The size-mass relation of galaxies

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Shany Danieli
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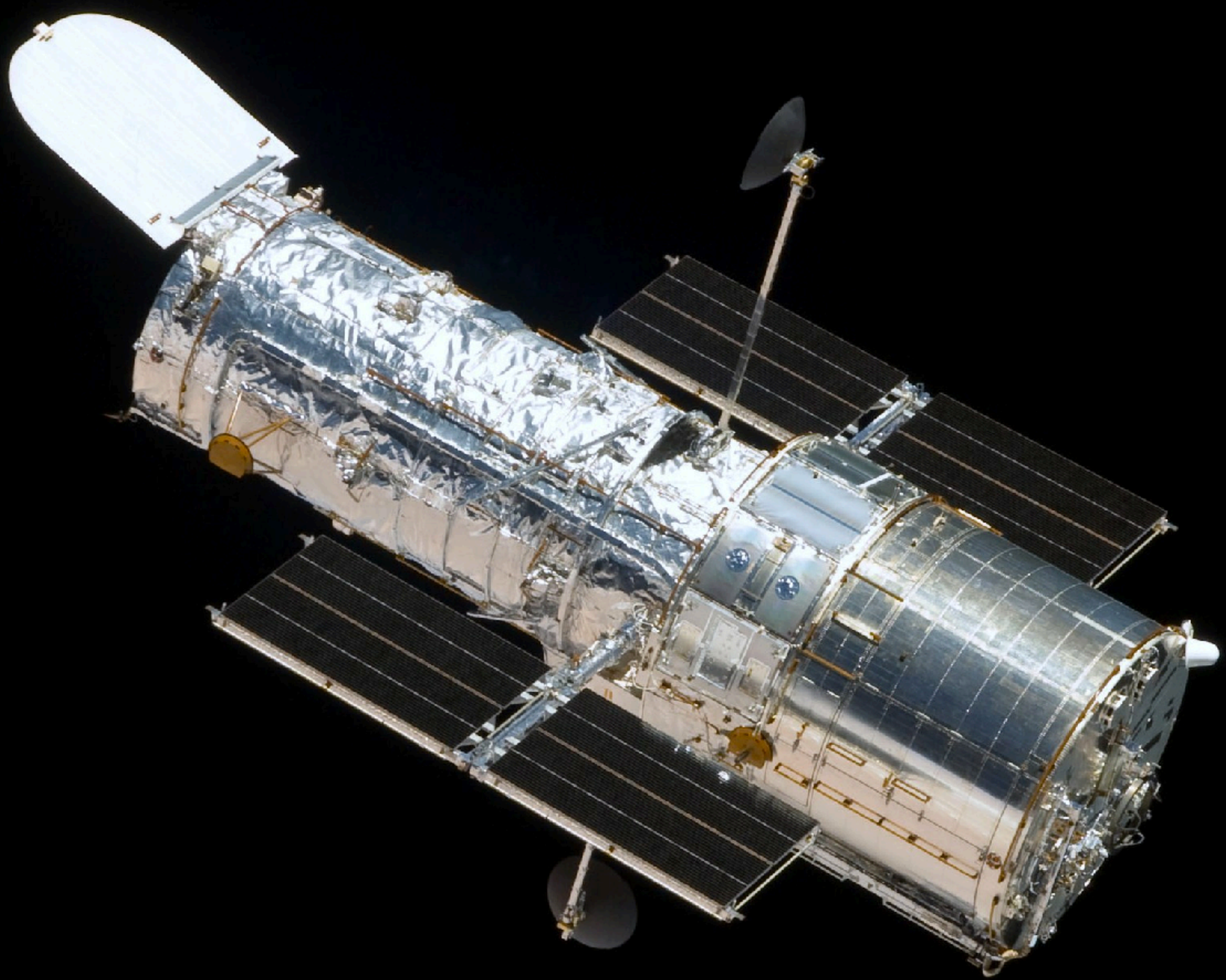
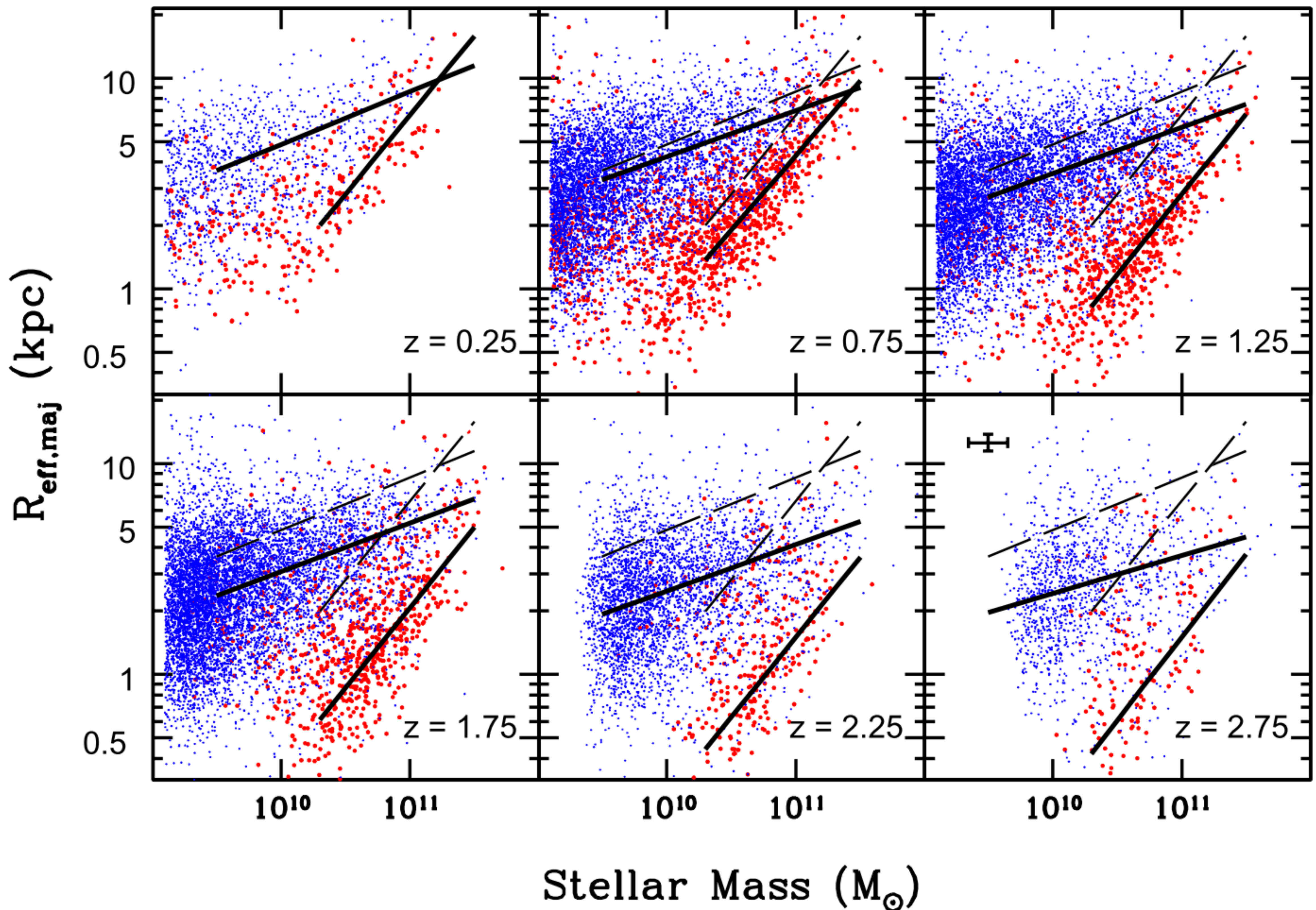
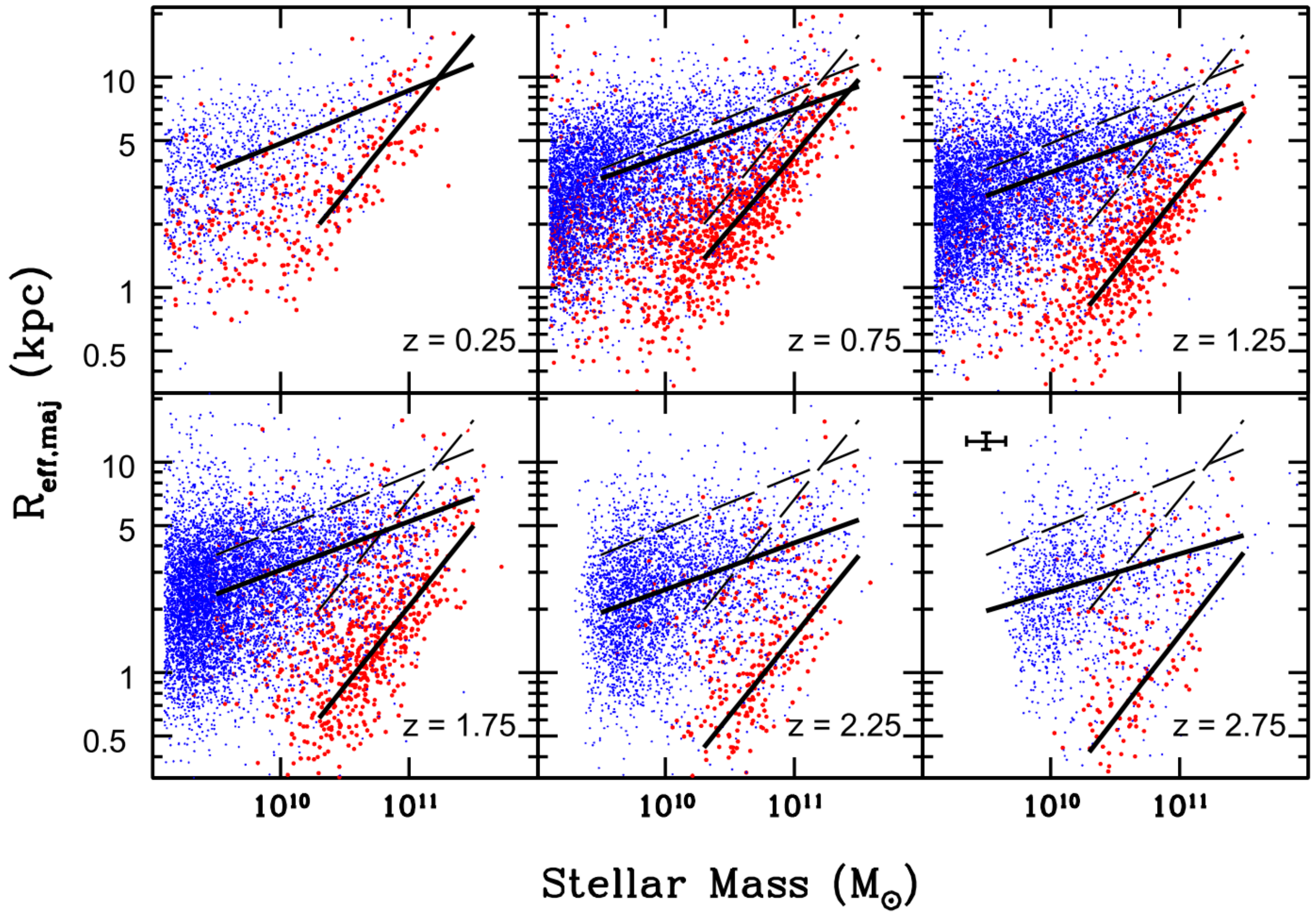
Marijn Franx
John MacKenty
Joel Leja
Mariska Kriek
Danilo Marchesini



The size - mass relation over the past 11 Gyr:

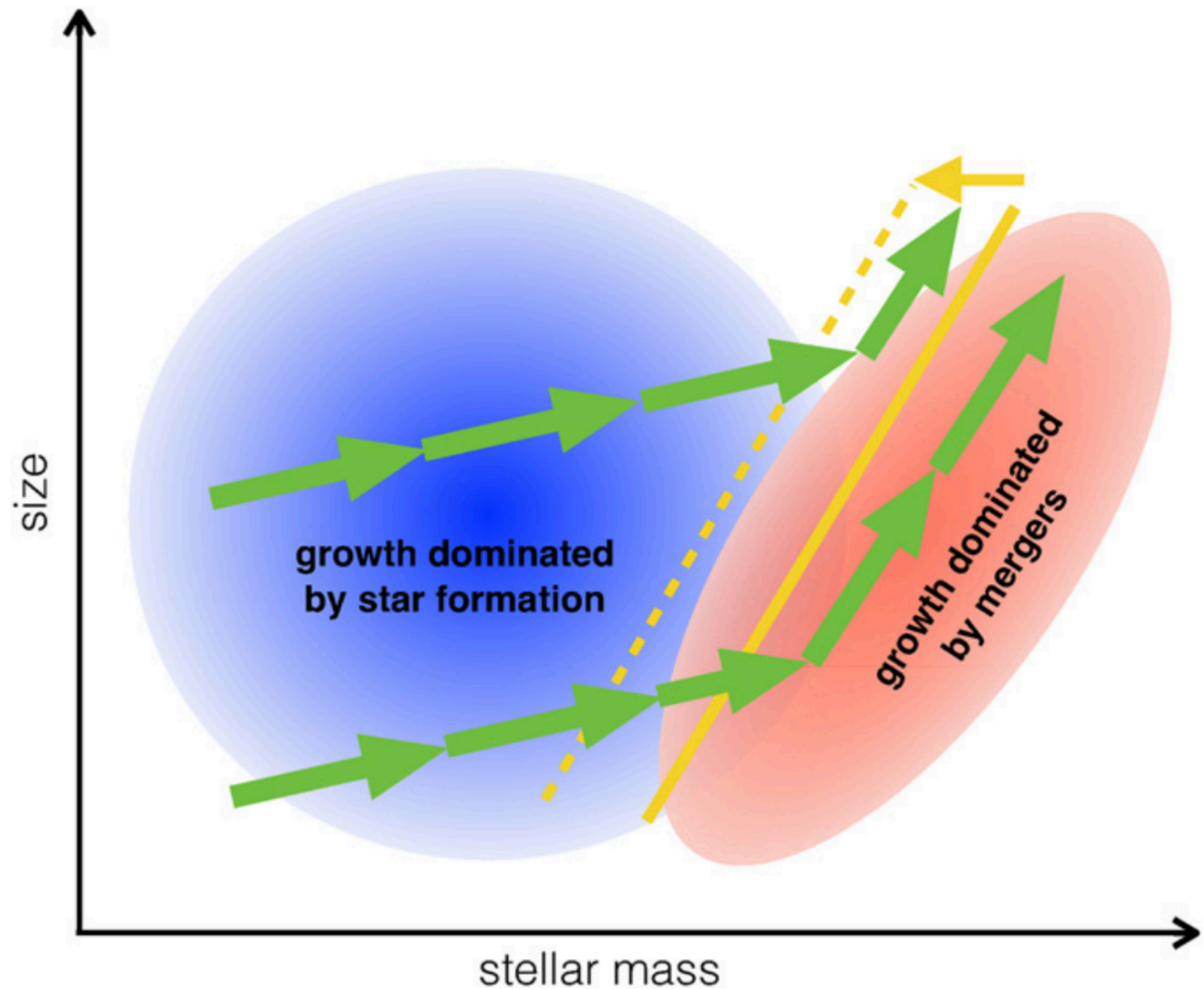


van der Wel et al 2014

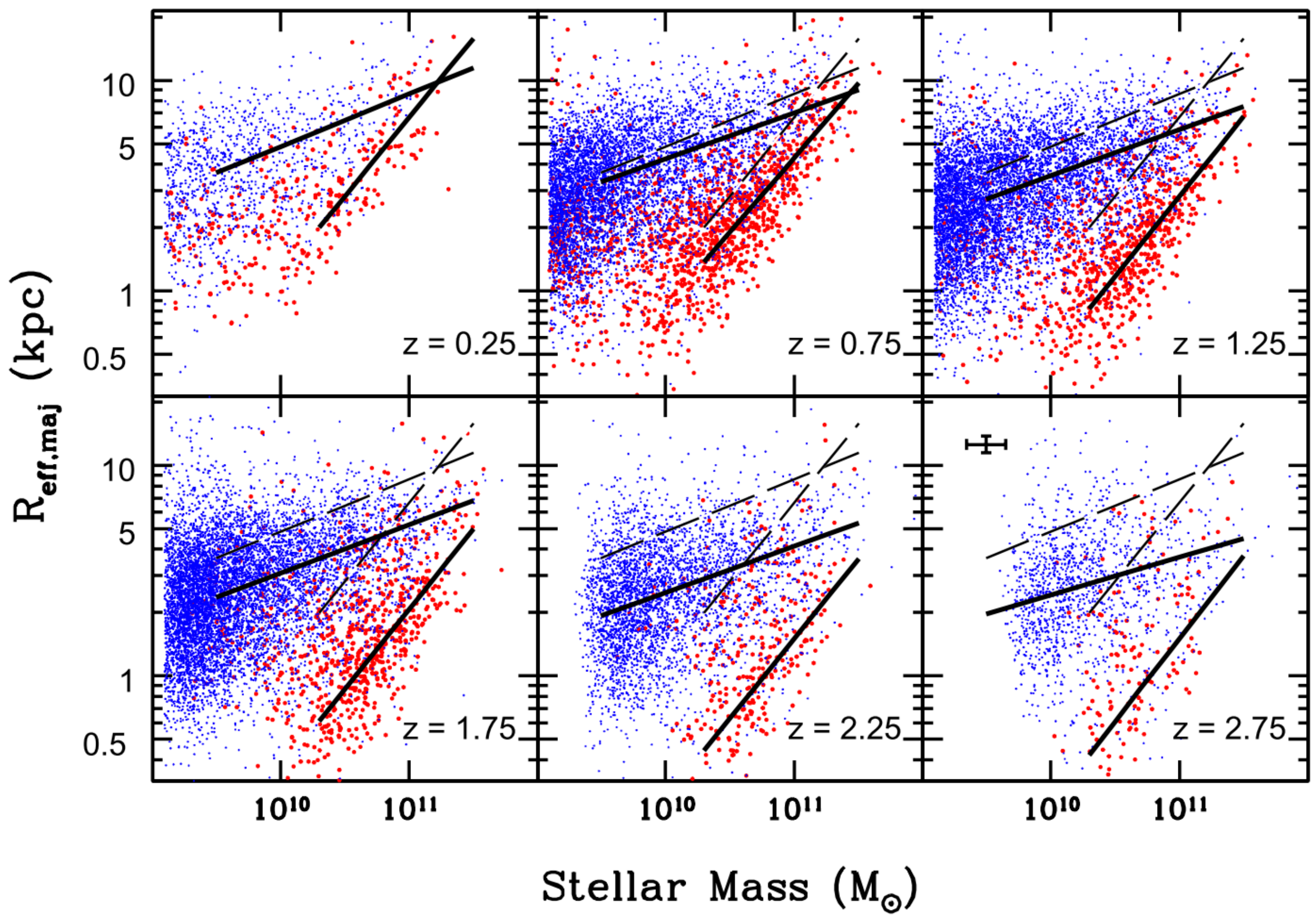


van der Wel et al 2014

- **At all redshifts:**
  - The size-mass relation is well approximated by a power law, with log-normal scatter
  - The slope of the relation is shallow for star forming galaxies and steep for quiescent galaxies
  - Star forming galaxies are larger than quiescent galaxies at fixed mass



van Dokkum et al 2015



van der Wel et al 2014

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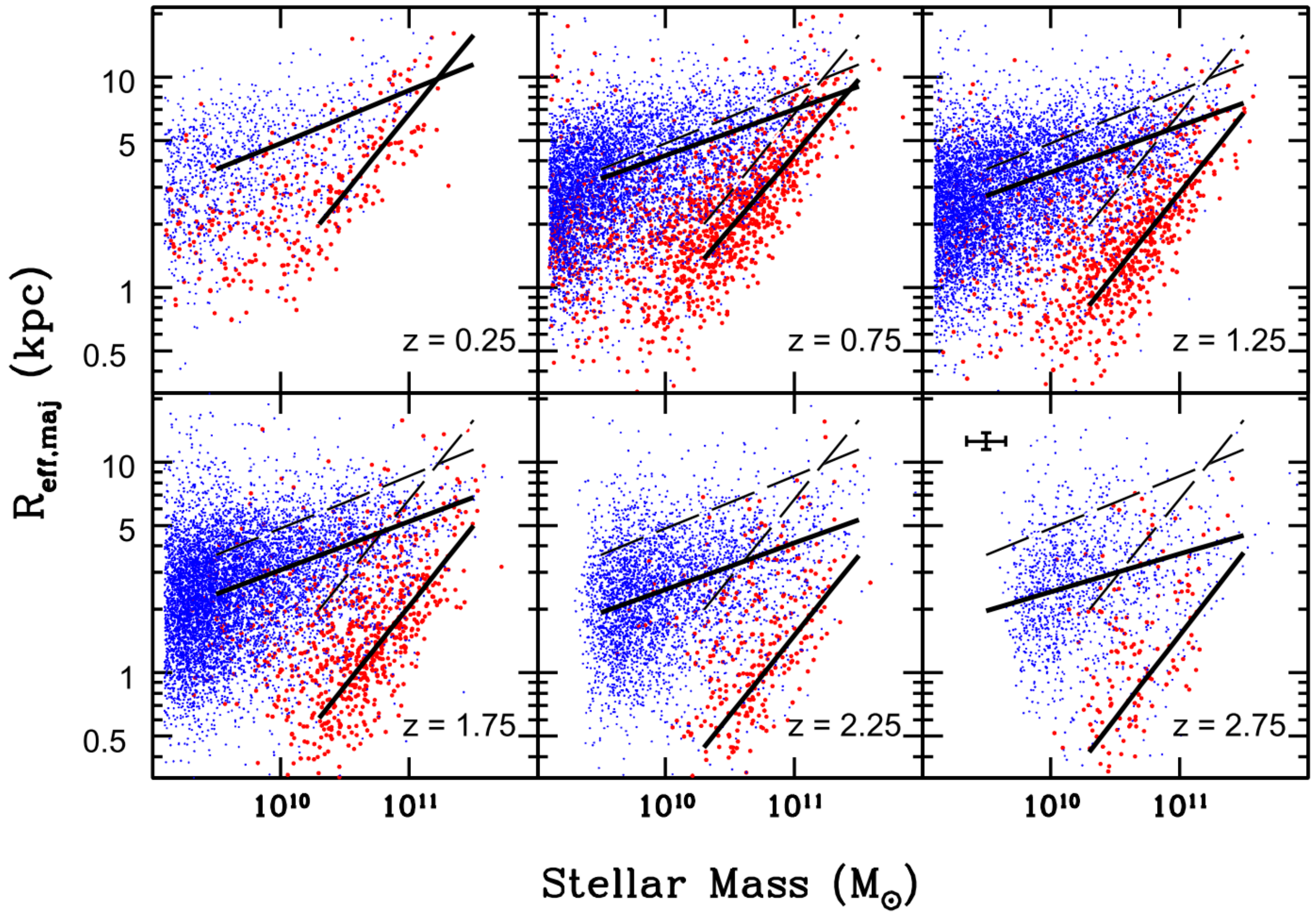

van der Wel et al 2014

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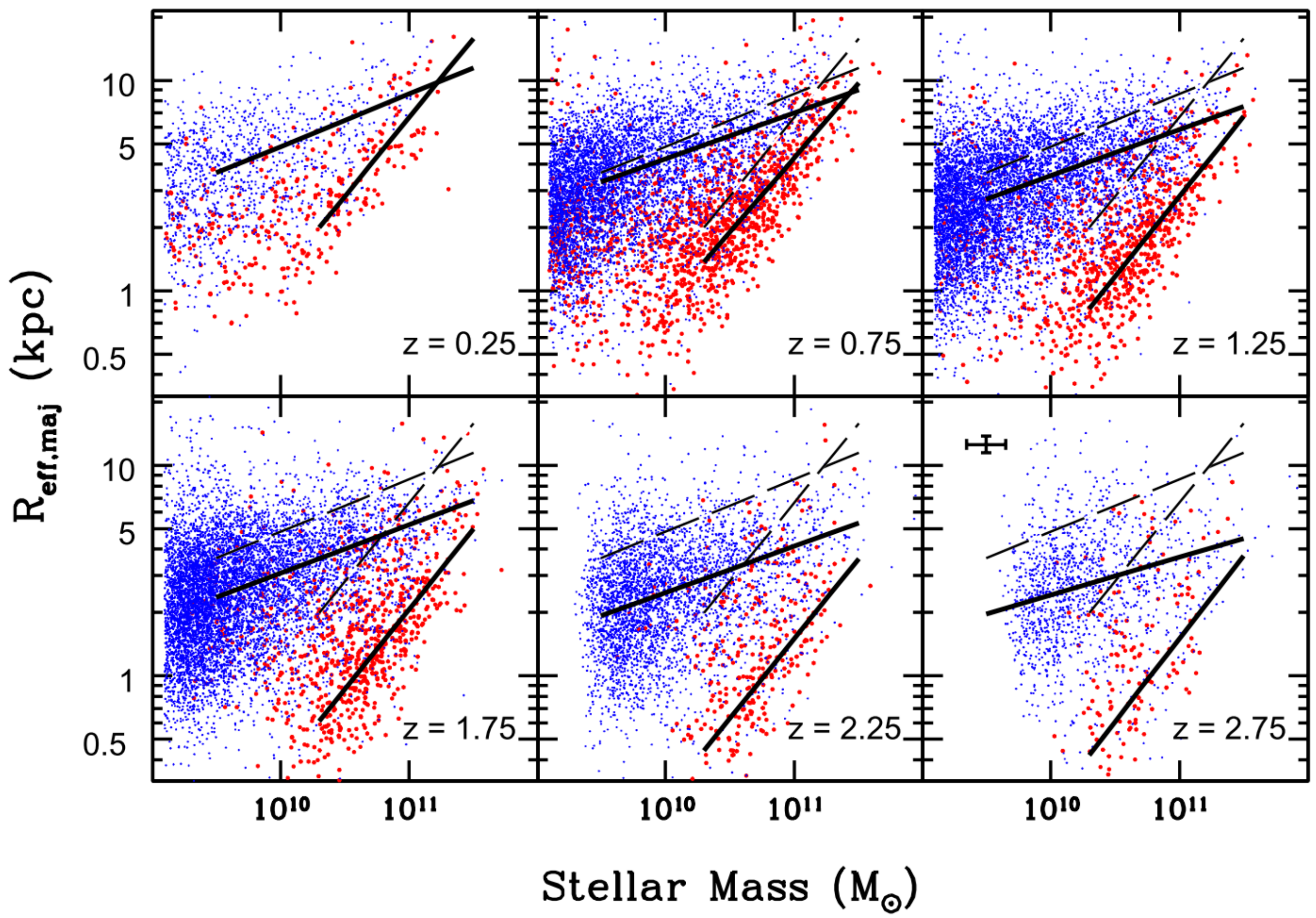


van der Wel et al 2014

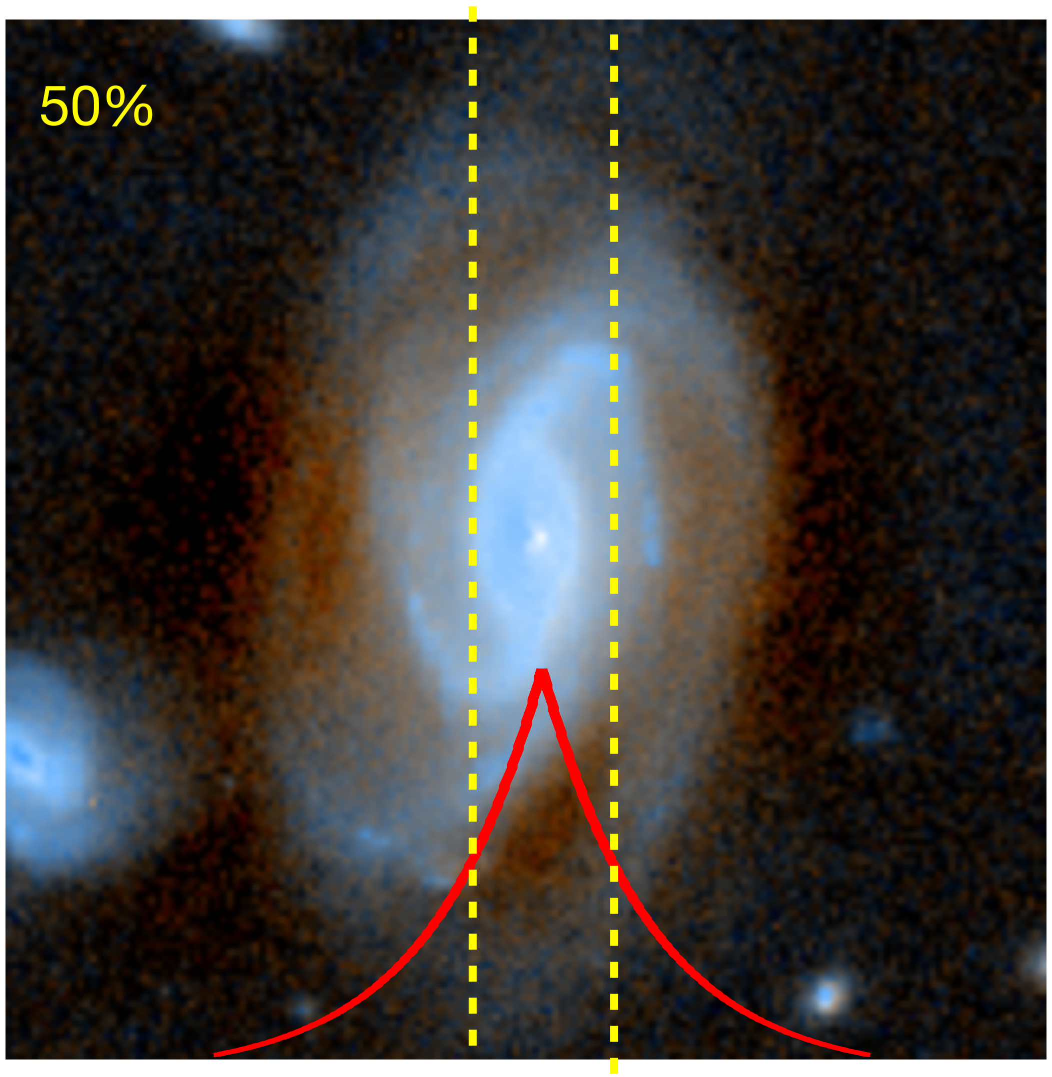
- **At all redshifts:**
  - The size-mass relation is well approximat… a power law, with log-normal scatter
  - The slope of the … star forming galaxies and steep for quies…

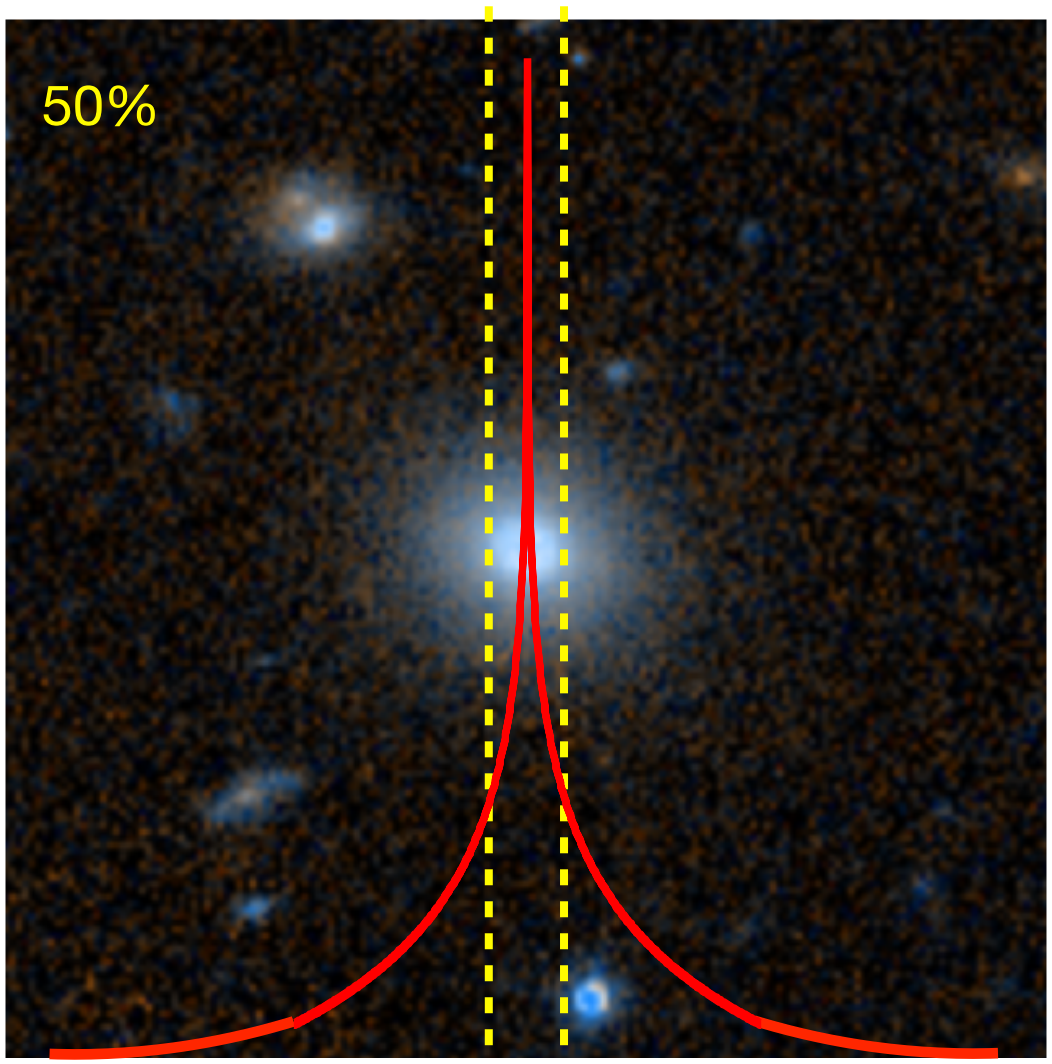
not necessarily!

  - Star forming galaxies are larger than quiescent galaxies at fixed mass

The definition of "radius"

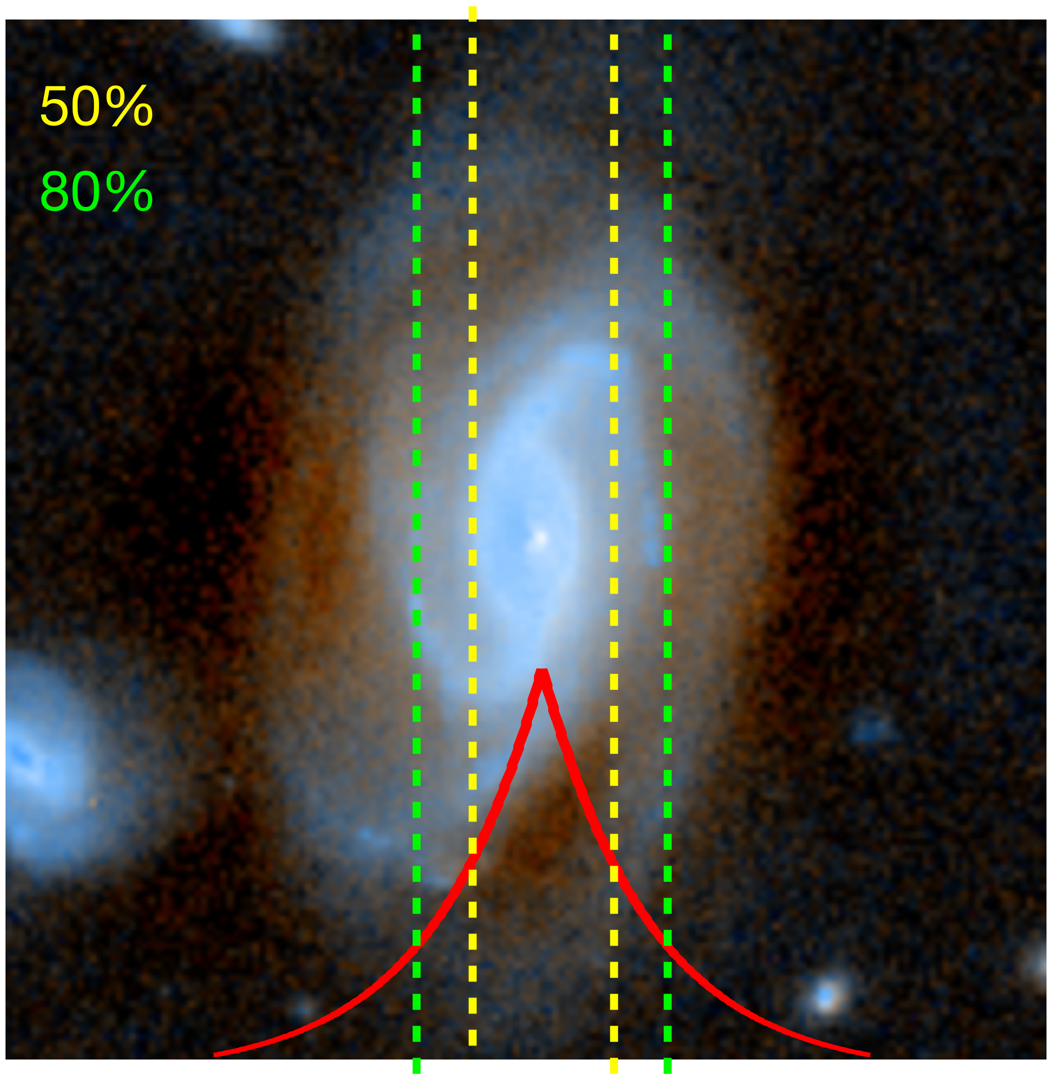
- Standard measure is half-light (or half-mass) radius, usually determined from a fit to a Sersic profil

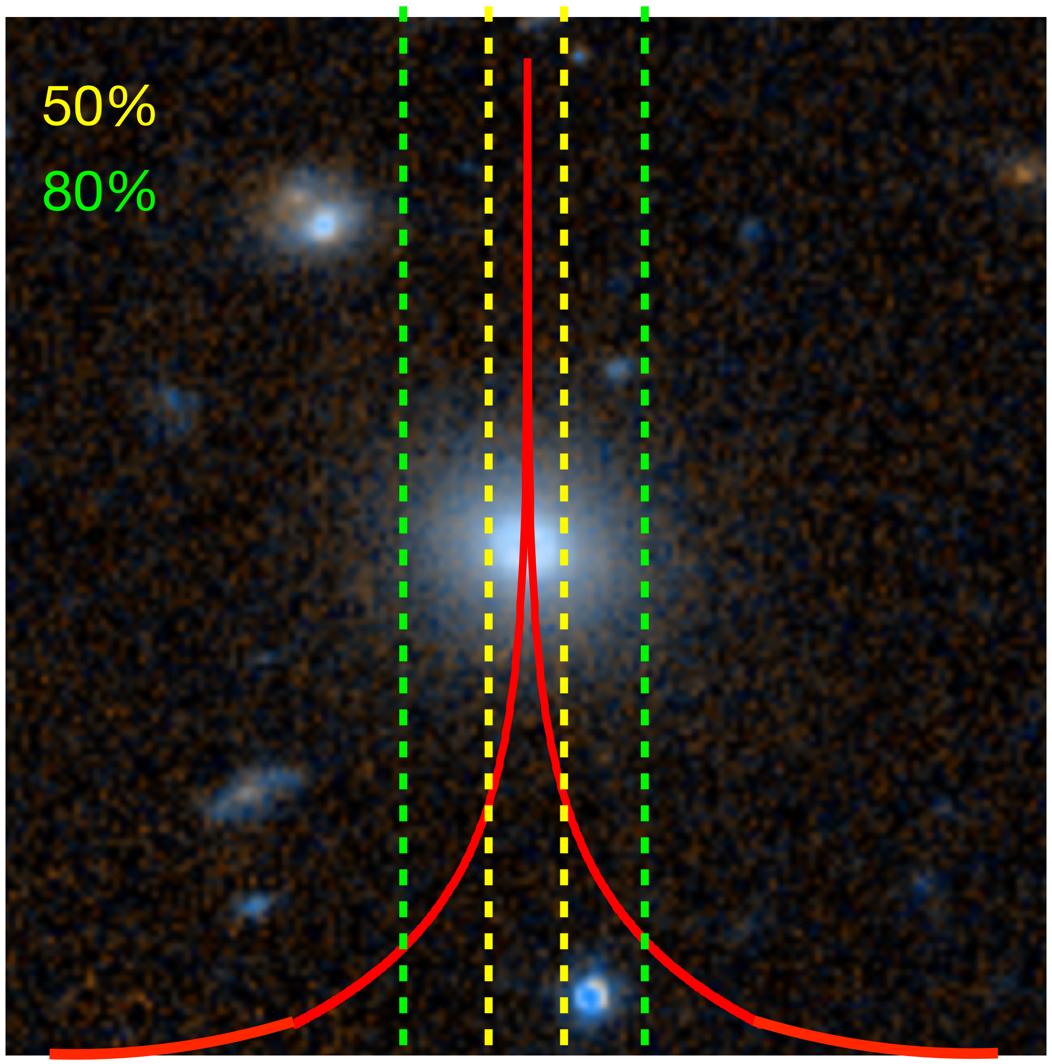




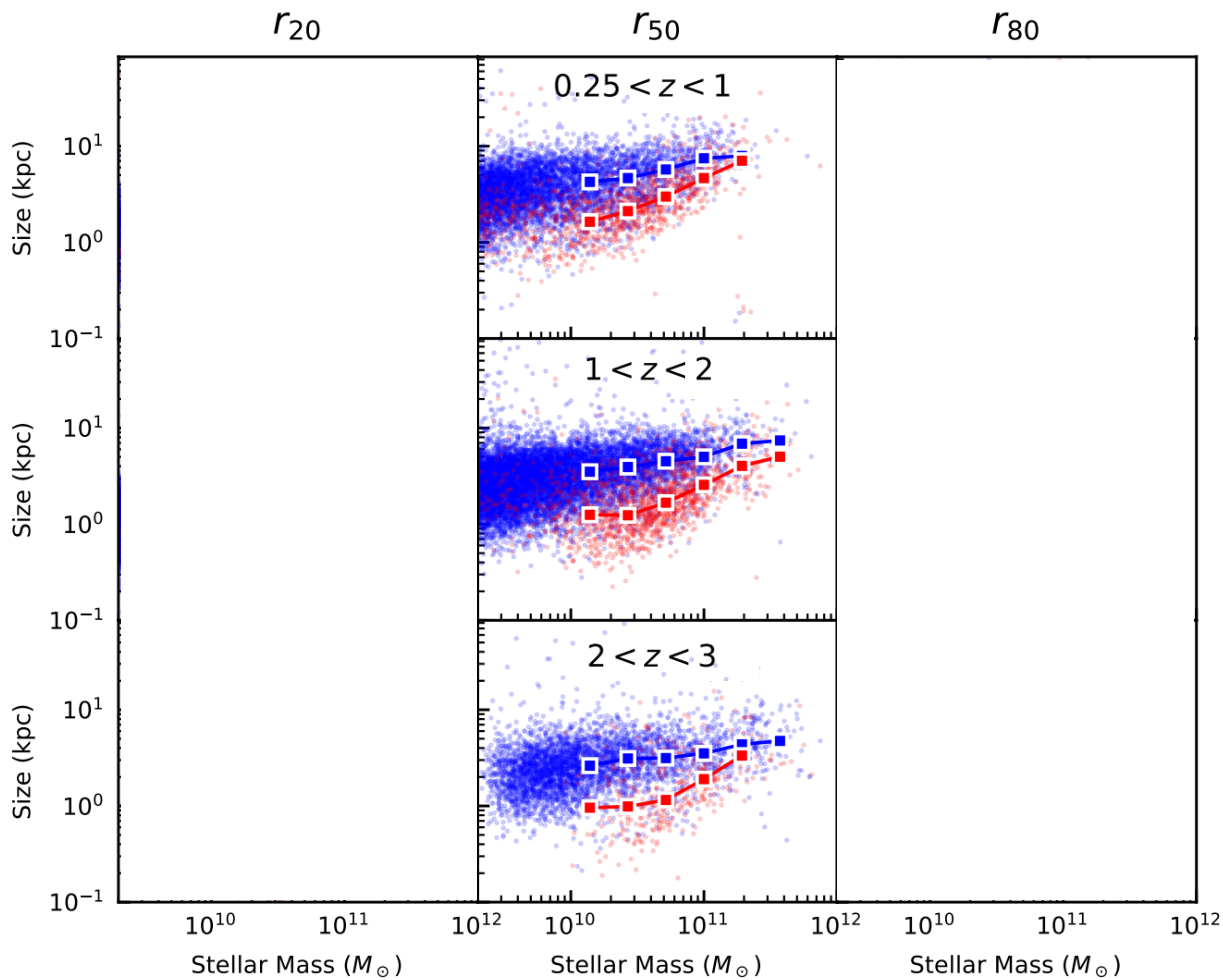
The definition of “radius”

- However, 50% is somewhat arbitrary - can also consider radius containing other fractions of the total luminosity





The definition of “radius”: r_{20} and r_{80}



Miller, vD, Mowla, & van der Wel 2019

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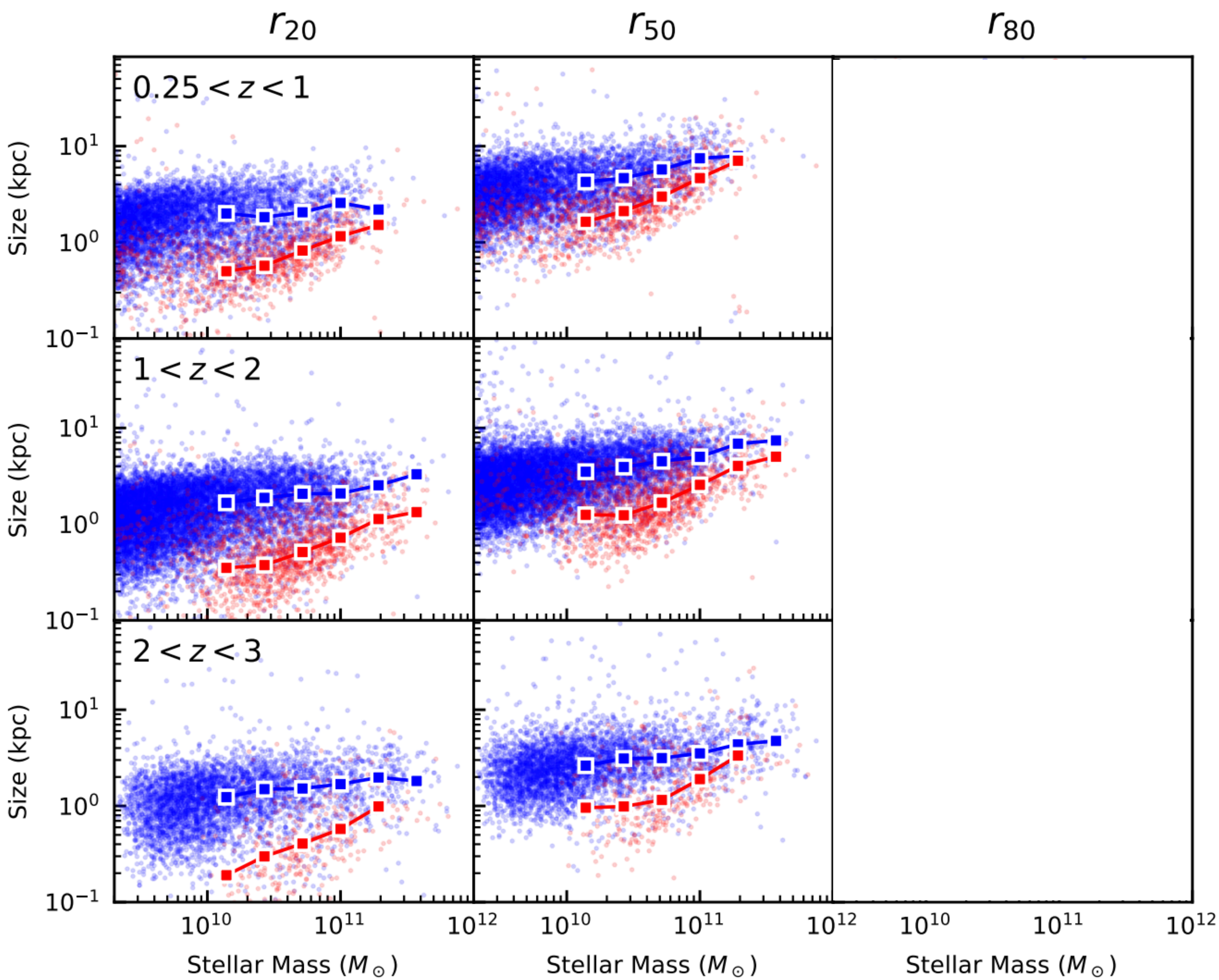

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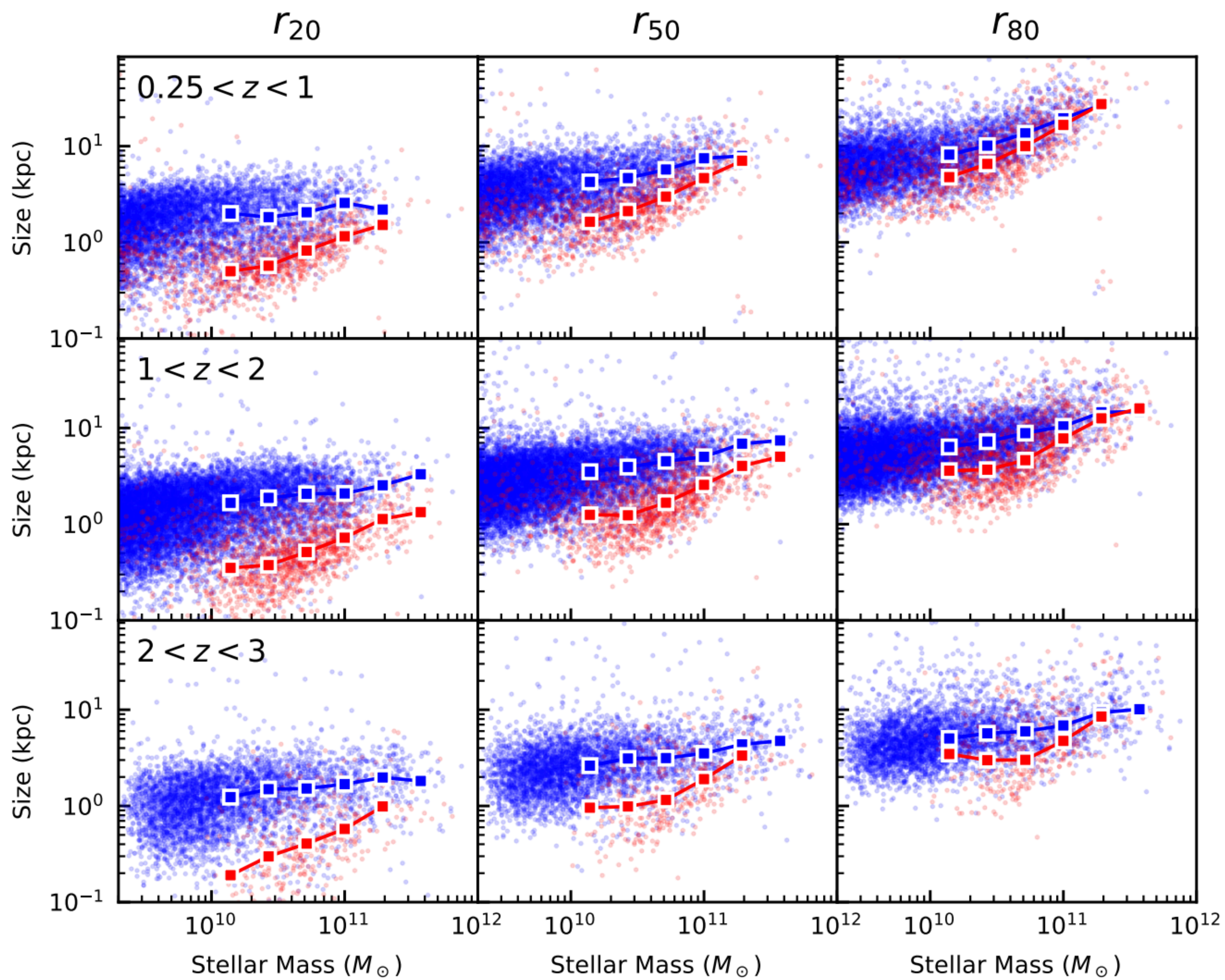

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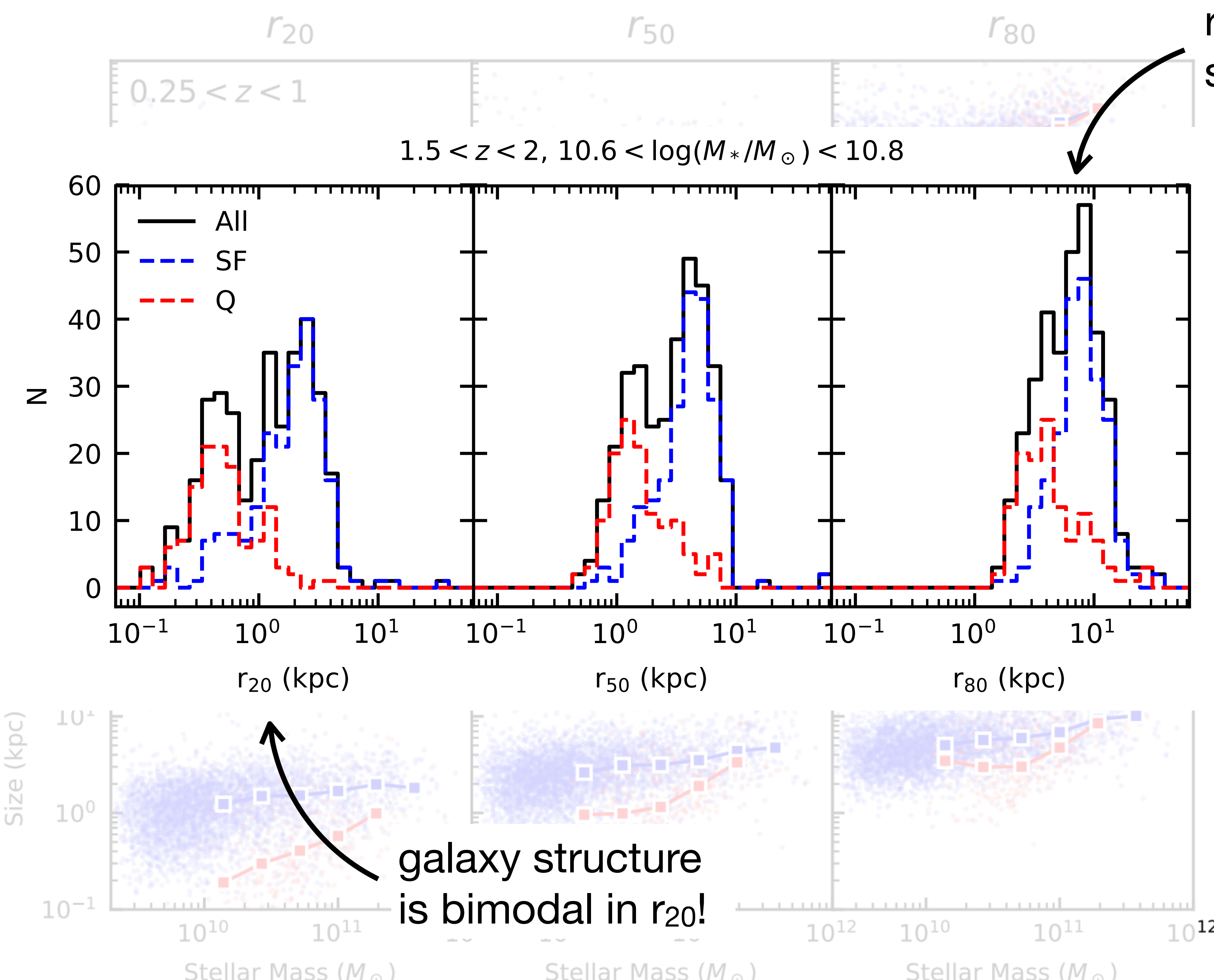


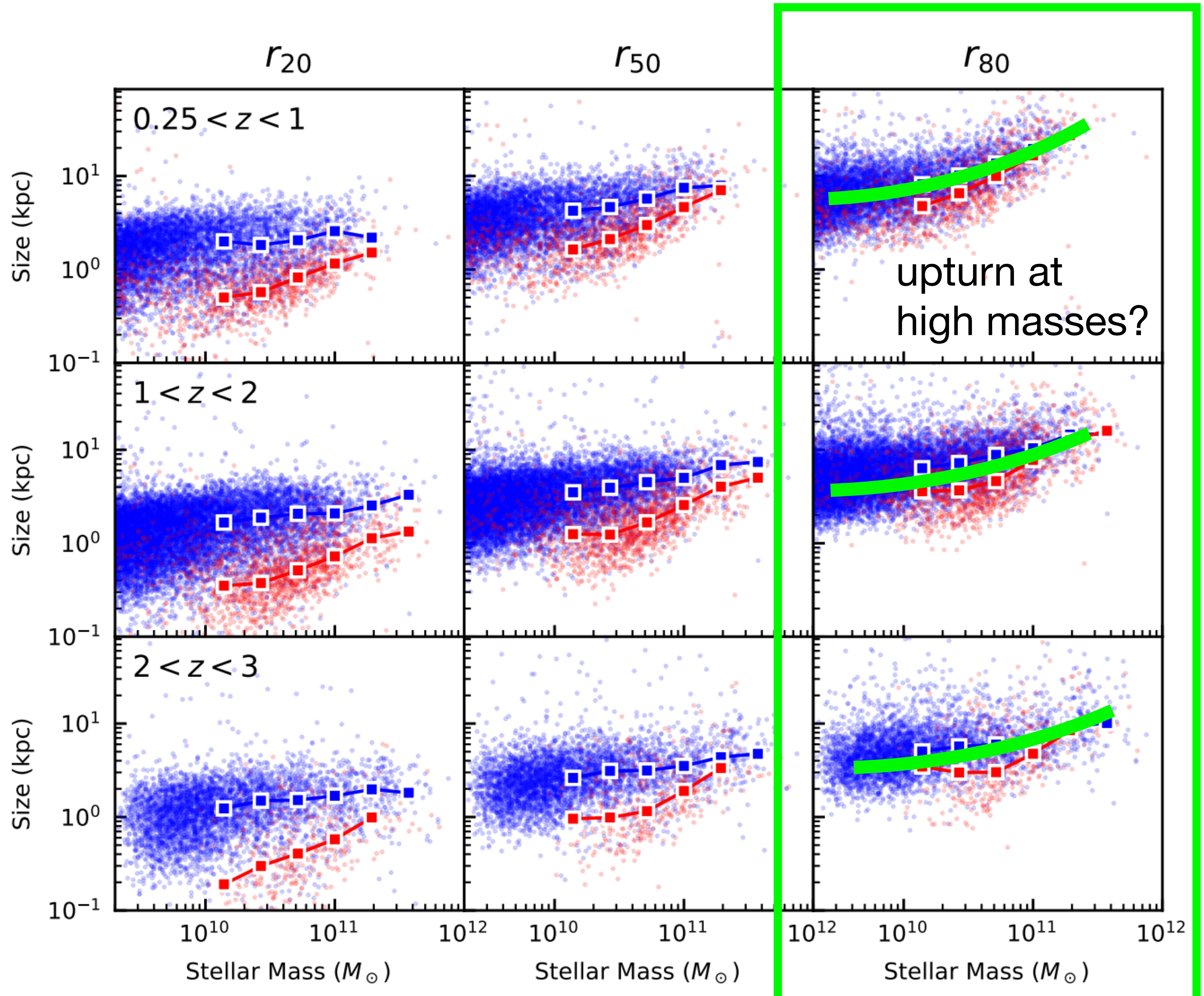
relatively small scatter in r_{80}

galaxies are a factor of ~8 larger in r_{80} than in r_{20}

galaxy structure is bimodal in r_{20}!

Miller, vD, Mowla, & van der Wel 2019

The definition of "radius": r_{20} and r_{80}



Miller, vD, Mowla, & van der Wel 2019

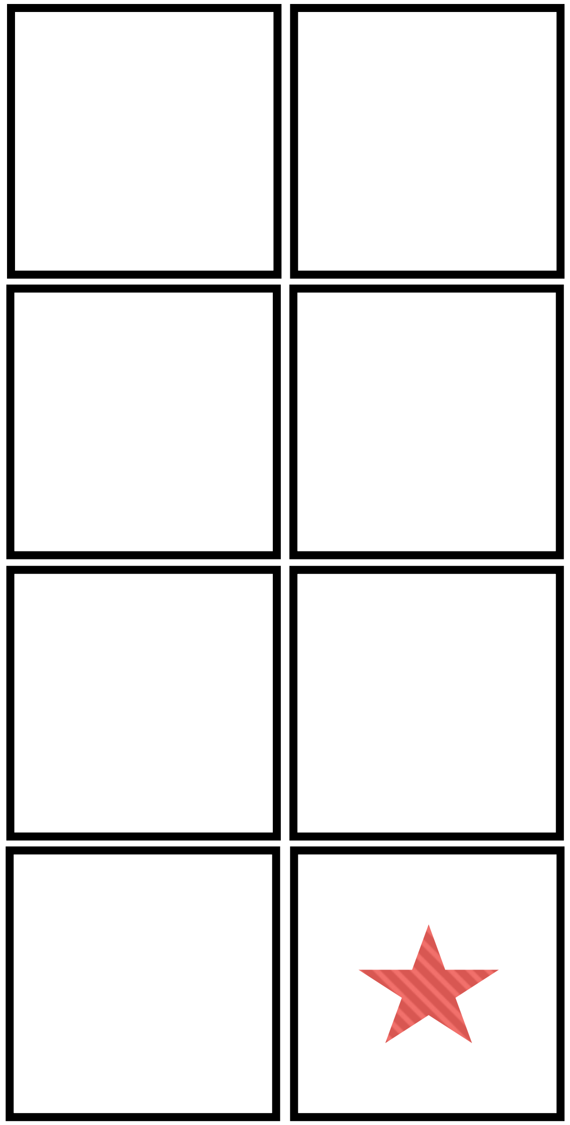
DASH: Drift And SHift

- Massive galaxies are rare & red, which means a large area needs to be surveyed in the near-IR
- HST/WFC3 is inefficient, due to small field of view and large overheads

4.6 $arcmin^2$

up to 10 min for guide star acquisition;
at 1 pointing per orbit, ~800 orbits
needed to cover one square degree

DASH: Drift And SHift

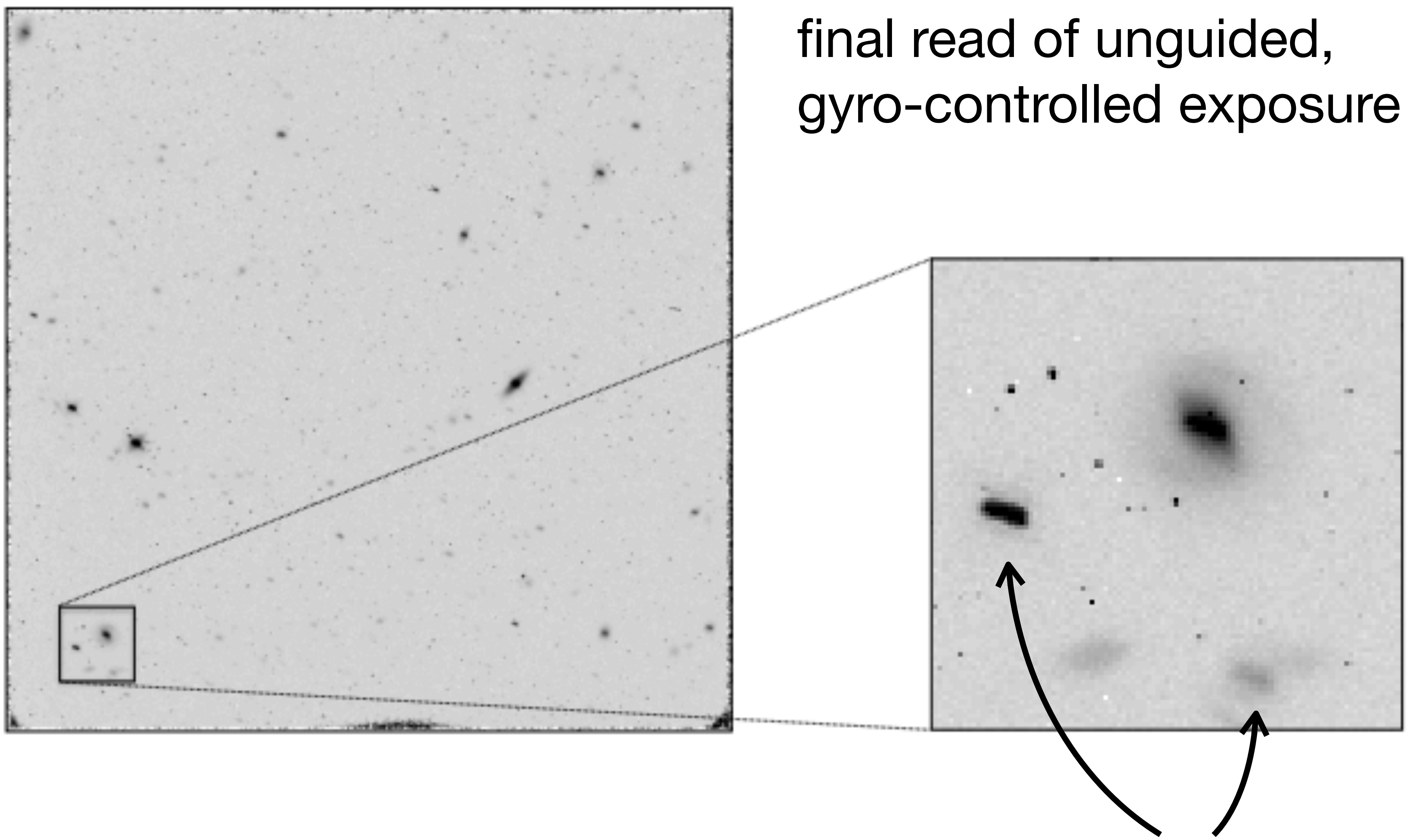


DASH technique: turn off guiding corrections after first pointing

Enables 8 pointings to be observed in a single orbit!

Momcheva, vD, et al. 2017

DASH: Drift And SHift

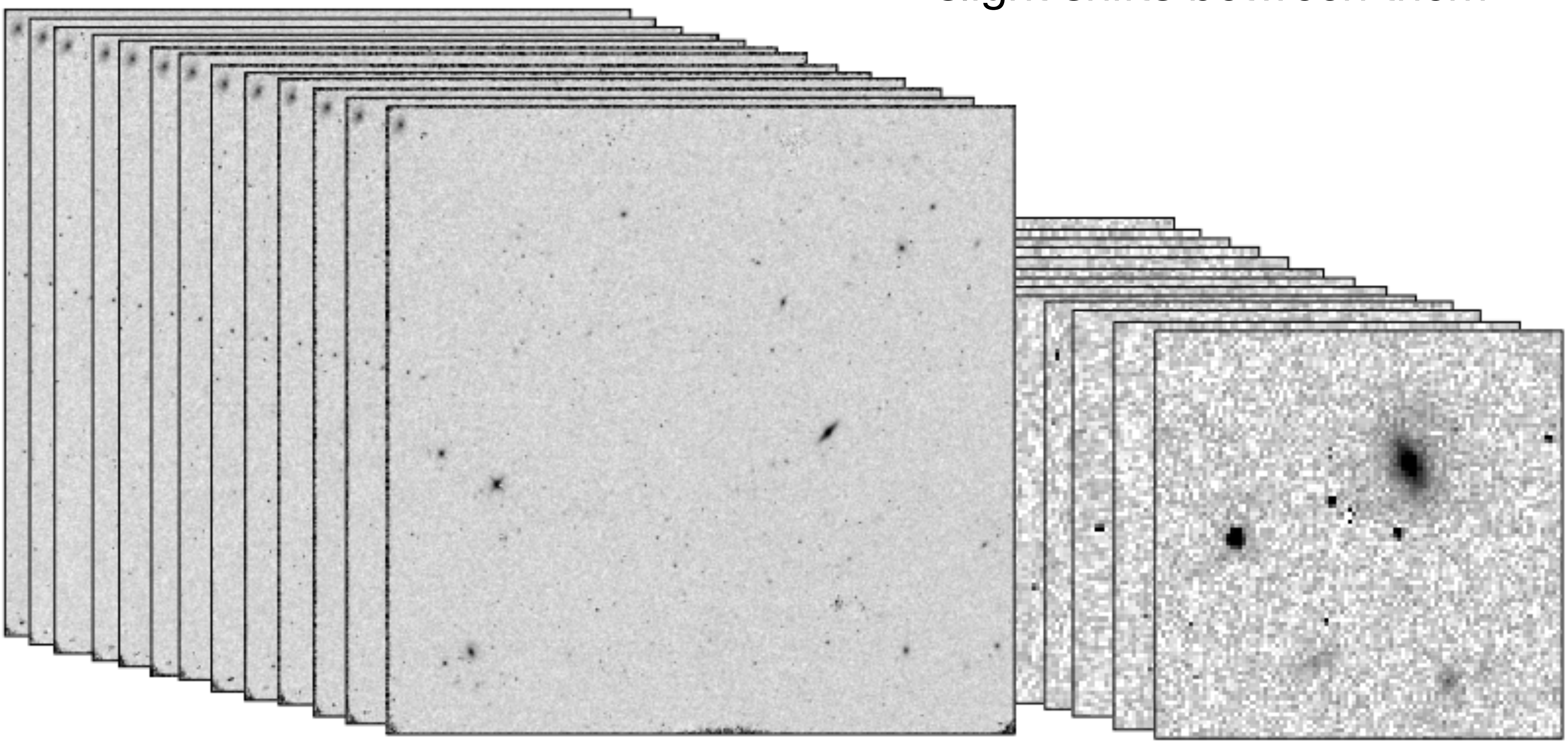


final read of unguided, gyro-controlled exposure

smeared due to drift of spacecraft

DASH: Drift And SHift

non-destructive reads:
exposure consists of 13
individual samples, with
slight shifts between them



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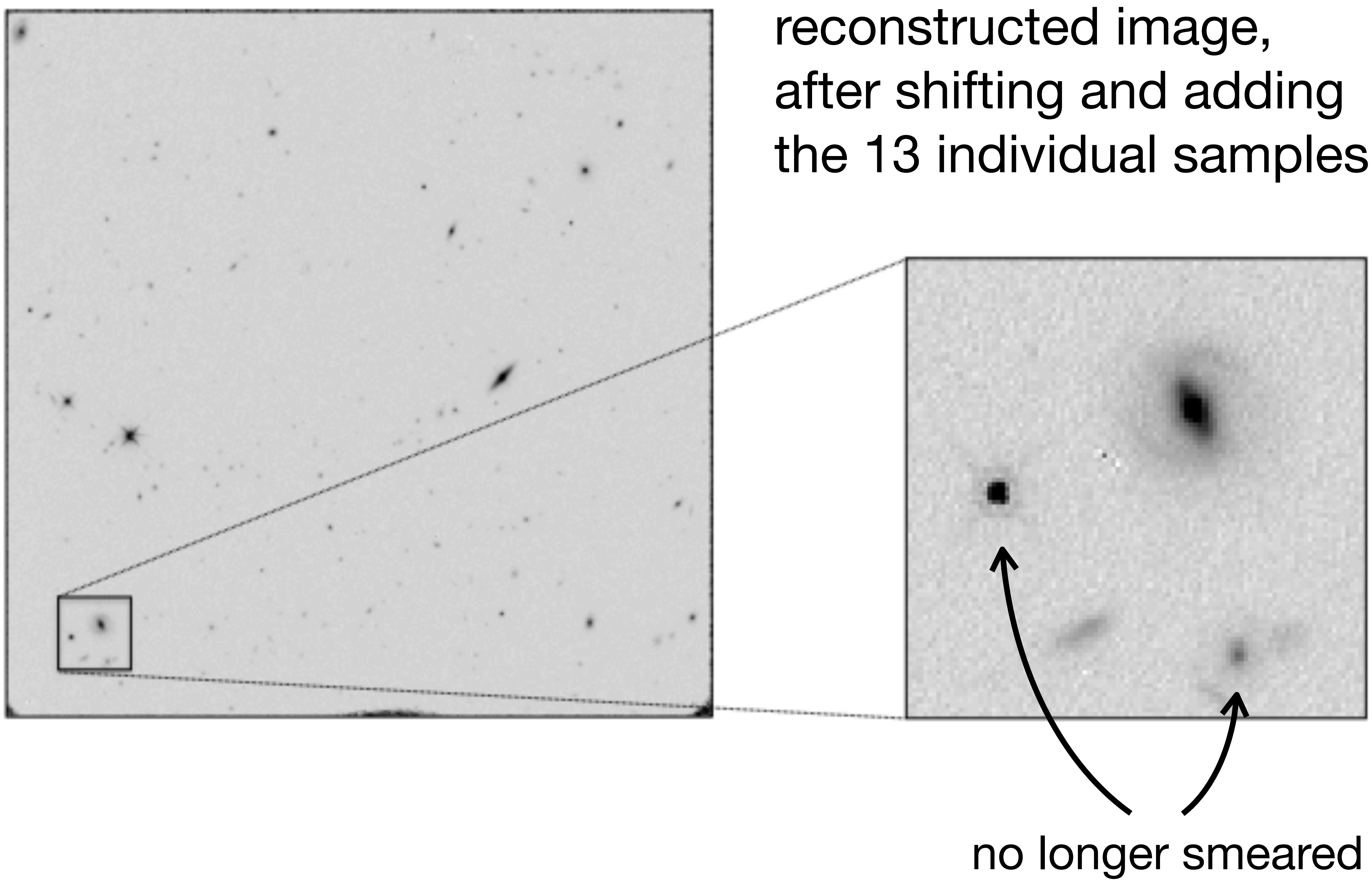
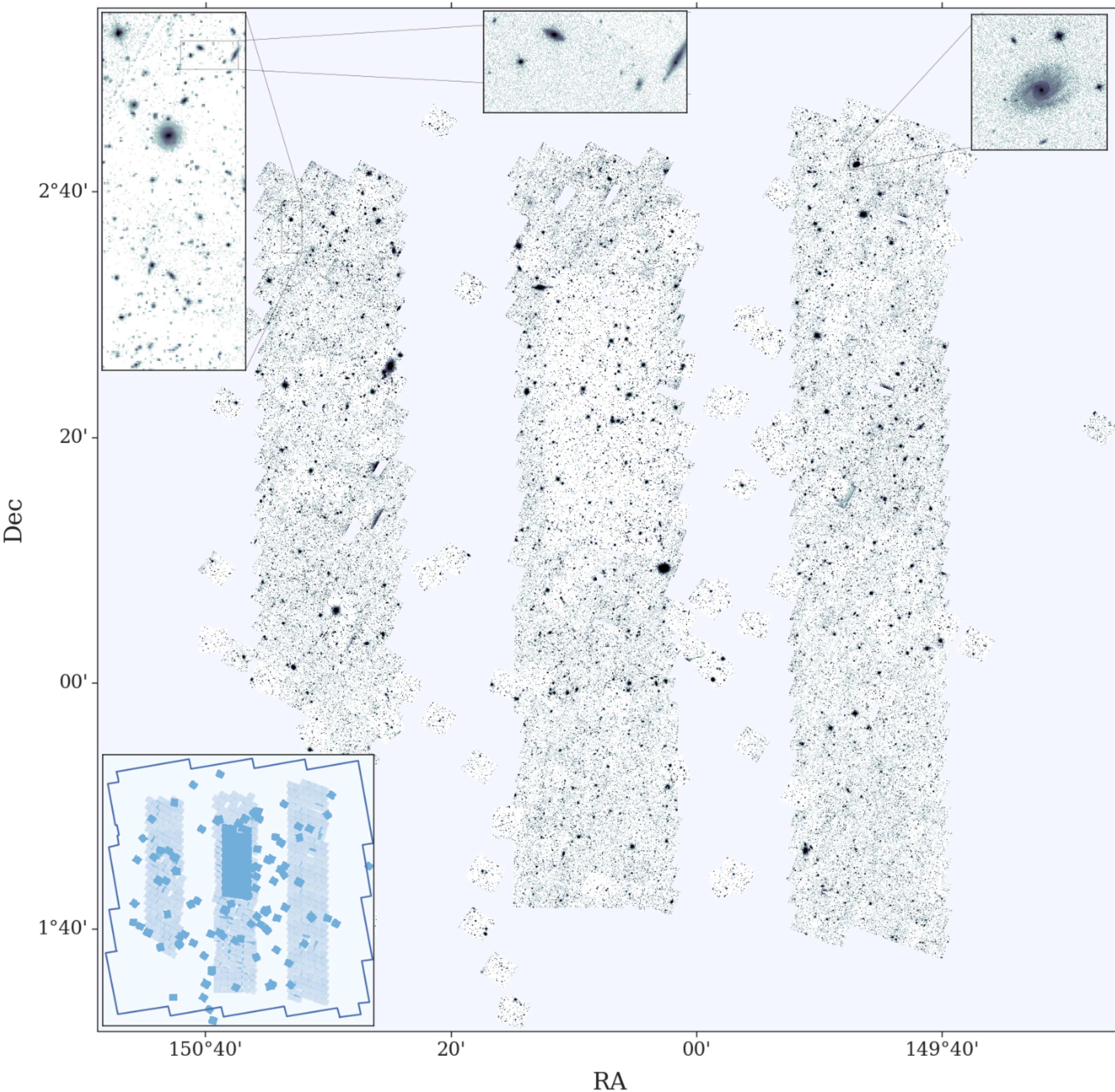


Momcheva, vD, et al. 2017



COSMOS-DASH

Orbits: 57

Pointings: 456

DASH area: 0.49 deg^2

Total NIR area in COSMOS: 0.66 deg^2

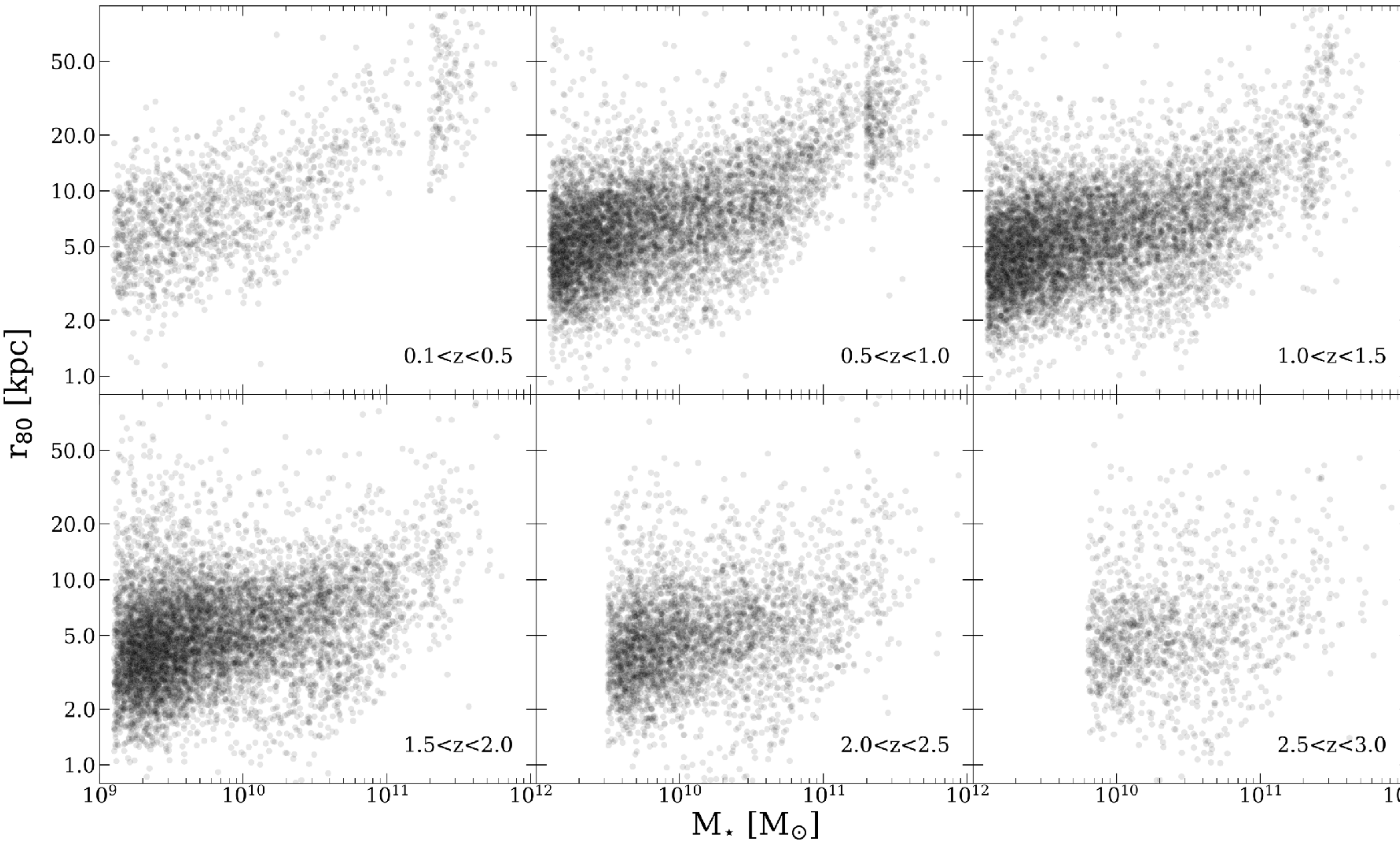
5σ point source depth: 25.2 H_{160}

FWHM: 0.21 arcsec

PUBLIC!

Mowla et al. 2018
Momcheva et al. 2017

The r_{80} size - mass relation of 3D-HST/CANDELS + COSMOS



Mowla et al. 2019

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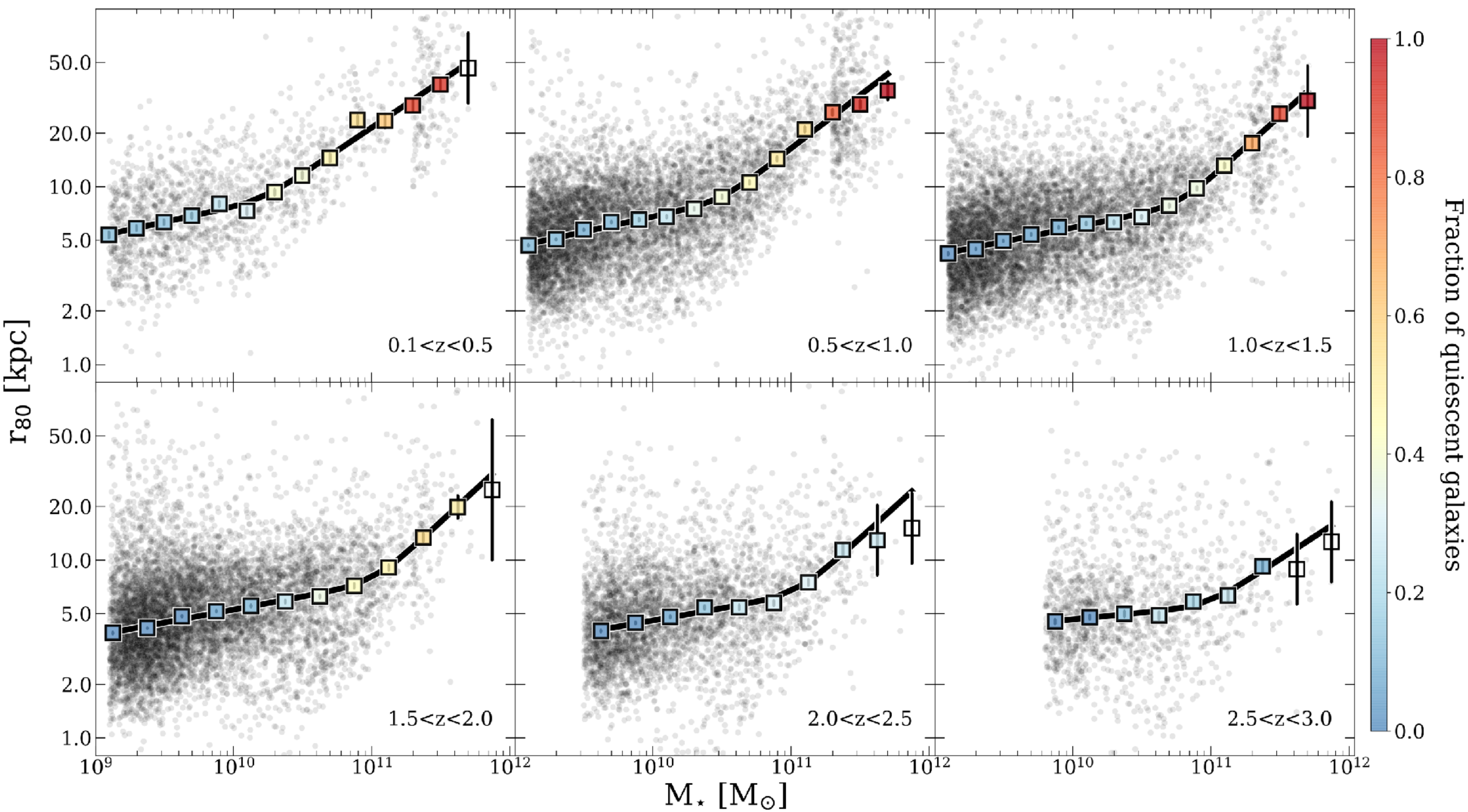
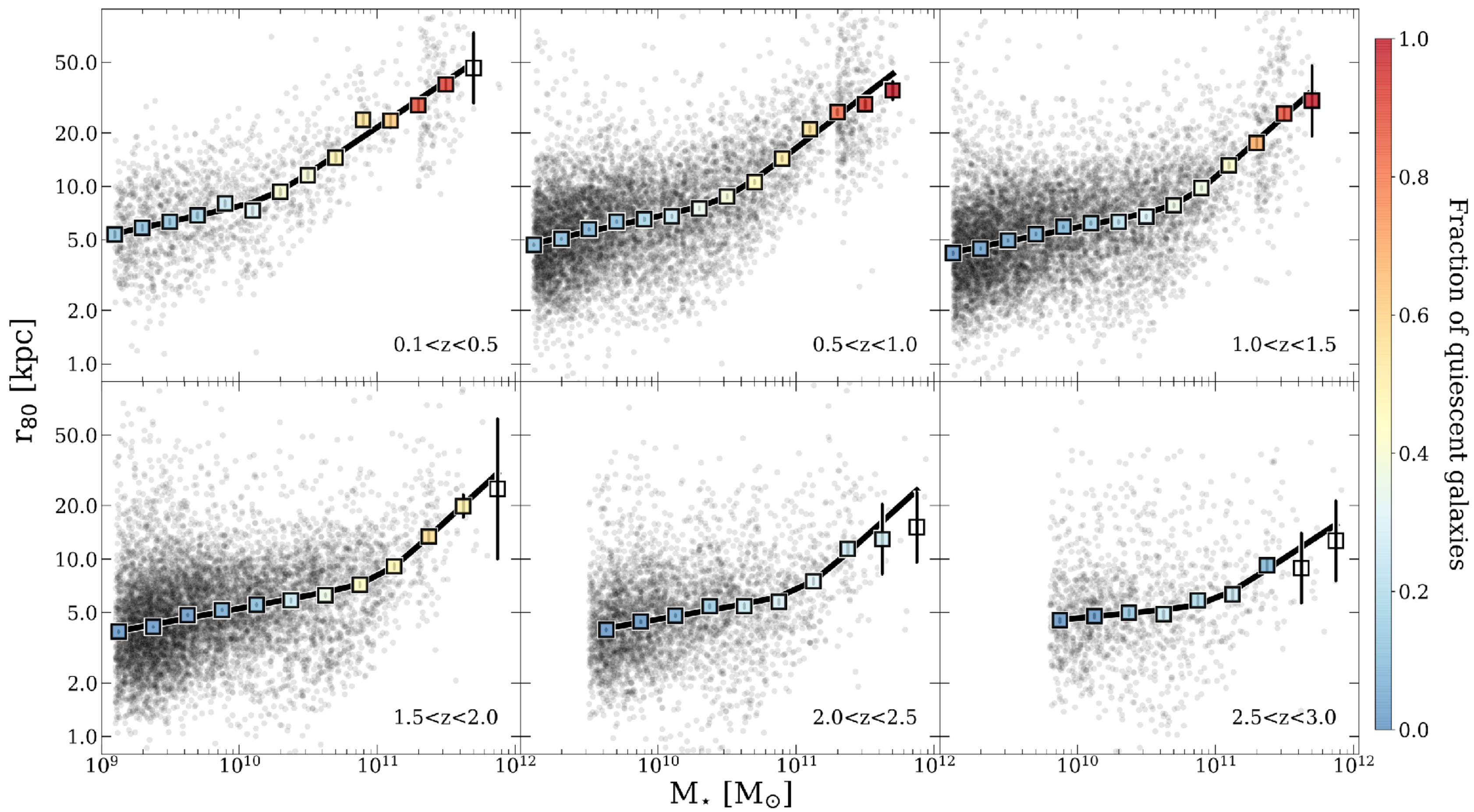


Mowla et al. 2019

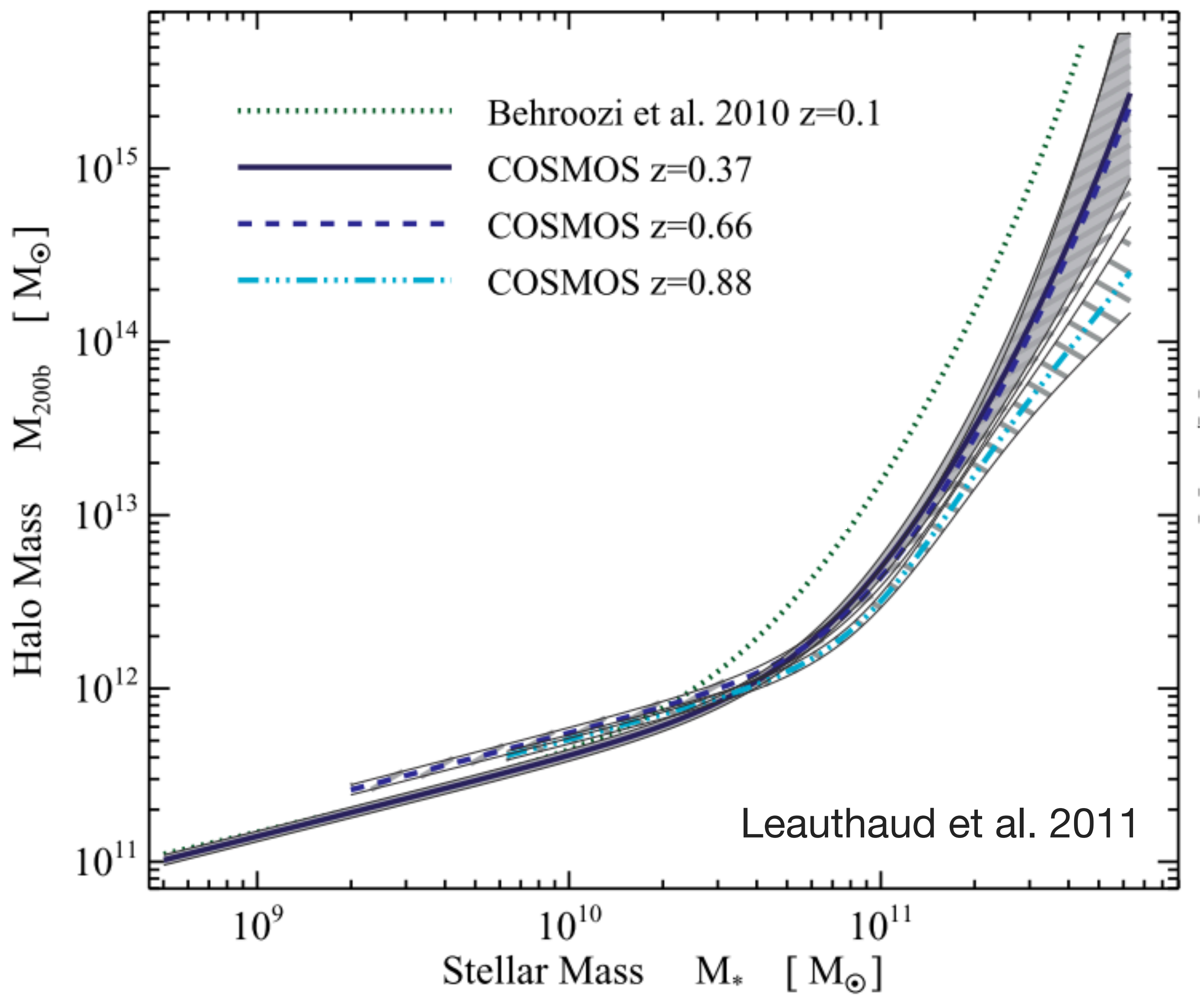


- **New view of the size-mass relation:**
  - The r_{80} size-mass relation is well approximated by a **broken** power law, with relatively low scatter
  - Star forming galaxies have **similar r_{80} sizes** as quiescent galaxies at fixed mass

Mowla et al. 2019
Miller et al. 2019

Interpretation

- Form of r_{80} - M_{stars} relation reminiscent of M_{halo} - M_{stars} relation



Interpretation

- Form of r_{80} - M_{stars} relation reminiscent of M_{halo} - M_{stars} relation
- Assume the following:

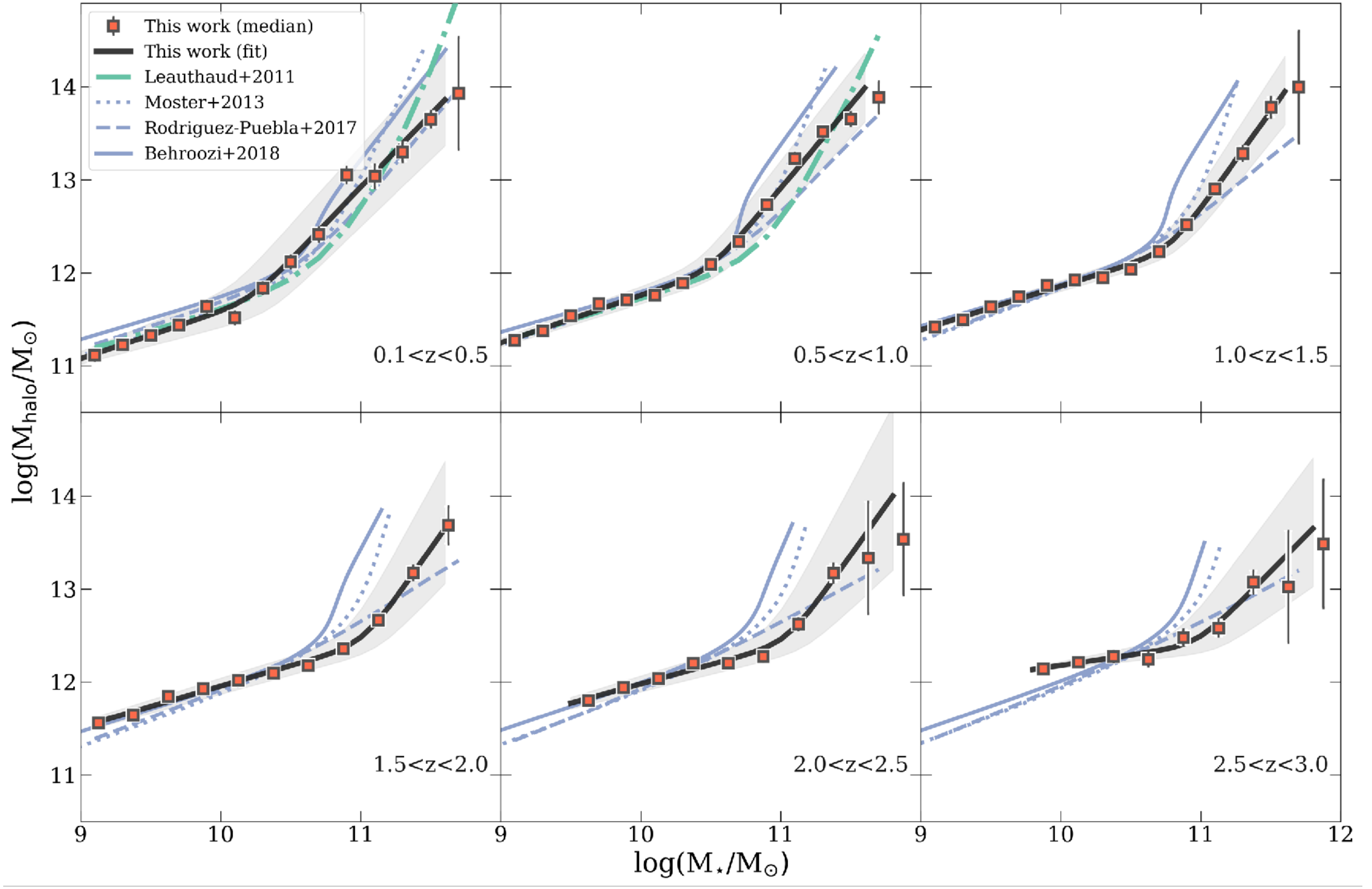
$$M_{\rm halo} = \frac{4\pi}{3}\Delta_{\rm vir}\rho_{\rm crit}R_{\rm vir}^3 \qquad R_{\rm vir} = \frac{r_{80}}{\gamma}$$

with γ a fit parameter (see also Kravtsov 2013)

- Compare inferred M_{halo} - M_{stars} relation to canonical ones

Comparison of M_{halo} - M_{stars} relations

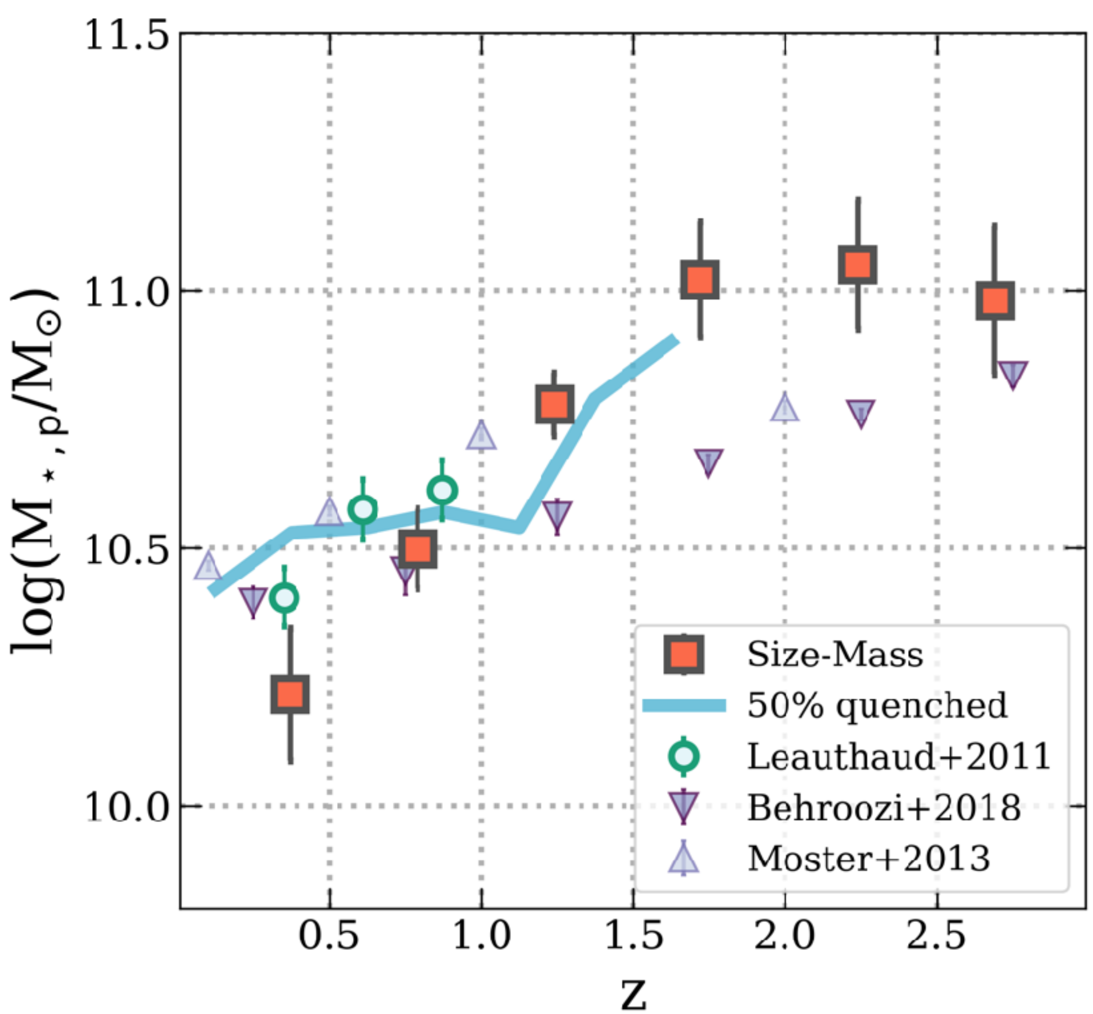
Mowla et al. 2019

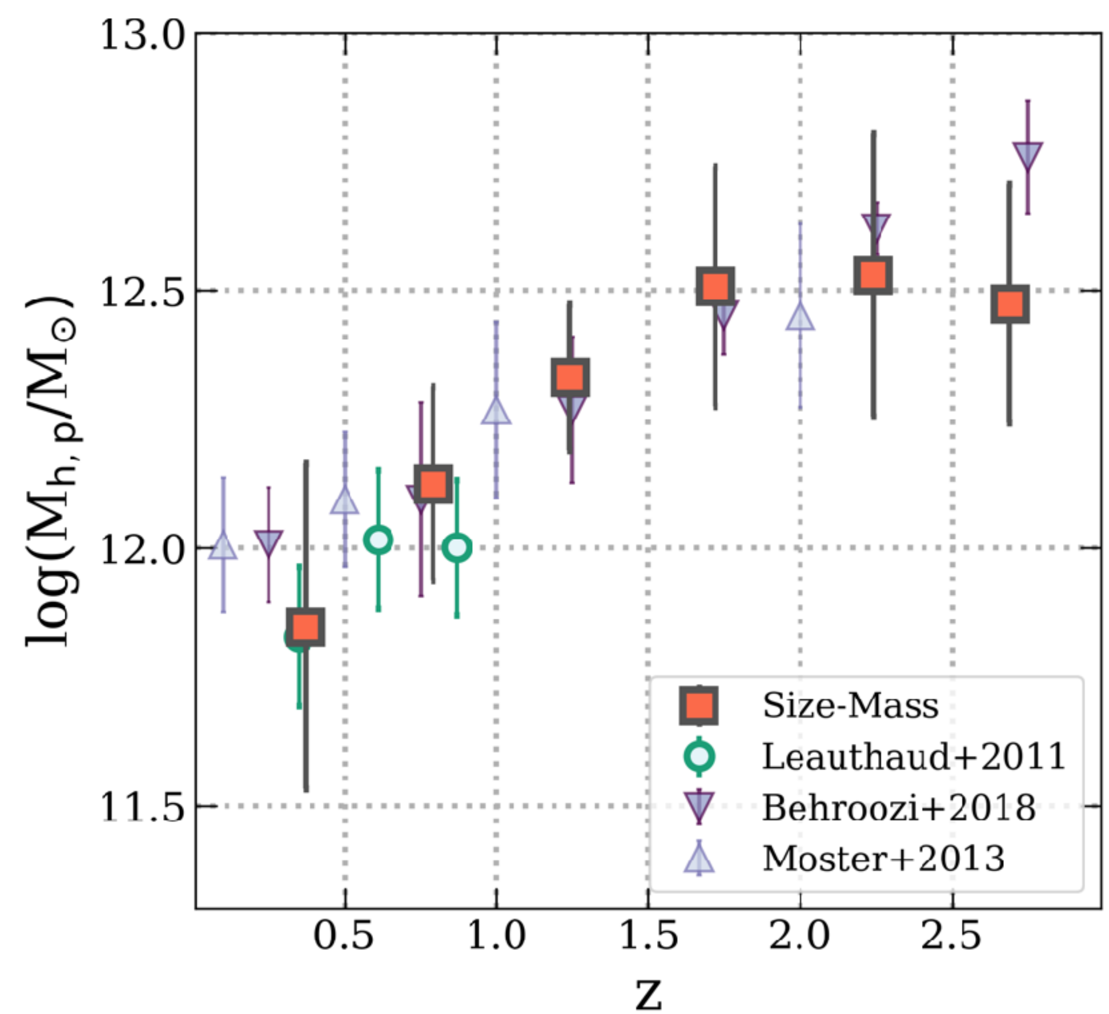


Interpretation

Mowla et al. 2019

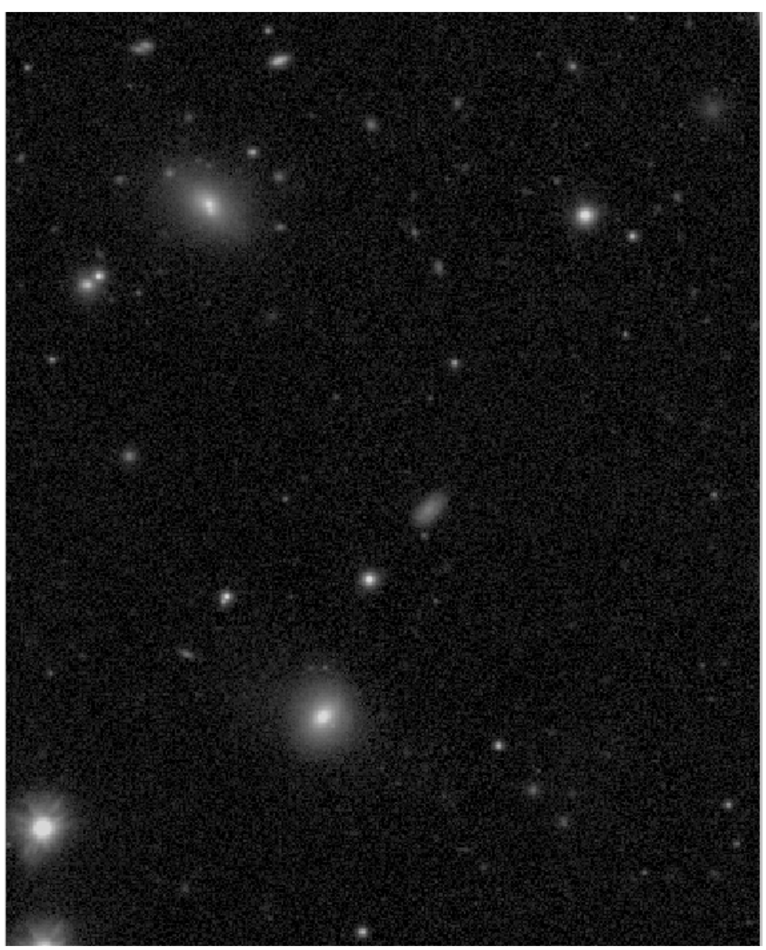
- Form of r_{80} - M_{stars} relation reminiscent of M_{halo} - M_{stars} relation
- Good agreement between the two for **R_{vir} ~ 20 r_{80}**
- Pivot mass remarkably similar (not tuned in any way):



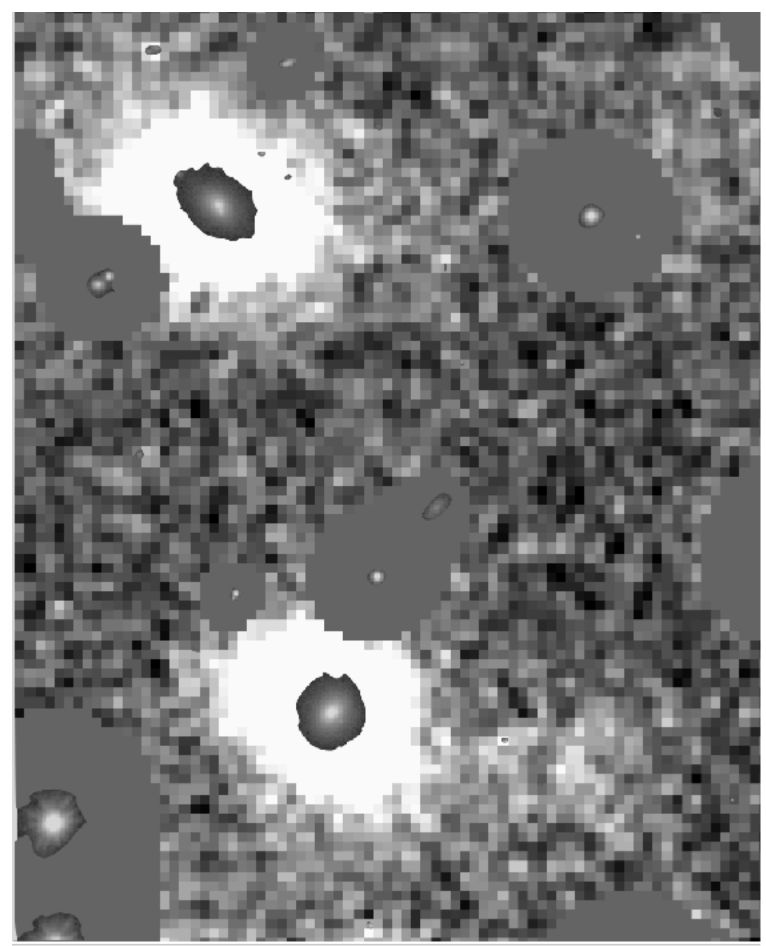


What is next?

- Use mass-weighted, rather than light-weighted, radii (e.g., Suess et al. 2019)
- Improve stellar masses (e.g., Leja et al. 2019)
- Explore relations with r_{10}, r_{90}, r_{95}, etc



KIDS survey



Dragonfly wide field survey

Danieli et al 2019
Miller et al, in prep

Summary

- **New view of the size-mass relation:**
  - The r_{80} size-mass relation is well approximated by a broken power law, with relatively low scatter
  - Star forming galaxies have similar r_{80} sizes as quiescent galaxies at fixed mass
- **Virial radius of the halo seems to correlate with r_{80},** with $R_{vir} \sim 20\, r_{80}$
- **Dragonfly Wide Field Survey:** "total light" images of nearby galaxies enable r_{95}, r_{99}, and better total stellar mass measurements