THE EDGE OF DM HALOS

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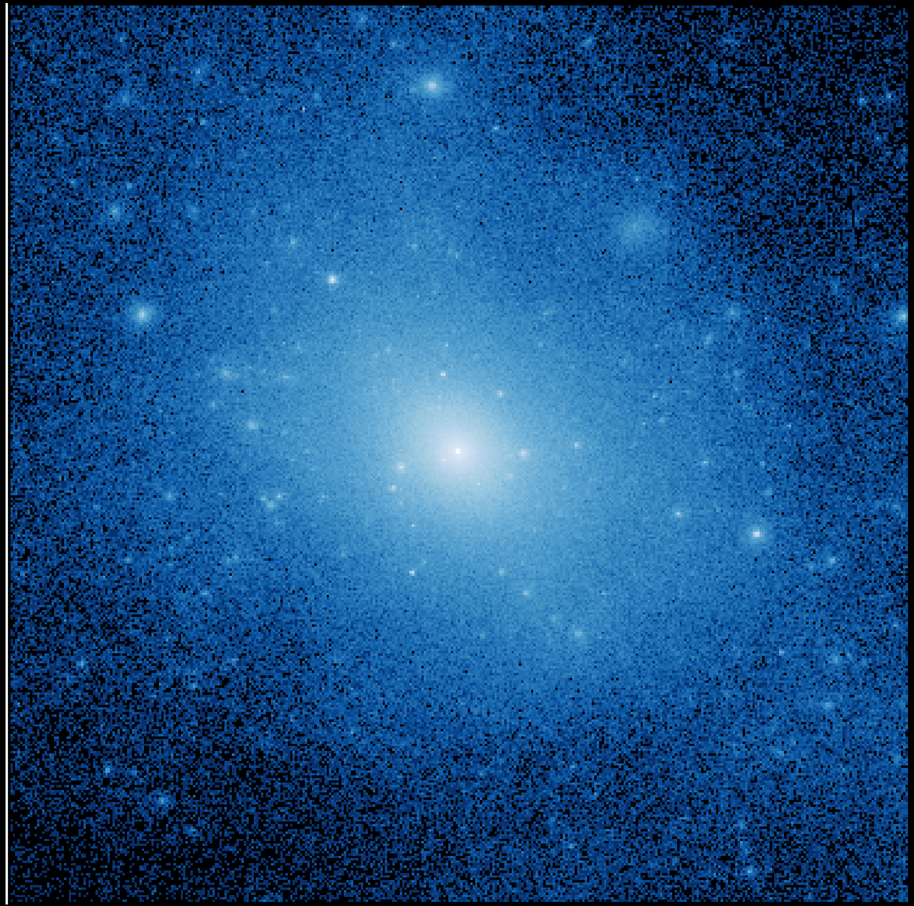
INTRODUCTION

- The radial density profiles of dark matter halos seem insensitive to the virial radius (Kravtsov & Borgani 2012)
- Splashback radius evident from the gradient of the density profile (e.g. Diemer et al. 2013)
- Splashback radius sensitive to the infall rate (More et al. 2015)
- Edge of a dark matter halo often defined as the virial radius – but this does not have a strong justification from simulations

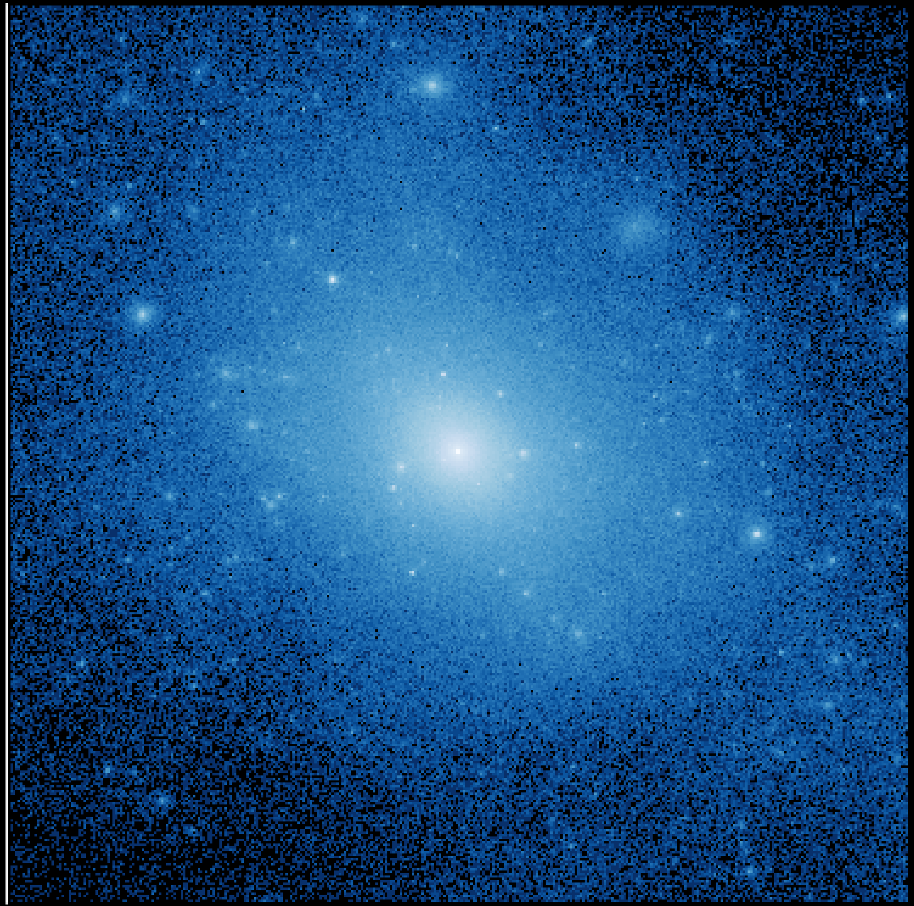


INTRODUCTION

- Halo properties include density profile, **shape profile**, phase space etc.
- Basic model assumes halo is spherical or approximately spherical inside R_{vir} and filamentary outside (but see Jing and Suto 2002)
- Considerable information is stored in the halo shape gradient

INTRODUCTION

- The shape measurement of DM halos usually stops at the virial radius
- But the influence of a halo can be at considerably further distances from the density peak
- What happens when we extend the shape profile?

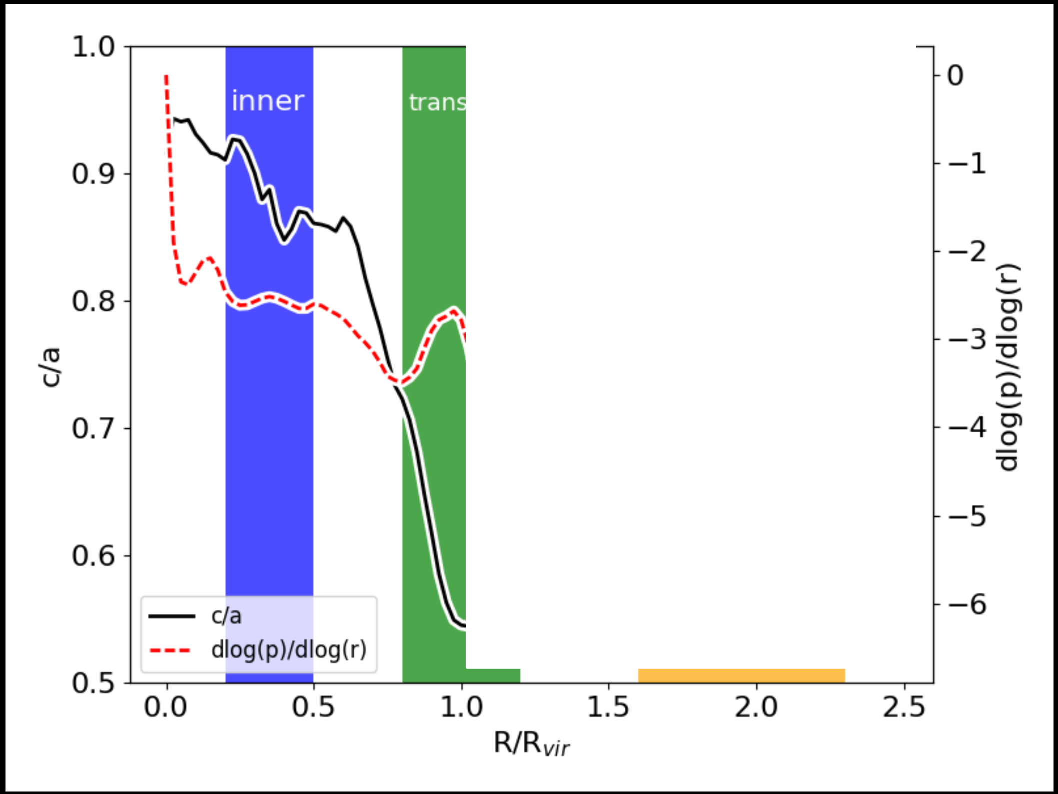


SIMULATIONS

- Illustris-1-Dark (Volgelsberger et al. 2014): Large range of masses and environments, 1.44 kpc resolution (4000 halos)
- MUGS (Stinson et al. 2010): Zoom simulations, 320 pc/h resolution, MW mass halos, Hydro simulation (16 halos)

RESULTS – HALO SHAPES

- In this example halo from MUGS – sphericity falls steeply with radius
- Gradient of the density profile is relatively constant
- What happens when we extend the profile beyond Rvir?



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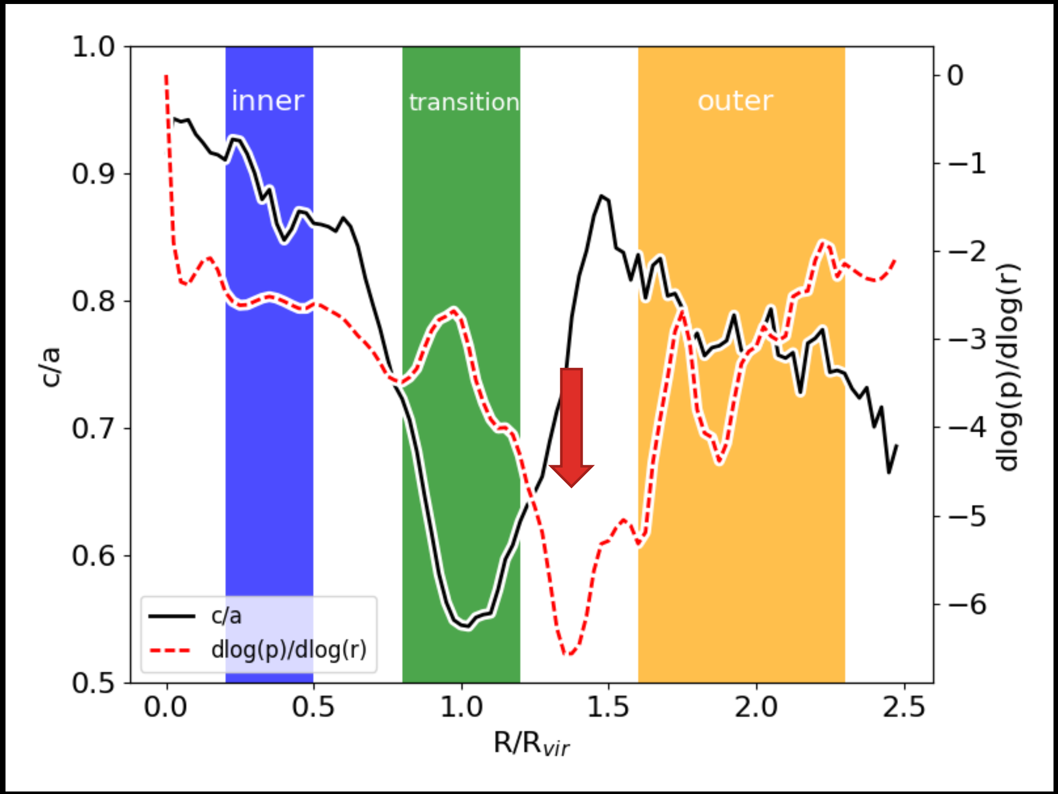
RESULTS – HALO SHAPES

- Dip in sphericity then recovery, followed by slow fall to the LSS
- Splashback radius seen in the density profile?
- Dip in sphericity lies inside the splashback radius



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RESULTS – AVERAGE OVER MANY HALOS

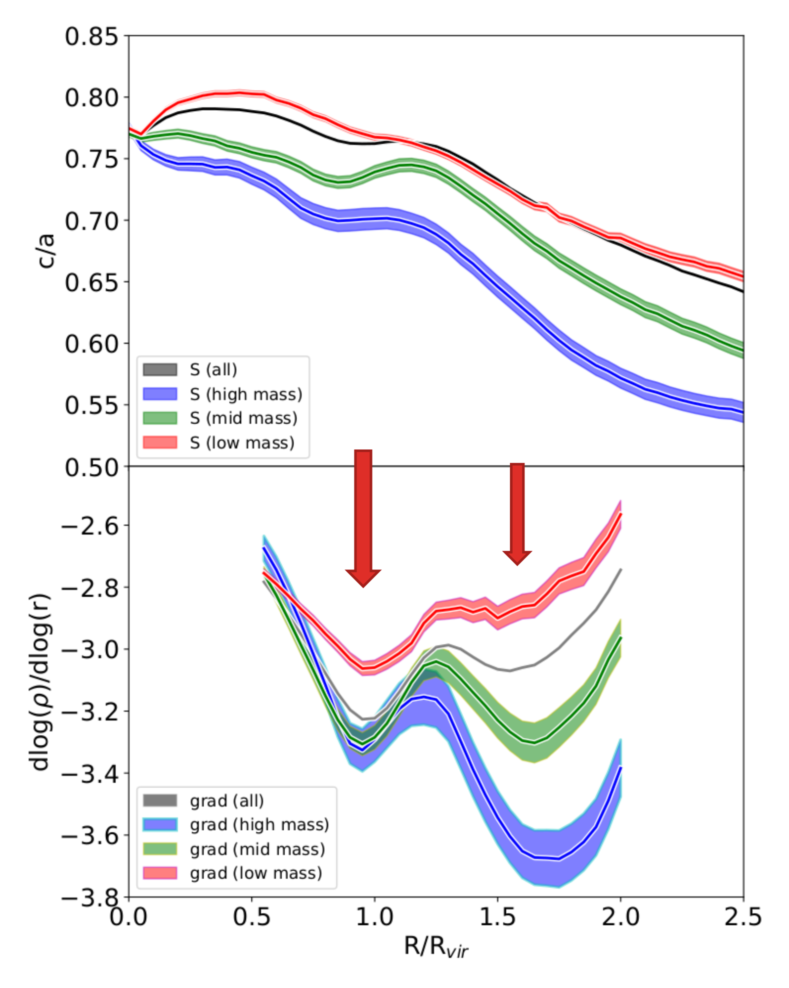
- Effect is weaker on average but it is present in Illustris halos
- Independent of mass but low mass galaxies show greater scatter
- Different density profiles outside the halo depending on mass

Solar masses

$>1\times10^{13}$

1×10^{12}-$1\times10^{12.5}$

1×10^{11}-$1\times10^{11.5}$



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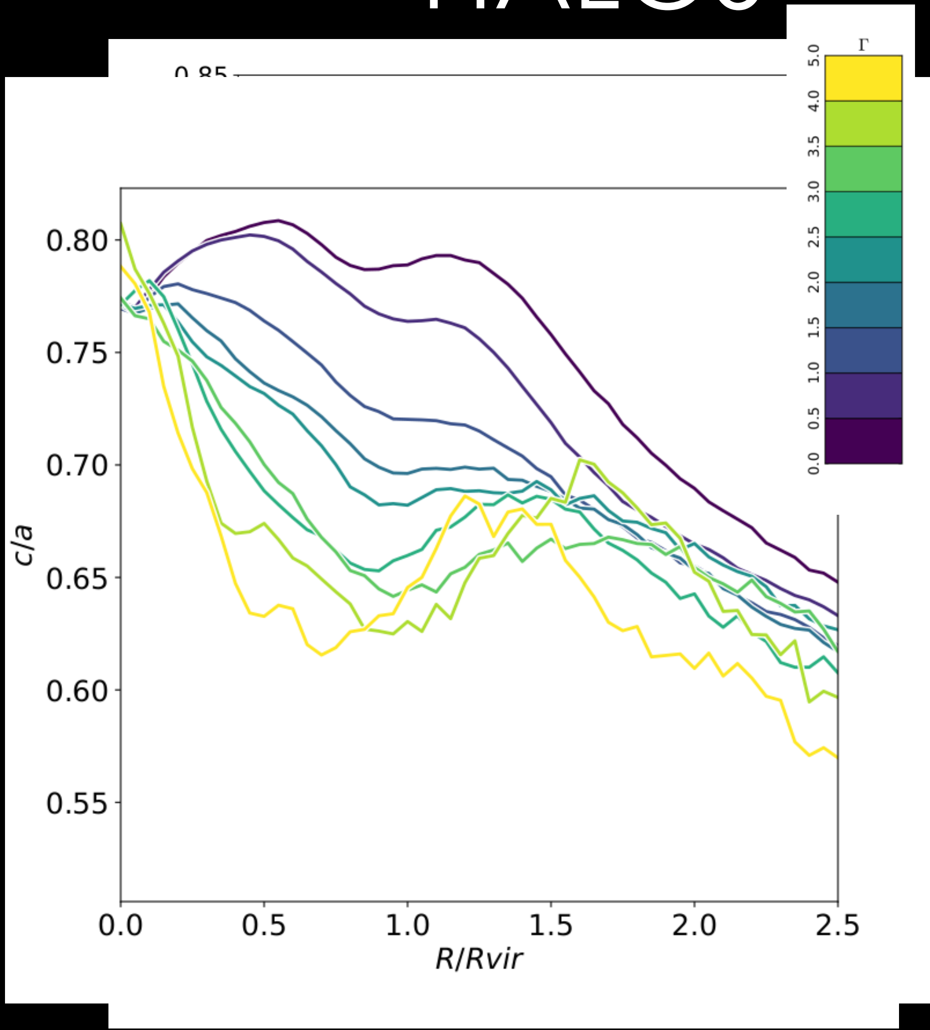
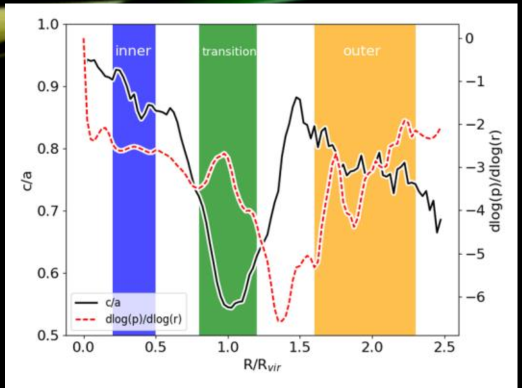
RESULTS – AVERAGE OVER MANY HALOS

- Effect is weaker on average but it is present in Illustris halos

- Shape profile depends on the infall rate

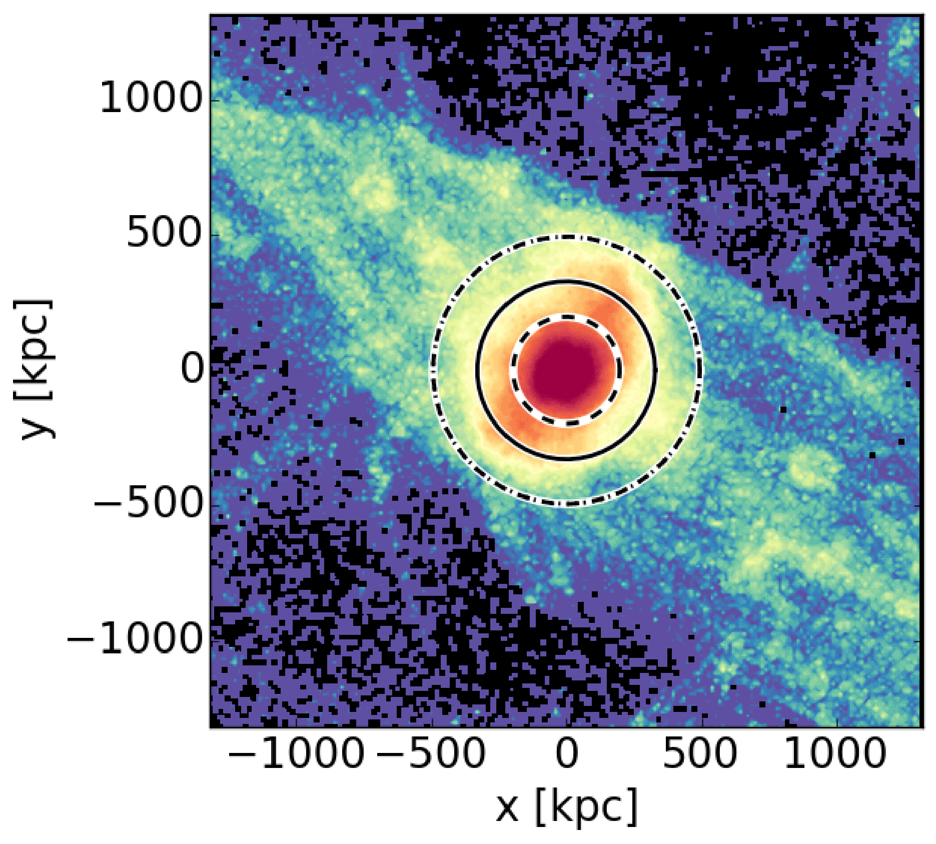
- $\Gamma = \log(\Delta M)/\log(\Delta a)$





RESULTS - MAPS

- Strong feature visible in the density distribution
- Inclined to the filament
- Shows out to 4 Rvir or 1200 kpc



0.6 Rvir
1 Rvir
1.5 Rvir

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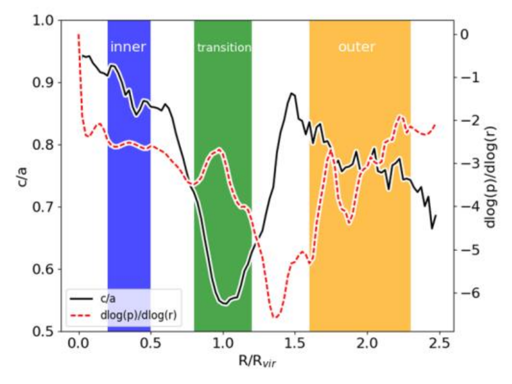
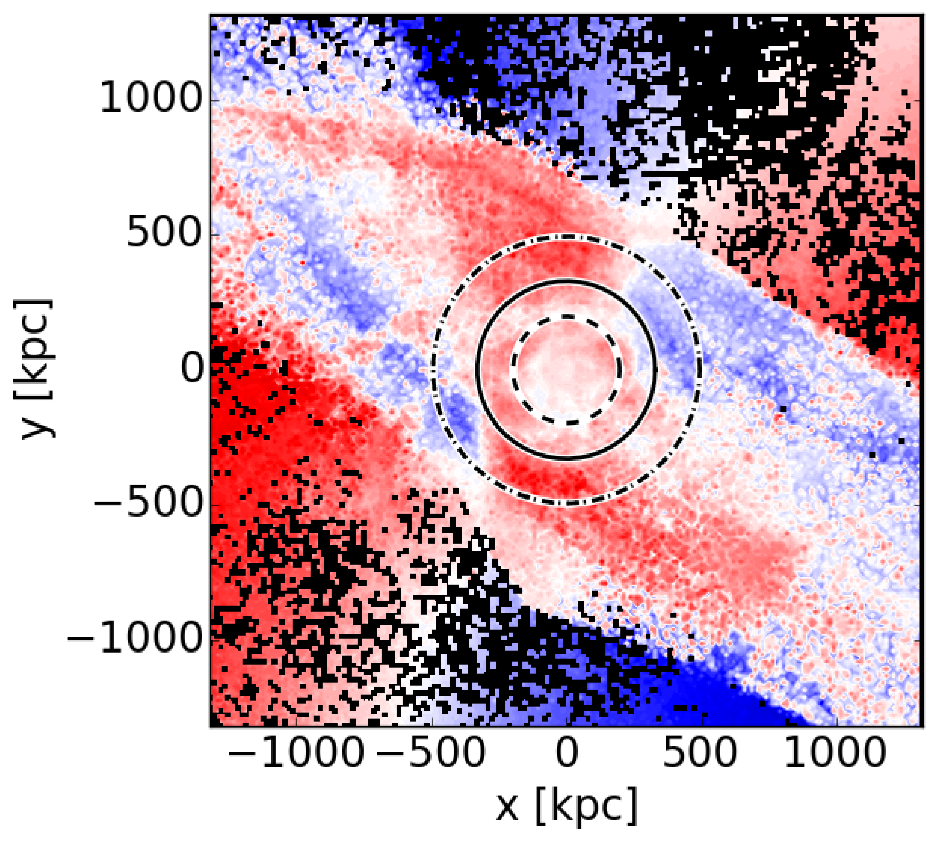


RESULTS - MAPS



- Strong feature visible in the density distribution
- Inclined to the filament
- Strong features in the velocity field
- Outside the shape feature strong velocity features but inside the velocity distribution shows no structure

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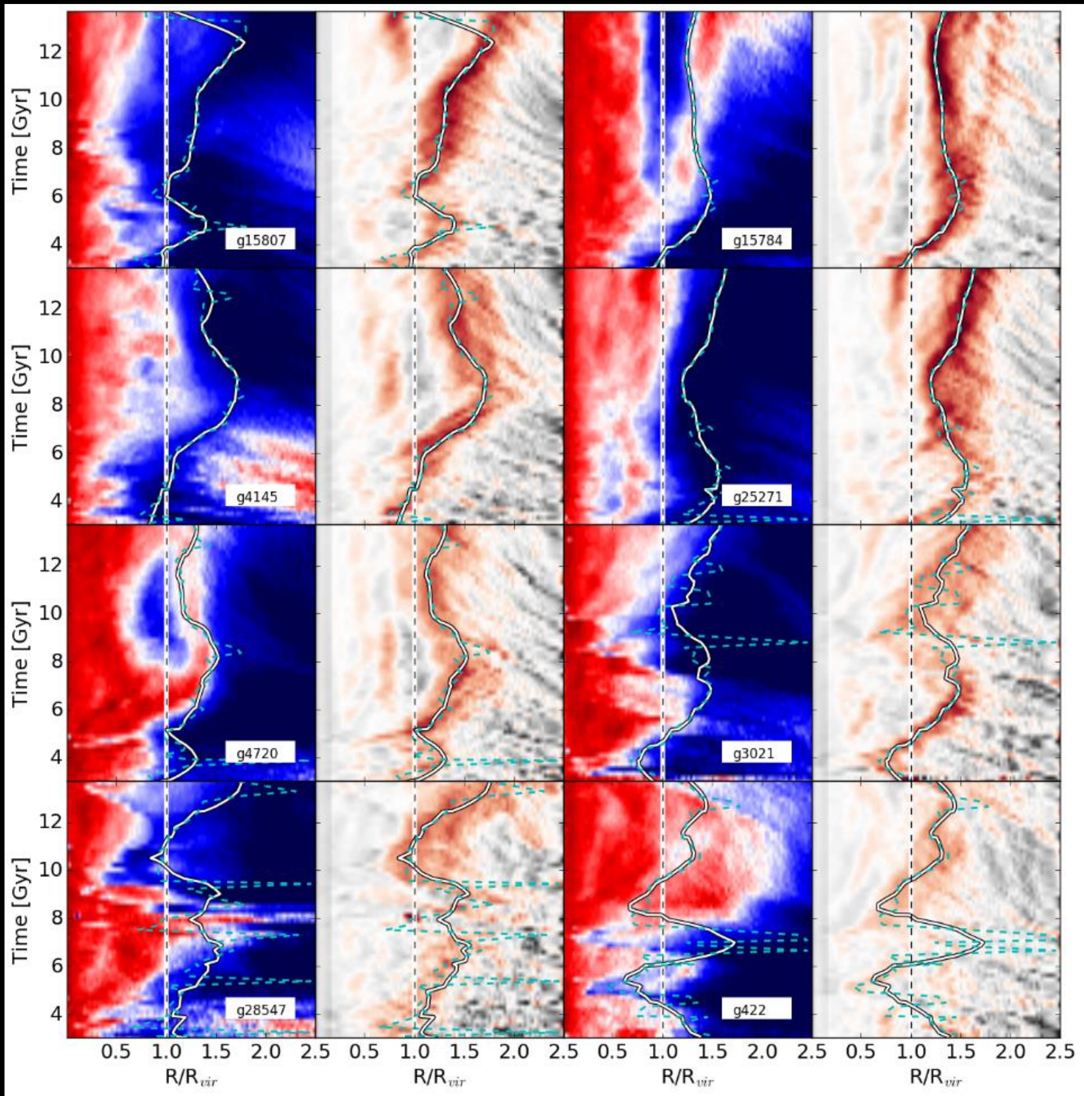
RESULTS – EVOLUTION THROUGH TIME

- See evolving shape profile with time and large halo-to-halo variation
- Long lasting features in the shape – present even with subhalos included
- Splashback radius stronger and less transient
- Similar features in both measurements



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CONCLUSIONS

- Considerable halo-to-halo variation but shape structure present on average
- Related to the splashback radius – material at the dip is material undergoing **second** orbit
- Considerable information is encodes in the shape distribution of material around DM halos
- Such features are persistent over Gyr timescales, where they occur