

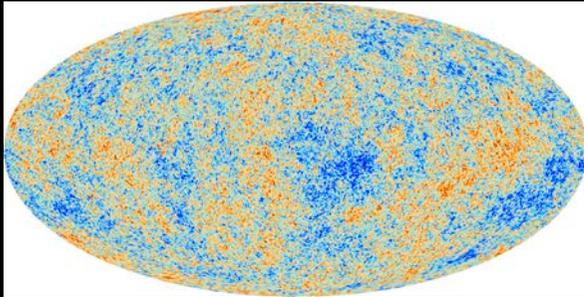
Beyond Models: A Direct Measurement of Galaxy Formation at $z < 6$

Christopher J. Conselice (Univ. of Manchester)



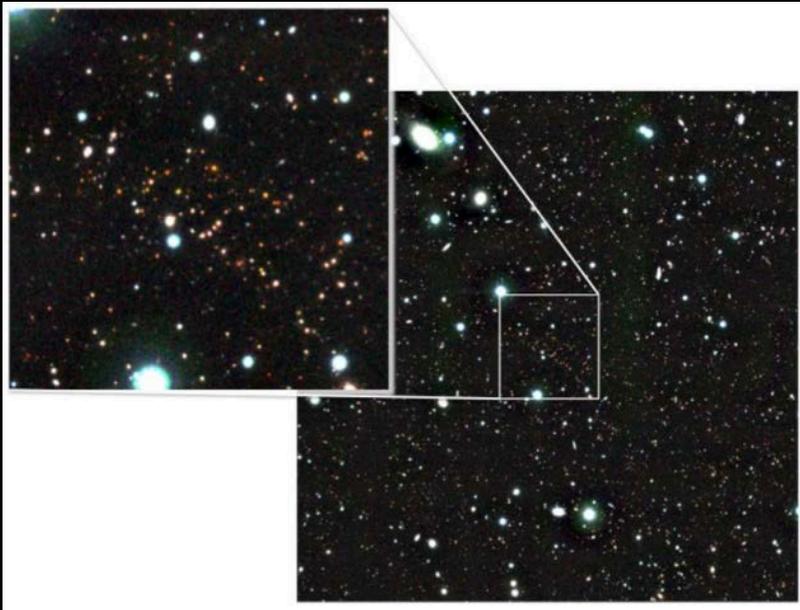
Carl Mundy, Leonardo Ferreira, Kenneth Duncan

How do we get from the early universe to the rich universe of nearby galaxies?

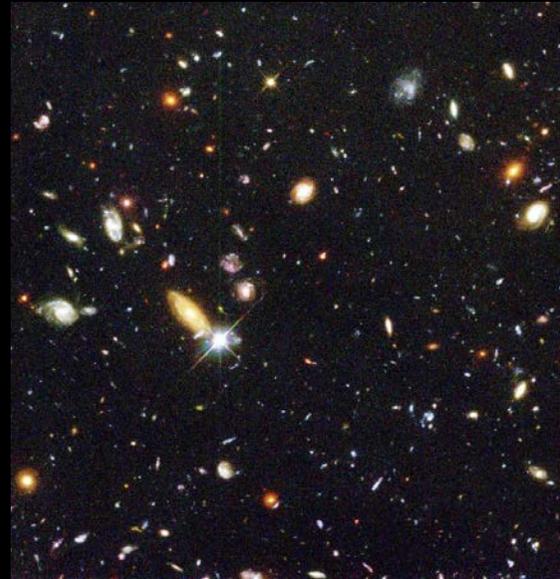


?

Exploring galaxy evolution in the distant Universe



Ground = wide+shallow



Hubble=deep+narrow

By using both deep but small area Hubble and wide but shallow ground based surveys



UKIRT (Hawaii)



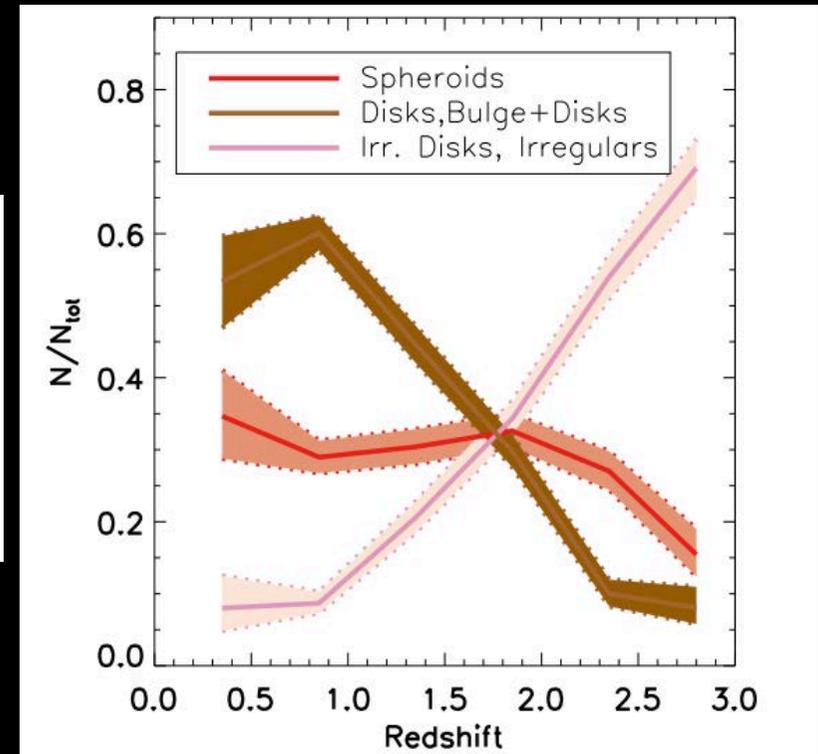
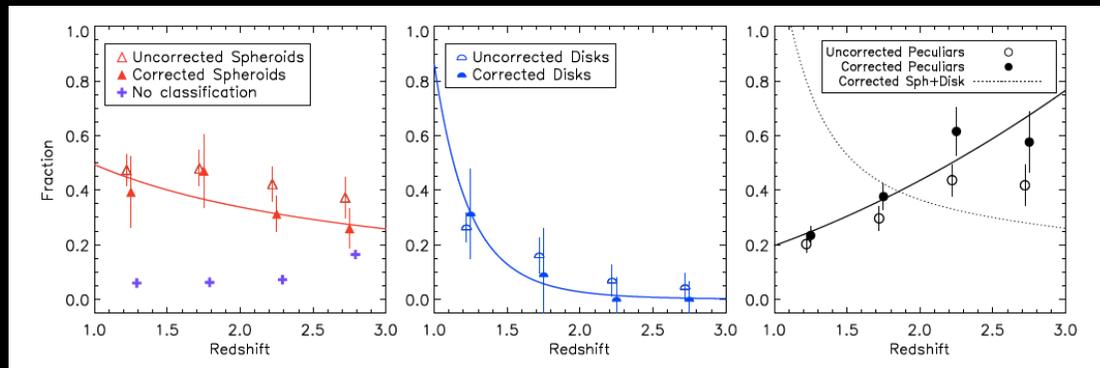
Hubble Space Telescope (HST)



ESO VISTA (Chile)

Combining both space and ground based optical/NIR telescopes is a powerful combination

The morphological evolution of galaxies

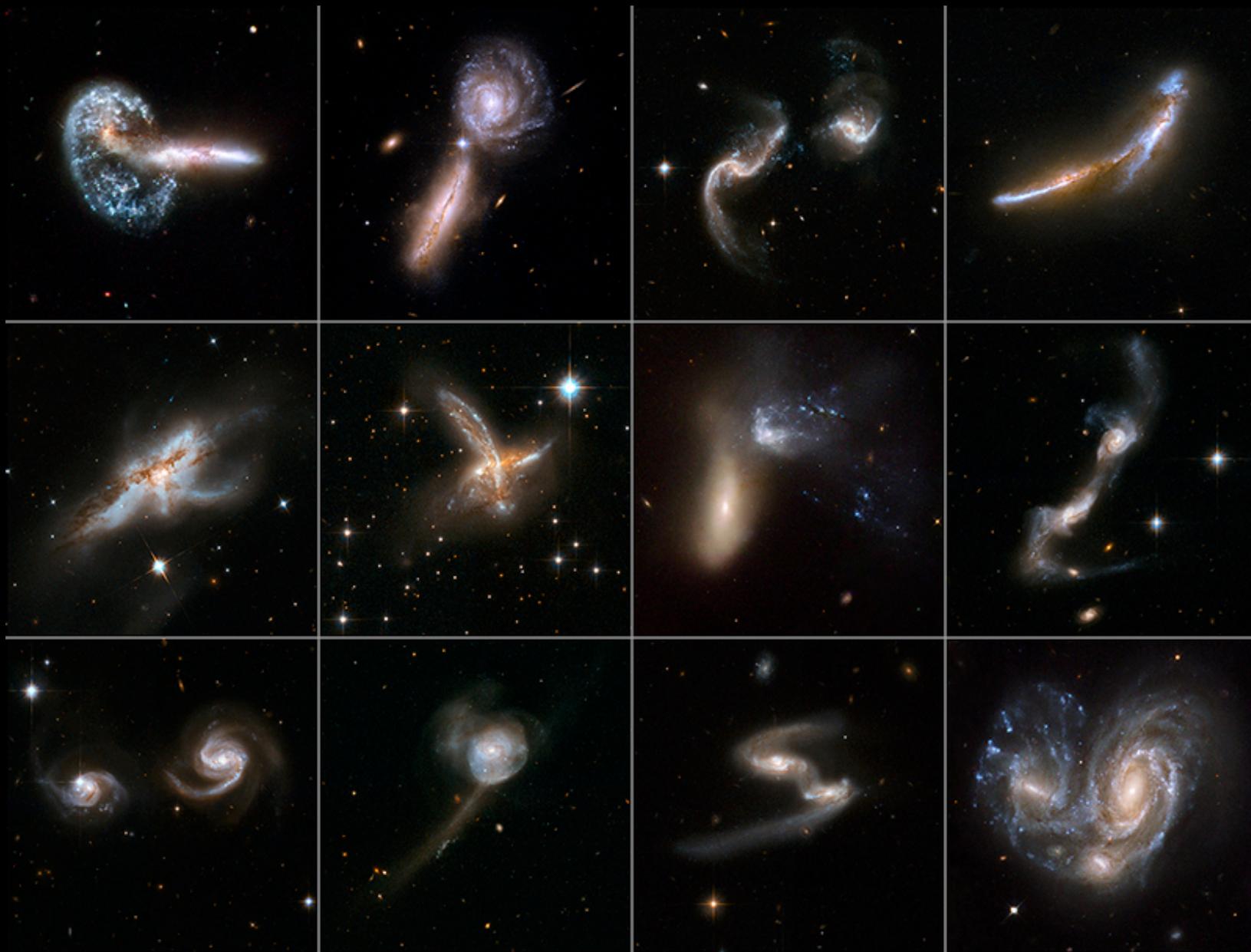


Note that visually determined disks are a very small fraction at $z > 2$
Peculiar galaxies dominate the population

For $\log M > 10$ systems

Mortlock et al. (2015), Huertas-Company+15

Key goal for galaxy formation studies is role of merging



Are these peculiars mergers?

REFINE

(Redshift Evolution and Formation in Extragalactic Systems)

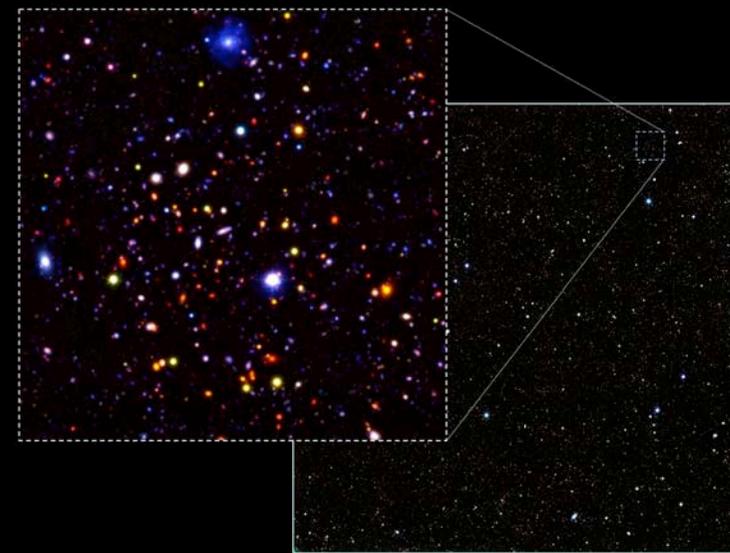
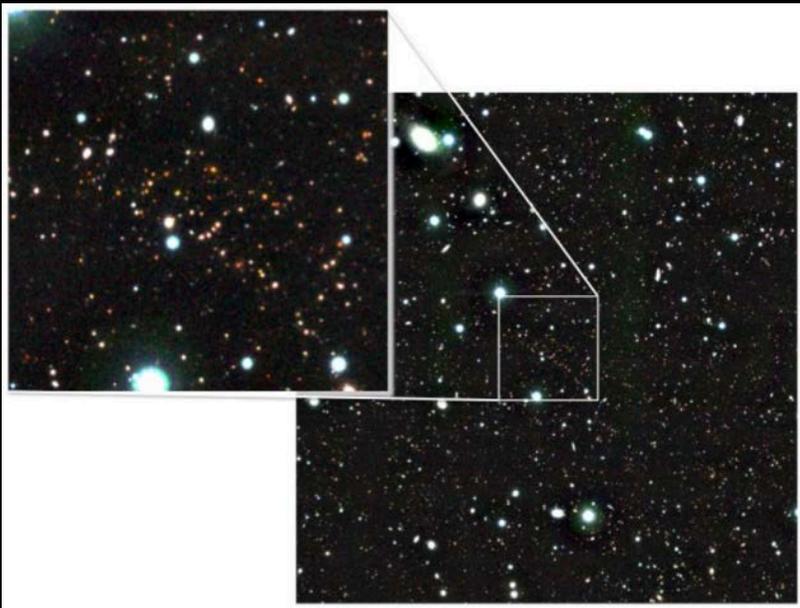
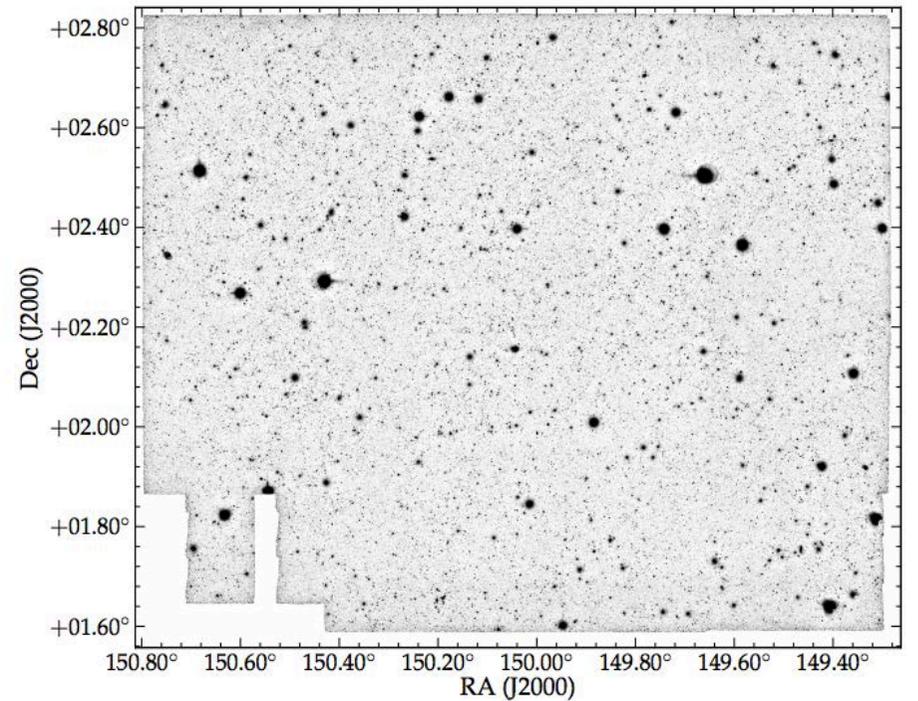
An analysis of redshifts and stellar masses for the three IR deep fields:

Ultra-VISTA: $K = 23.4$, 1.6 sq. degree

UDS: $K = 24.2$, 0.77 sq. degree

VIDEO: $K = 22.5$, 1 sq. degree

GAMA: 144 sq. degree (nearby uni)



Useful for $z < 3$ – large volume

The different surveys probe different parts of the universe's history

CANDELS(HST)

REFINE

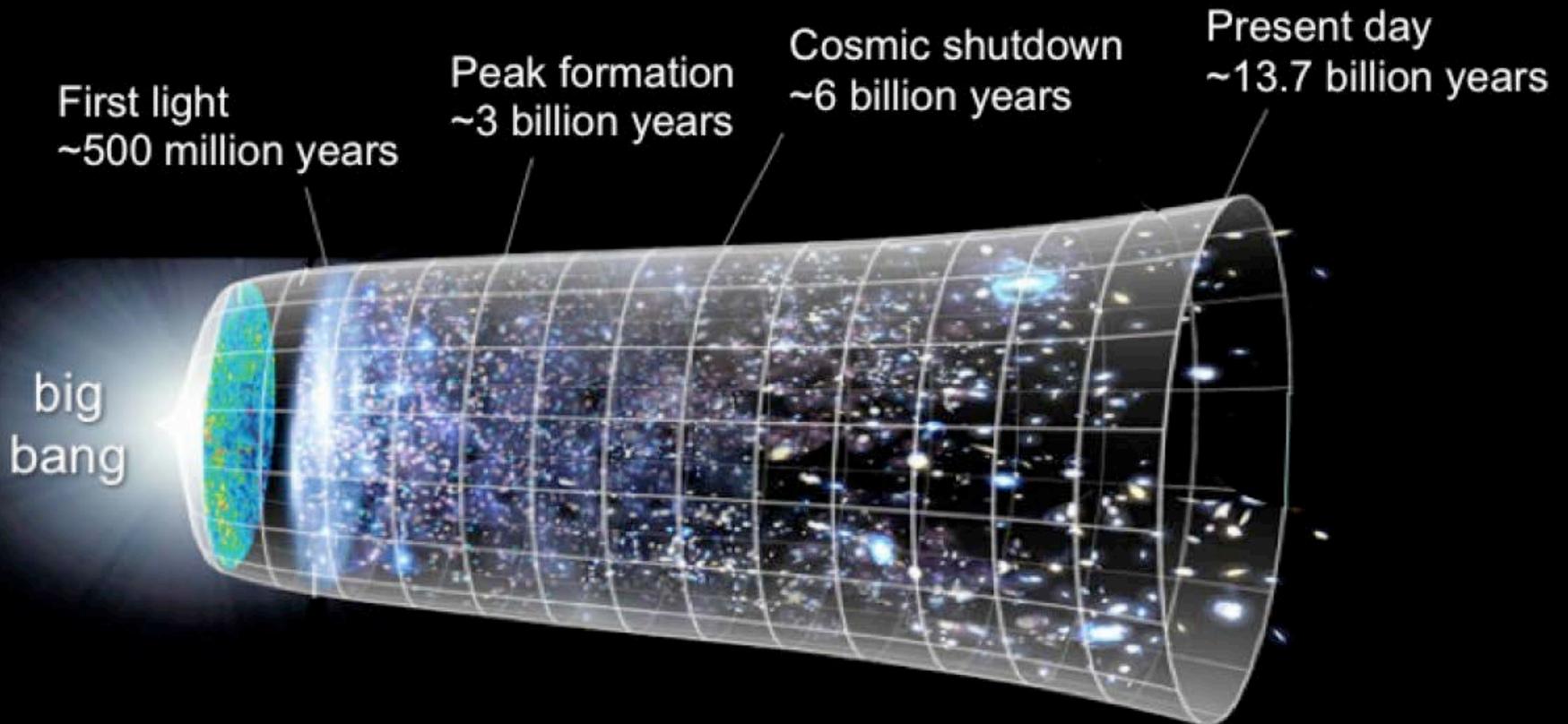
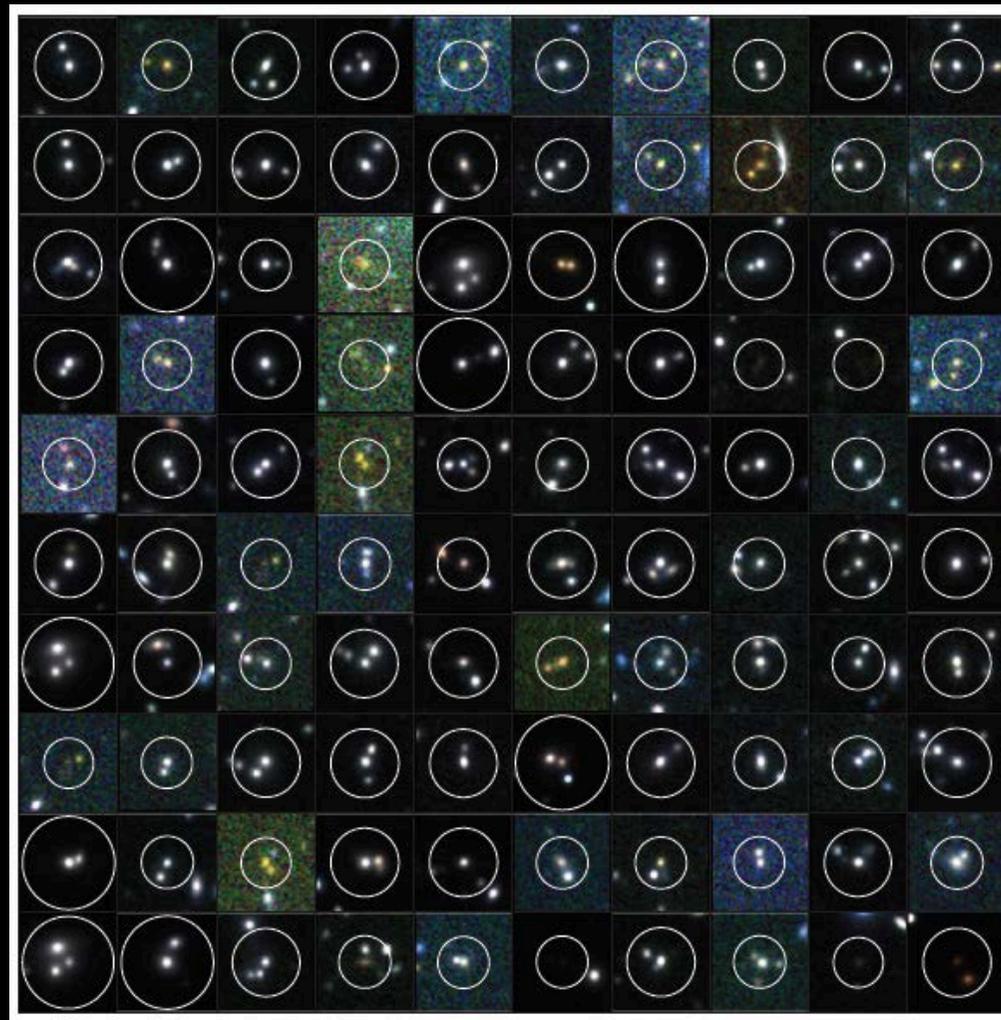


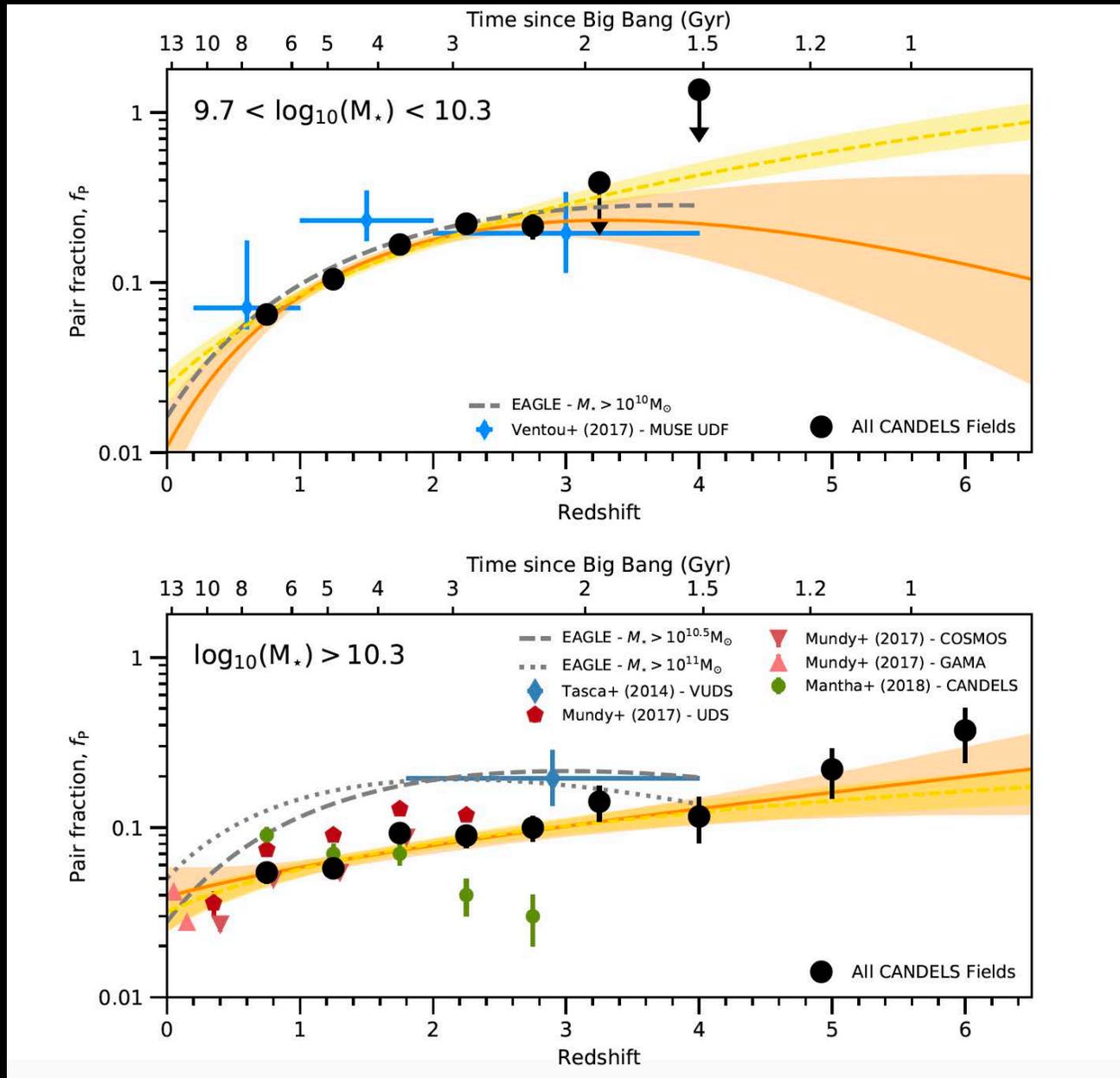
Image modified from an original by NASA/WMAP Science Team

Nearby Mergers – though pair counts



Method independent of looking for distorted galaxies

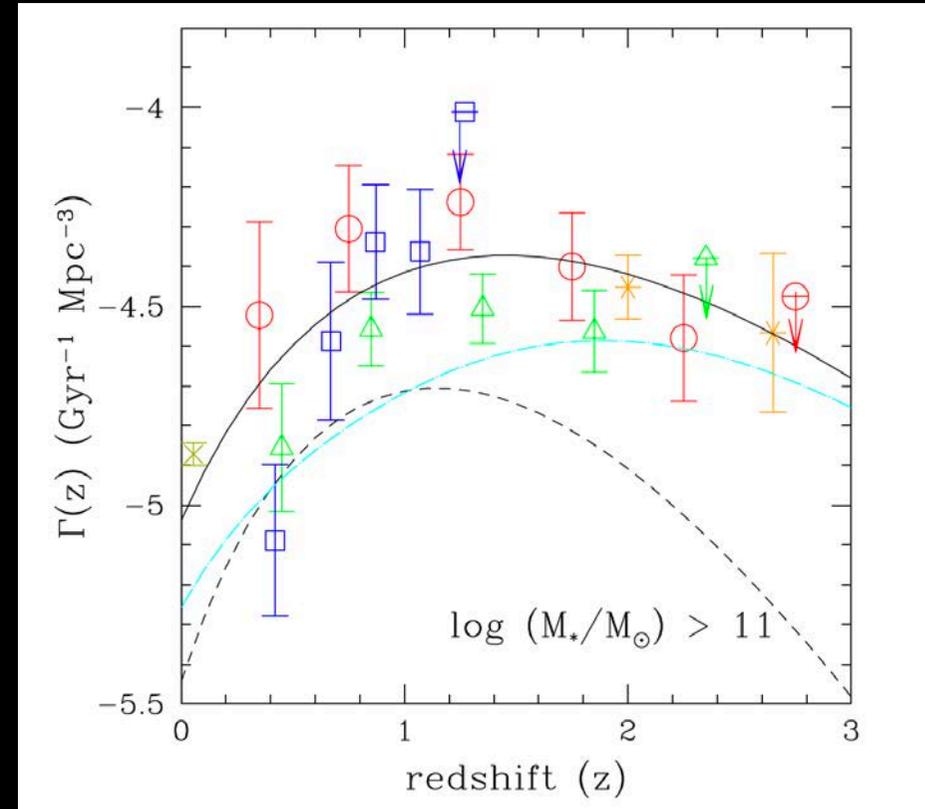
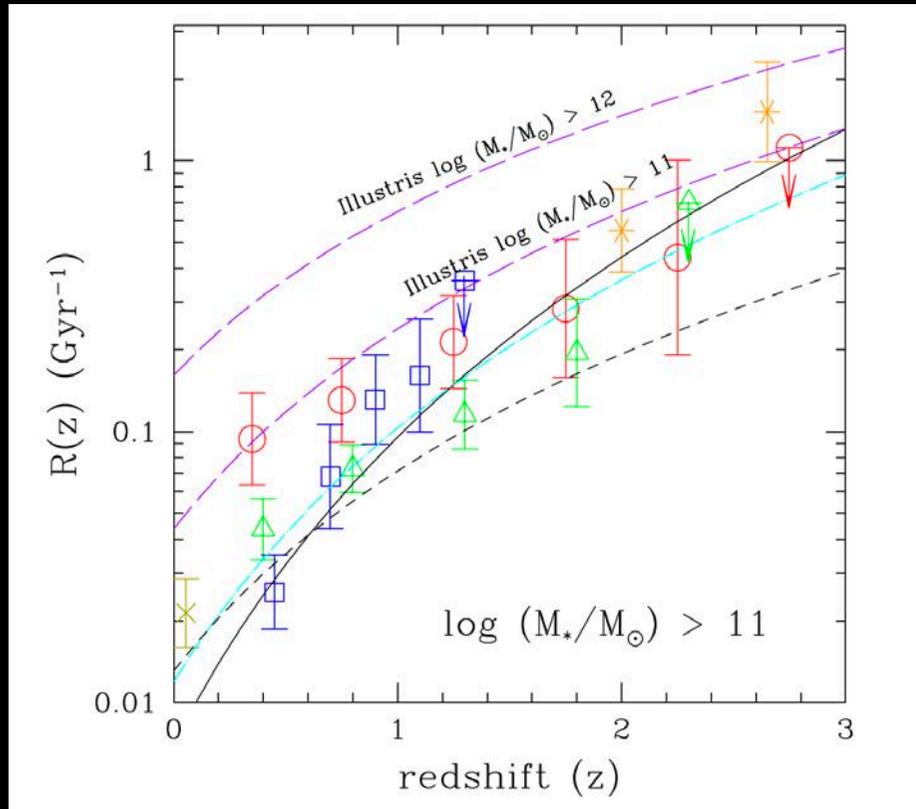
For redshifts up to $z = 6$



Duncan, CC+19
Mundy, CC+17

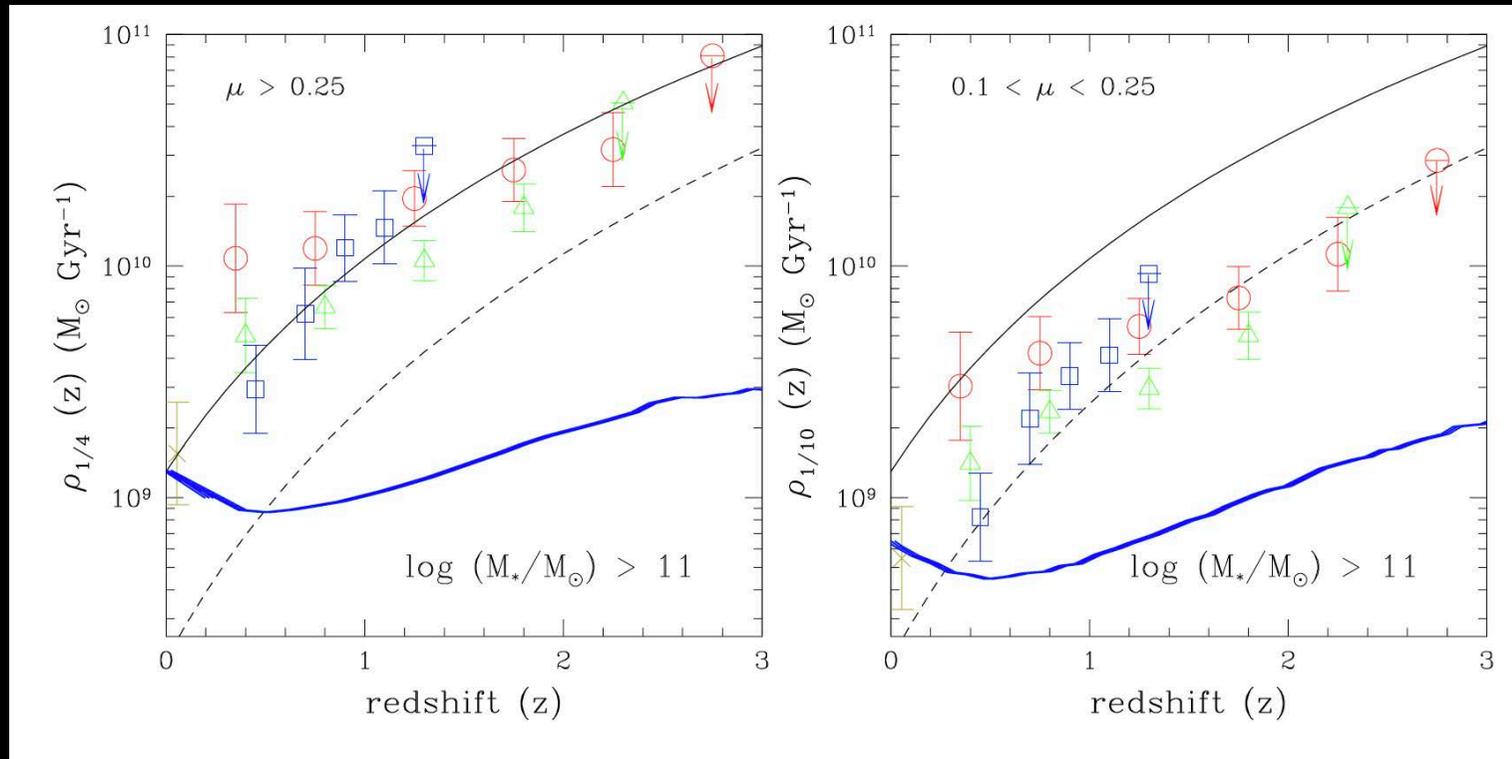
See an increase up to $z = 6$ in CANDELS and REFINE

Merger Rates



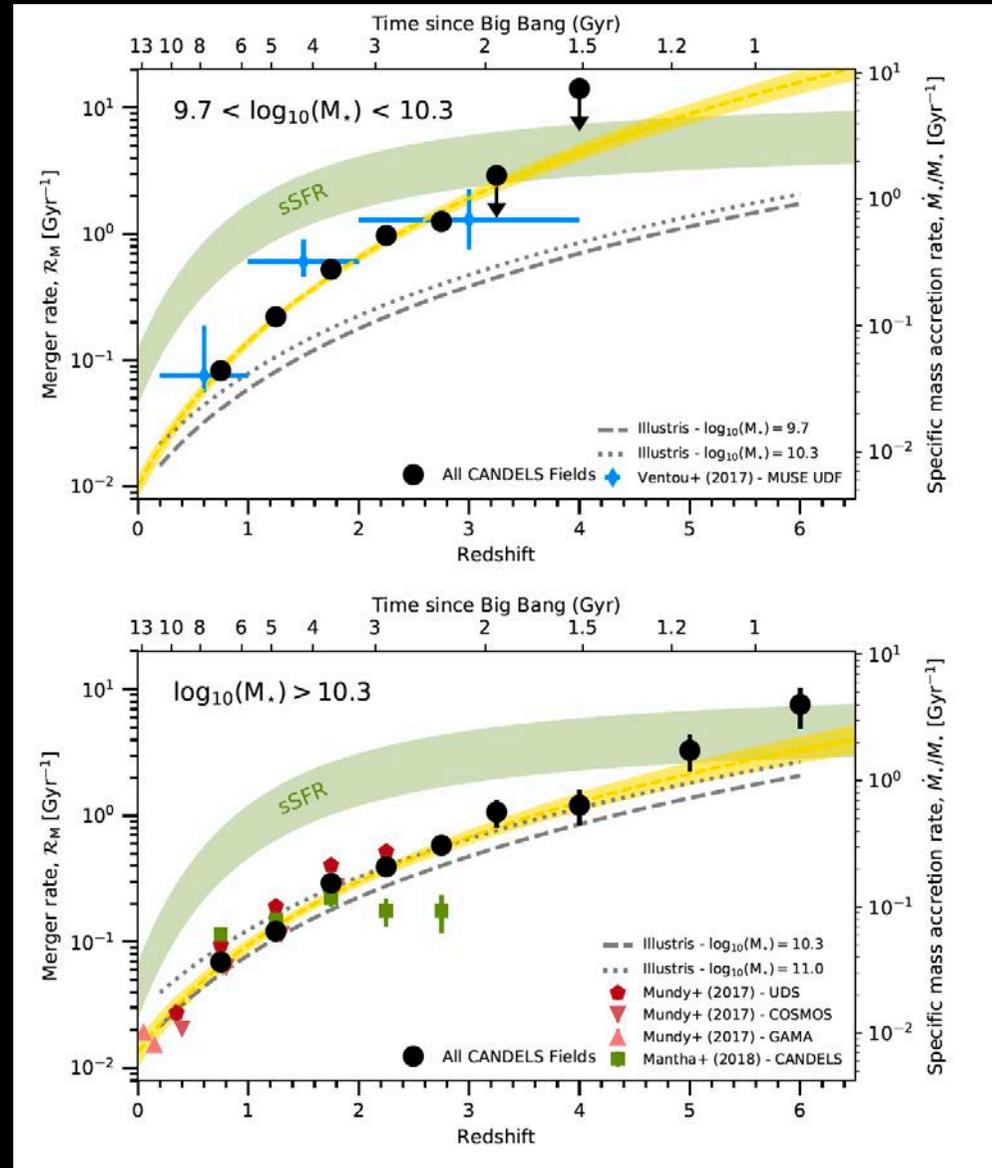
Can measure the rate per galaxy as well as a density rate

Mass Assembly Rates



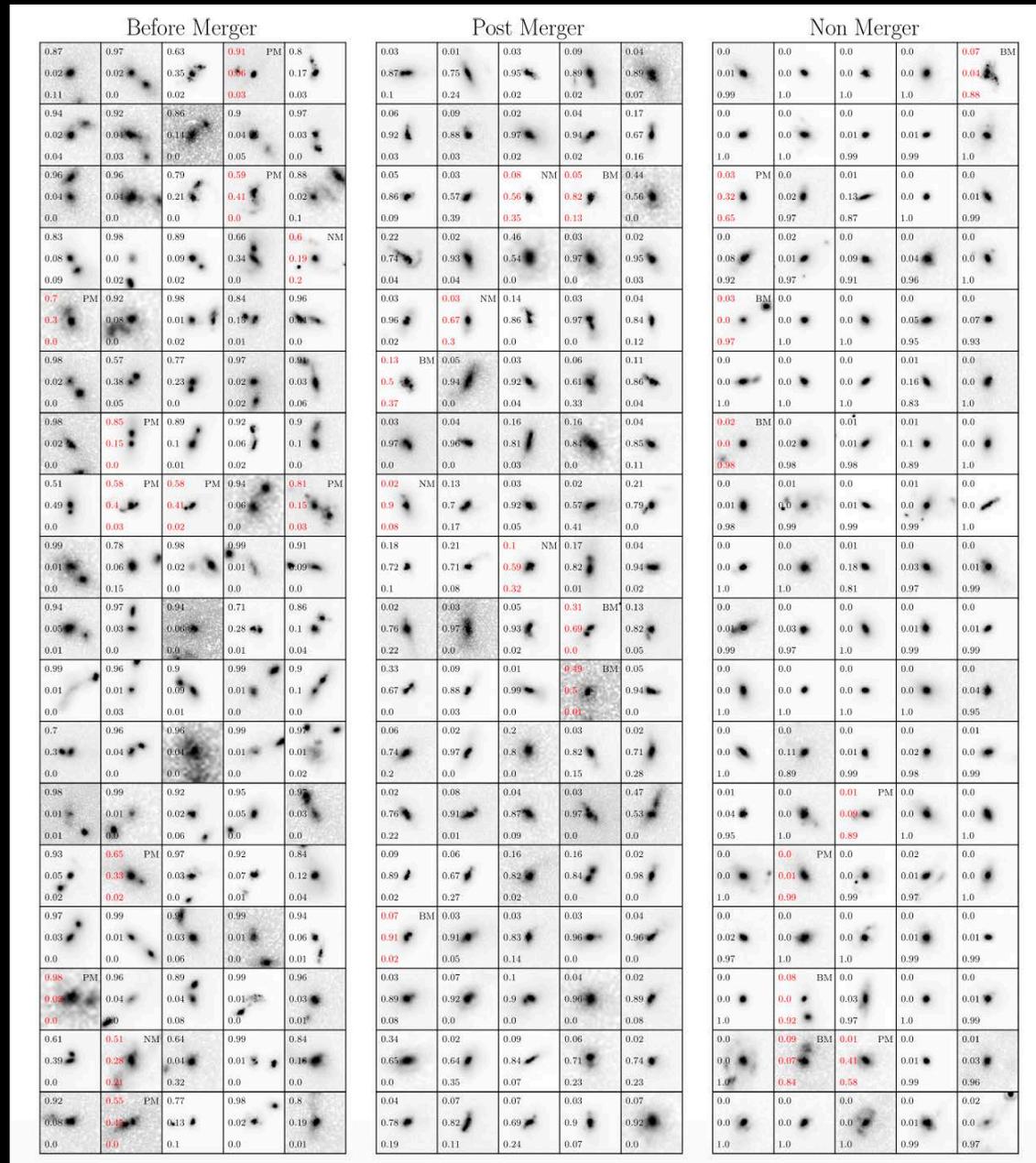
We find a significant increase with higher redshift in rate of mass assembly due to mergers – disagrees with models

Star formation vs. mergers – which builds a galaxy?



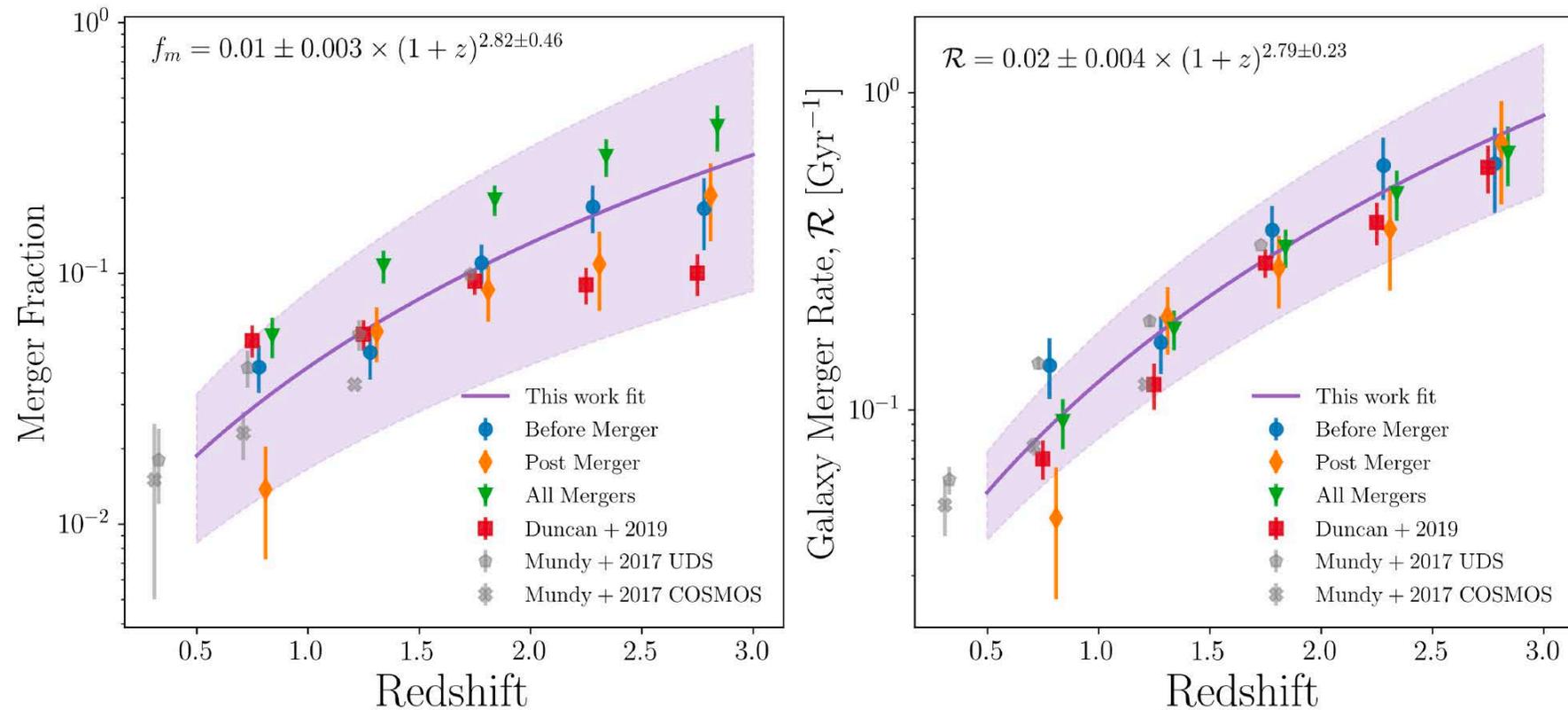
Mergers dominate in the early universe – star formation later

Pair merger rates consistent with a deep machine learning approach



CANDELS galaxies trained with Illustris TNG300

Merger rates consistent with a deep machine learning approach



Leonardo Ferreira, CC+2020

We can thus have confidence that we are measuring galaxy evolution

Summary

1. Galaxy formation and evolution are driven by mergers in part, but their role is just now being quantitatively, and reliability, revealed.
2. There are major and minor mergers in galaxies up to $z=3$.
Not the dominant method for formation, but still important at the 25-50% level.
3. Mergers are relatively more important for galaxy formation at late and early times, whereby at 'mid' times star formation is a factor of ~ 5 more important at $z \sim 2$.

Contact information:

Prof. Christopher Conselice

University of Manchester

conselice@manchester.ac.uk