Galaxy quenching in dense environments

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STAR-FORMING BLUE ETGS IN TWO NEWLY DISCOVERED GALAXY OVERDENSITIES IN THE HUDF AT $z = 1.84$ AND 1.9: UNVEILING THE PROGENITORS OF PASSIVE ETGS IN CLUSTER CORES

Simona Mei[1,2,3], Claudia Scarlata[4], Laura Pentericci[5], Jeffrey A. Newman[6], Benjamin J. Weiner[7], Matthew L. N. Ashby[7], Marco Castellano[5], Chistopher J. Conselice[8], Steven L. Finkelstein[10], Audrey Galametz[5,14], Norman A. Grogin[9], Anton M. Koekemoer[9], Marc Huertas-Company[1,2], Caterina Lani[8,13], Ray A. Lucas[9], Casey Papovich[11], Marc Rafelski[3,12], and Harry I. Teplitz[3]

HST GRISM CONFIRMATION OF TWO $z \sim 2$ STRUCTURES FROM THE CLUSTERS AROUND RADIO-LOUD AGN (CARLA) SURVEY

Gaël Noirot[1,2,3], Joël Vernet[2], Carlos De Breuck[2], Dominika Wylezalek[4], Audrey Galametz[5], Daniel Stern[3], Simona Mei[1,6,7], Mark Brodwin[8], Elizabeth A. Cooke[9], Anthony H. Gonzalez[10], Nina A. Hatch[9], Alessandro Rettura[11], Spencer Adam Stanford[12]

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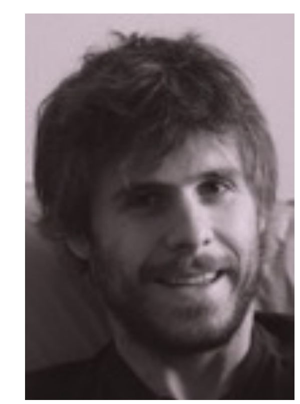
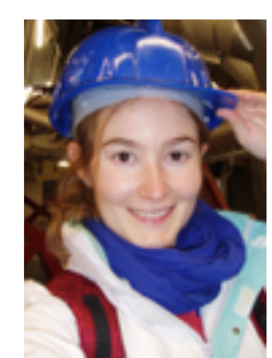
MNRAS 441, 203–223 (2014) doi:10.1093/mnras/stu496

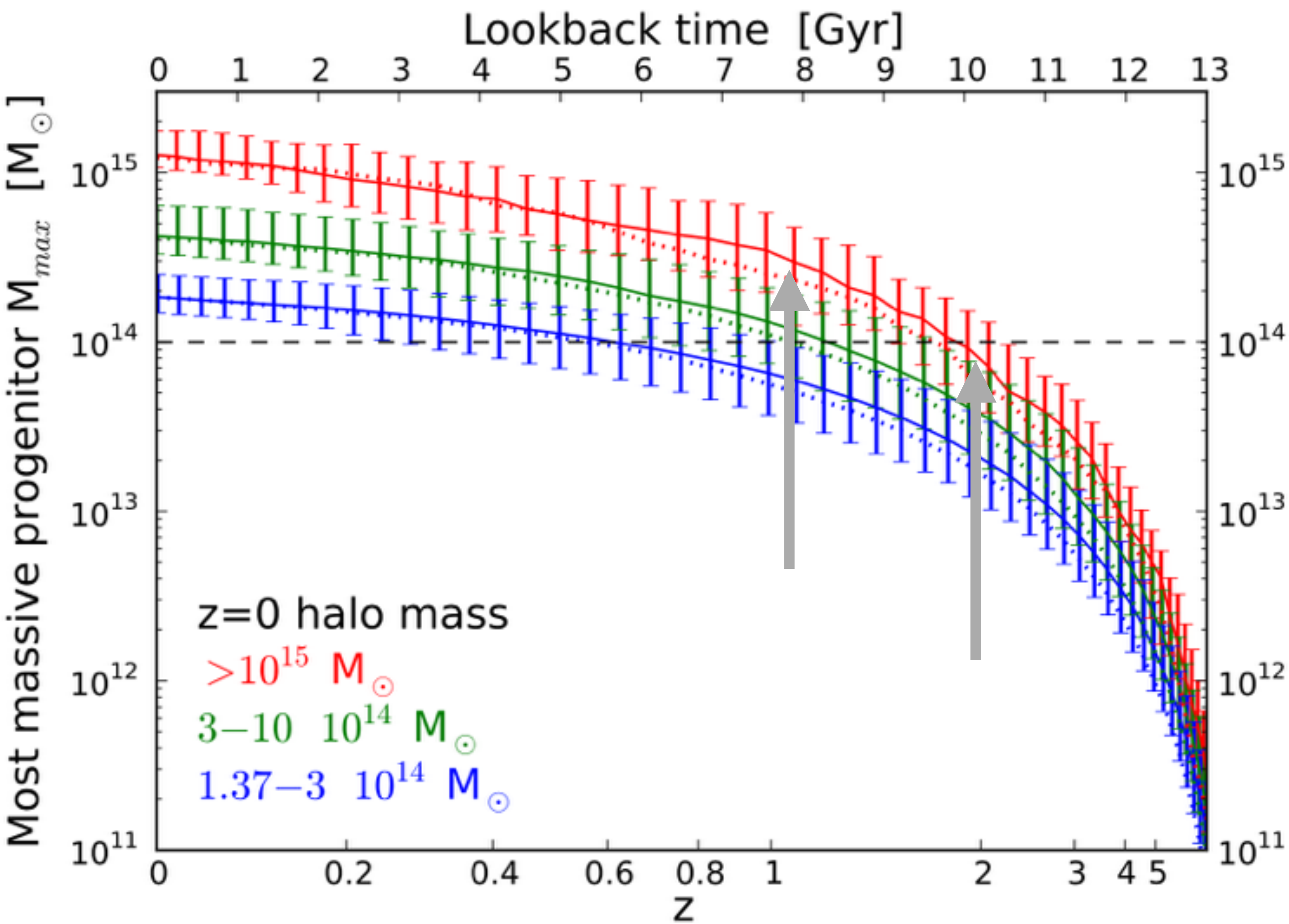


Larger sizes of massive quiescent early-type galaxies in clusters than in the field at $0.8 < z < 1.5$

L. Delaye,[1,2★] M. Huertas-Company,[1,3] S. Mei,[1,3] C. Lidman,[4] R. Licitra,[1] A. Newman,[5] A. Raichoor,[1] F. Shankar,[1] F. Barrientos,[6] M. Bernardi,[7] P. Cerulo,[8] W. Couch,[8] R. Demarco,[9] R. Muñoz,[6] R. Sánchez-Janssen[10] and M. Tanaka[11]



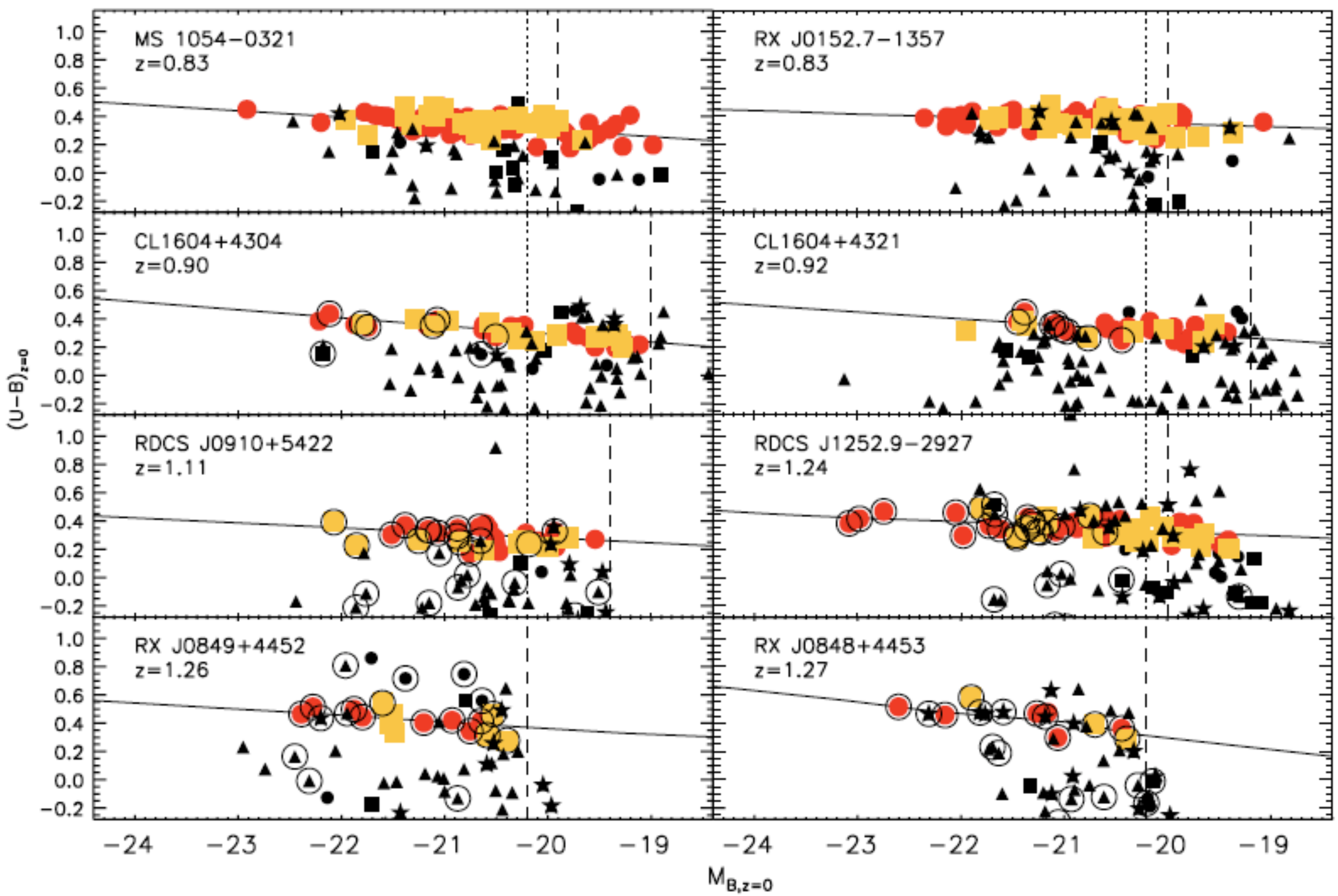
Galaxy stellar populations in cluster progenitors of ~$10^{15}\,M_{\odot}$ local clusters



Chiang et al. 2013

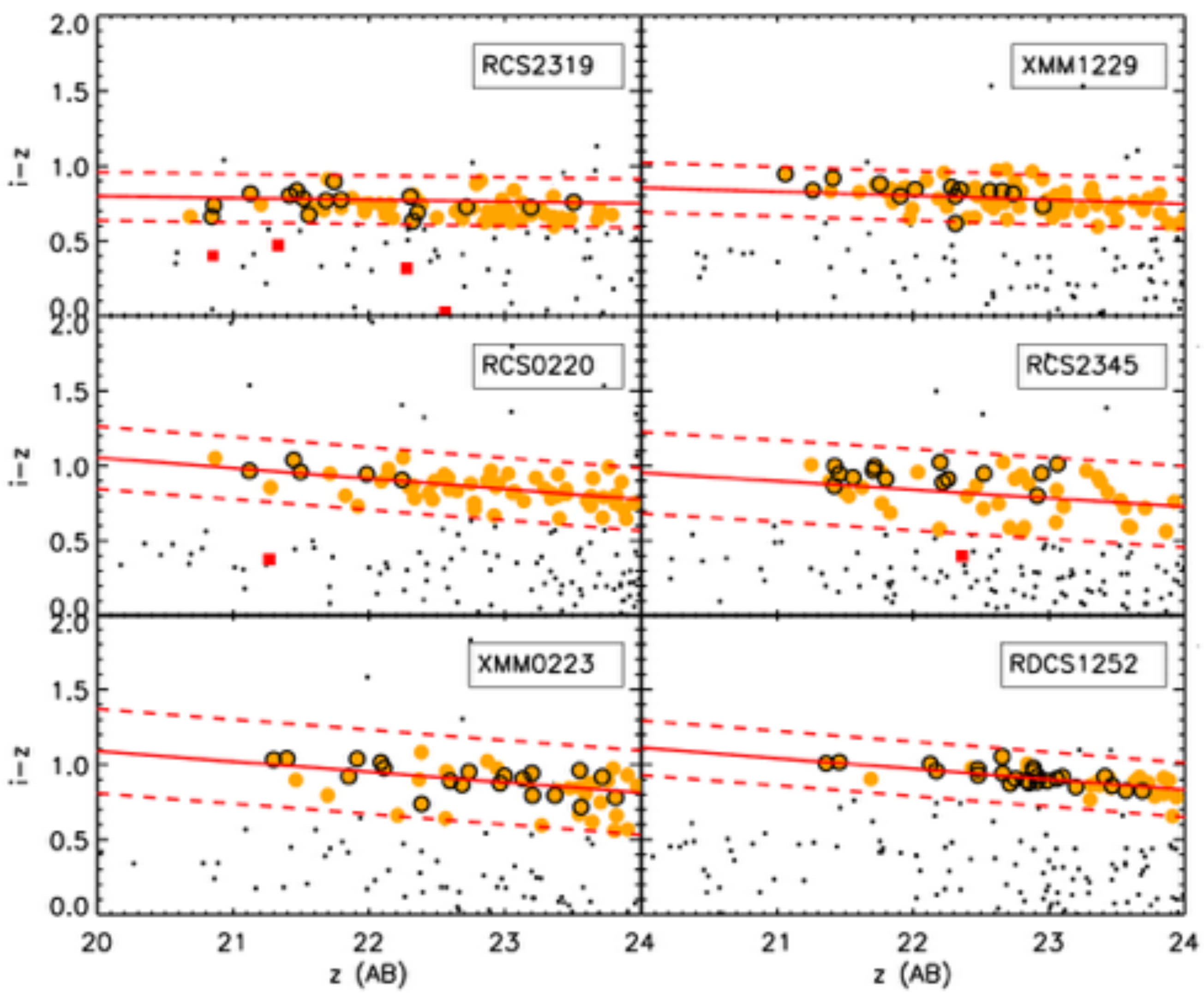
Quenching in galaxy clusters at z~1-1.5

Clusters @z~1-1.5 - Red sequence



ACS GTO, Mei et al. 2009, 2012

HAWKI Cluster survey (PI: Lidman)
Clusters 0.8<z<1.5, passive ETGs

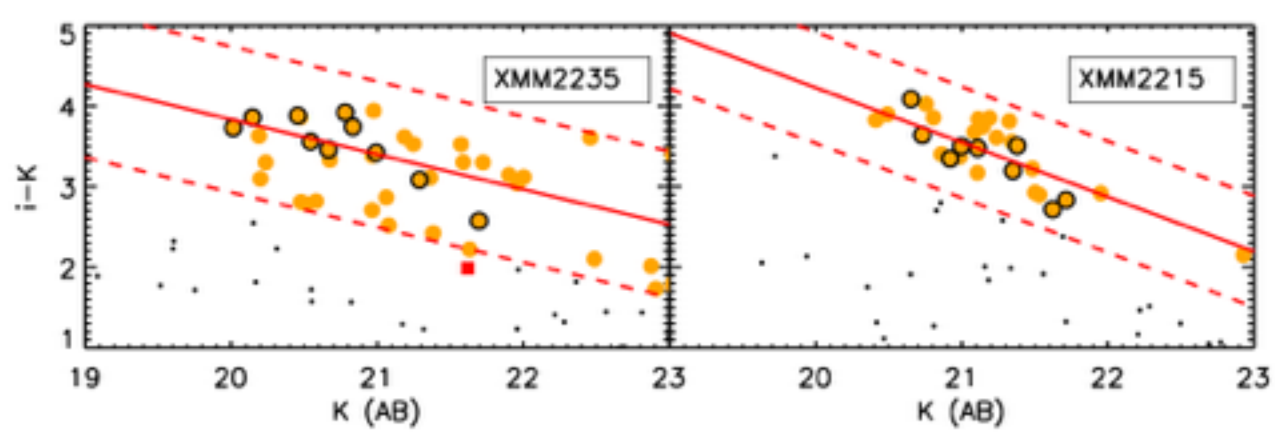


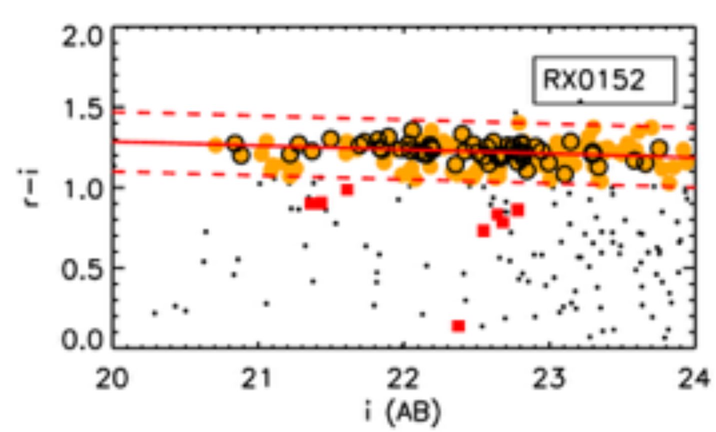
(b)

Nine clusters (ACS GTO, Sparcs, RCS) M= 2-7 x 10^{14} $M_{\odot}$ (Lidman et al. 2013).

~400 passive ETGs with masses M > $10^{10.5}$ $M_{\odot}$

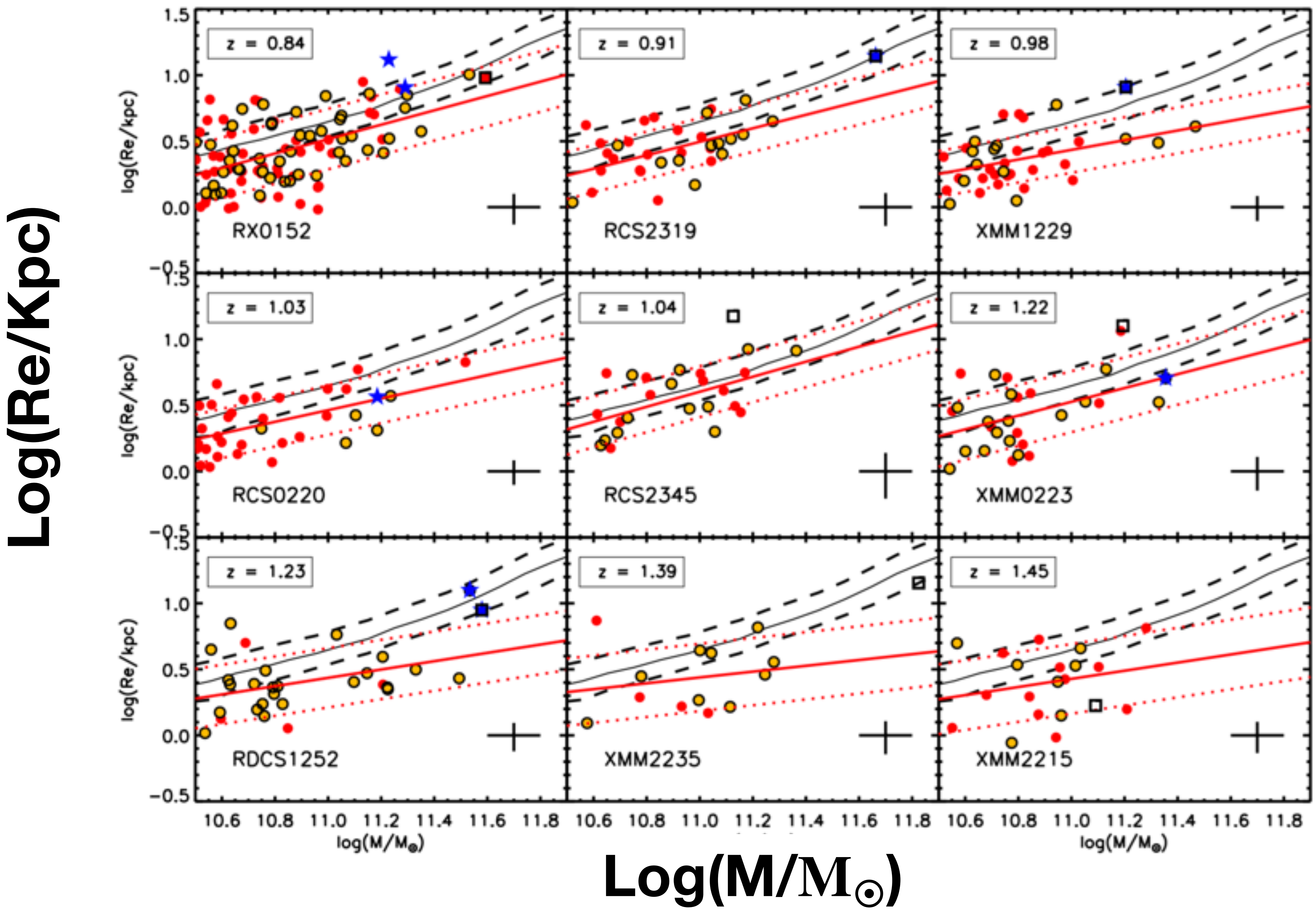
Delaye, Huertas-Company, Mei, Lidman et al. 2014





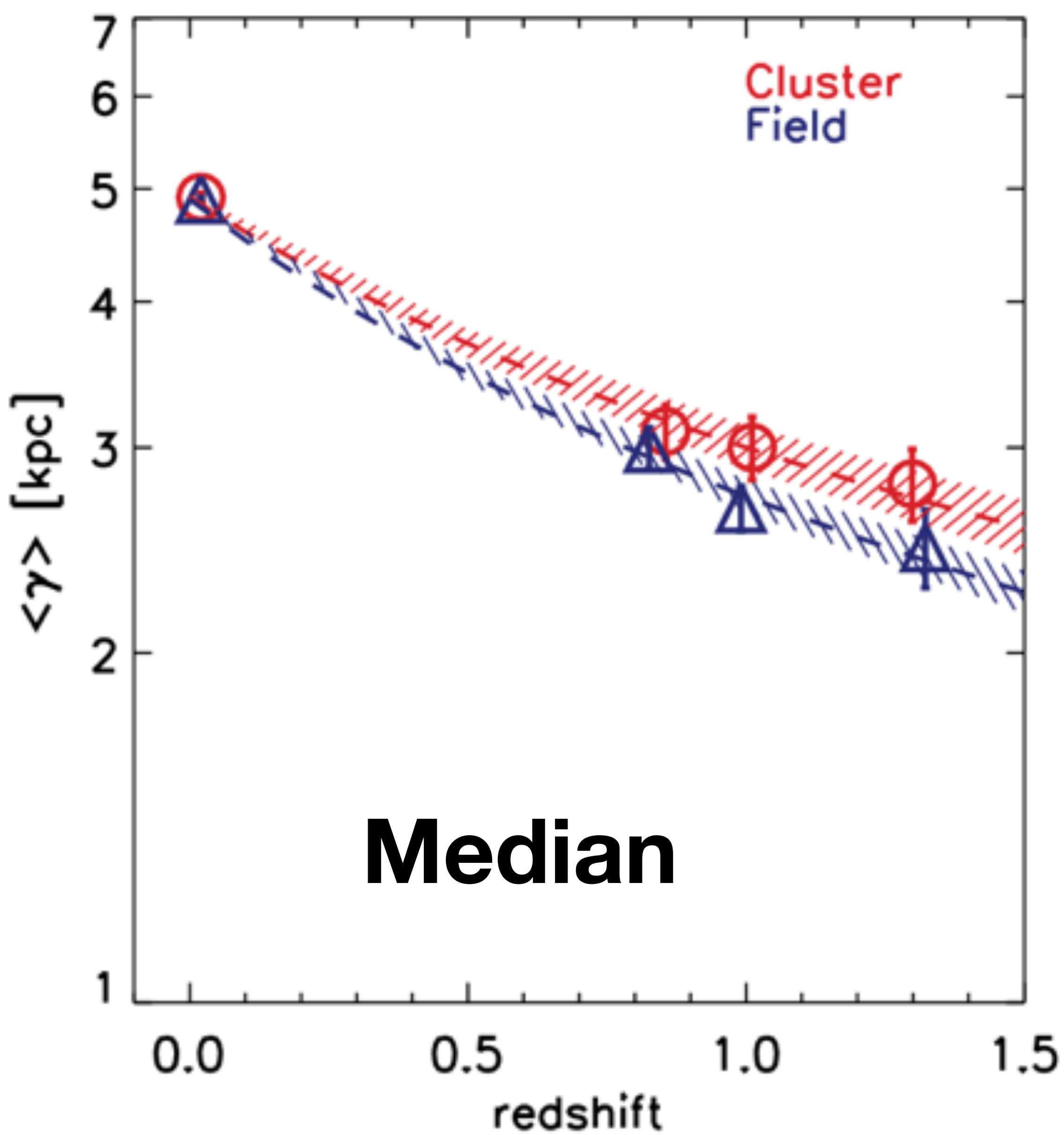
Clusters 0.8<z<1.5

Delaye, Huertas-Company, Mei, Lidman et al. 2014



Size evolution and Environment

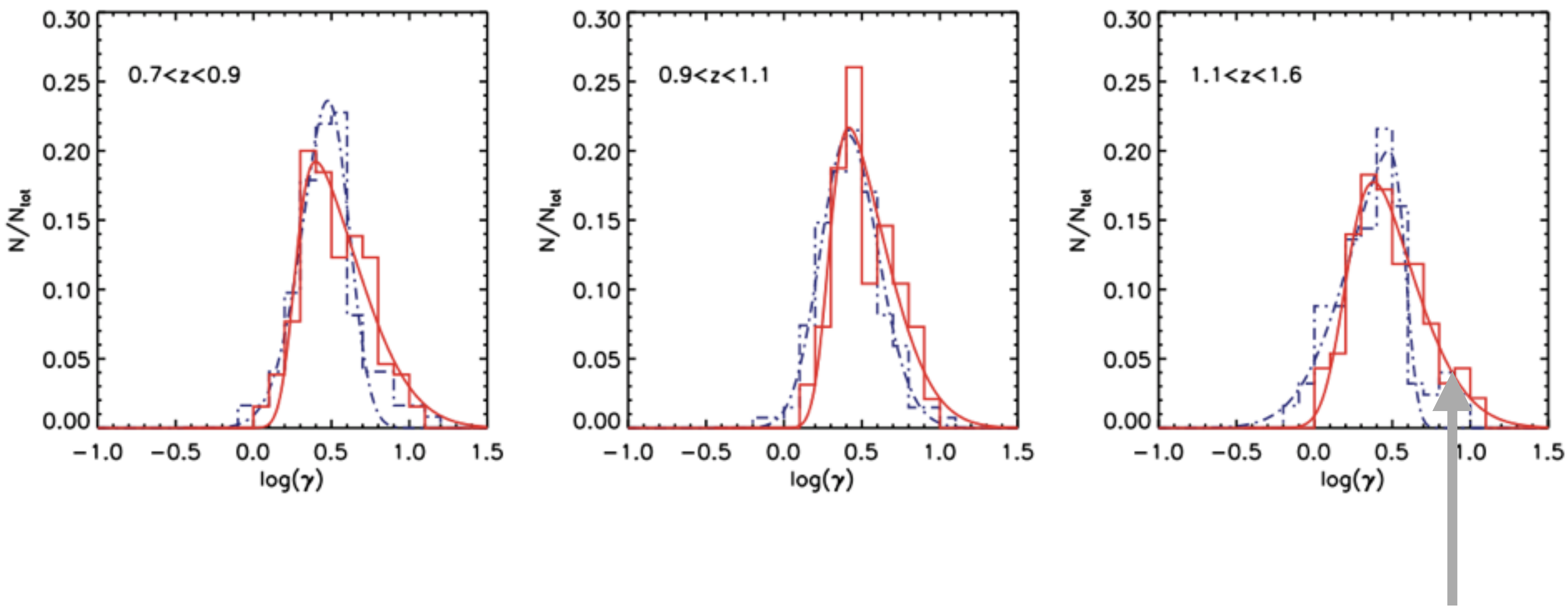
Delaye, Huertas-Company, Mei et al. 2014



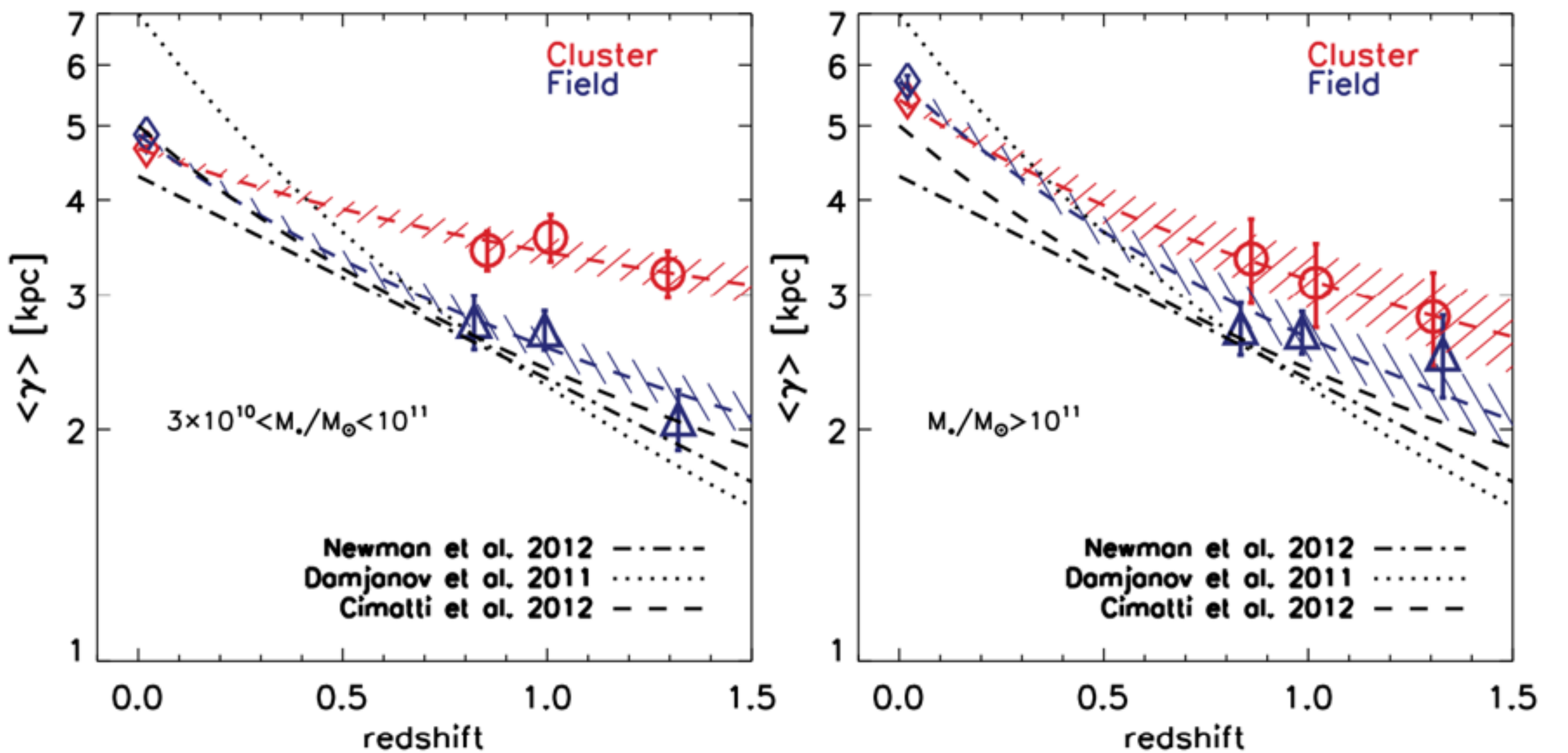
see also Weinmann et al. 2009; Maltby et al. 2010; Rettura et al. 2010, Valentinuzzi et al. 2010
Cooper et al. 2012, Papovich et al. 2012, Raichoor et al 2012, Poggianti et al. 2013, Lani et al. 2013, Bassett et al. 2013

Size evolution and Environment

Delaye, Huertas-Company, Mei et al. 2014



Which galaxies



The galaxies largest than the field are the low mass galaxies

Newly quenched galaxies…

- Accretion of new galaxies that are quenched more efficiently in clusters (see also recent results from Morishita et al. 2016)

- Different morphological mixing in the cluster (more S0 galaxies) and field environments (e.g. Poggianti et al. 2013)

- Higher merger rates in clusters at higher redshift, when galaxy velocities are lower

Quenching in galaxy clusters at z~2

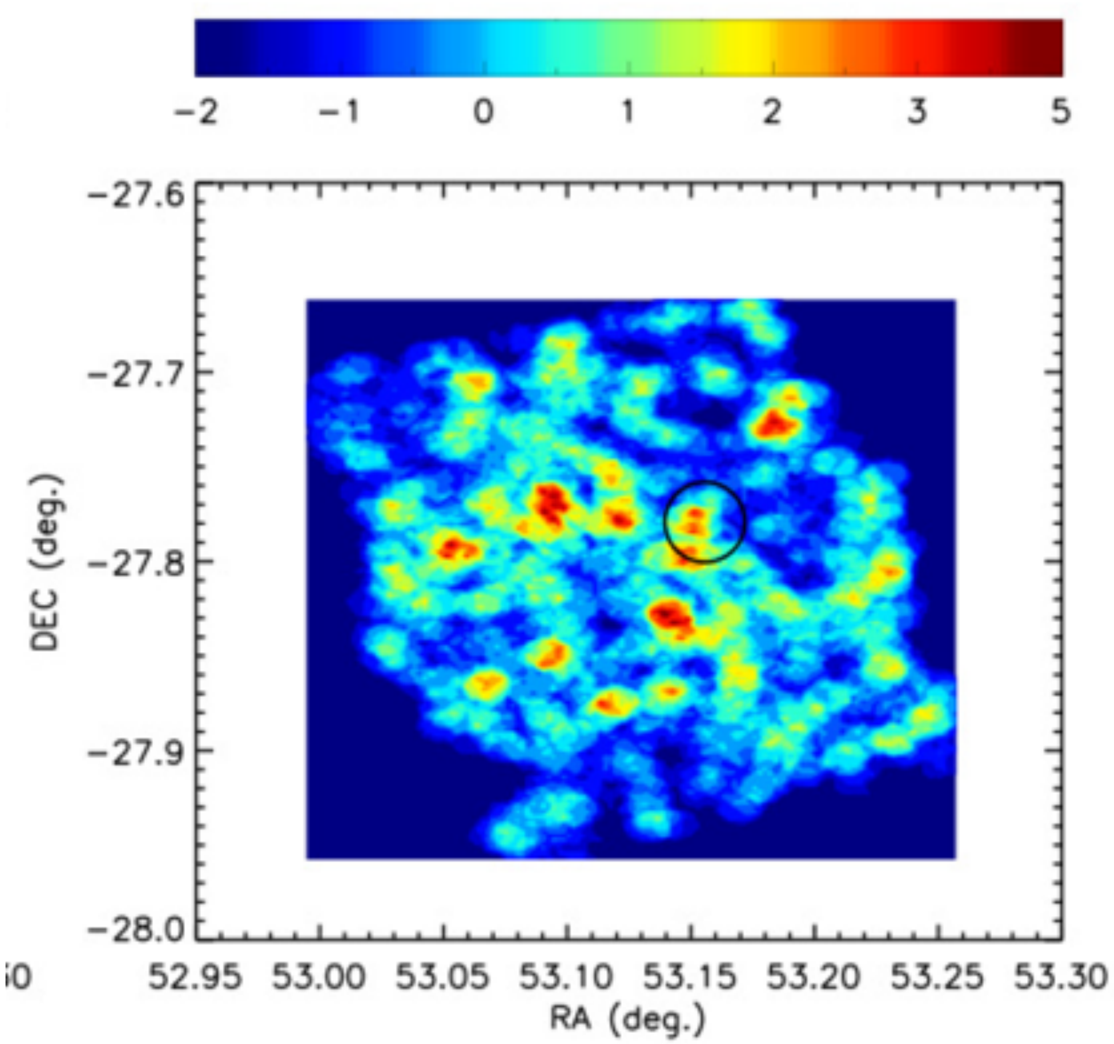
Clusters and proto-clusters at z~1.6-2

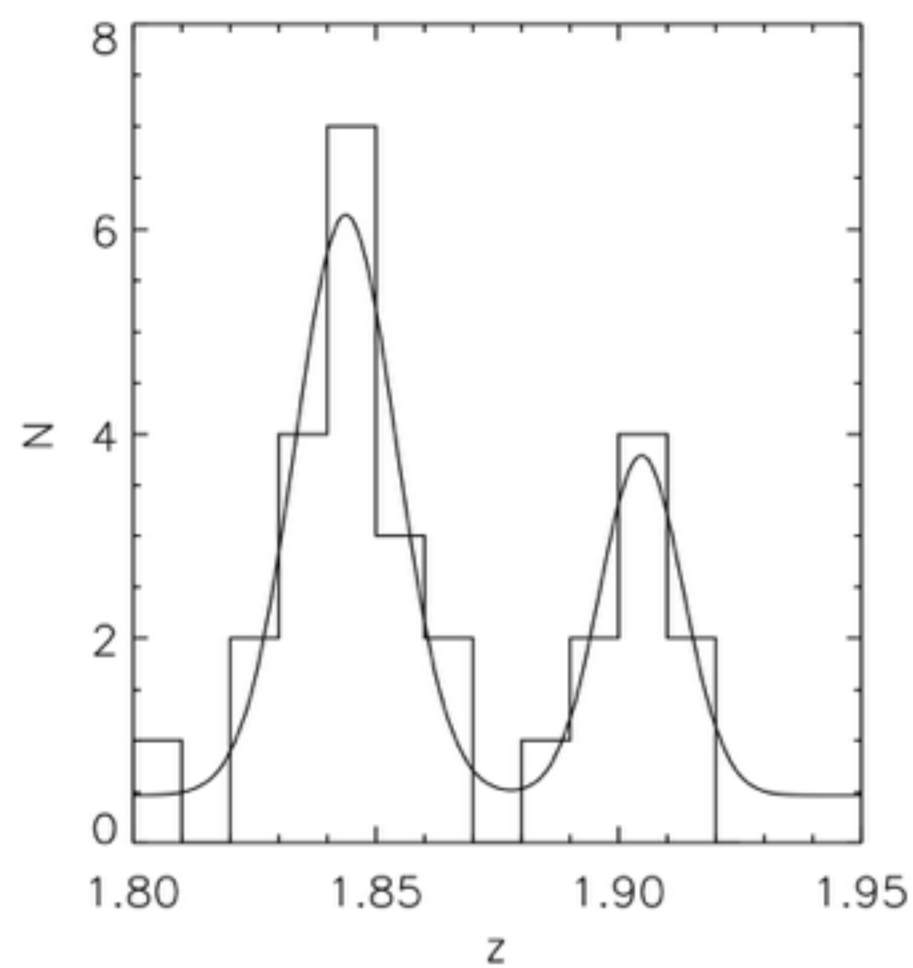
Name	Identification	z	Overdensity	σ_{disp} (km/s)	Mass ($10^{14} \times M_\odot$)	X–ray Lum./Detection (10^{43} erg s^{-1})	Reference
CL J033211.67-274633.8	Group	1.61	$\sim 5\sigma$	...	$M_{200}^{(a)} = 0.32 \pm 0.08$	1.8 ± 0.6	Tanaka et al.
IRC-0218A/XMM-LSS J02182-05102	Proto–cluster	1.62	$> 20\sigma$	860 ± 490	$M_{200}^{(b)} \sim 0.1 - 0.4$	$> 4\sigma$ Detection	Papovich et al. 2010; 2012
SpARCS J022427-032354	Cluster	1.63	...	...	...	Detection	Muzzin et al. (2013)
IDCS J1426+3508	Cluster	1.75	...	...	$M_{200}^{(a)} \sim 5.6 \pm 1.6$	55 ± 12	Stanford et al. 2012; Brodwin et al. 2012
JKCS 041	Cluster	1.80	...	...	$M_{200}^{(c)} \sim 2$	76 ± 5	Newman et al. 2013; Andreon et al. 2013
HUDFJ0332.4-2746.6	Proto–cluster	1.84	$\sim 20\sigma$	730 ± 260	$M_{200}^{(b)} = 2.2 \pm 1.8$	$< 1 - 6$	Mei et al. 2015
IDCS J1433.2+3306	Cluster	1.89	...	...	$M_{200} \sim 1$	...	Zeimann et al. 2012
HUDFJ0332.5-2747.3	Group	1.90	$\sim 4 - 7\sigma$	...	...	...	Mei et al. 2015
CL J1449+085	Cluster	1.99	$> 20\sigma$	...	$M_{200}^{(a)} = 0.53 \pm 0.09$	6.4 ± 1.8	Gobat et al. 2013

Mei et al. 2015

Star forming blue ETGs in significant overdensities at z=1.84 and 1.9 in the HUDF

WFC3 Grism Spectroscopy and photoz from CANDELS and 3D-HST+GMASS





Mei et al. 2015

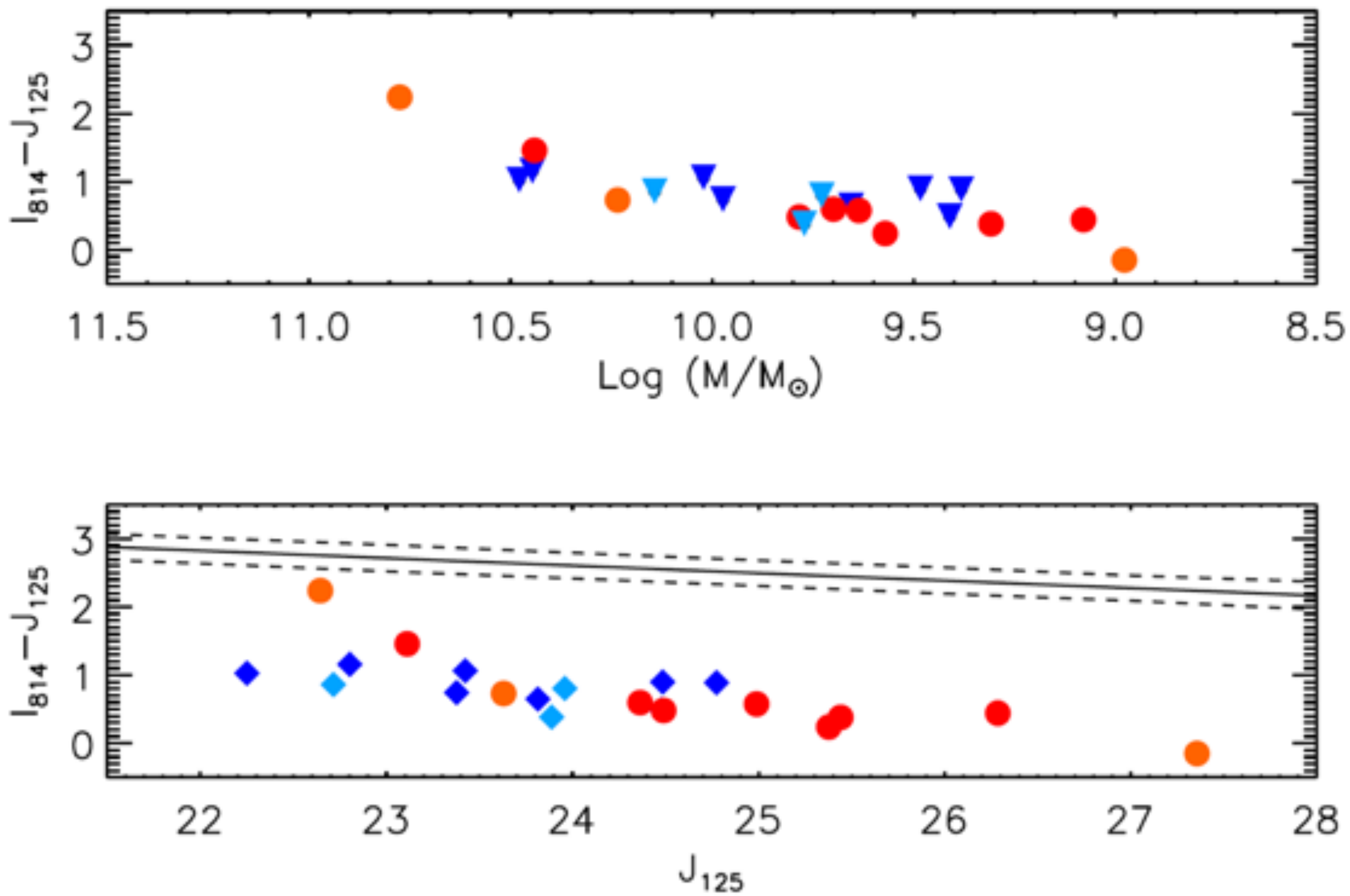
Morphology

- 50% of the structures' members show possible interactions or disturbed morphologies, all possible signatures of merger remnants or disk instabilities.

- **The ETG fraction is 50%,** compared to 80% in the cluster cores at z<1, and **all but 2 show OIII in emission and have blue (with respect to a SSP red sequence) rest-frame (U-B) colors**

Mei et al. 2015

Blue ETGs, all but 2 have OII in emission

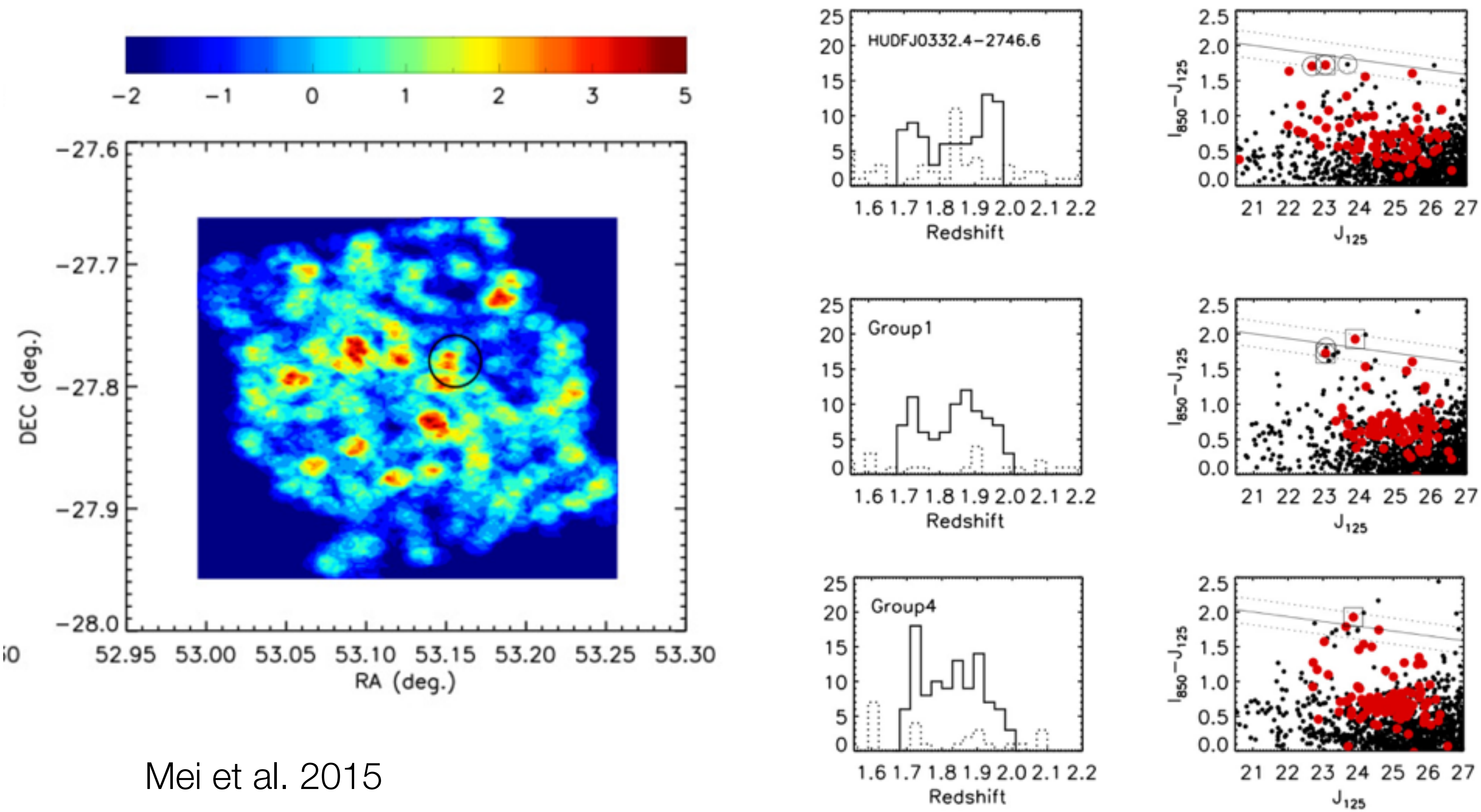


The two structures have not yet formed a red sequence. *For the first time, we confirmed a significant presence of star-forming blue ETGs in dense environments at z=1.84-1.9*

Mei et al. 2015

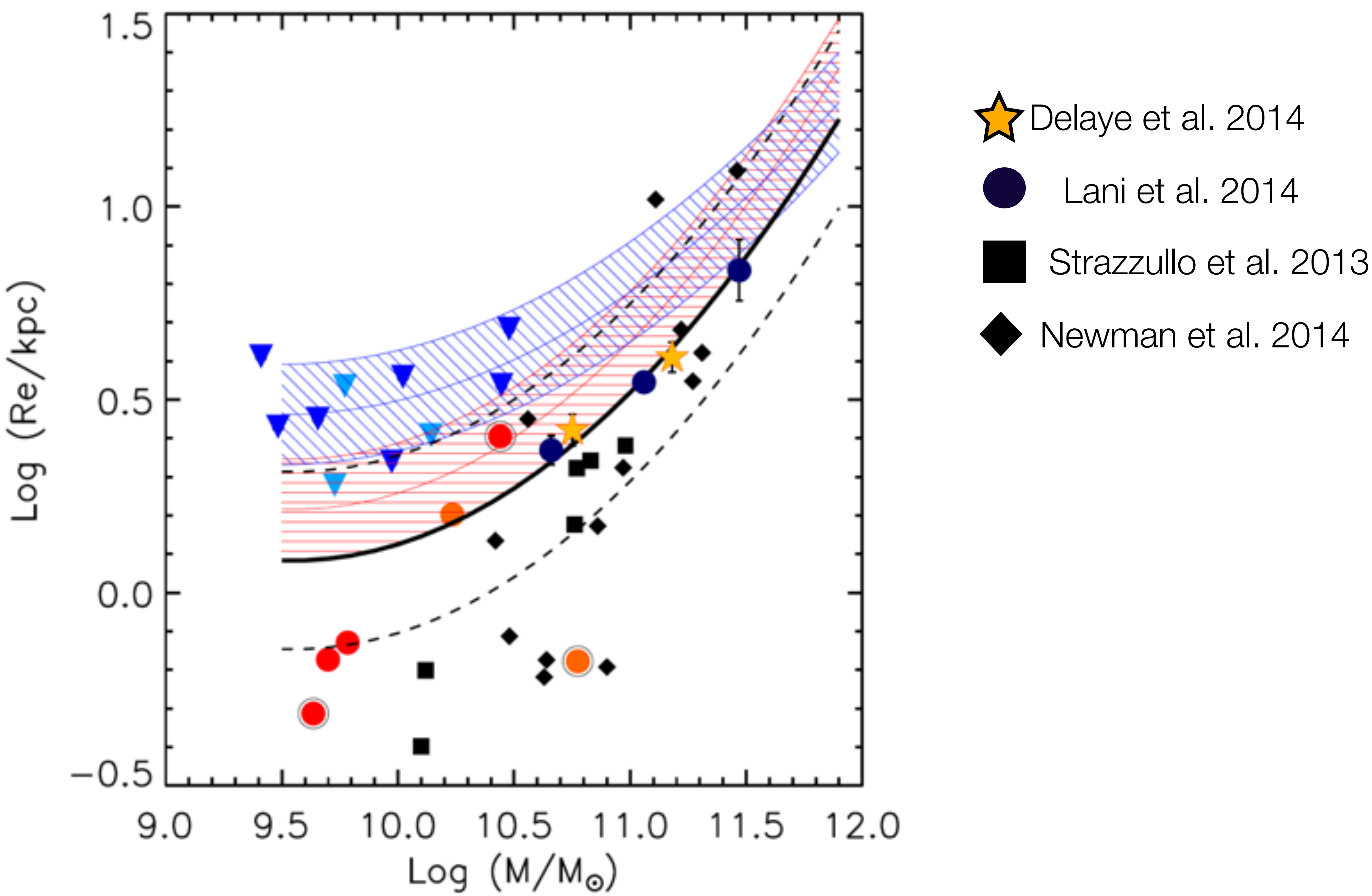
Extended structure at z~1.8-1.9

(CANDELS photoz, empty circles spectroscopic members)



Mei et al. 2015

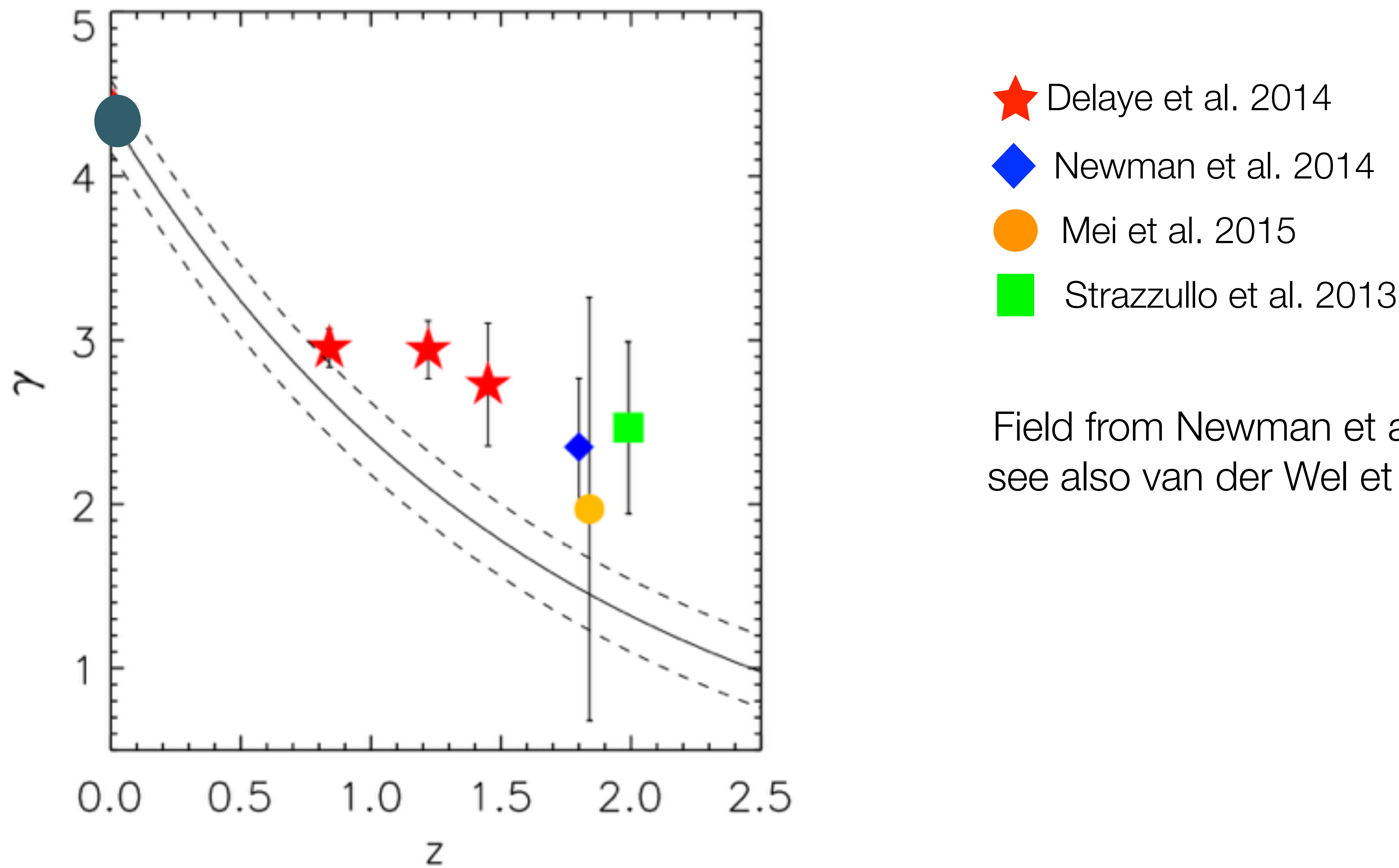
Mass-size relation at z~1.8



Mei et al. 2015

Passive ETG Size Growth

Delaye et al. 2014, Mei et al. 2015



Field from Newman et al. 2012, see also van der Wel et al. 2014

sizes. Since this size difference is not observed in the local Universe, the size evolution at fixed stellar mass from $z \sim 1.5$ of cluster galaxies is less steep ($\propto (1+z)^{-0.53\pm0.04}$) than the evolution of field galaxies ($\propto (1+z)^{-0.92\pm0.04}$). The size difference seems to

CARLA - Clusters Around Radio-Loud AGNs

HST program (PI: Dan Stern)

Noirot et al. 2016, ApJ, in press

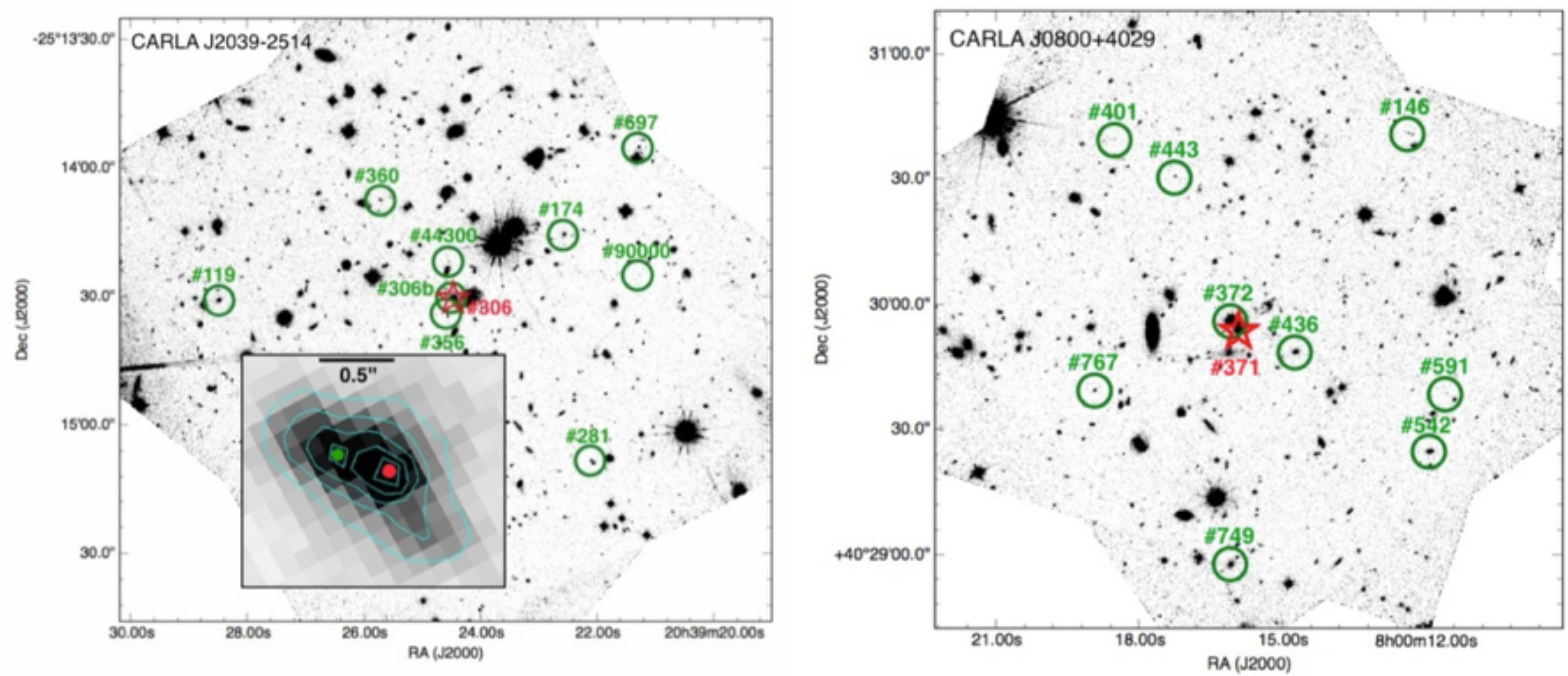
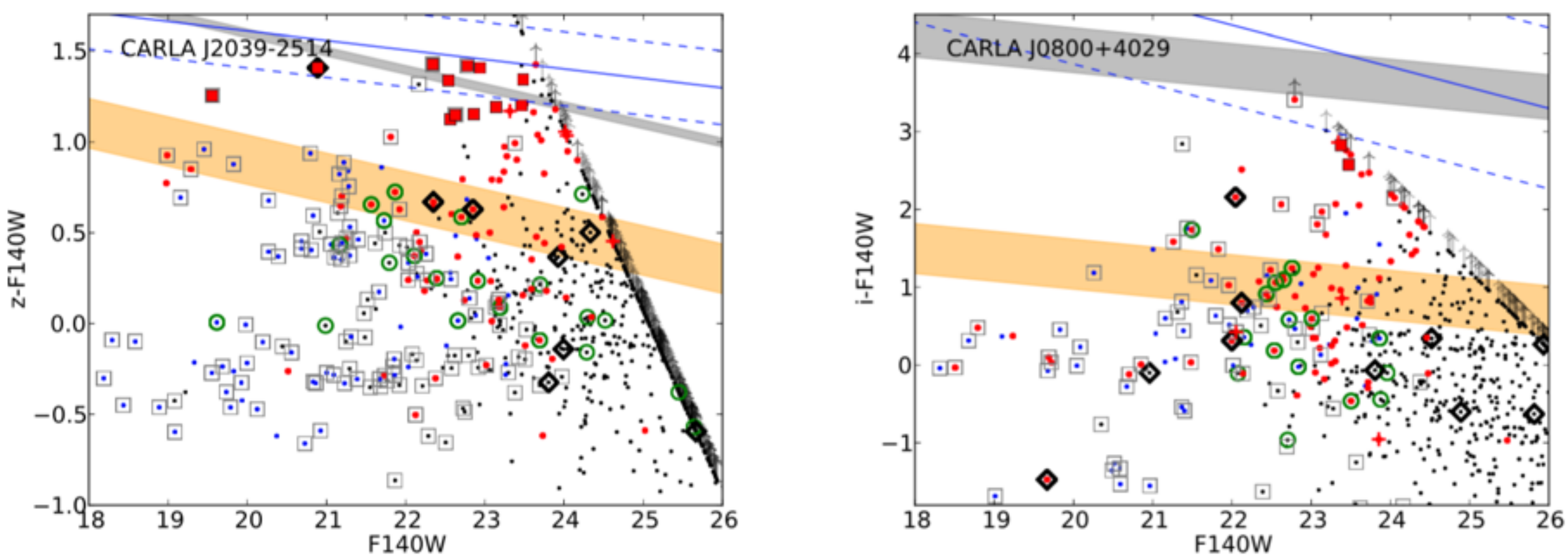


Figure 3. F140W images of our two RLAGN fields, showing the spatial distribution of CARLA J2039−2514 (left) and CARLA J0800+4029 (right) confirmed members. North is up and East is to the left. The red stars indicate the RLAGN, and the green circles indicate confirmed member galaxies. The inset in the left panel shows a close-up of the targeted HzRG, MRC 2036−254 (#306). The red dot shows the position of the source, and the green dot the position of its companion #306b; these two components are highlighted by contour lines.

First CARLA/HST overdensities confirmed at z~2

Galaxy overdensities around radio sources

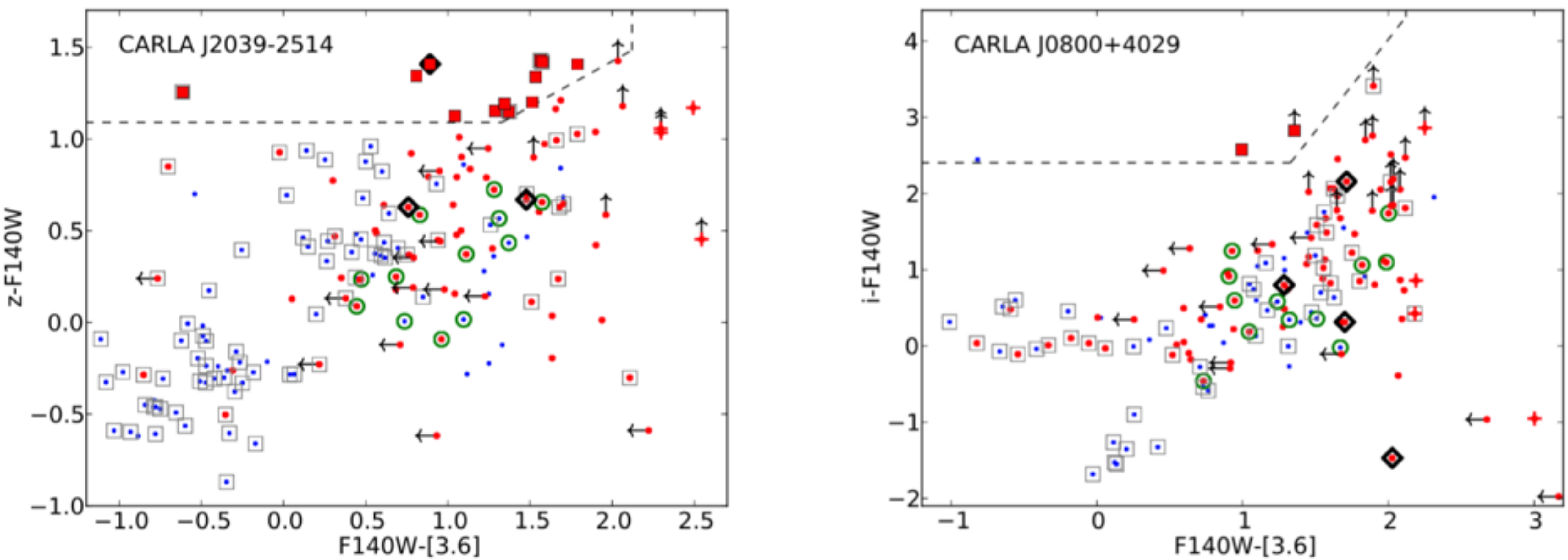
Noirot et al. 2016, ApJ, in press



see also Alberts 2014, 2016; Cooke et al. 2015

Galaxy overdensities around radio sources

Noirot et al. 2016



Color cuts from Williams et al. 2009, Whitaker et al. 2011

Conclusions

- We could observe the compact star-forming (blue and emission lines) progenitors of local massive ETG in clusters
- Variety of stellar populations in cluster progenitors at z~2
- ETGs show a different size evolution in clusters at z>1 with respect to the field
- We have hundreds of cluster and protocluster *candidates* from Spitzer Deep Surveys (e.g. SSDF, CARLA, SERVS, DEEPDRILL …)
- Euclid will revolutionize this field with thousands of newly discovered clusters and proto-cluster at z>1.5. WFIRST will reach to higher redshift proto-clusters.