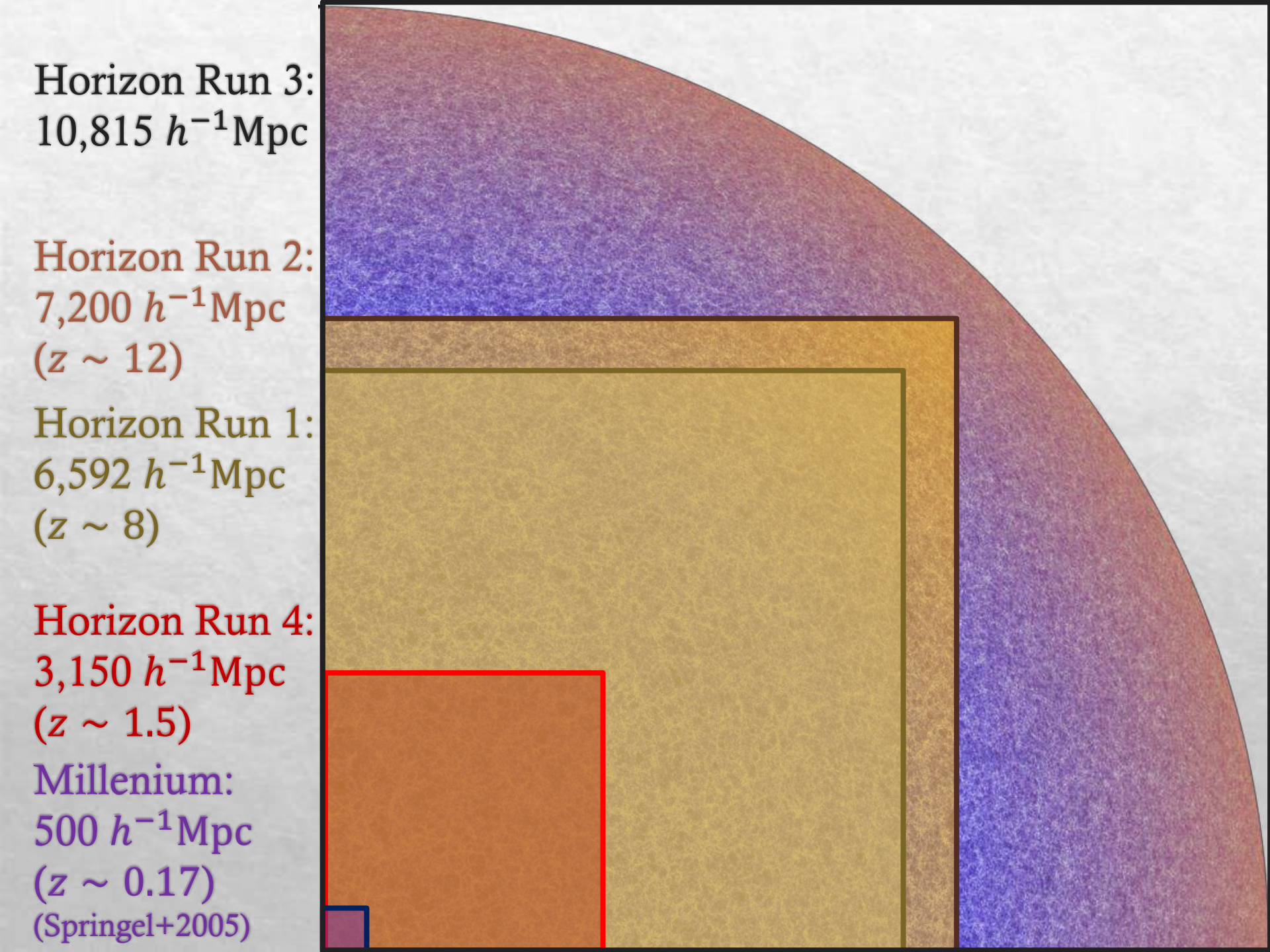
Mock Galaxy Catalogs from the Horizon Run 4 Simulation with the Most Bound Particle – Galaxy Correspondence Method

Sungwook E. Hong

with Changbom Park & Juhan Kim; ApJ **823**, 103 (2016)

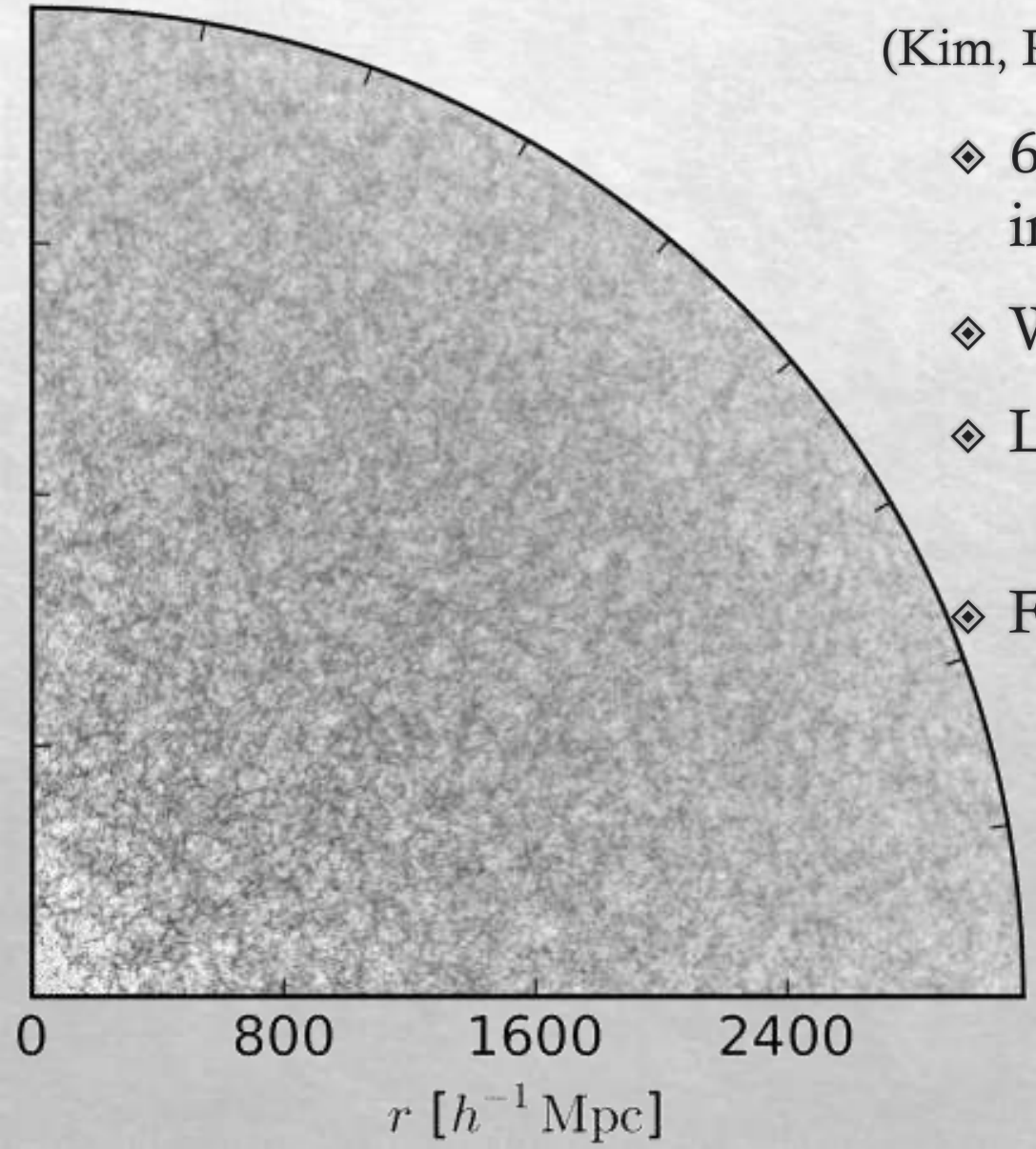
@ 7th KIAS Workshop on Cosmology & Galaxy Formation, Nov. 2th, 2016

KIAS KOREA INSTITUTE FOR ADVANCED STUDY

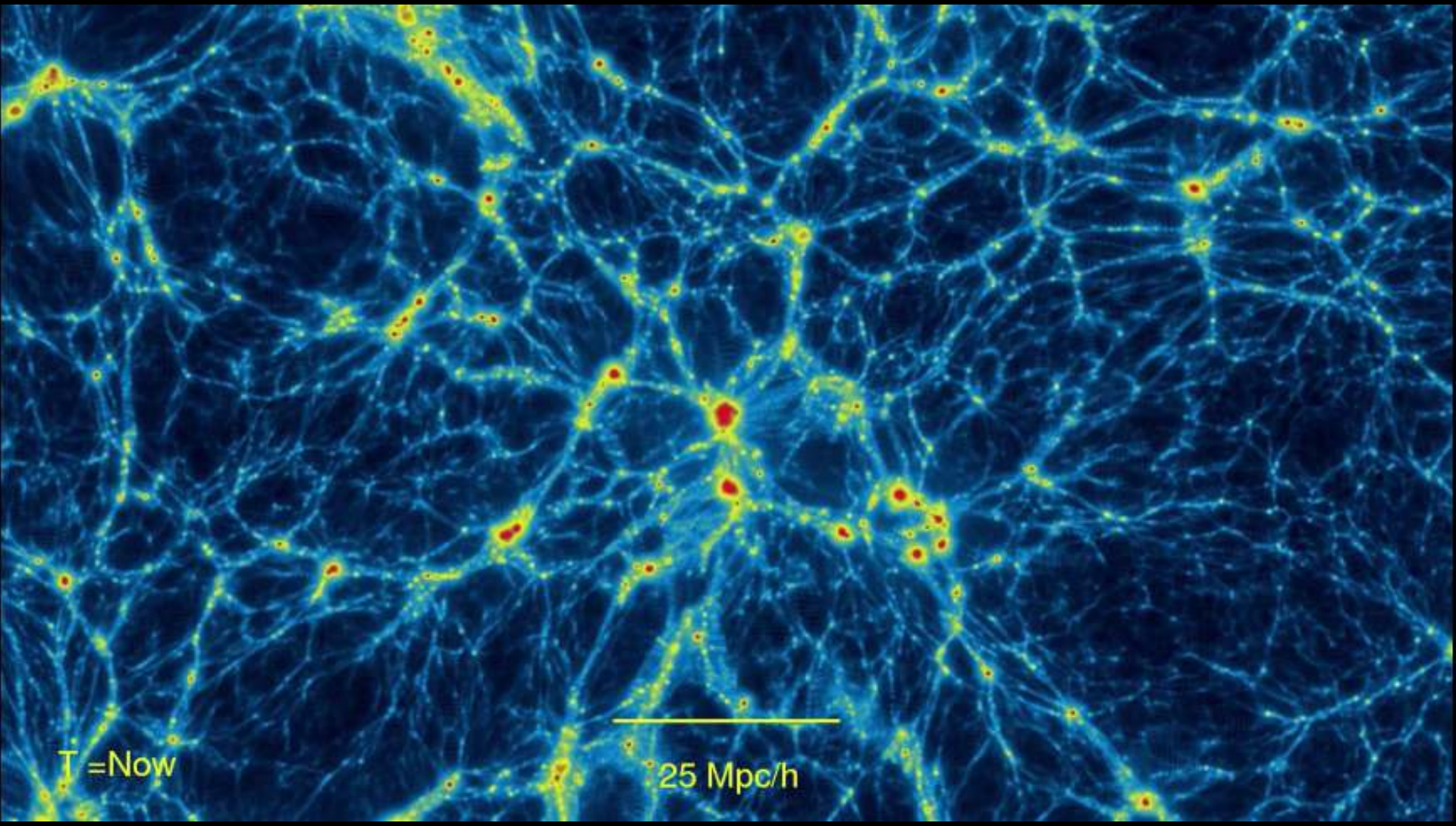

Horizon Run 3:
10,815 h^{-1}Mpc
Horizon Run 2:
7,200 h^{-1}Mpc
($z \sim 12$)
Horizon Run 1:
6,592 h^{-1}Mpc
($z \sim 8$)
Horizon Run 4:
3,150 h^{-1}Mpc
($z \sim 1.5$)
Millenium:
500 h^{-1}Mpc
($z \sim 0.17$)
(Springel+2005)

Horizon Run 4 Simulation

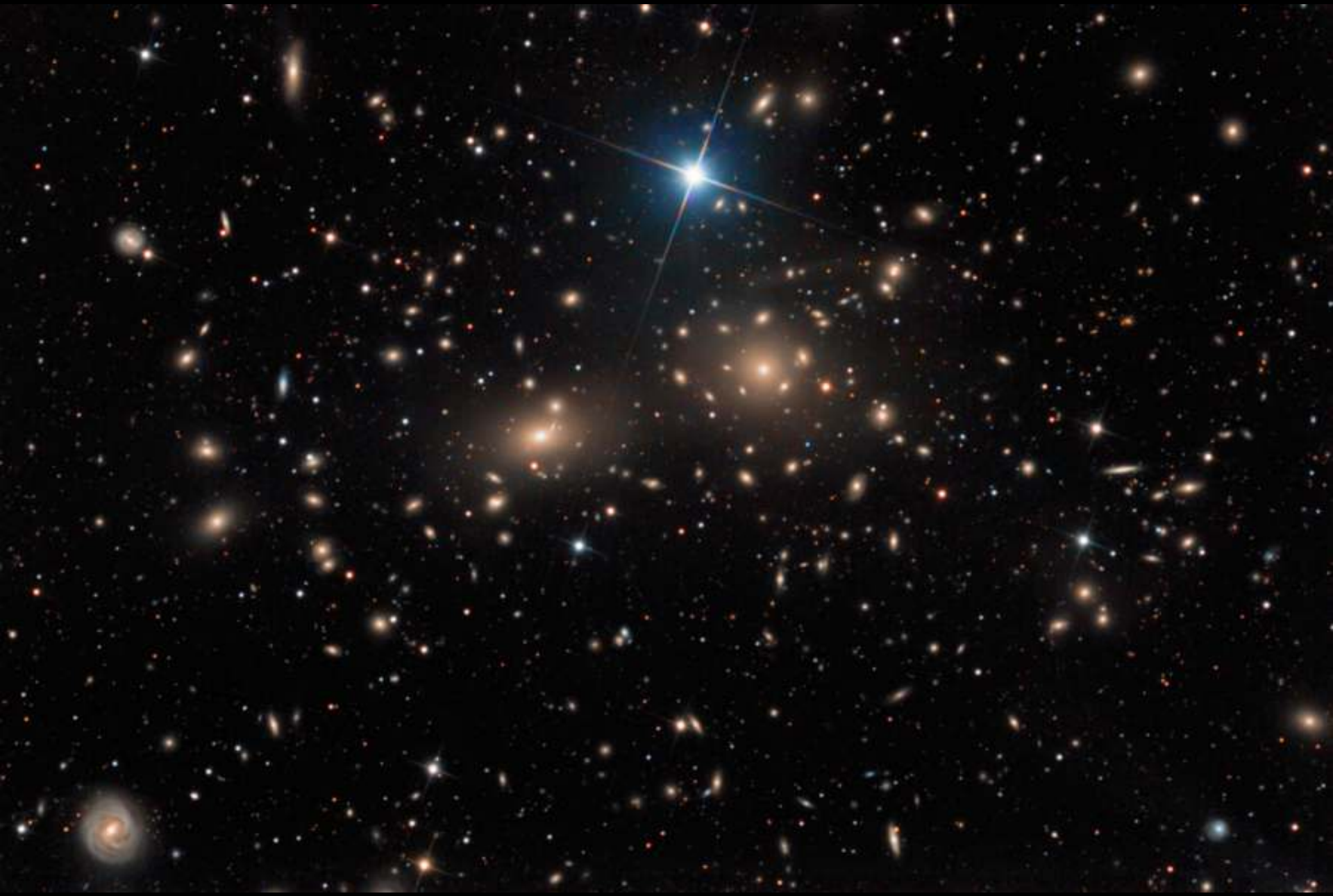
(Kim, Park, L'Huillier & **SEH**, 2015)



- $6{,}300^3$ DM particles in $3{,}150h^{-1}$Mpc box
- WMAP5 ΛCDM cosmology
- Lowest halo mass: $2.7 \times 10^{11}\ h^{-1}M_{\odot}$
- Full-sky lightcone up to $z = 1.5$

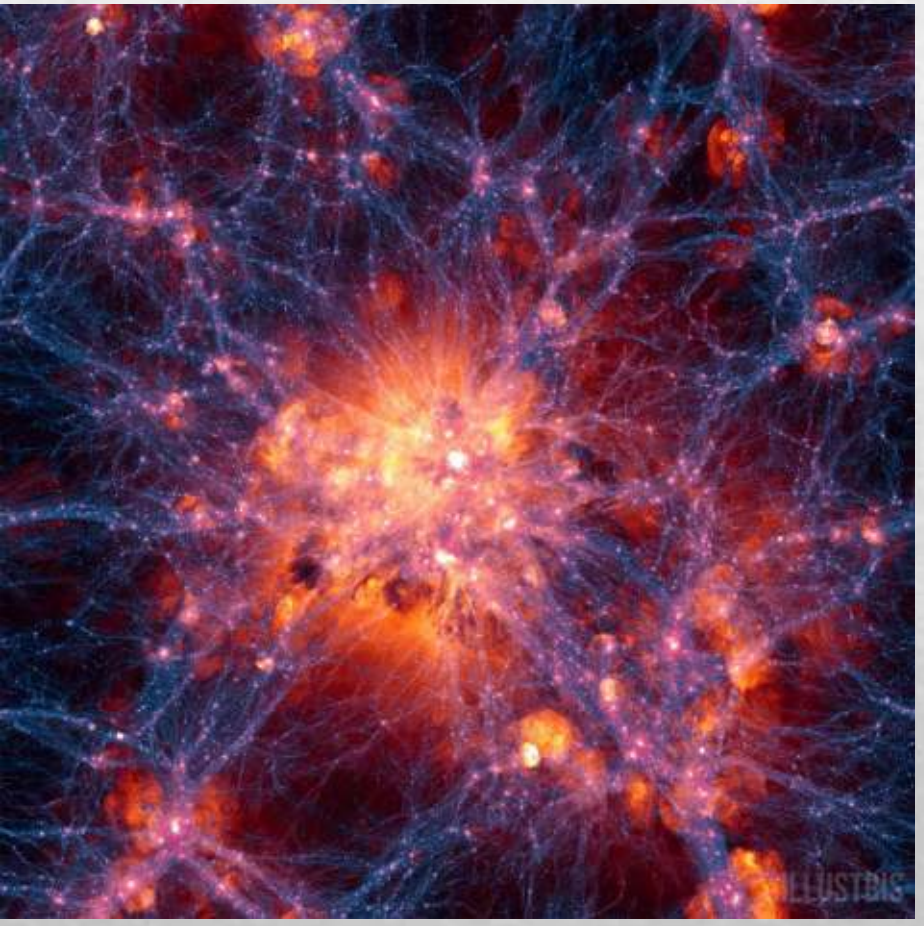


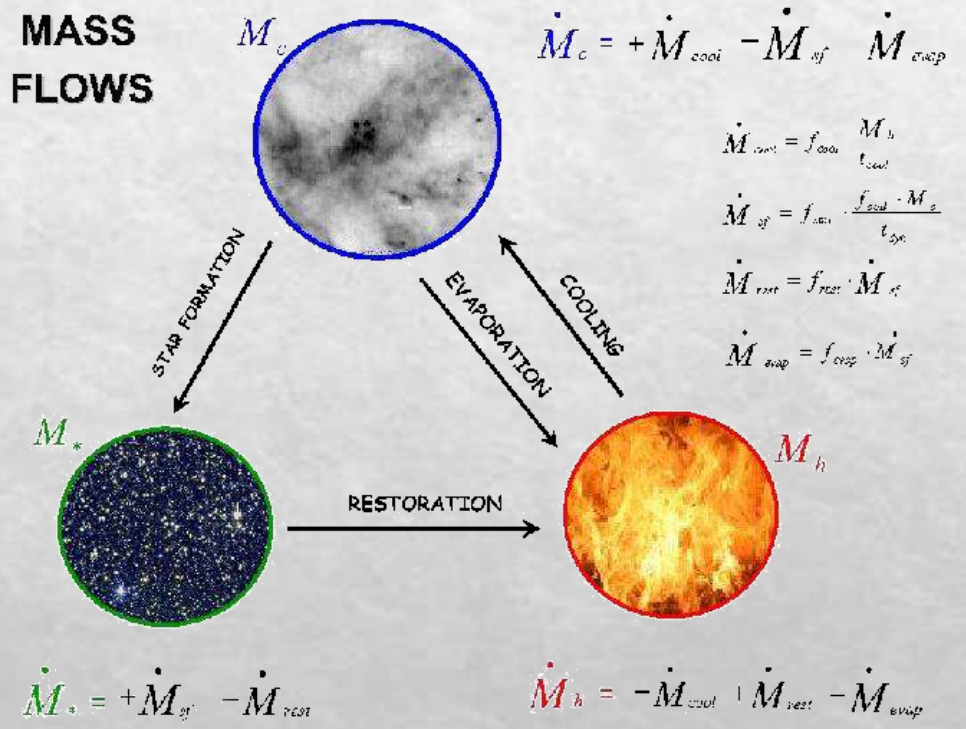
(Horizon Run 4; Kim+ 2015)



(Abell 1656; taken by Bob Franke)

How to Simulate Galaxies?

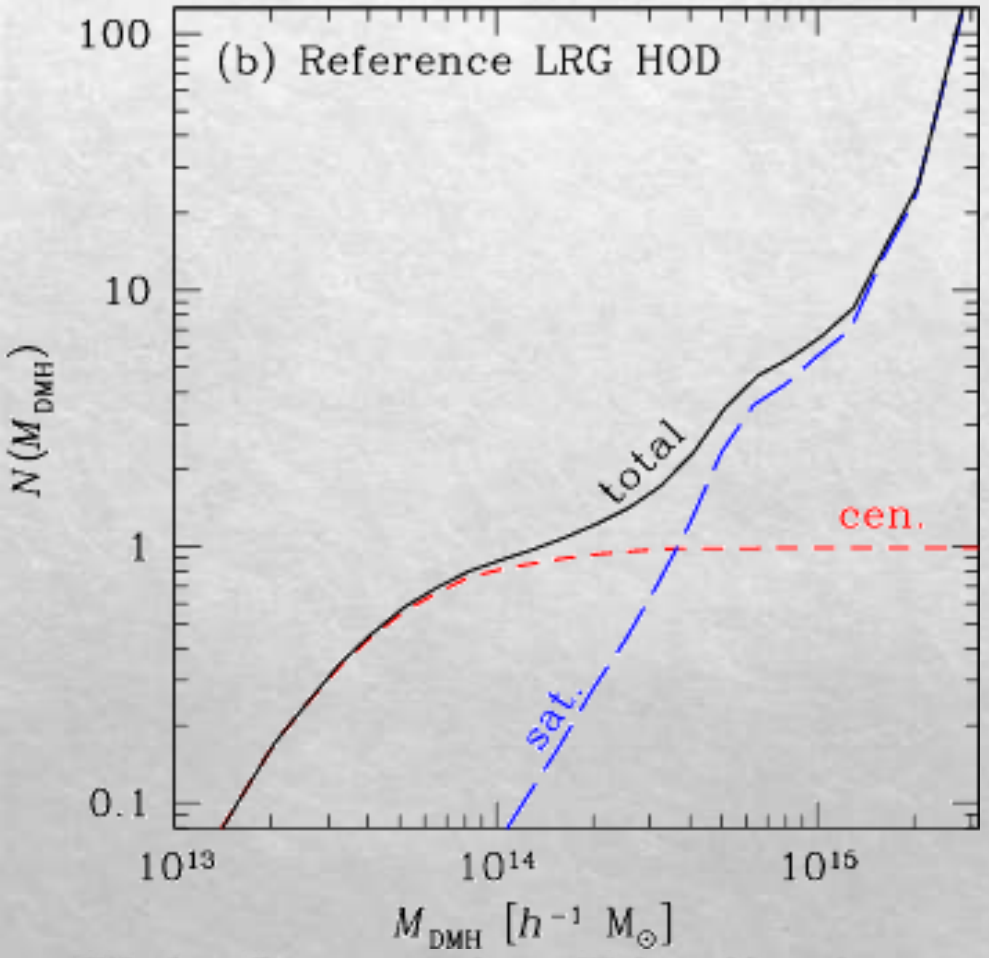




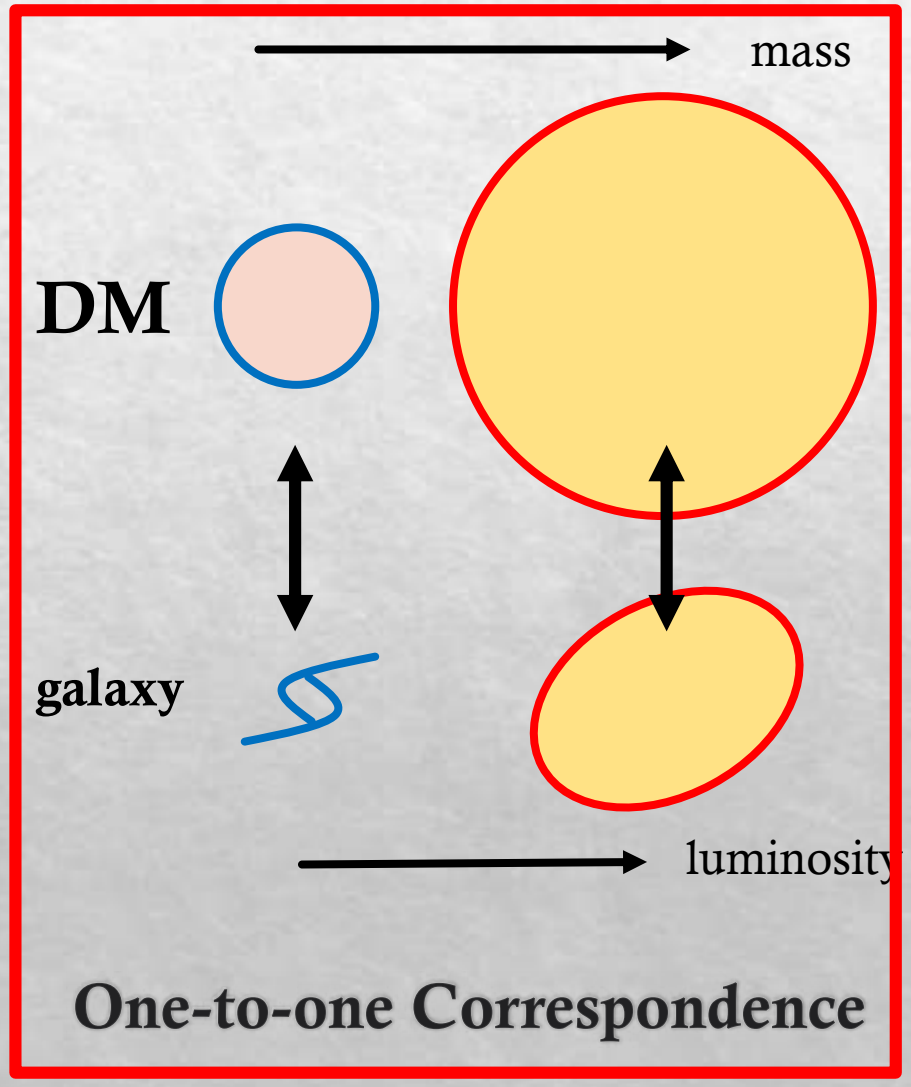
Hydrodynamic Simulations
(Illustris; Vogelsberger+2014)

Semi-Analytic Model
(MUPPI; Monaco+2004)

How to Simulate Galaxies?

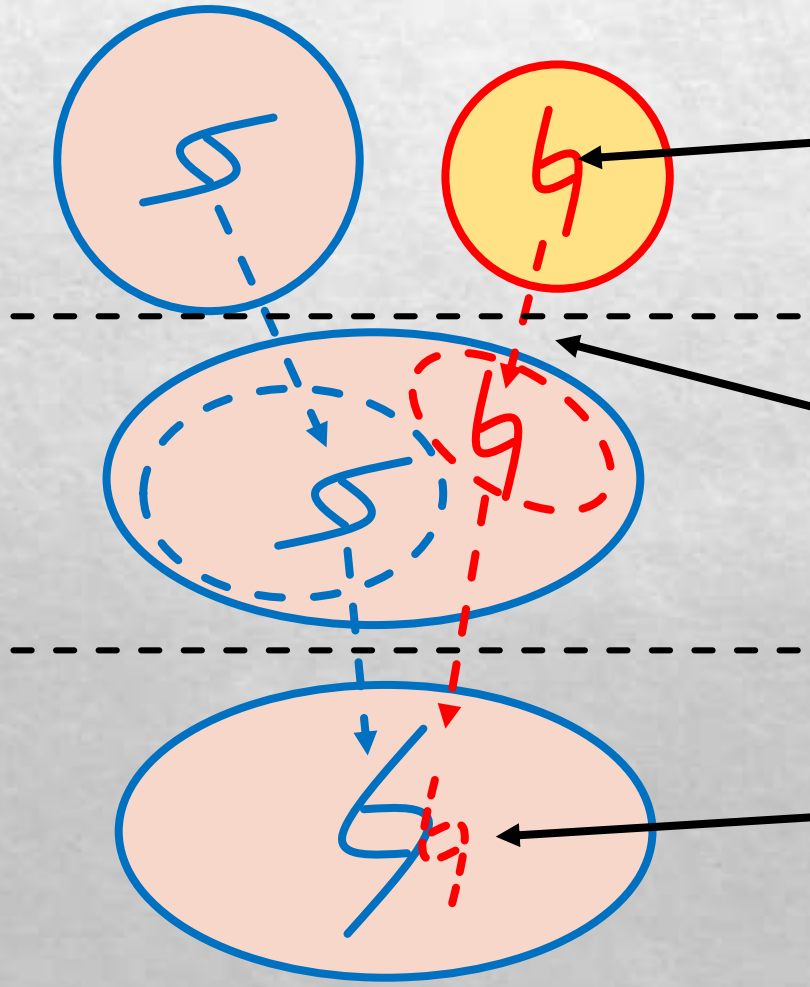


Halo Occupation Distribution
(Takamitsu+2011)



One-to-one Correspondence

Traditional One-to-one Correspondence: Subhalo-Galaxy



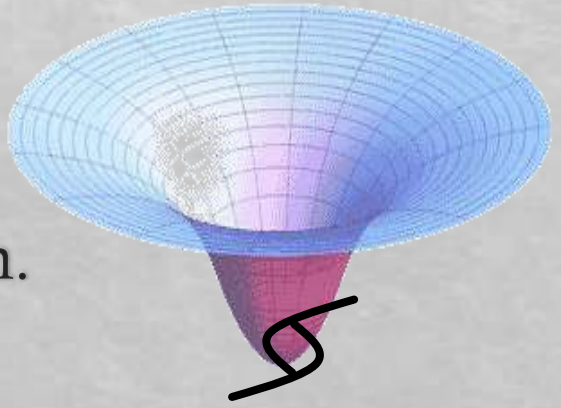
Galaxy position/velocity
= position/velocity of subhalo

Stellar mass of satellites:
more related to infall mass
than the current halo mass
(e.g. Nagai & Kravtsov 2005)

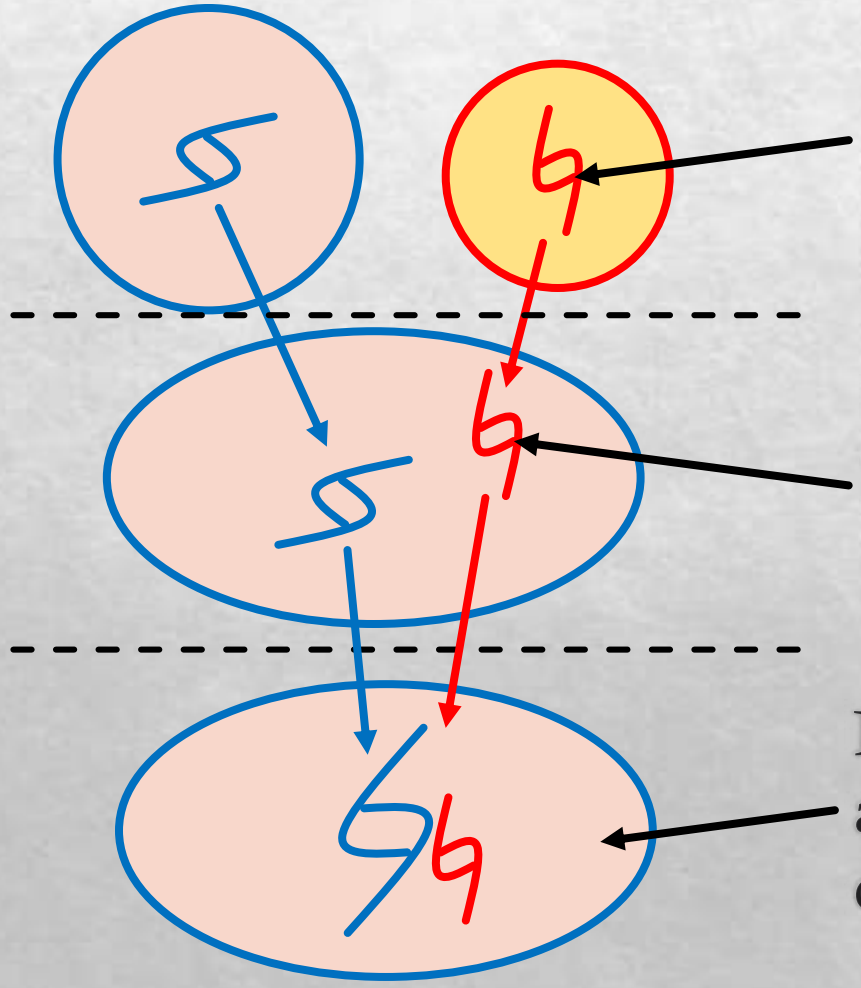
May not detect satellites
close to halo center
or *orphan* galaxies

Subhalo → Most Bound Particle (MBP)

- MBP: gravitationally most bound member particle of a halo (widely adopted in SAMs)
- MBPs can represent galaxies well because galaxies are compact and likely to be near the halo's potential well.
- Monitoring MBPs is easier than finding subhalos and linking them through merging tree.
- MBP could be found near the host center, even in simulations with a bit low resolution.



New One-to-one Correspondence: MBP-Galaxy



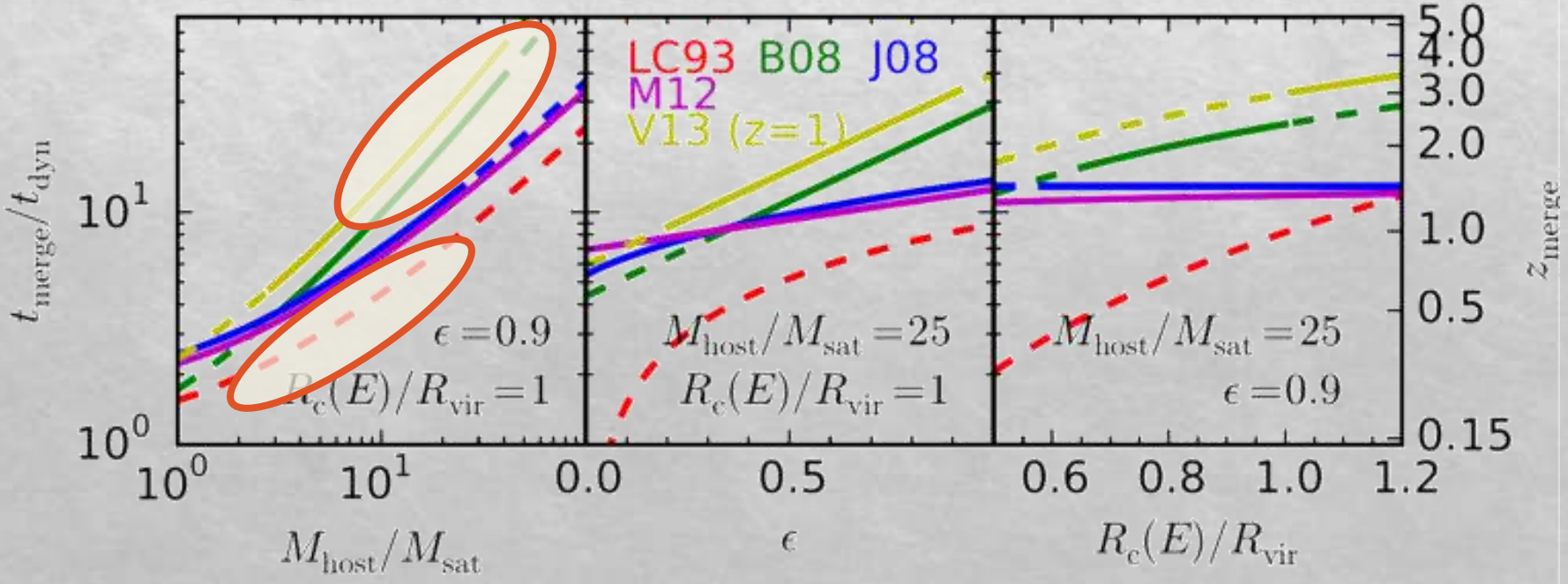
Galaxy position/velocity
= position/velocity of MBP

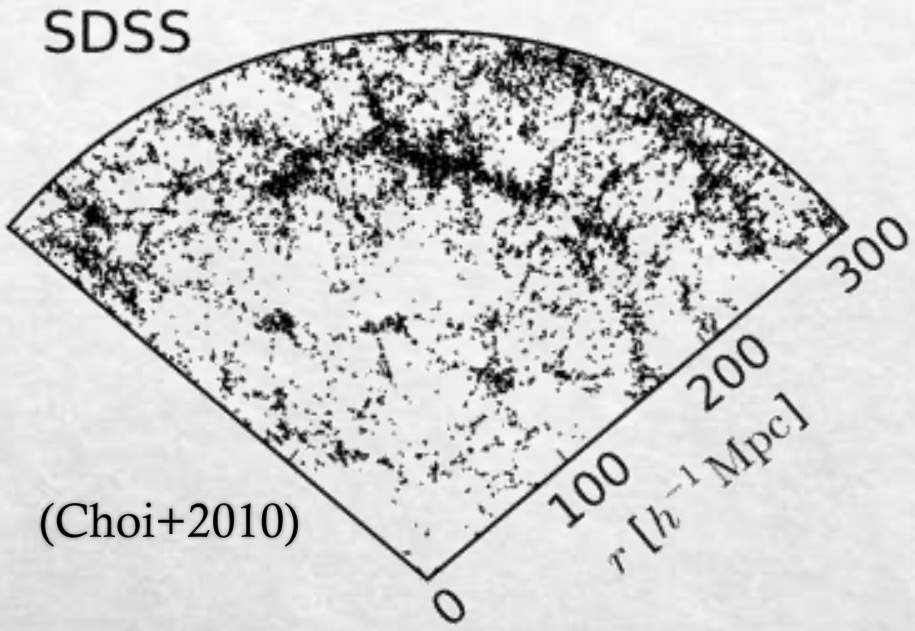
Monitor the MBP even after the infall, by using infall mass as stellar mass proxy

Merger timescale is additionally calculated:
close satellites could be resolved

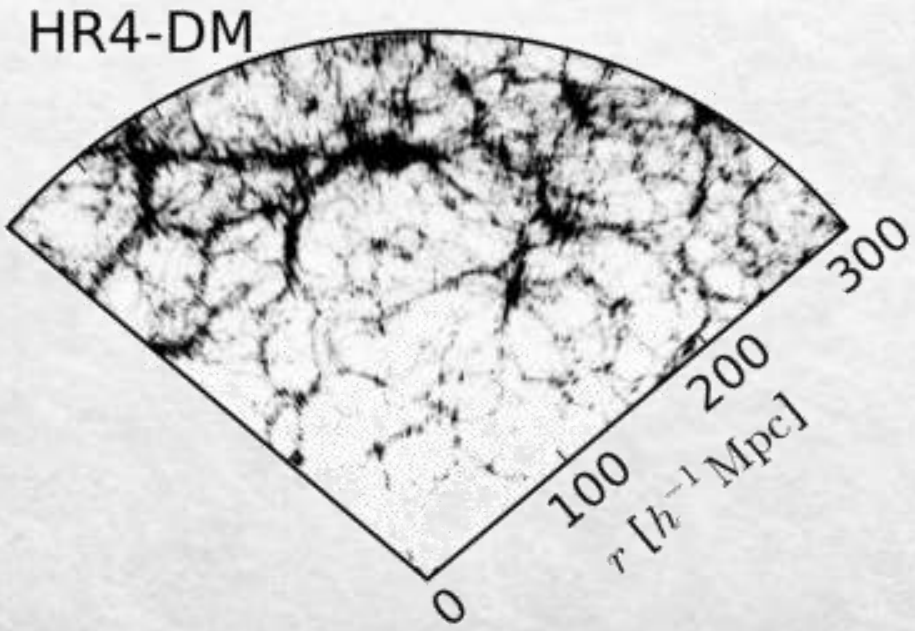
Models on Merger Timescale

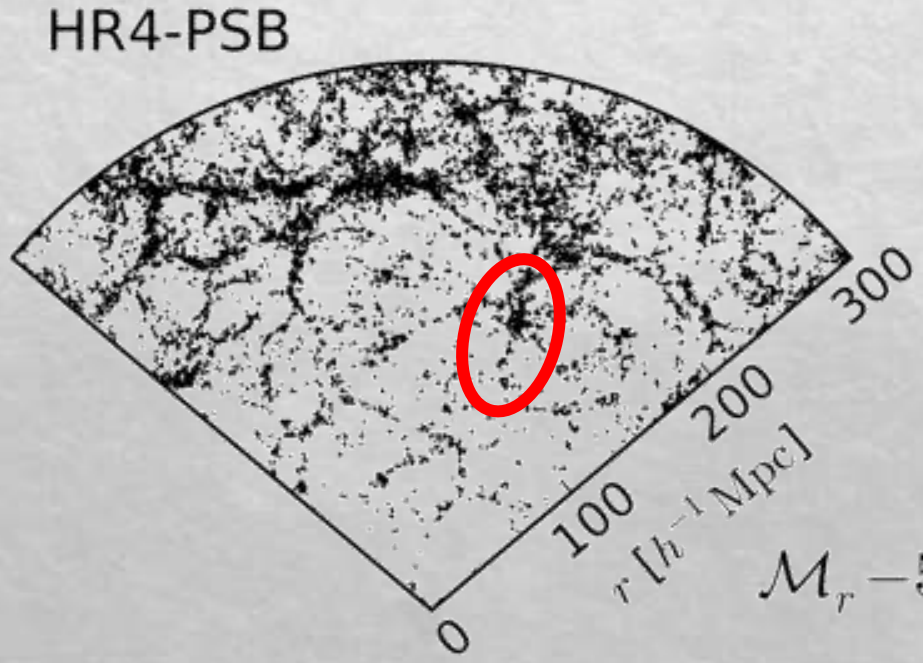
- Isothermal analytic model: LC93 (Lacey & Cole 1993)
- Isolated galaxy/halo simulations:
  B08 (Boylan-Kolchin, Ma & Qataert 2008), V13 (Villalobos+2013)
- Cosmological simulations:
  J08 (Jiang+2008), M12 (McCavana+2012)

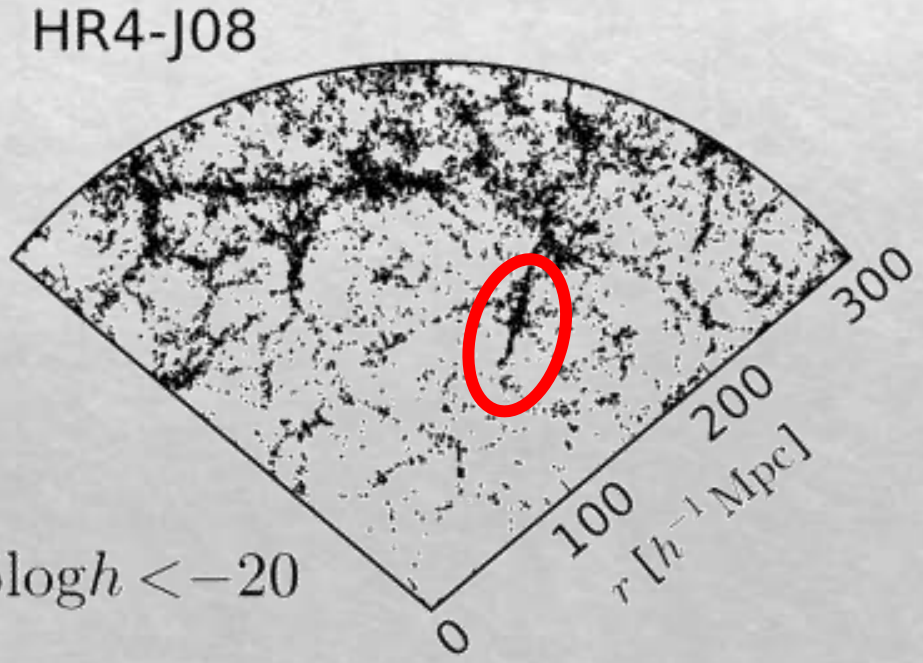




(Choi+2010)





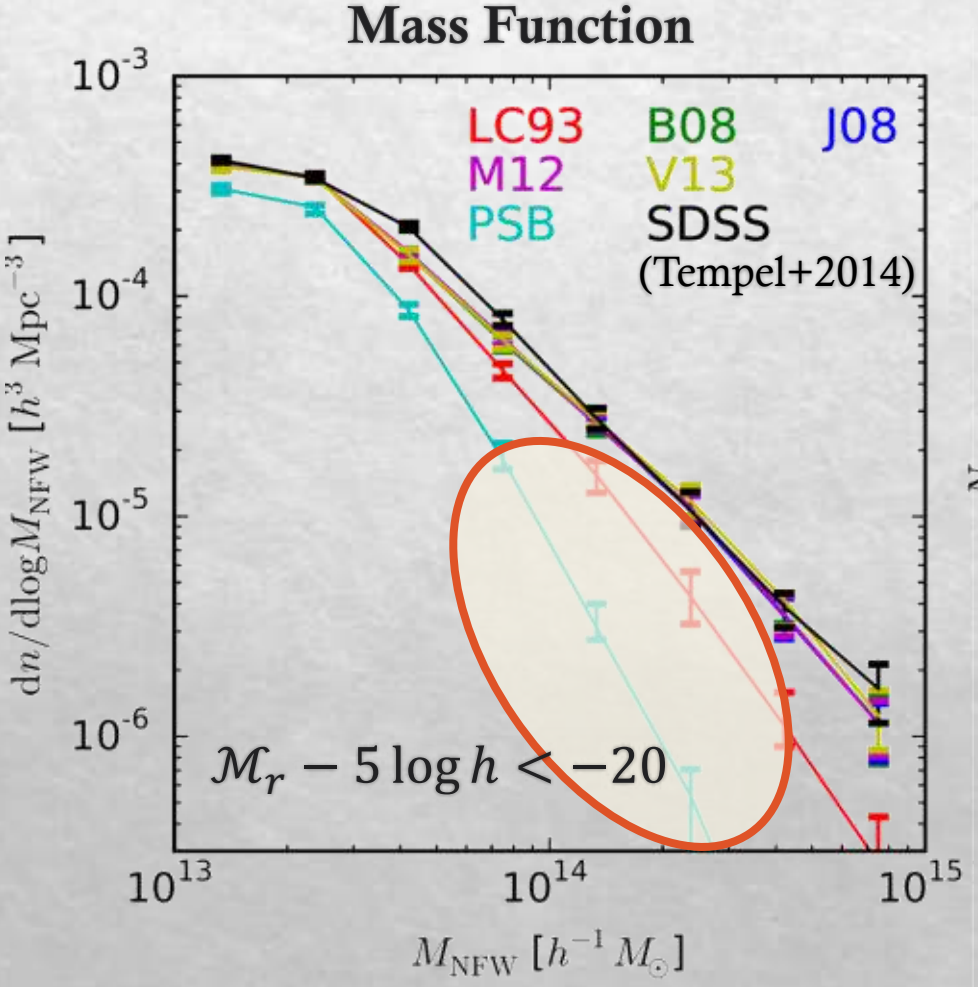


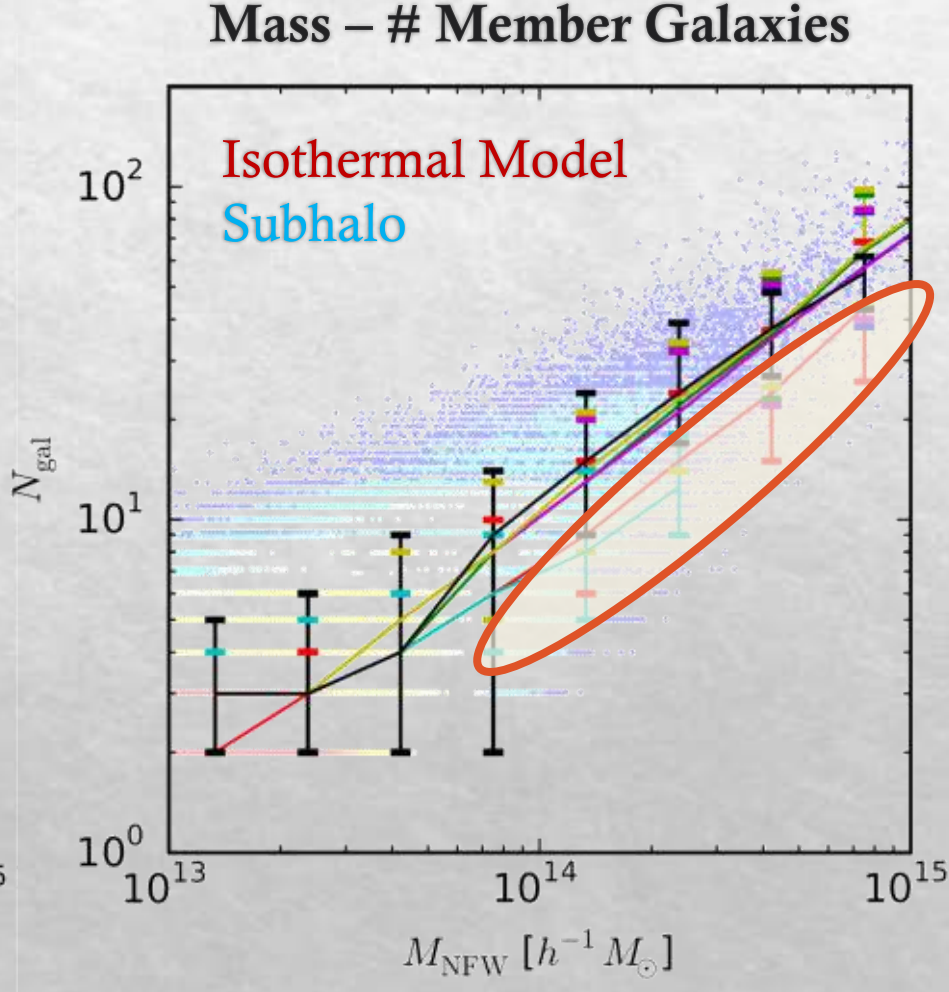
$\mathcal{M}_r - 5\log h < -20$

Subhalo

MBP + merger timescale

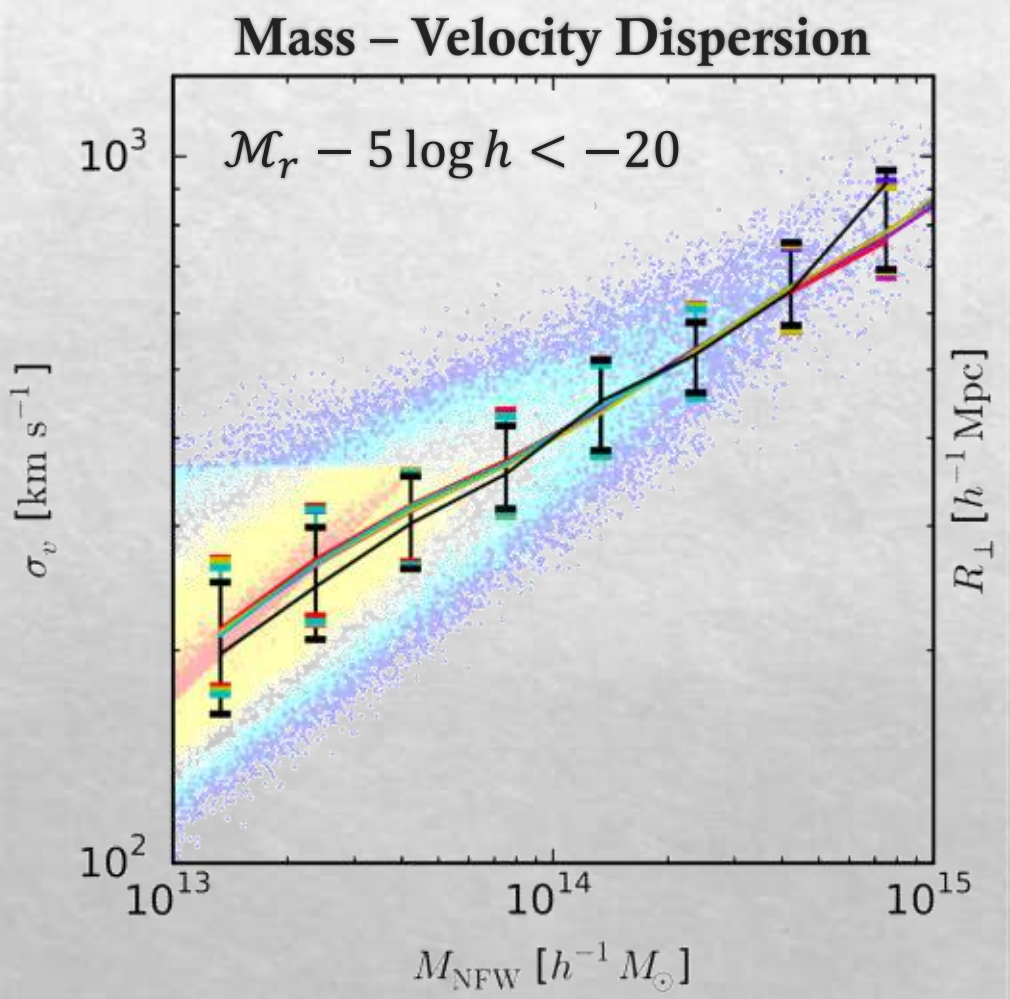
Galaxy Group Properties @ $z = 0$

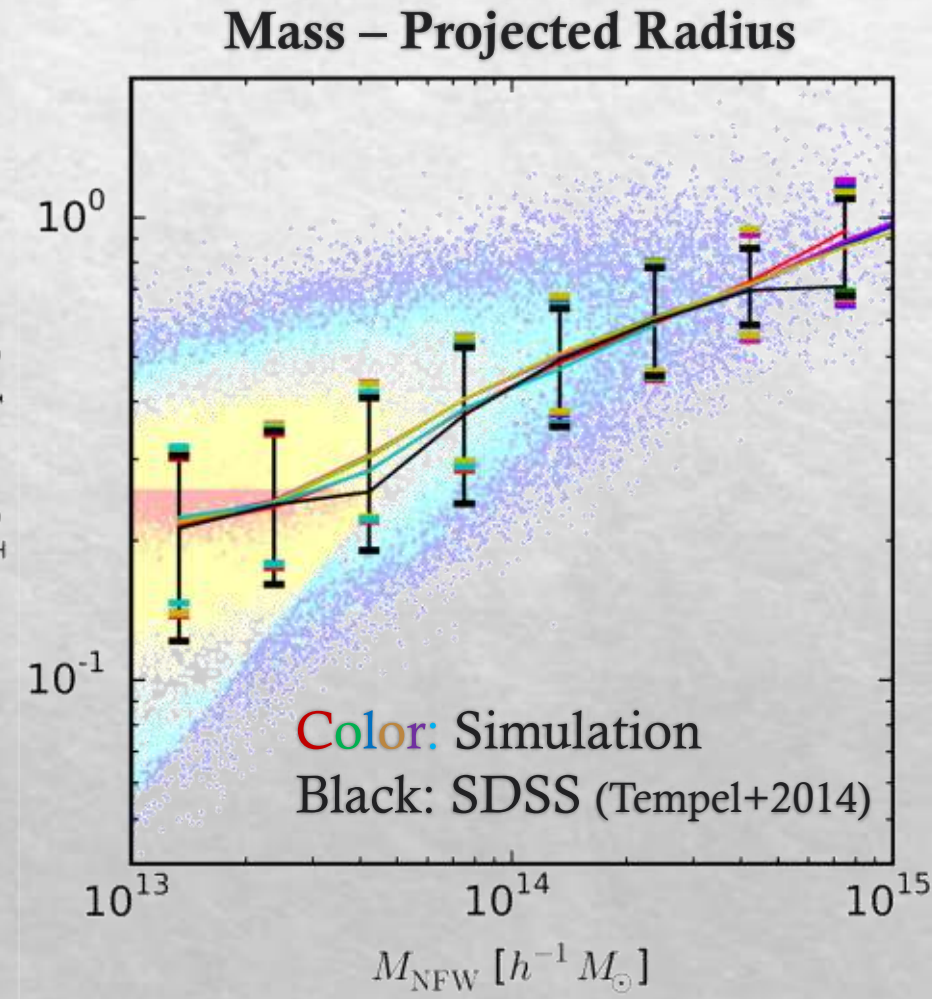




FoF galaxy-group mass from velocity dispersion & projected radius

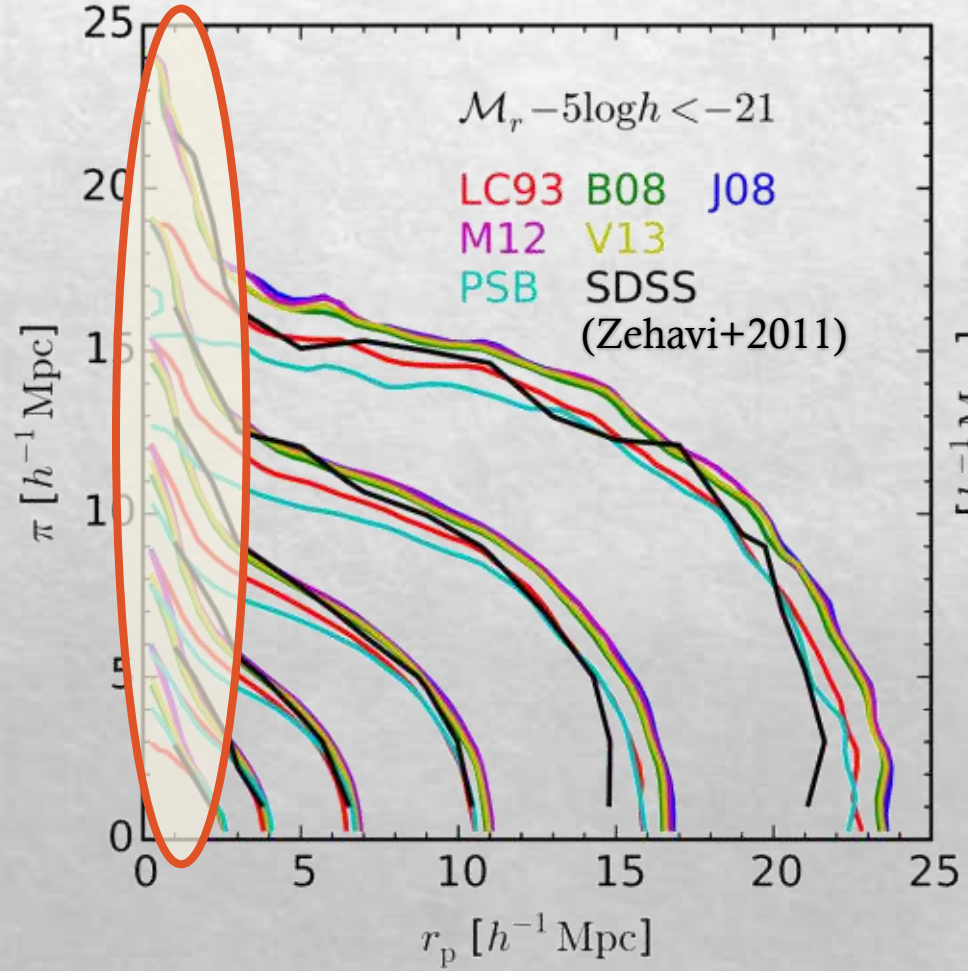
Galaxy Group Properties @ $z = 0$

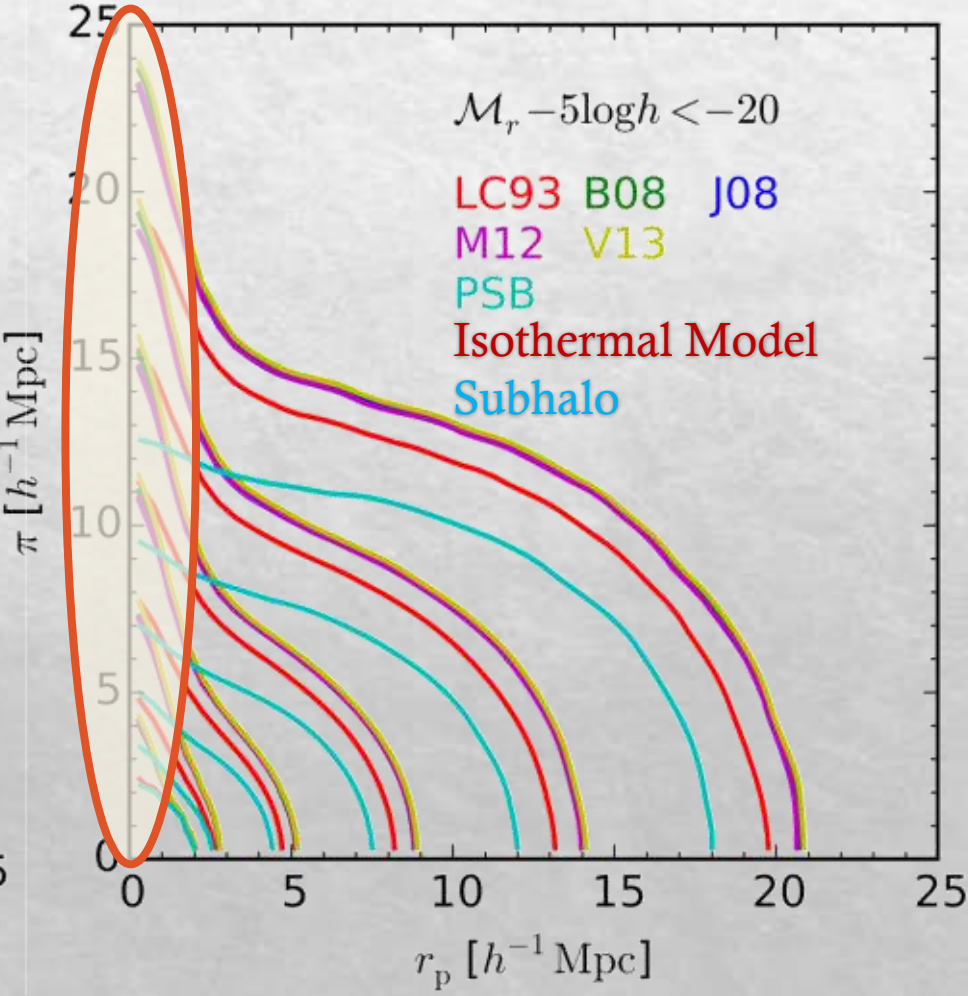




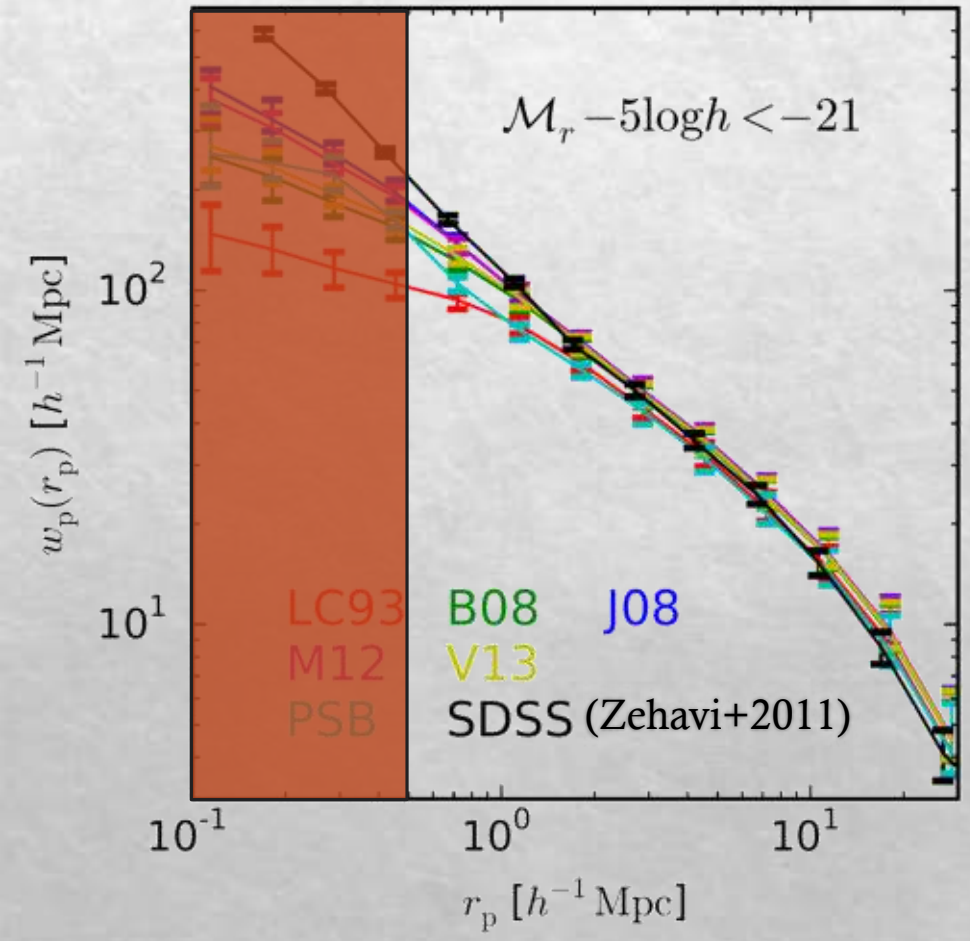
FoF galaxy-group mass from velocity dispersion & projected radius

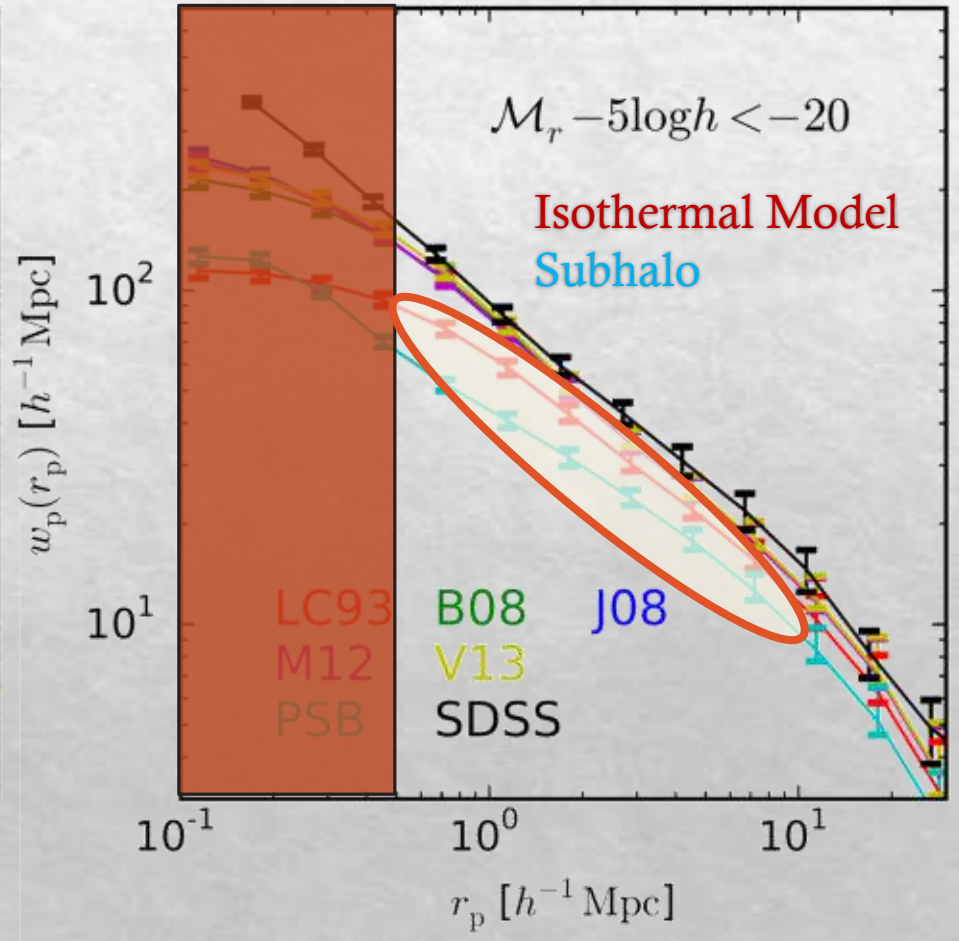
Two-Point Correlation Function @ $z = 0$



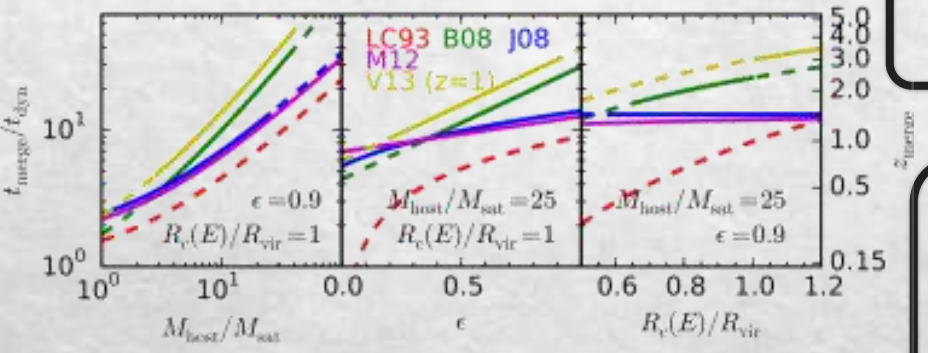


Two-Point Correlation Function @ $z = 0$





What Leads the Disagreement in the Isothermal Analytic Merger Timescale Model?



Short Merger Timescale

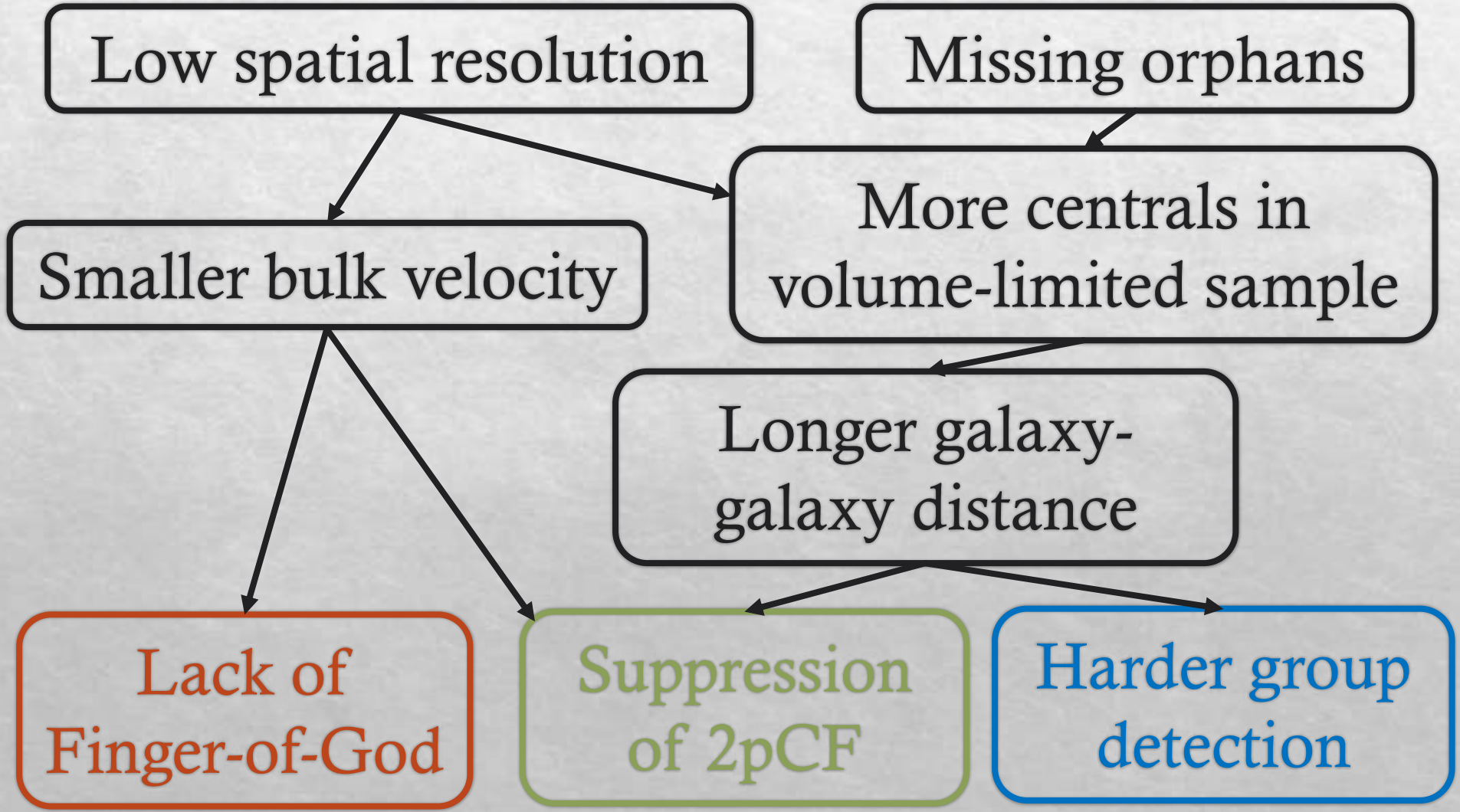
More centrals in volume-limited sample

Longer galaxy-galaxy distance

Suppression of 2pCF

Harder group detection

What Leads the Disagreement in the Subhalo-Galaxy Correspondence Model?



Summary

- We applied one-to-one correspondence model by using the gravitationally most bound member particle

- Our new method can resolve satellites close to host center better than traditional subhalo-galaxy correspondence model, and hence reproduce better Finger-of-God effect.

- Galaxy-group properties and two-point correlation function @ $z = 0$ match well with SDSS observations.

Can be applied to other studies!!!