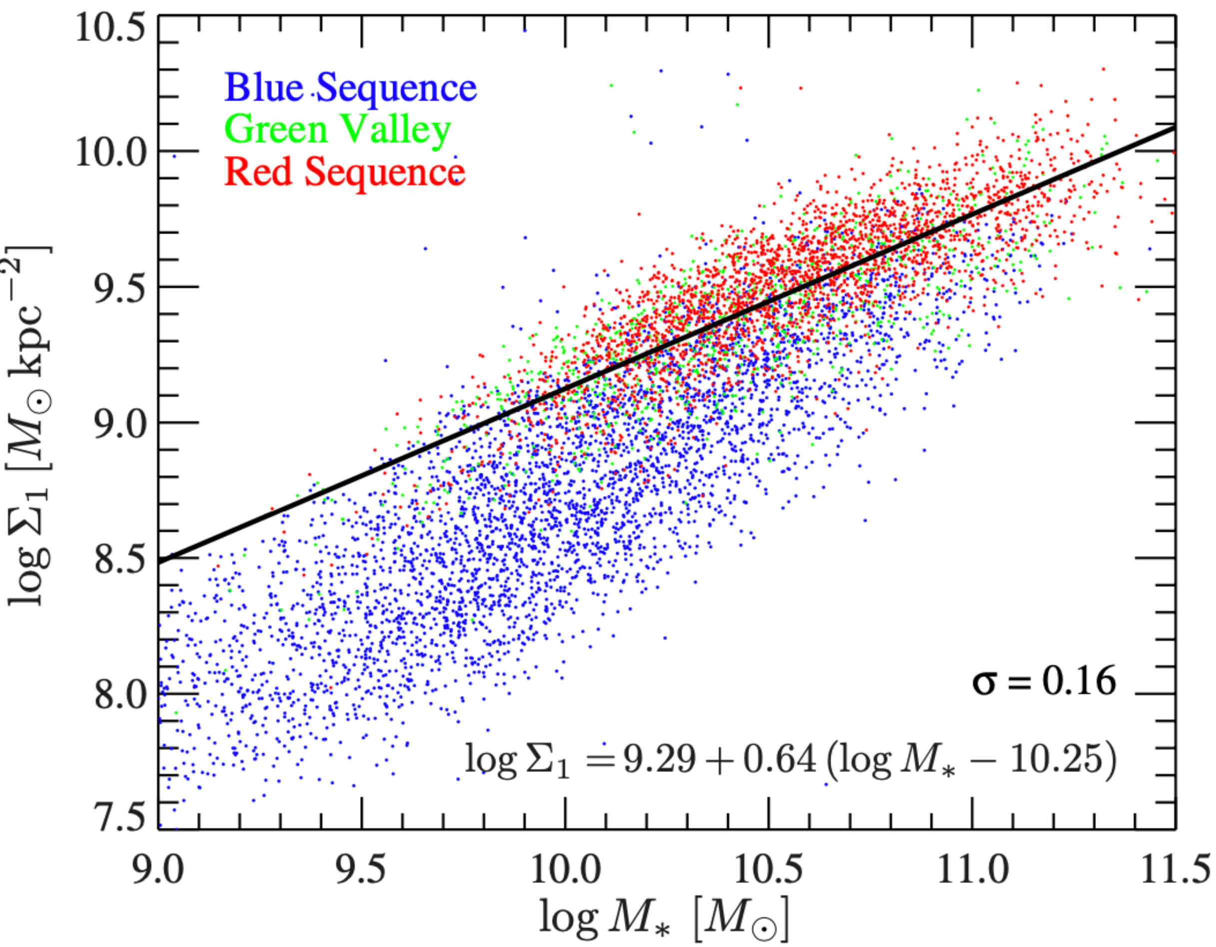
σ_1 versus Σ_1 in Quenching of Satellite Galaxies

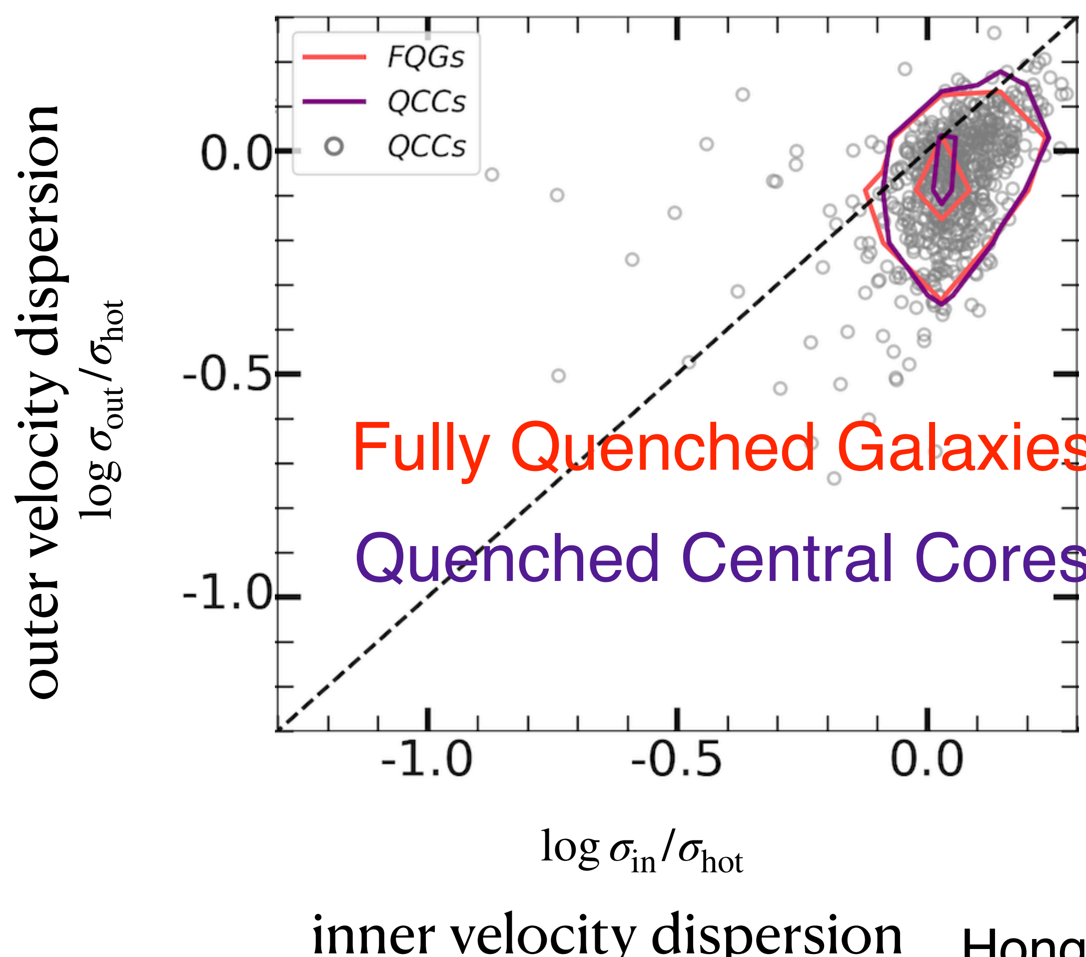
12.08 2023 Hui Hong

Background

Quenching of central galaxies



Fang+2013



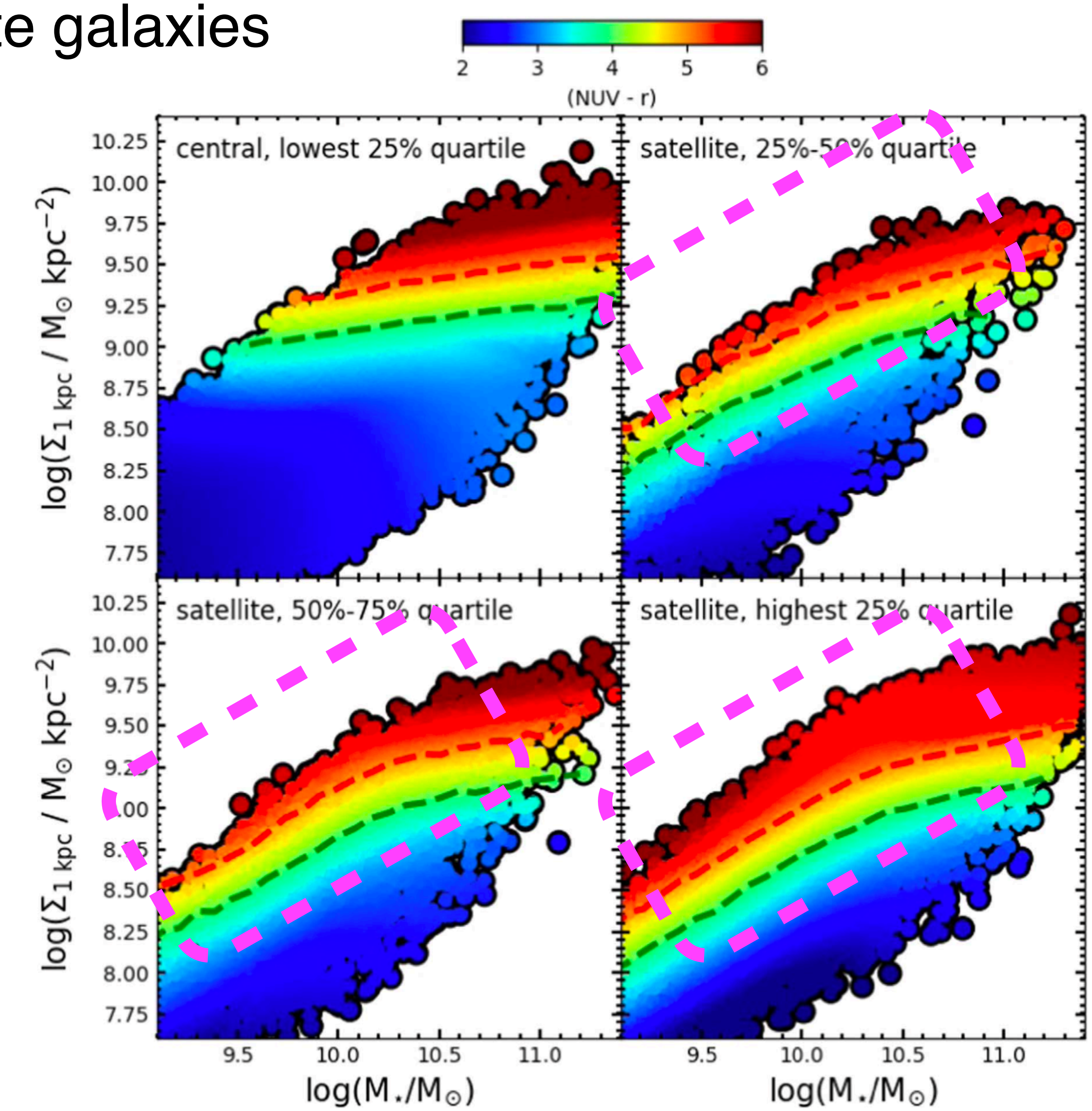
Hong+2023

Galaxy can be quenched when central Σ reaches critical value. (with **large Σ**)

Galaxy can be quenched when it is dynamically hot from inner to outer. (with **large σ**)

Background

Quenching of satellite galaxies



Xu&Peng2021

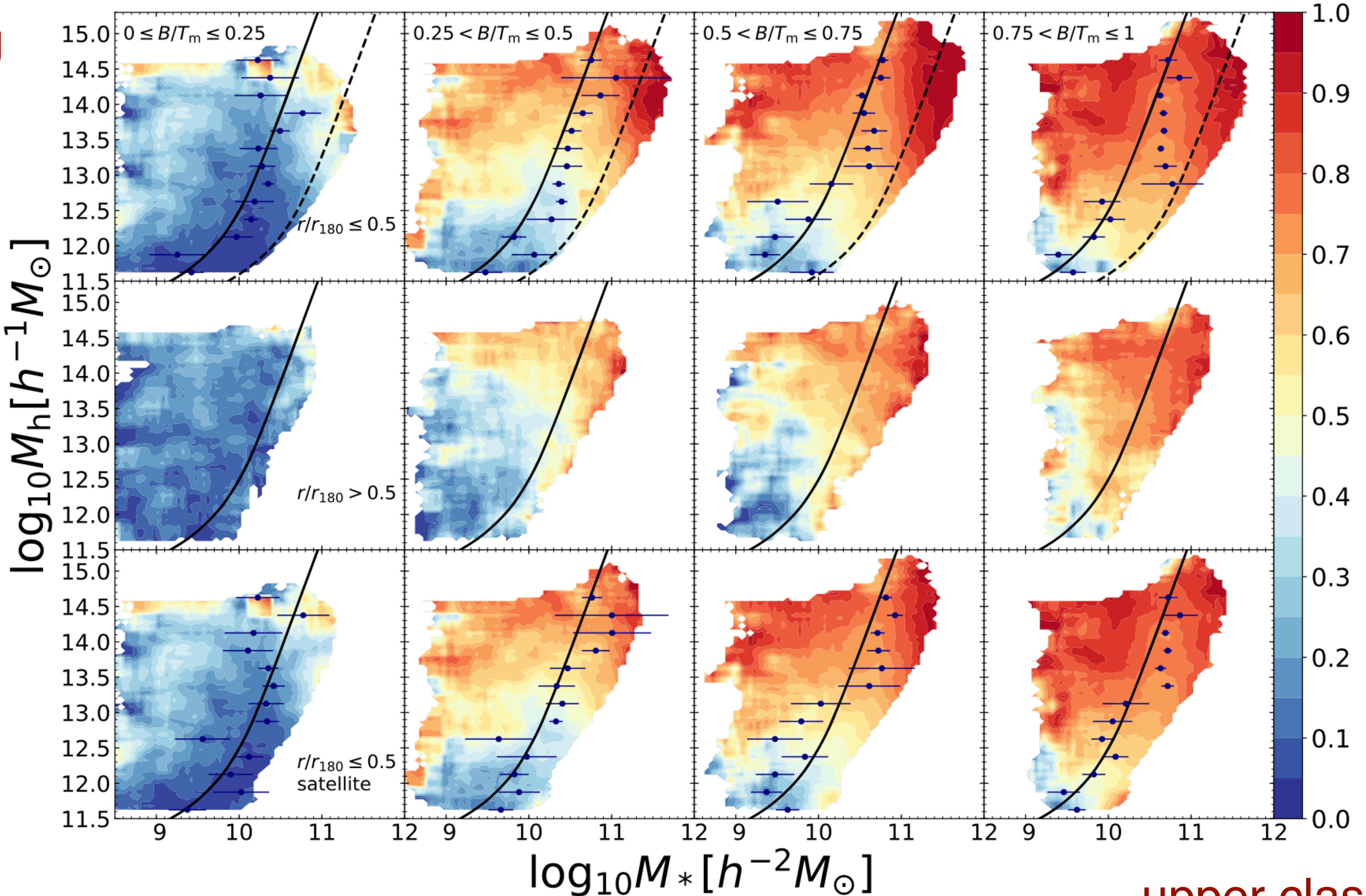
For satellite: **large Σ**

Why? The dependence on σ?

Background

lower class:
environmental
quenching

Li+2020



upper class:
internal quenching

Data

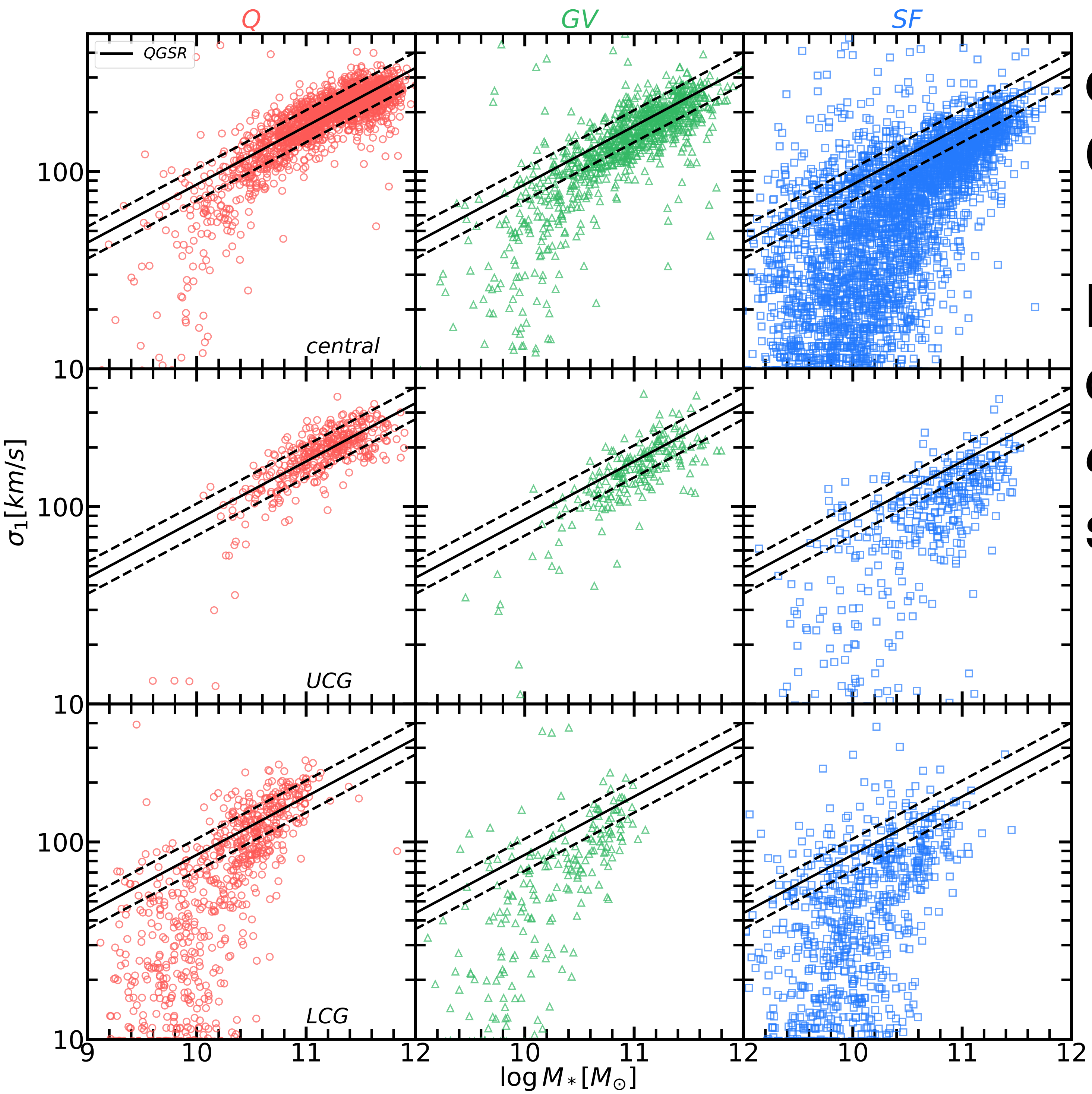
MaGNA DR17: σ_1 (less contribution from rotational velocity), Σ_1

According to group catalog:

central —> internal quenching (6231)
UCG(upper class galaxies) —> internal quenching (1678)
LCG (lower class galaxies) —> environmental quenching (979)

star-forming (SF): $\log \mathrm{sSFR} > -11$
green valley (GV): $-12 < \log \mathrm{sSFR} \leqslant -11$
quenched (Q): $\log \mathrm{sSFR} \leqslant -12$

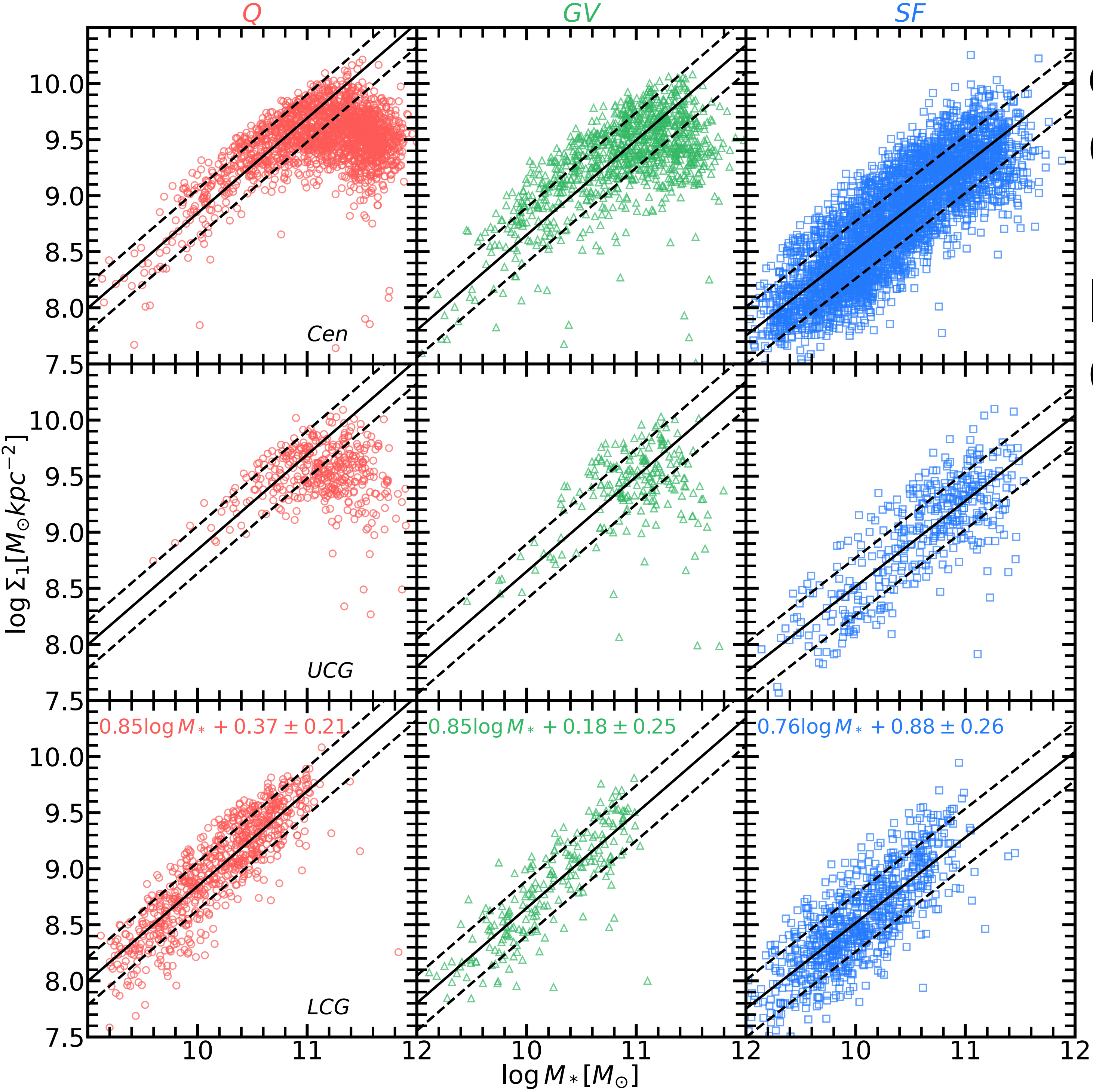
σ_1 v.s. $\Sigma_1 - \sigma_1 - M_*$ relation



central & upper class:
QGs —> tight $\sigma_1 - M_*$ relation.

lower class:
distributions for Q, GV SFGs on $\sigma_1 - M_*$ diagram are almost the same.

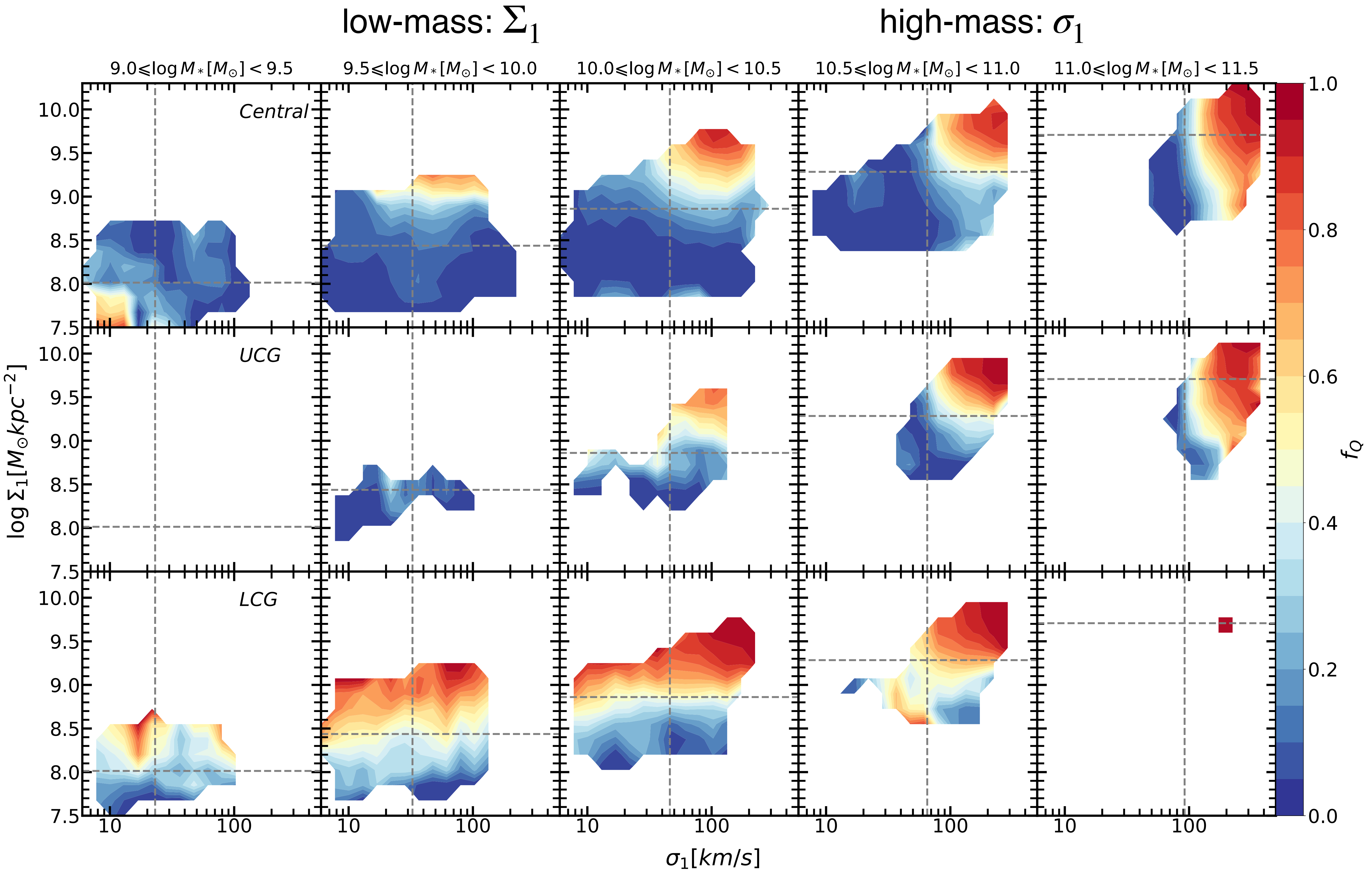
σ_1 v.s. Σ_1— $\Sigma_1 - M_*$ relation



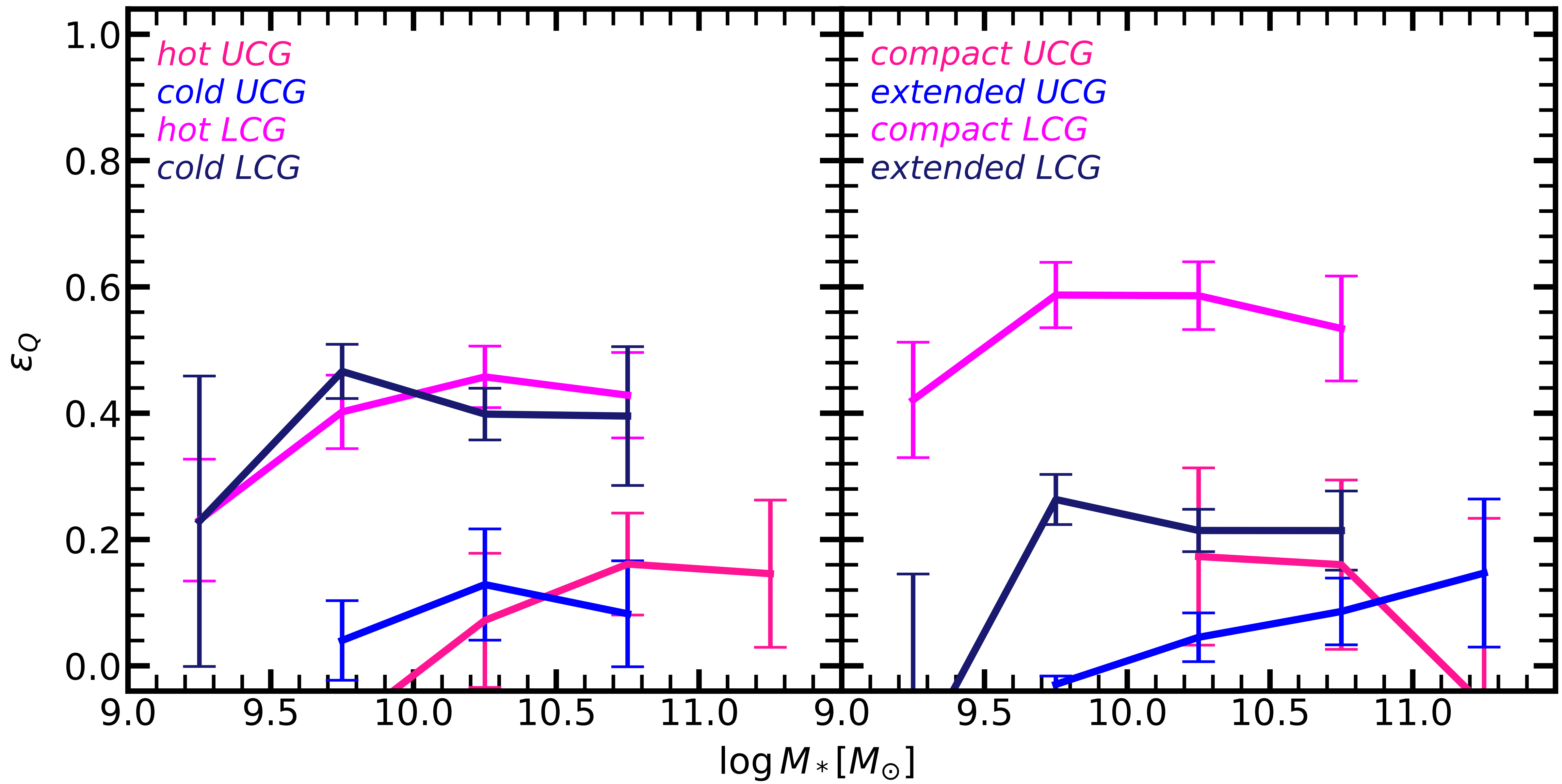
central & upper class:
QGs —> flat $\Sigma_1 - M_*$ relation.

lower class:
QGs —> tight $\Sigma_1 - M_*$ relation.

σ_1 v.s. Σ_1— Quenched fraction f_Q map



Quenching efficiency ϵ_q



quenching efficiency is almost independent of M*.
high or low σ_1 : quenching efficiency is the same.
high Σ_1 —> high quenching efficiency.

Definition of $\epsilon_Q = \frac{f_{Q,\mathrm{UCG\ or\ LCG}} - f_{Q,\mathrm{cen}}}{1 - f_{Q,\mathrm{cen}}}$. Here each galaxy is weighted.

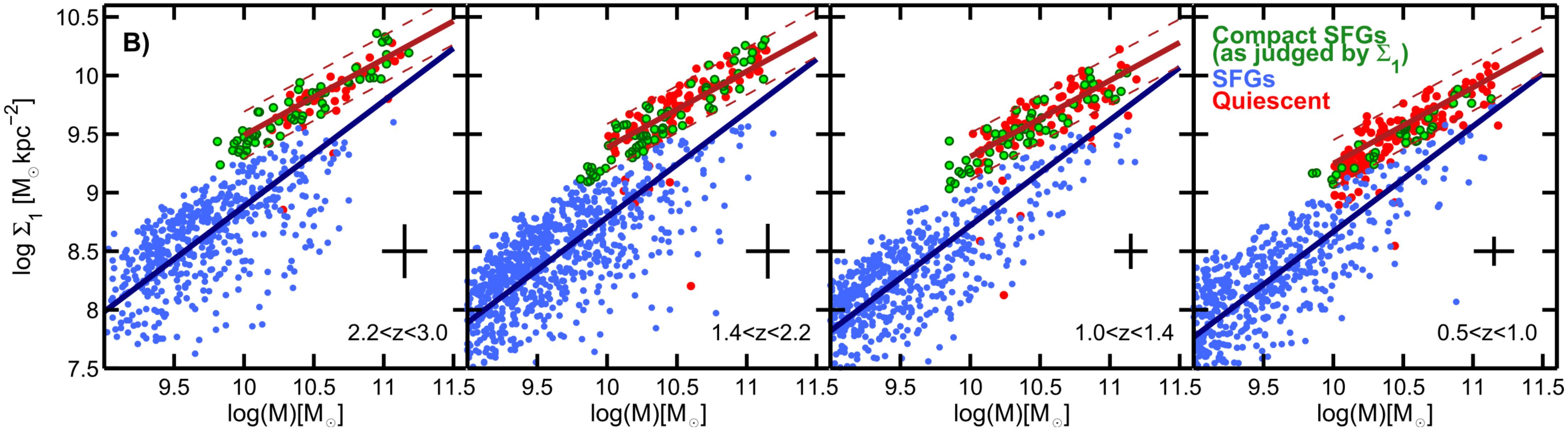
Why Σ_1 is important in the quenching of satellite galaxies?

(1) Progenitor bias?

(2) Growth of central region?

(3) Other reasons?

(1) Progenitor bias

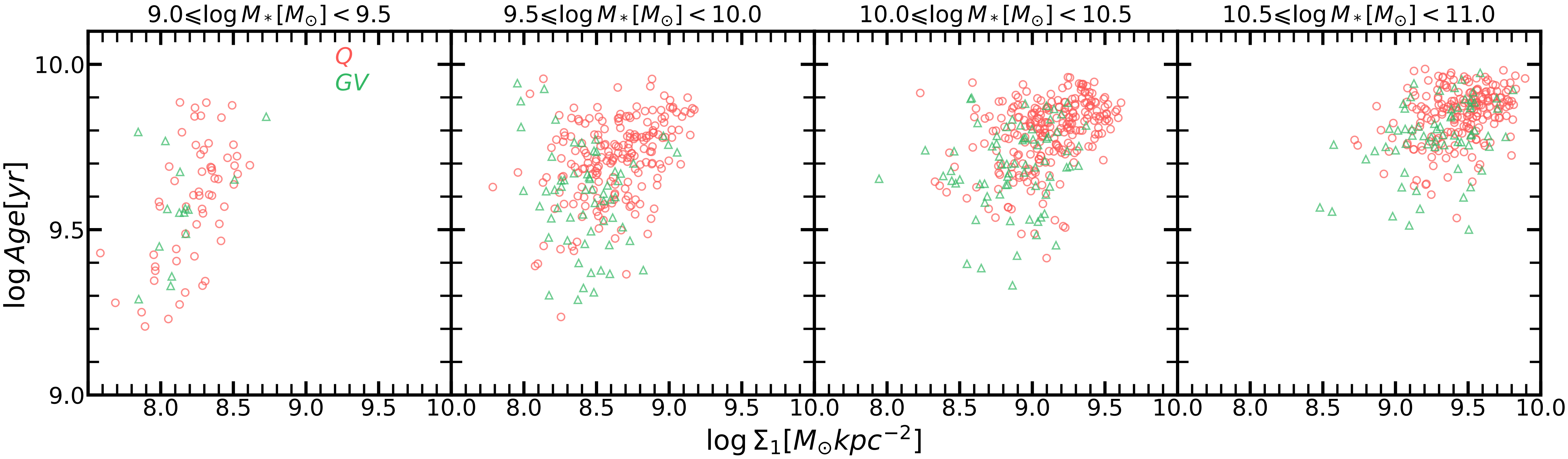


Barro+2017

The evolved $\Sigma_1 - M_*$ relation for star-forming galaxies.

The progenitor of today's QGs are high-redshift SFGs.
High-redshift SFGs are more compact than today's SFGs. —>
Today's QGs are more compact than today's SFGs.

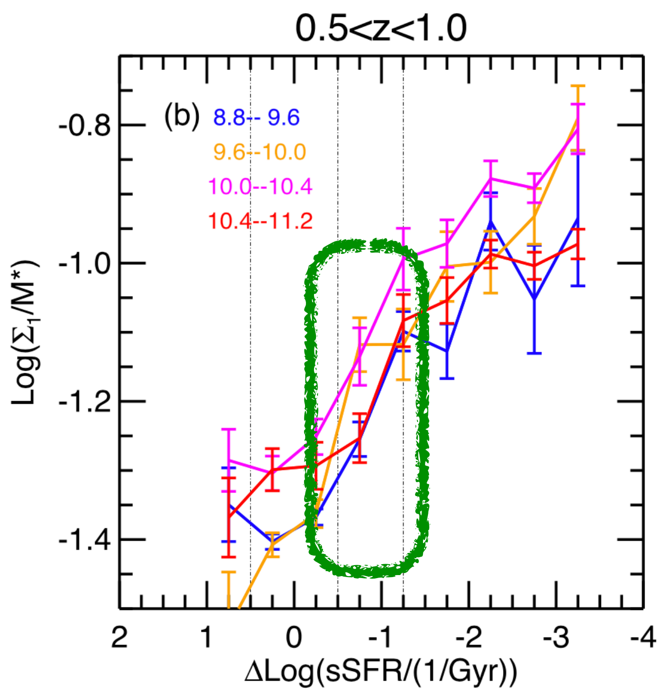
(1) Progenitor bias



Mass-weighted stellar age is almost independent with Σ_1.

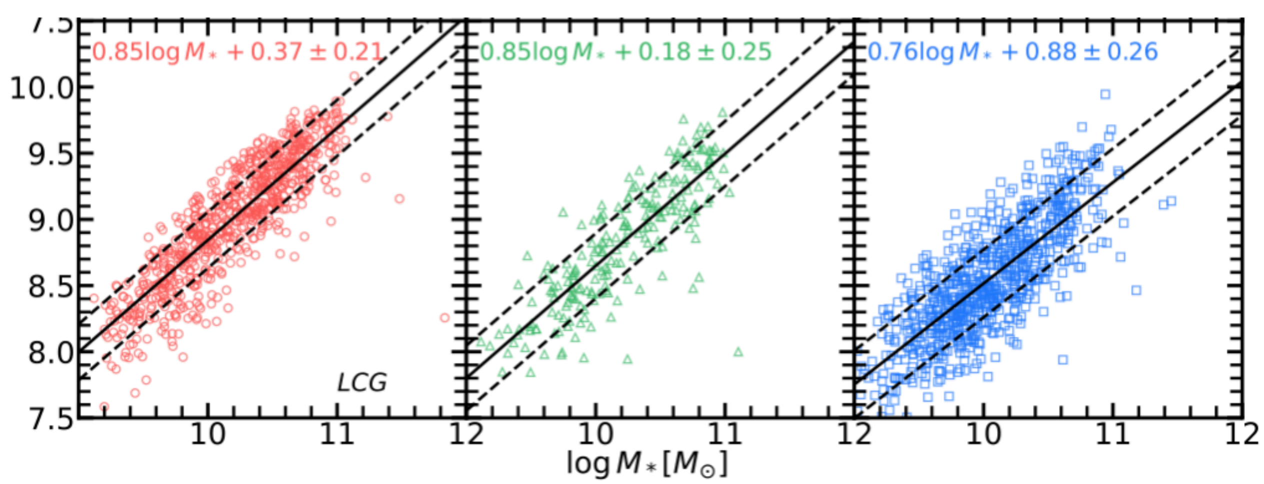
—> only progenitor bias ✕

(2) Growth of central region



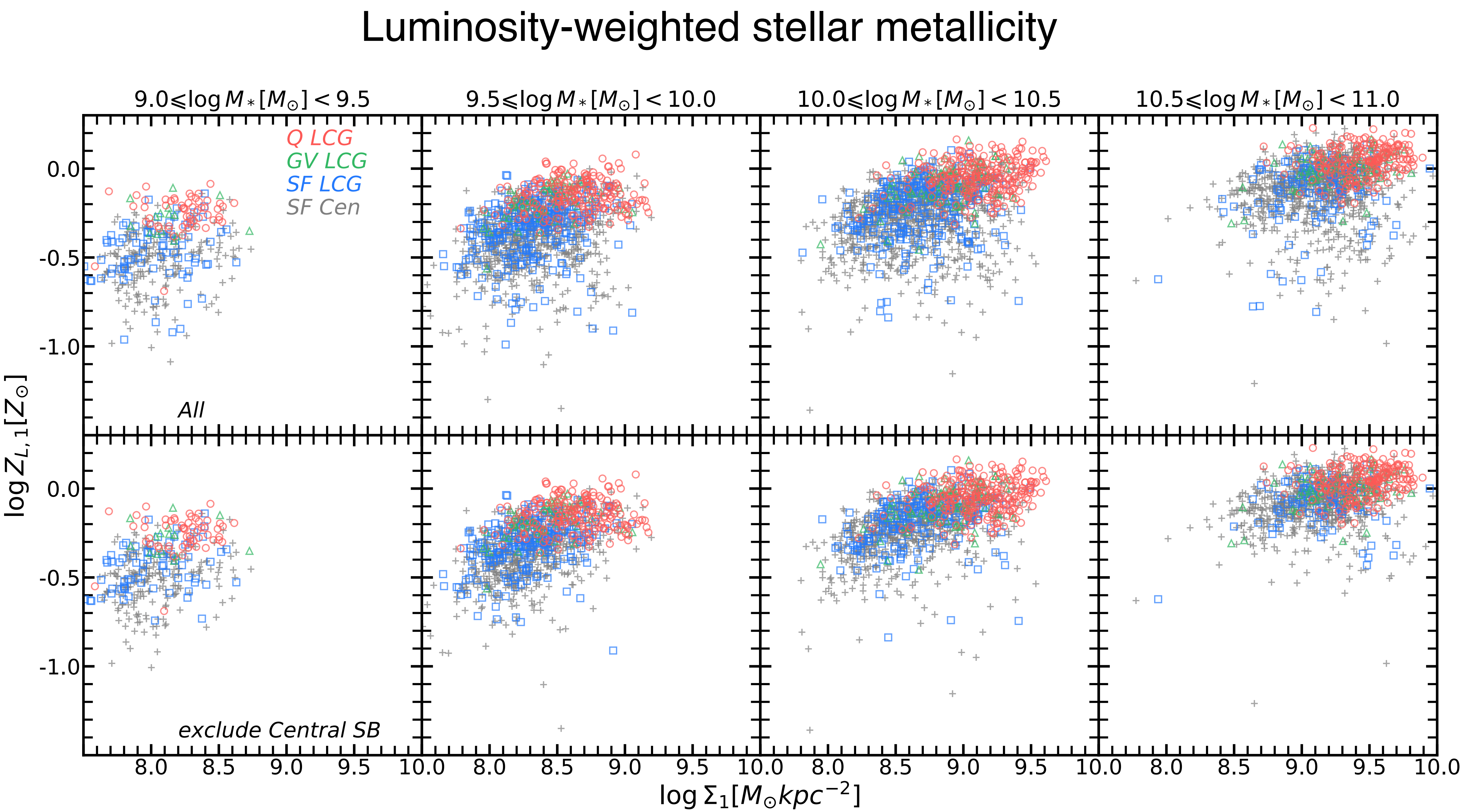
Guo+2021

Low-mass galaxies at GV, -0.25~-1.25 dex below MS, can grow their Σ_1 by 0.25 dex through 4 Gyr



LCGs, there is 0.2 dex difference in $\Sigma_1 - M_*$ relation between GV and QGs.
sSFR at GV ~ $10^{-11.5} yr^{-1}$, if $M_* \sim 10^{10} M_\odot$, star-forming all happens at central 1kpc.
—> The timescale of GV is 27.8 Gyr

(3) Other reasons?



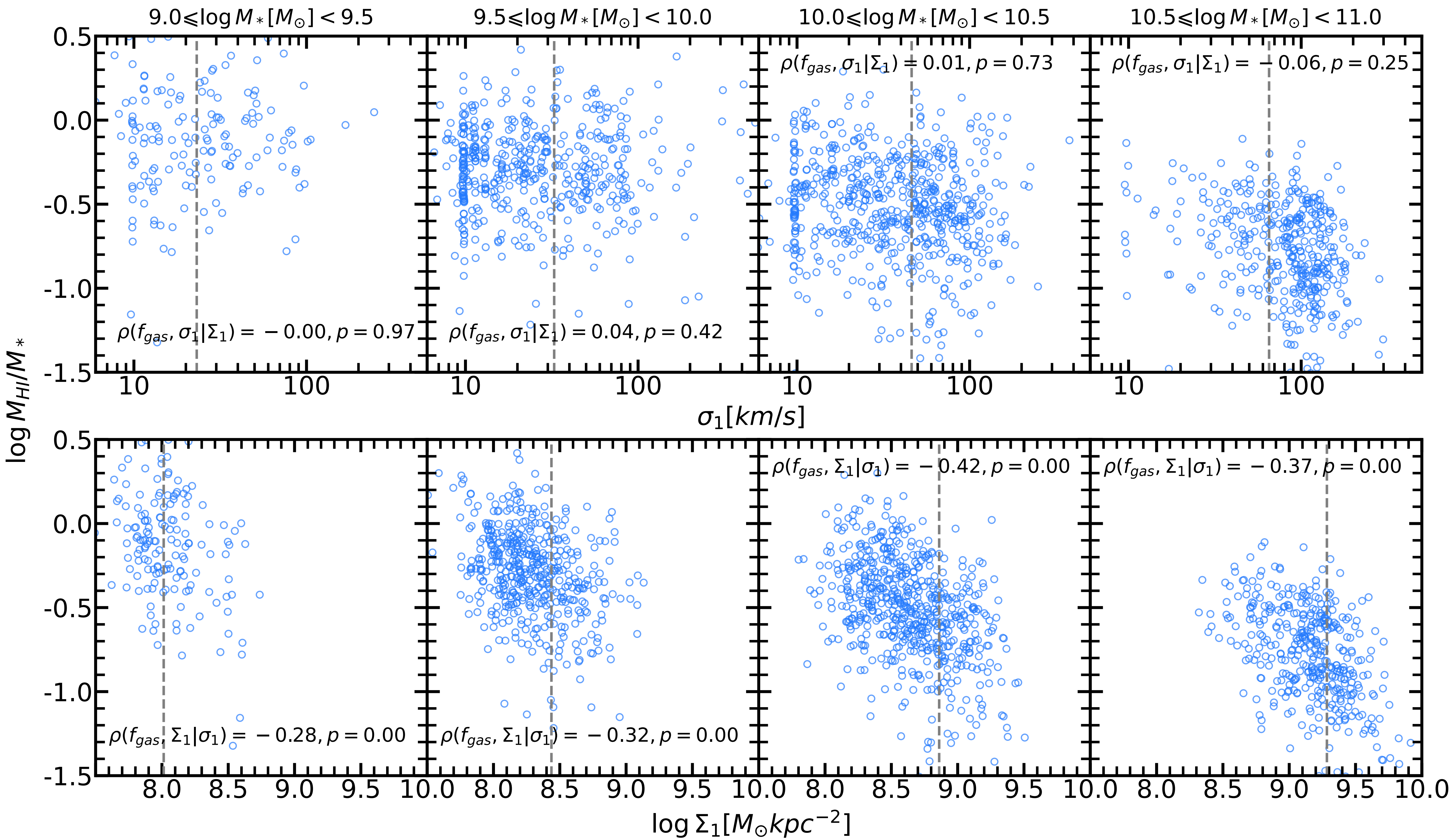
low Σ_1: SF central —> SF LCG —> GV or Q LCG, $Z_{\mathrm{L},1}$ increases a lot.

high Σ_1: SF central —> SF LCG —> GV or Q LCG, $Z_{\mathrm{L},1}$ increases a little.

—>low-Σ_1 galaxies experience more strangulation.

(3) Other reasons?

σ_1 v.s. Σ_1— Gas fraction f_{gas}



f_{gas} decreases as Σ_1 increases

(3) Quenching timescale

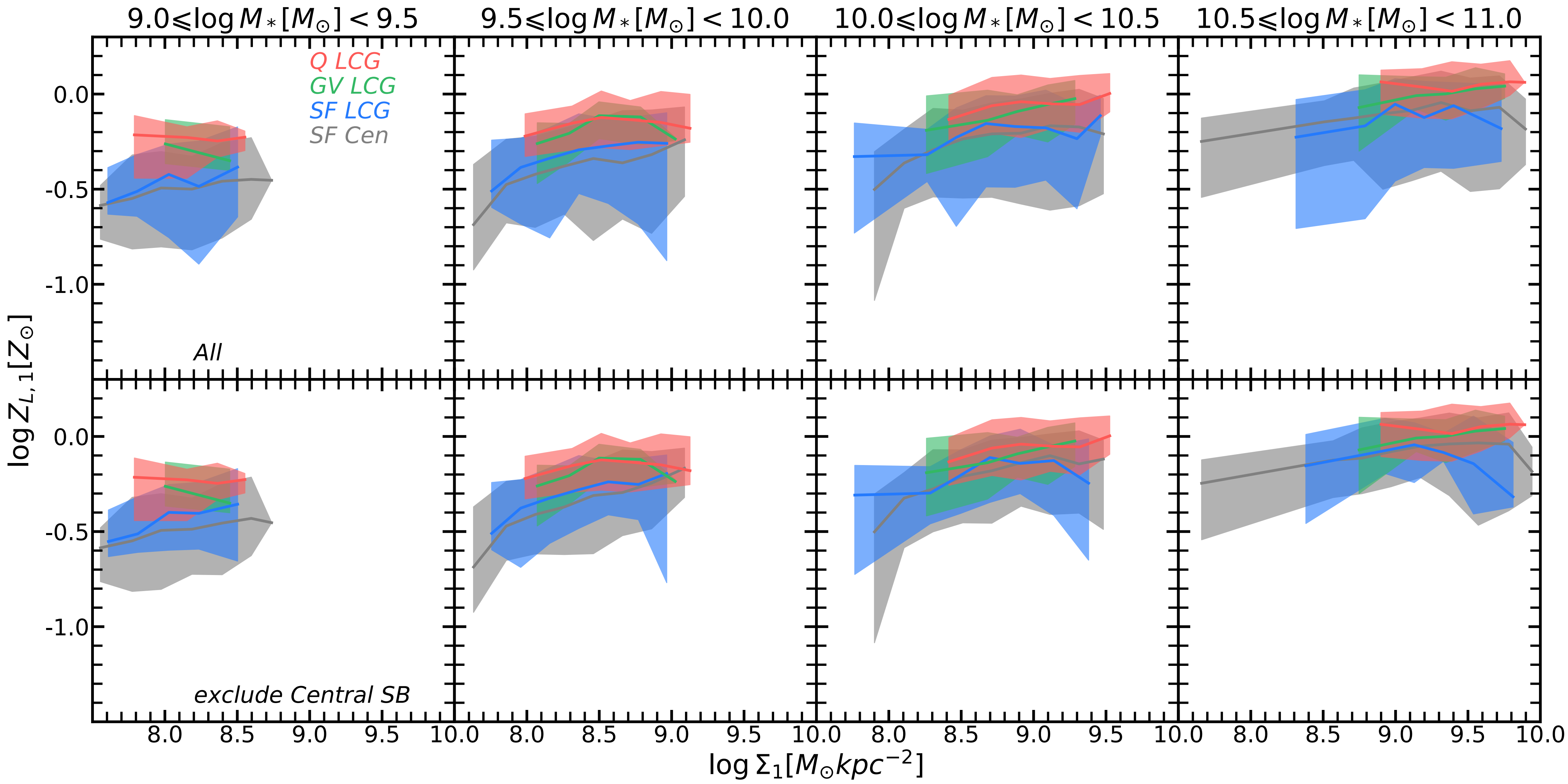
1. SFR=SFE*Mgas

Σ_{*} Σ_{SFR}

2. SFH

Summary

1. massive central : quenching correlates with σ_1 (AGN feedback); low-mass satellite: quenching correlates with Σ_1.
2. low Σ_1 : from SF central , SF satellite, GV satellite, Q satellite —> Z_L increases (strangulation) ; high Σ_1 —> Z_L almost the same.
3. high Σ_1 —> low $f_{\rm gas}$ —> short quenching timescale —> high $f_{\rm Q}$ or $\epsilon_{\rm Q}$



9.0⩽log $M_*[M_\odot]$ < 9.5
9.5⩽log $M_*[M_\odot]$ < 10.0
10.0⩽log $M_*[M_\odot]$ < 10.5
10.5⩽log $M_*[M_\odot]$ < 11.0
Q LCG
GV LCG
SF LCG
SF Cen
All
exclude Central SB
log $Z_{L,1}[Z_\odot]$
log $\Sigma_1[M_\odot kpc^{-2}]$
0.0
-0.5
-1.0
8.0
8.5
9.0
9.5
10.0