The progenitors of present-day early-type galaxies

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Progenitor bias

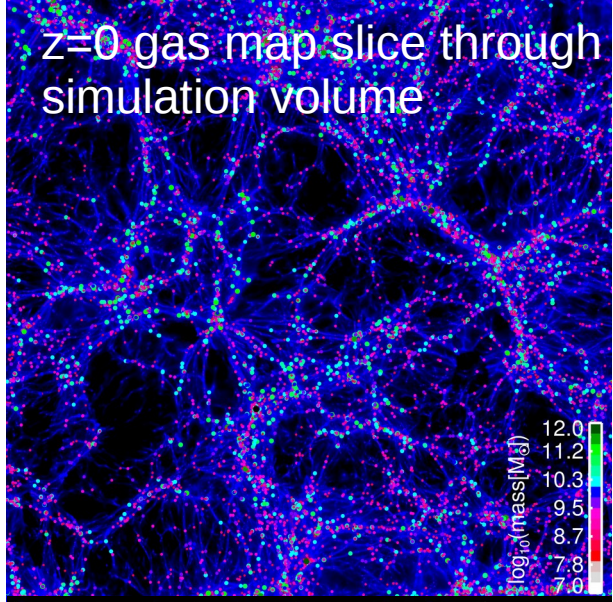
- Progenitor bias is a consequence of the morphological transformation of the late-type population over cosmic time.

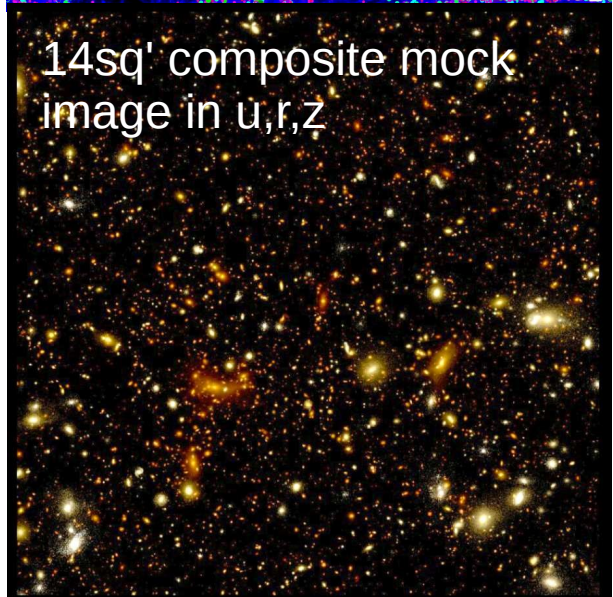
- At $z = 1$, 50% of the stellar mass found in early-type morphologies by the present-day is found in early types

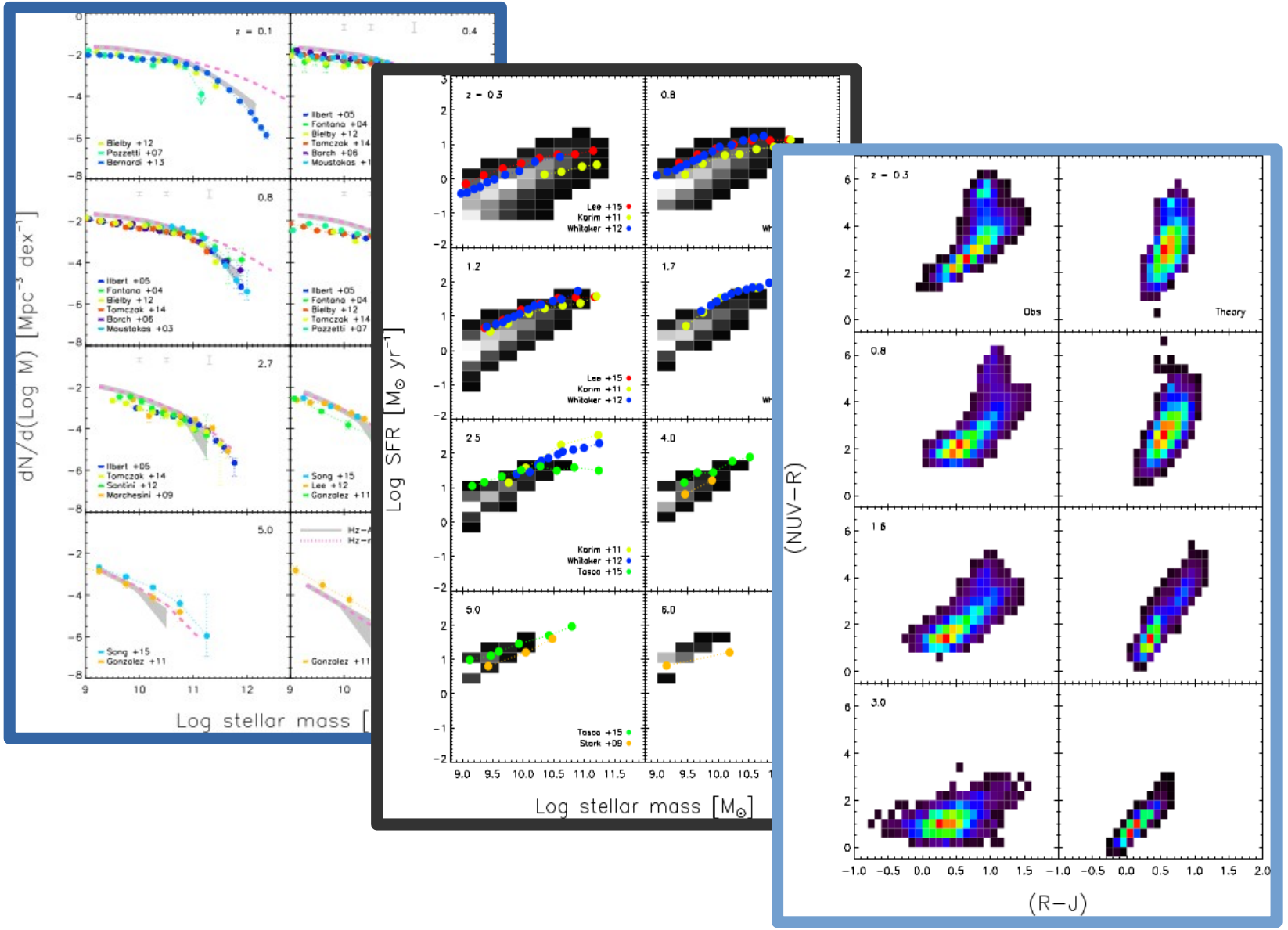
- Excluding late-types progenitors underestimates the evolution of the early-type population

Horizon-AGN

- 10 million CPU hours
- 100 CoMpc box length
- Minimum 1kpc resolution
- Cosmology corresponding to WMAP7 results (Komatsu+ 2011)
- Hz-AGN Provides good agreement with observations, (Kaviraj+16, previous talk)






z = 0.1
0.4
0.8
2.7
5.0
Bielby +12
Pozzetti +07
Bernardi +13
Ilbert +05
Fontana +04
Tomczak +14
Borch +06
Moustakas +03
Pozzetti +07
Tomczak +14
Santini +12
Marchesini +09
Song +15
Lee +12
Gonzalez +11
dN/d(Log M) [Mpc^{-3} dex^{-1}]
Log stellar mass [
z = 0.3
0.8
1.2
1.7
2.5
4.0
5.0
6.0
Lee +15
Karim +11
Whitaker +12
Tasca +15
Stark +09
Log SFR [M$_\odot$ yr^{-1}]
Log stellar mass [M$_\odot$]
Obs
Theory
1.6
3.0
(NUV−R)
(R−J)

Identifying galaxies and mergers

- **`AdaptaHOP`** structure finder identifies ~150000 galaxies per snapshot including galaxies in the process of merging

- 91 snapshots in the range $z \in [0, 7]$ in steps of ~130 Myrs

- Extract merger trees for each galaxy identified at the final time output by tracing their progenitors

- Use the merger trees to build merger histories for each of the early-type galaxies in the final time output.

Observables

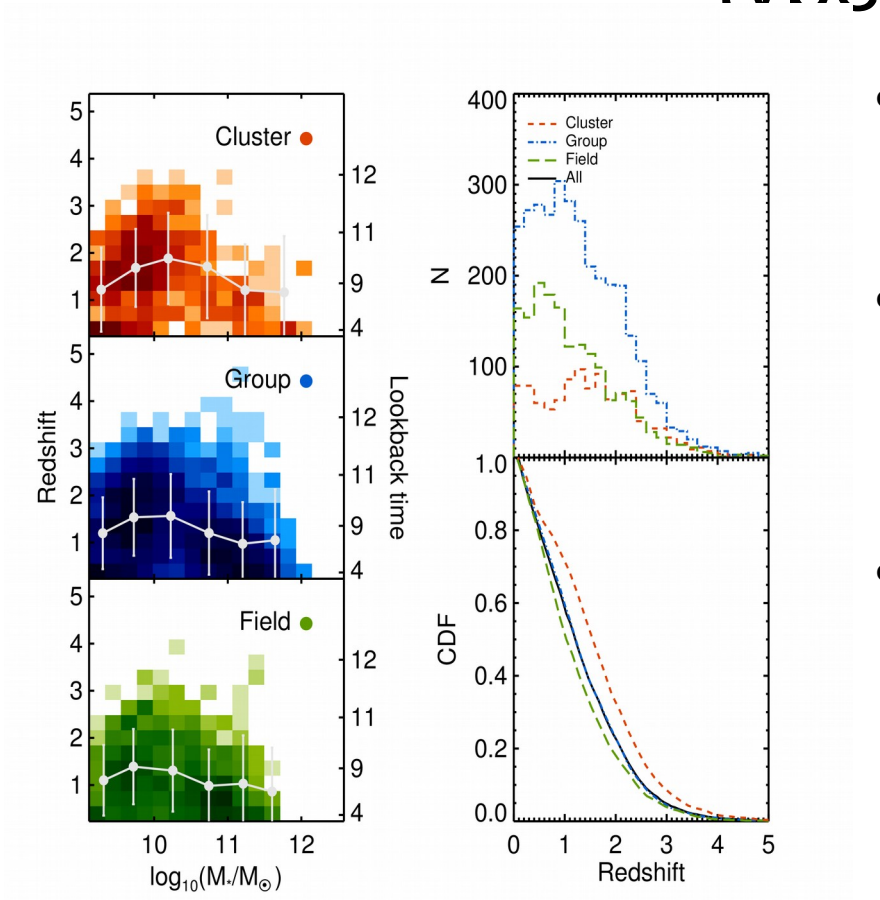
- Morphology – defined kinematically

$$V/\sigma = \frac{3\bar{V}_\theta}{\sqrt{\sigma_r^2 + \sigma_\theta^2 + \sigma_z^2}}$$

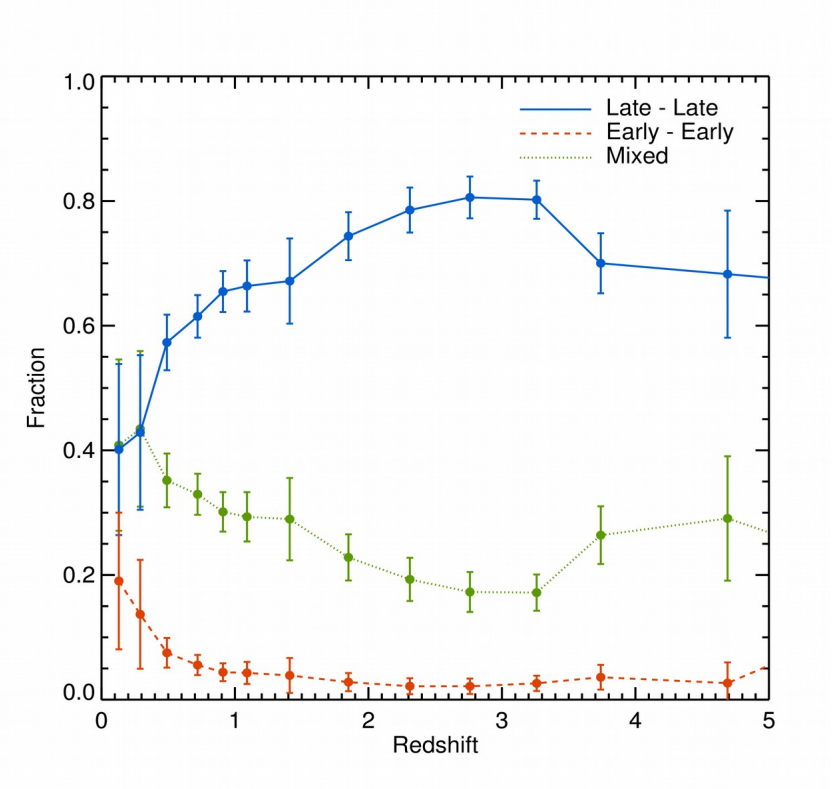
- Integrated SFR – defined by star particle formation times

- Environment – defined by the local number density

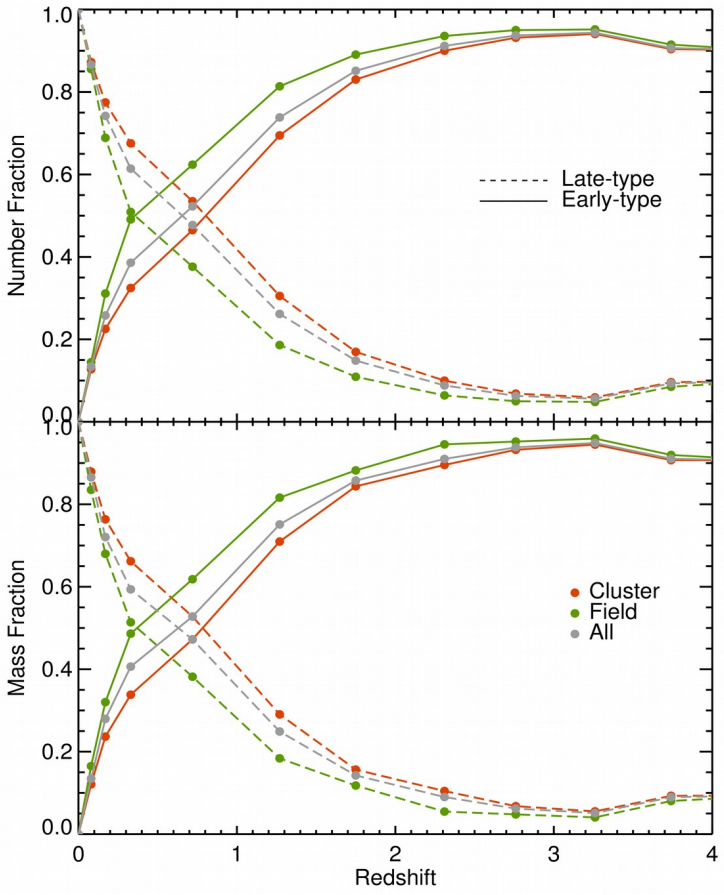
Redshift evolution of the progenitors of early-type galaxies



- Redshift of last merger <1:10
- The most massive galaxies finish assembling later on
- Galaxies in denser environments assemble earlier



- Morphology of early-type progenitors pairs undergoing binary mergers
- Few mergers occur between two galaxies of early-type morphology
- >20% at z = 0, all other mergers contain at least one early-type progenitor

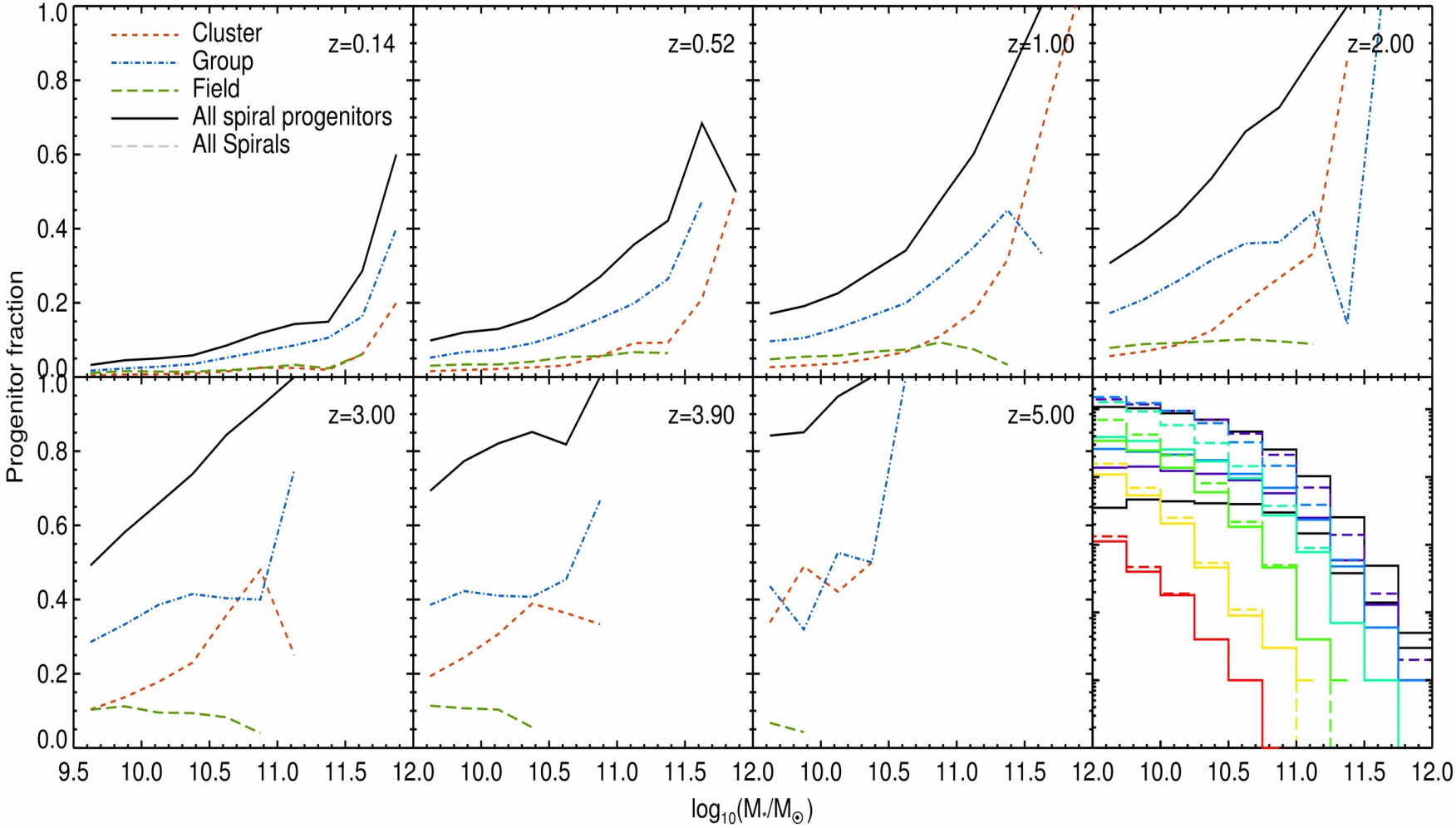


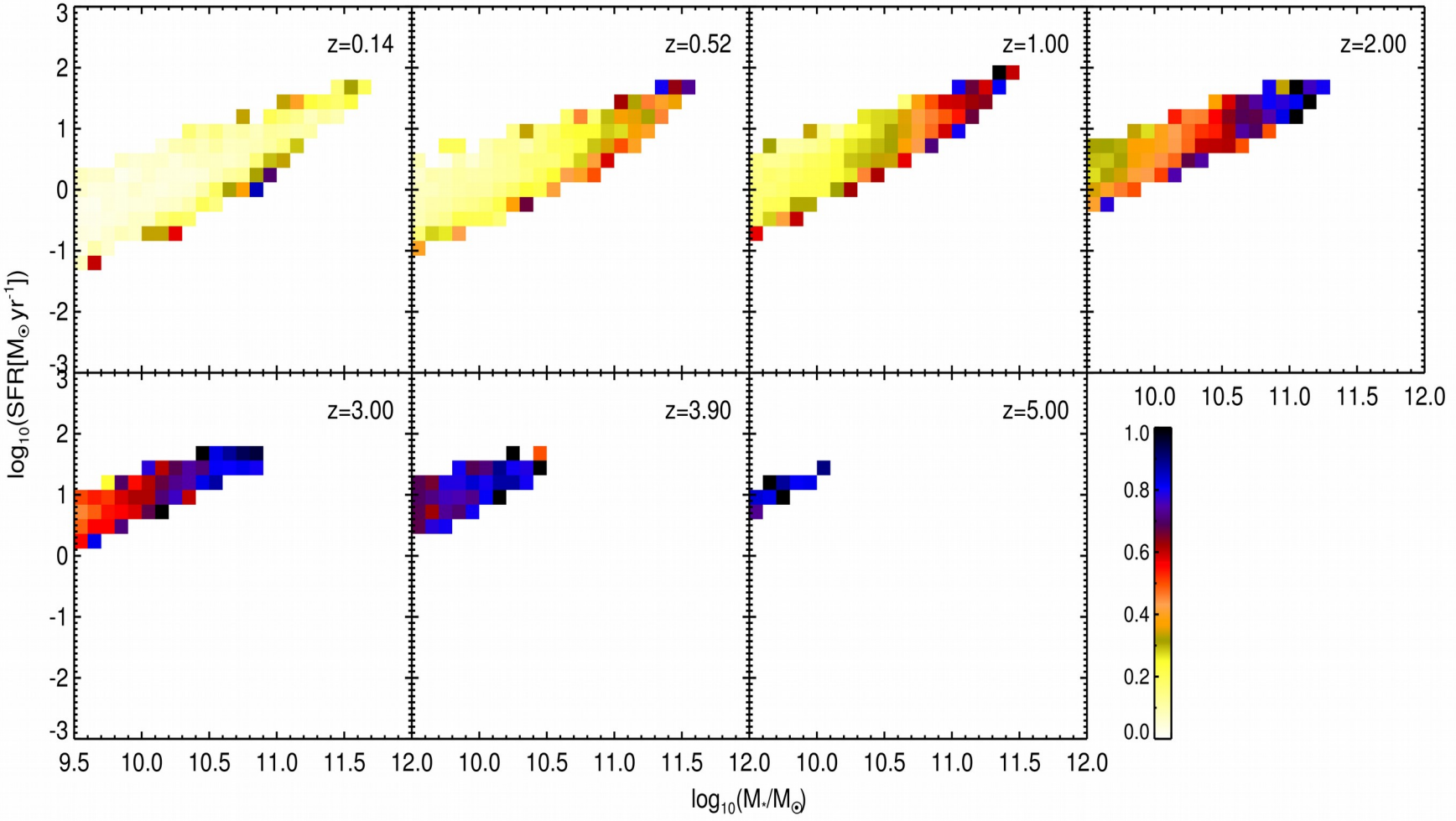
- Redshift evolution of morphologies in the progenitor set
- Less than 50% of mass in early-type galaxies at z=0 is found in progenitors with early-type morphology at z=1
- Morphological transformation and mass assembly are more rapid in denser environments

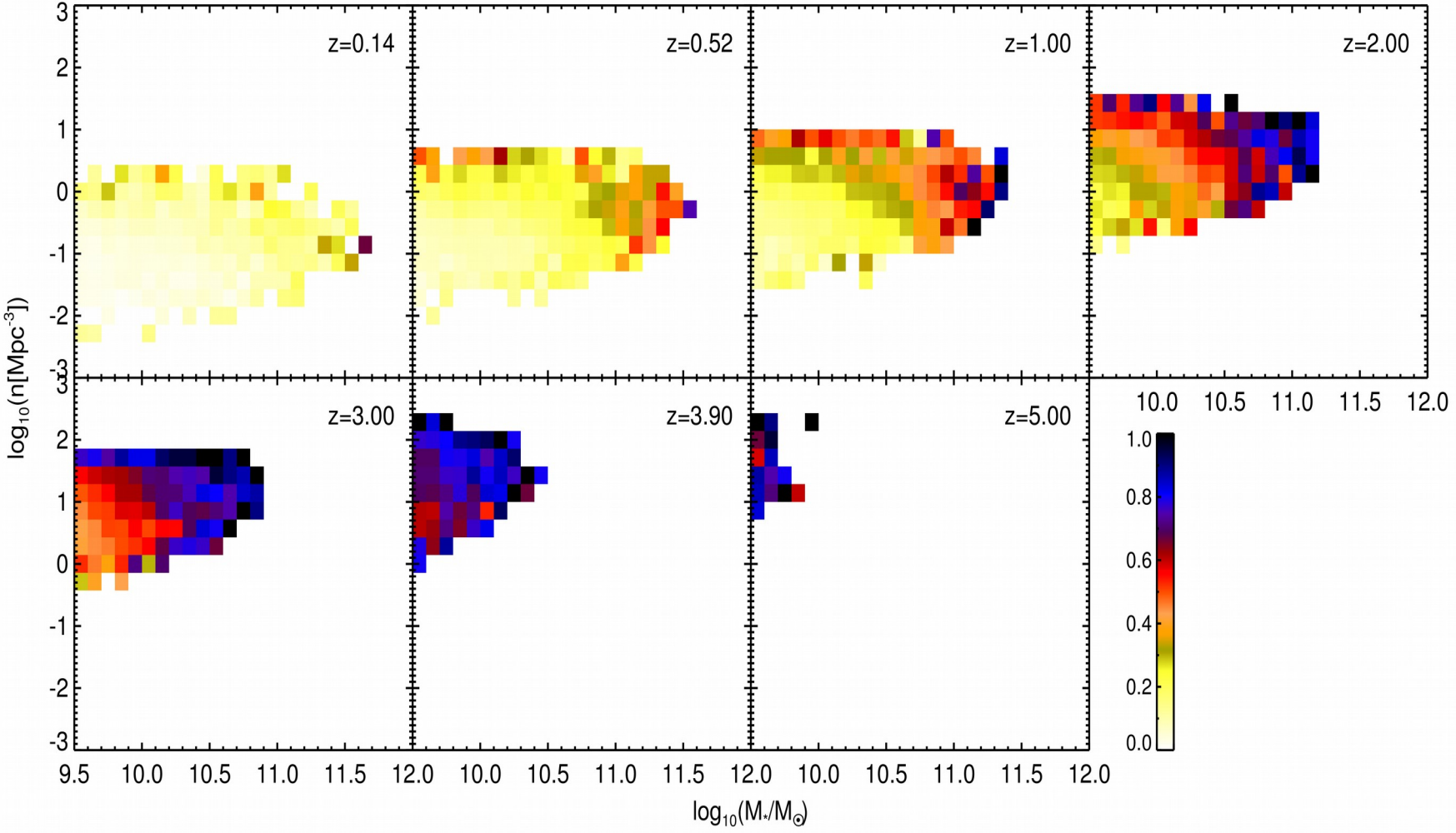
Progenitor fractions

- We can use the merger histories to calculate the fraction of late-type galaxies that are early-type progenitors with redshift

- Allowing us to produce a prescription for the inclusion of late-types


Cluster
Group
Field
All spiral progenitors
All Spirals
z=0.14
z=0.52
z=1.00
z=2.00
z=3.00
z=3.90
z=5.00
Progenitor fraction
log10(M*/M⊙)


z=0.14
z=0.52
z=1.00
z=2.00
z=3.00
z=3.90
z=5.00
log10(SFR[M⊙ yr-1])
log10(M*/M⊙)
3
2
1
0
-1
-2
-3
9.5
10.0
10.5
11.0
11.5
12.0
1.0
0.8
0.6
0.4
0.2
0.0


z=0.14
z=0.52
z=1.00
z=2.00
z=3.00
z=3.90
z=5.00
log10(n[Mpc-3])
log10(M*/M⊙)
3
2
1
0
-1
-2
-3
9.5
10.0
10.5
11.0
11.5
12.0
1.0
0.8
0.6
0.4
0.2
0.0

Conclusions