Correlations of DM halo properties: Building the Hyades Suite

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In collaboration with
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Hyades Simulations Suite

- Zoom-in simulations of galaxy halos spanning $M_{vir} = 0.05 - 5E12 M_{\odot}$
- Identical initial conditions (`MUSIC`, Hahn & Abel 2011) with multiple codes: `ENZO`, `GADGET`, `GASOLINE`
- Ultimate goal: **How robust are halo (& galaxy) properties from code to code?**

First step: Obtain a reliable and representative sample of halos

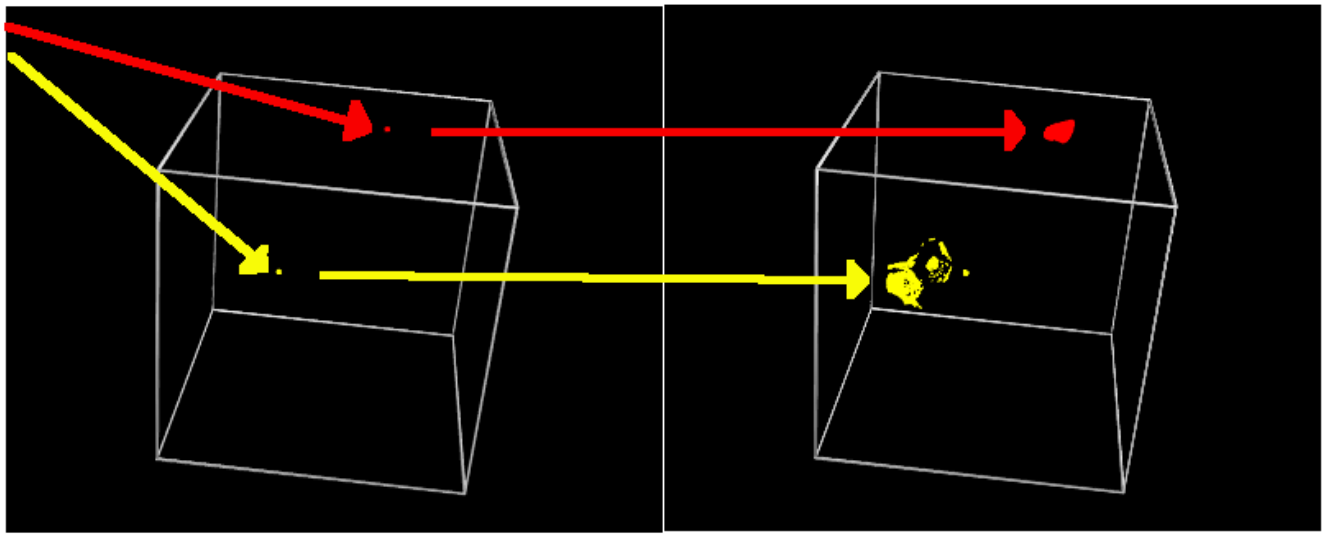
Hyades Simulations Suite

2 halos same mass @ z=0

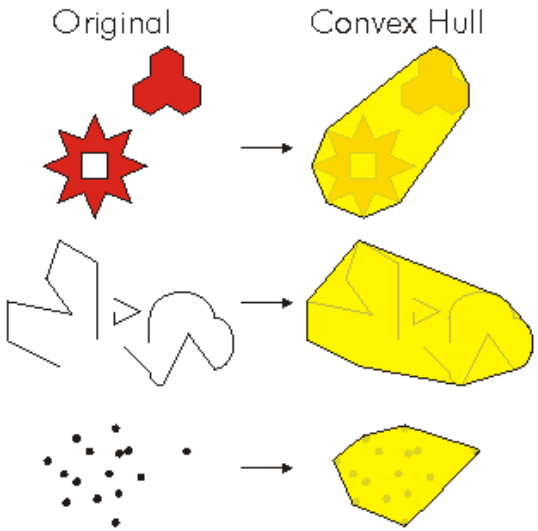
$2r_{vir}$

$z = 0$

Volume @ $z_{ini} = 250$



Red one would be much quicker run



The initial high redshift volume can be defined by the convex hull (minimal polyhedron that englobes all particles)

Hyades Simulations Suite

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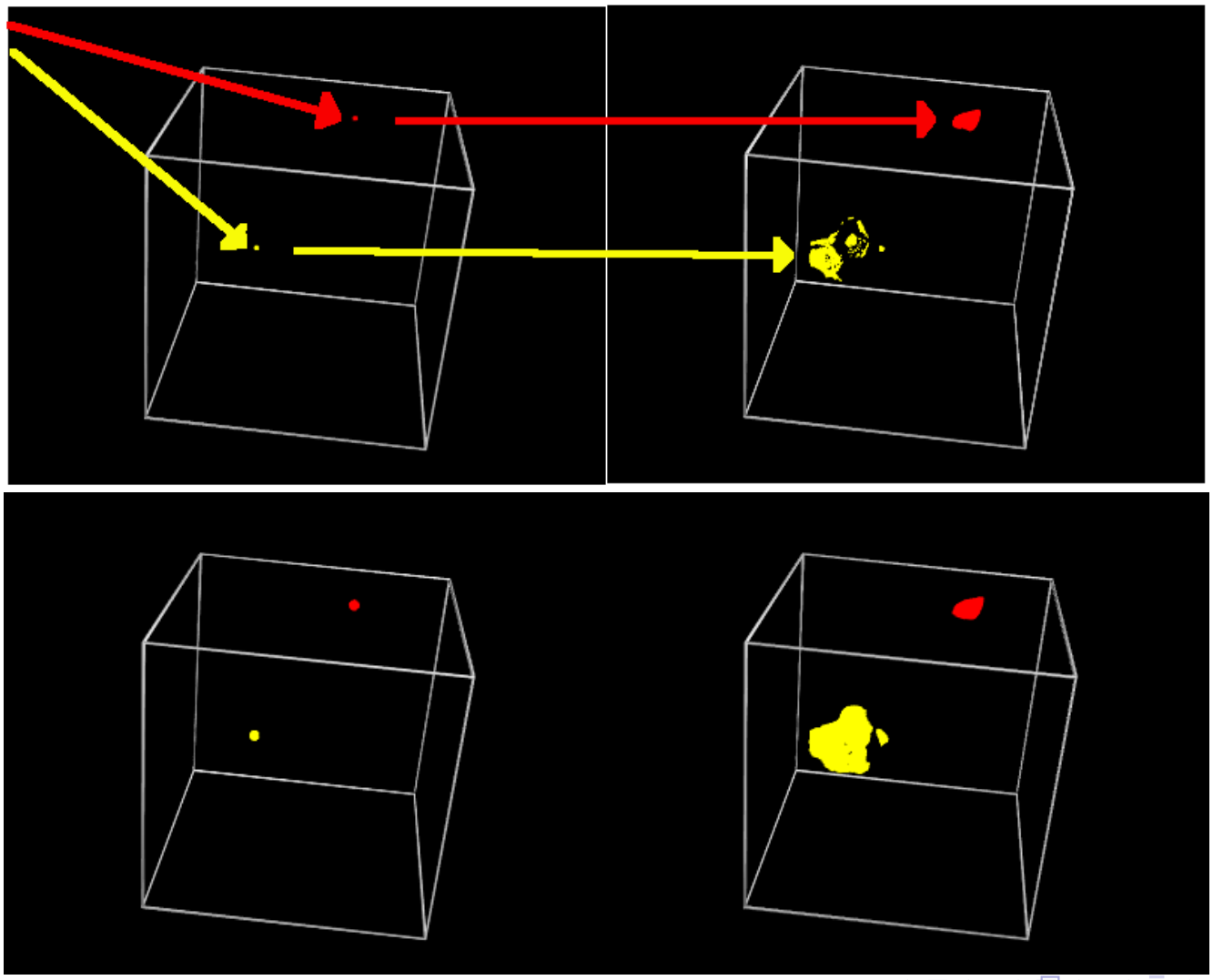


$2r_{vir}$

$5r_{vir}$

Red one would be much quicker run

Q: How big of a volume do we need to use to get no contamination?

Q: Can we pick small volumes without bias?

Use $L_{box} = 50 Mpc/h$, $N_p = 512^3$, $\epsilon = 1 kpc/h$ sim to explore how halo properties depend on the vol_{hz}

Dark Matter Halo Properties

M_{vir}, V_{max}, R_{max}, shape, λ, N_{neig}, a^{50}_{form}, $N_{mergers}$, subhalo, vol_{hz} $(1 \times r_{\rm vir})$,...

Cosmology: ΛCDM WMAP7

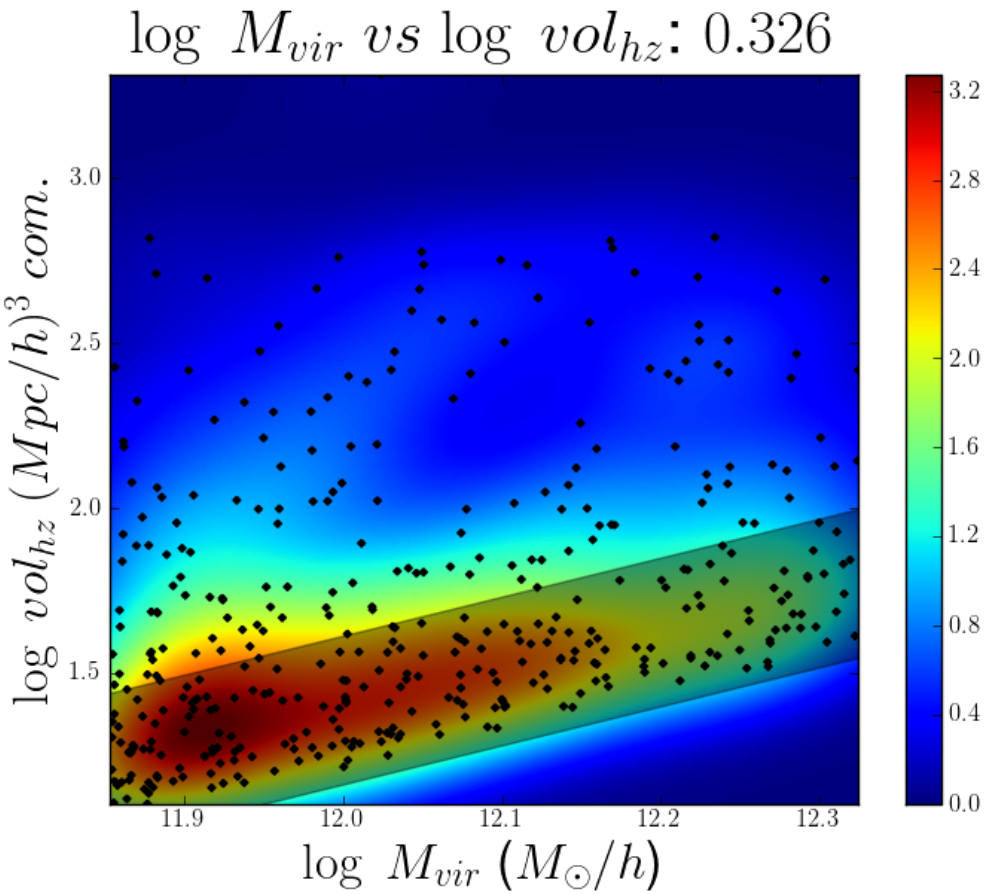
Sample: Halos with $N_{part} > 500$

- Which halo properties contain more information? (Skibba & Maccio 2011, Jeeson-Daniel et al. 2011)
- How can we build a reliable sample with the lowest number of halos?
- How selective can we be with vol_{hz}?

Selecting a Milky Way Halo: How selective can we be?

MW Mass bin:
$[1-3] \times 10^{12}\ M_\odot$
No subhalos

- How is correlated vol_{hz} for a fixed mass?
- For some specific halo properties can we choose a low vol_{hz}?



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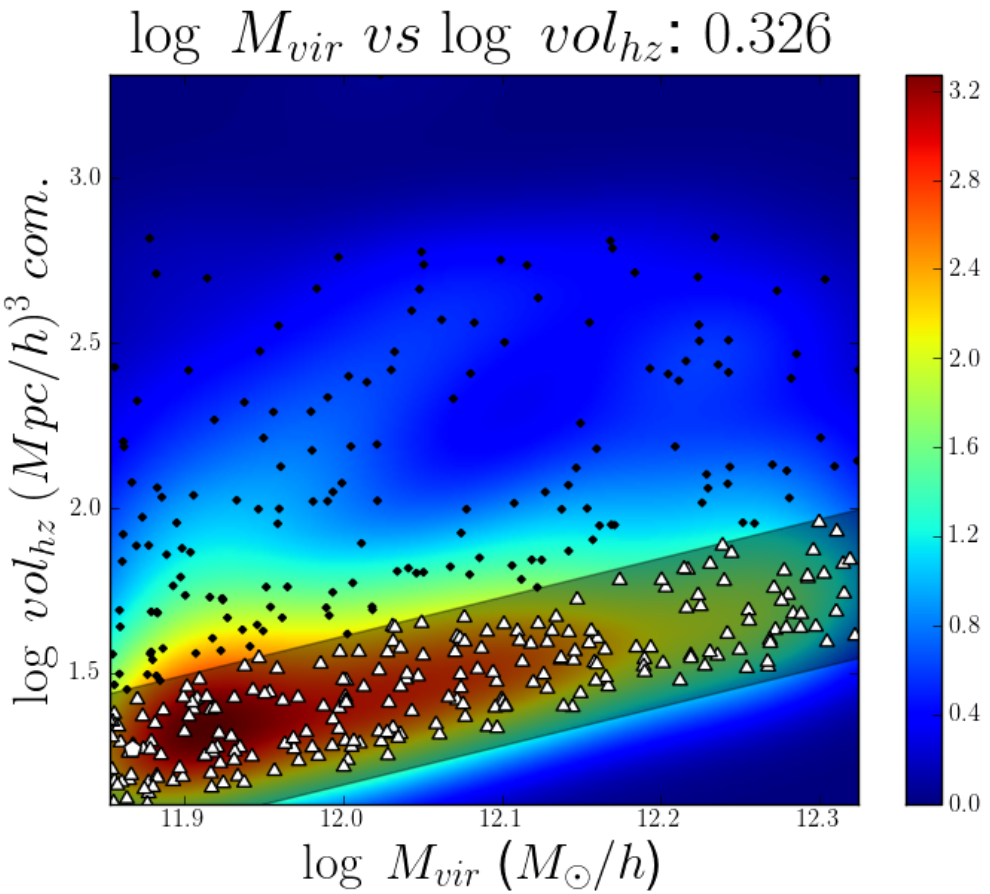
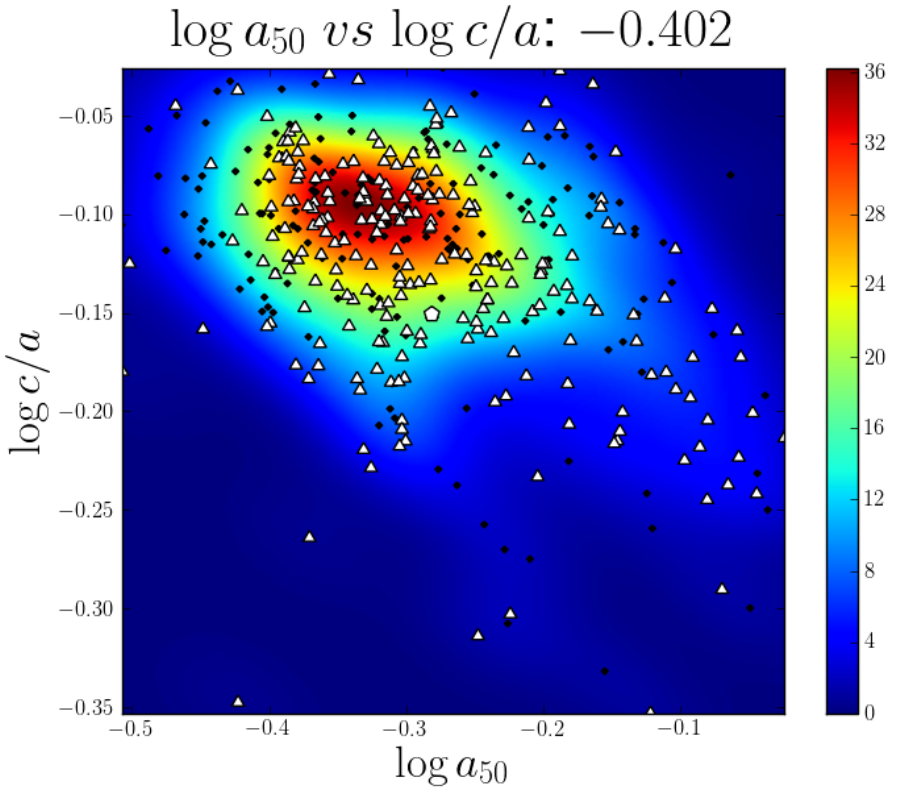
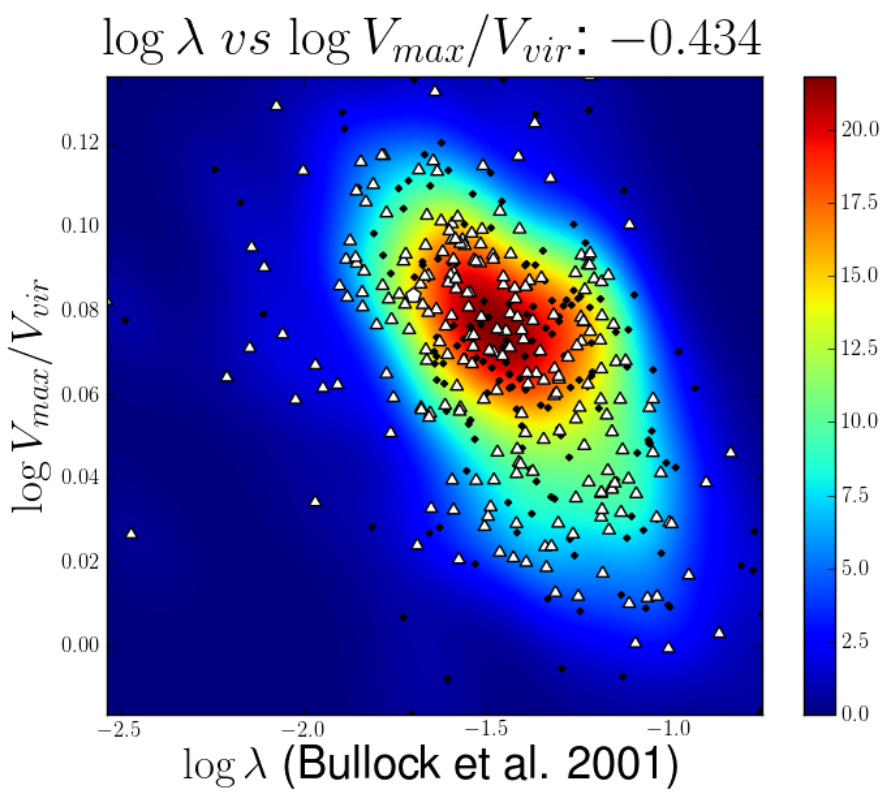


Selecting a Milky Way Halo: How selective can we be?

Color map and black points: full MW sample
White points: small initial volume





No bias with vol_{hz}

Testing reliability in Zoom-in simulations

- Using MUSIC (Hahn & Abel 2011)
- Set of dark matter zoom-in simulations.
  $m_p = 6.88E7 - 1.67E4\ M_\odot/h$

Comparison between Dark-Matter full box and zoom-in runs

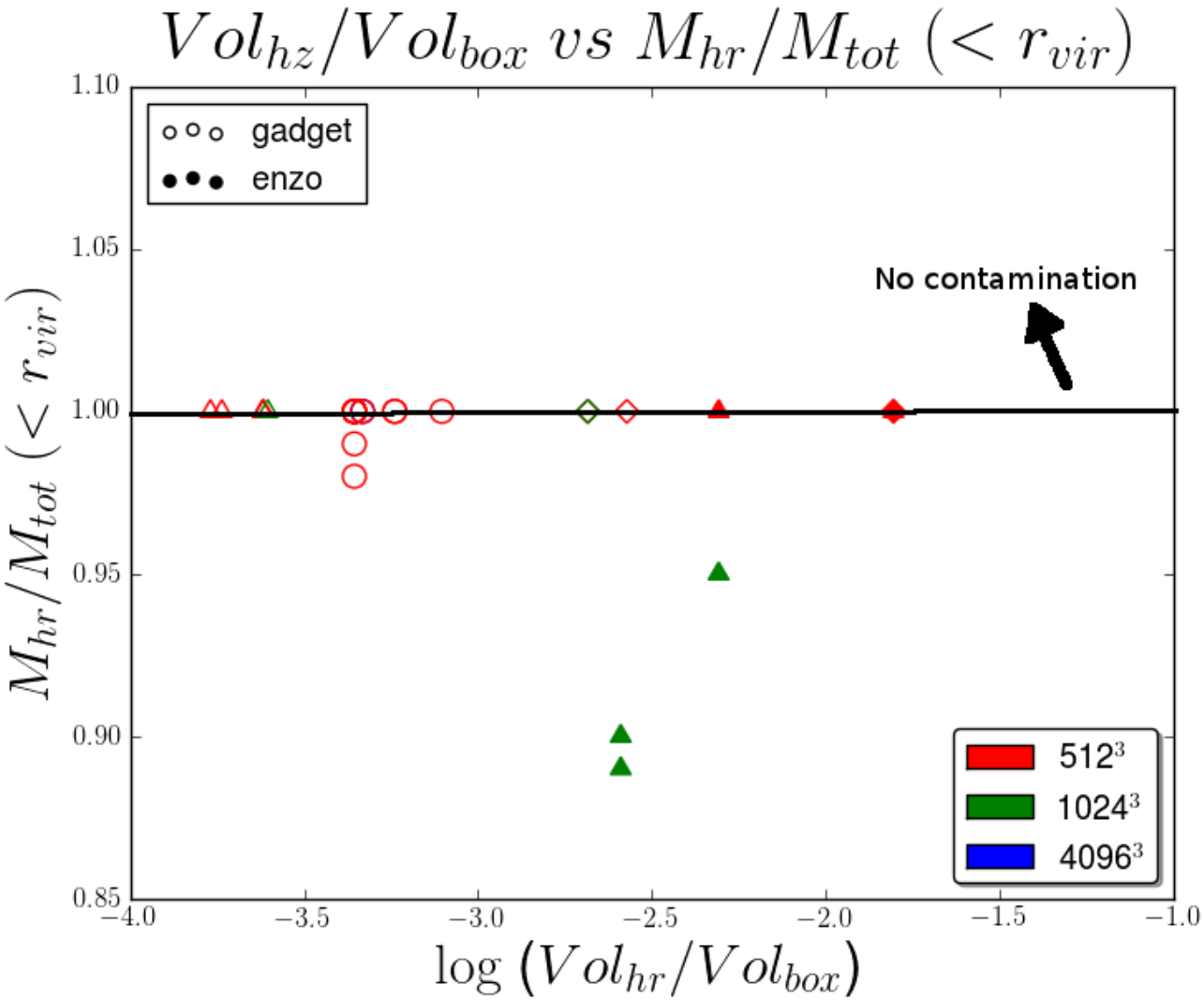
- Initial high-res volume: no contamination and stability of halo parameters.
- Mass and spatial resolution tests.
- Lower resolution levels sizes and resolution.
- Code differences.

Katz & White 1993, Klypin et al. 2001

Testing reliability in Zoom-in simulations

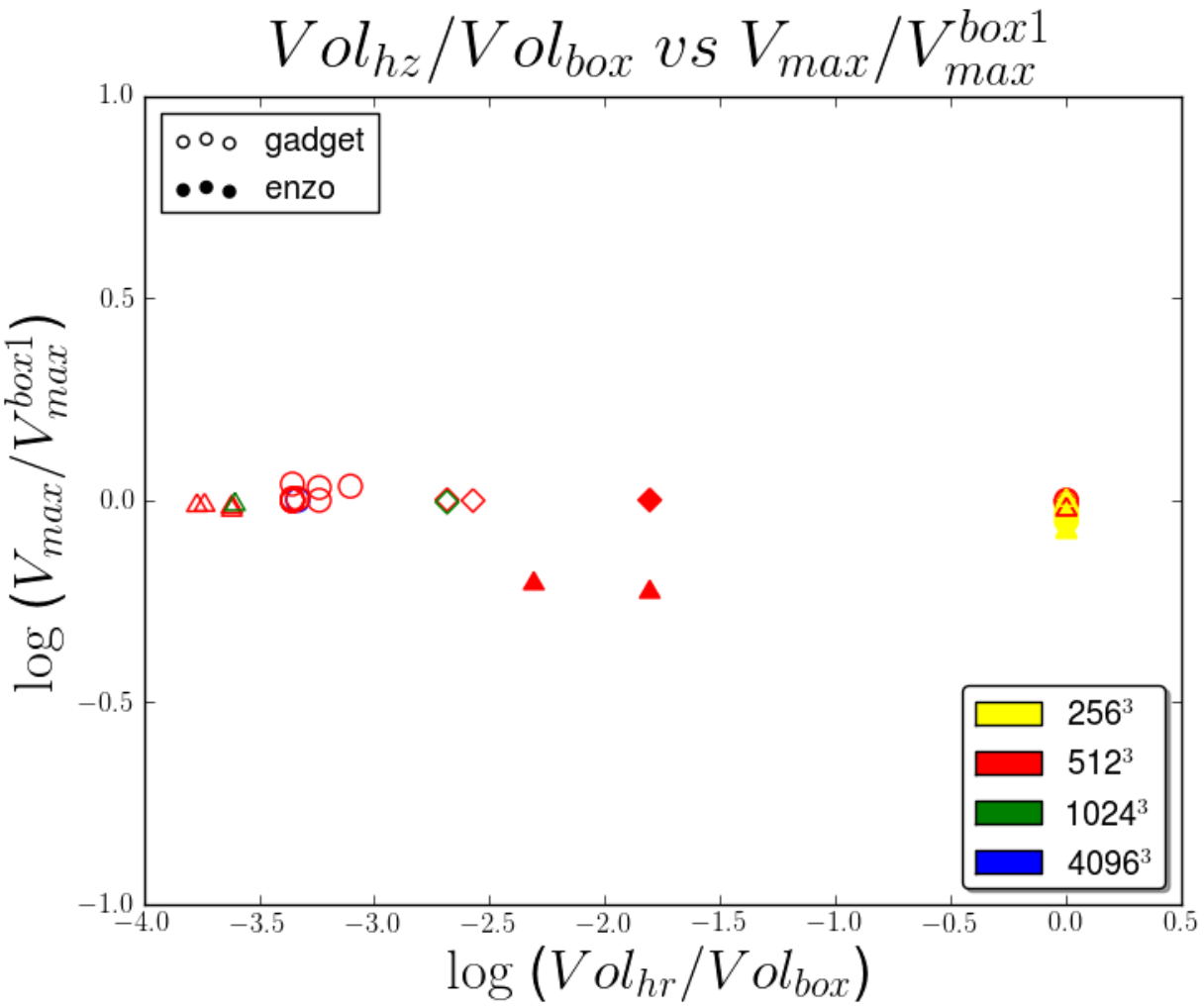
◇ $\sim 5E12M_{\odot}$
◯ $\sim 1E12M_{\odot}$
△ $\sim 5E11M_{\odot}$

Contamination: Any low res particles inside r_{vir}?



Log (Volume computed at high resolution)

Testing reliability in Zoom-in simulations

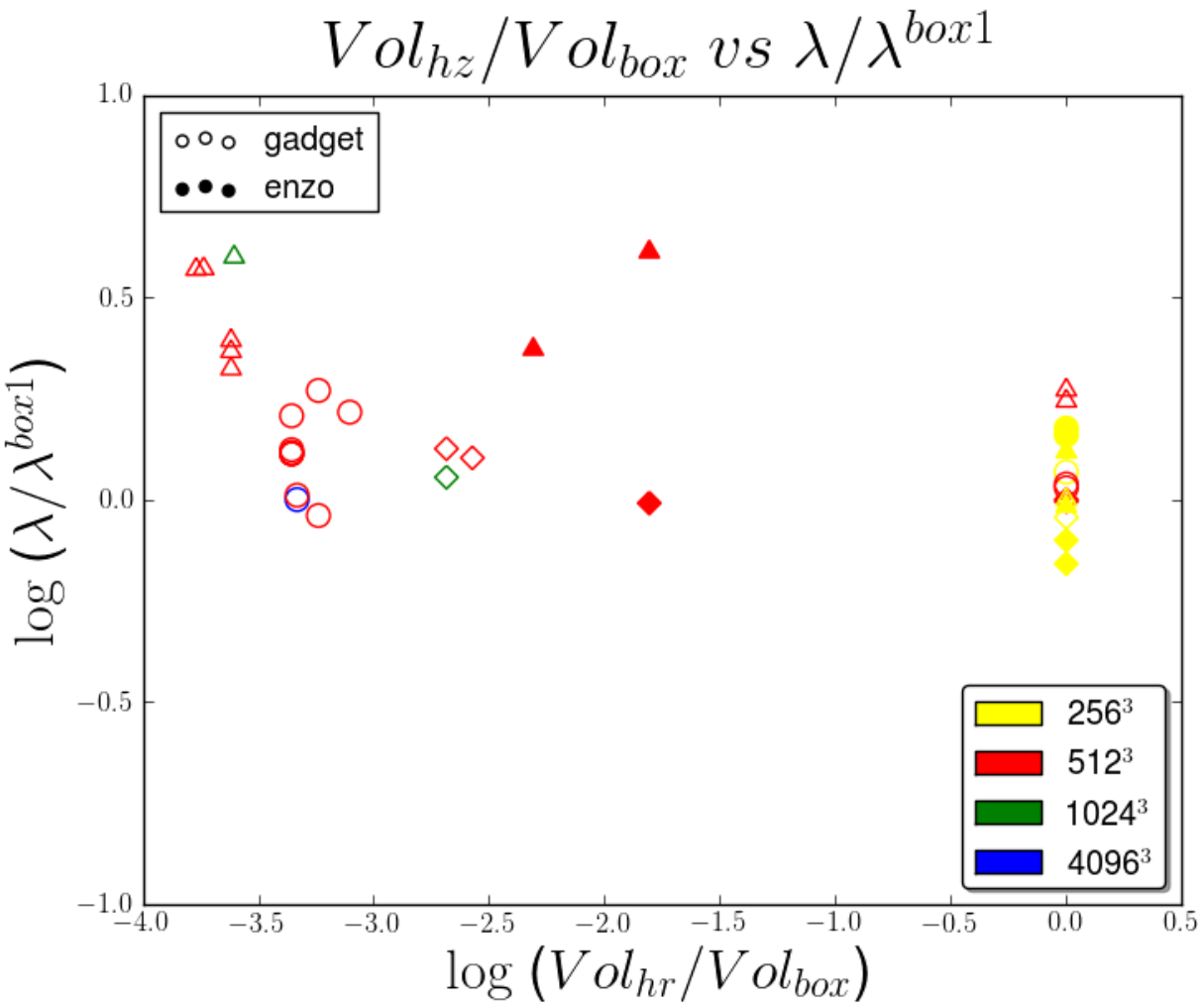


$\diamond \sim 5E12M_\odot$
$\bigcirc \sim 1E12M_\odot$
$\triangle \sim 5E11M_\odot$
Only runs with no contamination

V_{max} and most halo properties are very stable from run to run and as a function of initial volume.

Some problems with ENZO because the halo moves within grid...

Testing reliability in Zoom-in simulations



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Only runs with no contamination

Spin parameter less stable

Conclusions: Preliminary results

- For a fixed halo mass, there is no strong bias with the initial volume (good news for zoom simulations)
- Zoom volume need to be at least $\sim 2 \times r_{vir}$ for no contamination within r_{vir}
- Halo properties are stable for non-contaminated zooms, except for spin parameter.
- Enzo approach needs higher initial volume and more detailed information on halo history.

Thank you!

Hyades: Daughters of Atlas, nurses of Dionysus.
A sisterhood of nymphs that bring rain

Ambrosia
Coronis
Phyto
Erudora
Cardie
Niseis
Phaesyle
Cleeia
Pedile
Phyto
Polyxo
Synecho
Niseis

Phaeo

Would you like to try any Hyades nymph with your code?

Please contact us!!!

(jonorbeb@uci.edu)

Some Important Parameters

WMAP 7 Cosmology.
Model: $lcdm + sz + lens$

$\Omega_\Lambda = 0.734$, $\Omega_m = 0.266$,
$\Omega_b = 0.0449$, $h = 0.71$,
$\sigma_8 = 0.801$, $n_s = 0.963$

Full Box Parameters

$L_{box} = 50\ Mpc/h$, $\epsilon = 1\ kpc/h$,
$N_{part} = 512^3$, $z_{ini} = 250$,
$m_{dm} = 6.88 \times 10^7\ M_\odot/h$

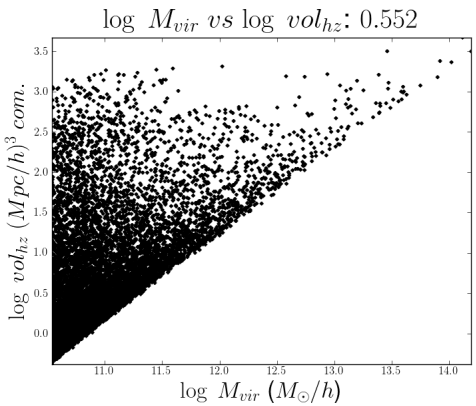
Full Box Halo Sample

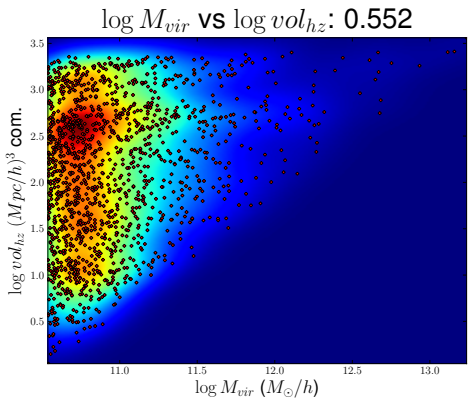
$N_{part} > 500 \rightarrow$
$M > 3.4 \times 10^{10} M_\odot/h$

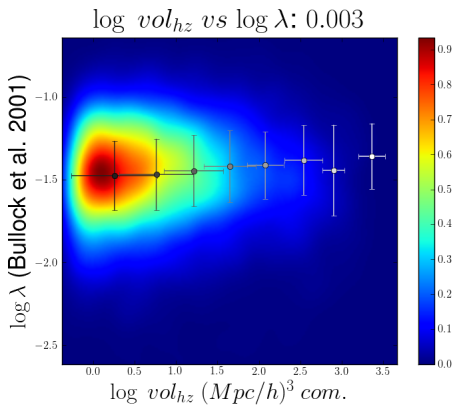
"MW" Mass Bin Halo Sample

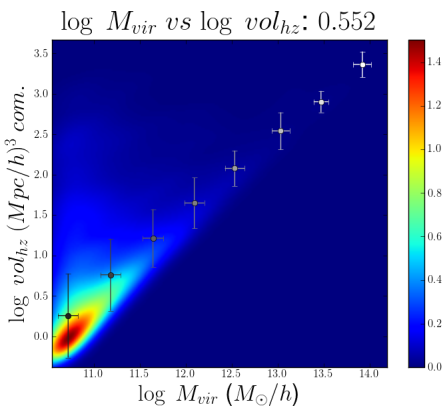
$1 \times 10^{12} M_\odot < M_{halo} < 3 \times 10^{12} M_\odot$
No subhalos

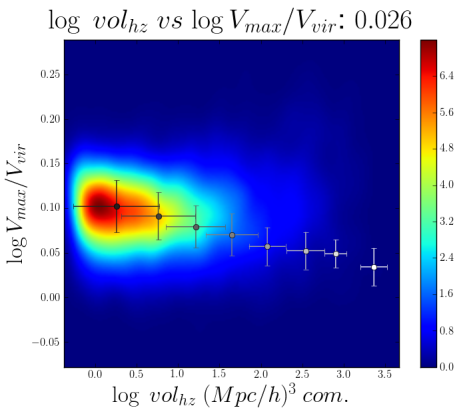
Other Figures: Full Sample

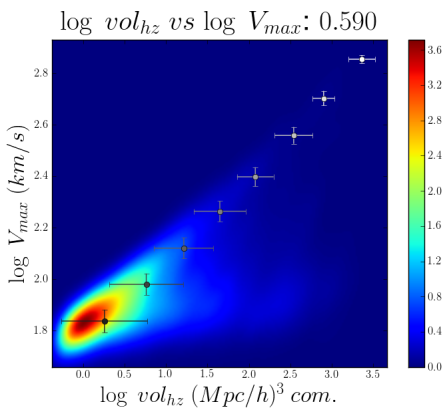












Other Figures: MW bin