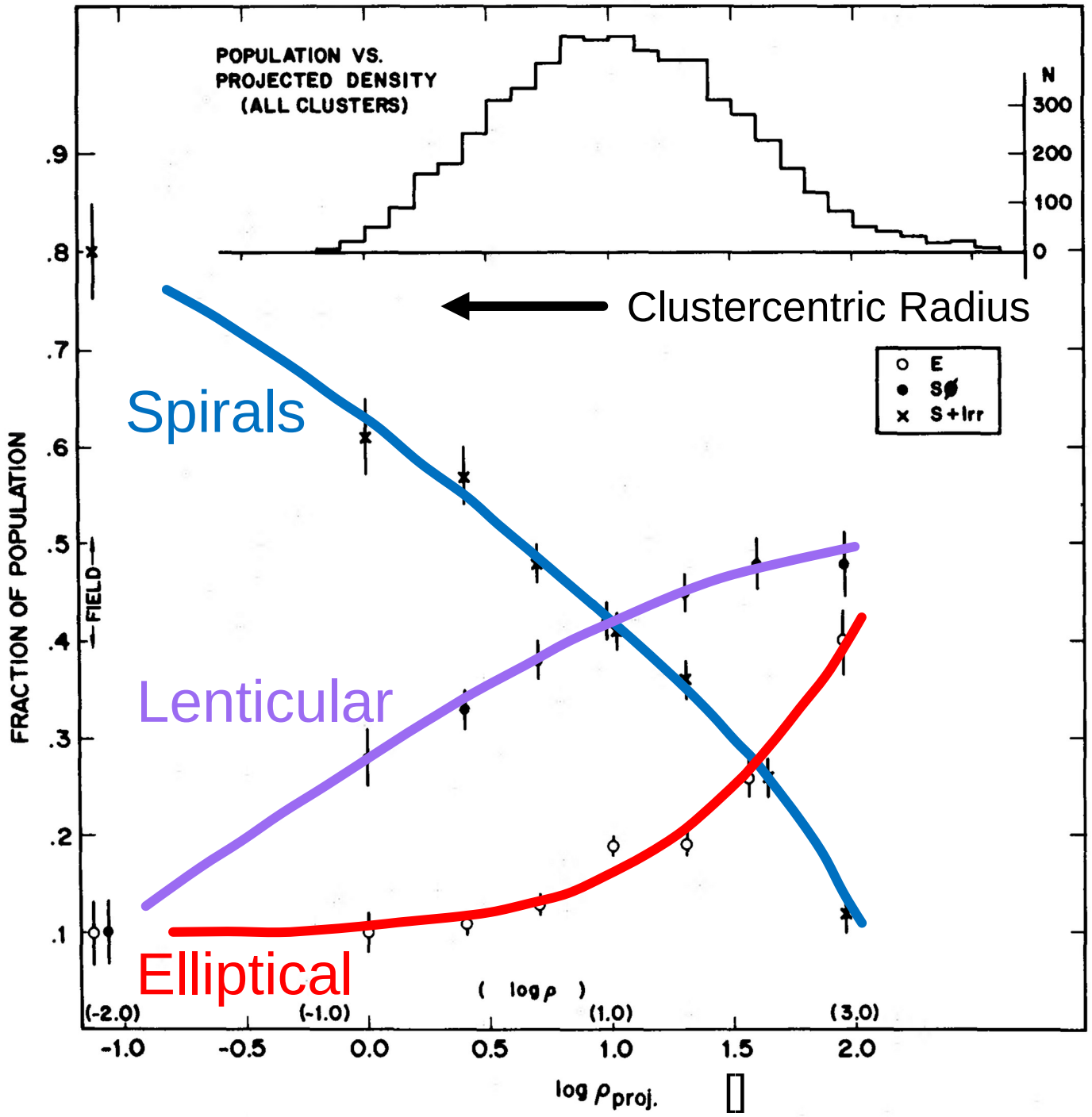
Emergence of the Galaxy Morphology-Star Formation Activity-Clustercentric Radius Relations in Galaxy Clusters

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OCTOBER 31ST, 2024 @ 11TH KIAS WORKSHOP, GYEONGJU





Strong relation between morphology/SFR vs. density(clustercentric radius)?

Dressler (1980)
w/ 55 nearby rich clusters

Horizon Run 5 Cosmological Simulation Lee & Shin et al. (2020)

Simulation box size: $(1049\ \mathrm{Mpc})^3$

Zoomed-in region: $(1049 \times 119 \times 127)\ \mathrm{Mpc}^3$

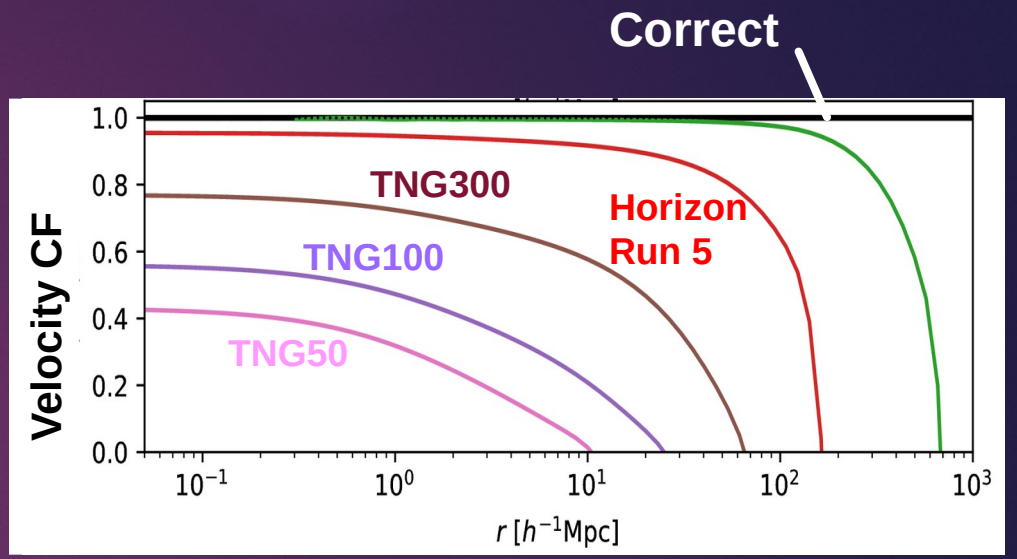
Resolution of the initial conditions: 128 kpc

Highest simulation resolution: 1 kpc

Simulation code: Hybrid MPI-OpenMP RAMSES

Initial conditions: generated by the MUSIC package using the second-order Lagrangian perturbation theory

Cosmological parameters: Ω_m=0.3, Ω_Λ=0.7, Ω_b=0.047, h_o=0.684

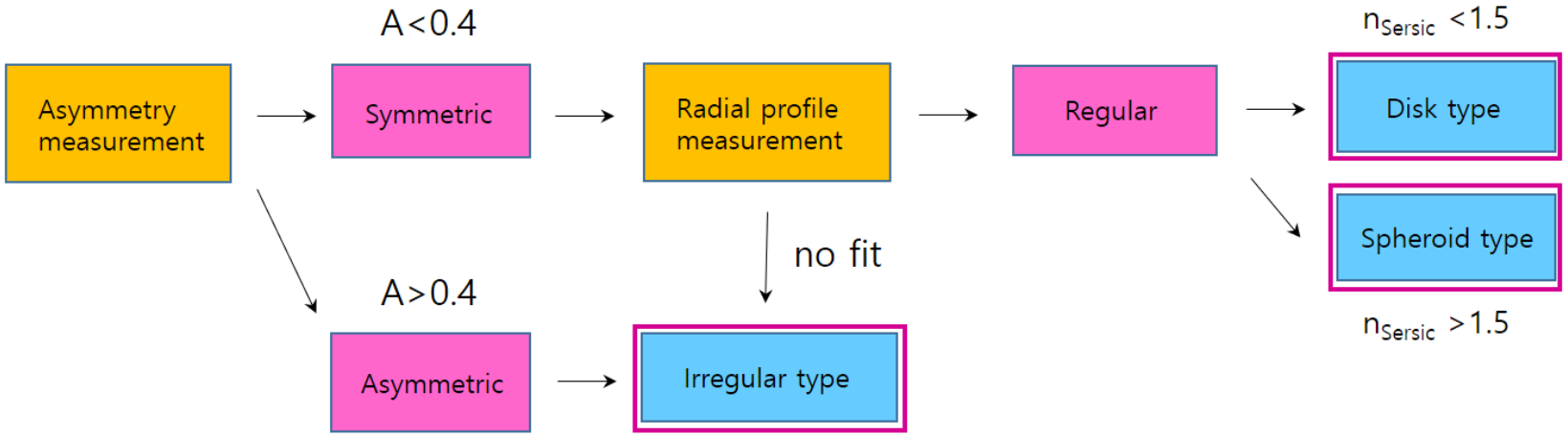


Dark matter density

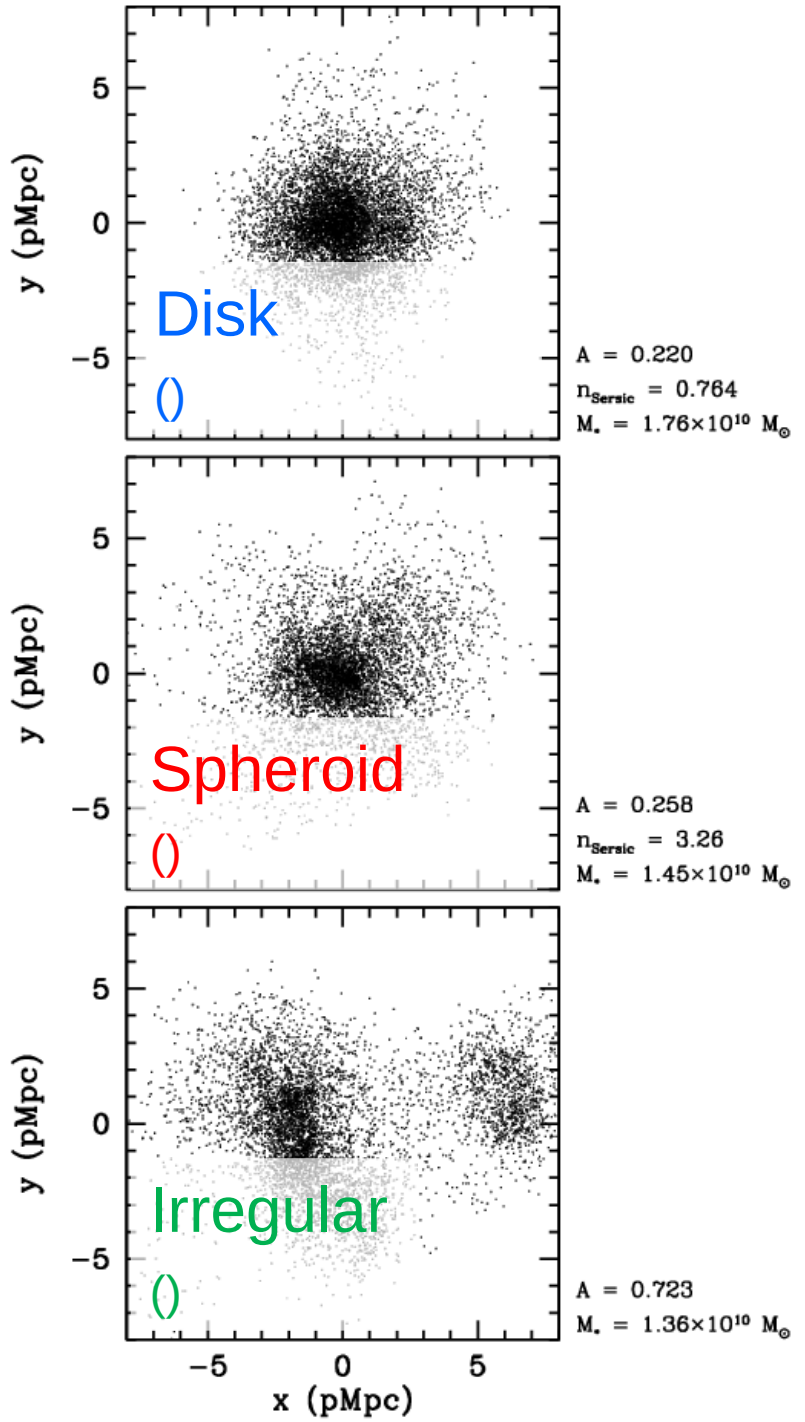
Baryon (stellar mass + gas temperature + gas density)

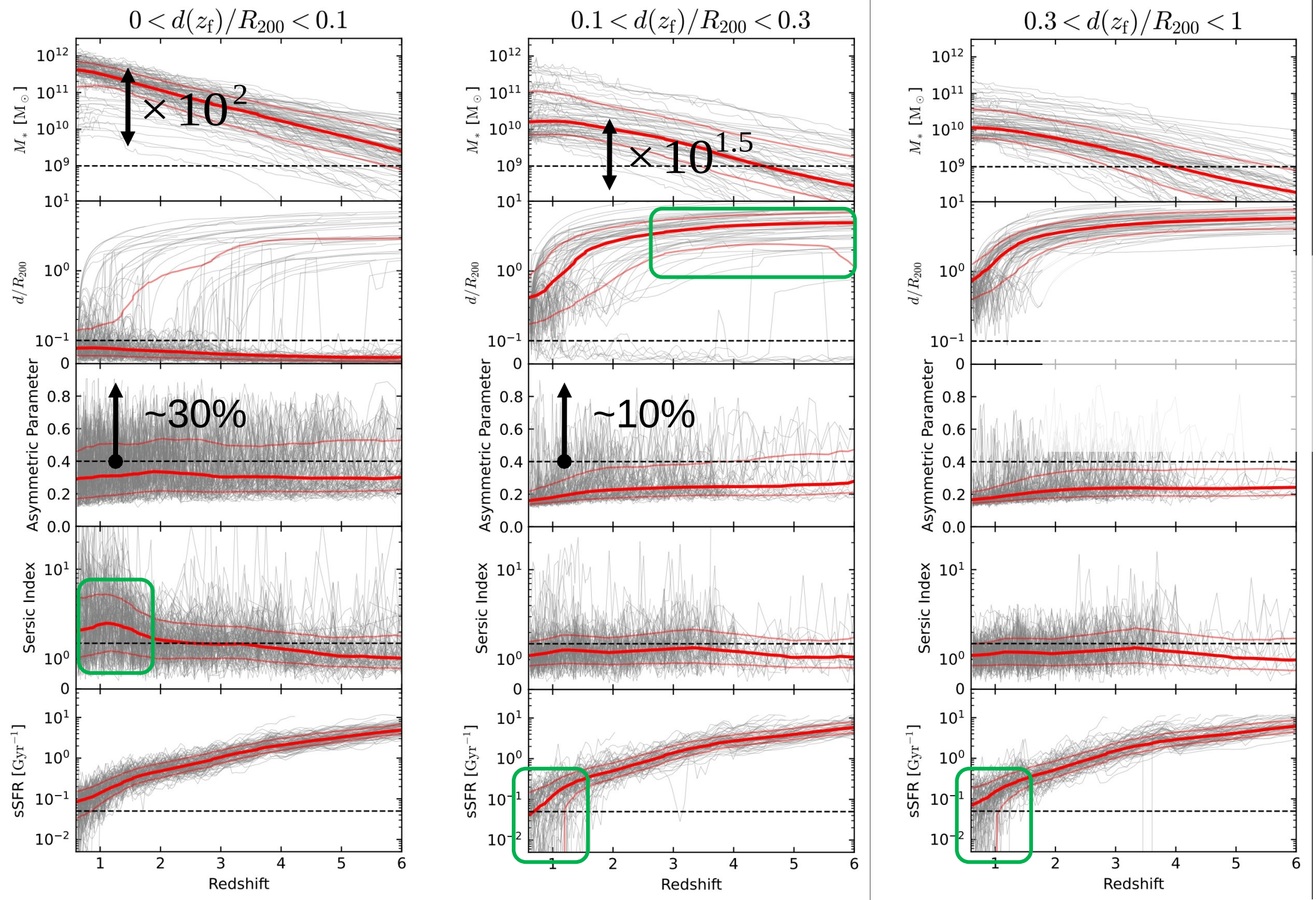
Galaxy Classification

1. **Asymmetry parameter**: relative difference of stellar mass density between positions symmetric about the galaxy center
2. **Sersic index** of the projected stellar mass radial profile
3. **Specific star formation rate (sSFR)**

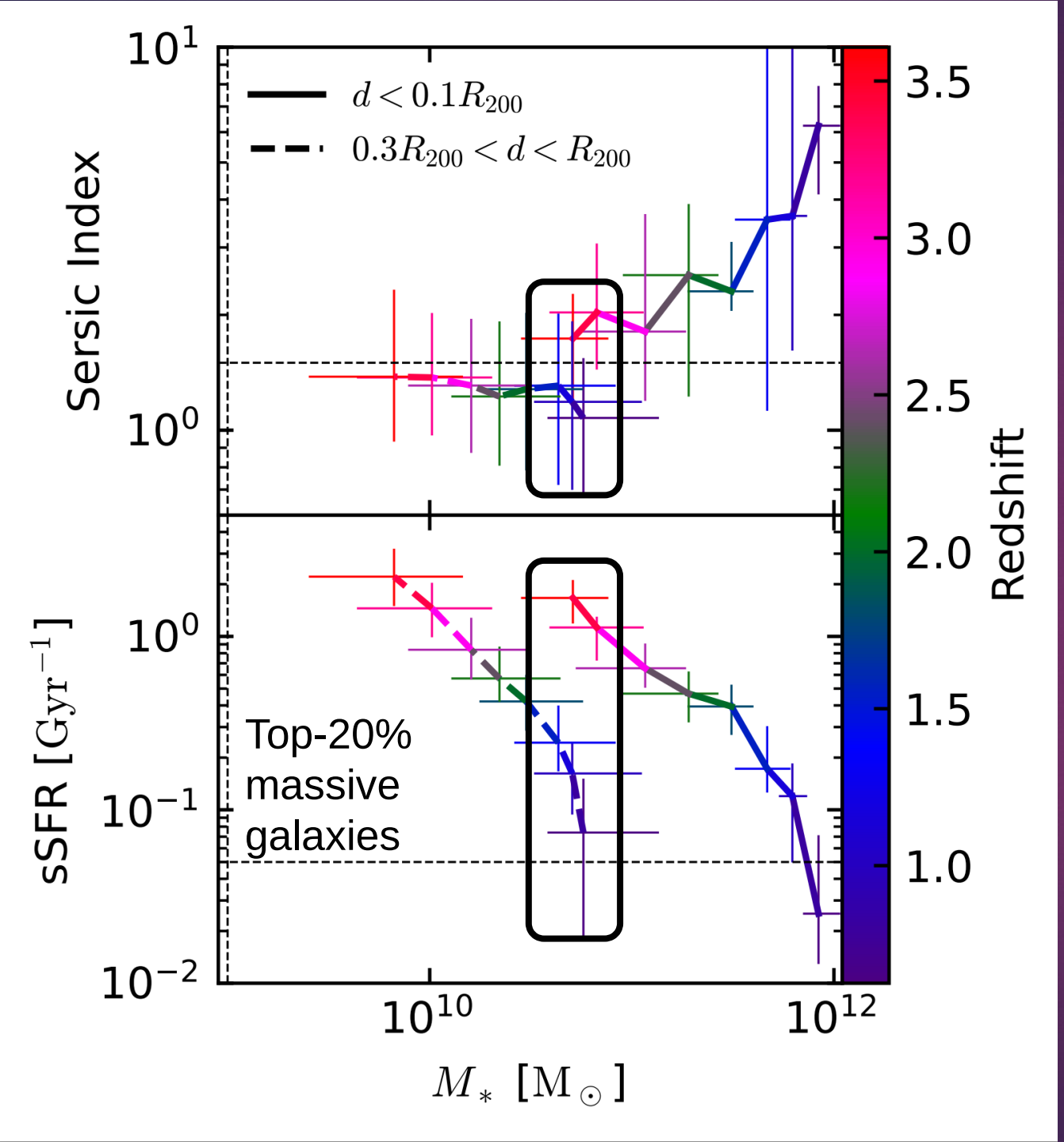


ETGs: **Spheroids** + **Passive disks** ()
LTGs: **Irregulars** + **Active disks** ()




$0 < d(z_f)/R_{200} < 0.1$
$0.1 < d(z_f)/R_{200} < 0.3$
$0.3 < d(z_f)/R_{200} < 1$
M_* [$M_\odot$]
$\times 10^2$
$\times 10^{1.5}$
d/R_{200}
Asymmetric Parameter
~30%
~10%
Sersic Index
sSFR [Gyr^{-1}]
Redshift

at





Stellar Mass

Evolution in Galaxy Clusters

Morphology



Each galaxy from $z = 1$ to 0.625



$d < 0.1\,R_{vir}$

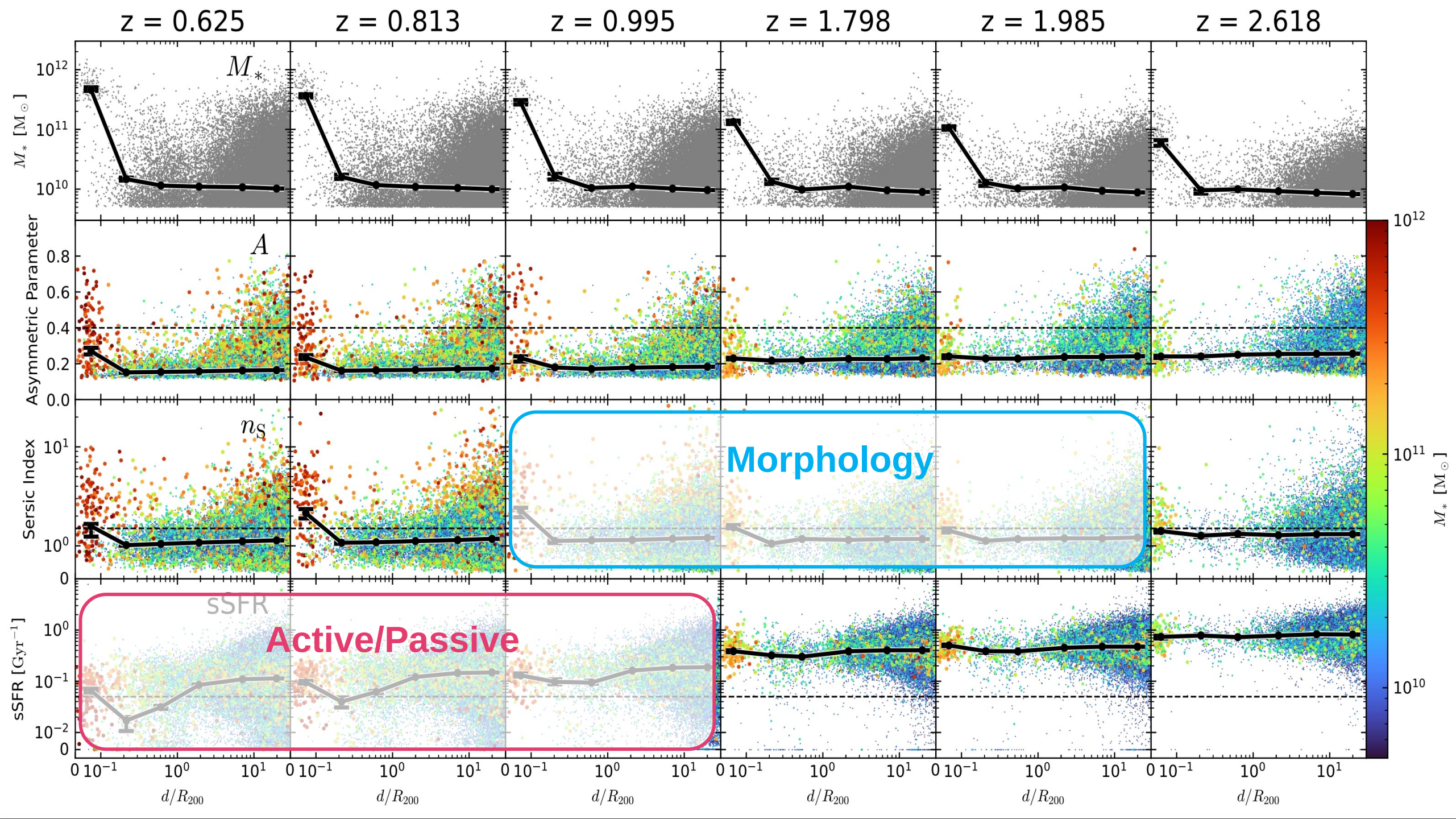
$0.1 < d/R_{vir} < 0.3$

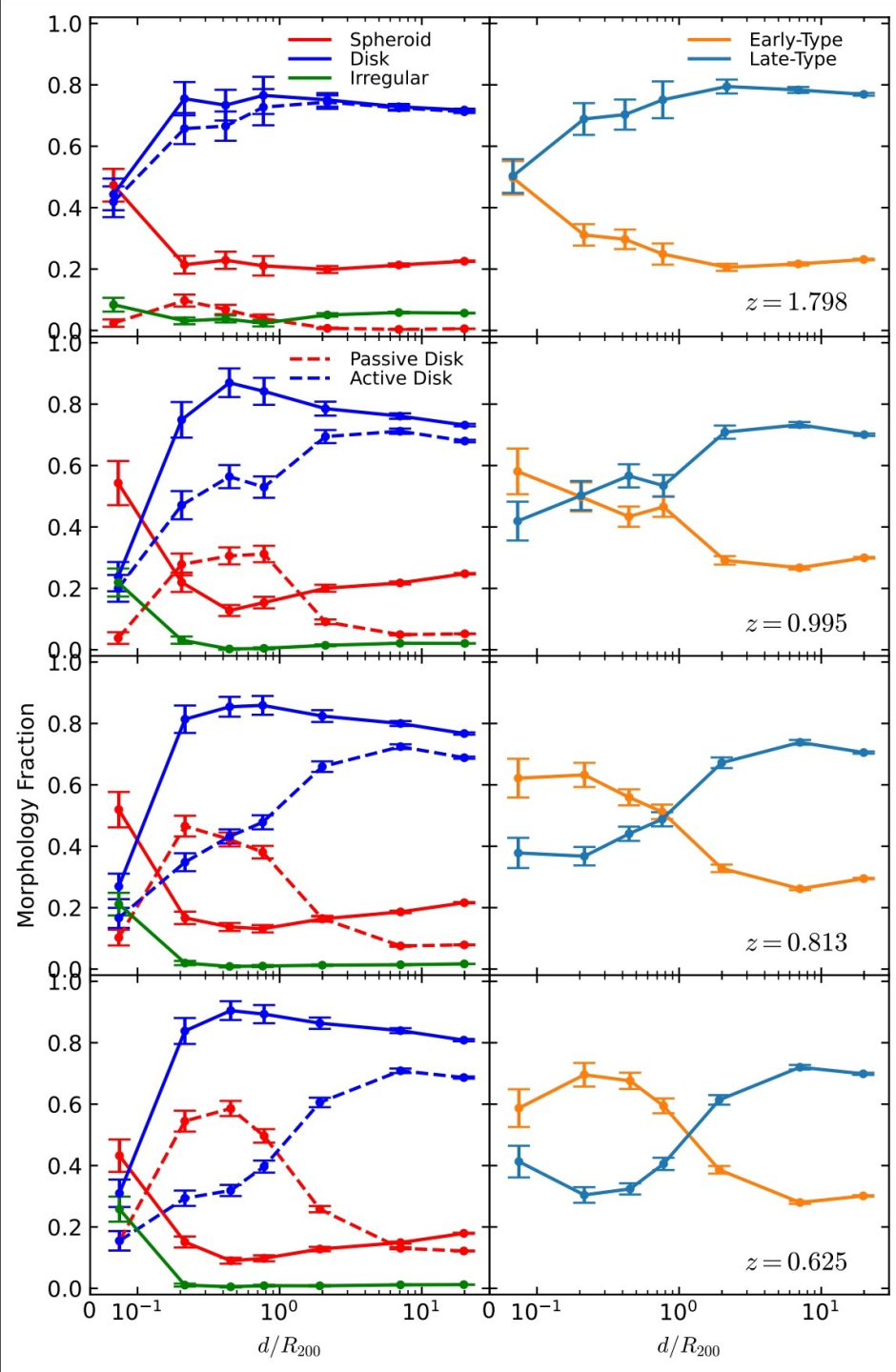
d/R_{200}

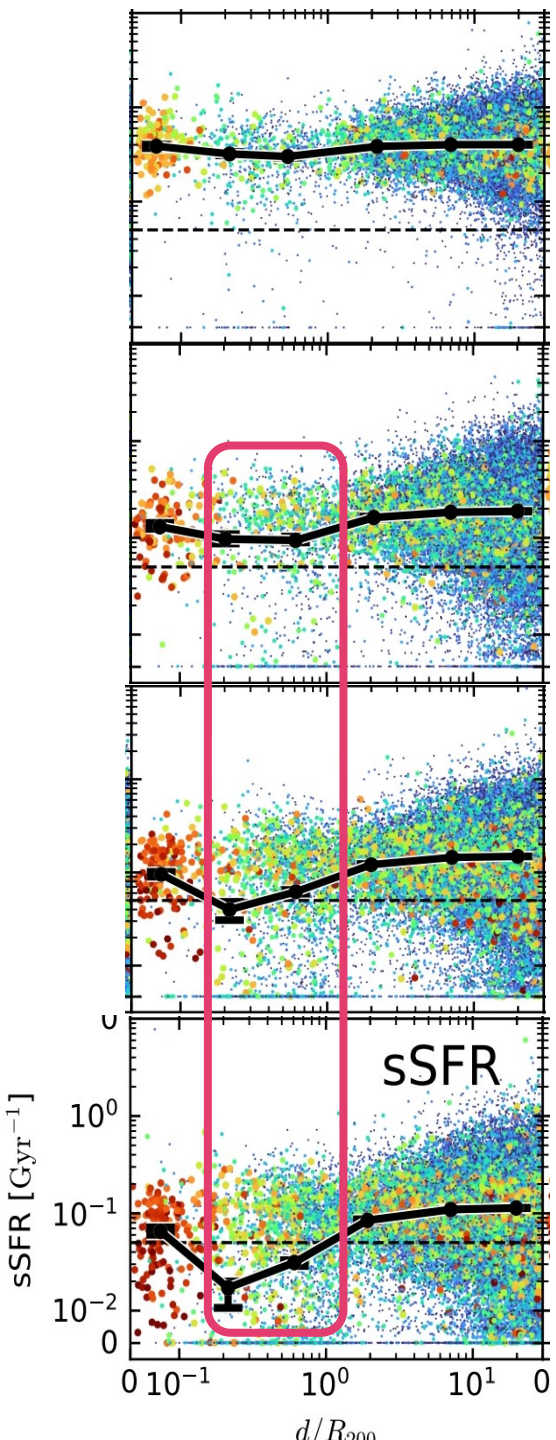
Asymmetric Parameter

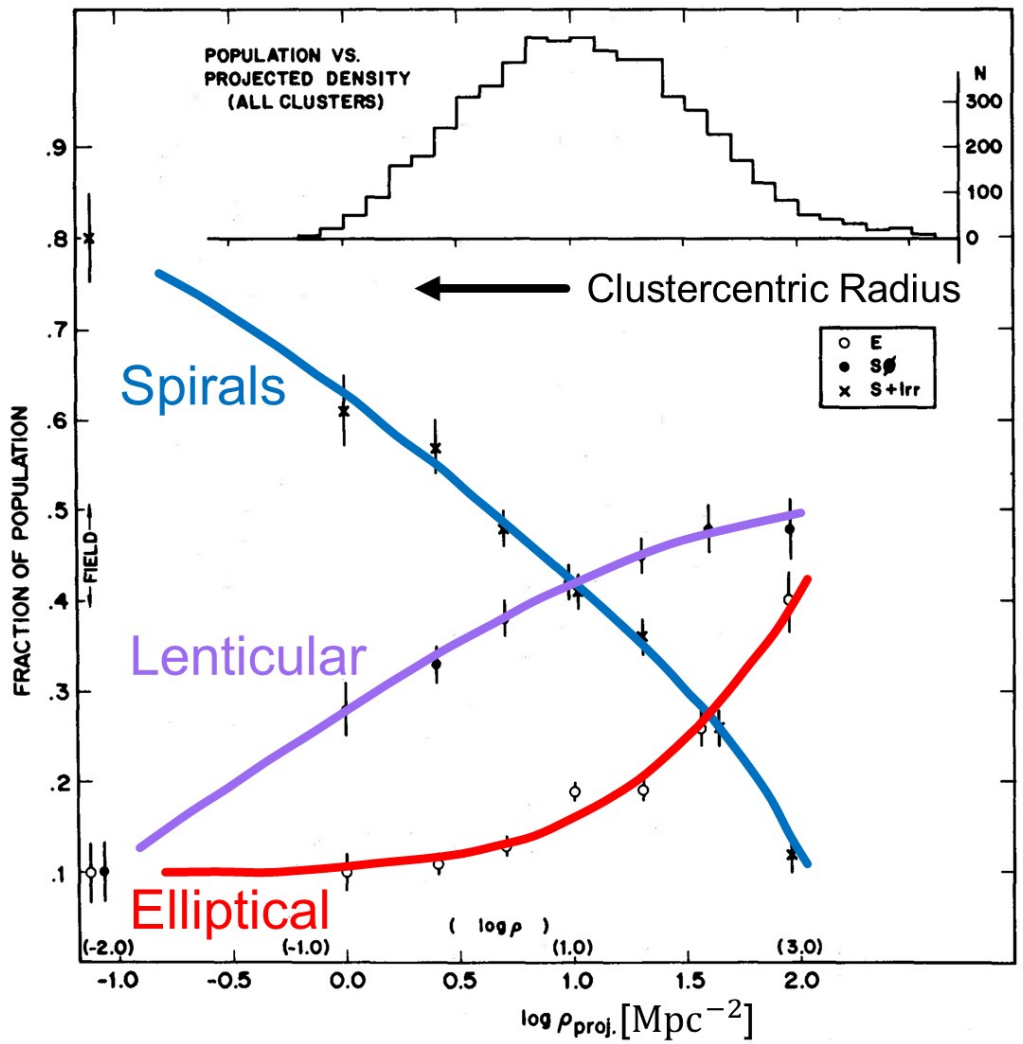
Sersic Index

M_* [$M_\odot$]


z = 0.625
z = 0.813
z = 0.995
z = 1.798
z = 1.985
z = 2.618
M_*
M_* [$M_\odot$]
10^{12}
10^{11}
10^{10}
A
Asymmetric Parameter
0.8
0.6
0.4
0.2
0.0
n_S
Sersic Index
10^1
10^0
0
Morphology
sSFR
Active/Passive
sSFR [Gyr^{-1}]
10^0
10^{-1}
10^{-2}
0
10^{-1}
10^0
10^1
d/R_{200}
10^{12}
10^{11}
10^{10}
M_* [$M_\odot$]


Spheroid
Disk
Irregular
Early-Type
Late-Type
Passive Disk
Active Disk
$z = 1.798$
$z = 0.995$
$z = 0.813$
$z = 0.625$
Morphology Fraction
d/R_{200}


sSFR
sSFR [Gyr^{-1}]
d/R_{200}

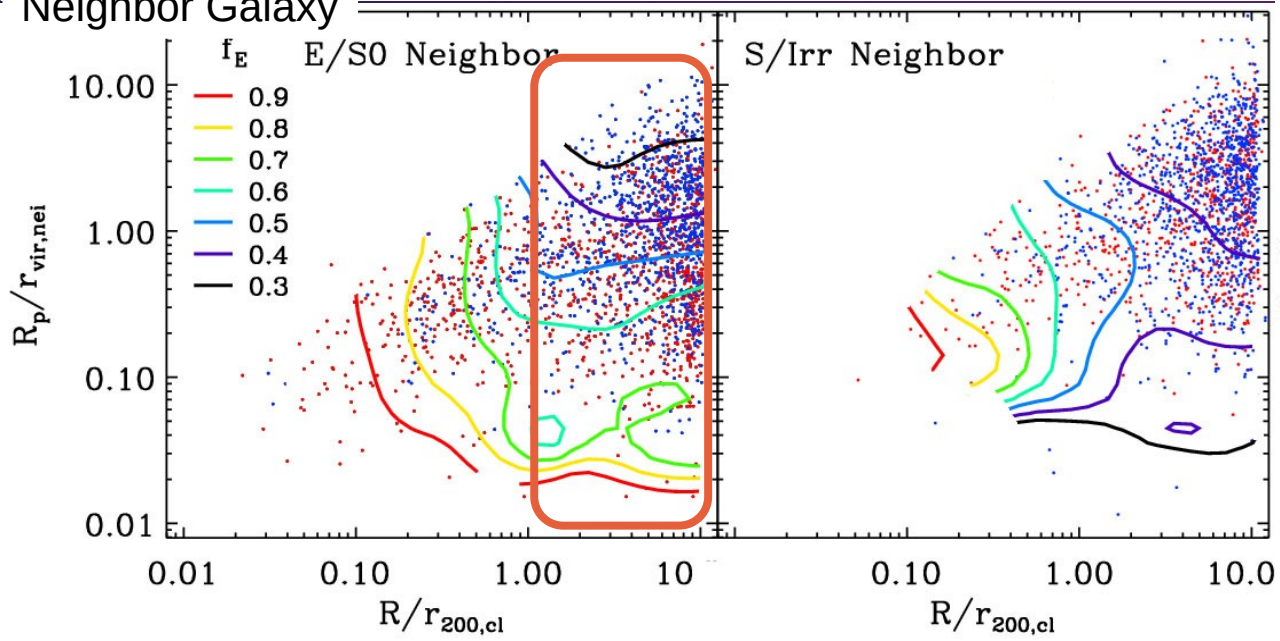

POPULATION VS.
PROJECTED DENSITY
(ALL CLUSTERS)
N
Clustercentric Radius
Spirals
Lenticular
Elliptical
FRACTION OF POPULATION
FIELD
log $\rho_{proj.}$ [Mpc^{-2}]

Summary

- Morphology of galaxy stellar mass density distribution studied in **Horizon Run 5 simulation**
  - 1cGpc simulation box size + 1pkpc high mass/force resolution
  - Coherence of **:** correctly represented on galaxy & cluster scales.
- **Morphology–clustercentric radius relation**
  - Emerges at , and well established at
  - Mass growth associated with mergers seems responsible for the relation
- **Star formation activity–clustercentric radius relation**
  - Emerges at (maybe underestimated due to ~low SF history of HR5)
  - Passive disk dominates over active disks at after

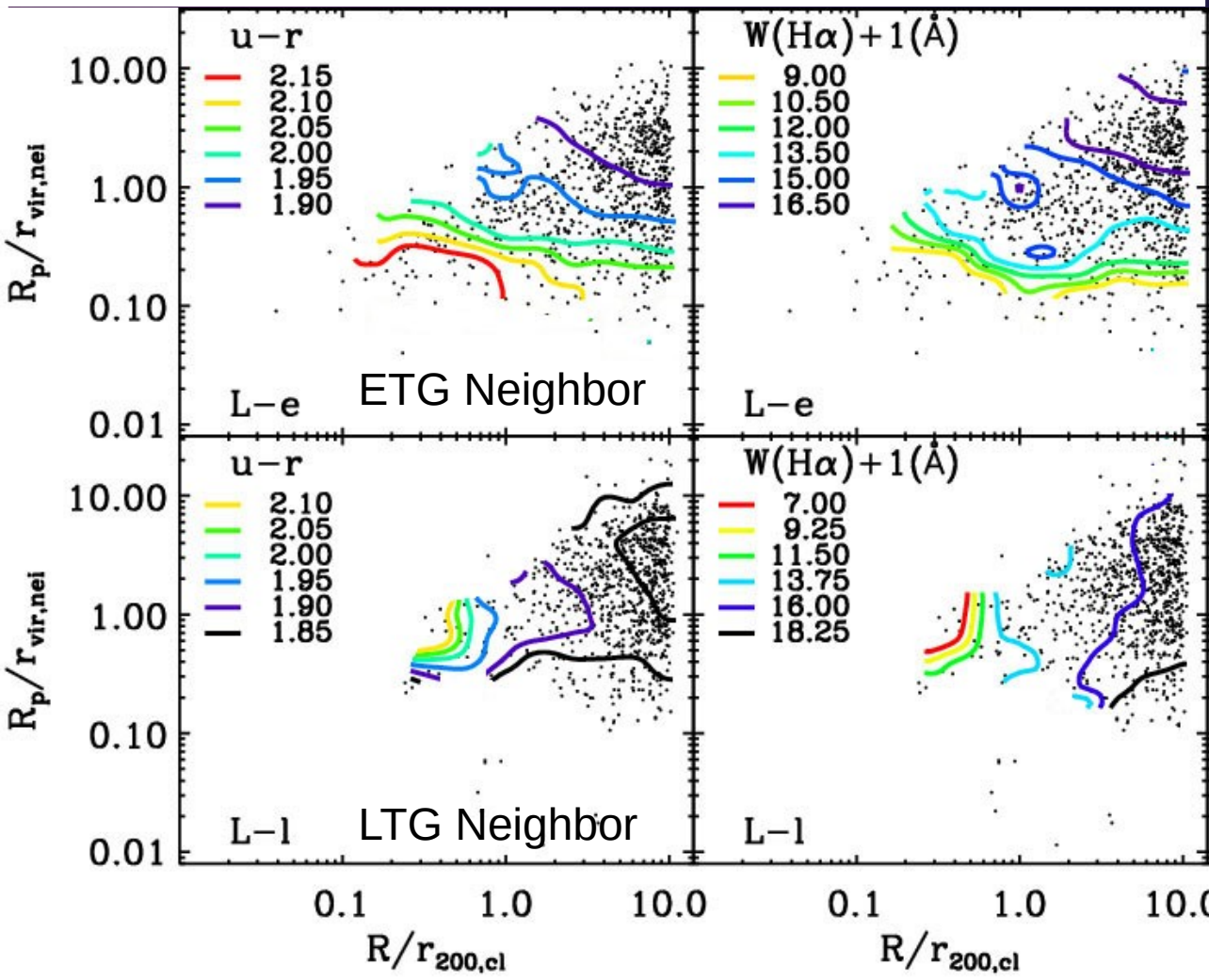
Distance to Neighbor Galaxy

Early-type Fraction



Clustercentric Radius

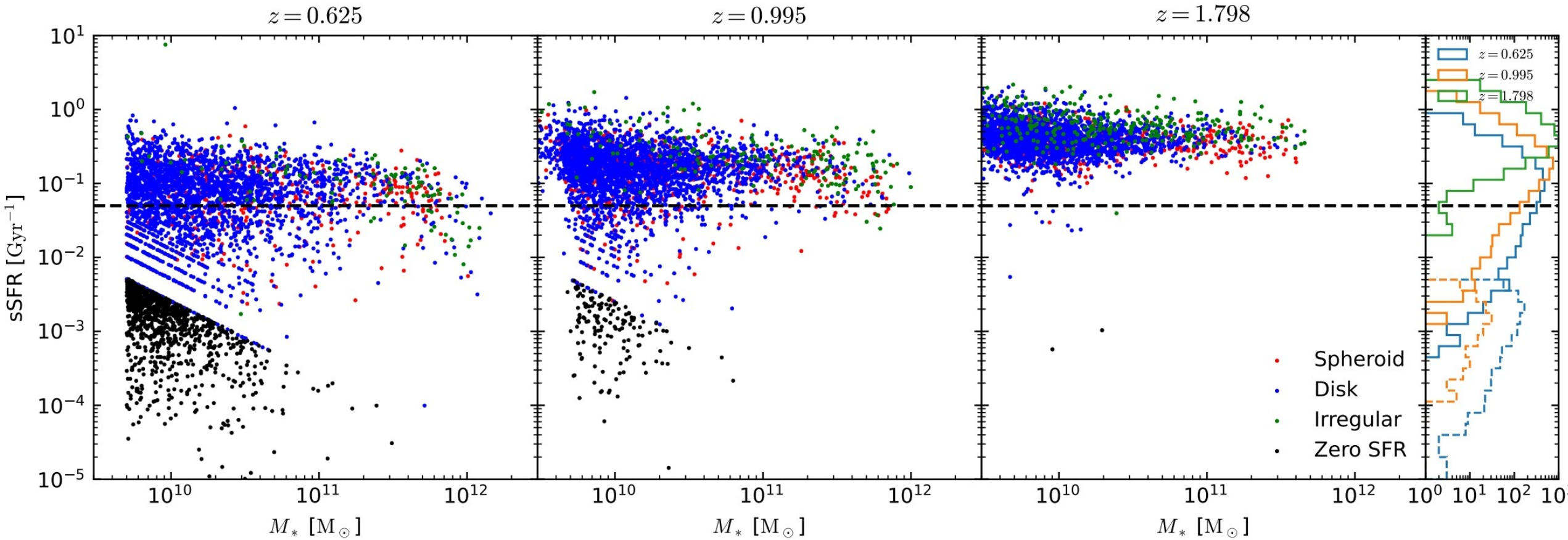
Star Formation Rate (SFR)



Morphology/SFR vs. density/clustercentric radius relation is not simple

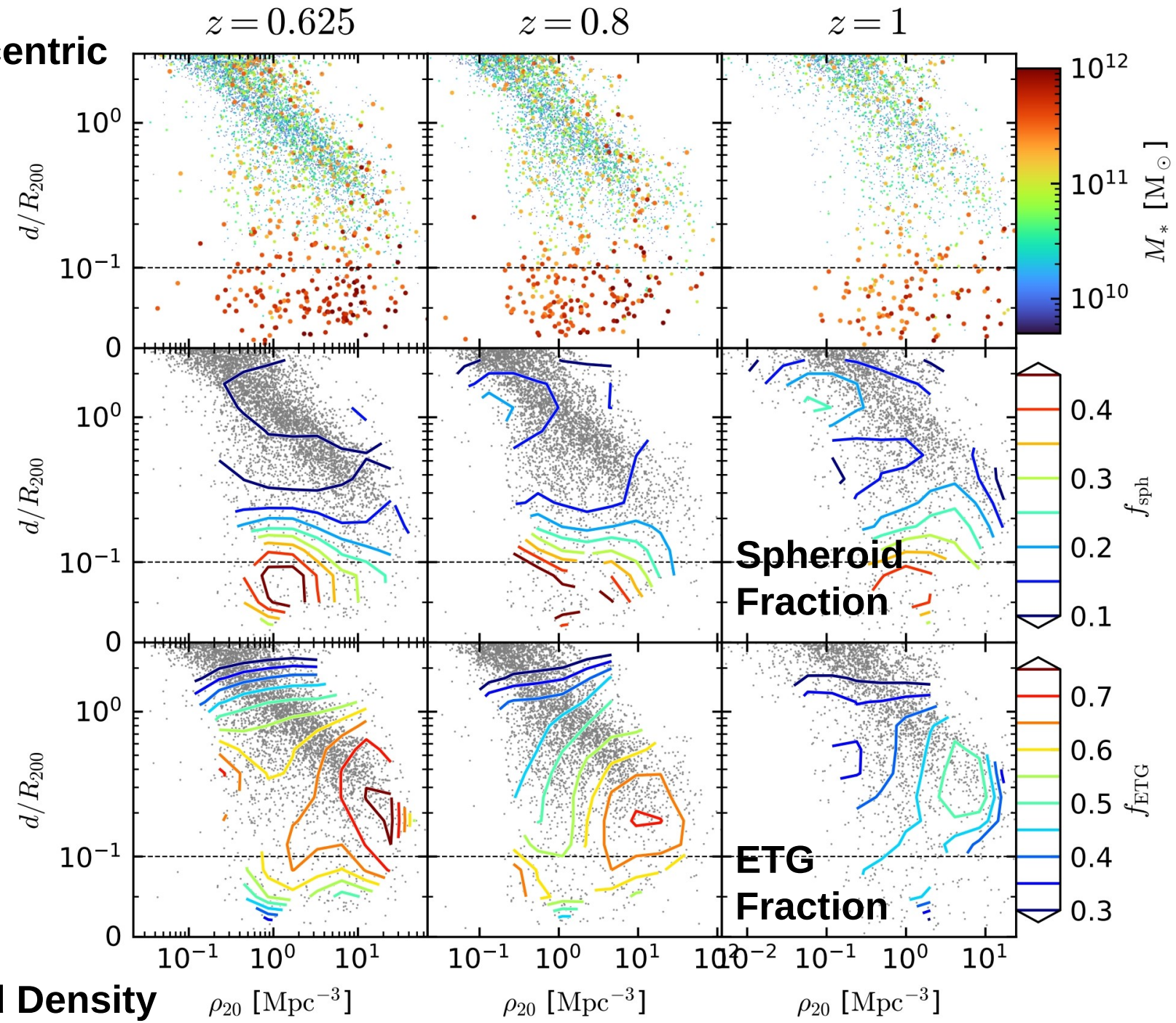
Interactions with neighbor galaxies strongly affect the SFR

Park & Hwang (2009)
w/ galaxies in & around 93 relaxed Abell clusters

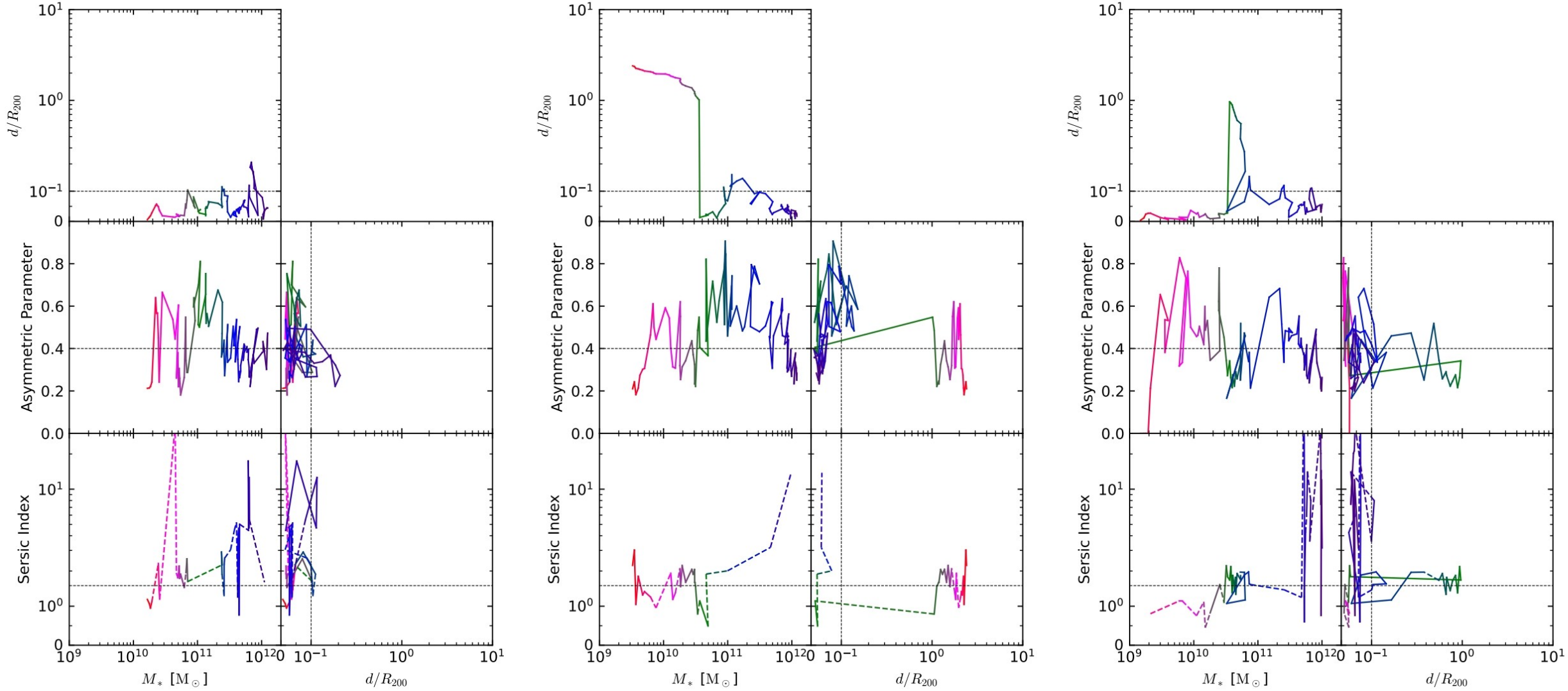

$z = 0.625$
$z = 0.995$
$z = 1.798$
sSFR [Gyr^{-1}]
M_* [M$_\odot$]
Spheroid
Disk
Irregular
Zero SFR
$z = 0.625$
$z = 0.995$
$z = 1.798$

Clustercentric radius, not local background density, affects spheroid fraction

Local background density seems to affect ETG fraction at ,
but it is actually
the nearest neighbor effect
(Park & Hwang 2009)



Selected Massive Galaxies



Selected Low-mass Outskirt Galaxies

