The stellar halo of isolated central galaxies in the Hyper Suprime-Cam imaging Survey

Wenting Wang
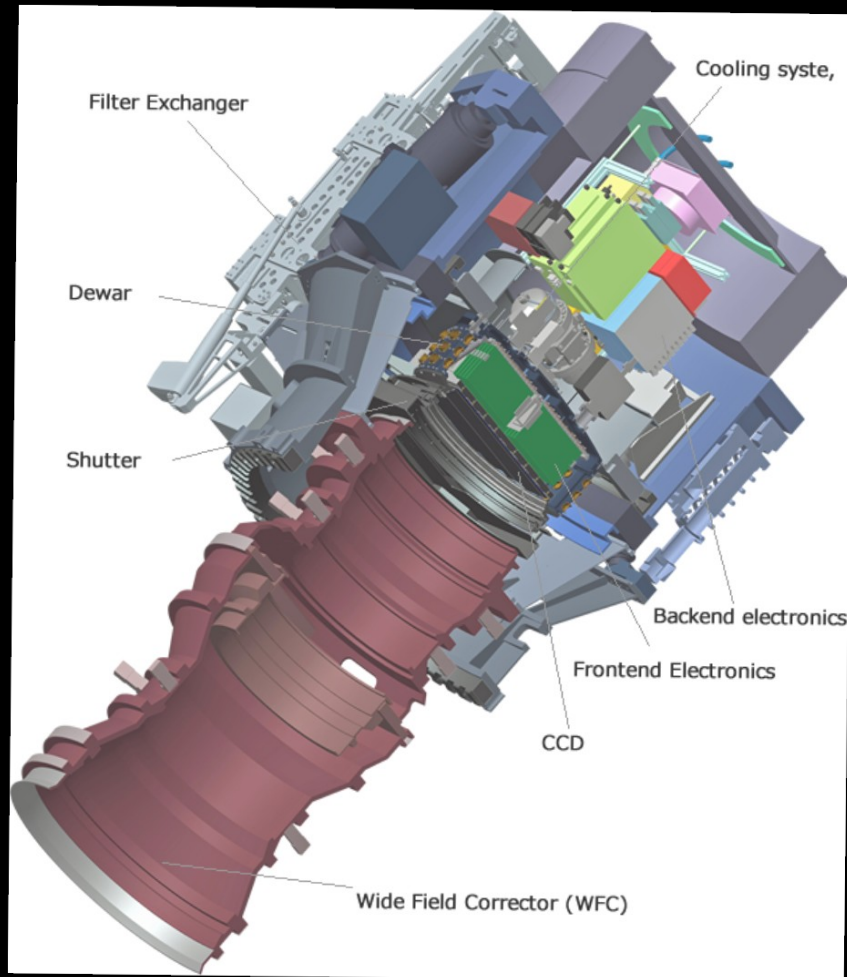SJTU

Shanghai 2019

ArXiv 1811.04714
MNRAS

Collaborators and coauthors:
Jiaxin Han, Alessandro Sonnenfeld, Naoki Yasuda, Xiangchong Li, Yipeng Jing,
Surhud More,Paul A. Price, Robert Lupton, Eli Rykoff, David V. Stark, Ting-Wen Lan,
Masahiro Takada et al.
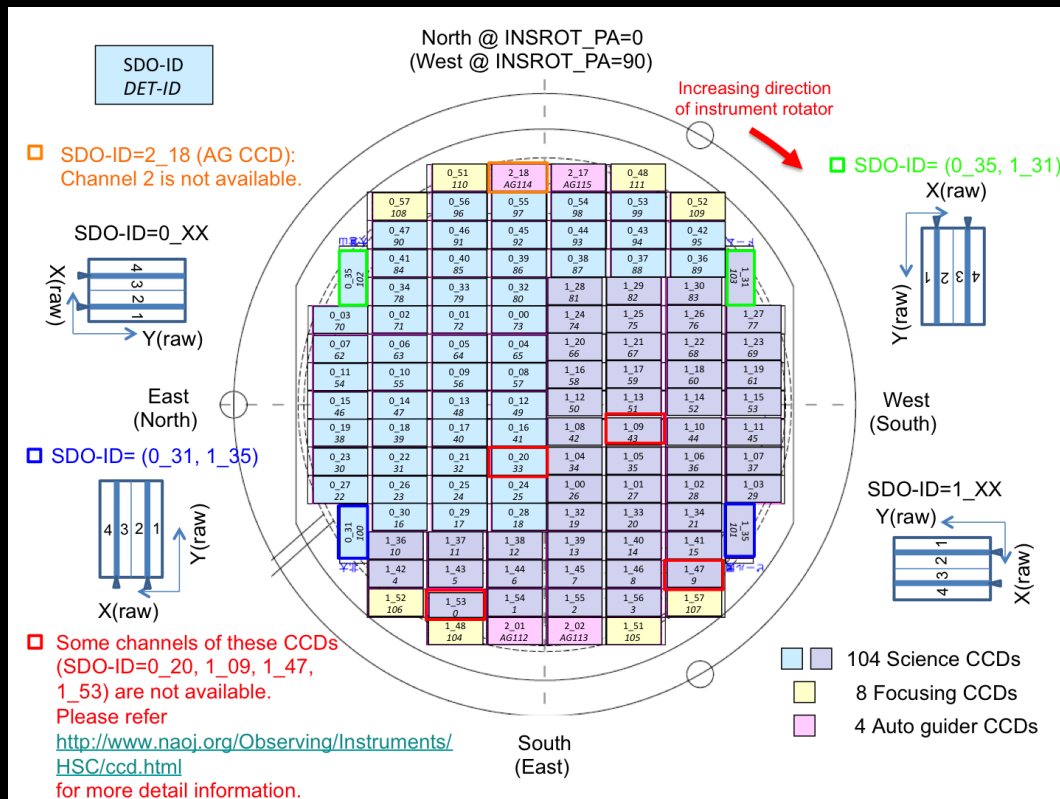
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Hyper Suprime-Cam

- HSC is a gigantic digital still camera for 8.2 m Subaru telescope built by NAOJ in collaboration with international academic and industrial partners.

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Hyper Suprime-Cam

- HSC is a gigantic digital still camera for 8.2 m Subaru telescope built by NAOJ in collaboration with international academic and industrial partners.

- 104 science CCDs, 1.5 deg FOV in diameter, pixel size of ~0.168 arcsec.

- The HSC pipeline is an enhanced version of the LSST.

Single exposures -> coadd image products
- sky background and instrumental features removed by the pipeline

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HSC photometry and data reduction

- The later S18a release also improves over-subtraction of the extended emission centered on bright objects.

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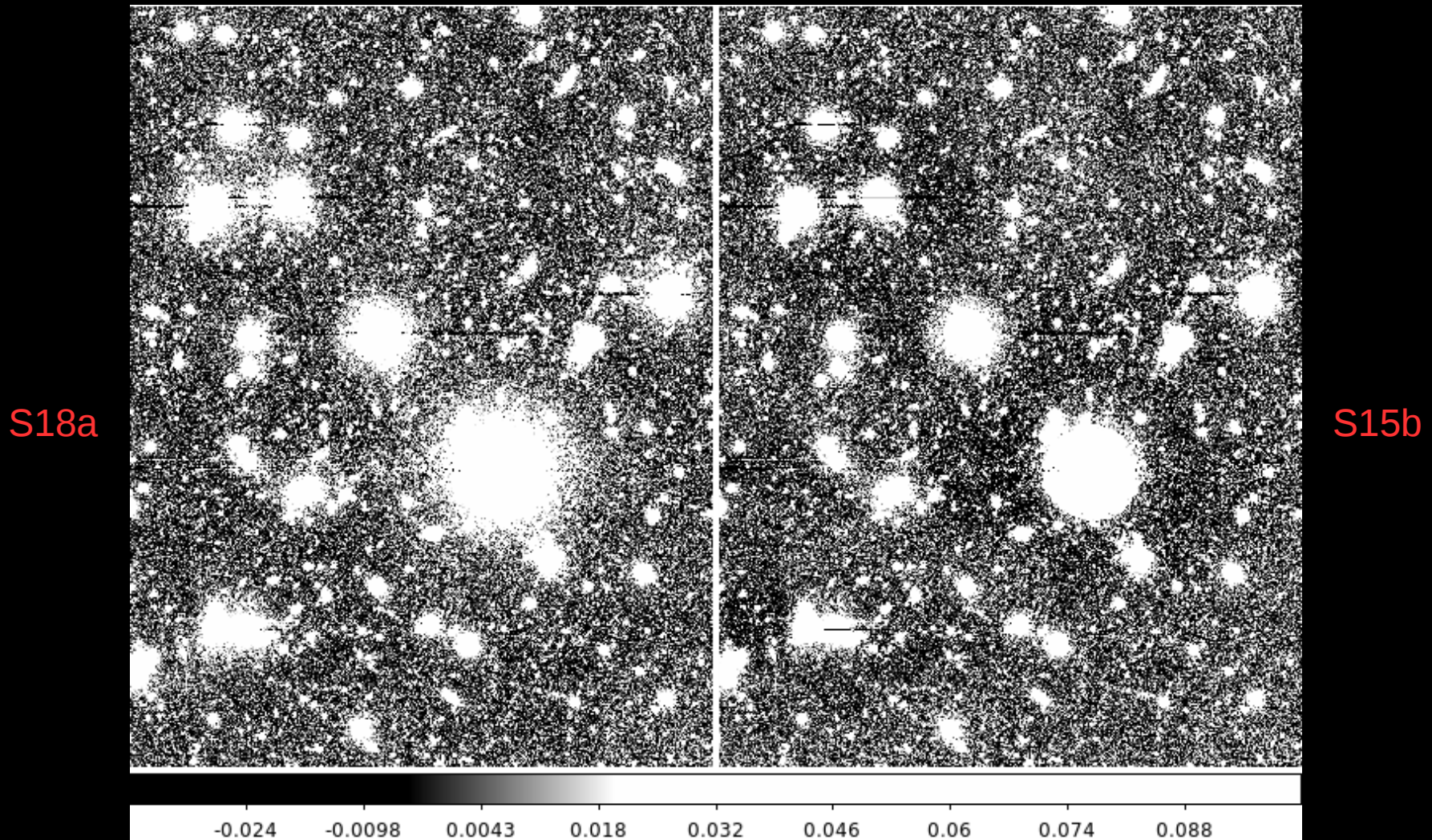
Isolated central galaxies

- Parent sample: SDSS DR7 spectroscopic Main galaxies

- Brightest within **the halo virial radius** in projection.

- Brightest within **three times the virial velocity** along the line-of-sight.

- Not within the virial radius of another larger object.

- Virial radius and velocity obtained through abundance matching.

- Using **photoz probability distribution** to compensate fiber collisions.

- **Redshift range: 0.05-0.16**
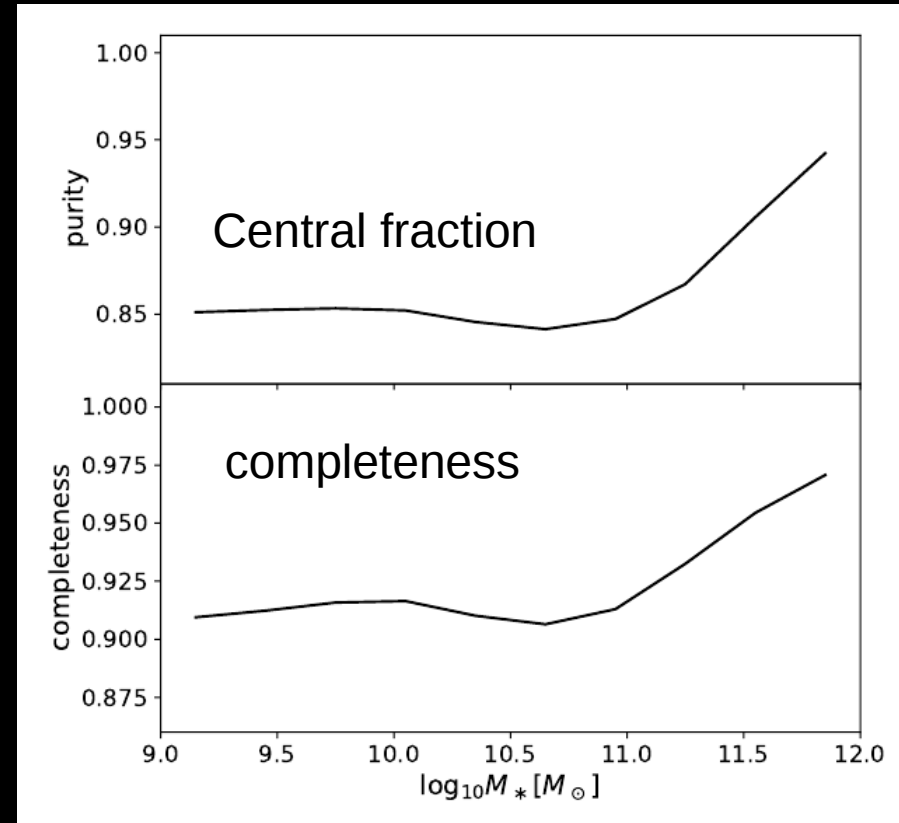
Based on a mock galaxy catalog of semi-analytical galaxy formation model (Guo et al., 2011)

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Methodology
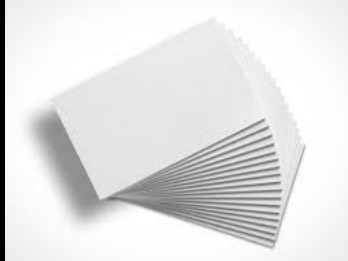
Galaxies with similar properties are stacked!

- Image cutouts

- Cosmic dimming correction

- **Source masking** by creating g,r and i band stacked images at first and run Sextractor with different detection thresholds

- Image resampling to the same WCS: pixel size~0.8 kpc

- Clipping and stacking galaxies with similar properties

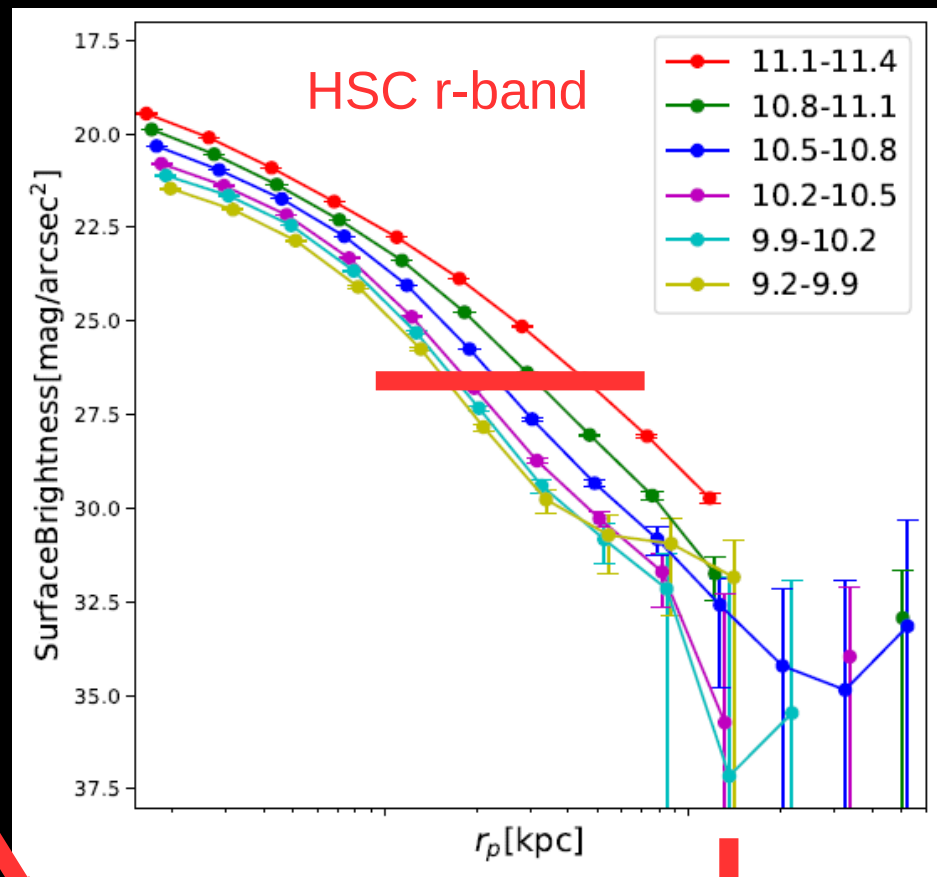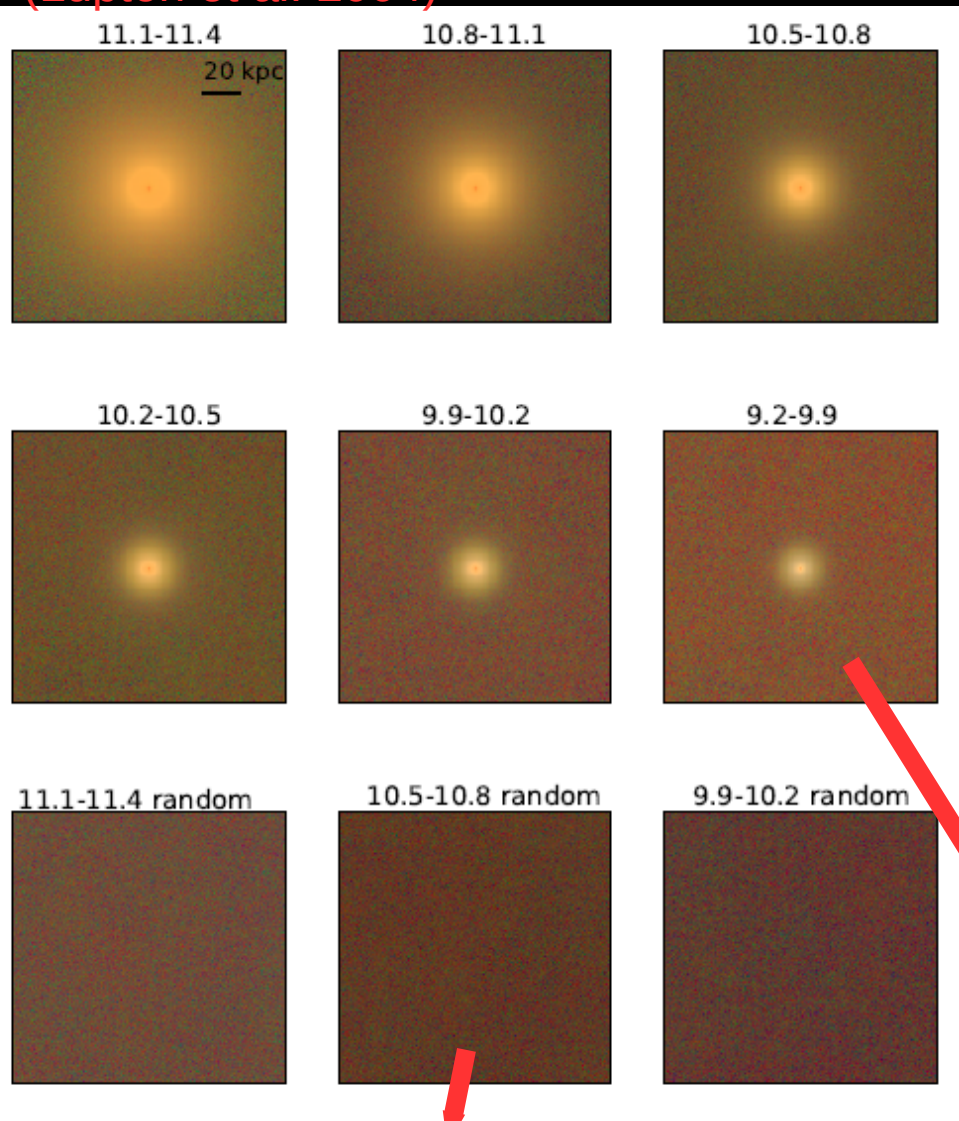- Random sample **correction for residual background**

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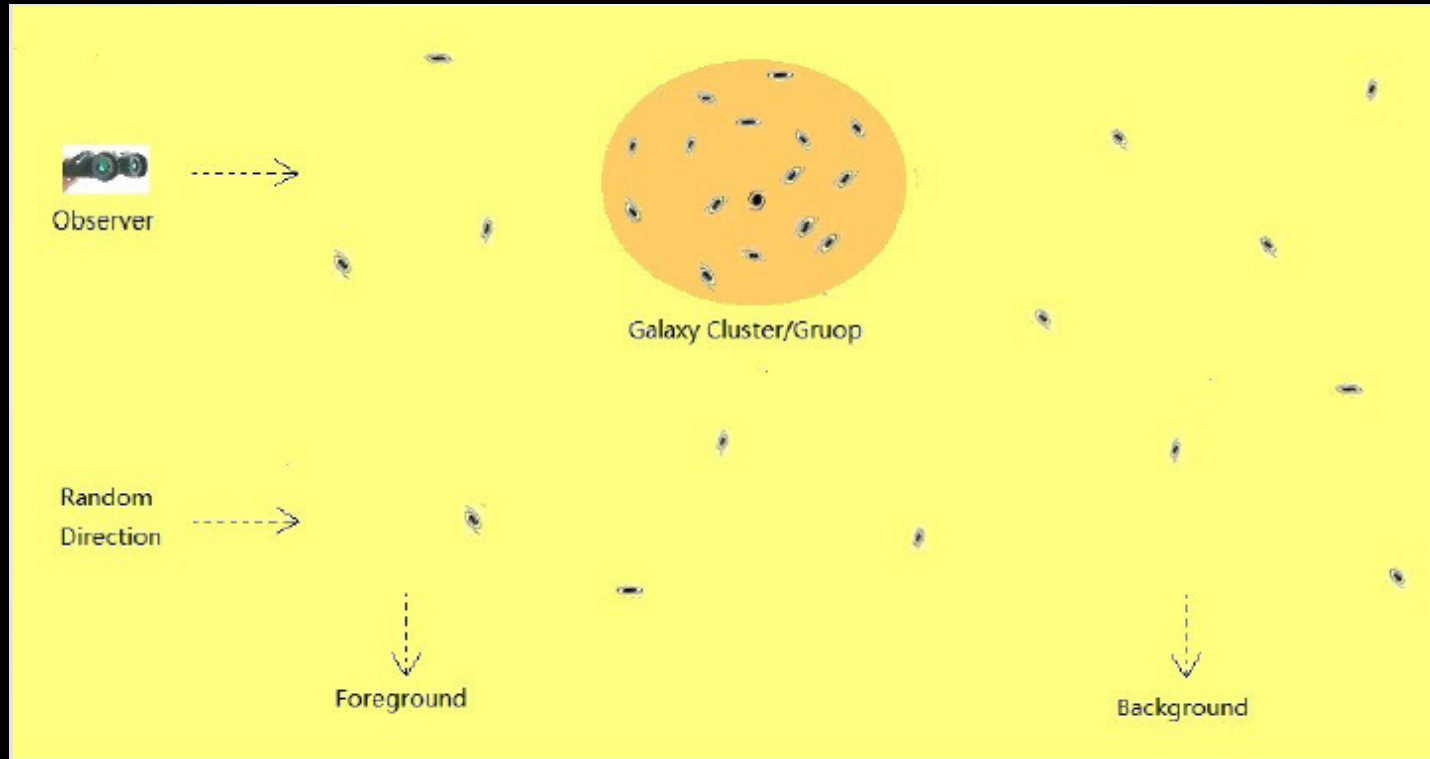
Random stacks

- Random stacks cannot account for incomplete masking of satellite galaxies!

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Surface Brightness

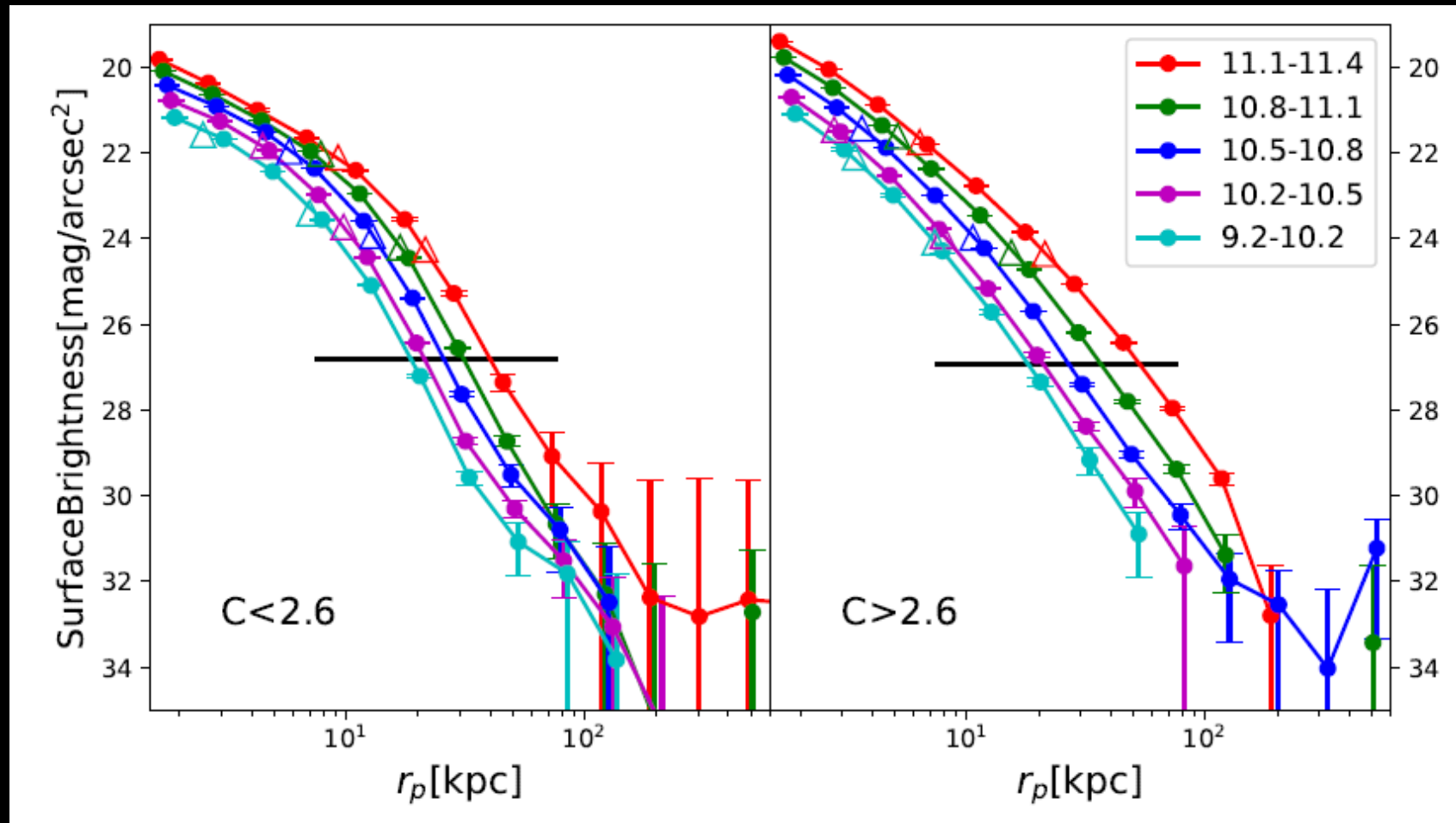HSC g,r,i-bands mapped to RGB
(Lupton et al. 2004)
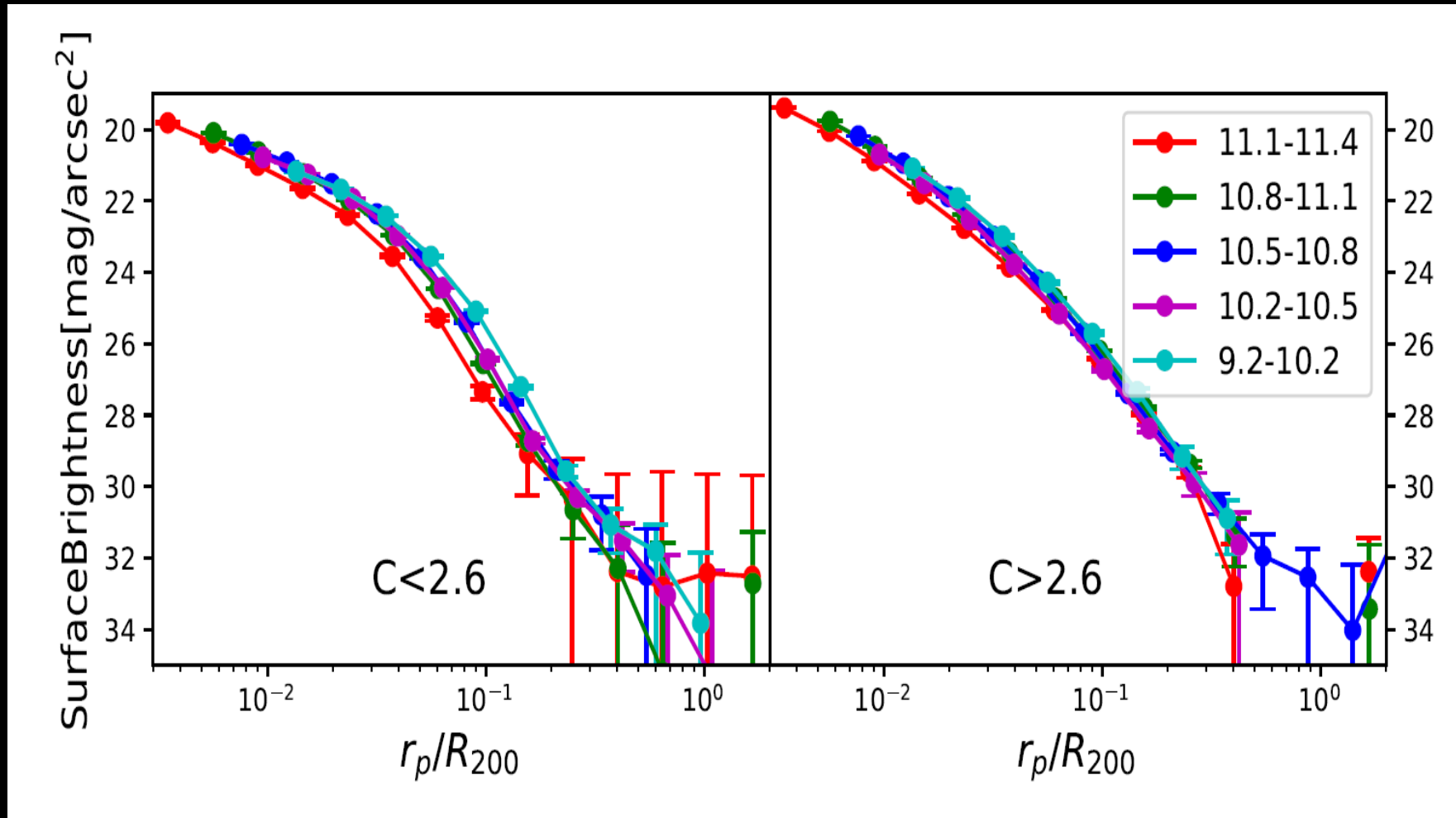

10^9.2-9.9 solar mass

120 kpc

Random stacks are ideally flat.

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Low and high concentration

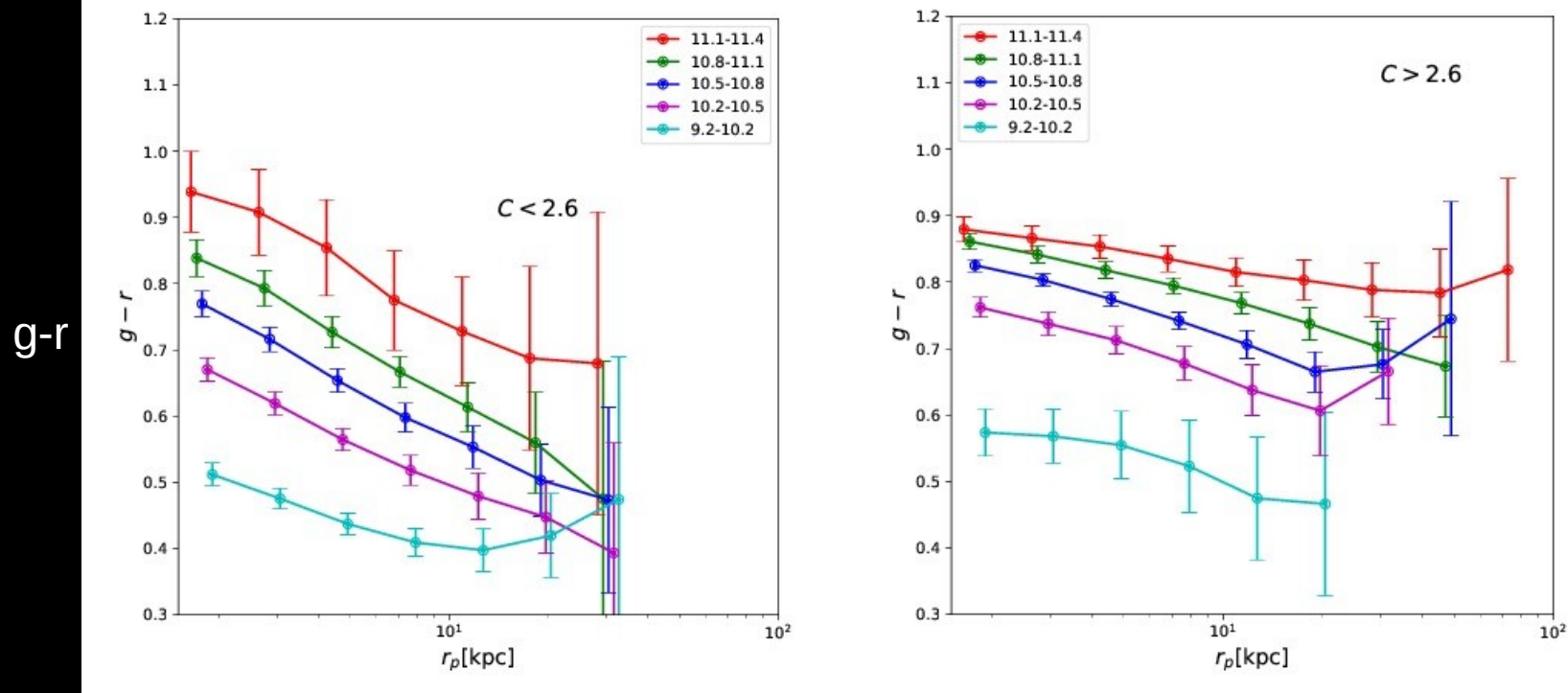- Low and high concentration galaxies show distinct features in their outer stellar halos.

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Universality of the stellar halo

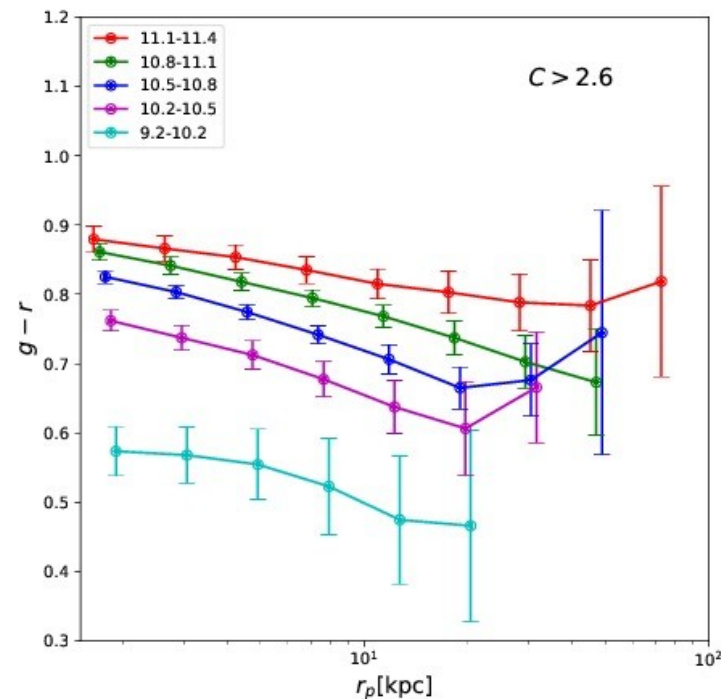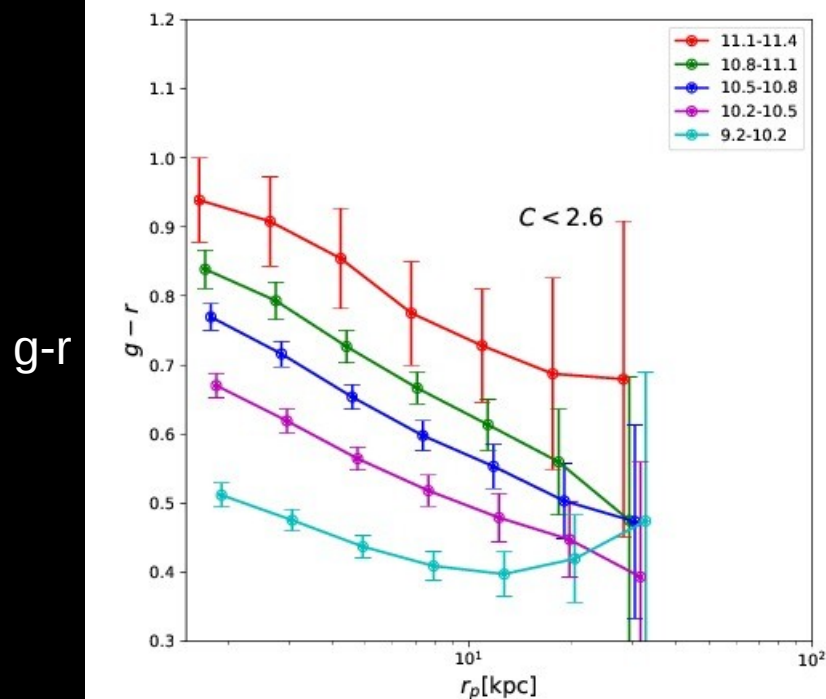- Profiles are close to universal after scaling r_p by R_200.

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Color profiles

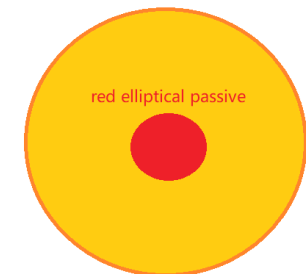Low and high concentration galaxies with 0.05<z<1

- High C galaxies have more flattened color profiles.

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Color profiles

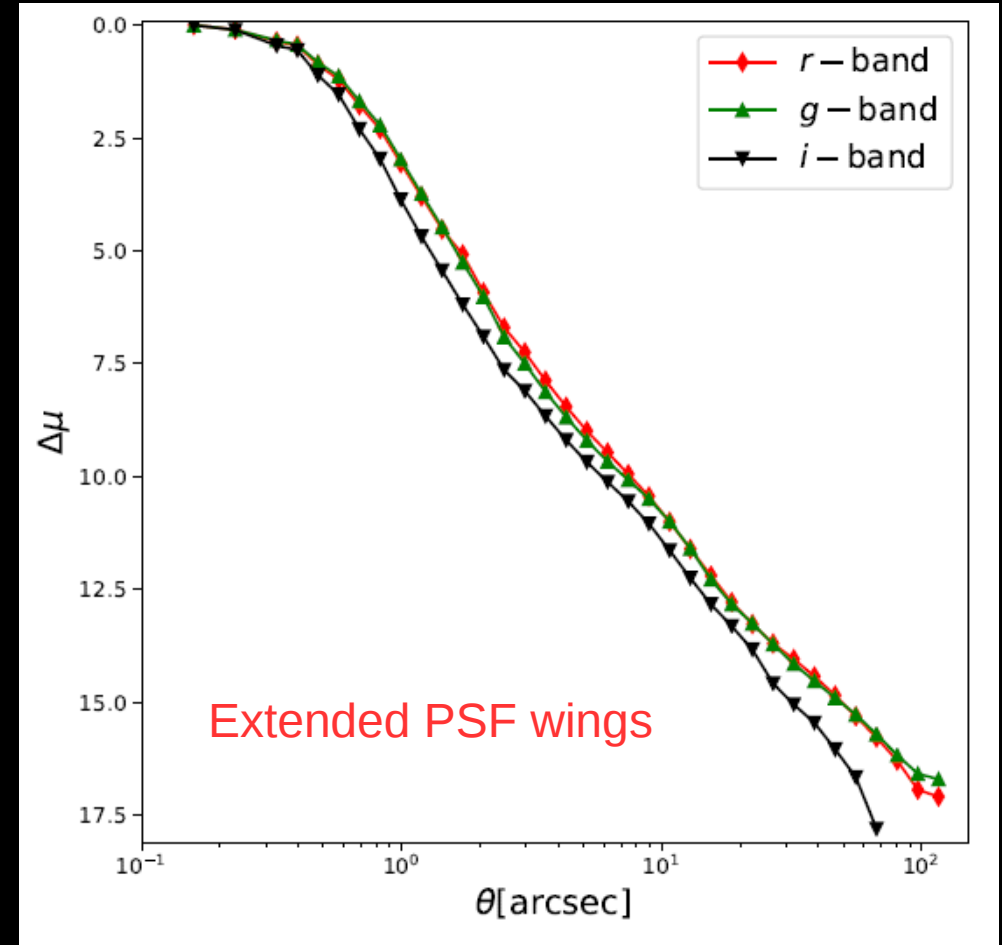Low and high concentration galaxies with 0.05<z<1

- Related to galactic conformity: satellites around red passive galaxies are redder (e.g. Weinmann et al. 2006)
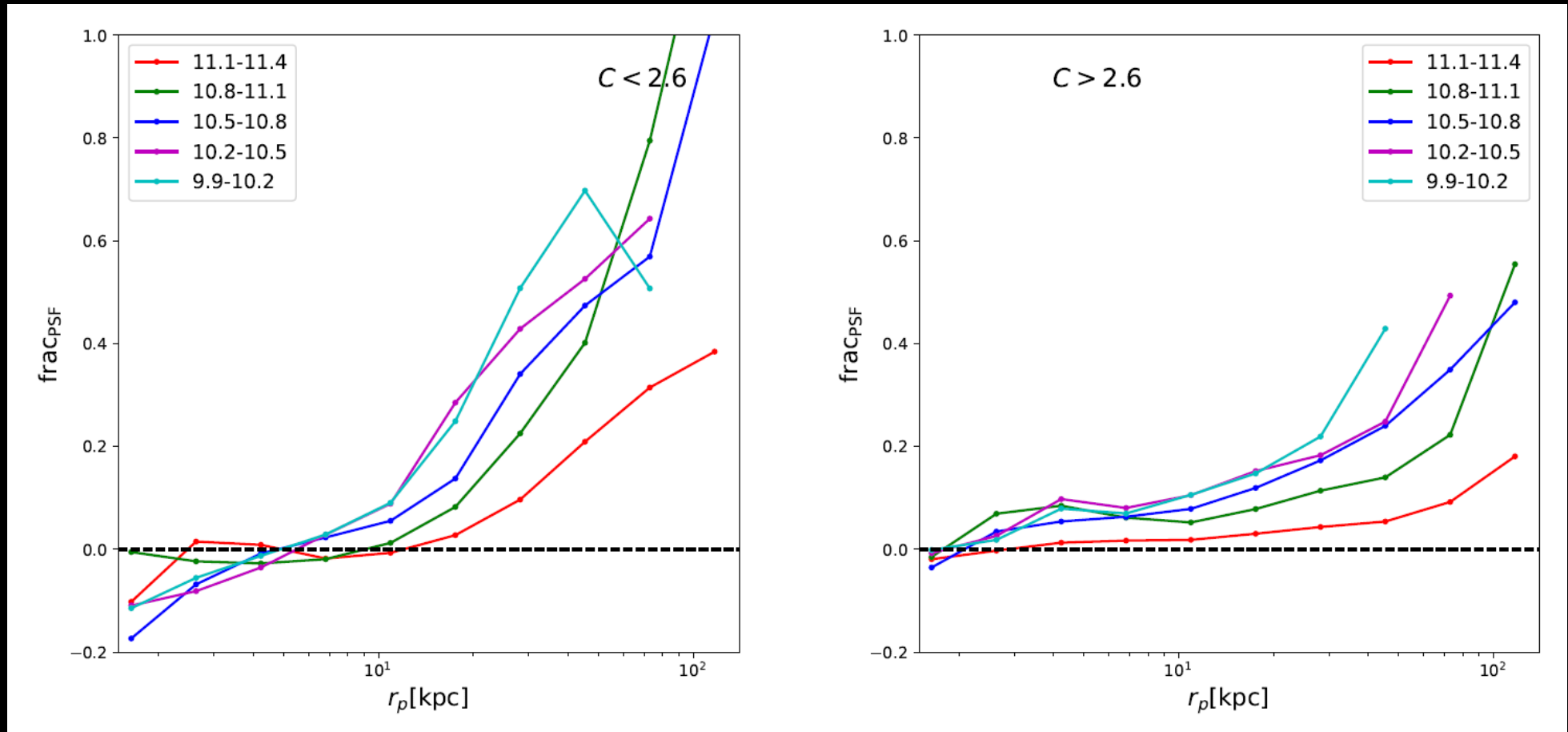
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PSF effect

- Inner PSF - dominated by atmosphere turbulence

- Outer PSF – CCD+ instrument+ atmosphere scattering

Extended PSF wings

100arcsec

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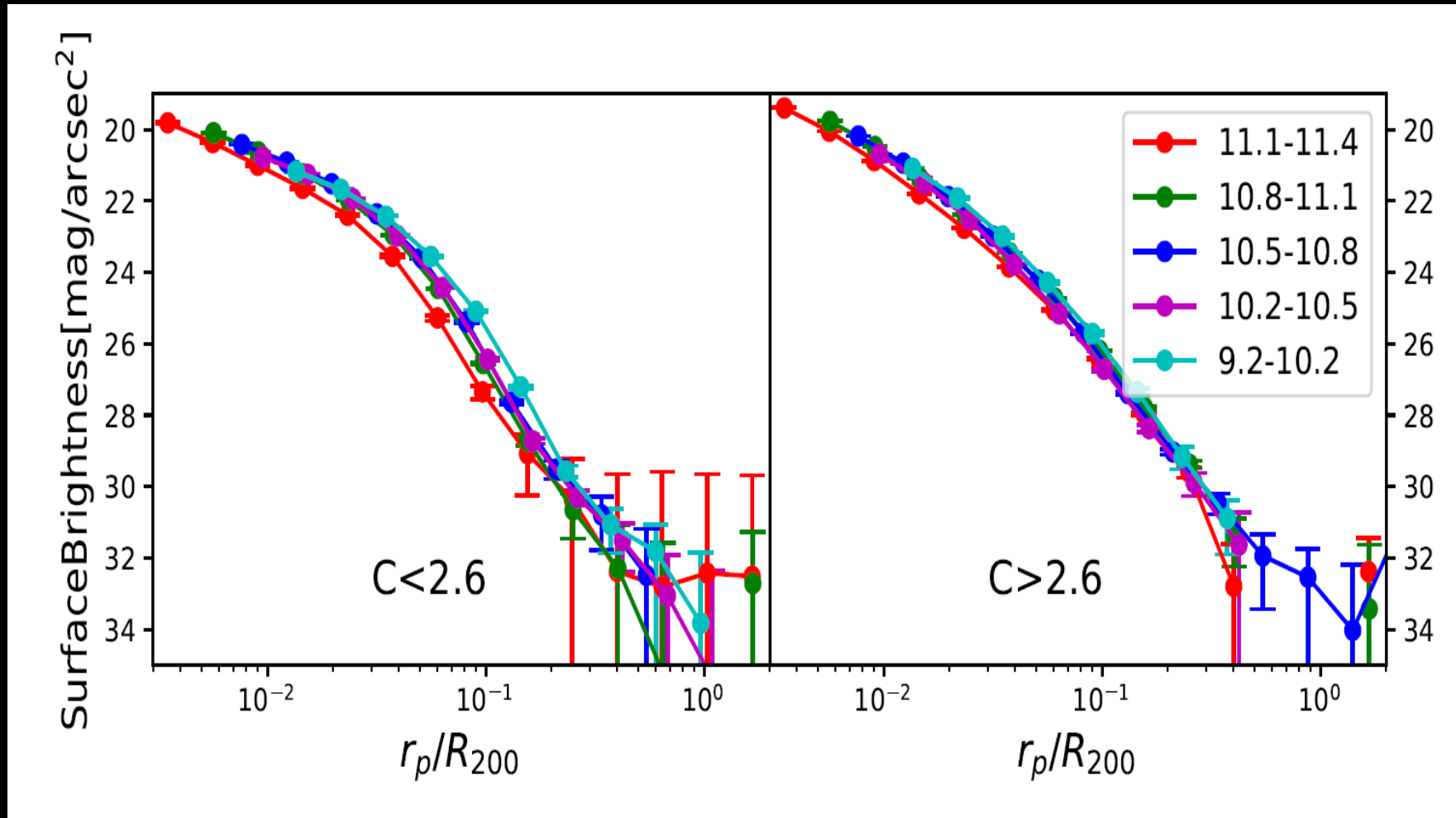
PSF effect

Outer stellar haloes of small and lowC galaxies are more strongly contaminated by PSF scattered light!
We can go down to **30 mag/arcsec^2**, out of which the PSF-free stellar halo contributes **31 mag/arcsec^2 (3-sigma significance)**.

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Universality of the stellar halo

- Profiles are close to universal after scaling r_p by R_200.
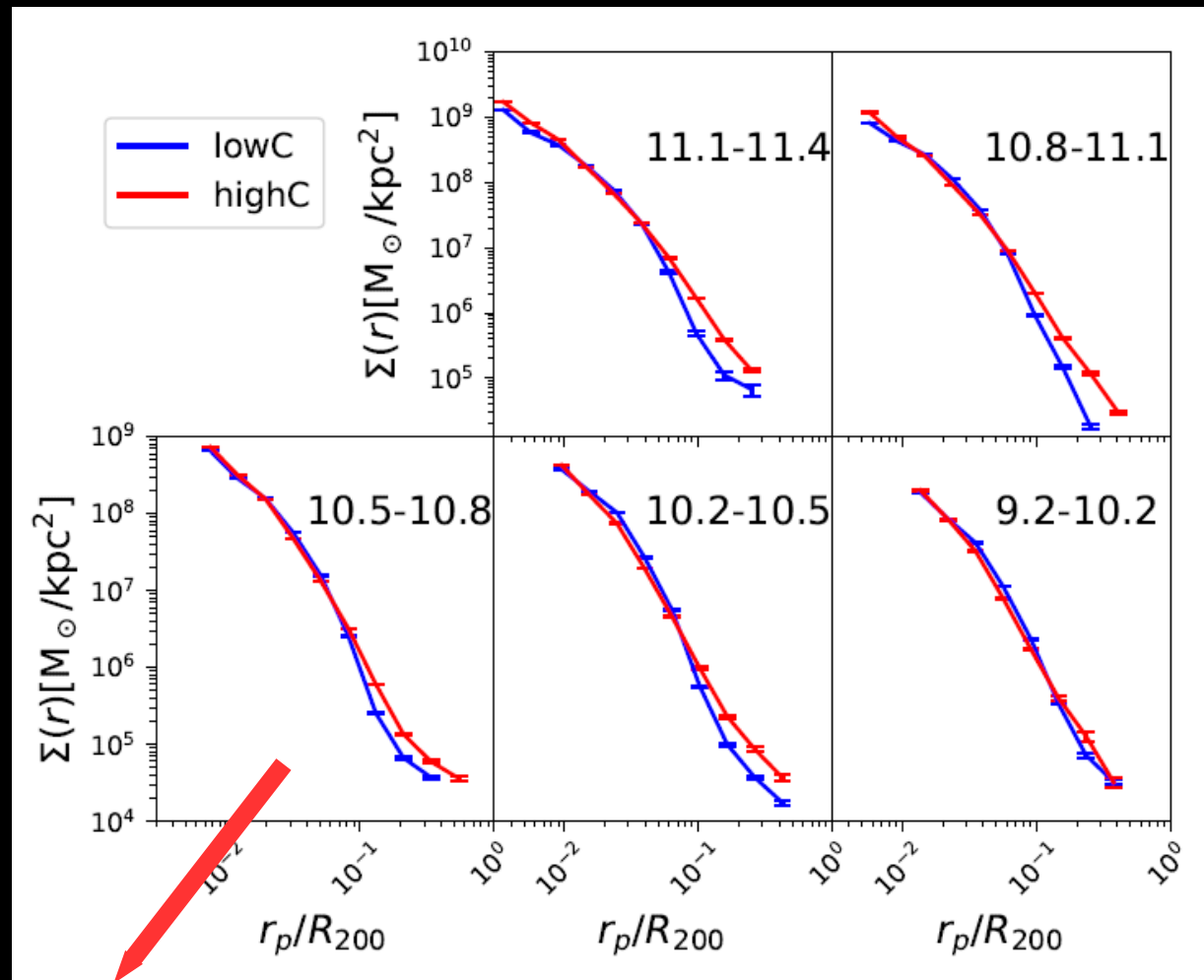
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Universality of the stellar halo
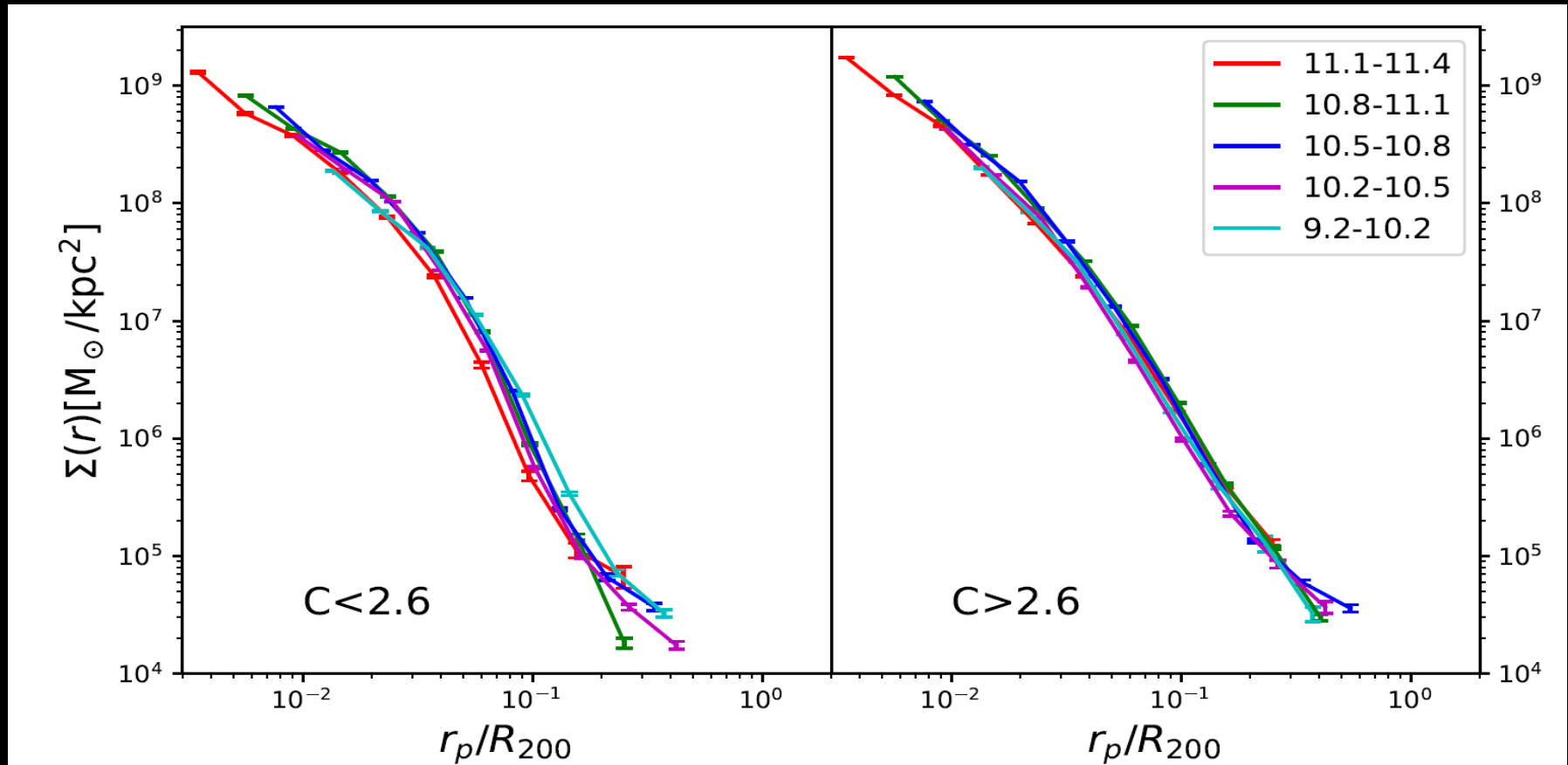
- Universality still holds after PSF-deconvolution.

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Low and high concentration

- PSF-deconvolved

 stellar mass profiles are more extended for highC galaxies

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HighC galaxies have more extended outer stellr haloes.

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Low and high concentration

- PSF-deconvolved stellar mass profiles are more extended for highC galaxies

- In good agreement with predictions by hydro-dynamical simulations (e.g. Pillepich et al. 2014, Rodriguez-Gomez et al. 2016)
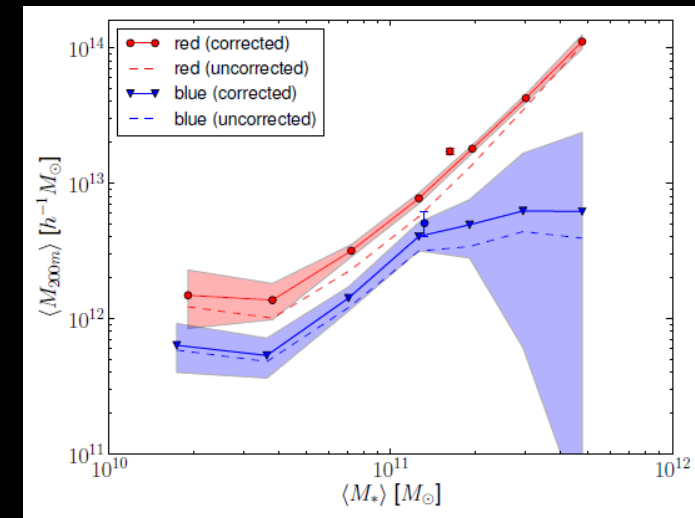

Pillepich et al. (2014)

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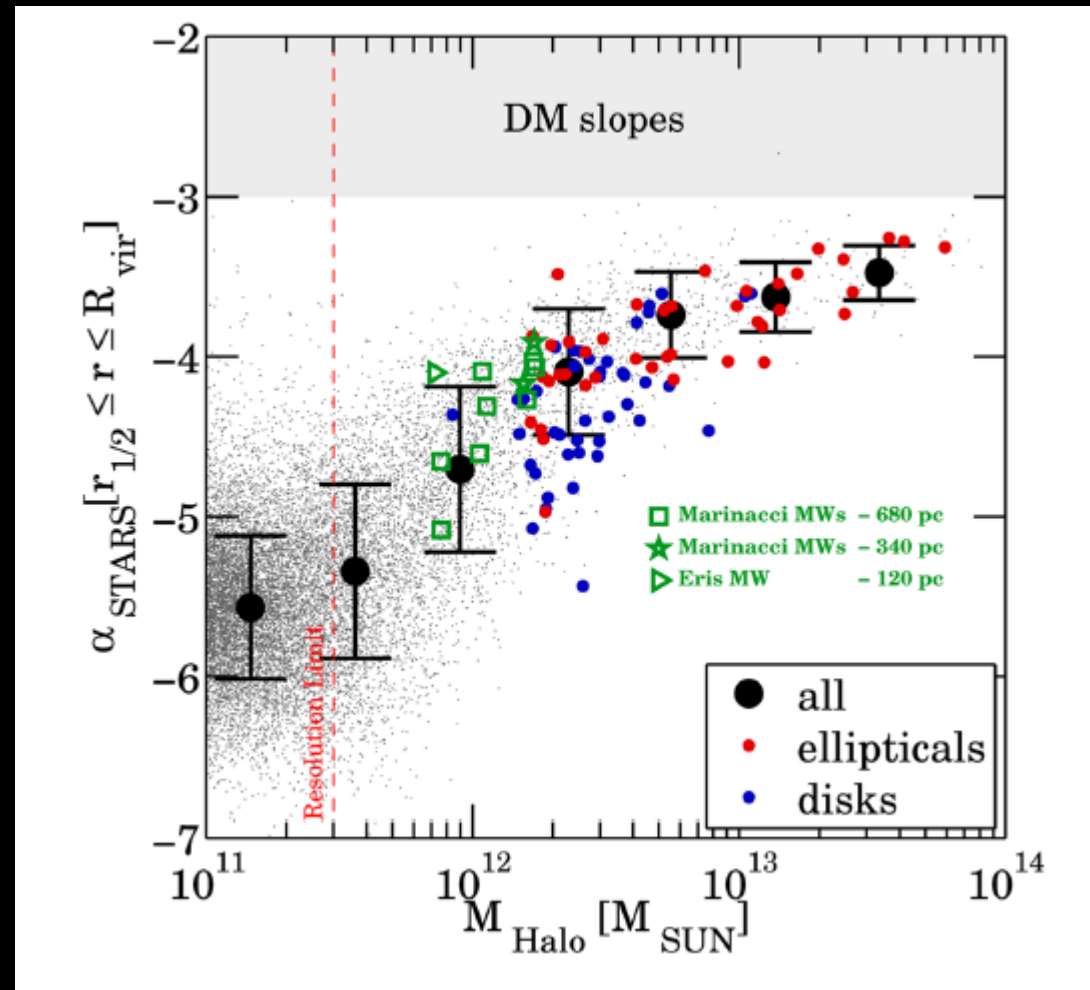
Low and high concentration
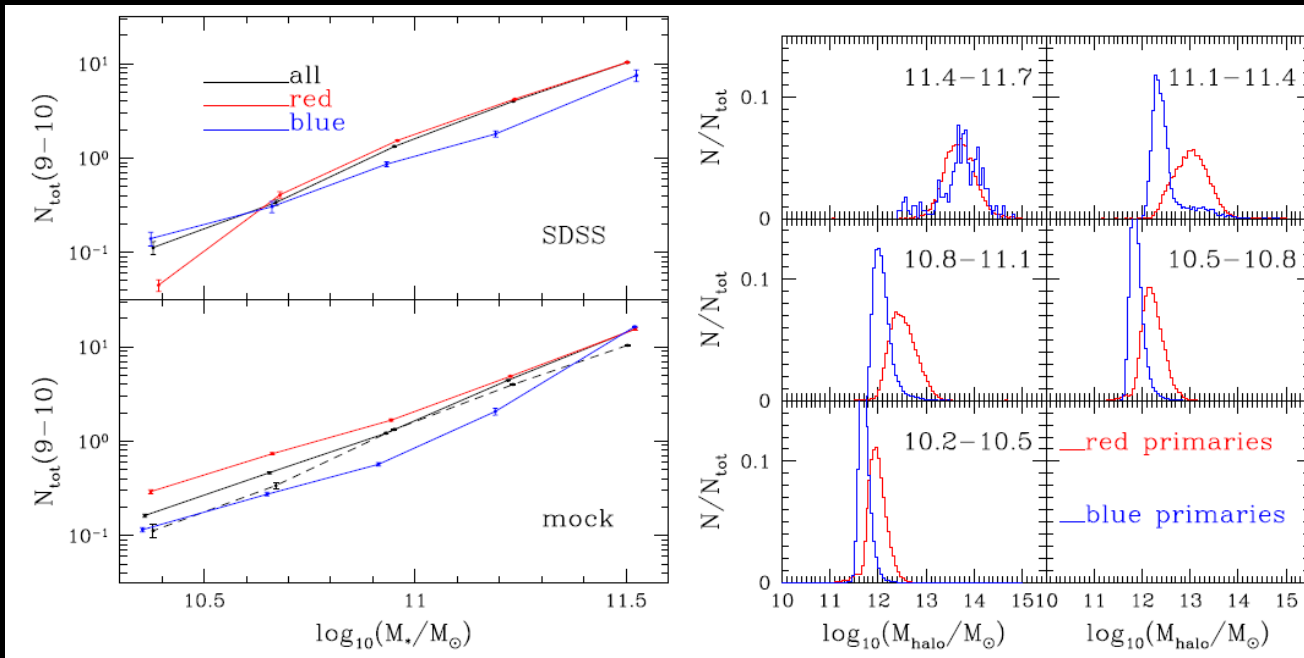
**Wang & White (MNRAS,2012)**
Wang et al. (2014)

Mandelbaum & Wang et al. (2016)

- Red galaxies are quenched early, but their stellar and dark matter halos continue grow in mass through accretion.

- At fixed halo mass, red centrals have smaller stellar mass.

- The difference in halo mass partly explains the small-scale

  Conformity signals (Wang et al. 2012).

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Color profiles

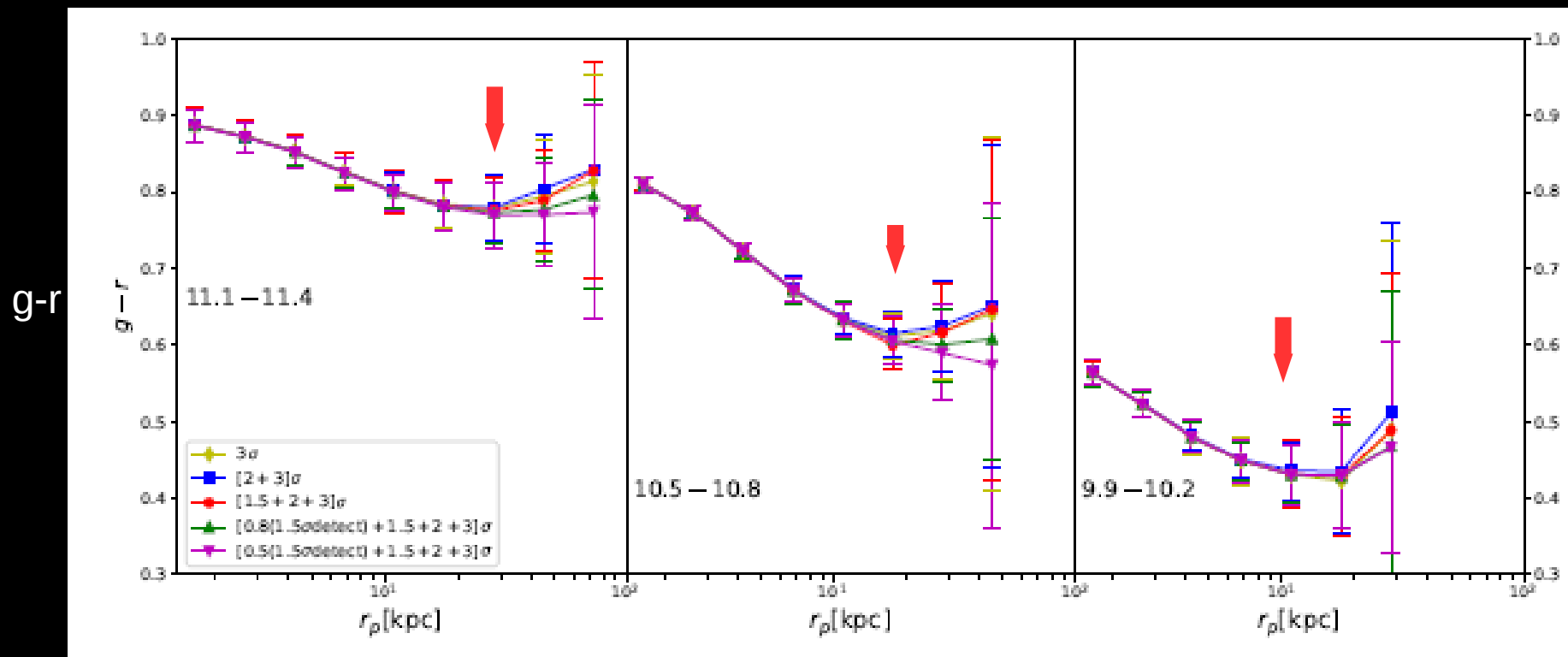Low and high concentration galaxies with 0.05<z<1
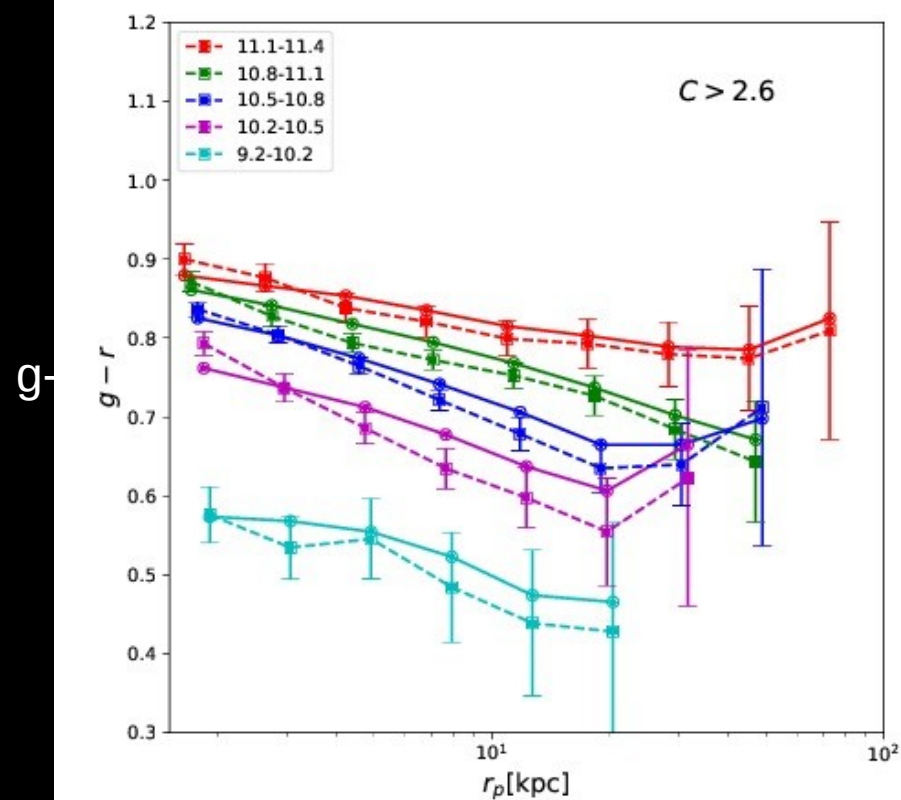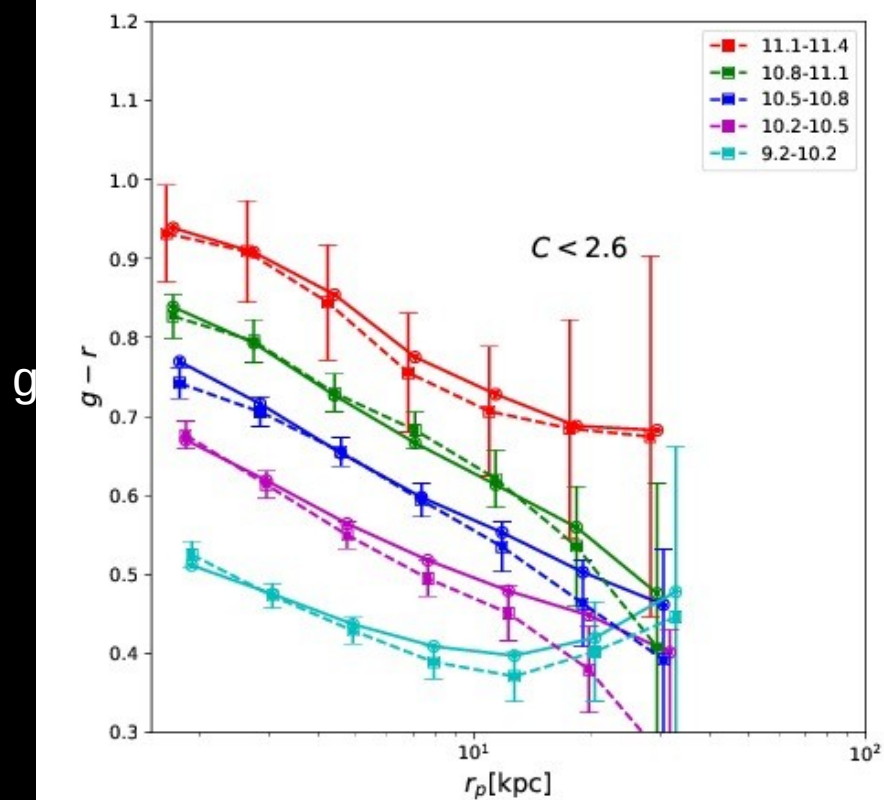
Dashed – PSF-free color profiles

The extended PSF wings slightly flattens the color profiles.
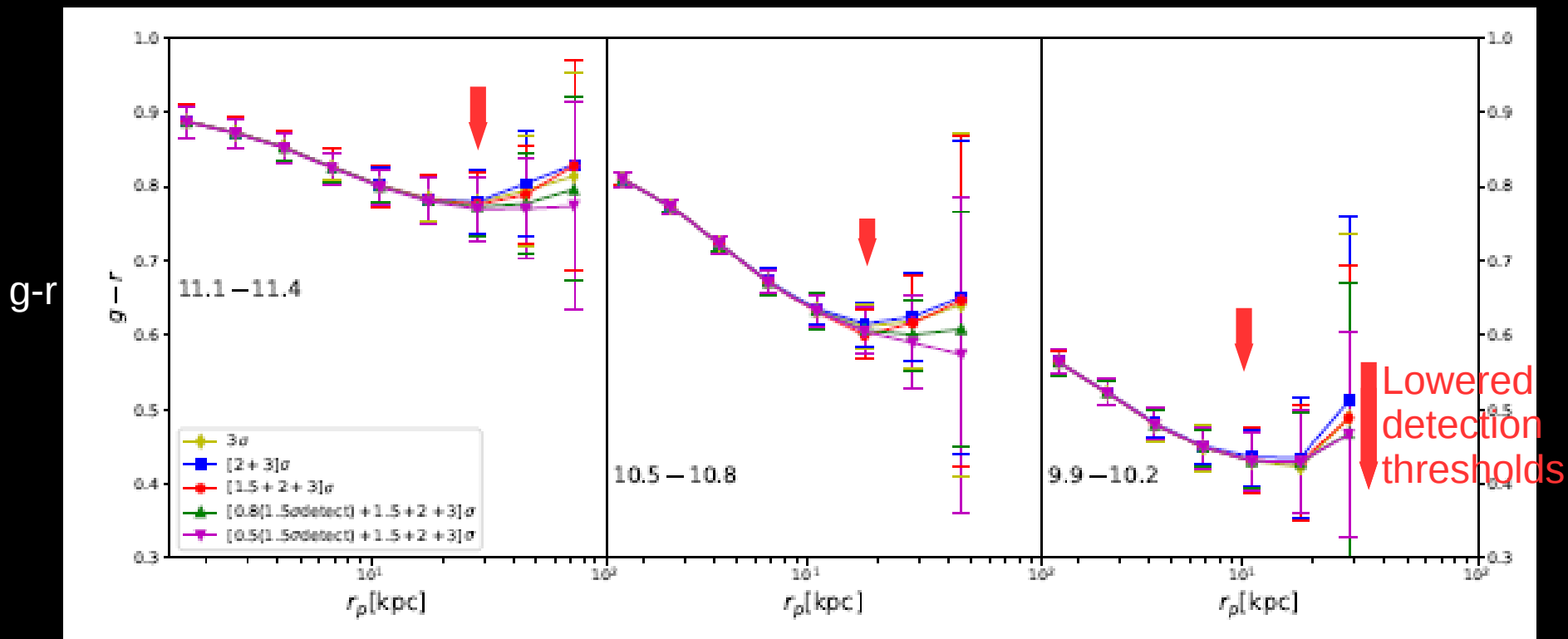
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Systematics in color profiles

Galaxies with 0.05<z<1 - to minimize K-corrections

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Systematics in color profiles

Galaxies with 0.05<z<1 - to minimize K-corrections

- Positive color gradients are sensitive to how satellite galaxies are masked!

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Summary

- The surface brightness profiles centered on isolated central galaxies can be measured down to 30mag/arcsec^2 (**31mag/arcsec^2** for the PSF-free stellar halo with 3-sigma significance).

- Our measurements cover a wide stellar mass range for galaxies (**9.2<logM*/Msun<11.4**).

- Stellar halos are **close to be universal after scaling** the projected radius by the halo virial radius.

- **High concentration galaxies have more extended outer stellar halo profiles**, and have shallower color profiles – related to Galactic conformity. They also have more satellites and are hosted by more massive dark matter haloes.

- The **extended PSF wings** significantly contaminate the outer stellar halo for smaller and late-type galaxies!

Thank you!