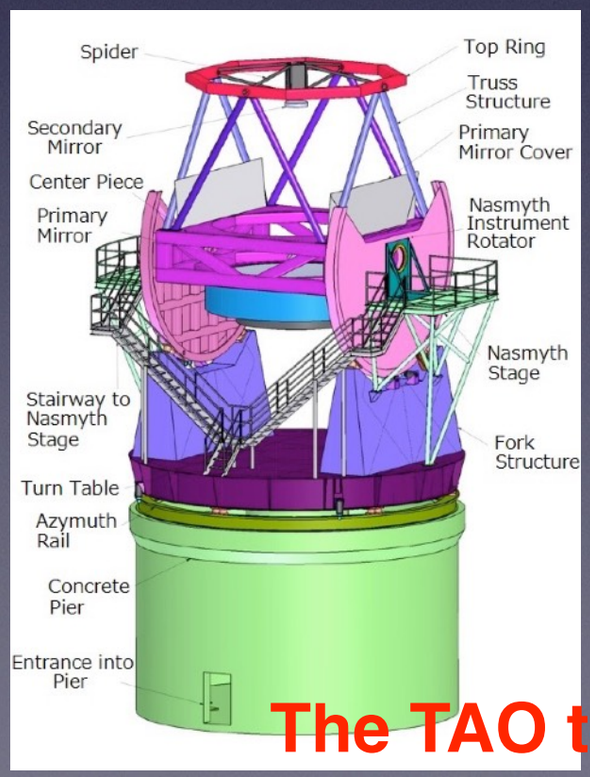
Environmental effects on massive galaxy formation in a distant X-ray cluster at z=2.51

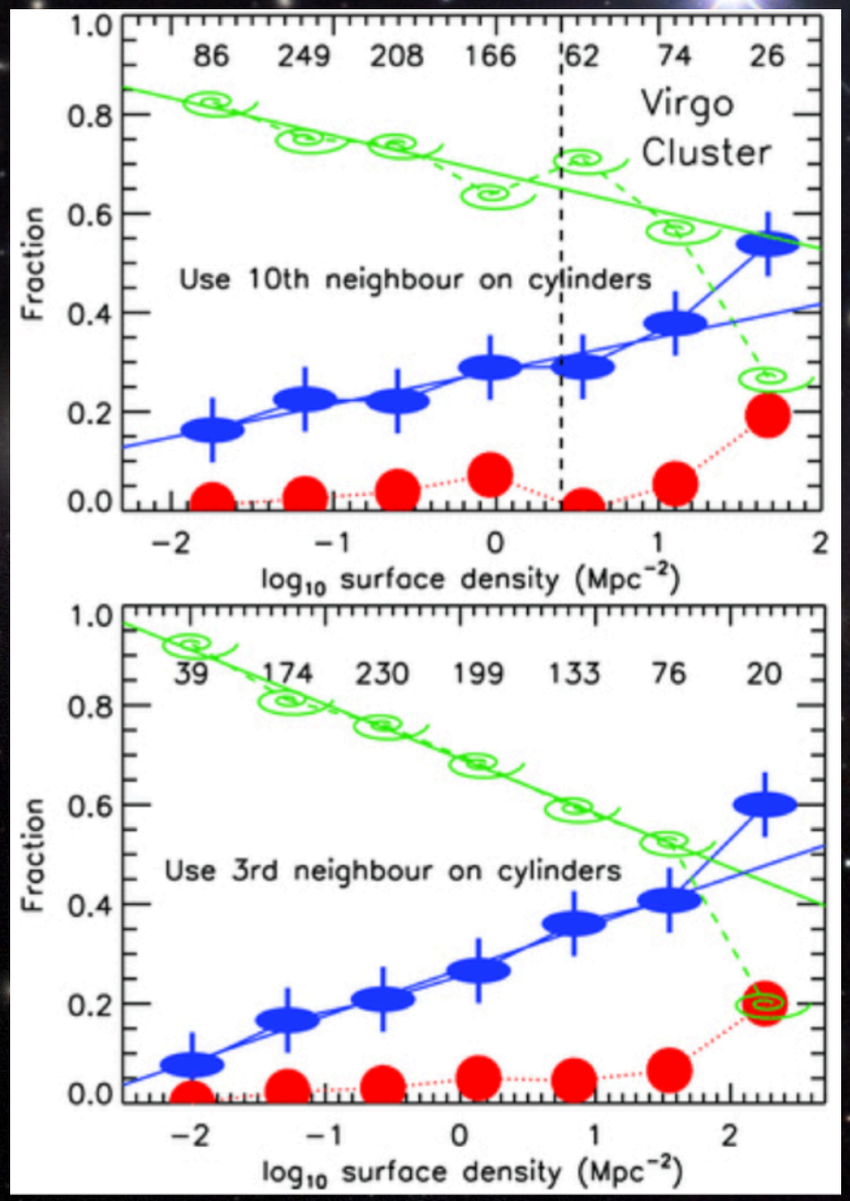
Tao Wang (U. Tokyo/NAOJ)



The TAO telescope

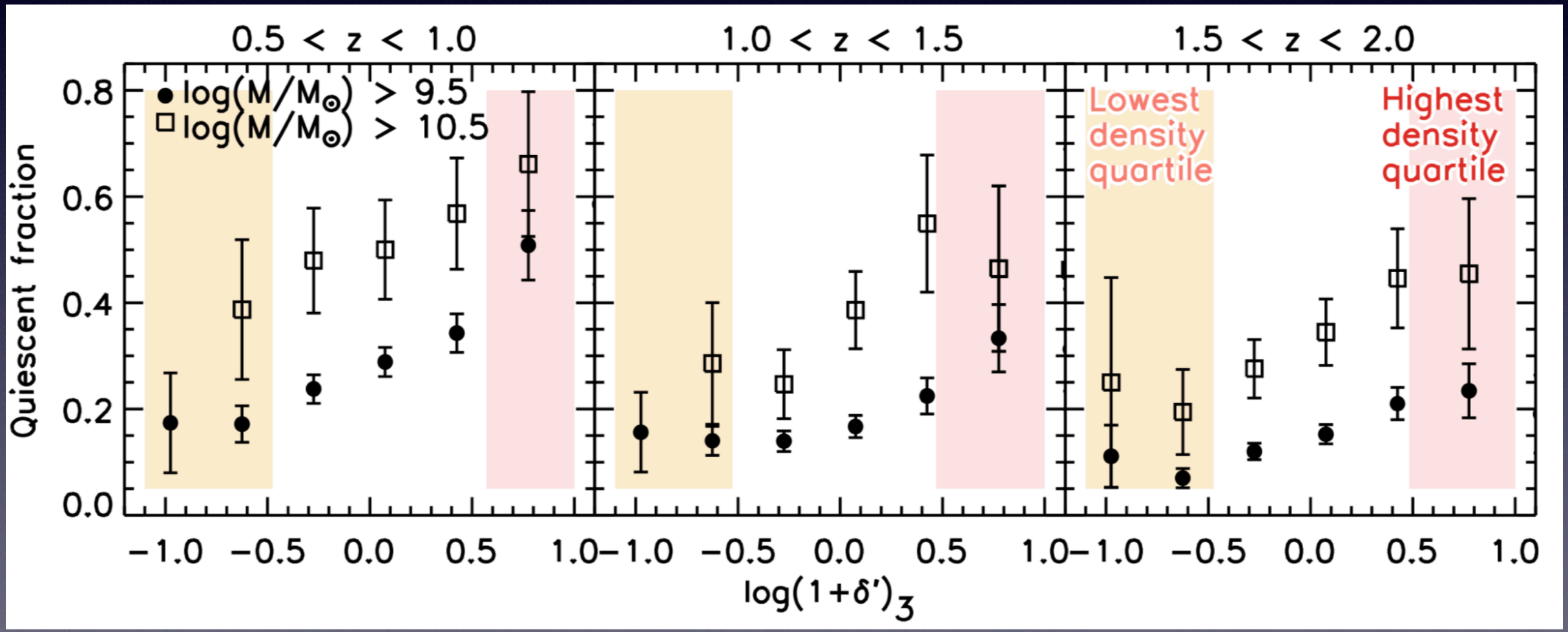
Galaxy evolution workshop@IPMU, 2019/06/07

Environmental effects on galaxy formation and evolution



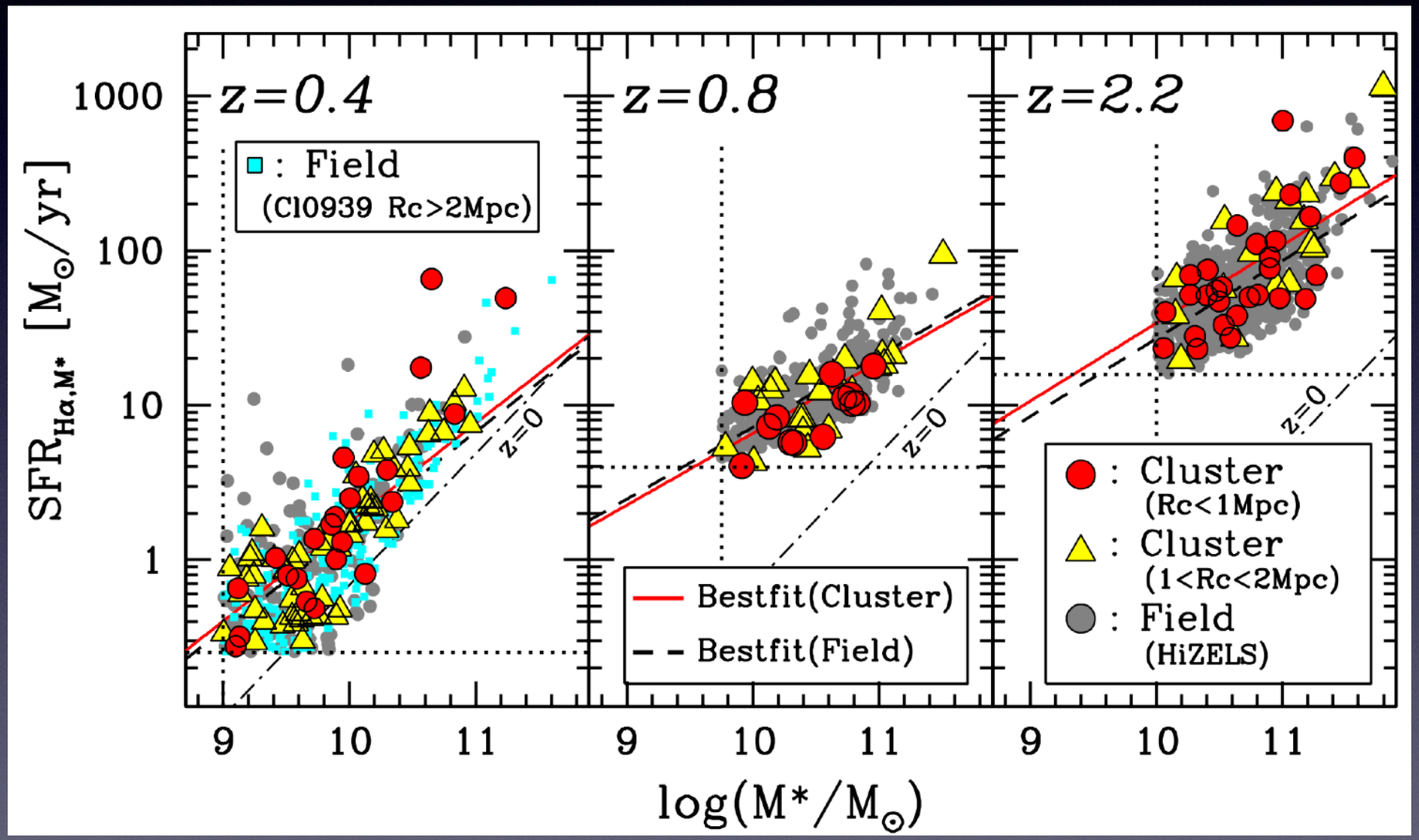
Morphology-density relation (Cappellari+2011)

Increasing quiescent fraction as increasing local density up to z~2



ZFOURGE survey, Kawinwanichakij+2017

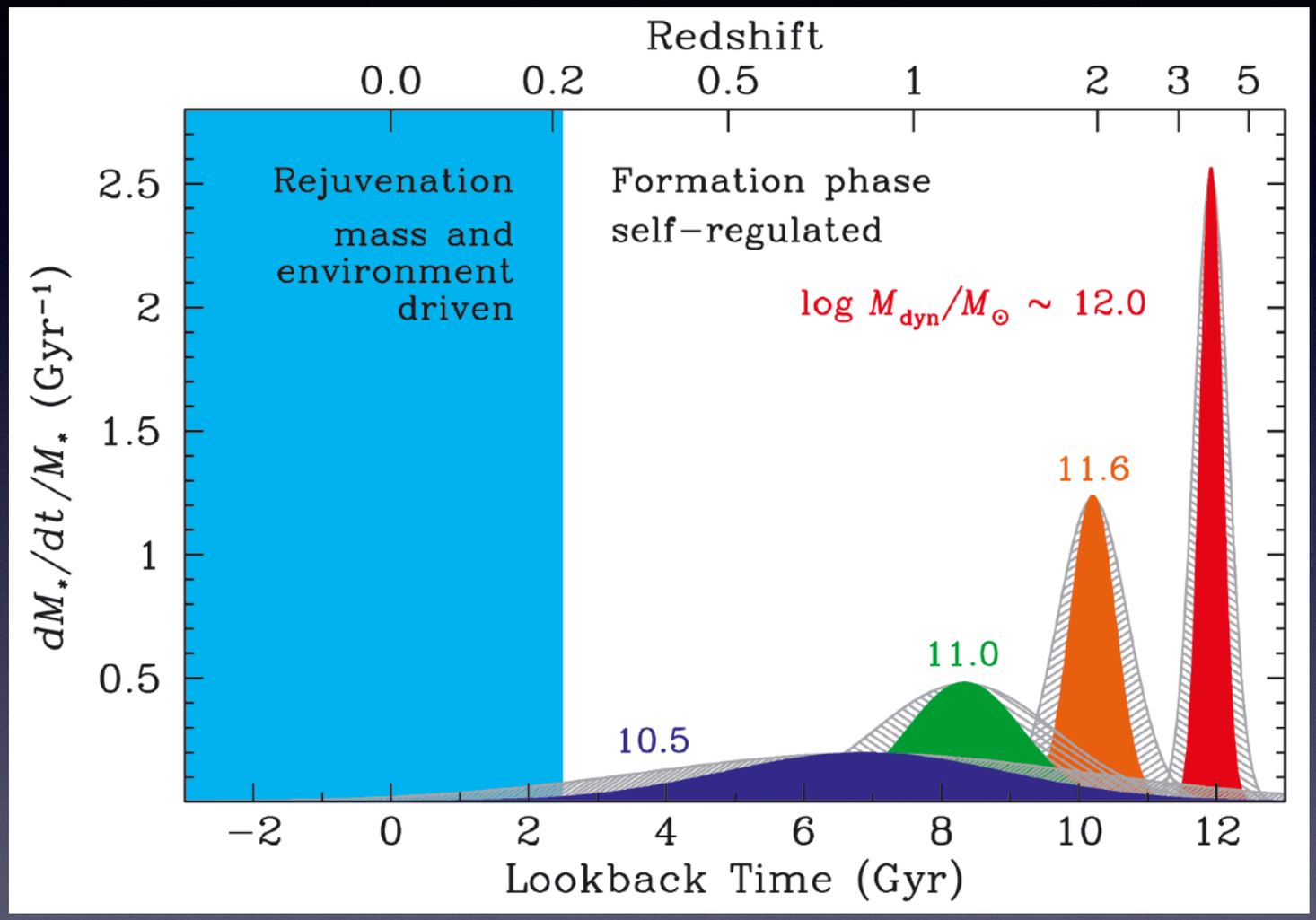
(Minor) Environmental effects on star formation properties of galaxies up to z~2



"MAHALO-Subaru" ,Koyama+2013

Indications: the quenching processes must be quite **rapid** in clusters.

Star formation history of massive galaxies



Thomas+2010

The more massive galaxies assembled their masses at earlier times.
Large galaxies die early.

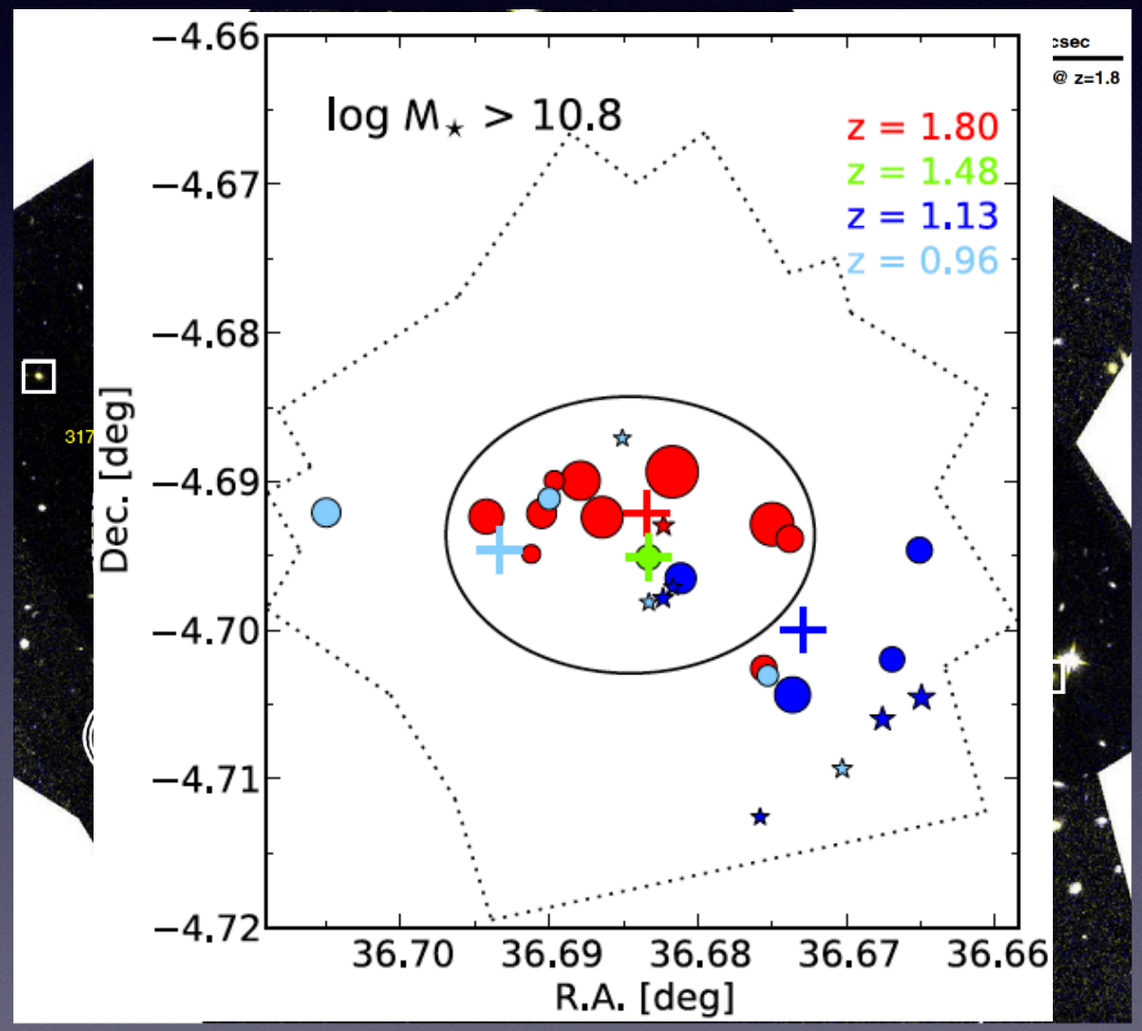
To uncover the role of (densest) environment in shaping galaxies:

hunting for high-z clusters

z~0

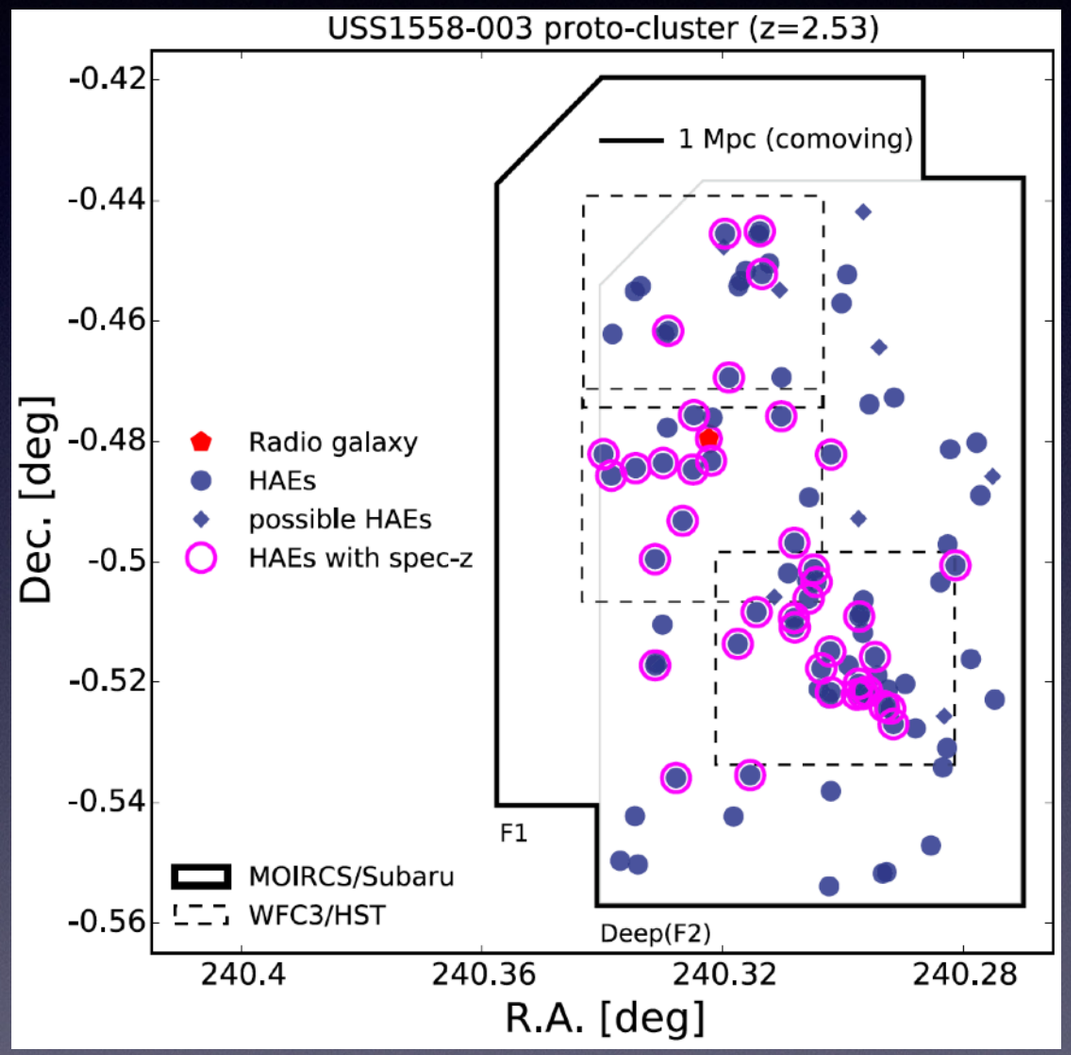
The Hubble Space Telescope Treasury
Survey of the Coma Cluster of Galaxies

z~2

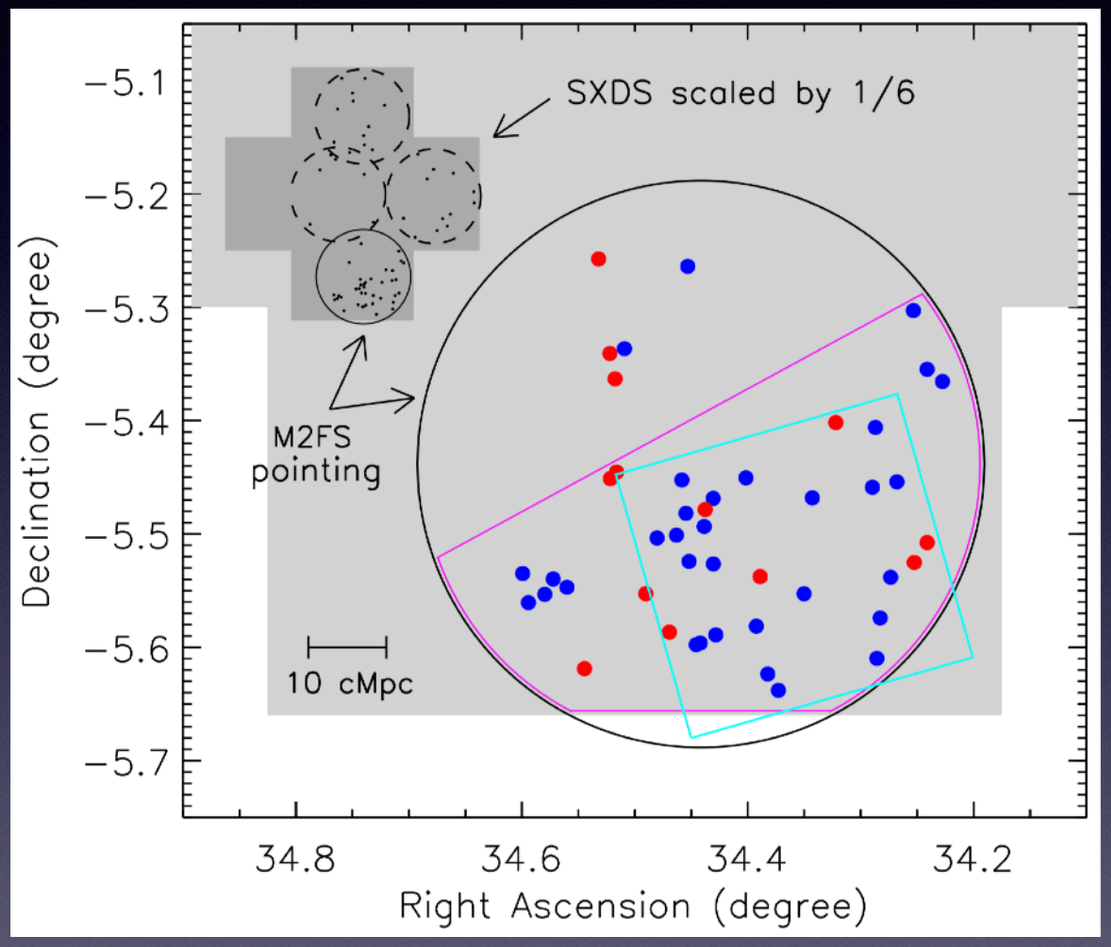


JKCS 041@z=1.803
Newman+2014

A large number of protoclusters at high redshift



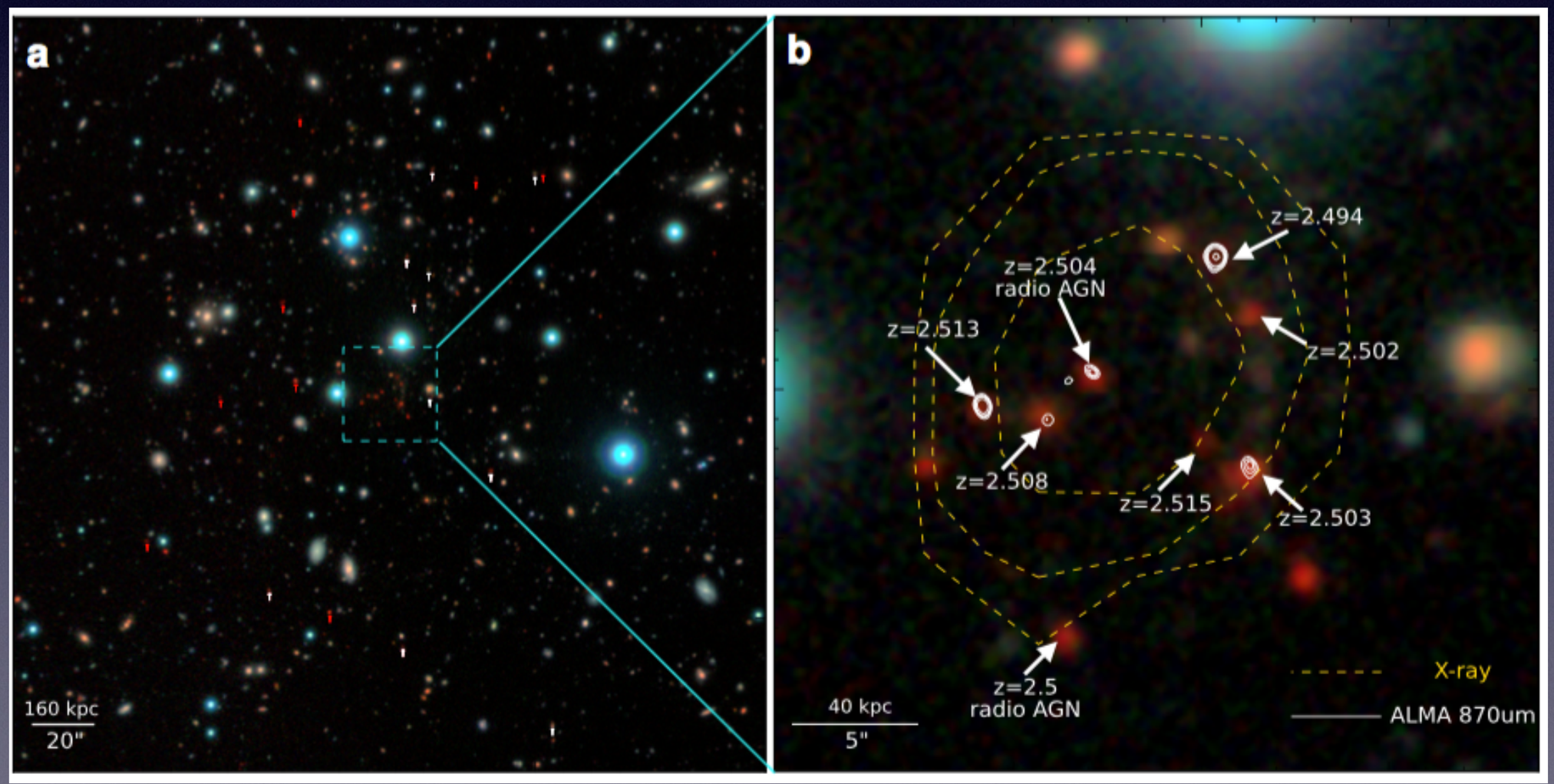
z=2.53, Hayashi+2016



z=5.7, Jiang+2018, Nature astronomy

low galaxy densities;
extended structure; not yet collapsed

J1001: A starbursting, X-ray cluster at z=2.51, the furthest ever known



Wang, T., et al. 2016, ApJ, 828, 56

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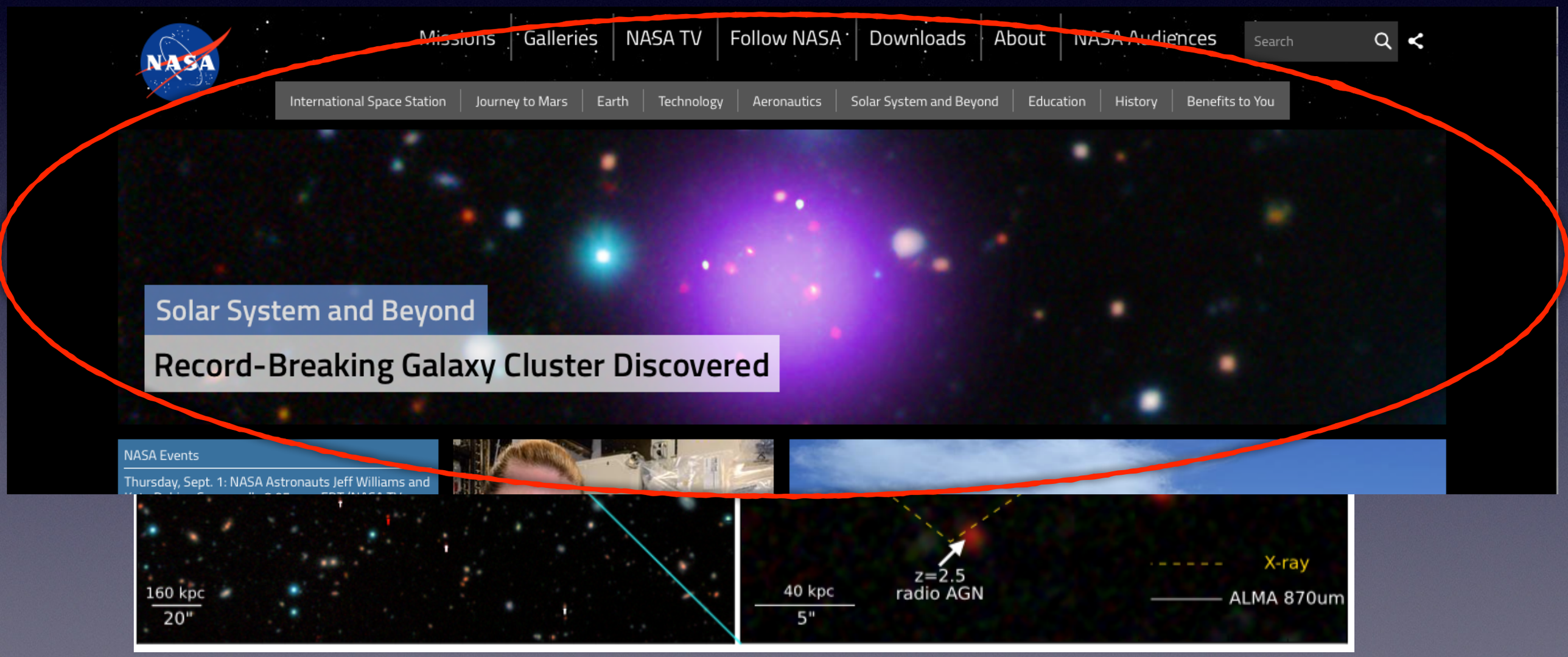


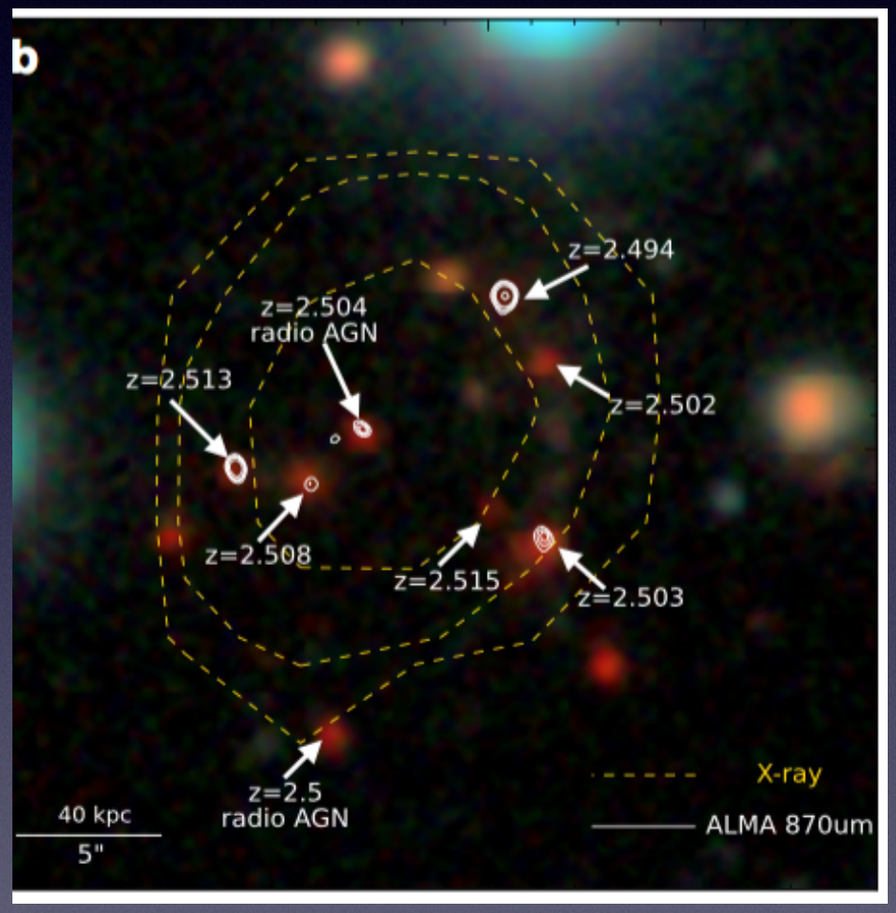
Wang, T., et al. 2016, ApJ, 828, 56

J1001 bridges the gap between mature clusters and protoclusters

z=0

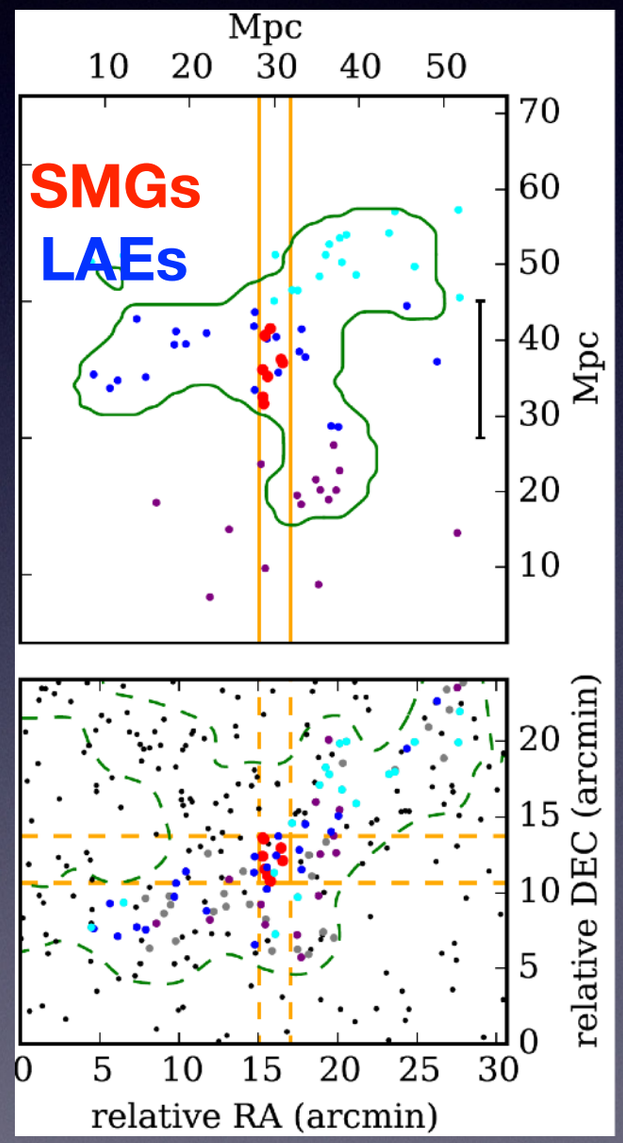
Coma Cluster

J1001@z=2.5



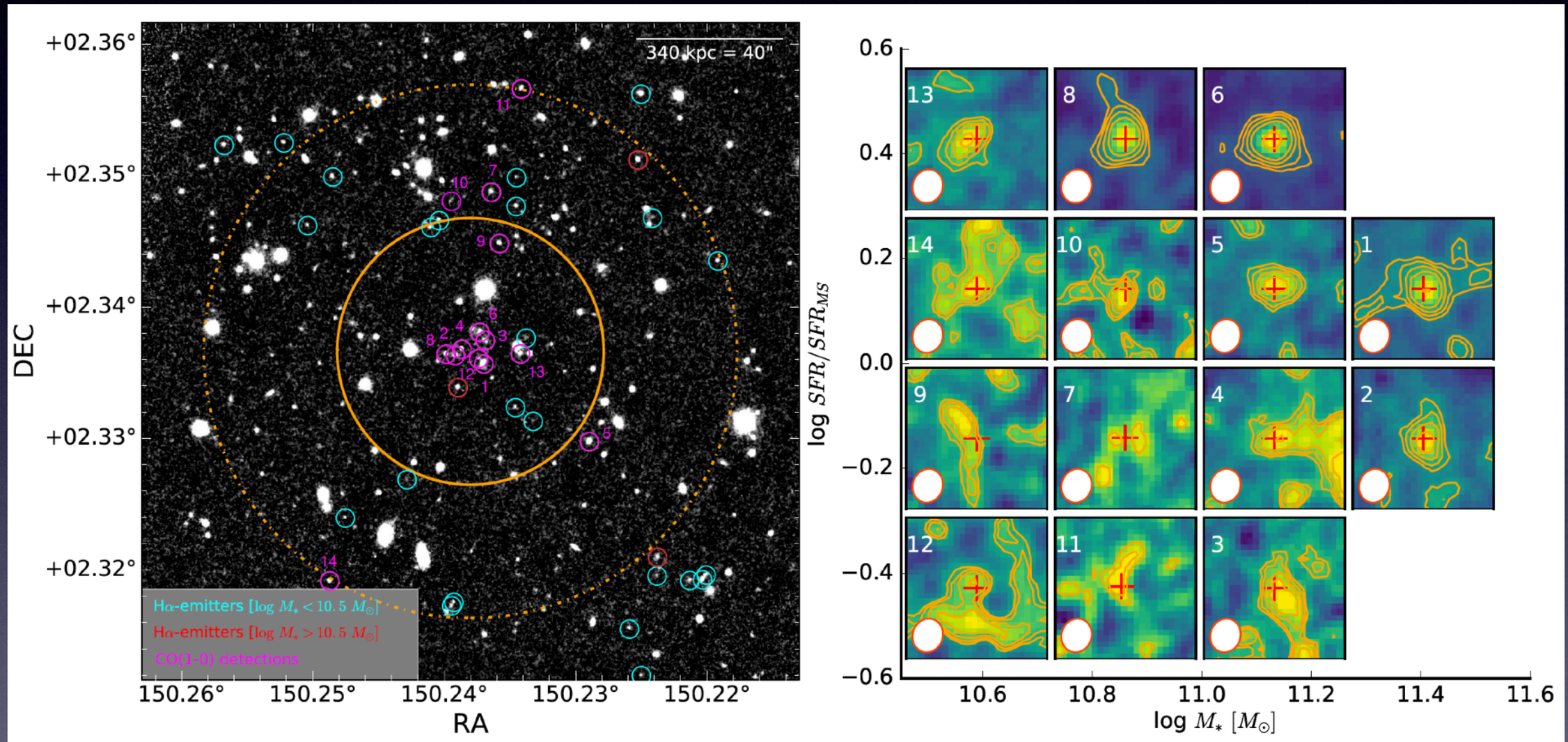
J1001: presence of both an X-ray halo and a starbursting core, ideal laboratory for studying environmental effects on massive galaxy formation

z=3.1



SSA22, Umehata+2015

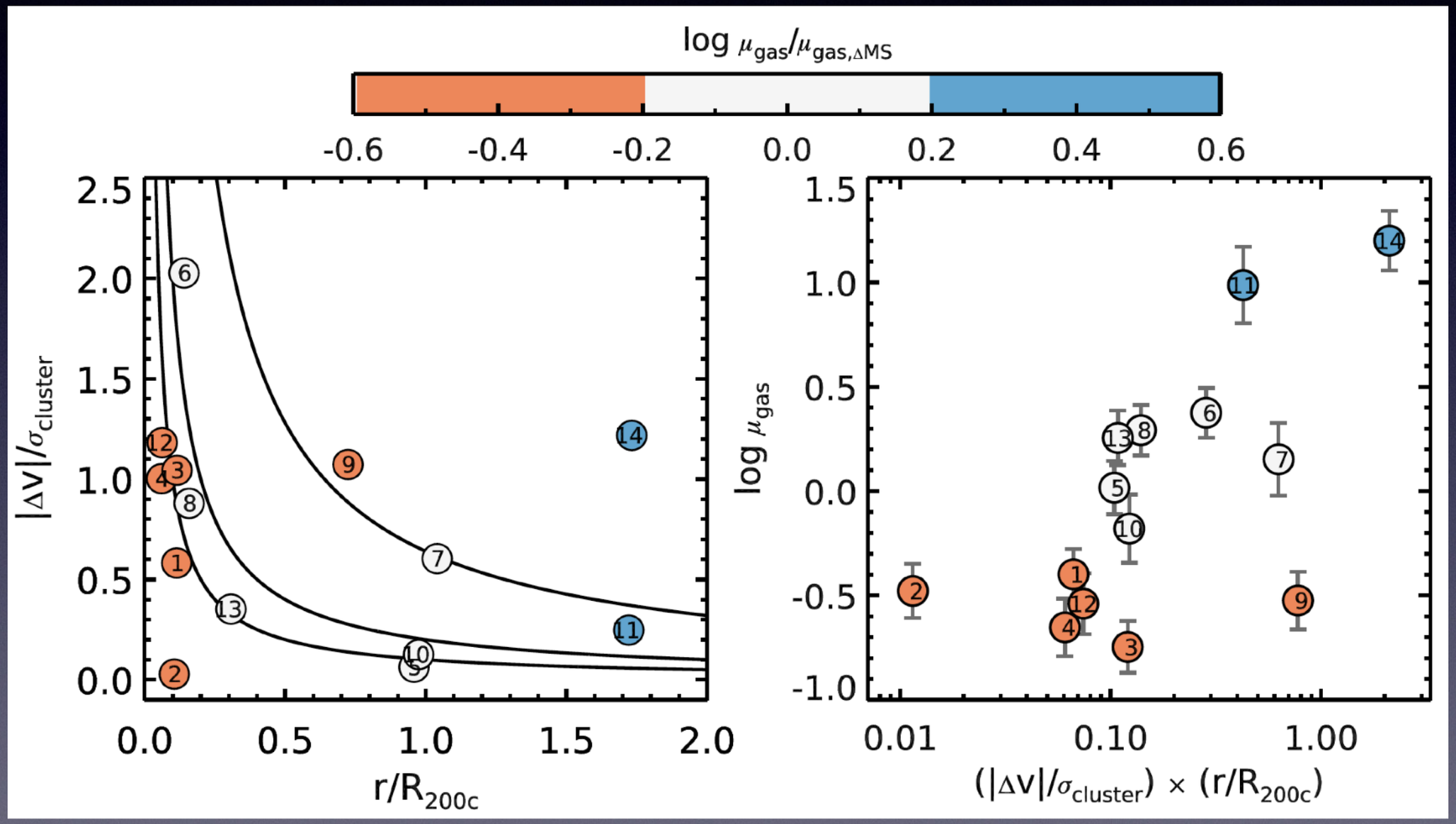
A census of CO(1-0) in J1001 with JVLA



CO(1-0) detections towards a **mass-complete** sample of cluster galaxies

Wang, T., et al. 2018, ApJL, 867, 29

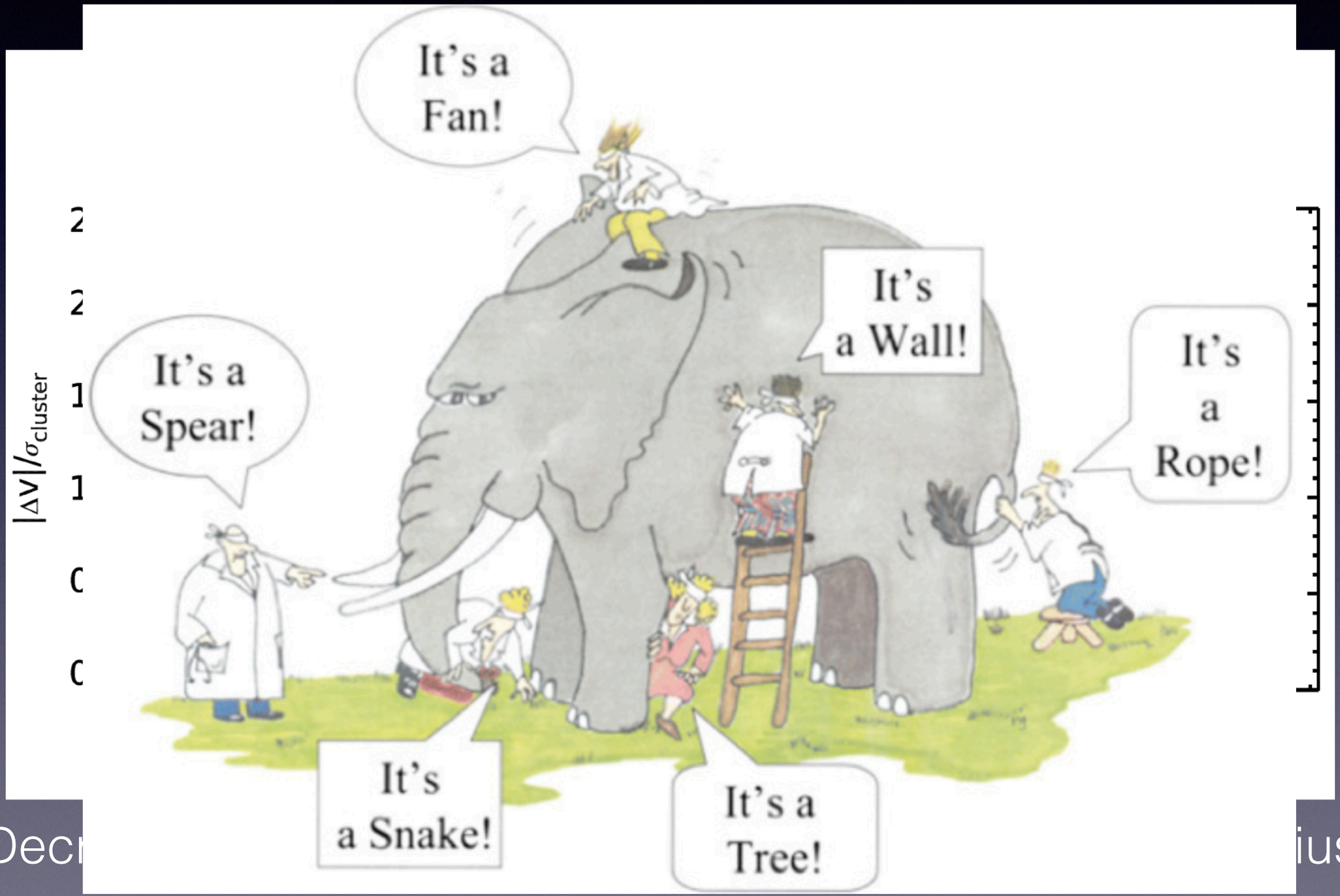
Evidence for strong environmental dependence of (molecular) gas content



Decreasing gas content as decreasing cluster-centric radius

Wang, T., et al. 2018, ApJL, 867, 29

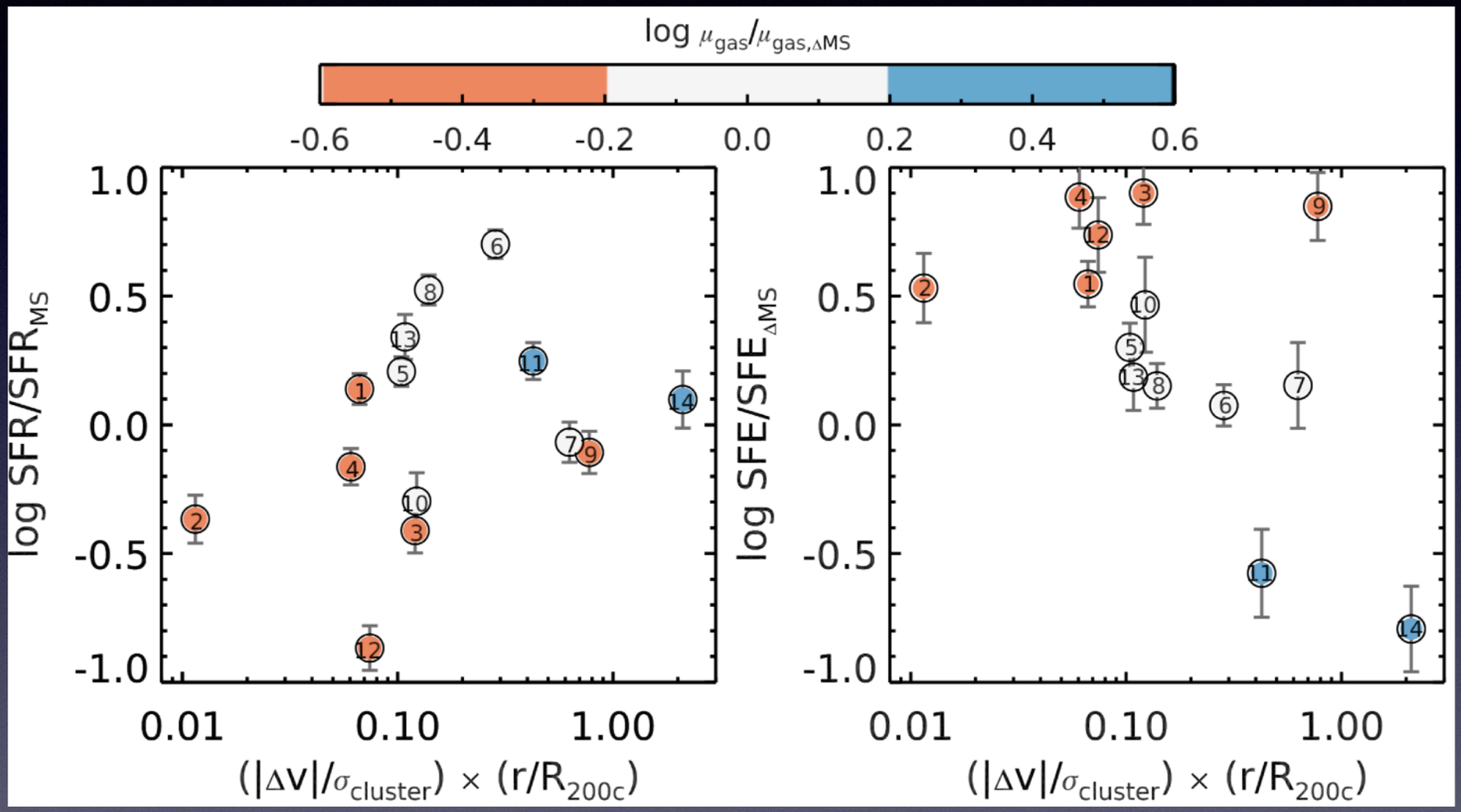
Evidence for strong environmental dependence of (molecular) gas content



Decr ius

Wang, T., et al. 2018, ApJL, 867, 29

Elevated star formation efficiency (SFE=SFR/M_gas) for galaxies in the cluster center

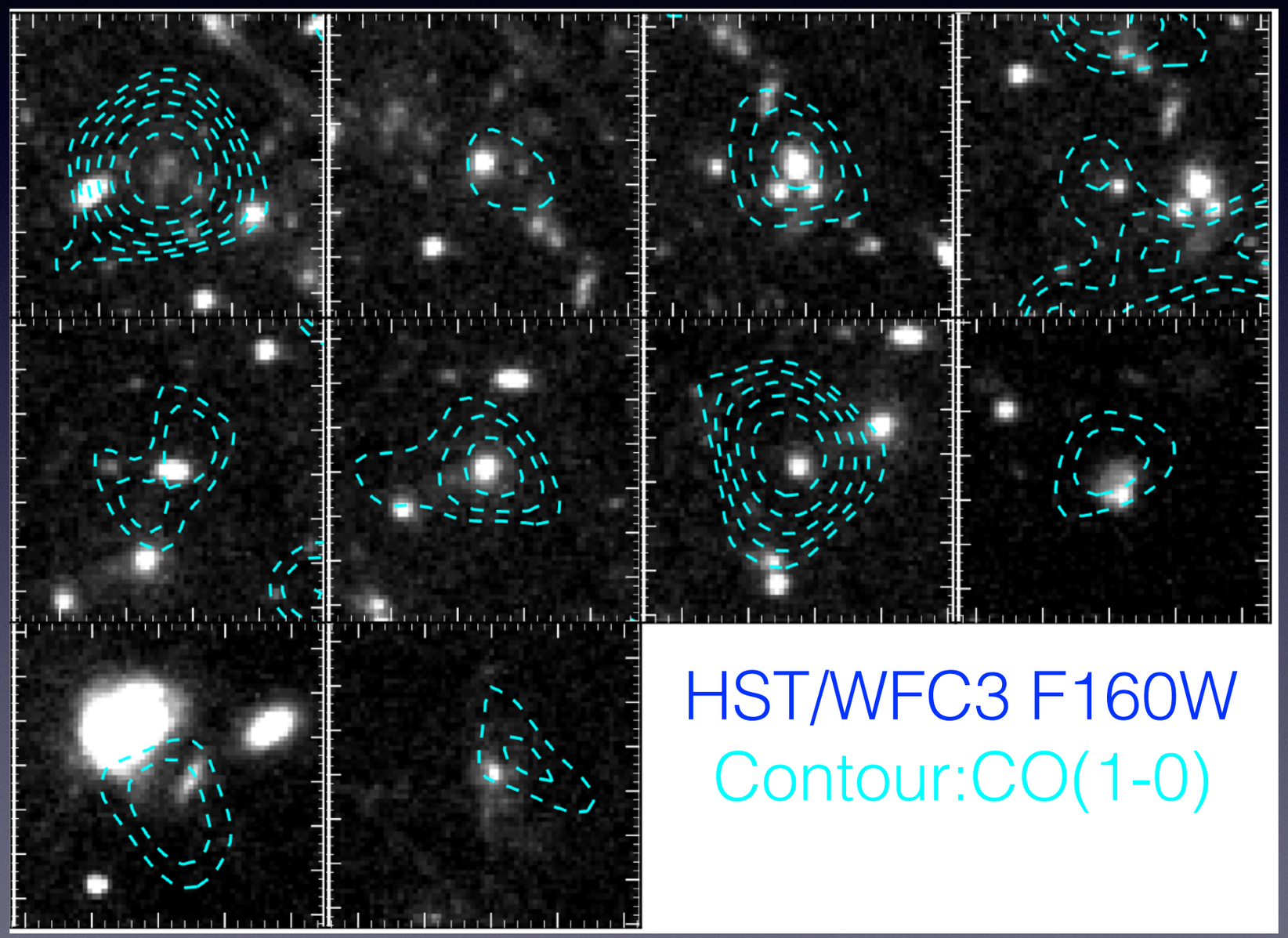


Environmental effects on the SFR of galaxies are likely delayed compared to that on the gas content.

The gas depletion time ranges 100 to 400 Myrs, comparable to the dynamical time of the cluster

Wang, T., et al. 2018, ApJL, 867, 29

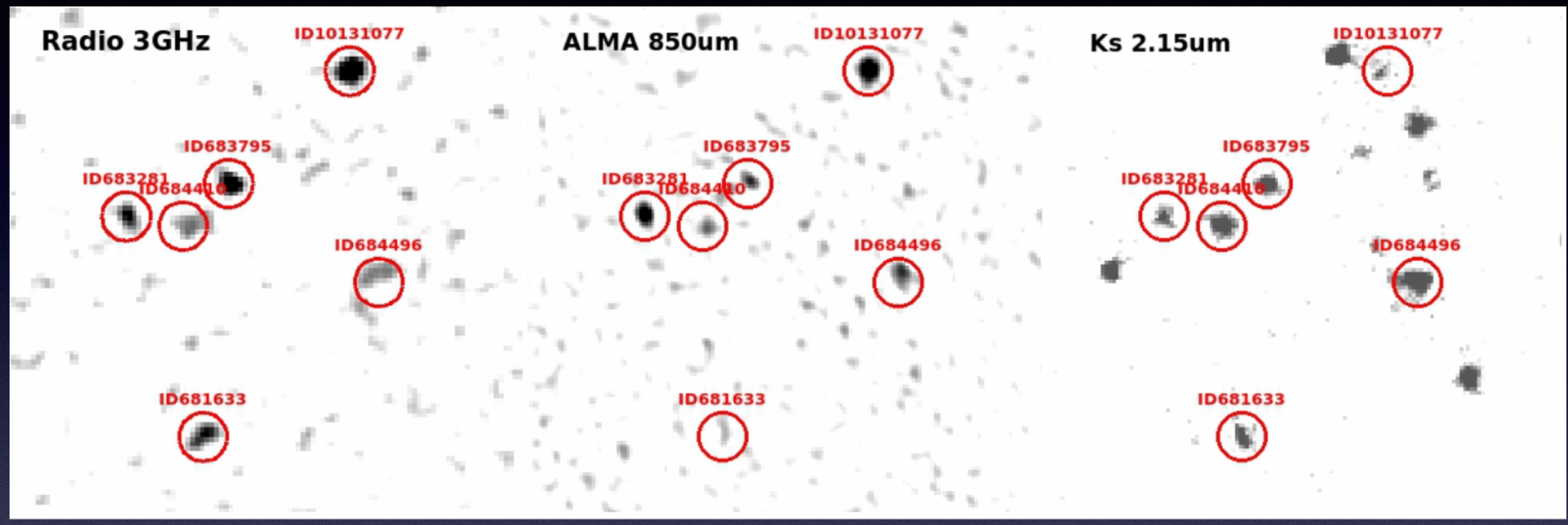
The physical origin of the rapid quenching in cluster cores: tidal and ram pressure stripping at z=2.5?

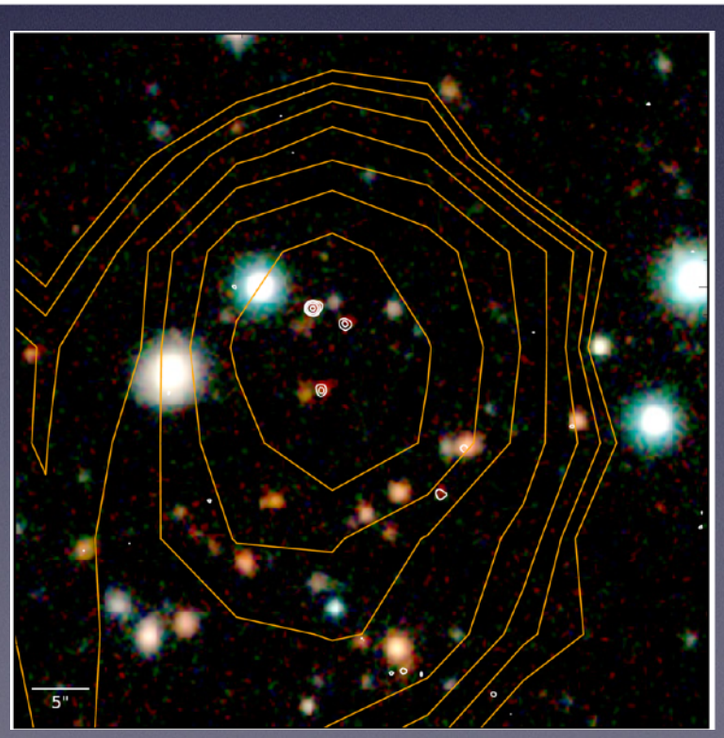


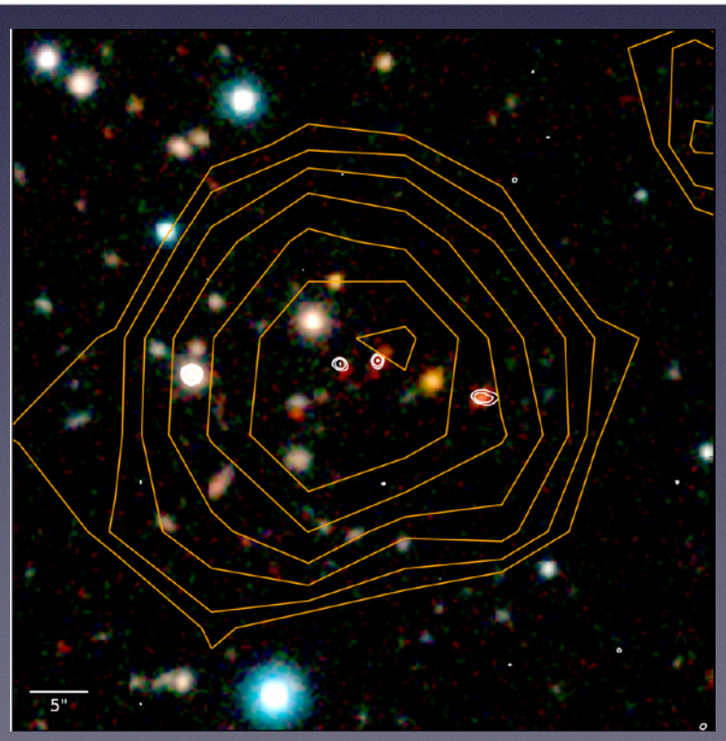
HST/WFC3 F160W
Contour:CO(1-0)

Wang+2019, in prep

Next:
Radio selection of distant galaxy clusters





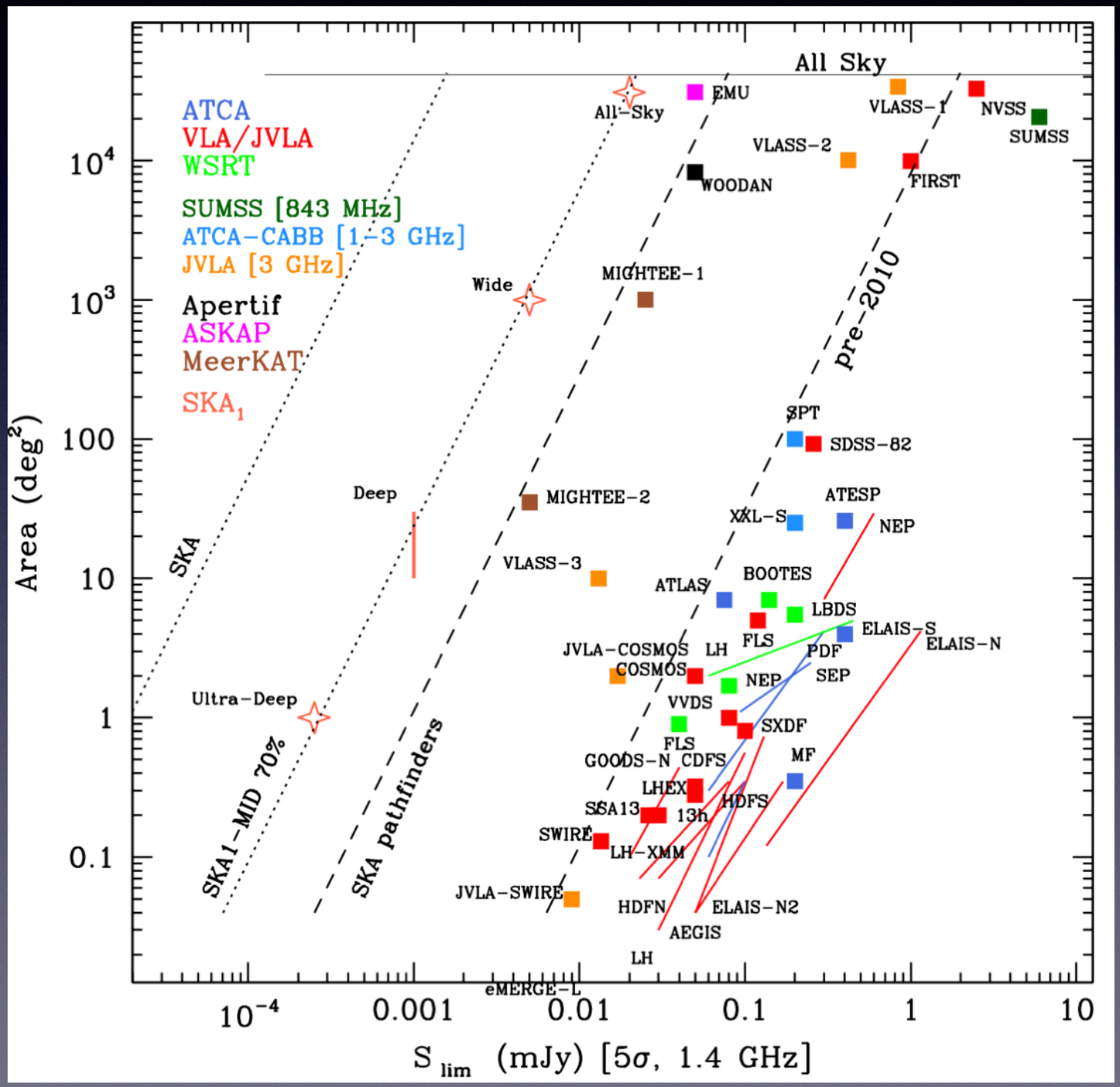


Daddi,+**Wang**,…et al.,+2017, ApJ

Great potential for SKA

Square Kilometer Array

Great potential for SKA:
200~2000 clusters like J1001



Summary

- We have discovered the most distant X-ray cluster J1001 at z=2.51 known to date. This structure is unique in the presence of both an X-ray emitting halo and a starbursting core, bridging the gap between mature clusters and protoclusters.

- Based on CO(1-0) detections towards a mass-complete sample of member galaxies in J1001, we have found a strong clustercentric radius dependence of molecular gas content, with galaxies closer to the cluster core being increasingly gas-poor.

- Despite their low gas content, galaxies in the cluster center suggest an elevated star formation efficiency, suggesting that the effects on the SFR are likely delayed compared to that on the gas content.

- Future wide-field, deep radio continuum surveys with SKA could help to reveal thousands of similar clusters at high redshifts, which will revolutionize the field on both galaxy formation and **cosmology**.