Statistical Properties of the Stellar Haloes of Galaxies

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Motivation

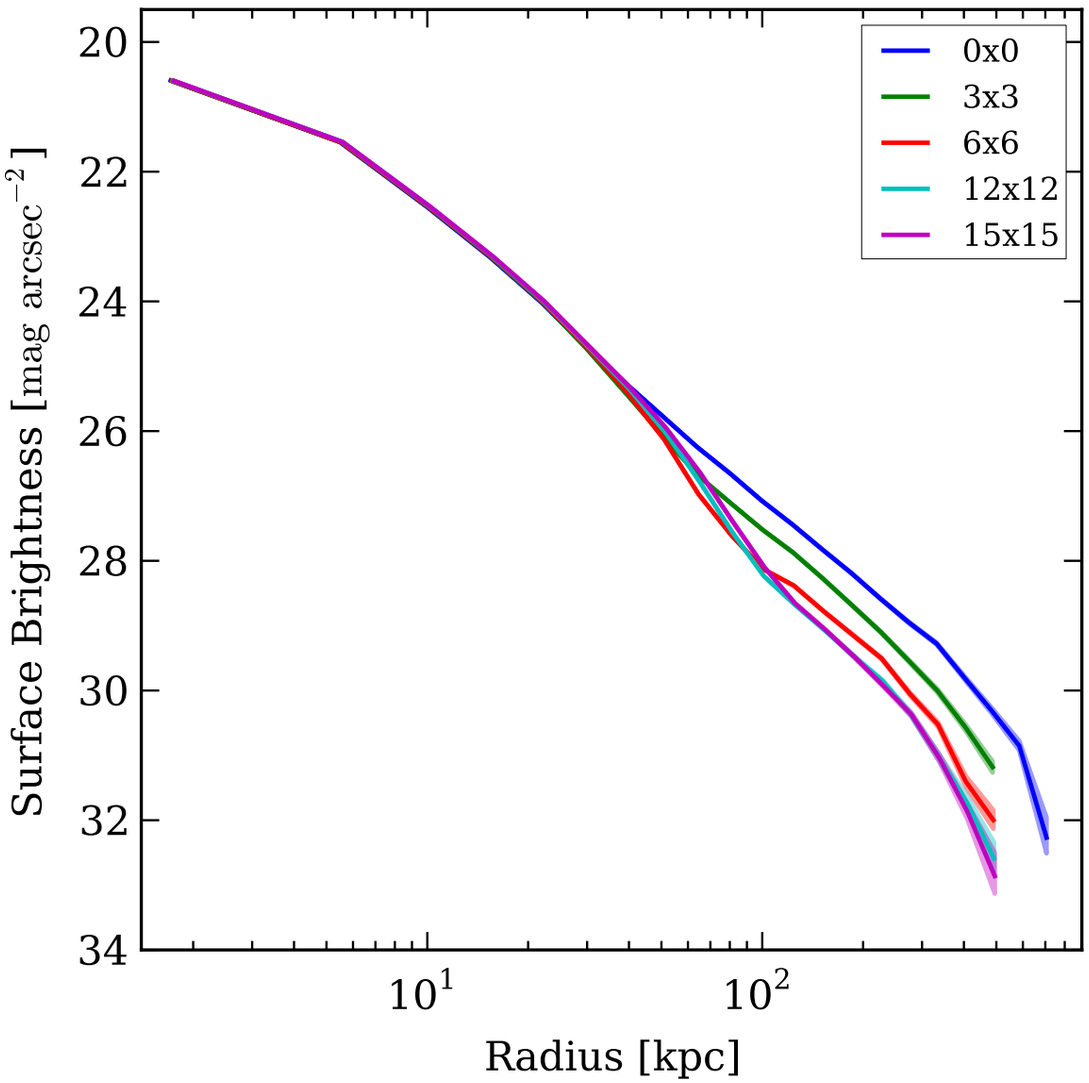
- How do we validate and update our current global paradigm of how stellar haloes are formed?
- By studying the average statistical properties of the smooth component of the stellar haloes of galaxies.
- In the near future, only possible way is to stack a large number of galaxies of similar types together from all sky surveys.
- Shift in motivation for stacking: from trying to beat S/N to studying the average properties of large populations of galaxies.

Stacking Galaxies

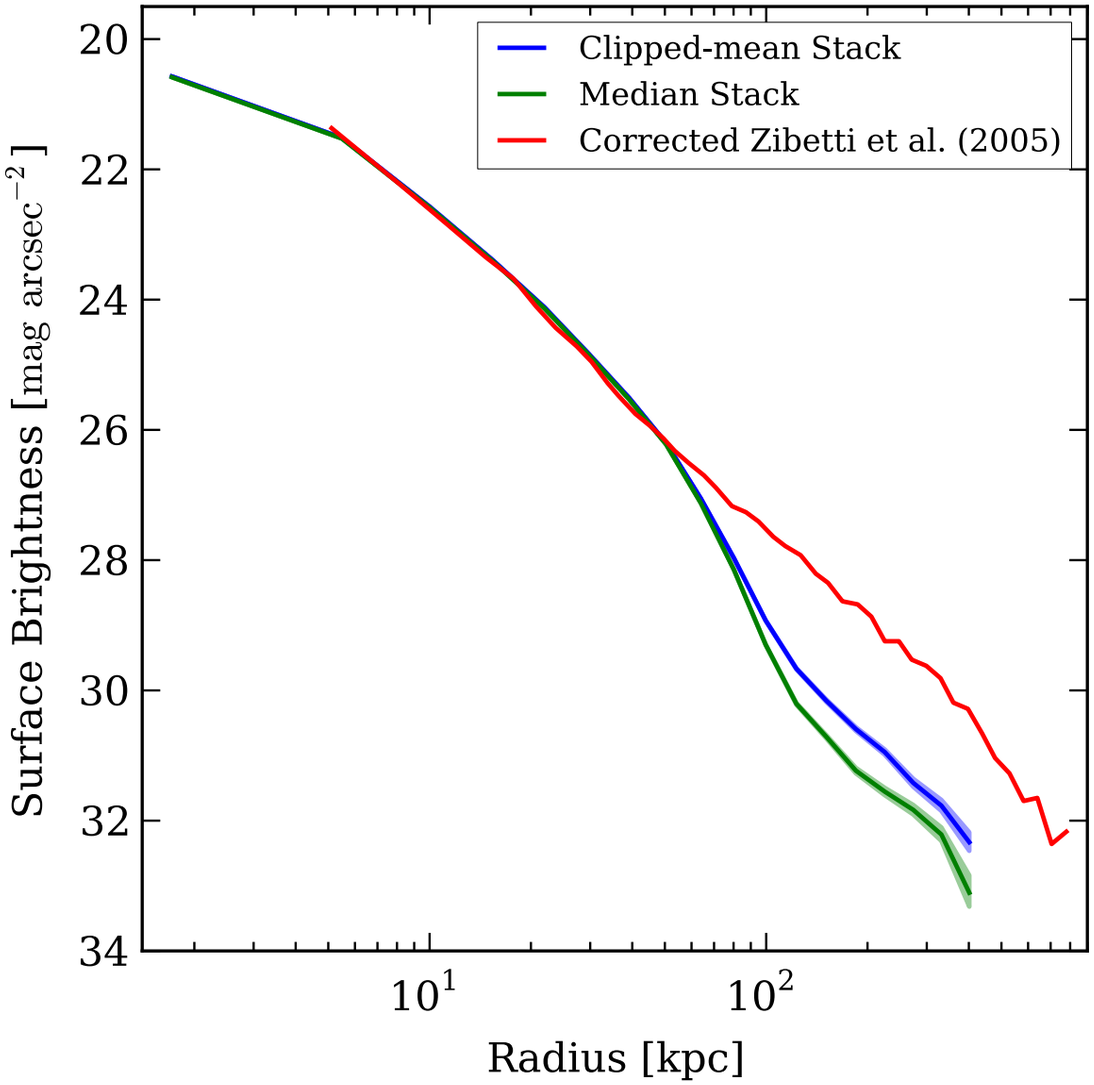
- Examples of stacking galaxies with SDSS data set: Zibetti et al. (2004, 2005), de Jong (2008), Tal & van Dokkhum (2008), D'Souza et al. (2013)
- History of stacking is the history of dealing with the various systematics:
  - Background subtraction, PSF and Effective masking
  - Dealing with unresolved objects, Type of stacking: median, mean, weighted.
- Sample definition (isolation criterion, accounting for magnitude limited survey)

Example of Systematics: PSF and effective masking

Not only the PSF of the central galaxy but also from the PSF of masked neighbours

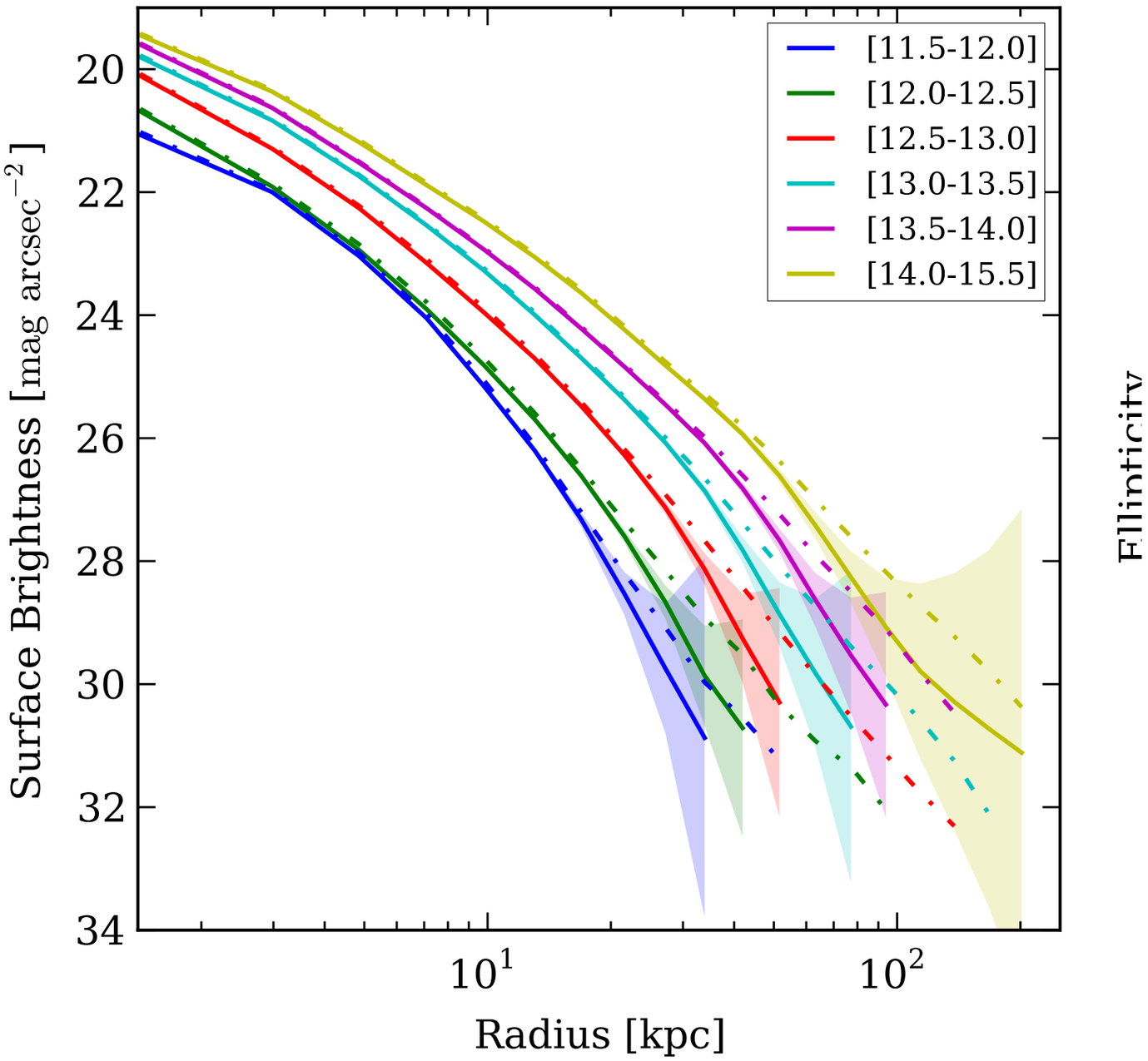


for 500 galaxies stacked from redshift 0.2 < z<0.3



Stellar haloes of BCGs much less than shown by Zibetti et al. (2005)

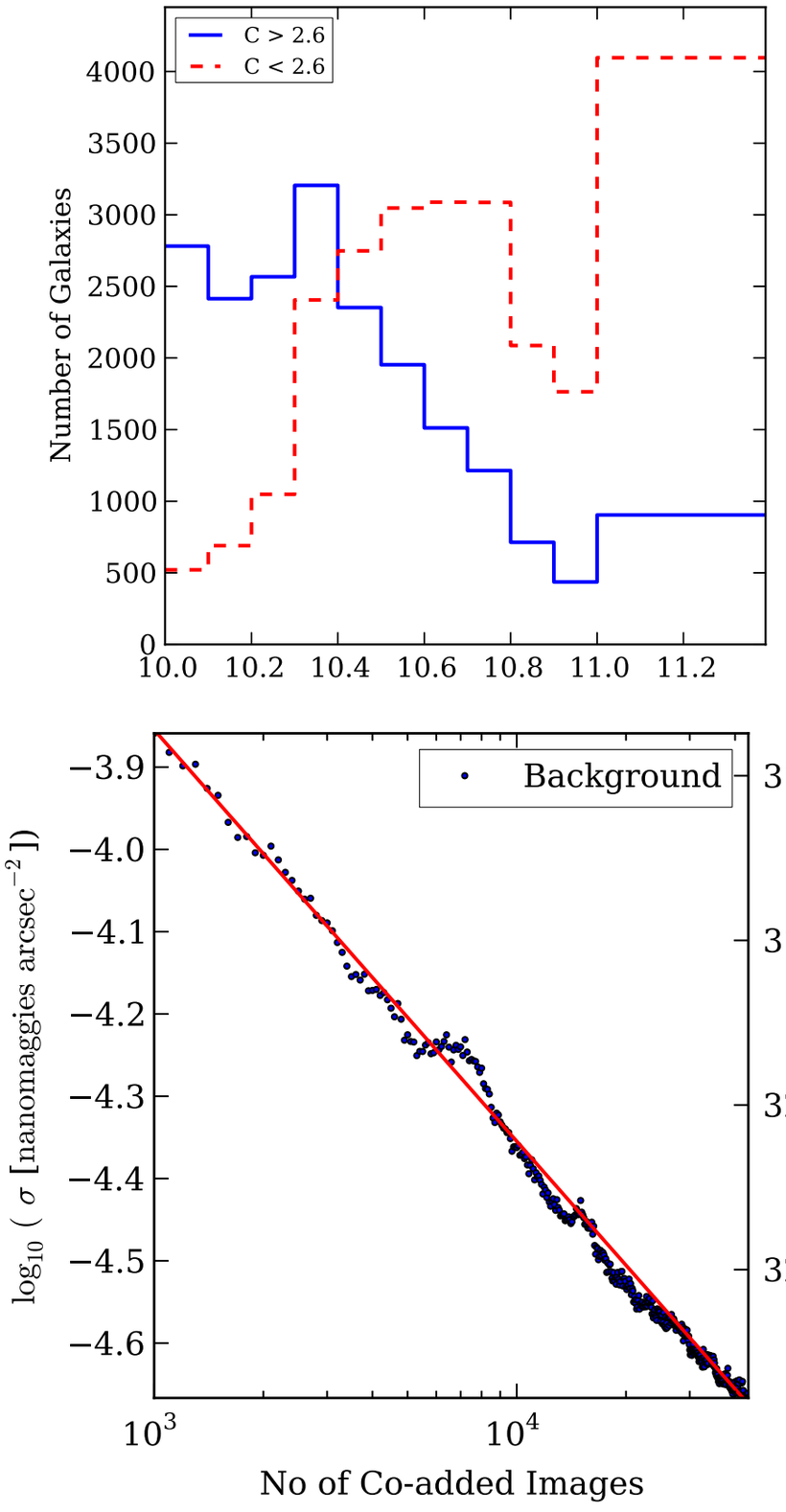
Example: Median and Clipped-mean stacks



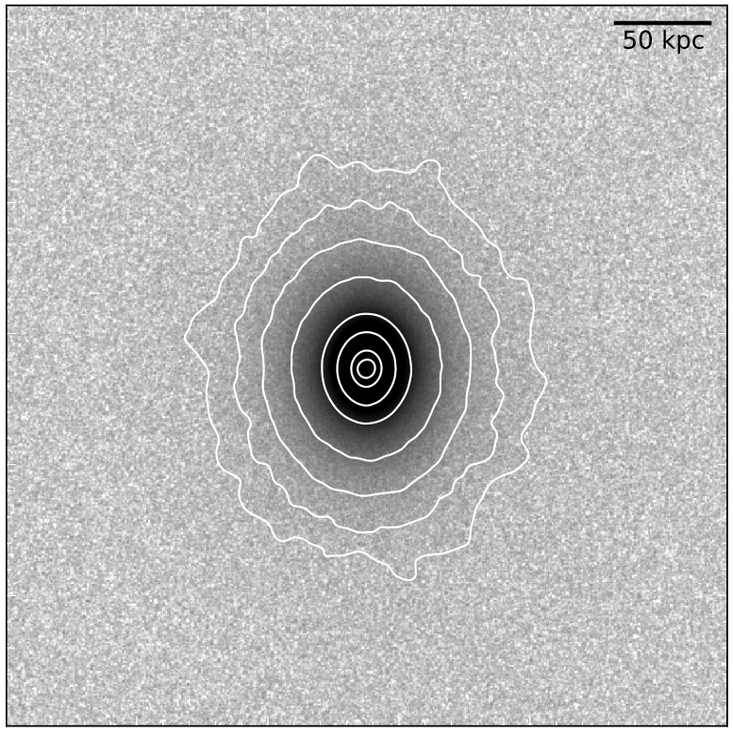
Stacking as a function of Stellar Mass and Galaxy type

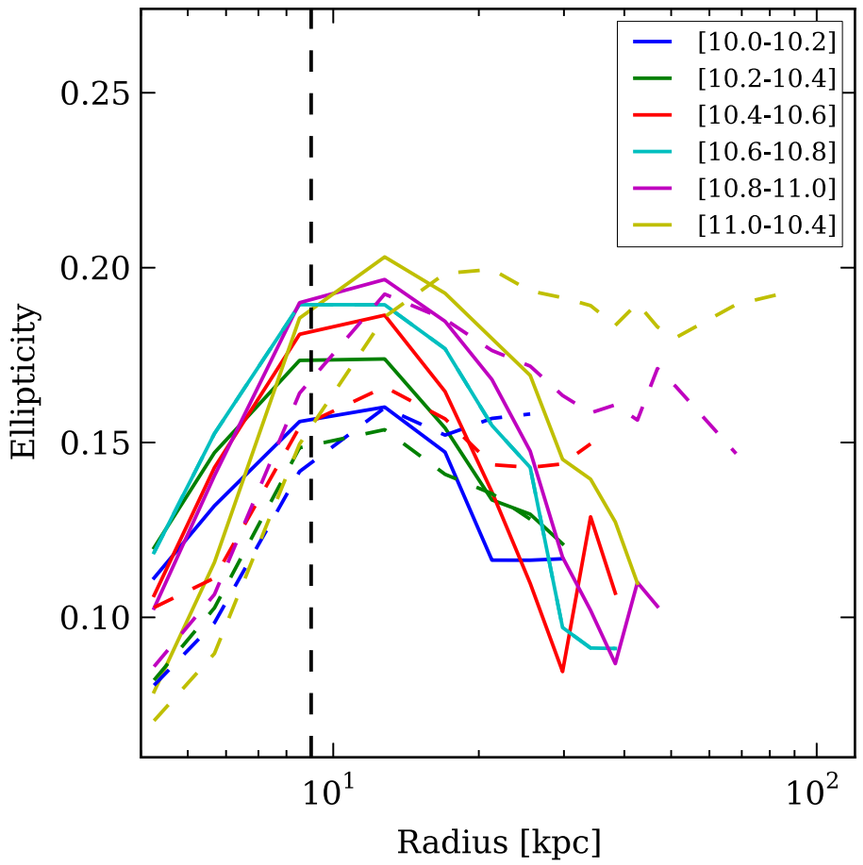
D'Souza et al. 2014

- Galaxies from MPA-JHU: 10.0 M_sun to 11.4 M_sun, 0.06 < z < 0.1 in g and r.
- ISOLATION criterion
- SDSS DR9 - improved background subtraction.
- Preparation for stacking: Masking, transforming to z~0.1 , de-reddening, alignment, removal of disk galaxies, residual background subtraction, etc.

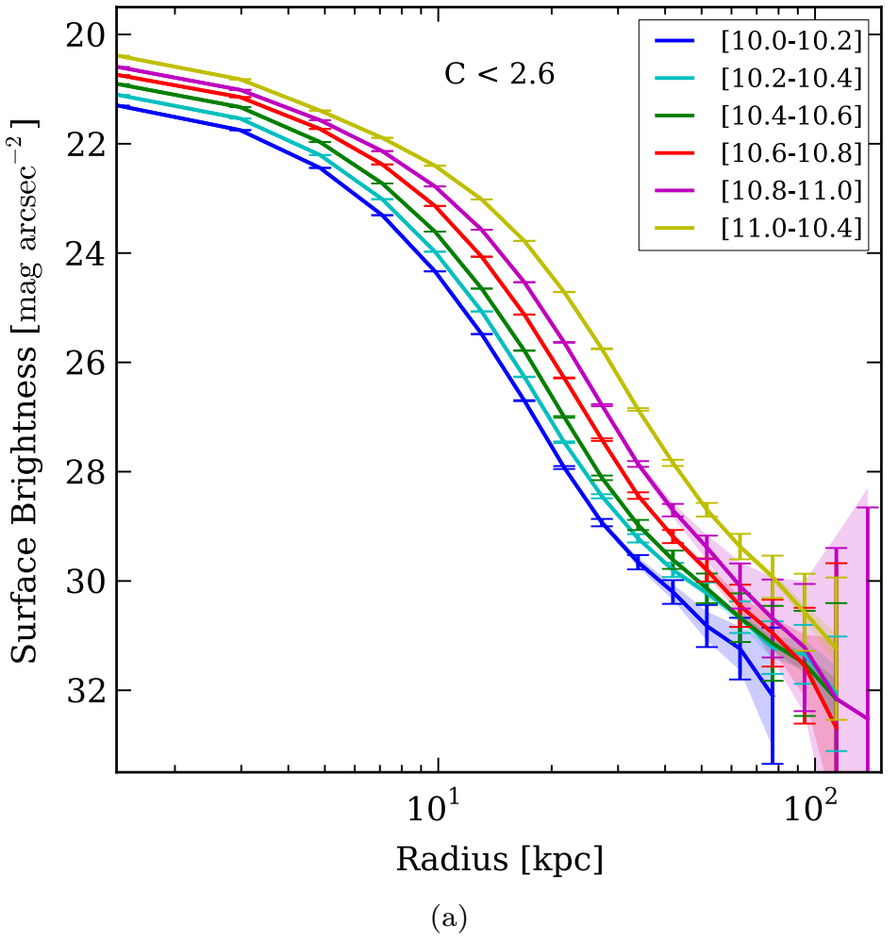


Ellipticity of Stellar Haloes

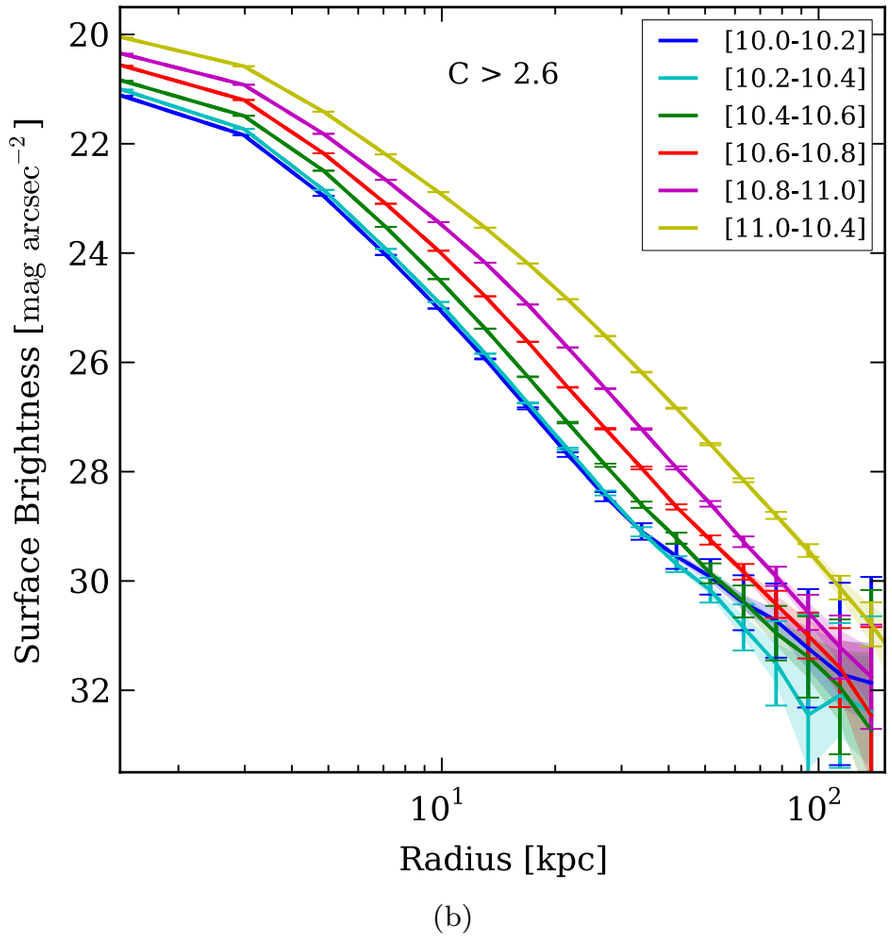




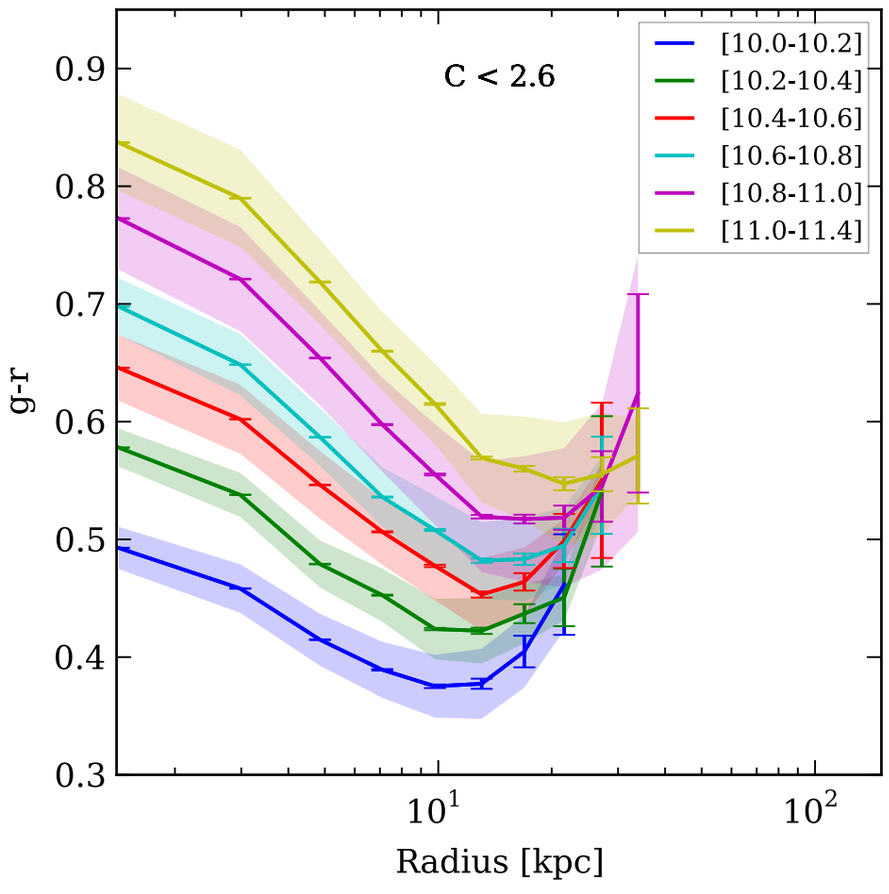
- Ellipticity as a function of stellar mass and galaxy type.
- Stellar haloes of late-type galaxies tend to be spherical, while of early-type galaxies tend to be elliptical.
- Ellipticity increases with stellar mass of the galaxy.



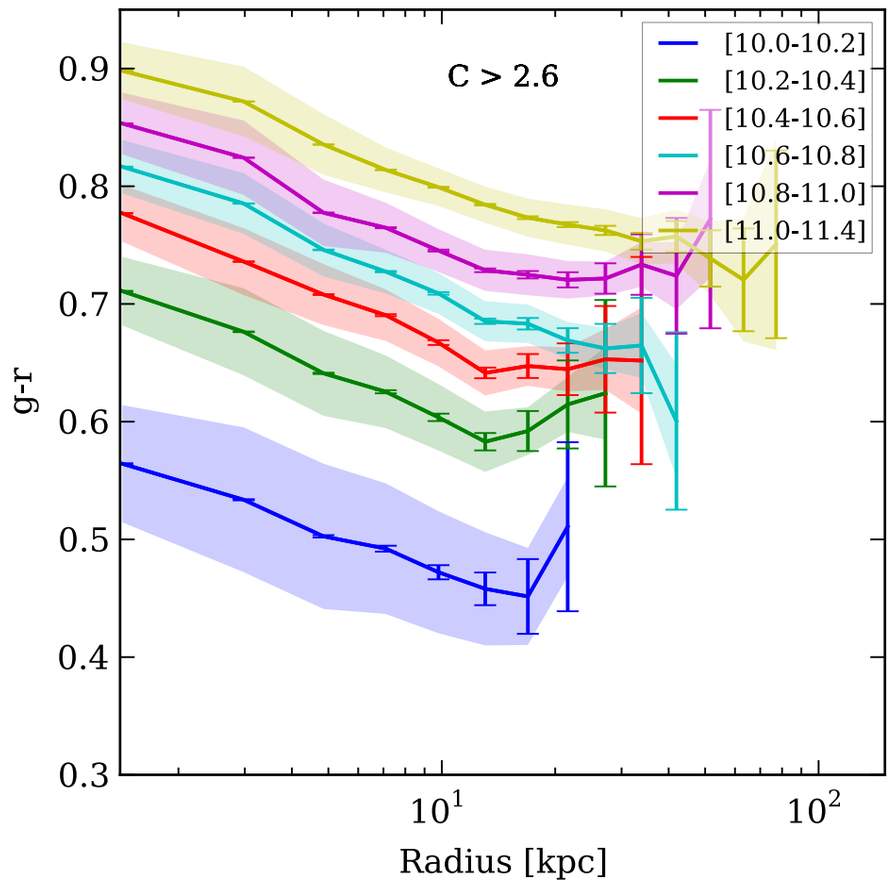
(a)



(b)



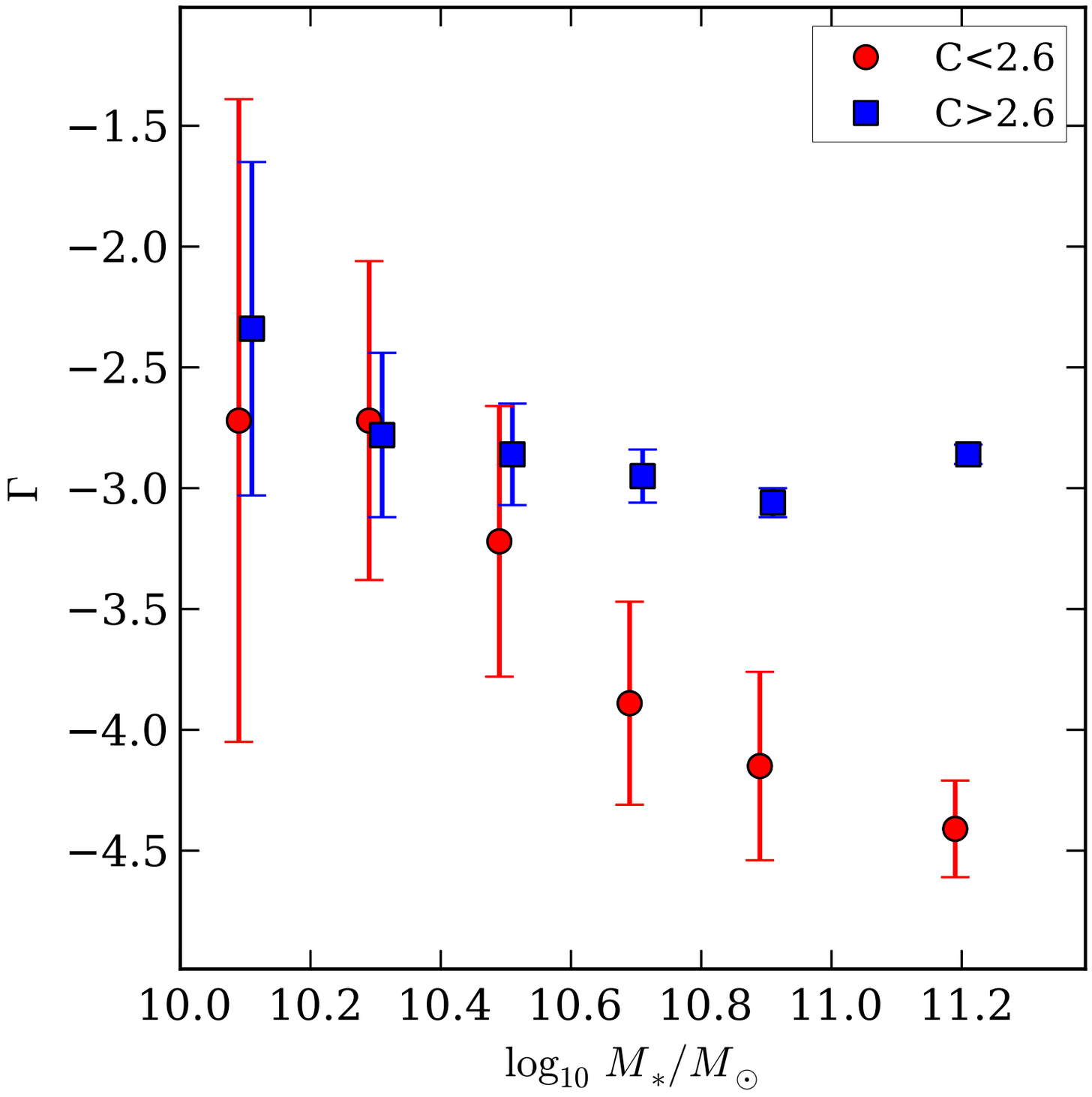
(c)



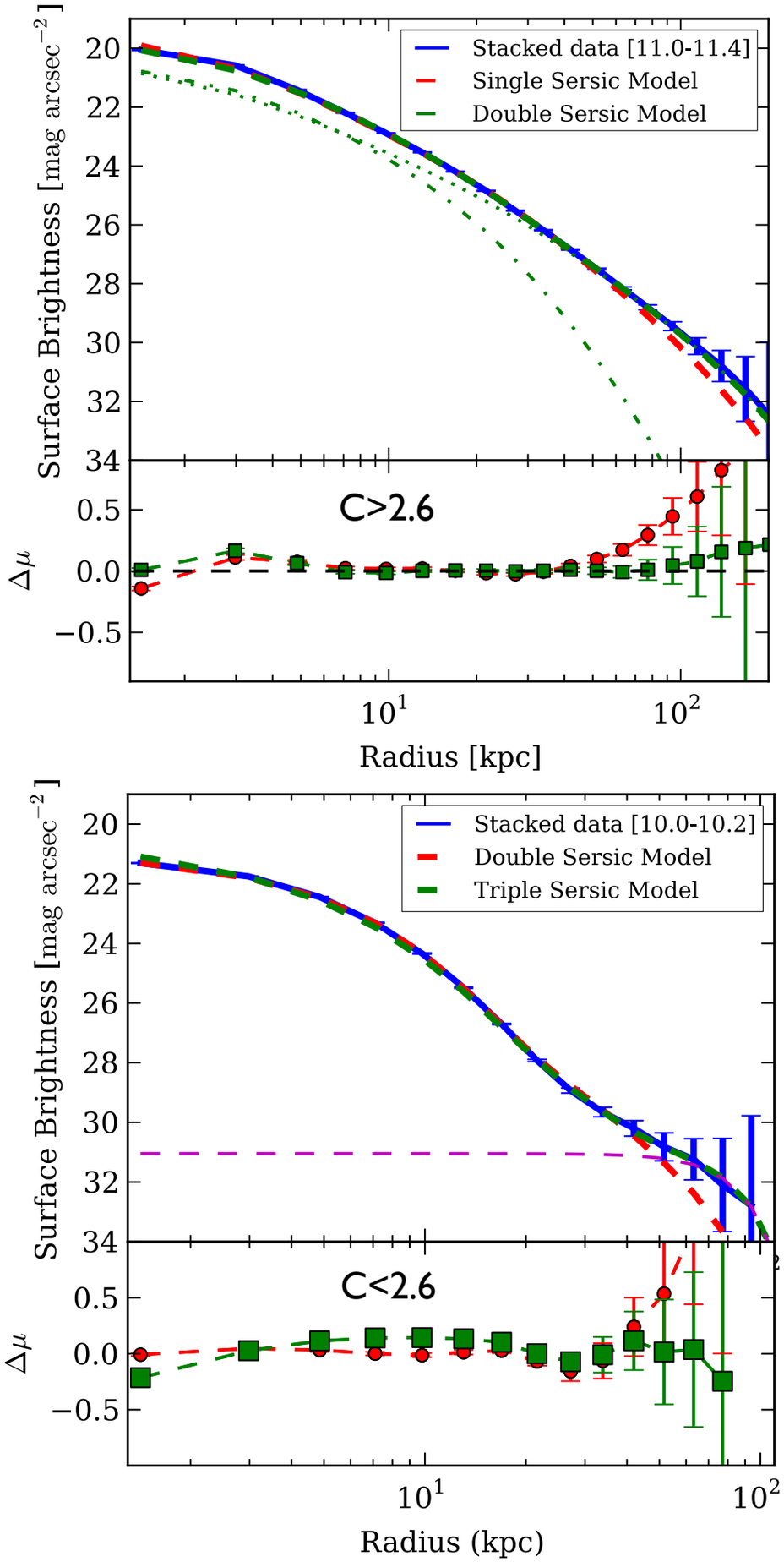
(d)

- Stellar haloes extend out to 100 kpc
- surface brightness and g-r colour profiles are a function of both stellar mass and galaxy type.
- Stellar halo light is bluer than the main galaxy.
- Colour of stellar halo is redder for more massive galaxies

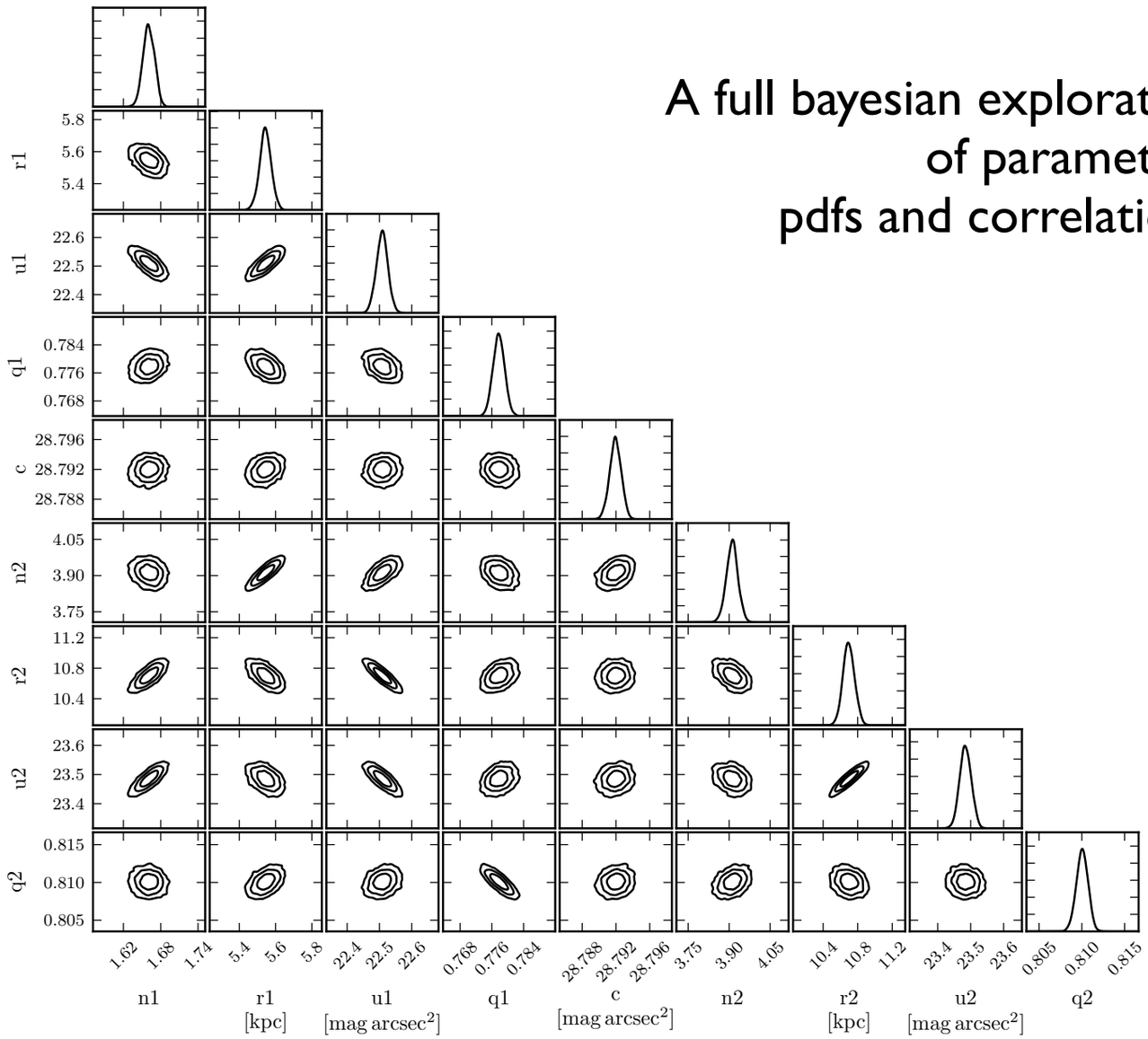
Projected Outer slopes of the surface brightness profiles



2D Modelling of the Galaxy and the Stellar haloes



- Need Multiple Sersic components: a) Double Sersic: Early Types b) Triple Sersic: Late Types
- Shape of the luminosity profile and ellipticity contribute to the need of multiple components.

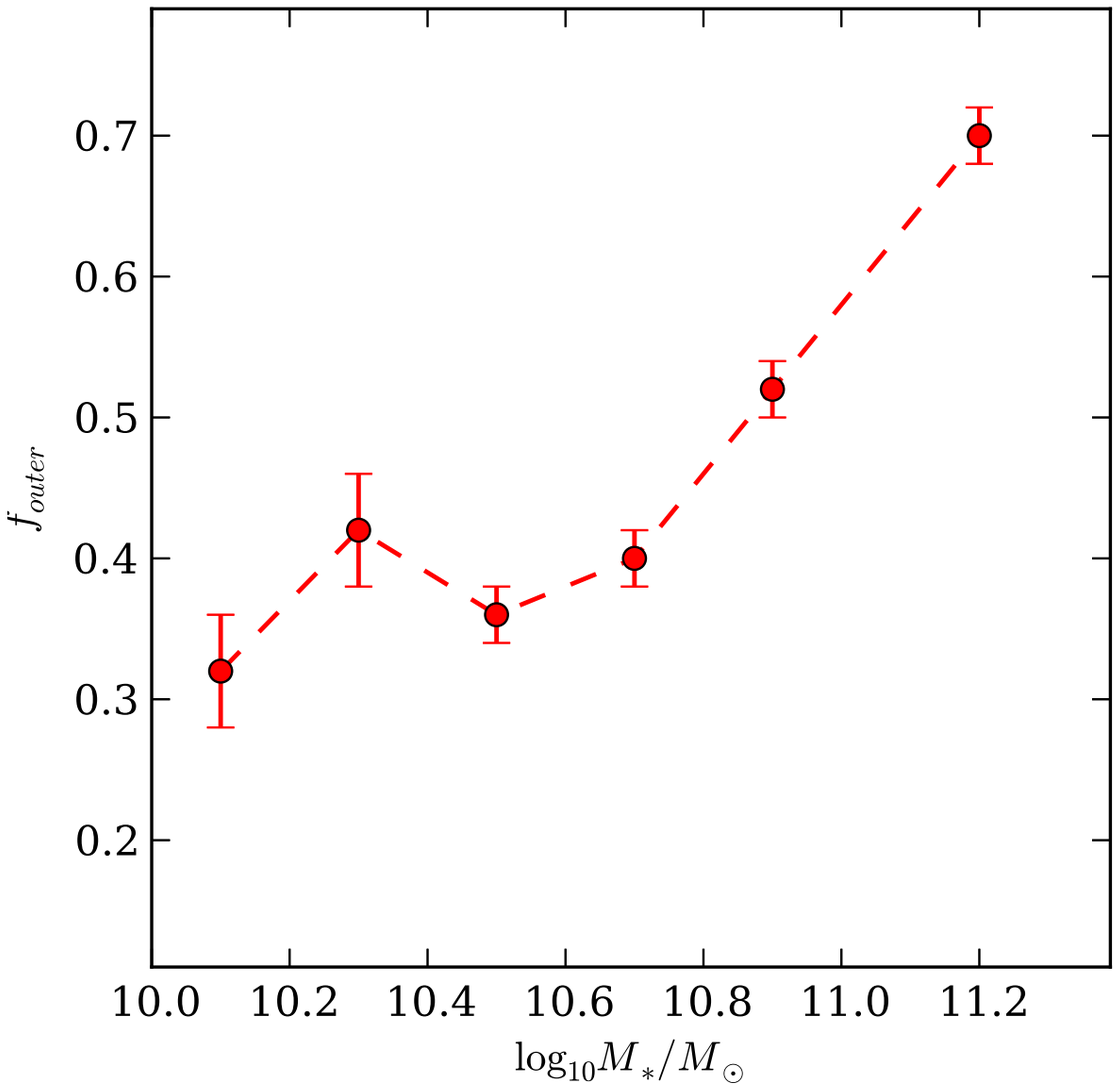


A full bayesian exploration of parameters pdfs and correlations

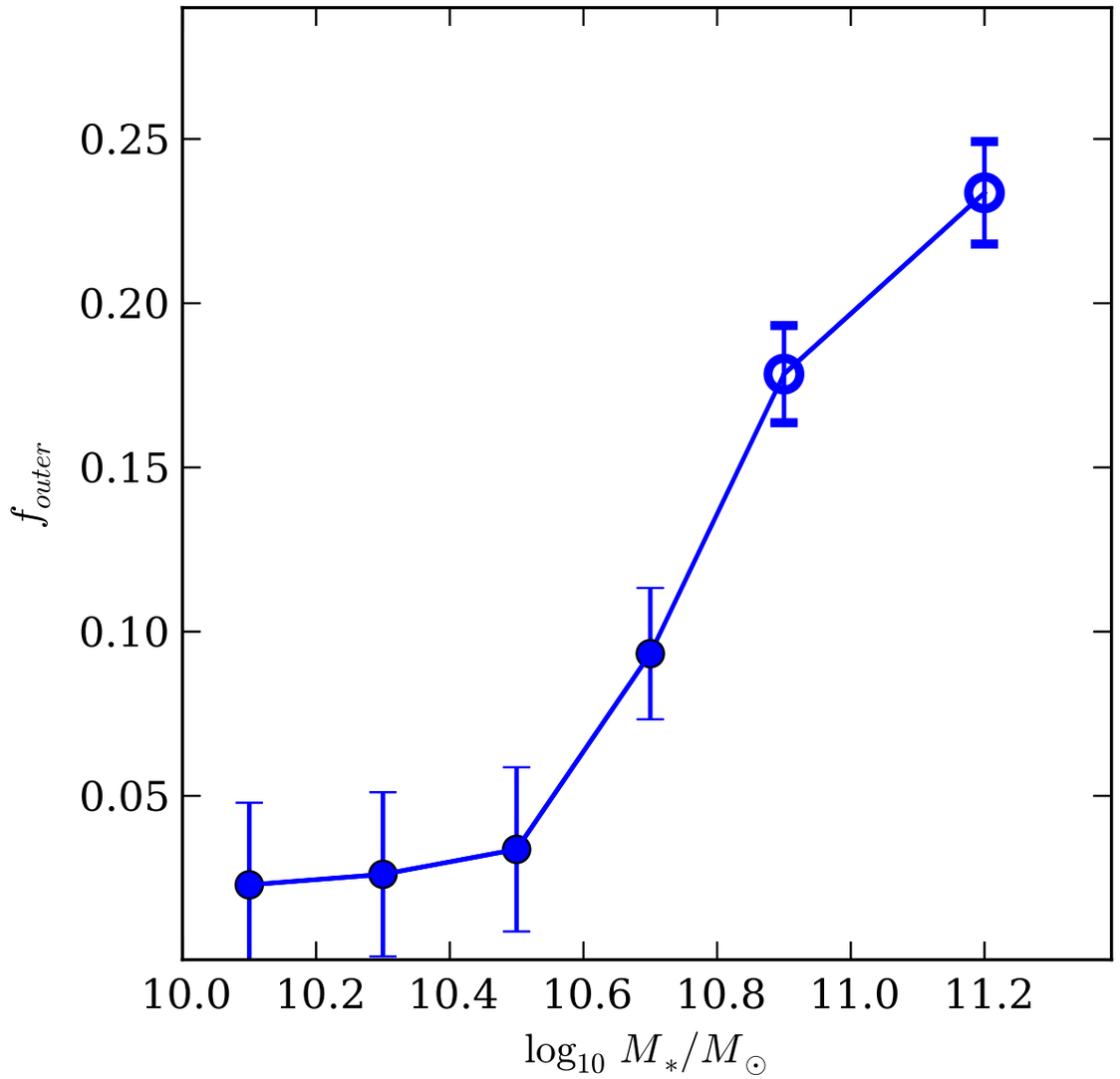
Accreted Stellar Mass Fraction

Use the fraction of light in outer component as a proxy for accreted stellar mass fraction.

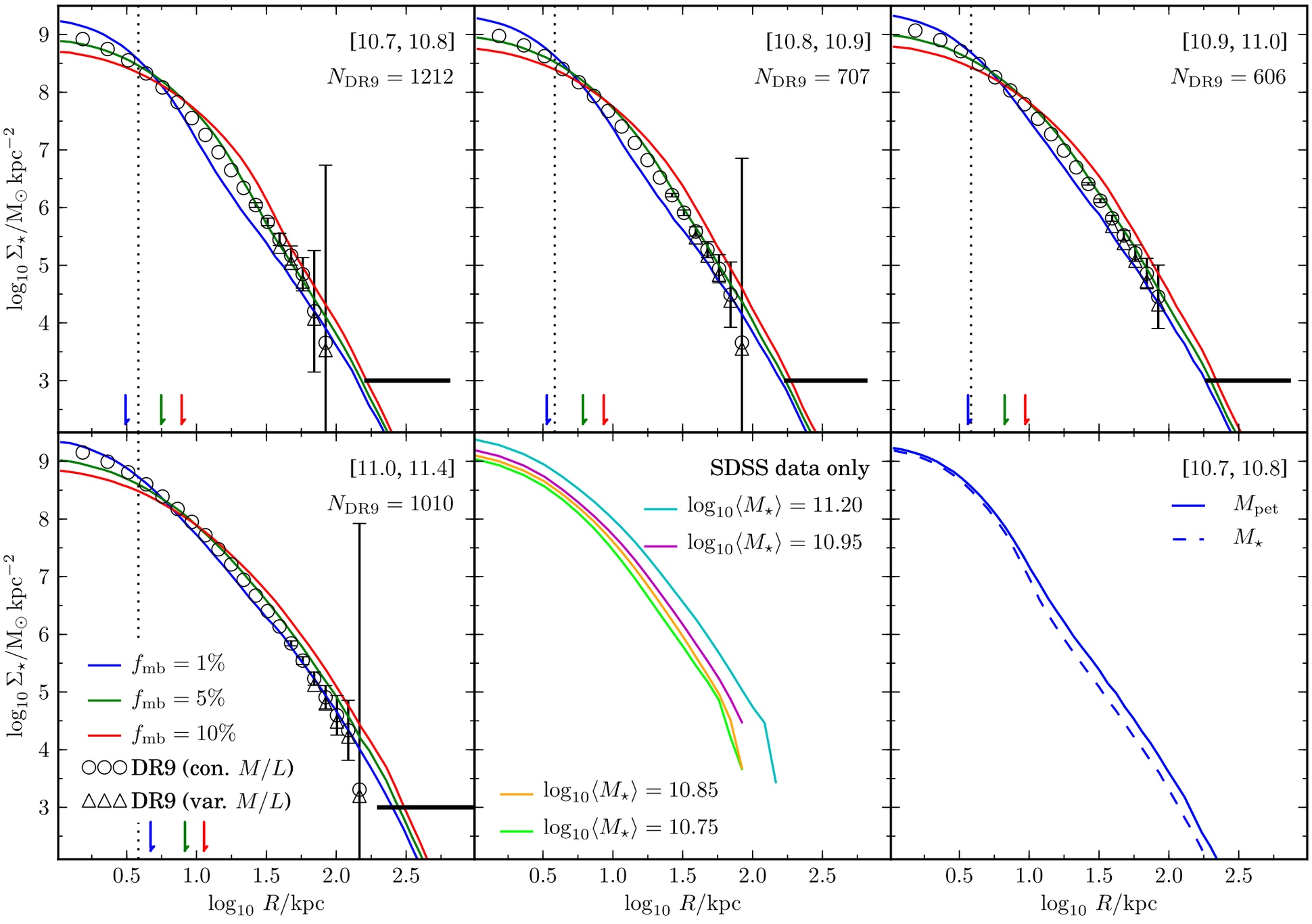
C > 2.6



C < 2.6



Surface Density profiles from stacks agree with predictions from particle tagging methods



Cooper et al. 2013

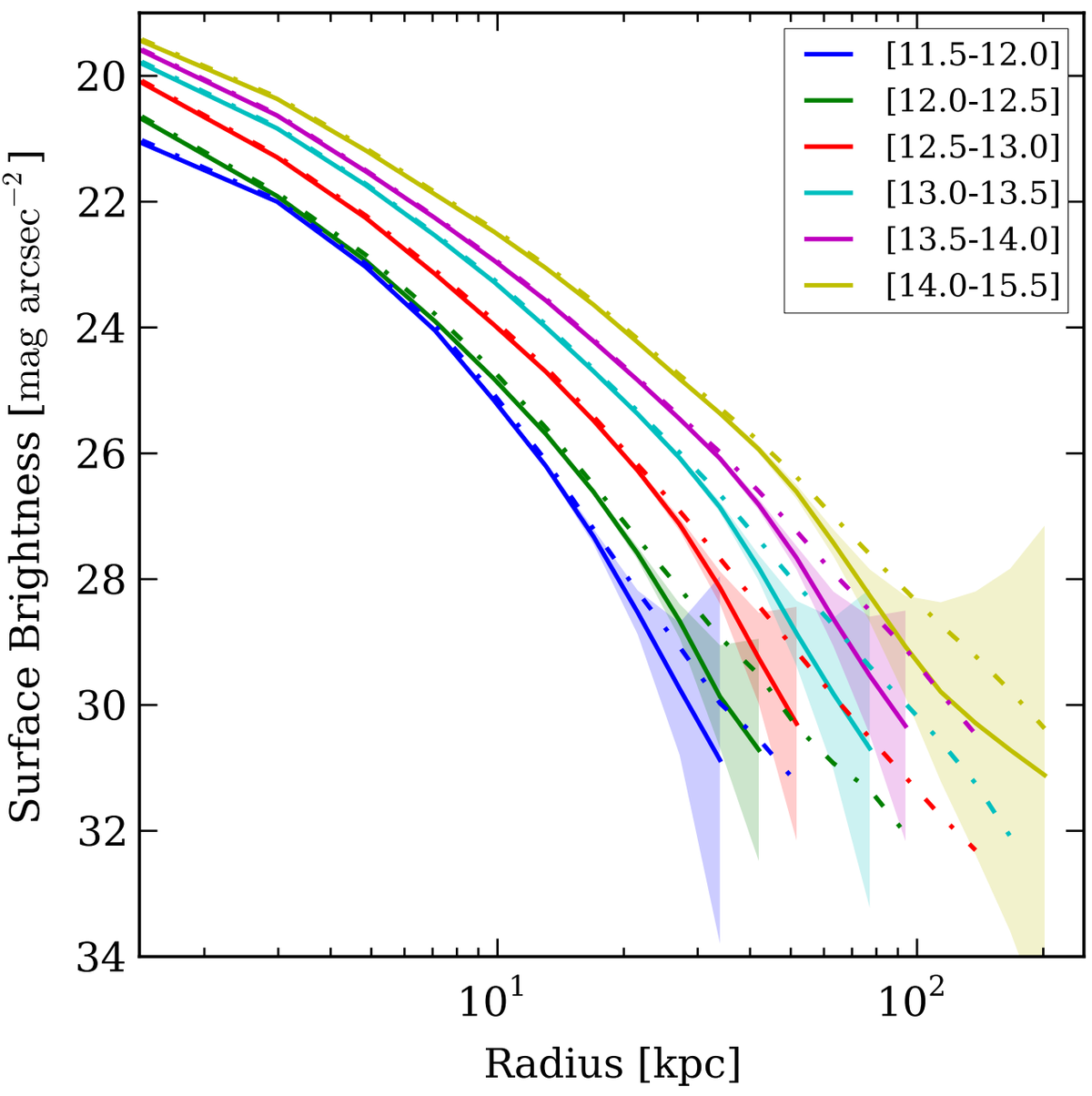
Stacking as a function of Halo Mass

D'Souza et al (In preparation)

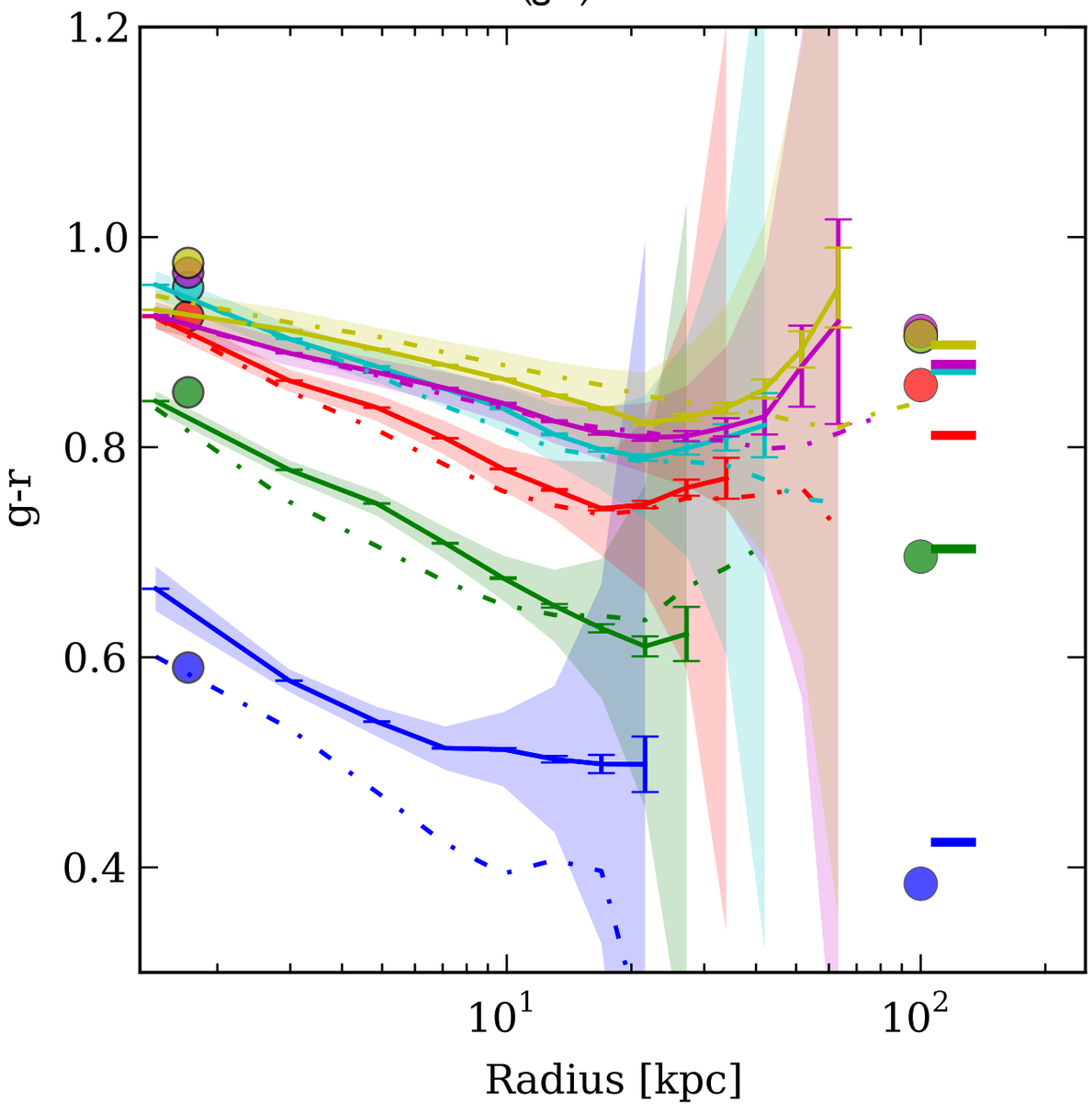
- Use a galaxy group catalogue (Yang et al. 2008)
- Galaxies at the center of groups and clusters.
- Have a handle on both halo mass and stellar halos.
- Halo mass - function of environment and number of satellite neighbours

Stacking in Halo Mass Bins

SB profiles

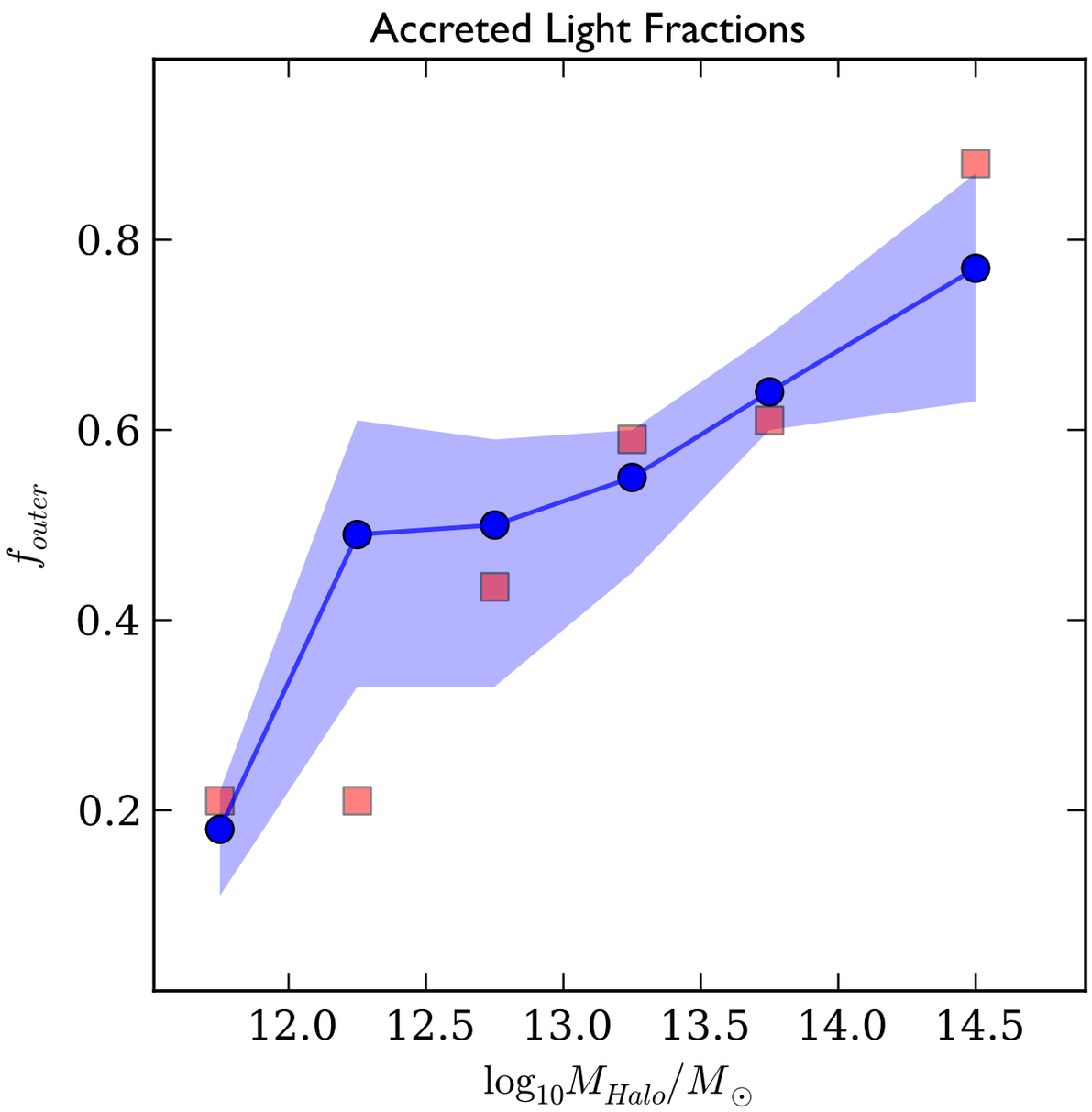


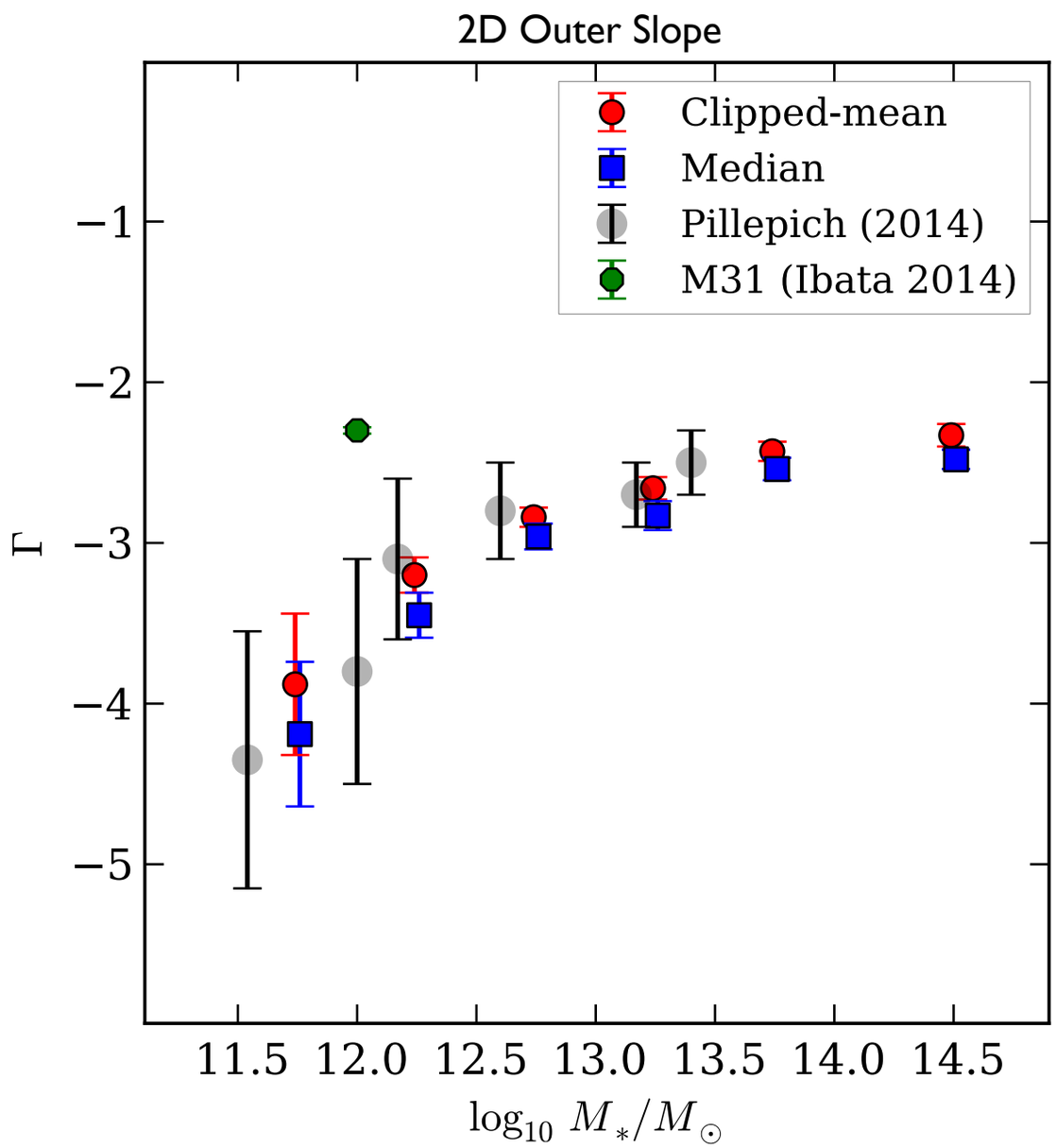
(g-r) colour



Preliminary

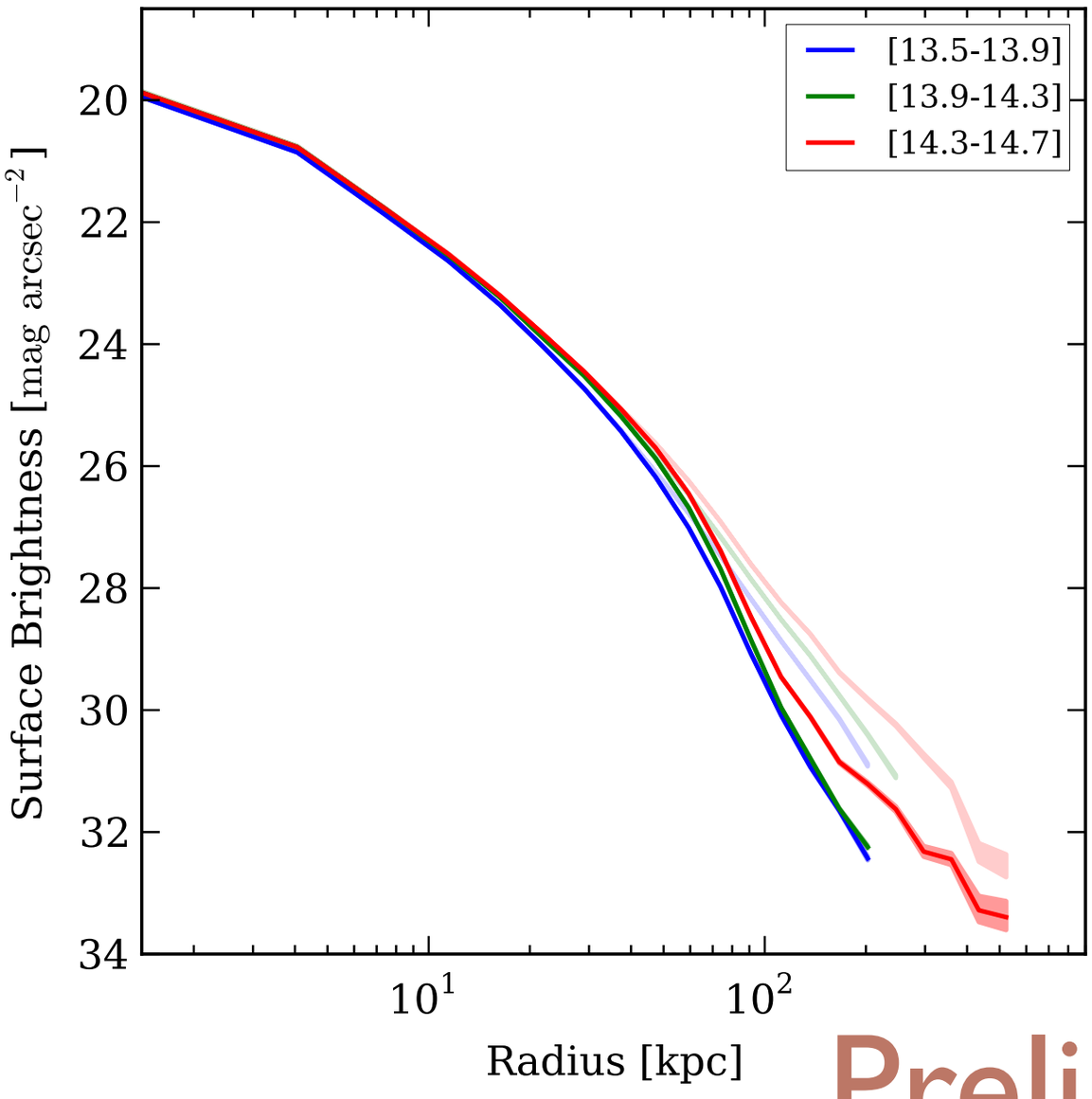
Stacking in Halo Mass Bins

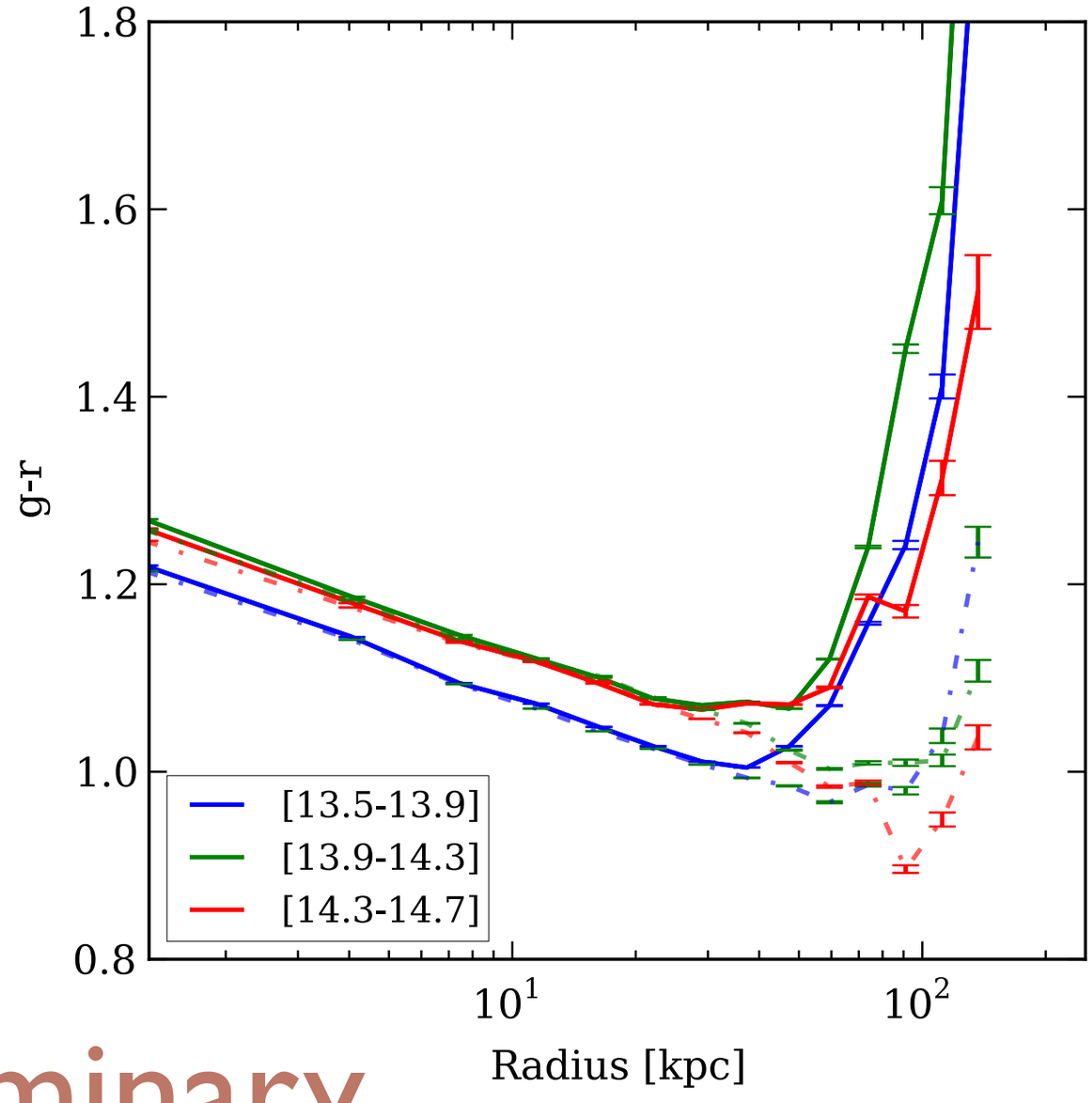




Preliminary

Stellar Haloes as a function of Environment





Preliminary

Main Results

- Fraction of accreted stellar material increases with as a function of stellar mass and is larger in early types than late-types.
- Stellar haloes of late types tend to be more elliptical. Ellipticity increases with stellar mass.
- g-r colour of the outer halo light of late types is bluer than the centre of the galaxy and is an increasing function of stellar mass.
- Multi-component Sersic models are needed to fit the two dimensional surface brightness profiles.
- For a given stellar mass, the stellar halo is also a function of the environment.