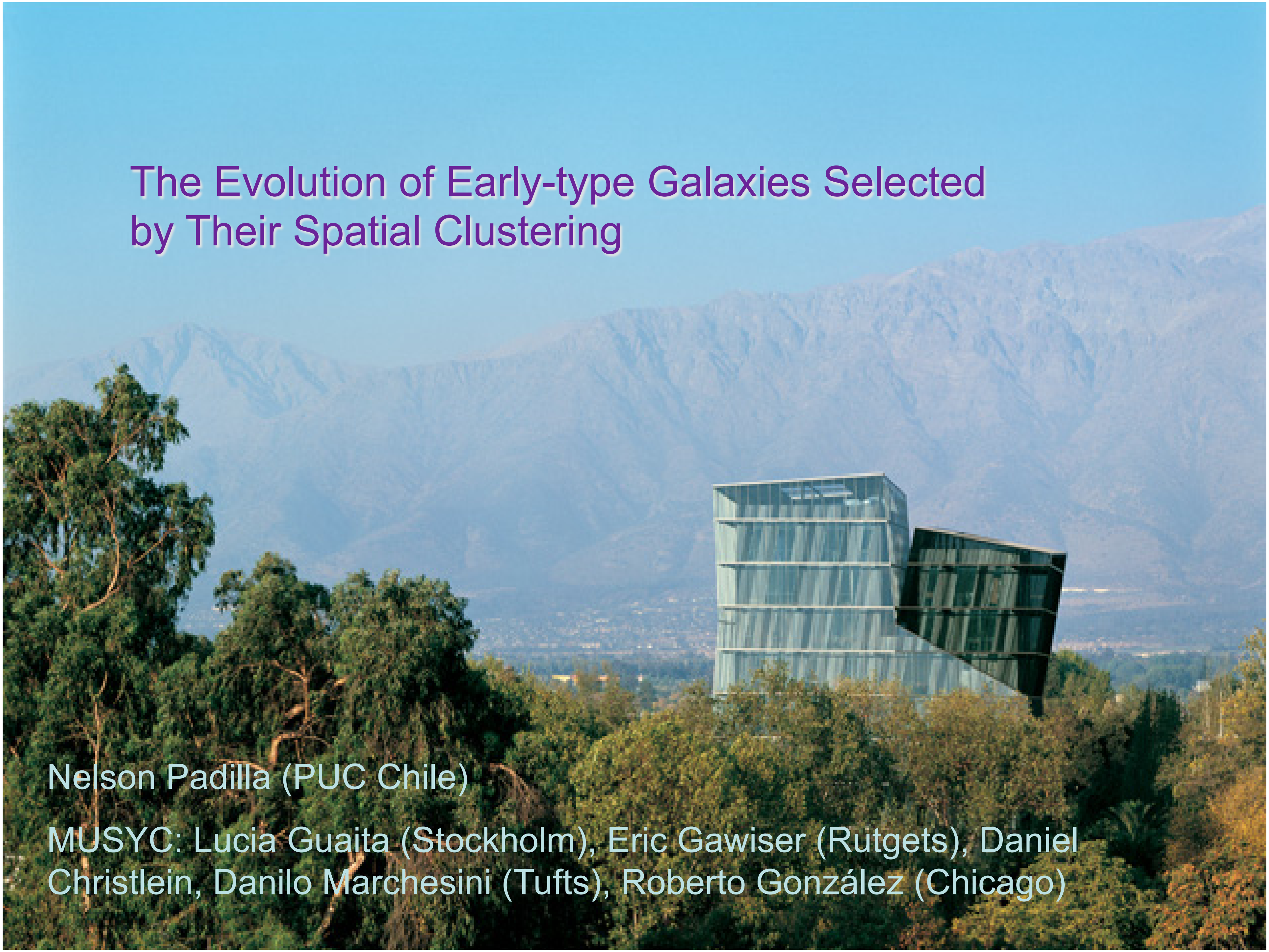
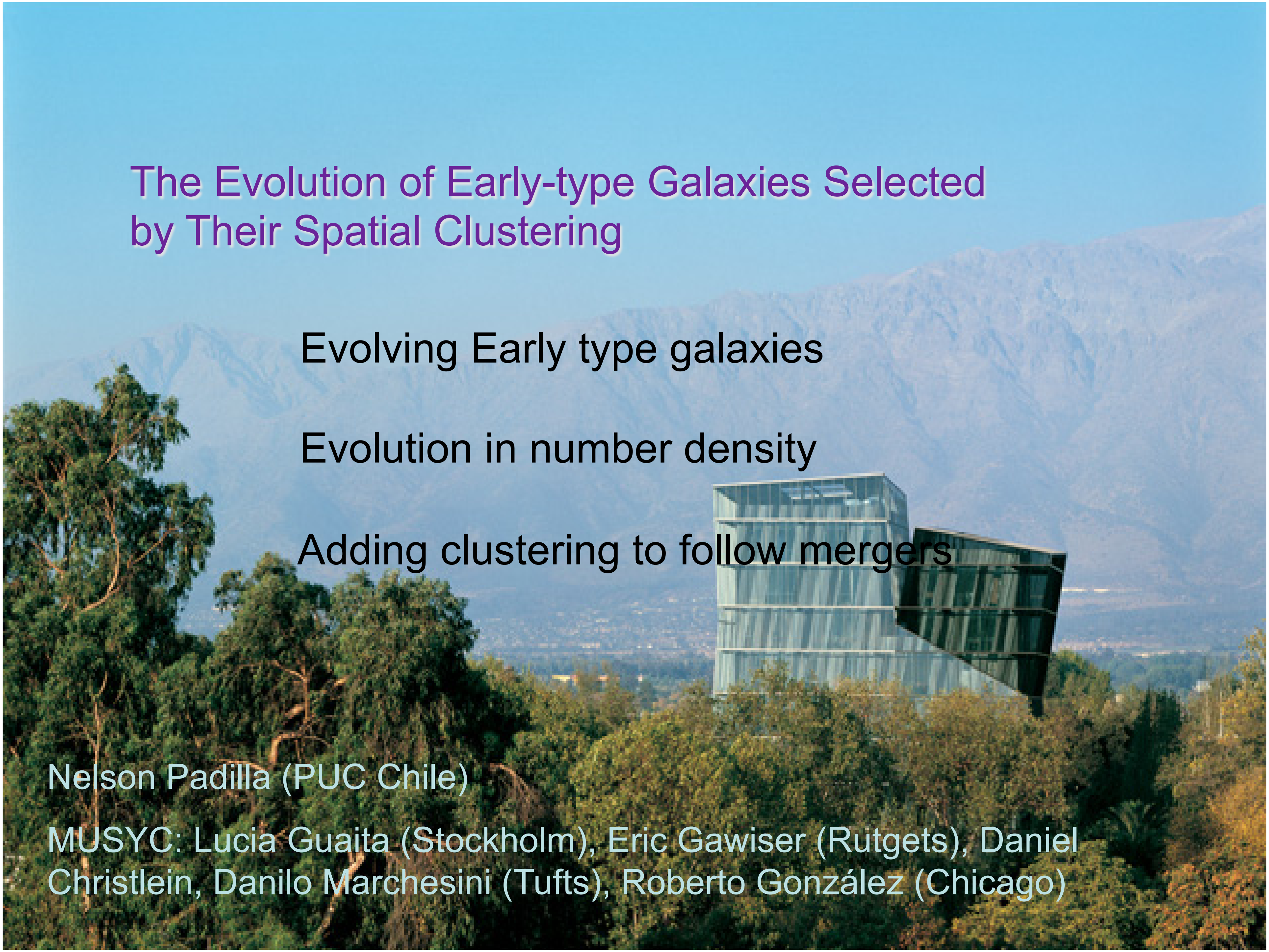


The Evolution of Early-type Galaxies Selected by Their Spatial Clustering

Nelson Padilla (PUC Chile)

MUSYC: Lucia Guaita (Stockholm), Eric Gawiser (Rutgets), Daniel Christlein, Danilo Marchesini (Tufts), Roberto González (Chicago)



The Evolution of Early-type Galaxies Selected by Their Spatial Clustering

Evolving Early type galaxies

Evolution in number density

Adding clustering to follow mergers

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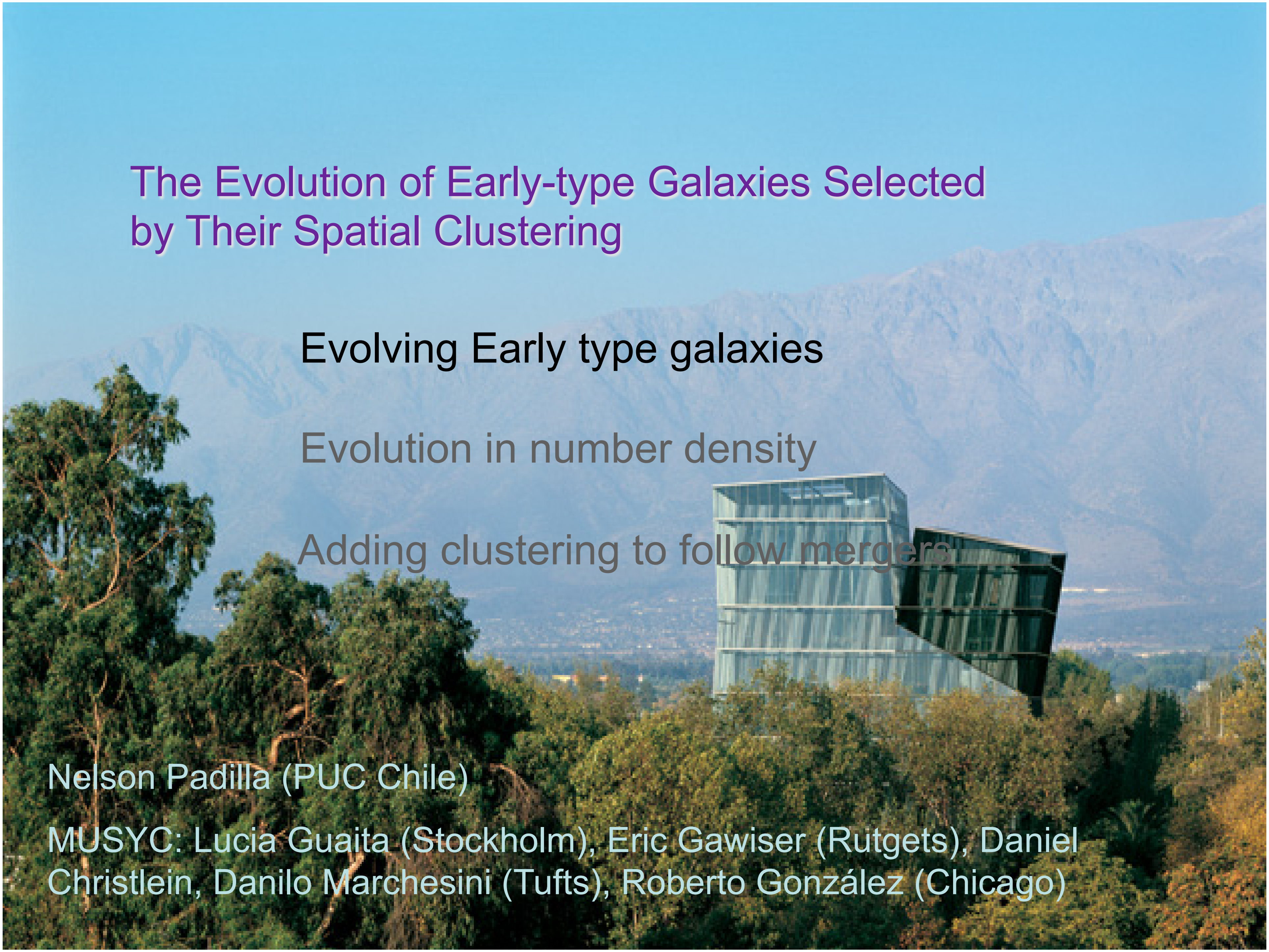

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Evolution of Early Type Galaxies (ETGs)

Why Early types?

Little or no star-formation activity leads to simple evolution recipes: aging alone (Stellar masses from passively evolved luminosities).

As hierarchical clustering progresses mergers may be expected. If gas free, larger ETGs (but it may be difficult to infer the number of mergers in a statistical way).

Selection: via red sequence, SED fitting, morphologies (difficult even at intermediate redshifts).

Mass selection: descendant samples at different redshifts?

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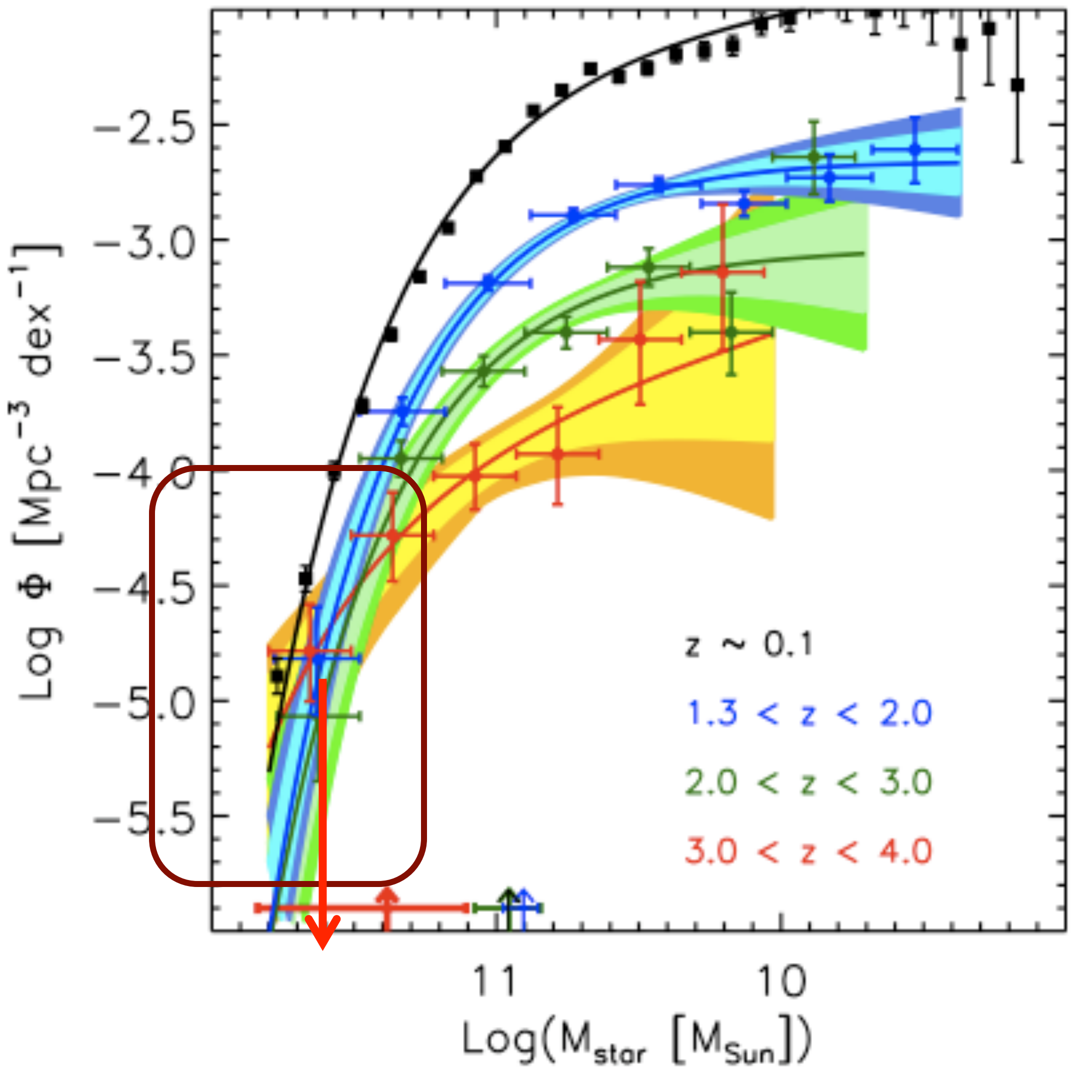
Evolution of Early Type Galaxies (ETGs)

How can we follow their evolution?

St. Mass Selection: Mass Functions

the number density of massive ETGs seemed to be fixed since very high redshifts, z~2-3 (Marchesini et al., 2009)

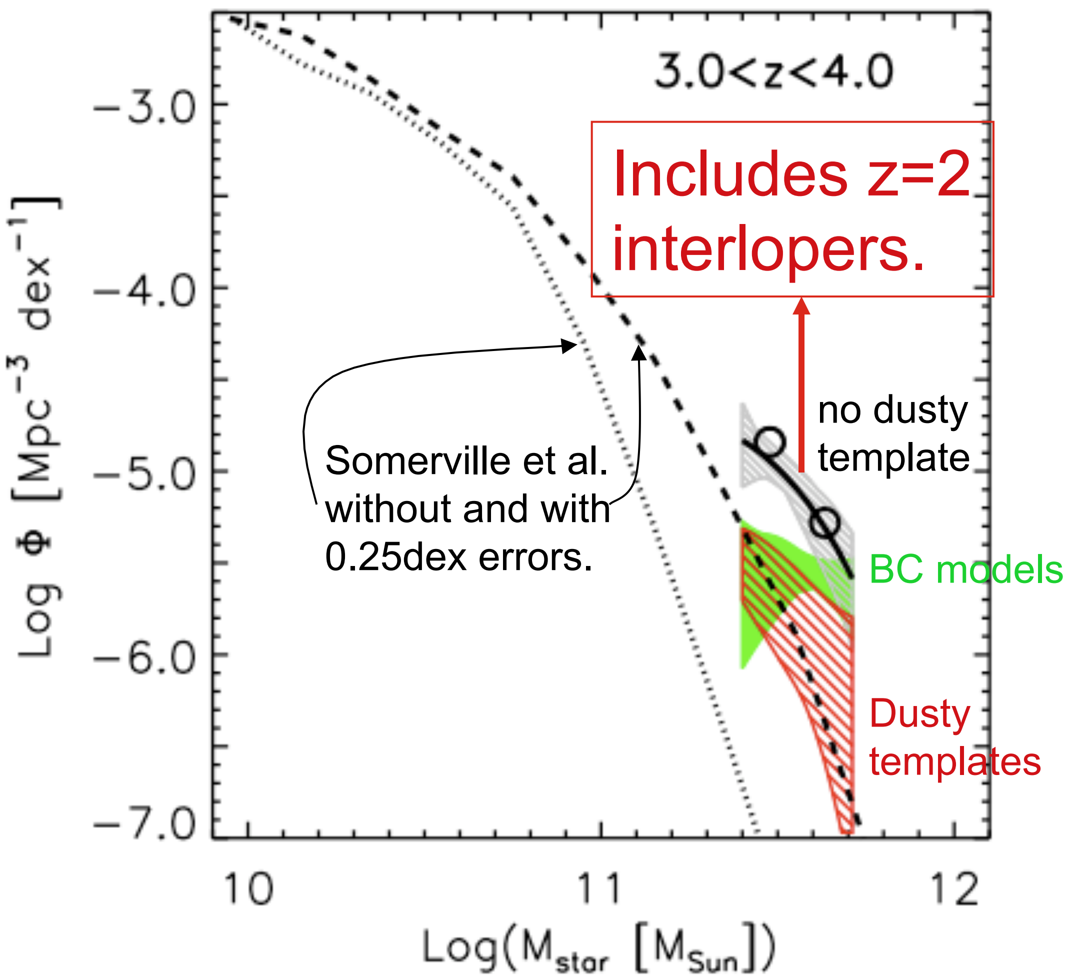


Marchesini et al. (2009)

Evolution of Early Type Galaxies (ETGs)

However,
when using mid-IR
photometry and
dusty templates
for mass-selected
elliptical
galaxies, some evolution
of the ETG number
density is found.

By including a 0.25dex
error in stellar masses,
there is agreement with
models.
(to the degree the
uncertainties allow)



NEWFIRM Medium Band Survey
Marchesini et al. (2010)
Ok with models at high-z (Simon´s talk)

Padilla et al., 2010, MNRAS, 409, 184

Descendants of Early Type Galaxies (ETGs) at lower redshifts

Choose ETGs (via photometry and similarity to ETG templates) with similar evolved luminosities even if *it is possible they aren´t* the same evolving population at different redshifts.

Evolve the luminosities to z=0 using empirical or model passive luminosity dimming (i.e. from the evolution of the Fundamental Plane of cluster ETGs).

Compare them to z=0 galaxies in the same rest-frame band.

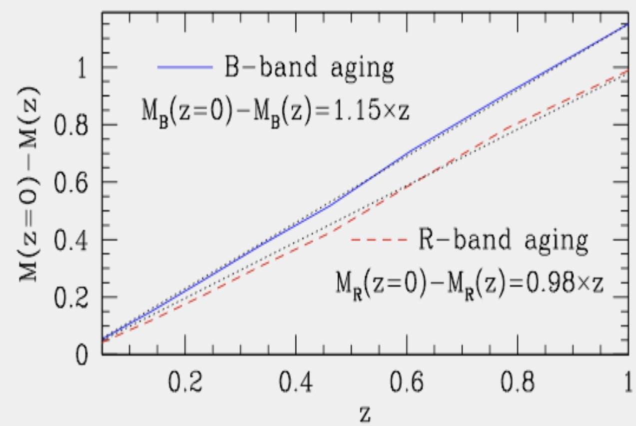


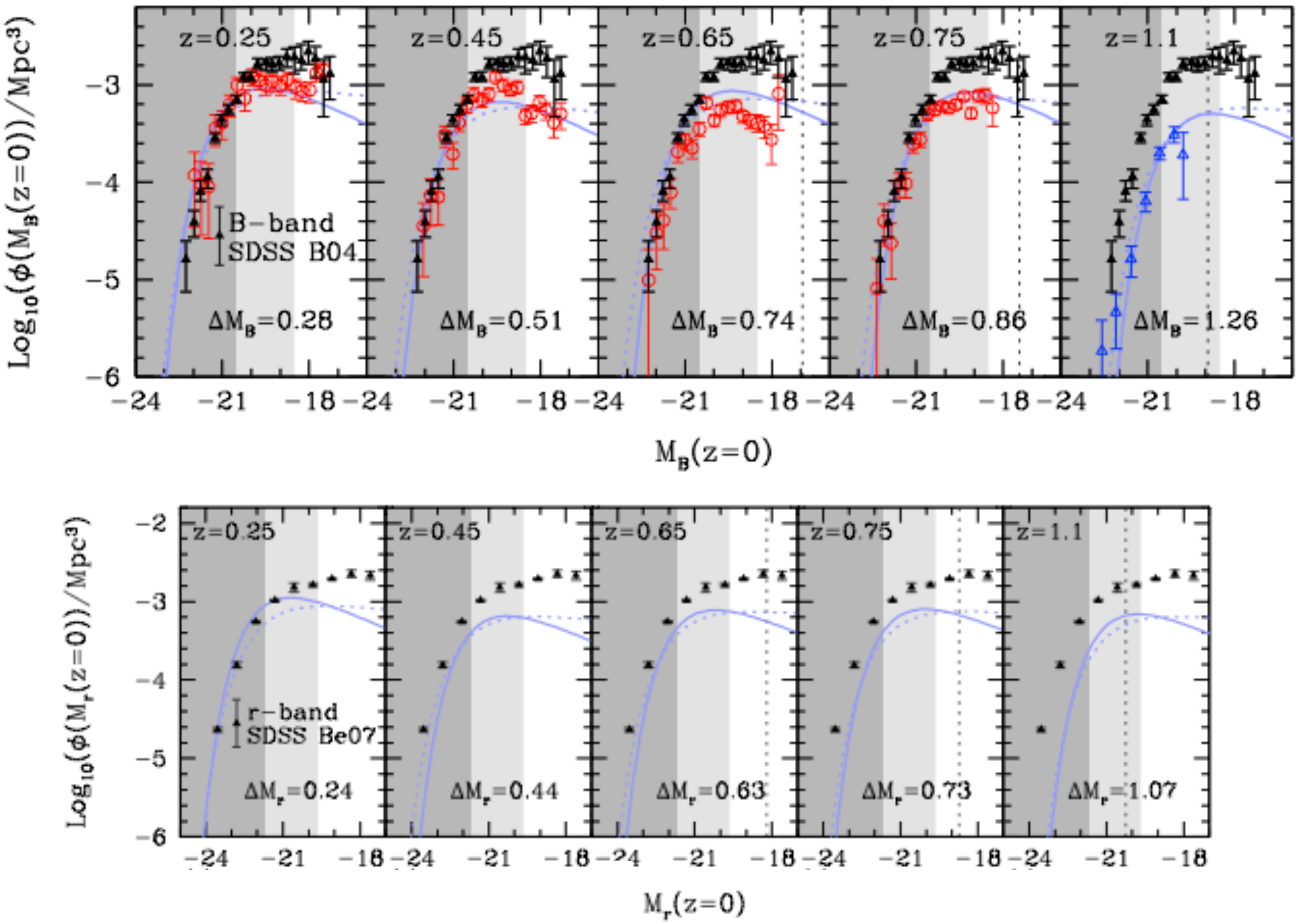
Figure 3. Variation in the absolute magnitude of a SSP (3.5Gyr old at $z = 1$) as a function of redshift, in the B- and R-band (solid and dashed lines, respectively). The dotted lines correspond to the fits indicated in the figure key. The upper line shows the recipe adopted by Cimatti et al. for the B-band, the lower dotted line shows the best fit to the evolution of the SSP in the R-band.

Study the evolution of this population using early type LF measurements from z=1 to z=0.

e.g.: di Serego Alighieri et al. (2005)

SDSS DEEP2 Combo17

MUSYC ECDF-S (Christlein et al., 2009, MNRAS, 400, 429)

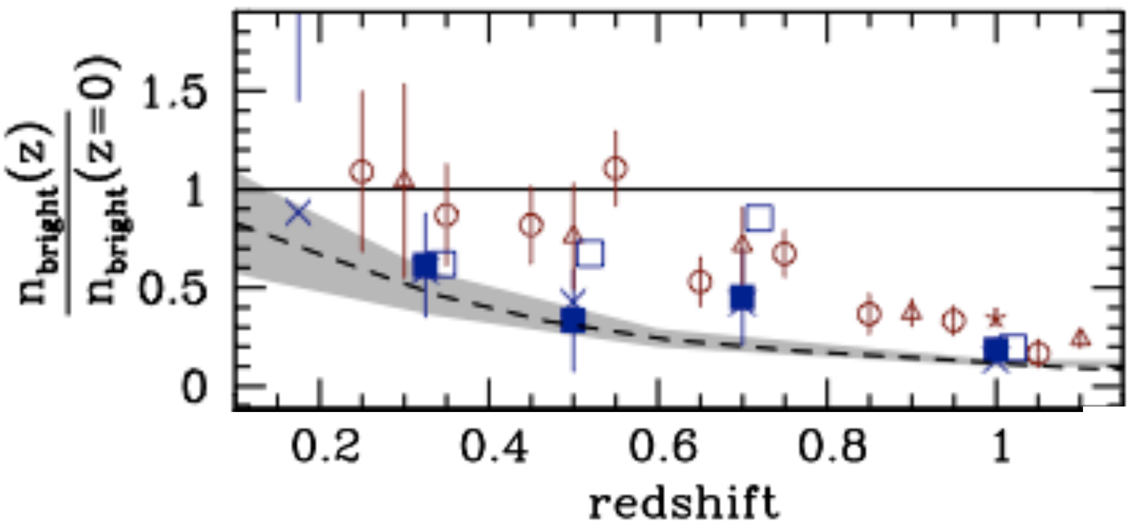


M_B and M_r are passively evolved luminosities -> stellar mass

Padilla et al., 2011, A&A, 531, 142.

Ratios between number density of bright galaxies to the z=0 values, for

COMBO17 SXDF DEEP2 MUSYC



Dashed lines: expected evolution in ΛCDM (De Lucia et al., 2006) shown as an example of evolution in a SAM.

Ratio shows some evolution, also consistent with SAM models.

But, are mass-selected samples related in a parent/descendant way?

The Evolution of Early-type Galaxies Selected by Their Spatial Clustering

Evolving Early type galaxies

Evolution in number density from MUSYC

Adding clustering to follow mergers

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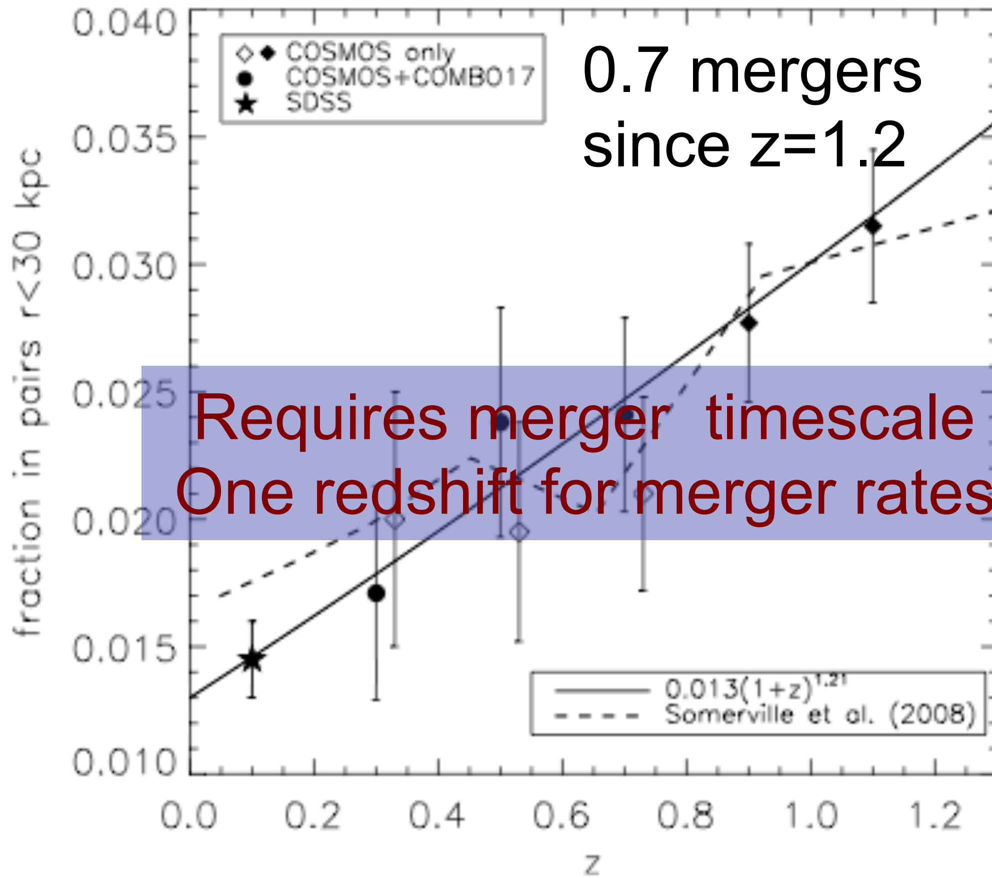
Clustering: correlation functions or pair counts

Mass selection
plus Correlation
Functions:
Count Pairs

the fraction of galaxies in close groups can be used to infer number of mergers.

Robaina et al. (2010)
for mass selected samples (M>5e10Msun)
use the fraction of pairs
(COSMOS, COMBO-17)

$$P(r \leqslant r_f) = \int_0^{r_f} n[1+\xi(r)]dV.$$



0.7 mergers since z=1.2

Requires merger timescale
One redshift for merger rates

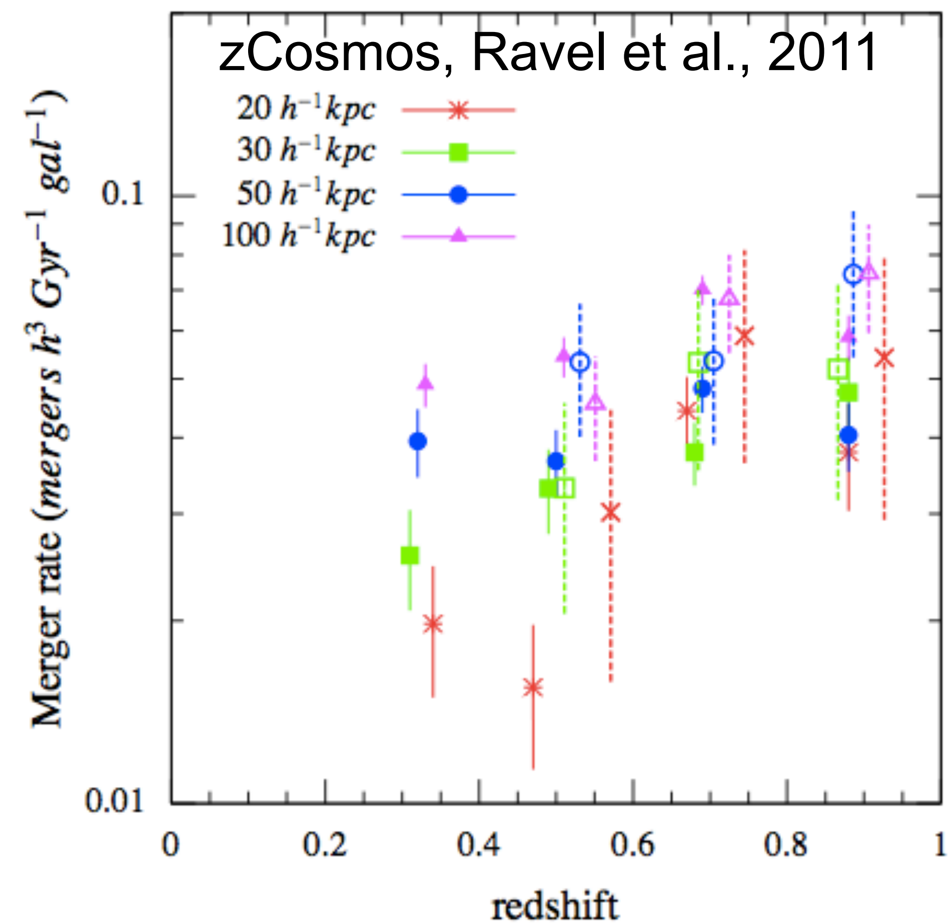
Proving mass-selected samples are not related in a parent/descendant way.

See also Patton et al. 2000; Le Fevre et al. 2000; Lin et al. 2004; Kartaltepe et al. 2007

Clustering: correlation functions or pair counts

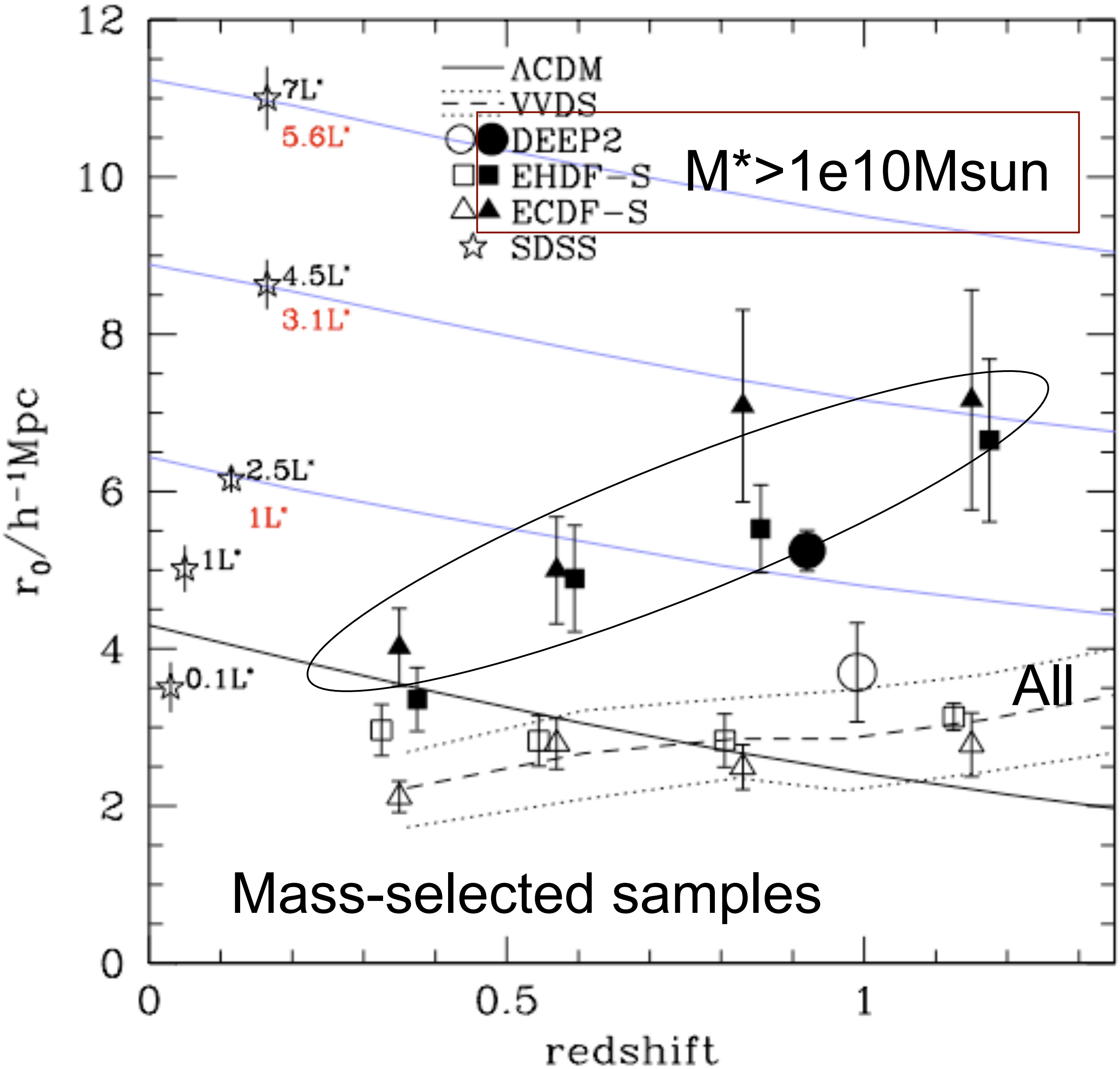
Counting pairs
in a spectroscopic
survey

Using
Millennium simulation
merger timescales



Our approach: combine clustering and mass functions

■ and ▲ :
Early-types, same stellar mass
□ and △:
All galaxies brighter than M_r=-21

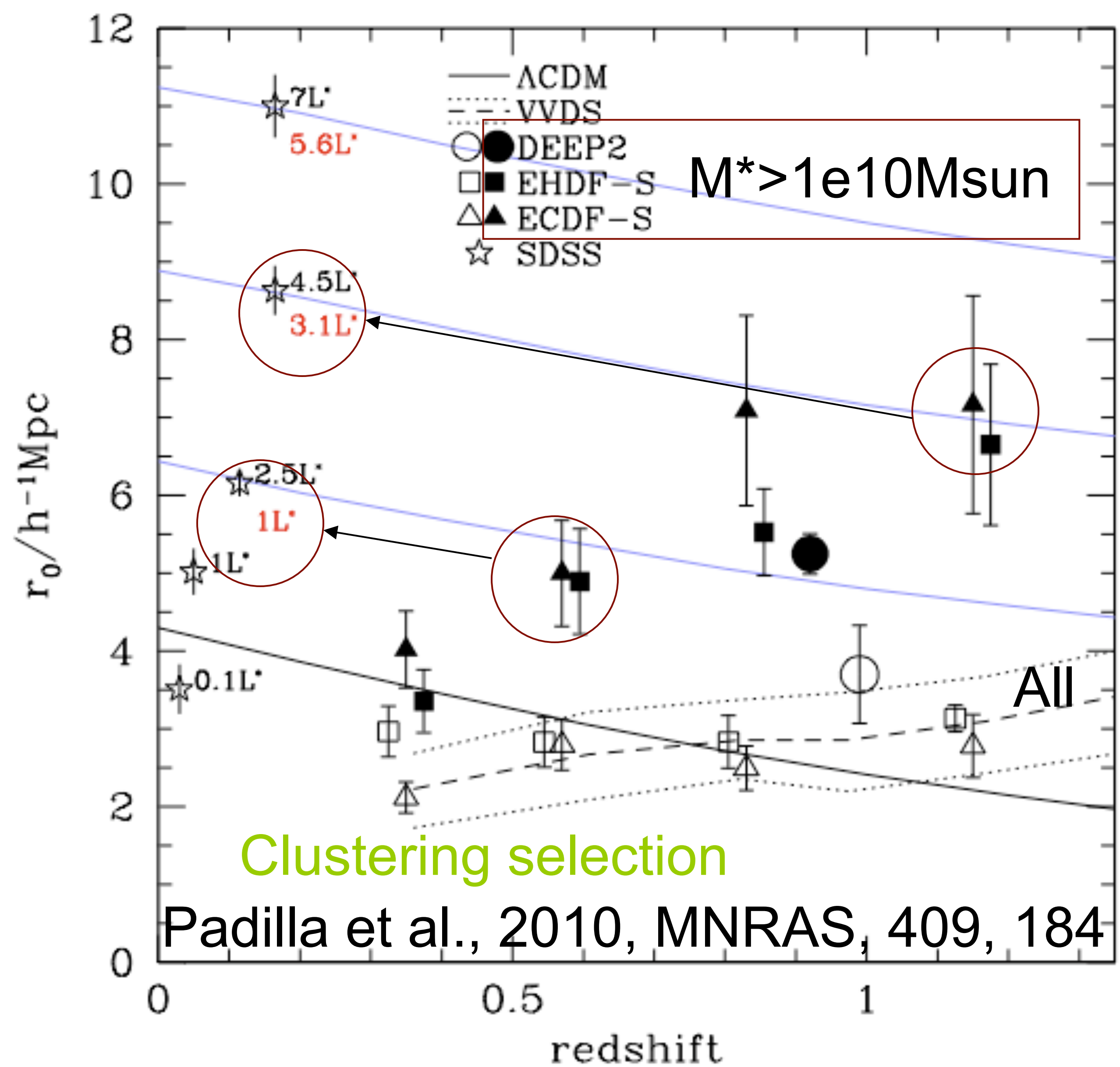


Instead of mass selection:

Selection by Clustering

■ and ▲:
Early-types, same stellar mass
□ and △:
All galaxies brighter than M_r=-21

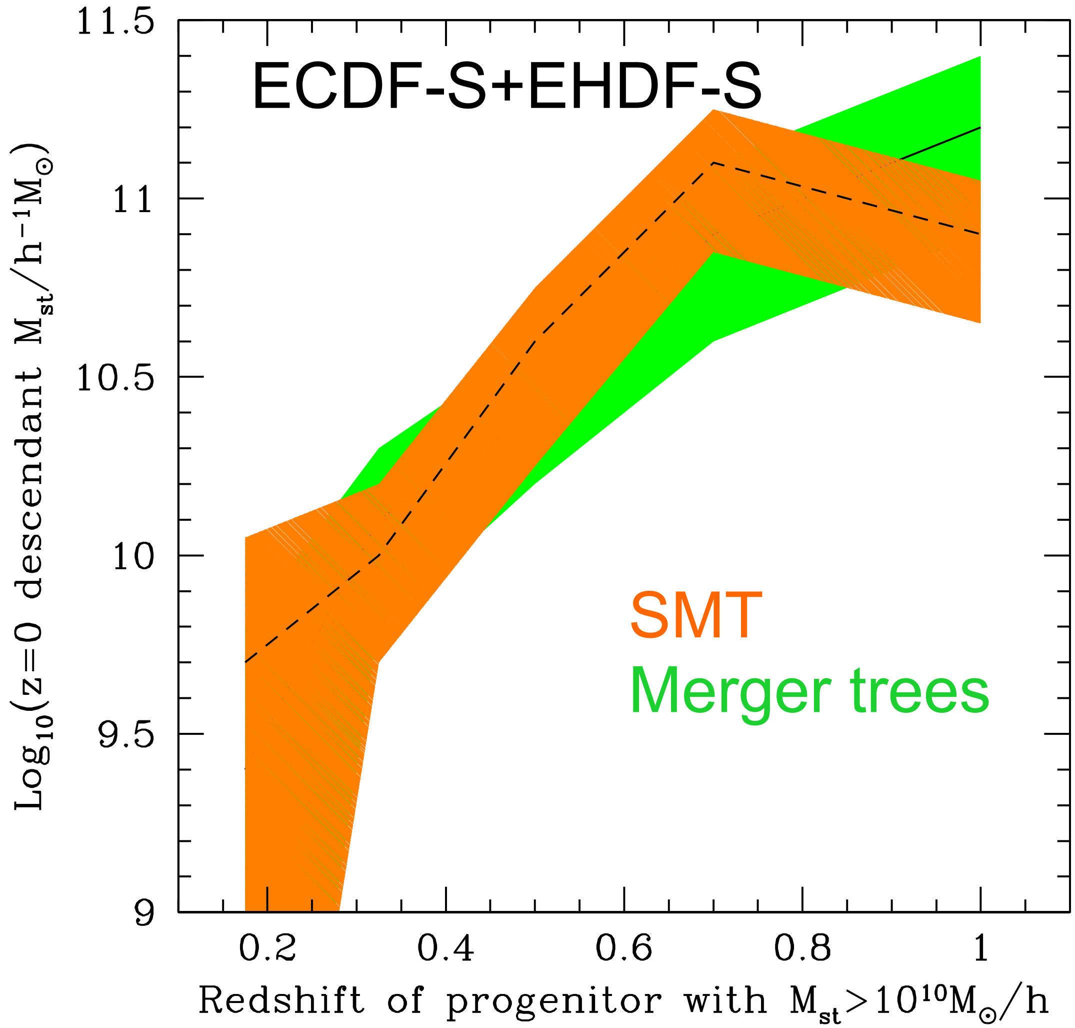
Blue lines:
Haloes followed in a numerical simulation (to help understand evolution).
Similar to assu-ming EPS-SMT



ETG descendants selected by their clustering.

MUSYC results on clustering-selected Descendant luminosities:

According to clustering measurements, ETGs of similar stellar mass would evolve to different final typical stellar masses from diffe-rent redshifts.

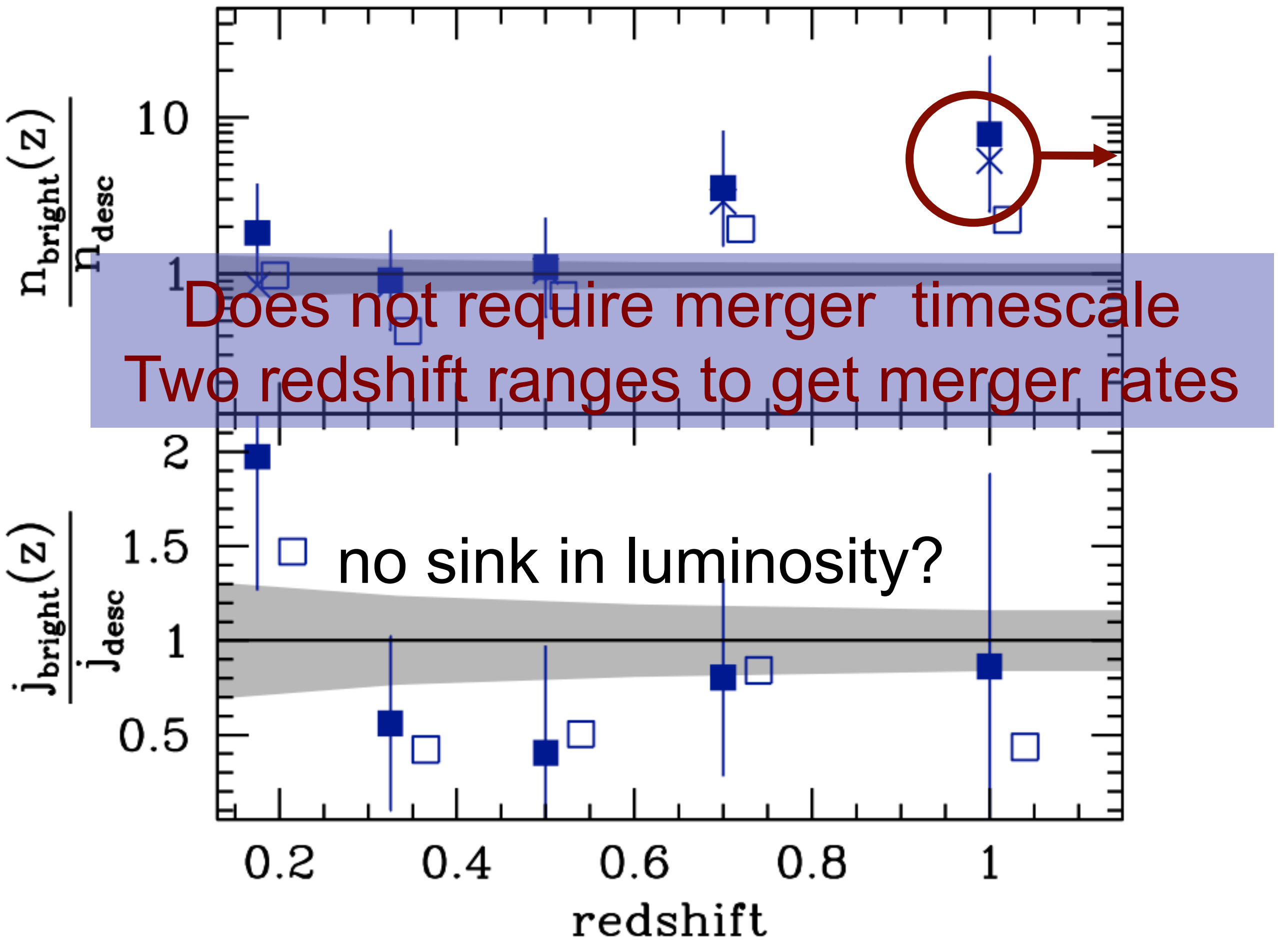


Compare space densities of progenitors and descendants

Combining with MUSYC LF measurements: ETG merger rates!

Top: Ratio of number density of clustering-selected ETGs at red-shift z, to that of their z=0 descendants

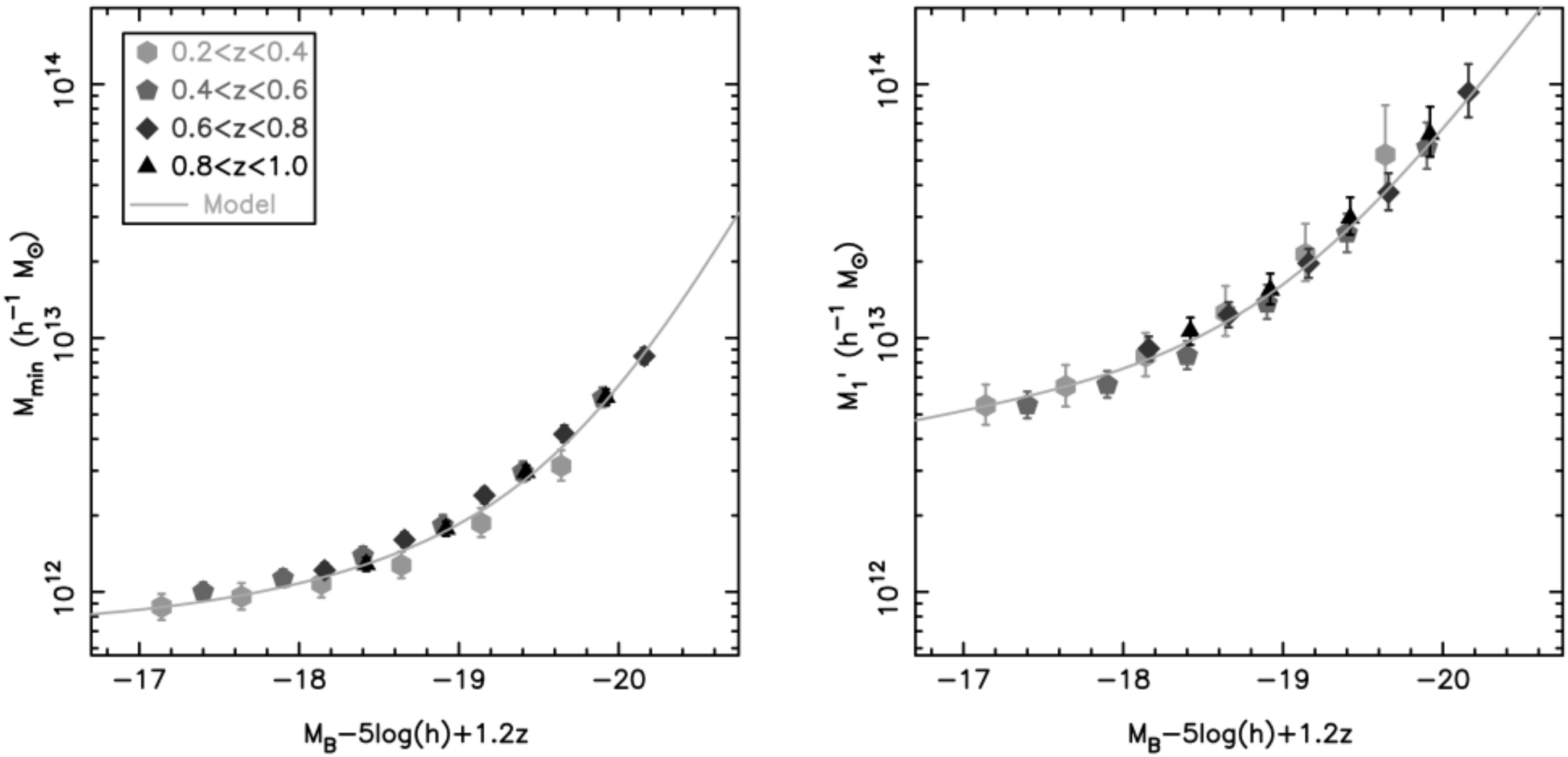
Bottom: Ratio of Luminosity density of descendants to redshift z ETGs



5.5 +- 4.0 mergers since z=1 seem to be needed. Major or minor?

Padilla et al., 2011, A&A, 531, 142

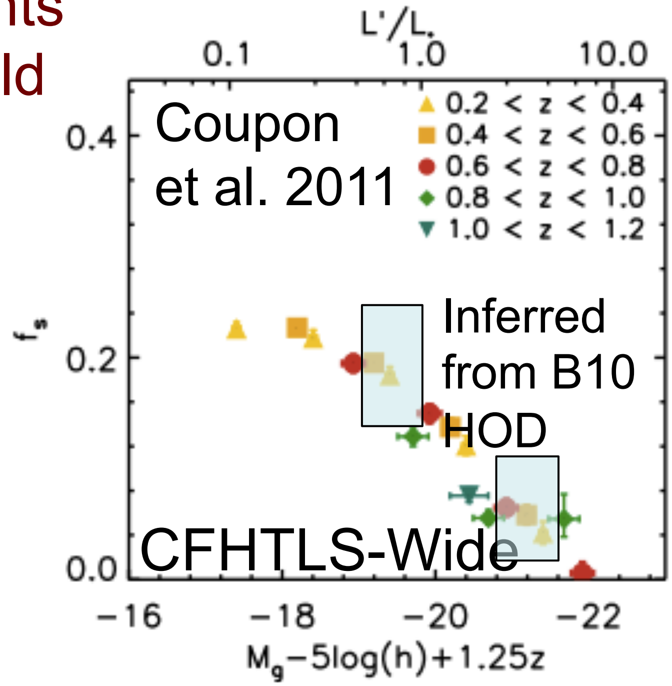
Combining with MUSYC LF measurements with universal HOD from the Boötes Field (from Brown et al, 2008, 2010)



Combining with MUSYC LF measurements with universal HOD from the Boötes Field (from Brown et al, 2008, 2010)

Padilla et al., 2011, A&A, 531, 142

Case of z=1 ETGs and their z=0 descendants.



z=1: (80±5)% are centrals

z=0: (93±4)% are centrals

Use sharp cutoffs in luminosity to separate centrals and sats:

Centrals increase their luminosity by x1.7(+2.2-0.5)

Satellites increase theirs by a factor x2.5(+1.0-1.2)

Total luminosity in progs. to that of desc. x4(+4-2) SINK? (Conroy+ 07)

Centrals decrease their num. density x4.0(±2)

Satellites decrease their num. density x10 (±7)

Combining with MUSYC LF measurements with universal HOD from the Boötes Field

Padilla et al., 2011, A&A, 531, 142

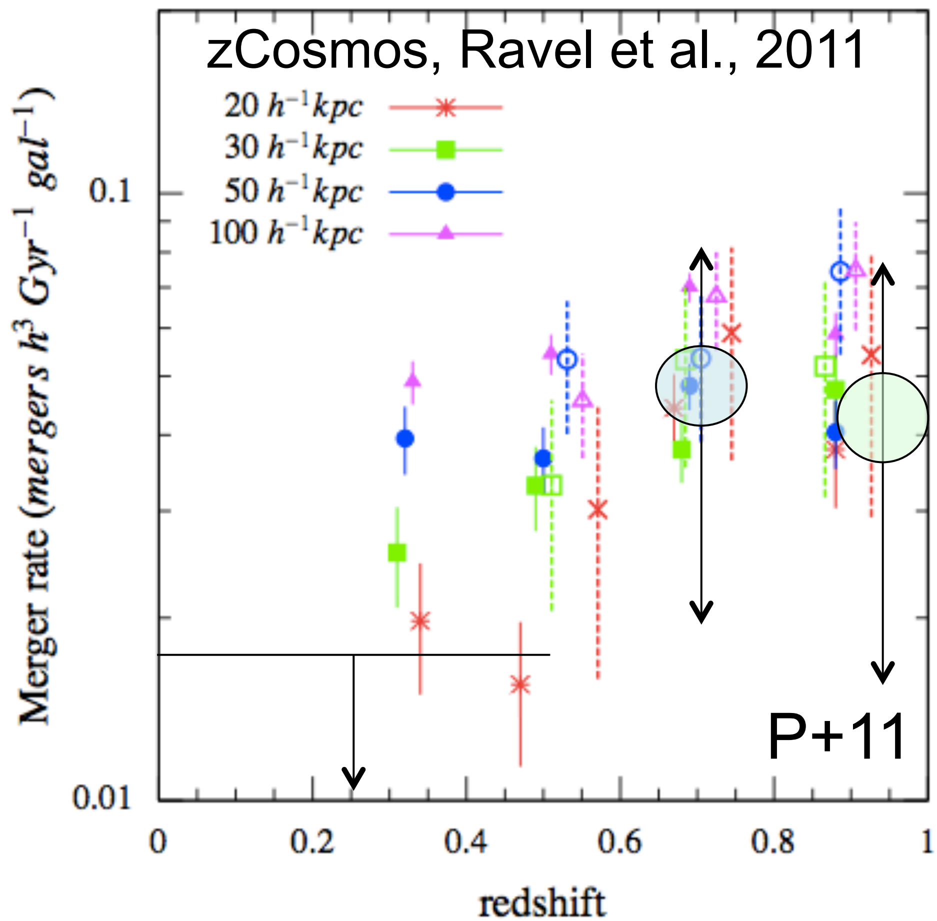
Case of z=1 ETGs and their z=0 descendants.

From an average of 4 mergers needed, only one occurs with another central galaxy (dashed).

~31% of galaxies undergo a major merger since z=1

~4% probability of Major merger/gx/Gyr.

~70% of major mergers are with another central.



Christlein et al. 2009, MNRAS, 400, 429
Padilla et al., 2010, MNRAS, 409, 184
Padilla et al., 2011, A&A, 531, 142

Conclusions

Stellar masses: using dusty templates increases the evolution of the stellar mass function since z=4,.

When using mass selection for descendants, not much disagreement between observations and models in the evolution of the number density of ETG galaxies.

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Conclusions

Clustering and LF measurements can be combined to obtain independently the relation between
progenitors and descendants (selection using clustering).

In MUSYC: Descendants of z=1 M_r<-21 clustering selected ETGs:
5.5±4.0 times rarer, equal luminosity density.

z=1 $10^{10}M_o/h$ => z=0 $10^{11}M_o/h$

Dry mergers in progenitor groups
4% of $10^{10}M_o/h$ ETGs from major merger in their last Gyr

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Christlein et al. 2009, MNRAS, 400, 429
Padilla et al., 2010, MNRAS, 409, 184
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Conclusions
Thank you

Clustering-selected samples:
studies of merger rates.

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