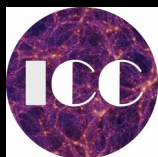


Missing dwarf galaxies around the Local Group

Fattahi, Navarro & Frenk 2019 (arxiv: 1907.02463)
and APOSTLE collaboration

Azadeh Fattahi

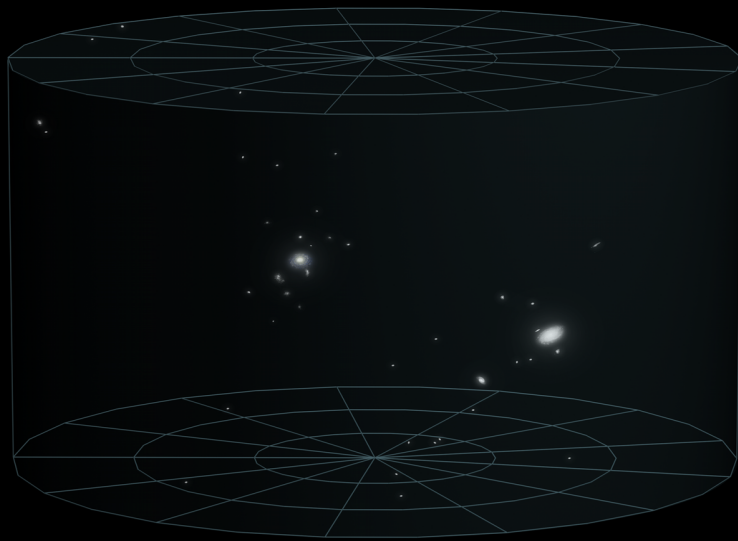
Institute for Computational Cosmology
Durham University, UK



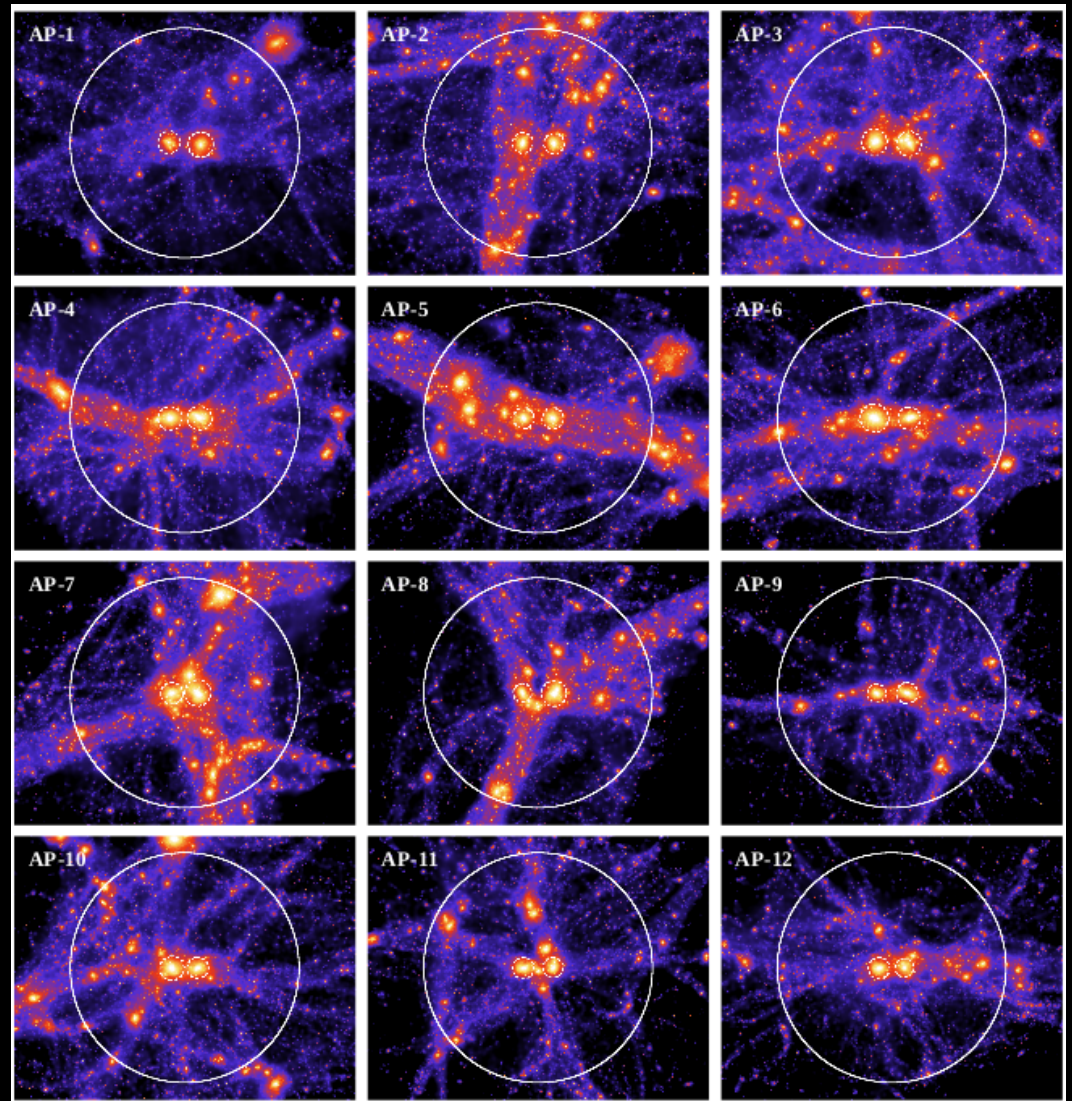
Background:
Stars and DM around a simulated Local Group
(Sawala et al. 2016, Fattahi et al. 2016)

Local Group beyond the MW and M31

Observed Local Group



APOSTLE Local Group simulations



Penarrubia & AF 2016

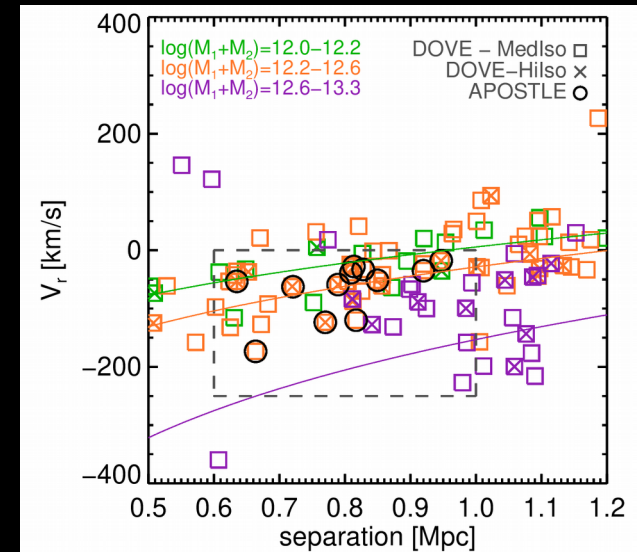
APOSTLE simulations

A Project Of Simulating The Local Environment

Zoom-in hydrodynamical simulations of **12 Local Group like environments** using **EAGLE** galaxy formation model (Sawala+2016, AF+2016)

LG like:

- Separation of MW-M31
- Relative radial and tangential velocity
- Mass of MW+M31
- Hubble flow



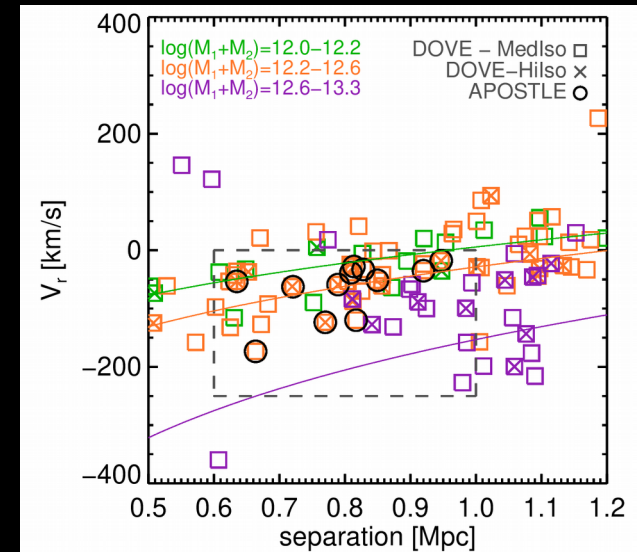
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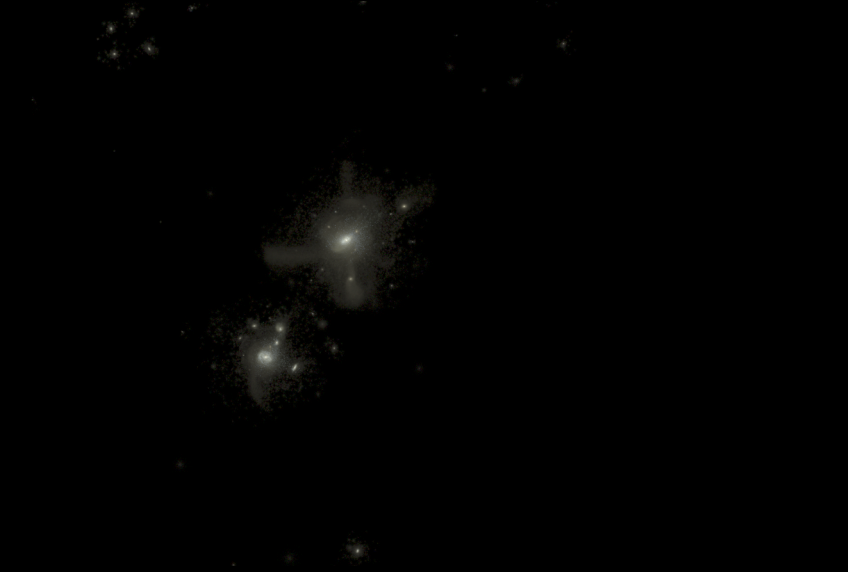
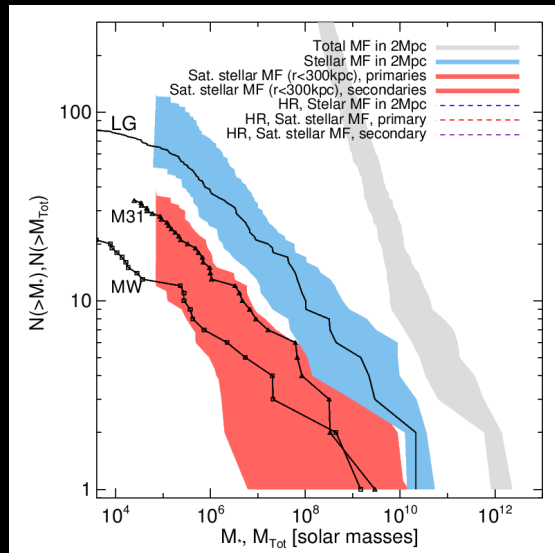
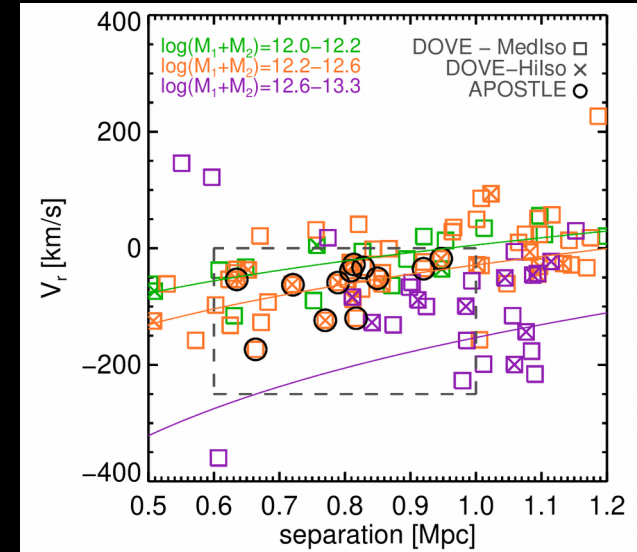
APOSTLE simulations

A Project Of Simulating The Local Environment

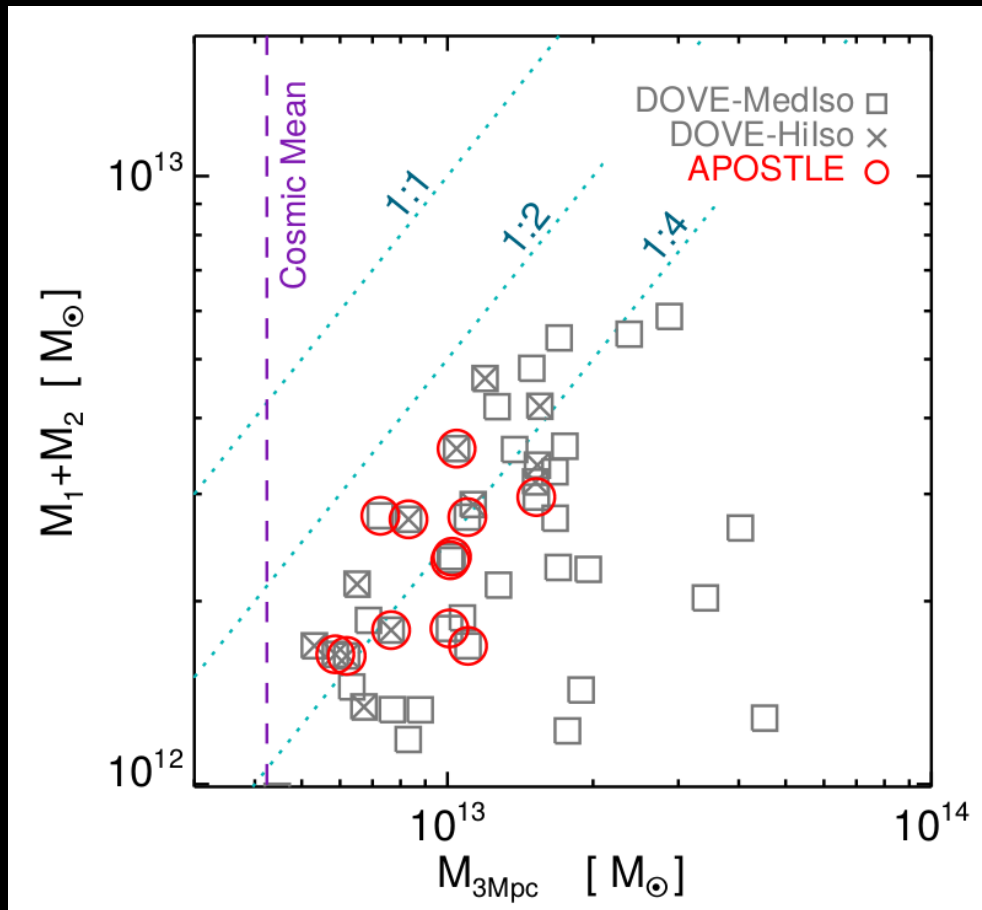
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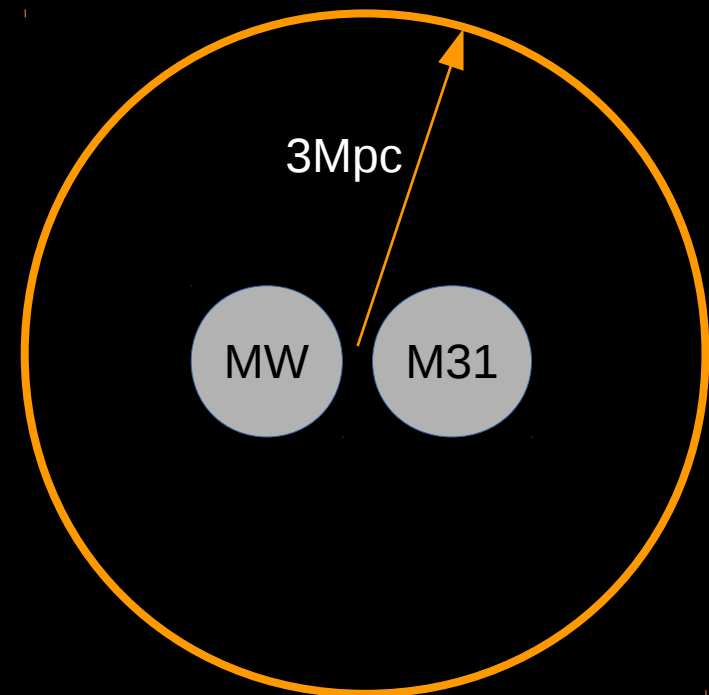
Local Group beyond the MW and M31



Total mass within 3Mpc

Local Group-like pairs from
DOVE N-body simulation:

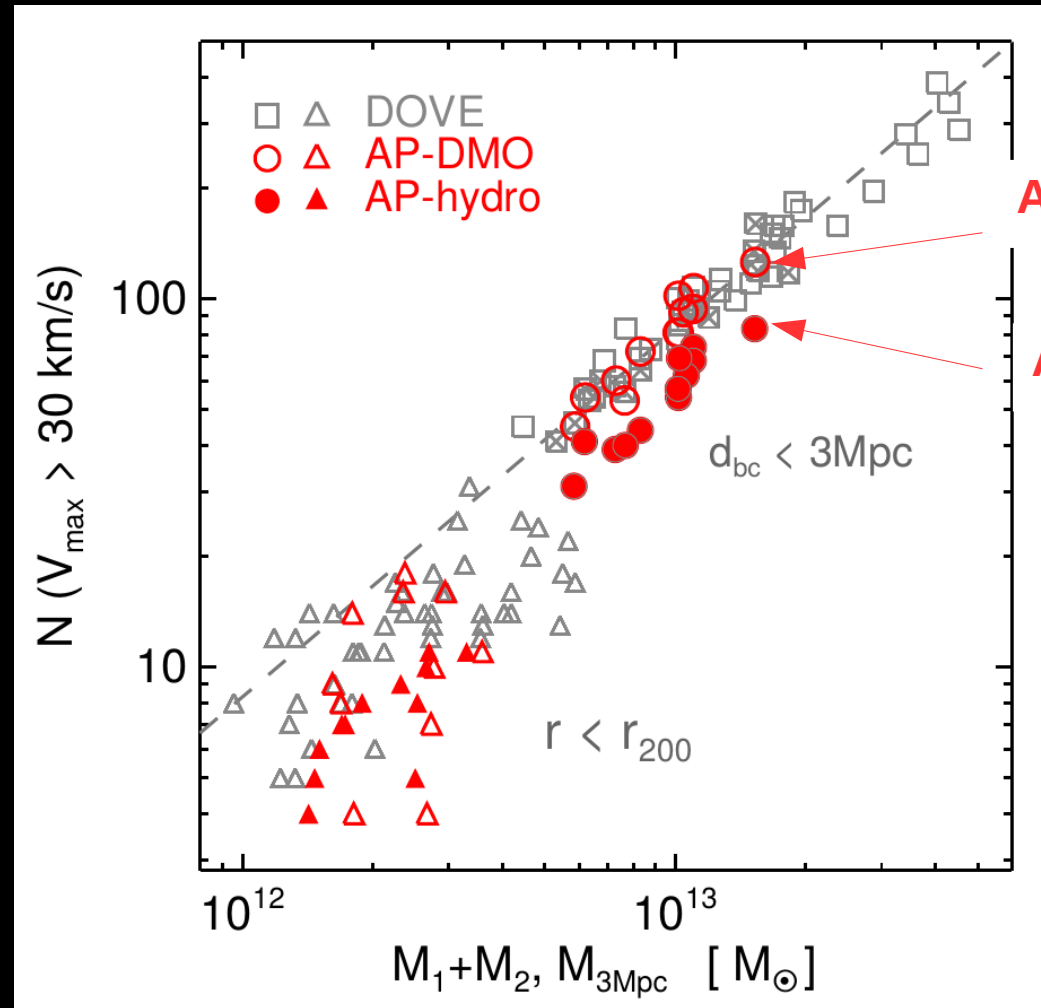
Mass within 3Mpc is $\sim 3\text{-}4\times$ the
virial masses of the main halos.



Local Group beyond the MW and M31

Total mass within 3Mpc and substructures

- Tight correlation between total mass and the number of substructures
- Reduction in number of (sub)structures in hydro runs compared to DMO runs

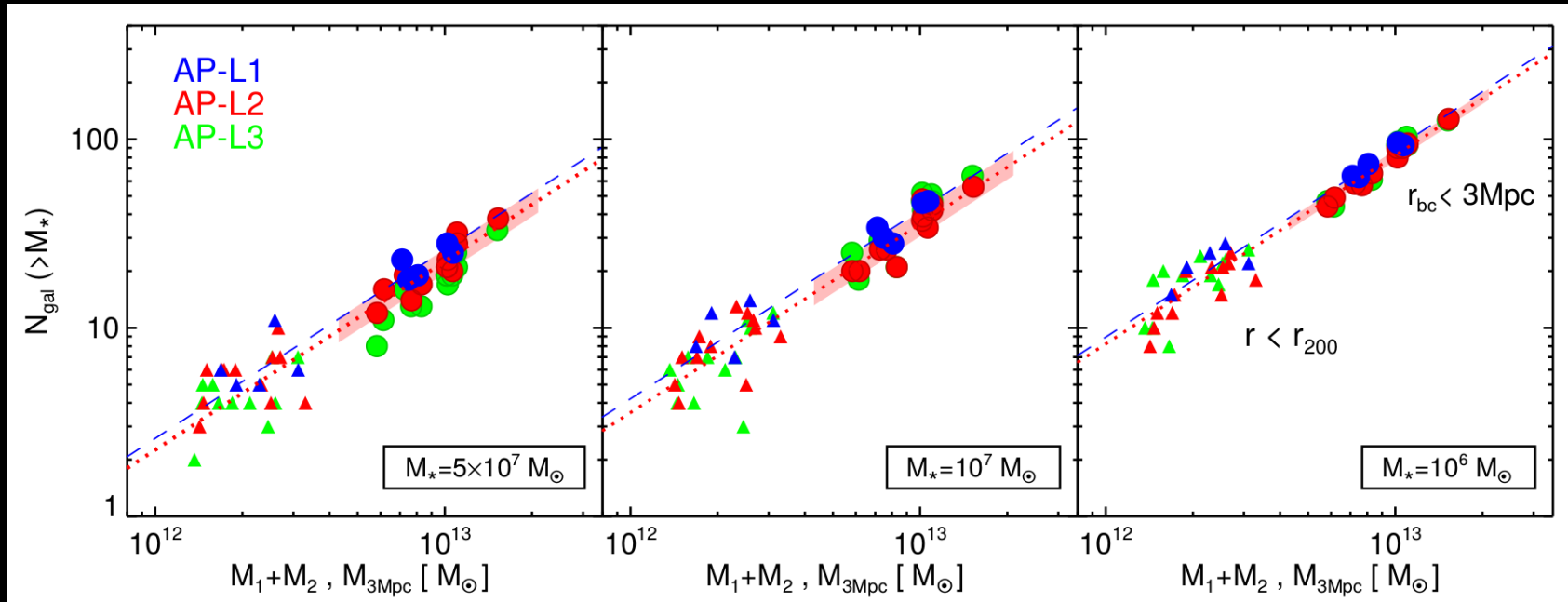


Apostle-DMO

Apostle-Hydro

Local Group beyond the MW and M31

Total mass within 3Mpc and galaxies

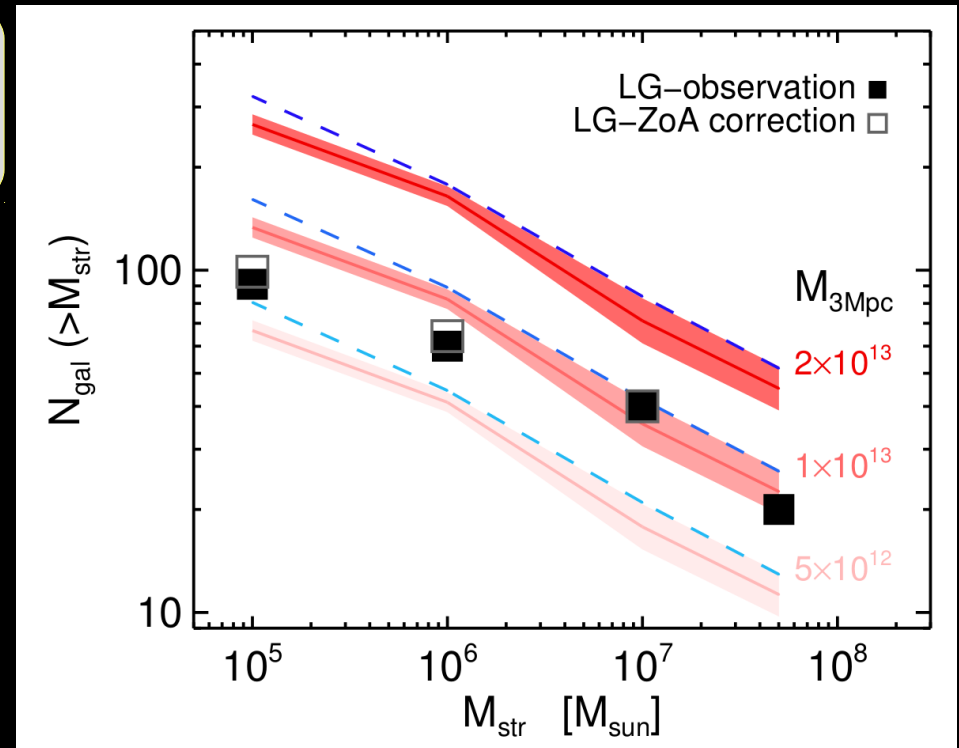


- (i) There is a tight correlation between the number of galaxies and total mass
- (ii) “Galaxy formation efficiency” is similar between satellites and field dwarfs

Total mass within 3Mpc

(i) There is a tight correlation between the number of galaxies and total mass

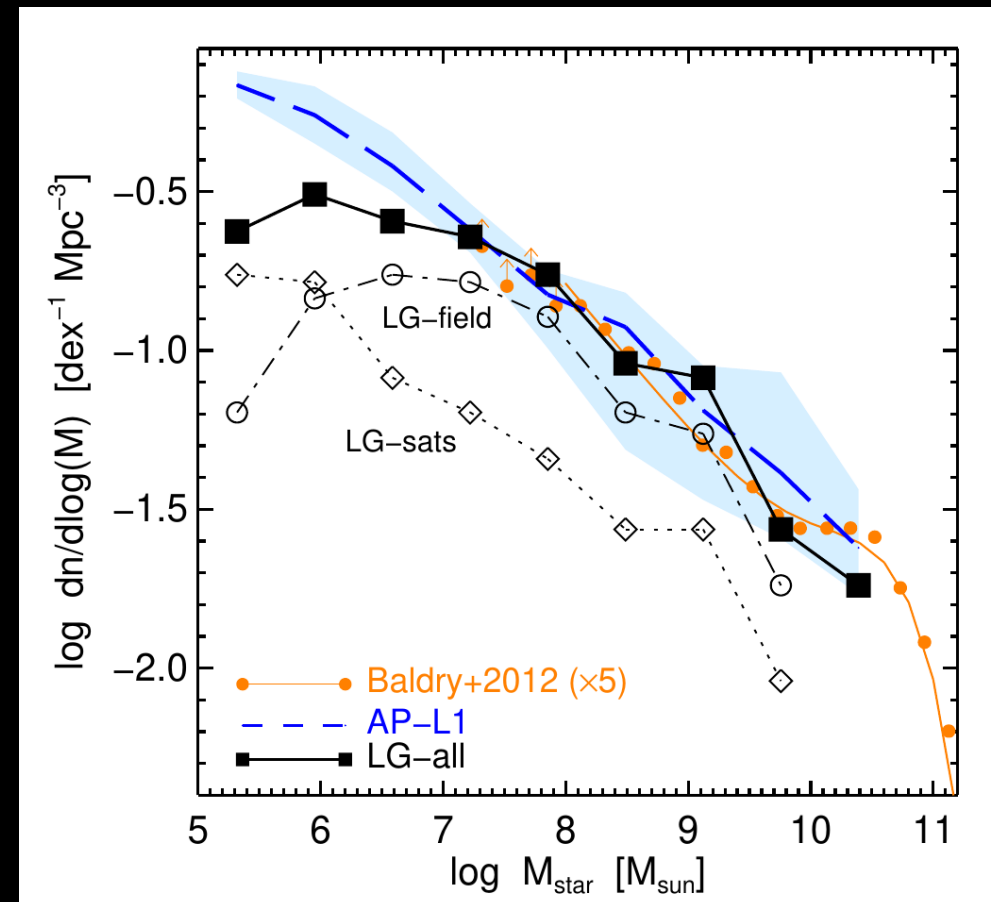
- Mass within 3Mpc $\sim 10^{13} M_{\text{sol}}$



Total mass within 3Mpc and the missing dwarfs

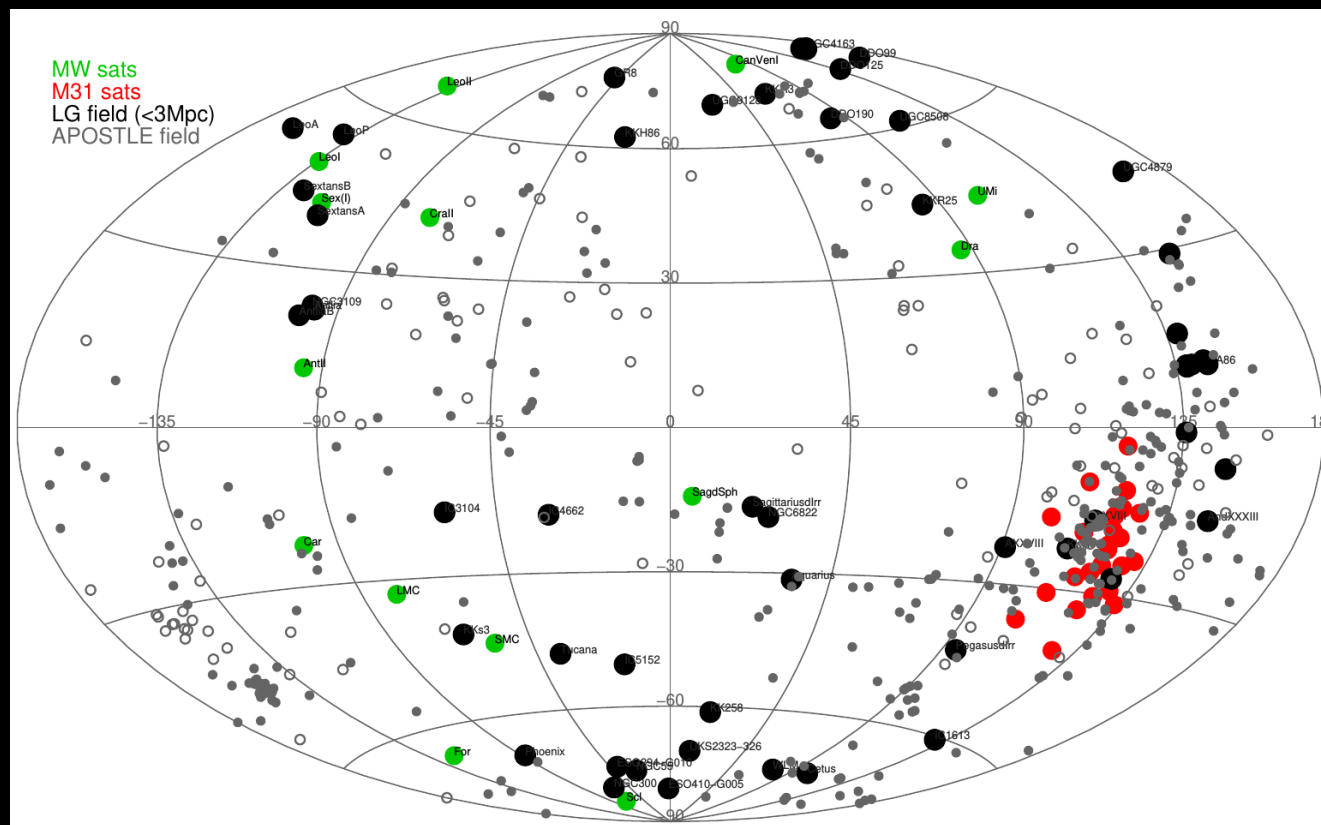
- (ii) Galaxy formation efficiency is similar between satellites and field dwarfs;
 $N_{\text{sat}} / N_{\text{tot}} \sim \text{constant}$

Adding ~ 50 dwarf galaxies with stellar mass $\sim 10^5 - 10^7 M_{\text{sun}}$ brings up the fraction of field dwarfs to an expected value



Where are the missing dwarfs?

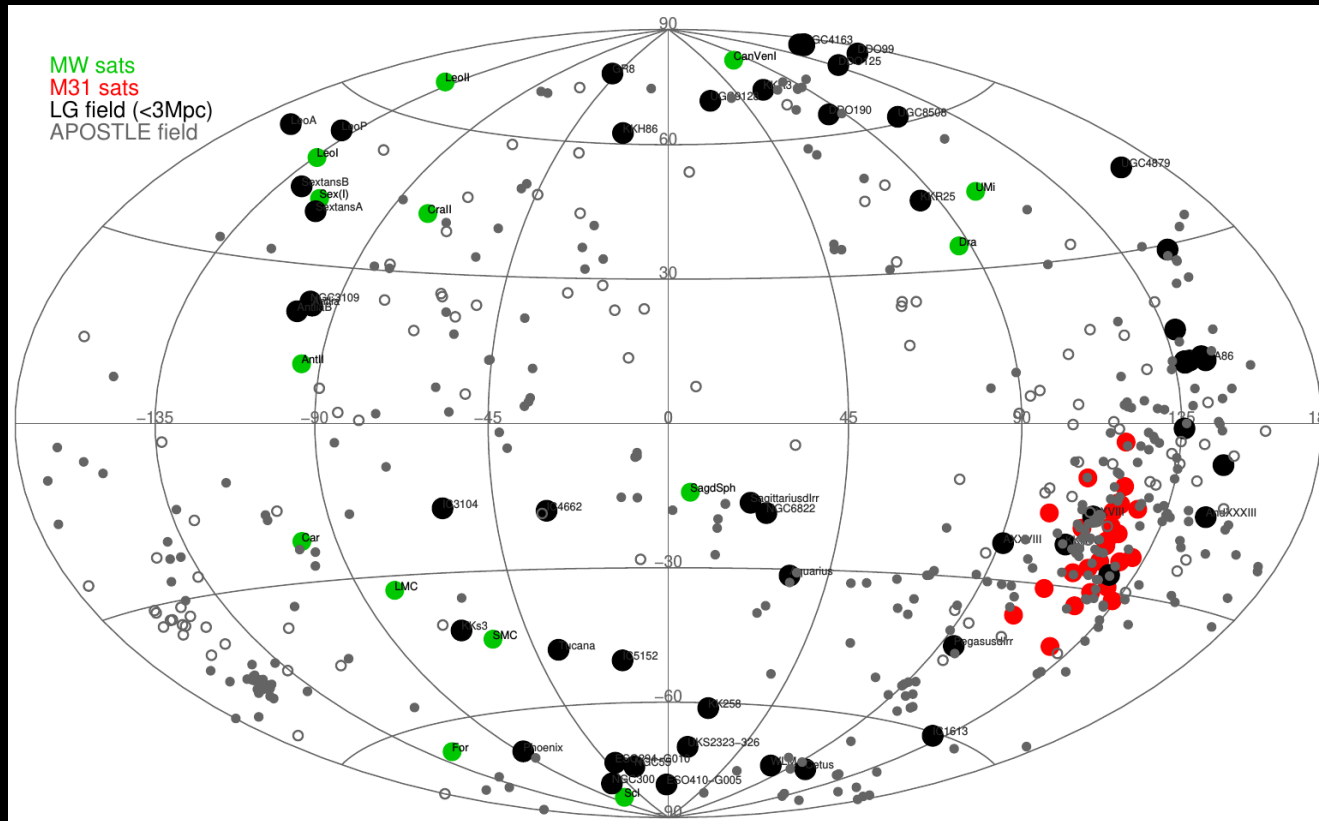
Sky projection of field dwarf galaxies in the simulations (grey)



MW satellites
M31 satellites
Field dwarf galaxies

Where are the missing dwarfs?

Sky projection of field dwarf galaxies in the simulations (grey)

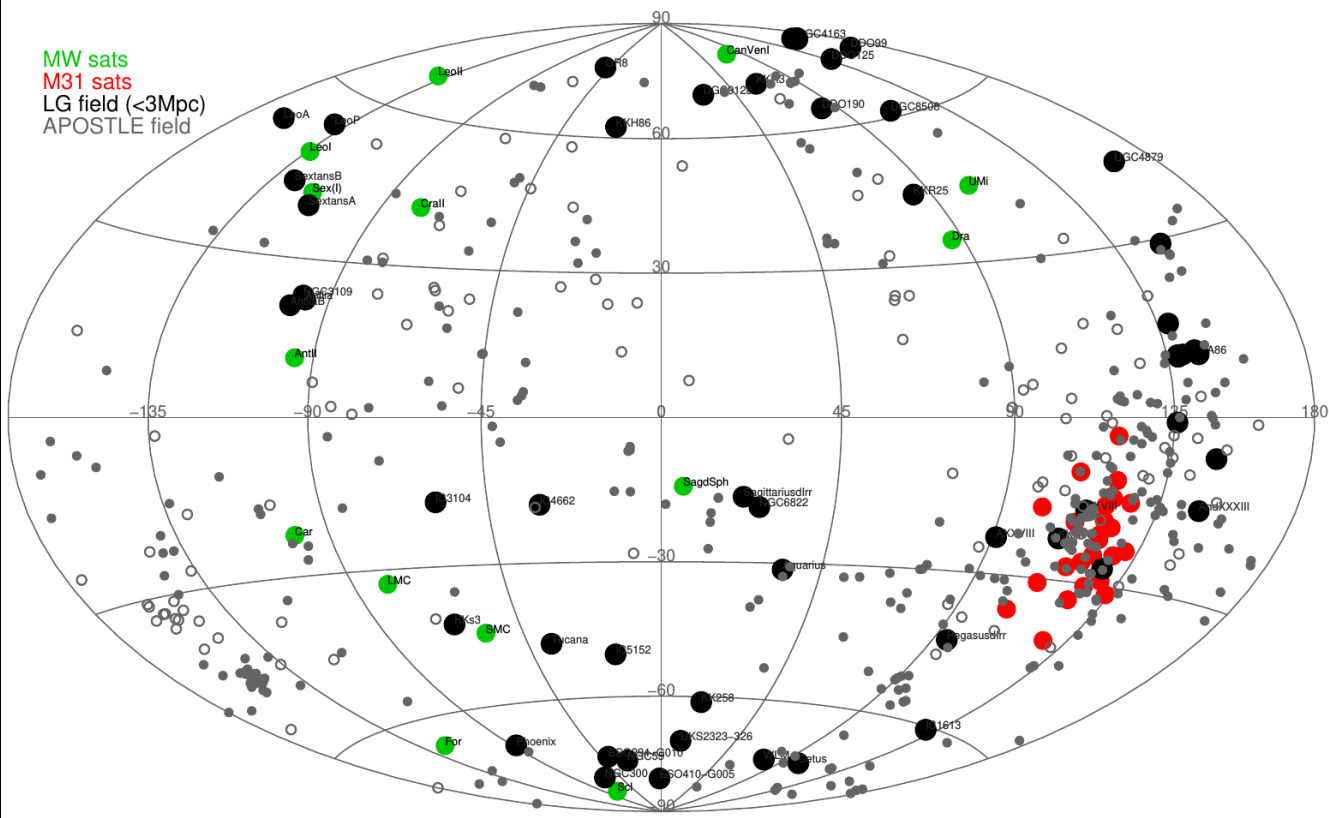


MW satellites
M31 satellites
Field dwarf galaxies

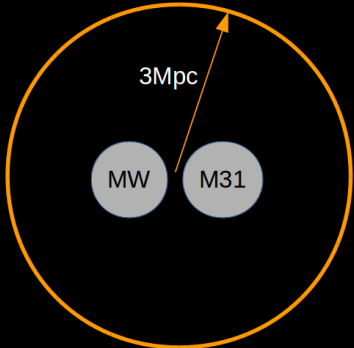


Where are the missing dwarfs?

Sky projection of field dwarf galaxies in the simulations (grey)

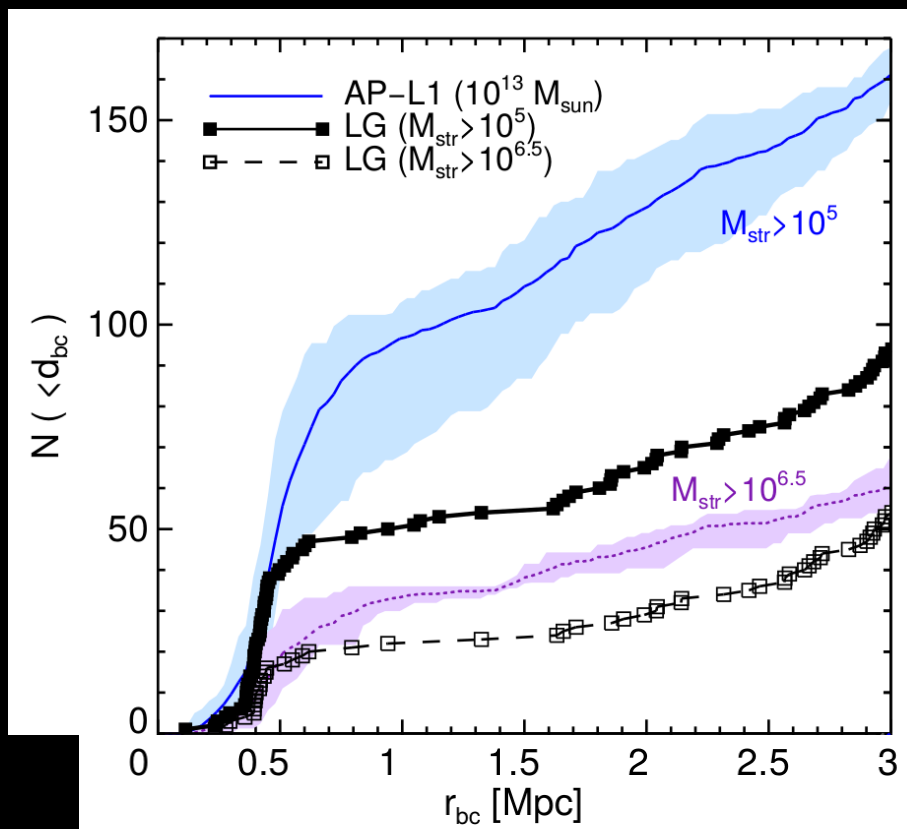


MW satellites
M31 satellites
Field dwarf galaxies



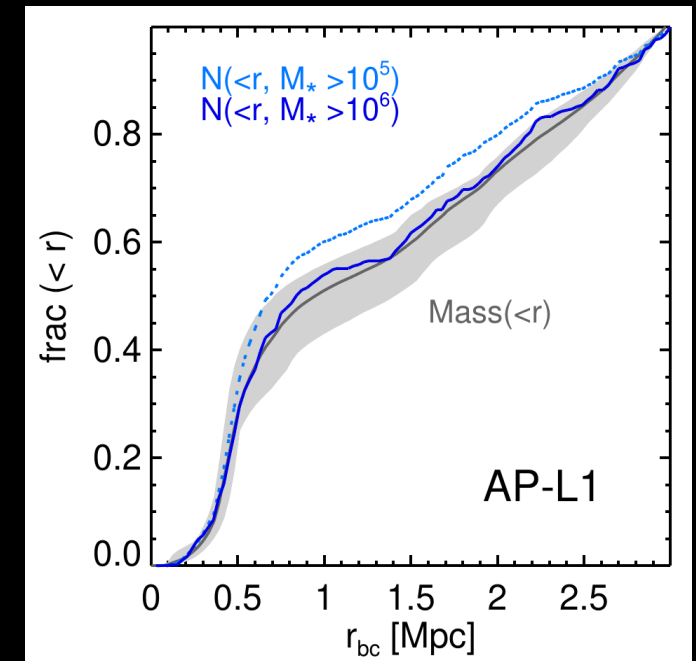
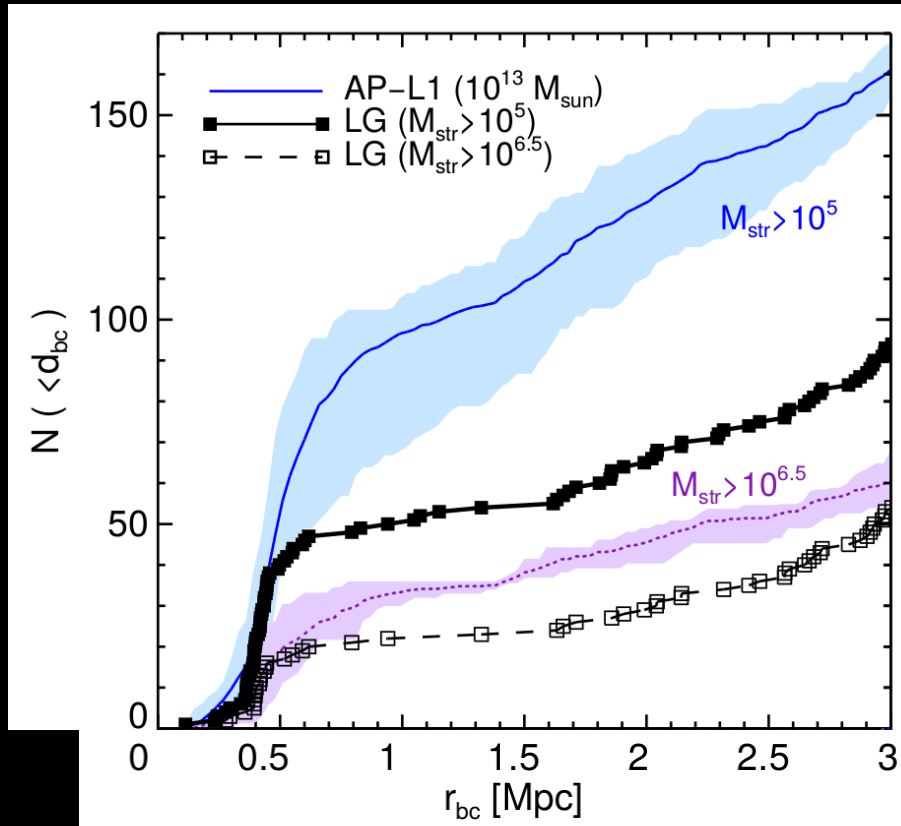
Where are the missing dwarfs?

Radial distribution of galaxies from the midpoint between MW and M31

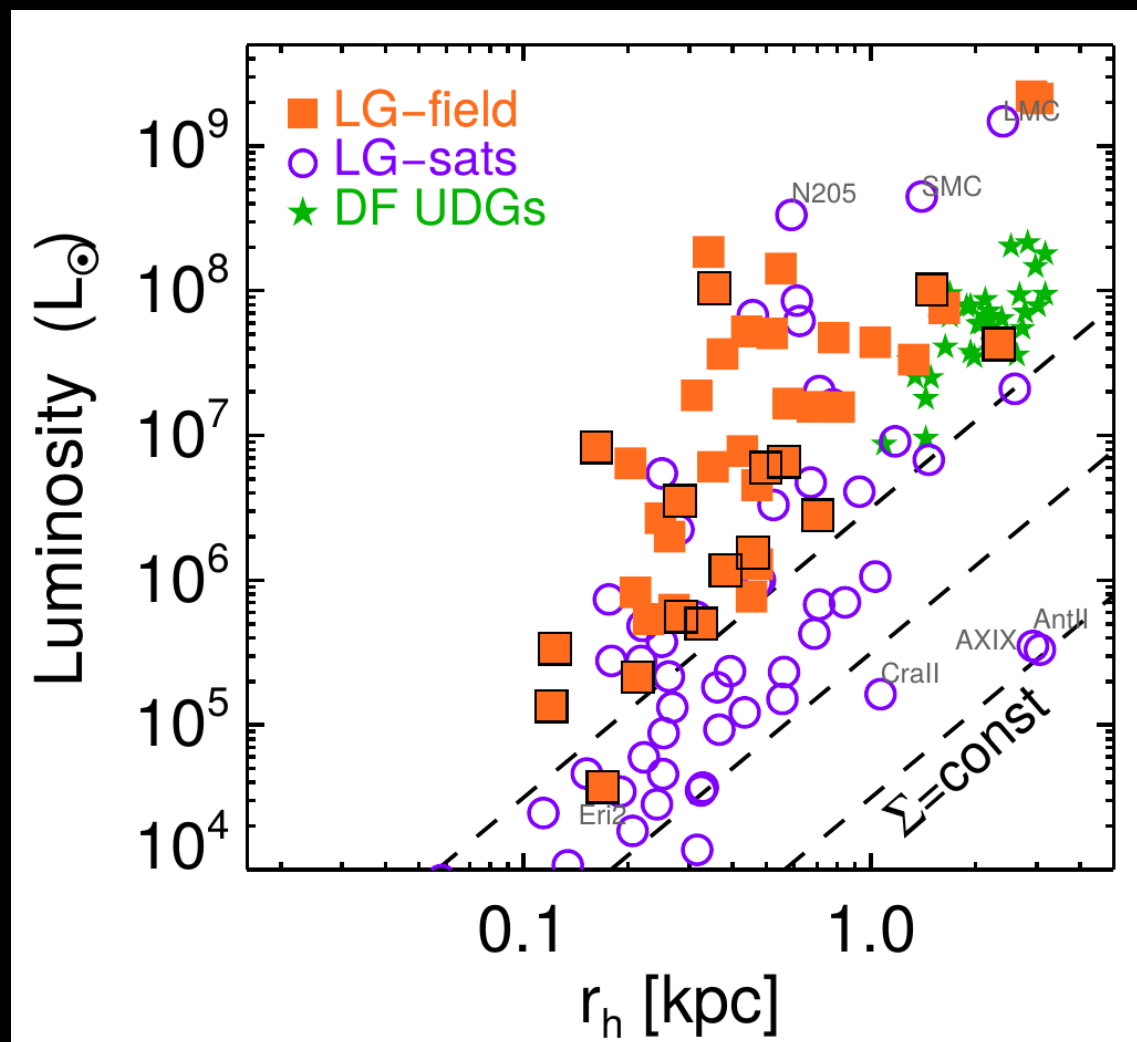


Where are the missing dwarfs?

Radial distribution of galaxies from the midpoint between MW and M31



What are the properties of the missing dwarfs?

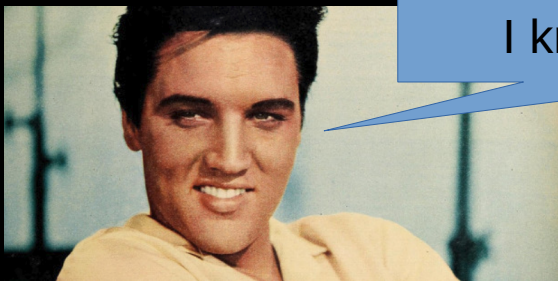
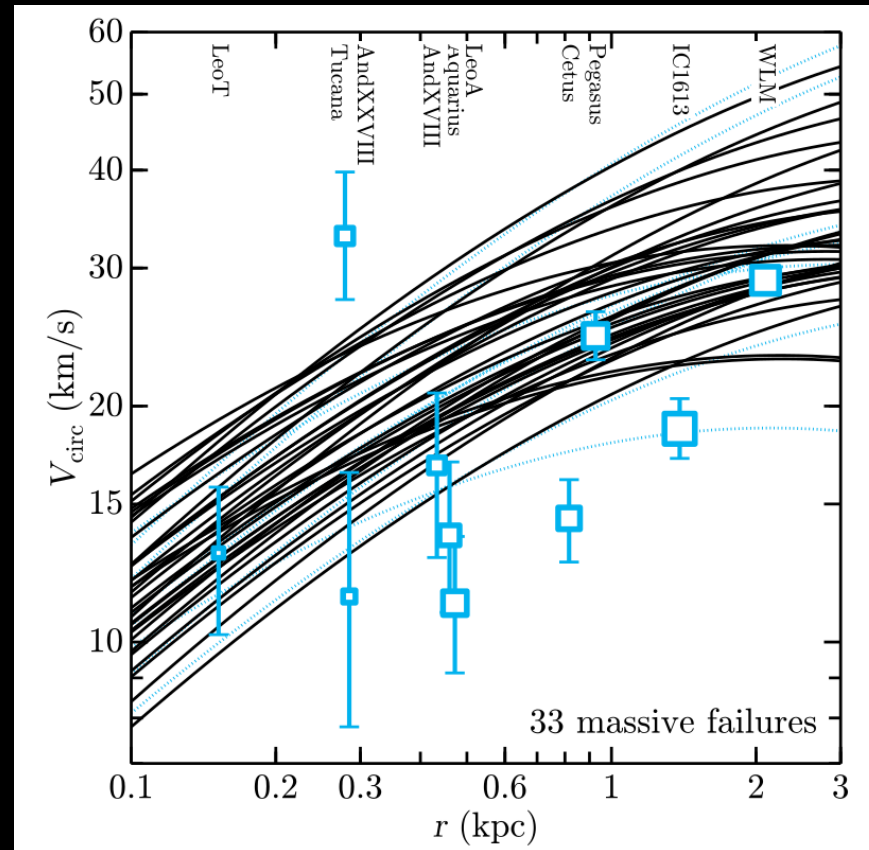


Take away points:

- There is a significant amount of mass in the Local Volume outside the virial radii of MW and M31
 - total mass within a 3Mpc sphere is roughly $10^{13} M_{\text{sol}}$
- We predict ~ 50 dwarf galaxies with stellar mass $> 10^5 M_{\text{sol}}$ are missing around the Local Group
- The missing dwarf galaxies are located primarily around the virial boundaries of the MW and M31 and towards M31 on the sky.
- Implications for too-big-to-fail problem in the field?!

Too-big-to-fail in the field

Too many “big” halos



I knew CDM did not work!

A. Fattahi

Dwarf Galaxies, Durham, 2019

ELVIS simulations;
Garrison-Kimmel+2014a
Garrison-Kimmel+2014b

Too-big-to-fail in the field

