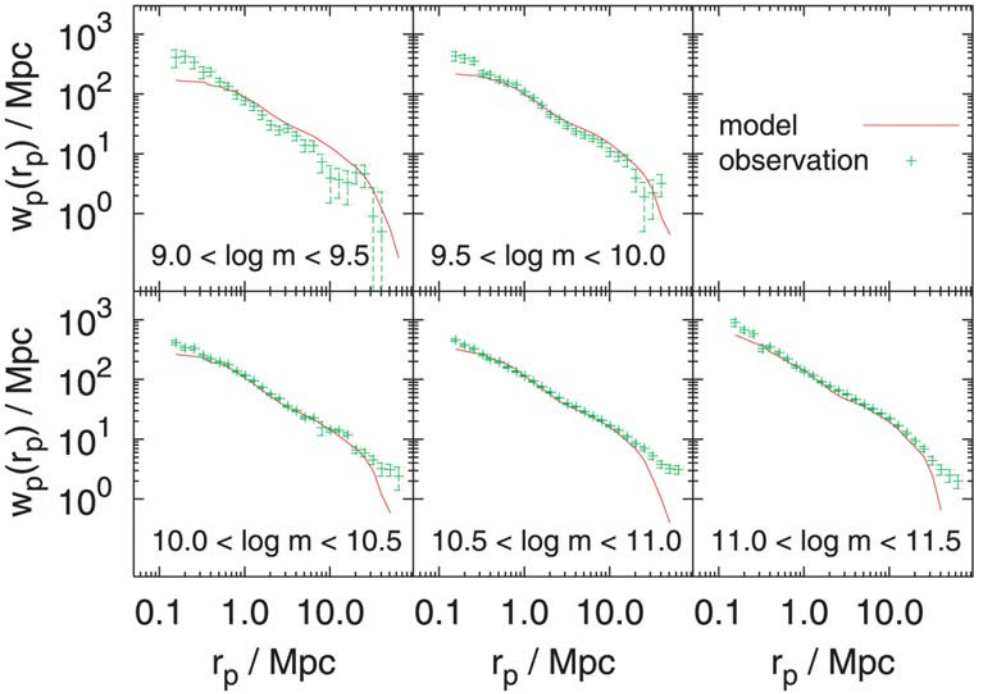
- 4 free parameters:
  - $\beta$ slope for low halo masses
  - $\gamma$ slope for high halo masses
  - $\left(\frac{m}{M}\right)_0$ maximal ratio
  - $M_1$ halo mass for maximal ratio



# Constraining the parameters

- Compute stellar mass function of the model: Φ(m)
- Compute projected correlation functions for 5 stellar mass bins: $w_p(r_p)$
- Use Powell's direction set method to fit model to observed properties



# Conditional mass function

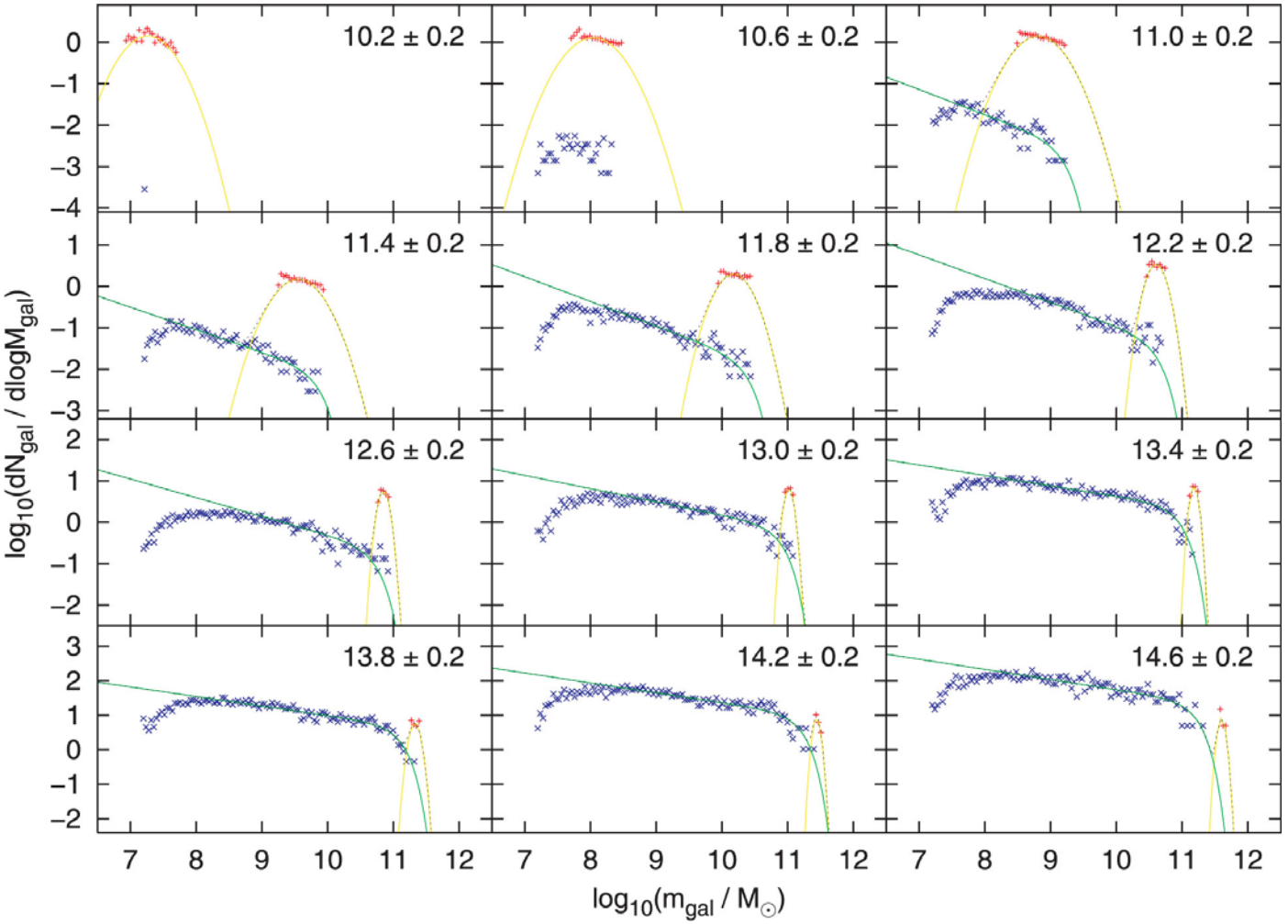
- The conditional mass function (CMF) $\Phi(m|M)\mathrm{d}m$ gives the average number of galaxies with stellar masses in the range $m \pm \mathrm{d}m/2$ that live in a halo of mass $M$
- Split CMF in central and satellite components
- Central galaxies live at the center of host halos and are described by a lognormal distribution
- Satellite galaxies live at the center of subhalos and are described by a modified Schechter function

$$\Phi(m|M)\mathrm{d}m = \Phi_c(m|M)\mathrm{d}m + \Phi_s(m|M)\mathrm{d}m$$

$$\Phi_c(m|M)\mathrm{d}m = \frac{1}{\sqrt{2\pi}\ln(10)\sigma_c}\exp\left[-\left(\frac{\log(m/m_c)}{\sqrt{2}\sigma_c}\right)^2\right]\frac{\mathrm{d}m}{m}$$

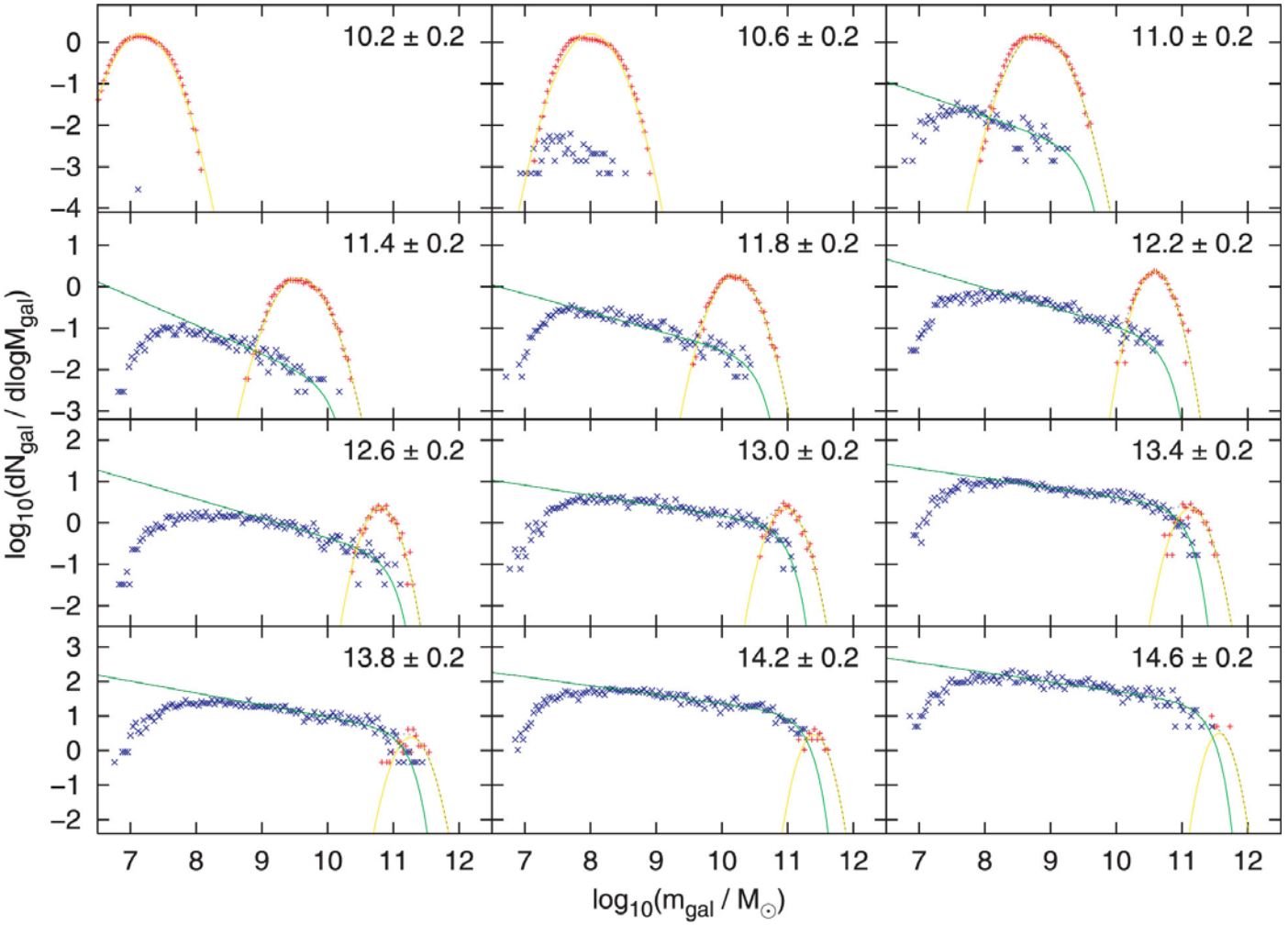
$$\Phi_s(m|M)\mathrm{d}m = \frac{\Phi_s}{m_s}\left(\frac{m}{m_s}\right)^{\alpha_s}\exp\left[-(m/m_s)^2\right]\mathrm{d}m$$

# CMF

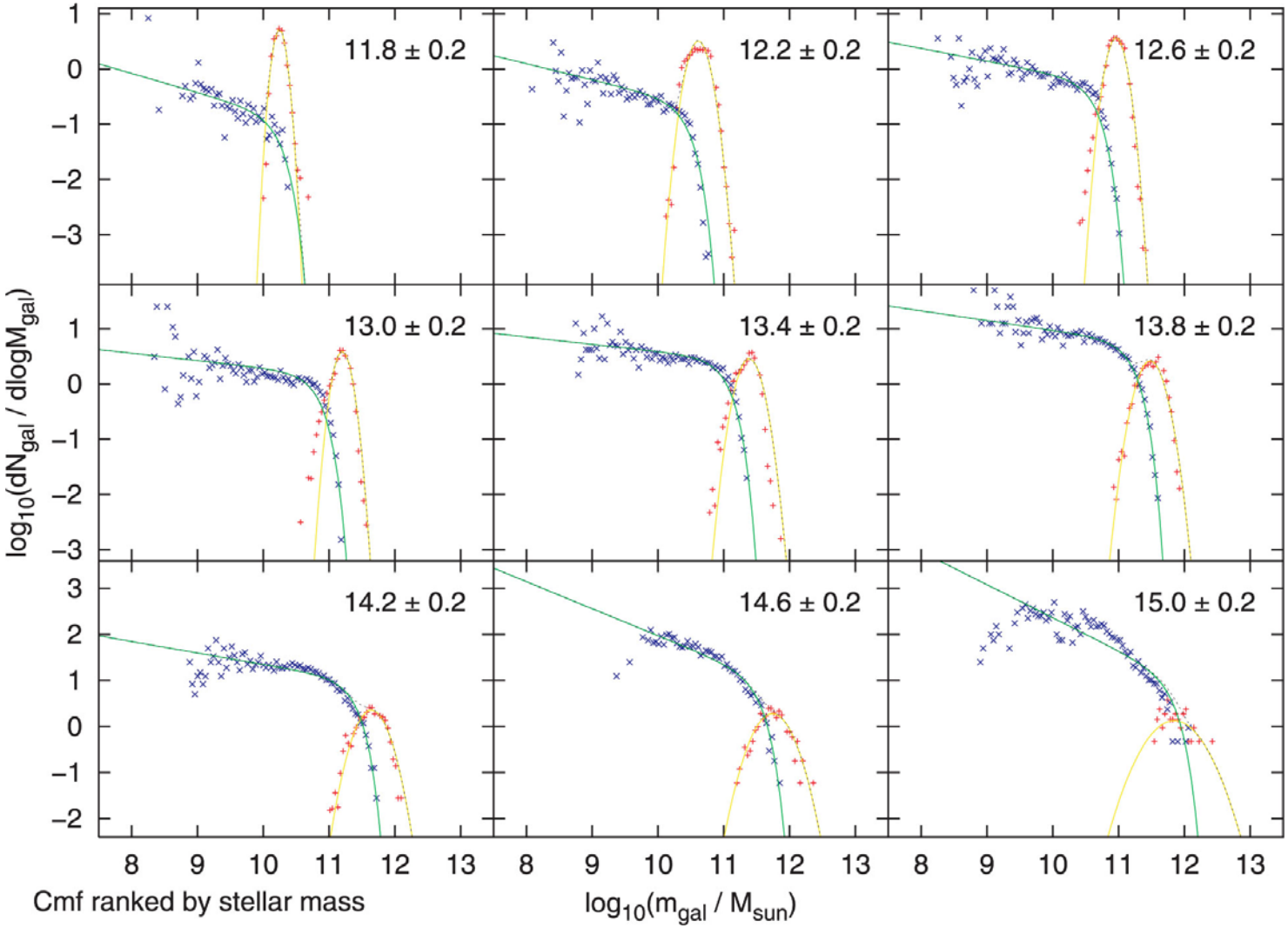

10.2 ± 0.2
10.6 ± 0.2
11.0 ± 0.2
11.4 ± 0.2
11.8 ± 0.2
12.2 ± 0.2
12.6 ± 0.2
13.0 ± 0.2
13.4 ± 0.2
13.8 ± 0.2
14.2 ± 0.2
14.6 ± 0.2
log10(dNgal / dlogMgal)
log10(mgal / M⊙)

# CMF with scatter $\sigma_{inp}$= 0.15

Now: $M_h \rightarrow m_g(M_h) + \sigma_{inp} \cdot \text{gaussian}$



# CMF for SDSS


11.8 ± 0.2
12.2 ± 0.2
12.6 ± 0.2
13.0 ± 0.2
13.4 ± 0.2
13.8 ± 0.2
14.2 ± 0.2
14.6 ± 0.2
15.0 ± 0.2
log10(dNgal / dlogMgal)
Cmf ranked by stellar mass
log10(mgal / Msun)

# Outview

Redshift dependence

- Take simulation at different redshifts (i.e. $0<z<1$)
- Map and fit to stellar mass functions and correlation functions for corresponding redshifts
- Determine redshift dependence of free parameters, i.e. $\beta(z)$
- Predict stellar mass function, mass dependent clustering and CMF for higher redshifts $1<z<6$

Cosmology dependence

- Take simulation for different cosmologies (i.e different $\Omega_m$, $\sigma_8$)
- See how mass function, clustering and CMF change