Reconciling a significant recent assembly of massive early-type galaxies at z≤1 with mass-downsizing

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IX Reunión Científica de la SEA

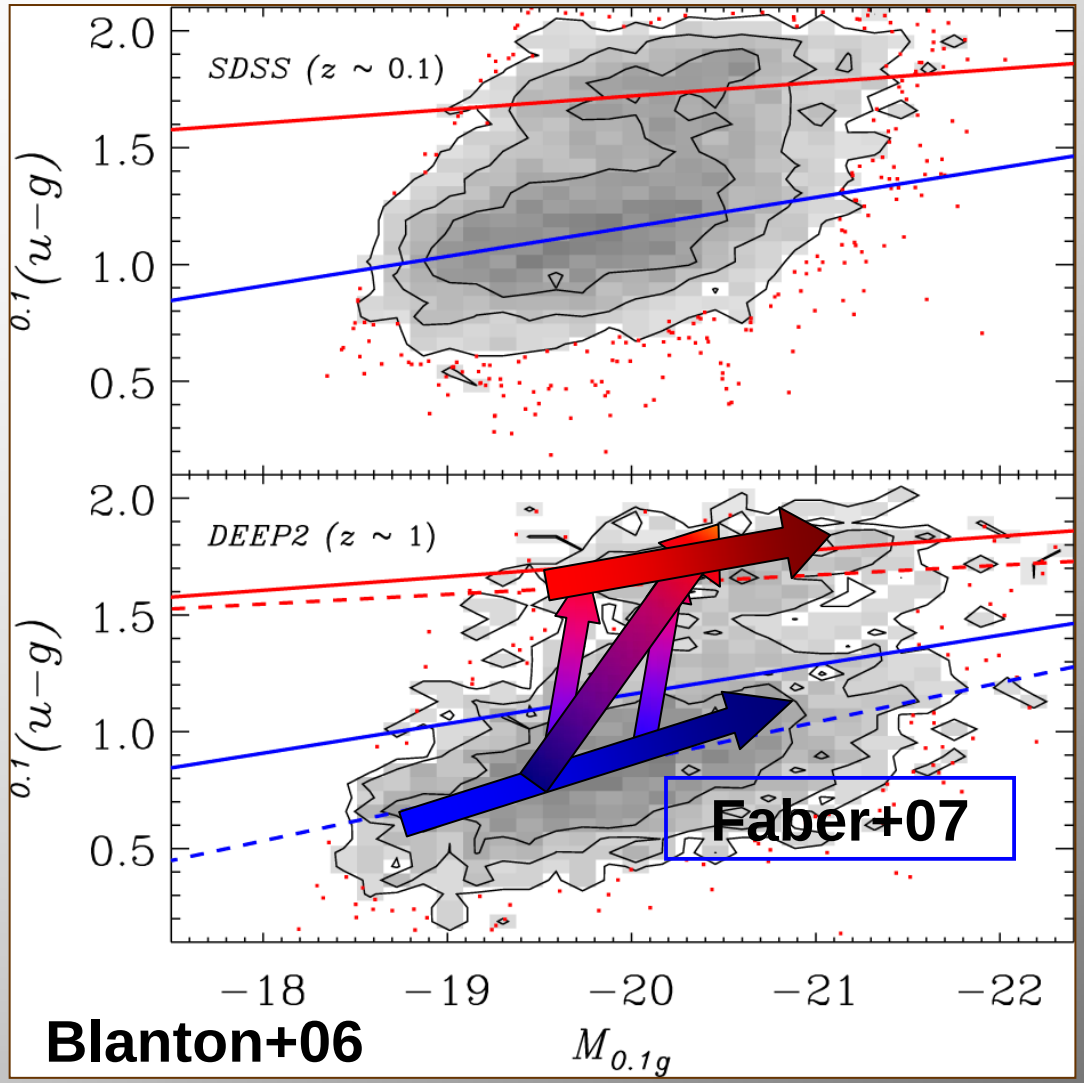
Madrid, September, 15th 2010

Outline

1. **Introduction**
   - **Mass downsizing vs. hierarchical theories.**
   - **Testing the role of major mergers in the assembly of massive early-type galaxies.**
2. **Semi-analitycal models.**
3. **Results.**
   - **Model predictions of galaxy LFs at z<~1.**
   - **Model predictions of assembly redshift of the massive early-type galaxy population.**
4. **Conclusions.**

I- Introduction

Assembly of Galaxy Red Sequence

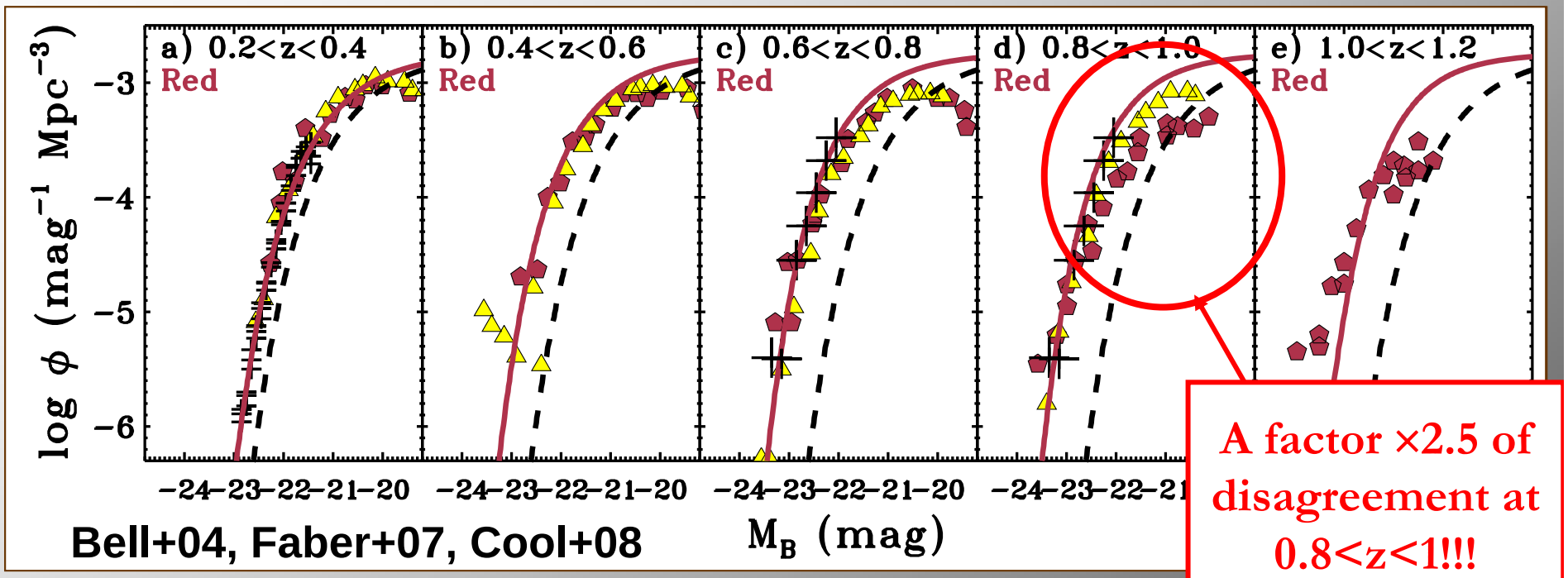


- ✓ **Galaxy color bimodality exists up to z~1** (Kauffmann+03, Baldry+04).
- ✓ **Strong evolution of Red Galaxy Sequence since z~1** (Blanton+06).
- ✓ **Mixed evolutionary scenario** (Faber+07).
- ✓ **Accordingly with the hierarchical models and simulations** (Naab+06, Romeo+08): **S's ⇒ S0's ⇒ E's**

Hierarchical ΛCDM models ⇒ Early-type galaxies with log(M/Msun)>11 are "in place" at z~0.5 (De Lucia+06)

I- Introduction

Number evolution in the Red Sequence



A factor ×2.5 of disagreement at 0.8<z<1!!!

1) **MASS DOWNSIZING:** (Kodama+07, Pérez-González+08)

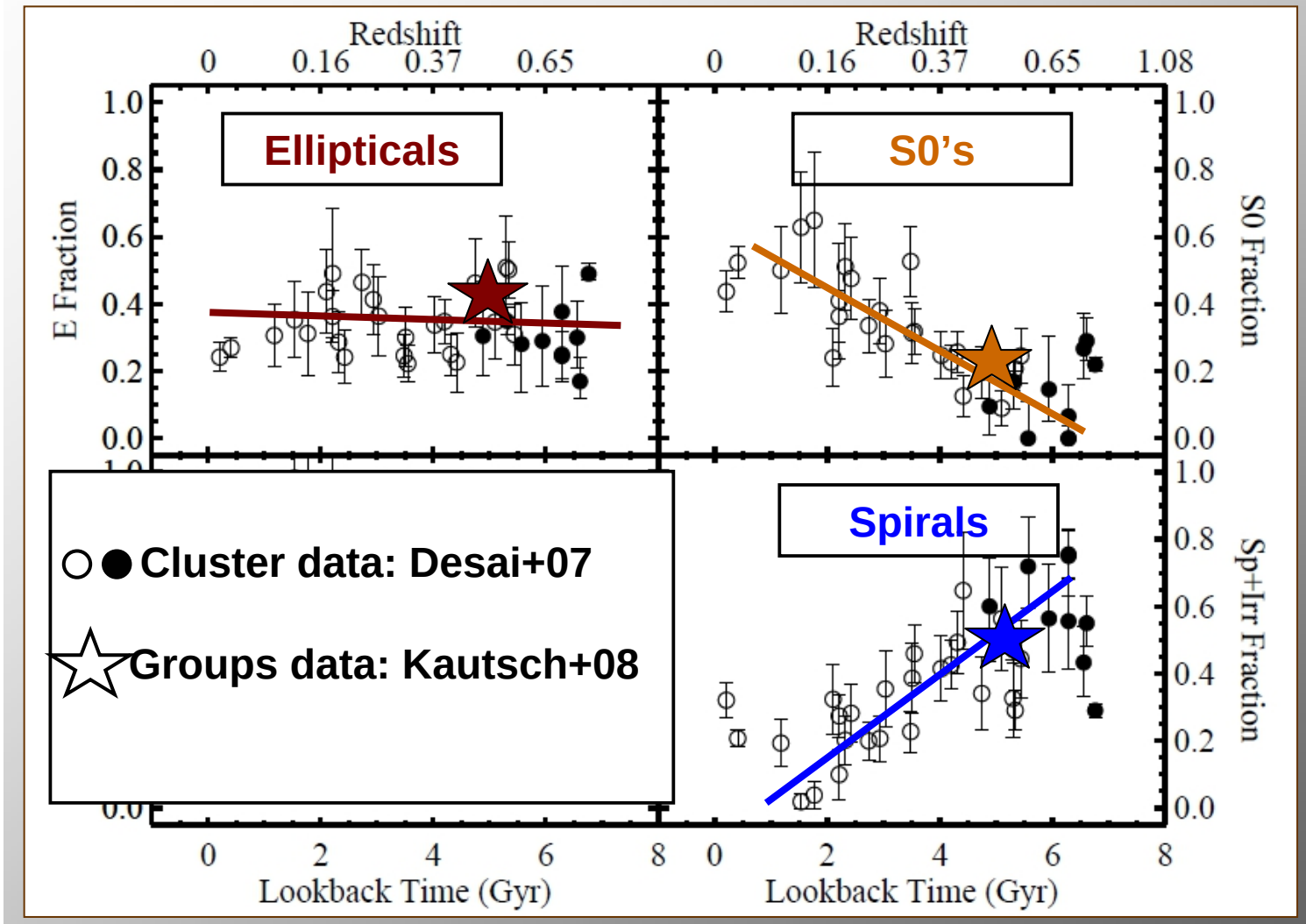
Are major mergers really the main drivers of E-S0a's assembly?

[Is the hierarchical scenario wrong?]

2) **DISAGREEMENT AT M~M*:** (Faber+07)

What is the real number evolution experienced by E-S0a's since z~1?

I- Introduction
The effects of environment

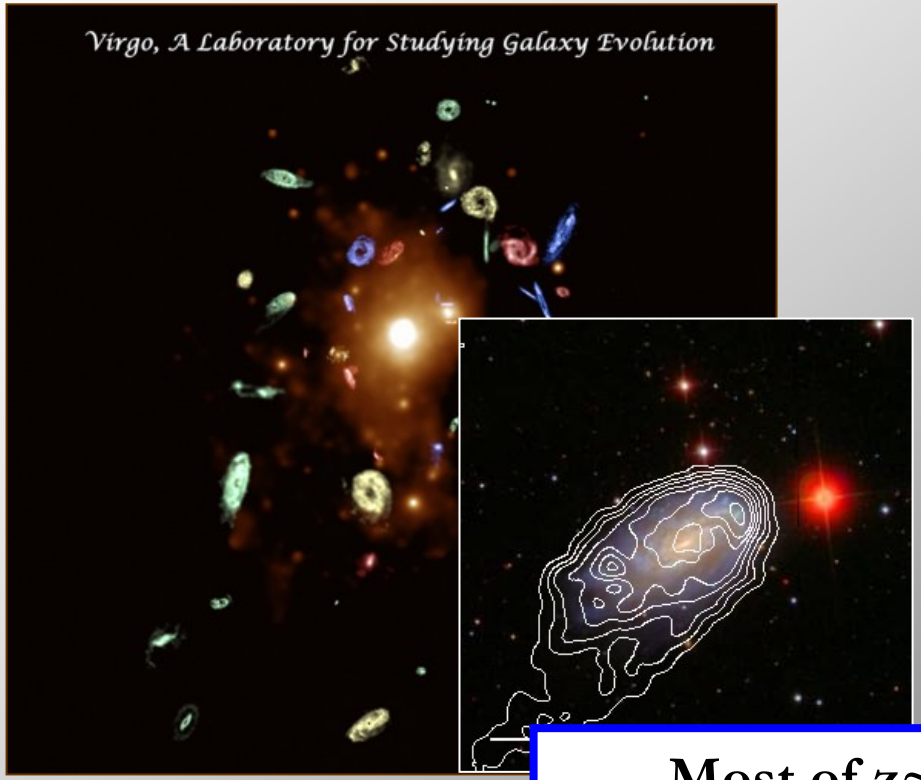


- ✓ **Environment seems to be a poor driver of galaxy evolution** (Poggianti+08, Dressler+09, Simard+09).
- ✓ **In clusters: S's ⇒ S0's ⇏ E's (talk by Aragón-Salamanca).**
- ✓ **BUT similar morphological content in groups at z~0.5!**

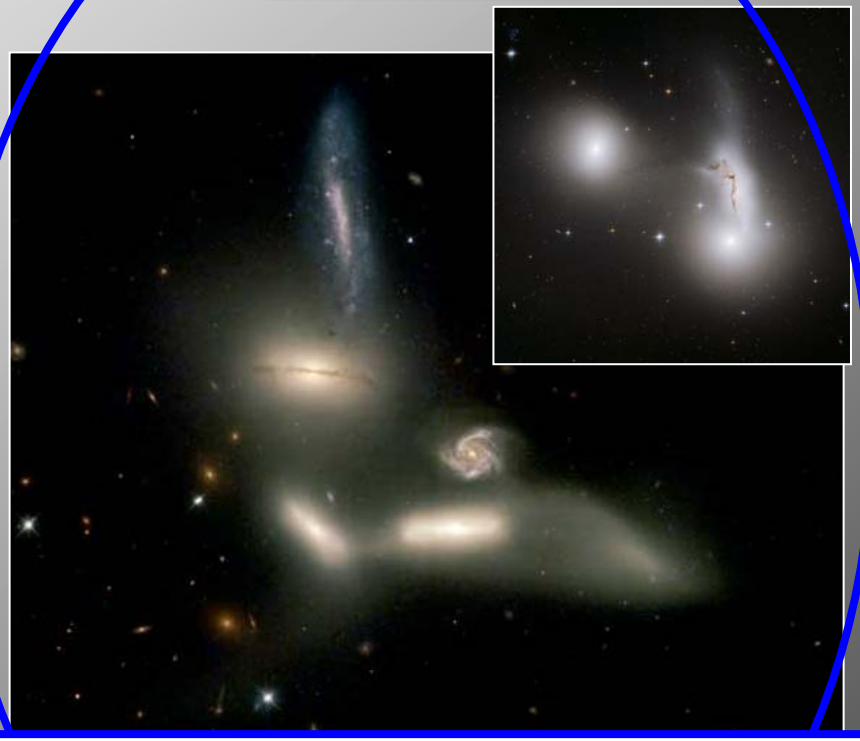
I- Introduction

Processes in different environments

Clusters



Groups



✓ <u>Clusters</u> ⇒ **Ram stripping** (Chung+0

Most of z~0 galaxies are in groups (>70%)!
(Huchra+82, Berlind+06, Crook+07).

We are basically detecting E-S0a's in groups.

I- Introduction

Pre-processing of E-S0's in groups

✓**Evolved groups have higher fractions of early-types, basically containing E's** (Freeland+09, Bai+10).

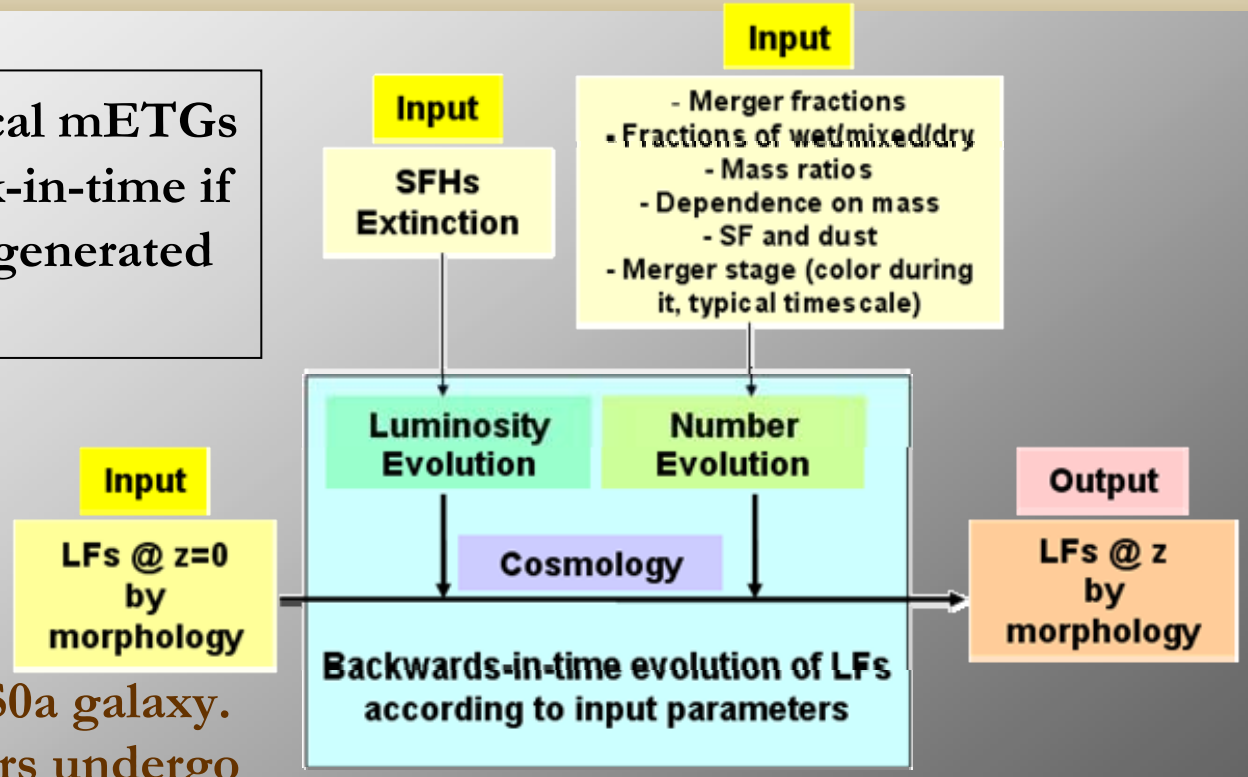
In groups: S's ⇒ S0's ⇒ E's
Galaxies experience a <u>pre-processing in groups</u> before/during falling into clusters (Wilcots+10)

Main evolutionary process in groups: MERGERS

Can the observational major merger fractions really account for the assembly of massive E-S0a's?

II- Semianalitical model

Simple test: How the local mETGs would have evolved back-in-time if each major merger has generated an E-S0?



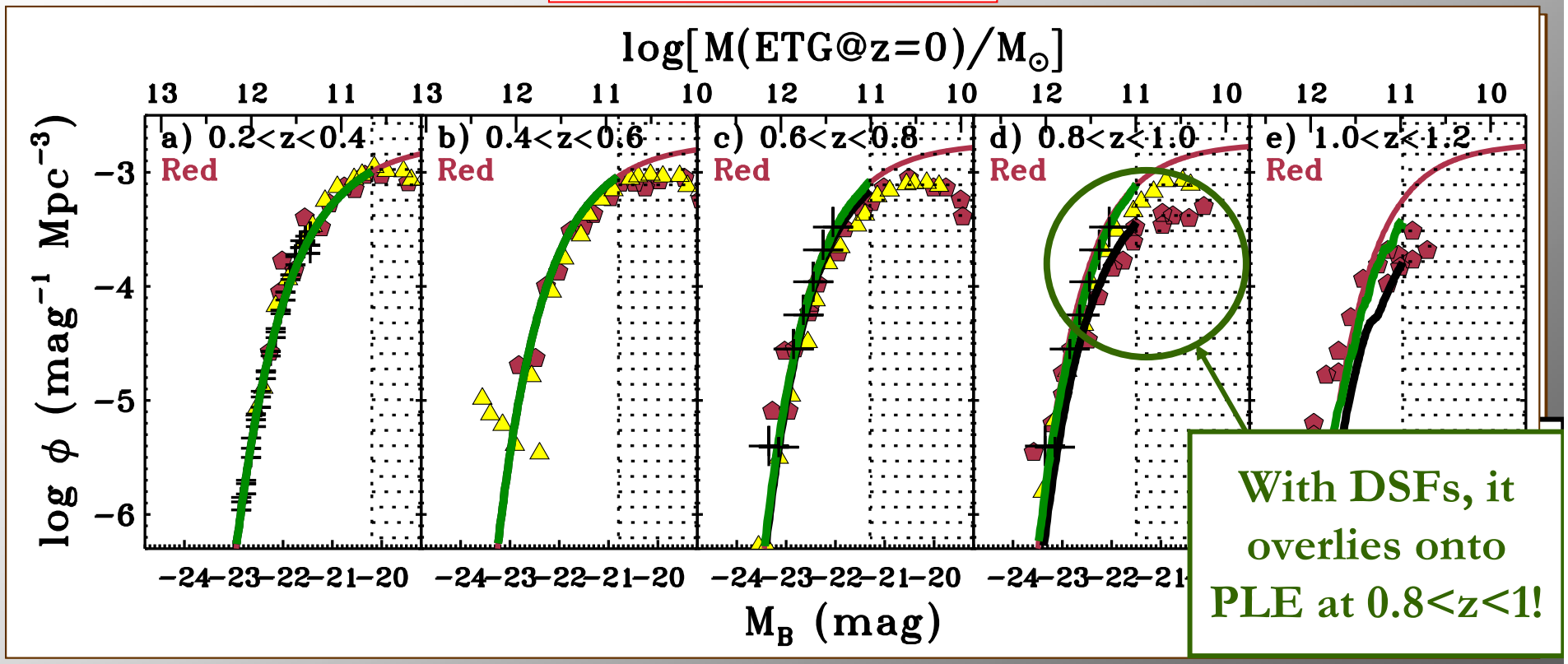
Main hypotheses:

- ✓ **A major merger ⇒E-S0a galaxy.**
- ✓ **Gas-rich major mergers undergo phases as dust-reddened, star-forming galaxies (DSFs).**
- ✓ **Gas-rich progenitors are Sc-Irr** (Poggianti+08, Tasca+09).

Eliche-Moral et al. 2010a, A&A in press
Eliche-Moral et al., 2010b, A&A submitted

III- Results:
B-band LFs by color up to z~1

RED GALAXIES



With DSFs, it overlies onto PLE at 0.8<z<1!

Pure luminosity evolution (PLE)

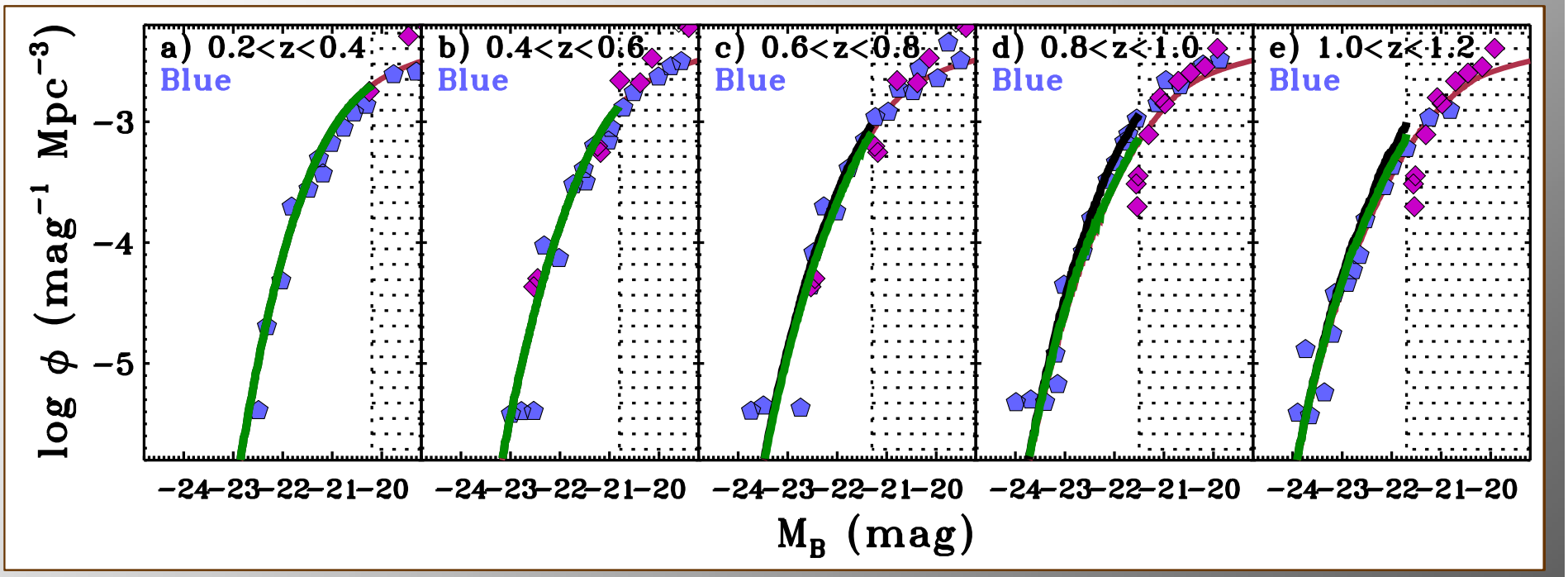
If only E-S0a's are red (mergers)

If also DSFs are red (mergers)

III- Results:

B-band LFs by color up to z~1

BLUE GALAXIES

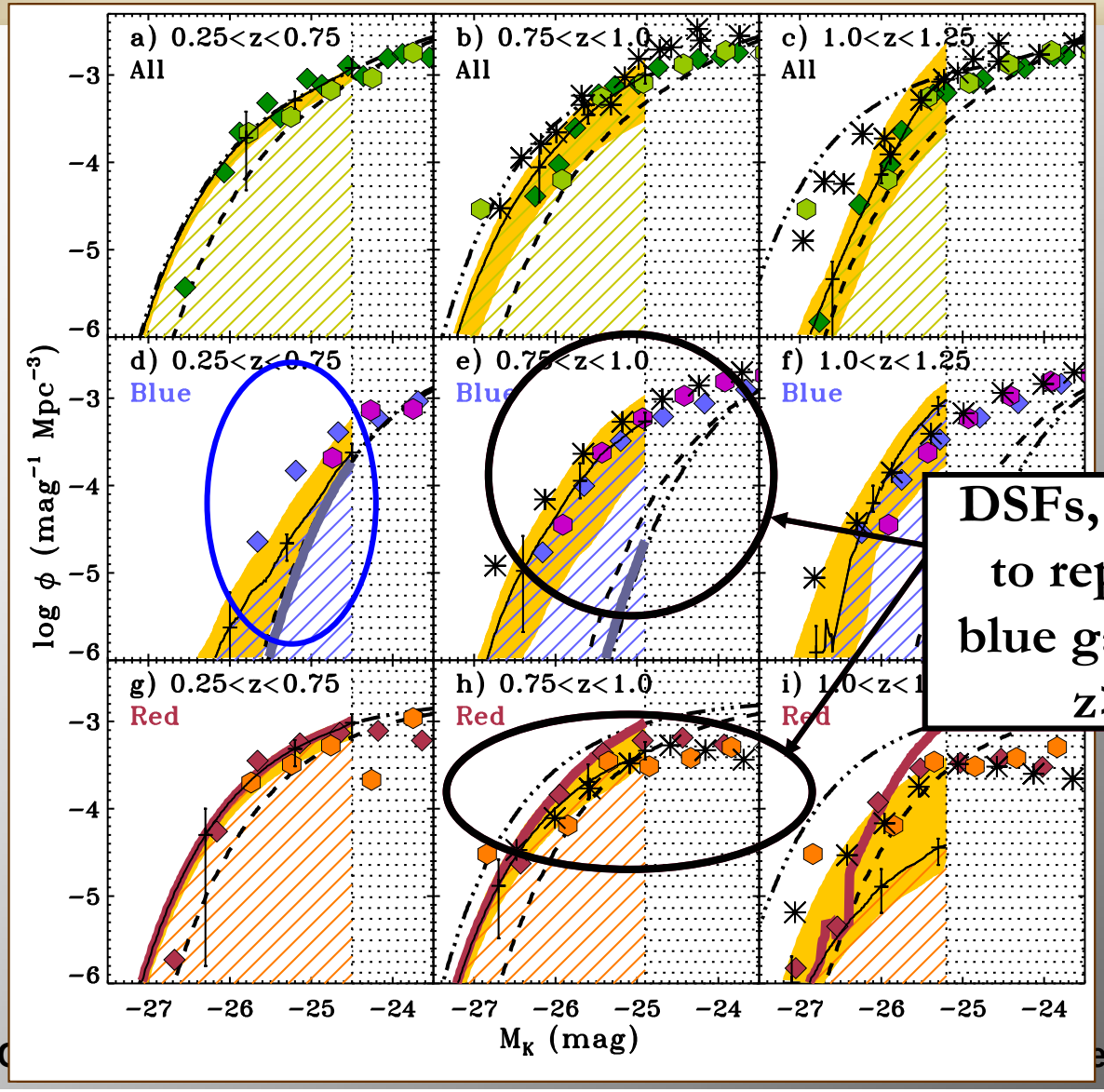


Pure luminosity evolution (PLE)

If only E-S0a's are red (mergers)

If also DSFs are red (mergers)

III- Results:
K-band LFs by color up to z~1



DSFs, essential to reproduce blue galaxies at z>0.8

✓ The model reproduces the LFs up to z~1 <u>simultaneously in different bands and using different selection criteria</u> (color & MORPHOLOGY).

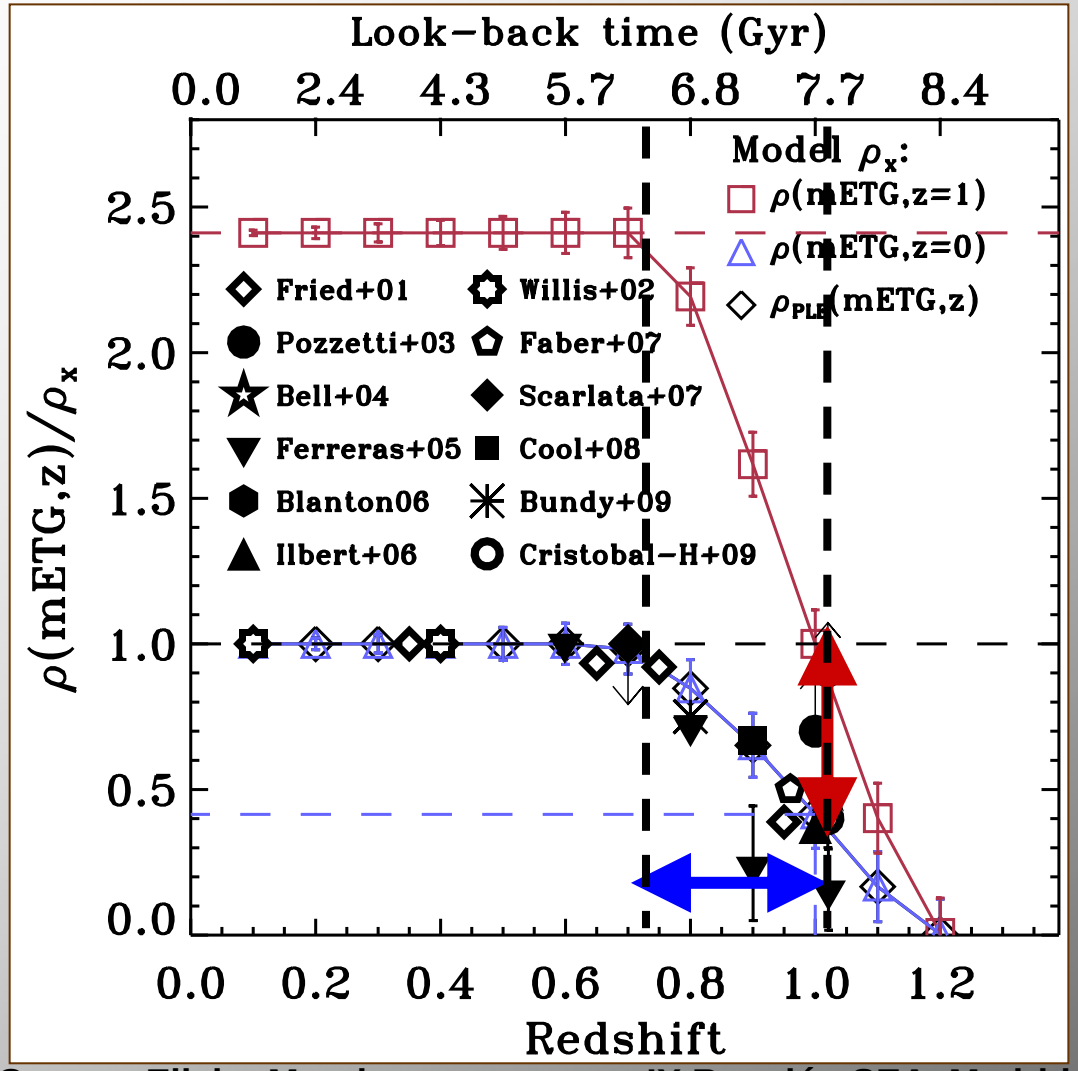
y, the most nd of LFs. edicted gas-rich rs and DSFs explain naturally the blue galaxy excess at z>0.8.

✓ It fails at z>1.

✓Low no. of bright blue galaxies at z<0.75 in K.

III- Results:

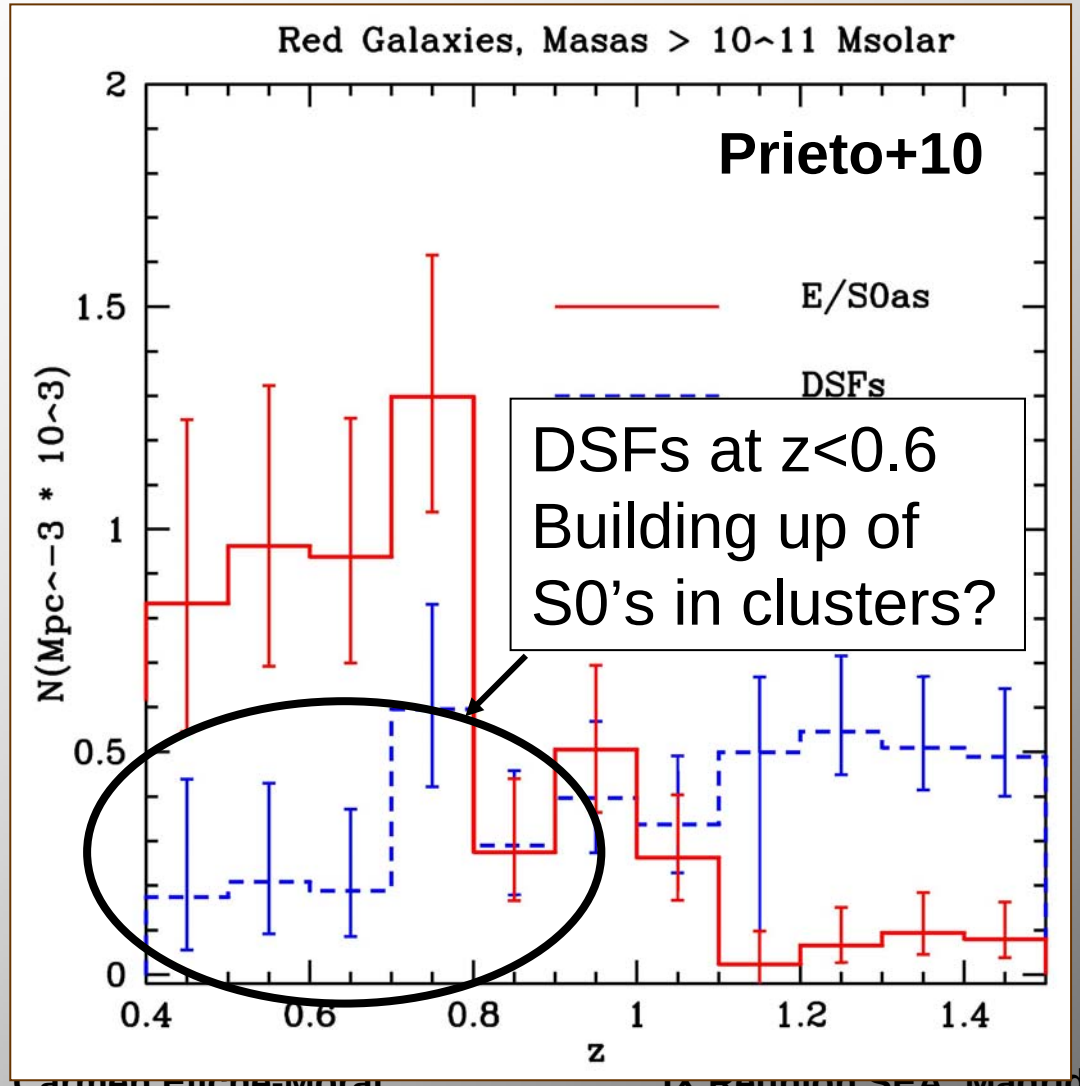
Number evolution of E-S0a's since z~1



- ✓ It is feasible to explain the increase by a factor of ~2.5 of the number density of massive E-S0a's since z~1 just considering the observed major mergers.
- ✓ This assembly takes place during the period elapsed at 0.7<z<1 (~1.5 Gyr).

III- Results:

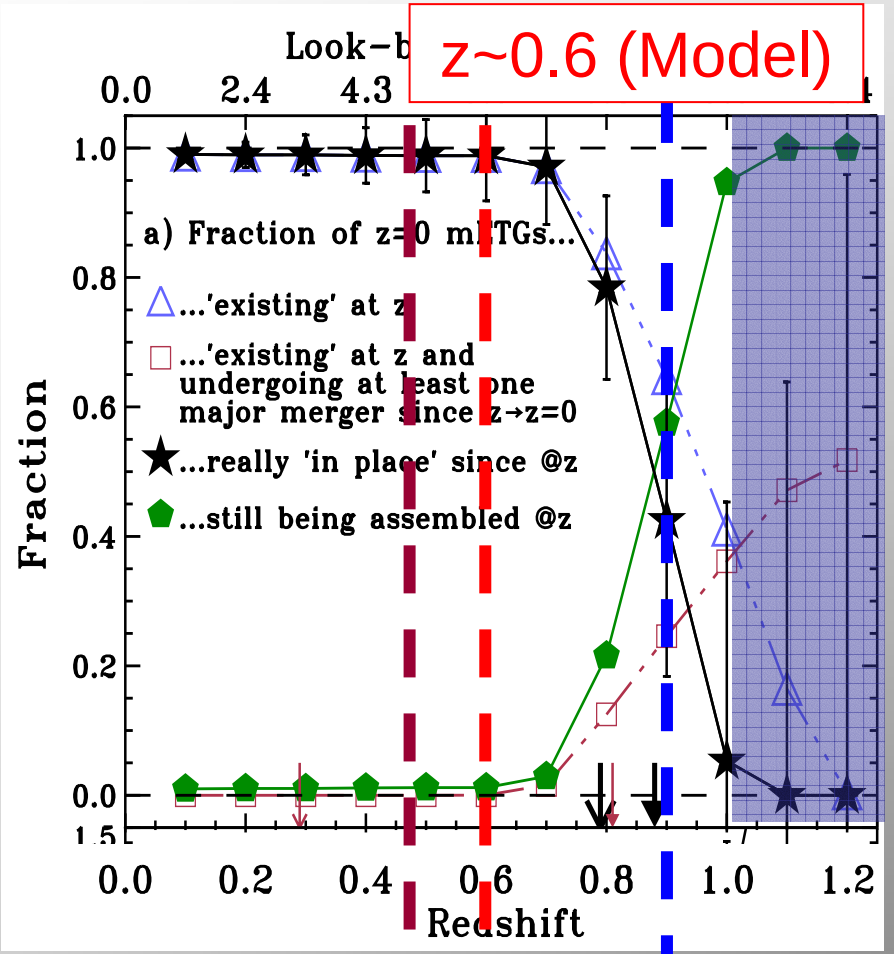
Number evolution of E-S0a's since z~1



- ✓ **Observationally confirmed in Prieto et al. 2010 (in preparation).**
- ✓ **Galaxies selected according to their color AND morphology.**
- ✓ **Confirmed the increase by a factor of ~2.5 in the number density of passive E-S0a's between 0.7<z<1.**
- ✓ **Number density of DSFs (reddened mergers) ~ to that of E-S0a's at 0.8<z<1.**

See poster by Prieto et al.

III- Results:
E-S0a's really in place since z~1



- ✓ A galaxy is in place since z if it is not involved in any major merger since then.
- ✓ <u>Model:</u> most of the E-S0a's at z~1 are the gas-poor progenitors of present E-S0a's (not their passively-evolved high-z counterparts!).

Predicted redshift at which E-S0a's are in place in agreement with hierarchical models, reproducing the global mass downsizing trends at z<~1 at the same time.

IV- Conclusions

1) Different routes of building up E-S0a's must be considered.
2) Current estimates of major mergers can explain the evolution of the number density of massive E-S0a's since z~1.
3) Mass downsizing and a significant recent hierarchical assembly of E-S0a's can be reconciled: E-S0a's at z~1 are not necessarily "in place".
4) Apparently-contradictory results on the observed LFs of red and blue galaxies can be reconciled if contamination by DSFs at z>0.8.
5) The DSFs population at z>0.8 can be explained if transitory stages of major mergers.

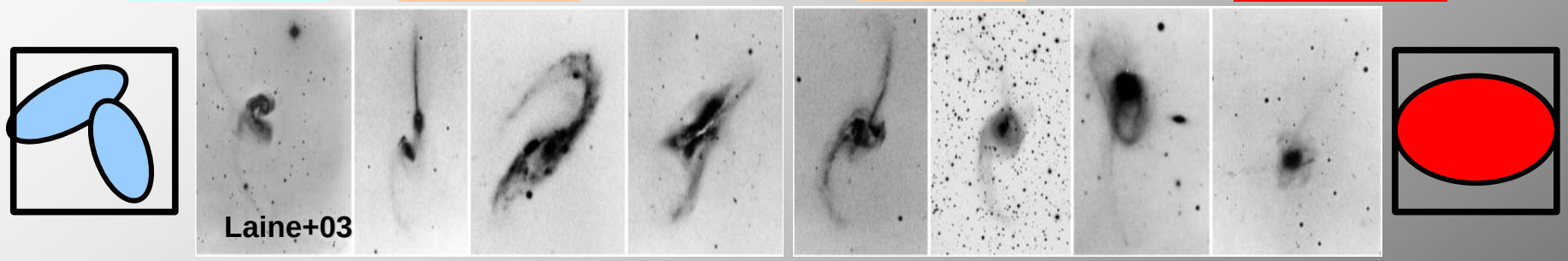
Major mergers must have been the main driver of the observed migration of mass from the blue galaxy cloud to the red sequence since z~1, for galaxy with masses > 10^{11} Msun at z=0.

Extra material

II- Models
Merging procedure

Wet merger

time — 2 Sc-Irr's — 2 DSFs — 1 DSF — 1ETG



Mixed merger

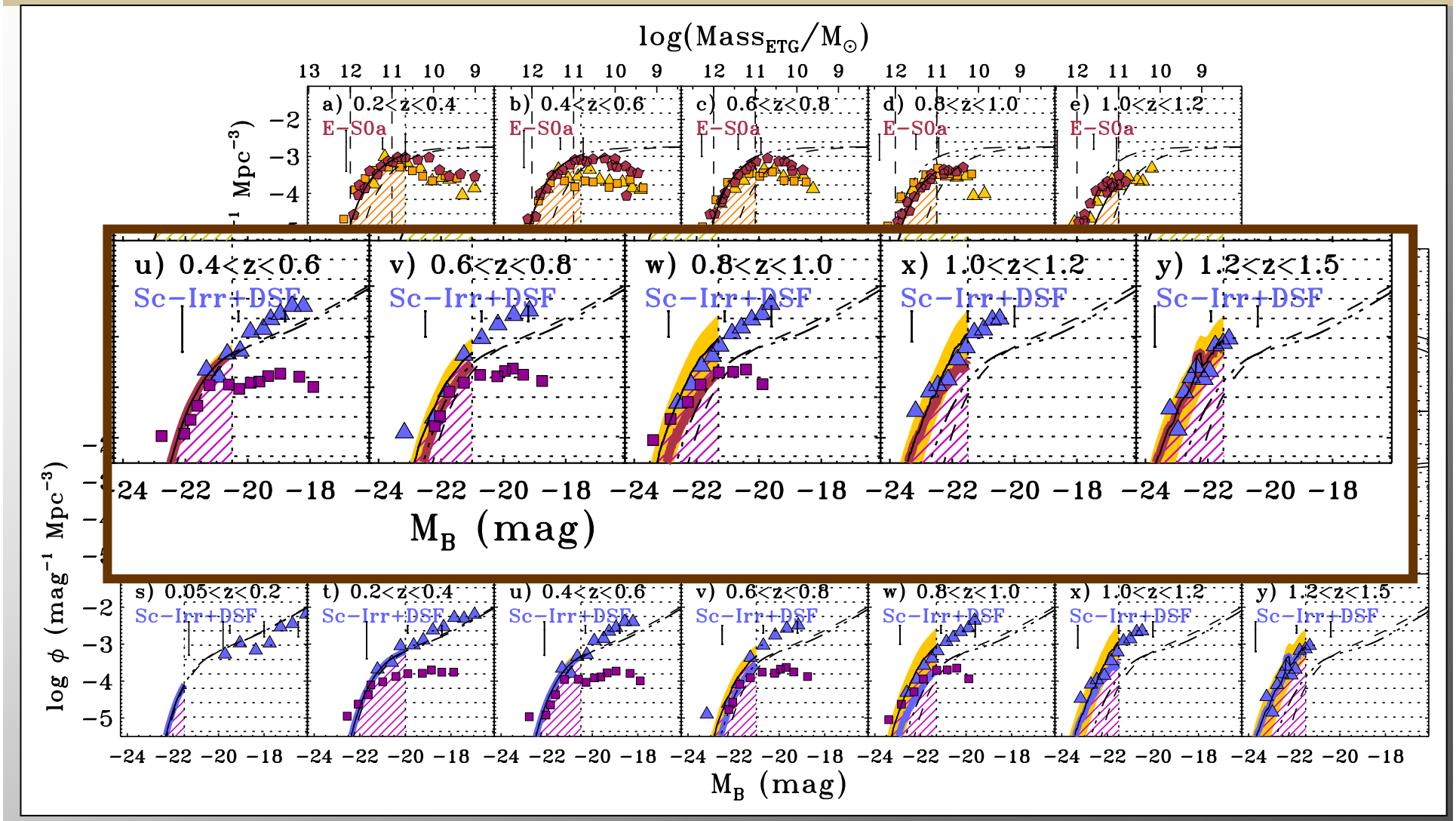
time — 1 Sc-Irr / 1ETG — 1 DSF / 1ETG — 1 DSF — 1ETG

Dry merger

time — 2ETGs — 2ETGs — 1ETG — 1ETG

III- Results:

B-band LFs by morphology up to z~1



III- Results:

Comparison to observations