The Many Manifestations of "Downsizing"

Fabio Fontanot (INAF-OATs)

OATs Seminar 09/12/09

Outline

- 1st Review
  - Definition of Downsizing

Outline

- 1st Review
  - Definition of Downsizing
- 2nd Comparison with semi-analytical models
  - Discussing tensions

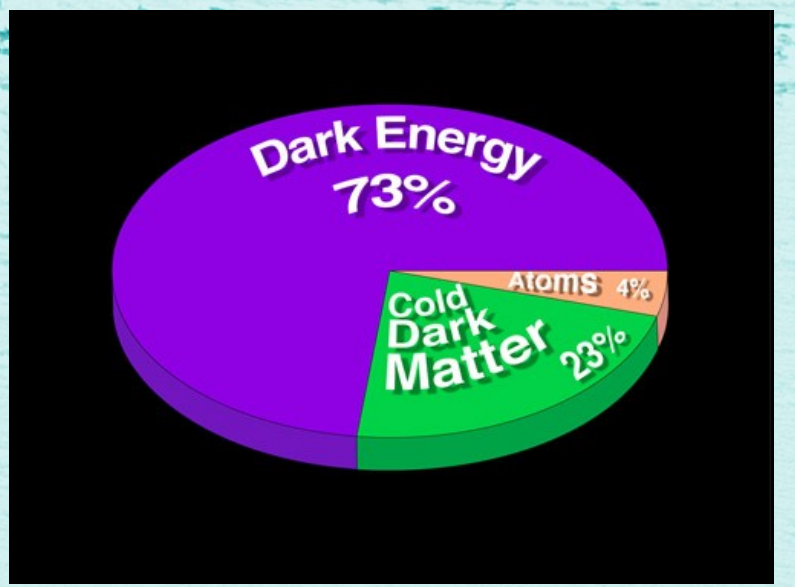
Outline

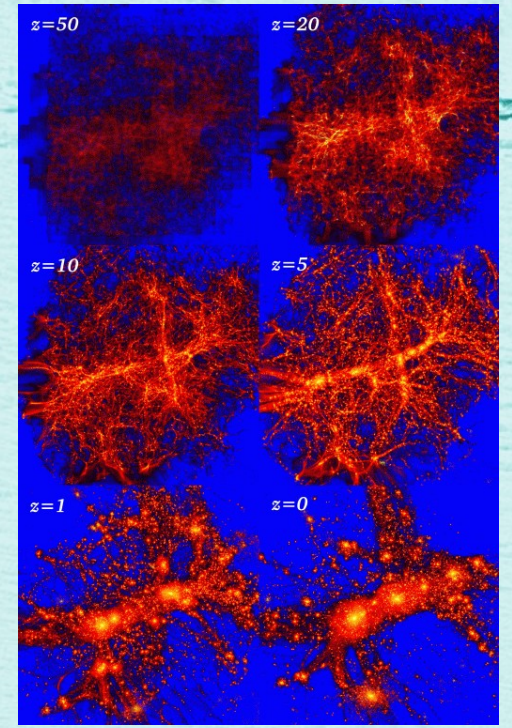
- 1st Review
  - Definition of Downsizing
- 2nd Comparison with semi-analytical models
  - Discussing tensions
- 3rd Origin of the discrepancies
  - Possible solutions?

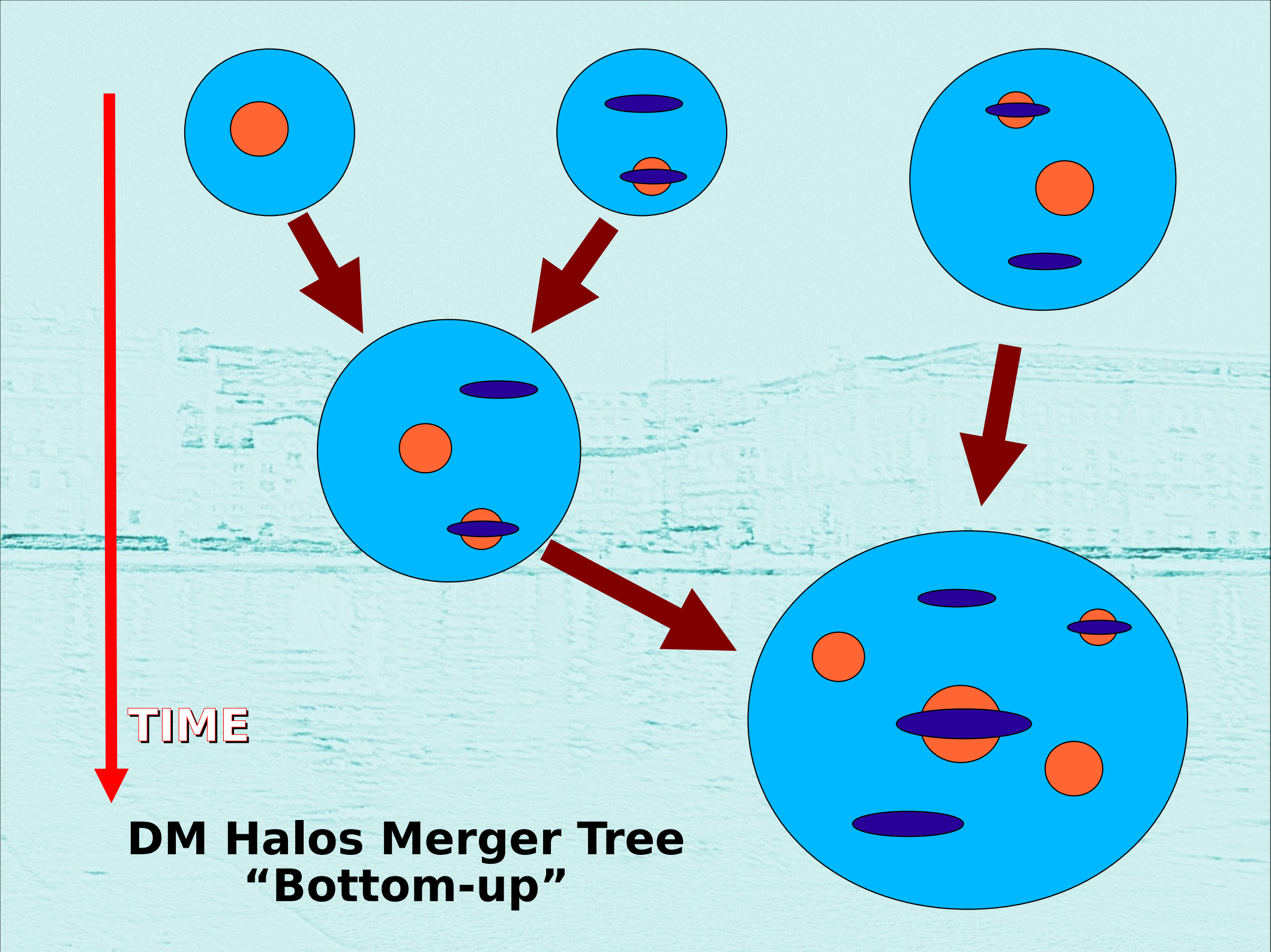
Introduction

Structure Formation

- Dark Matter Structures assemble "bottom-up"
  - Small halos first
  - Massive halos as the result of mergers







DM Halos Merger Tree
“Bottom-up”

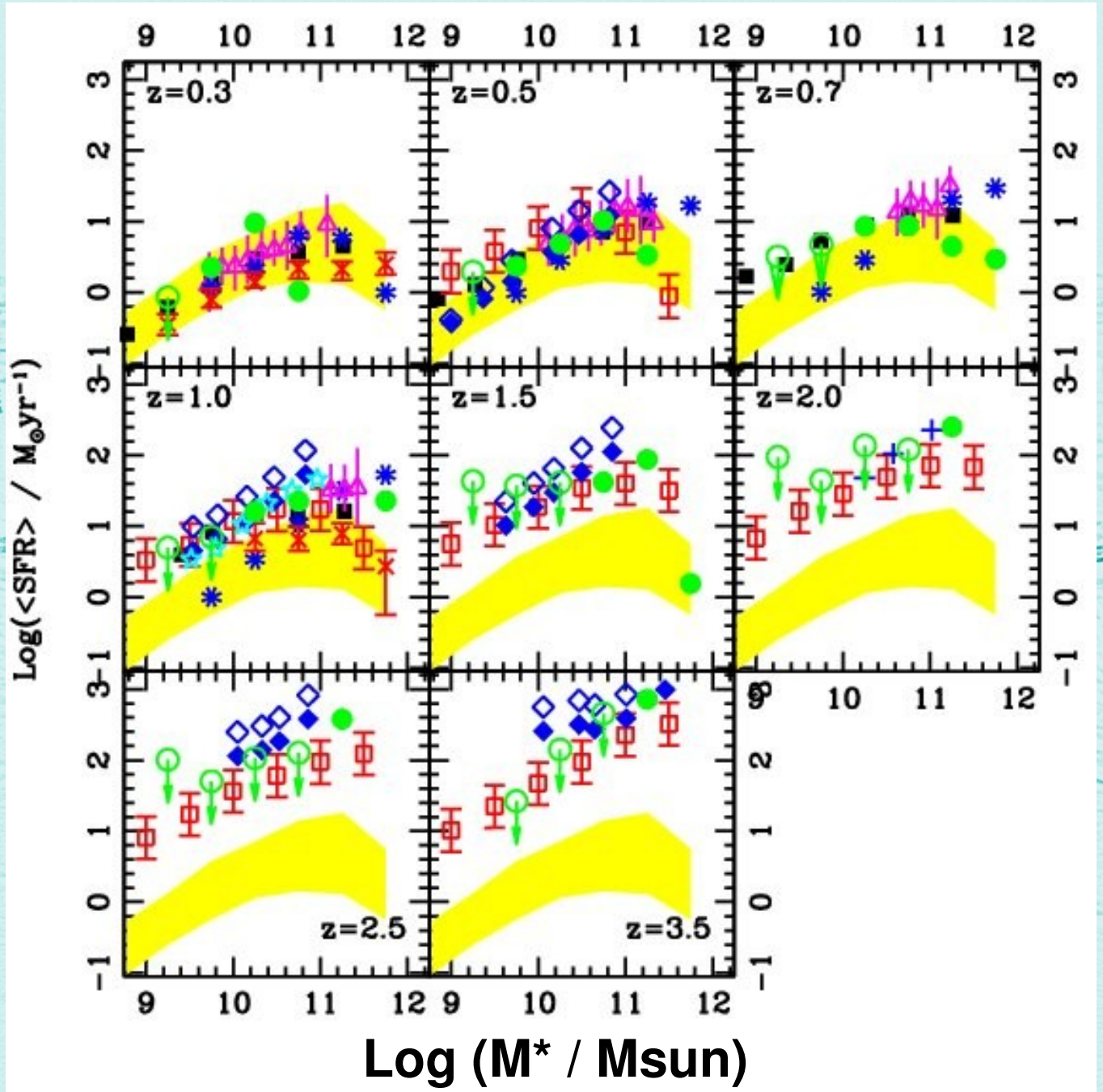
Structure Formation

- Dark Matter Structures assemble "bottom–up"
  - Small halos first
  - Massive halos as the result of mergers
- Properties of galaxies show evidences of the opposite behavior
  - Downsizing Cowie et al., 1996
- Notation
  - DS = Downsizing
  - mMG = more Massive Galaxies
  - SSFR = specific SFR

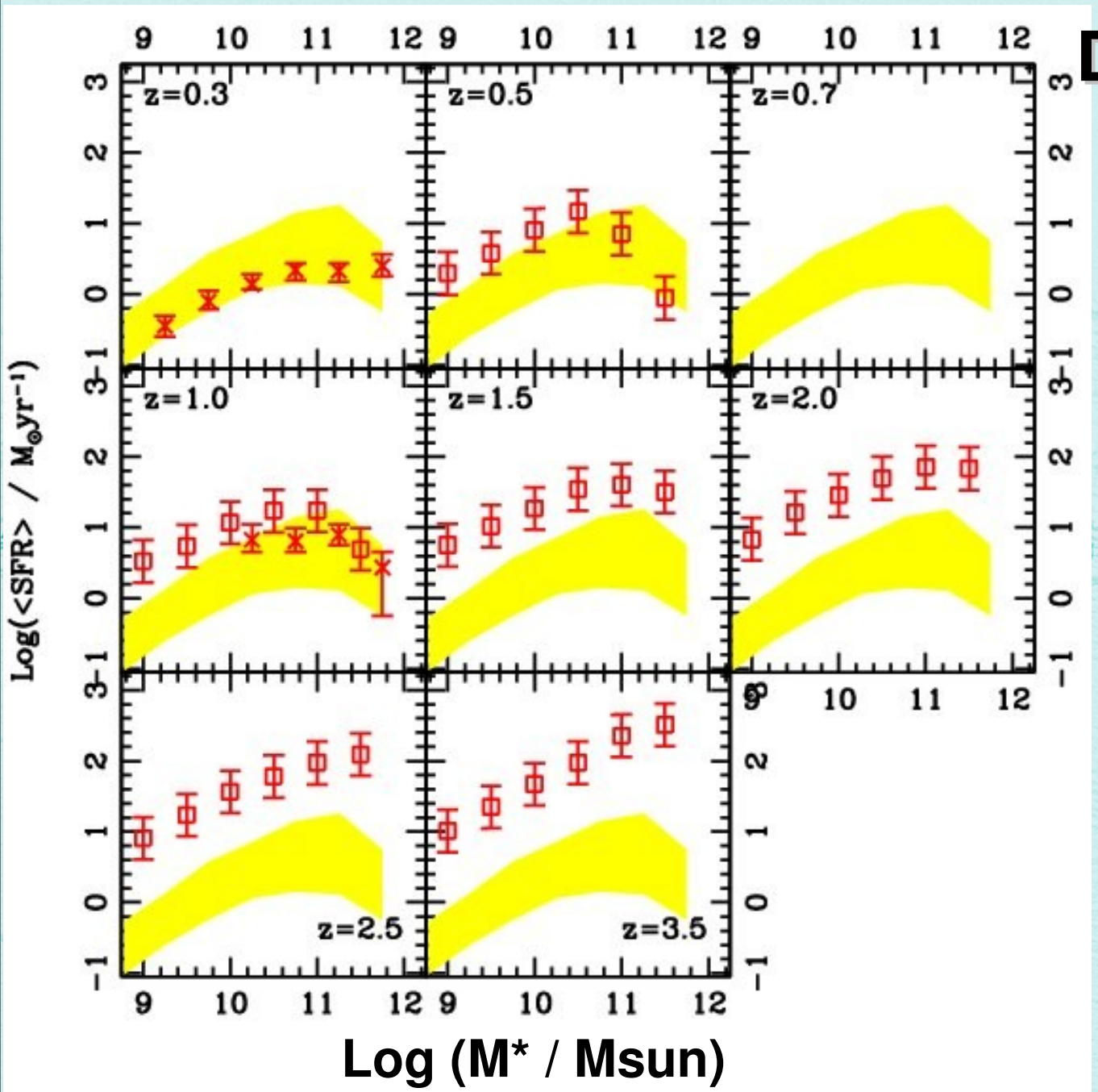
The many Manifestations:

- **DS in (specific) SFR**
  (Cowie+96,Zheng07,Noeske+07,Drory&Alvarez08,Dunne+08,Santini+09...)
  - **Mass of the "typical" SF galaxy decreases with z**
  - **The decline of SSFR is faster for mMG**

DS in SFR



DS in SFR



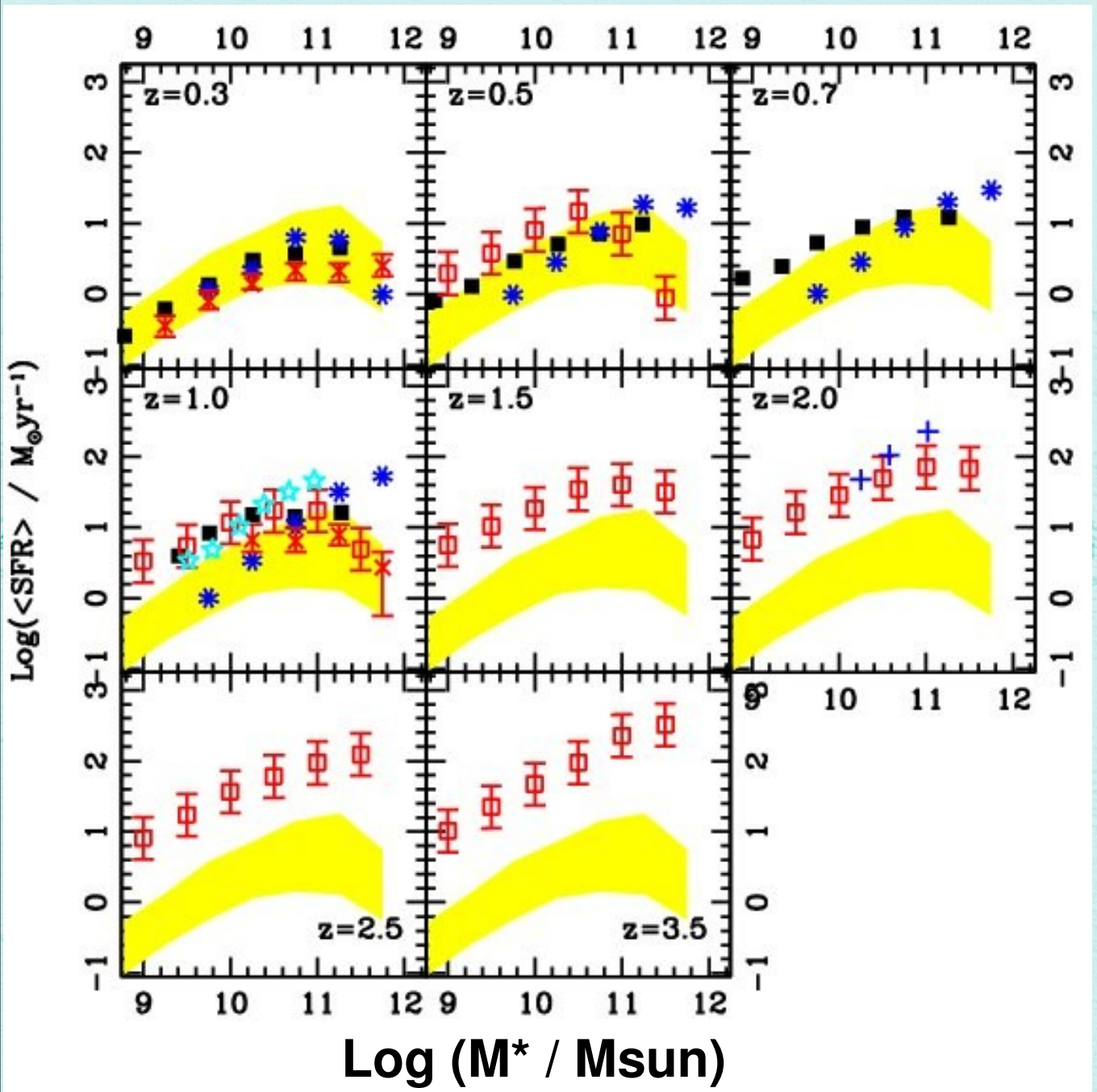
Dust Corrected UV

Chen+09

DroryAlvarez+08

Clear DS in <SFR>

DS in SFR



UV + 24 micron

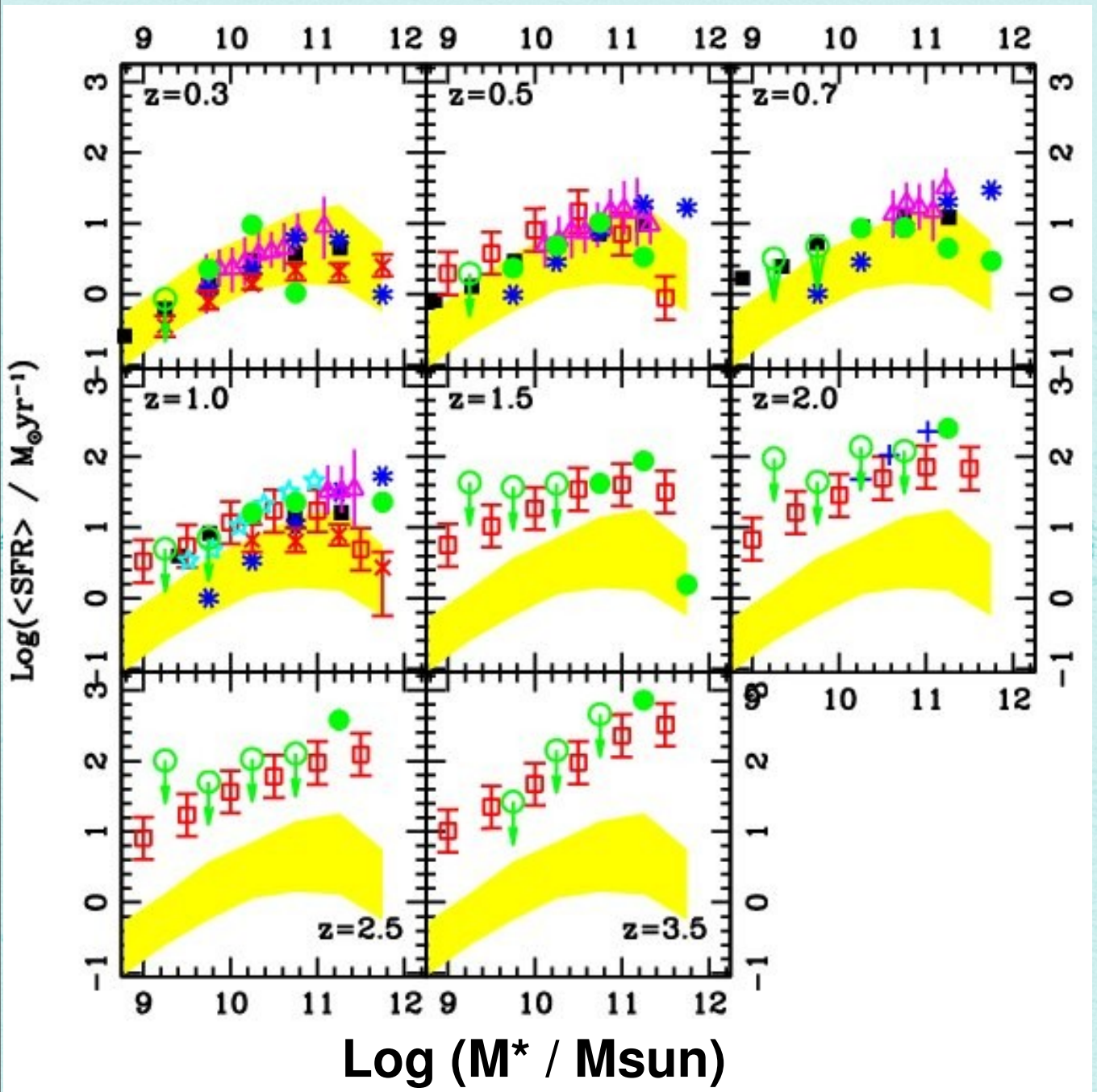
Bell+07

Martin+07

Daddi+07

Elbaz+07

DS in SFR

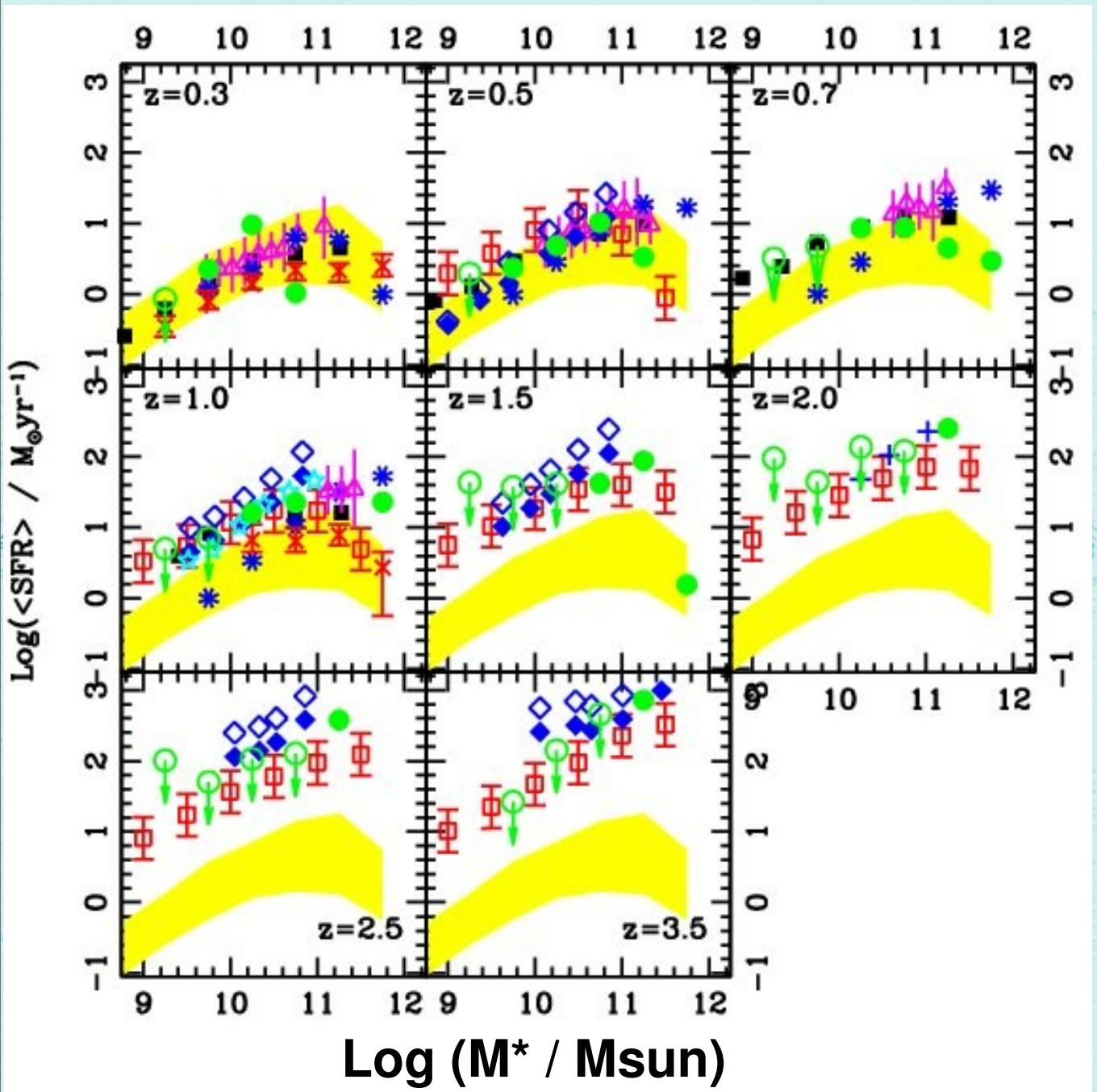


SED Fitting

Noeske+07

Santini+09

DS in SFR



Radio Stacking

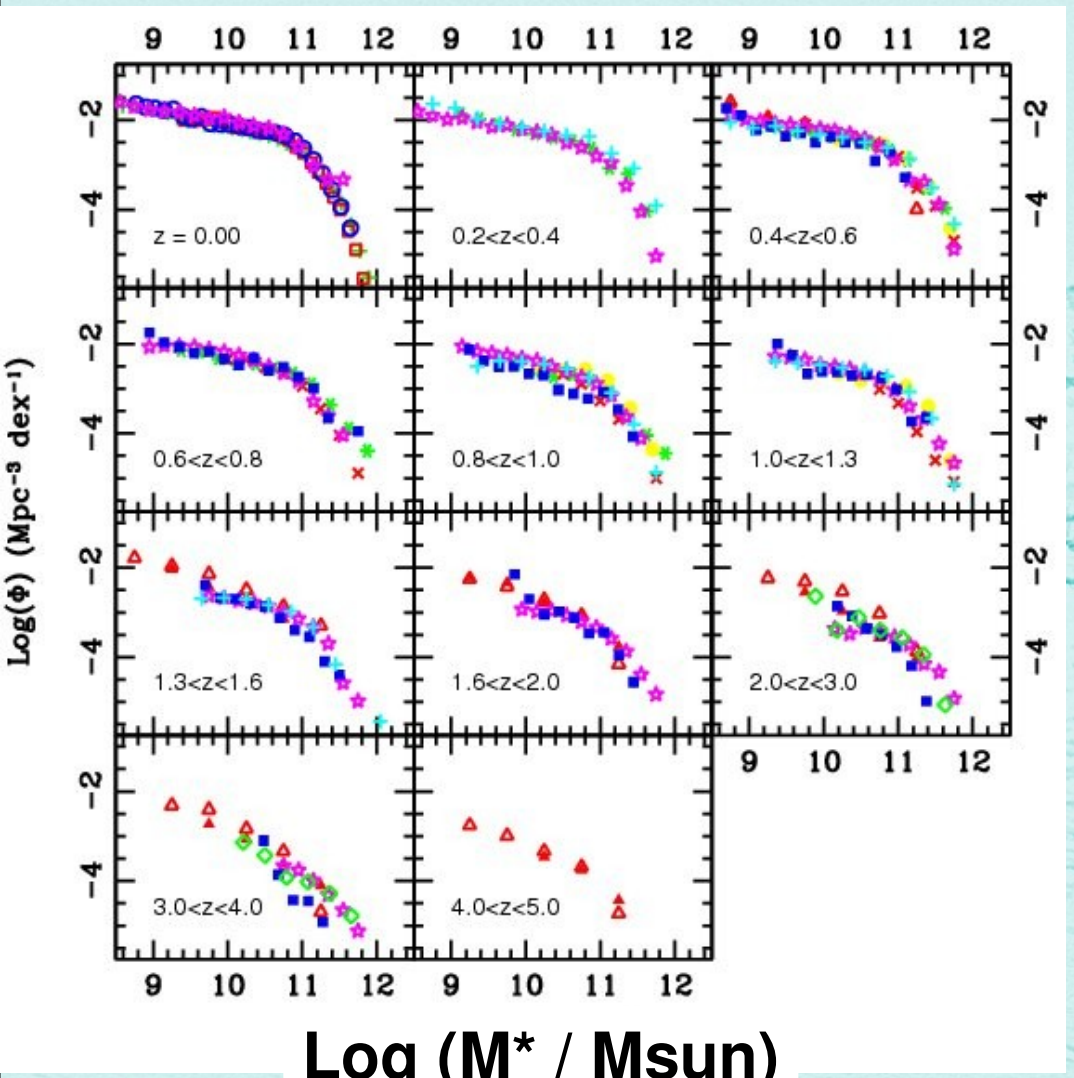
Dunne+08

DS as a s election effect?

The many Manifestations:

- **DS in (specific) SFR** (Cowie+96,Zheng07,Noeske+07,Drory&Alvarez08,Dunne+08,Santini+09...)
  - **Mass of the "typical" SF galaxy decrease with z**
  - **The decline of SSFR is faster for mMG**
- **DS in stellar mass** (Drory+05, Cimatti+06, Fontana+06, Pozzetti+07, Conselice+07,...)
  - **mMG assemble at higher z**

DS in stellar mass



Cole+00

Bell+03

Drory+05

Bundy+05

Borsch+06

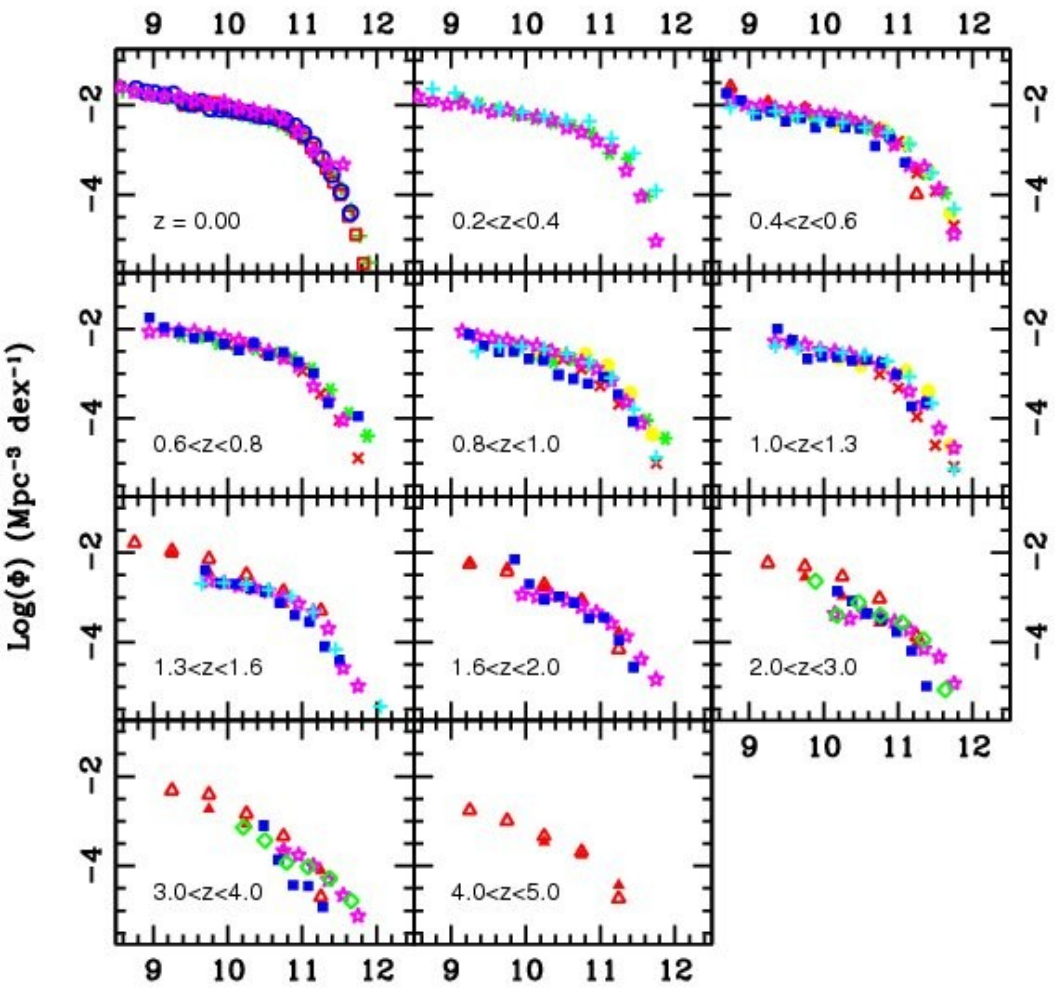
Fontana+06

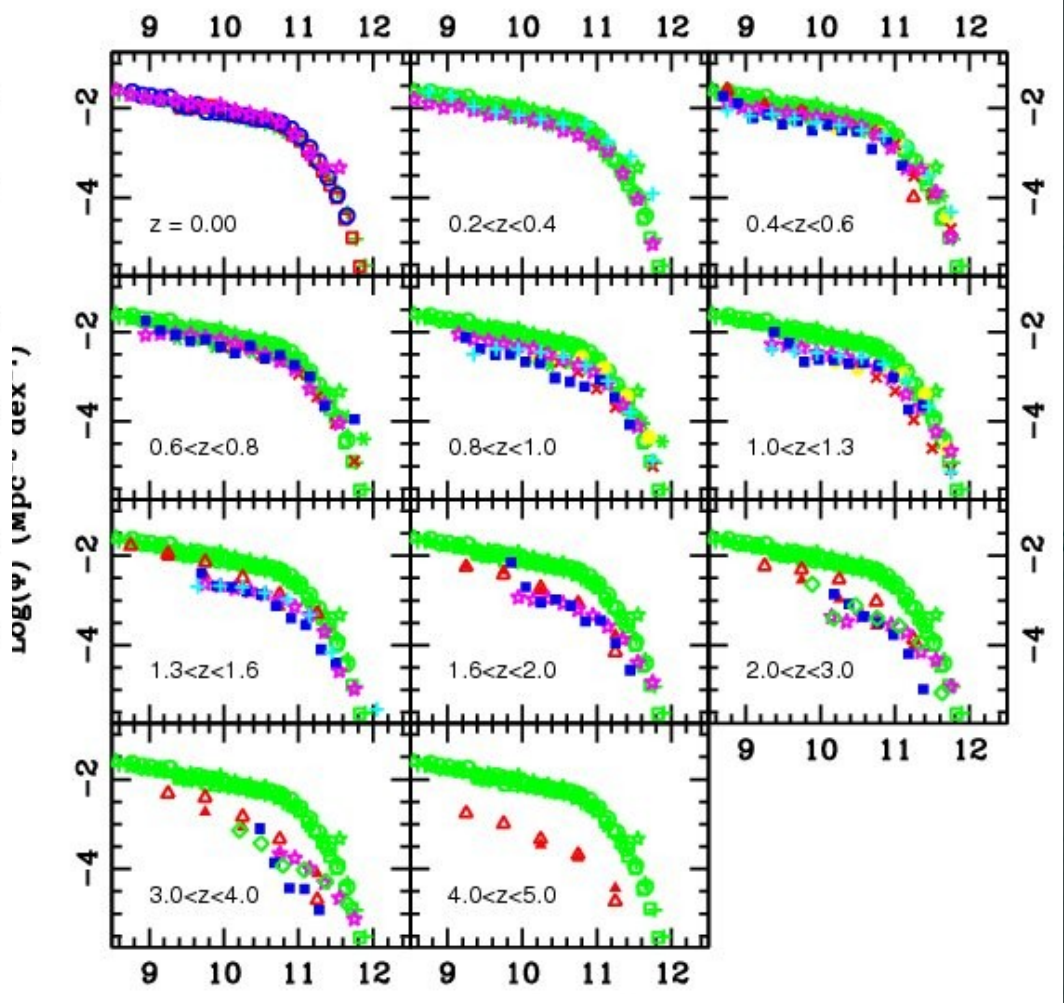
Pozzetti+07

PerezGonzalez+07

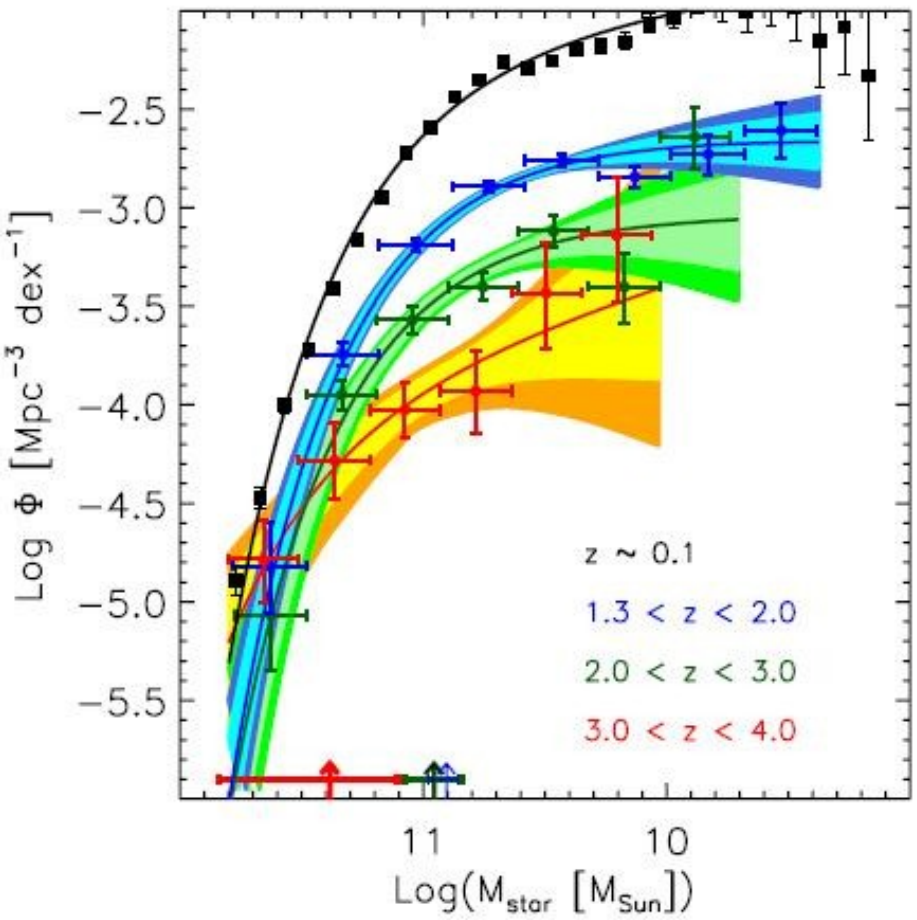
Panter+07

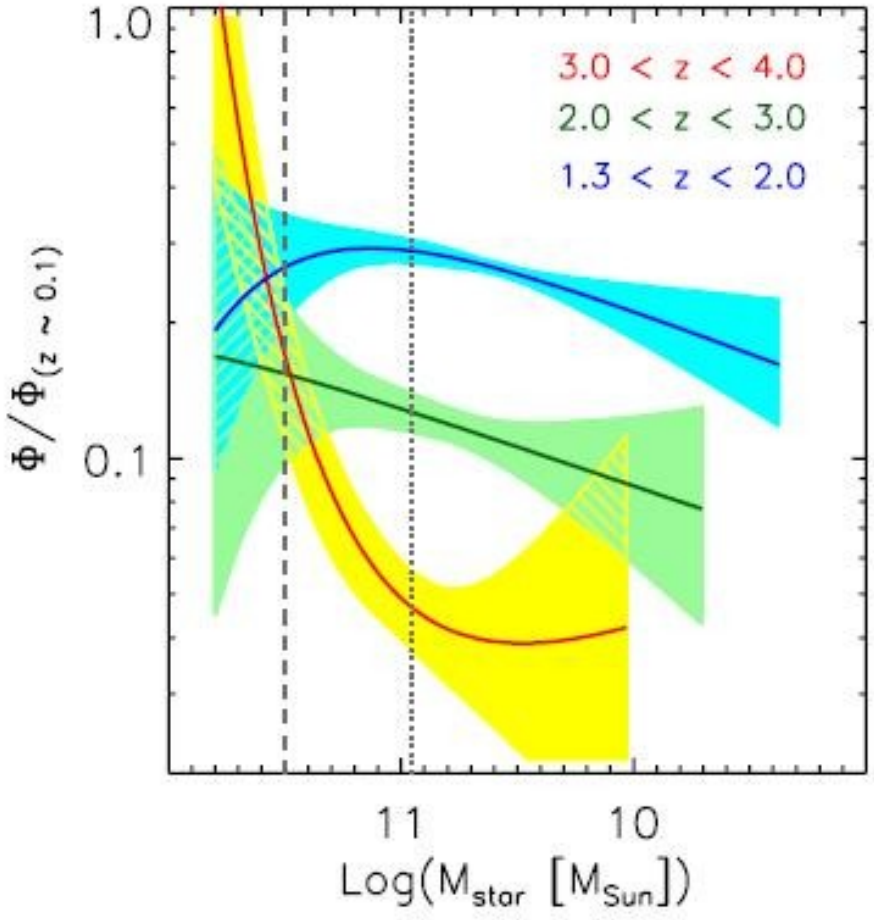
DS in stellar mass



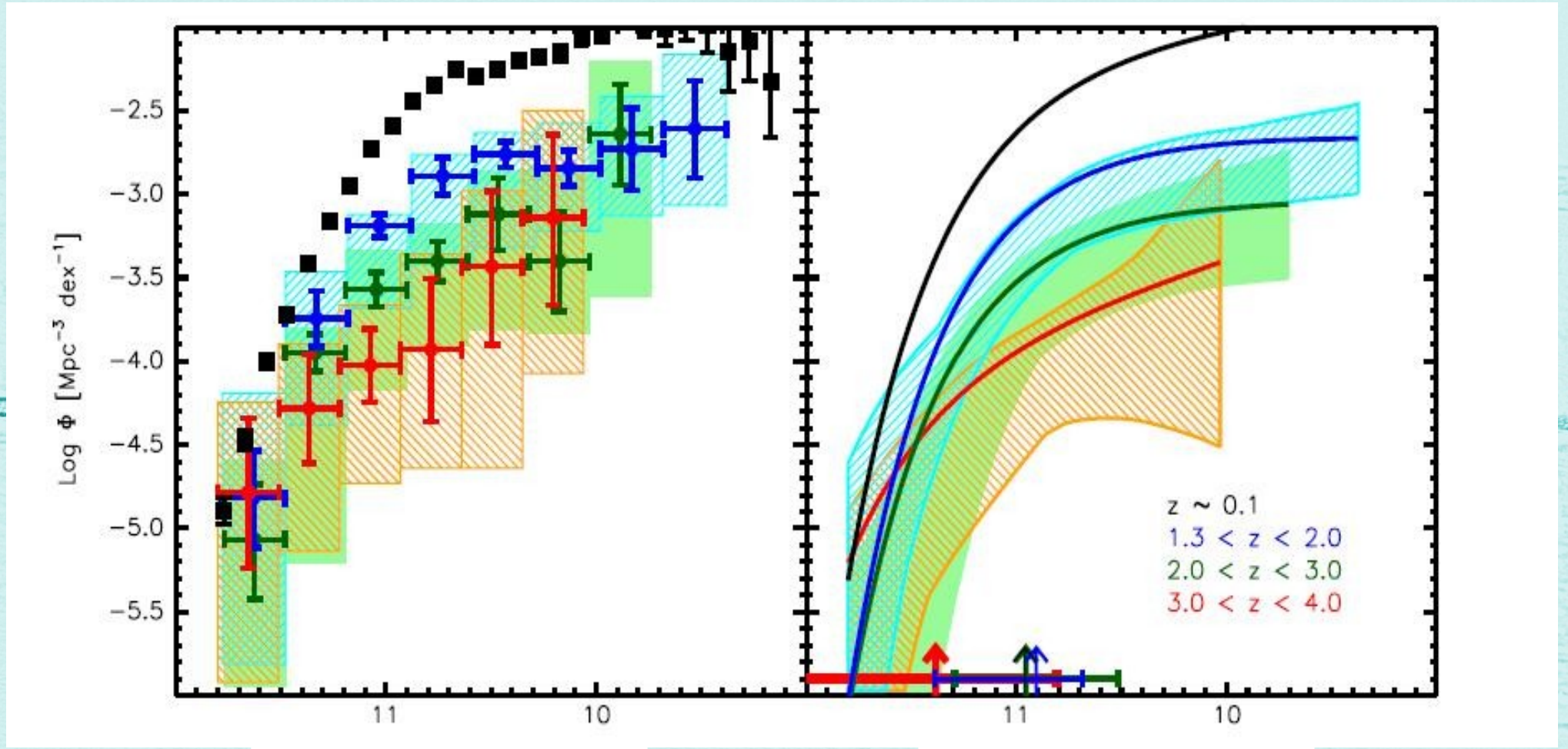


Marchesini+09





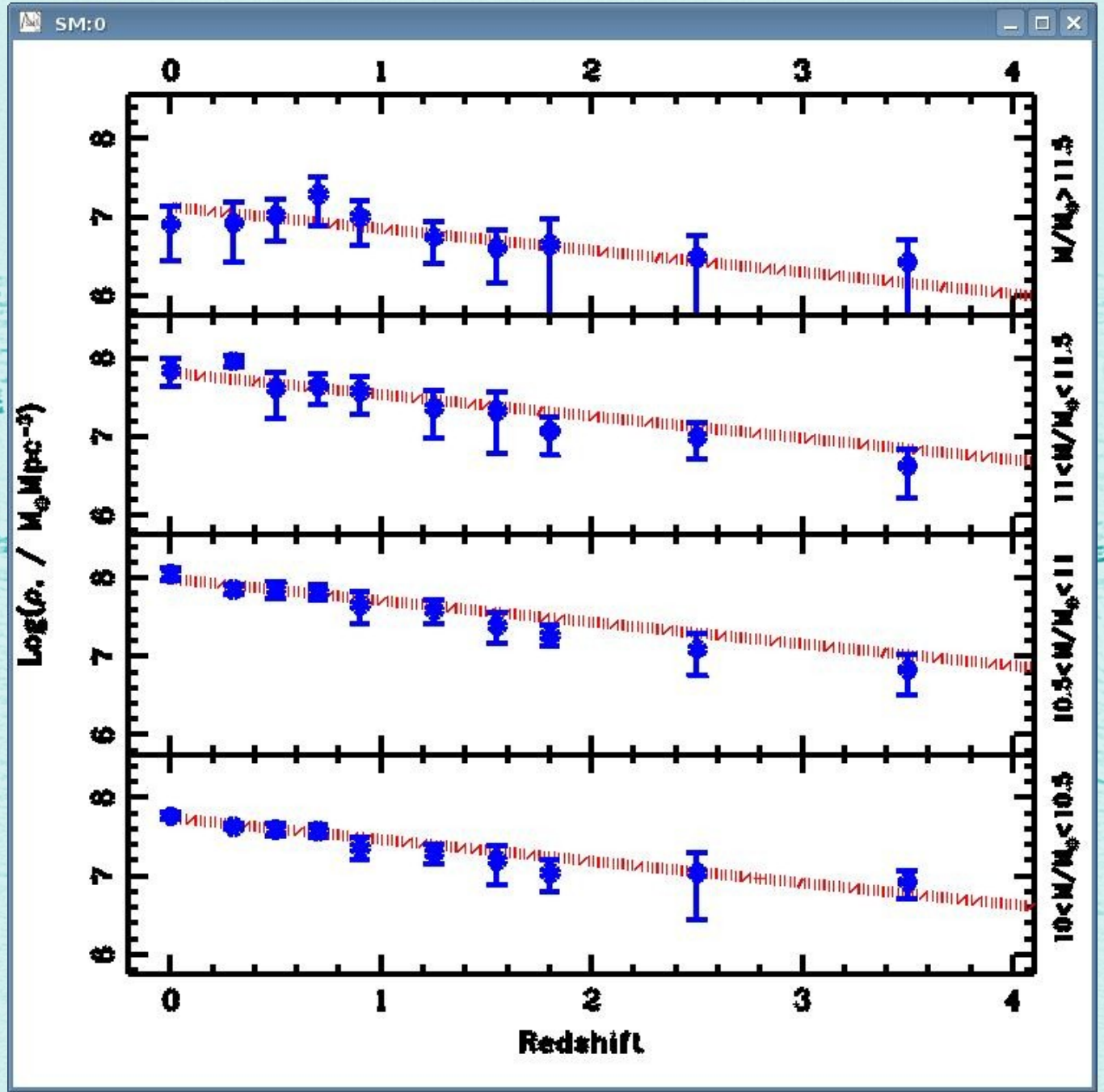
Marchesini+09



Log (M* / Msun)

Log (M* / Msun)

DS in stellar mass

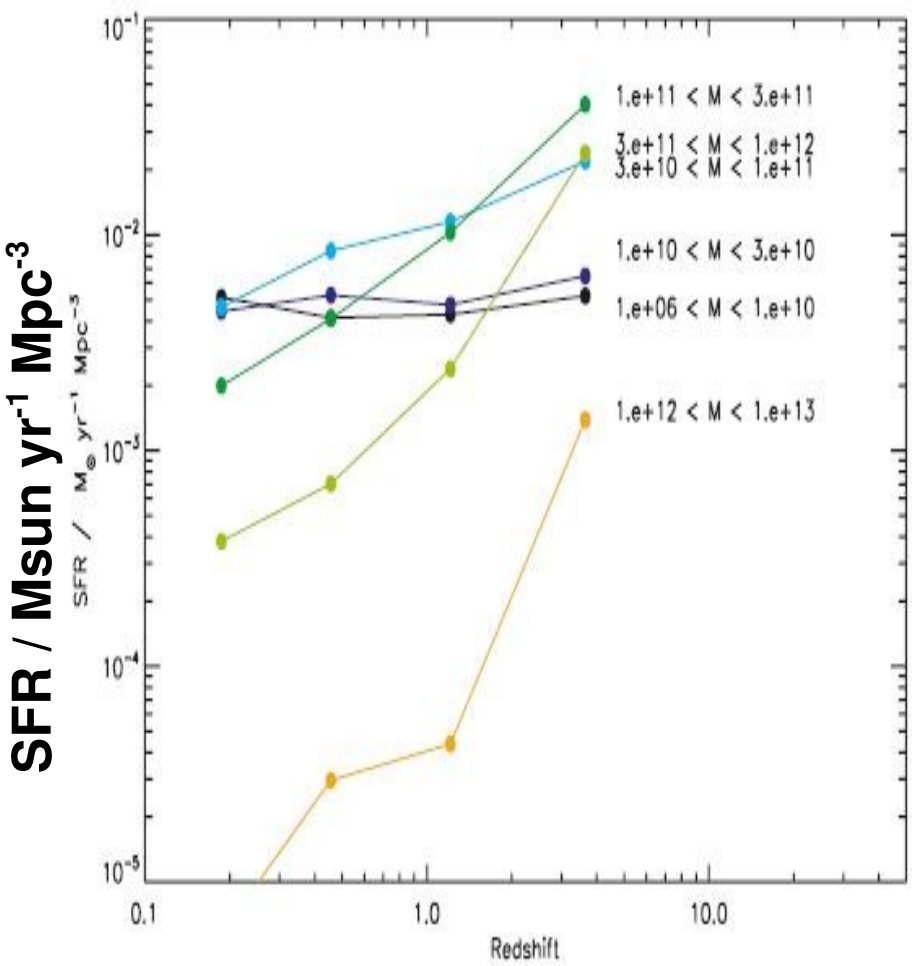


The many Manifestations:

- **DS in (specific) SFR** (Cowie+96,Zheng07,Noeske+07,Drory&Alvarez08,Dunne+08,Santini+09...)
  - **Mass of the "typical" SF galaxy decrease with z**
  - **The decline of SSFR is faster for mMG**
- **DS in stellar mass** (Drory+05, Cimatti+06, Fontana+06, Pozzetti+07, Conselice+07,...)
  - **mMG assemble at higher z**
- **Archeological DS** (Thomas+05, Gallazzi+05, Panter+07, ...)
  - **mMG host the older stellar populations**

Archeological DS

Panter+07

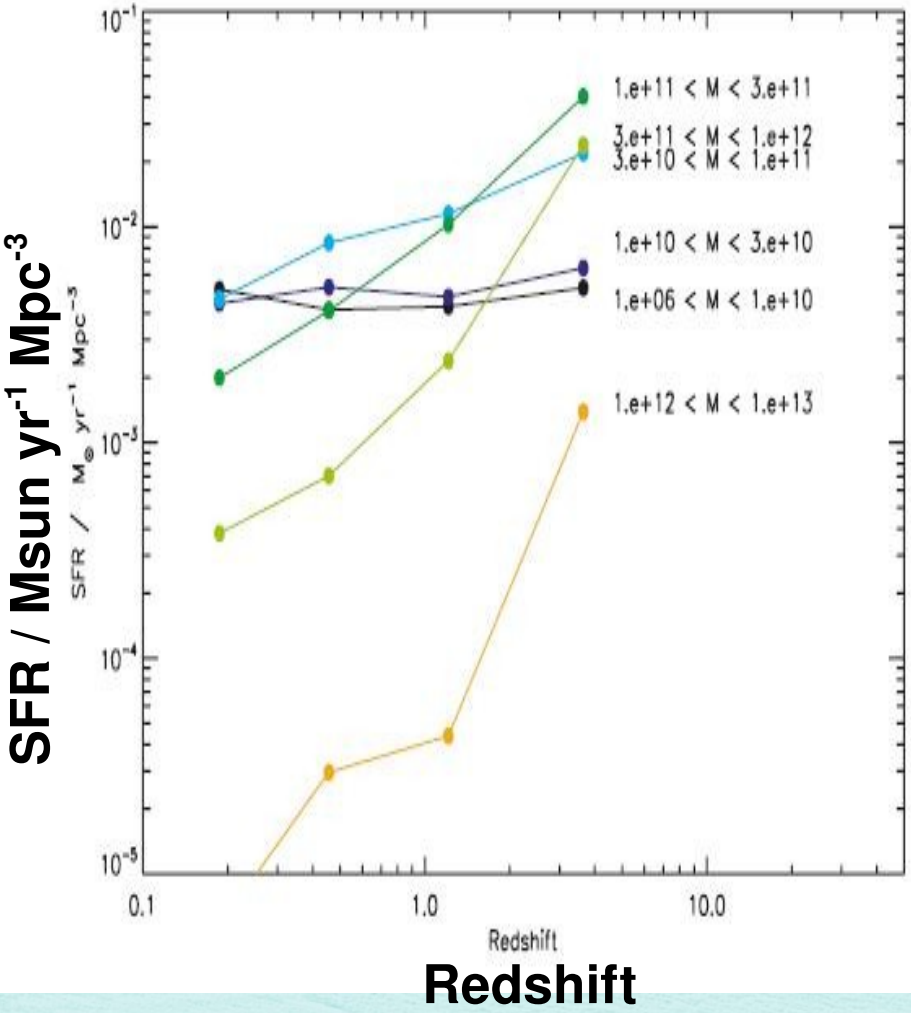


Redshift

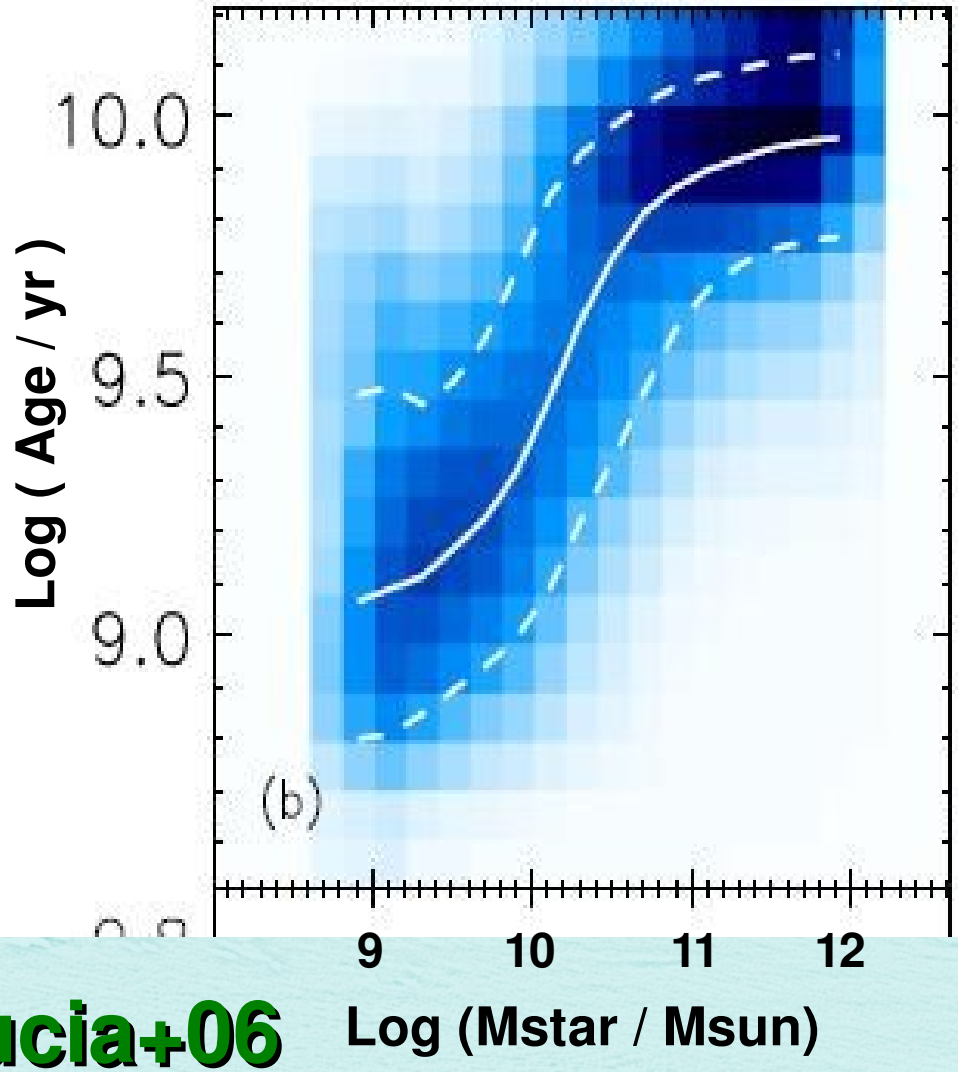
- **Mass binning as a function of z=0 stellar mass**

Archeological DS

Panter+07



Gallazzi+05



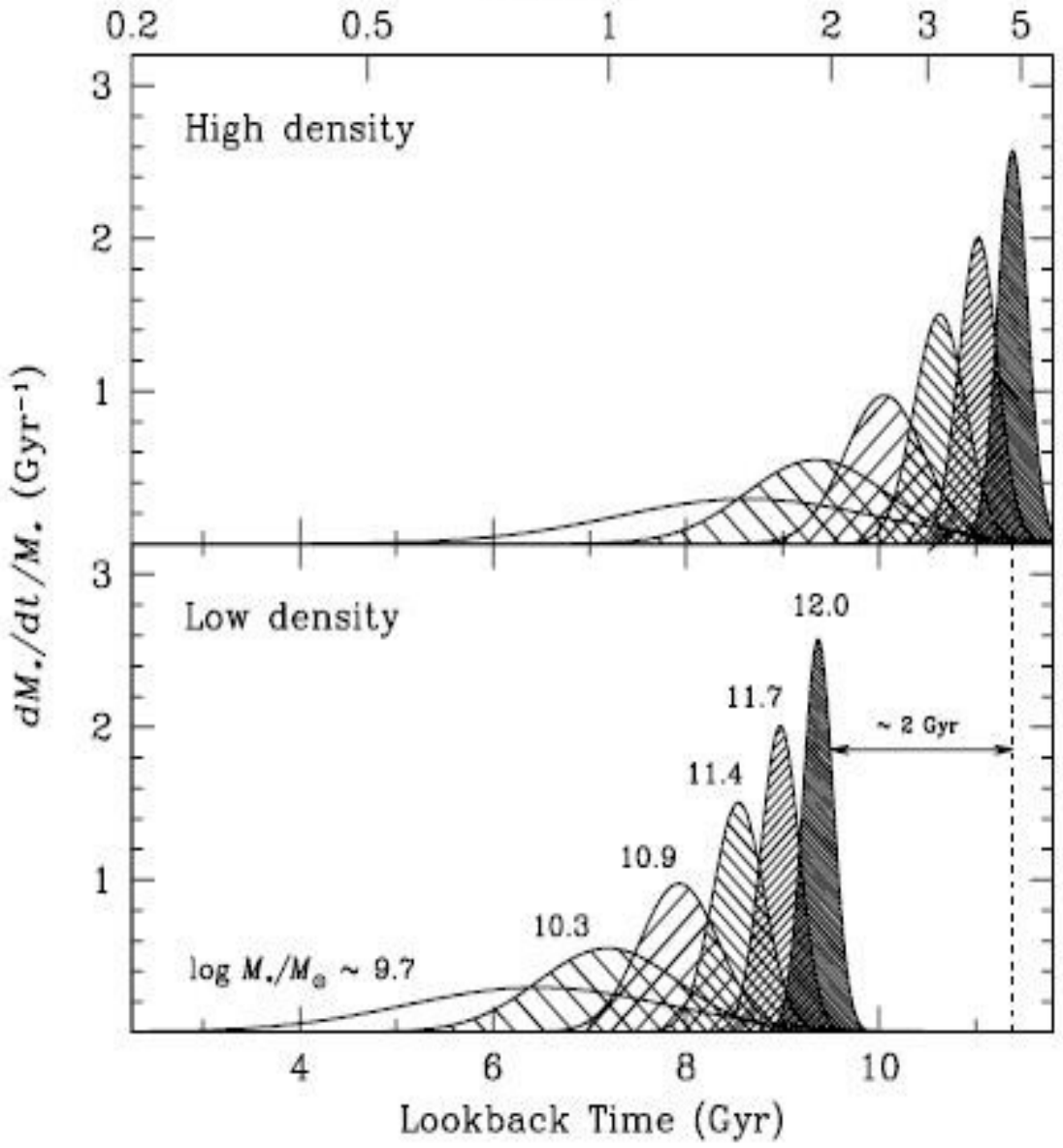
But see **De Lucia+06**

The many Manifestations:

- **DS in (specific) SFR** (Cowie+96,Zheng07,Noeske+07,Drory&Alvarez08,Dunne+08,Santini+09...)
  - **Mass of the "typical" SF galaxy decrease with z**
  - **The decline of SSFR is faster for mMG**
- **DS in stellar mass** (Drory+05, Cimatti+06, Fontana+06, Pozzetti+07, Conselice+07,...)
  - **mMG assemble at higher z**
- **Archeological DS** (Thomas+05, Gallazzi+05, Panter+07, ...)
  - **mMG host the older stellar populations**
- **Chemo-Archeological DS** (Carollo+93,Trager+00,Matteucci+04,Thomas+05,...)
  - **mMG have higher [α/Fe] ratios**

Chemo-Archeological DS

Matteucci94; Thomas+05



See also

Pipino+09

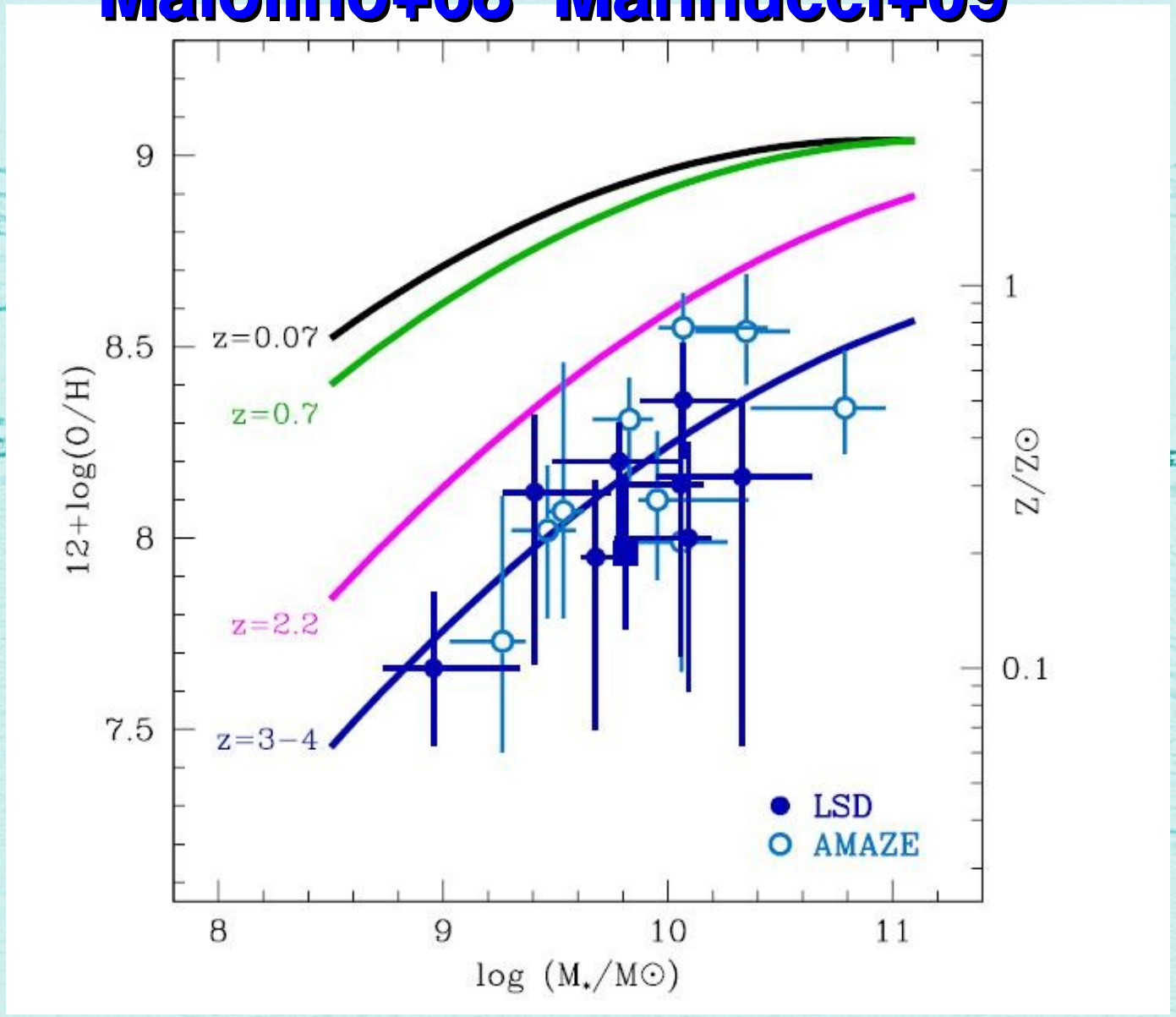
Calura&Menci09

The many Manifestations:

- **DS in (specific) SFR** (Cowie+96,Zheng07,Noeske+07,Drory&Alvarez08,Dunne+08,Santini+09...)
  - **Mass of the "typical" SF galaxy decrease with z**
  - **The decline of SSFR is faster for mMG**
- **DS in stellar mass** (Drory+05, Cimatti+06, Fontana+06, Pozzetti+07, Conselice+07,...)
  - **mMG assemble at higher z**
- **Archeological DS** (Thomas+05, Gallazzi+05, Panter+07, ...)
  - **mMG host the older stellar populations**
- **Chemo-Archeological DS** (Carollo+93,Trager+00,Matteucci+04,Thomas+05,...)
  - **mMG have higher [α/Fe] ratios**
- **DS in metalicity** (Savaglio+05,Erb+06,Maiolino+08,...)
  - **Metalicity of mMG decrease slower with z**

DS in Metalicity

Maiolino+08 Mannucci+09

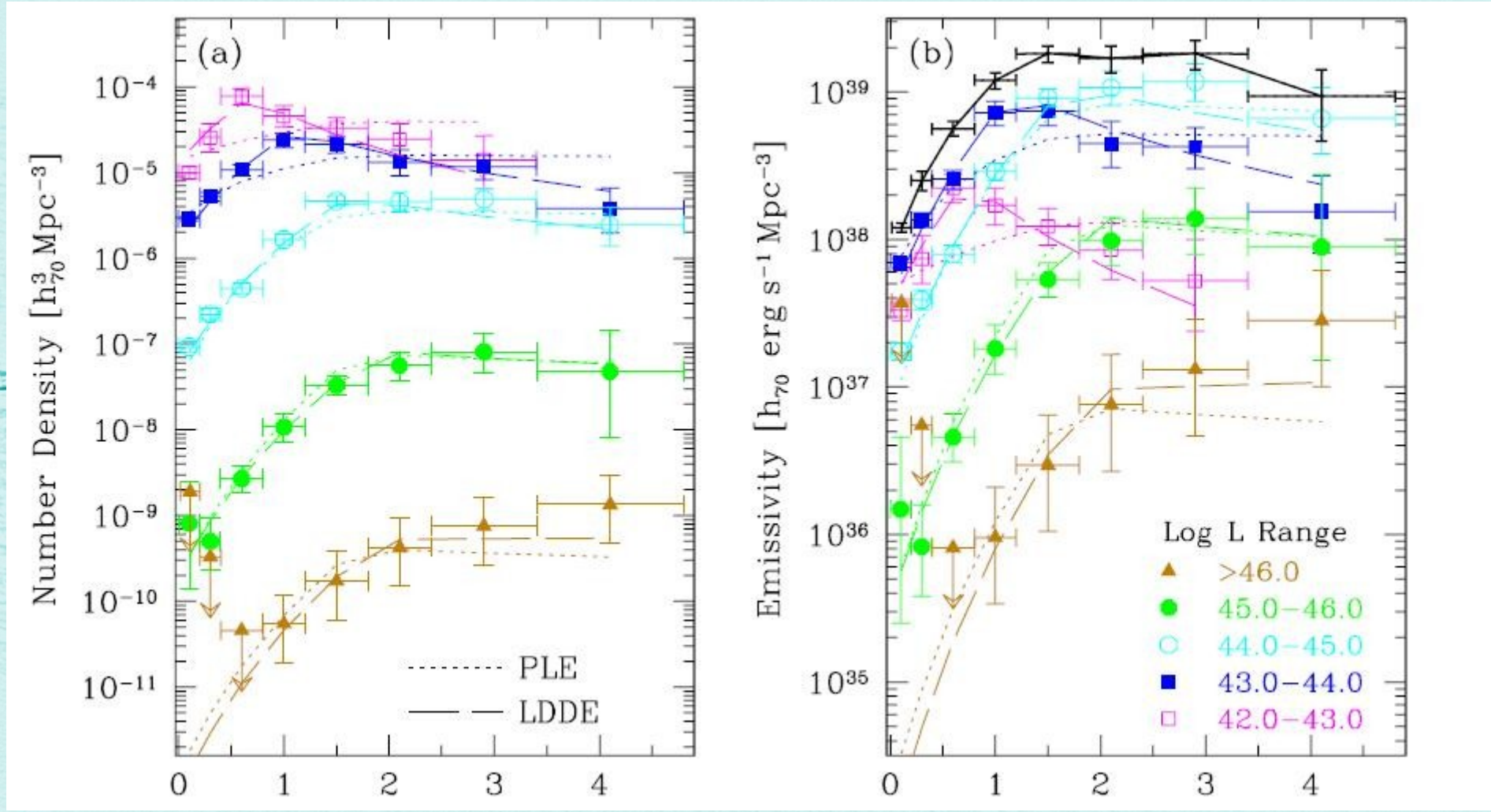


The many Manifestations:

- **DS in (specific) SFR** (Cowie+96,Zheng07,Noeske+07,Drory&Alvarez08,Dunne+08,Santini+09...)
  - Mass of the "typical" SF galaxy decrease with z
  - The decline of SSFR is faster for mMG
- **DS in stellar mass** (Drory+05, Cimatti+06, Fontana+06, Pozzetti+07, Conselice+07,...)
  - mMG assemble at higher z
- **Archeological DS** (Thomas+05, Gallazzi+05, Panter+07, ...)
  - mMG host the older stellar populations
- **Chemo-Archeological DS** (Carollo+93,Trager+00,Matteucci+04,Thomas+05,...)
  - mMG have higher [α/Fe] ratios
- **DS in metalicity** (Savaglio+05,Erb+06,Maiolino+08,...)
  - Metalicity of mMG decrease slower with z
- **AGN DS** (Ueda+03,Hasinger+05,LaFranca+05,...)
  - The LF of more luminous AGNs peaks at higher z

AGN DS

Hasinger+05



Redshift

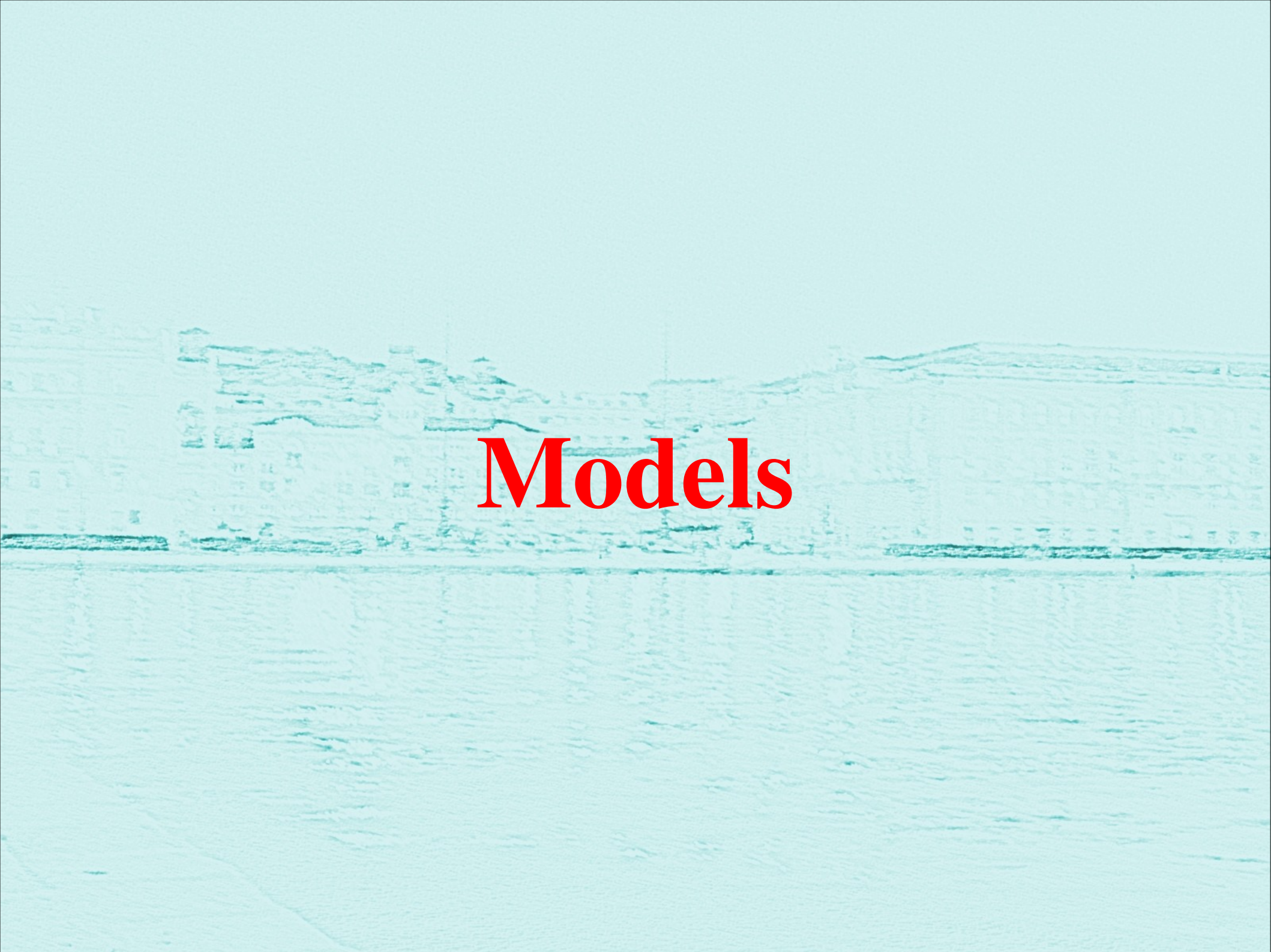
Redshift

The many Manifestations:

- **DS in (specific) SFR** (Cowie+96,Zheng07,Noeske+07,Drory&Alvarez08,Dunne+08,Santini+09...)
  - Mass of the "typical" SF galaxy decrease with z
  - The decline of SSFR is faster for mMG
- **DS in stellar mass** (Drory+05, Cimatti+06, Fontana+06, Pozzetti+07, Conselice+07,...)
  - mMG assemble at higher z
- **Archeological DS** (Thomas+05, Gallazzi+05, Panter+07, ...)
  - mMG host the older stellar populations
- **Chemo-Archeological DS** (Carollo+93,Trager+00,Matteucci+04,Thomas+05,...)
  - mMG have higher [α/Fe] ratios
- **DS in metalicity** (Savaglio+05,Erb+06,Maiolino+08,...)
  - Metalicity of mMG decrease slower with z
- **AGN DS** (Ueda+03,Hasinger+05,LaFranca+05,...)
  - The LF of more luminous AGNs peaks at higher z

The many Manifestations:

- **DS in (specific) SFR** (Cowie+96,Zheng07,Noeske+07,Drory&Alvarez08,Dunne+08,Santini+09...)
  - Mass of the "typical" SF galaxy decrease with z
  - The decline of SSFR is faster for mMG
- **DS in stellar mass** (Drory+05, Cimatti+06, Fontana+06, Pozzetti+07, Conselice+07,...)
  - mMG assemble at higher z
- **Archeological DS** (Thomas+05, Gallazzi+05, Panter+07, ...)
  - mMG host the older stellar populations
- **Chemo-Archeological DS** (Carollo+93,Trager+00,Matteucci+04,Thomas+05,...)
  - mMG have higher [α/Fe] ratios
- **DS in metalicity** (Savaglio+05,Erb+06,Maiolino+08,...)
  - Metalicity of mMG decrease slower with z
- **AGN DS** (Ueda+03,Hasinger+05,LaFranca+05,...)
  - The LF of more luminous AGNs peaks at higher z

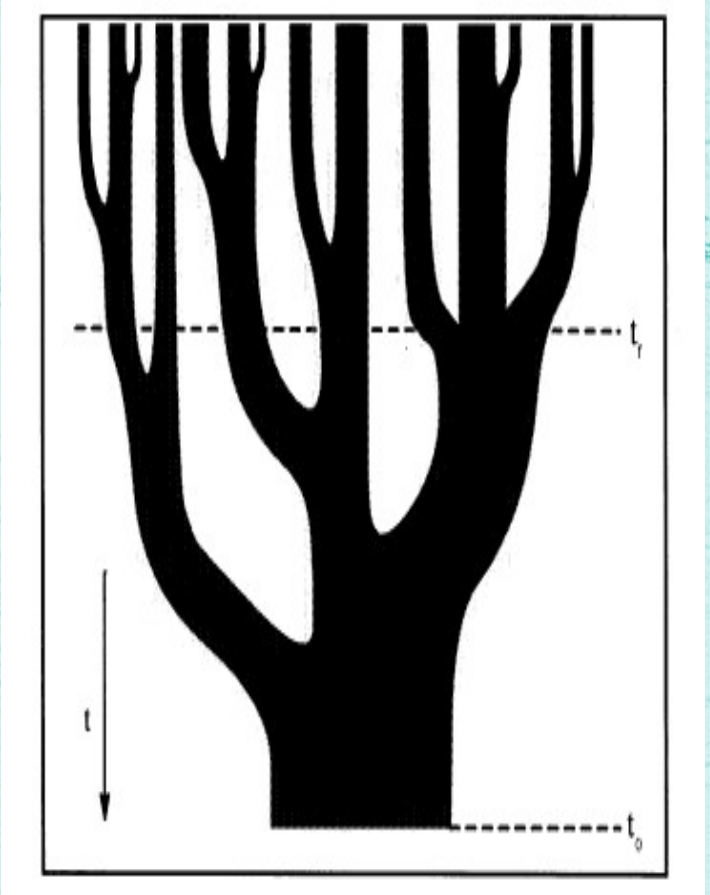

Models

Semi-Analytical Models (SAMs)

- **Simulate the formation and evolution of galaxies populations within the ΛCDM cosmology**
- **Main ingredients (1)**
  - **Cosmological parameters**
  - **DM halos merger trees**
  - **Substructure evolution**

Semi-Analytical Models (SAMs)

- Simulate the formation and evolution of galaxies populations within the ΛCDM cosmology
- Main ingredients (1)
  - Cosmological parameters
  - DM halos merger trees
  - Substructure evolution

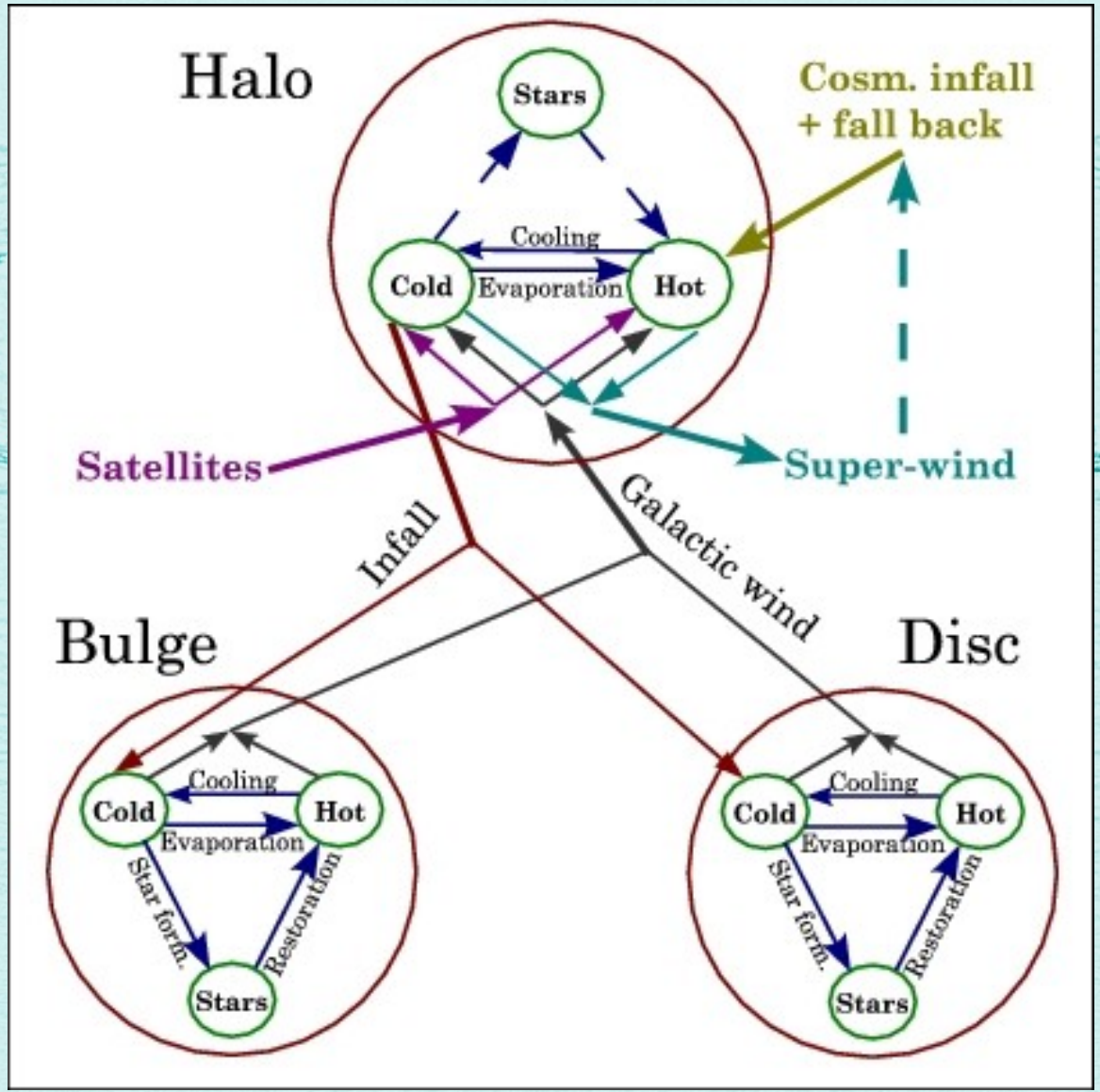


Semi-Analytical Models (SAMs)

- The evolution of baryonic component is followed by using physically motivated analytical approximations
- Main Ingredients (2)
  - Gas cooling and Infall
  - Star Formation and Stellar feedback
  - Galaxy size, morphology
  - BH growth
    - AGN activity and AGN feedback

Semi-Analytical Models (SAMs)

Monaco Fontanot & Taffoni 07

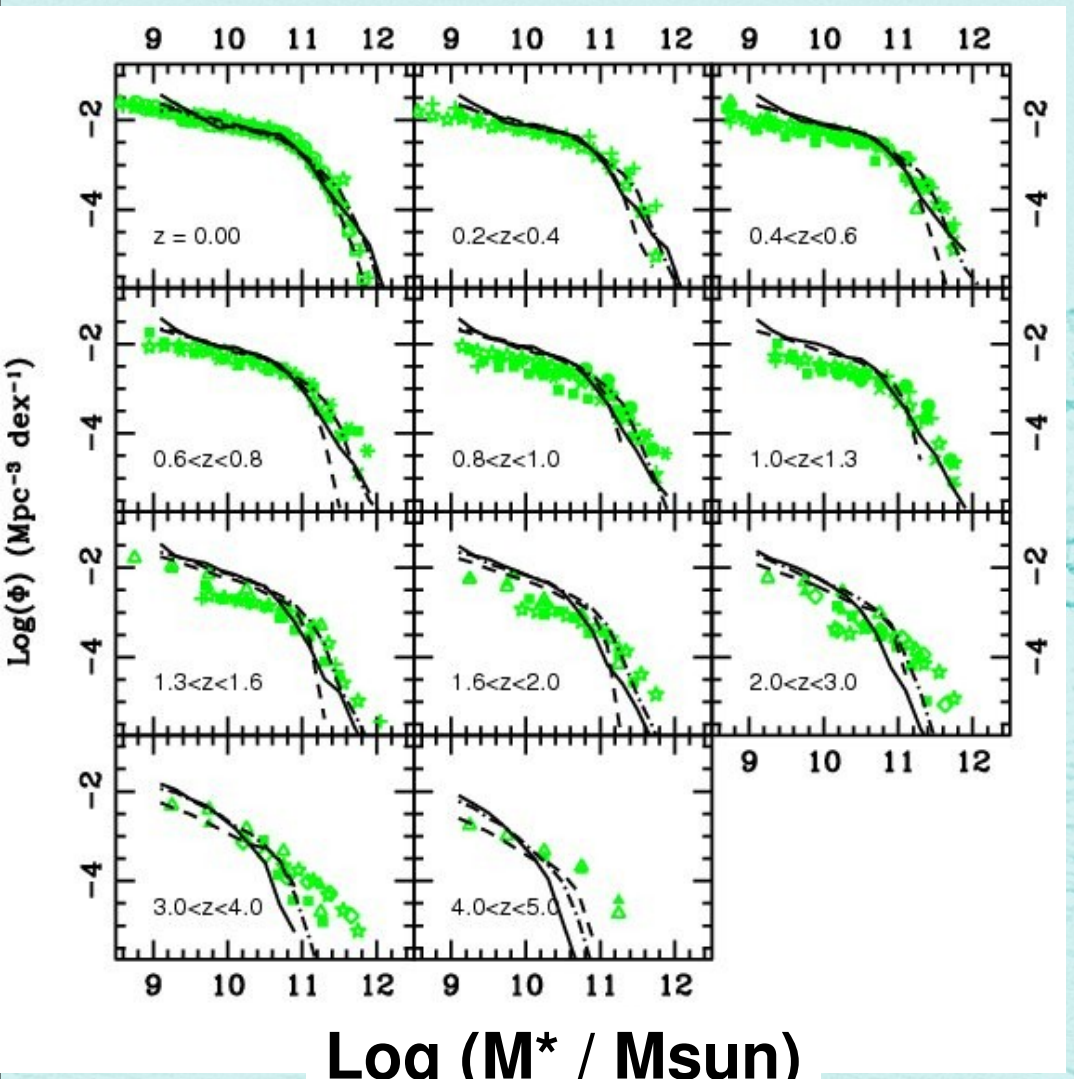


Semi-Analytical Models (SAMs)

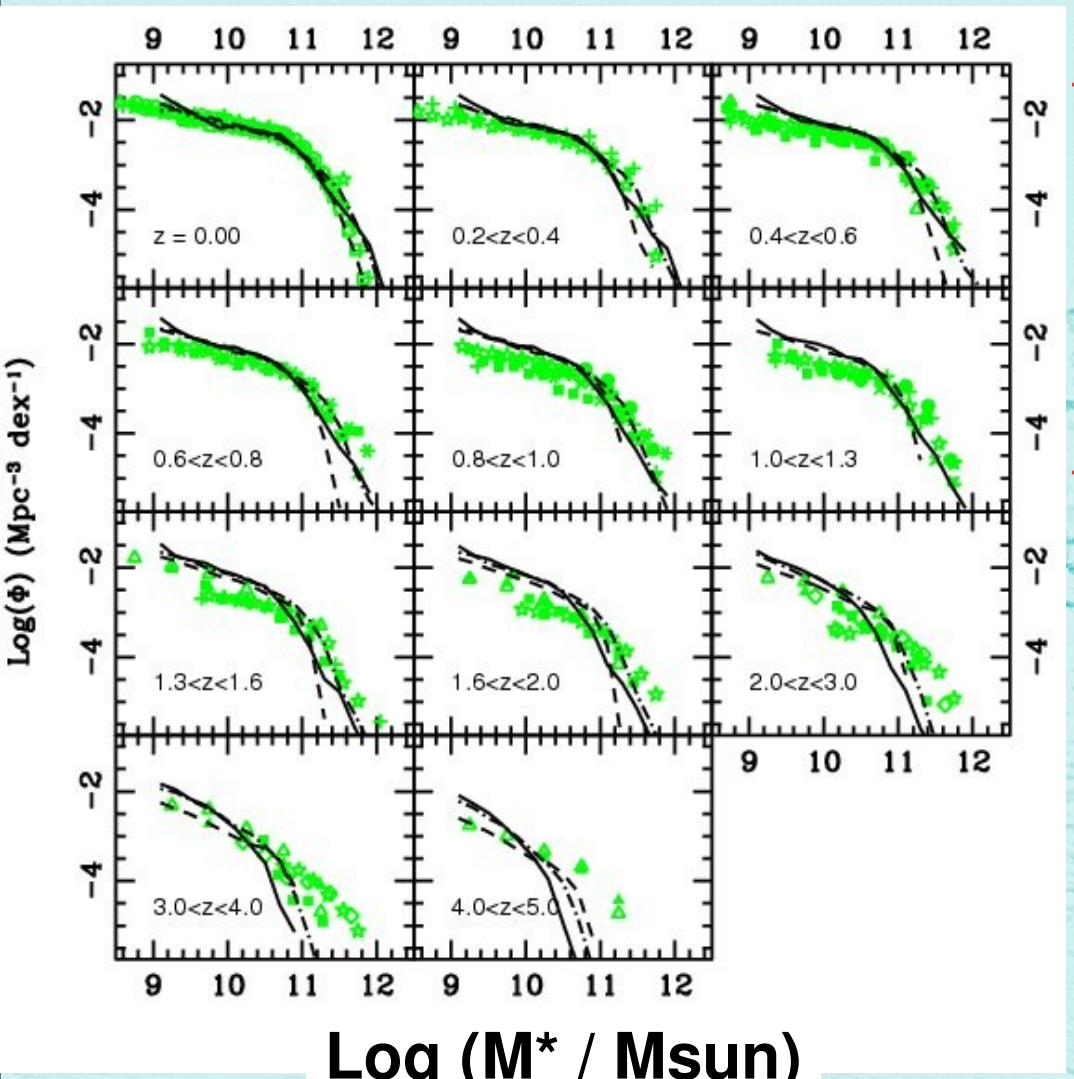
- This work
  - MORGANA
    Monaco, Fontanot & Taffoni 2007
  - WDL08 Wang, De Lucia +08
  - RSS08 Somerville+08
- Different choices for the treatment of physical processes
- Normalized to (almost) the same subset of low-z observations

Results

DS in stellar mass

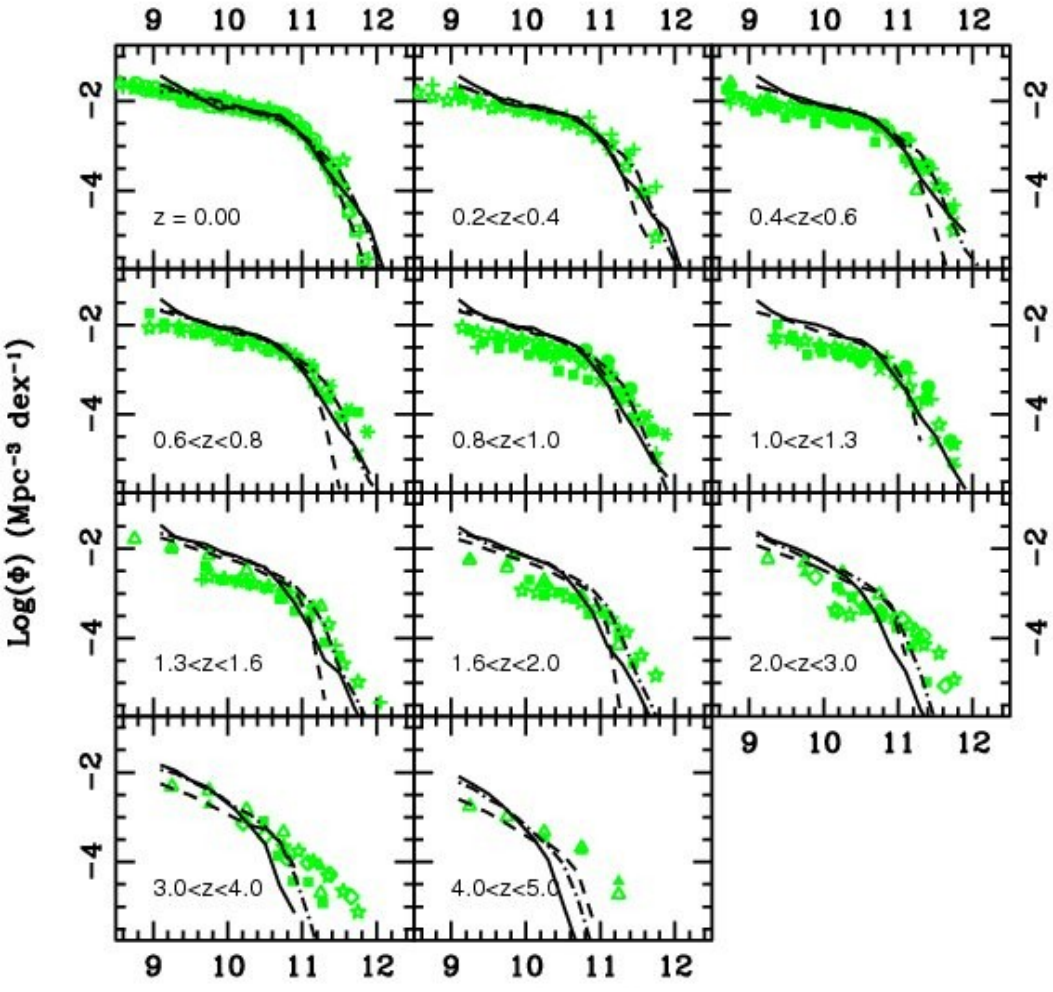


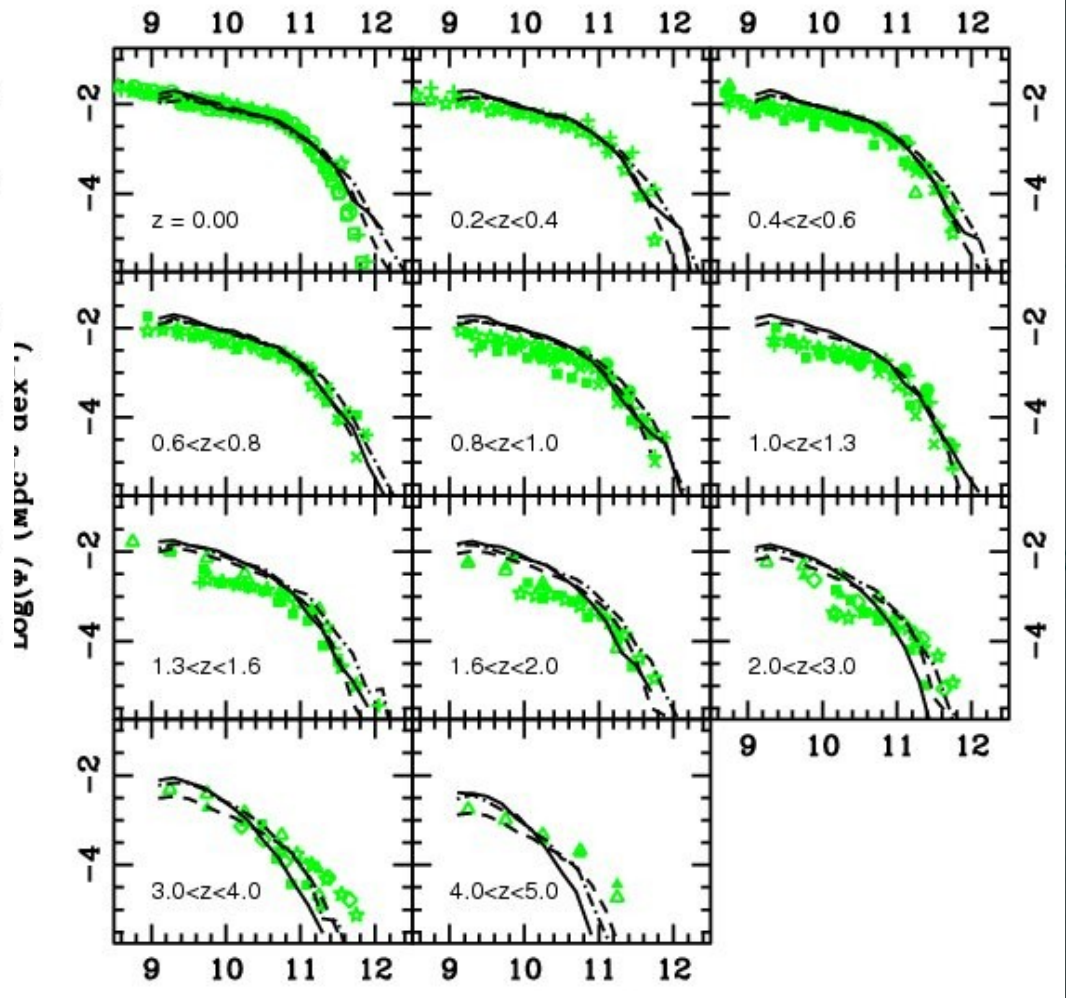
DS in stellar mass



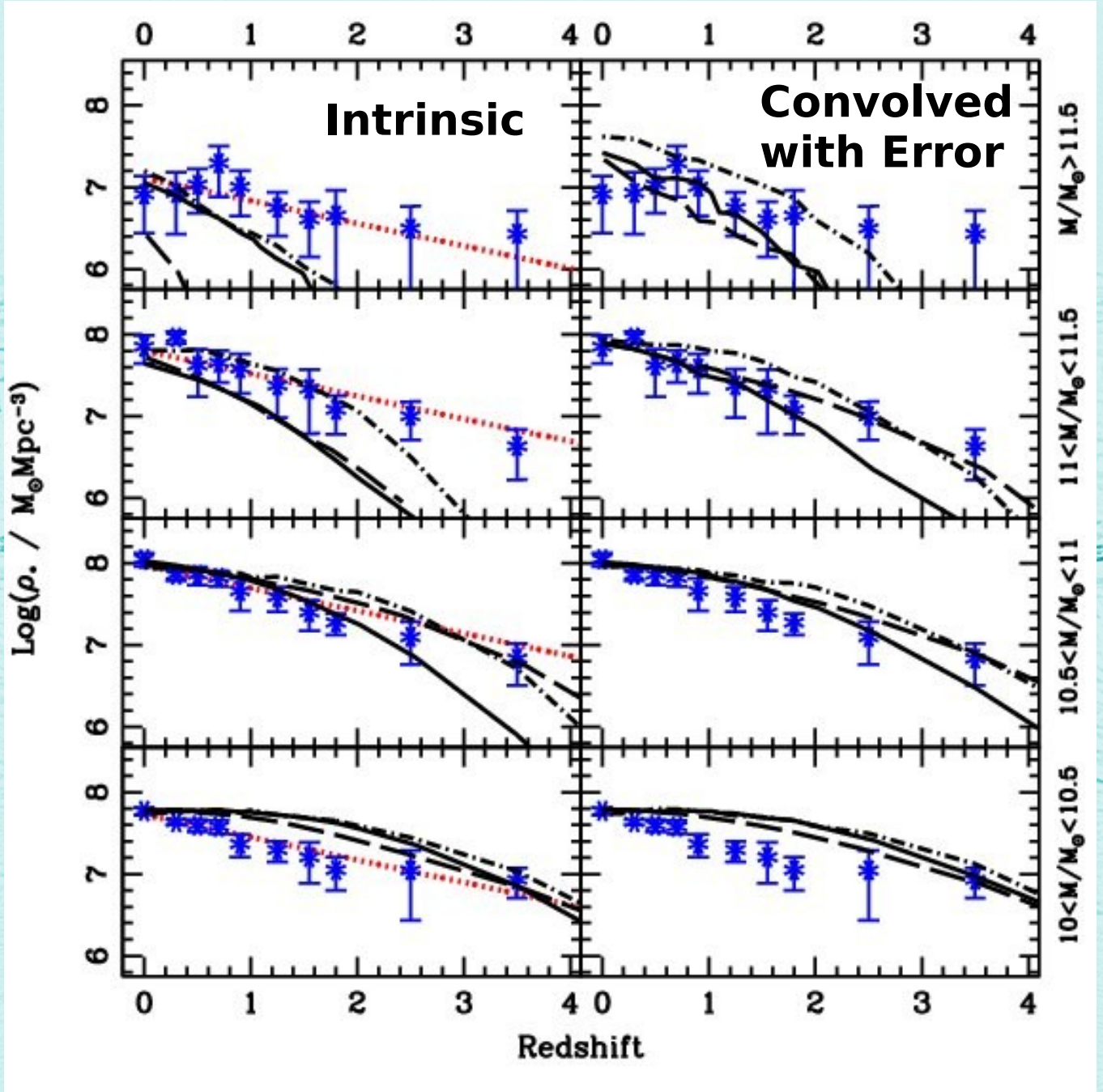
- Error on the mass estimate
  Kitzbichler&White07
  Marchesini+09
- Normal distribution with σ = 0.25 dex

DS in stellar mass





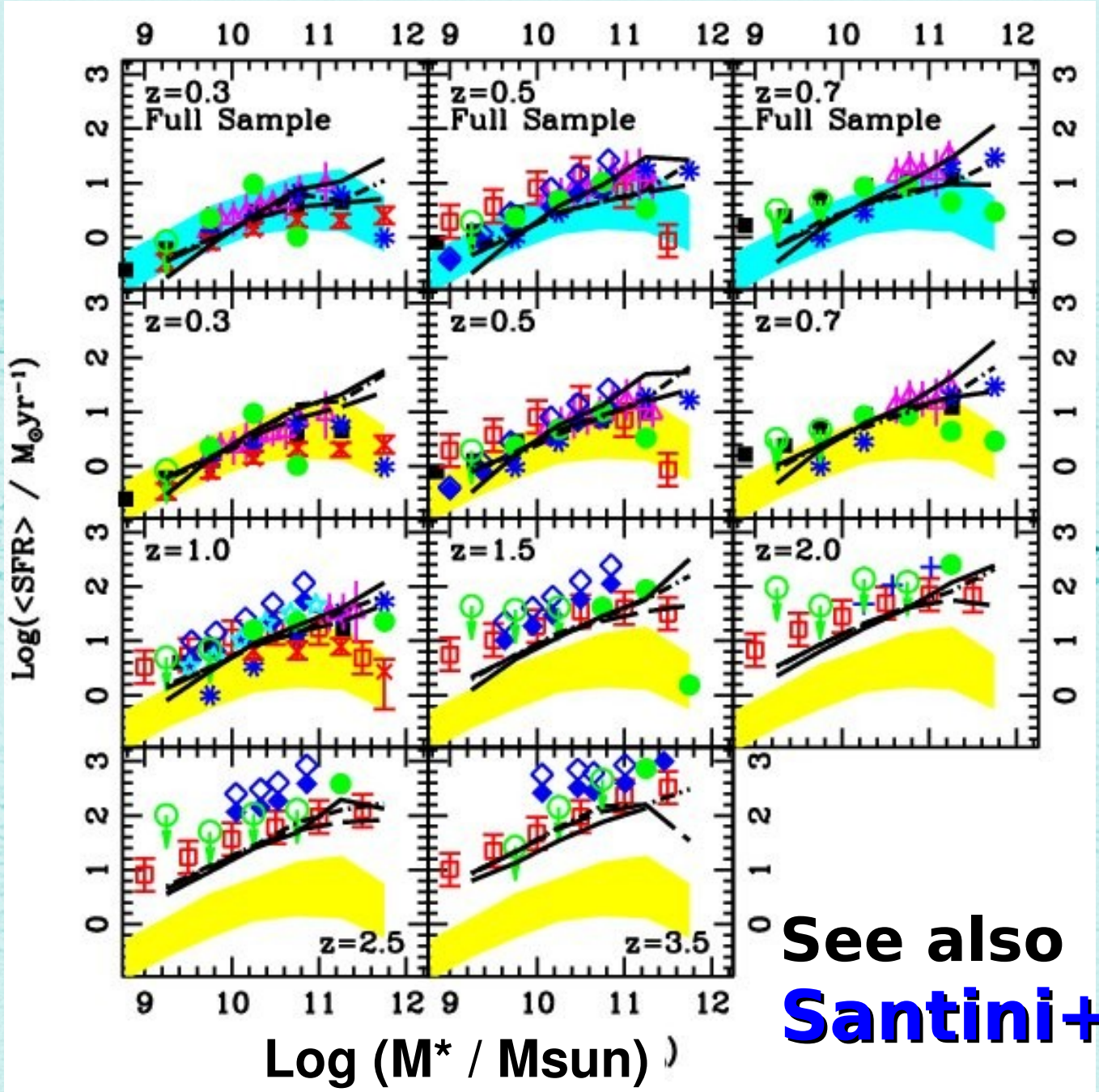
Stellar Mass Density Evolution



DS in SAMs ?

- **The strongest discrepancies are seen in the intermediate-to-low mass galaxy population.**
  - **They form too early**

DS in SFR



Active Galaxies

SSFR > 10^{-11} yr^{-1}

Brinchmann+04

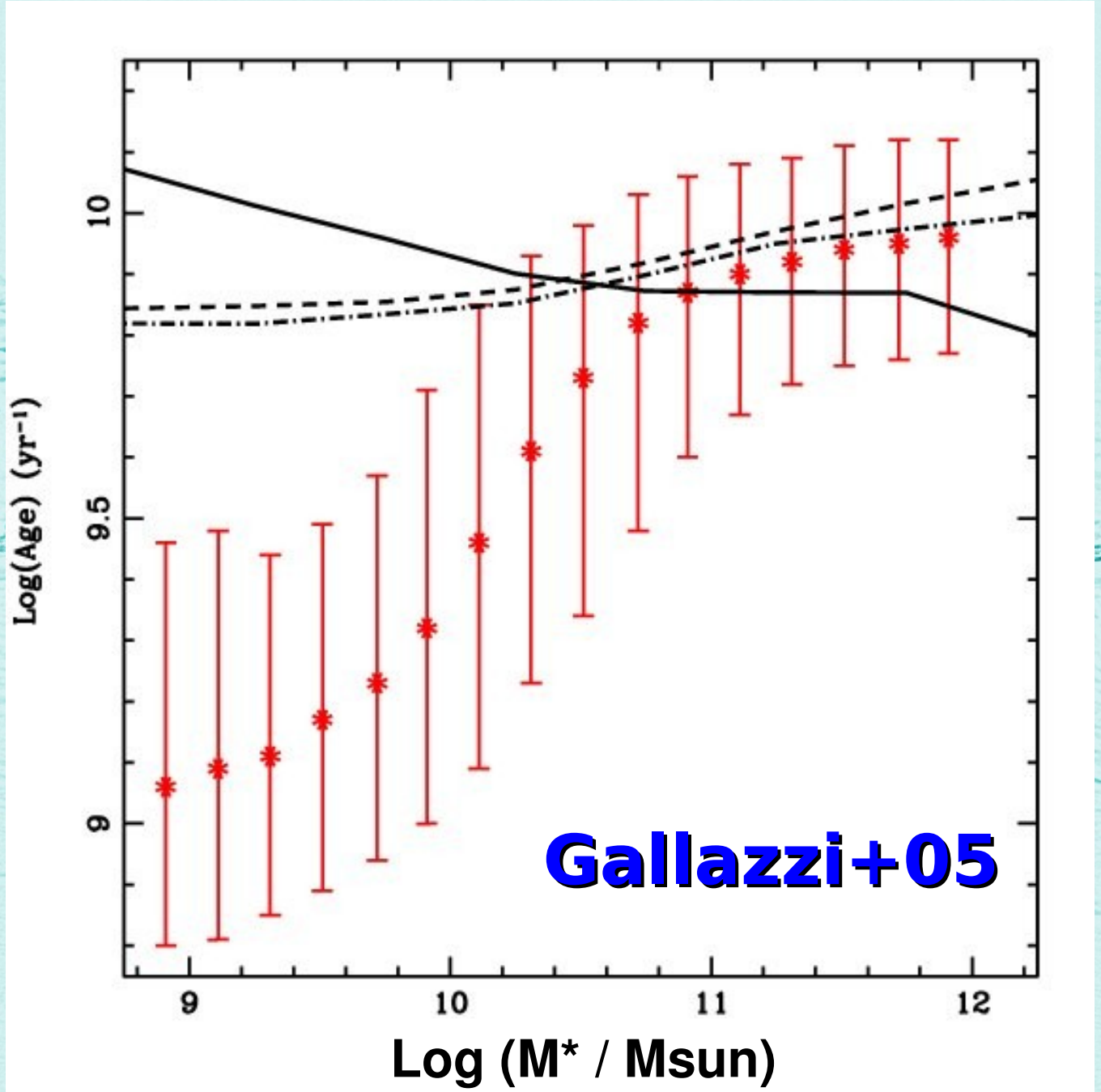
See also

Santini+09

DS in SAMs ?

- **The strongest discrepancies are seen in the intermediate-to-low mass galaxy population.**
  - **They form too early**
  - **They are too passive**

Age of stellar populations



DS in SAMs ?

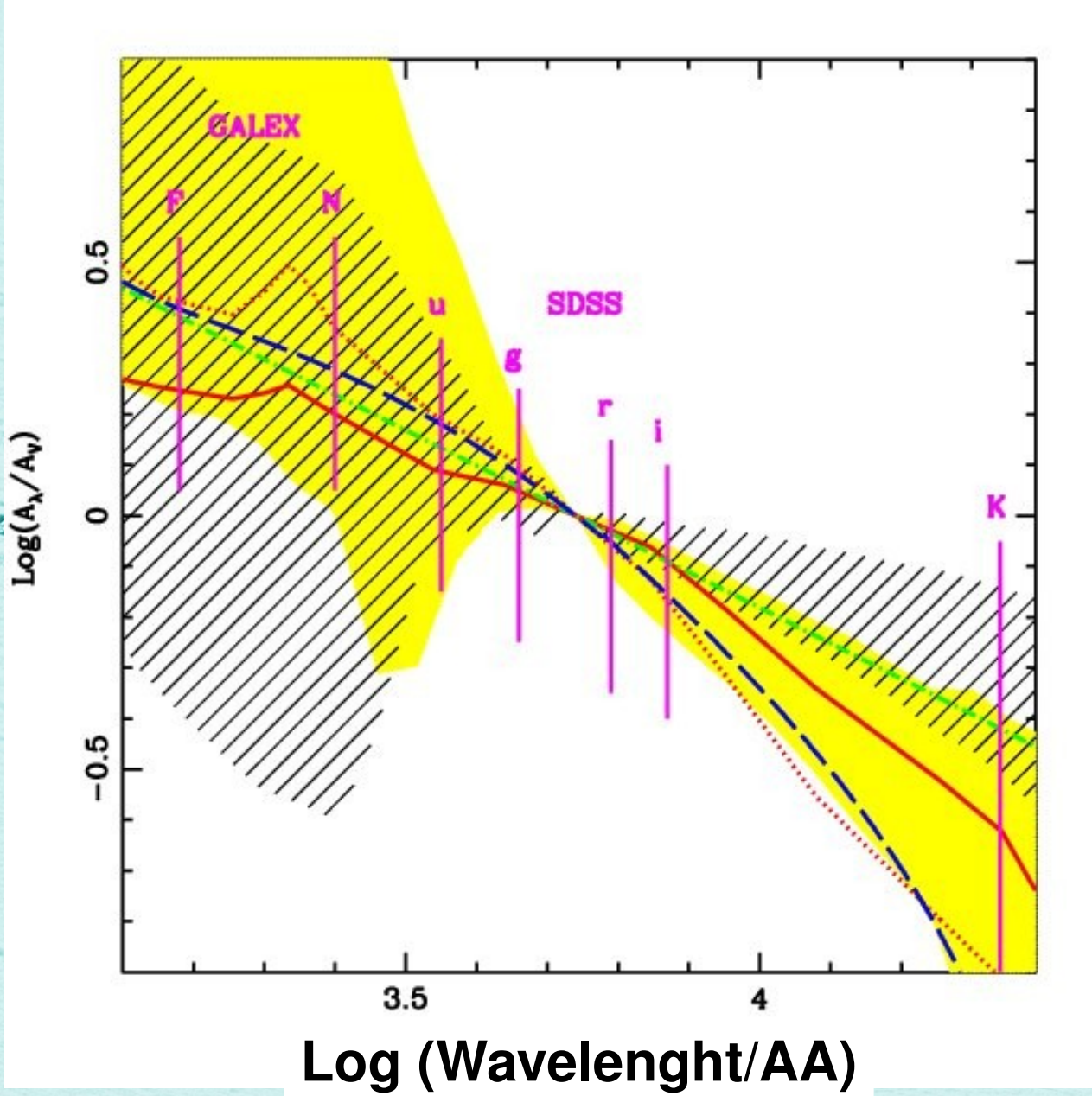
- **The strongest discrepancies are seen in the intermediate-to-low mass galaxy population.**
  - **They form too early**
  - **They are too passive**
  - **They are too old**


Interlude

More Conclusions (2)

- **The error on the stellar mass and SFR determinations play a key role in the comparison between observational constraints and model predictions**
  - **Understanding the systematics**
    (Stringer+08,Marchesini+08)
  - **Testing reconstruction algorithms against synthetic SEDs and star formation histories**
    - **Role of complex vs simple star formation histories**
    - **Role of dust attenuation recipes**
    - **Role of multi-wavelength photometry**

Dust modeling

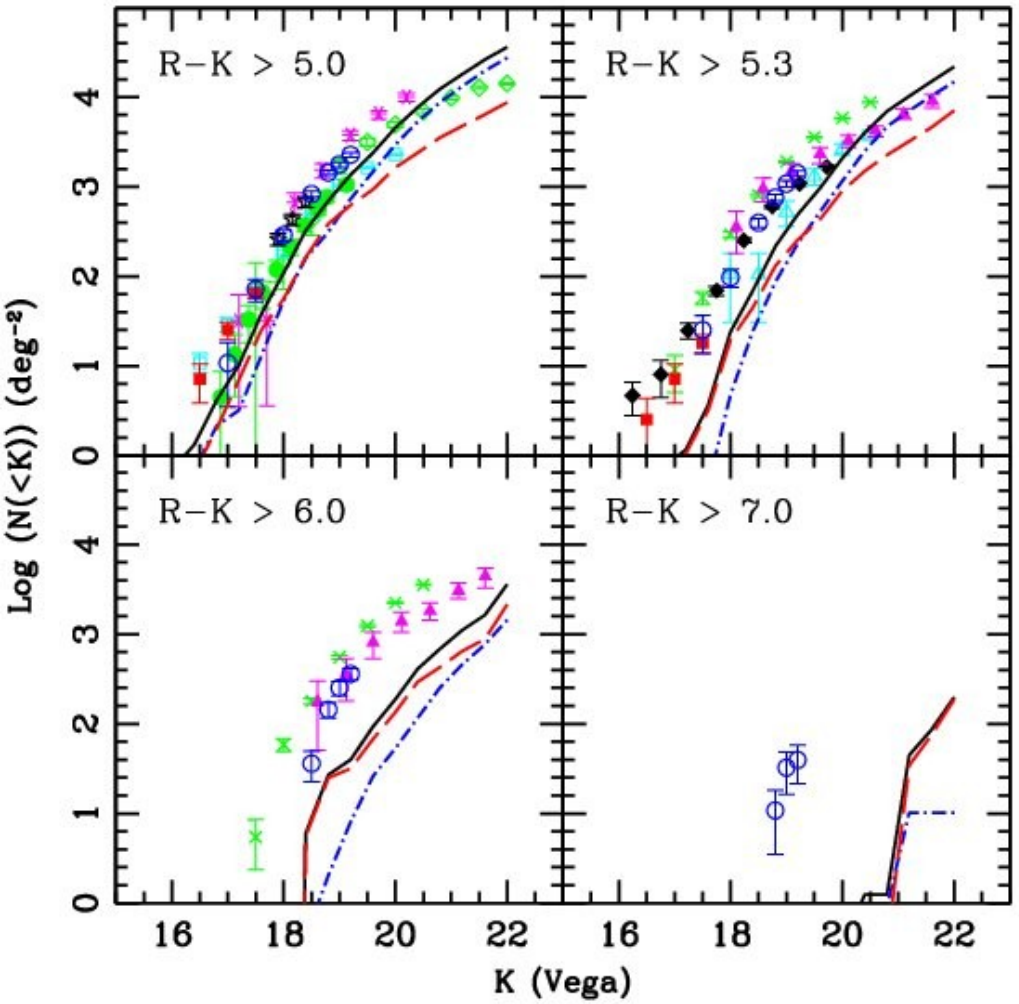


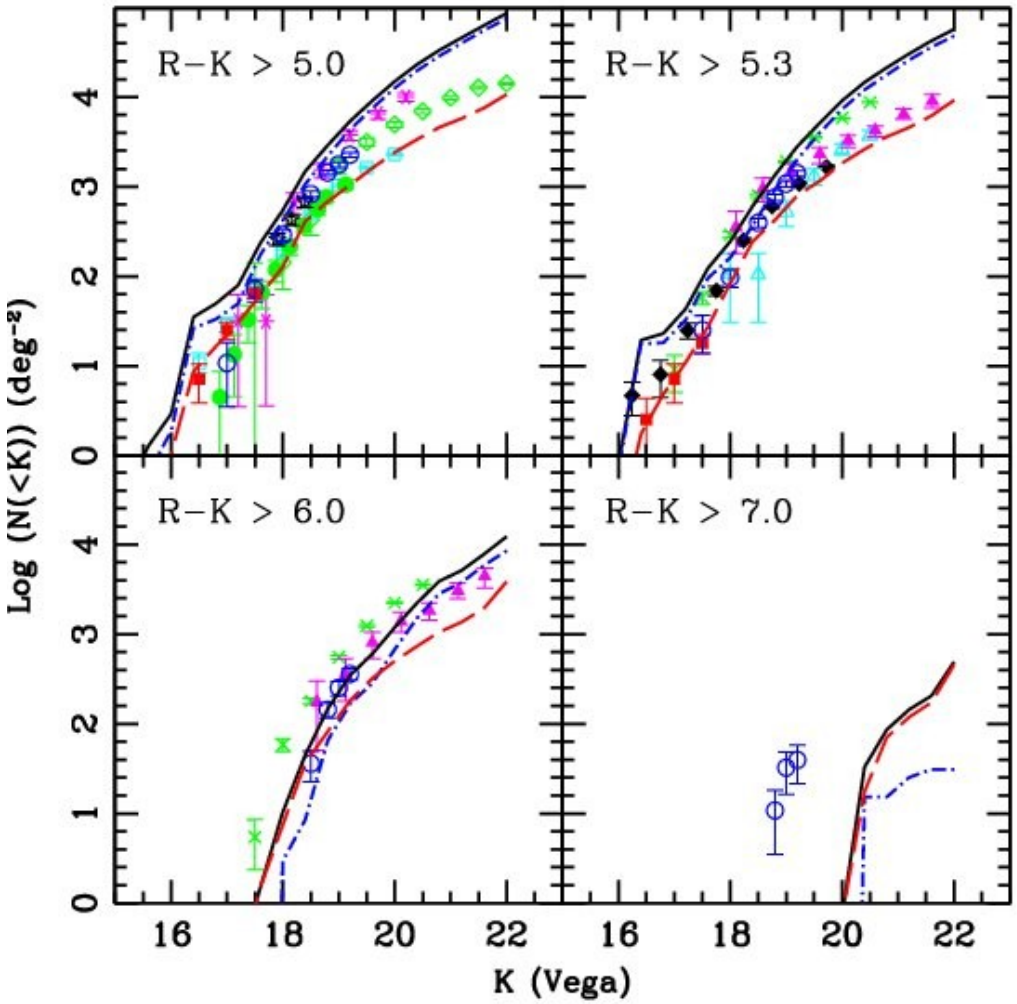
MORGANA+GRASIL
Synthetic Spectra

Fontanot+09a

SSP modeling

EROs number counts **Fontanot&Monaco10**





Bertelli+94 *Padova* SSP **Maraston+05 SSP**

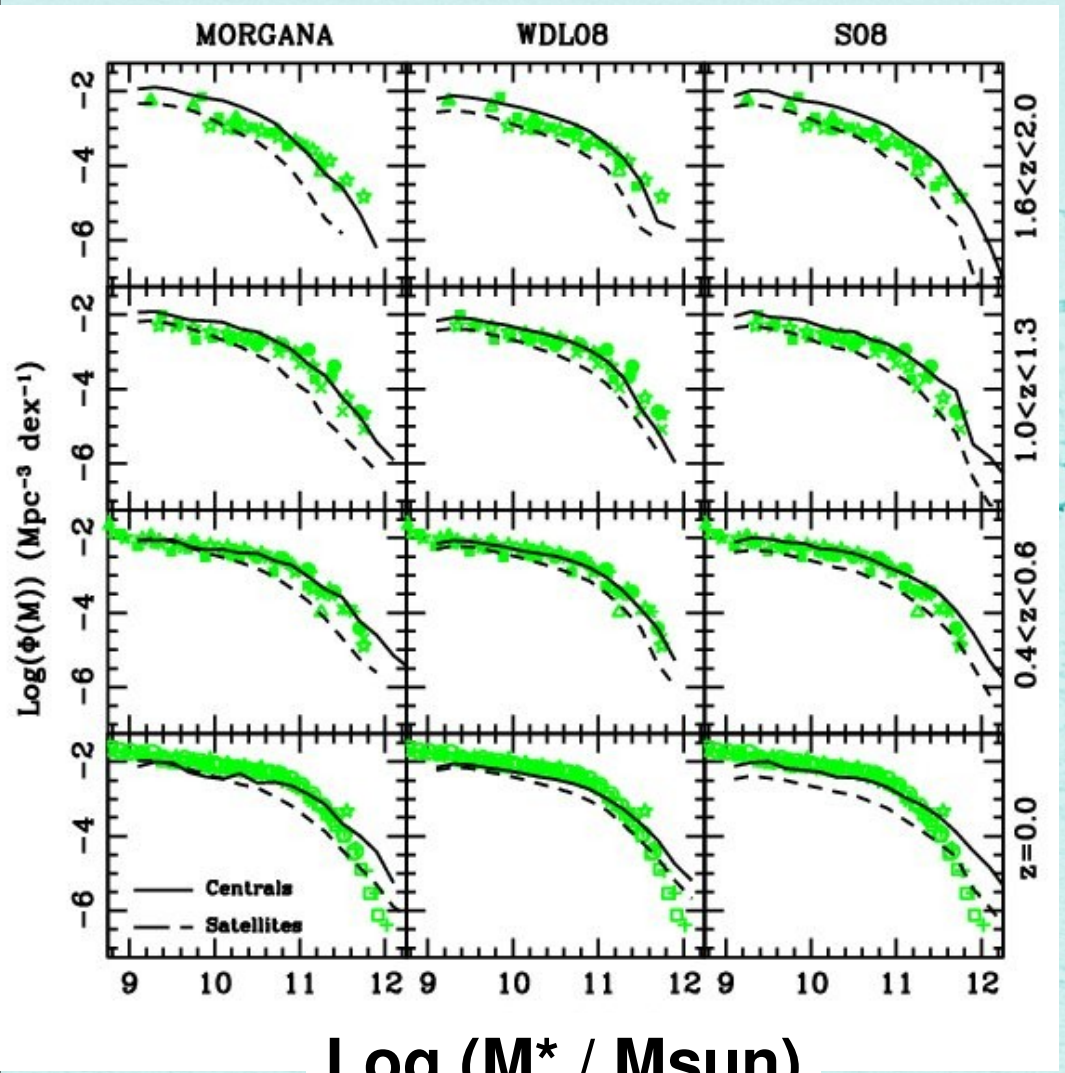
Discussion

Origin of the Excess

- **Characterizing the properties of the galaxy population determining the excess of low-mass galaxies in SAMs**
  - **Hierarchy**
  - **Activity**
  - **Environment**
  - **Cosmic Time**

Origin of the Excess

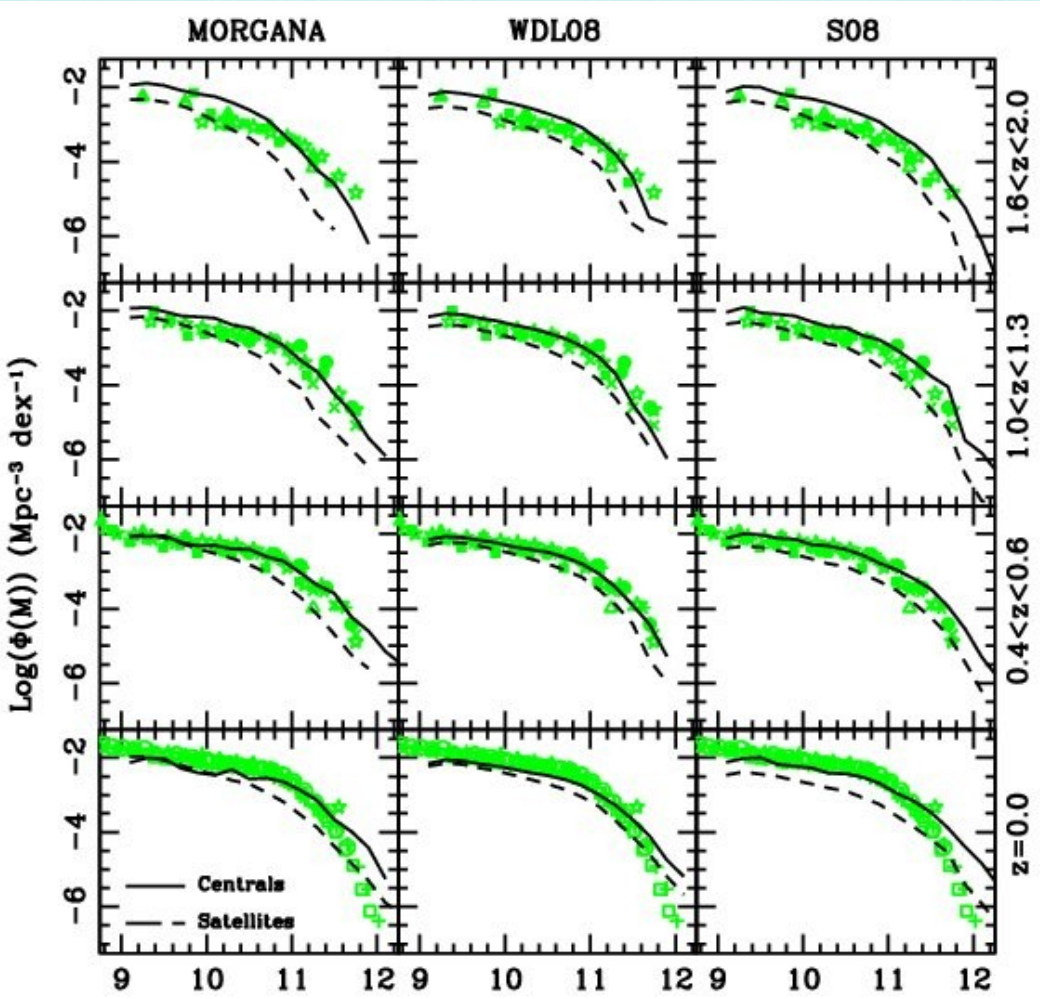
Central/Satellite Hierarchy



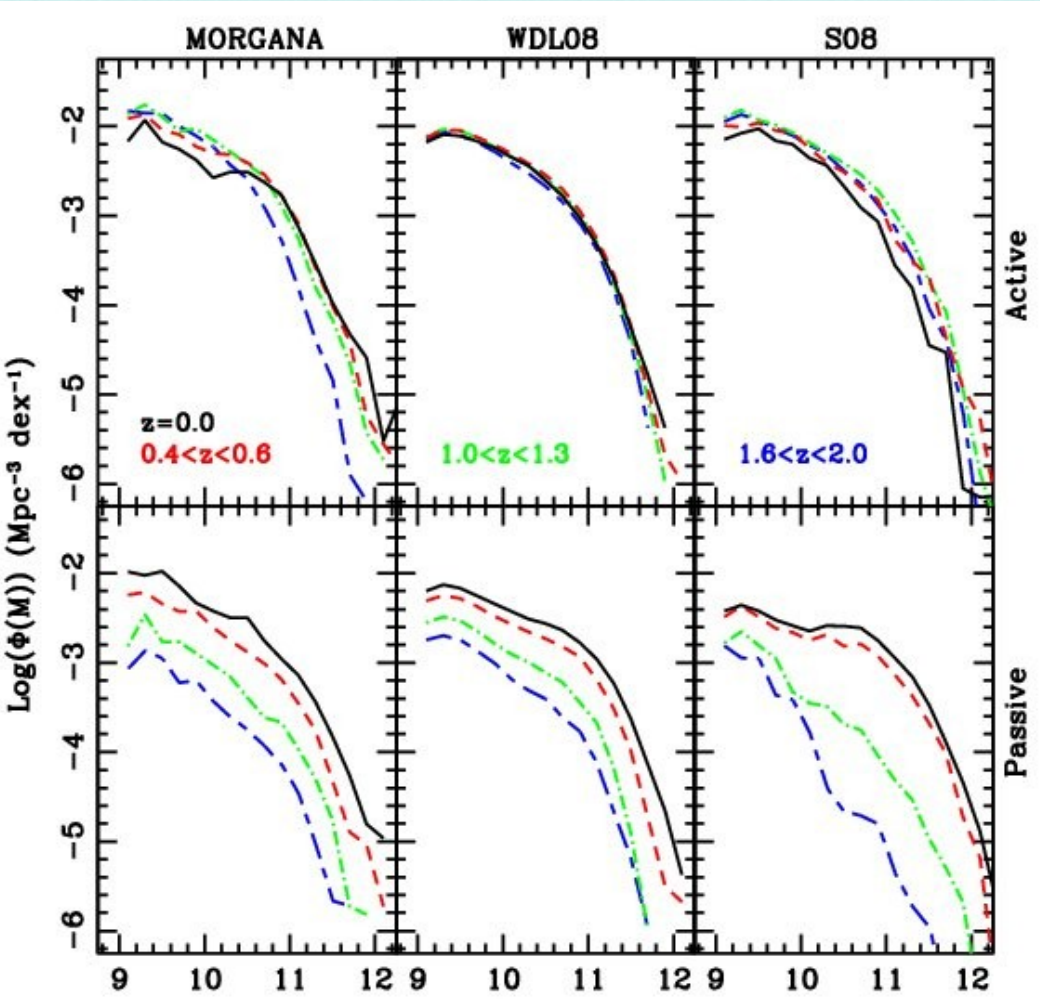
Origin of the Excess

Hierarchy

Activity



Log (M* / Msun)

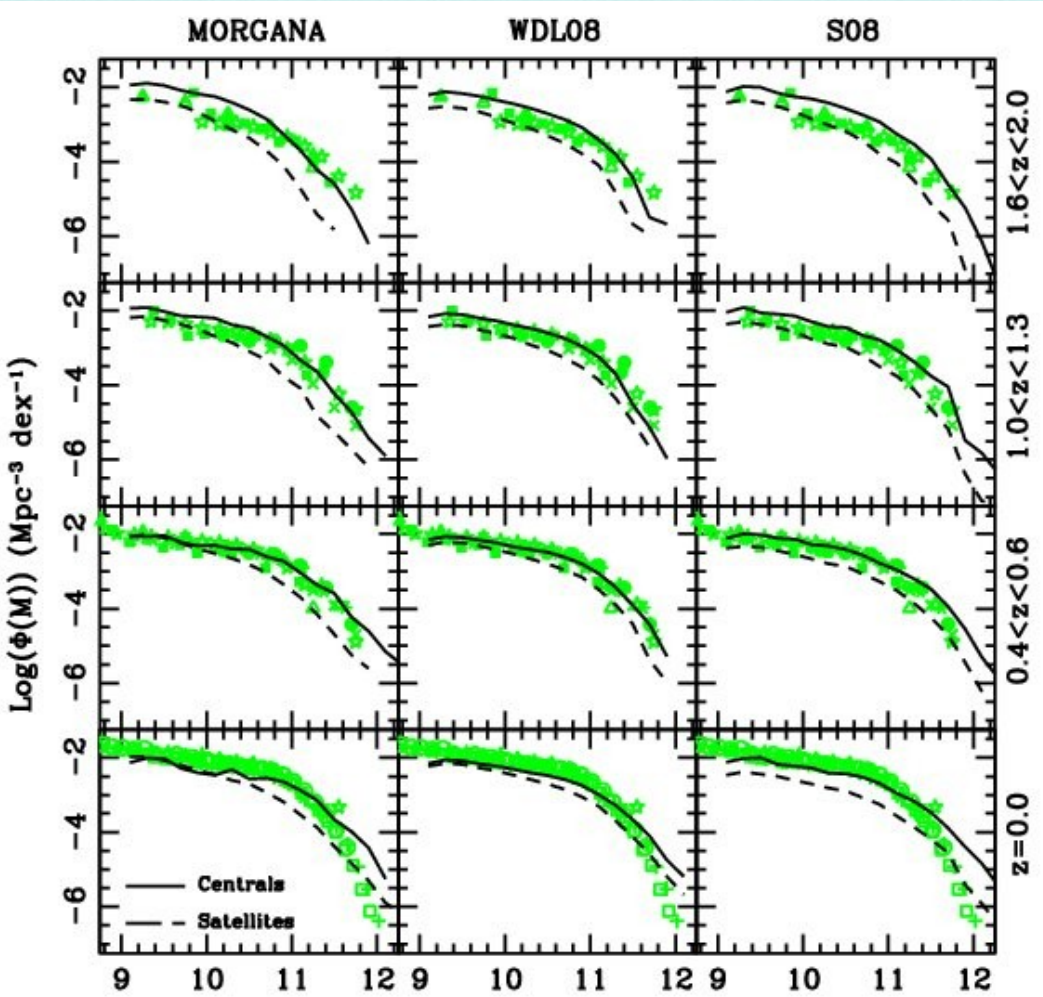


Log (M* / Msun)

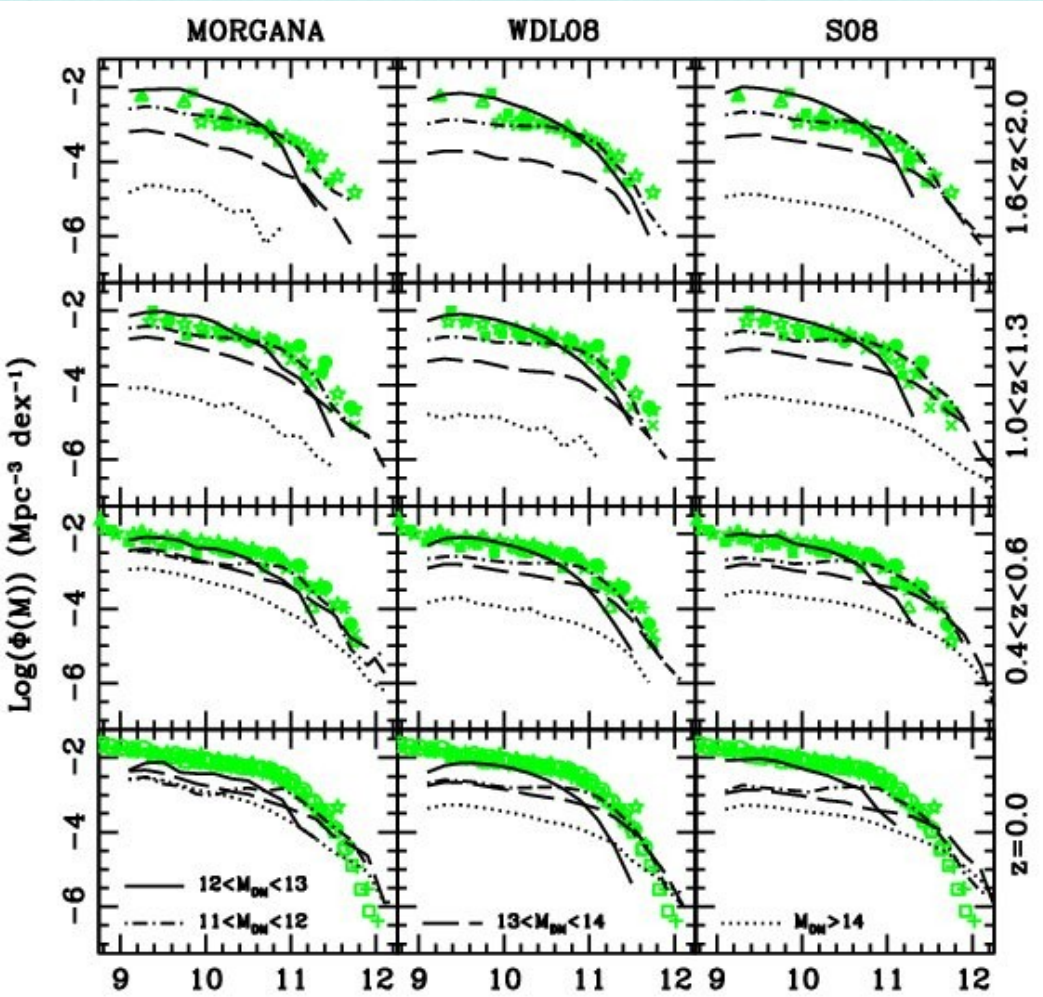
Origin of the Excess

Hierarchy

Environment



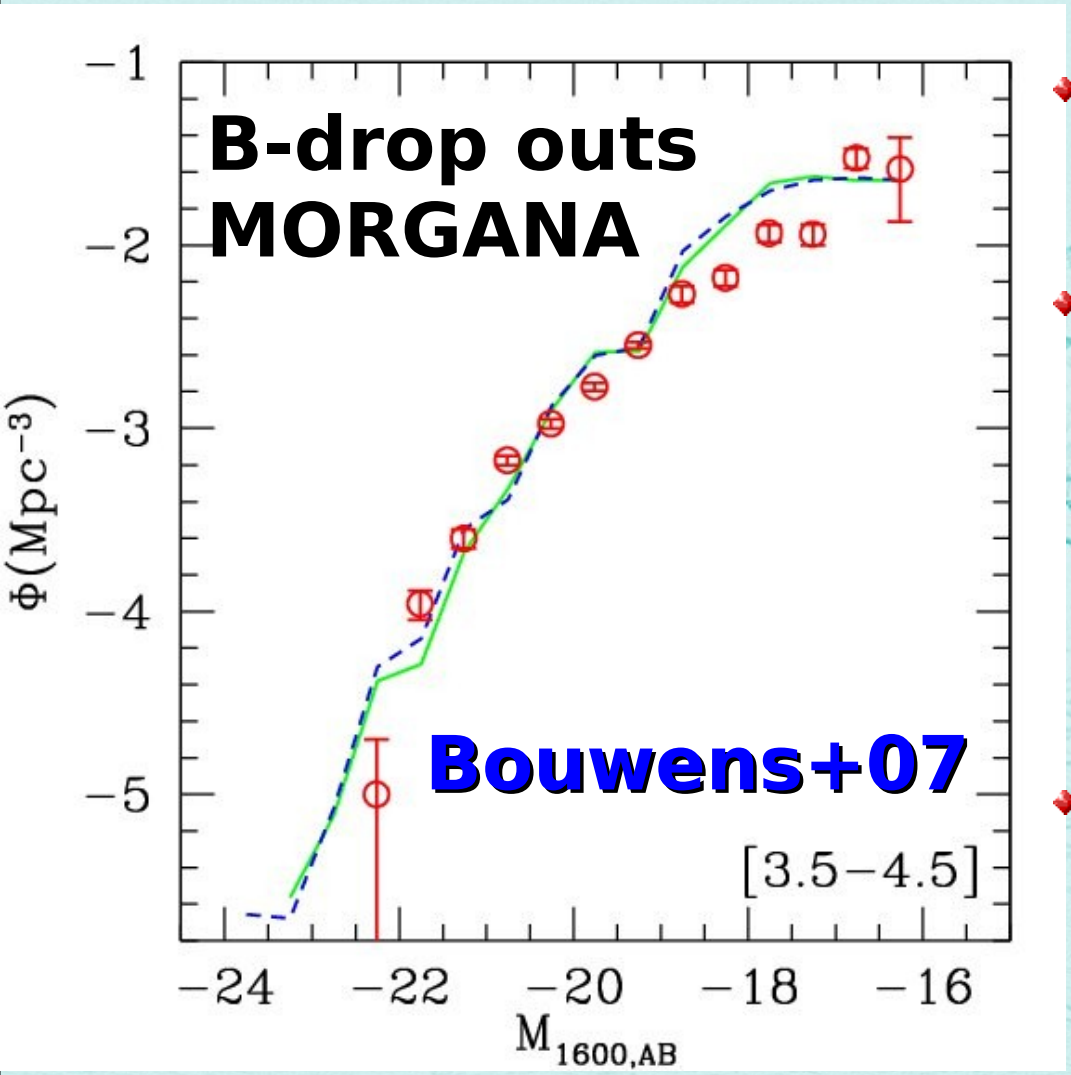
Log (M* / Msun)



Log (M* / Msun)

Origin of the Excess

Cosmic Time



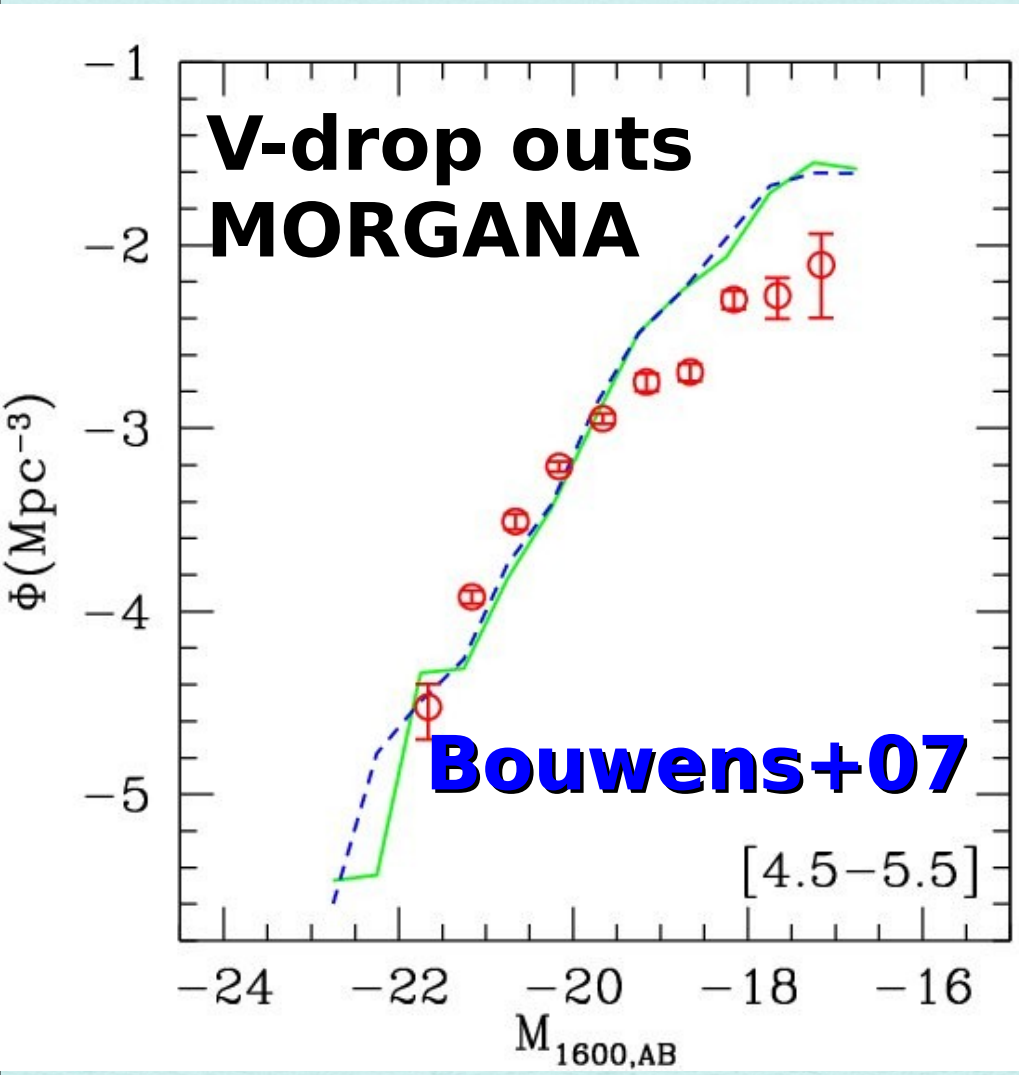
Lo Faro+09

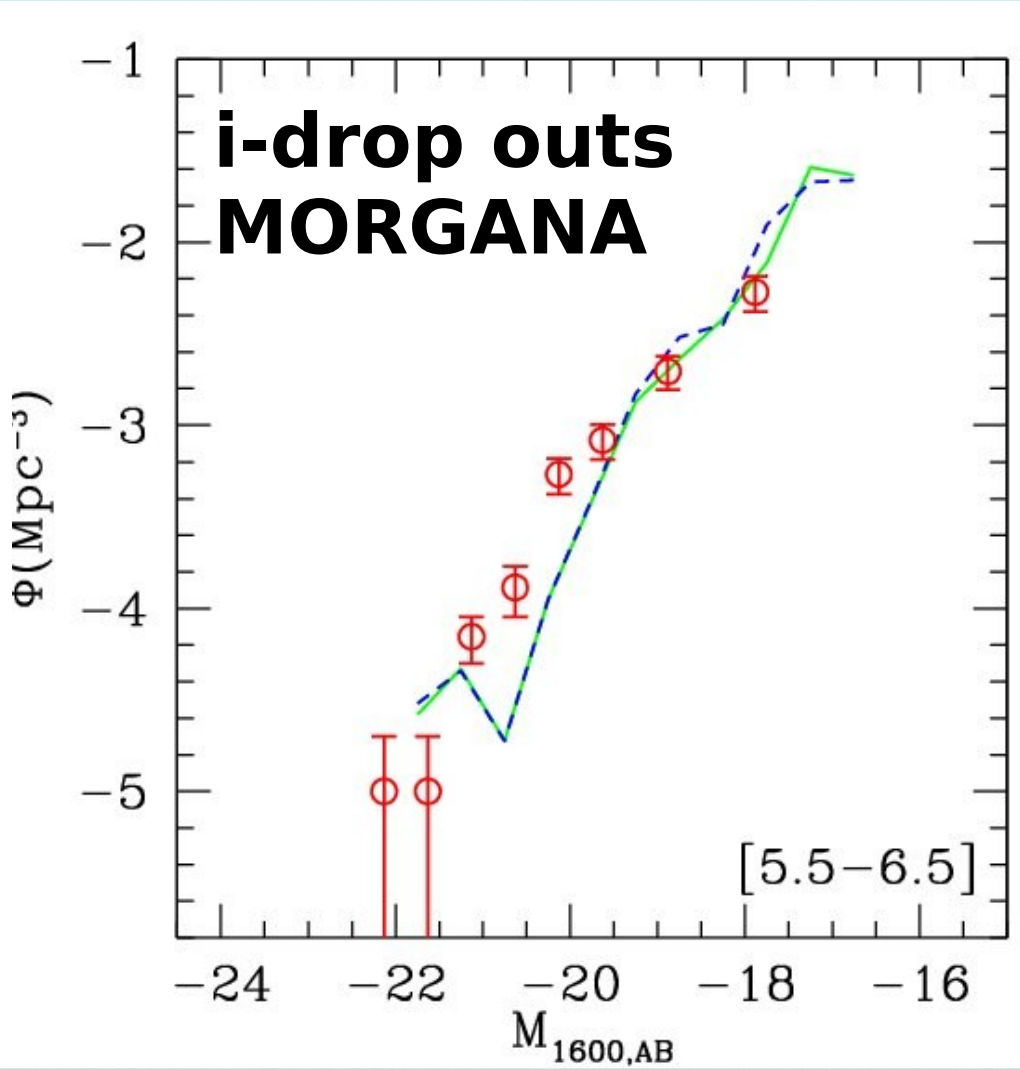
- Same MORGANA realization
- Different dust parameters
  - Higher molecular fraction
  - Faster escape time
- Calibrated to reproduce the bright tail of UV LF

Origin of the Excess

Cosmic Time

Lo Faro+09





Conclusions (3)

- **Central Galaxies hosted in rather massive halos z>2 are responsible for the excess of low-mass objects in SAMs**
  - **High-redshift halos with Vcirc~100-200Km/s**
  - **Physical mechanisms acting on this scale**