

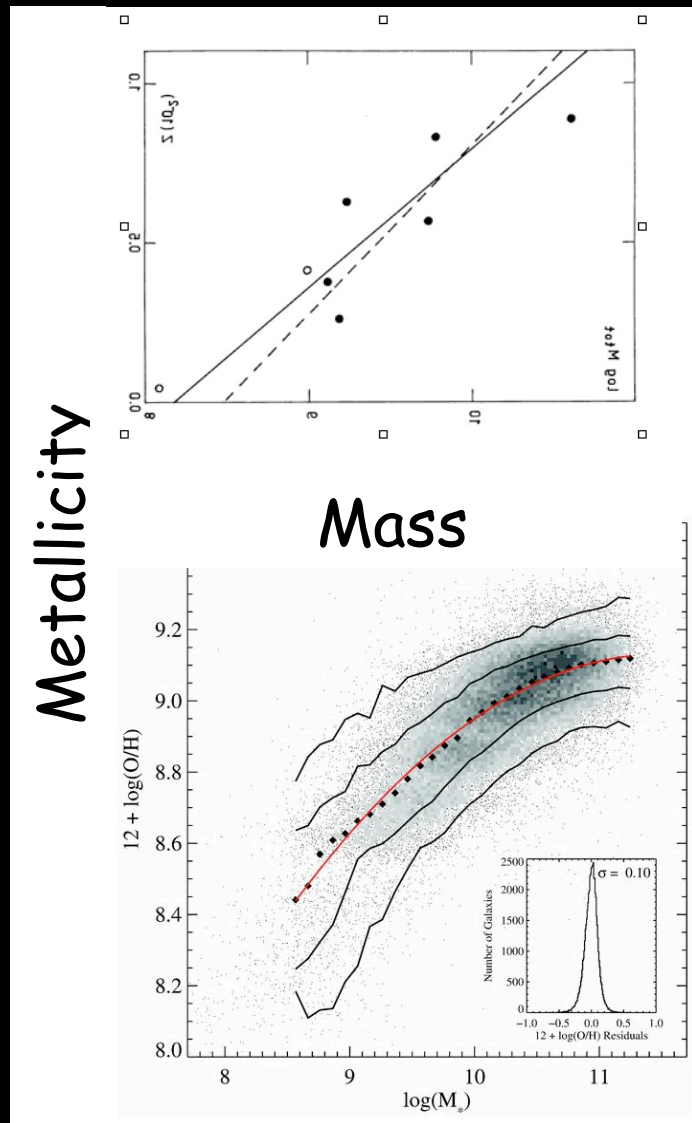
# The mass-metallicity relation and its dependence on environment.

Sara L. Ellison: University of Victoria

Dave Patton (Trent U.), Luc Simard (HIA),  
Alan McConnachie (HIA), Nick Cowan (UW),  
Ivan Baldry (LJM), Lisa Kewley (IfA).



# The mass- (gas) metallicity relation



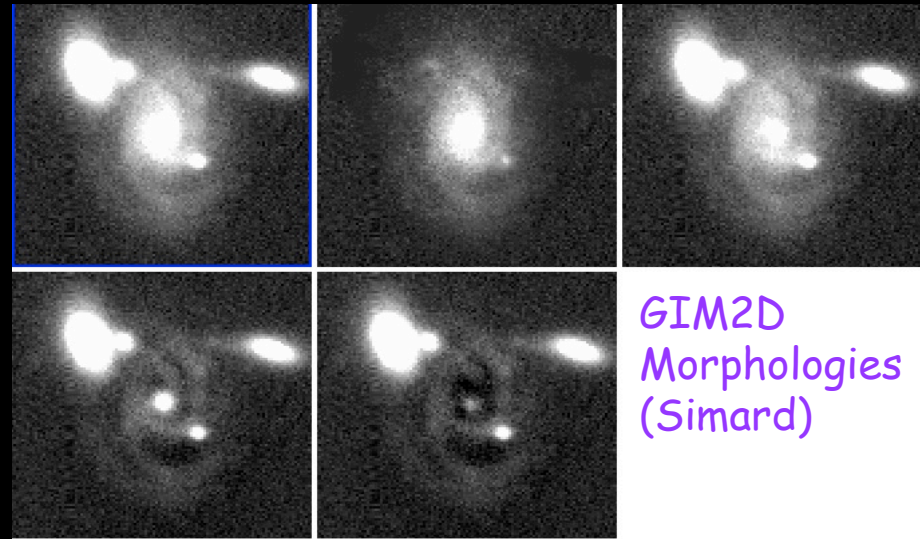
1979: Lequeux et al. sample  
calculated total masses from HI  
rotation curves of 8 irregular and  
blue compact galaxies

2004: Tremonti et al used  
stellar masses from SED fits

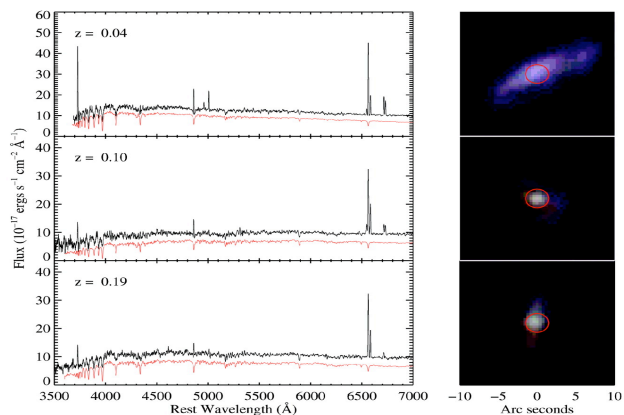
Scatter in the MZR is  $\sim 0.1$  dex,  
what is the cause of this scatter,  
and is some of it due to  
environment?

# The dataset and tools of the trade

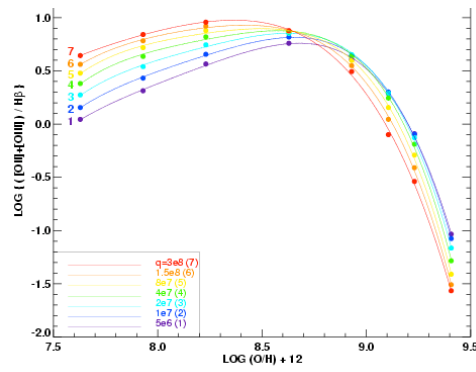
~ half a million galaxies  
in the SDSS DR4:  
stellar masses,  
metallicities, SFRs,  
colours, bulge  
fractions, asymmetries  
and local densities.



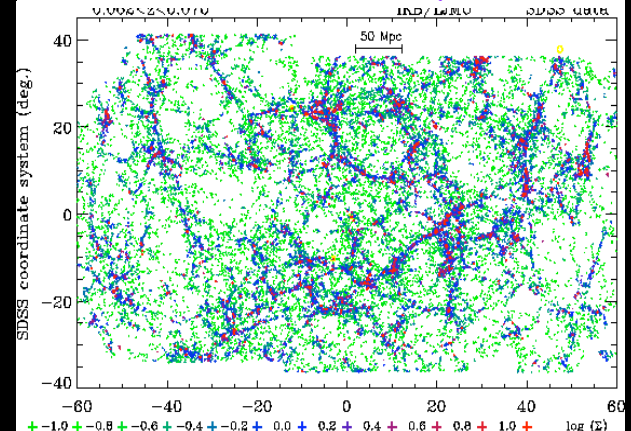
## Masses, SFRs ...: Munich



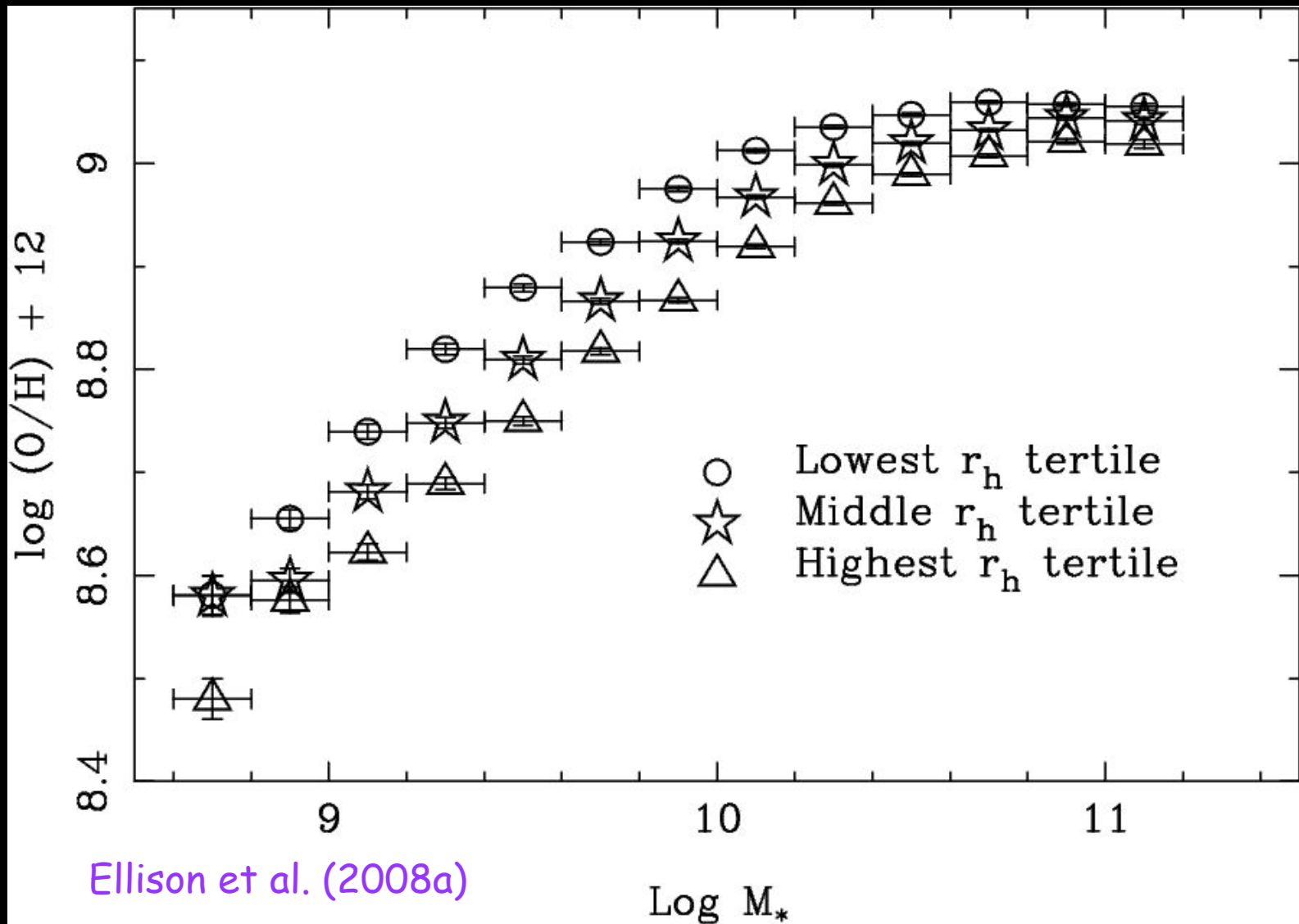
## Metallicities: Kewley/ Ellison



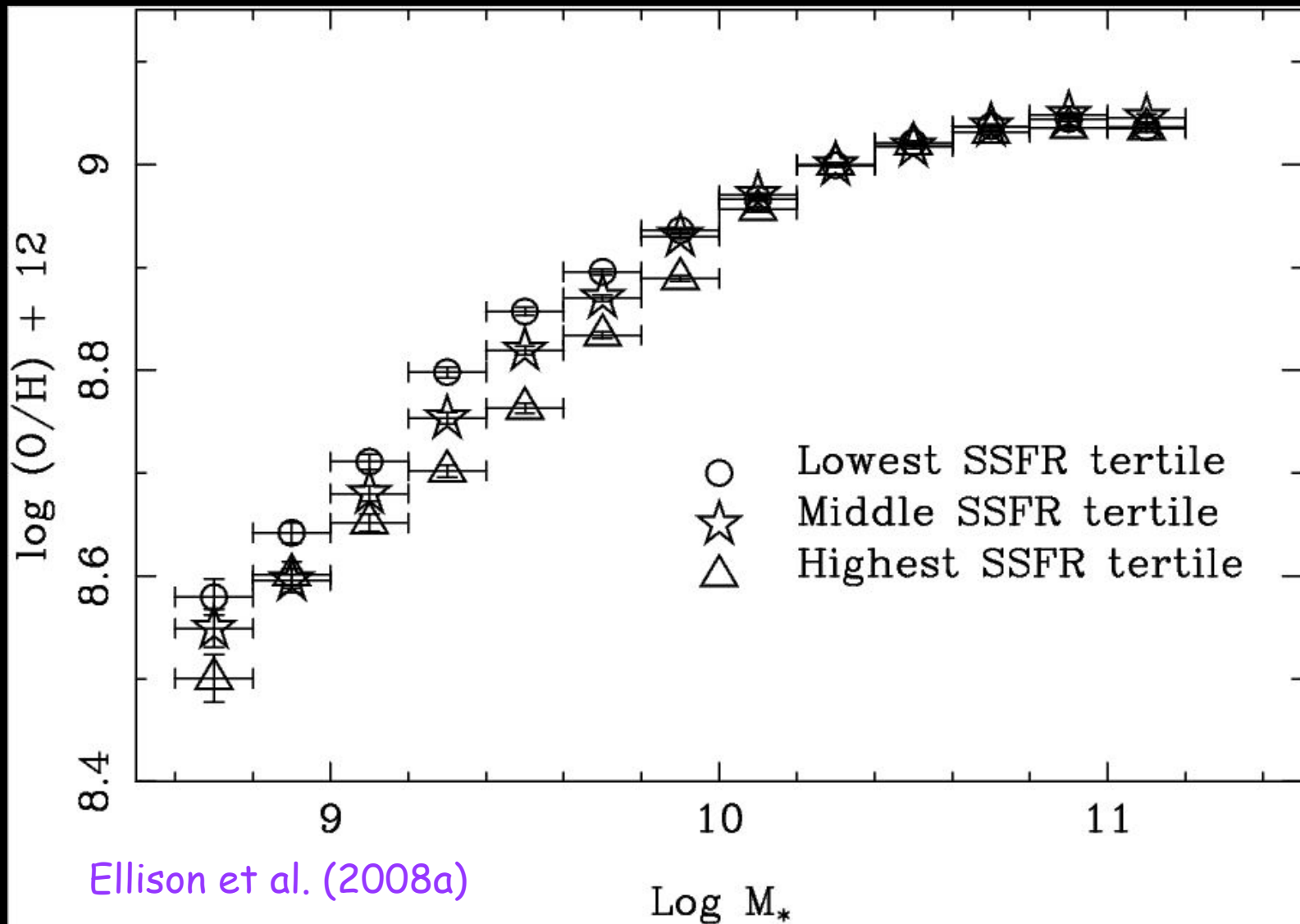
## Environments: Baldry/Cowan



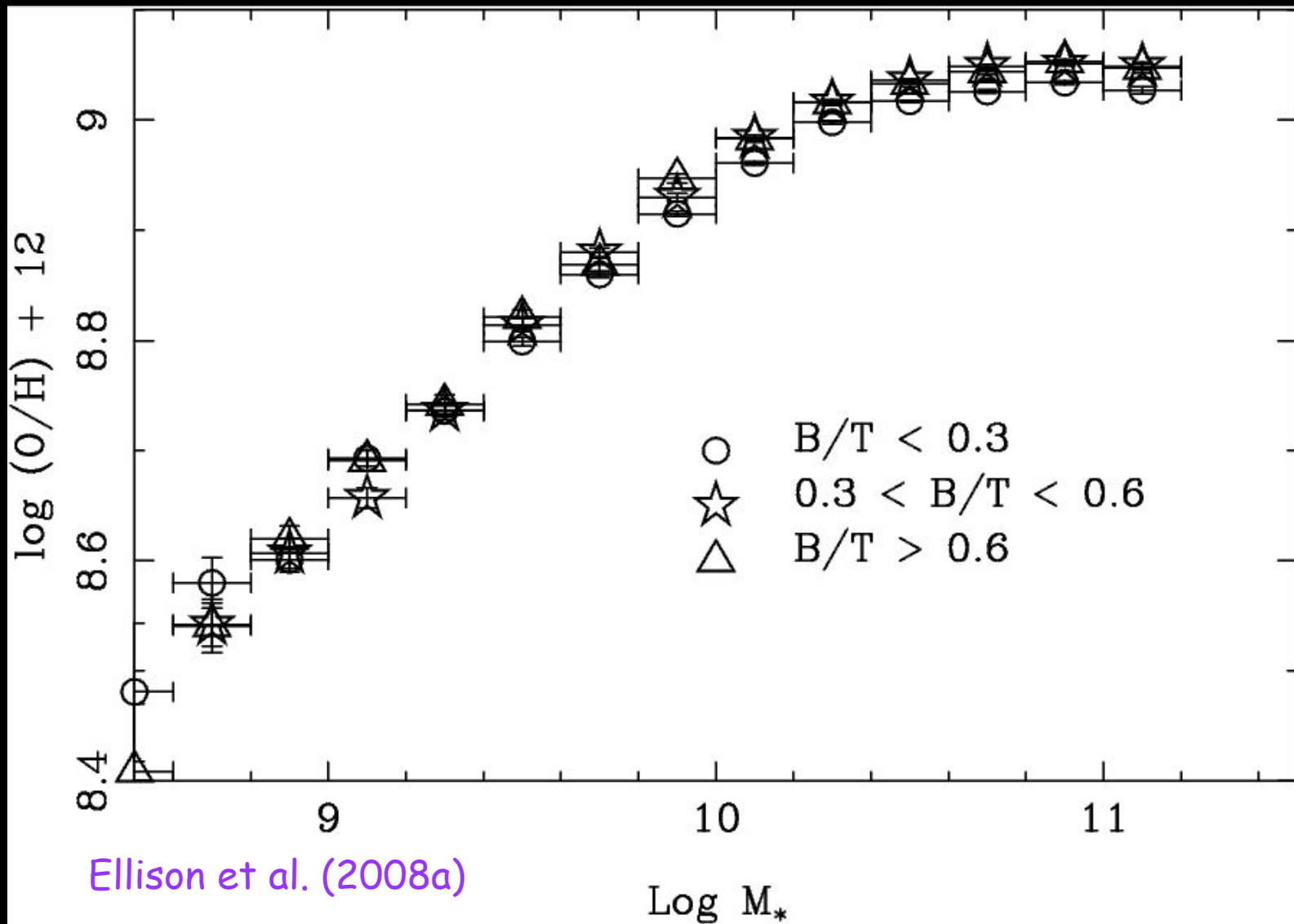
## Dependence of the MZR on galaxy properties: optical size



## Dependence of the MZR on galaxy properties: specific SFR



# Dependence of the MZR on galaxy properties: bulge fraction





# The environment hierarchy

Galaxy pairs - probe effects of individual mergers



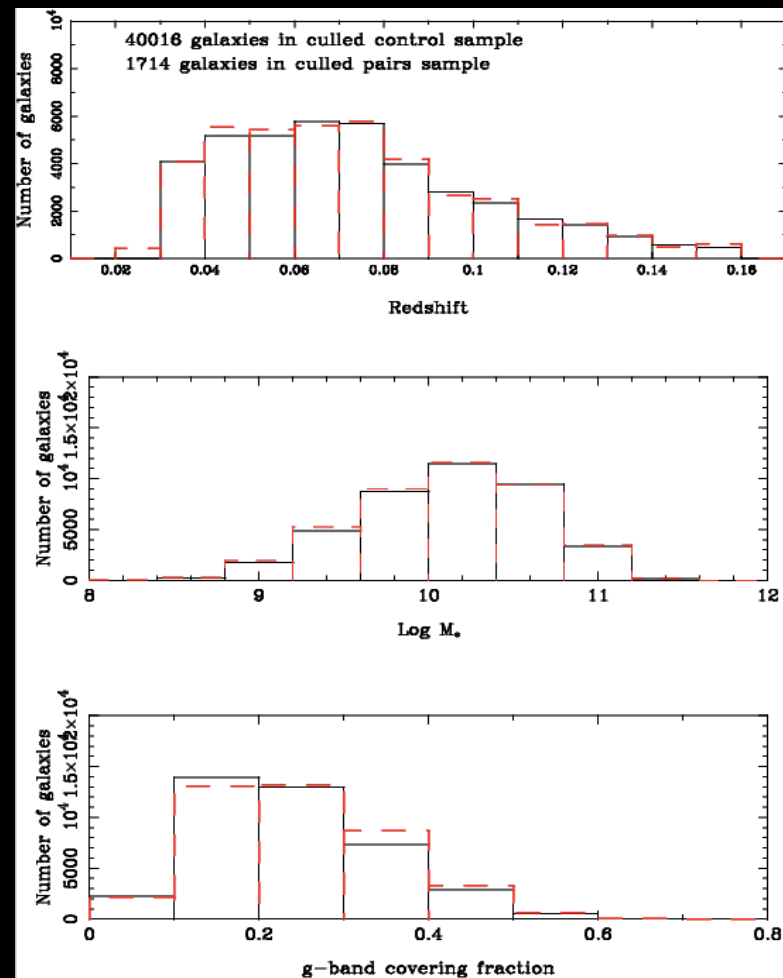
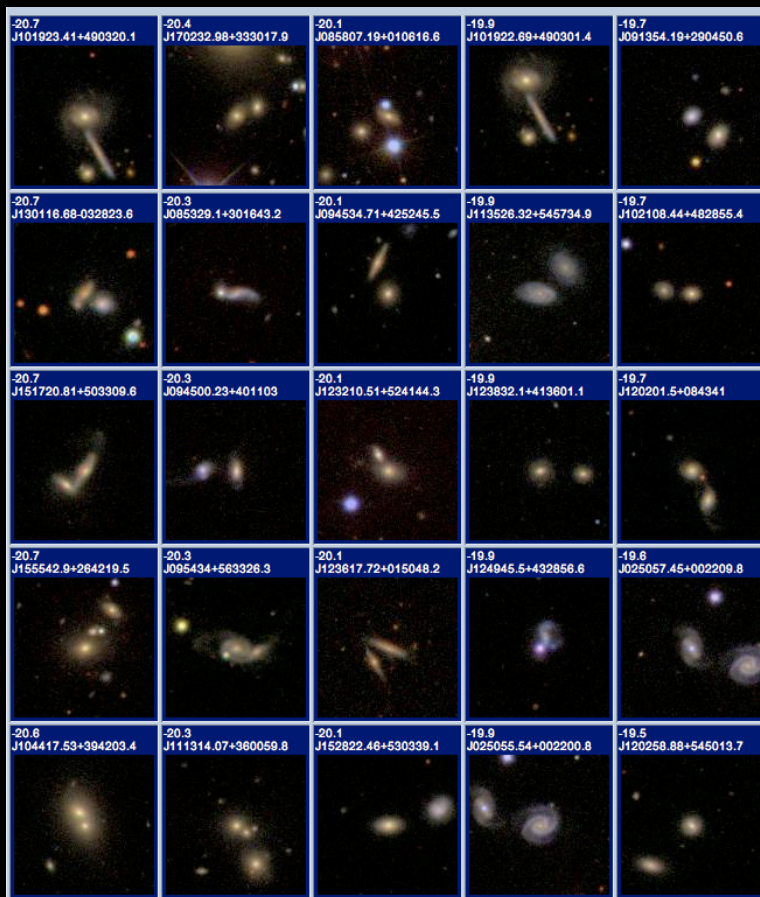
Local density - probe effects of high density



Galaxy clusters - probe effects of high density and presence of hot intra-cluster gas



SDSS pairs: galaxies selected from main galaxy sample and having projected separation  $r < 30 h_{70}^{-1}$  kpc, velocity separation  $< 500$  km/s, relative masses within 1:10. Control sample matched in mass, CF and  $z$ .



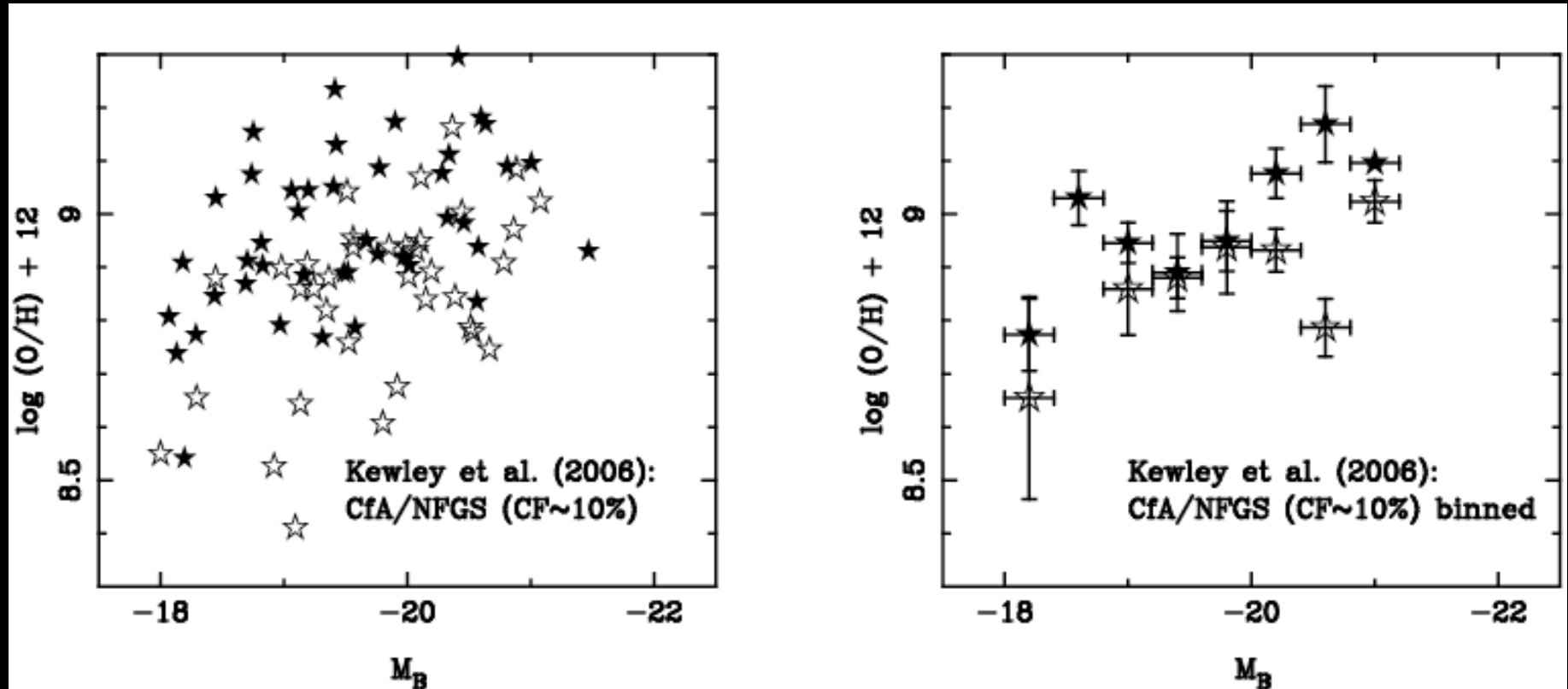
Ellison et al. (2008b)

sarae@uvic.ca



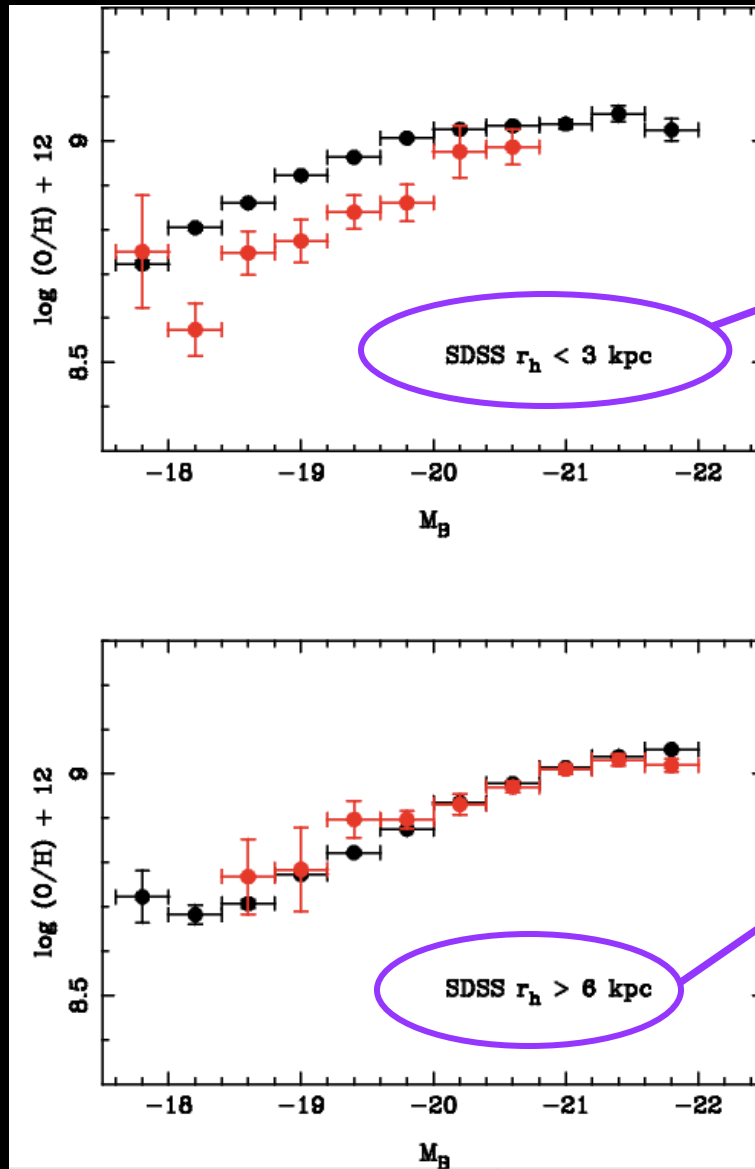


Kewley et al. (2006) found that nuclear spectra (covering fraction  $\sim 10\%$ ) had lower metallicities at a given luminosity for  $\sim 40$  pairs in CfA.



How much of this difference is due to  $Z$  and how much is  $L$ ?

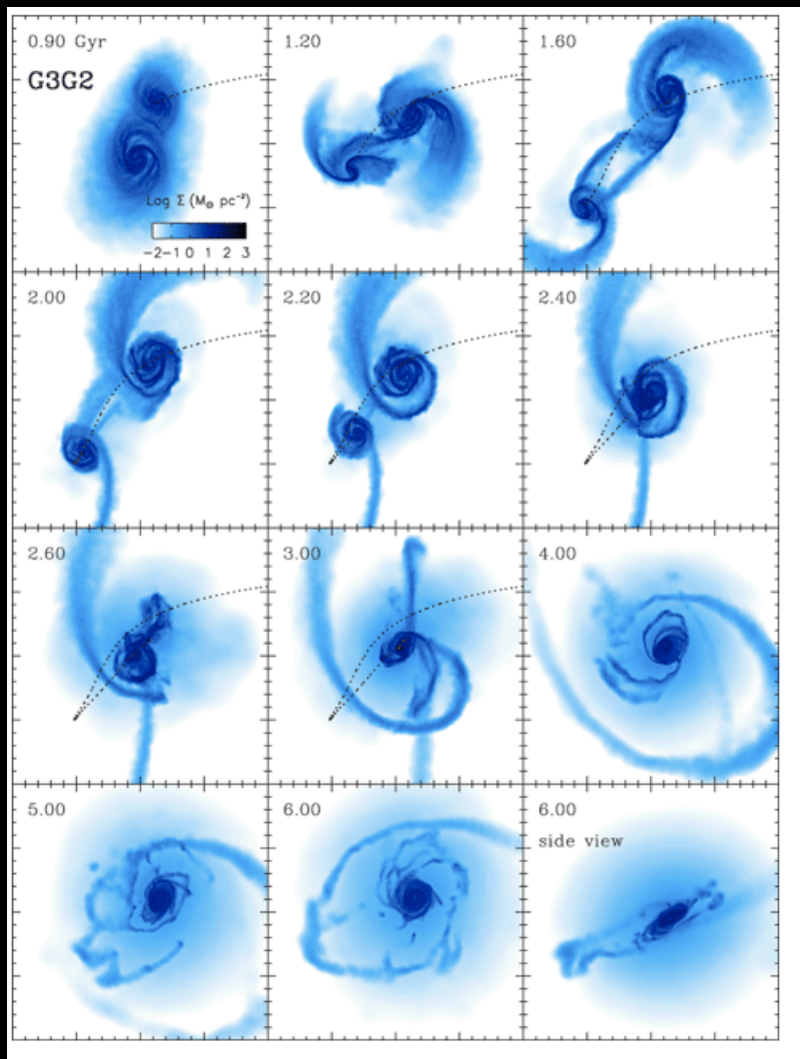
SDSS results show that the offset is by radius.



Small galaxies in pairs are typically more metal-poor than the control by 0.1 dex

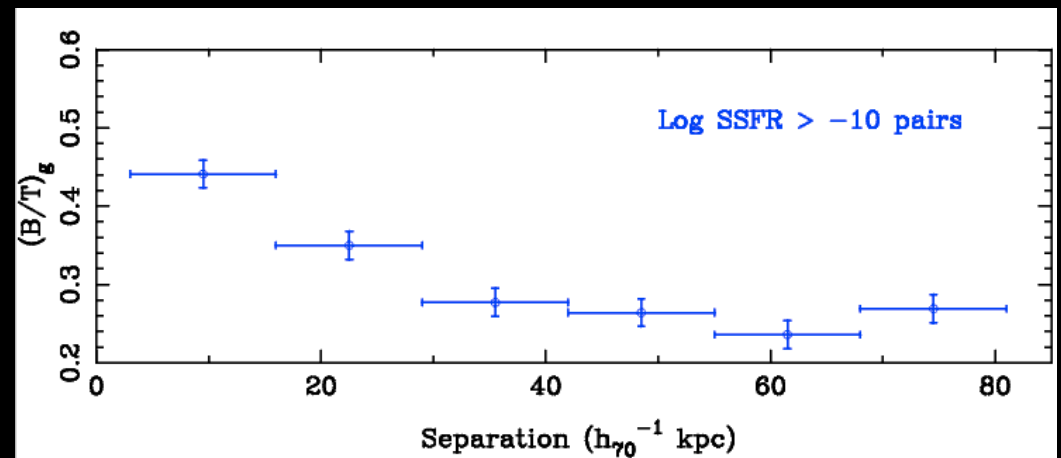
Large galaxies in pairs are consistent with the control

Ellison et al. (2008b)



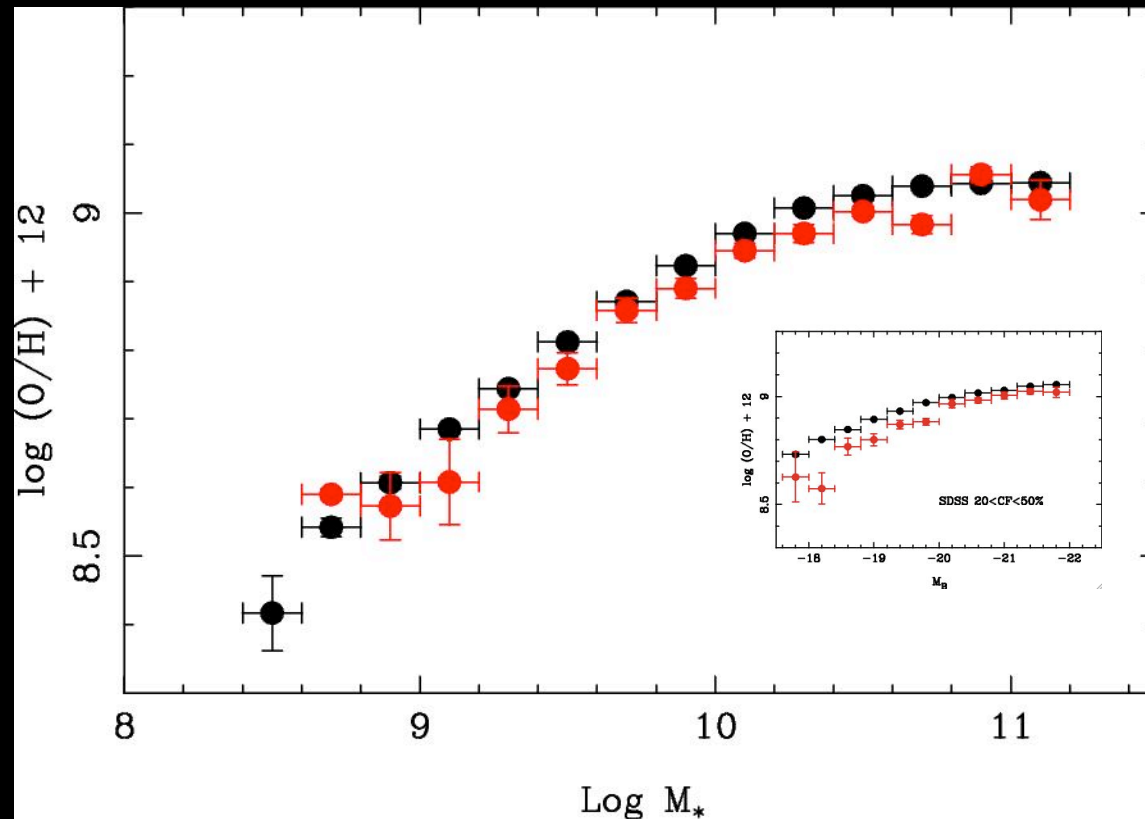
Cox et al. (2008)

Why should the LZR depend on the size of the galaxy? There is a broad anti-correlation between  $r_h$  and bulge fraction. Triggered star formation in the bulge?



Simard et al. in prep.

# The mass-metallicity relation in pairs



The stellar-mass-metallicity relation shows a much smaller offset than the LZR, indicating that changes in metallicity only account for about 50% of the shift. I.e. the offset in the LZR is caused by both lower metallicities and brighter magnitudes.

Ellison et al. (2008b)



# The environment hierarchy

Galaxy pairs - probe effects of individual mergers



Local density - probe effects of high density

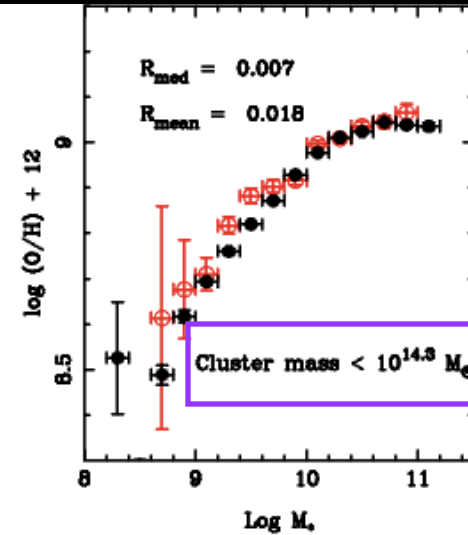
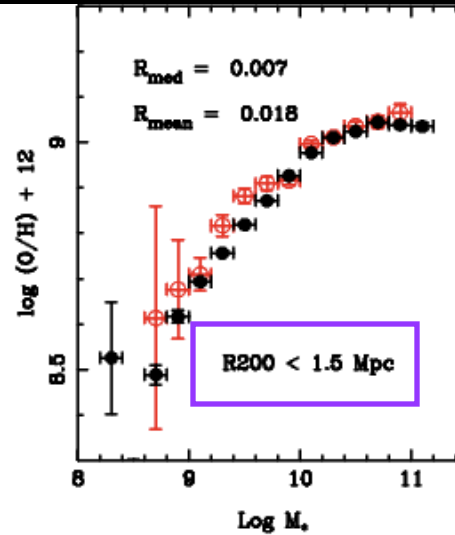
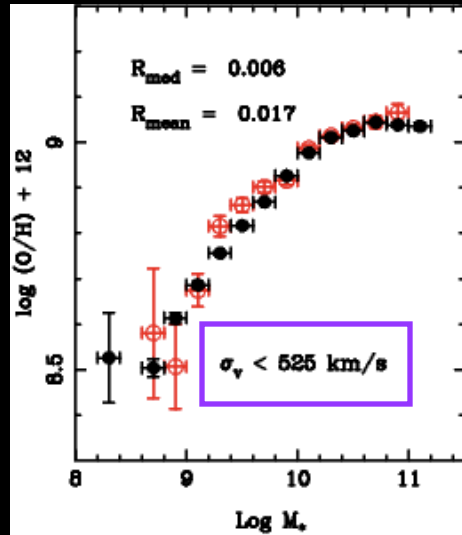


Galaxy clusters - probe effects of high density and presence of hot intra-cluster gas

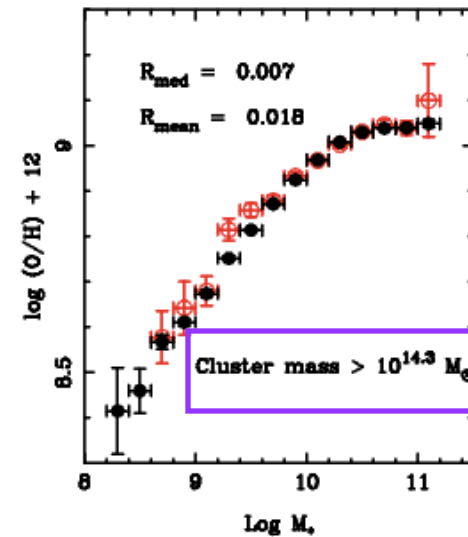
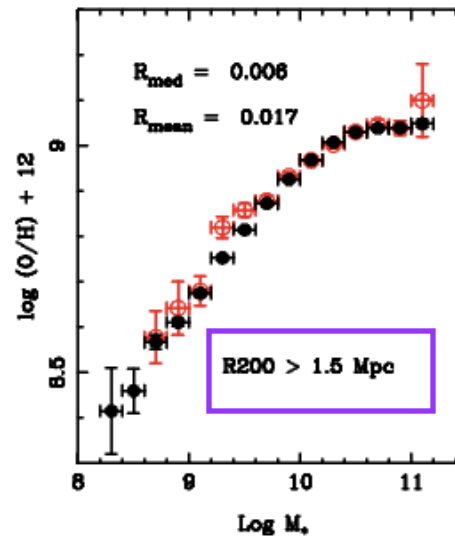
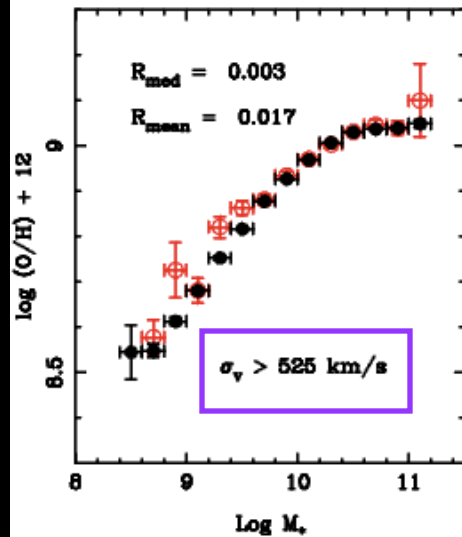


~ 1300 SDSS cluster galaxies from von der Linden et al. (2007).  
Although cluster galaxies are slightly more metal-rich than the  
'control', this does not appear to depend on cluster properties.

Low  $\sigma_v$ , R200, mass



High  $\sigma_v$ , R200, mass

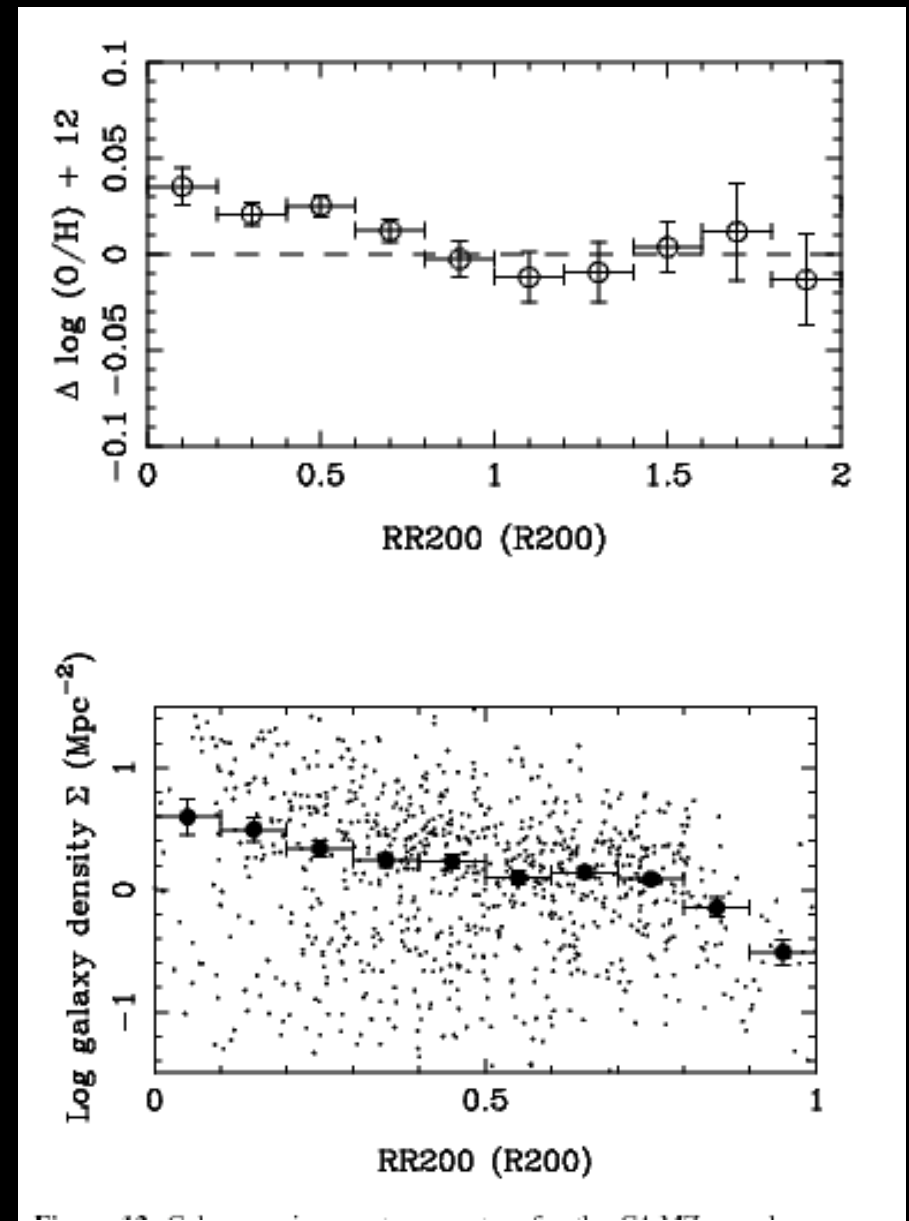




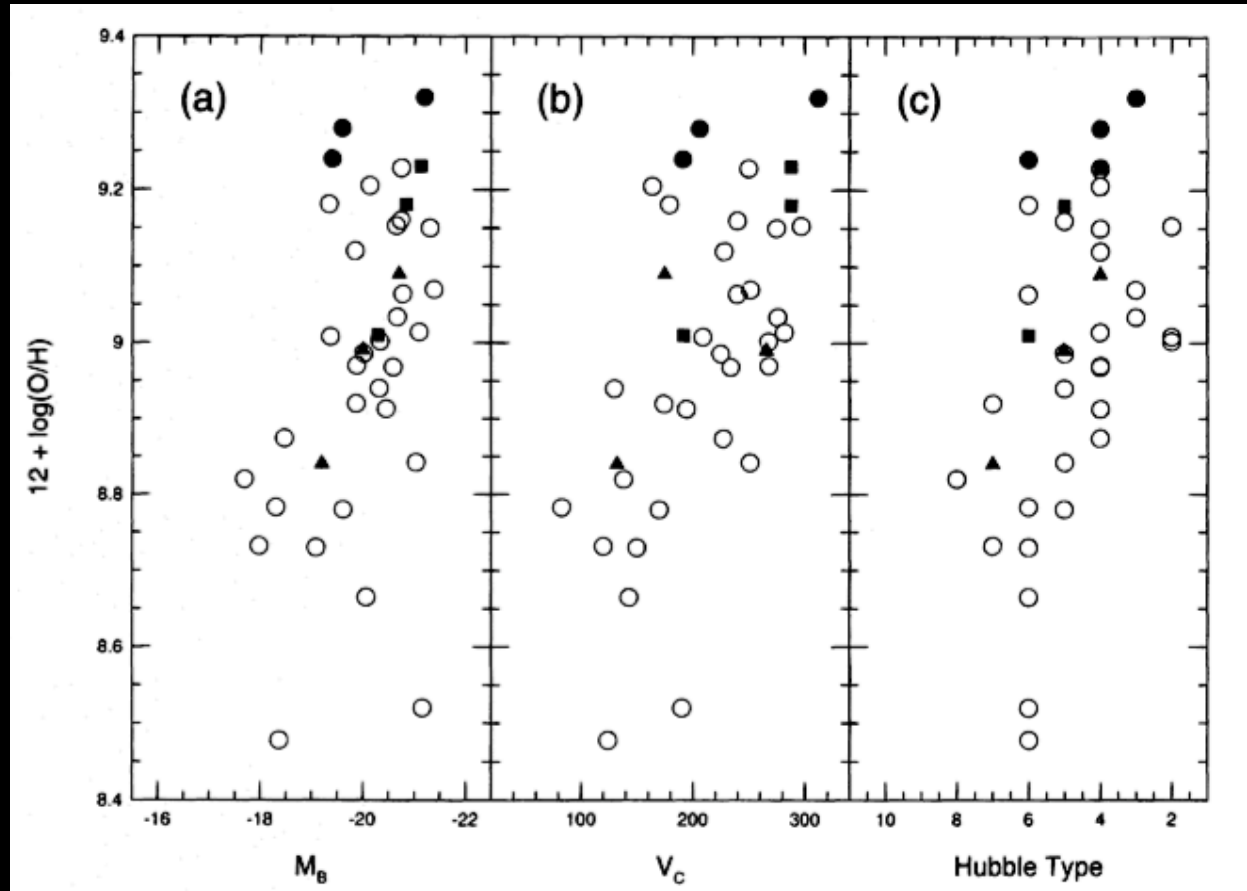
The only cluster-related property which affects the MZR is the clustercentric distance of a galaxy. However, this is driven by a dependence on local density.

At a given local density, non-cluster galaxies show a similar metallicity enhancement.

Ellison et al., (2009)



BUT! The very small offset in median metallicity is in apparent conflict with (gas-poor) Virgo spirals.



Skillman et al. (1996)

# Summary

- The metallicity of the general star-forming galaxy population is sensitive to its optical size and specific SFR, but not bulge fraction.
- Galaxies in pairs are relatively metal poor for their stellar mass by  $\sim 0.05$  dex. Larger offsets in the LZR are due to the combined effects of metallicity and luminosity.
- Galaxies in clusters are relatively metal-rich for their stellar mass by  $\sim 0.03$  dex. The offset is independent of cluster properties, but is largest for galaxies at small clustercentric radii.
- Both cluster and 'field' galaxies show similarly enhanced metallicities when the local density is high, by up to  $\sim 0.05$  dex.

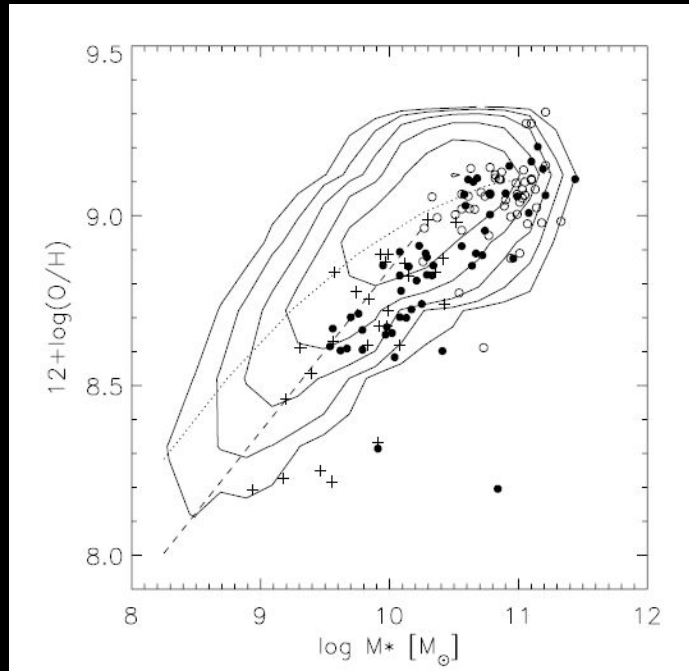
Almost every galaxy property seems to depend on environment. However, the median MZR is very robust with changes  $< 0.05$  dex at a given stellar mass.



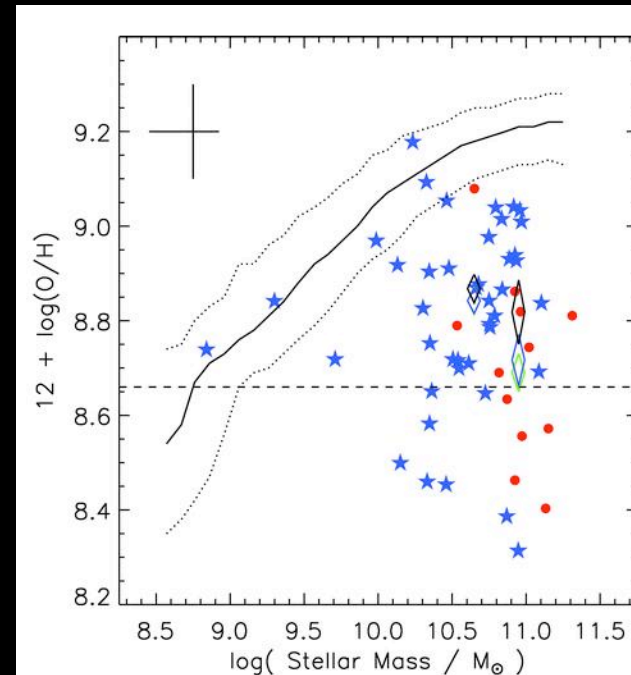
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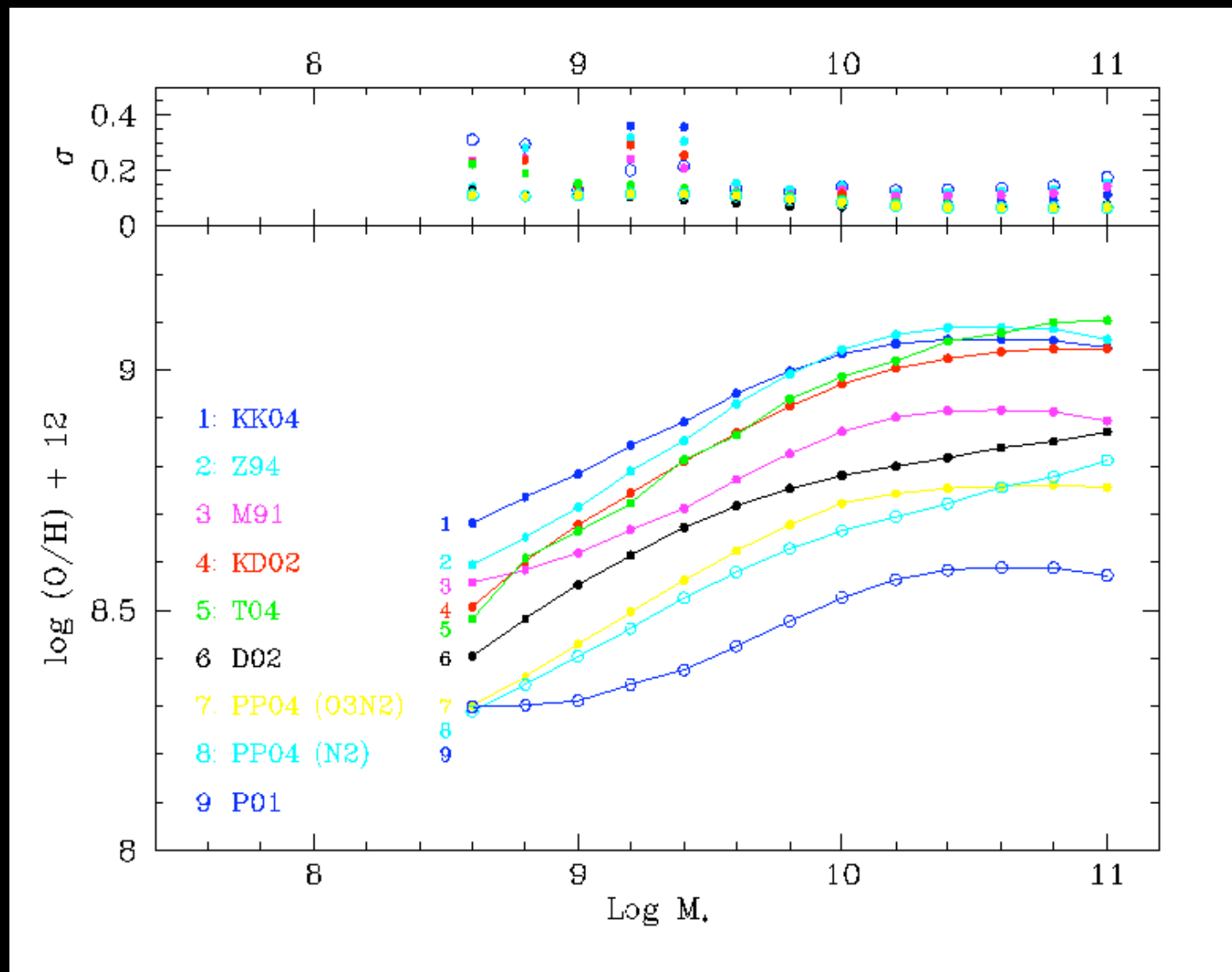
## Other evidence of the effects of mergers on the MZR



Hoopes et al. (2007) found that compact UV luminous galaxies had low metallicity for their mass, similar to the trend seen in small  $r_h$  galaxy pairs.



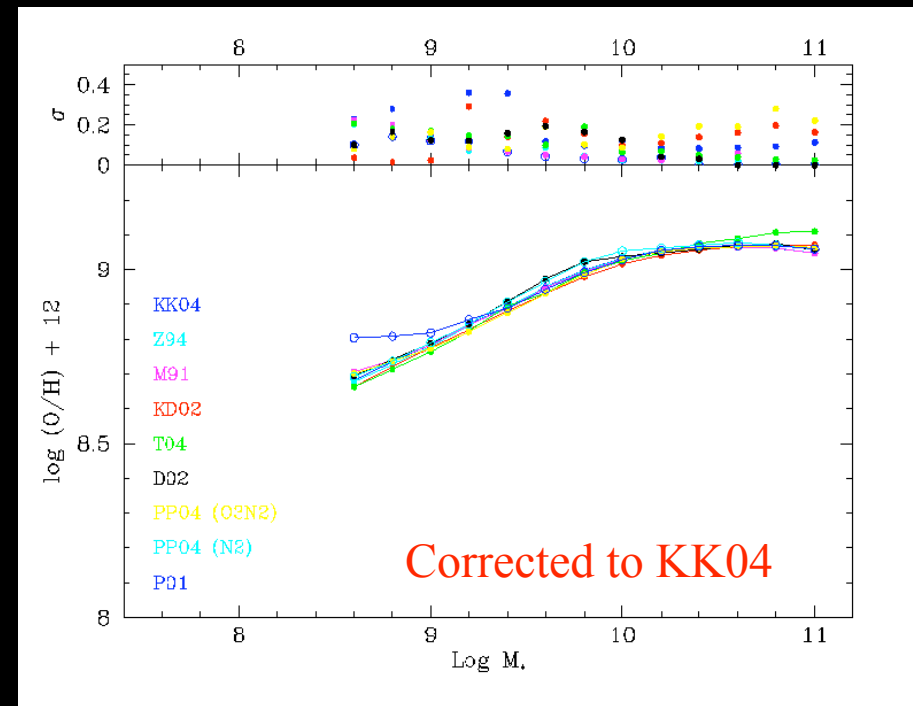
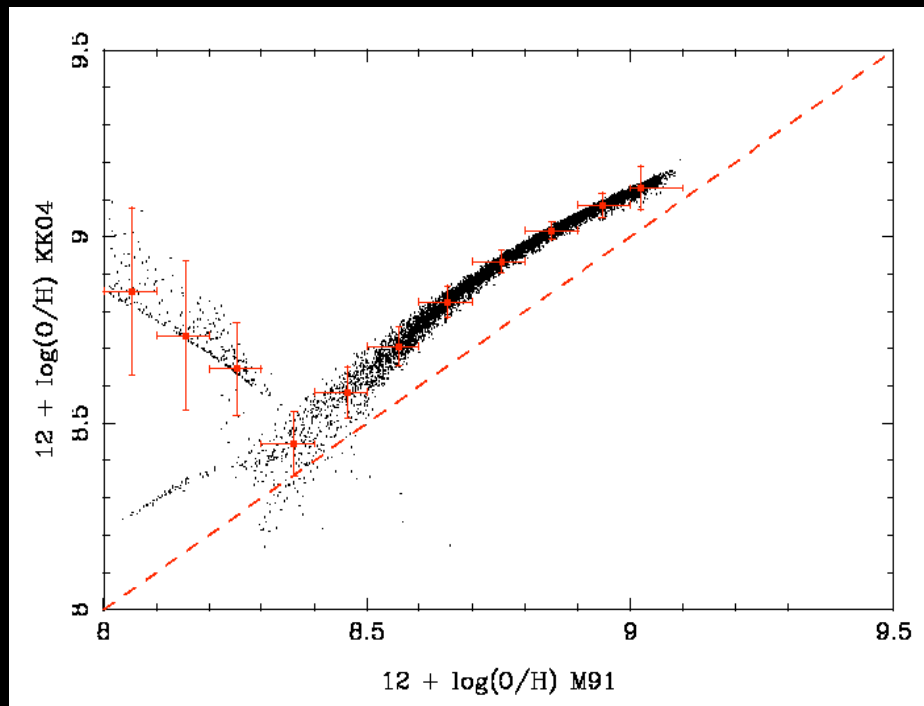
Rupke et al. (2008) find that both LIRGs and ULIRGs have low metallicities for their mass.



Kewley & Ellison (2008)



Metallicity determinations are very sensitive to diagnostic, and can vary by factors of several.



However, many calibrations lend themselves to "conversion", which can be used to correct to your favourite diagnostic (see Kewley & Ellison 2008 for recipes).