Fundamental plane of massive quiescent galaxies at z=2

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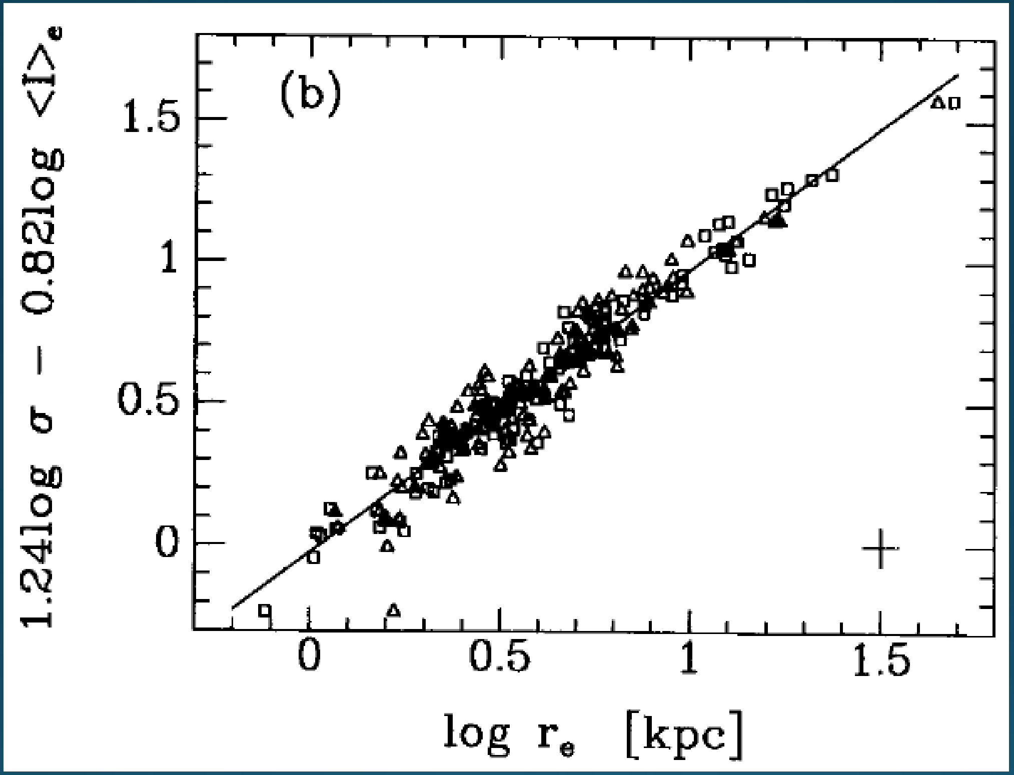
Fundamental plane of elliptical galaxies



Early-type galaxies in the local universe form a plane in the sigma, re, and mu plane with a very small scatter.

Psuedo-color image based on ACS/WFC3 images from CANDELS

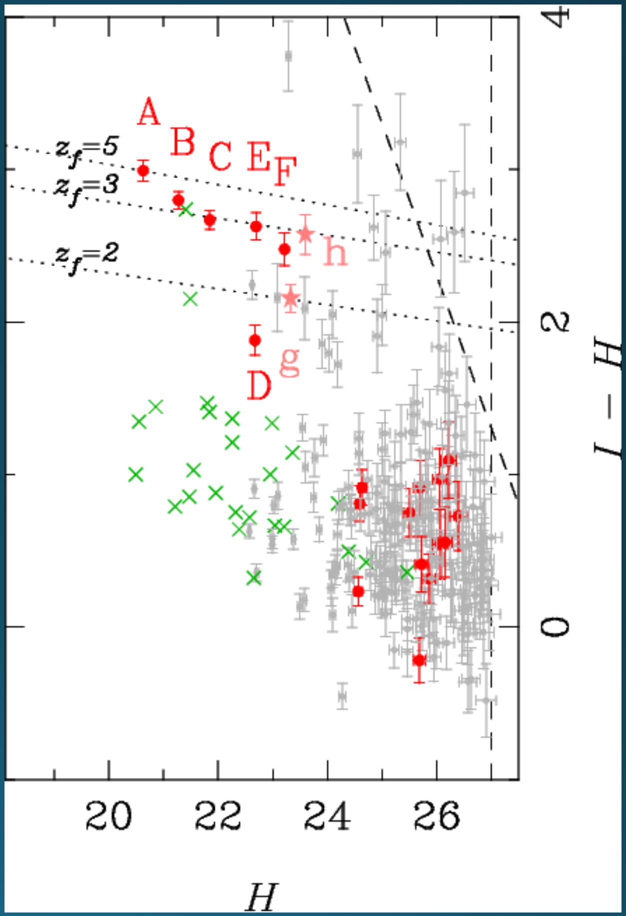
A group of galaxies at z=1.61 in the Chandra Deep Field South

Tanaka et al. 2013 PASJ, 65, 17

Color-magnitude diagram

Photo-z member candidates

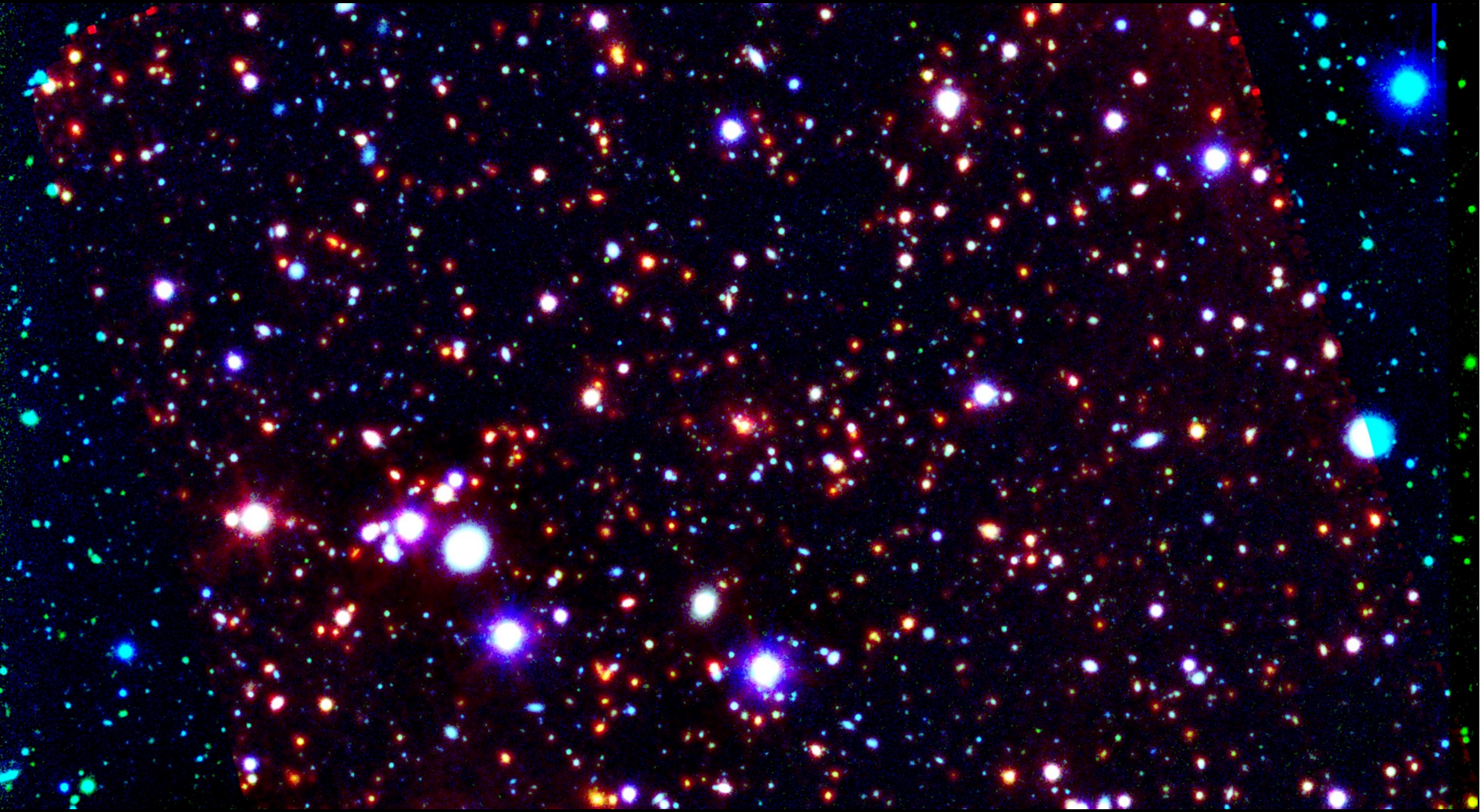
Spectroscopically confirmed fg/bg galaxies.



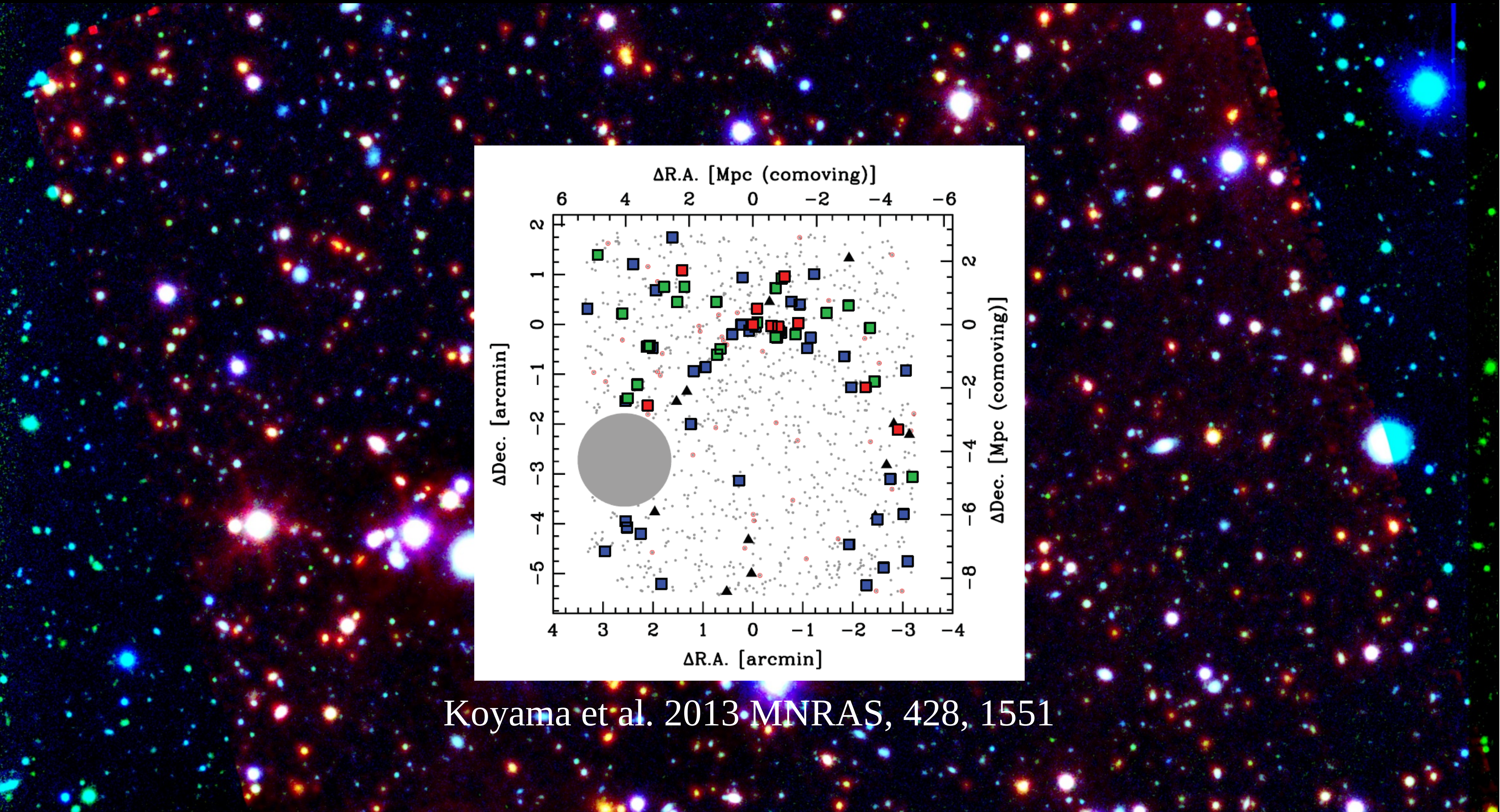
Mags/Colors are from ACS/WFC3 from CANDELS.

Tanaka et al. 2013, PASJ, 65 17

PKS1138 at z=2.16 : *ugVRIzJHKs[3.6][4.5][5.7][8.0]*

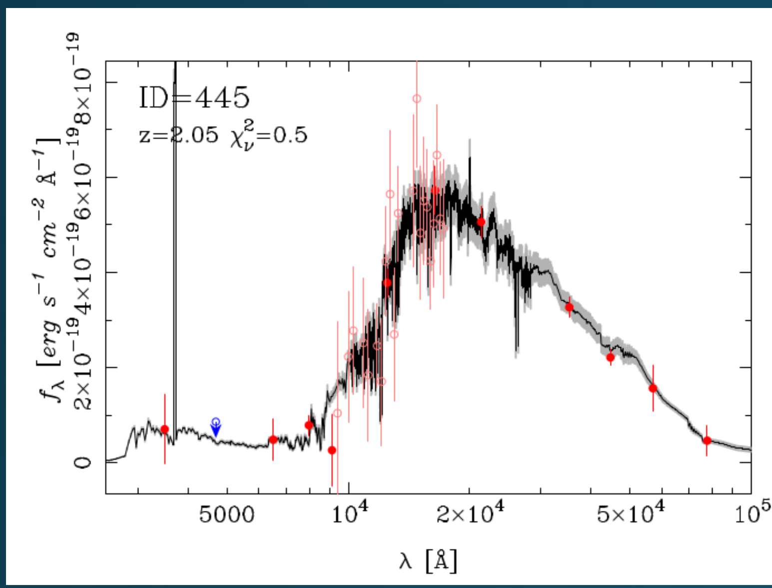


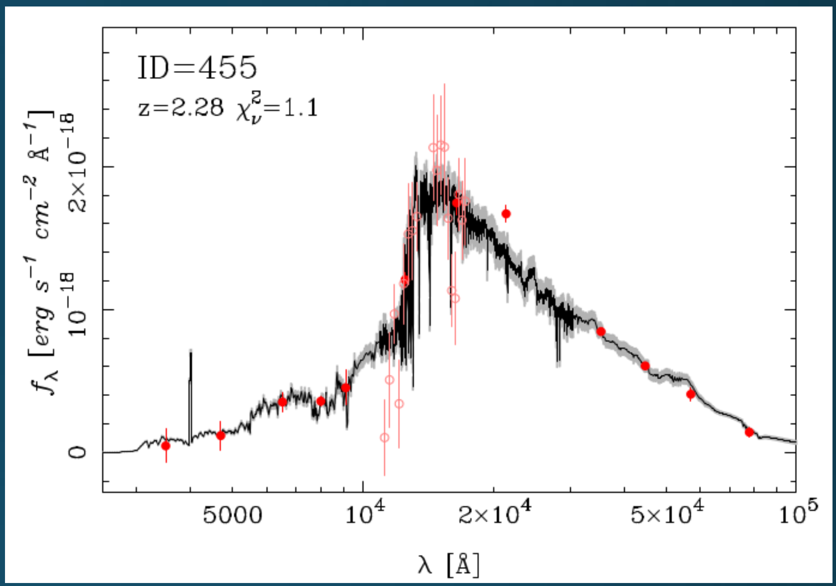
PKS1138 at z=2.16 : *ugVRIzJHKs[3.6][4.5][5.7][8.0]*



Koyama et al. 2013 MNRAS, 428, 1551

Spectrophotometric redshifts





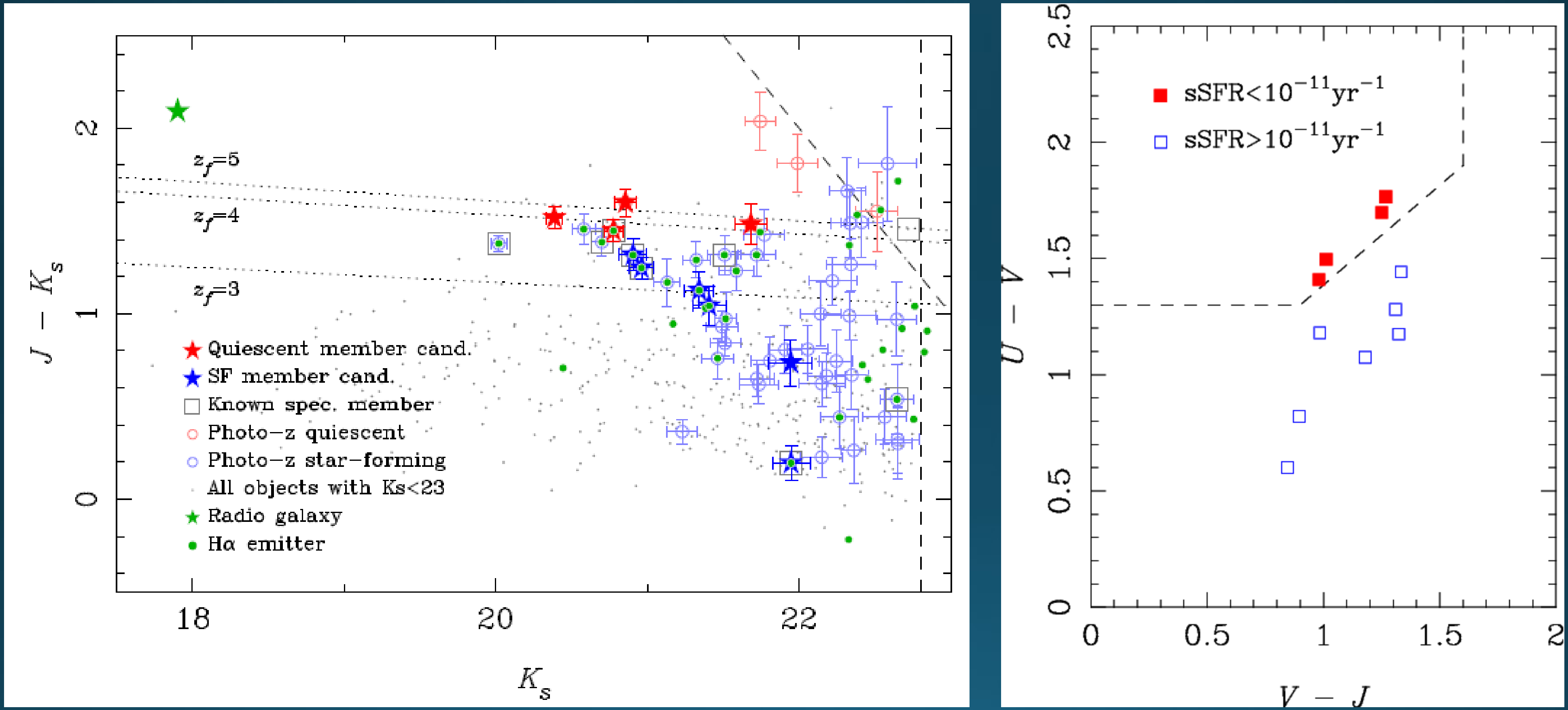
Broad-band photometry

MOIRCS spectra

Combined broad-band and spectrum fitting allows us to constrain redshifts and physical parameters fairly well.

Tanaka et al. 2013 ApJ, 772, 113

Nascent red sequence



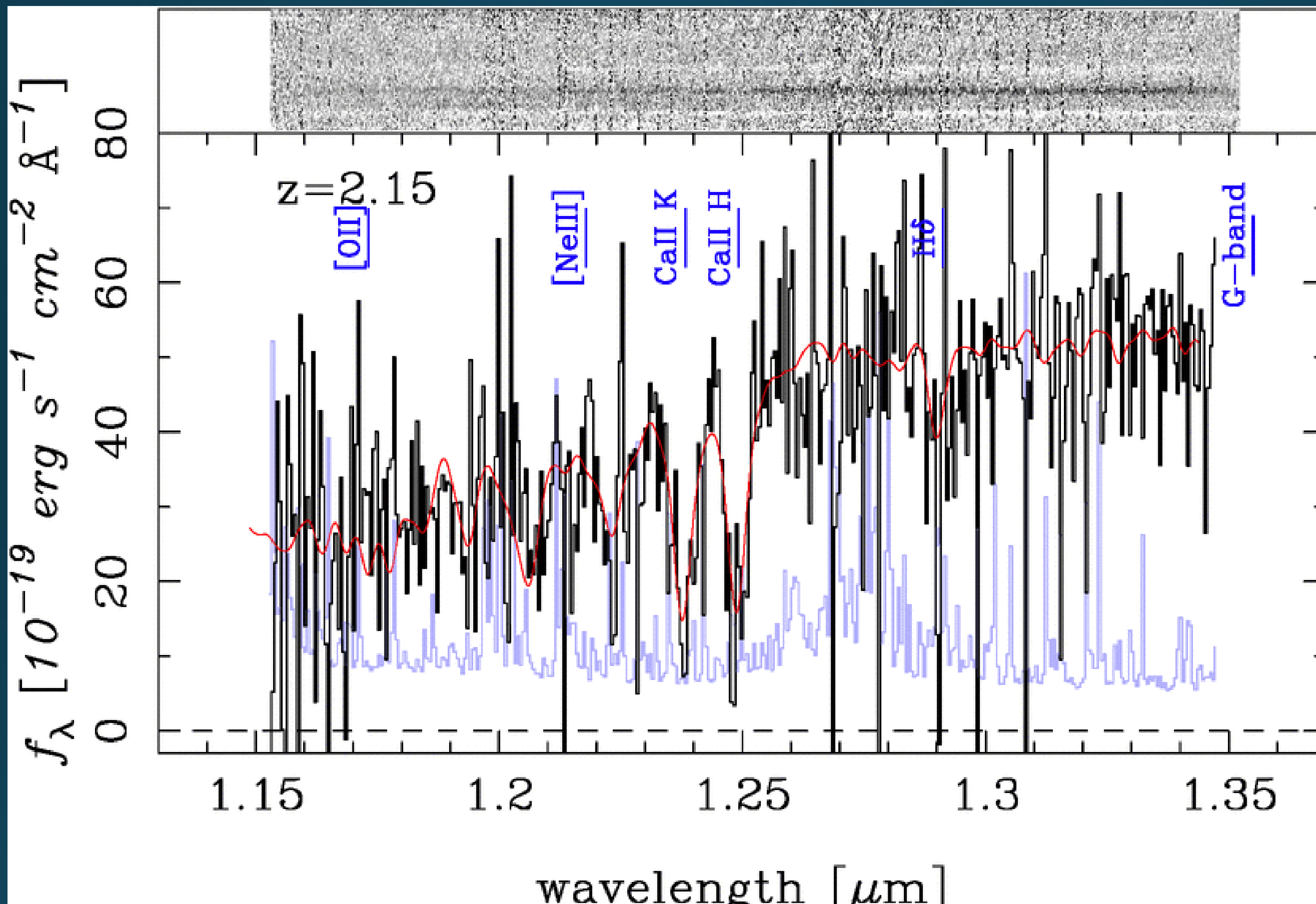
The quiescent galaxies occupy the upper envelope of the red sequence.

Tanaka et al. 2013 ApJ, 772, 113

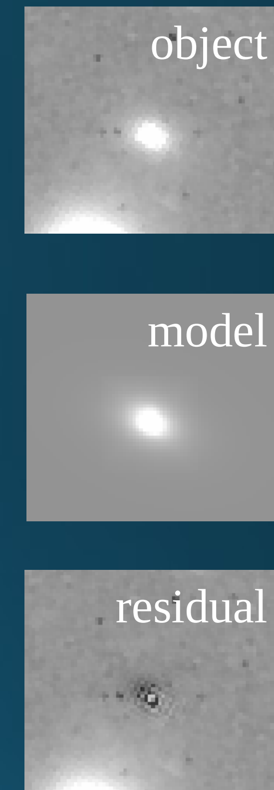
Keck MOSFIRE follow-up observation in 2015:

CDFS group (z=1.6) : no sufficient signal due to short integration time.
PKS1138 (z=2.1) : ~8 hours of integration time.

Work in progress!



NICMOS F160W



object

noise

pPXF best-fit

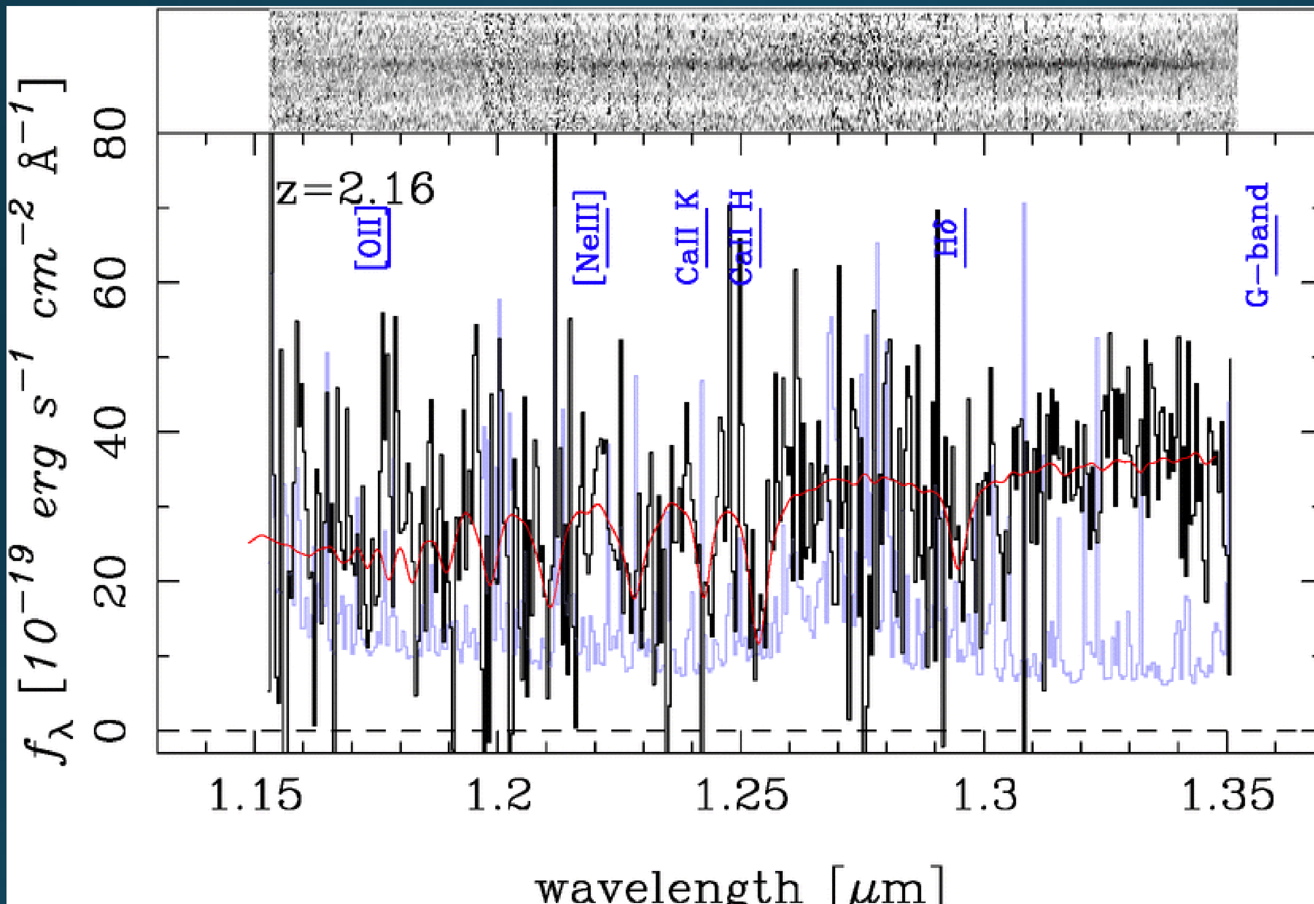
sigma=287 ± 49 km/s

Re=4.3 ± 1.0 kpc

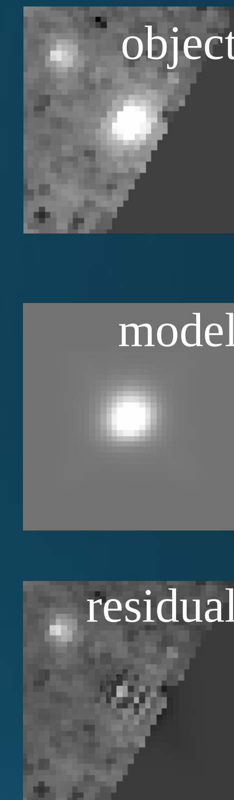
Sersic n = 3.04 ± 0.14

M*= 1.82e+11 +9.39e+09 -8.87e+09 Msun

Work in progress!



NICMOS F160W

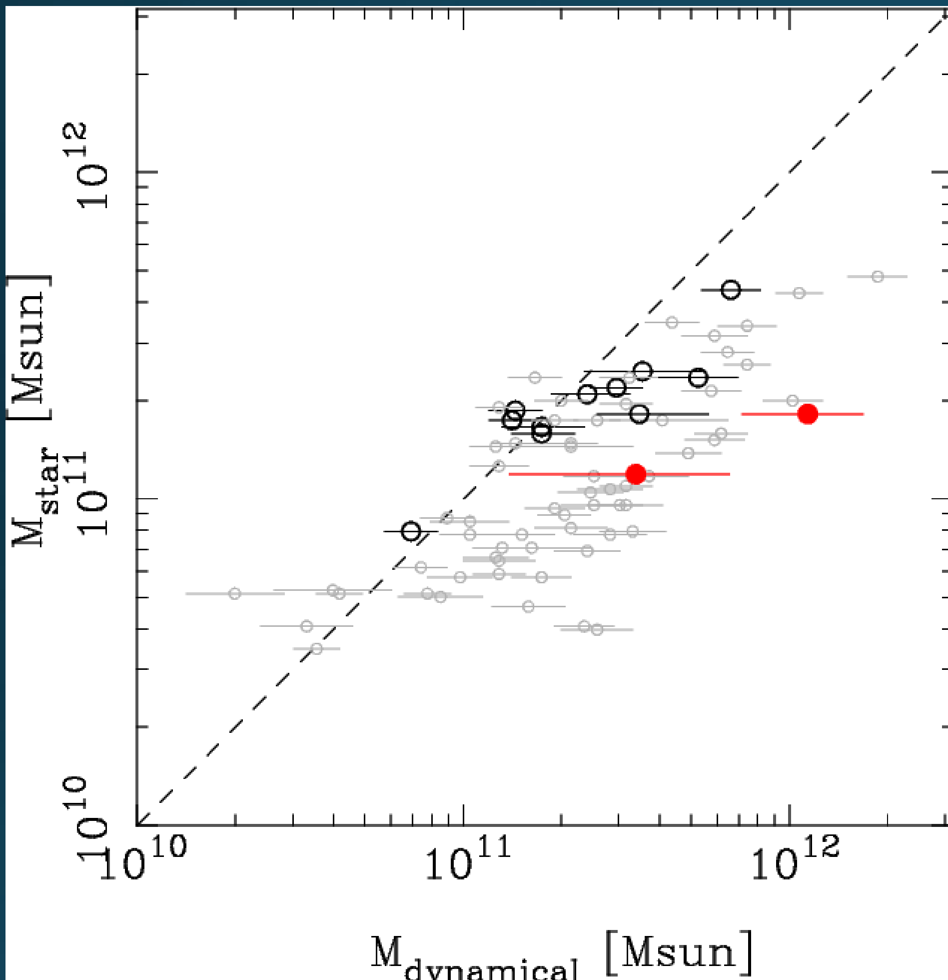


object noise pPXF best-fit

Sigma= 228 ± 82 km/s Re=1.6 ± 0.2 kpc Sersic n =0.96 ± 0.11

M*=1.19e+11 +7.04e+09 -6.65e+09 Msun

Work in progress!



This work

z>1.5 from the literature

z<1.5 from the literature

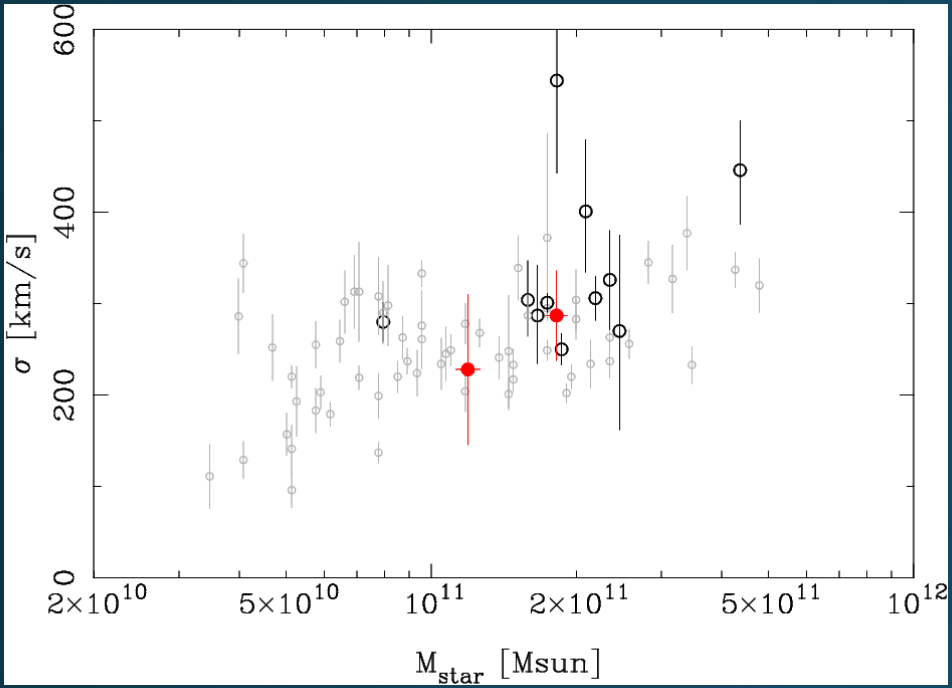
$$M_{\mathrm{dyn}} = \frac{\beta(n)\sigma_e^2 r_e}{G}$$

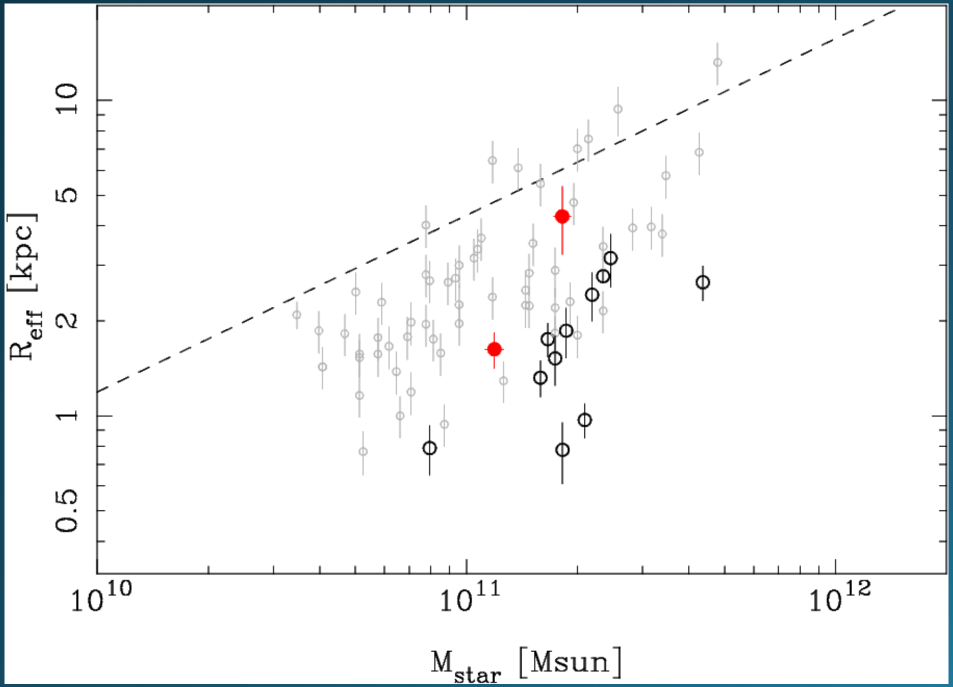
$$\beta(n) = 8.87 - 0.831n + 0.0241n^2$$

Literature data from van de Sande et al. 2013, Bezanson et al. 2013, van Dokkum et al. 2009, Onodera et al. 2012, Cappellari et al. 2009, Newman et al. 2010, van der Wel et al. 2008, Blakeslee et al. 2006, Toft et al. 2012.

The proto-cluster galaxies seem to have larger dynamical masses than field galaxies at fixed stellar mass.

Work in progress!





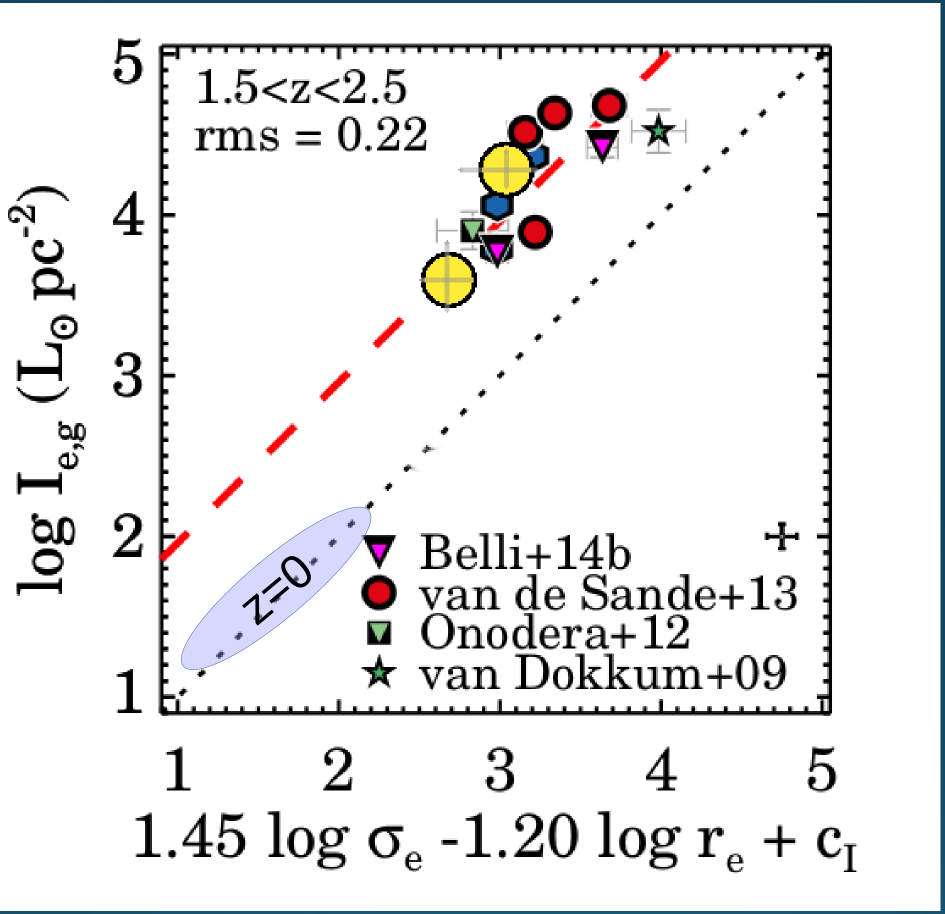
This work

z>1.5 from the literature

z<1.5 from the literature

The proto-cluster galaxies have similar velocity dispersion to the field galaxies. It seems the observed offset in Mdyn is primarily driven by larger Re.

Work in progress!



Overlaid on figures from van de Sande+ 2014.

The proto-cluster galaxies seem to be more evolved than the field galaxies.

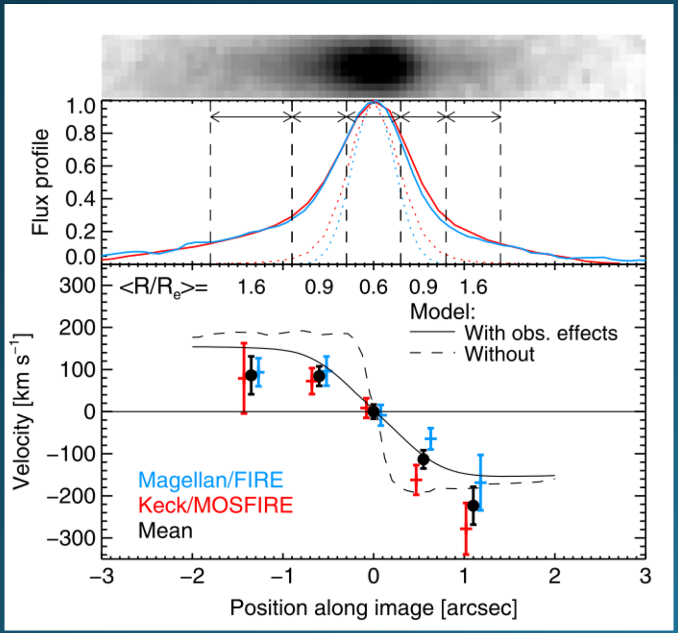
What does all this mean?

Proto-cluster galaxies seem to be more evolved than field galaxies at similar redshifts. That makes sense. A few possible interpretations/caveats:

1) Accelerated formation in high-density regions

2) The field sample is actually biased; many of them are post-starburst galaxies and they are centrally concentrated due to the nuclear starbursts

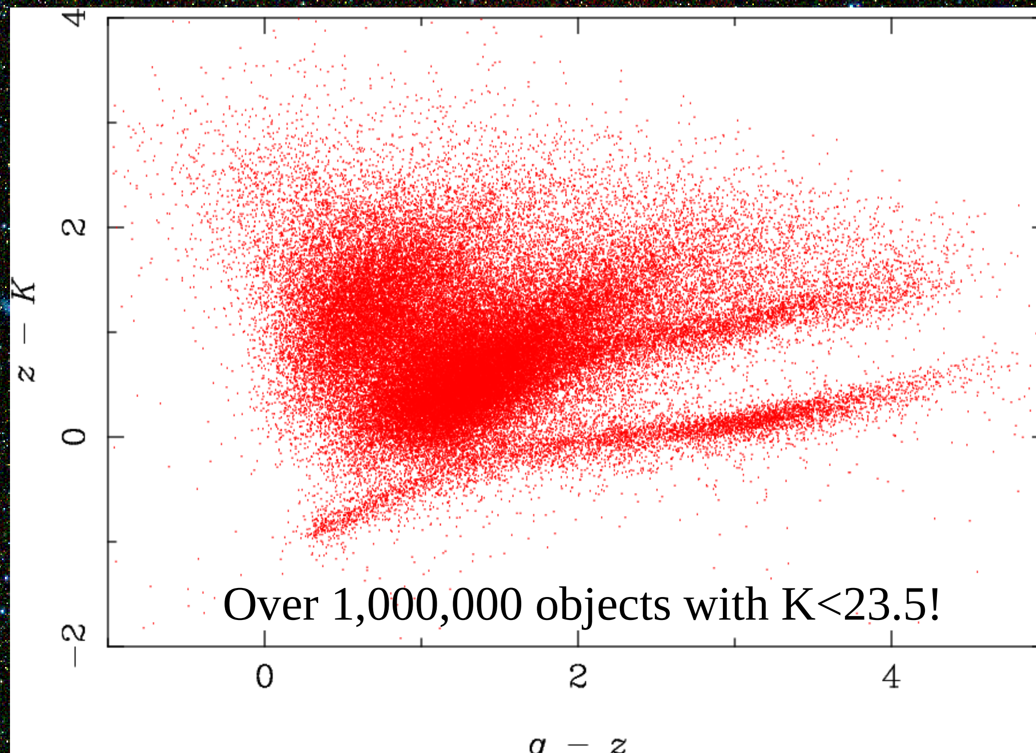
3) Quiescent galaxies may actually be rotating. This will make the interpretation of velocity dispersion difficult.



Newman et al. 2016:
A rotating massive quiescent galaxy.
But, MUCH better example of this by Toft et al. (in review).

HSC is an obvious step forward!

ELAIS-N1: gzK pseudo-color composite
(note this is just one tract!)



Summary

- We performed deep near-IR spectroscopy of proto-cluster galaxies at z=2.2 with MOSFIRE.
- The proto-cluster galaxies seem to be more evolved than field galaxies at similar redshifts.
- The observed difference seems to be primarily driven by the larger Re.
- But, we have just two proto-cluster galaxies here!!
- Future massive surveys will improve the situation fairly quickly.