Interpreting the Clustering of the Most Massive Galaxies at z~2.5

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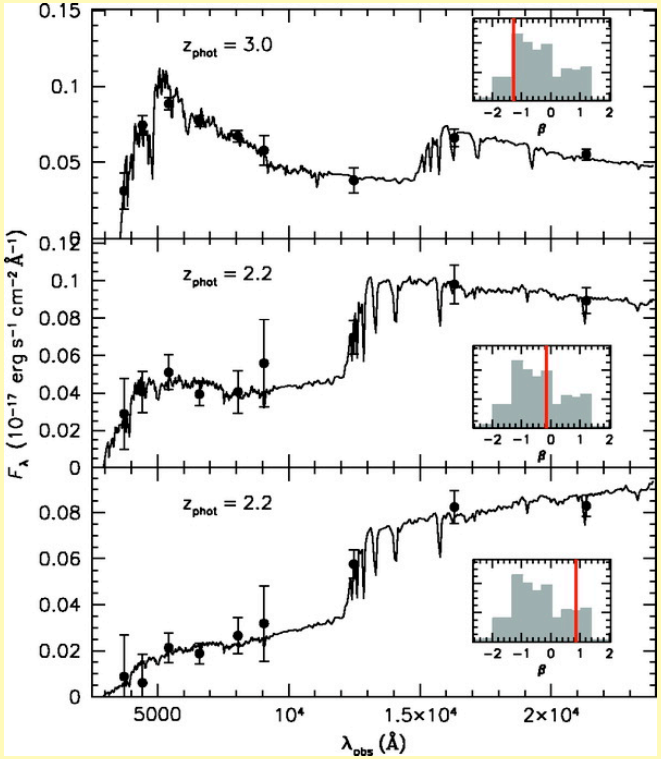
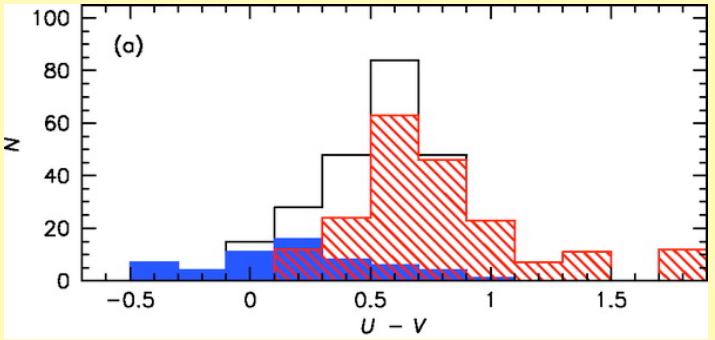
The most massive galaxies: a diversity of properties



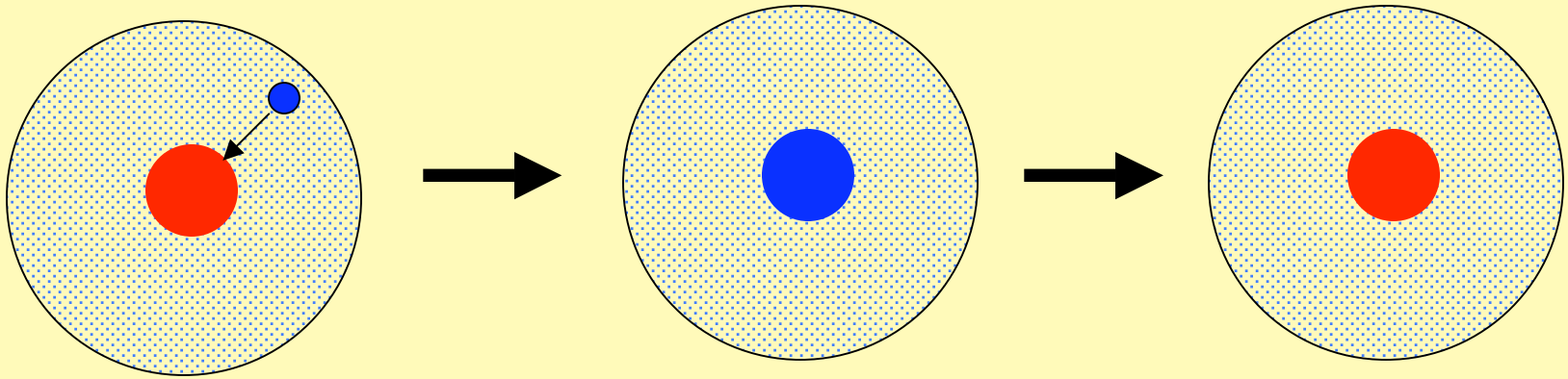
van Dokkum et al. 2006

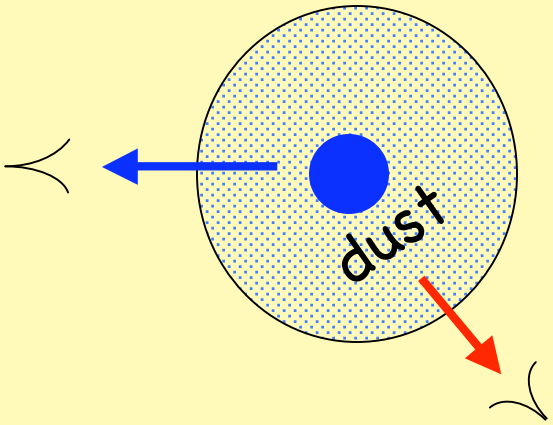
- Wide range of colors
- Both the distant red galaxy (DRG) selection of the optical selections give a biased sample
- But DRGs make of *70% of galaxies with* $M_* > 10^{11} M_\odot$



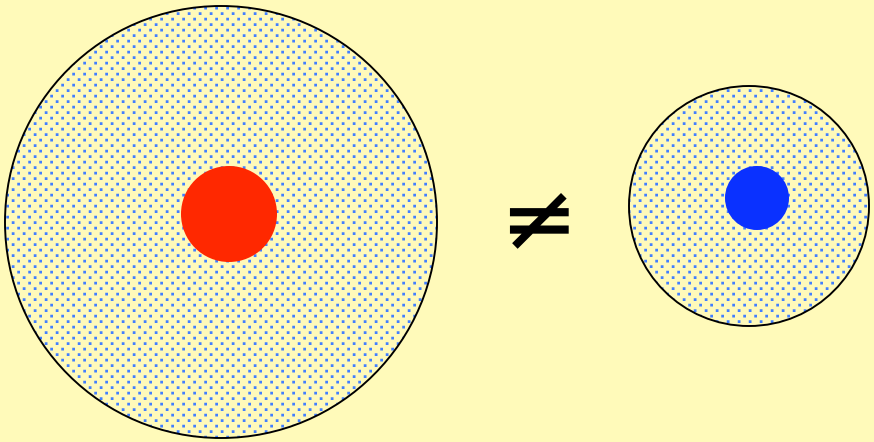
What is the nature of the differences?

Are they transient?





or fundamental?



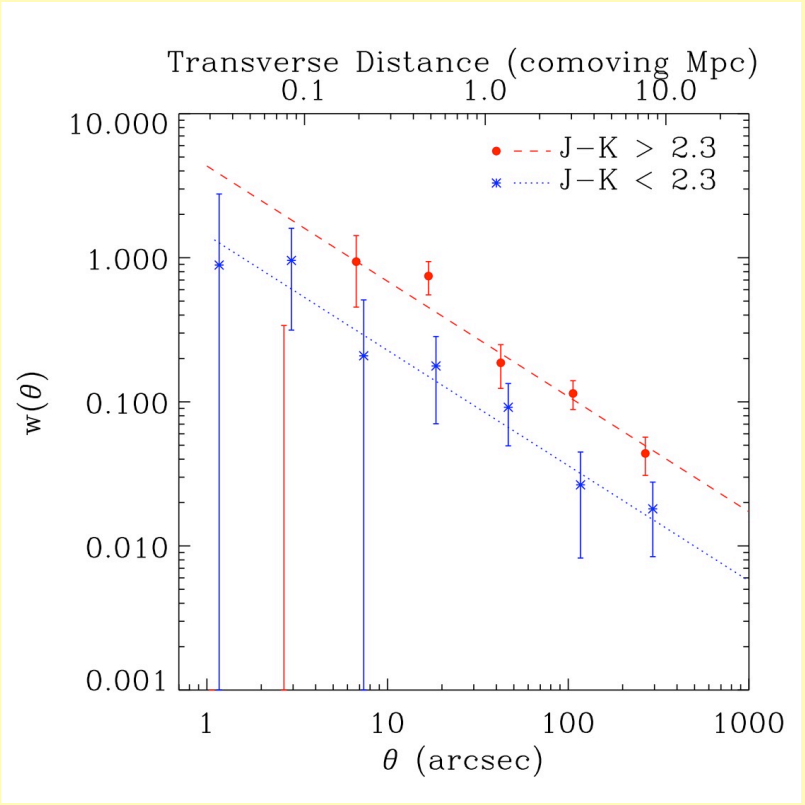
Galaxy clustering

- Fundamental property of galaxies
  - Provides another way to distinguish differences between different populations
- Relationship between galaxies and dark matter halos: $r_0(M_h)$
- Evolutionary links between galaxies at different redshifts

Clustering as a function of color

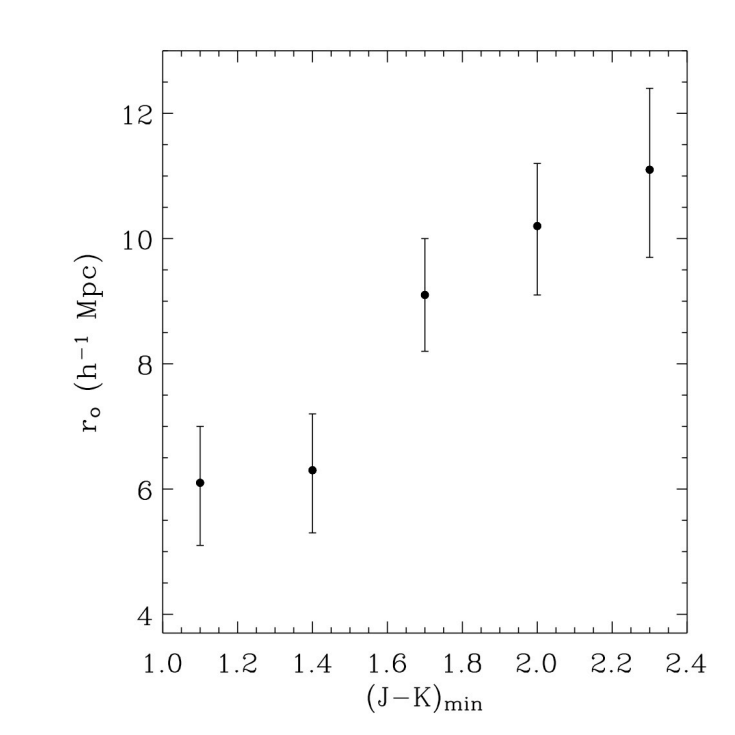
- Direct comparison of the clustering of DRGs to non-DRGs, selected in the same way
- Deep NIR imaging from the Multiwavelength Survey by Yale-Chile (MUSYC)

www.astro.yale.edu/MUSYC



Quadri et al. 2007

r_o vs. color



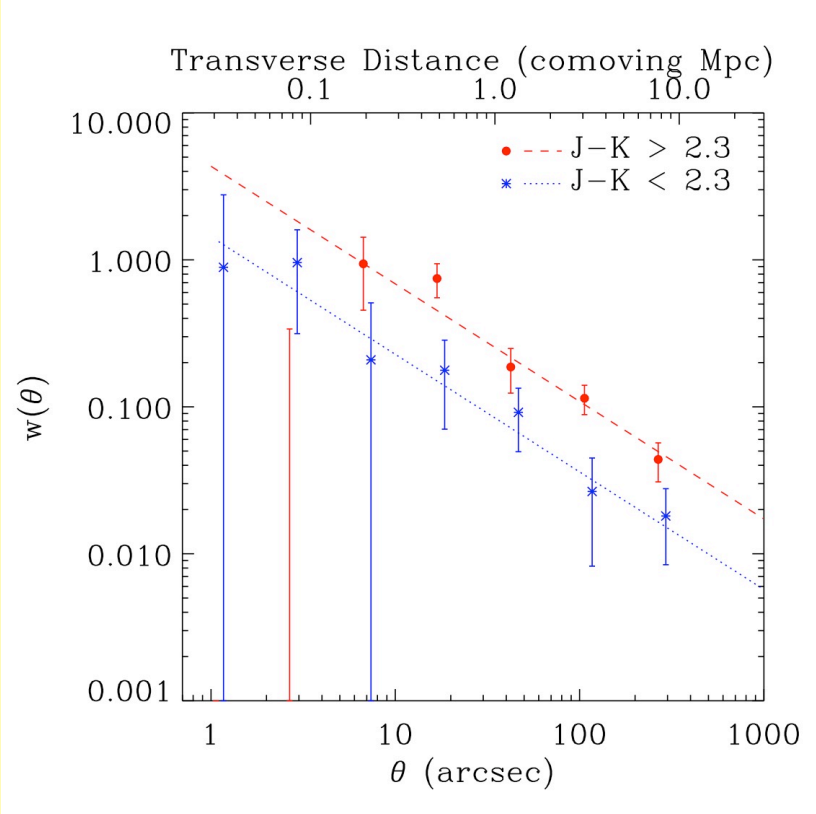
Quadri et al. 2007

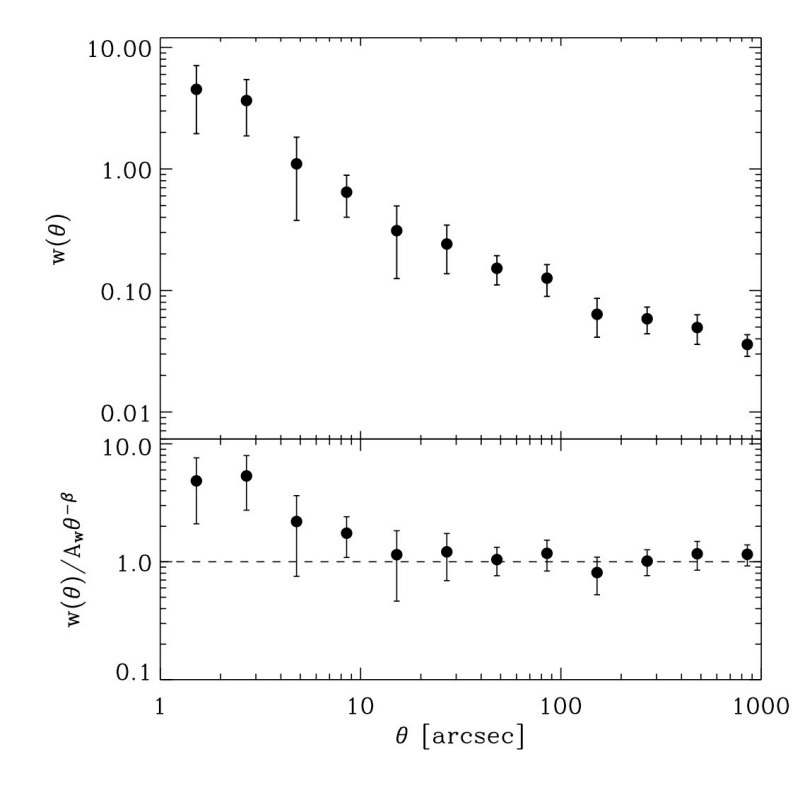
- r_o increases with rest-frame optical color
- DRGs have $r_o=11\pm1.5h^{-1}$Mpc (total uncertainty ~twice as large)
- Differences are fundamental, not simply transient

=>it appears that a color-density relation was already in place at z~2.5

UKIDSS Ultra Deep Survey: DRG angular correlation function

$r_o = 9.5 \pm 0.8 h^{-1} Mpc$

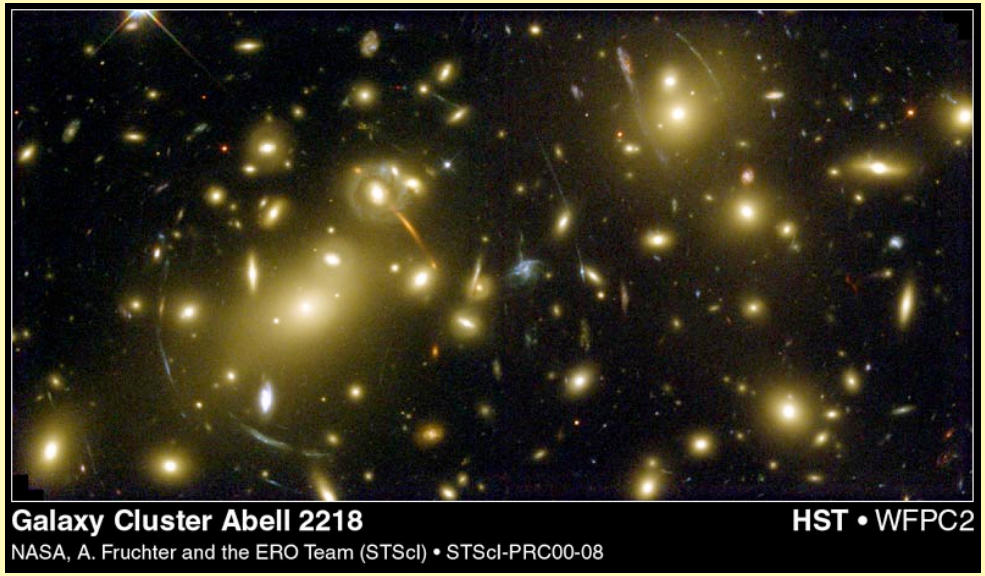




Quadri et al., in prep

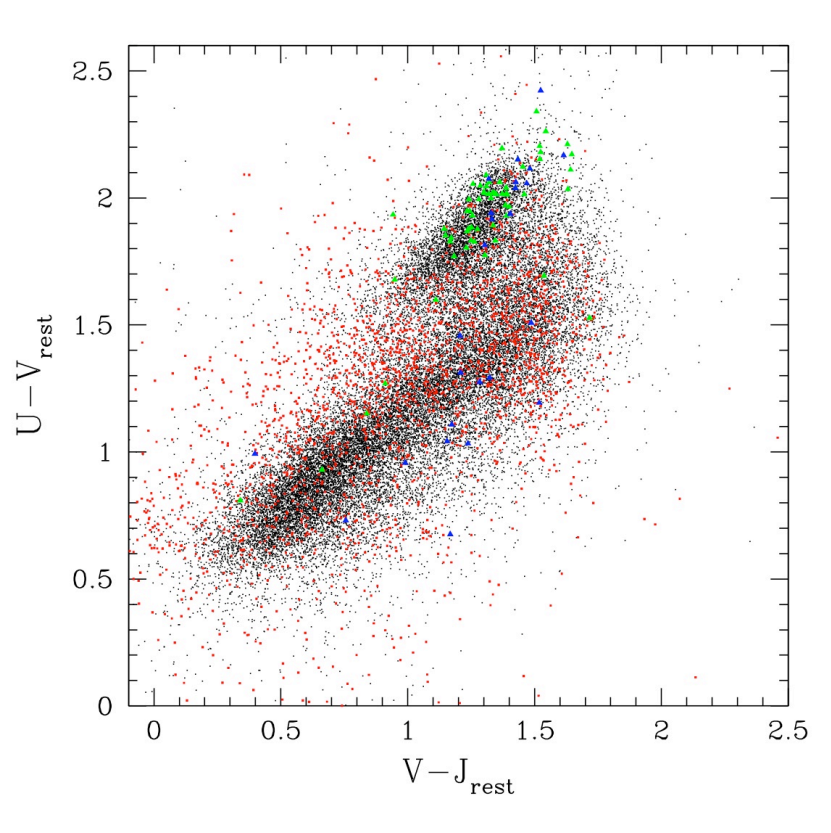
What drives the color-density relation?

- A color-density relation was in place when the universe was only ~2.5Gyr old
- Are the red colors of the clustered galaxies caused by dust or age?



Star-forming and passive galaxies

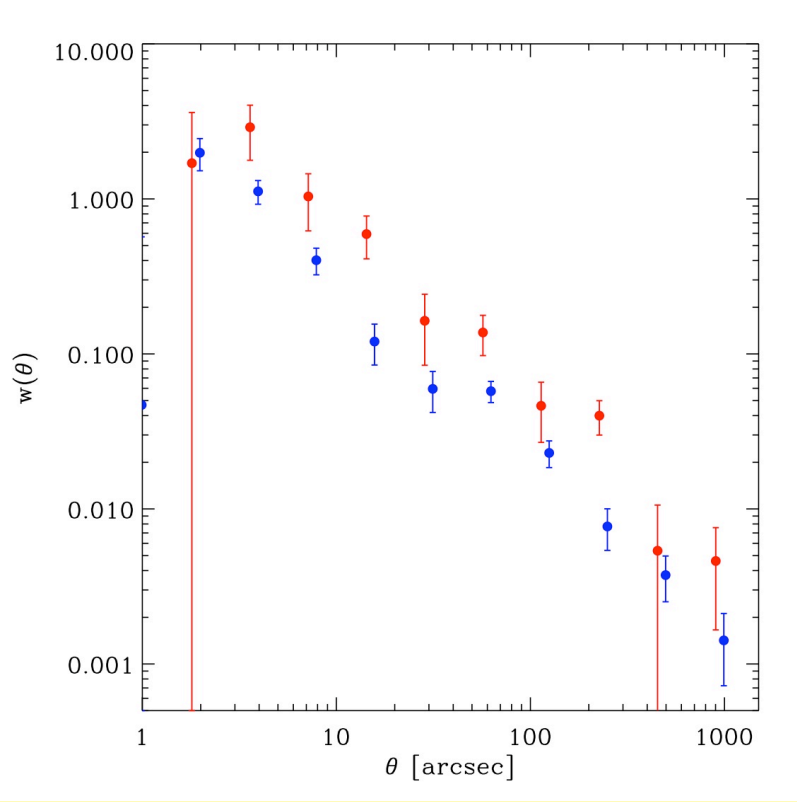
- Following Labbé et al. (2005) and Wuyts et al. (2007), we can separate star-forming and passive galaxies using the rest-frame optical/NIR colors
- UKIDSS+SXDS+SWIRE: galaxies at $0<z_{phot}<2.5$



Williams et al., in prep

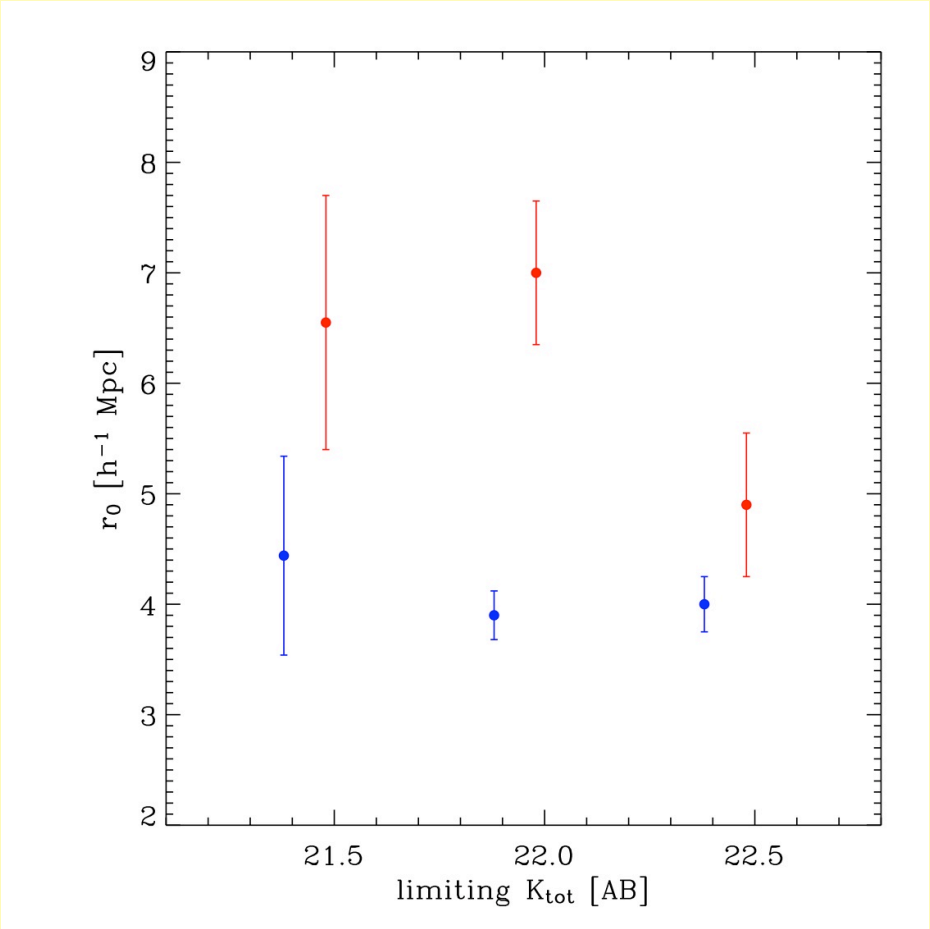
Angular clustering of passive/ star-forming galaxies at z=1.5-2

- Unfortunately, current data doesn't allow us to accurately separate galaxies at higher redshifts
- Passive galaxies cluster more strongly than star-forming galaxies



Williams et al., in prep

Spatial clustering of passive/ star-forming galaxies at z=1.5-2

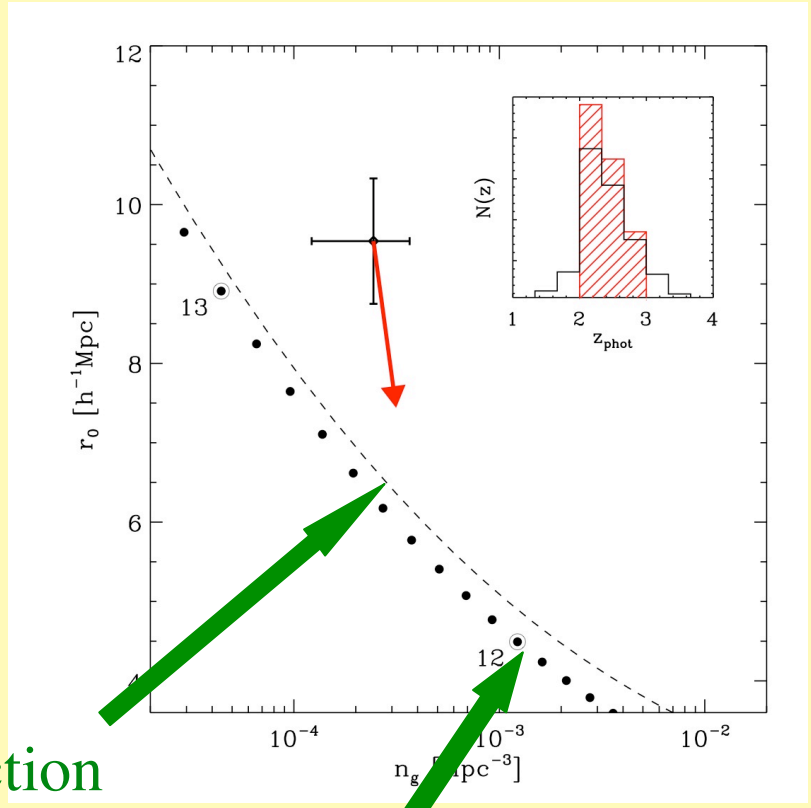


Williams et al., in prep

Why do DRGs strongly outnumber their host halos?

- Inaccurate photometric redshifts seems like the most obvious answer, but doesn't appear to explain the discrepancy.
- But there is no good reason to expect a one-to-one relationship between galaxies and halos anyway.

example model prediction for galaxies



halos

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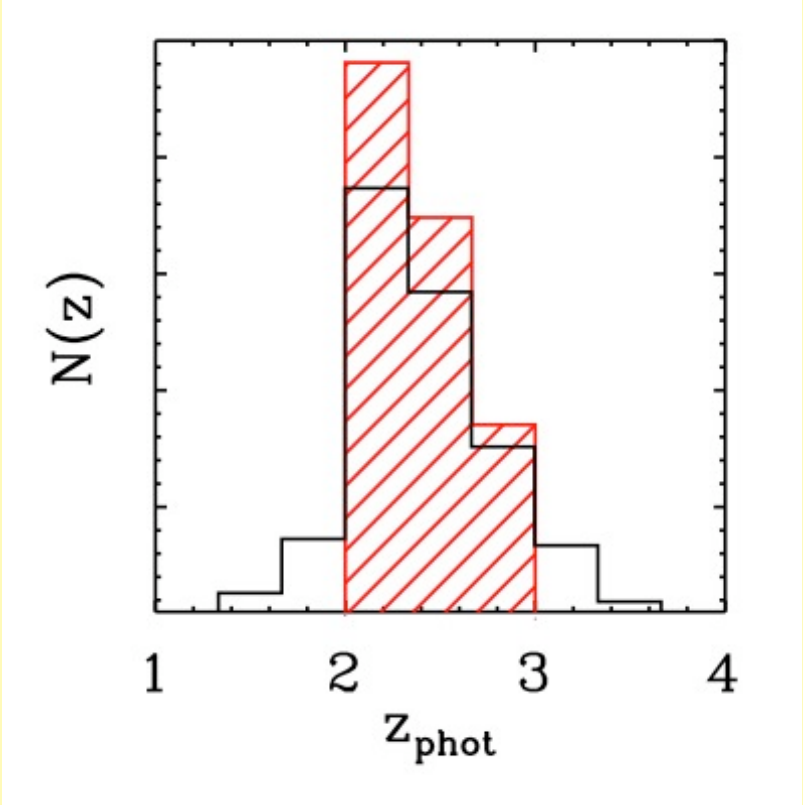
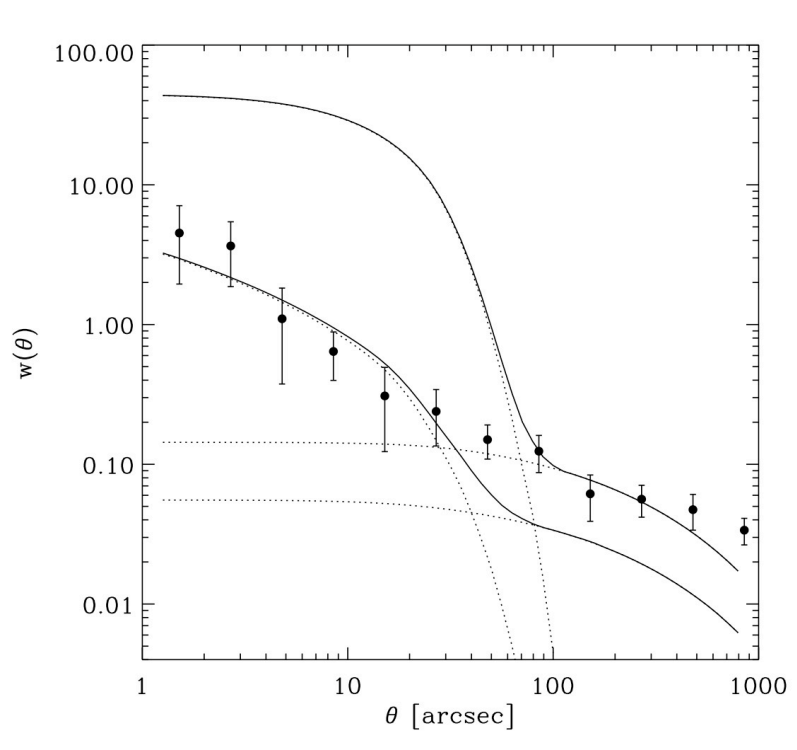
Redshift distribution

- Need N(z) to deproject the angular correlation function
- Wider distribution (e.g. from random z_{phot} errors) implies more galaxies strongly clustered
- Template mismatch, systematic errors...



UKIDSS: models

- To match the large-scale clustering (two-halo term), galaxies must occupy very massive halos
- But there aren't very many of these halos, so many galaxies must share halos
- This leads to a huge one-halo term, which does not appear in the data



Quadri et al., in prep

Discrepancy due to insufficiently detailed models?

- Basic assumption behind halo modeling is that halo clustering depends only on mass
- We now know that halo clustering also depends on e.g. age and concentration; this is known as “assembly bias”
  - Appears to boost clustering by an insufficient amount
- Halo clustering also depends on halo environment

Conclusions

- DRGs ($K<21$, $2<z_{phot}<3$): $r_0=9.5\pm0.8h^{-1}$Mpc
- Passive galaxies cluster more strongly than massive star-forming galaxies, providing for a color-density relation
- Why don't models of galaxy clustering provide a satisfactory fit to the observations?
  - strong systematic errors in the photometric redshifts
  - current models of galaxy/halo clustering are too simplistic