Post-merger Signatures of Red-sequence Galaxies

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Take-Home Points

- **38%** vs **49%** post-merger fractions among bulge-dominated red-sequence galaxies in *cluster* and *field* at $z \leqq 0.1$

- Previous halo (less dense environment) those galaxies may have carried over their merger-features from their previous halo environments

- Dry-mergers(?) there is no significant differences of GALEX UV properties between the featured galaxies and the featureless galaxies

Motivation

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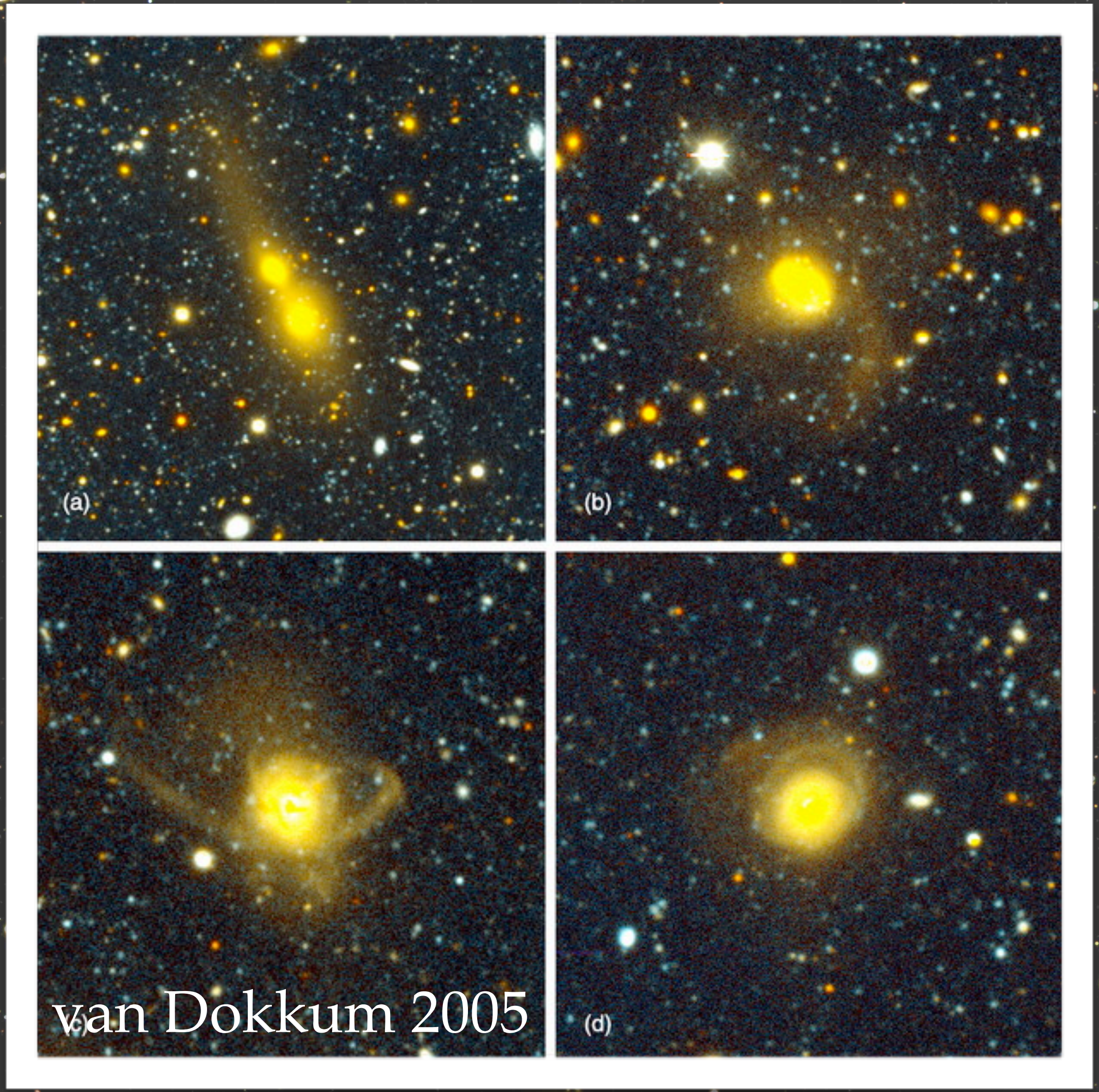
- Massive early-type galaxies formed through galaxy mergers and accretion of satellite systems
- It is observationally supported by field galaxies



van Dokkum 2005

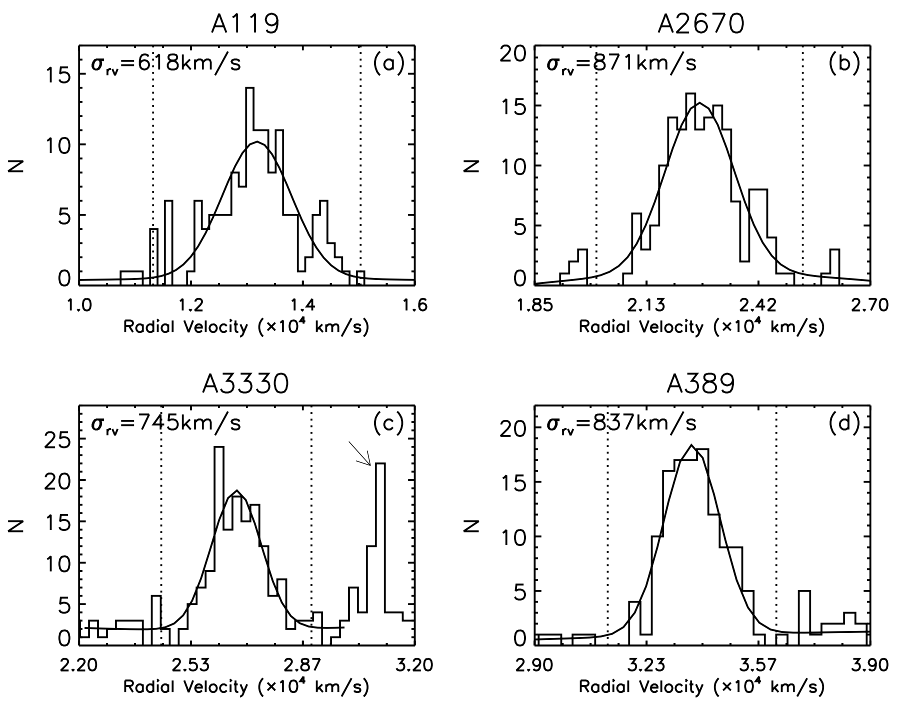
Motivation

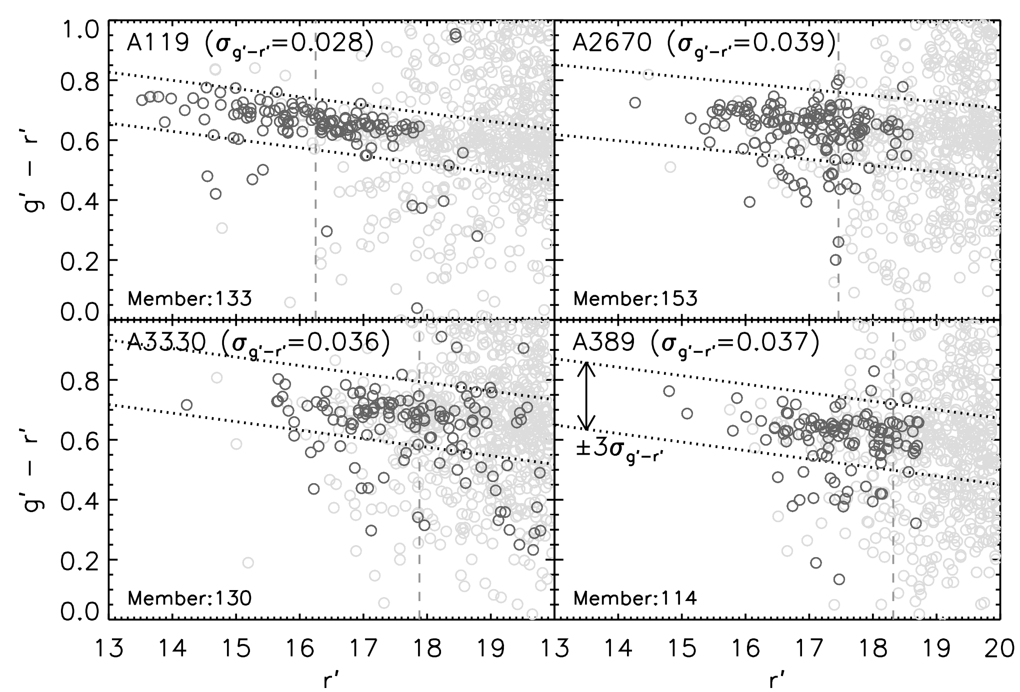
- Massive early-type galaxies formed through galaxy mergers and accretion of satellite systems
- It is observationally supported by field galaxies
- However, most of massive early-type galaxies are found in galaxy clusters
- Frequent galaxy mergers in cluster environment is not likely due to large peculiar motions of galaxies
- We tried to search post-merger signatures from red-sequence galaxies in rich Abell clusters at $z \leqq 0.1$

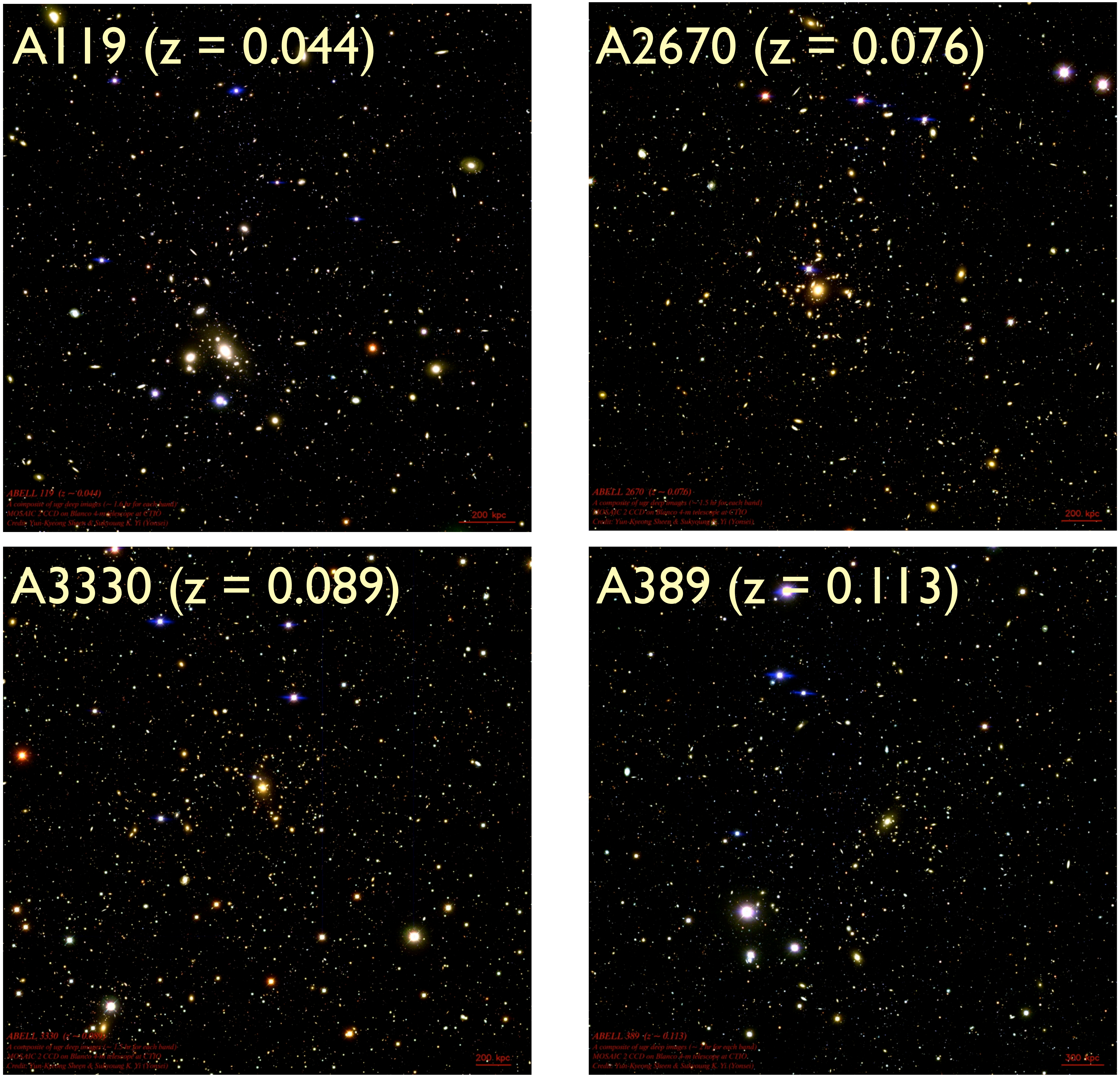
Observations and Data

★ Blanco 4-m telescope at CTIO:

MOSAIC 2 CCD + Hydra MOS






A119 (z = 0.044)
ABELL 119 (z ~ 0.044)
A composite of ugr deep images (~ 1.6 hr for each band)
MOSAIC 2 CCD on Blanco 4-m telescope at CTIO
Credit: Yun-Kyeong Sheen & Sukyoung K. Yi (Yonsei)
200 kpc
A2670 (z = 0.076)
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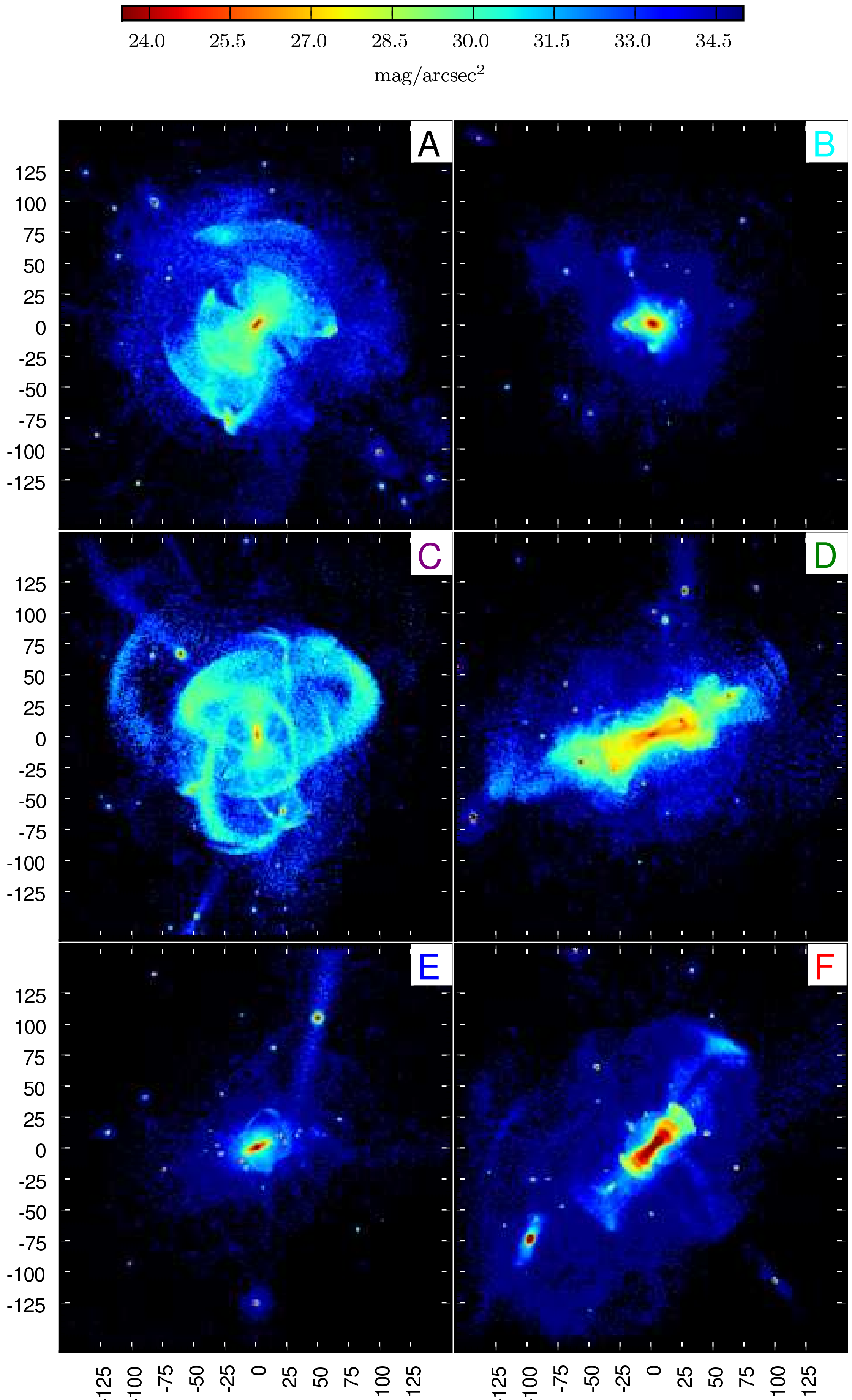
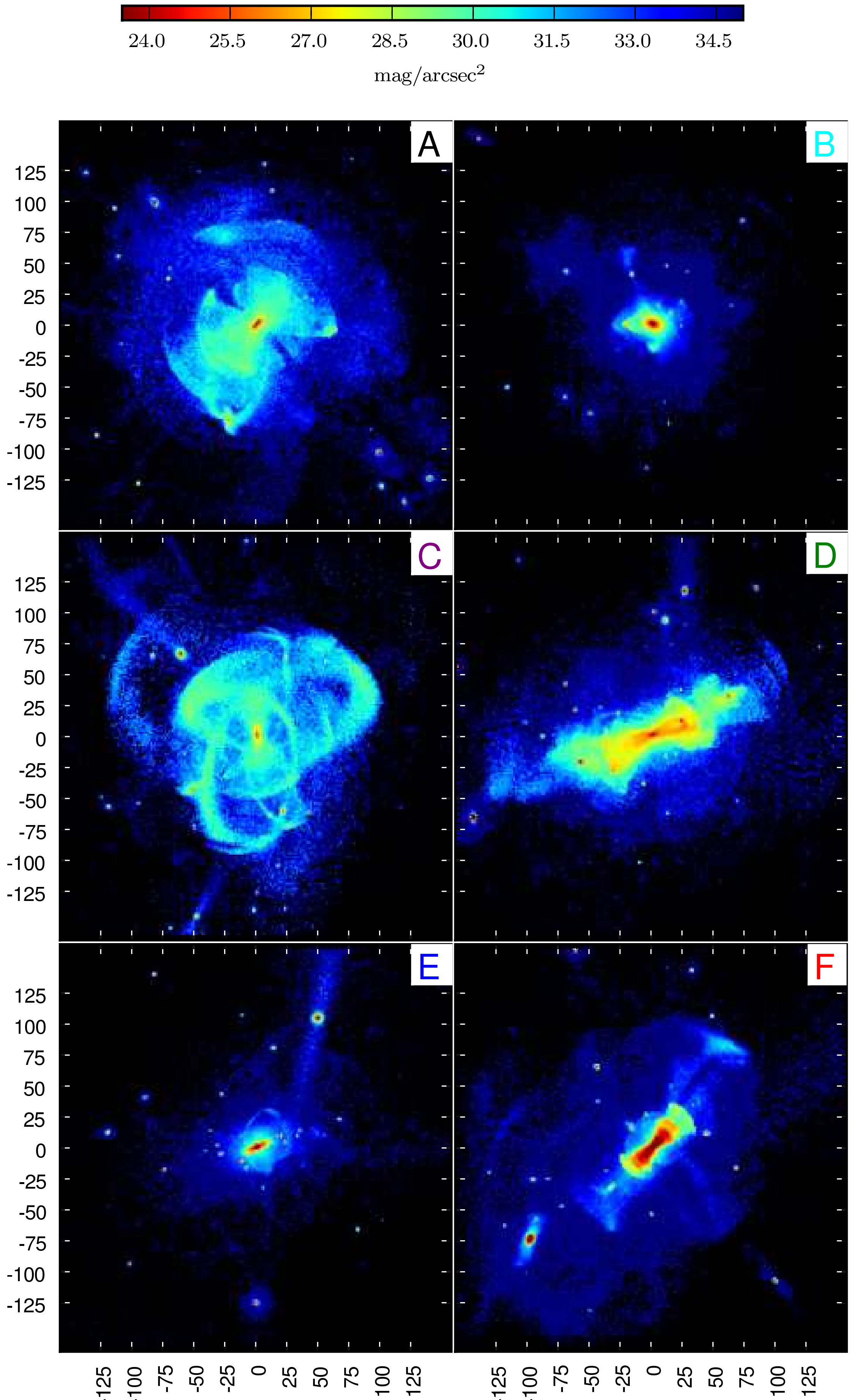


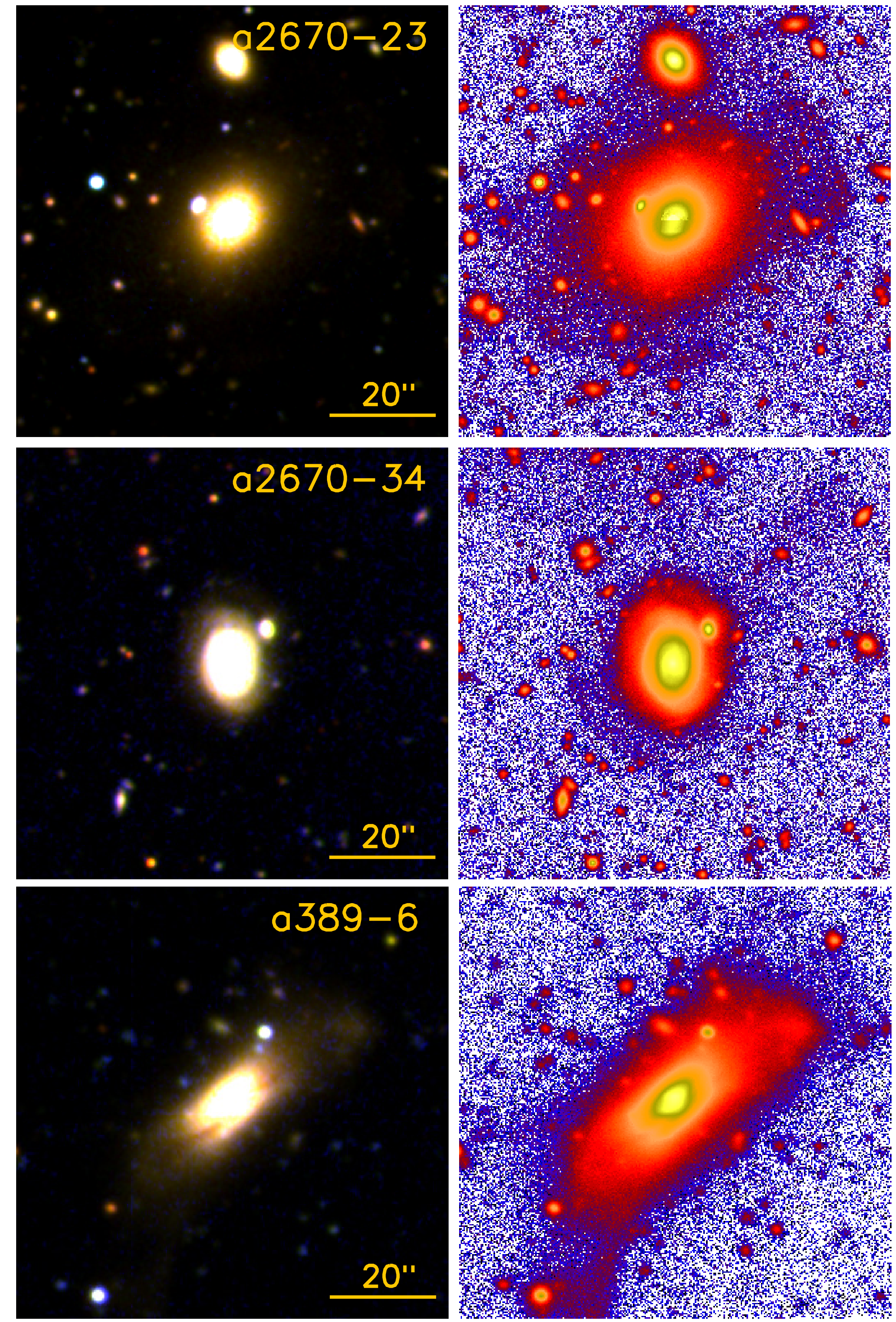
(Cooper et al. 2010)



(Cooper et al. 2010)

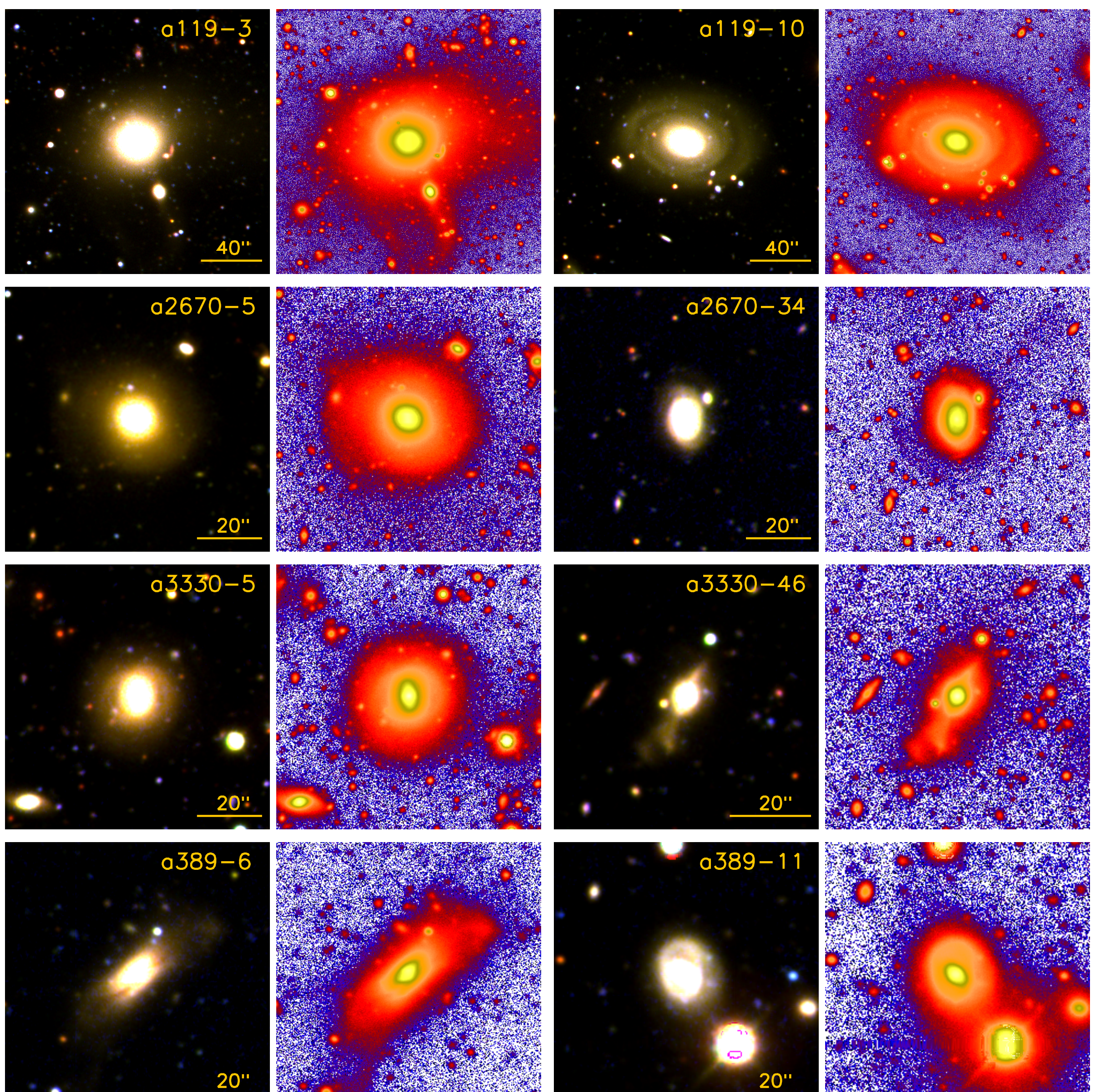
u'g'r' composite

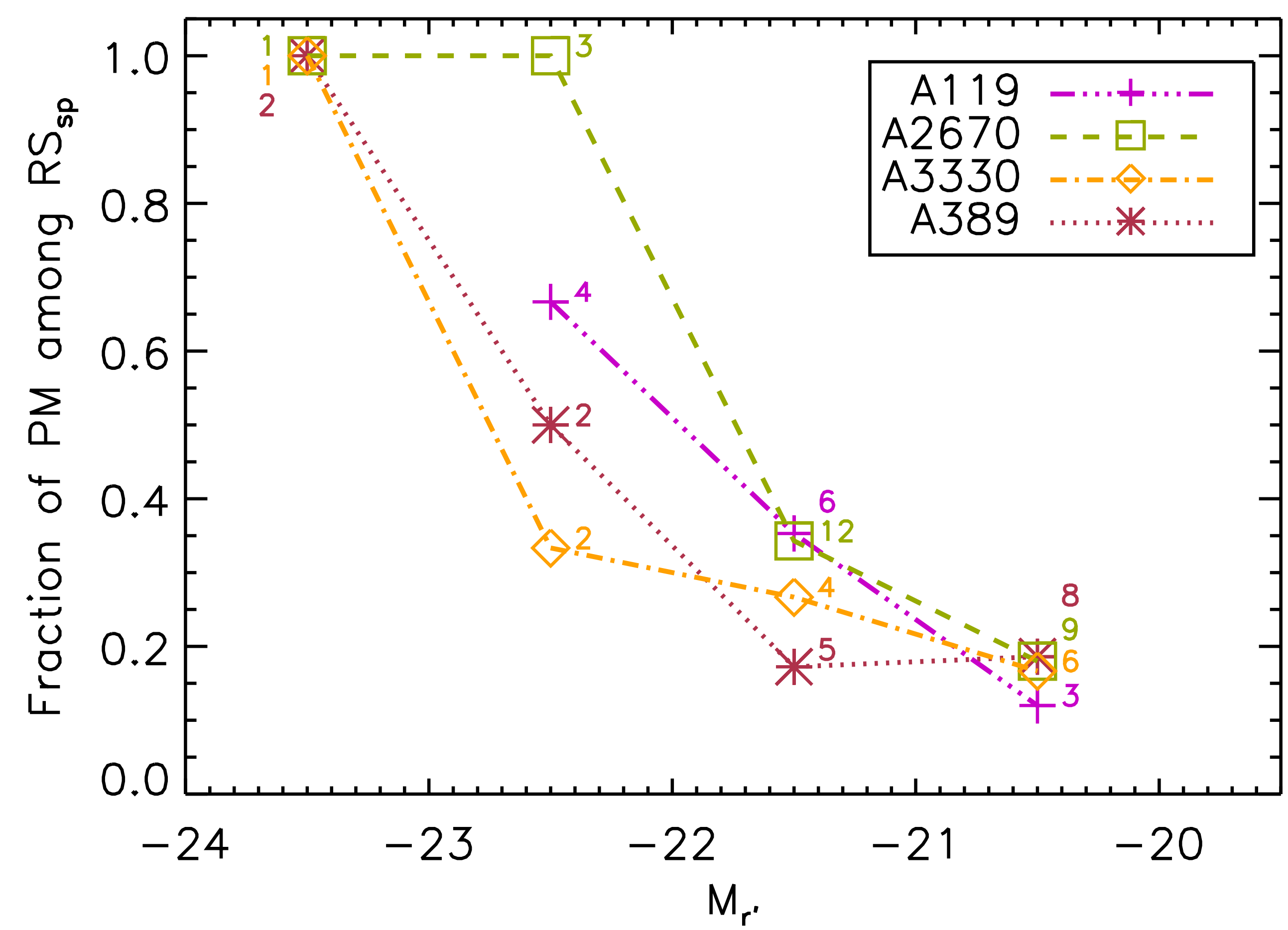
r' surface brightness



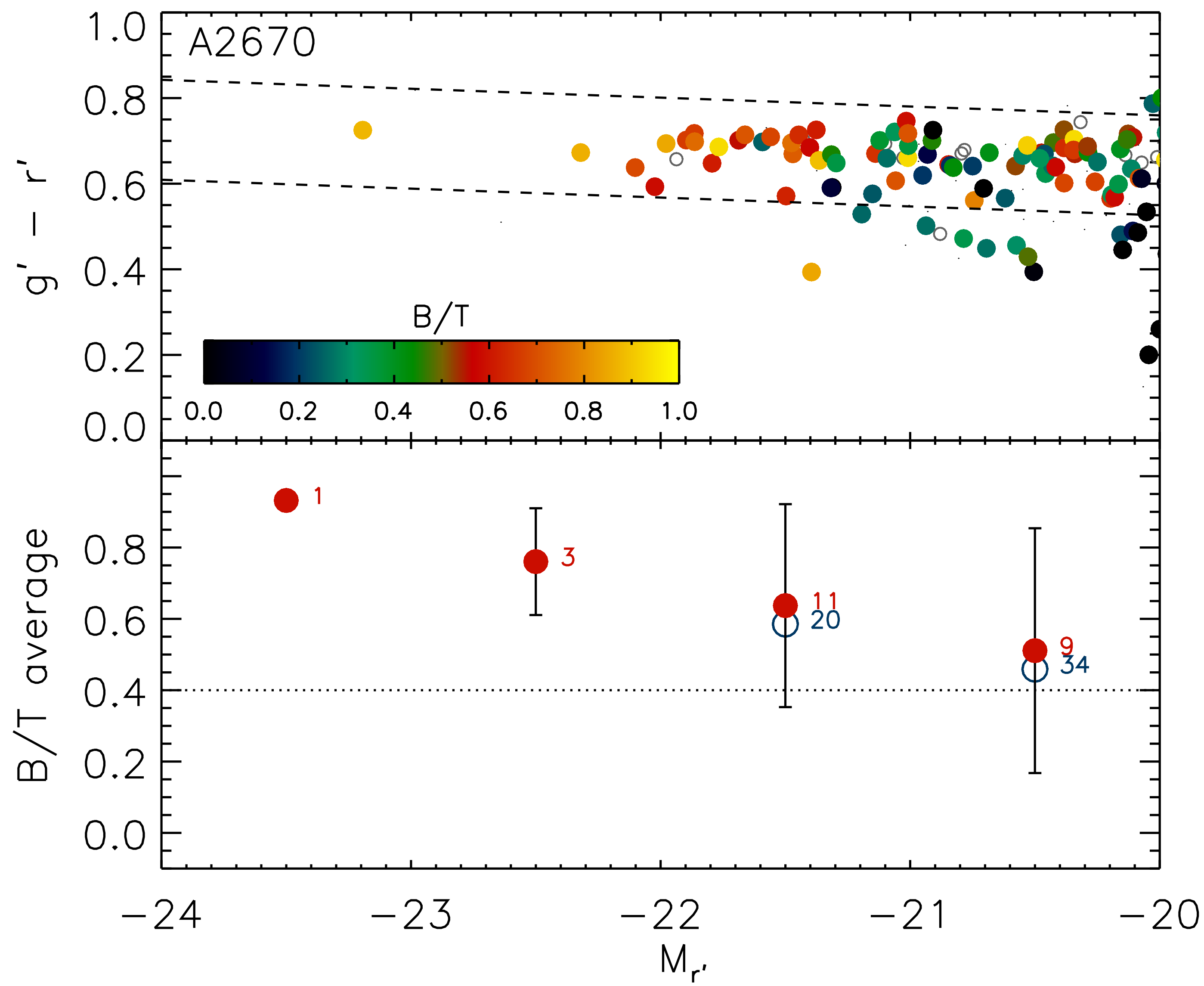
Post-merger Fractions

- Post-merger fraction among bright (Mr < −20) red-sequence galaxies in the four Abell clusters is ~ 25%
- Post-merger features are more common in bright red-sequence galaxies in a cluster environment



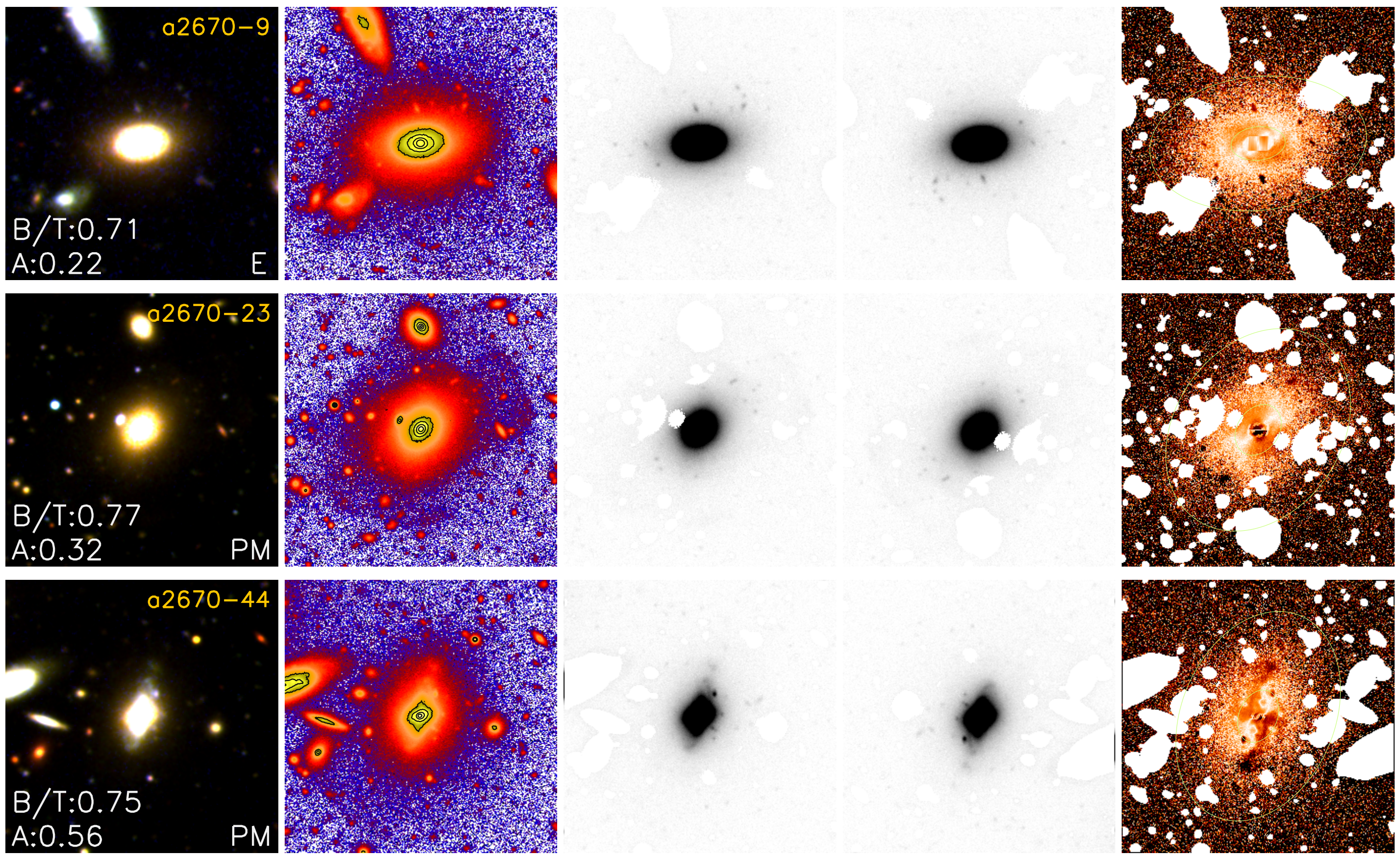


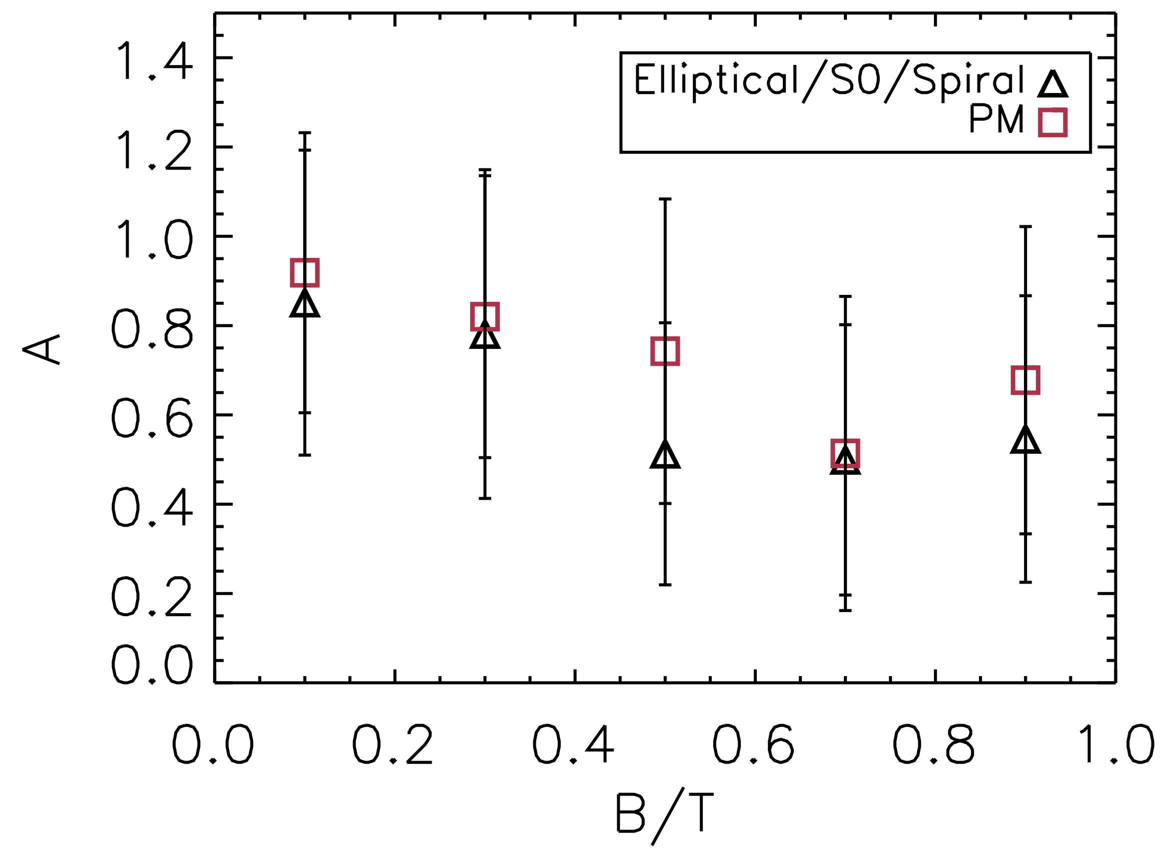
Contamination by Spirals?



- Most (~71%) of the featured galaxies were found to be bulge-dominated
- For the subsample of bulge-dominated red-sequence galaxies, the post-merger fraction rises to ~38%

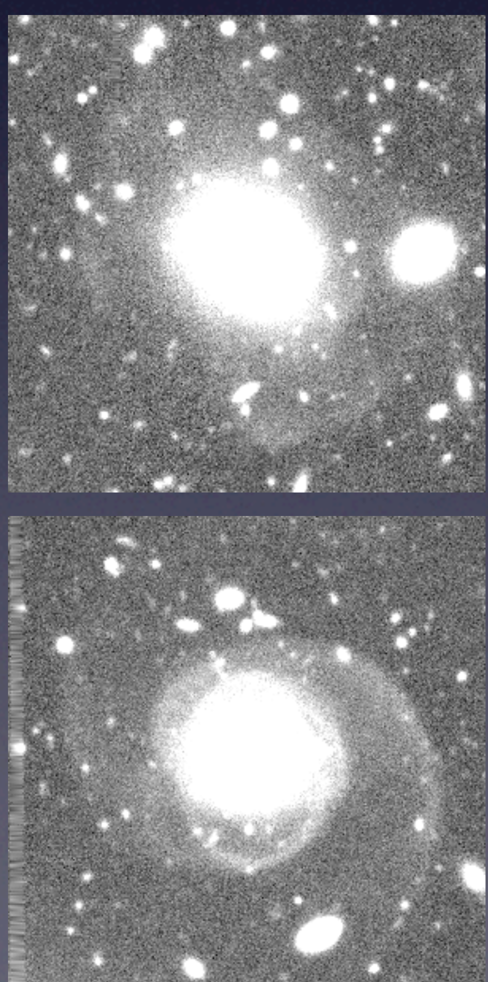
Morphological Examinations: A

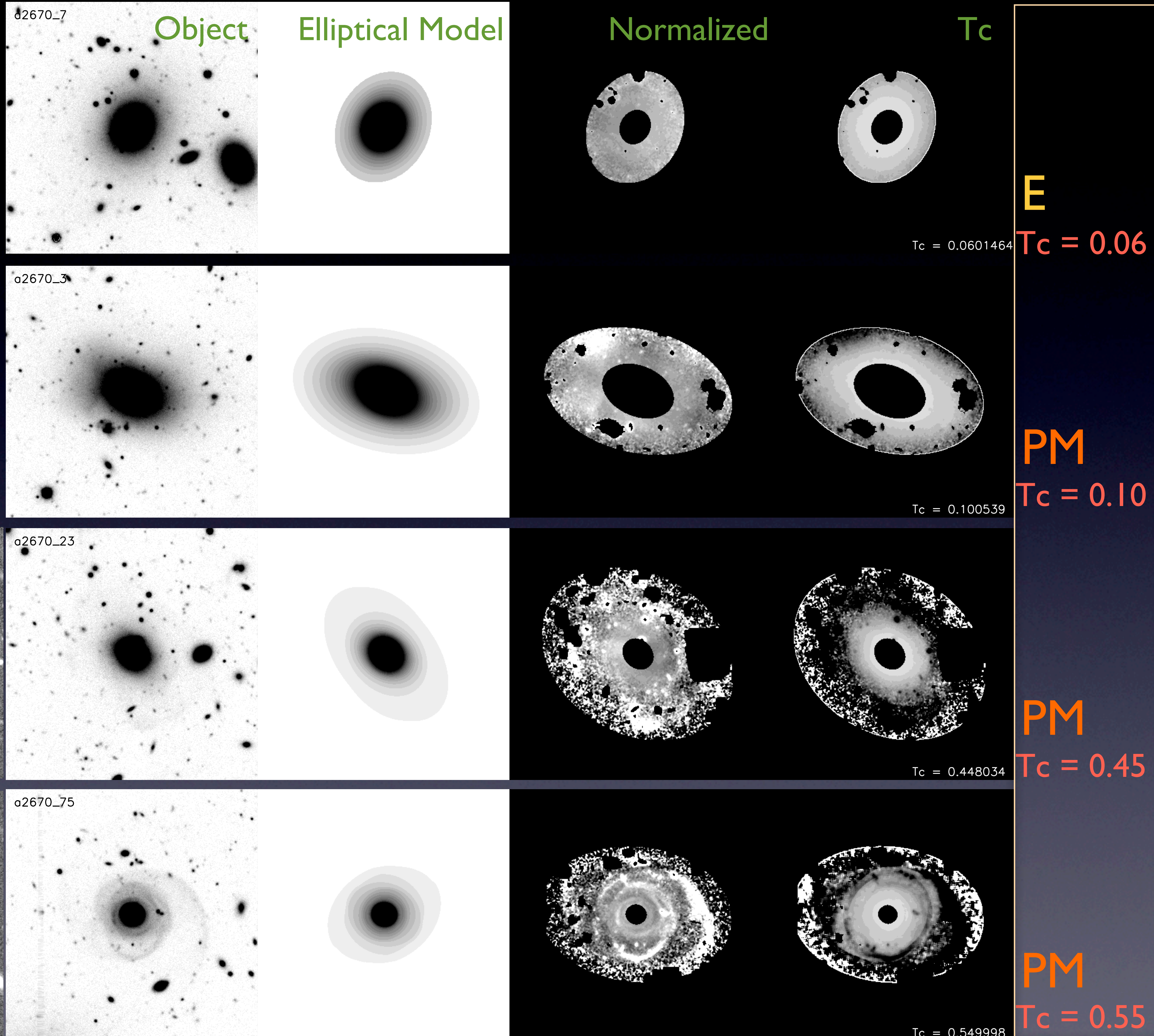




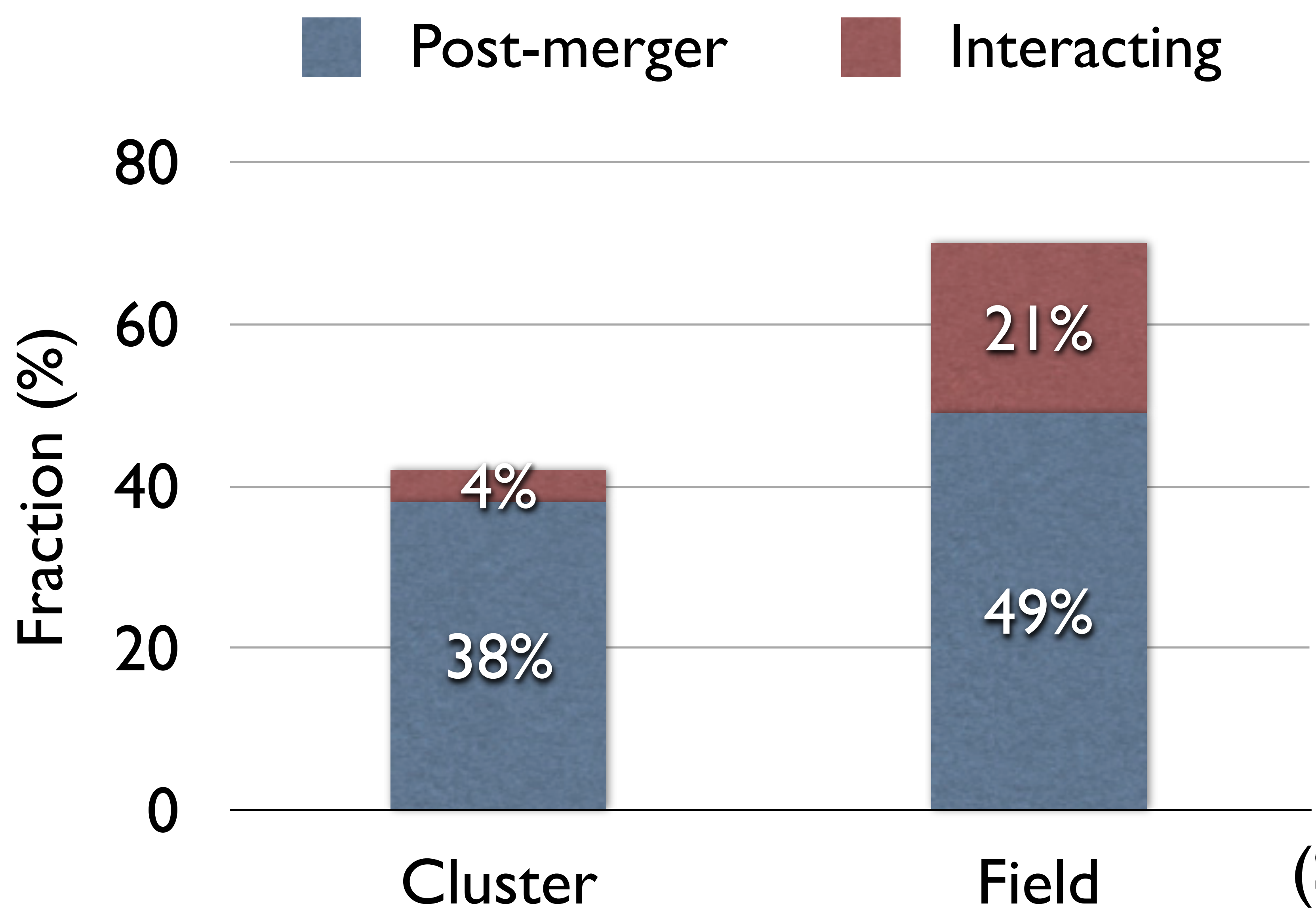
- Although the post-merger galaxies turned out to have higher 'A' values than the normal galaxies, it was not clear enough to classify galaxies

Tidal Parameter of Cluster Red-sq. Galaxies





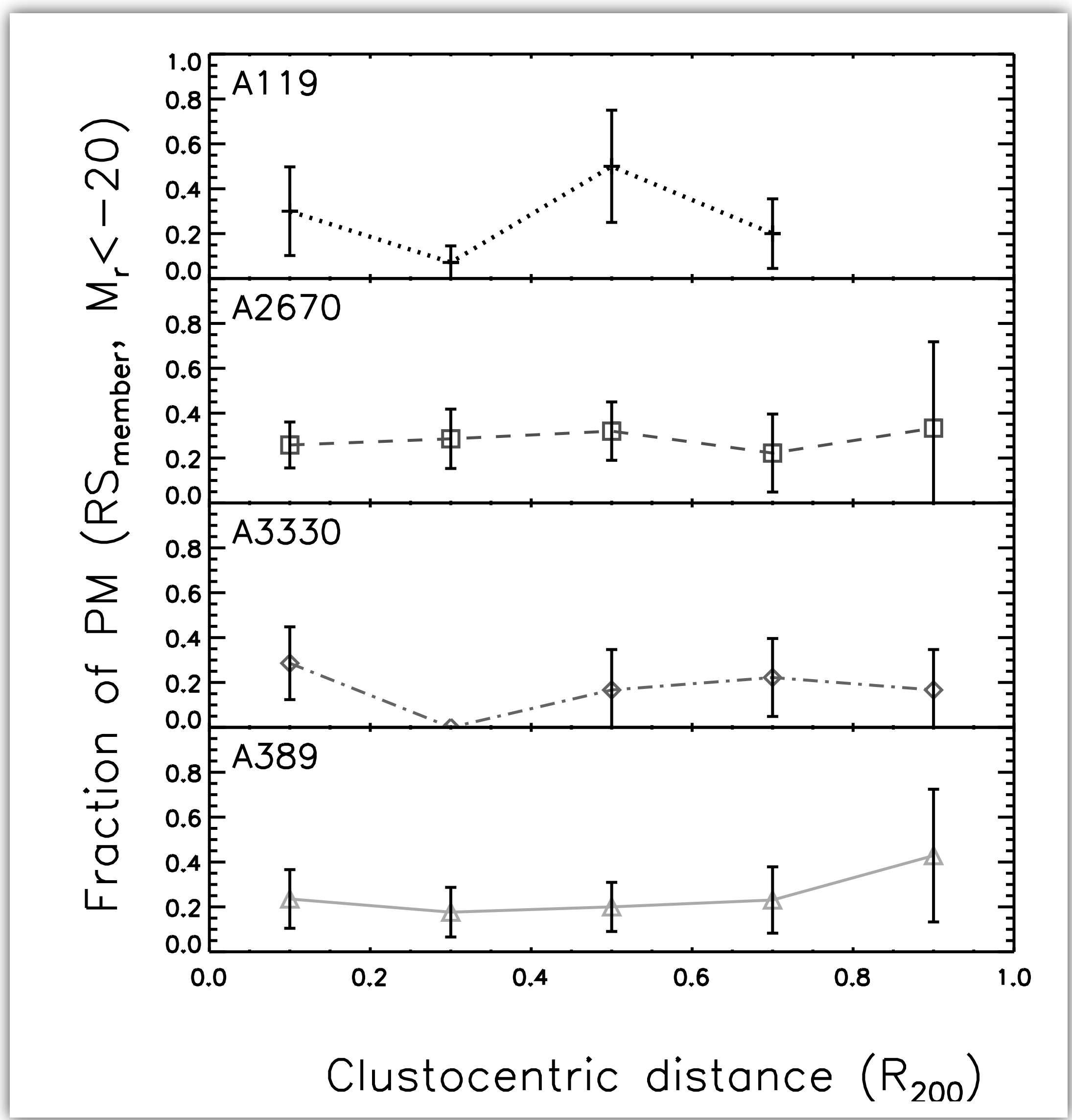
Comparison with Field

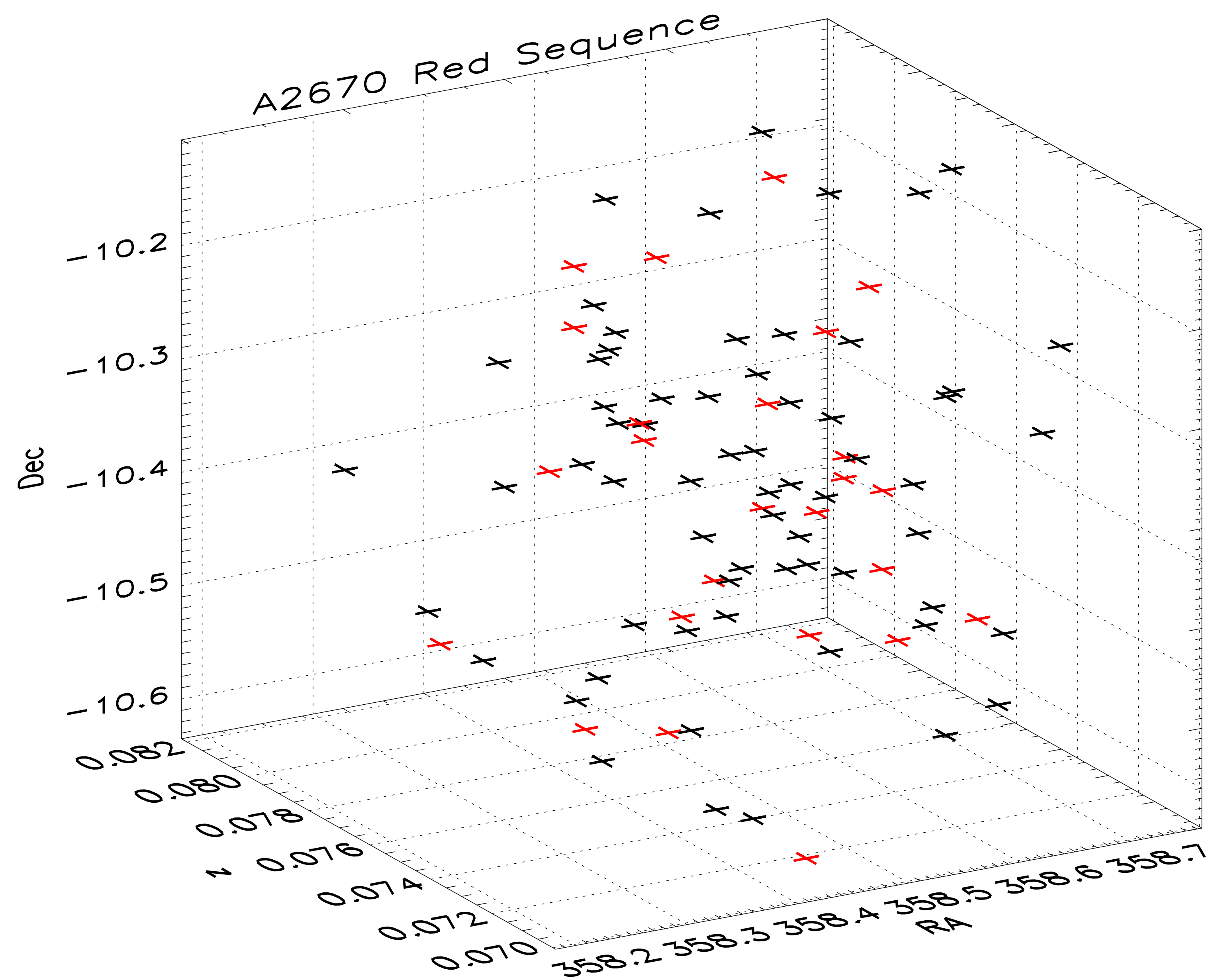


(Sheen et al. 2012)

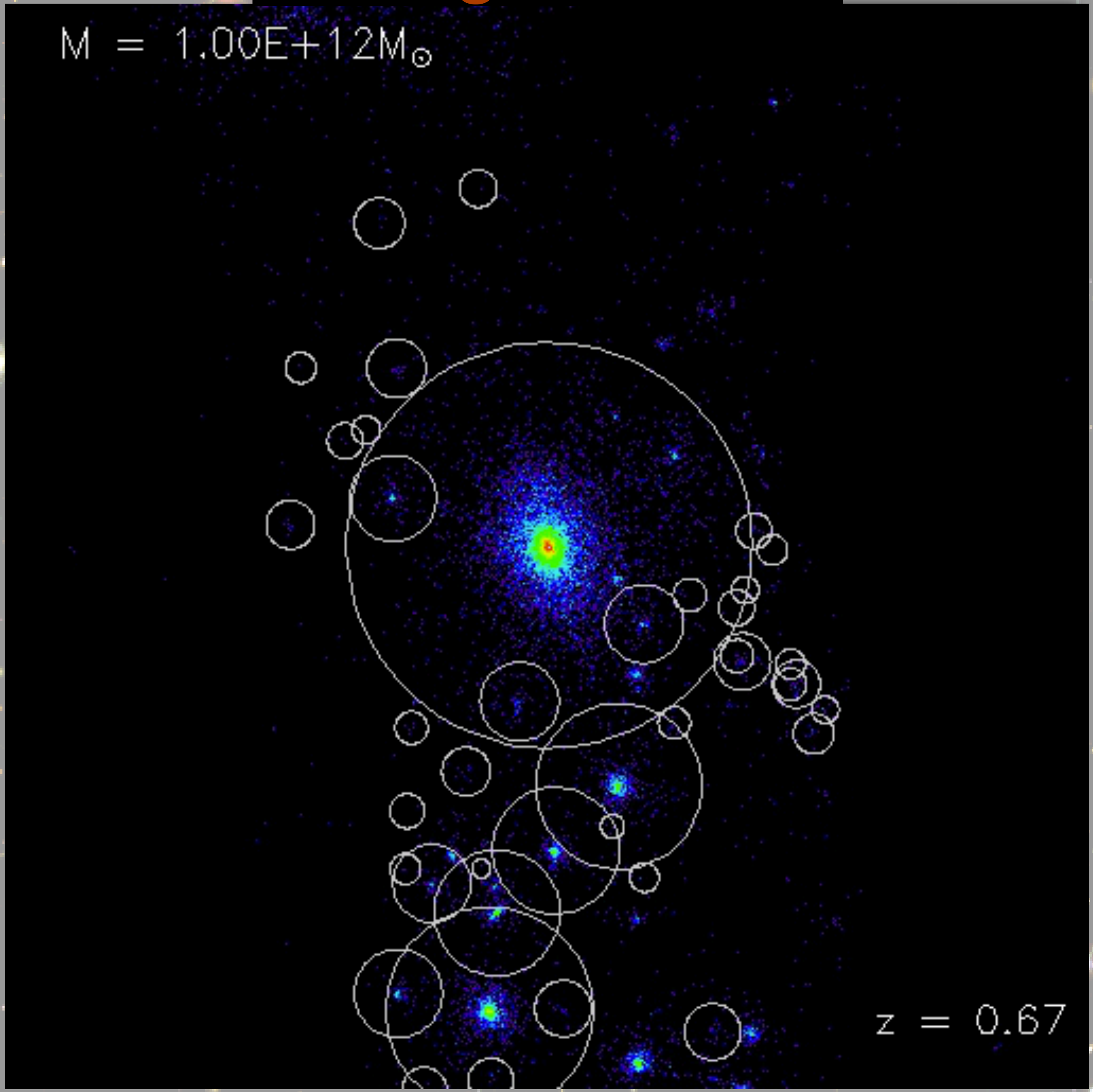
- Compared to a field galaxy study with a similar limiting magnitude by van Dokkum in 2005, our cluster study presents a similar post-merger fraction but markedly lower ongoing merger fraction

- No dependence of the fractions to clustocentric distance
- Most of the post-merger galaxies may have carried over their merger features from their previous halo environment



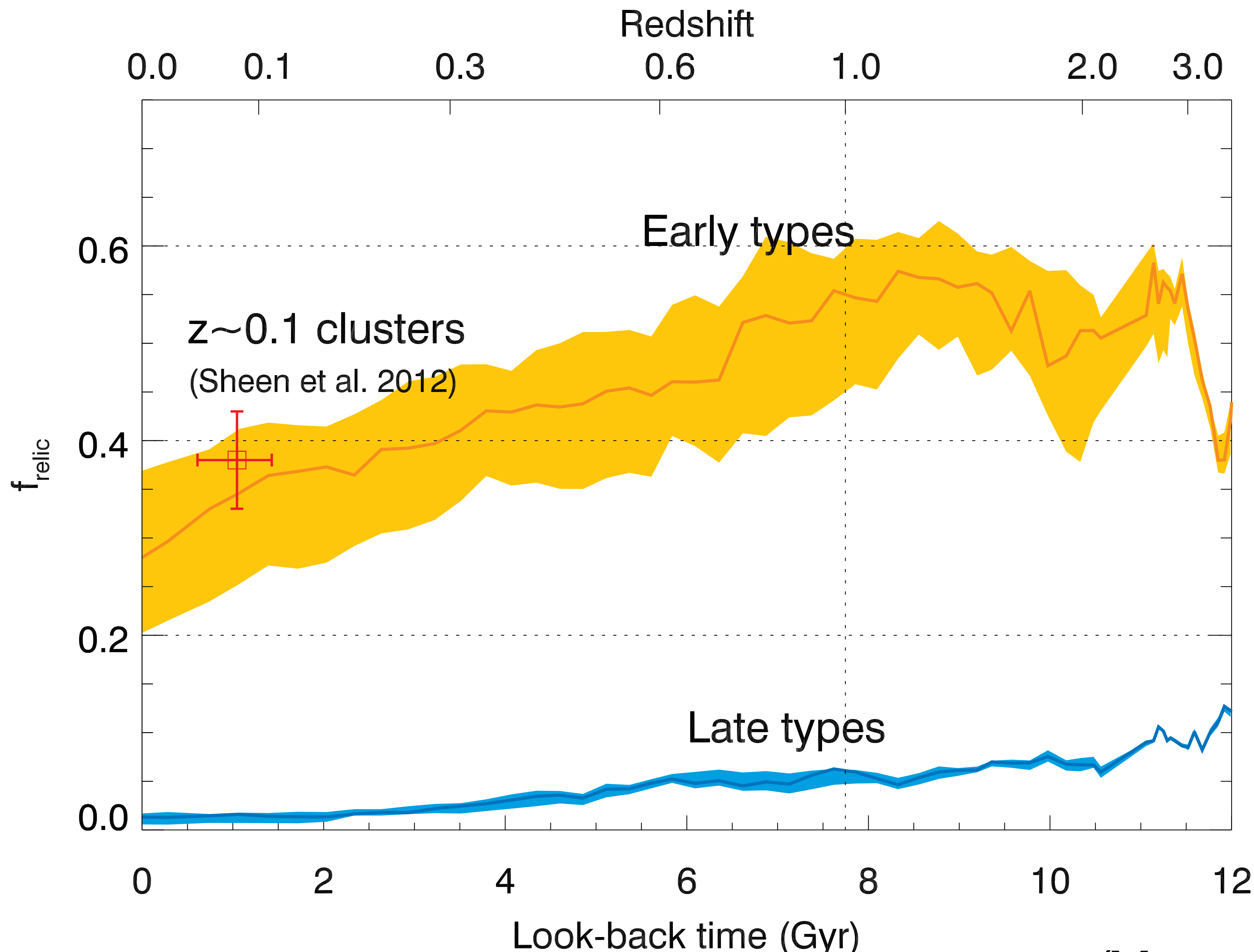


Merger Relics



- It is important to understand their **previous halo environment**
- In that sense, **cluster outskirts** are getting more important observationally

Evolution of Mean Merger Relic Fraction

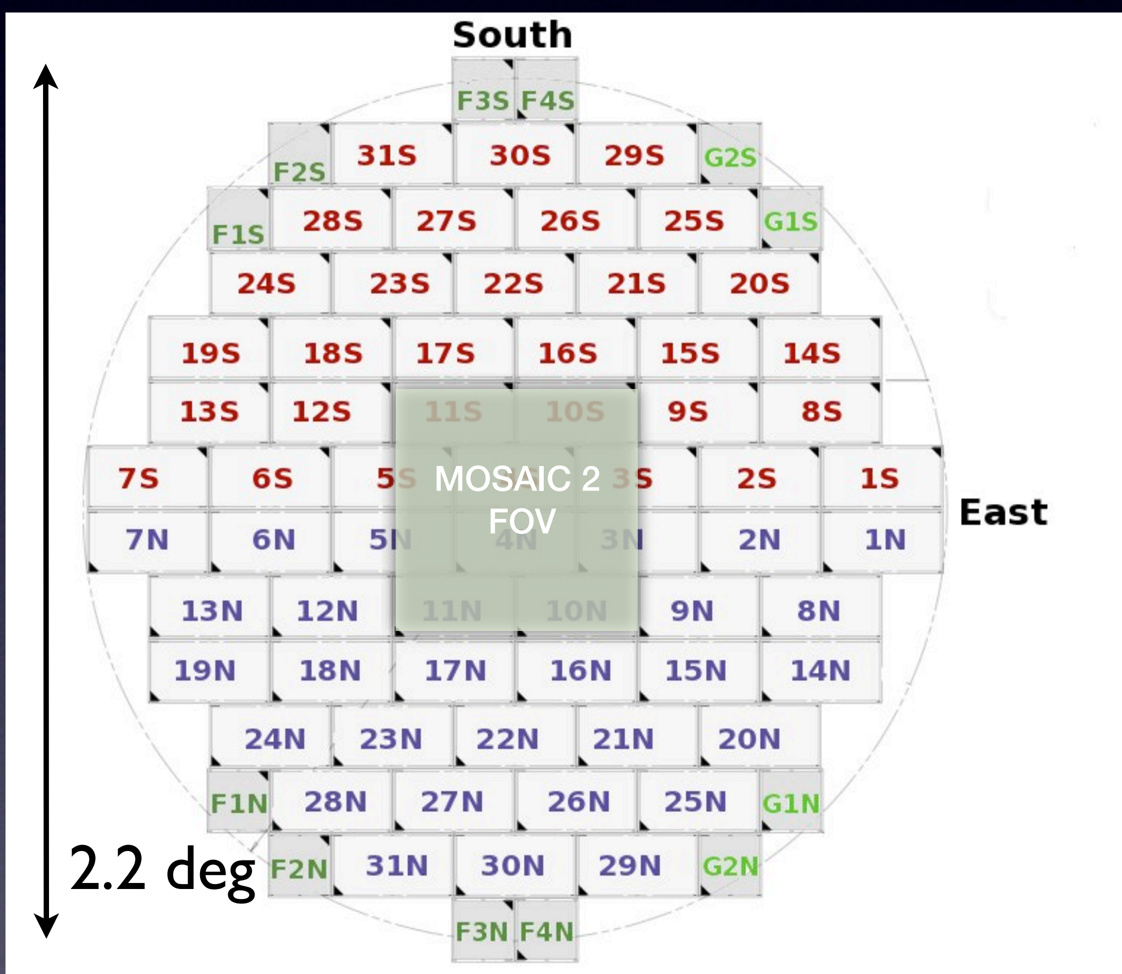


(Yi et al. 2013)

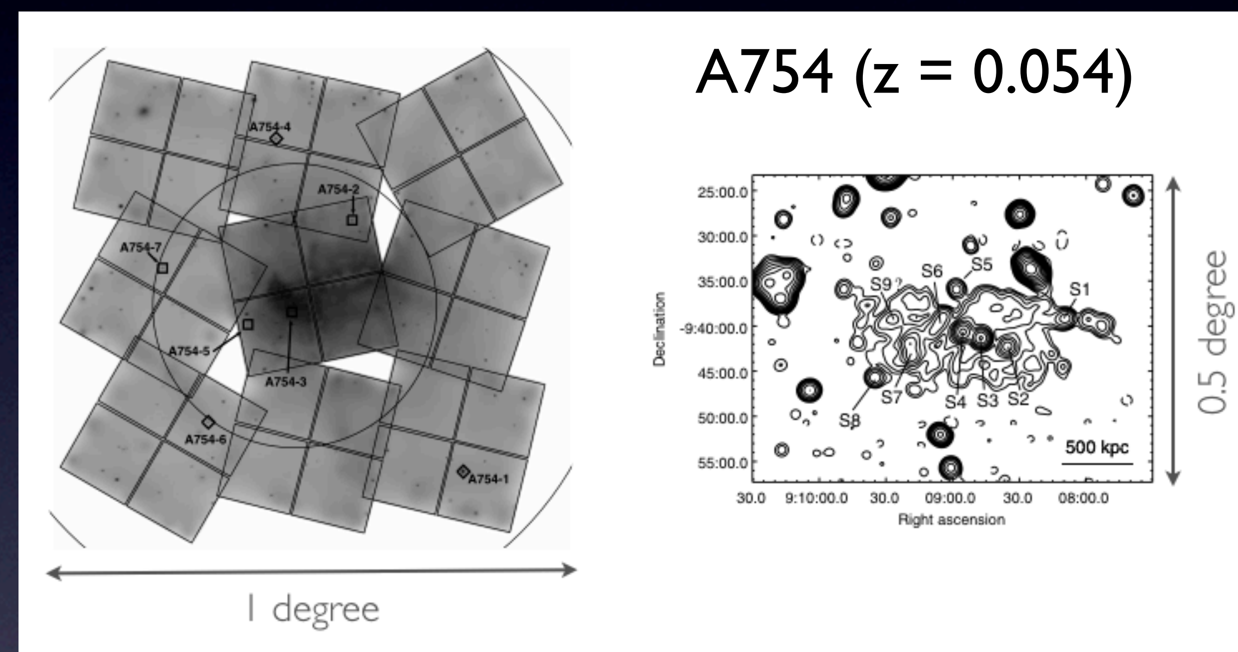
Results of Other Cluster Surveys

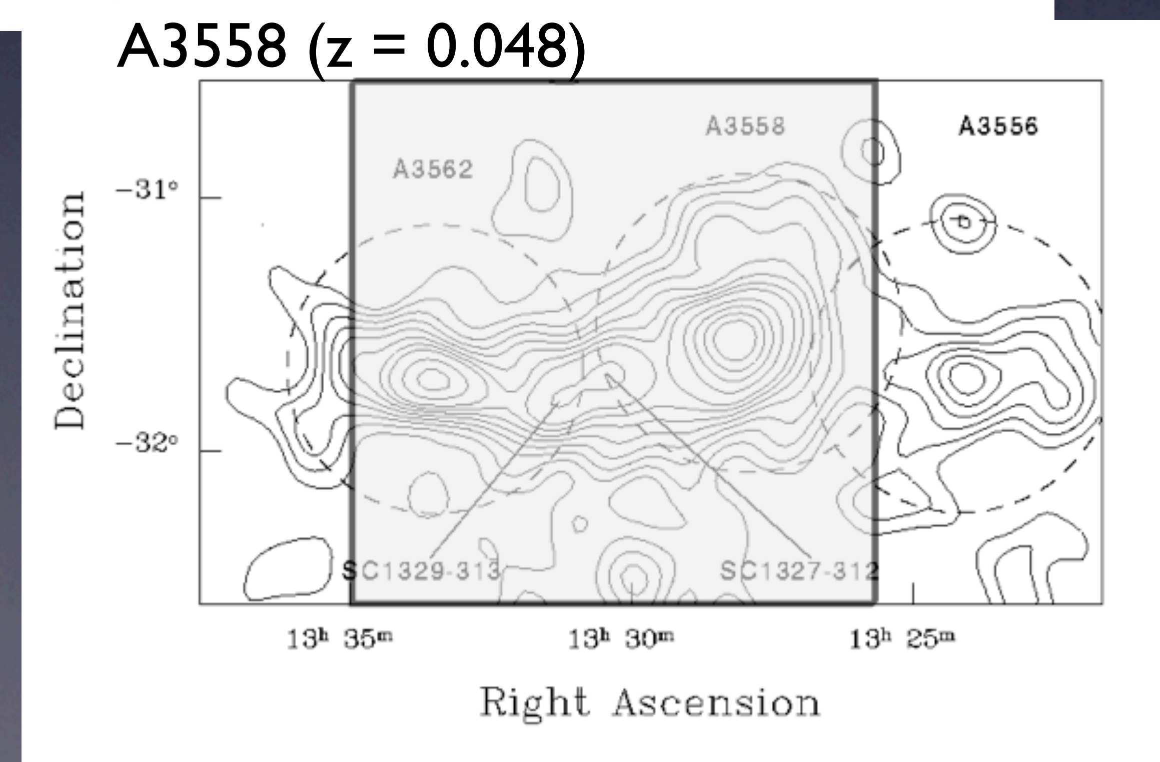
- Adams et al. 2012, Atkinson et al. 2013:
  - ✓ Lower fraction of tidal-featured galaxies
  - ✓ No Spec-z
  - ✓ CFHT
  - ✓ Shallower deep images
- Therefore, we are continuing our survey with
  - ★ Spectroscopic confirmation of cluster memberships
  - ★ Deep imaging campaign for cluster outskirts
  - ★ Various dynamical stages of clusters

- Wide Field Deep Optical Imaging of two Merging Clusters
  - A merging cluster, A754 (z = 0.0542)
  - The center of Shapley Supercluster, A3558 (z = 0.048)



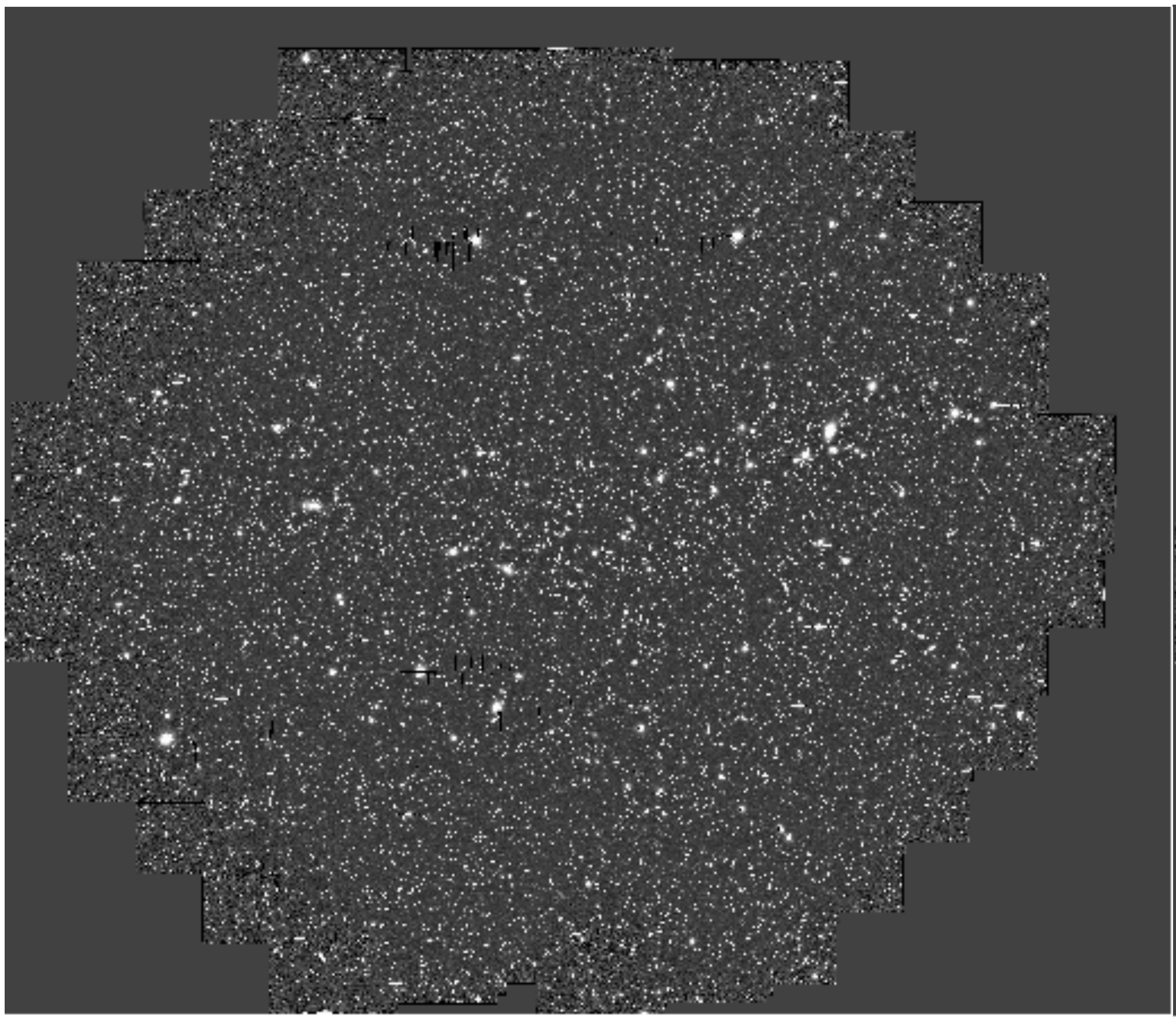
DECam CCD array



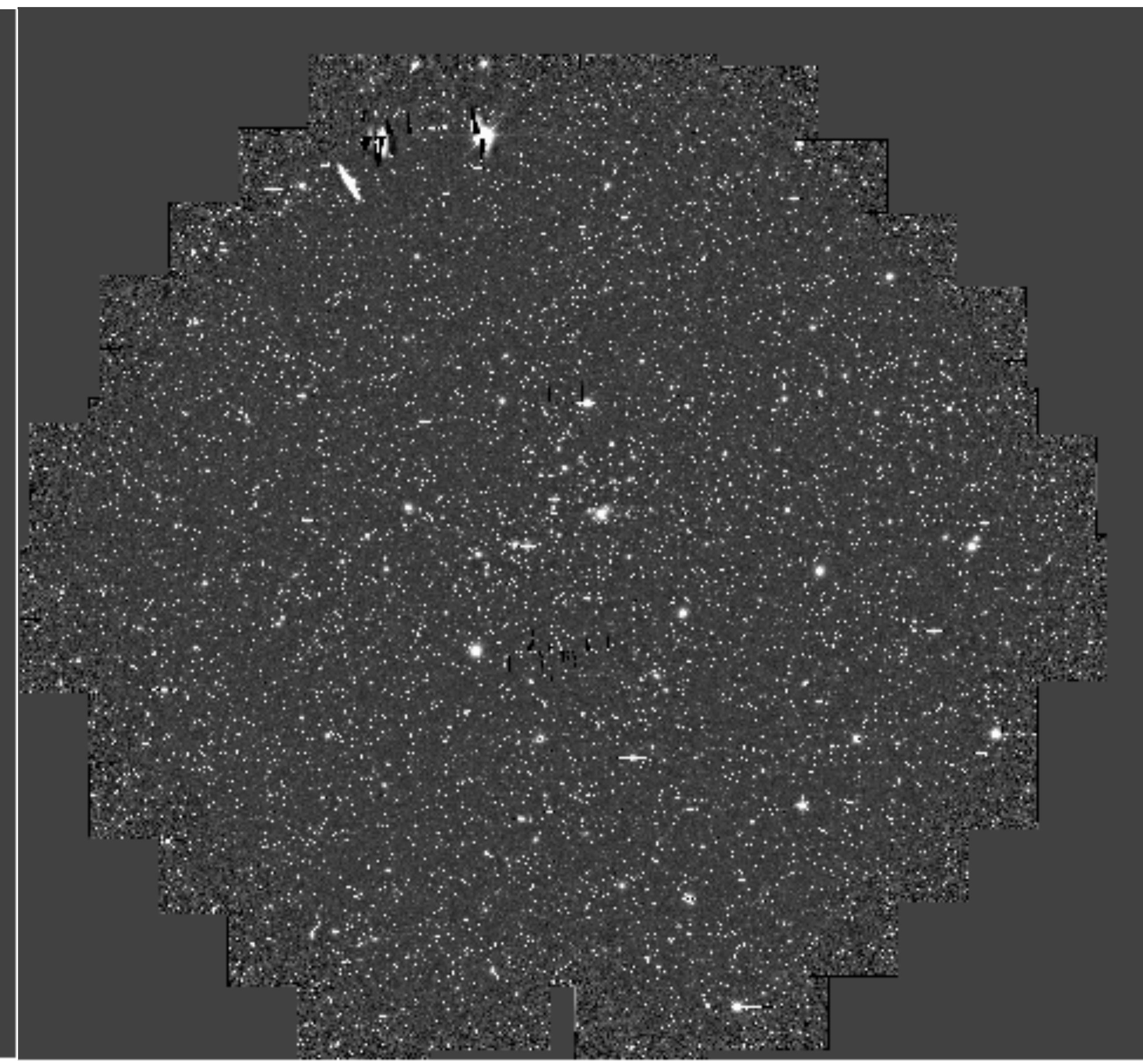


DECam Deep Imaging of Merging Clusters at z = 0.05

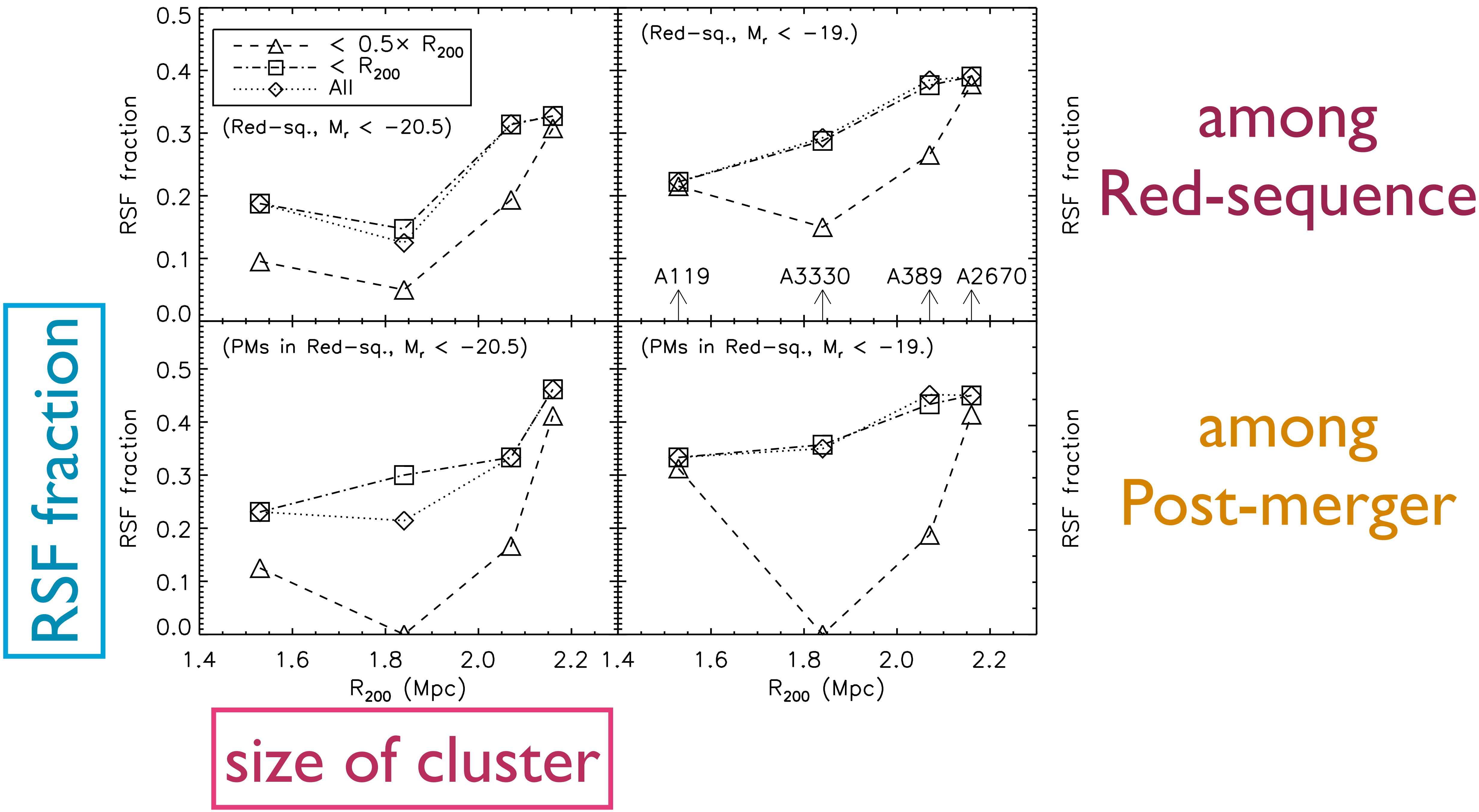
A3558



A754



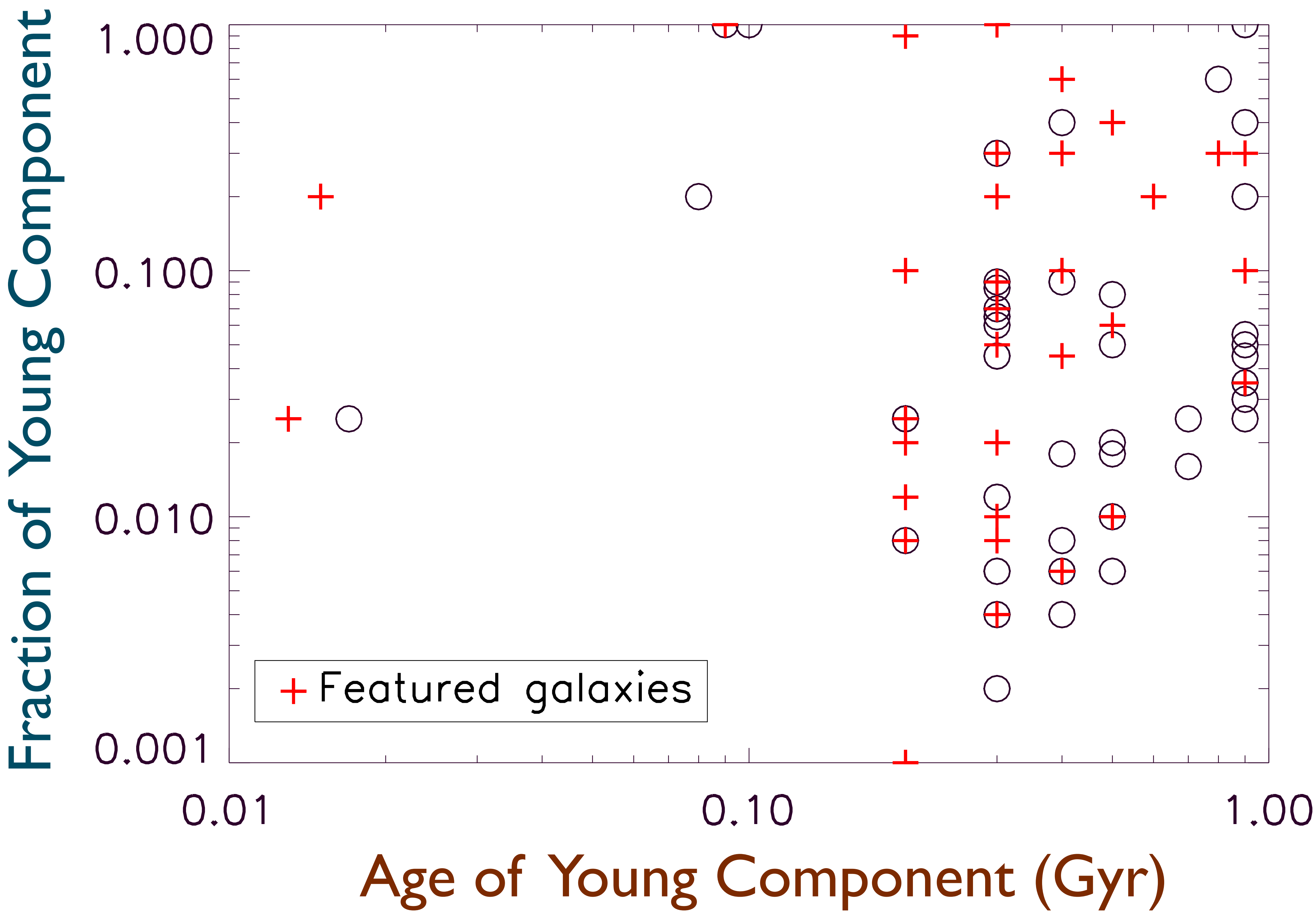
RSF Fraction with GALEX UV



1. Cluster size ↑ → RSF fraction ↑

2. RSF fractions in post-merger galaxies are slightly higher than that of red-sequence galaxies but it is not significant

UV-Optical two-component stellar population modeling



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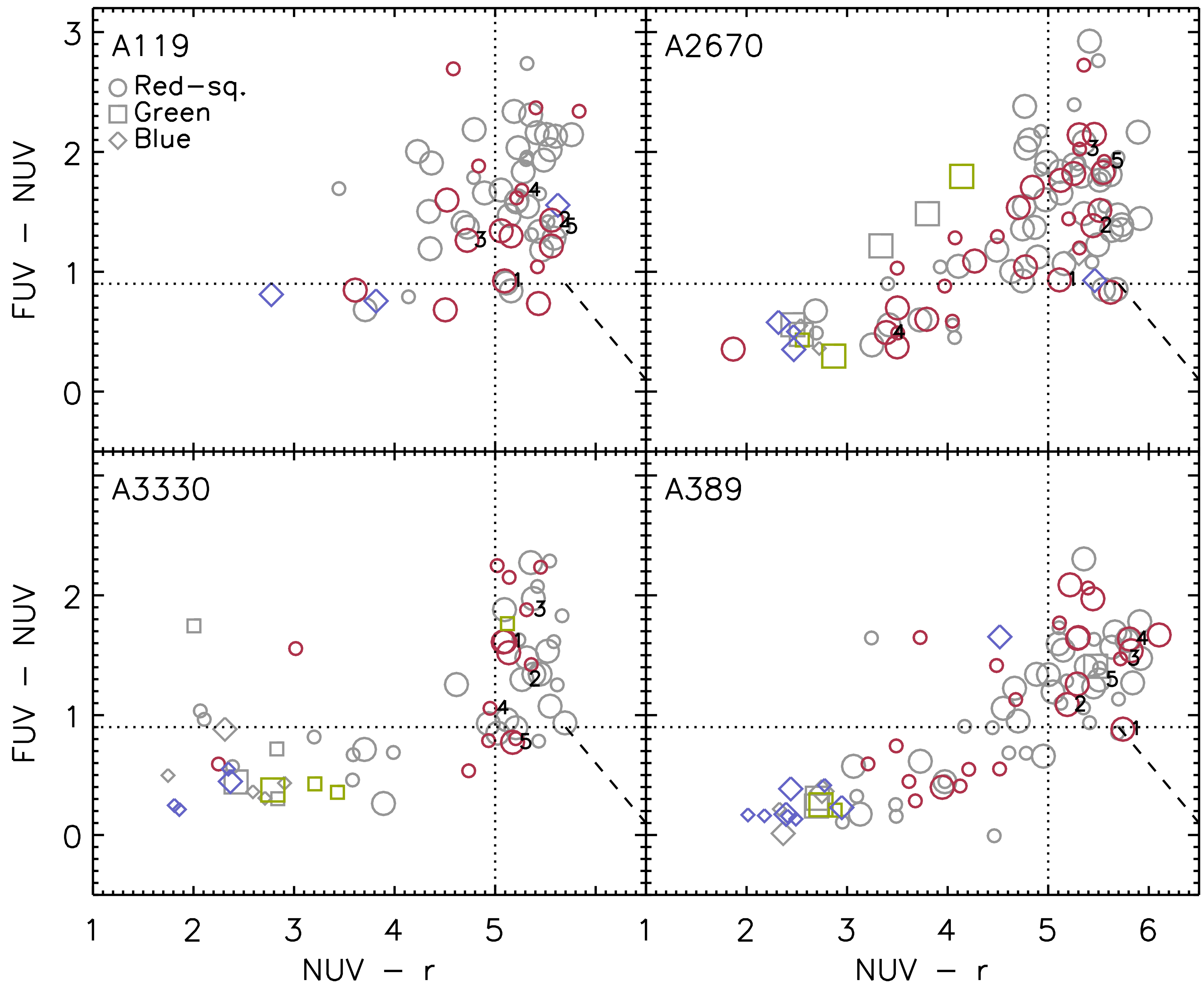
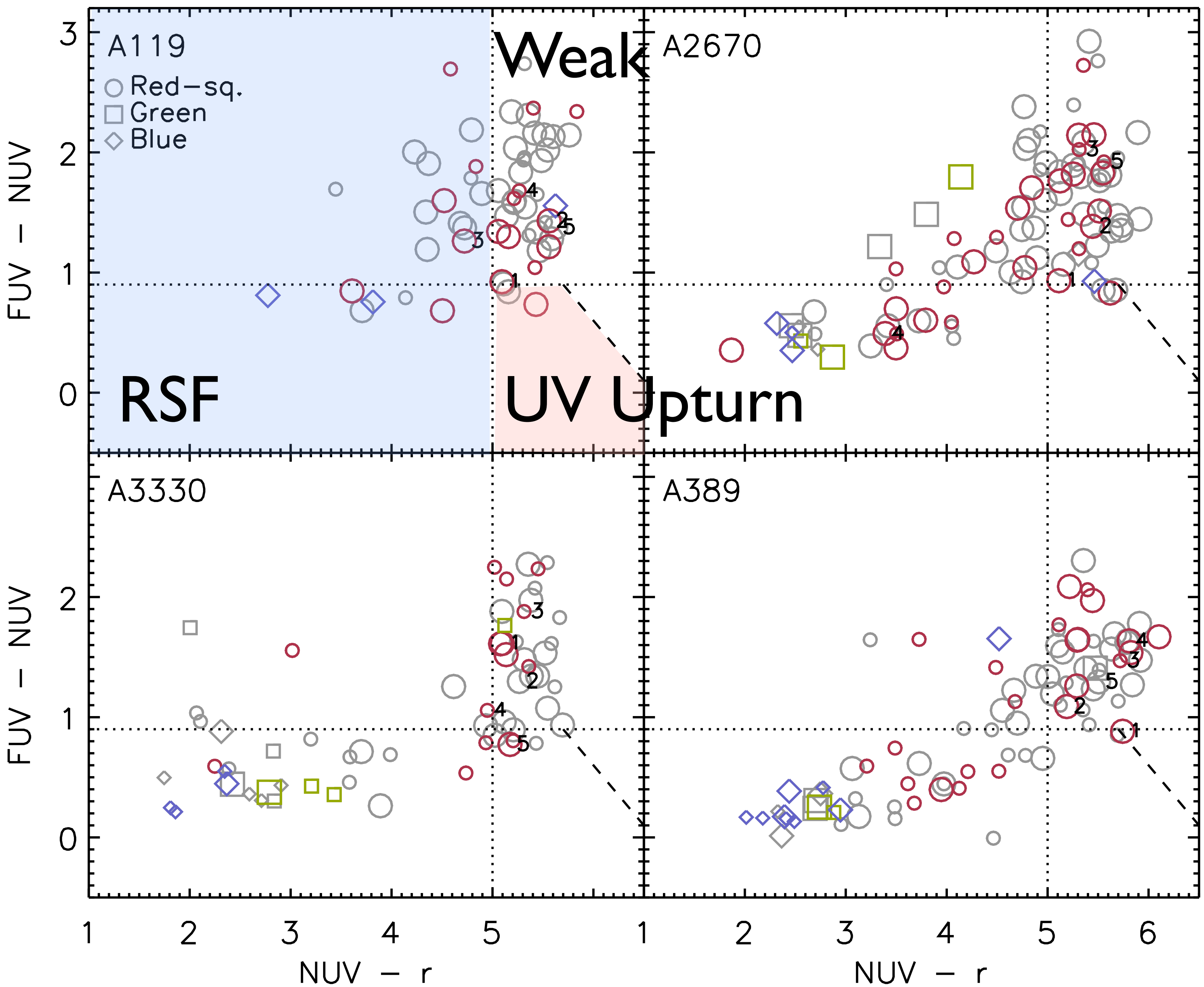
Thank you

The lack of UV bright post-merger galaxies in the center of A3330 and A389



Color symbols: Post-merger galaxies

The lack of UV bright post-merger galaxies in the center of A3330 and A389



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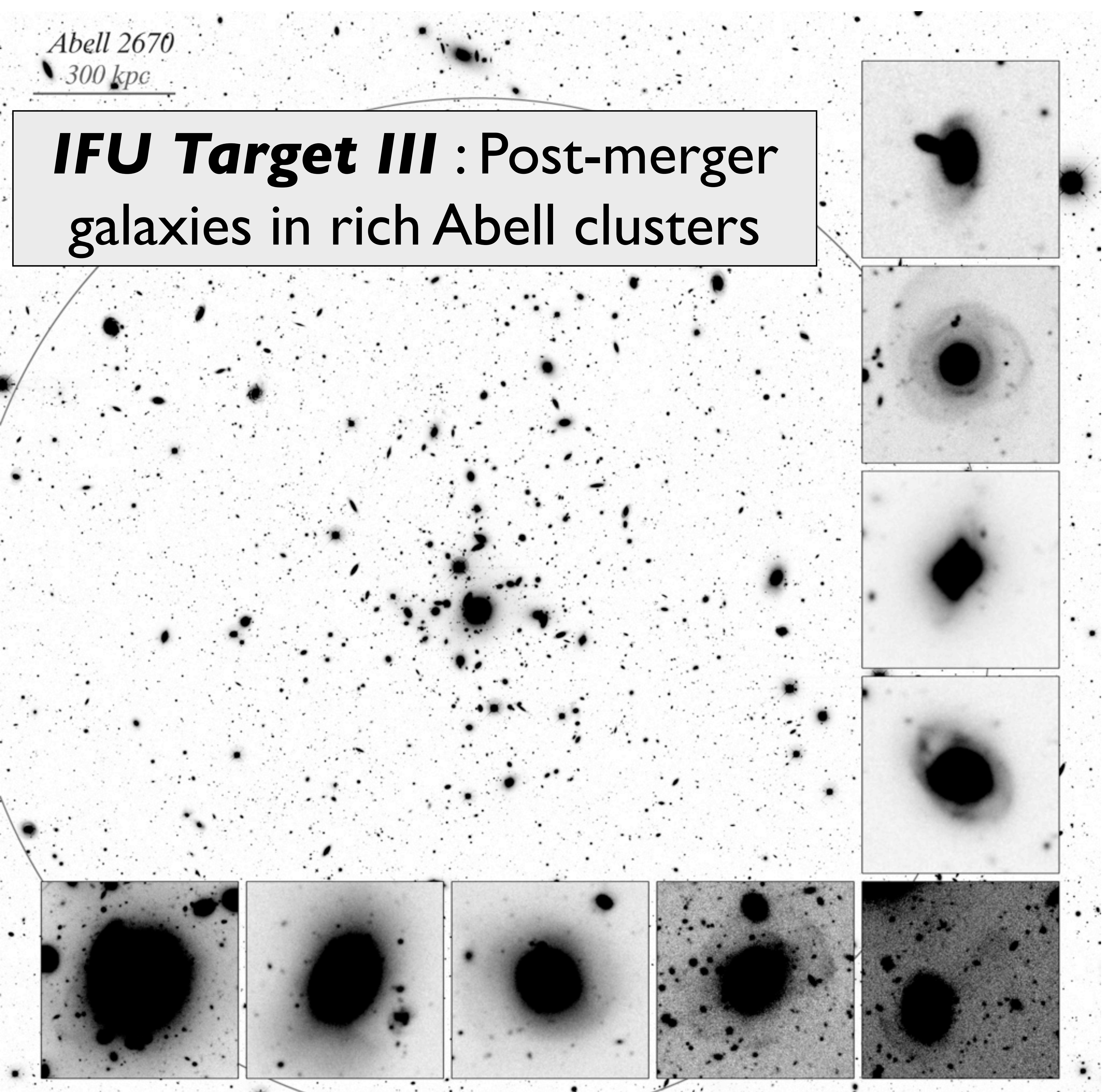
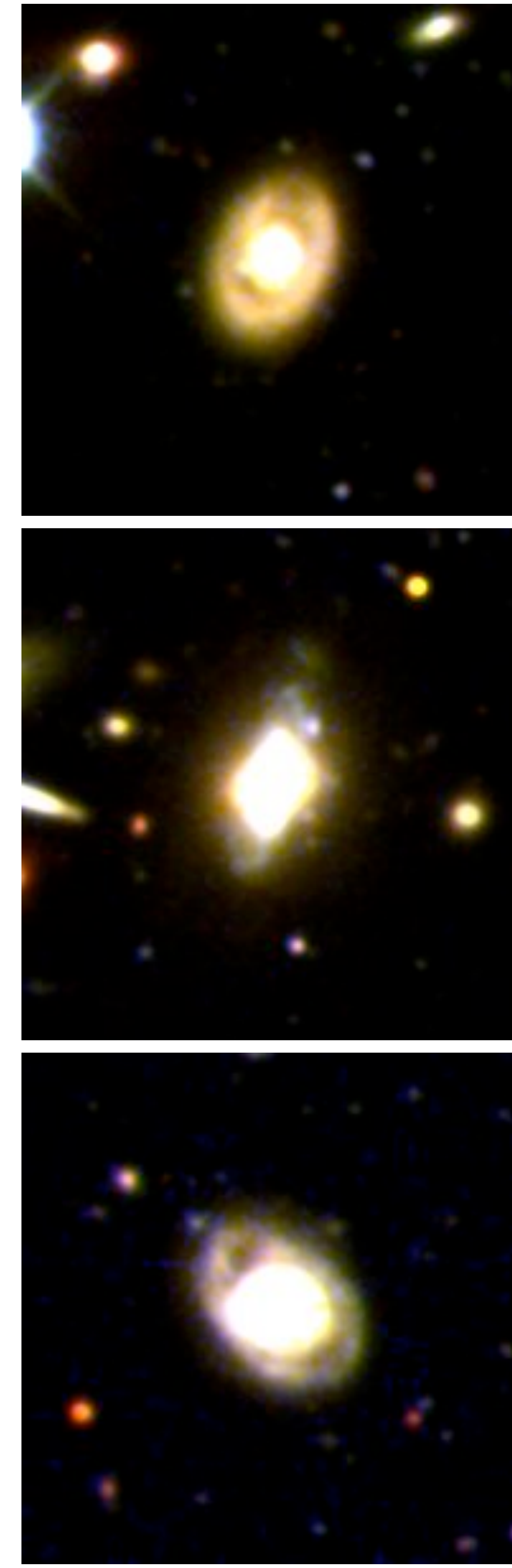
Post-merger galaxies

IFU Target III : Post-merger galaxies in rich Abell clusters

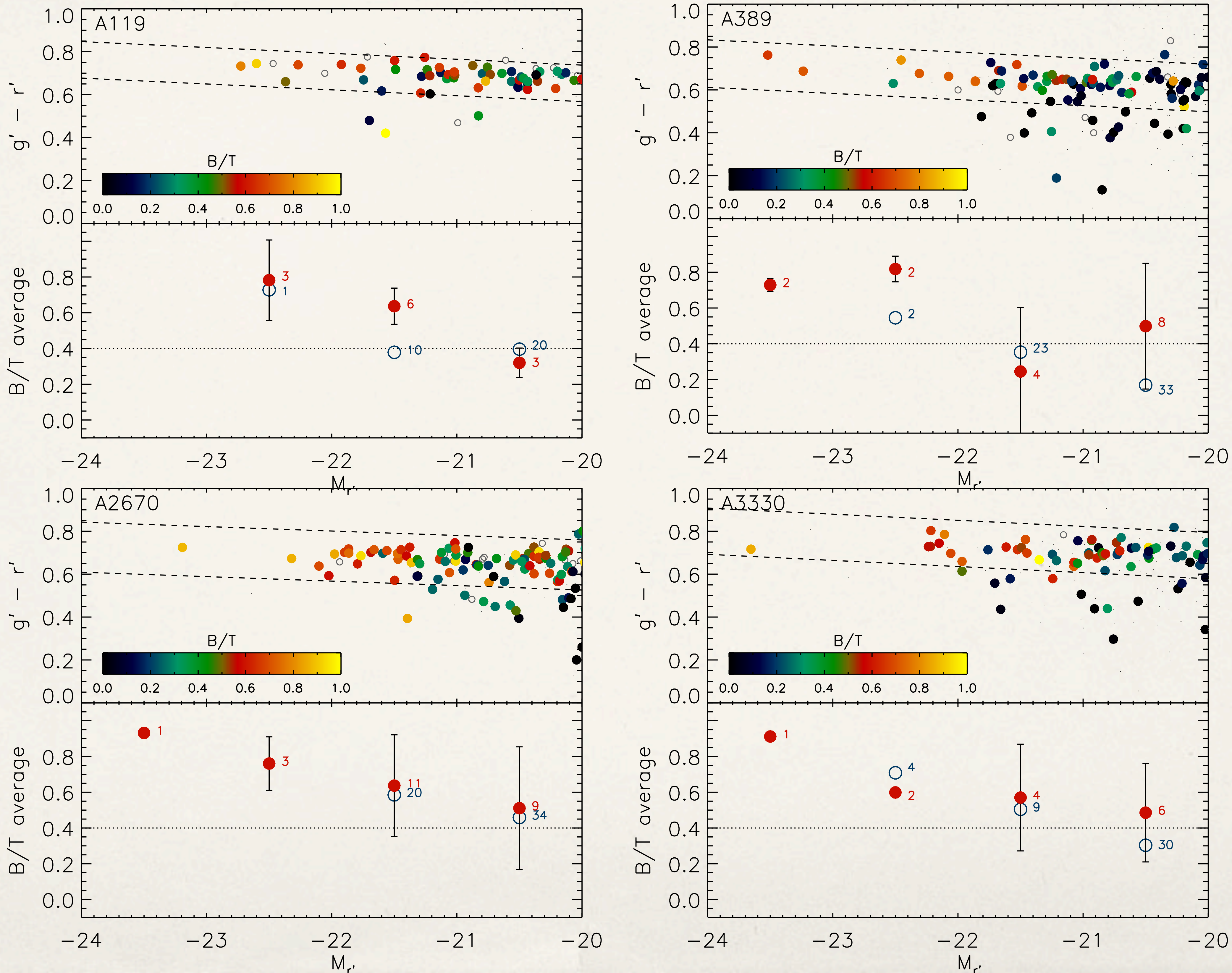




Why z ~ 0.1?

- A lack of observational studies for this redshift range (e.g., DEEP2 sample starts z ~ 0.2 because probably they do not have enough galaxies for this redshift within a given FOV and for nearby galaxy clusters Virgo and Coma(z=0.023) are studied well)
- Large telescope with small FOV: many FOV required
- Small telescope with large FOV: poor S/N obtained
- But, z ~ 0.1 is important as a bridge linking the galaxy evolution scenarios suggested by the deep sky surveys (high-z) and SDSS (low-z)
- CTIO Blanco 4-m + MOSAIC 2 CCD (40'x40' FOV)
- Wide-field survey is possible with good S/N and reasonable spatial resolution

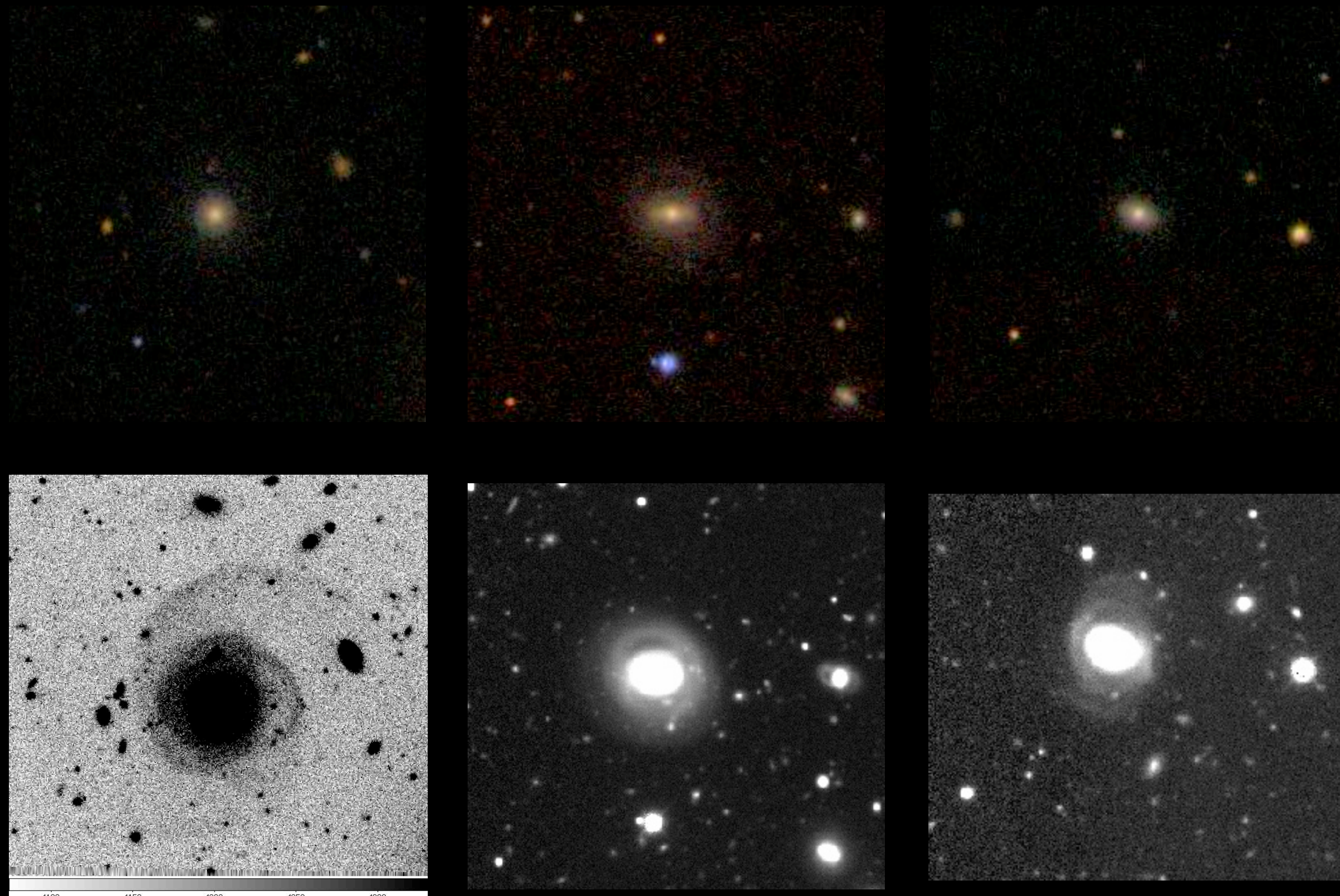
B/T Distributions

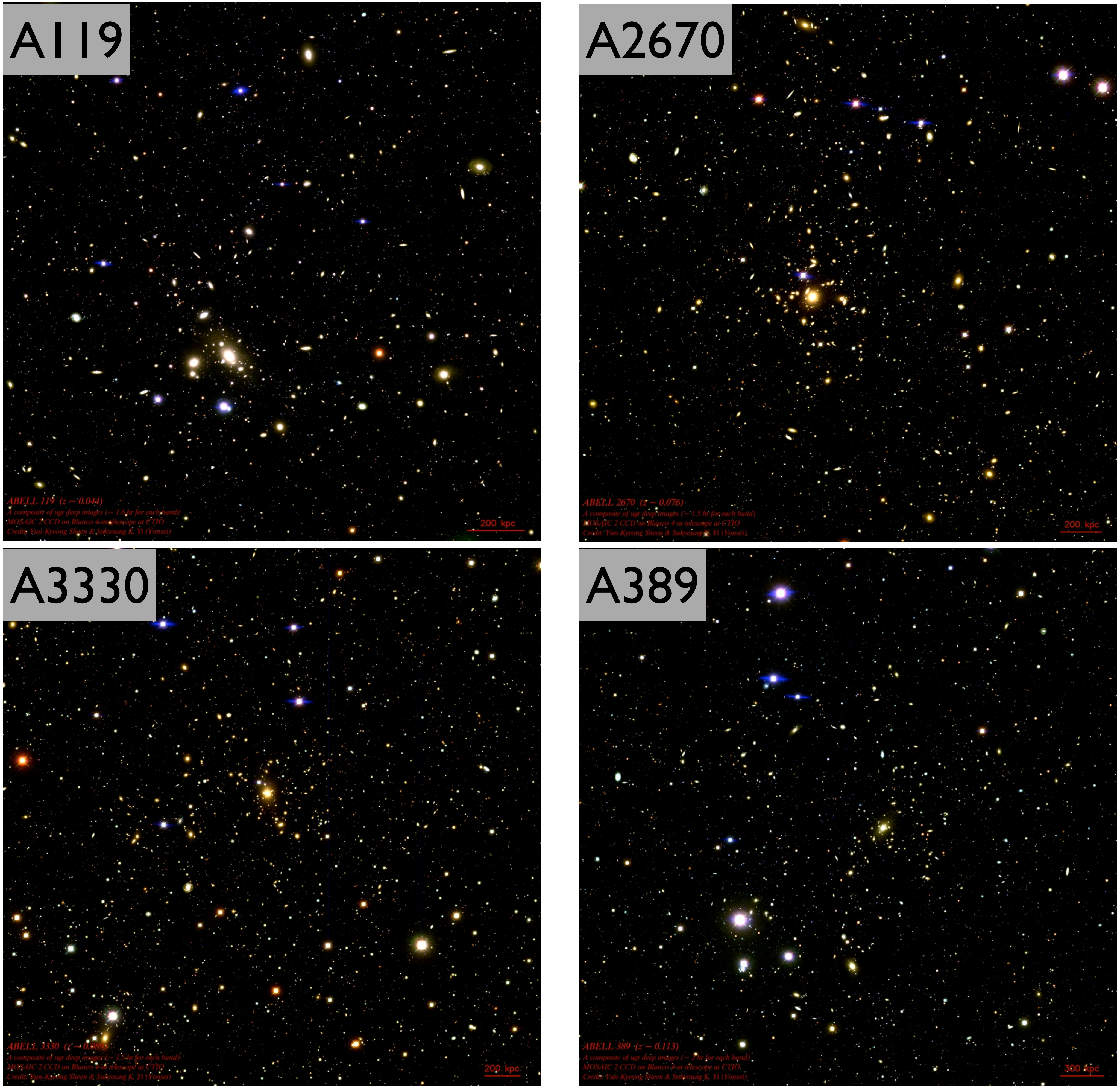


Abell 2670 (z~0.076)

SDSS

CTIO r

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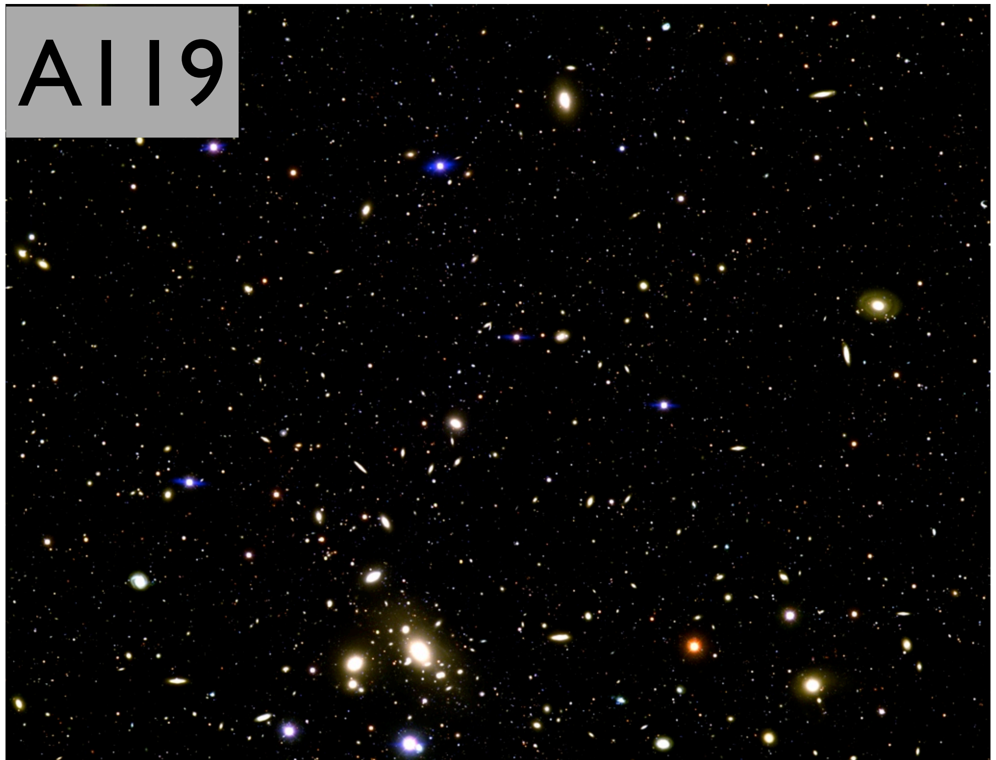

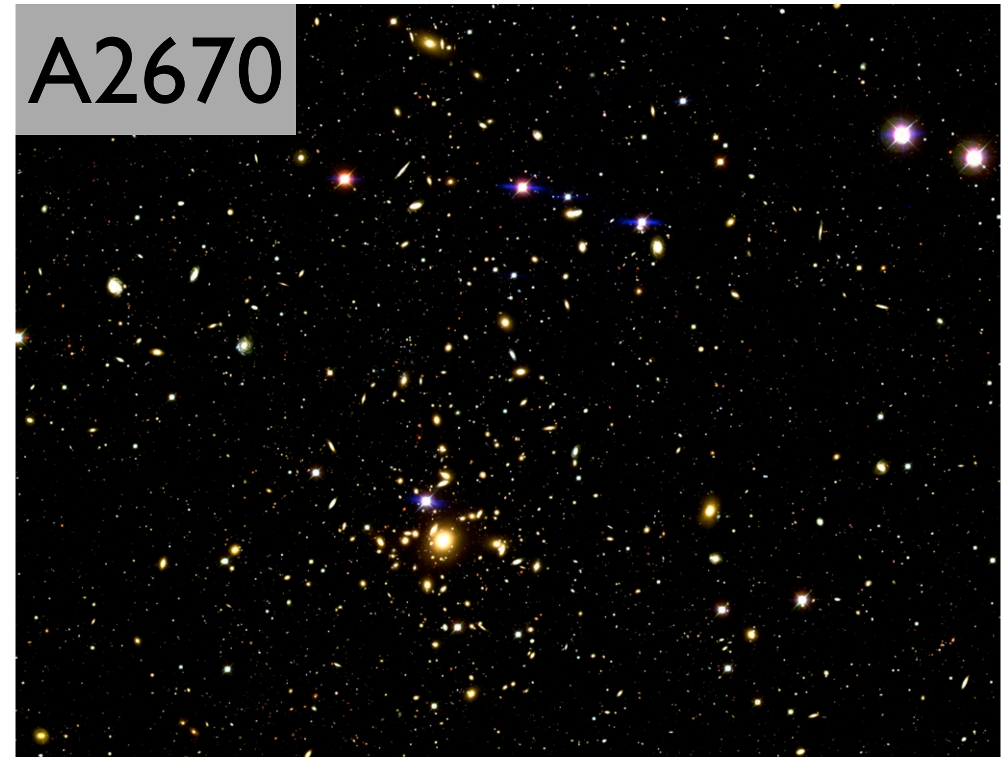

	A119	A2670	A3330	A389
Chandra	45,630s	40,140s	20,140s	-
XMM-Newton	34,992s	33,298s	23,616s	-