How Large Scale Structure Speaks to Star Formation

Future Insights on *Nurture* from WFIRST-AFTA

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With great help from:

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Influences on galaxy evolution

- ***Nature*** — internal factors.

  - Mass, morphology/structure, dynamics …

- ***Nurture*** — external factors.

  - Environment, mergers …

Influences on galaxy evolution

- ***Nature*** — internal factors.

  - Mass, morphology/structure, dynamics …

- ***Nurture*** — external factors.

  - **Environment**, mergers …

Environment

- **Environment** usually implies **overdensity**…

- **Overdensity** usually implies **quenching**.

Abel 1689

Dense ⇒ dead, for clusters…

Dressler+13

z ~ 0.4 cluster galaxies

Non-starforming

- Spectroscopic passive fractions increase with environmental density.

Fraction of galaxies

Starforming
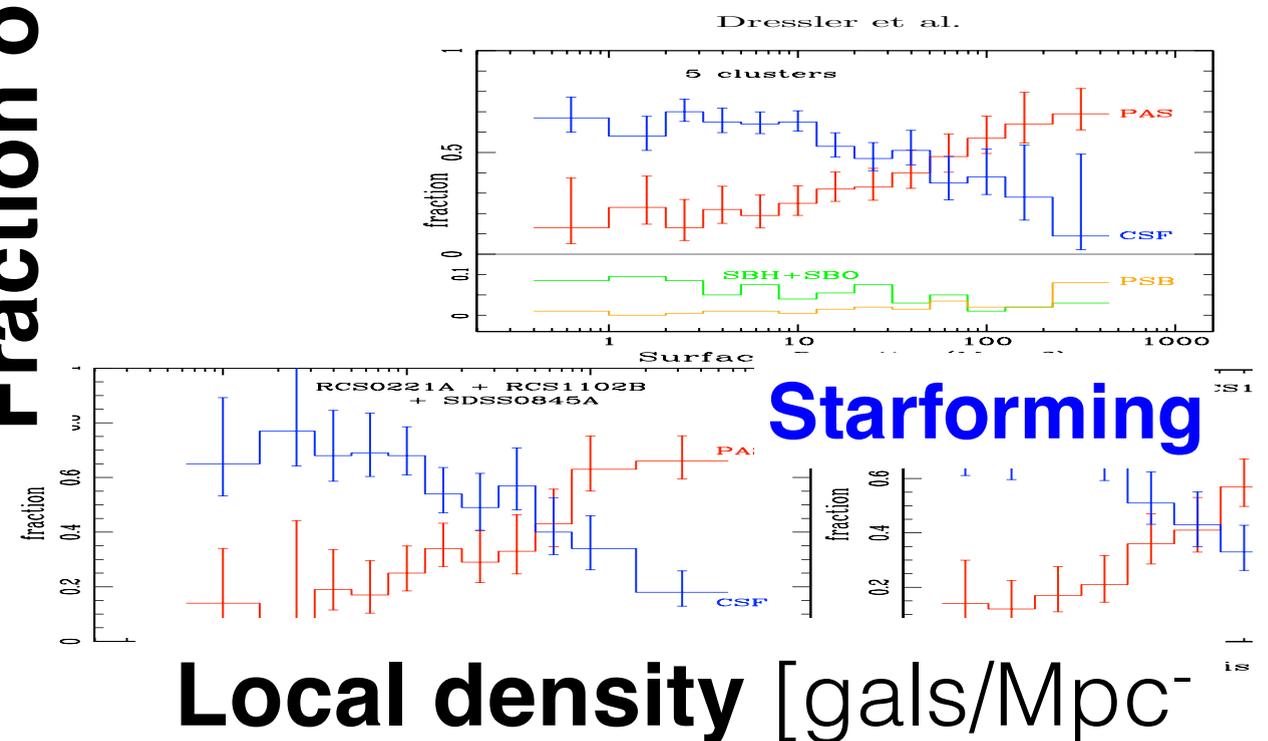
Local density [gals/Mpc⁻²]

…and for groups

Dressler+13

z ~ 0.4

Passive fraction →
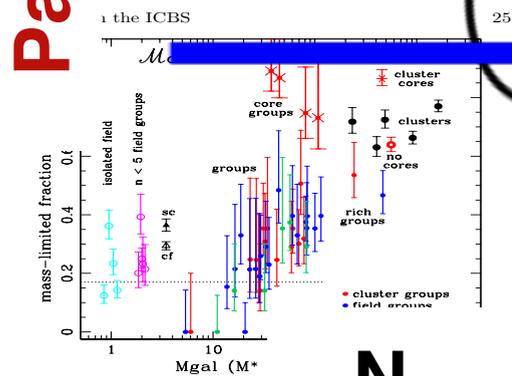
Groups

Field

$N_{gals}(M_{stel} \geq M^*) \rightarrow$
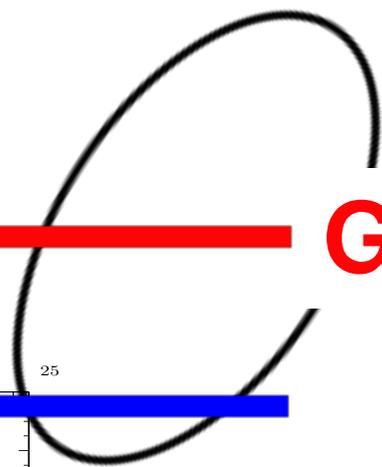
Group M$_{halo}$

z ~ 0

Red fraction →
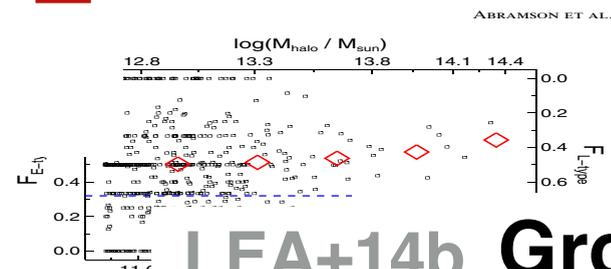
LEA+14b **Group M$_{stel}$ →**

State of affairs

- **Resolved:** Environmental **density** increases fraction of "dead" galaxies.

- **At issue:** *Is it a **killer?***

Environment rephrased

- A different framework:

Environment is a source of **diversity** in galaxy **star formation histories**.

Our approach

- If star formation histories:

  - are differentiated on Hubble timescales ($10^{\sim 10}$ yrs);

  - share the *form* of the cosmic SFH (Madau/Lilly diagram)…

    - **Lognormal** in time; **Gladders+13**.

- Then today's Milky Way-mass galaxies grew-up like this:
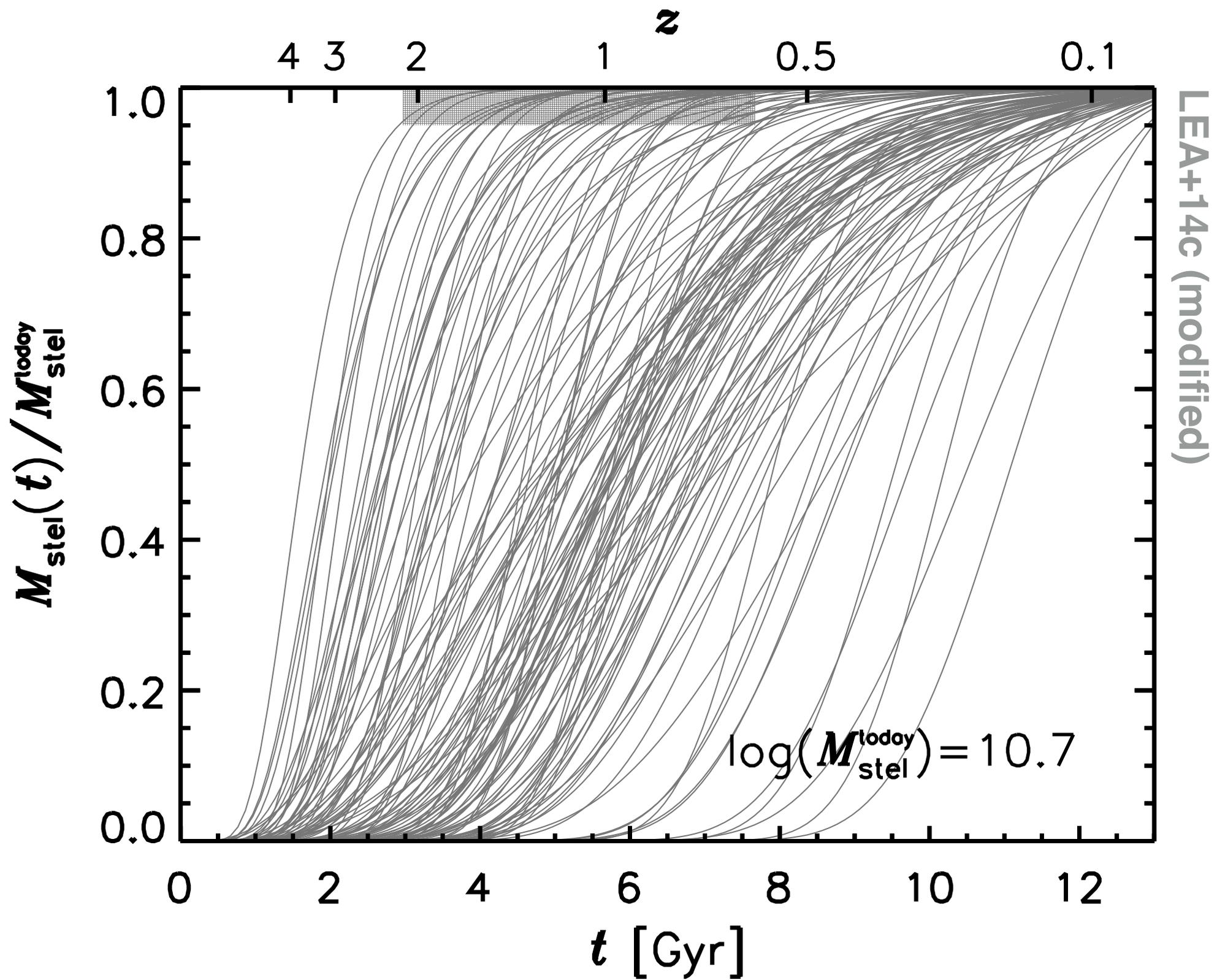
Where's the quenching?
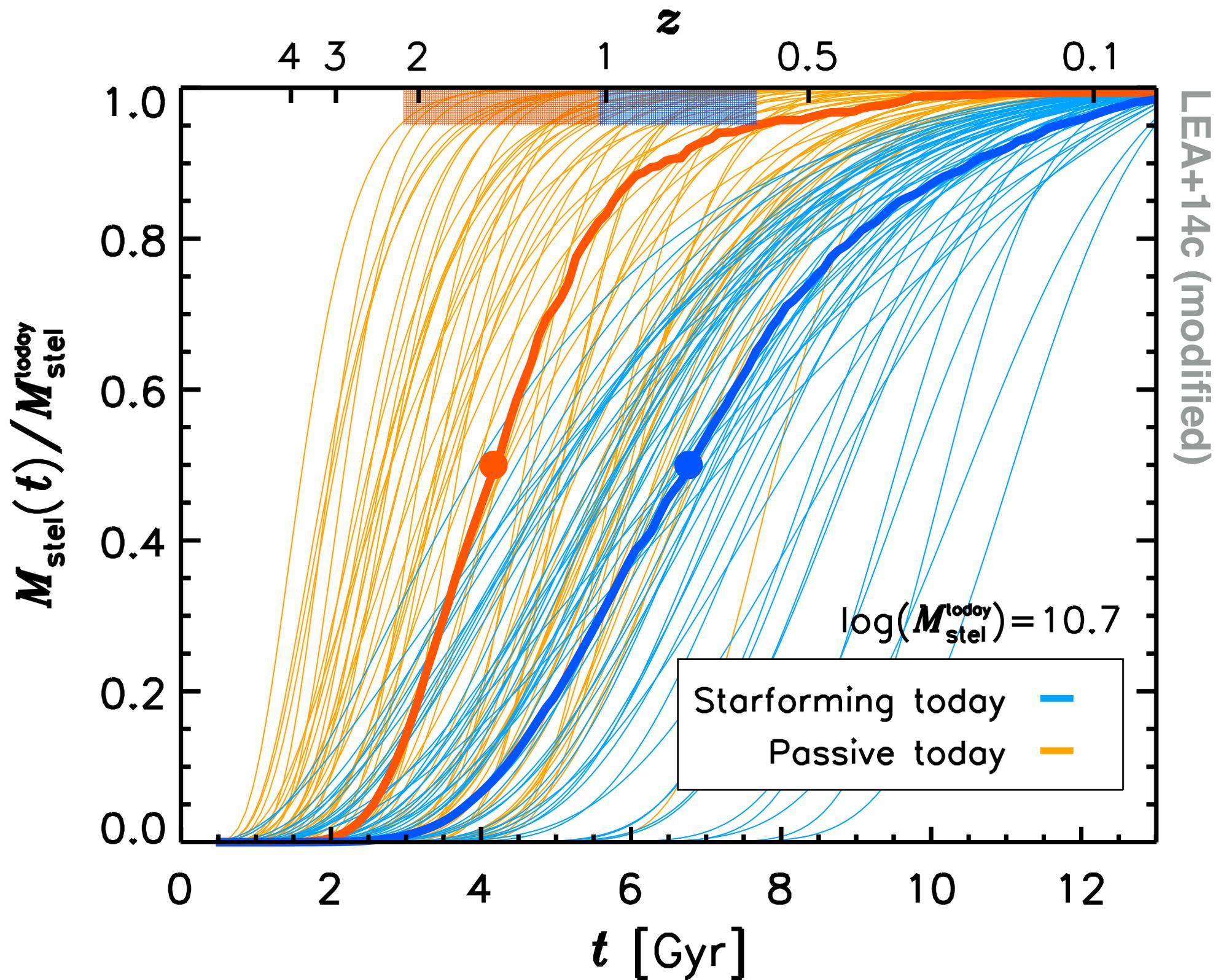
Not quenching — *diversification*
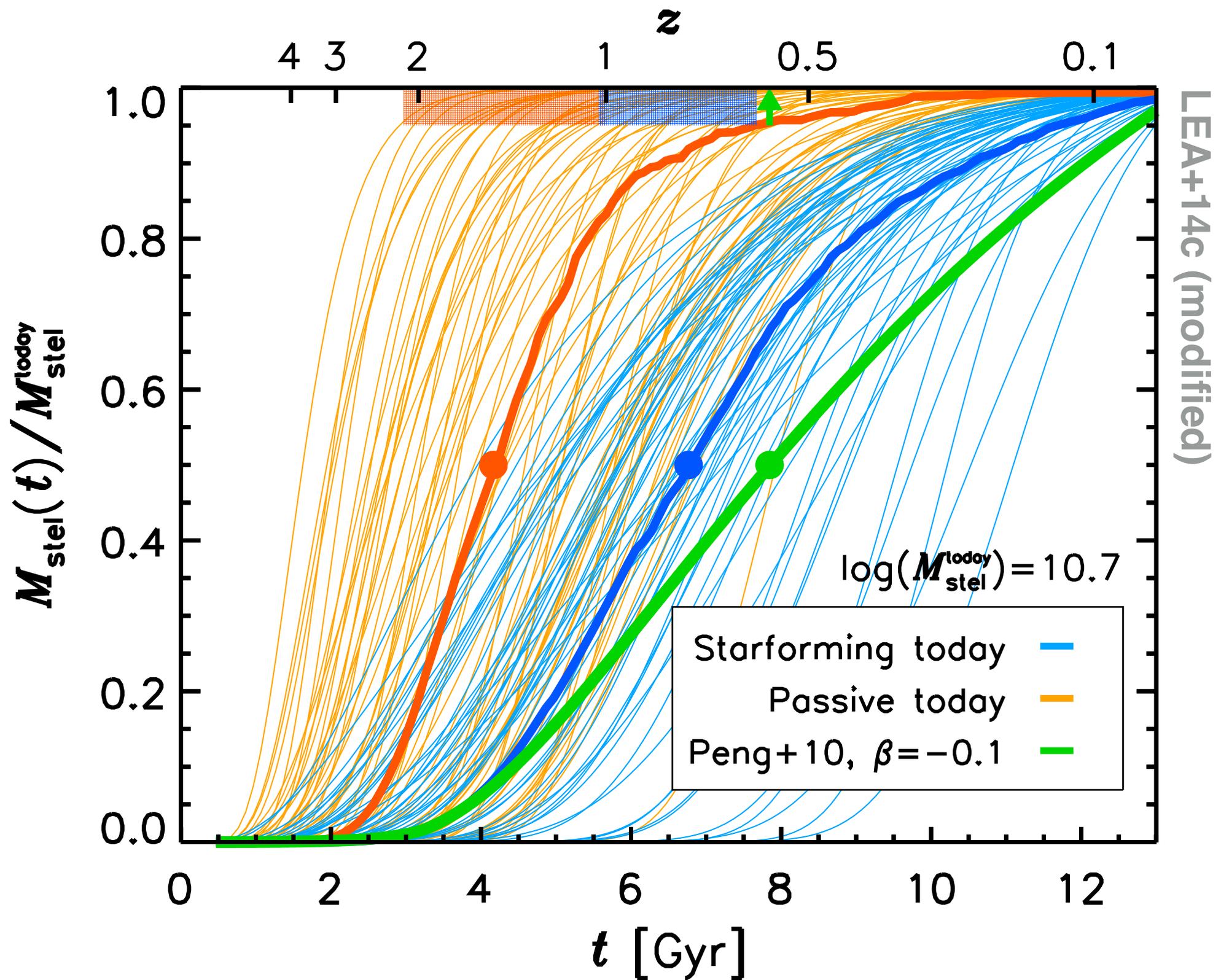
Not quenching — *diversification*

"Finished" galaxies

- Galaxies need not quench, can simply **finish first**.

  - Growth is **accelera** z ut trajectories are fundamentally similar to starforming pe ̓.

LEA+14c

"Finished" galaxies

- Galaxies need not quench, can simply **finish first**.

Late, slow formers

Early, fast formers

How much of this is *Environment*?

In **SFH width**

In **SFH peak time**

Gladders+13
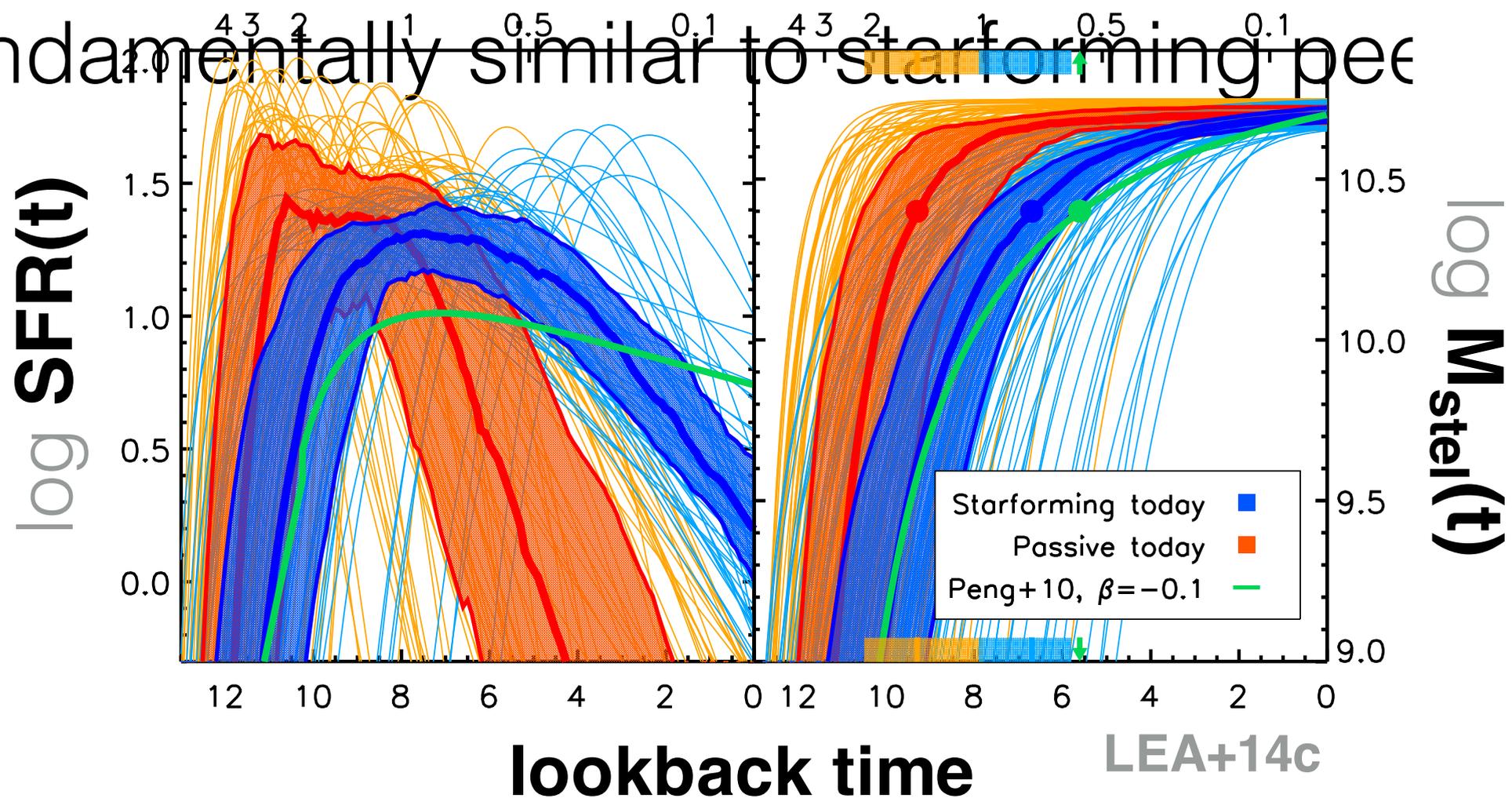
Environment's effect

- Might simply **accelerate** galaxy evolution.

  - e.g., Hearin & Watson 13

    - Halo **age** sets final properties of galaxies in it (e.g., color, SFR).

- Alternatively, it might not.

  - e.g., Newman+14

    - Similar ages for $z = 1.8$ quiescent systems in cluster and field.

- To find out, we need a lot of high-z galaxies.

  - Most systems growing rapidly, so imprints of
    mechanisms are most different

Epoch of galaxy activity

...not at *z* ~ 2

Passive today...

Starforming today
Passive today
Peng+10, $\beta = -0.1$

redshift

4 3 2   1   0.5   0.1   4 3 2   1   0.5   0.1

log $SFR(t)$/M$_\odot$ yr^{-1}

log $M_*(t)$/M$_\odot$

lookback time [Gyr]

LEA+14c
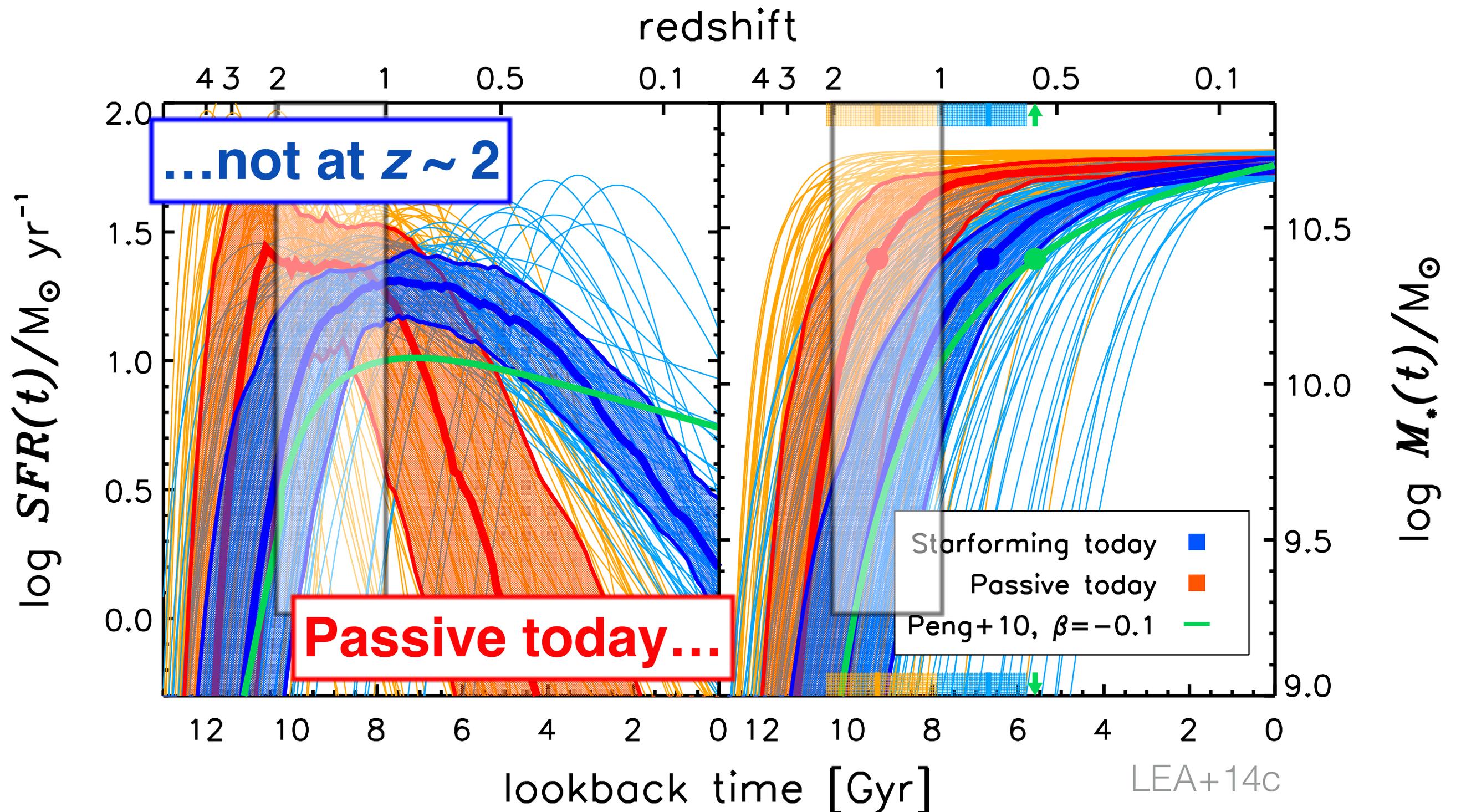
A perfect mission…

- Probes a wide **variety** of (over)densities at an epoch when galaxies in them are still active.

  - $1 < z < 2$

- Has uniform **spectroscopic** coverage over large areas.

  - **Clean selection function** for *galaxies* **and** *groups* — pure redshift association; no color/dynamical state bias; no fiber collisions.

  - Reduce cosmic variance issues.

- Digs deep in the mass function and SFR—M_{stel} relation (MW progenitors).

A perfect mission…

…looks like WFIRST!

A perfect mission…

- Probe a wide **variety** of (over)densities at an epoch where galaxies in them are still actively starforming.

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- Uniform **spectroscopic** coverage over large areas.

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SFR ≥ 10 M$_\odot$ per yr *WFIRST-AFTA*

High-Latitude and Galaxy Redshift Surveys: WISPS etc.

WFC3 F140W Image → G141 grism spectra
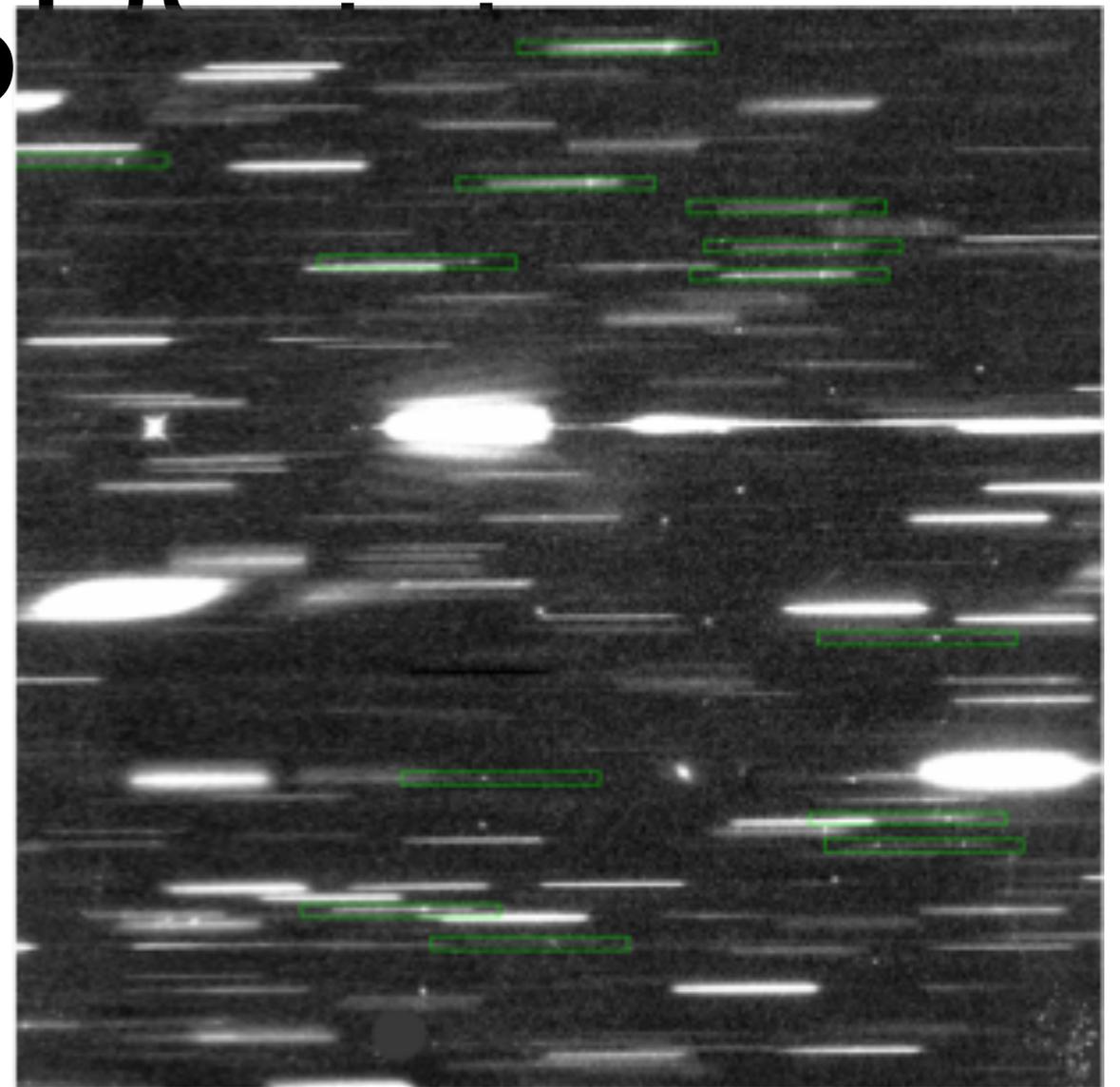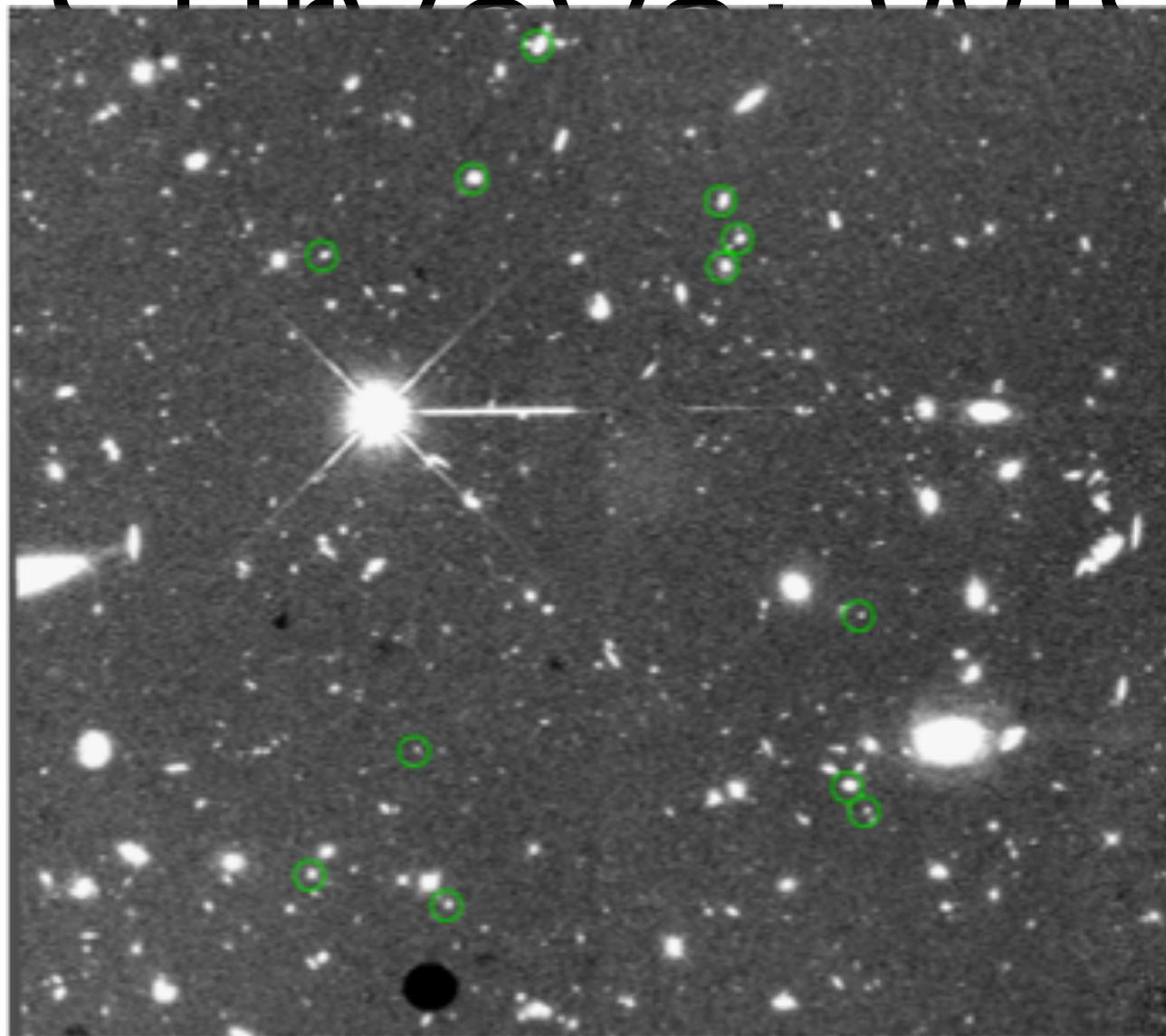
Dan Masters and the WISPS team

High-Latitude and Galaxy Redshift Surveys: WISPS at...

WFIRST F140W Image → WFIRST grism spectra

WFIRST-AFTA FOV

WFC3 FOV

WFIRST-AFTA FOV

WFC3 FOV

Dan Masters and the WISPS team

L. Abramson

WFIRST-AFTA

17 Nov. 2014
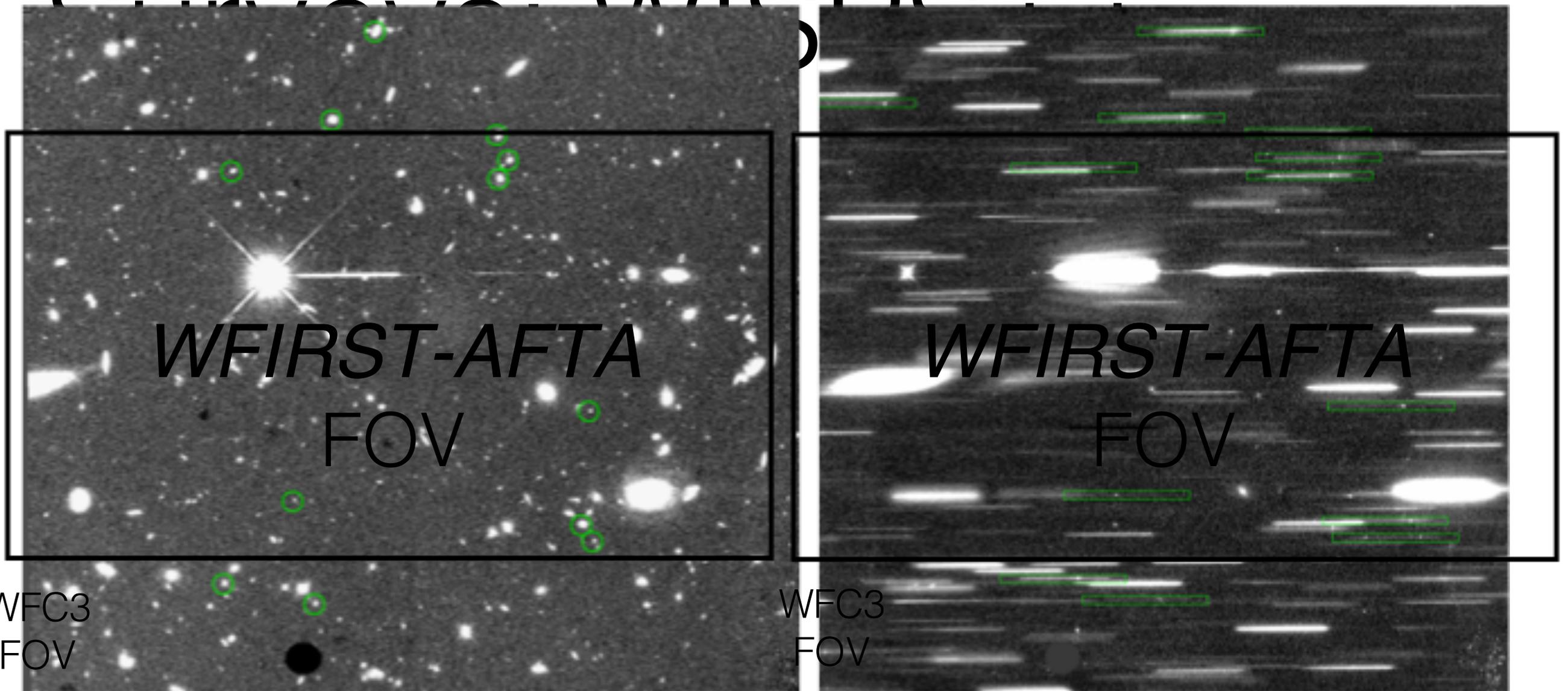
More than redshifts

Great for learning about **cosmology**…
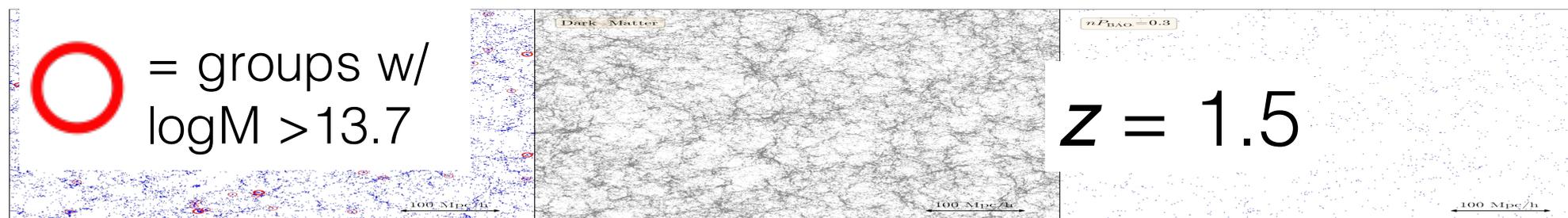
= groups w/ logM >13.7

z = 1.5

Hubble-quality astronomy

- Not just identification, **characterization**.

  - Spectrophotometric analyses of individual galaxies.

  - More than just passive fractions!

Studies of *z* = 1.8 group/cluster galaxies — ***Will become the norm!***
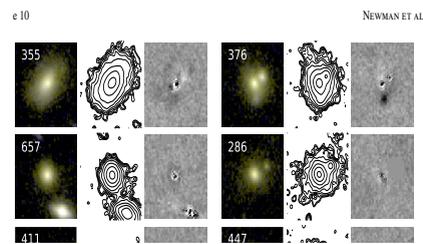
Newman+14
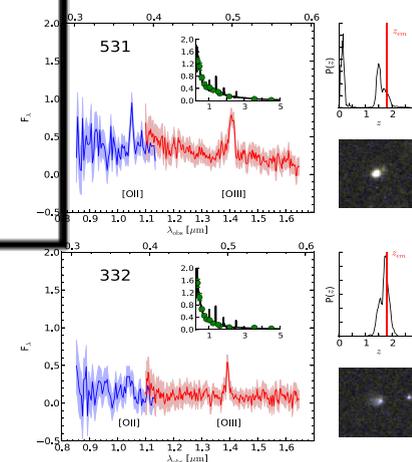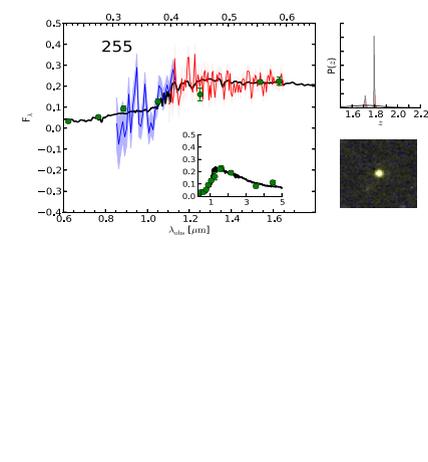
Hubble-quality astronomy

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Also great for learning about **astrophysics**!
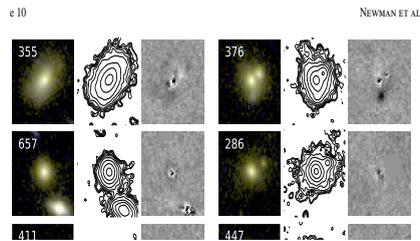
Newman+14
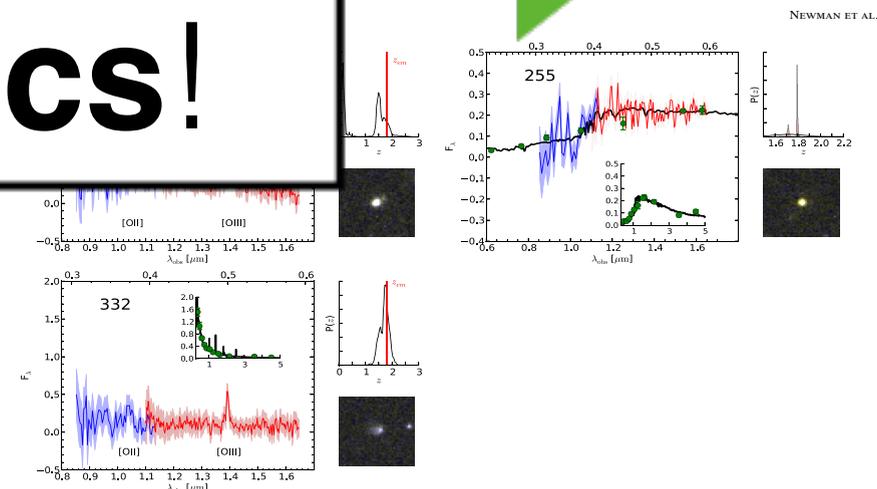
Conclusions

- We are on the edge of a revolution in our understanding of environment.

  - Does it kill galaxies, or accelerate aging processes?

- WFIRST-AFTA will herald this revolution.

  - Finding and characterizing an unprecedented number of galaxies in all environments at an epoch in which they are evolving rapidly.

  - **First** (largely) **unbiased assessment of environment.**

Availability of large group/cluster samples
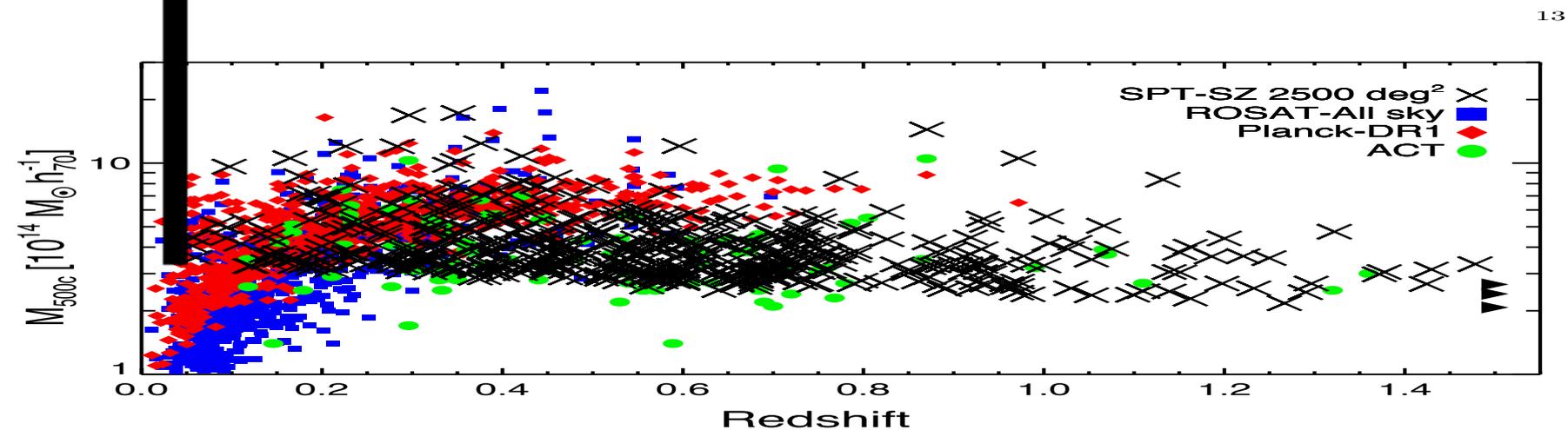
Epoch of galaxy activity
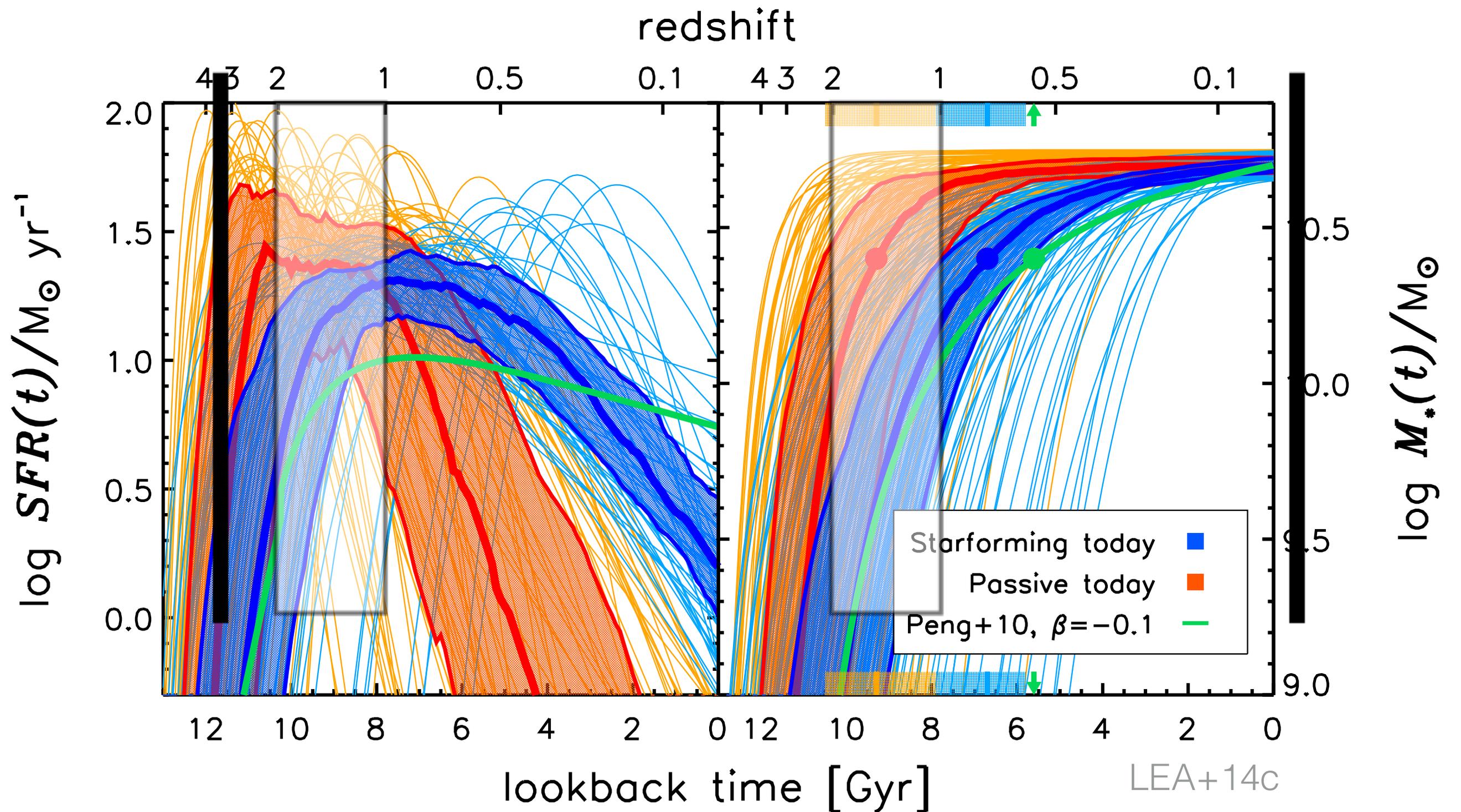
Availability of large group/cluster samples

- Massive, relaxed systems: special subset of environments
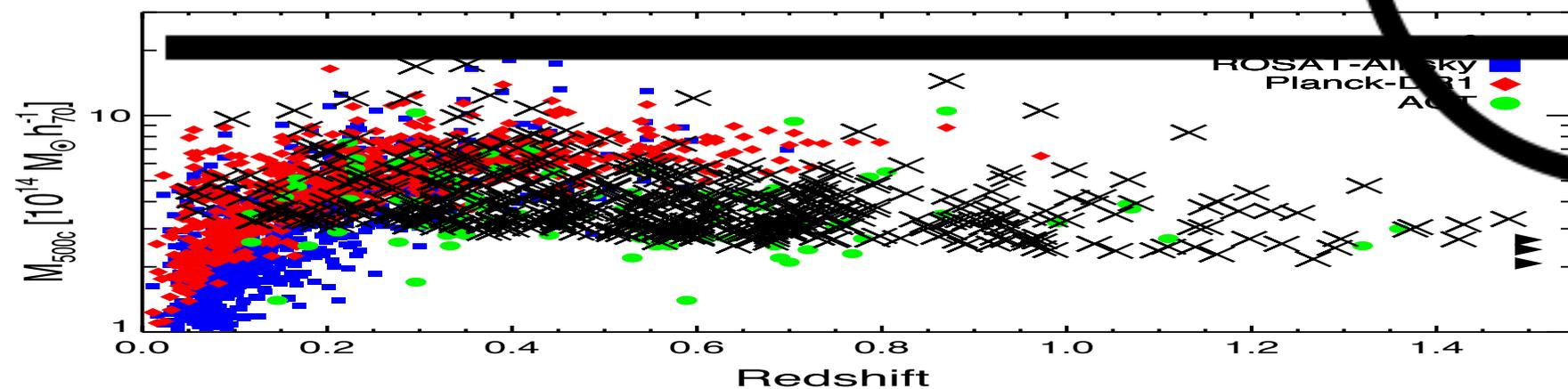
"Finished" galaxies

- Galaxies need not quench, can simply **finish first**.

SFR

$\sim \tau au$

$\sim T_0$

age of universe [Gyr]

Gladders+13
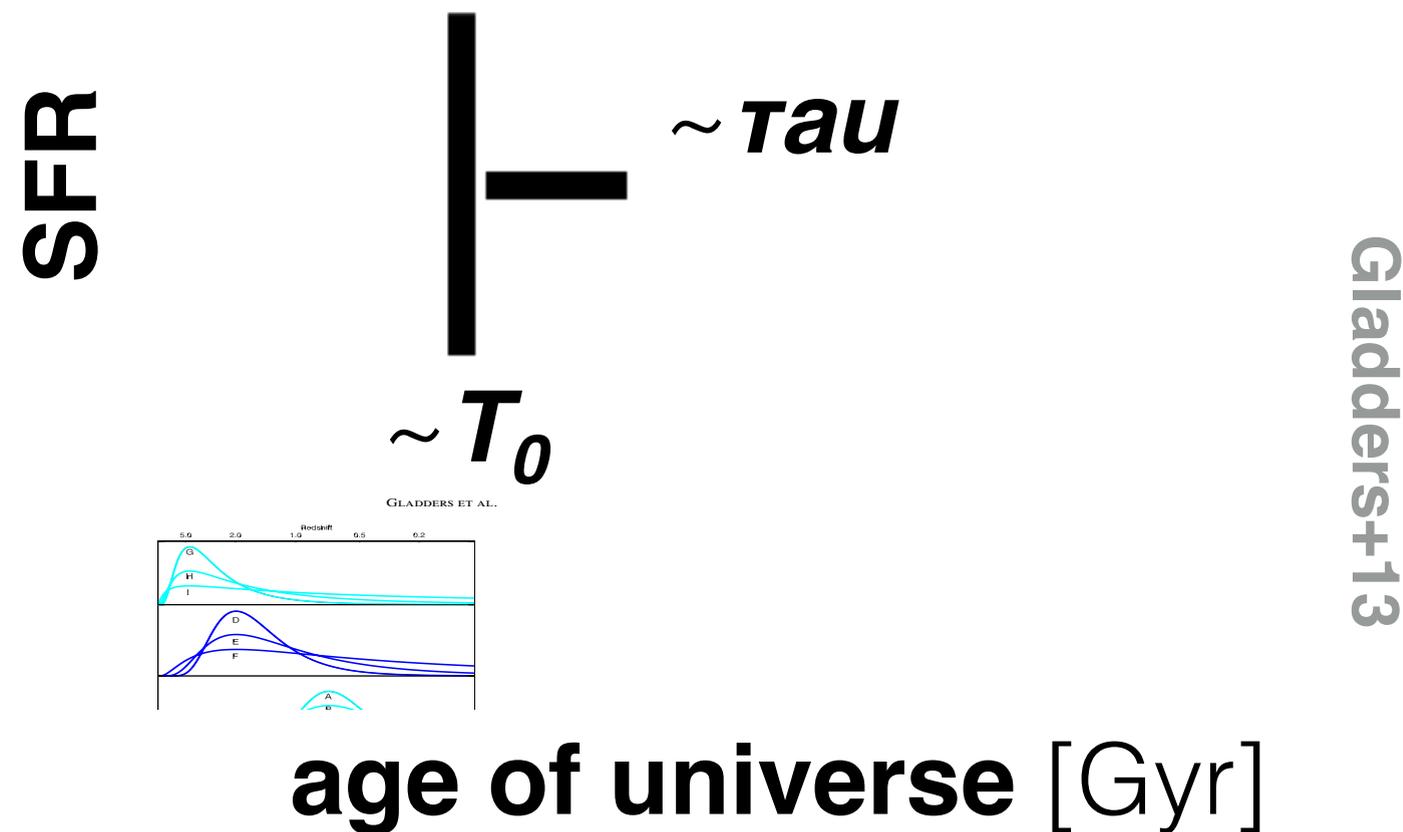
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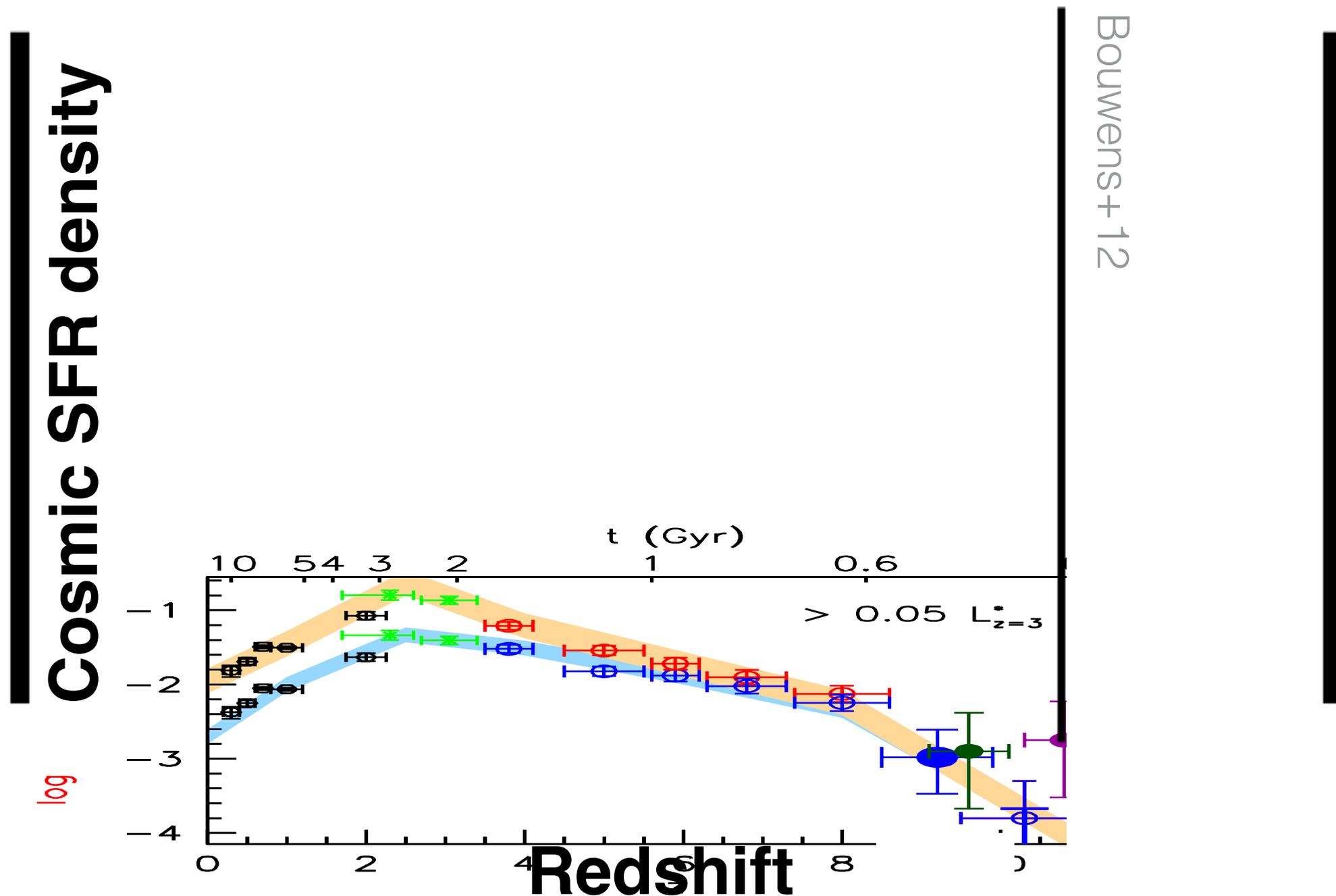
Dense ⇒ dead, for clusters…

Dressler+13

Clusters at $z \sim 0.4$

Fraction of galaxies

Passive

Passive

Starforming

Starforming

Enviro. density (Mpc^{-2})

Distance from cluster
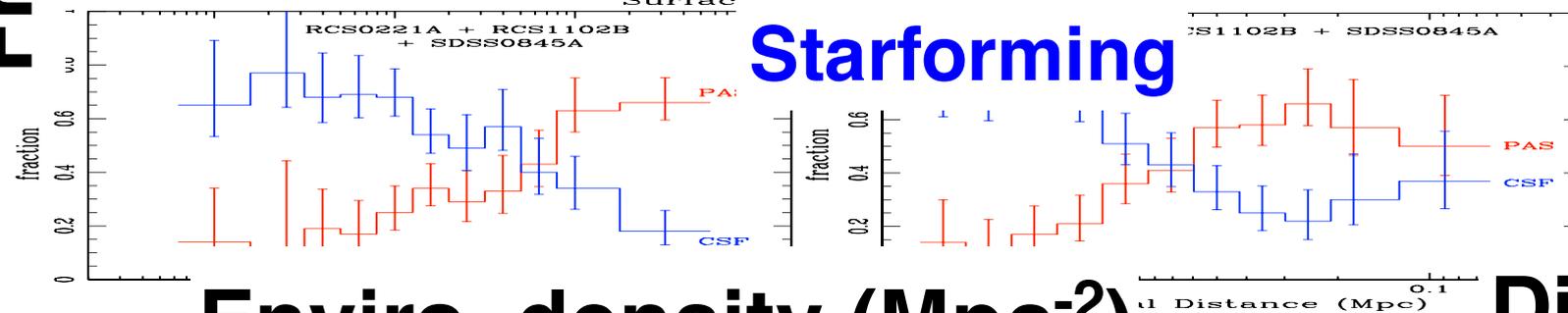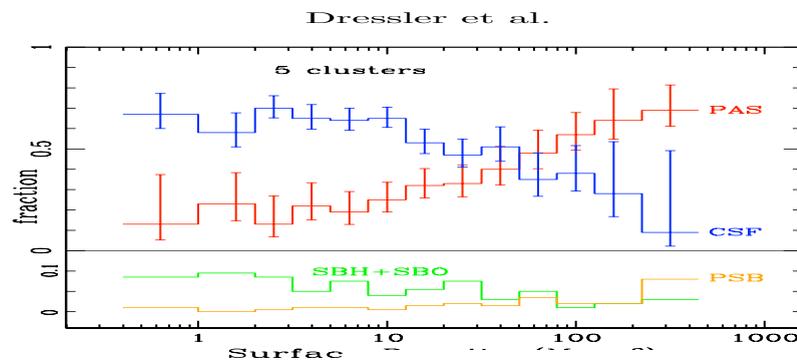
Outline

- Forces shaping gal evo: *Nature* & *Nurture*

  - Nature = mass, dynamics, internal structure, etc.

  - Nurture = **environment**, mergers.

    - Focus on **Nurture** here.

- Used to thinking about environment as "quenching" mechanism.

  - Show various images of clusters / plots of passive fractions.

- Reframe as "sources of **diversity in SFHs**".

- Describe our model

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