galaxy populations in sdss clusters

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with
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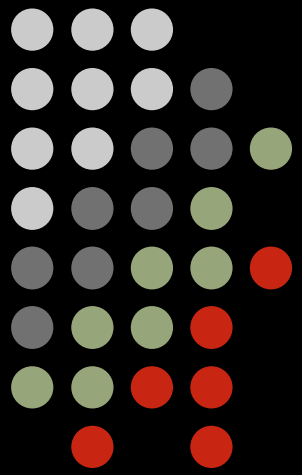
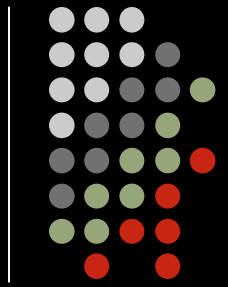
risa h. wechsler (stanford)
& the maxBCG group



november 13, 2007

outline



- motivation

- sdss maxBCG cluster sample
- characterizing the galaxy population

- luminosity function: dependence on cluster mass, galaxy color
- red fraction: dependence on cluster mass, redshift, galaxy luminosity & cluster-centric radius
- BCG population: comparison with satellites
- mass-to-light: dependence on mass and radius

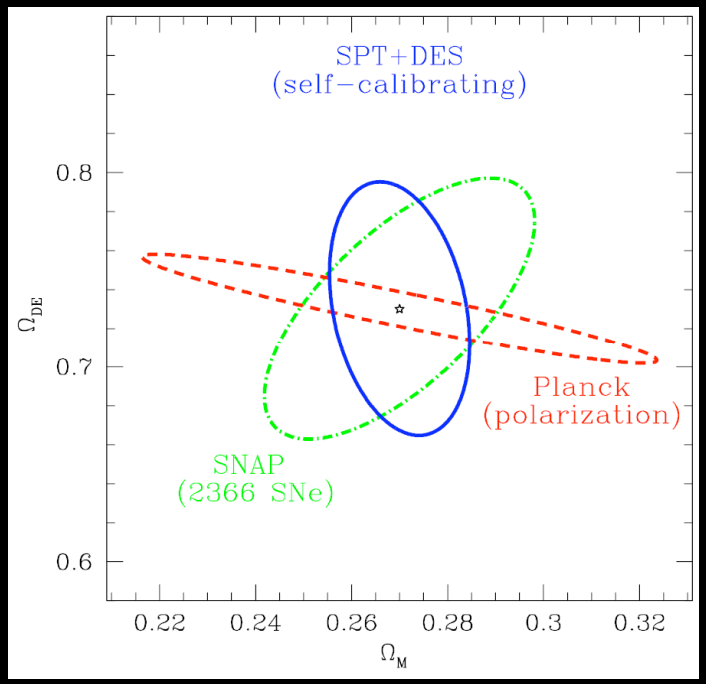
- future

motivation

clusters as cosmological probes:

$$\frac{dN(>M)}{dz} \longrightarrow w$$

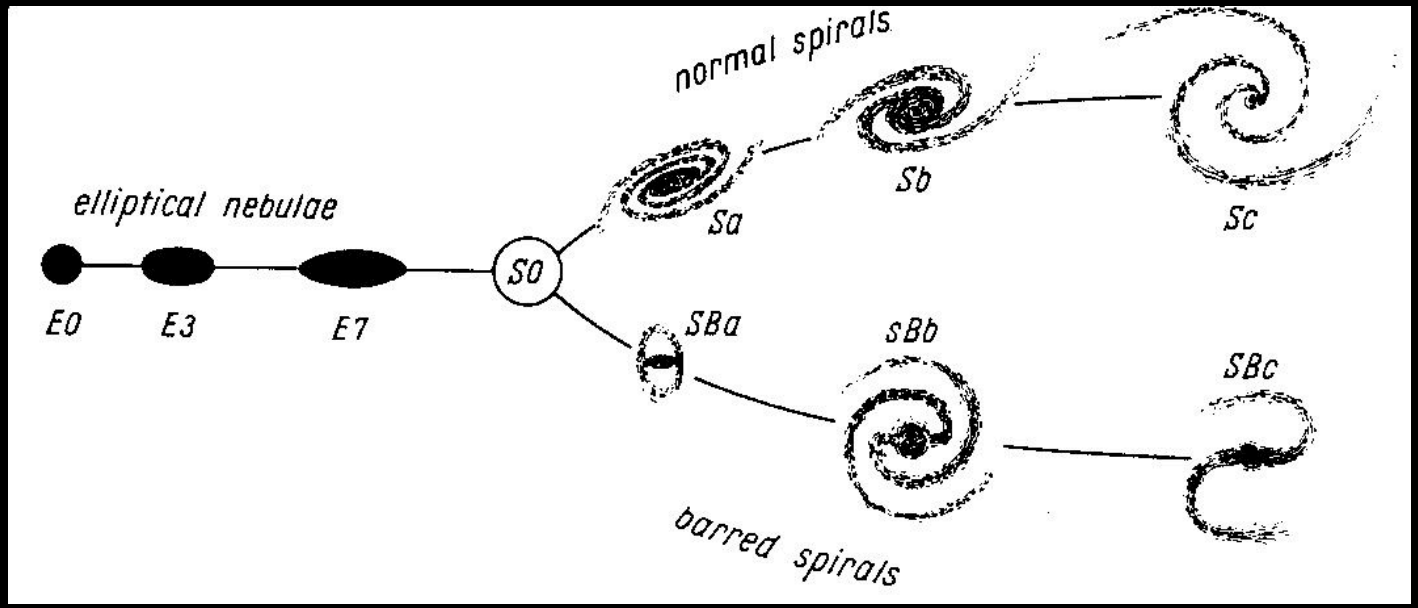
- how to connect dark & luminous matter?
- how to connect stars & gas?



motivation

clusters as galaxy evolution laboratories

- why such a particular cluster galaxy population?

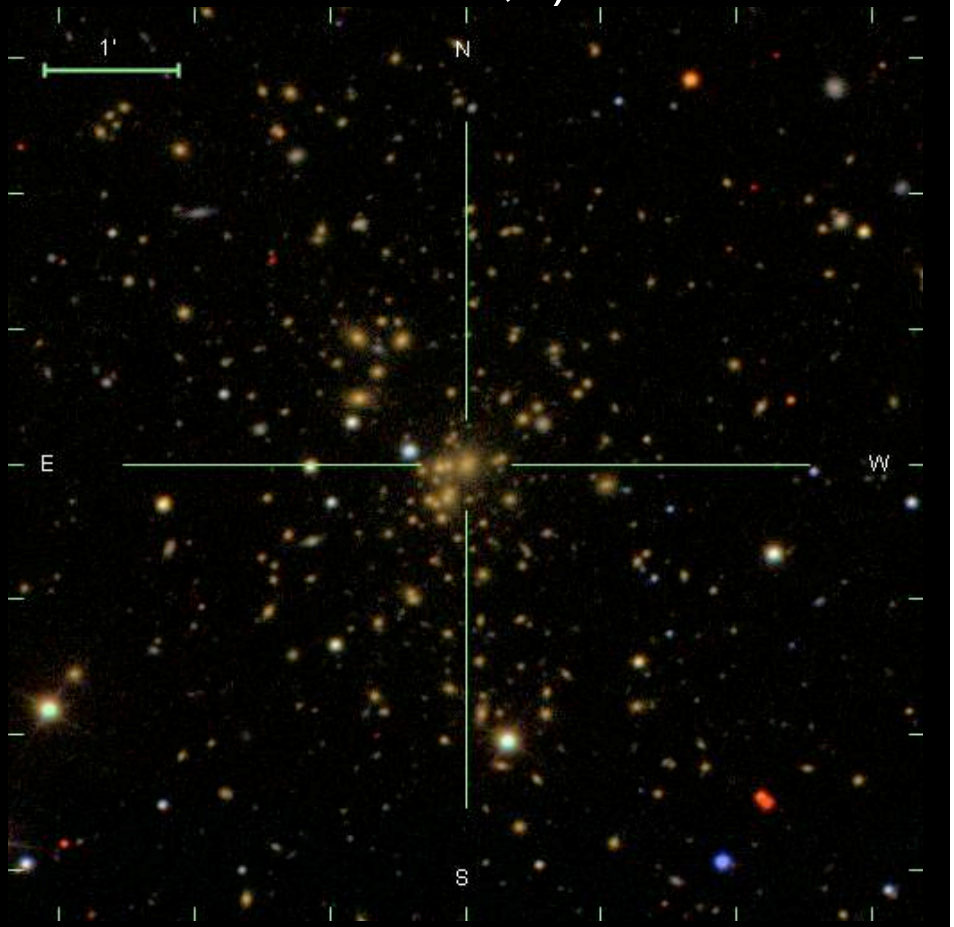


Hubble, *Realm of the Nebulae, 1936*

for upcoming large surveys,
must understand these details better!

sdss MaxBCG clusters

- > 7300 deg^2 of *ugriz* photometric data
- MaxBCG cluster finding algorithm
  - red sequence matched filter (koester et al. 2007a,b)
  - $0.1 \leq z \leq 0.3$; $\Delta z \sim 0.01$
  - mass proxy: N_{200}



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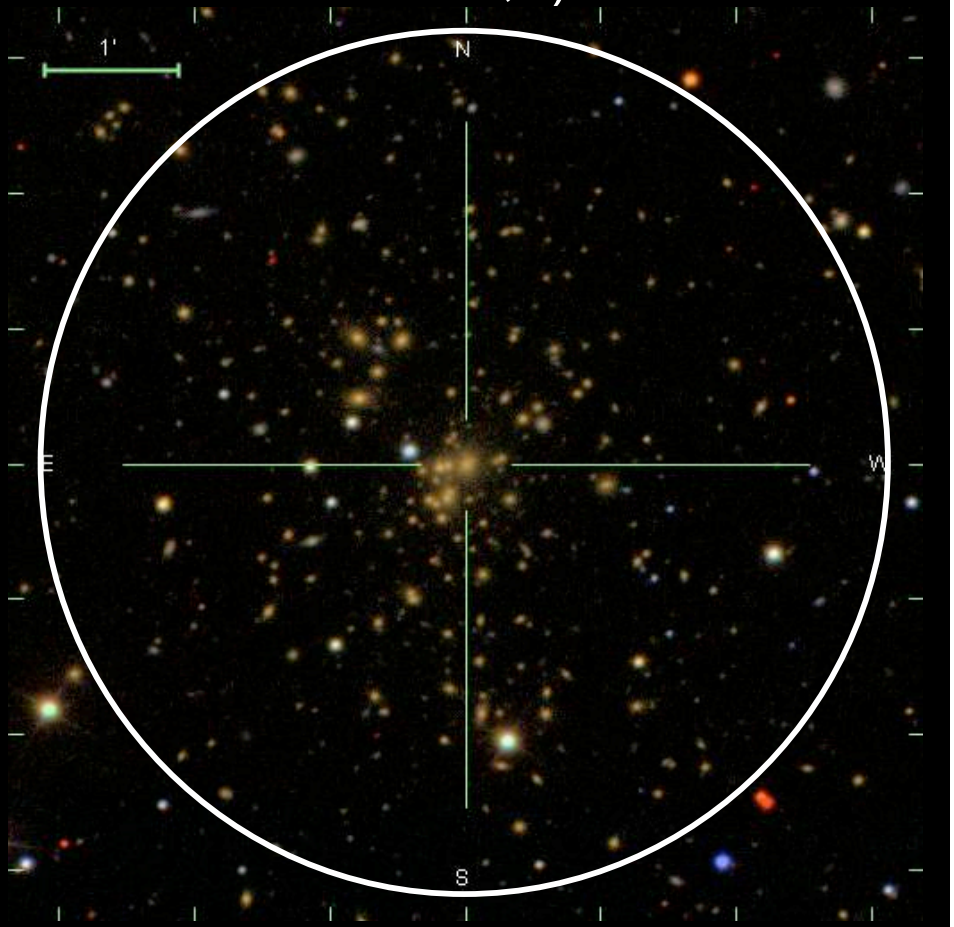
count red galaxies
within 1 Mpc (= N_{1Mpc})
of likely BCGs



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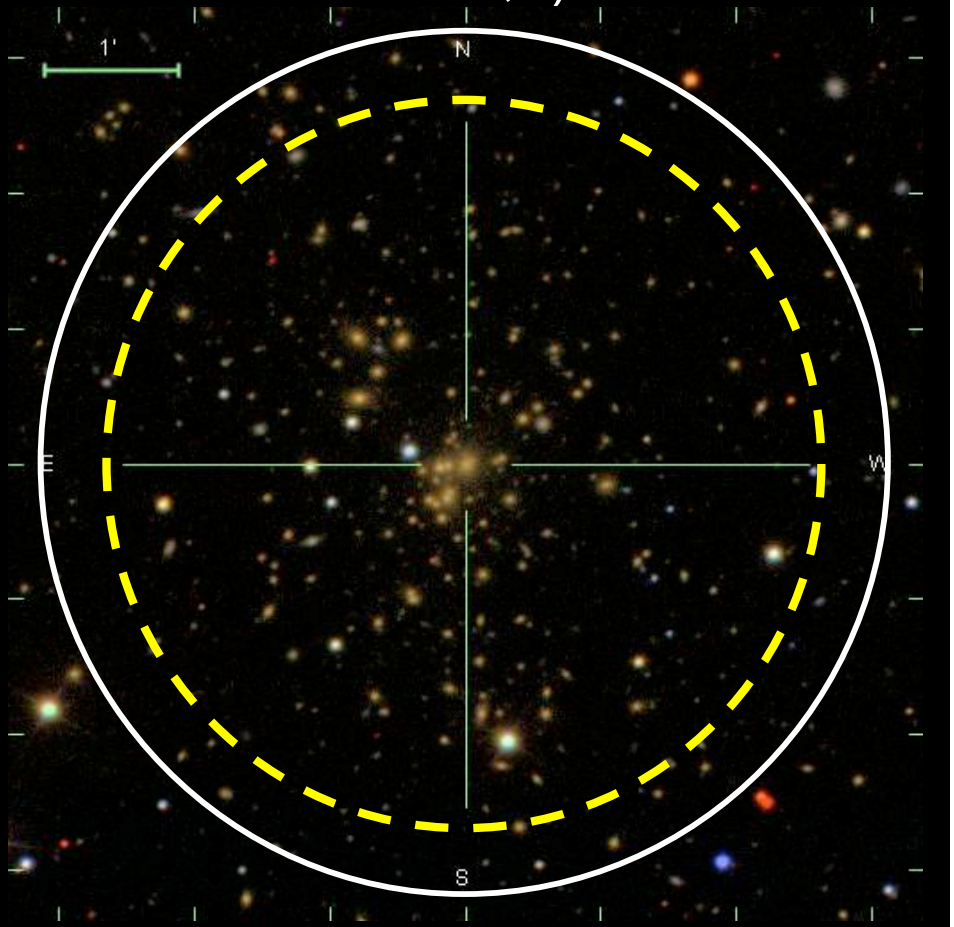
use galaxy distribution to estimate r_{200} *vs* N_{1Mpc}

(hansen et al. 2005)



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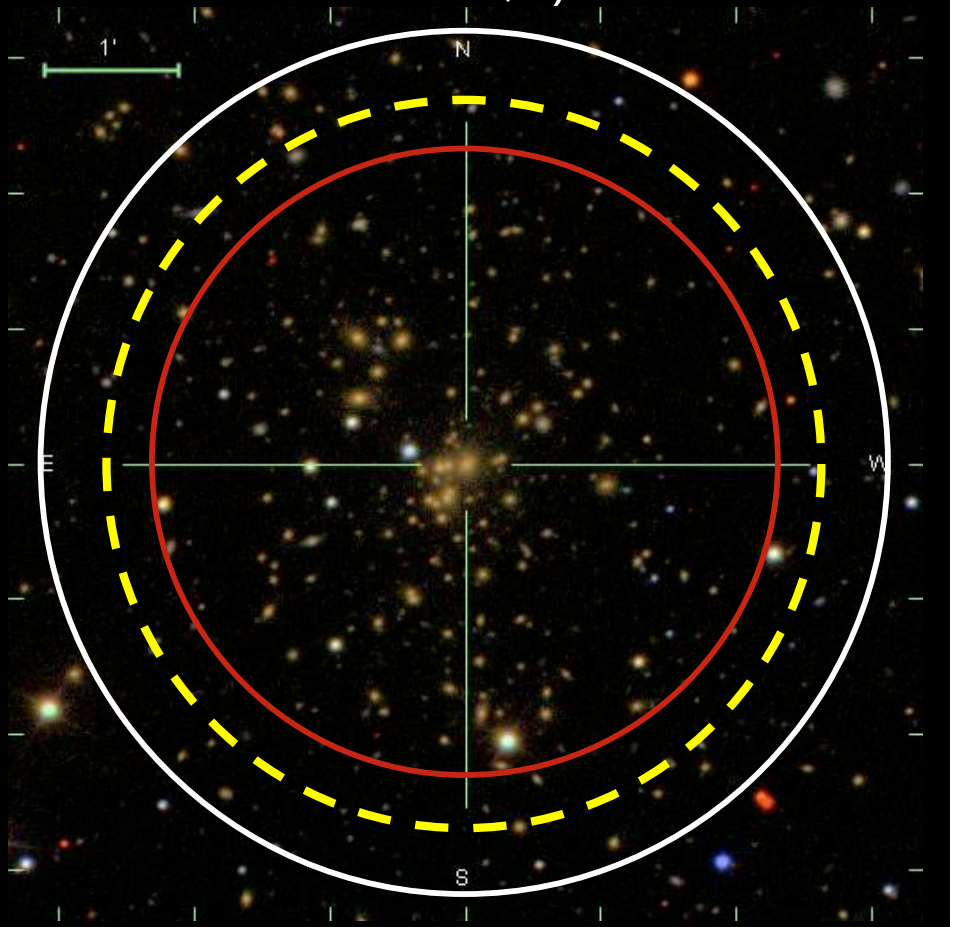
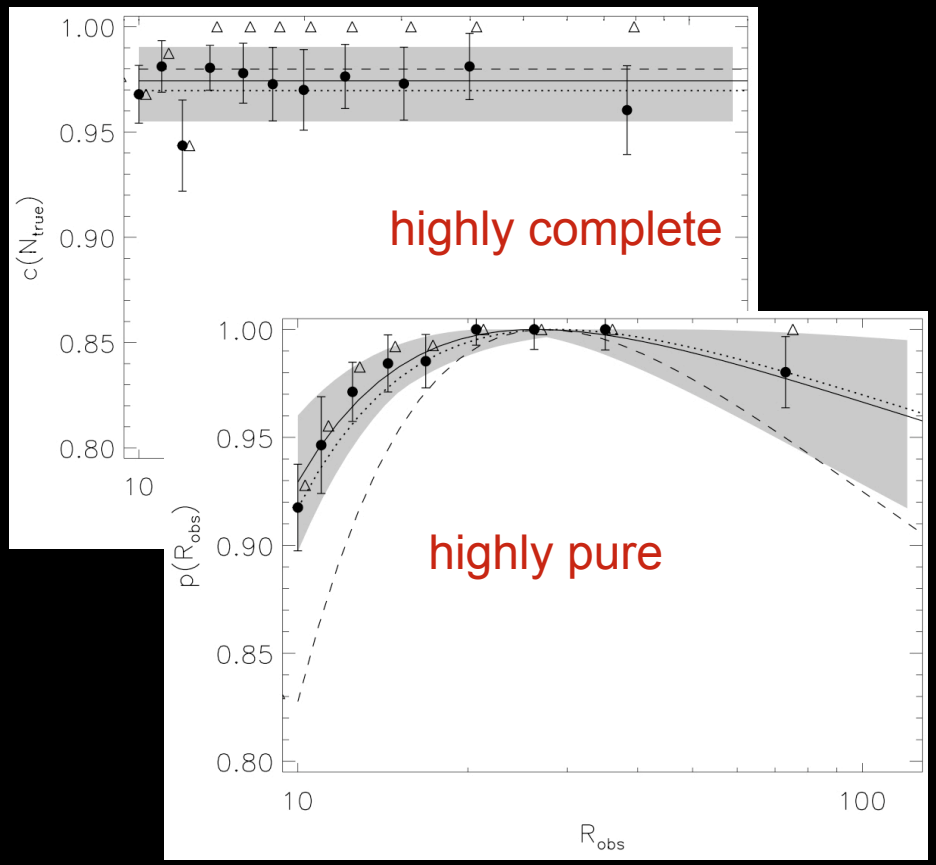
N_{200} = number of red galaxies within estimated r_{200}, then re-measure r_{200} *vs* N_{200}

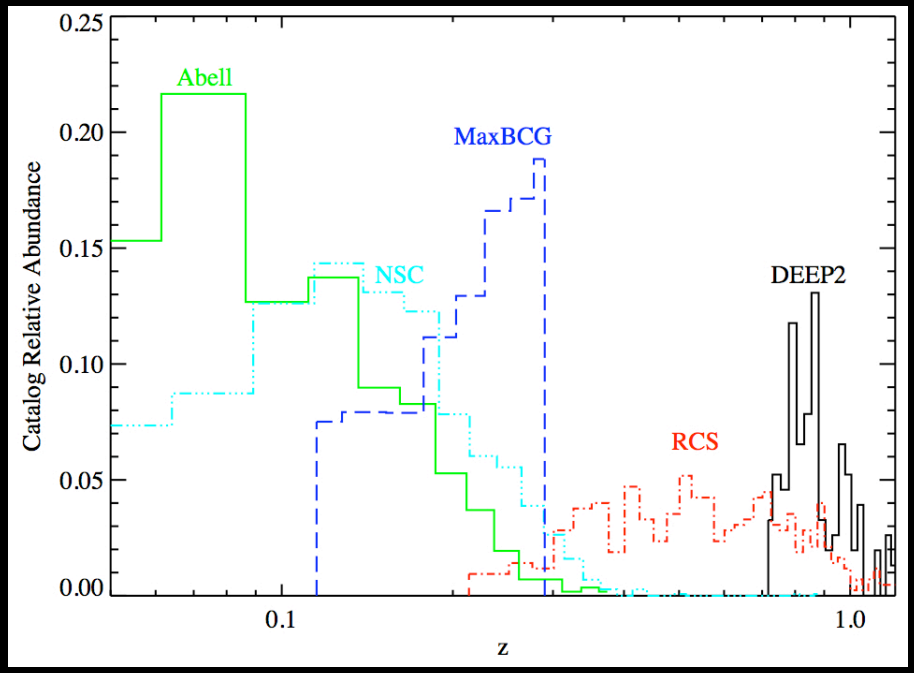


sdss MaxBCG clusters

extensive testing to quantify selection function

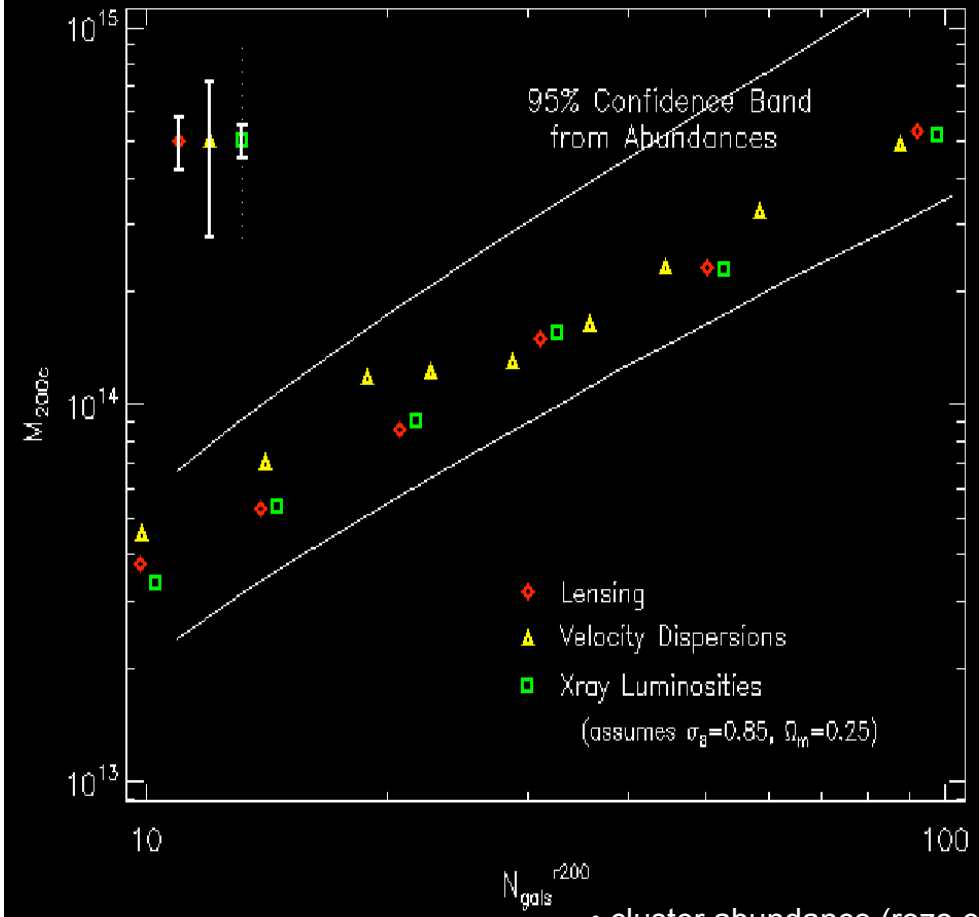


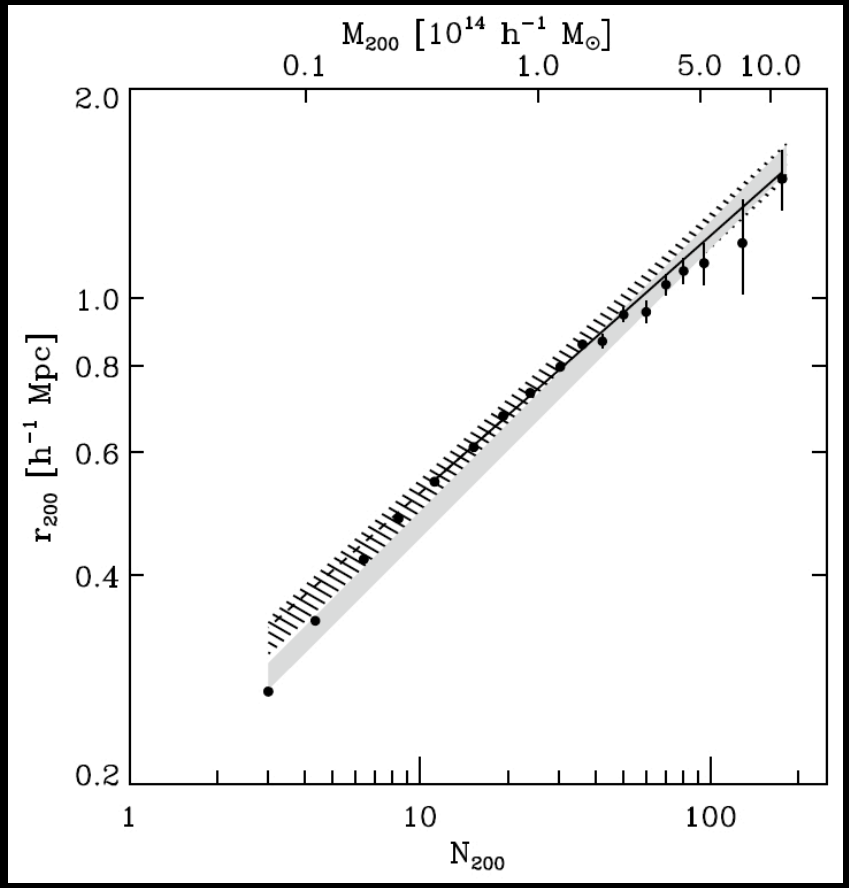
13,823 systems
with $N_{200} \geq 10$ and $0.1 \leq z \leq 0.3$
(165,597 with $N_{200} \geq 3$)



Rozo et al. 2007

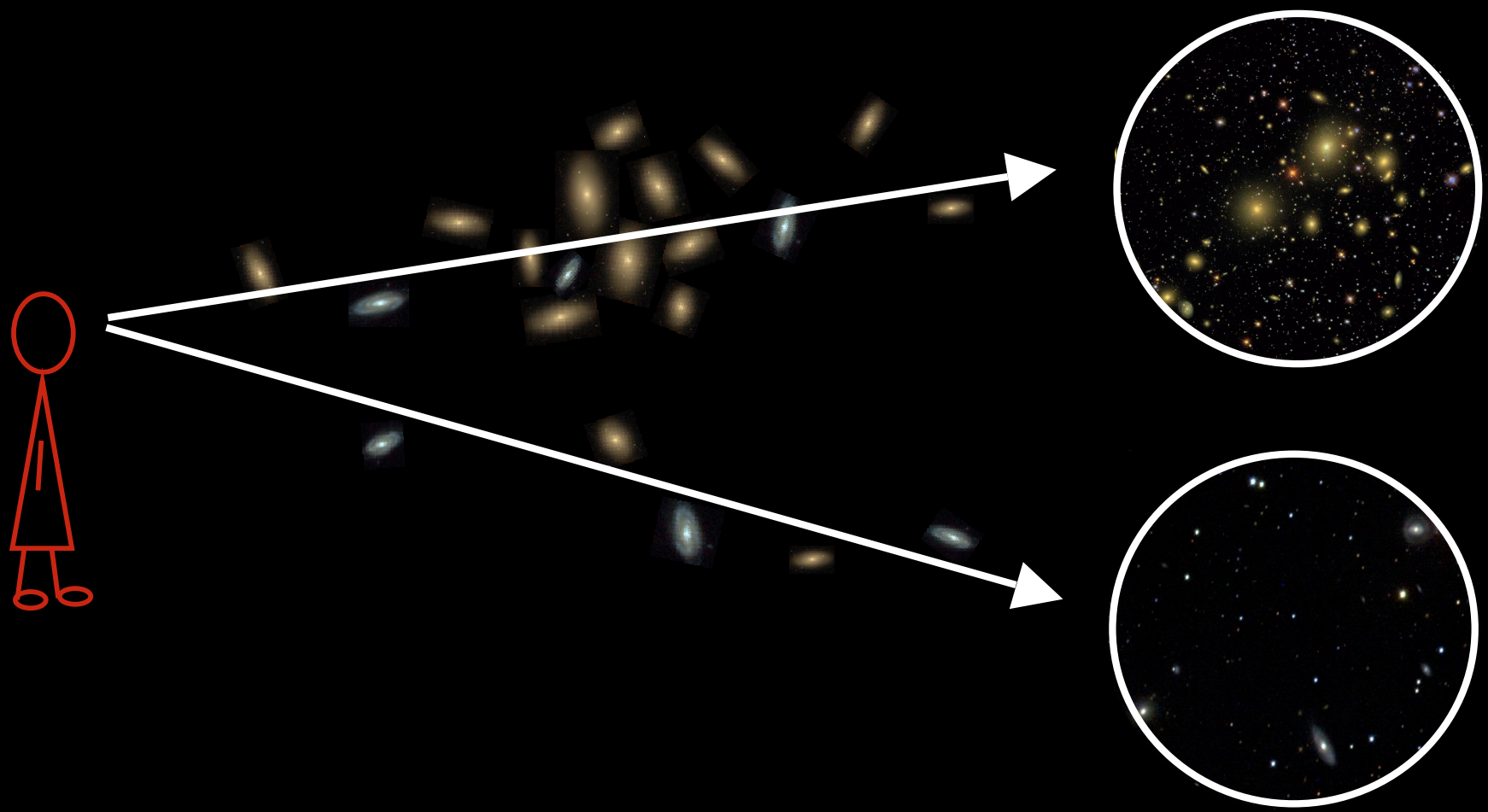
mass and size *vs* richness





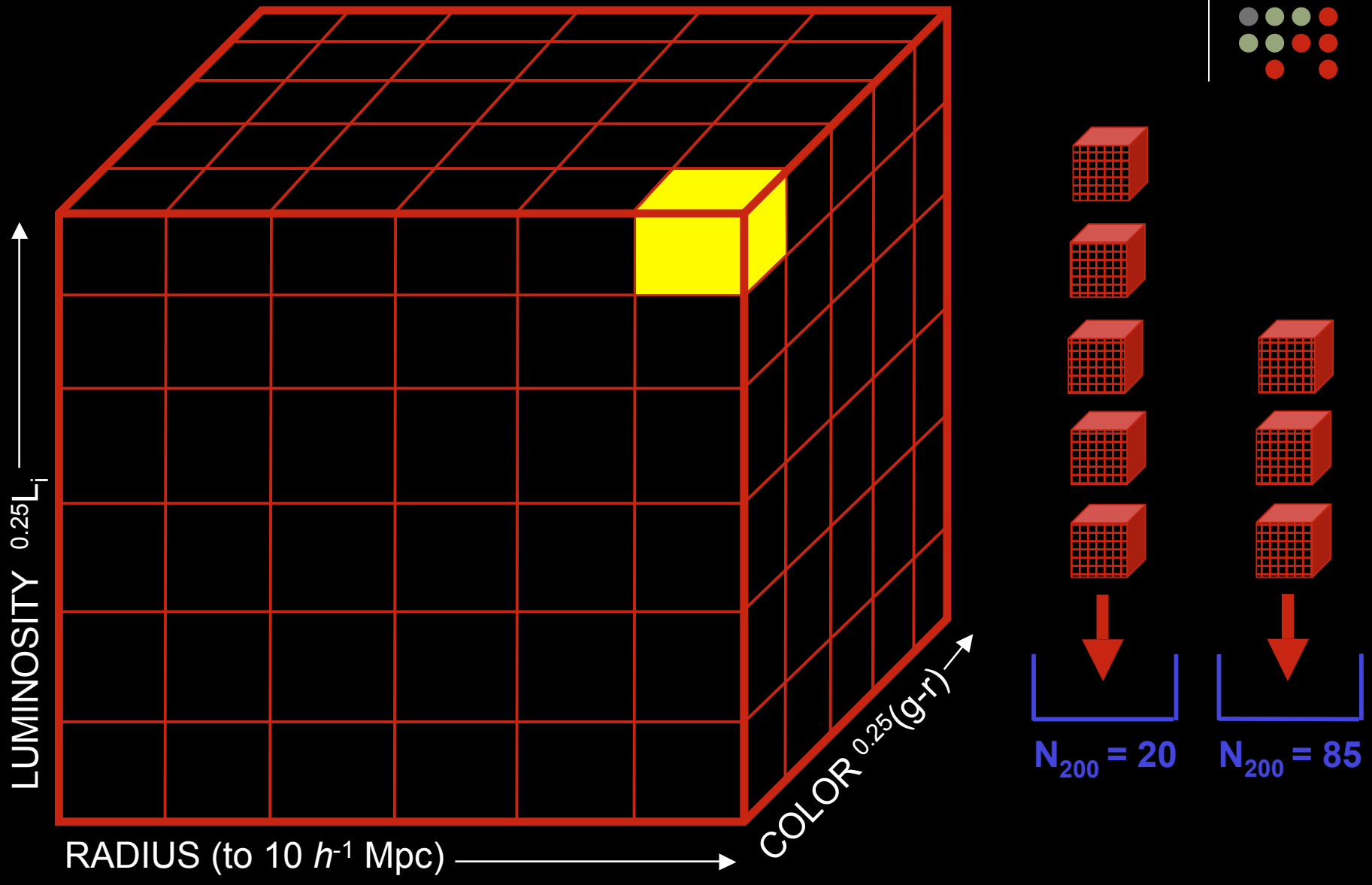
- cluster abundance (rozo et al. 2007)
- velocity dispersion (becker et al. 2007)
- weak lensing (sheldon et al. 2007, johnston et al. 2007)
- x-ray (rykoff et al. 2007)
- galaxy distribution (hansen et al. 2007)

method: cluster *vs* random

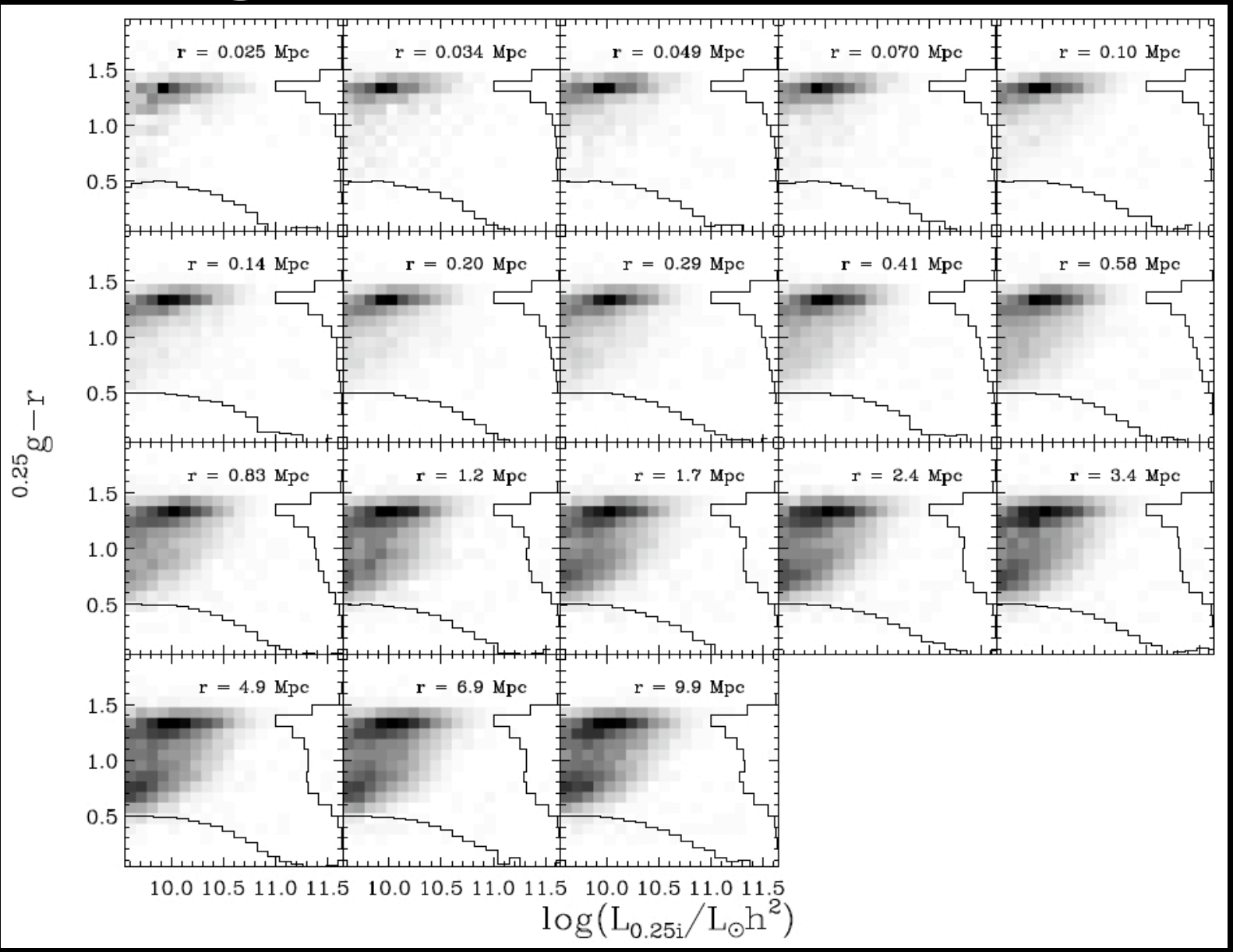


correlation function yields excess-over-random = cluster-associated galaxies

cross-correlation data cube



slicing the cube



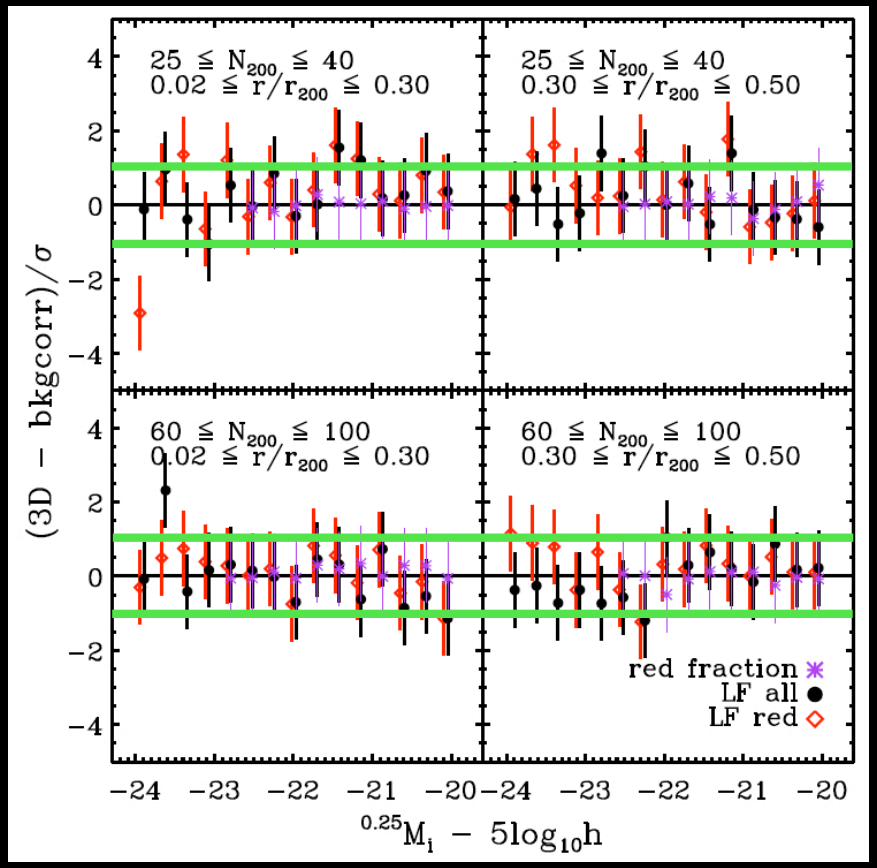
testing

ADDGALS (wechsler et al. 2007)

hubble volume + galaxies with $L > 0.4L_*$

- matches global luminosity function in SDSS
- matches global color-density relationship in SDSS

background-corrected, deprojected reconstruction matches well with intrinsic 3D halo galaxy population

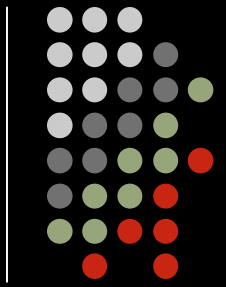


±1σ

±1σ

hansen et al. 2007

method, summarized



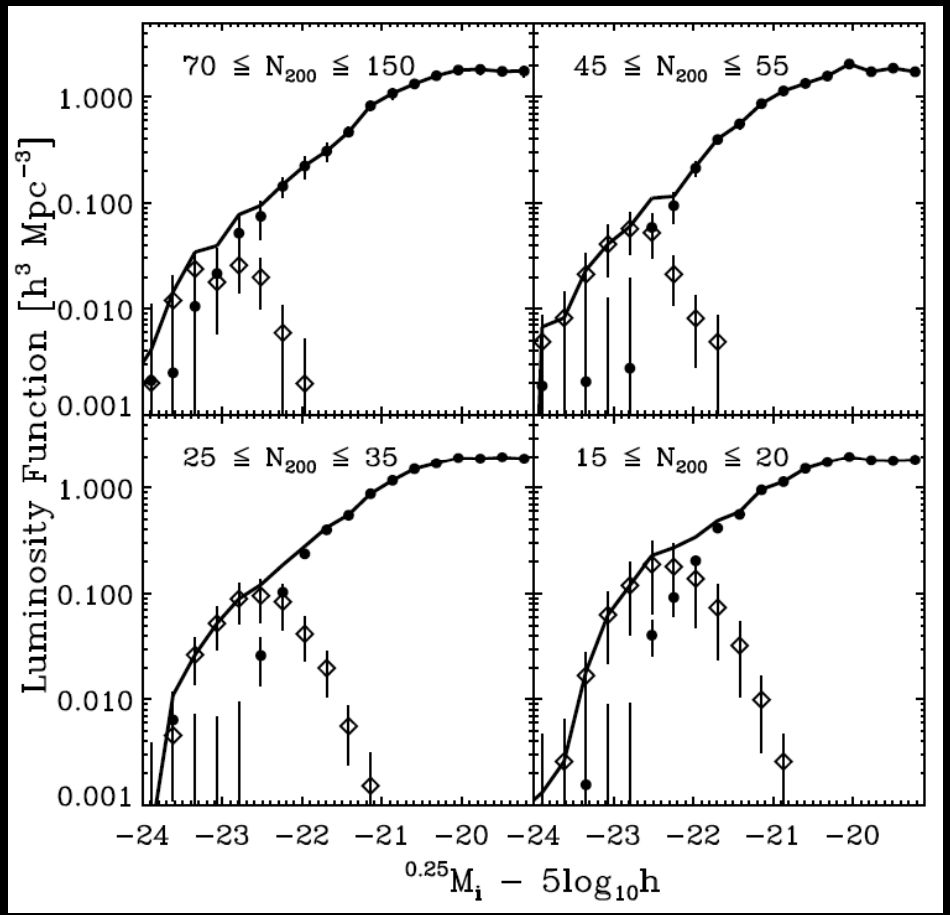
cross-correlation-based background correction provides K-corrected, deprojected distribution of galaxies associated with clusters, binned by cluster & galaxy properties

cluster properties	galaxy properties
richness / mass	BCG or not?
total luminosity	radial distance
redshift	luminosity
BCG properties	color

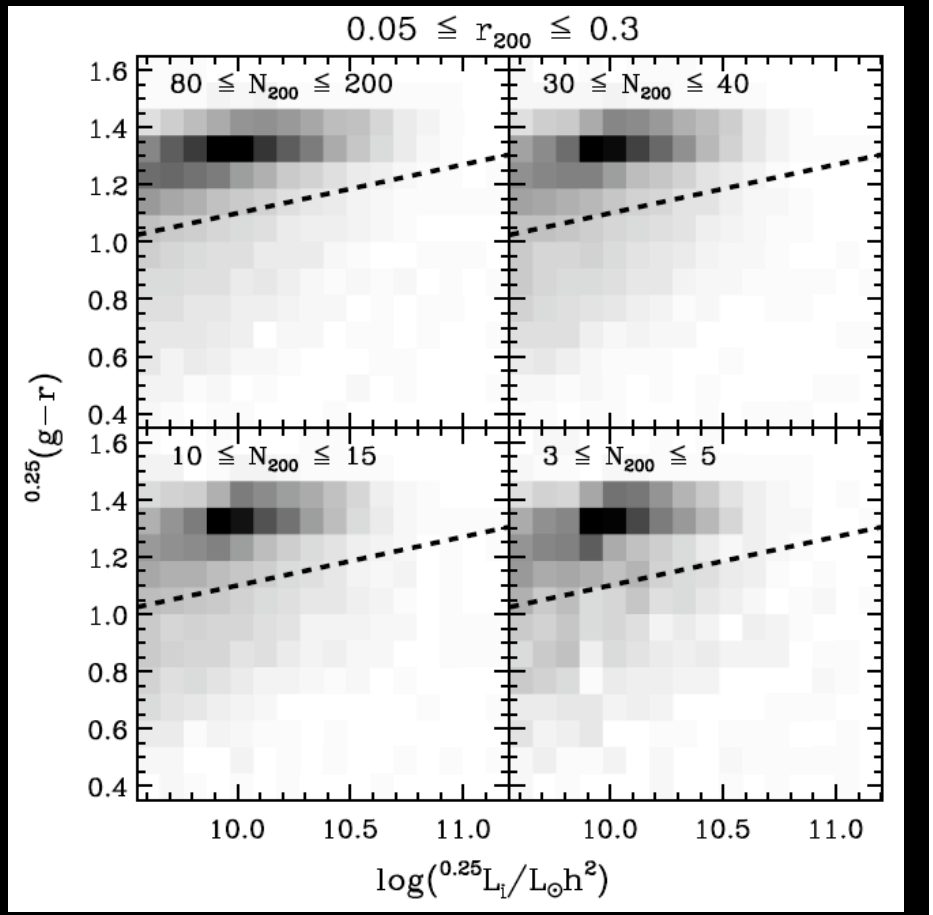
- luminosity function as *f* (richness, color)
- red fraction as *f* (richness, redshift, radius, luminosity)
- BCG luminosity

splits

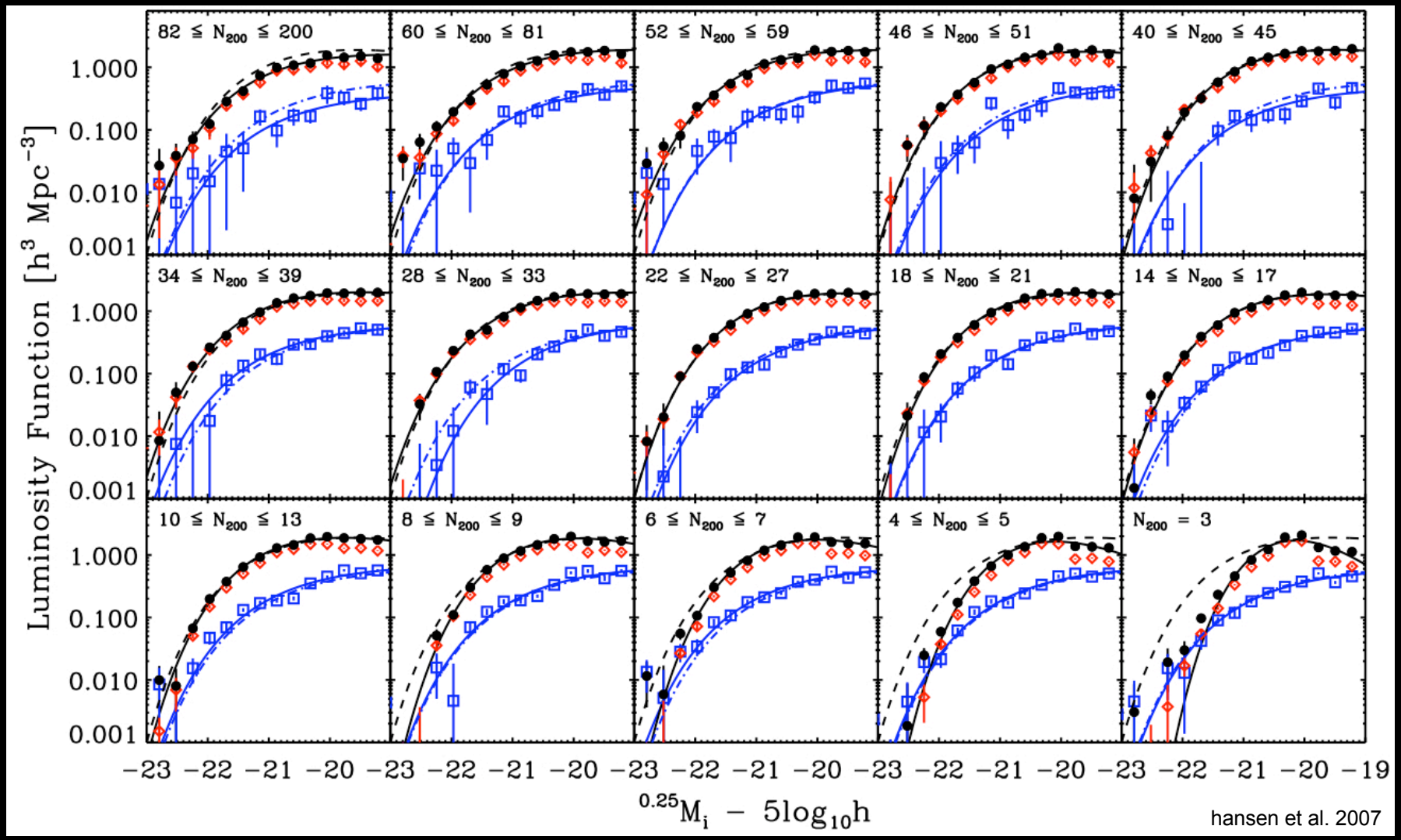
BCGs vs satellites



red and blue satellites



satellite luminosity function
($r \leq r_{200}$)



hansen et al. 2007

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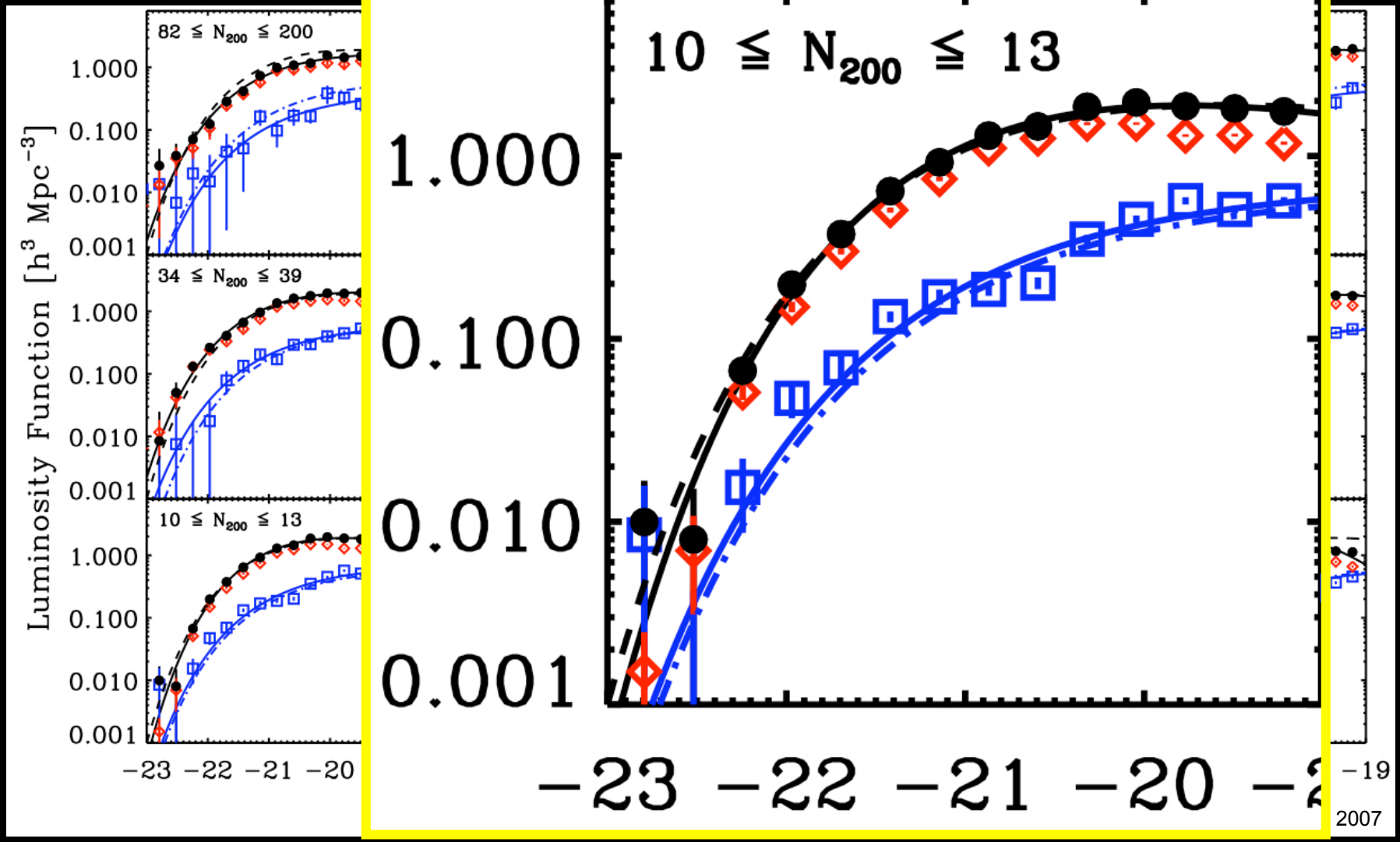

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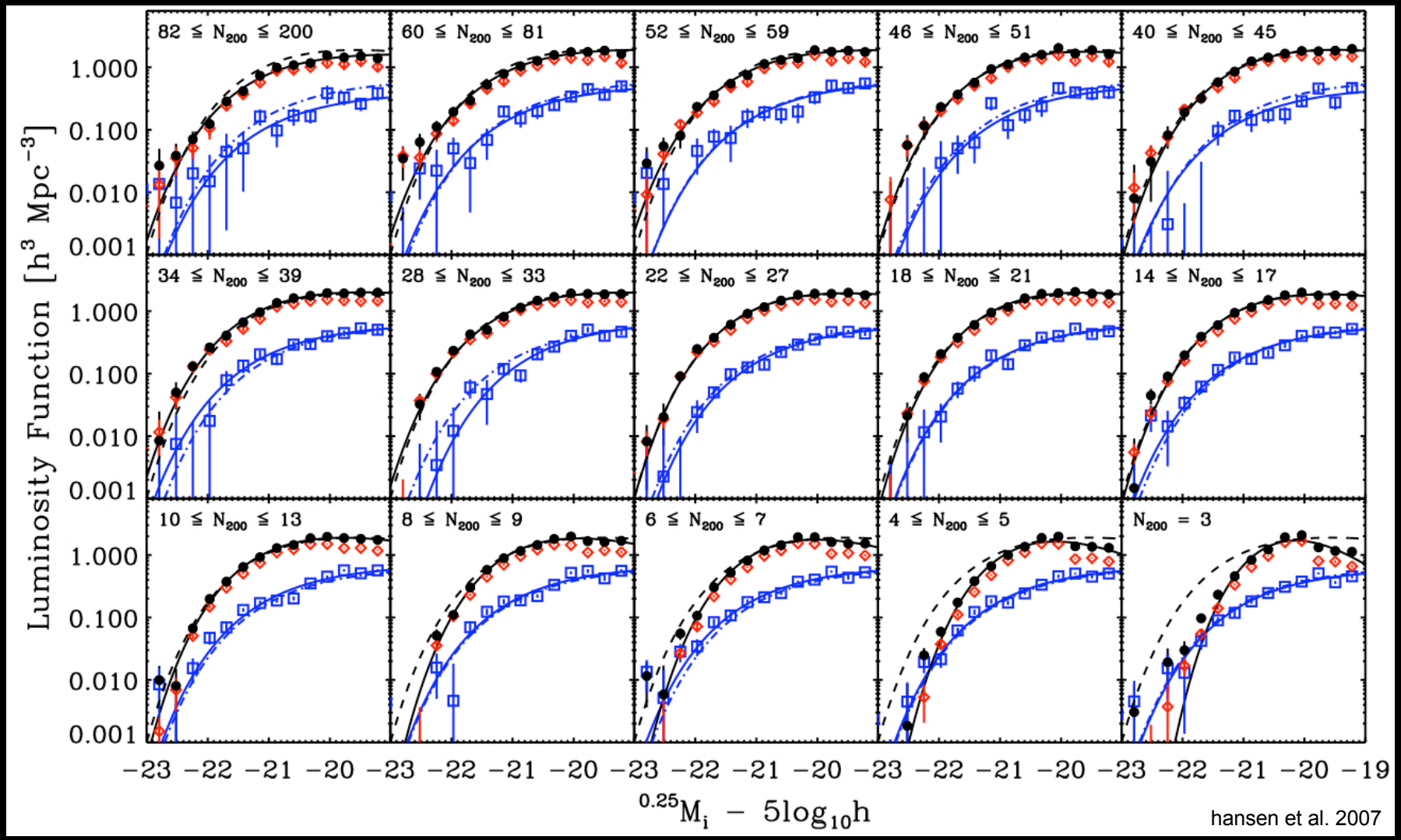
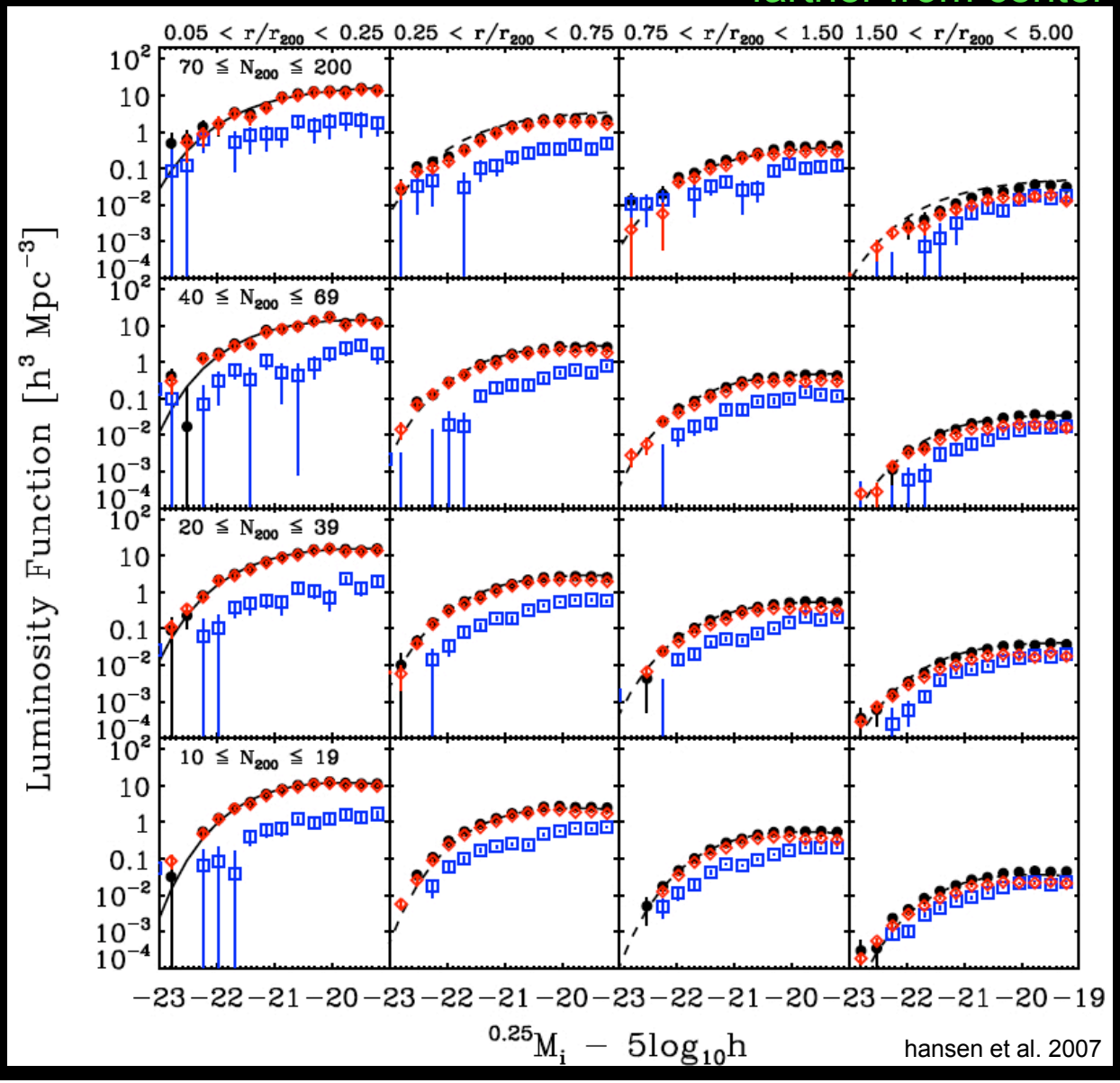


hansen et al. 2007

luminosity functions, radially

closer to center → farther from center

less massive → more massive



hansen et al. 2007

changes are primarily in sub-L* galaxies, providing constraints on processes influencing galaxies as they fall into a cluster

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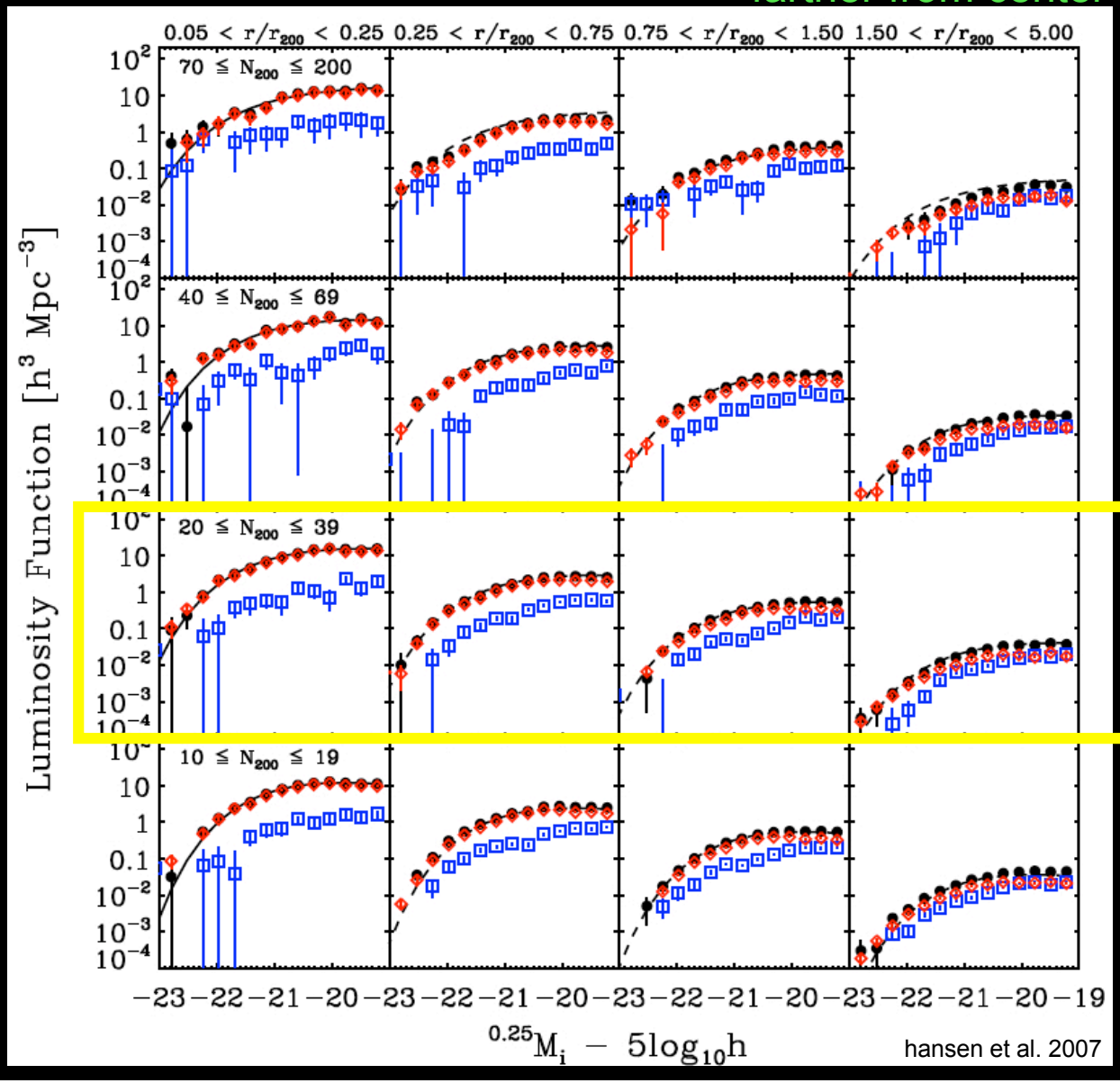

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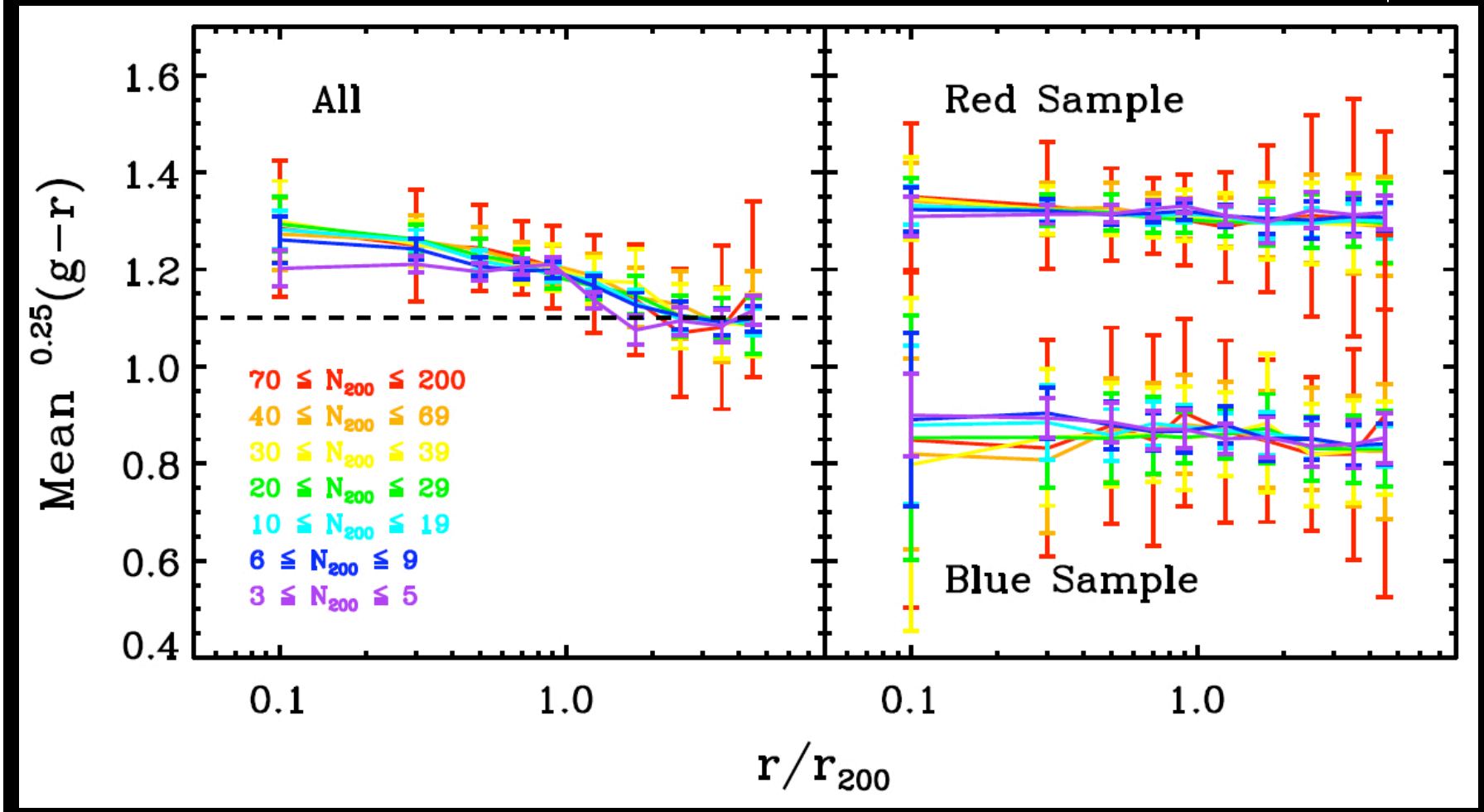
color distribution, radially

all satellites

red satellites; blue satellites

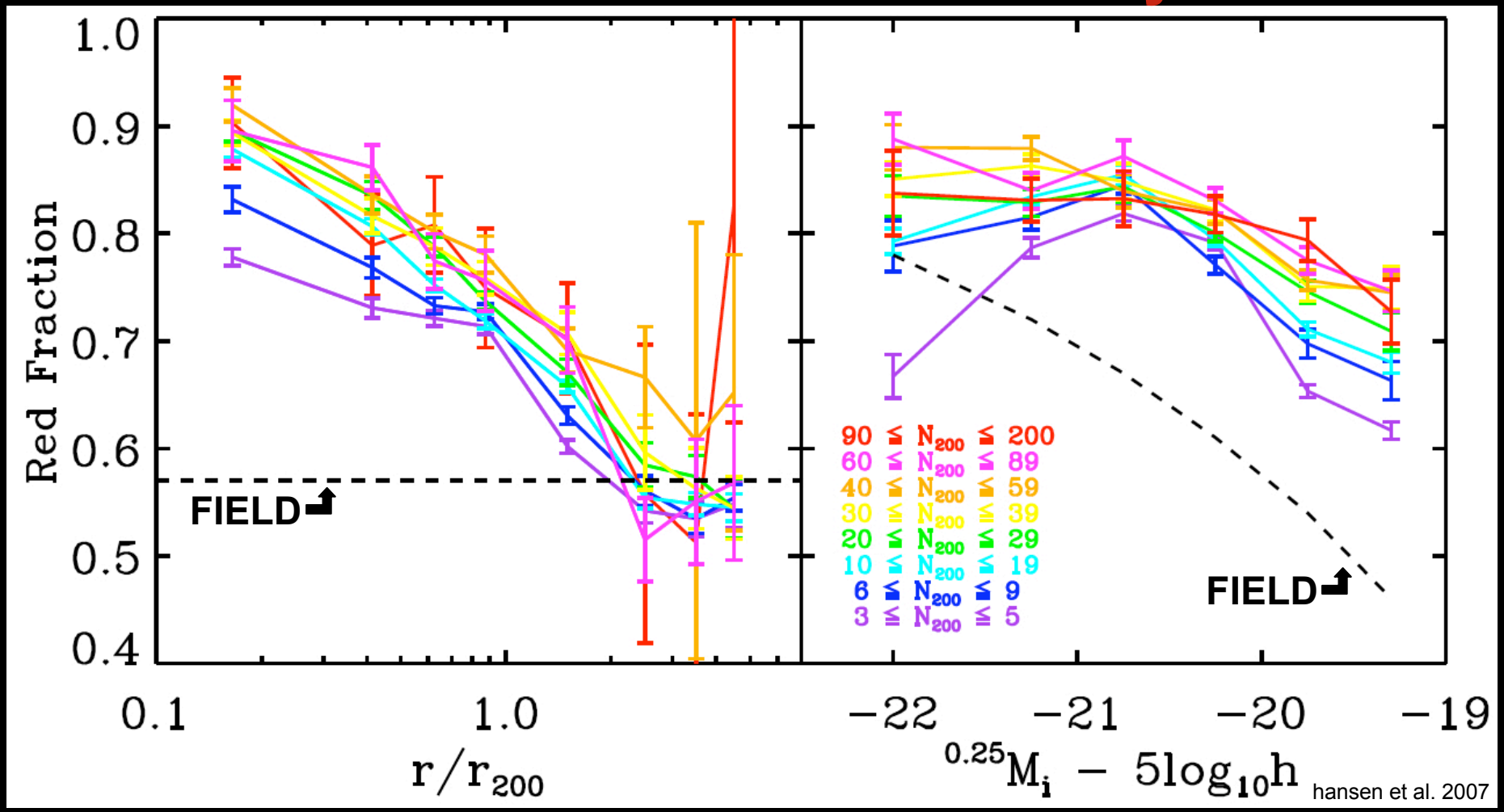


radial color trend is due to changing number of galaxies on the red sequence *vs* in the blue cloud

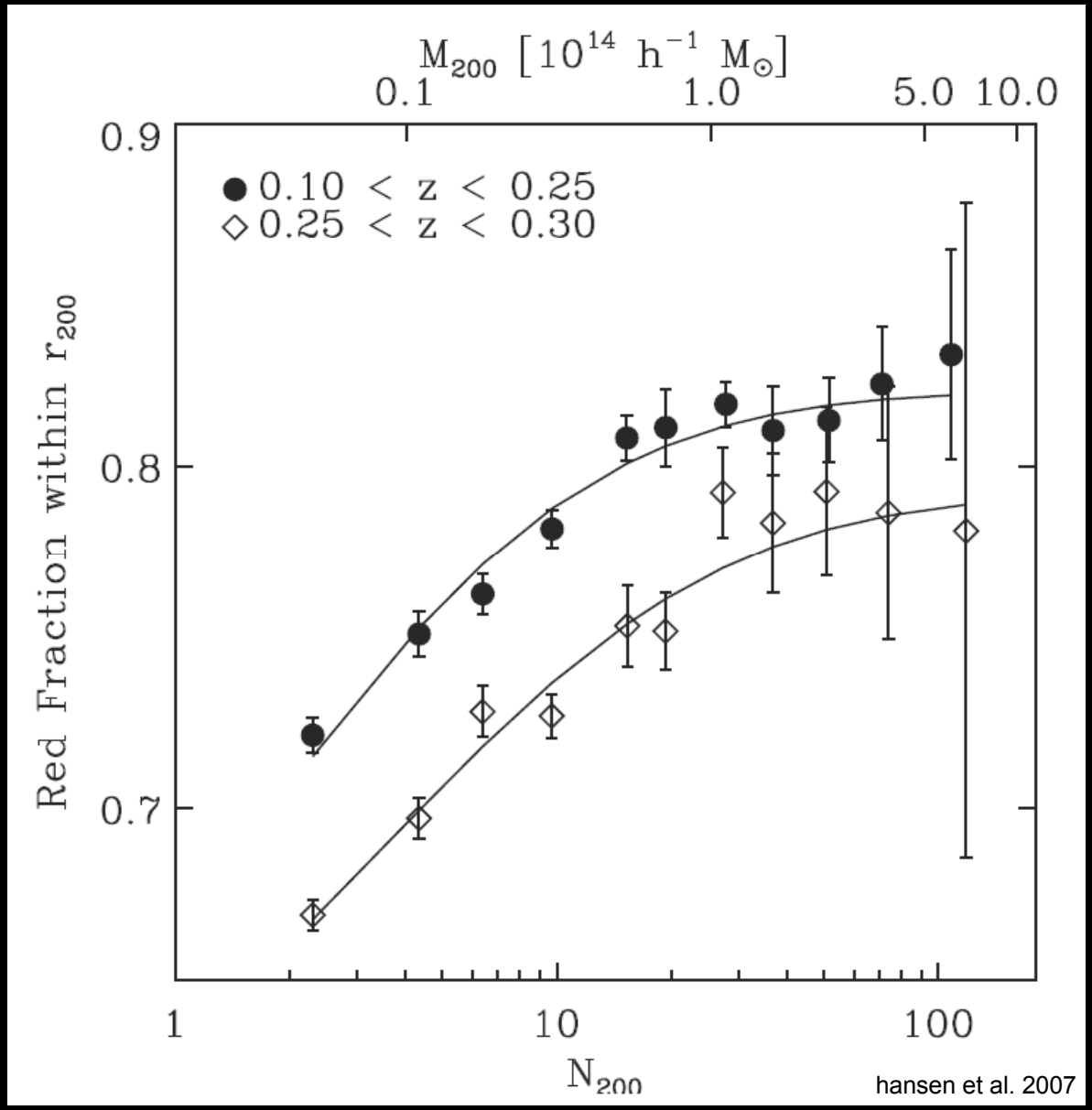
red fraction dependencies

radial trend

luminosity trend



red fraction within r_{200}

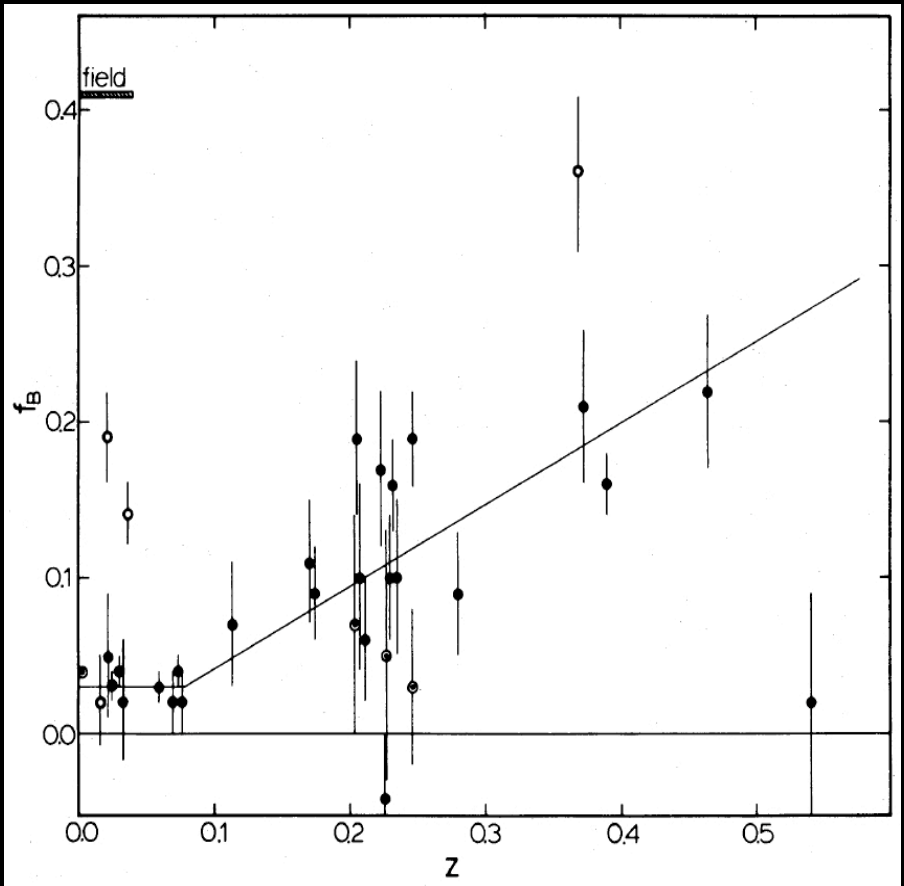


hansen et al. 2007

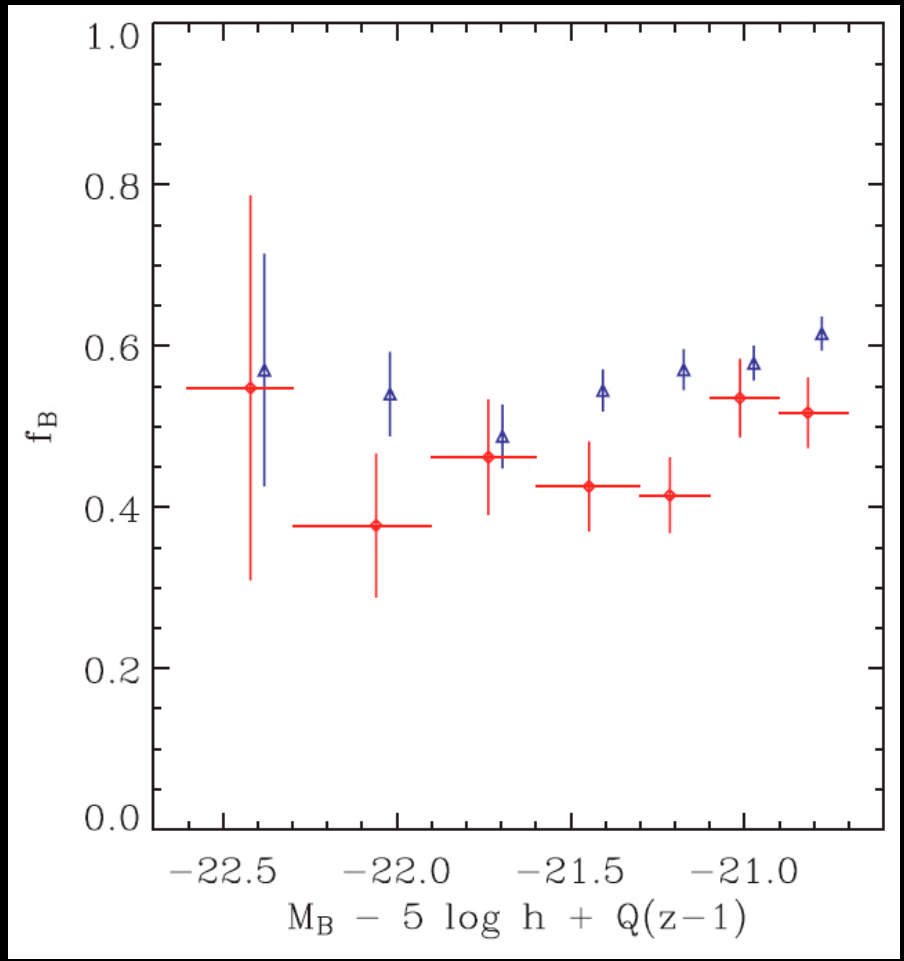
red fraction of satellites brighter than $^{0.25}M_i$ = -19 increases by 5% from z=0.28 to z=0.2 providing constraints on physics & timescale of galaxy evolution in clusters

comparison with other results

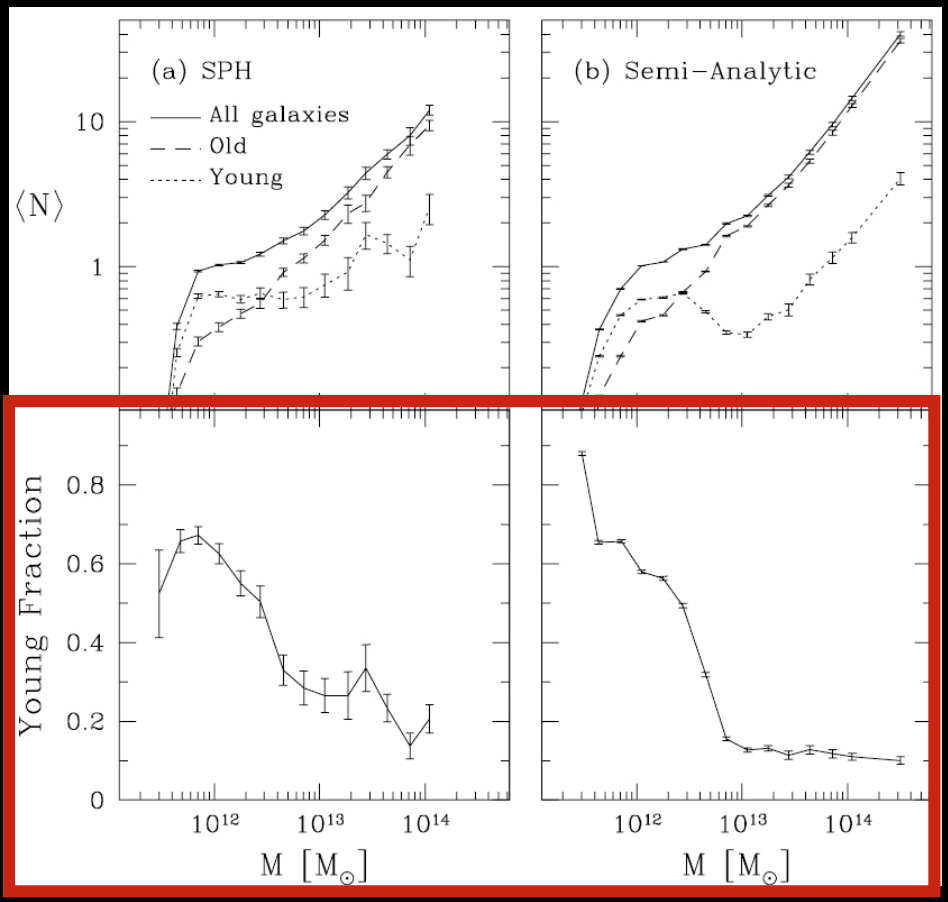
butcher & oemler 1984



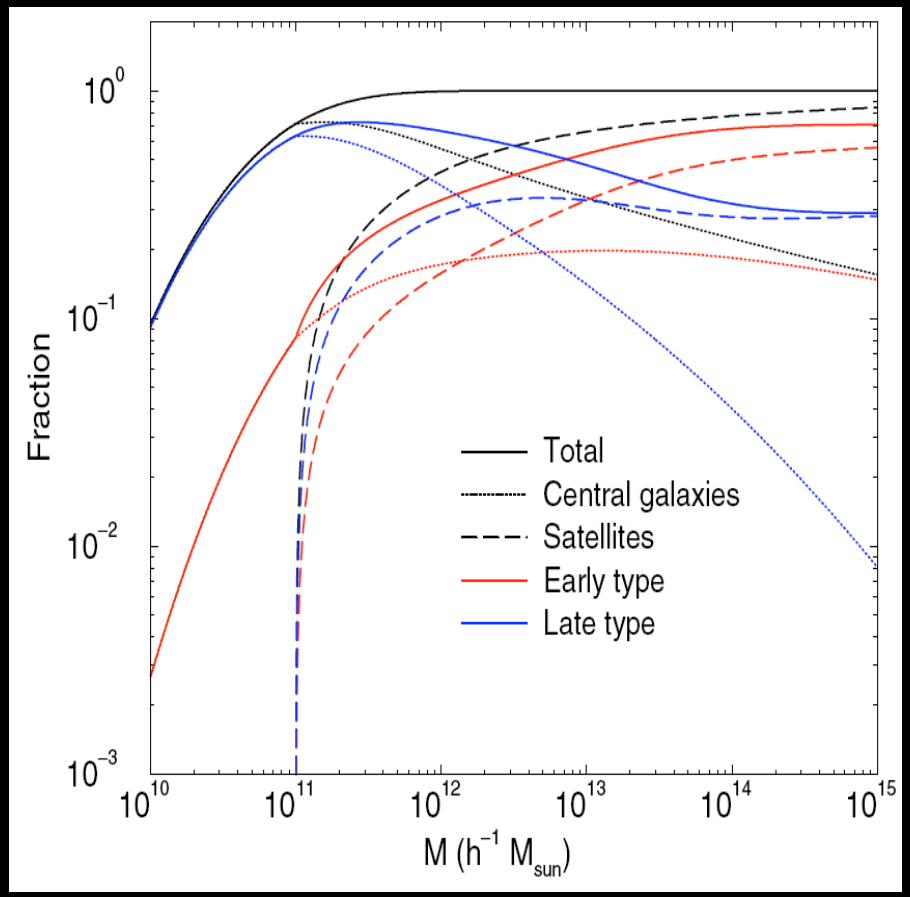
gerke et al. 2007 (DEEP2 groups)



comparison with modeling



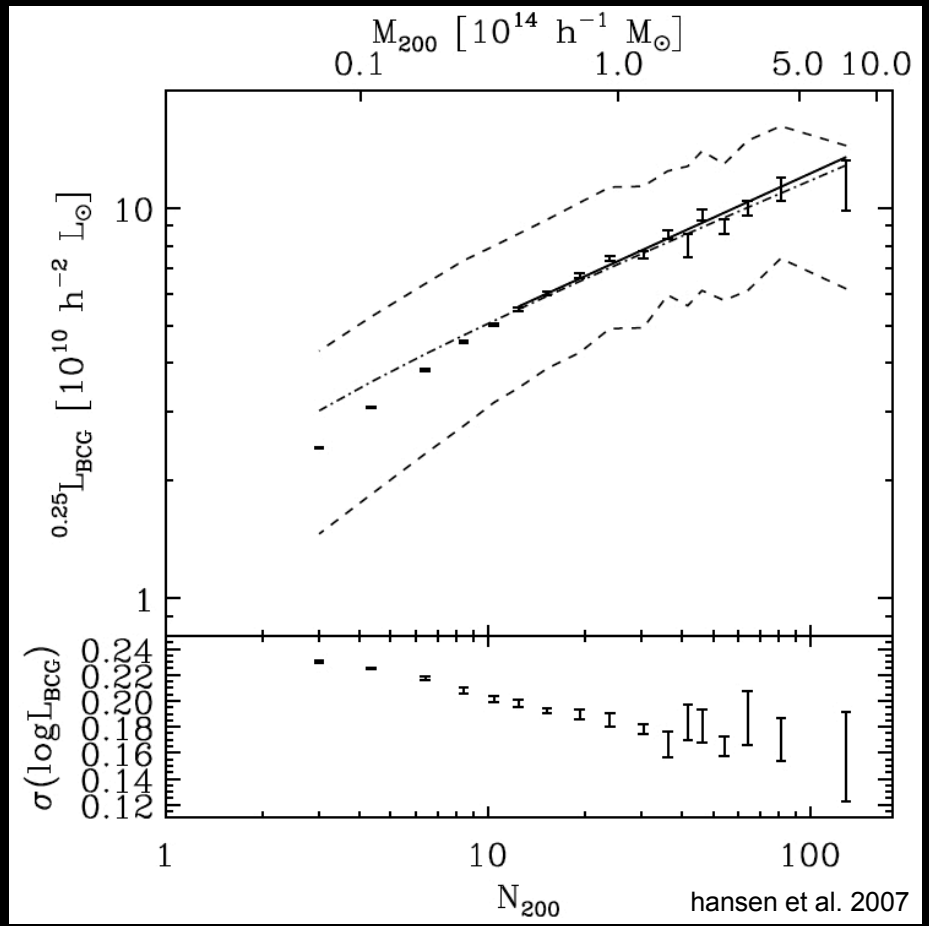
berlind et al. 2003



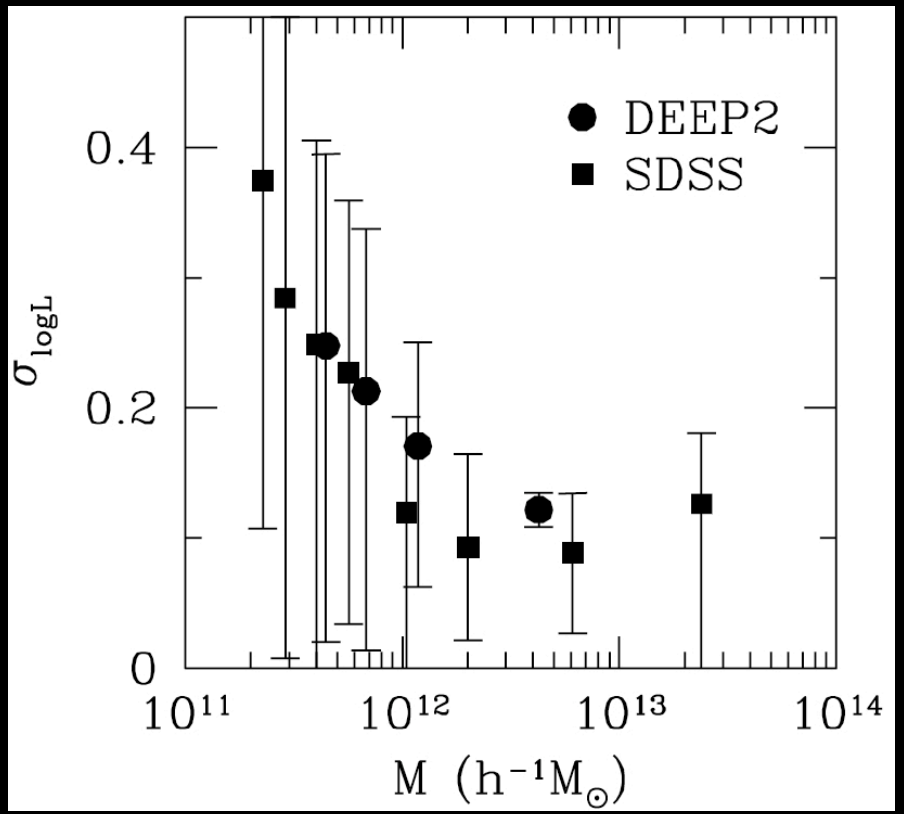
cooray 2005

BCG light

as a function of cluster mass



zheng, coil & zehavi 2007



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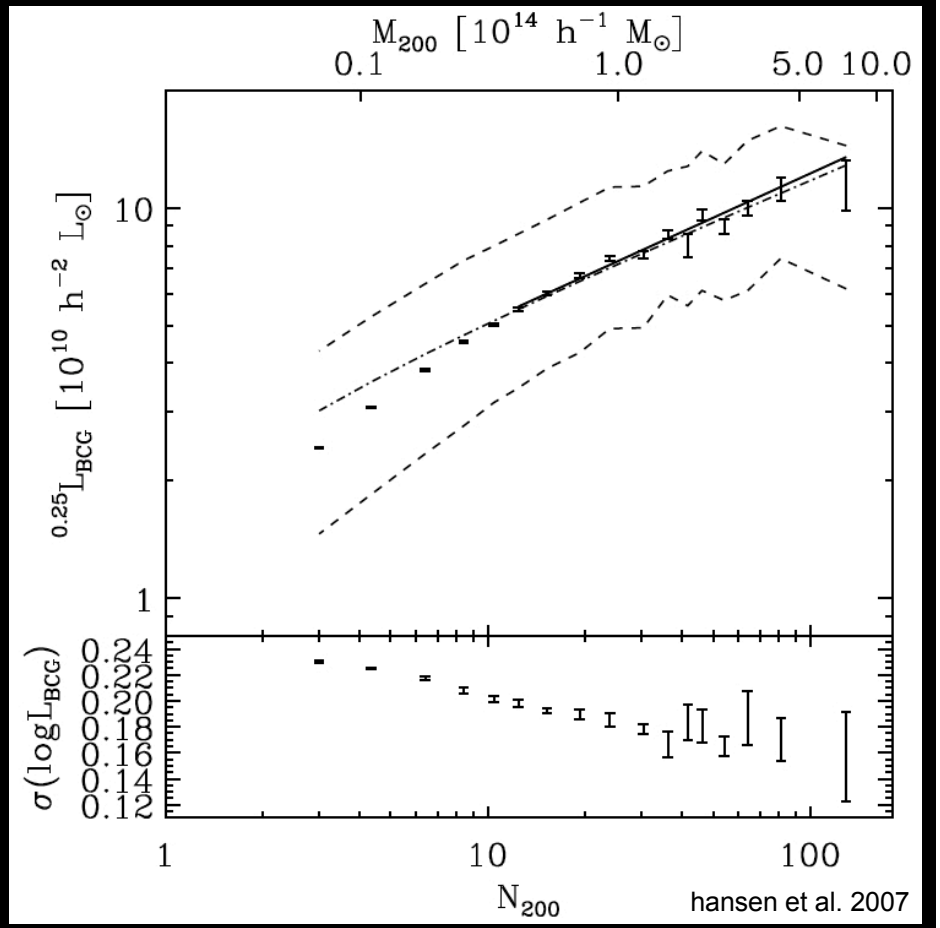
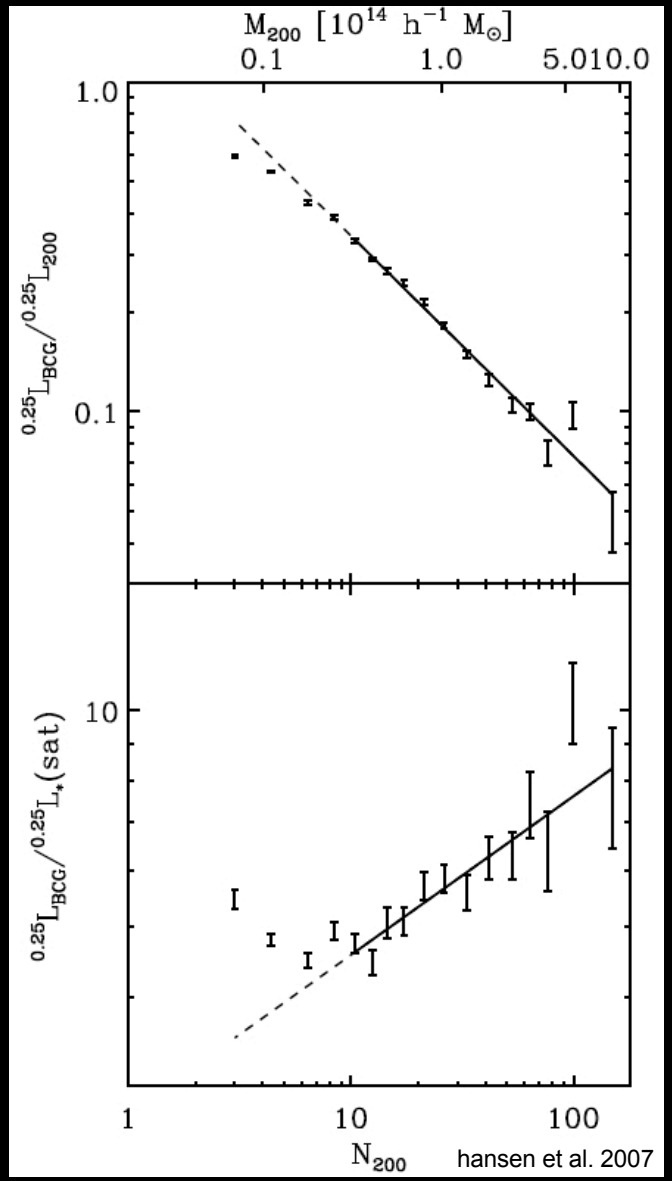
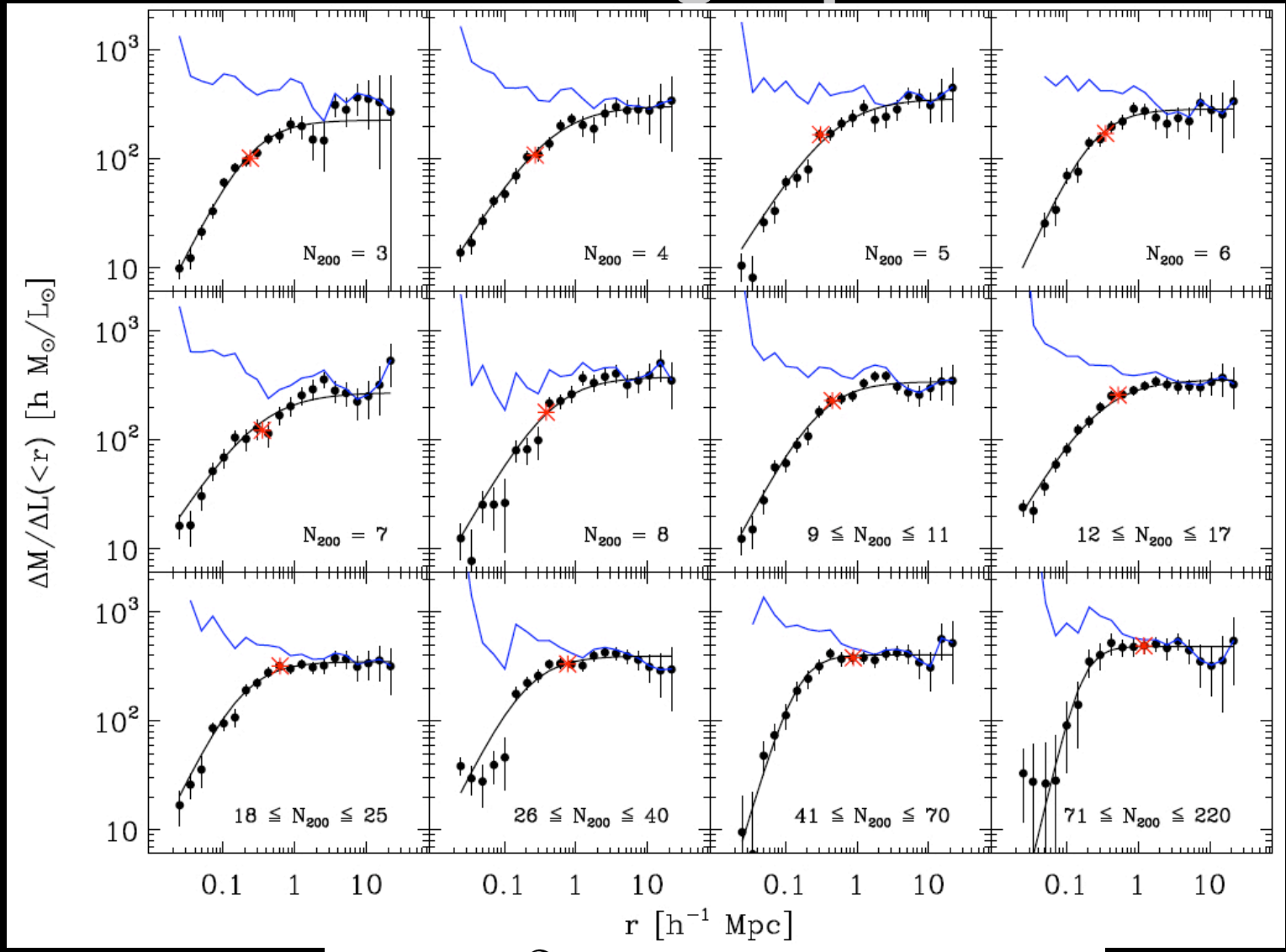




BCGs contribute less of the total light but are brighter (absolutely & relative to satellites) in more massive systems

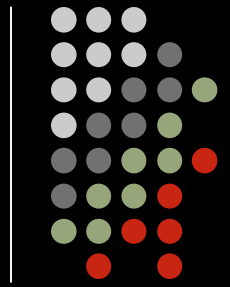
cluster mass-to-light profiles



$$\Omega_m b^{-2}_{M/L} = 0.20 \pm 0.03$$

sheldon et al. 2007

what else?



compare with high-z and/or spectroscopic samples

SZA + SZAOptical

- first cross-correlation of optical and SZ signals in an SZ survey

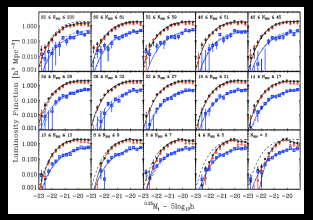
SPT + BCS & SPT + DES

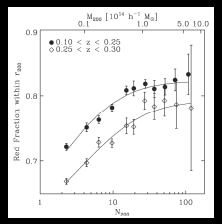
- improve mass-observable calibration (➔ cosmology)
- compare with SDSS (➔ galaxy evolution)

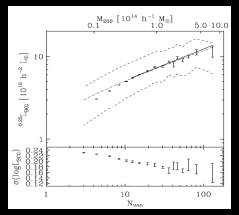
LSST, Pan-STARRS, others……

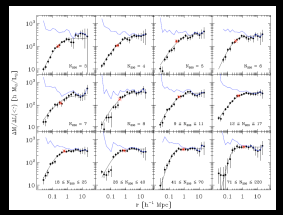
Summary

sdss data allows detailed investigation of the population of galaxies in clusters, including









- conditional luminosity function
- red fraction
- BCG light
- combined with lensing, M/L profiles

this local-universe information constrains models of galaxy evolution in the cluster environment; techniques used here are applicable to any large photometric survey

see hansen et al., `arXiv:0710.3780`