CONNECTING THE BRIGHT & DARK SIDES OF MASSIVE GALAXIES

What have we learned from HSC? What can we expect from NGRST?

Song Huang (黄崧), Alexie Leauthaud, Peter Behroozi, Andrew Hearin,
Josh Speagle, Christopher Bradshaw, Felipe Ardila & HSC Collaboration

@dr_guangtou dr-guangtou

2020-10-07 Roman 2020

Image credits: HSC Collaboration

Take Home Messages

HSC

1 Remember the Low Surface Brightness

Stellar halo, Tidal feature & LSB dwarfs

See posters by Alejandro Borlaff & Mireia Montes;
Also the talk by Yuan-Yuan Zhang on Fri.

2 Don't Forget the Dark Side

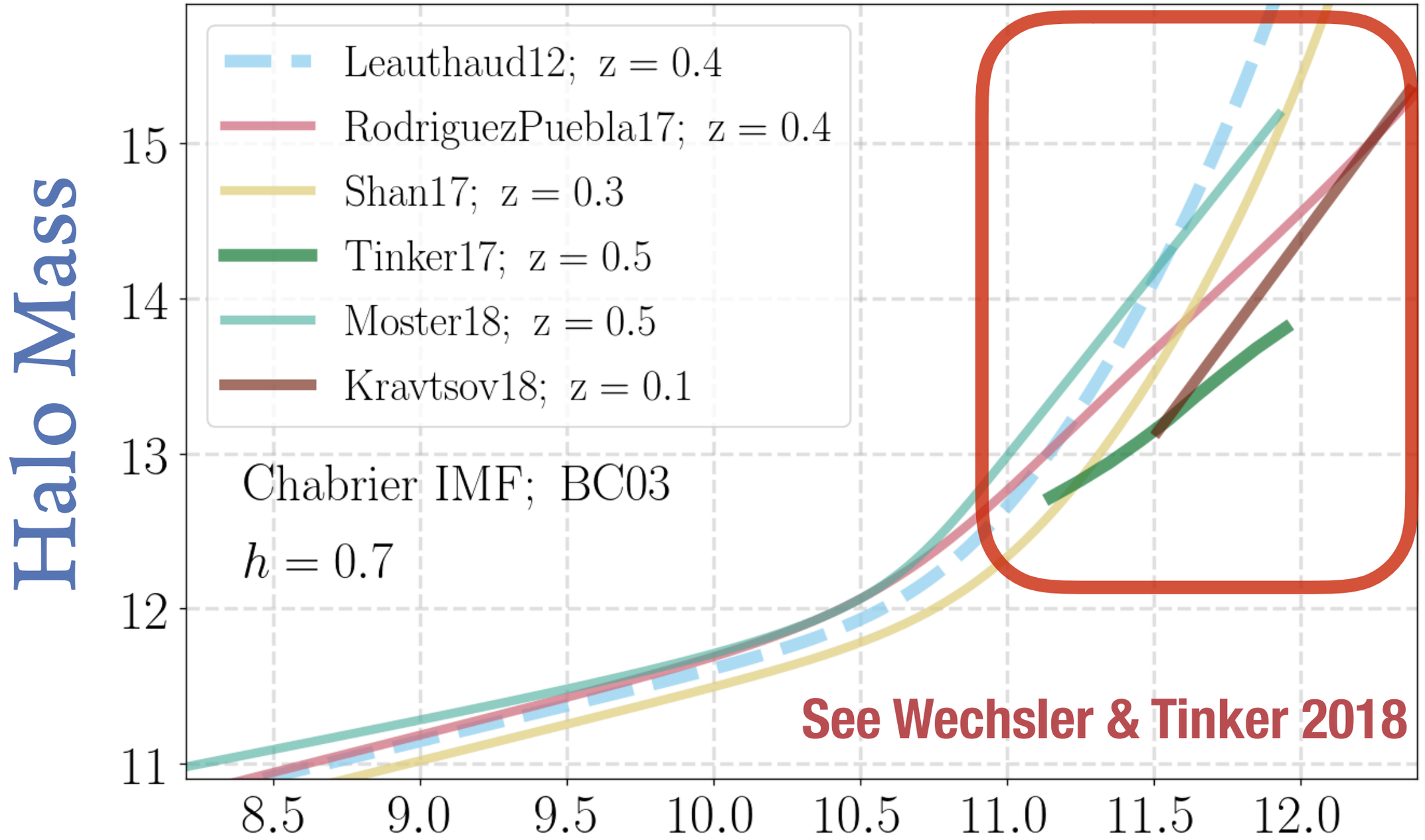
Weak Lensing is a Unique Strength of NGRST

See talks by Risa Wechsler on Thu & Tommaso True on Fri;
Also the posters by Stephanie O'Neil & Lorenzo Zanisi

A New Era for Galaxy-Halo Connection

HSC

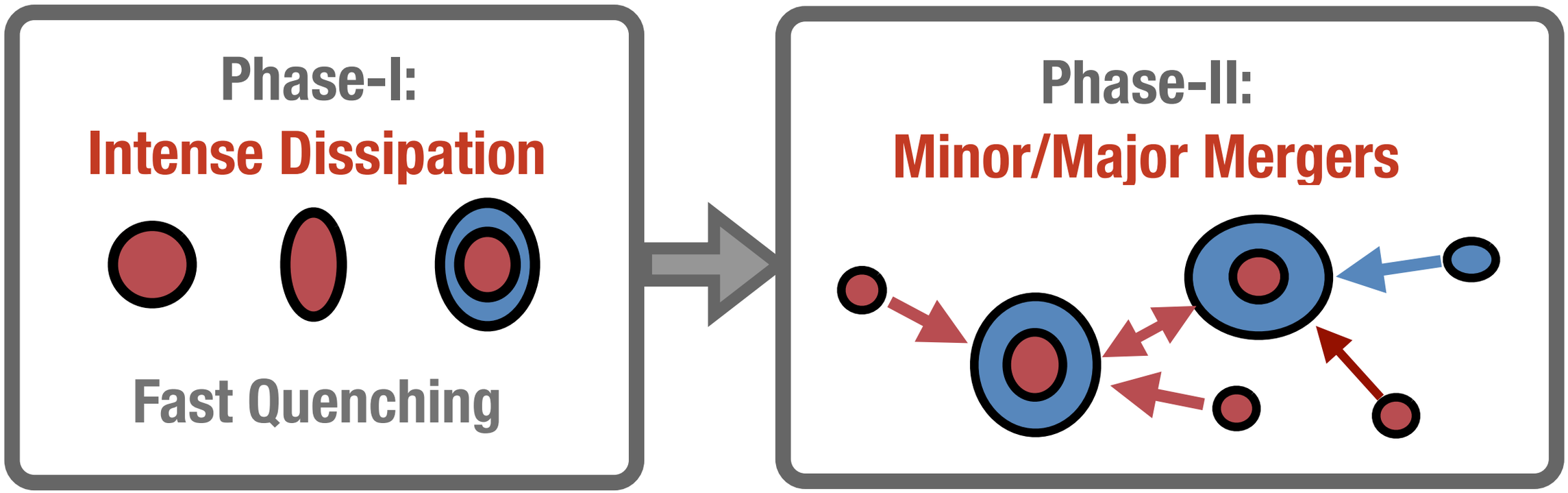
- Massive galaxies trace the most massive dark matter halos, or clusters.
- At high-mass end of SHMR, we need better constraints of both **stellar and halo mass**!



The list is not complete

Why Stellar Halo? Why Massive Galaxy?

HSC



Huang+2013a,b, 2016

- Massive galaxies have very extended stellar mass distribution
  - Very hard to observe and model
  - We have to reach to large radii to measure “true” stellar mass
- Outskirts of massive galaxies are dominated by “ex-situ” stars
  - Keeps crucial fossil records of the assembly history
  - Outer stellar halo may have a closer connection to DM halo

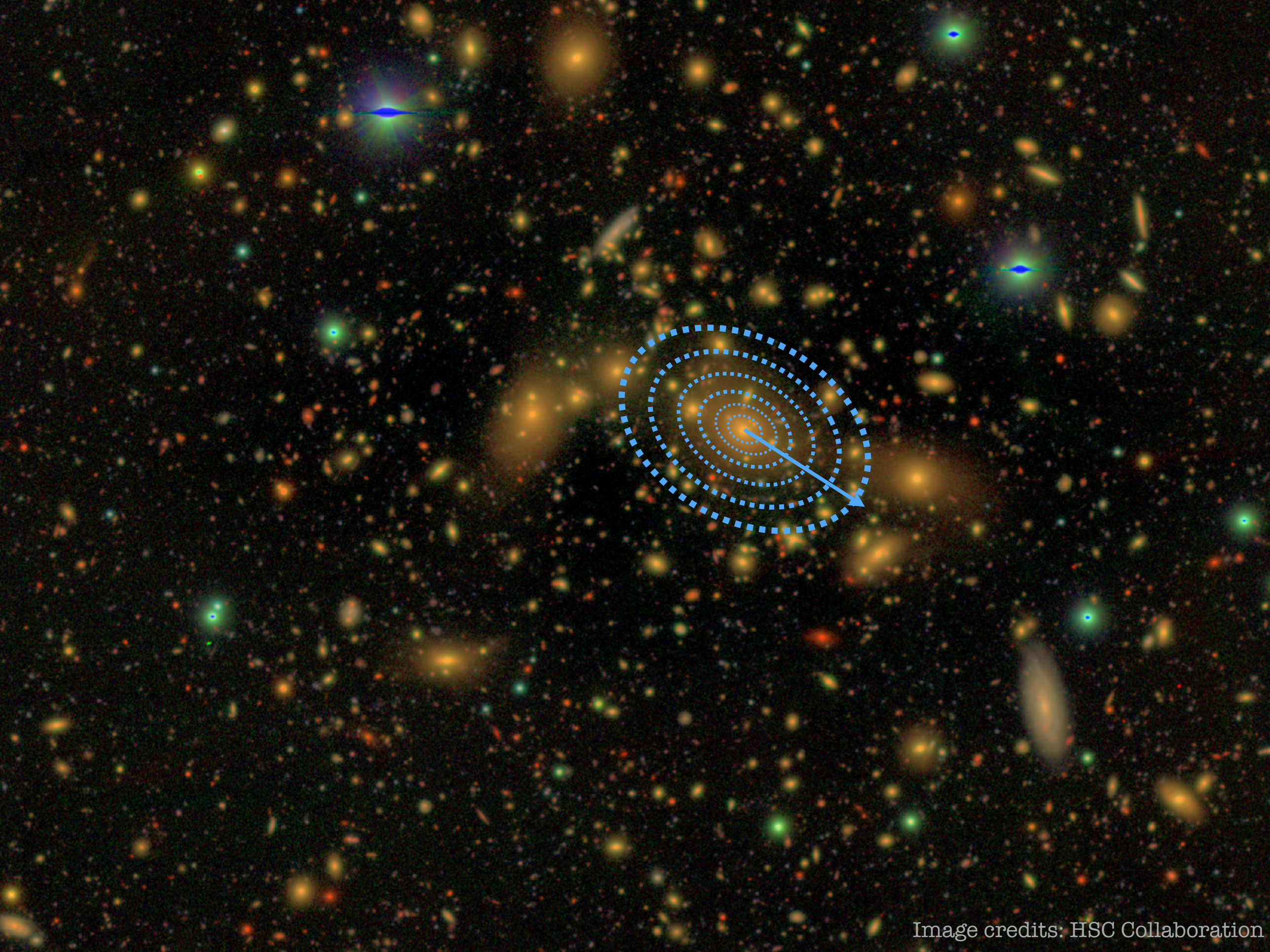
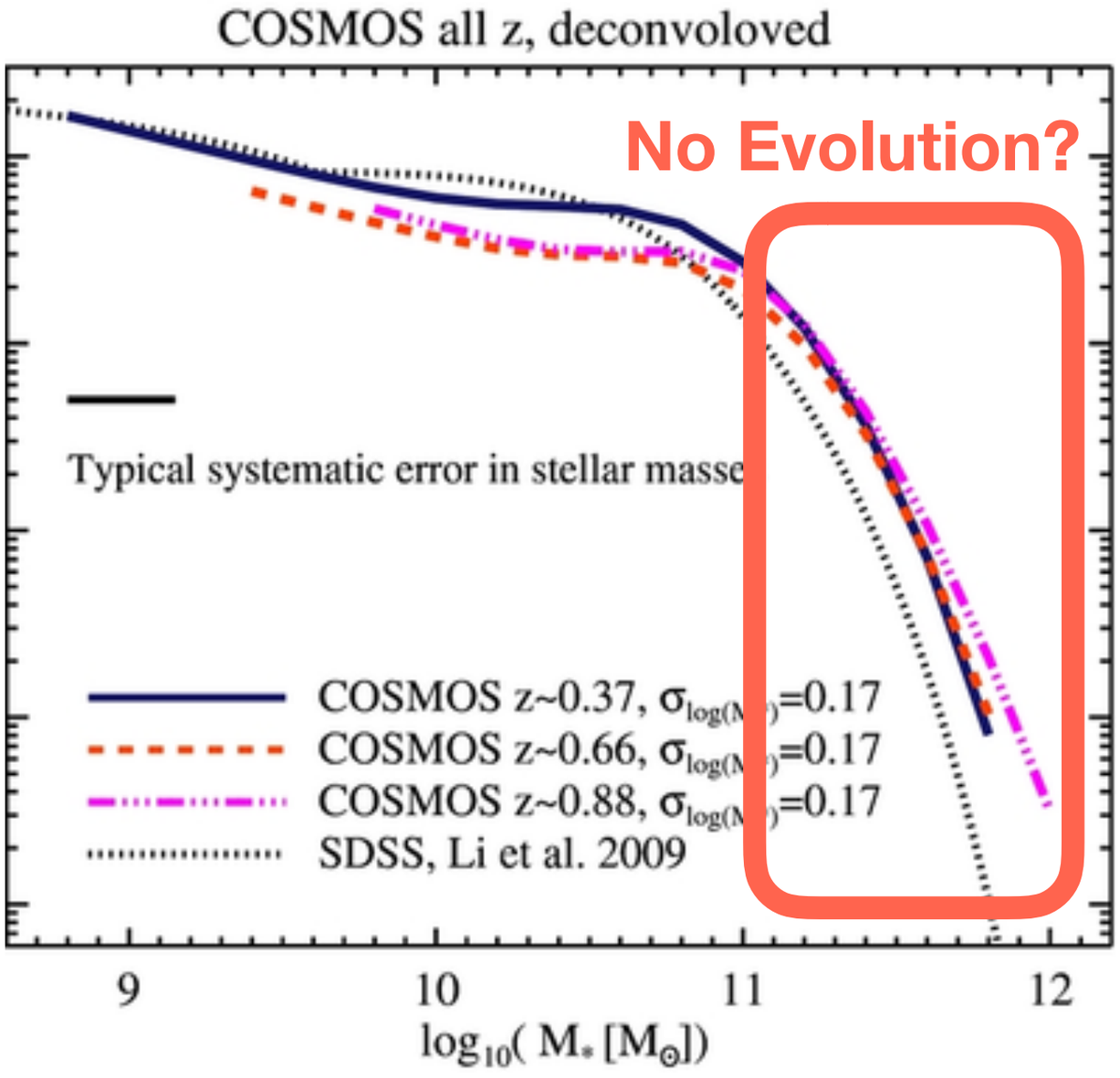


Image credits: HSC Collaboration

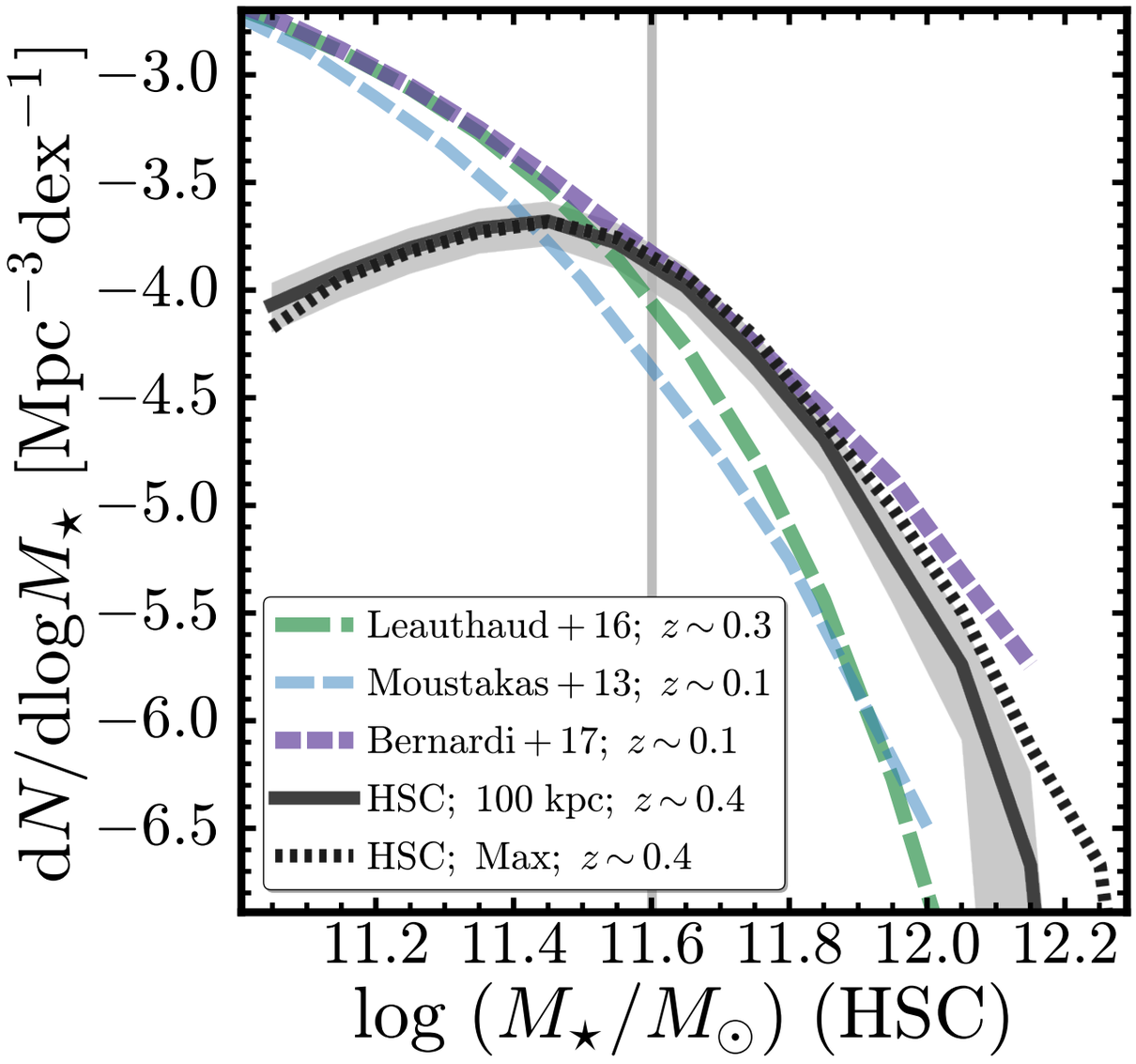
Evolution of the Stellar Mass Function at High-Mass End

HSC

- The lack of evolution of SMF at high-mass end is puzzling!
- The measurements out to larger aperture can help!



Behroozi+2011; Also see Bundy+2017

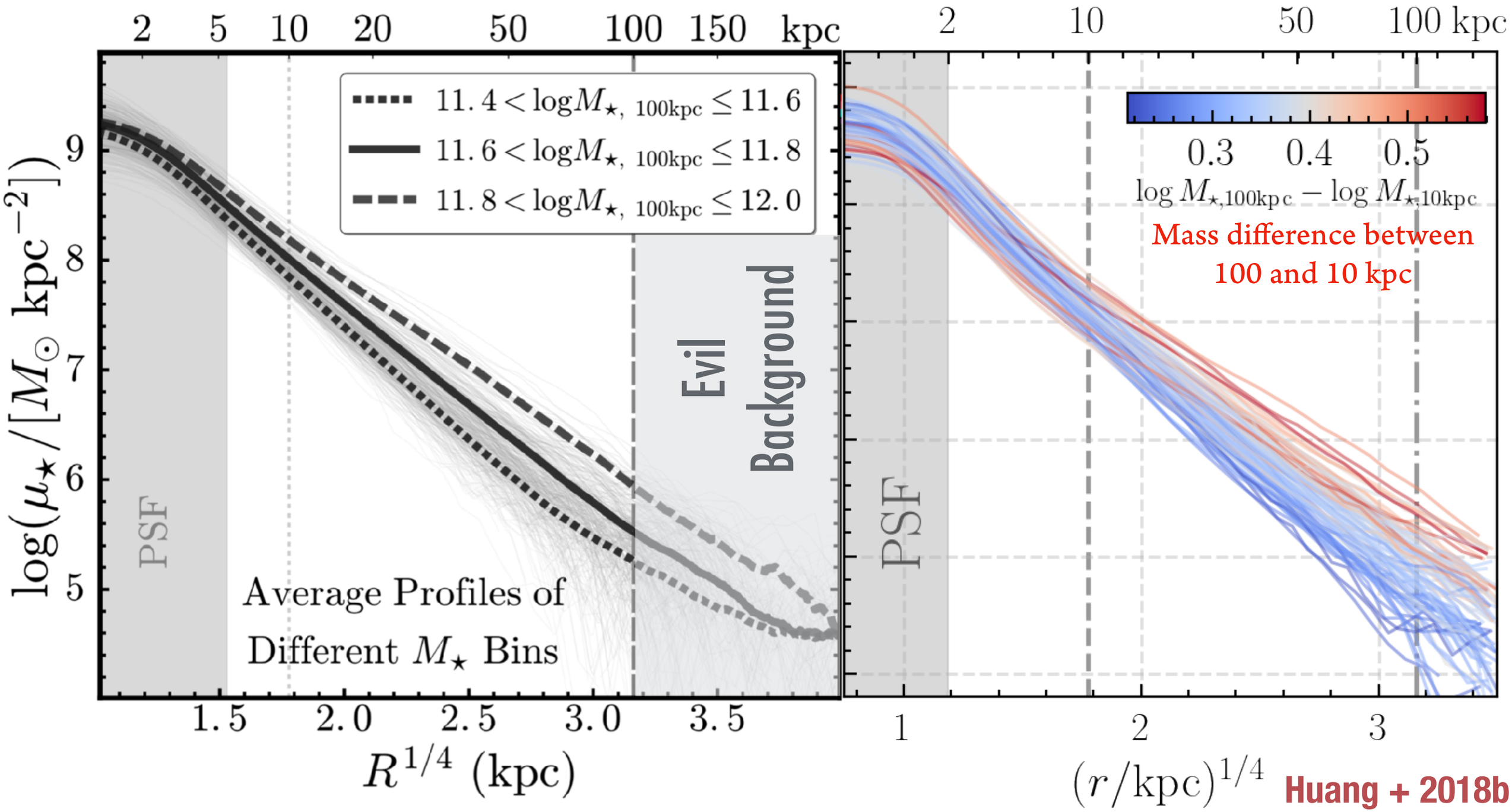


Huang et al. 2018

Large Diversity in the Stellar Halos of Massive Galaxies

HSC

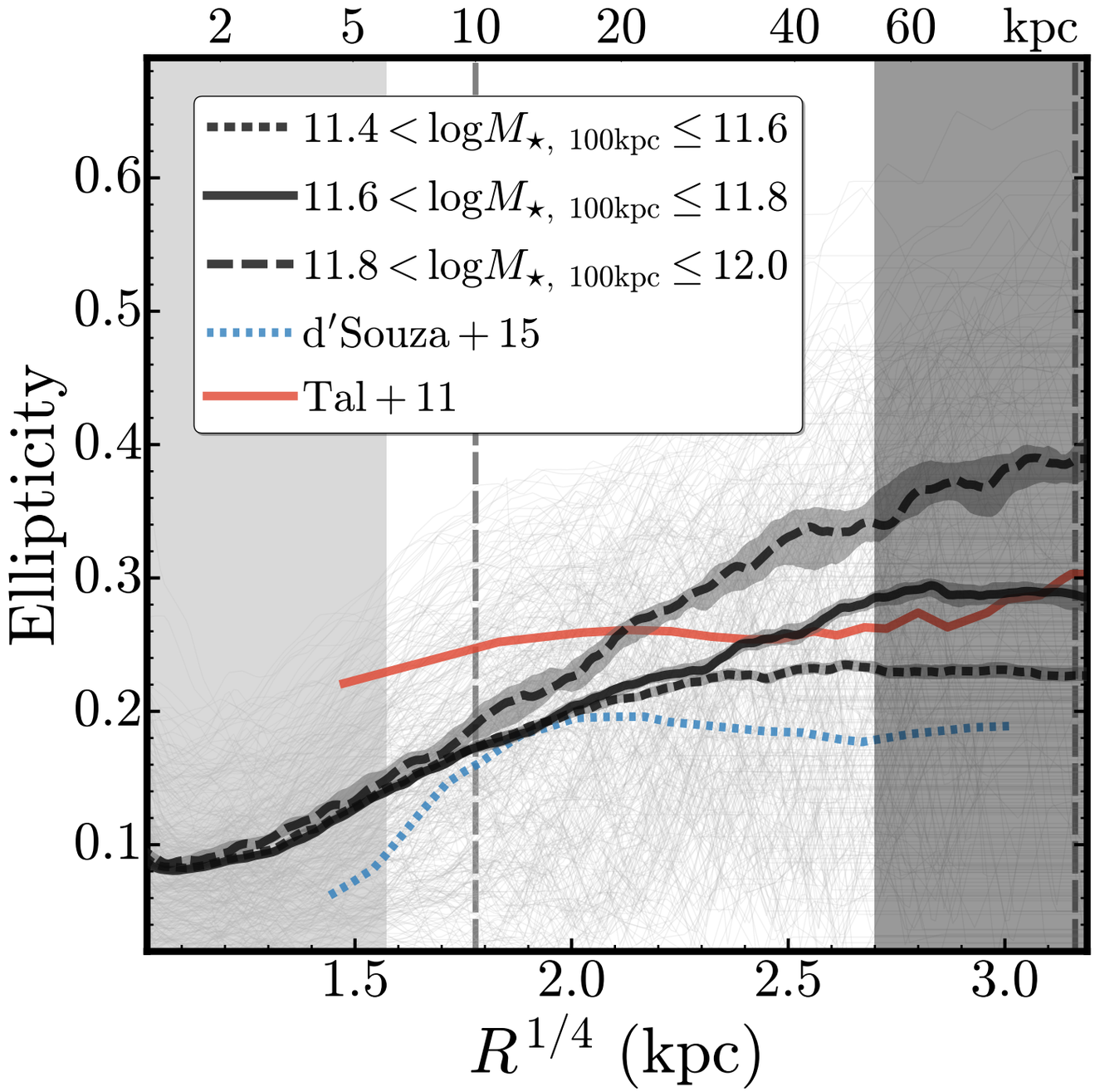
- At similar "total" stellar mass, there is a large **intrinsic** scatter of outer profile.
- No clear separation of "**normal**" and '**cD**" galaxies.
- Likely due to the difference in **mass assembly history** (merger history).

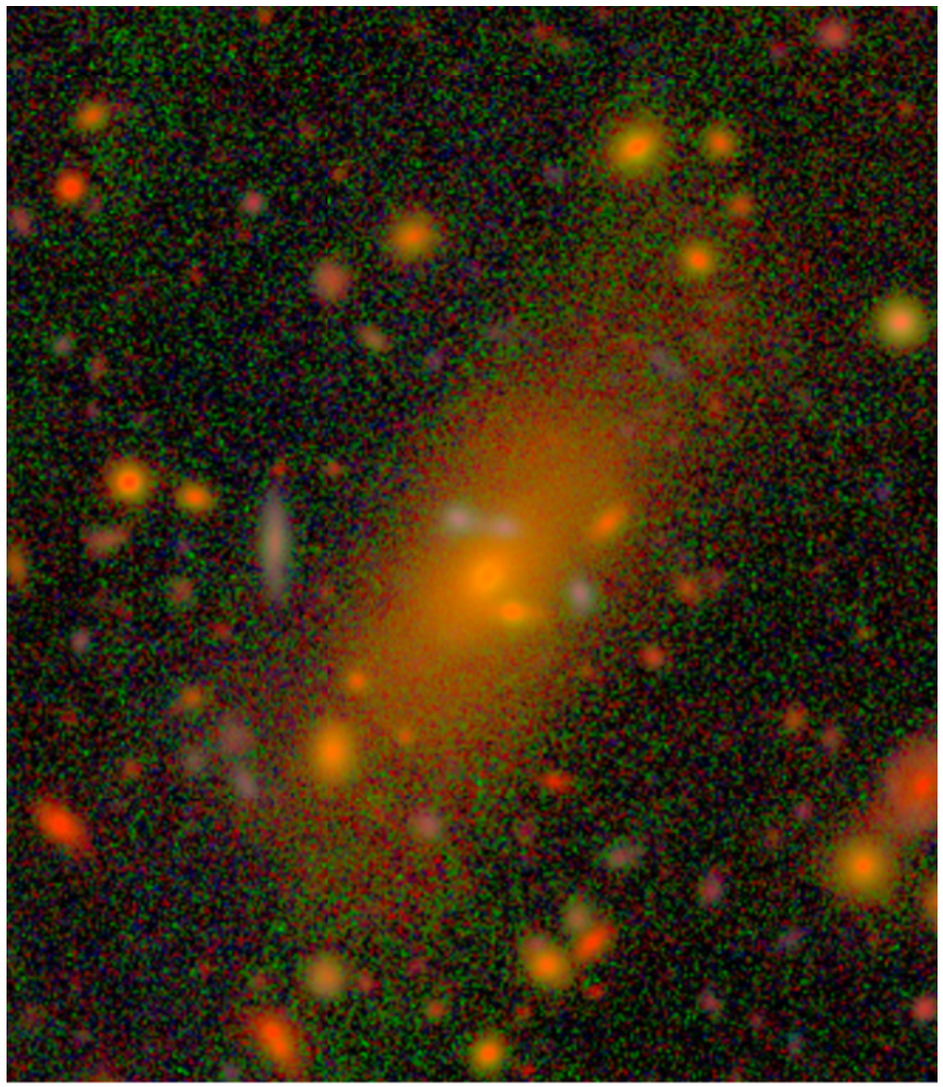


Huang + 2018b

The Shape of Stellar Halo also Depends on Stellar Mass

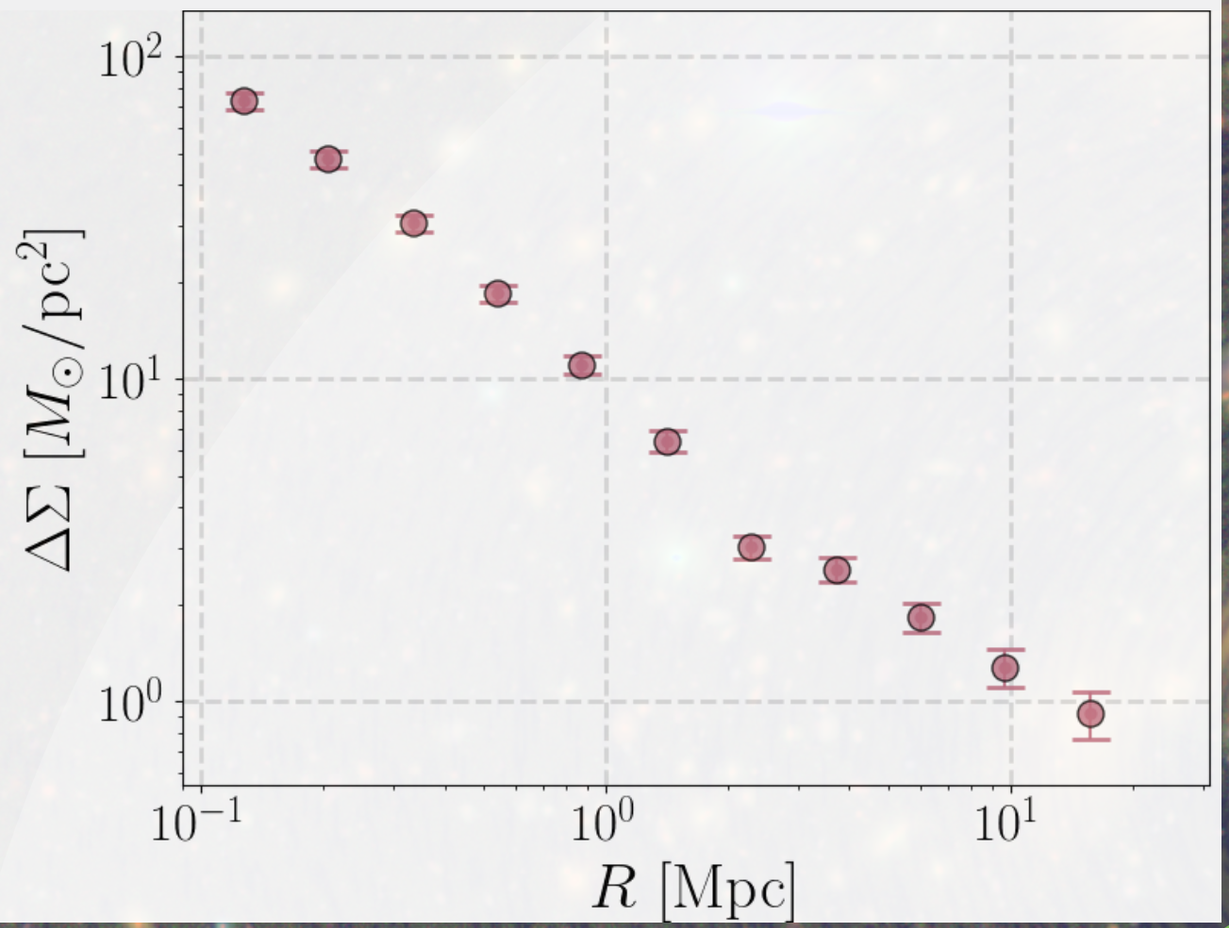
- Massive galaxies are, on average, **more elliptical in the outskirt**
- More massive galaxies tend to have more elliptical outer halo
- May help us study the **intrinsic shape of halo**, and halo assembly history
- Such subtle trend is easily washed out in stacking analysis





Huang + 2018b

$$\Delta\Sigma(r) \equiv \overline{\Sigma}(< r) - \overline{\Sigma}(r) = \Sigma_{\rm crit} \times \gamma_t(r)$$



~1 Mpc

Stellar Mass Distribution - Halo Mass Connection

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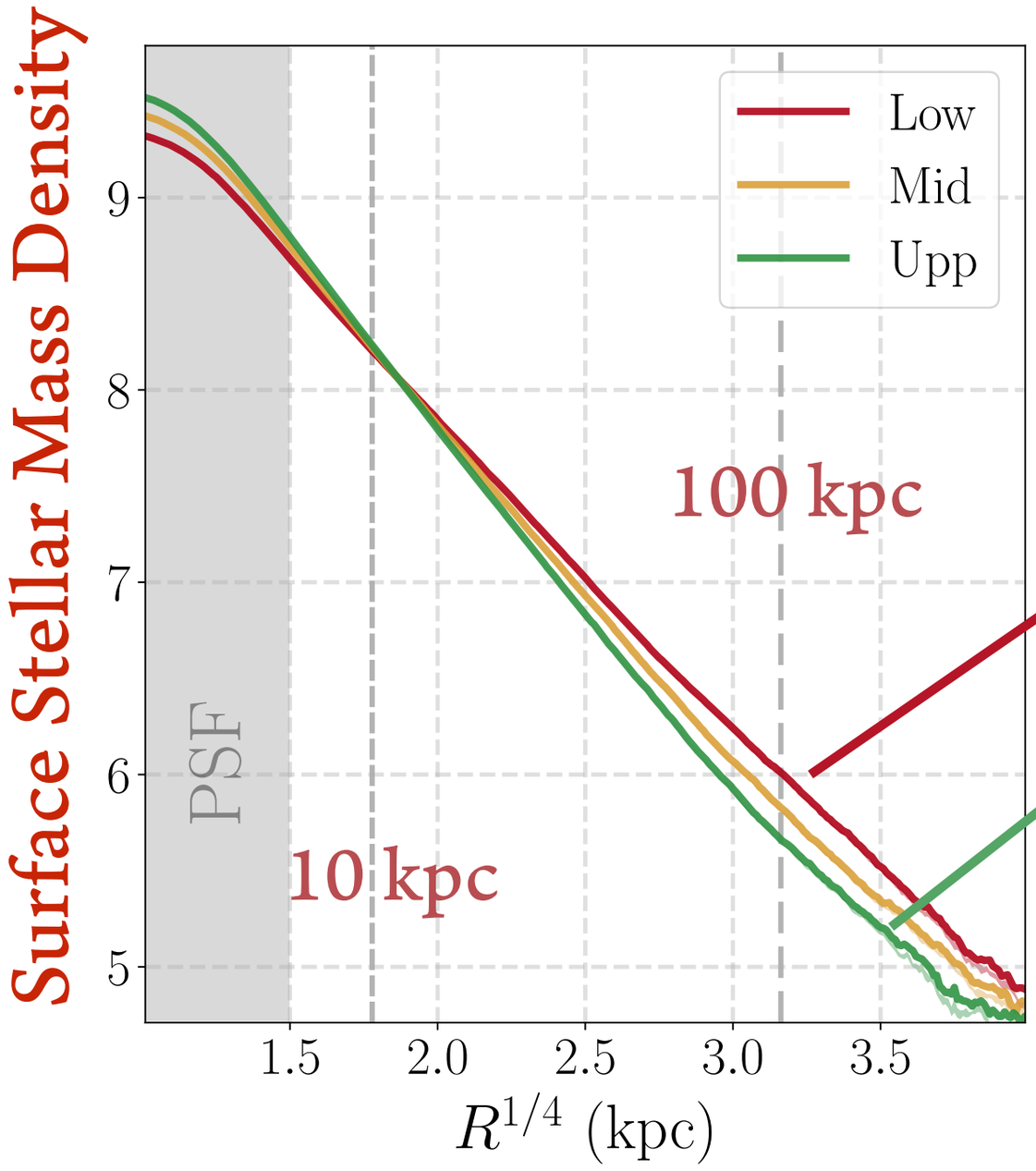
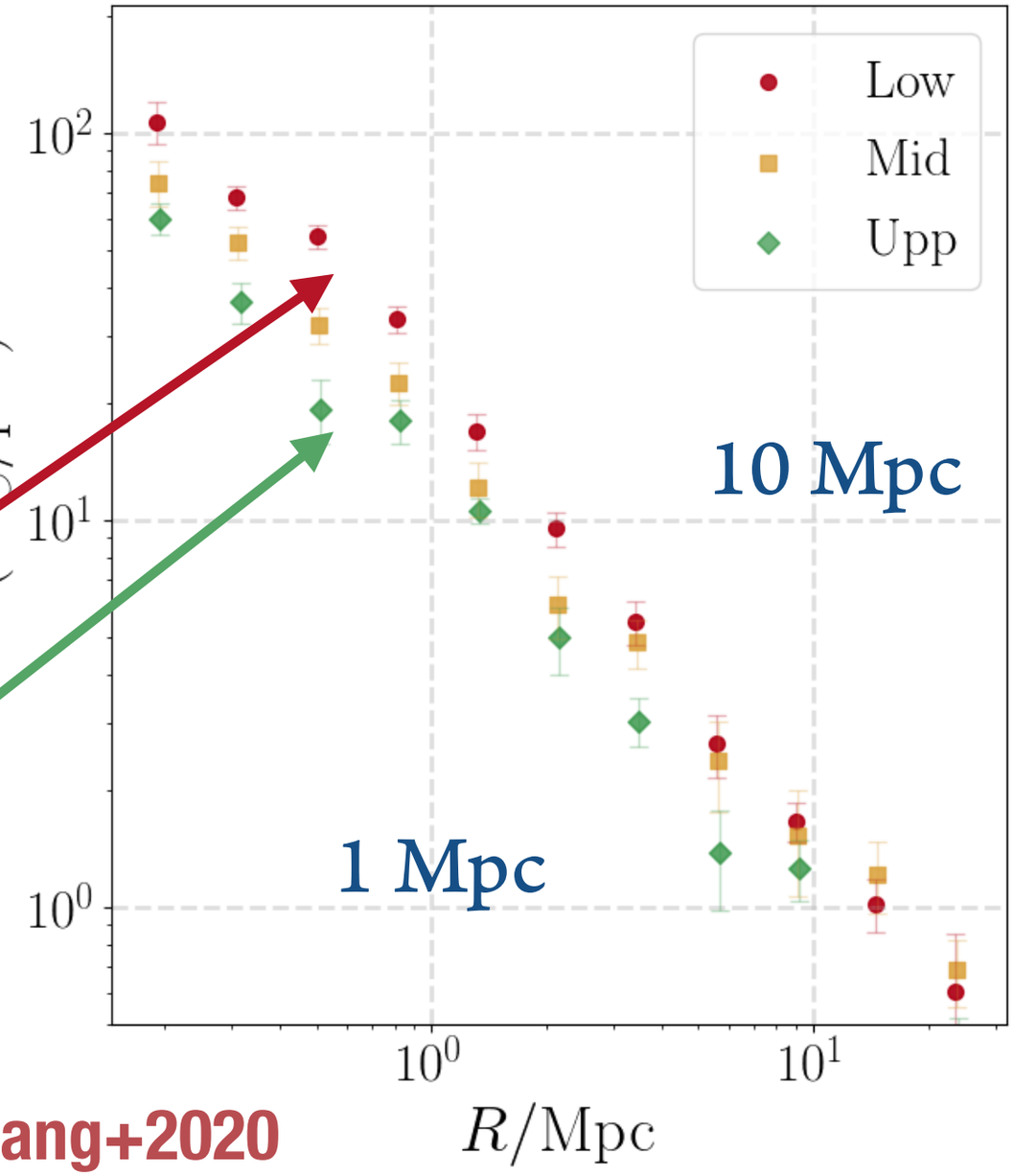
- At similar "total" mass, massive galaxies with different outer profile live in dark matter halos with different halo mass.
- Massive galaxy with more prominent outer halo **lives in more massive halos**, thanks to HSC lensing capability.



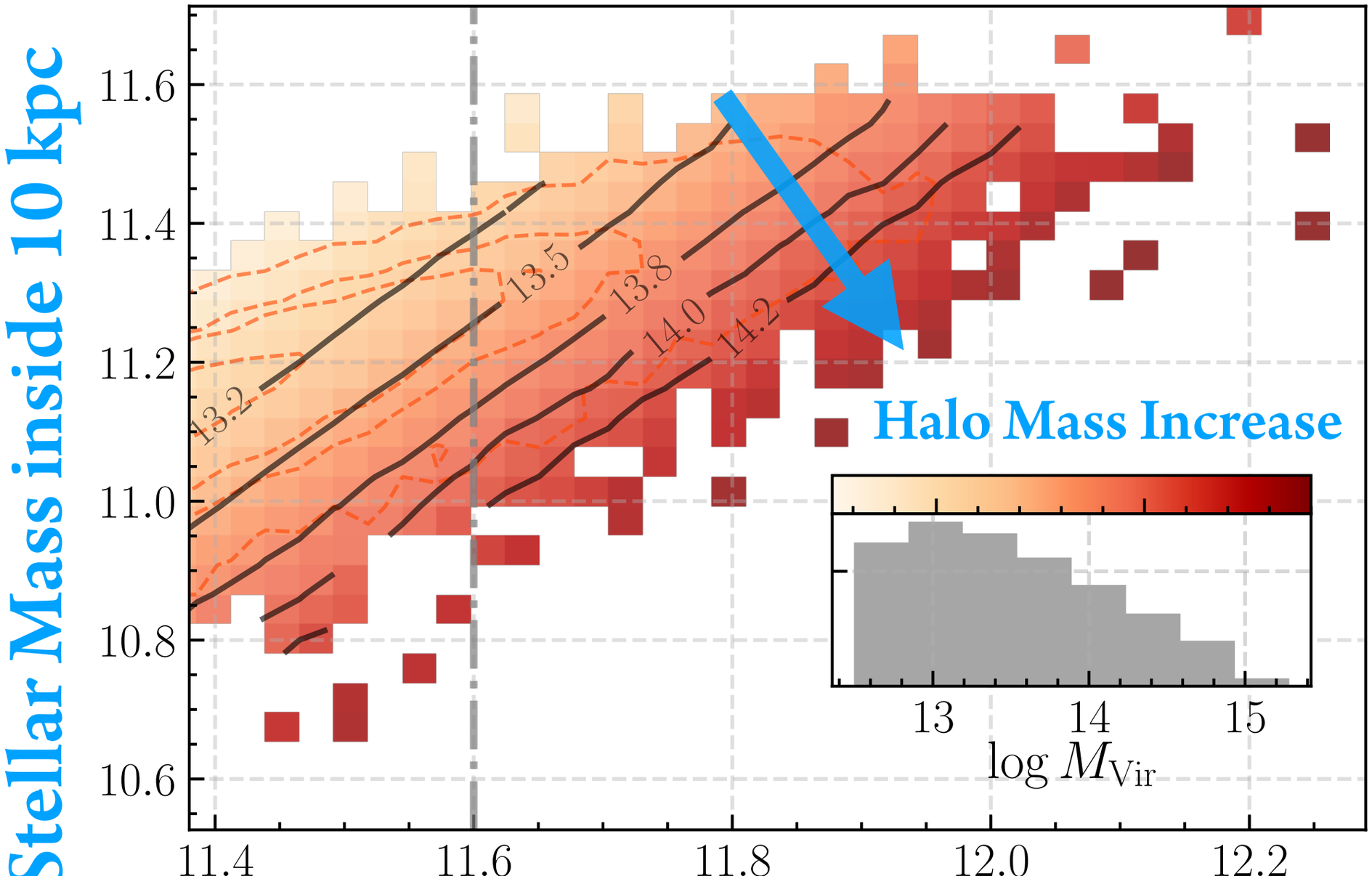


Huang+2020

Galaxy-Galaxy Lensing in the Era of HSC

HSC

- We extended the SHMR to connection halo mass with two aperture stellar mass as an empirical description of the relation between stellar mass distribution and halo mass.
- Still limited by sample size and S/N or lensing signals.



Black-solid lines: halo mass trend

Huang+2020

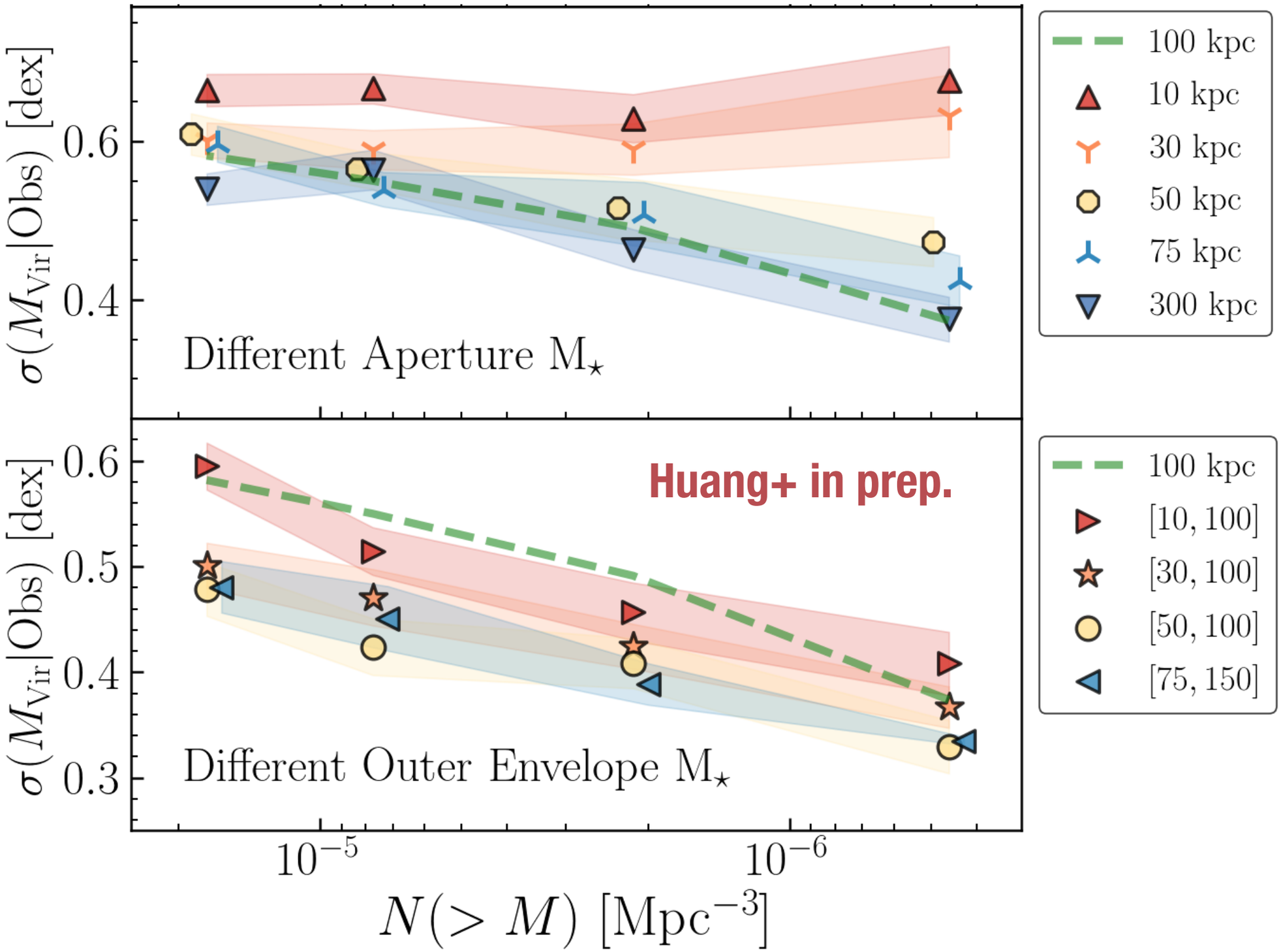
Comparisons of Different Halo Mass Proxies

HSC

- The inner 30 kpc of these galaxies really don't care about their halos

Lower Halo Mass → **Higher Halo Mass**

Worse → **Better**



What to Expect from NGRST

HSC

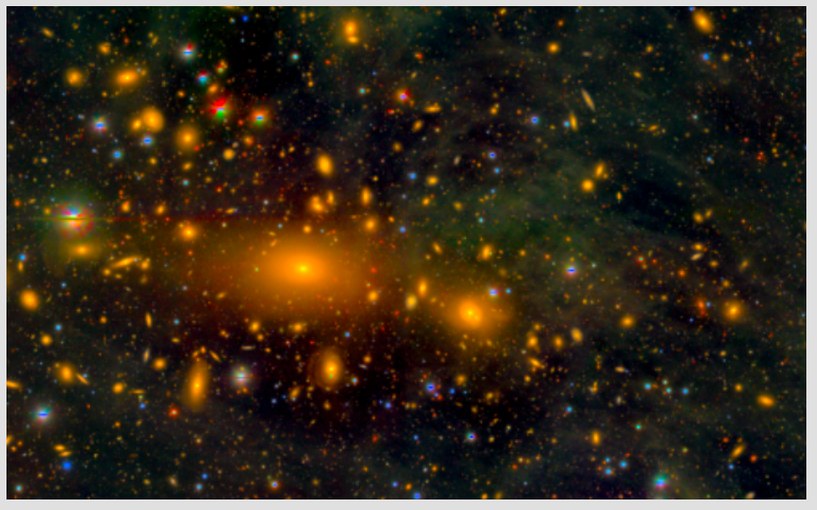
Incredible g-g lensing capability

Higher density of source galaxies;
Higher mean source redshift;
More accurate shear measurements

Survey	N source per arcmin^2	Mean redshift of sources $\langle z_s \rangle$
COSMOS	39	1.2
HSC Wide	18.5	0.81
LSST Wide	30	1.2
Euclid Wide	30	0.9
WFIRST HLS	45	1.1

Near Infrared Imaging

Better tracer of stellar mass;
Suffer less from the Galactic Cirrus;
Help us extend to higher redshift



Better Redshift

Grism-z; Photo-z with LSST data;
Separate central and satellites;
Better deal with projection effect

Higher Resolution

Making deblending easier;
Push the study to higher-z;
Probe central profile at low-z

Why Stellar Halo? Why Massive Galaxy?

HSC

1 GALAXY FORMATION

Huang+2018a, b

Mass assembly history; Better SMF for model calibration

2 GALAXY-HALO CONNECTION

Huang+2020
Huang+in prep

Improve SHMR; Extend beyond simple SHMR

3 COSMOLOGY

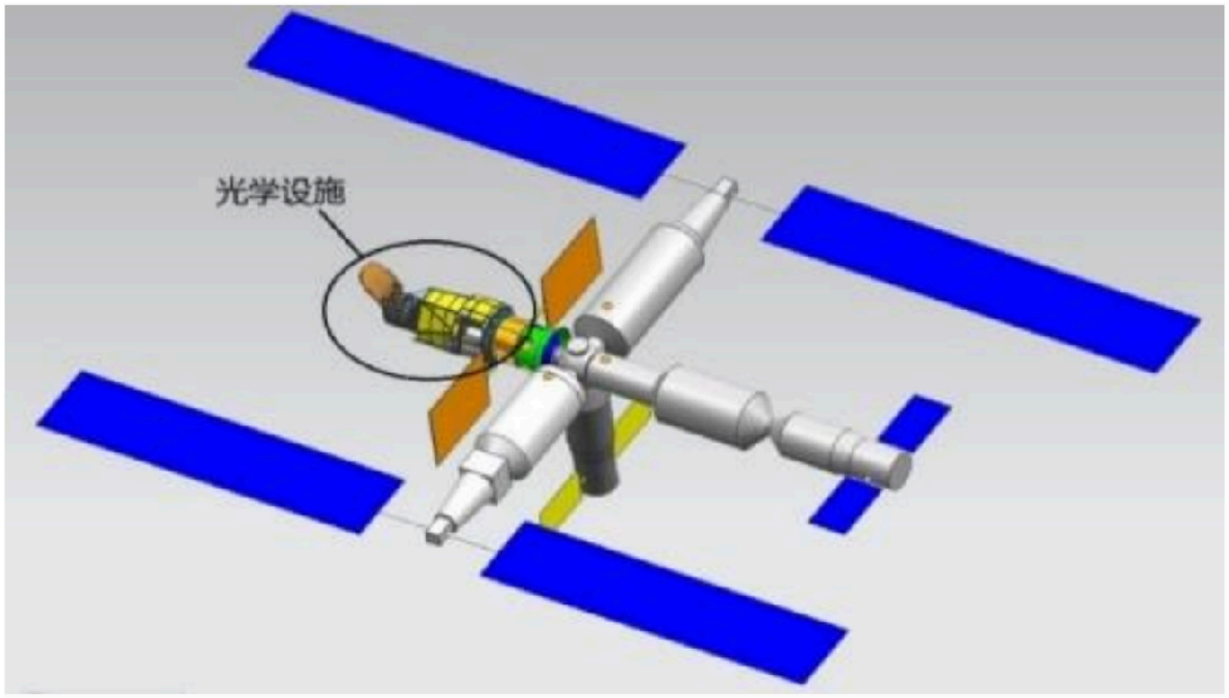
Bradshaw+ in prep;
Huang+in prep

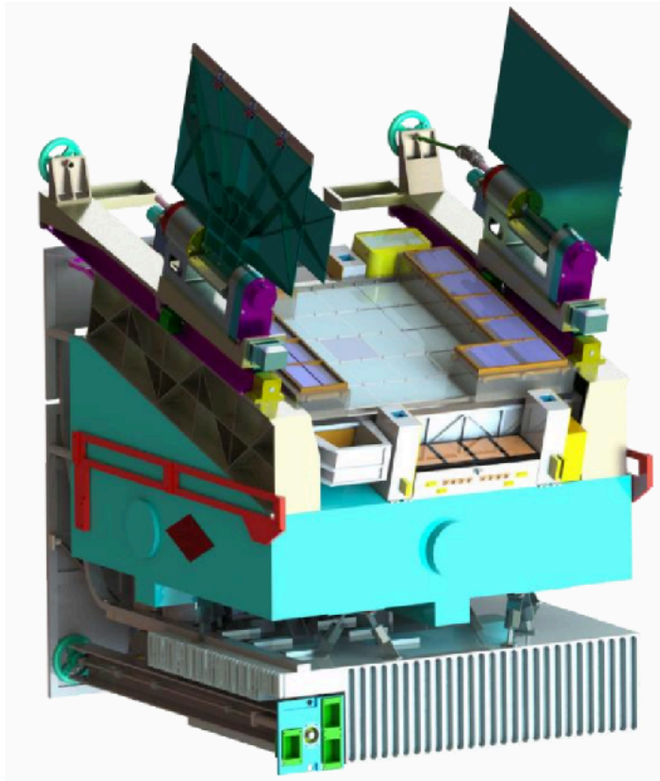
Help identify massive halos (galaxy clusters)

Thank You Very Much !

HSC

Chinese Space Station Telescope (CSST or Xun-Tian 巡天)





- Launch Date: 2025?
- 2-m Telescope; Off-axis design
- NUV-Optical 5 (or 6)-band survey of ~10000 square degree; 0.15” PSF
- With Grism spectroscopy

Image credits: Hu Zhan/NAOC