Credit: NASA, ESA, and The Hubble Heritage Team (STScI/AURA)
Acknowledgment: J. Blakeslee (Washington State University)

z=0
ESO 325-G004

?

10 kpc

1289
z = 1.79
10 kpc

n = 3.26±0.40

2531
z = 1.60
10 kpc

n = 4.08±0.30

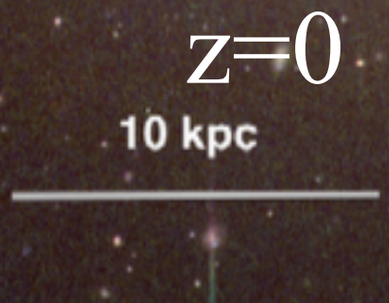
5890
z = 1.76
10 kpc

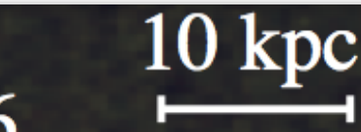
Szomoru et al. 2013

n = 1.89±0.12

Red Nuggets at Intermediate Redshifts

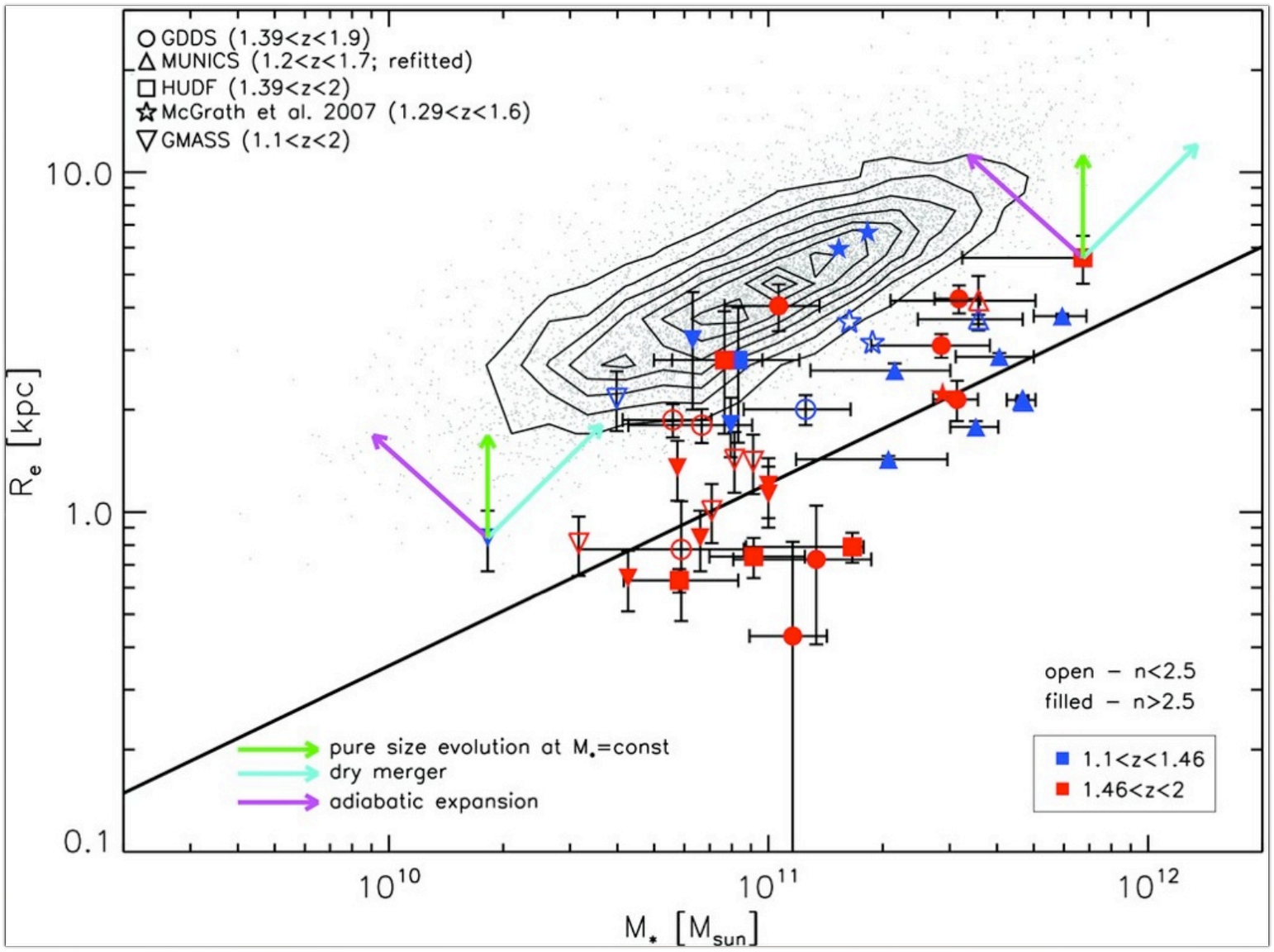
Ivana Damjanov, Igor Chilingarian,
Ho Seong Hwang, and Margaret J. Geller
(Harvard-Smithsonian CfA)





MORPH2013: Deconstructing Galaxies, ESO, Santiago, Chile, Nov. 18 2013

THE PUZZLE



Damjanov et al. 2009

Daddi et al. 2005

Trujillo et al. 2007
Toft et al. 2007
Van Dokkum et al. 2008
Buitrago et al. 2008
Cimatti et al. 2008
Bezanson et al. 2009
Carrasco et al. 2010
Strazzullo et al. 2010
Cassata et al. 2011
Damjanov et al. 2011
Saracco et al. 2011
Szomoru et al. 2012
Bruce et al. 2012
Zirm et al. 2013
Van de Sande et al. 2013
....

Intermediate Redshift Compacts - Hard to Find

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Compact galaxies may be misclassified in large surveys (such as SDSS) as stars because of poor seeing (e.g. Taylor et al. 2010, Carollo et al. 2013)

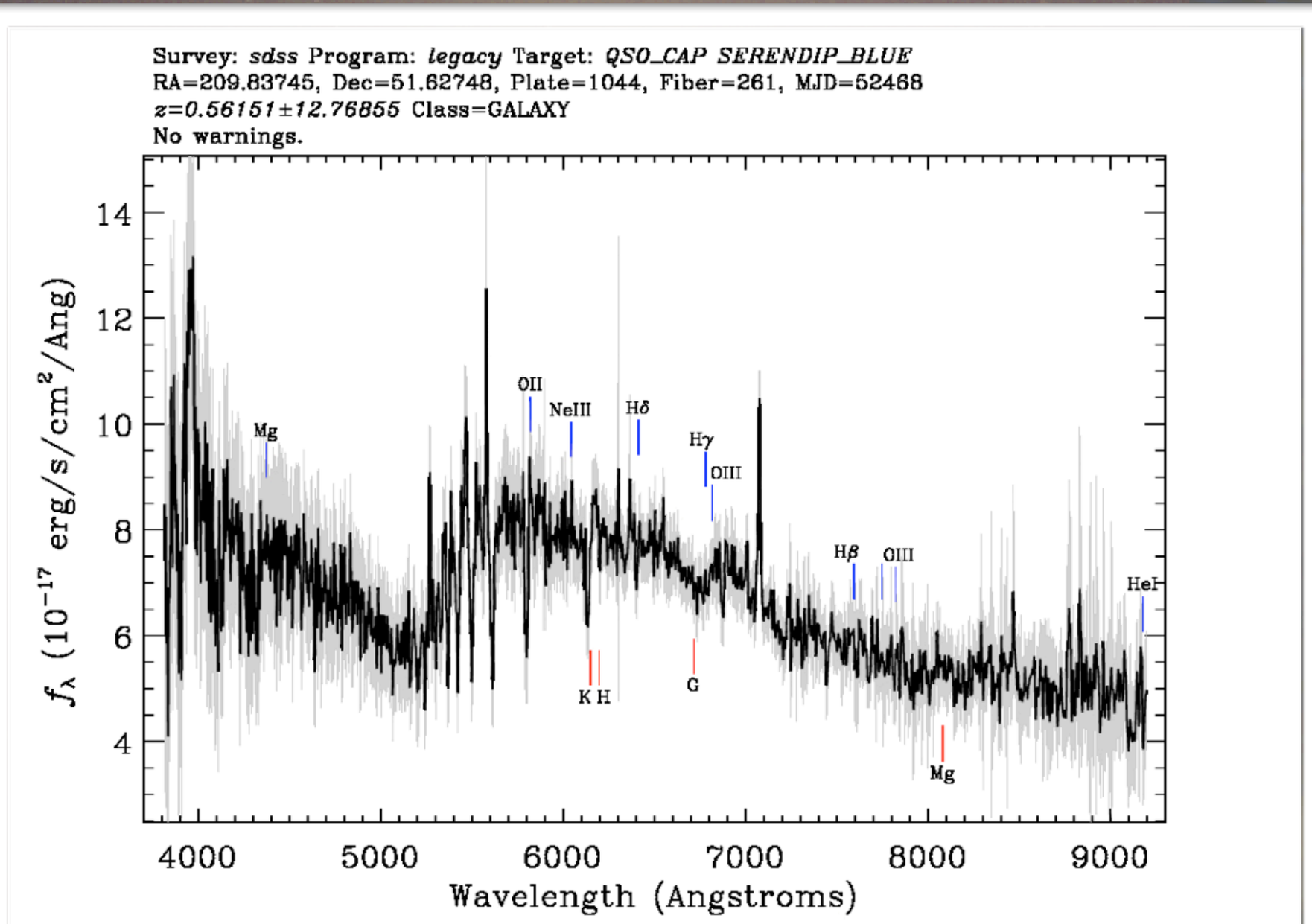
Intermediate Redshift Compacts - Hard to Find

Compact galaxies may be misclassified in large surveys (such as SDSS) as stars because of poor seeing (e.g. Taylor et al. 2010, Carollo et al. 2013)

So how to look for them?

How to look for compact intermediate redshift galaxies in SDSS

Step 1: spectroscopic database



How to look for compact intermediate redshift galaxies in SDSS

Step 1: spectroscopic database → Step 2: photometric classification

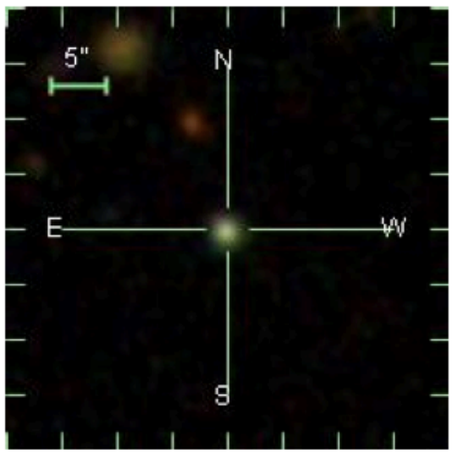
Summary data for: SDSS J135920.98+513738.9

Position Data (How do I find it?)

Object ID (objID):	Right ascension (ra):	Declination (dec):
1237658800970858637	209.83743678	51.62748411

Image Data
(What does it look like?)

Preview image (click to go to Navigate tool)



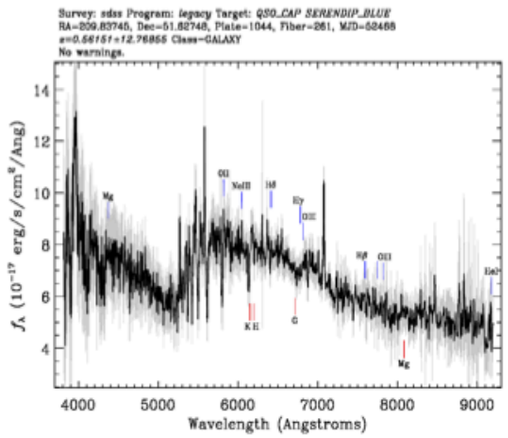
Object Type (type): STAR

Magnitudes:

Ultraviolet (u):	19.95 ± 0.04
Green (g):	19.59 ± 0.01
Red (r):	18.89 ± 0.01
Infrared - 7600 Å (i):	18.75 ± 0.01

Spectrum Data
(What does its spectrum look like?)

Preview spectrum (click for a larger version)



Interactive spectrum

Spectral classification (Class): GALAXY

Redshift Data:

Redshift (z):	0.56151

Get spectrum as CSV

How to look for compact intermediate redshift galaxies in SDSS

Step 1: spectroscopic database

Step 2: photometric classification

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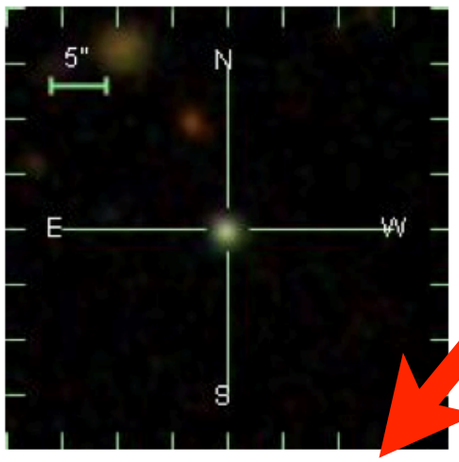

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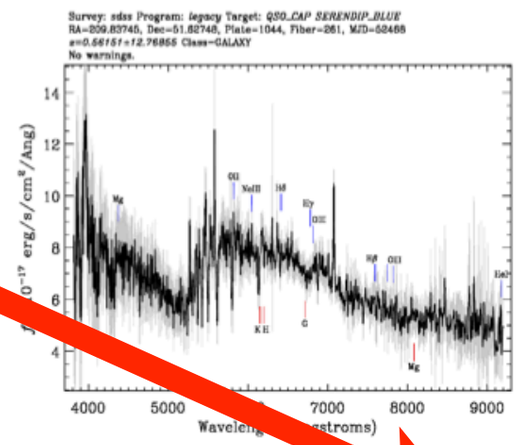

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How to look for compact intermediate redshift galaxies in SDSS

Step 1: spectroscopic database

↓

Step 2: photometric classification

→

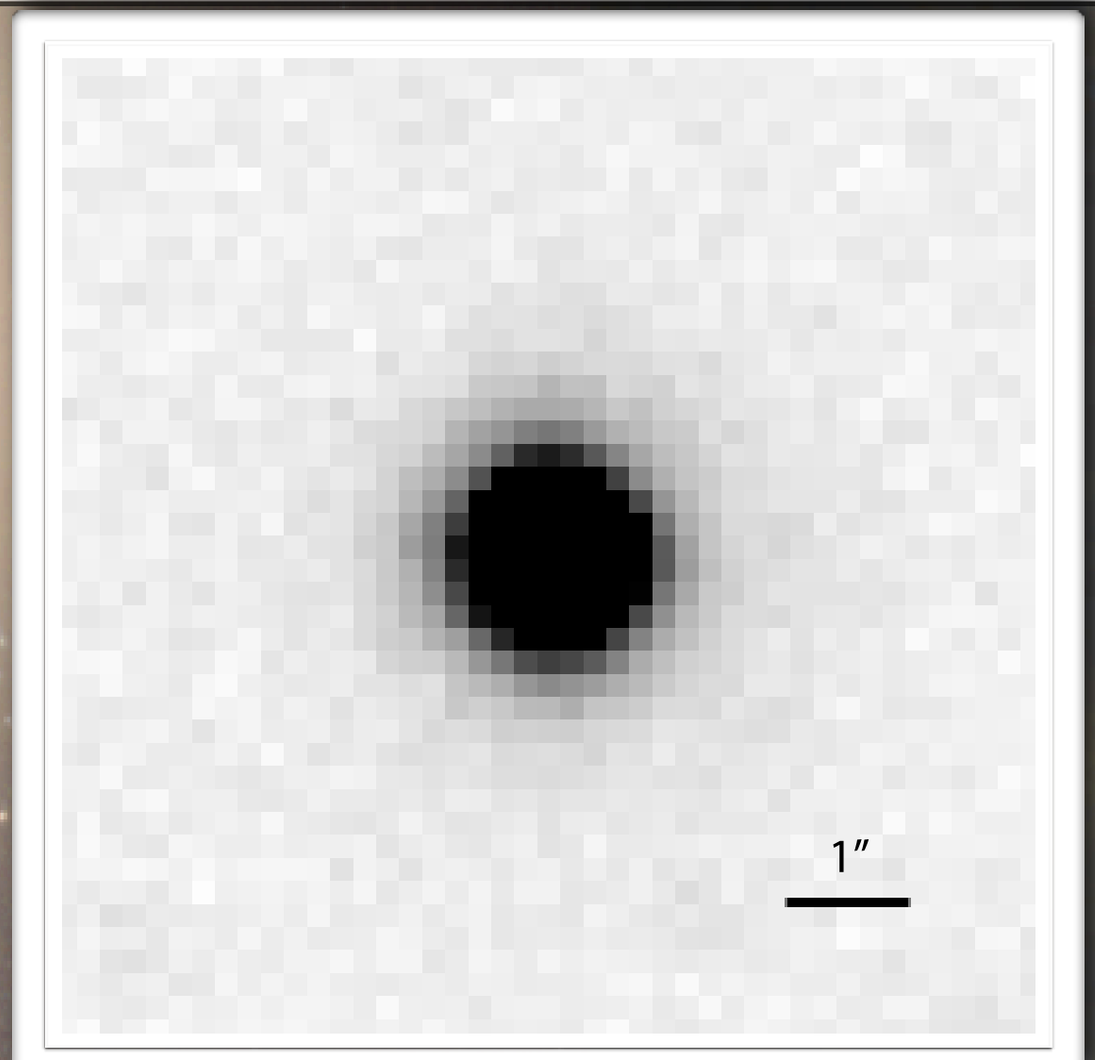
Step 3:
better ground-based imaging?

How to look for compact intermediate redshift galaxies in SDSS

Step 1: spectroscopic database

Step 2: photometric classification

Step 3:
better ground-based imaging?



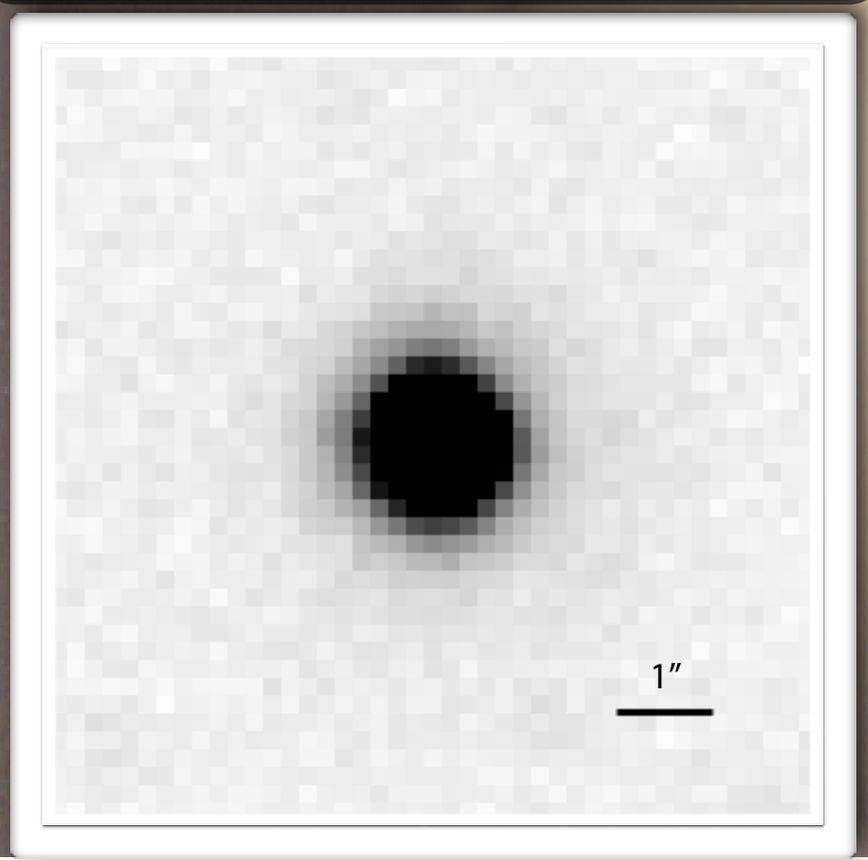
CFHTLS I-band
(PSF FWHM~0.5”)
unresolved

How to look for compact intermediate redshift galaxies in SDSS

Step 1: spectroscopic database

Step 2: photometric classification

Step 3: better ground-based imaging?



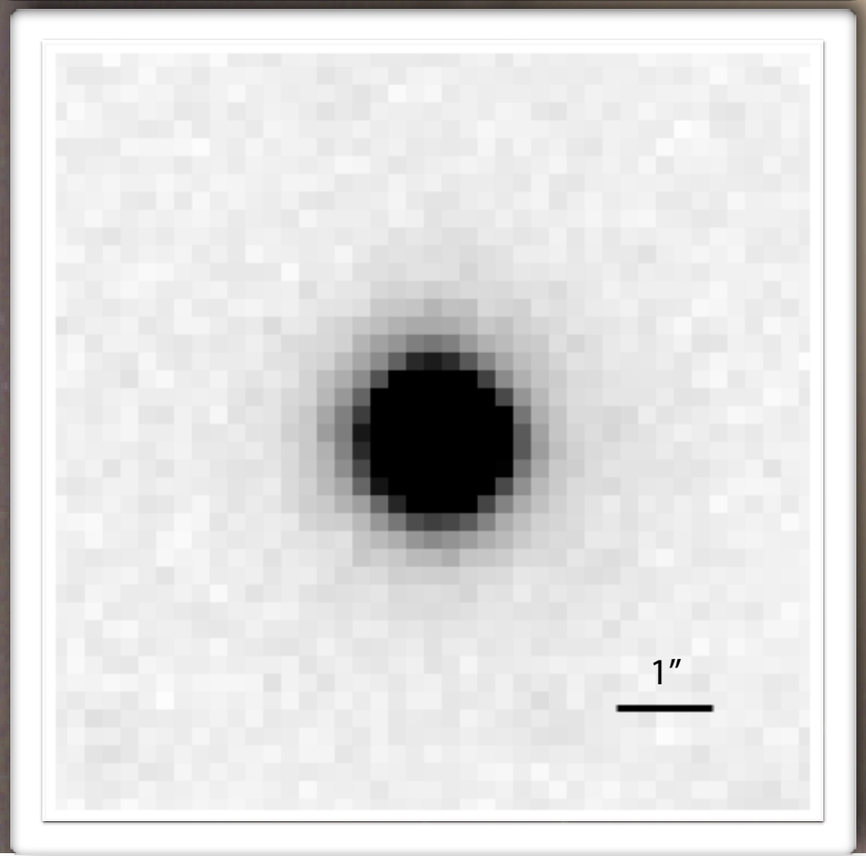
Step 4:
HST Database

How to look for compact intermediate redshift galaxies in SDSS

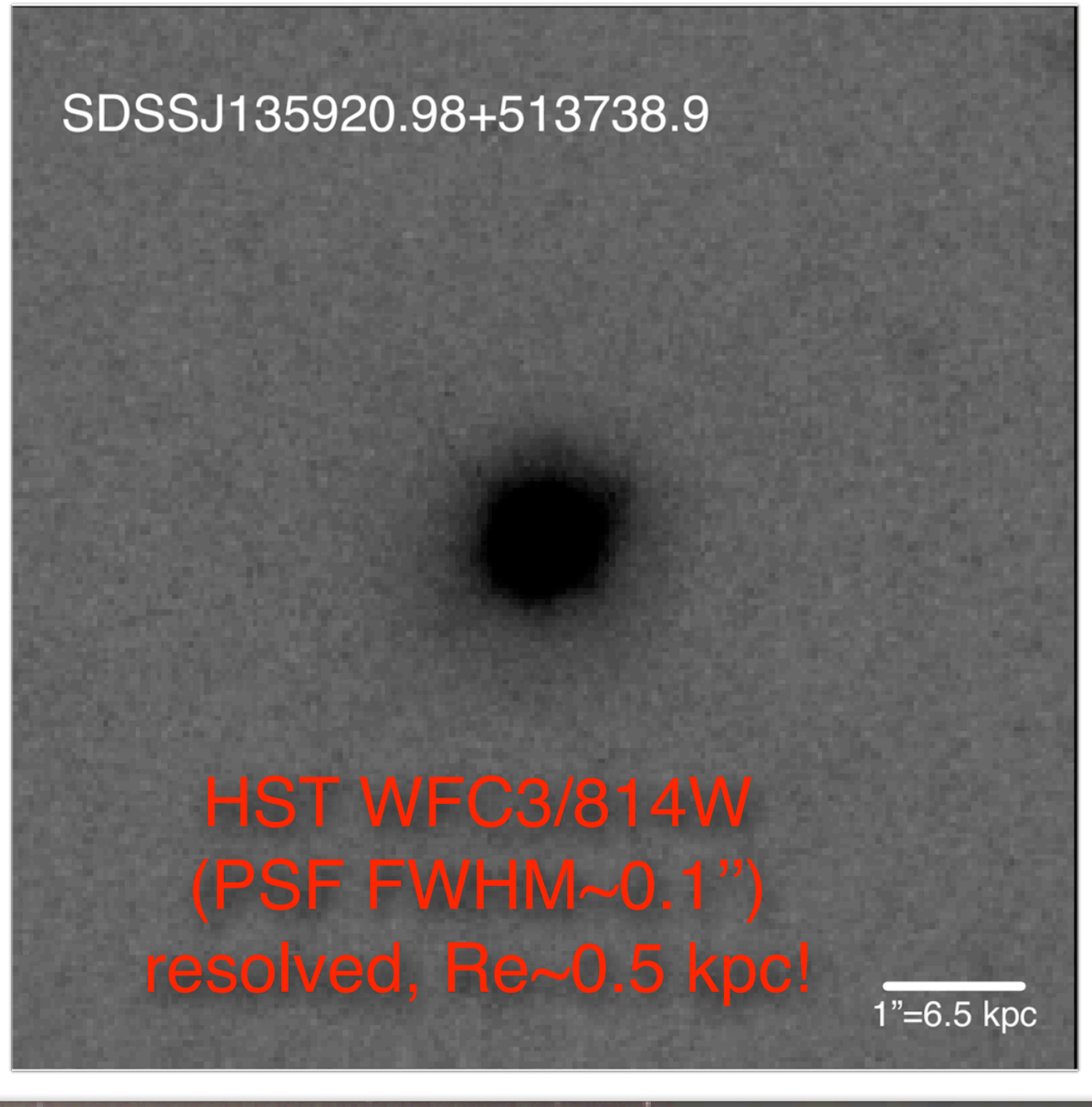
Step 1: spectroscopic database

Step 2: photometric classification

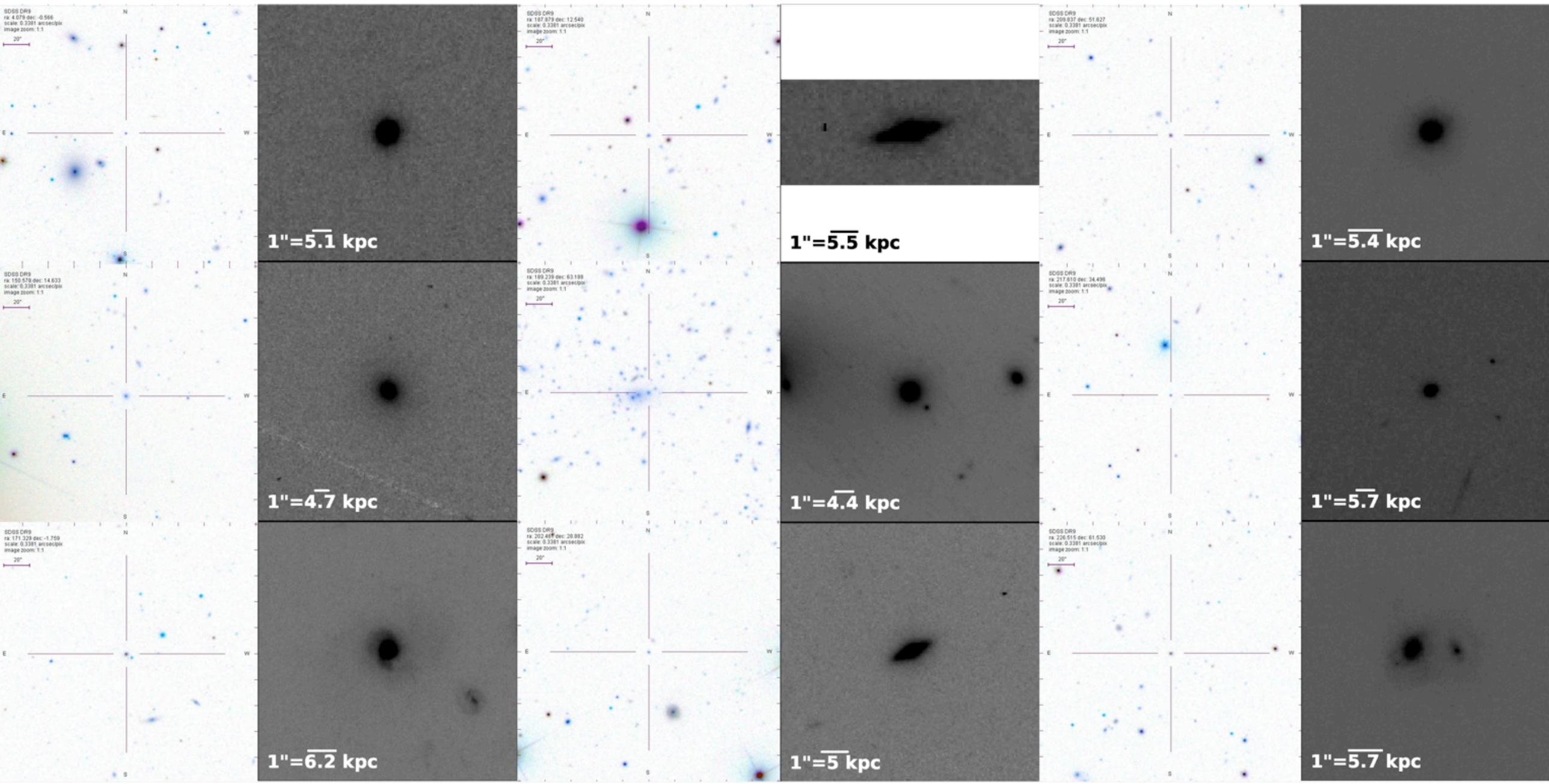
Step 3: better ground-based imaging?



Step 4: HST Database

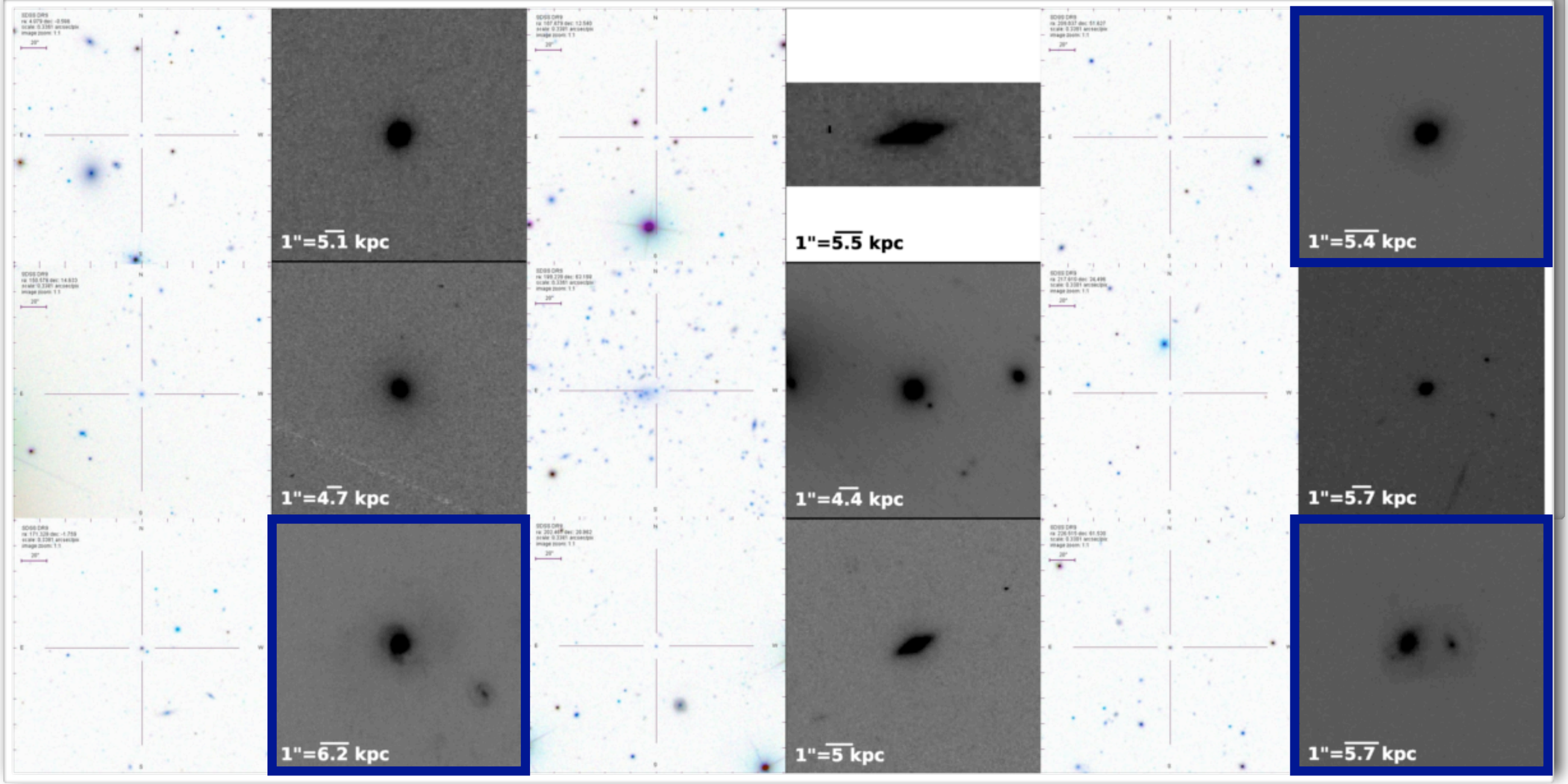


The SDSS+HST sample



Damjanov,I., Chilingarian, I., Hwang, H. S., Geller, M. J. 2013, ApjL, 775, L48

Two distinct compact galaxy populations at 0.2<z<0.6



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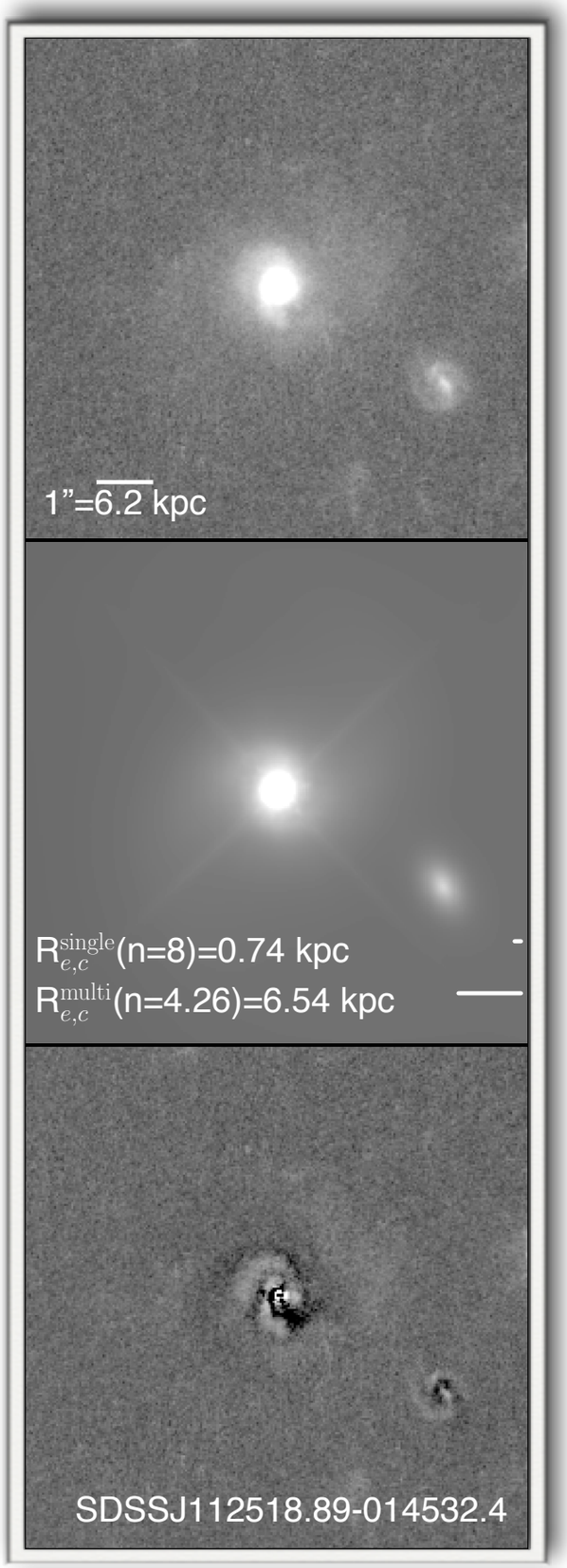
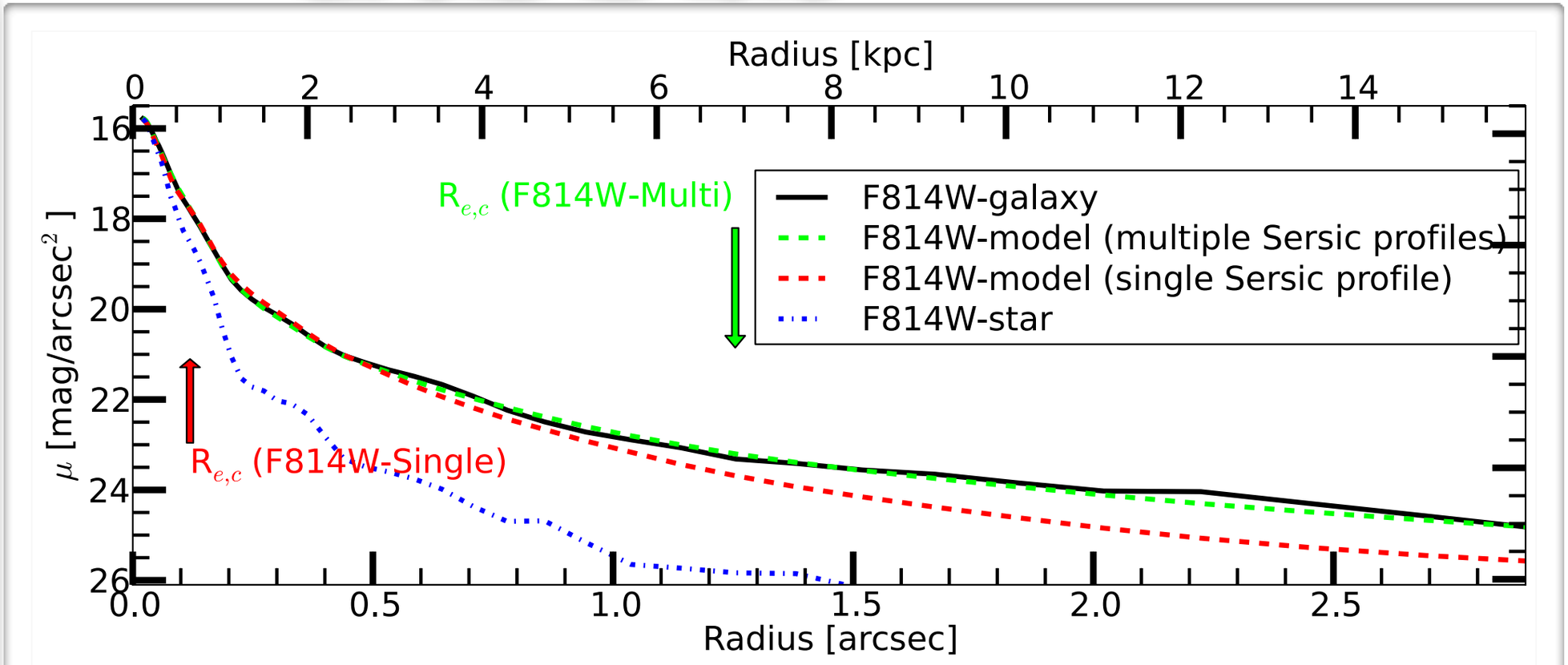
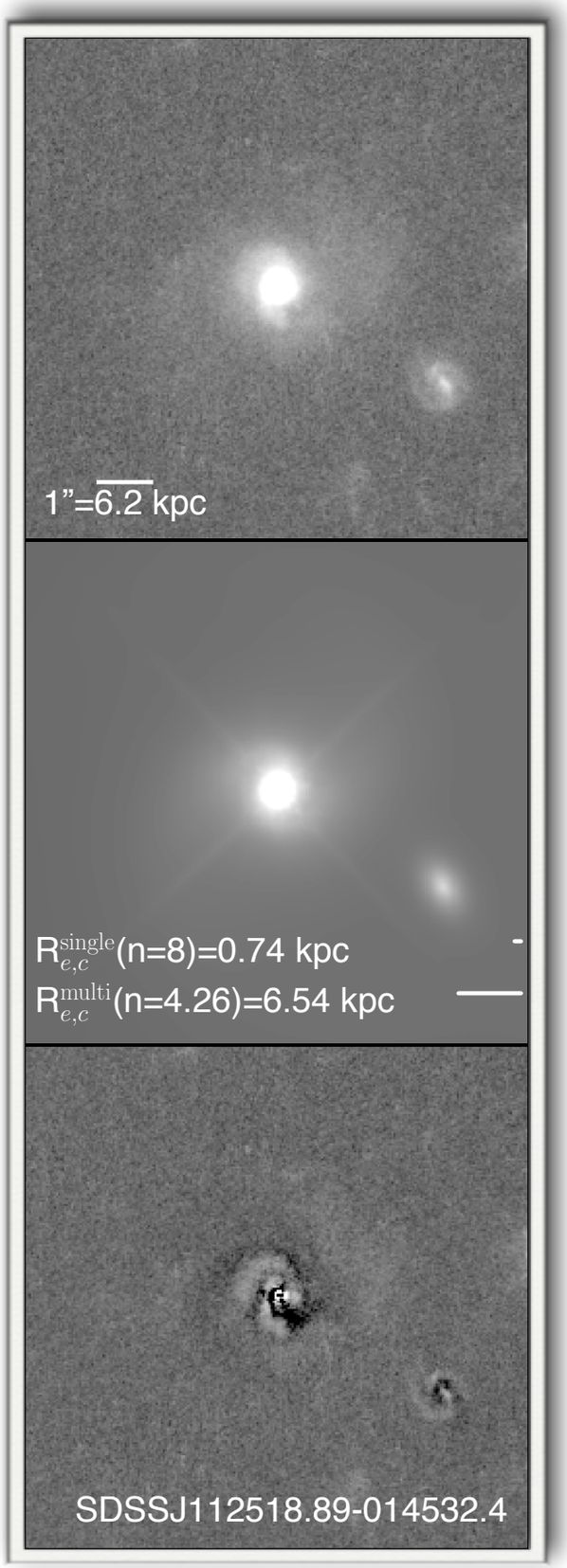
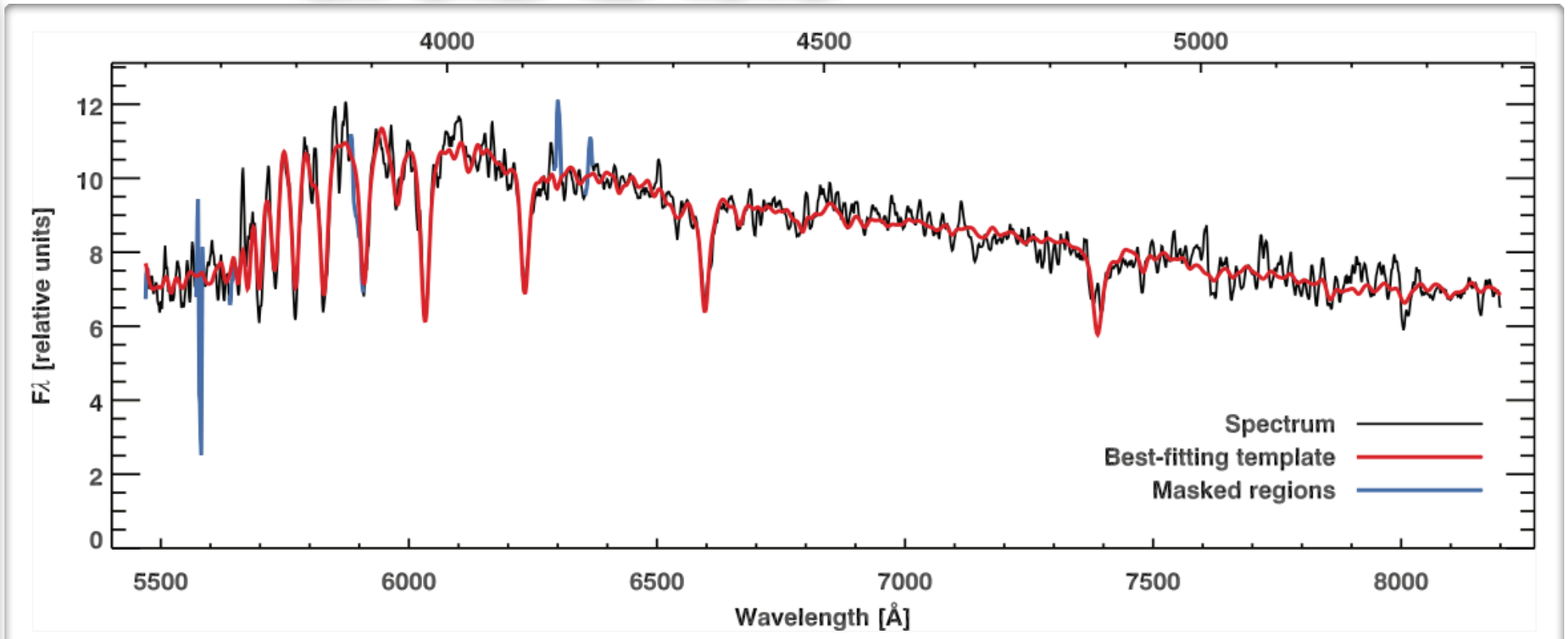




Extremely compact (Re=0.45-0.75 kpc) for their dynamical mass (σ=145-210 km/s)

Two distinct compact galaxy populations at 0.2<z<0.6

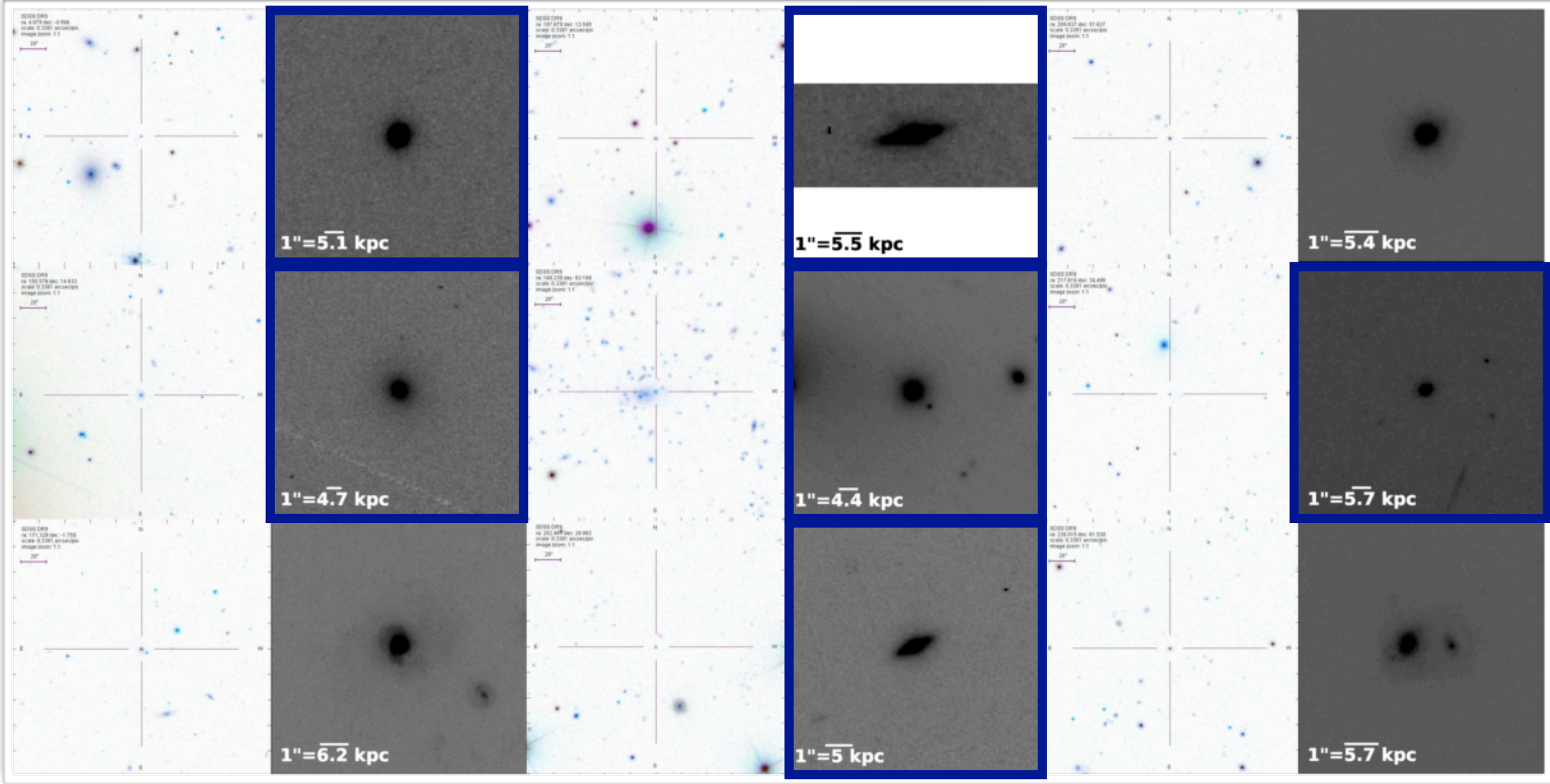




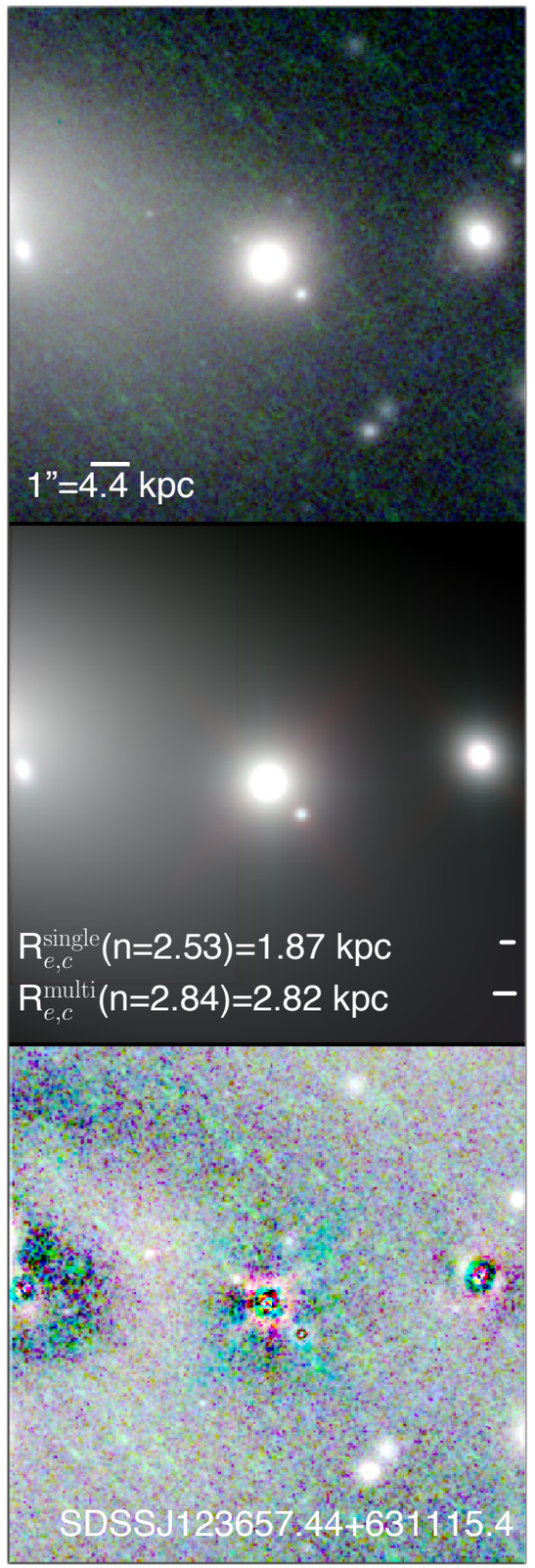
Extremely compact (Re=0.45-0.75 kpc) for their dynamical mass (σ=145-210 km/s)

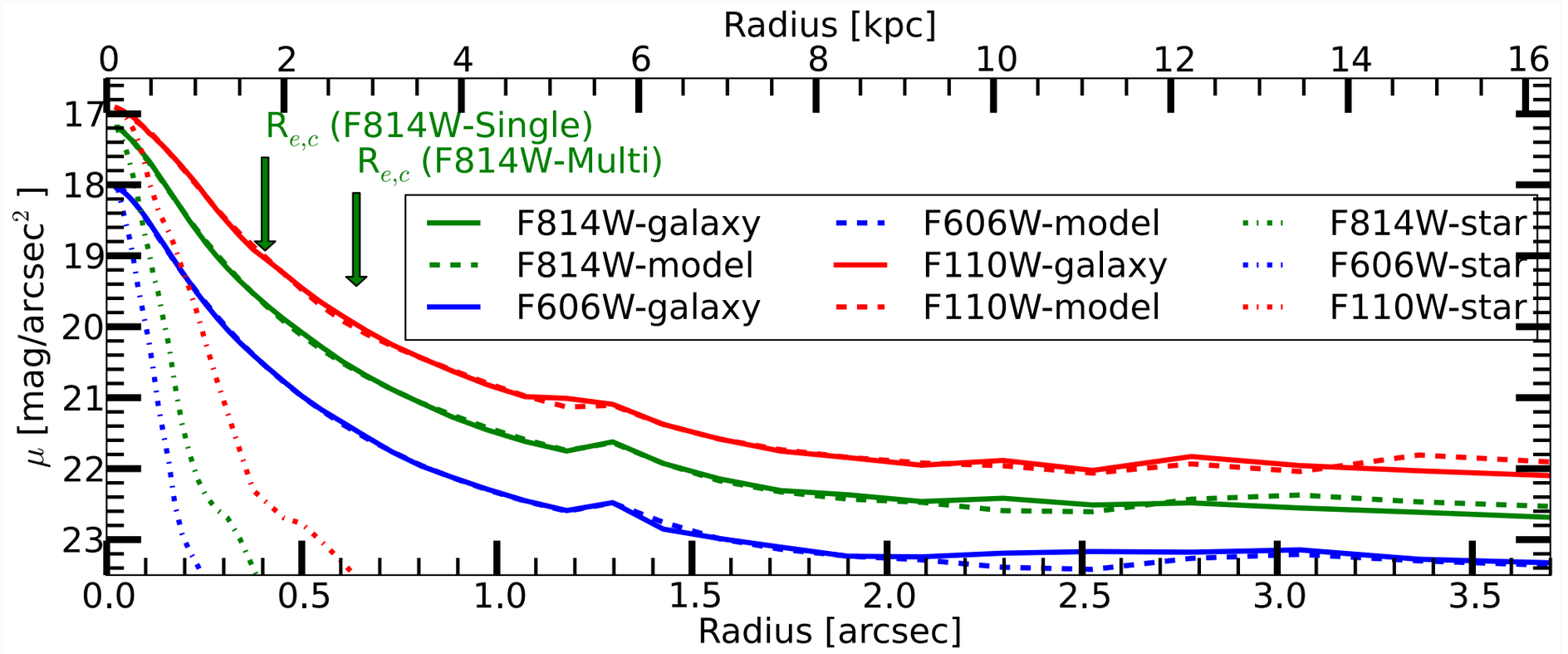
AND extremely young (<100 Myr)

Two distinct compact galaxy populations at 0.2<z<0.6



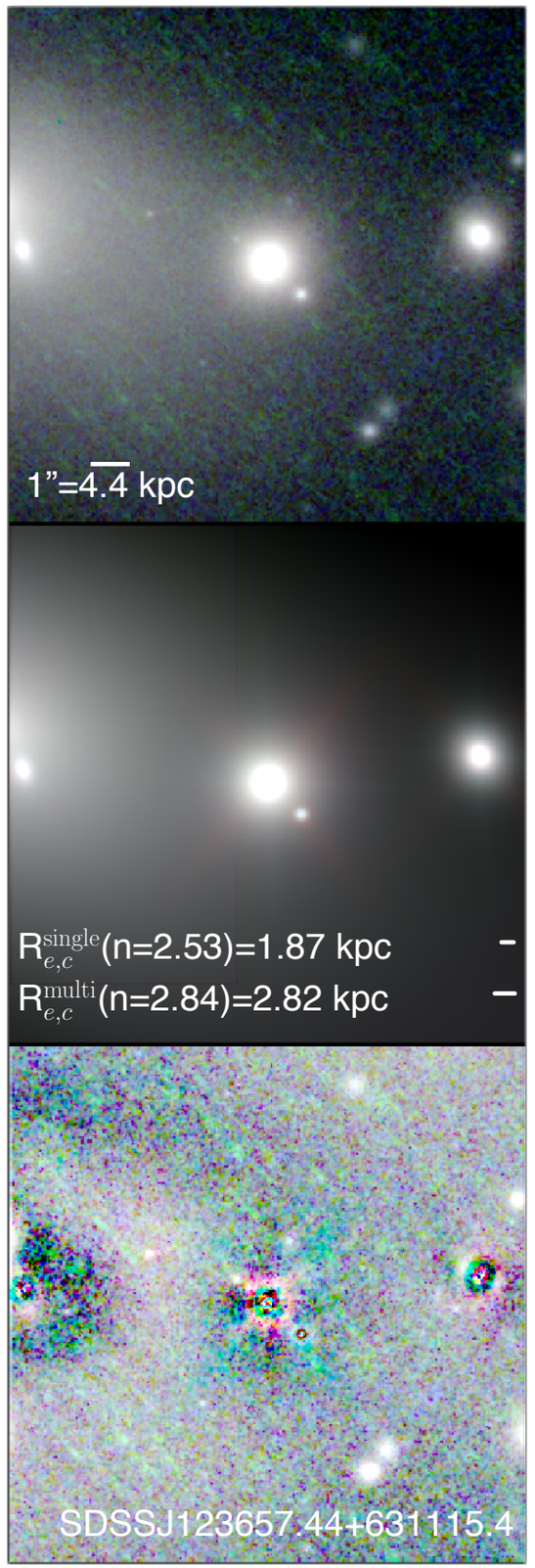
Two distinct compact galaxy populations at 0.2<z<0.6

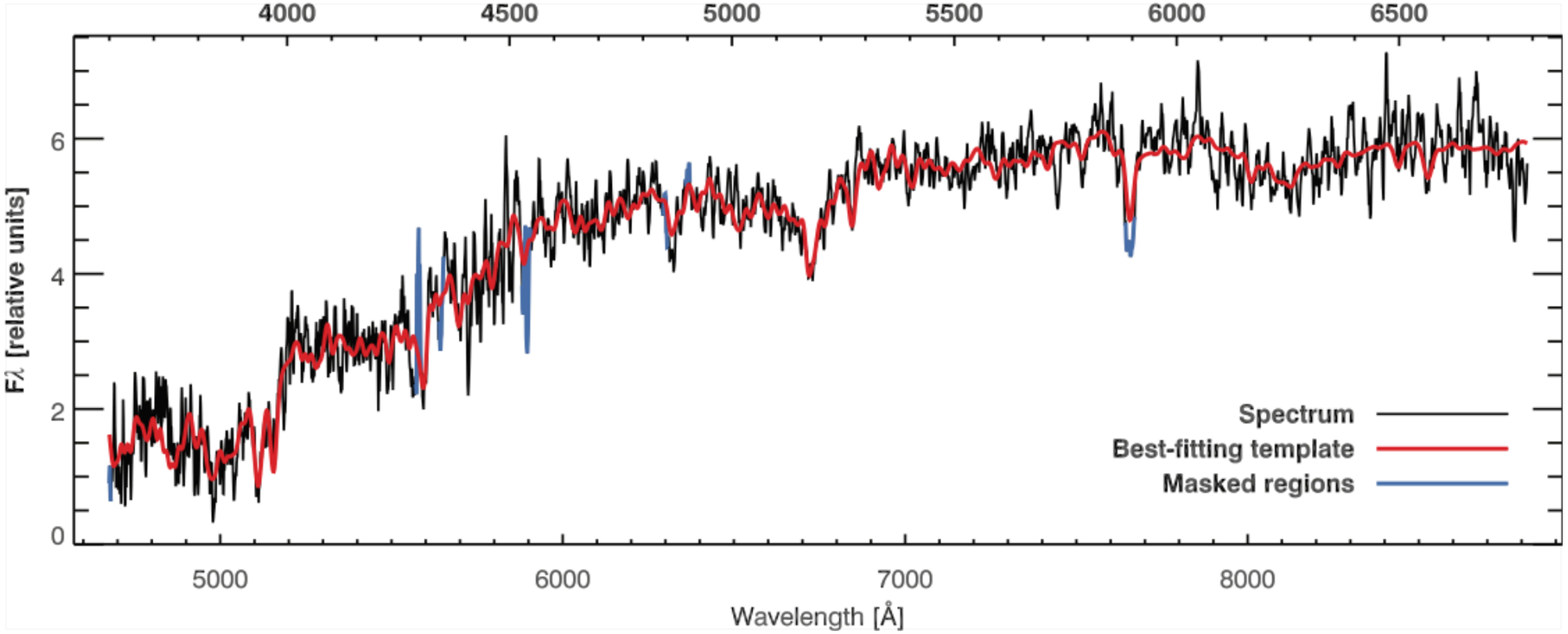




Extremely compact (Re=0.5-6.5 kpc, median 0.79 kpc) for their dynamical mass (σ=115-330 km/s, median 197 km/s)

Two distinct compact galaxy populations at 0.2<z<0.6

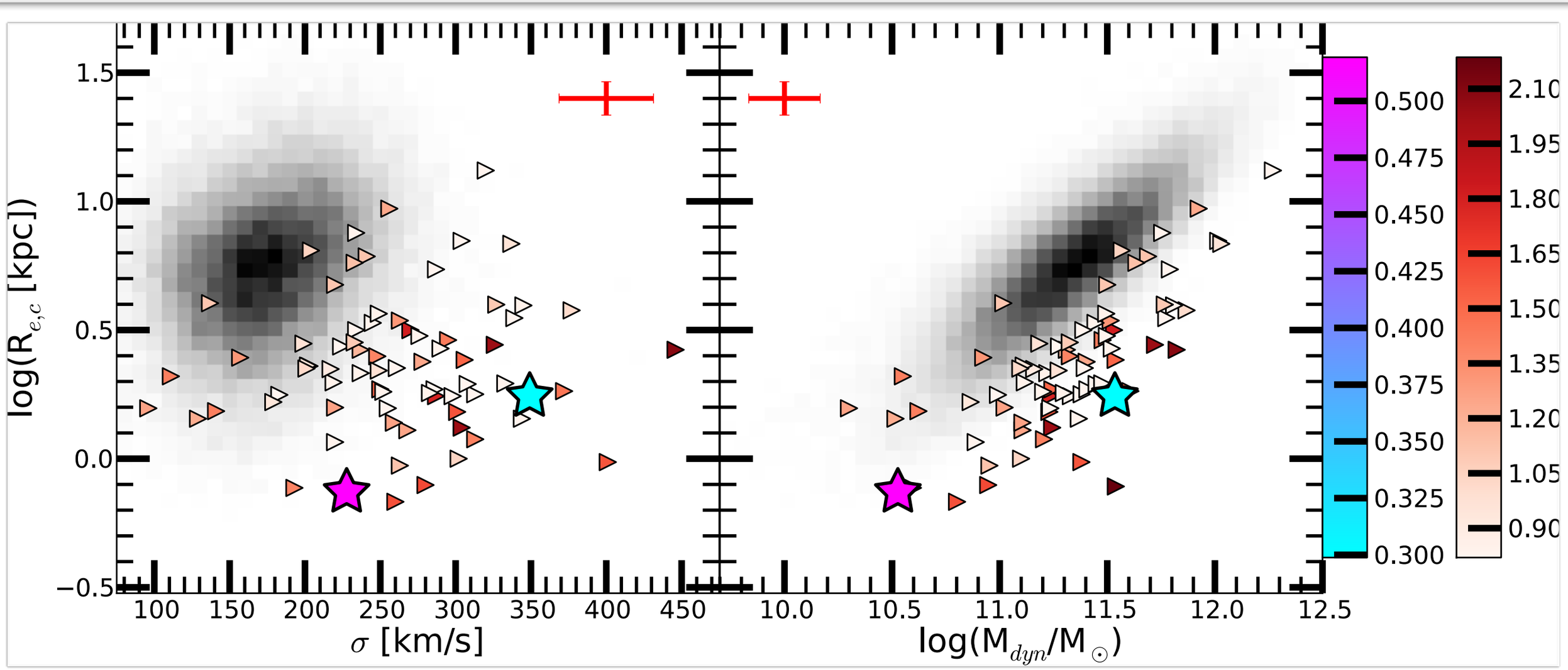




Extremely compact (Re=0.5-6.5 kpc, median 0.79 kpc) for their dynamical mass (σ=115-330 km/s, median 197 km/s)

AND old (≳1Gyr)

Dynamical Mass-Size Relation



Damjanov,I., Chilingarian, I., Hwang, H. S., Geller, M. J. 2013, ApjL, 775, L48

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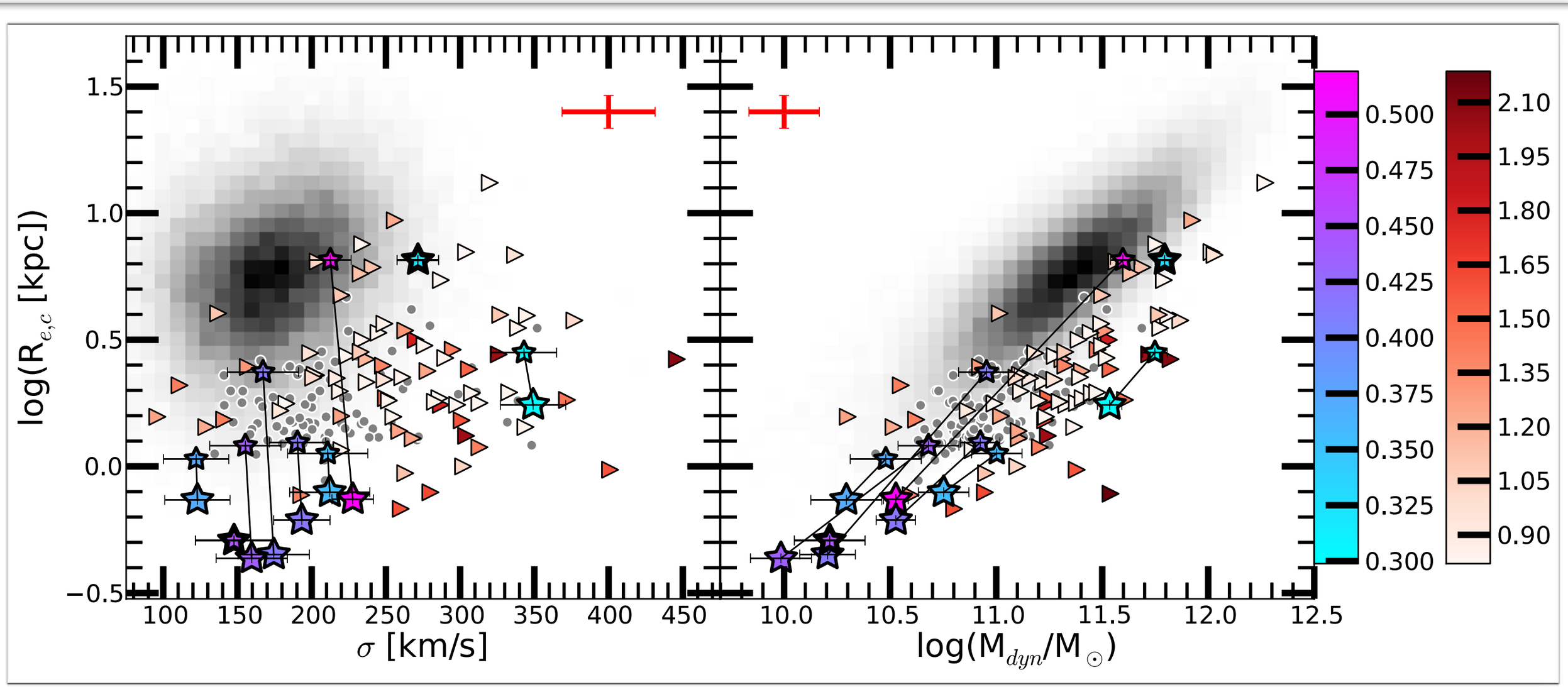

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What can we learn from intermediate redshift compacts?

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Redshift evolution of the number density

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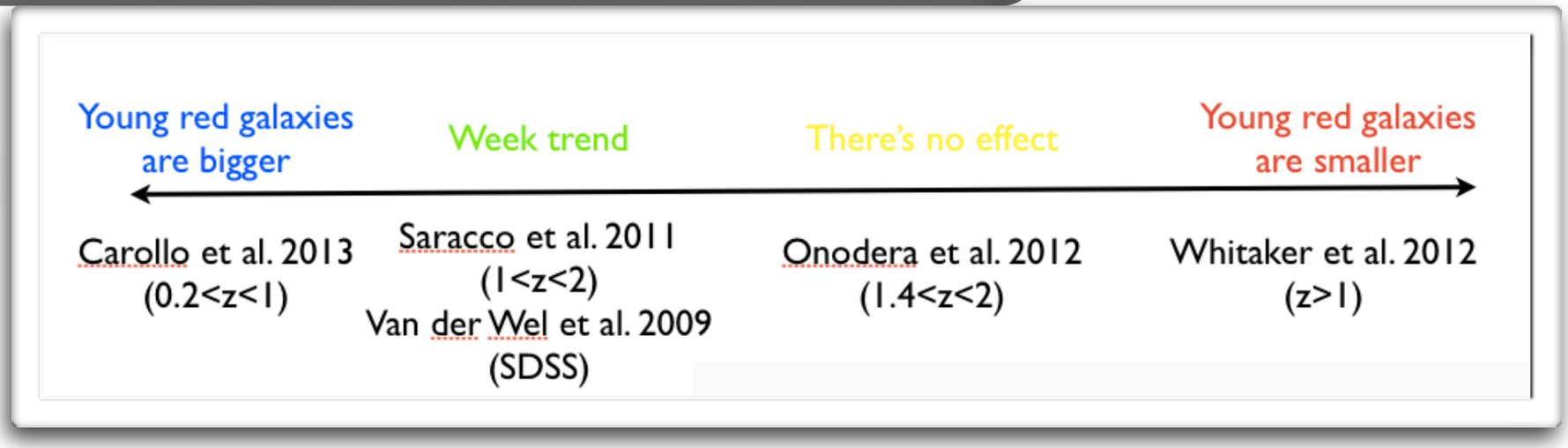
Redshift evolution of the number density

Progenitor bias



What can we learn from intermediate redshift compacts?

Redshift evolution of the number density

Progenitor bias

Young red galaxies are bigger — Week trend — There's no effect — Young red galaxies are smaller

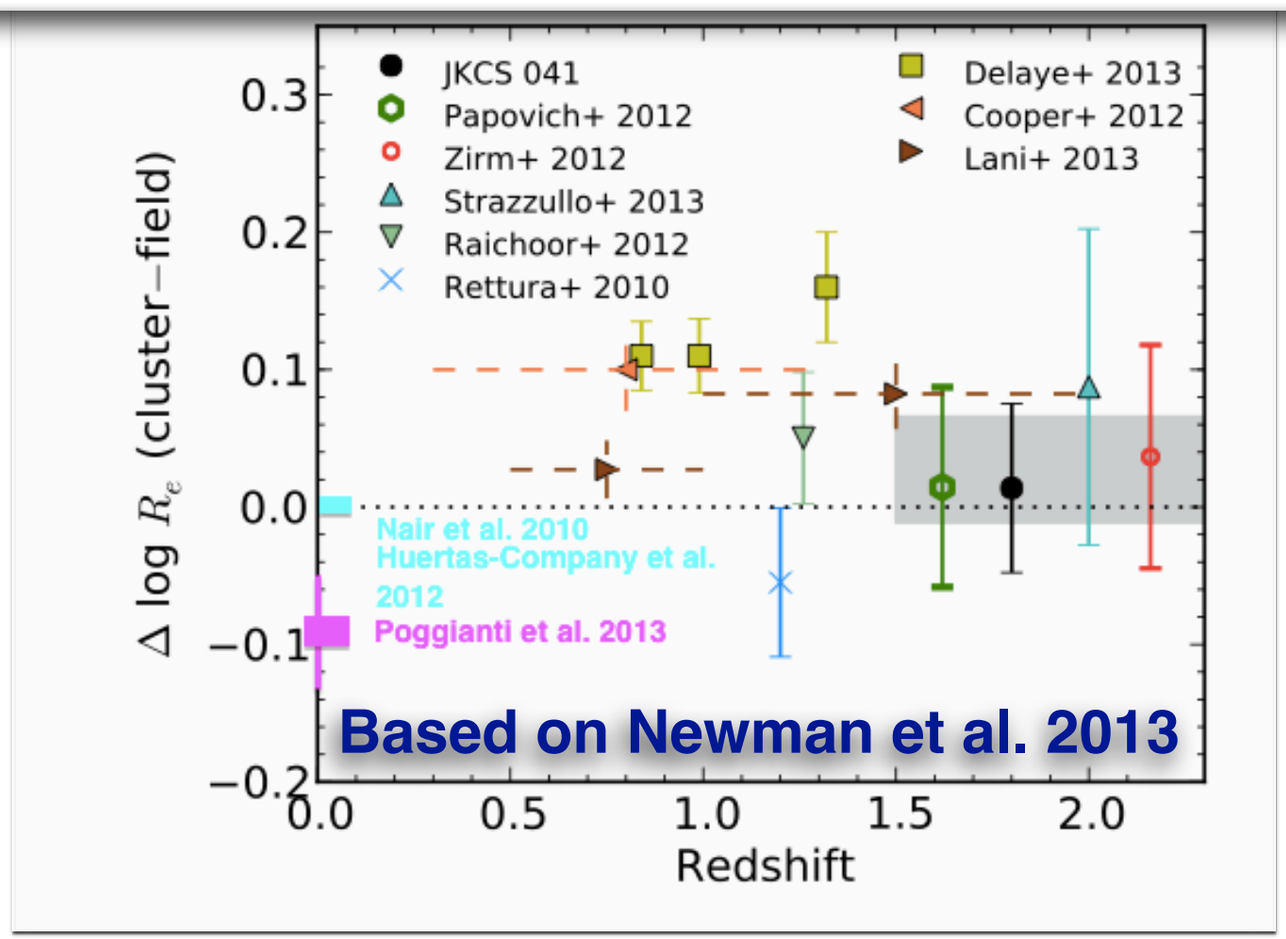
Carollo et al. 2013 (0.2<z<1)

Saracco et al. 2011 (1<z<2)
Van der Wel et al. 2009 (SDSS)

Onodera et al. 2012 (1.4<z<2)

Whitaker et al. 2012 (z>1)

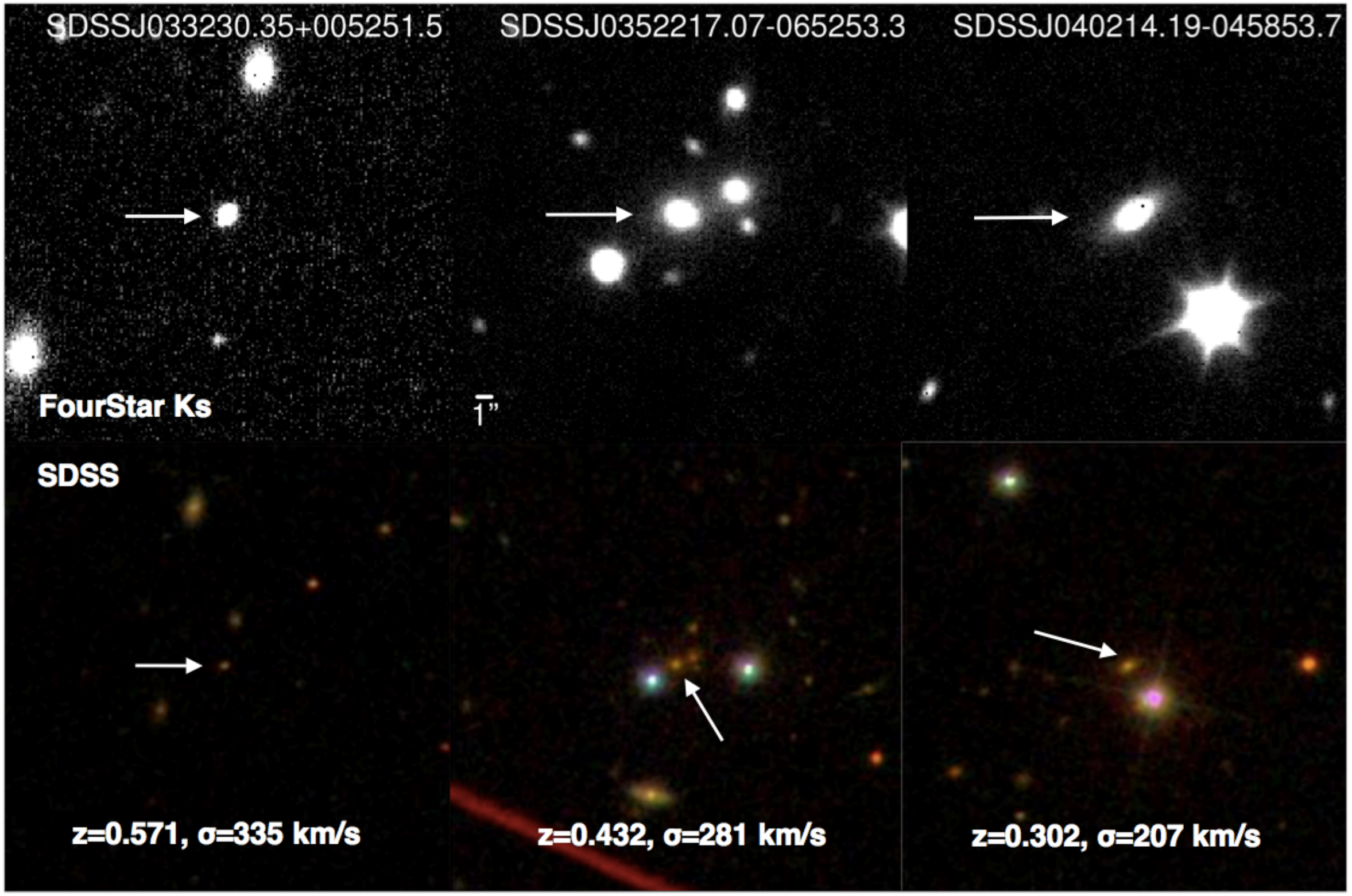
Environment



Ongoing and Future Work

- CFHT imaging of ~100 objects
- Magellan MMIRS+FourStar Ks-band imaging of ~15 objects (and counting)

Ongoing and Future Work



Summary

- Compact massive galaxies at intermediate redshifts - a missing link between high-z red nuggets and their rare z~0 analogs
- SDSS stars with galaxy spectra ⟶ intermediate redshift compact galaxies
- 1000 SDSS candidates at 0.2<z<0.6, 9 confirmed with HST, additional ~100 with ground-based optical and near-IR imaging
- Two types: red and post-starbursts
- Their dynamical mass-size relation: remarkably similar to the one at z>1
- Future: number density evolution, probing ages, surroundings...