Galaxy Evolution with ELT

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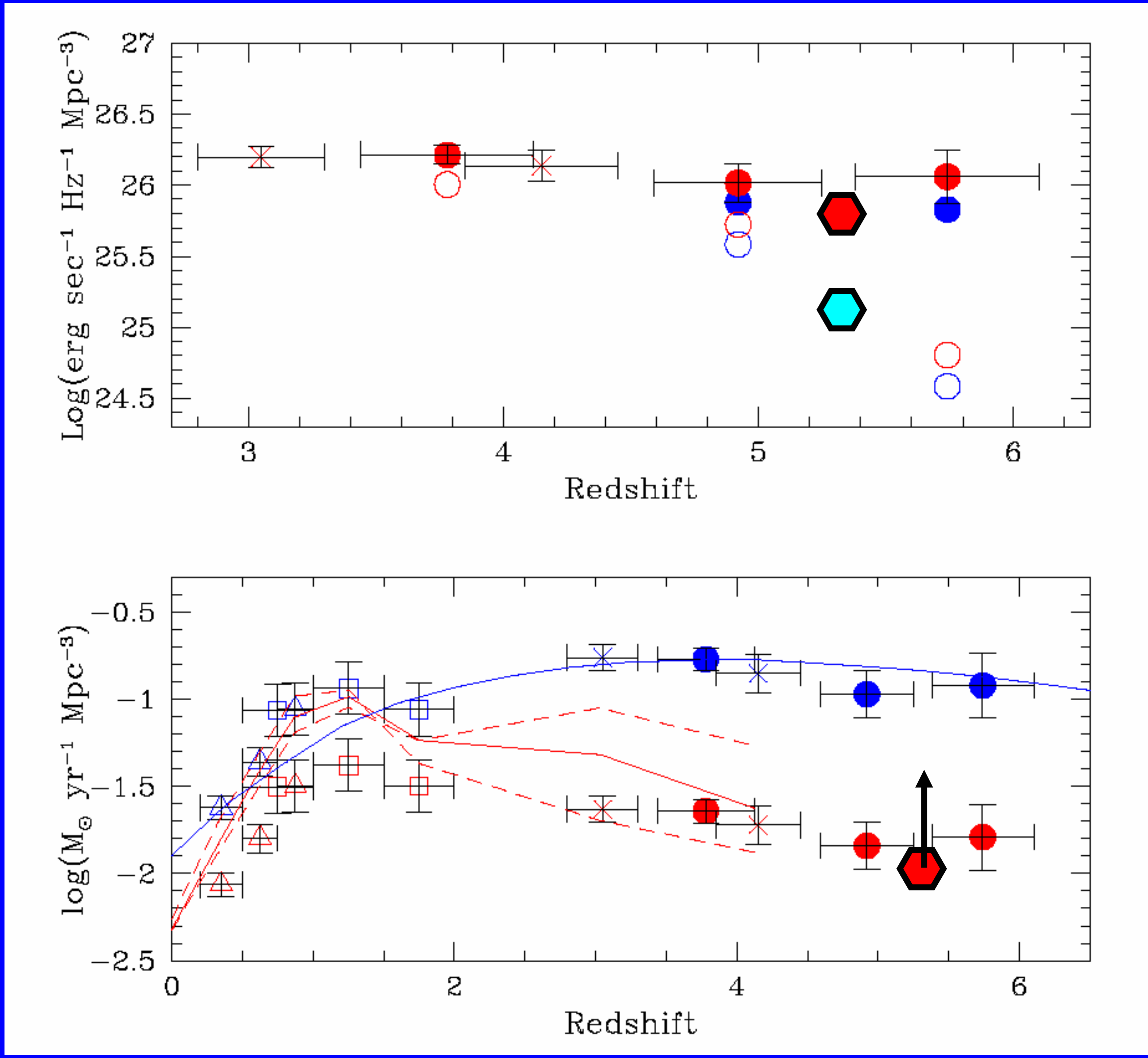
Or

Three questions that I would like answered with an ELT … a fools errand

Star-formation "history"

Comoving ρ_{UV} and SFR at high redshift:



Giavalisco et al. (2003)

Frankly, not very constraining … can be fit with almost any type of model.

Massive High-z Galaxies

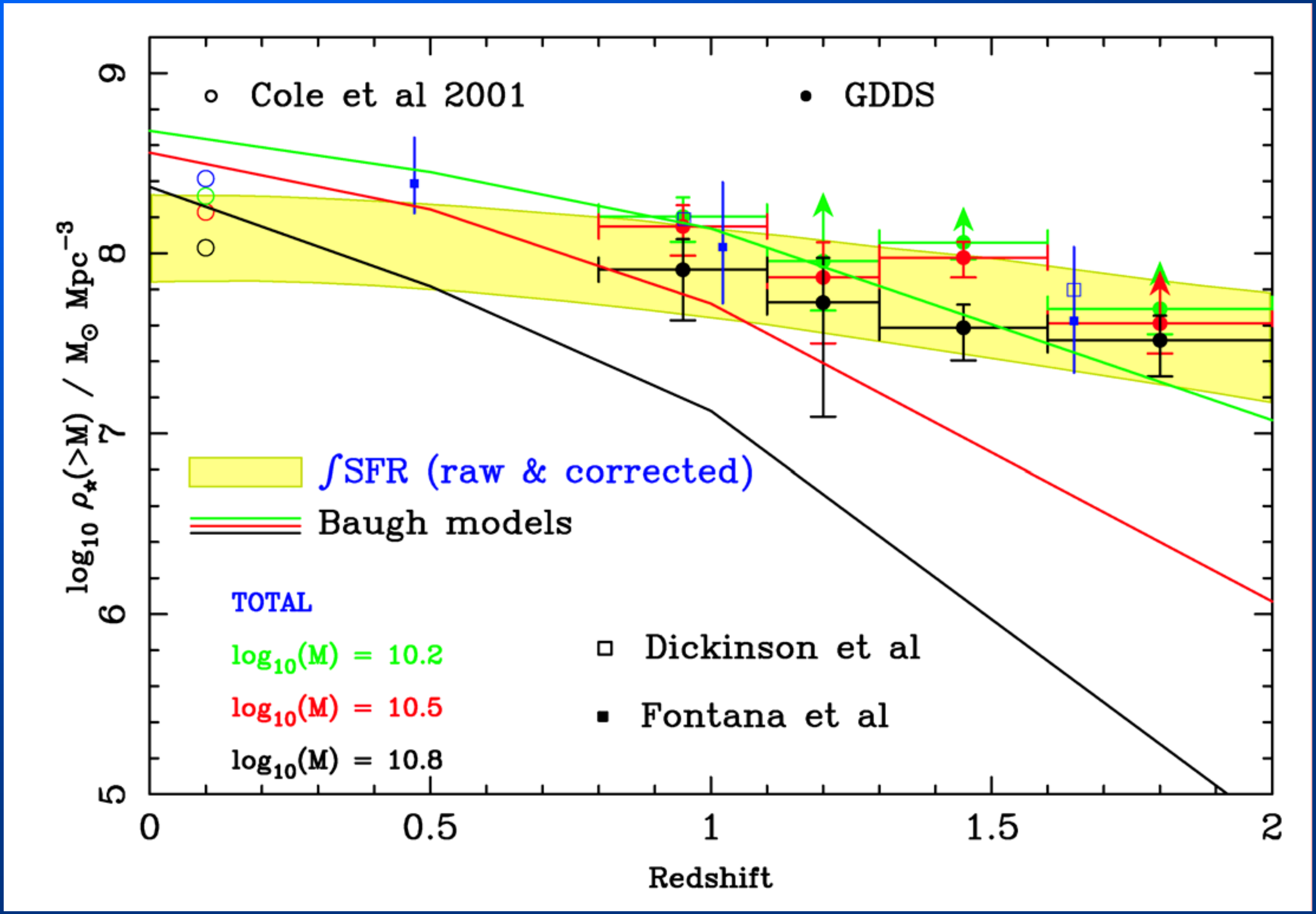
It is easily possible for ΛCDM to get 0^{th} order quantities like the total baryonic masses or DM masses correct but still be wrong – quantity over quality.

Becoming clear that baryons collapsed much earlier than the simple models predict – especially for the massive systems

•predict too few massive galaxies at high redshifts,
•nearby massive galaxies look old,
•high metal abundances in massive high redshift galaxies,
• ratio of metals in nearby galaxies all wrong, etc.

Galaxy Growth … the integral

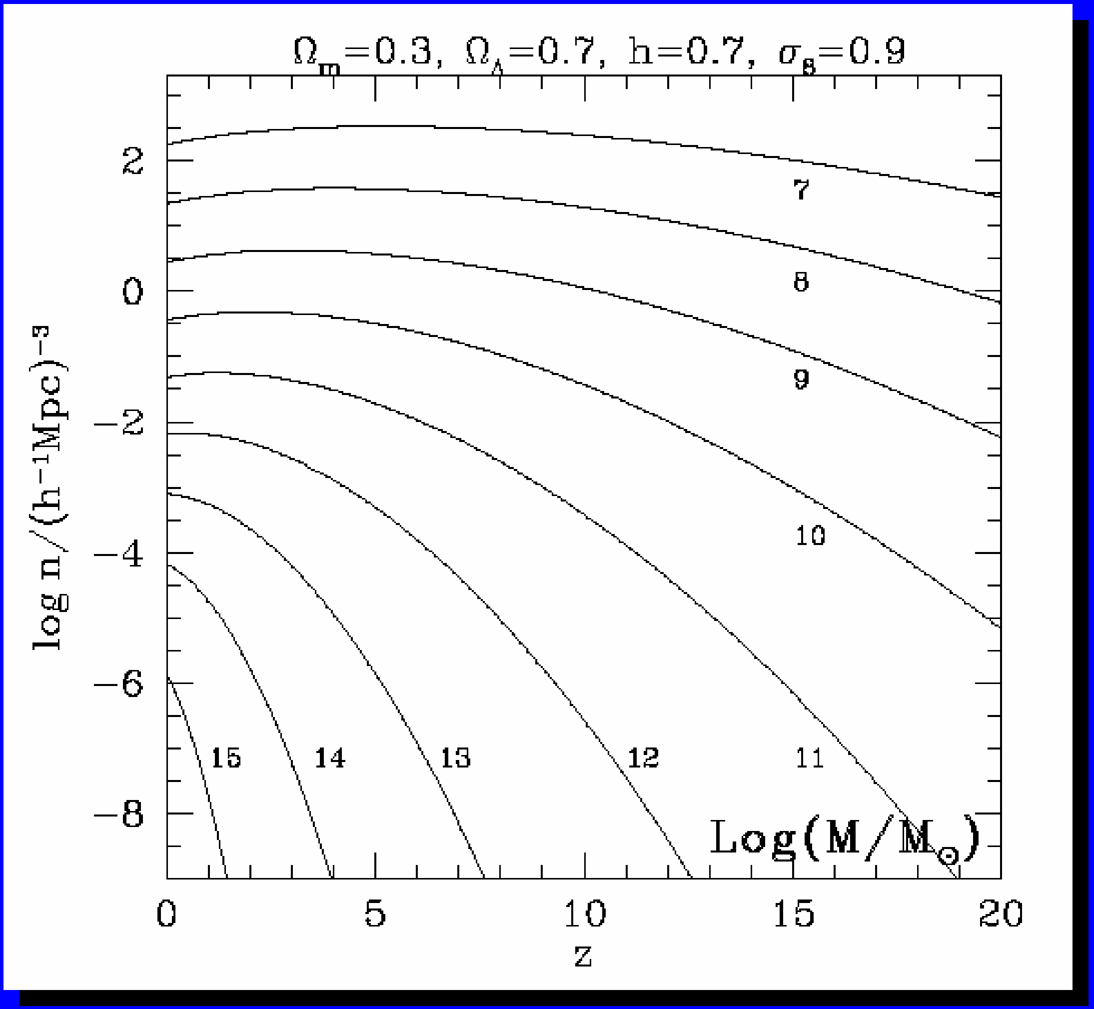
I like integrals …. but



Glazebrook et al. (2004), the GDDS

Not a problem with ΛCDM ?

Plenty of massive DM halos at high redshift



Mo and White (2002)

Evolution of High-z Galaxies

We have no coherent model for the growth of baryons in galaxies! Why not?

- Inherently non-linear problem
- Wide range of physical scales
- Lots of unconstrained physics like feedback, efficiency of star-formation, environmental effects, merging, etc. -- all highly stochastic.

little direct predictive power – need observational constraints

Evolution of High-z Galaxies

My thesis is that some form of CDM is basically correct ….

There are a lot of successes of the model, ….

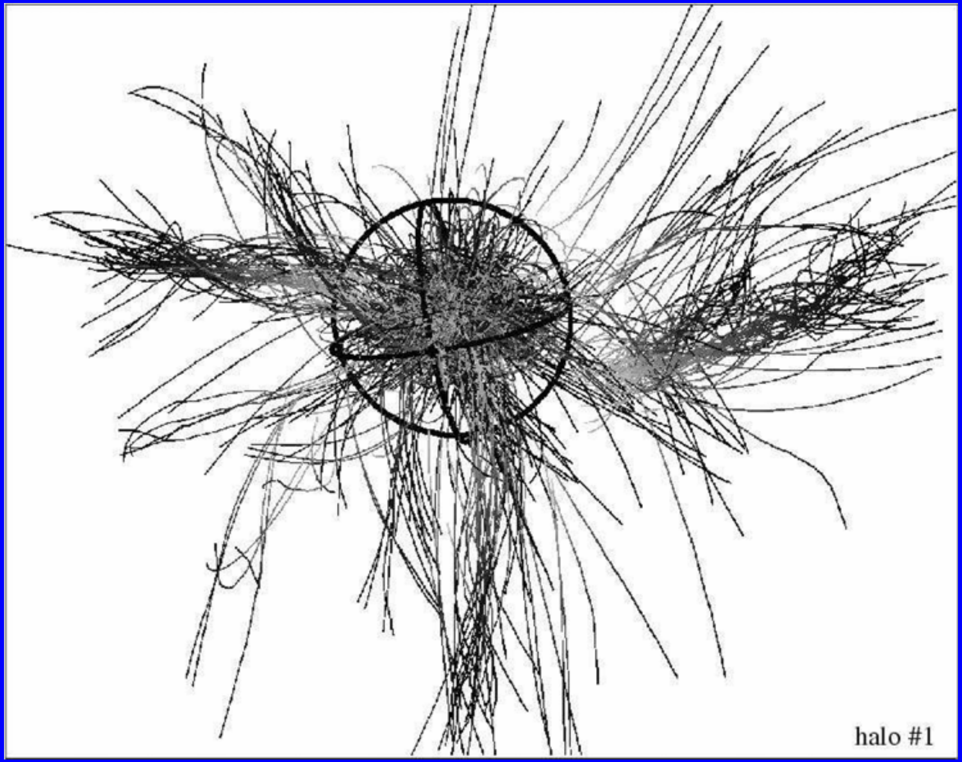
but ….

just not when baryons are involved.

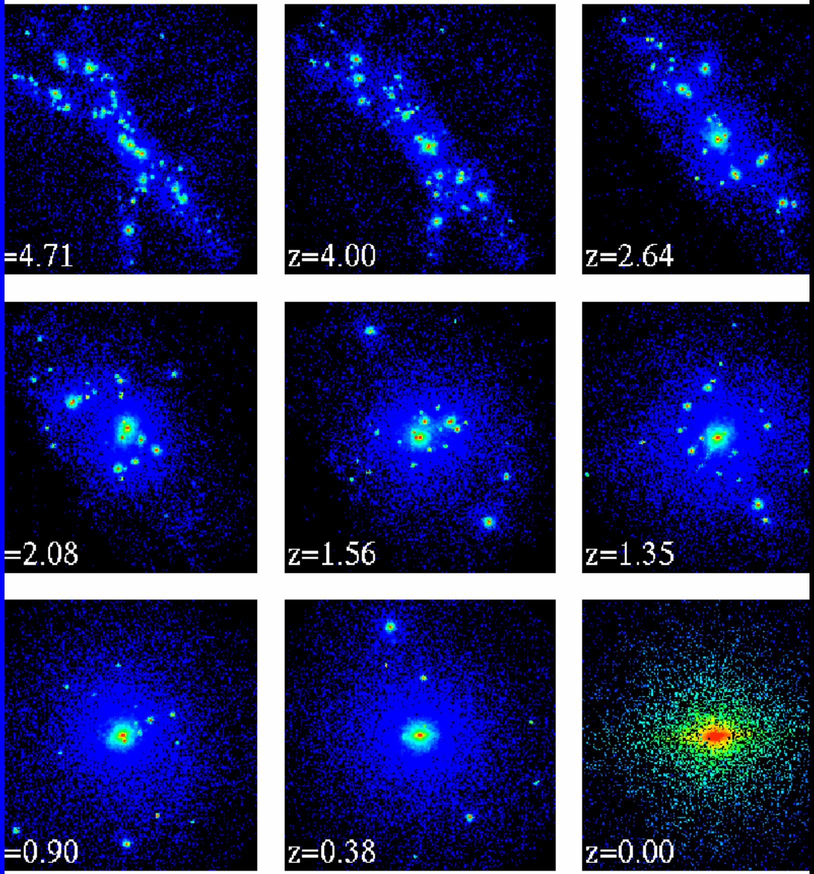
Question 1: When and how did the halos come together?

Galaxies in Pieces

Dark matter distribution on 100s kpc.



Gill et al. (2004)

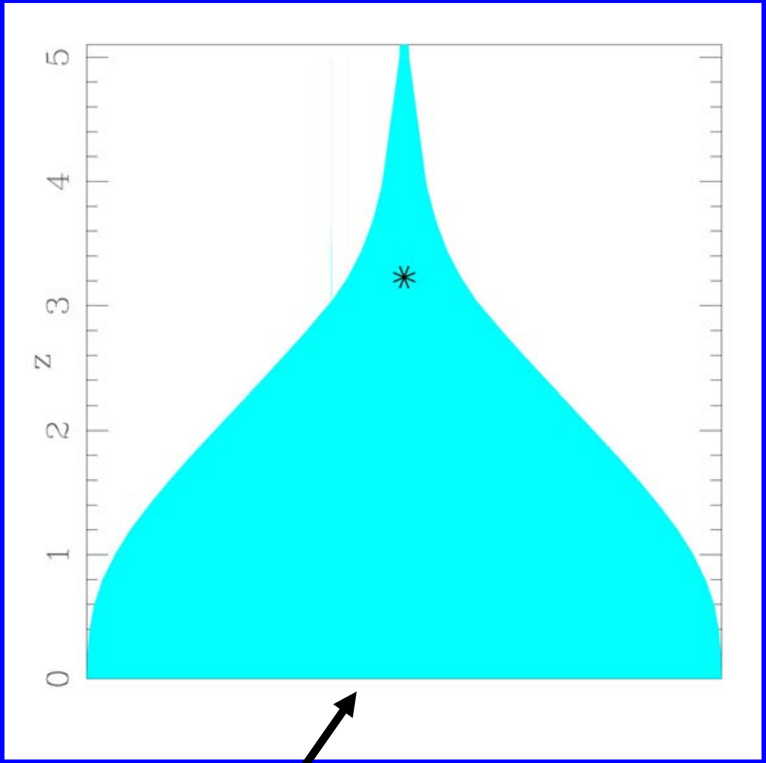


Abadi et al. (2002)

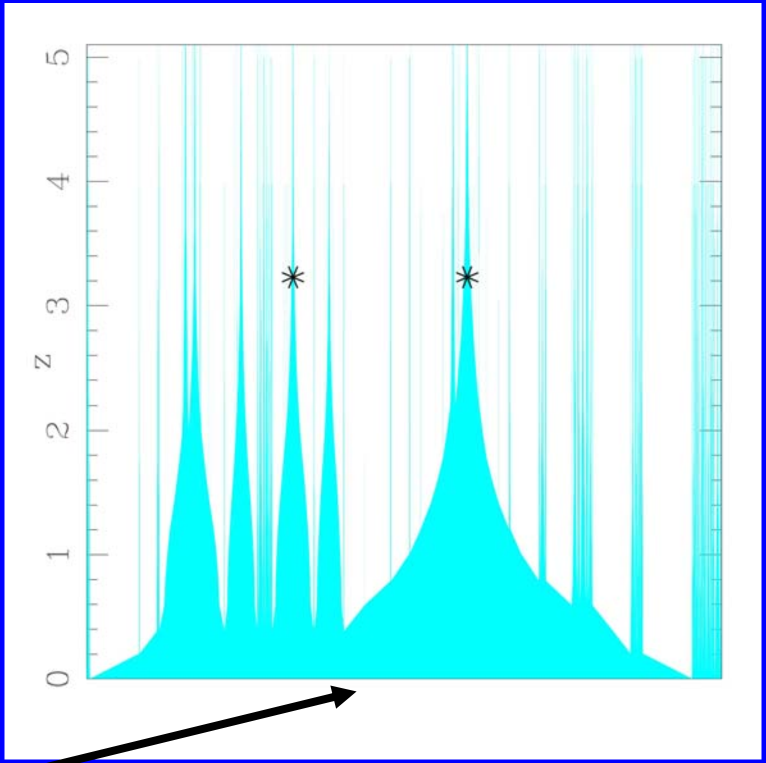
Merger Trees

Ultimately:

Spiral



Elliptical

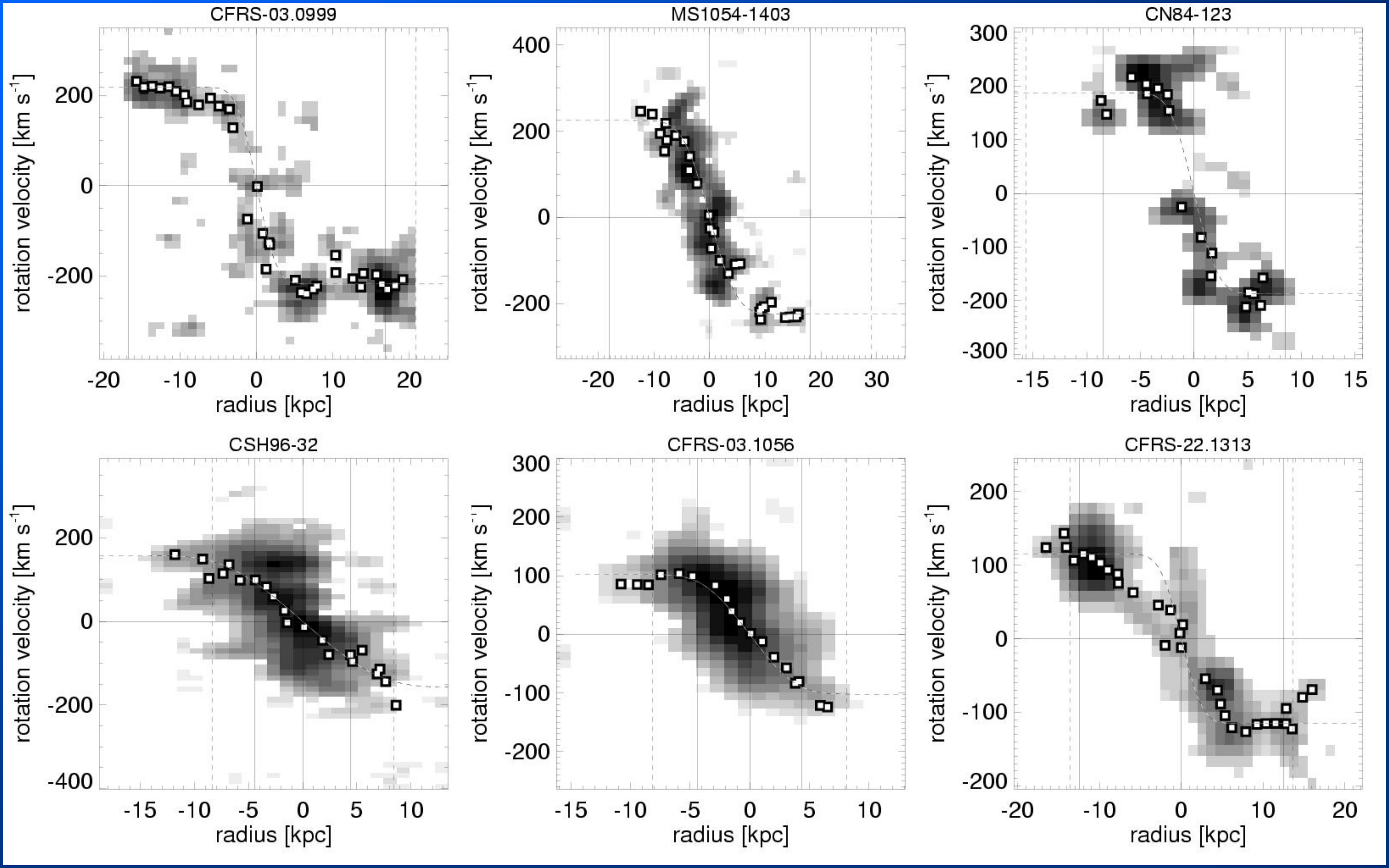


Frenk, Baugh, & Cole (1996)

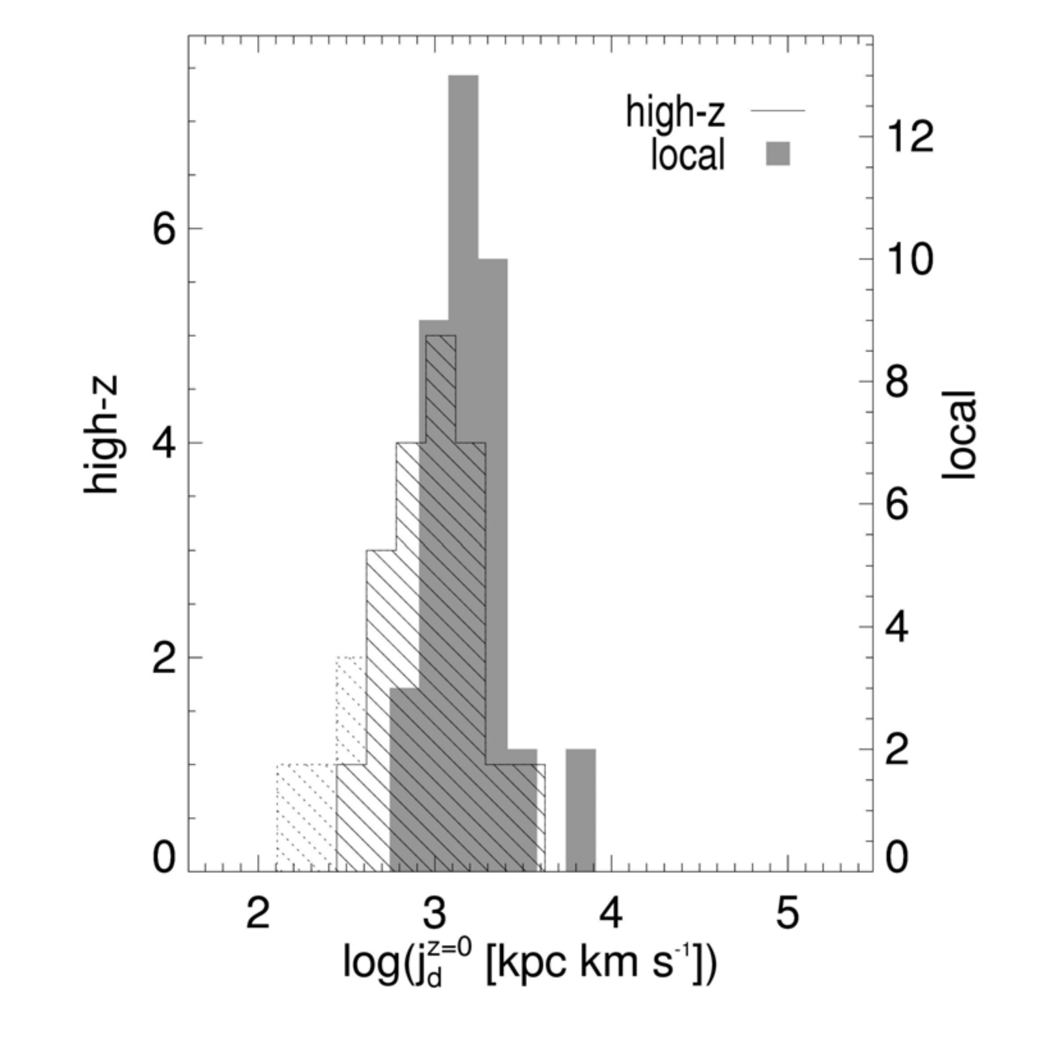
smooth vs complex … angular moment

Question 2: Where did all the angular momentum come from?

Rotation Curves at z≅0.9



Angular Momentum Evolution?



$j_d = 1.68 R_d V_{rot}$

But,

Only for exponential disks

Galaxy Growth and Angular Momentum

Fall & Efstathiou (1980)

To sustain Hoyle (1953) and Peebles (1969) idea of gravitational tidal torques as the sources of angular momentum, implies:

1) Collapse factors > 10 and $m_{halo}/m_{disk}>5$

2) Gas and DM have identical initial angular moment distributions

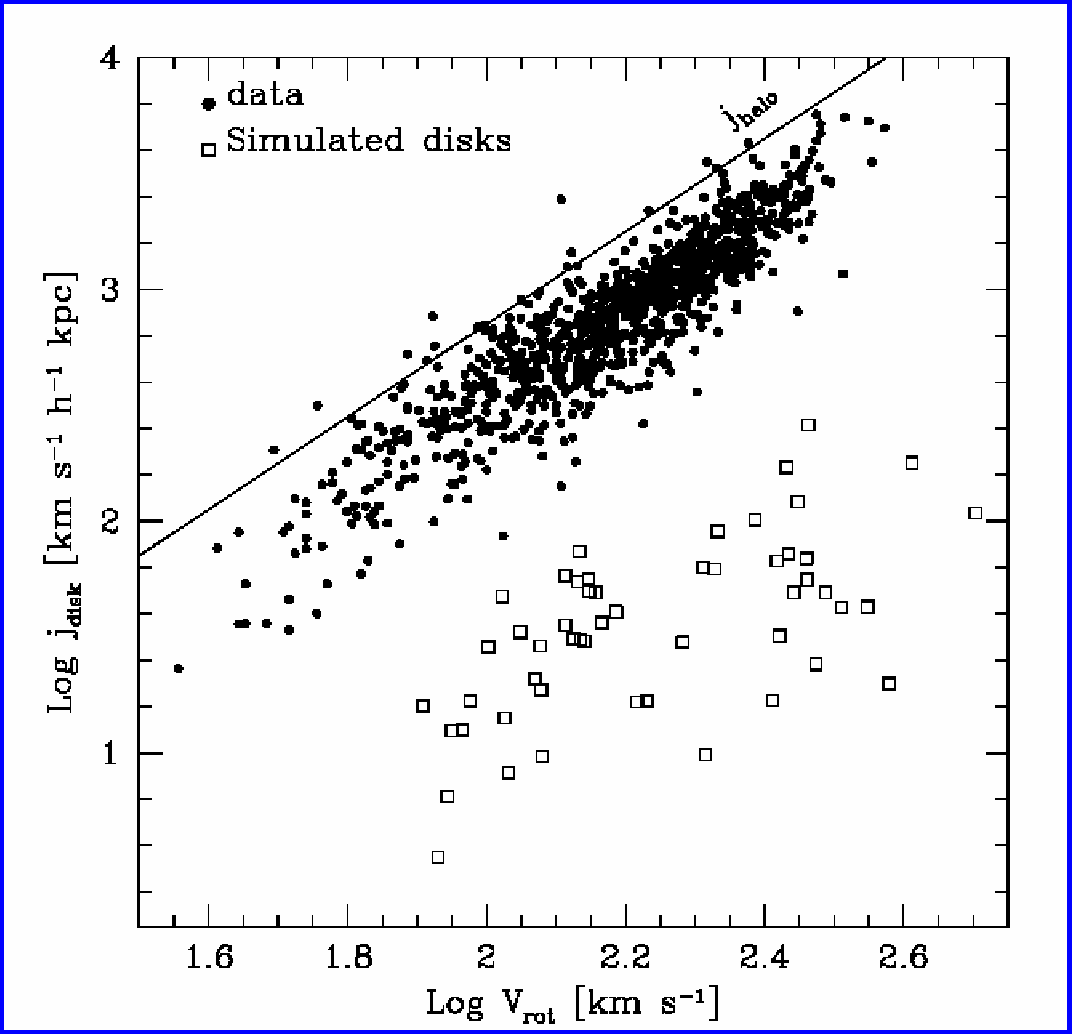
3) Must have detailed conservation of momentum

Trouble ahead?

But DM and gas have different relaxation/dissipation mechanisms …

shocks and UV heating to hydrostatic equilibrium
vs.
violent relaxation to virialization

Angular momentum problem



Steinmetz and Navarro (2000)

SPH plus N-body cannot predict the total angular momentum even if they include feedback.

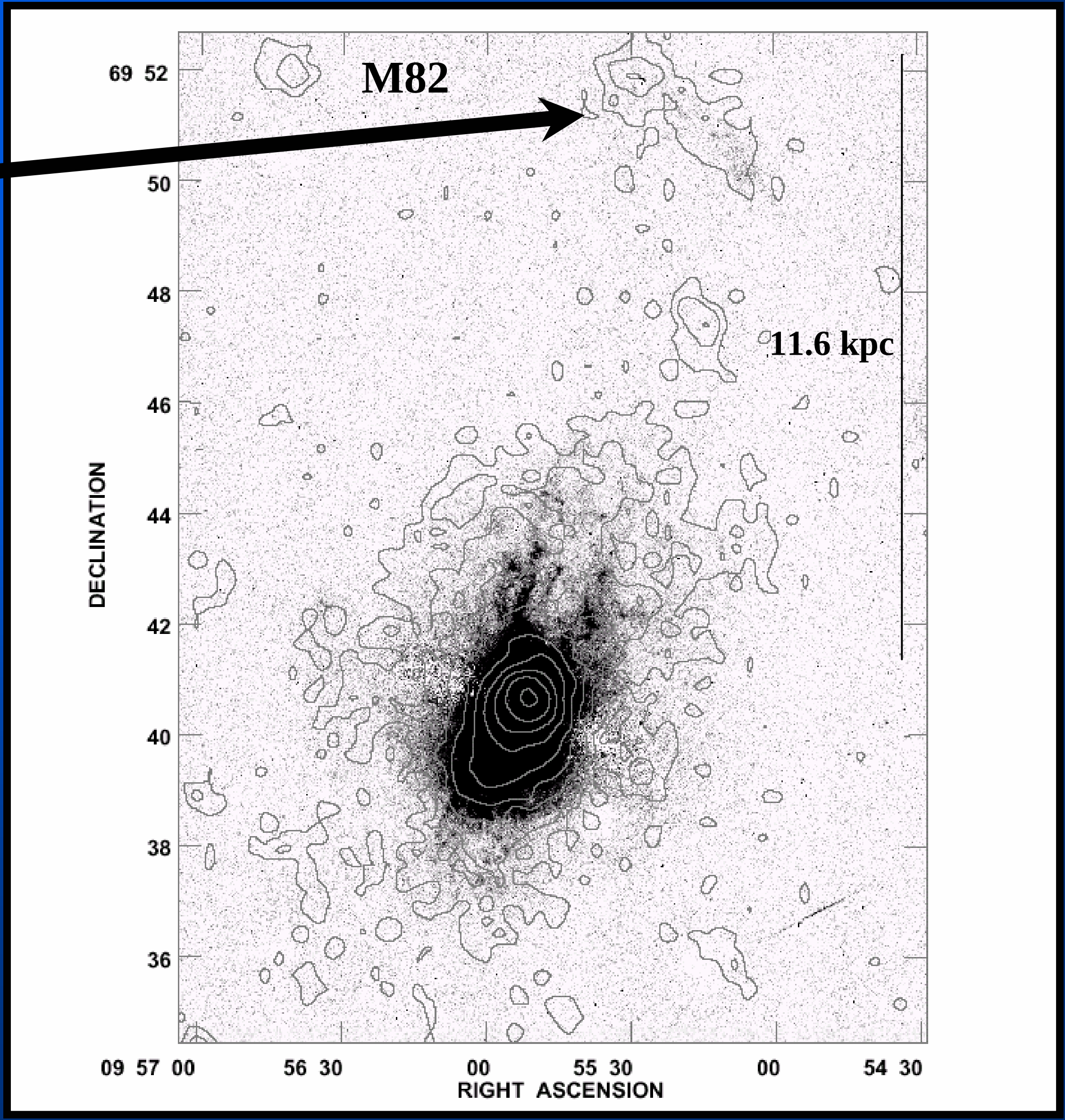
Need angular momentum of halo and baryons to be roughly the same which is difficult to do and difficult to understand.

The Escaping Wind in M82!

Region of spatially coincident X-ray and Hα emission.

Characteristics suggest fast shock of 800 km s^{-1} being driven in an ambient halo cloud. 800 km s^{-1} is well above escape speed

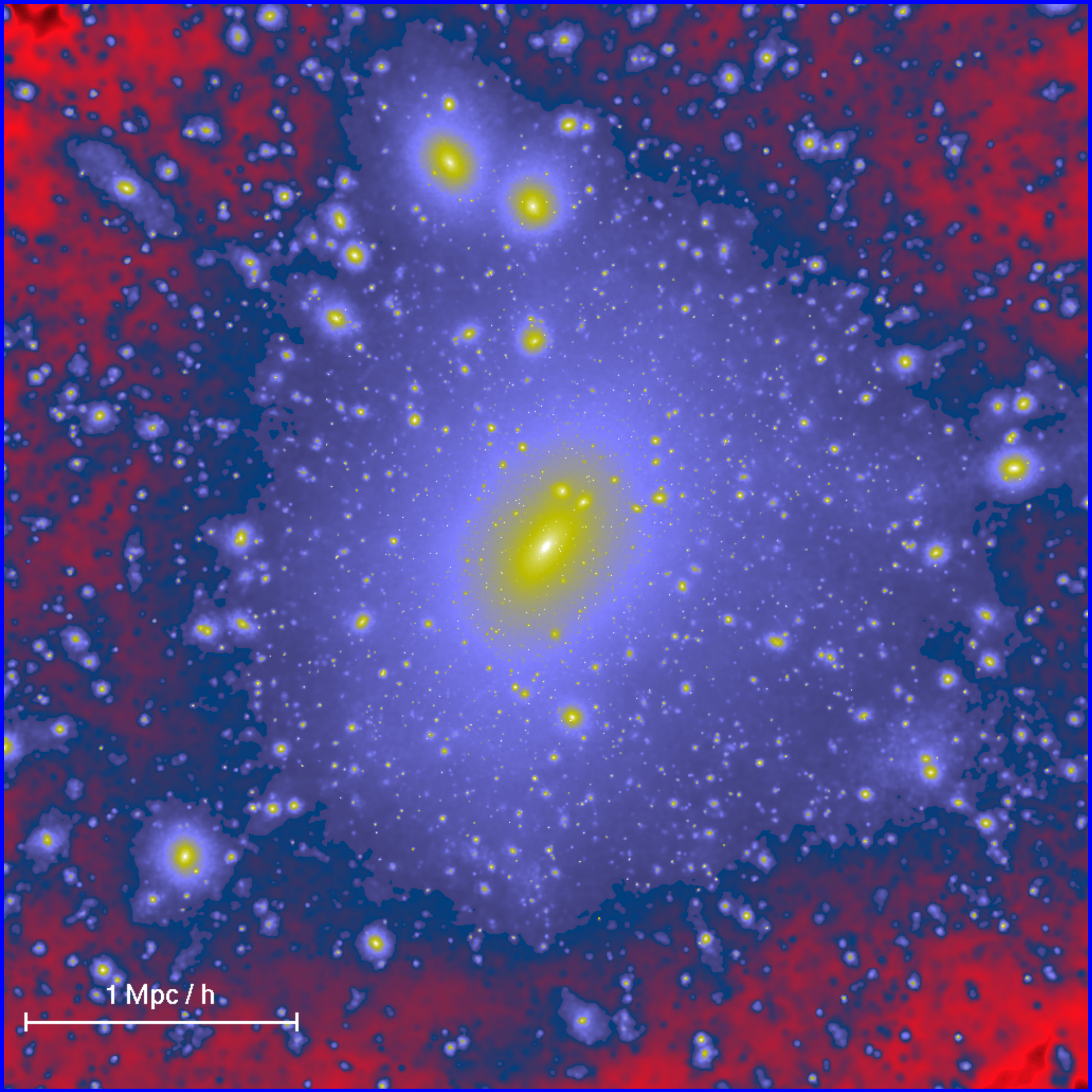
Escaping!



Lehnert, Heckman, & Weaver (1999)

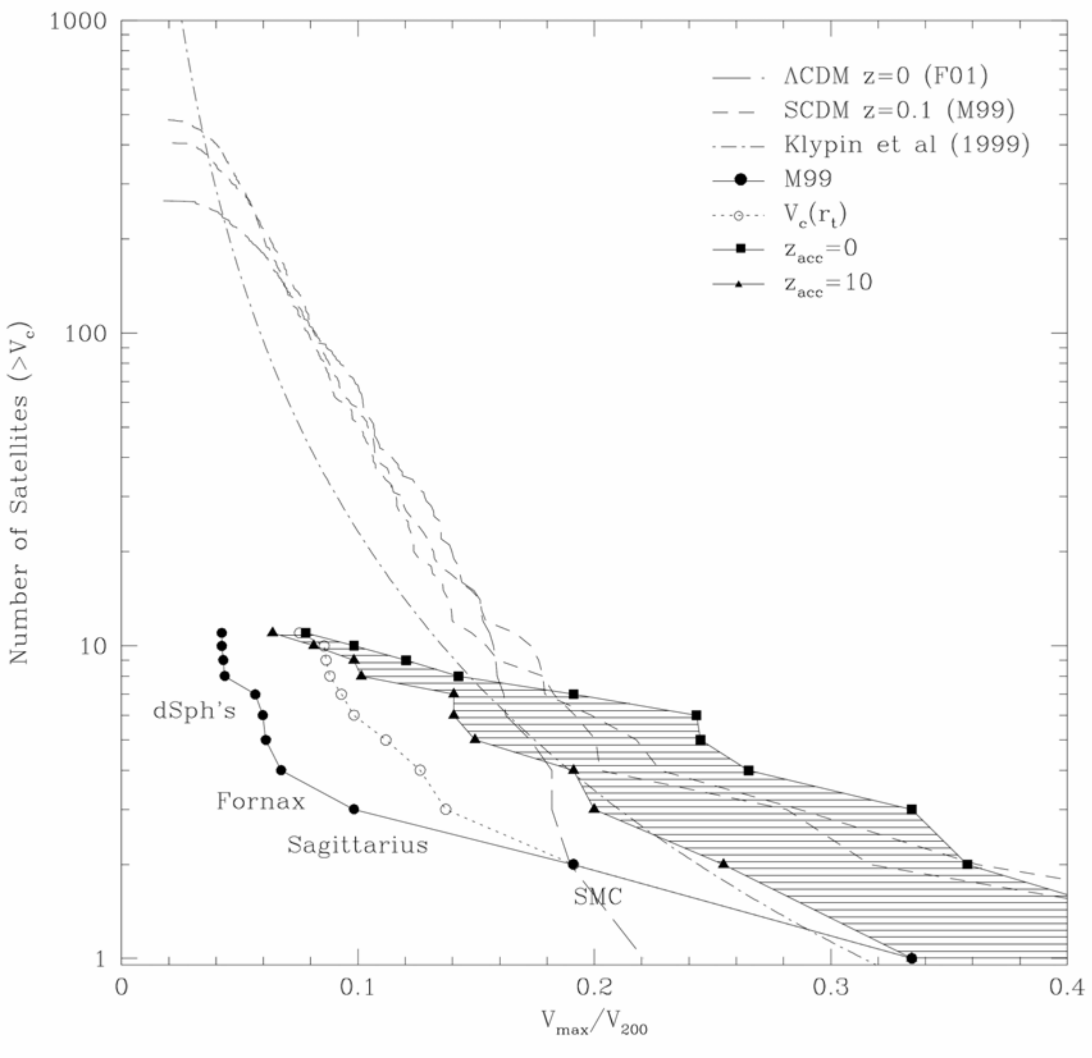
Question 3: How did the DM distribution evolve and what is its relationship to the baryons?

Substructure in Halos



Springel et al.

Halo Substructure



Hayashi et al. (2003)

Evolution of High-z Galaxies

Given the complexity, must get beyond 0^{th} quantities (masses and sizes) and 1^{st} order quantities such as:

- the spatial distribution of age and gas phase metallicity,
- SFR $\propto \alpha\, t_{dyn}$
- angular momenta of disks, its distribution, its growth rate,
- merger rate, orbital angular momenta of companions,
- feedback – blow away gas in least massive halos,
- ratio of dark to baryonic matter as a function of radius (bias),
- profile/distribution of the dark matter, etc.

All of this as $f(M_{gal},z)$

Ambitious or Ridiculous

Map out the distribution and dynamics of low luminosity companion galaxies for large sample of galaxies from z=1-5.

- line emitters down to SMC like luminosities,
- distribution of brighter continuum objects (sub-L*),
- relative velocities/total dispersion of ensemble to large radii,
- spatially resolve galaxies/clumps (>1 kpc; color/age/dynamics),
- see how these parameters change with redshift.