Too few to be relevant: major merger statistics in $0 < z < 1$

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Galaxy Evolution: Emerging inshigts and future challenges

Austin, 12 November 2008

GALAXY ORIGINS & YOUNG ASSEMBLY

OUTLINE

- Introduction
- Morphological fractions: methodology
- Results: early-type, late-type, and merger fraction evolution
- Conclusions

INTRODUCTION

SRF has its maximum
e.g., Hopkins 2004

SRF decreases ← Galaxies become red

Irregular/peculiar galaxies are common
Conselice et al. 2005; Cassata er al. 2005

Hubble types are well stablished ← Galaxies have bulges and disks

$z \sim 1 - 1.5$

The relative importance of major mergers in the morphological evolution of galaxies since z = 1 is still unclear

Naab et al. 1999

Le Fèvre et al. 2000; Patton et al. 2000, 2002, 2008; Conselice et al. 2003, 2006, 2008; Lin et al. 2004, 2008; Bundy et al. 2004; Lavery et al. 2004; De Propris et al. 2005, 2007; Bell et al. 2006; Kartaltepe et al. 2007; Bridge et al. 2007, Kampczyk et al. 2007; Hsieh et al. 2008; Rawat et al. 2008; Lotz et al. 2008; Ryan Jr. et al. 2008; Jogee et al. 2008

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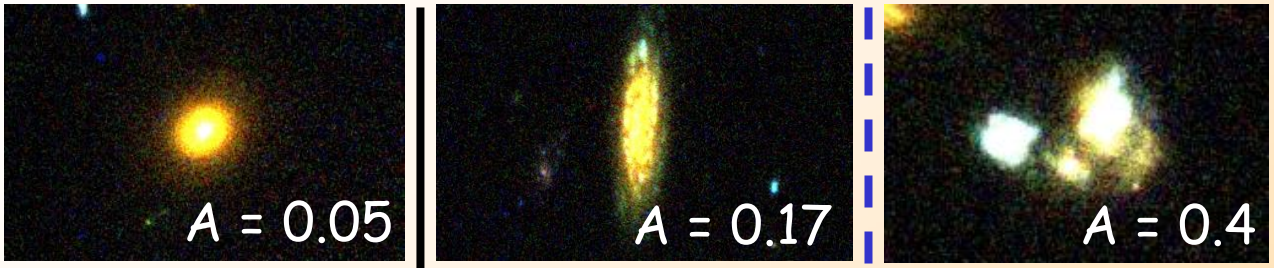
METHODOLOGY

Asymmetry as merger indicator

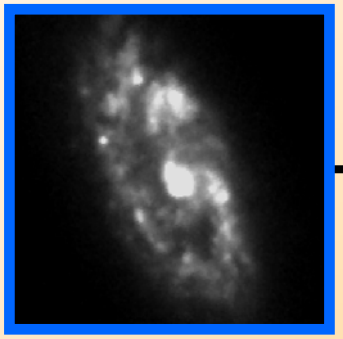


(Abraham et al. 1996)

A > 0.35

Major mergers
(Conselice 2003)

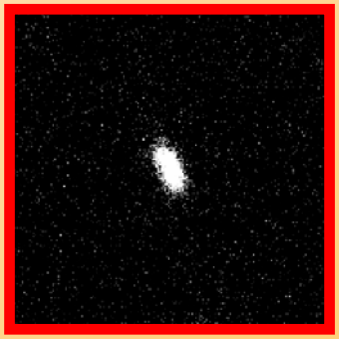
Spatial resolution decreases and cosmological dimming
→ Asymmetry depends on redshift
(Conselice 2003, Cassata et al. 2005)



z = 0.2

Artificially redshifted

COSMOPACK
(Balcells et al. 2003)



z = 1

A > 0.30

Major mergers
(GOODS-S)

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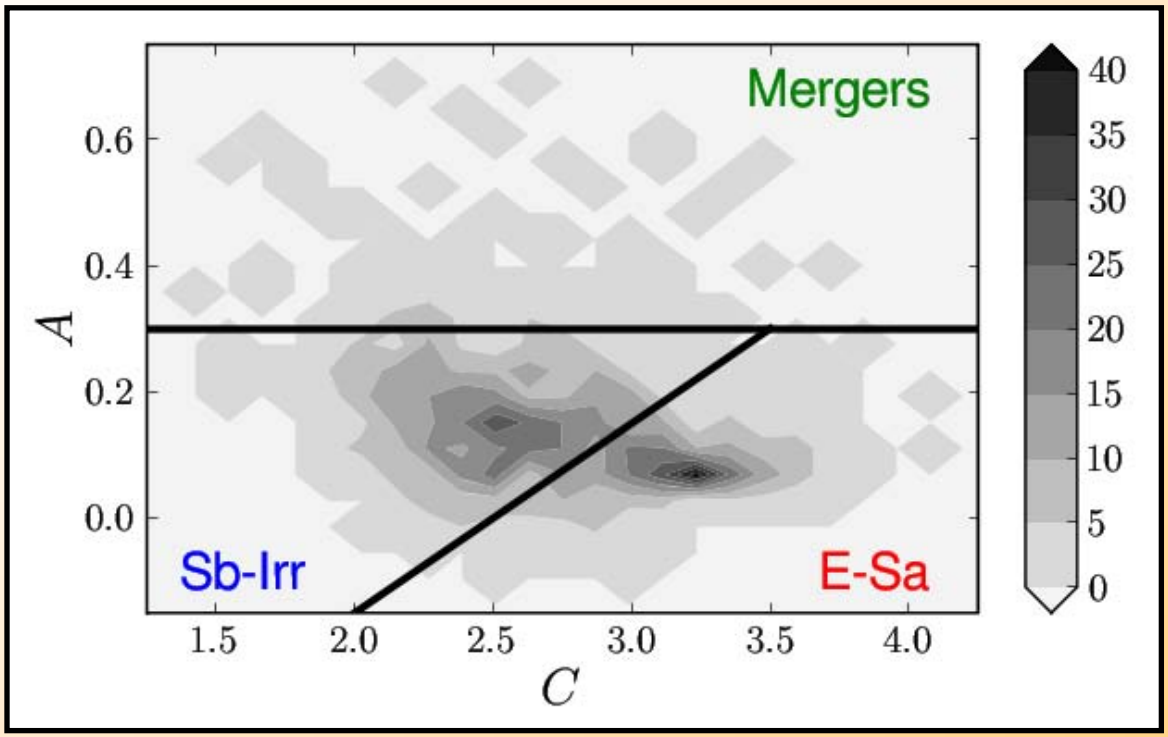
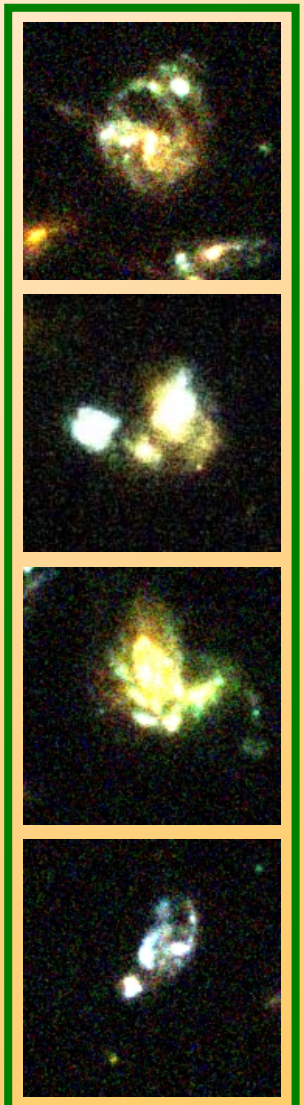
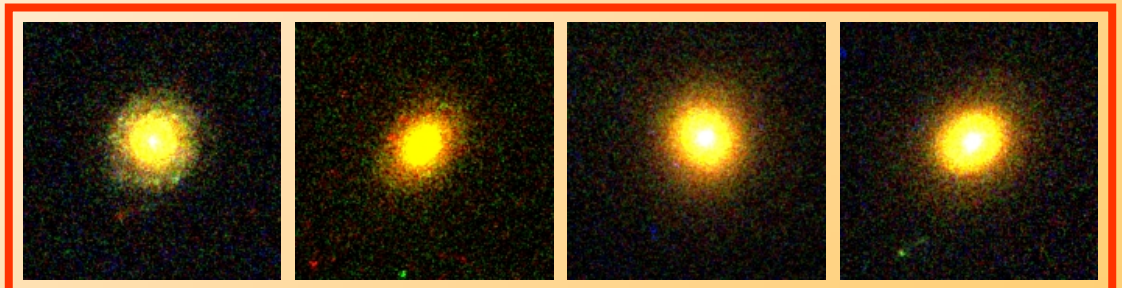
METHODOLOGY

C-A plane bimodality







METHODOLOGY

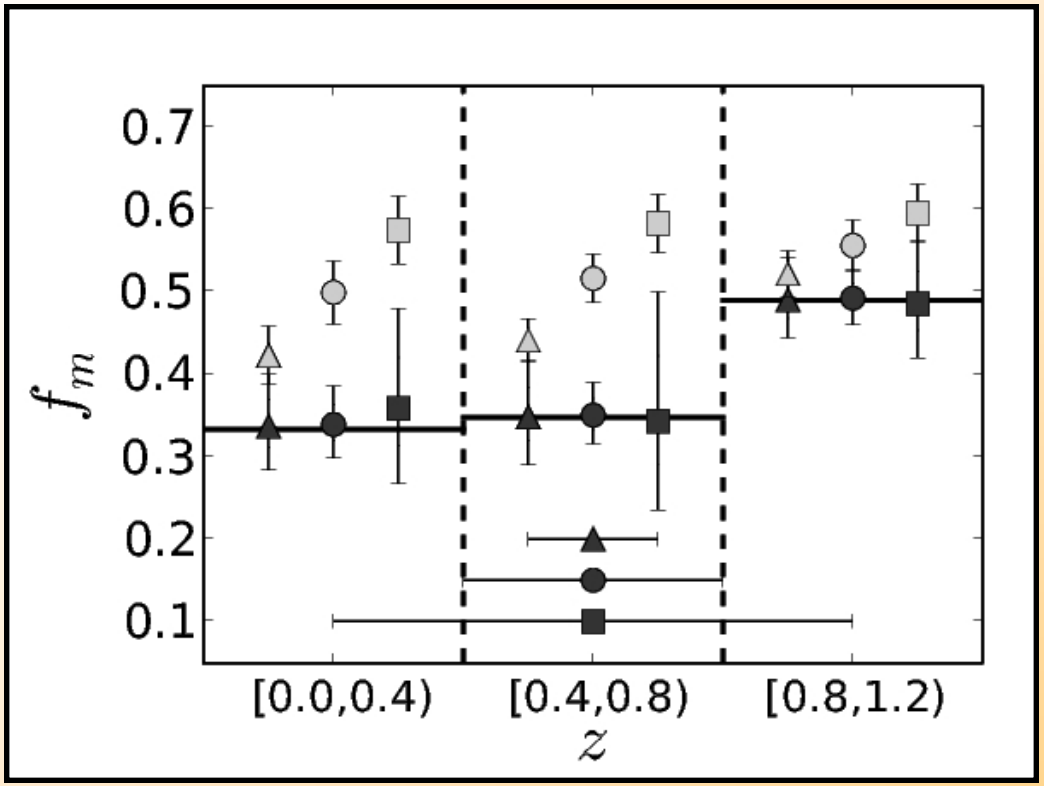
Experimental errors effect

We have: $z_i, A_i, \sigma_{z,i}, \sigma_{A,i}$

We want to know: f

→ Maximum likelihood techniques

(García-Dabó, C.E. 2002)



López-Sanjuan, C., García-Dabó, C.E. & Balcells. M. 2008, PASP, 120, 571

Observational errors tend to overestimate the merger fraction in observational samples

$$\Delta f_{\mathrm{m}} \sim 10-50\%$$

Lotz et al. 2008

López-Sanjuan et al. 2008 ApJ submitted

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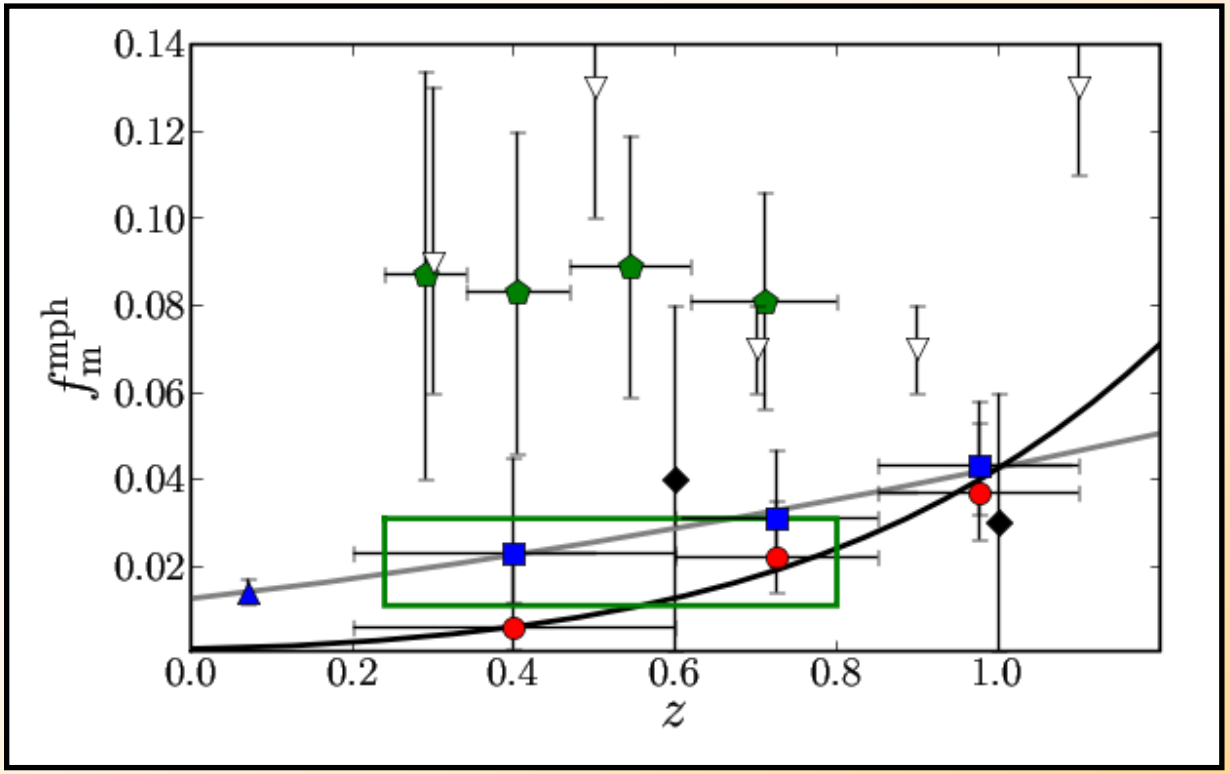
RESULTS

Major merger fractions



This work

- $M_B < -20$
- $M_\star > 10^{10}\ M_\odot$

- De Propris et al. 2007
- Lotz et al. 2008
- Conselice et al. 2008
- Jogee et al. 2008 (major + minor)

$$f_{mg}(z) = f_0(1+z)^m$$

$M_B < -20$

$f_0 = 0.012$

$m = 1.8 \pm 0.5$

$M_\star > 10^{10}\ M_\odot$

$f_0 = 0.001$

$m = 5.4 \pm 0.4$

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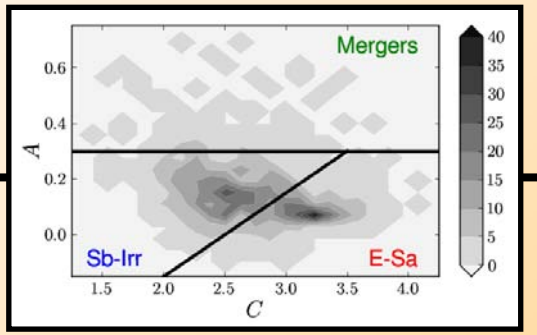
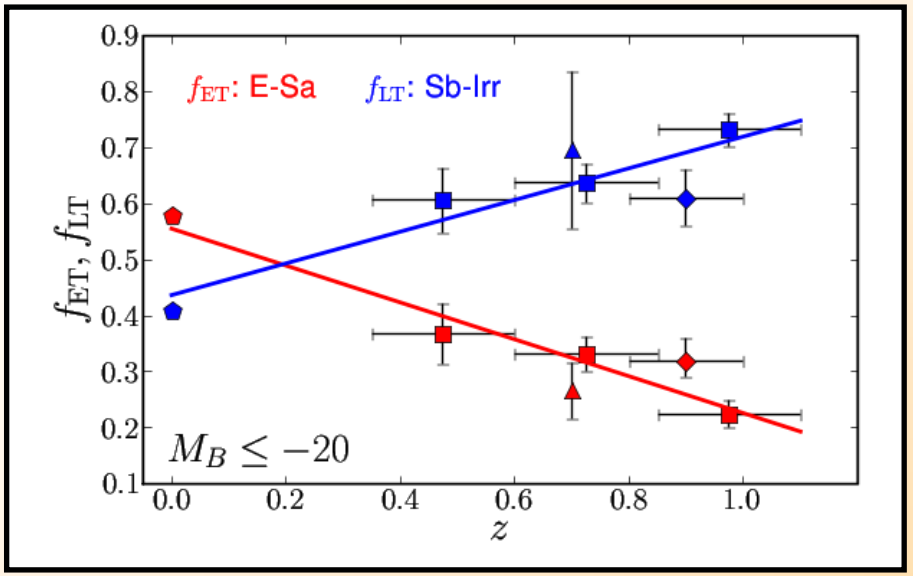
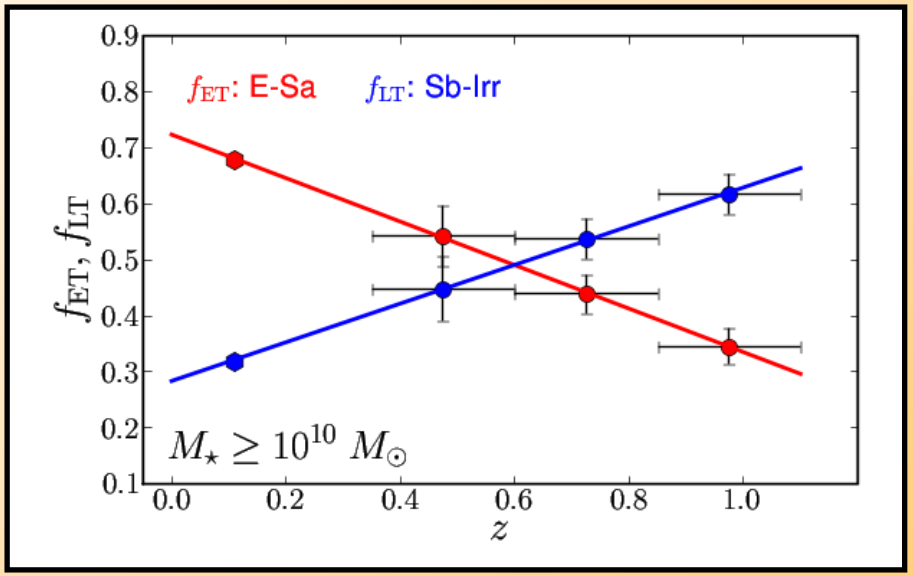
GALAXY ORIGINS & YOUNG ASSEMBLY

RESULTS

ET - LT fraction evolution







- This work
- Scarlata et al. 2007
- Lotz et al. 2008
- Conselice 2006

- This work
- Maldelbaum et al. 2006

ET fraction increase with cosmic time
ET fraction is higher in mass selected sample

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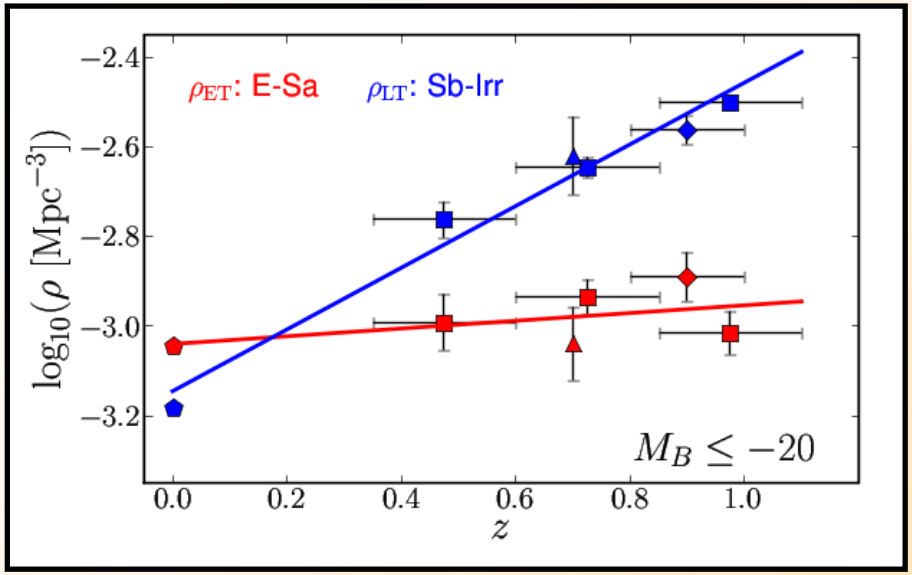
RESULTS

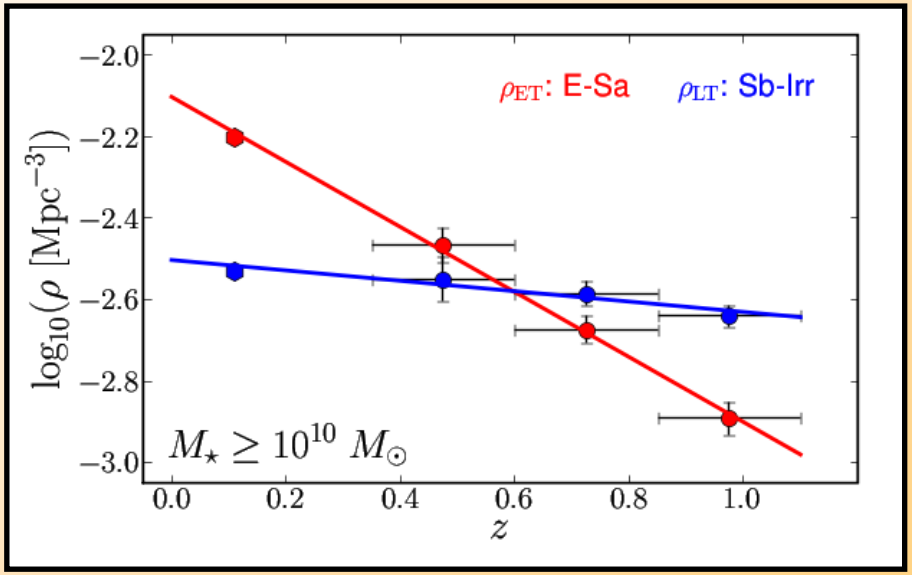
ET – LT number density evolution



Decrease in total number density is due to LT (star forming systems)

Bell et al. 2005

Robaina & Jogee's talks



Increase in total number density is due to ET

Bell et al. 2007

Bundy et al. 2005

Morphological transformation due to disk-disk major megers?

CONCLUSIONS

Morphological transformation due to disk-disk major megers?

Only 15% of new morphological early-type galaxies (E/S0/Sa) that appeared between z = 1 and 0 in the mass selected sample ($M_\star > 10^{10} M_\odot$) can be explained by disk-disk major mergers

Different processes are needed to explain the observed morphological evolution, e.g., minor mergers and secular evolution

SUMMARY

We have developed a robust methodology to determine merger fractions by morphological criteria:

1) **Artificially redshifted** of the galaxies to avoid lost of information bias.

2) **Maximum likelihood** method to take into account the observational errors, that tend to overestimate the merger fraction.

We obtained low merger fractions (lower than 6% up to z = 1).

The evolution of the merger fraction depends on tha sample: the merger index varies from **m = 1.8** for $M_B < -20$ galaxies, to **m = 5.4** for $M_\star > 10^{10}\ M_\odot$ galaxies.

The fraction of ET galaxies increase with comic time in both samples and its always higher in the mass selected sample.

The number densisty descent in the $M_B < -20$ sample is due to descent in the number density of LT, star forming galaxies, while the increase in the $M_\star > 10^{10}\ M_\odot$ sample is due to the increase of ET galaxies.

Disk-disk major mergers only can explain **15% of the new ET** that appeared since z = 1: minor mergers and secular evolution may be important processes in the morphological evolution of galaxies since z = 1.