Multidark Galaxies: Sampling Local Group Analogs

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Andrew Benson, Alexander Knebe, Francisco Prada, Noam Libeskind, Kristin Riebe, Stefan Gottlöber, and many others

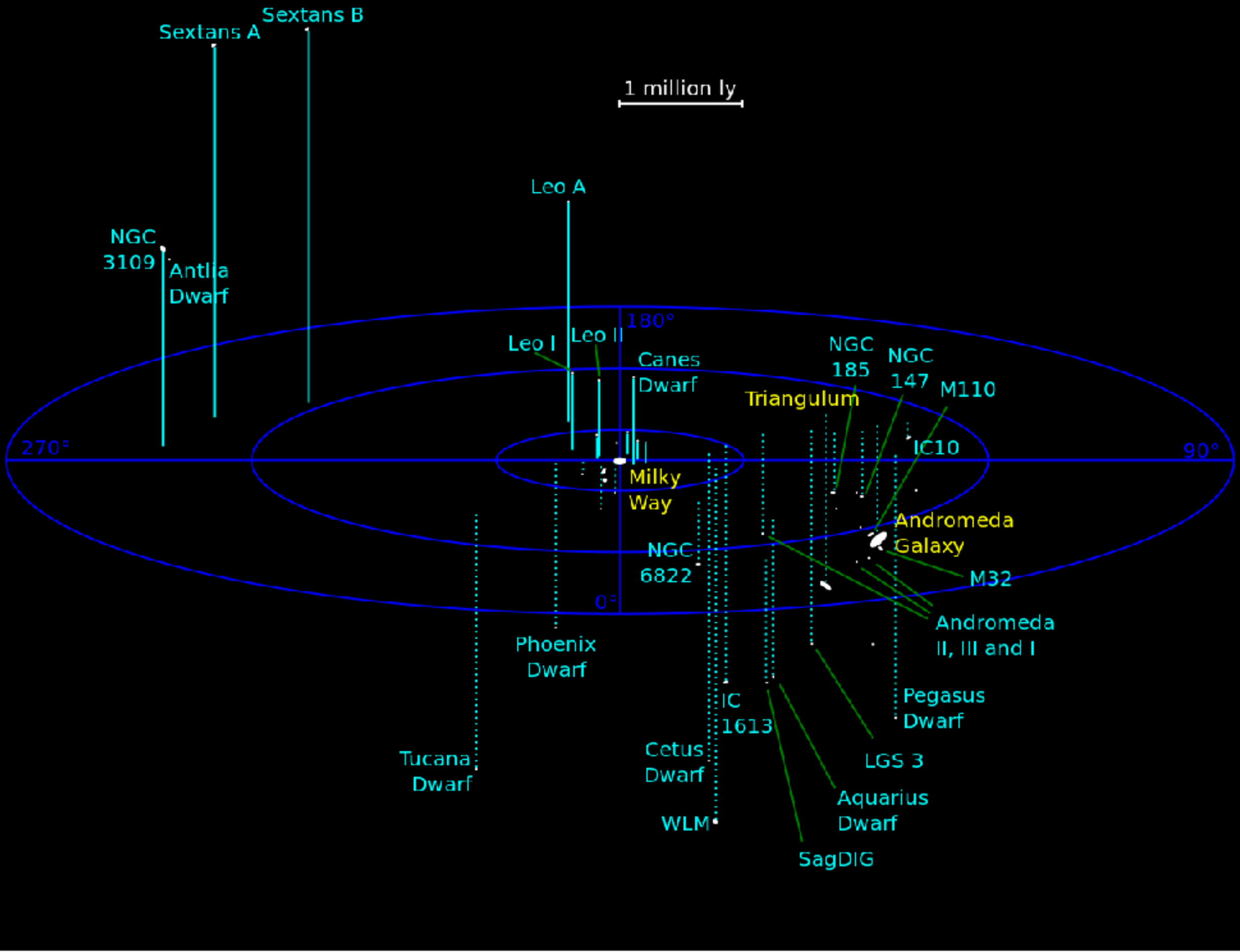
SCUOLA
NORMALE
SUPERIORE

Our neighborhood

	I_{TRGB}	$(m-M)_\circ$	D (kpc)		ΔD (kpc)
M31	20.54 ± 0.03	24.47 ± 0.07	785	$\pm$	25
M33	20.57 ± 0.03	24.54 ± 0.06	809	$\pm$	24
NGC 205	20.65 ± 0.03	24.58 ± 0.07	824	$\pm$	27
NGC 185	20.23 ± 0.03	23.95 ± 0.09	616	$\pm$	26
NGC 147	20.43 ± 0.04	24.15 ± 0.09	675	$\pm$	27
Pegasus	20.87 ± 0.03	24.82 ± 0.07	919	$\pm$	30

- two massive galaxies: MW and M31
- ~tens of dwarfs

McConnachie+2005

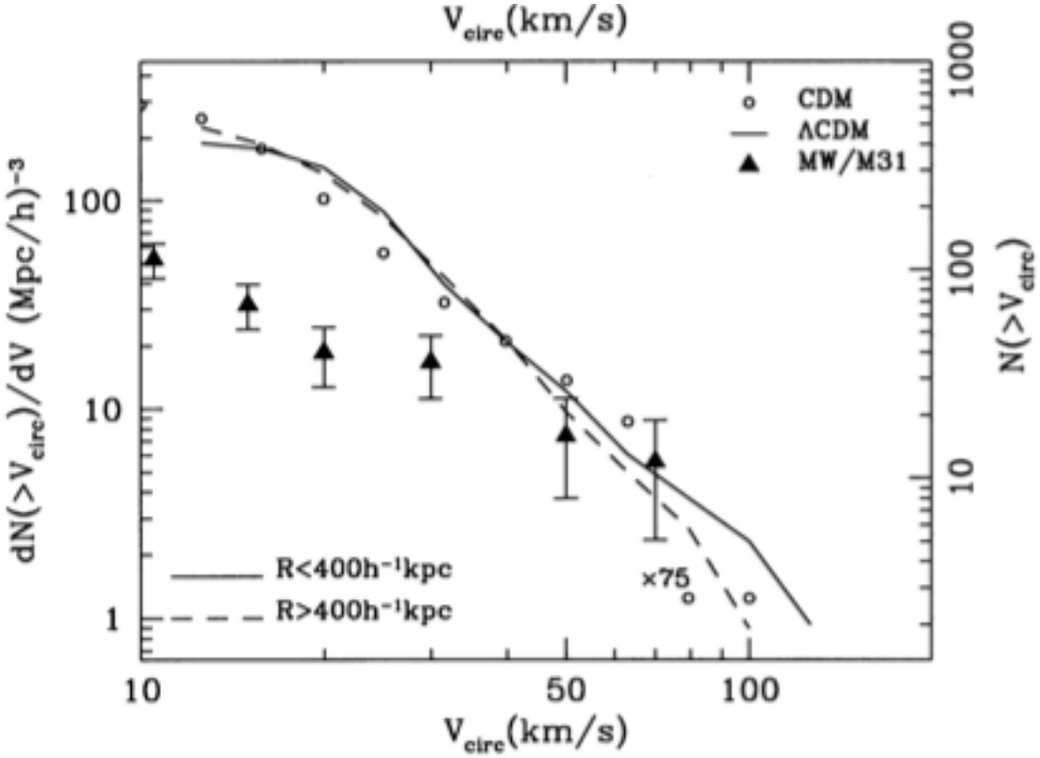

Sextans B
Sextans A
1 million ly
Leo A
NGC
3109
Antlia
Dwarf
180°
Leo I
Leo II
Canes
Dwarf
NGC
185
NGC
147
M110
Triangulum
270°
90°
IC10
Milky
Way
Andromeda
Galaxy
NGC
6822
M32
0°
Andromeda
II, III and I
Phoenix
Dwarf
IC
1613
Pegasus
Dwarf
Tucana
Dwarf
Cetus
Dwarf
LGS 3
Aquarius
Dwarf
WLM
SagDIG

Motivation: Why the Local Group?

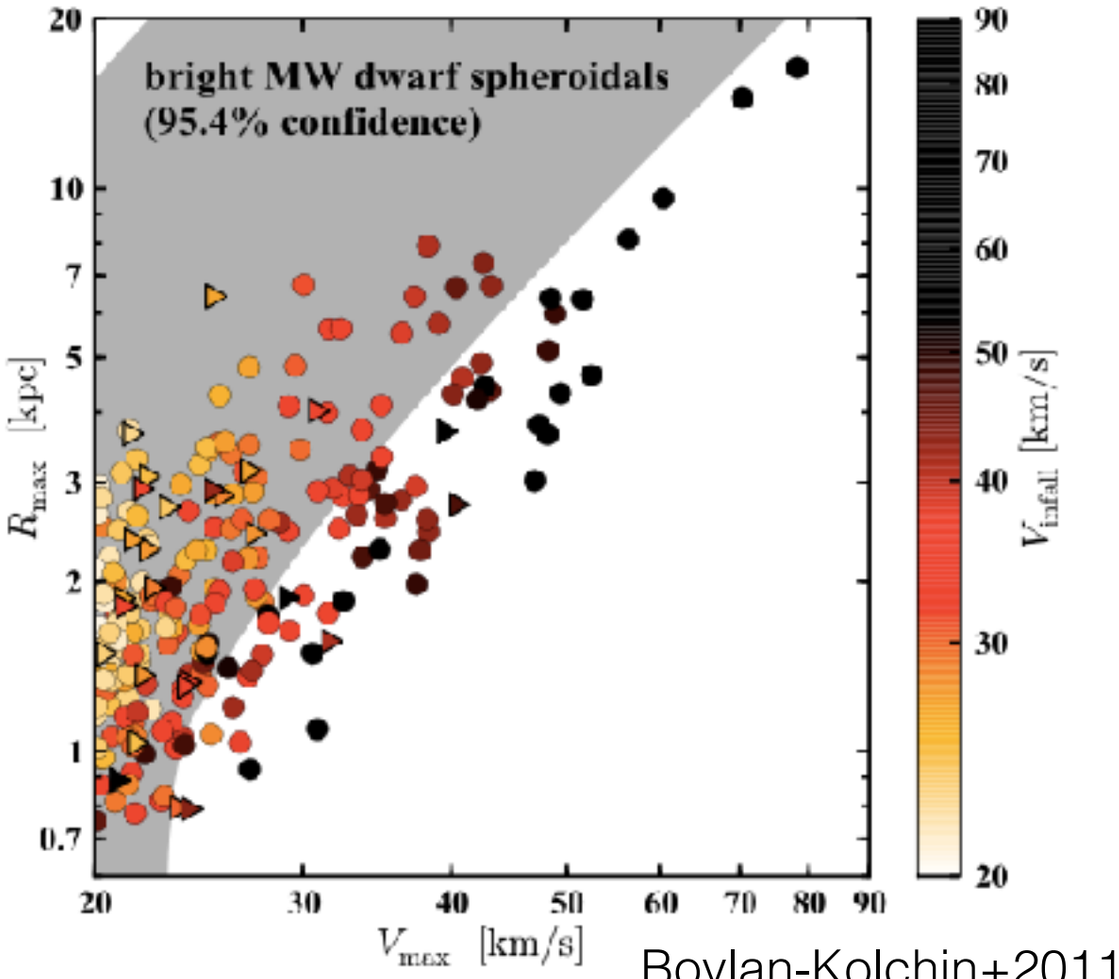
- Local Group = local lab for dwarf galaxies/massive satellites, detailed star formation, etc.

- challenge: if we base our conclusions on observations of the Local Group, we need to know how typical it is

The connection to cosmology

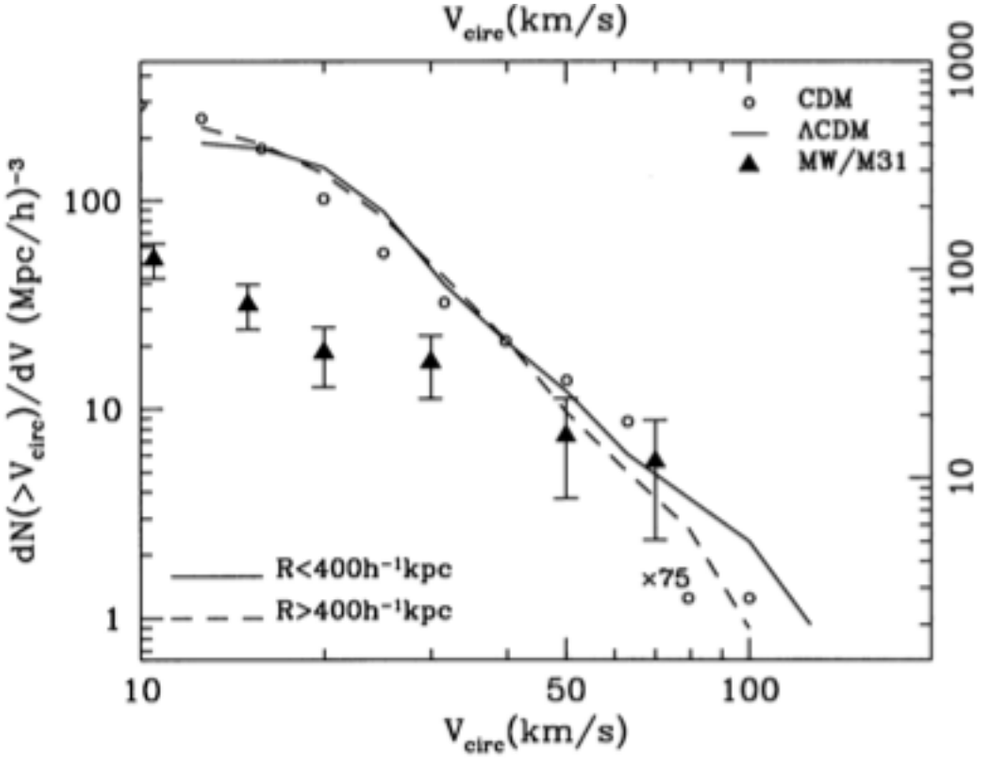


Klypin+1999

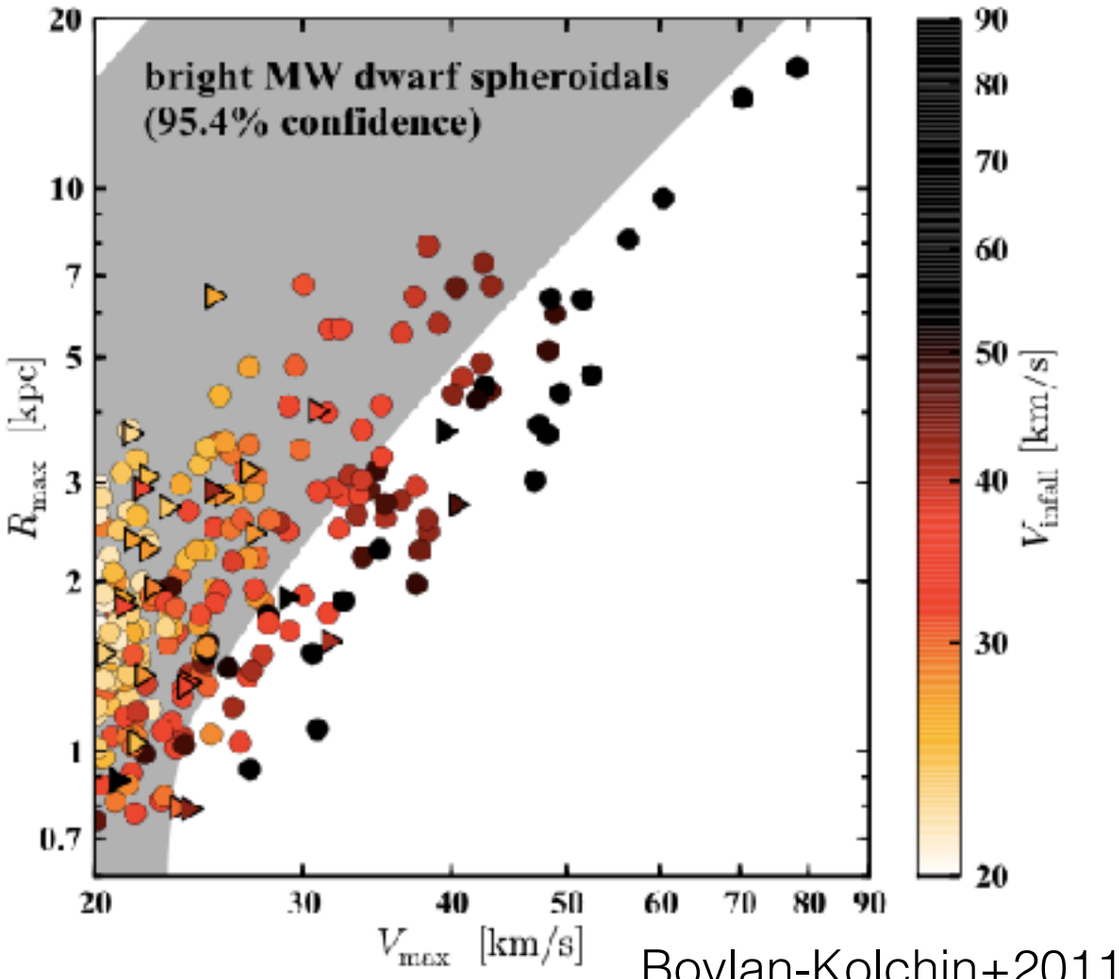


Boylan-Kolchin+2011

The connection to cosmology



Klypin+1999



Boylan-Kolchin+2011

Question: Is the Local Group a weirdo?

Sampling the Local Group

1. Do a large cosmological simulation with sufficient resolution

2. Select groups of objects that are similar to the Local Group, dubbed Local Group Analogs

3. Investigate their statistical properties, e.g. their kinematic properties, mass assembly, etc. and compare to the Local Group

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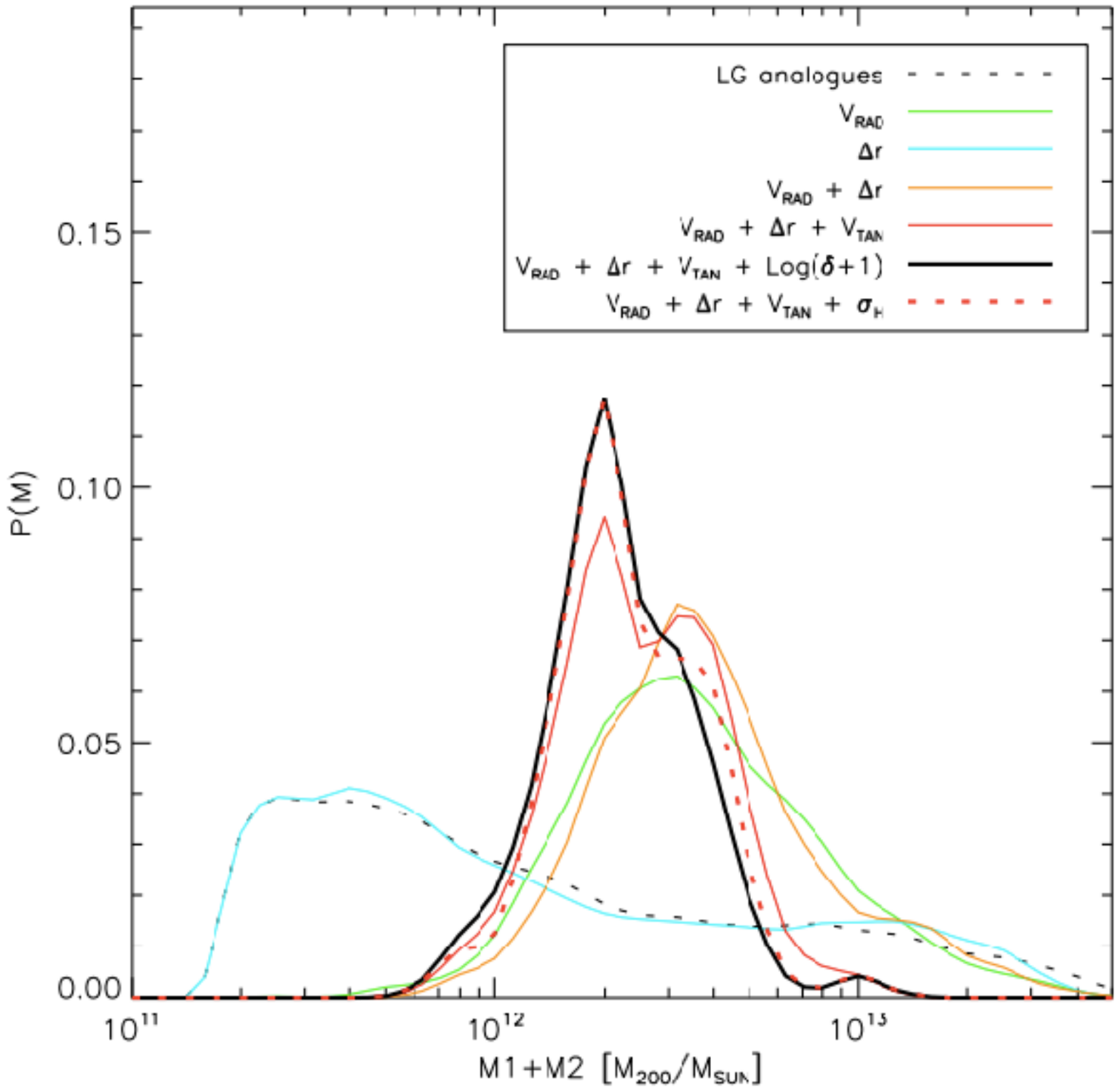
Local Group Analogs



Gonzalez+2014

Our selection criteria

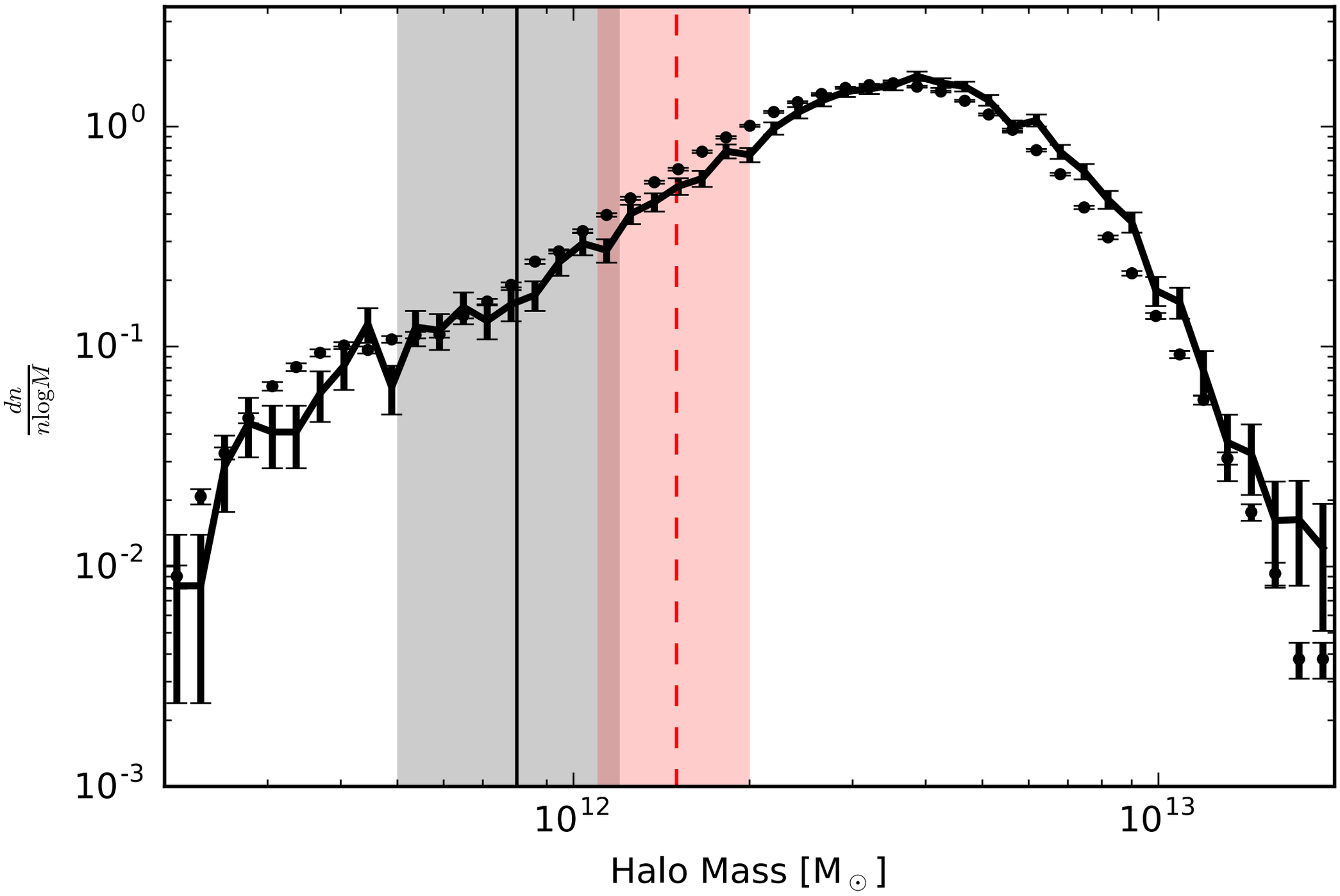
1. Select galaxies at z=0 with a stellar mass of 5-7e10 Msol

2. Select pairs (= M31 and MW) of such galaxies with distance 0.5-1.5 Mpc

3. Select only pairs that are isolated, i.e. no object with mass > 5e11 Msol within 3 Mpc and no cluster-like object within 10 Mpc

   => We end up with about 3000 objects

Halo mass function



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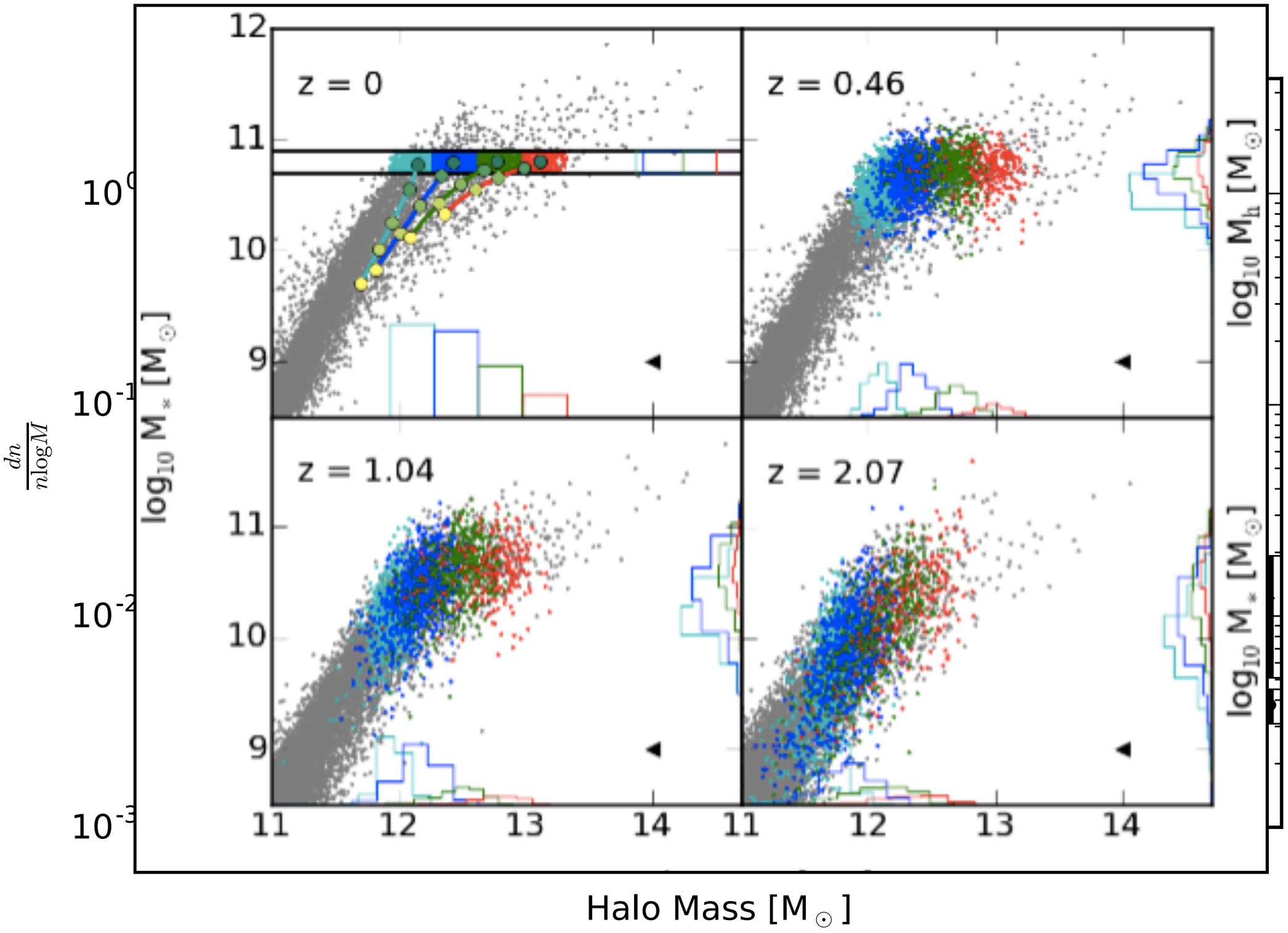
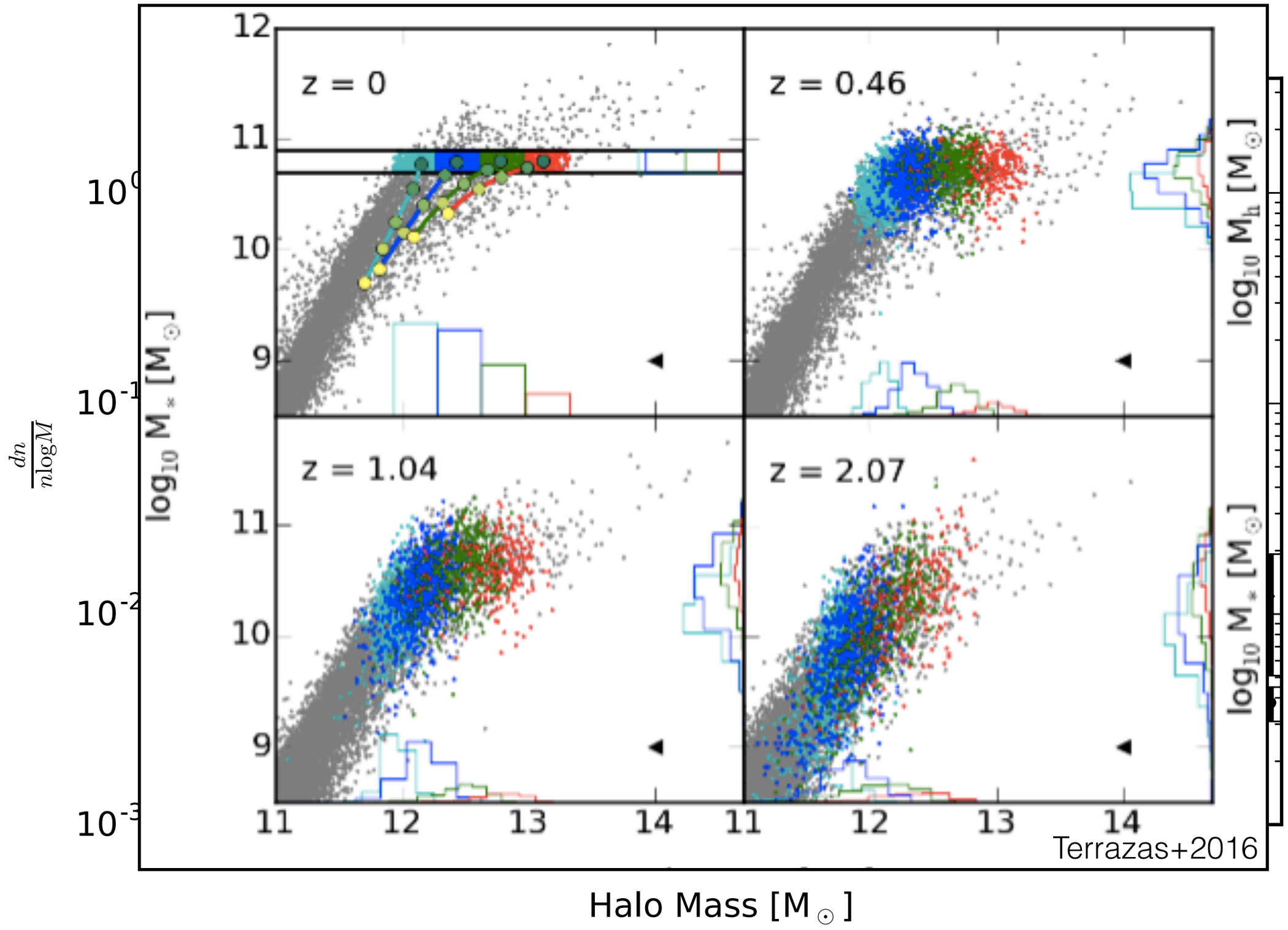
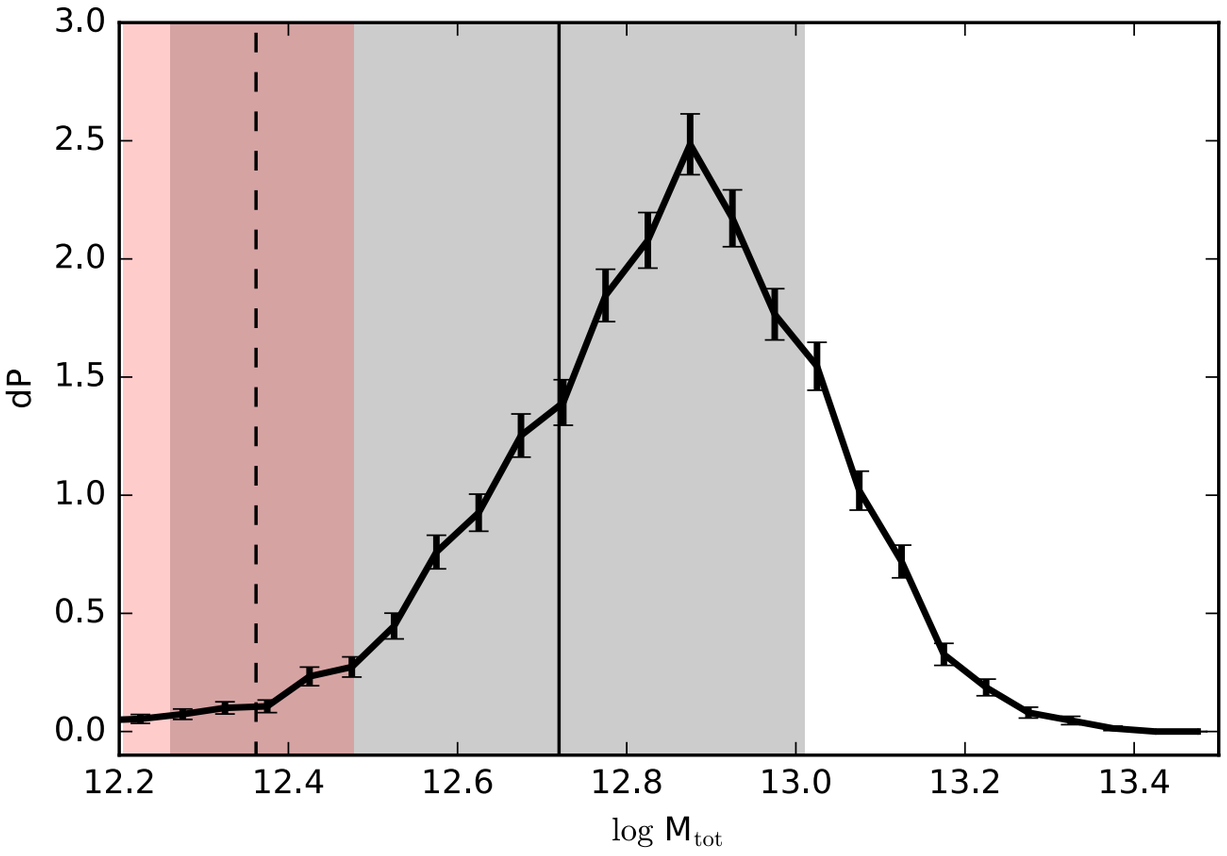
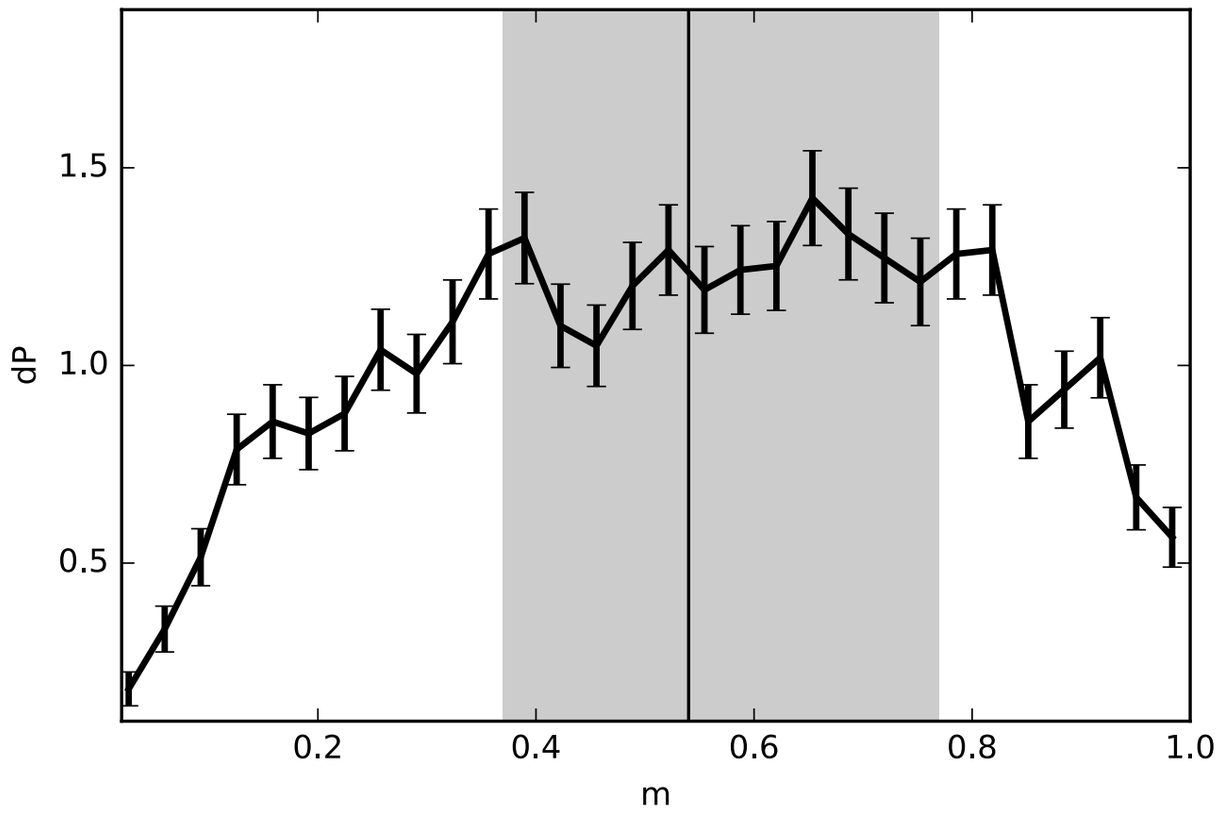


Halo mass function



Total mass and mass ratio





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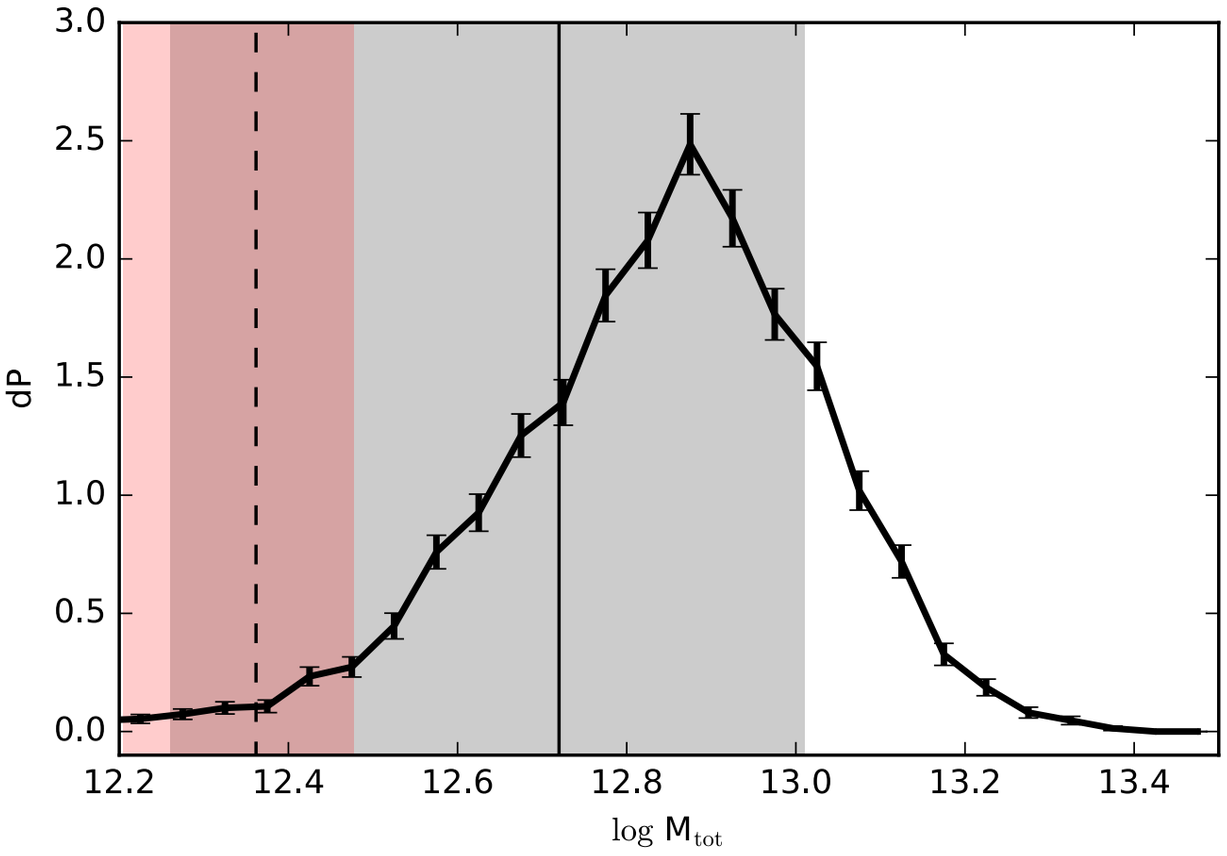
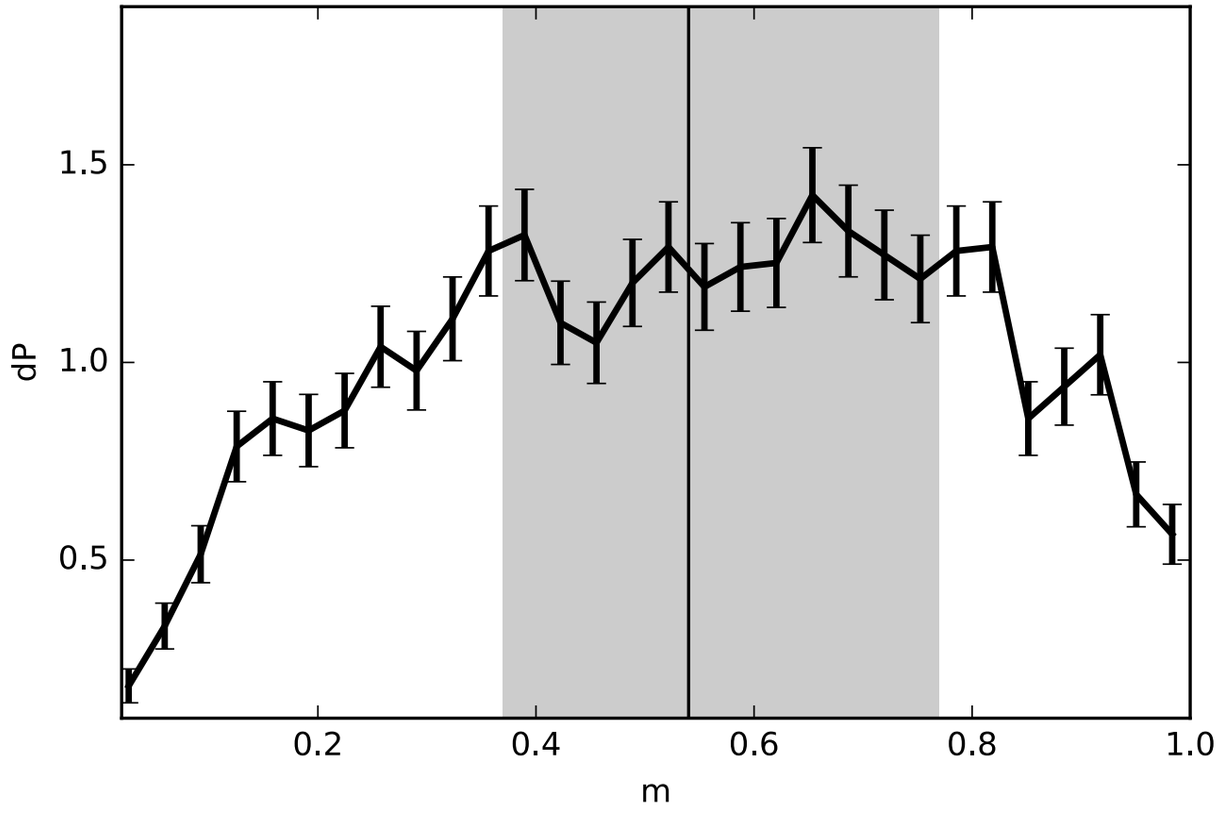


shaded, grey: Constraints from Li & White 2007
shaded, red: Constraints from Pennarubia+2014



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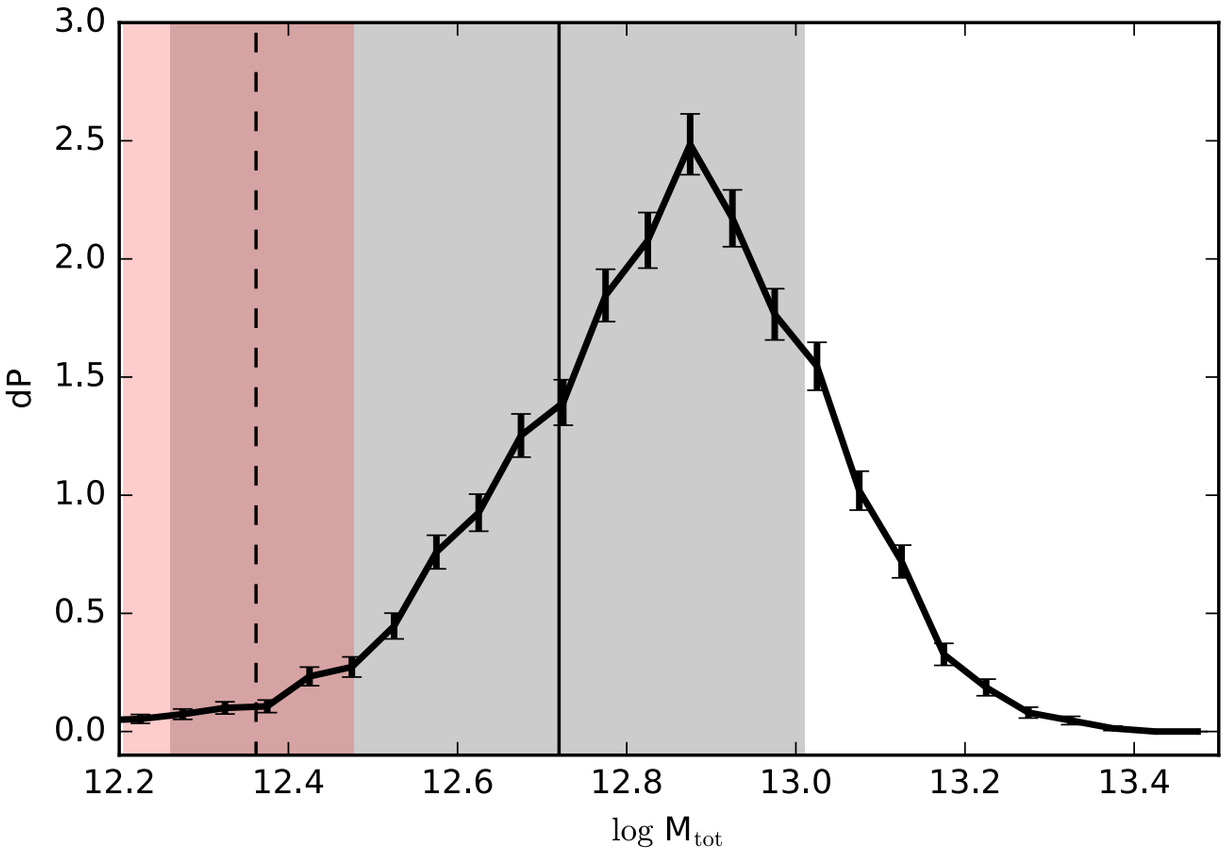

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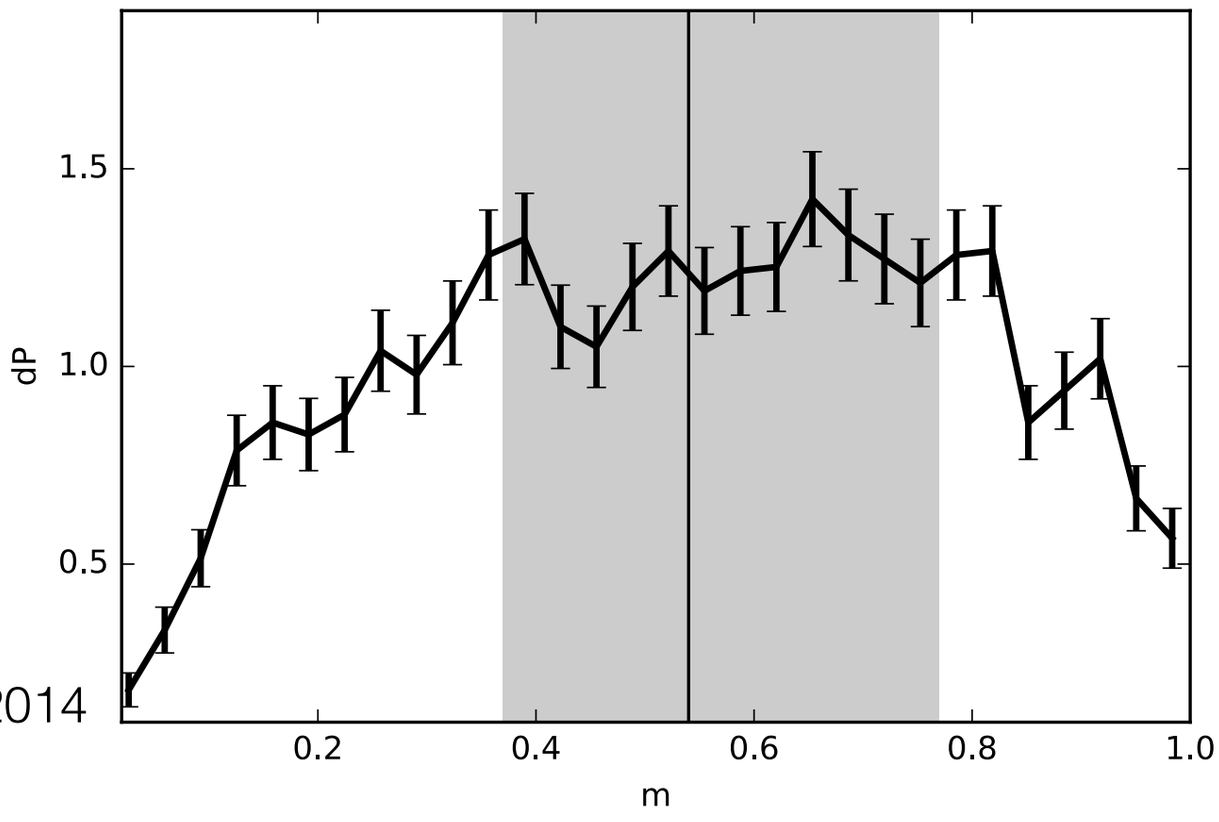

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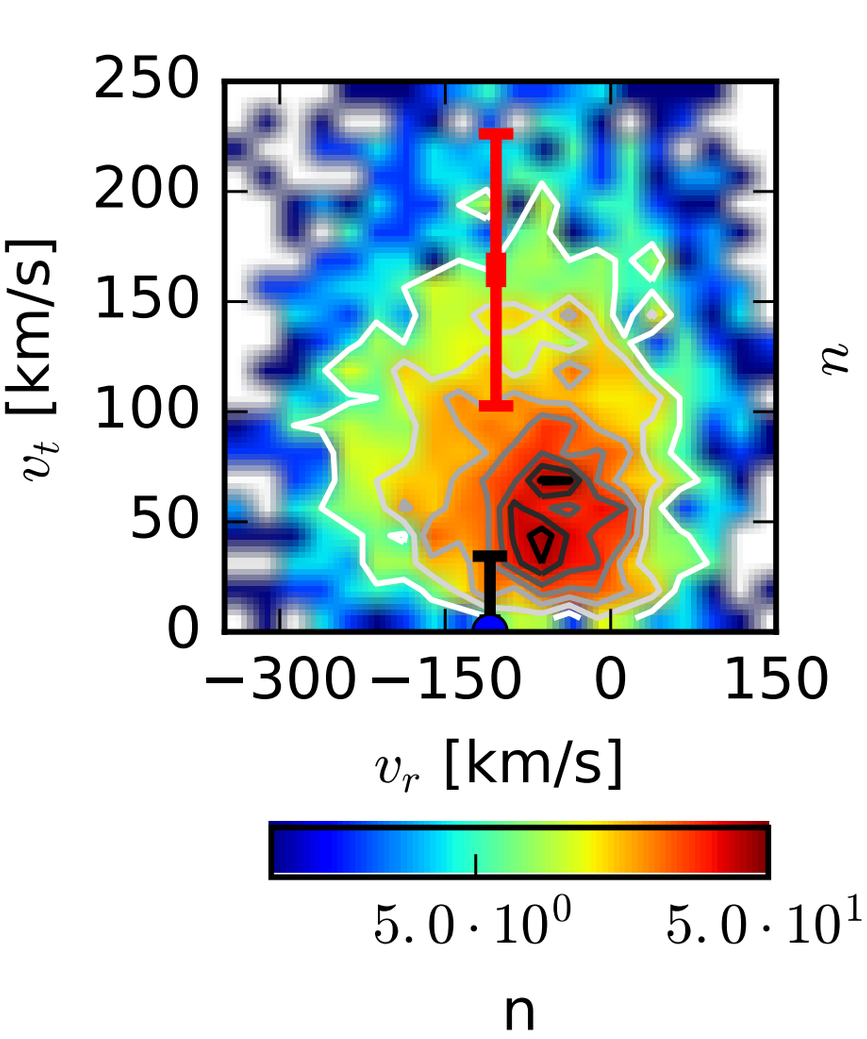
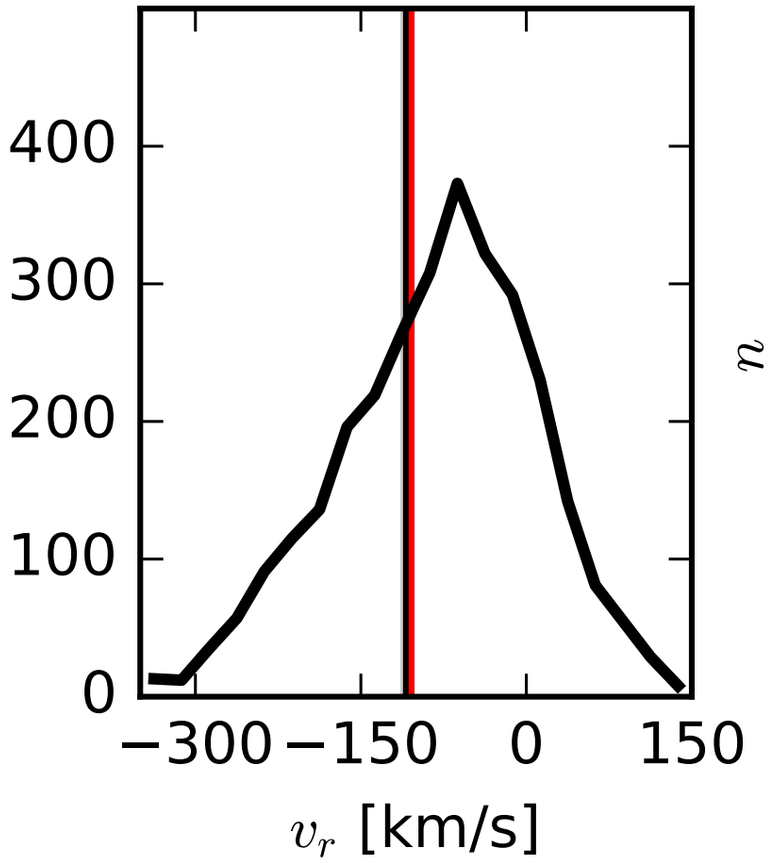
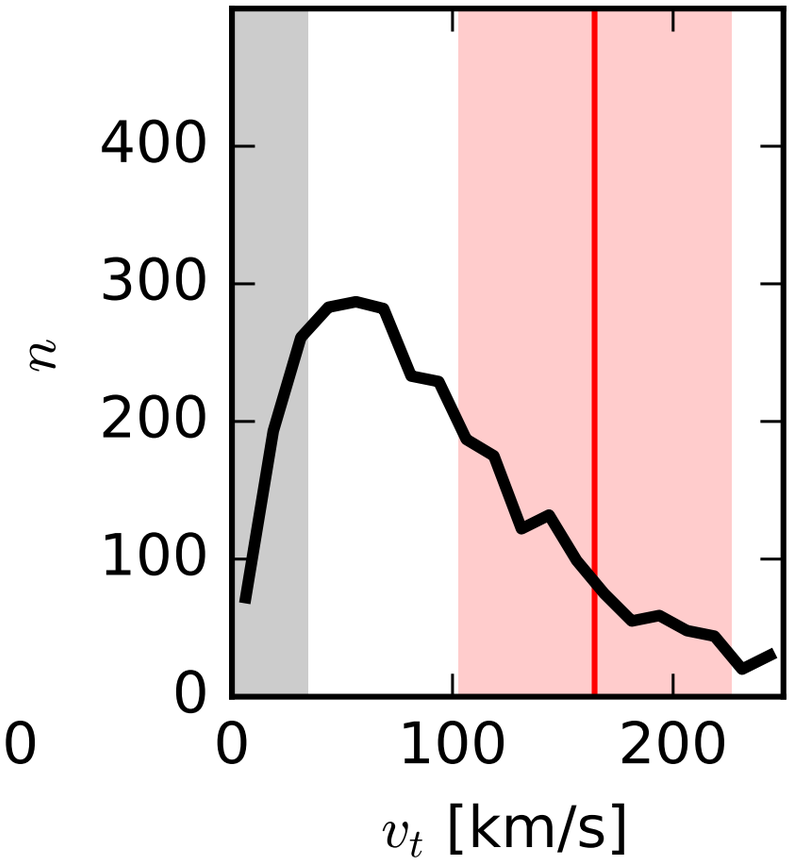
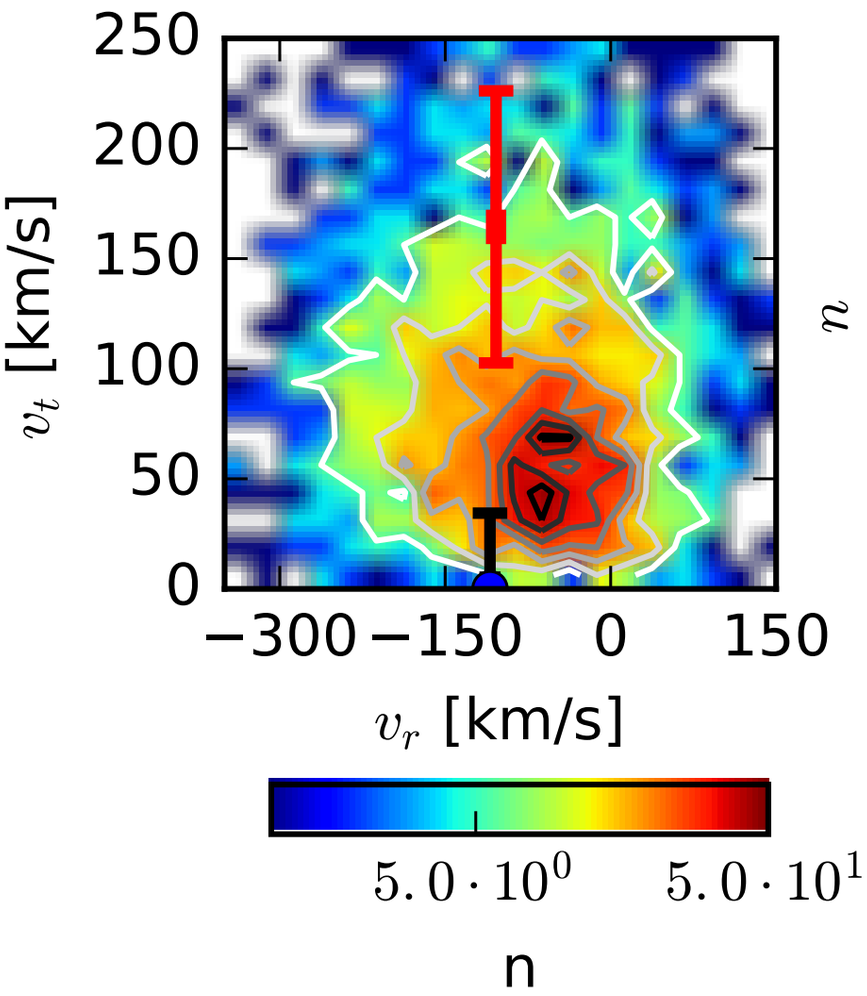
Kinematics

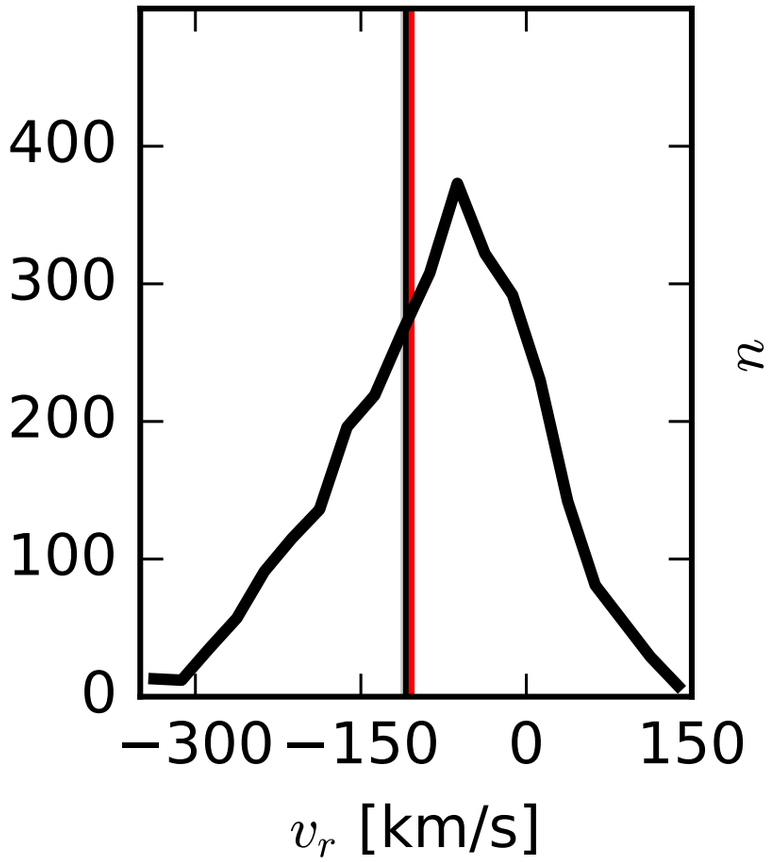

250
200
150
100
50
0
v_t [km/s]
−300
−150
0
150
v_r [km/s]
$5.0 \cdot 10^0$
$5.0 \cdot 10^1$
n

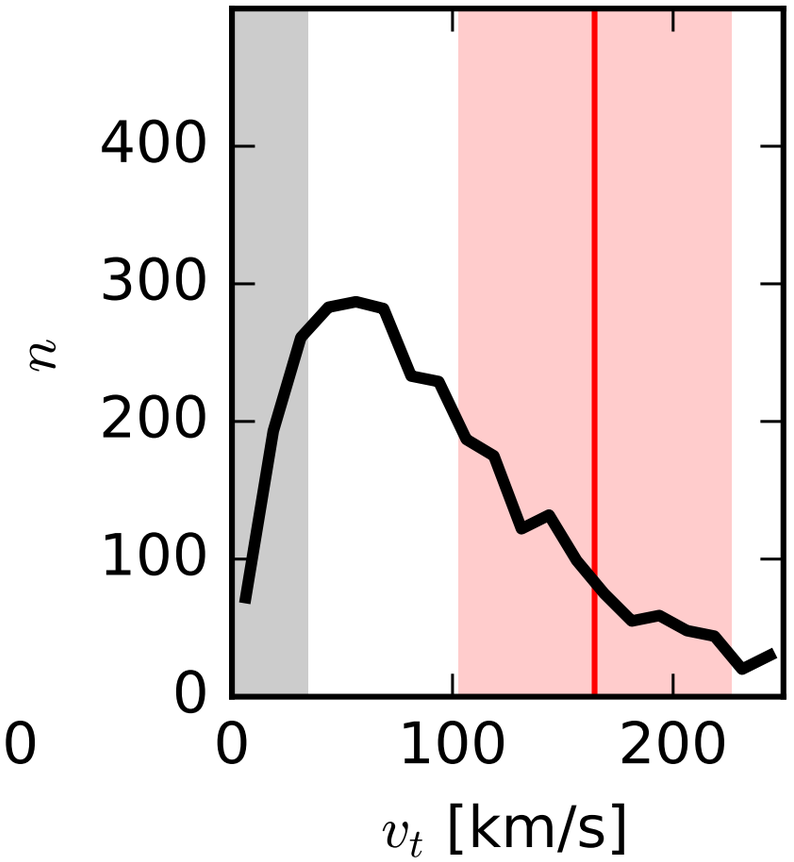

400
300
200
100
0
n
−300
−150
0
150
v_r [km/s]


400
300
200
100
0
n
0
100
200
v_t [km/s]

Kinematics







black: Constraints from van der Marel+2012
red: Constraints from Salomon+2016

Conclusions

- the vast size and versatility of the catalogs provide a great chance to investigate statistical properties of galaxies in a LambdaCDM Universe

- we find our stellar mass selected sample to have on average larger halo masses compared to a selection on halo mass and, consequently, larger group masses

- mass ratios and kinematic properties are consistent with observational evidence