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A first look at the shapes of ICL in Euclid Q1

Dr Tutku Kolcu

In collaboration with: Nina Hatch, Steven Bamford, Hua Gao and Jesse Golden-Marx

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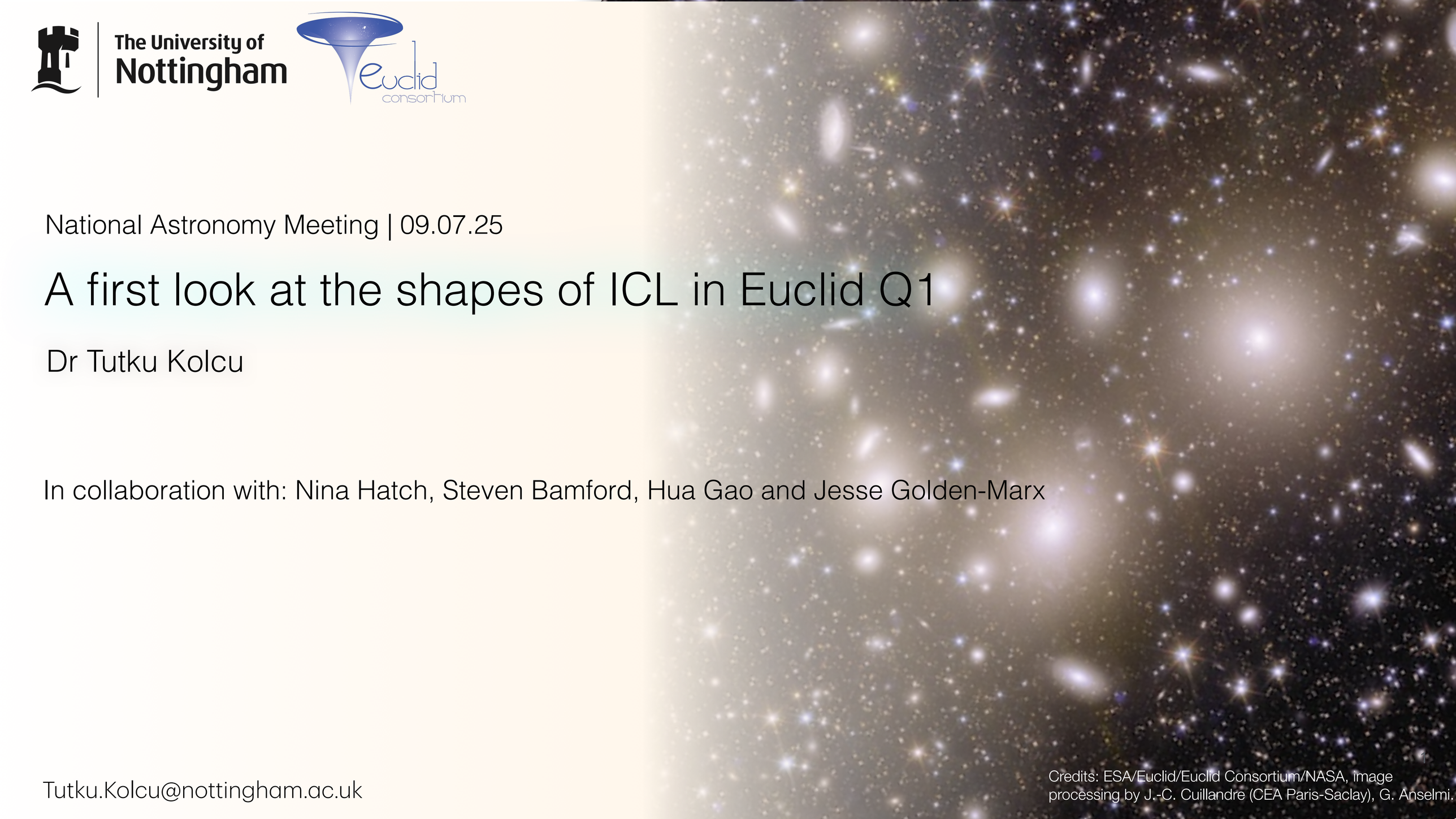
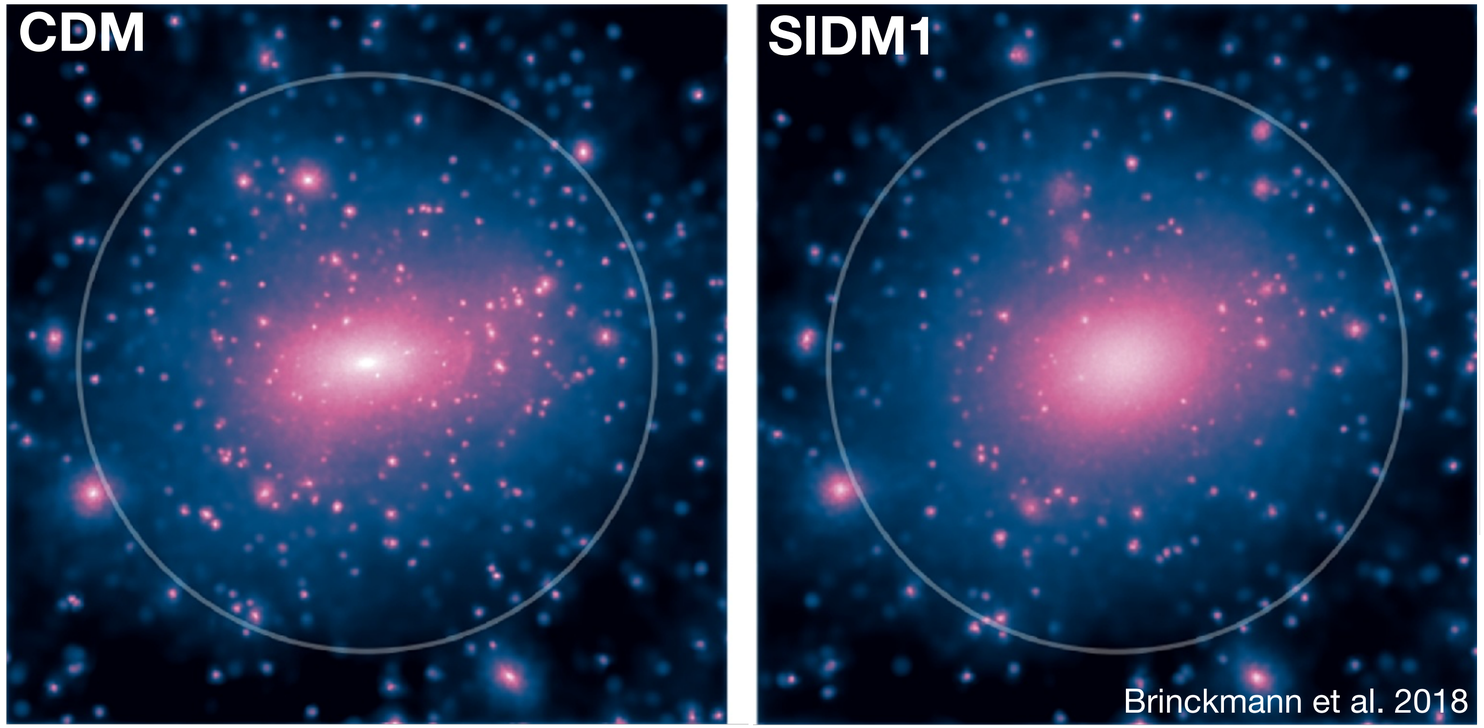


Credits: ESA/Euclid/Euclid Consortium/NASA, image processing by J.-C. Cuillandre (CEA Paris-Saclay), G. Anselmi.

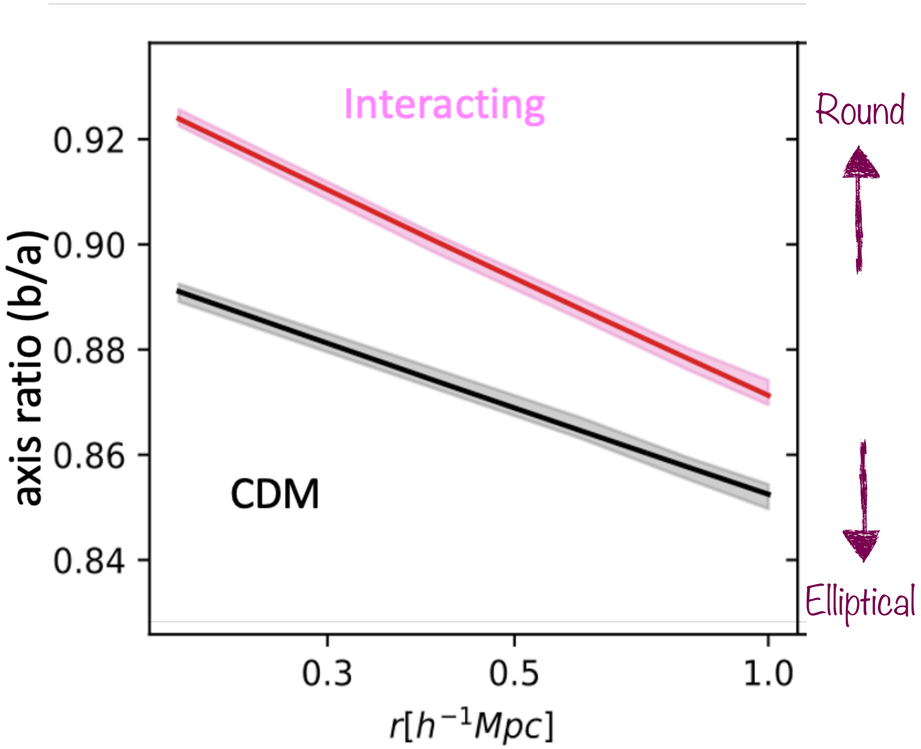
Why to study the shape of intracluster light (ICL)?

Self-interacting dark matter (SIDM) produces more spherical and cored halo profiles, in contrast to cold dark matter (CDM), which results in more elongated, cuspy halos.
Measuring **shape** and **profile** of DM halos informs us about the nature of DM.

ICL is considered to be a distinct component, bound to cluster halo, thus can be used as a tracer of DM. Thus, studying ICL shapes provides insights on the nature of DM.



The circle marks the viral radius of the halo
($R_{200} \sim 2$ Mpc h^{-1}, $M_{200} \sim 2 \times 10^{15} M_{\odot} h^{-1}$)

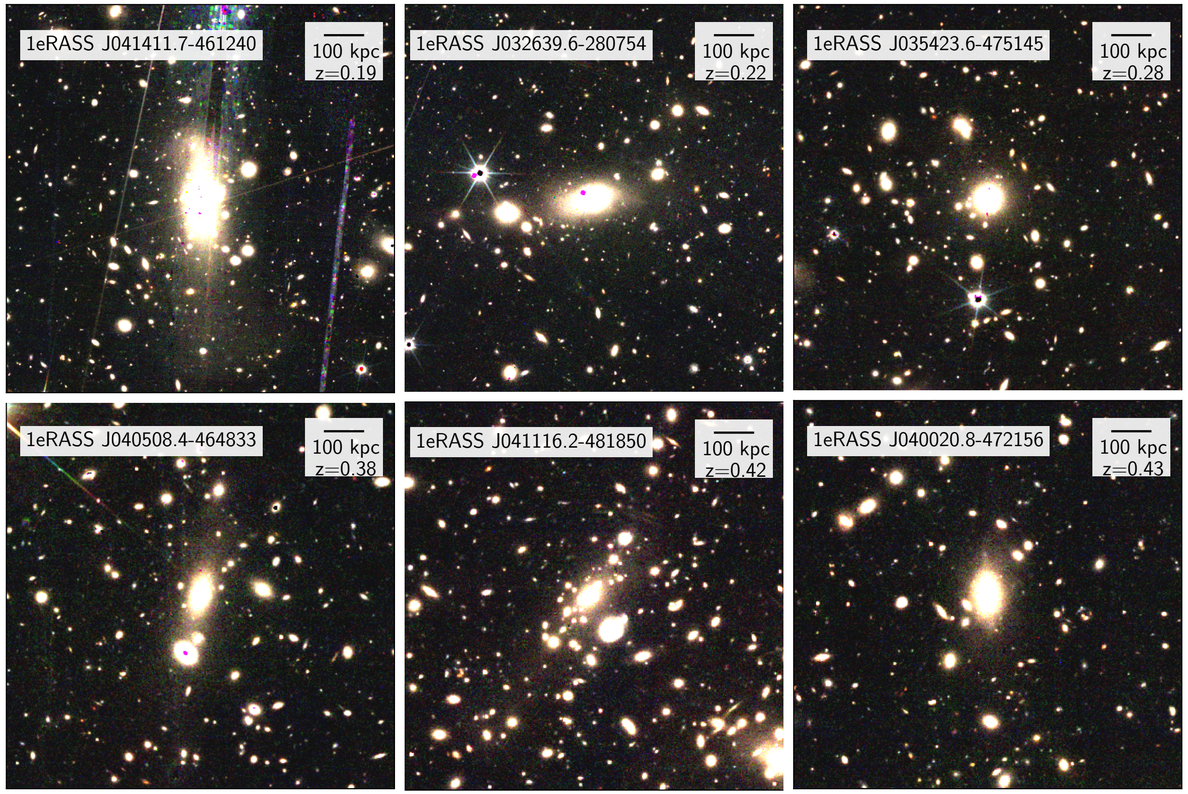


A first look at the shapes of ICL in Euclid Q1

Q1 covers ~63 deg^2 of the sky; whole planned survey will cover 1/3 of the sky in 4 bands (VIS :I_E and NISP :Y_E, J_E, H_E)

No cluster catalogue released yet, so we use an overlap of DES and eROSITA in South and Fornax fields ~200 clusters within $0.1 \leq z \leq 0.8$ and with $M_{halo} \sim 10^{14} - 10^{15}\ M_\odot$

various morphologies!



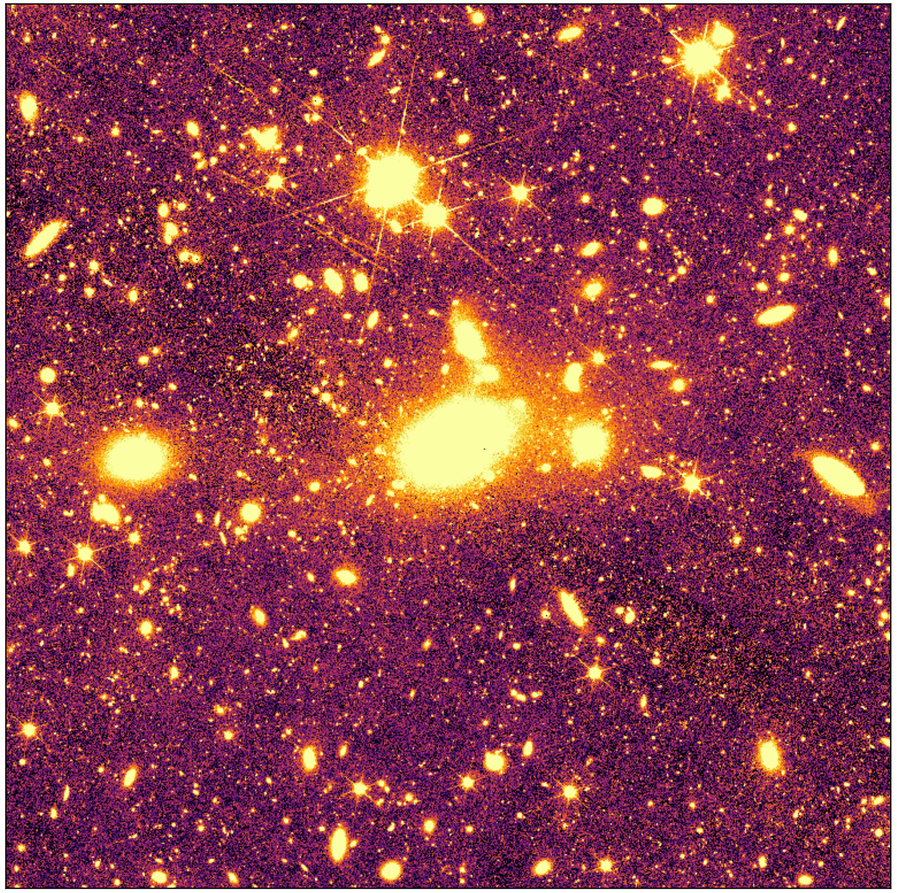
Questions

- How and how far out we can measure ICL signal and shape in individual clusters and stacks?
- Which band traces the ICL extent and shapes further?
  (no time, ask me later…)
- How does ICL shapes compare to shape of galaxy distribution in clusters?
  (no time, ask me later…)

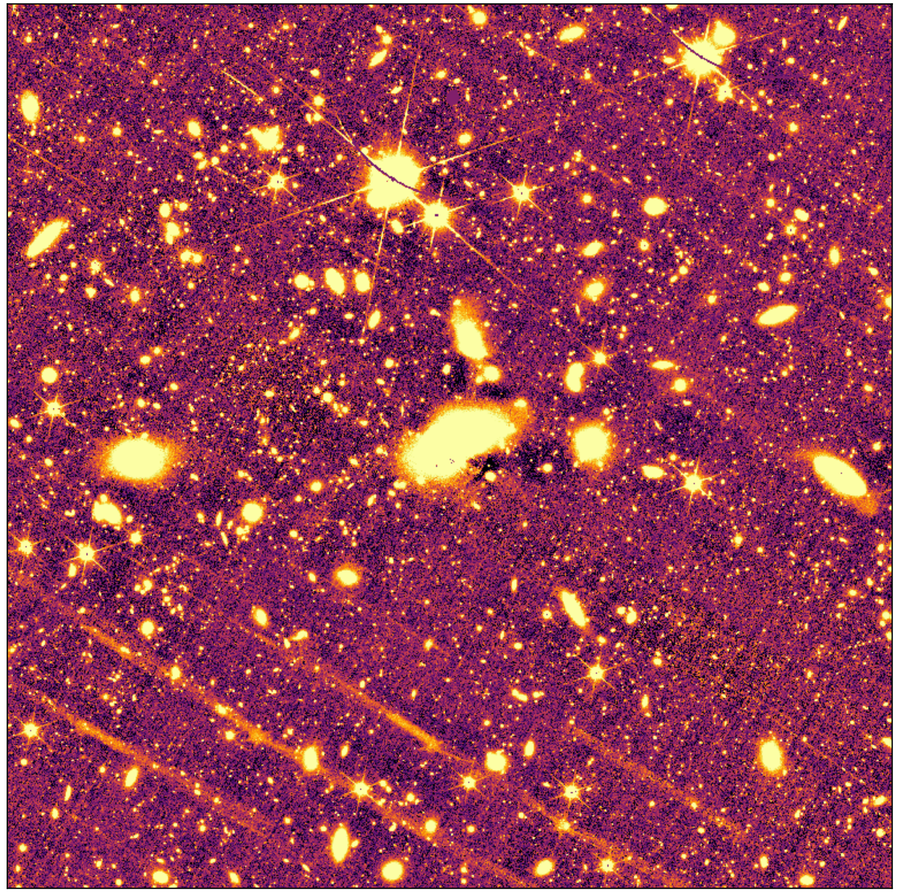
Processing of images for low surface brightness (LSB) science

We follow careful processing steps with several large and small scale corrections to preserve as much ICL as possible in images

Fully post processed by **nicl** pipeline



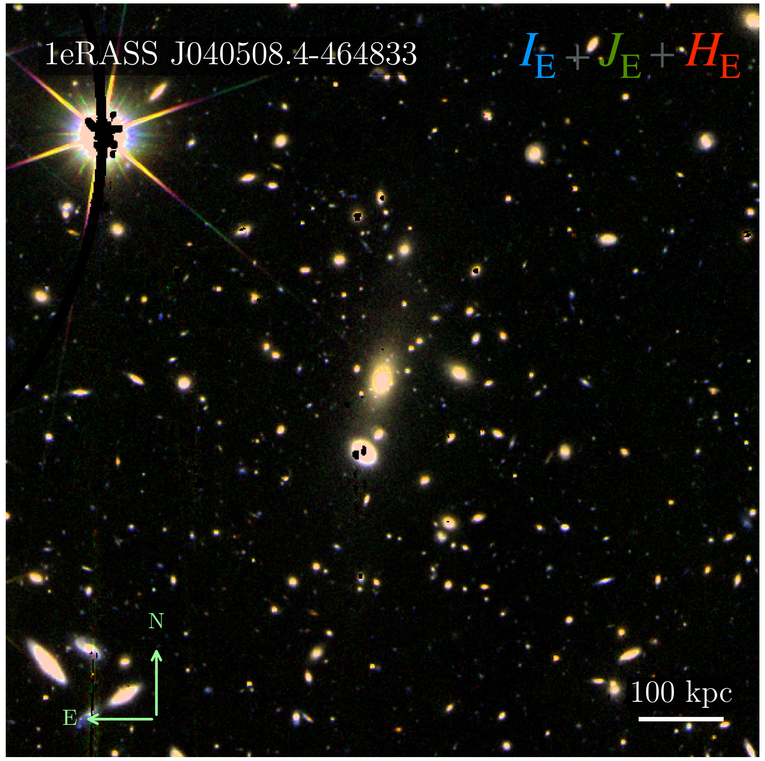
Standard final product in Euclid archive

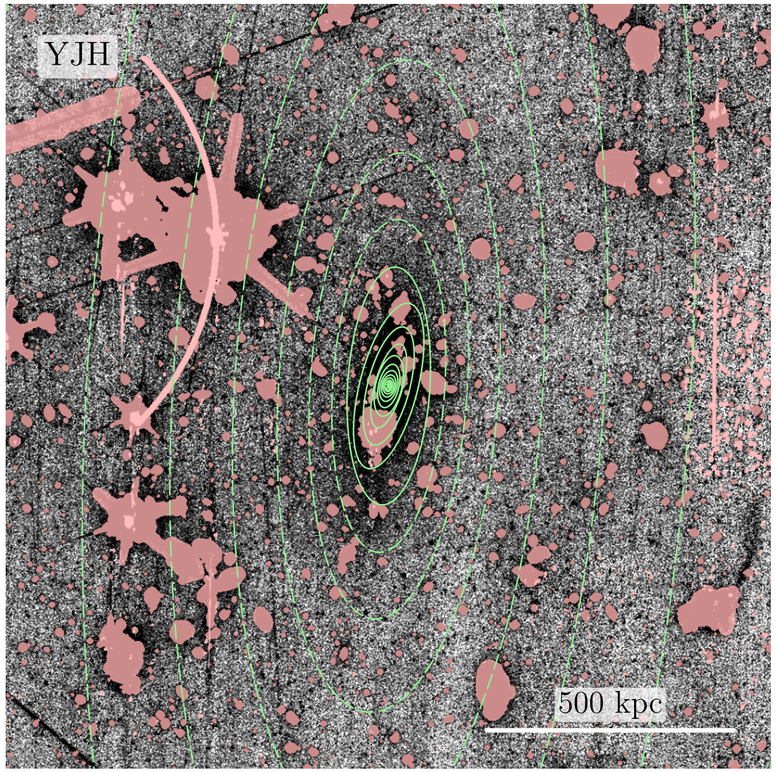


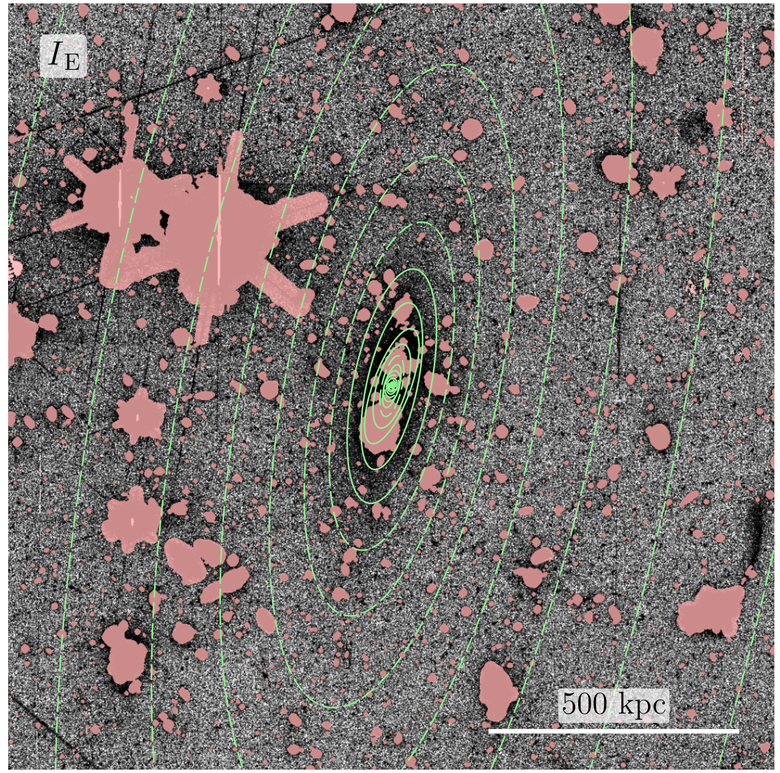
Bamford et al. in prep

Measuring ICL shapes and surface brightness

- Bright sources are masked leaving only BCG+ICL
- Elliptical isophotes are fit to the BCG+ICL using AutoProf software (Stone et al. 2021)
- Ellipticity and PA are measured out to ~S/N= 10, then are fixed to last values.



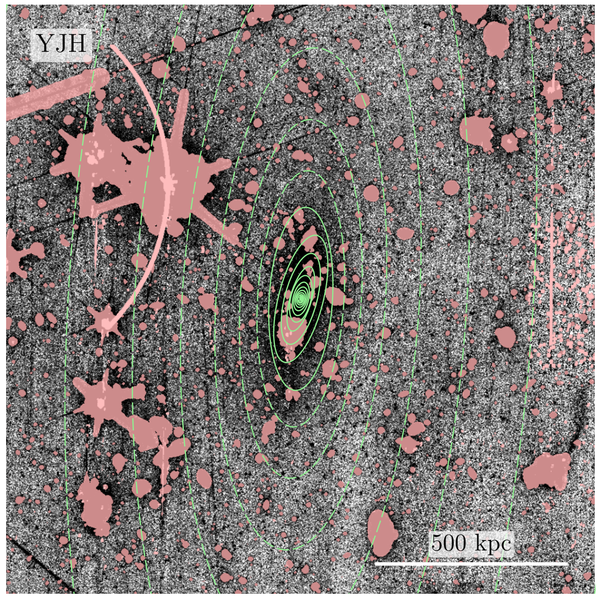


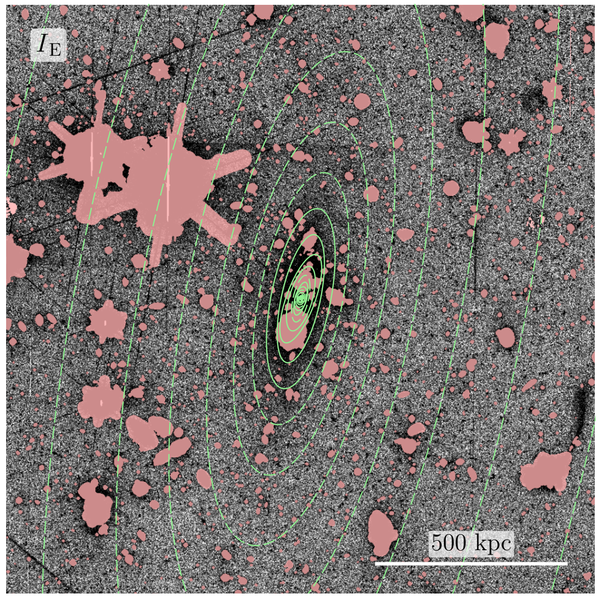


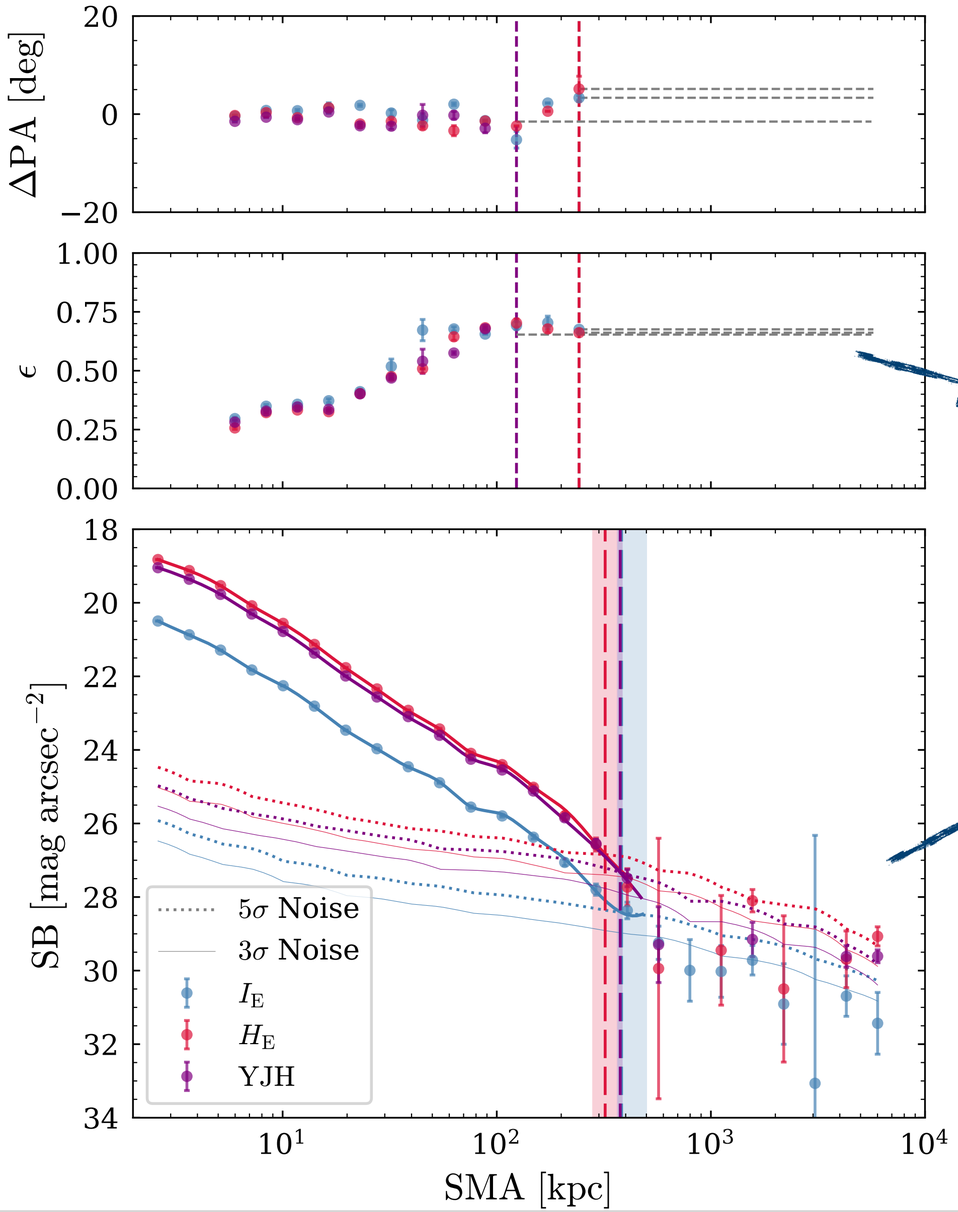
$M_{200} \sim 2 \times 10^{14} M_\odot$
$z \sim 0.4$

Kolcu et al. in prep

Measuring ICL shapes and surface brightness





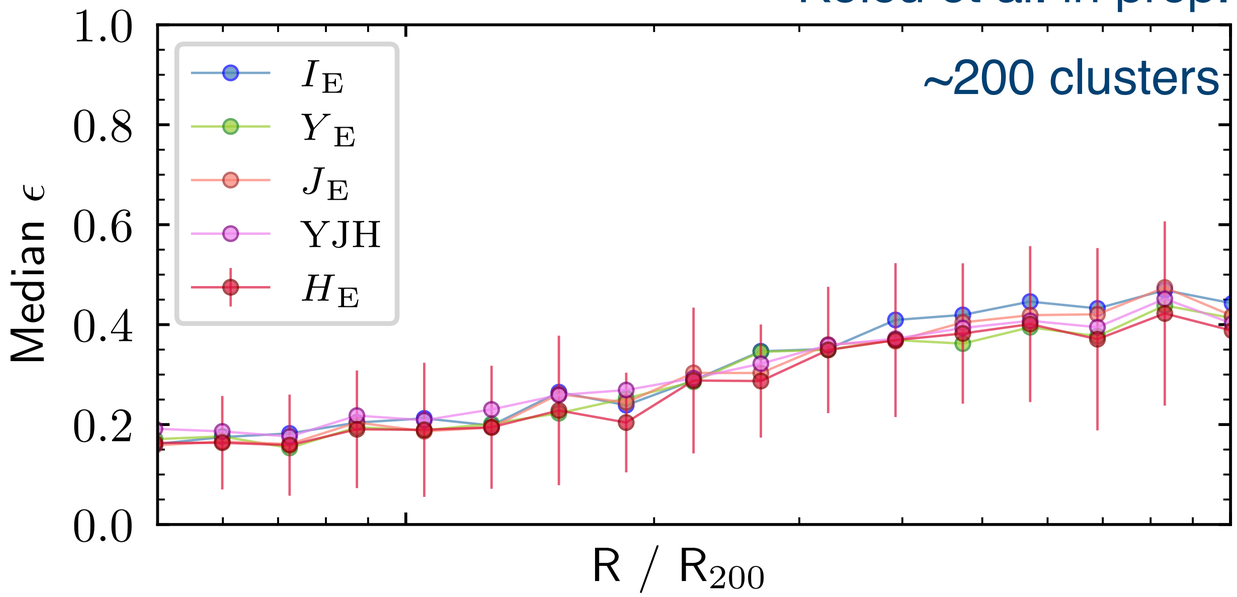


In individual near-infrared bands of Euclid, metallicity-sensitive colours:

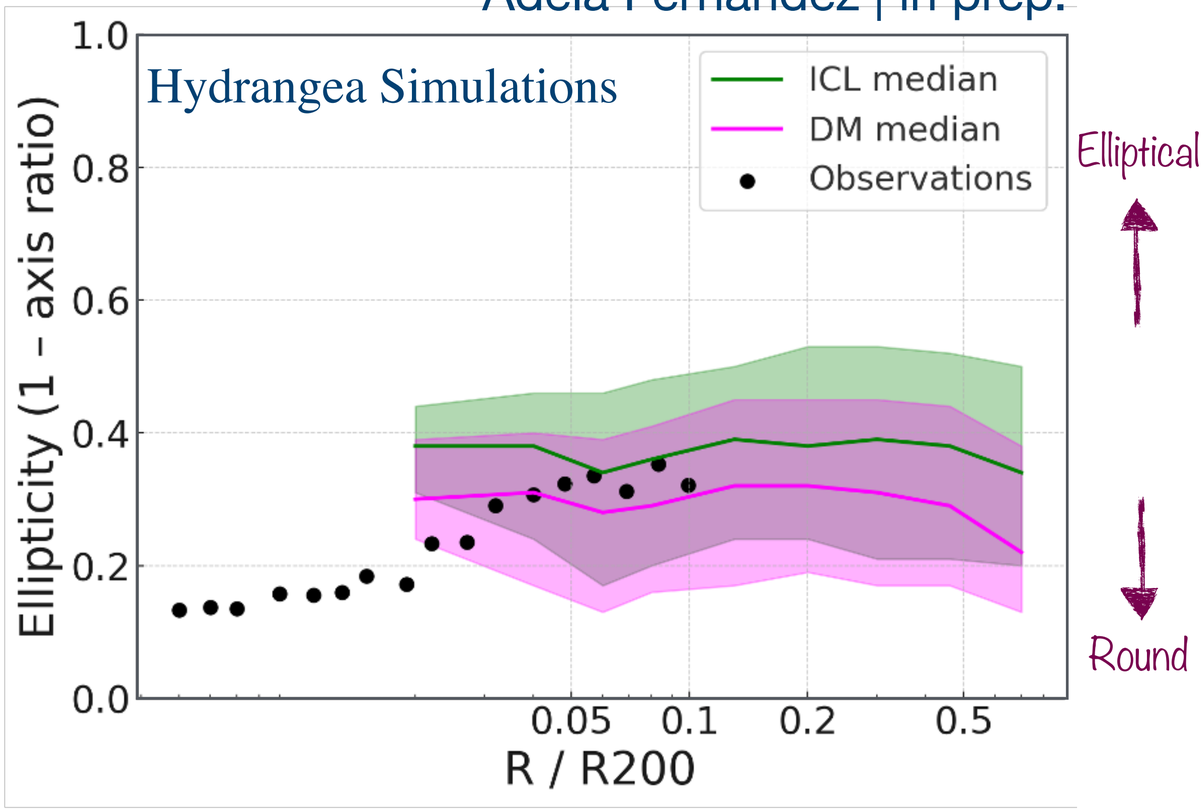
- We can measure ICL shapes at R ~100—200 kpc
- We can measure the ICL signal confidently up to ~400 kpc

Average shape of ICL

Kolcu et al. in prep.

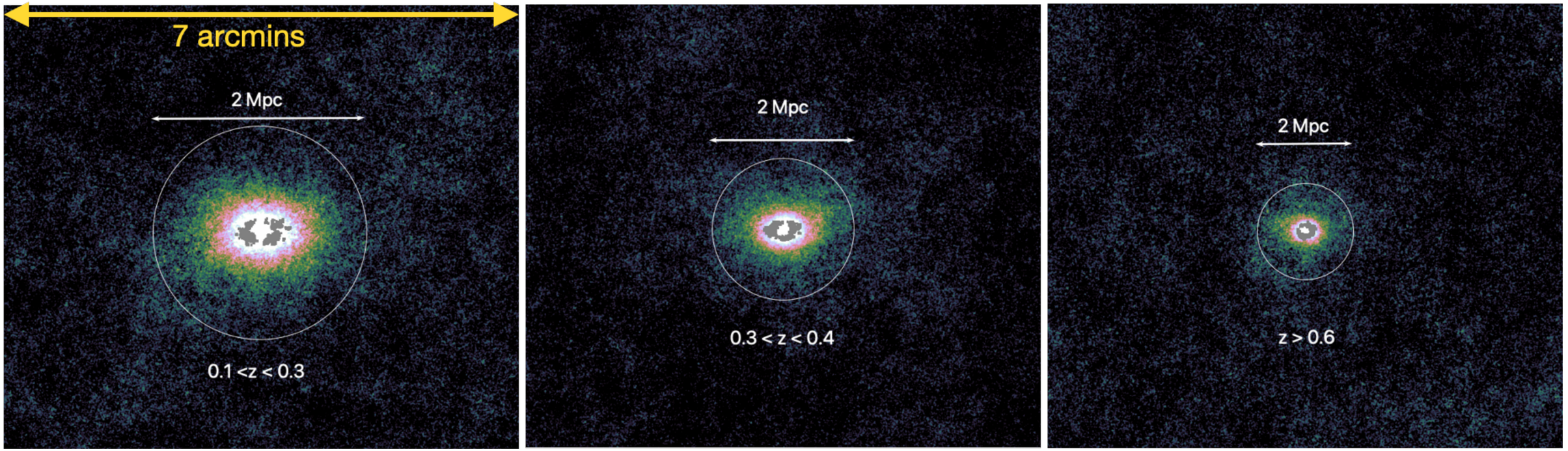


Adela Fernandez | in prep.



- The median ellipticity across bands are consistent.
- Inner regions have consistently round isophotes and outer regions are more elliptical.
- Both observations and simulations trace a similar ellipticity for DM halo with ~0.4

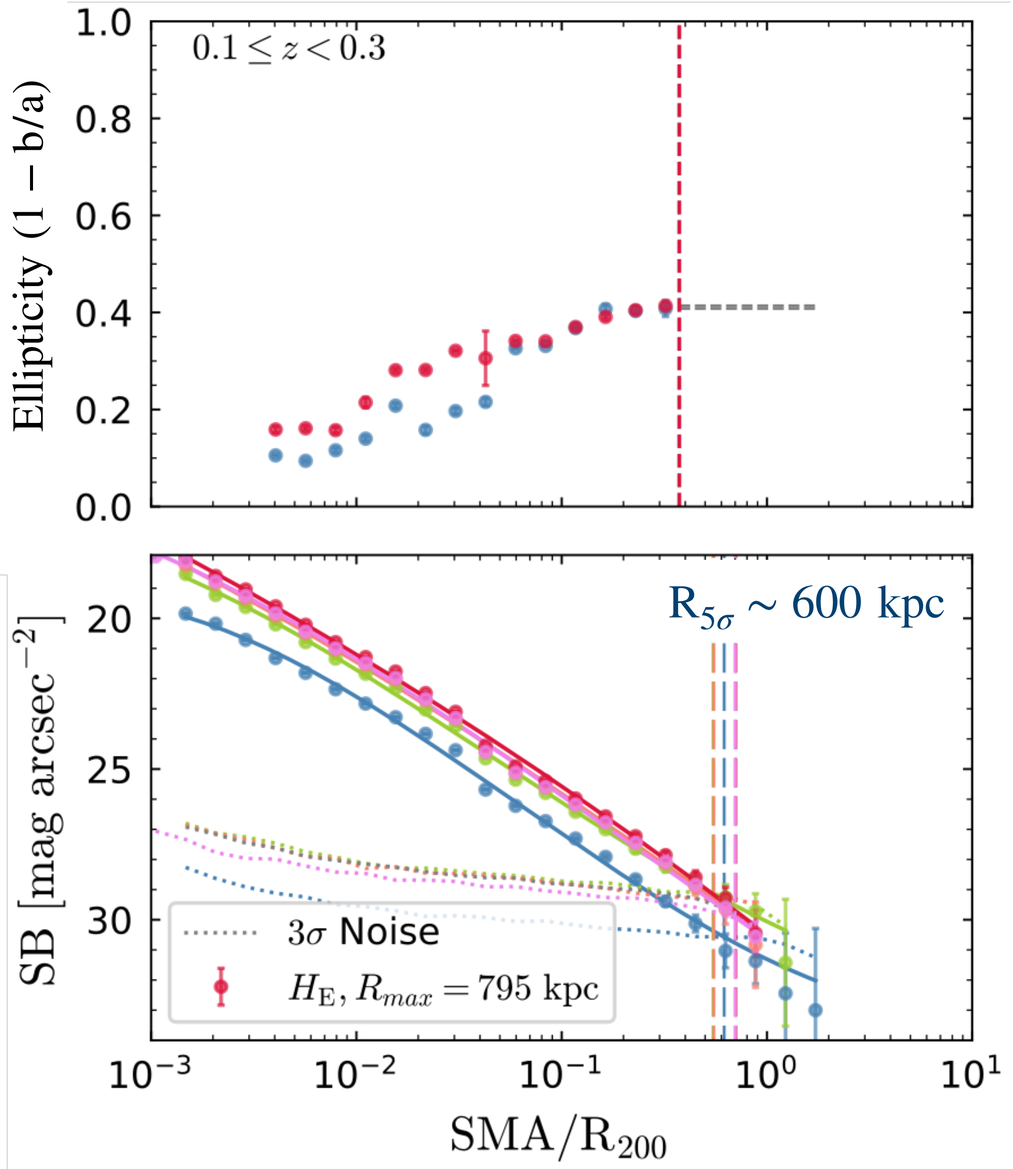
Shape of ICL Halo

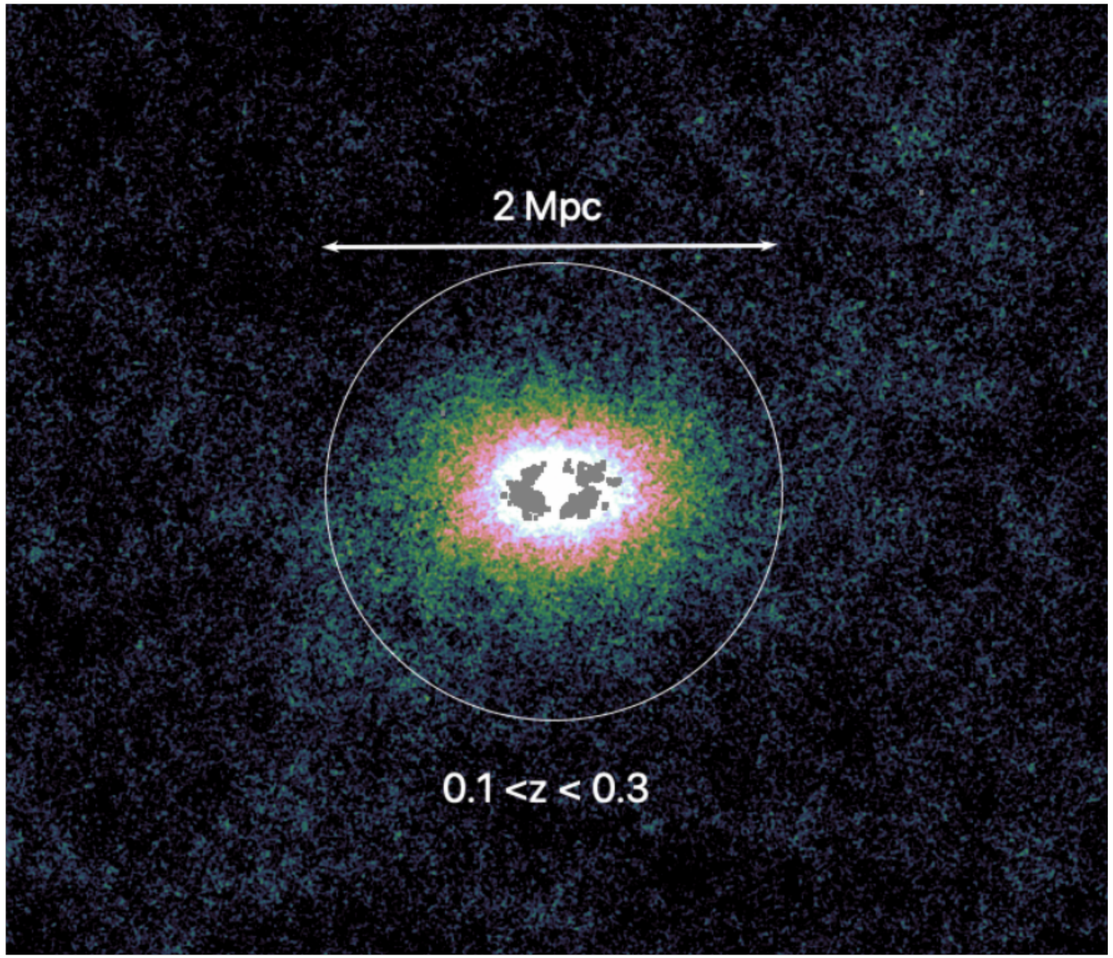


- Stacked images of ~40 clusters in each redshift bin with all galaxies masked to show the ICL.
- All images rotated by the position angle of ICL measured in each cluster at ~0.1R_{500}

Kolcu et al. in prep

Stacking of clusters allow us to see further





Kolcu et al. in prep

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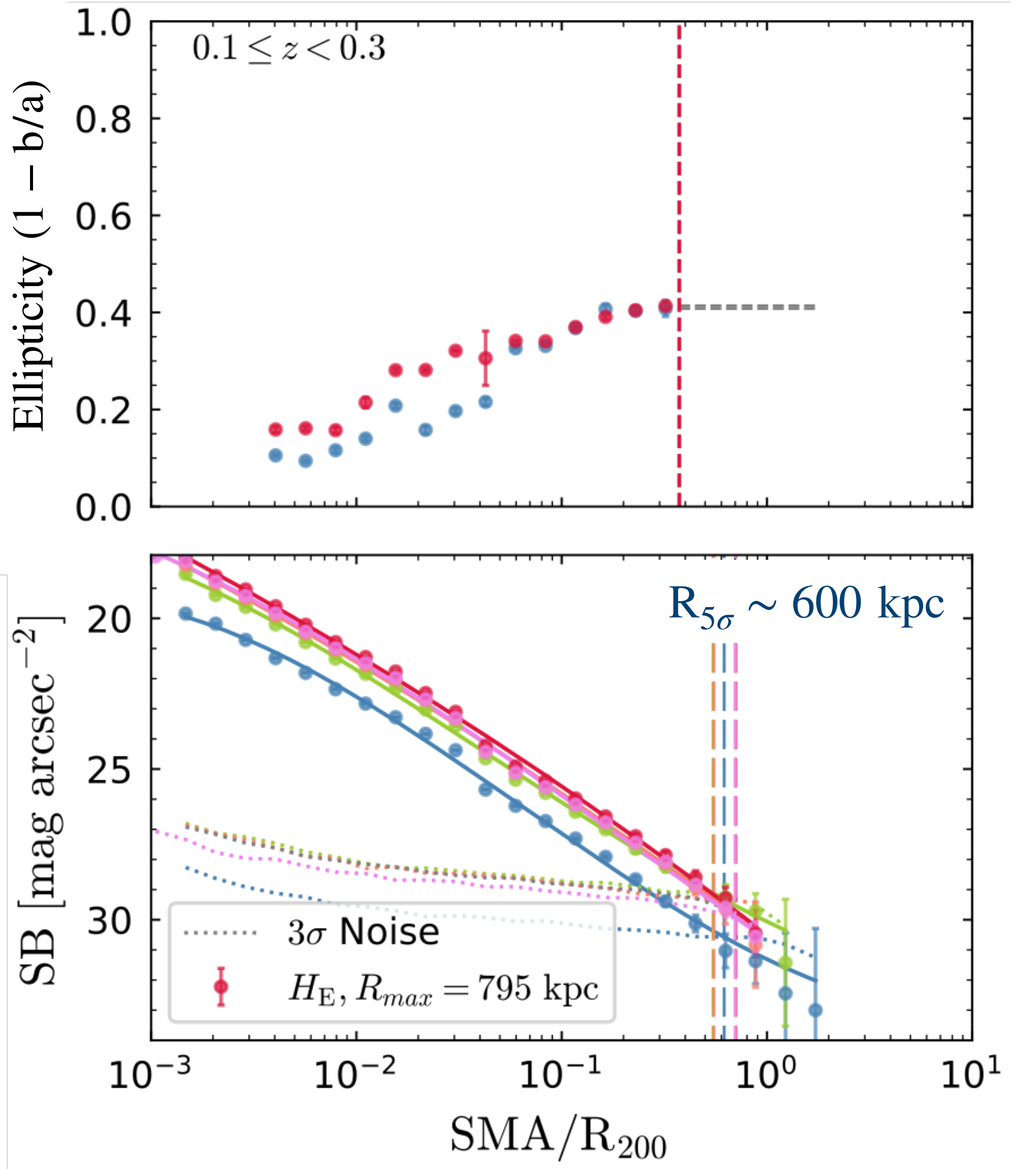

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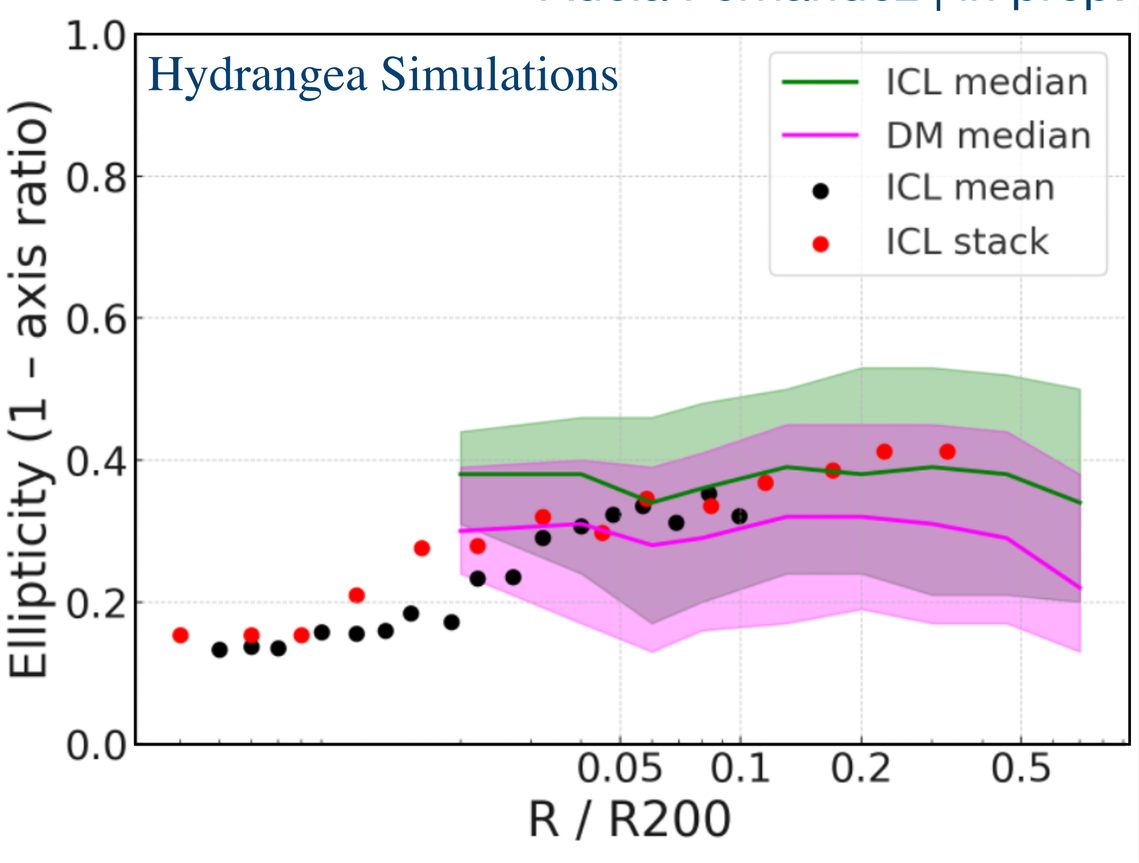

Simulations and observations do not match for BCG

- Horizon-AGN predicts slightly more elliptical ICL than Hydrangea
- Predict highly elliptical BCG in cluster core due to overcooling problem
- Massive disks forms in BCGs via cooling flows

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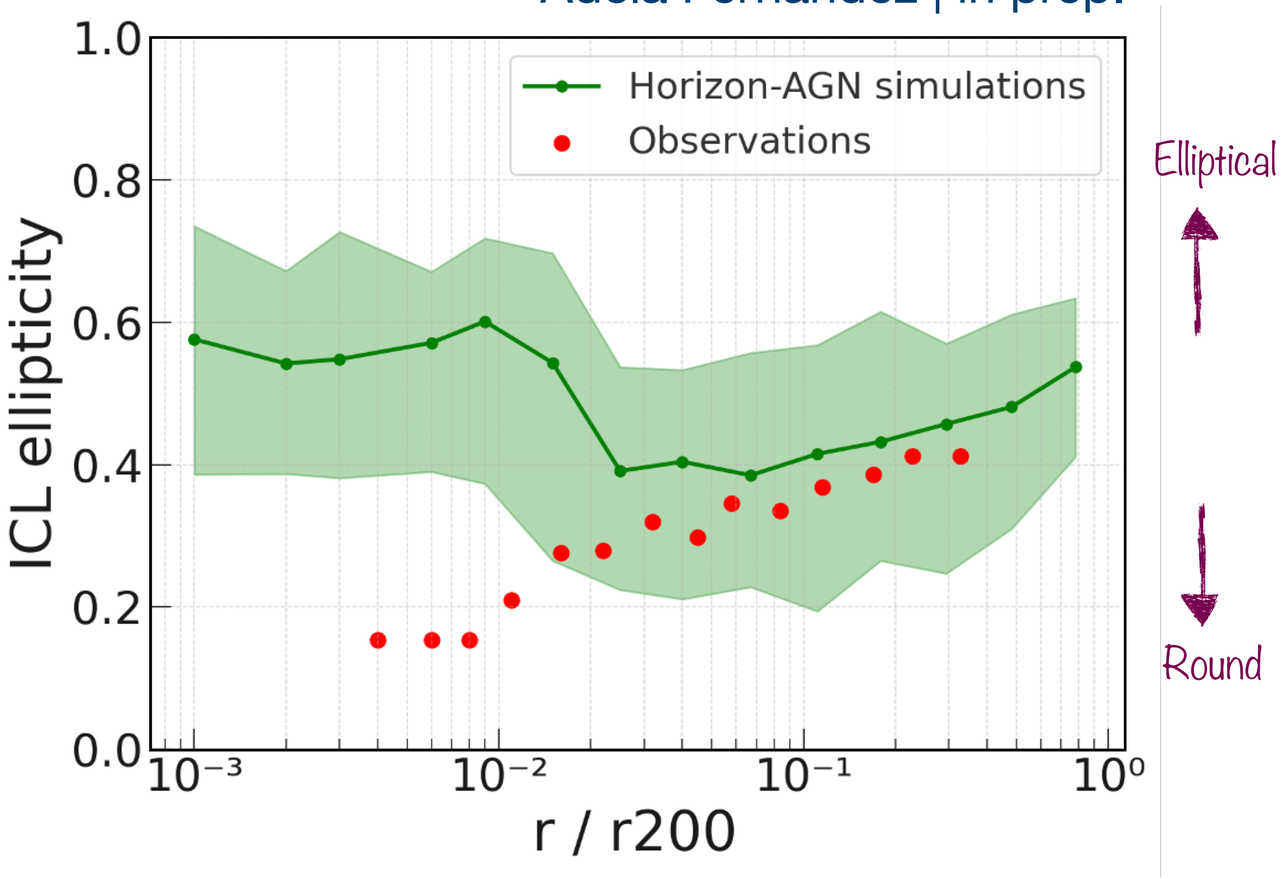
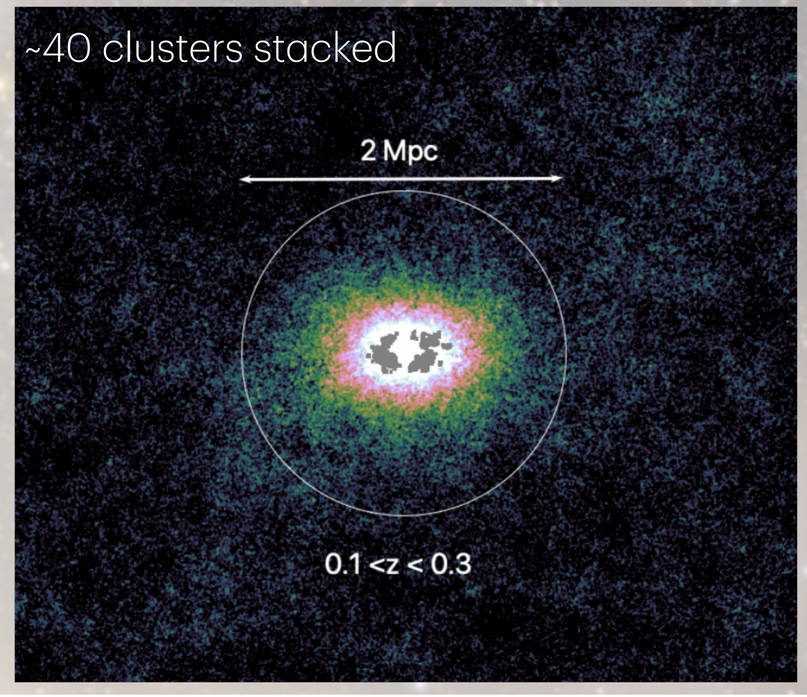
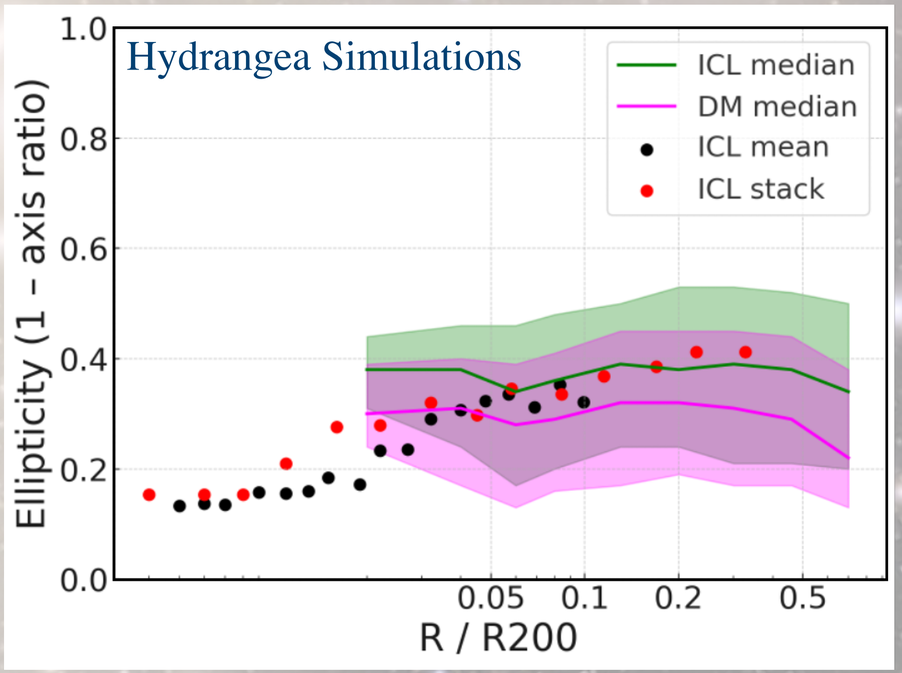


Take home messages…

- Measuring the shape and profile of ICL informs us about the nature of dark matter
- We can measure shape of ICL halo at R ~100-200 kpc in individual clusters, while stacking allows us to measure it much further
- Simulations and observations trace similar ellipticities for the ICL halo





We will process and analyse ~12,000 clusters in the next few months as a part of Euclid DR1. We can then study the evolution of ICL shape with redshift, mass and magnitude gap.

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