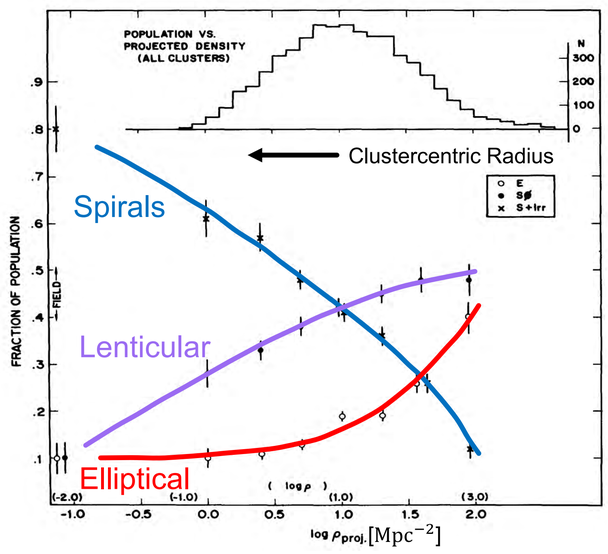
Emergence of the Galaxy Morphology-Star Formation Activity-Clustercentric Radius Relations in Galaxy Clusters

Sungwook E. Hong[1,2], Changbom Park[3], Preetish K. Mishra[3], Juhan Kim[4], Brad K. Gibson[5], Yonghwi Kim[6], C. Gareth Few[5], Christophe Pichon[3,7,8], Jihye Shin[1,2], Jaehyun Lee[1]

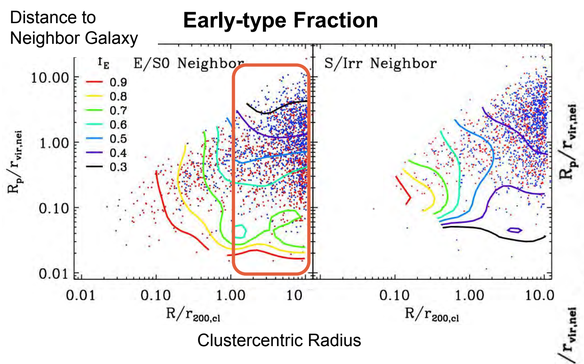
[1]Korea Astronomy and Space Science Institute [2]Astronomy Campus, University of Science and Technology [3]School of Physics, Korea Institute for Advanced Study [4]Center for Advanced Computation, Korea Institute for Advanced Study [5]Woodmansey Primary School [6]Korea Institute of Science and Technology Information [7]Institut d'Astrophysique de Paris, CNRS, Sorbonne Université [8]IPhT, DRF-INP, UMR 3680, CEA

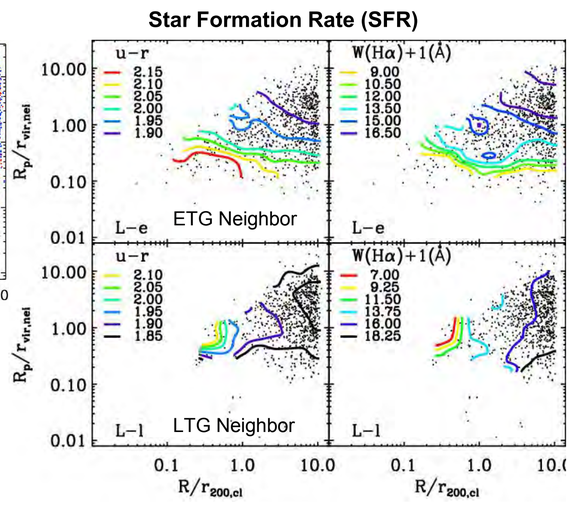




Strong relation between morphology/SFR vs. density(clustercentric radius)?

Dressler (1980)
w/ 55 nearby rich clusters





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

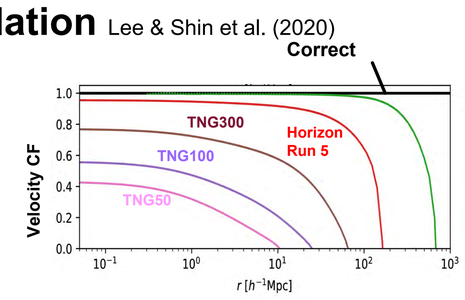
Interactions with neighbor galaxies strongly affect the SFR

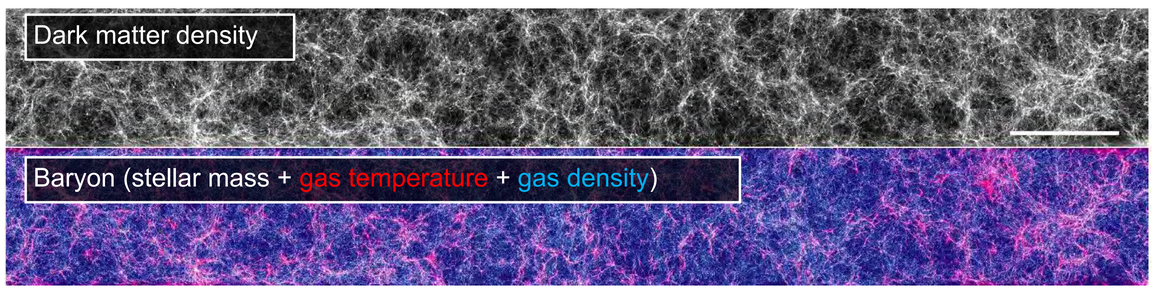
Park & Hwang (2009)
w/ galaxies in & around 93 relaxed Abell clusters

→ How does this relation emerge?

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

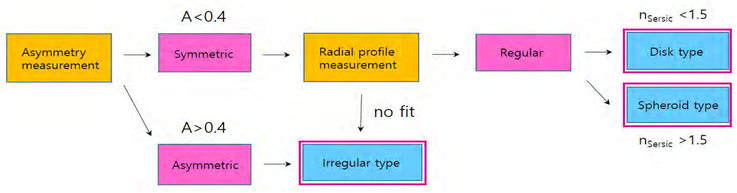
Simulation box size: $(1049\ \mathrm{Mpc})^3$
Zoomed-in region: $(1049 \times 119 \times 127)\ \mathrm{Mpc}^3$
Resolution of the initial conditions: 128 kpc
Highest simulation resolution: 1 kpc



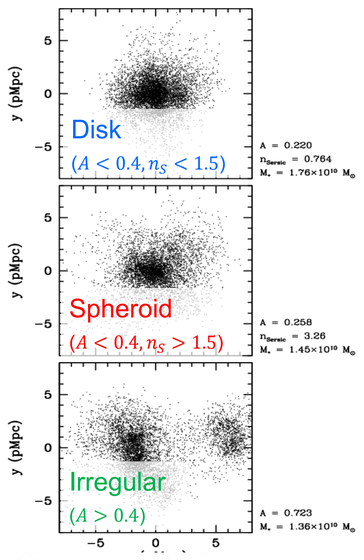


Galaxy Classification

1. **Asymmetry parameter**: relative difference of stellar mass density between positions symmetric about the galaxy center
2. **Sersic index** of the 3D stellar mass radial profile

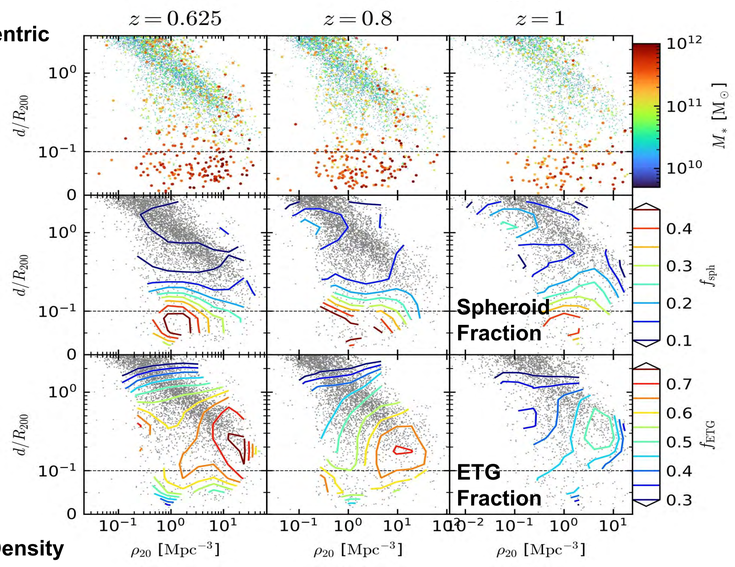


3. **Specific star formation rate (sSFR)**
ETGs: **Spheroids** + Passive **disks** ($\mathrm{sSFR} < 0.05\ \mathrm{Gyr}^{-1}$)
LTGs: **Irregulars** + **Active disks** ($\mathrm{sSFR} > 0.05\ \mathrm{Gyr}^{-1}$)

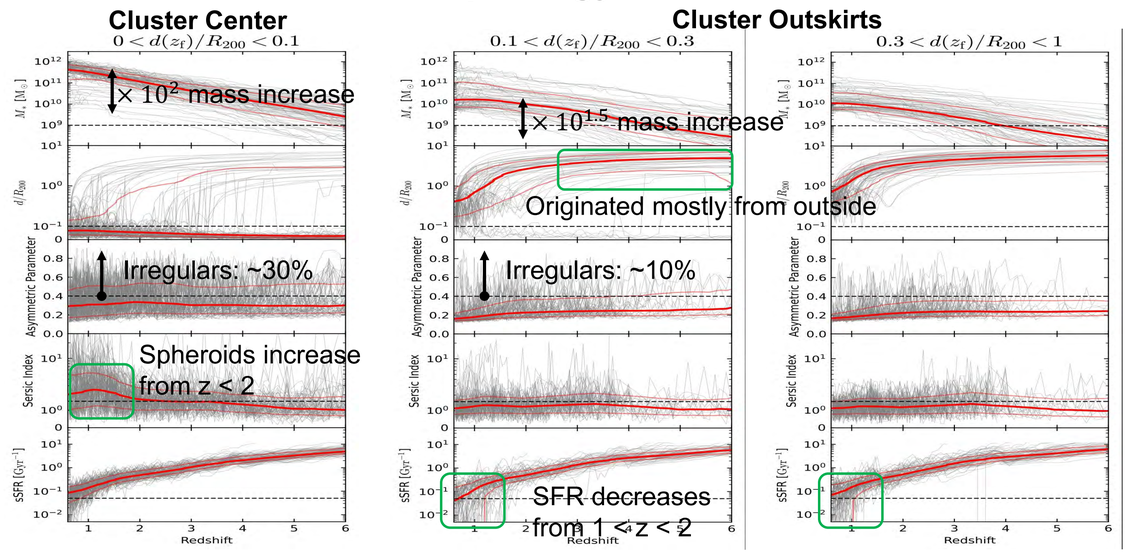


Clustercentric radius,
not local background density,
affects spheroid fraction

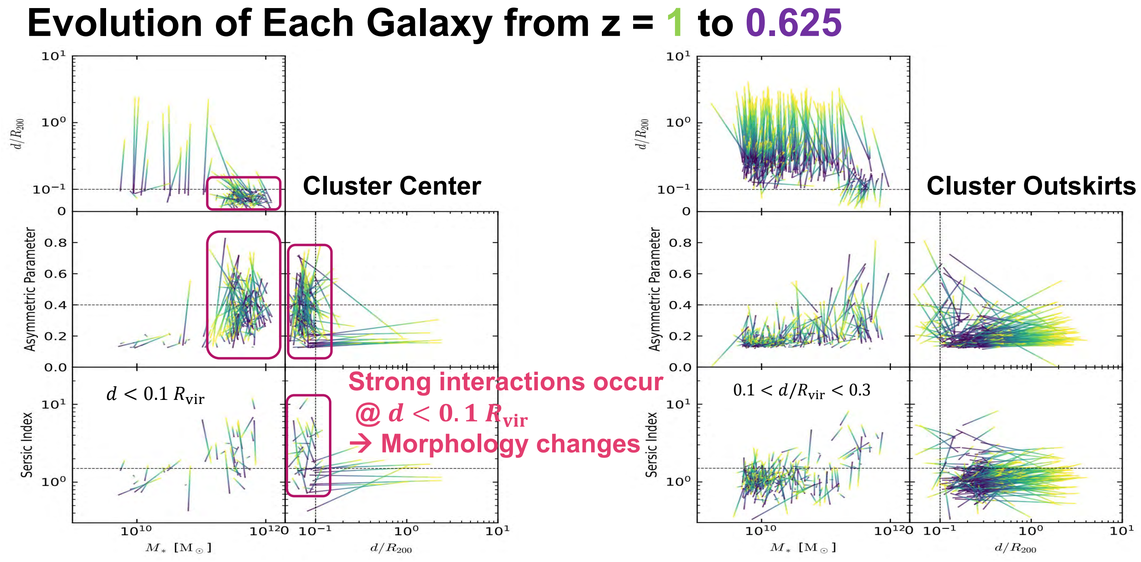
Local background density seems to affect ETG fraction at $0.1 < d/R_{200} < 1$,
but it is actually
the nearest neighbor effect
(Park & Hwang 2009)



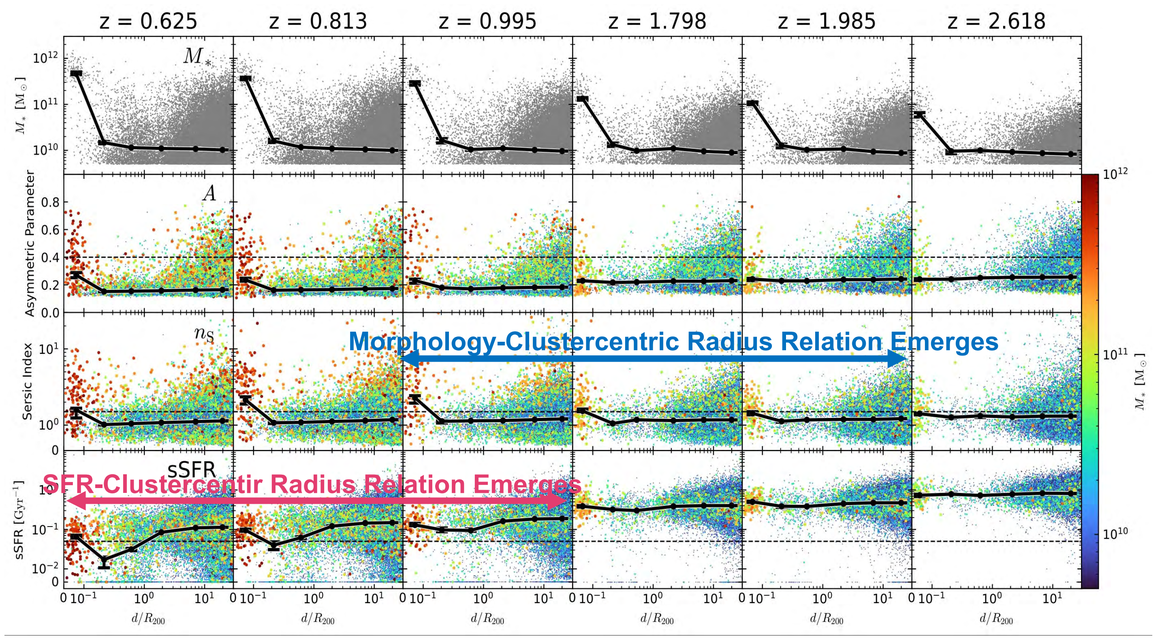
Global Evolution of Morphology/SFR-related Parameters



Evolution of Each Galaxy from z = 1 to 0.625



Clustercentric Radius vs. Morphology/SFR-related Parameters



Clustercentric radius vs. Galaxy Classification Fraction

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 v_{pec}: correctly represented on galaxy & cluster scales.
- **Morphology–clustercentric radius relation**
  - Emerges at $z{\sim}2$, and well established at $z{\sim}1.5$
  - Mass growth associated with mergers seems responsible for the relation
- **Star formation activity–clustercentric radius relation**
  - Emerges at $z{\sim}1$ (maybe underestimated due to ~low SF history of HR5)
  - Passive disk dominates over active disks at $d < R_{200}$ after $z{\sim}1$