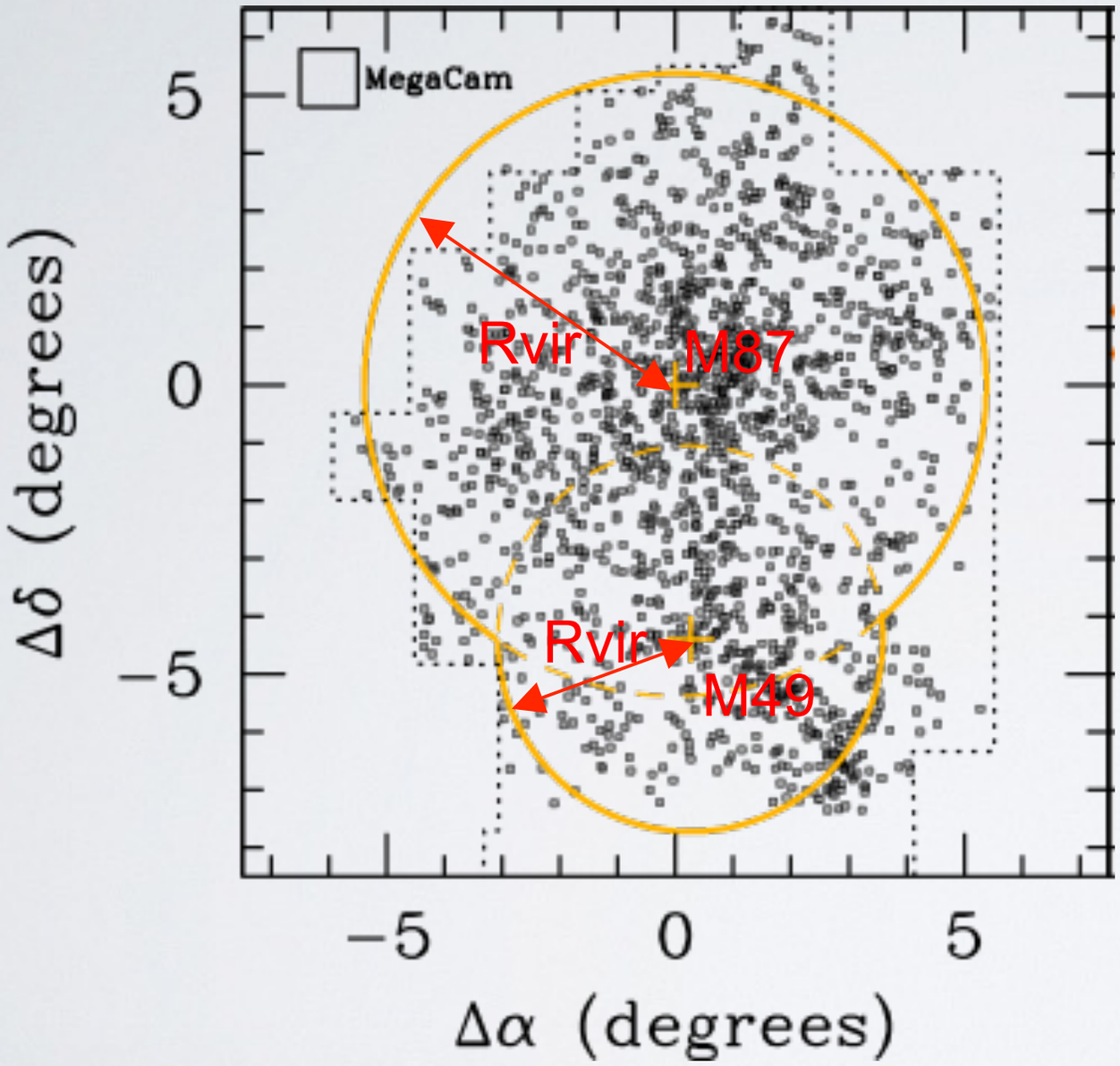
Disruption Timescales of Satellite Halos in a Dense, Clustered Environment (Preliminary result)

Jihye Shin[1], James E. Taylor[2] & Eric Peng[3]

[1]Korea Institute for Advanced Study, Korea
[2]University of Waterloo, Canada
[3]Kavli Institute for Astronomy and Astrophysics, China

NEXT GENERATION VIRGO CLUSTER SURVEY (NGVS)



= Multipassband (ugriz) optical survey
with MegaCam at the CFHT

= cover ~104 degree^2 (R_{vir} of M87 and M49)

= spatial resolution : 0.6" (~48pc)

= surface brightness : ~ 29 mag/arcsec^2

= detection limit : ~25.9 mag

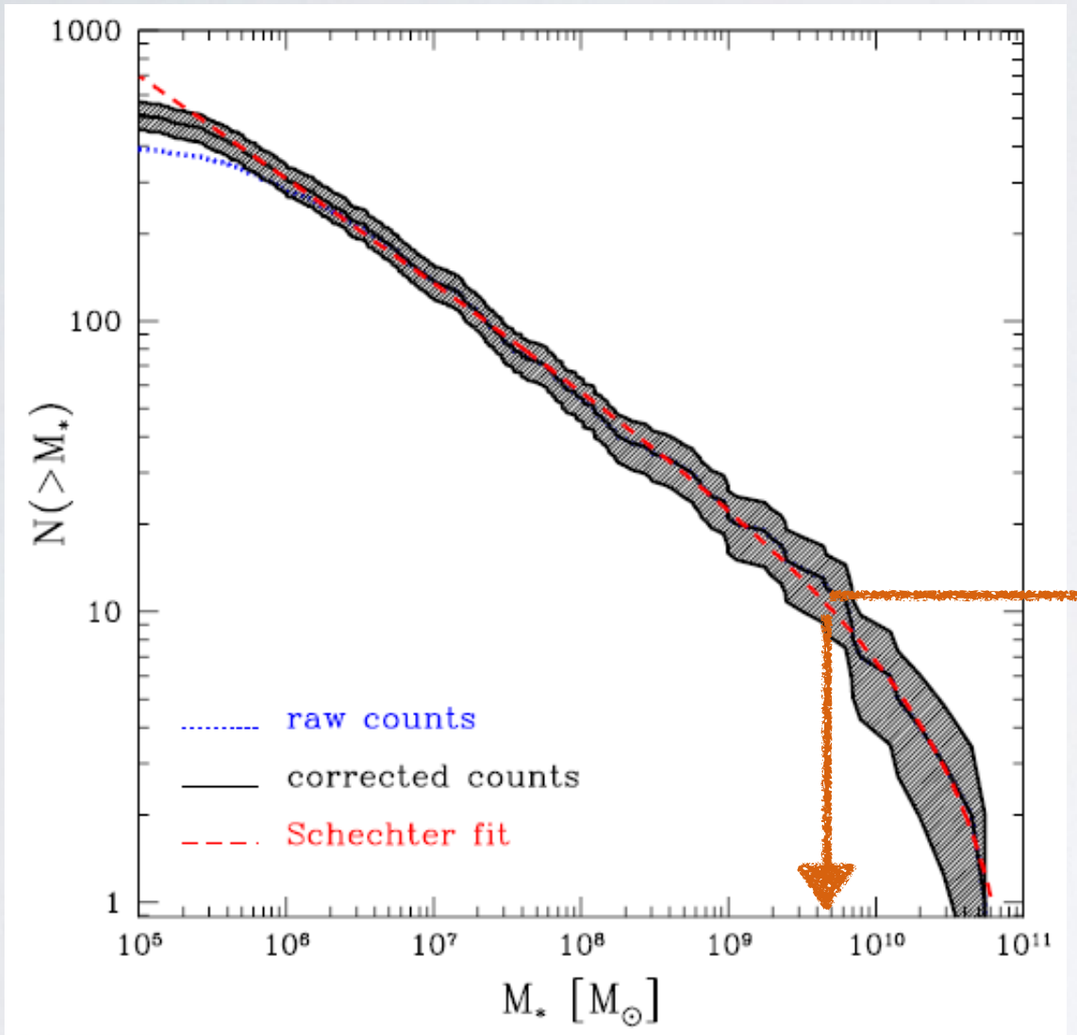
: ~5 mag fainter than VCC

(Binggeli et al. 1985)

Ferrarese et al. 2012

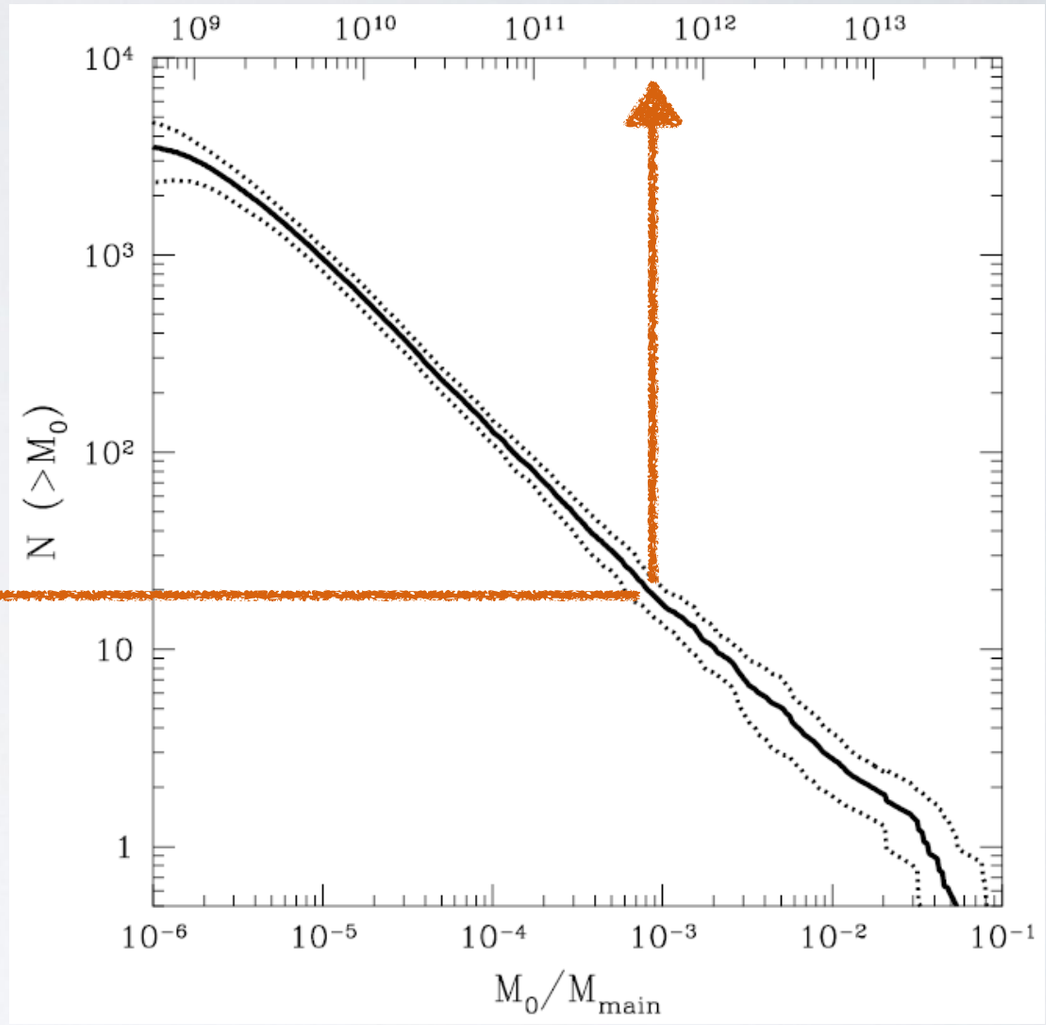
ABUNDANCE MATCHING

stellar mass function (virgo cluster)



Ferrarese et al. (2016)

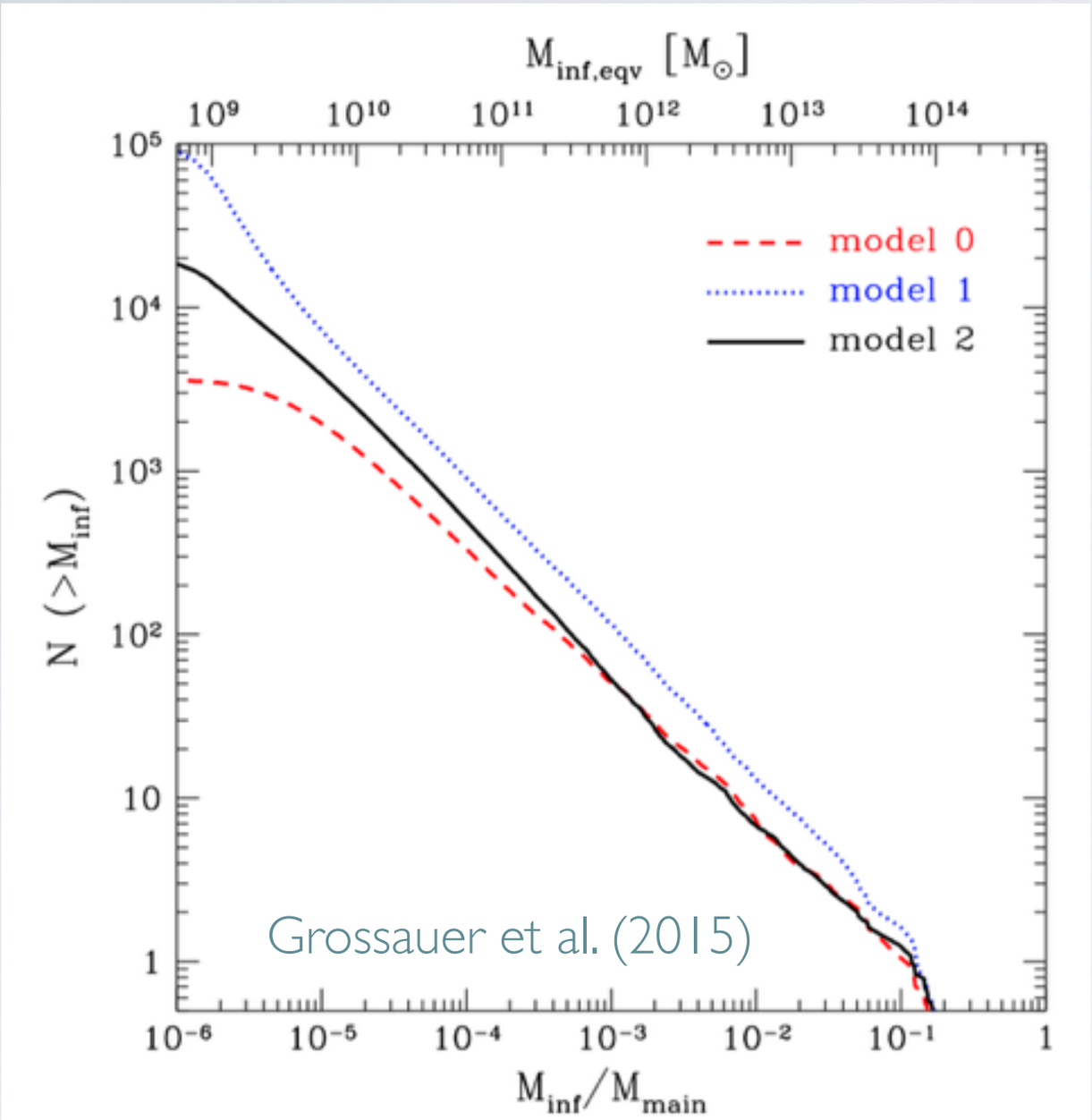
sub-halo mass function



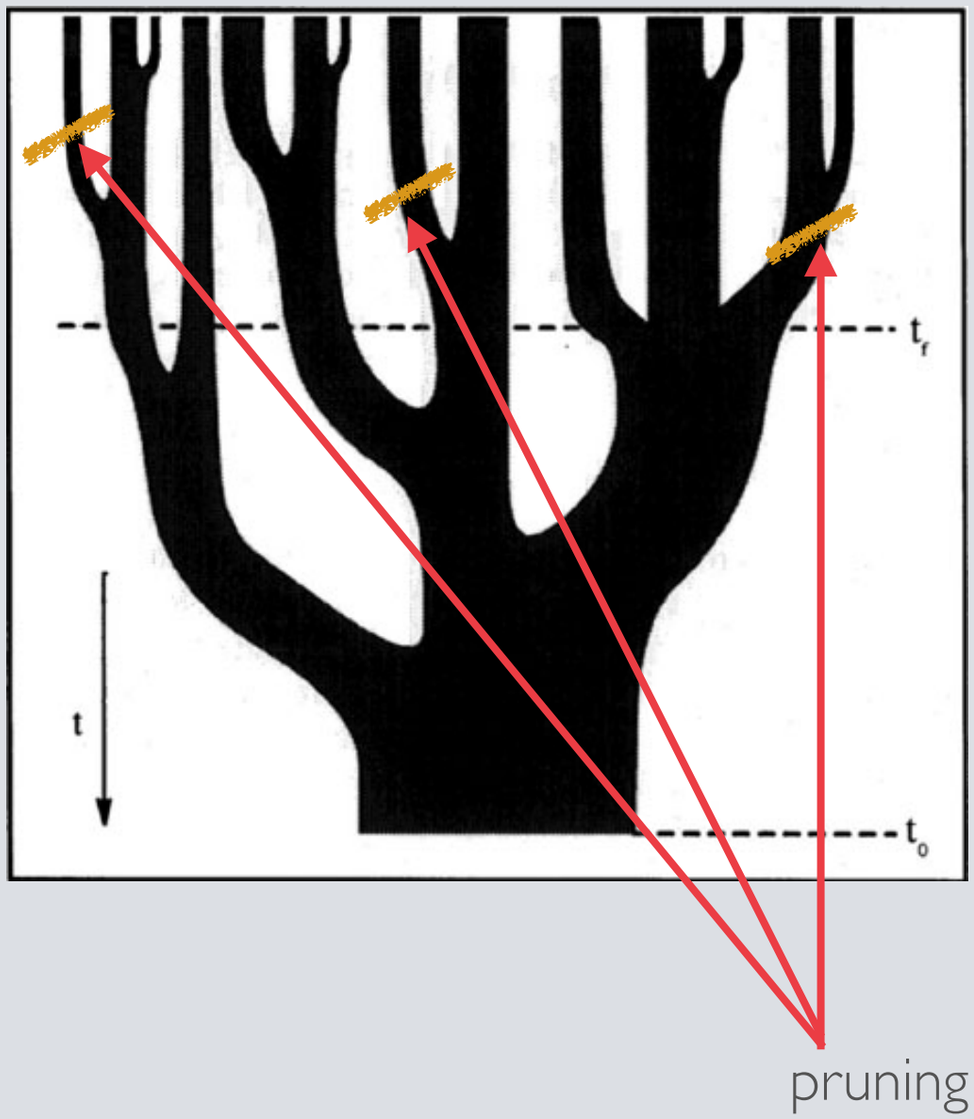
Grossauer et al. (2015)

Key assumptions - one galaxy per one dark matter clump
- galaxy luminosity tightly correlated with halo mass

SUB-HALO MASS FUNCTION



Halo merger tree

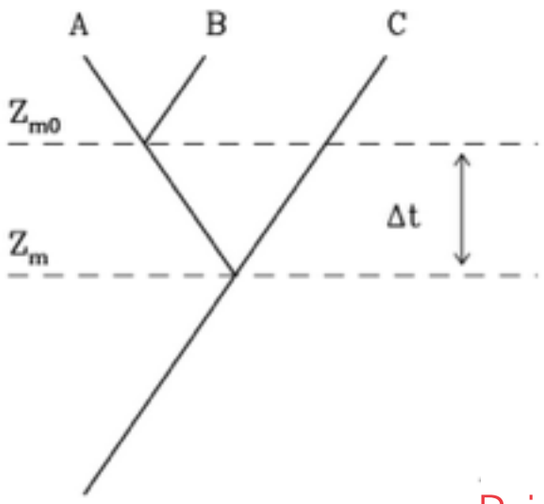


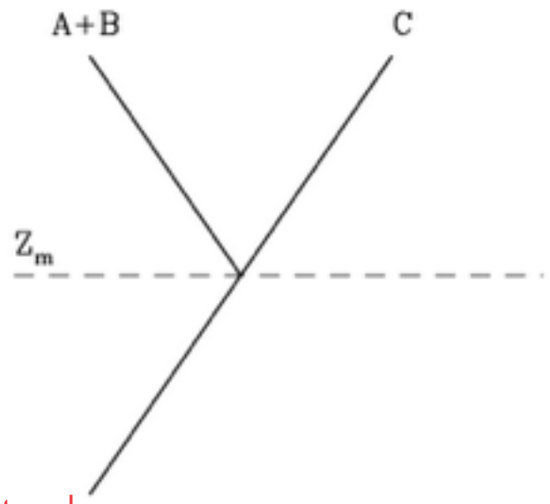
Model 0 : constructed by sub-halo catalog (sub-halo : AHF or Rockstar) - lower limit

Model 1 : constructed by halo merger tree (field halo : FoF) - upper limit

Model 2 : halo merger tree + pruning algorithm (sub-halo disruption) - realistic

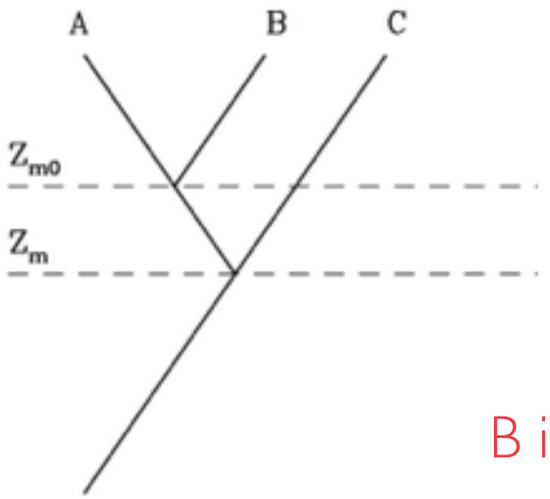
PRUNING MERGER TREES

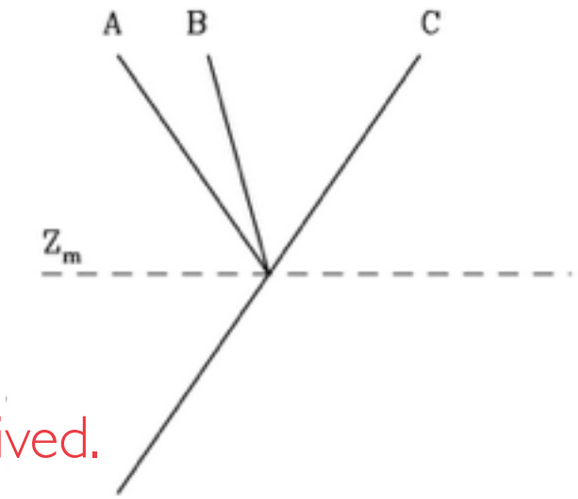




B is disrupted.

: B is spiraled into A's center by dynamical friction.
($t_{dis} < \Delta t$)





B is survived.

: B is considered to be a distinct object.
($t_{dis} < \Delta t$)

Taylor & Babul 2004

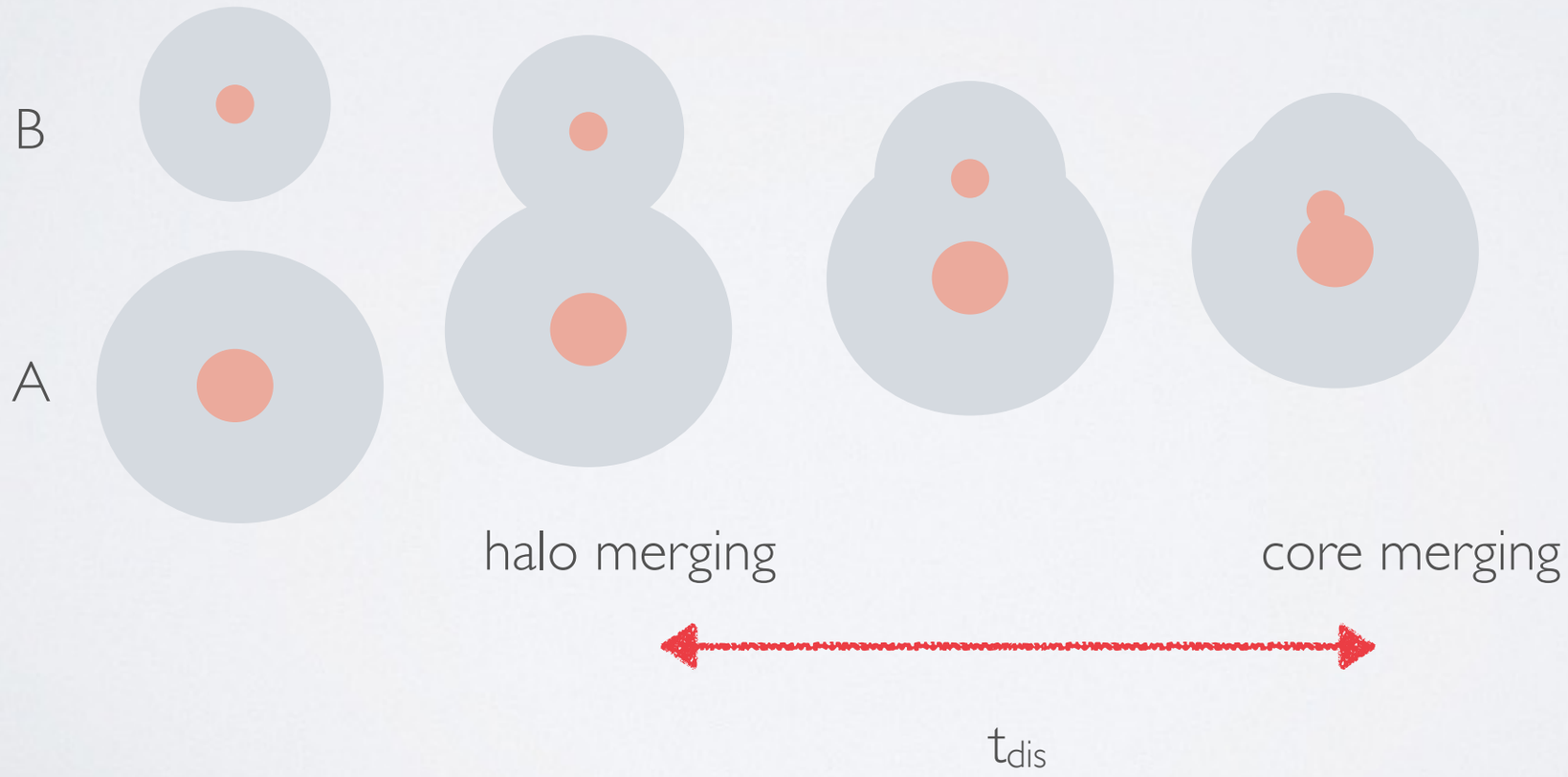
Disruption timescale by dynamical friction (Colpi et al. 1999)

$$t_{\rm dis} = \frac{k}{f_m} \frac{M_{\rm h}/M_{\rm s}}{\ln(M_{\rm h}/M_{\rm s})} \epsilon^{\alpha} \frac{P_{\rm vir}}{2\pi},$$

AIM & METHOD

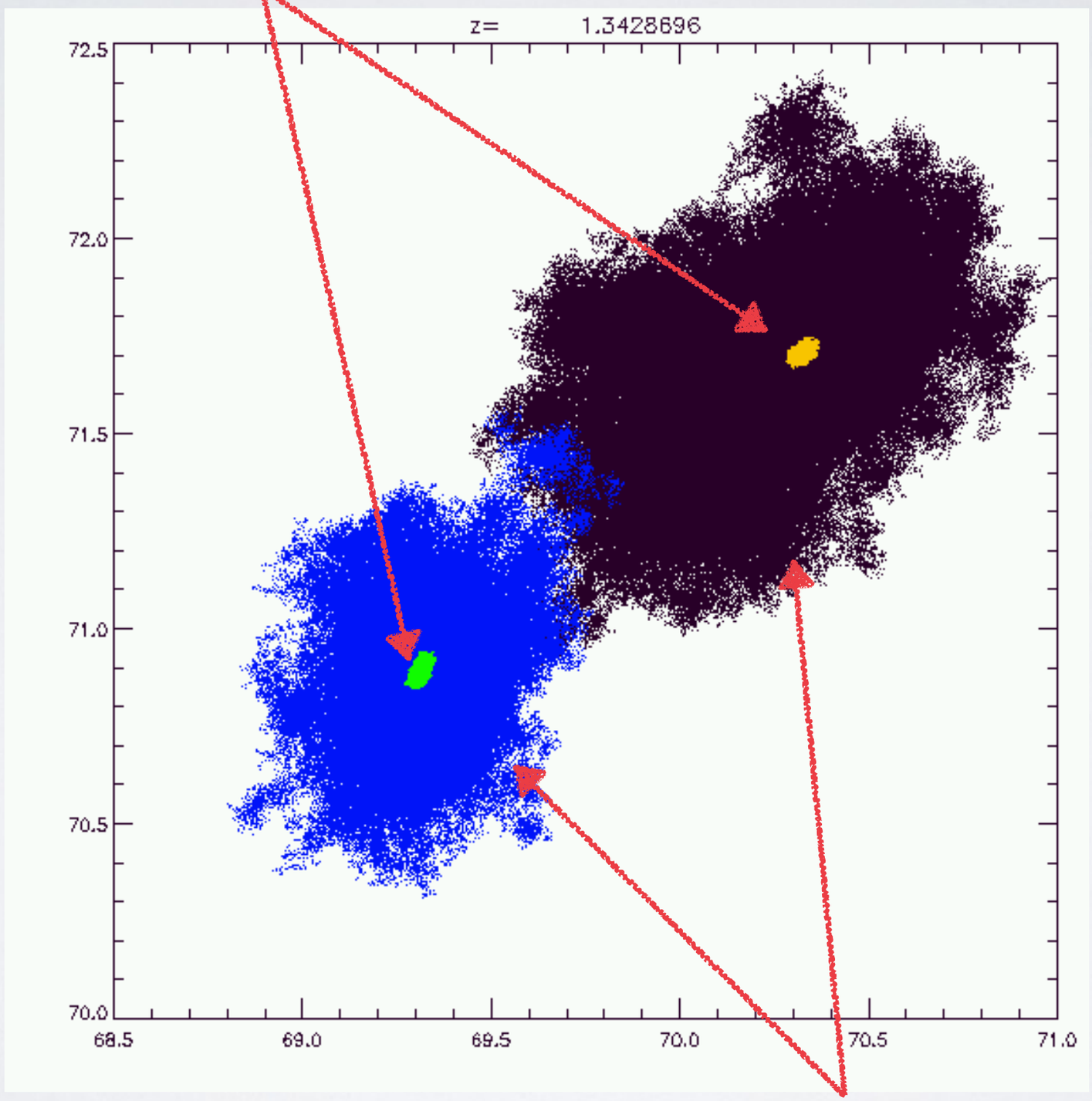
We perform cosmological high-resolution zoom simulations
targeting a Virgo cluster-like halo (using Gadget 2).
- particle mass = 3.32×10^6 $M_\odot/h$
- particle number for a Virgo cluster-like halo = ~40 M

Then, we measure disruption timescale of sub-halos (t_{dis}) by tracing their
core structures, and suggest the more realistic pruning criteria.



AIM & METHOD

cores identified by FoF (l=0.02)



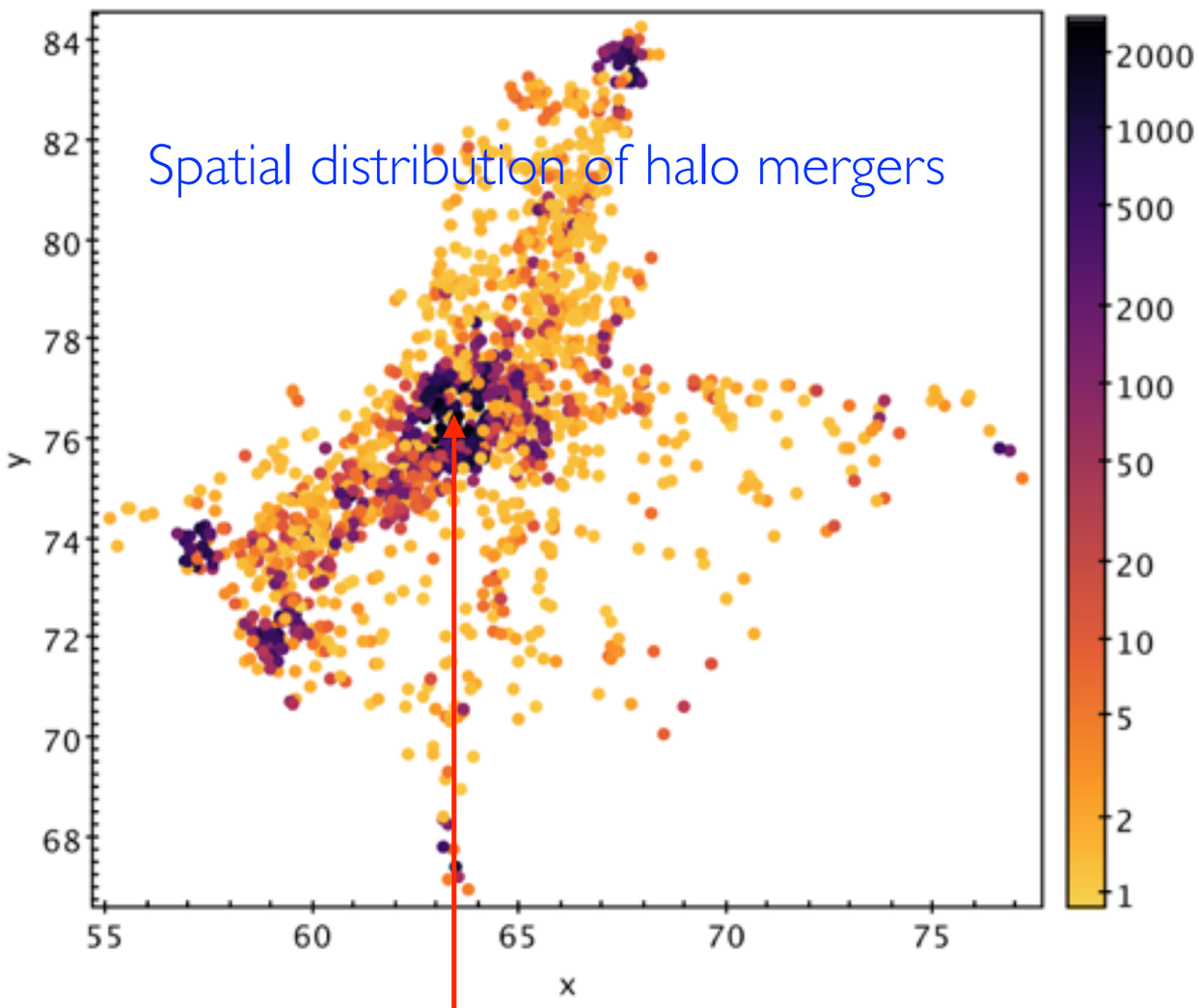
field halos identified by FoF (l=0.2)

FoF HALO MERGER TREES

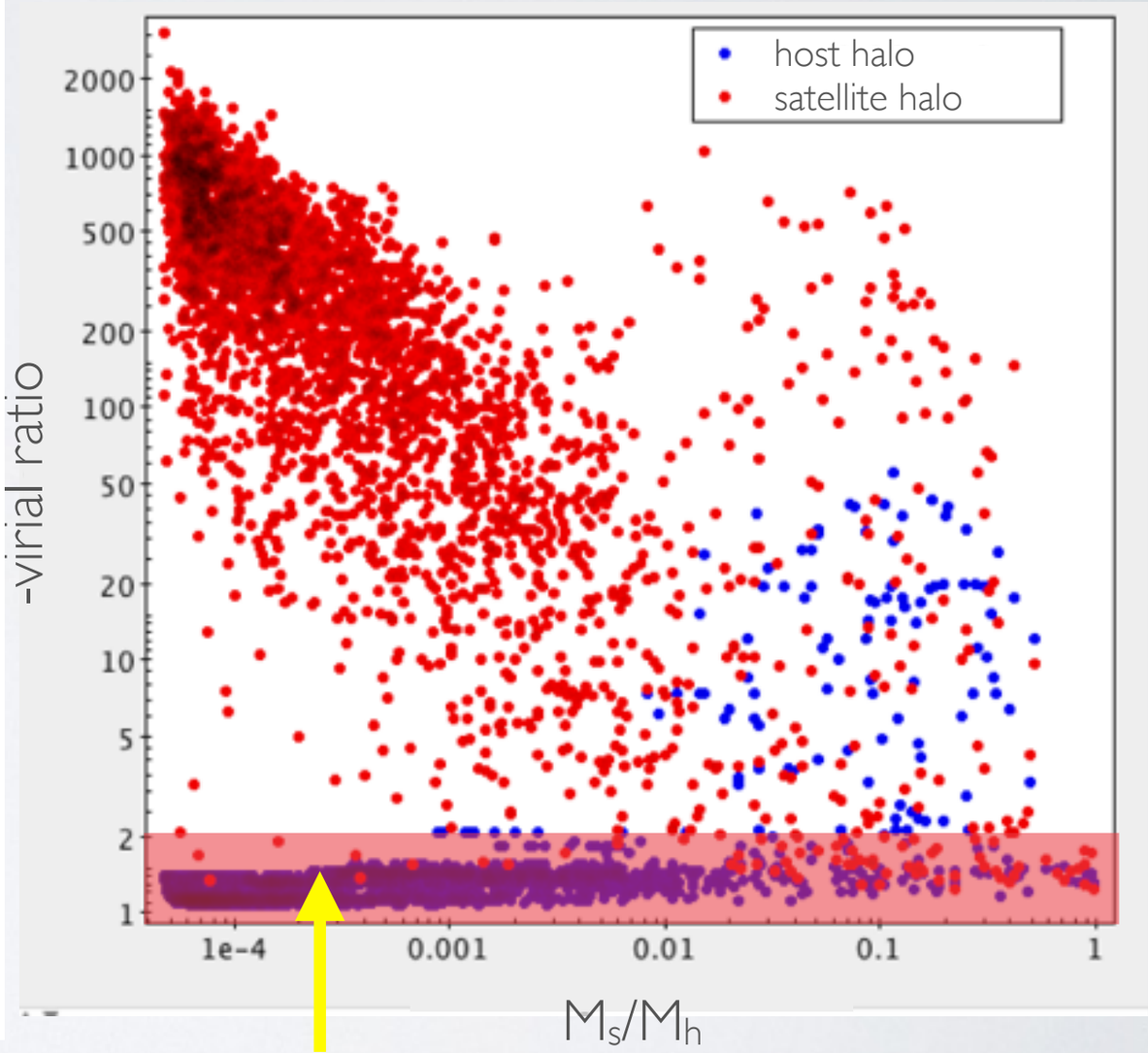
We first construct halo merger tree with FoF field halo catalog.

- problem : Many of FoF field halos are unvirilized, especially in clustered region.

virial ratio = -2K/P, unvirialized halo : viral ratio < -2



Cluster center



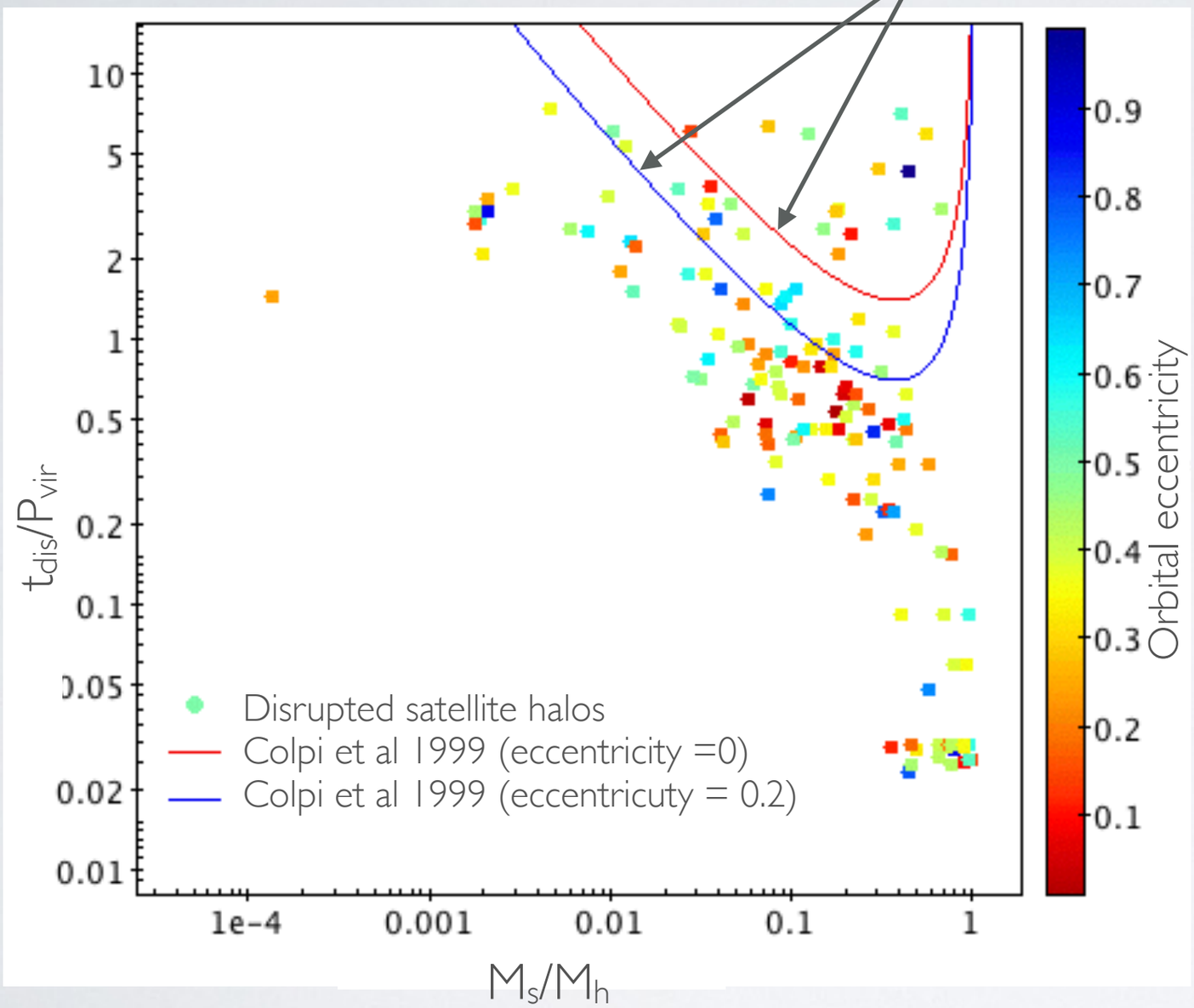
We choose only mergers with virialized halos.

M_s/M_h : mass ratio of satellite and host halos

FoF HALO MERGER TREES

Predicted disruption timescale
by dynamical friction (Colpi et al. 1999)

$$t_{\rm dis} = \frac{k}{f_m} \frac{M_{\rm h}/M_{\rm s}}{\ln(M_{\rm h}/M_{\rm s})} \epsilon^{\alpha} \frac{P_{\rm vir}}{2\pi},$$



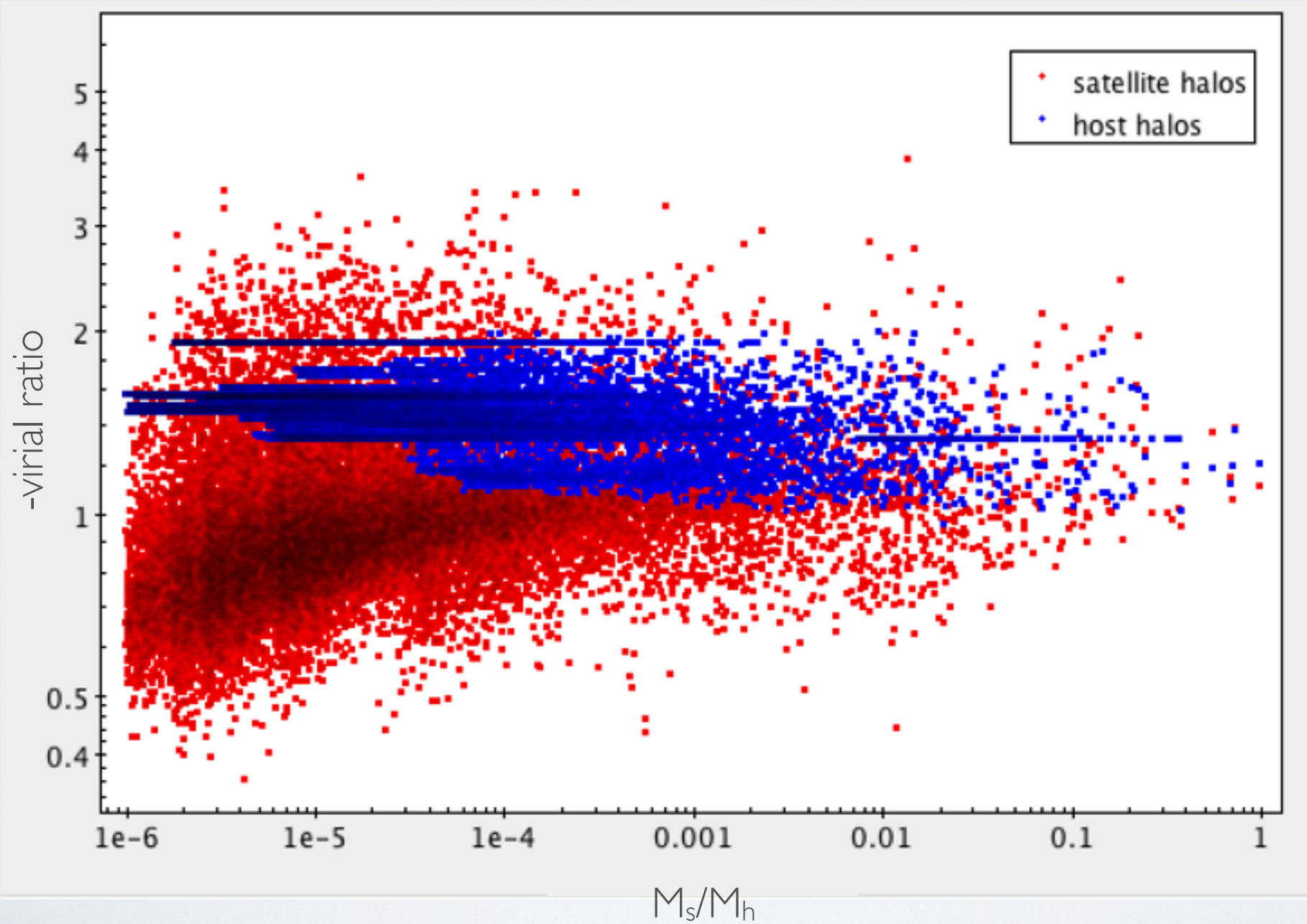
T_{dis}/P_{vir} : disruption timescale normalized by dynamical time

- Measured disruption timescale is slightly shorter than predicted timescale by dynamical friction of Colpi et al. (1999).
- Disruption timescale is not a function of orbital eccentricity.
- What is the other effects that shorten the disruption timescale?
  : major mergers, triaxial shape

AHF HALO MERGER TREES

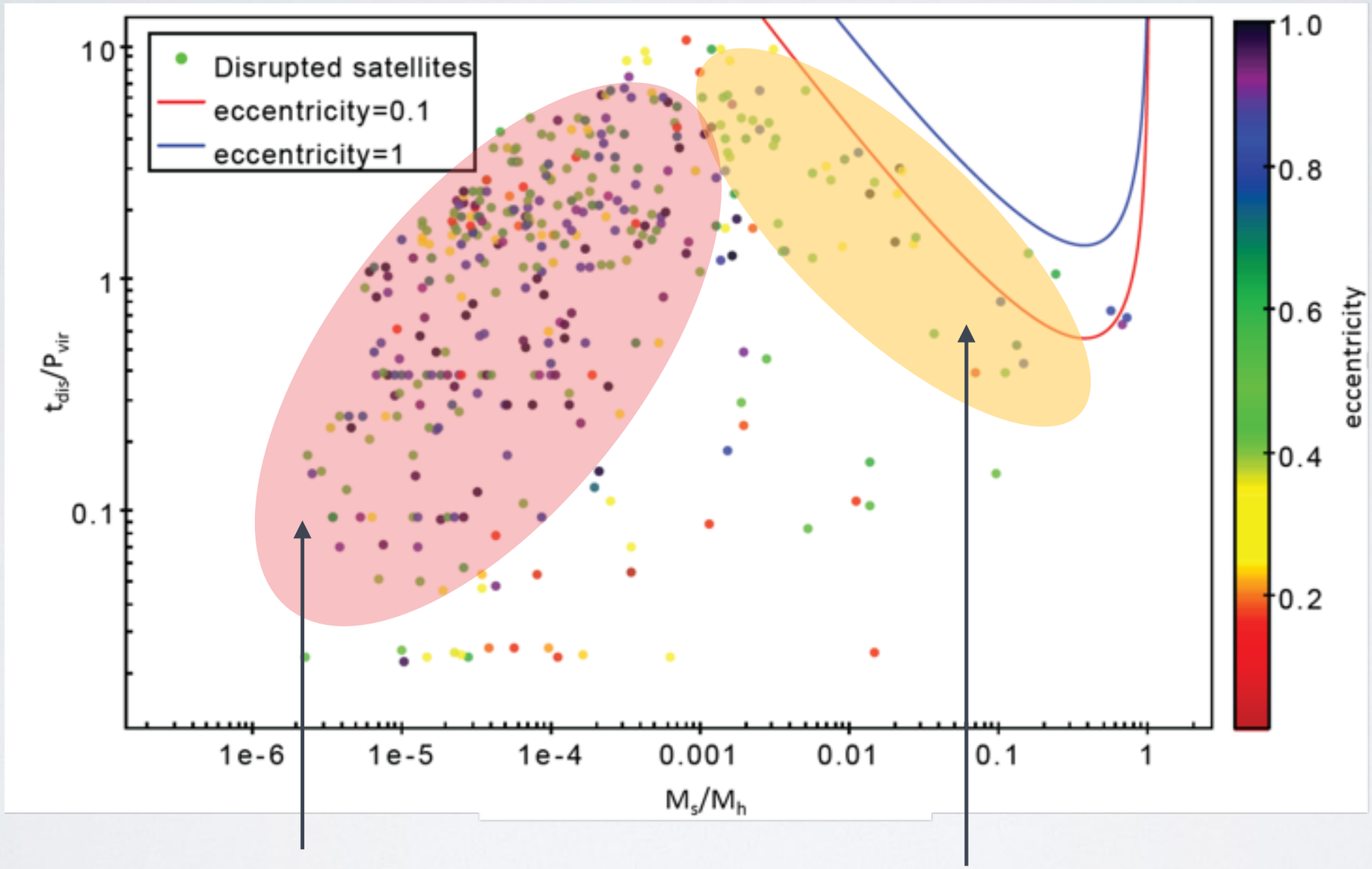
We construct halo merger tree with AHF (Amiga Halo Finder; Knollmann & Knebe, 2009) field halo catalog.

: AHF -> remove unbound particles



AHF HALO MERGER TREES

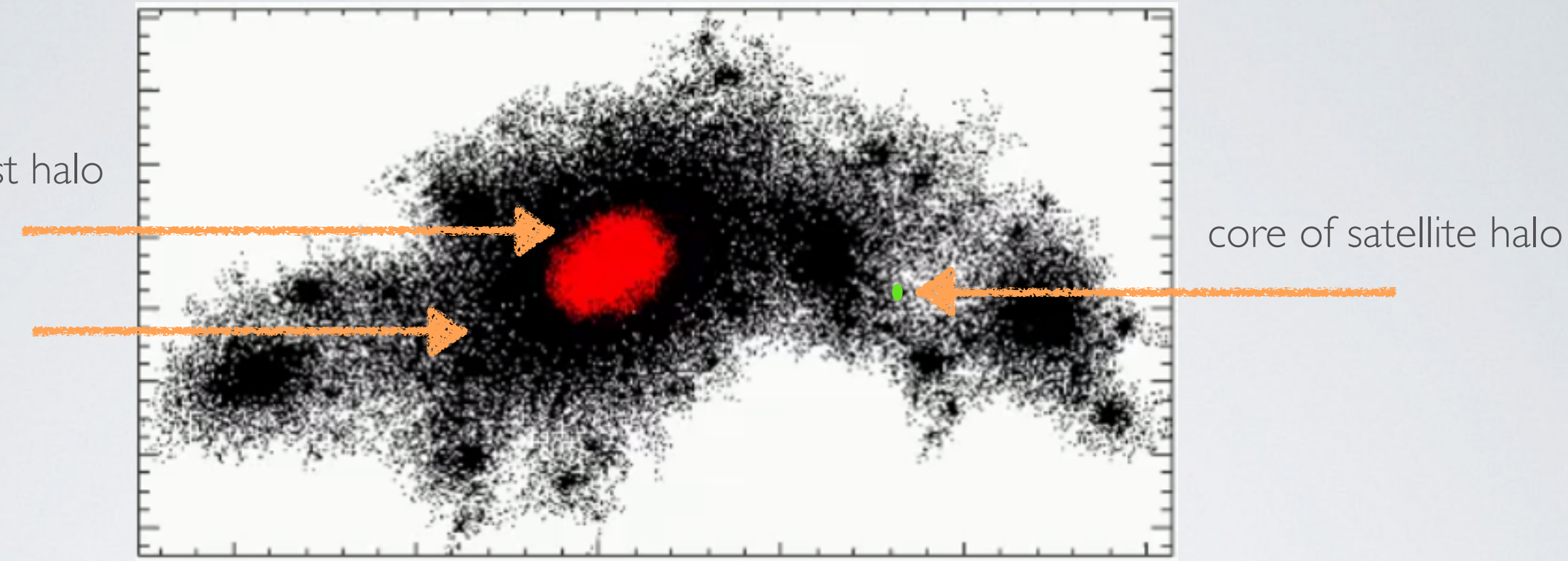
scaled disruption time Vs. Ms/Mh



Low M_s/M_h mergers: Dynamical friction is not the major effect to disrupt. Lower M_s/M_h mergers tend to be more quickly disrupted.

High M_s/M_h mergers: Dynamical friction is the major effect to disrupt. Overall timescale is slightly shorter than that of Colpi et al. (1999).

FUTURE WORKS



Which effects shorten the disruption timescale of satellites?

1) dynamical friction for high-mass satellites
2) major merging events for low-mass satellites.

-> quantifying the effects -> making the more realistic pruning criteria -> constructing sub-halo mass function for a virgo cluster -> assigning each galaxy mass

HALO PROPERTIES & ACCRETION HISTORY

Halo shape changes during major mergers.