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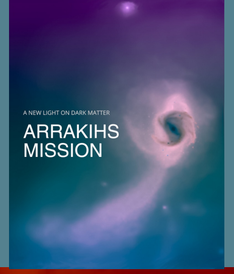


EuroHPC Joint Undertaking

ACRECIÓN Y DISRUPCIÓN DE GALAXIAS SATÉLITE ENANAS EN SIMULACIONES COSMOLÓGICAS

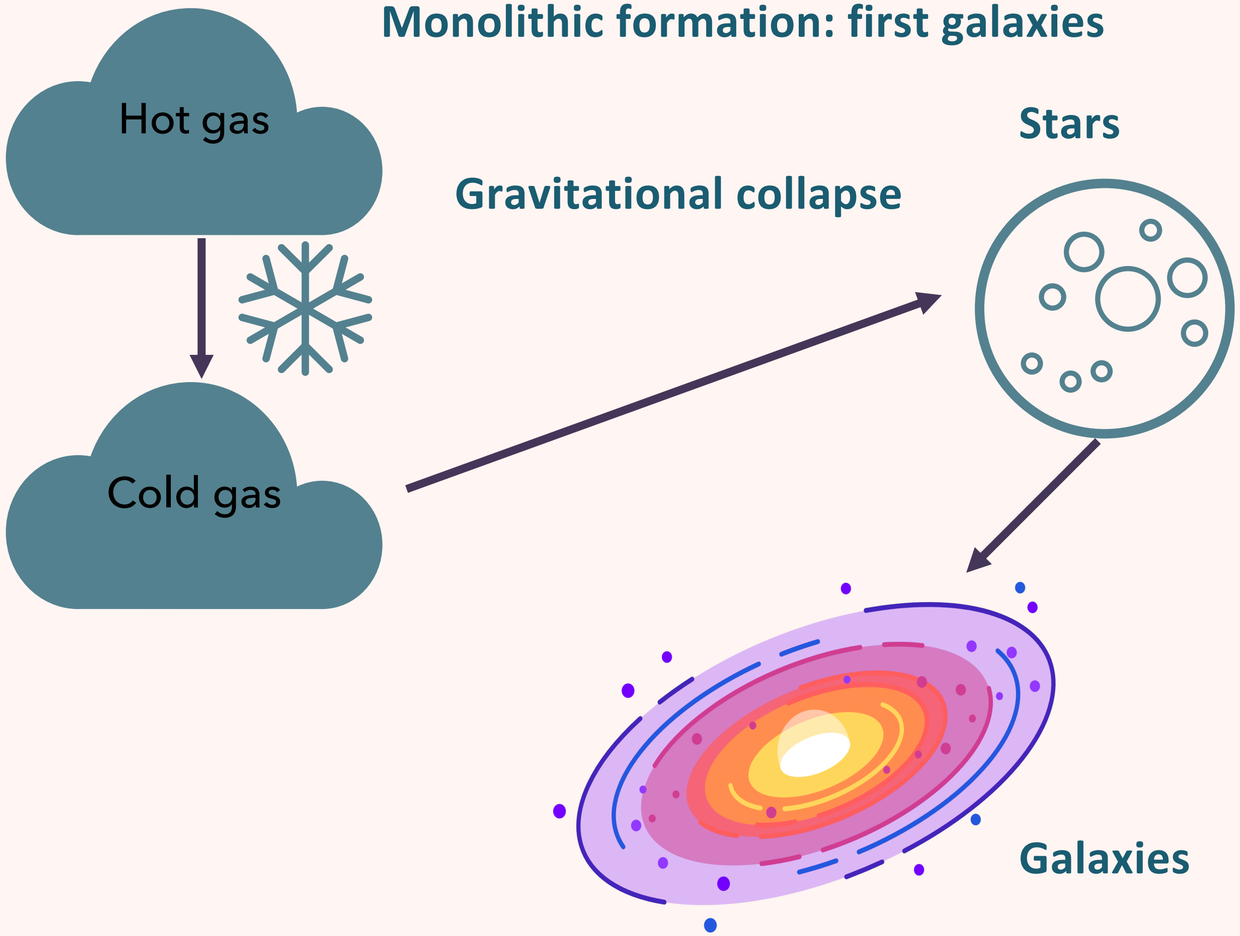
Doctorando: Sergio García Moreno (segarc19@ucm.es)

Supervisores: Mariángeles Gómez y Santi Roca

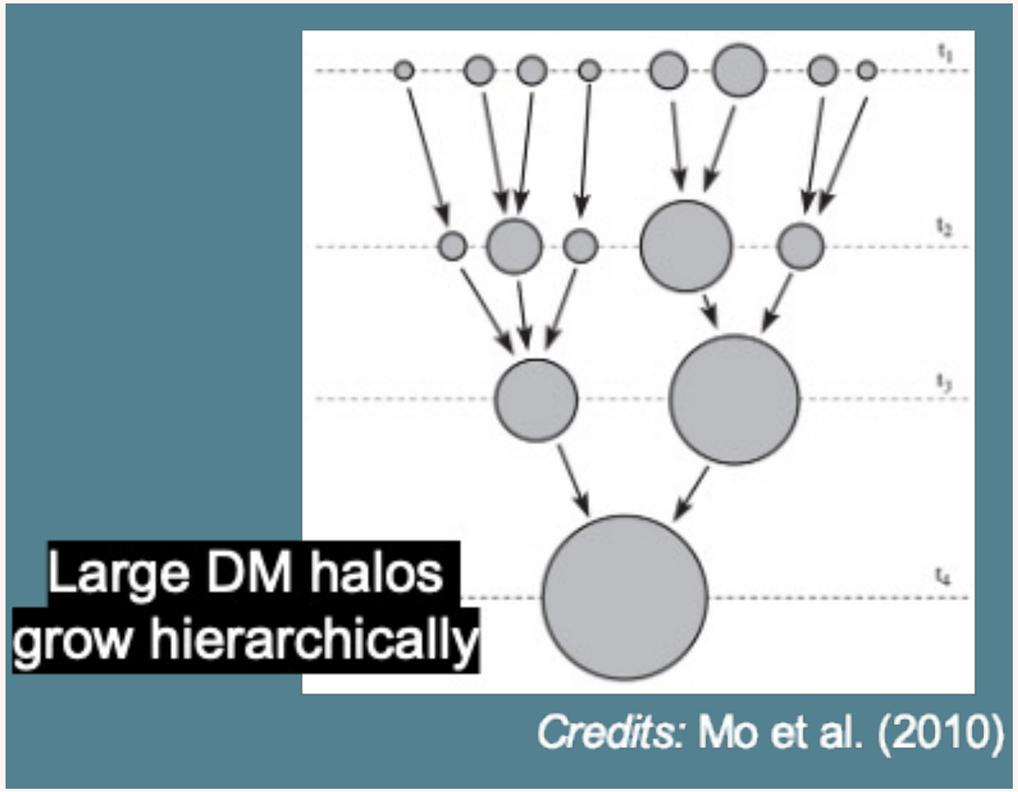
PID2022-138896NB-C55, funded by MCIN/AEI/10.13039/501100011033/FEDER, EU

GALAXY FORMATION

Monolithic formation: first galaxies



Hierarchical formation: main process



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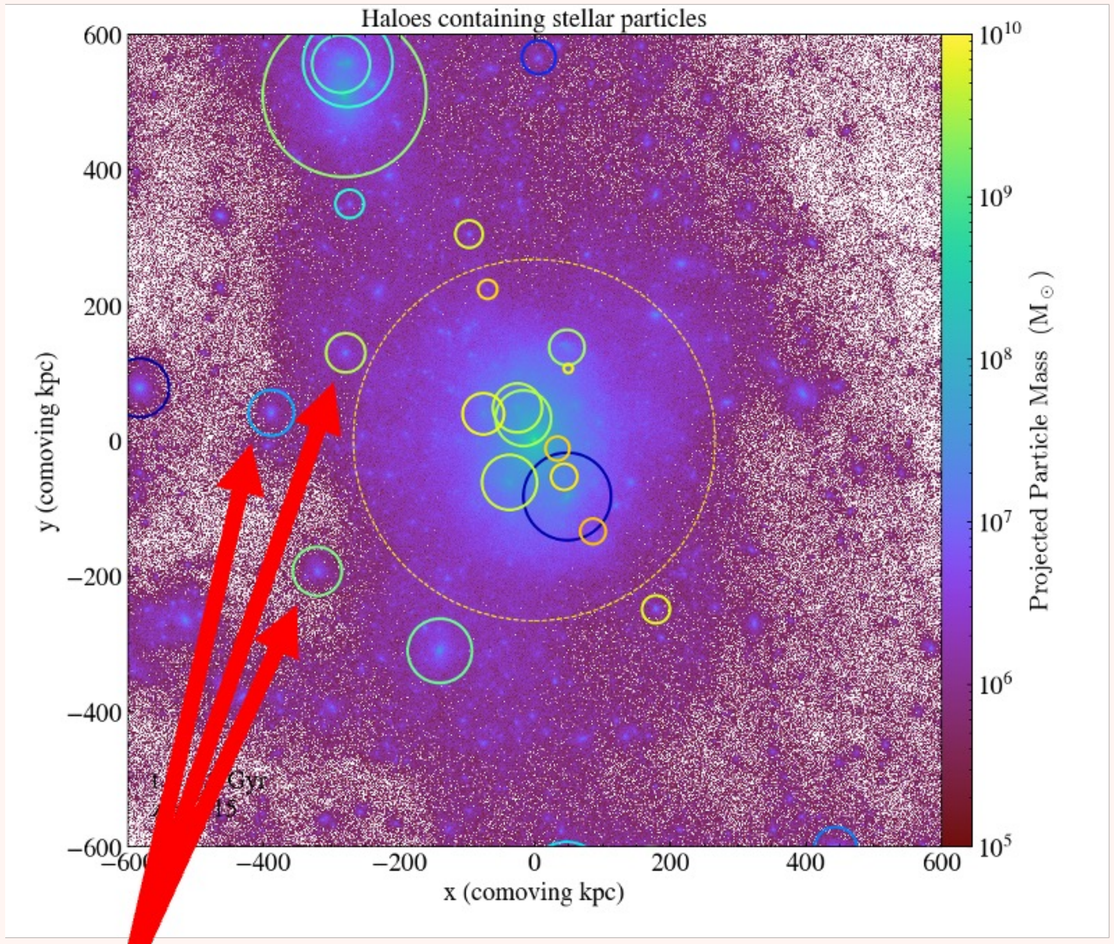
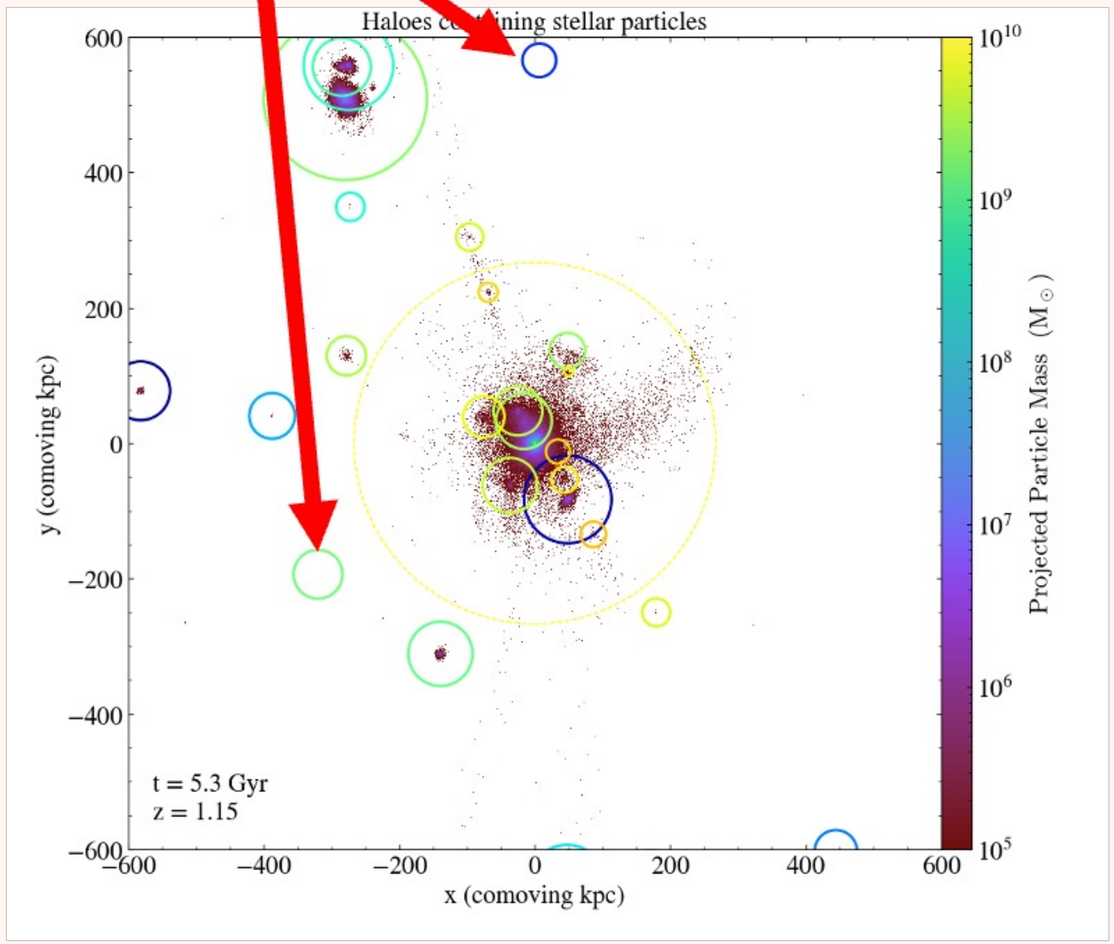
They all have similar halo mass, but only some have stars





Data from the Auriga simulations (Grand et al, 2017)

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WHAT IS A SIMULATION?

Initial Conditions → **Simulated Universe with gas, stars and galaxies**

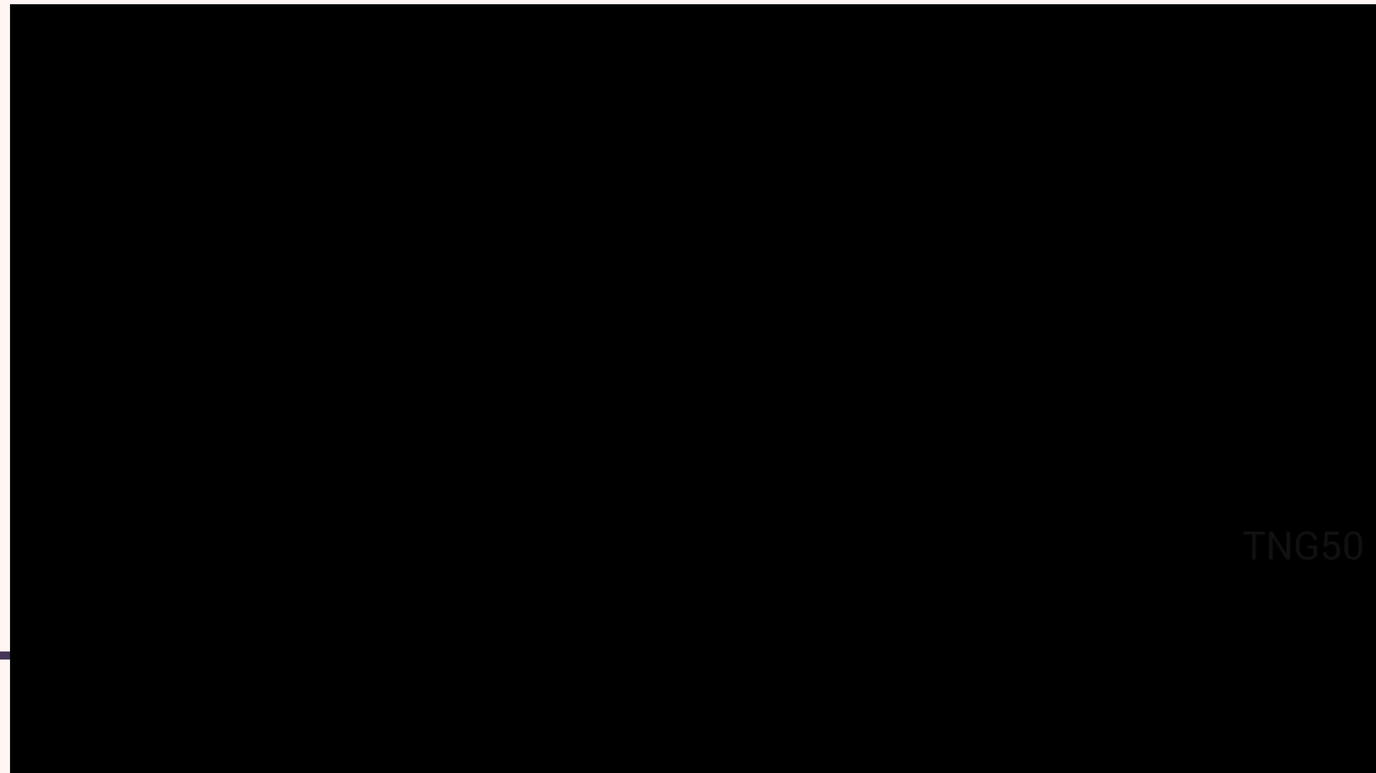
Models of gravity and hydrodynamic physics

But we need to know where the galaxies and halos are

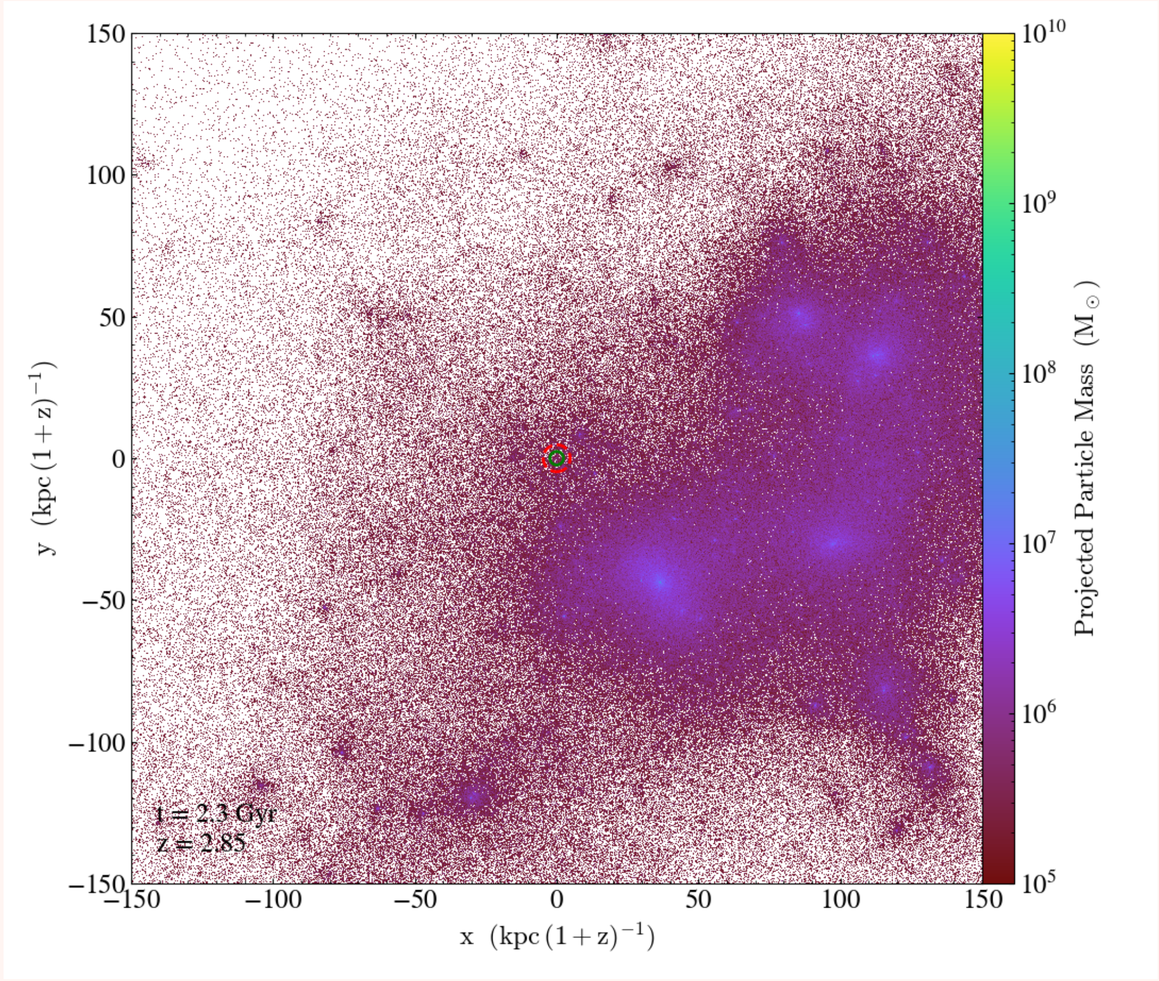
Halo finders cluster particles into halos and galaxies

These halo finders have limitations and problems during interactions

We developed a software tool to correct these limitations.



SPURIOUS HALOS



$\nu(M_{\rm h}, z)$ → **Significance of the matter overdensity**

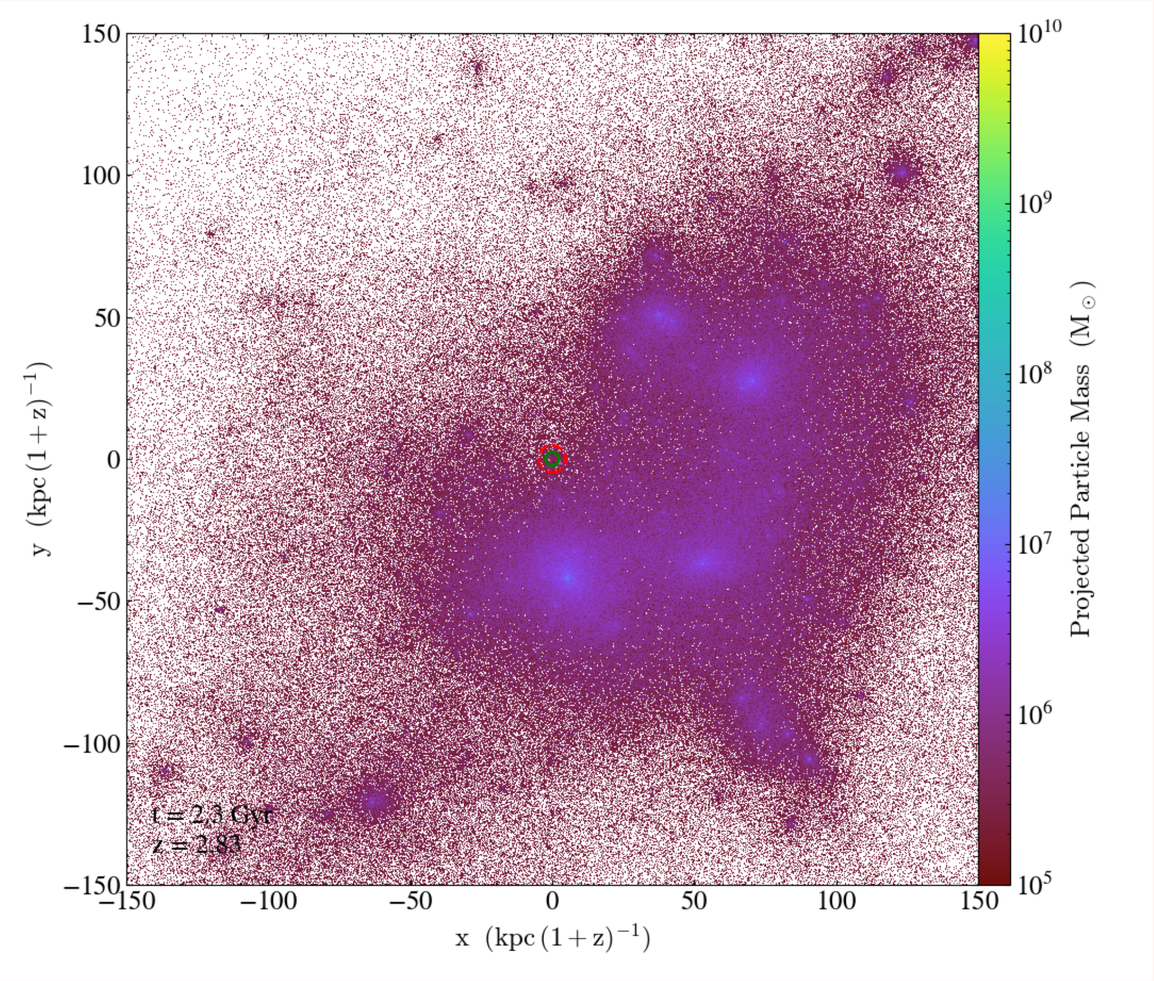
$$\nu < 0.7 \rightarrow d_{\rm cn} \overset{?}{<} 0.5 R_{\rm vir,\,cn}$$

If too close to the nearest more massive halo, we mark as spurious

We mark around 4% of total halos as spurious

Data from the Vintergatan simulations (Agertz et al, 2021)

SPURIOUS HALOS



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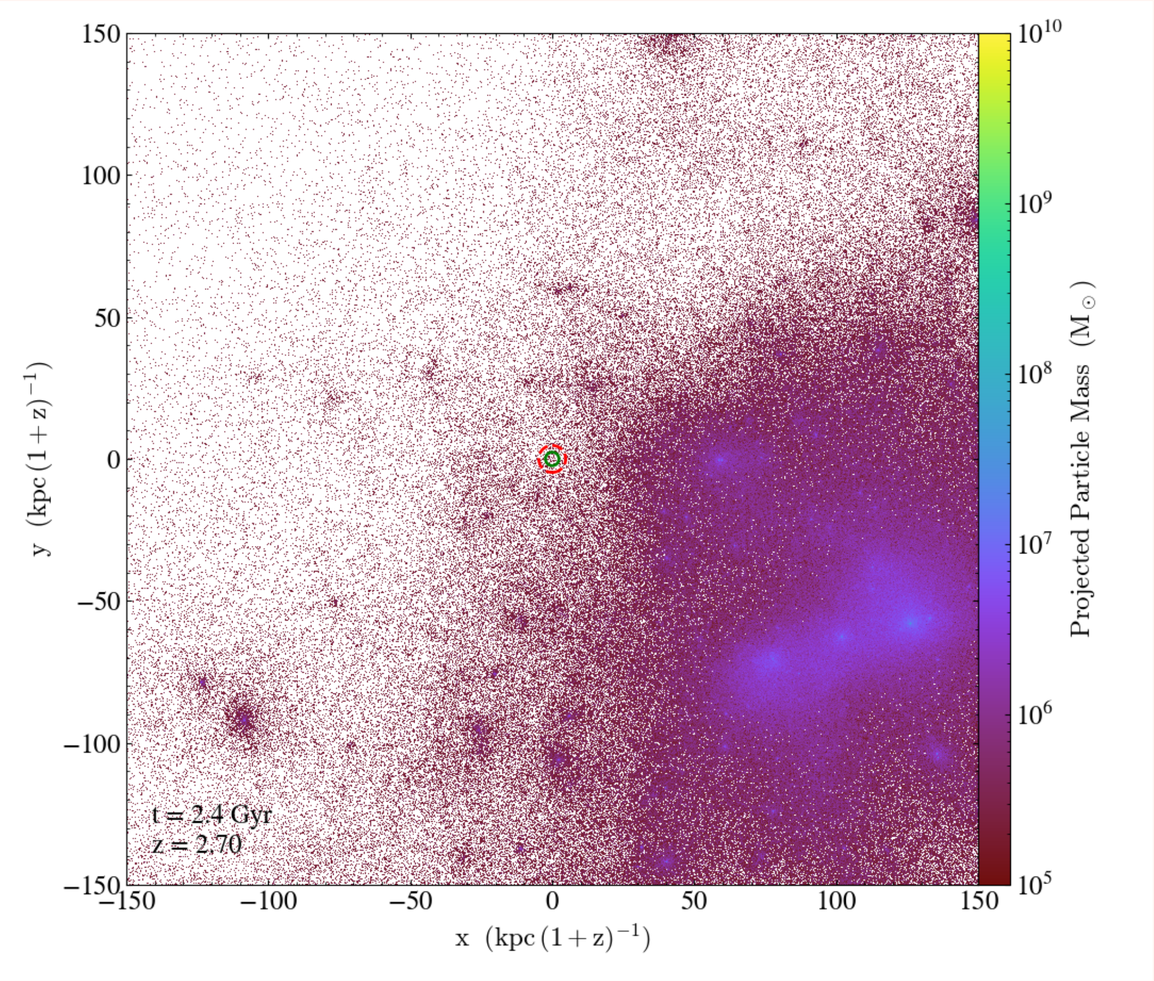

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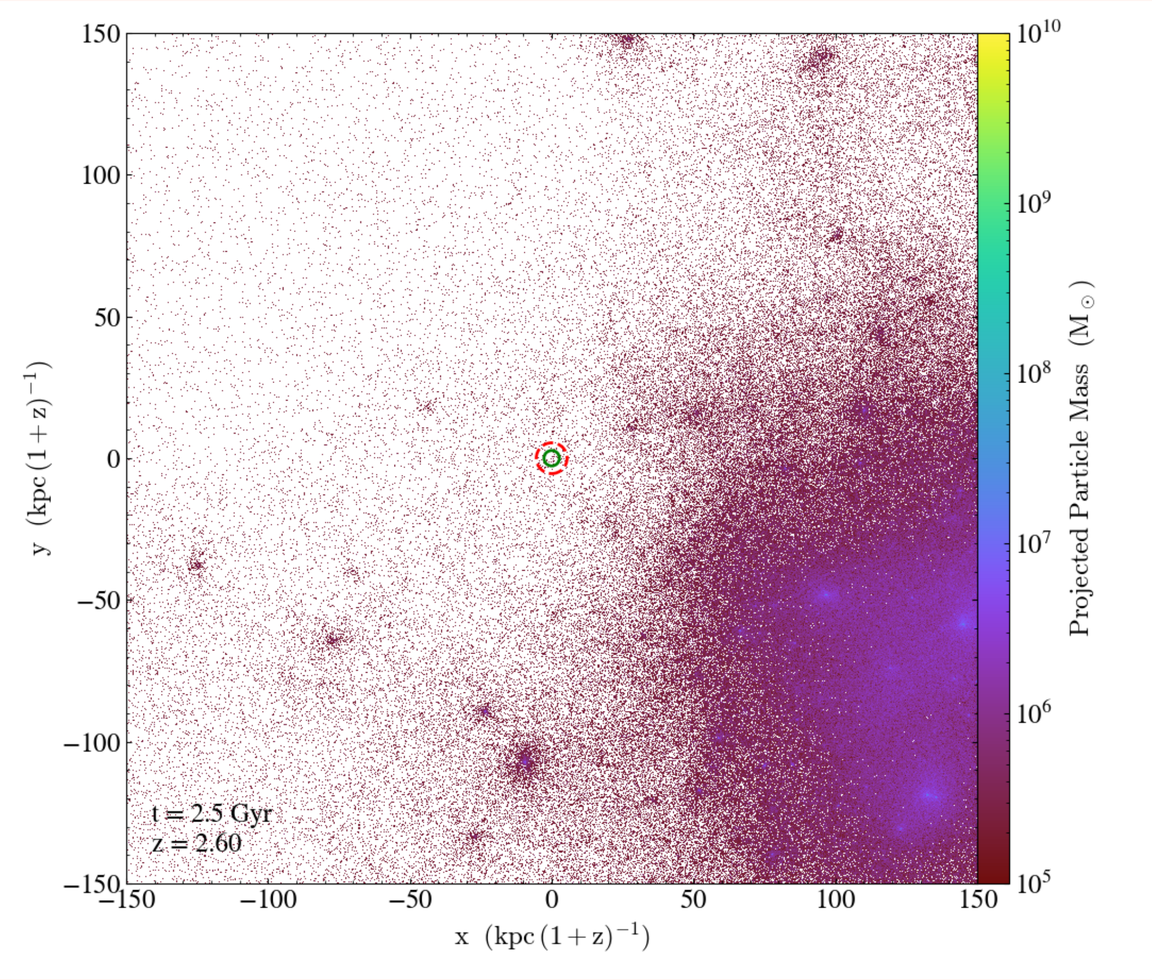

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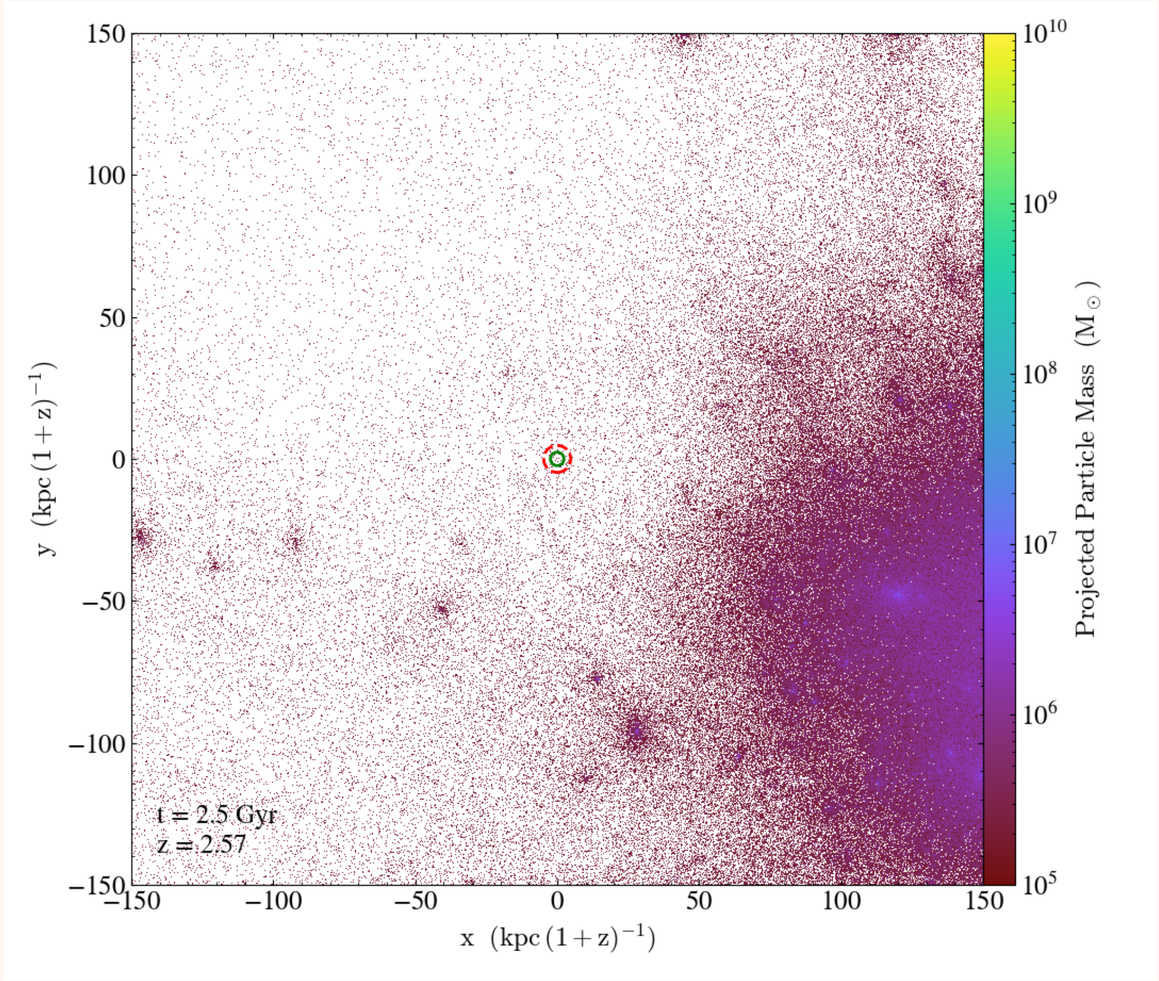

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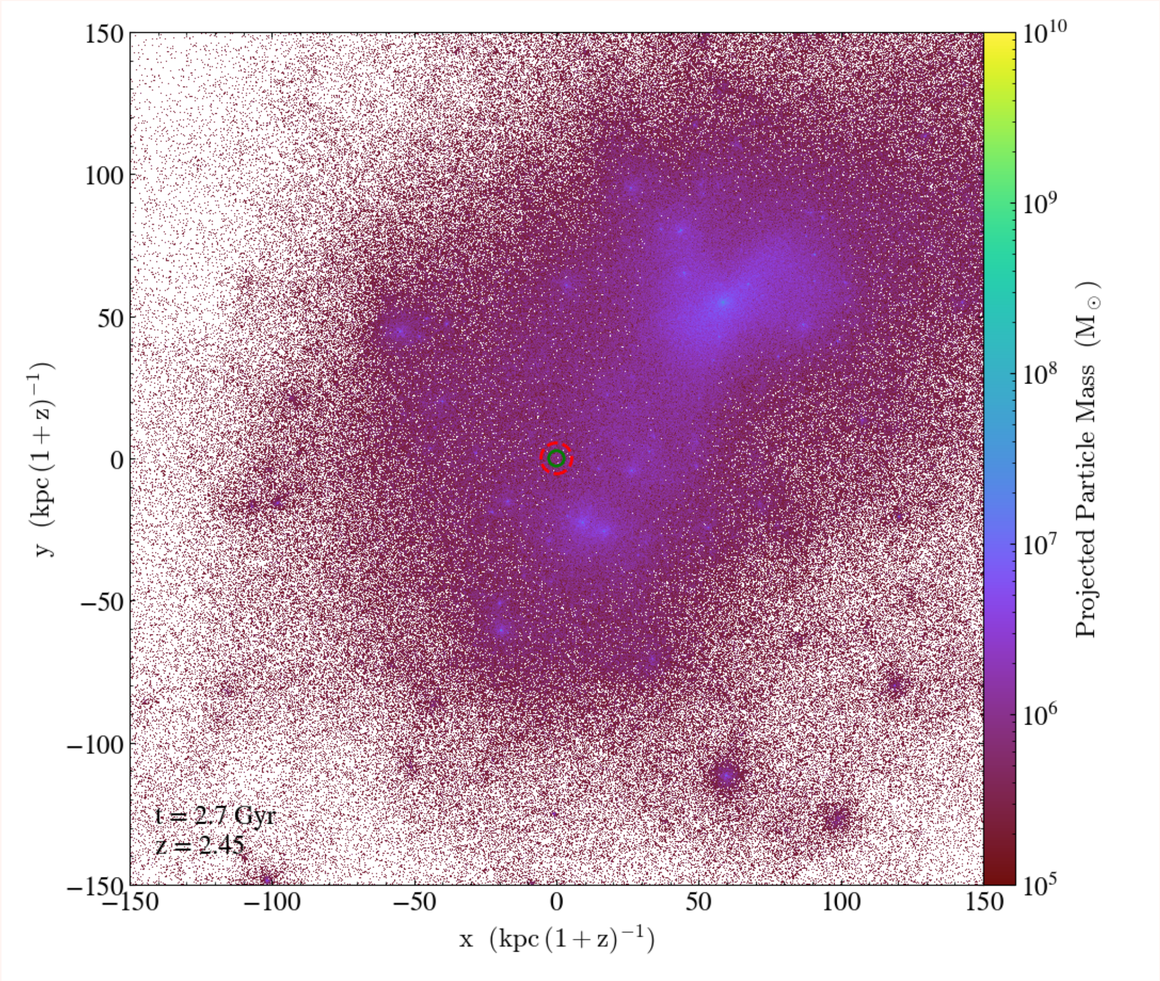

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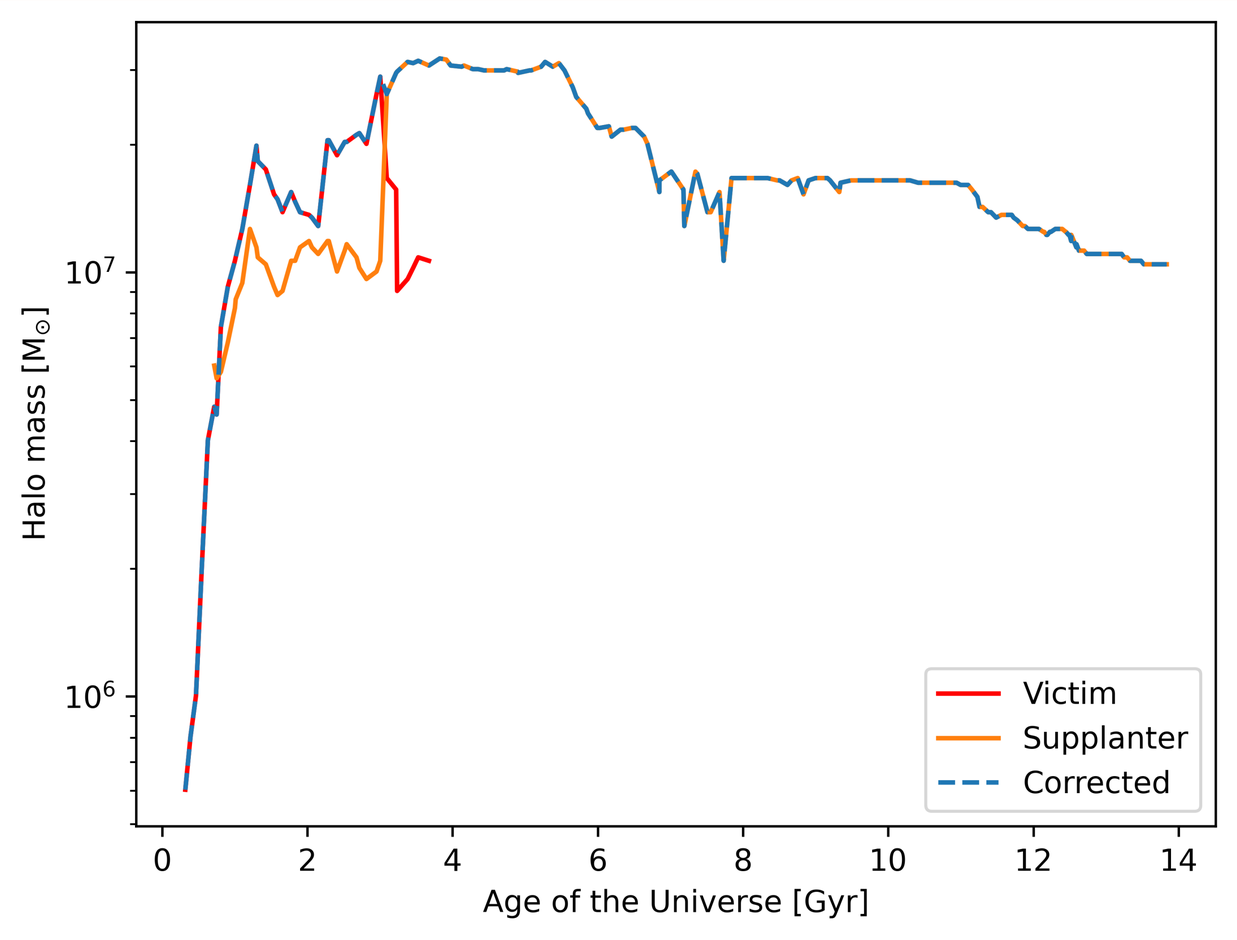
SUPPLANTED HALOS



Halos supplanted because of numerical artifacts. ID changed in consecutive snapshots

We look for sudden mass loses.
The supplanter candidate must gain that mass

We keep the valid information from both

Data from the Vintergatan simulations (Agertz et al, 2021)

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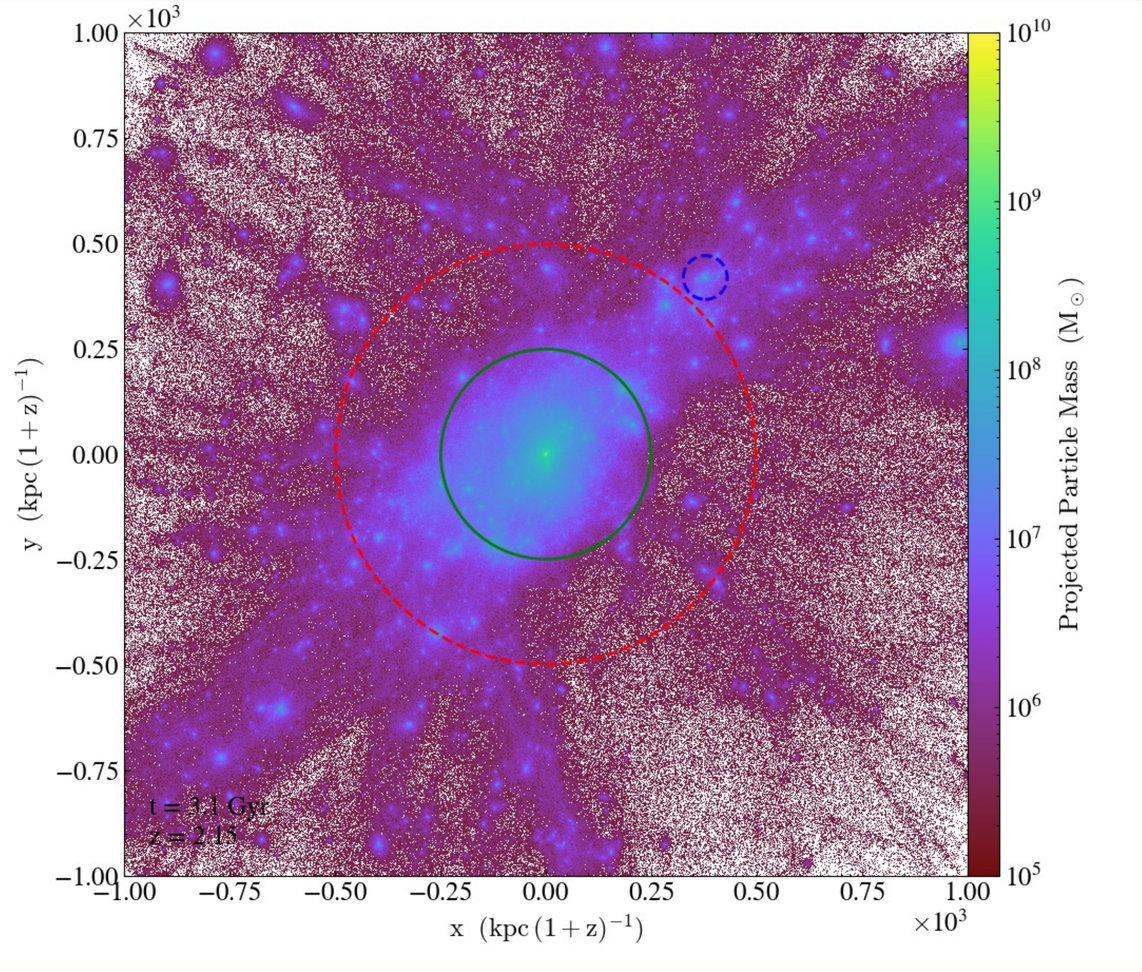
LOST HALOS IN INTERACTIONS



- Halo finders have difficulties finding halos in interaction
- We track the particles through time
- We extend halo lifetimes by several Gyrs (10^9 years)

Legend:

- Host halo:

Blue circle = 1Rvir

Red circle = 2Rvir

-Satellite halo:

Blue circle: Alive in original halo finder

Red circle: Not in original halo finder

Data from the Vintergatan simulations (Agertz et al, 2021)

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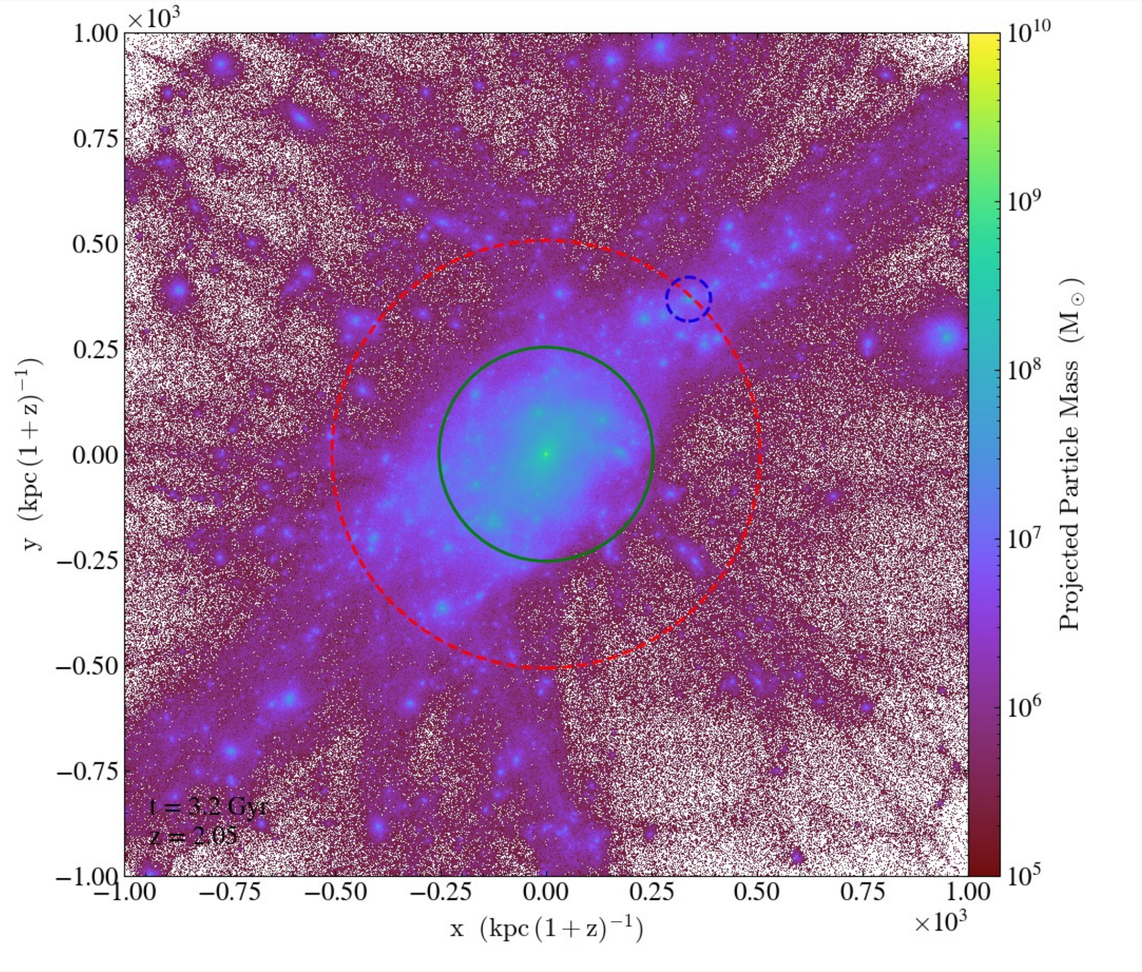

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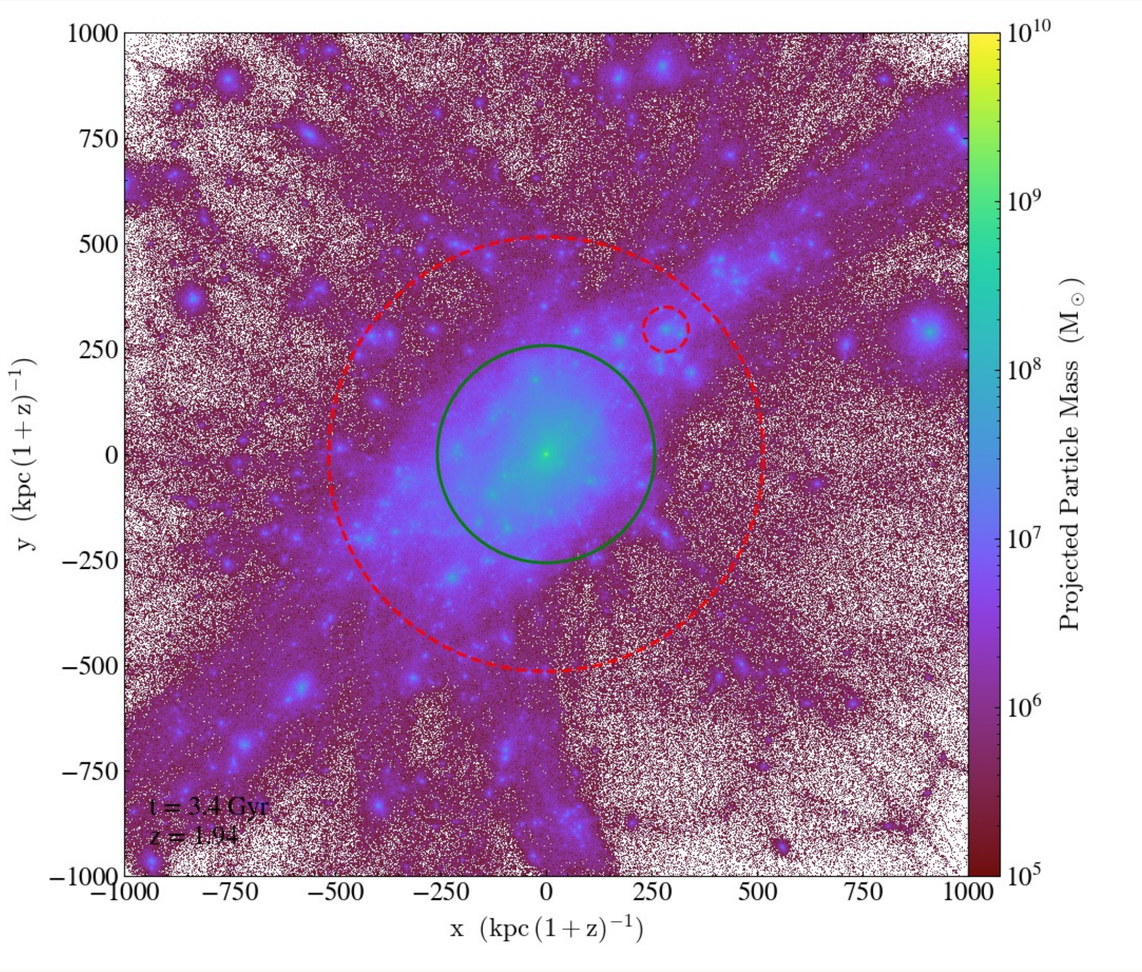

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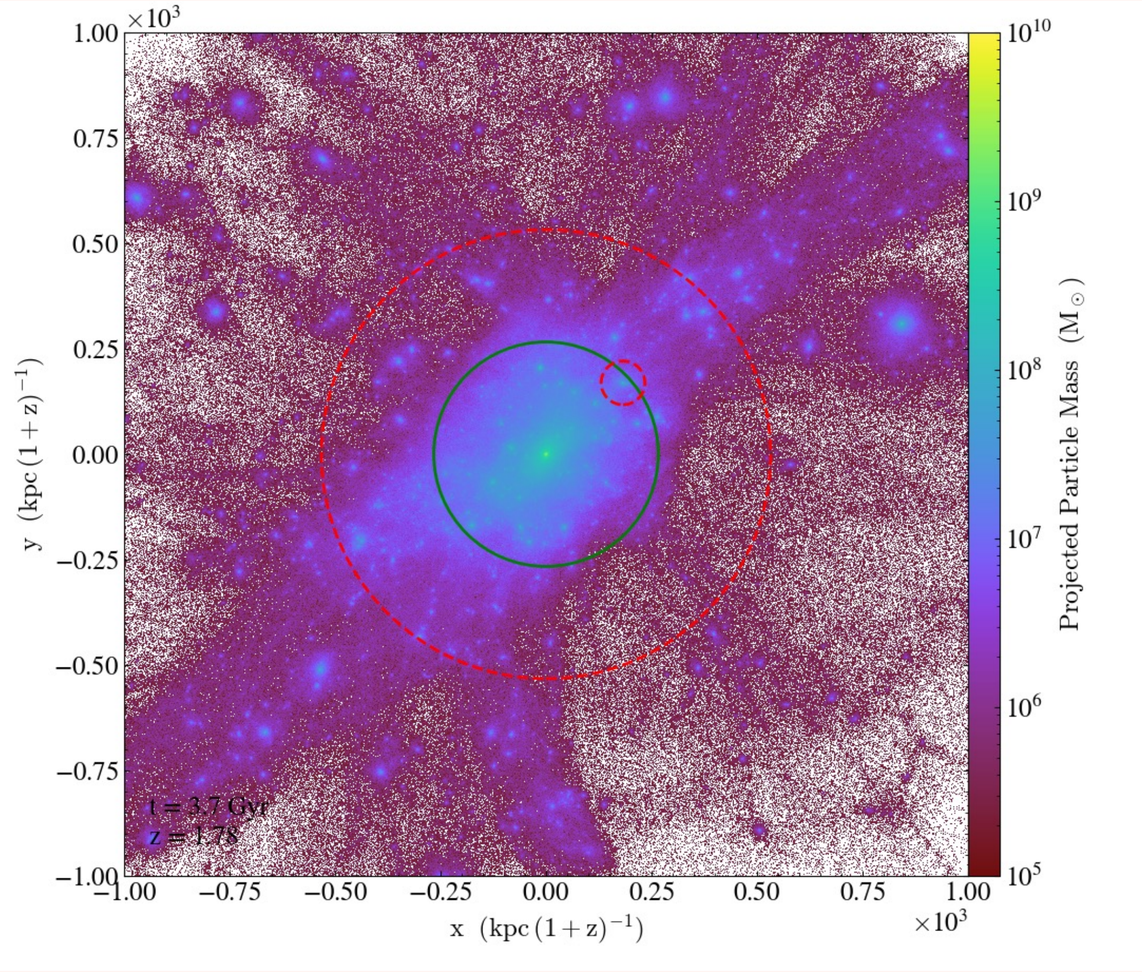

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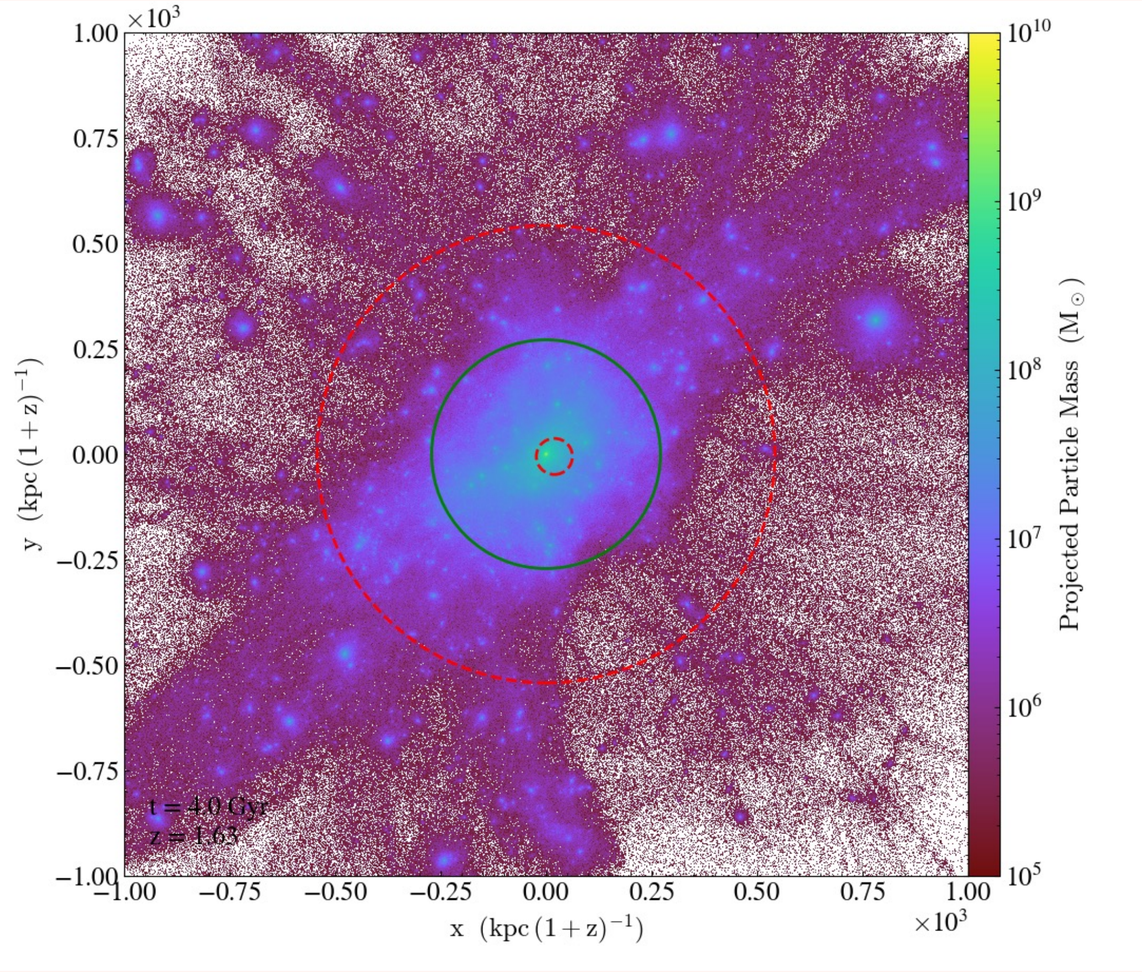

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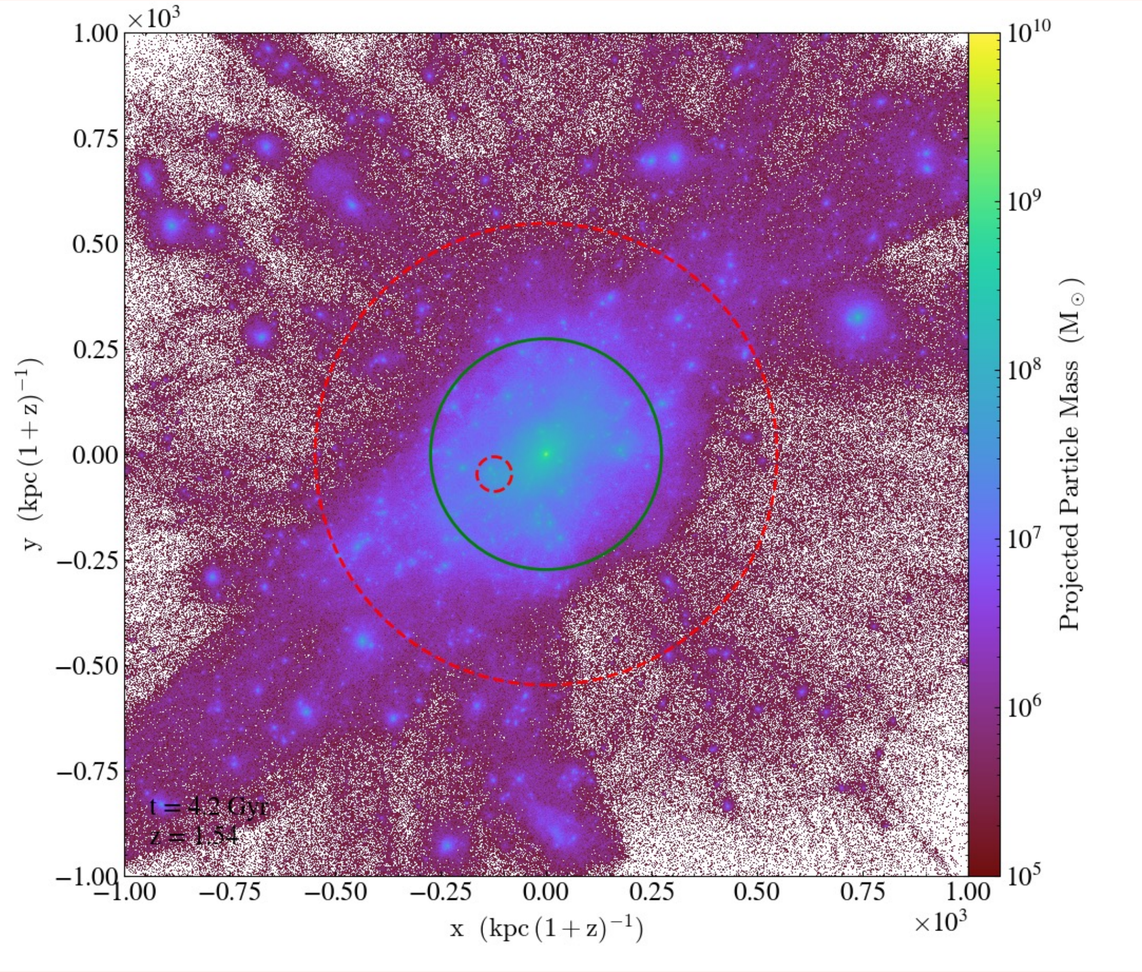

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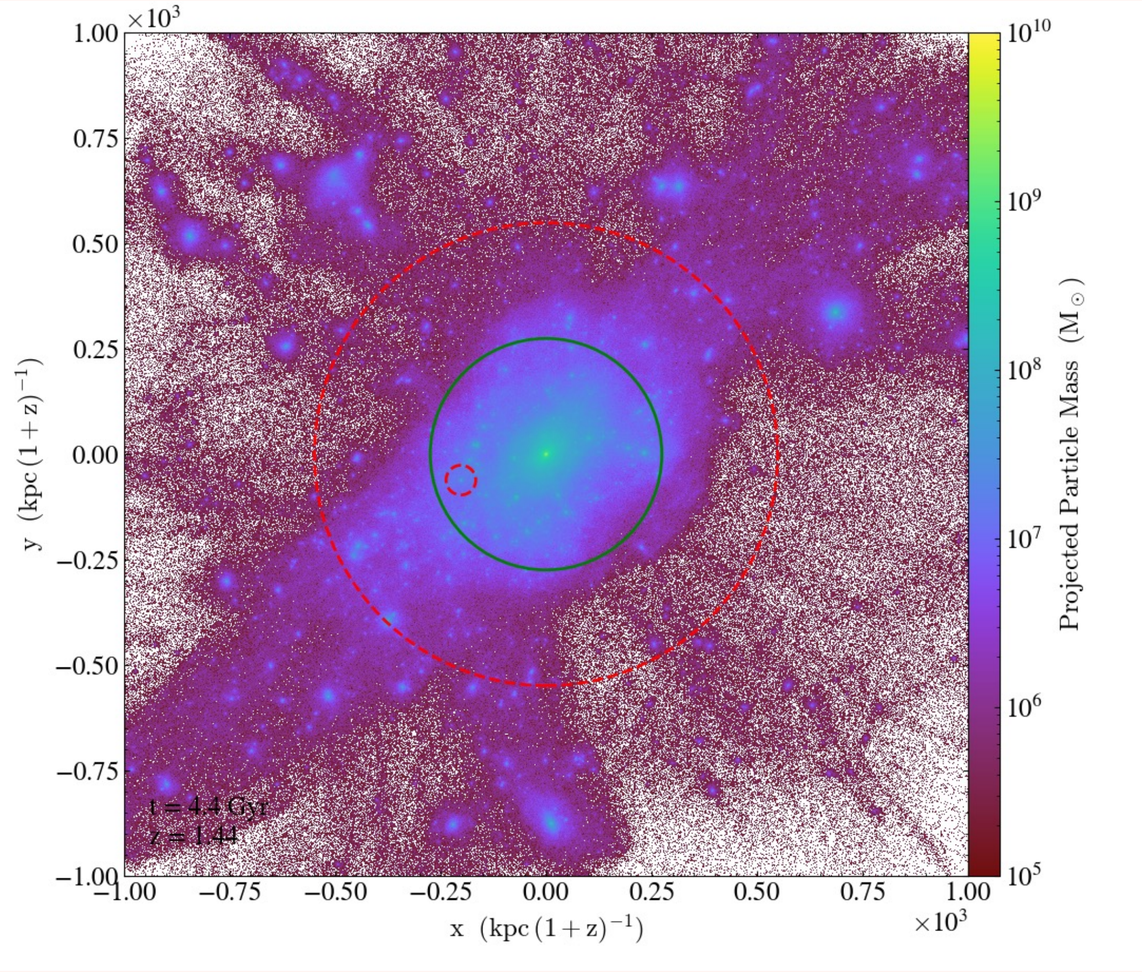

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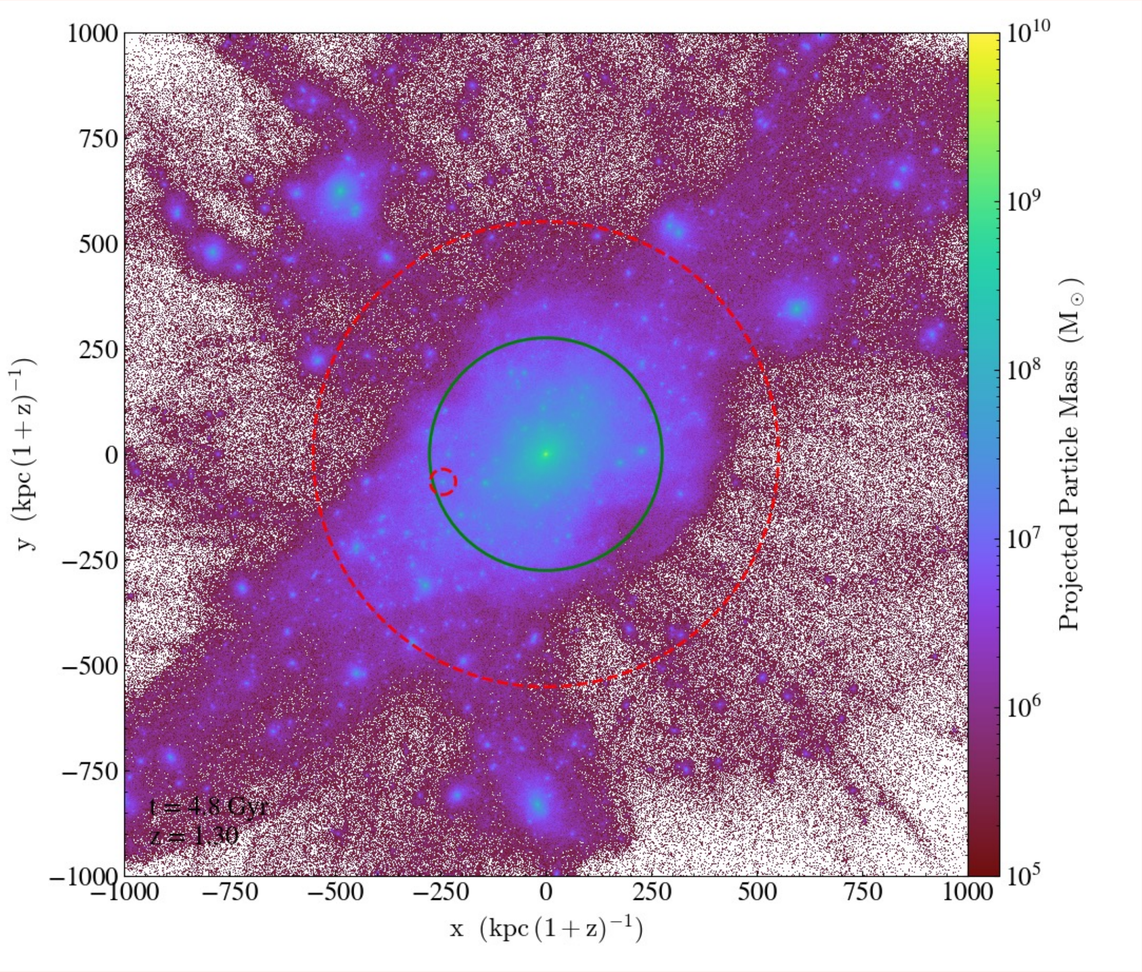

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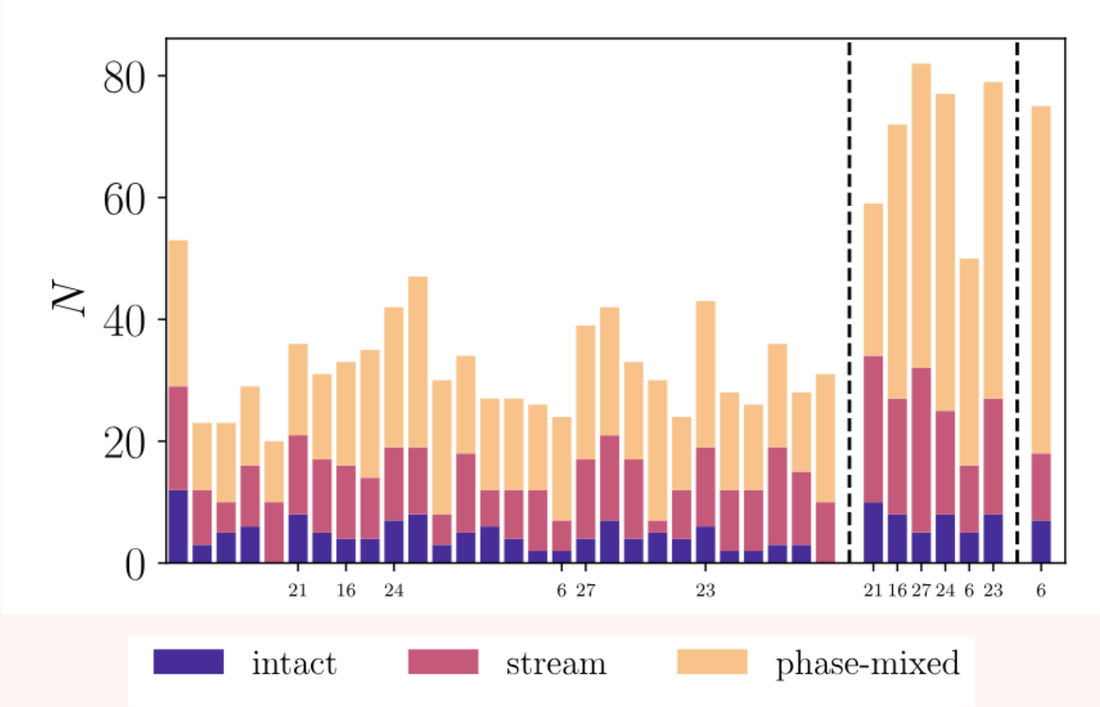
WHEN DOES A HALO VIRIALIZE?

Riley, A. H., et al. 2025



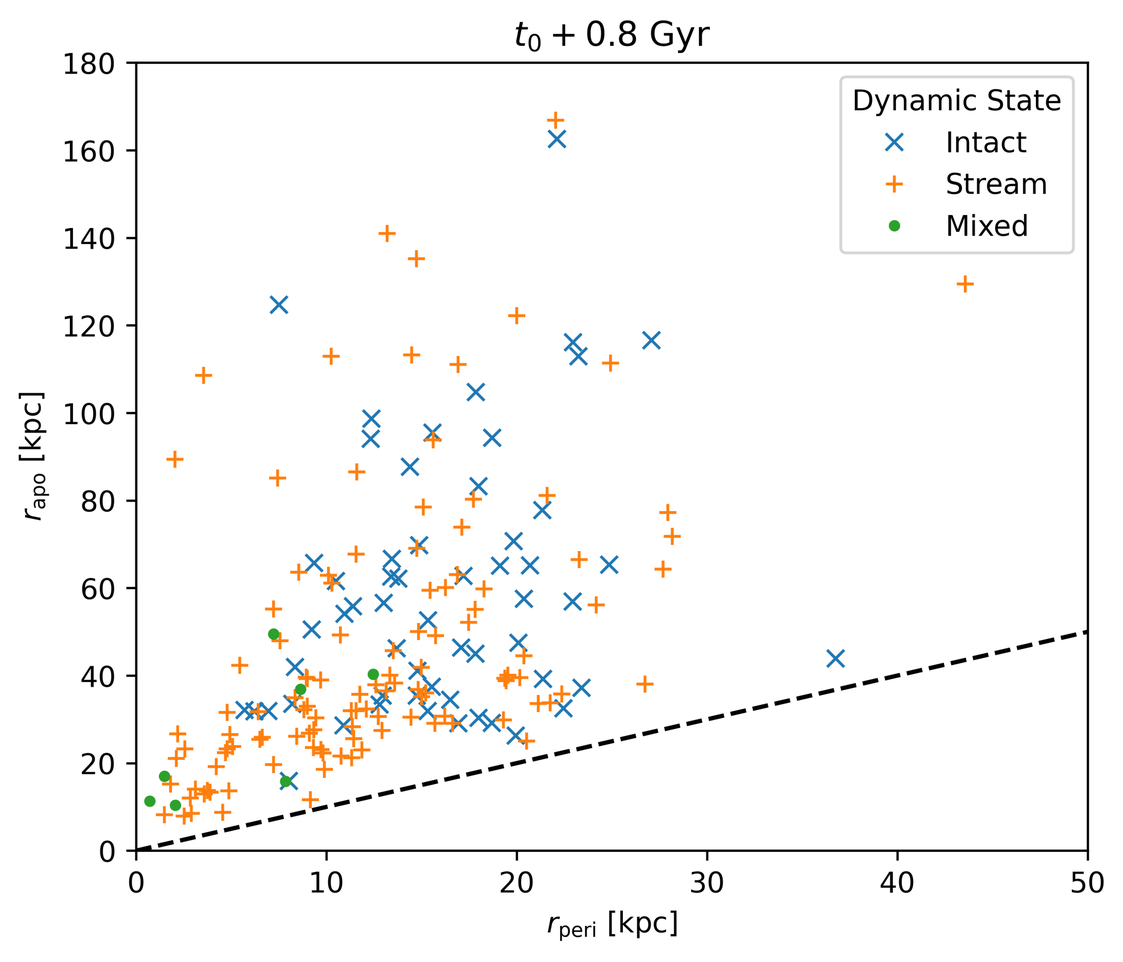
$\sigma_{\rm vel}^{50}$ → **Median of the local dispersion velocity**

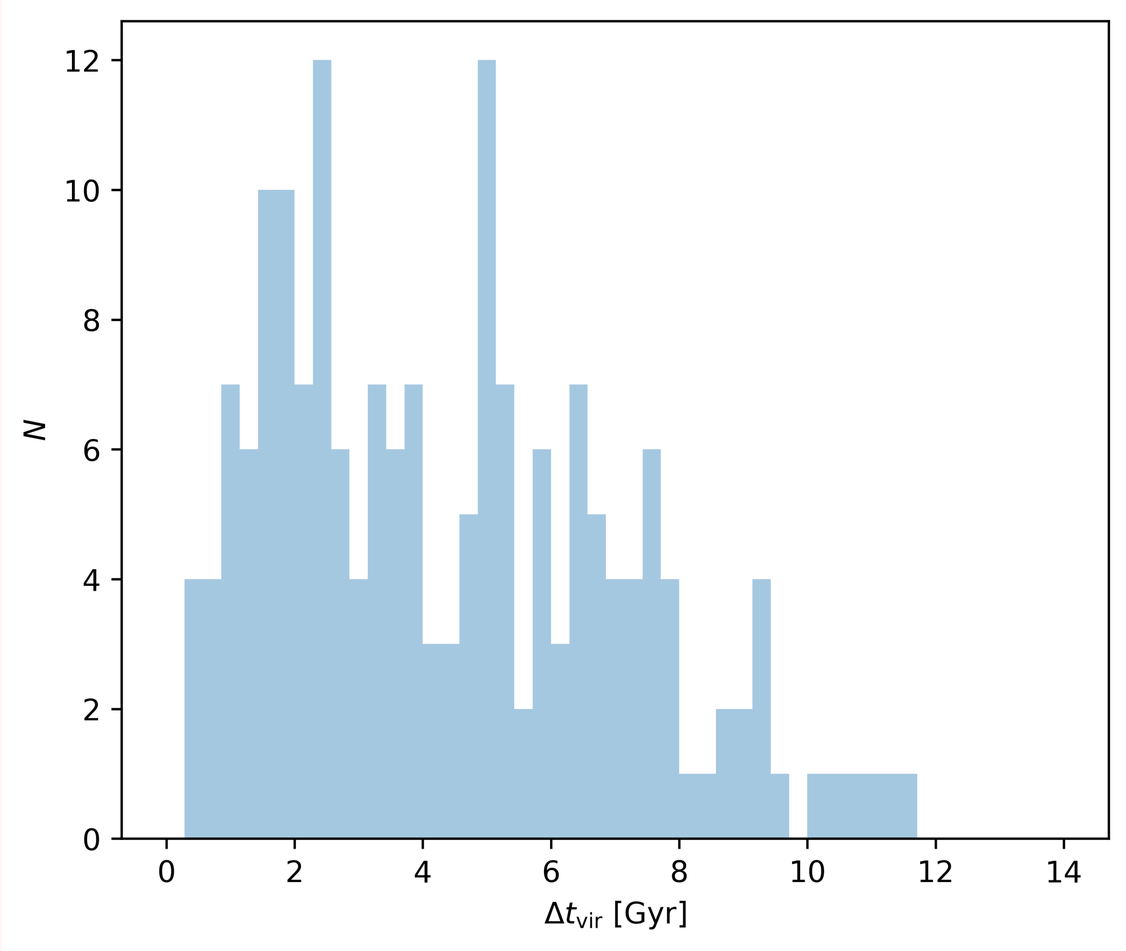
$$f_{\rm bound} > 0.97 \rightarrow \text{Intact}$$

$$\sigma_{\rm vel}^{50} < \sigma_{\rm vel,th}(M_*) \rightarrow \text{Stream}$$

Otherwise, phase-mixed

RESULTS





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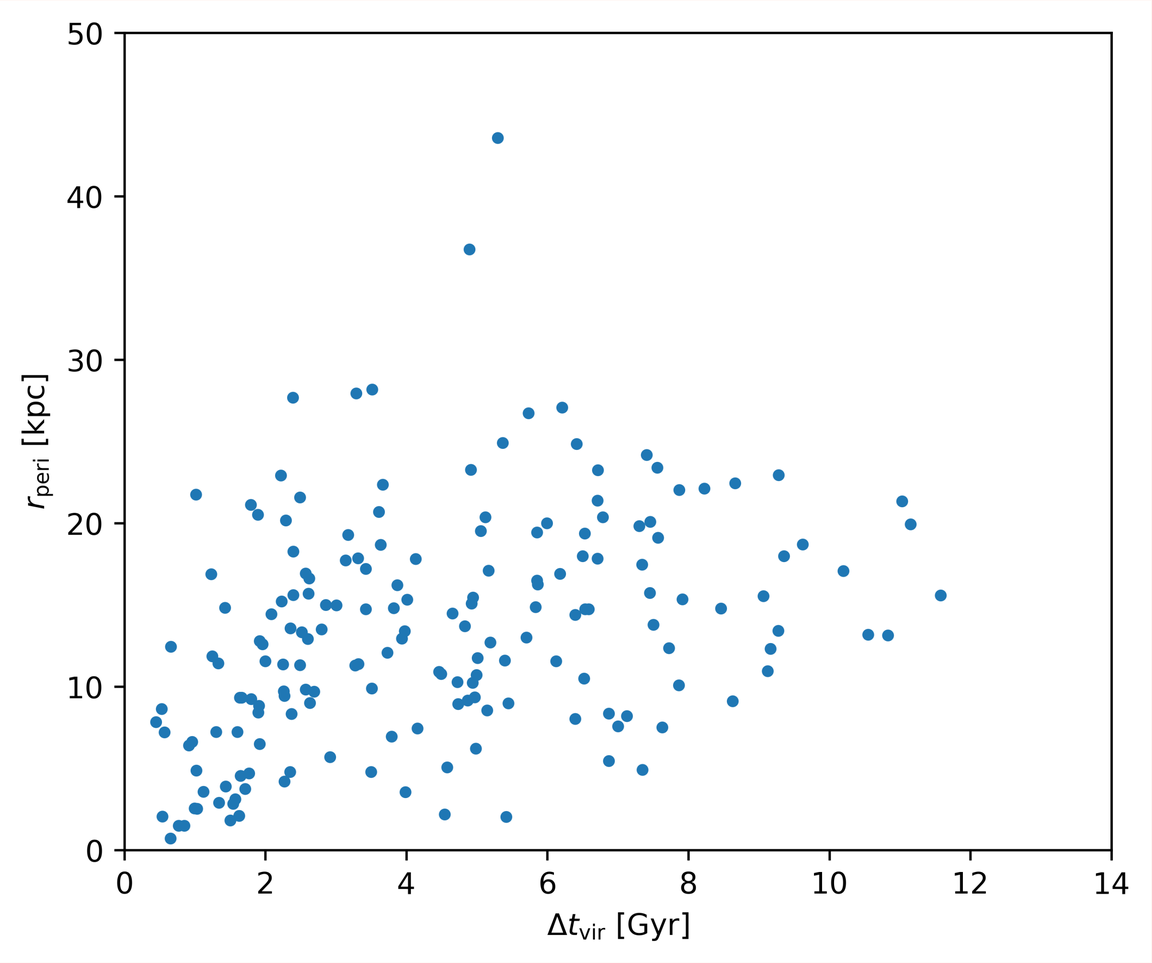
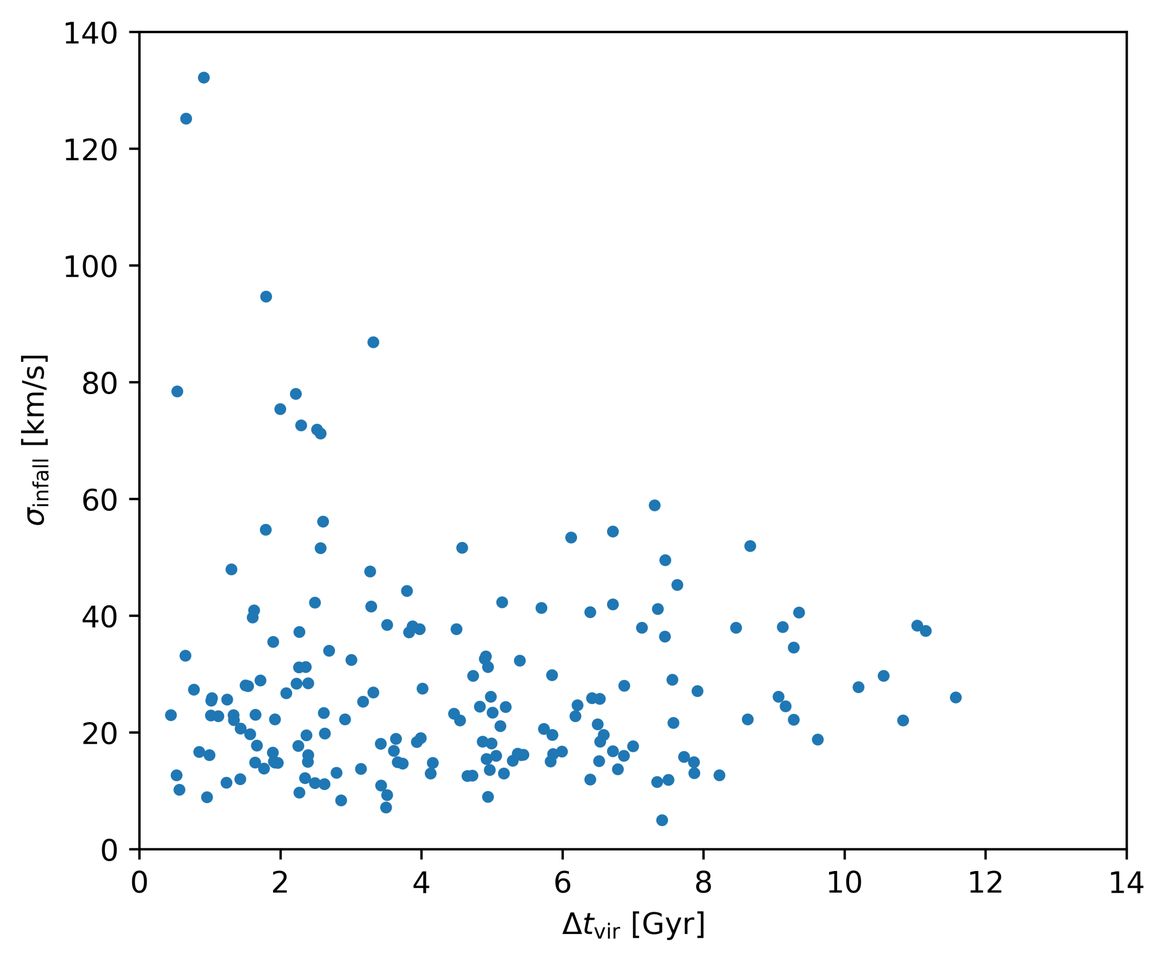




Data from the Vintergatan simulations (Agertz et al, 2021)

CONCLUSIONS

- This new software tool enables the accurate tracking of the interaction between a satellite halo and its host, effectively extending the lifetime of merging halos for several Gyrs.
- The usage of said tool allows us to research the interaction events between satellites and their hosts, something that was very difficult with previous halo finders.
- The preliminary results yield extended interaction times even for shallower pericenters.
- Both the software and the results are being prepared for publication.

APPENDIX

VINTERGATAN RESOLUTION

Dark matter particle mass: 3.5 * 10^4 Msun

Spatial resolution: ~20 pc

Time resolution: Simulation dependent, but up to 470 snapshots
from redshift 15.65 to the present day.
This means that from z~1.5 onwards, there may be a ~0.0001 Gyr timestep

Which is a really good resolution!

HALO FINDER TYPES

All halo finders start with a 3D Friends of Friends process and later refine

Density-space

Uses positions to define halos and subhalos.

↓

If two halos are physically close, it can't distinguish them

Example: SUBFIND

Phase-space

Uses both positions and velocities to define halos and subhalos.

↓

Can still lose halos during interactions. If a group of particles of the same halo are somewhat separated in velocity space, it generates spurious halos

Example: Rockstar

History-space

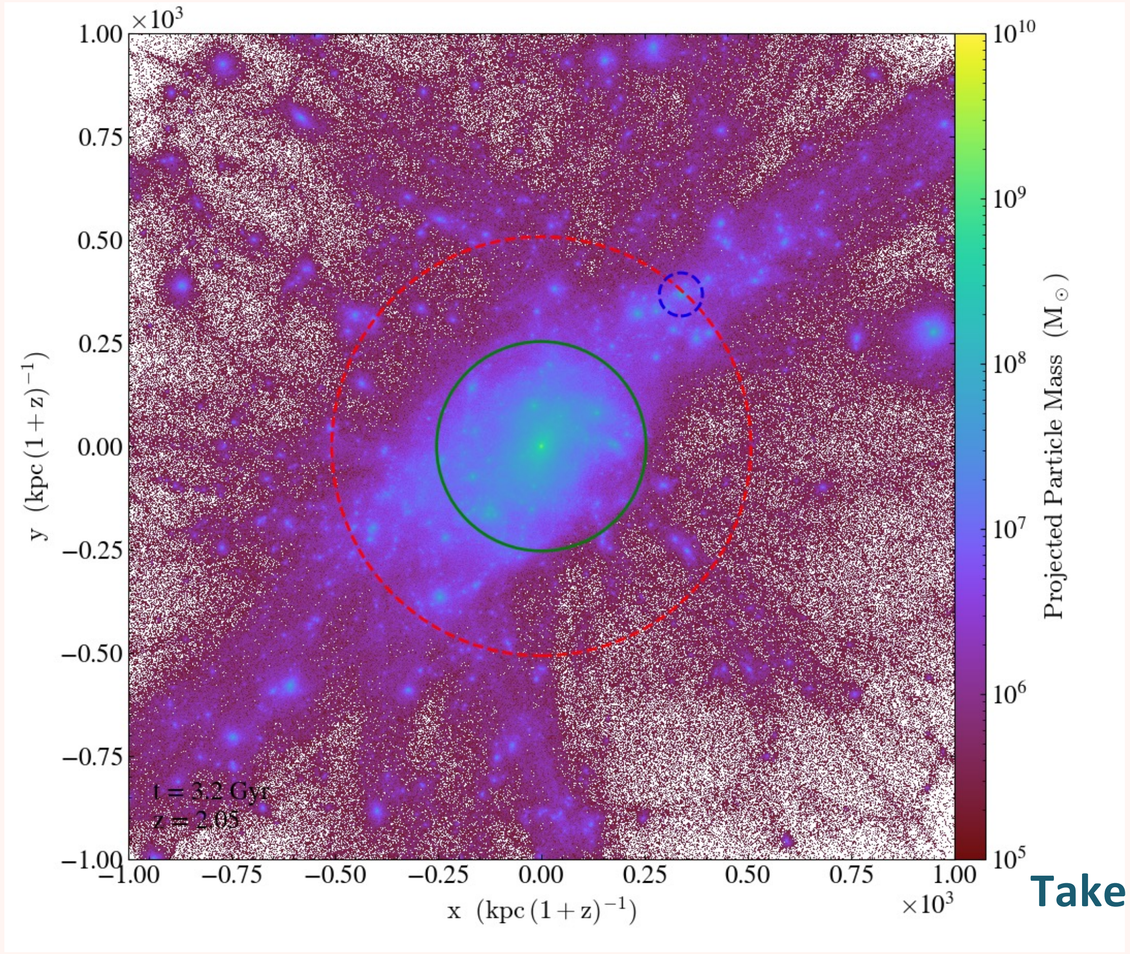
Uses information from previous time steps.

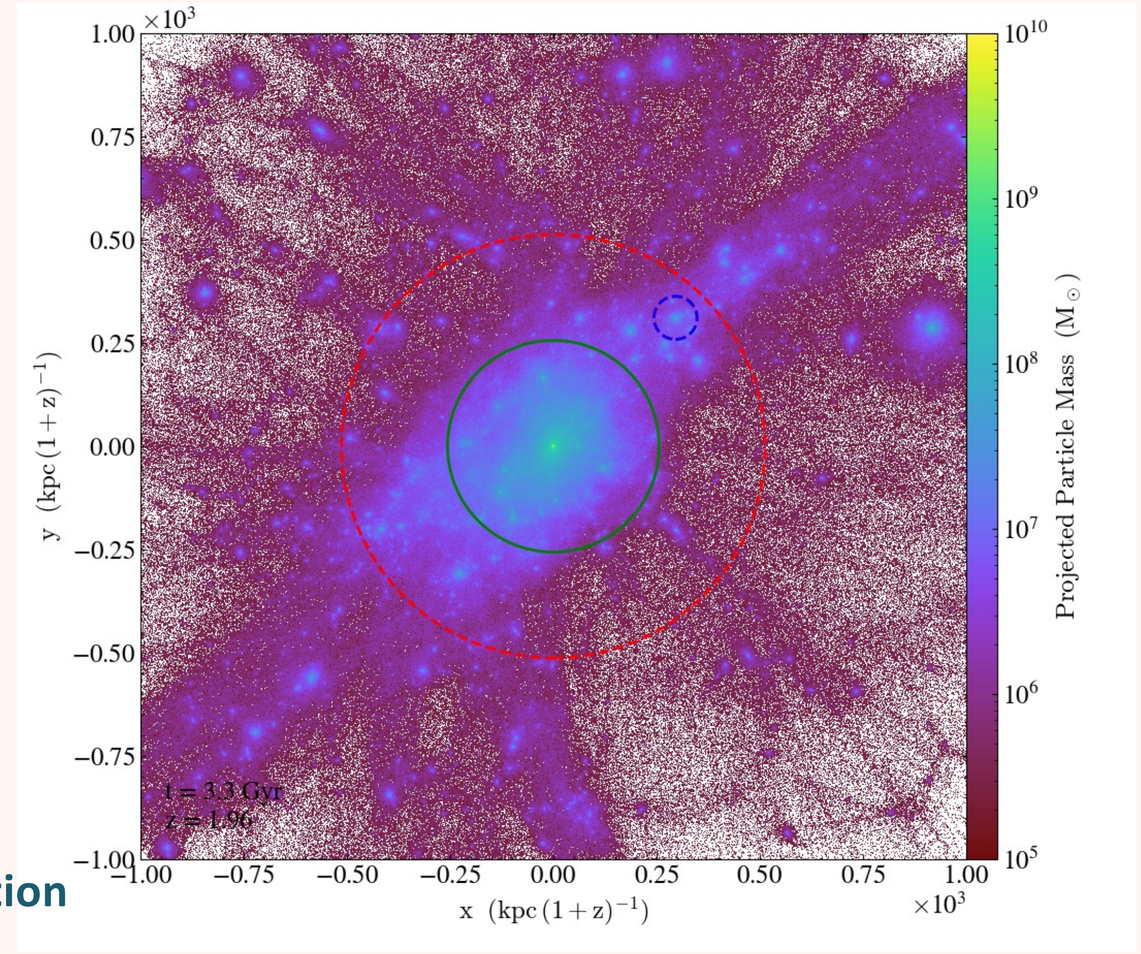
↓

Is ganing traction as improves results. Needs good temporal resolution and disk space

Example: HBT-Herons, particle tracking

PARTICLE SELECTION





Take intersection

Select particles within 1Rvir of the satellite

Select particles within 2Rvir of the satellite

LOCAL DISPERSION VELOCITY

Let's assume our halo has N stellar particles. For each particle, we take min(0.1*N, 7) nearest particles in 6D and compute the velocity dispersion. Then, we compute the median value.
The metric reads:

$$D_{ij} = |x_i - x_j|^2 + w_v * |v_i - v_j|^2$$

$$w_v = \sigma^i_{\rm pos} / \sigma^i_{\rm vel} \quad \text{where i is [x,y,z]}$$

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