Galaxy Evolution and Environment from DEEP2

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Brian Gerke (SLAC/Stanford) among others

Galaxy Evolution and Environment
Kuala Lumpur
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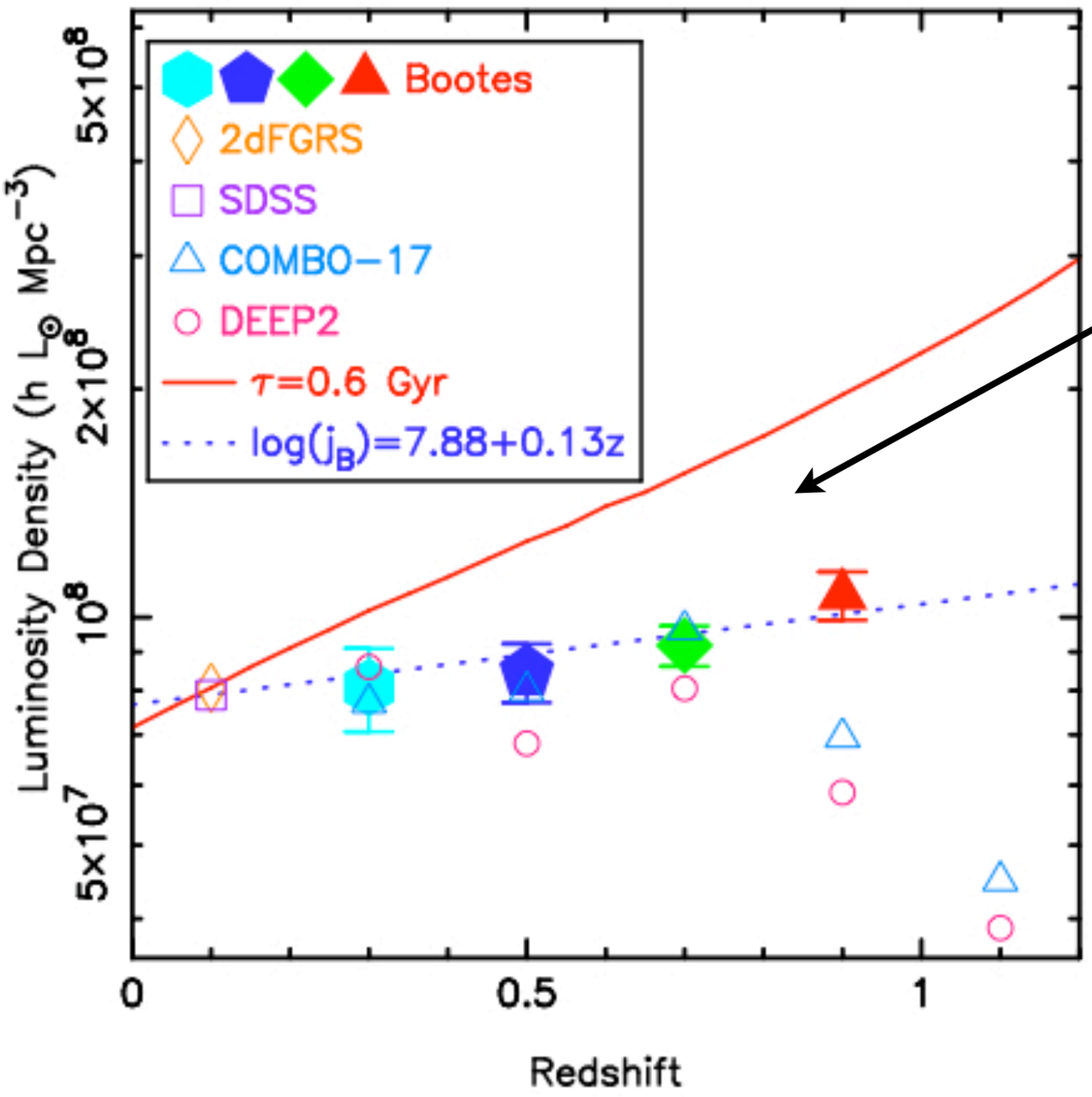
The Build-Up of the Red Sequence

Brown et al. 2007



Factor of 2 growth in stellar mass on red sequence since $z \sim 1$.

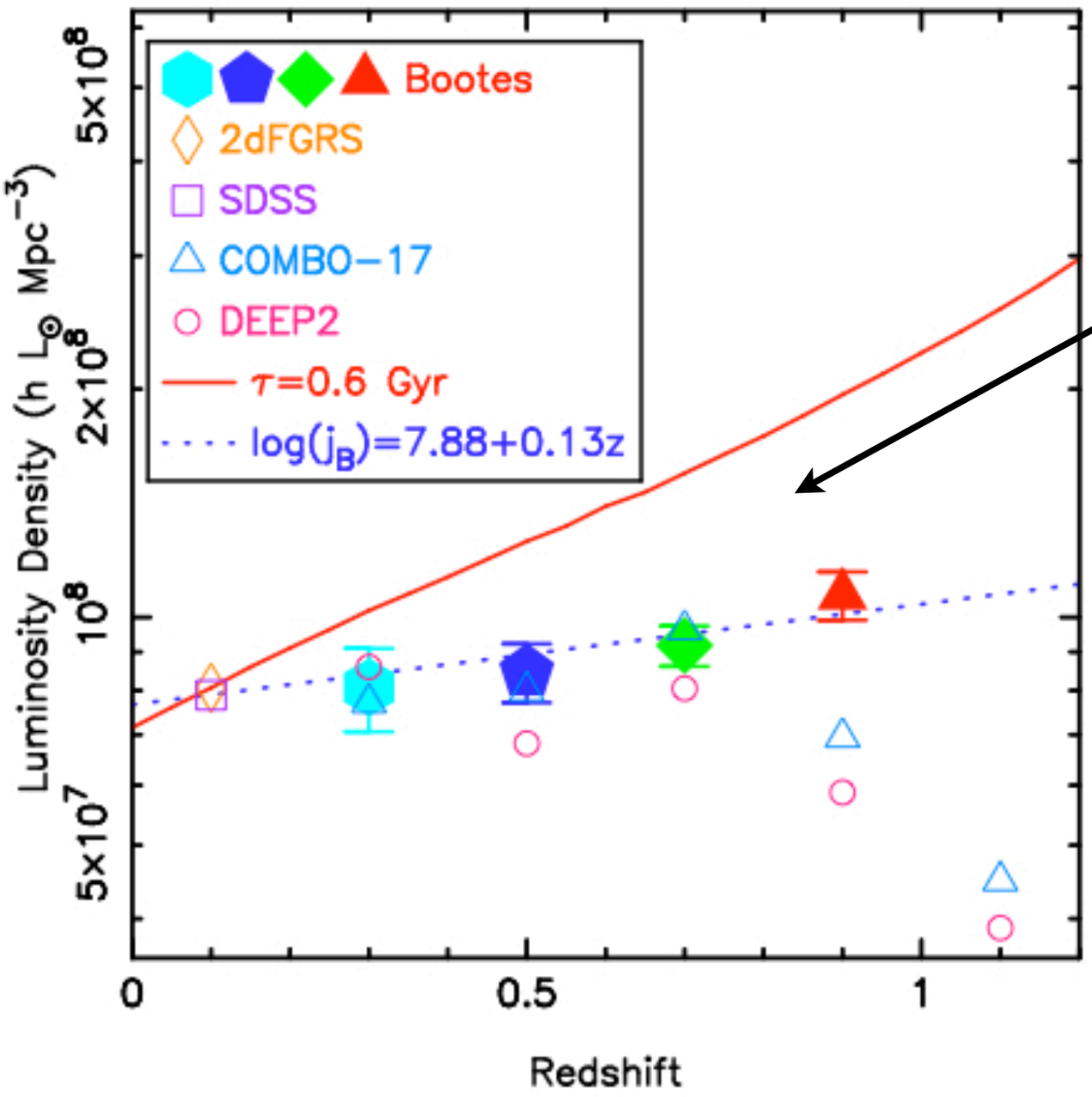
and ~L^* galaxies [outside of clusters] dominate the luminosity density...

see also Bell et al. 2004, Ilbert et al. 2006, Wake et al. 2006, Bundy et al. 2006, Faber et al. 2007, among others.

The Build-Up of the Red Sequence

Where, **When**, and **How** did the L^* red-sequence galaxies form?

Brown et al. 2007



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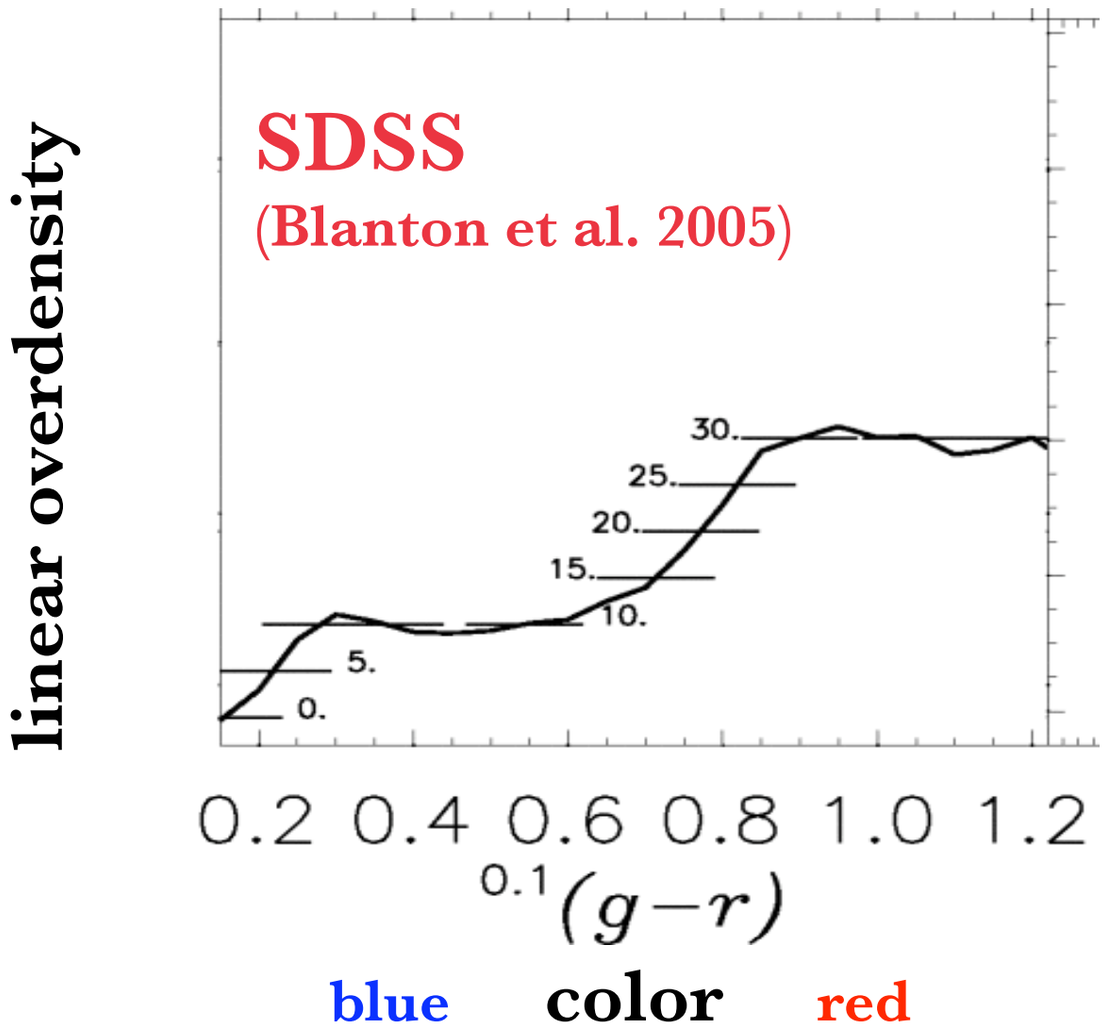
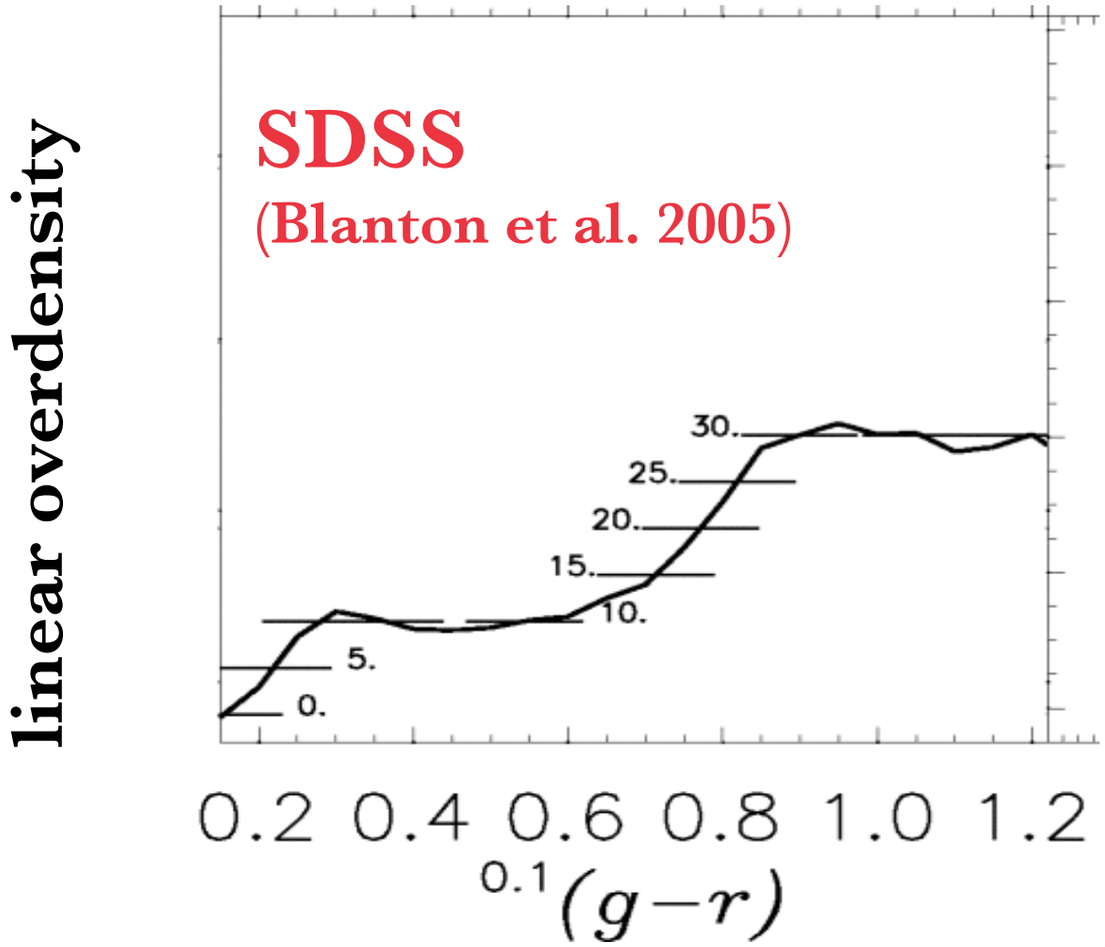
The Color-Density Relation at $z < 1$



The Color-Density Relation at $z < 1$

SDSS

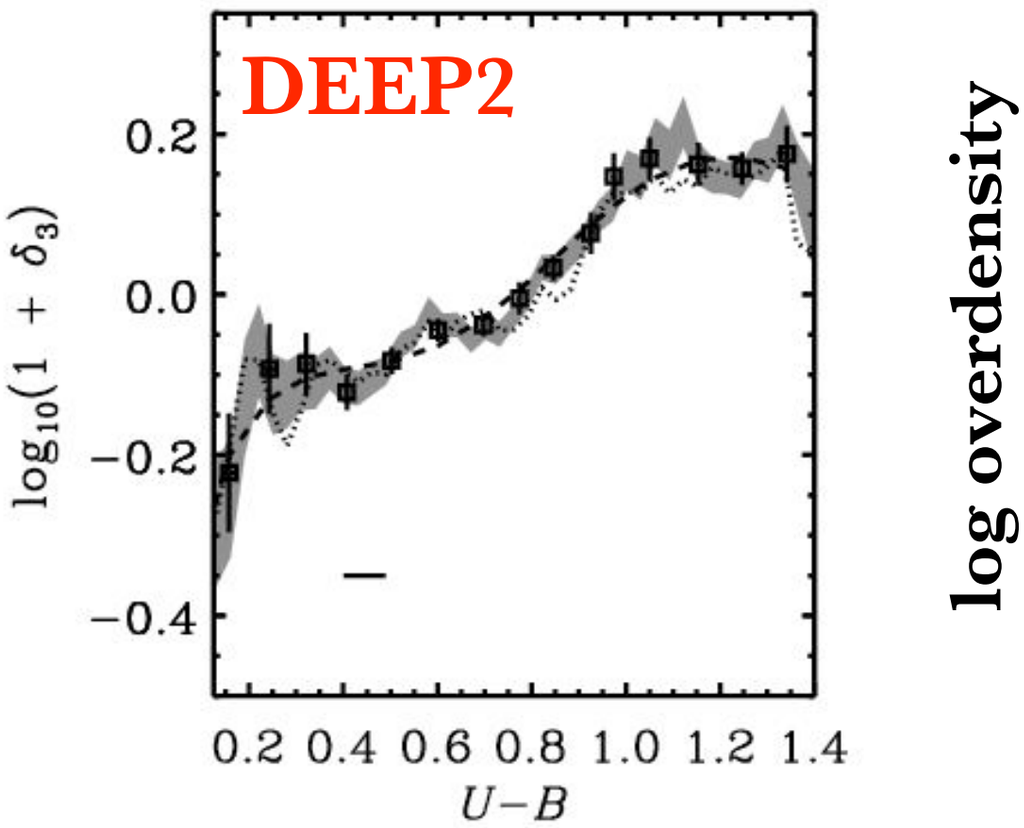
(Blanton et al. 2005)



blue **color** **red**

Cooper et al. 2006

DEEP2



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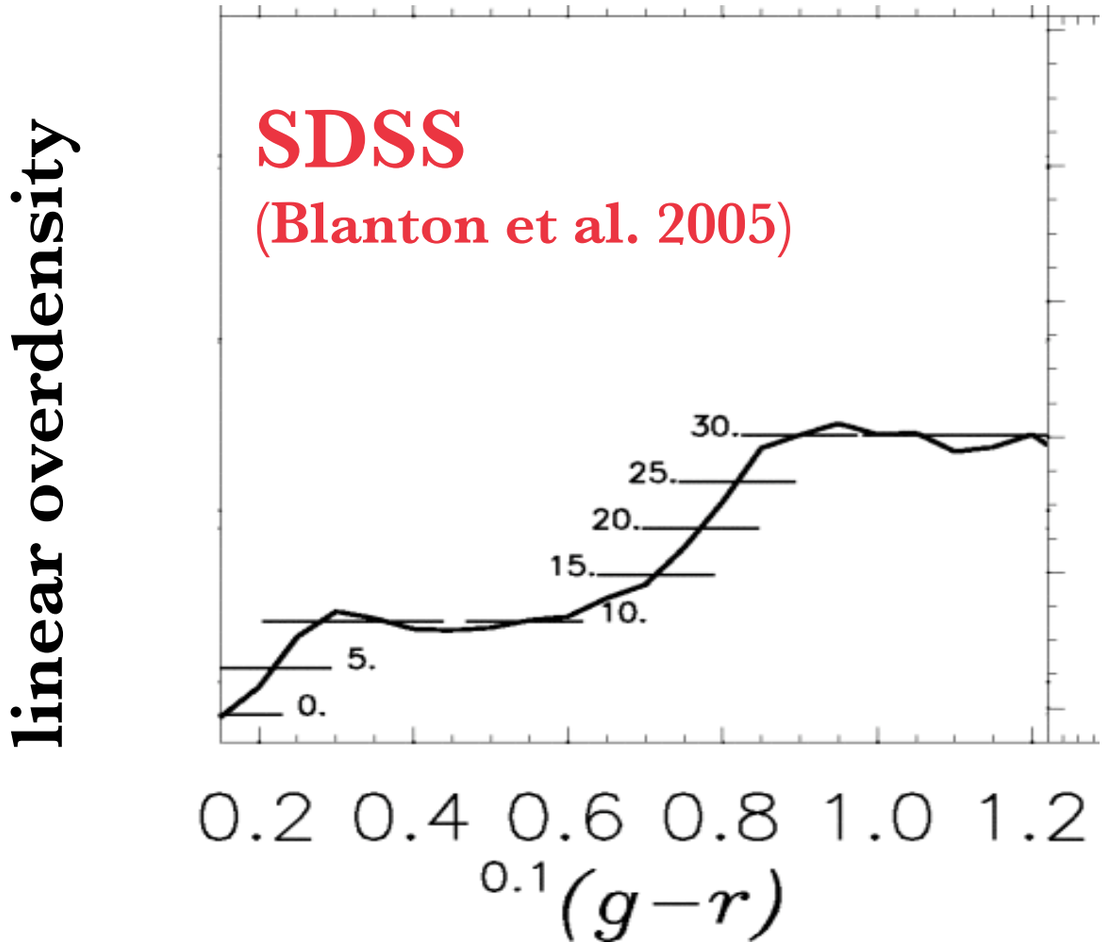
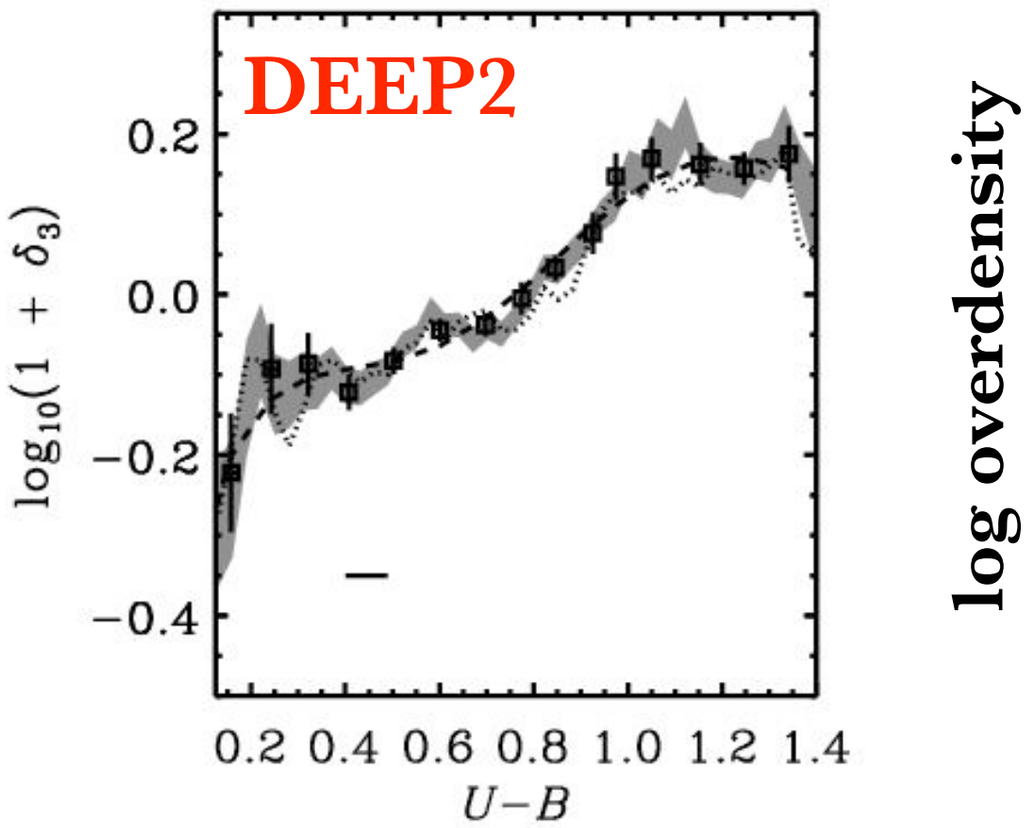
The Color-Density Relation at $z < 1$

Where: Group regime is important in establishing the color-density relation and red sequence.



Cooper et al. 2006

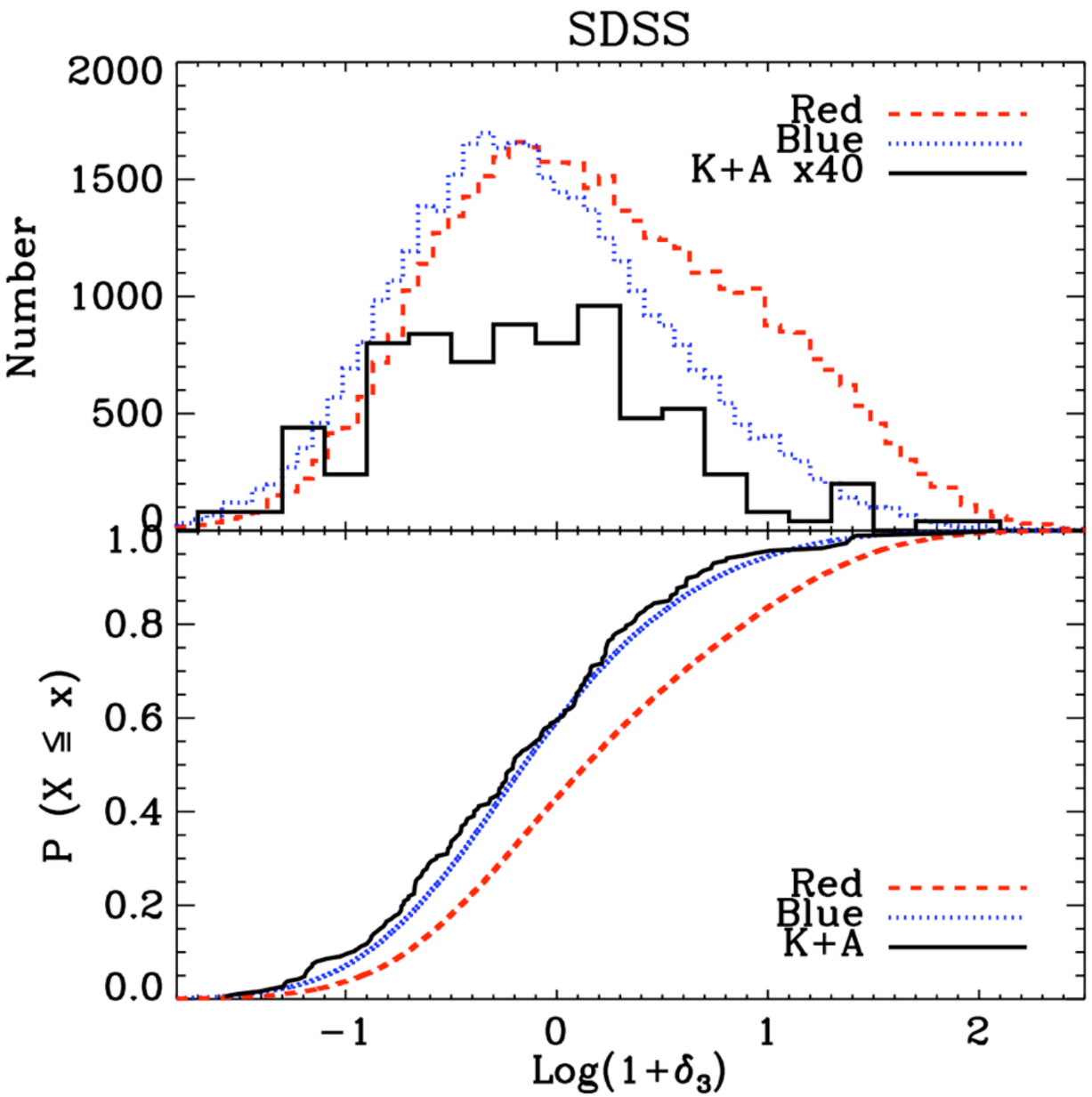


➡ **Cluster-specific mechanisms (e.g., RPS) are not needed.**

The Environments of K+As at z ~ 0

Yan et al. [astro-ph/0805.0004]

see also Zabludoff et al. (1996), Blake et al. (2004), Poggianti et al. (2004), Goto (2005), Hogg et al. (2006)



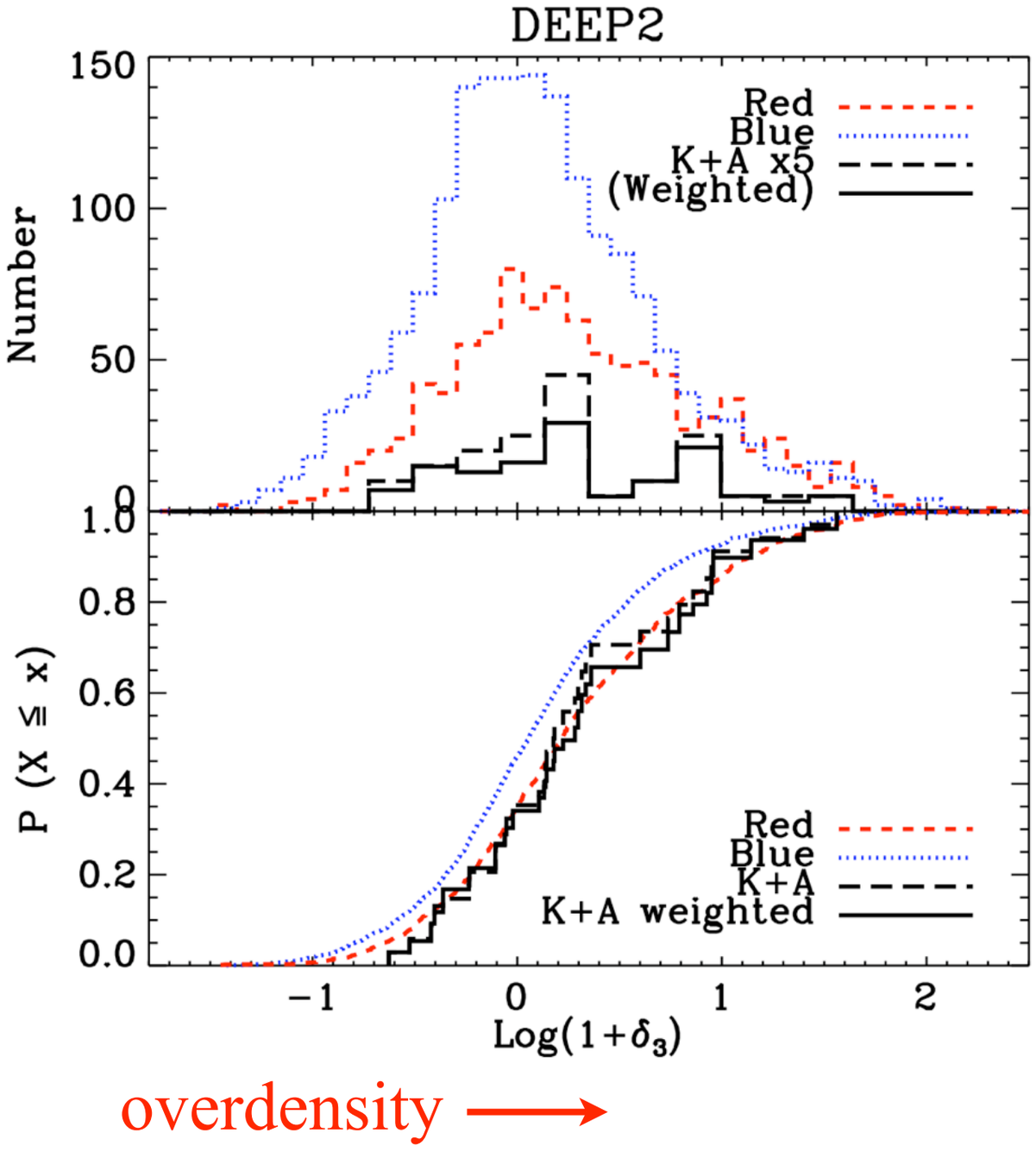
overdensity ⟶

➡ K+As cluster like **blue** galaxies at $z \sim 0$

The Environments of K+As at z ~ 1

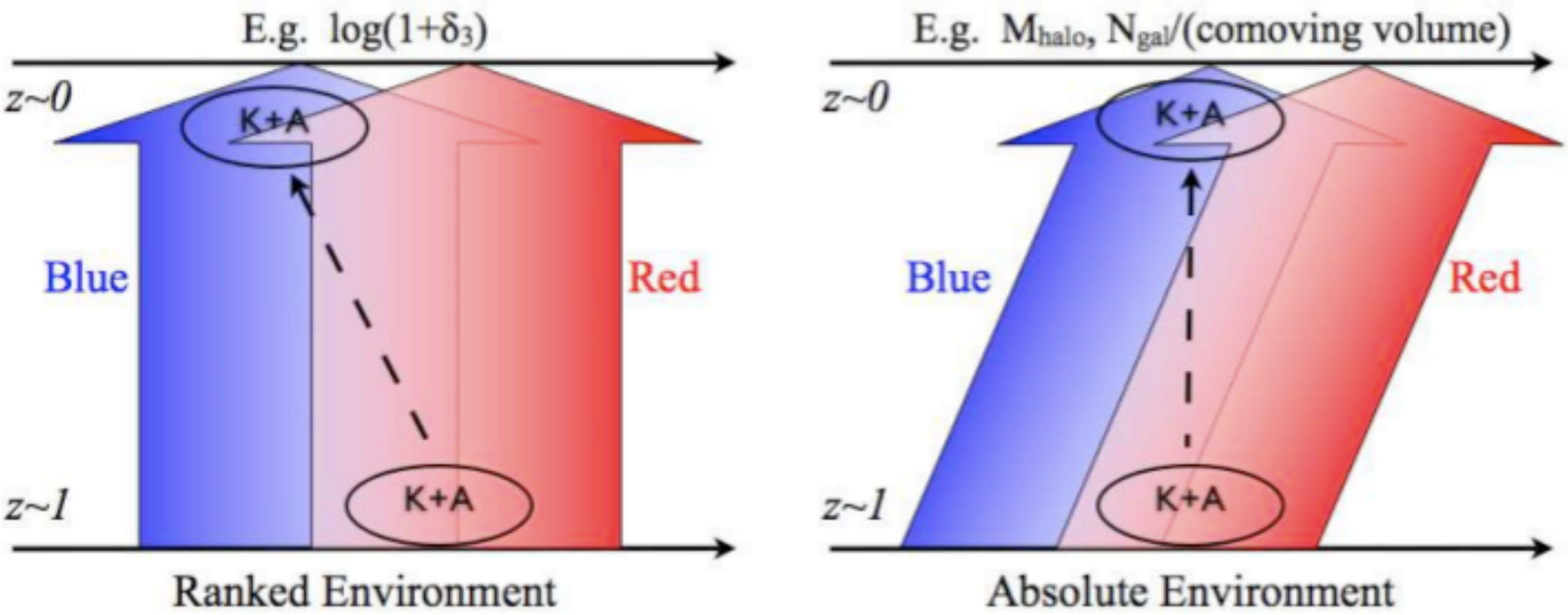
Yan et al. [astro-ph/0805.0004]

see also Balogh et al. 1999, Tran et al. 2004, Poggianti et al. 2008



➡ K+As cluster like **red** galaxies at $z \sim 1$

So what to make of these environment trends?



➡ Consistent picture at $z < 1$, where K+As result from merger-induced bursts of star formation in group environments.

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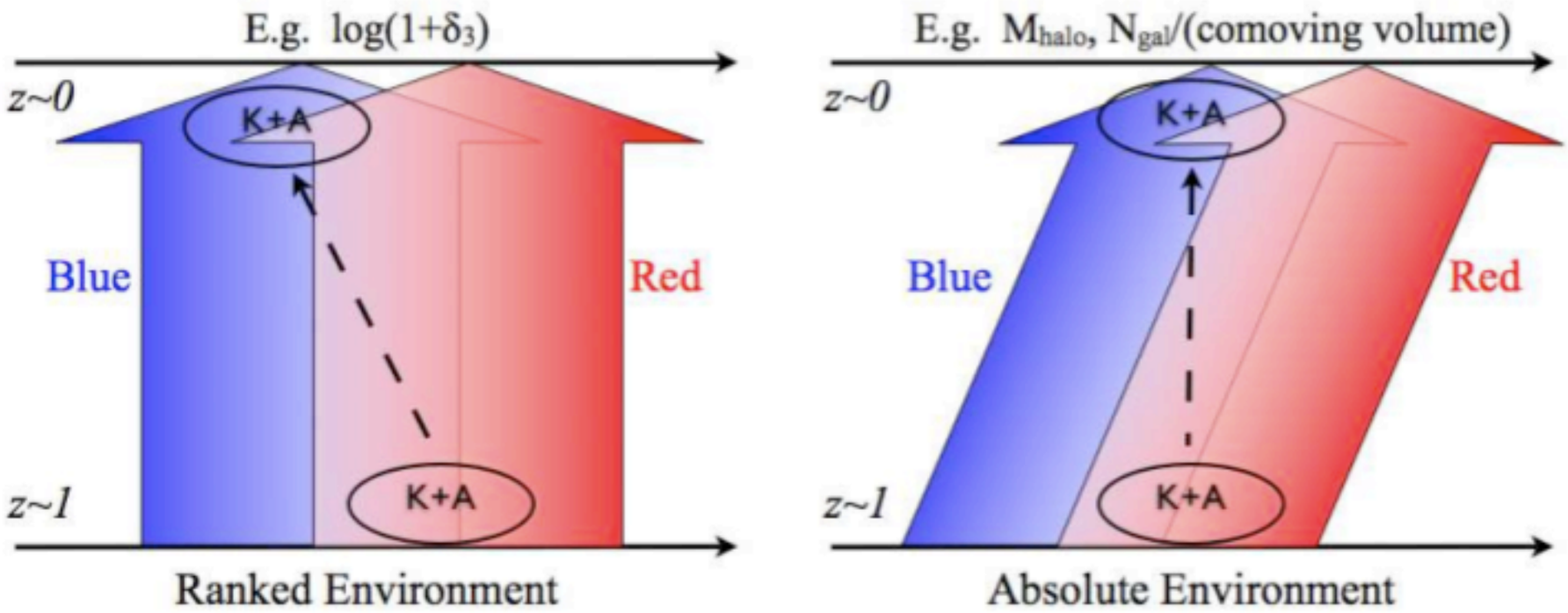


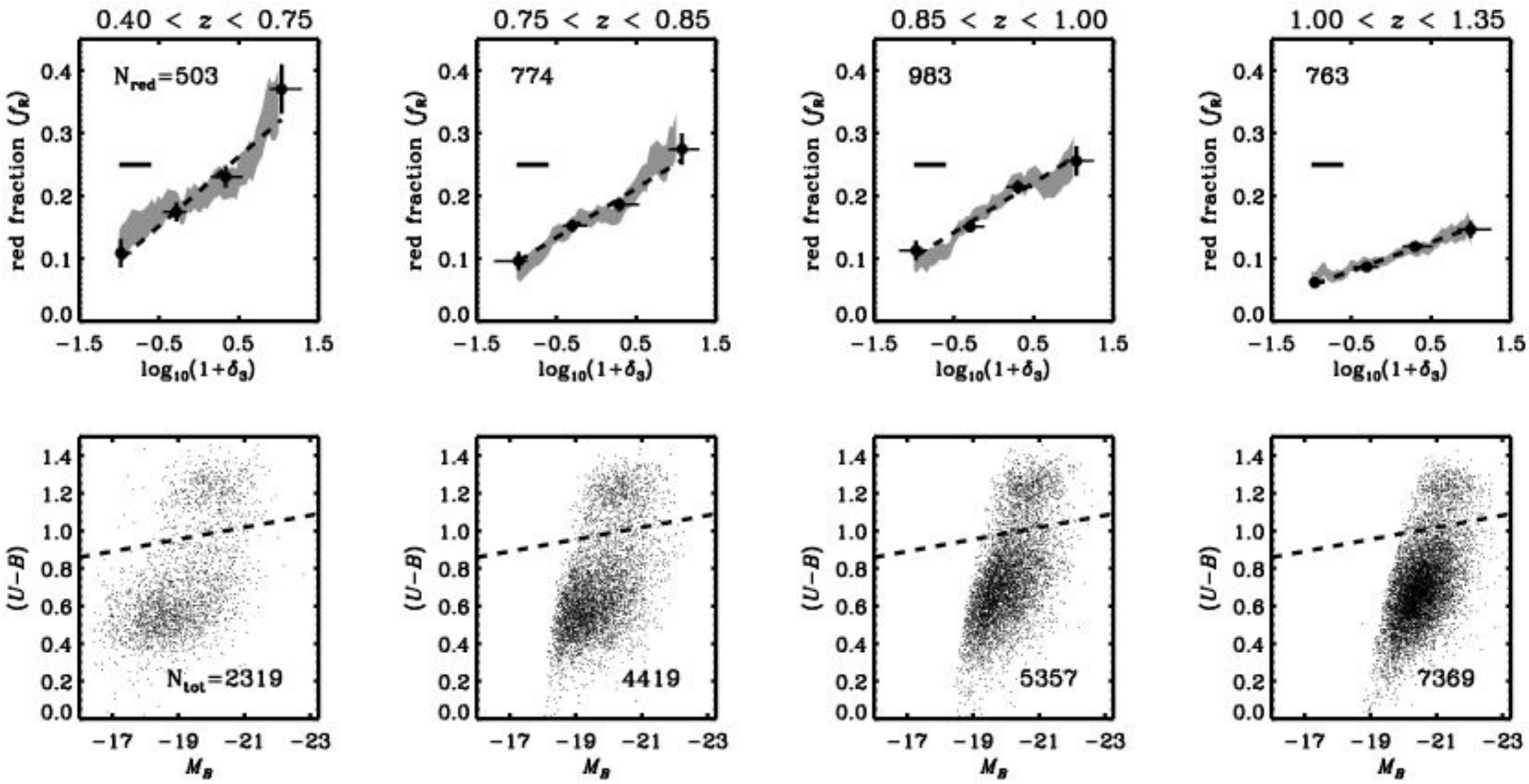
➡ Consistent picture at $z < 1$, where K+As result from merger-induced bursts of star formation in group environments.

Perhaps, this is evidence for Where...

Evolution in the Color-Density Relation

$f_R = N_{red} / (N_{red} + N_{blue})$

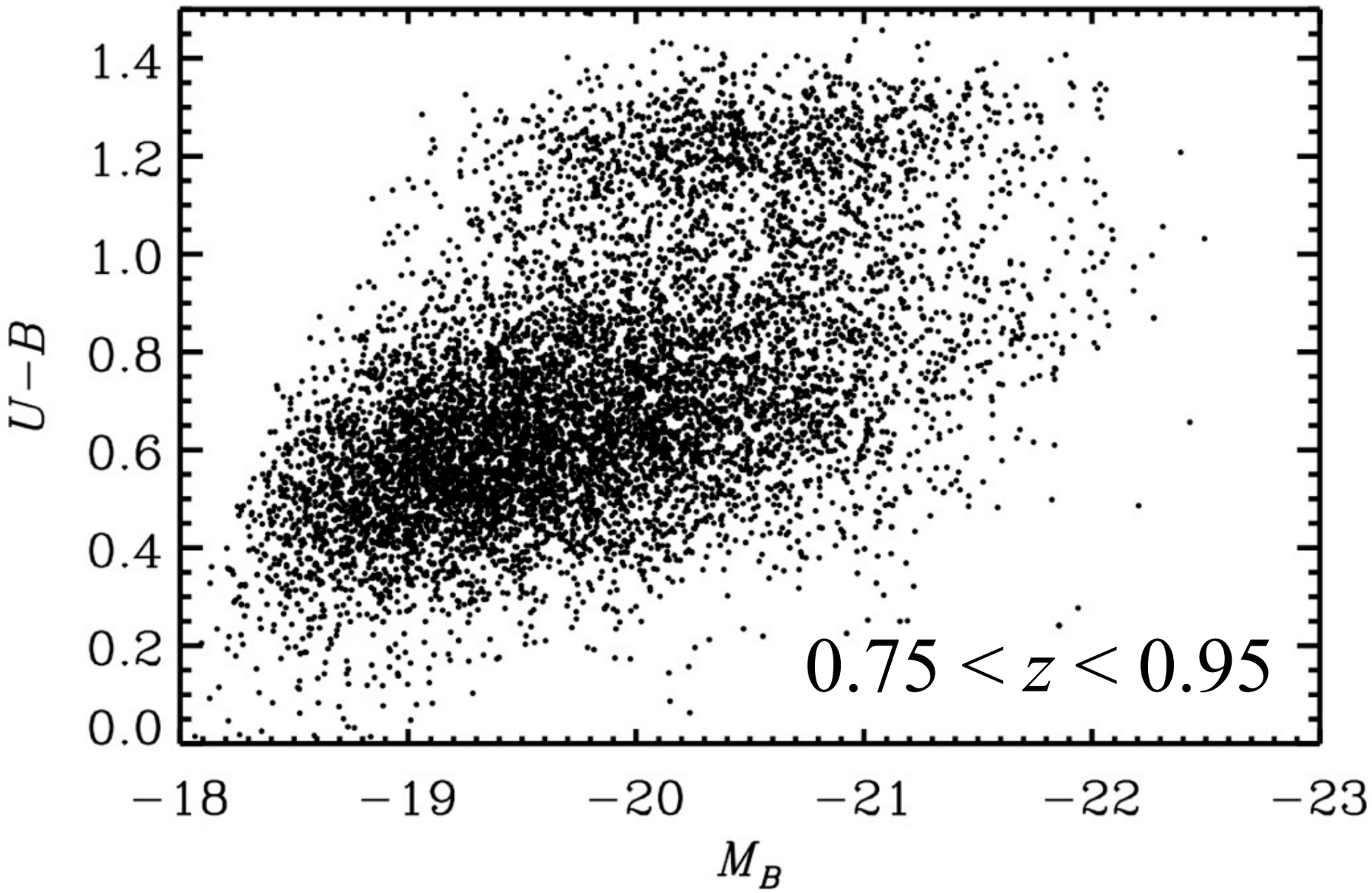
$z \sim 0.6$ | **$z \sim 0.8$** | **$z \sim 0.95$** | **$z \sim 1.15$**



Cooper et al. 2007

But what about looking at fixed stellar mass?

As Simon said, luminosity-selected samples include a stellar mass bias.



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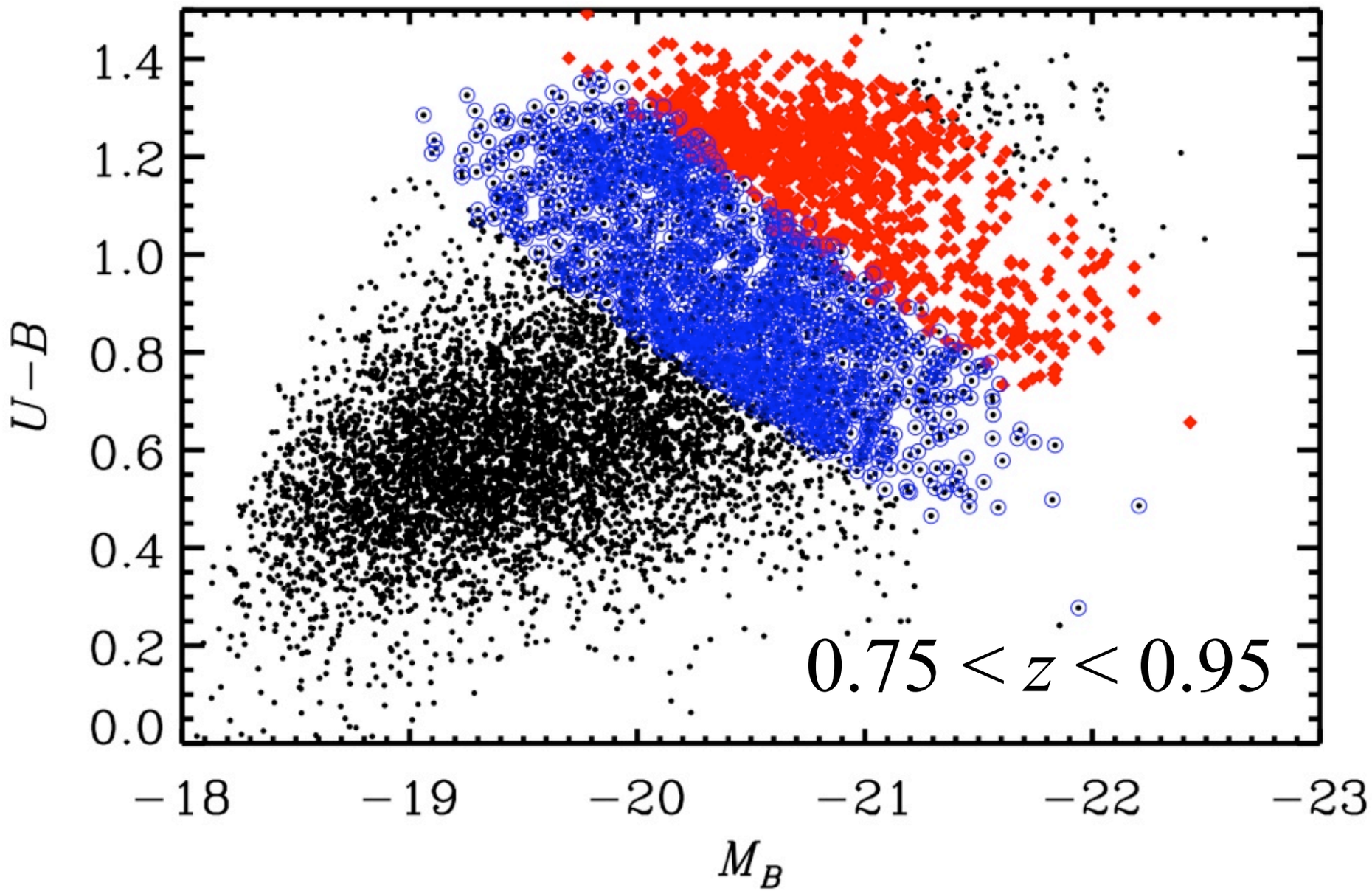
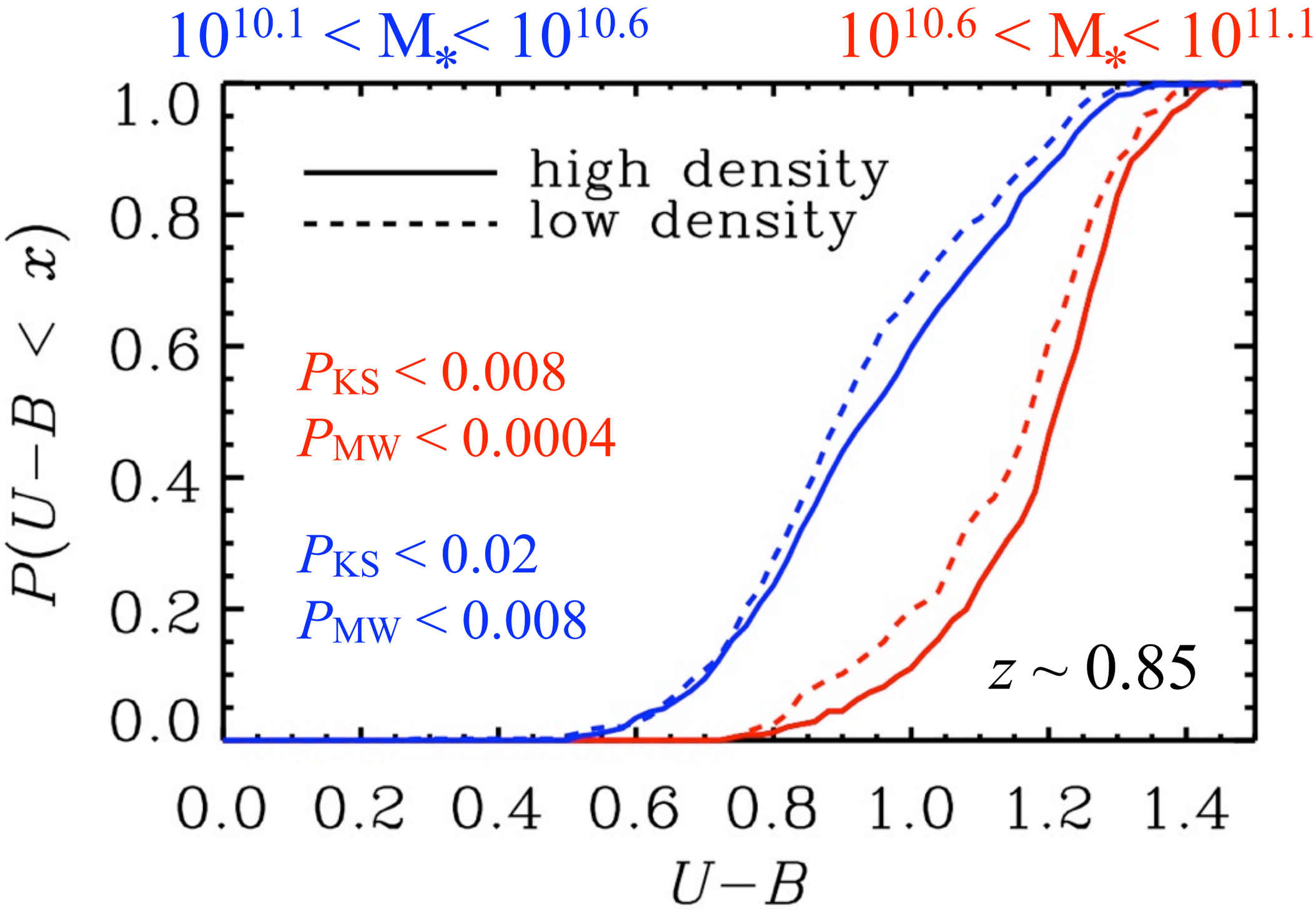
$10^{10.1} < M_* < 10^{10.6}$ $10^{10.6} < M_* < 10^{11.1}$



So is there still a color-density relation?

At $z \sim 0.85$, there is a color-density relation at fixed M_*



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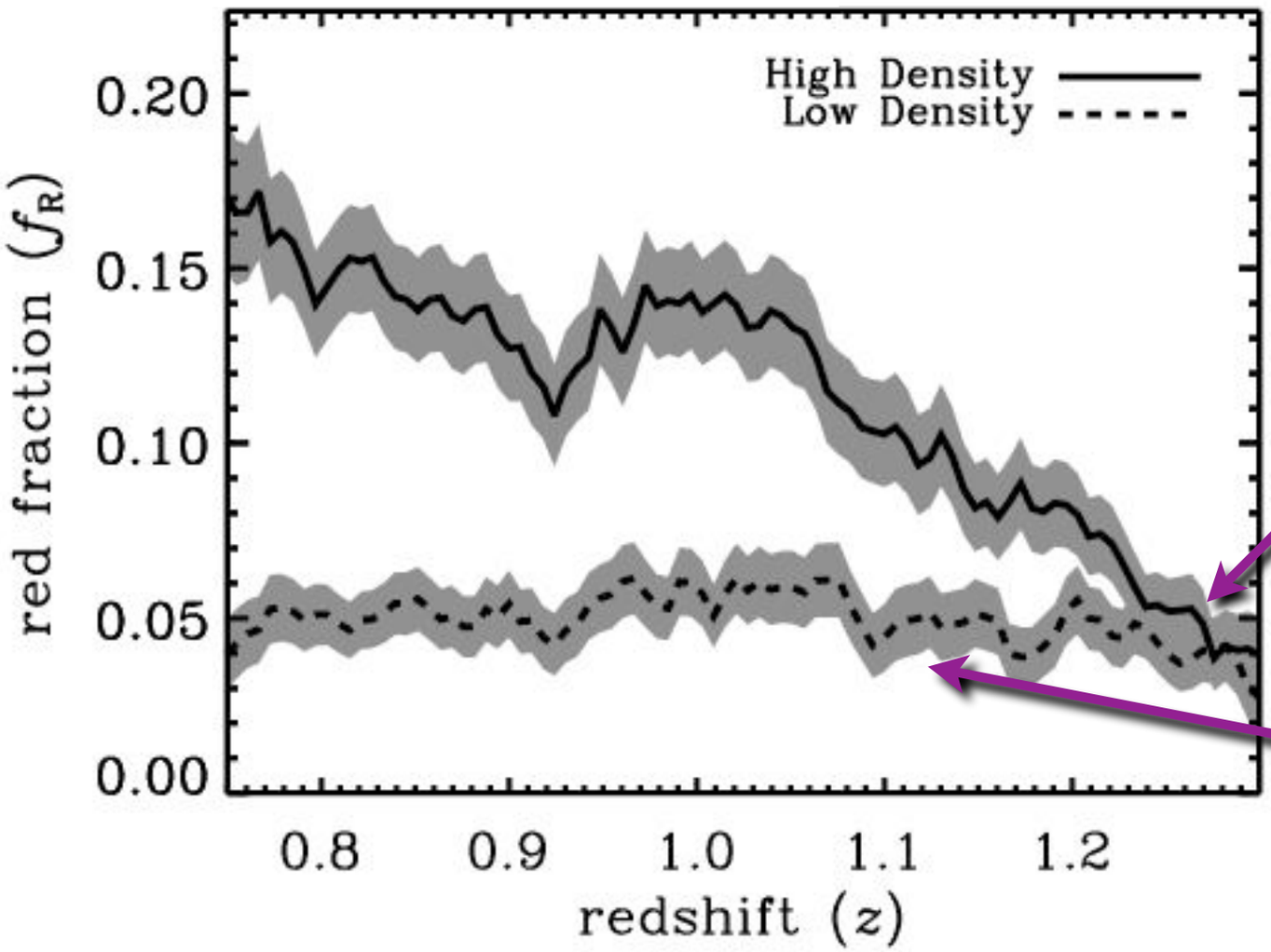

The color-density relation disappears at $z \sim 1.3$

$f_R(z)$ constant and non-zero in low-density environments

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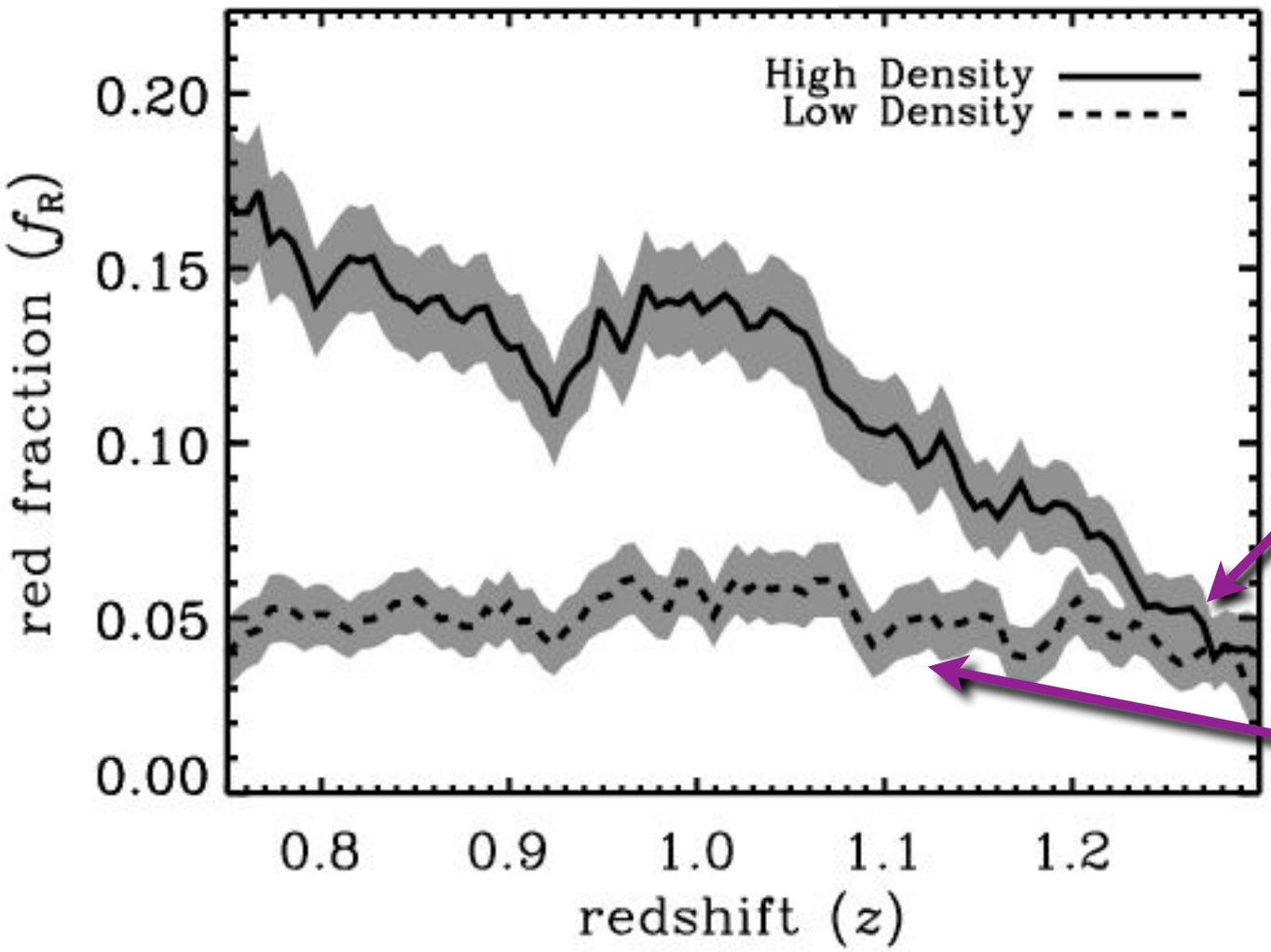

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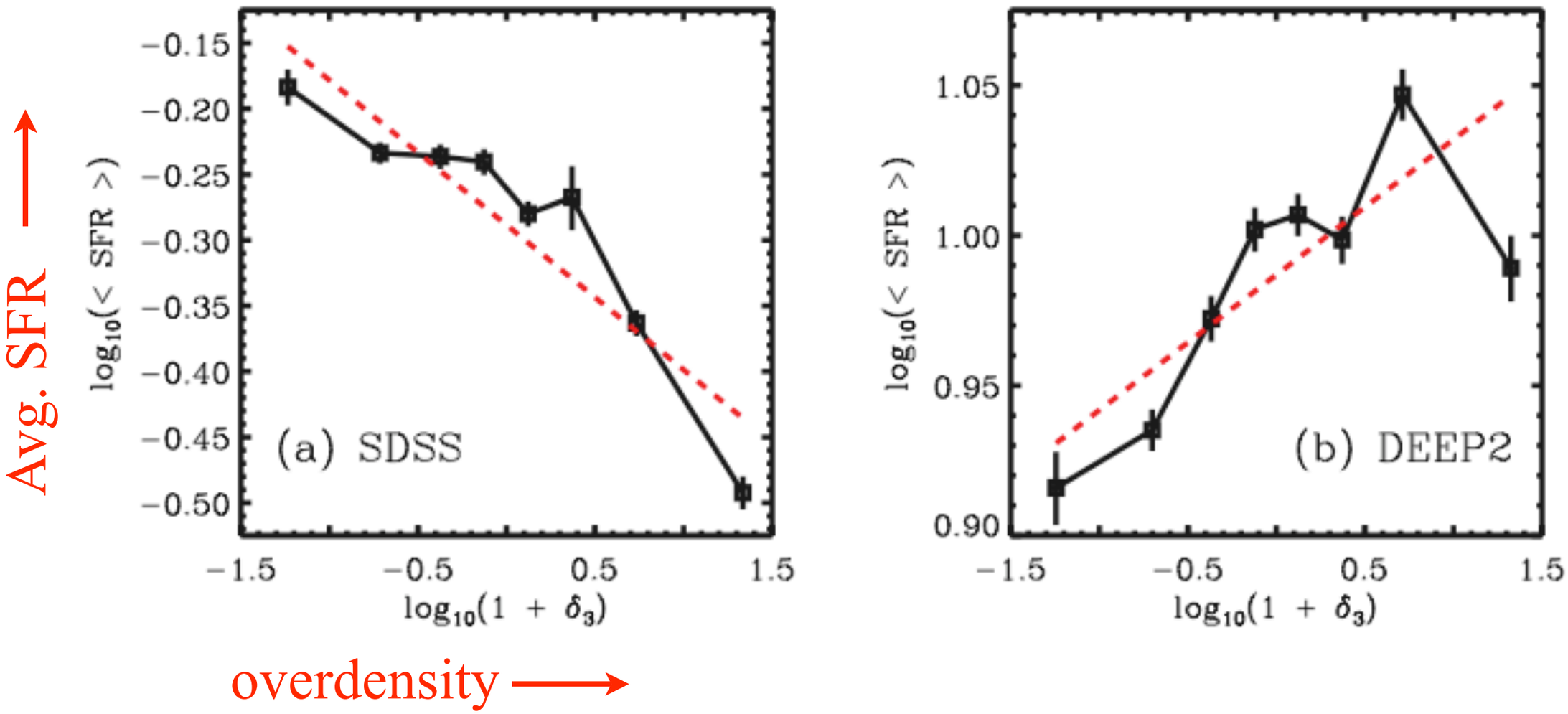
$f_R(z)$ constant and non-zero in low-density environments

When: L^* galaxies appear to begin moving onto the red sequence in groups at $z \sim 1.5$.

So does environment drive the ρ_{SFR}?

Cooper et al. 2008
[see also Elbaz et al. 2007]



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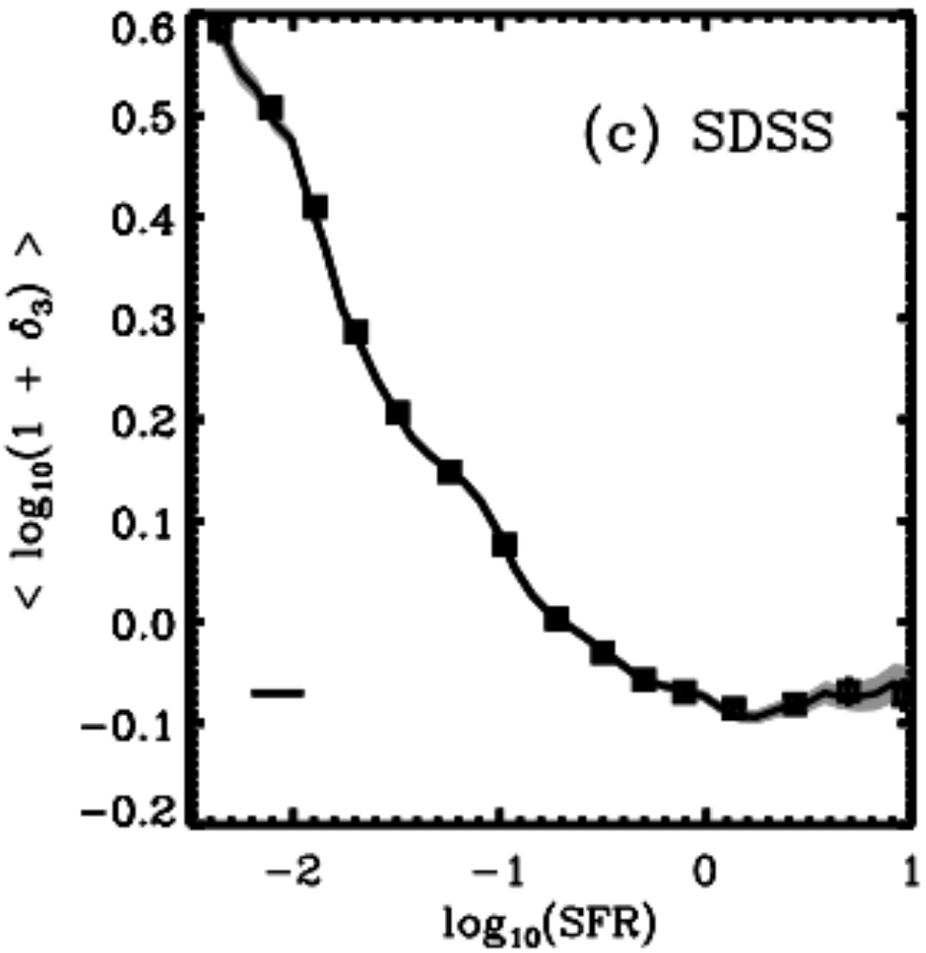
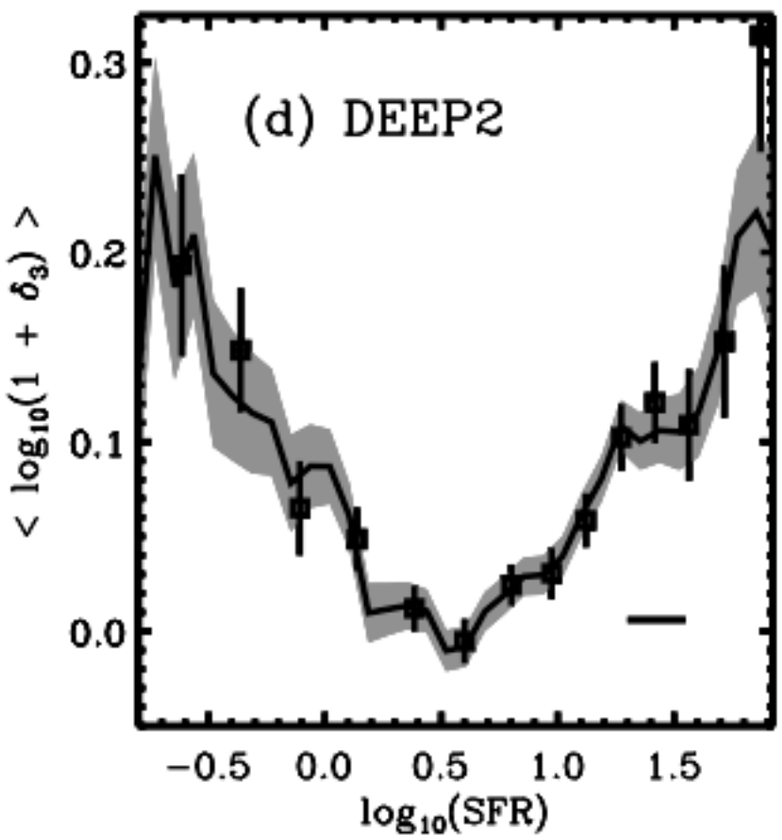
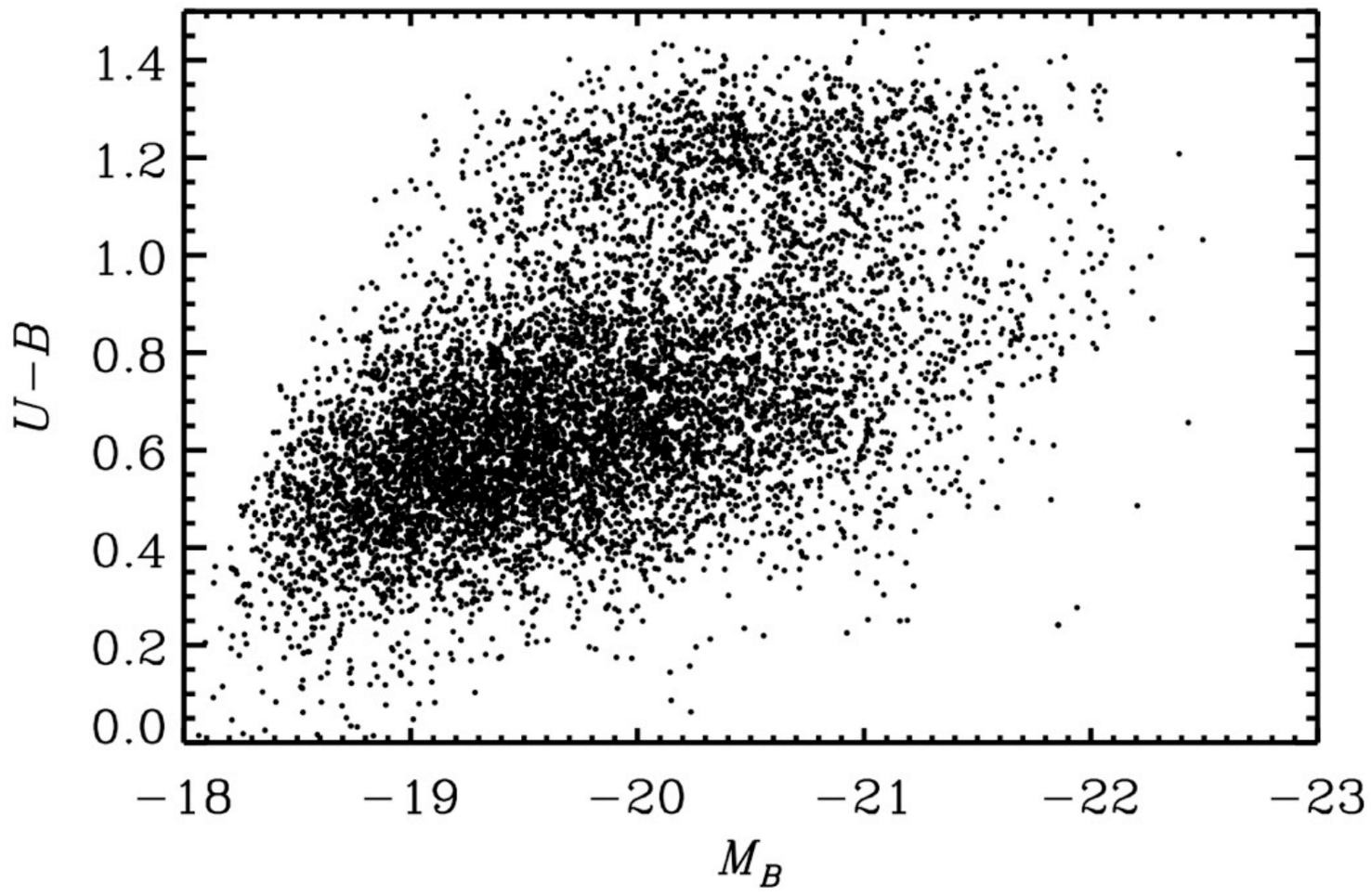


SFR-density relation at $z \sim 1$ is a result of two effects:
[1] quenching preferentially occurs in dense regions and
[2] mean environ depends on mass (luminosity) along
the blue cloud at $z = 1$.





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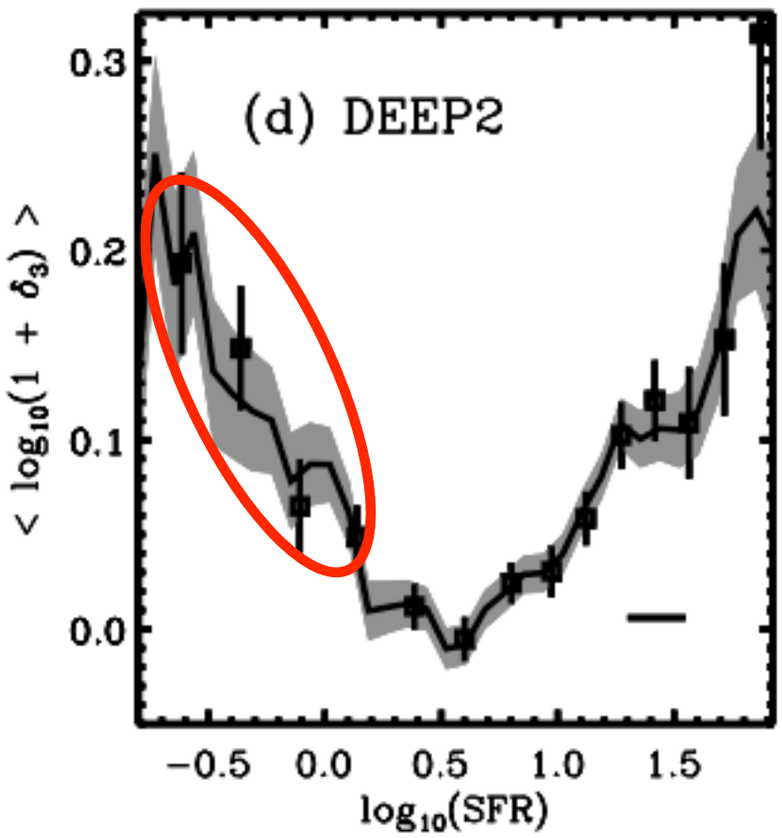

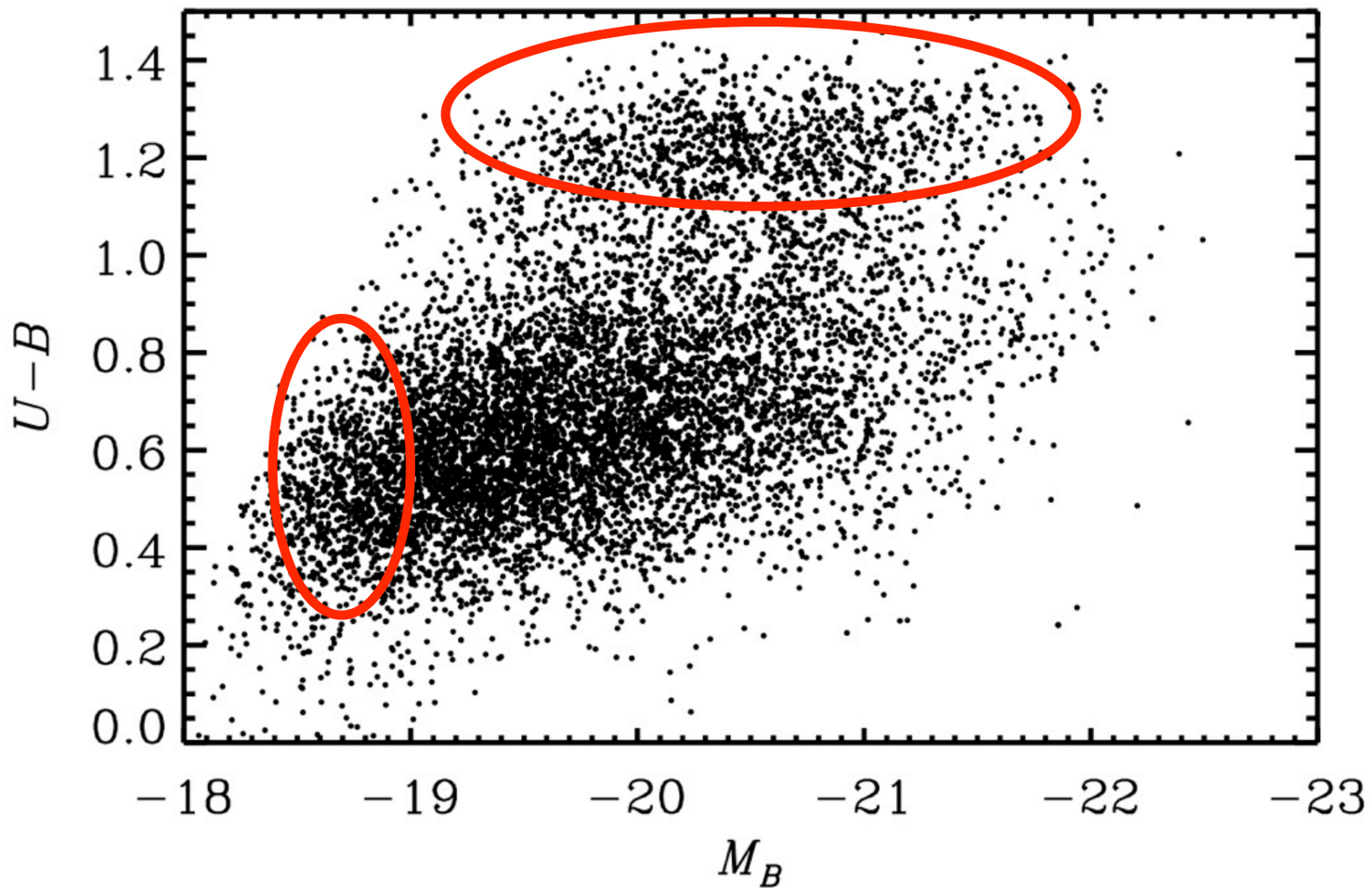

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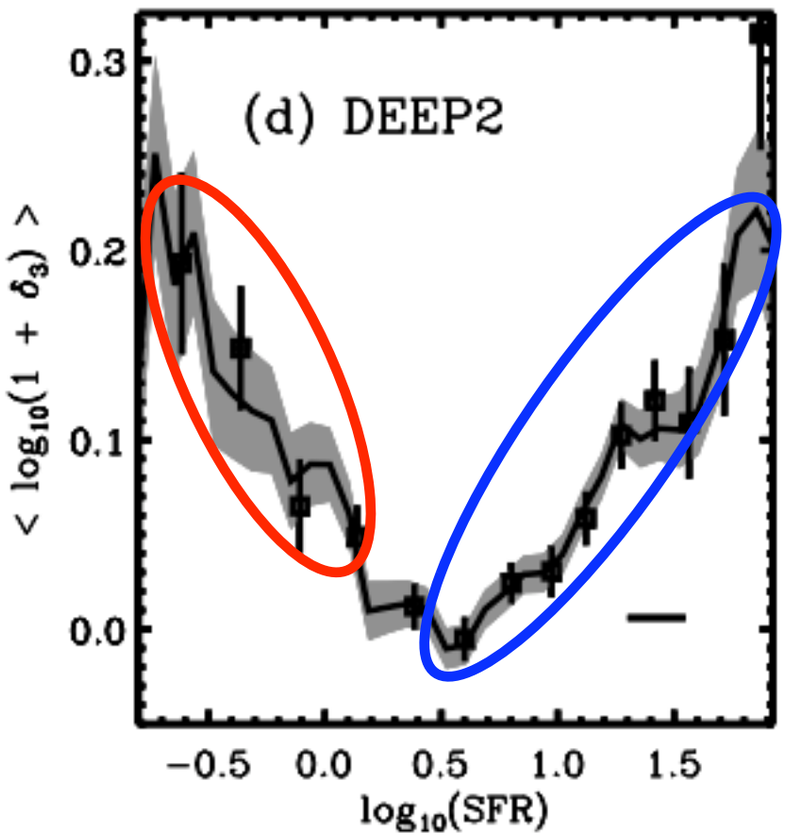

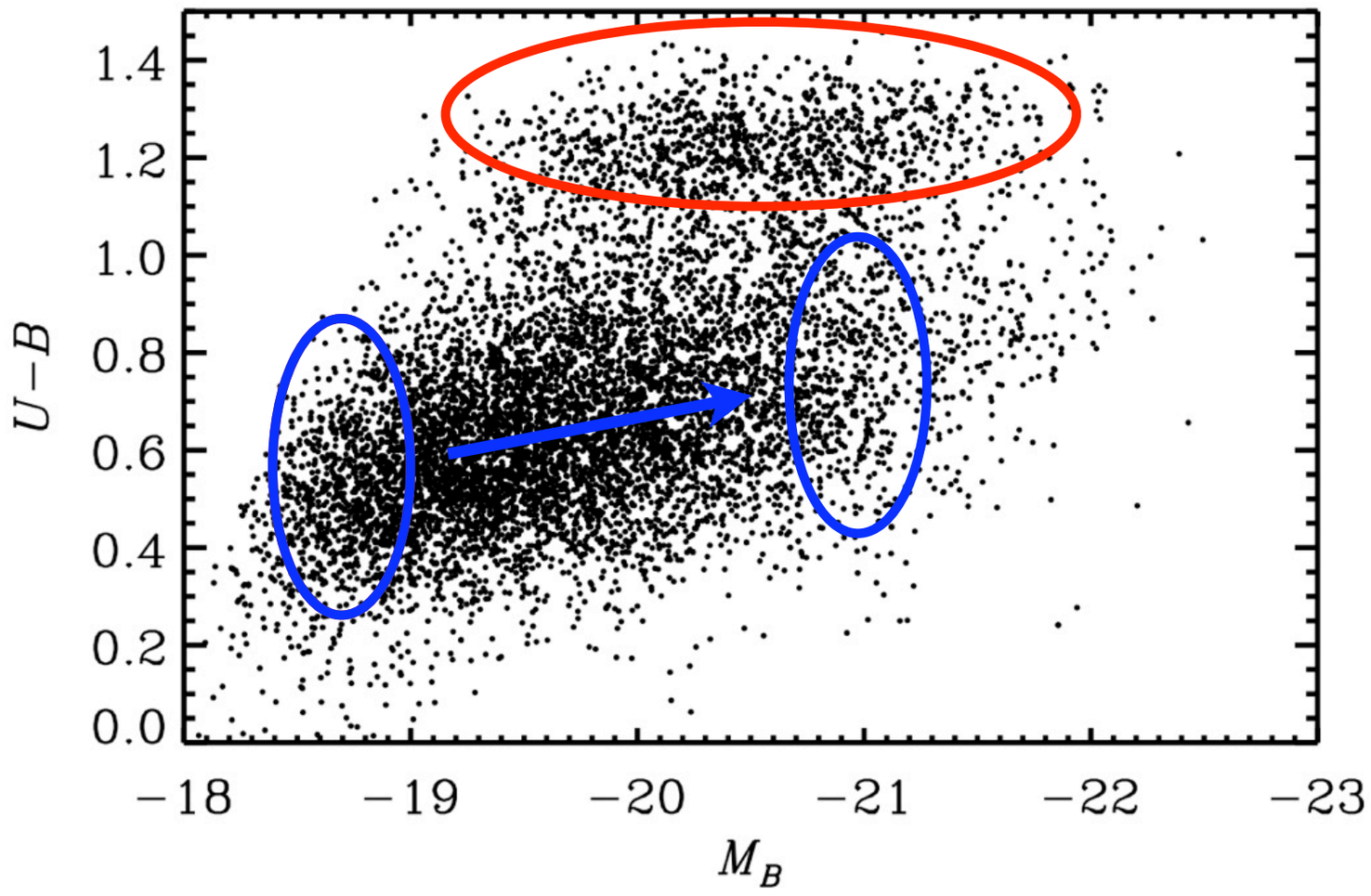

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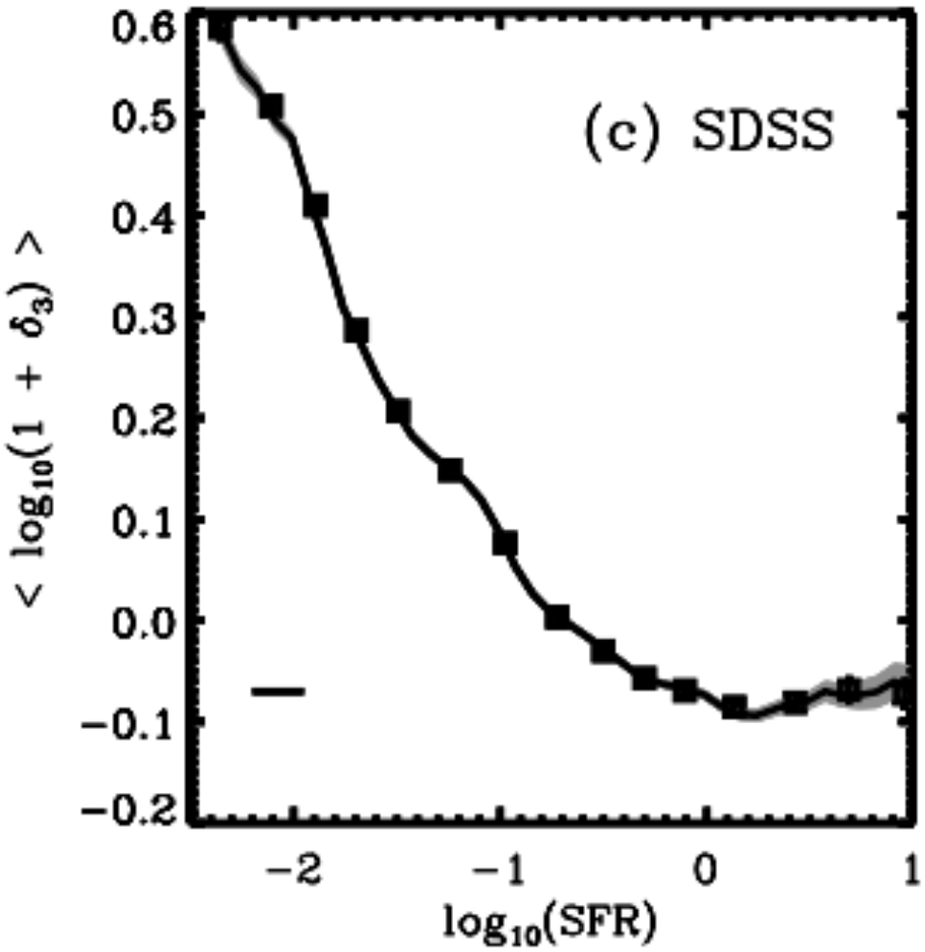

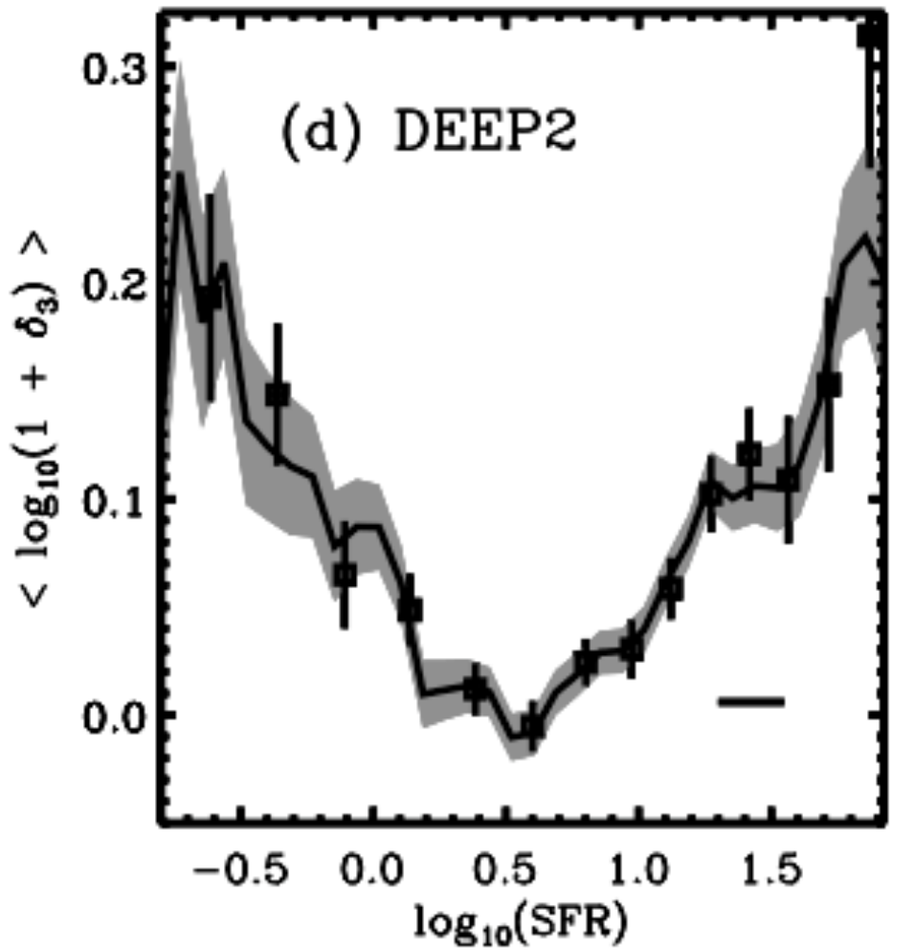

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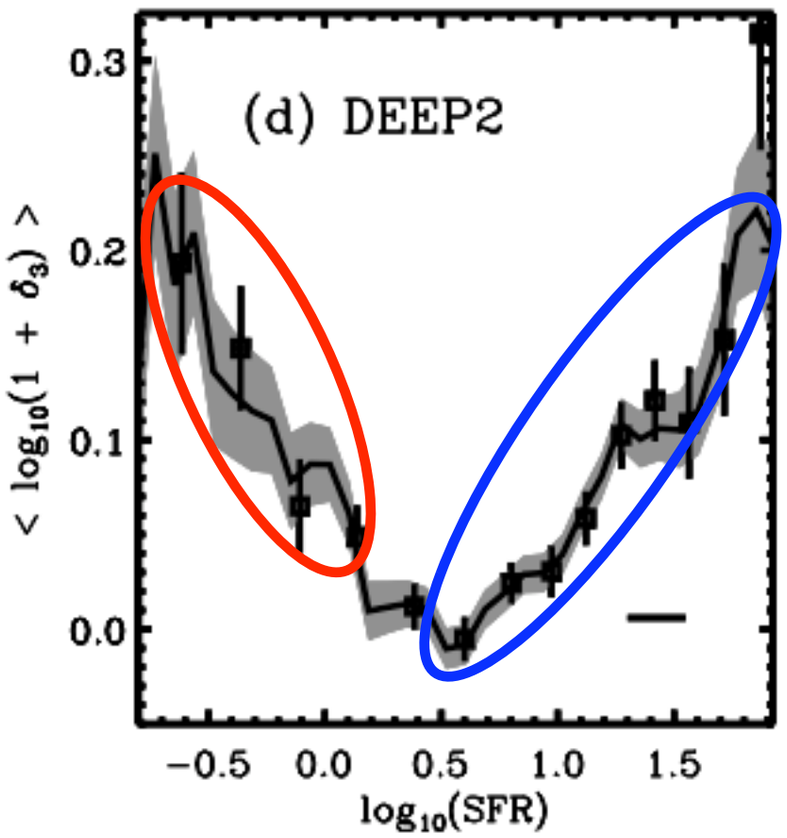
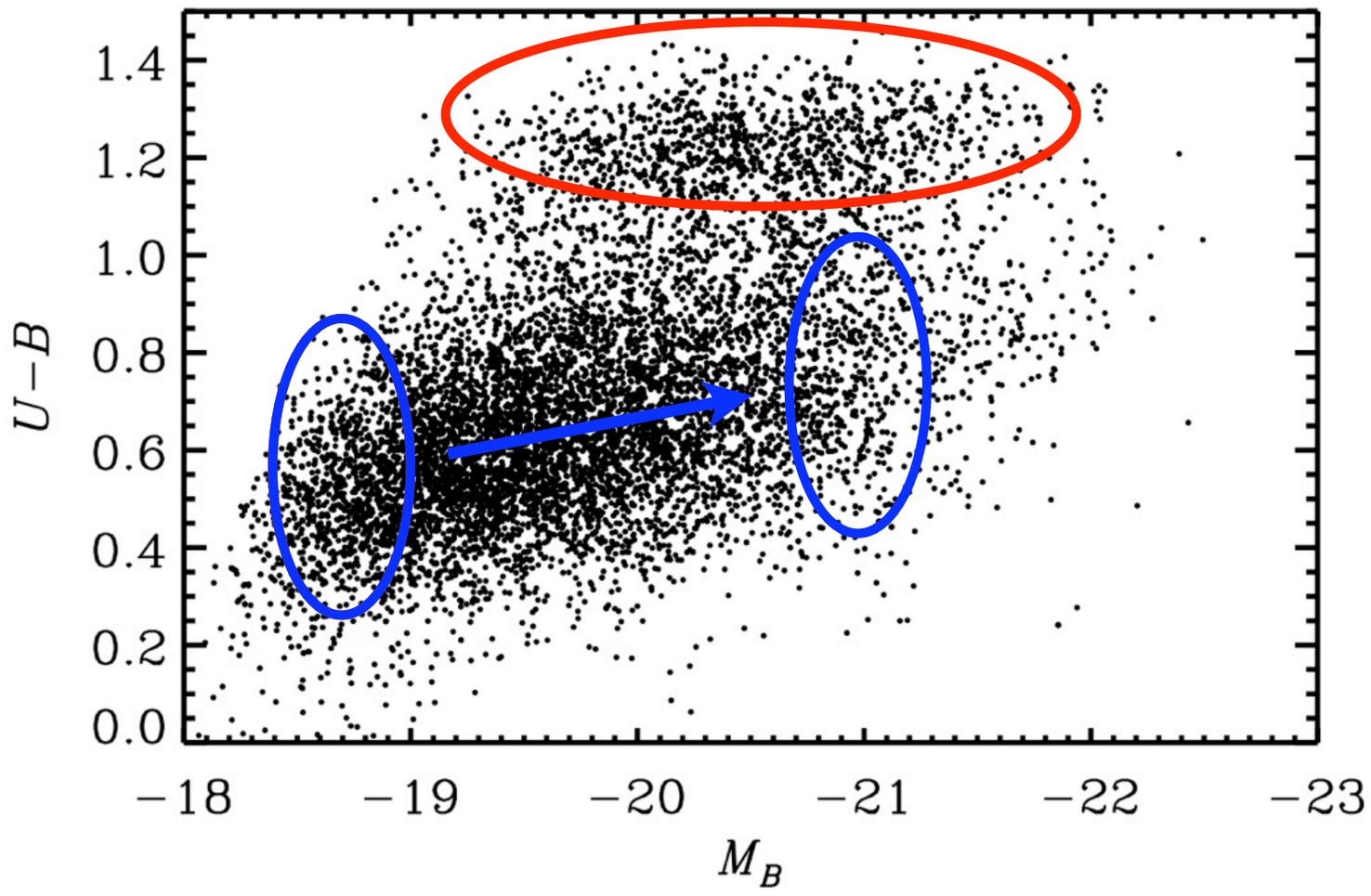
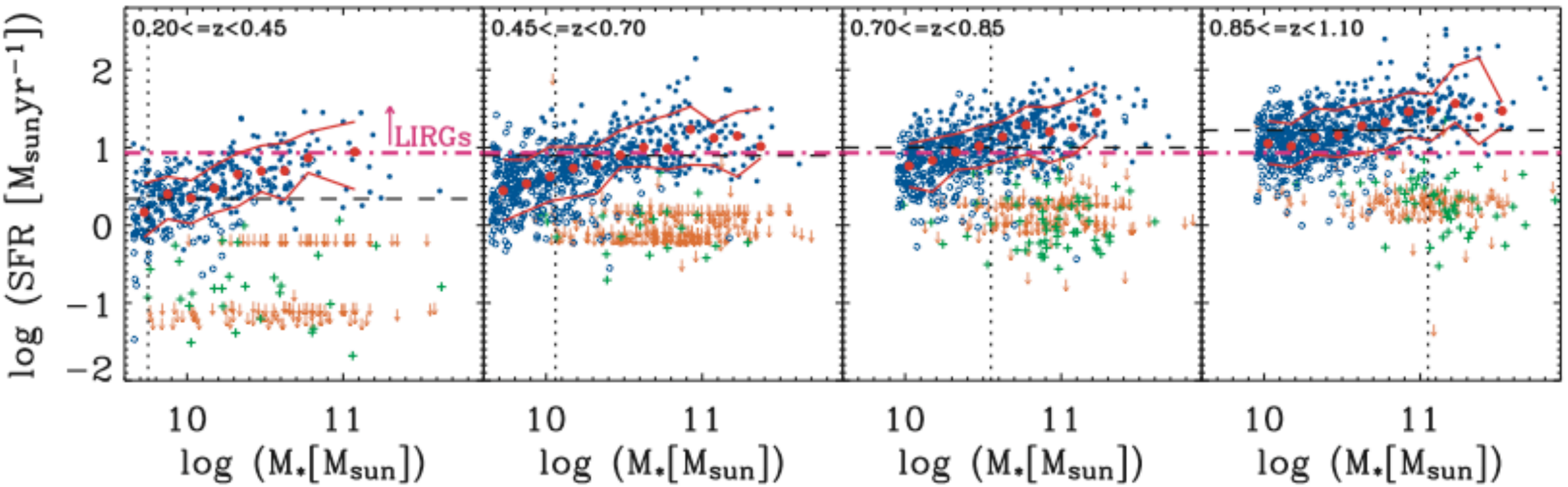




While quenching mechanisms tied to halo mass may drive the build-up of the red sequence...they don't explain the decline in ρ_{SFR}!

Noeske et al. 2007



Gas depletion and NOT mergers drive the cosmic ρ_{SFR}.

also see Zheng et al. 2007

Summary

1. Care needs to be taken when looking at trends with environment.
2. Cluster-specific processes are not important in establishing the color-density relation at $z < 1.5$.
3. The build-up of the red sequence is an environment-driven trend, with L^* galaxies moving to the red sequence preferentially in groups.
4. Environment does not drive the decline in the cosmic ρ_{SFR}.

So where, when and how did the red sequence form?

Where = in group environments
When = starting at $1.5 < z < 2$
How = through a combination of mergers, suffocation/strangulation