The peak activity in the Universe as seen from the perspective of environment and galaxy size

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UKIDSS UDS

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- Motivation – galaxy size evolution
- The data – UDS
- Method – galaxy sizes and environments
- Results – relationship between galaxy size and environments
- NEW work – light profiles
- Conclusions and Future Work

GALAXY SIZE EVOLUTION

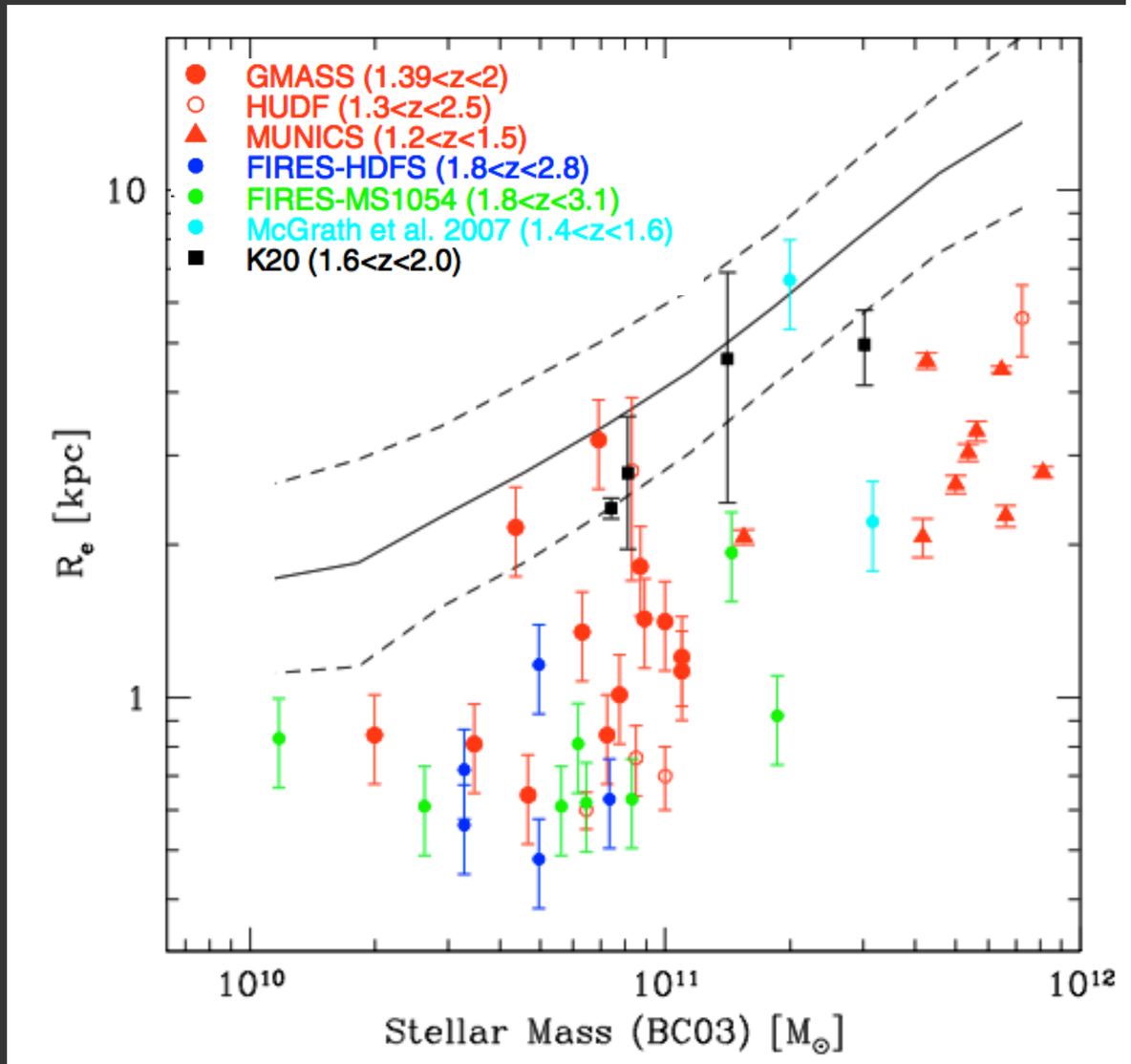
In the the recent years massive (>$10^{11}M_{\odot}$) passive galaxies were found to be remarkably more compact (2-4 times) at higher redshift than galaxies of same stellar mass in the local Universe.

Did galaxies puff up via:

- internal processes such as feedback (e.g Fan et al., 2008, 2010)

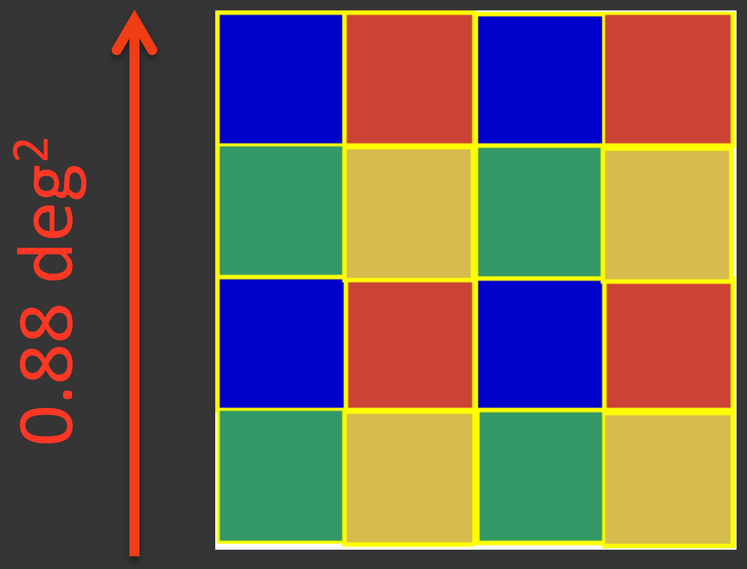
or

- mergers (e.g. Khochfar & Silk 2006, Naab et al., 2009)



Cimatti et al., 2008

THE DATA: UKIDSS UDS/CANDELS-UDS

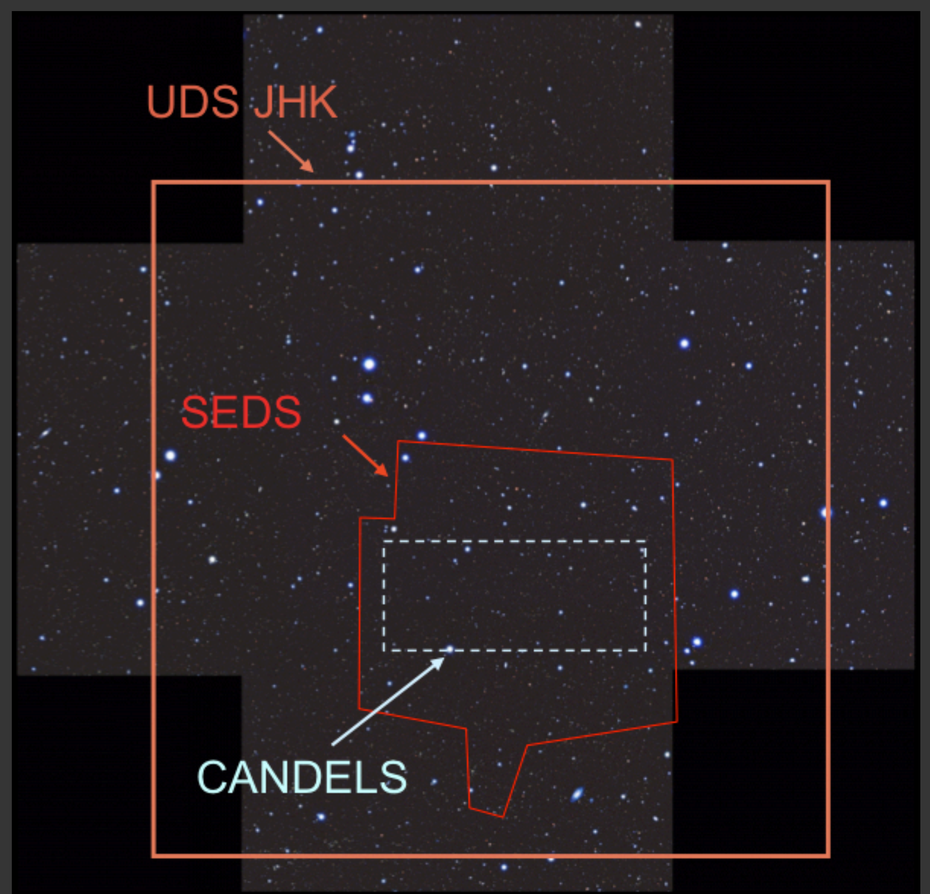


Near-infrared imaging of ~ 1 deg²

Limiting magnitudes (AB, 5σ, 2"apertures):

DR8 (this work): J=24.9, H=24.2, K=24.6

(504 hours)



CANDELS-UDS: Wide program, 88 orbits & limiting magnitudes (AB, 5σ, 1 arcsec²):

J=26.22 H=26.32

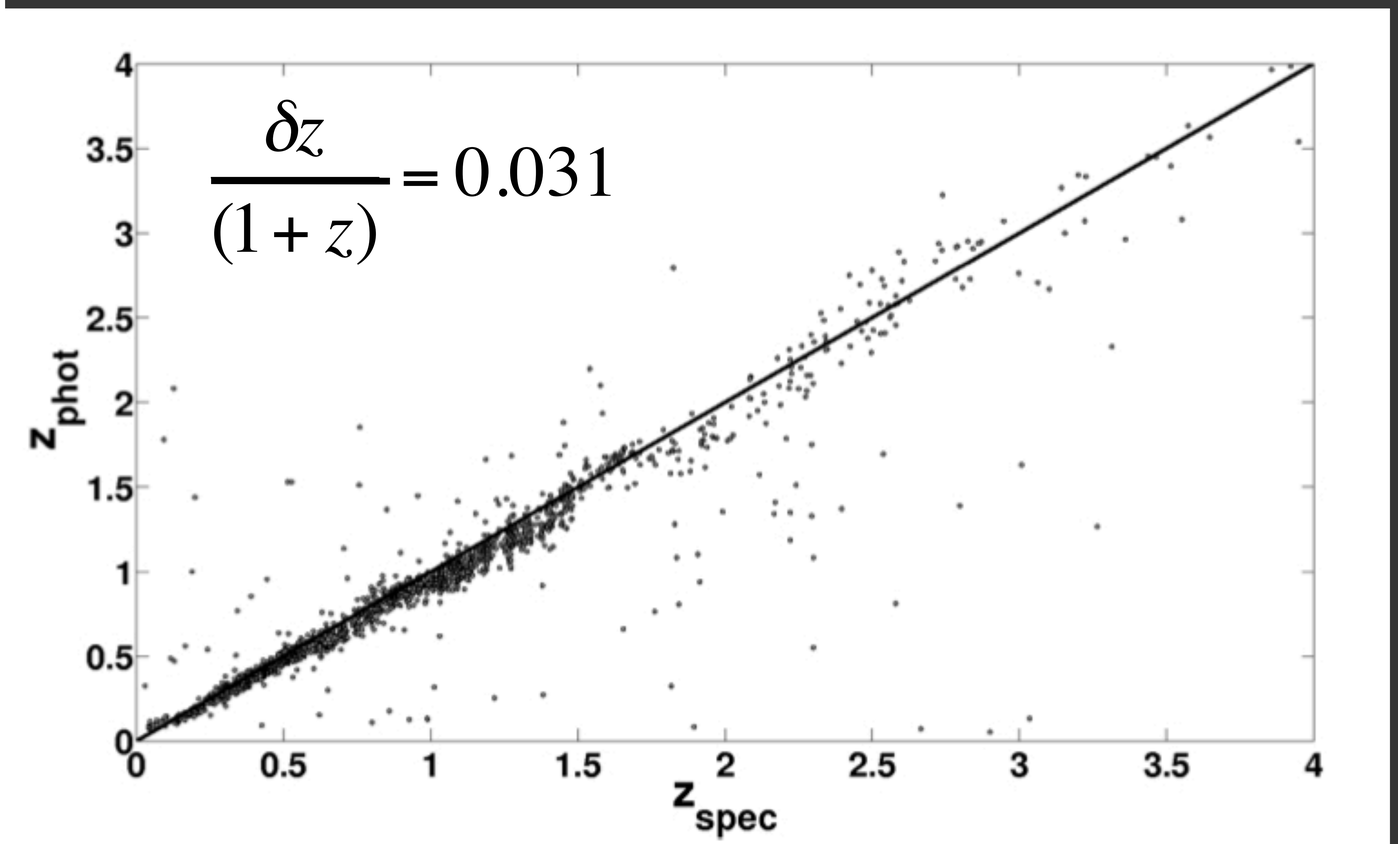
(Galametz et al., 2013)

◆ Full **UDS** field ≈ **10x CANDELS-UDS**

PHOTO z & STELLAR MASSES

Photometric redshifts and stellar masses were determined from **11-band photometric fitting**: **U, B, V, R, i' ,z', J, H, K, 3.6µm, 4.5µm.**

2000 spectra from UDSz were used to train and calibrate

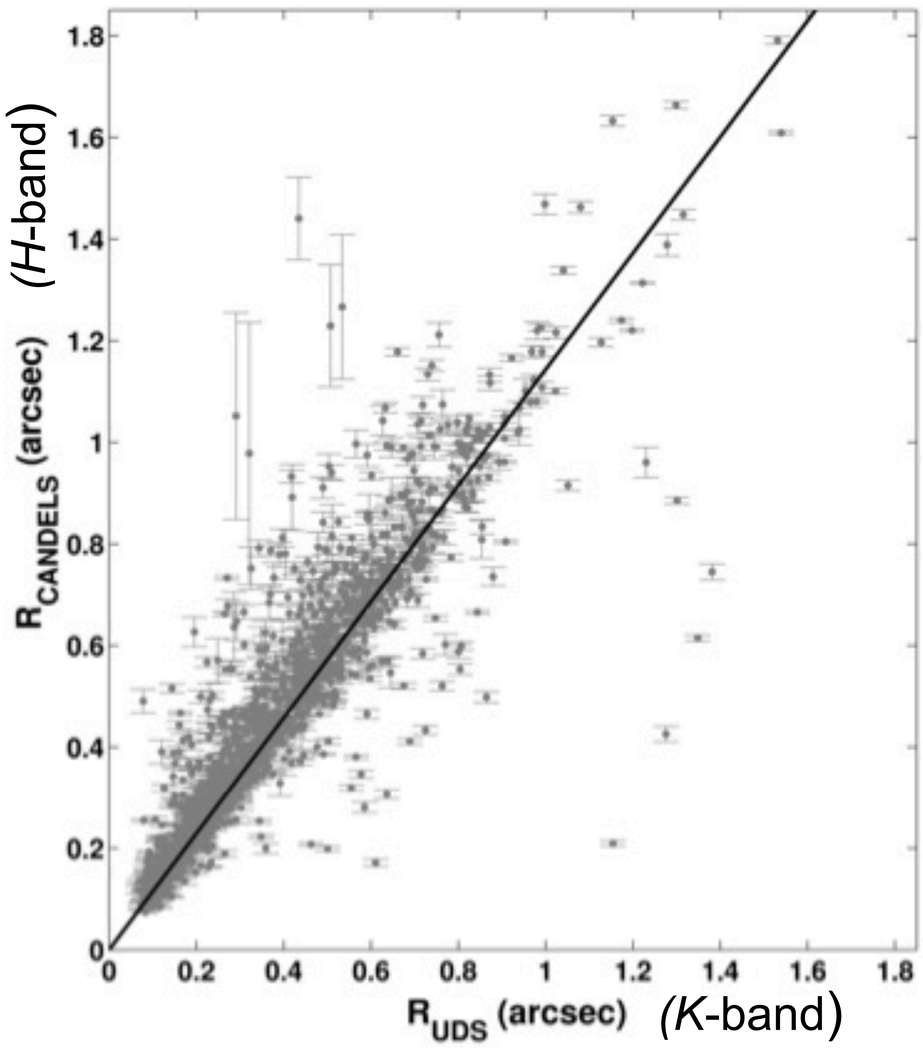


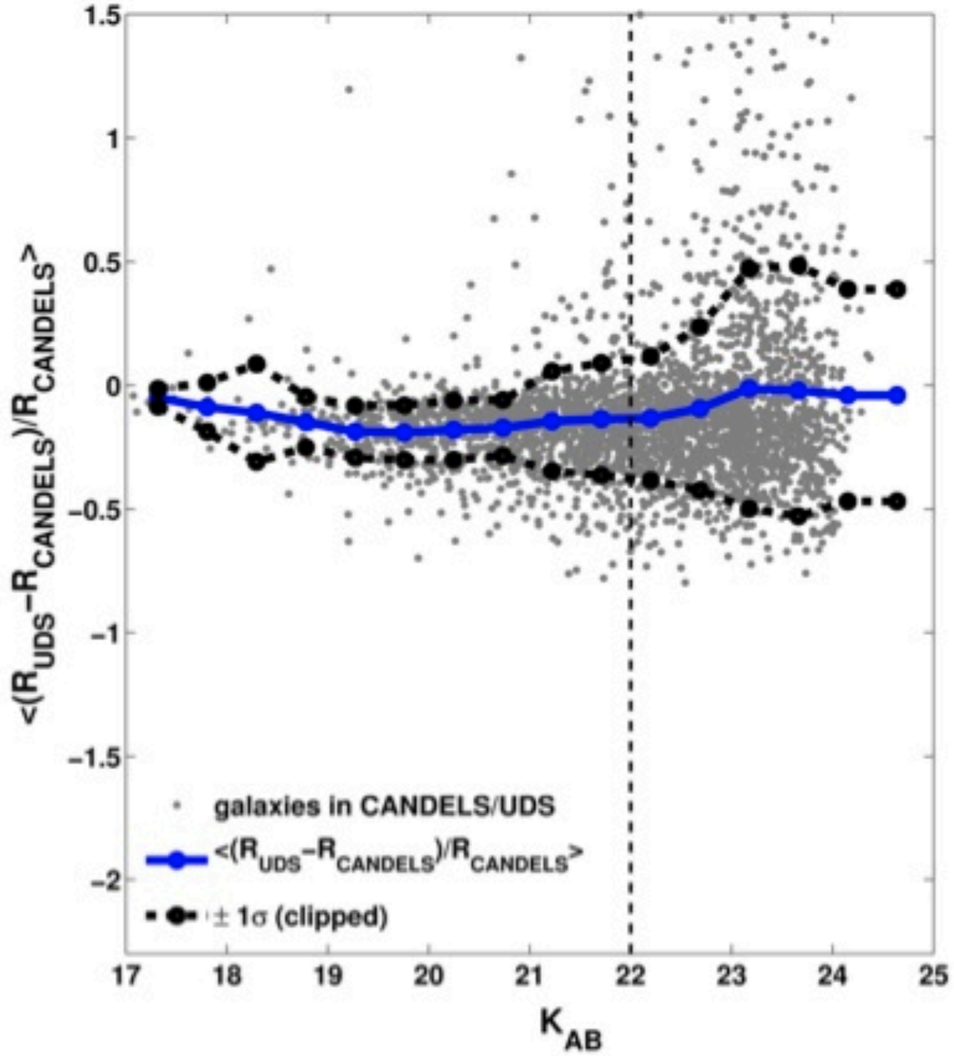
Stellar masses and rest-frame colours were obtained from **SED fitting**

MEASURING GALAXY SIZES

Sizes were measured on ground based *K*-band data and then calibrated against *H*-band HST CANDELS data (van der Wel et al. 2012)

(galaxies with K_{AB}<22) only





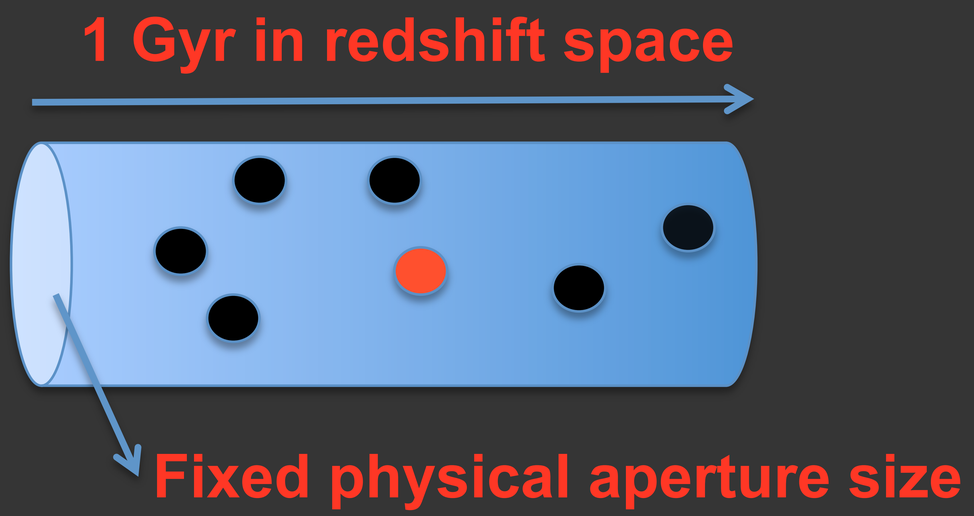
≈14% offset is consistent with measuring sizes in different wavebands (see Kelvin et al., 2012)

We alligned UDS sizes to CANDELS sizes to facilitate comparison with future work

Lani et al., 2013

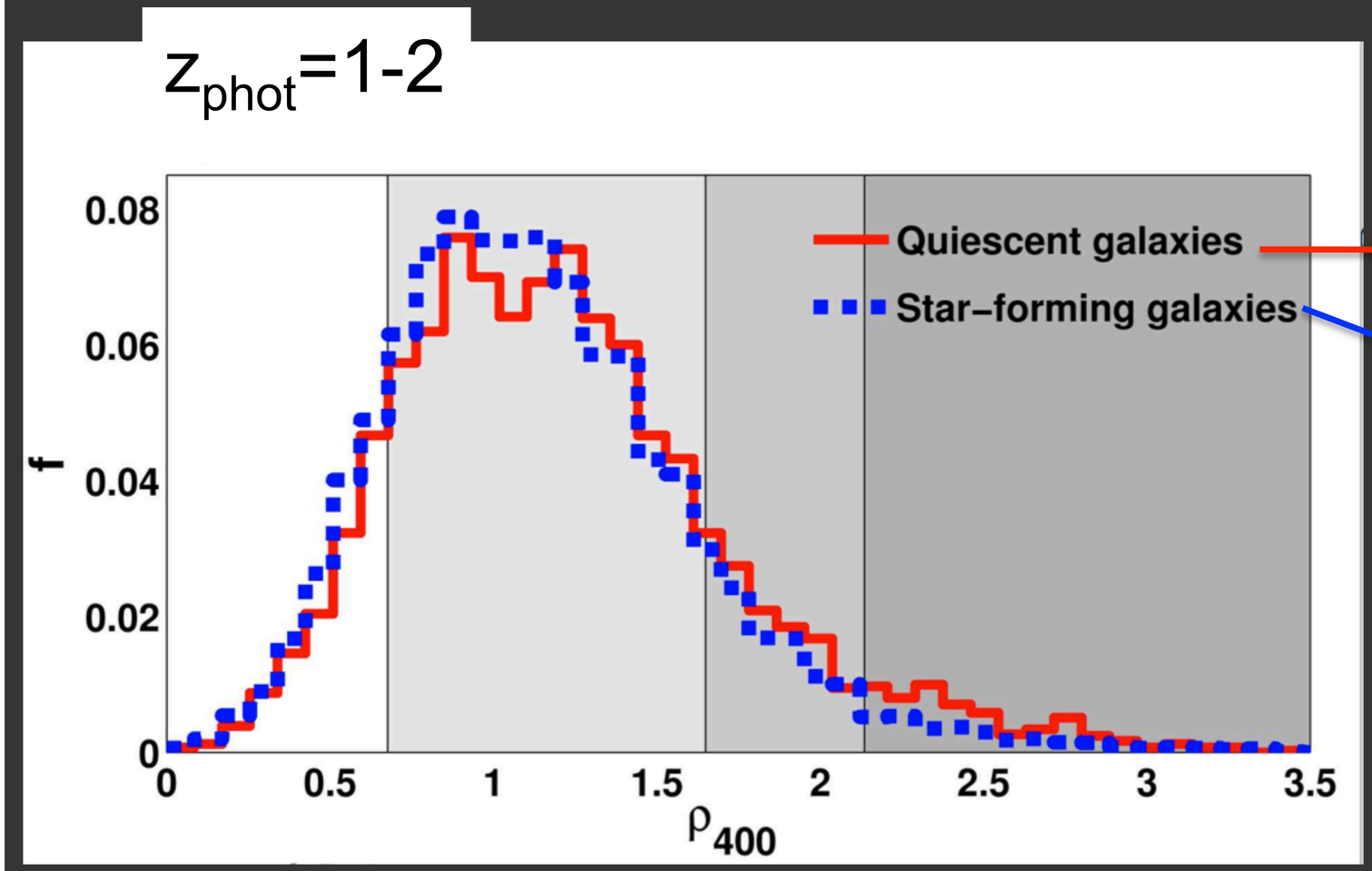
APERTURE DENSITIES

Environments were measured using the method of galaxy counts in an fixed physical aperture. We counted the number of galaxies within a cylinder constructed around the galaxy under consideration.



$$\rho_{aperture} = \frac{N_g^{Aper}}{N_z} \times \frac{N_{Mask}^{Tot}}{N_{Mask}^{Aper}}$$

COLOUR vs ENVIRONMENT



defined by UVJ (rest-frame) + sSFR

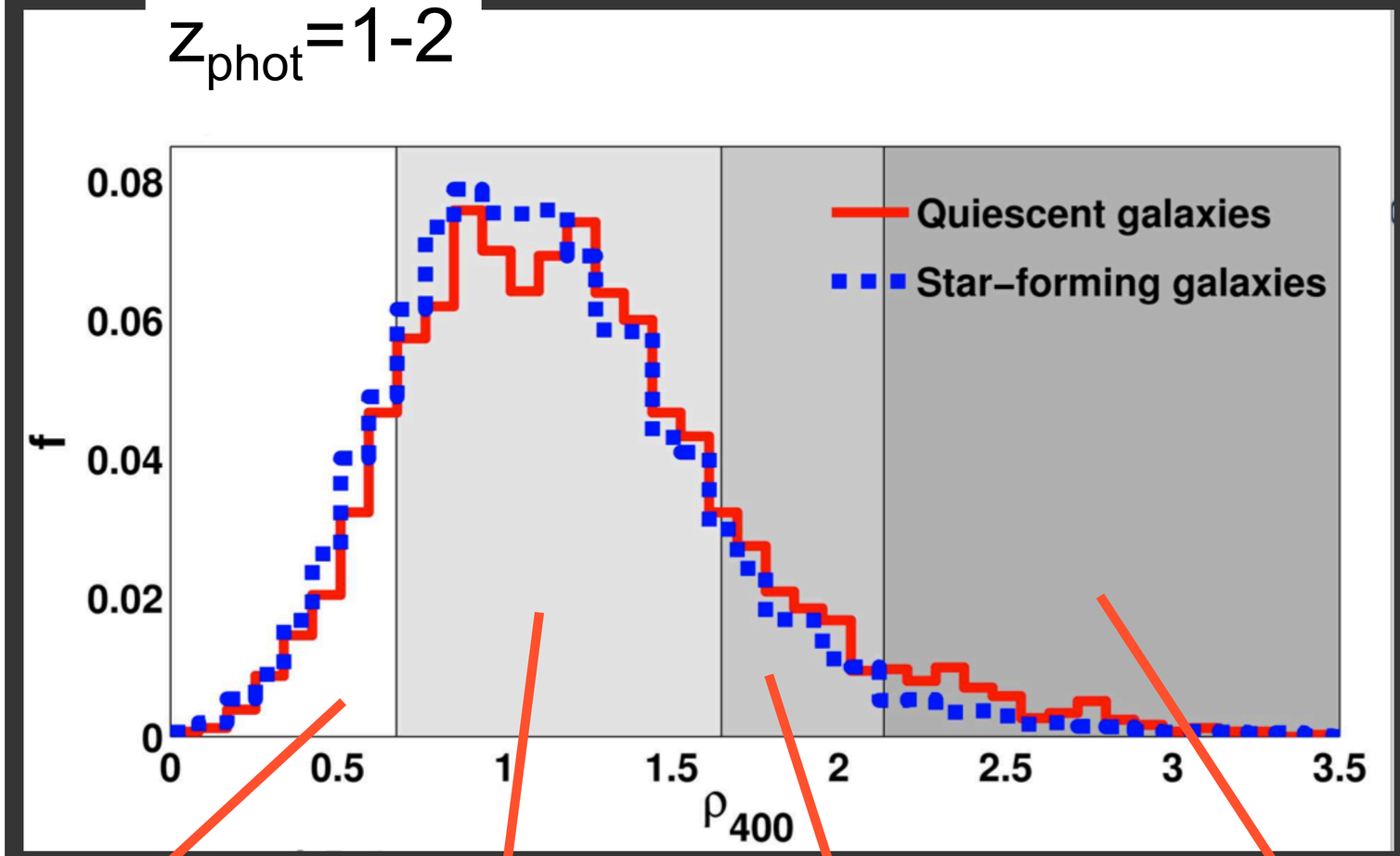
the remainder

Our environmental measure can recover previously know trends such as the colour-density relation.

Lani et al.,2013 and Chuter et al.,2011

COLOUR vs ENVIRONMENT

z_{phot}=1-2



μ → mean of the density distribution

σ → standard deviation

density1
$\rho_{400}<\mu-1\sigma$

density2
$\mu-1\sigma<\rho_{400}<\mu+1\sigma$

density3
$\mu+1\sigma<\rho_{400}<\mu+2\sigma$

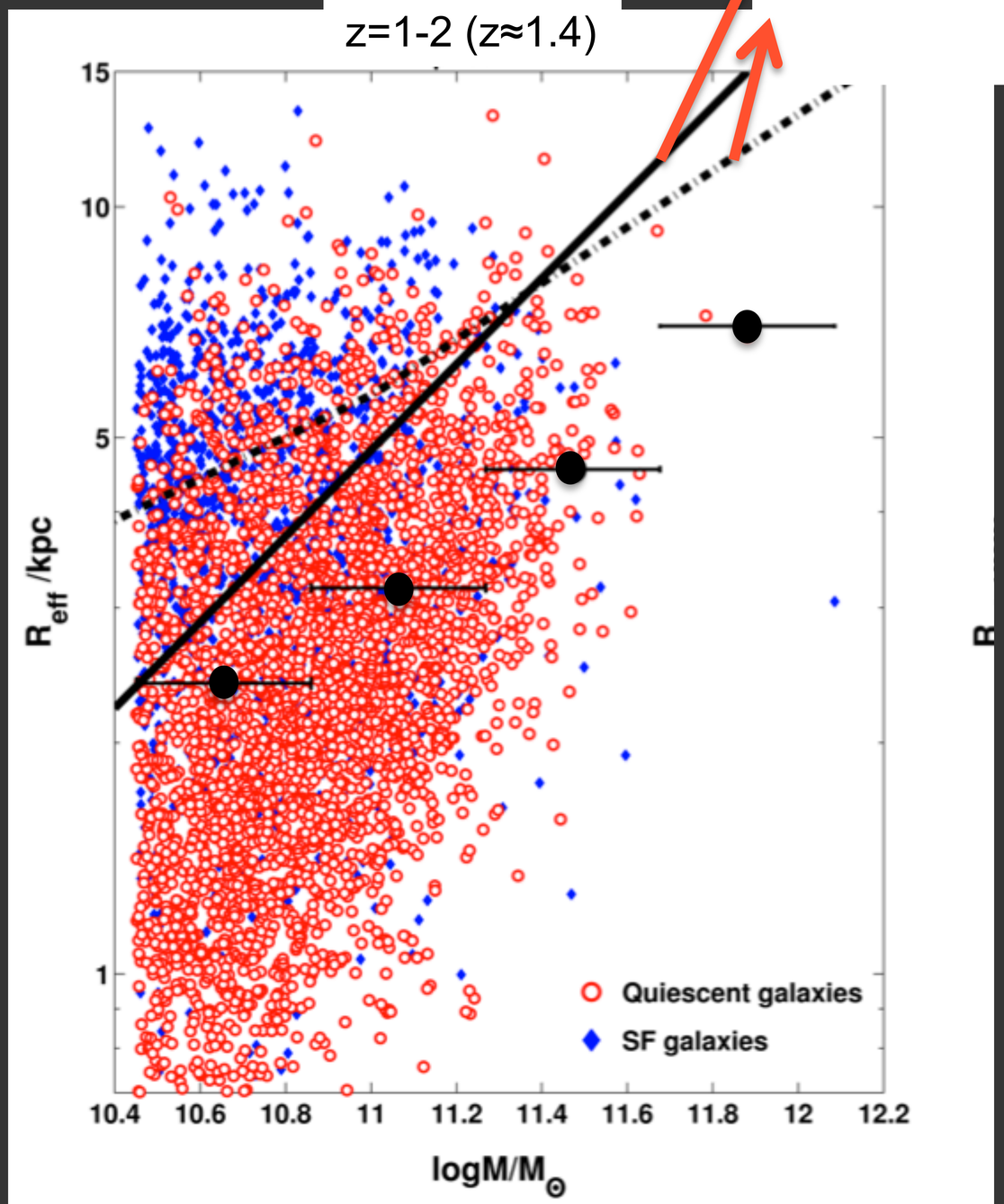
density4
$\rho_{400}>\mu+2\sigma$

Lani et al.,2013 and Chuter et al.,2011

HIGH z SIZE–MASS RELATION

local size mass relation for ETGs (Shen et al., 2003)

local size mass relation for LTGs (Shen et al., 2003)



For $M_* > 10^{11} M_\odot$:

- At z≈1.4 quiescent galaxies were typically 50% smaller

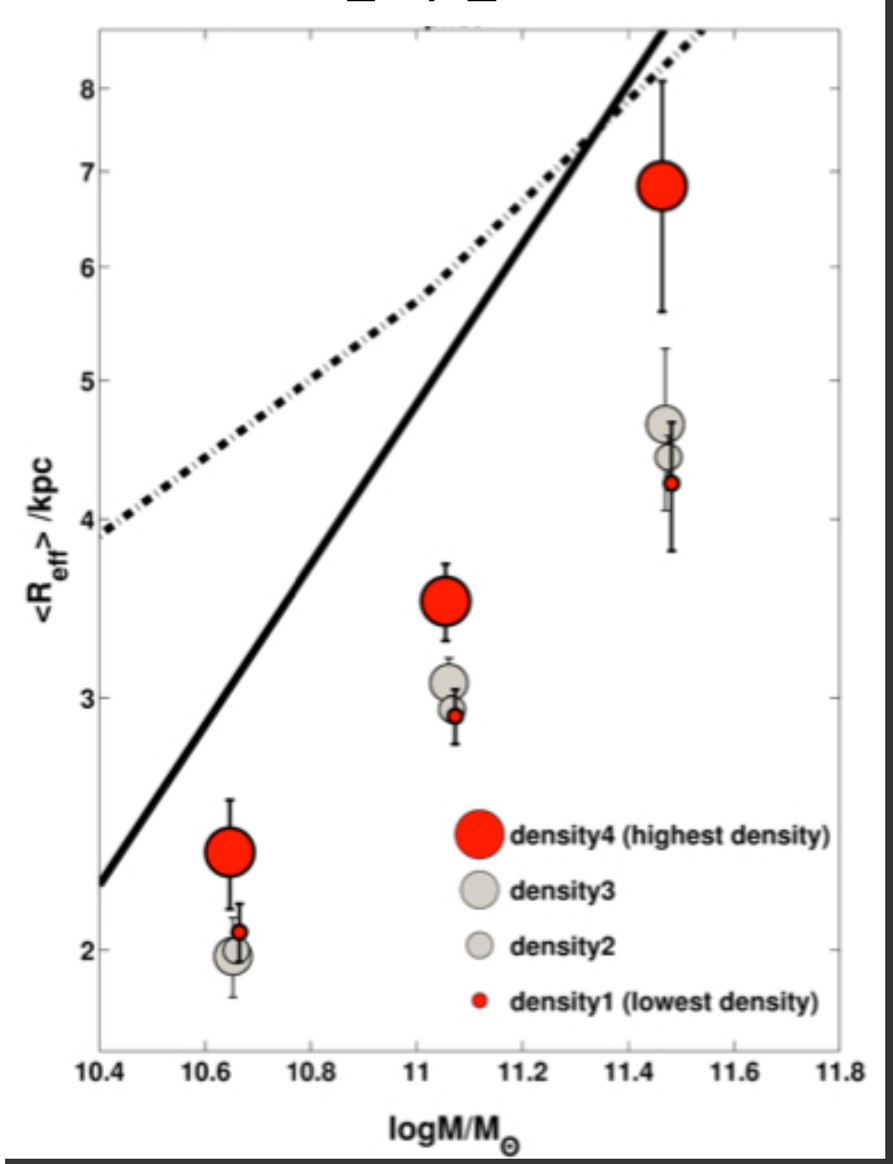
For $M_* < 10^{11} M_\odot$:

- At z≈1.4 quiescent galaxies were typically 40% smaller

Lani et al., 2013

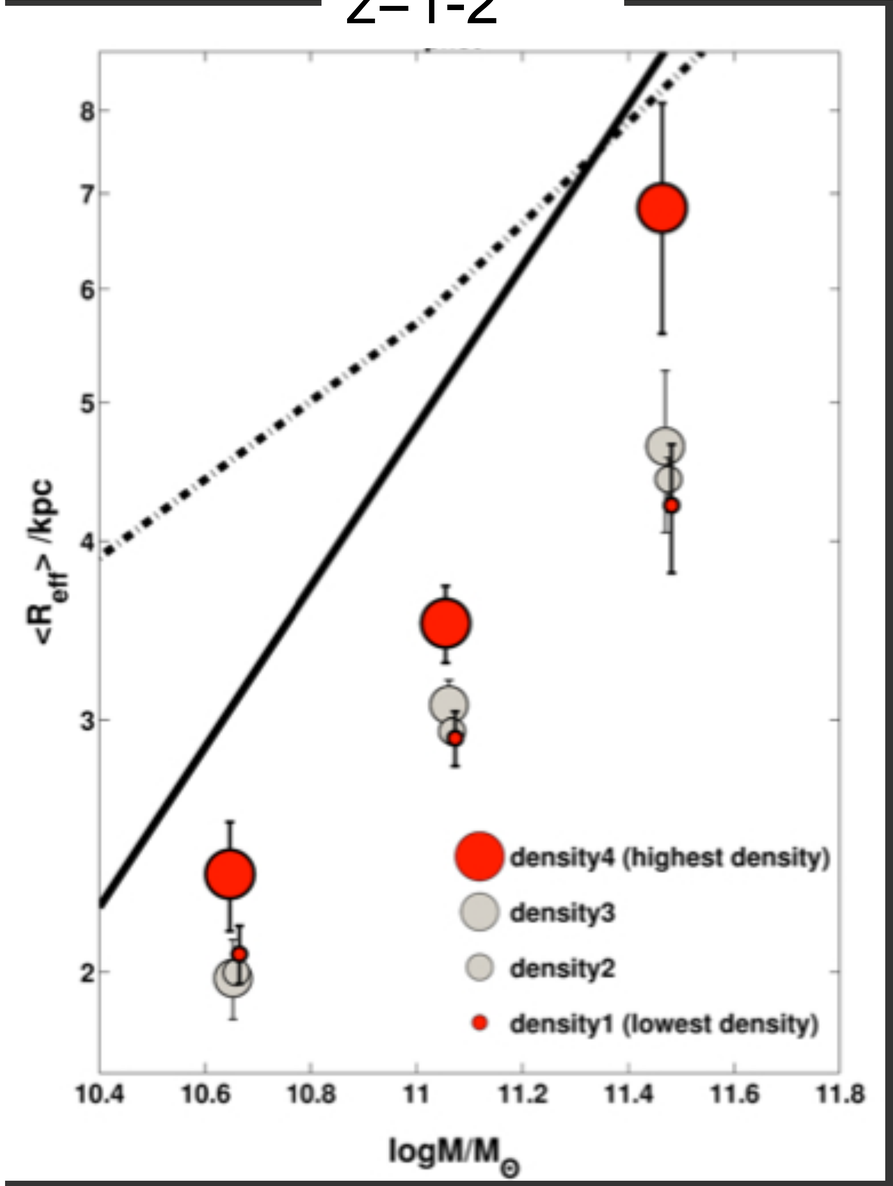
HIGH z SIZE−MASS RELATION vs ENVIRONMENT

z=1-2

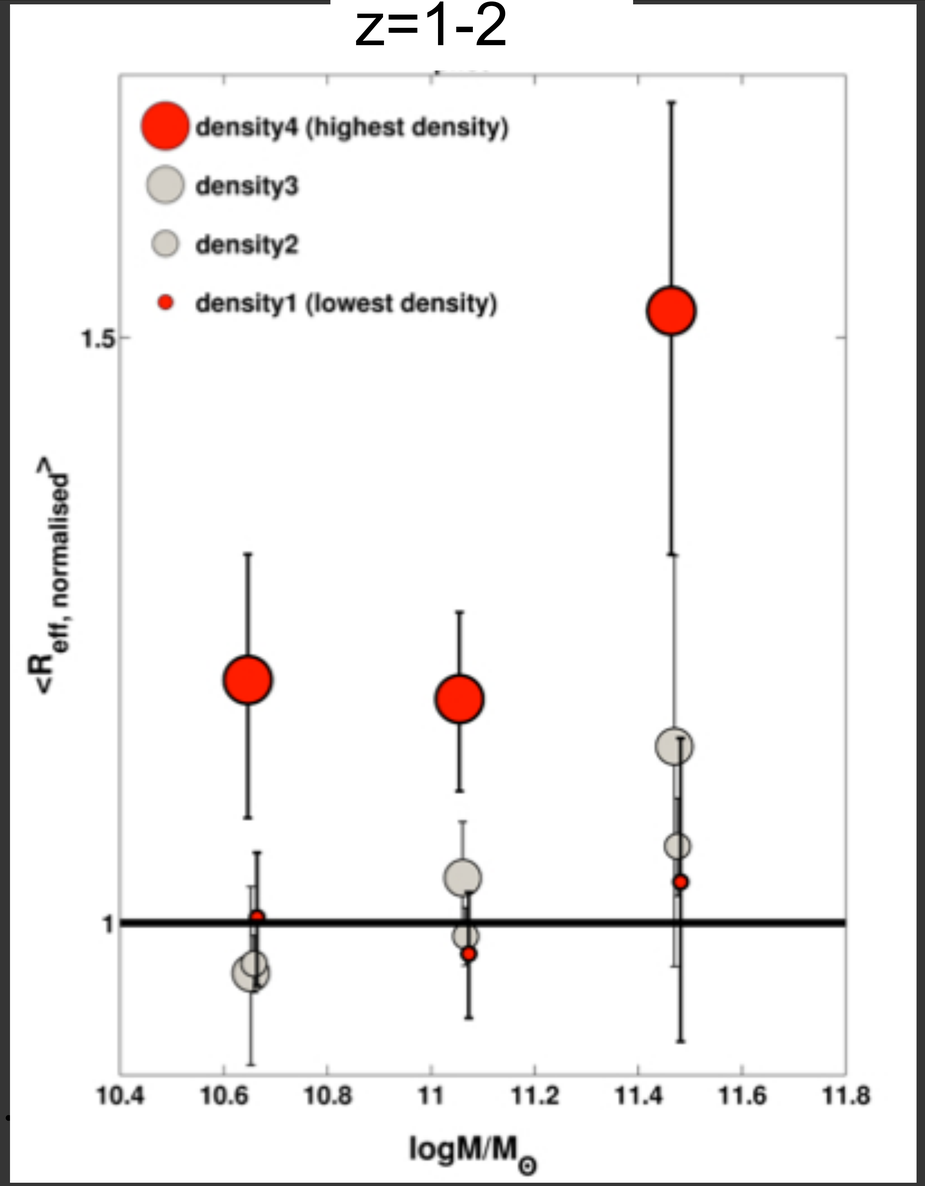


HIGH z SIZE—MASS RELATION vs ENVIRONMENT

z=1-2



z=1-2



◆ Galaxies in the highest densities show $R_{eff,norm}$ which are (by increasing mass) 18±12%, 19±9%, 48±25% larger (from fractional difference) than objects in the lowest densities. MC tests!

Lani et al., 2013

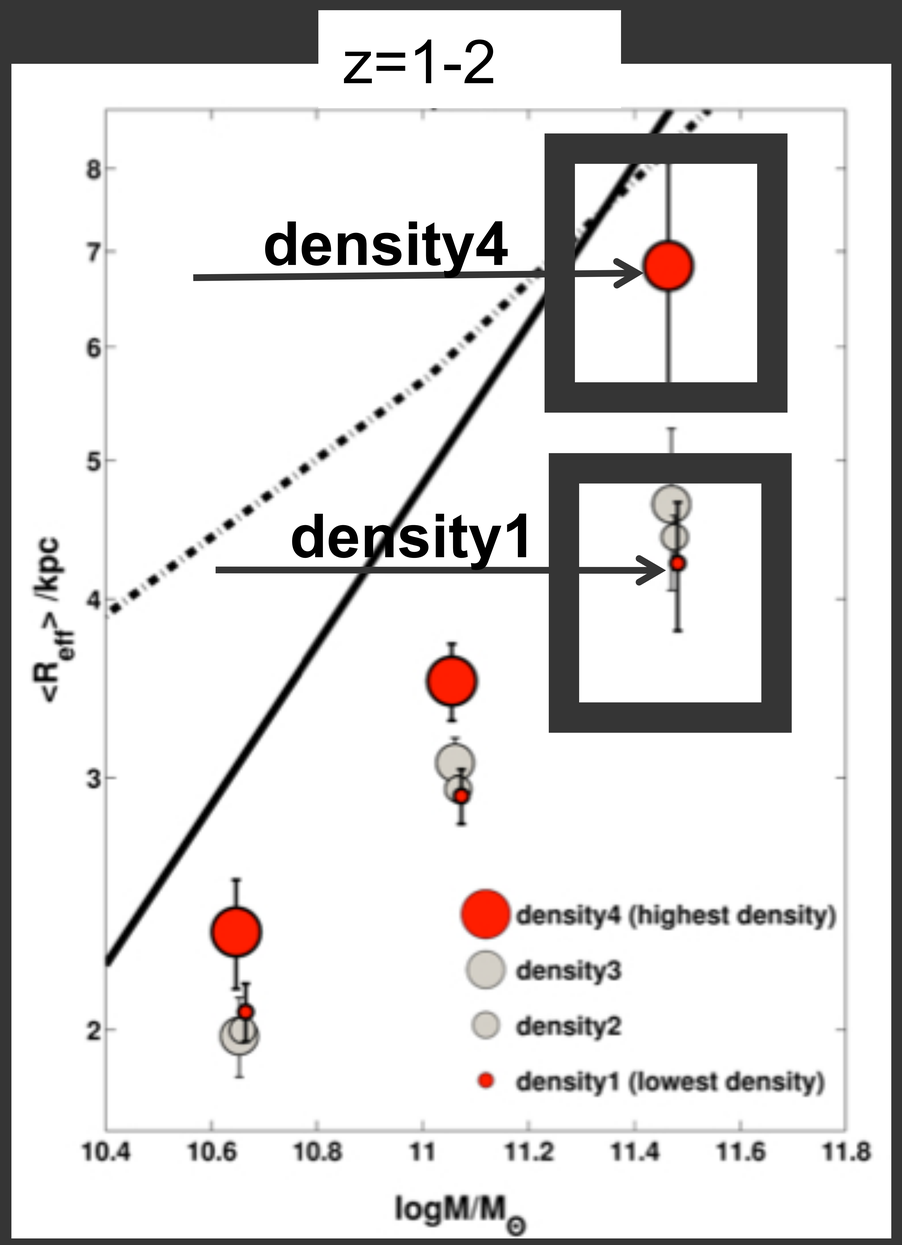
SO FAR…

- We observe the colour–density relation to hold up to z≈2.
- We confirm size evolution for the quiescent population.
- **We find that passive galaxies in denser environments (on a scale of 400 kpc) are significantly larger at a given stellar mass, at a significance > 4.8 σ at z>1.**

More details in Lani et al. 2013 (MNRAS, 435, 207)

… BUT WHAT IS DRIVING THIS TREND?

GALAXY STACKS



For quiescent galaxies in the redshift range z=1-2:

1) We stacked (flux normalised) galaxies in different mass-density bins

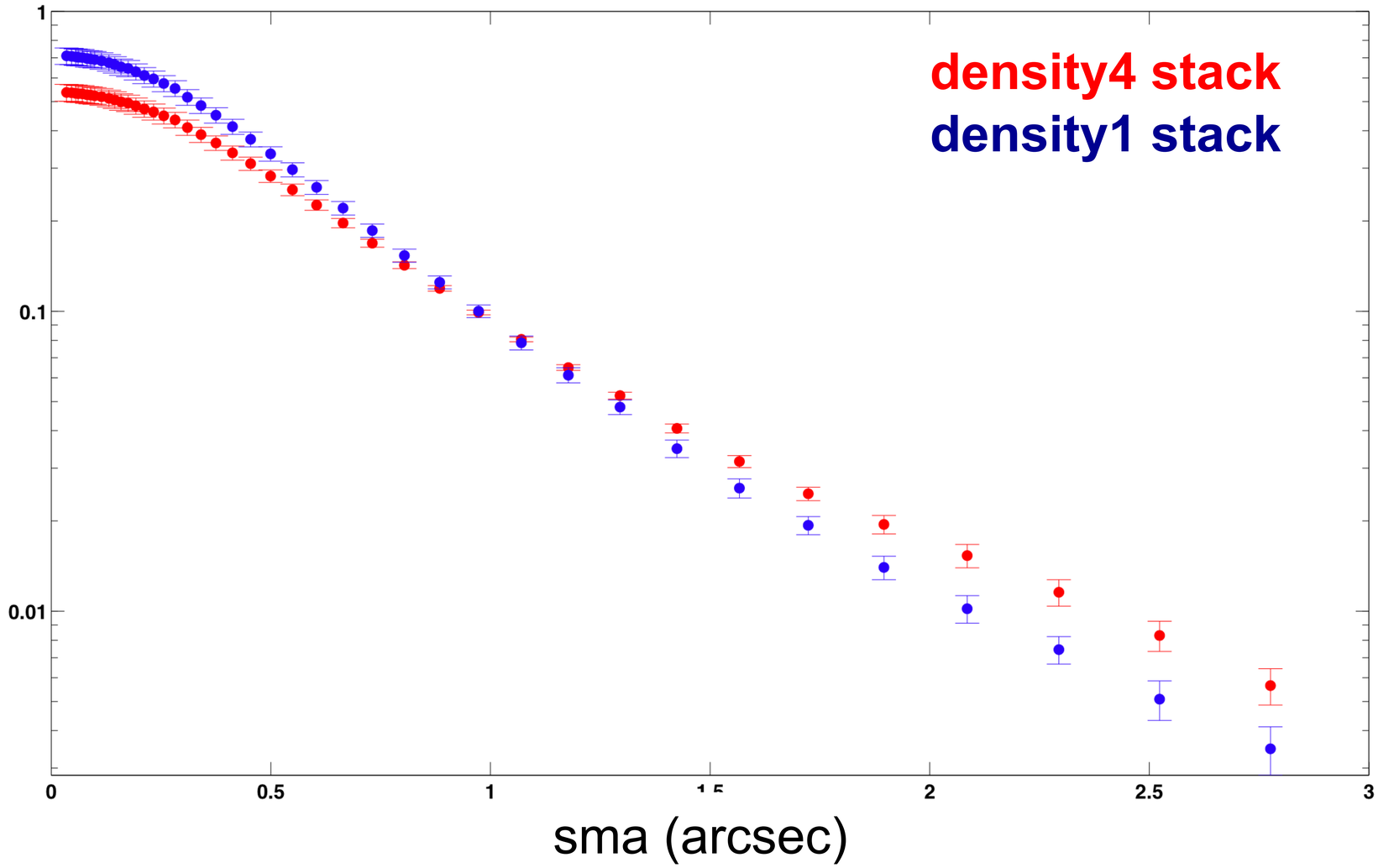
2) We ran IRAF–*ellipse* on the (mean) stacks to extract the light profiles

3) We used the bootstrap method to determine the 1σ uncertainty on the light profile

LIGHT PROFILES OF STACKS

Quiescent galaxies in the redshift range z=1–2

WORK IN PROGRESS



Lani et al., in prep

The light profiles are different but how can we quantify such a difference?

BEST FIT PARAMETERS

4) We produce a set of mock galaxies defined by a 1-component Sérsic light profile, with a range of Sérsic indices and effective radii ($\Delta n = 0.1$, $\Delta R_{eff} \approx 2.5 \times 10^{-3}$''), convolve them with the PSF and run IRAF–*ellipse* on them

5) We fit the mock light profiles to the ones extracted from the mean stacks of **density1 galaxies** and **density4 galaxies**

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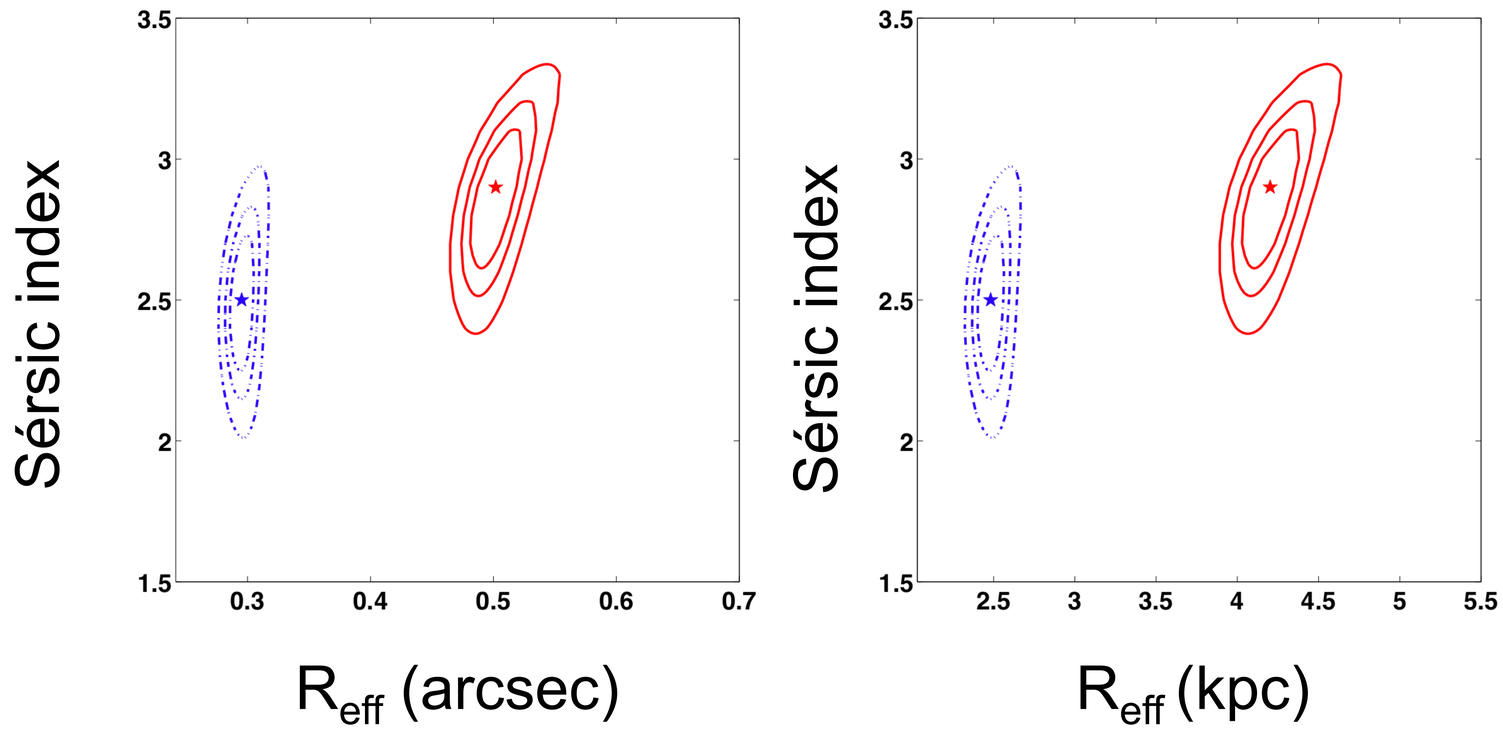
density4 stack
density1 stack

(quiescent galaxies only, z=1–2)

WORK IN PROGRESS

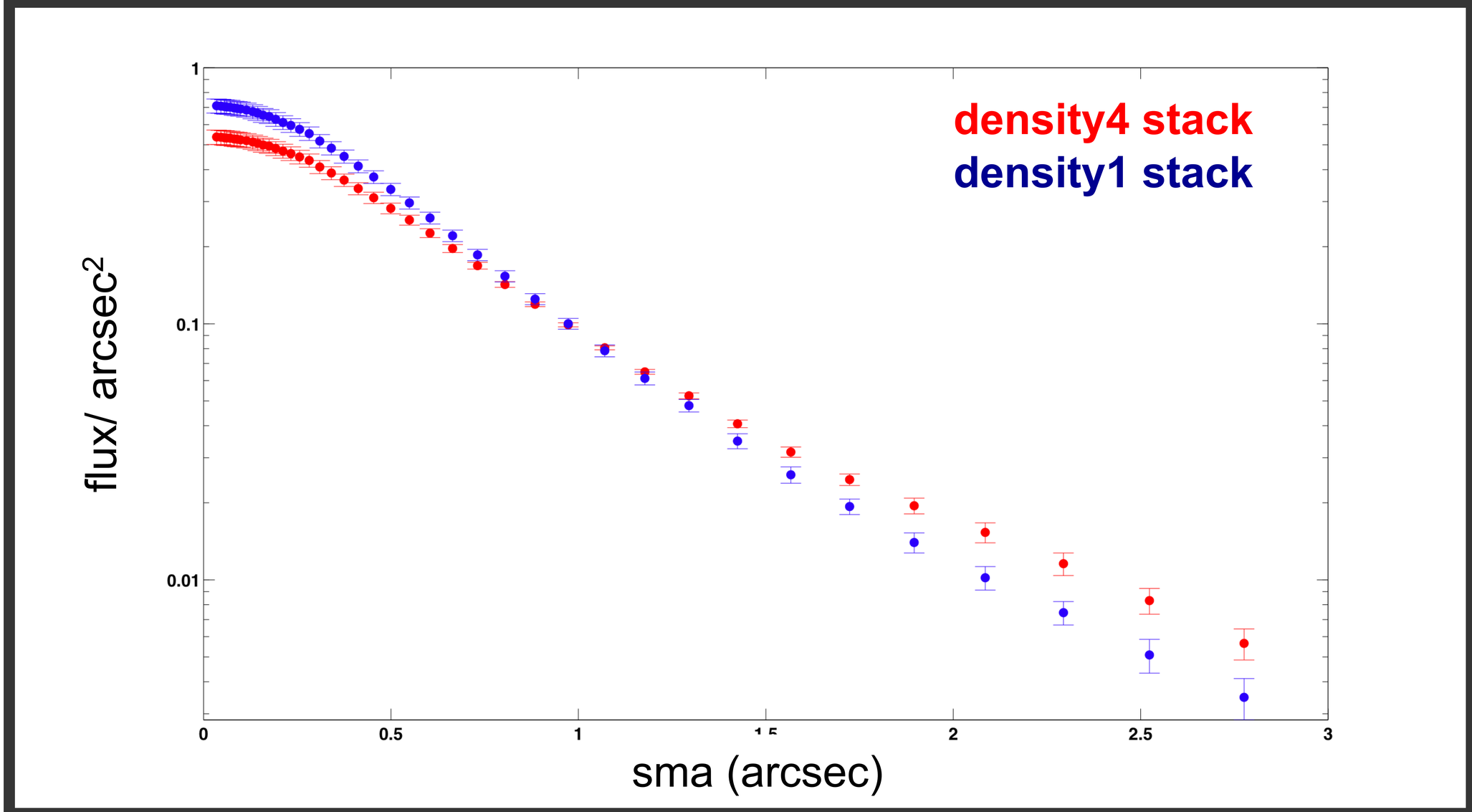
Lani et al., in prep



LIGHT PROFILES OF STACKS

Quiescent galaxies in the redshift range z=1–2 (normalised flux before stacking)

WORK IN PROGRESS



Lani et al., in prep

The light profiles are different but how can we quantify such a difference?

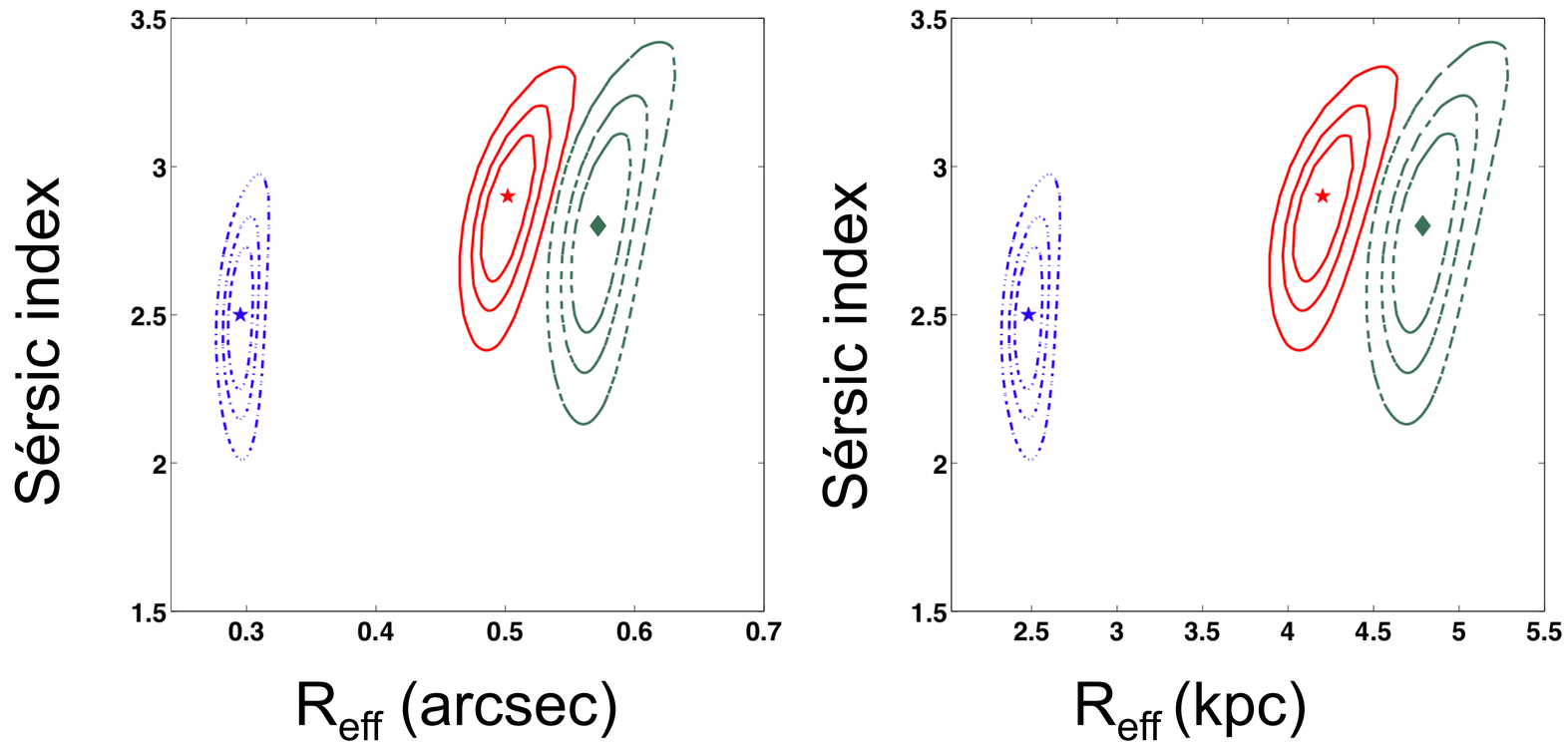
BEST FIT PARAMETERS

4) We produce a set of mock galaxies defined by a 2-components light profile, with a range of Sérsic indices and effective radii ($\Delta n = 0.1$, $\Delta R_{eff} \approx 2.5 \times 10^{-3}$''), convolve them with the PSF and run IRAF–*ellipse* on them

5) We fit the mock light profiles to the ones extracted from the mean stacks of **density1 galaxies** and **density4 galaxies**

density4 stack
density1 stack

(quiescent galaxies only, z=1–2)



WORK IN PROGRESS

Lani et al., in prep

INTERPRETATION

What does all of this mean?

From previous works (e.g. Hopkins et al. 2010, Hiltz et al. 2012, Ascaso et al. 2013):

MAJOR MERGERS → Sérsic index is ≈ conserved & size increases

MINOR MERGERS → Sérsic index & size increase with the build up of wings

ADIABATIC EXPANSION → Sérsic index & size will remain ≈ constant/ increase, both depending on the amount of lost gas

ADIABATIC CONTRACTION → Sérsic index & size will decrease, the extent depending on the amount of in-falling gas

……

GALAXY STACKS

- The light profiles extracted from (mean) stacks of galaxies inhabiting the highest and lowest density environments differ
- Their effective radii differ at a significance >3σ, confirming previous results
- No significant difference was found between the Sérsic indices of galaxies from the highest and lowest density environments

…. BUT STILL MUCH LEFT TO DO…

1) Need to explore further the 2 components model
2) Does it make a difference if we consider median stacks?
3) How do the observed trends vary in density–stellar mass space?
4) Need to explore alternative methods to centre the galaxies before stacking them