Galaxy evolution in groups and on the Cosmic Web

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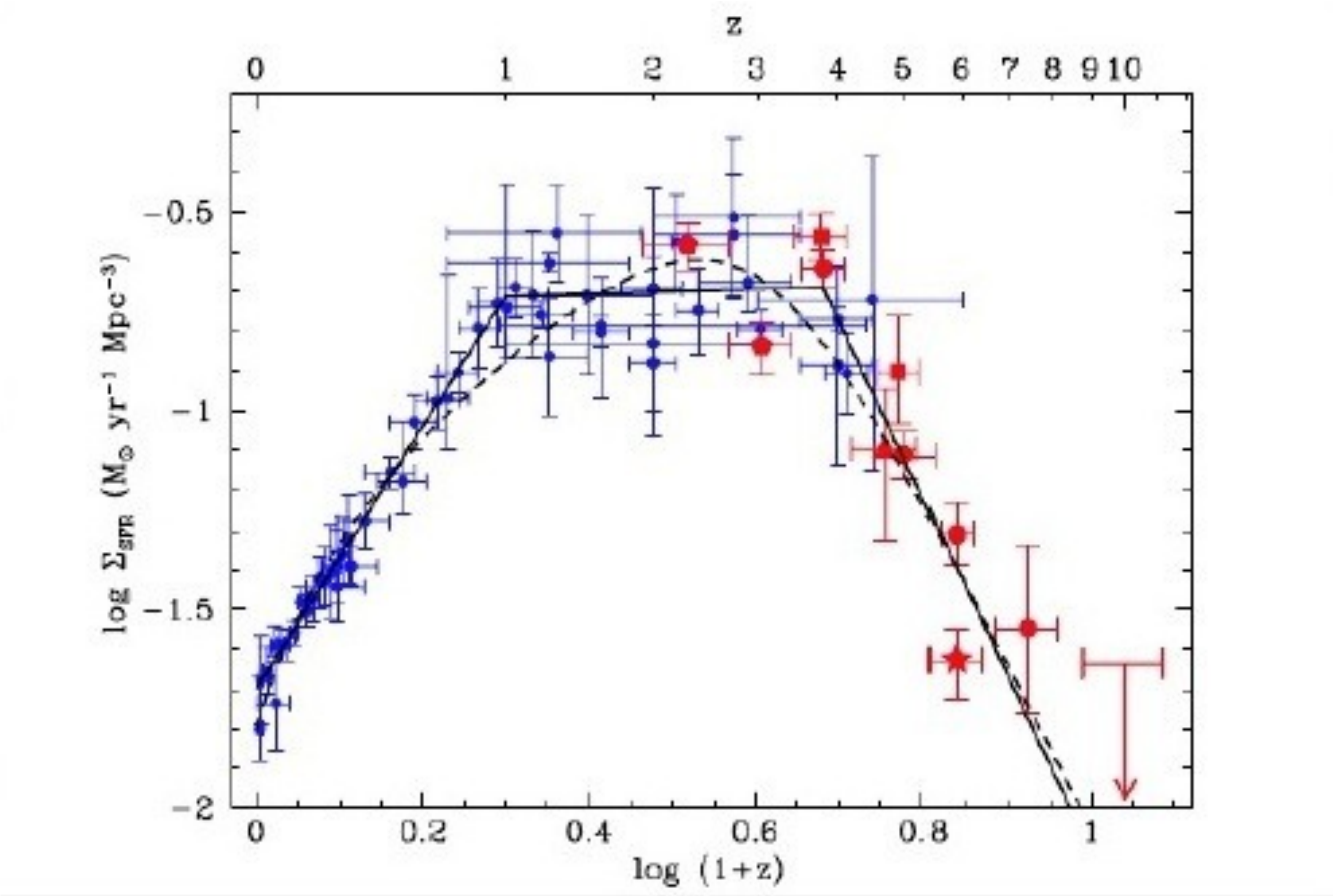
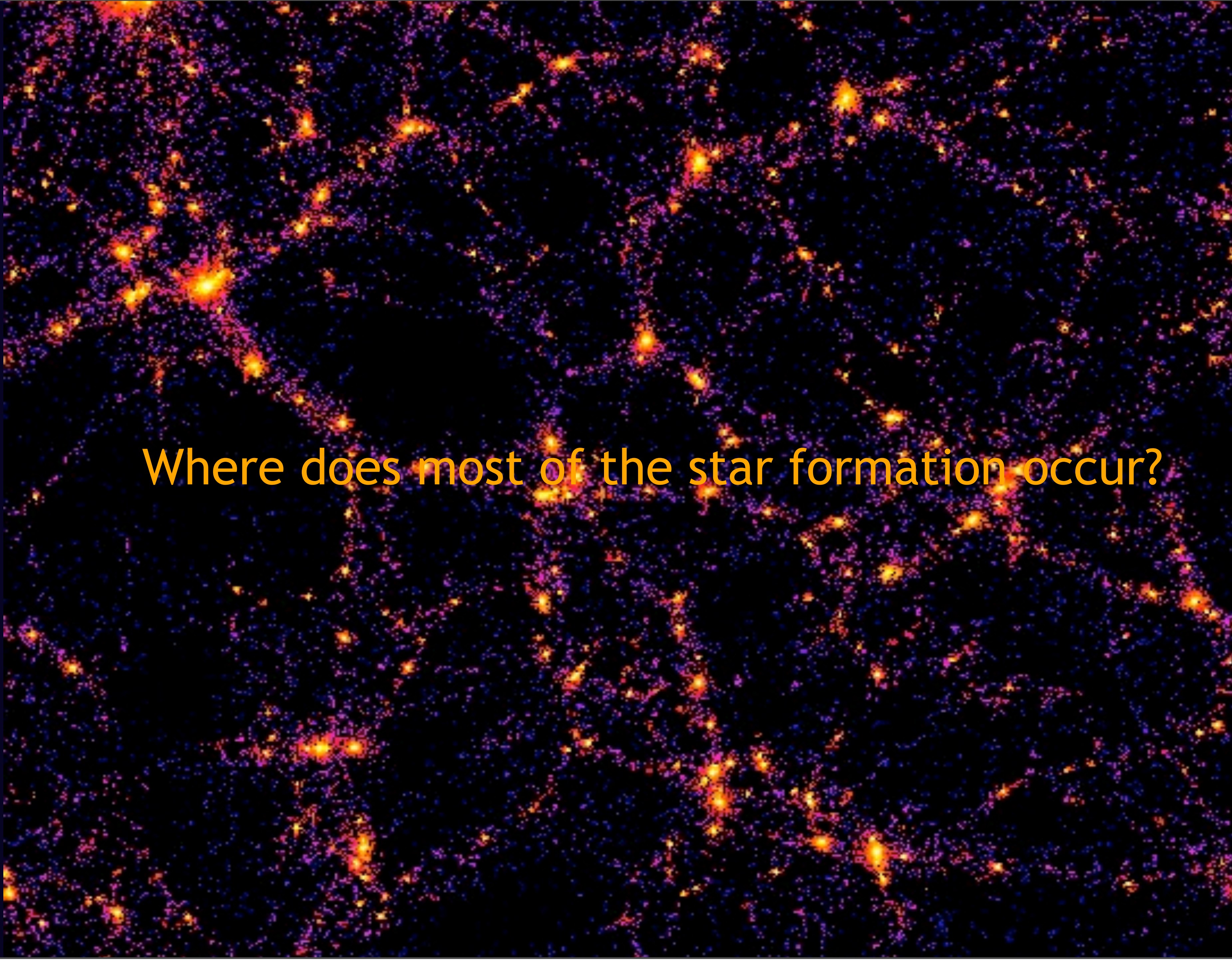
History of star formation



“Madau Plot”
Li-Xin Li, MNRAS 2008

Where does most of the star formation occur?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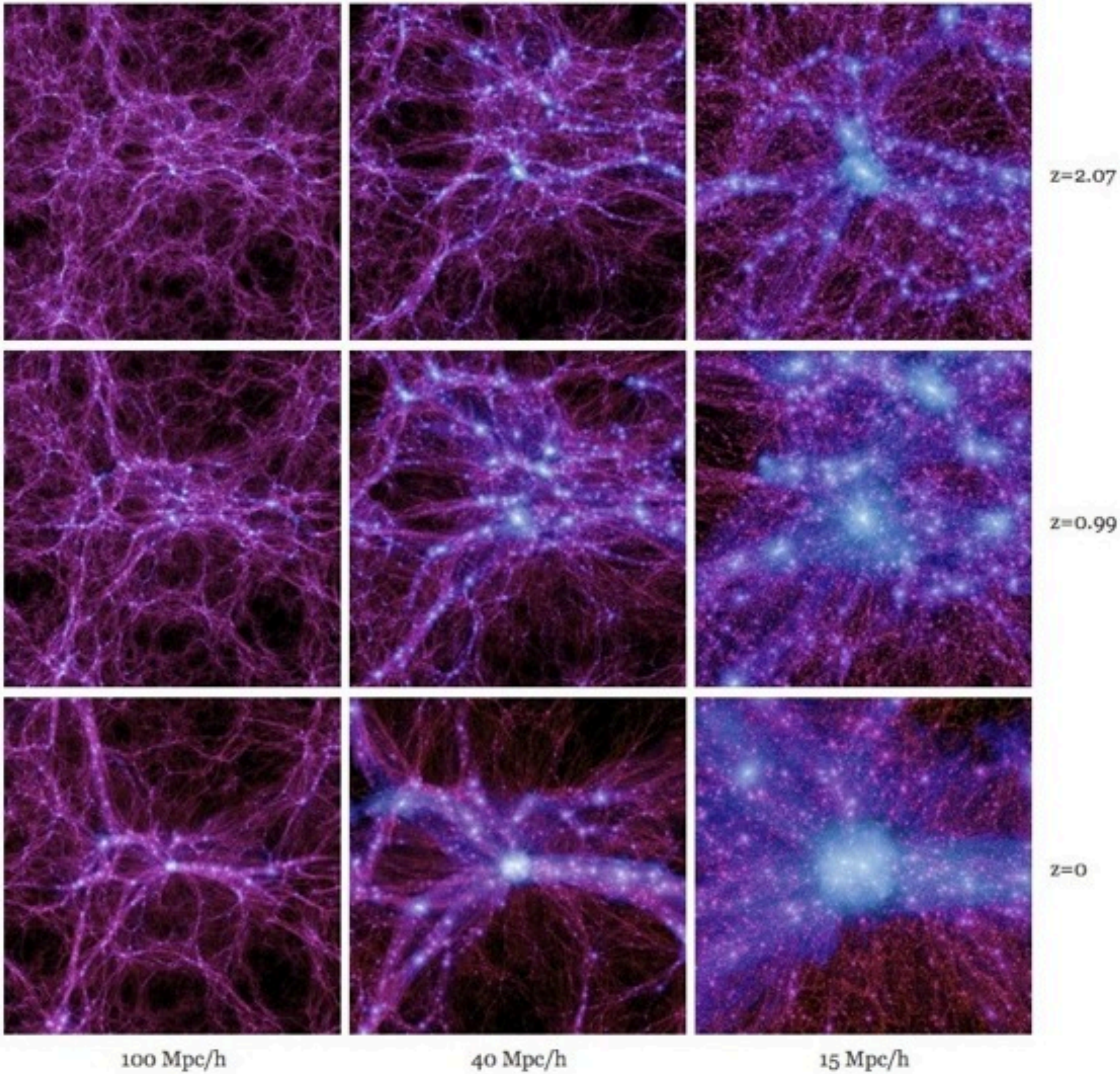
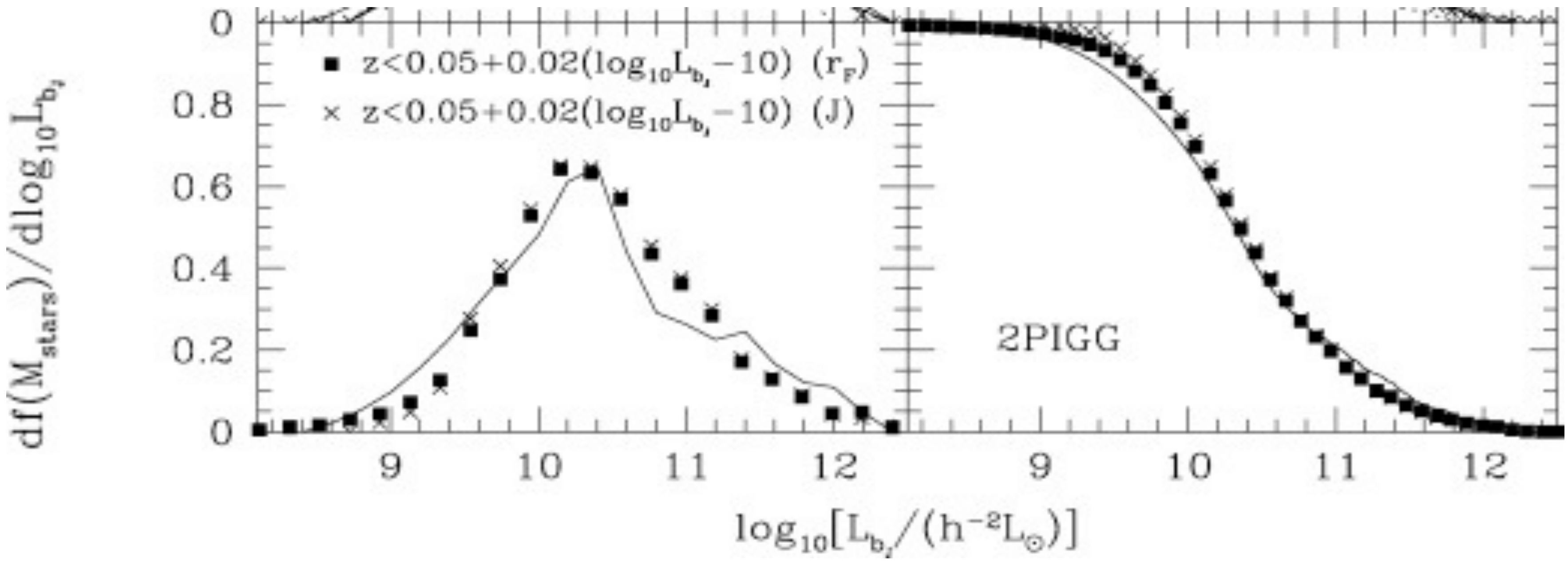

z=2.07
z=0.99
z=0
100 Mpc/h
40 Mpc/h
15 Mpc/h

Why look at groups rather than clusters?



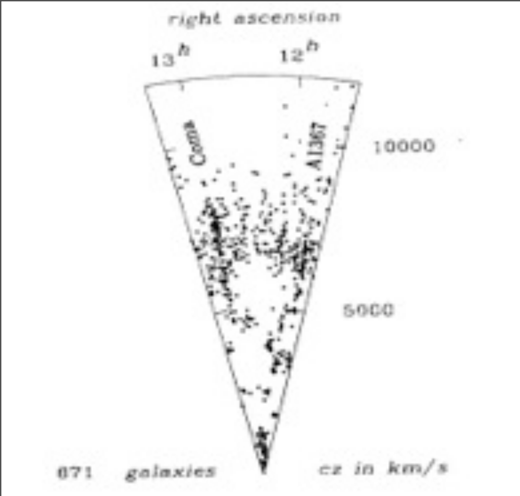
Eke et al. (2005) Log Stellar Mass 10, 11, 12 ≈ Log Total Mass 12, 13.6, 14.7

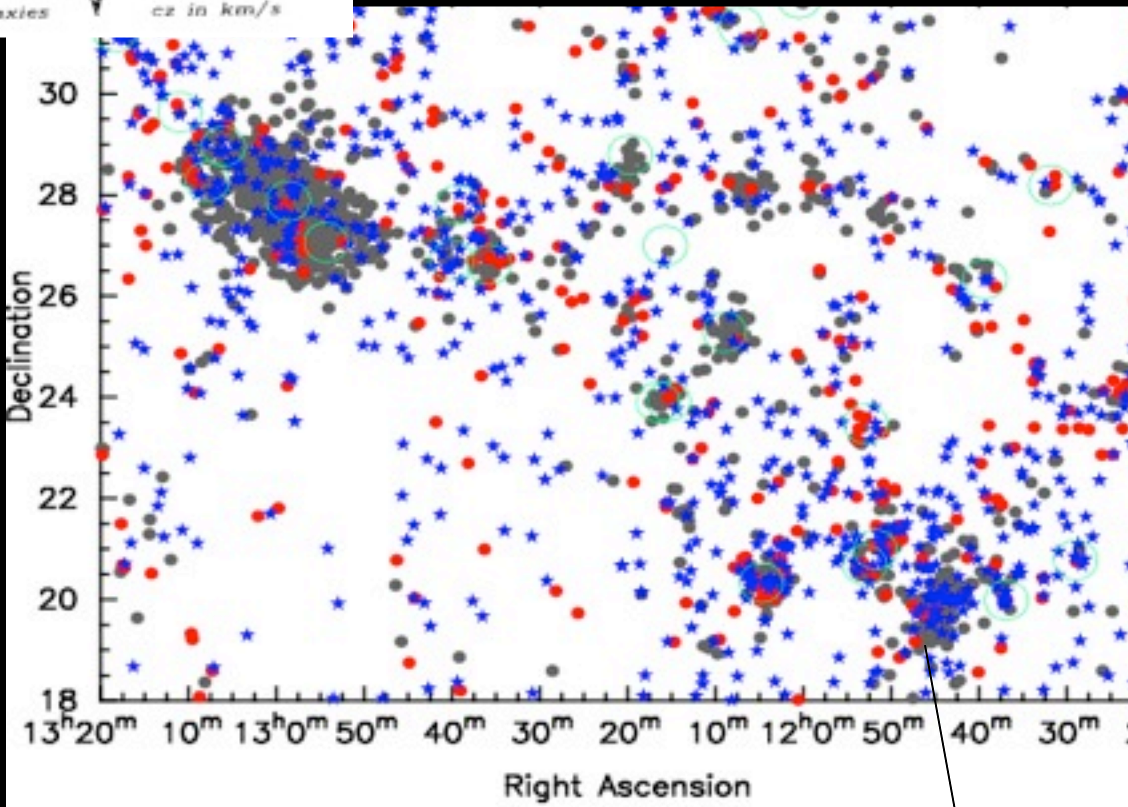
1. **Only 2% of stars are found in clusters (log $L_B/L_\odot$ > 12)**
   - Half of all stars in systems with log $L_B/L_\odot$ = 10-11

     -- galaxies & small groups
2. **Groups are the locus of much of galaxy evolution, so impact of feedback important**

This is at z~0

The Coma "supercluster" (z=0.023)





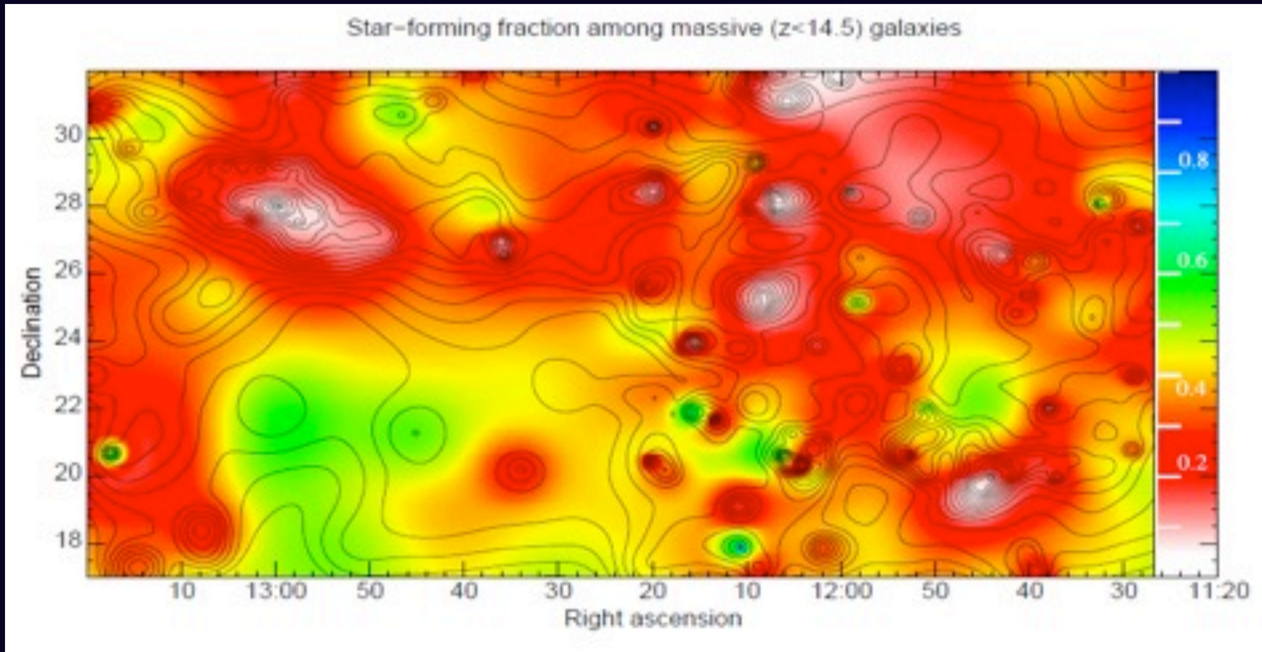
- Around 500 sq. degrees on sky
- One of the richest nearby Large-scale structures

- Red: AGN hosts
- Blue: SF galaxies (EW Hα>2.5A)
- Green: groups of galaxies

Mahajan, Haines SR 2010

Abell 1367

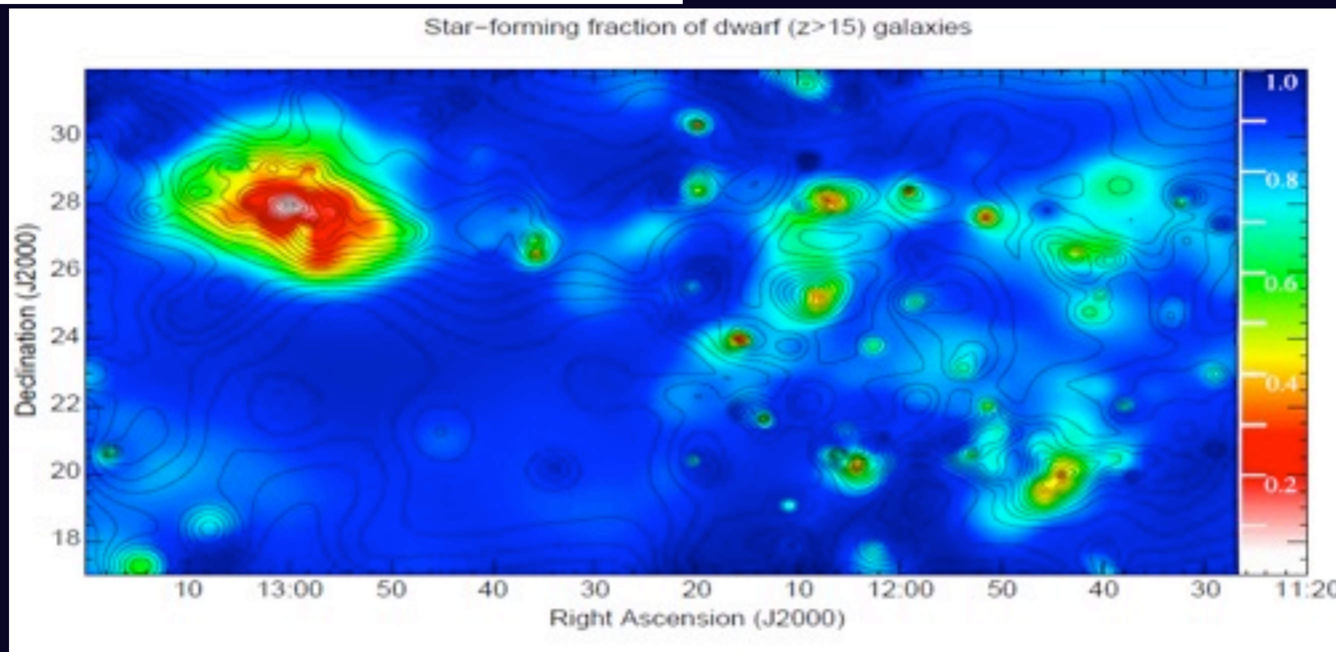
Mahajan, Haines, SR 2010



Star forming: EW(Hα)> 2 Å

Giants are passive irrespective of their environment

Dwarf galaxies are star-forming everywhere, except in the cores of clusters and groups

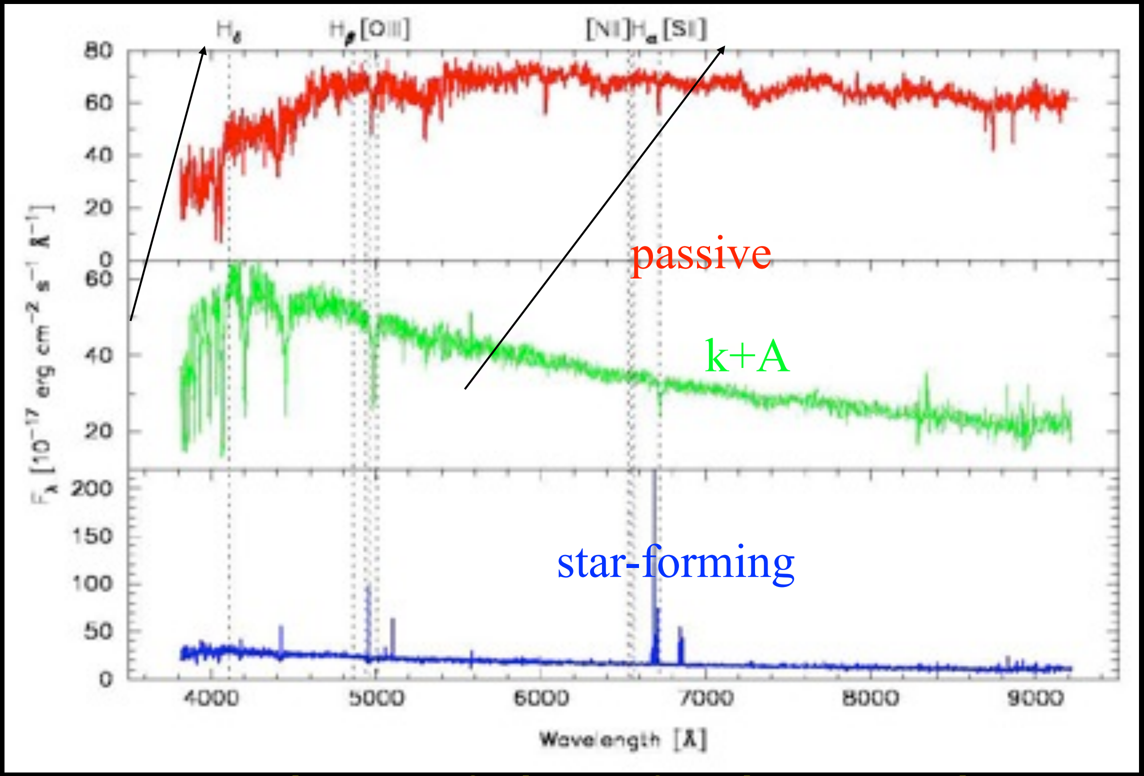


Contour: SDSS z-band luminosity-weighted galaxy density

Mahajan, Haines, SR 2011

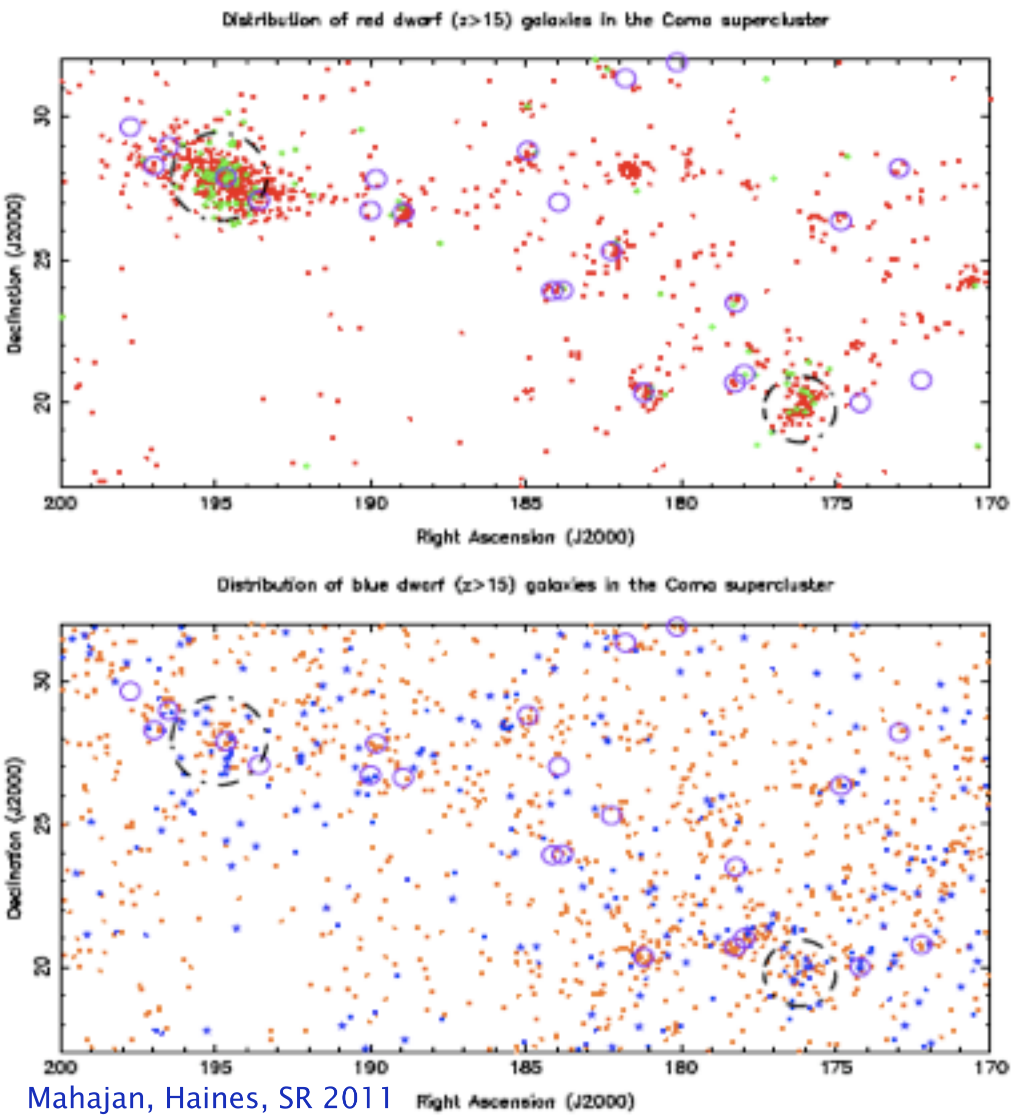
The post-starburst (k+A) galaxies

(Red dots) k+A: Strong Hδ absorption and no Hα emission



- The mean colour of dwarfs changes by ~0.4 mag between thrice the radius of the cluster and its centre
- Almost all k+A dwarf galaxies are found within 1.5 times the radius of the cluster

Dwarfs in Coma (z'>15)



Mahajan, Haines, SR 2011

- Red: Passive (70%)
- Circles: groups
- Green: k+A galaxies

- Red dwarfs in high density regions (trace giant passive galaxies)
- k+A galaxies also in clusters and groups

- Red: EW Hα< 50 A
- Blue: EW Hα>50 A
- Circles: groups

- Blue dwarfs are all over the entire supercluster

k+A galaxies in Coma

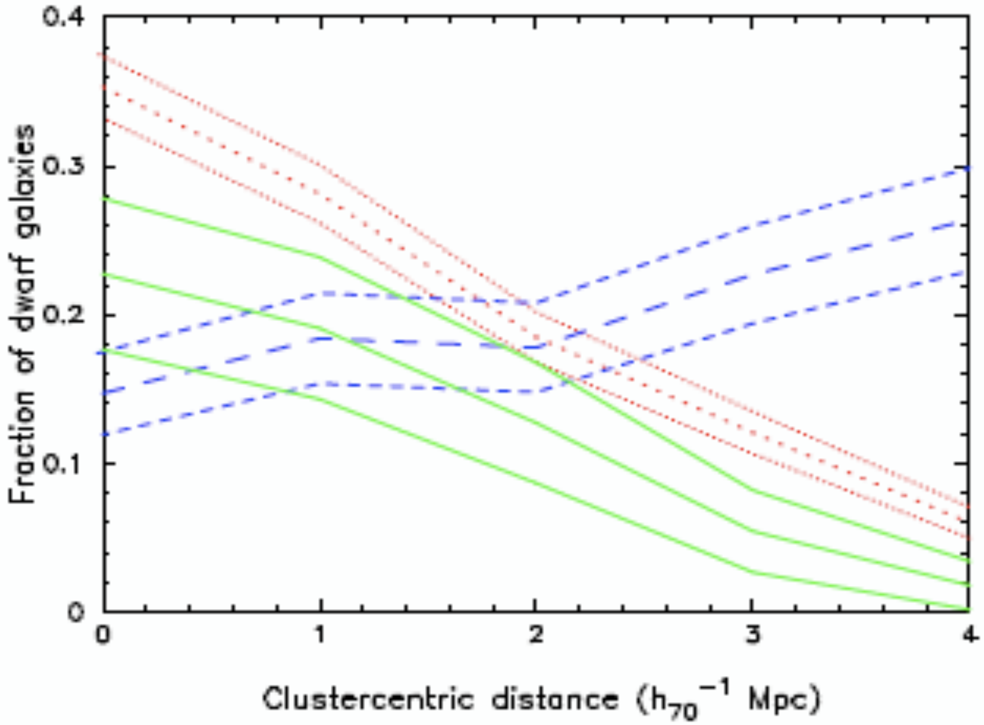


Figure 5. This figure shows the distribution of the red (*red dotted line*), blue (*blue dashed line*) and k+A (*green solid line*) galaxies as a function of clustercentric radius from the centre of the Coma cluster. 525, 157 and 67 galaxies contribute to each of the 3 curves respectively. The *thin lines* corresponding to each distribution represent the $\pm 1\sigma$ scatter, assuming binomial statistics. All curves are individually normalized to unity.

K+A dwarfs

< 2A H alpha em

> 3A H delta abs

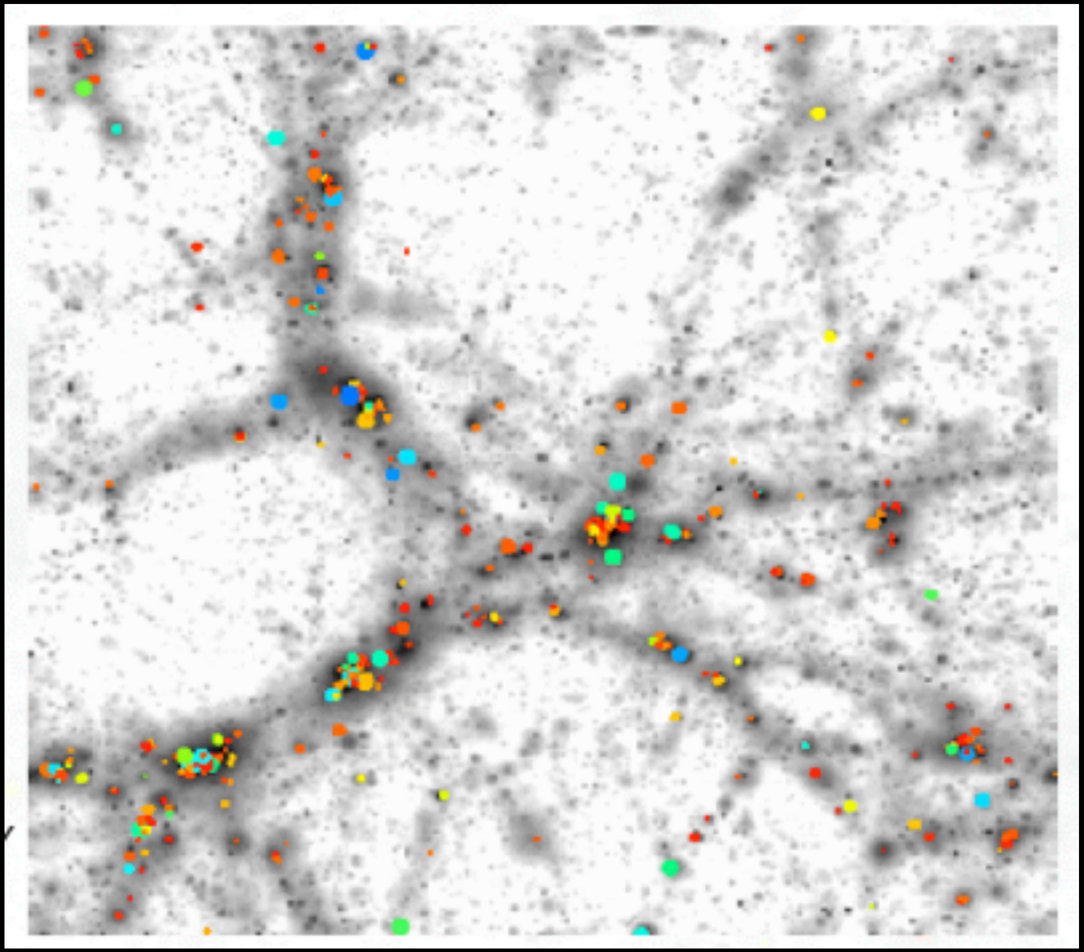
> M_Z >-20

To create the k+A phase (which lasts < 1 Gyr), we need sudden quenching of star formation- so need groups, clusters

Mahajan, Haines, SR 2011

As galaxies fall into clusters...

- More starbursts will be found on filaments feeding clusters
- Is Cluster mass important?
- What role does the Group environment on the filament play?
- Observationally, projection effects will need to be modelled

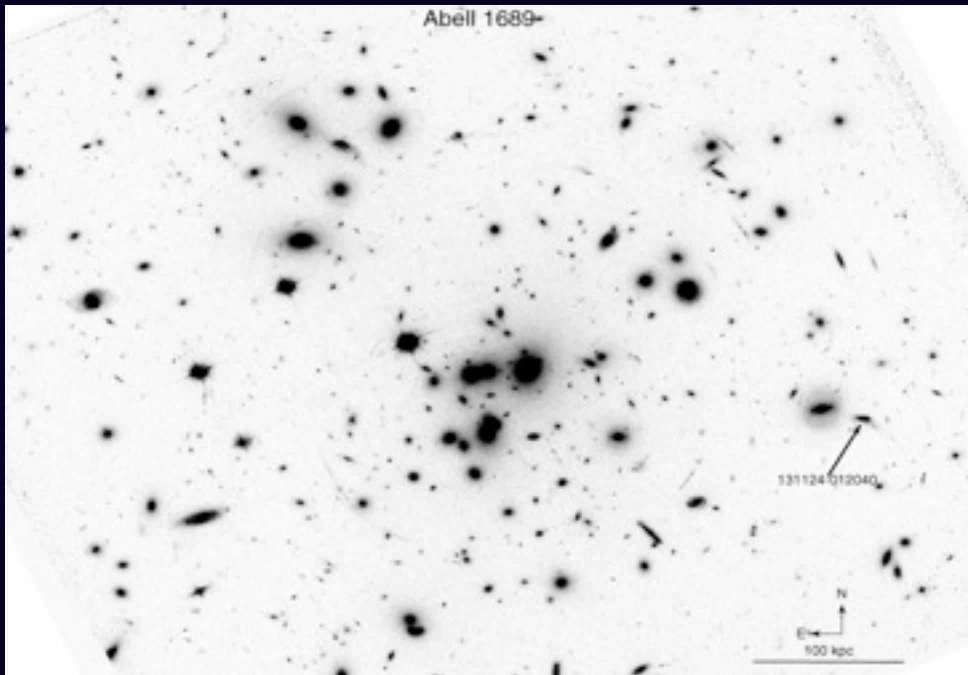


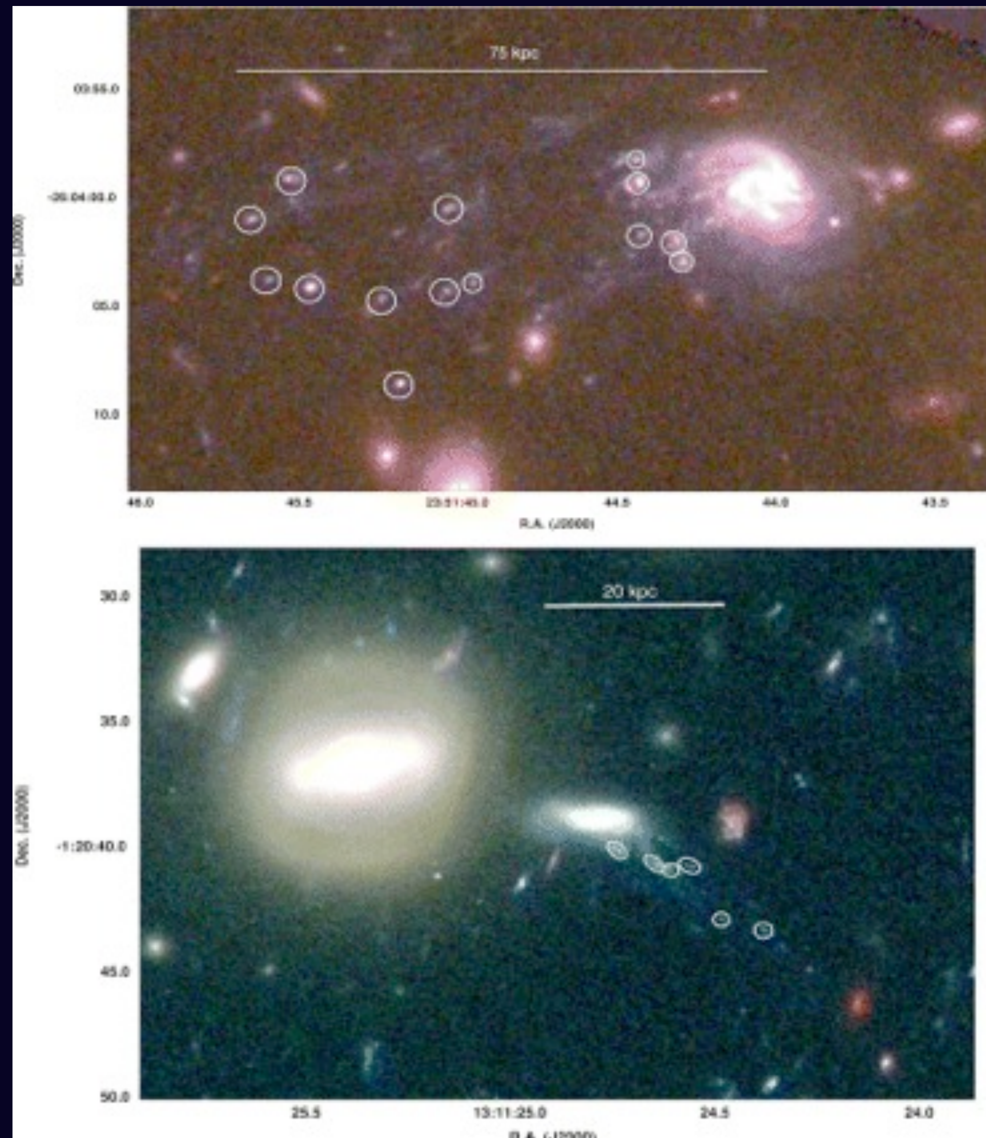
Strong interaction between galaxies along filaments

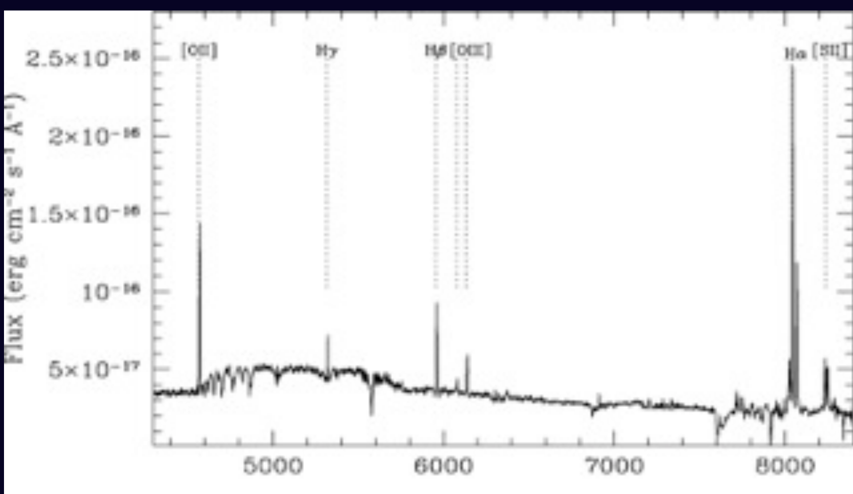
What do these galaxies look like?

Abell 1689 & 2667

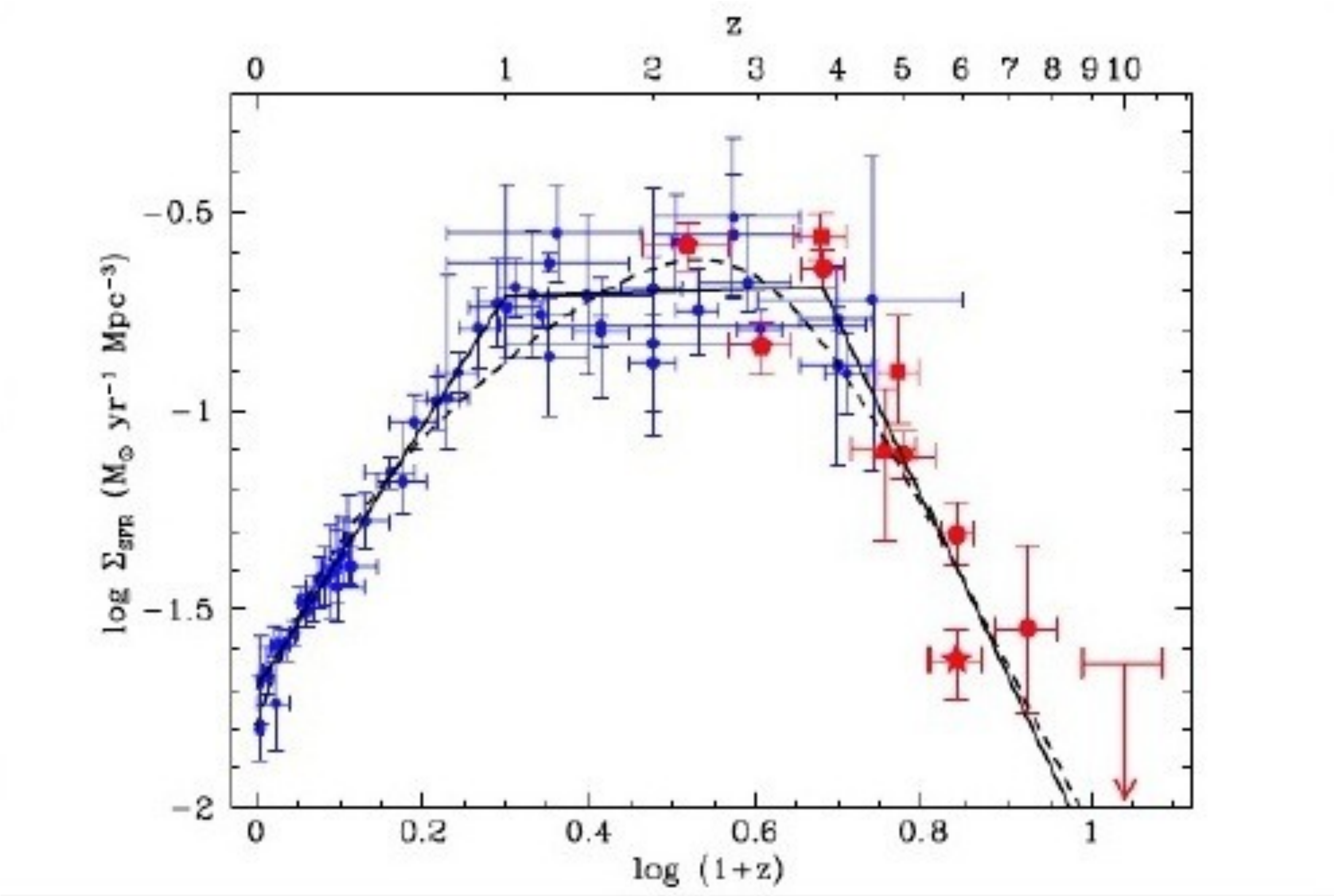
Cortese et al 2006







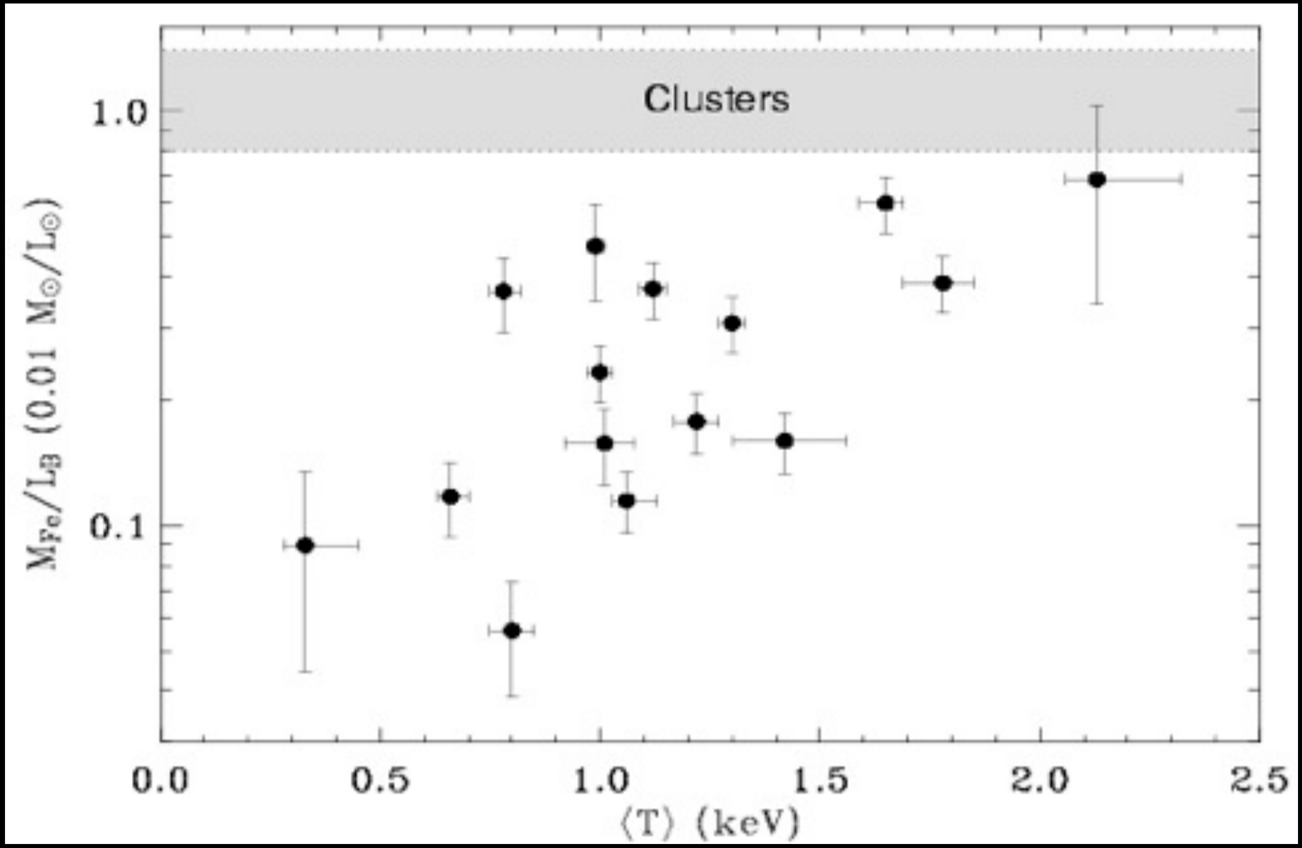
History of star formation



"Madau Plot"
Li-Xin Li, MNRAS 2008

Metal abundances in galaxy groups

Integrating the iron mass within r_{500}, there is a strong trend with system mass in the Fe-mass-to-light ratio.



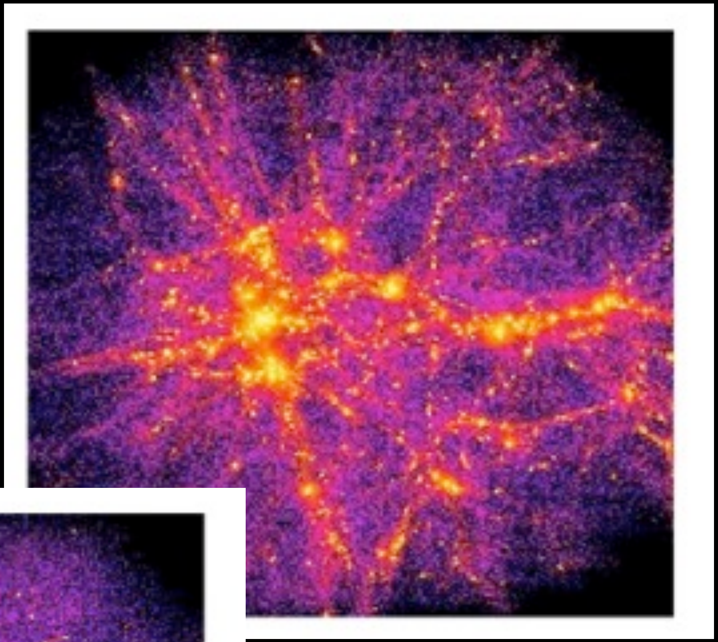
Rasmussen & Ponman (2011)

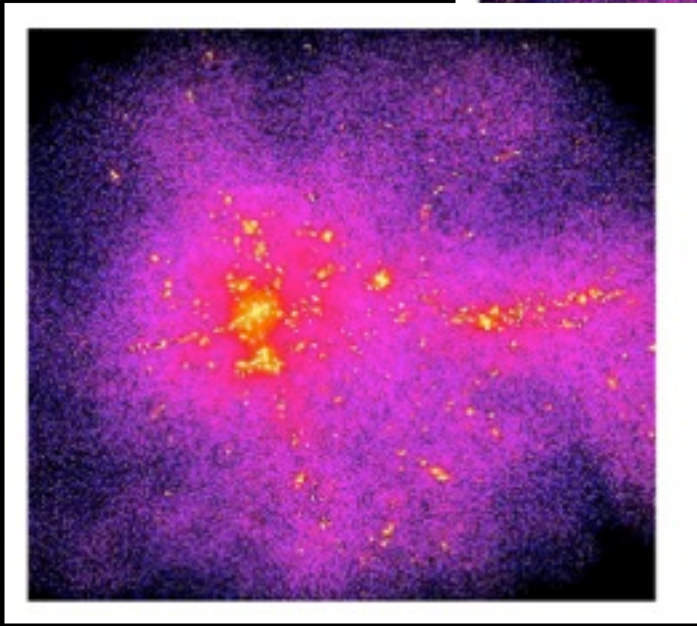
Preheating in filaments - a mechanism for losing SNII products?

Preheating at z~3 blows up the baryons in filaments, increasing the entropy of gas accreted by clusters, and accounting for the high excess entropies seen to large radii in groups and clusters.

Could SNII products could escape from the small filaments which feed groups?

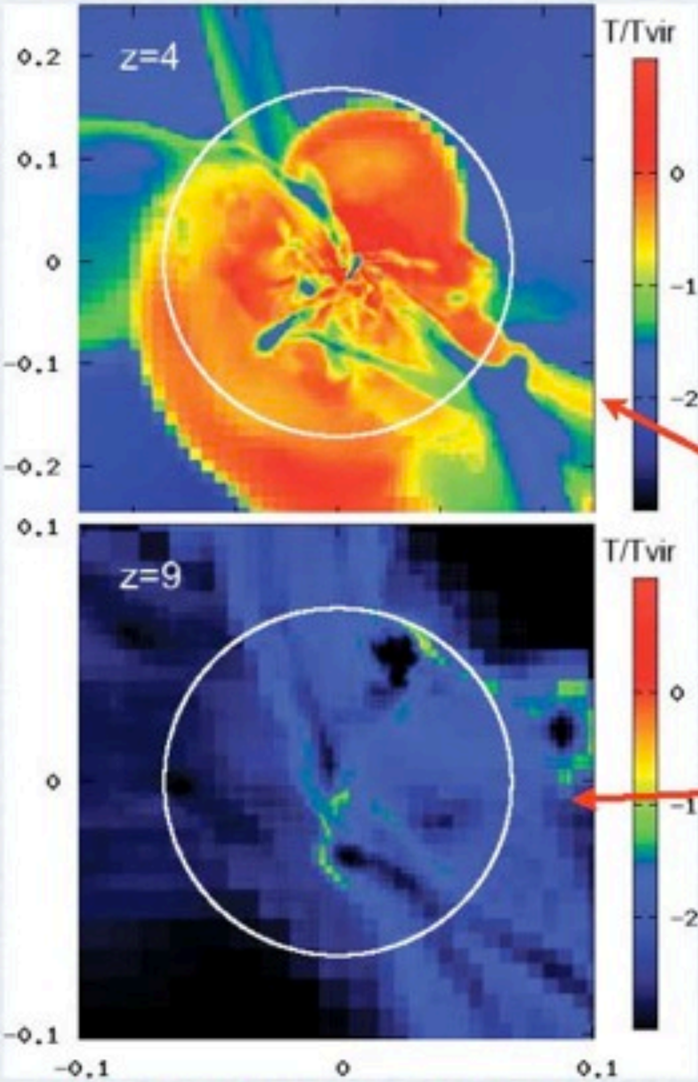
→ Could account for reduced IMLR in groups, and the low metallicity of gas outside the group core.





Borgani et al 2005 - baryons at z=2 with low and high feedback

(1) How do DM halos assemble their baryons?



Dekel & Birnboim (2006)

Galaxies can acquire their gas through hot and cold accretion modes, the dominant mode depends on the DM halo mass.

Temperature map:

massive halo @ z= 4,
$M_{halo} \approx 3 \times 10^{11} M_{\odot}$

massive halo @ z= 9,
$M_{halo} \approx 2 \times 10^{10} M_{\odot}$

gas flow remains cold ($T<T_{vir}$)

Keres et al (2005); Dekel & Birnboim (2006)

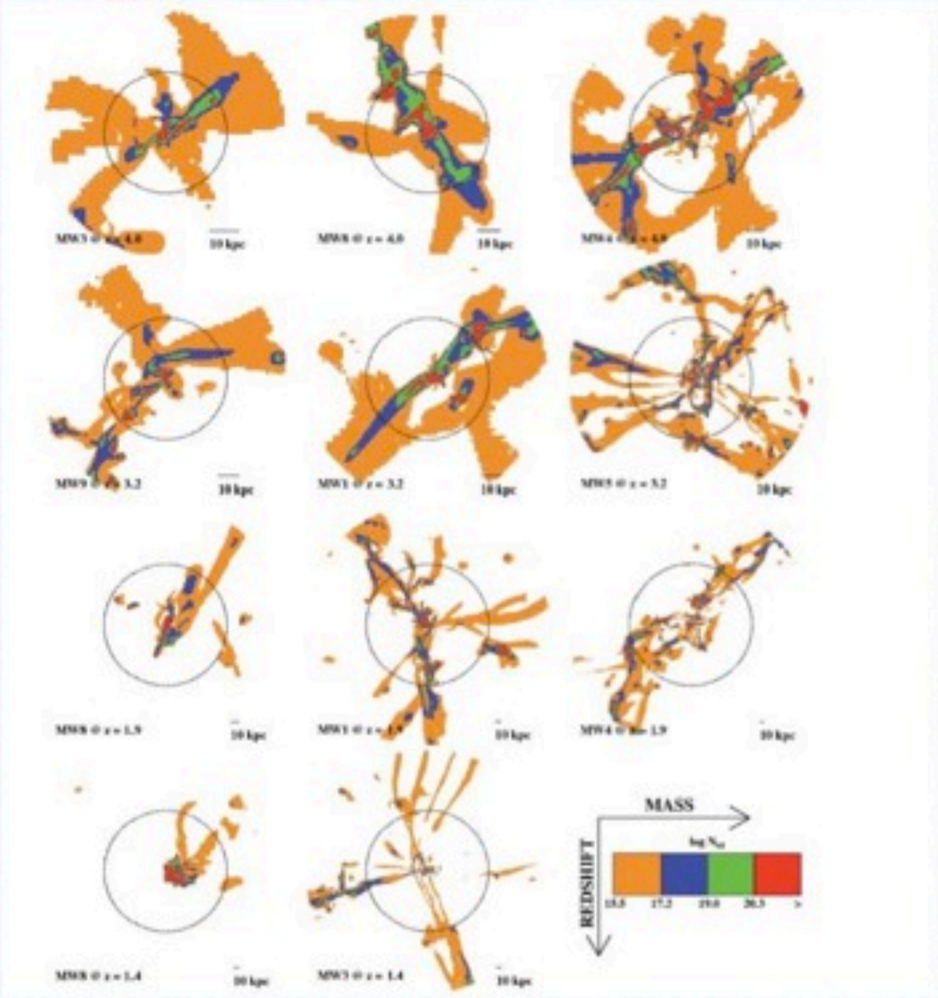
How can TMT help?

Wide-field optical+IRMS

- Direct resolved imaging of galaxies in groups on the cosmic web
  - Current images with 1'' imaging at z=3 corresponds to about 8 kpc and so does not resolve filament structure
  - Same resolution as 1'' at Coma is 0.05" at z=3
- Trace star formation and AGN in groups and on filaments in the redshift range z=2—3 from abs/em lines
  - H-alpha in the K-band, H-delta in the J-band,
  - At higher redshift, OIII and H-beta will be used
  - Need to resolve rotational velocities/velocity dispersions of 100 km/s for galaxies and velocity dispersions of 200 km/s for groups

Absorption-line systems

Fumagalli et al. (2011)



- Comparison of incidence of absorption line systems between the observed and simulated systems, show that cold streams can be responsible for 30% of ALS.

- The cold accretion streams have column densities of $N(HI) = 10^{19} - 10^{20}\ cm^{-2}$

- The cold accretion streams have covering factors of $f = 4 - 40\%$

- Simulations with predictions for detectability, expected column densities, metallicities: *Fumagalli et al (2011); Goerdt et al. (2012); Stewart et al. (2011)*

How can TMT help?

Wide-field optical+IRMS

- Direct resolved imaging of galaxies in groups on the cosmic web
  - Current images with 1'' imaging at z=3 corresponds to about 10 kpc and so does not resolve filament structure
- Trace star formation and AGN in groups and on filaments in the redshift range z=2—3 from abs/em lines
- What fraction of absorption line systems are due to cold streams flowing along filaments? Can use galaxies as background sources instead of QSOs.