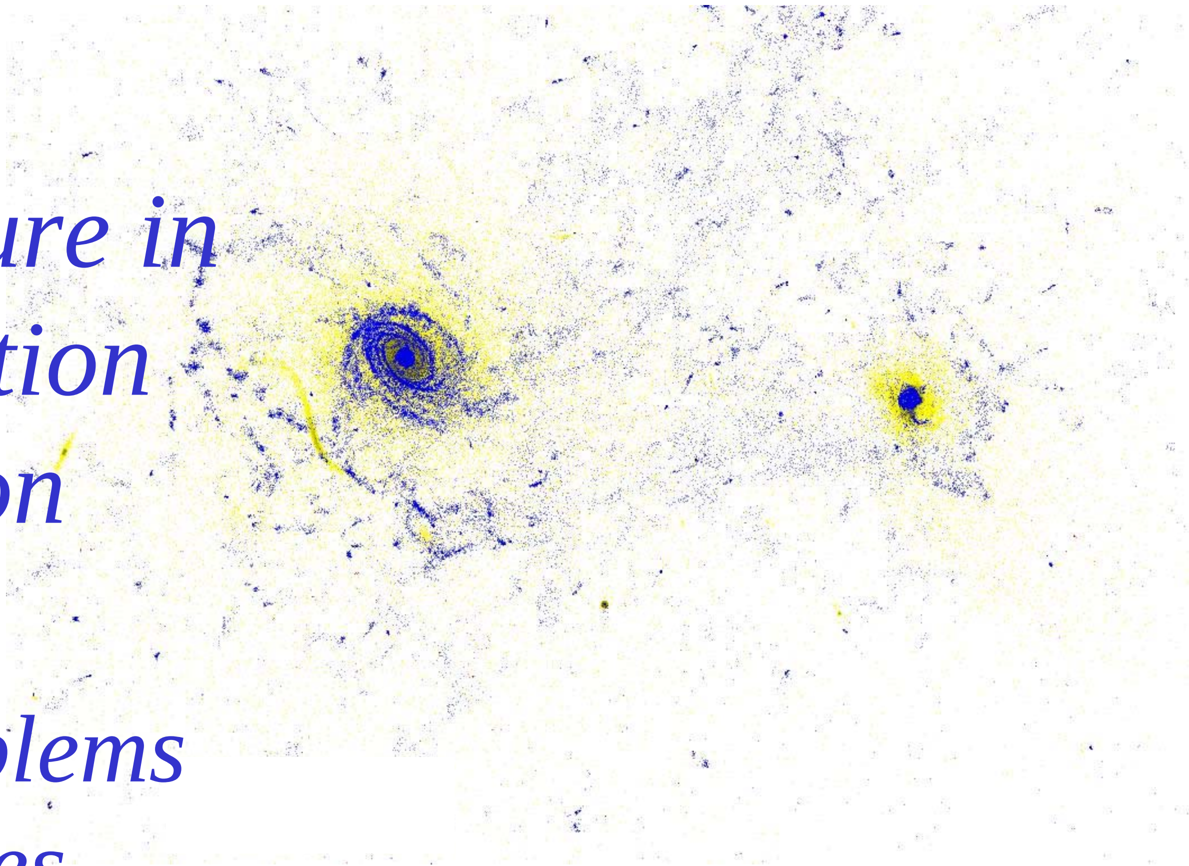


Nature or Nurture in Galaxy formation and evolution

Theoretical problems & Perspectives

Françoise Combes

Observatoire de Paris

Granada, 15 May 2009

Solved questions ?

➔**Are there isolated galaxies? May be!**
Robust definitions, criteria (Karachentseva, AMIGA..)

➔The Void Problem? Solved at zeroth order!
Environment is a secondary parameter (Tinker, Croton)
But expected dwarfs are not there (Koribalski)

➔Compact Groups: a real nurture effect!
CA? (Mamon), colors, SF, morphology (McConnachie),
AGN (Dultzin, Martinez)

..

➔Isolated early-type galaxies: Fossil Groups?
20% ETG in LDE (Forbes)

Remaining questions

➔Luminosity functions versus environment:
+Low efficiency of SF: 6% of baryons in stars and visible gas
Feedback from SF and AGN

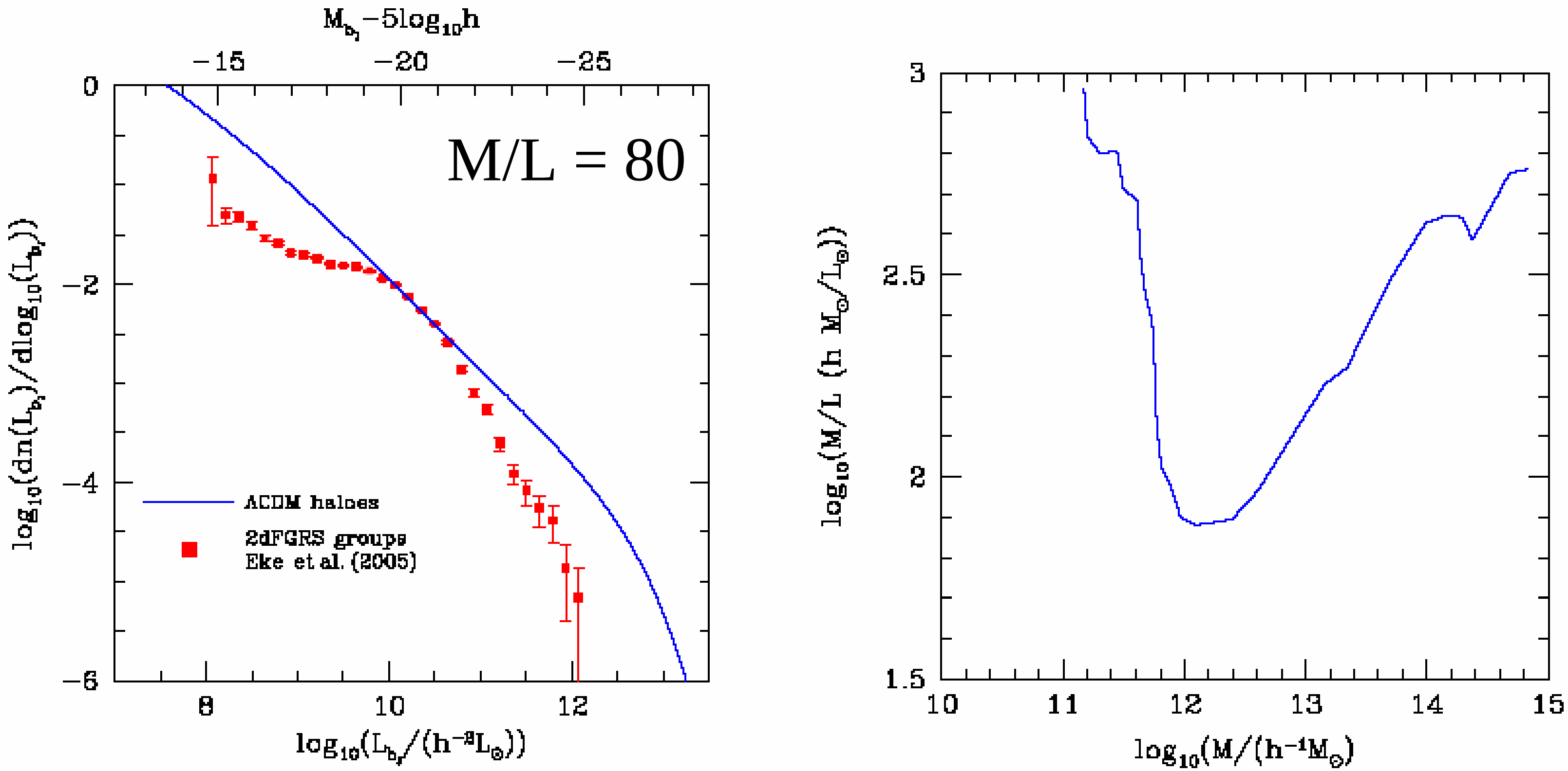
➔Bimodality, and mass limit of 3 10^{10}Mo??
Variation of the limit with environment?
(radio mode, but less AGN in LDE)

➔Downsizing and environment
Obvious ways to quench SF: harassment strangulation..

➔Bulge-less galaxies? vs environment
Very large fraction of them in isolated galaxies
Problem for ΛCDM hierarchical scenario?

Mass & Light DF

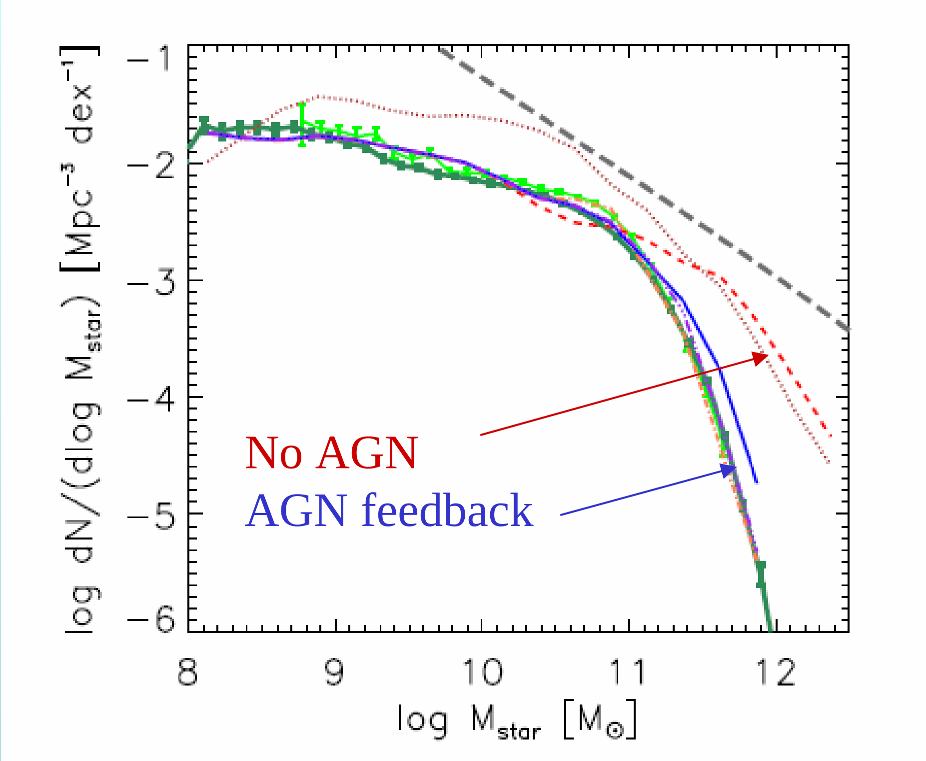
ΛCDM SAM: Too many bright and too many faint galaxies



Baugh 2006, Eke et al 2006, Jenkins et al 2001

SF Feedback to fit faint end

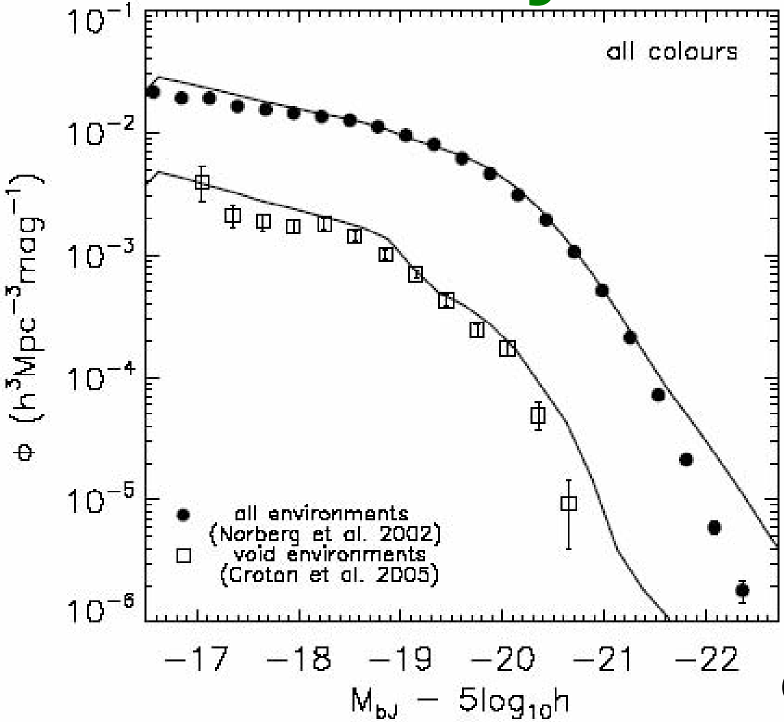
Gas is heated in dwarfs, but falls in heavier haloes
➔ worsen the bright end problem



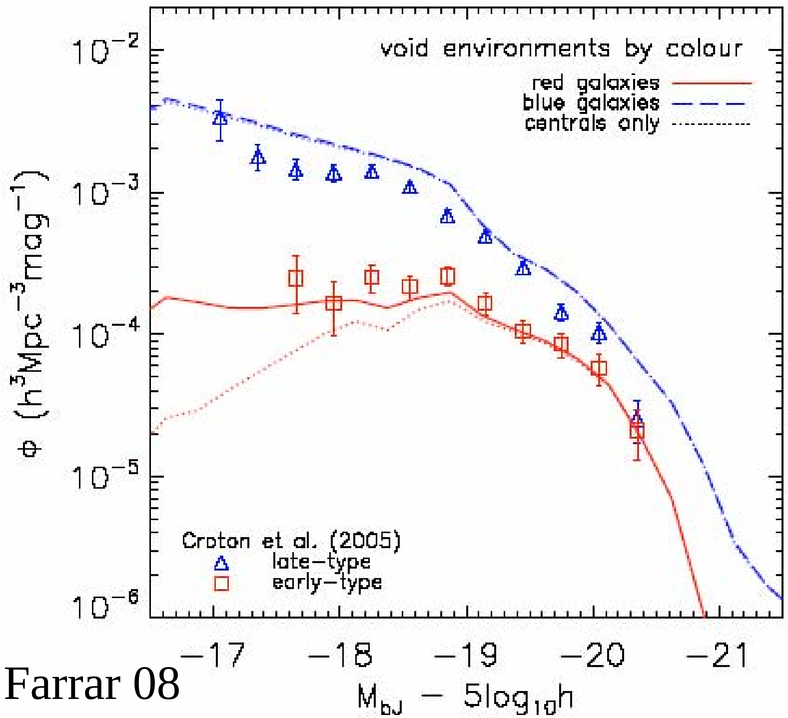
Somerville et al 2008

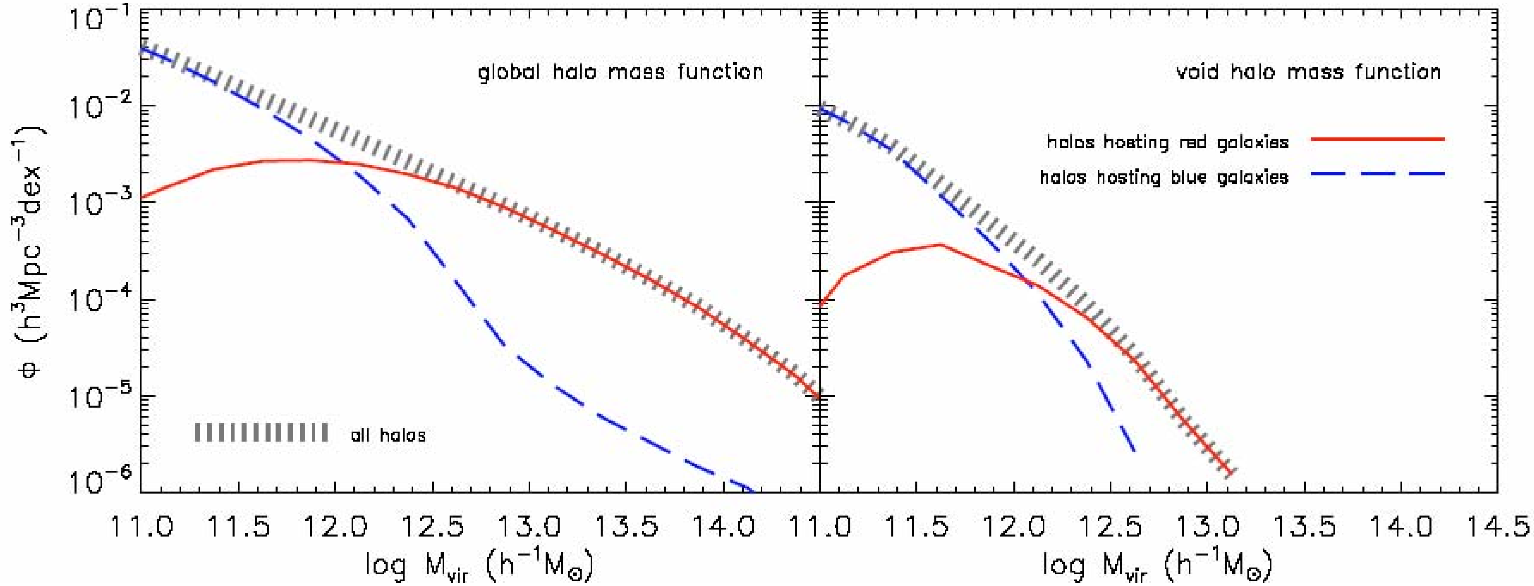
➔ Requires AGN feedback at the bright end

Luminosity function vs environment



Croton & Farrar 08

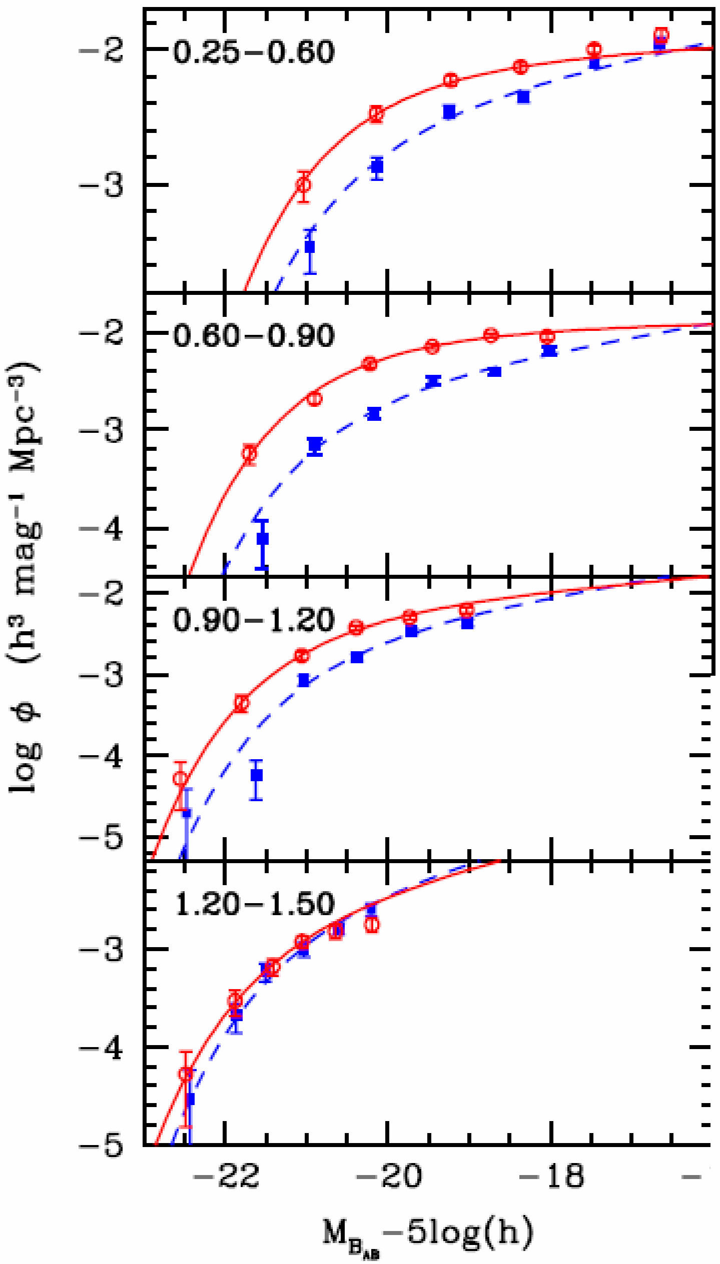




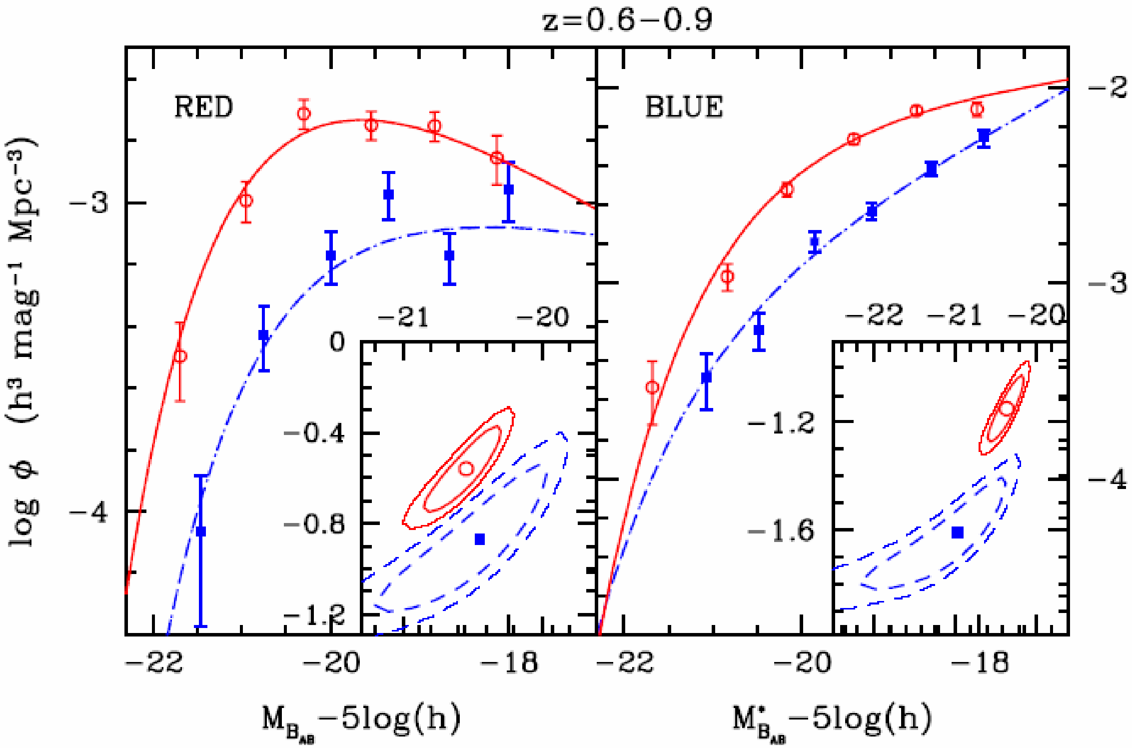
LF and environment

Blue: under-dense
Red: over-dense

➔Nurture should act quite early
(or nature is important)



Ilbert et al 2006



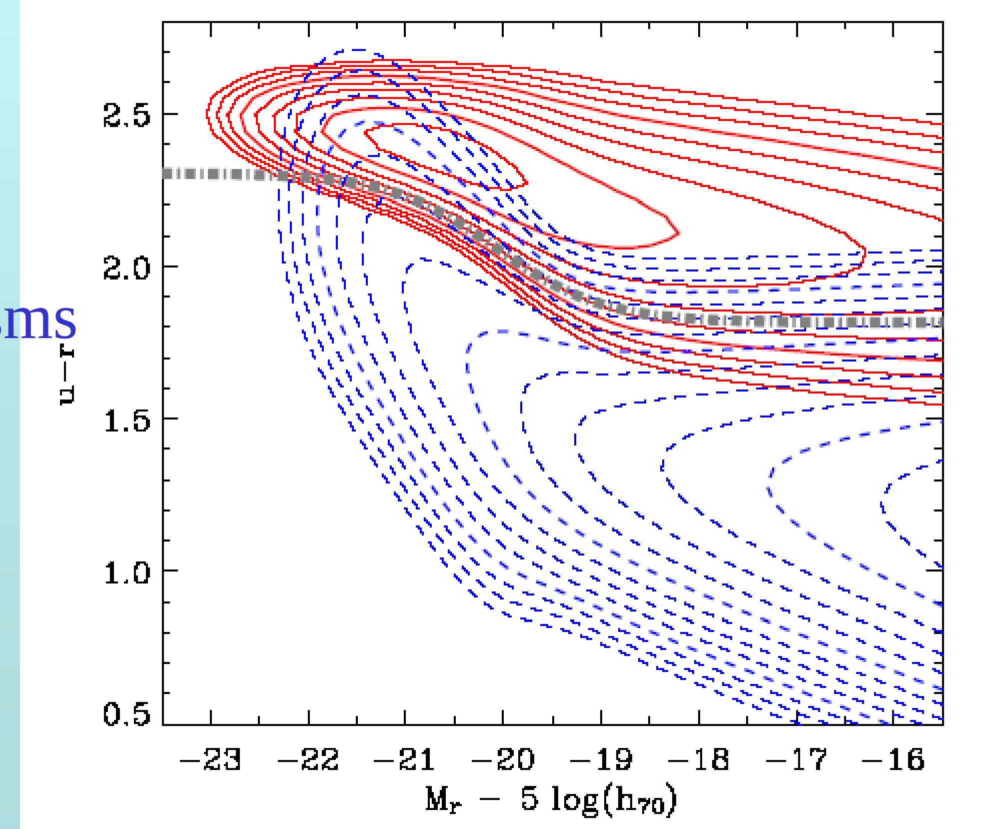
Red sequence & Blue cloud

Color-Magnitude diagrams (CMD)
150 000 galaxies in the SDSS

Baldry et al 2004

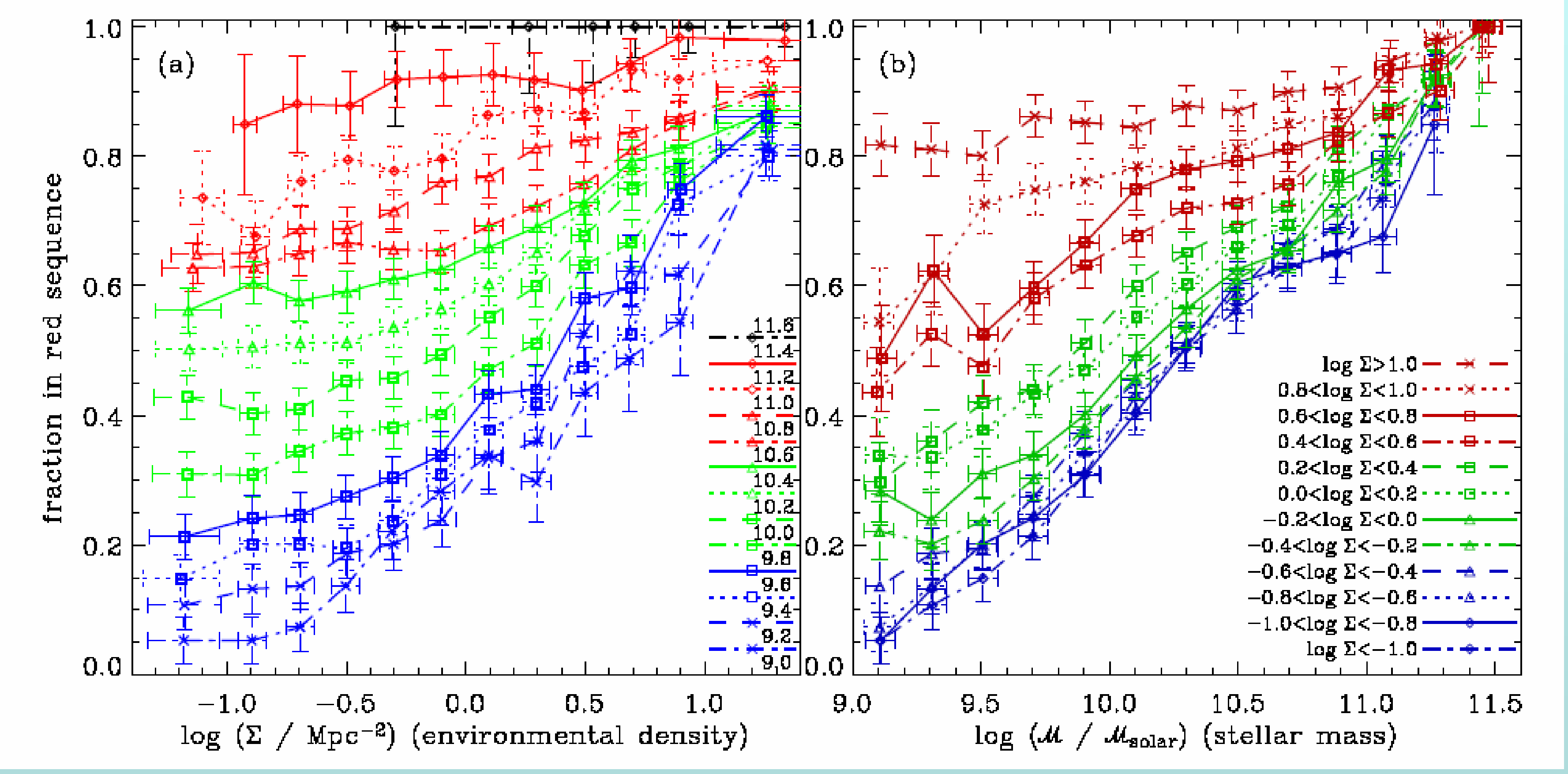
➔Parameter: essentially SFR
But SFH, dust, age, metallicity..

➔2 different formation mechanisms
Separating stellar mass 3 10^{10}Mo



Fraction in red sequence increases with mass and environment

Baldry et al 2006

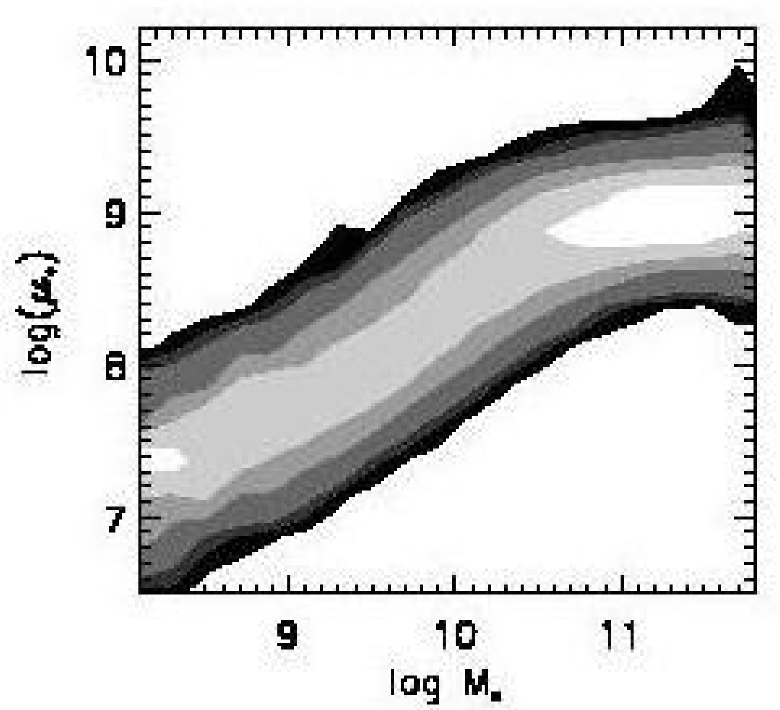


SF History depends on surface density

LSB dwarfs HSB high mass

Transition at M_*=3 10^{10} Mo, or 3 10^8 Mo/kpc^2
SFH depends more on surface density than on mass

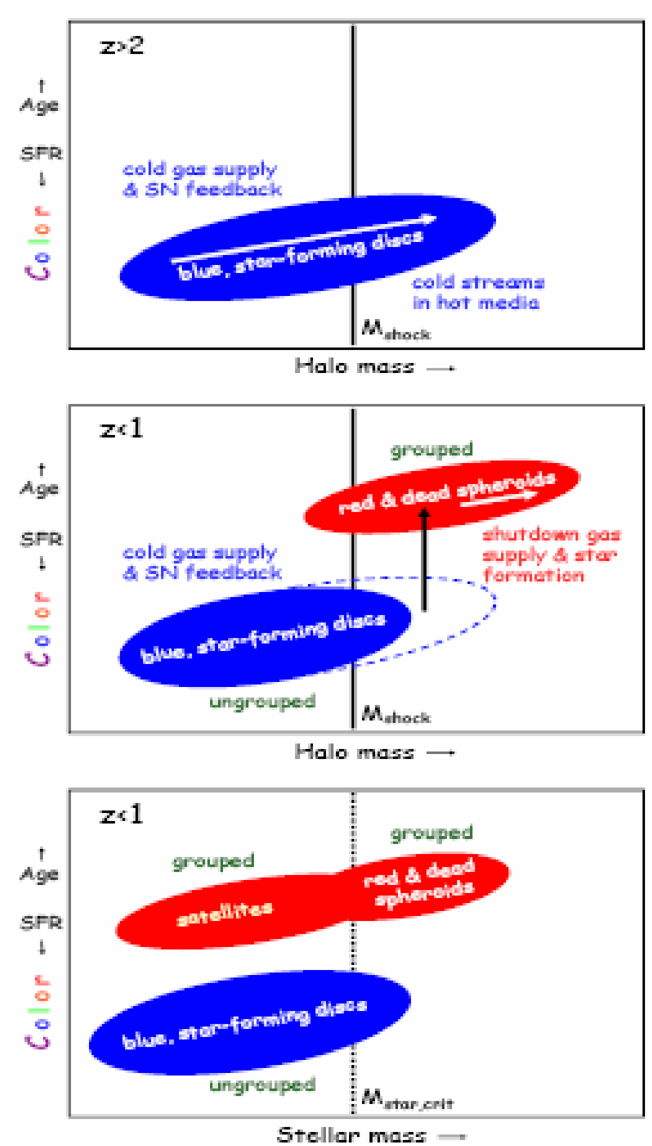
There is a transition where the gas begins to outflow, at the V_{SN} velocity ~100km/s



Kauffmann et al 2003

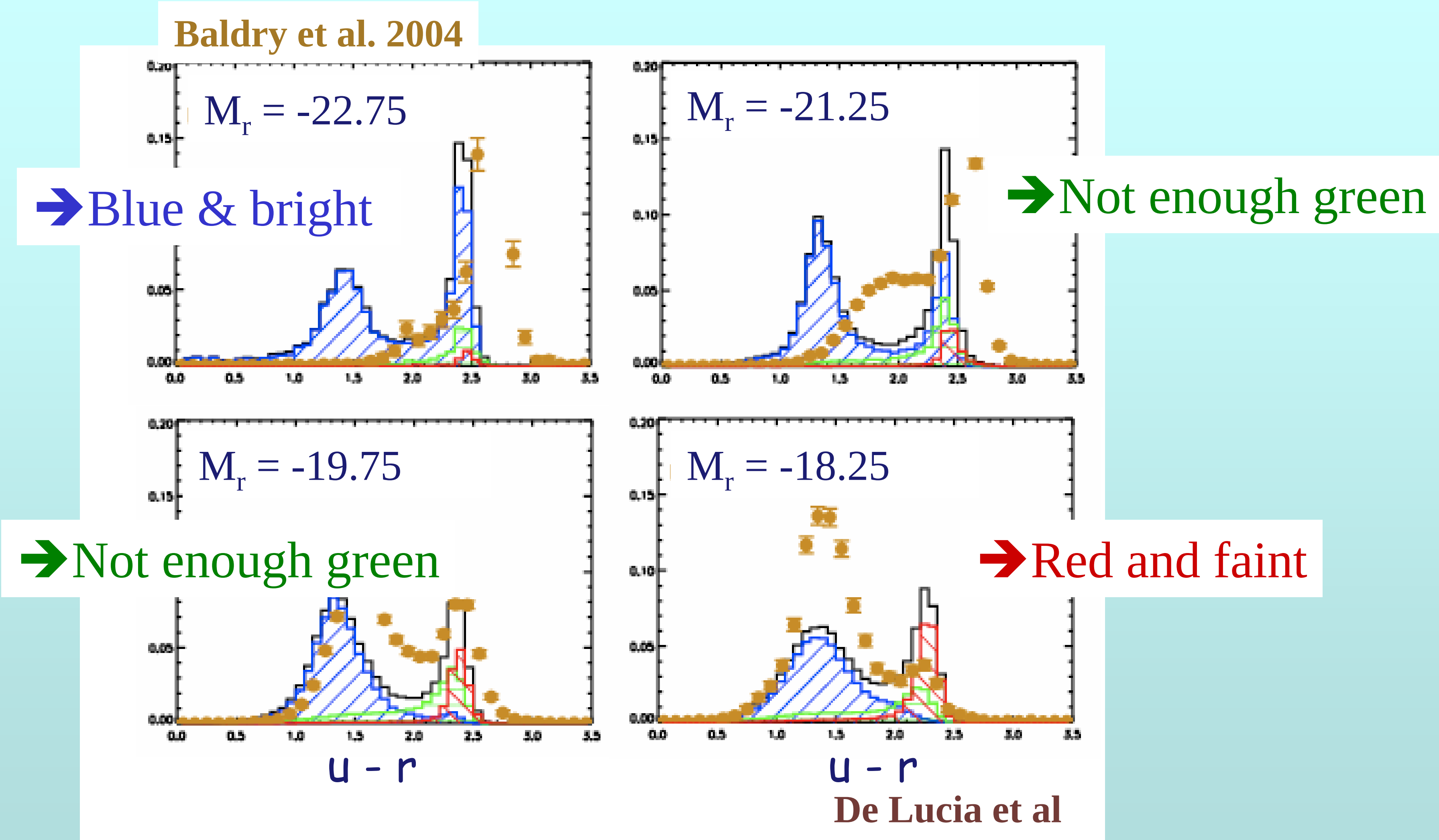
Origin of the bimodality

➔Above a certain mass (3 10^{11} M_o), the gas is not accreted cold, but is heated in shocks and has no time to cool (or AGN feedback)
Dekel & Birnboim 2006
Keres et al 2005



➔Or above a certain surface density of stars (3 $10^8 M_o/kpc^2$), the gas is quickly transformed into stars, and the time spent in the « blue » regime is short.

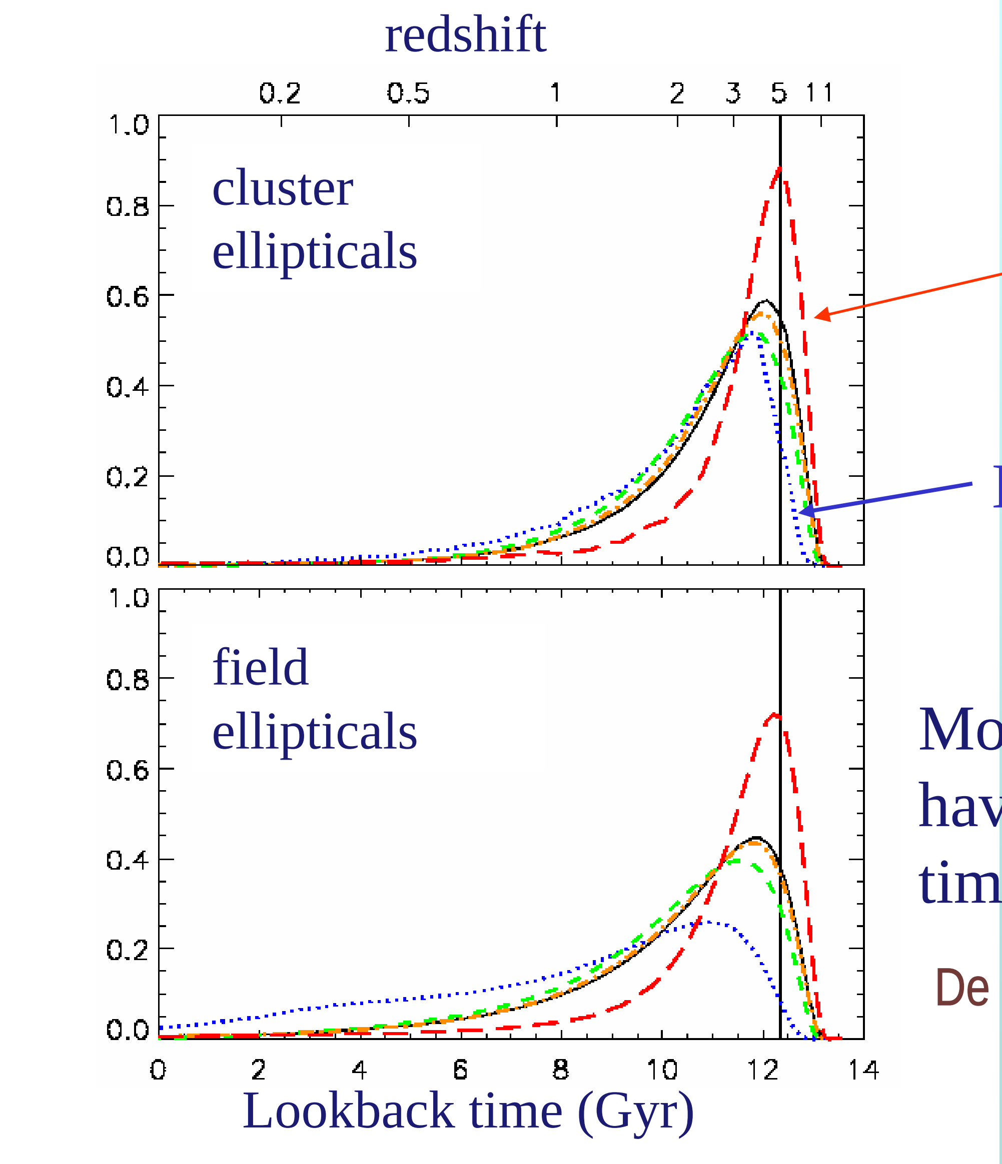
The bimodality as a function of M (SAM)



Excess of blue bright objects, and red faint satellites

➔Gas accretion on the satellites?

The star formation history



$M_{star} = 10^{12} M_{sun}$

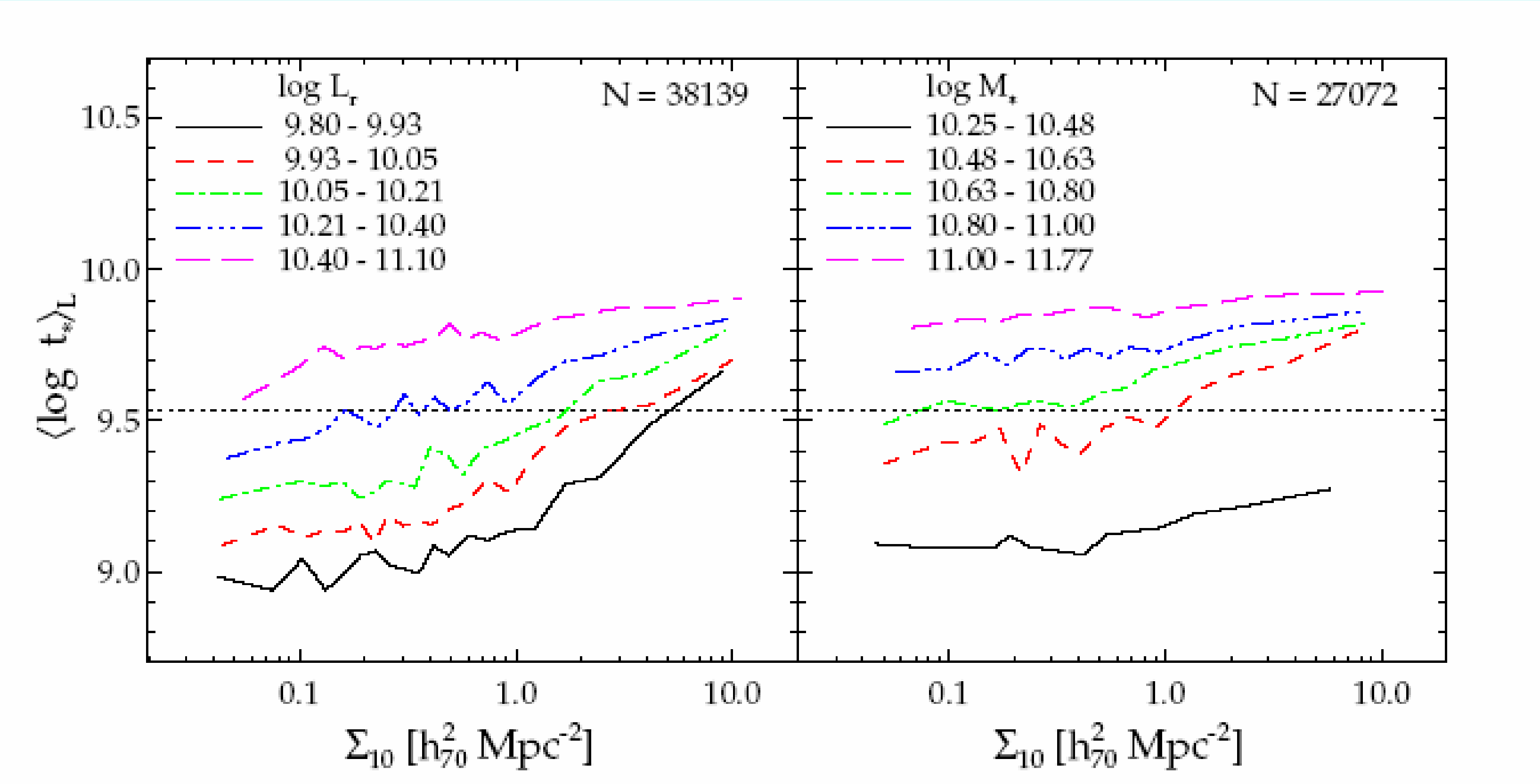
$M_{star} = 10^{9} M_{sun}$

Most massive elliptical galaxies have the shortest formation timescales

De Lucia et al. 2006

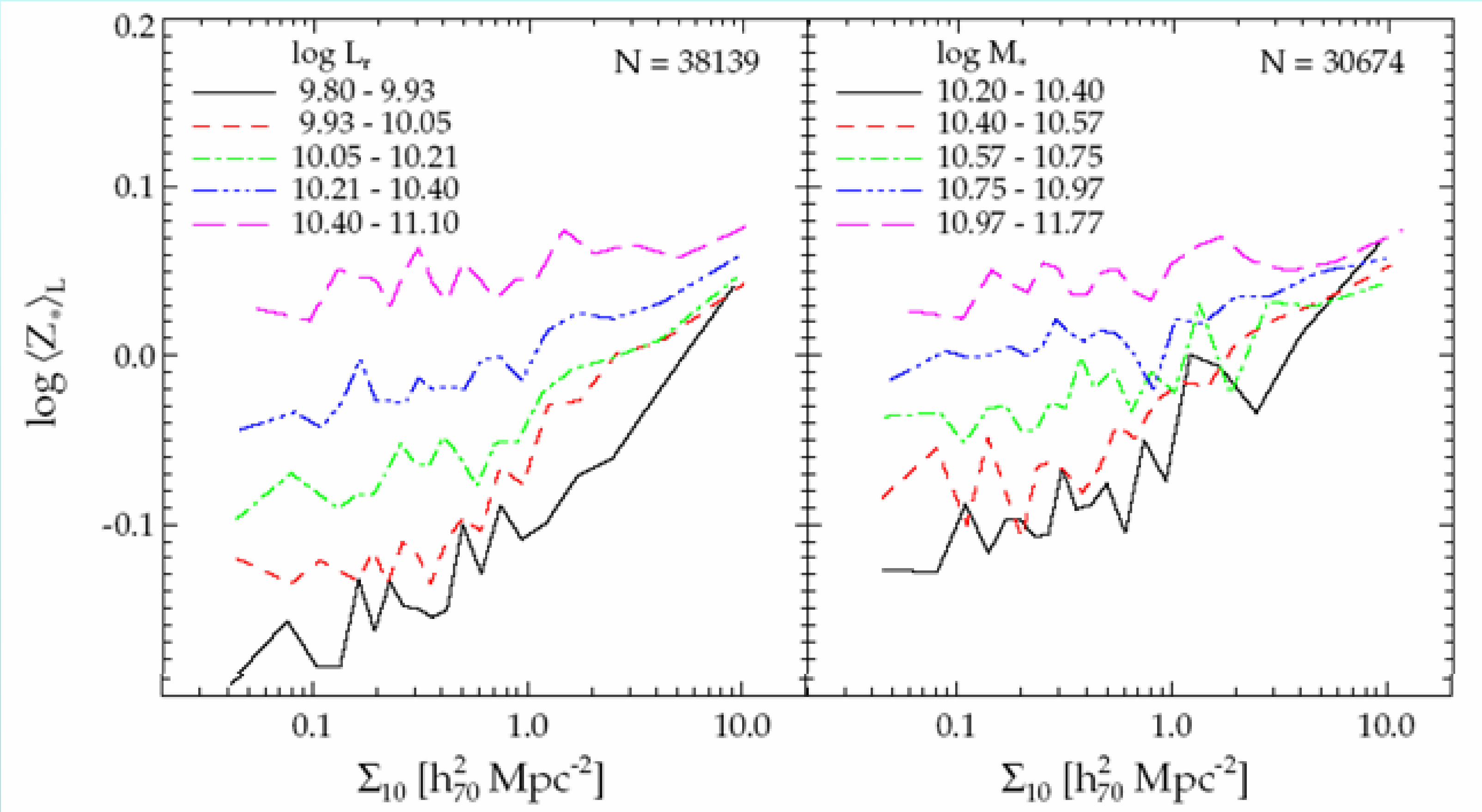
Galaxy age vs environment

In clusters, massive ETG are older and more metallic
Mateus et al 2007



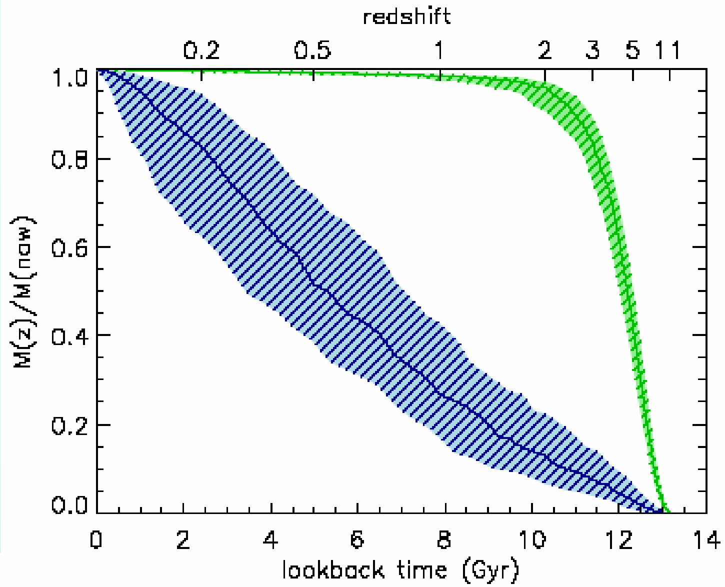
Galaxy metallicity vs environment

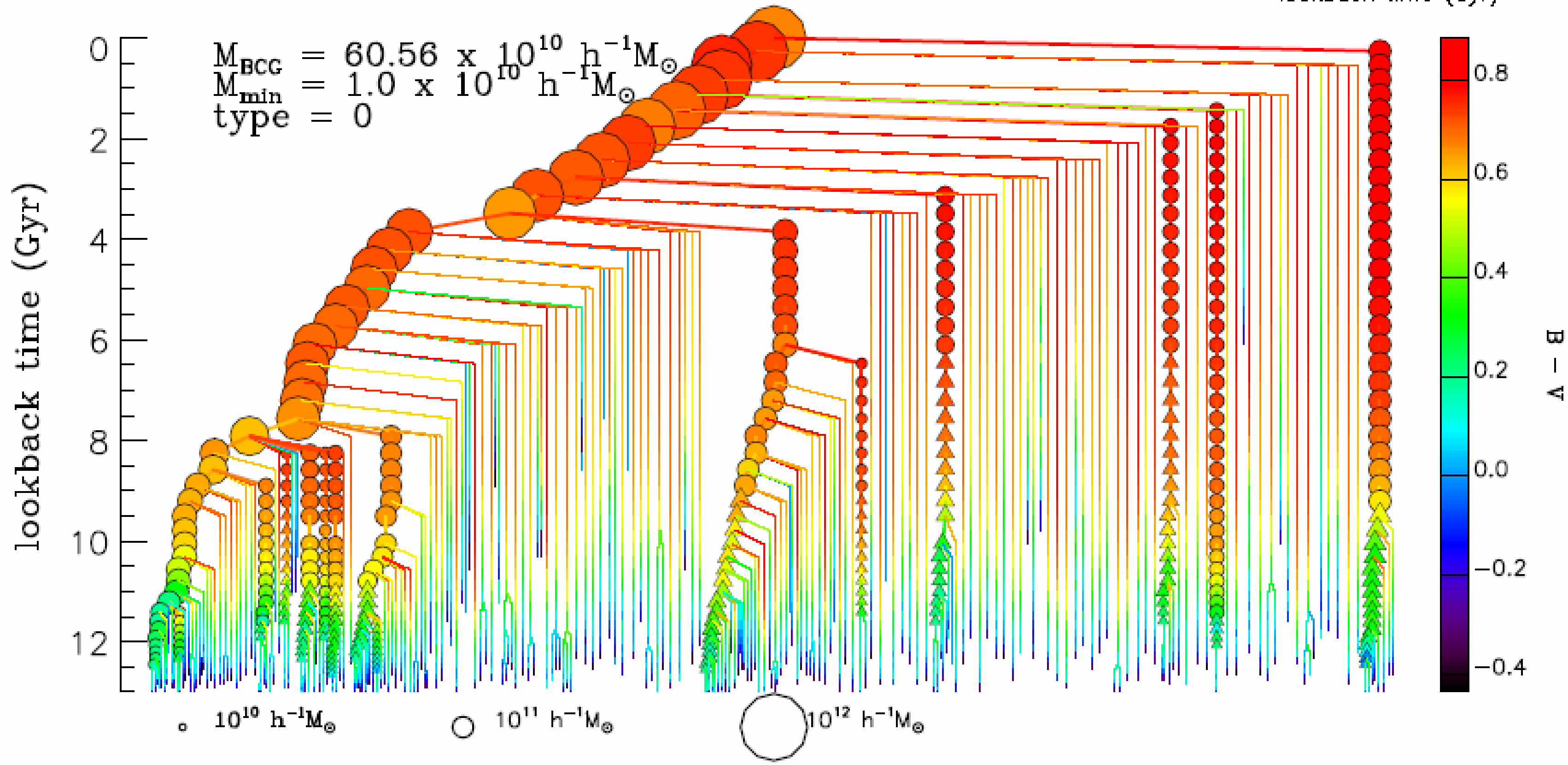
Mateus et al 2007



Hierarchical formation of BCG

De Lucia & Blaizot 2007:
dry mergers since z=1
50% of stars formed at z=5;
mass assembling after z=0.5





Problem of bulge-less galaxies

-Locally, about 2/3 or the bright spirals are bulgeless, or low-bulge
Kormendy & Fisher 2008, Weinzirl et al 2008

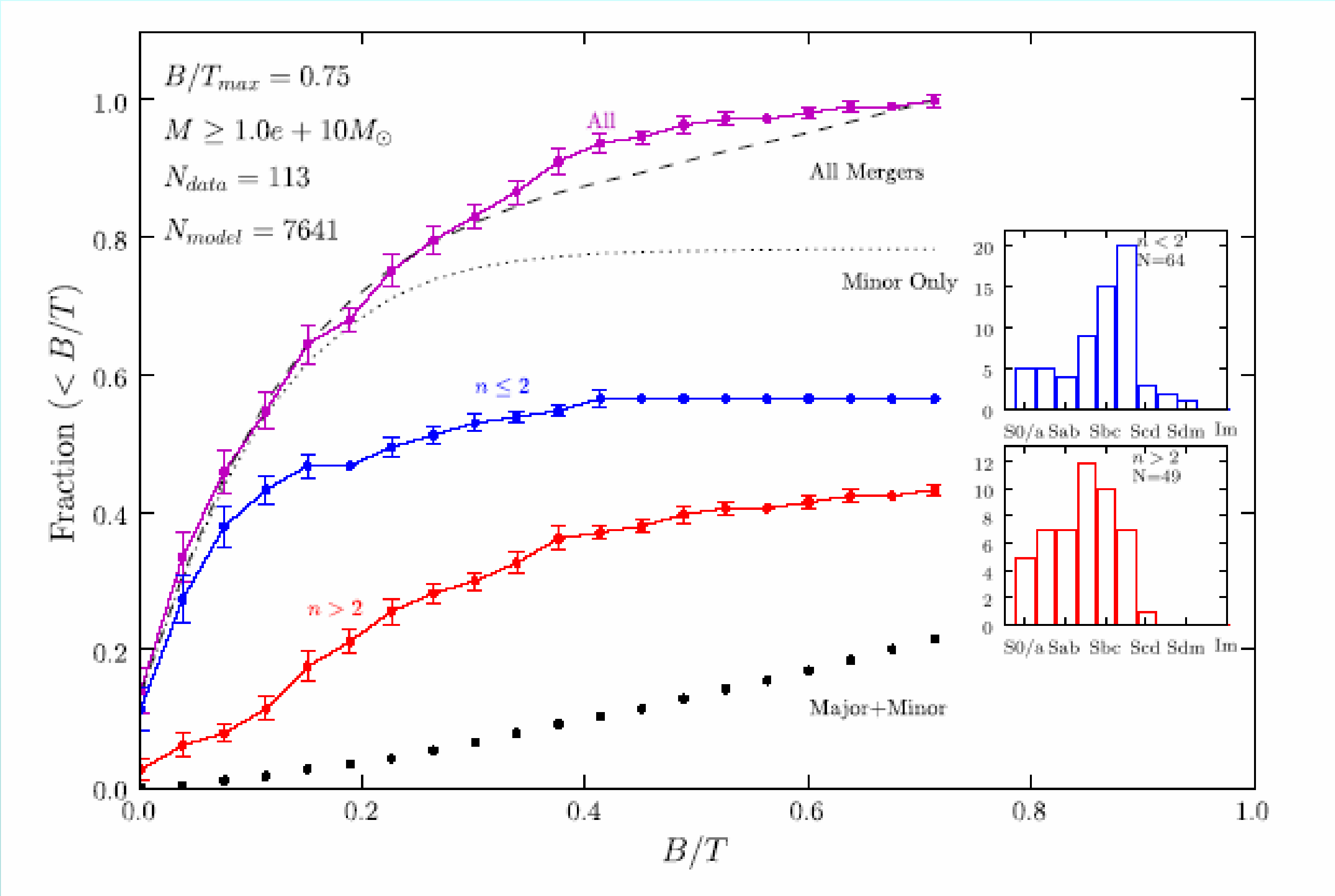
-Frequency of edge-on superthin galaxies *(Kautsch et al 2006)*
1/3 of galaxies are completely bulgeless

-SDSS sample : 20% of bright spirals are bulgeless until z=0.03
(Barazza et al 2008)

➔ **In low-density environment *(Karachentsev on Wednesday)***

In ΛCDM, a B/T<0.2 galaxy requires no merger since 10 Gyr (z>2)
Predicted frequency: 15 times lower than observed

Comparison with predicted B/T



Semi-analytic models, with major mergers (mass ratio <1/4)

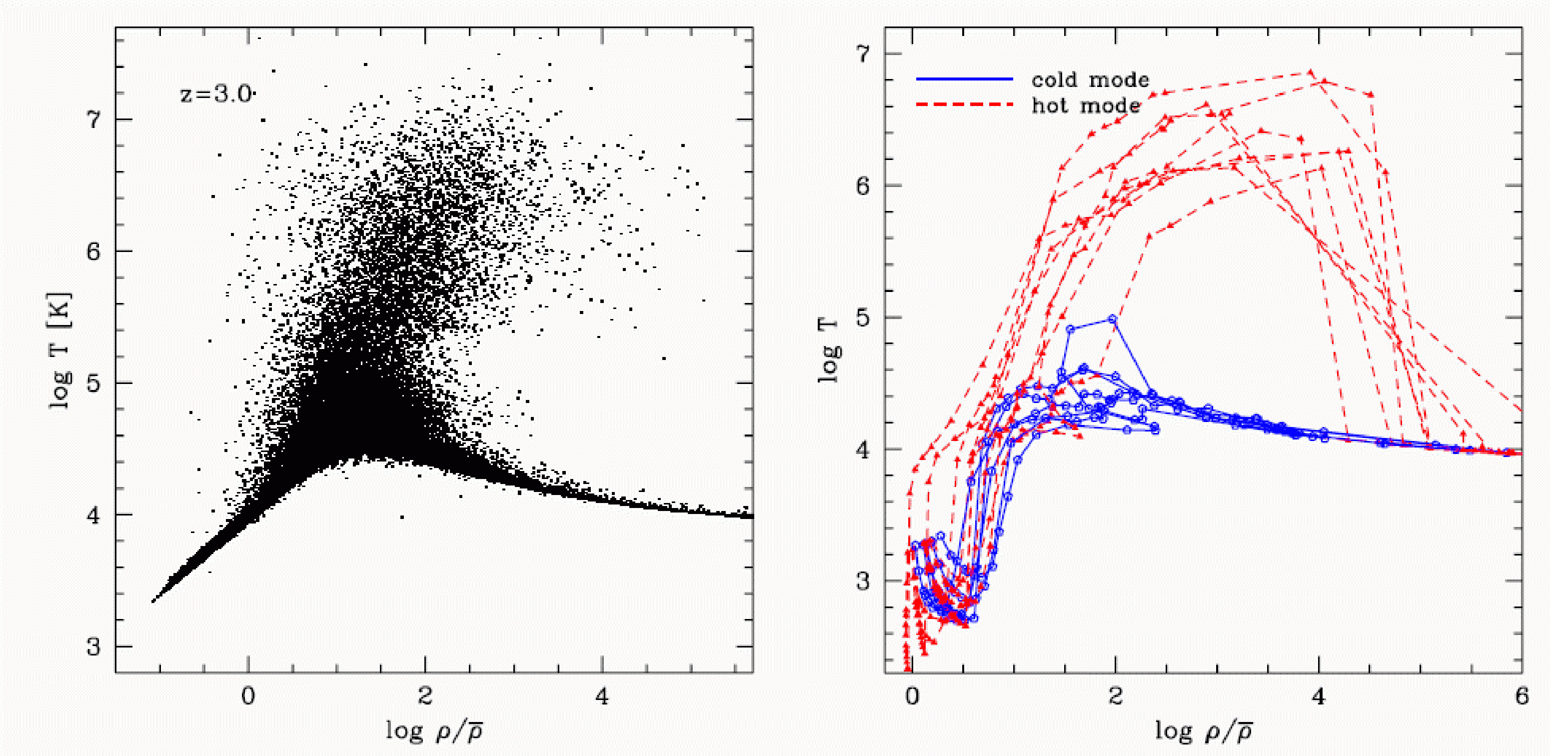
Weinzirl et al 2008

Cold accretion on galaxies

Previous assumption: shock heating to the Virial temperature

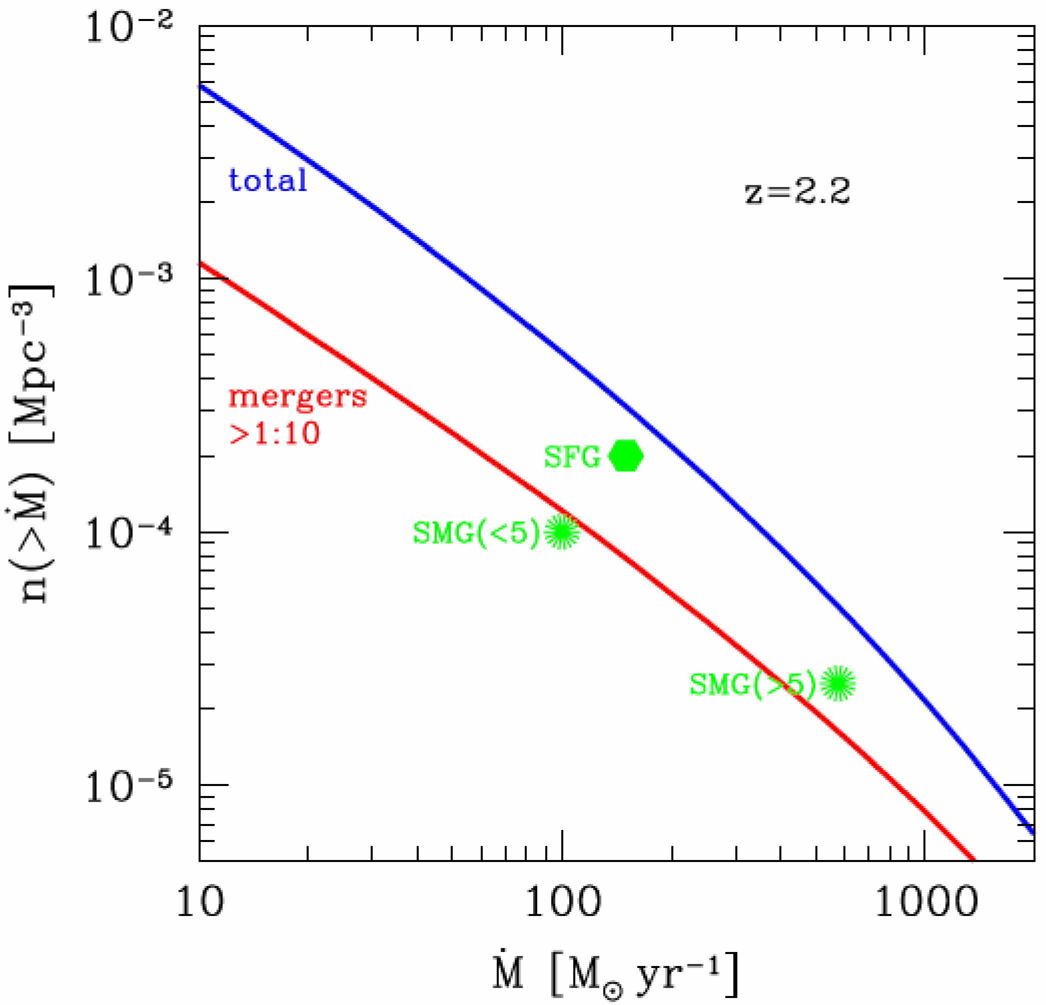
But: Cold gas falling along filaments, the fraction of cold gas being larger in low-mass haloes ($M_{CDM} < 3\ 10^{11}\ M_o$)

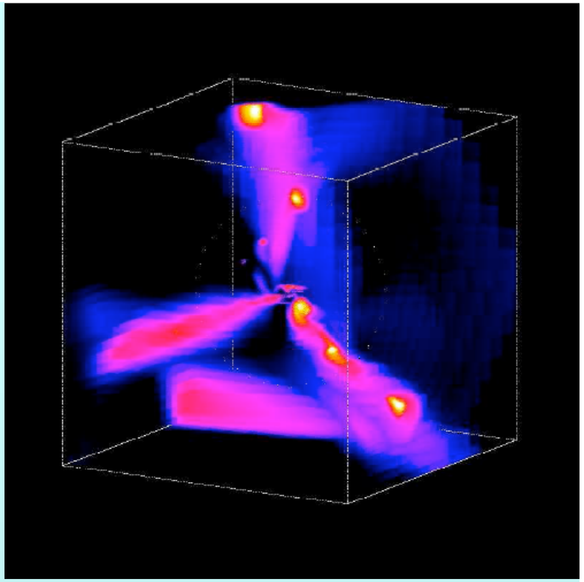
Keres et al 2005



Relative role of gas accretion and mergers

Dekel et al (2008)





Most of the starburst are due to smooth flows

Inflow rates are sufficient to assemble galaxy mass (10-100 Mo/yr)

Galaxy aligned along a wall between voids

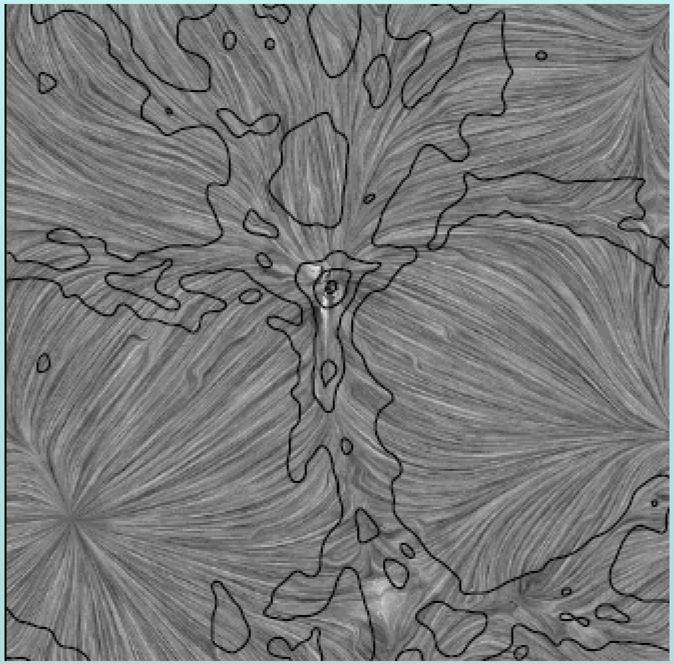
Talk of R. van de Weygaert, and winning poster!

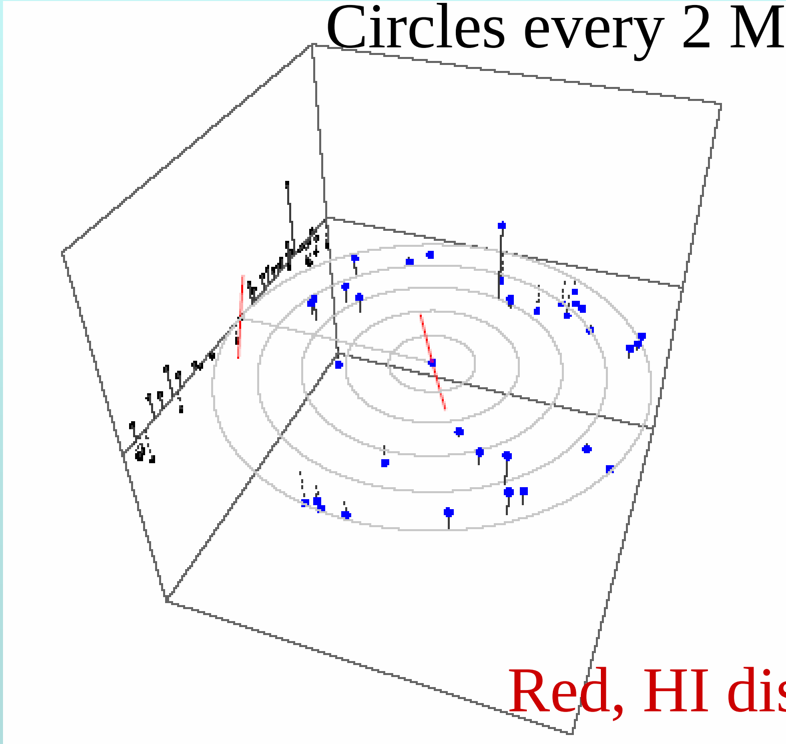
Gas from the cosmic filaments flowing to the wall, and perpendicular to it

➔ Formation of the gaseous polar disk

Up to 10 Mpc

Circles every 2 Mpc





Red, HI disk

Stanonik et al 2009

Perspectives

➔Role of both Nature and Nurture ?:
-faster evolution and merging in dense regions, that will become clusters
-when cluster is formed: strangulation, ram-pressure, harassment

➔SF and AGN feedback to fit the L-function, and f_bar in stars

➔Downsizing partly due to environment, but models have
-still too many bright blue objects at z=0
-and too many red faint satellites

➔May be gas accretion should not be stopped for these faint satellites
-would enhance also the green valley