Common sense

Local galaxies in massive cluster are Red

because local clusters are
the most evolved system in the Universe

A young galaxy cluster in the old universe

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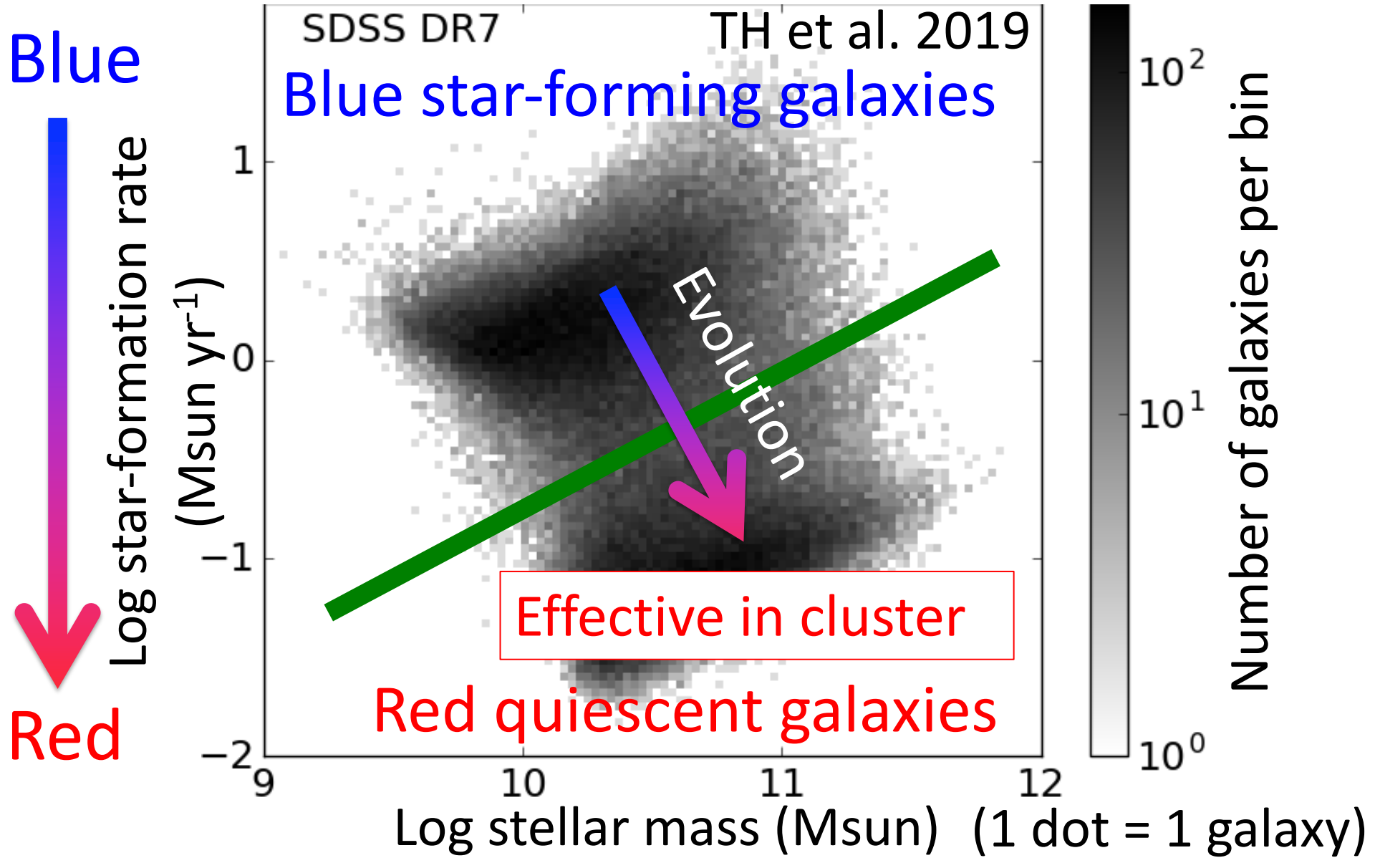
Hashimoto et al. 2019c, Monthly Notices of the Royal Astronomical Society, Volume 489, Issue 2, p.2014-2029

Subaru 20th anniversary 19 Nov.

Outline

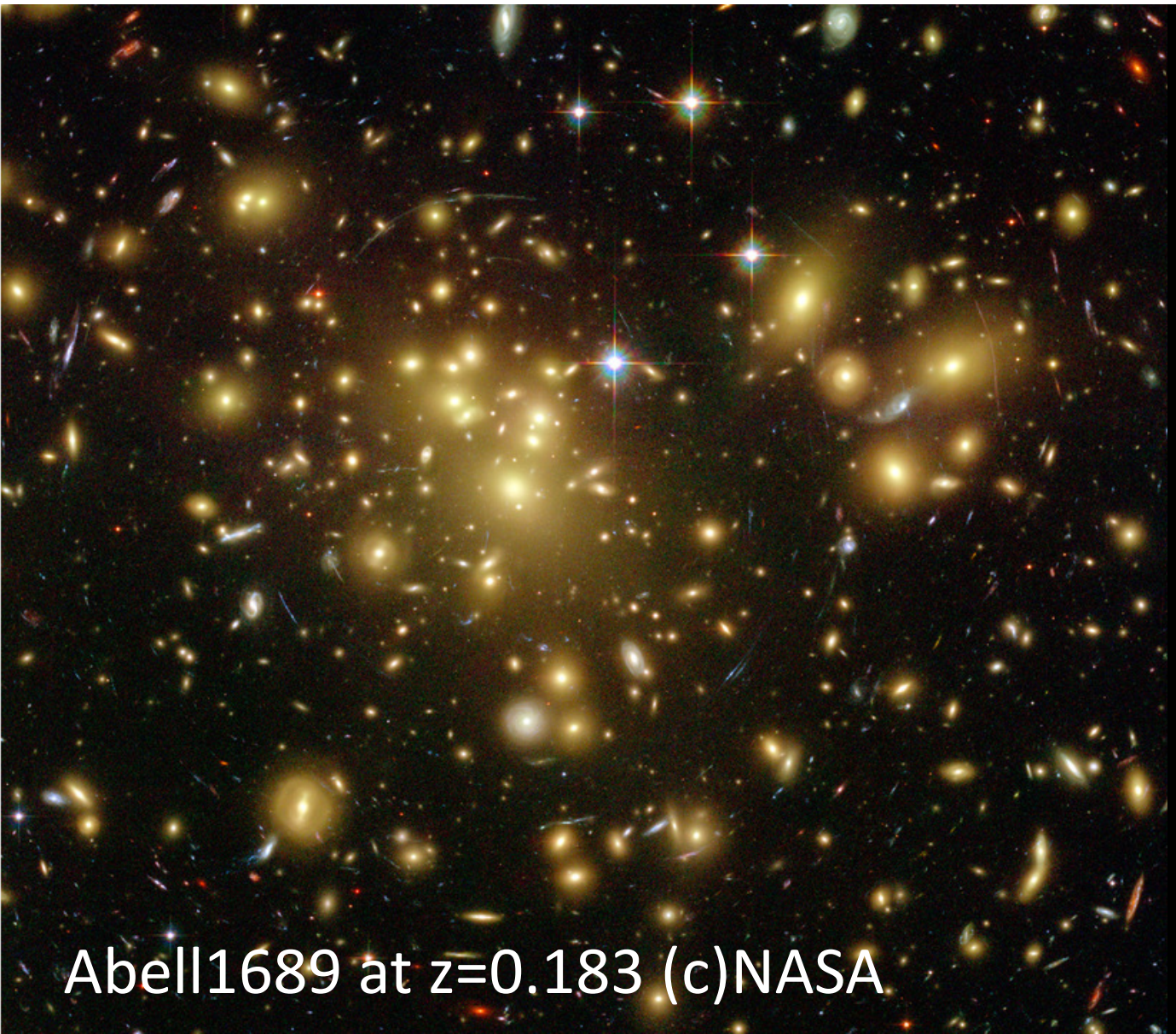
1. Introduction
2. Sample
   Sloan Digital Sky Survey Data Release 7 (SDSS DR 7)
3. Results
   Discovery of a blue cluster (SDSS–C4 3028)
   and its physical properties
4. Discussion
5. Conclusion

Introduction: Galaxy populations Blue/Red



Introduction:

Galaxy population in local cluster=Red



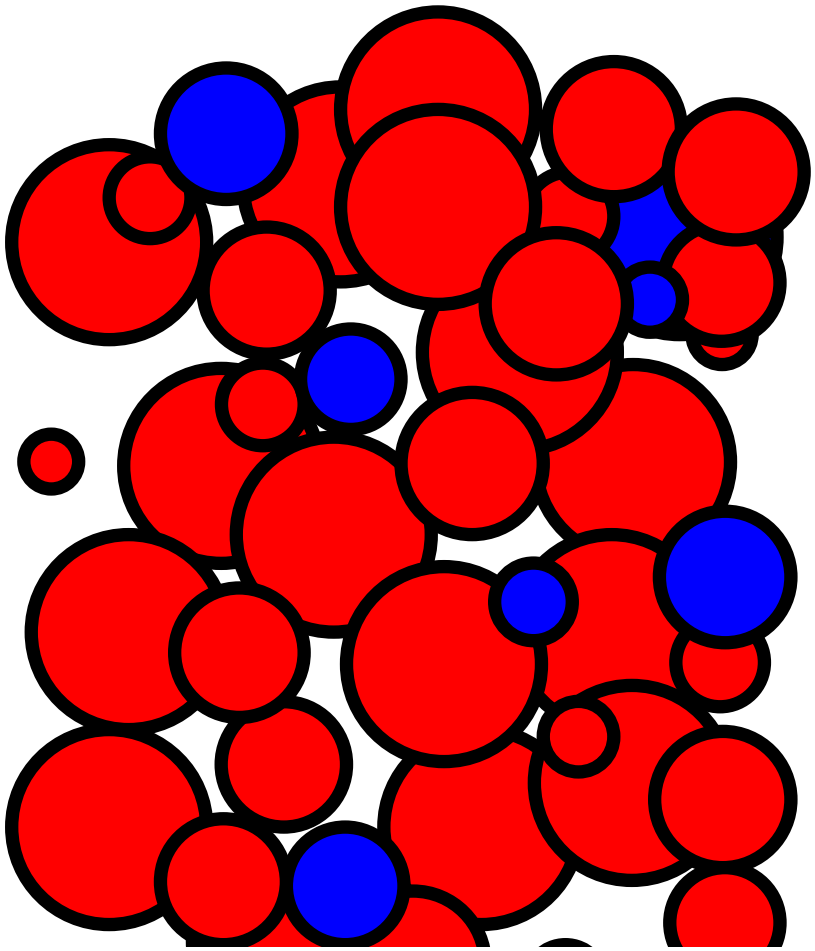
Abell1689 at z=0.183 (c)NASA

Blue fraction ~ 0.2 in local massive clusters

Introduction:

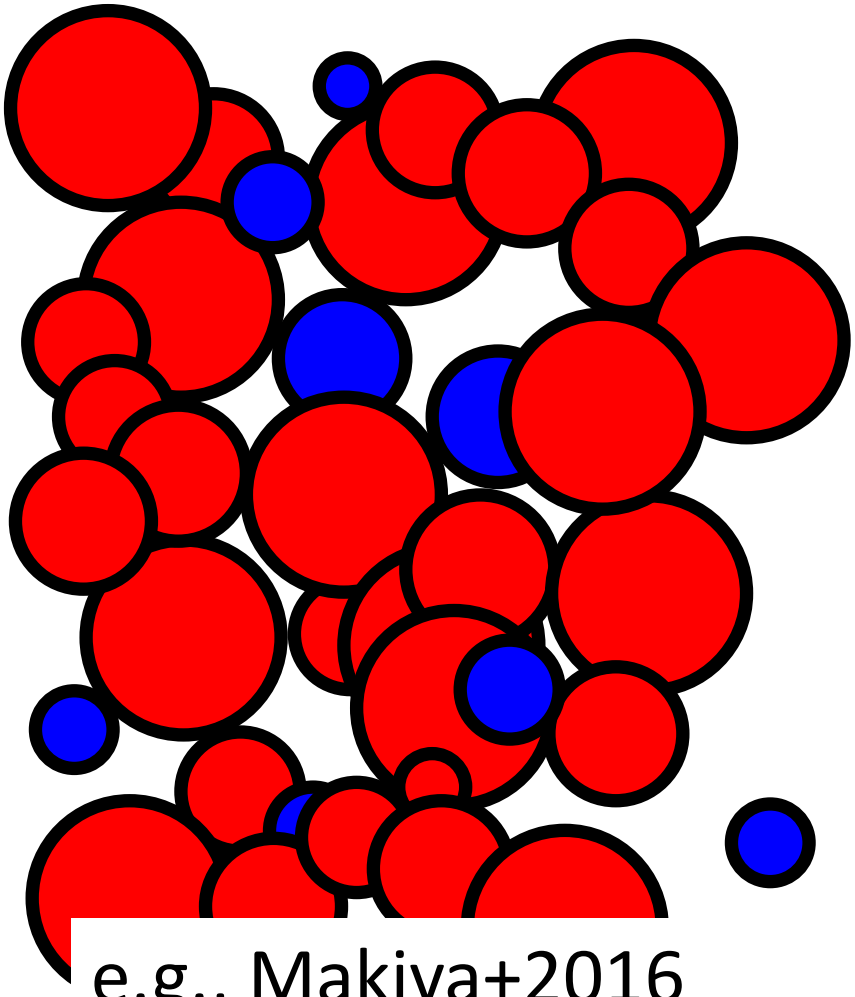
Some "blue clusters" in previous studies

Observation



e.g., Campusano+2018

Model prediction

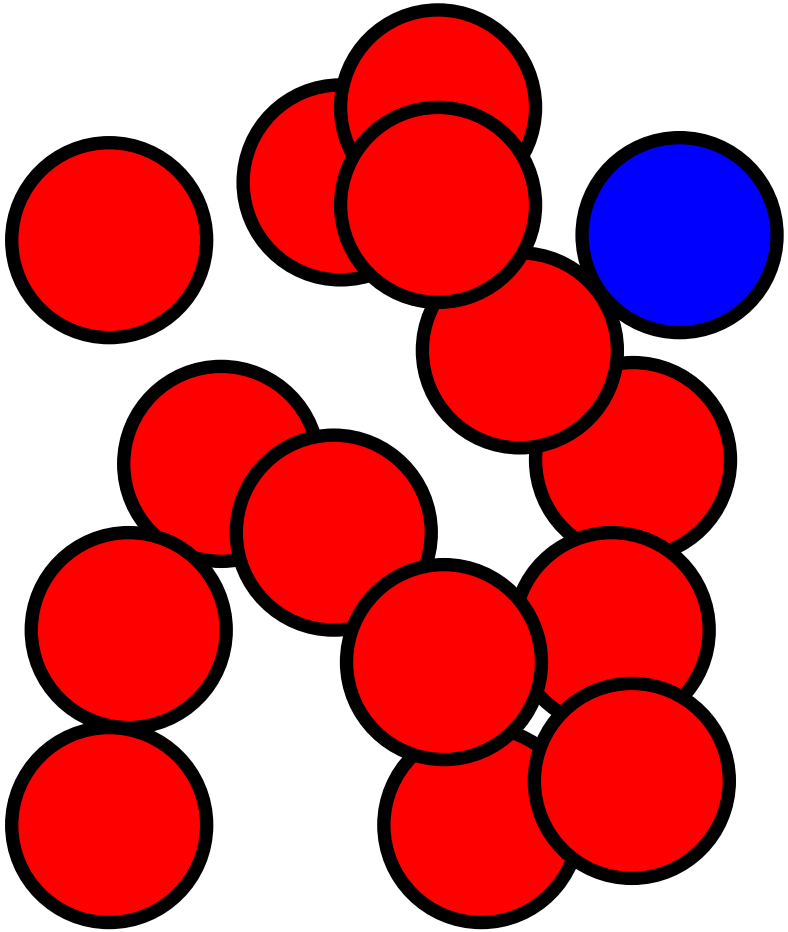


e.g., Makiya+2016

Sample: Sloan Digital Sky Survey

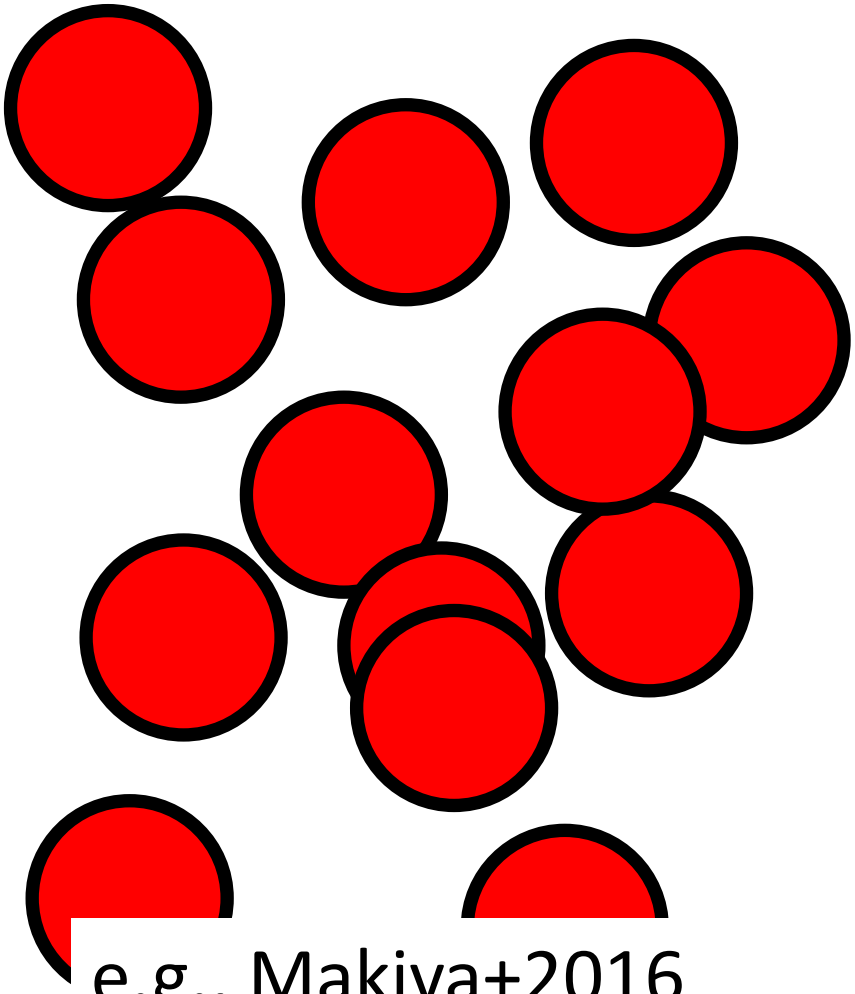
What we did→Only dense/massive clusters

Observation



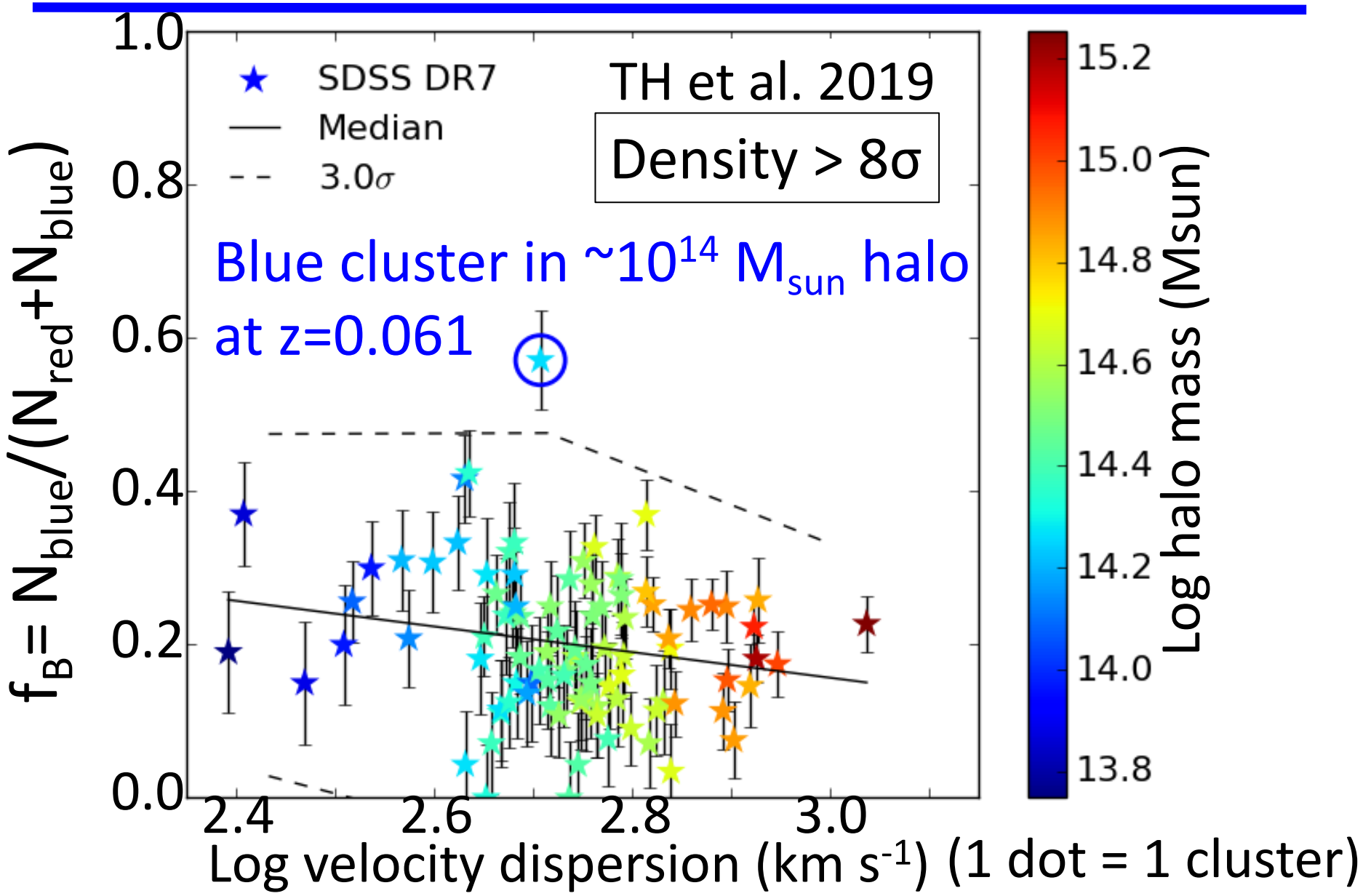
Hashimoto+2019

Model prediction



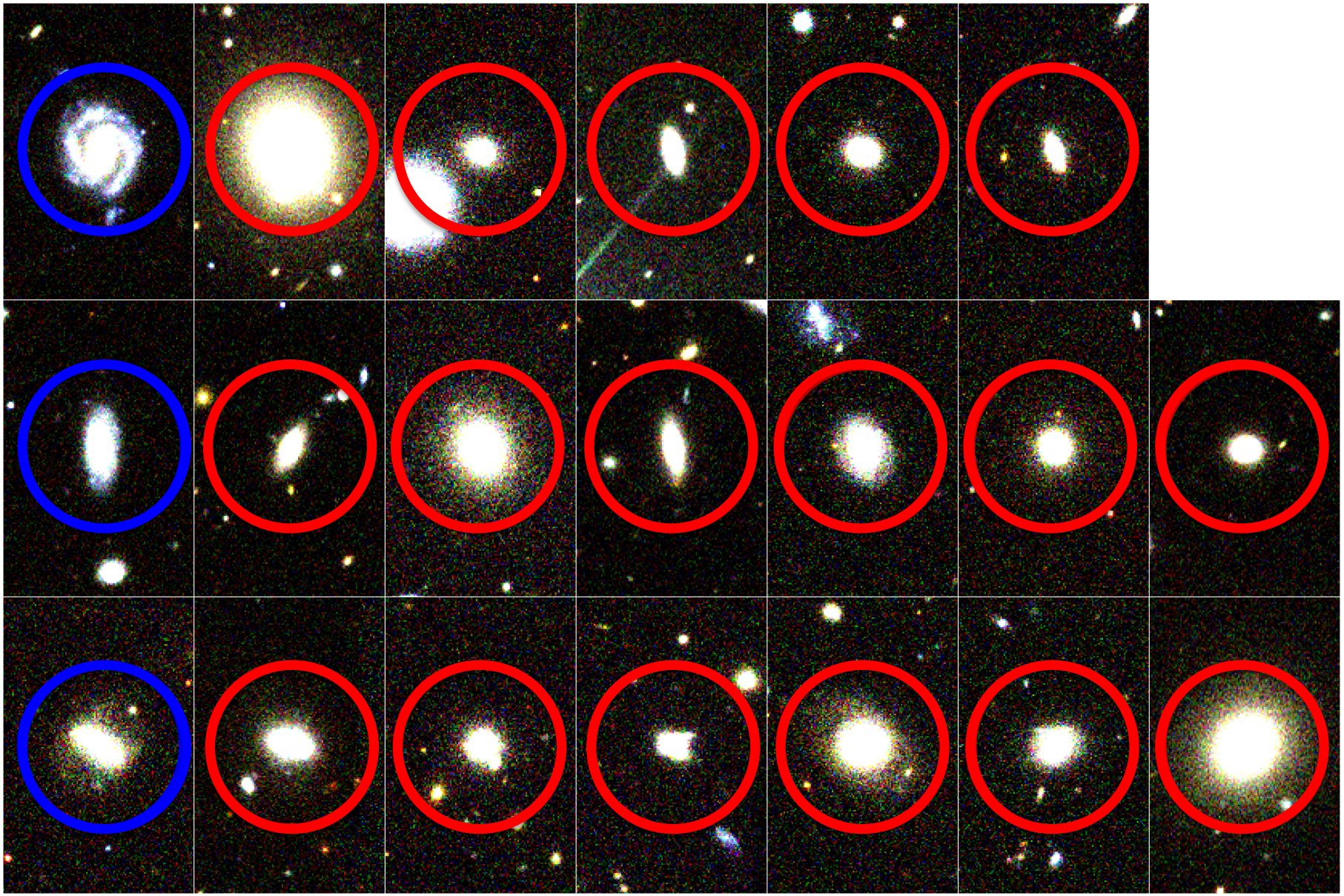
e.g., Makiya+2016

Results: a blue cluster (4σ outlier of f_B)

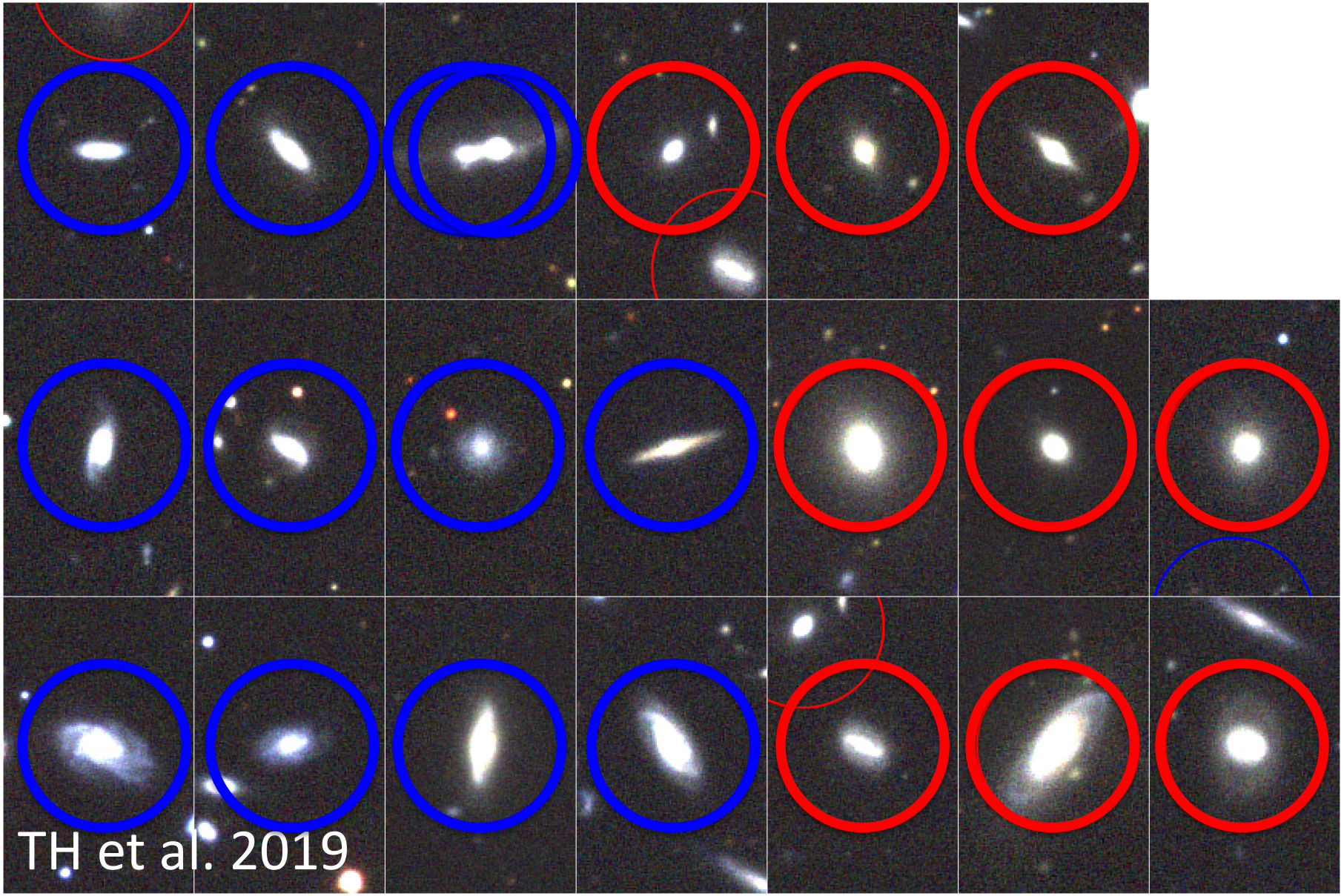


Example: galaxies in a typical cluster

(halo mass and redshift are same as the blue cluster)

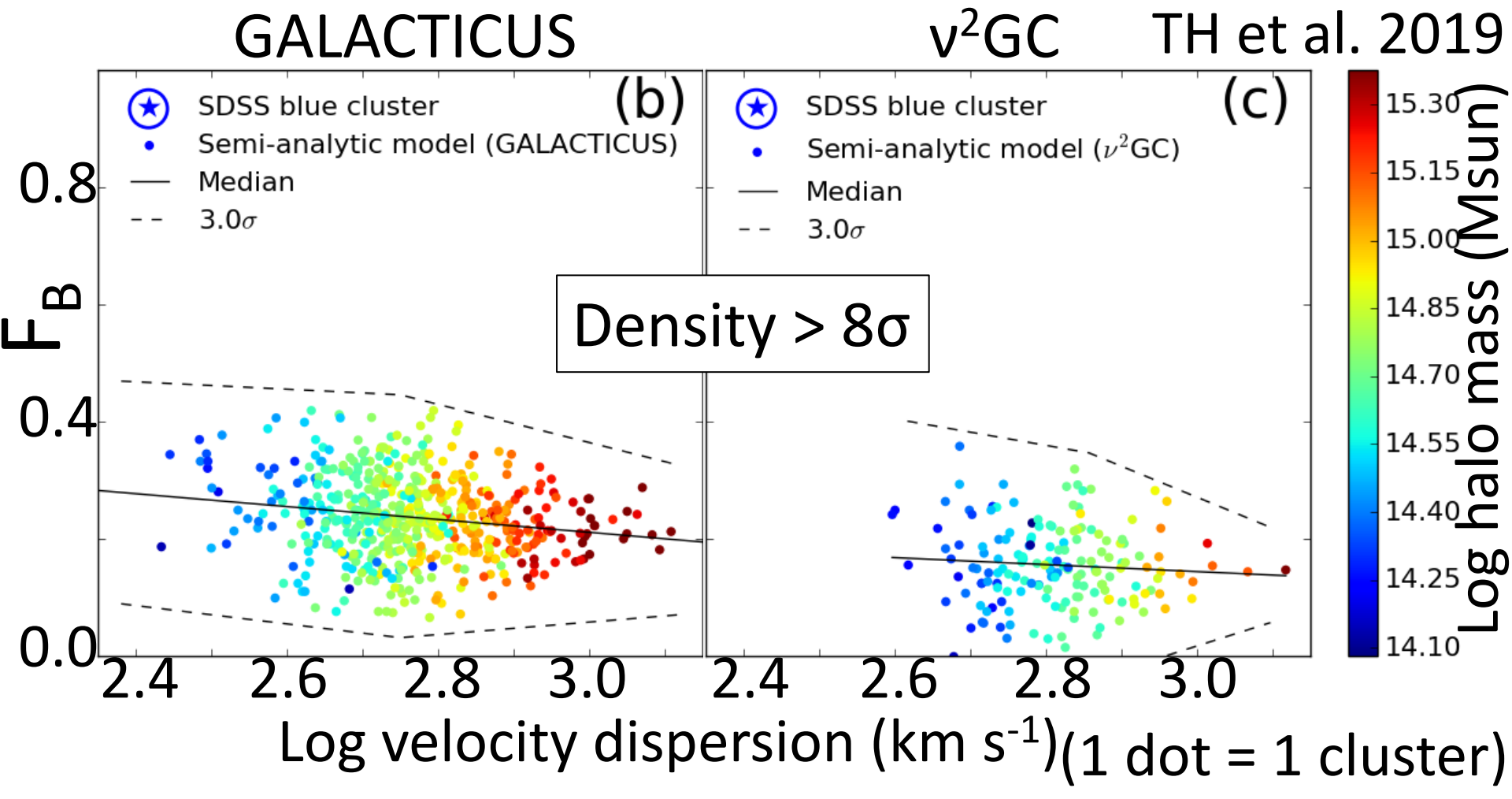


Results: member galaxies of the blue cluster



Results: models do not explain the blue cluster

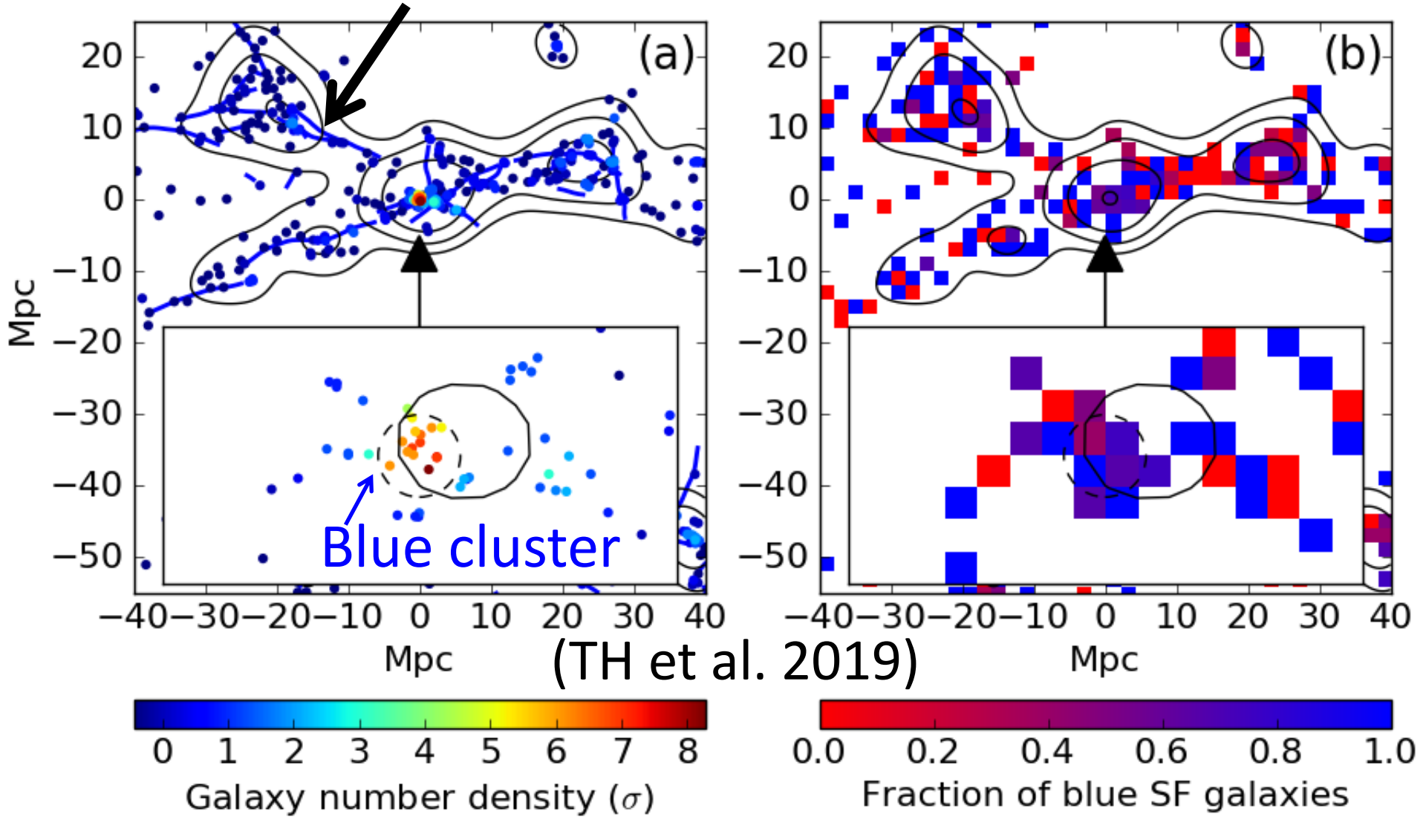
The criteria/analysis of the SDSS sample →applied to semi-analytic models



Results: Filamentary structure

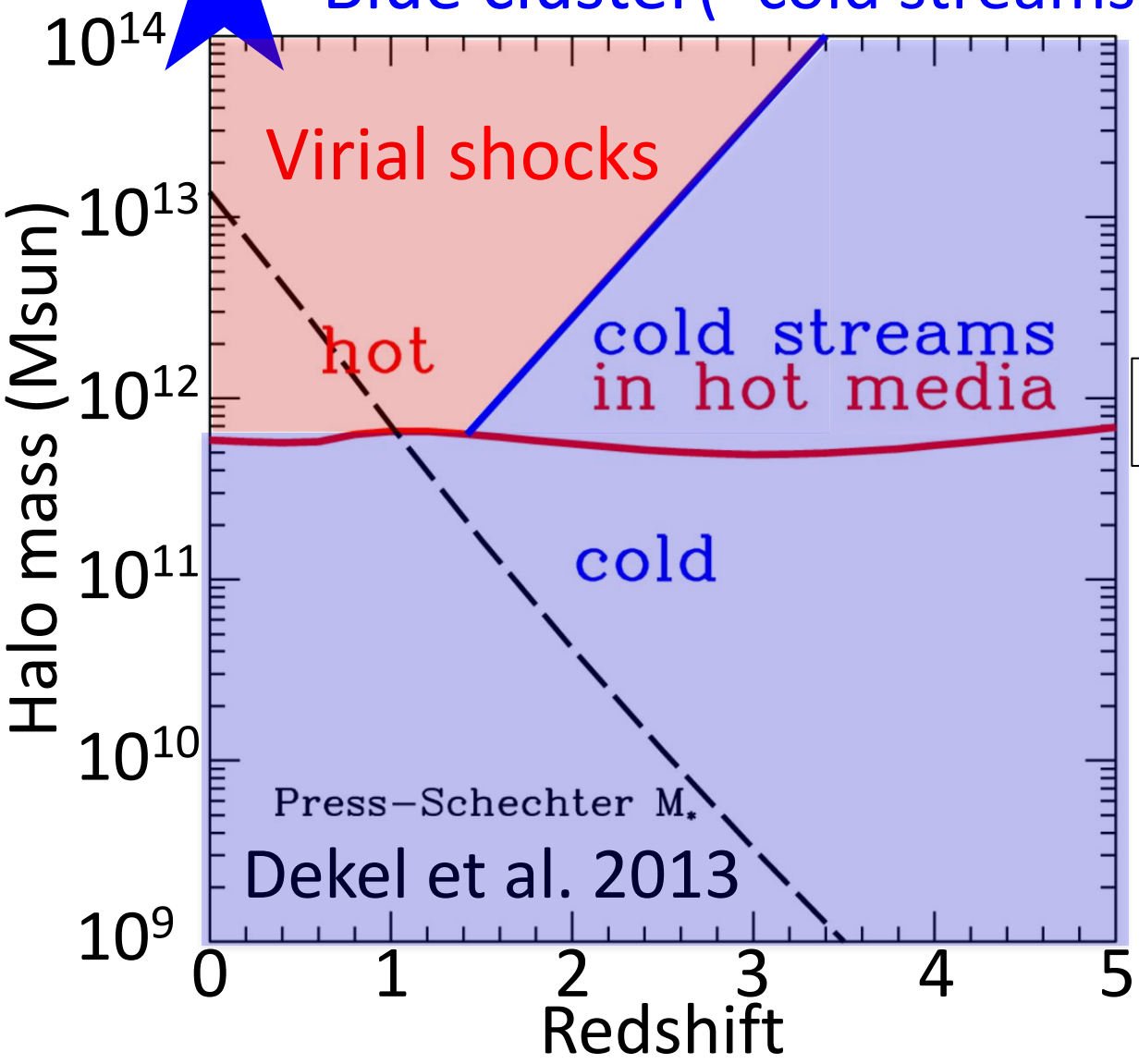
=Cold gas accretion (so called 'cold streams')?

Filament by Temple+2014



(TH et al. 2019)

However 'virial shocks' prevent cold streams



Cold streams survive if $t_{cool} < t_{comp}$

Cold stream | Shock

Mystery

Cold streams already disappeared in simulated local Universes

Conclusion

1. We discovered a blue cluster (f_B=0.57 > 4σ) hosted by a massive dark matter halo at z=0.061 from SDSS DR7.

2. No reasonable explanation for the high blue fraction.

3. The blue cluster challenges the current standard frameworks of the galaxy formation and evolution in the ΛCDM Universe.

Backup slides

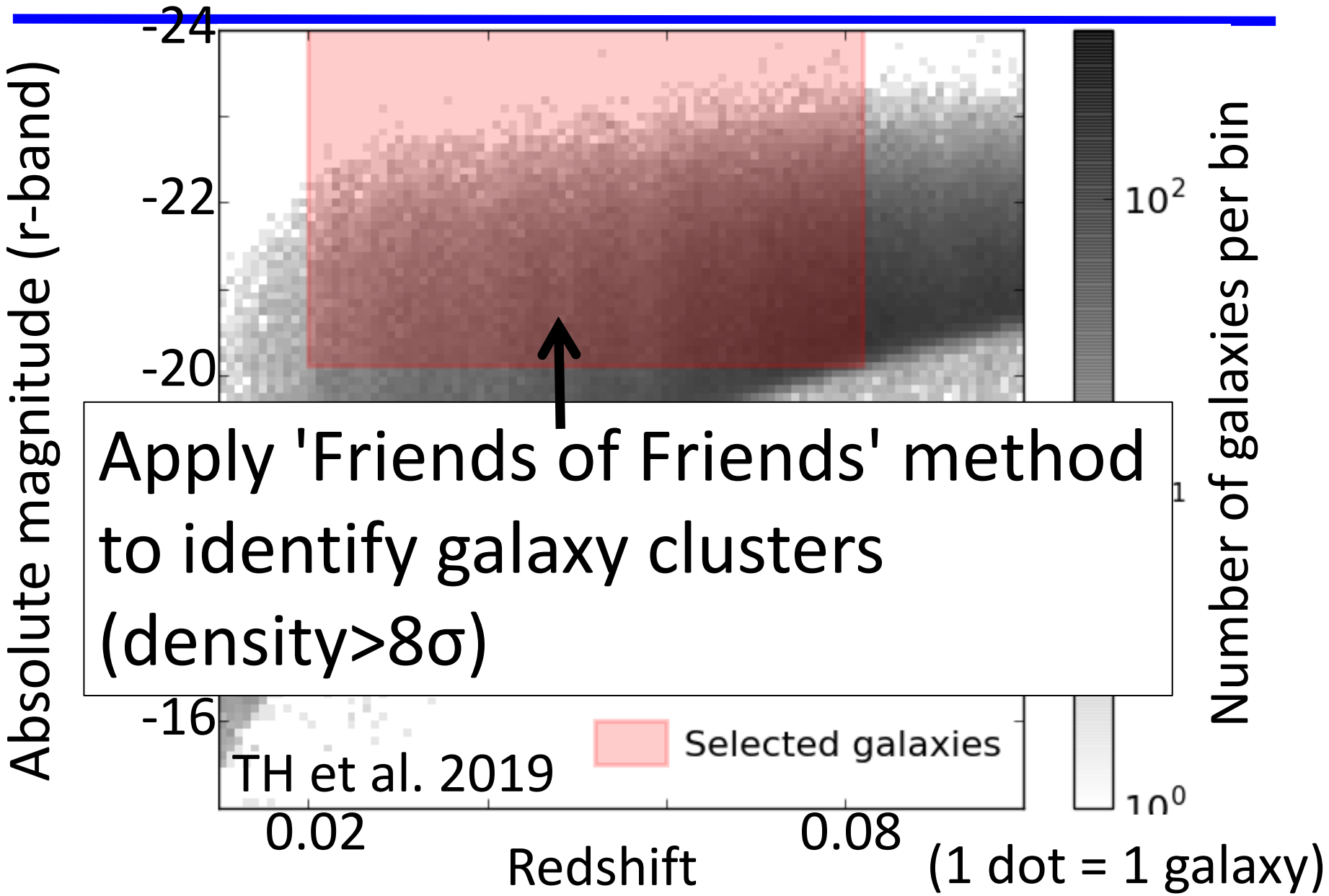
No clear indication of substructure

Dressler-Shectman test

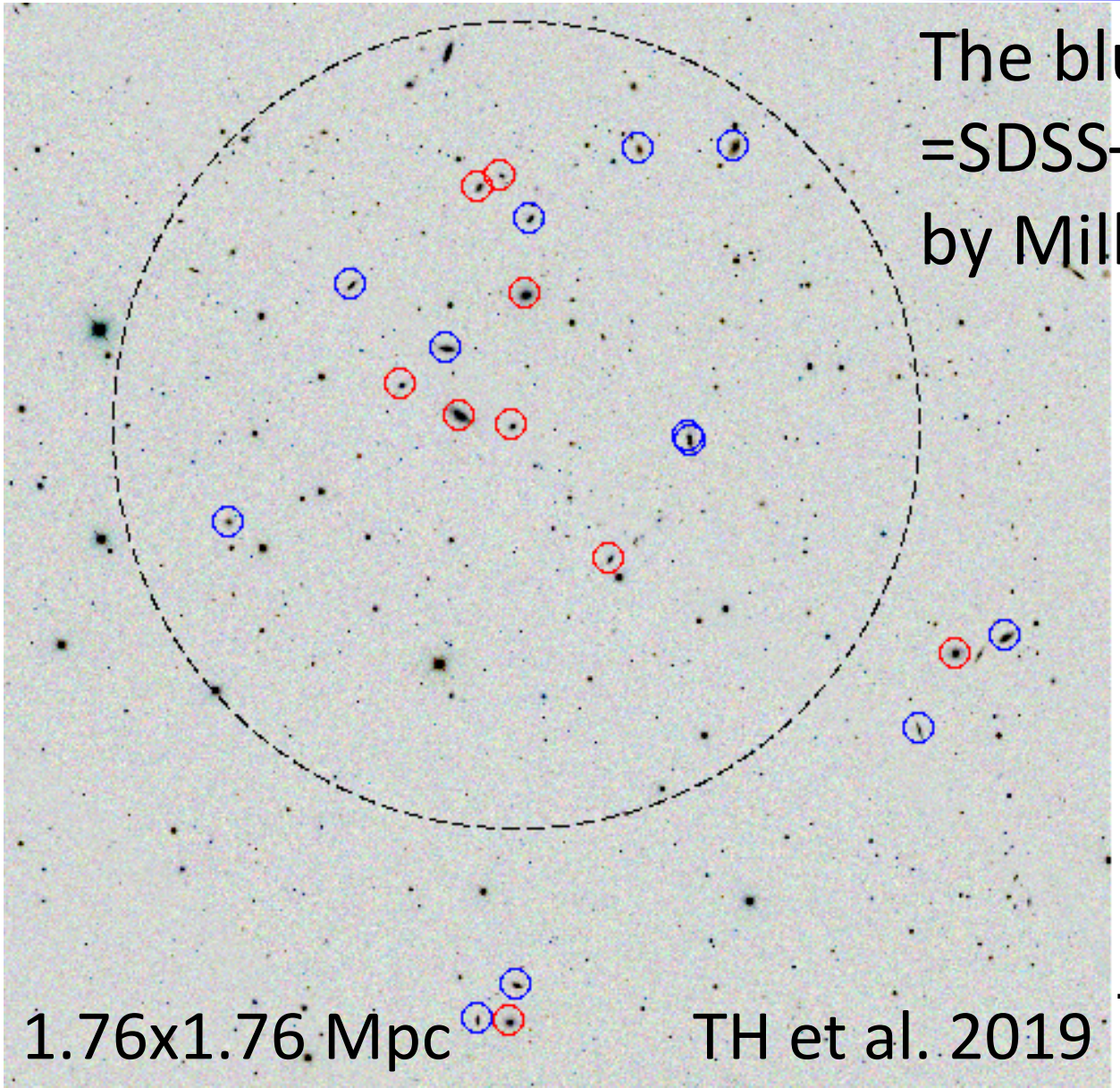
$\Delta/N_{member} < 1$ → No substructure

Δ/N_{member} of the blue cluster is 0.89

Sample: Sloan Digital Sky Survey Data Release 7



Results: a blue cluster (4σ outlier of f_B)



Results: the blue cluster (4σ outlier of f_B)

Physical properties

-Redshift = 0.061

-f_B=0.57 (4σ outlier)

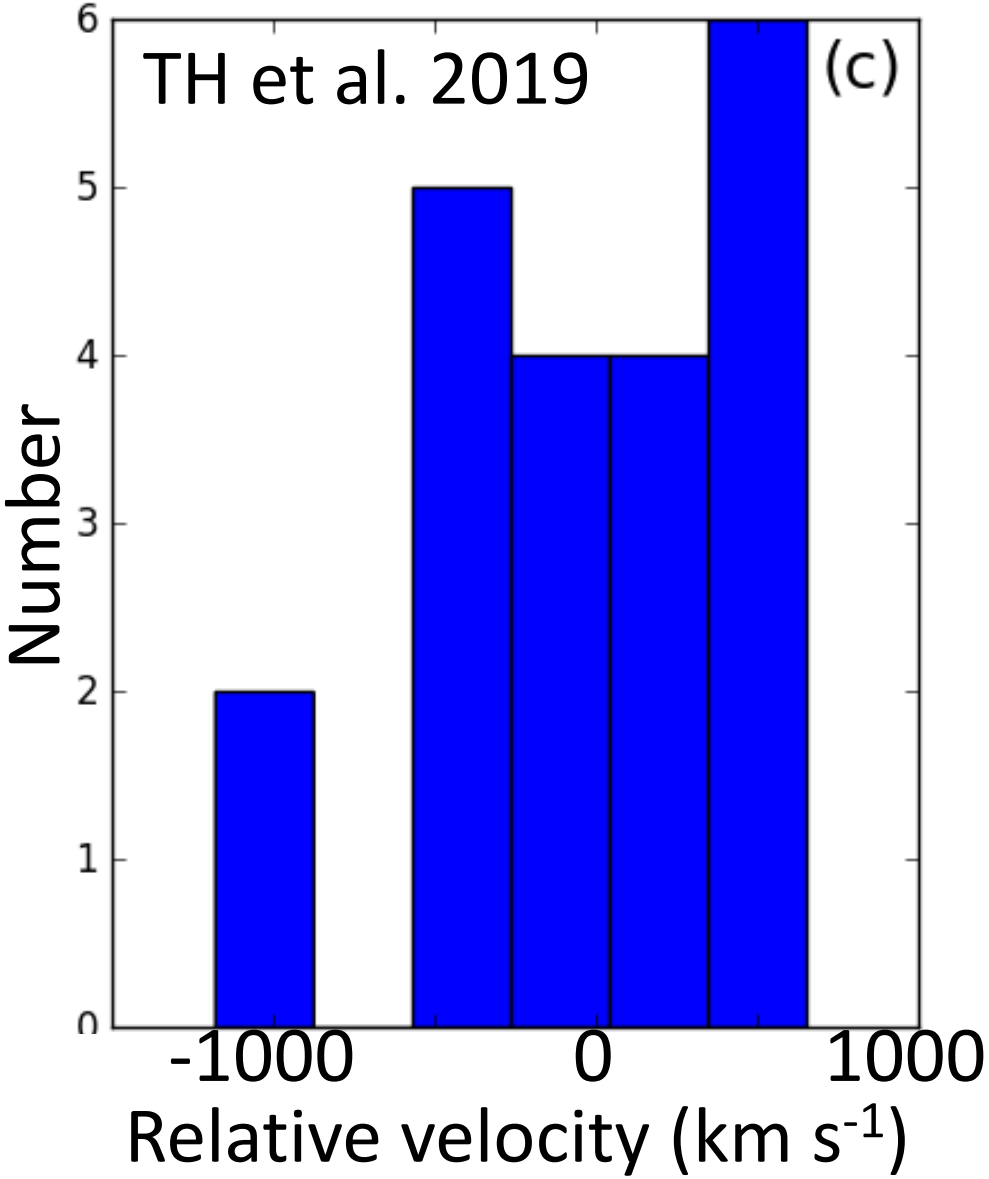
-Velocity dispersion

$$V_\sigma = 510(km/s)$$

-Dark matter halo mass

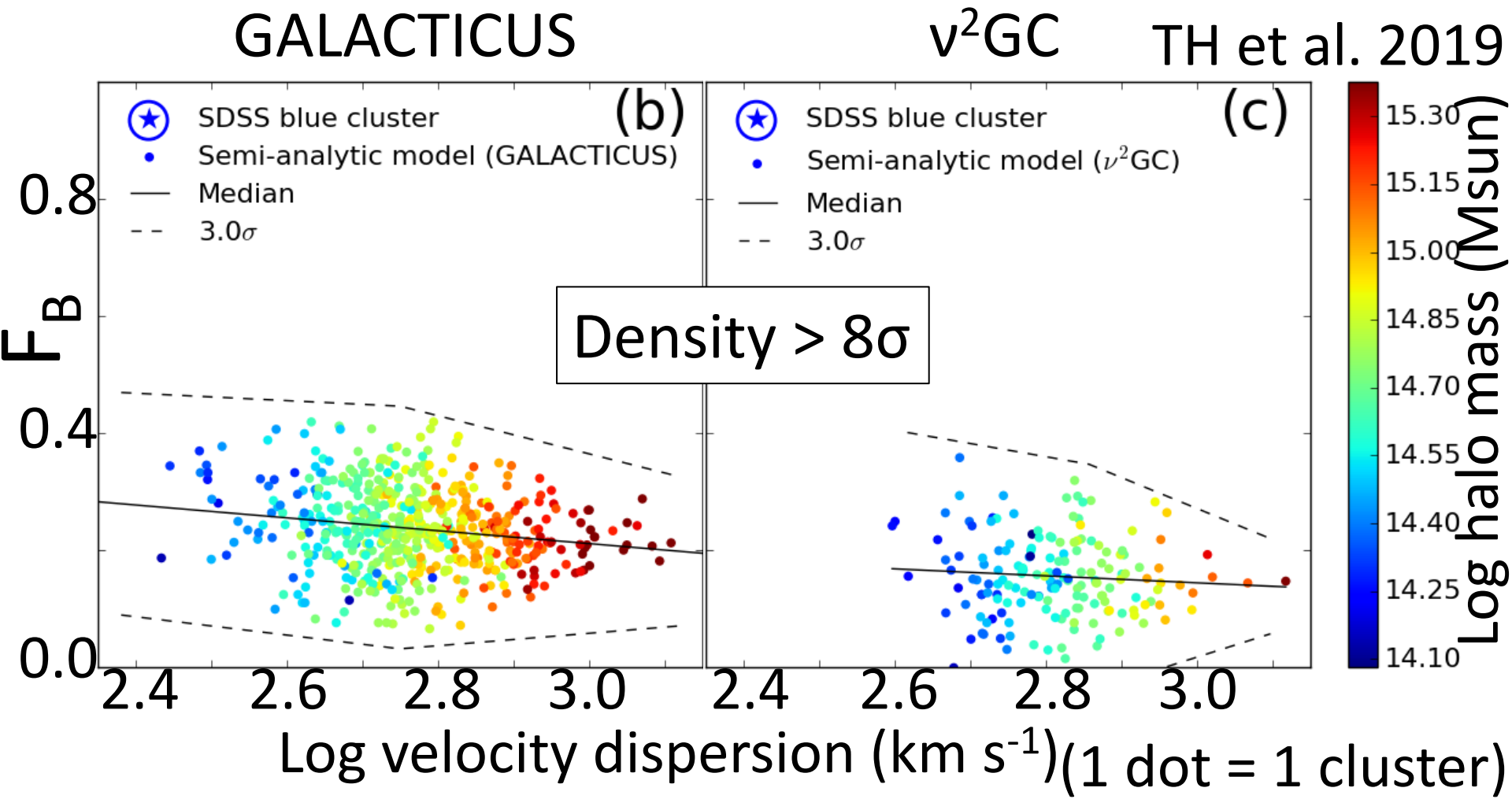
M_{halo} =

$$(2.0^{+2.0}_{-1.4}) \times 10^{14}(Msun)$$

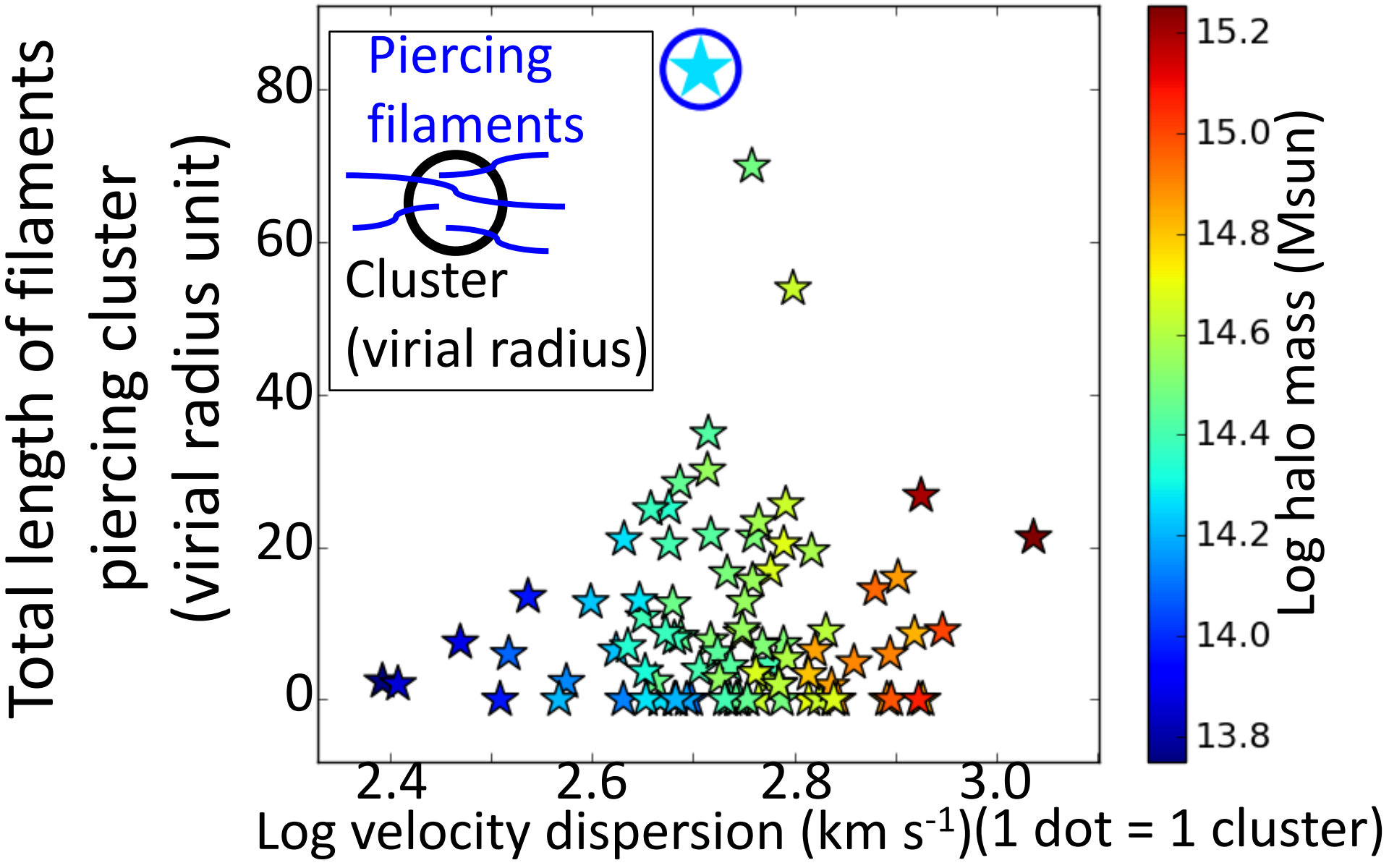


Results: models do not explain the blue cluster

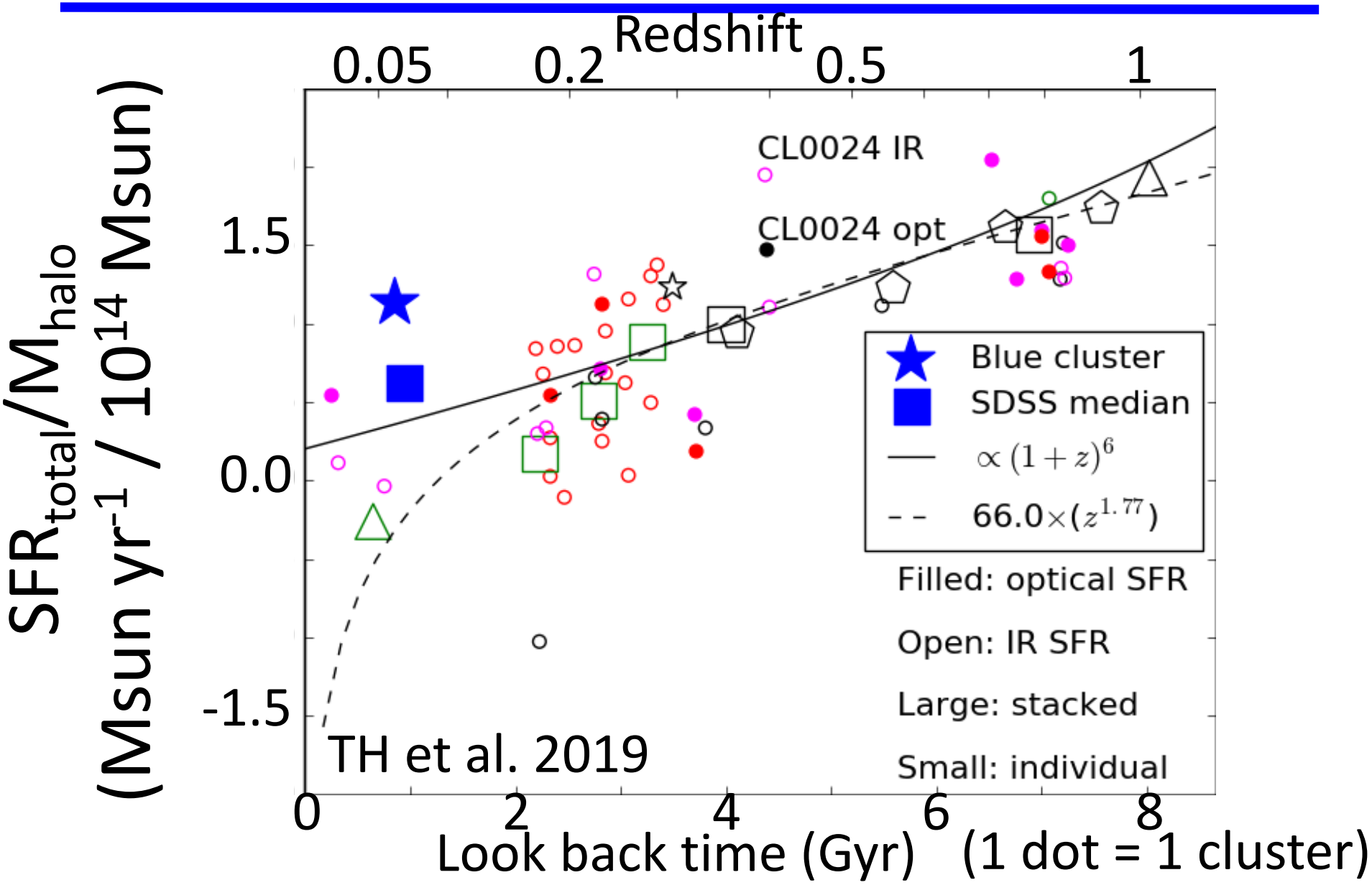
The same criteria/analysis → semi-analytic models



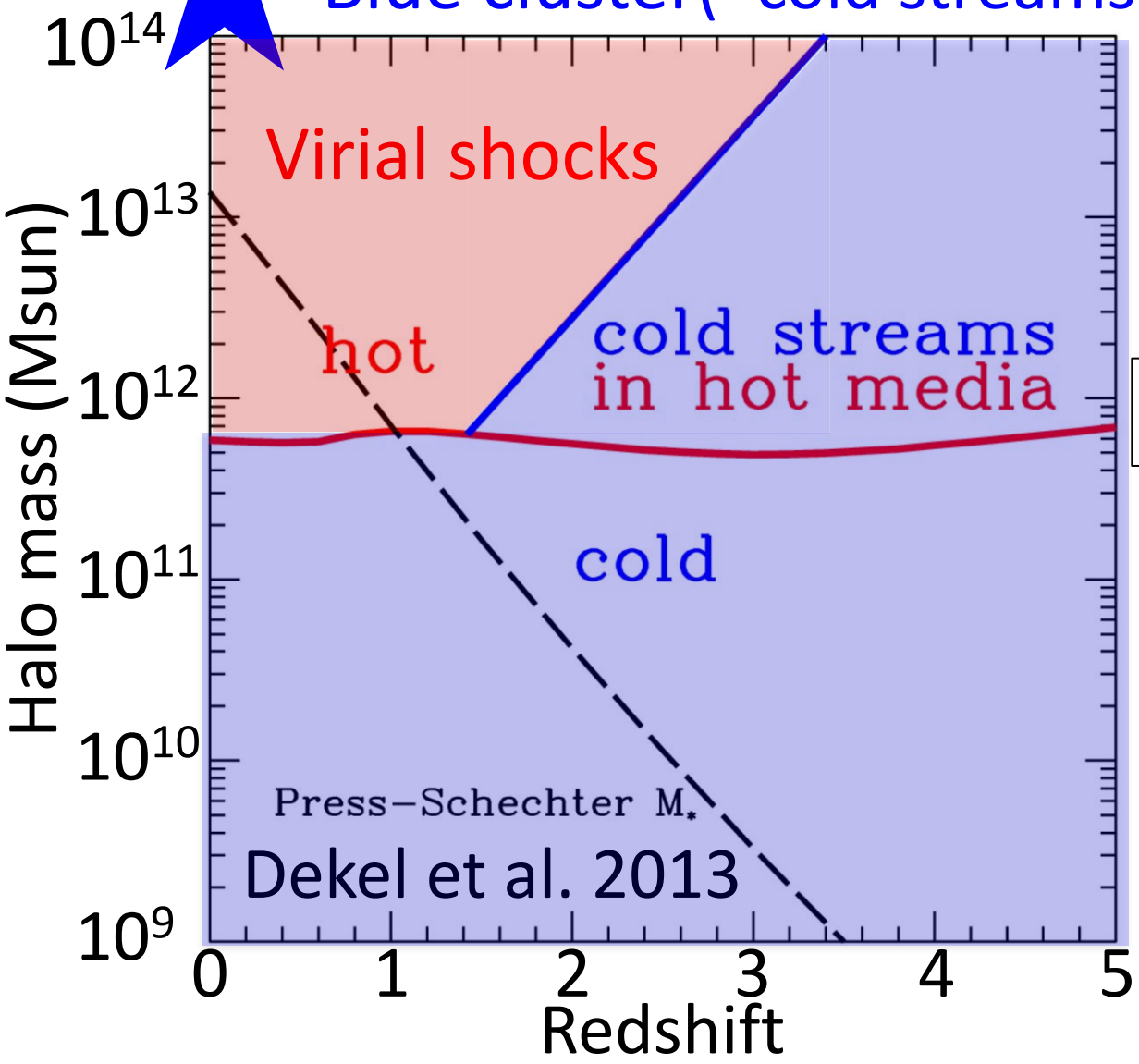
Results: Long filaments (=cold streams?)



Results: SFR/M_{halo} is high (=cold streams?)



However 'virial shocks' prevent cold streams



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Cold stream | Shock

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Conclusion

1. We discovered a blue cluster (f_B=0.57) hosted by a massive dark matter halo at z=0.061 from SDSS DR7.

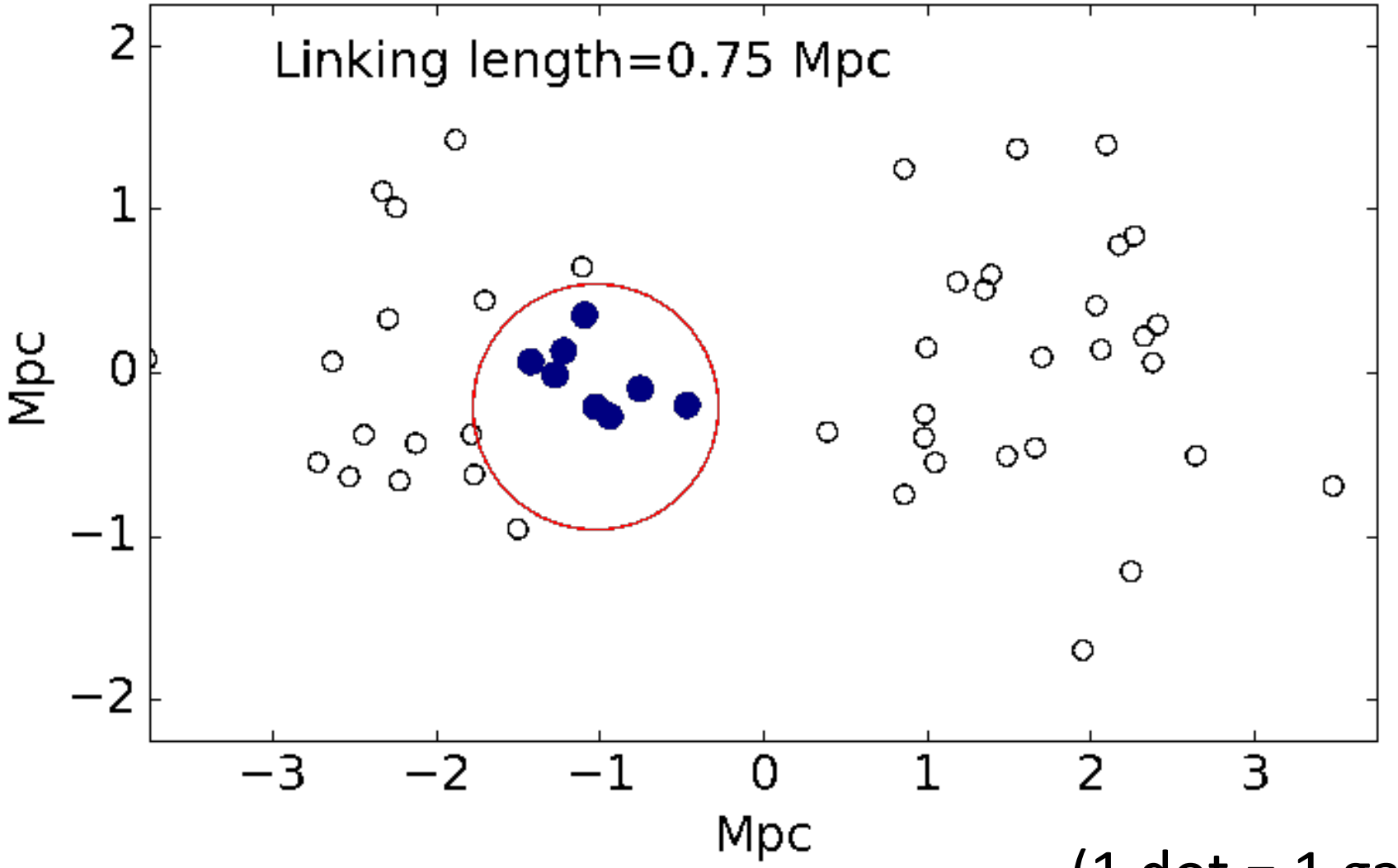
1. The blue fraction is > 4σ beyond the other SDSS clusters and theoretical predictions.

2. Cold streams could be responsible for the blue fraction. However the cold streams have already disappeared in the simulated local Universes.

3. The blue cluster challenges the current standard frameworks of the galaxy formation and evolution in the ΛCDM Universe.

Method: Friends of Friends (for density > 8σ)

Friends = ±0.75Mpc and ±1000km/s



(1 dot = 1 galaxy)

Multi-wavelength data of the blue cluster

Blue cluster (z=0.061)

$$(2.0^{+2.0}_{-1.4}) \times 10^{14} (Msun)$$

-Planck SZ effect counter part → No.
Planck SZ effect completeness
~20% for M_{halo}~10^{14} Msun at z=0.05
(Planck collaboration 2016)

-ROSAT X-ray counterpart → Yes(?)
→ log L_X=42.8 erg/s with SN=1.27 (Wang+2014).
M_{halo}-X-ray luminosity scaling relation predicts
log Lx=43.1 erg/s

No clear indication of substructure

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