

CANDELS Sheds Light on the Environmental Quenching of Low-mass Galaxies

(ApJL, 2017, 841L, 22)

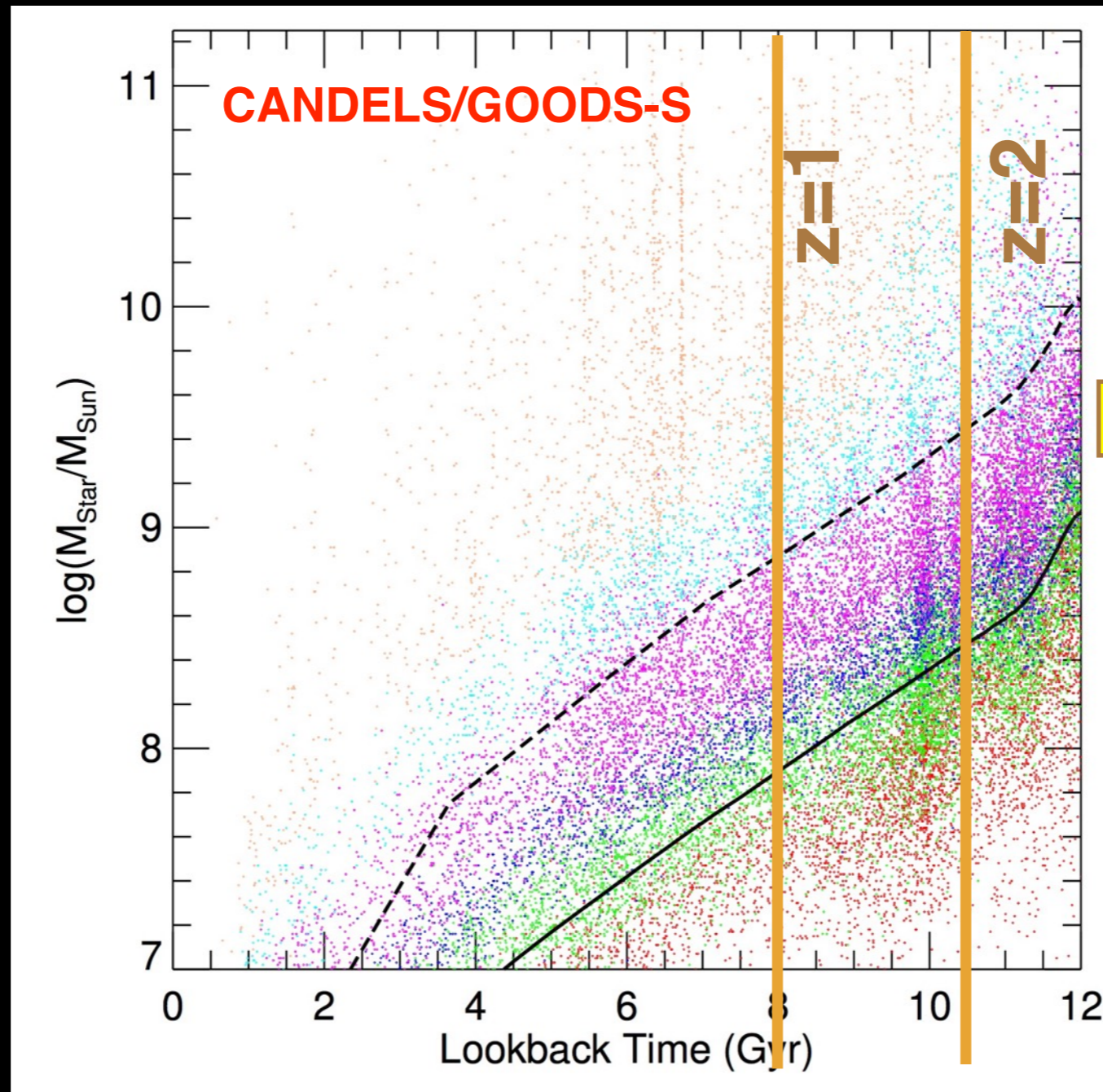
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and CANDELS team

Why are low-mass galaxies important?

- 0. Low-mass galaxies: $M^* < 10^9 M_{\text{Sun}}$
- I. The majority of galaxies are low-mass galaxies
- II. Low-mass galaxies are building blocks or progenitors of massive galaxies like our MW
- III. Low-mass galaxies provide stringent tests on galaxy formation (especially feedback)
- IV. Low-mass galaxies are sensitive to environment

CANDELS: A New Window to Study Low-mass Galaxies



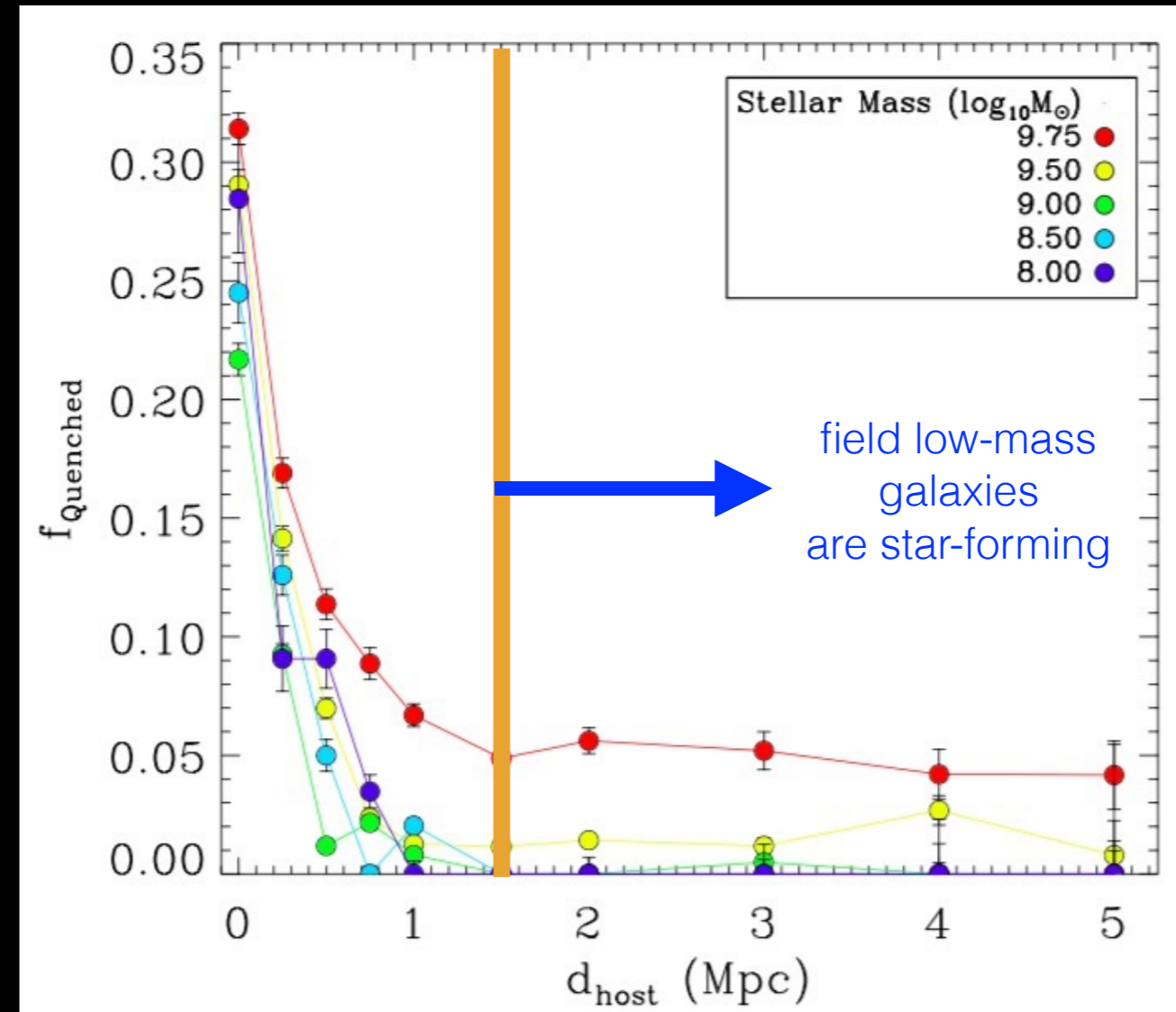
H=26 AB, Maximal Old SSP
very conservative mass limit

H=26 AB, Constant SFH
aggressive mass limit

Y. Guo+2013, 2015
Mobasher+2015
Santini+2015

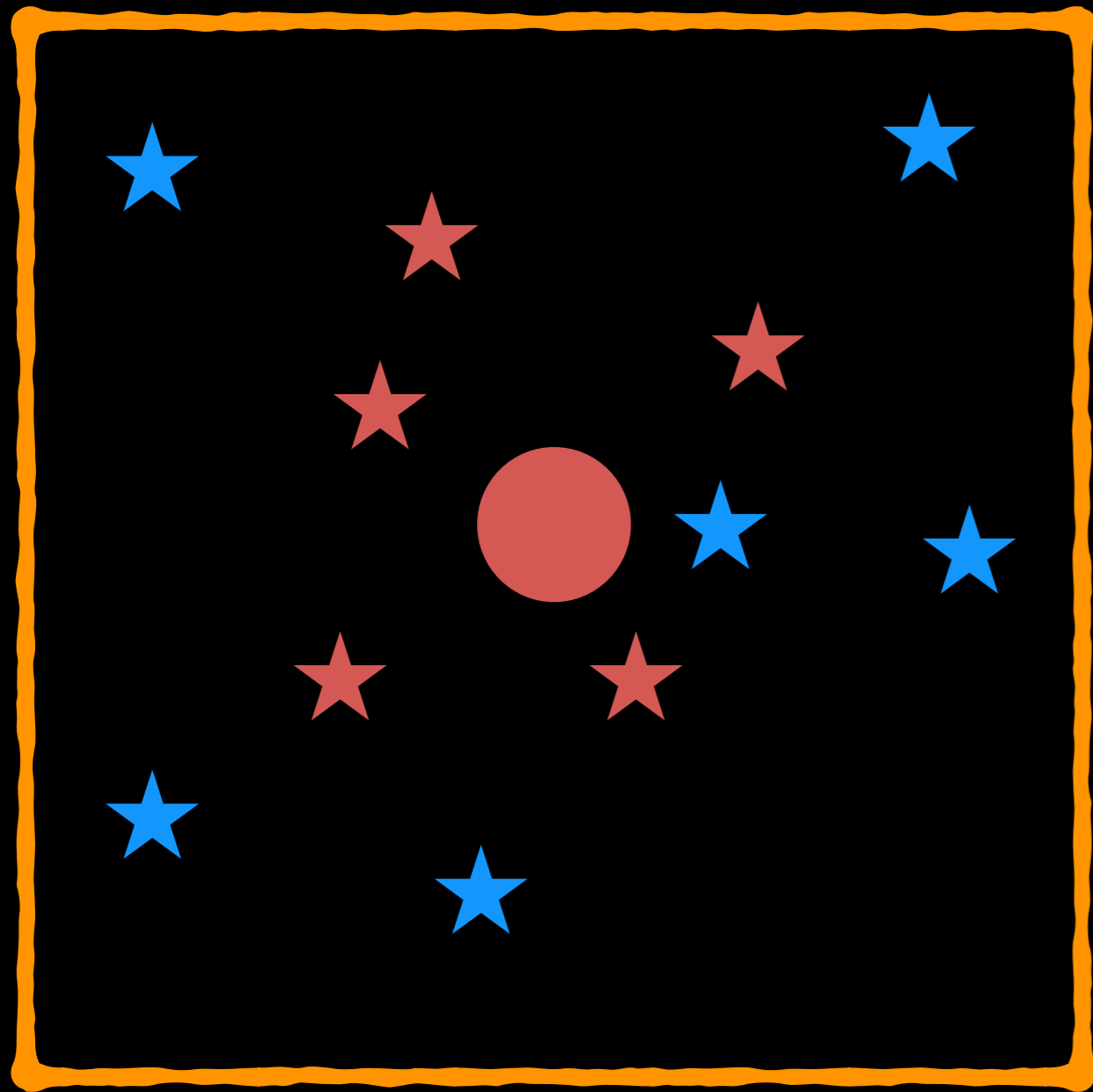
Environmental Quenching

- ★ **Environmental effects:** primary process of ceasing star formation in low-mass galaxies (e.g. Geha+2012, Davies+2016)
- ★ The quenched fraction of galaxies with $\log(M) < 9$ drops rapidly as a function of distance to massive host galaxies and essentially all **local field low-mass galaxies** are forming stars (e.g., Geha+2012)
- ★ The **physical mechanisms** of environmental quenching are still under investigation (e.g., Tinker+2013, Cen+2014, Fillingham+2015, Peng+2015, Wetzel+2015)
- ★ **When** was the environment—quench connection established for low-mass galaxies?
- ★ But the observation is **challenging at $z > 0$** due to the faintness of distant low-mass galaxies: what can **CANDELS** do?



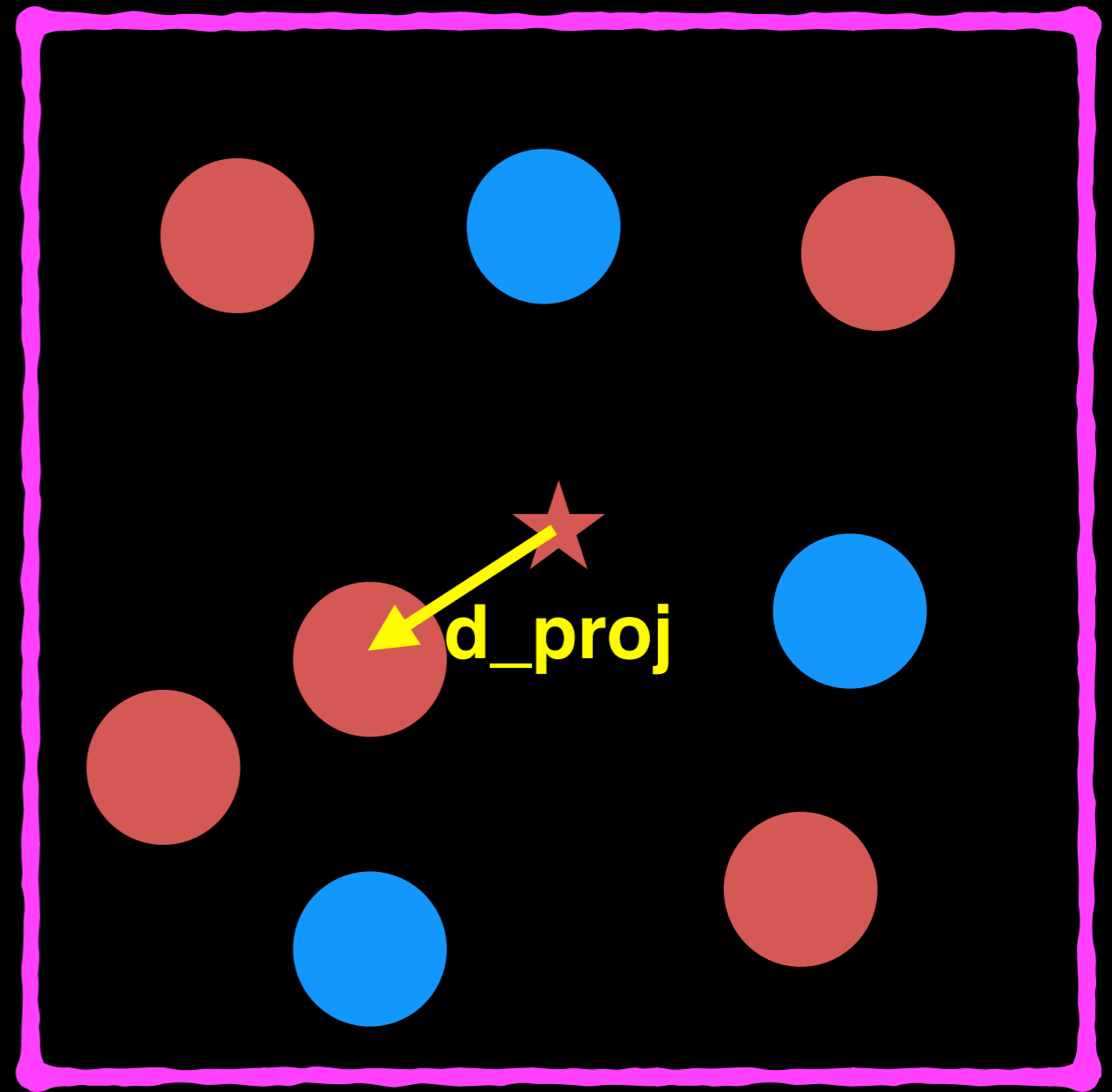
Geha+2012

Usual Method



- ★ Starting from massive hosts
- ★ Looking for low-mass satellites
- ★ Need complete low-mass samples

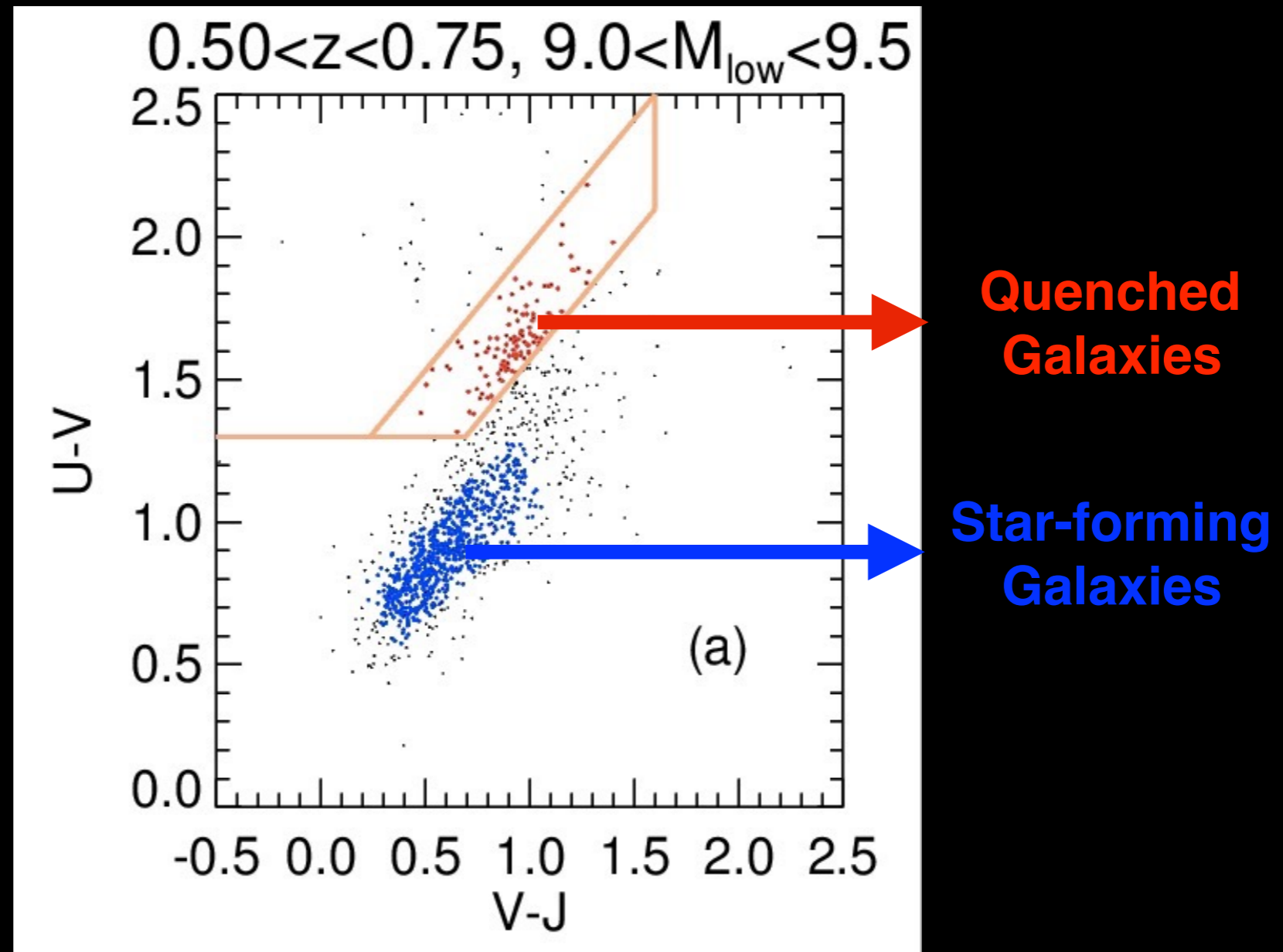
Our Method



- ★ Starting from quenched low-mass galaxies
- ★ Looking for the **nearest** massive ($M > 10.5$) galaxies
- ★ Does not need complete low-mass samples: test a “whether or not” question

Sample Selection

Example: $0.75 < z < 1.0$, $8.5 < M_{\text{low}} < 9.0$

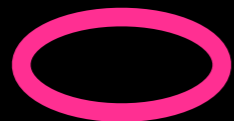
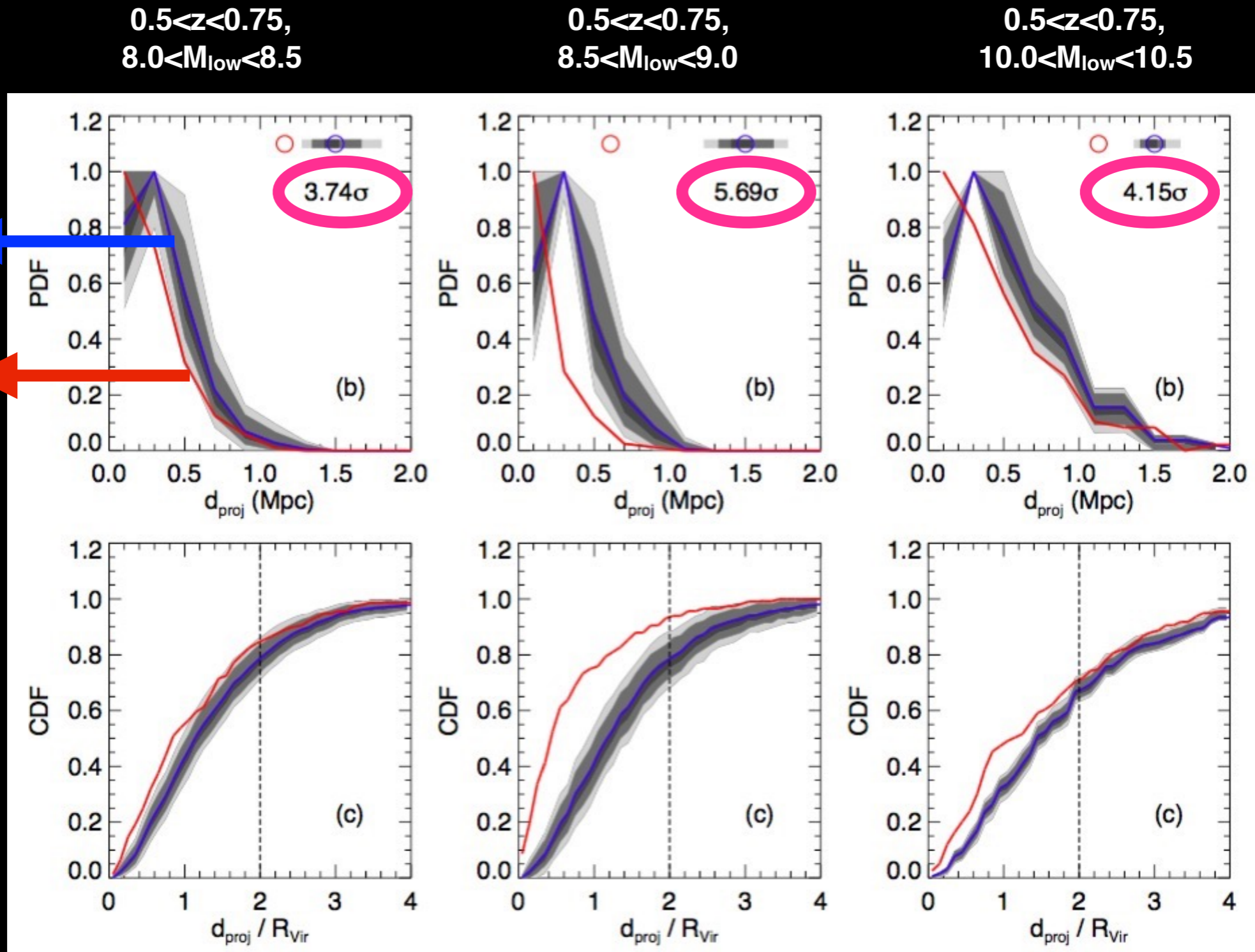


The whole sample (CANDELS, $H < 26$ AB, $0.5 < z < 2.0$, and $8.0 < M < 10.5$) is divided into different (z , M) bins

Results (Examples of Three Bins at $0.5 < z < 0.75$)

Star-forming
Galaxies

Quenched
Galaxies



Quenched (or not) has a relation with environment

Results (Examples of Three Bins at $0.75 < z < 1.0$)

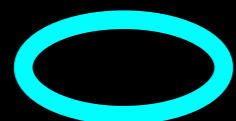
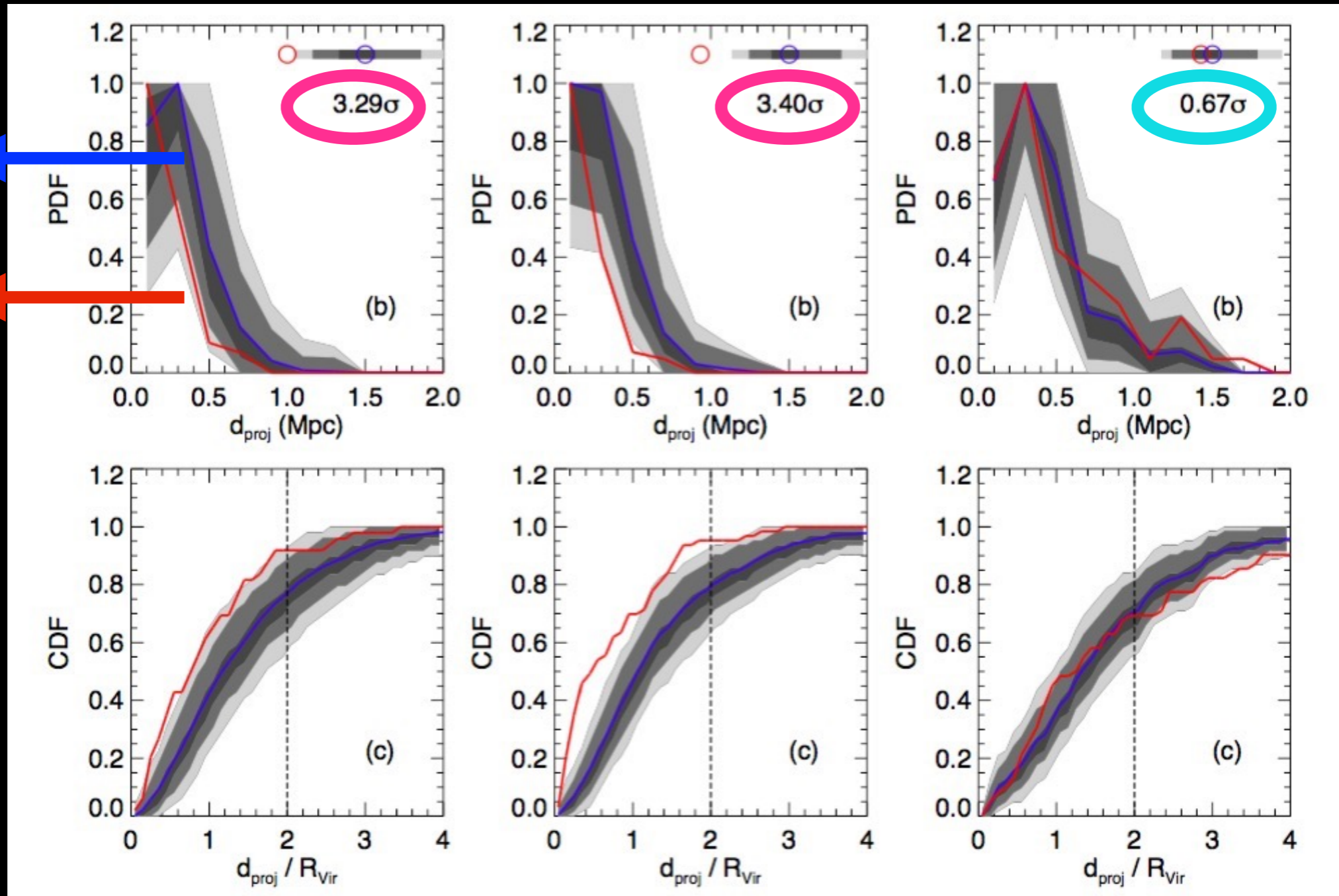
Star-forming
Galaxies

Quenched
Galaxies

$0.75 < z < 1.0$,
 $8.0 < M_{\text{low}} < 8.5$

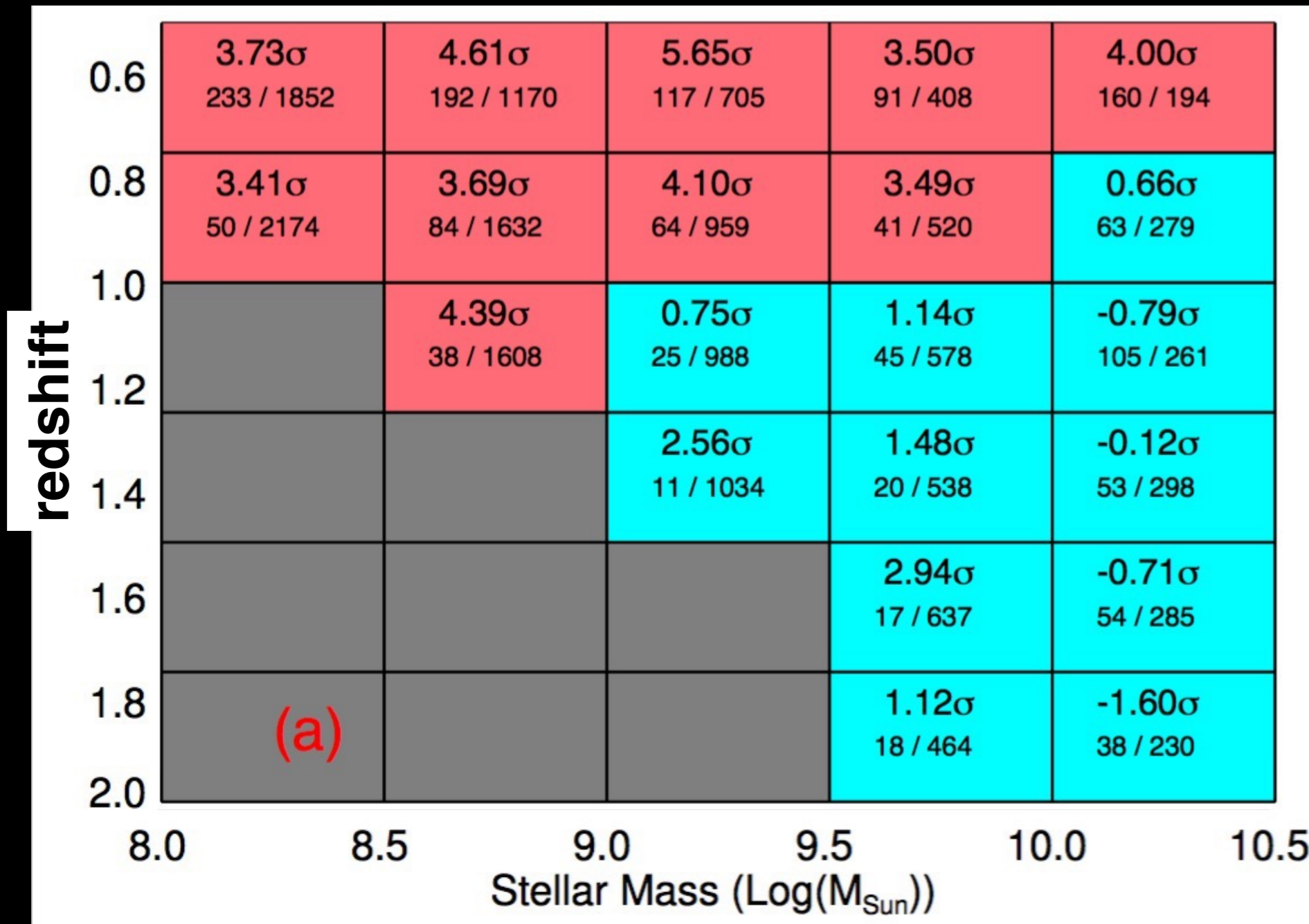
$0.75 < z < 1.0$,
 $8.5 < M_{\text{low}} < 9.0$

$0.75 < z < 1.00$,
 $10.0 < M_{\text{low}} < 10.5$



Quenched (or not) has **NO** relation with environment

Evidence of Environmental Quenching Seen at $z \sim 1$ for Low-mass Galaxies

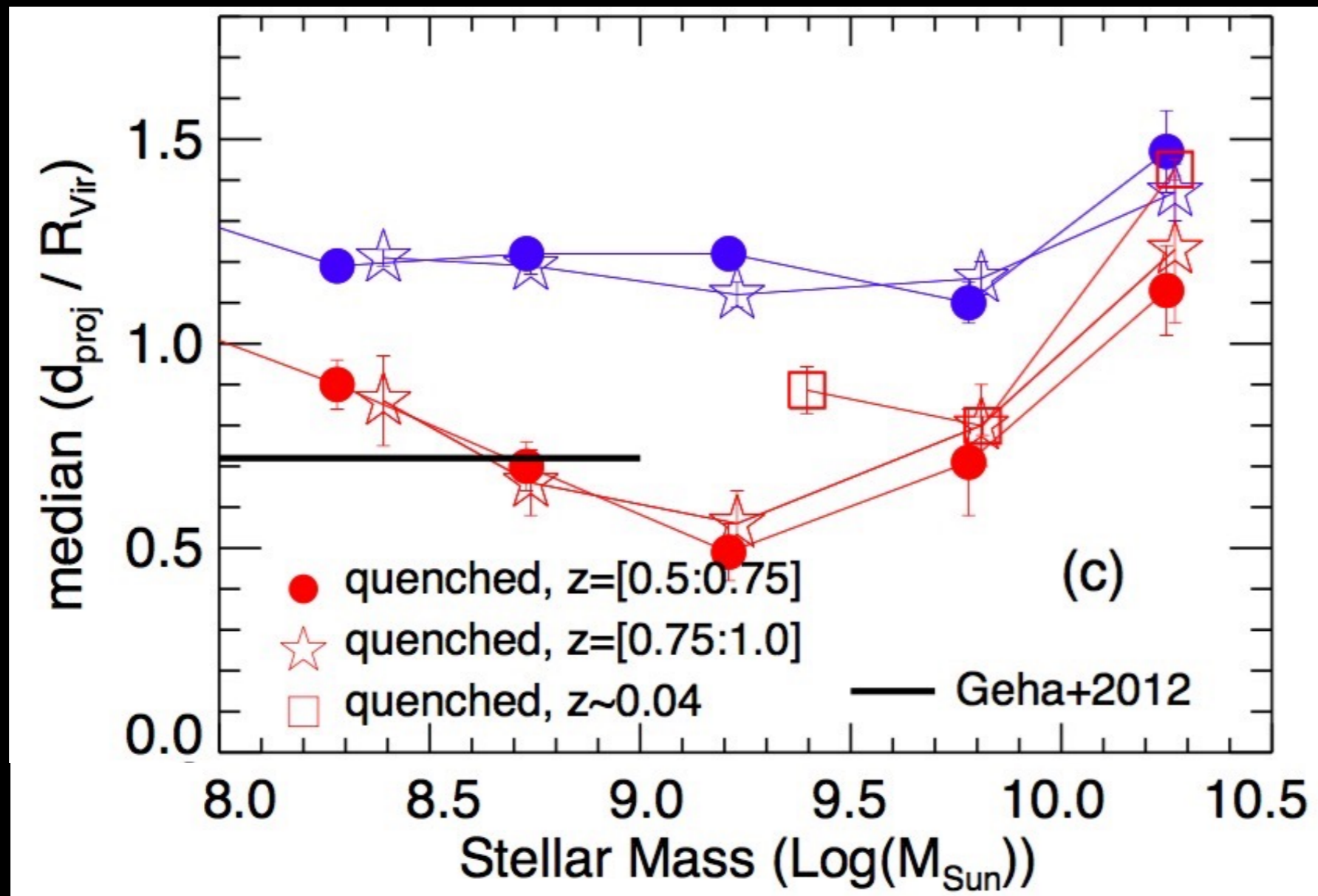


RED: Quenched (or not) has a relation with environment

Cyan: Quenched (or not) has NO relation with environment

Gray: No data (too faint)

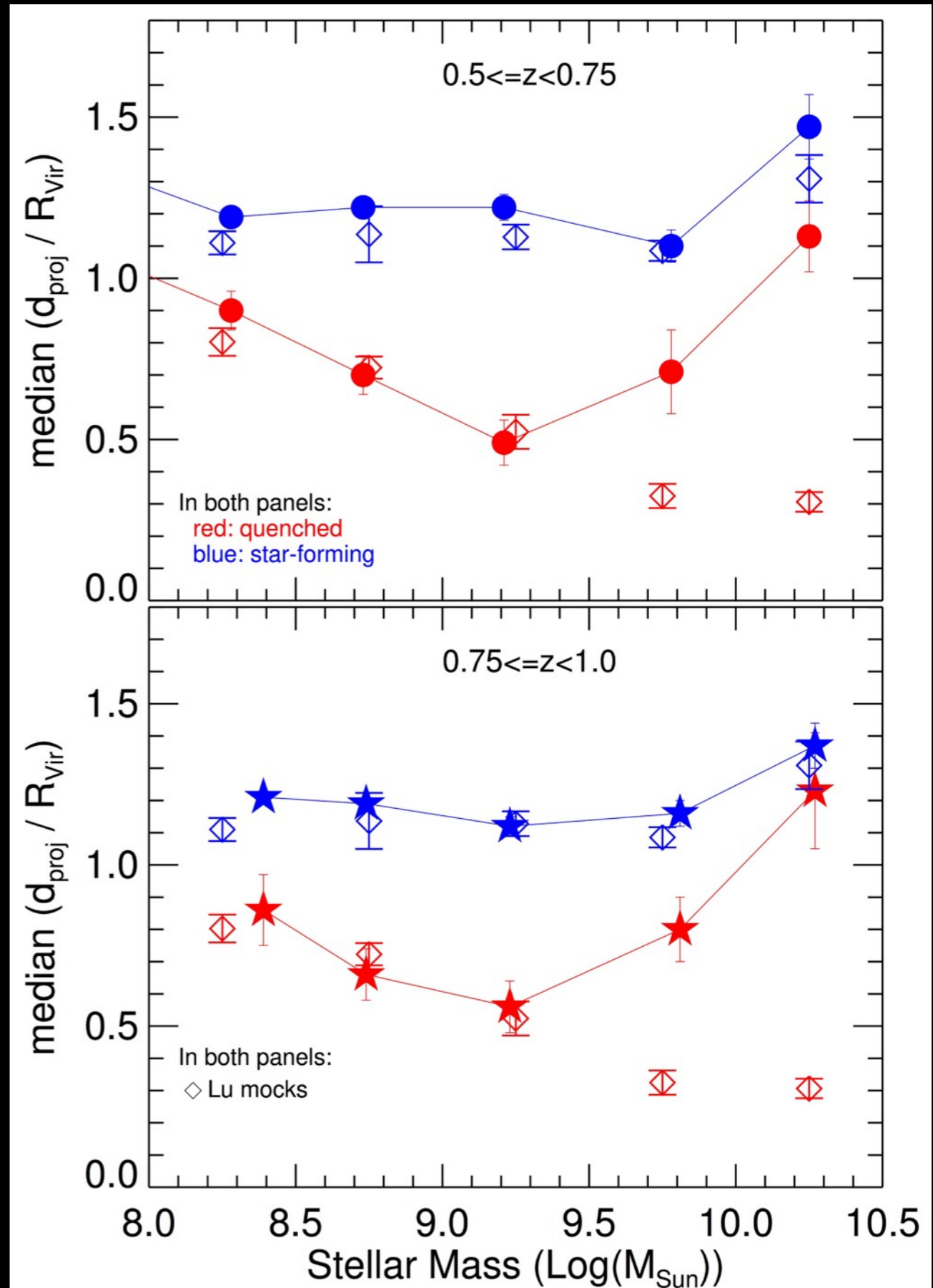
Median Distance to Massive Neighbors



- ★ Median projected distance (scaled by the virial radius of massive halos) to massive neighbors for **quenched** and **star-forming** galaxies
- ★ **Star-forming**: no mass dependence until $\log(M^*) > 10$
- ★ **Quenched**: (1) smaller than star-forming's
(2) mass dependence — implying transition of quenching mechanisms?
(3) no redshift dependence

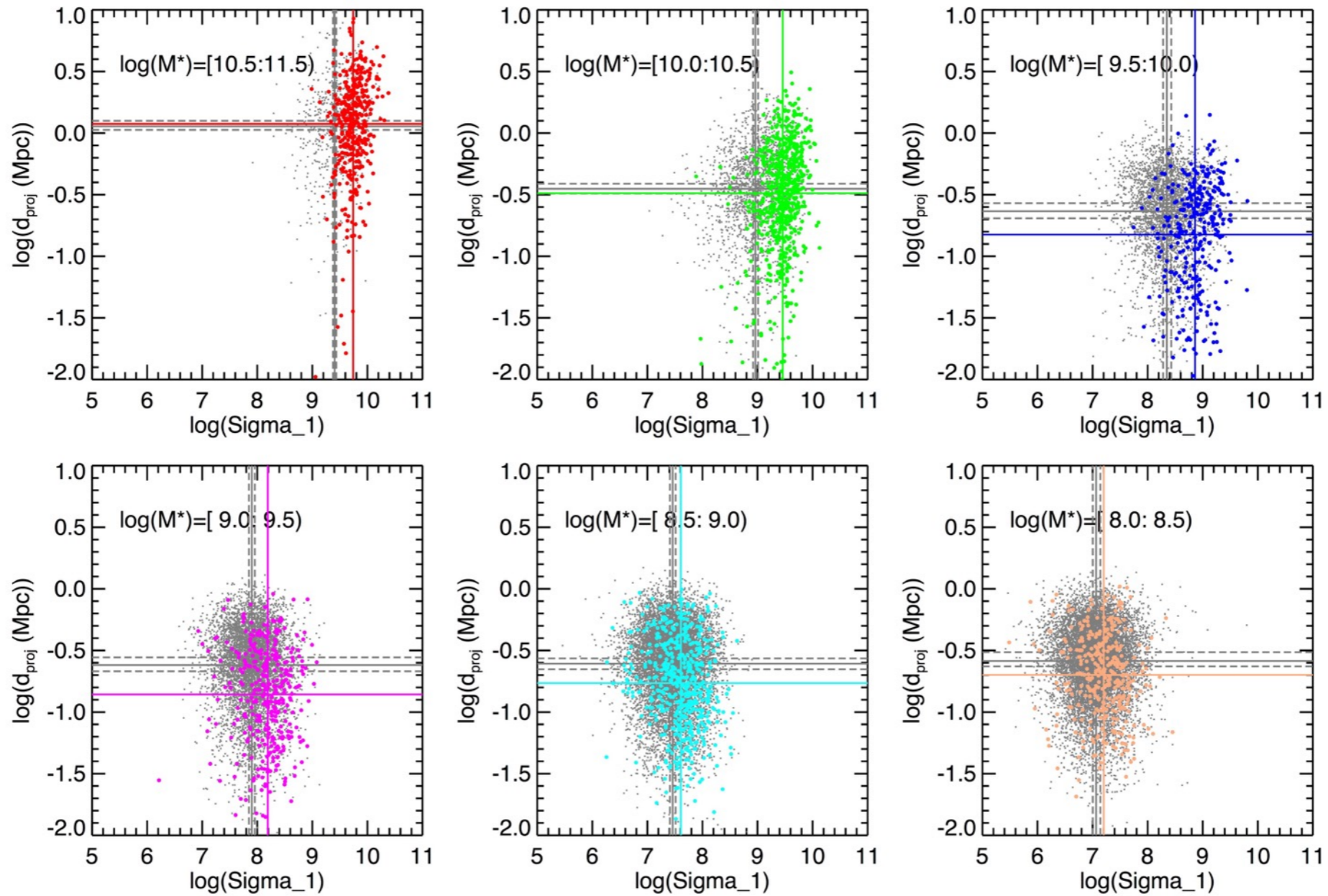
A Simple Way to Test Models

- Distance to massive neighbors provides a simple and straightforward test of models
- Compare observations with CANDELS mock catalogs (**preliminary results**)
- Lu model: hot gas stripped instantaneously, cold gas intact



Environment vs. Σ_1

d_proj



Central Mass Density

Summary

- ★ CANDELS opens a new window to study low-mass galaxies
- ★ At $z < \sim 1$ and $10^8 M_{\odot} < M_{*} < 10^{10} M_{\odot}$, quenched galaxies are statistically closer to massive galaxies than star-forming galaxies are
- ★ Projected distance from quenched galaxies to their nearest massive neighbors depends on the mass of low-mass galaxies
- ★ Projected distance provides a simple test to models
- ★ $\Sigma 1$ of low-mass galaxies: new clue of quenching