stellar mass growth of brightest cluster galaxies

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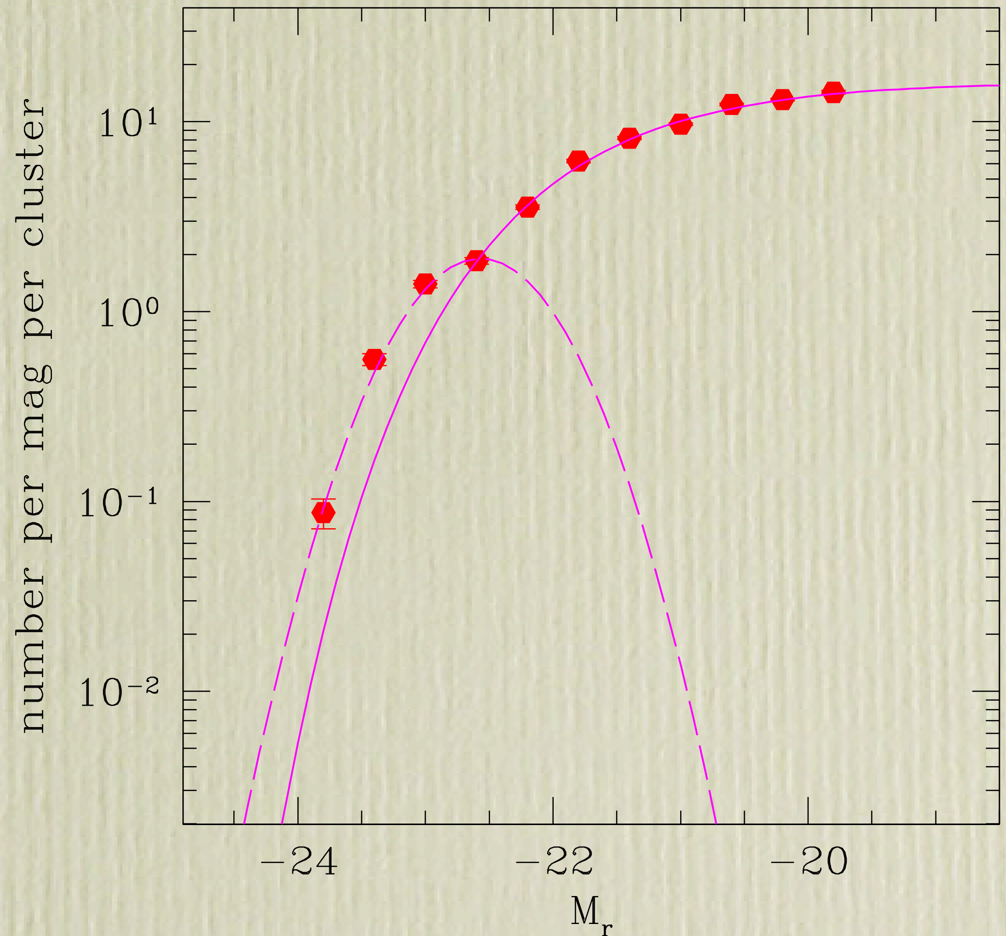
BCGs as central galaxies

- most galaxies are centrals
- BCGs are central galaxies in very massive halos*
- top of the "food chain" in the world of galaxies
- may well have different formation path compared to other (massive) galaxies



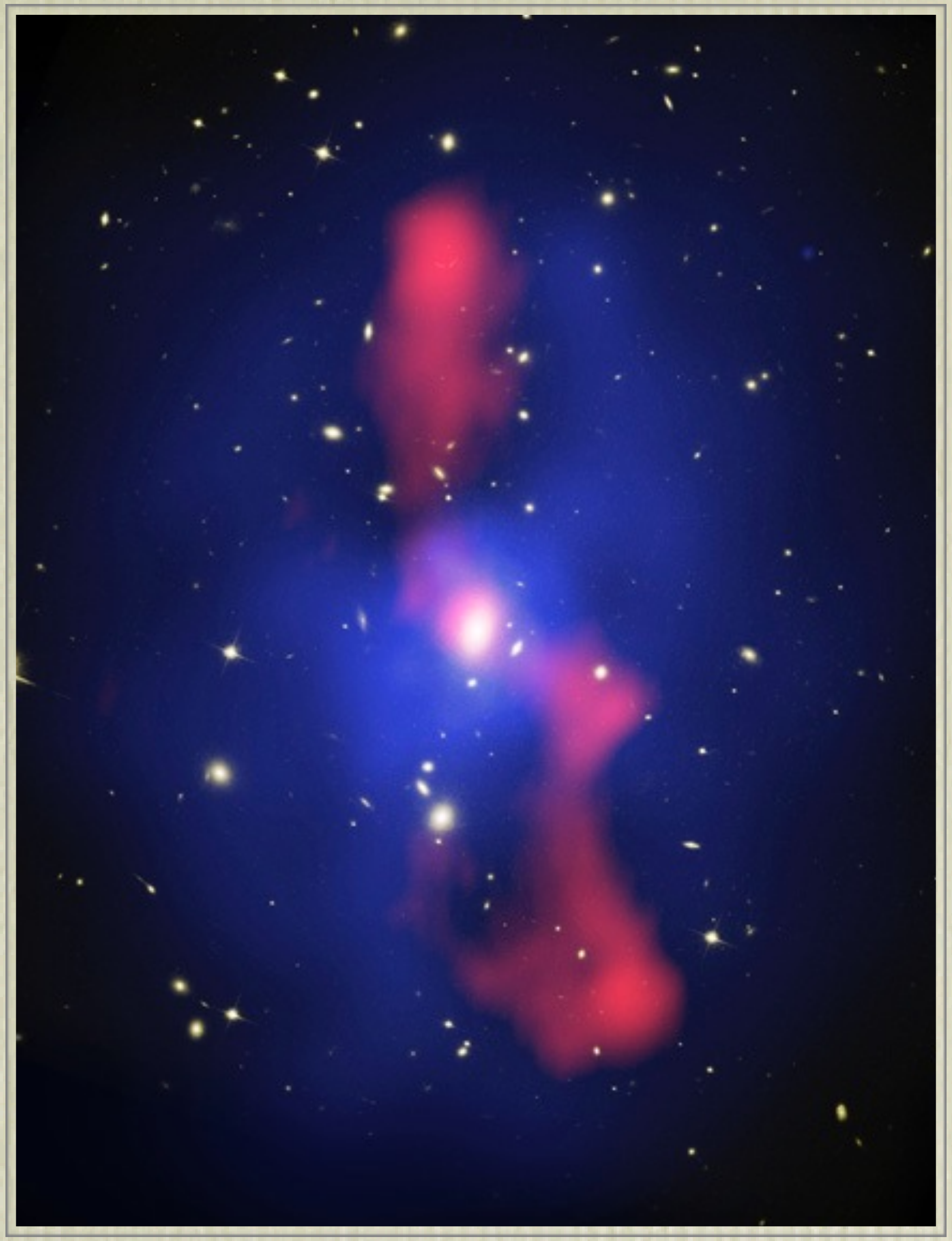
* ignoring complications where BCGs ≠ central

BCGs as special centrals

central location controls how they feed

HST

BCGs as special centrals



they should be blue
but most of them are not!

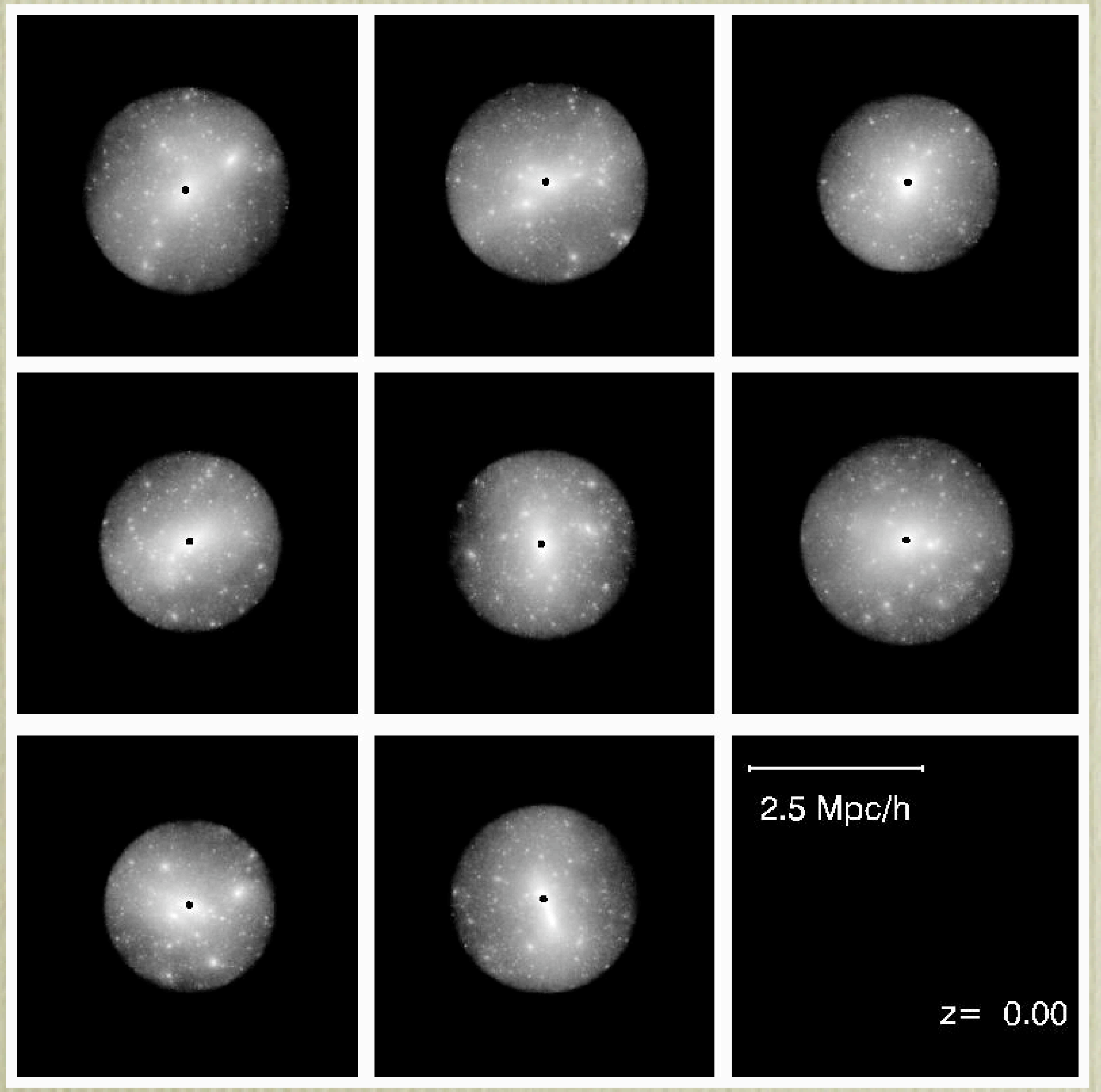
B. McNamara, C. Conselice

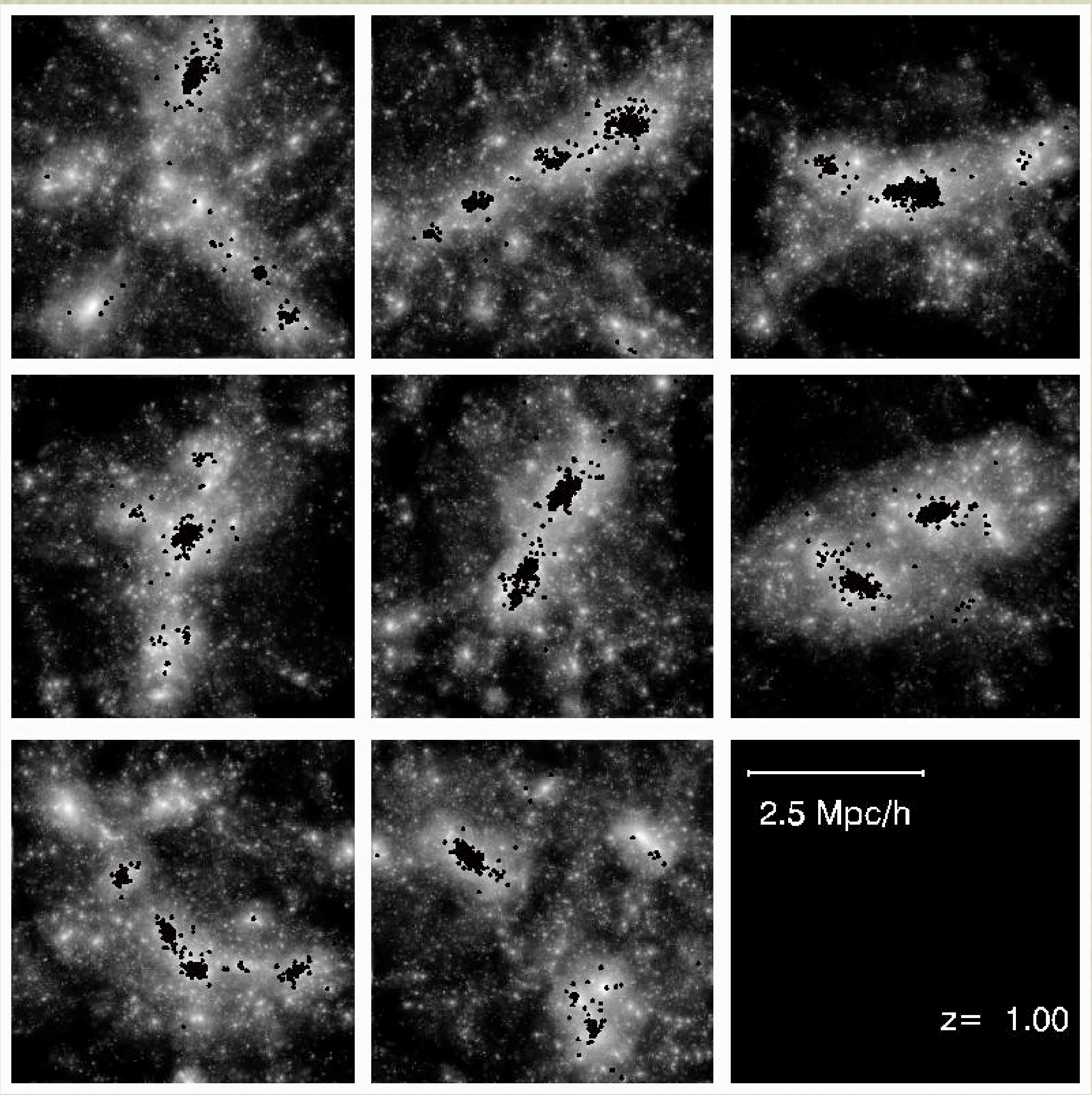
plan

- motivation
  - BCGs as central galaxies with special formation mechanisms
  - as a class, may be clear manifestation of "progenitor-descendant relation in growing environments" that Taddy discussed yesterday
- stellar mass assembly history of BCGs I: observationally constructing merger trees
- stellar mass assembly history of BCGs II: most massive clusters

BCGs: stellar mass assembly history from z~1.5 to z~0

theory predicts substantial late-time growth





Gao+04, De Lucia & Blaizot 07

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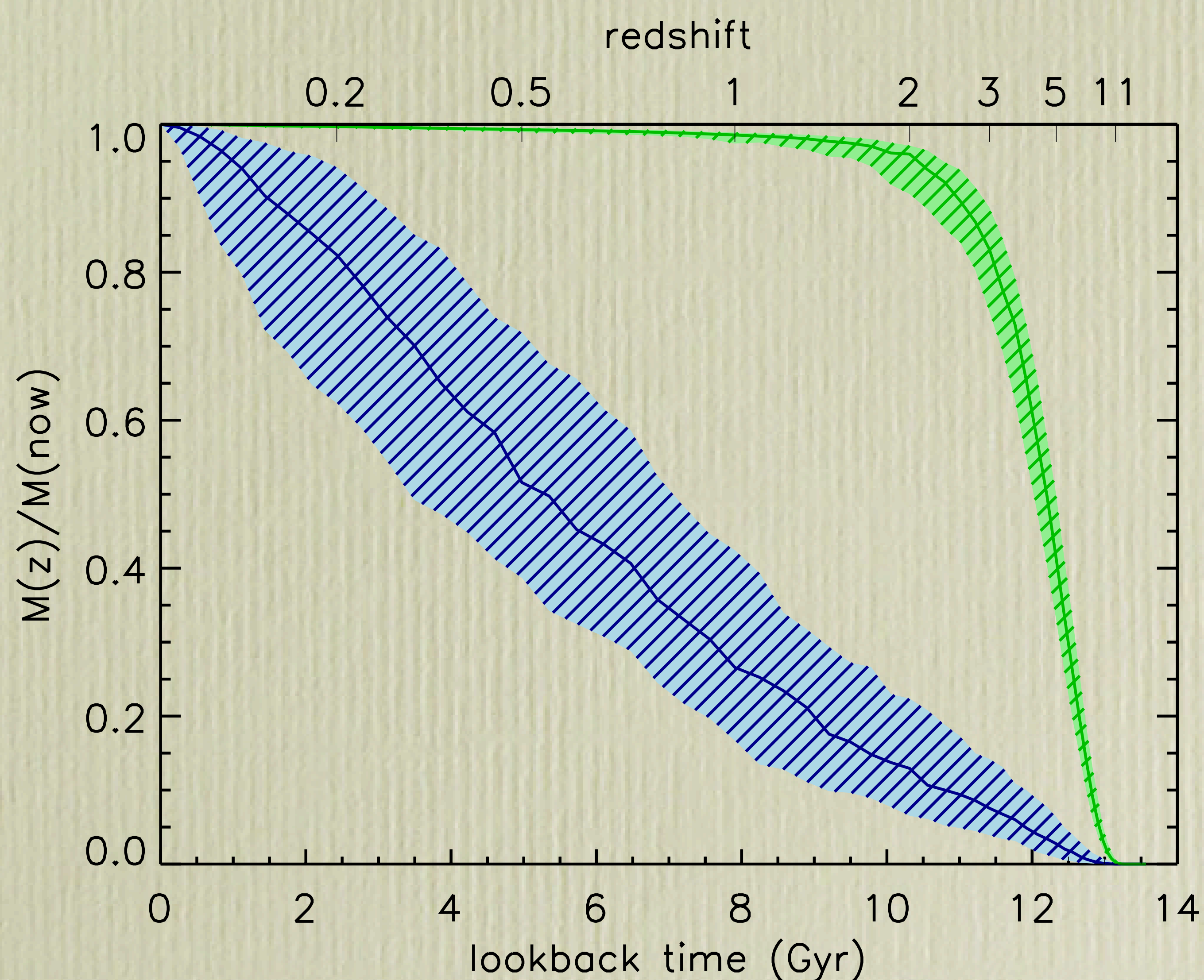
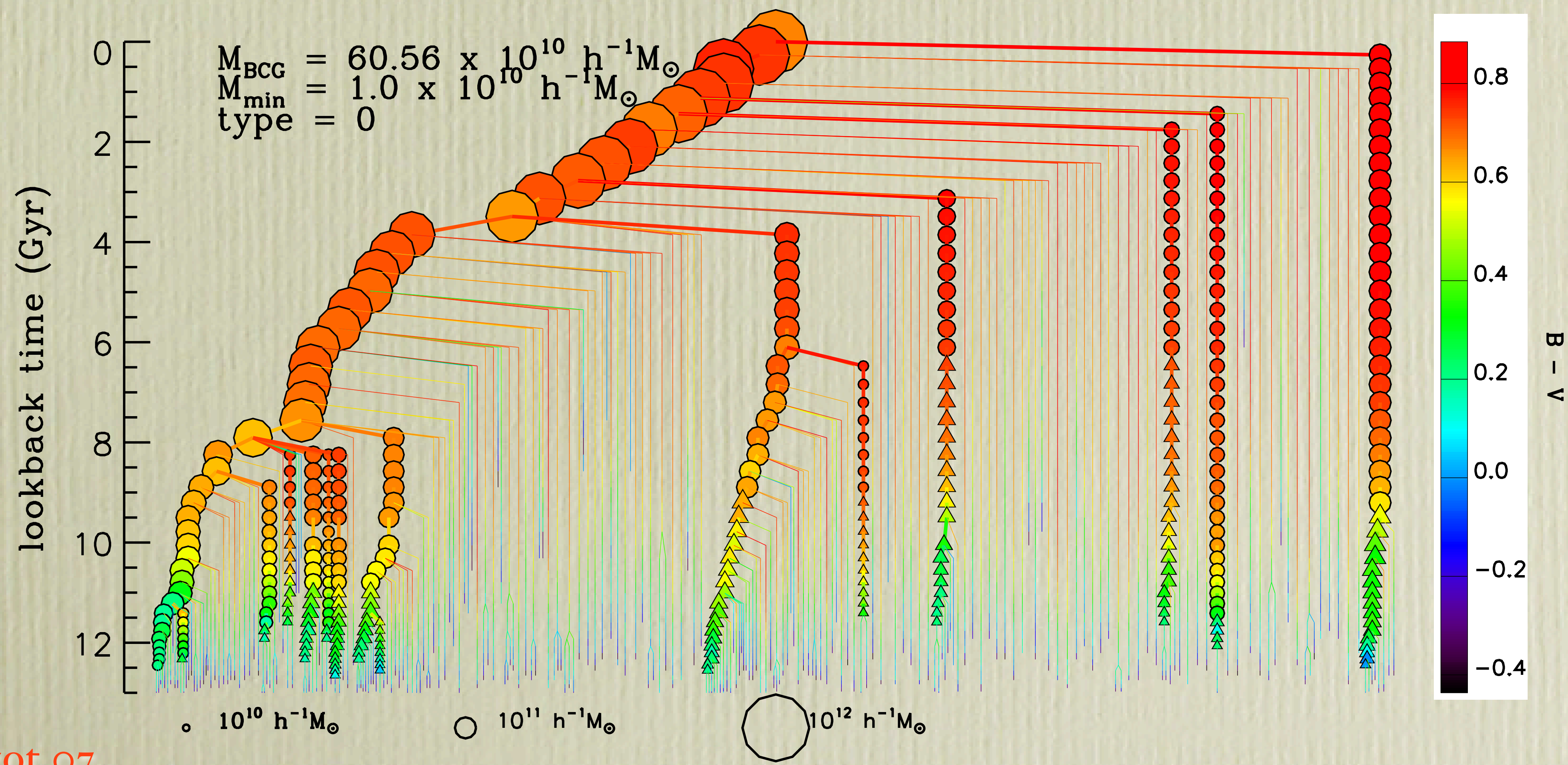


Gao+04, De Lucia & Blaizot 07

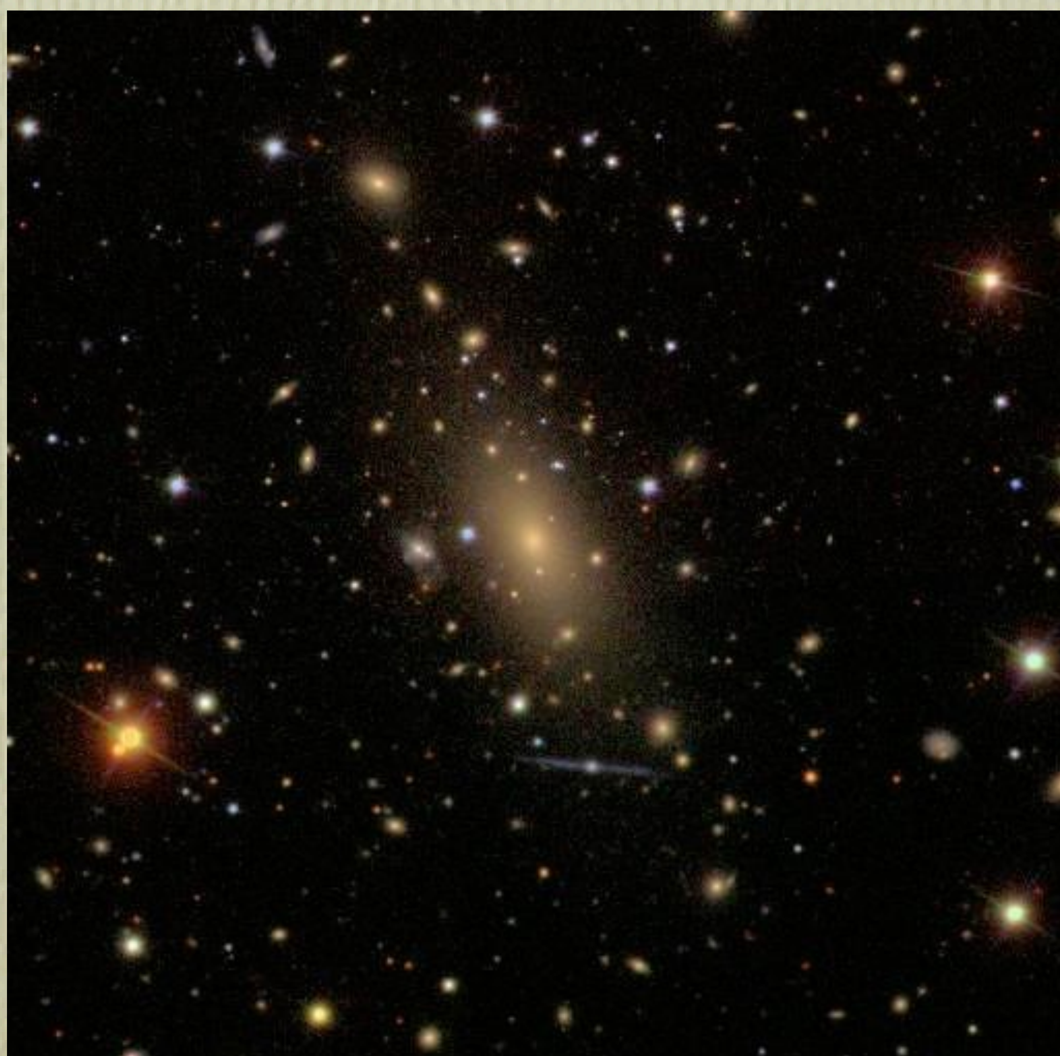
a new approach to trace the BCG evolution

- guided by dark matter halo merger history, incorporating scatter between luminosity and mass contents of clusters
- allows us to follow the growth of BCG stellar mass in clusters that form an evolutionary sequence
- applied to a complete sample of clusters selected by stellar mass content (z=0.2-1.5) in Bootes field

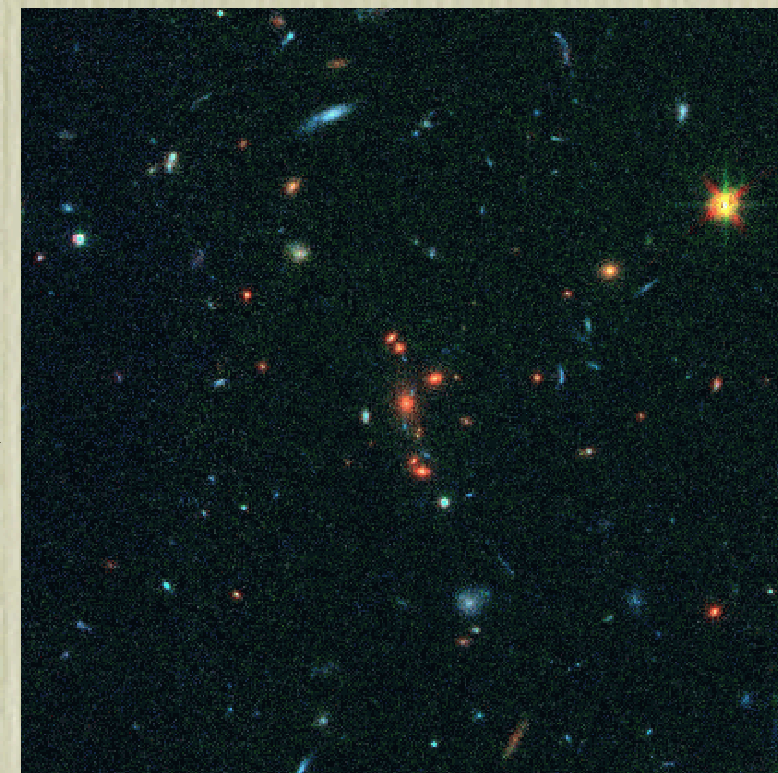


De Lucia & Blaizot 07

descendants vs progenitors: BCGs



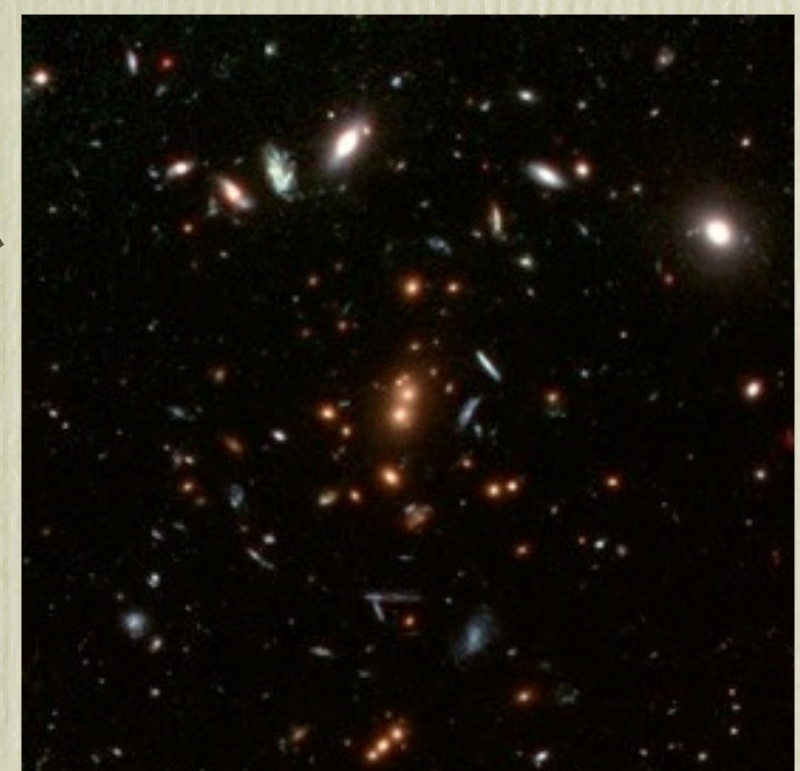
A2029
z=0.078
M_{200}~$10^{15} M_{sun}$



XMM2235.3-2557
z=1.39
M_{200}~$6 \cdot 10^{14} M_{sun}$

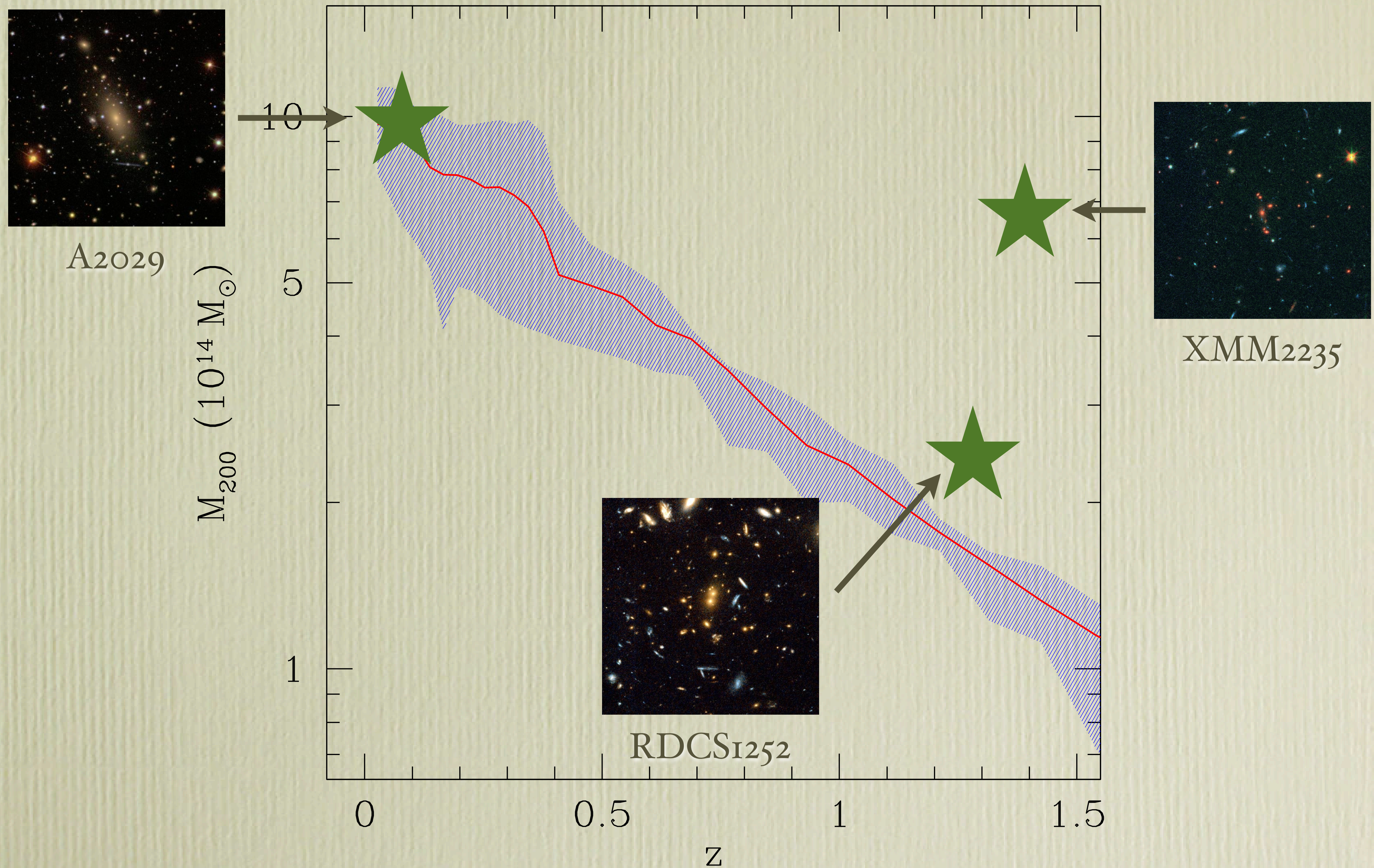
?

?



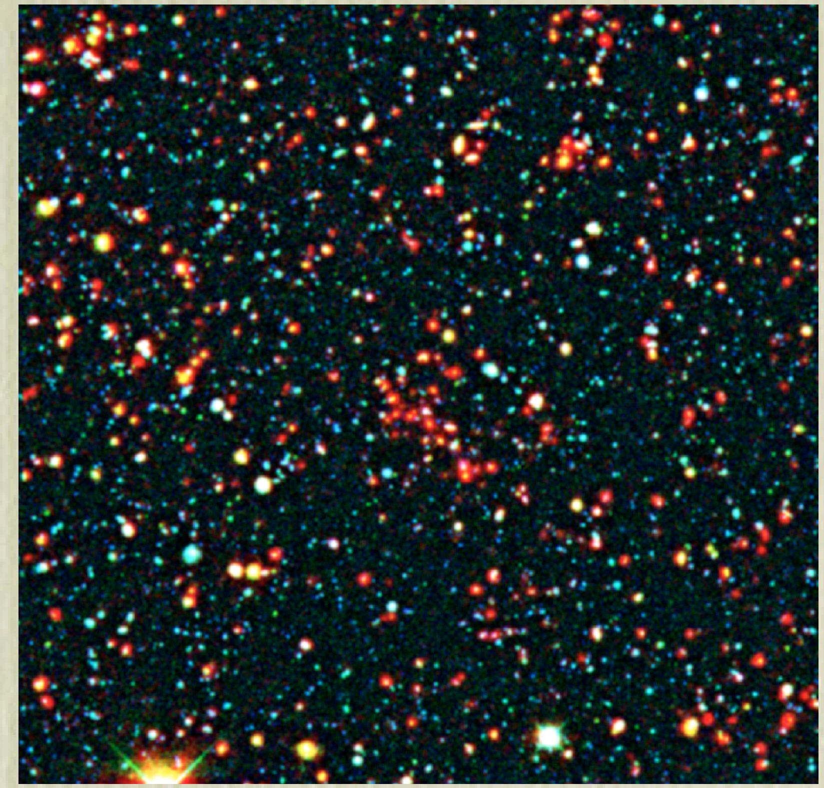
RDCS1252.9-2927
z=1.24
M_{200}~$3 \cdot 10^{14} M_{sun}$

image credit: SDSS, NASA/ESA


A2029
XMM2235
RDCS1252
10
5
1
0
0.5
1
1.5
z
M_{200} $(10^{14}\ M_\odot)$

cluster evolution seen by Spitzer

- IRAC shallow cluster survey (ISCS; PI: Eisenhardt)
- 9 deg² Bootes field, with rich multiwavelength data and good photo-z
- detecting clusters with wavelet from density peaks
- 335 4.5micron (~restframe K-band/stellar mass) selected groups/clusters out to z~2
- galaxy number (N_{gal}) and luminosity (L_{tot}) in each cluster determined via statistical background correction
- lack of cluster mass info (although with good stellar mass estimates)



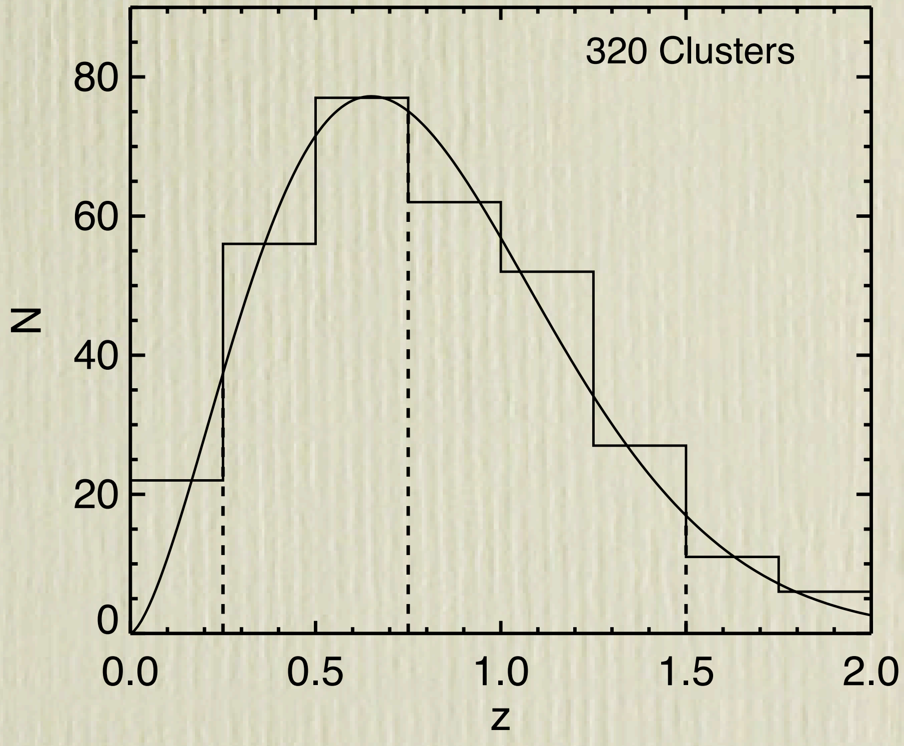
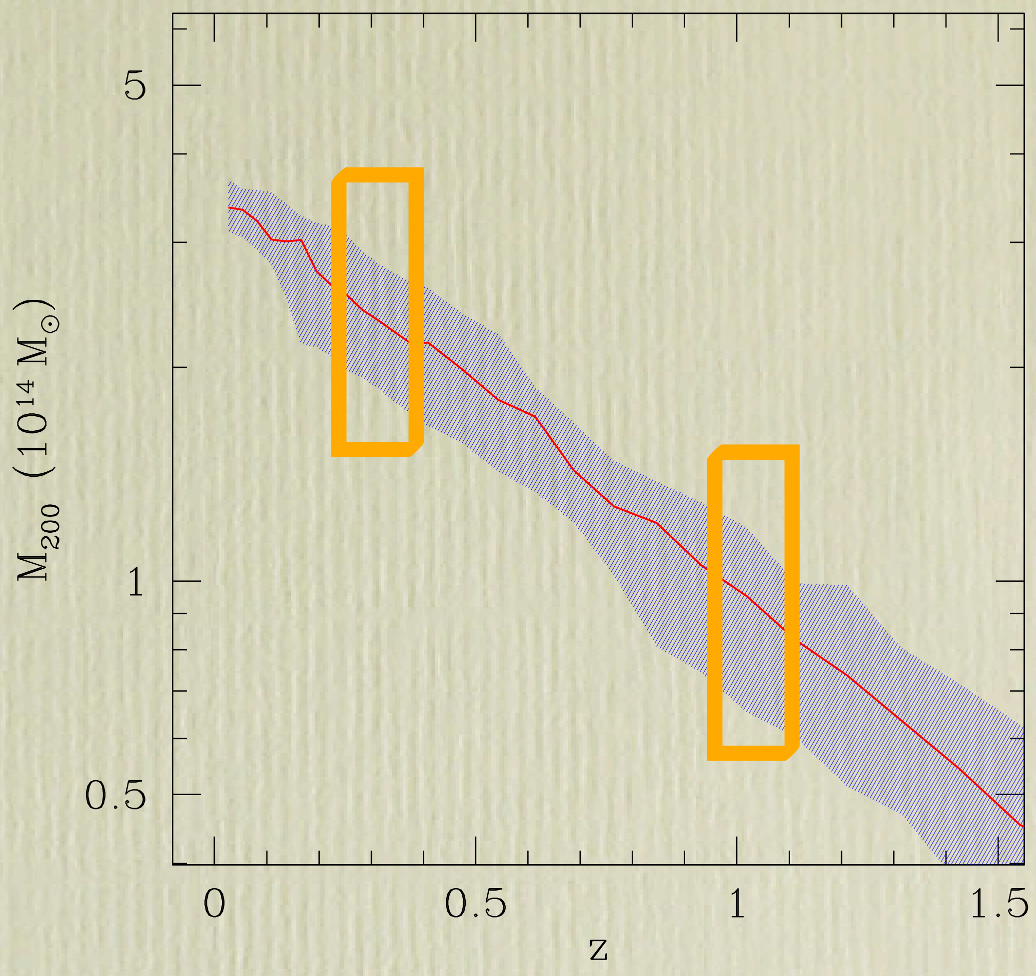
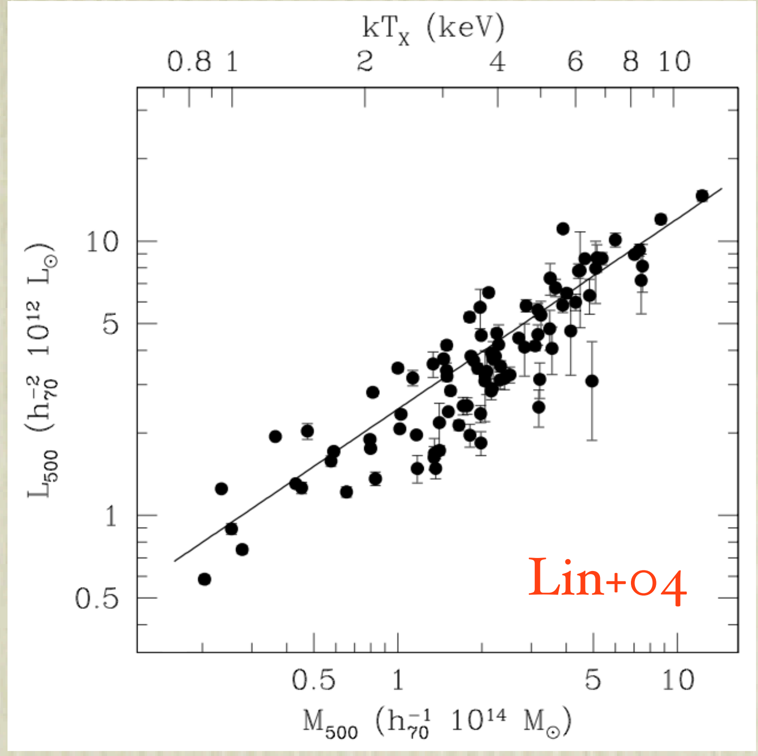


image credit: M. Brodwin

the approach

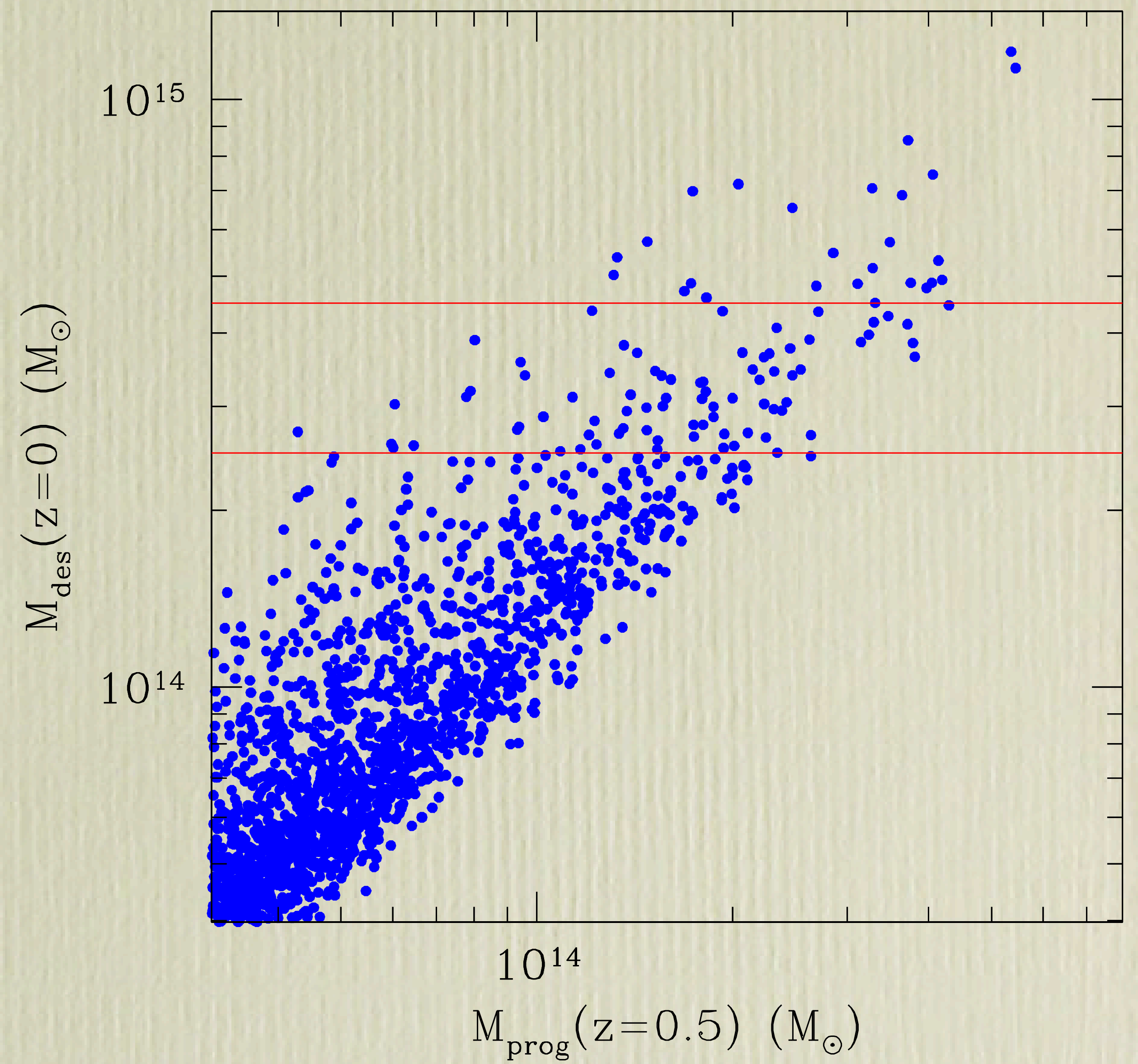
- given z ⇒ select a complete sample whose median mass traces the mass growth history
- infer cluster mass via luminosity ranking ⇒ given top N most luminous clusters, we know the median mass
- extract 16 Bootes-like patches from a lightcone simulation
- populate halos with assumed L-M relation
    - slope, scatter
    - galaxy spatial distribution
    - field-to-field variation





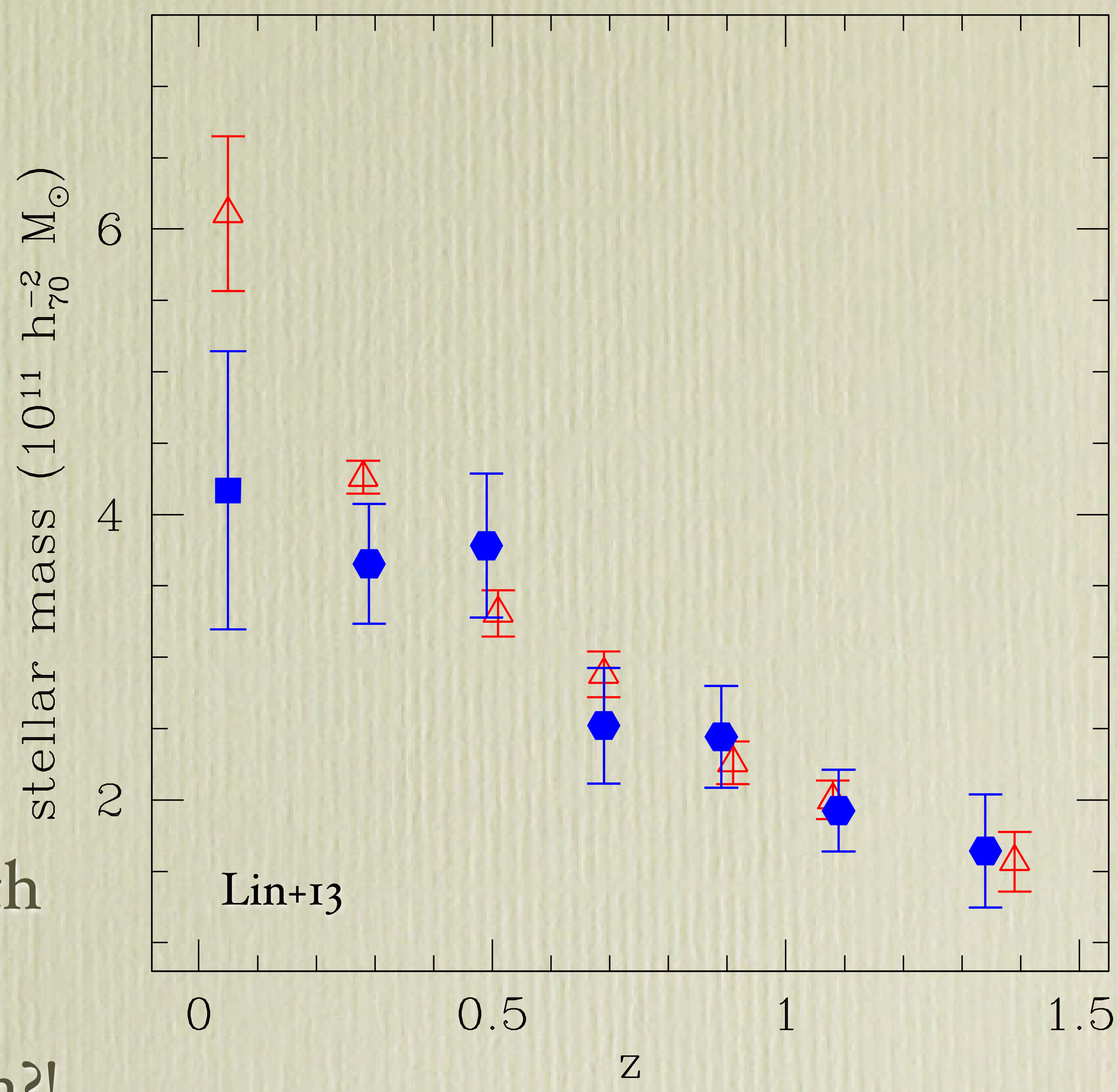
descendants vs progenitors: halos

- we are interested in descendant halos within a narrow mass range
- progenitors have a wide mass range
- not all of the progenitors with such masses will end up as descendants of the mass we care
- for each possible progenitor, given its mass, we find the corresponding observed cluster using the top N–mass lookup table, but weigh the observed M_{bcg} by the relative fraction of all progenitors with the same mass
- average M_{bcg} over all possible progenitors



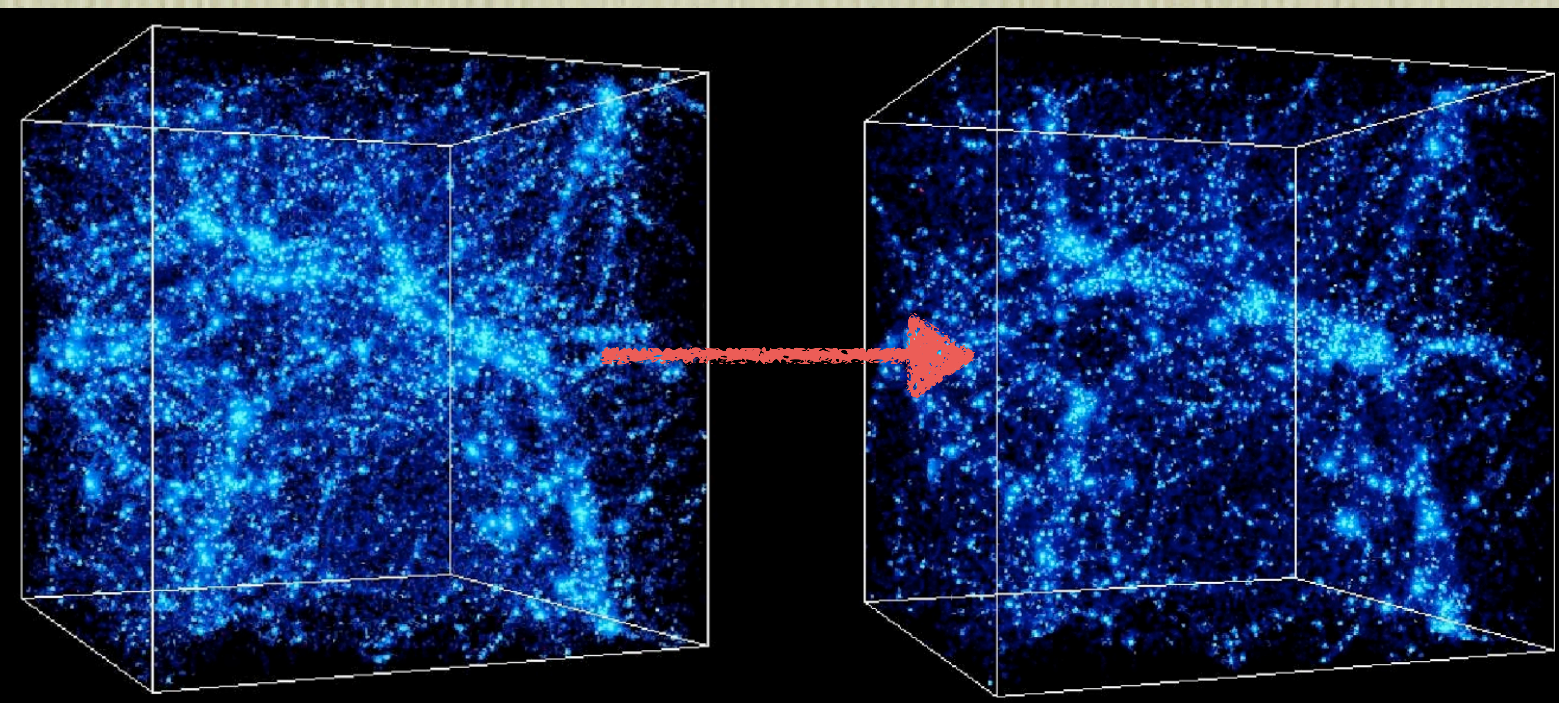
BCG mass growth up to z~1.5

- identified progenitors of clusters whose present-day M~3x10[14] M_{sun}
- blue: median BCG mass within 32kpc aperture
- red: prediction from Guo+10 SAM (no intracluster light, ICL)
- fairly good agreement down to z~0.5; results seem to diverge at lower-z
- results in z=0.2-1 in agreement with Lidman+12 (*why?*)
- ICL may help alleviate the tension?!

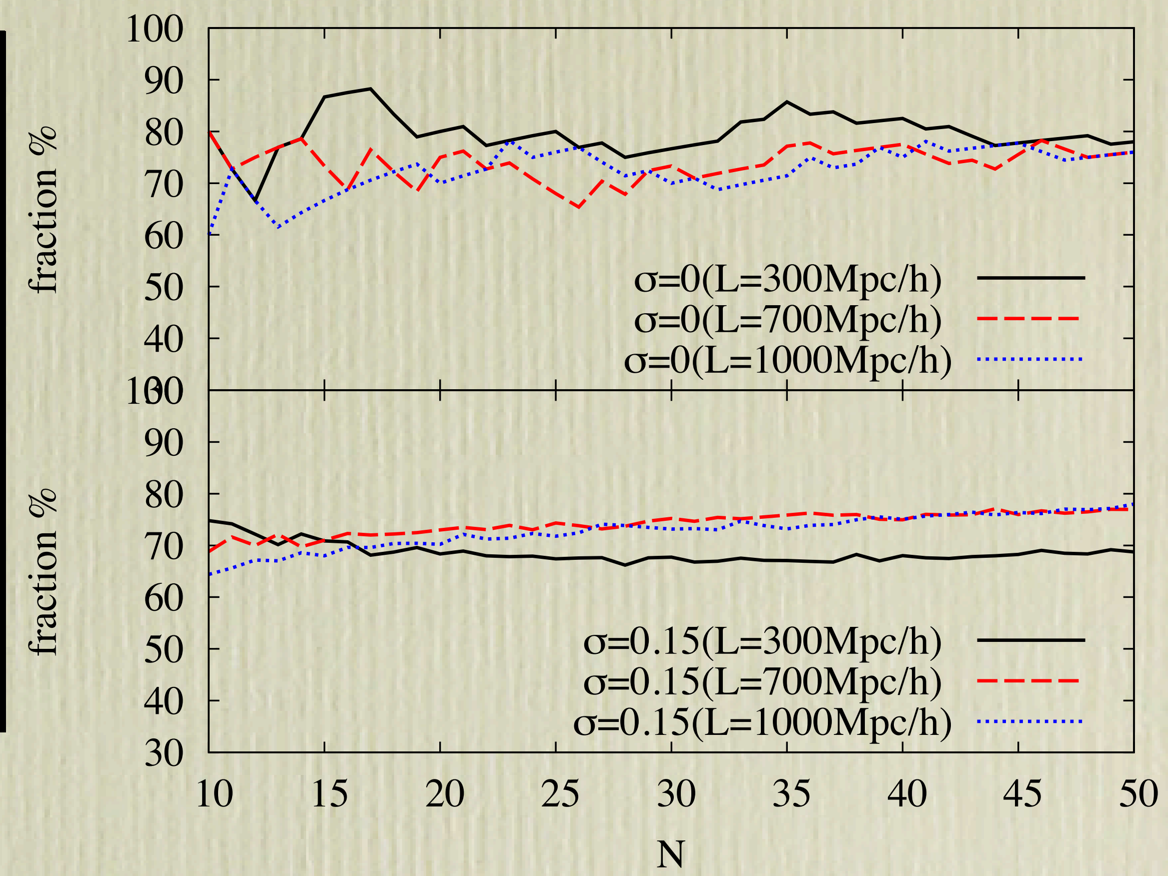


late time evolution of BCGs in most massive clusters

top N selection of halos



A. Kravtsov

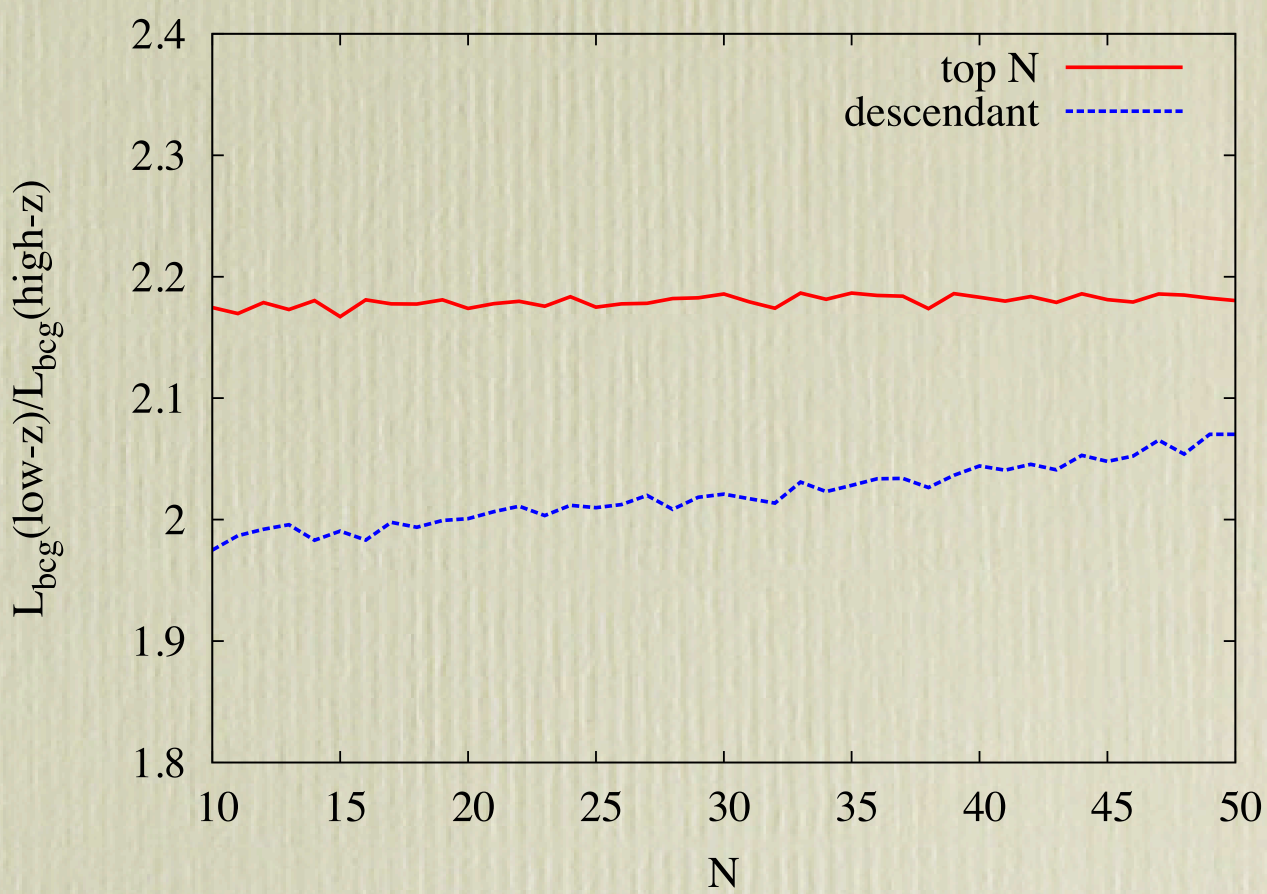


- Ansatz: given comoving volume, the most massive N halos will remain among the most massive N over short cosmic time interval
- tests with large N-body simulations suggest above holds to ~70-80% (including scatter in mass-observable relation)
- similar in spirit to the fixed cumulative number density selection for field galaxies

Inagaki, Lin et al. 2014, submitted

does this work for BCGs?

- a simple simulation
  - at z=0.4, assign BCGs to halos with $L_{bcg} = A\ M^{0.2}$ with 30% scatter
  - similarly, at z=0.2, $L_{bcg} = B\ M^{0.2}$
  - set B/A=2
- inferring B/A from descendants of top N z=0.4 halos gives unbiased results
- top N selection at both redshifts seems to give slightly biased B/A (by ~10%)



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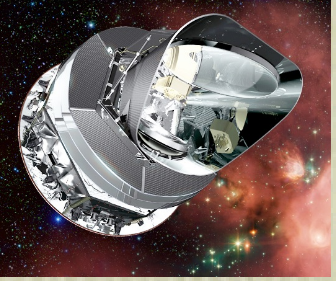
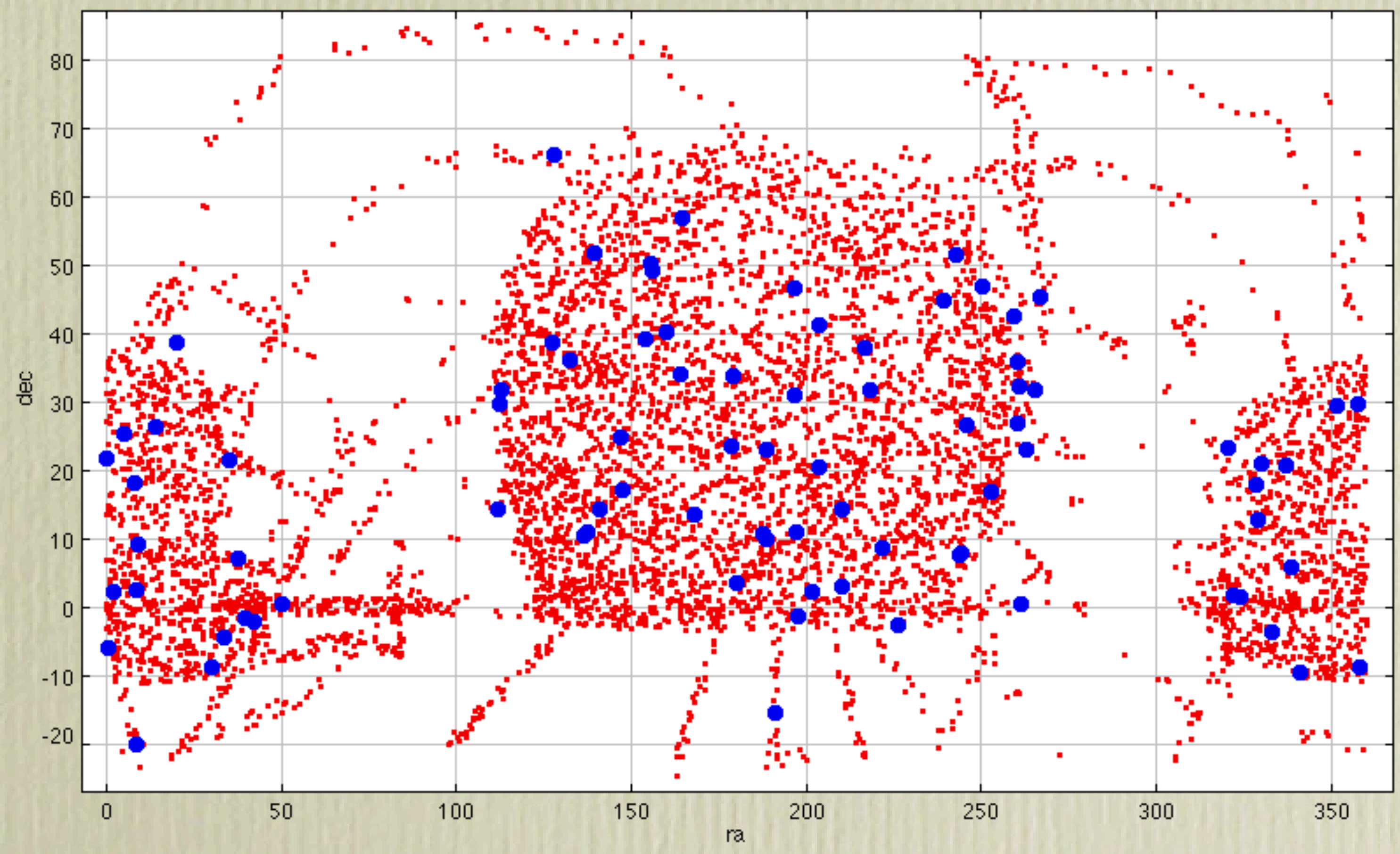


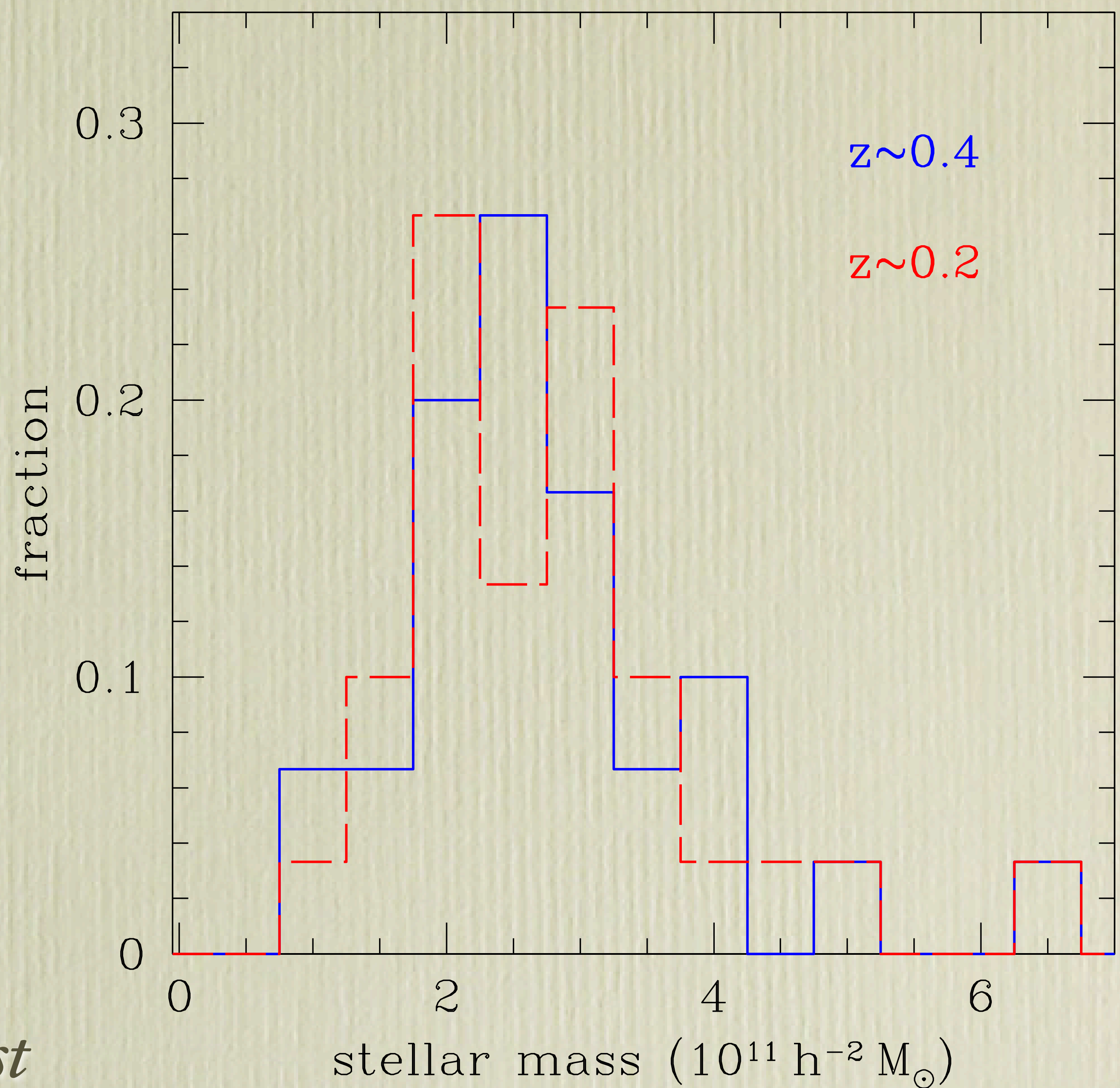
application to *Planck* clusters

- consider two redshift bins: 0.13-0.26, 0.37-0.41
- same comoving volume
- use SDSS data to confirm the presence of cluster red sequence & selection of BCGs
- select top 30 cluster using M_{Yz}; limiting mass ~$3\times10^{14} M_{sun}$
- use SDSS photometry to estimate stellar mass of BCGs



little growth at late times

- BCGs in top 30 clusters at these epochs have very similar masses
- mass growth, if any, likely ~few %
- in Guo+13 (Millennium run with WMAP7), BCGs in top 30 most massive clusters within same comoving volume grow by 30% from z=0.4 to 0.2



- *z<0.5 seems to be a critical phase to test theoretical predictions with observations!*

Inagaki, Lin et al. 2014, submitted

summary & prospects

- developed a way to connect BCGs in clusters at different redshifts even when the cluster mass is not known well
- main trunk of BCG merger tree thus determined agrees well with SAM at $z=0.5$ to 1.5
- at $z<0.5$, there seems to be little stellar mass growth of real BCGs
- similar results also found for massive clusters detected by *Planck* (explains why Lin+13 agrees with Lidman+12)
- will apply these methods to on-going Subaru HyperSuprimeCam (HSC) survey

- collaboration between Japan, Taiwan, and Princeton
- 300 nights over 6 years granted
- 1.8 deg^2 FOV, *grizy* + narrow band
- wide: 1400 deg^2, $r\sim26$