How to Quench **Massive** Galaxies

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with
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What we know about average galaxy properties

1. Star-forming galaxies live on **M-SFR relation**

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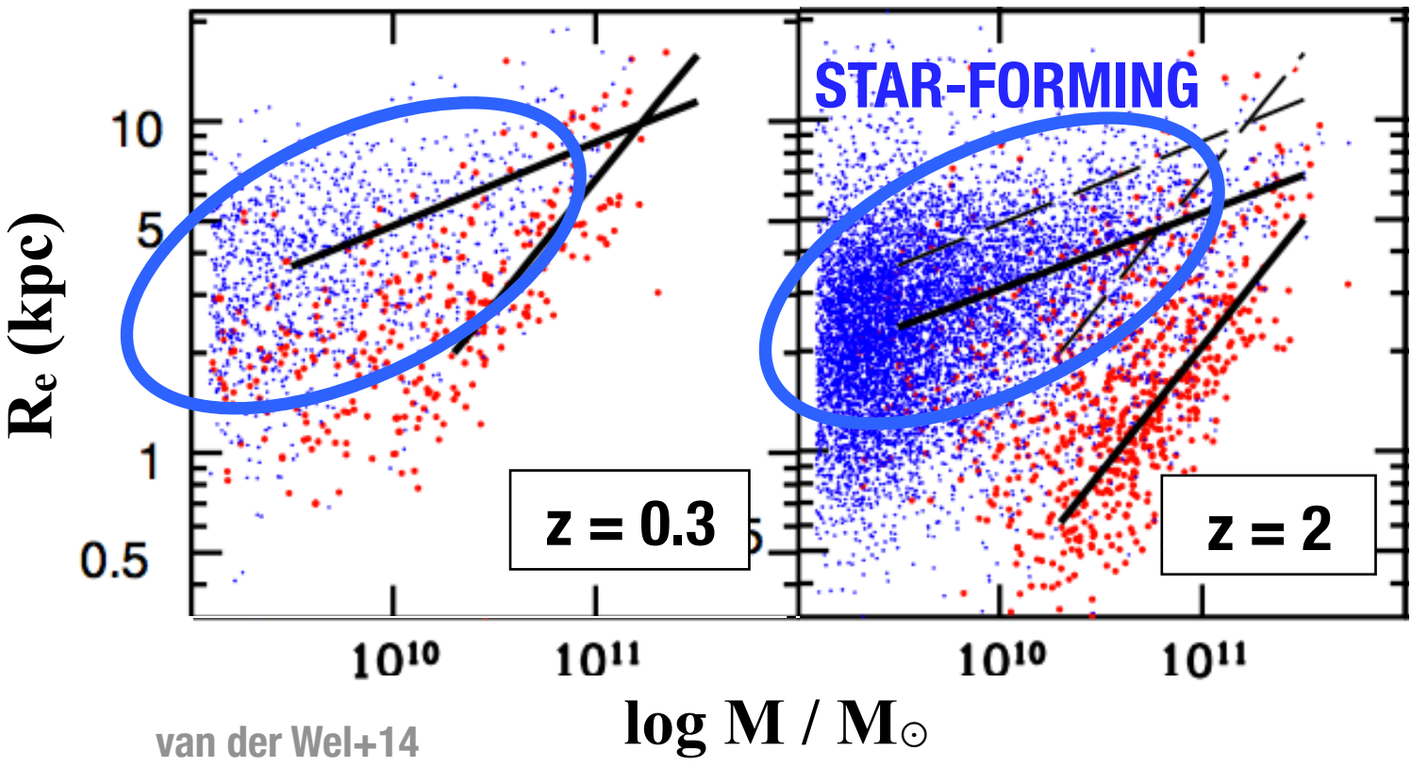

van der Wel+14

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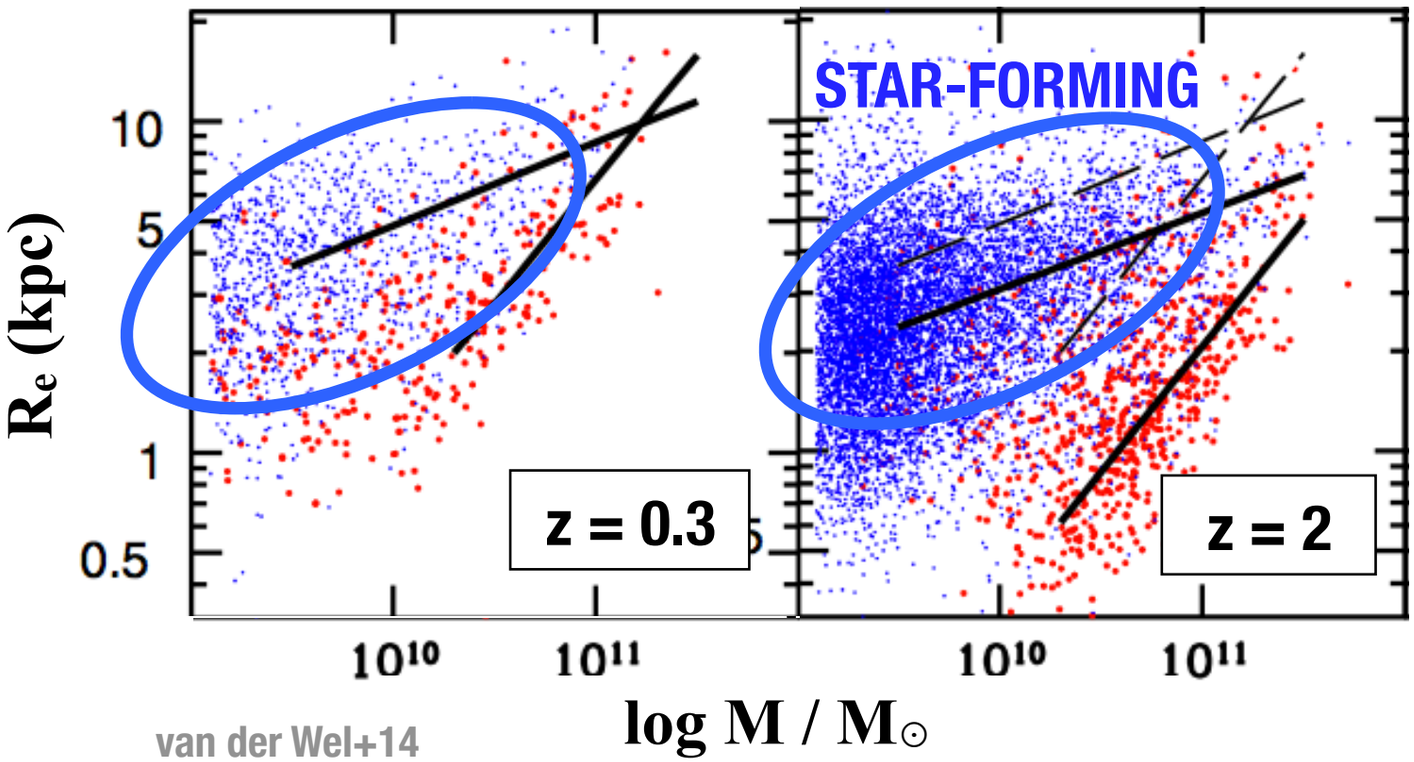

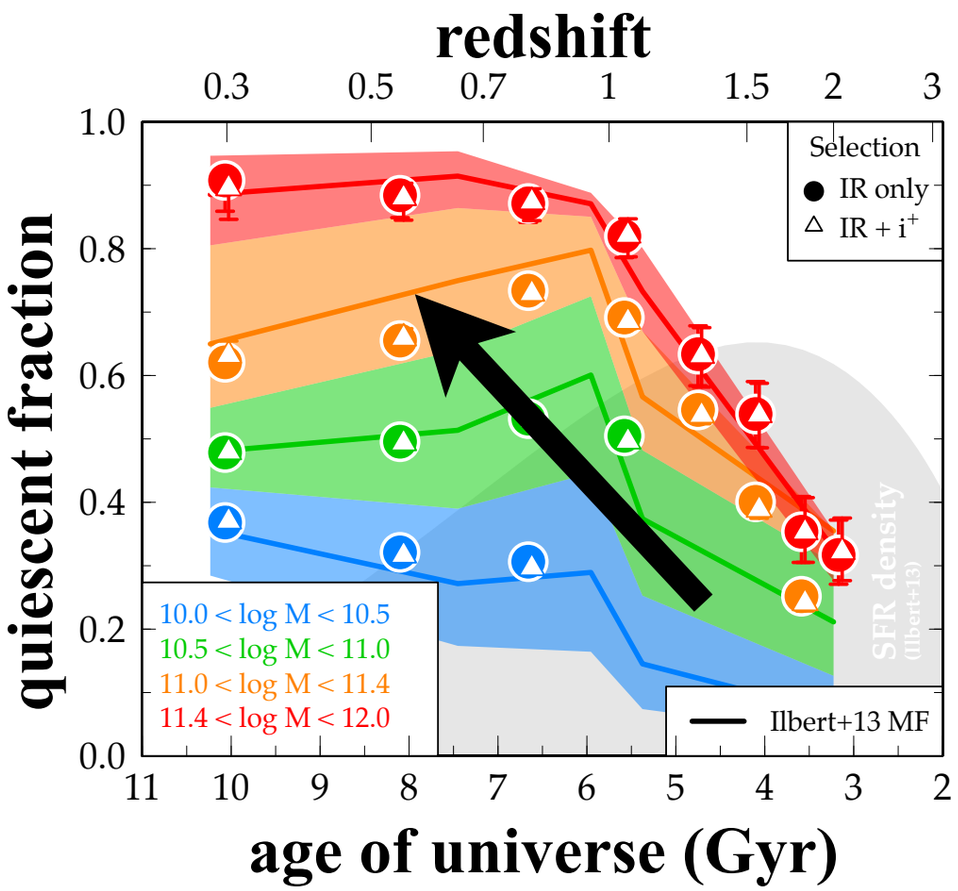

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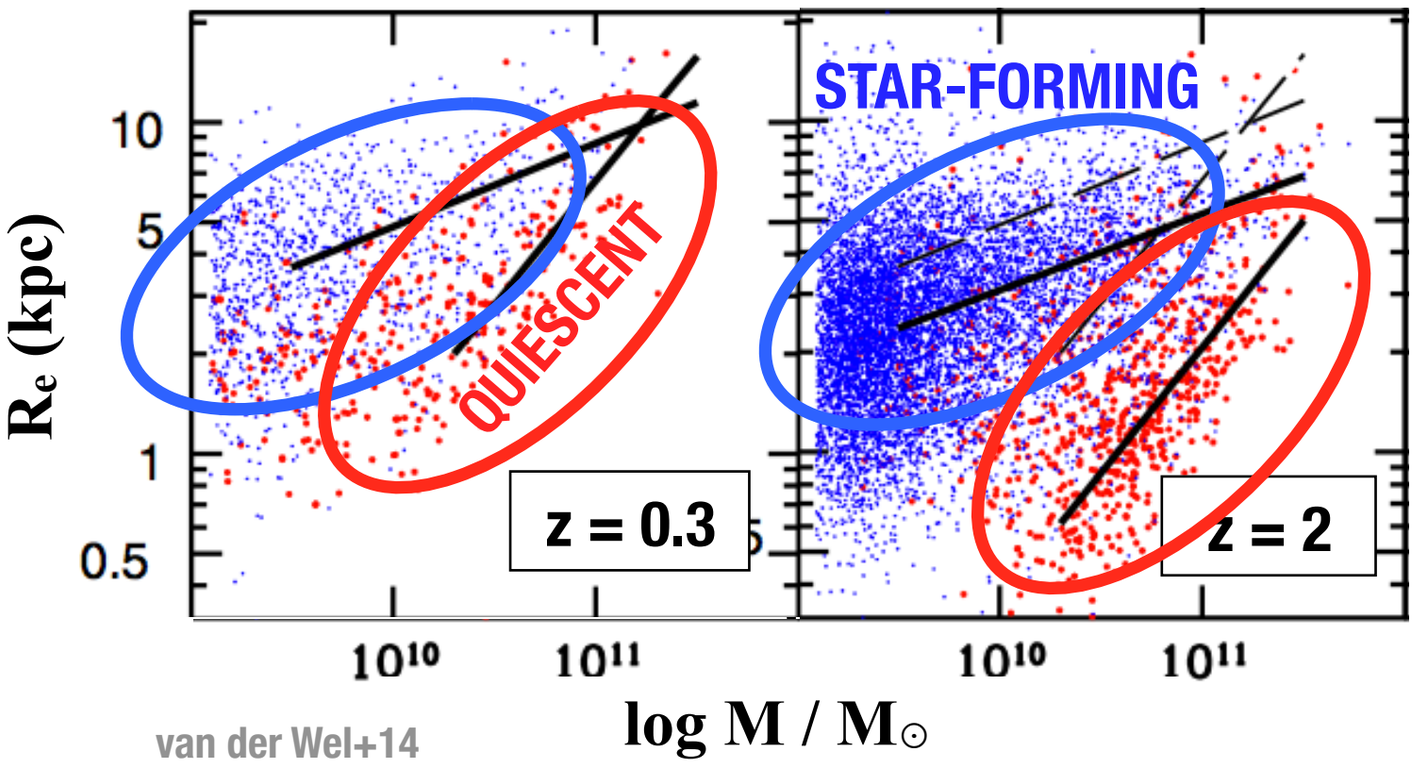

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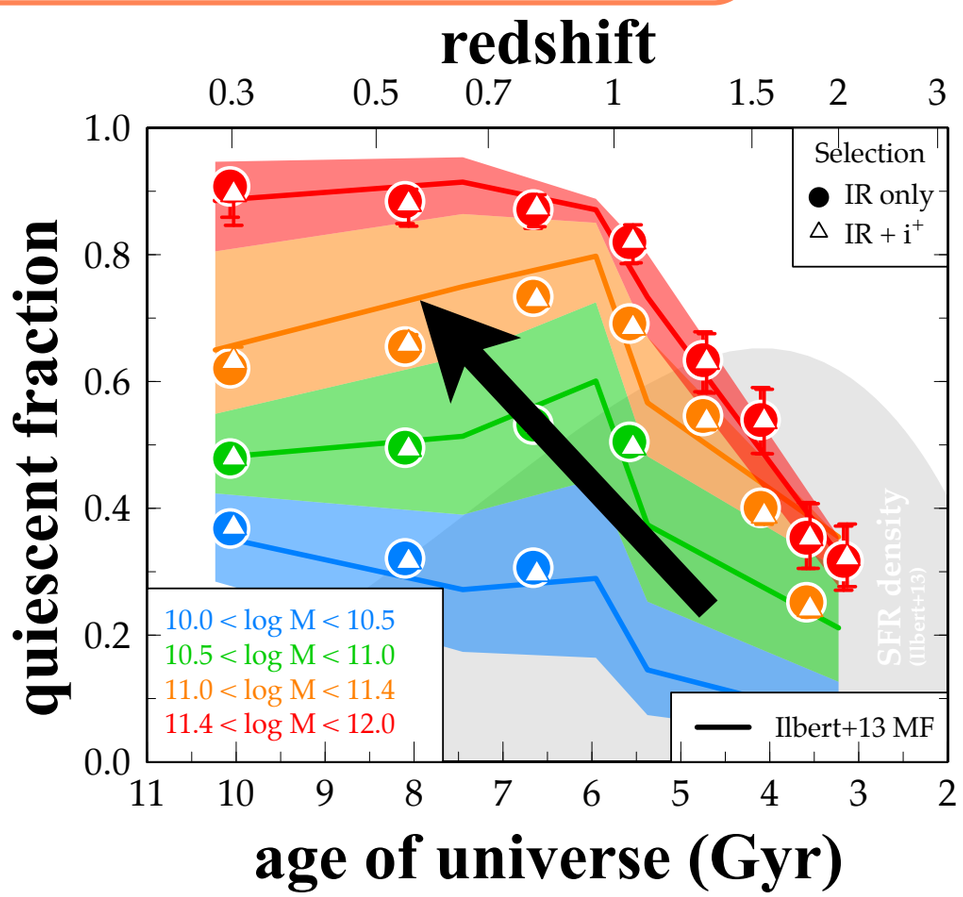

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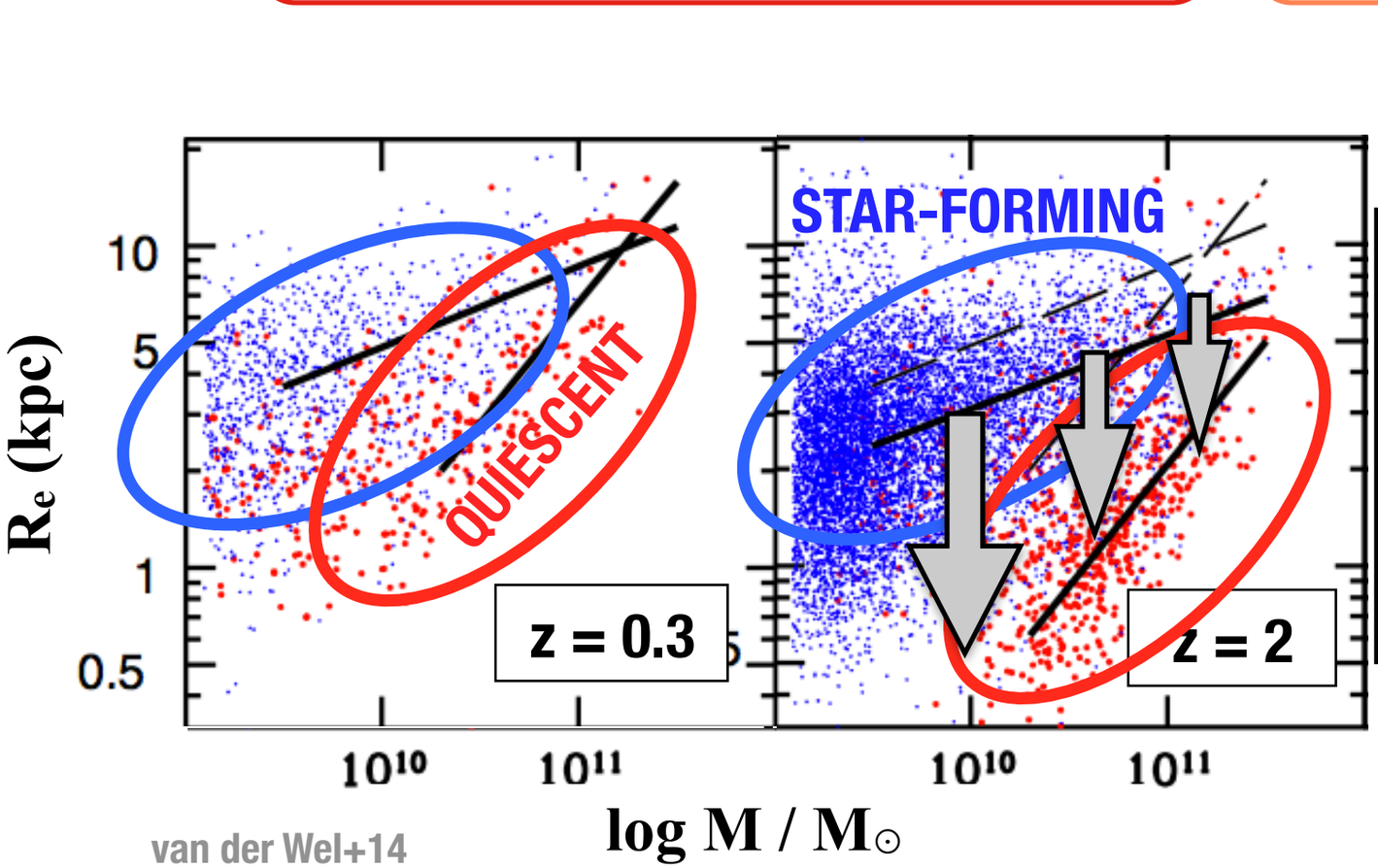

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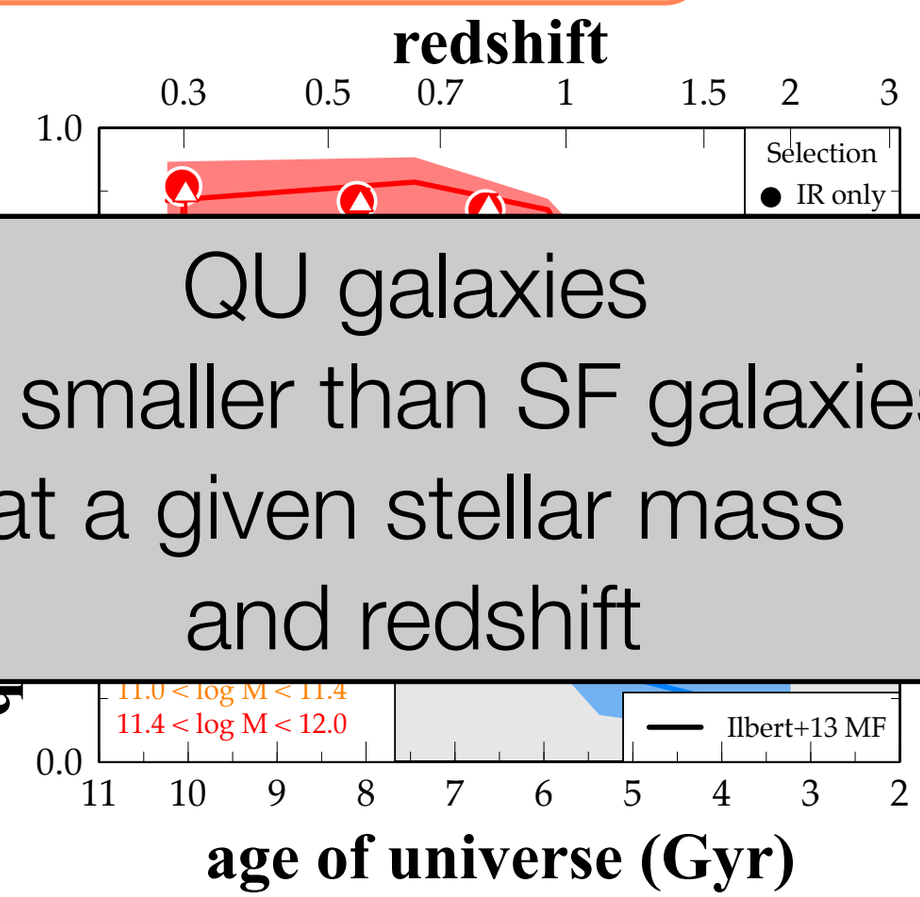

QU galaxies
are smaller than SF galaxies
at a given stellar mass
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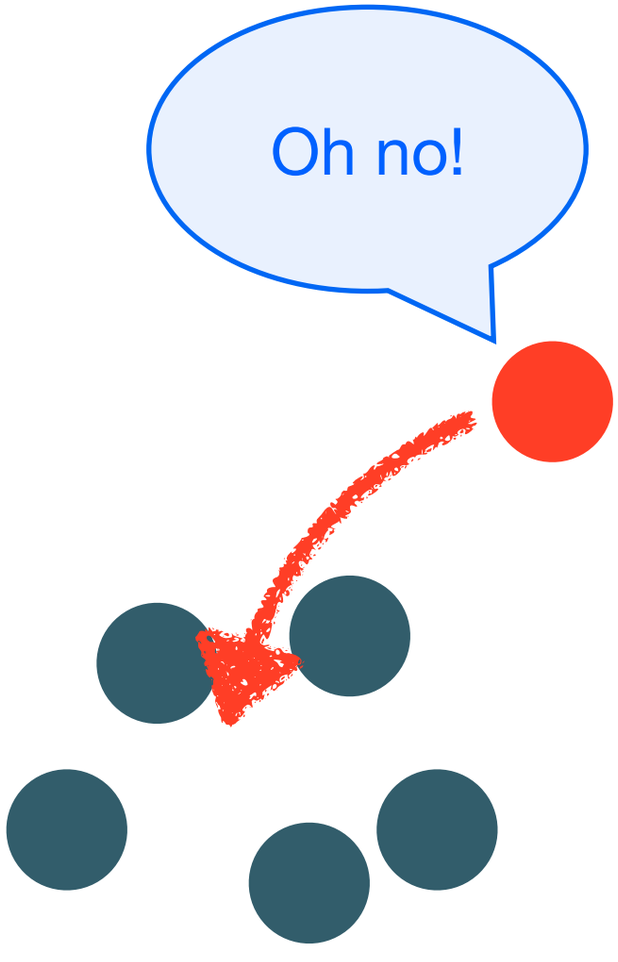
What we don’t really know: Process of quenching

Quenching depends on various parameters

- Environment: large- and small-scale structure
  - stripping and heating of cold gas used for star formation
  - Merger + starburst + AGN + quick consumption of gas
  - …



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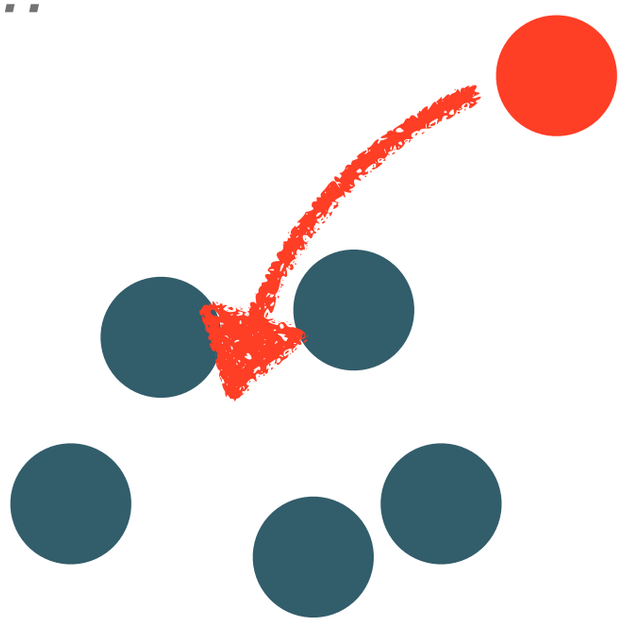
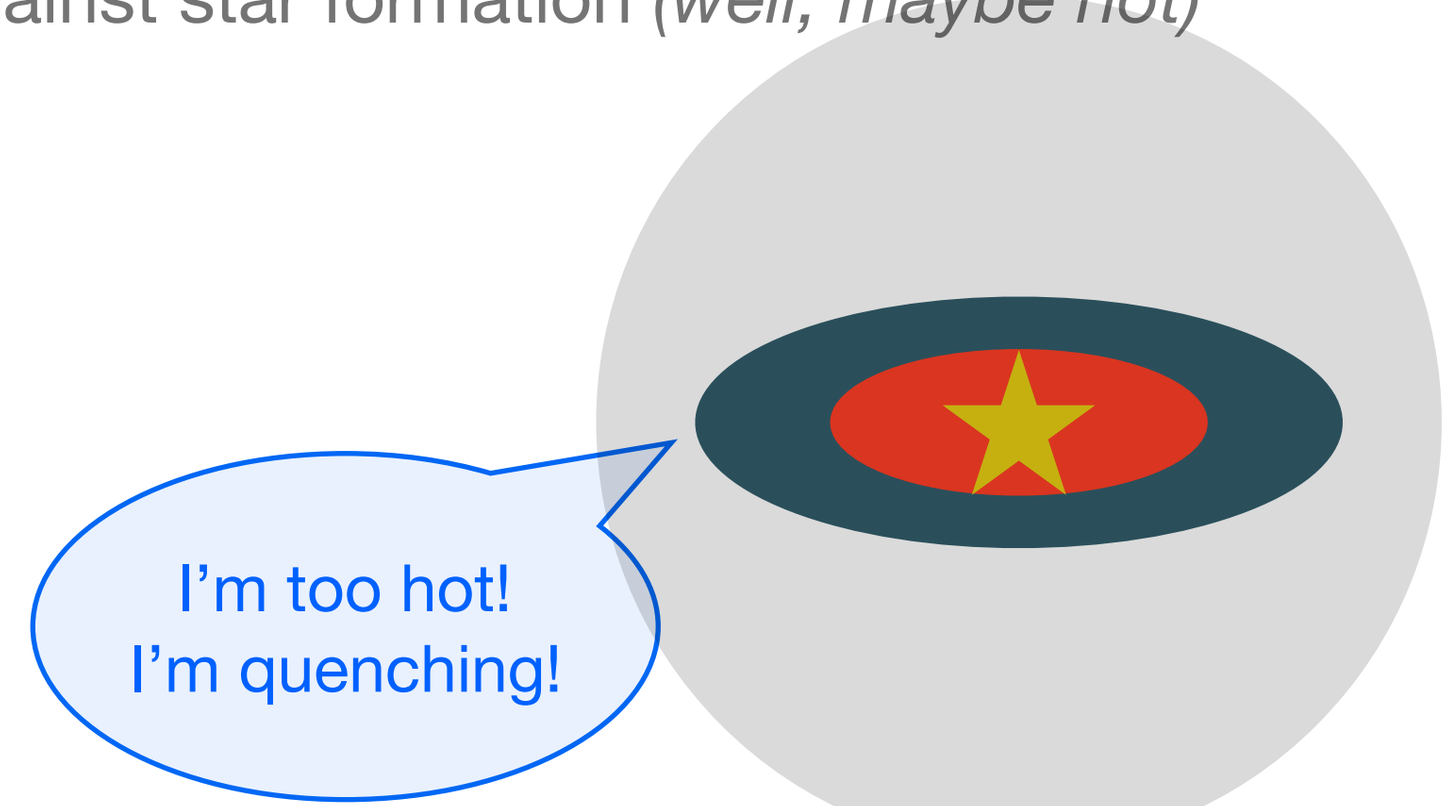
- Mass: halo mass, stellar mass (density)
  - Heating of (infalling) gas through > 10^{12} $M_\odot$ halo
  - Stabilization of disk against star formation *(well, maybe not)*
  - *…*





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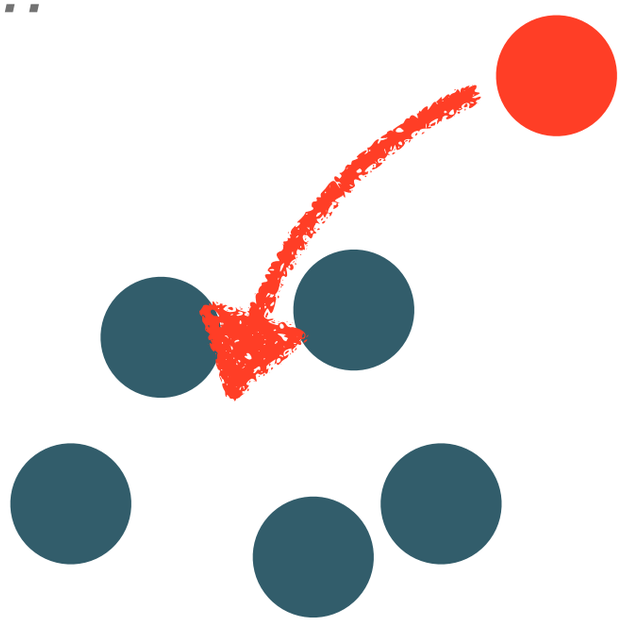
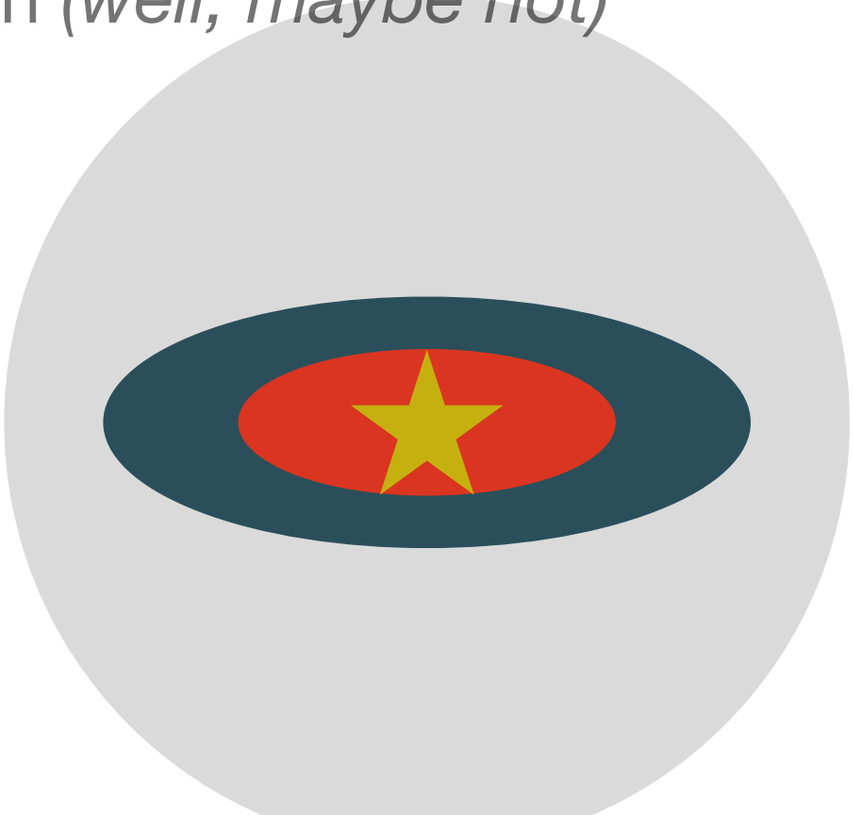


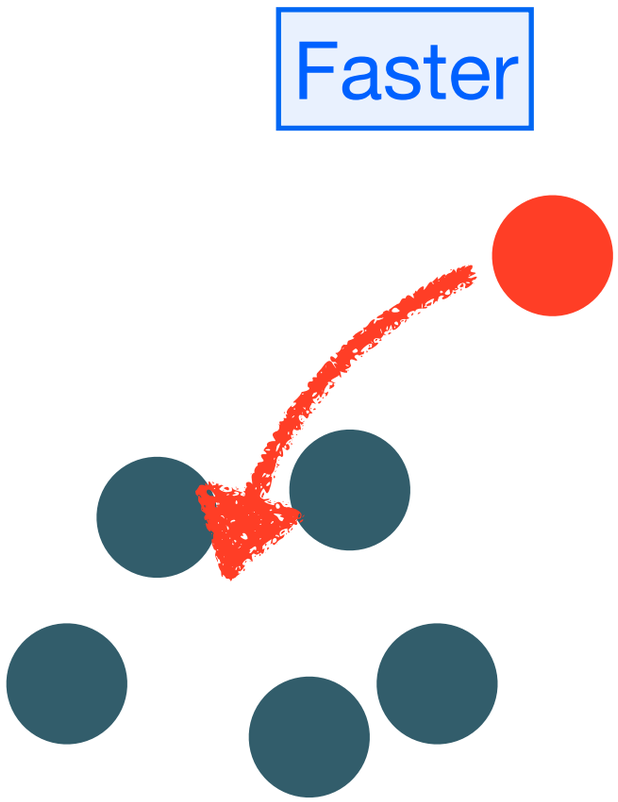
And everything in between

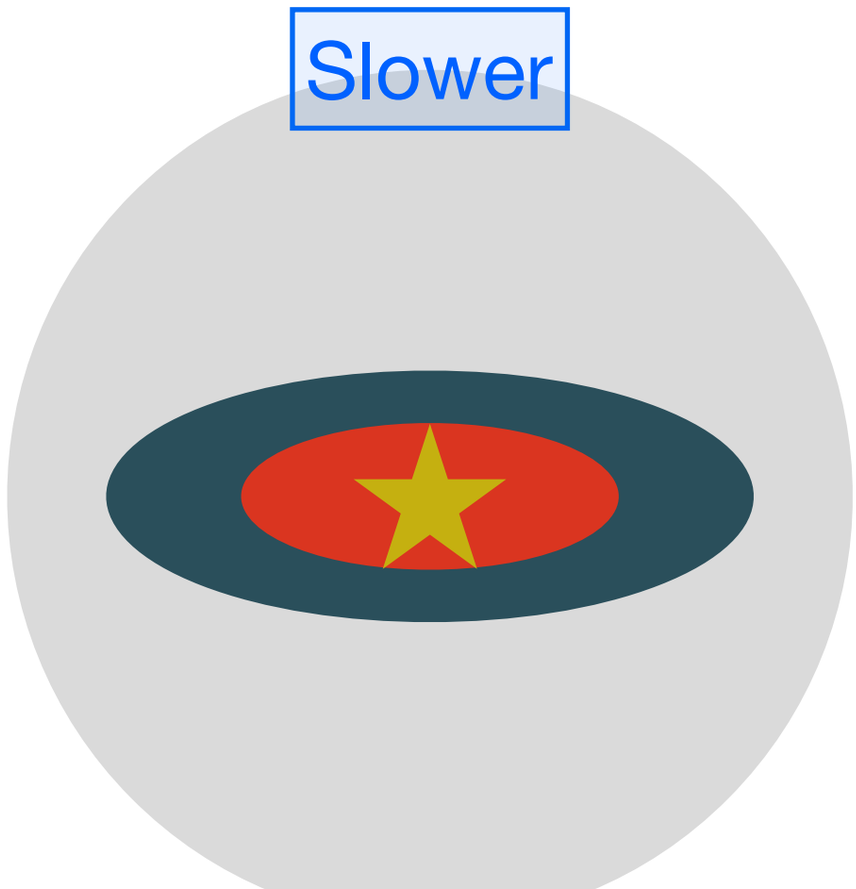


What we don’t really know: Process of quenching

These processes act on different time scales

- Strangulation, starvation, etc
  - may act on several Gyrs
- mergers, stripping, etc
  - may act on dynamical time scales (couple of 100 Myrs)

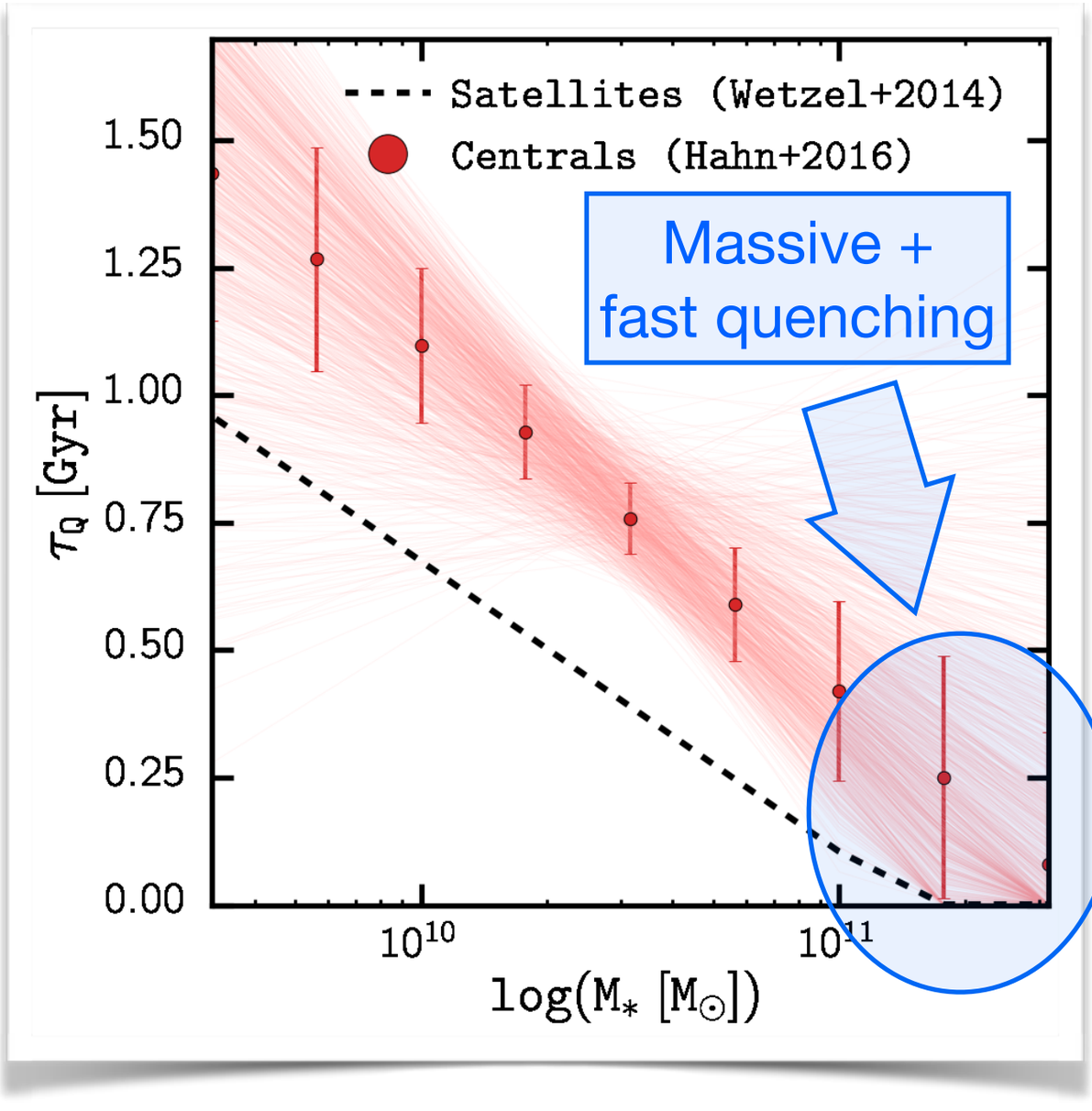




What we don't really know: Process of quenching

These processes act on different time scales

- There is likely a mass dependence, too
  - Different quenching mechanisms act at different stellar masses



e.g., Hahn+16
(poster #13)

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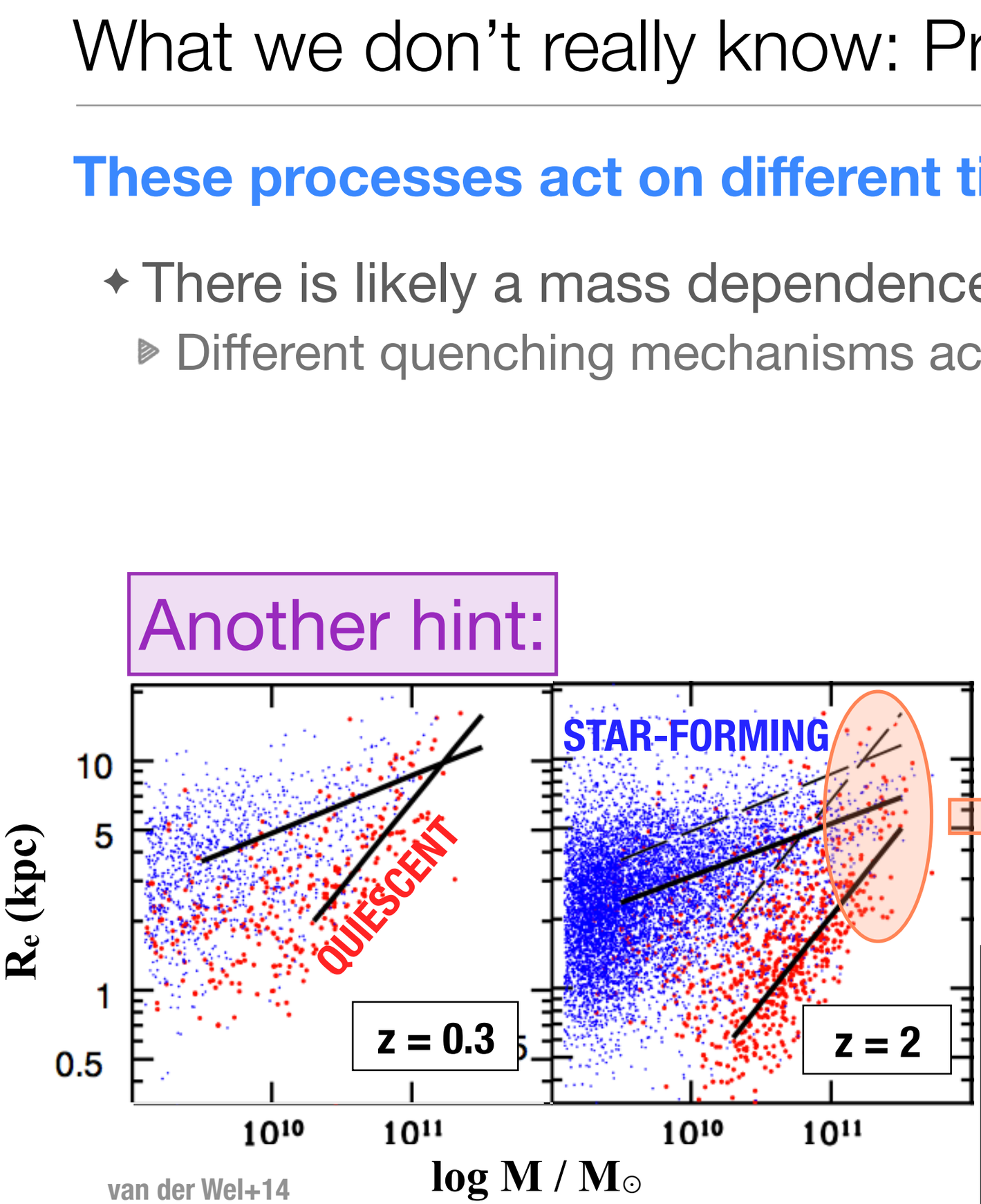
Another hint:



van der Wel+14

Fast quenching?
Merger + starburst?

But **not** for
the **most massive**!

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focus on **massive (logM > 11) galaxies**
at **z < 2**

Plan:

1) Consistently model evolution of SF and QU galaxies

2) Constrain quenching time-scales

3) Fantasize about quenching mechanisms

Let’s model it!

We have various relations for the average galaxy parameters

- Stellar mass vs. star formation relation (**Main sequence**)
- Size - stellar mass relation (**MS relation**) 

Let’s model it!

Model to predict size evolution of quiescent galaxies

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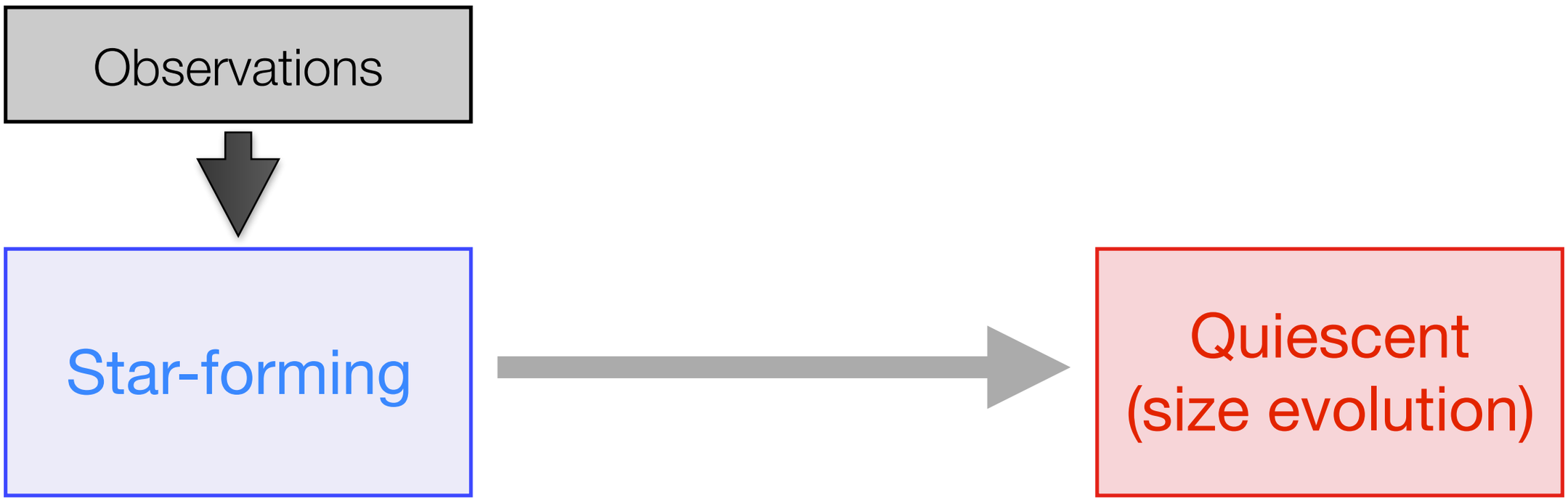
Simple model to predict size evolution of quiescent galaxies



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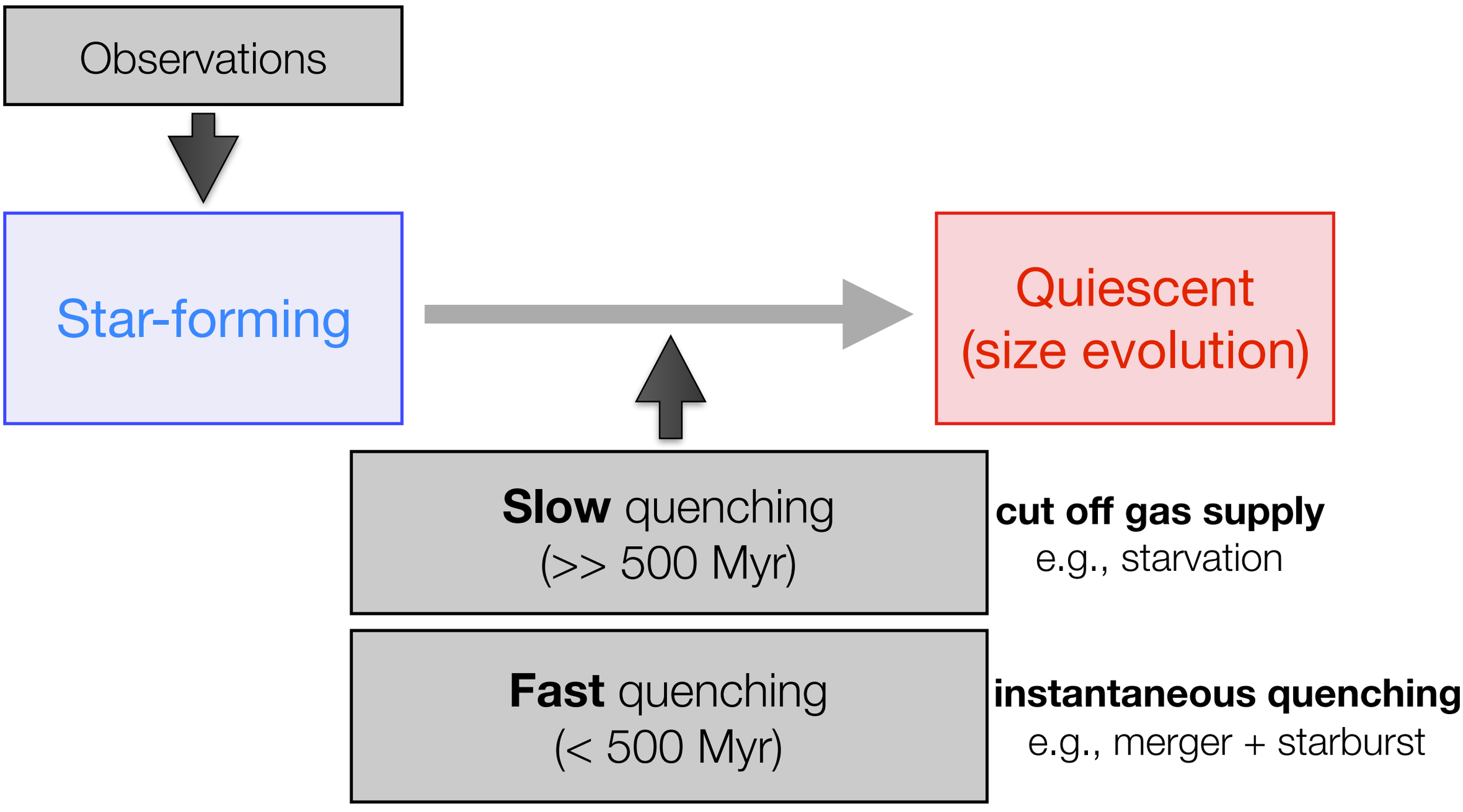

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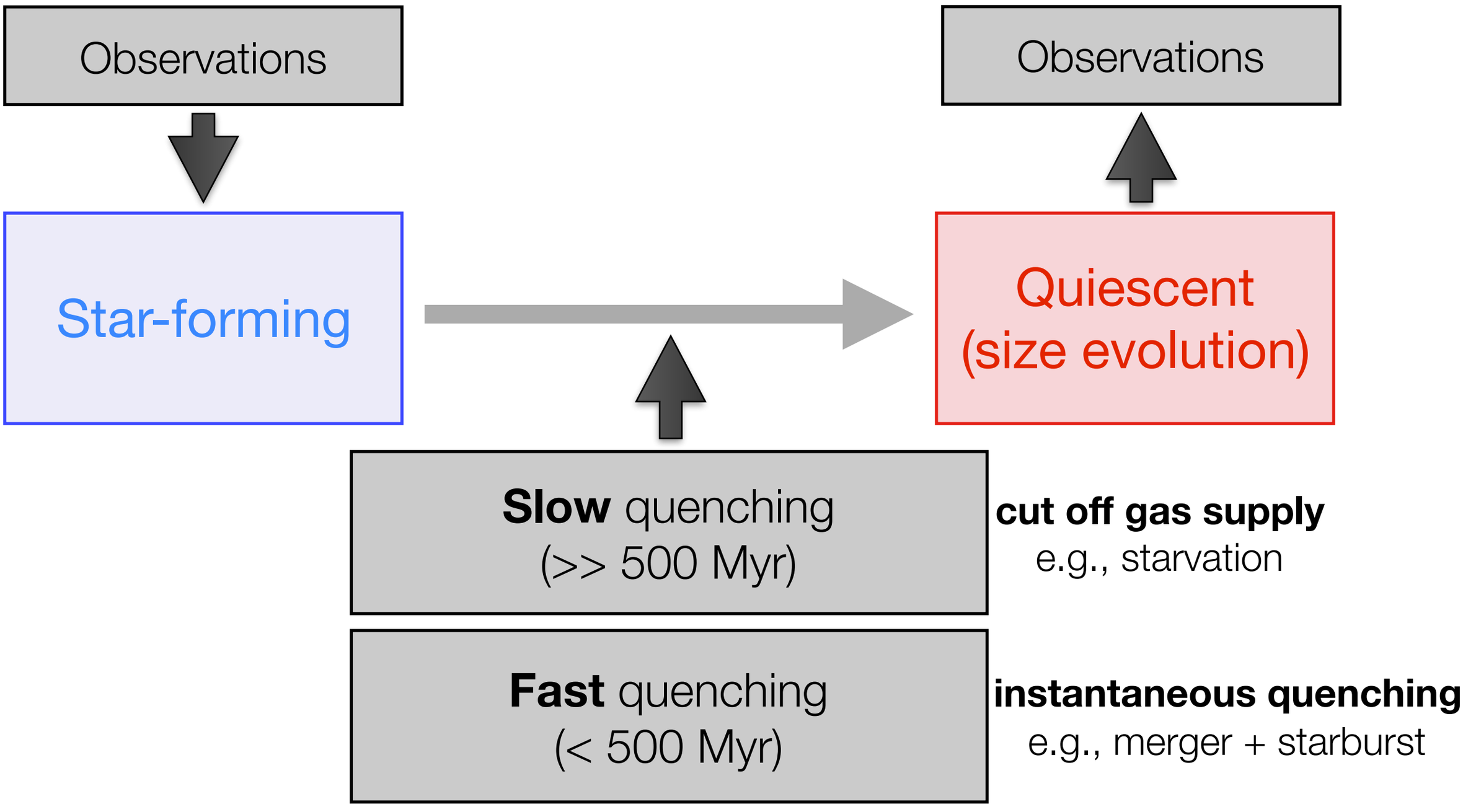

Let's model it! - More qualitatively

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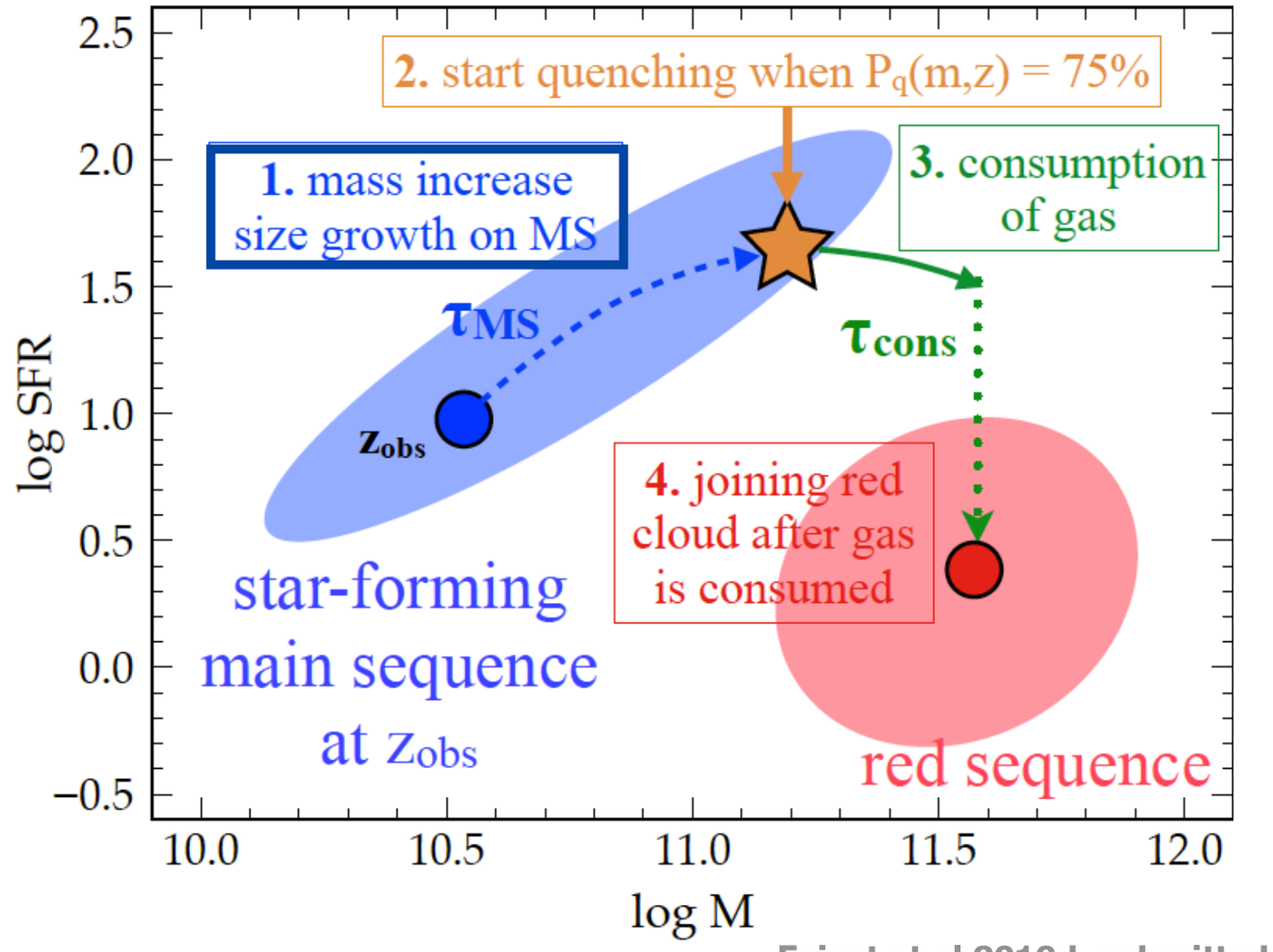

Faisst et al 2016d, submitted

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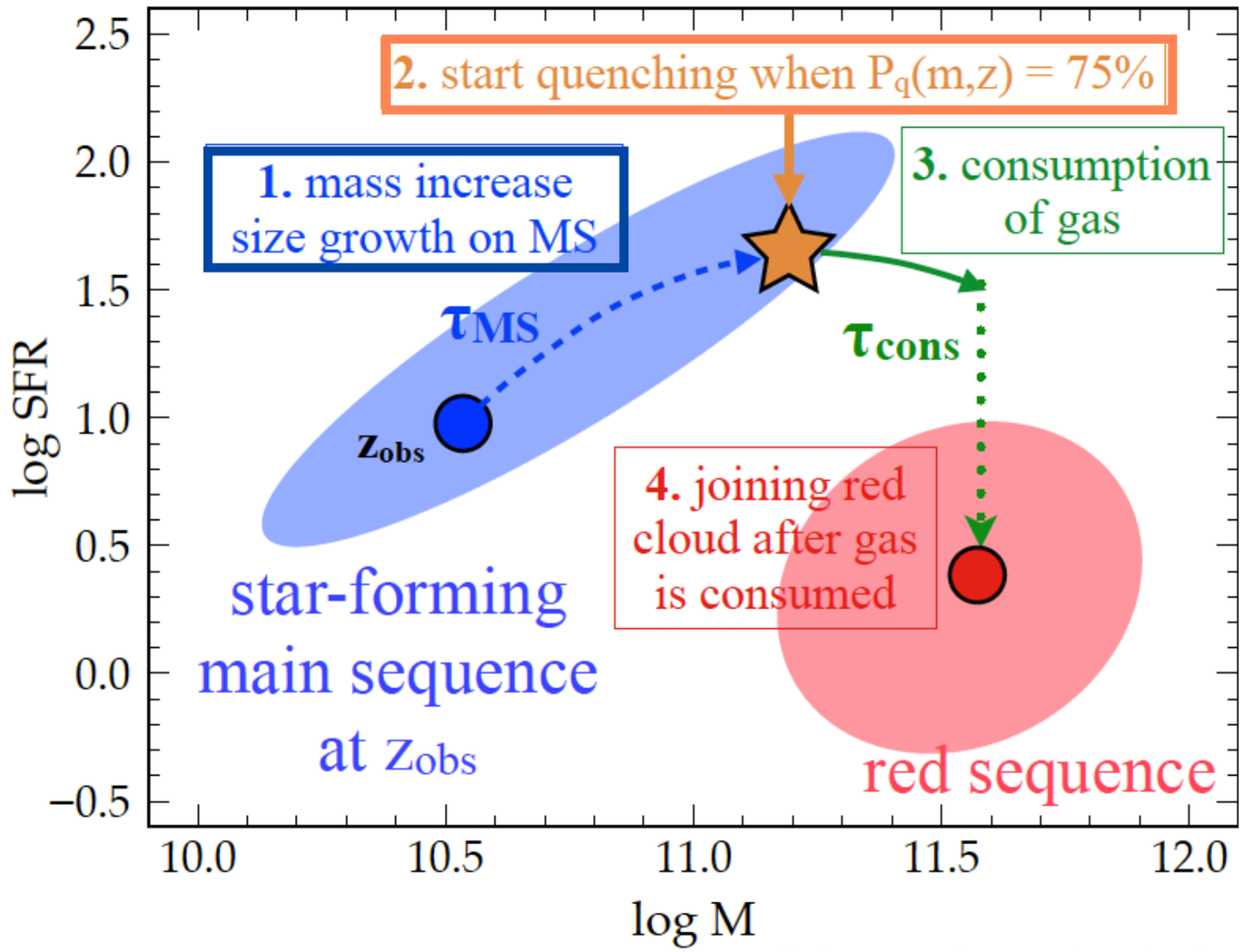

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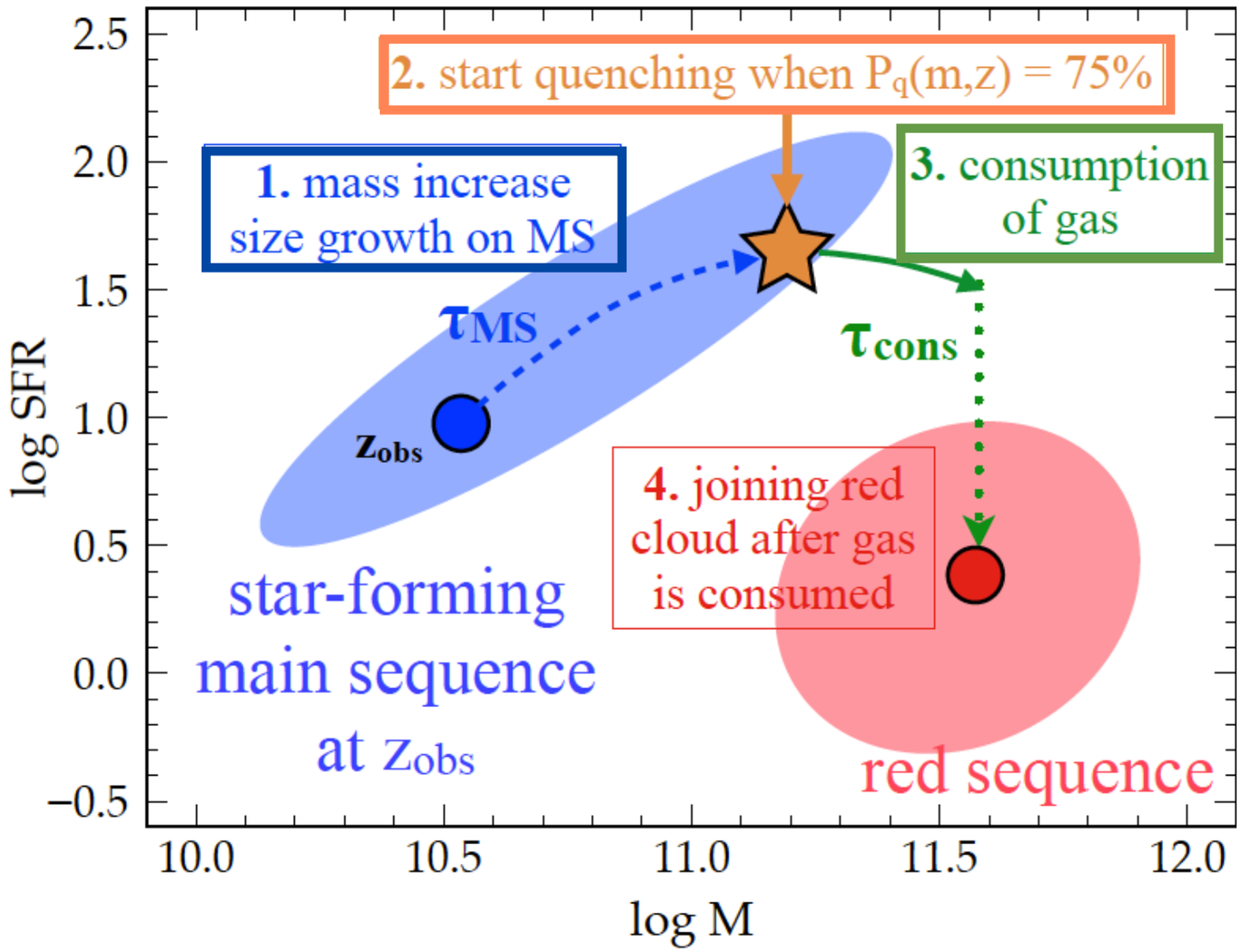

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Sizes of massive galaxies?

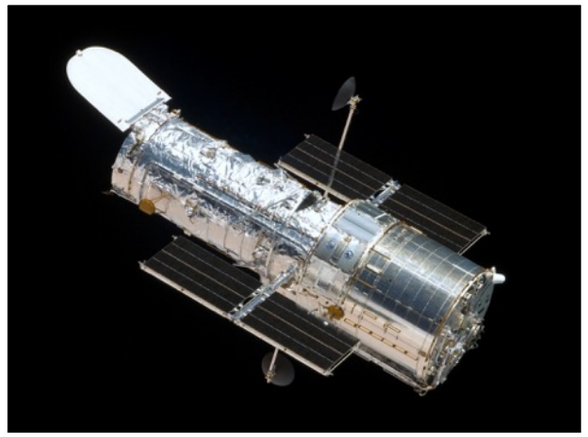
cosmos.astro.caltech.edu

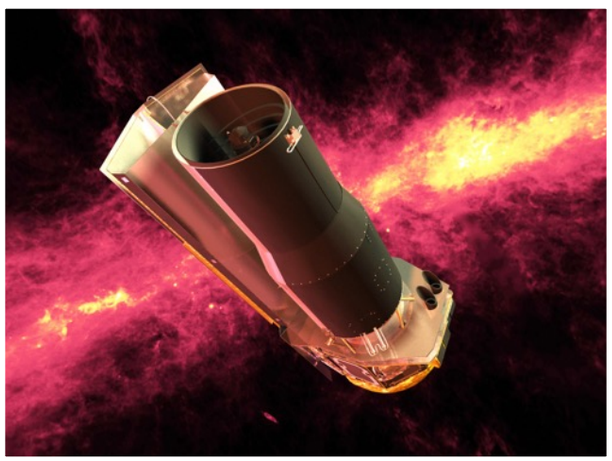
@cosmosastro

Massive galaxies are rare.

➔ Use **COSMOS**/UltraVISTA:

- large area (2 deg^2)
- deep NIR imaging (UltraVISTA Y - Ks band)





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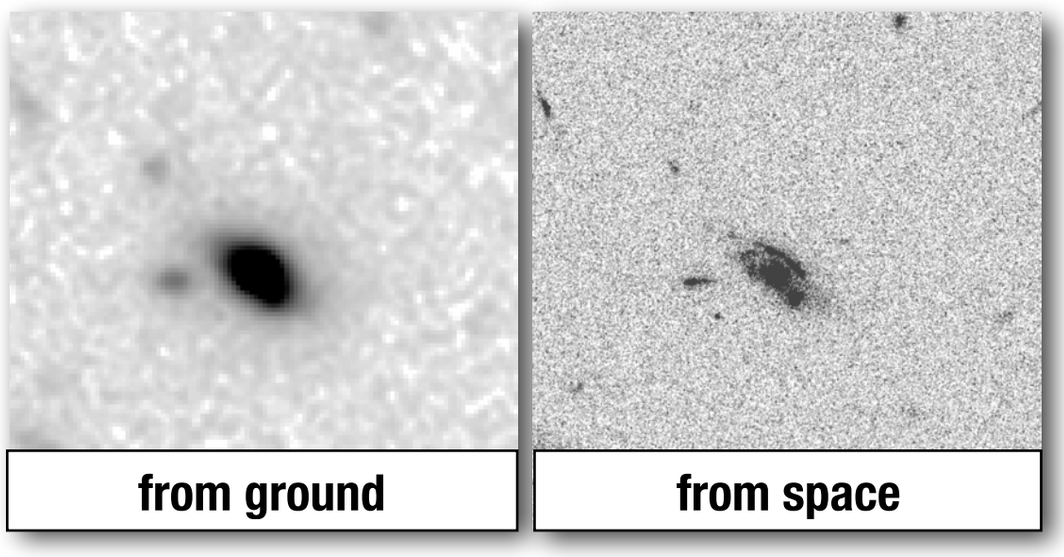

Scoville+07, McCracken+12

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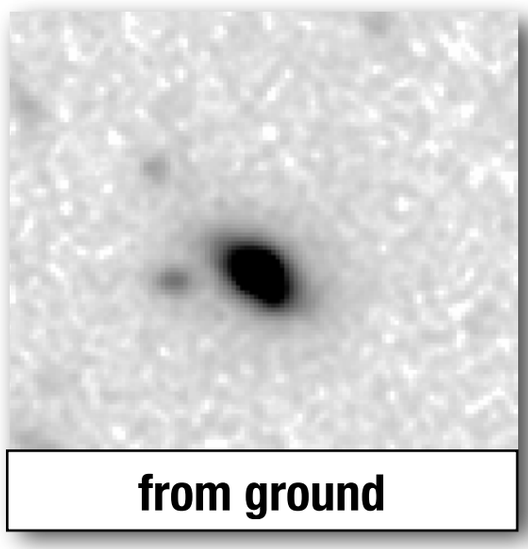

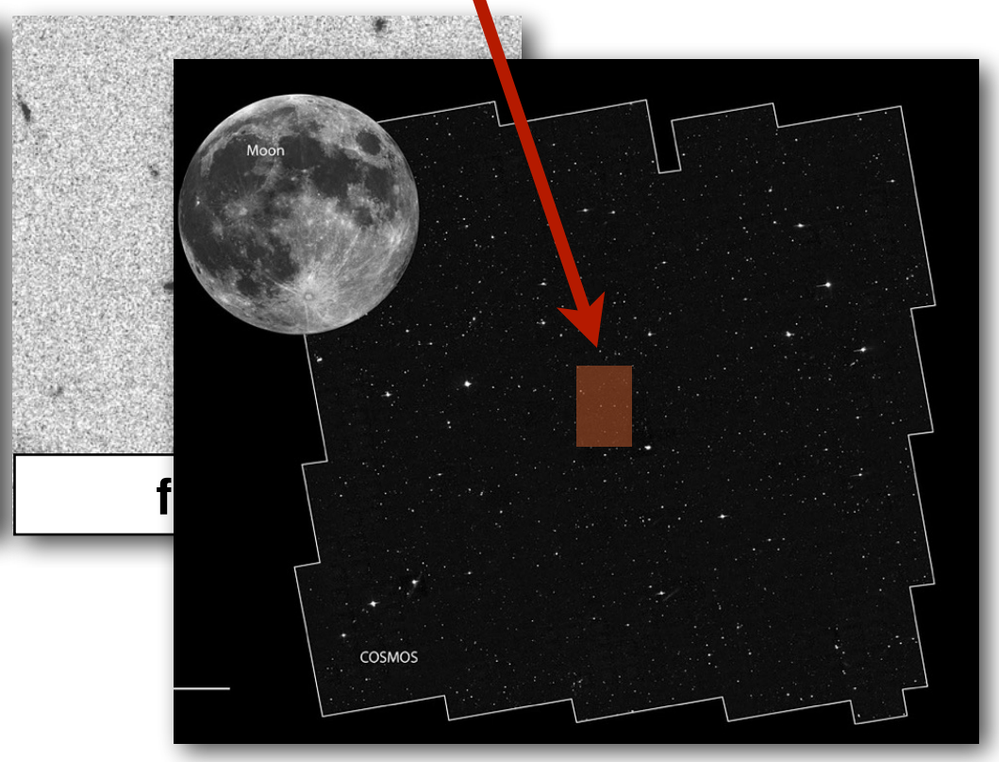

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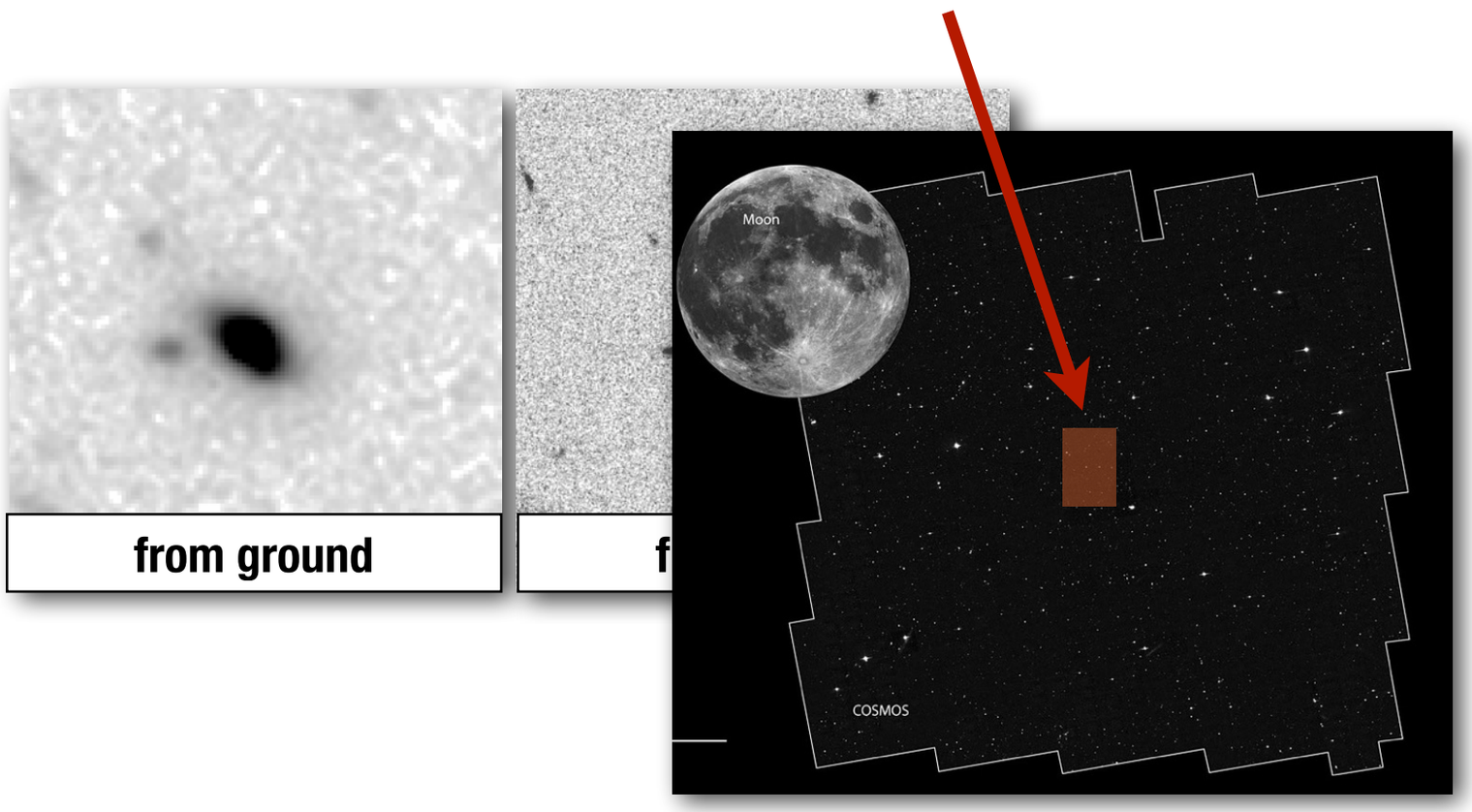
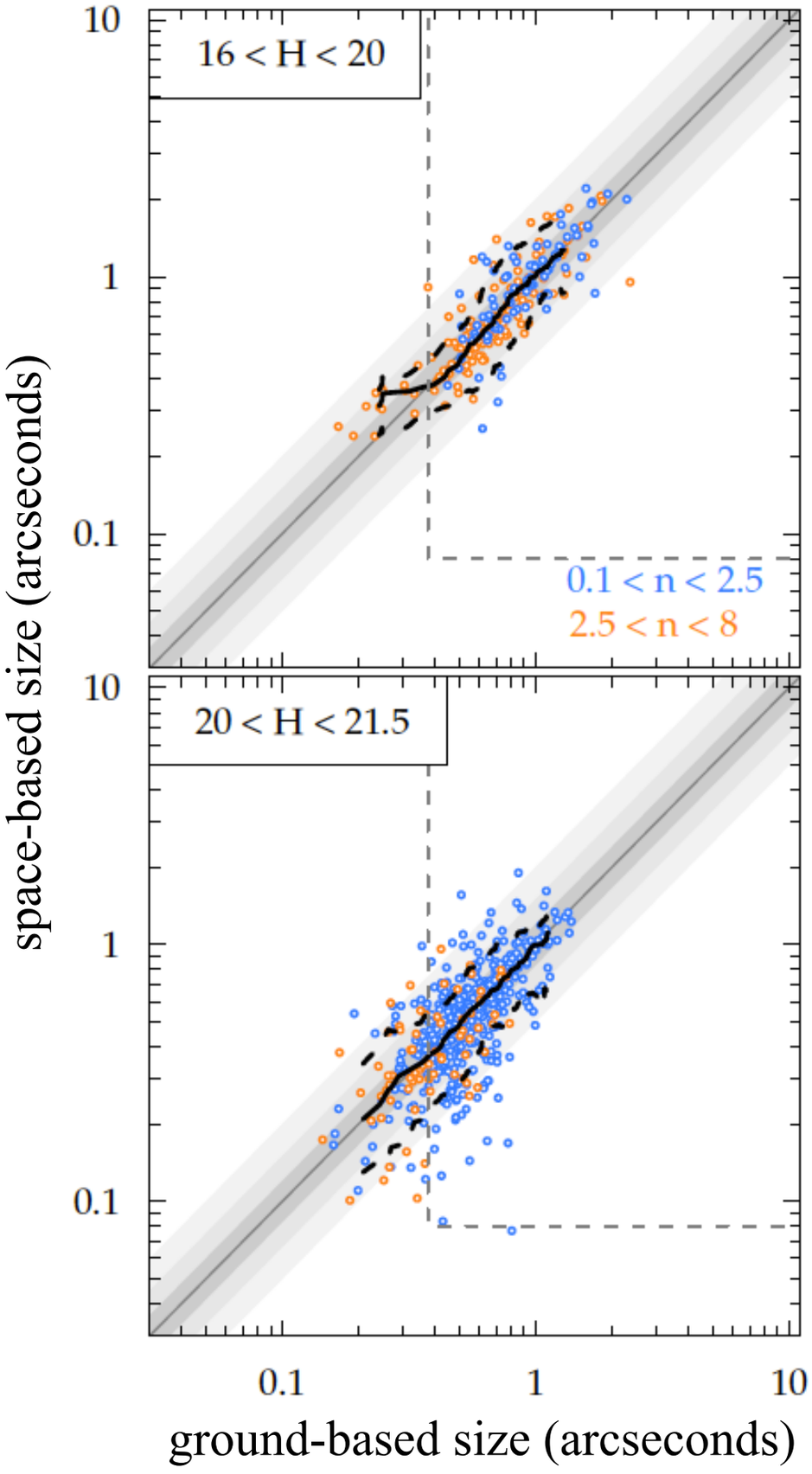
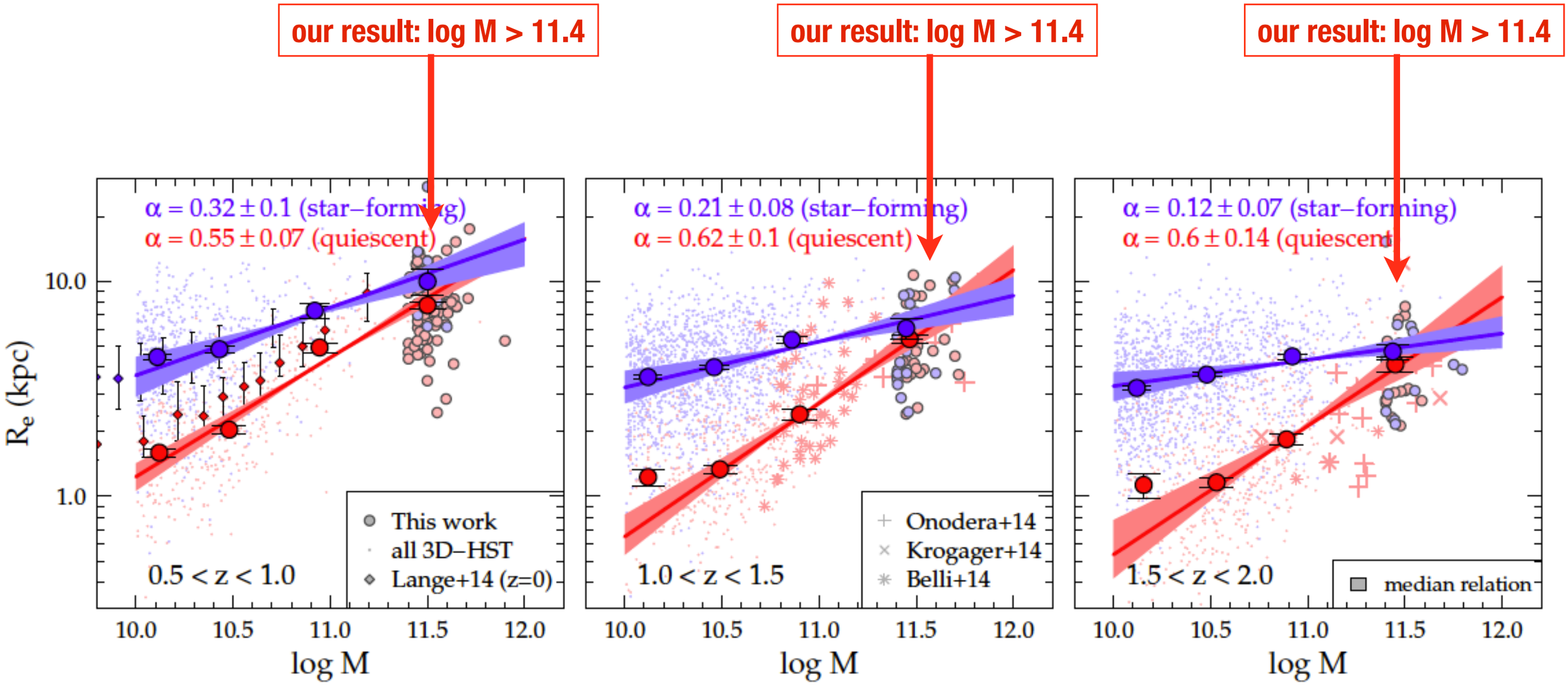




Faisst et al 2016d, submitted

Sizes of massive galaxies?

Sizes of star-forming and quiescent **massive** galaxies are **similar** at **fixed redshift and logM > 11.5**.



Faisst et al 2016d, submitted

How to quench massive galaxies

Simple model to predict size evolution of quiescent galaxies

Measured this for high masses!

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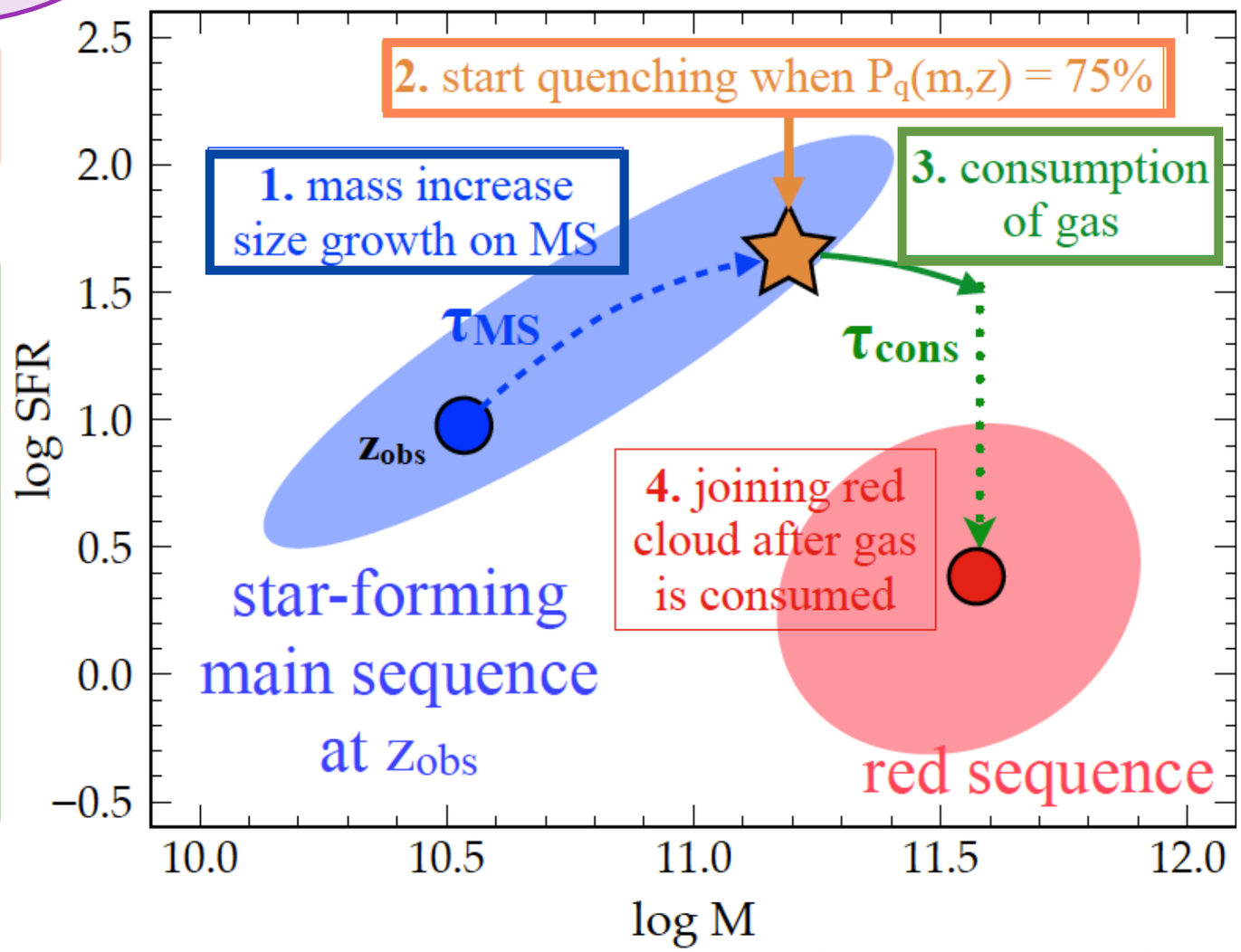


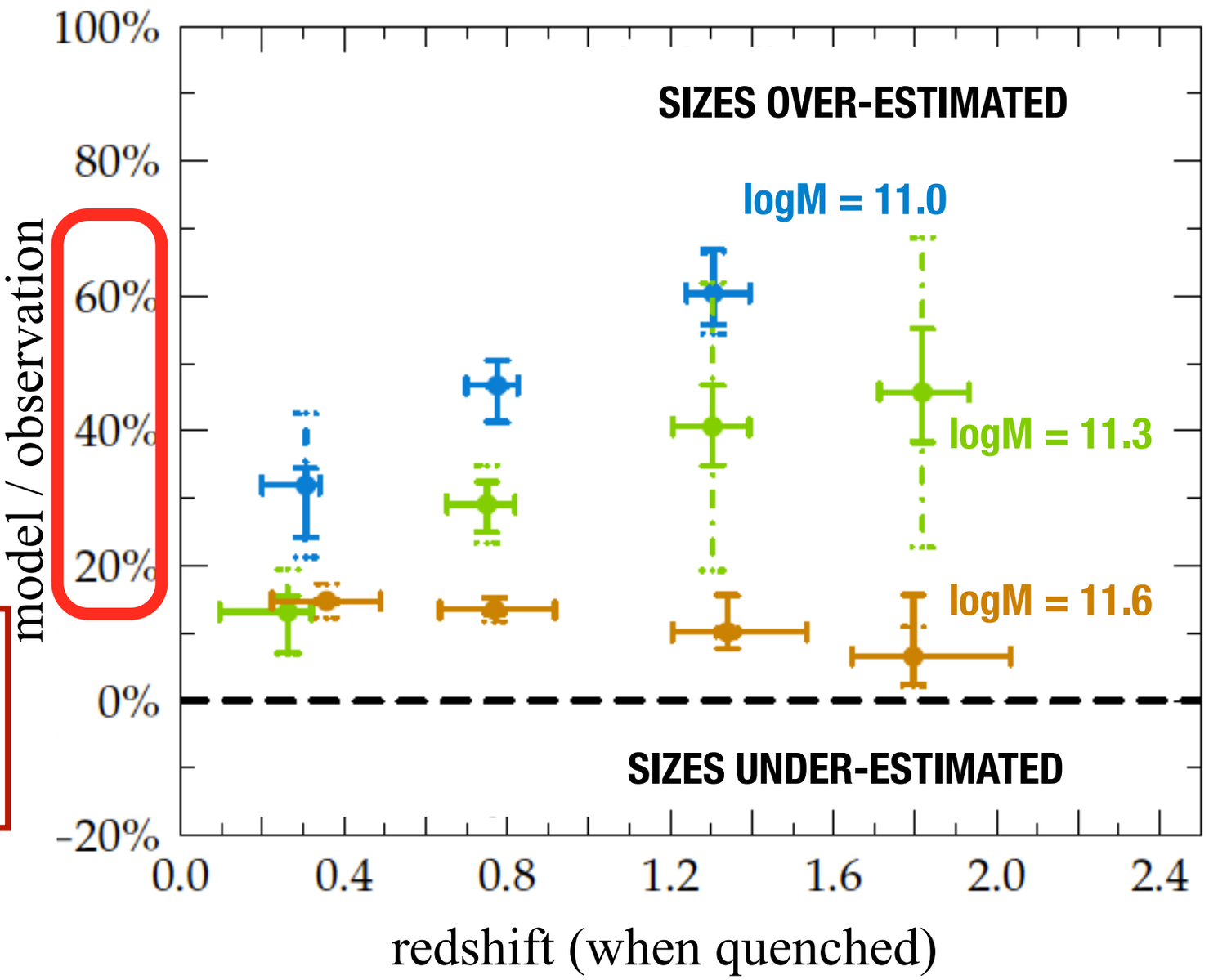
Faisst et al 2016d, submitted

How to quench massive galaxies

Gas cut-off? (slow quenching 500 Myrs to Gyrs)

- Model over-estimates sizes of quiescent galaxies significantly.
- Up to 70% at logM = 11.

MODEL GALAXIES TOO BIG!



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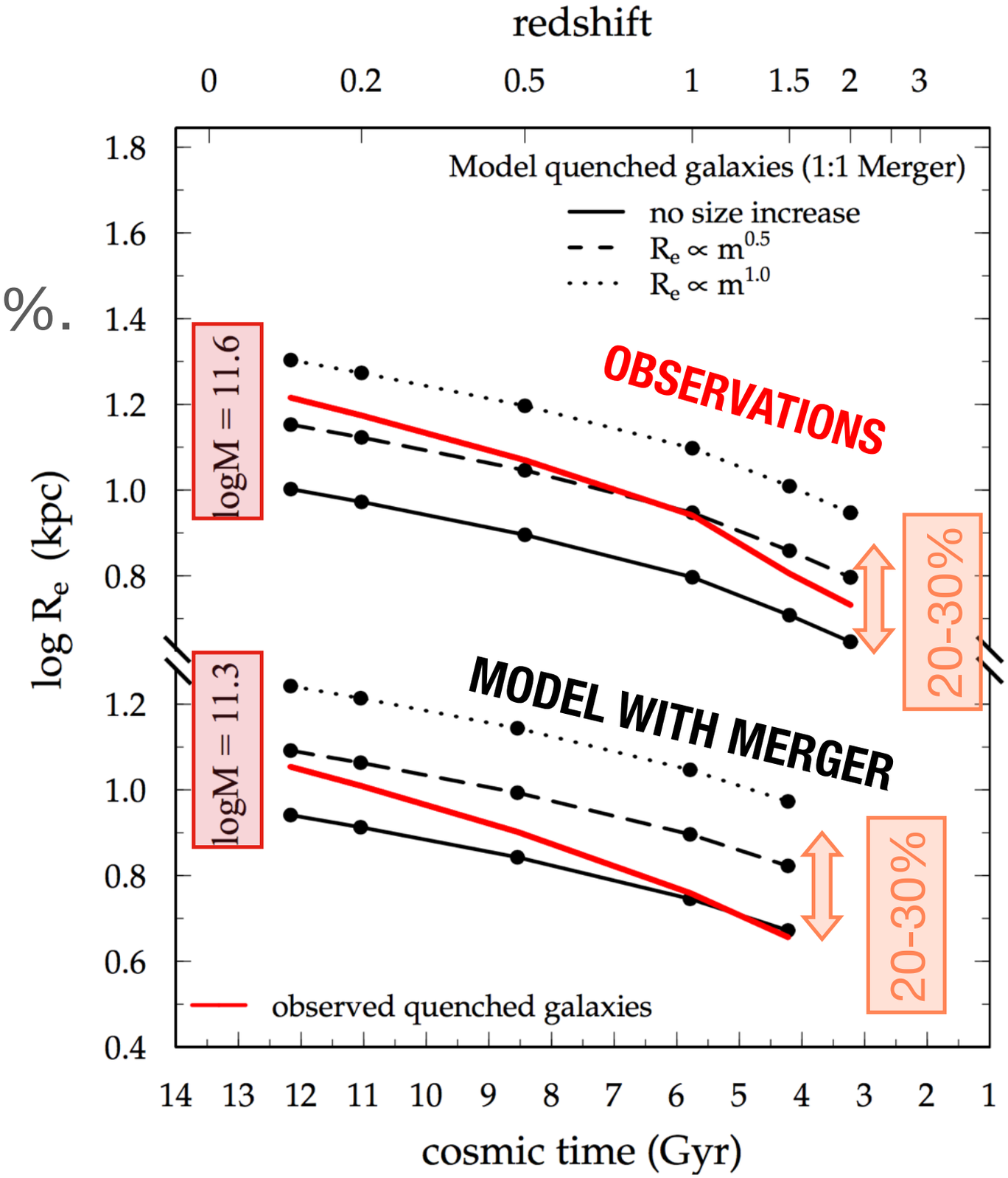
How to quench massive galaxies

Instantaneous quenching?

- Good agreement with observations within ~20%.
- Possible mechanism: Merger + starburst
- Better agreement if including ~20% size increase due to merger



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Conclusions

Very massive SF and QU galaxies **trace similar size evolution** (in normalization and slope).

We **model size evolution of QU galaxies** from SF galaxies for short and long quenching time scale.

Very massive galaxies (logM > 11) favor **fast quenching** (< 500 Myrs): Probably merger + starburst!

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… and… we'll get HST near-IR imaging
of massive (logM>11.2) quiescent z~2 galaxies
to study their structure in detail!