1 deg

Phase-Space Analysis:

Revealing

The Quenching History

of Cluster Galaxies

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with

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Image credit@SDSS DR10

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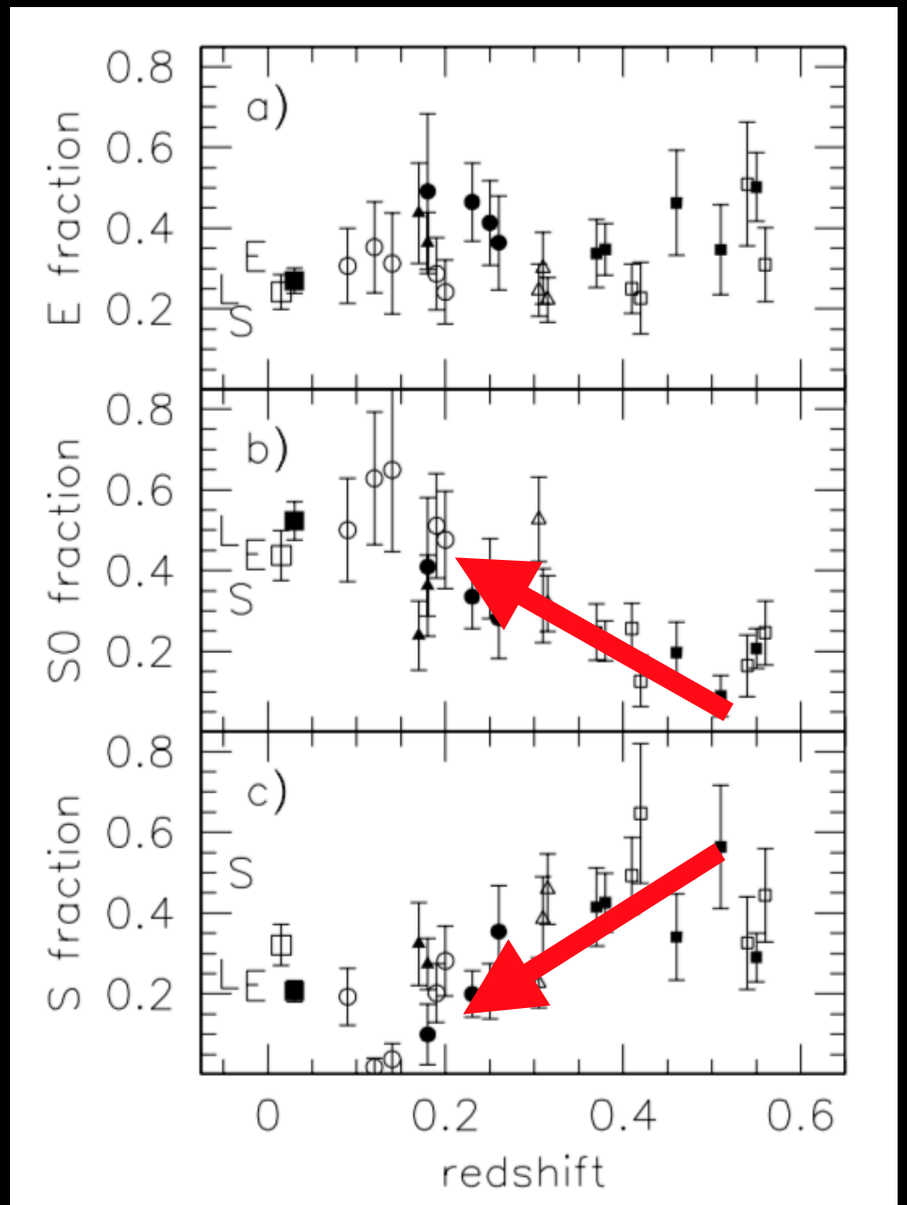
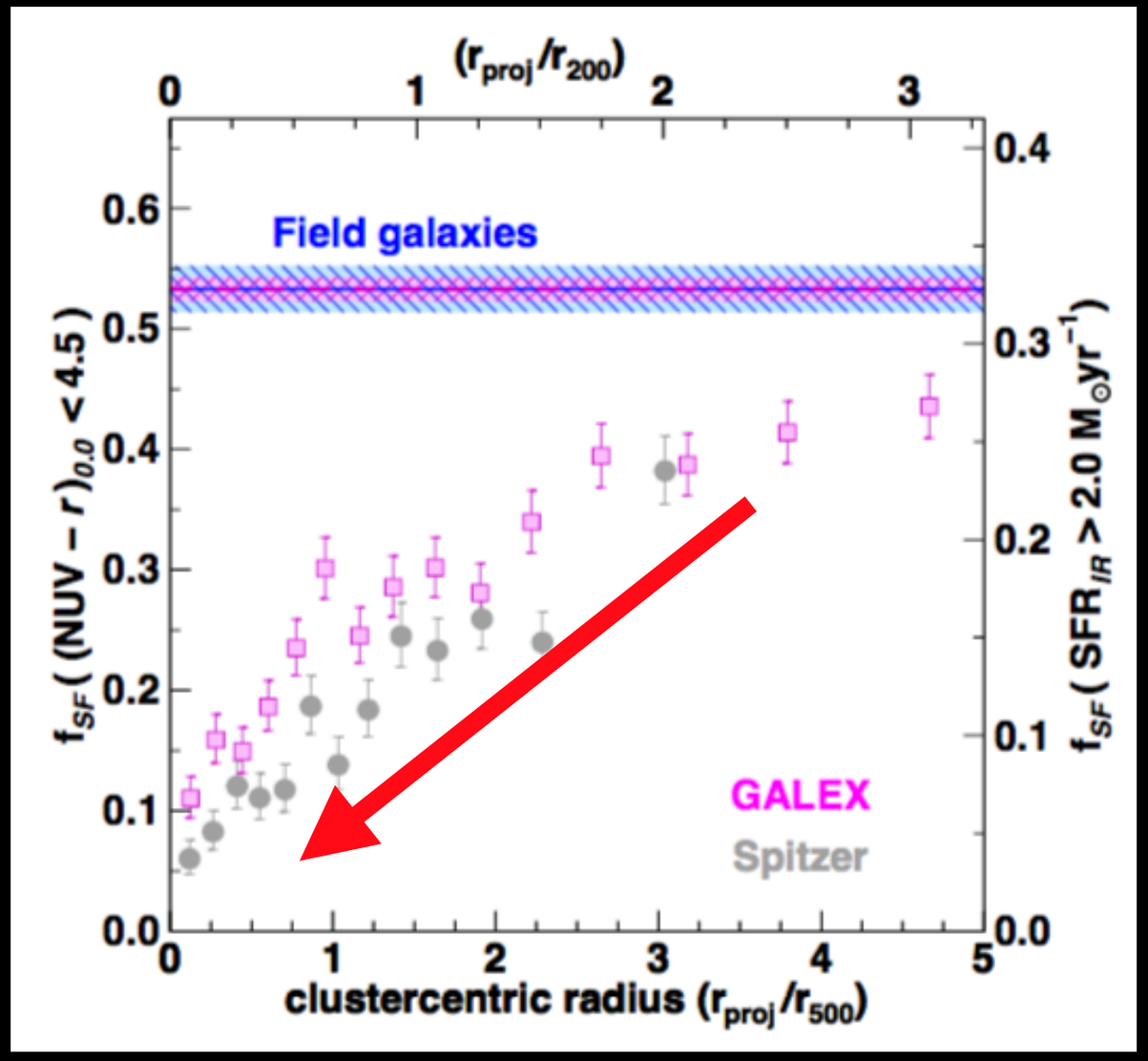
Observational Reports

Morphological fractions



Fasano et al. 2000

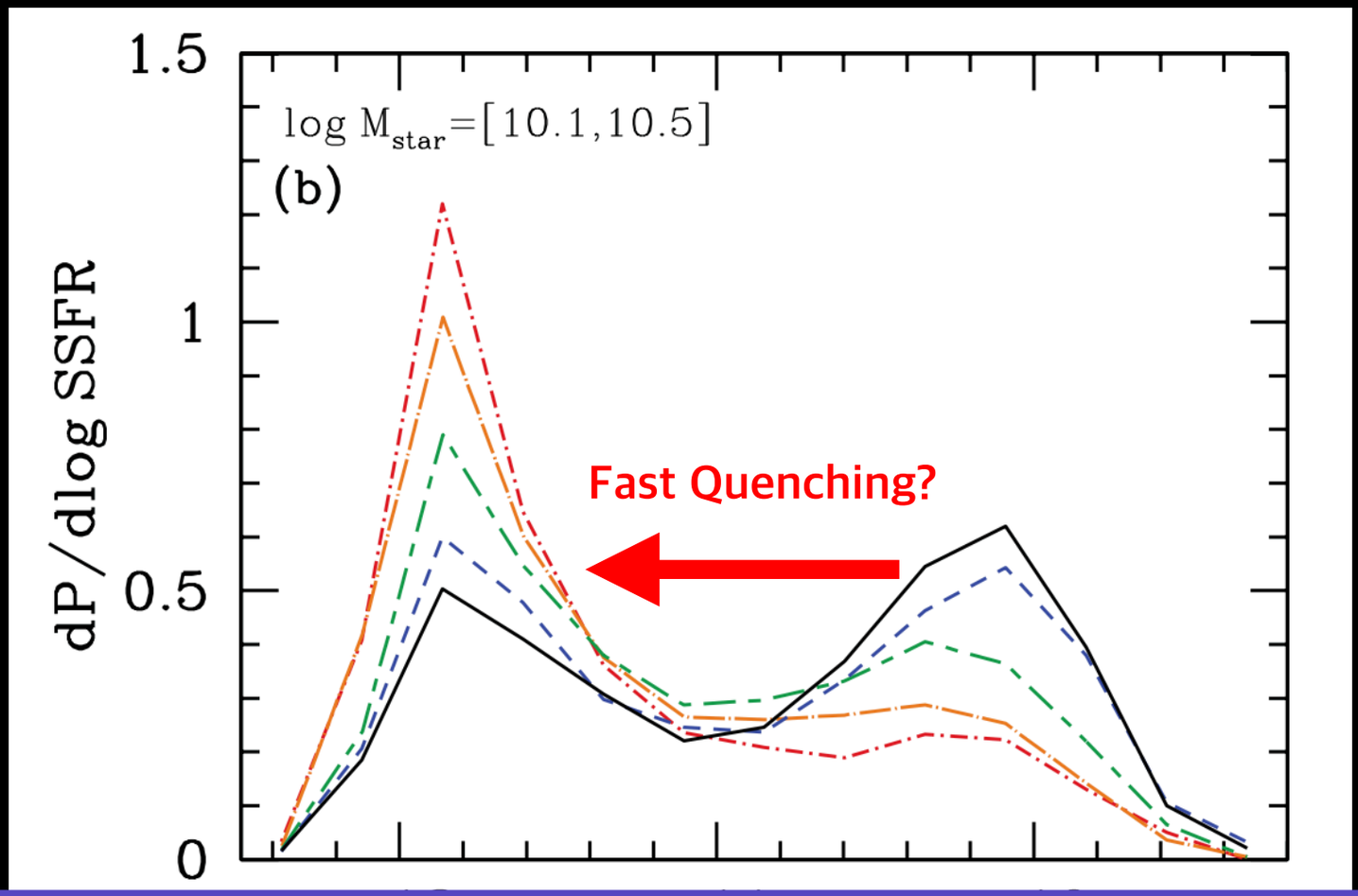
Star Forming Fraction



Haines et al. 2015

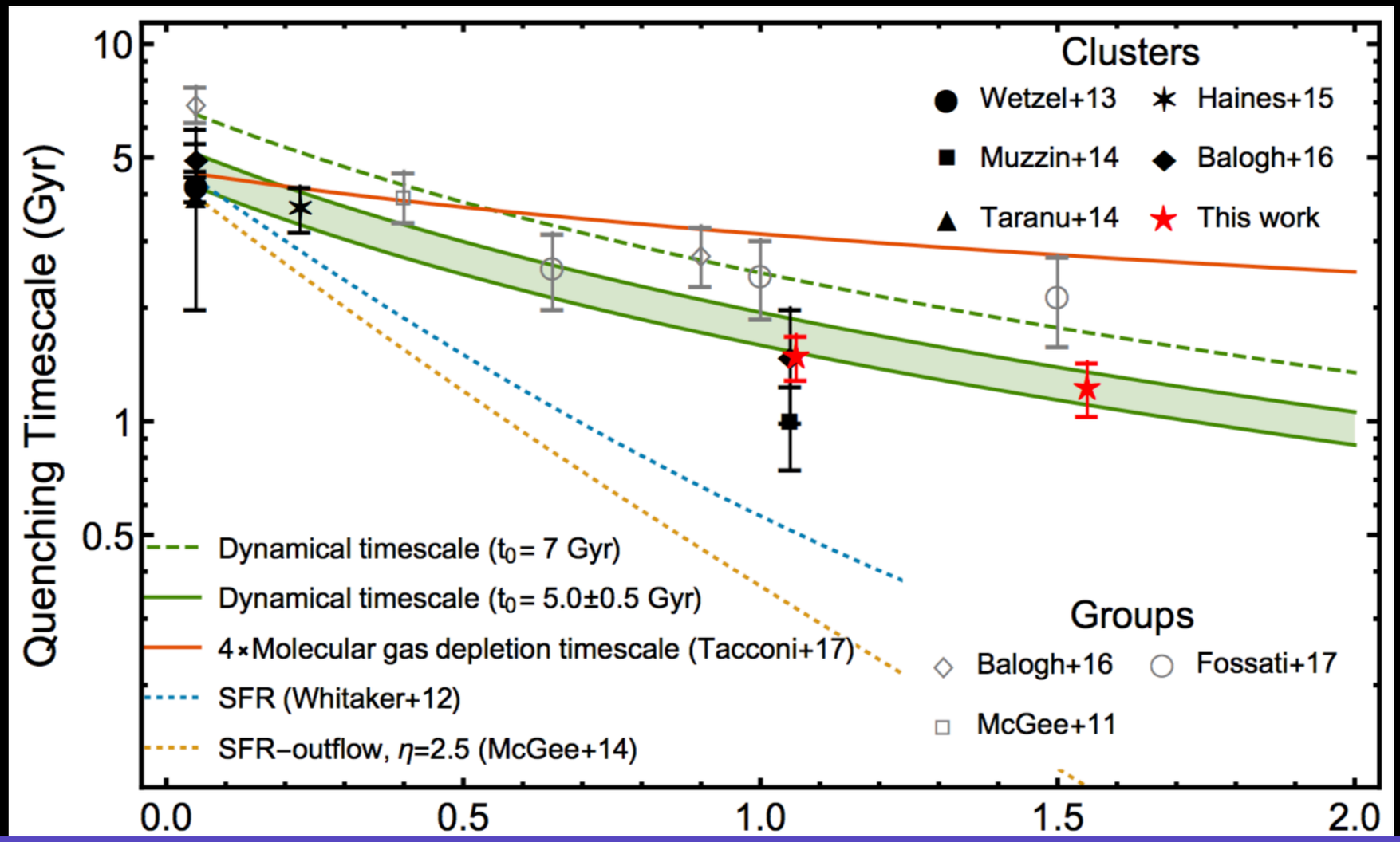
Observational Reports

Bimodal distribution of cluster galaxies' sSFR



- How fast galaxies are quenched in clusters?

Observational Reports

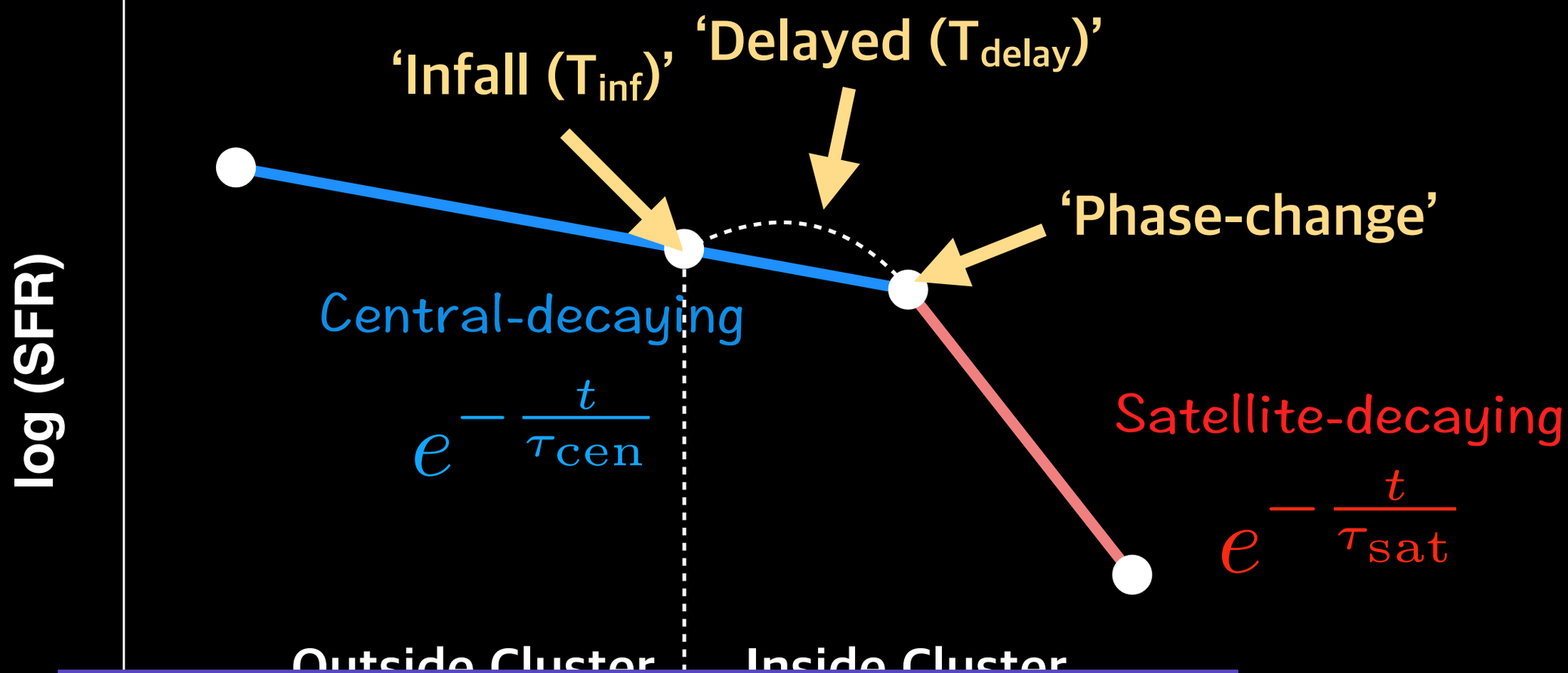


- Which process is a main driver for quenching?

Quenching History Model

Two Phases of Quenching

Delayed-then-Rapid model (Wetzel+13)

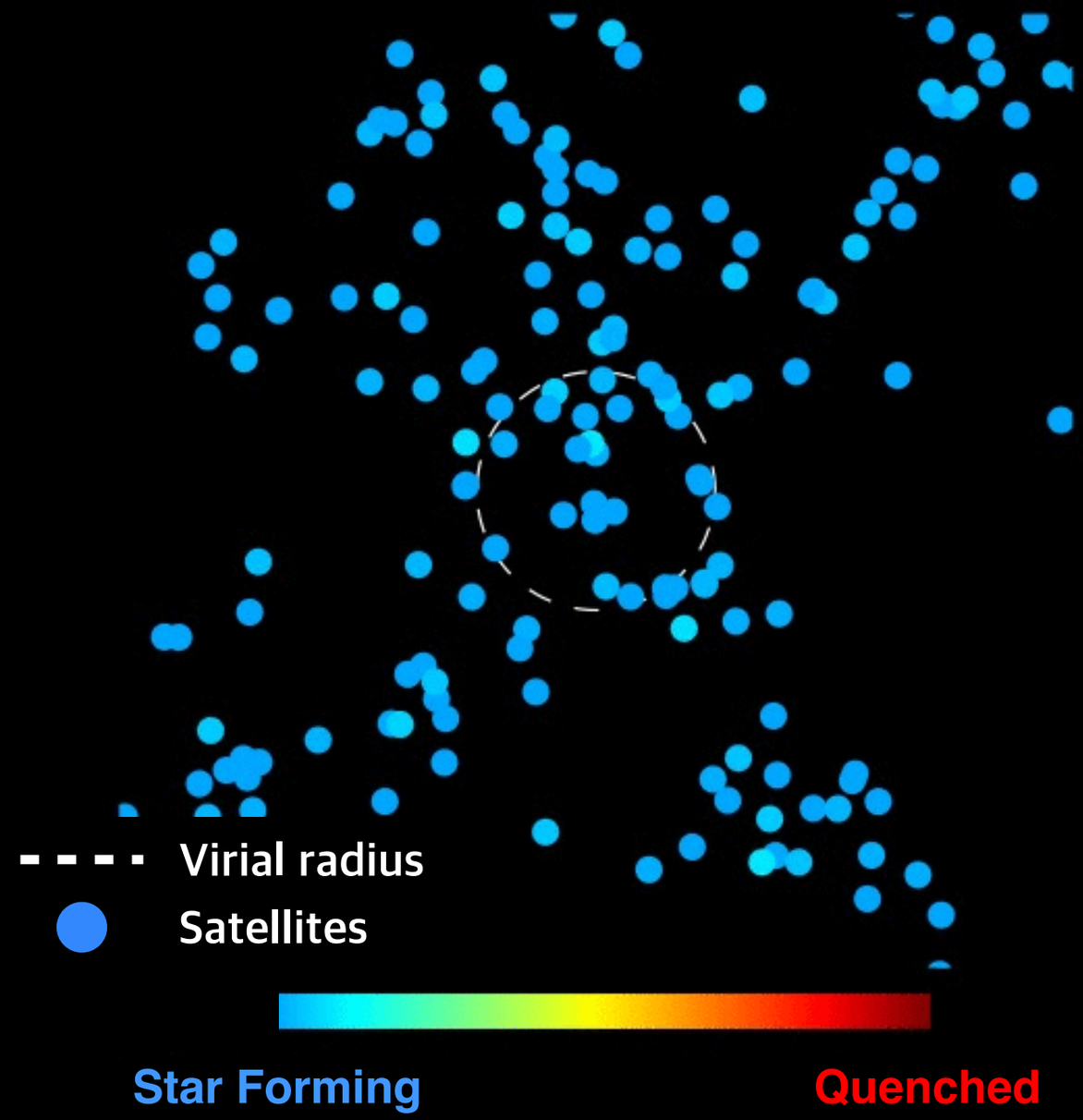


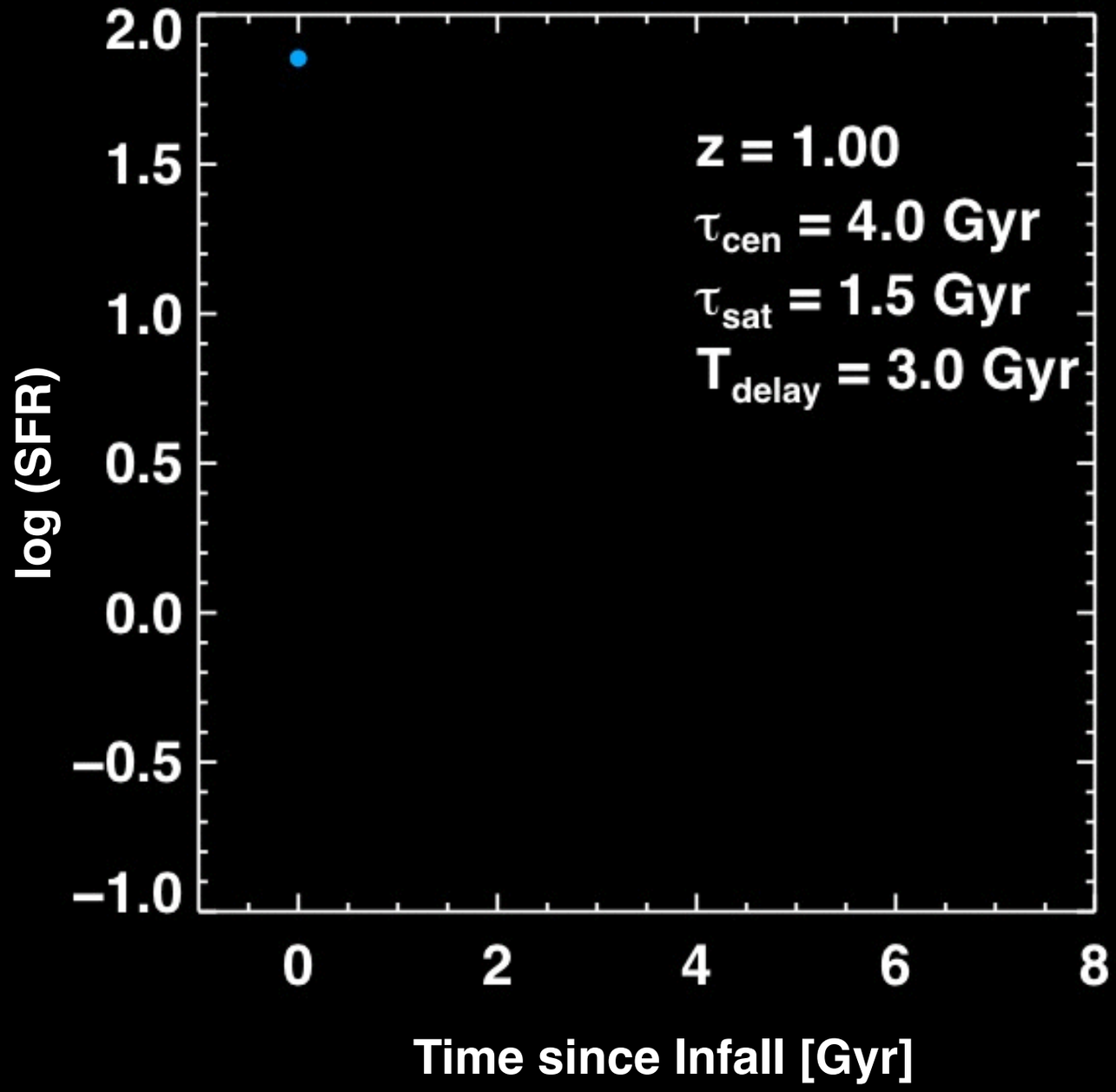
Main parameter: T_{inf}

Model dependencies: τ_{cen} τ_{sat} T_{delay}

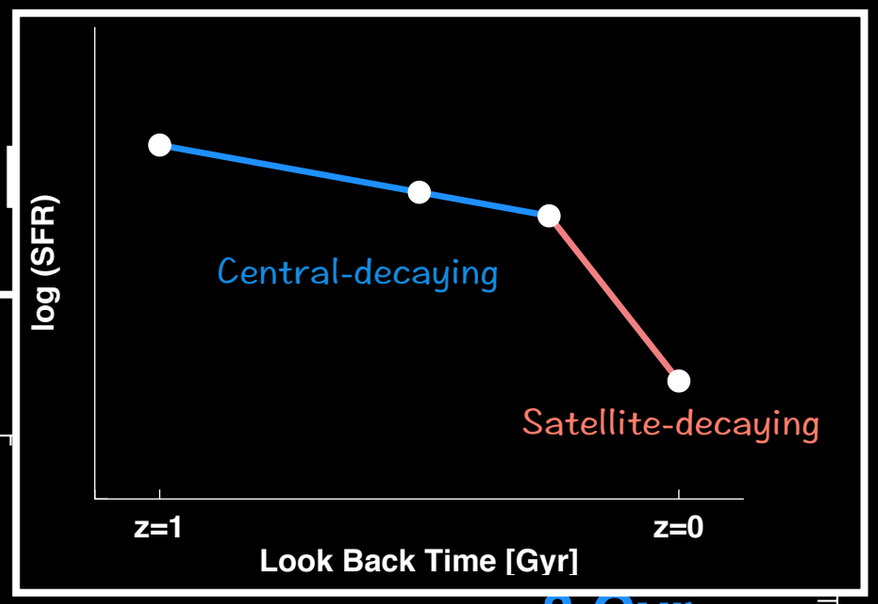
T_{inf} - SFR relation

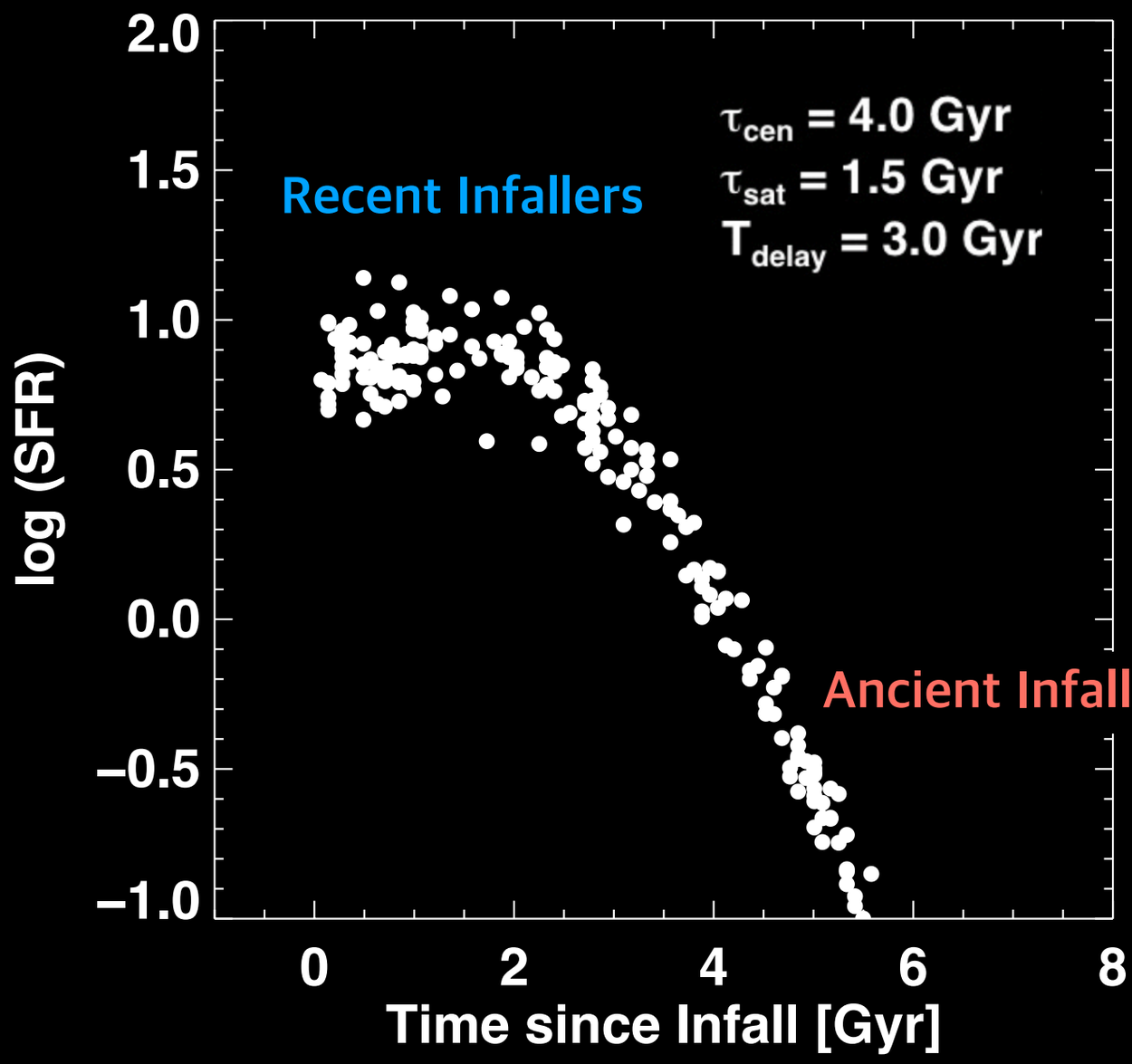
"Toy Model for Quenching"



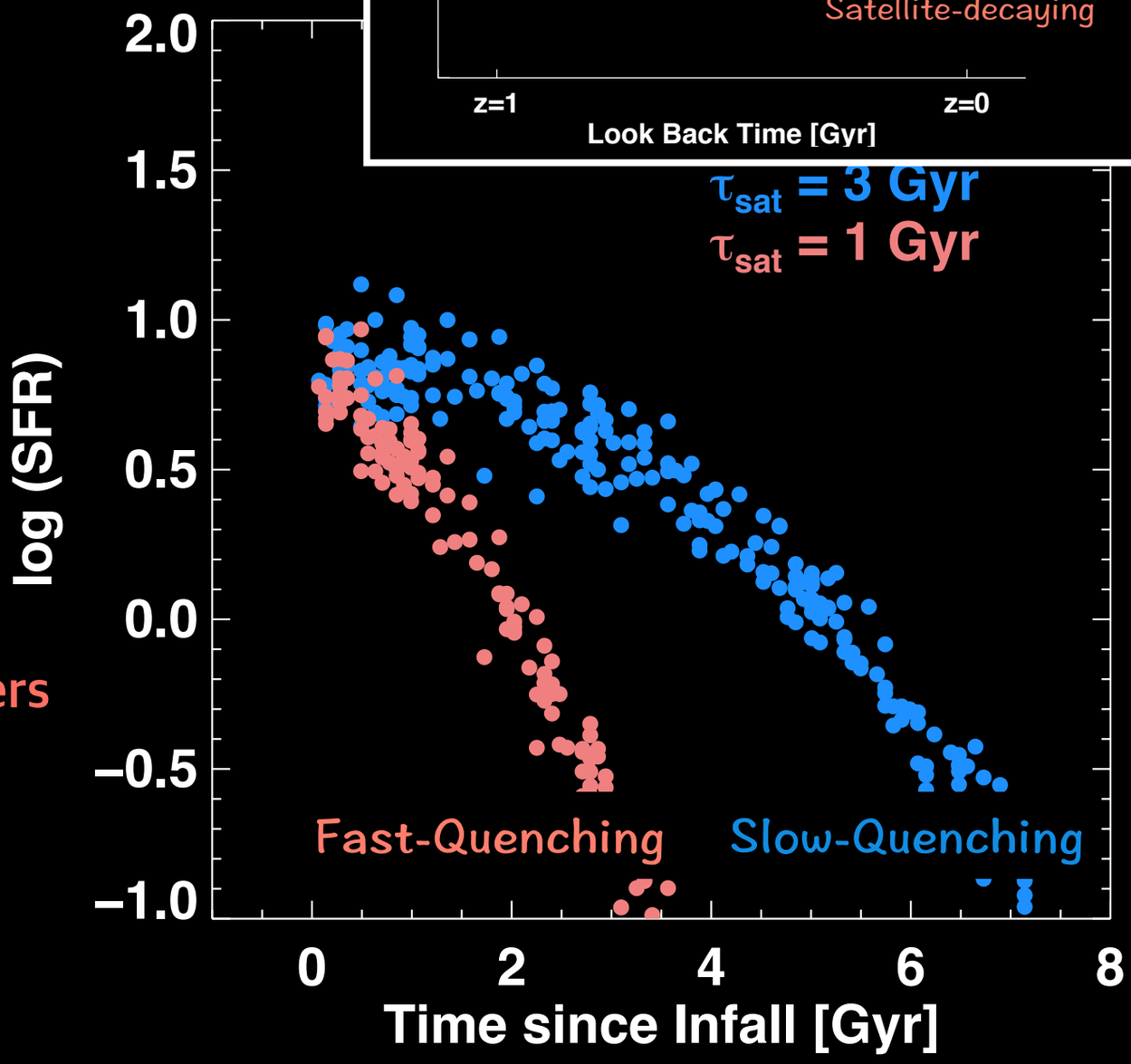


T_{inf} - SFR relation





$T_{delay} = 3.0\ (1+z)^{-1.5}$ Gyr

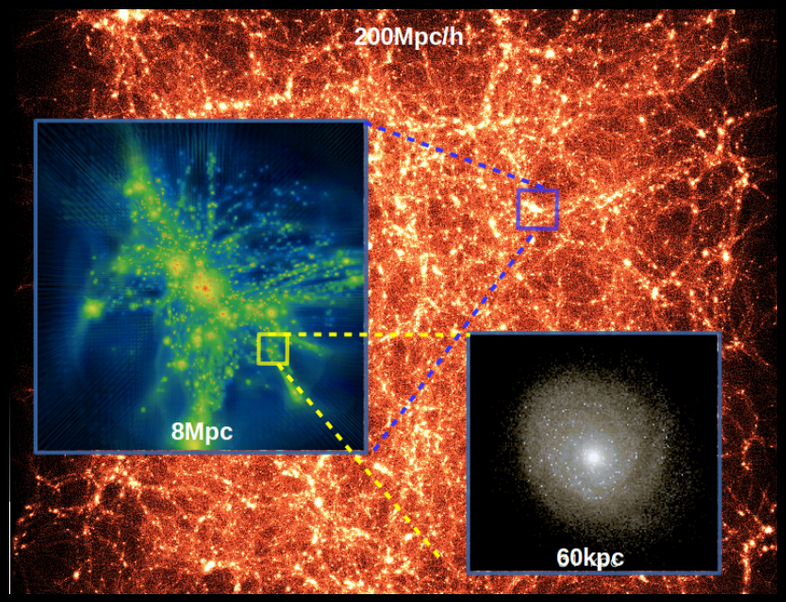


T_{delay} = 0 Gyr

Sample

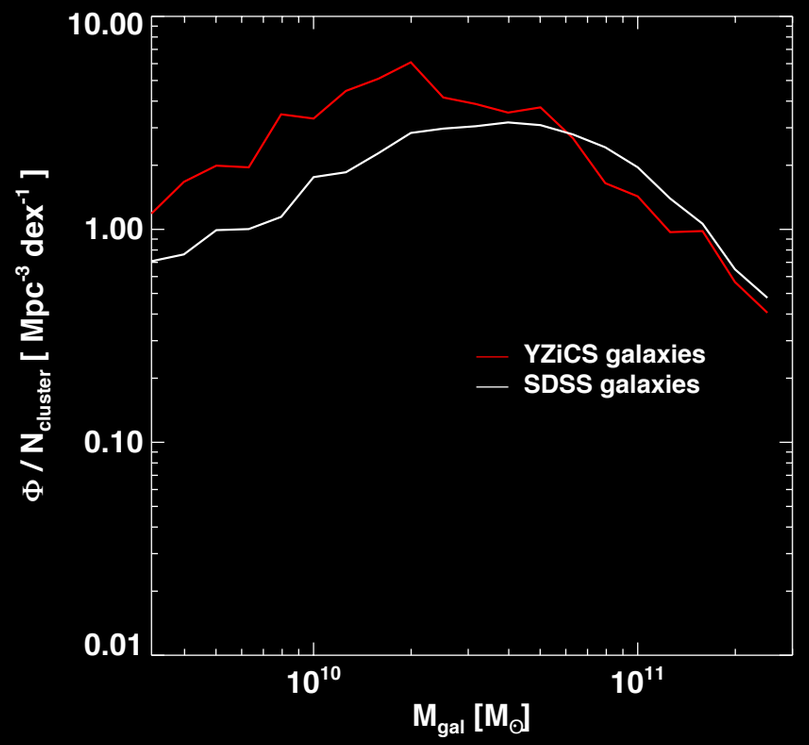
[Simulation]

- YZiCS (**Y**onsei **Z**oom-**i**n **C**luster **S**imulations)
  Using RAMSES, **Choi & Yi (2017)**
- 15 Clusters in a **200 Mpc/h** cubic box
- dM_{DM}=8e7 M_{sun}, dM_{Star}=5e6 M_{sun}, dx=0.76 kpc/h
- **Over-quenching problem**



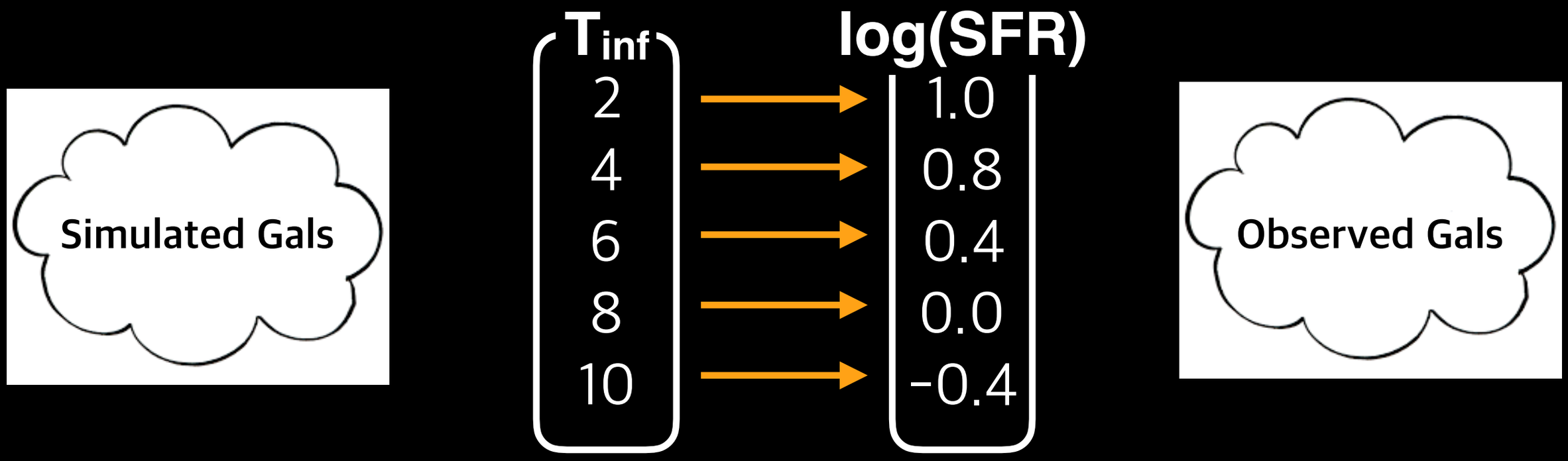
[Observation]

- Cluster Catalogue in **Tempel et al. 2014**
  Used SDSS DR10 Galaxies
- 421 Clusters **($z < 0.166$ & $M_{vir} > 5e13\ M_{sun}$)**
- 17,218 Satellite **Disk** galaxies **($\log(M_{star}) > 9.5$)**



Quantile Matching Method

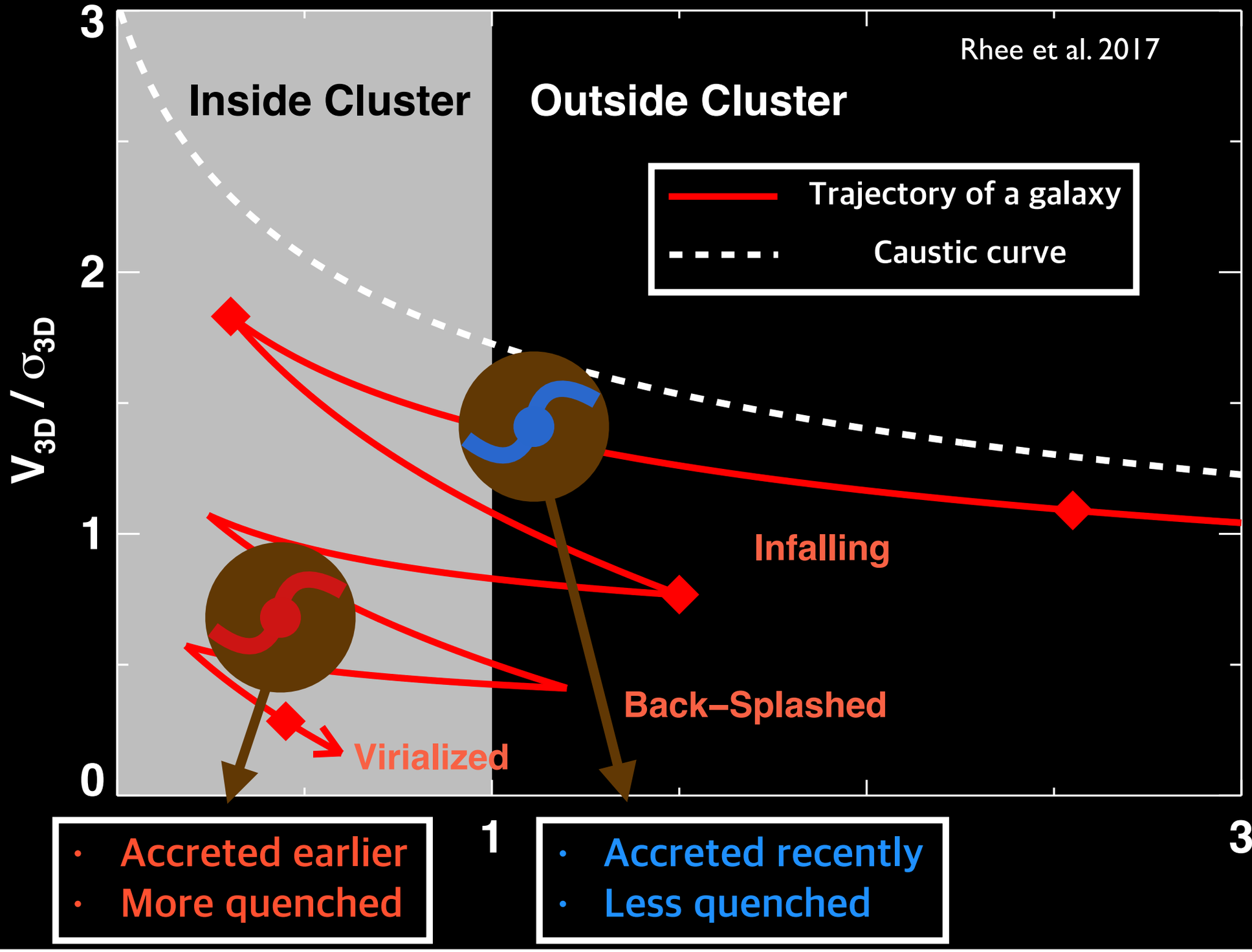
A method to infer **the relation** between two parameters



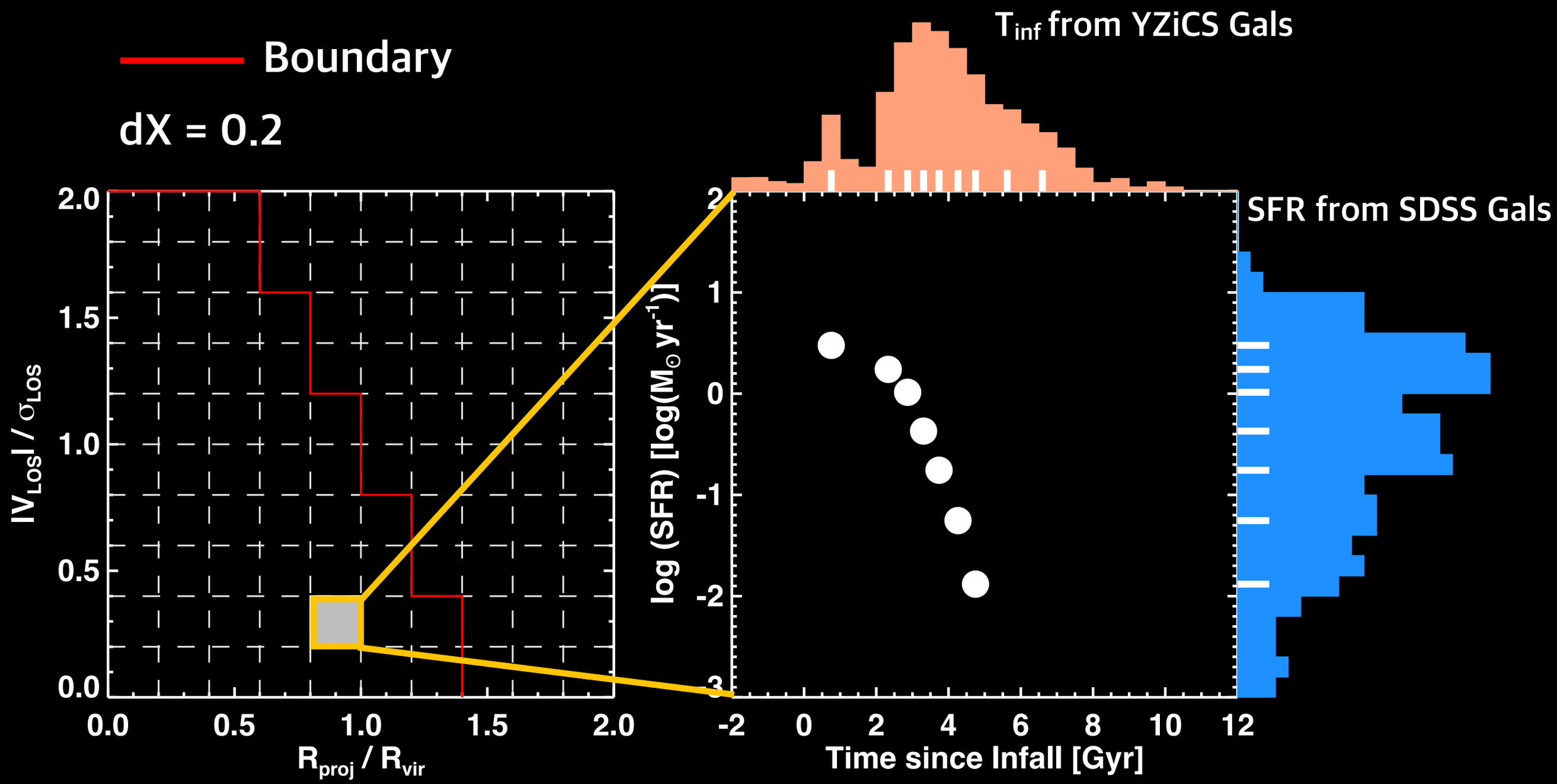
Assumptions

1. Two parameters are correlated, that is, Y is driven by X **("Causality")**
2. The relation is monotonic

Phase-space Analysis for Causality

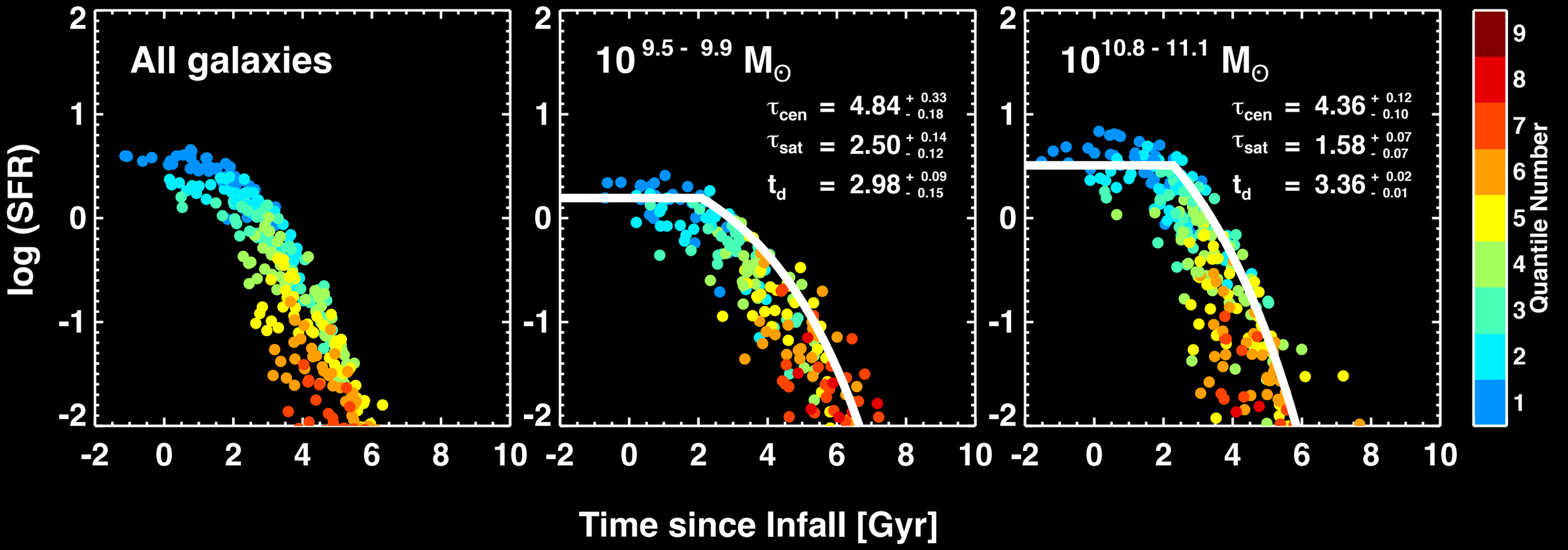


Phase-space Analysis for Causality



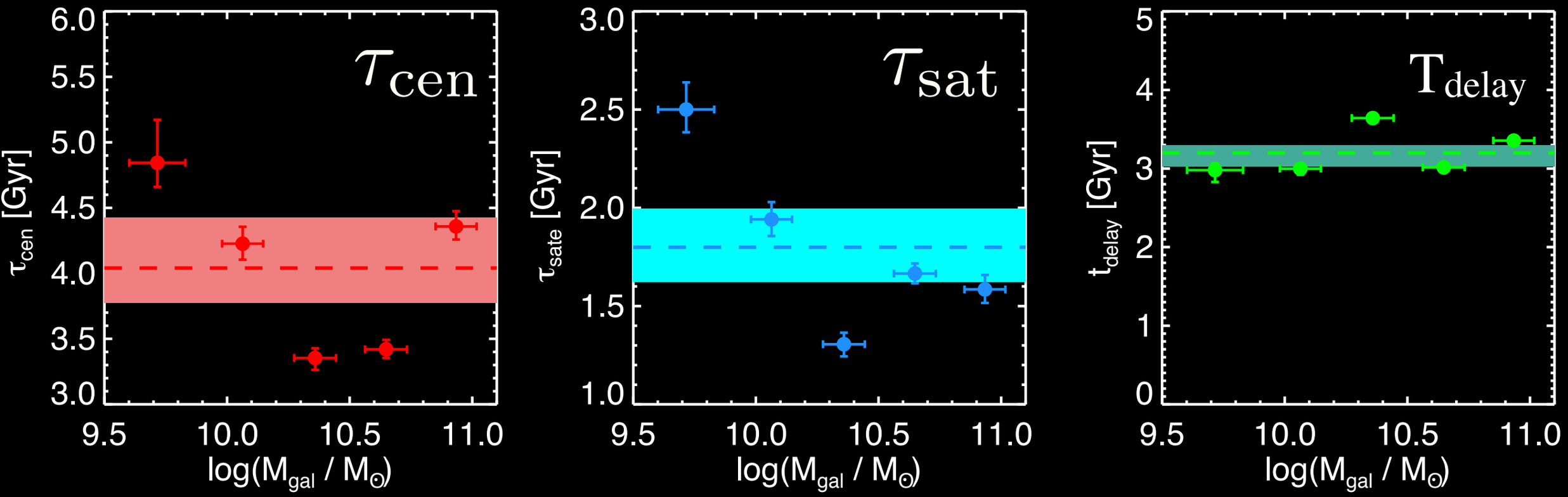
Derived T_{inf} - SFR relation

Rhee et al. 2018, in prep



- Result from ~ 50 pixels (9 points per each pixel)
- Each data point has different weight

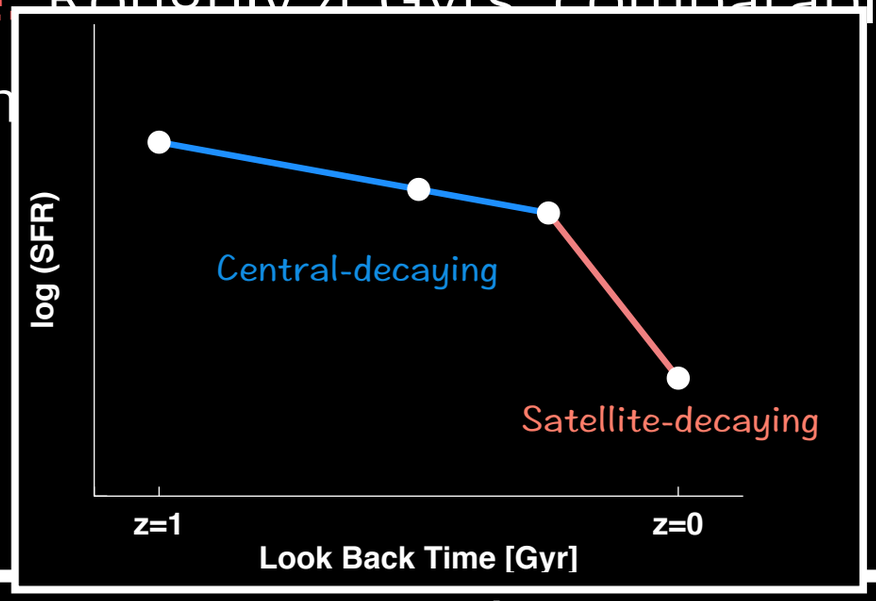
Quenching Parameters



Rhee et al. 2018, in prep

- **Central phase:** Roughly 4 Gyrs, comparable to other studies

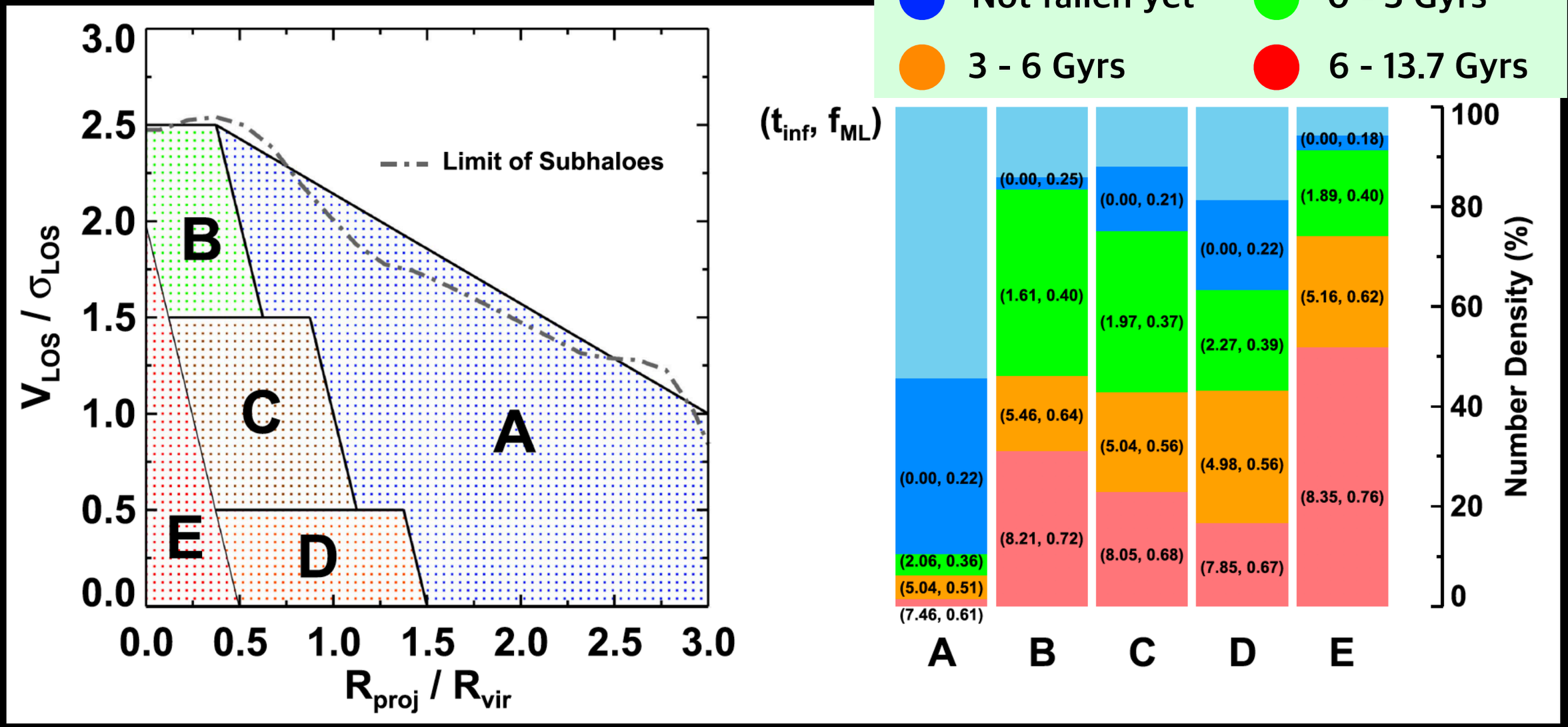
  (Wetzel+13, Oman



Take Home Messages

- We measure time since infall and SFR, in a statistical context
- We derive the relation of T_{inf} versus SFR, using the quantile matching method
- We constrain a quenching model

Phase-space Analysis for Causality



Rhee et al. 2017

- Bar length ~ number density of each population
- Numbers ~ mean tinf, mass loss

Phase-space Analysis for Causality