Probing Paradigms in Galaxy Evolution with *WFIRST*

How one telescope could provide a **last look** on the story of star formation

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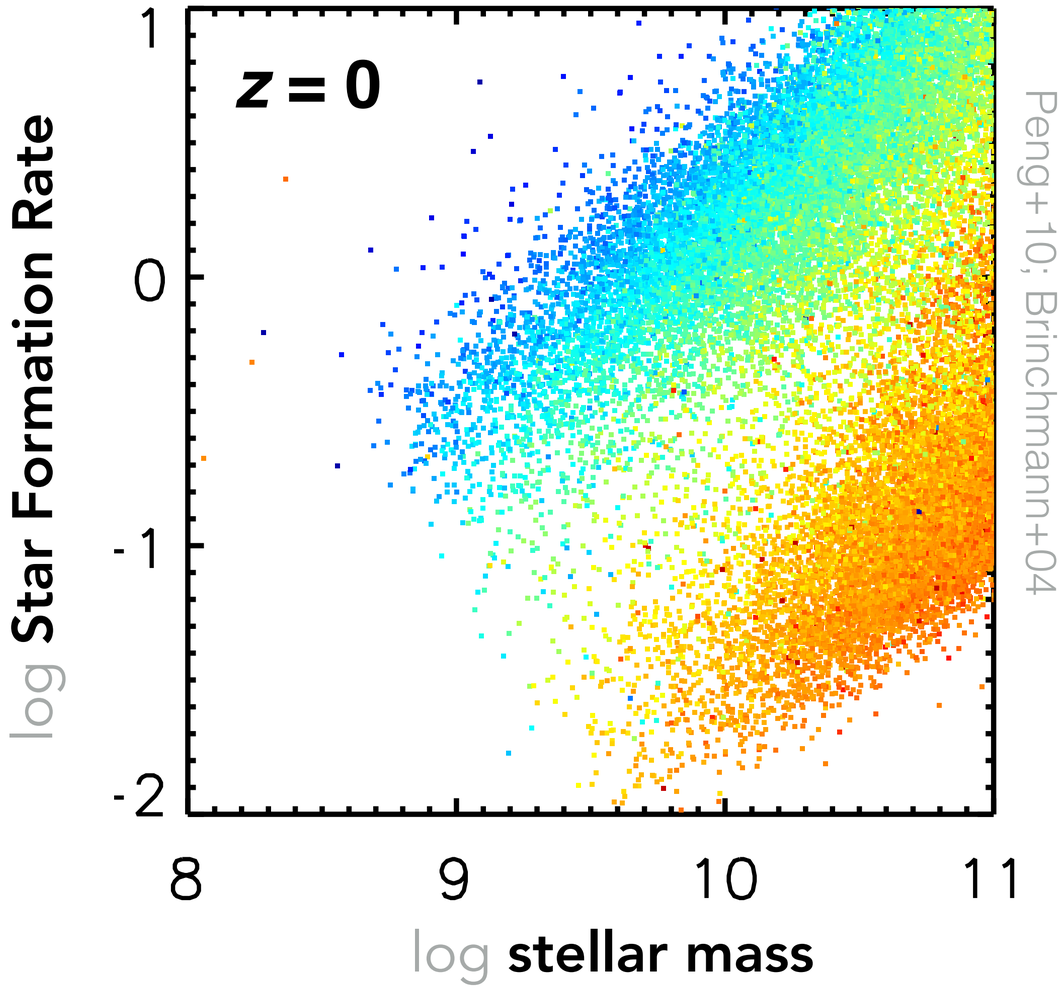
* = member of ***GLASS***

How we infer **star formation histories**

- Popular paradigm:

  single epoch scatter diagrams
  reveal **evolutionary trajectories**.



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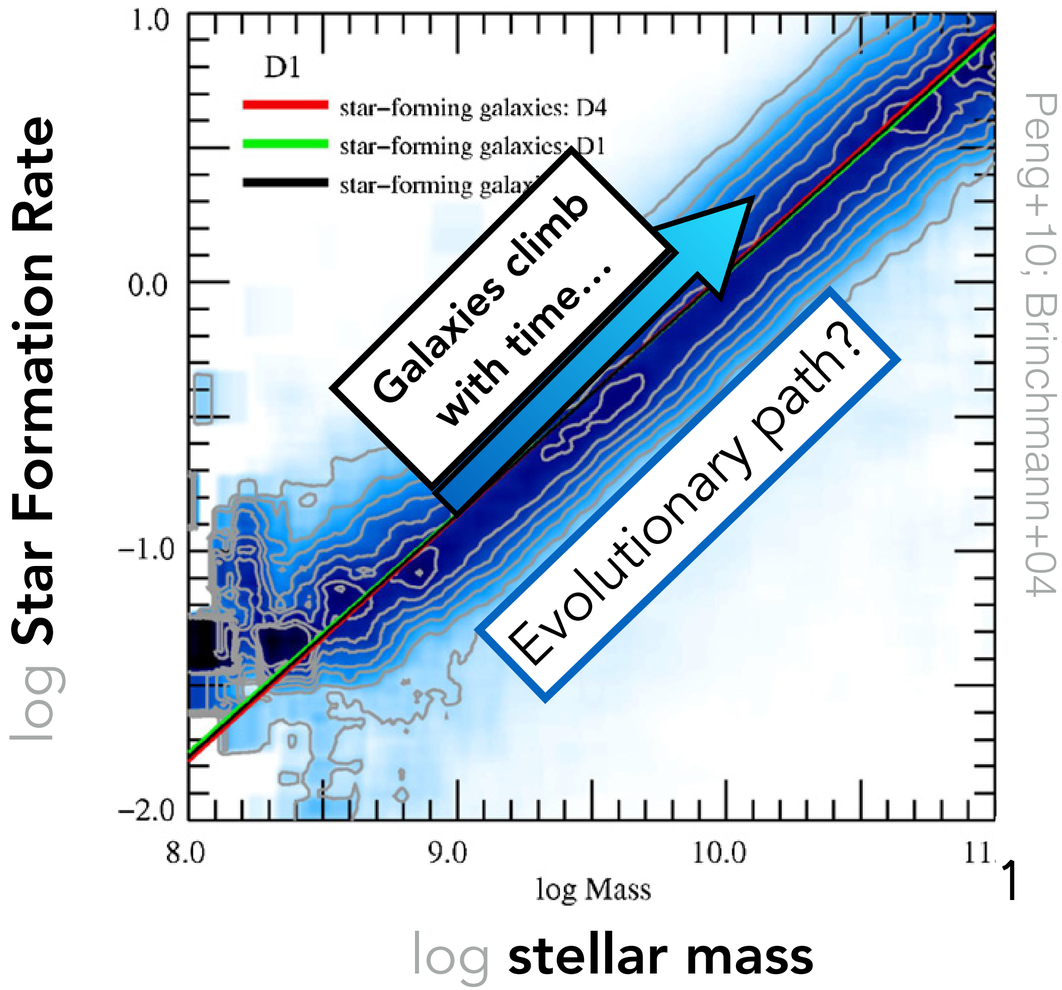
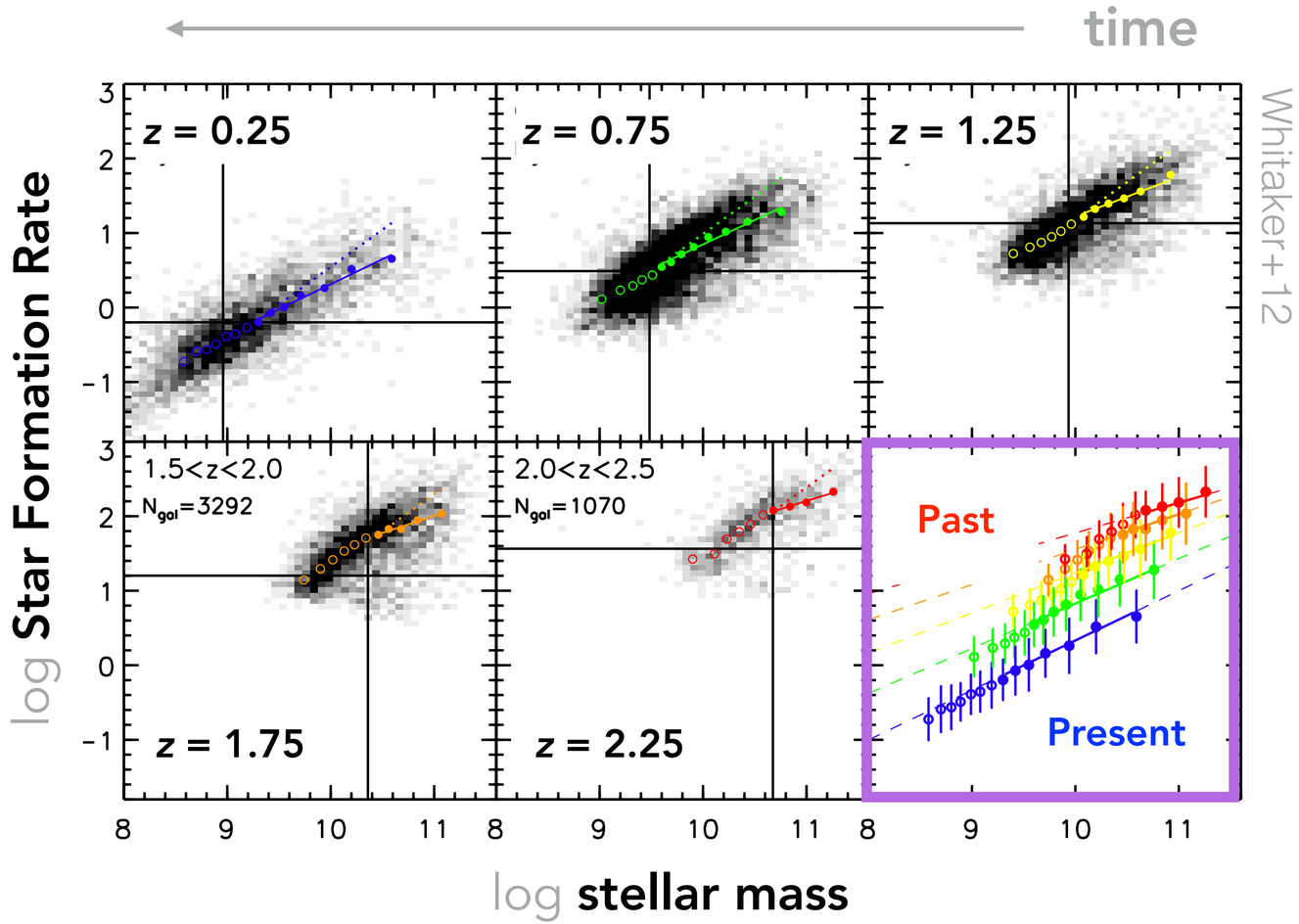


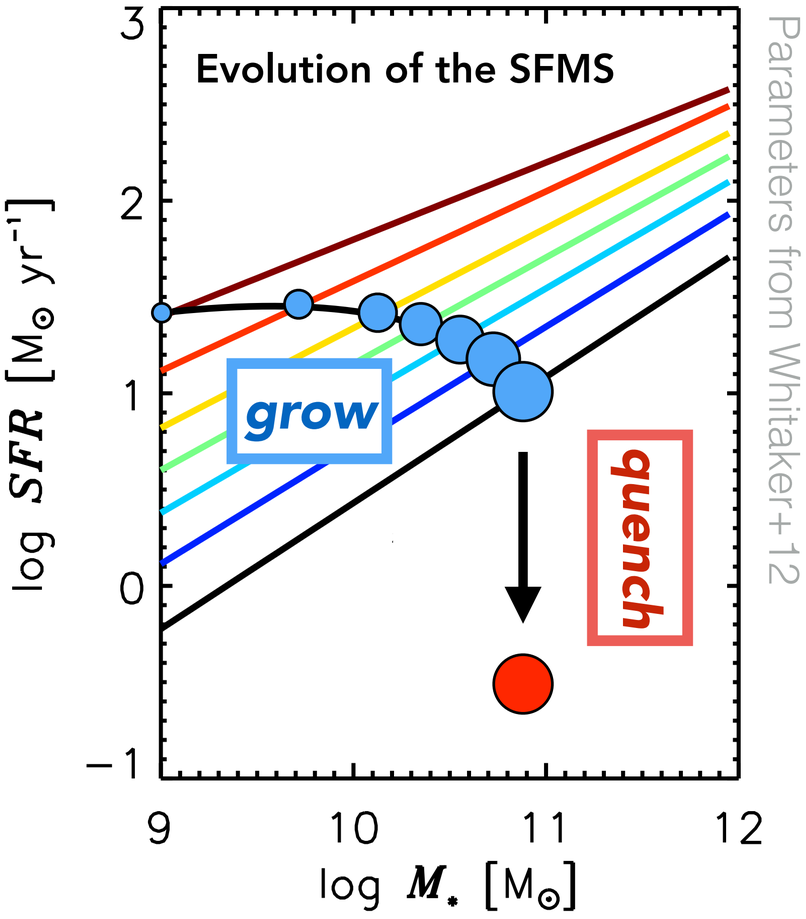
How we infer star formation histories

- Take scatter plots at many epochs.
- Assume **galaxies follow locus**
  - Produces ***a*** SFH.
    - The ***mean*** SFH(Mstel)…ish.



Just add calculus (and quenching…)

- If you want a star formation history, just **follow the flock**.
- We know how **loci** evolve, so we **think** we know how **galaxies** evolve.
  - Provided there is some way to creates red galaxies
  - “Quenching”



The current paradigm is: “grow and quench”

- Question is:

What ***stops*** star formation?

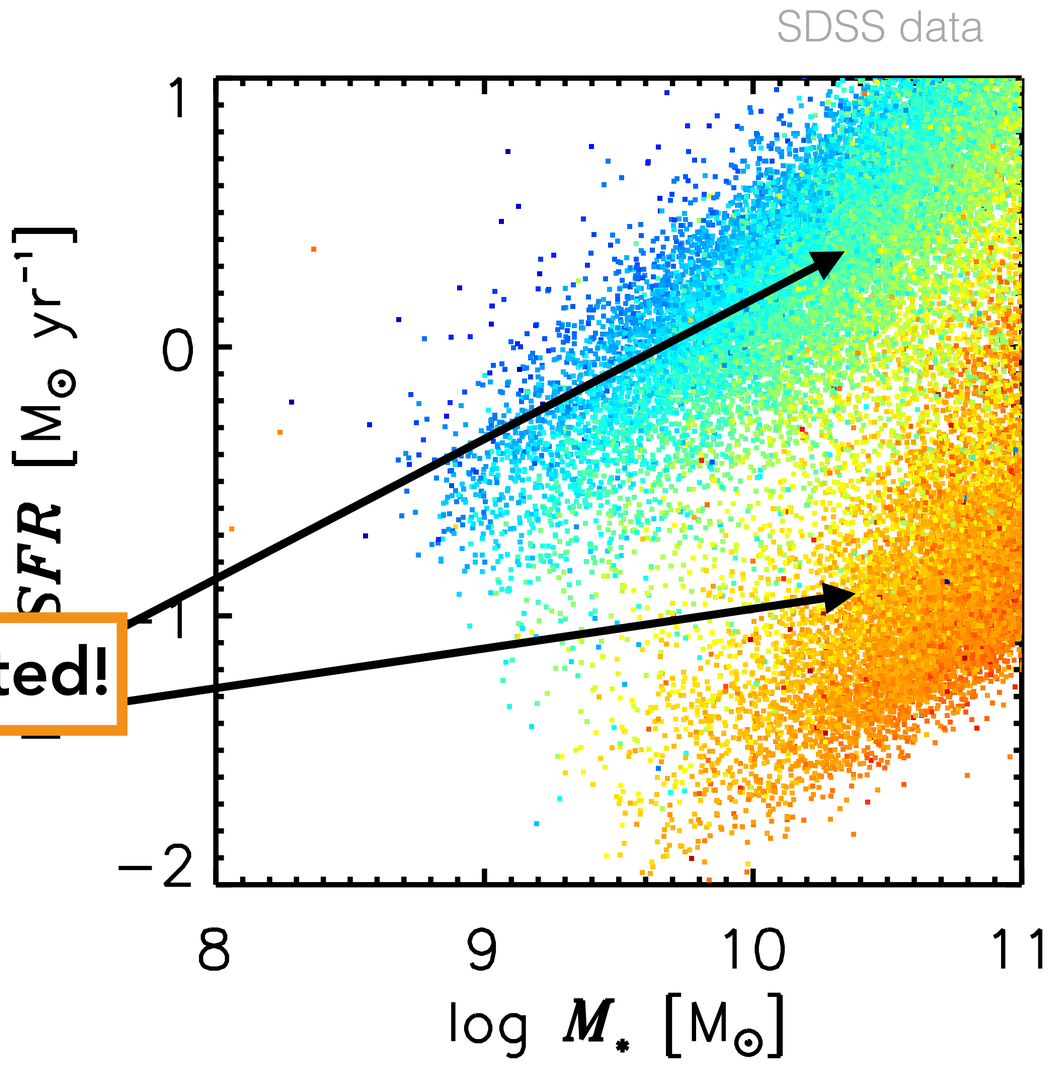
This has led to great successes!

But there's a catch!

The catch

- **Zero** passive galaxies descend from starforming galaxies at the same epoch!

Not ancestrally related!



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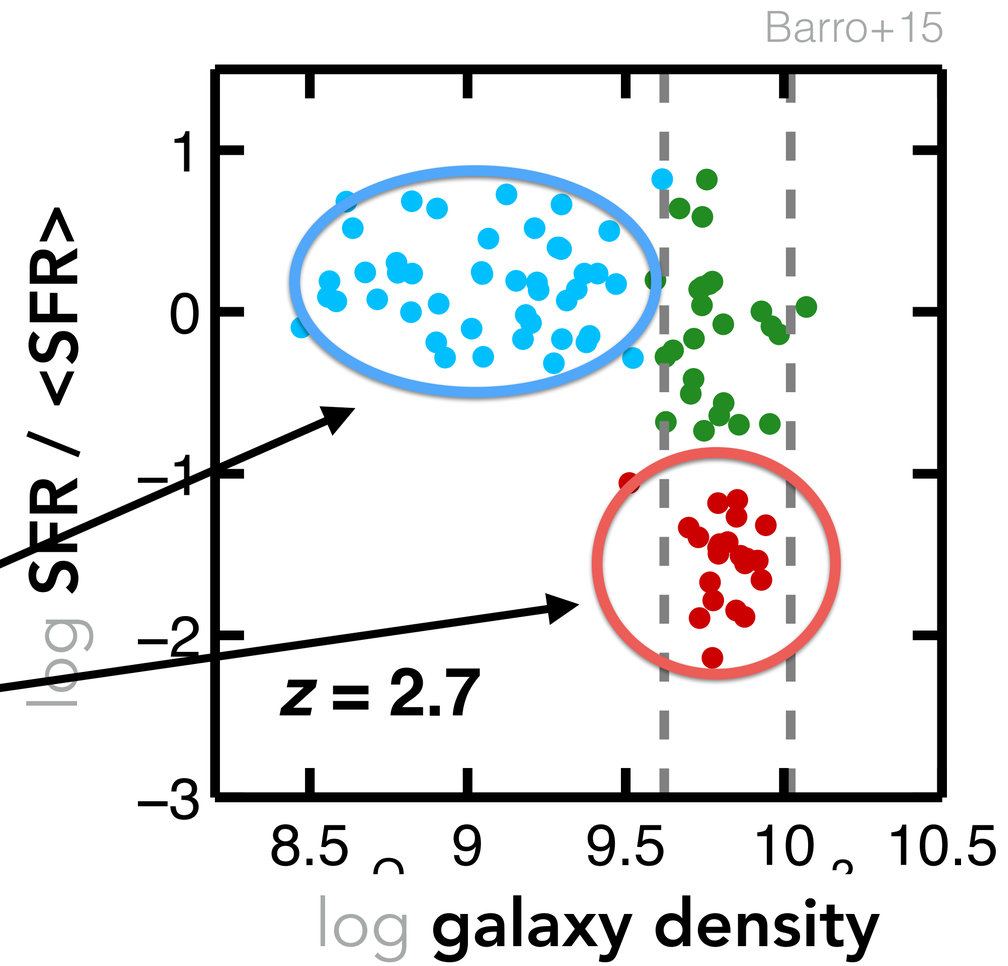
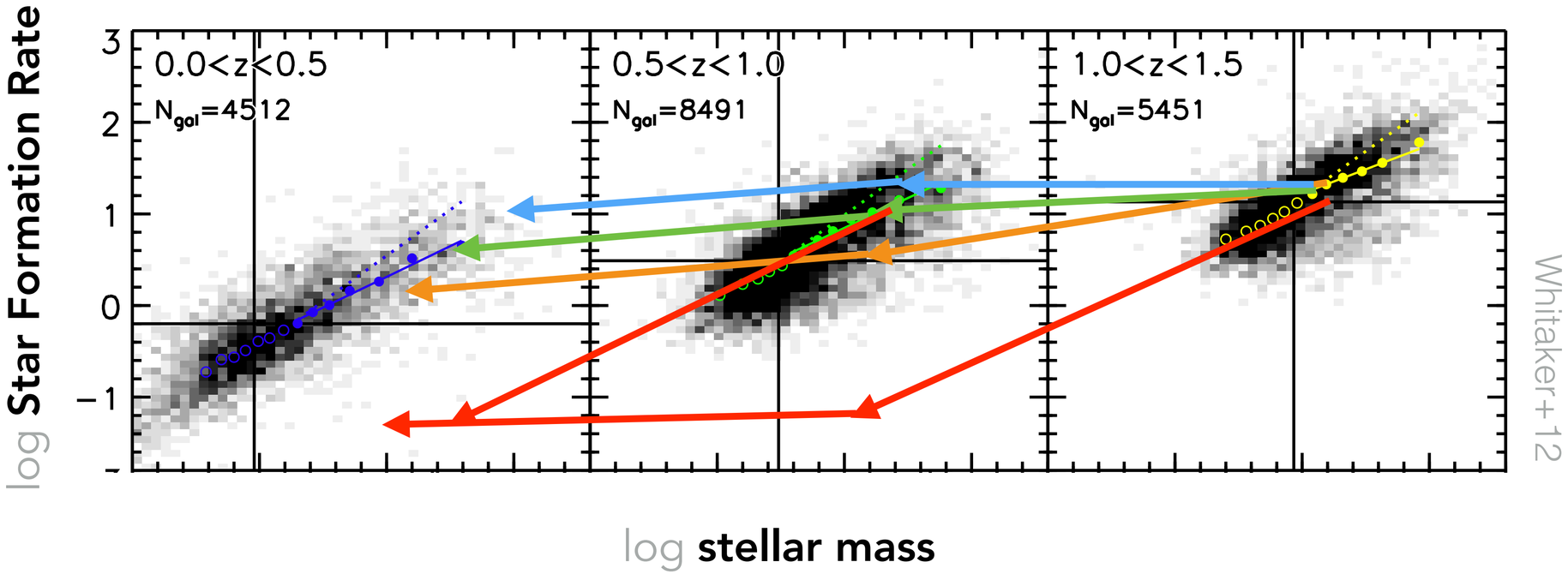


The catch

- Passive galaxies at one epoch descend from starforming galaxies at **earlier** epochs.



The catch

- Passive galaxies at one epoch descend from starforming galaxies at **earlier** epochs — **the SFMS need not be an evolutionary path!**

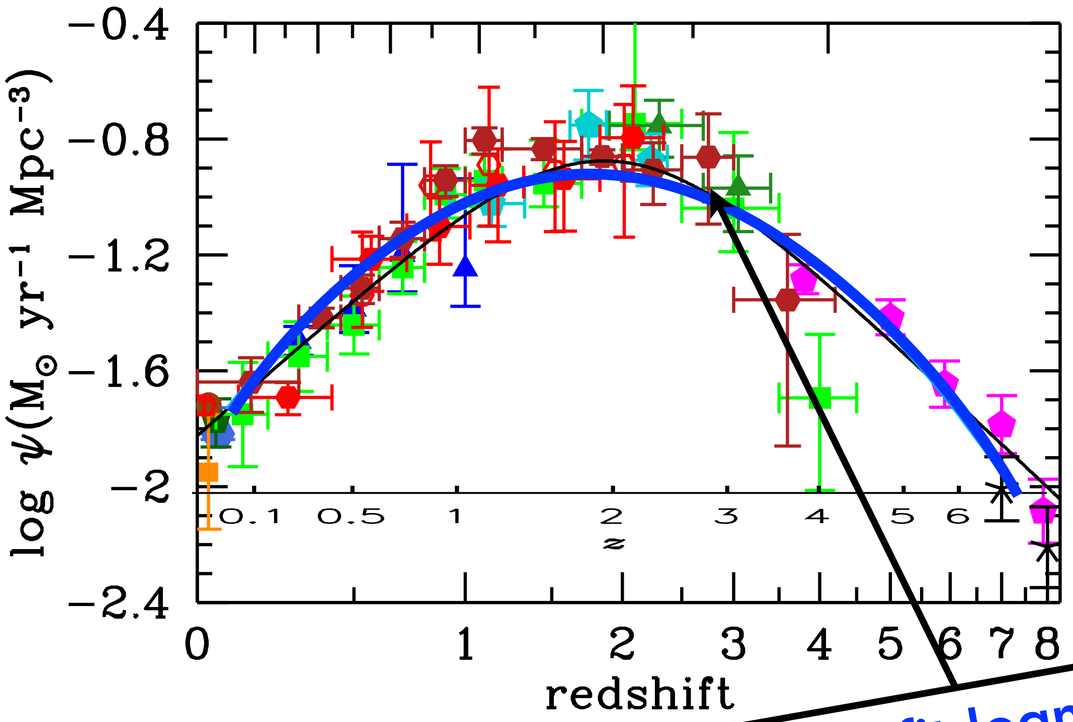
Rephrase the question:

*What **shapes** star formation histories?*

(Not: “What **stops** star formation?”)

Our model:

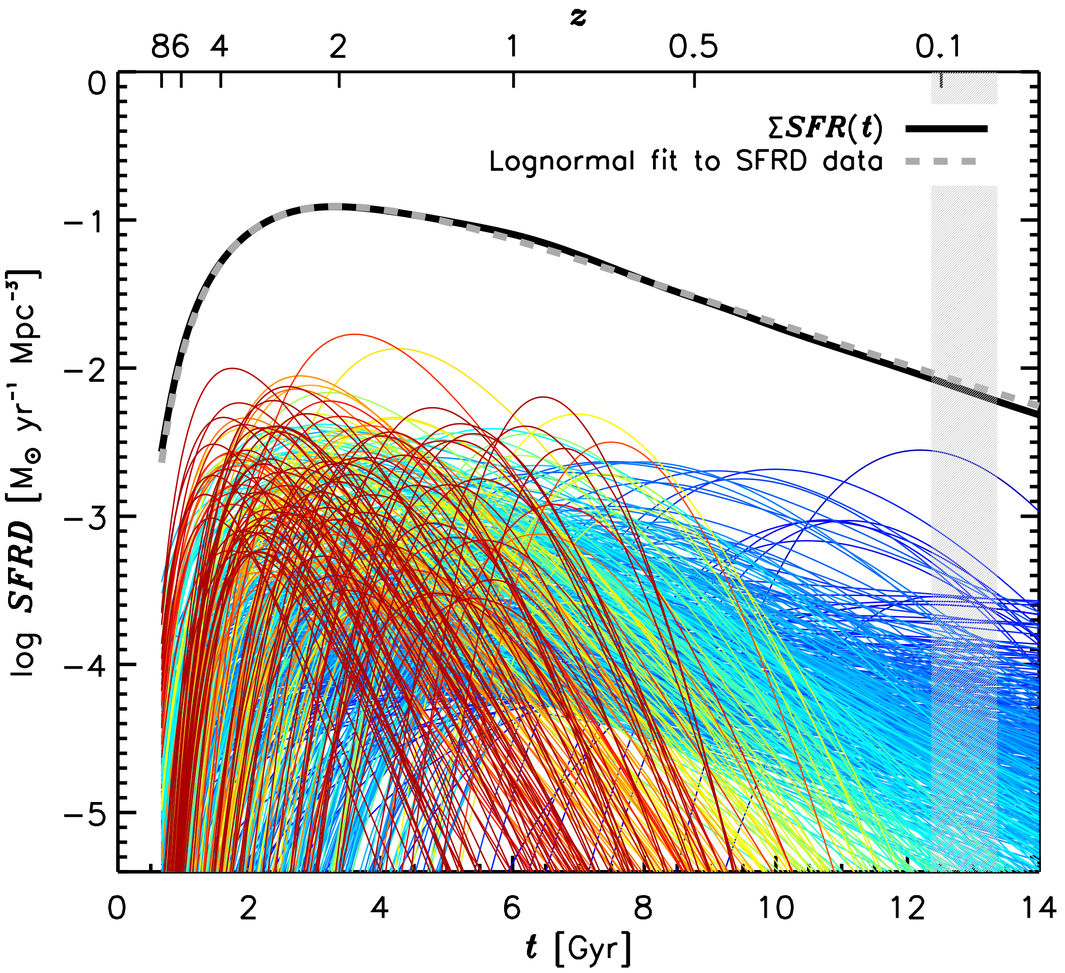
Madau & Dickinson ‘14



- Draw inspiration from the **cosmic SFH**.
  - The Madau/Lilly diagram is **lognormal**.
  - What if galaxies also had this form?

Best-fit lognormal from Gladders+13

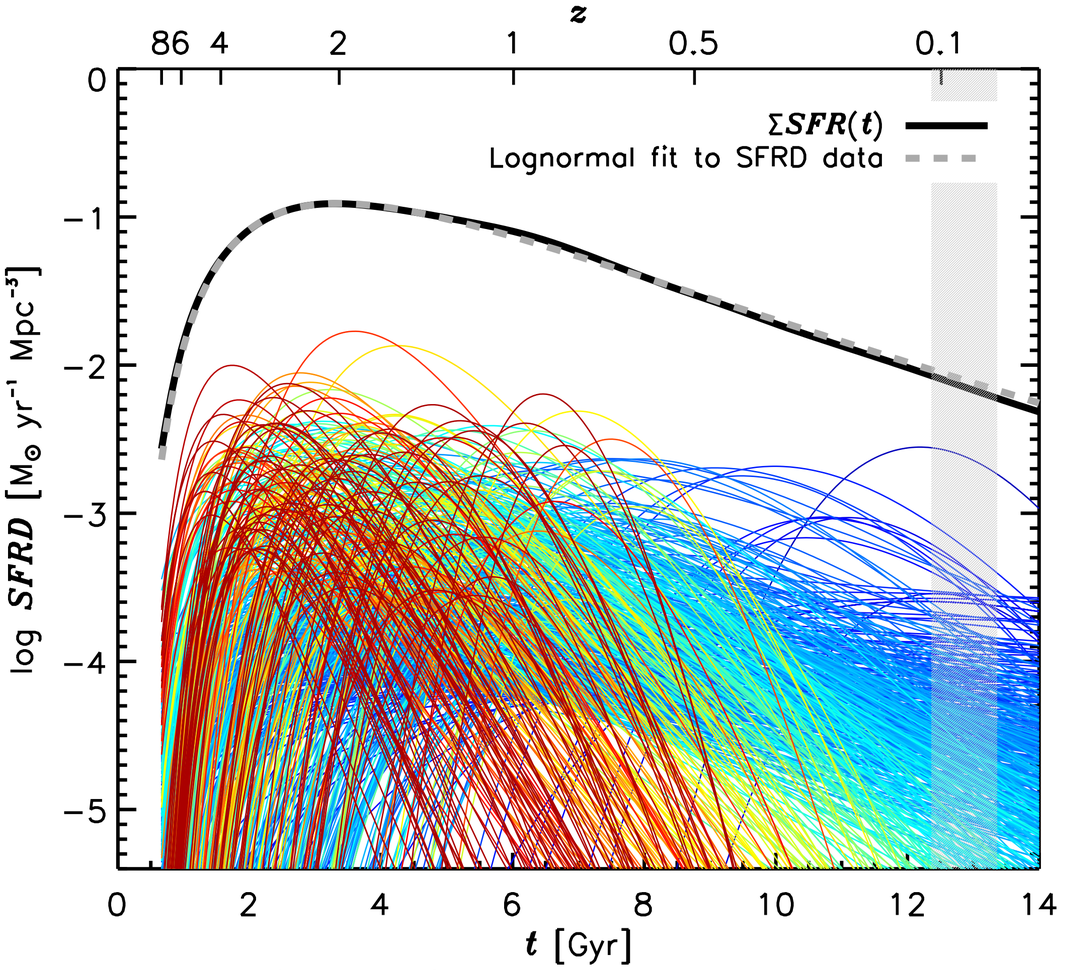
Our model:



LEA+16 (in prep.)
Gladders+13b

- Every galaxy in the input data gets a **lognormal SFH**.
  - No discontinuities
  - No explicit quenching
  - **No physics.**

Our model:



LEA+16 (in prep.)
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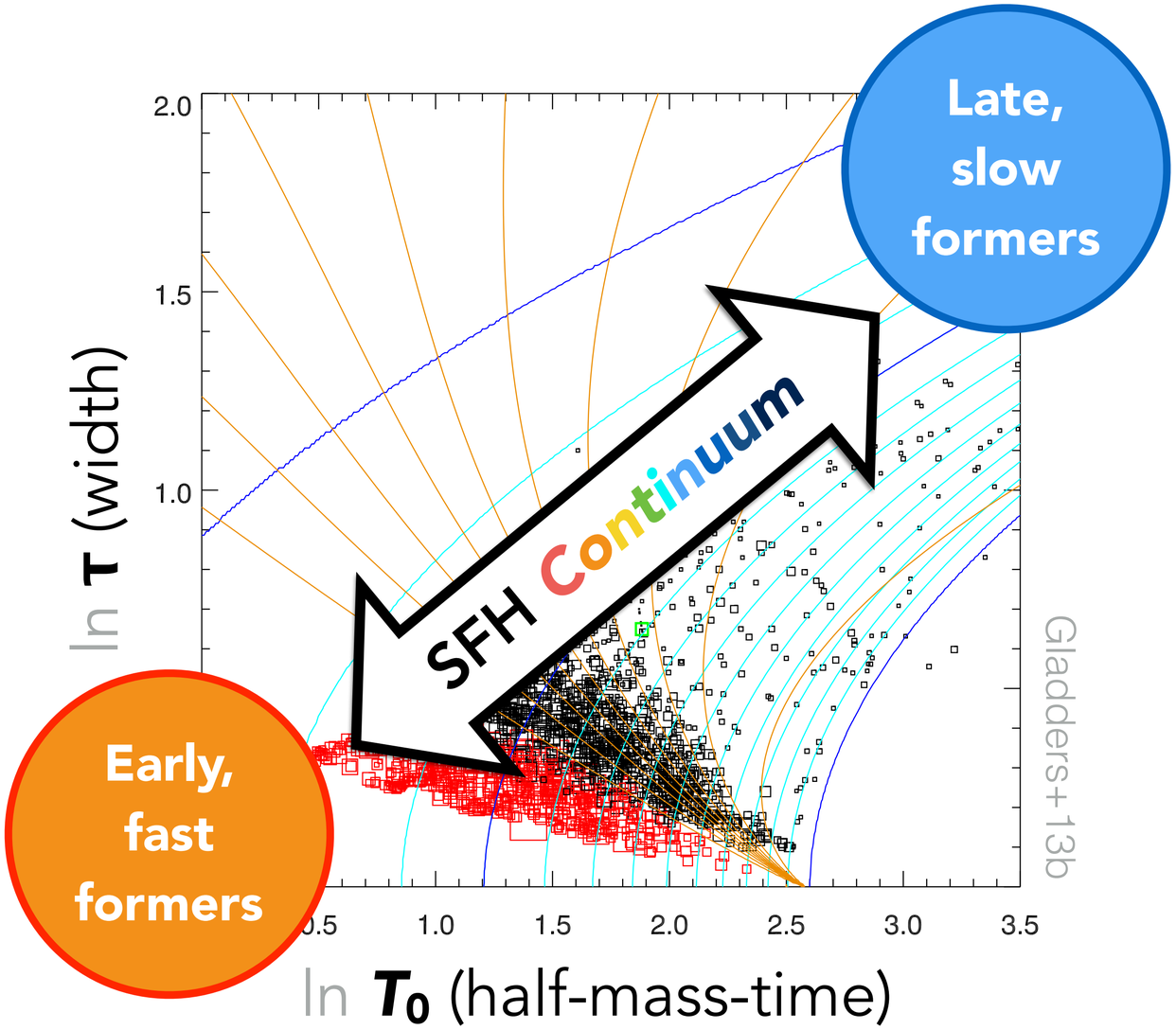
- Every galaxy in the input data gets a **lognormal SFH.**
- I.e., **just two numbers**:

$$T_0, \tau$$

half-mass-time

SFH width

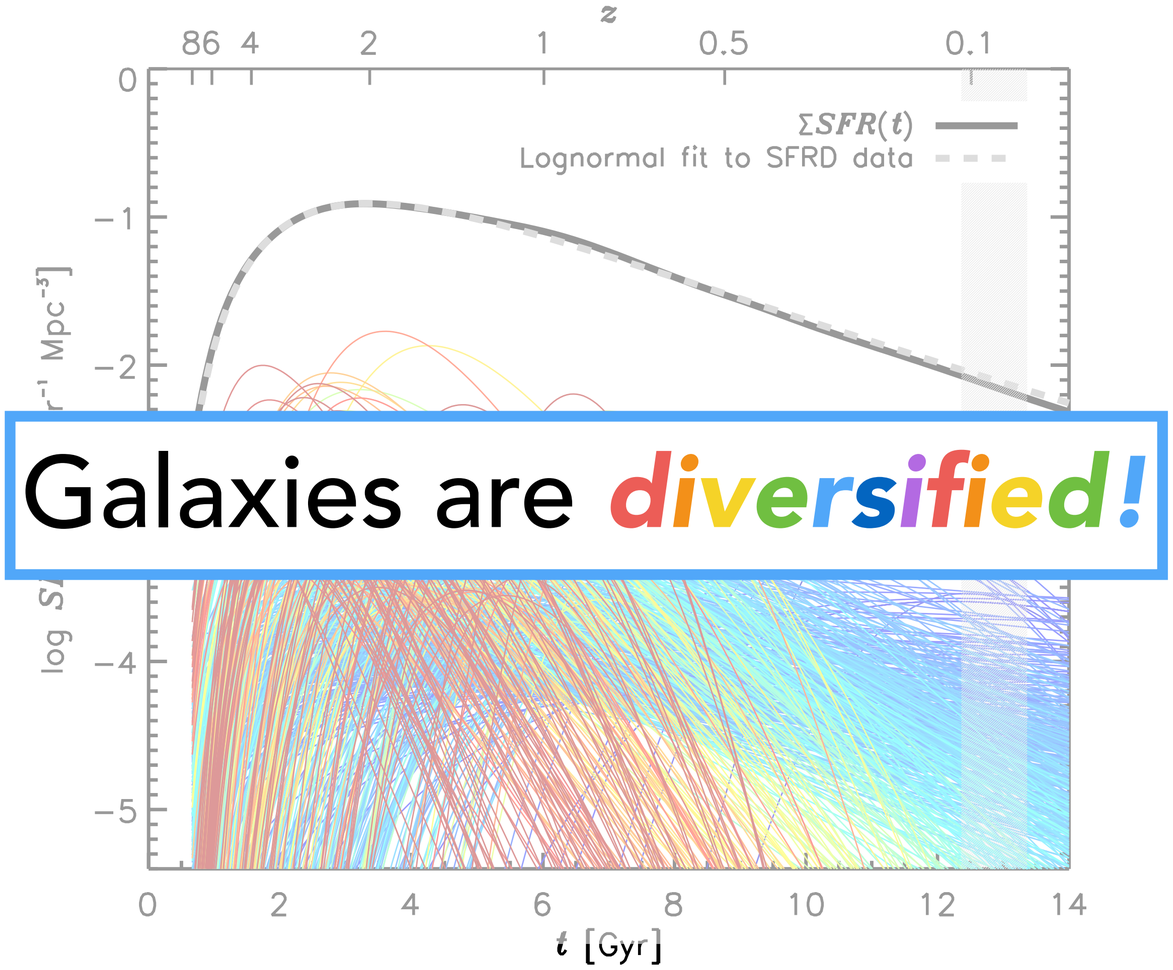
One model:



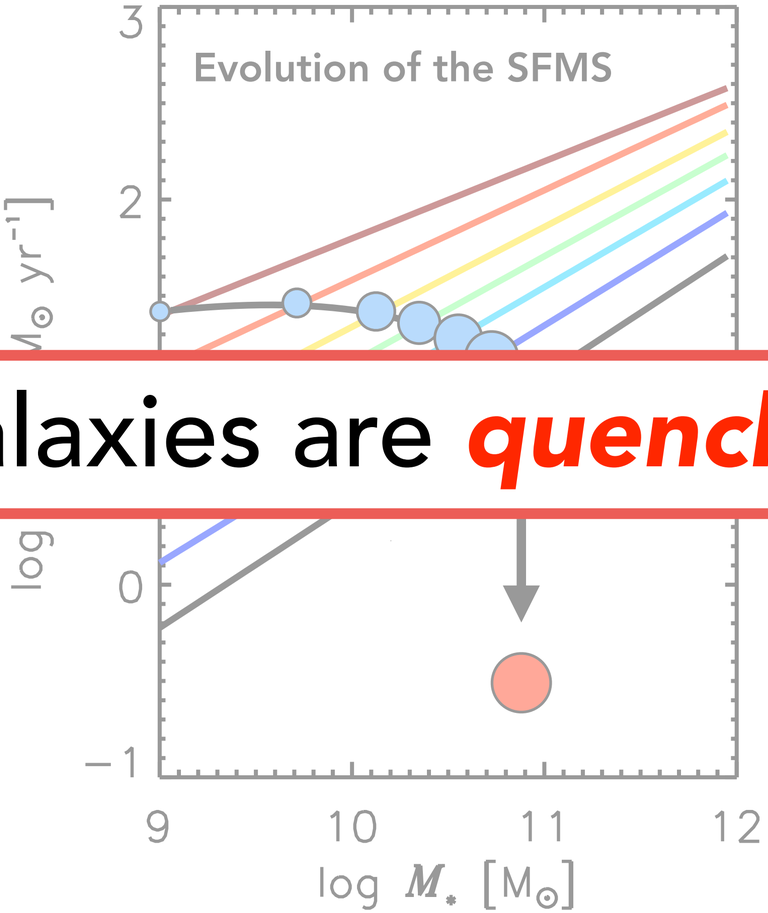
- Every galaxy in the input data gets a **lognormal SFH.**
- I.e., **just two numbers**:

$$T_0, \tau$$

In sum:



Galaxies are ***diversified!***



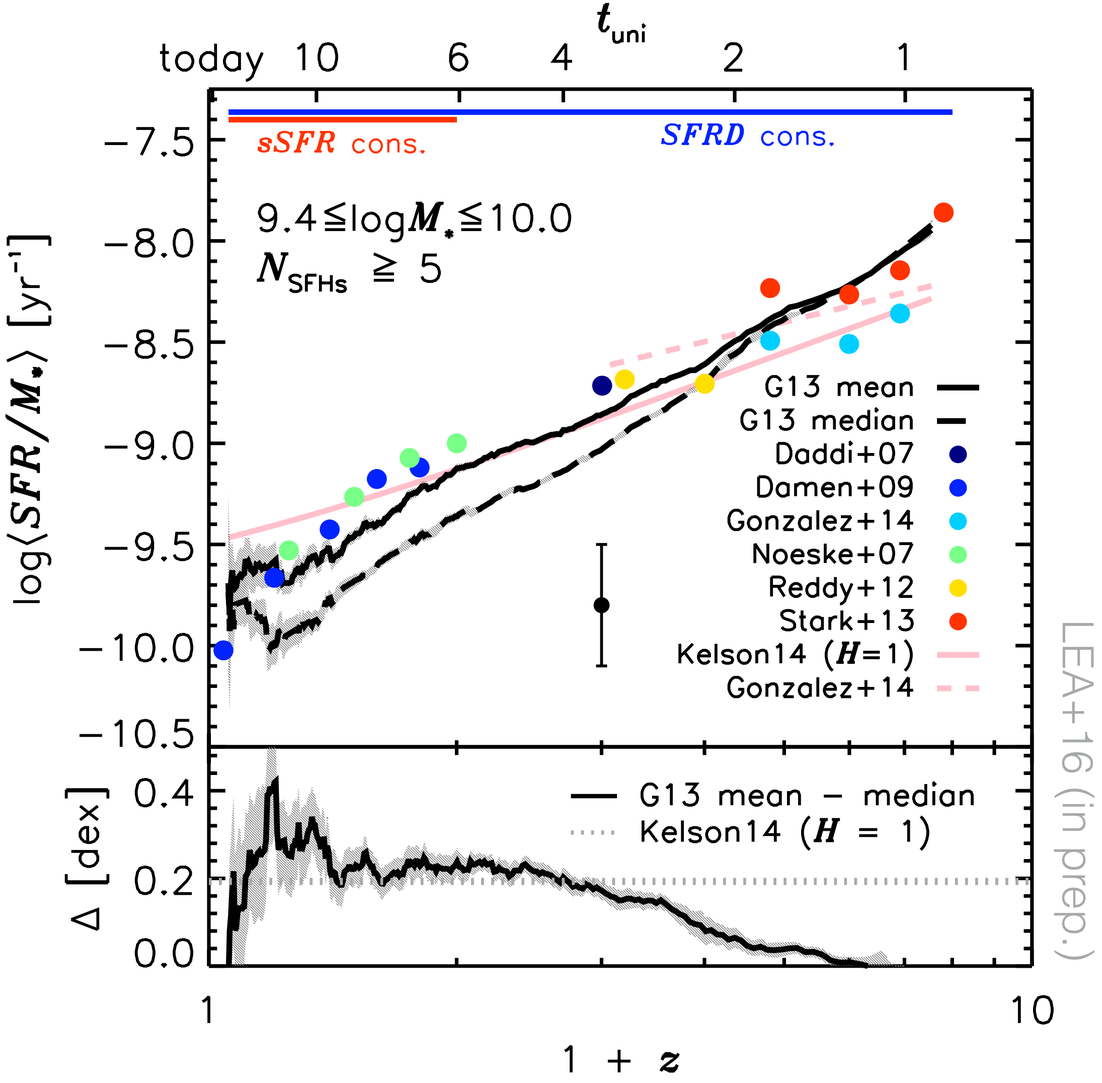
Galaxies are ***quenched!***

These are very
different physical pictures.

Yet…

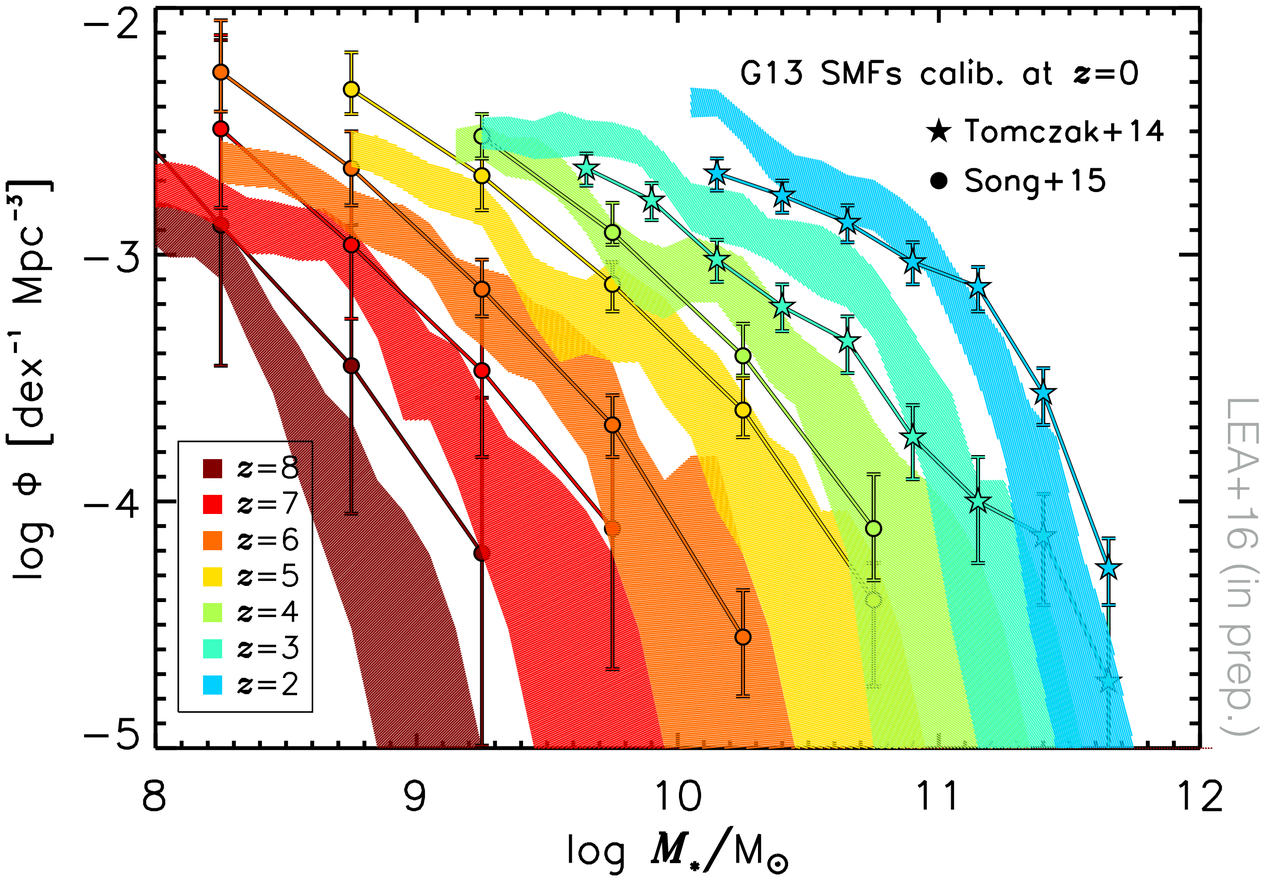
Both reproduce:

- The <sSFR> of low mass galaxies from ***z* = 7 to today**.



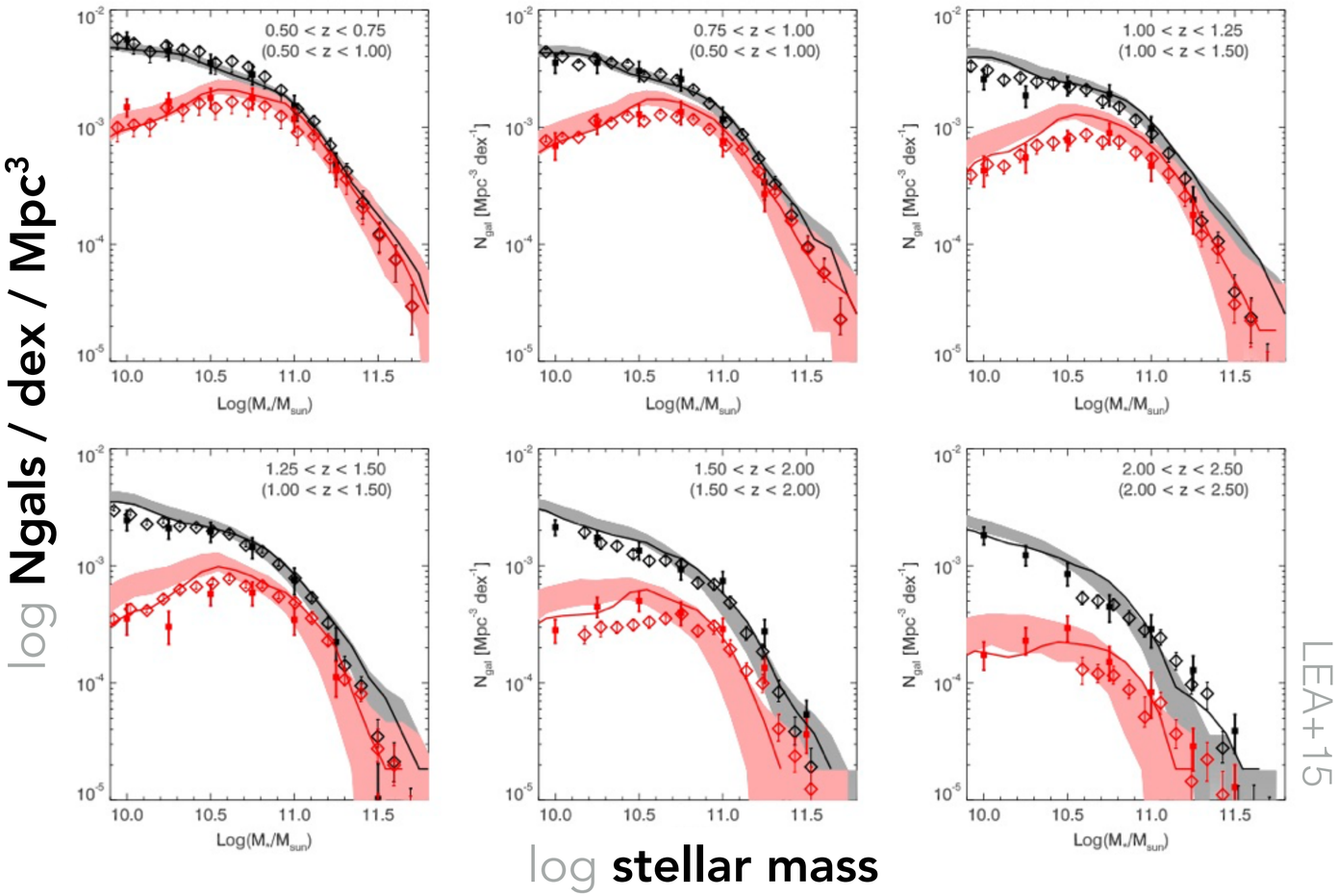
Both reproduce:

- The evolution of the stellar mass function from ***z* = 8 to today**.



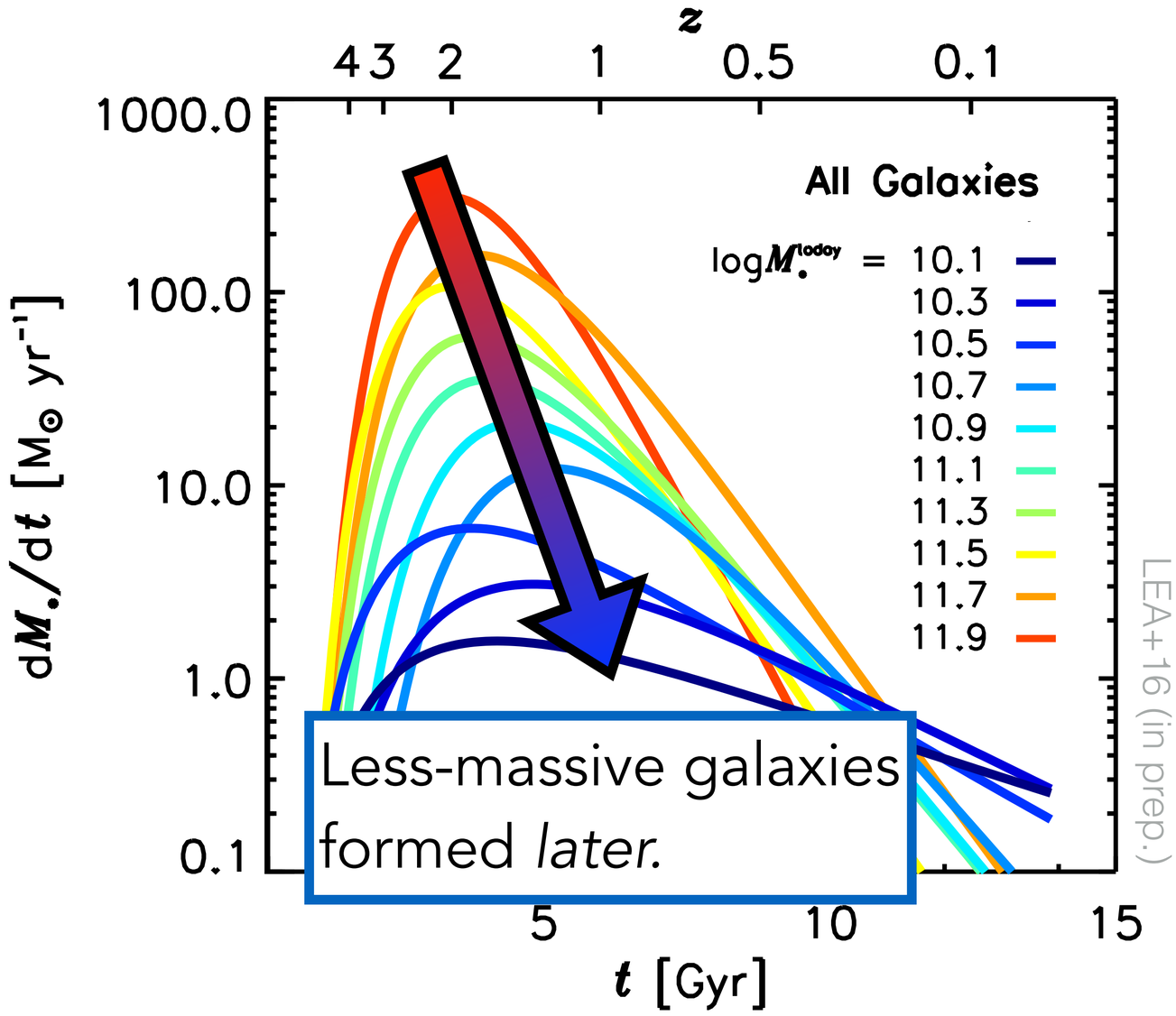
Both reproduce:

- The evolution of the stellar mass function of **quenched** galaxies from ***z* ≥ 2 to today**.



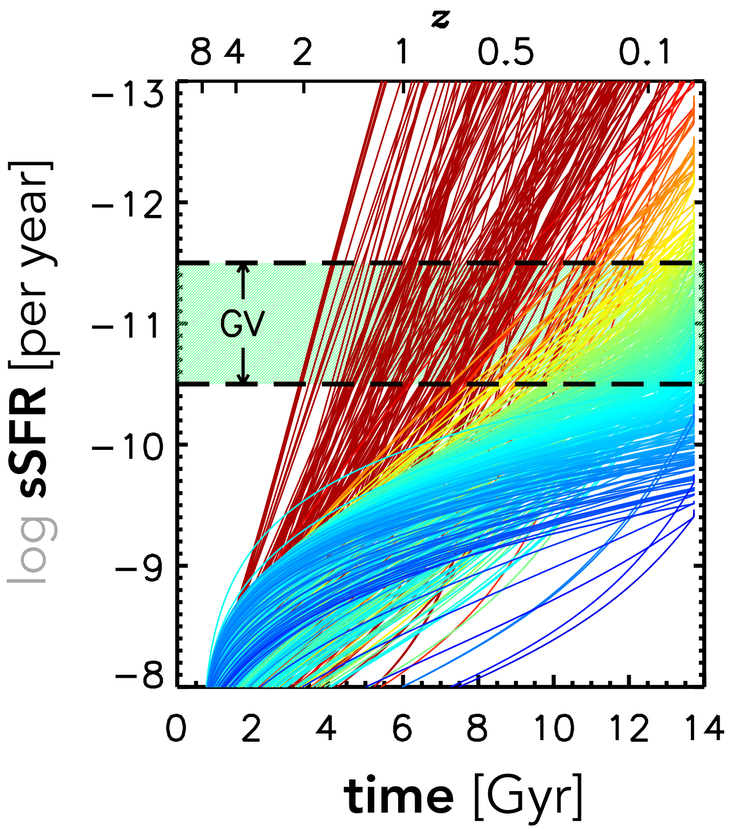
Both reproduce:

- Galaxy **downsizing**.

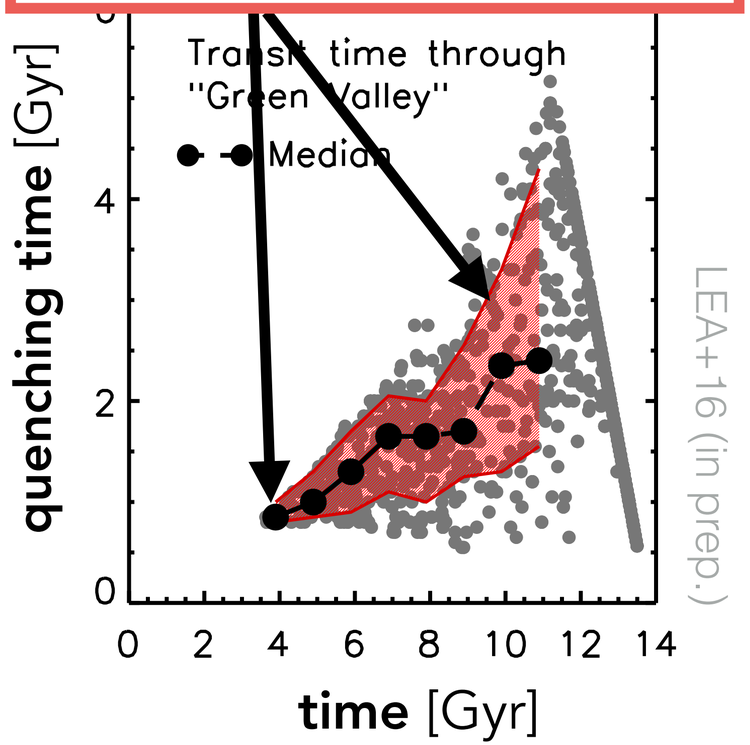


Both reproduce:

- Transition from **“fast-track”** to **“slow-track”** quenching.

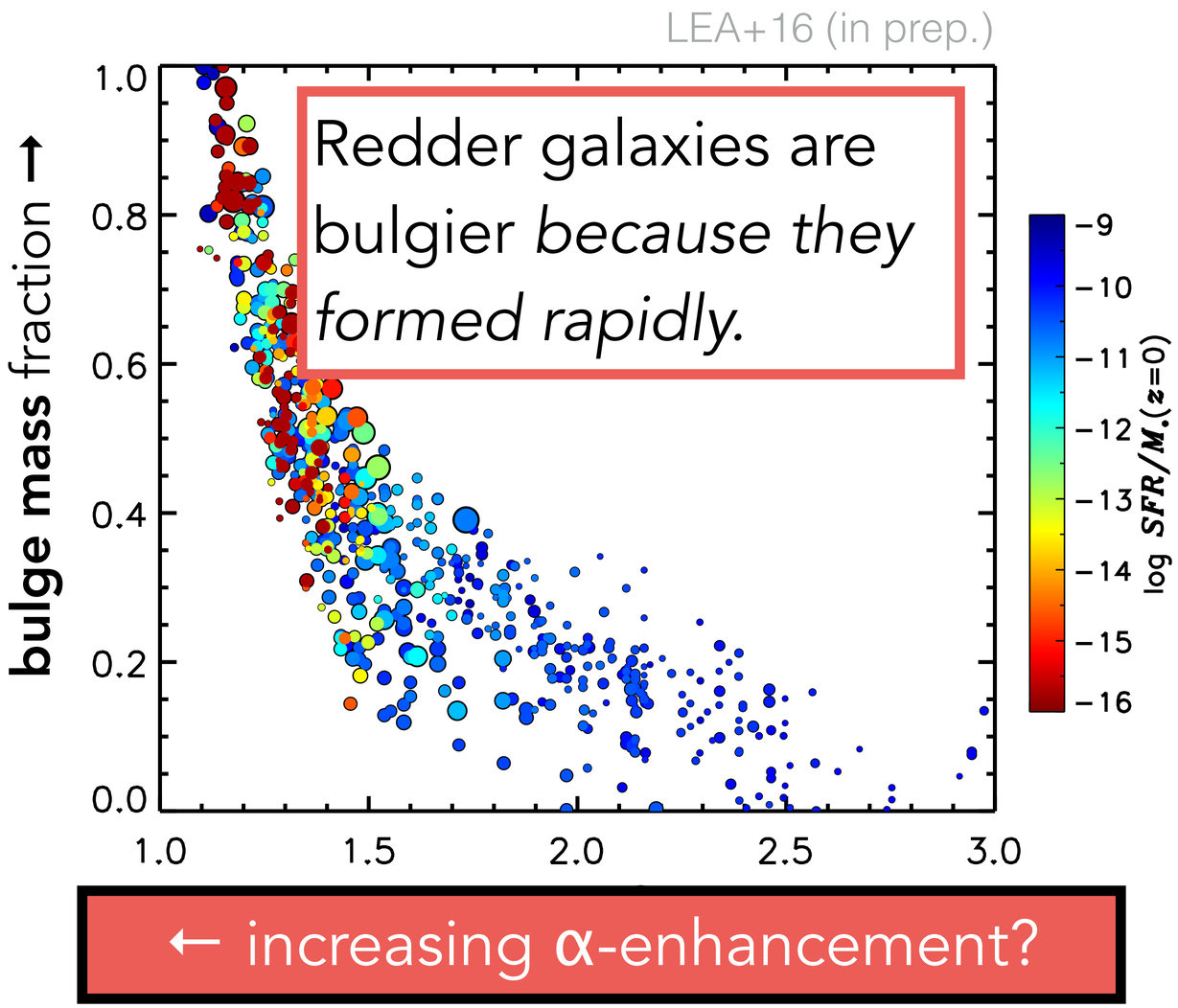


galaxies took less time to “quench” in the past

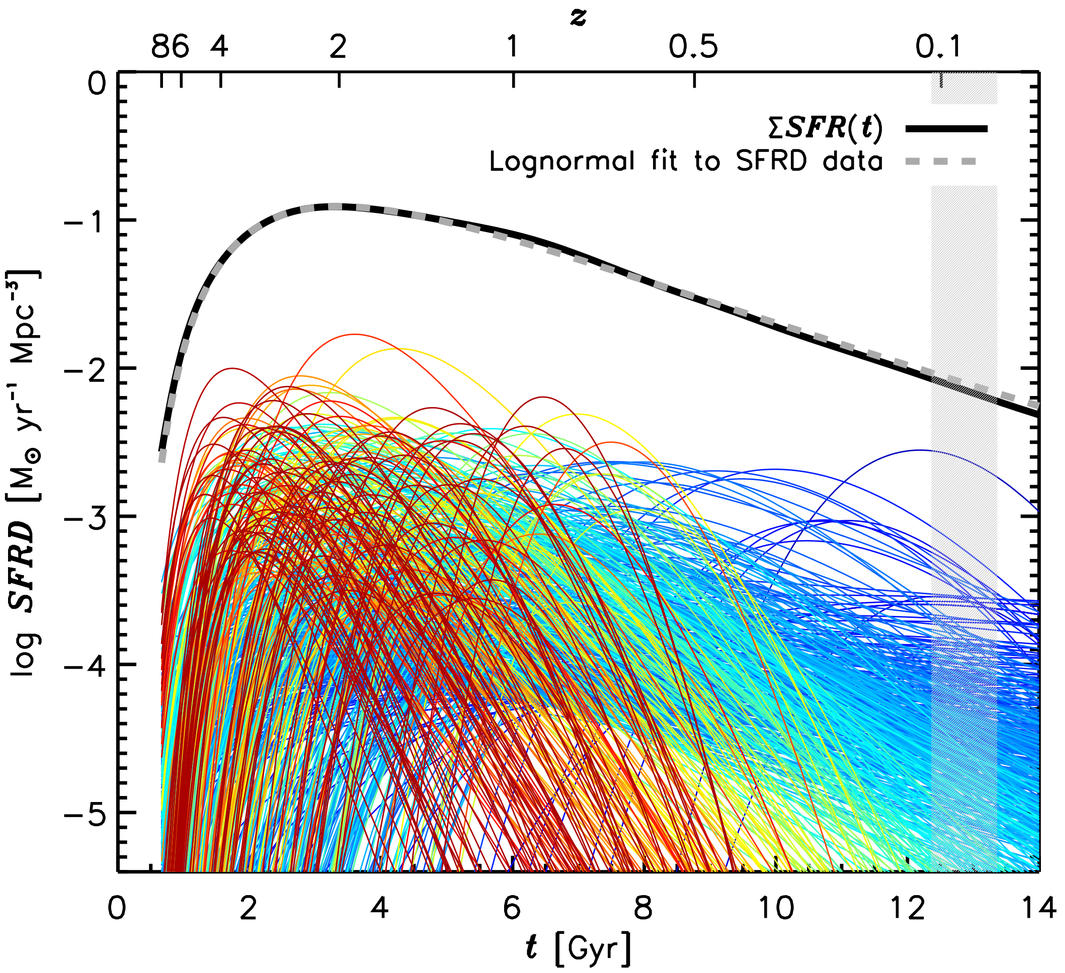


Ours (re)produces:

- Correlations between **chemical enrichment history**, **bulge mass**, and **sSFR**.
  - "Quenching" causality is **reversed!**



Our model:



LEA+16 (in prep.)
Gladders+13b

What sets these galactic clocks?

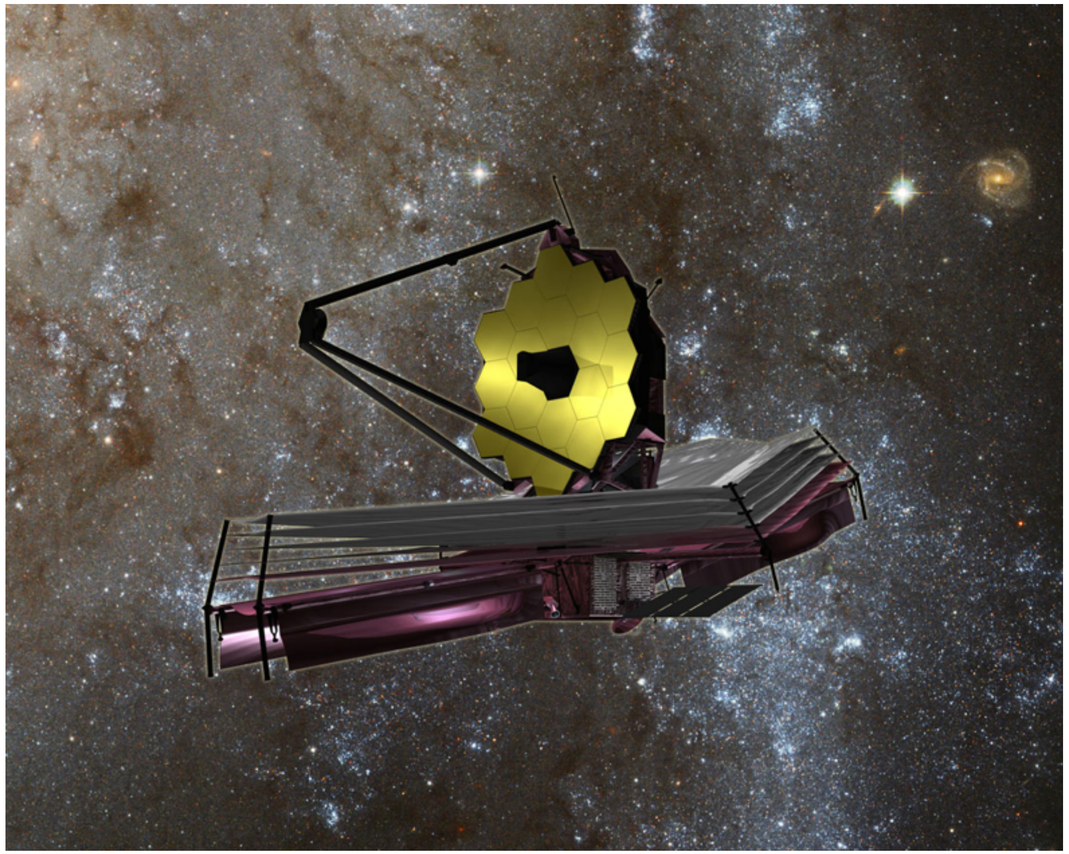
We **don't** understant star formation histories!

- We do not have a unique **descriptive** paradigm.
  - Clocks?
  - Explicit quenching?
- We don't know…
  - *how* **individual** galaxies grow in time.
  - *if* **mean trends** reveal forces differentiating individual SFHs.
  - *which* **global phenomena best-set a galaxy's fate**.
- Kelson: "We don't even know if these are *knowable!*"

We need *different* data.

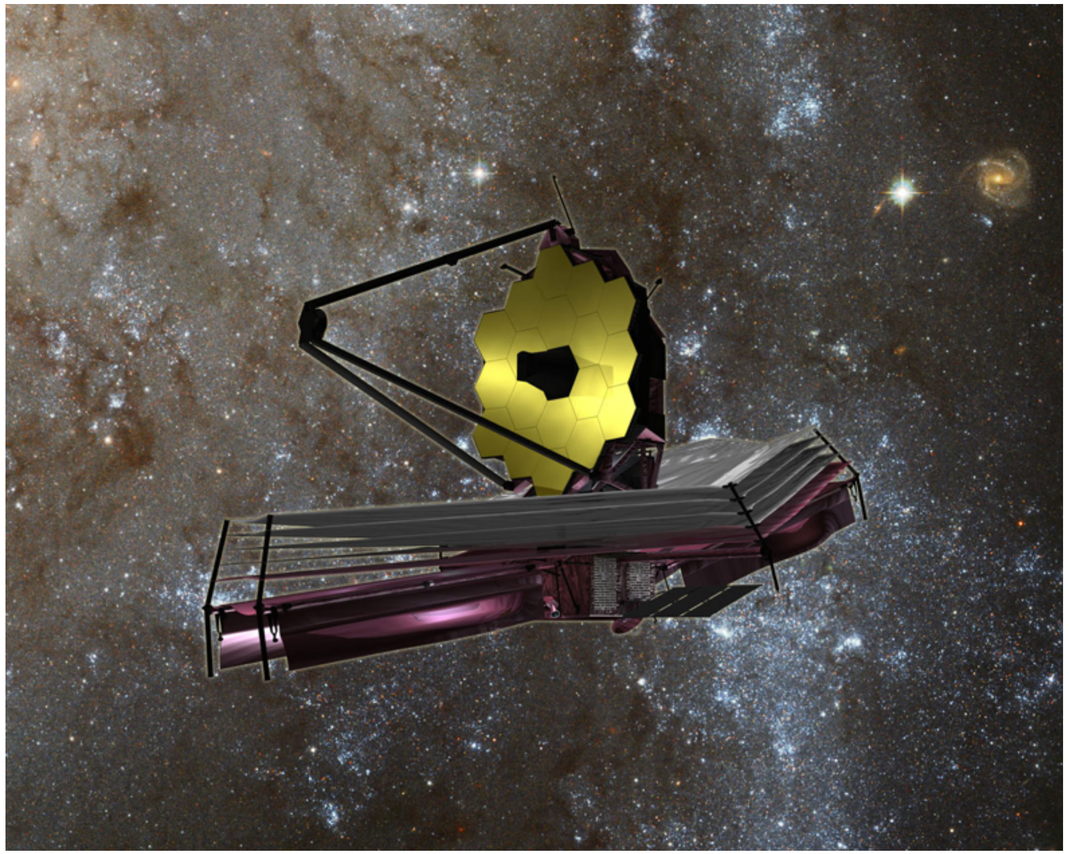
JWST will reveal physics

- **PROS**:
  - Deep, high resolution spectroscopy
  - Covers effectively all of cosmic time
- **CONS**:
  - Narrow FOV
    - No environmental information
    - Little *context.*



JWST will reveal physics

- Will provide:
  - words;
  - the rules of grammar;
  - perhaps sentences.
- Will **not** provide **narrative**.



WFIRST will reveal the **story**

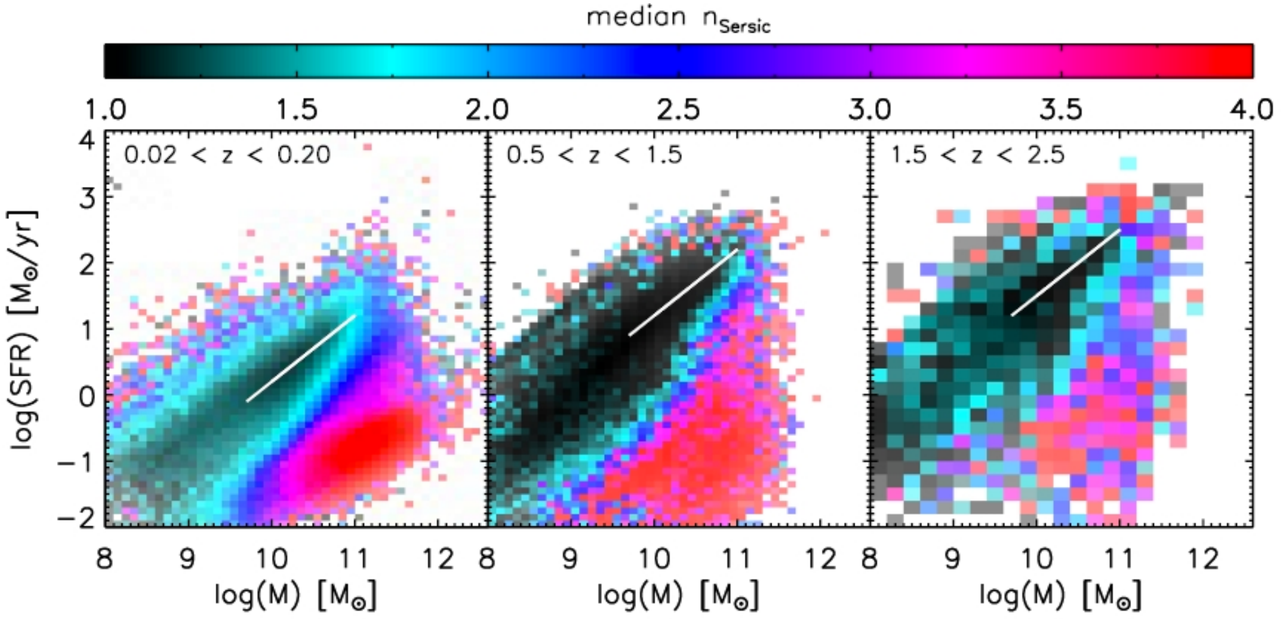
- Must situate physics revealed by JWST for small samples in a global narrative.
- *WFIRST* will do that.

WFIRST will reveal the **story**

- Fine **tomography + spatially resolved spectroscopy** over **huge areas** will provide *the narrative* of galaxy evolution.
  - Will allow ***true progenitor connections*** via, e.g., **metallicity *gradients***.
  - Will test environmental implications of above paradigms.

How *WFIRST* will finish the story

- Trick: isolate progenitors
  - Gradients
  - Tomography
- Test paradigms
  - Environmental trends?
  - Reionization sources?



Wuyts+11

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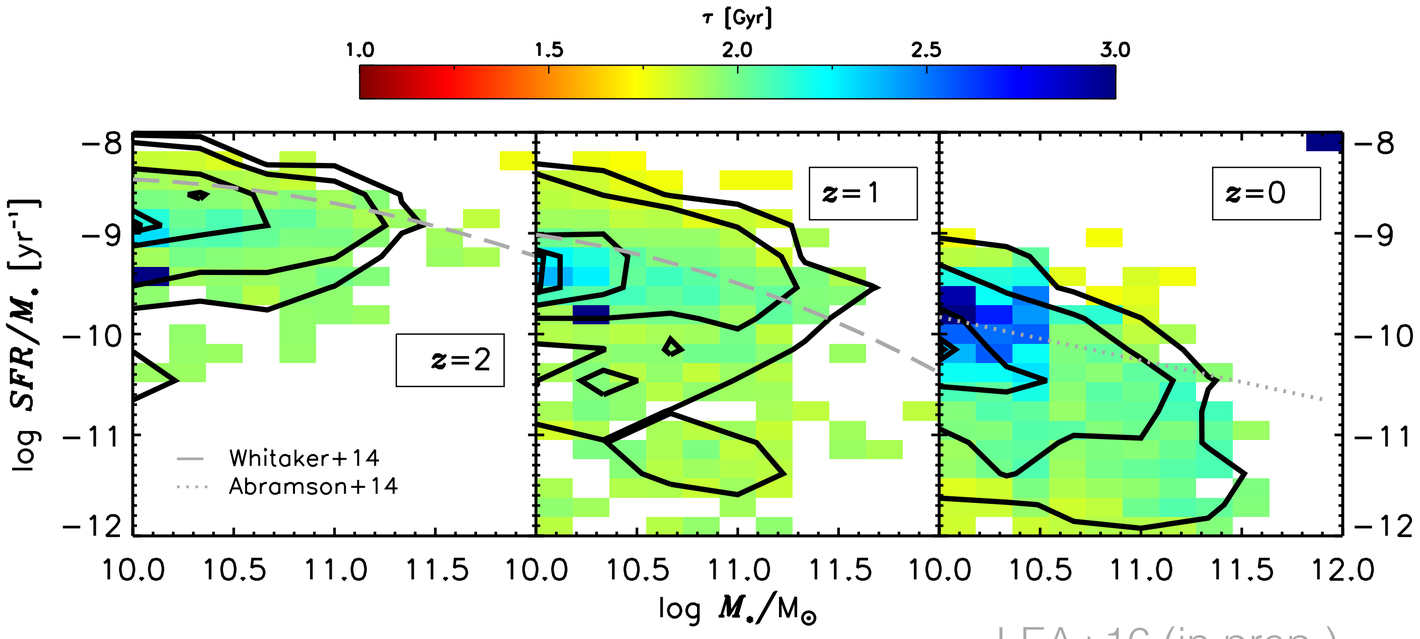

LEA+16 (in prep.)

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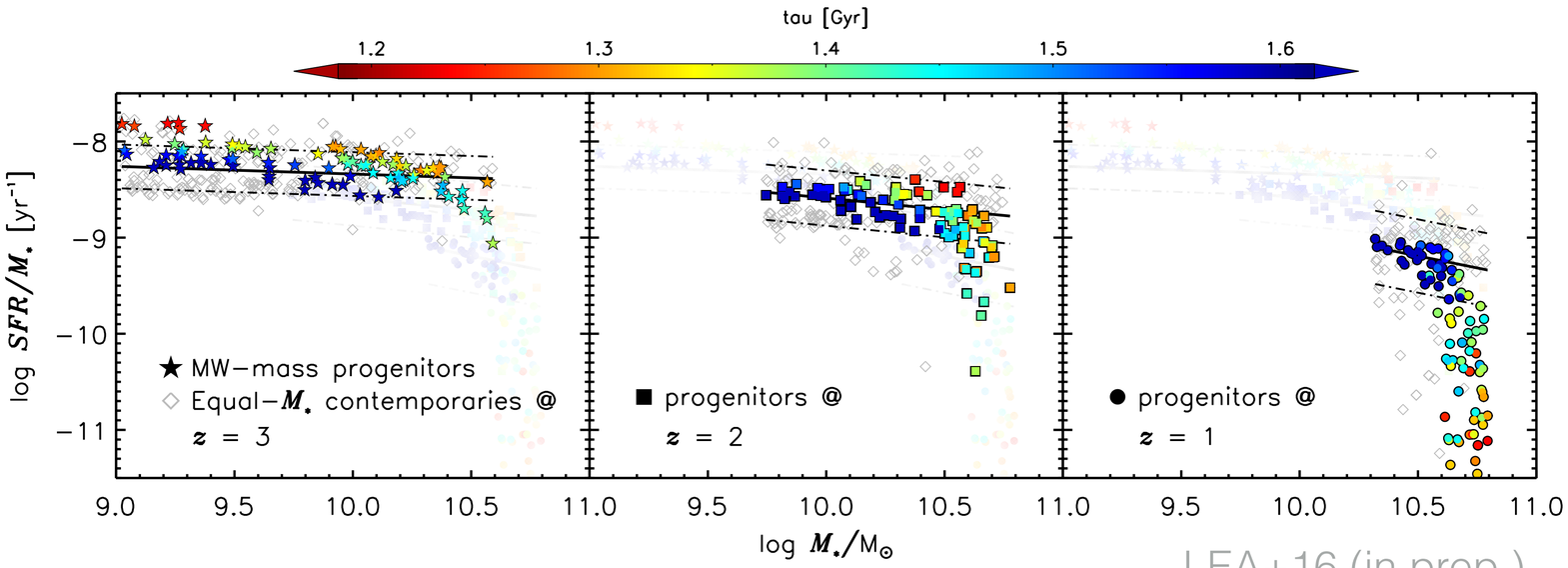
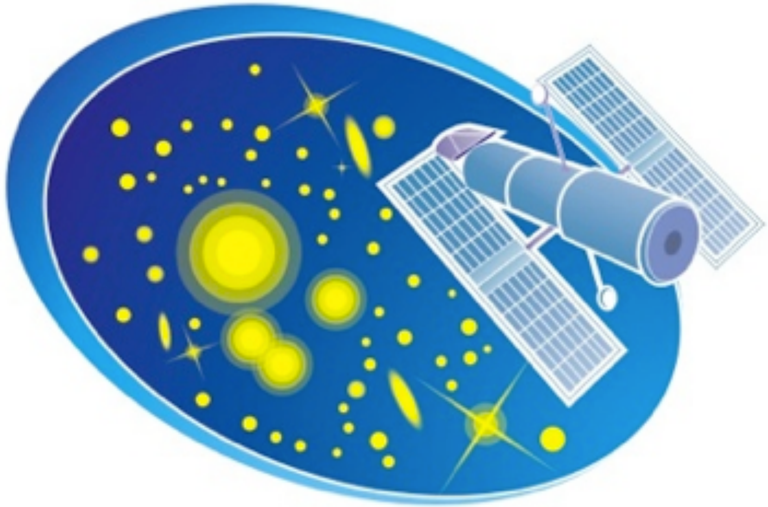


LEA+16 (in prep.)

We *can* do this! *HST* proves it!

- "Technology demonstration" is underway.
  - Being led across town by **T. Treu** and **M. Malkan**
  - And up the street by **A. Dressler**.

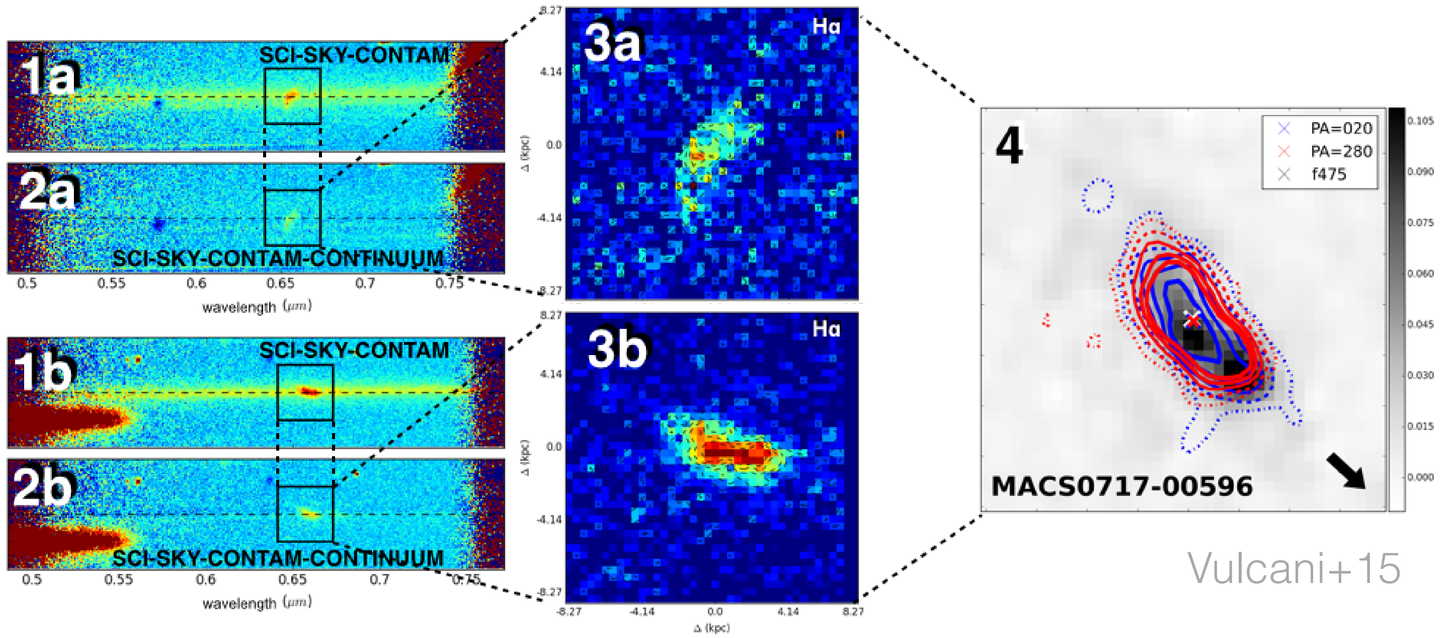
GLASS



***G**rism **L**ens-**A**mplified **S**urvey from **S**pace*

Paving the way

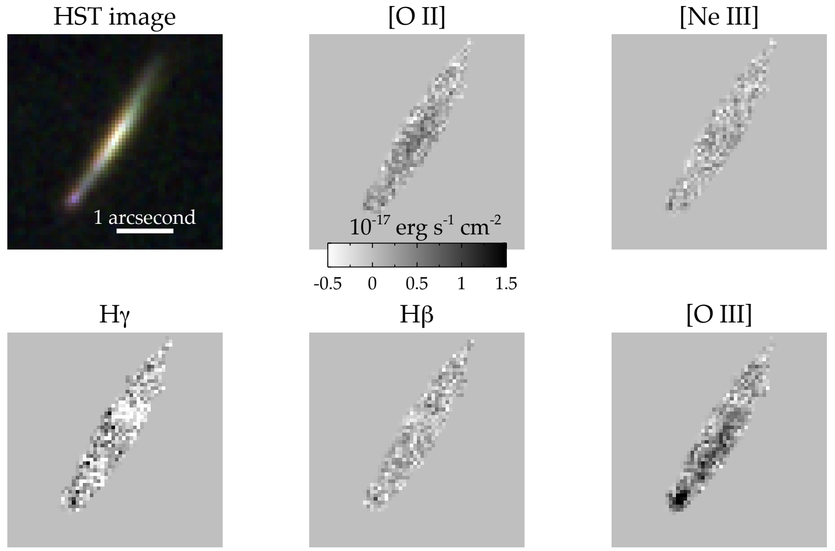
- *GLASS* is showing *WFIRST* grism will enable spatially resolved spectroscopy
  - Hα maps @ z ≤ 1.9 for *individual objects*



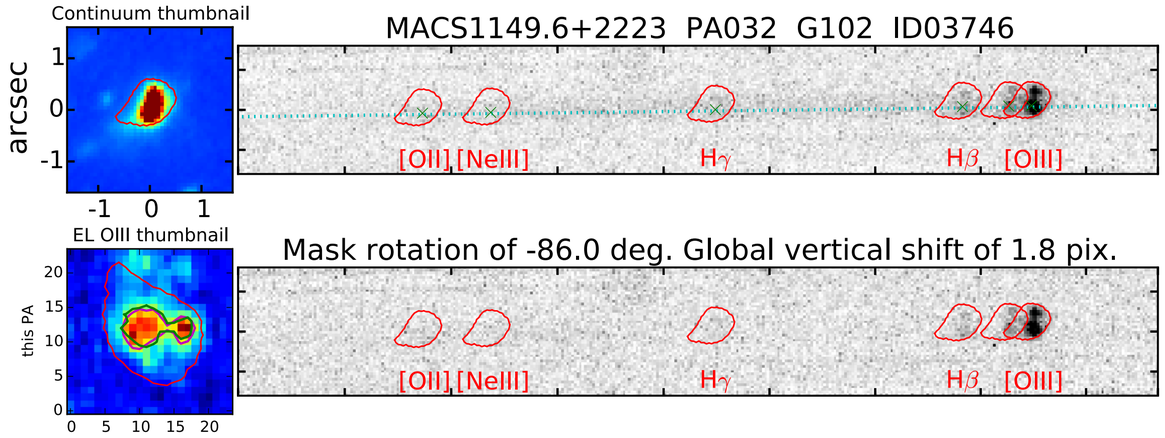
Vulcani+15

Gas-phase metallicity gradients

- Multiple strong lines for:
  - gas-phase metallicity gradients & dust maps
  - Balmer decrements for **dust corrections**
    - **Necessary for good SFRs!**



Jones+15
z = 1.85

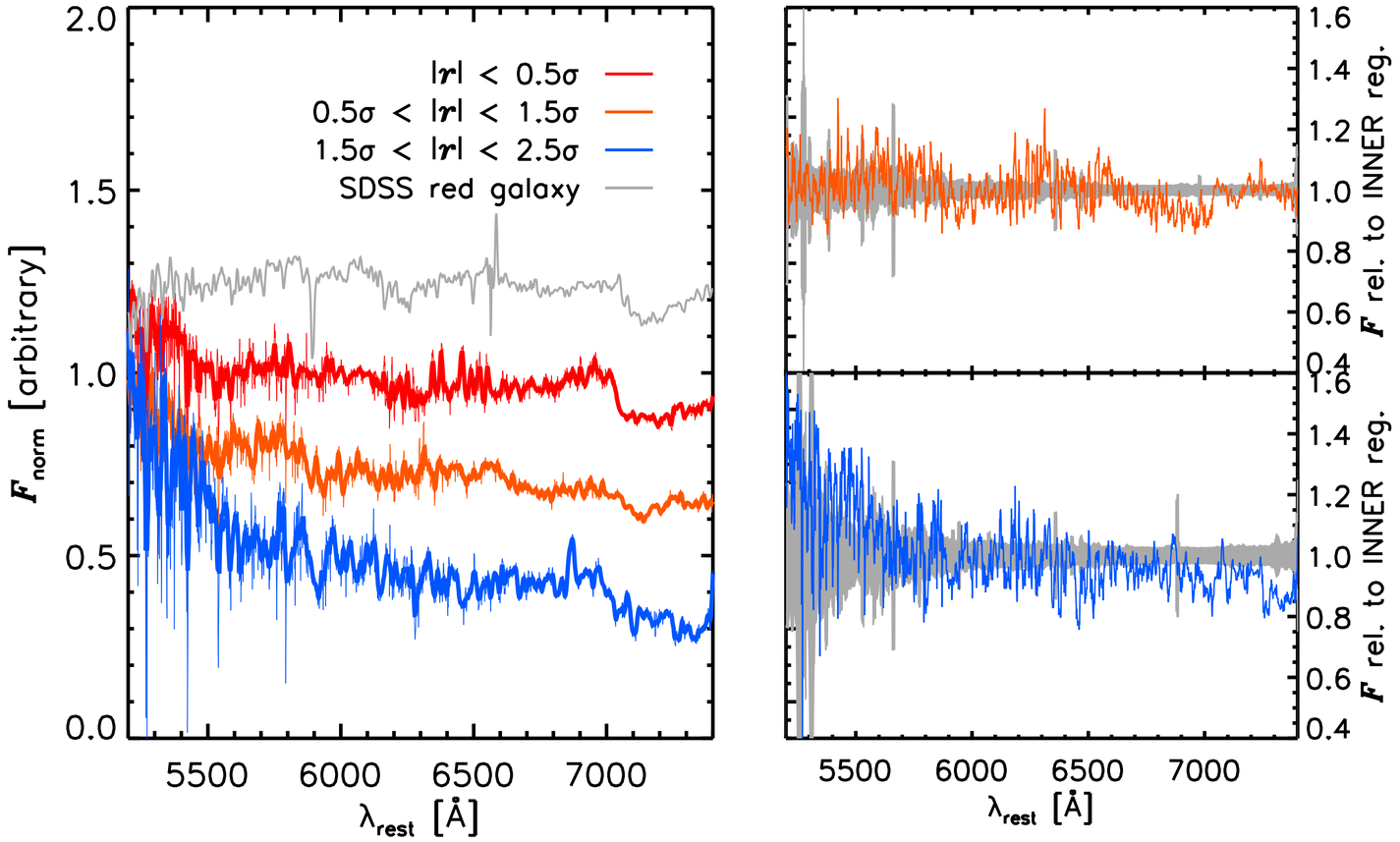


Wang+ (in prep)
z = 1.25

Stellar metallicity gradients

- **Absorption** line gradients
  - Can connect **gas-phase metallicity gradients** @ high-z to **stars** at low-z.
  - Very powerful evolutionary tests!

GLASS PRELIMINARY



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