Groups: The Rich, the Poor, and the Destitute

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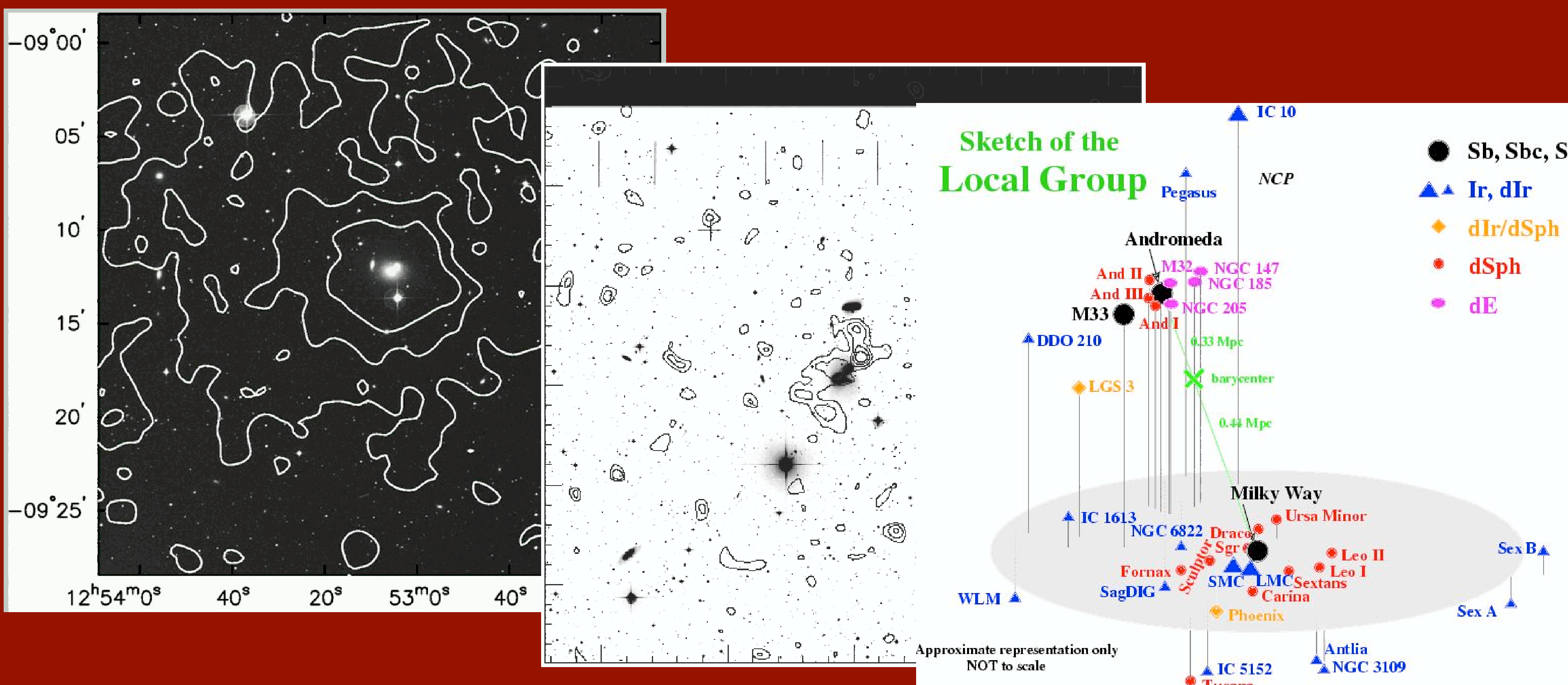
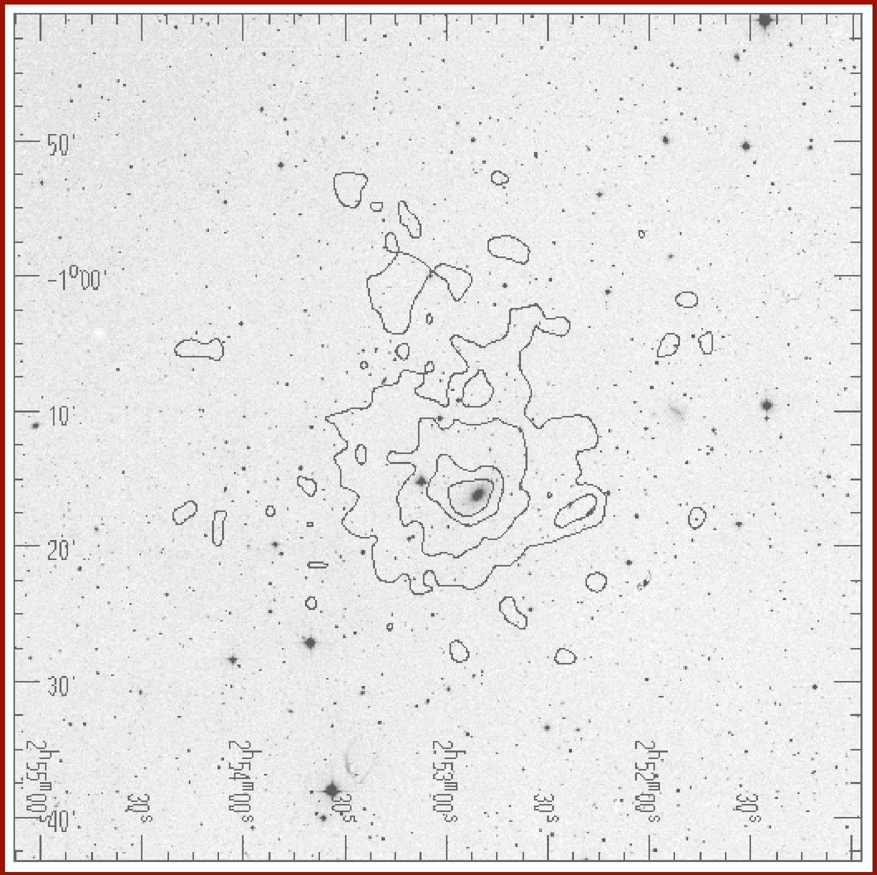
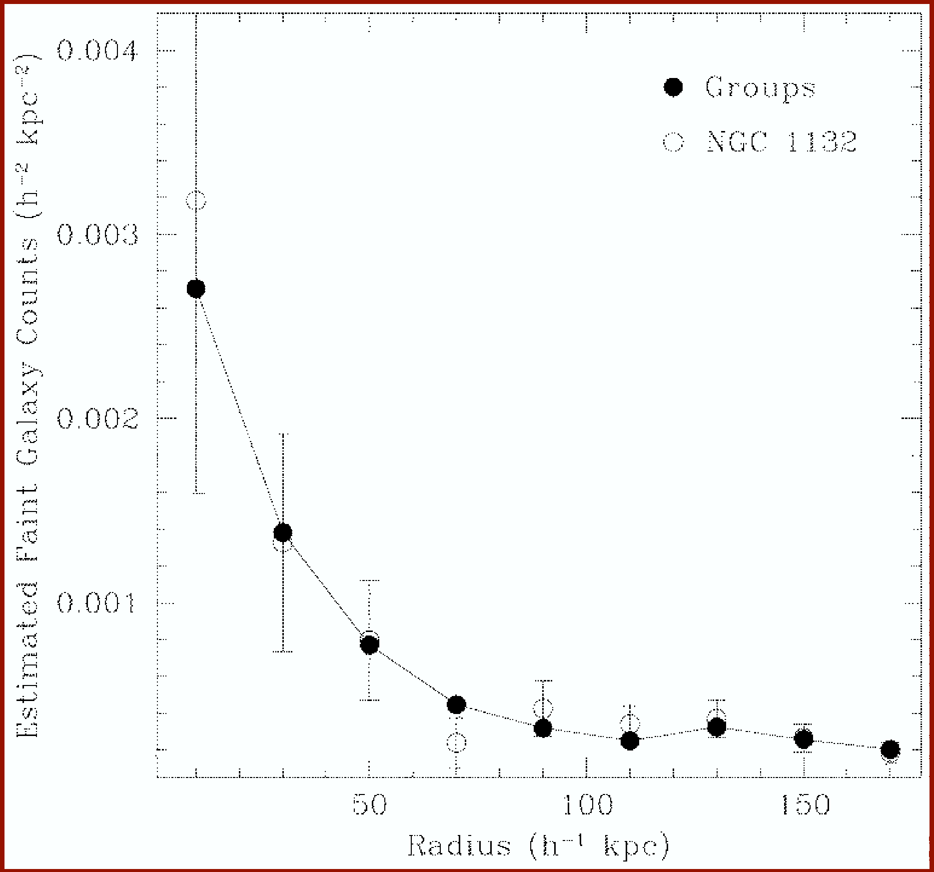


A Fourth Class of Group?



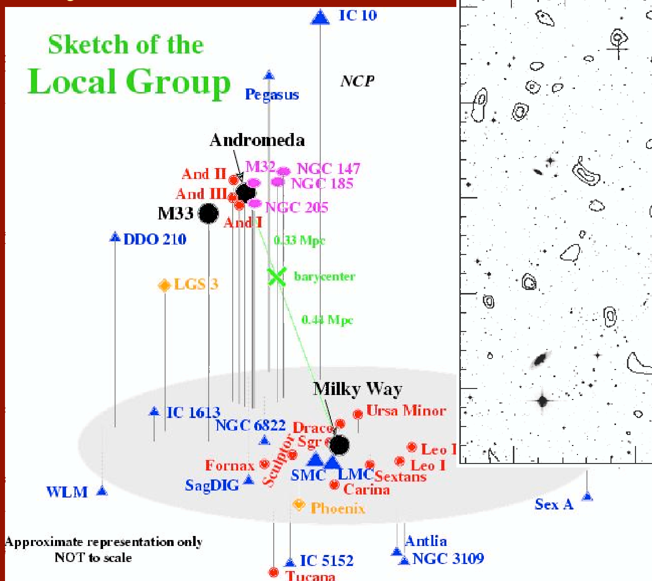


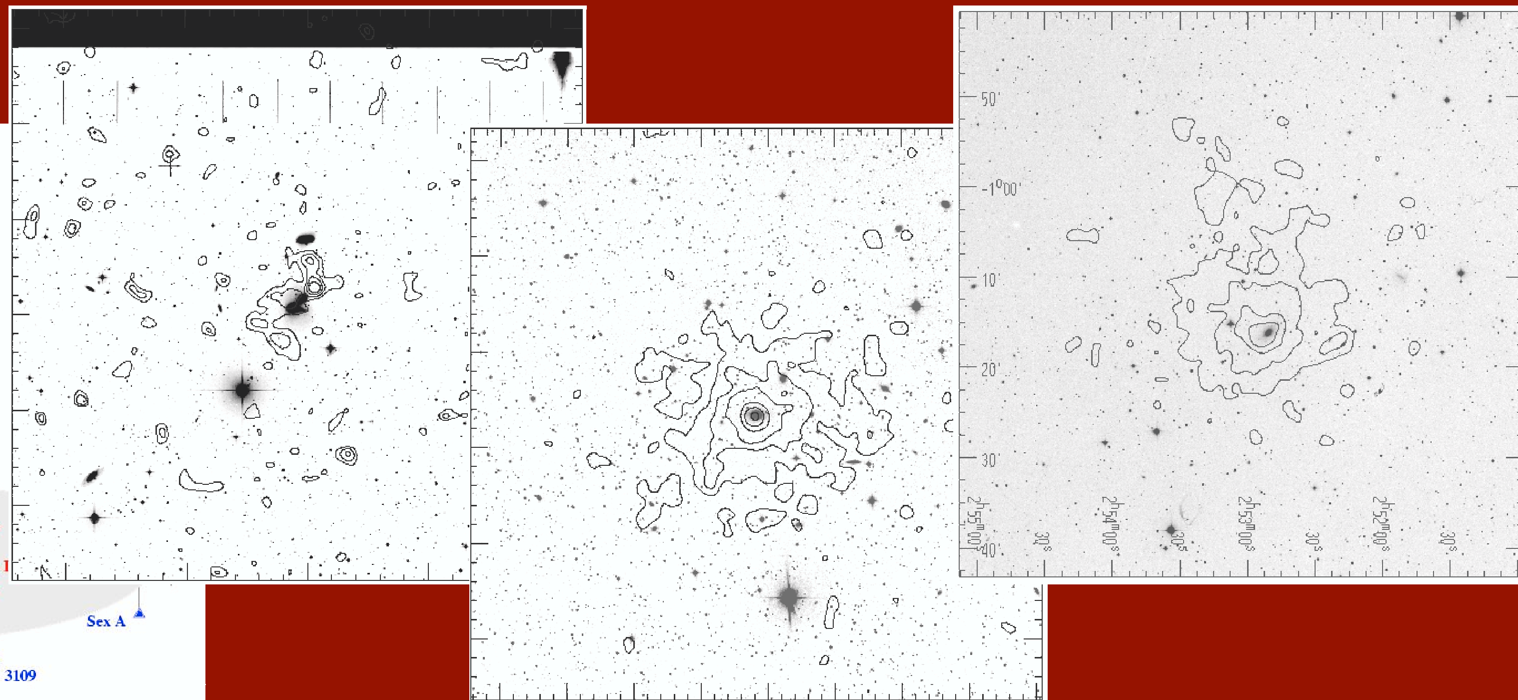
Mulchaey & Zabludoff 1999

isolated ellipticals: X-ray extent, luminosity, temperature, metallicity, gas mass, total mass, and dwarfs like groups

One Possible Scenario...

E. Grebel



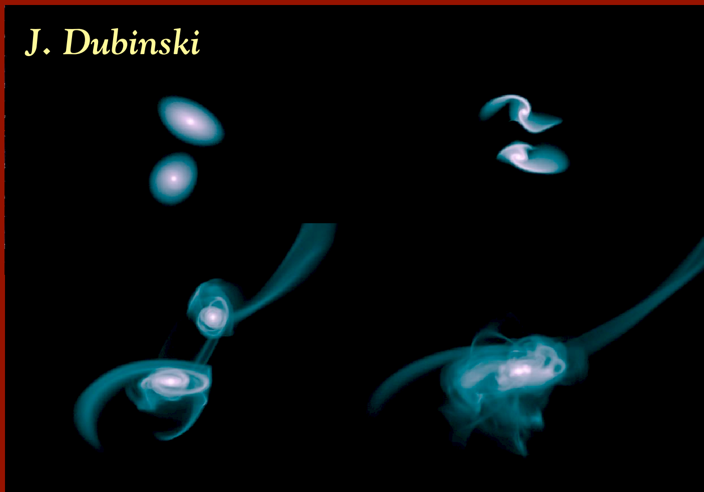


mergers/stripping ---> central gE, more dwarf-to-giants, early-types, intragroup stars and metallicity as velocity dispersion rises

dark matter, hot gas in common halo, hydrostatic equilibrium

group dynamically-evolved (and looks like cluster that accretes it)

There *is* Galaxy Evolution via Mergers



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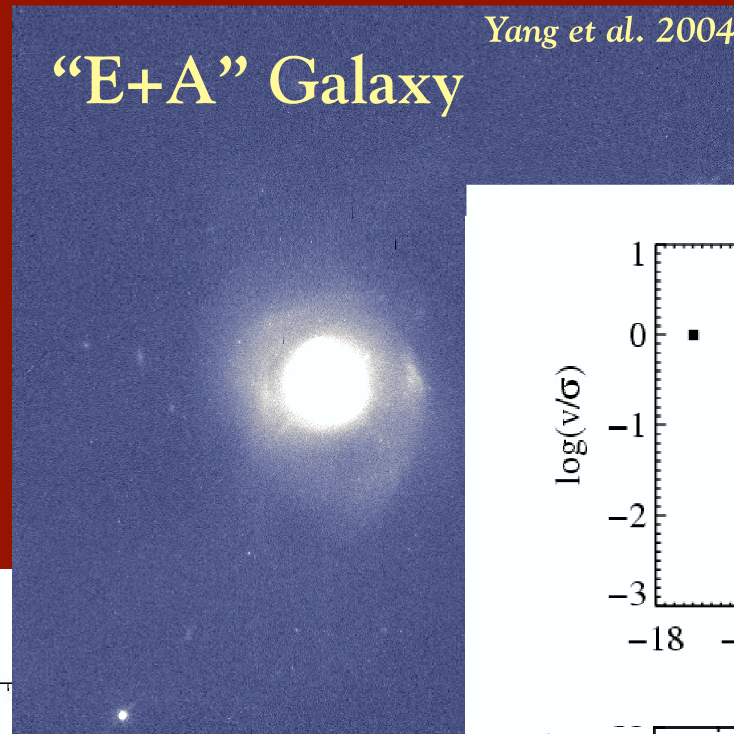
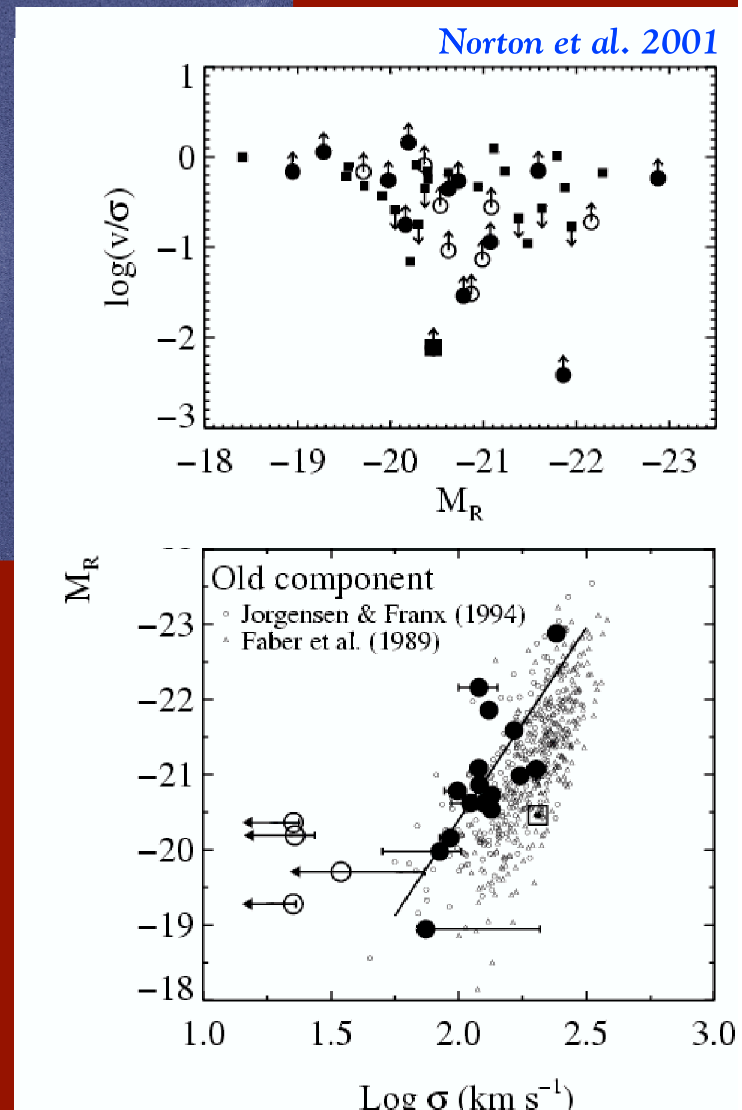
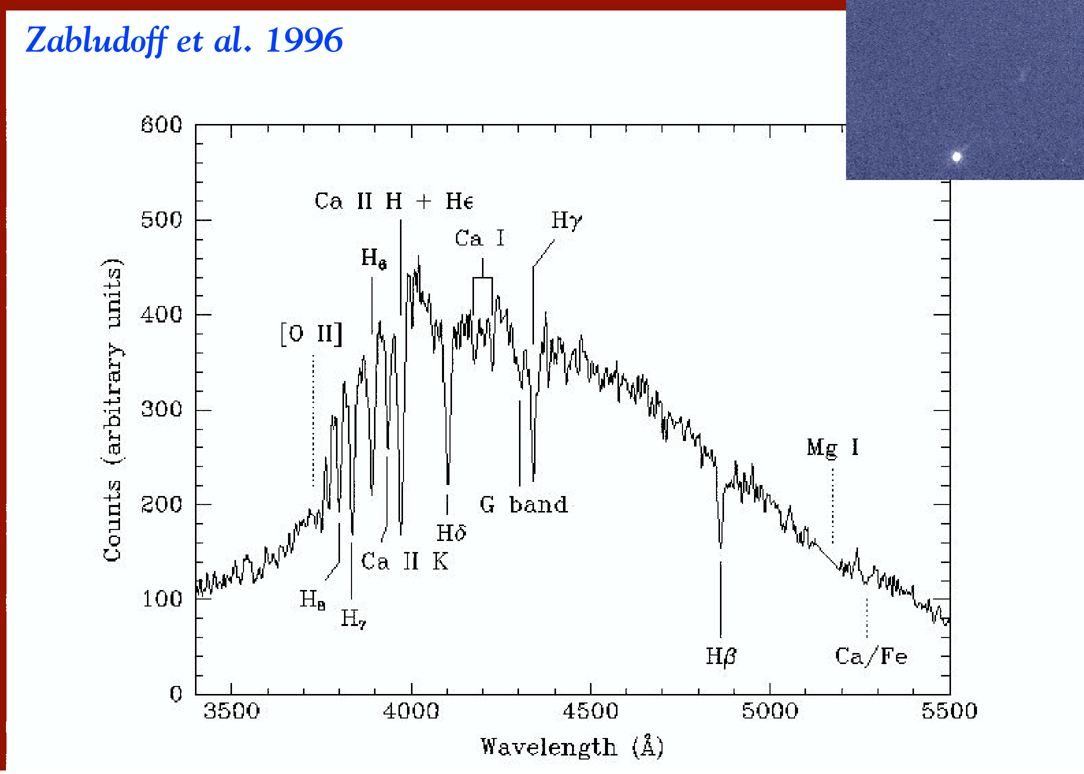
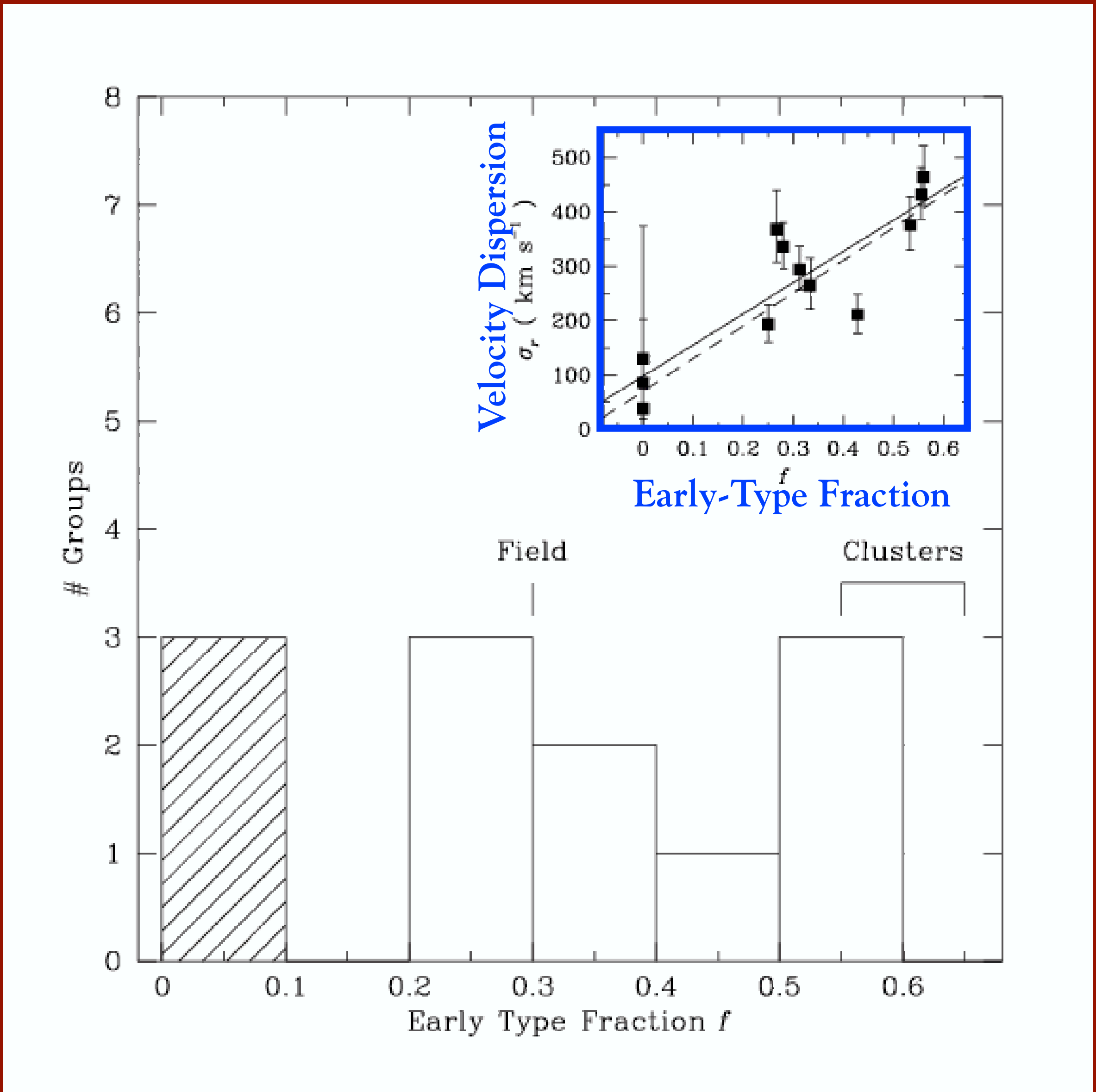






Evolution of Early-Type Fraction



Zabludoff & Mulchaey 1998

do groups form this way or evolve along sequence?

at 1000 km/s, early-type fraction = 120%!

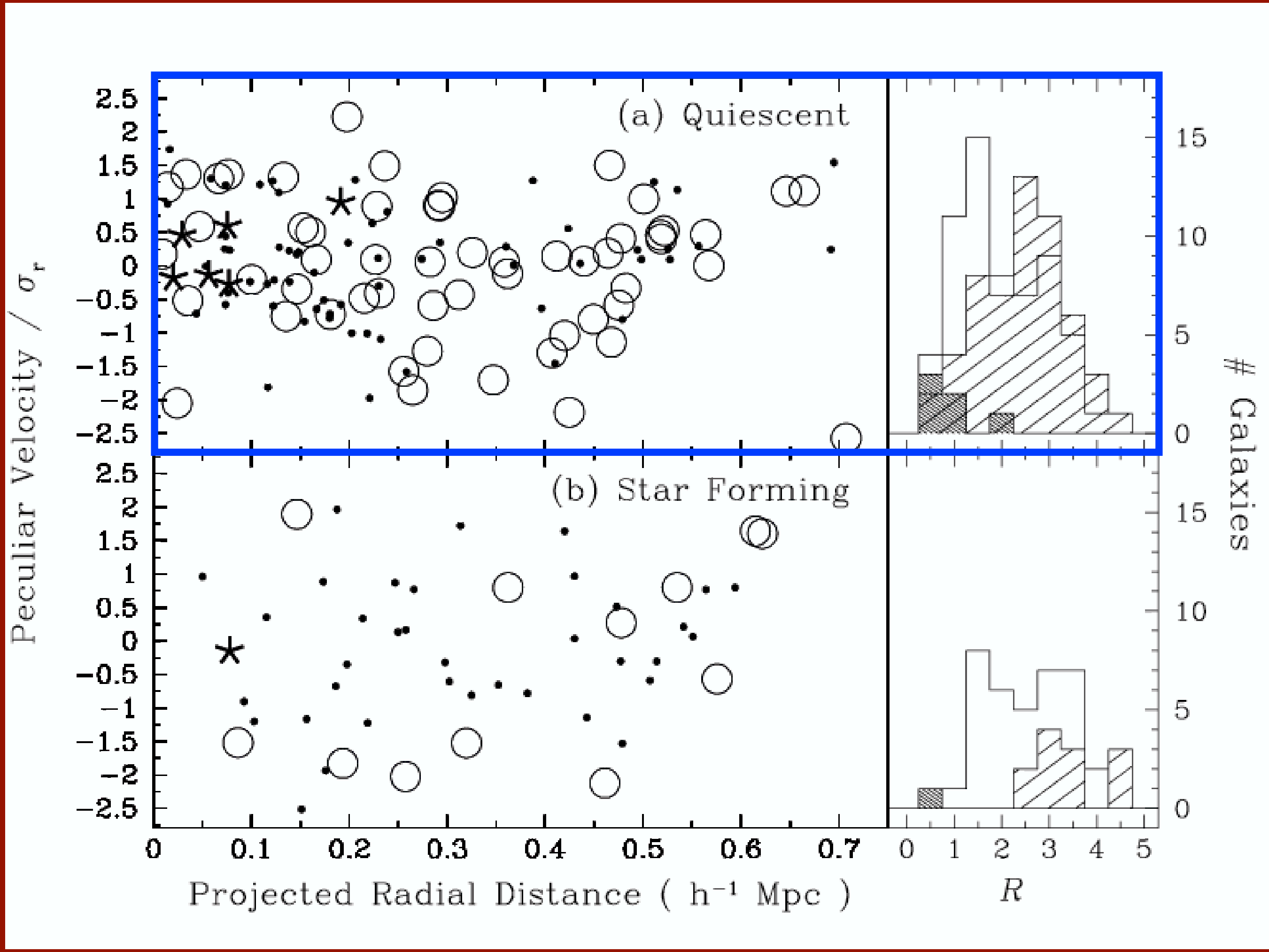
saturation point: upturn at ~400-500 km/s corresponds to L* merger

Evolution of Dwarf-to-Giant Ratio, Brightest Group Galaxy

BGGs lie in group centers (then dwarfs, giants)

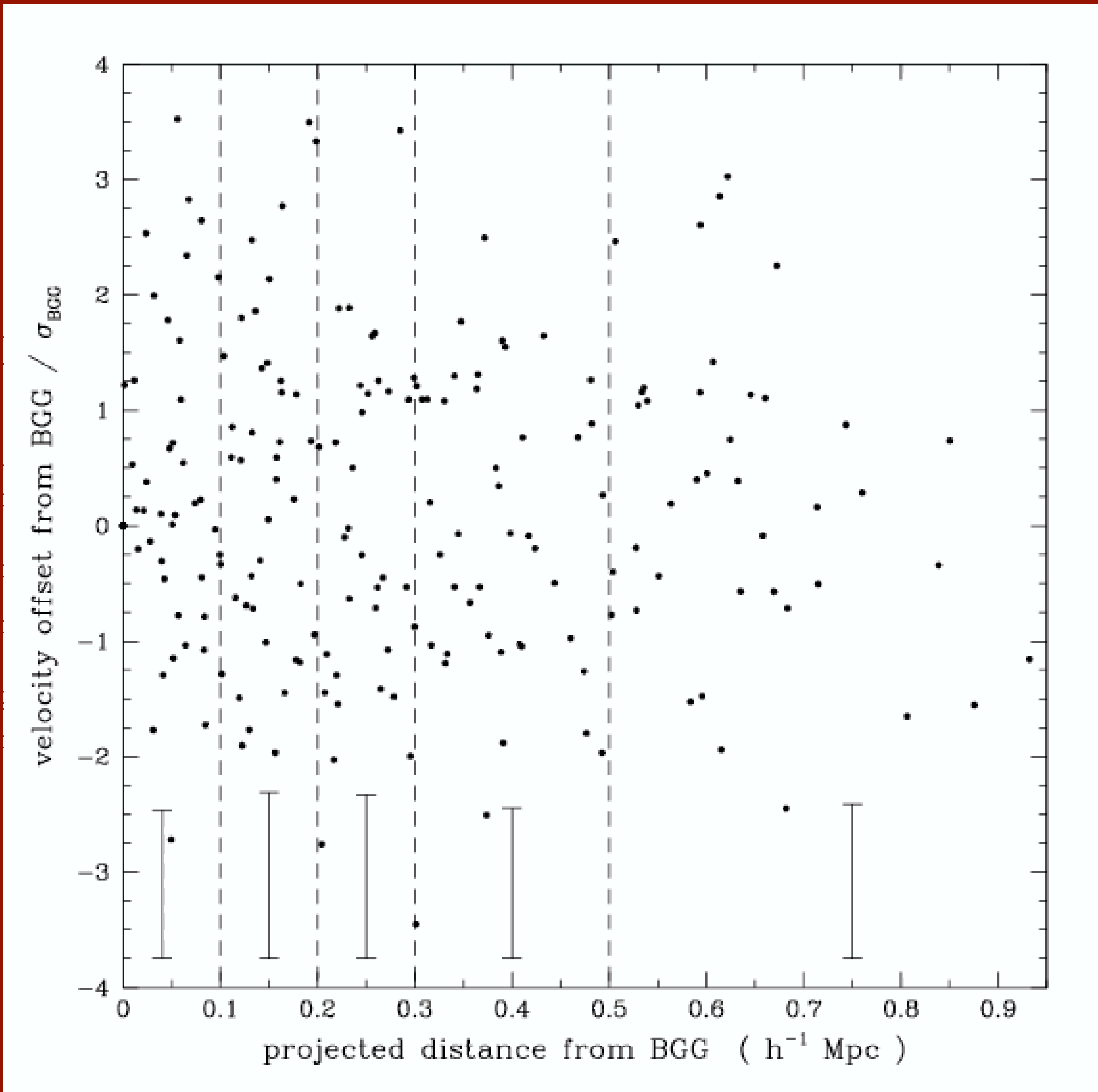
populations not mixed ==> *later formation*

BGGs offset in lower dispersion groups (*Momcheva et al. 2005, Williams et al. 2005*)



Zabludoff & Mulchaey 2000

Evolution of Dark Matter Halo



Zabludoff & Mulchaey 1998

spread in galaxy velocities constant

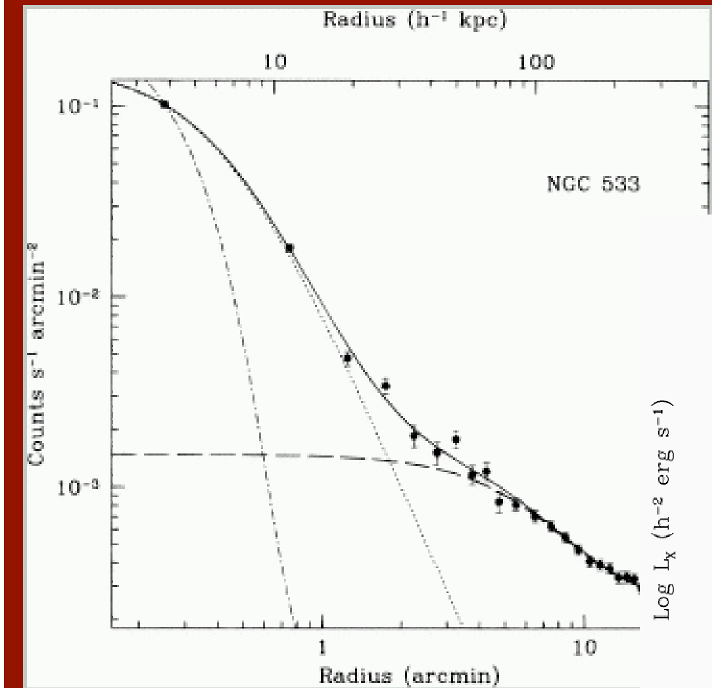
mass increasing like *r*

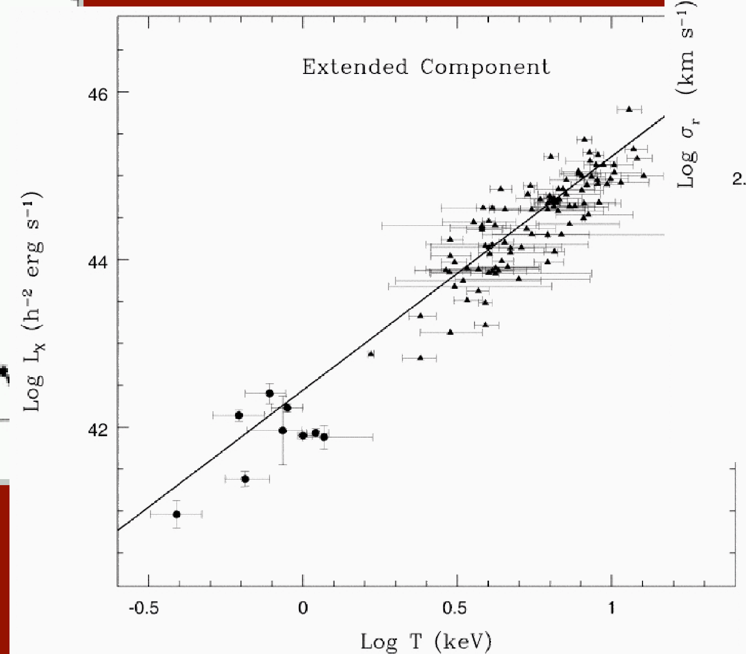
==> *mass not in galaxy halos, but diffuse*

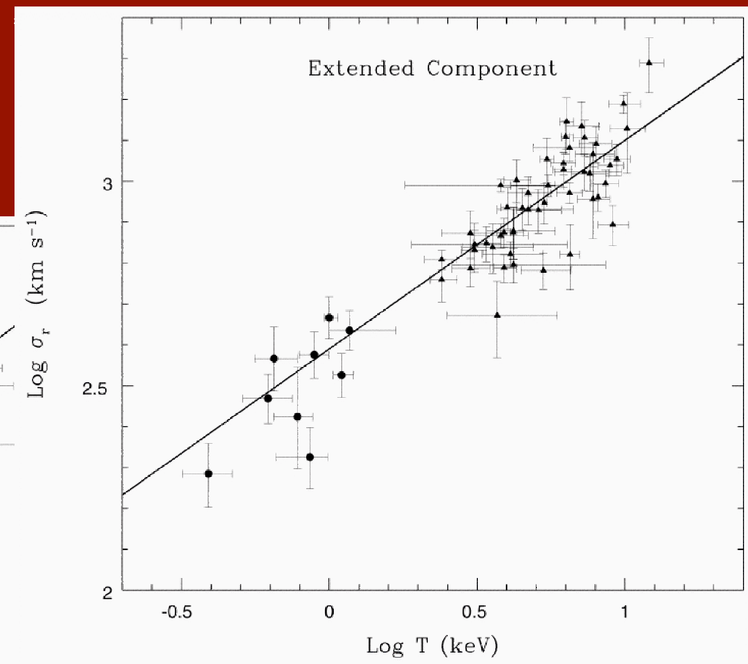
higher dispersion groups survive because cross-sections smaller

Local Group has yet to collapse

Evolution of X-Ray Halo







Zabludoff & Mulchaey 1998

two components, outer lies on cluster relations ==> *1) gas, galaxies trace same potential, 2) hydrostatic equilibrium, 3)* IGM, ICM *evolve similarly*

what about lower dispersion groups?

Evolution of Intragroup Starlight

two component model best fit, not random view of triaxial system

intragroup light:

distinct, ubiquitous

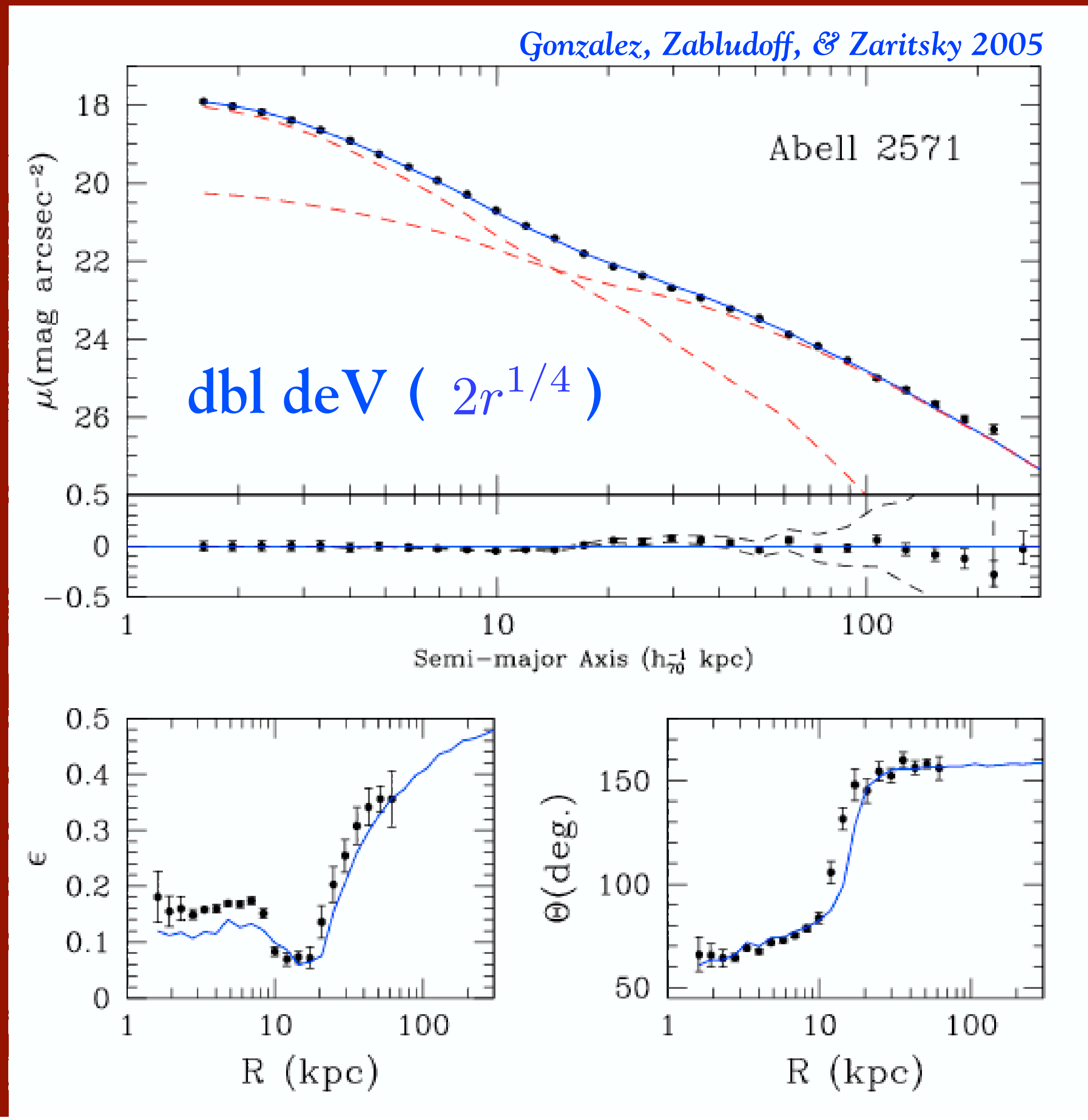
80-90% of light

10-40x bigger, more elliptical (like group members)

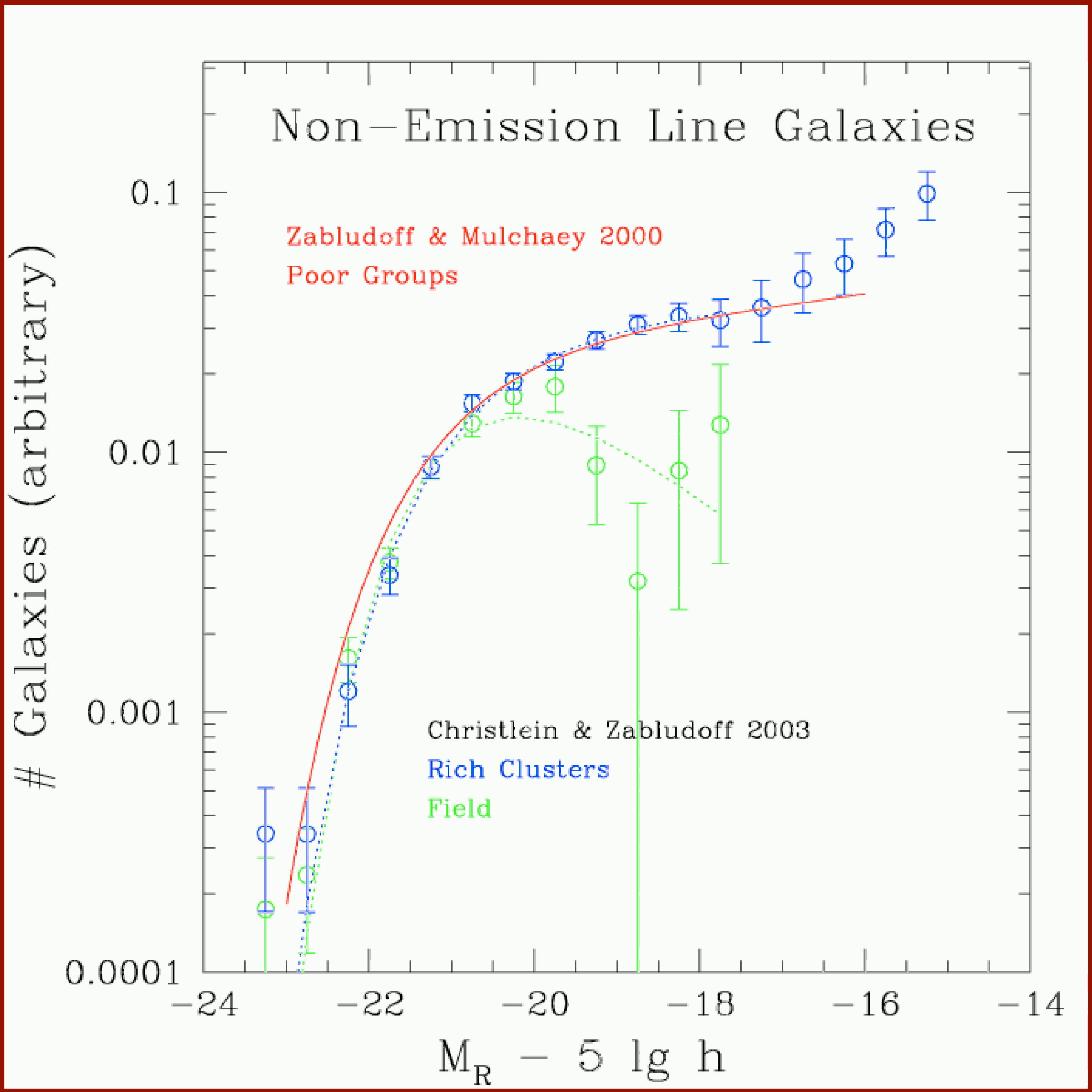
closely aligned

injects >50% metals?

what about poorer groups?



Importance of Group Evolution to Galaxies in *Clusters*



D. Christlein

some groups look like clusters in early-type fraction...

and quiescent dwarf-to-giant ratio

BGGs centered in evolved groups, not clusters

BGG velocity dispersions max out at ~400 km/s

main driver in groups, not clusters?

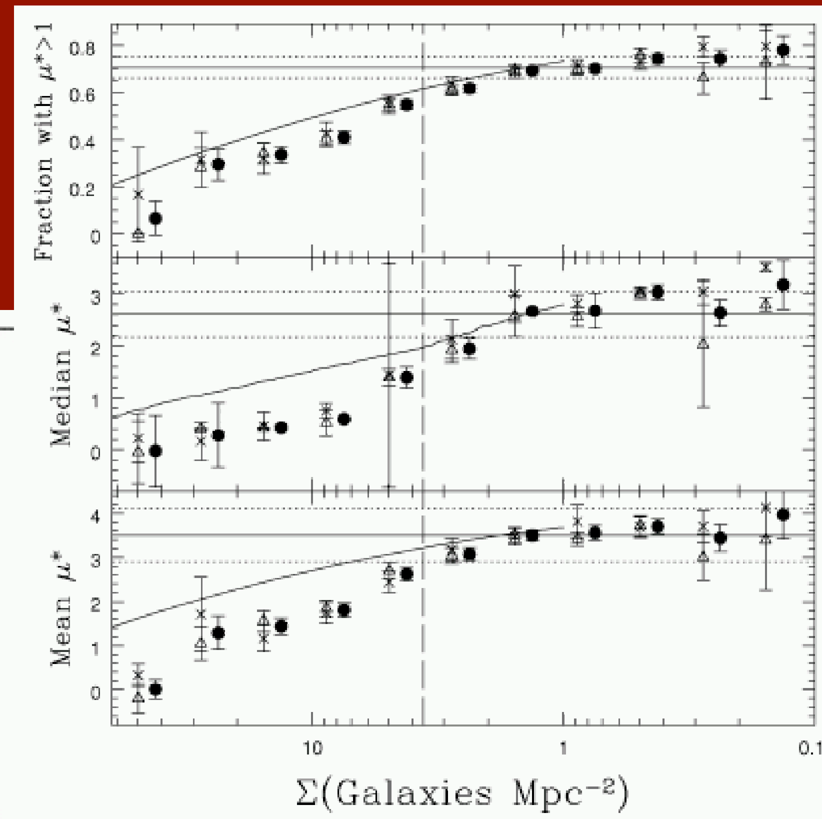
Importance of Group Evolution to Galaxies in *Clusters* (cont.)

break in SFR-density relation

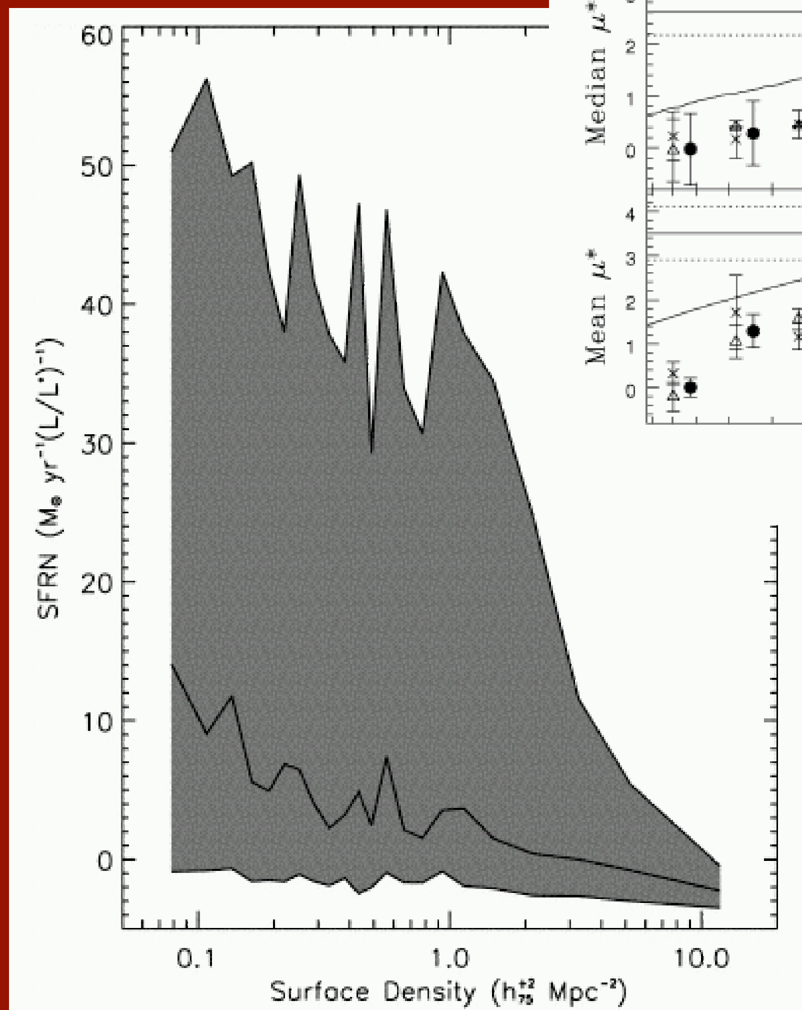
SFR falls at ~ few gal/Mpc^2

~ cluster infall radius (3-4 r_{vir})

~ poor group!



Lewis et al. 2003 (2df)

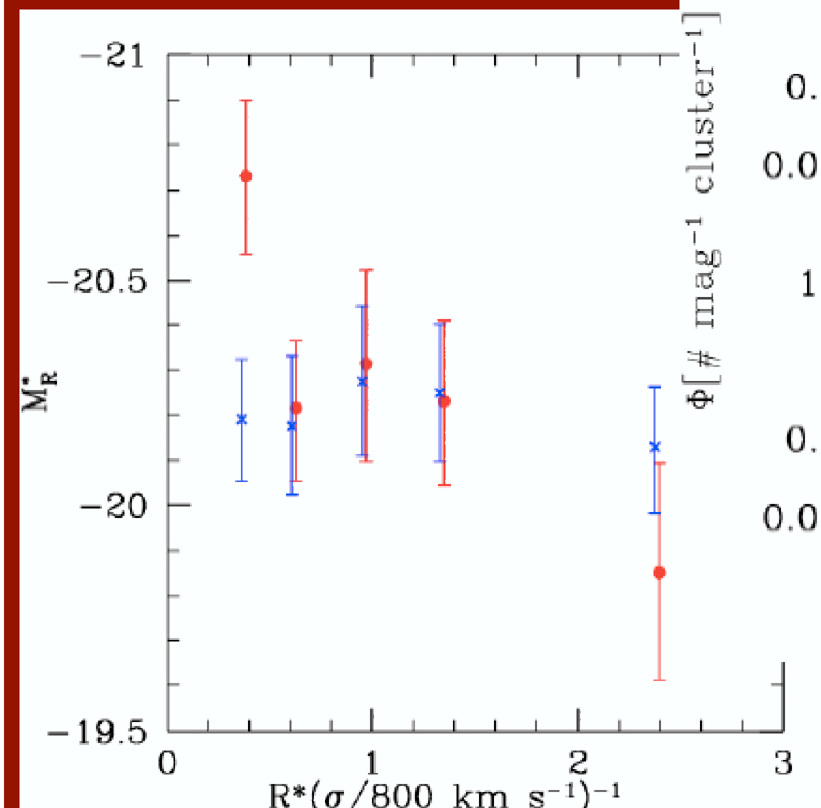


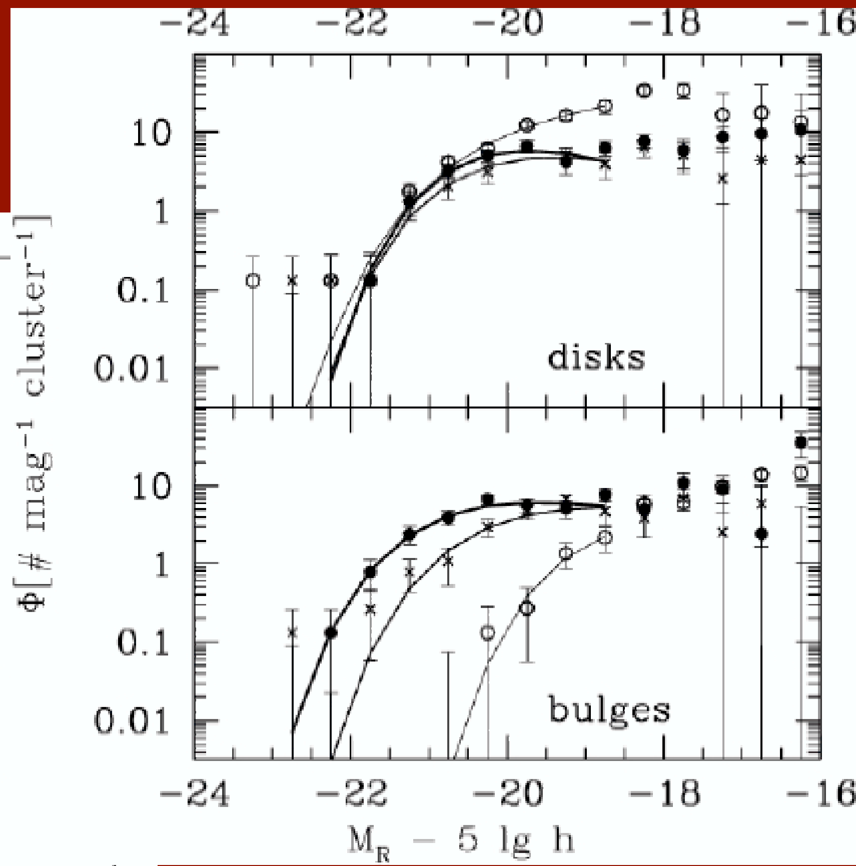
Gomez et al. 2003 (SDSS)

Importance of Group Evolution to Galaxies in *Clusters* (cont.)

Can early types form from fading the disks of late types?

Christlein & Zabludoff 2004





bulges brighter from late to early types, disks not fainter

morph-enviro relation due to brighter bulges

galaxy-galaxy interactions favored

Groups Are Where the Action Is (or Was)

mergers in groups, group-cluster correlation, and increased infall at higher redshifts produce Butcher-Oemler Effect (Zabludoff et al. 1996)

morphology-environment relation, dwarf-to-giant evolution, gE growth saturate when mergers become less likely (Zabludoff & Mulchaey 1998, 2000)

BCG formation occurs in groups

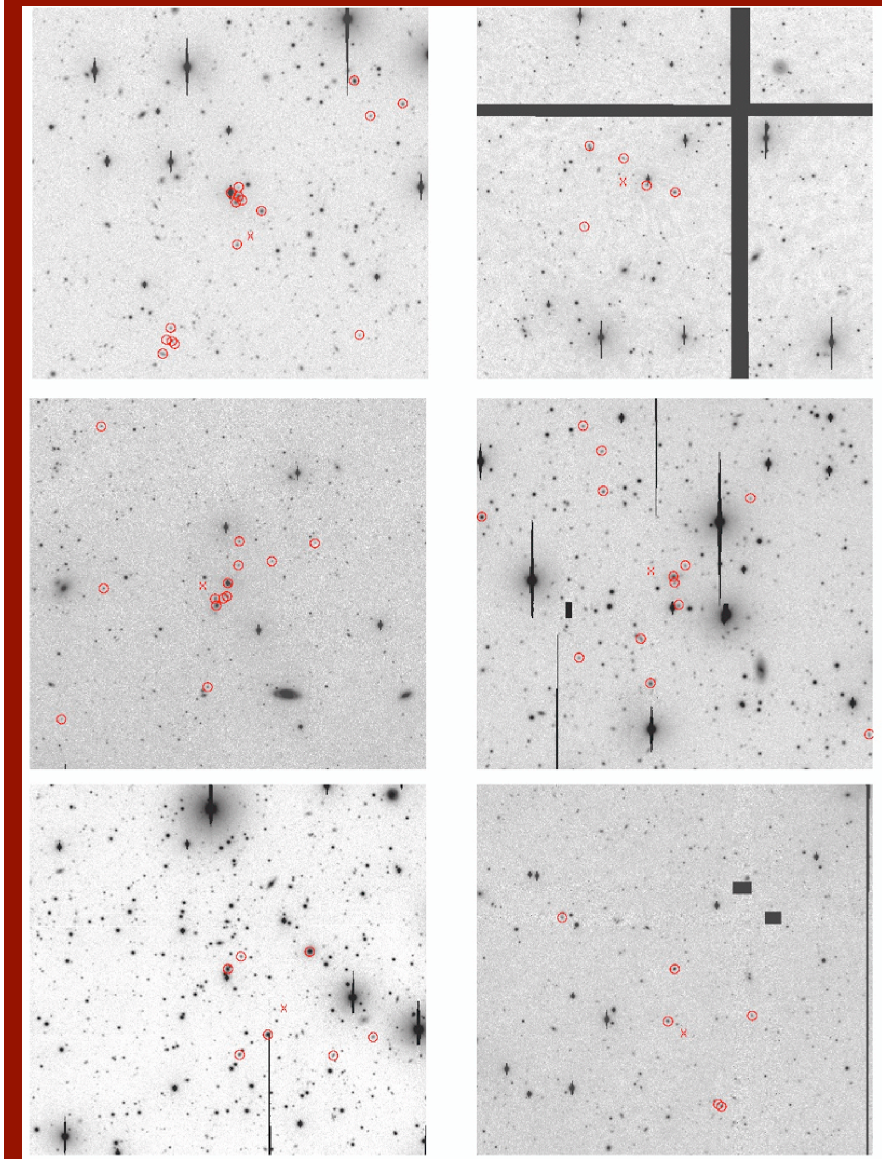
galaxy-galaxy interactions dominate group, and cluster, galaxy evolution

what about cluster dark matter, X-ray gas, and intracluster light components? Mihos (this conference), metallicity saturates

Measuring Group Evolution Directly: Strong Lensing Groups

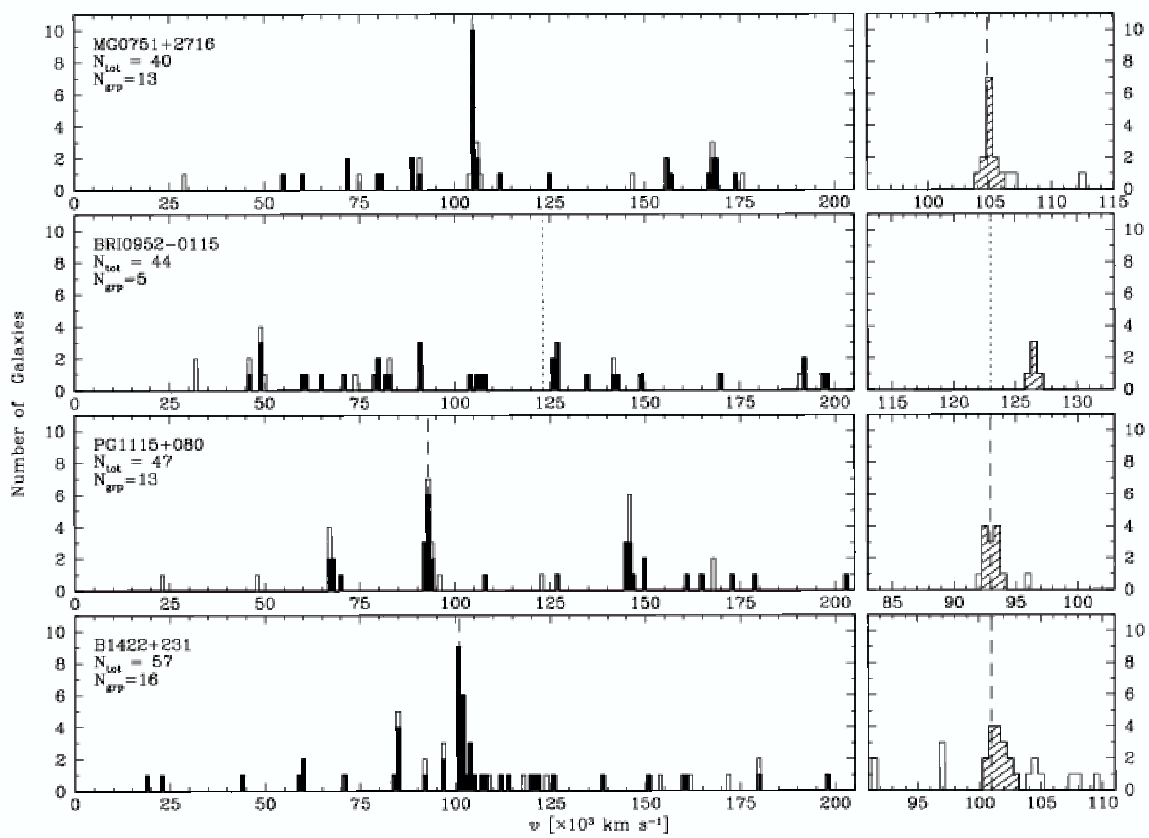
groups at high redshift? >25% of lenses in groups

poor model ==> group potential



Williams et al. 2005

Momcheva et al. 2005



Conclusions

mergers and stripping important to group evolution

as group evolves, dwarf-to-giant ratio, early-type fraction, intragroup starlight and metallicity, and central gE grow

dark matter, hot gas in common halo, equilibrium

isolated gE/“fossil” group endpoint?

many saturation points where groups look like clusters, but unlike rarefied field

group galaxy evolution may dominate clusters (morph-enviro relation, Butcher-Oemler effect, BCG formation)