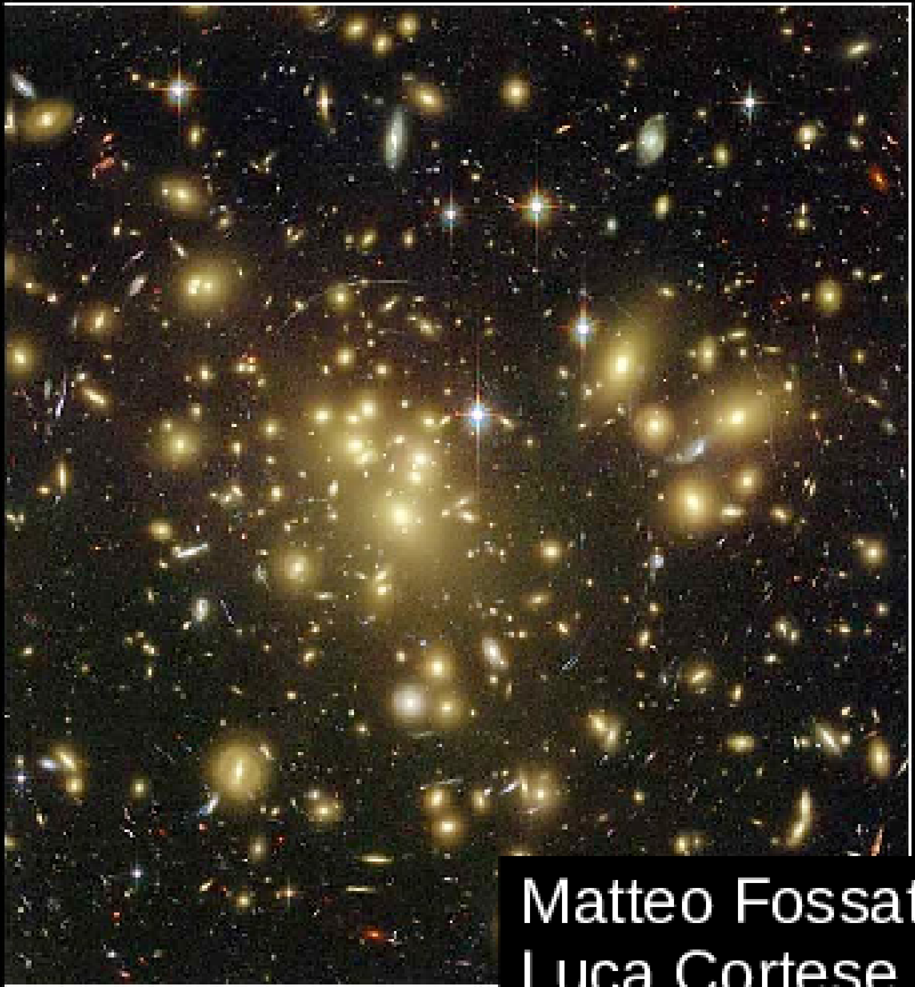
Galaxy Evolution in Groups and Clusters at 'low' Redshift: Observational Review

Hubble Ultra Deep Field
Hubble Space Telescope ▪ Advanced Camera for Surveys

NASA, ESA, S. Beckwith (STScI) and the HUDF Team STScI-PRC04-07a

Galaxy Cluster Abell 1689 HST ▪ ACS



NASA, N. Benitez (JHU), T. Broadhurst (Hebrew M. Clampin (STScI), G. Hartig (STScI), G. Illingw the ACS Science Team and ESA

Matteo Fossati
Luca Cortese
Bernd Vollmer
Eric Peng
Reynier Peletier

1. Introduction

2. Observations of Transformation Processes in the Nearby Universe
   B. Vollmer

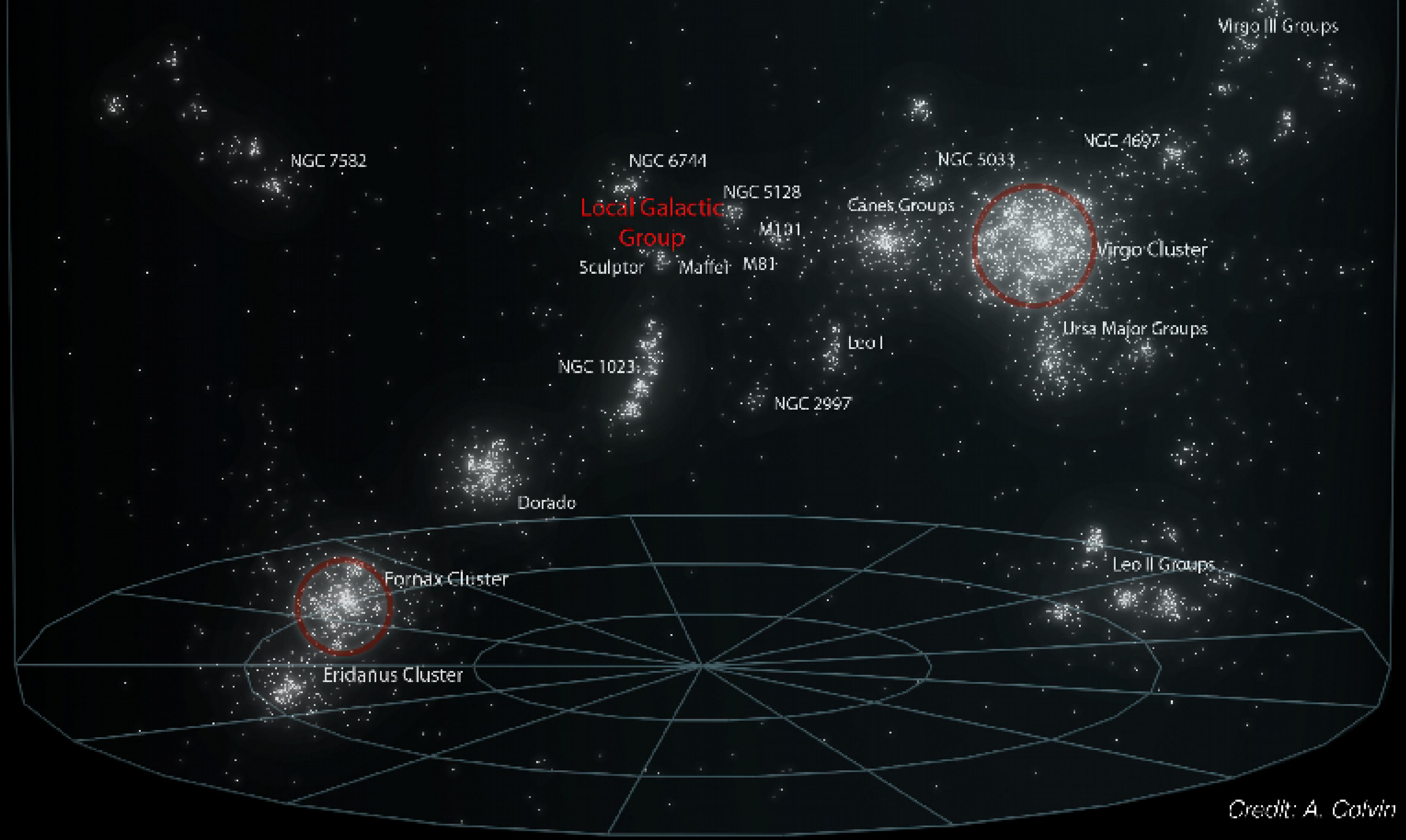
3. Cold Atomic and Molecular Hydrogen across Environments
   L. Cortese

4. Galaxy Properties in the Nearby Universe showing the Effects of the Environment
   R. Peletier

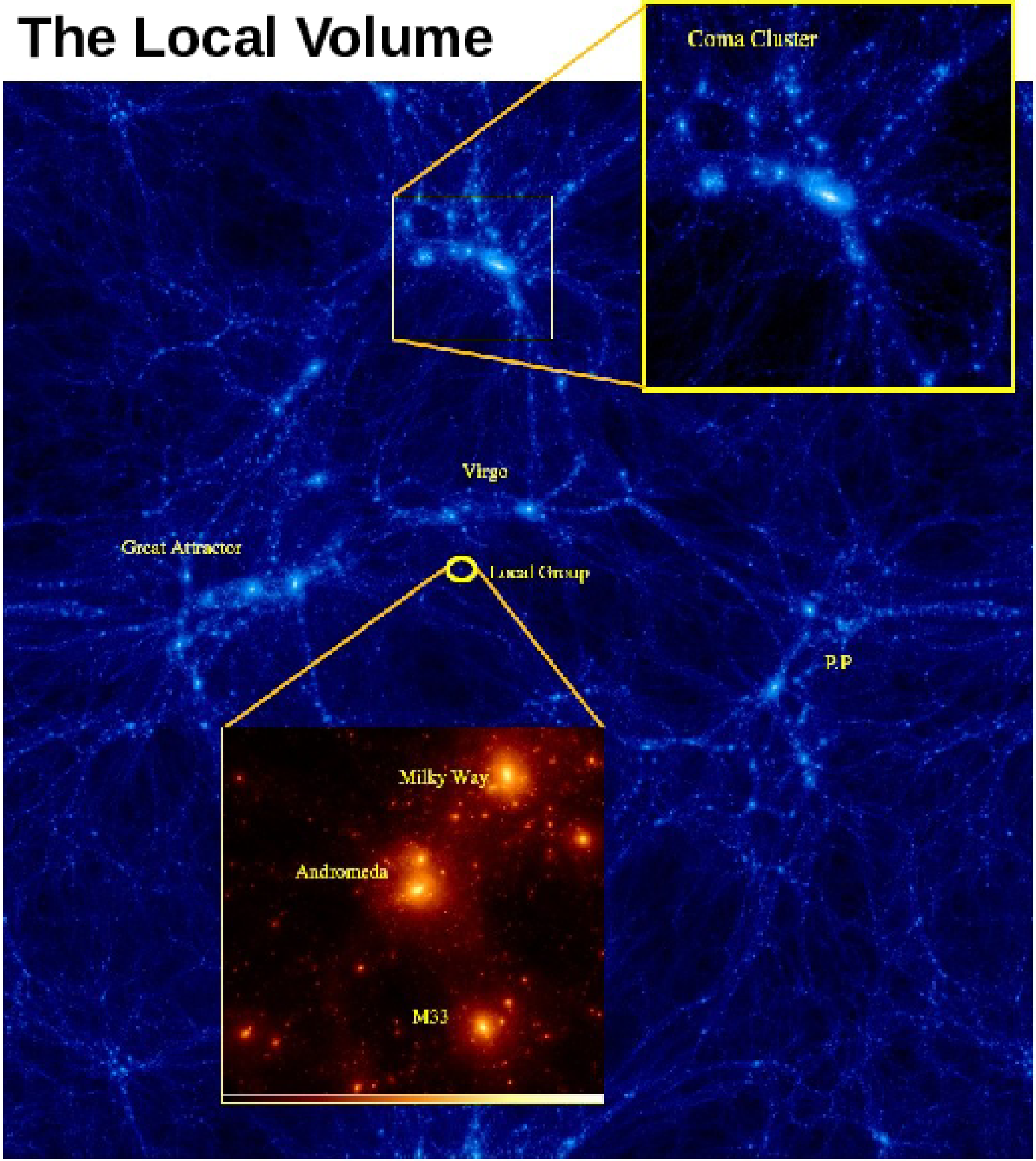
5. Compact Stellar Systems in the Nearby Universe
   E. Peng

6. Environmental Transformations at Early Cosmic Times
   M. Fossati

The Local Neighborhood
(i.e., what we have to work with)



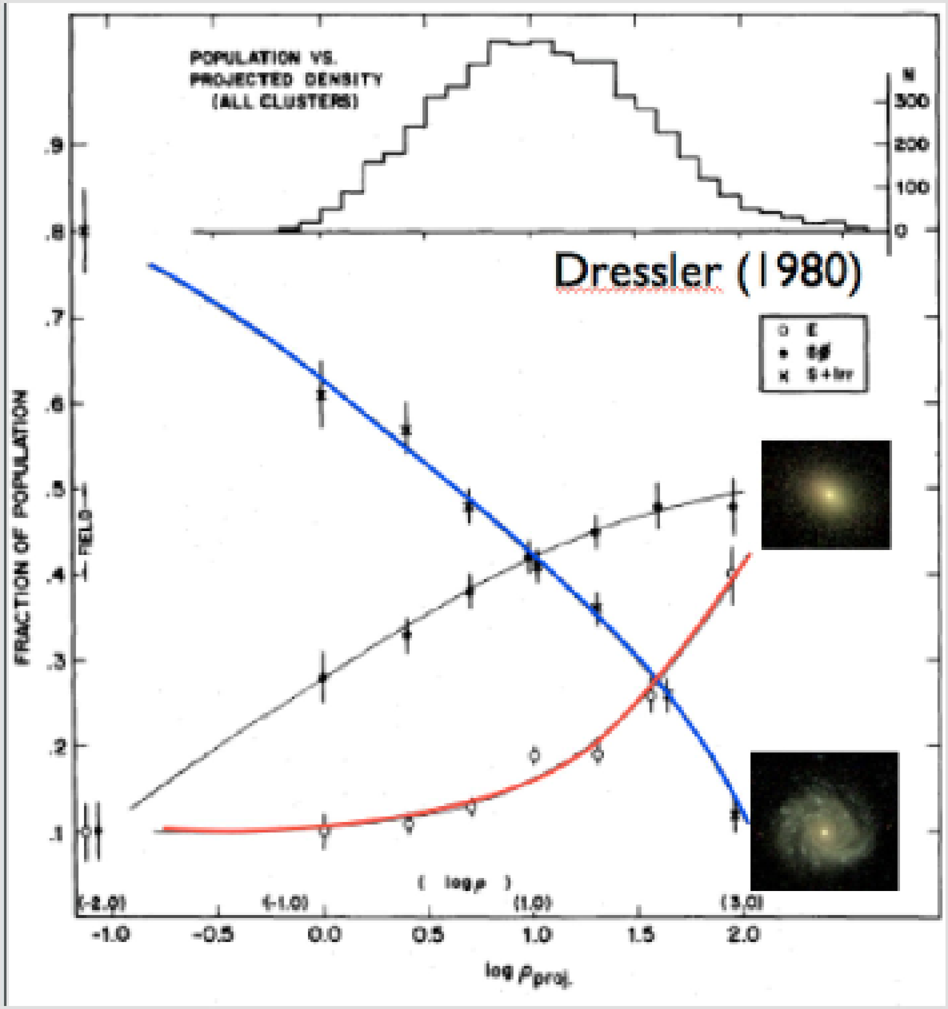
The Local Volume



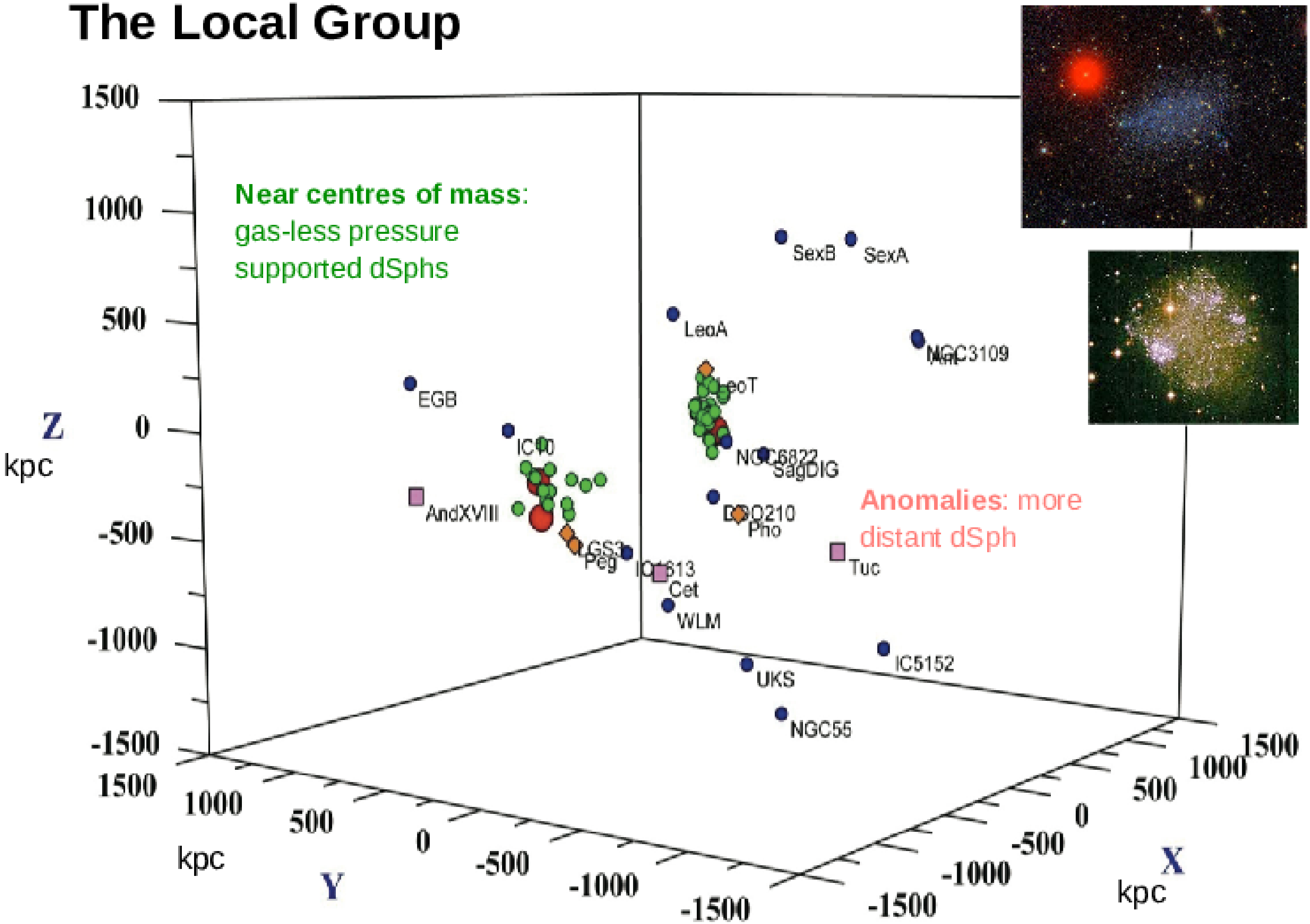
Environment effects galaxy evolution

- Galaxies in dense environments are much more likely to be quenched than their field counterparts.
- Suggests that environment must have a strong effect on the gas content of galaxies

→ How? When? Why?



The Local Group



Near centres of mass: gas-less pressure supported dSphs

Anomalies: more distant dSph

Outer regions: dominated by gas rich quiescently evolving dwarf irregulars

Mateo 2008, Garching workshop

dE's: Strong Dependence of Properties on Environment

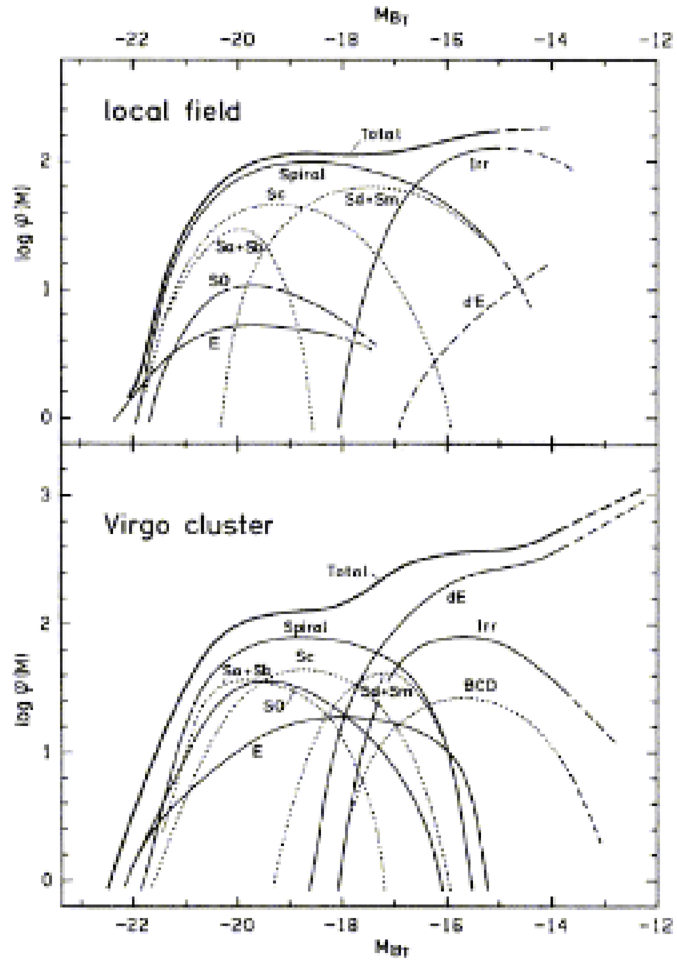
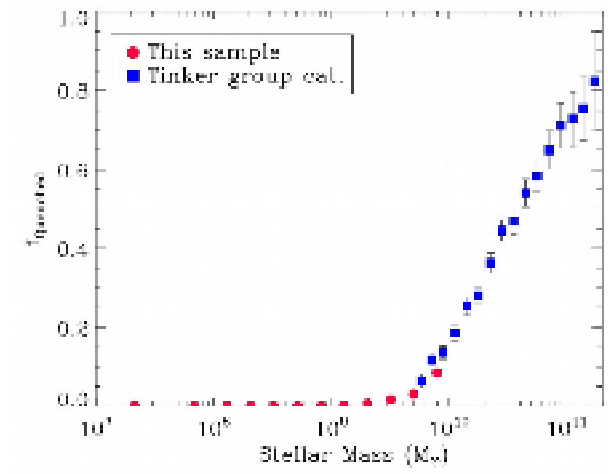
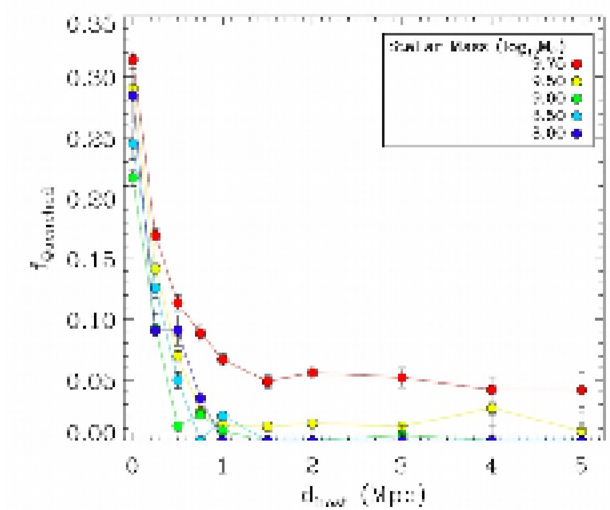


Figure 1 The LF of field galaxies (top) and Virgo cluster members (bottom). The zero point of log φ(M) is arbitrary. The LFs for individual galaxy types are shown. Extrapolations are marked by dashed lines. In addition to the LF of all spirals, the LFs of the subtypes Sa+Sb, Sc, and Sd+Sm are also shown as dotted curves. The LF of Irr galaxies comprises the Im and BCD galaxies; in the case of the Virgo cluster, the BCDs are also shown separately. The classes dS0 and "dE or Irr" are not illustrated. They are, however, included in the total LF over all types (heavy line).

Binggeli et al. 1988





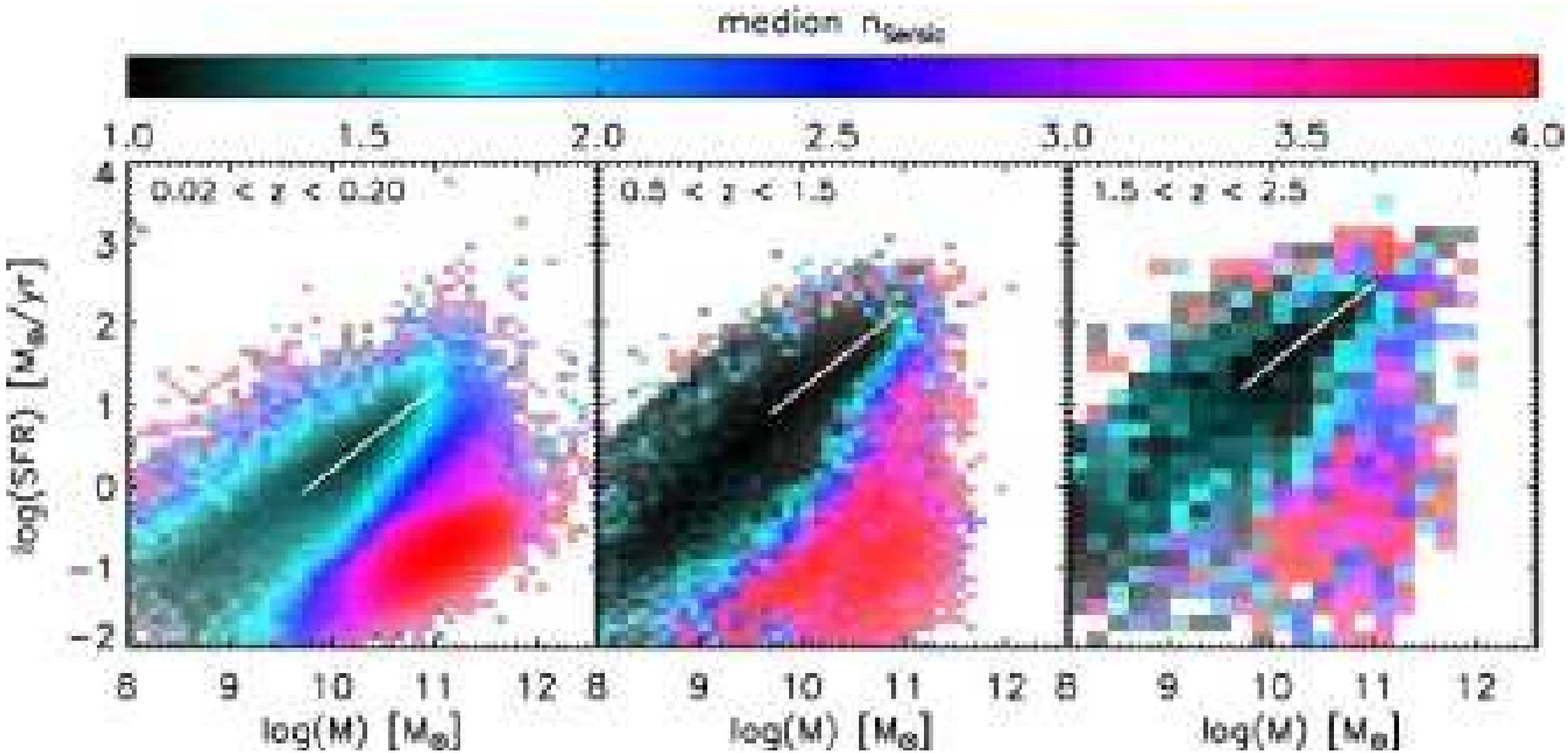
(Geha et al. 2012; NASA-SDSS Atlas)

NO quenched dwarfs in the field!

Observations of Transformation Processes in the Nearby Universe

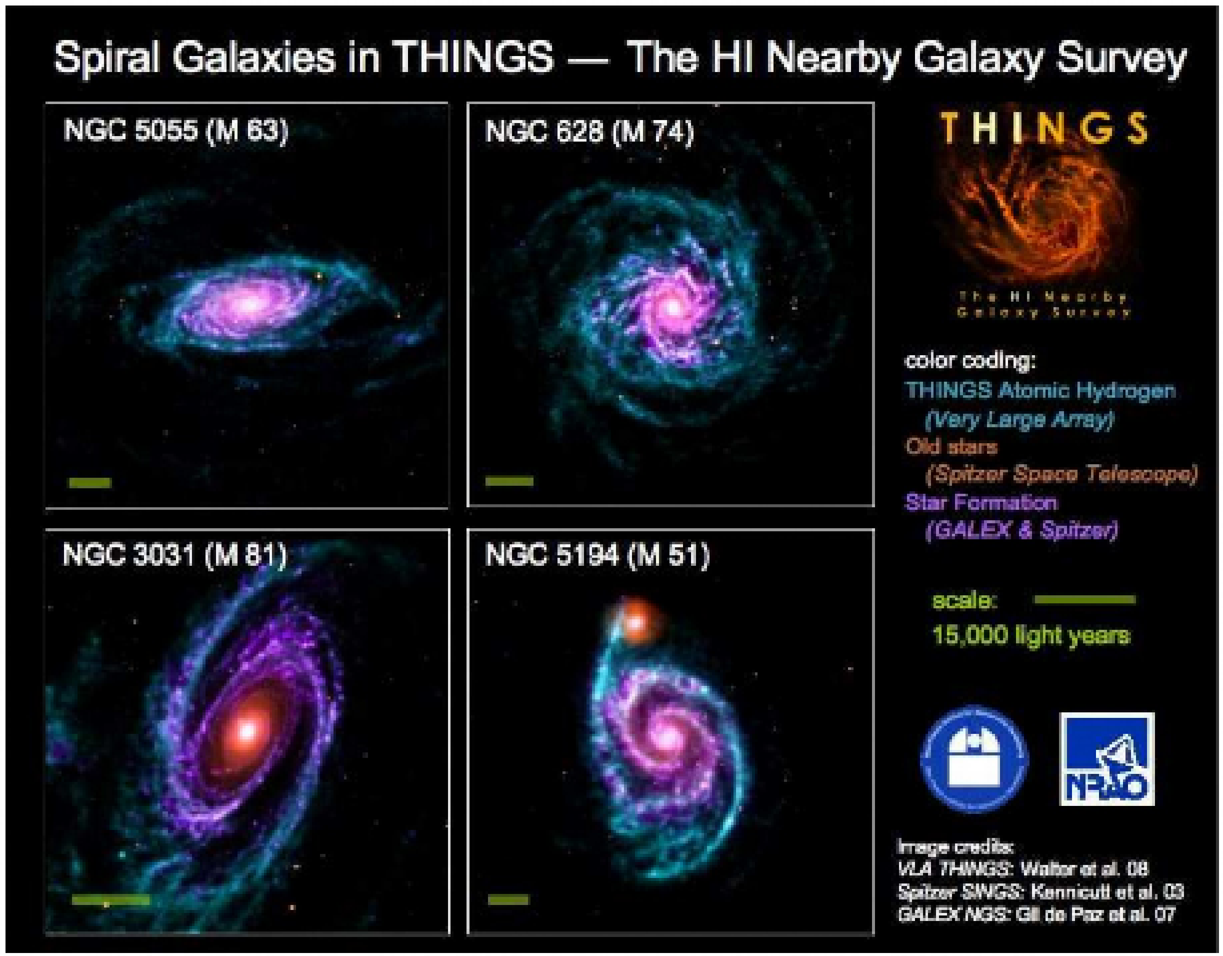
Bernd Vollmer

Galaxy evolution/transformation



Wuyts et al. (2011)

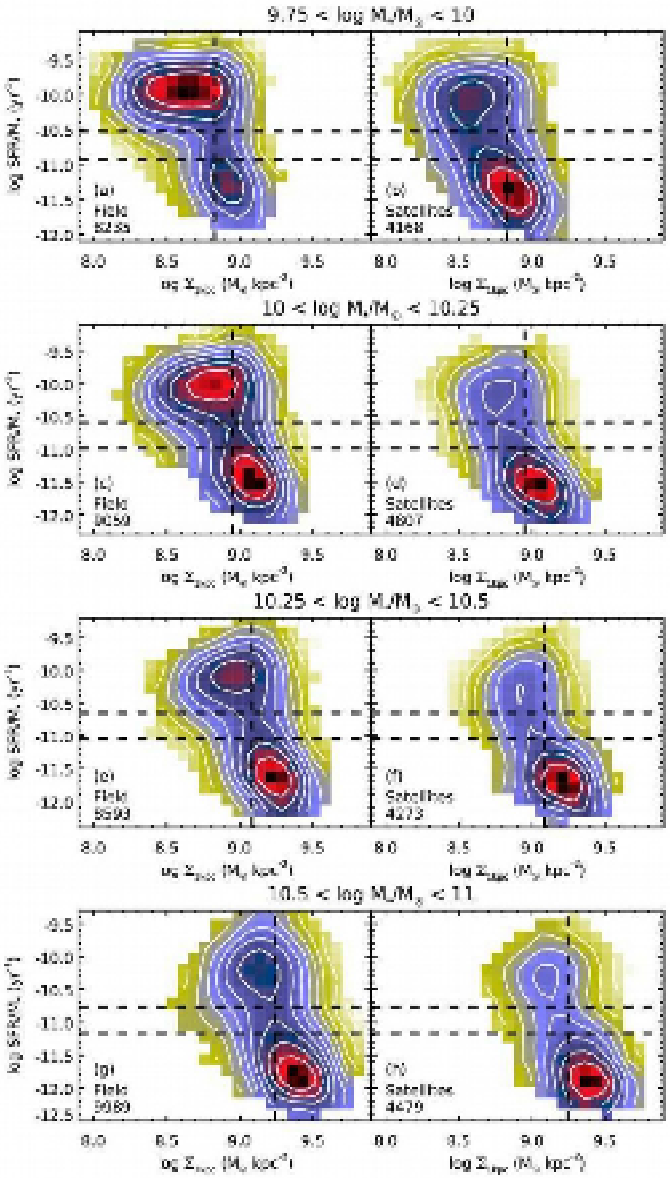
Galaxies are all different



Quiescence

SDSS

- Quiescence: colors, SFR (distance from MS), or SSFR=SFR/M?
- Sersic index – surface density within the inner kpc
- Field – groups
- Minimum interpretation: Galaxies have piled up mass in the inner kpc before halting SF

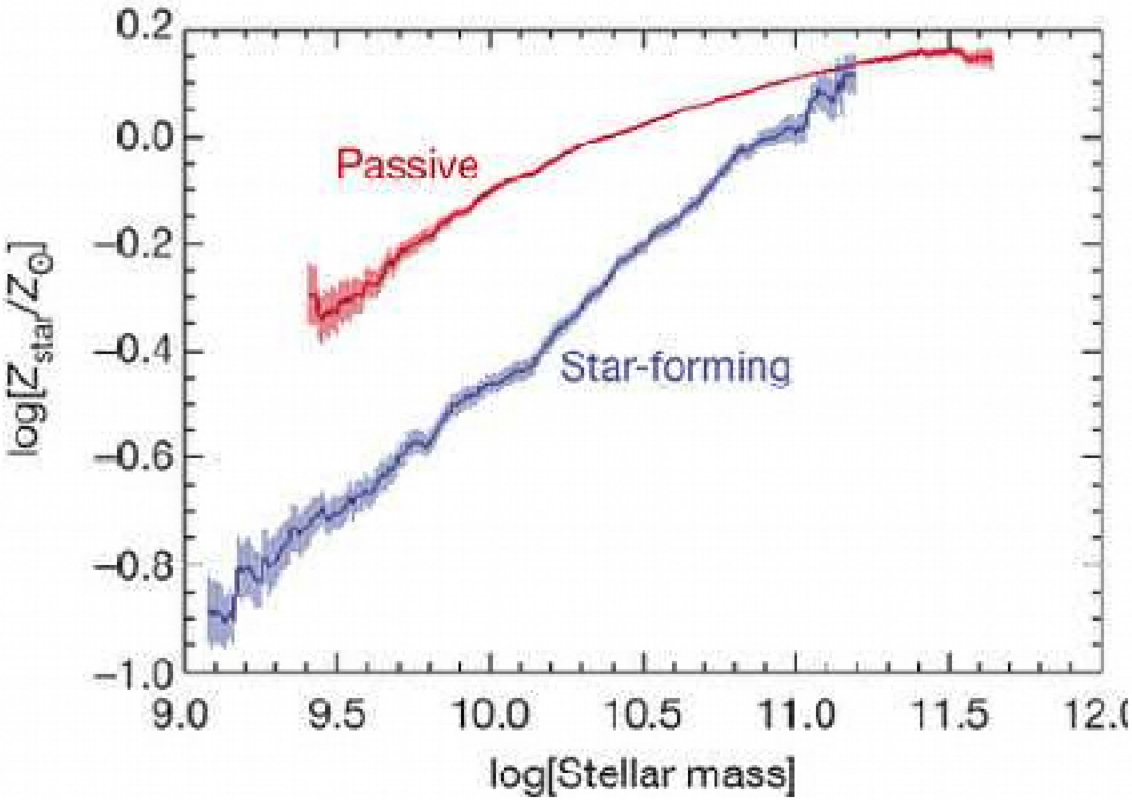


Woo et al. (2017)

Metallicity

SDSS

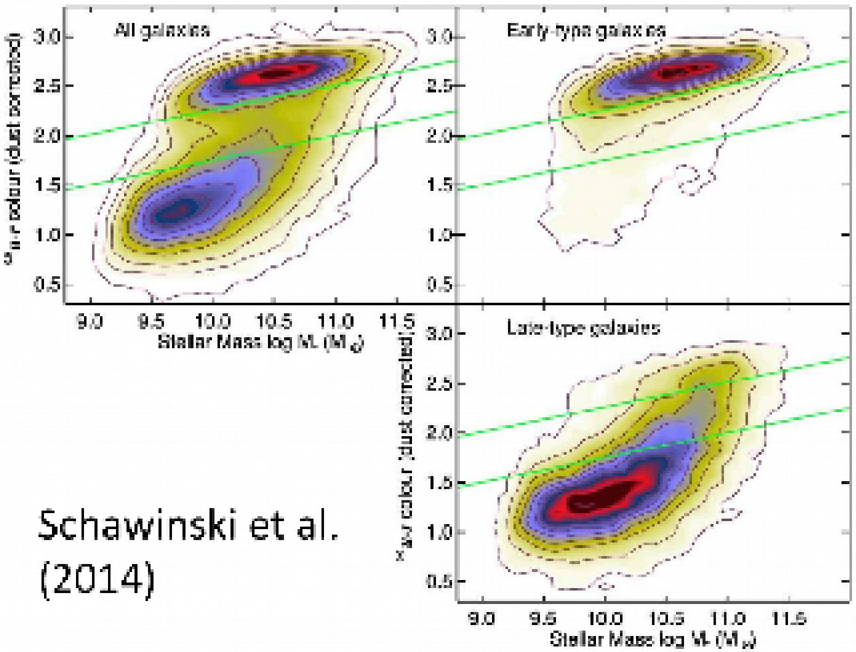
- Information on gas inflows and outflows
- Formation of passive/quiescent galaxies



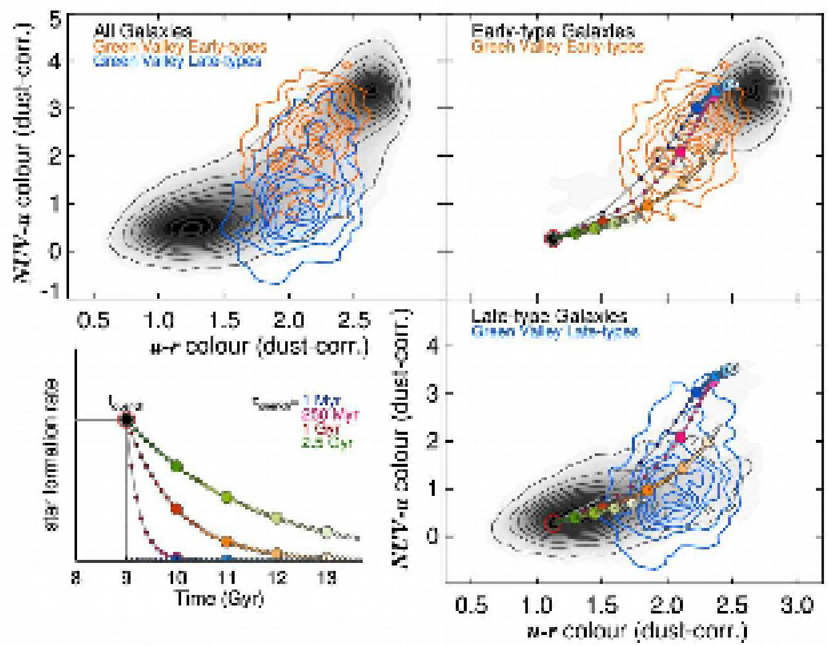
Peng et al. (2015)

Becoming quiescent

SDSS/GALEX

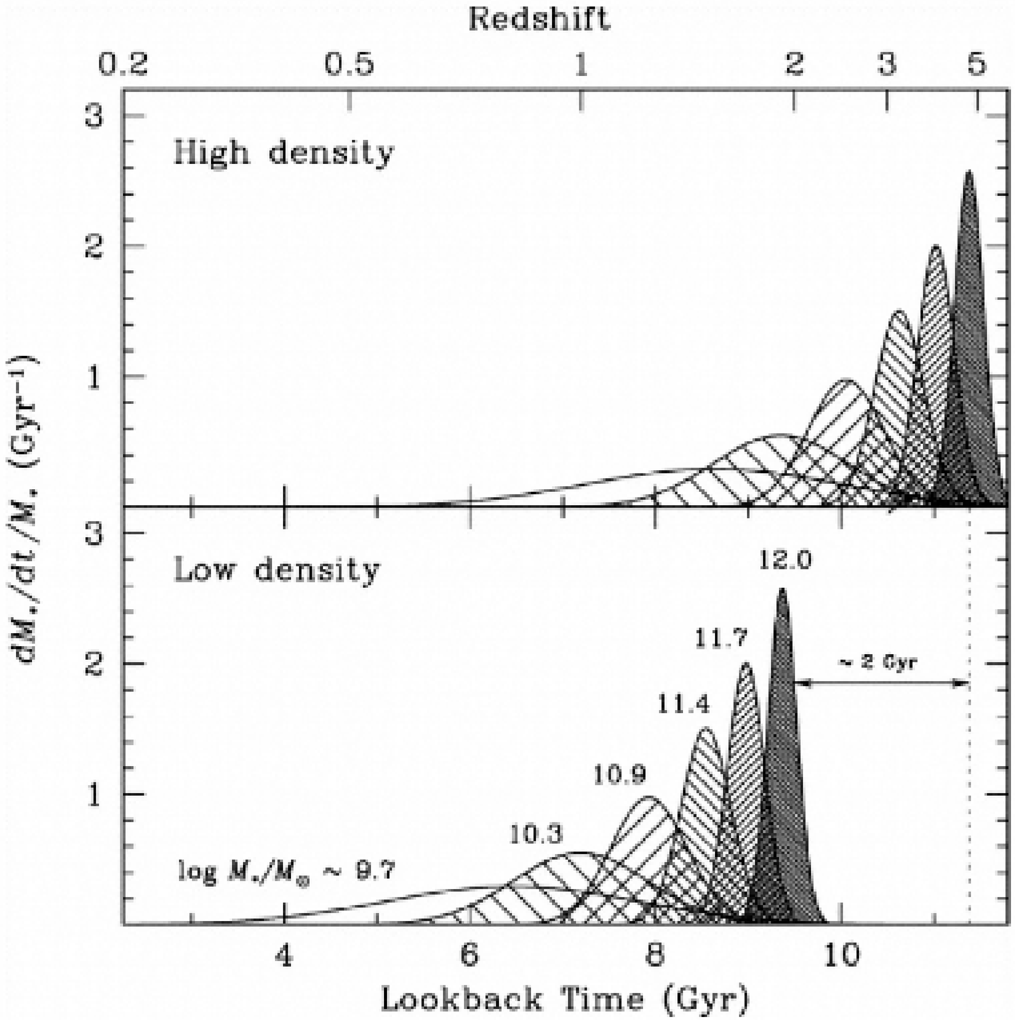


Schawinski et al. (2014)



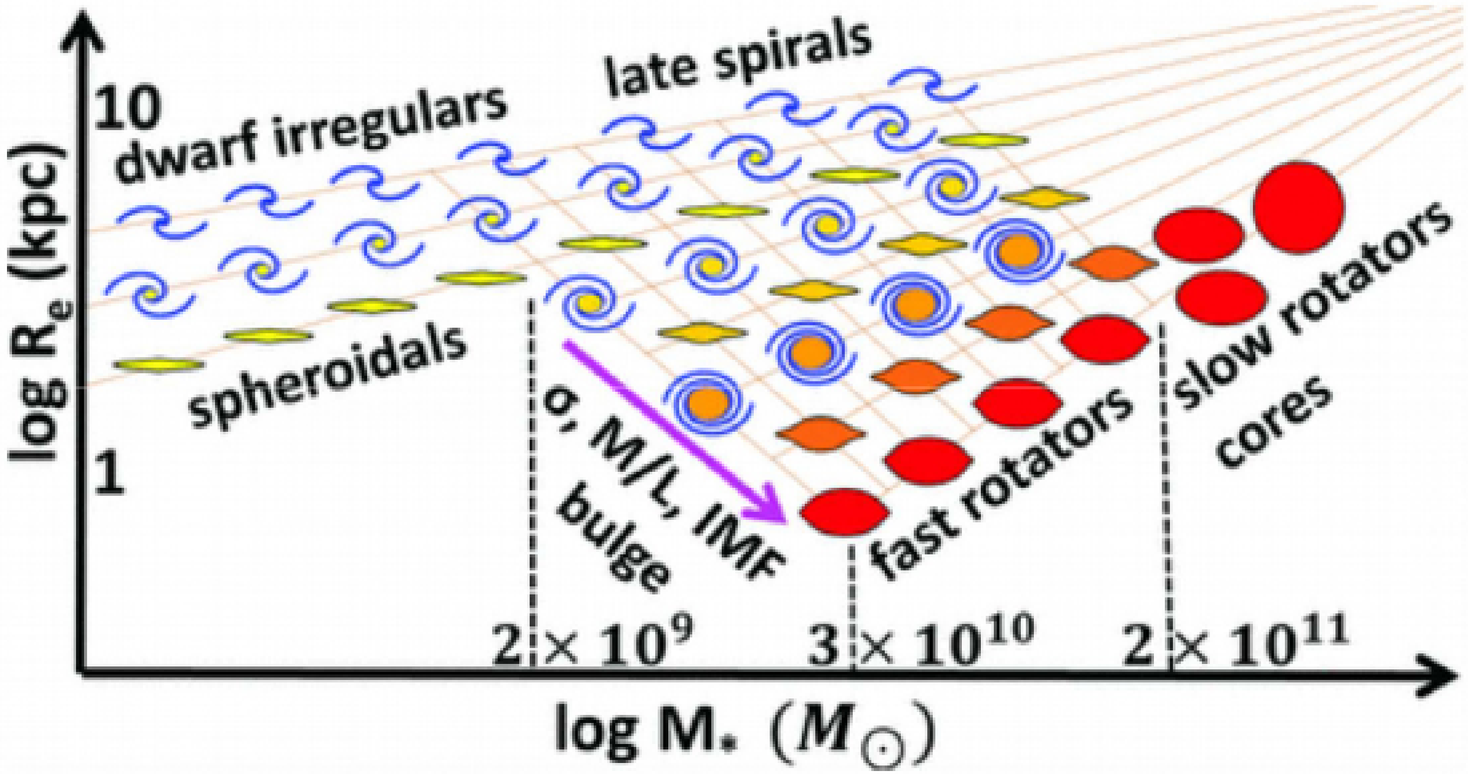
- Red sequence contains late-type galaxies
- Early-type galaxies: short quenching timescale ~250 Myr
- Late-type galaxies: long quenching timescale ~1 Gyr

Early type galaxies



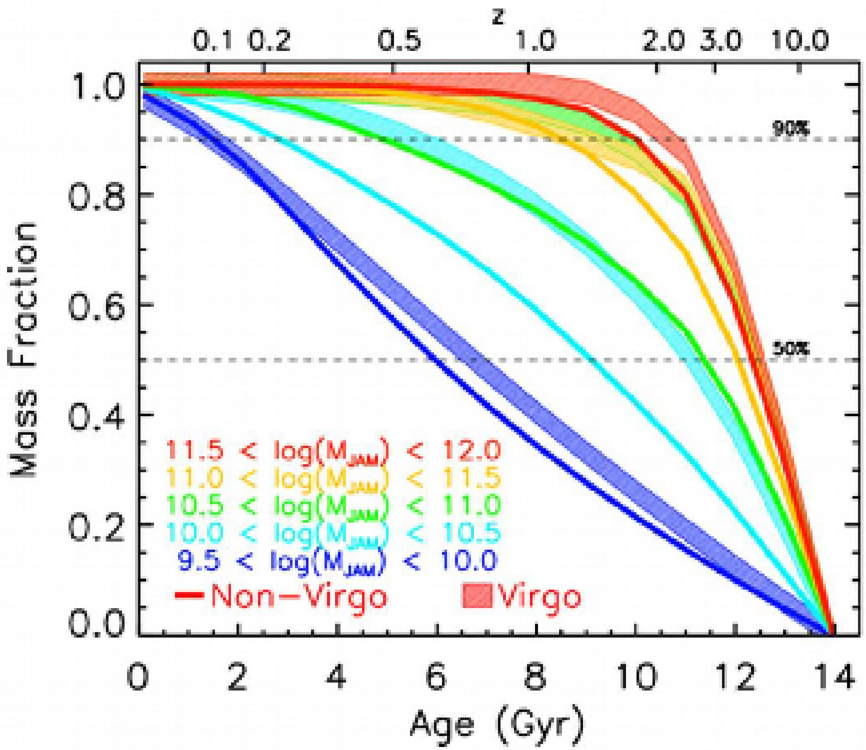
Thomas et al. (2005)

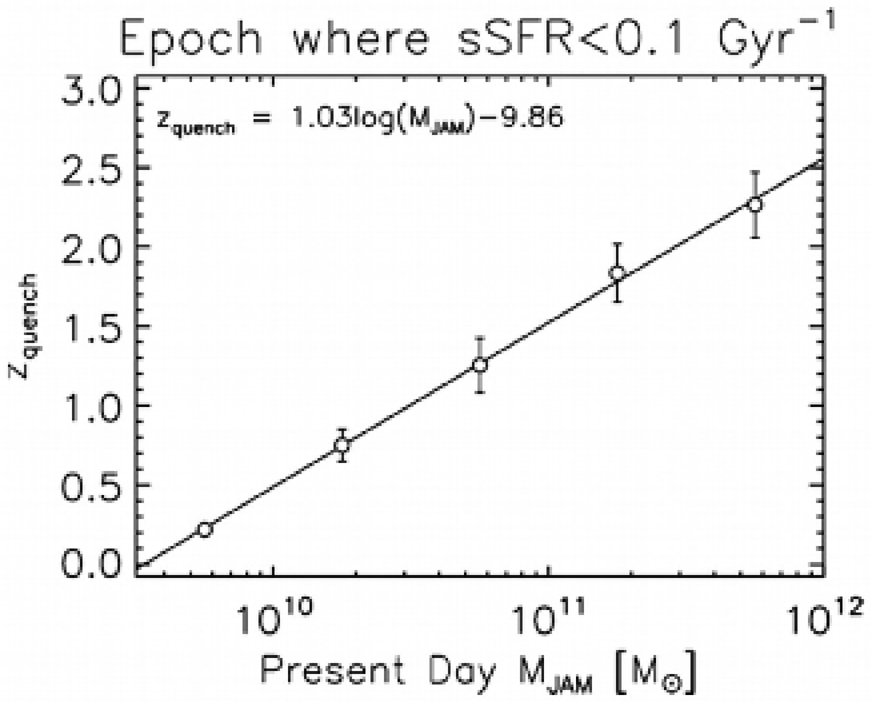
Early type galaxies



ATLAS3D Capellari et al. (2013)

Early type galaxies

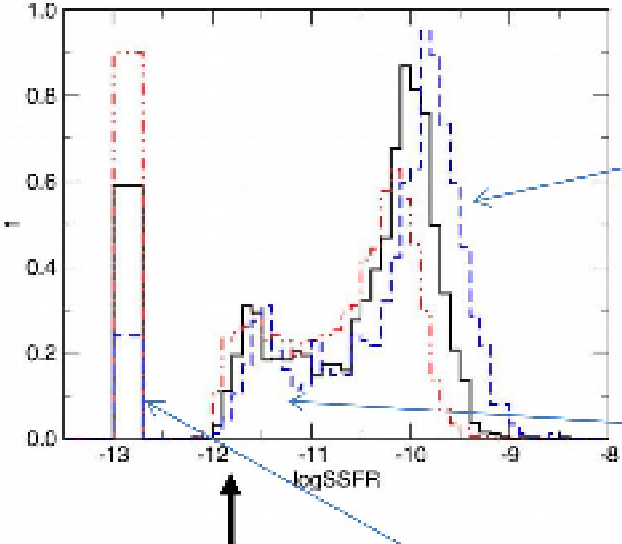


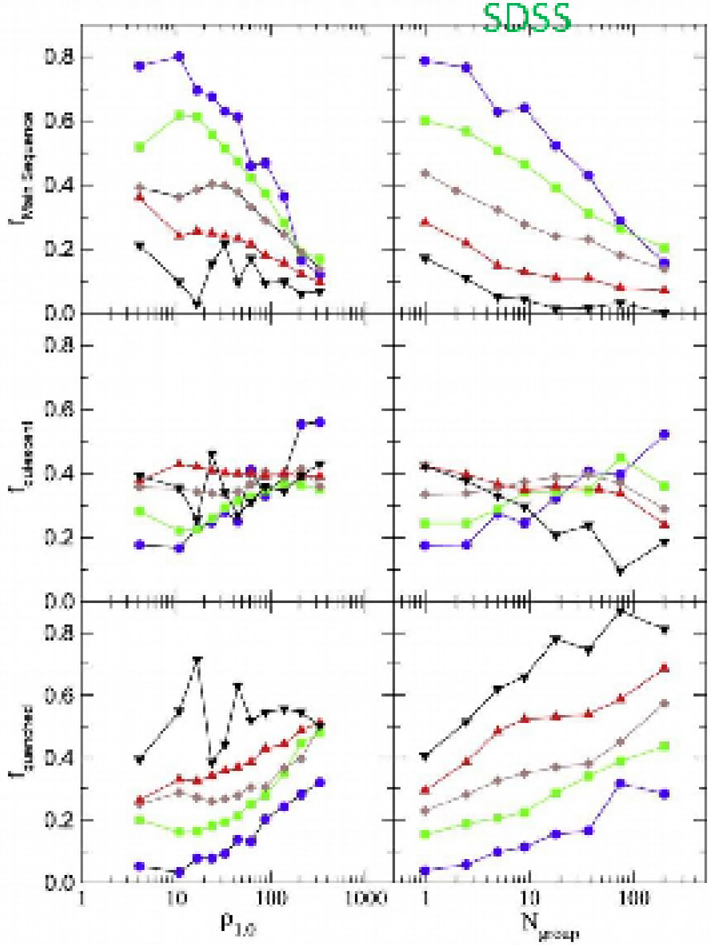


ATLAS3D McDermid et al. (2015)

Dependence on environment

Oemler et al. (2017)

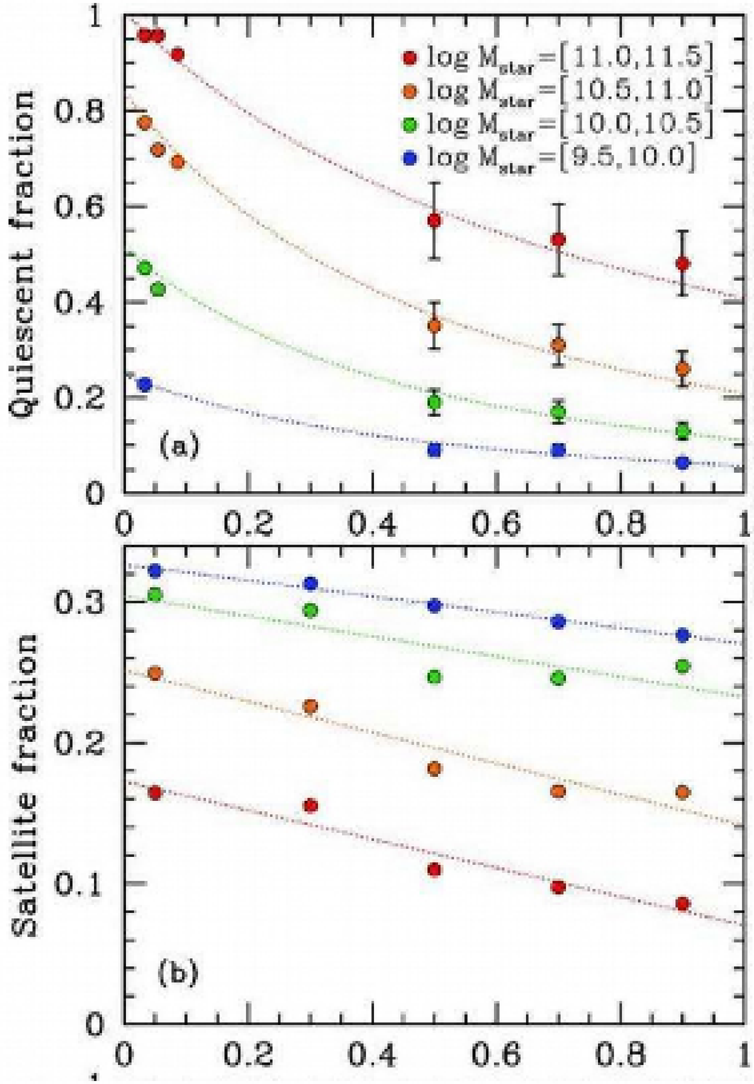


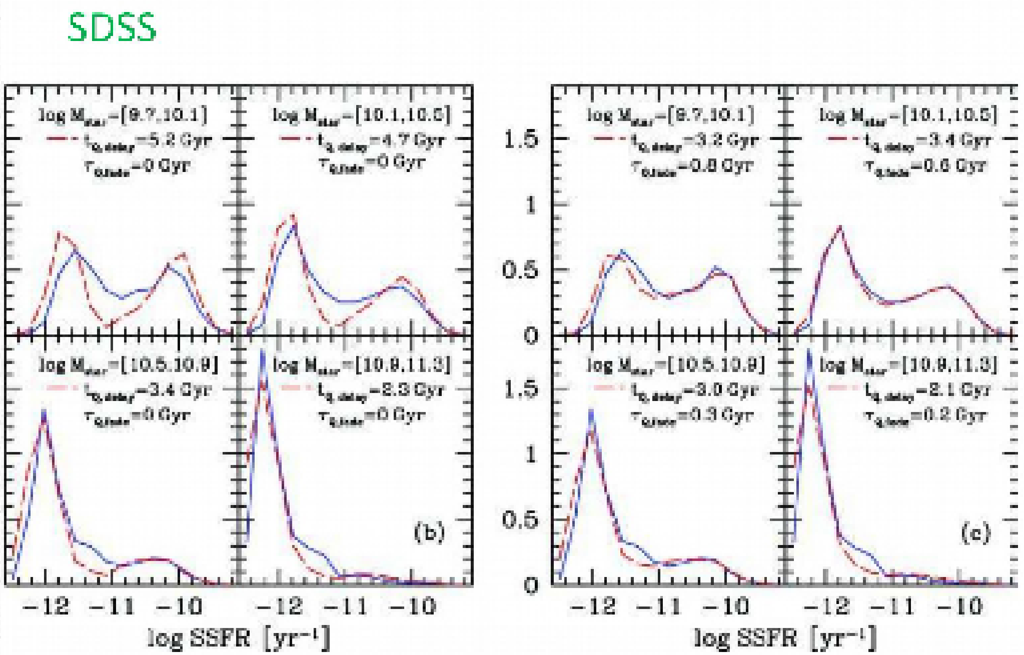


Dependance on mass and environment

Bernd Vollmer, Observatoire astronomique de Strasbourg, Ringberg 2017

Star formation quenching in groups



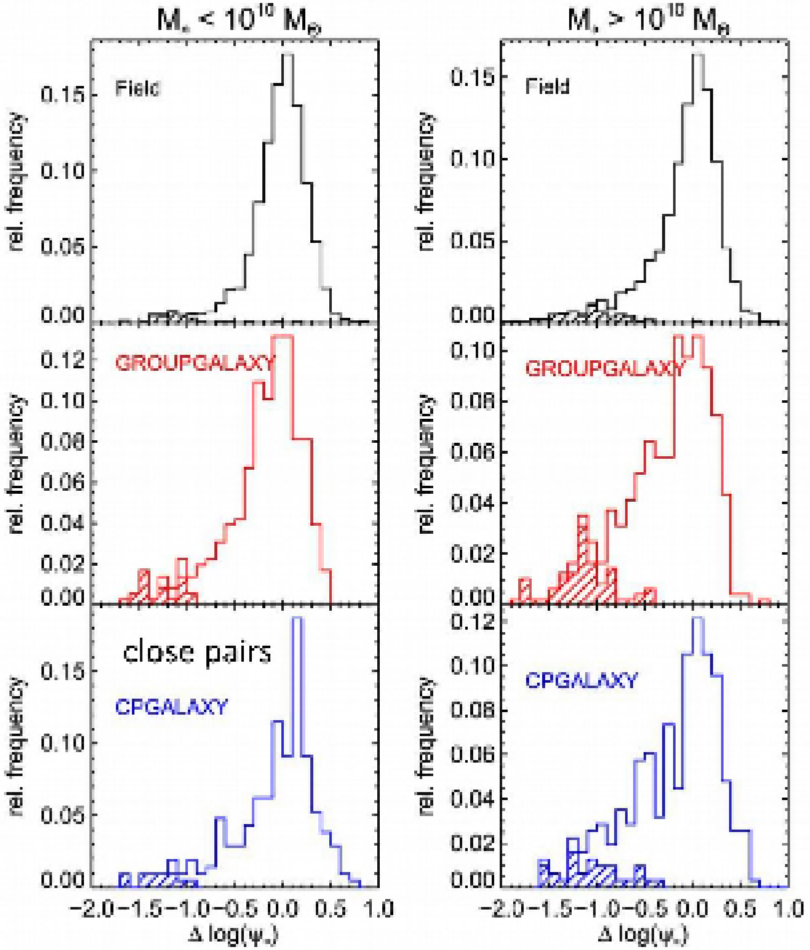


Wetzel et al. (2013)

- Delayed quenching in galaxy groups
- Quenching time ~4 Gyr = delay (~3.5 Myr) + fading (~0.5 Gyr)

Star formation quenching in groups

GAMA

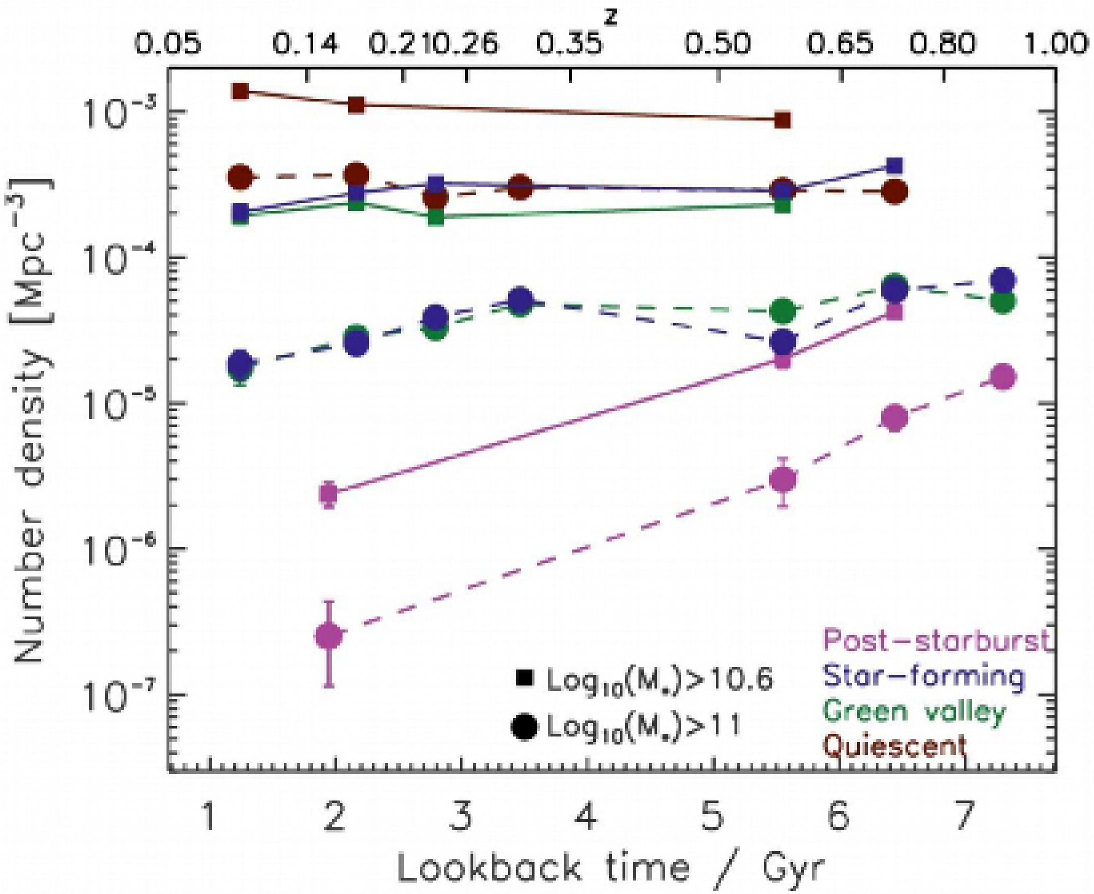


Grootes et al. (2017)

- SFR of the majority of group galaxies indistinguishable from that of field galaxies
- Small minority of strongly quenched satellites

Star formation quenching

GAMA Rowlands et al. (2018)

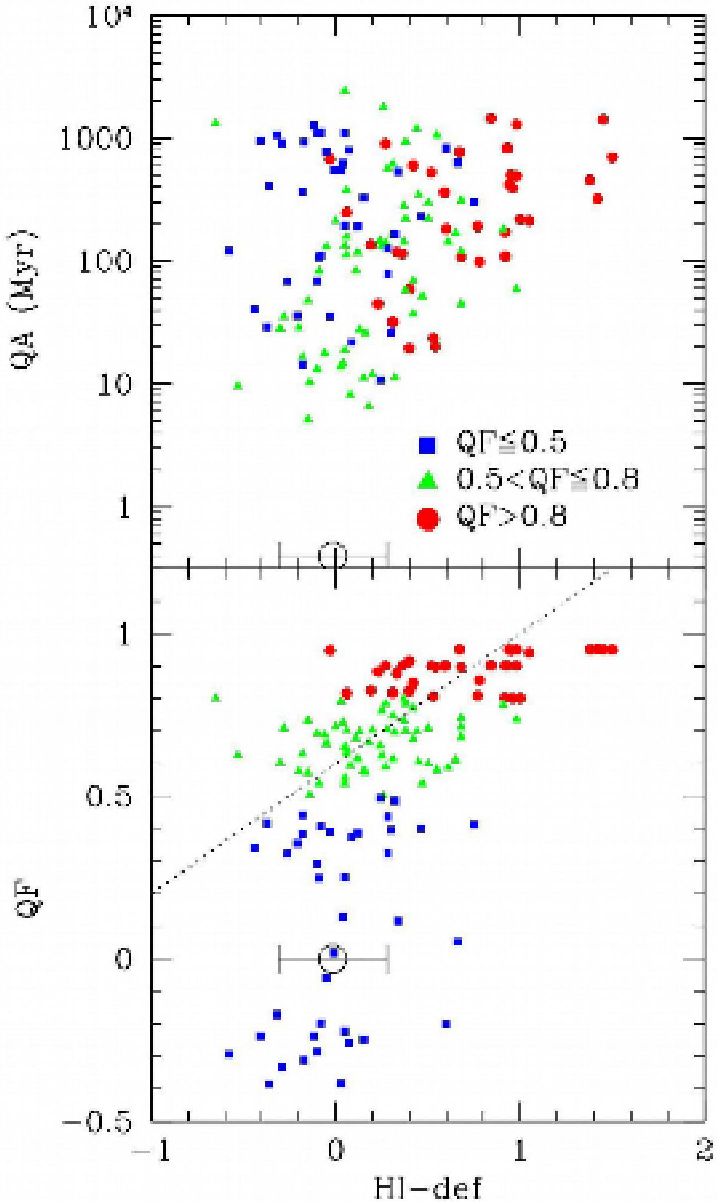


- the quiescent population grows in number and mass density more quickly for intermediate-mass

  (10.6 < logM <11)
- Green valley transition time ~2.6 Gyr
- Post starburst galaxies; transition timescale ~0.5 Gyr at z~0.7

Star formation quenching in the Virgo cluster

- if only those galaxies where *QA* is securely determined (*QF*> 0.5) are considered. The activity of star formation has been reduced ~1 Gyr ago in the most HI-deficient objects of the sample (*HI−def* ≳ 0.8).
- The typical quenching age of the perturbed late-type galaxies is *QA* ≲ 300 Myr whenever the activity of star formation is reduced by 50% < *QF* ≤ 80% and *QA* ≲ 500 Myr for *QF* > 80%, while that of the quiescent early-type objects is *QA* ≃ 1–3 Gyr.
- The fraction of late-type galaxies with a star formation activity reduced by *QF* > 80% and with an HI-deficiency parameter *HI−def* > 0.4 drops by a factor of ~5 from the inner half virial radius of the Virgo cluster ($R/R_{vir} < 0.5$), where the hot diffuse X-ray emitting gas of the cluster is located, to the outer regions ($R/R_{vir} > 4$).



Boselli et al. (2016)