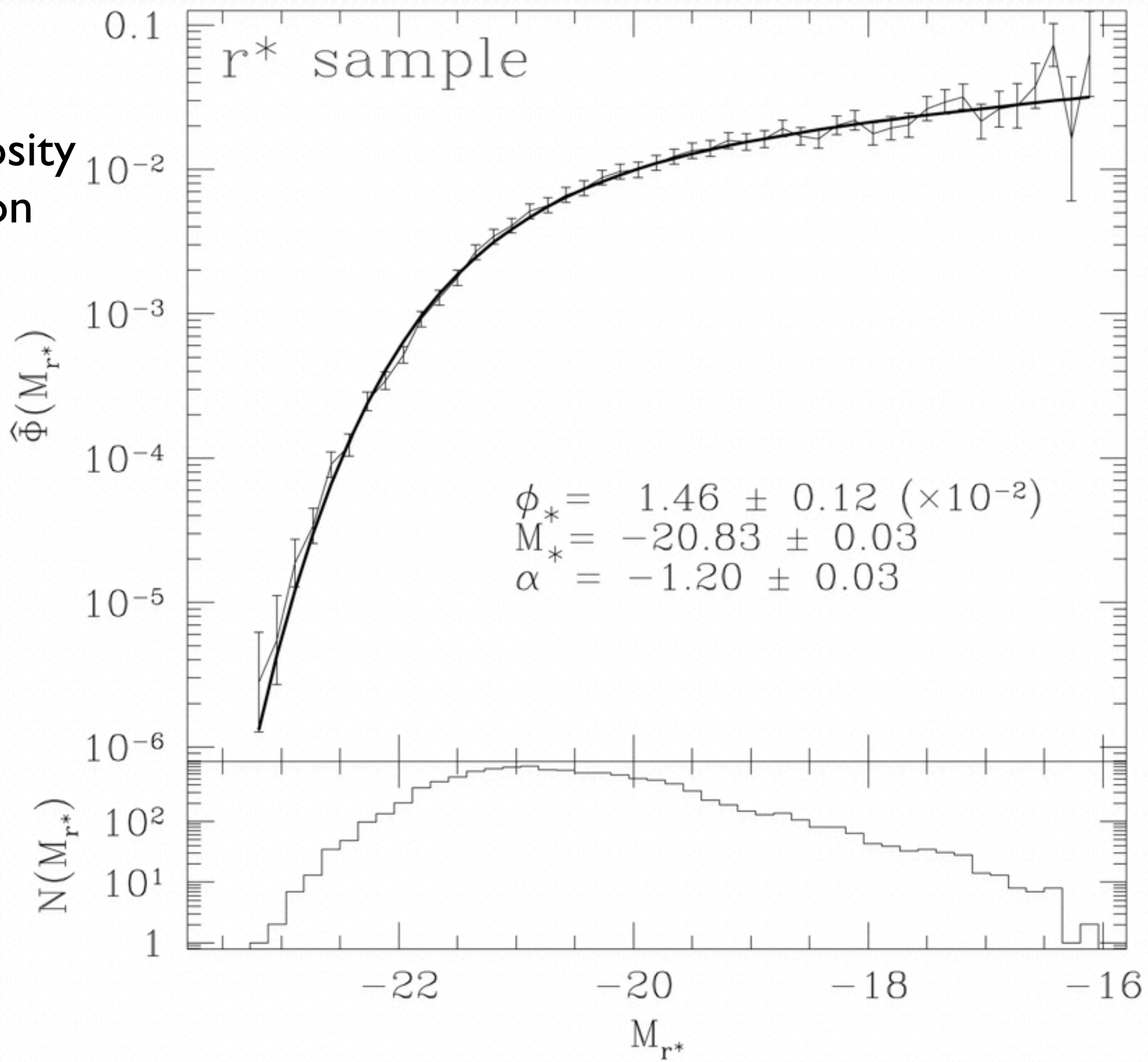
# Scaling relations

Luminosity & mass fcns

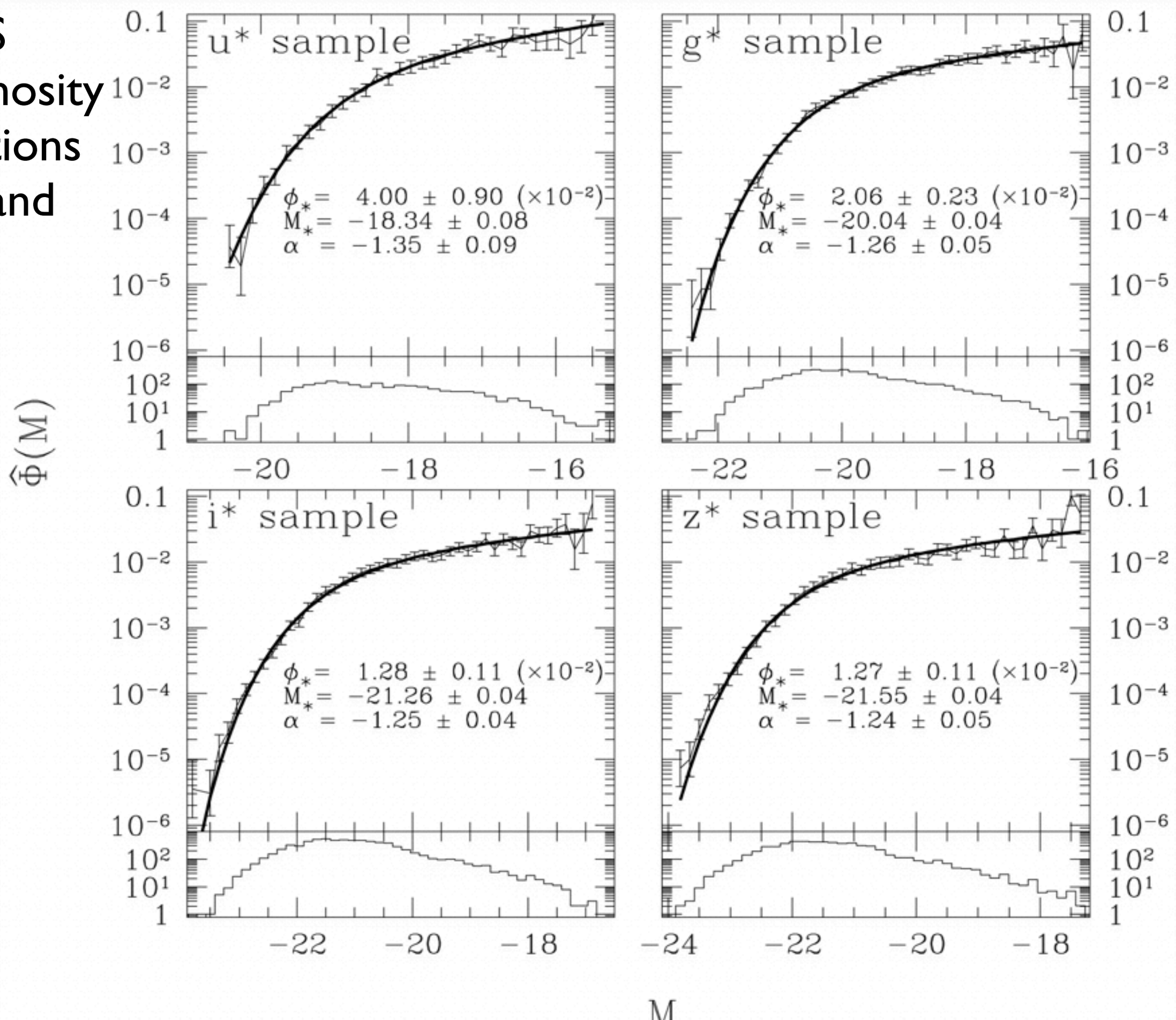
abundance matching

missing satellite problem

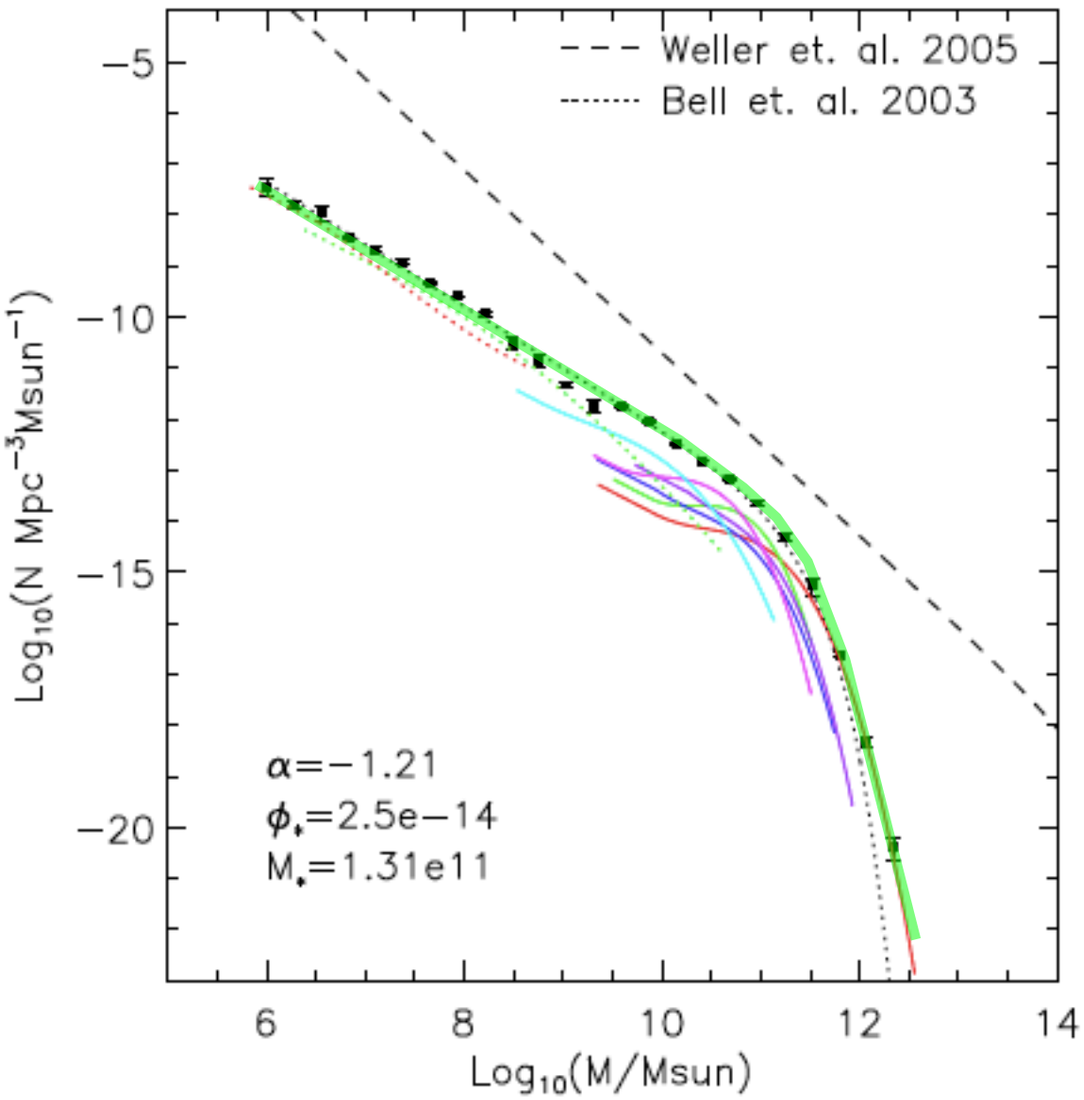
SDSS r-band luminosity function



SDSS luminosity functions by band



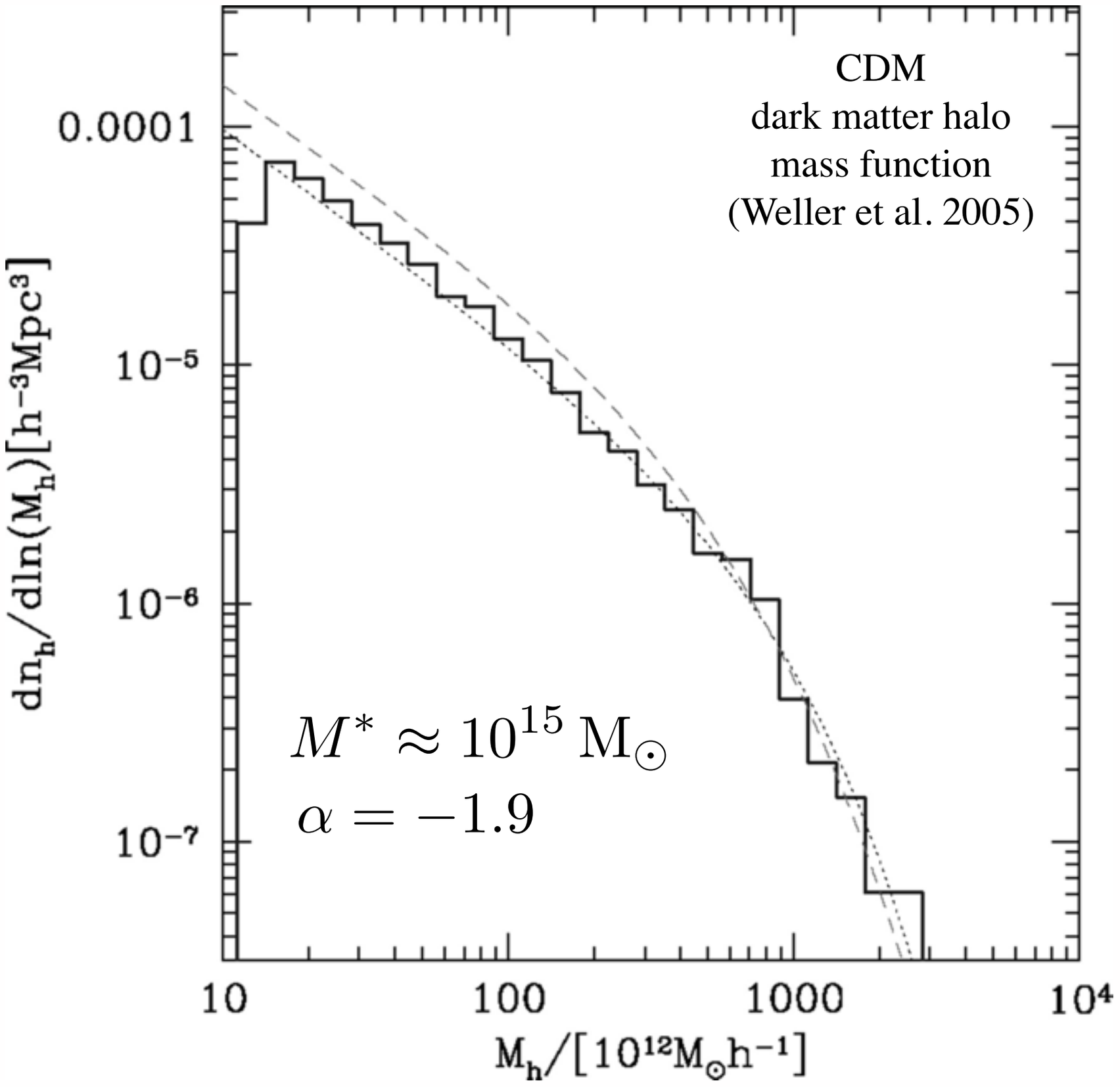
# Baryonic Mass Function
# (Read & Trentham 2005)



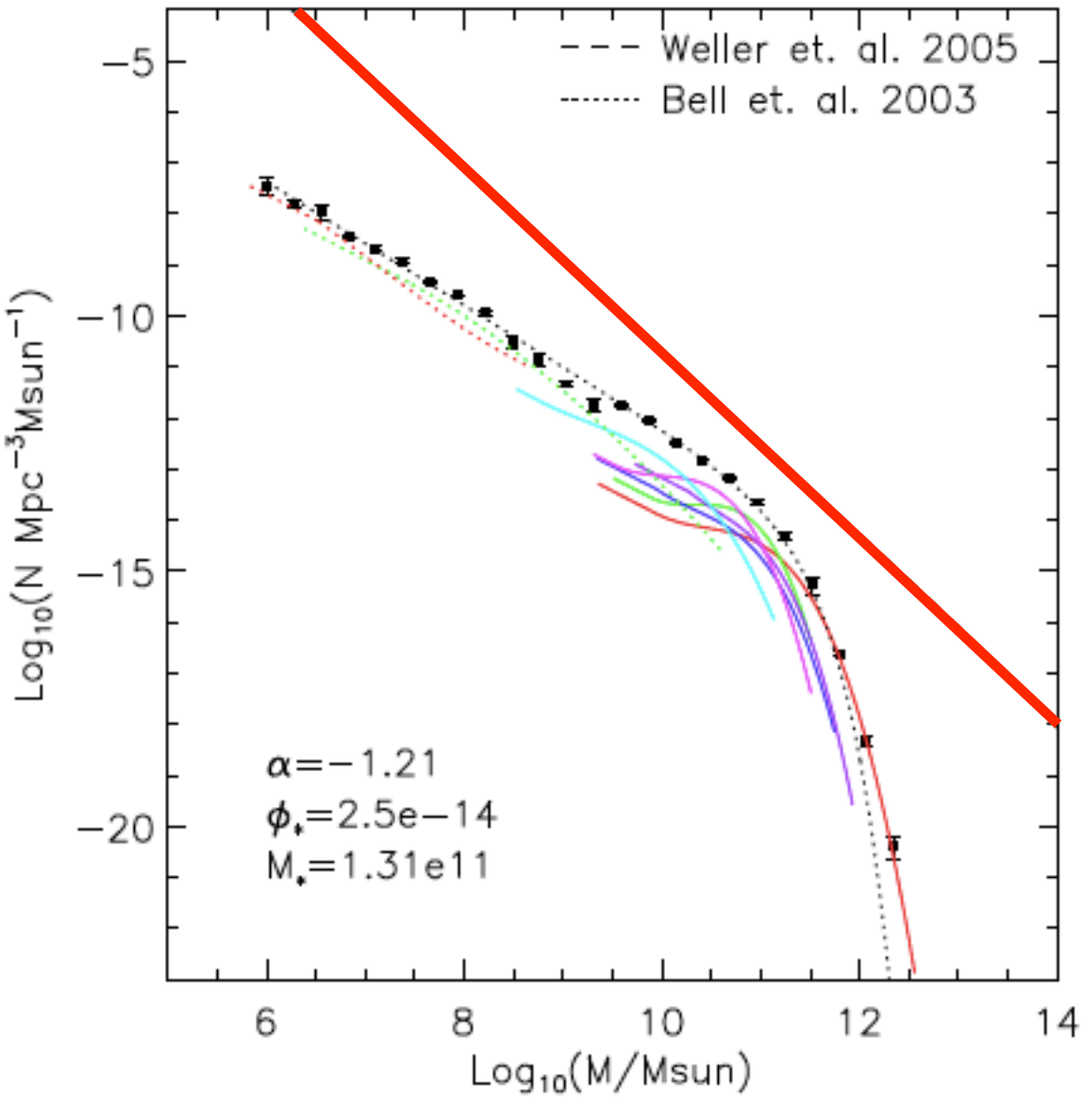

observed galaxies

Figure 4. The field galaxy baryonic mass function. The data points are for all galaxies, while the lines show spine fits by Hubble Type. The lines are as in Figure 2. The CDM mass spectrum from the numerical simulations of Weller et al. (2004) is also shown. Overlaid are parameters for a Schechter fit to the total mass function.

Dark matter halos in a large scale simulation (Aquarius)


CDM
dark matter halo
mass function
(Weller et al. 2005)
$M^* \approx 10^{15}\,\mathrm{M}_\odot$
$\alpha = -1.9$
0.0001
$10^{-5}$
$10^{-6}$
$10^{-7}$
$dn_h/dln(M_h)[h^{-3}Mpc^3]$
10
100
1000
$10^4$
$M_h/[10^{12}M_\odot h^{-1}]$

# Baryonic Mass Function
# (Read & Trentham 2005)

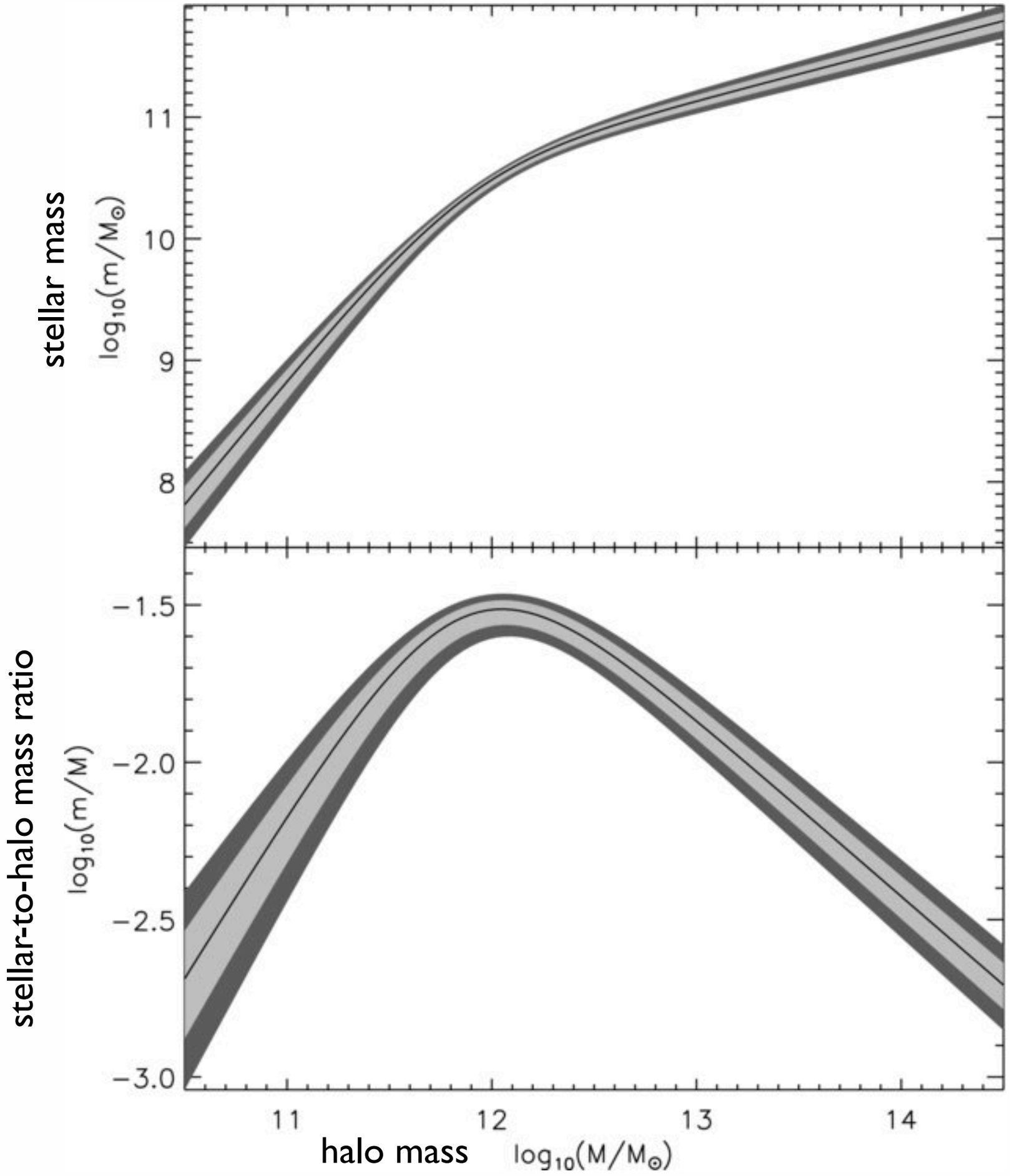



CDM halo
mass function

$\alpha = -1.9$

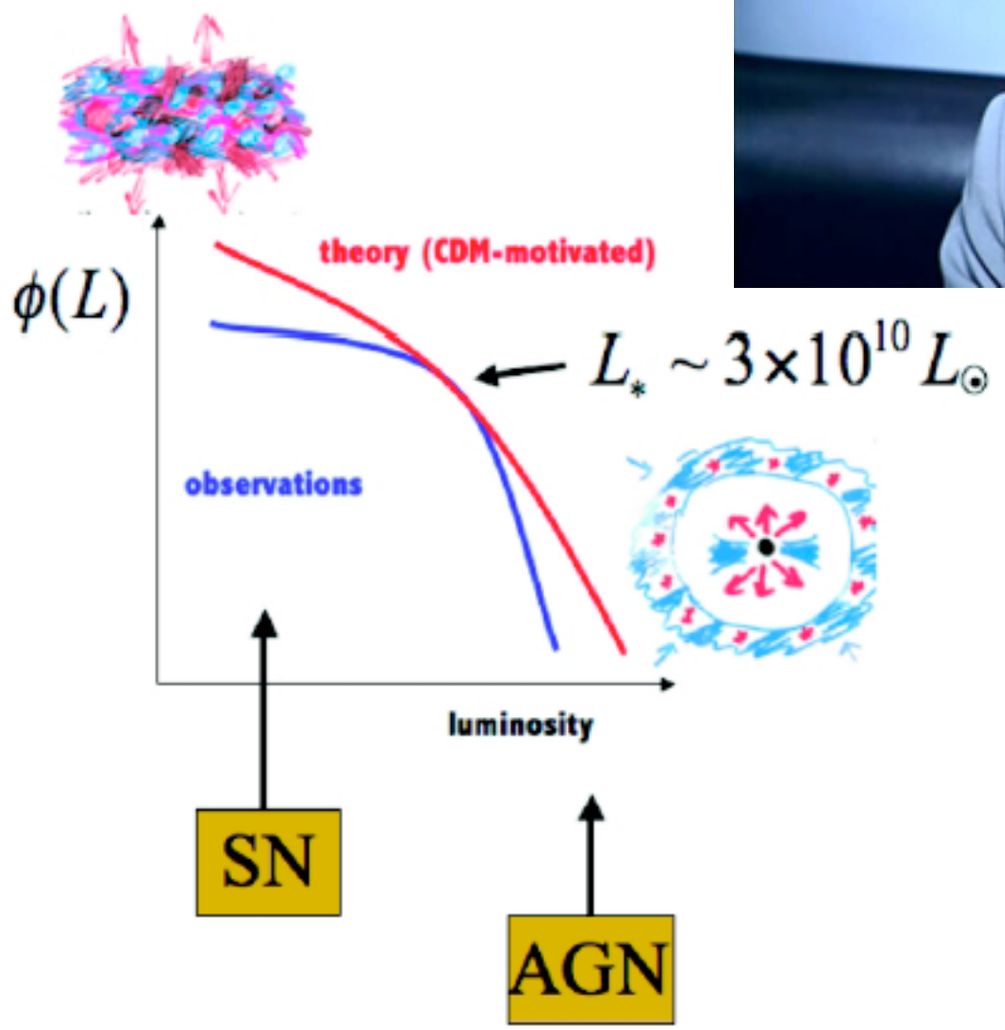
Figure 4. The field galaxy baryonic mass function. The data points are for all galaxies, while the lines show spine fits by Hubble Type. The lines are as in Figure 2. The CDM mass spectrum from the numerical simulations of Weller et al. (2004) is also shown. Overlaid are parameters for a Schechter fit to the total mass function.

"Moster relation"



# Why? Feedback!

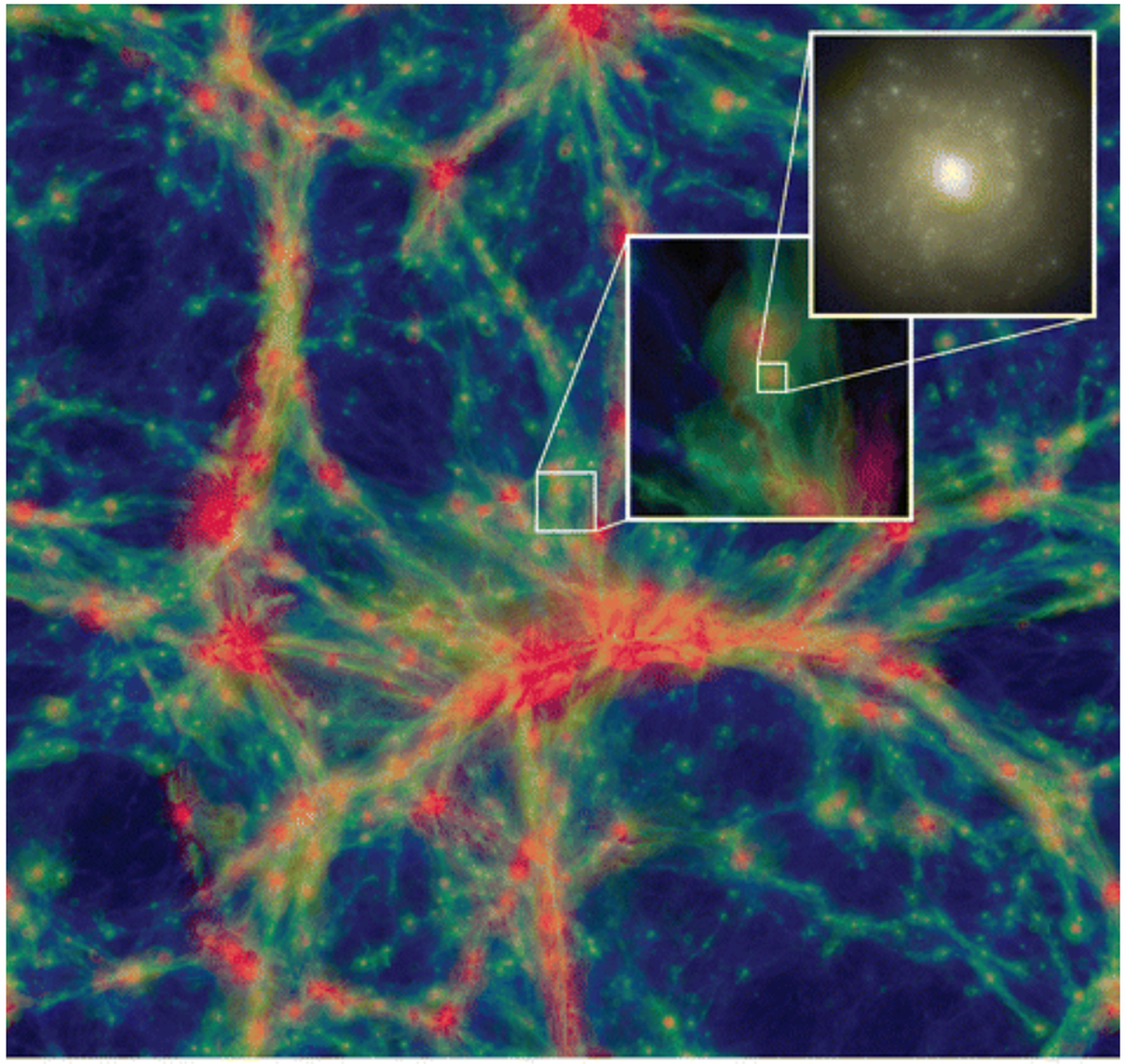
What?




Basic idea: SN affect low mass halos
AGN affects high mass halos

# Kitchen sink cosmological models

Somerville & Dave 2015 ARA&A, 53, 51



Somerville RS, Davé R. 2015.
Annu. Rev. Astron. Astrophys. 53:51–113

# Illustris simulation

now

time

gas metallicity

gas temperature

dark matter

gas density

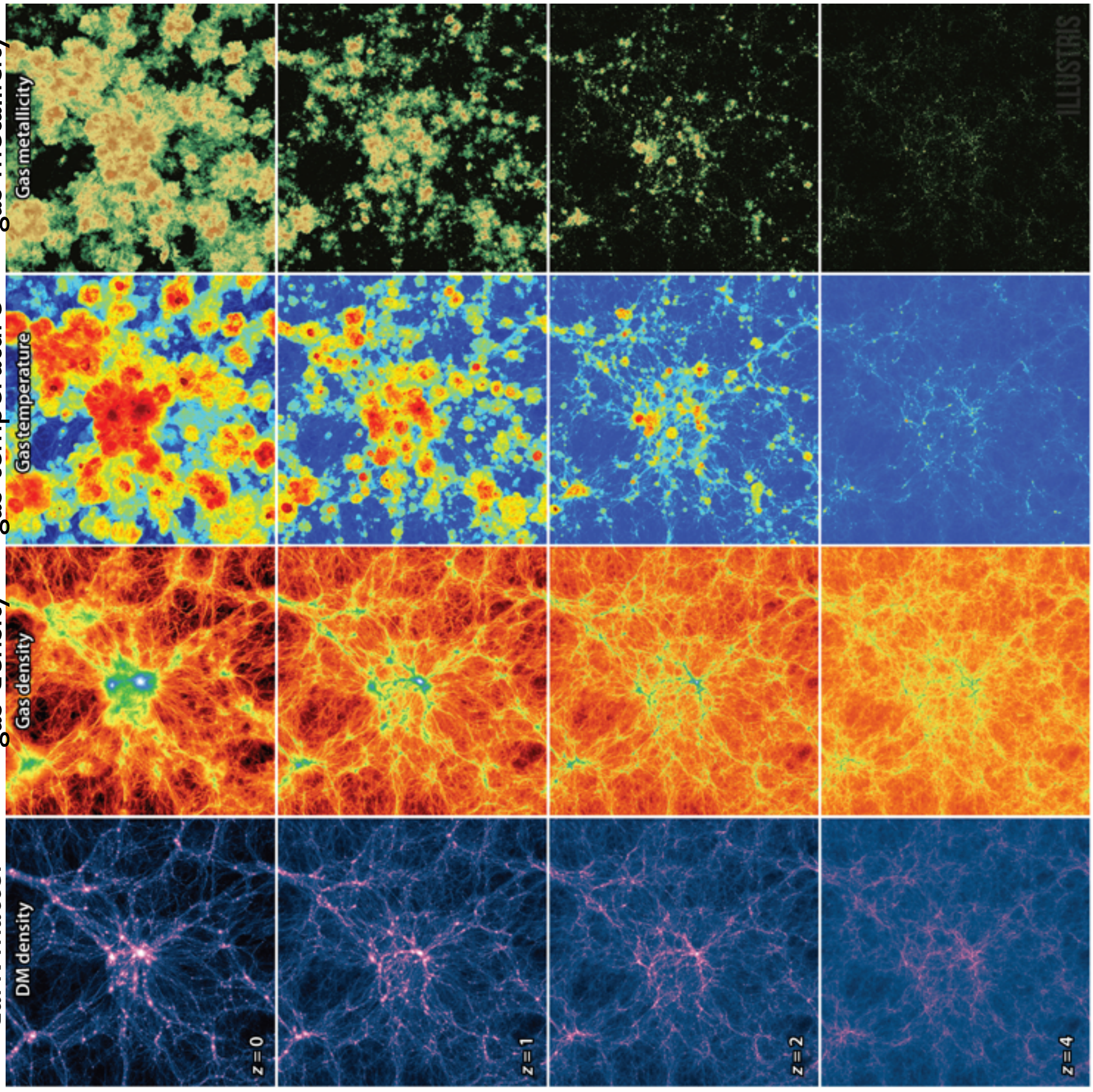
redshift

z=0

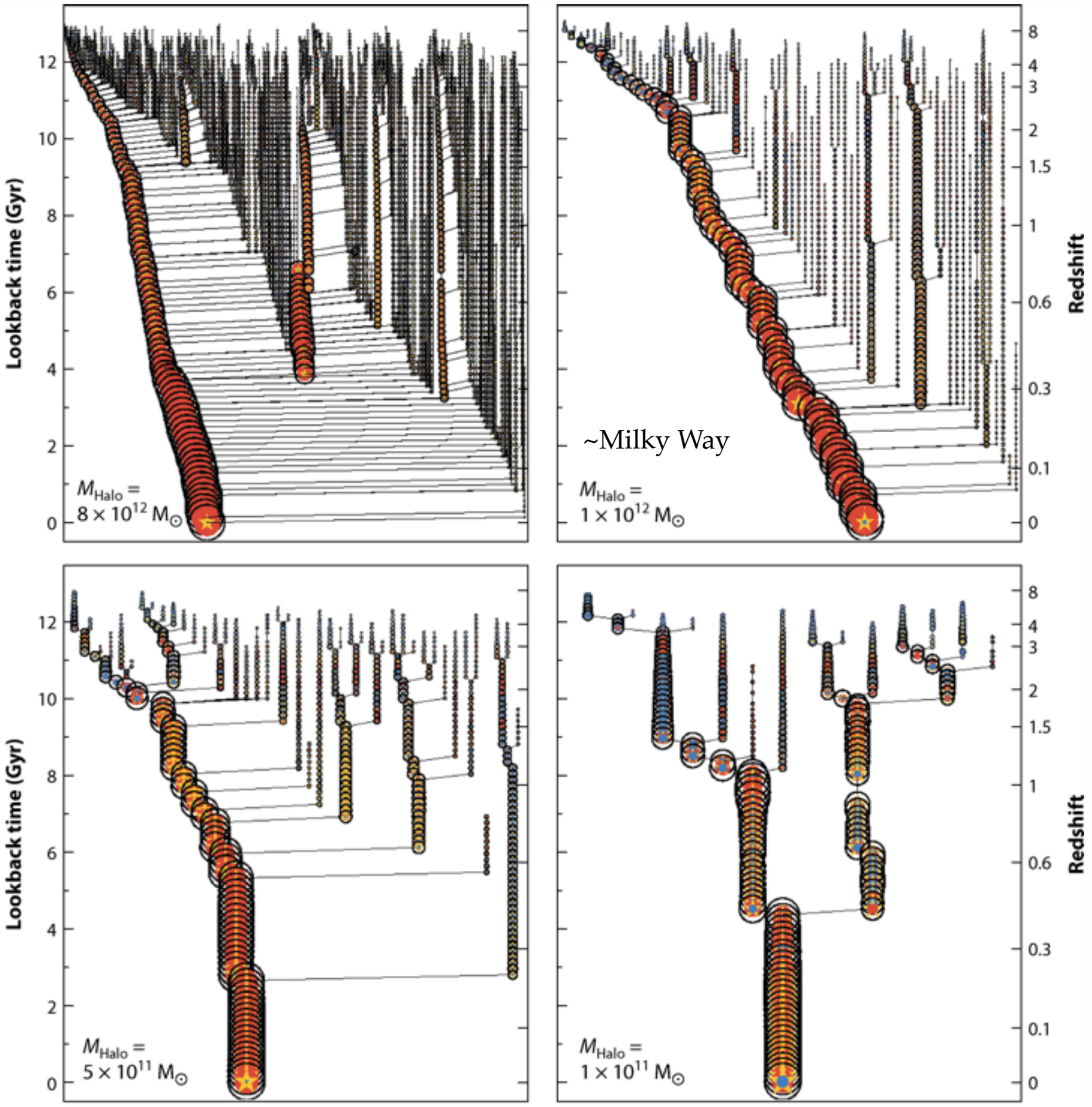
z=1

z=2

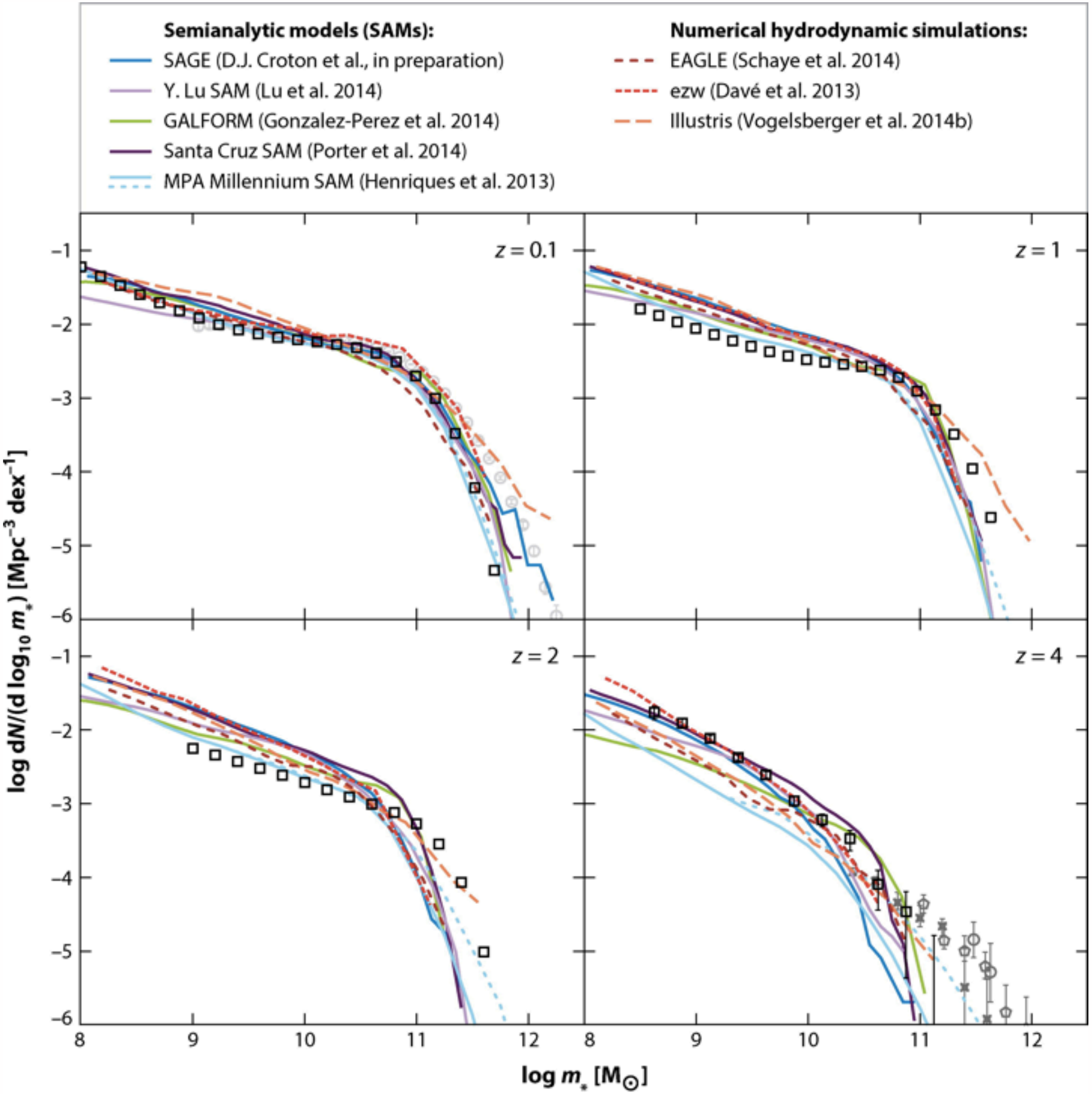
z=4



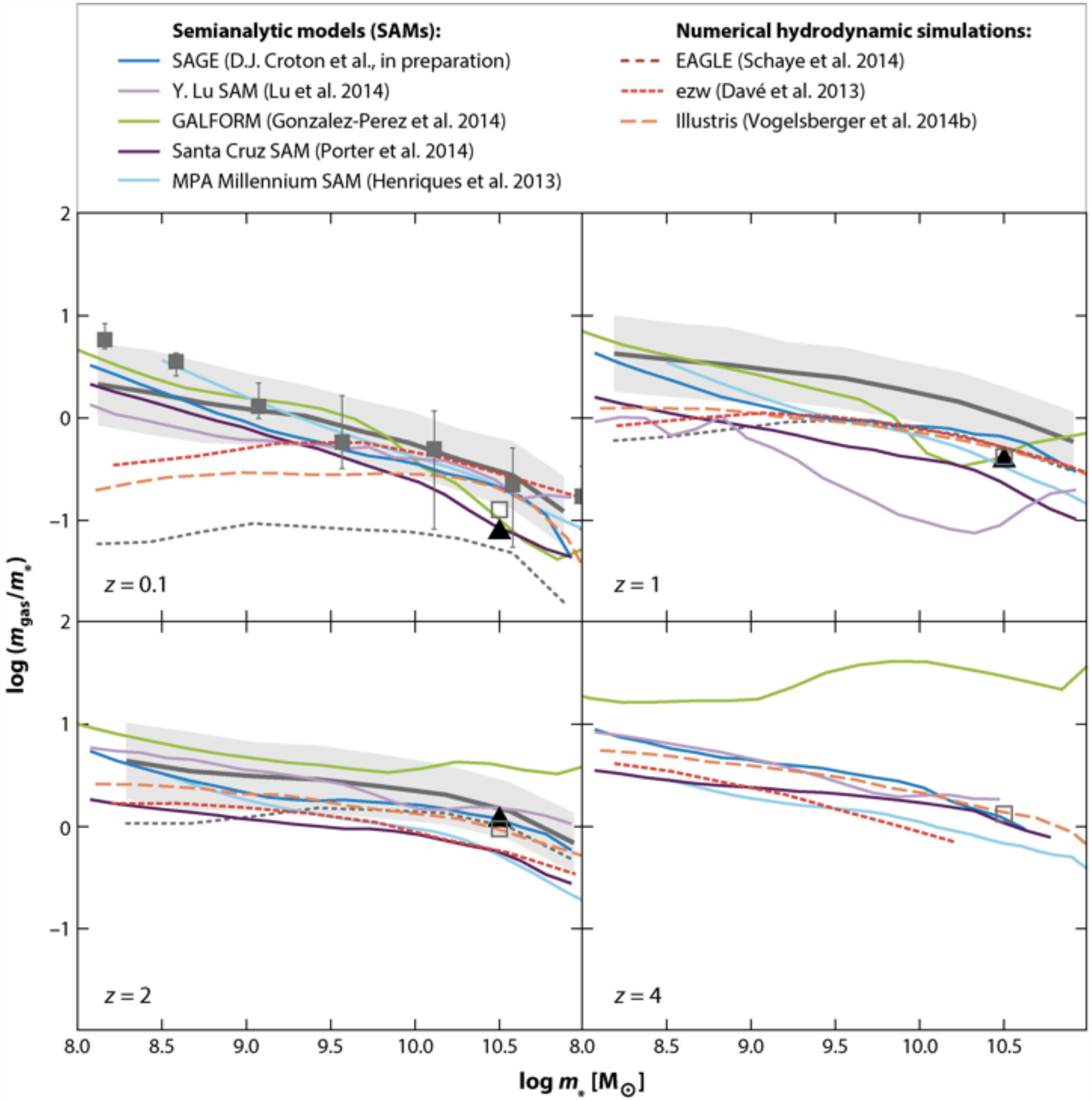
# Halo assembly by mass



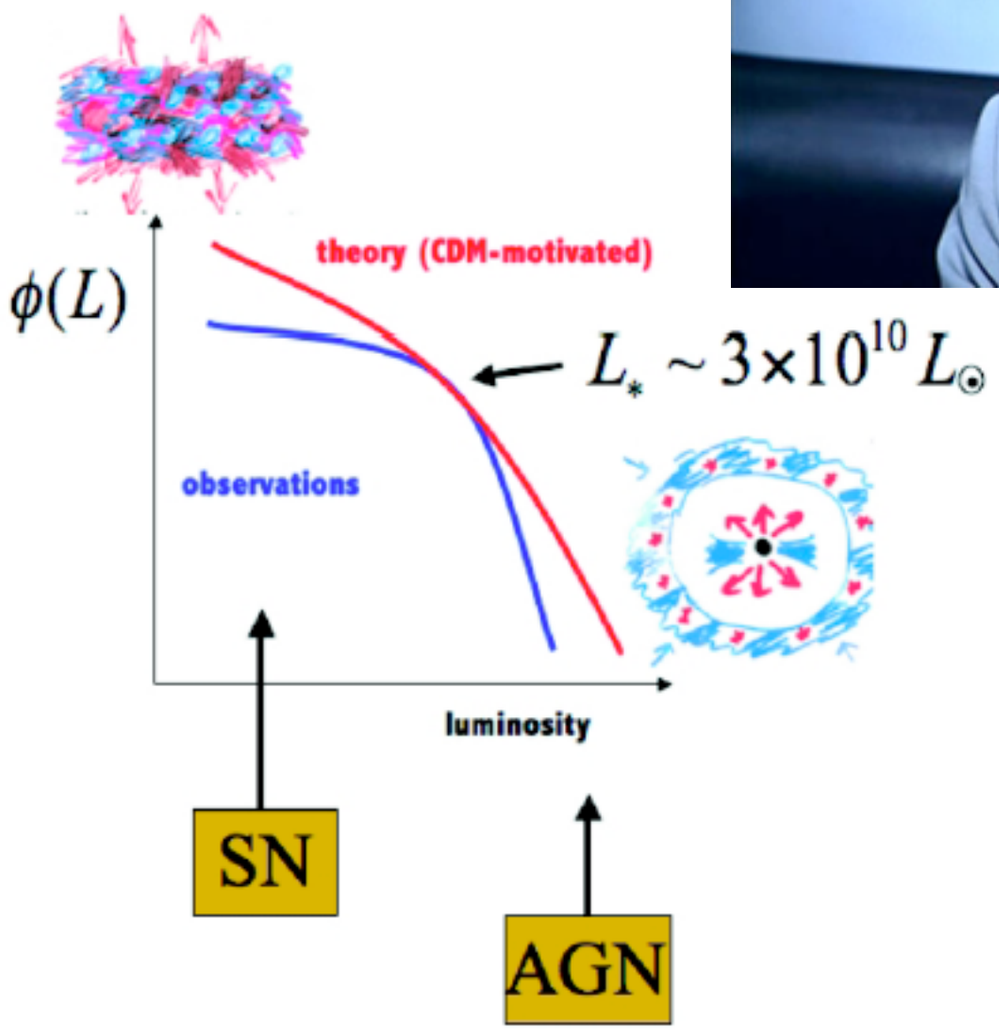
Stellar mass function

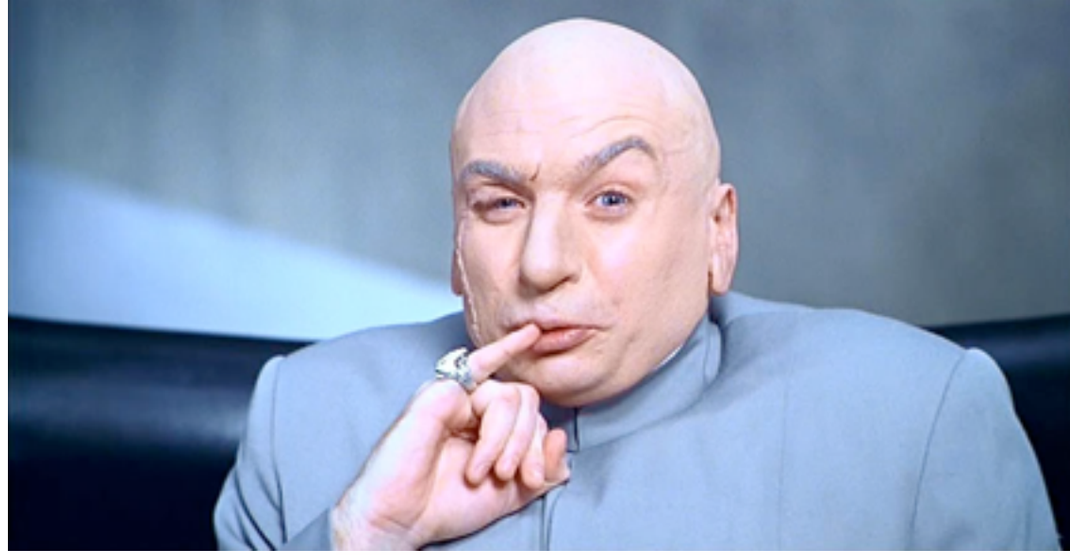


Cold gas to stellar mass ratio



# Feedback



Need non-linear mapping between properties of dark matter halos and observed, luminous galaxies

It does not work to make the obvious assumption

$$M_{tot} \propto L$$

One infers the presence of numerous dark sub-halos

# Not all sub-halos host proportionately luminous galaxies

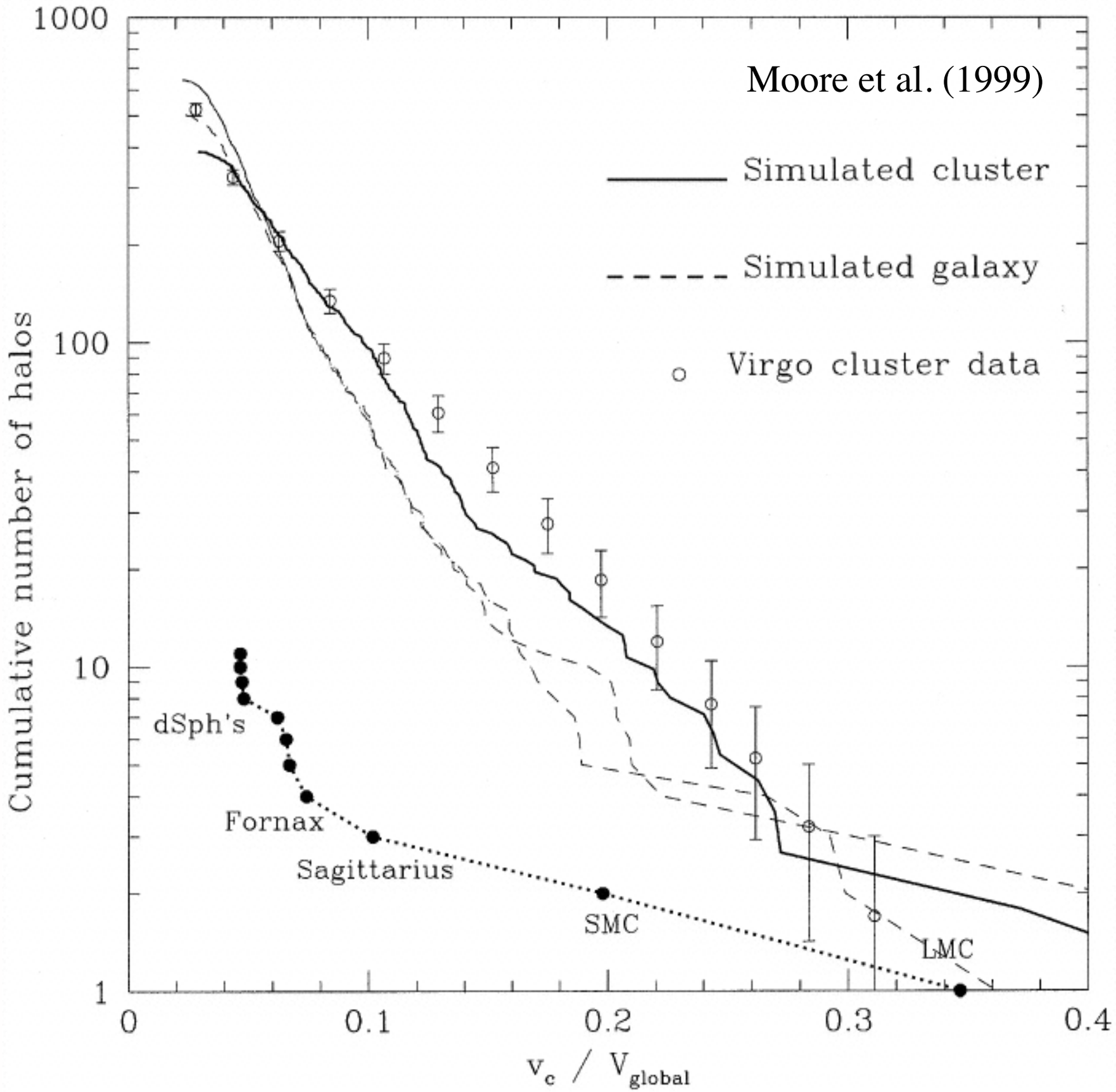
# CDM is scale free

Moore et al. (1999)

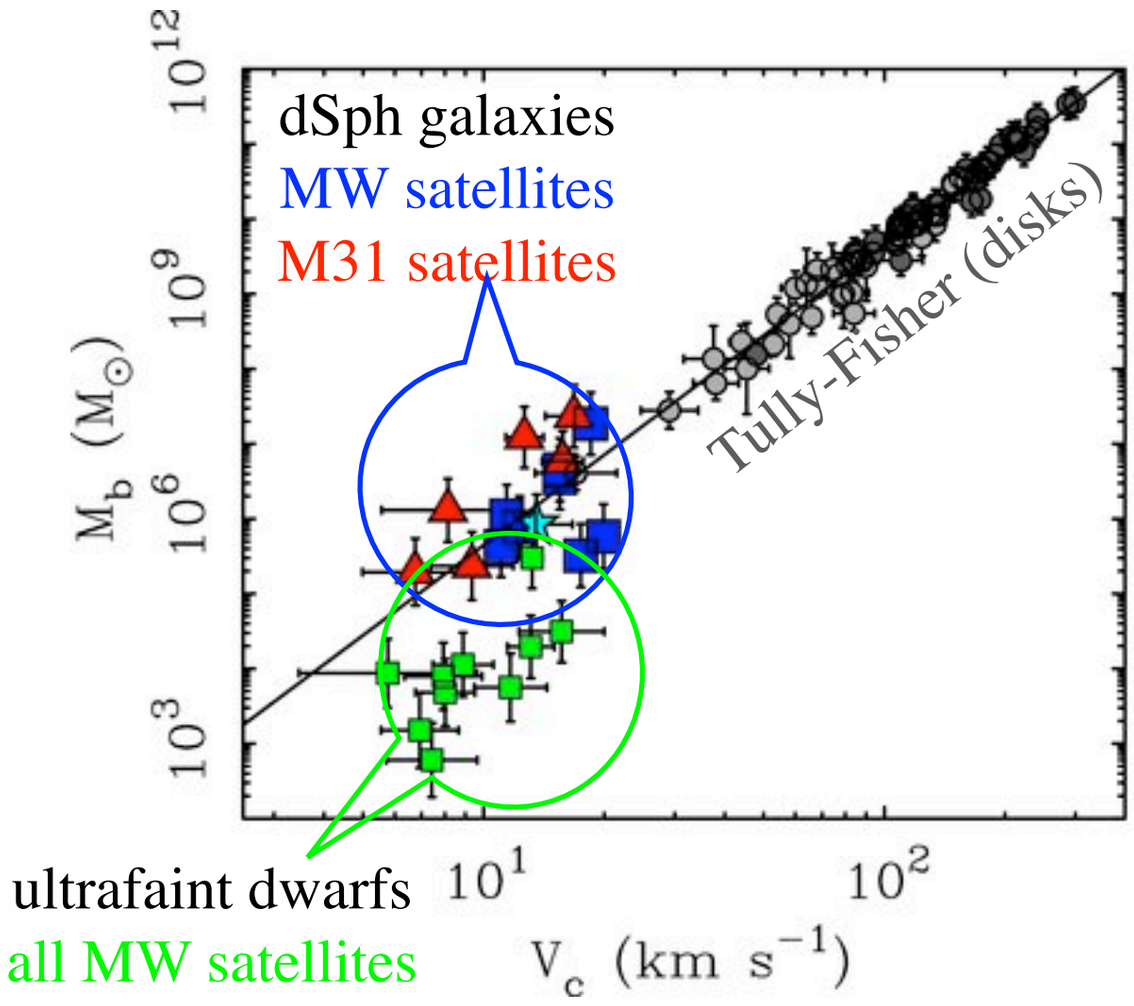
Density of dark matter within a cluster halo of mass $5 \times 10^{14}\,M$ (*top*). The edge of the box is the virial radius, 2000 kpc for the cluster (with peak circular velocity 1100 km $s^{-1}$).

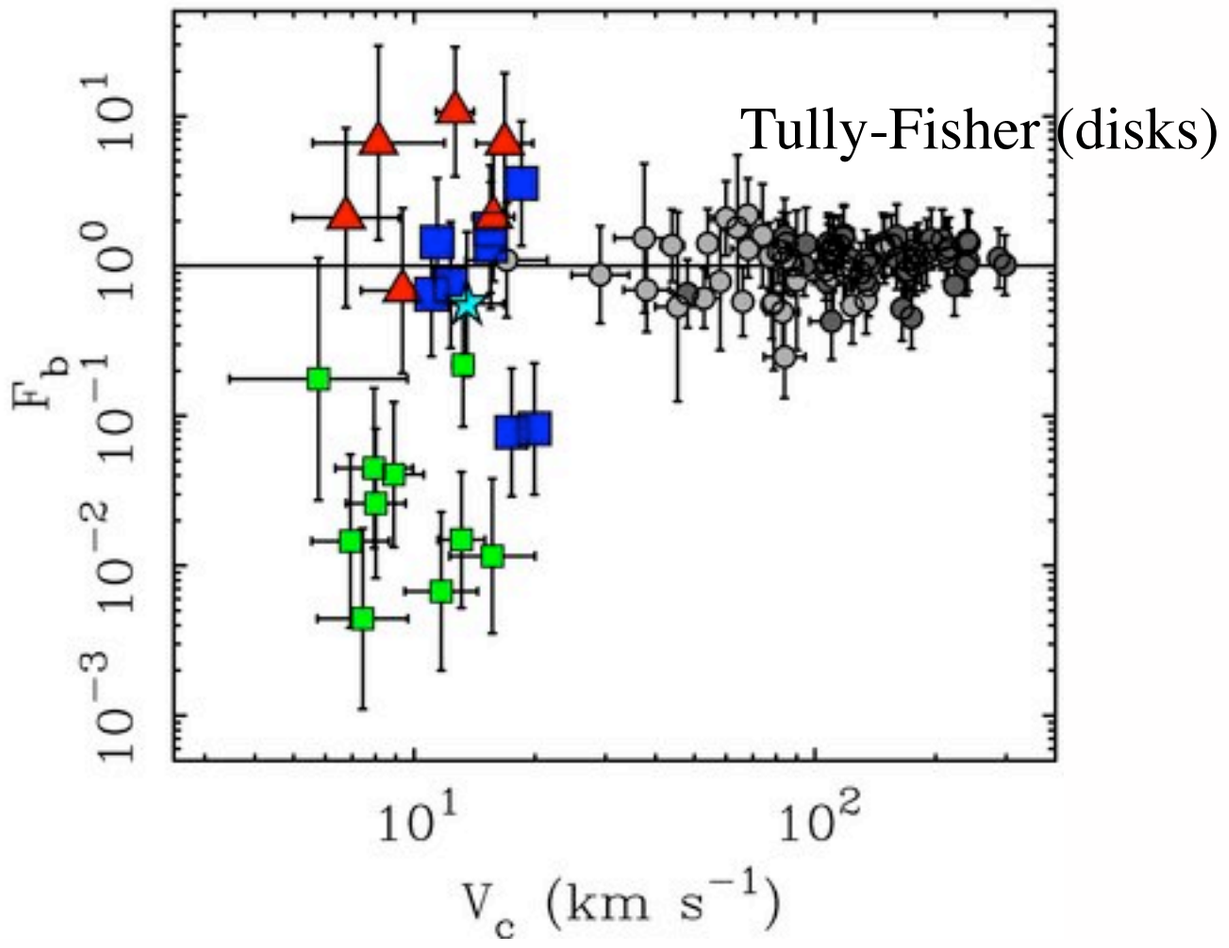
Density of dark matter within a galaxy halo of mass $2 \times 10^{12}\,M$ (*bottom*). The edge of the box is the virial radius, 300 kpc (with peak circular velocity of 200 km $s^{-1}$).

# Missing satellite problem



dwarf Spheroidal galaxies (satellites of the Milky Way)

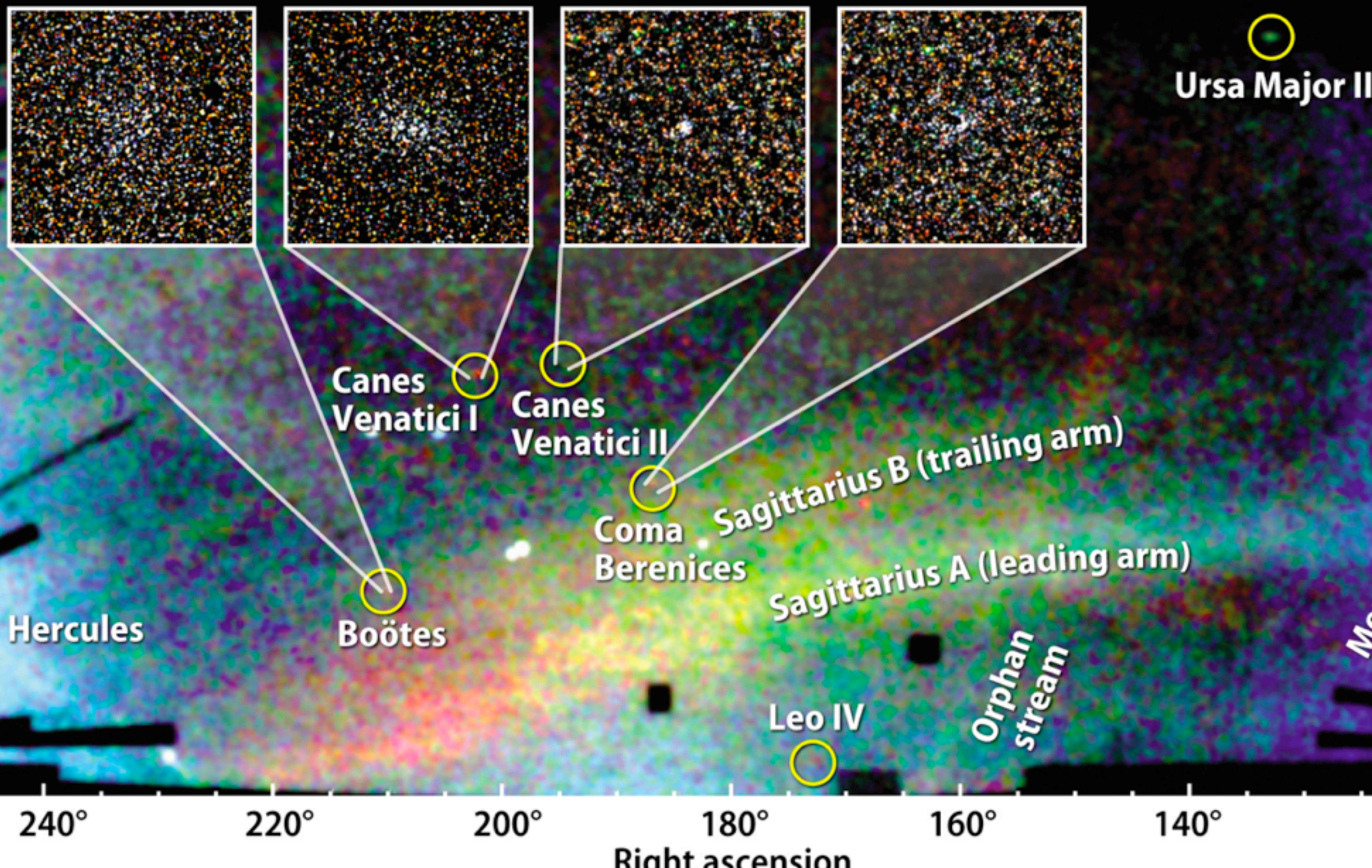


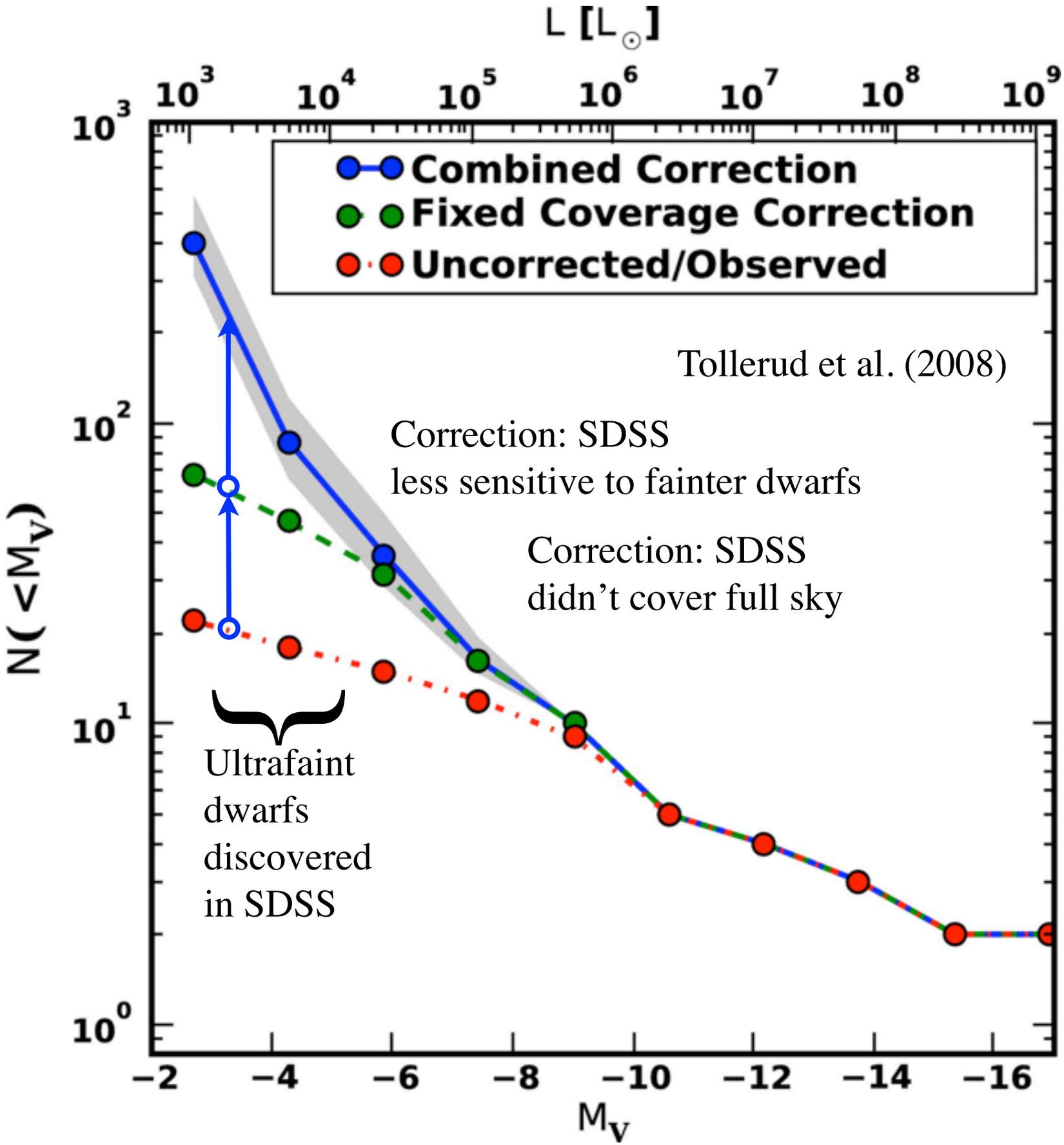




"Classical" dSph galaxies $10^5 < L < 10^7\ L_\odot$

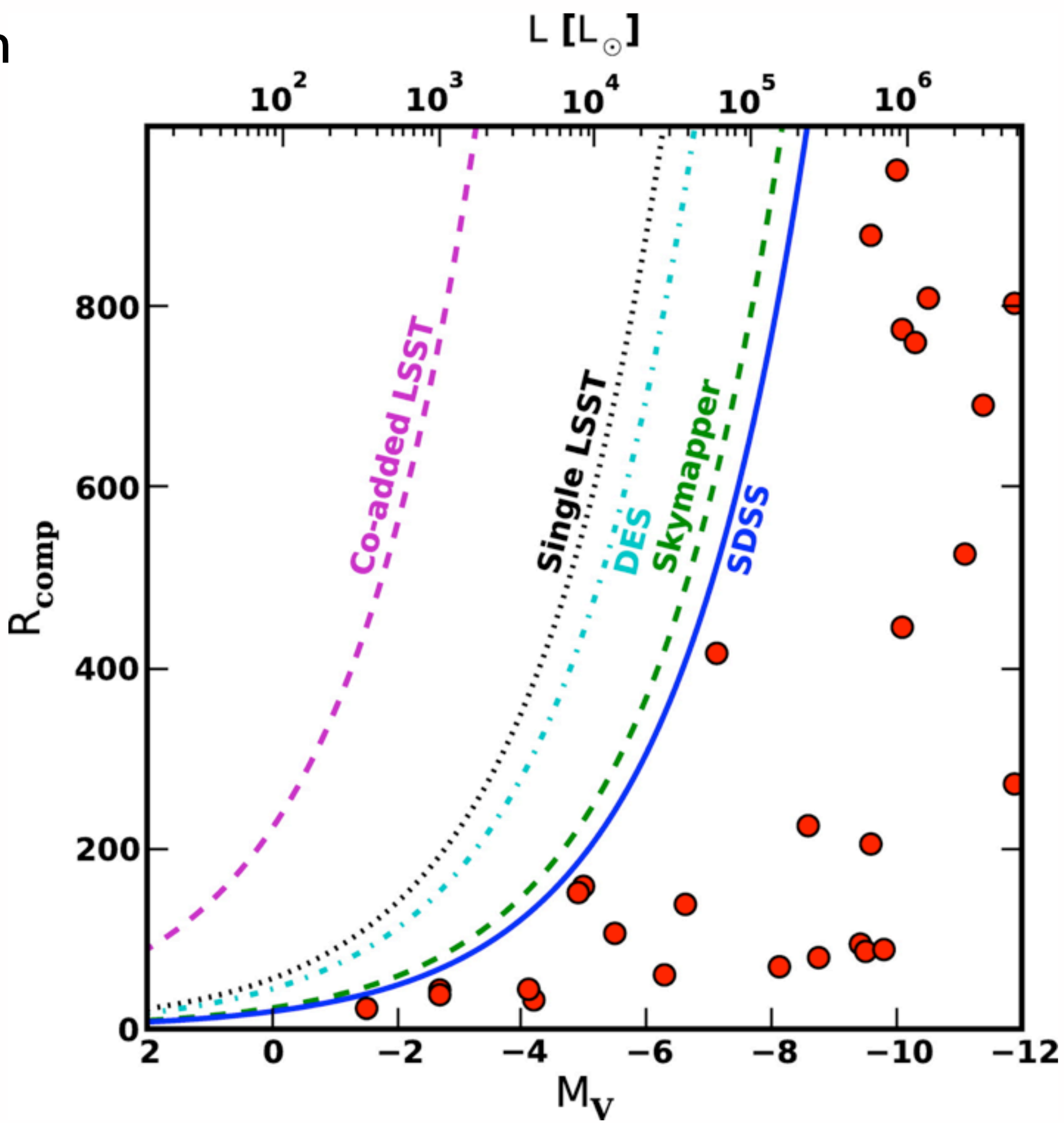
ultrafaint dSph galaxies $L < 10^5\ L_\odot$

# Ultrafaint dwarf satellite galaxies discovered by SDSS

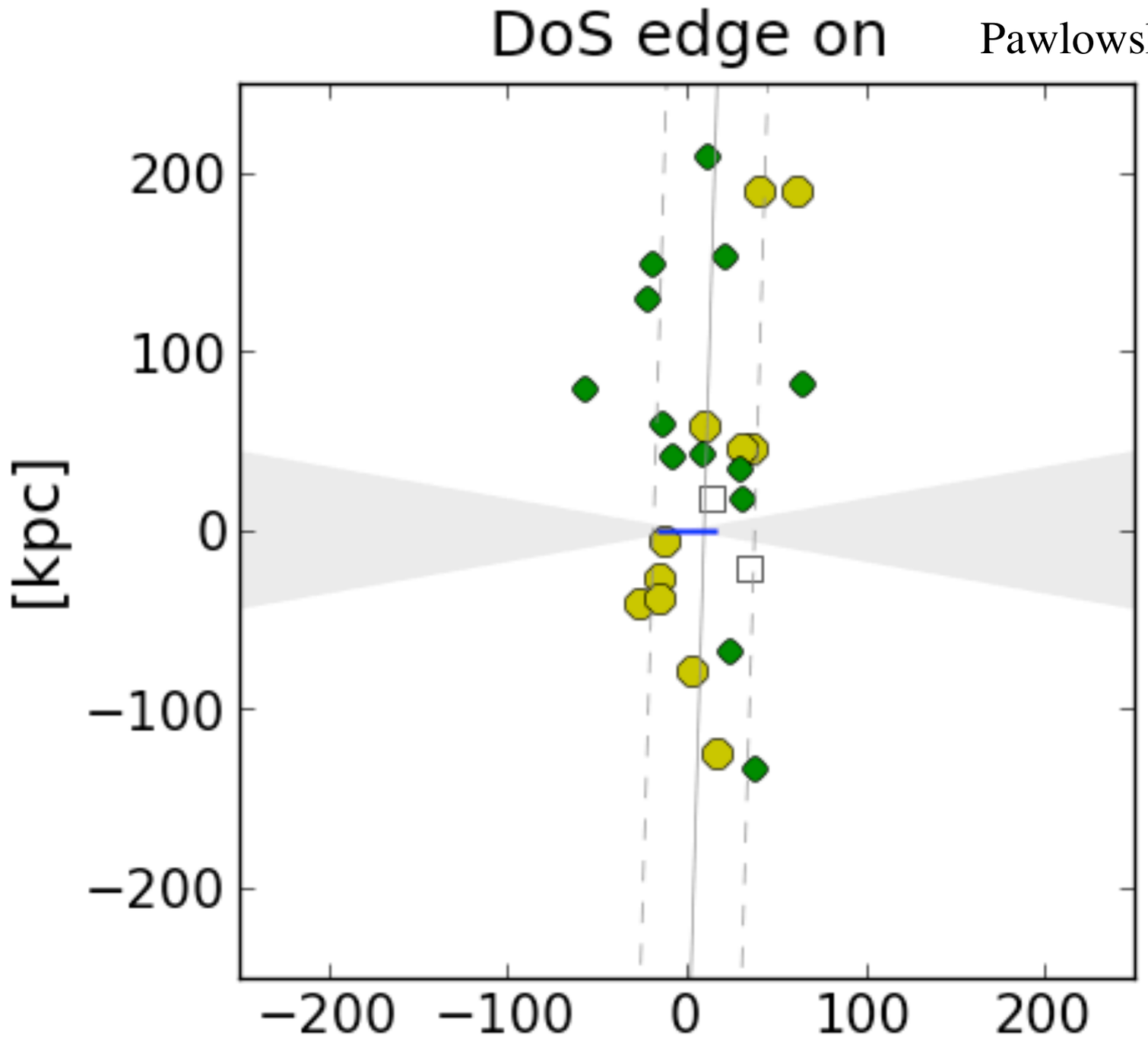



L [L⊙]
10^3
10^4
10^5
10^6
10^7
10^8
10^9
Combined Correction
Fixed Coverage Correction
Uncorrected/Observed
Tollerud et al. (2008)
Correction: SDSS
less sensitive to fainter dwarfs
Correction: SDSS
didn't cover full sky
Ultrafaint
dwarfs
discovered
in SDSS
N(<M_V)
10^2
10^1
10^0
−2
−4
−6
−8
−10
−12
−14
−16
M_V

# Selection Limits

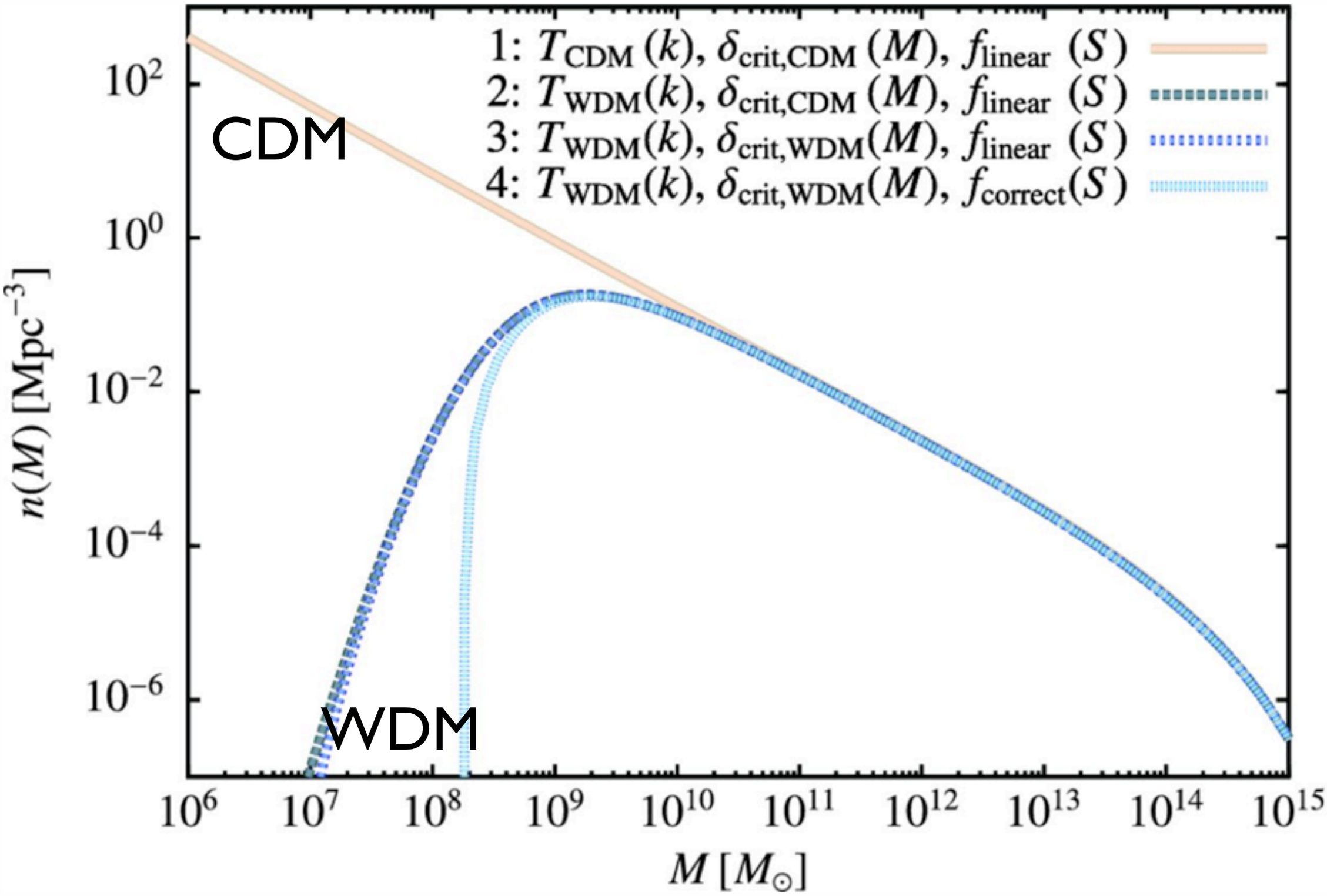


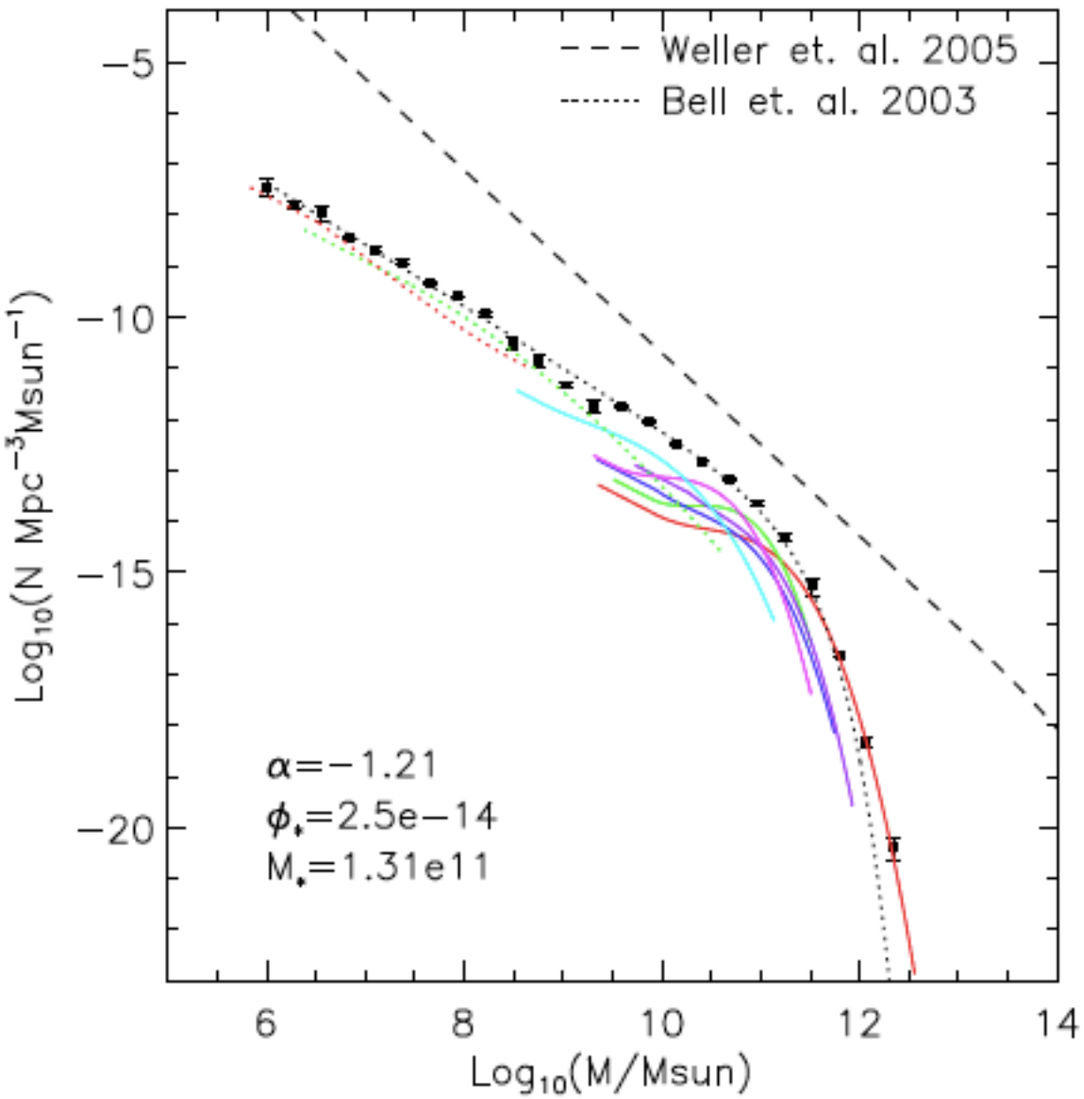
Is sky coverage correction appropriate?
dwarf satellites appear primarily to reside in a polar plane.




Pawlowski et al. (2012)

Benson et al (2013)






Slopes are mismatched everywhere, so it isn't obvious that WDM helps

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