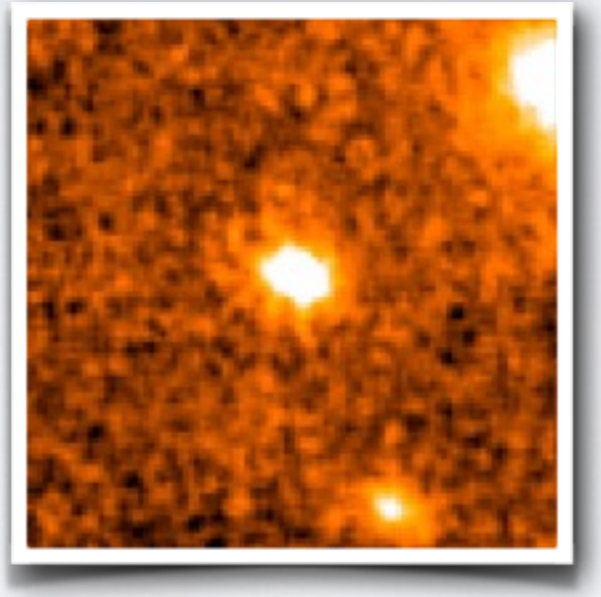
THE SIZES OF Z ~ 6-8 LENSED GALAXIES FROM THE DATA OF ABELL 2744

Submitted to ApJ, astro-ph/1410.1535



Ryota Kawamata

The University of Tokyo

With:
Masafumi Ishigaki, Kazuhiro Shimasaku, Masamune Oguri, Masami Ouchi

OUTLINE

- Measurements of sizes and magnitudes
- Properties of z~6-8 galaxies
- The redshift evolution of sizes and its implication for disk formation and evolution

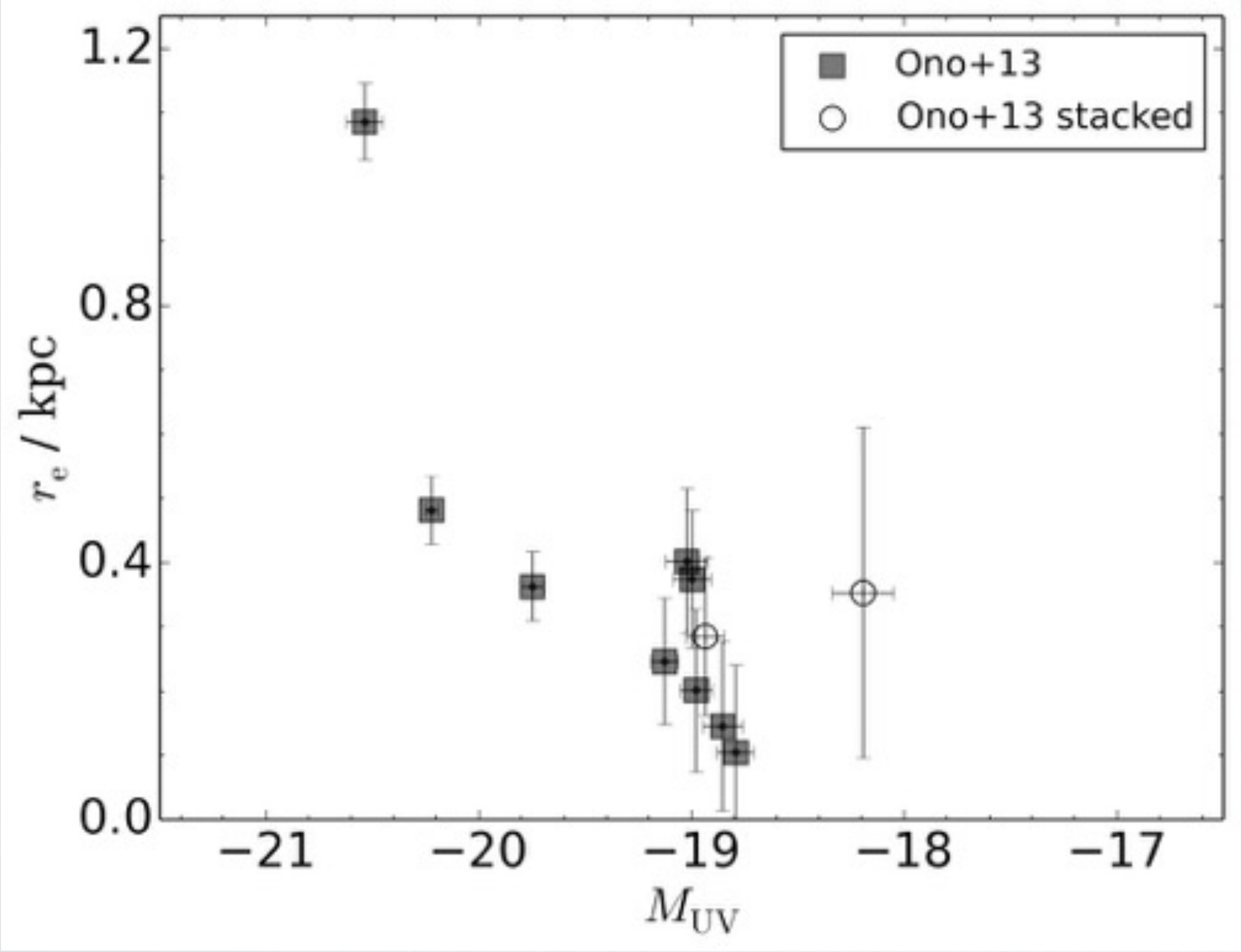
OUTLINE

- Measurements of sizes and magnitudes
- Properties of z~6-8 galaxies
- The redshift evolution of sizes and its implication for disk formation and evolution

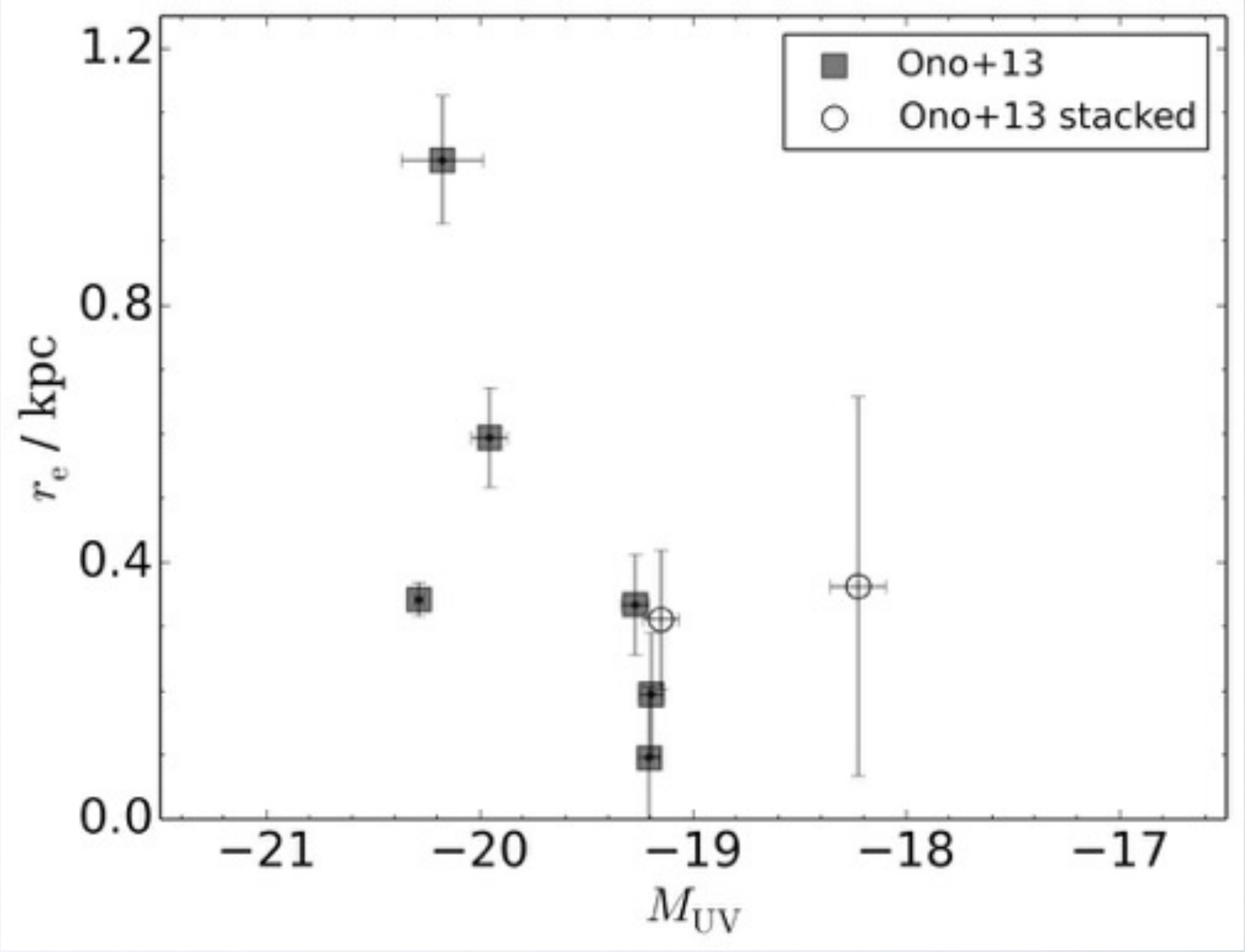
PREVIOUS SAMPLES OF Z~7 & 8 BY GALFIT ARE SMALL

from HUDF12

z~7: 9 galaxies



z~8: 6 galaxies



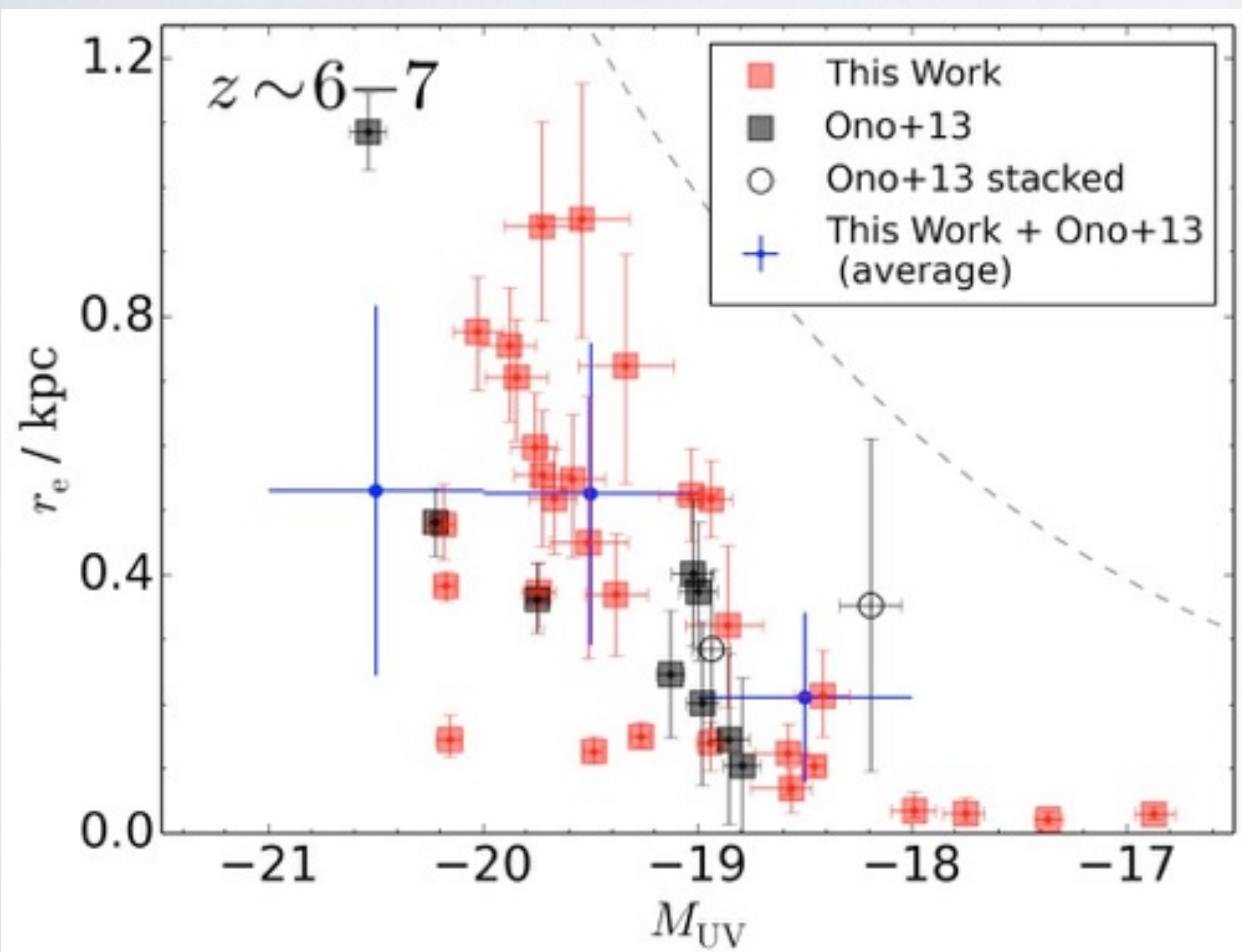
Ono+13

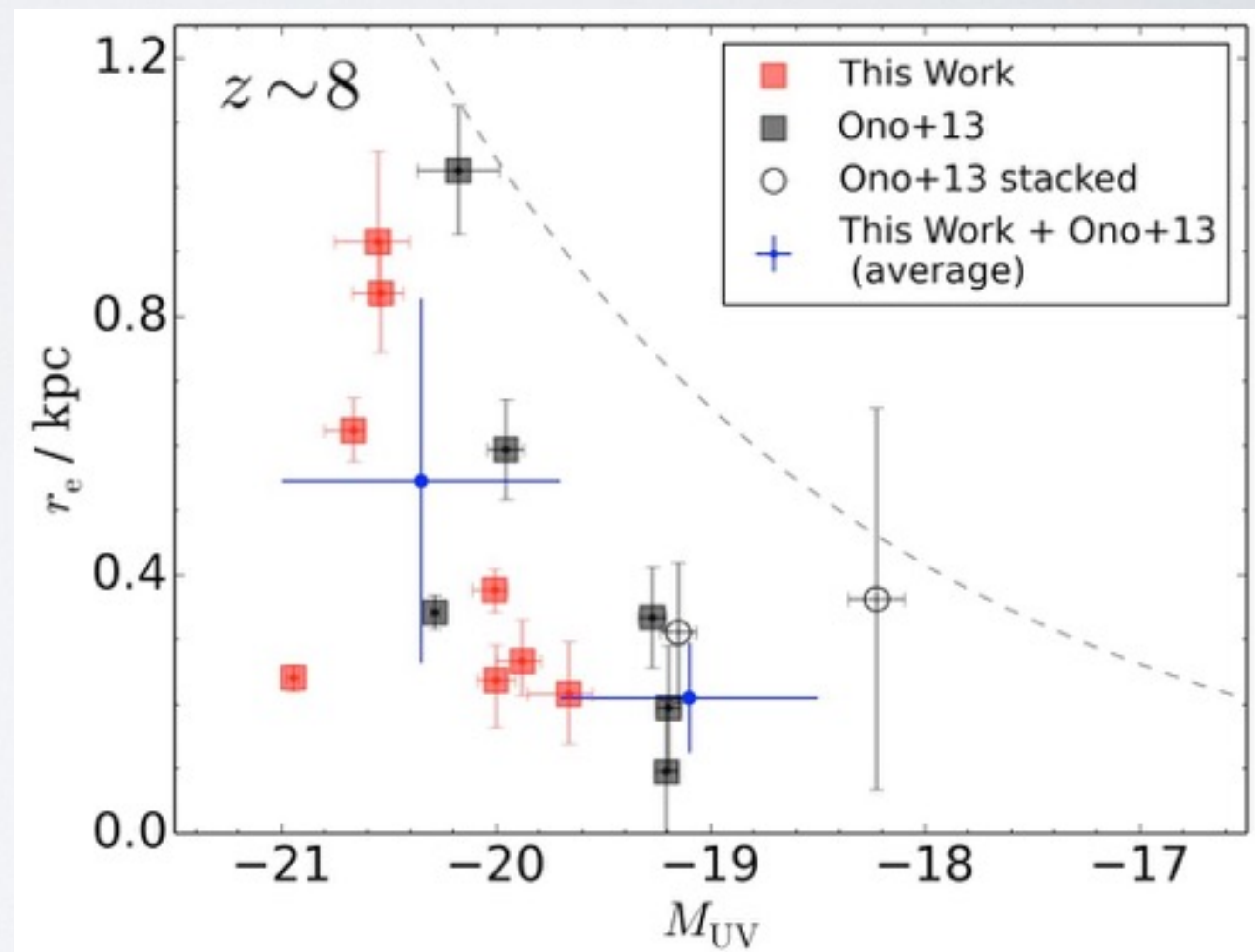
PREVIOUS SAMPLES OF Z~7 & 8 BY GALFIT ARE SMALL

from HUDF12+HFF

z~6-7: ~~9~~ 40 galaxies

z~8: ~~6~~ 14 galaxies



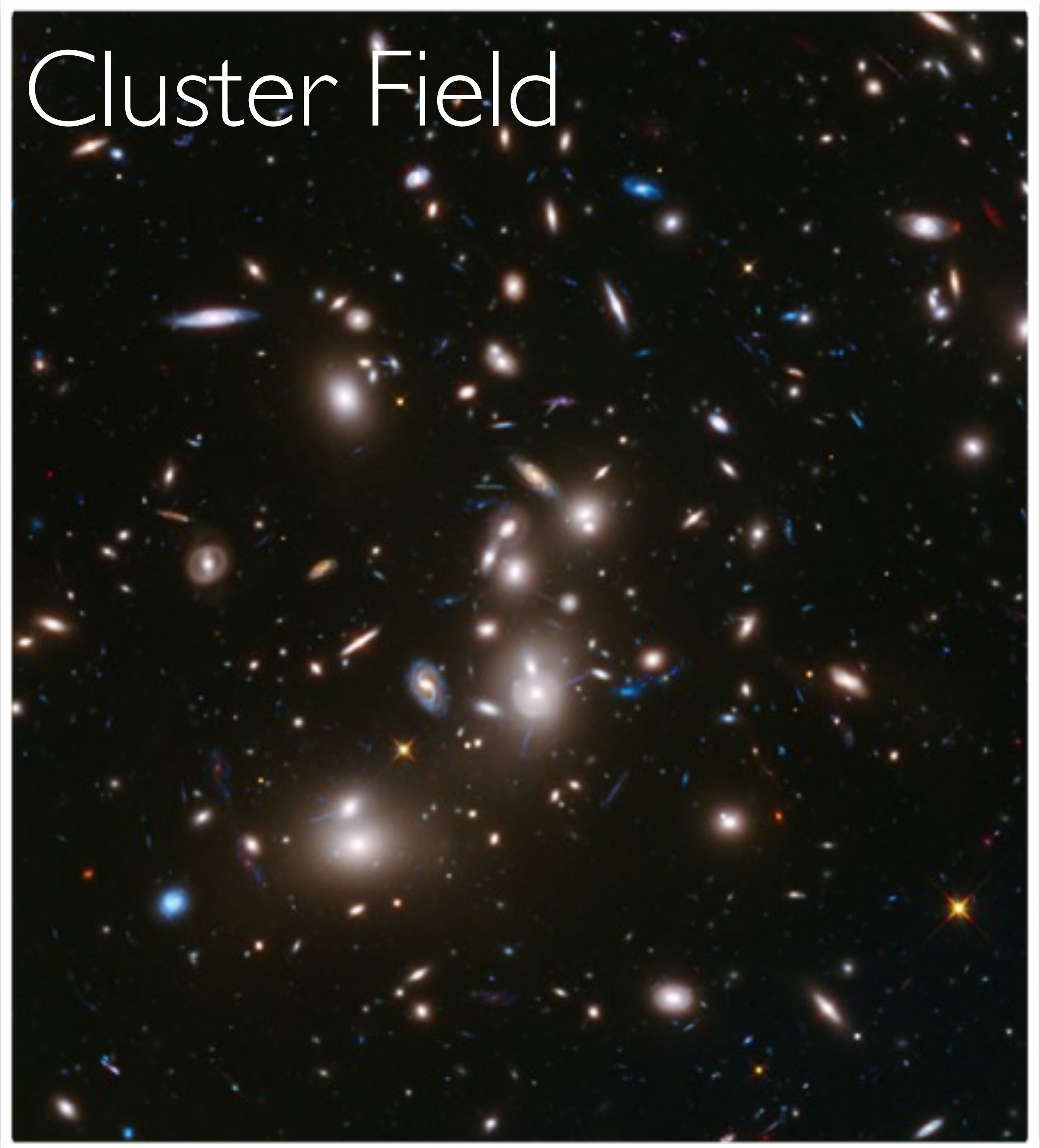


Kawamata+2014

ABELL 2744 DATA

35→31 galaxies at z~6-7 (i-drop)

15→ 8 galaxies at z~8 (Y-drop)



STScI

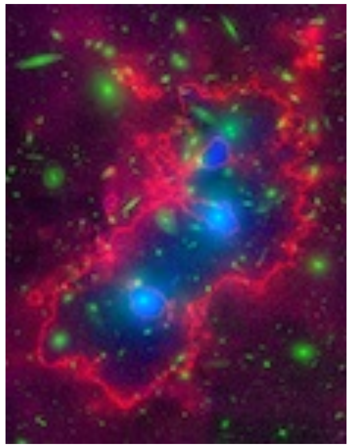
MASS MODEL CONSTRUCTION

- *glafic* (Oguri 2010)
- Parametric modeling method
- 3 NFW profiles as dark halo components
- Member galaxies are modeled as elliptical pseudo-Jaffe models
- External shear
- 24 sets of multiple images
- $\chi^2 = 52.8$ while $N_{DOF} = 41$, where $\sigma_{pos} = 0.4$ arcsec

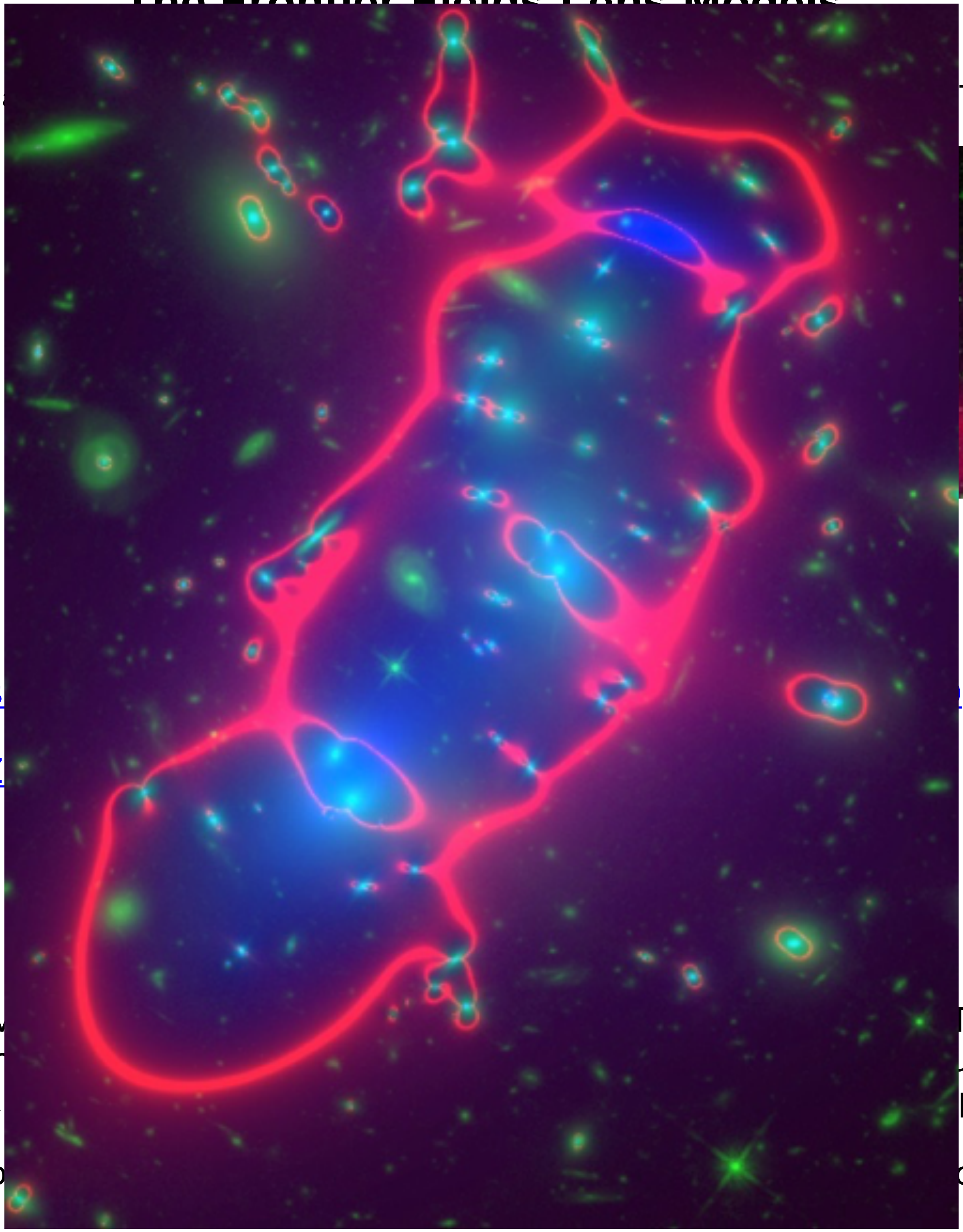
OUR MASS MODEL

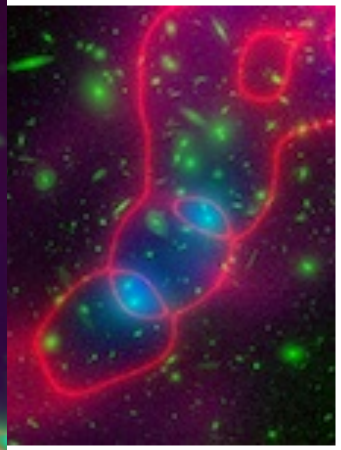
The Frontier Fields Lens Models

Abell 2744: Overl T imaging (green)



Bradač et al.





Williams et al.

- +M. Bradač (PI)
- +The Clusters As
- +J. Merten & A. Z
- +K. Sharon (PI)
- +L. Williams (PI)

The lens models were deriv T imaging in previous works an of this project. Other lens m uster galaxies; and ground-bas imaging (primarily for weak prior to performing their analys

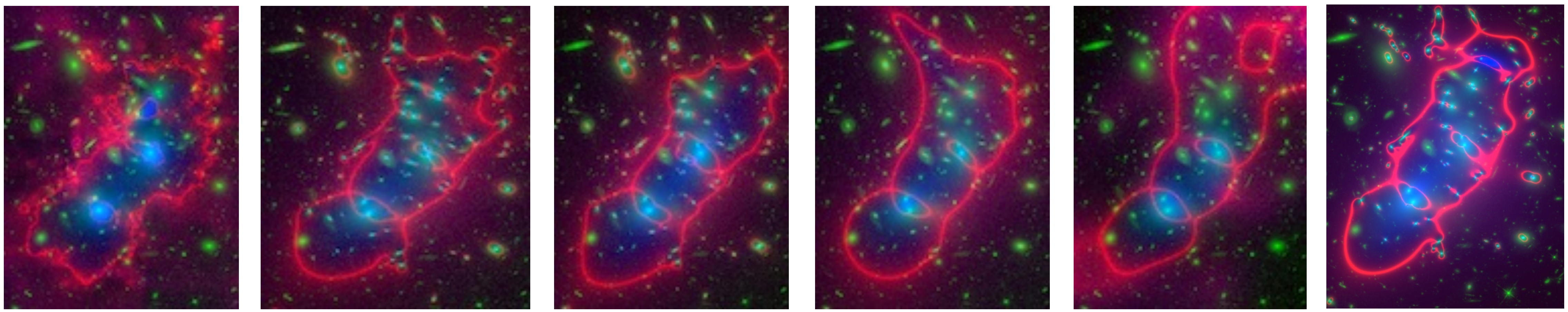
Subsequent lens models (b ovided by some of the teams lis above, as well as:

- +GLAFIC (M. Ishigaki et al.)

OUR MASS MODEL

The Frontier Fields Lens Models

Abell 2744: Overlay of magnification (red) and mass models (blue) on the full-band HST imaging (green)



Bradač et al. | CATS Team | Merten, Zitrin et al. | Sharon et al. | Williams et al. | GLAFIC

- [+M. Bradač (PI)]
- [+The Clusters As TelescopeS (CATS) team (Co-PI's J.P. Kneib, P. Natarajan)]
- [+J. Merten & A. Zitrin (Co-PI's)]
- [+K. Sharon (PI)]
- [+L. Williams (PI)]

The lens models were derived based on strongly lensed galaxies identified in archival HST imaging in previous works an of this project. Other lens model ingredients were spectroscopic redshifts of lensed and cluster galaxies; and ground-bas imaging (primarily for weak lensing analyses). The lens modelers shared all of these data prior to performing their analys

Subsequent lens models (based in part on the Frontier Fields HST imaging) have been provided by some of the teams lis above, as well as:

- [+GLAFIC (M. Ishigaki et al.)]

SIZE MEASUREMENT

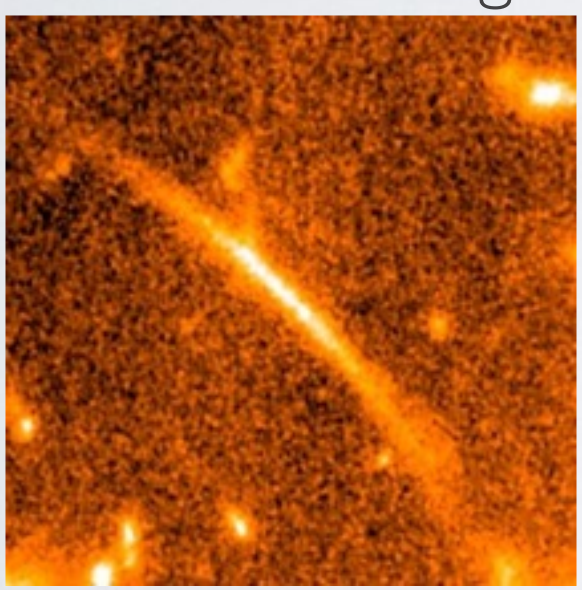
Fit galaxy light profiles with
lensed and distorted Sérsic profiles.

Image Plane

Source Plane

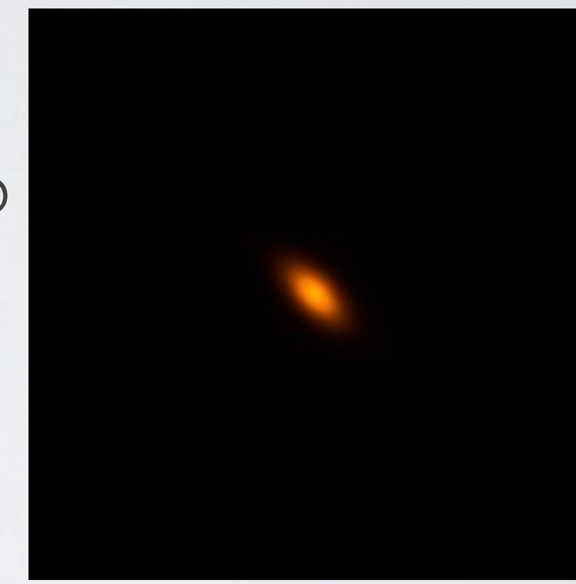
Our Method

Observed Image

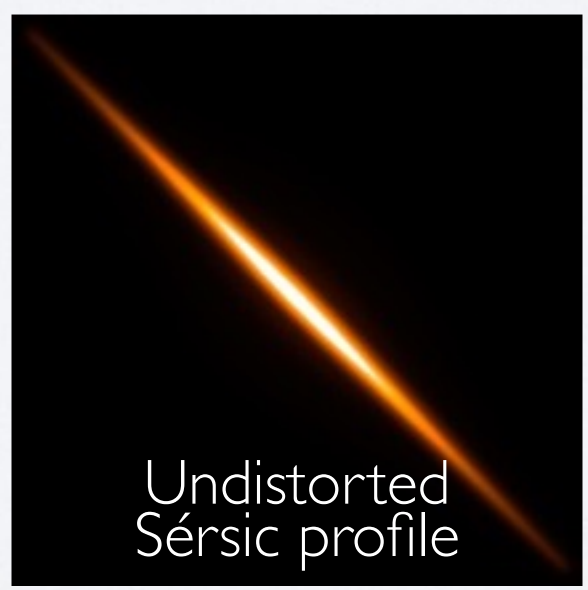


Profile fitting

Lensed by the mass map



Profile fitting



Correct the output r_e & M_{UV} for magnification

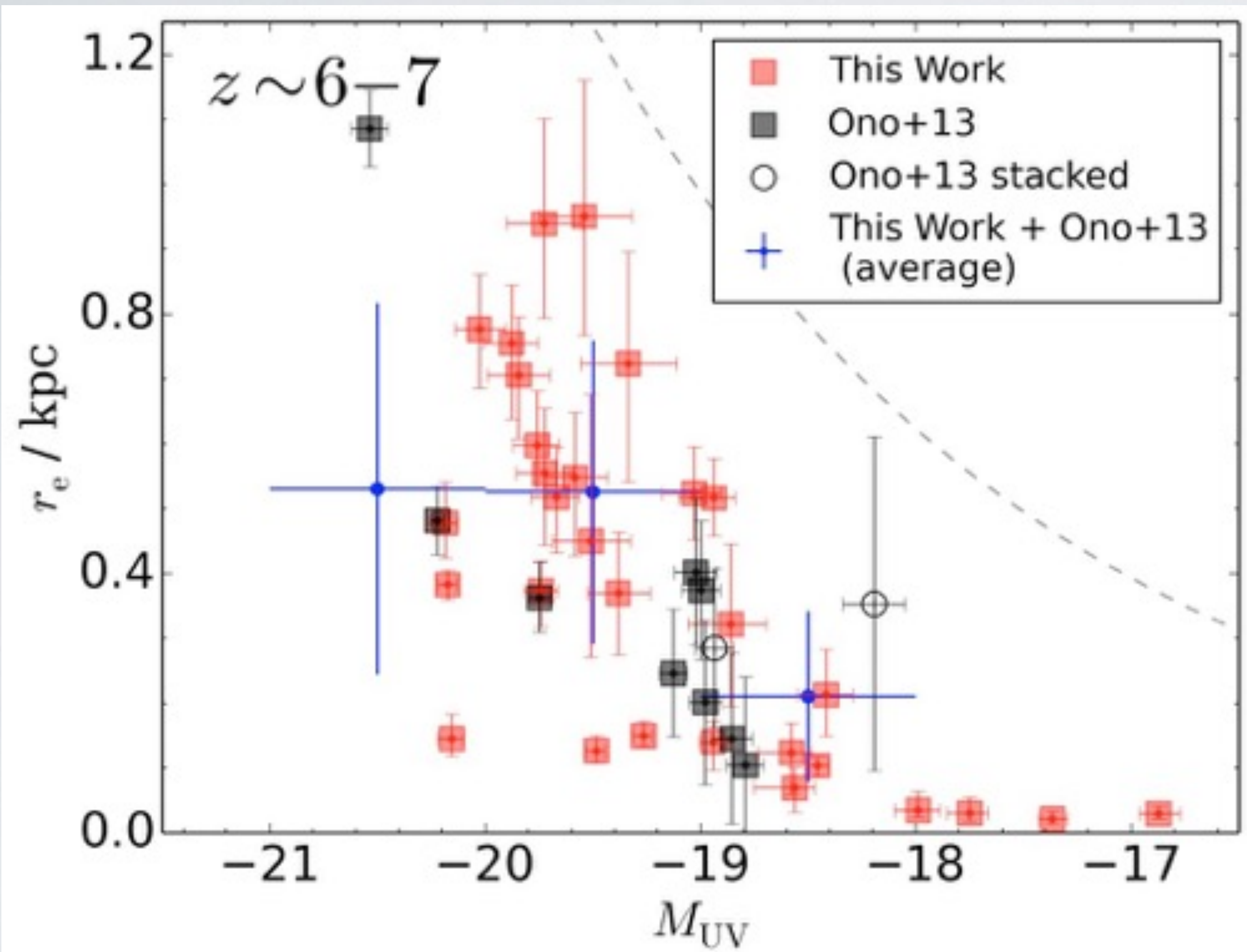
Ordinary Method

OUTLINE

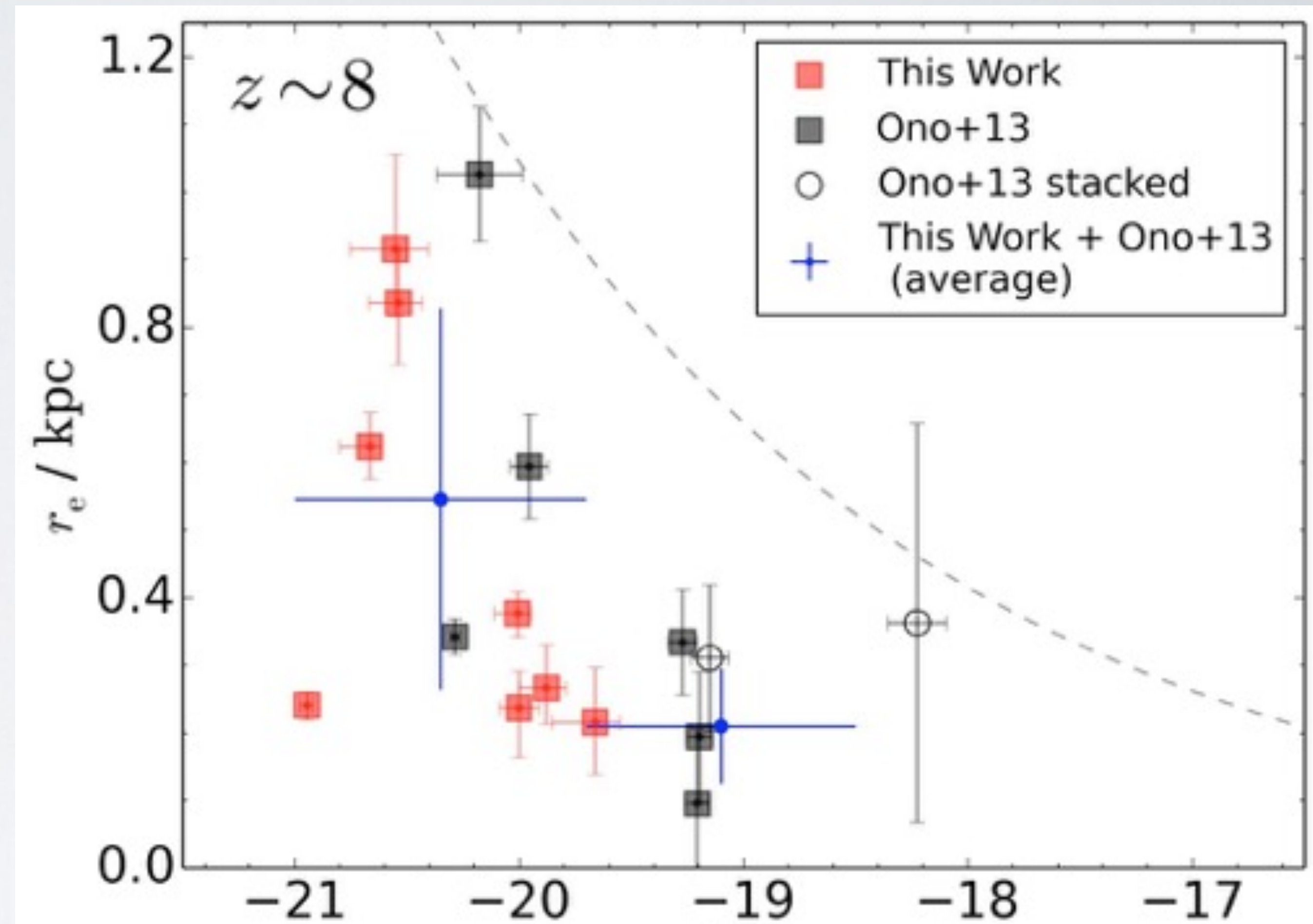
- Measurements of sizes and magnitudes
- Properties of z~6-8 galaxies
- The redshift evolution of sizes and its implication for disk formation and evolution

SIZE-LUMINOSITY RELATION

z~6-7: 40 galaxies



z~8: 14 galaxies

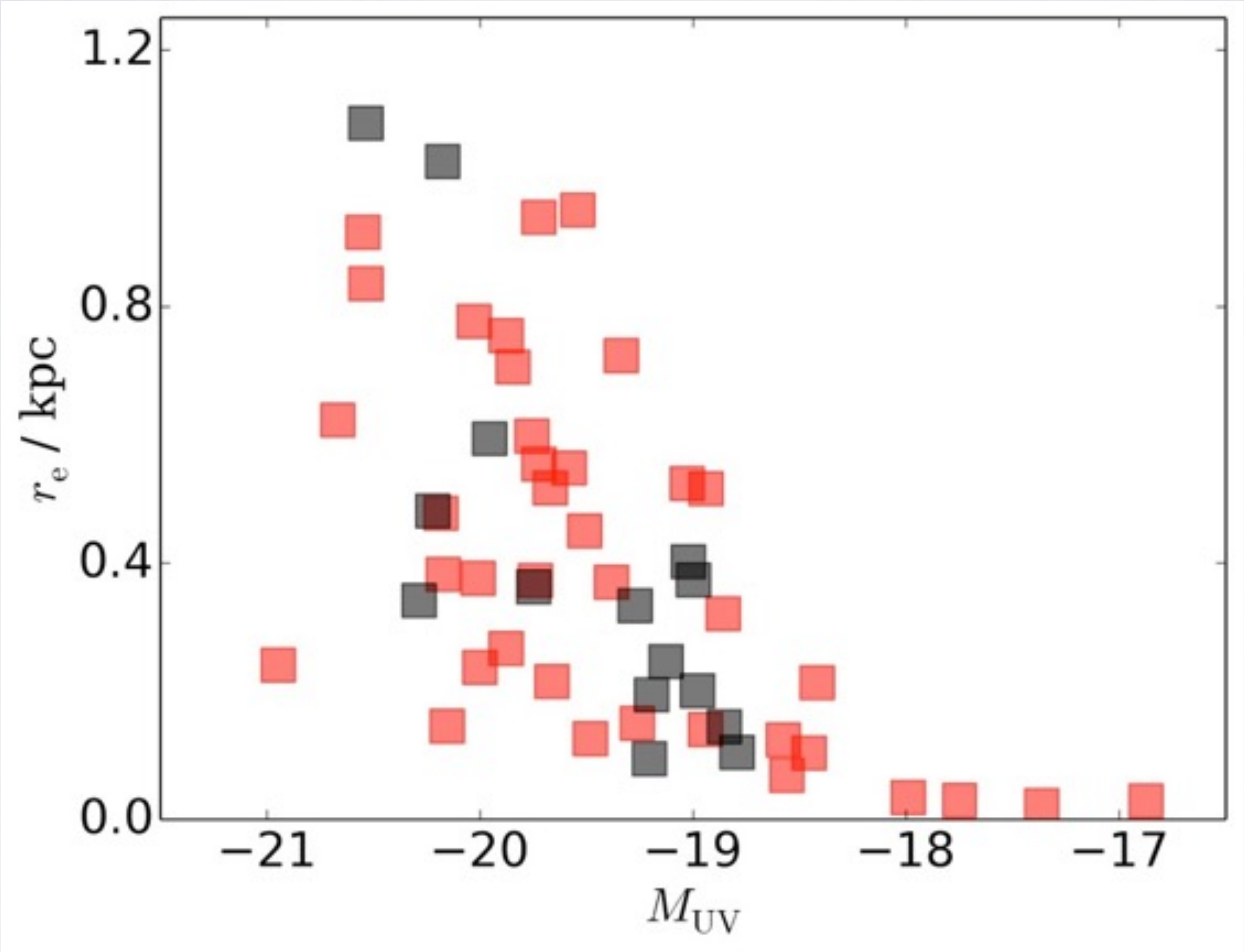


Kawamata+14

- Positive but weak correlation
- Large scatter as expected from the simulated halo spin parameters

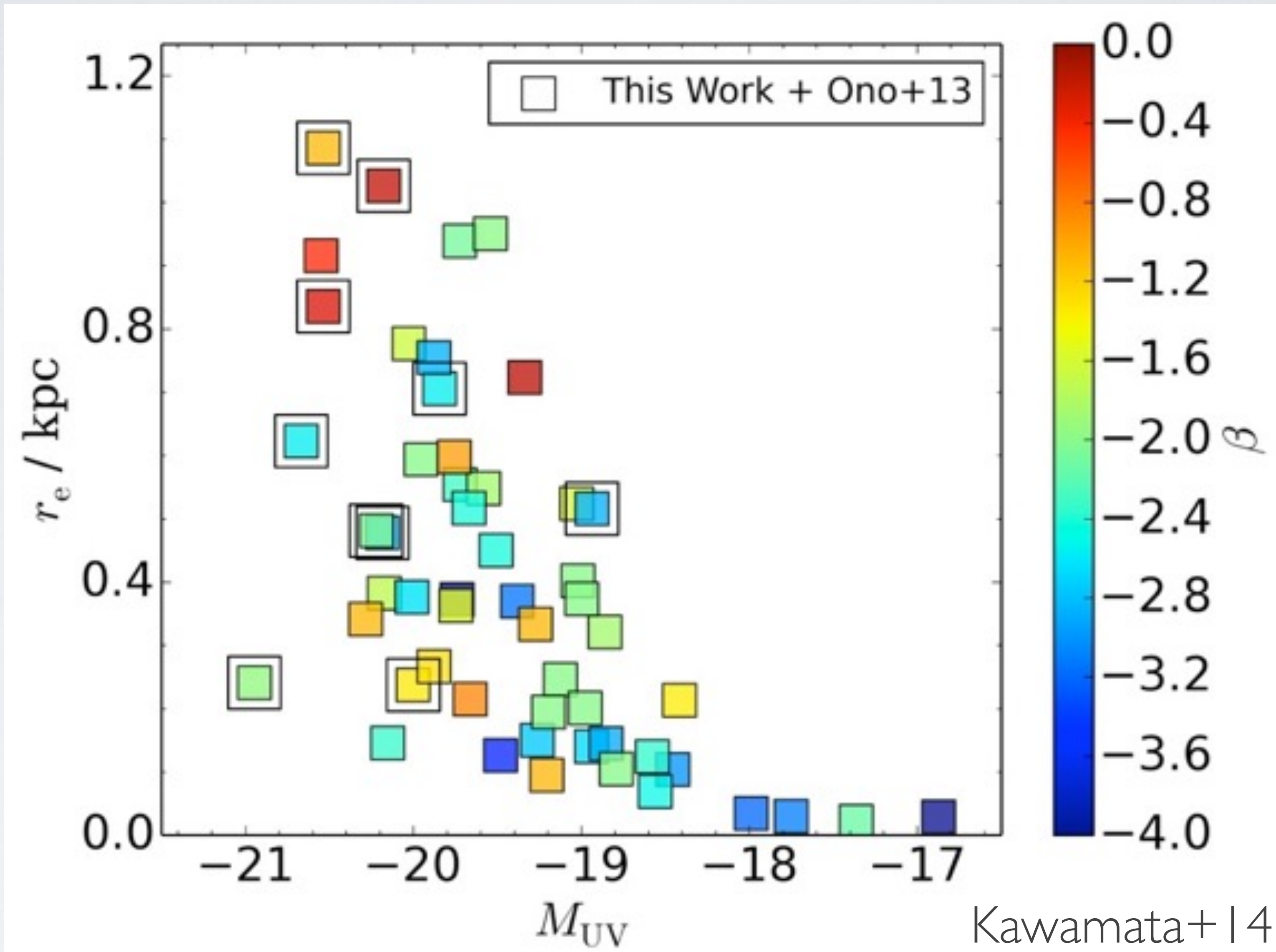
DEPENDENCY ON COLOR & MULTIPLICITY

z~6-8
(merged)



DEPENDENCY ON COLOR & MULTIPLICITY

z~6-8
(merged)



- Largest galaxies are mostly red and smallest galaxies are mostly blue.
- Galaxies with multiple cores (□) are bright.

OUTLINE

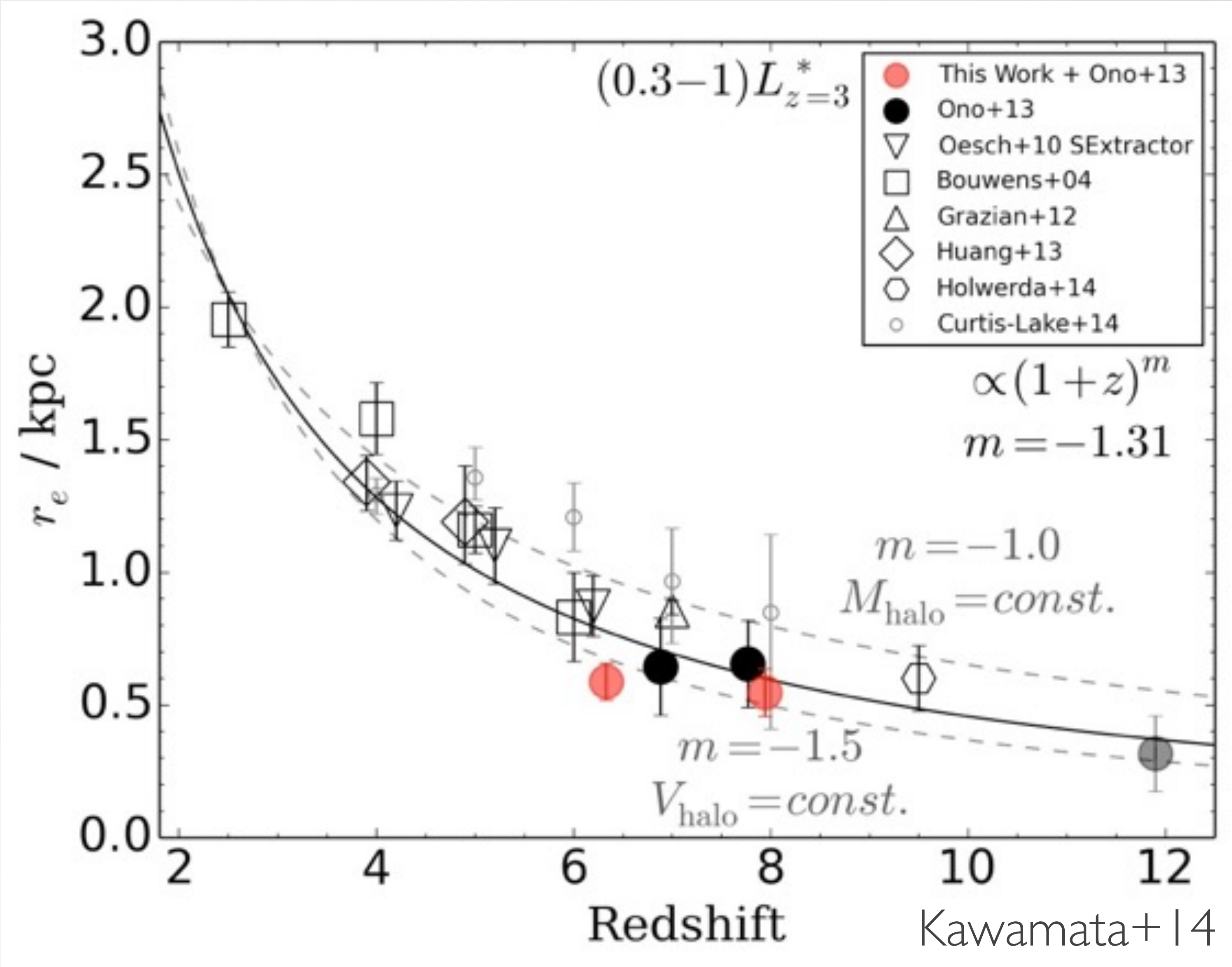
- Measurements of sizes and magnitudes
- Properties of z~6-8 galaxies
- The redshift evolution of sizes and its implication for disk formation and evolution

PREVIOUS INTERPRETATION

Nontrivial Assumption:

the half-light radius scales with the virial radius

One can get information on what halos are traced.



$$r_{\rm halo} \propto \begin{cases} (1+z)^{-1.0} & (M_{\rm halo} = const.) \\ (1+z)^{-1.5} & (V_{\rm halo} = const.) \end{cases}$$

ESTIMATING HALO RADII FROM M_{UV}

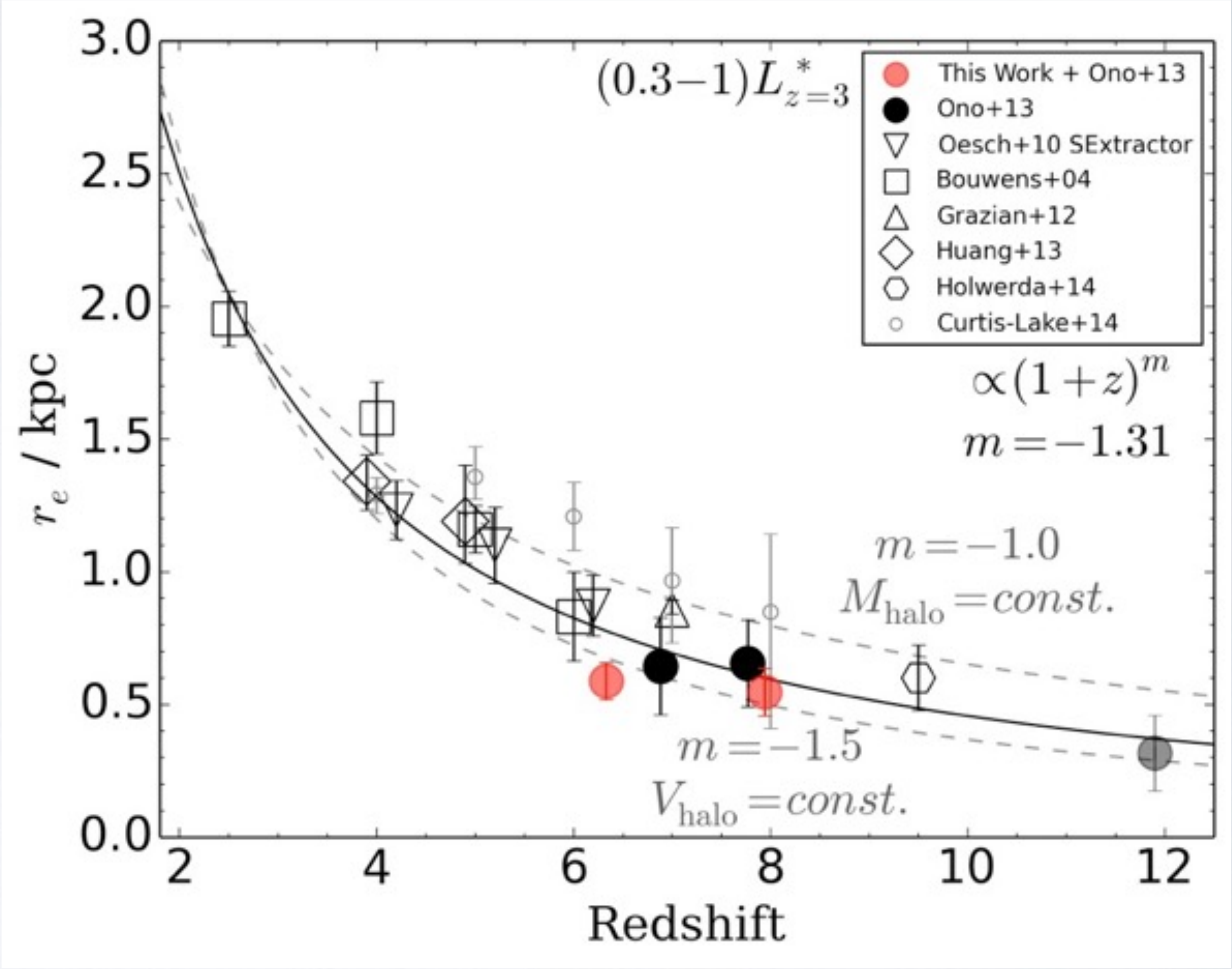
Luminosity

↓ Mass-Luminosity Relation (González+2011 etc.)

Stellar Mass

↓ Abundance matching (Behroozi+2013)

Halo Mass or Halo Radius



The ratio of half-light radius to halo radius is constant at 3.5% over z~2.5-9.5.

DISK FORMATION MODEL

Mo+1998

$$\frac{r_{\rm e}}{r_{\rm vir}} = \frac{1.678}{\sqrt{2}} \left(\frac{j_{\rm d}}{m_{\rm d}}\lambda\right) f_{\rm c}(c)^{-1/2} f_{\rm R}(j_{\rm d}/m_{\rm d}, m_{\rm d}, \lambda, c)$$

j_d: angular momentum ratio of disk to halo

m_d: mass ratio of disk to halo

λ: spin parameter of halo

c: concentration parameter of halo

Need to know the angular momenta of disks

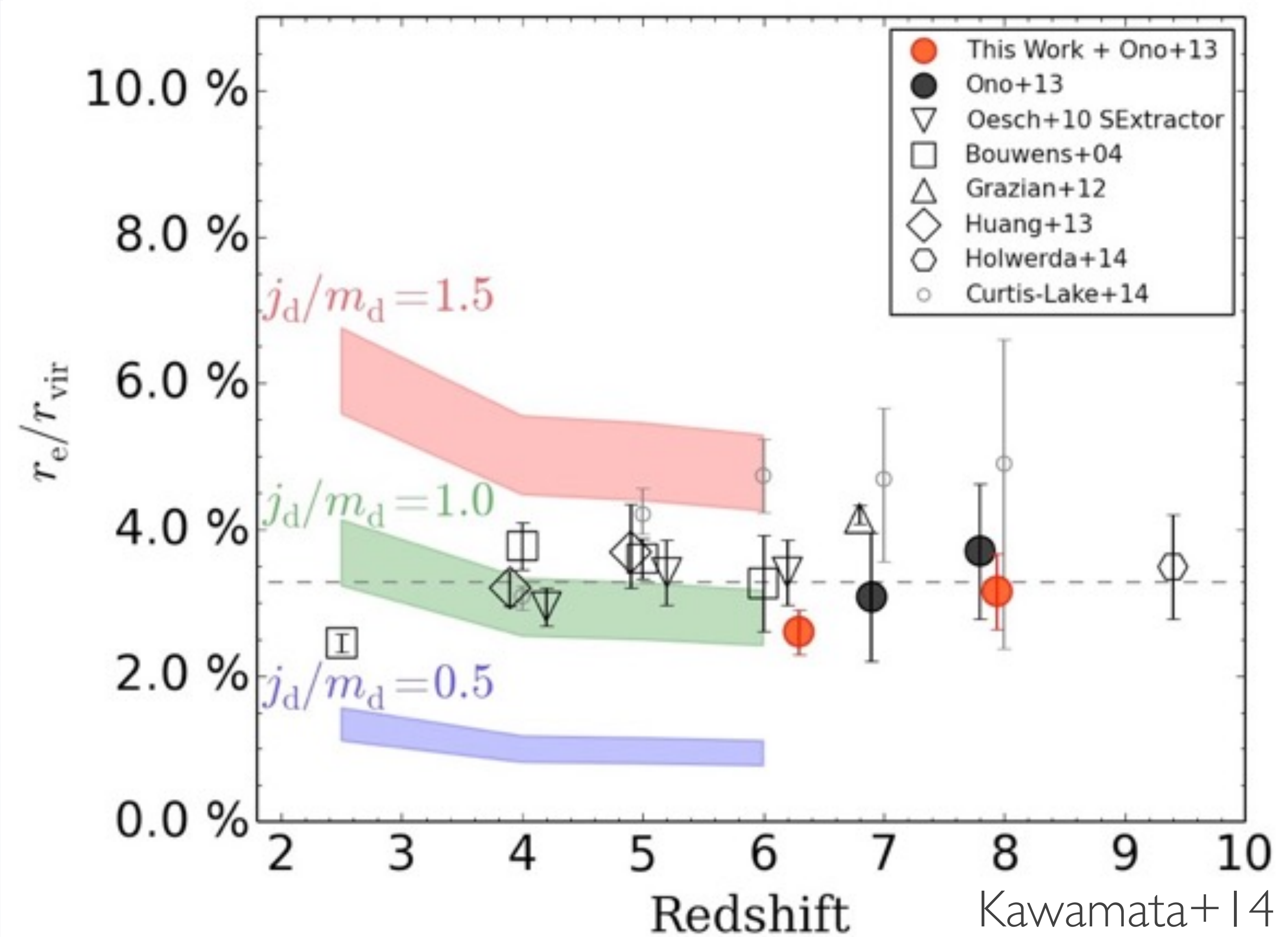
- λ and c are well determined by N-body simulations. (e.g. Bullock+01)
- j_d and m_d depend on baryonic physics and are not reliably predicted.
- Too small disk sizes at given luminosity are thought to be a result of small angular momenta of disks.

j_d/m_d OF HIGH-Z GALAXIES

$$\frac{r_{\mathrm{e}}}{r_{\mathrm{vir}}} = \frac{1.678}{\sqrt{2}}\left(\frac{j_{\mathrm{d}}}{m_{\mathrm{d}}}\lambda\right) f_{\mathrm{c}}(c)^{-1/2} f_{\mathrm{R}}(j_{\mathrm{d}}/m_{\mathrm{d}}, m_{\mathrm{d}}, \lambda, c)$$

Mo+1998

- λ and c are well determined by N-body simulations.
- f_R weakly depends on j_d/m_d and m_d.
- r_e/r_{vir} strongly depends on j_d/m_d.



Kawamata+14

The observed size ratio is consistent with $j_d/m_d = 1$

SUMMARY

- Measured sizes of 31 z~6-7 and 8 z~8 lensed galaxies
- Used our own mass map
- The ratio of half-light radius to virial radius is constant at 3.5%, which is consistent with $j_d/m_d = 1$
- Positive but weak correlation between r_e and L_{UV}
- Largest galaxies are red, and smallest galaxies are blue
- Galaxies with multiple cores are bright

FUTURE WORK

- Quantify the typical size by the modal value
- Measure sizes of low-z galaxies with the HFF data