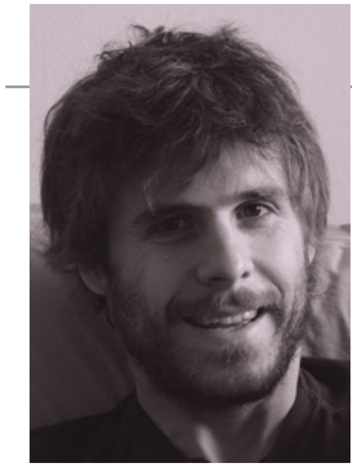
Evolution of massive galaxies in clusters and less dense environments from z~1.5 to present

Simona Mei - GEPI - Observatory of Paris - University of Paris D. Diderot

EARLY-TYPE GALAXIES AT $z \sim 1.3$. IV. SCALING RELATIONS IN DIFFERENT ENVIRONMENTS

A. Raichoor[1,17], S. Mei[1,2,3], S. A. Stanford[4,5,18], B. P. Holden[6], F. Nakata[7], P. Rosati[8], F. Shankar[9], M. Tanaka[10], H. Ford[11], M. Huertas-Company[1,2], G. Illingworth[6], T. Kodama[7,12], M. Postman[13], A. Rettura[4,11,14], J. P. Blakeslee[15], R. Demarco[16], M. J. Jee[4], and R. L. White[13]

Anand Raichoor



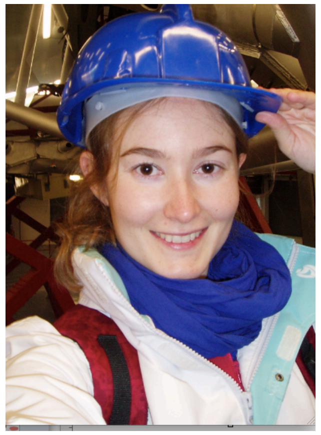
Marc Huertas-Company

The dependence of the mass–size relation of early-type galaxies on environment in the local Universe

M. Huertas-Company[1], F. Shankar[1], S. Mei[1], M. Bernardi[2], J.A.L. Aguerri[3], A. Meert[2], V. Vikram[2]

The evolution of the mass–size relation for early type galaxies from $z \sim 1$ to the present: dependence on environment, mass–range and detailed morphology

M. Huertas-Company[1,2*], S. Mei[1,2], F. Shankar[1], L. Delaye[1,9], A. Raichoor[3], G. Covone[4,5], A. Finoguenov[6], J.P. Kneib[7] , O. Le Fèvre[7], M. Povič[8]



Lauriane Delaye

Rossella Licitra

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

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

Environmental dependence of bulge-dominated galaxy sizes in hierarchical models of galaxy formation. Comparison with the local Universe.

Francesco Shankar[1*], Simona Mei[1,2], Marc Huertas-Company[1,2], Jorge Moreno[3], Fabio Fontanot[4,5], Pierluigi Monaco[6,7], Mariangela Bernardi[8], Andrea Cattaneo[9], Ravi Sheth[10,8], Rossella Licitra[1,2], Lauriane Delaye[1], Anand Raichoor[1]

Francesco Shankar

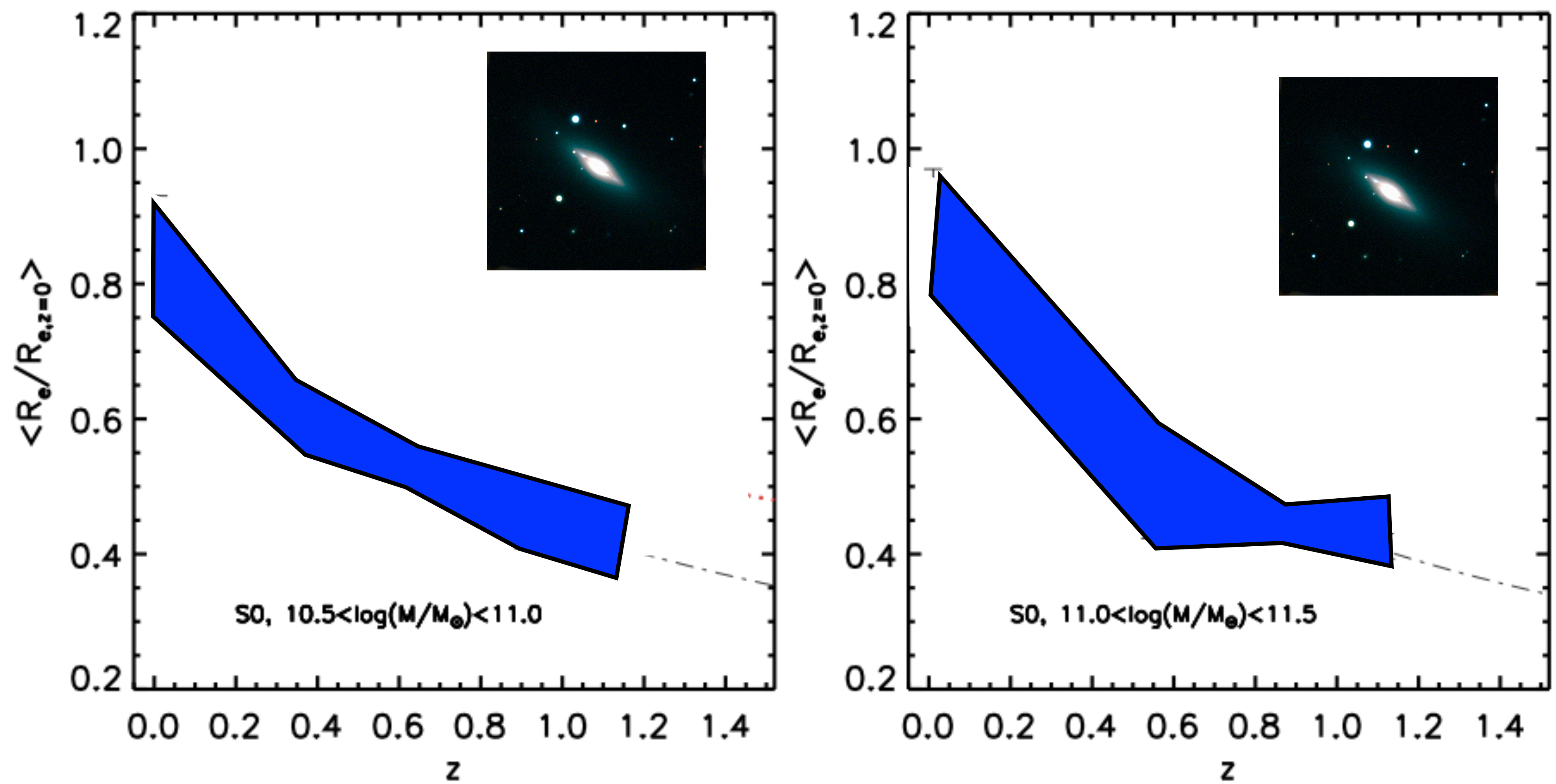
Questions

- Does Environment change galaxy size evolution?
- Are massive and central galaxies special?

Cosmos X-ray groups $0.2<z<1$ (George et al. 2011)

- X-ray detected groups in the Cosmos field (Finoguenov et al. 2007), with weak lensing mass estimates (Leauthaud et al. 2007) in the range 10^{13} - 10^{14} $M_{\odot}$
- 298 group and 384 field quiescent early-type galaxies with stellar masses > $10^{10.5}$ $M_{\odot}$ Photometric redshifts from Ilbert et al. 2009: $0<z<1$. Galaxy sample purity ~70% - 85% within 0.5 x R_{200}
- Spectroscopic redshifts from zCOSMOS, Keck, MMT, SDSS, and our own VLT/FORS 2 spectroscopic follow-up of BCGs, bright satellites and galaxy mergers (P.I. Mei)
- Galaxy masses from Bundy et al 2007 and independent estimation by LePhare using BC03 stellar population models

Disky ETG mass-size relation 0.2<z<1

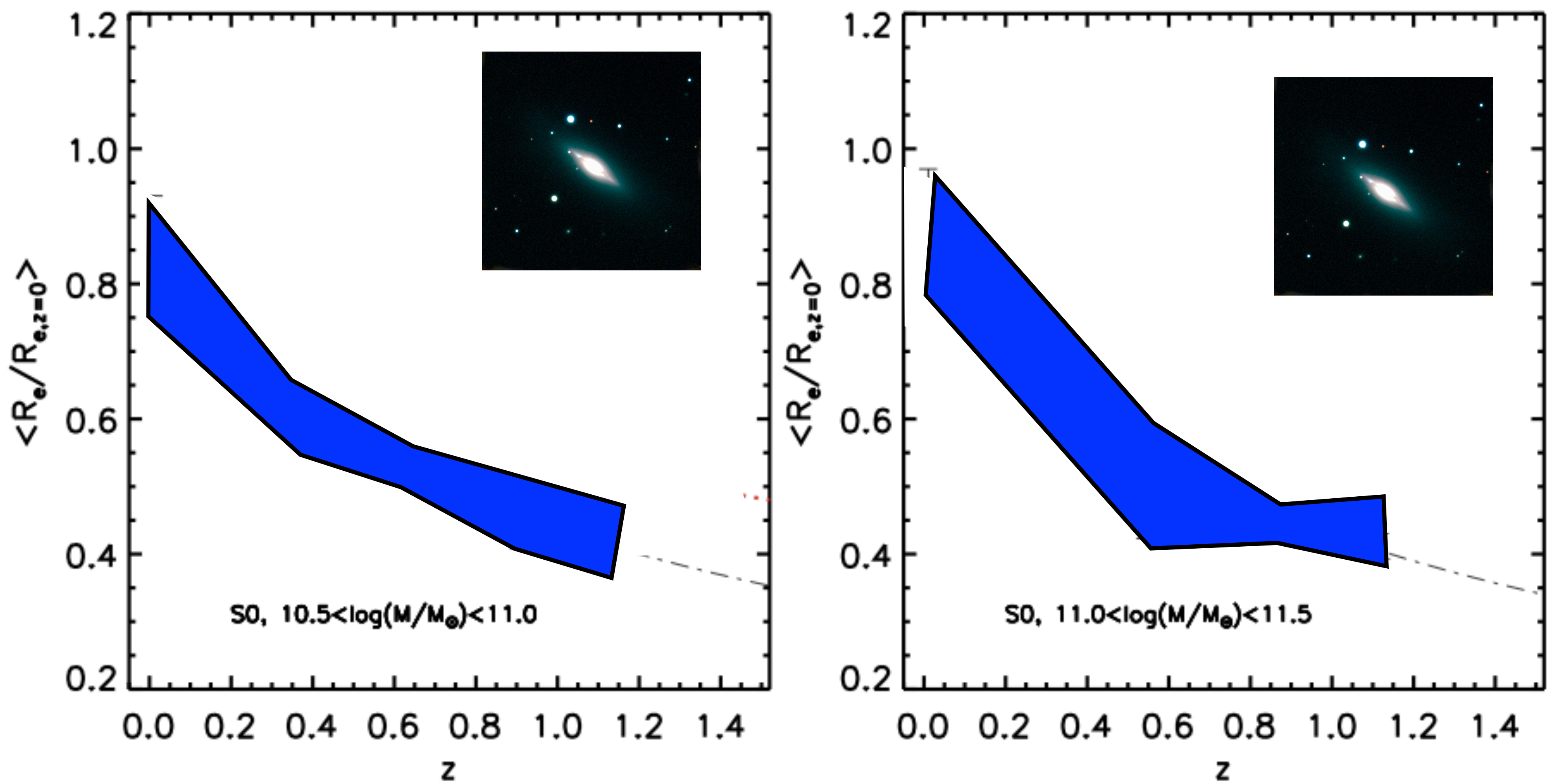


Huertas-Company, Mei et al. 2013

X-ray detected groups in the Cosmos field (Finoguenov et al. 2007) from the George et al. 2011, weak lensing mass estimates (Leauthaud et al. 2007) in the range 10^{13} - 10^{14} $M_{\odot}$, 298 group and 384 field quiescent ETGs with stellar masses > $10^{10.5}$ $M_{\odot}$

Disky ETG mass-size relation 0.2<z<1

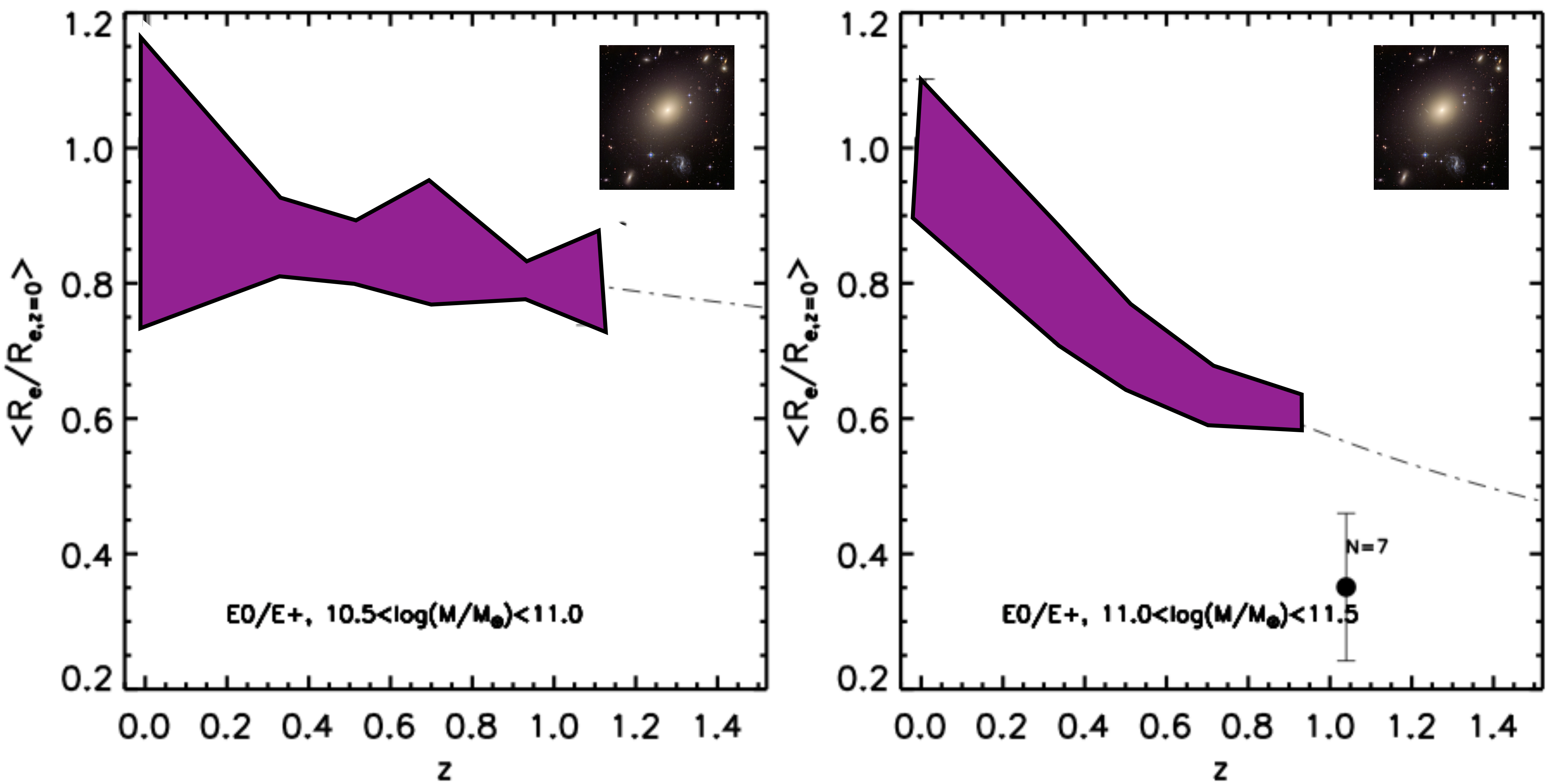
Size Evolution does not depend on Mass Range



Huertas-Company, Mei et al. 2013

X-ray detected groups in the Cosmos field (Finoguenov et al. 2007) from the George et al. 2011, weak lensing mass estimates (Leauthaud et al. 2007) in the range 10^{13} - 10^{14} $M_\odot$, 298 group and 384 field quiescent ETGs with stellar masses > $10^{10.5}$ $M_\odot$

E (not disky) mass-size relation 0.2<z<1

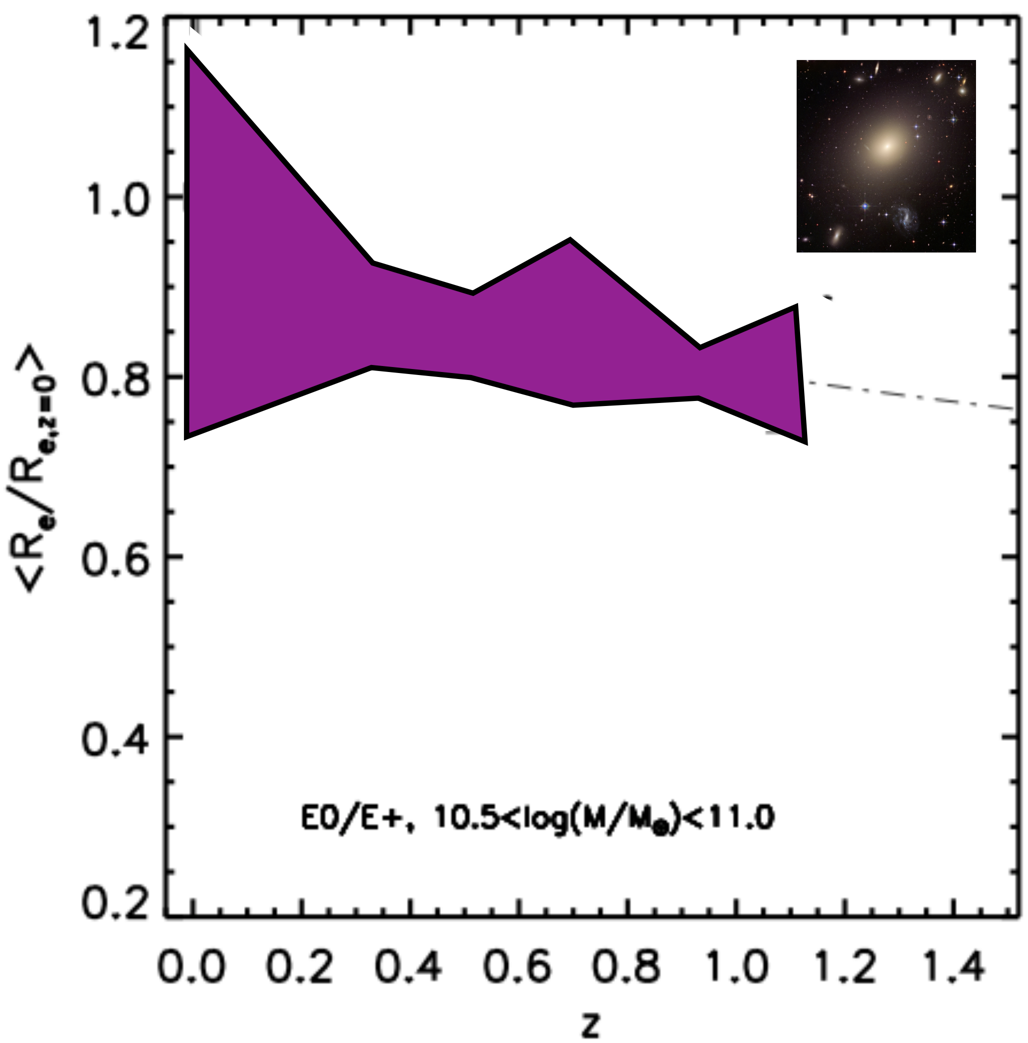


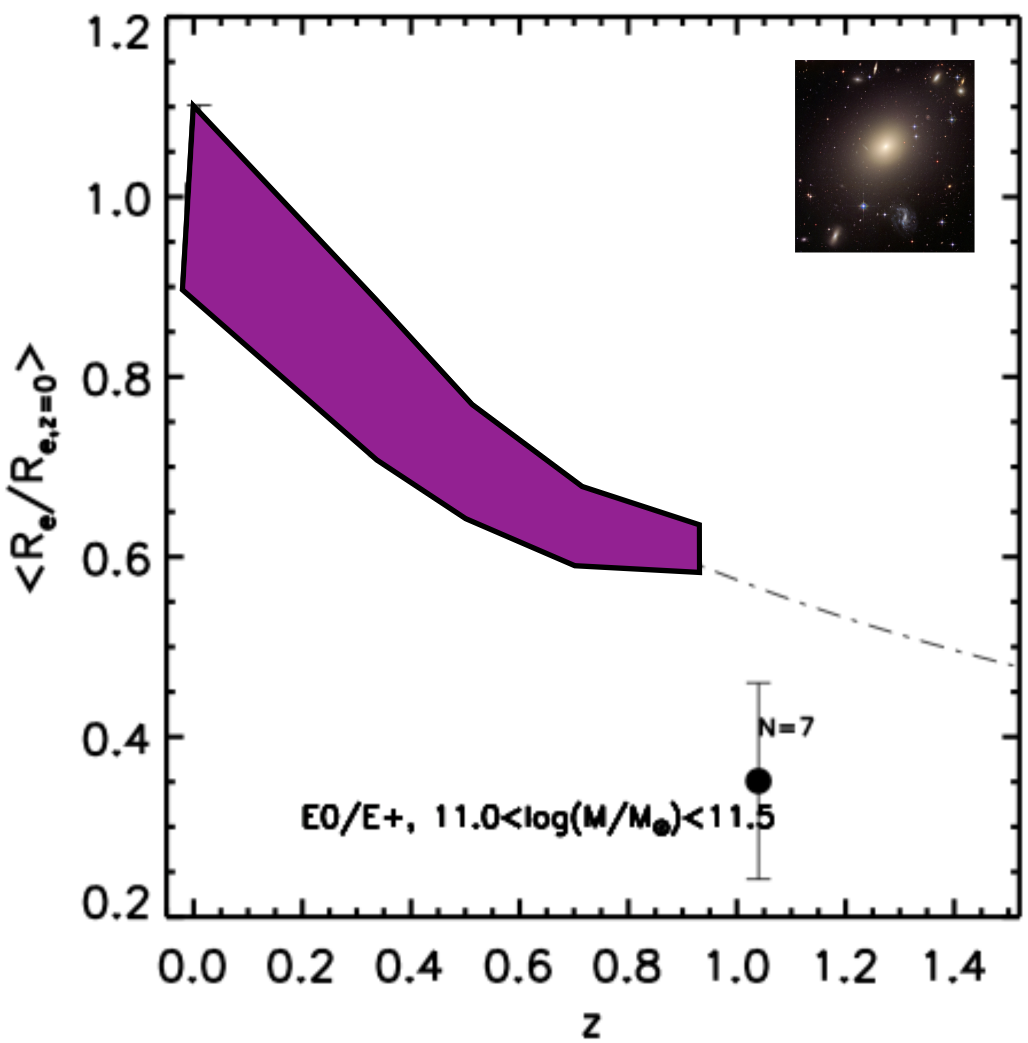
Huertas-Company, Mei et al. 2013

X-ray detected groups in the Cosmos field (Finoguenov et al. 2007) from the George et al. 2011, weak lensing mass estimates (Leauthaud et al. 2007) in the range 10^{13} - 10^{14} $M_{\odot}$, 298 group and 384 field quiescent ETGs with stellar masses > $10^{10.5}$ $M_{\odot}$

E (not disky) mass-size relation 0.2<z<1

Size Evolution depends on Mass Range



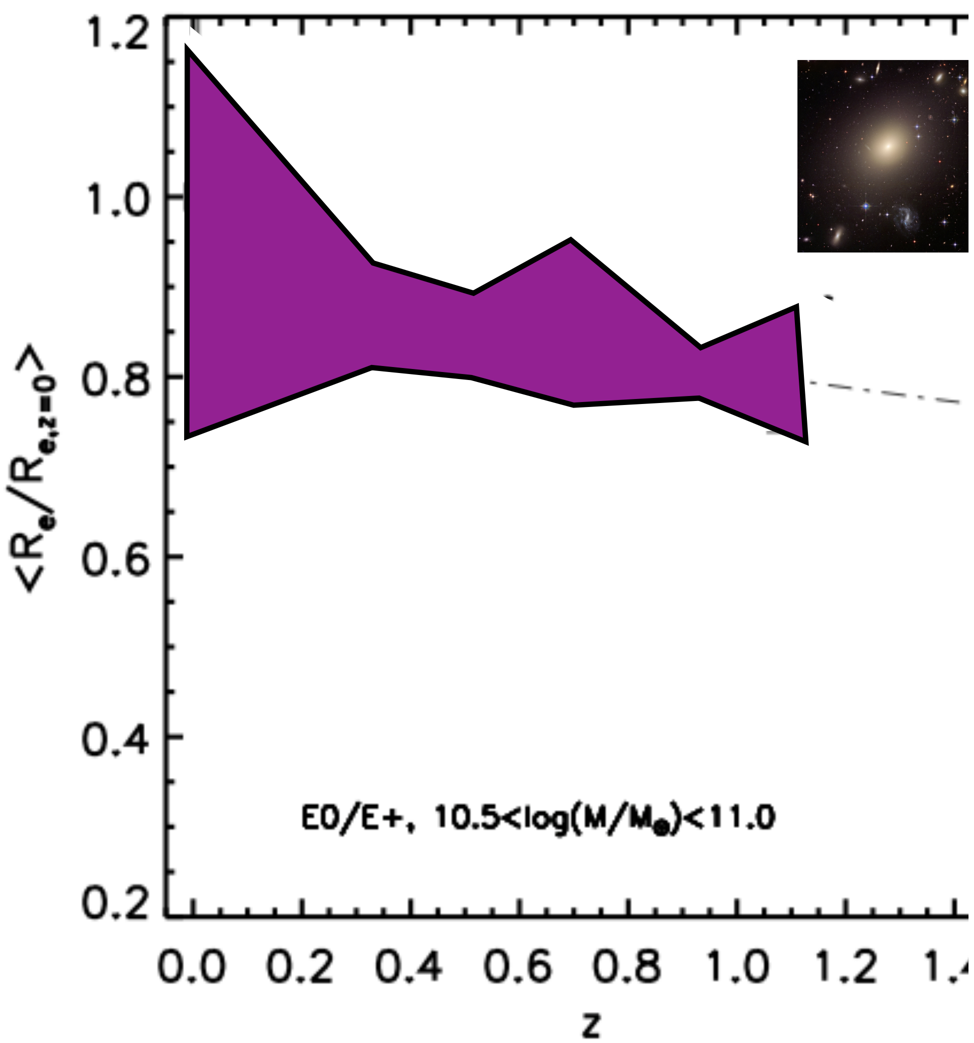


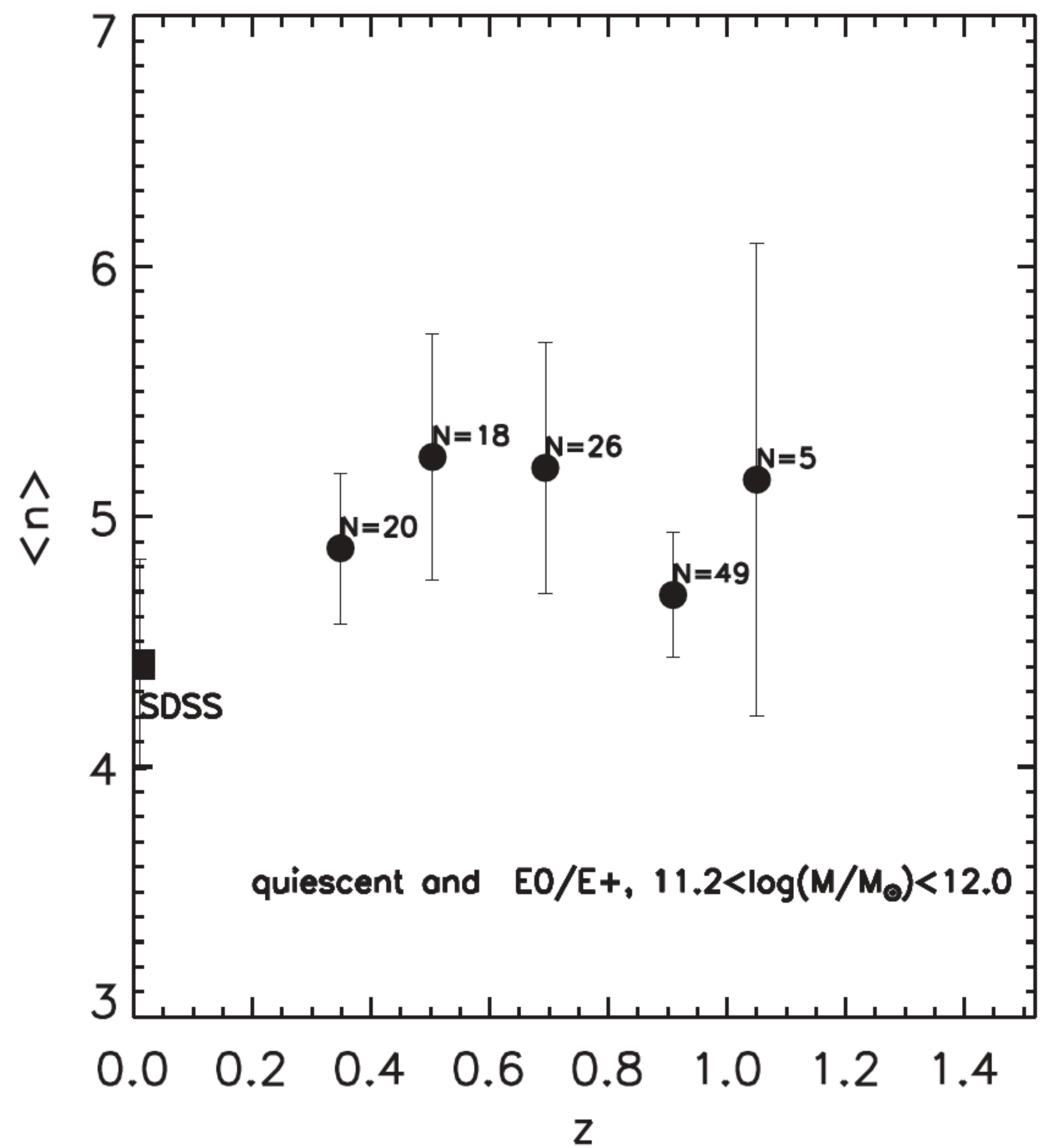
Huertas-Company, Mei et al. 2013

X-ray detected groups in the Cosmos field (Finoguenov et al. 2007) from the George et al. 2011, weak lensing mass estimates (Leauthaud et al. 2007) in the range 10^{13} - 10^{14} $M_\odot$, 298 group and 384 field quiescent ETGs with stellar masses > $10^{10.5}$ $M_\odot$

E (not disky) mass-size relation $0.2<z<1$

Size Evolution depends on Mass Range

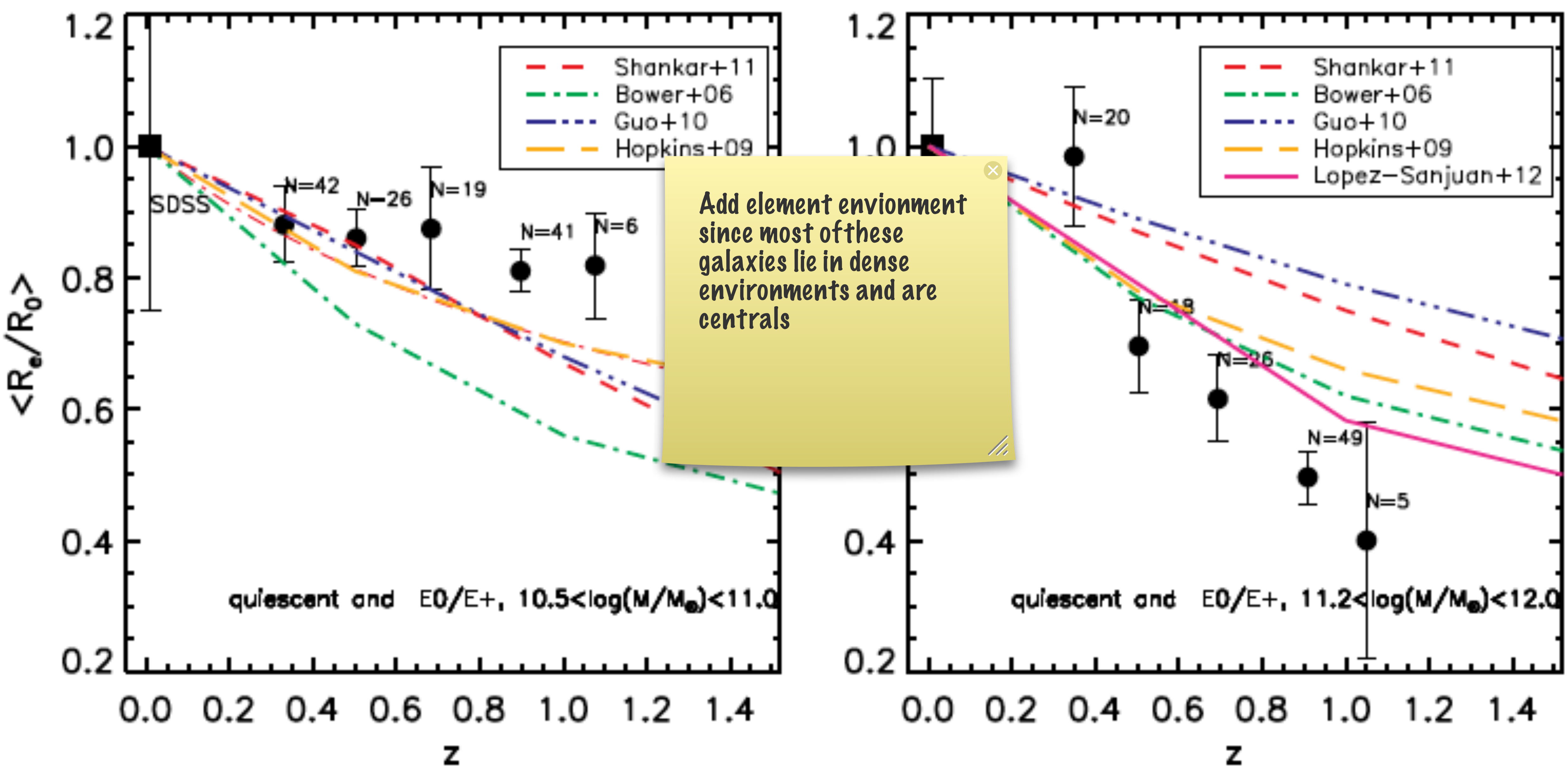




Huertas-(

X-ray detected groups in the Cosmos field … 11, weak lensing mass estimates (Leauthaud et al. 2007) in the range 10^{13} - 10^{14} $M_\odot$, 298 group and 384 field quiescent ETGs with stellar masses > $10^{10.5}$ $M_\odot$

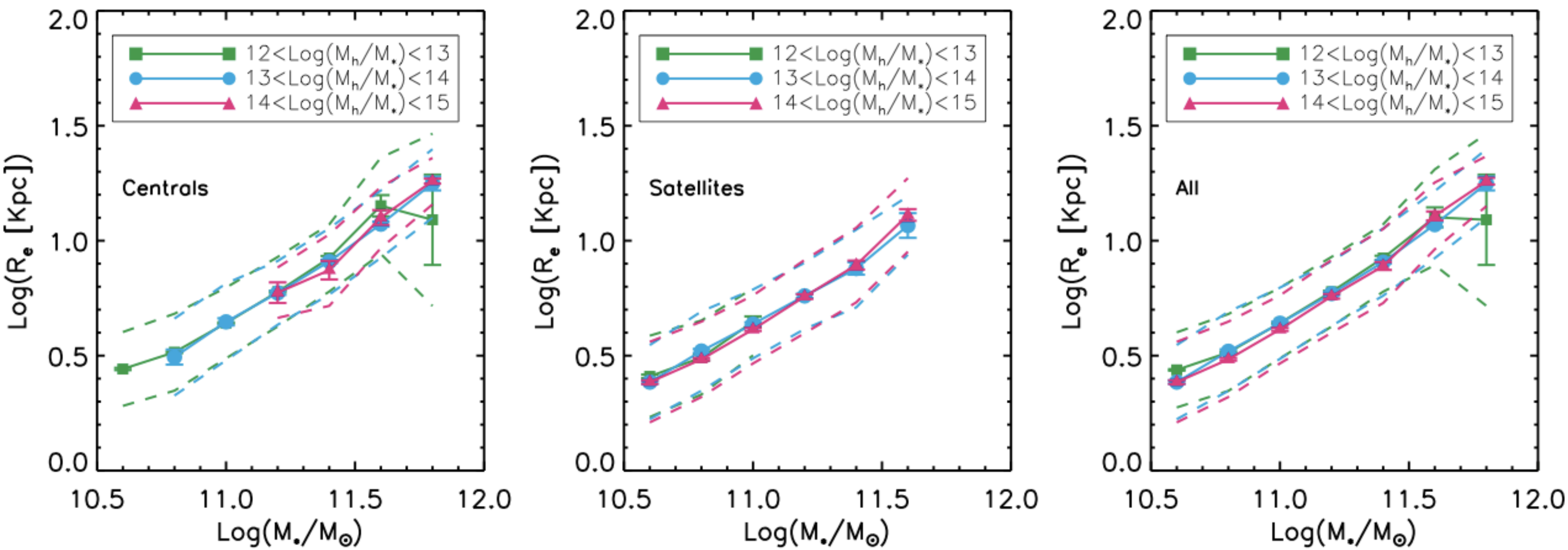
Cosmos X-ray group E mass-size relation



Huertas-Company, Mei, Shankar et al. 2013

see also Newman et al. 2012, Bluck et al. 2011

Size, Mass and Environment



Huertas-Company, Shankar, Mei et al. 2013

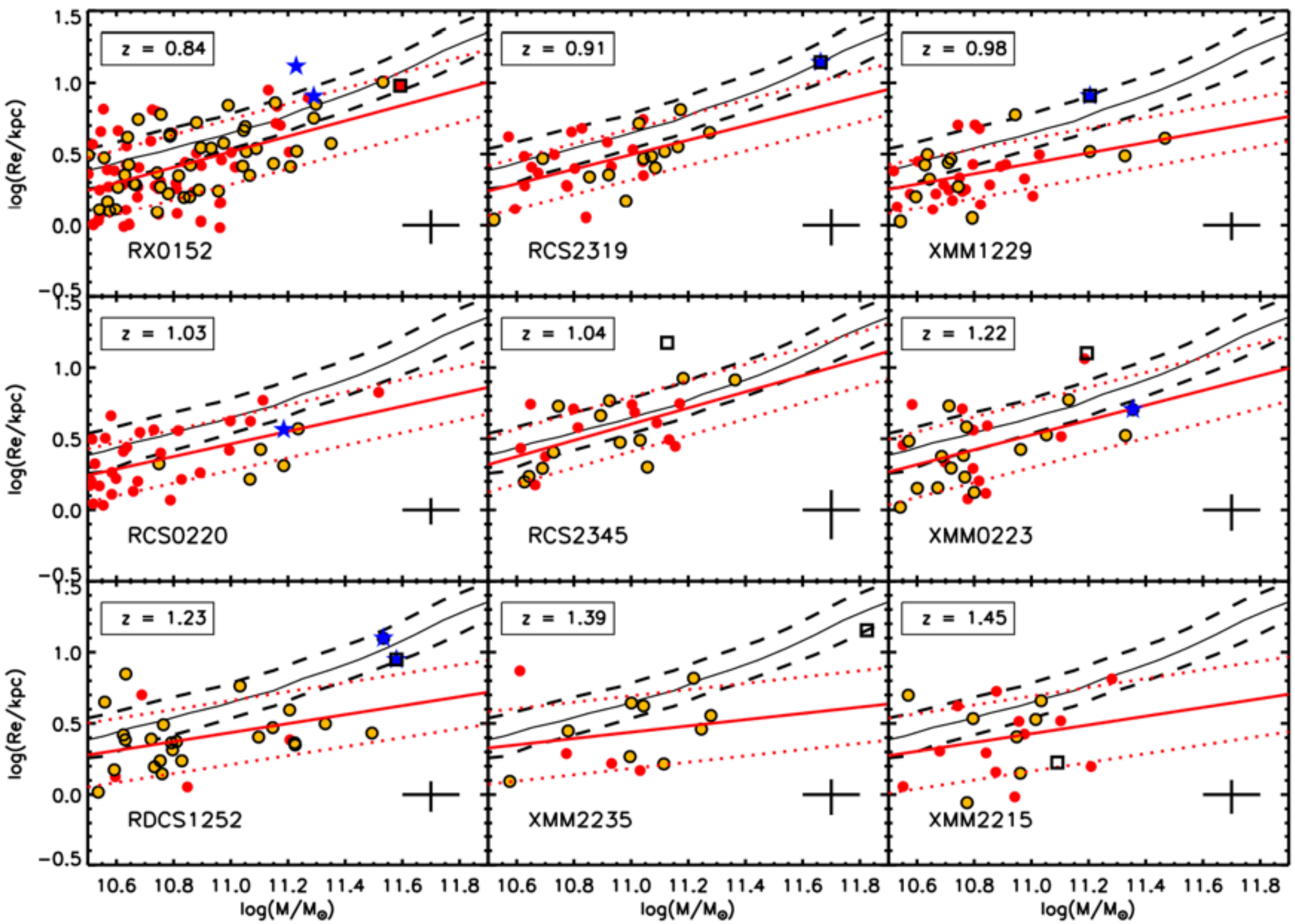
z~0 SDSS

Yang et al. 2007 group sample; sizes from Bernardi et al. 2012

see also Poggianti et al. 2013, Vulcani et al. 2014

Clusters 0.8<z<1.5

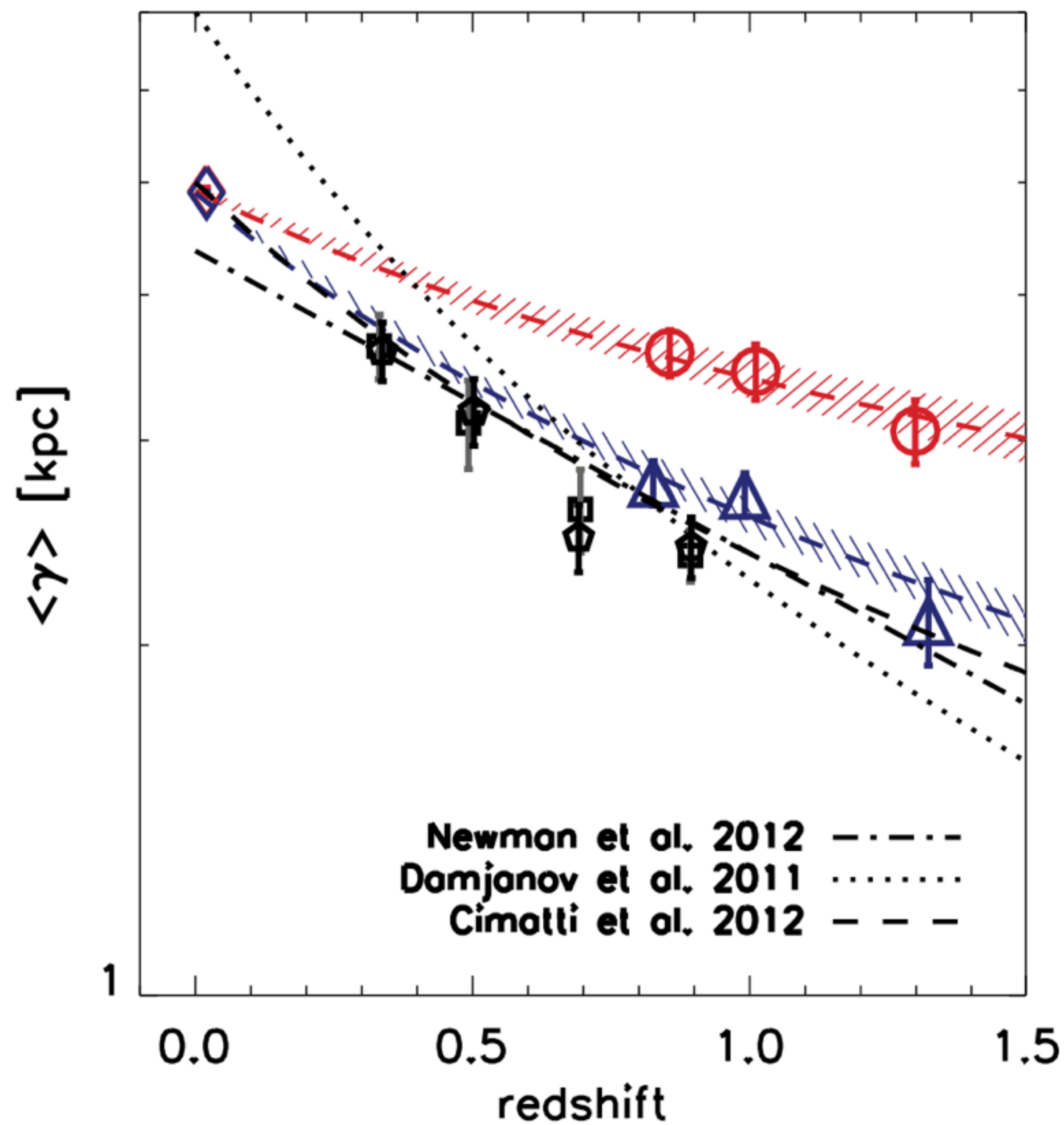
Delaye, Huertas-Company, Mei et al. 2014



Nine clusters (ACS GTO, Sparcs, RCS) with z~0.8-1.5 and mass in the range 2-7 x 10^{14} $M_\odot$ from the HAWKI Cluster survey (Lidman et al. 2013). ~400 ETGs (morphology selected and passive) with masses > $10^{10.5}$ $M_\odot$

Size evolution and Environment

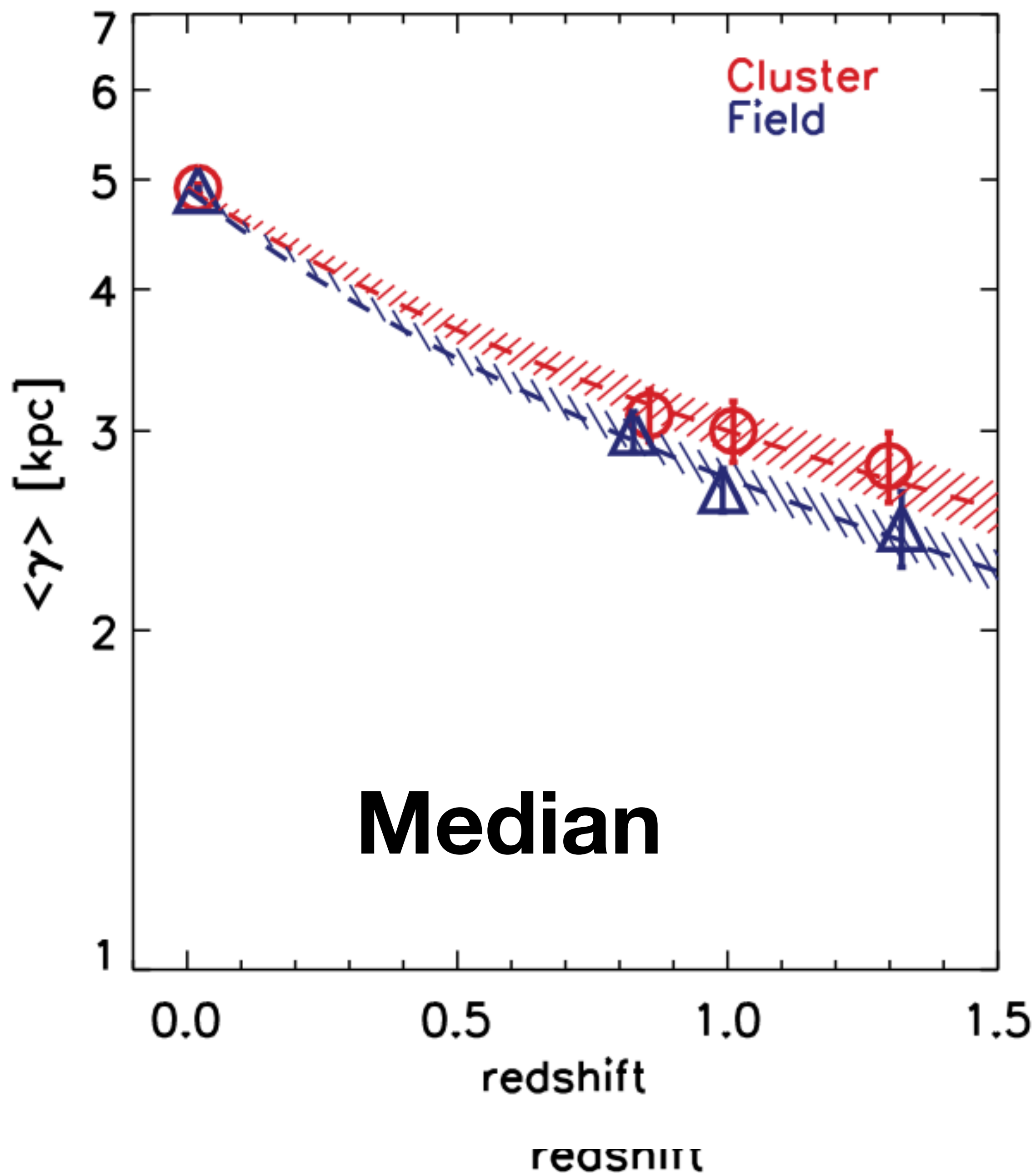
Delaye, Huertas-Company, Mei et al. 2014



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

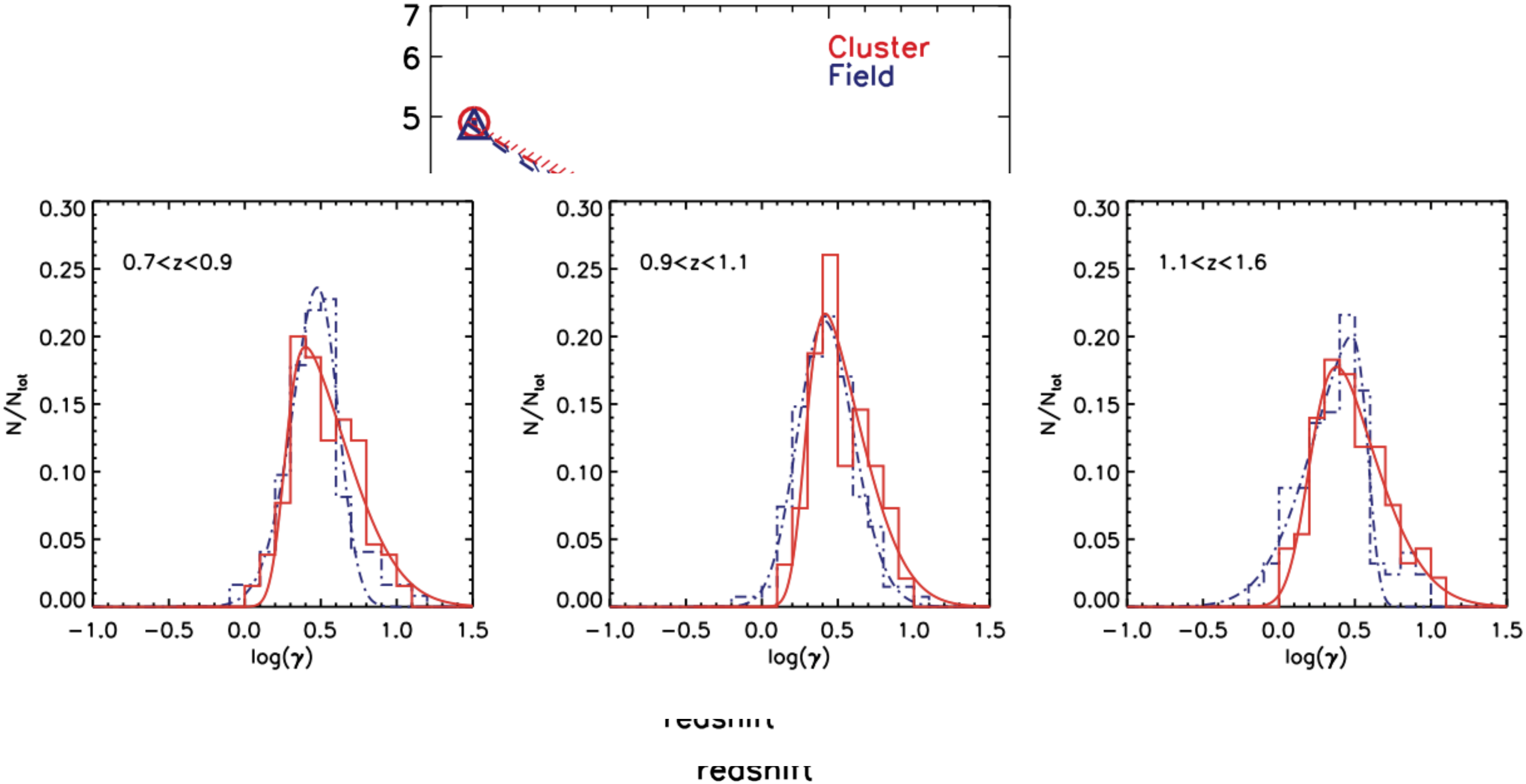
Delaye, Huertas-Company, Mei et al. 2014



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

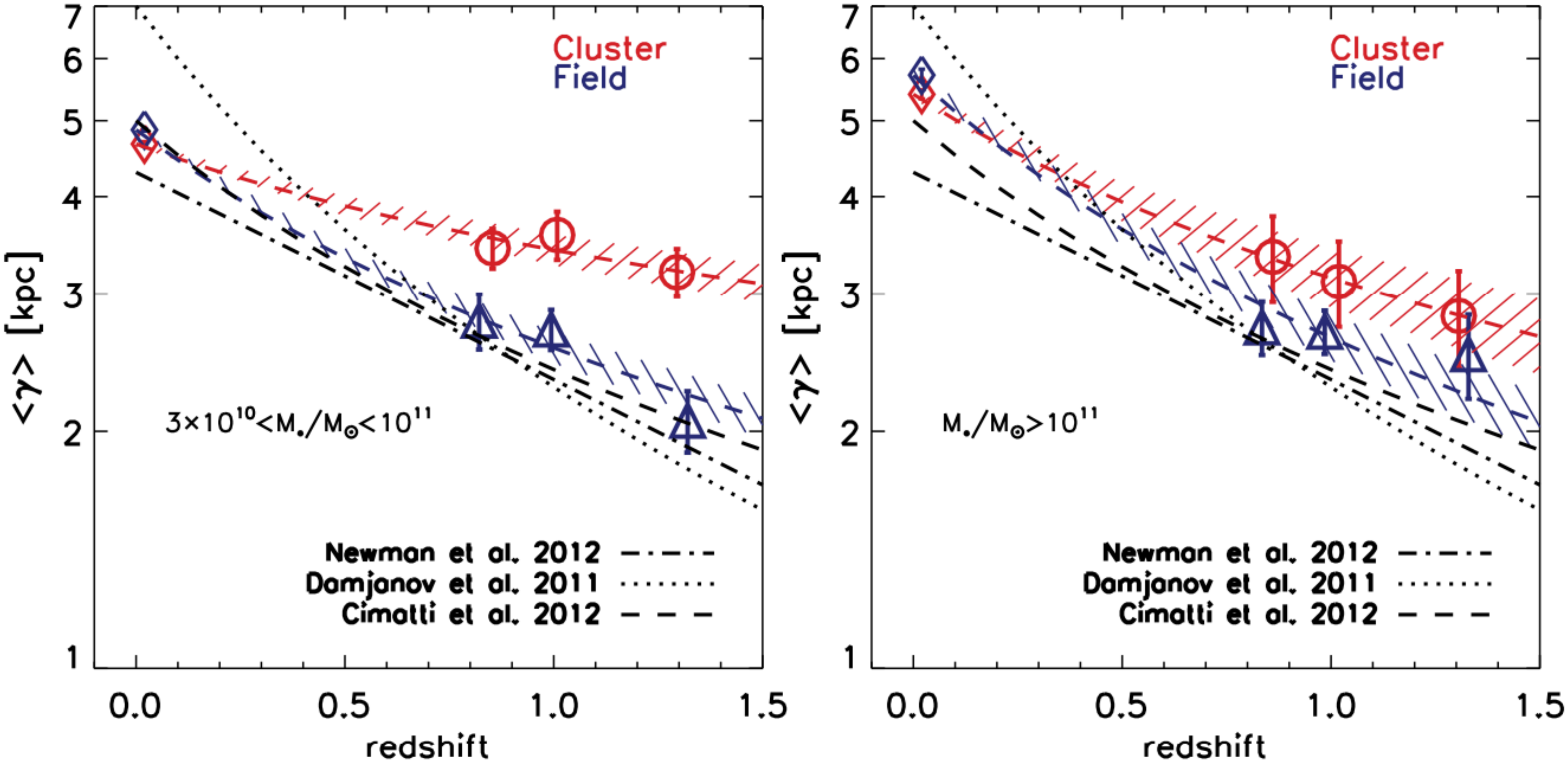
Size evolution and Environment

Delaye, Huertas-Company, Mei et al. 2014



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

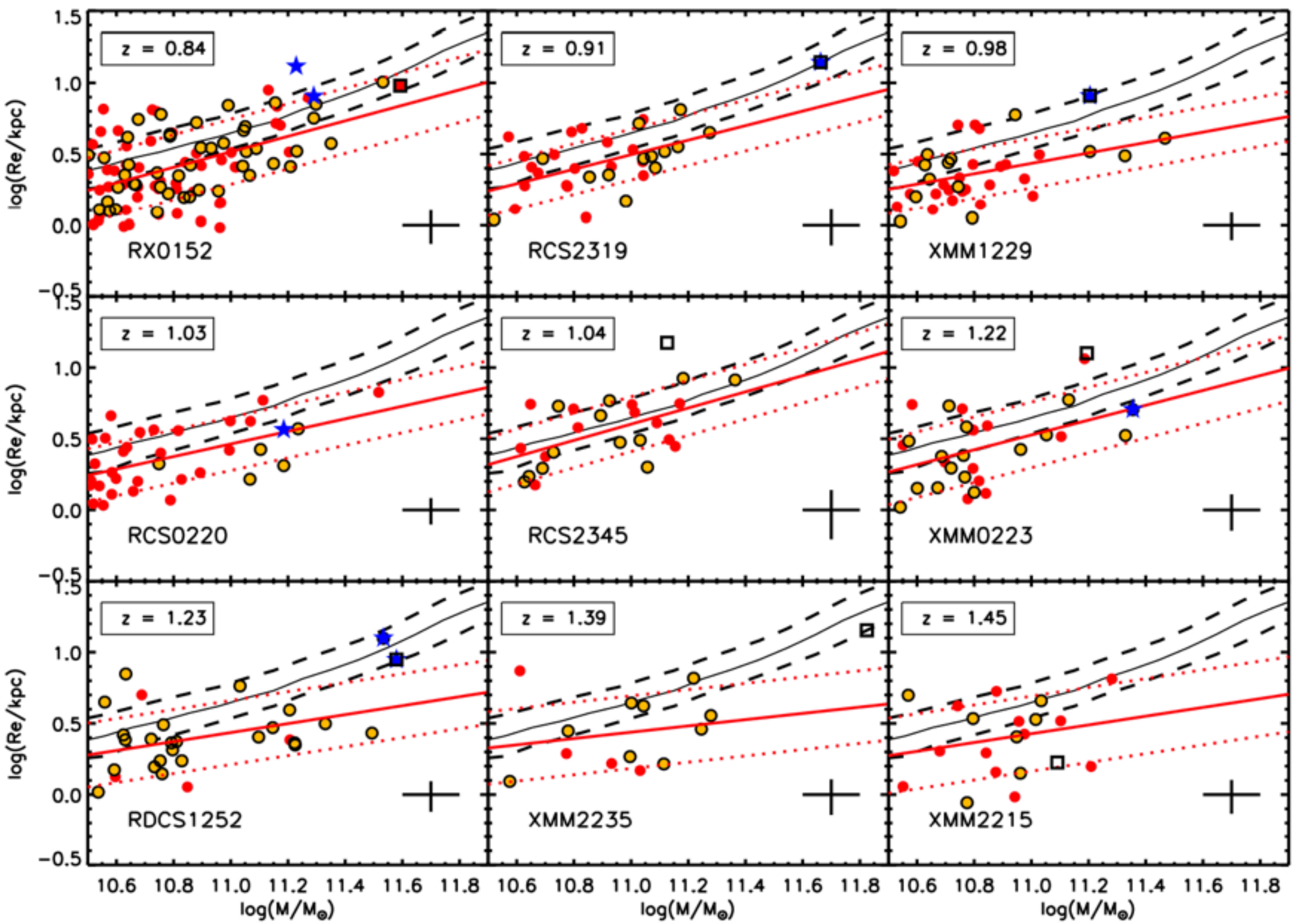
Which galaxies



The larger galaxies are the last massive

Clusters 0.8<z<1.5

Delaye, Huertas-Company, Mei et al. 2014

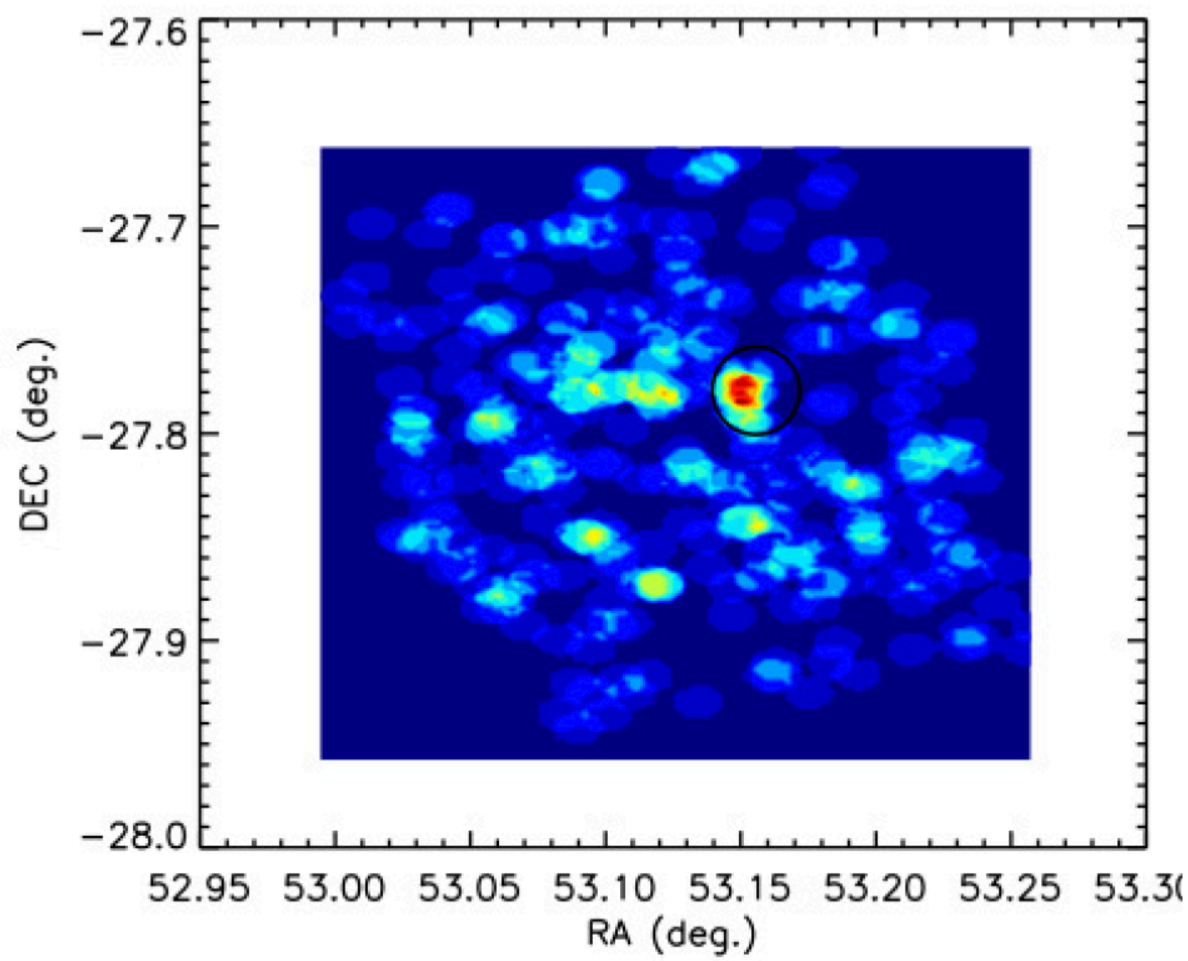


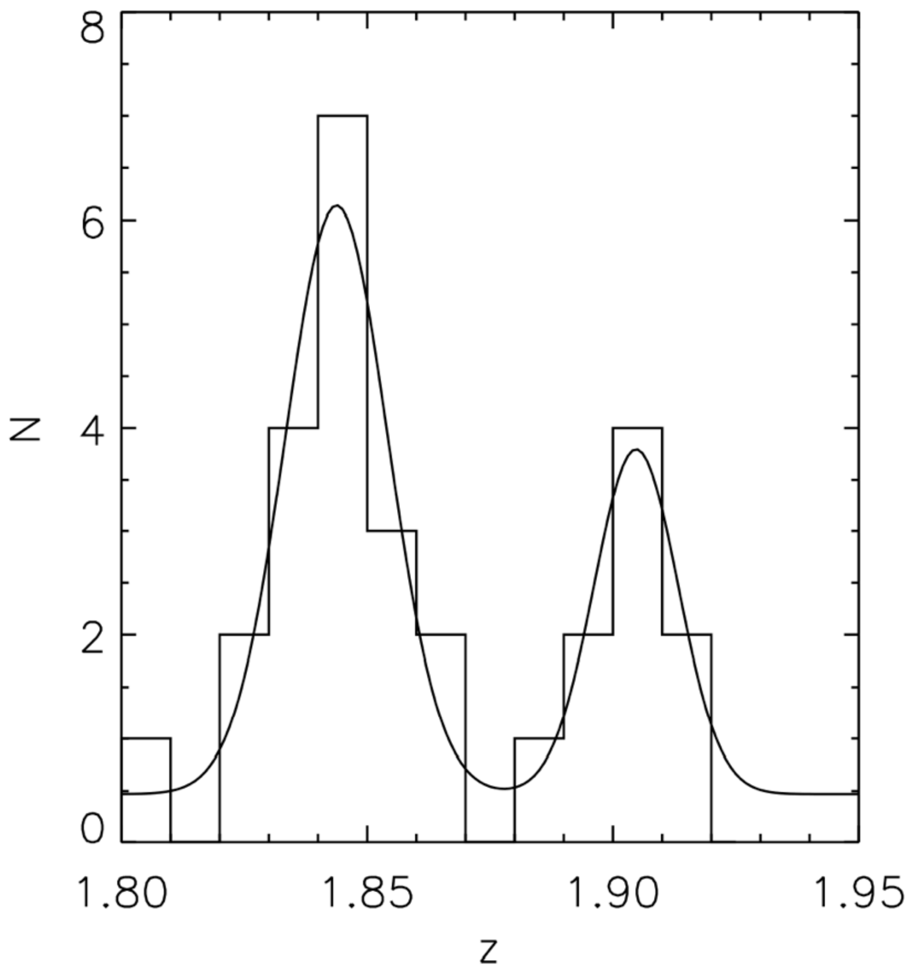
Nine clusters (ACS GTO, Sparcs, RCS) with z~0.8-1.5 and mass in the range 2-7 x 10^{14} $M_\odot$ from the HAWKI Cluster survey (Lidman et al. 2013). ~400 ETGs (morphology selected and passive) with masses > $10^{10.5}$ $M_\odot$

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

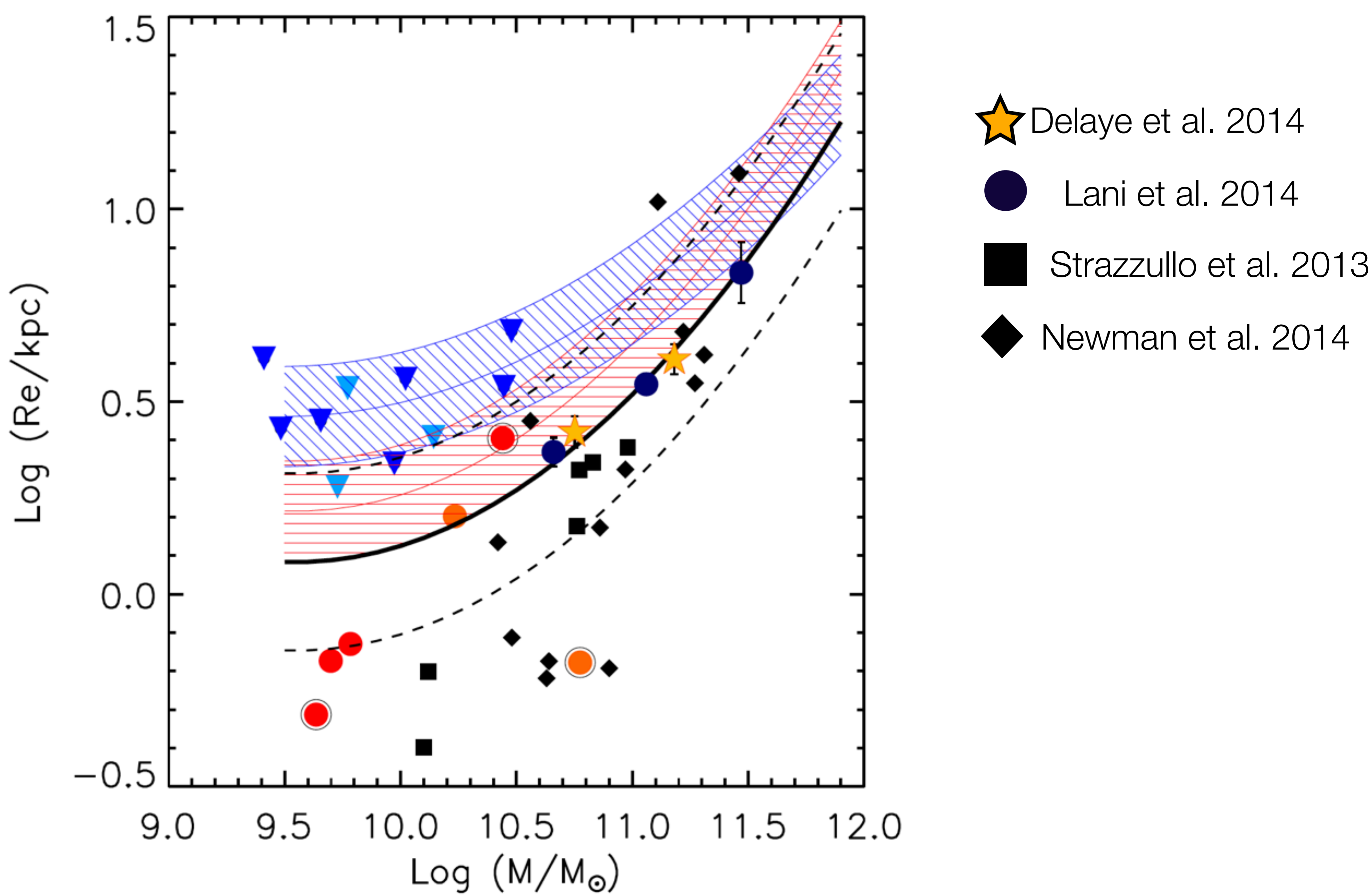
Star–forming blue ETGs in two newly discovered galaxy overdensities in the HUDF at z=1.84 and 1.9: unveiling the progenitors of passive ETGs in cluster cores

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



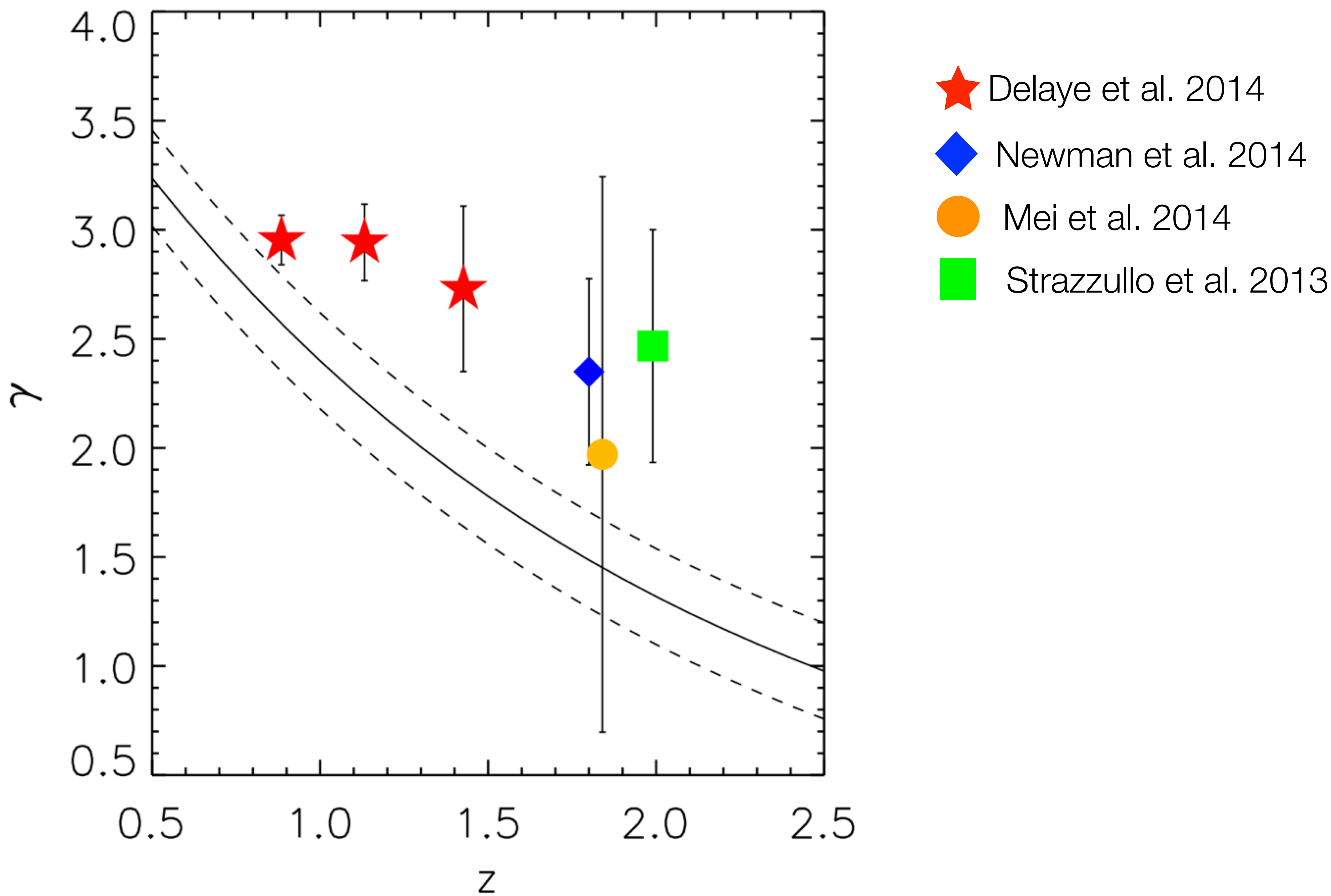


Mass-size relation at z~1.8



Mei et al. arXiv:1403.7524

Size growth - only ETGs



Mei et al. arXiv:1403.7524

Hierarchical model predictions

(Shankar et al. 2012, Shankar, Mei et al. 2014)

- Models based on the standard model and Millenium simulations- Different prescription for size growth

and that of the remnant Cole et al. (2000)

$$\frac{(M_1 + M_2)^2}{R_{\rm new}} = \frac{M_1^2}{R_1} + \frac{M_2^2}{R_2} - \frac{f_{\rm orb}}{c} \frac{M_1 M_2}{R_1 + R_2}$$

Mergers

$$c_B \frac{(M_{\rm bulge} + M_{\rm disc})^2}{R_{\rm new}} = c_B \frac{M_{\rm bulge}^2}{R_{\rm bulge}} + c_D \frac{M_{\rm disc}^2}{R_{\rm disc}} - f_{\rm int} \frac{M_{\rm bulge} M_{\rm disc}}{R_{\rm bulge} + R_{\rm disc}}$$

Disk Instabilities

We concentrated on the size evolution of central galaxies

Hierarchical model predictions

(Shankar et al. 2012, Shankar, Mei et al. 2014)

PROCESS	*DESCRIPTION*
DISC INSTABILITIES	Mostly effective if violent and impulsive. Induce more compact bulges in less massive haloes with lower circular velocities
MERGERS	Only effective (at $z = 0$) if short dynamical friction timescales. More effective (minor) galaxy mergers in more massive host haloes, thus larger centrals
GAS DISSIPATION	Progressively more effective in less massive haloes with gas-richer progenitors
SATELLITE EVOLUTION	Overall milder effect. Present if fast quenching/gas stripping, thus proportionally less growth in satellites in lower mass haloes. Induces more compact remnants in less massive haloes

Environment can distinguish predictions from different models

Shankar, Mei, Huertas-Company et al. 2014

Observations are at z~0 from Bernardi et al. 2012, Huertas-Company et al. 2013

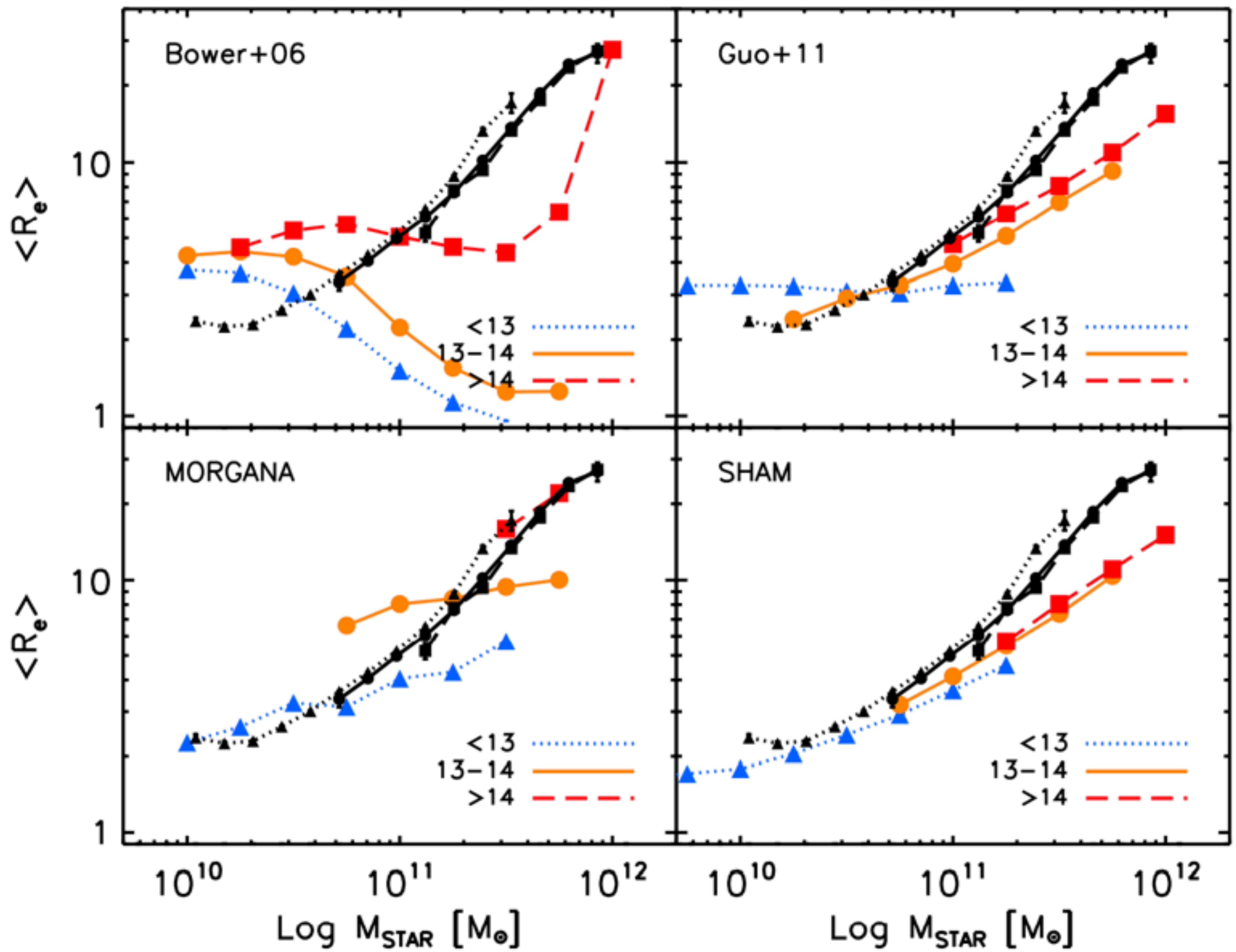


Figure 6. Predicted median size-stellar mass relation of central galaxies in different bins of halo masses, $\log M_{\rm halo}/M_\odot < 13$, $13 < \log M_{\rm halo}/M_\odot < 14$, and $\log M_{\rm halo}/M_\odot > 14$, for different models, as labelled. There is a large variation of median sizes up to a factor

Environment can distinguish predictions from different models

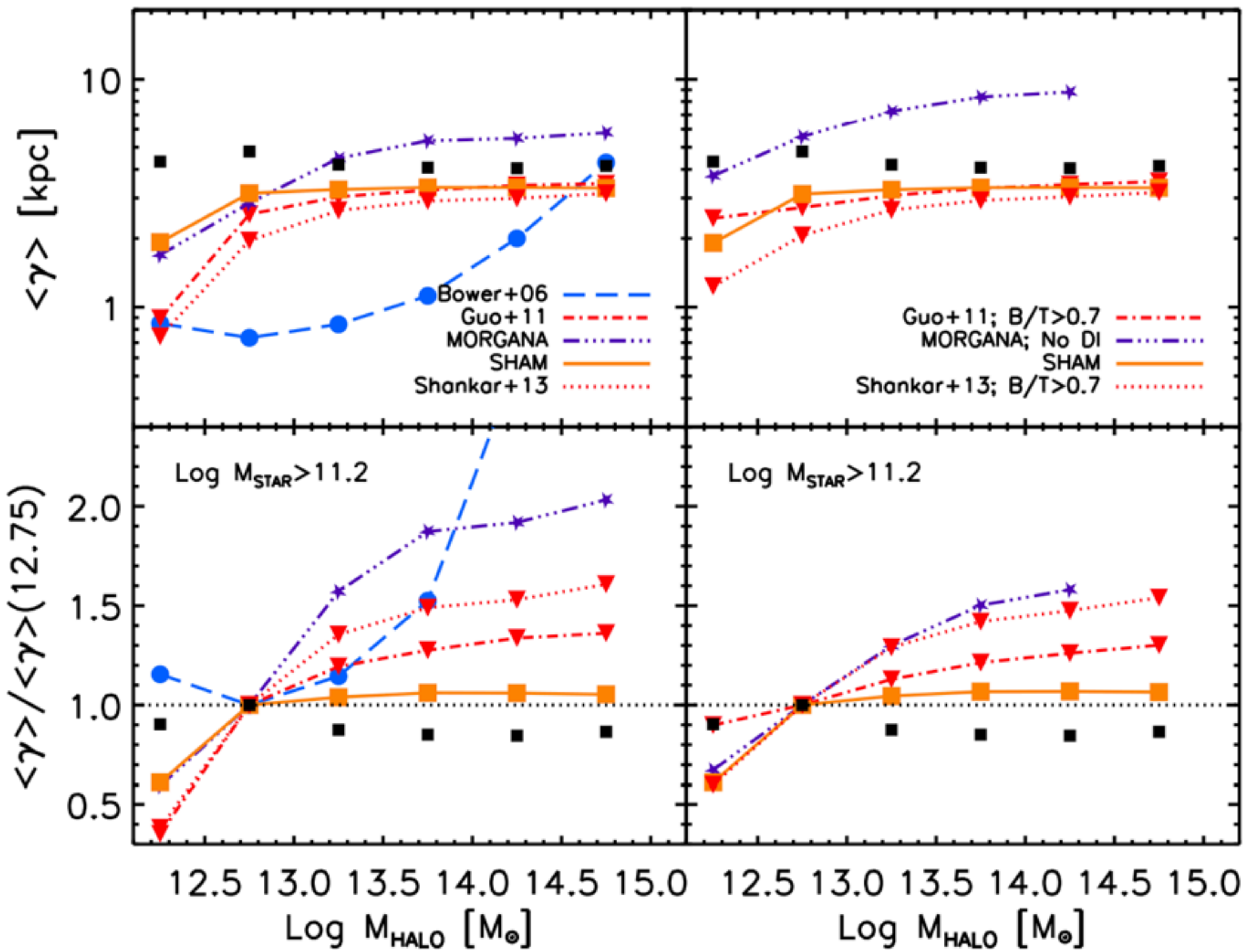
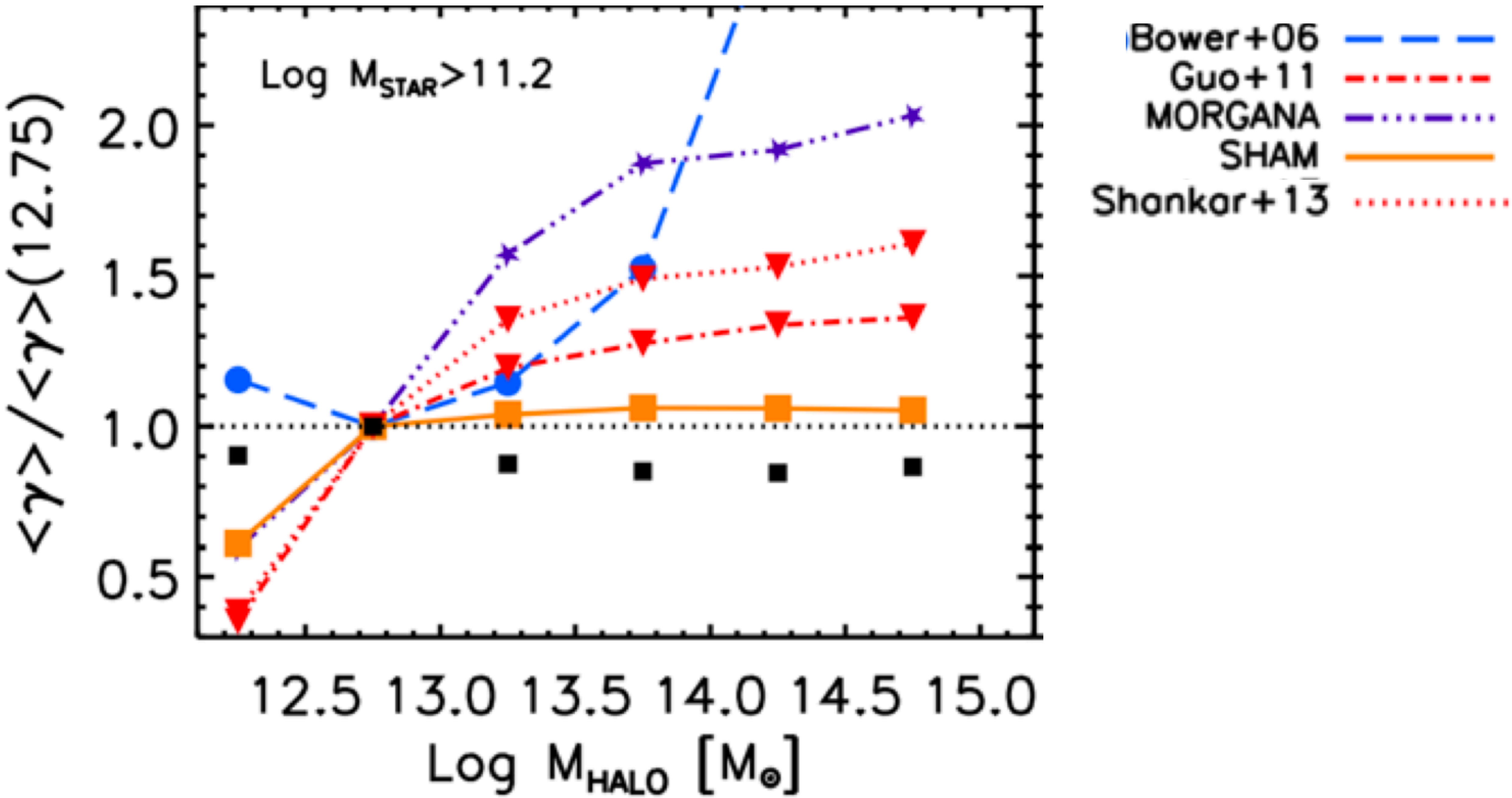


Figure 7. Fractional increase of median size in the stellar mass bin log $M_{star}/M_{\odot} > 11.2$ and $B/T > 0.5$ for different type of models, as labelled. Data are from Huertas-Company et al. (2012). Models with less strong or absent disc instabilities are favoured.

Shankar, Mei, Huertas-Company et al. 2013

Observations are at z~0 from Bernardi et al. 2012, Huertas-Company et al. 2013

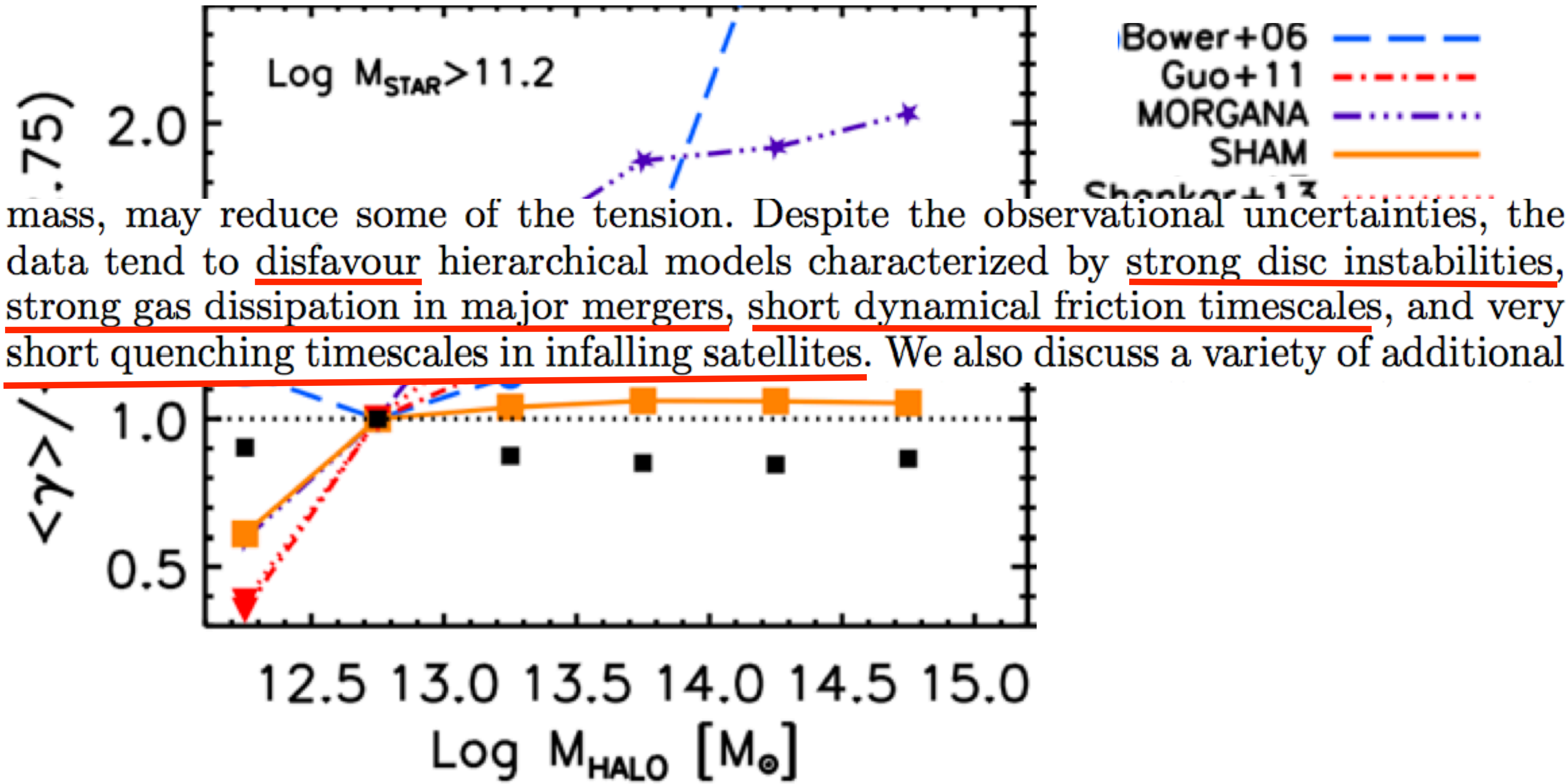
Environment can distinguish predictions from different models



Shankar, Mei, Huertas-Company et al. 2013

Observations are at z~0 from Bernardi et al. 2012, Huertas-Company et al. 2013

Environment can distinguish predictions from different models

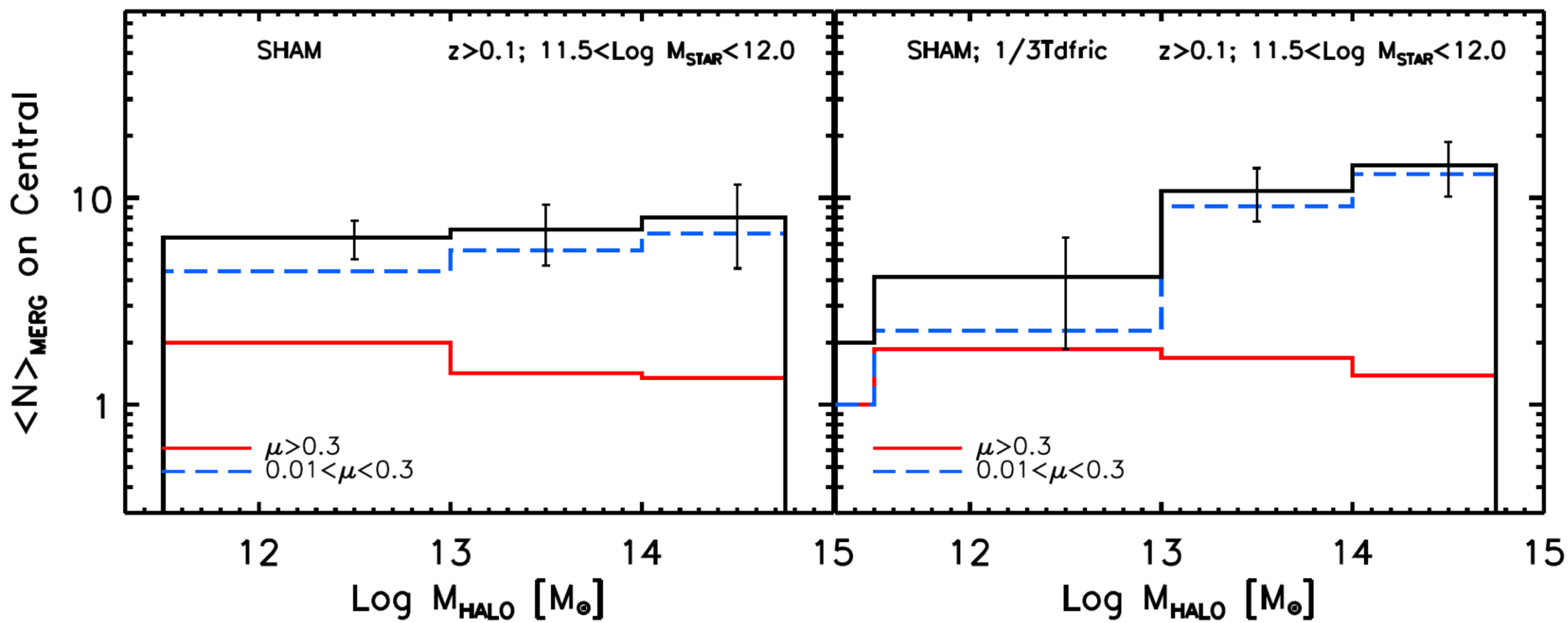


mass, may reduce some of the tension. Despite the observational uncertainties, the data tend to disfavour hierarchical models characterized by strong disc instabilities, strong gas dissipation in major mergers, short dynamical friction timescales, and very short quenching timescales in infalling satellites. We also discuss a variety of additional

Shankar, Mei, Huertas-Company et al. 2013

Observations are at z~0 from Bernardi et al. 2012, Huertas-Company et al. 2013

What about mergers?



Shankar, Mei, Huertas-Company et al. 2013

see also Maulbetsch et al. 2007, Bertone & Conselice 2009

Some caveats...

- Estimation of galaxy stellar masses can be biased up to 0.2dex in the high mass end due to different estimator and stellar population models (Bernardi et al. 2010, Raichoor, Mei et al. 2011)

- Fit with a single Sersic profile of a galaxy that has an exponential component can bias the Size and the Mass estimation up to 20%/0.2 dex, respectively (Bernardi et al. 2013a,b)

Some caveats...

- Estimation of galaxy stellar masses can be biased up to 0.2dex in the high mass end due to different estimator and stellar population models (Bernardi et al. 2010, Raichoor, Mei et al. 2011)

- Fit with a single Sersic profile of a galaxy that has an exponential component can bias the Size and the Mass estimation up to 20%/0.2 dex, respectively (Bernardi et al. 2013a,b)

Some caveats...

- Estimation of galaxy stellar masses can be biased up to 0.2dex in the high mass end due to different estimator and stellar population models (Bernardi et al. 2010, Raichoor, Mei et al. 2011)

- Fit with a single Sersic profile of a galaxy that has an exponential component can bias the Size and the Mass estimation up to 20%/0.2 dex, respectively (Bernardi et al. 2013a,b)

Questions

- Signature of quenching?
- What is the role of mergers in different environments at at different redshifts?

Comparison to other structures at z~1.8-2

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	$M_{200}^{(b)} = 2.2 \pm 1.8$	$< 1 - 6$	This work
IDCS J1433.2+3306	Cluster	1.89	...	...	$M_{200} \sim 1$	...	Zeimann et al. 2012
HUDFJ0332.5-2747.3	Group	1.90	$\sim 4 - 7\sigma$	...	...	...	This work
CL J1449+085	Cluster	1.99	$> 20\sigma$	...	$M_{200}^{(a)} = 0.53 \pm 0.09$	6.4 ± 1.8	Gobat et al. 2013

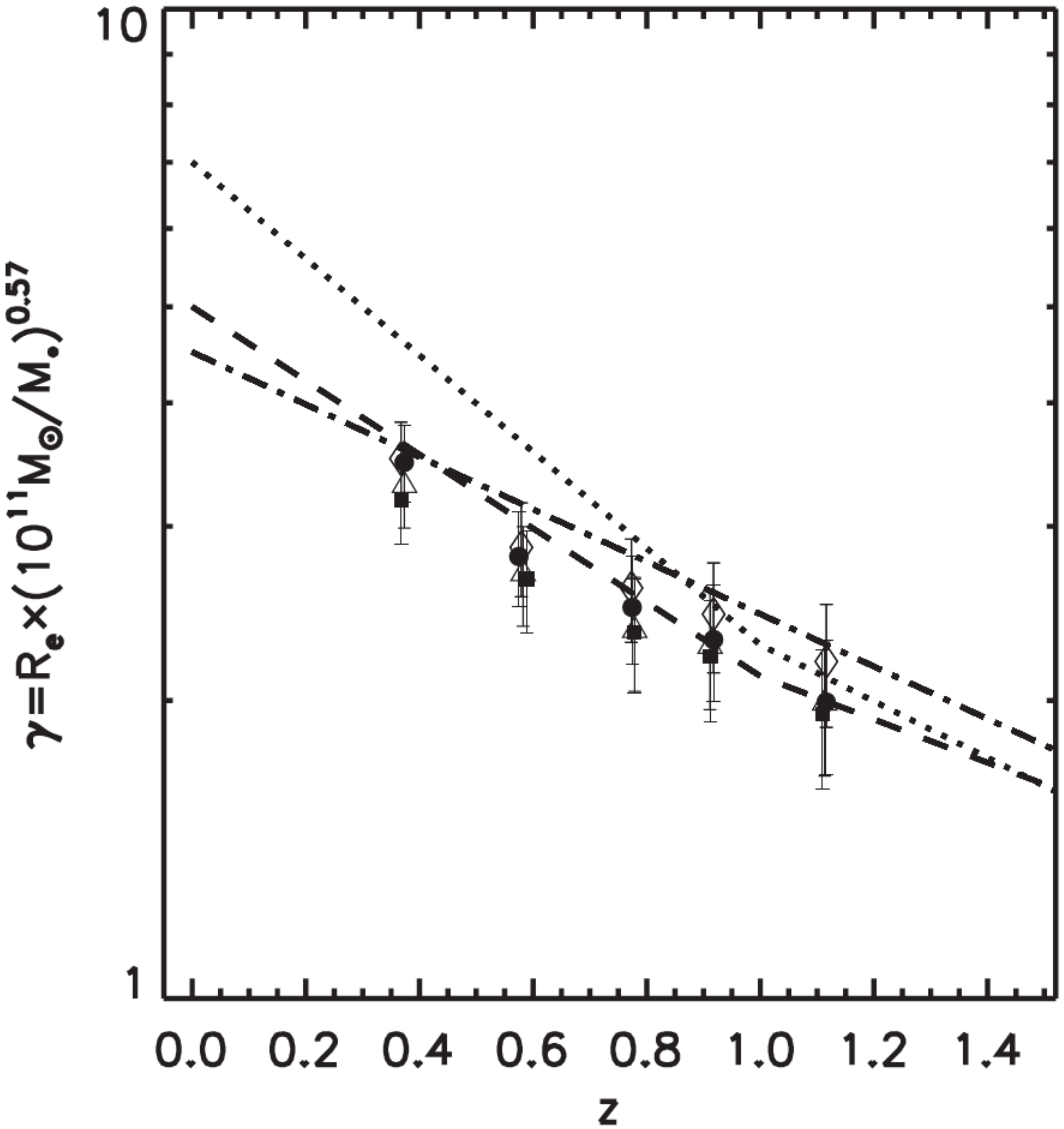


Figure 9. Mass-normalized radius for our sample for galaxies with masses $\log(M/M_{\odot}) > 10.7$, as a function of redshift for different selections compared to recent published results. The circles are ETGs, the squares passive galaxies, the triangles passive ETGs and the diamonds $n > 2.5$ galaxies. The dashed line shows the Cimatti et al. (2012) fit, the dot–dashed line shows the Newman et al. (2012) fit and the dotted line shows the Damjanov et al. (2011) fit. Samples selected using the Sérsic index tend to show larger sizes, because of the contamination from passive spirals, which is larger in field samples. However, these differences are within 1σ.