Backward Evolutionary models: Stellar Mass and Velocity Functions of Galaxies

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cnrs dépasser les frontières

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Context: Nearby and far far away galaxies

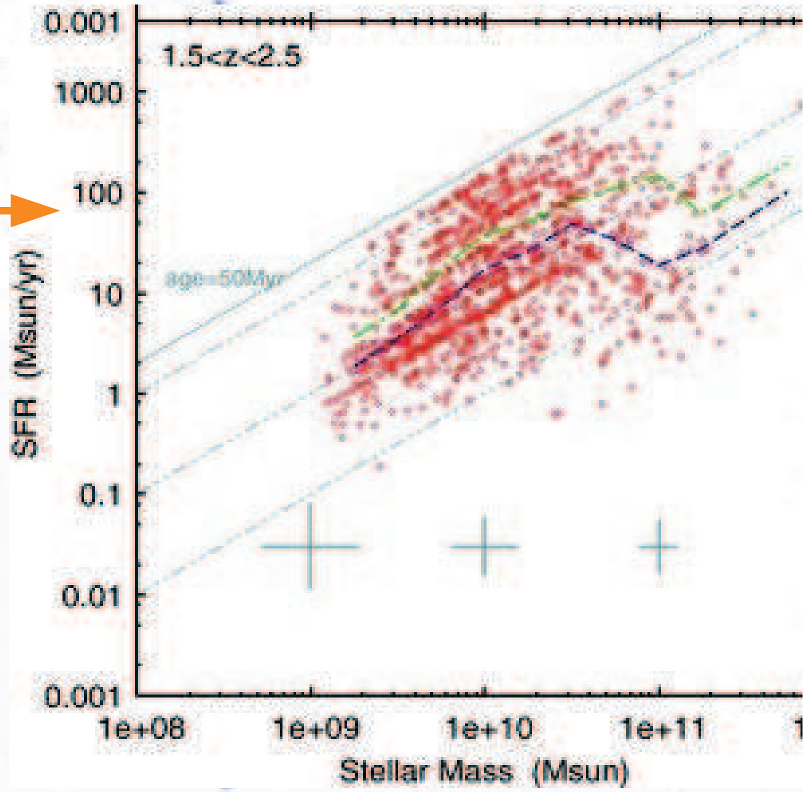
Nearby galaxies:
Fossils of their evolution

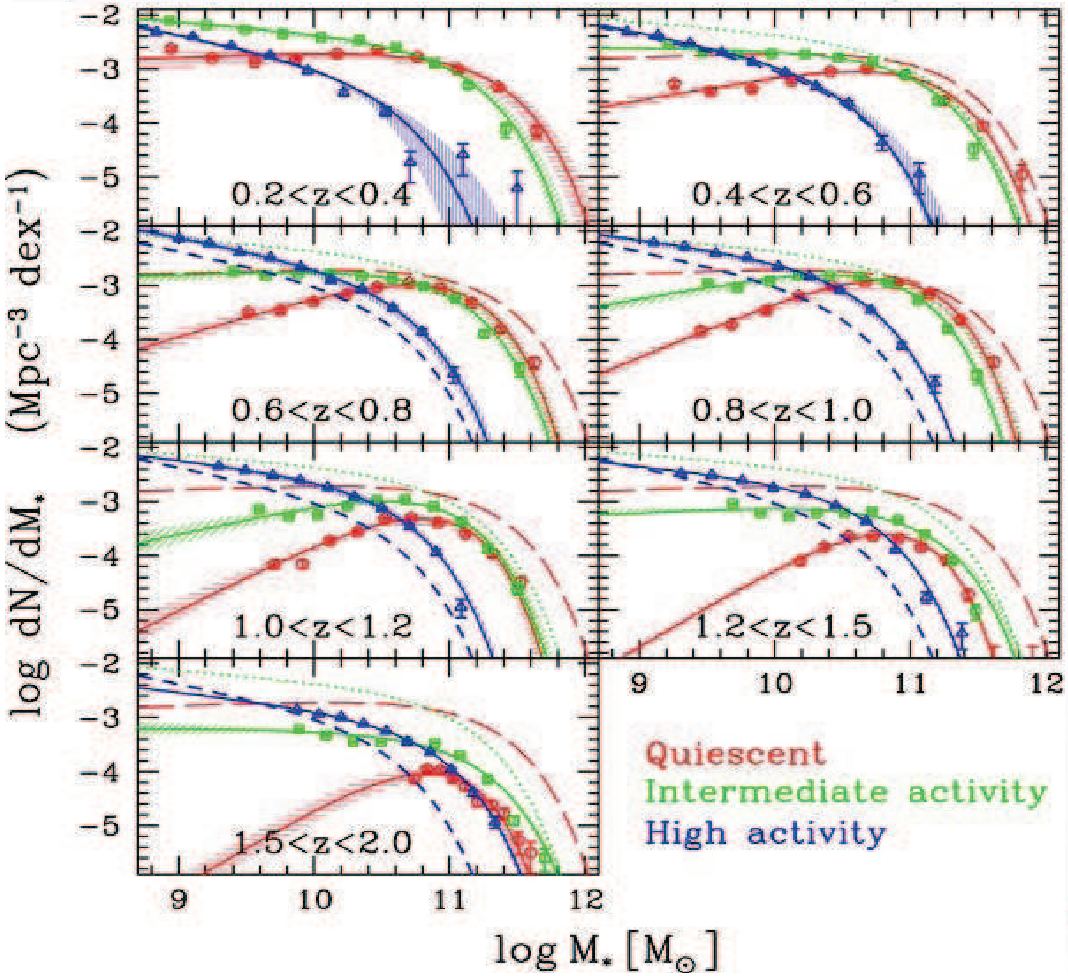
Deep surveys:
Seeing galaxies at various epochs

Backward Models

Context: distant galaxies

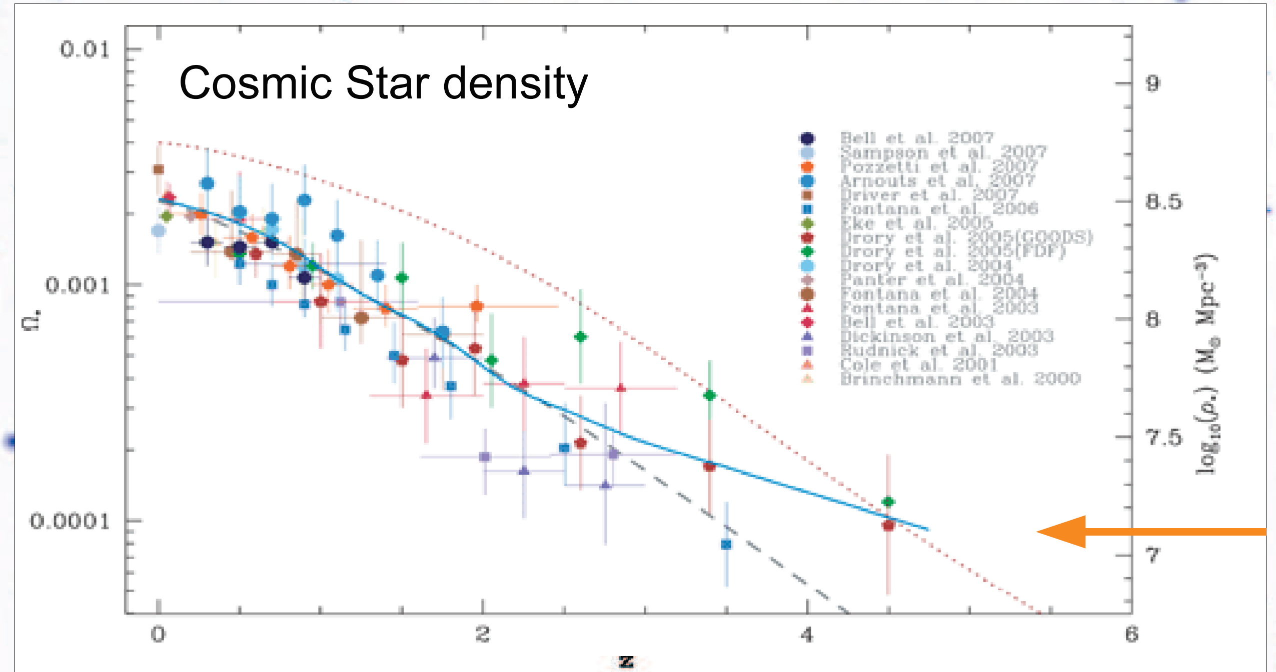
Deep surveys tell us about the "cosmic" evolution of the **Stellar Mass**, the **SFR** (e.g. Kajisawa 2010)...

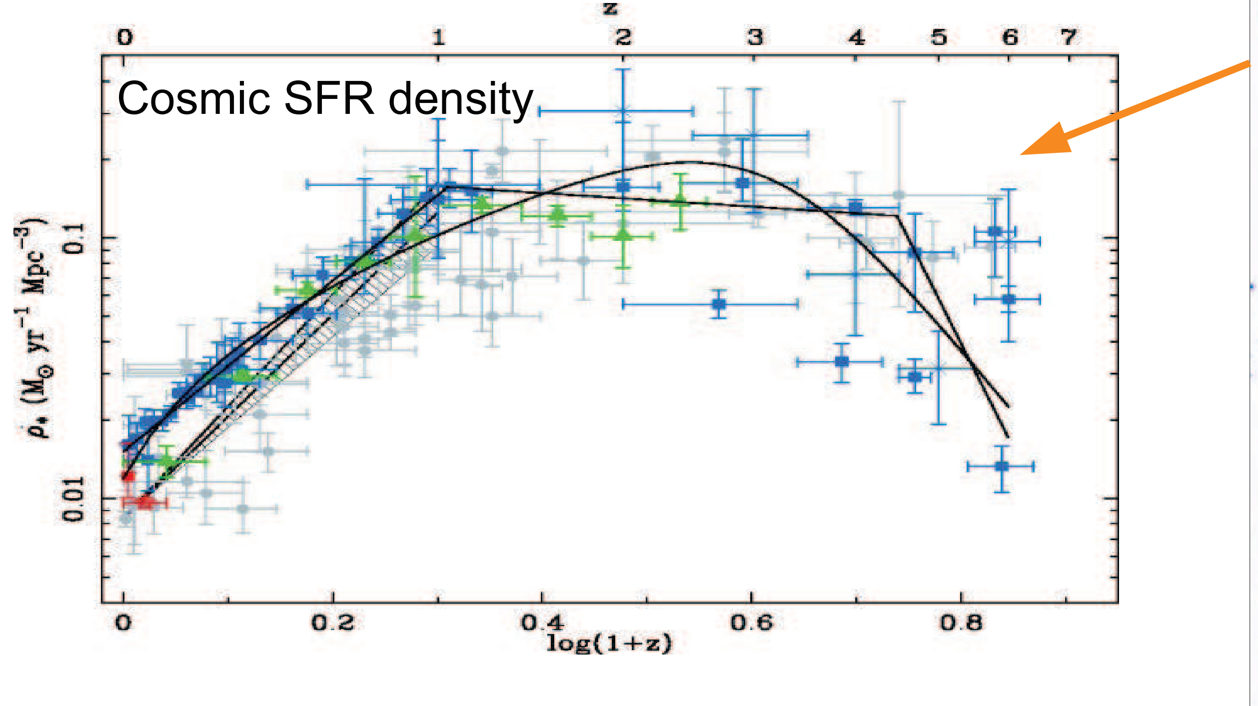




... and their **distributions** (e.g. Mass Functions of Ilbert el al. 2010, by type)

Context: “cosmic” evolution



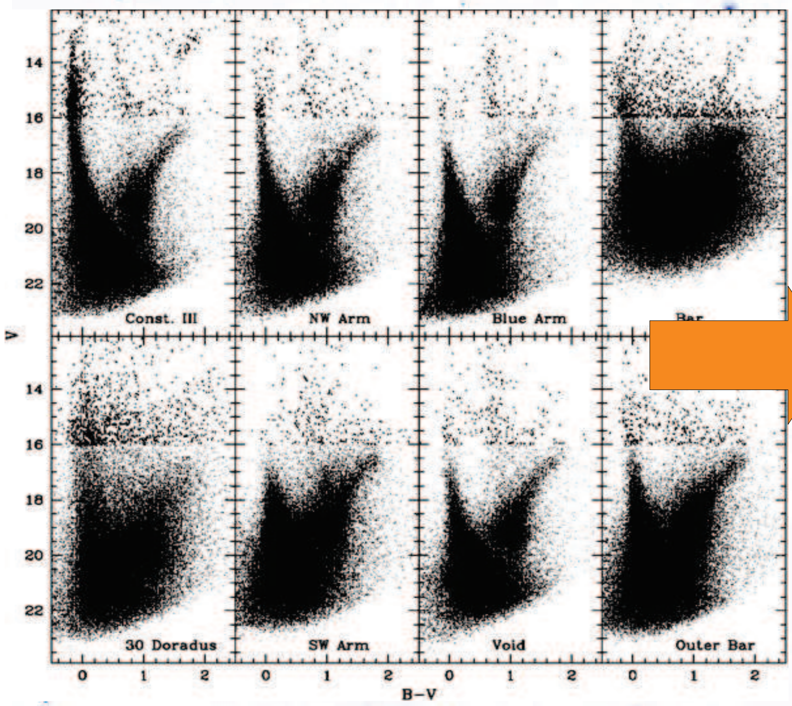


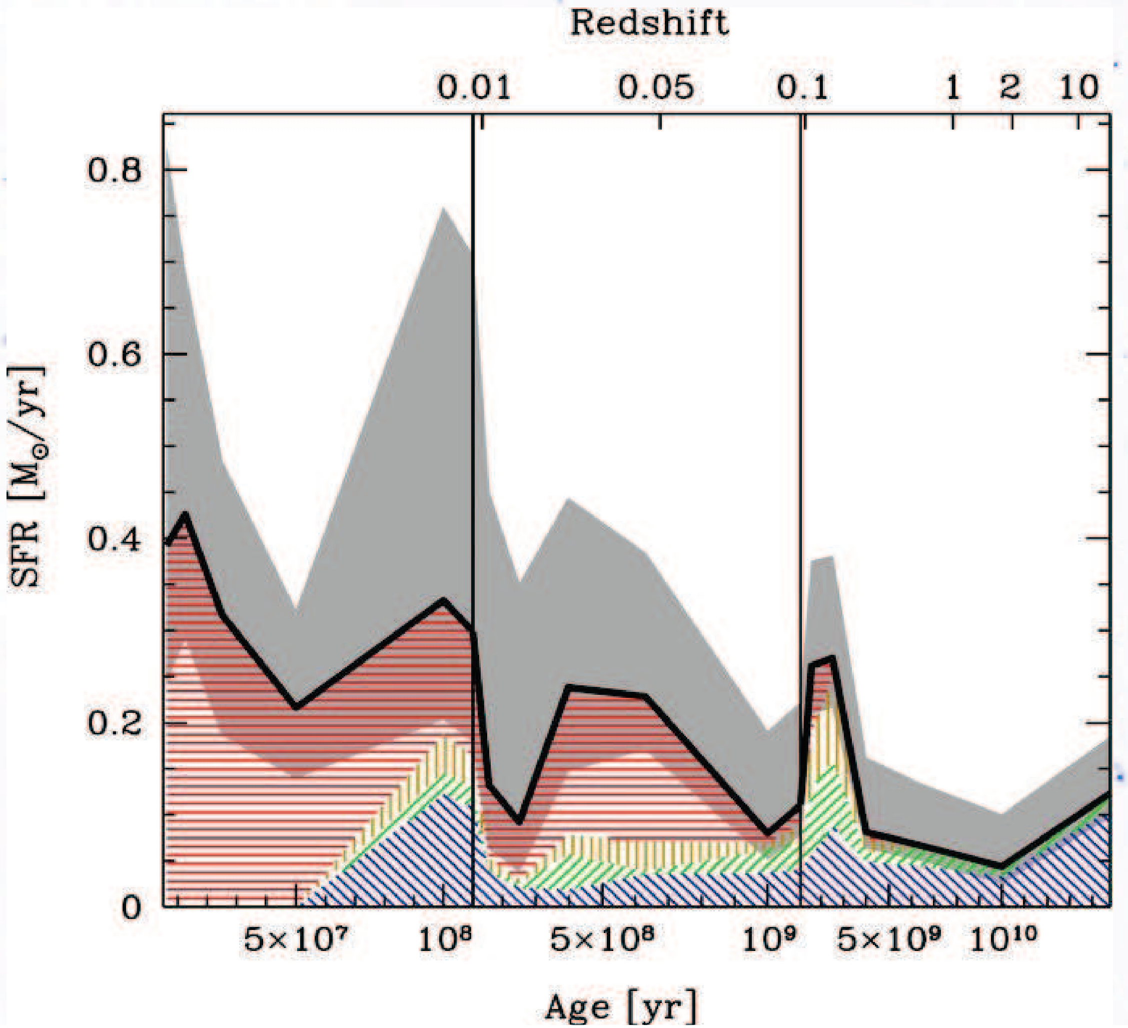
Integrating the SFR and M* Functions, we obtain the “Cosmic” evolution (e.g. Wilkins et al. 2008, Hopkins & Beacom 2006)

Context: History of nearby galaxies

Fossil records in the Milky Way and nearby galaxies

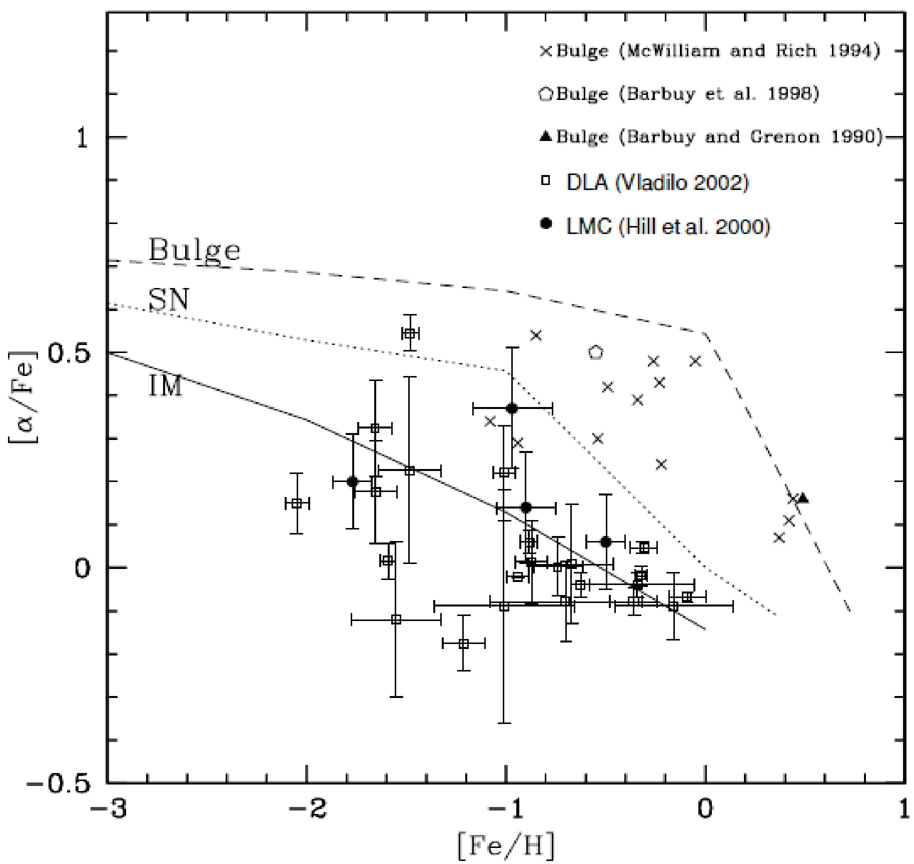
Recovery of Star Formation Histories from CMD diagrams (e.g. LMC by Harris & Zaritsky 2009)



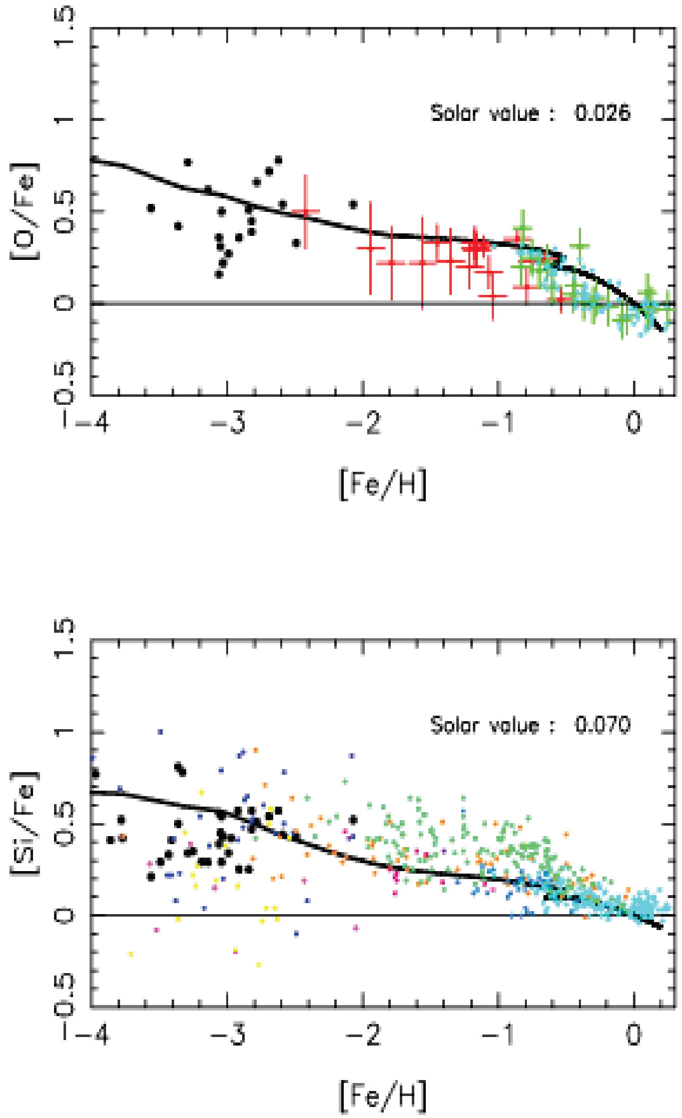


Context: History of nearby galaxies

Fossil records in the Milky Way and nearby spirals: use of “backwards” models to “guess” their SFR History (e.g. Matteucci 2007).

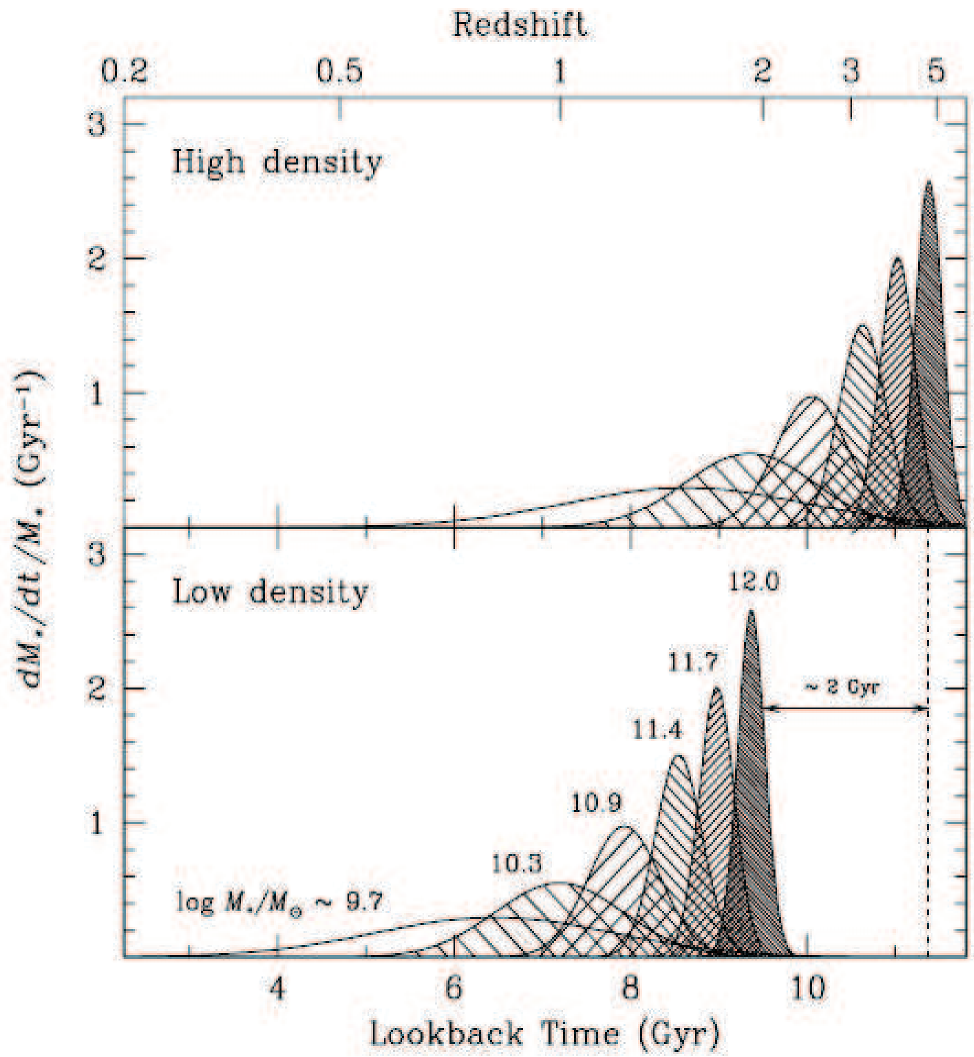


Abundance ratios in the Milky Way (Francois et al. 2004).



Context: History of nearby galaxies

Other example: fossil records in E type galaxies (abs. Lines indices, also linked to variable abundance ratios)



Stars in more massive galaxies “formed” at higher redshift, density effect

(Thomas et al. 2010)

Context: our approach in this context...

Use “backward” models + statistical approach + Data at “high/intermediate” redshift to address some issues:

1) “Typical” histories of star forming-galaxies derived from local constraints :
consistent with the “cosmic” picture ?

2) Number evolution of star forming galaxies:
do some disappear ? When ? What do they become ?

Coming next:

I- MODELS OF DISK-GALAXY EVOLUTION IN THE NEARBY UNIVERSE, AND APPLICATION TO HIGH z (“individualist” approach)

II- FROM MASS TO VELOCITY FUNCTIONS AND APPLICATIONS (statistic approach)

III- ENVIRONMENTAL EFFECTS ON THE EVOLUTION OF GALAXIES

I-A grid of models for star forming galaxies

BASED ON Boissier & Prantzos 2000 + New component

- Scaling relationships

2 parameters : **V, spin**
Mass α **V****3 (~ Tully Fisher)
Scale-length α **spin** x **V**

(e.g. Mo Mao and White 98)

- A universal SFR LAW
(Boissier et al. 2003 : observed in nearby spirals)

- Accretion History

  - The more massive, the earlier (downsizing)
  - The denser, the earlier (inside out formation)

- Note on the IMF :
Kroupa et al. 1993 -> Kroupa 2001 "universal IMF"

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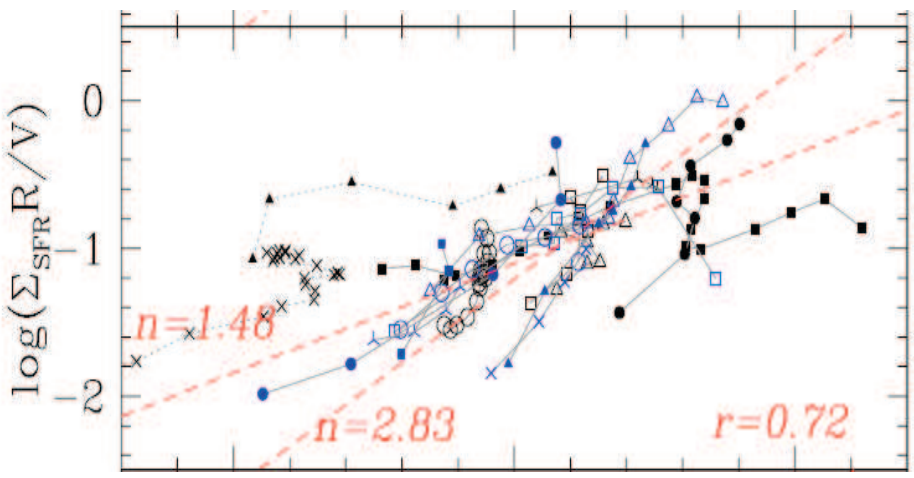
SFR= a GAS**1.48 V(R) / R



GAS

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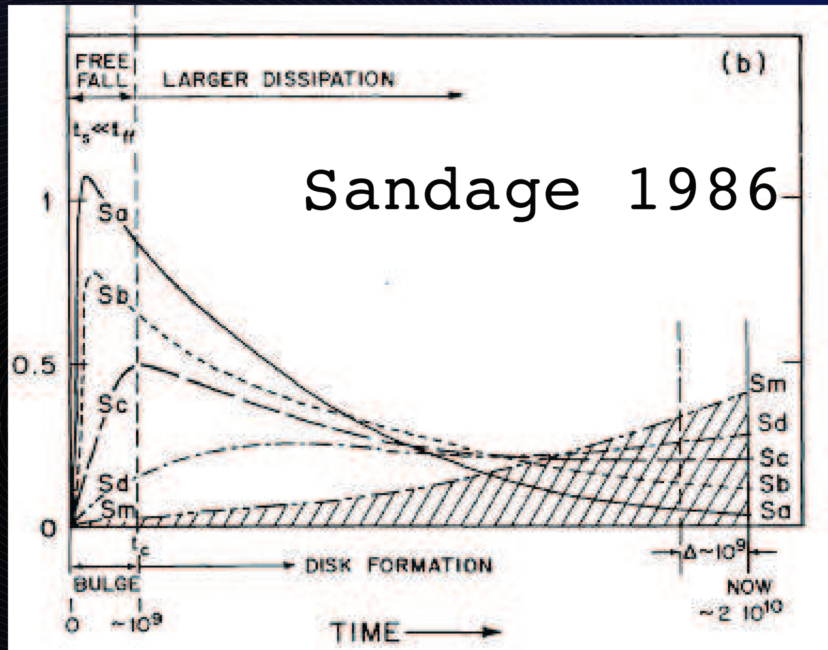

-> a "downsizing" trend

- Note on the IMF :
Kroupa et al. 1993 -> Kroupa 2001 "universal IMF"

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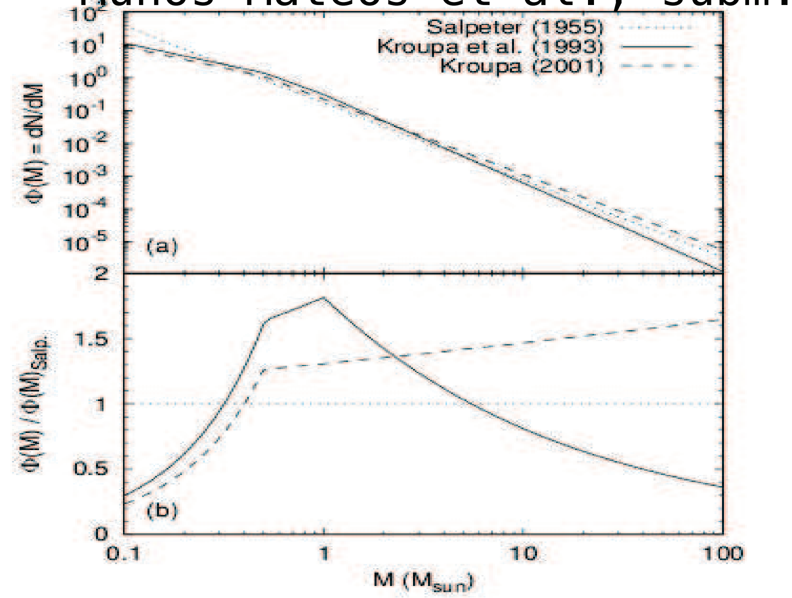
Muños Mateos et al., subm.



The IMF affects the full grid, however switching from KTG93 to K01 leaves most of the evolution changed by less than 20% (except UV emission and metals)

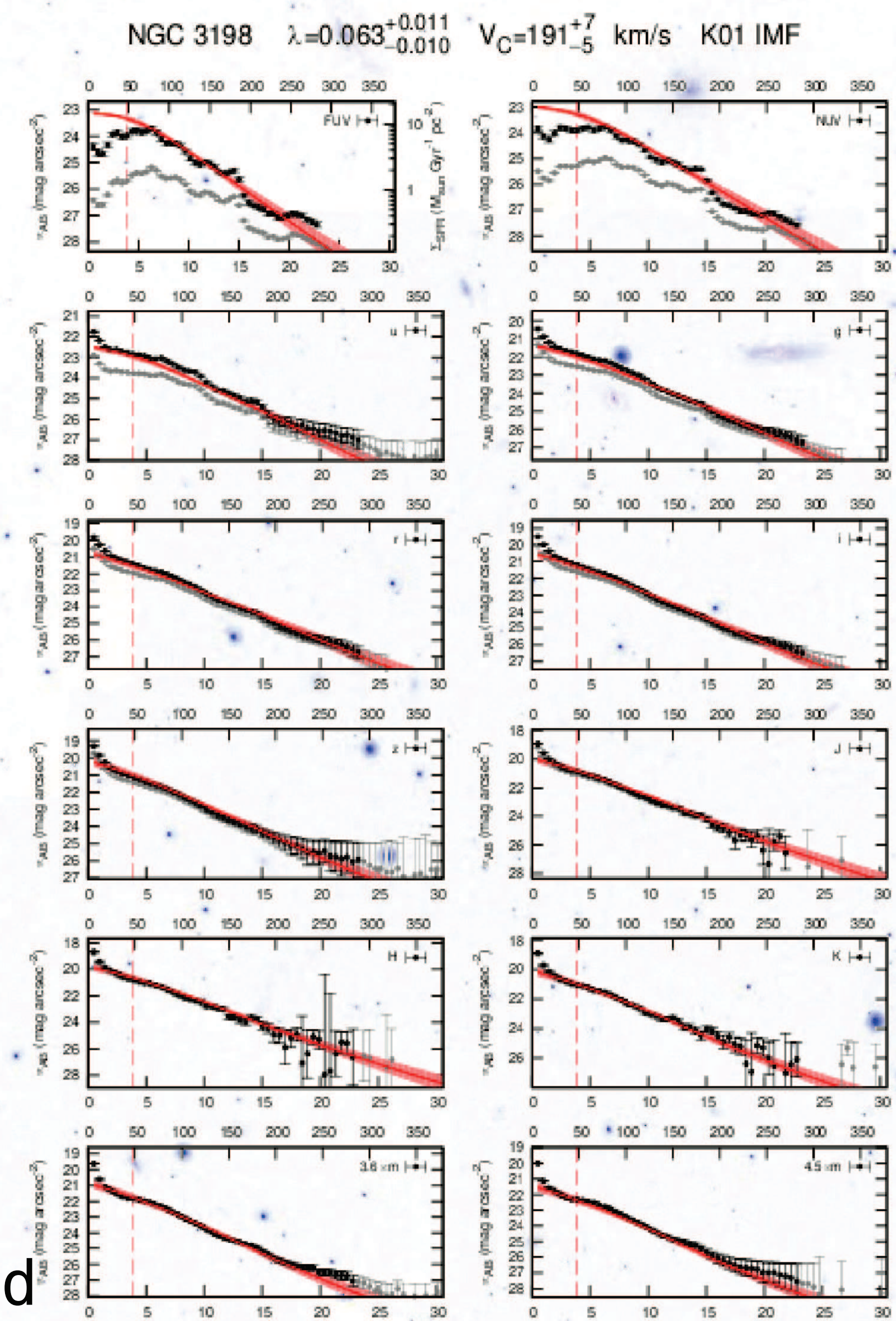
-> Kroupa 2001 "universal IMF"

I-The Grid of Models vs the SINGS sample

(spin, V)= one unique model (SFR History, profiles,...)

Comparison with observations:

- calibration in "old" papers
- recently checked with SINGS galaxies: Thesis of Juan Carlos Muños Mateos.



Muños Mateos et al., submitted

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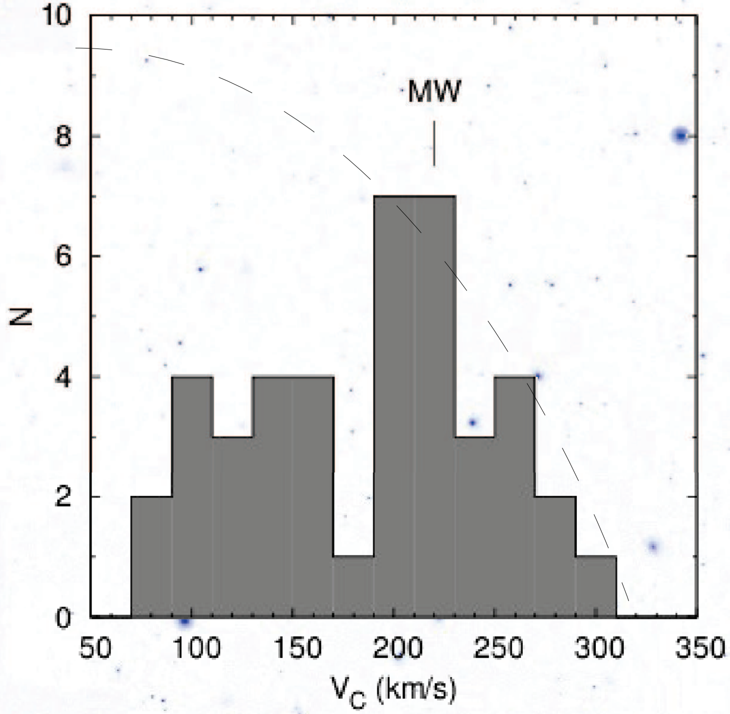
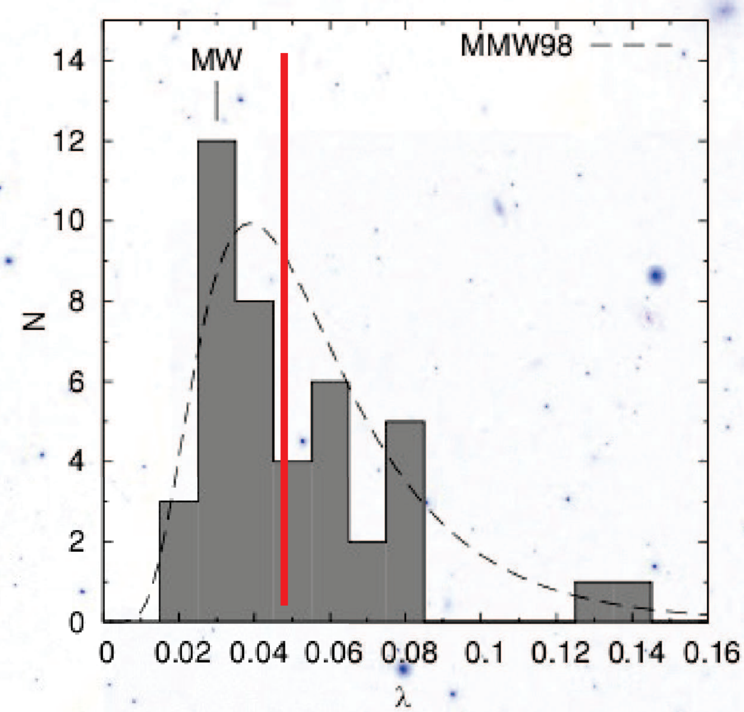




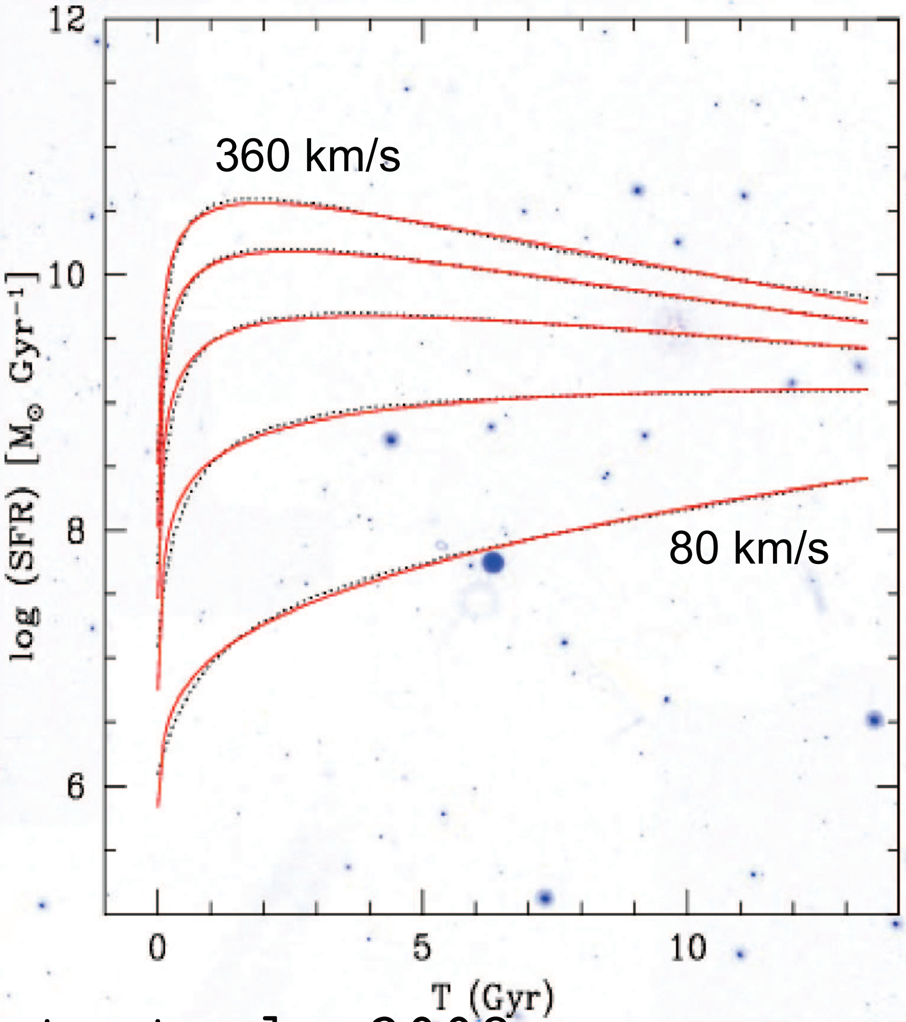
Velocity distribution: not representative but covers the range from ~ dwarfs to big spirals

Spin distribution: representative. Only a typical value adopted in what follows

Muños Mateos et al., submitted

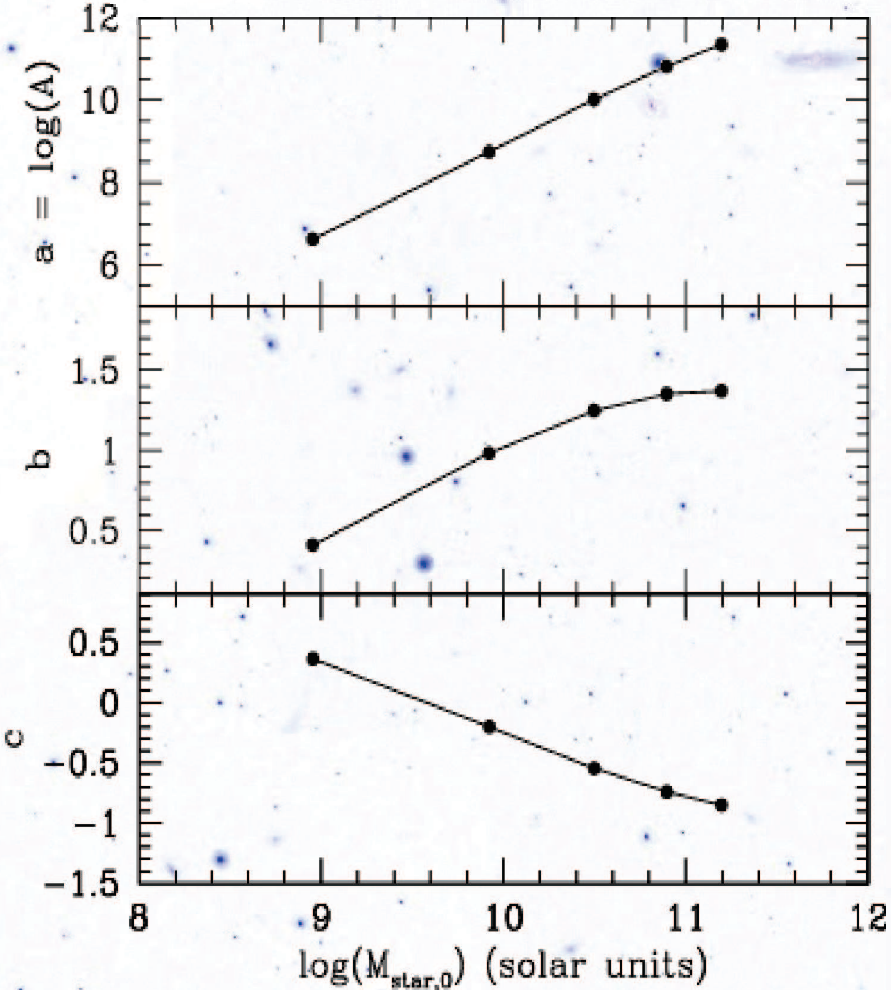
I-The Grid of Models vs the high z galaxies

SFR Histories for typical spin for various Velocity



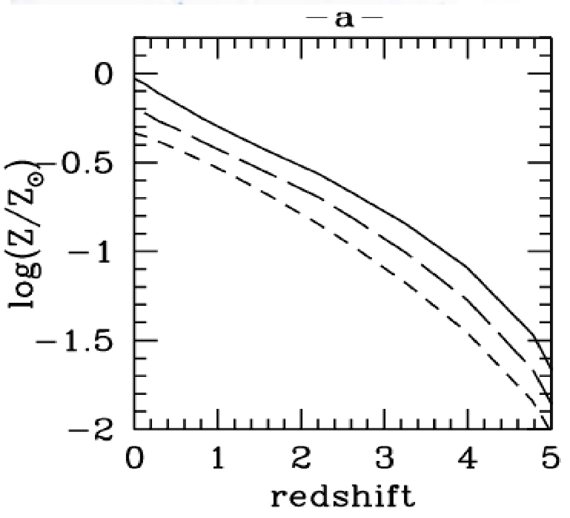
SFR History Fit:

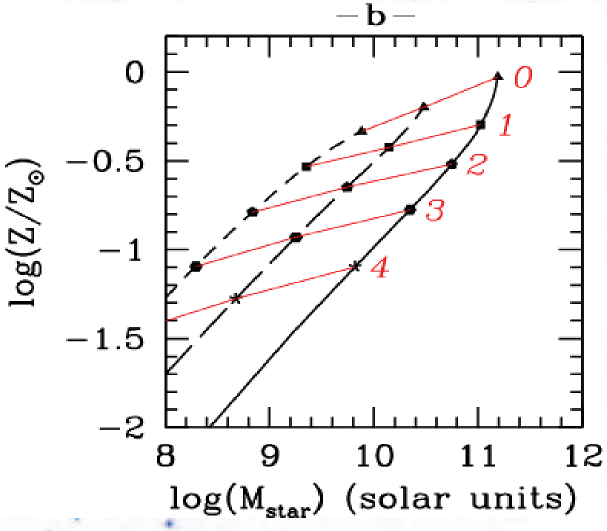
$$SFR(t) = At^b \exp(-(t/\tau)^{0.5}) \text{ or}$$
$$\log(SFR(t)) = a + b\,\log(t) + c\,t^{0.5}$$
$$\text{with } a = \log A \quad c = -0.43\tau^{-0.5}.$$

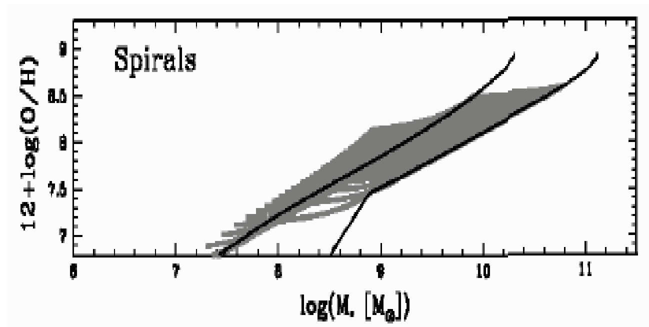


Buat et al. 2008

I-The Grid of Models vs the high z galaxies



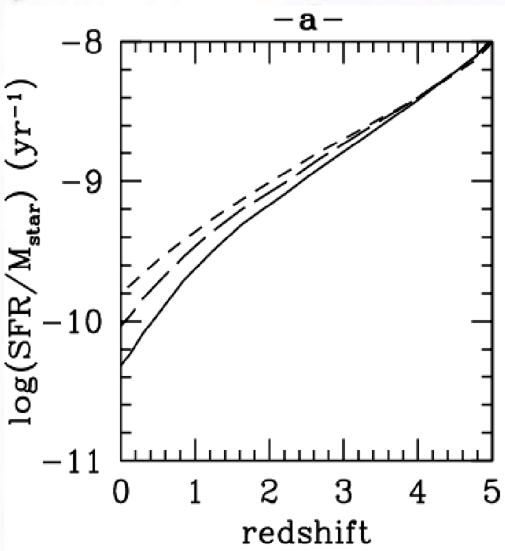


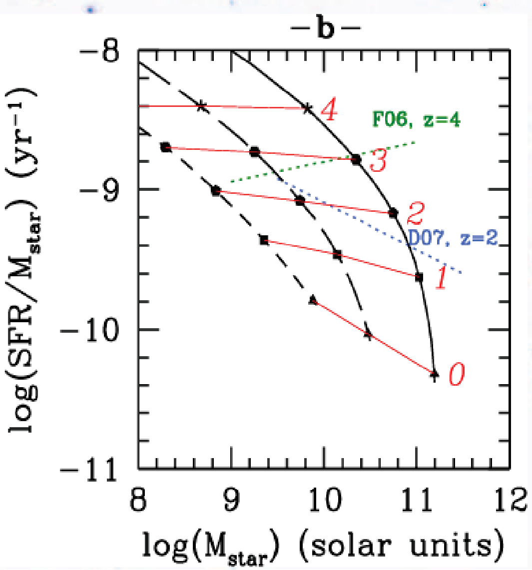


See also e.g.
Calura et al. 2009

Evolution of the Mass-Metallicity relationship

Evolution of the Mass-Specific Star Formation Rate relationship

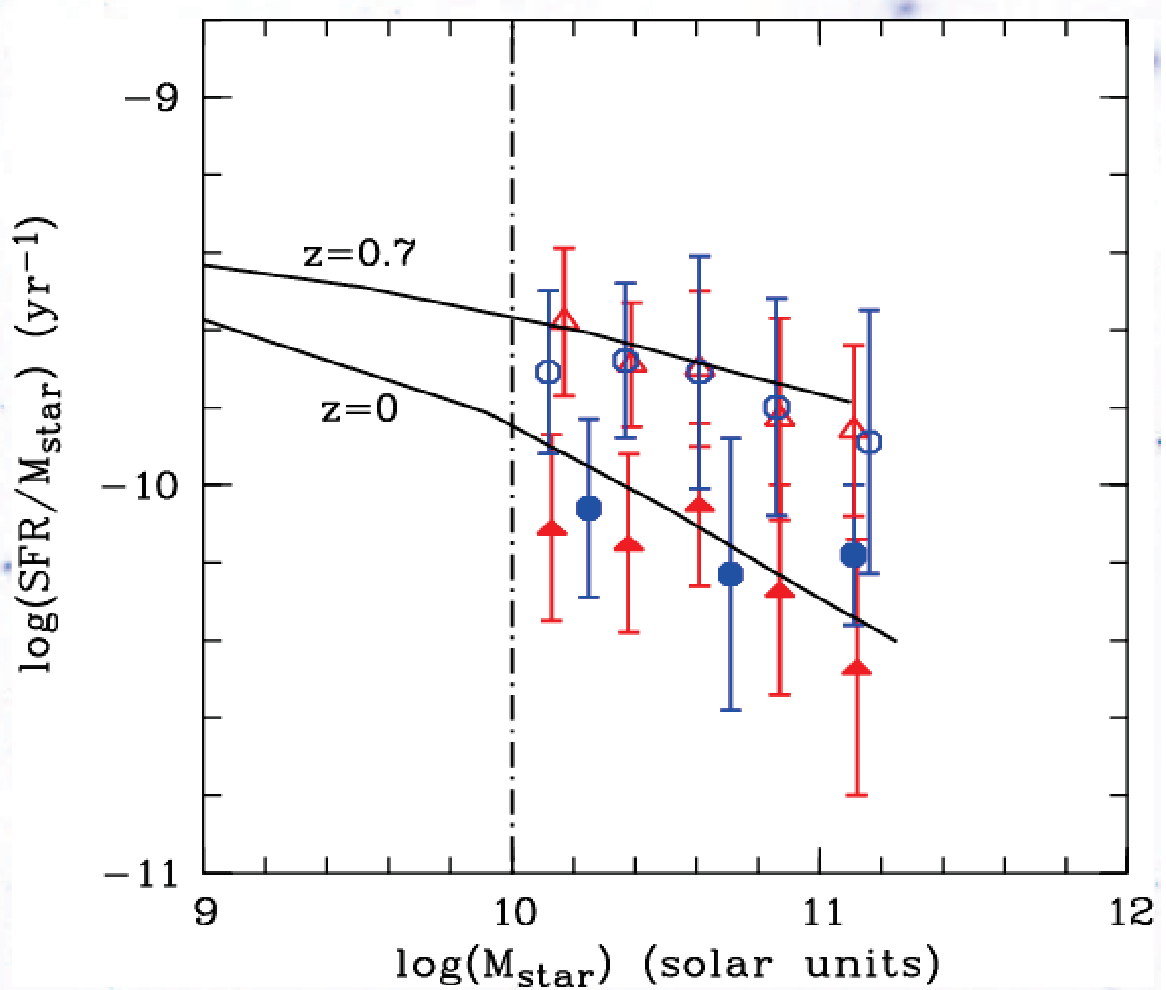




I-The Grid of Models vs the high z galaxies

IR-selected and
UV-selected samples
at z=0 and z=0.7

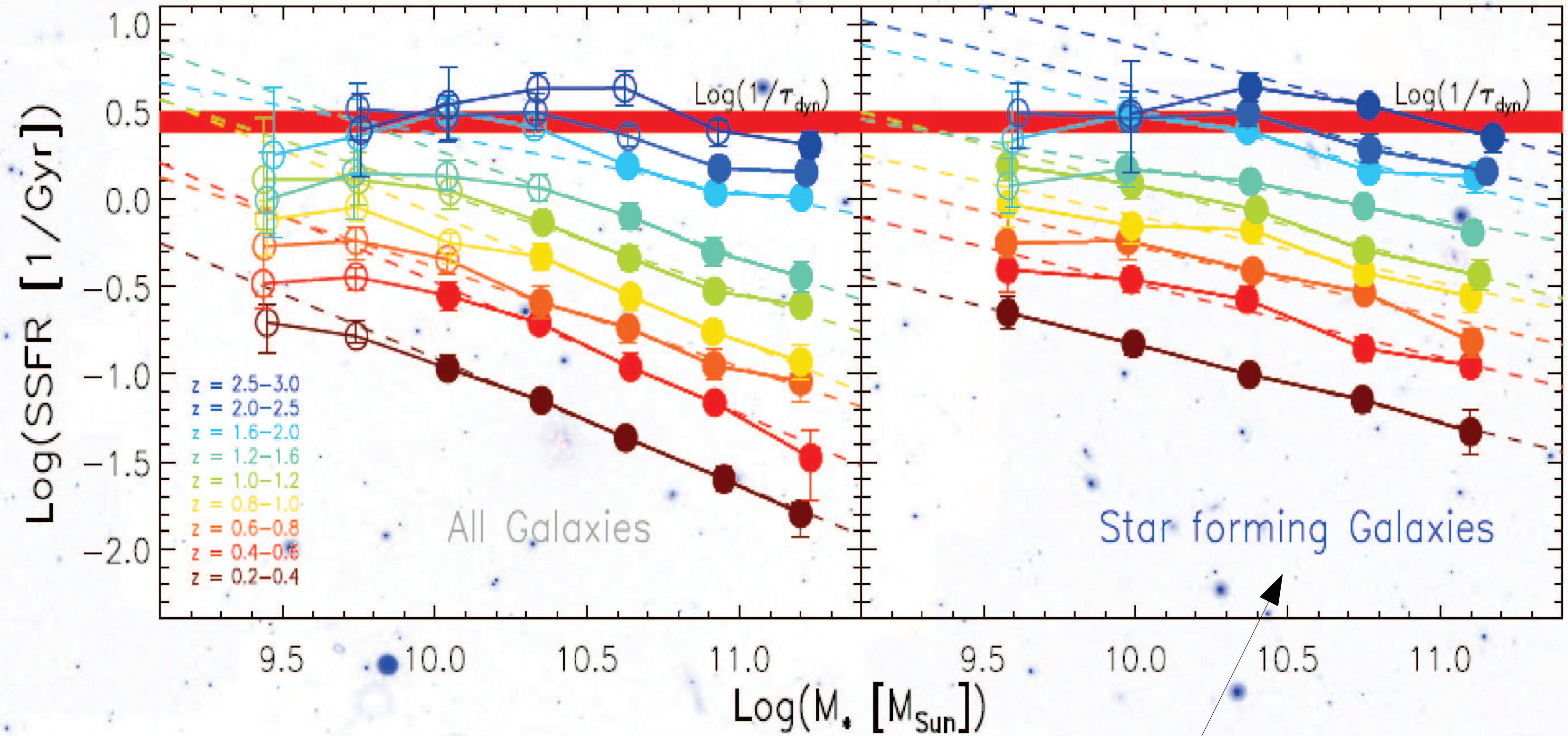
Evolution of the
Specific Star
Formation Rate
(SSFR) vs M*
relationship.



Buat et al. 2008

I-The Grid of Models vs the high z galaxies

Karim et al. 2011



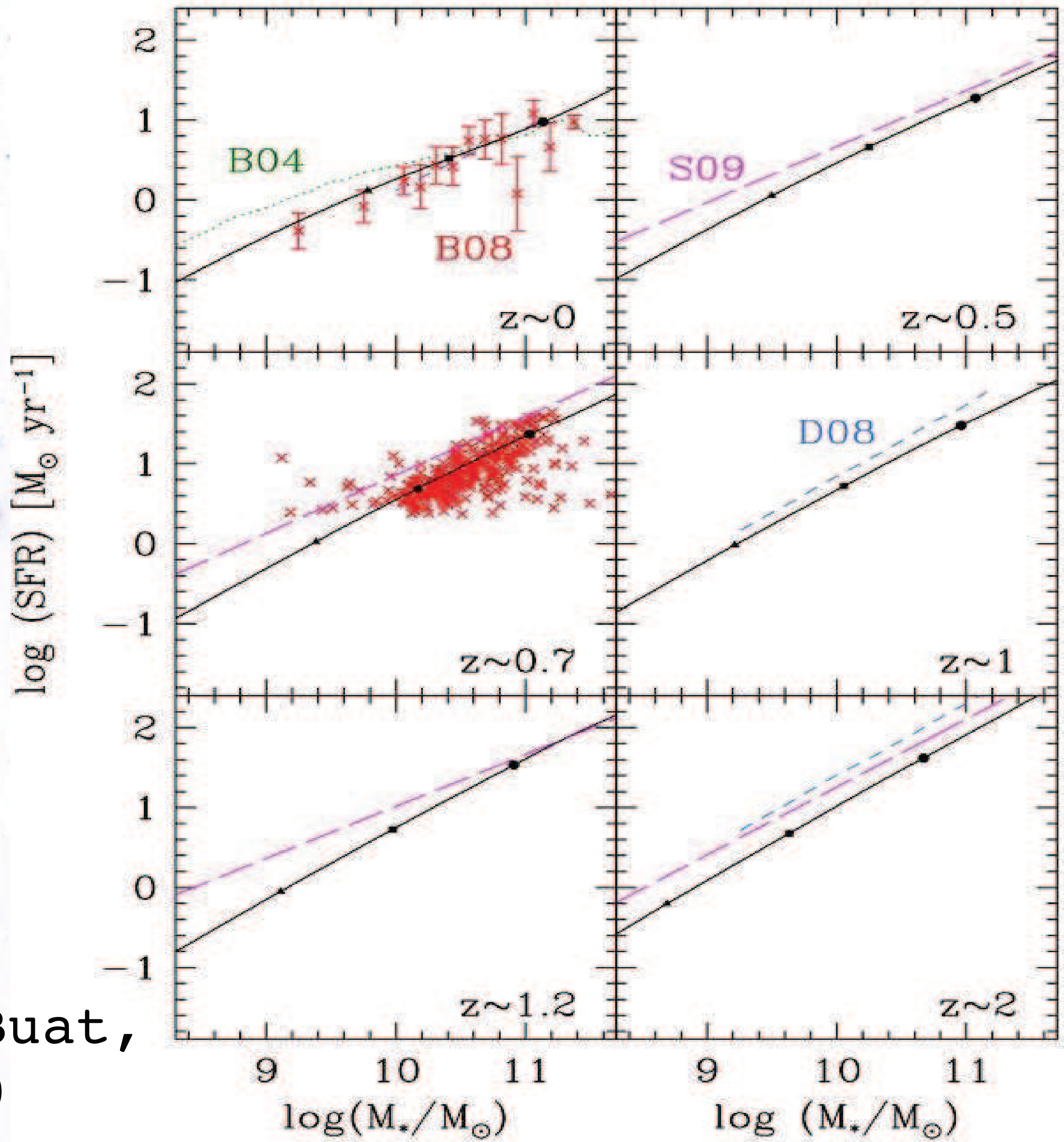
Trend confirmed in other studies

(3.6 microns selection. Star forming based on color)

I-The Grid of Models vs the high z galaxies

Evolution of the SFR-M* relationship up to redshift 2

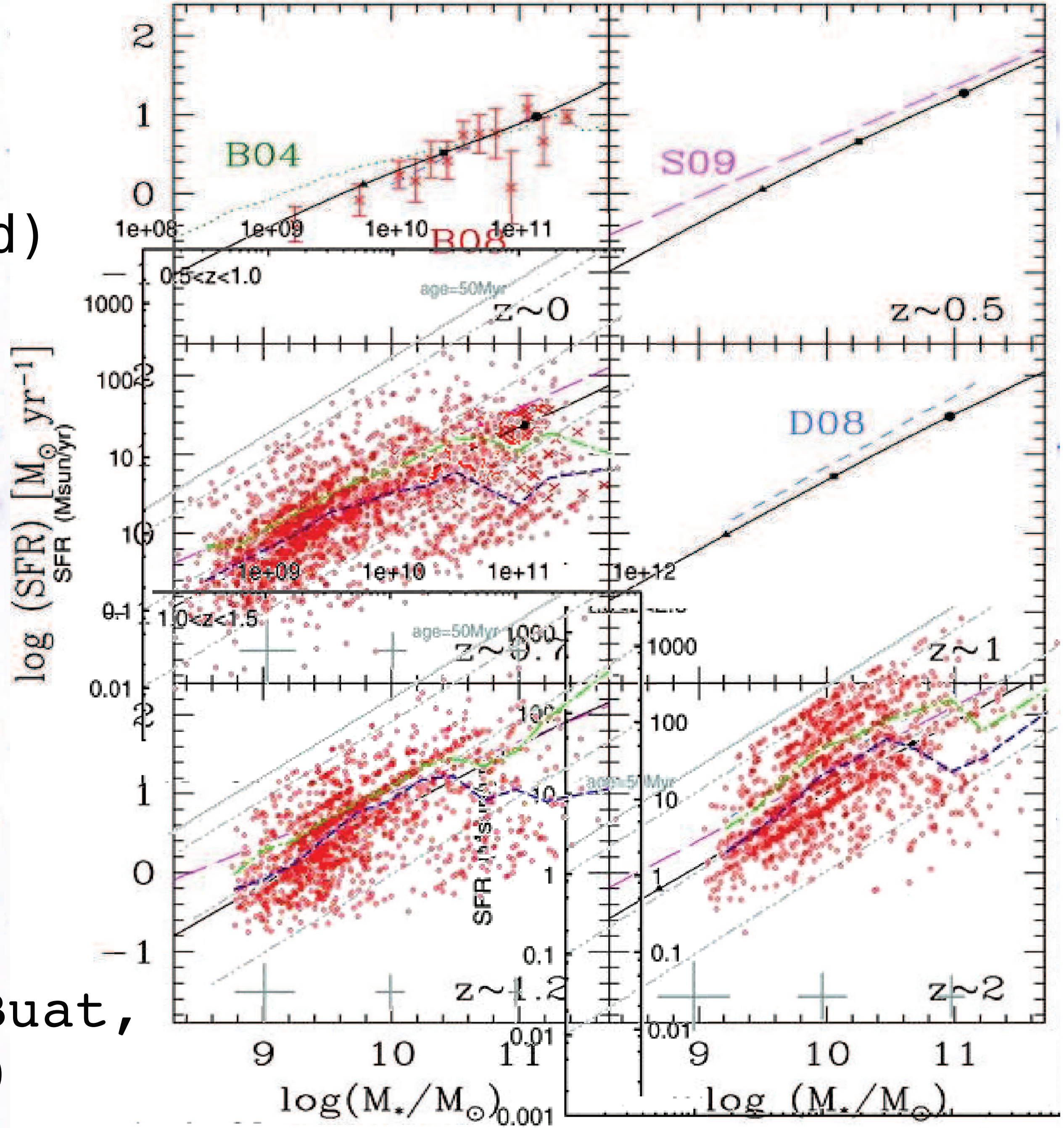
(black : model, color:data)



Boissier, Buat, Ilbert 2010

I-The Grid of Models vs the high z galaxies

Overplotting
Kajisawa et al. 2010
(stellar mass limited)

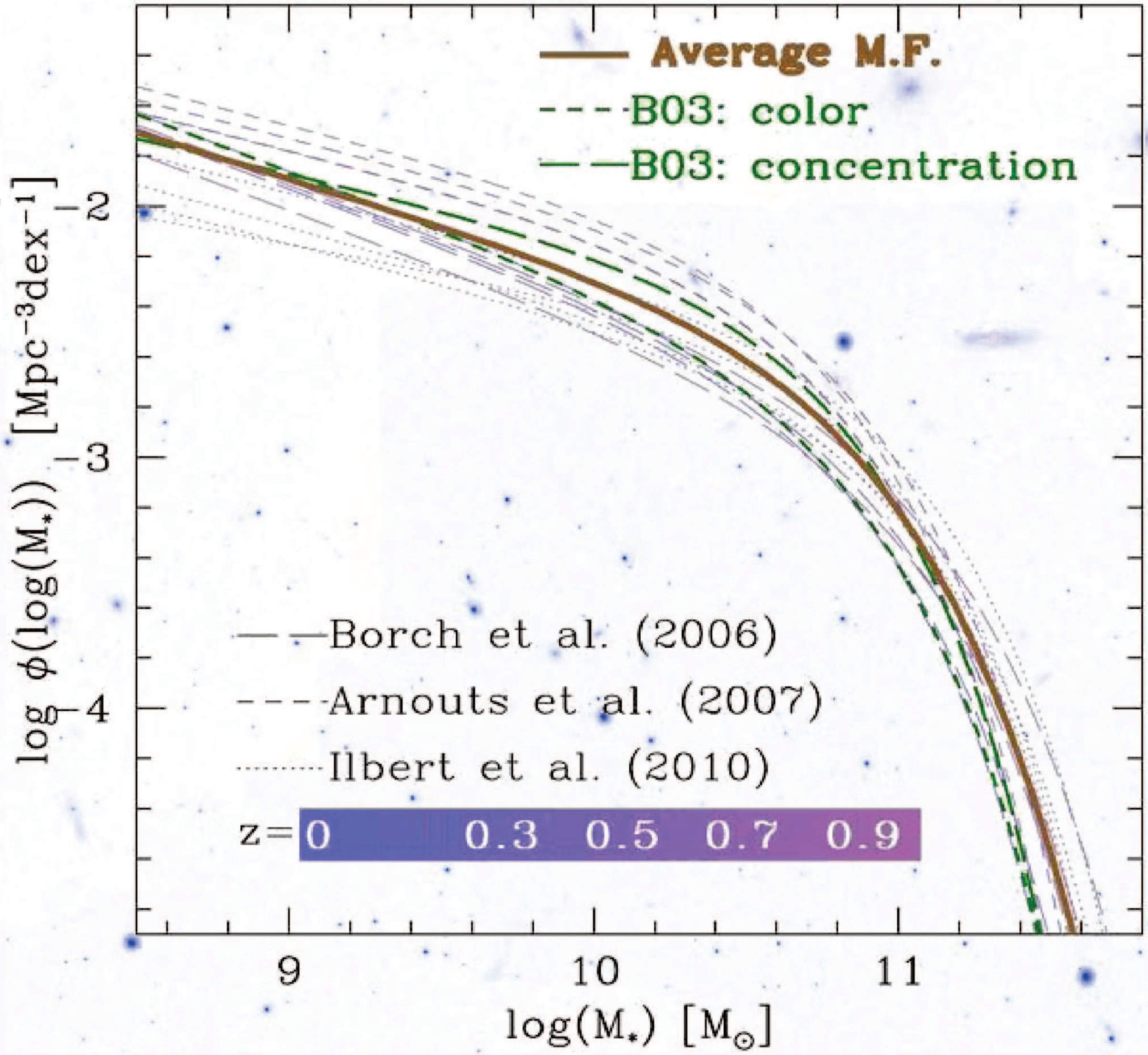


Boissier, Buat,
Ilbert 2010

II-Implementing a Velocity Distribution

Stellar Mass Function F(M*) of star-forming galaxies is “constant”

M* evolves but F(M*) is constant: M* not a good parameter to follow star forming galaxies (e.g. Noeske, 2007)

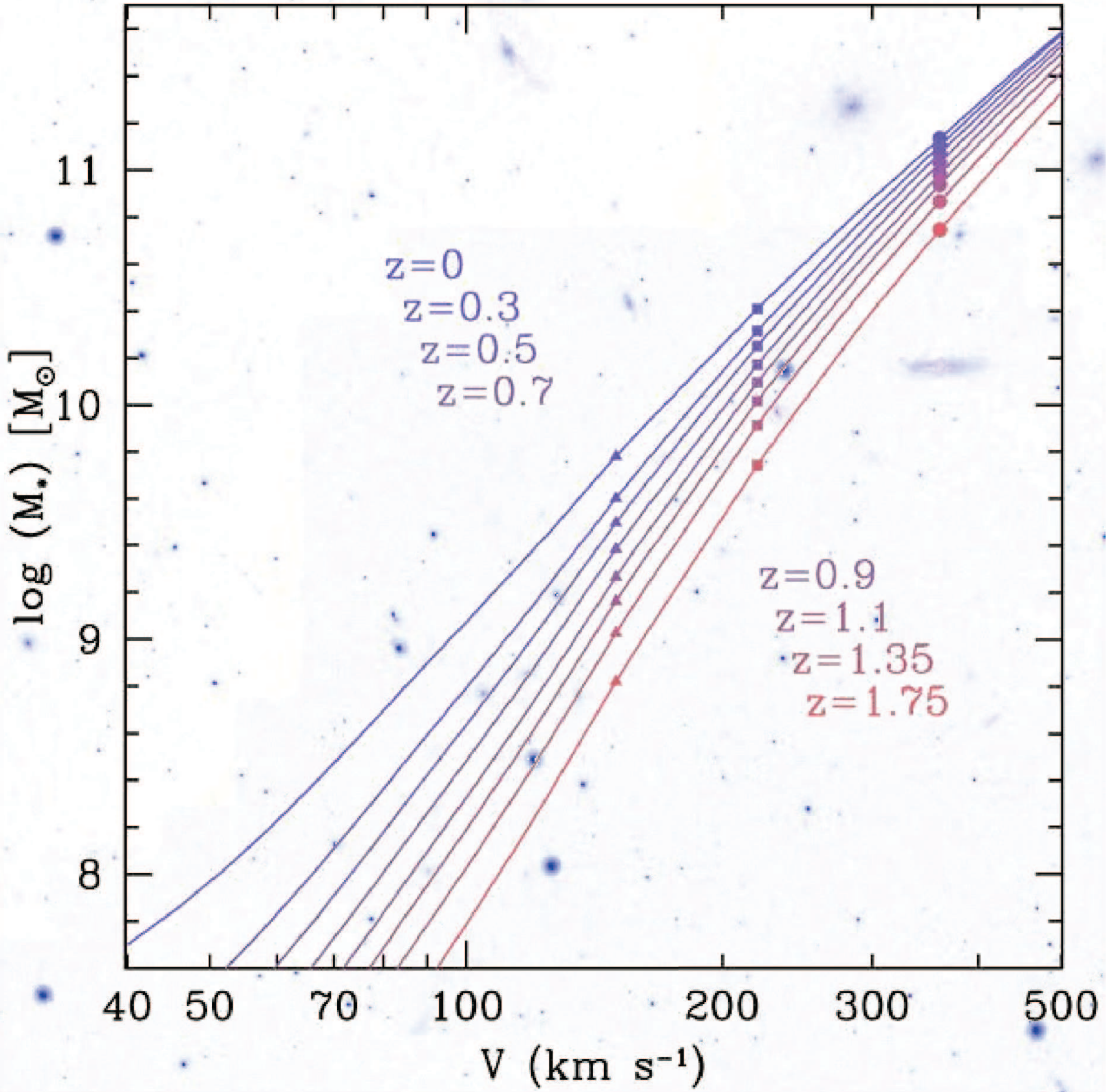


Boissier, Buat, Ilbert 2010

II-Implementing a Velocity Distribution

The models provide the relation M*-Velocity at various redshift.

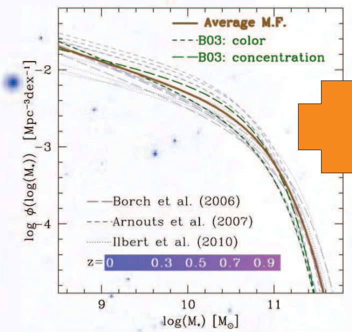
“V” tags a galaxy (does not evolve).

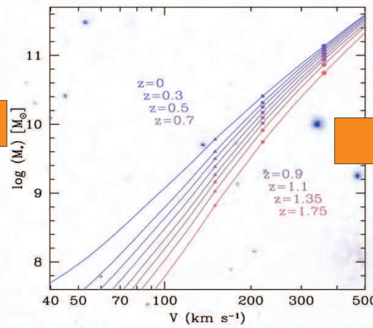


Boissier, Buat, Ilbert 2010

II-Implementing a Velocity Distribution

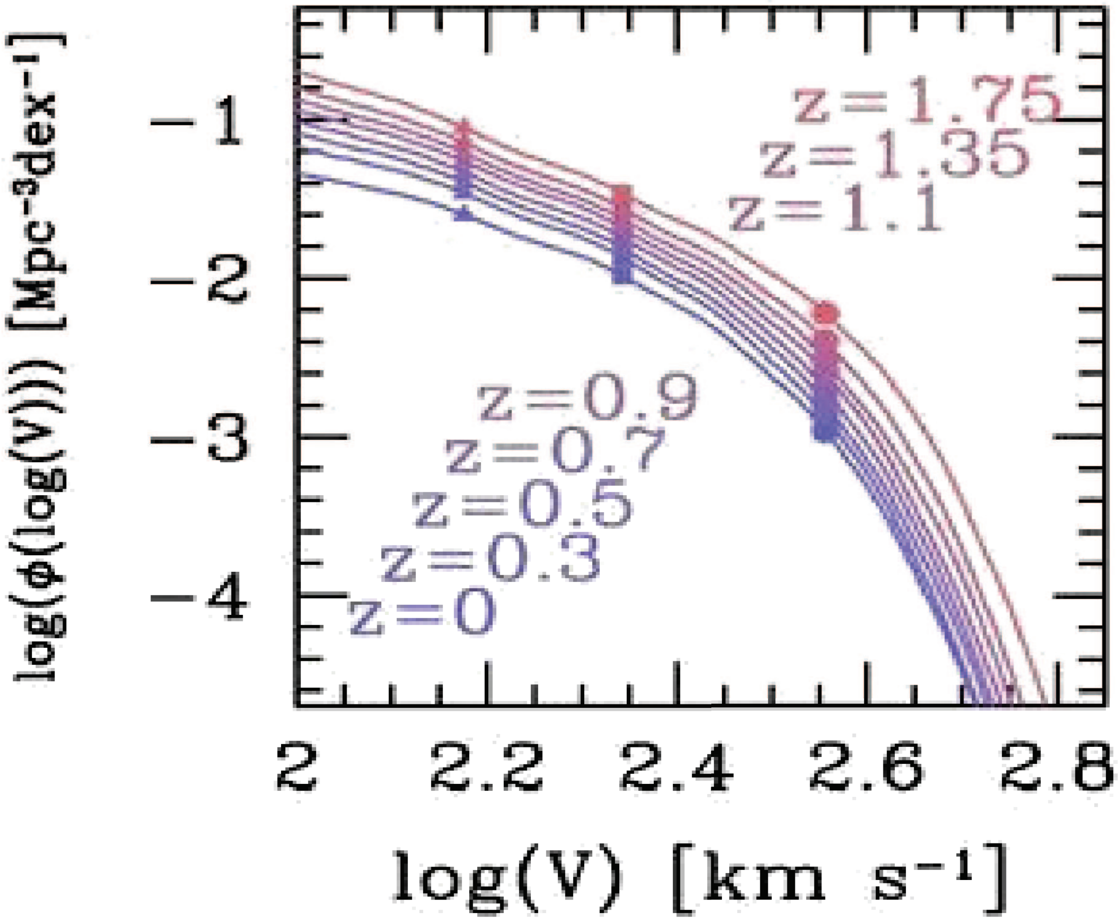
At each redshift, we can compute a Velocity Function F(V)





F(M*)
(cst)

(M*-V)
(f(z))

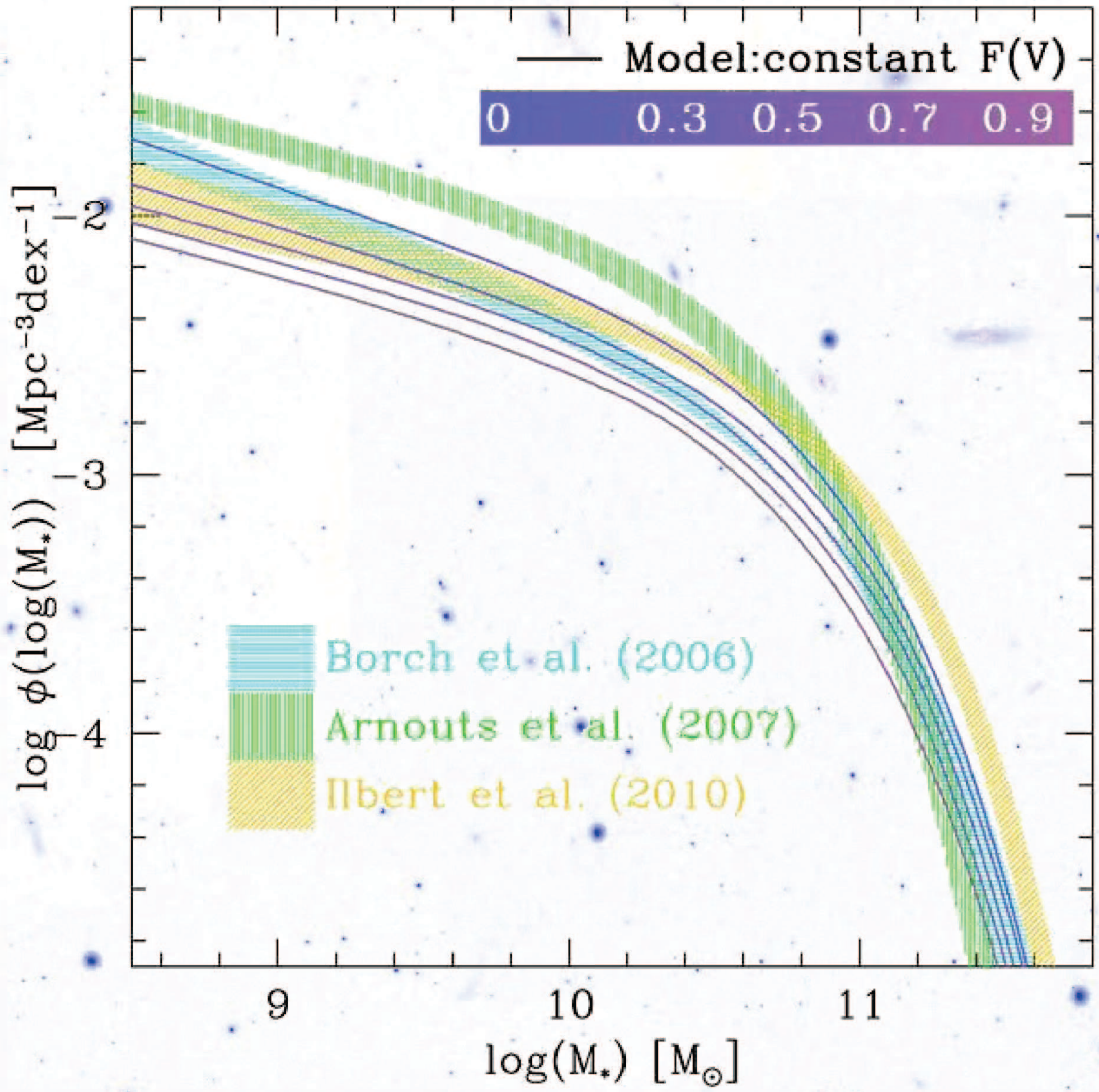


Boissier, Buat, Ilbert 2010

II-Implementing a Velocity Distribution

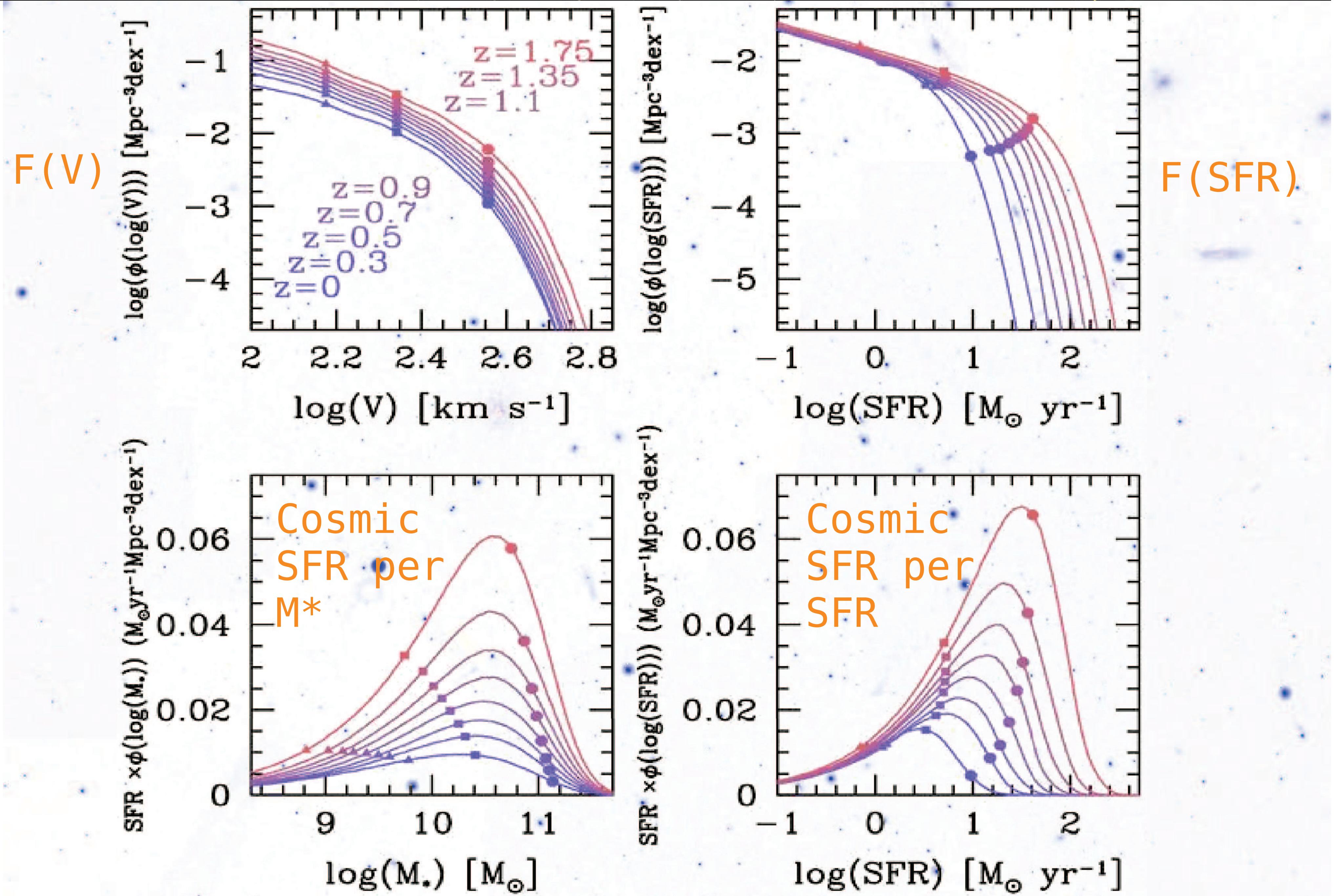
Evolution of F(V) necessary ?

Assuming F(V) = cst, we predict an evolution of F(M*) that should be detected in the various studies.



Boissier, Buat, Ilbert 2010

II- Statiscial evolution

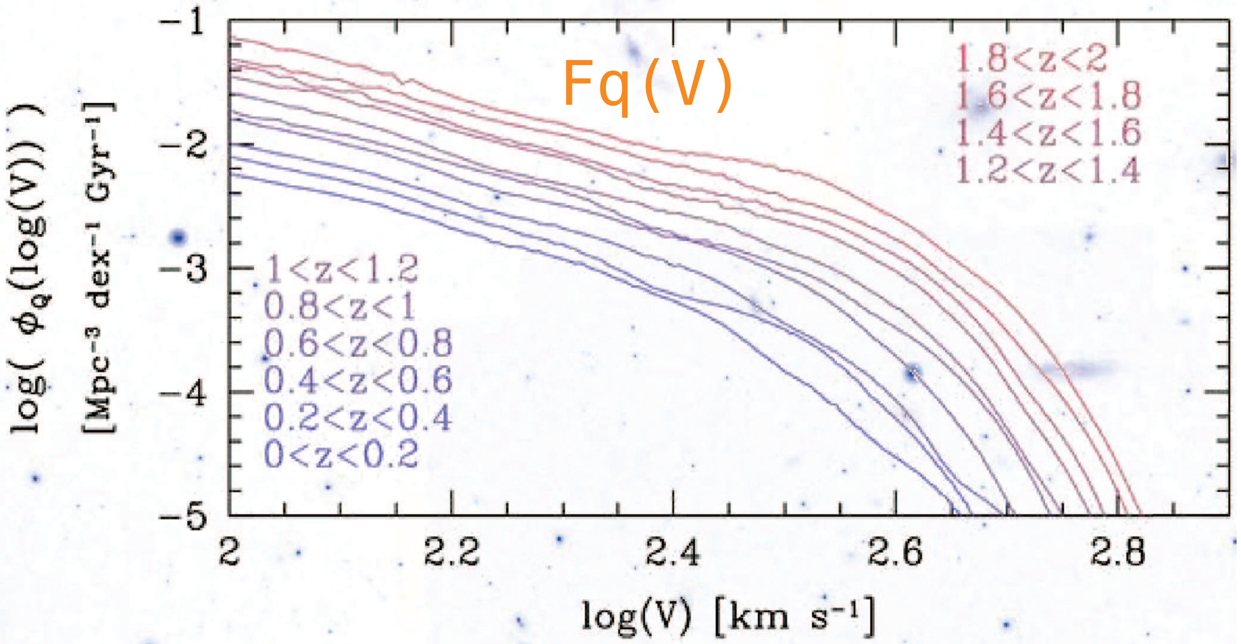


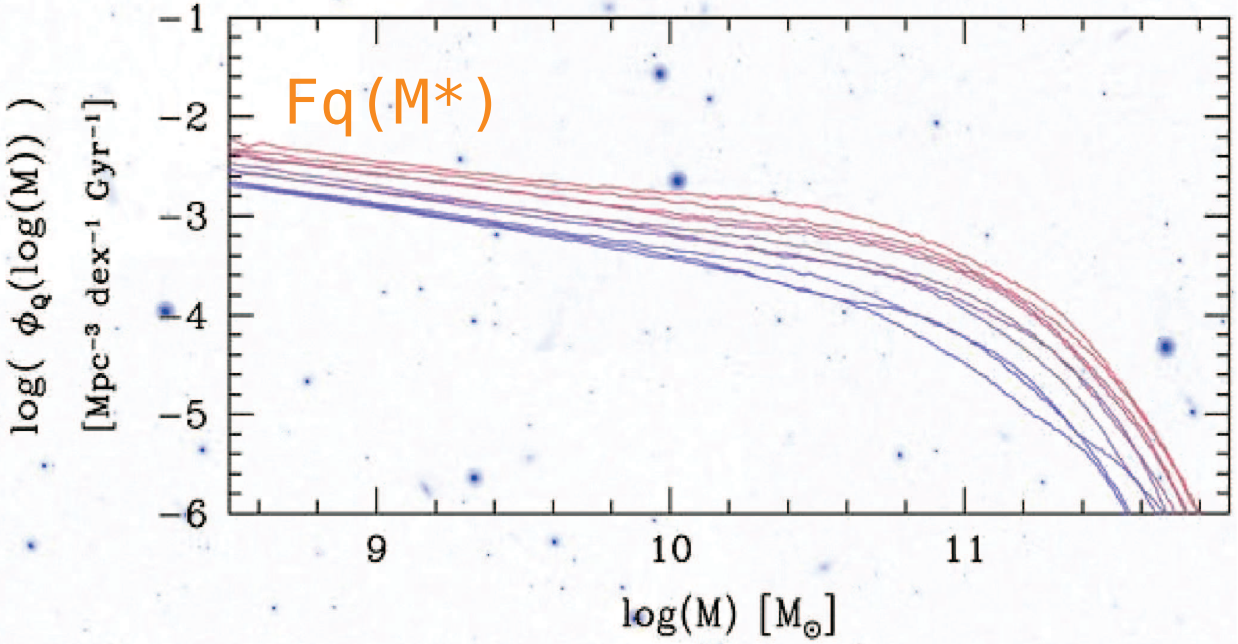
II- Statiscial evolution

We found that F(V) evolves :

at each V, in each redshift bin, a fraction of star-forming galaxies disapear :

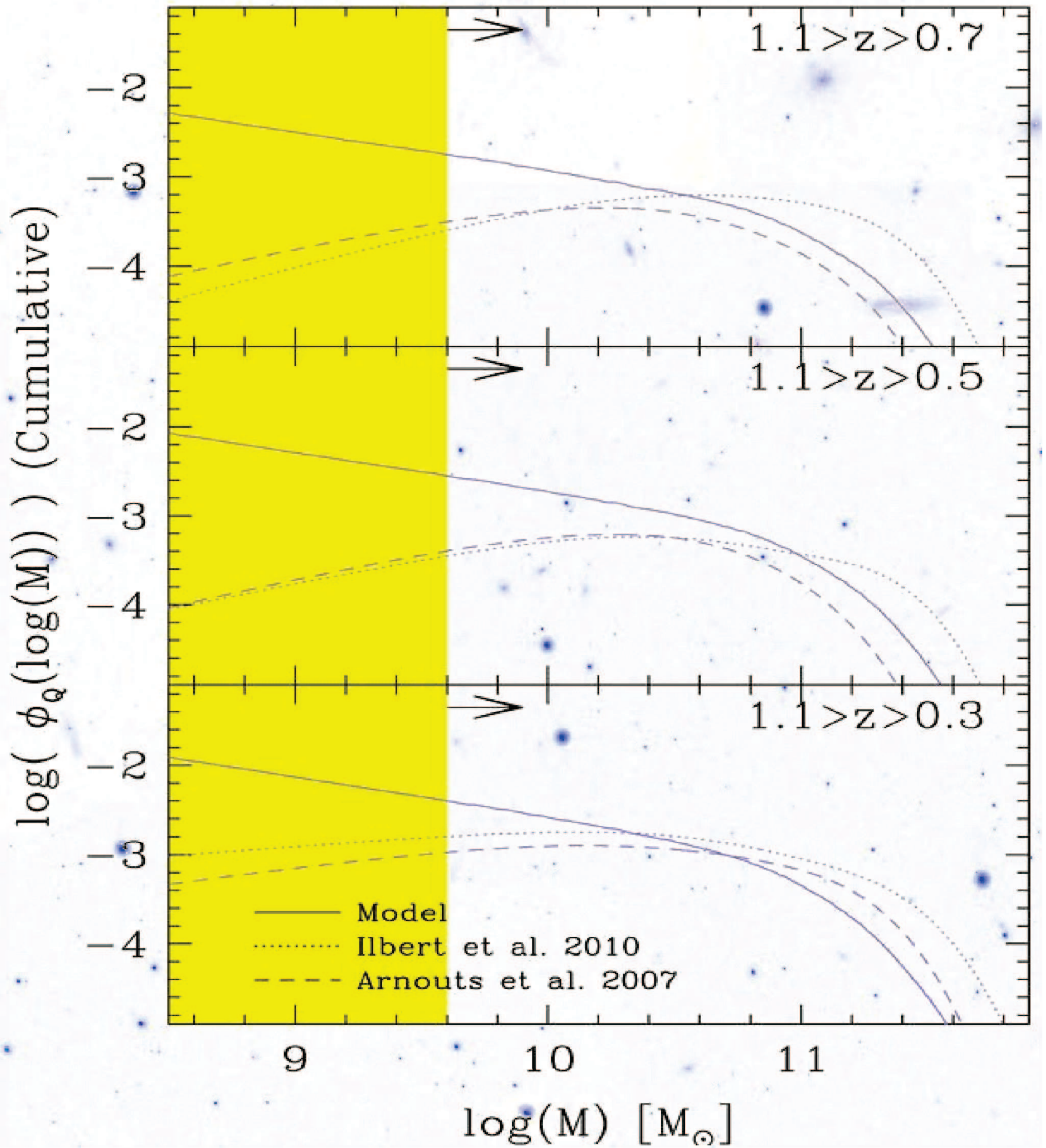
We can compute a “Quenching Flux Function” : Fq



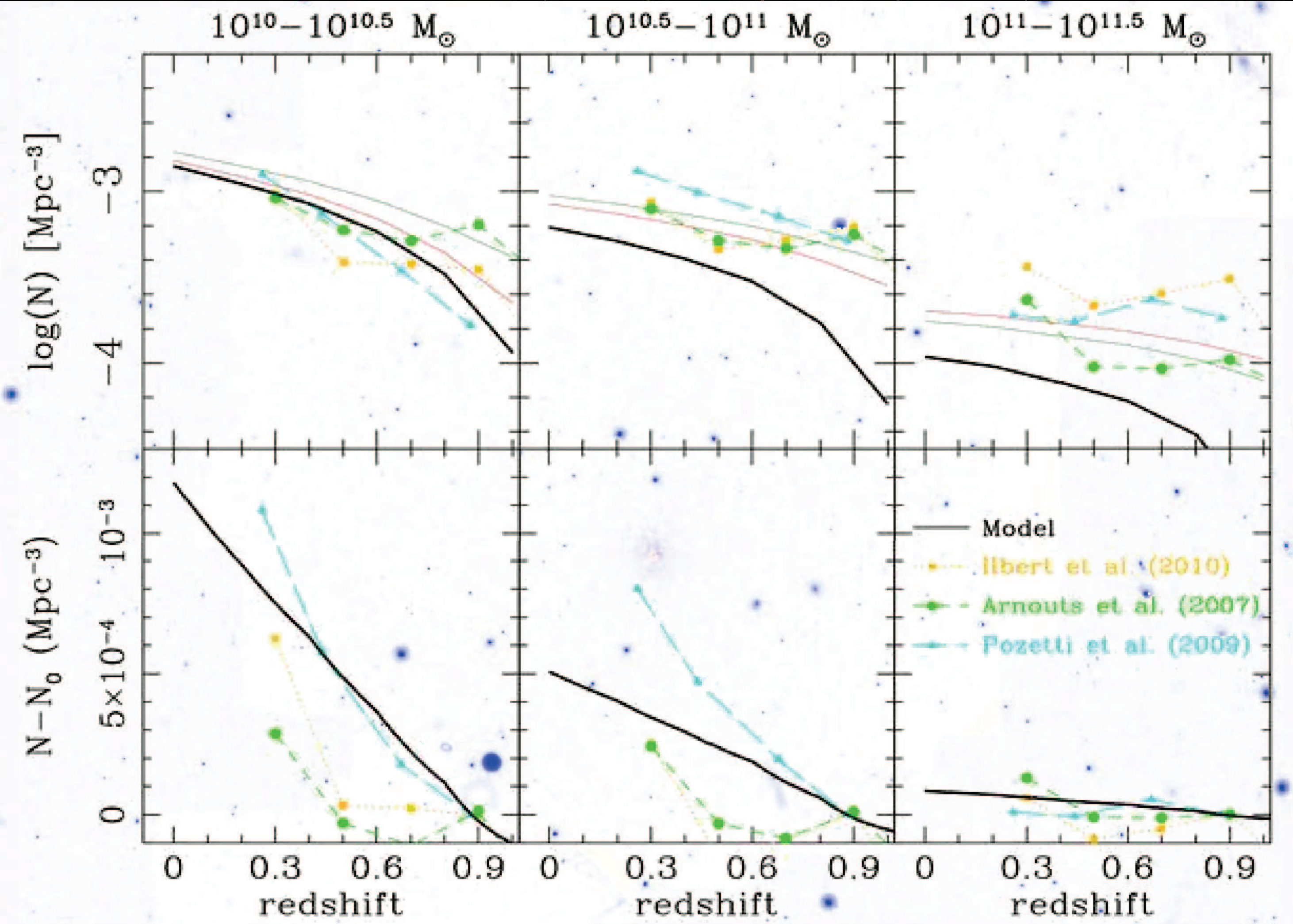


II- Statiscial evolution

If Fq = quenched star-forming galaxies, it should be equal to the increase in quiescent galaxies mass functions in the same redshift bins !



II- Statiscial evolution



Absolute number

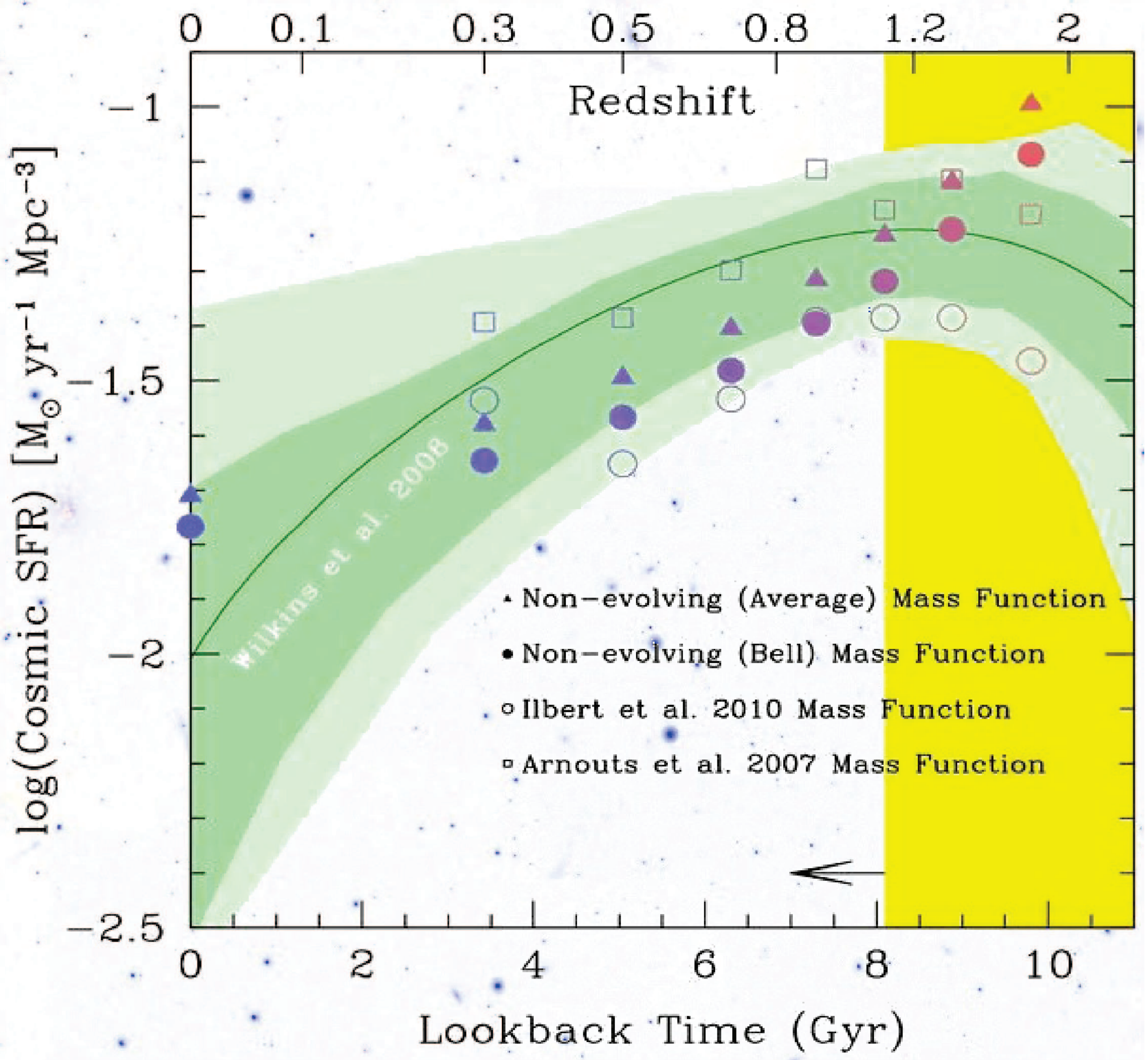
Relative Number

Quenching at “intermediate” mass : Quiescent galaxies are forming from the quenching of Star-forming ones. At high masses: they were already in place at z ~ 1

II- Statiscial evolution

Evolution of the Cosmic SFR: slightly too weak...

Largely due to our z=0 point

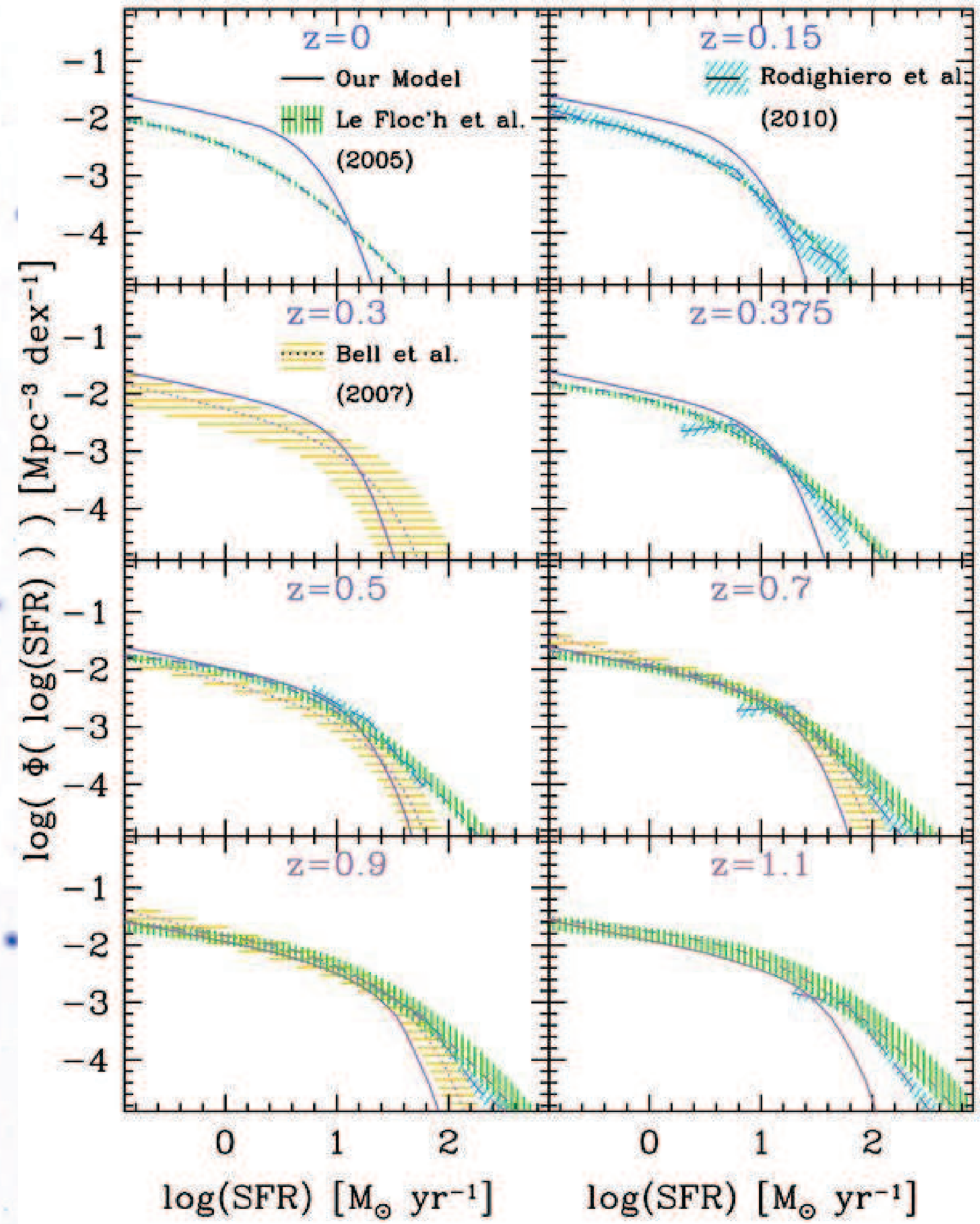


II- Statiscial evolution

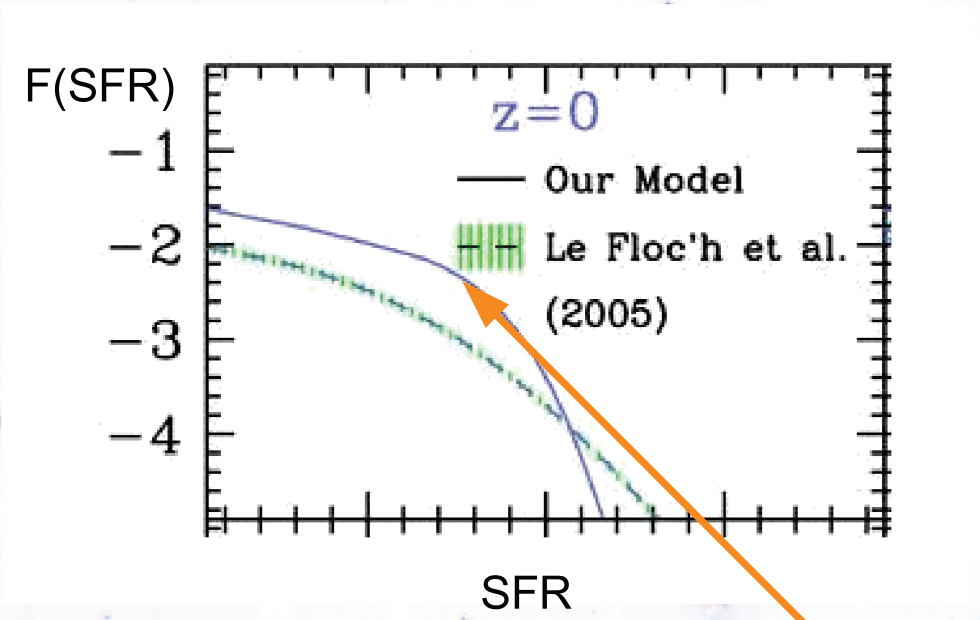
Evolution of SFR functions

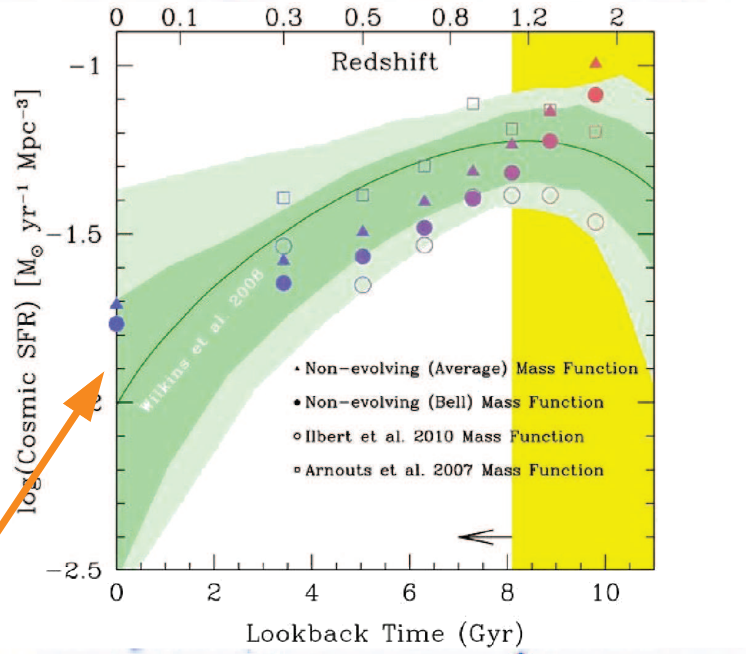
-High z: absence of the most active galaxies...

- Low z:too many low / intermediate mass galaxies ?

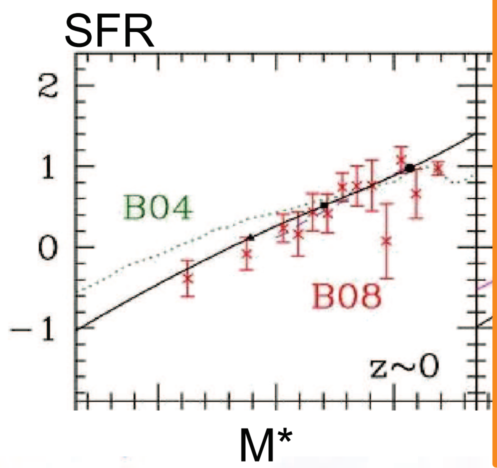


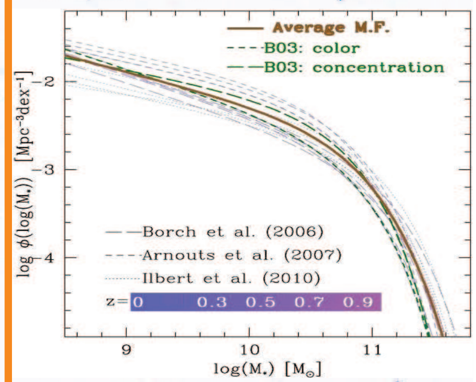
II- Back to redshift 0 : what is happening ?





This excess results from the combination of the stellar mass function and the SFR-M* relationship, both directly observed at z~0 ! Something is not consistent in the observations themselves !





III-Environment : the physical cause ?

Implementing **environmental effects**, reducing the SFR in the models (e.g; Boselli et al. 2006, 2008).

- Starvation
- Ram-Pressure

We can reproduce many properties of dwarfs and anemic spirals in **Virgo** with models incorporating Ram Pressure.

On-going surveys of Virgo: **GUViCS** (UV), NGVS (optical), HRS/HeViCS (FIR), Alfalfa (HI)

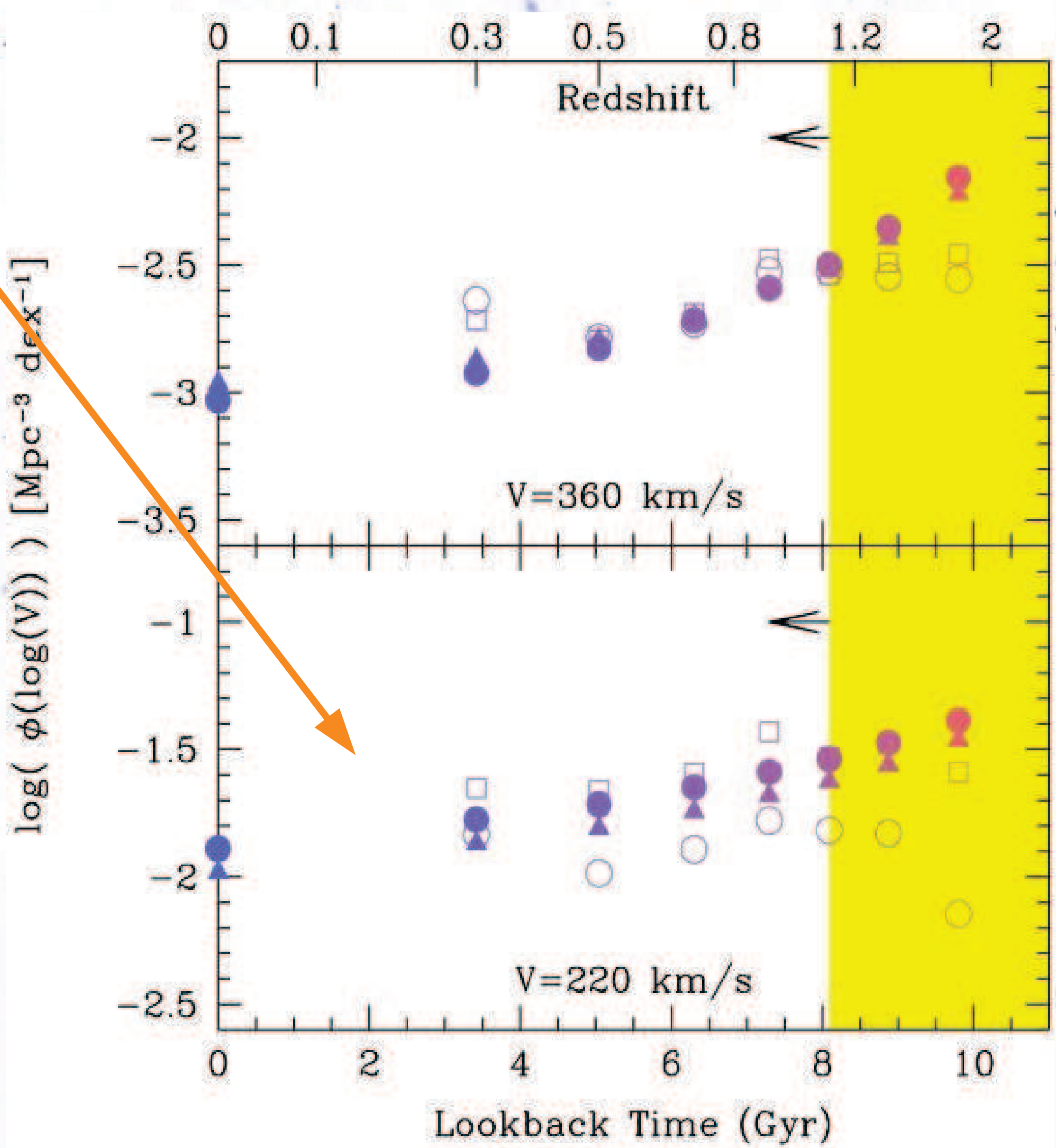
III-Environment ? But ...

What happened to the **Milky Way sibling** ?

50% are not any more star forming galaxies.

Massive clusters like Virgo are not enough to explain these numbers !

It has to be groups (e.g. tidal interactions).



Conclusions & Perspectives

Backward models + simple "statistical" prescriptions allow us to put all the observables of the "cosmic" evolution of galaxies in an educational framework.

NEXT:

-Predict **Luminosity Functions**, to be compared with observations up to the highest redshifts (in collaboration with Tresse, Ilbert, Cucciati) to constrain the evolution of the star-forming velocity function and study consequences (role of quenching, mergers)

- Track the possible **physical causes** of quenching, and develop models incorporating them.