

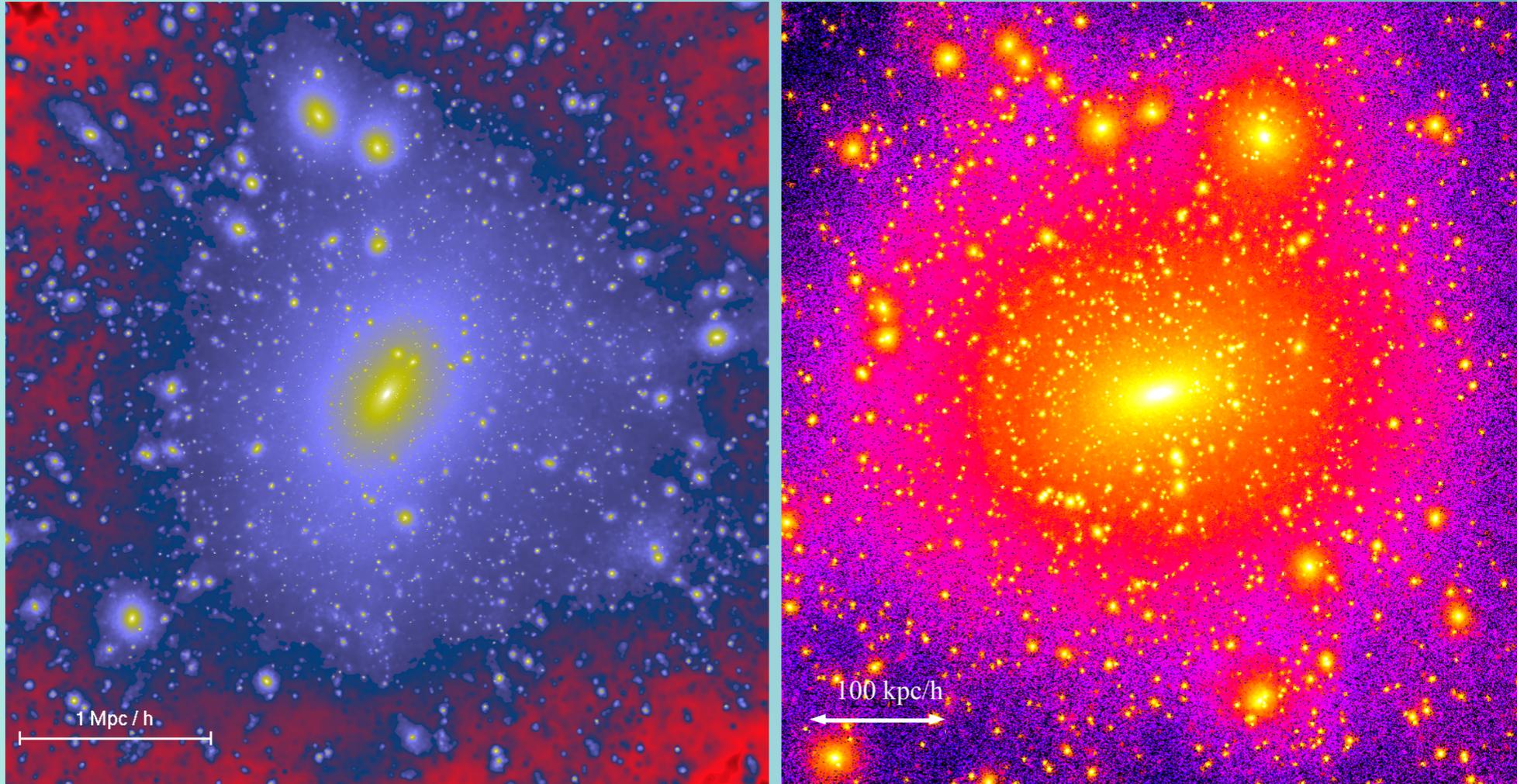
# Mass distribution of galaxy groups

Anupreeta More

Apr 3, 2018

(Kavli IPMU, University of Tokyo)

# Mass distribution in halos

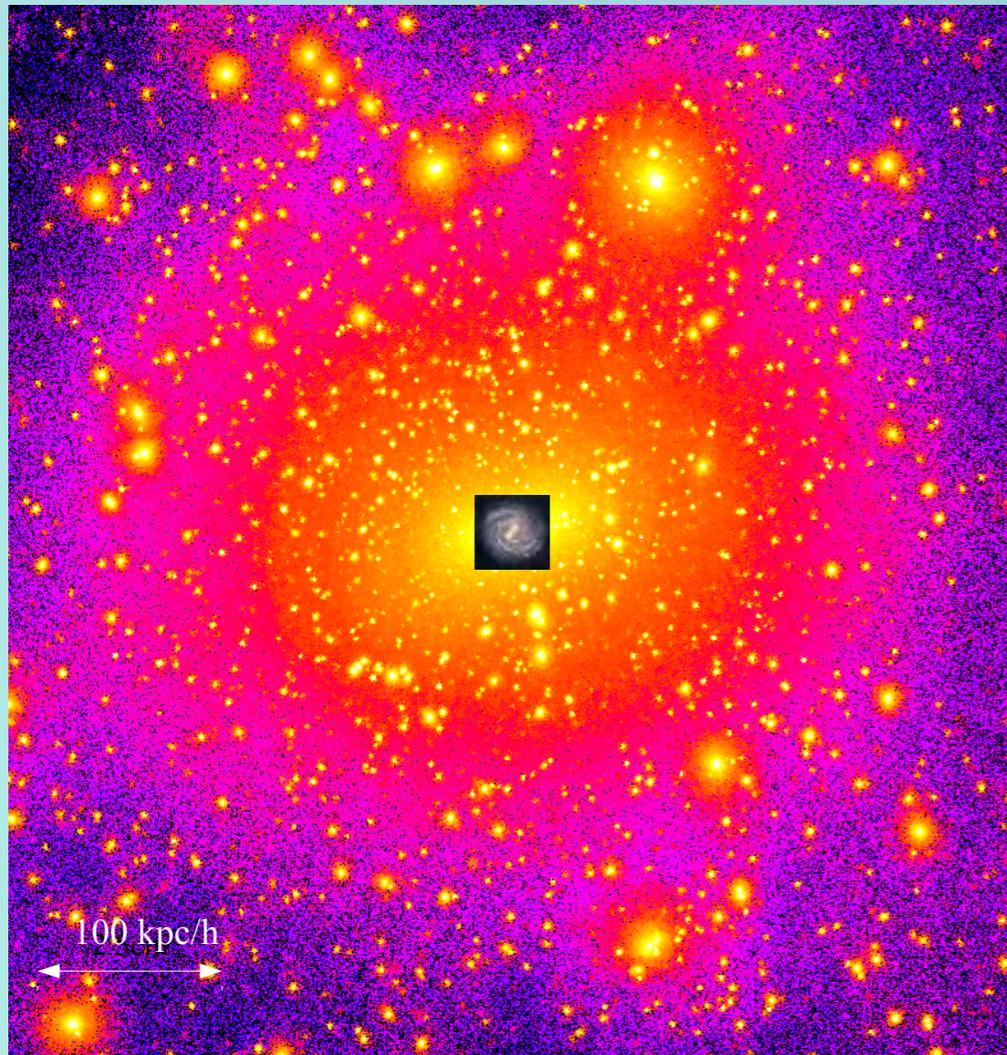


Density profile of dark matter halos is universal, parameterized with a single parameter - concentration (Navarro, Frenk and White 1997)

concentration = virial radius / scale radius

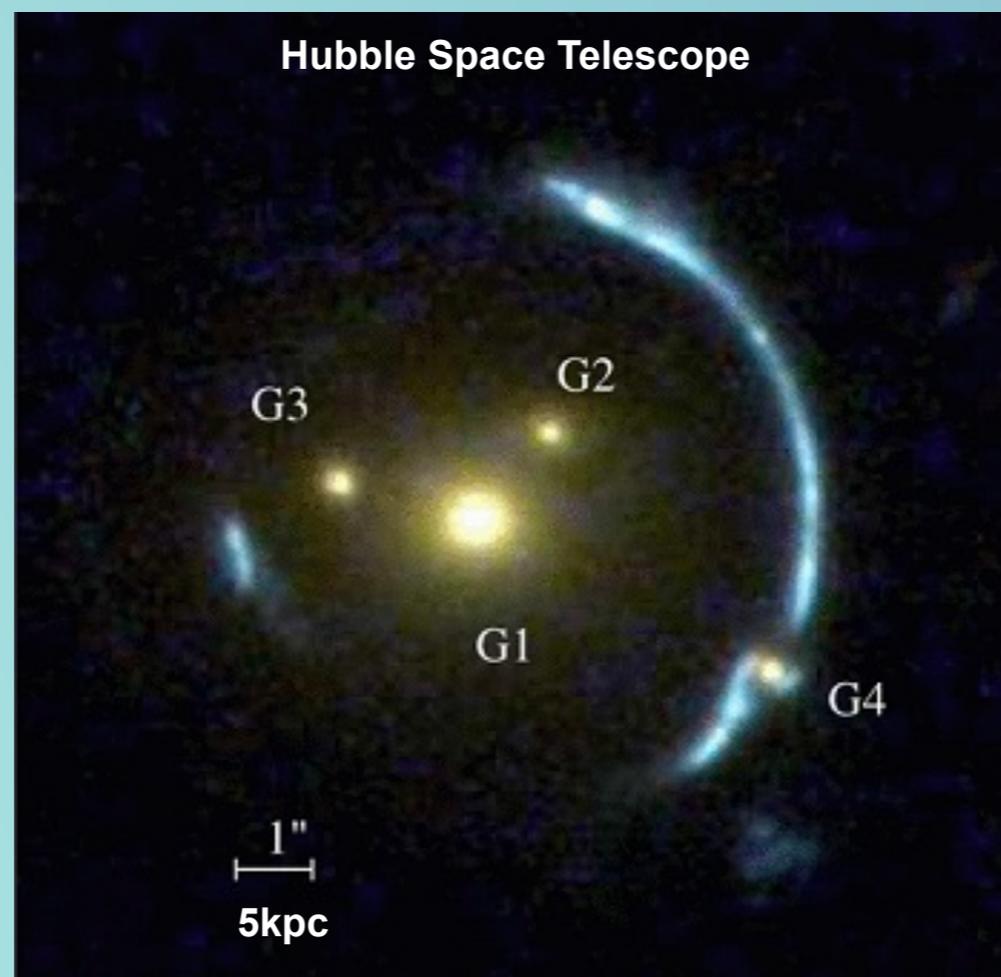
concentration and mass are related

# Mass distribution in halos



- Presence of baryons alter DM distribution
- What is the total mass (DM+baryons) distribution?
- What is the distribution of dark matter in the inner regions?
- What is the concentration-mass relation?

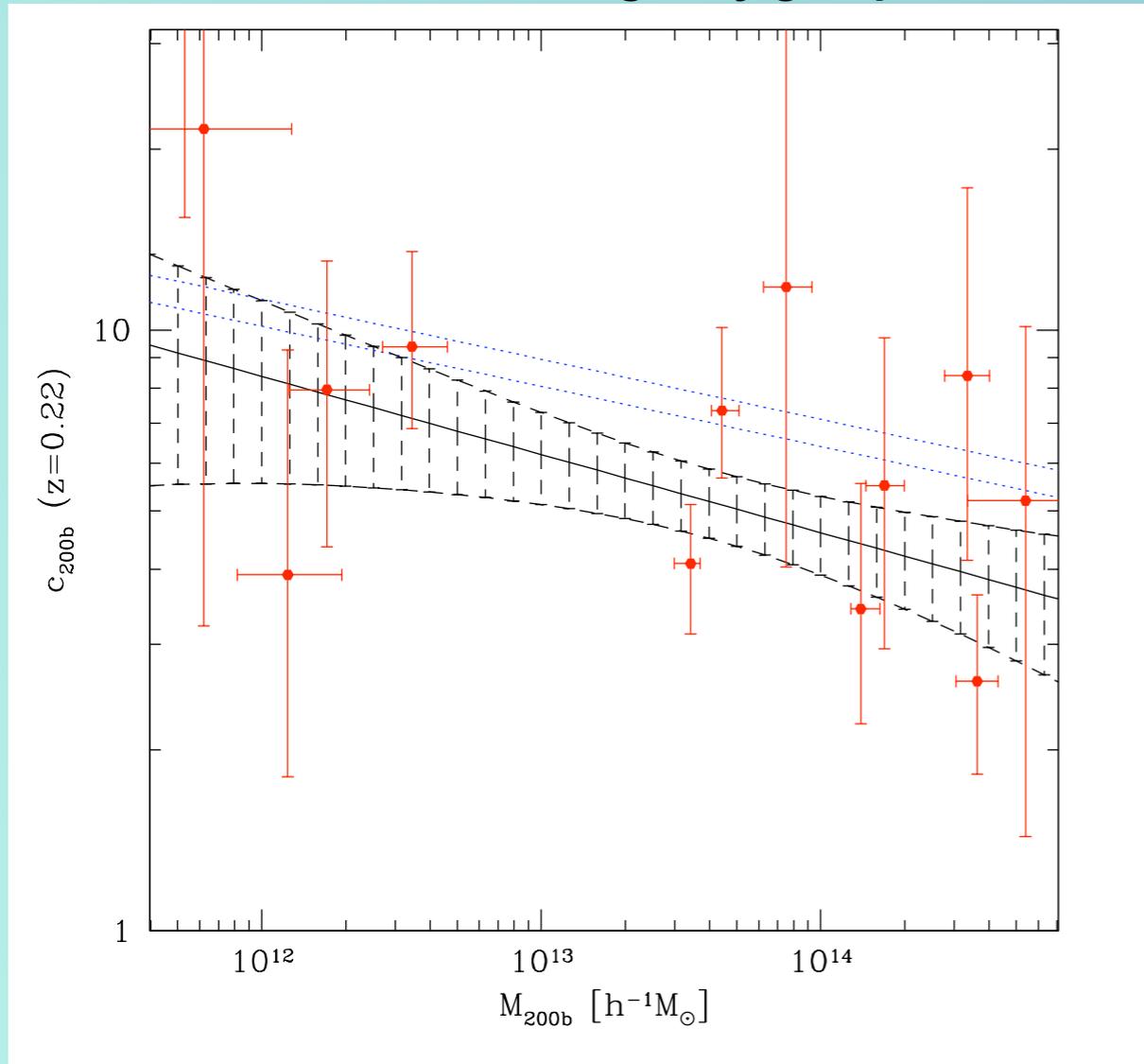
# Galaxy groups with strong lensing



- Strong lensing probes the central few kilo parsecs where baryons are expected to affect dark matter

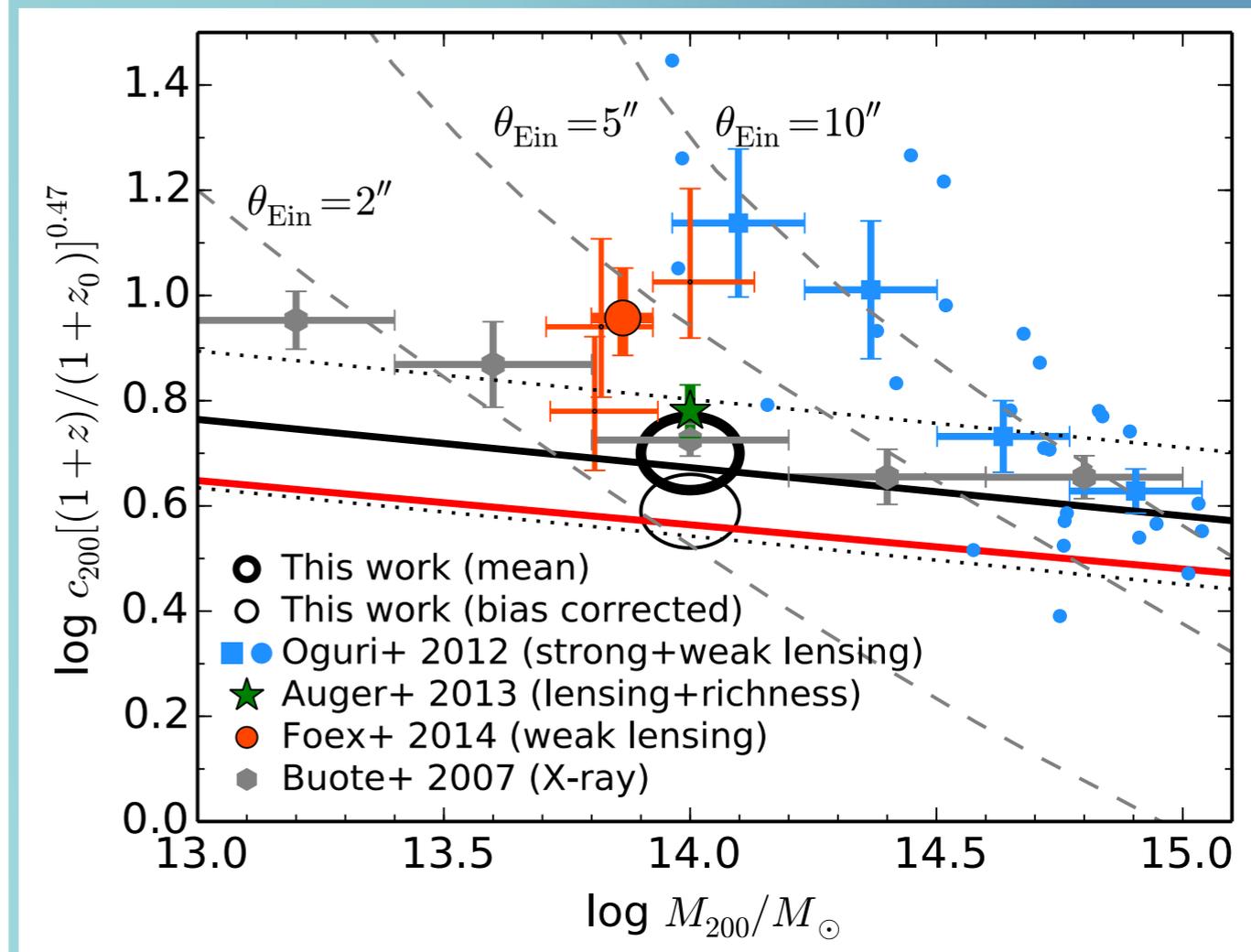
# Concentration-Mass relation

Stacked WL of galaxy groups



Mandelbaum et al. 2008

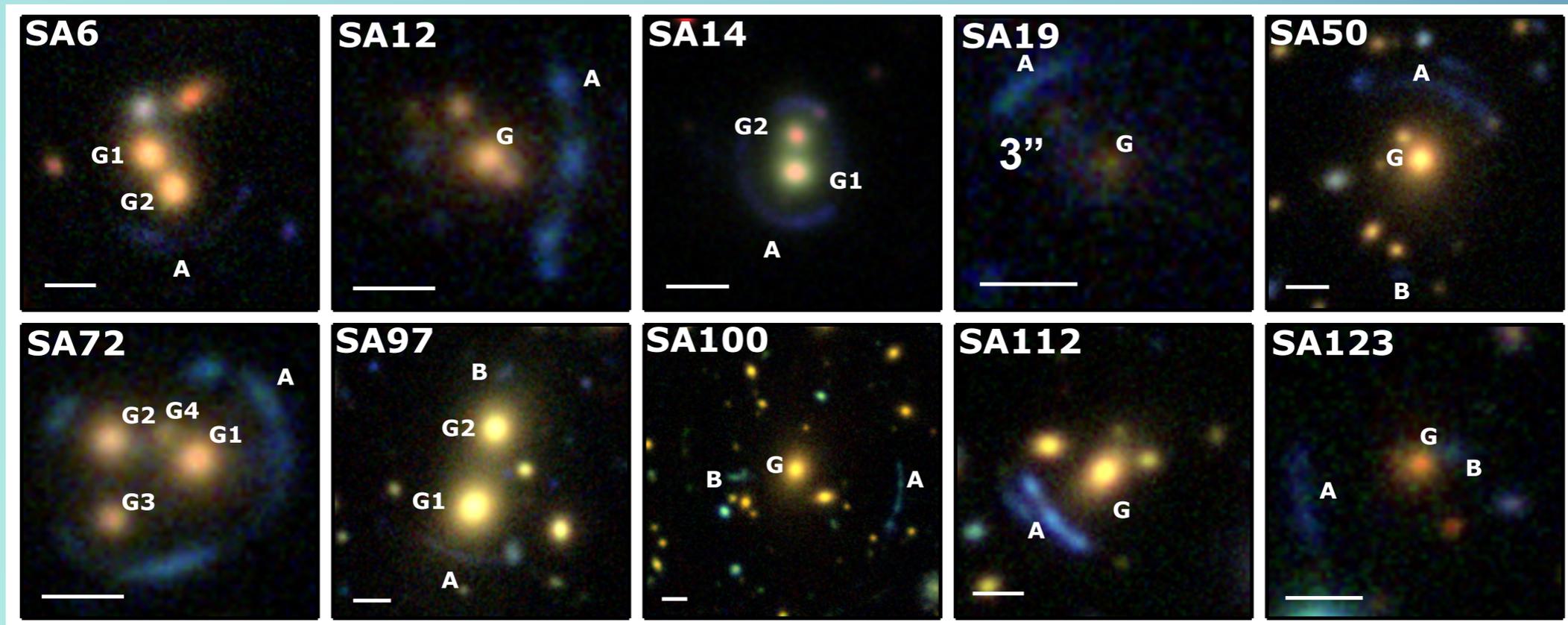
Strong lensing galaxy groups



Newman et al. 2015

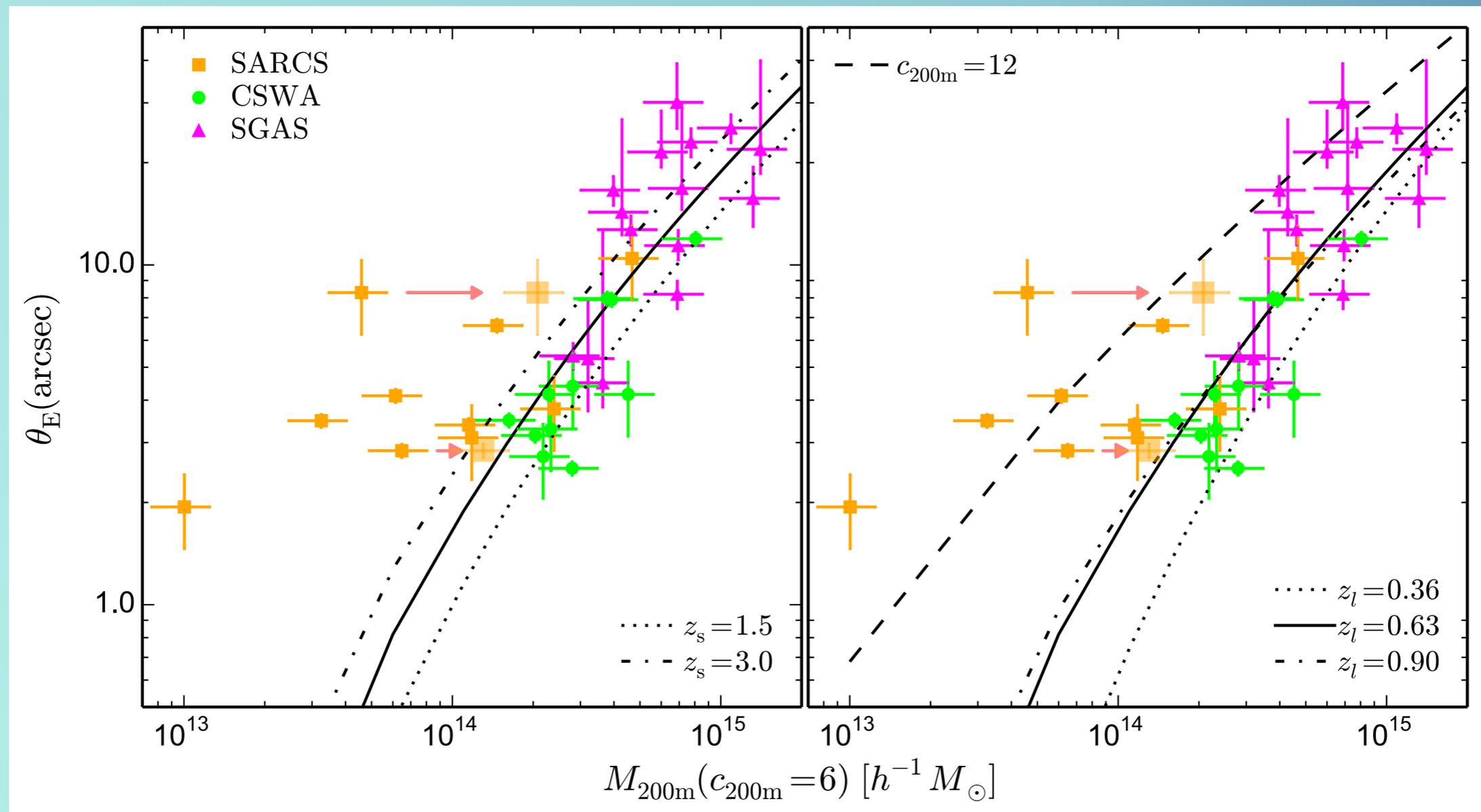
# SARCS lenses

**SARCS lens sample : Over 100 lens candidates discovered from CFHT Legacy Survey (AM et al. 2012)**



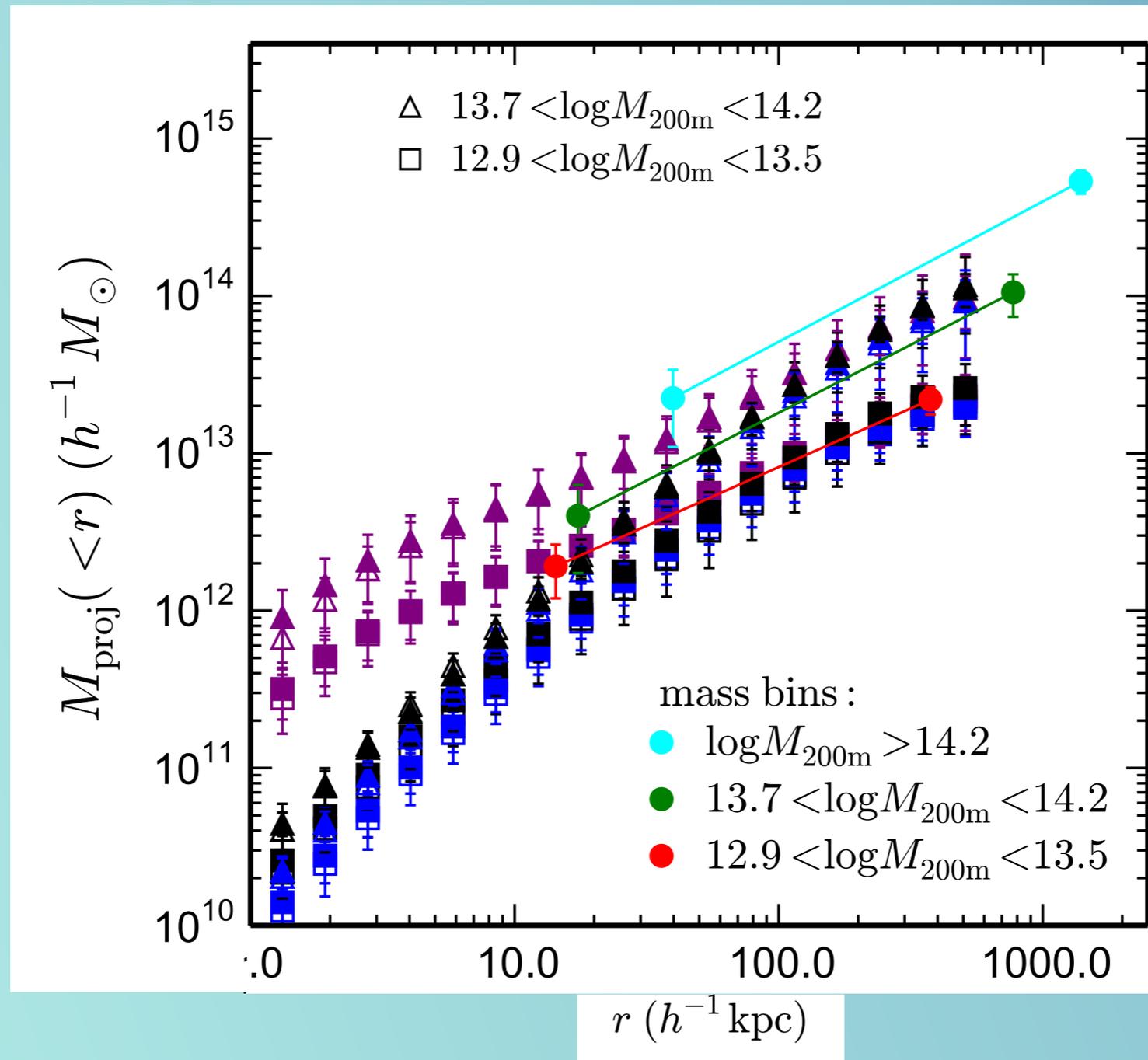
- Measure strong lensing mass  $\sim 10$ s Kpc
- Measure optical richness-based mass  $\sim 100$ s Kpc

# Einstein Radius - Mass distribution



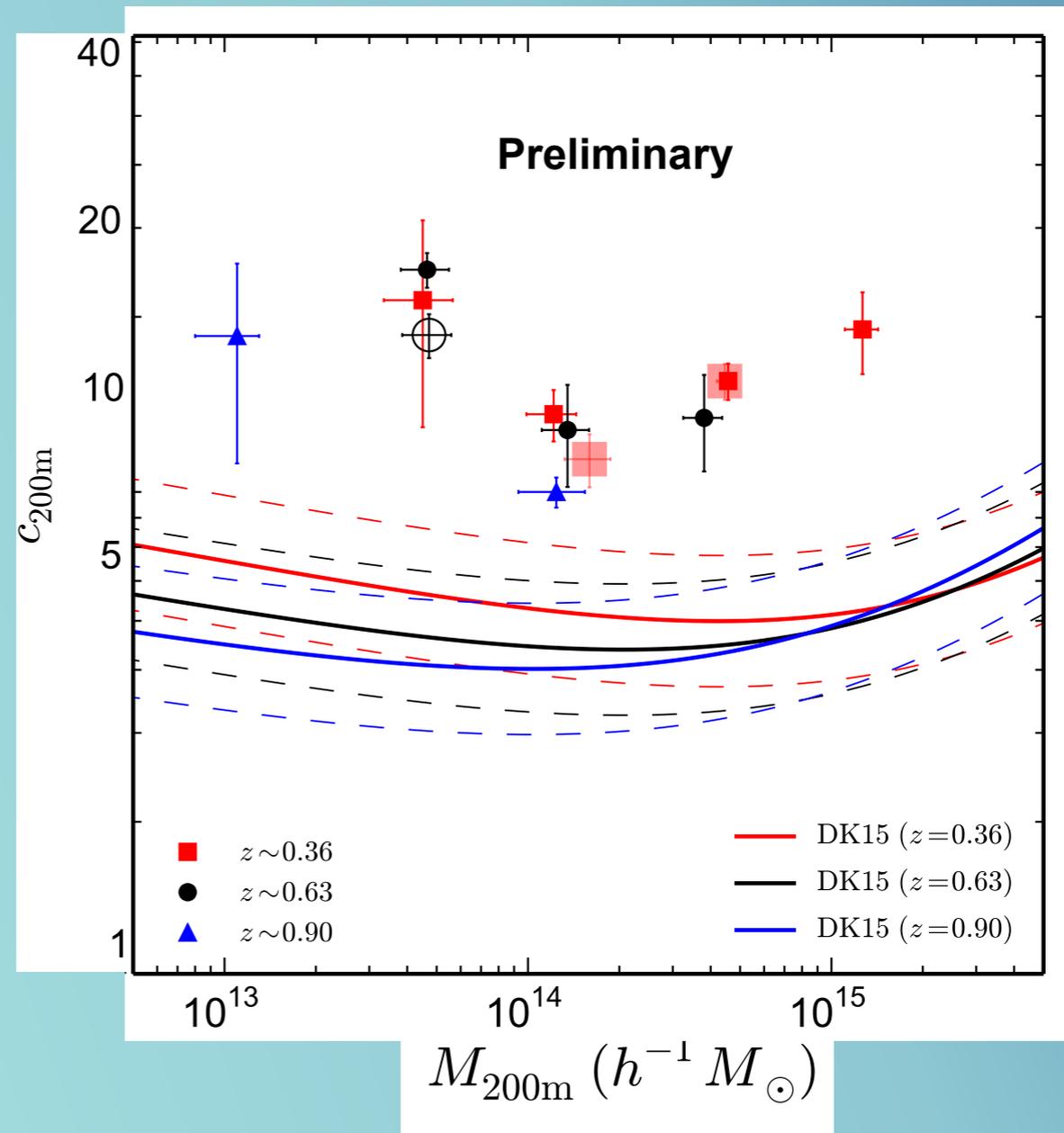
Jaelani, AM, et al. 2018  
in prep.

# Mass distribution



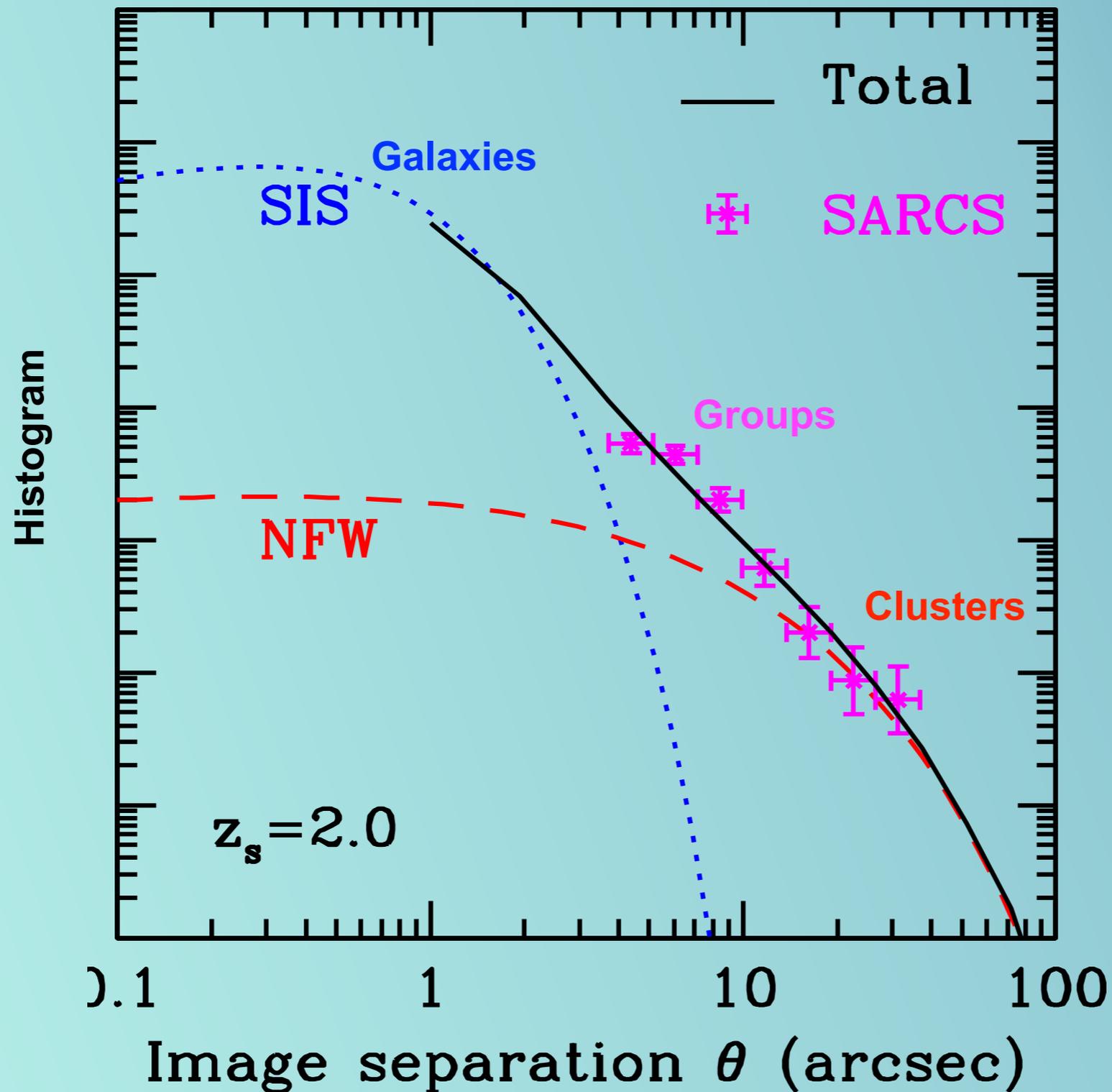
# Concentration-Mass relation

- c-M relation higher than expectation
- inner slope of DM mass distribution not NFW ?



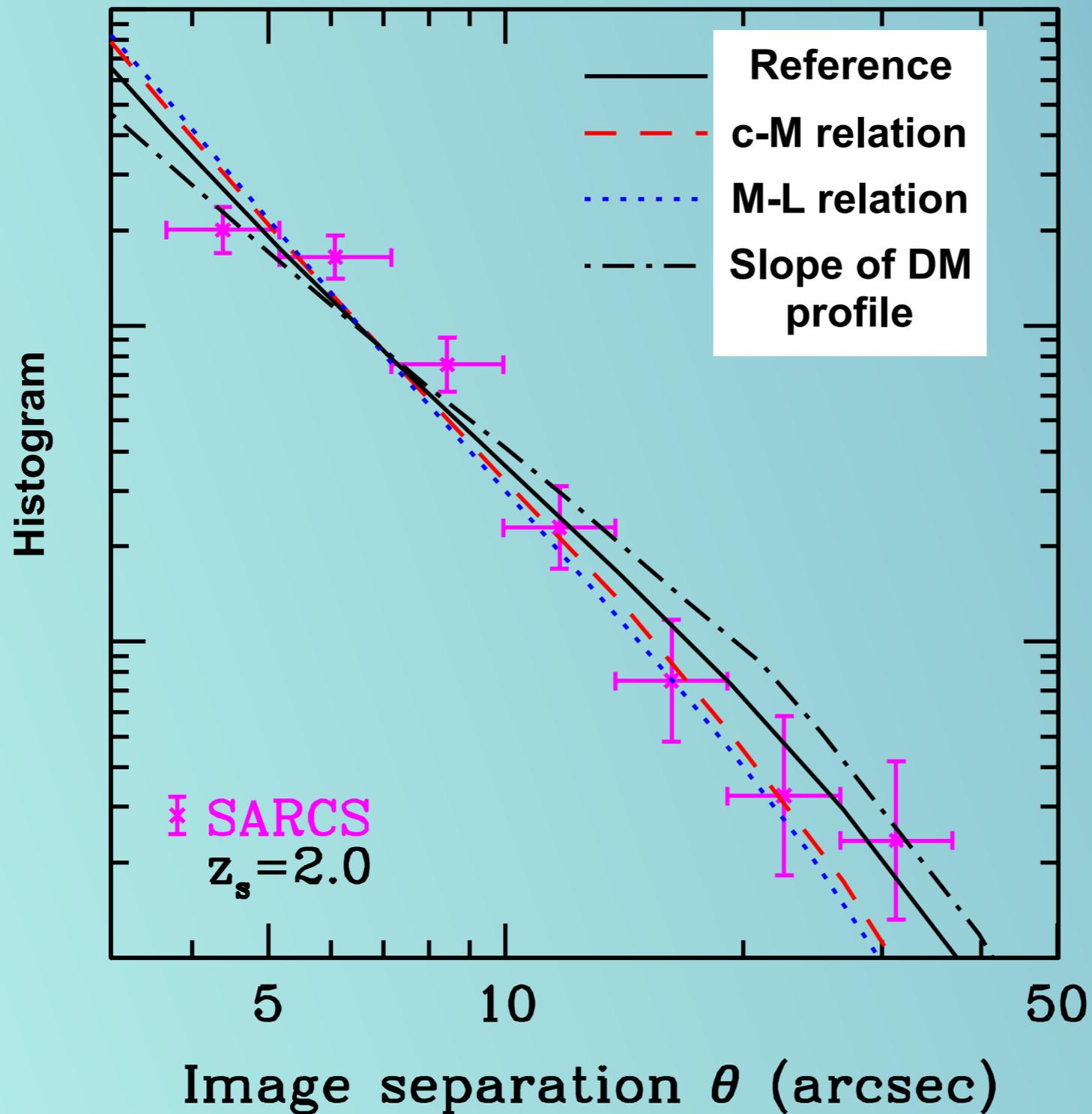
Jaelani, AM, et al. 2018  
in prep.

# Image Separation distribution



- SARCS: **largest** sample of SL groups with an arc-finding algorithm
- **First** statistical constraints on mass distribution of SL groups

# Image Separation distribution



- Constraints on c-M relation or inner slope of the DM profile will be feasible with larger lens samples

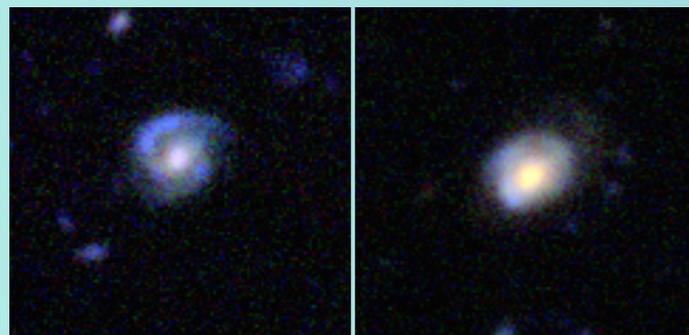
# Space Warps

- **PIs:** Anupreeta More, Phil Marshall, Aprajita Verma



**Training sample**

- **Space Warps** - first citizen science project within Zooniverse\* to use **supervised learning** approach for processing multiple classifications



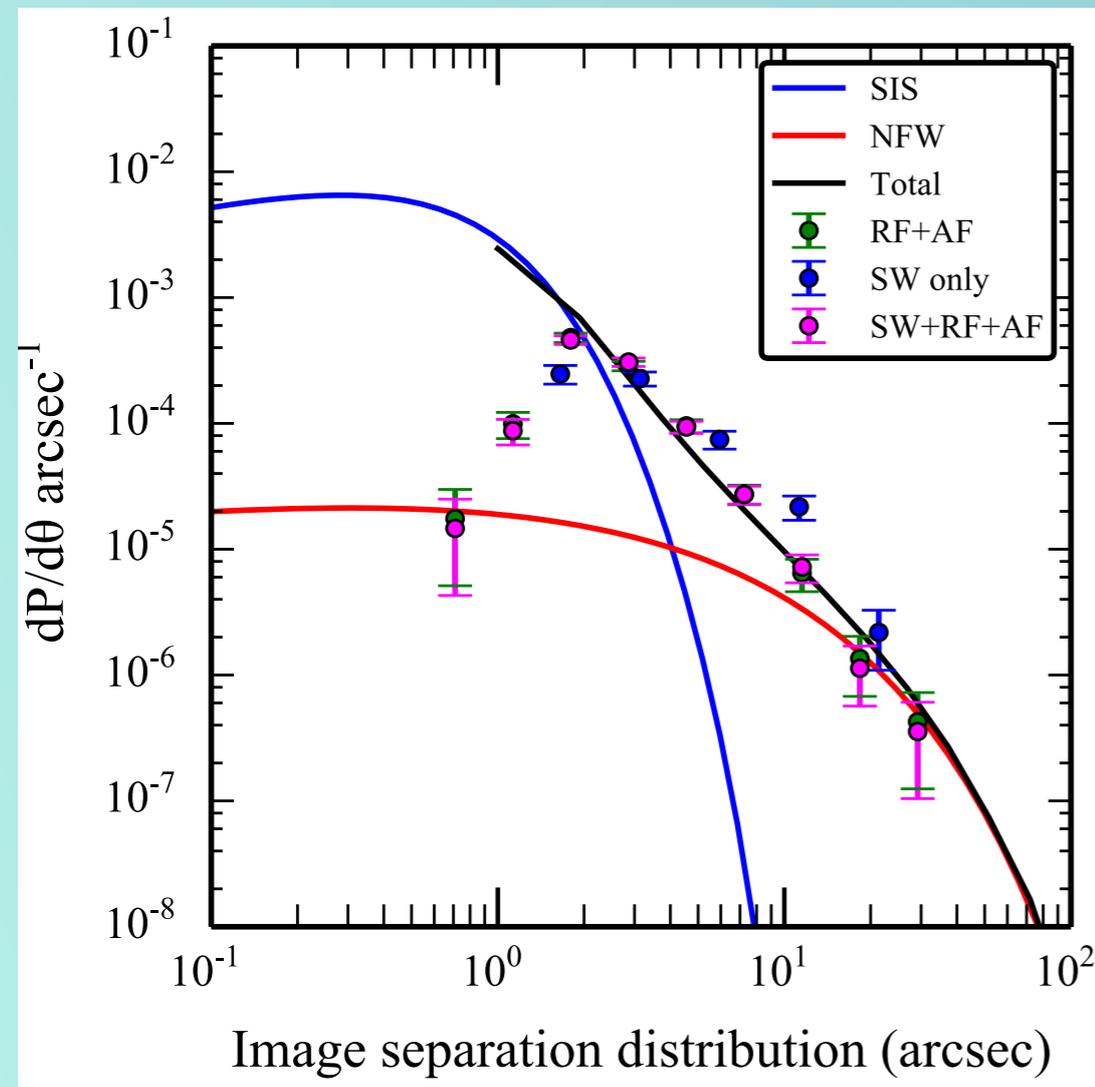
**Lens impostors**

**Simulated Lenses**

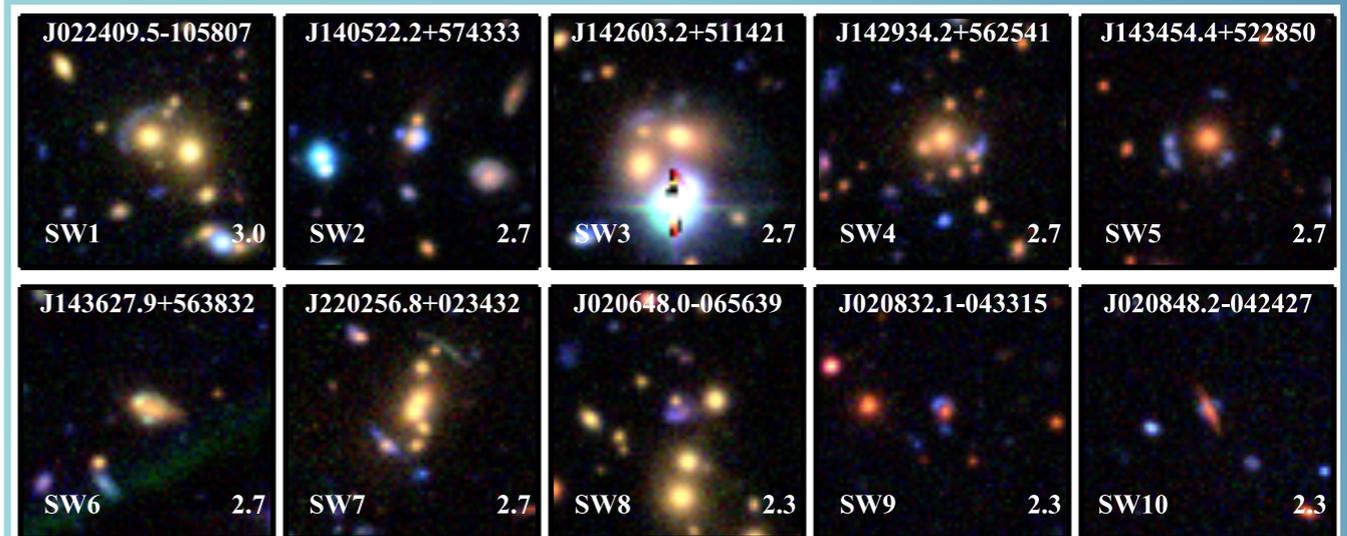


\* [zooniverse.org](http://zooniverse.org)

# Space Warps: lens search



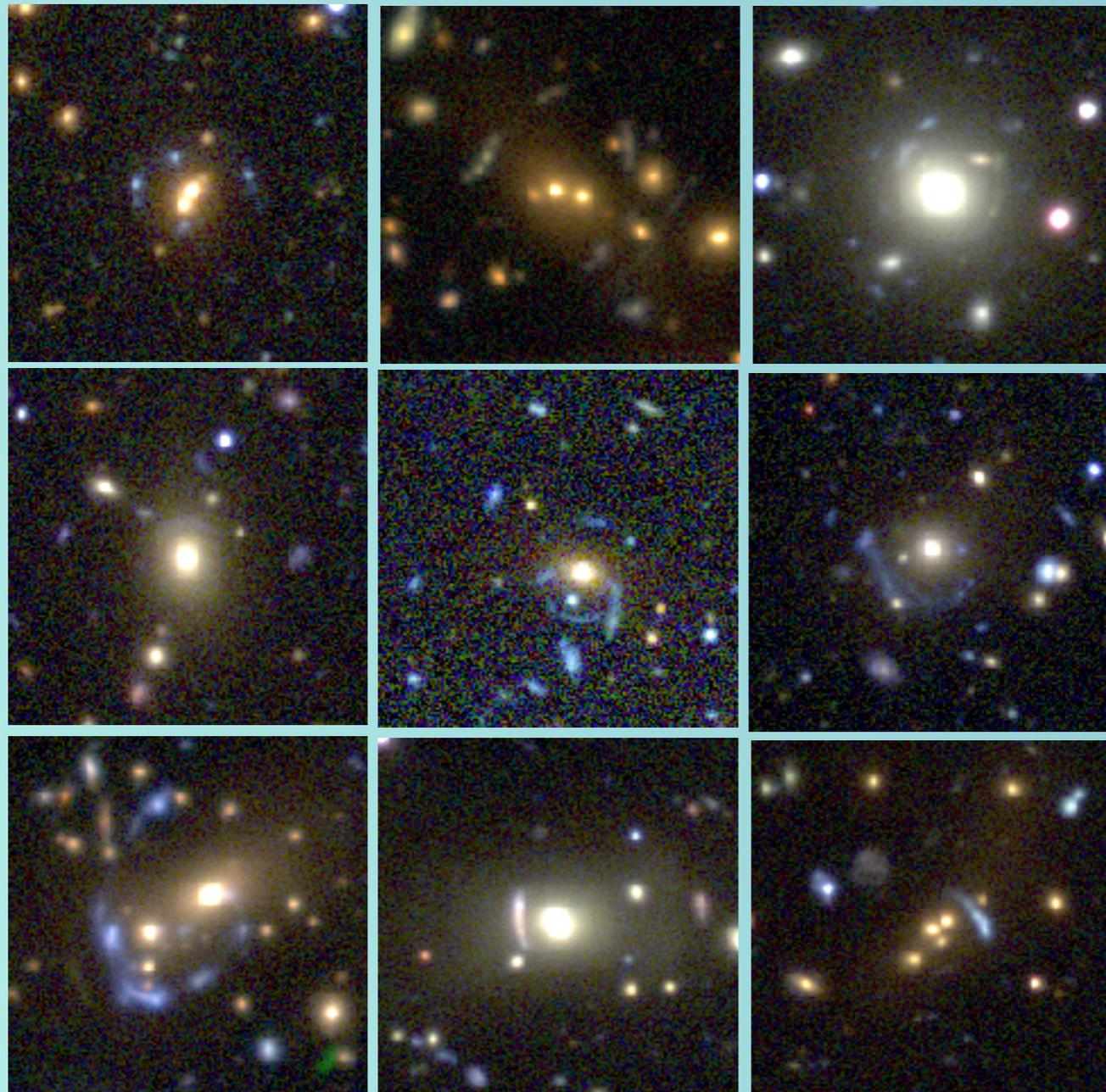
AM et al. 2016



Nearly 60 new lens candidates which were missed by previous searches in CFHT Legacy Survey

Selection function can be characterized for such systems for the first time

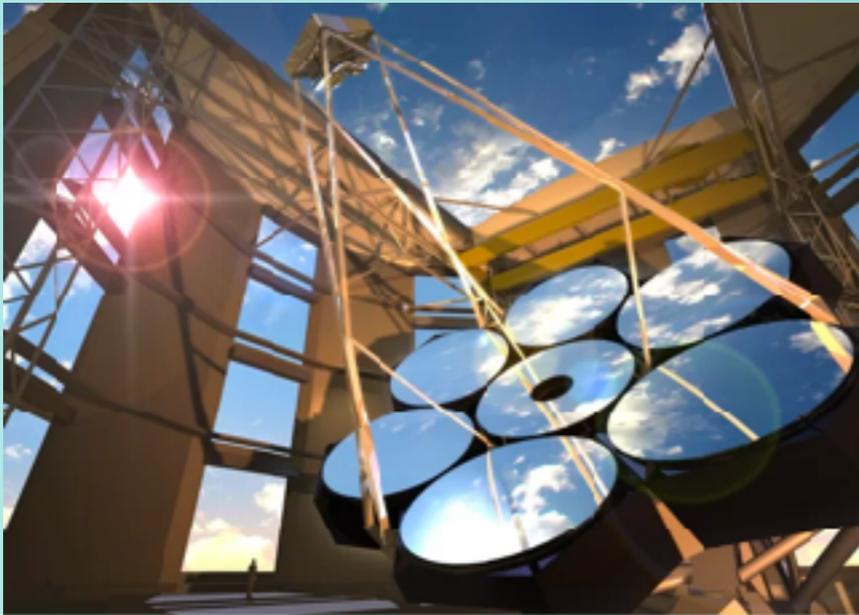
# Hyper Suprime-Cam Survey



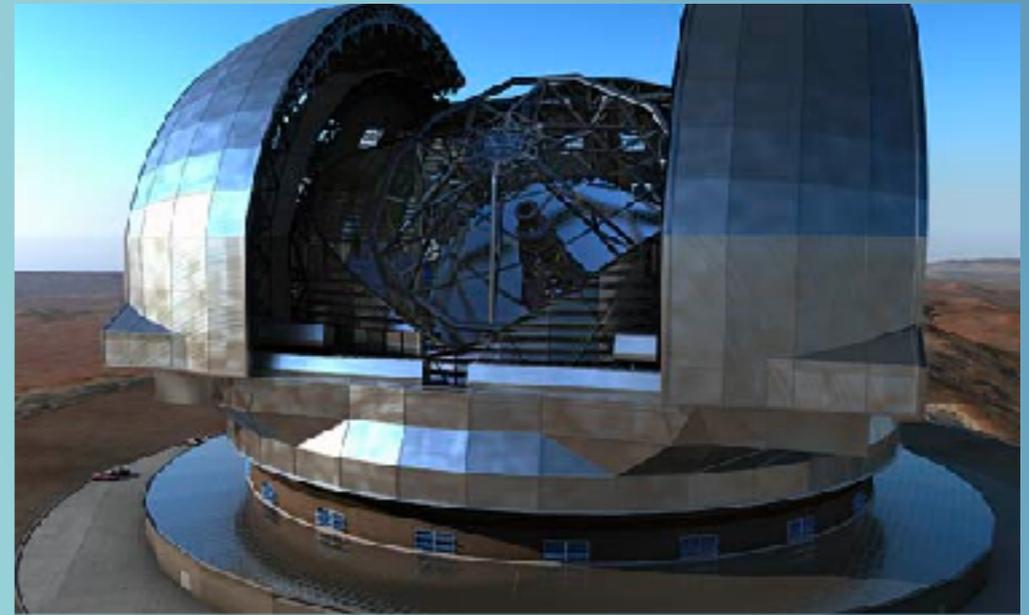
- HSC Survey ongoing with Subaru Telescope (1400 sq. deg,  $r \sim 26.5$  AB)
- 500 lenses (order of magnitude increase in sample size)

Over 70 new lenses from early HSC data (AM et al. 2018 in prep)

# ELTs



Credit: Giant Magellan Telescope/GMTO Corporation



Credit: ESO



Credit: NAOJ

# Summary

- Mass distribution in galaxy groups will help understand nature of dark matter and its properties in the central regions of the halos
  - Individual group-scale lenses
  - Lens statistics
- Current and upcoming imaging surveys (e.g. DES, HSC, LSST) will discover the lens systems we need
- Extremely Large Telescopes will be critical in measuring the observables to enable the above goals