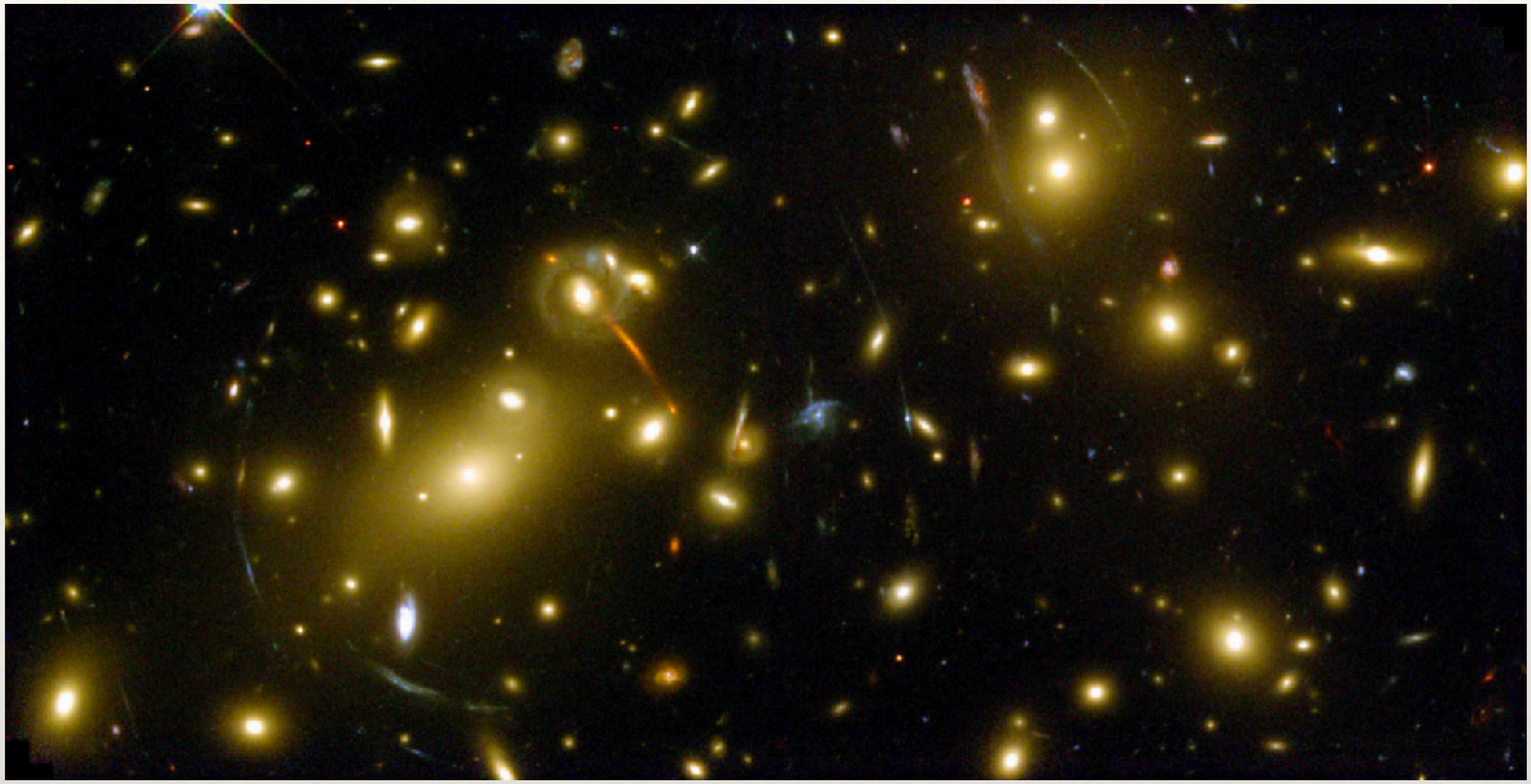


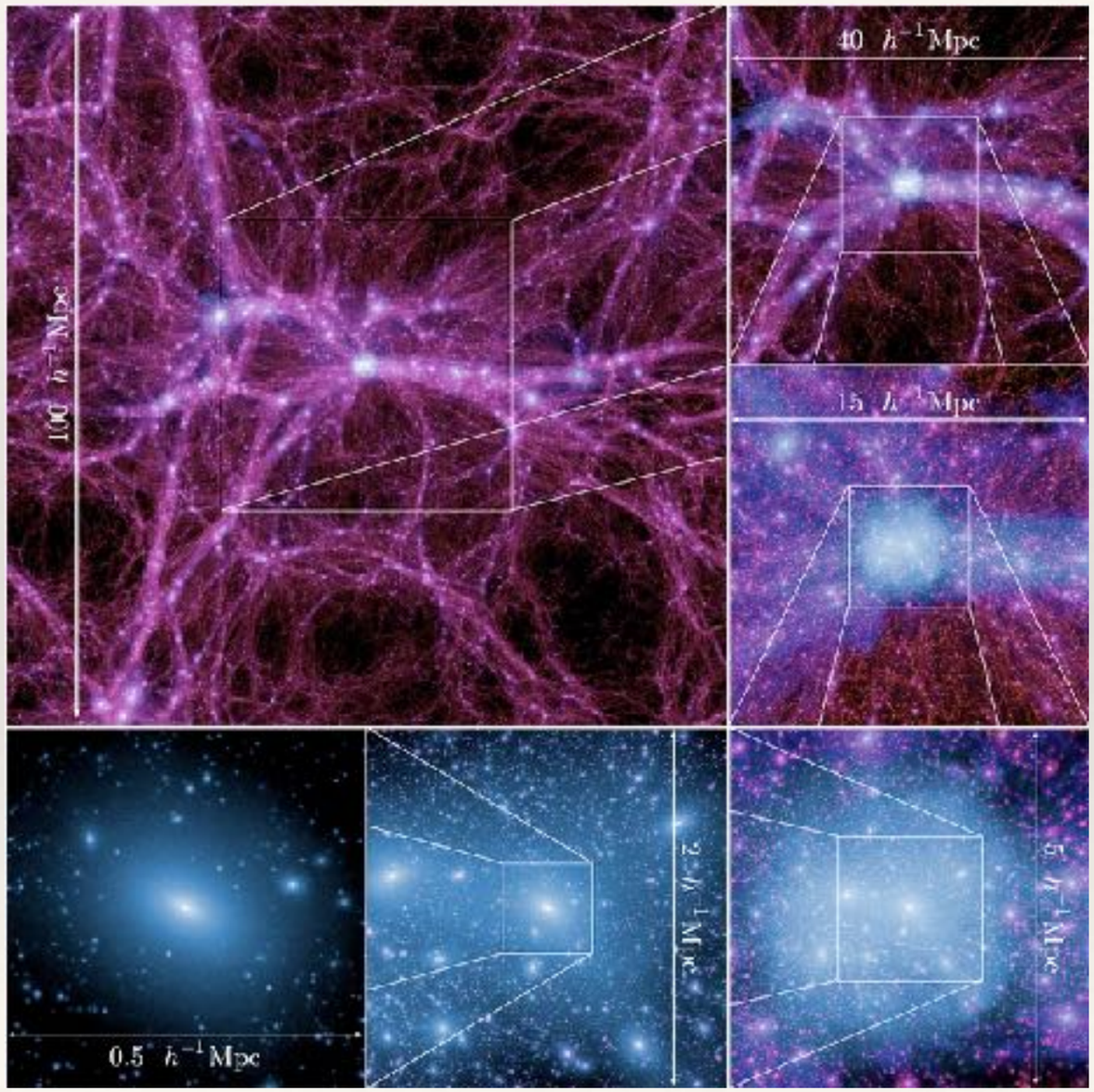
The dark matter content of cluster galaxies

From LRGs to UDGs

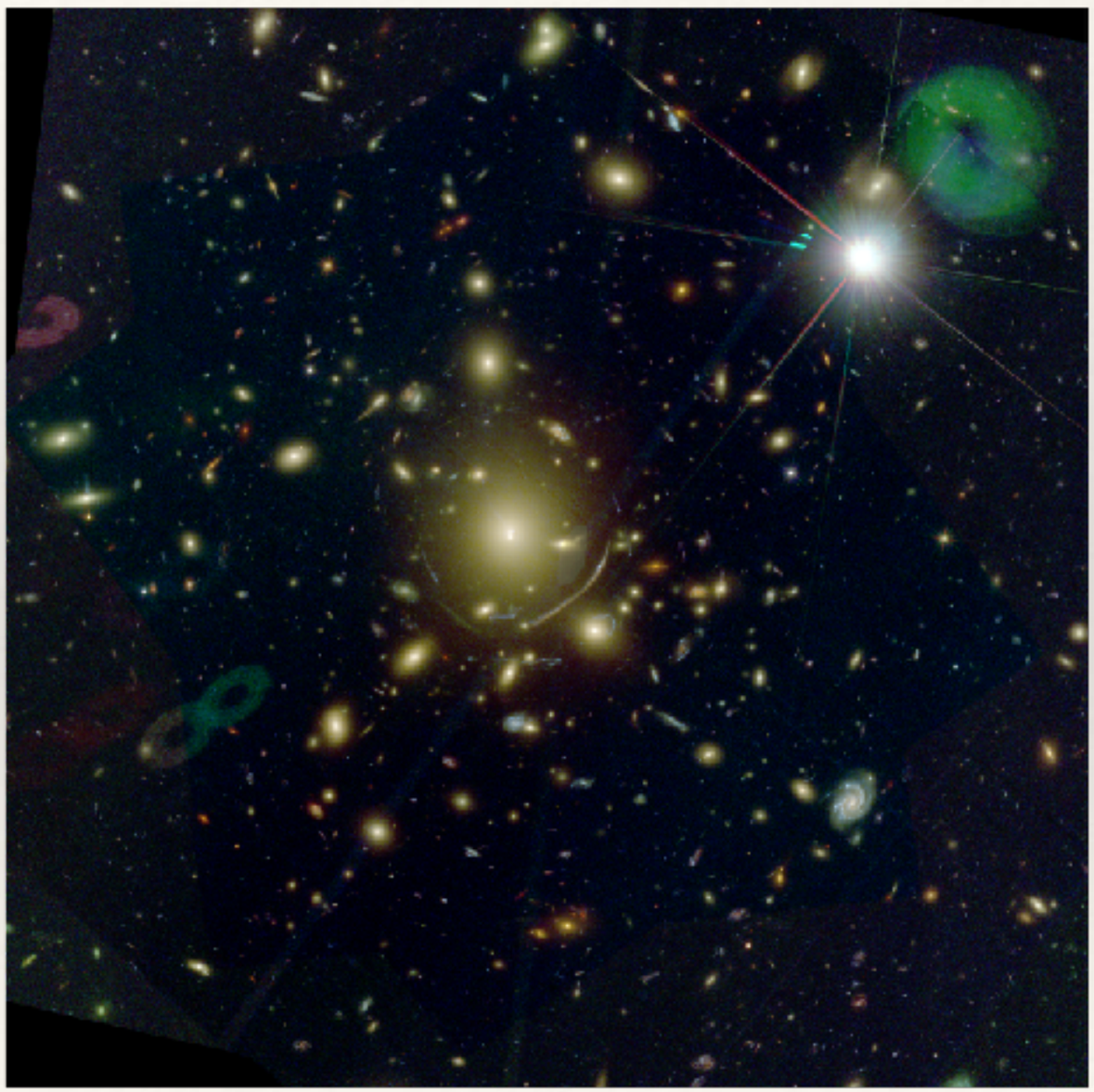
Cristóbal Sifón
Clusters 2017
Santander, July 2017

w/ Ricardo Herbonnet, Henk Hoekstra, Remco van der Burg

Subhalo: DM counterpart of satellite galaxy

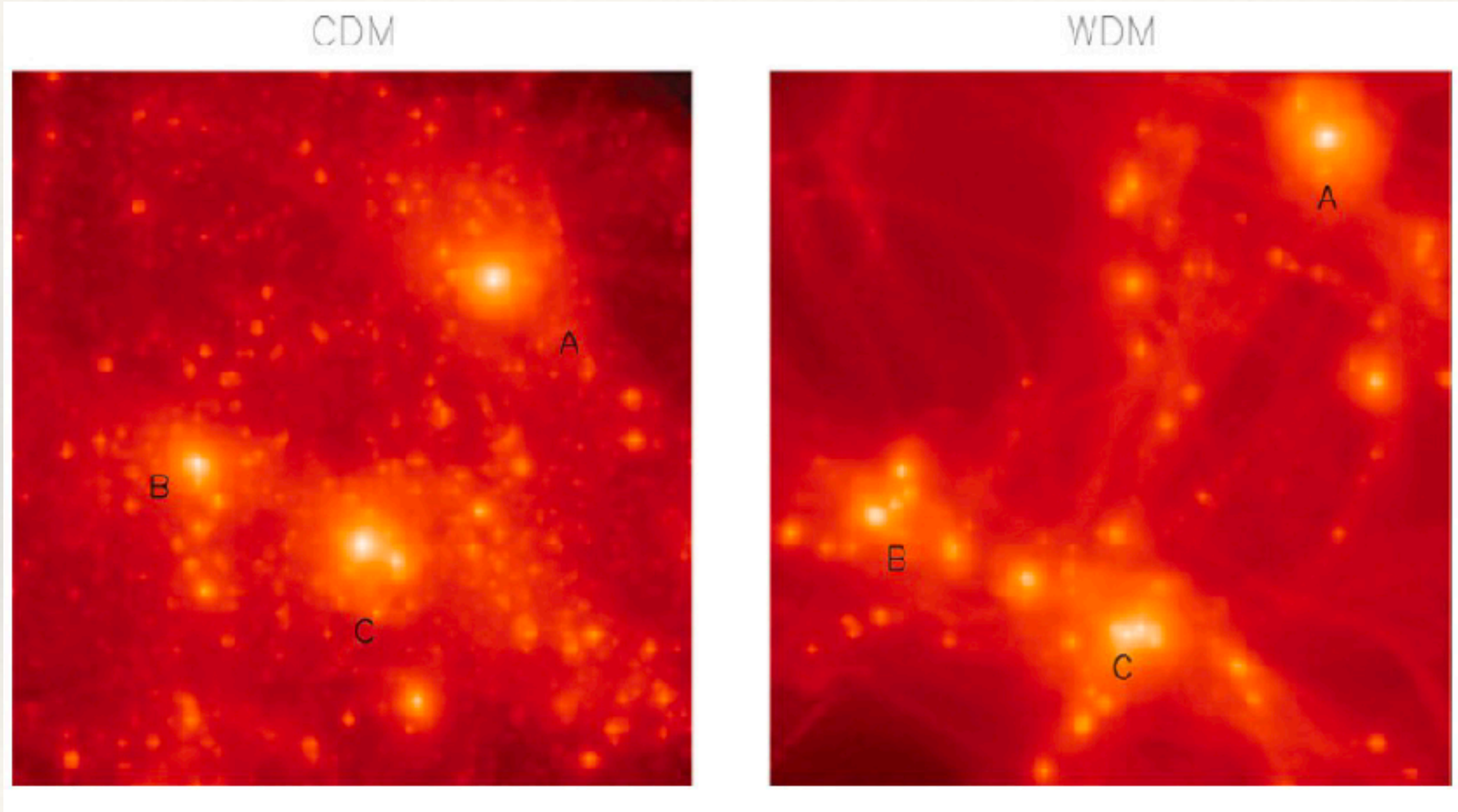


Millenium Simulation (Springel+01)



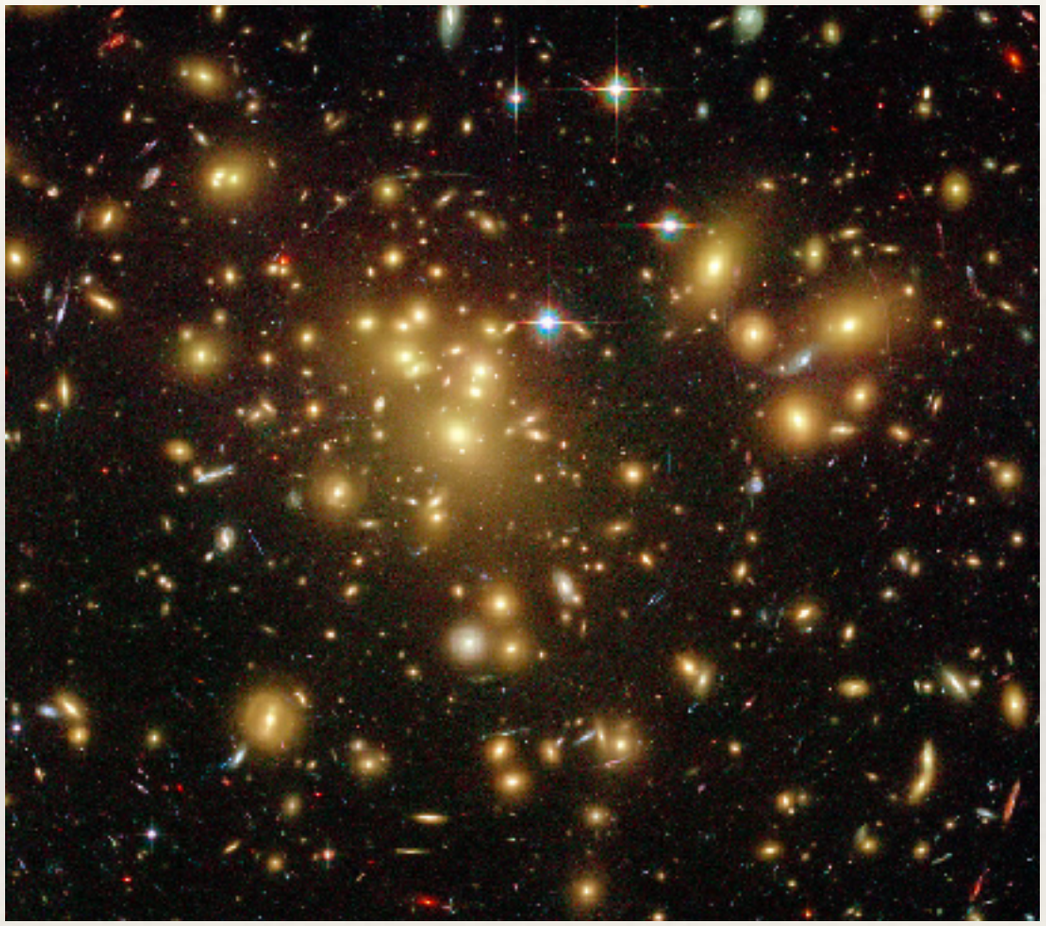
Abell 611 (Credit: Hubble Frontier Fields, Jennifer Lotz et al.)

Sensitive to cosmology

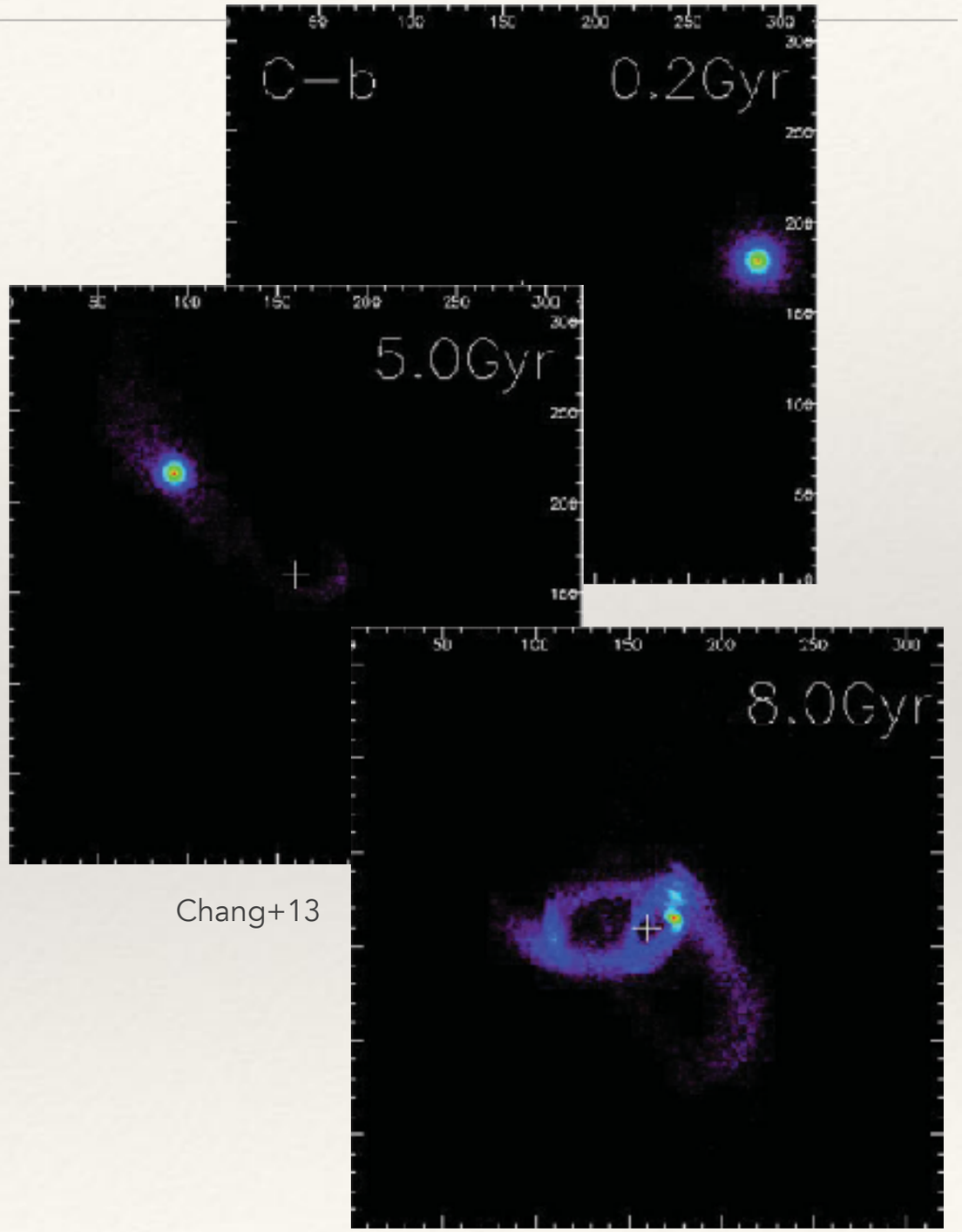


Libeskind+13

Different than central halos

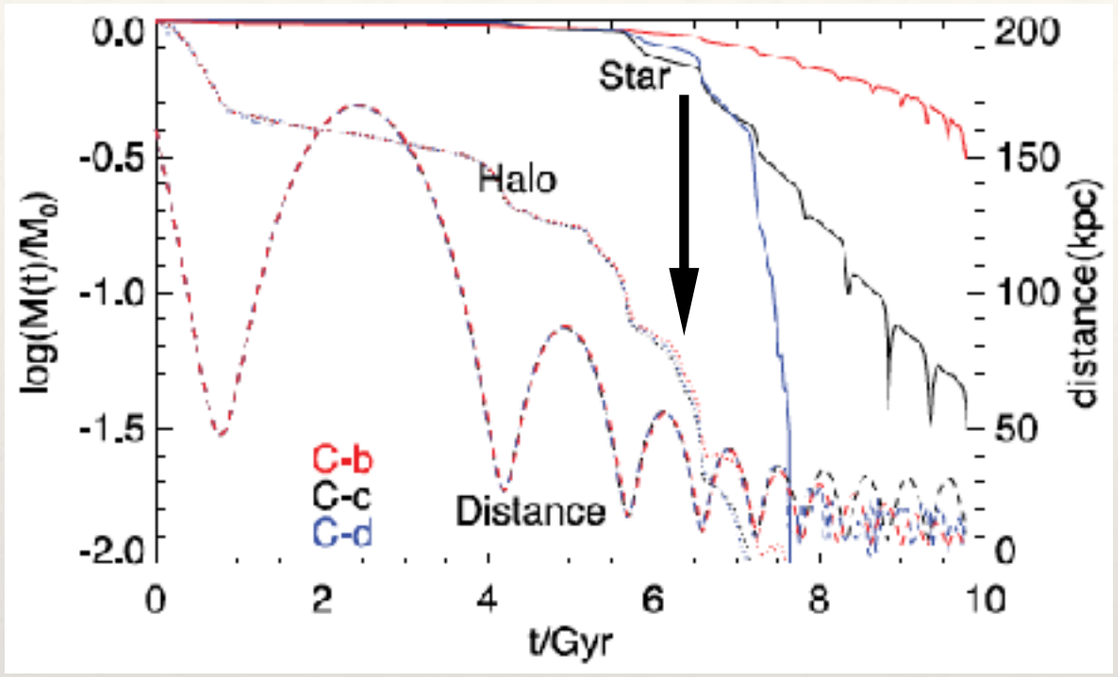


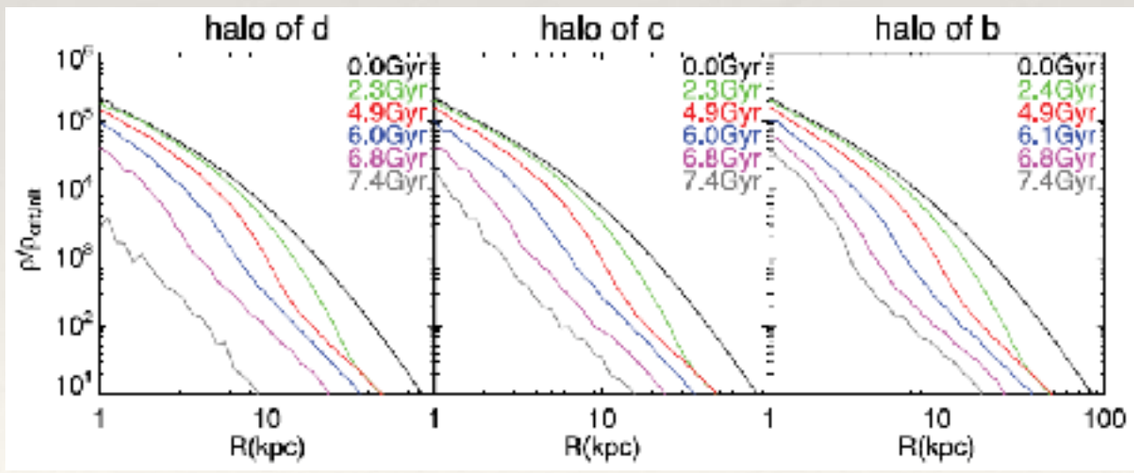
Not an easy life



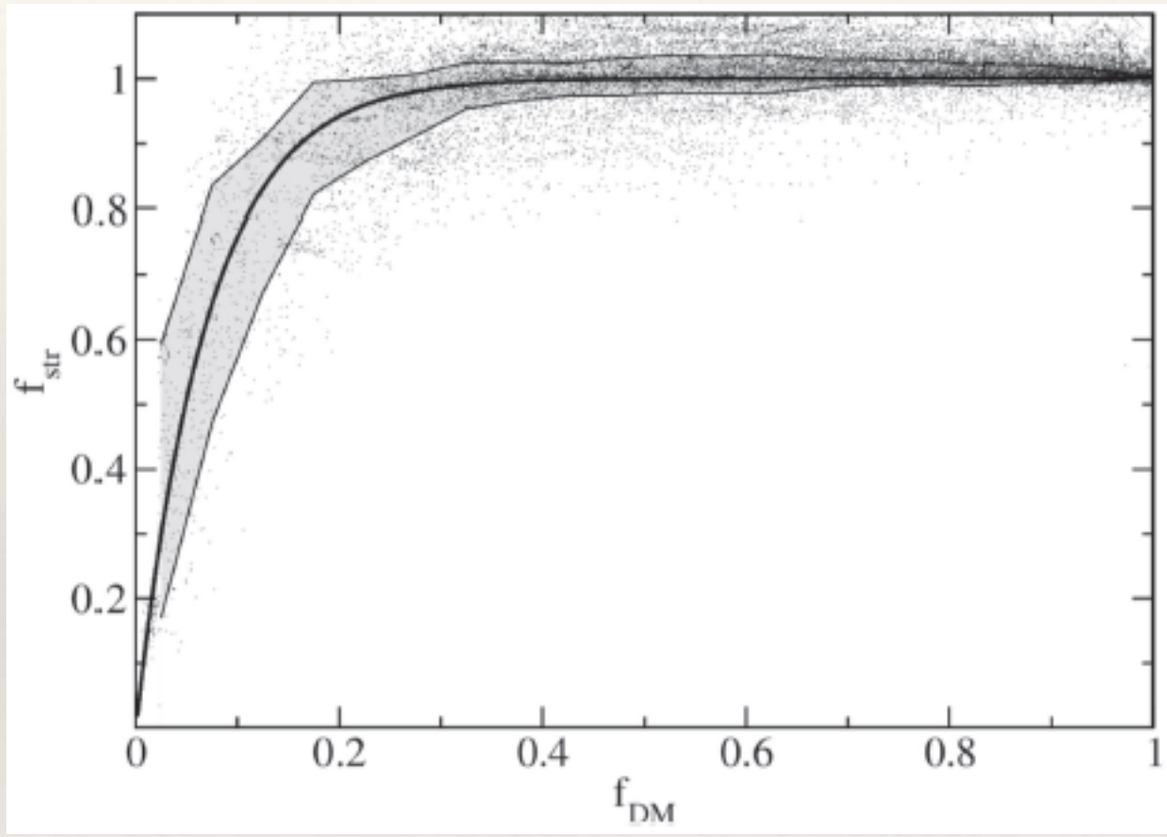
Chang+13

Subhalo evolution



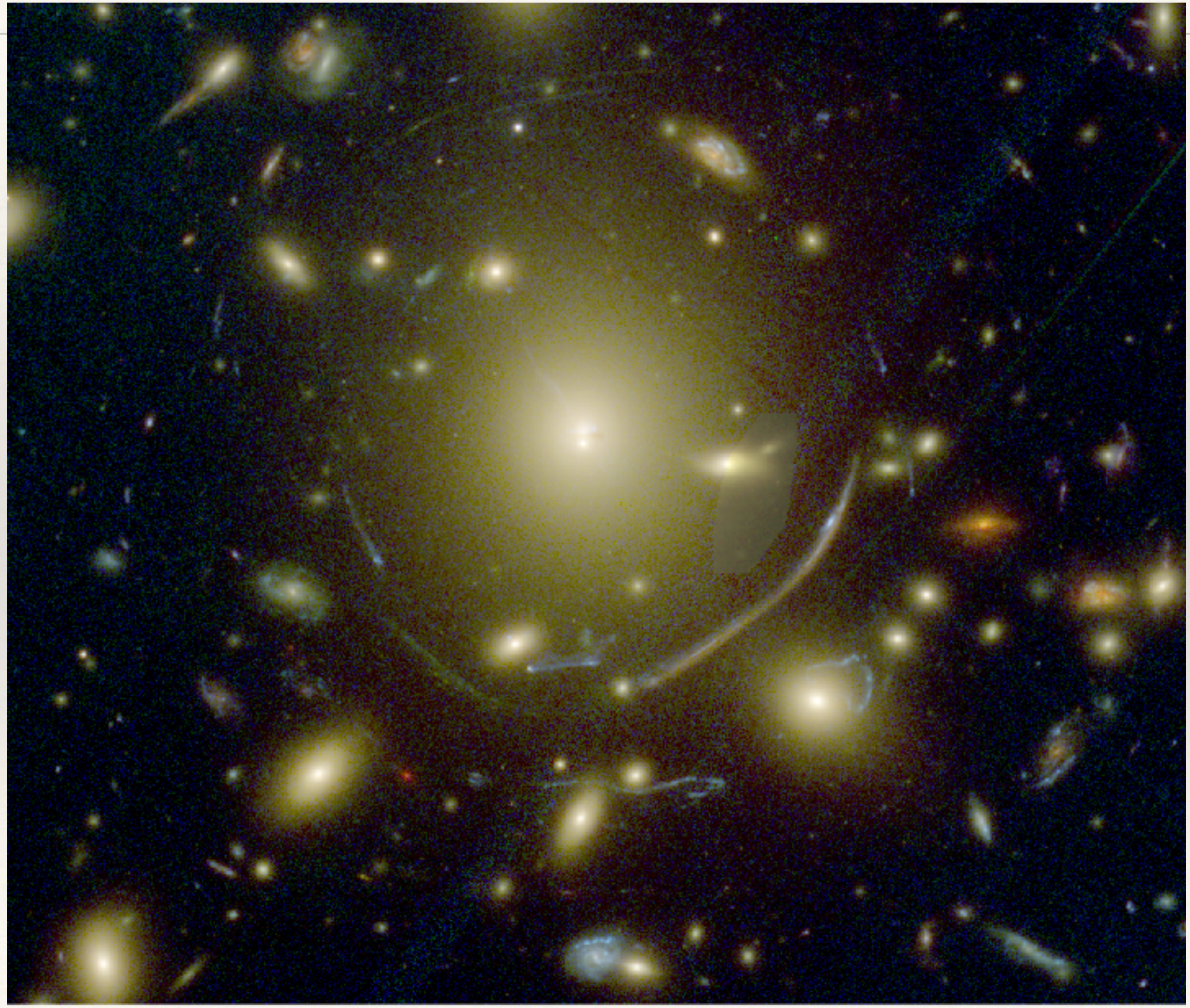


Chang+13



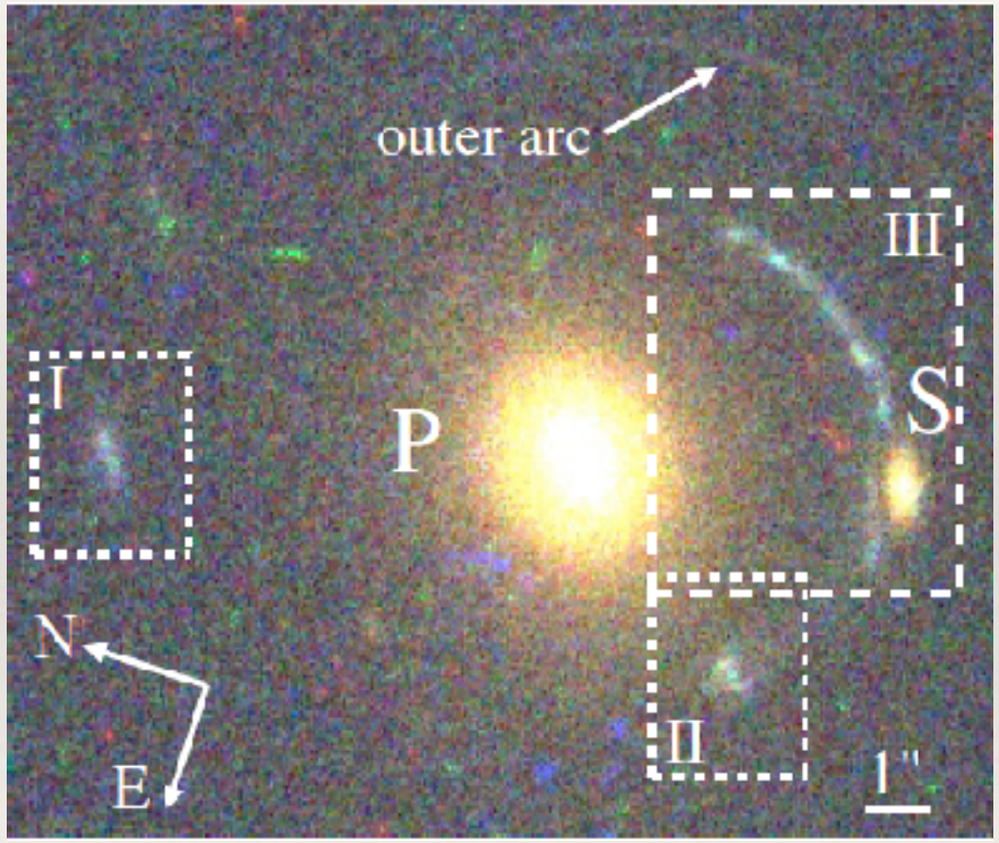
Smith+16

Subhalos warp space just a bit more



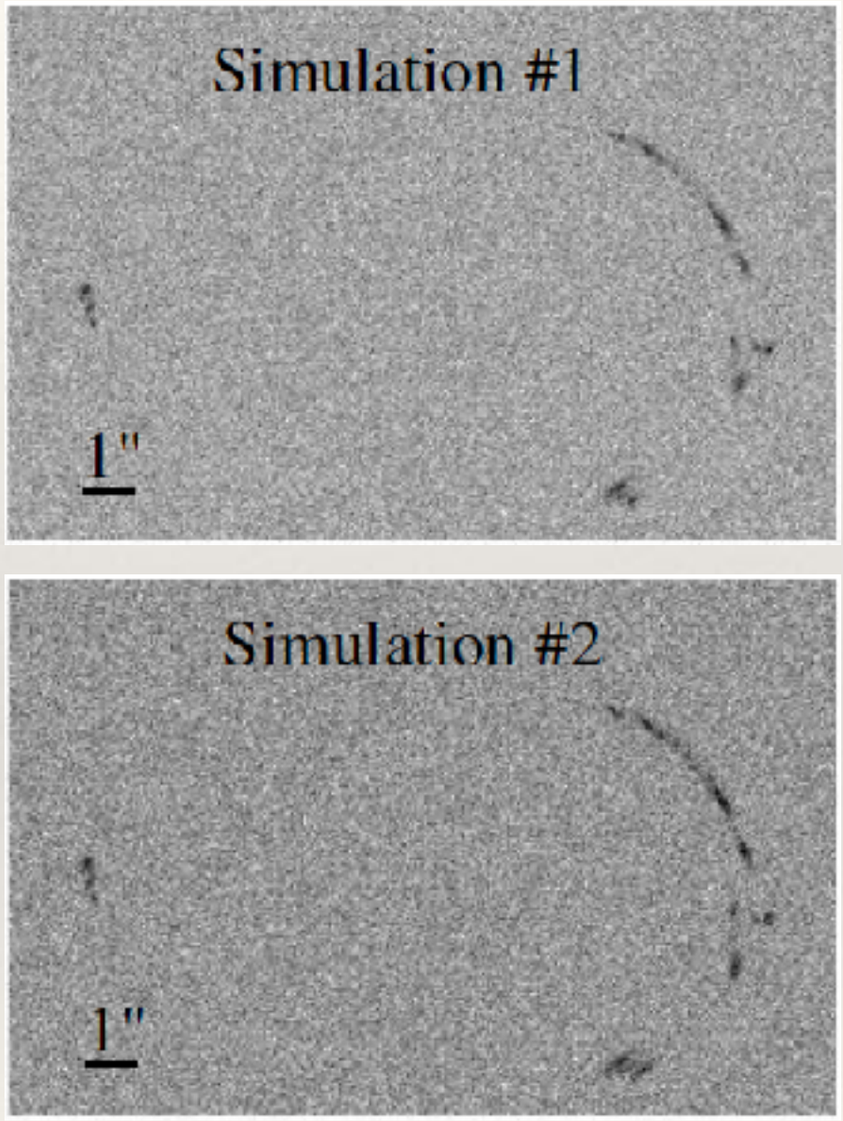
Subhalo lensing

Strong lensing: very detailed information for single objects



Suyu&Halkola10

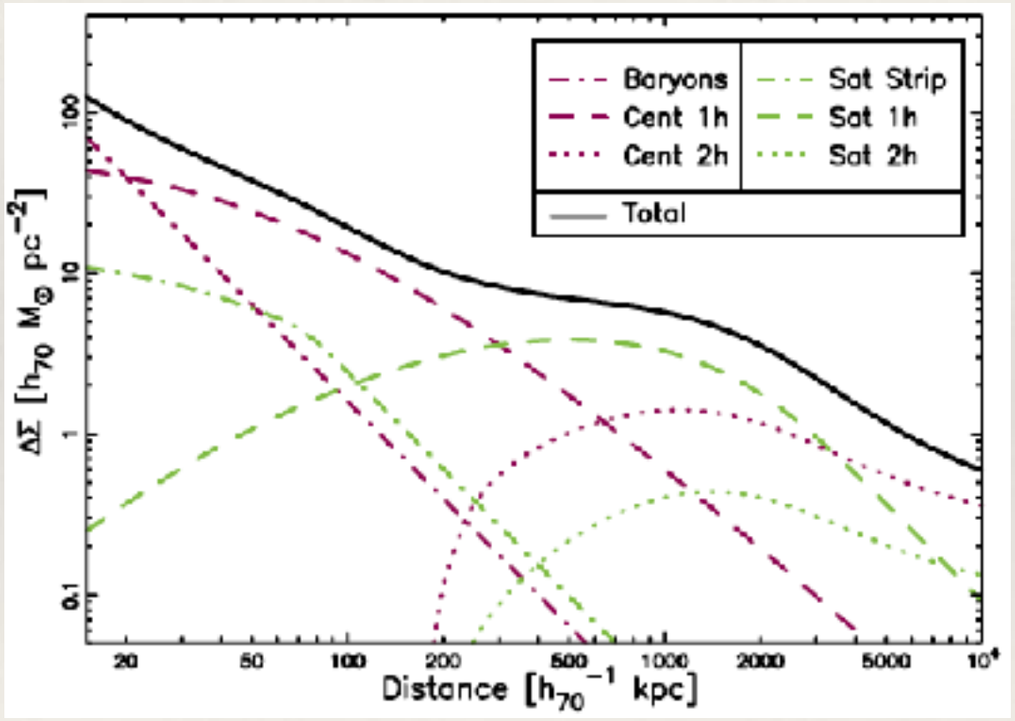
$r_t = 6.0_{-2.0}^{+2.9}$ kpc



Difference in lensed images for factor 2.5 difference in extent of subhalo

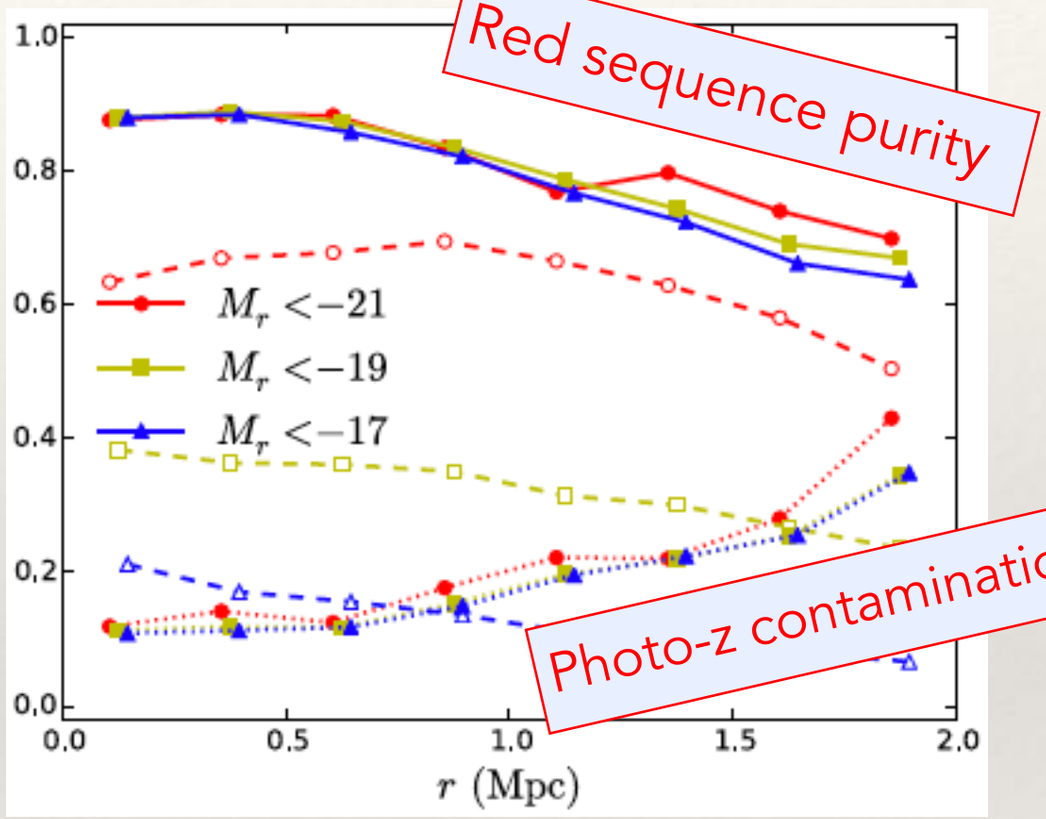
Statistical studies of subhalos

Need to identify satellites individually



Velander+14

Sifón+15b

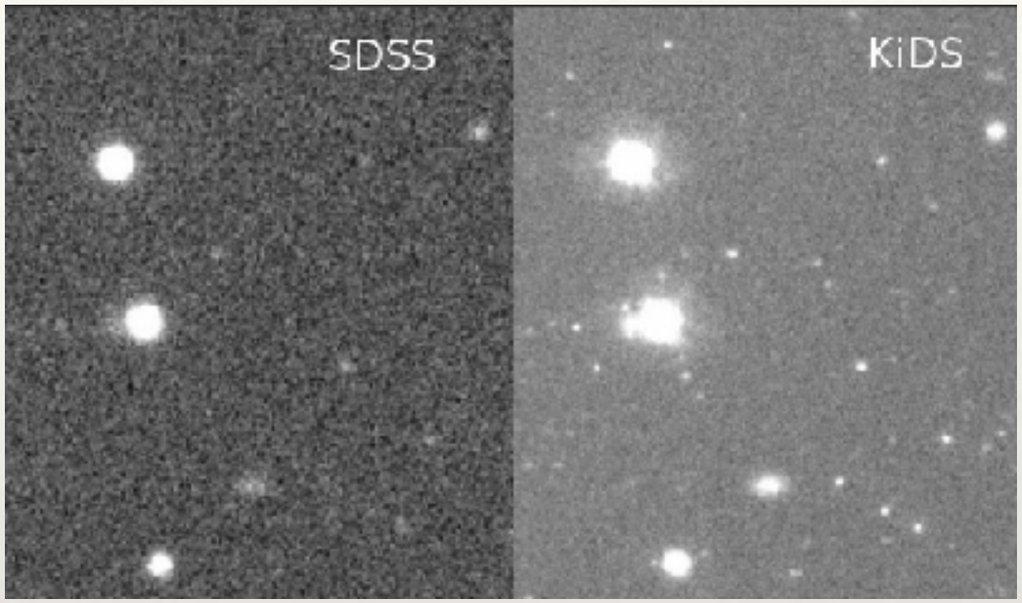


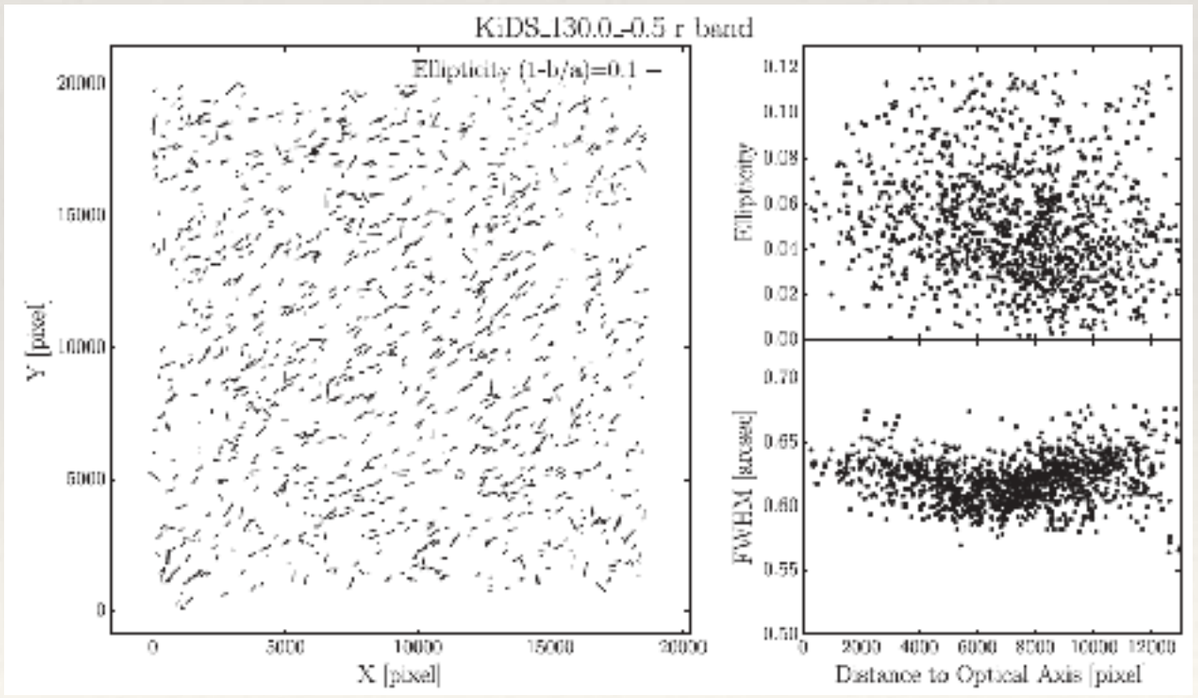
10-20% contamination in red sequence/photo-z selections

Need spectroscopy.

KiDS x GAMA

- Kilo-Degree Survey (KiDS):
  - 1,500 deg^2 ugri @ VST (+VIKING zYJHK @ VISTA)
  - PSF FWHM < 0.8'' in r-band, extremely uniform over 1 deg^2 FoV
  - r-mag < 25.0 (5σ in 2'')
  - ~5 gal/arcmin2
- Galaxy And Mass Assembly (GAMA):
  - ~300 deg^2 AAOmega spectroscopy
  - 98% complete to r-mag = 19.8
- KiDSxGAMA:
  - 100 deg^2 (now 240)
  - 10,000 satellites in ~$10^{13.8}$ M_o clusters at z<0.3

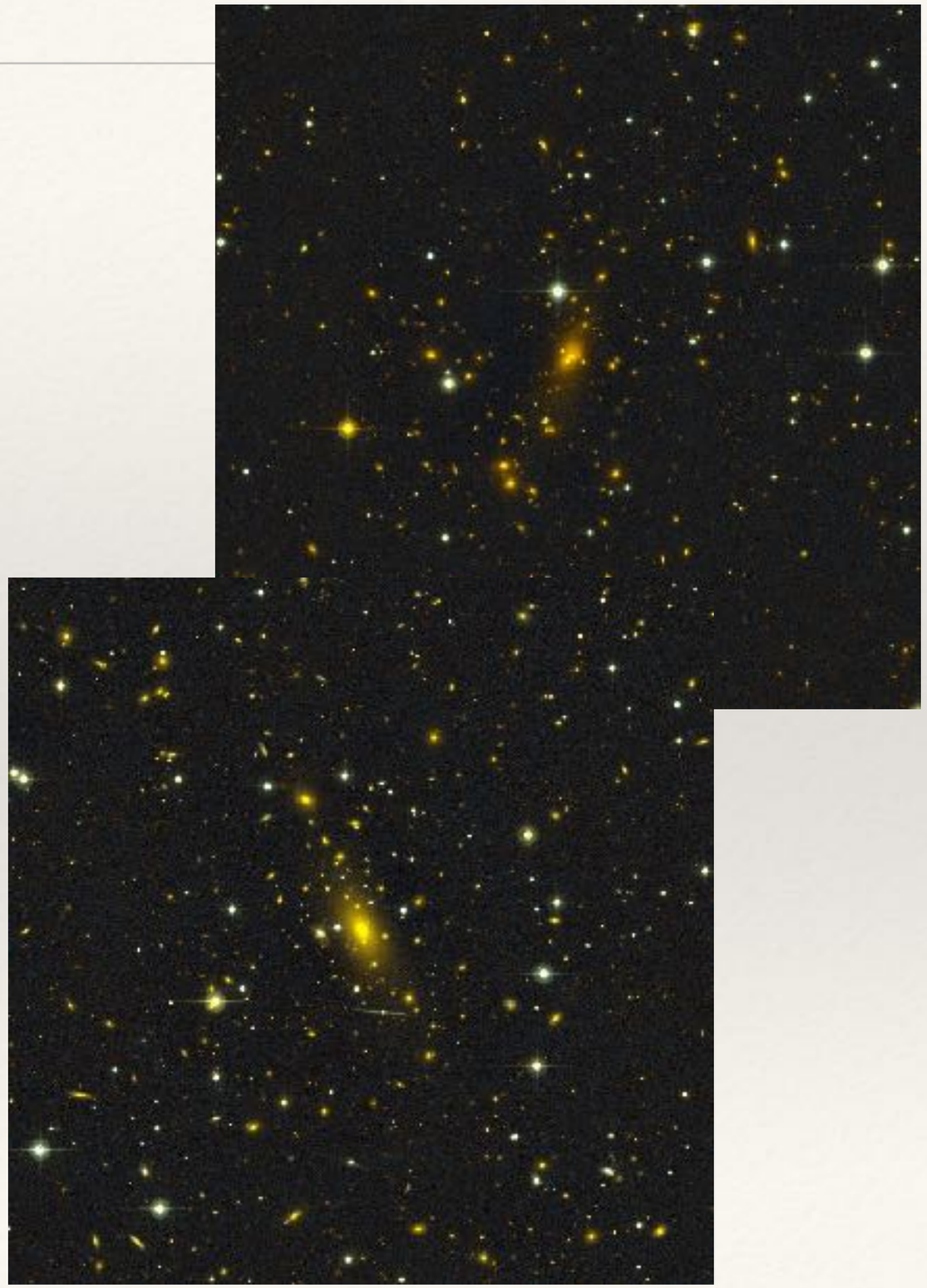




Kuijken+15

MENeaCS

- Multi-Epoch Nearby Cluster Survey (MENeaCS):
  - 55+ X-ray selected clusters, $z < 0.15$, $M > 10^{14}\ M_{\odot}$
  - CFHT/MegaCam, 1 deg^2, PSF < 0.9″
  - 5,400 spectroscopic members from literature redshifts (SDSS, HeCS, etc)



MENeaCS

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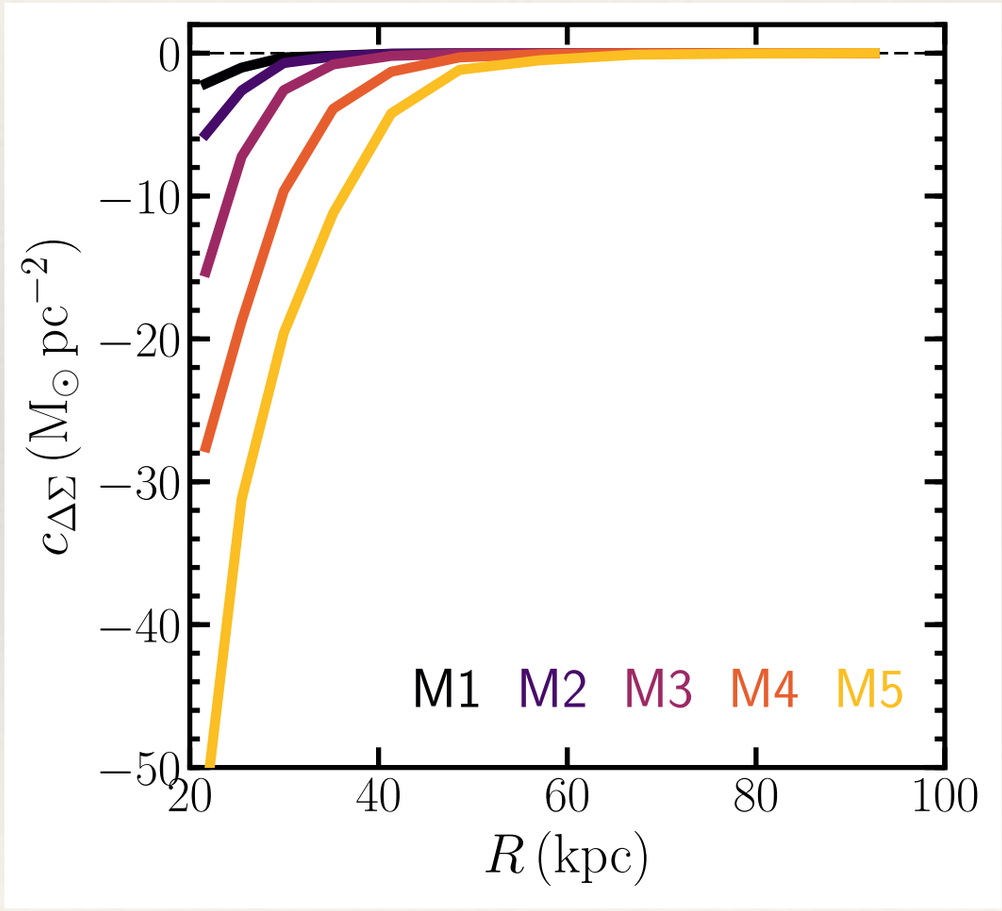
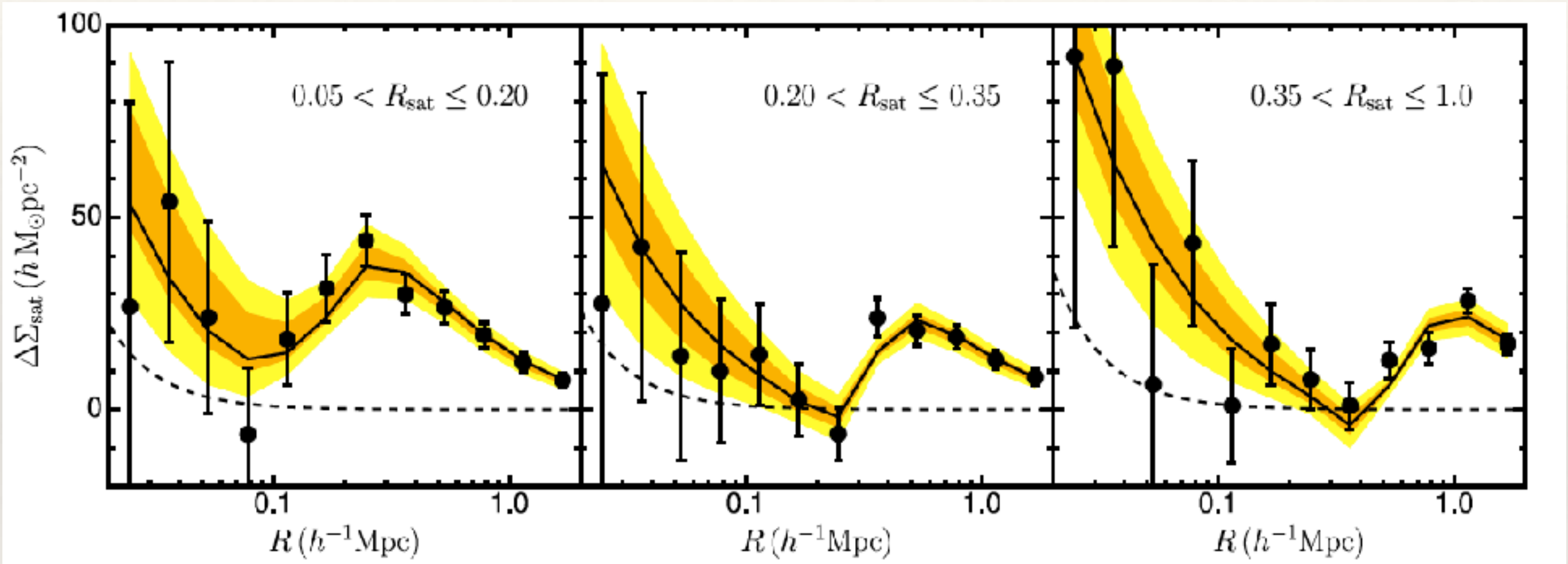
  - CFHT/MegaCam, 1 deg^2, PSF < 0.9″
  - 8,000 spectroscopic members from literature redshifts (SDSS, HeCS, etc)
  - Physical PSF & FoV ~ HST @ z=0.5

Radial bias in shape measurements from lens light seen in image simulations

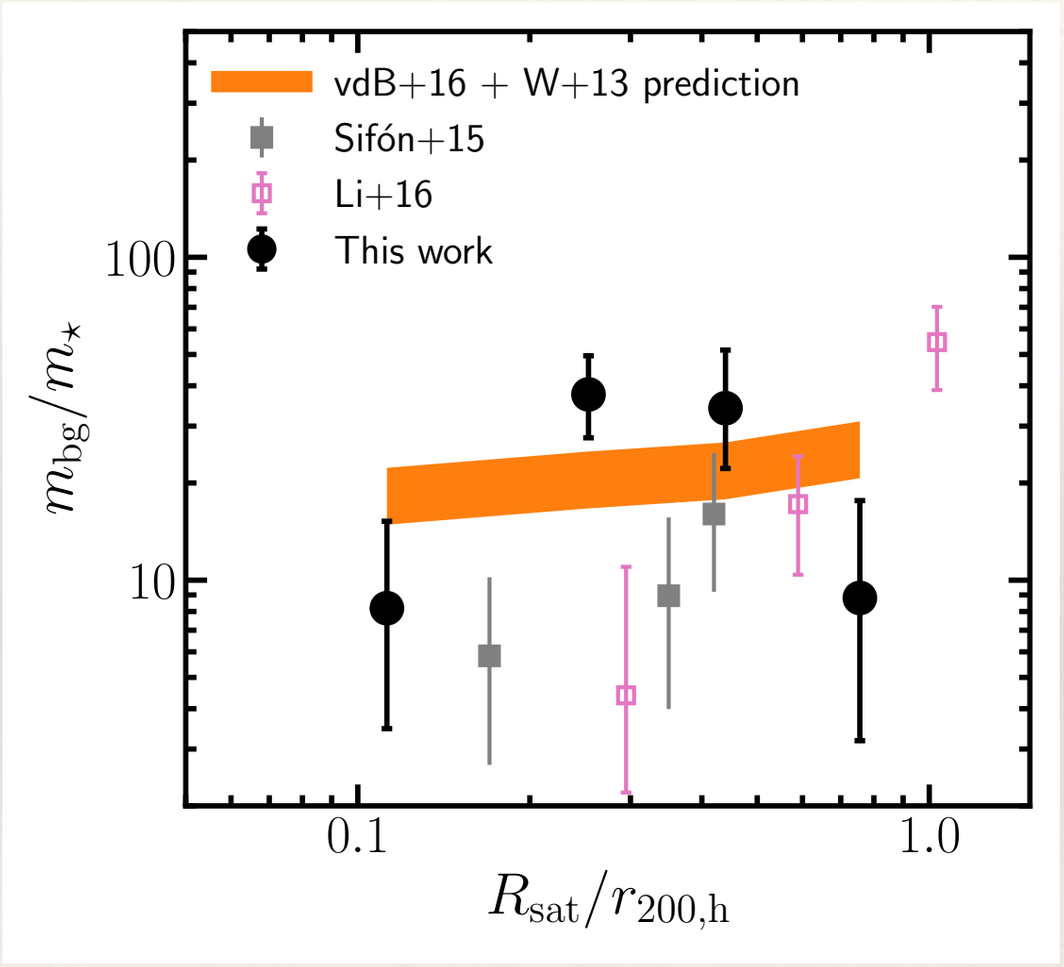


Satellite galaxy-galaxy lensing



KiDSxGAMA (Sifón+15)

Mass segregation



Sifón+17a

DM segregation (vdBosch+16)

+

Semi-analytic model (Wang+13)

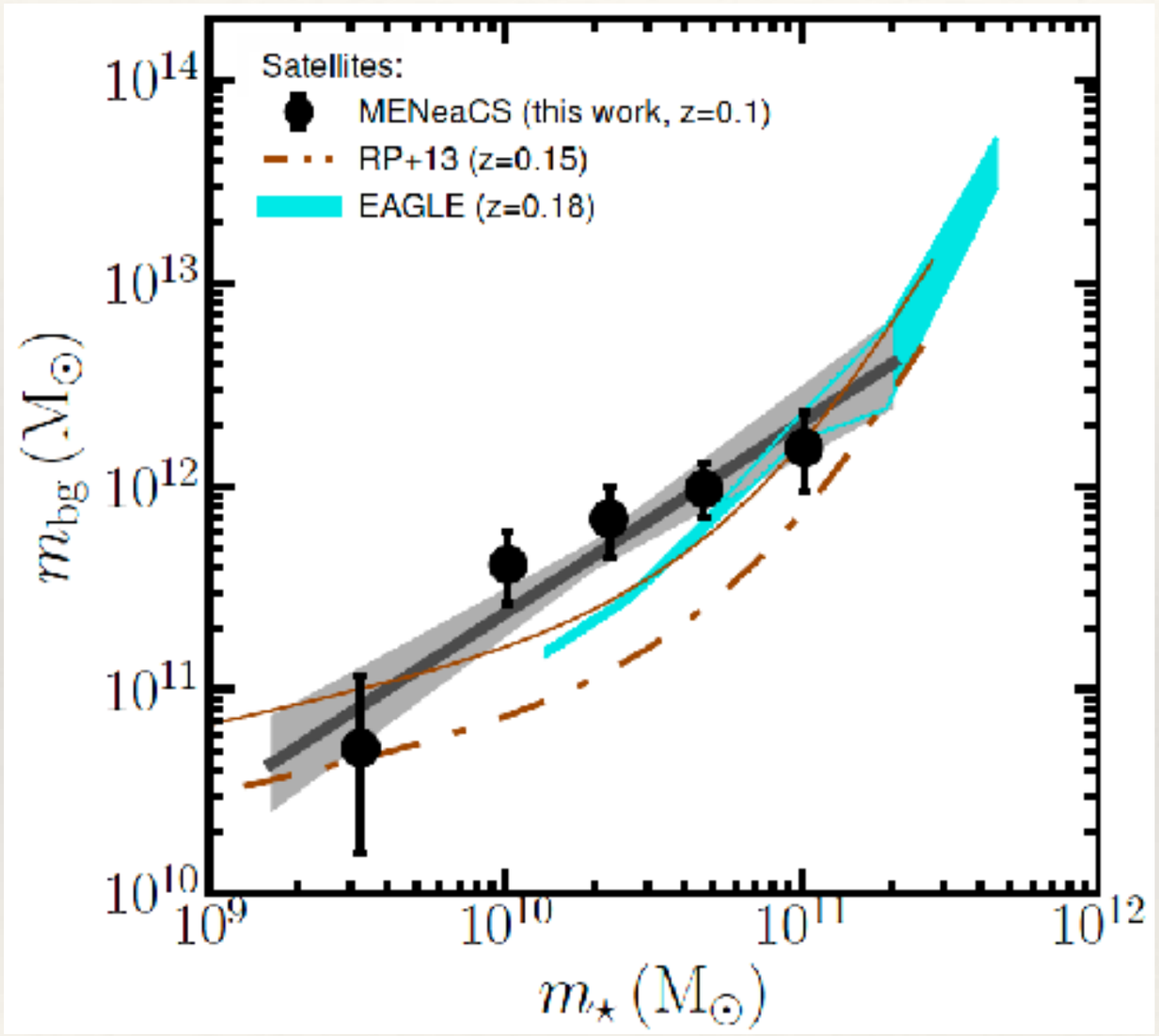
+

Mean m*

=

Factor ~2 segregation

The relation between total and stellar mass

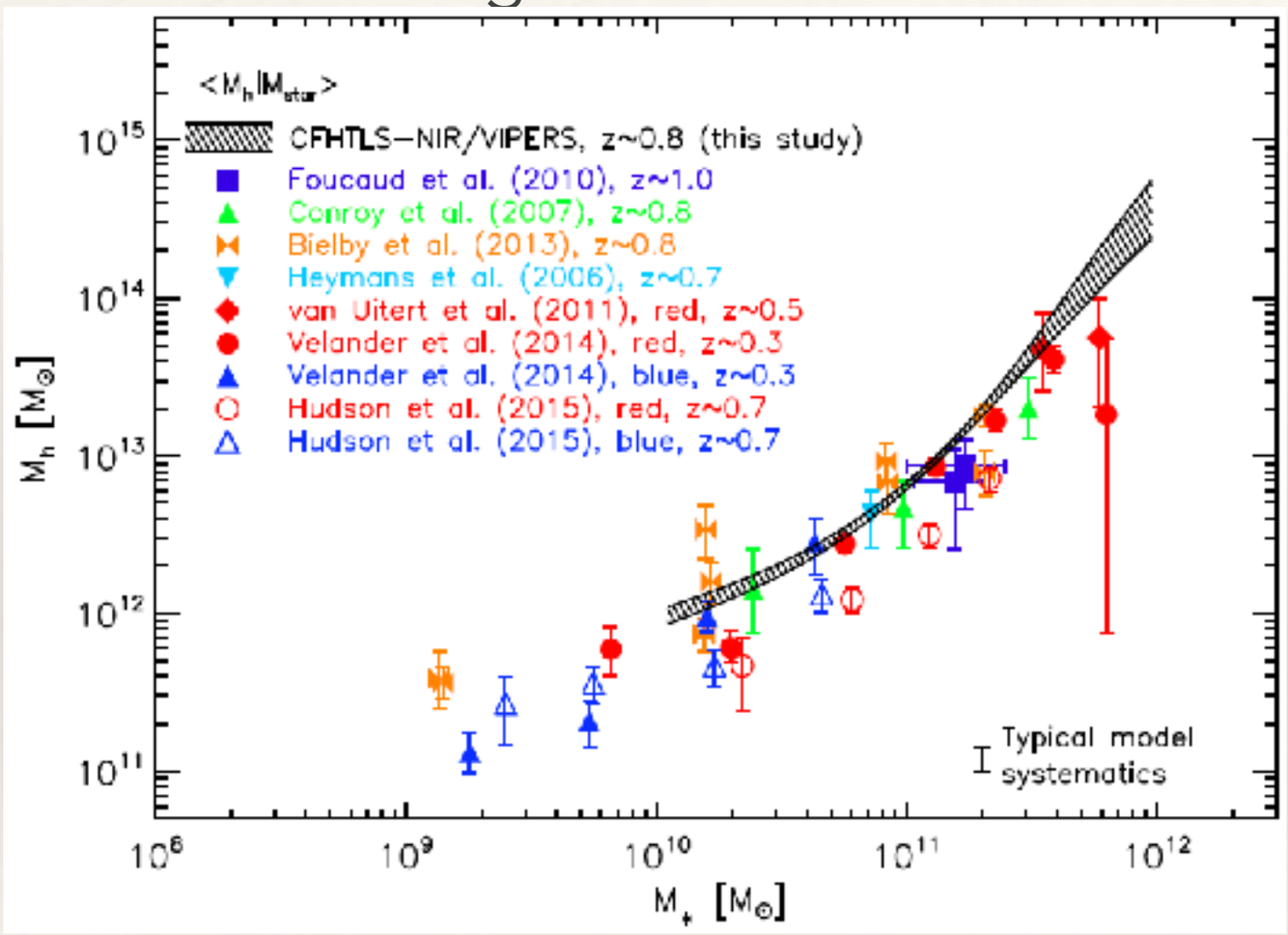


Sifón+17a

- Hydro simulations and SAMs seem to underpredict subhalo masses at intermediate stellar masses

The relation between total and stellar mass

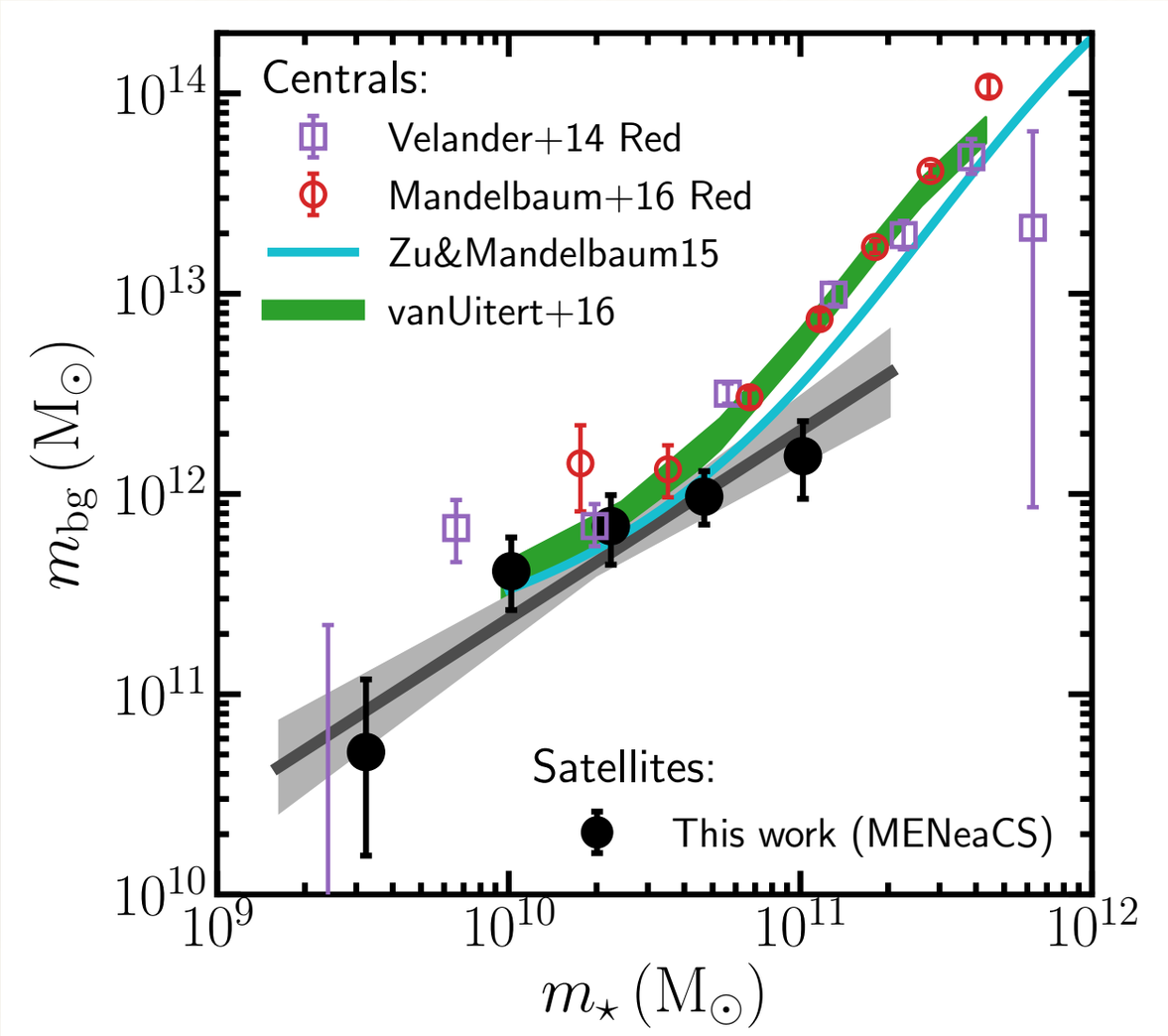
For central galaxies:



Coupon+15

How does tidal stripping (and any other effects) affect this relation?

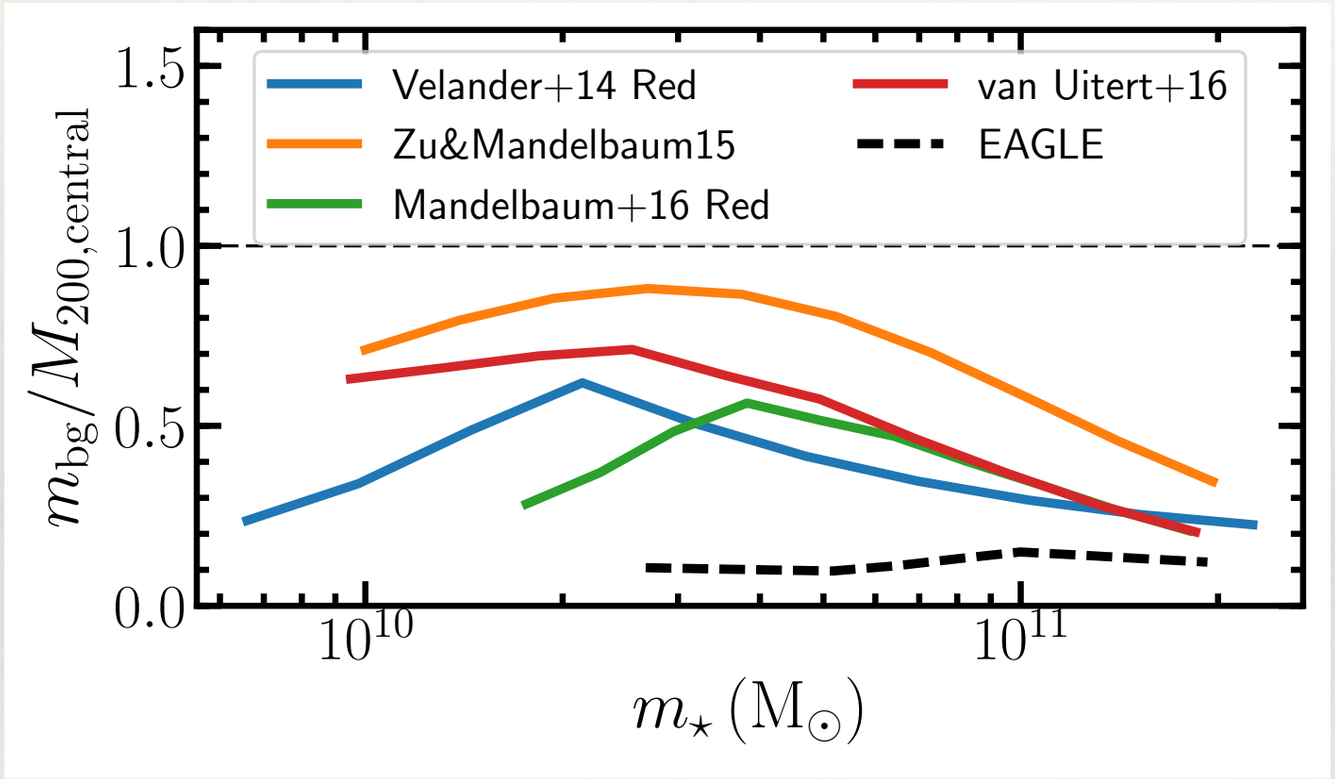
The relation between total and stellar mass



Sifón+17a

- Subhalo masses similar to central halo masses at same stellar mass
- Mild evidence for a difference at high m*

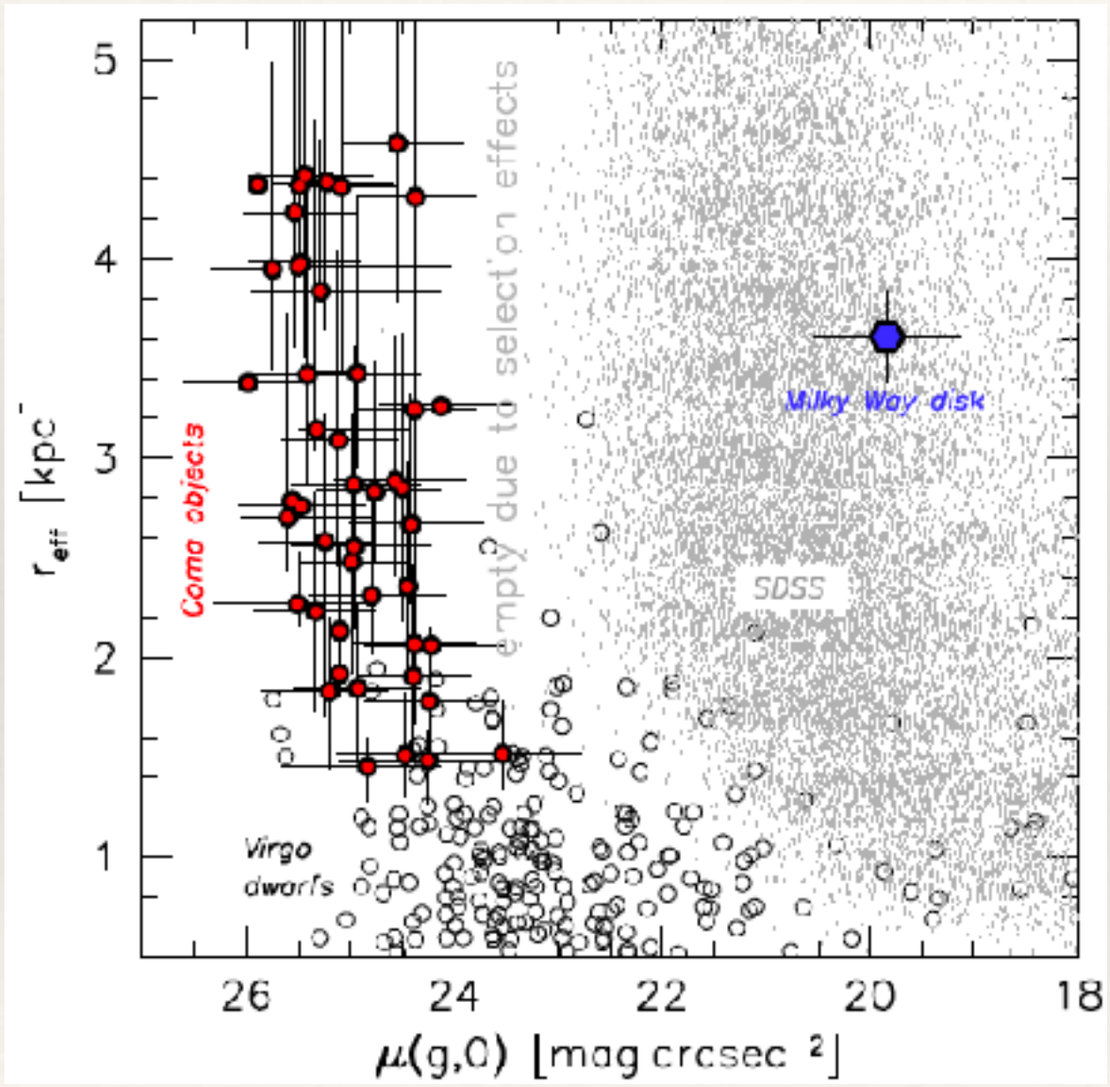
The relation between total and stellar mass



Sifón+17a

- Subhalo masses similar to central halo masses at same stellar mass
- Mild evidence for a difference at high m*
- **Not what we see in hydrodynamical simulations**

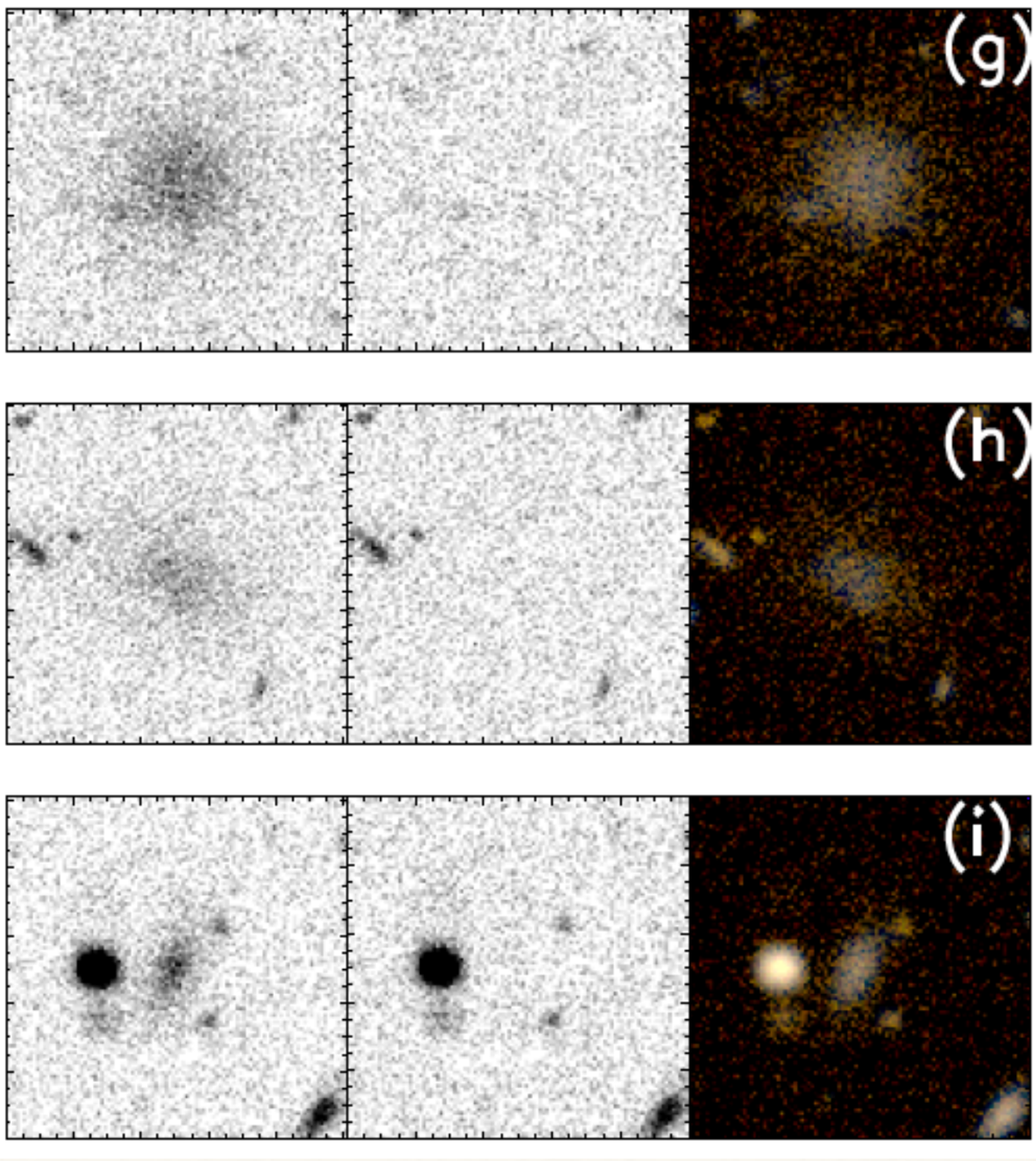
Ultra Diffuse Galaxies



van Dokkum+15

- UDG: the new buzzword in galaxy evolution
- $m^* \sim 10^8$ Msun
- Not new in principle (cf. Malin 1, ca. 1986)
- What's new: they abound in clusters and they are red and smooth

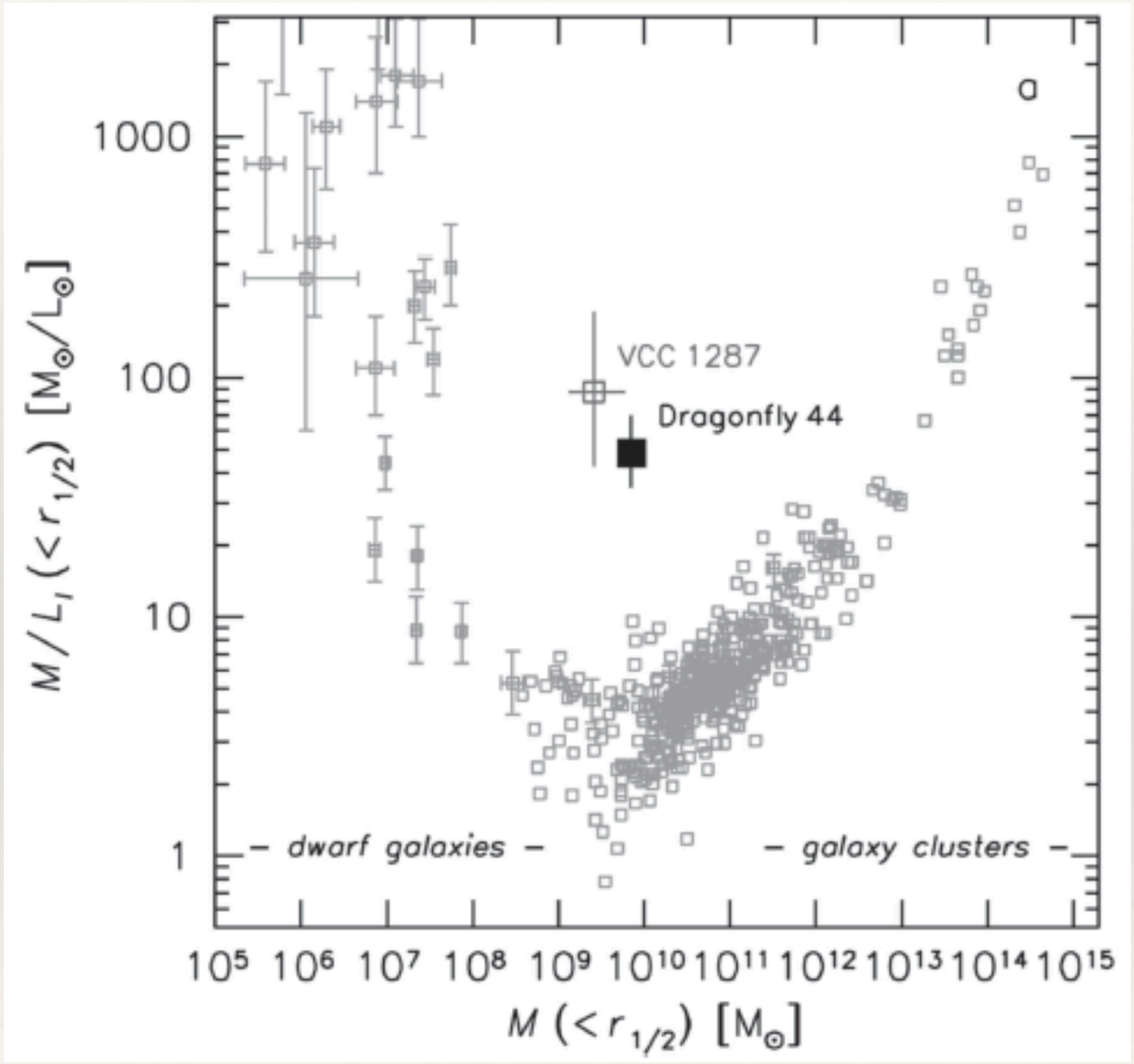
Ultra Diffuse Galaxies



- $m^* \sim 10^8$ Msun (~SMC)
- r_{eff} > 1.5 kpc (~MW)
- Not new in principle (cf. Malin 1, ca. 1986)
- What's new: they abound in clusters and they are red and smooth

van der Burg+16

Ultra Diffuse Galaxies

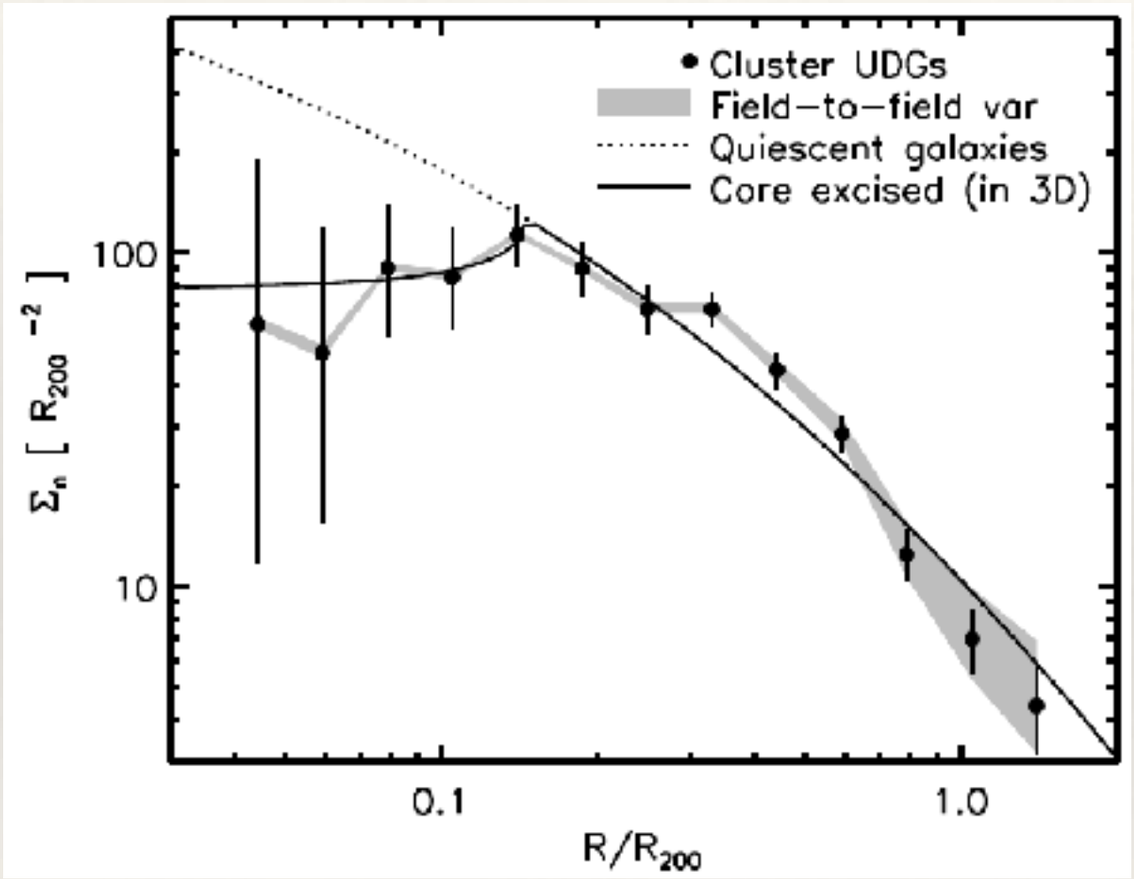


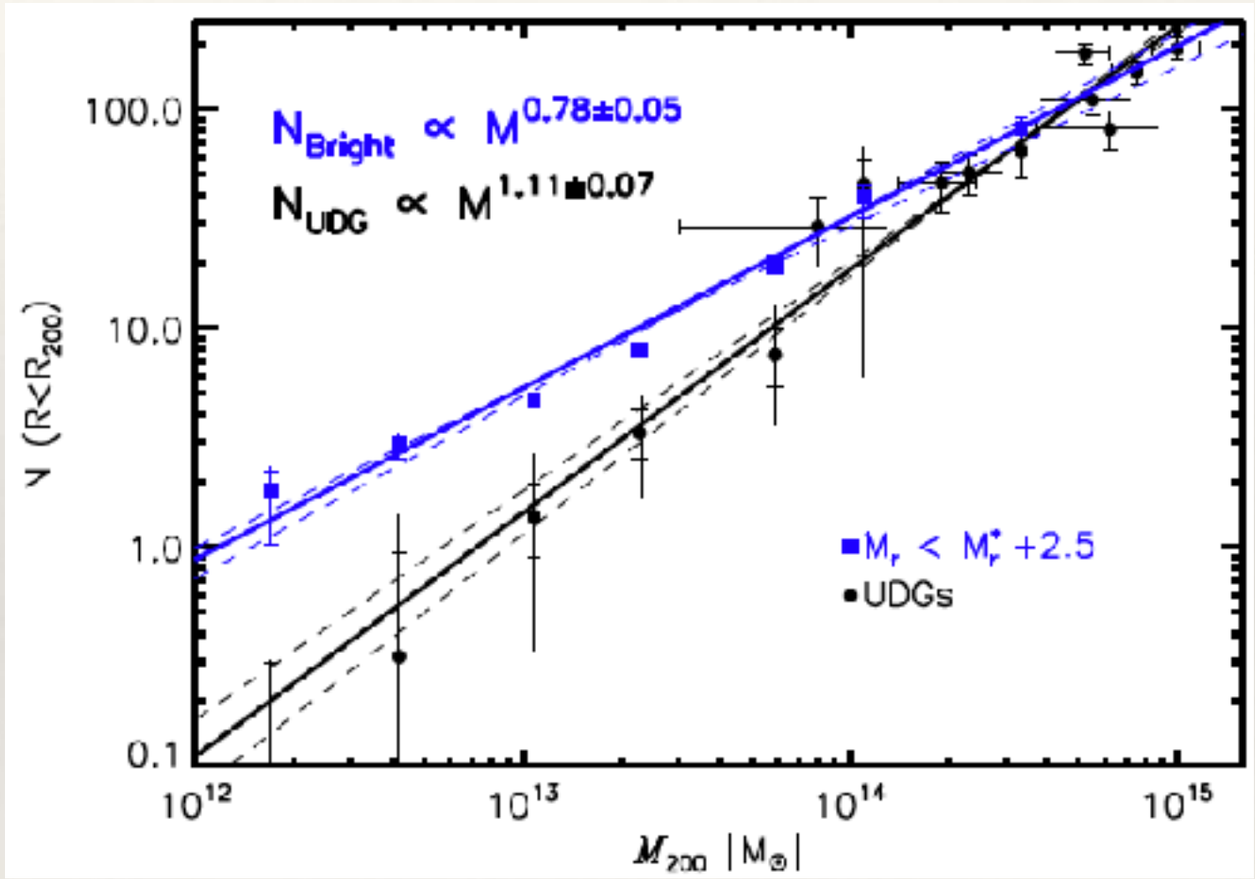
van Dokkum+16

- Their number increases with cluster mass, with ~200 (!) at Mcl~10^{15} M_{sun}.
- They follow the same radial distribution as regular cluster galaxies but disappear in the center
- *Are they failed galaxies?*

Ultra Diffuse Galaxies

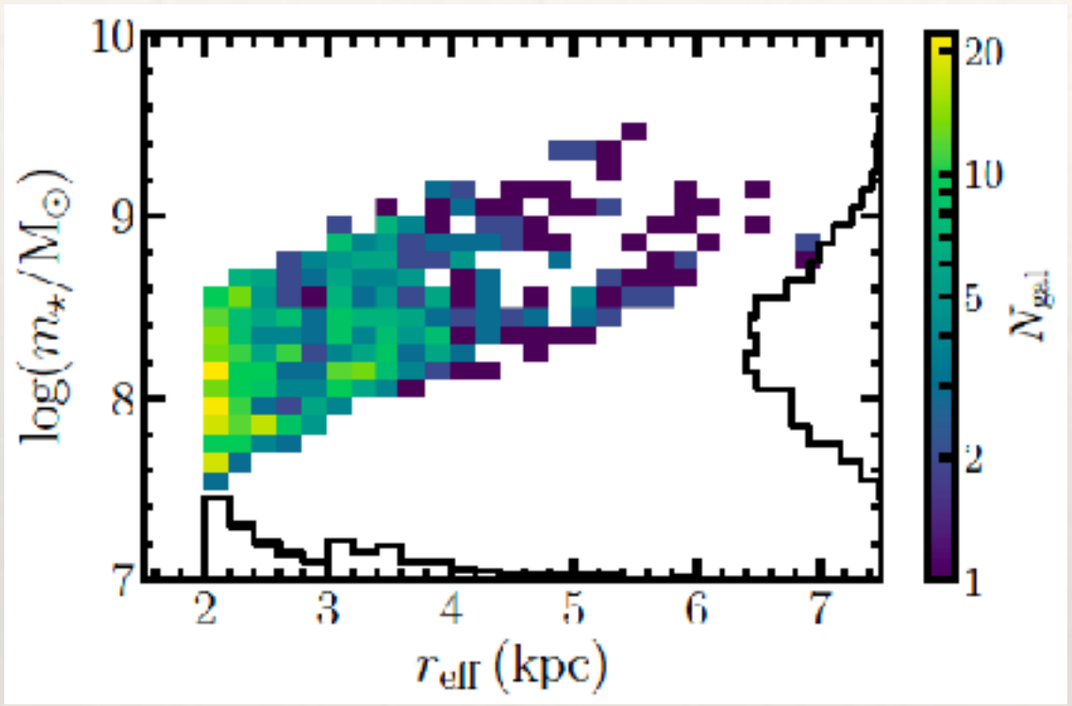
van der Burg+16,17 MENeaCS+KiDS



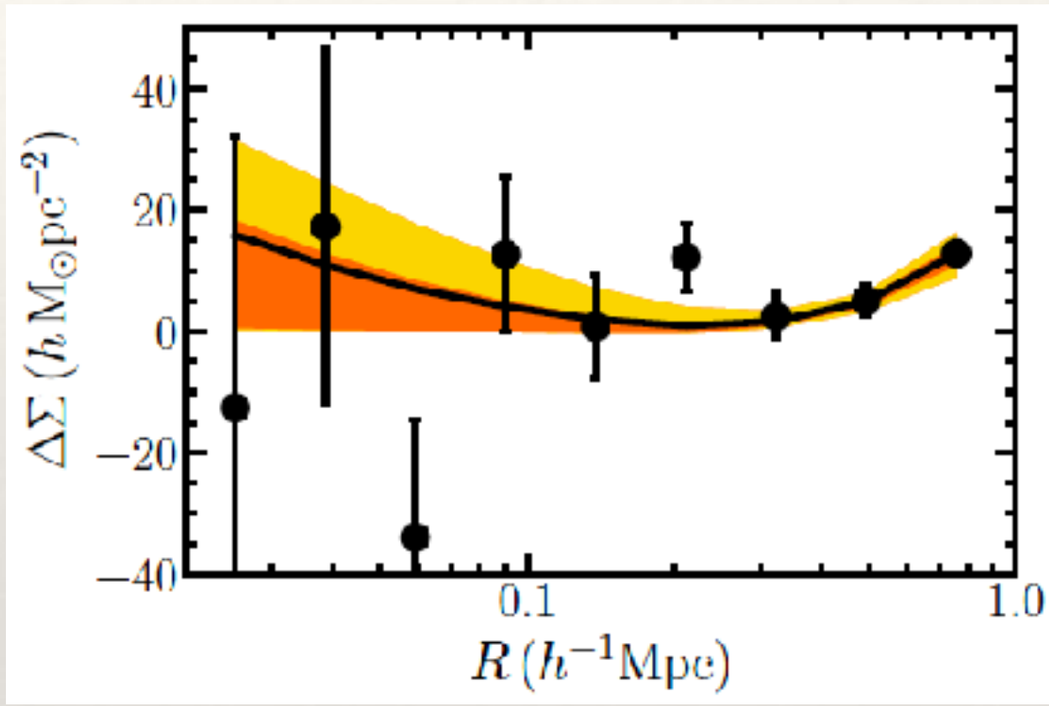


UDGs are more abundant in massive clusters but avoid the cores

UDG Lensing with MENeaCS



Sifón+17b

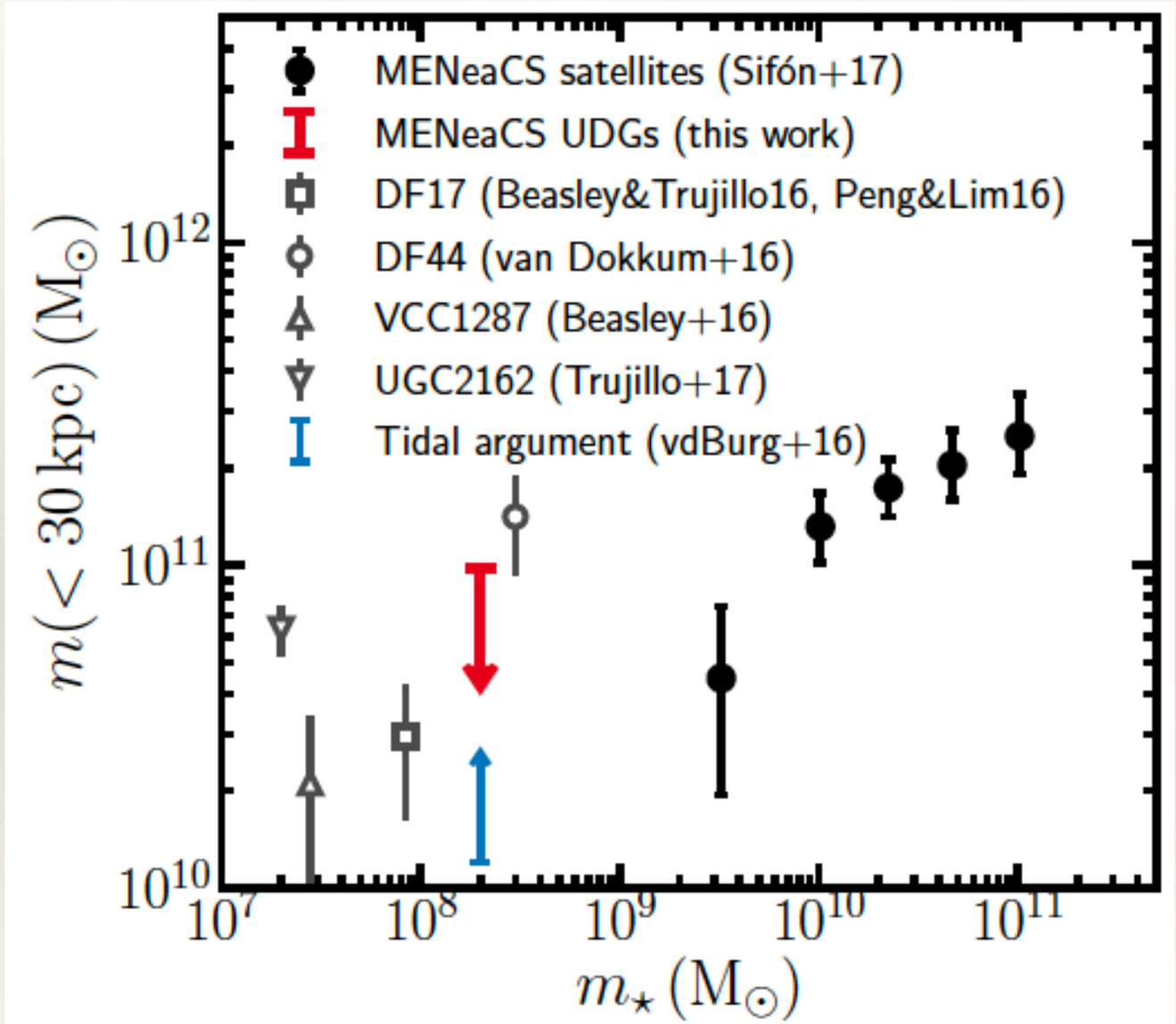


- 18 CFHT clusters at z<0.1
- 780 UDGs (r_{eff}>2 kpc)

- Lensing signal consistent with zero within 1σ

The masses of UDGs in context

- Our results put other individual UDG masses in context
- Average UDG mass consistent with simple extrapolation of relation of regular galaxies
- On average, dwarf halo masses; extremes may well be failed galaxies



$$\log m(r < 30\,\mathrm{kpc})/\mathrm{M}_\odot \leq 10.99$$

Sifón+17b

Conclusions

- We exploit a combination of spectroscopic cluster galaxy catalogs with weak lensing data to obtain a unique view at the galaxy-subhalo connection
- No evidence for mass segregation across a range of cluster masses. Consistent with expectations within uncertainties
- Tentative evidence for differences in subhalo-to-stellar mass relation compared to central galaxies *and to theoretical predictions*
- First direct measurement of average UDG mass: UDGs probably an extension of the normal galaxy population, but possibly with larger scatter in total mass