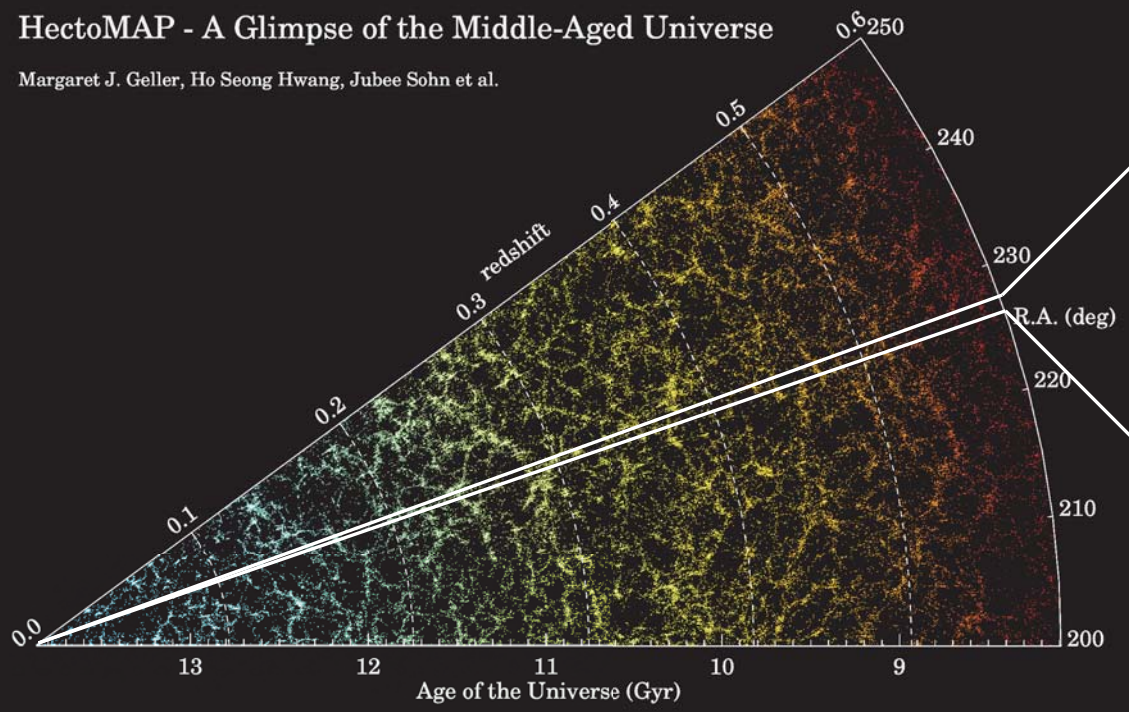
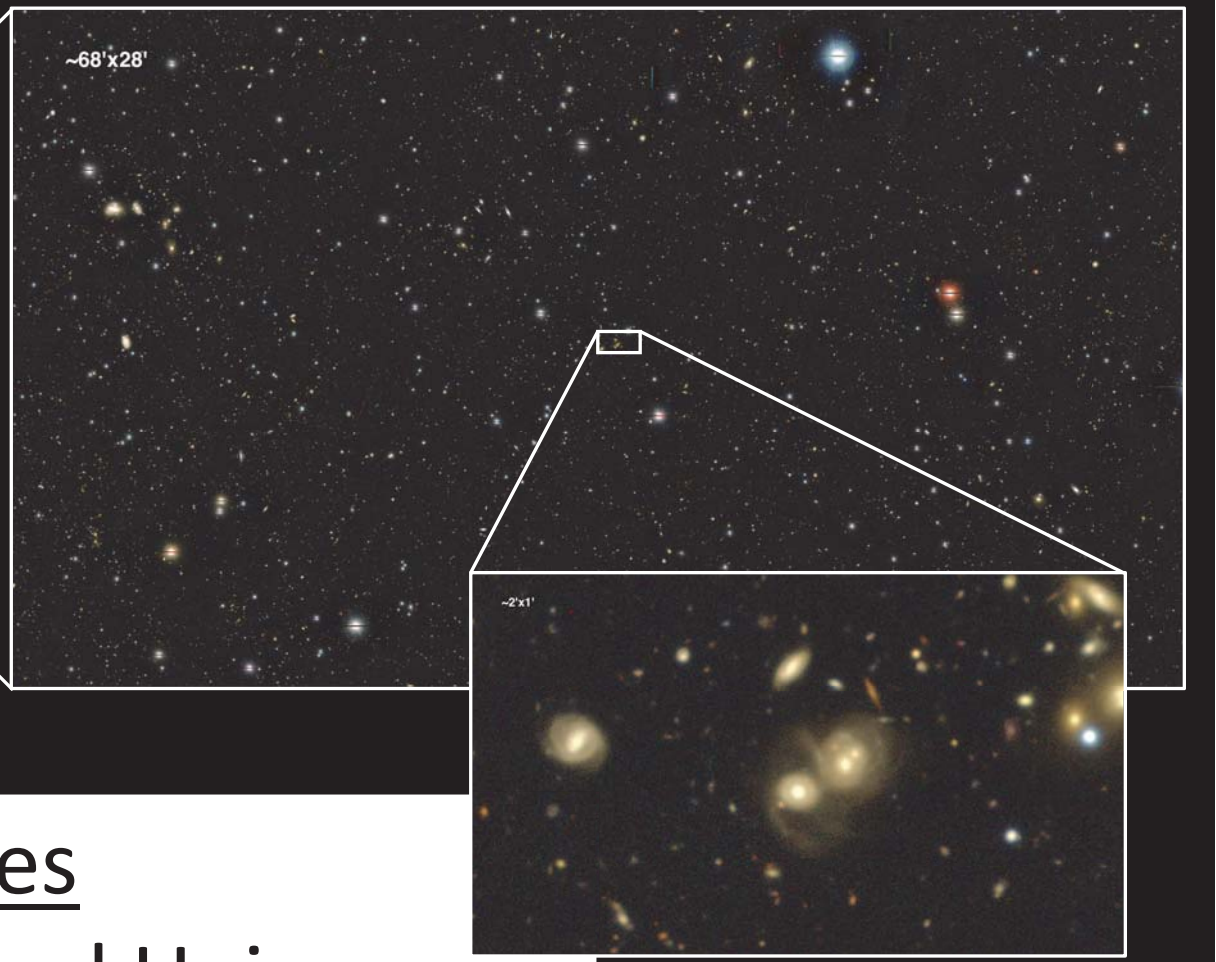
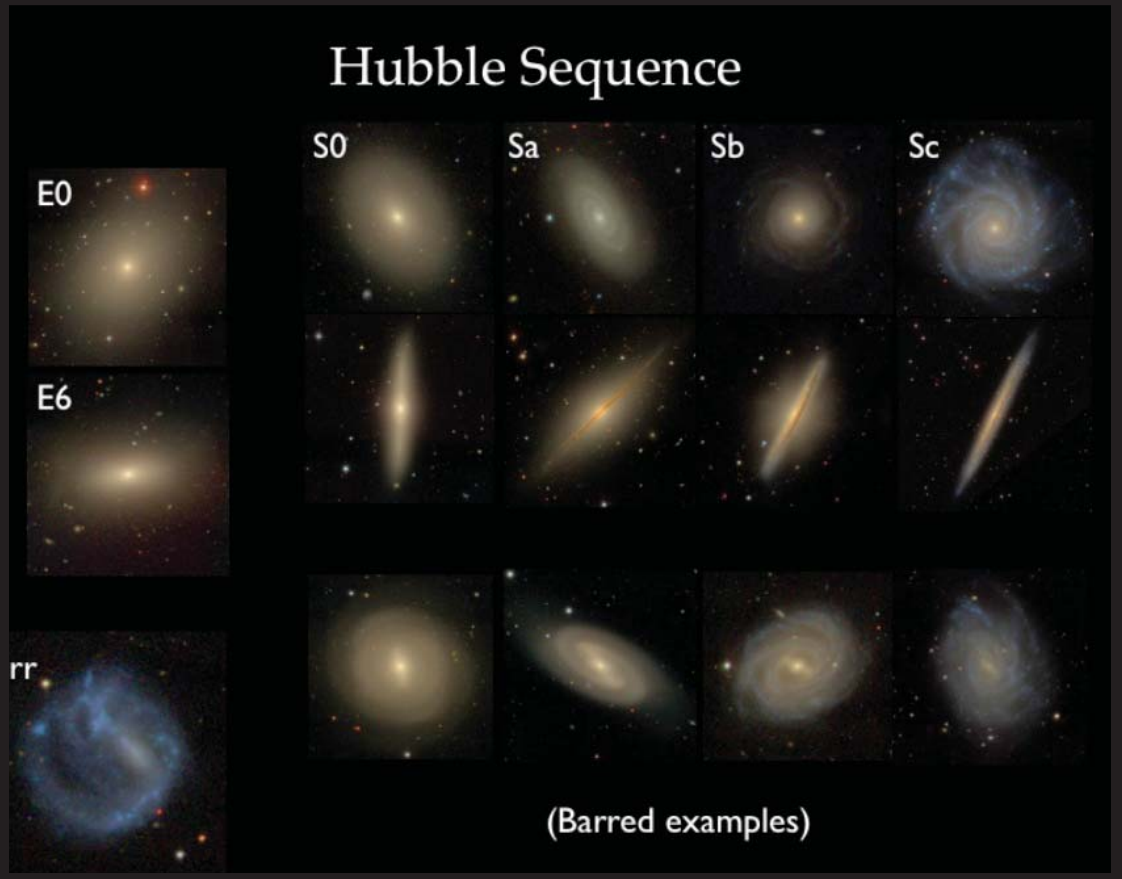


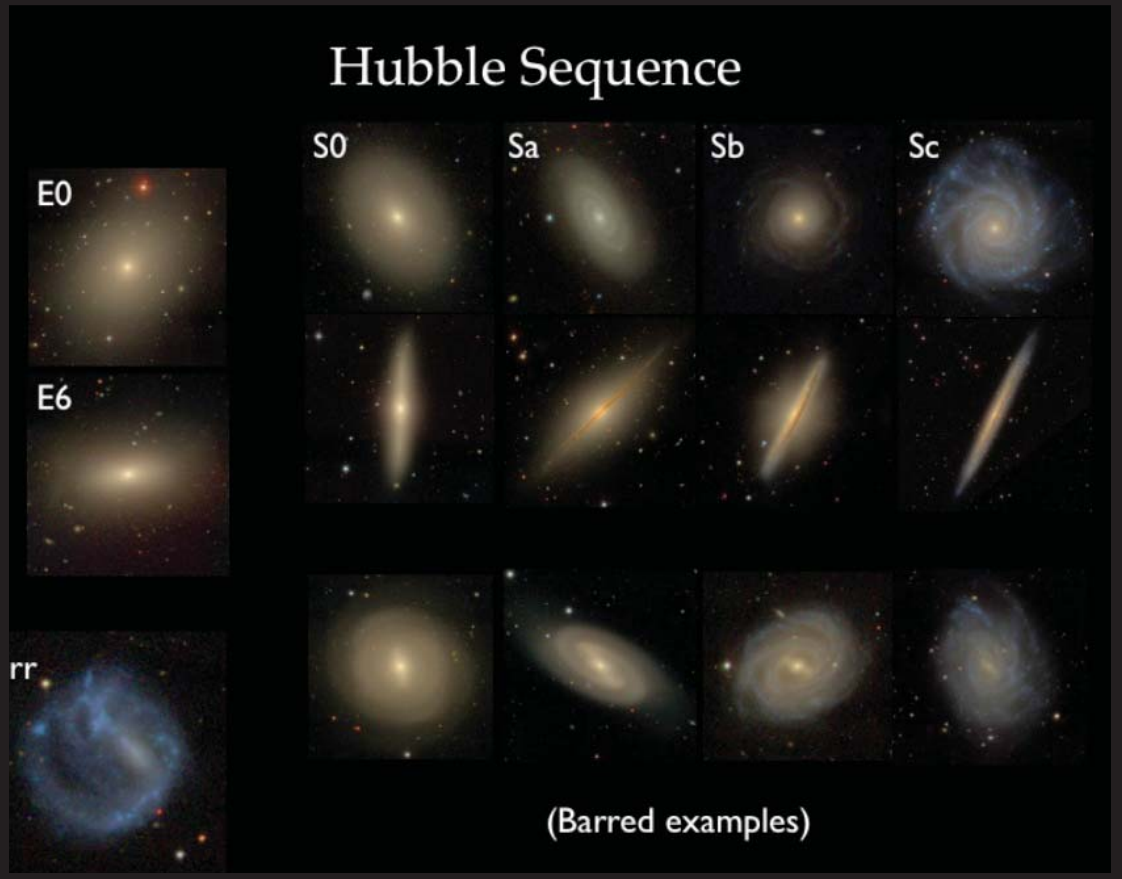


Galaxies in the Middle-Aged Universe

Ivana Damjanov
Canada Research Chair, Saint Mary's University
with the members of the Extragalactic Group at Saint Mary's,
Margaret Geller, Jabran Zahid, Jubee Sohn (SAO), Yousuke Utsumi (Stanford), Ian Dell'Antonio (Brown)



Credit: Mark Whittle, University of Virginia



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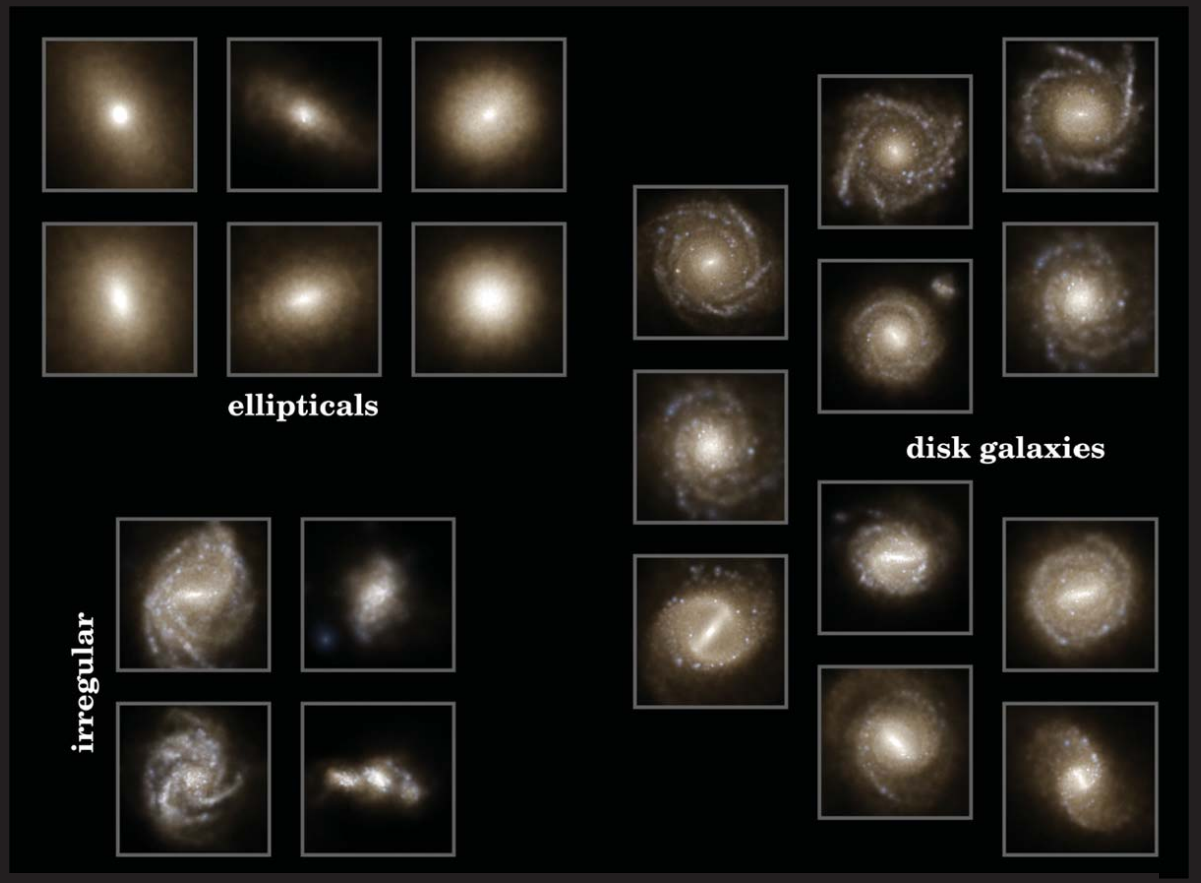
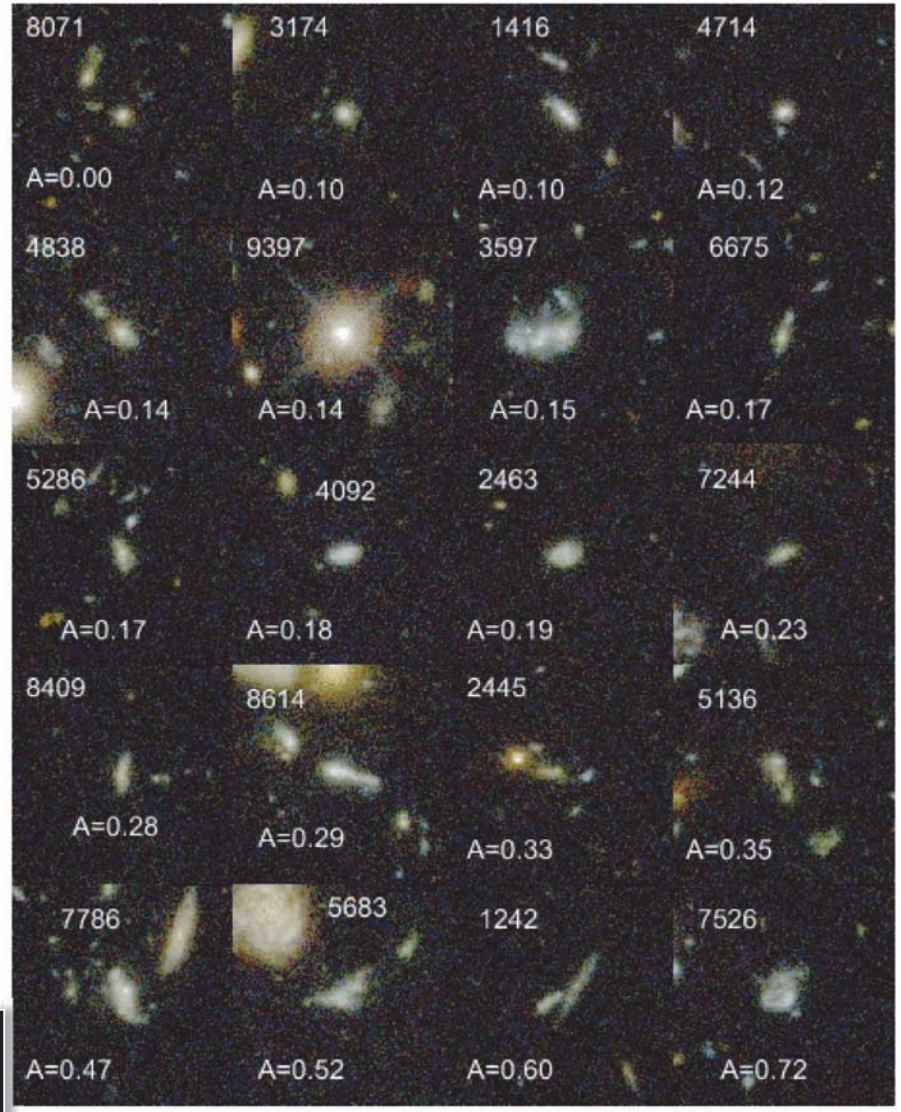
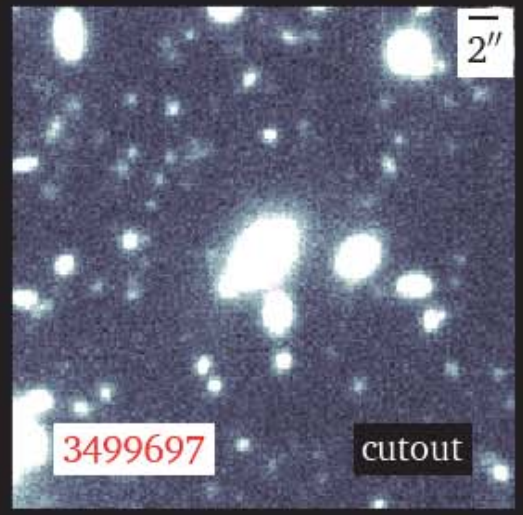


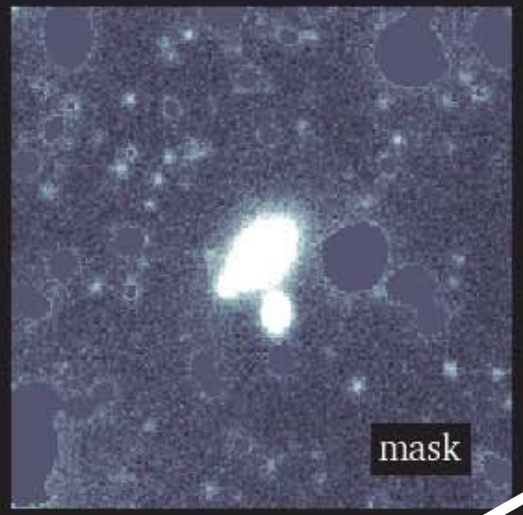
Credit: Illustris Team

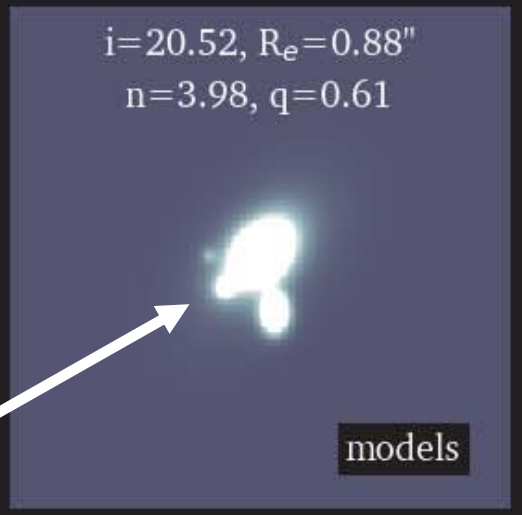


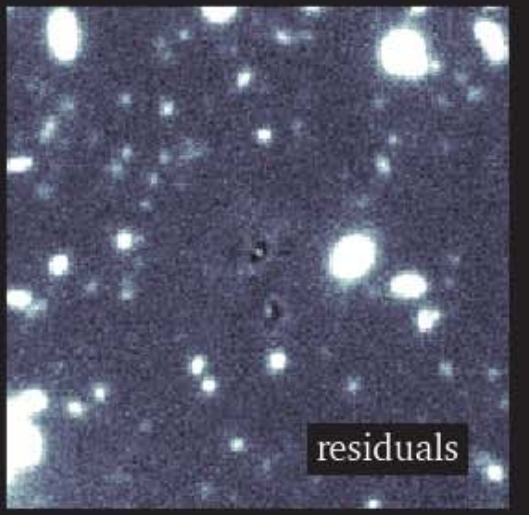
Conselice et al. 2008 (HUDF)

Sérsic (1968) profile fitting





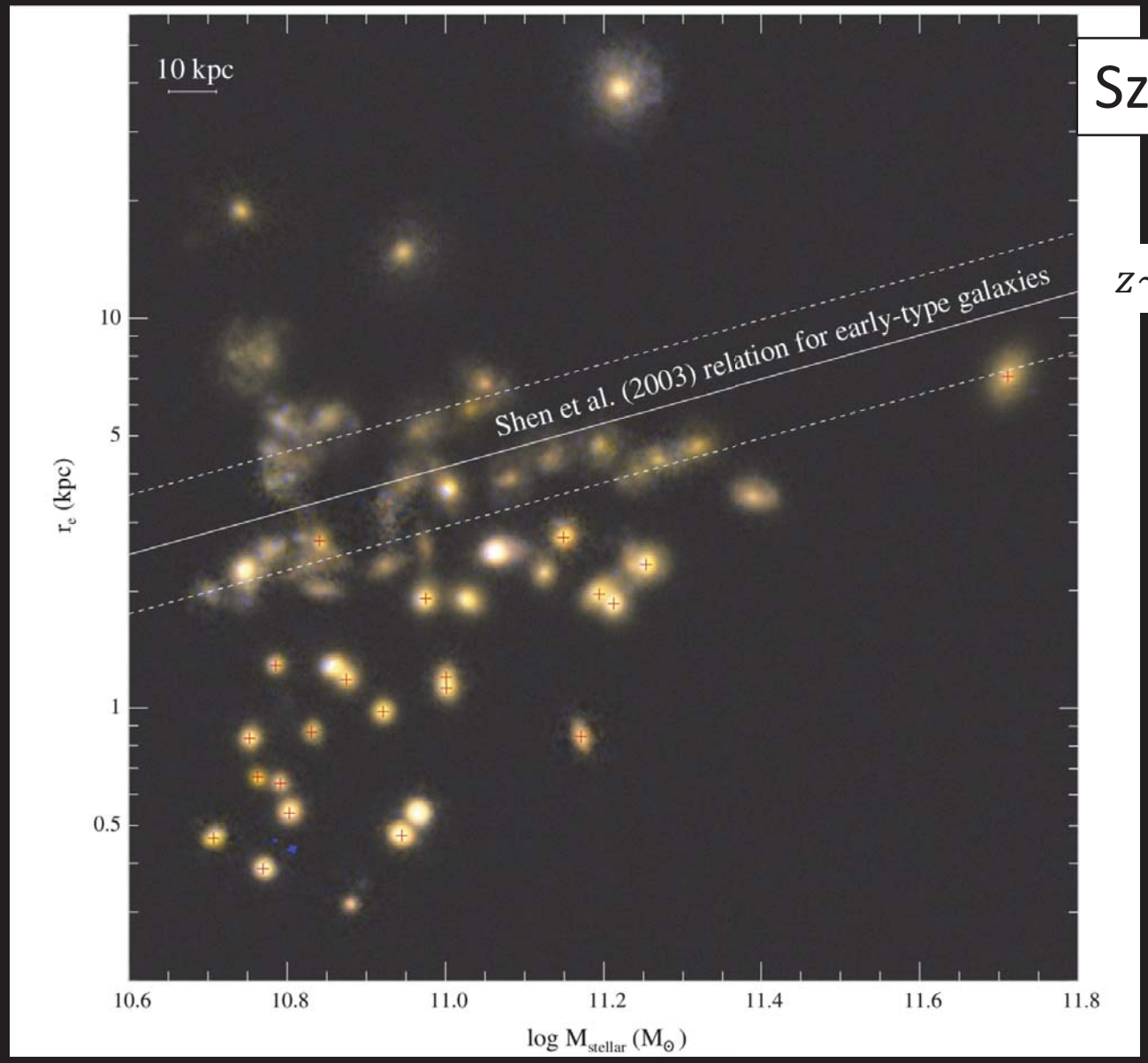




$$I(r) = I_0 \exp\left\{-b_n \left(\frac{r}{r_e}\right)^{1/n}\right\}$$

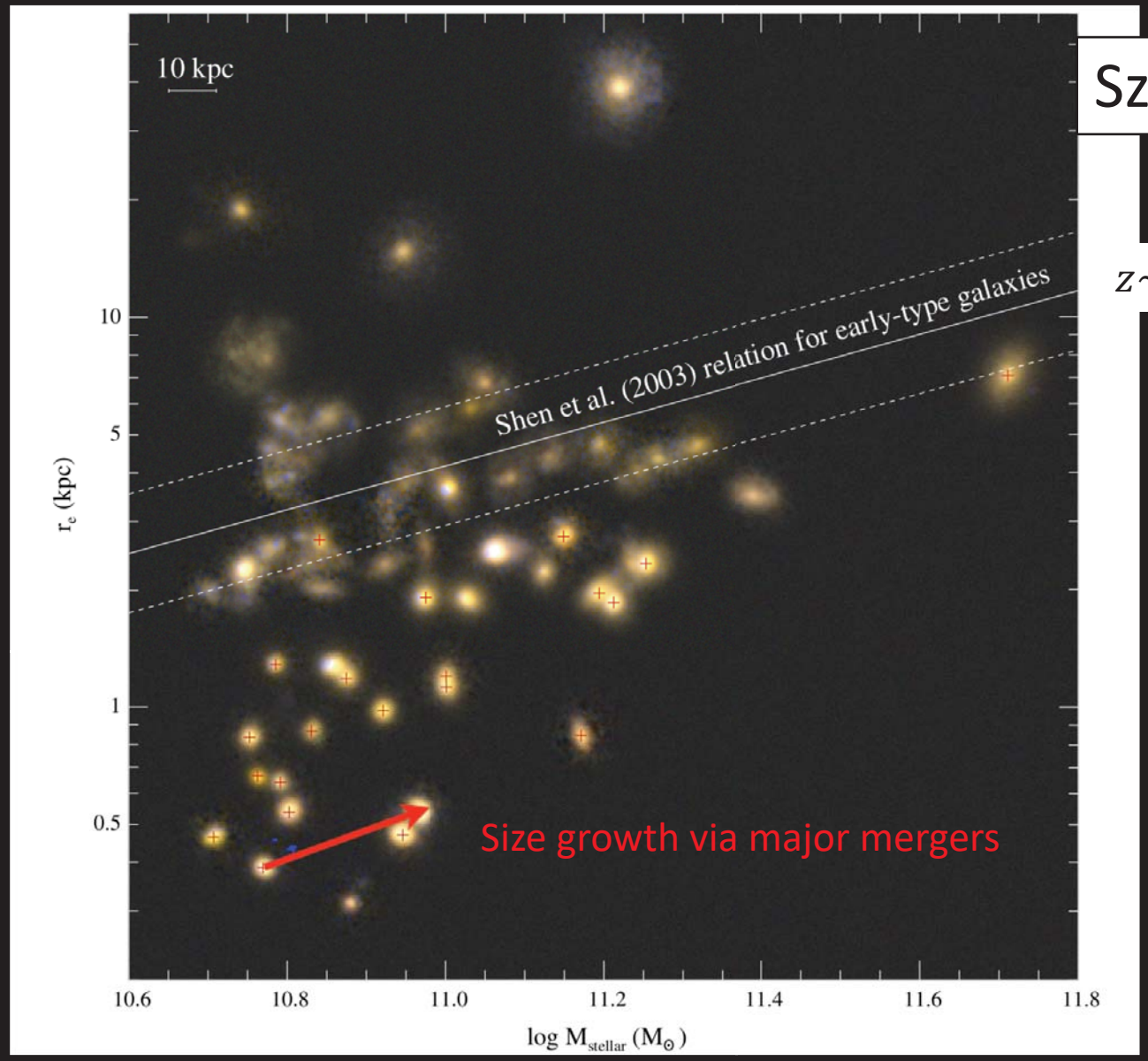
Angelo George, MSc in Astronomy, PhD candidate at Saint Mary's

Figure adapted from George et al. 2021 in prep.



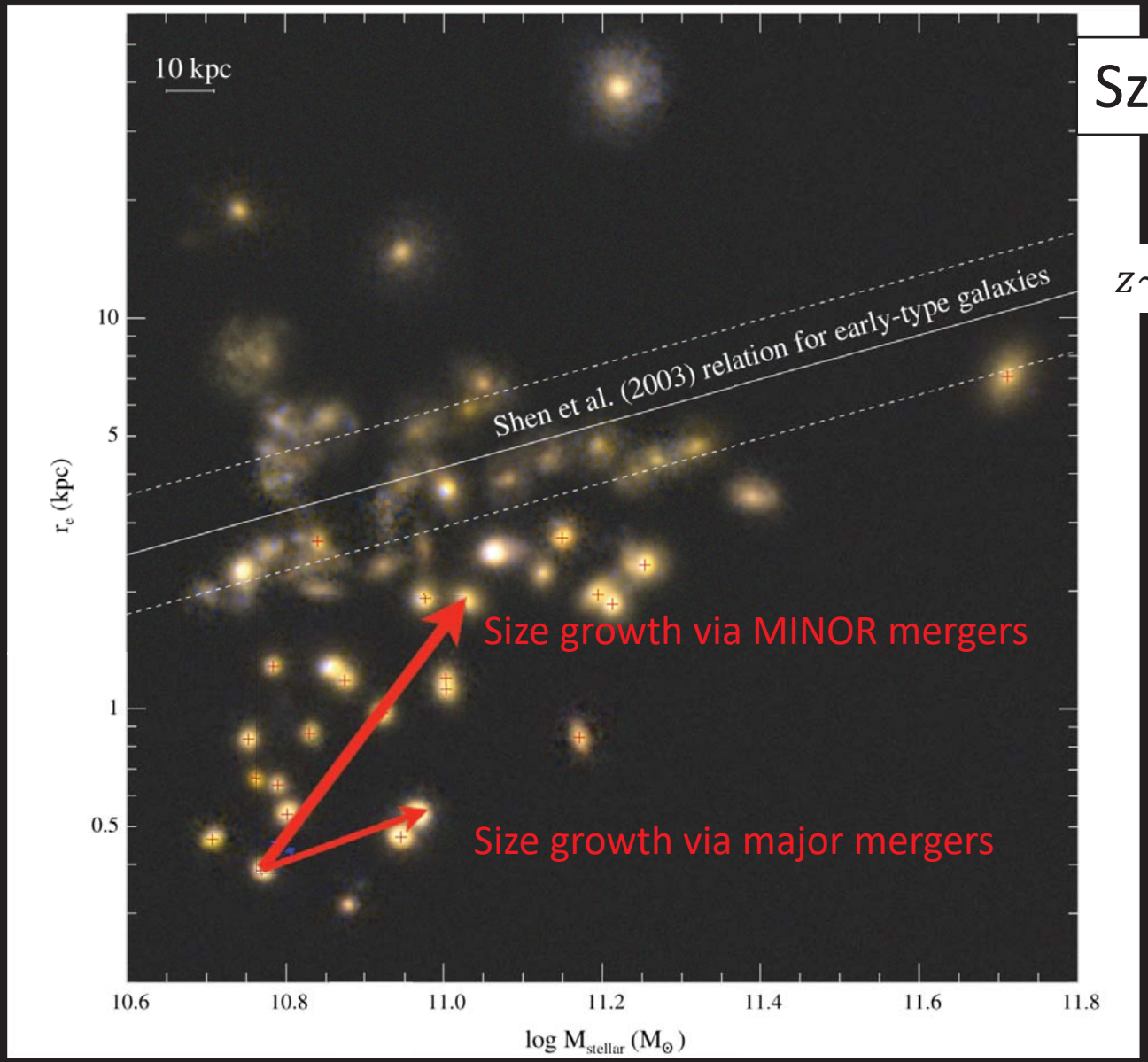
Szomoru et al. 2012

$z \sim 0$ Size-mass relation



Szomoru et al. 2012

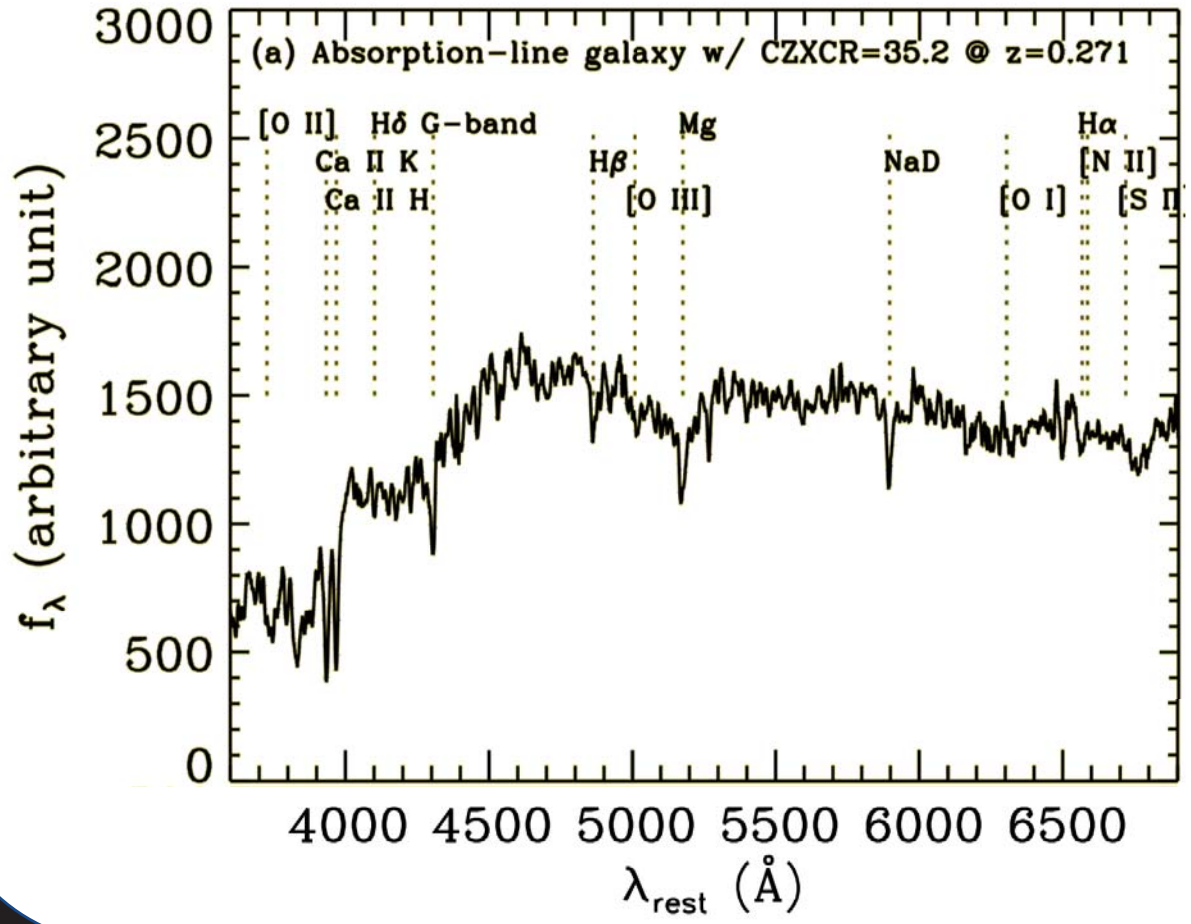
$z \sim 0$ Size-mass relation

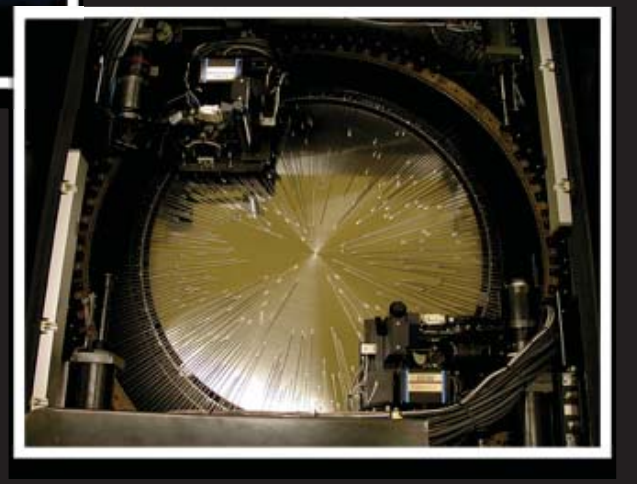


Szomoru et al. 2012

$z \sim 0$ Size-mass relation

SHELS spectra (Geller et al. 2014)

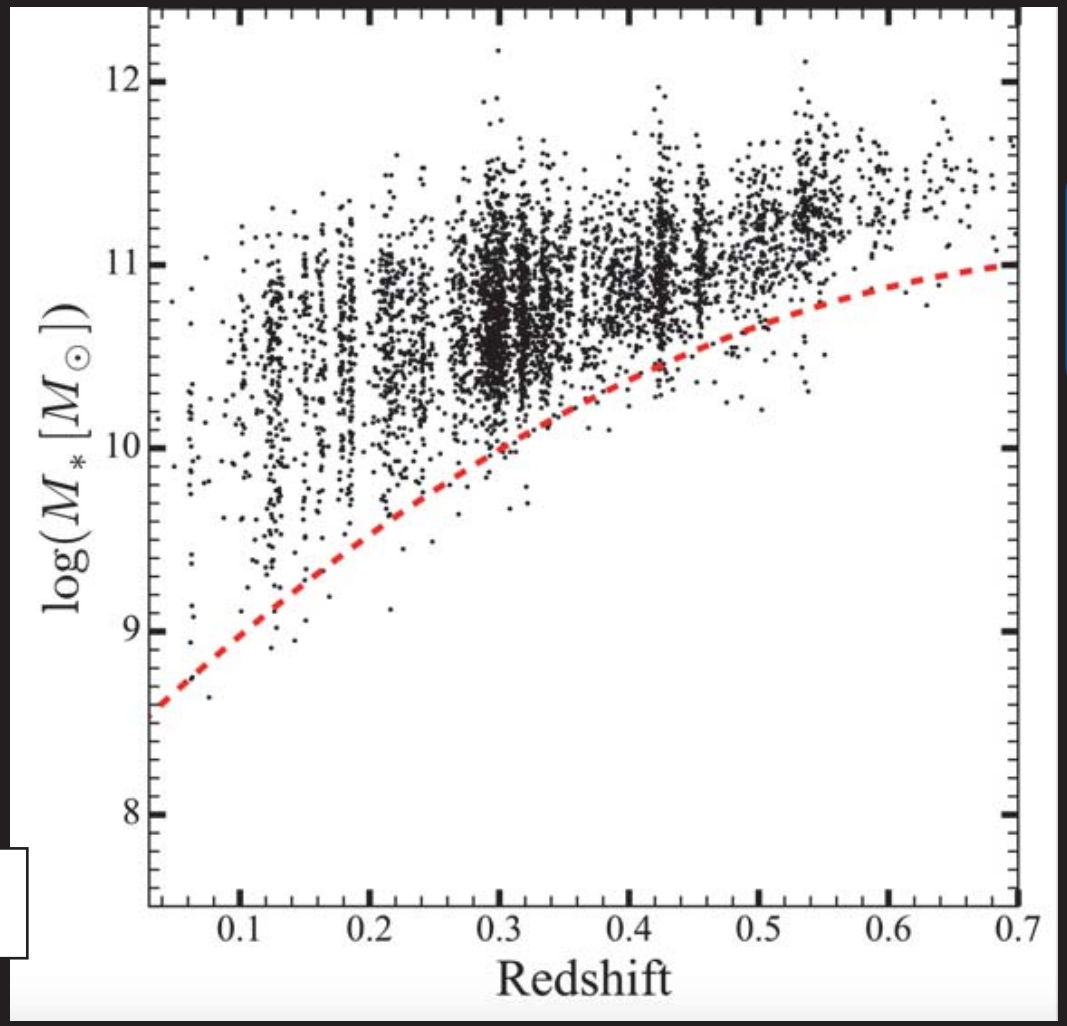




DATASET:

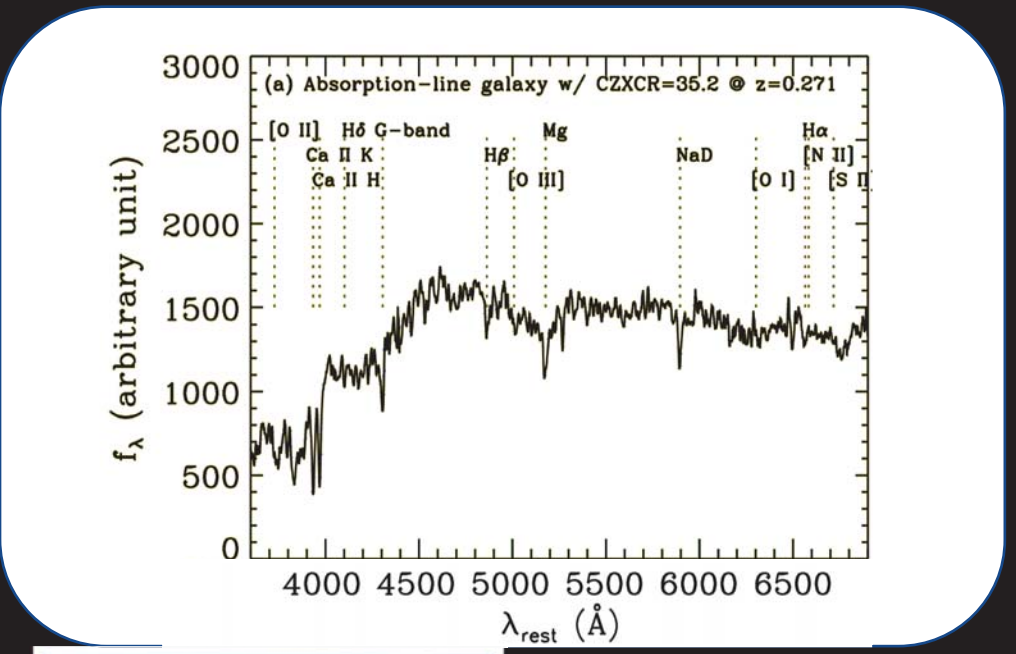
- 4 deg2
- Spectroscopy:
  - redshift
  - Dn4000
  - stellar mass
  - velocity dispersion
- Limiting magnitude $r_{\mathrm{SDSS}} \sim 20.9$

Following size-mass-age relations for quiescent galaxies through cosmic time



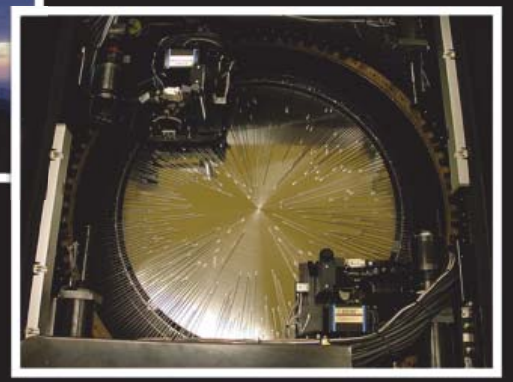
~4000 quiescent objects

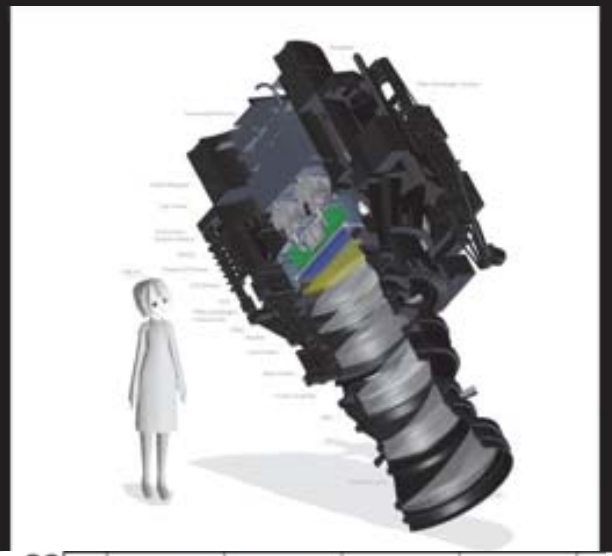
Damjanov et al. 2019

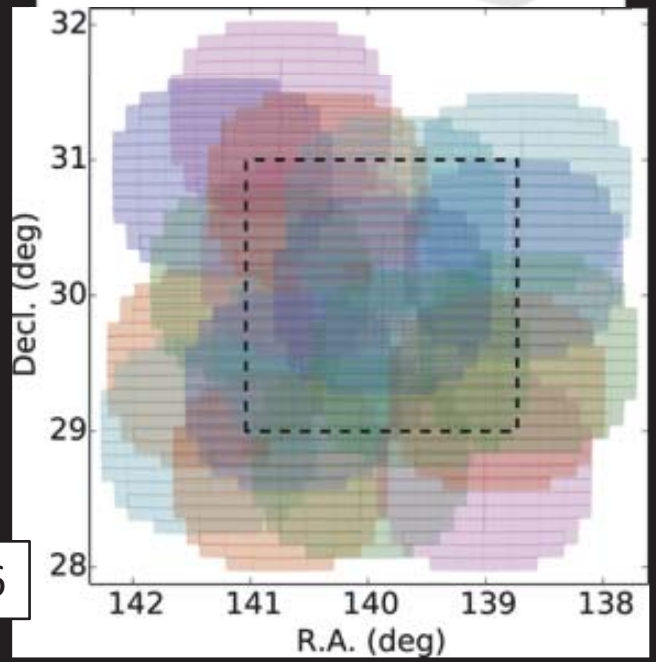


DATASET:

- 4 deg2
- Spectroscopy:
  - redshift
  - Dn4000
  - stellar mass
  - velocity dispersion
- Limiting magnitude $r_{\mathrm{SDSS}} \sim 20.9$
- Imaging: Hyper Suprime-Cam i-band with ~0.5" resolution



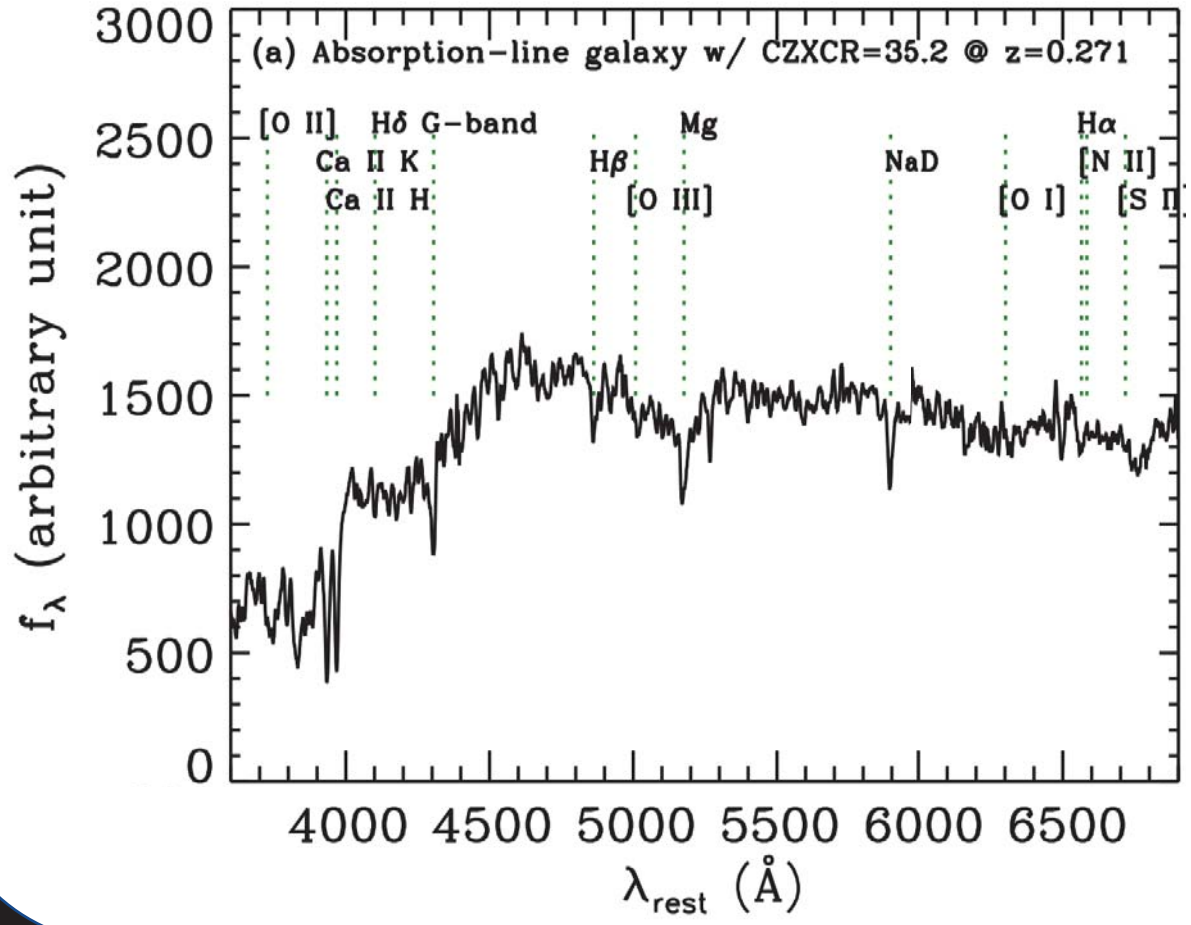




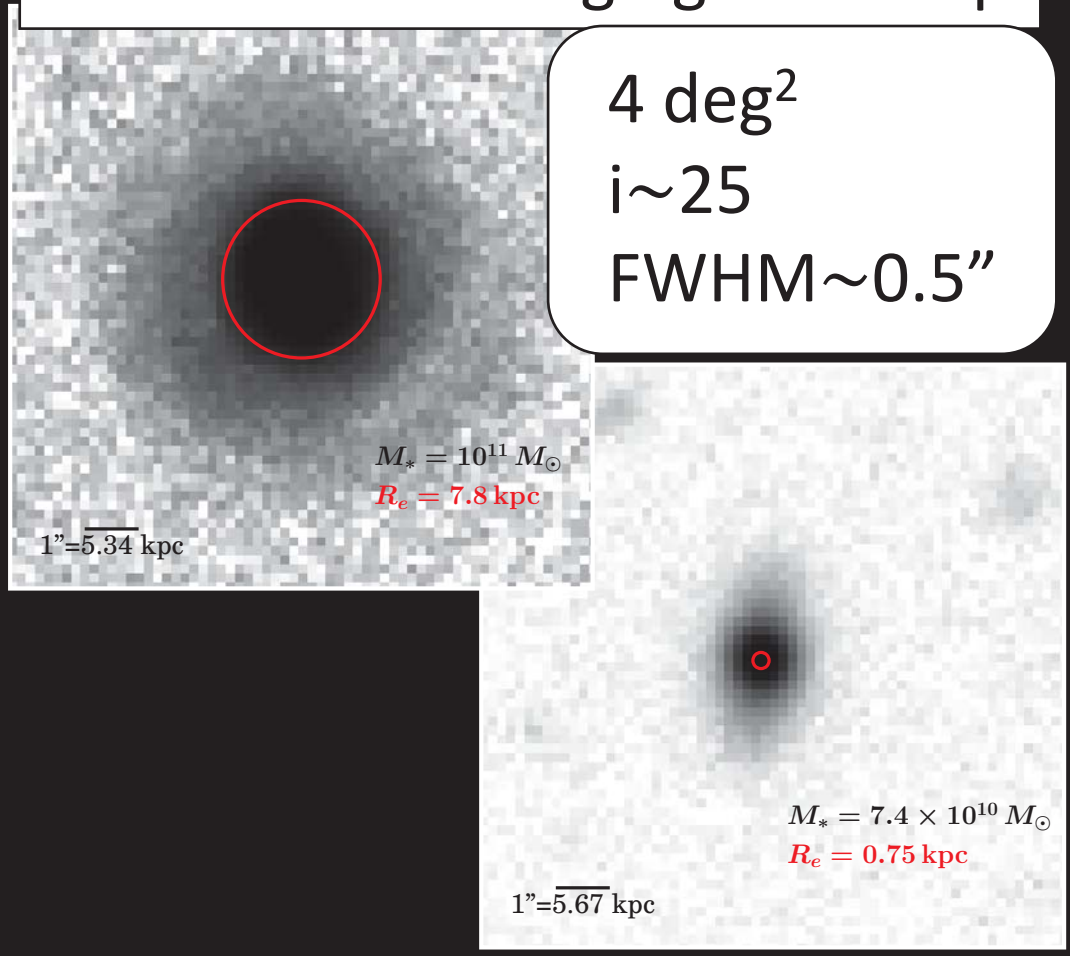
Utsumi et al. 2016

Following size-mass-age relations for quiescent galaxies through cosmic time

SHELS spectra (Geller et al. 2014)

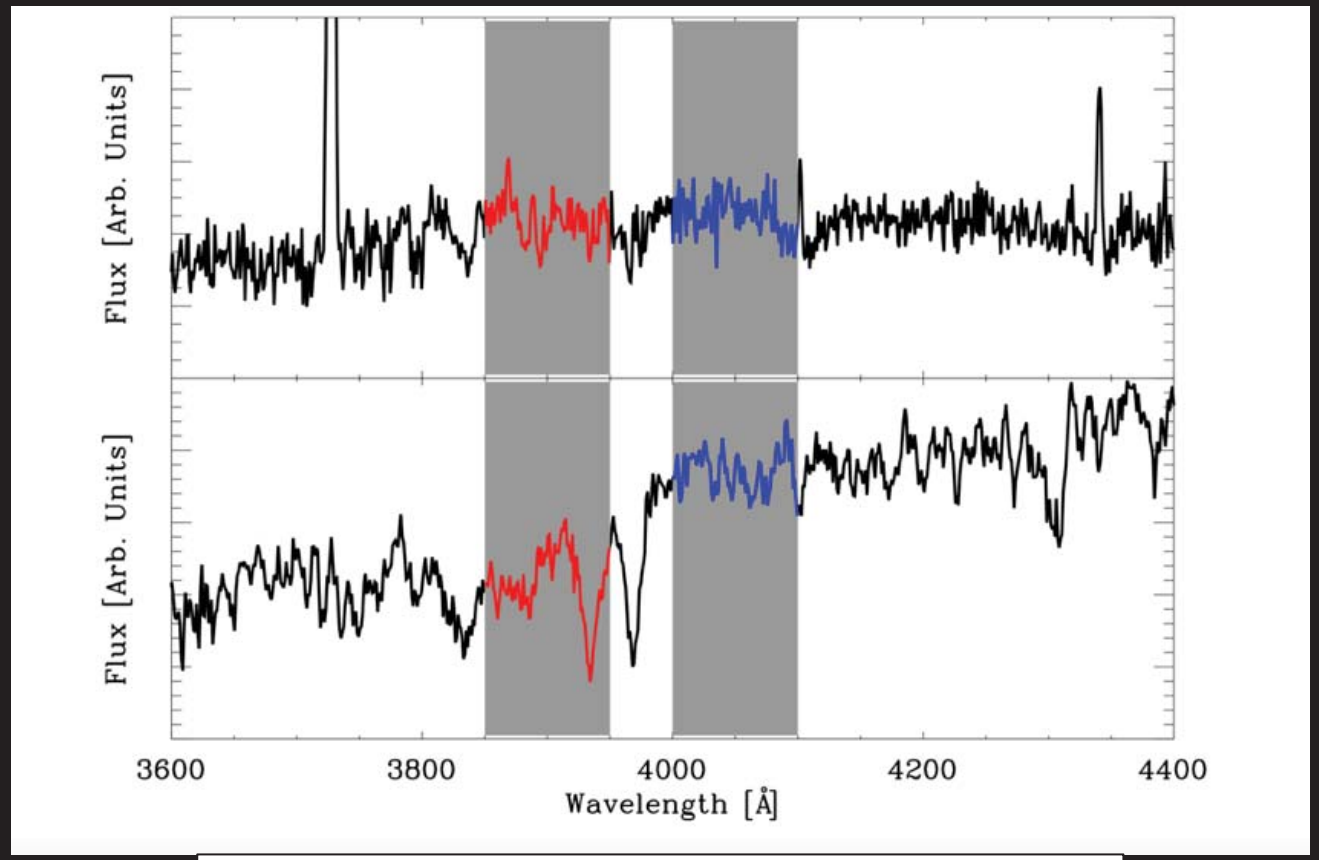


and their HSC imaging follow-up

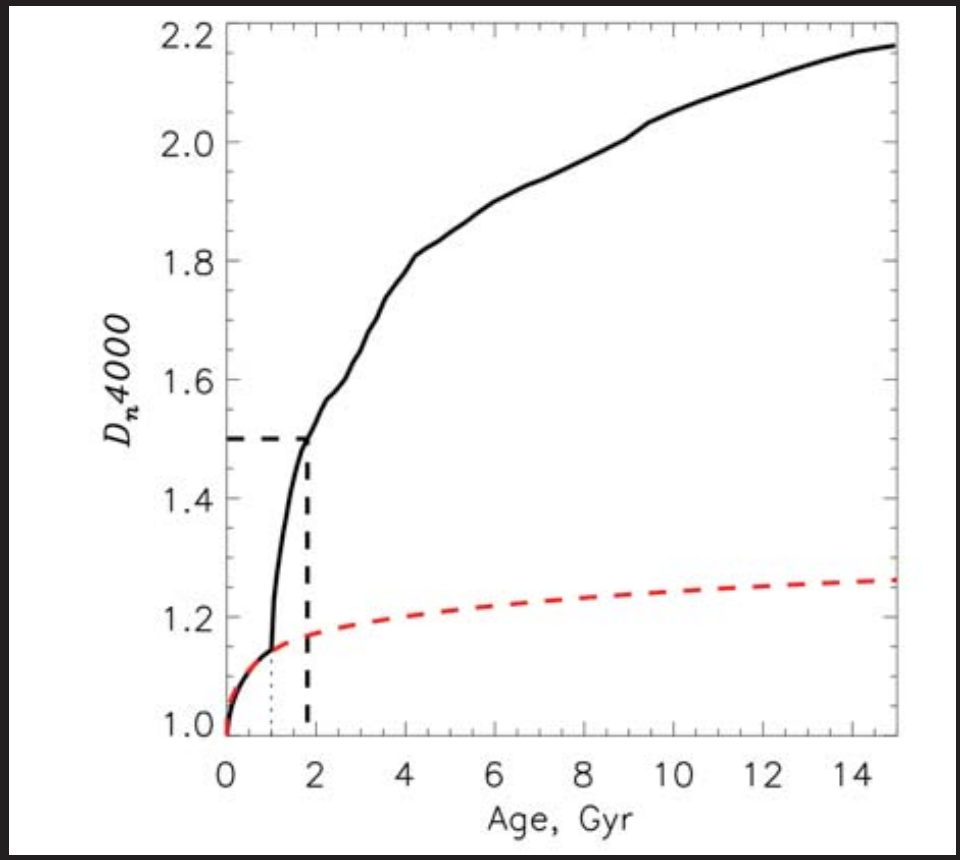


4 deg^2
i~25
FWHM~0.5"

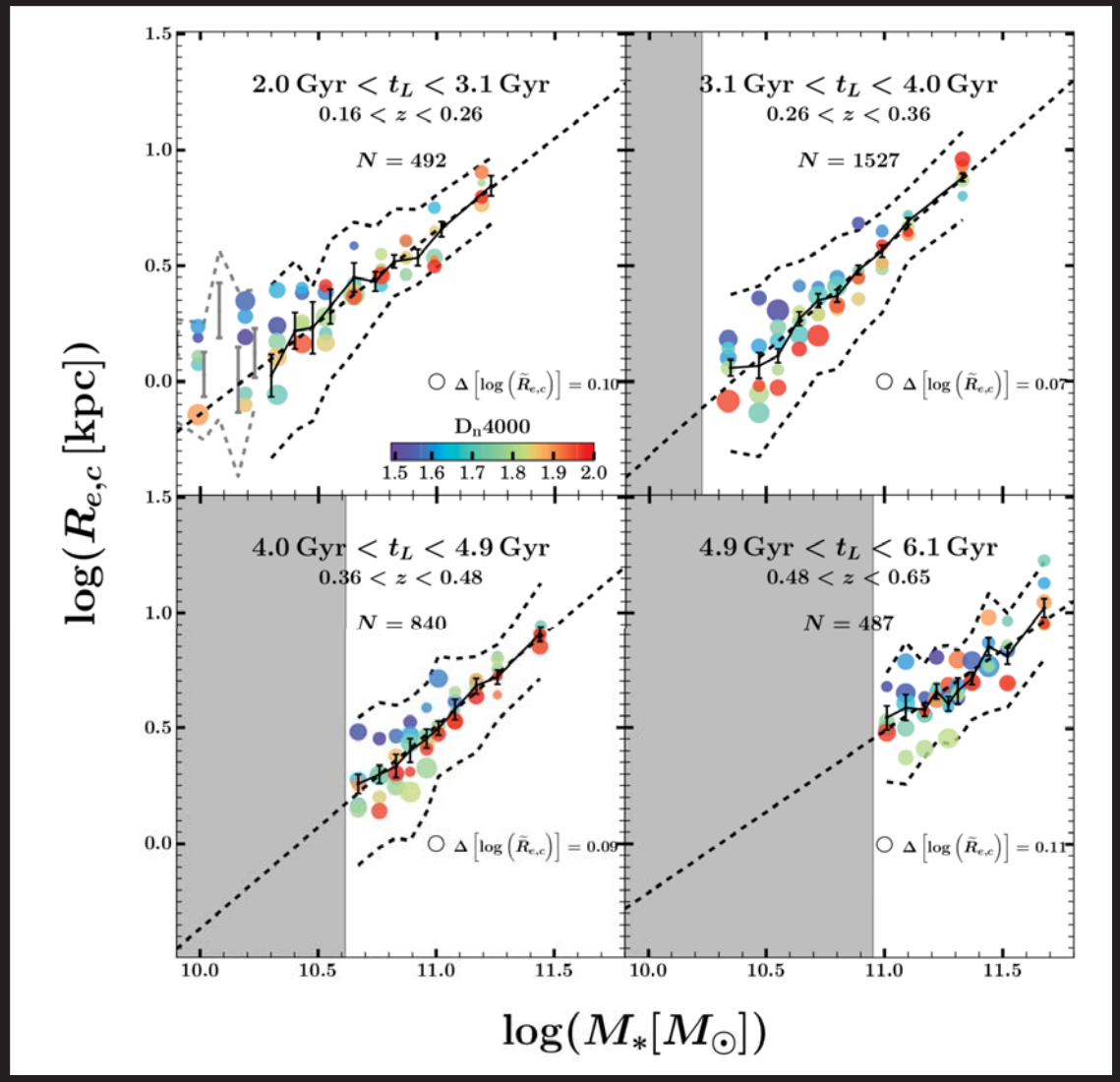
Following the change in galaxy properties with age - Dn4000 index



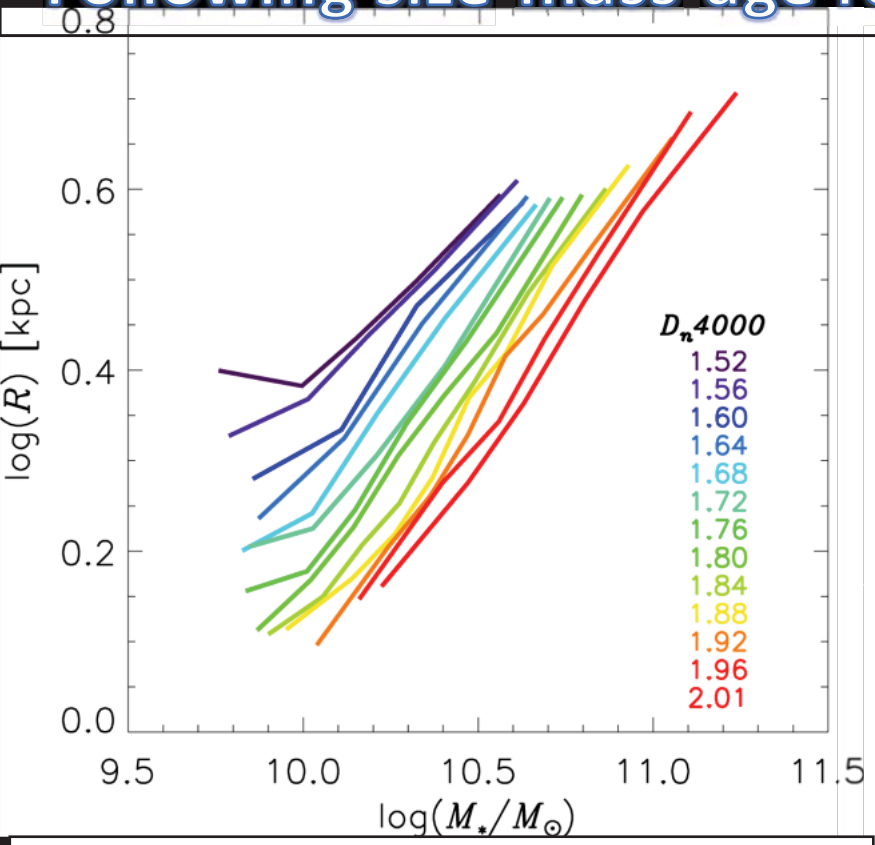
EXAMPLES: SHELS Spectra (Geller et al. 2014)



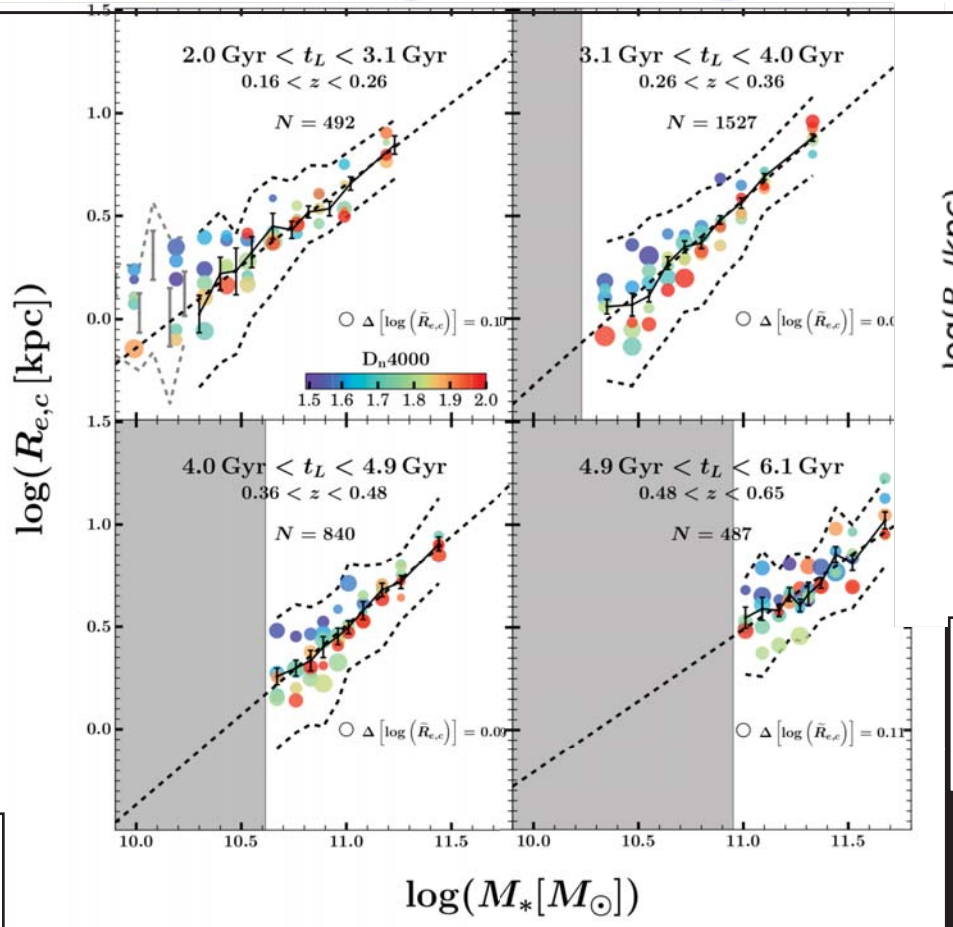
Following size-mass-age relations for quiescent galaxies through cosmic time



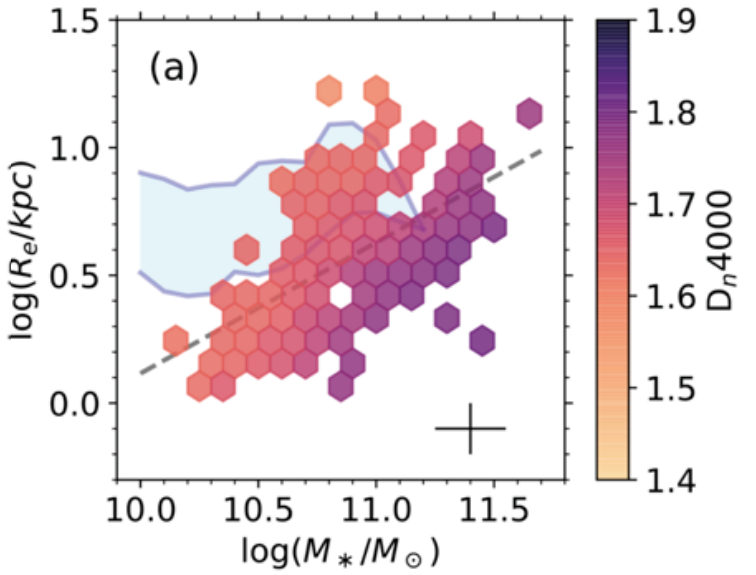
Following size-mass-age relations for quiescent galaxies through cosmic time



The relation between quiescent galaxy size, mass, and age at z~0
(Zahid & Geller 2017)



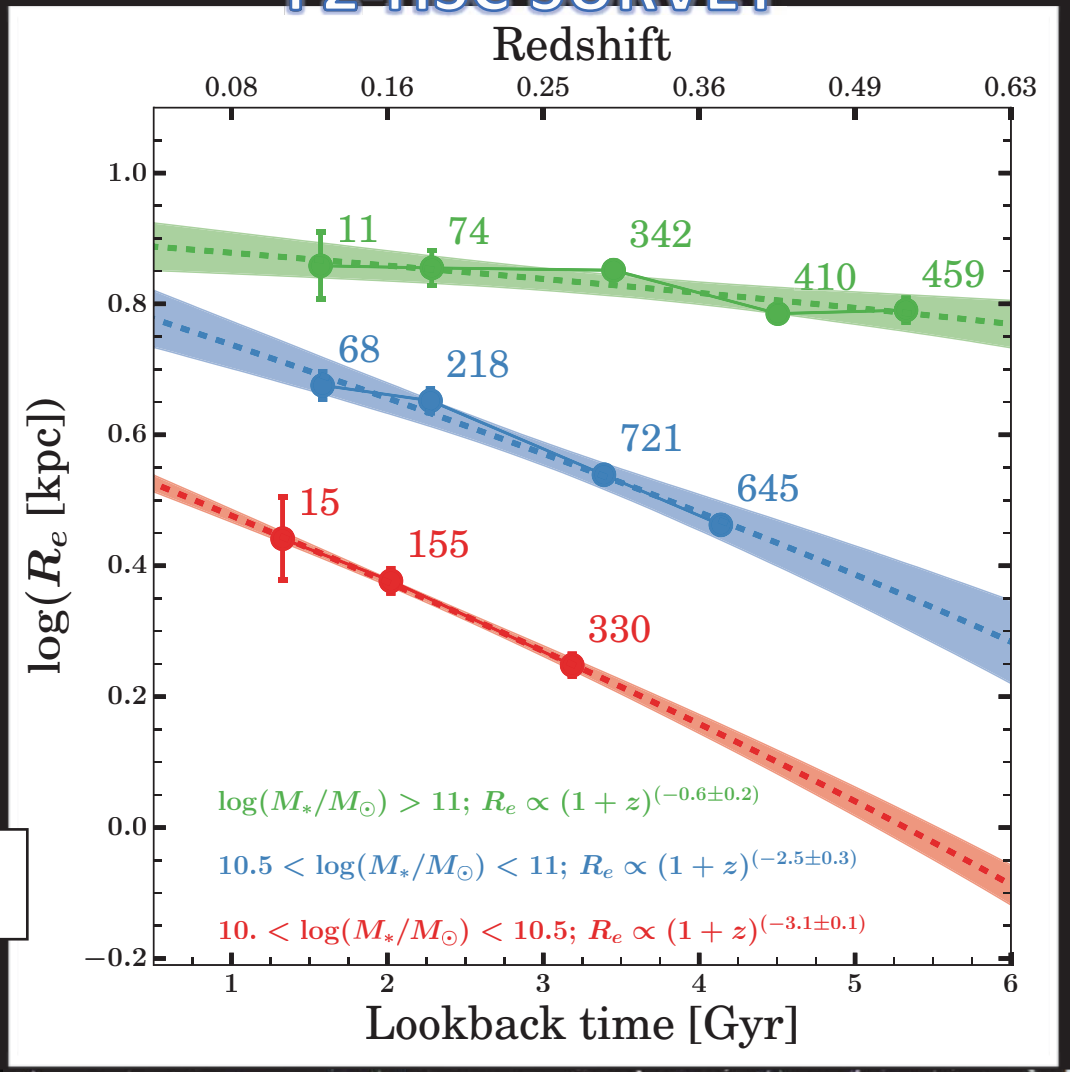
Damjanov et al. 2019



z~0.7 relations
(Wu et al. 2018, LEGA-C)

Average size growth of quiescent galaxies over 6 Billion years of cosmic time

F2-HSC SURVEY



Damjanov et al. 2019

Average size growth of quiescent galaxies over 6 Billion years of cosmic time

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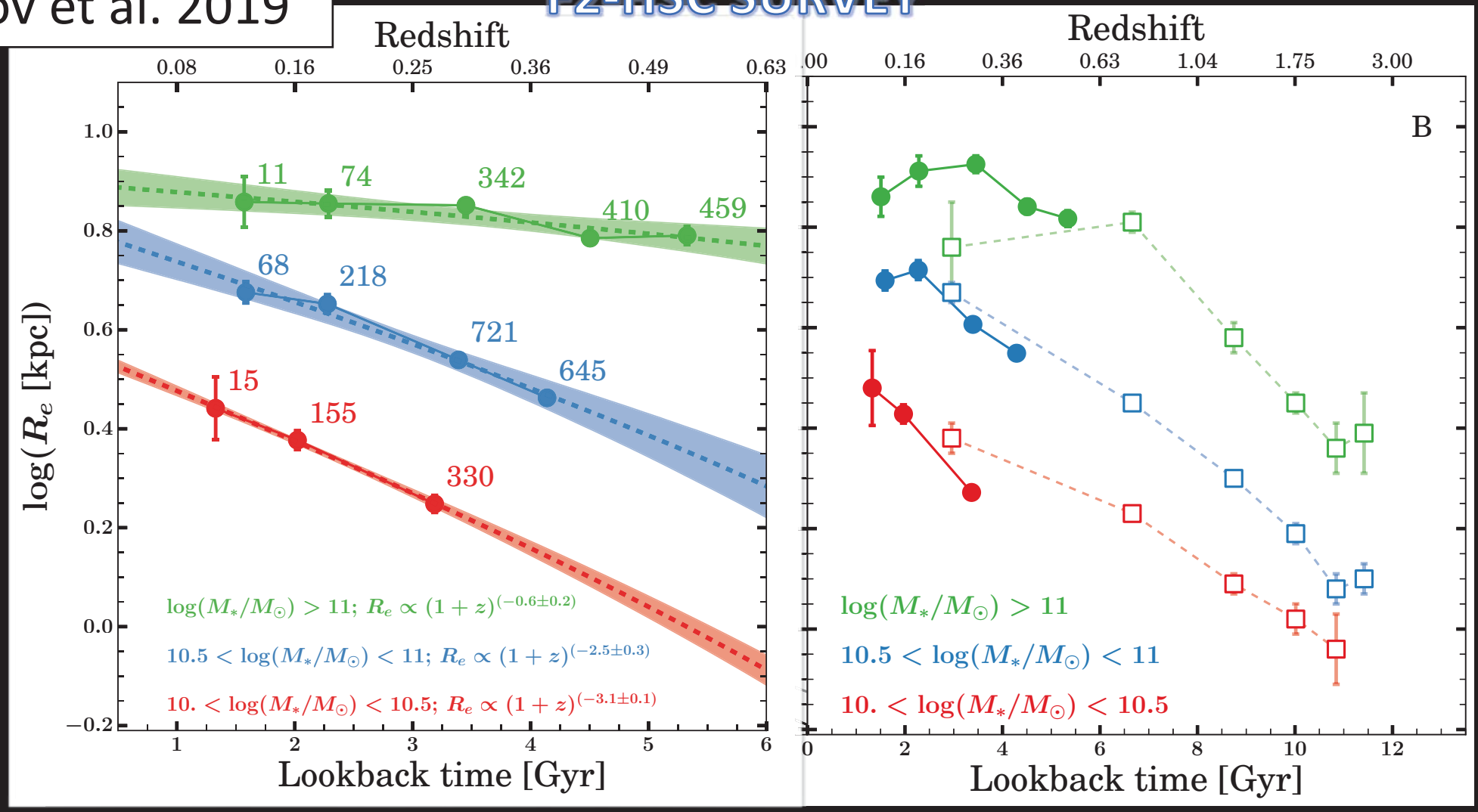
Damjanov et al. 2019



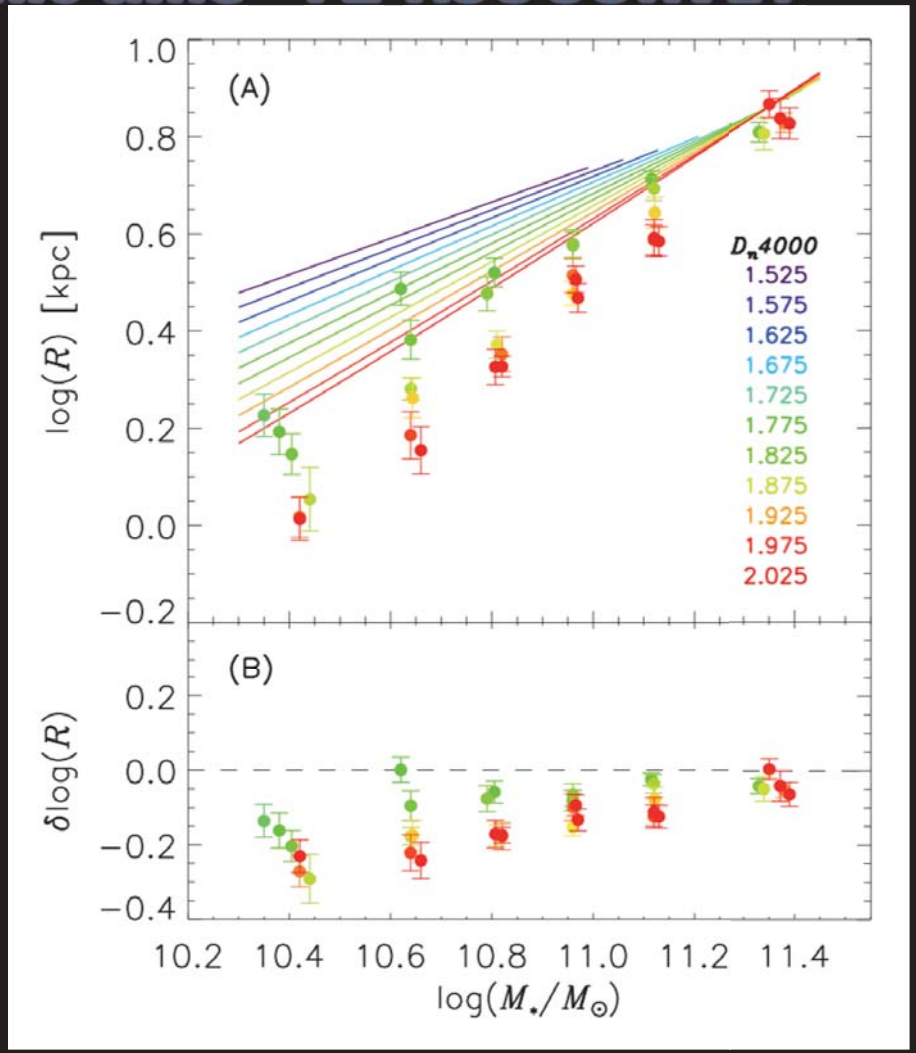
Ivana Damjanov

Modeling the evolution of spectro-photometric properties of quiescent galaxies over 6 billion years of cosmic time - F2-HSC SURVEY

$$\Delta\log(R) = \alpha\Delta\log(M_*)$$

$$\Delta\log(M_*) = \log\left(\frac{M_*^e}{M_*}\right)$$

Zahid et al. 2019



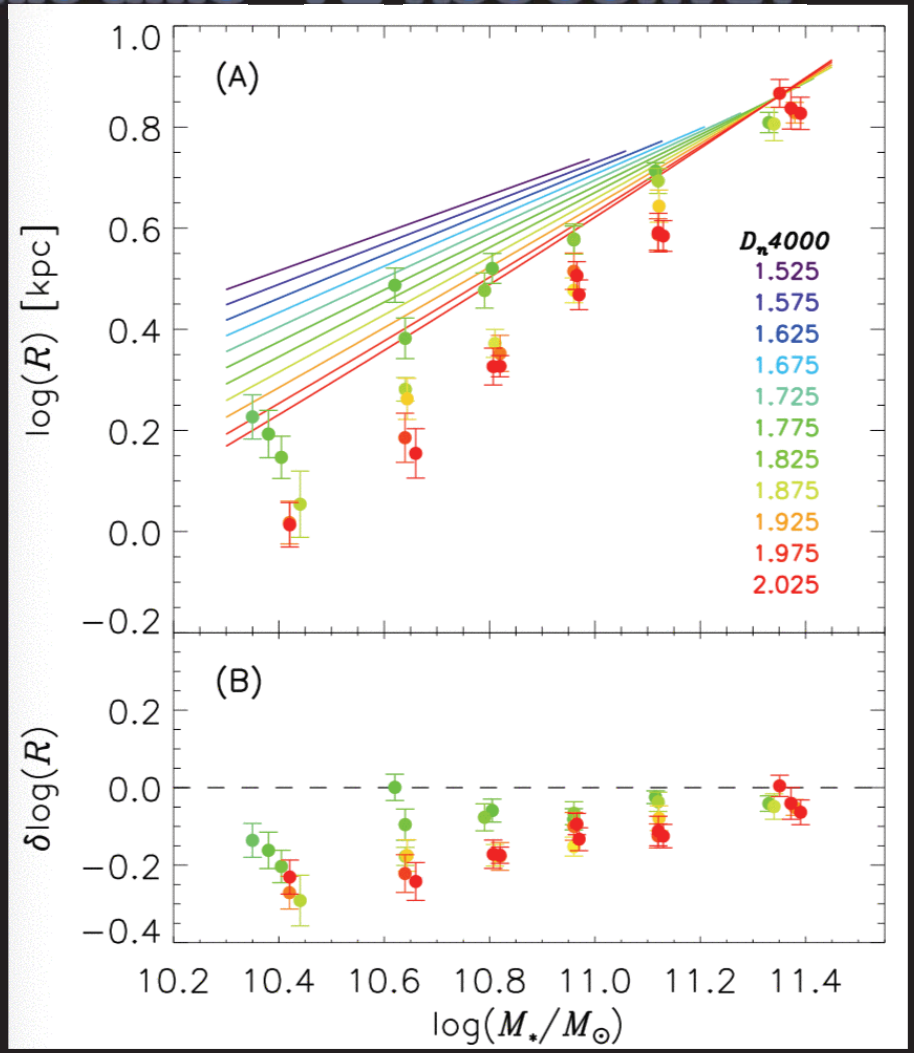
Modeling the evolution of spectro-photometric properties of quiescent galaxies over 6 billion years of cosmic time - F2-HSC SURVEY

$$\Delta\log(R) = \alpha\Delta\log(M_*)$$

$$\Delta\log(M_*) = \log\left(\frac{M_*^e}{M_*}\right)$$

$$\alpha = 1.5$$

Zahid et al. 2019

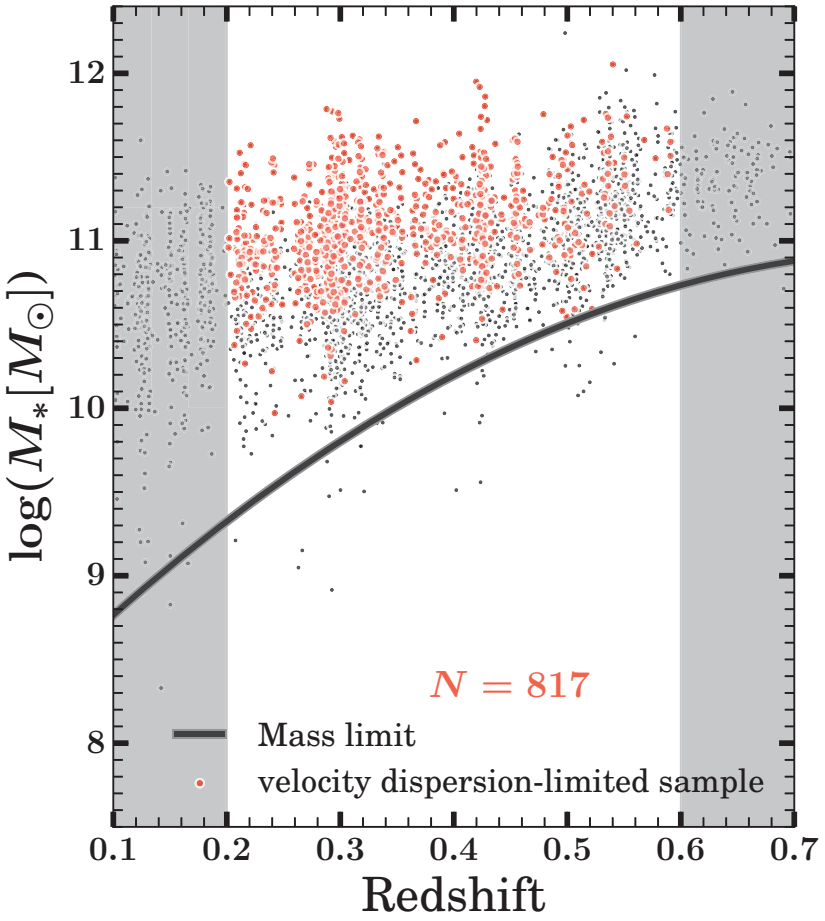


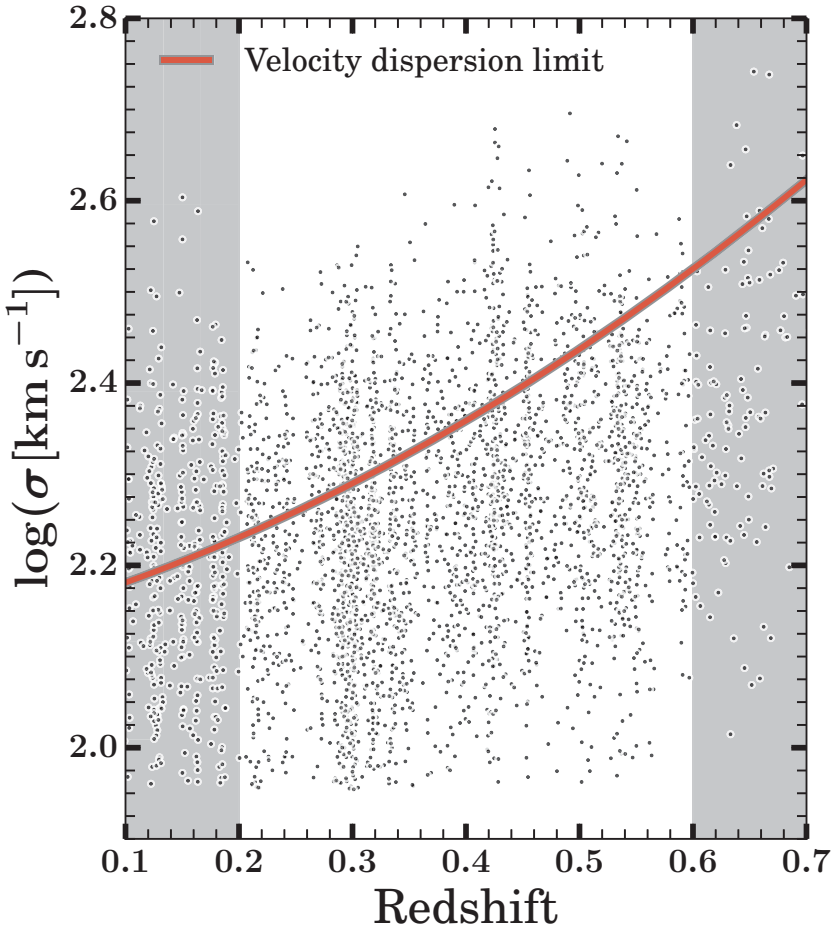
Ivana Damjanov

The evolution in the dynamical to stellar mass ratio of quiescent galaxies over 6 billion years of cosmic time - F2-HSC SURVEY

$$M_{dyn} = \frac{\beta(n)\sigma^2 r_e}{G}$$

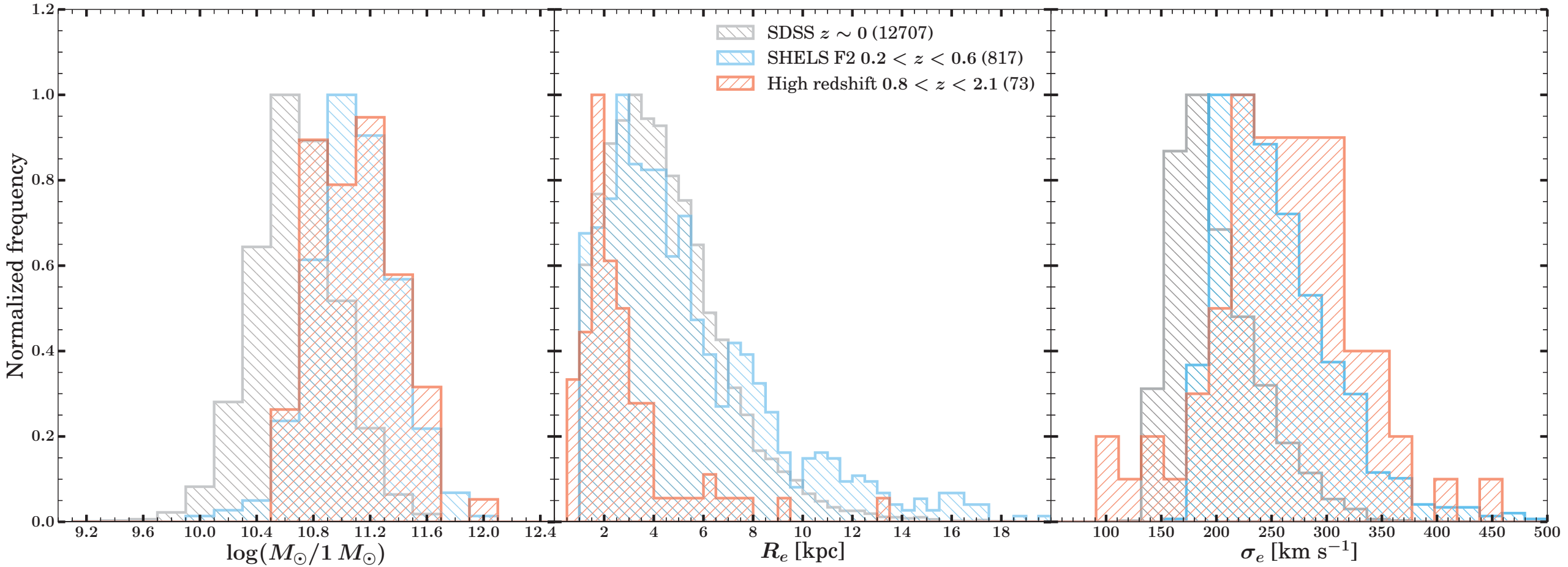
Damjanov et al. 2021
to be submitted





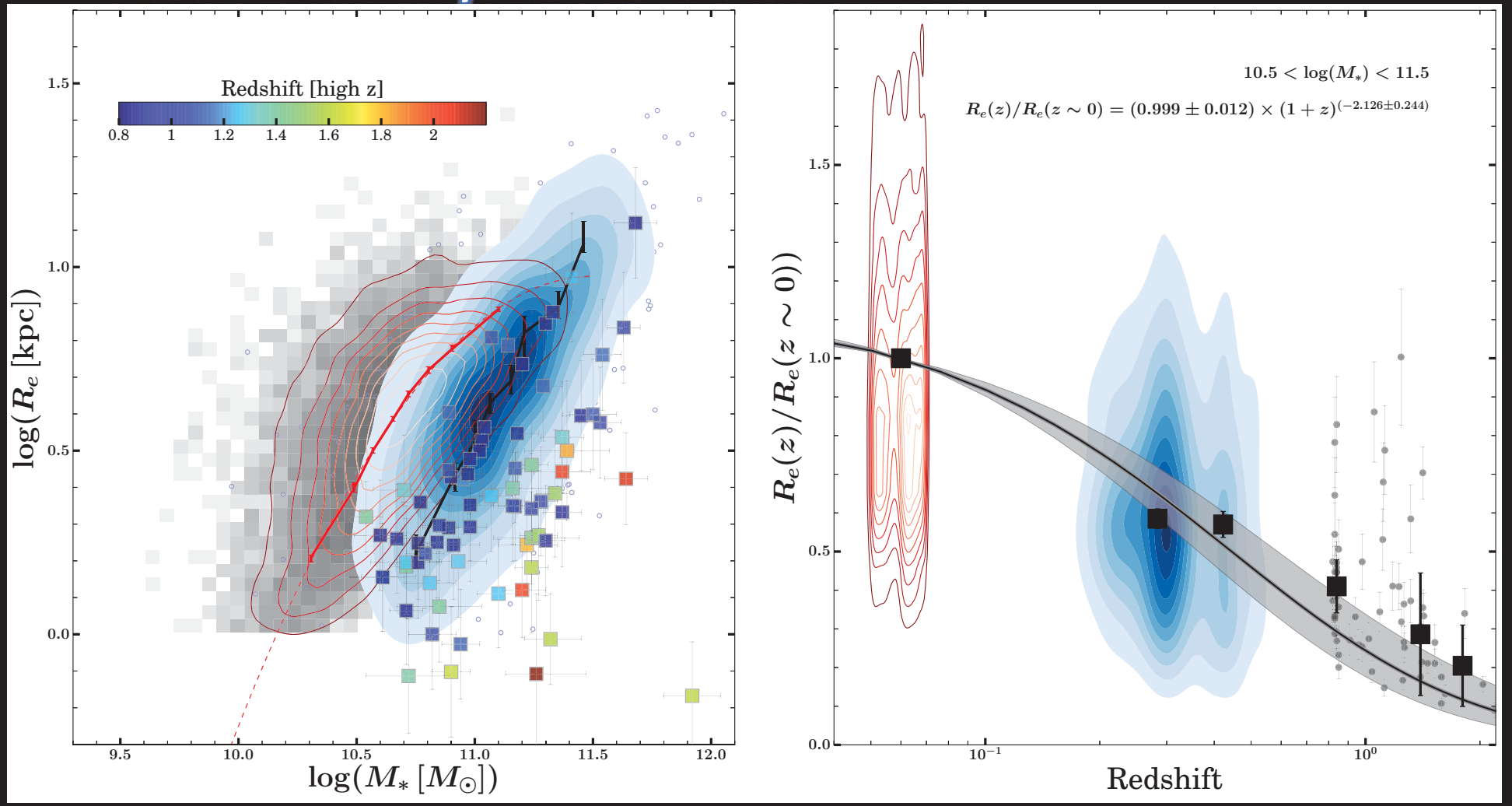
Canada Research Chairs / Chaires de recherche du Canada
Ivana Damjanov
Saint Mary's University

The evolution in the dynamical to stellar mass ratio of quiescent galaxies over 6 billion years of cosmic time - F2-HSC SURVEY



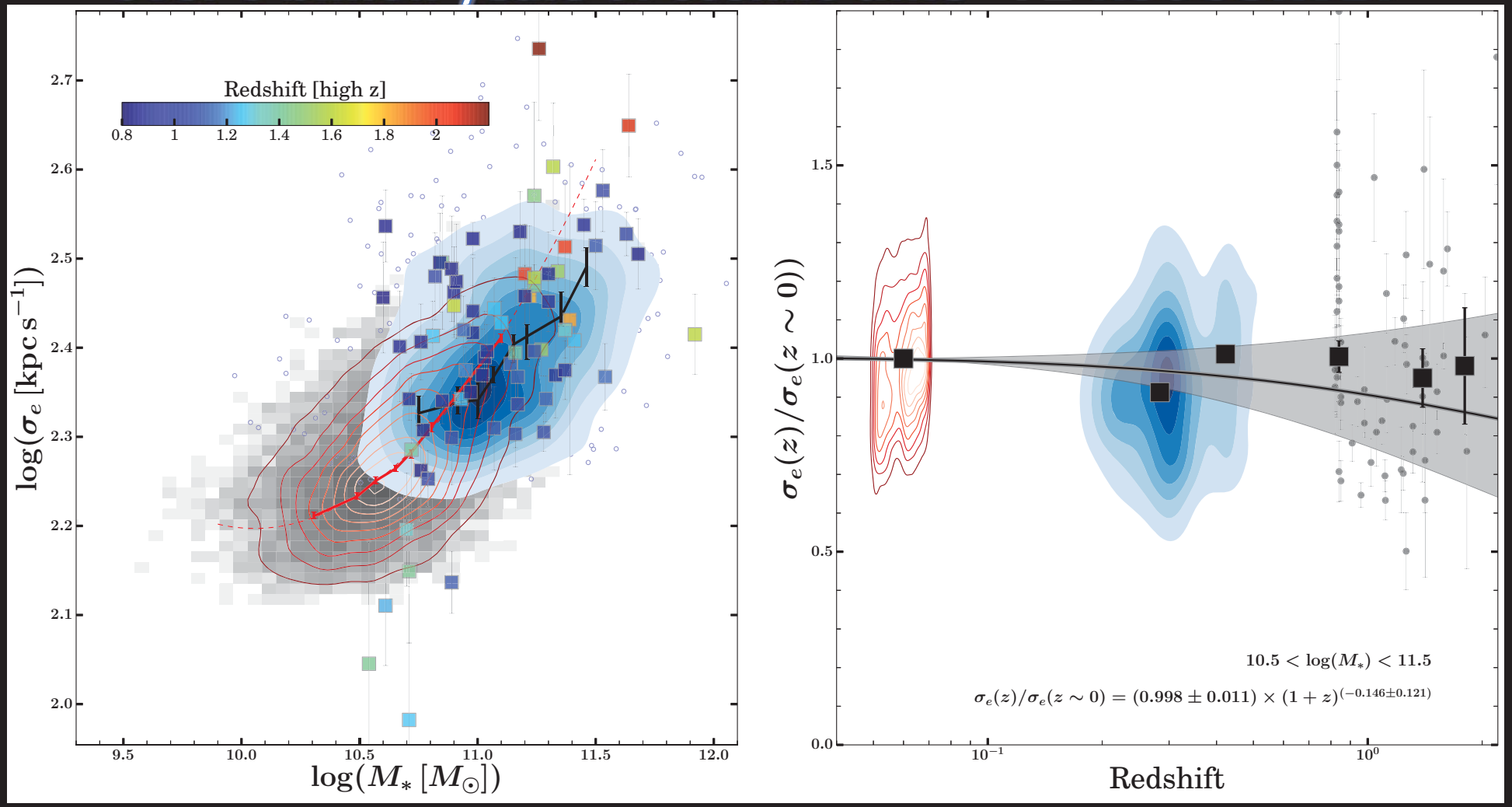
Ivana Damjanov

The evolution in the dynamical to stellar mass ratio of quiescent galaxies over 6 billion years of cosmic time - F2-HSC SURVEY



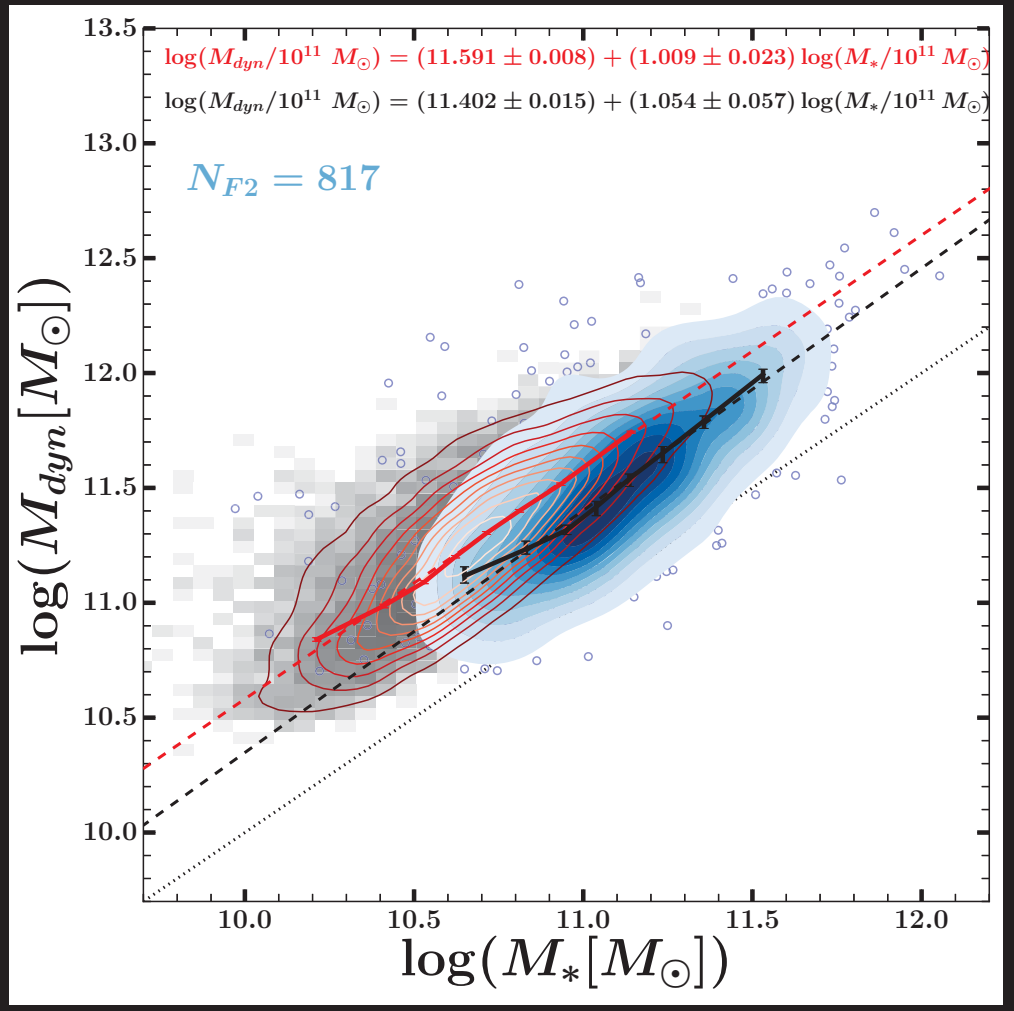
Ivana Damjanov

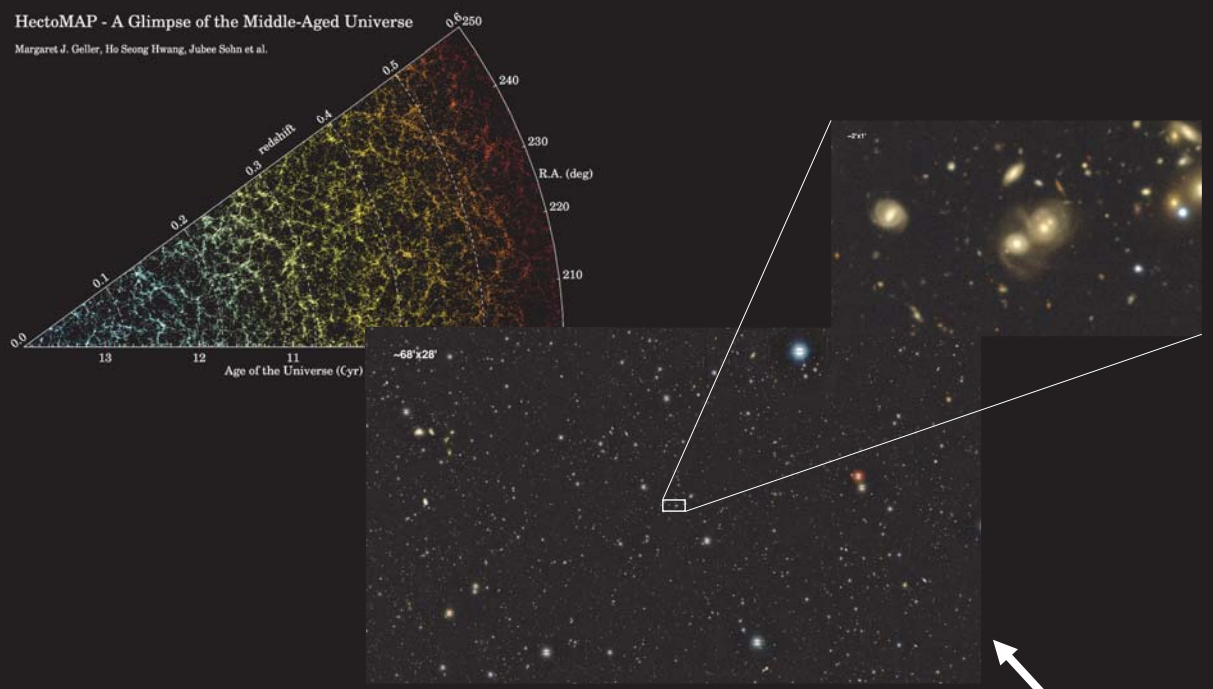
The evolution in the dynamical to stellar mass ratio of quiescent galaxies over 6 billion years of cosmic time - F2-HSC SURVEY



Ivana Damjanov

The evolution in the dynamical to stellar mass ratio of quiescent galaxies over 6 billion years of cosmic time - F2-HSC SURVEY





To summarize:

- Morphological evolution is one of the key constraints for models of galaxy mass assembly
- Based on SHELS F2 spectro-photometric sample, the size of the most massive ($M_* > 10^{11} M_\odot$) quiescent galaxies did not change much in the last 6 10^9 yrs.
- In $0.2 < z < 0.6$ interval the rate of size growth increases with decreasing stellar mass of the galaxy
- In our quiescent sample ($M_* > 10^{10} M_\odot$) there is a clear anti-correlation between the size and average stellar population age for a given stellar mass.
- For quiescent galaxies in our sample the evolutionary trends are explained by an empirical model of simultaneous mass and size growth with growth parameter $\frac{\Delta \log R_e}{\Delta \log M_*} = 1.5$, equal to the results of simulations that include a series of minor mergers.
- The dynamical-to-stellar-mass ratio increases with cosmic time (by a factor of $\lesssim 2$ from $z{\sim}0.35$) independently of stellar mass. This may also be consistent with the minor merger growth scenario.
- New large and deep spectro-photometrics campaigns as **HectoMAP**, Prime Focus Camera Survey, and MSE will enable us to test these trends and their interpretations for different mass and redshift ranges as well as for different environments.