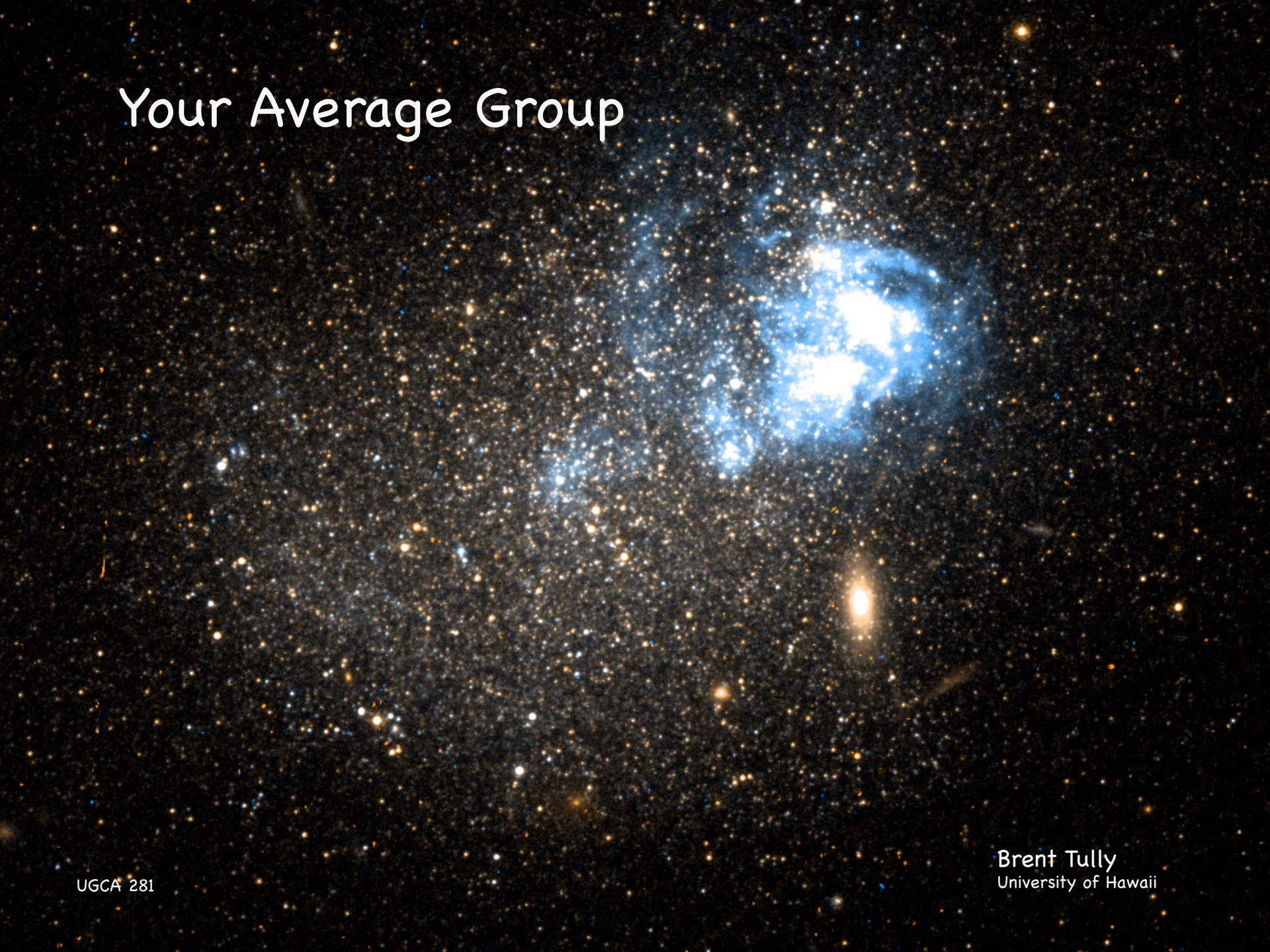
Your Average Group



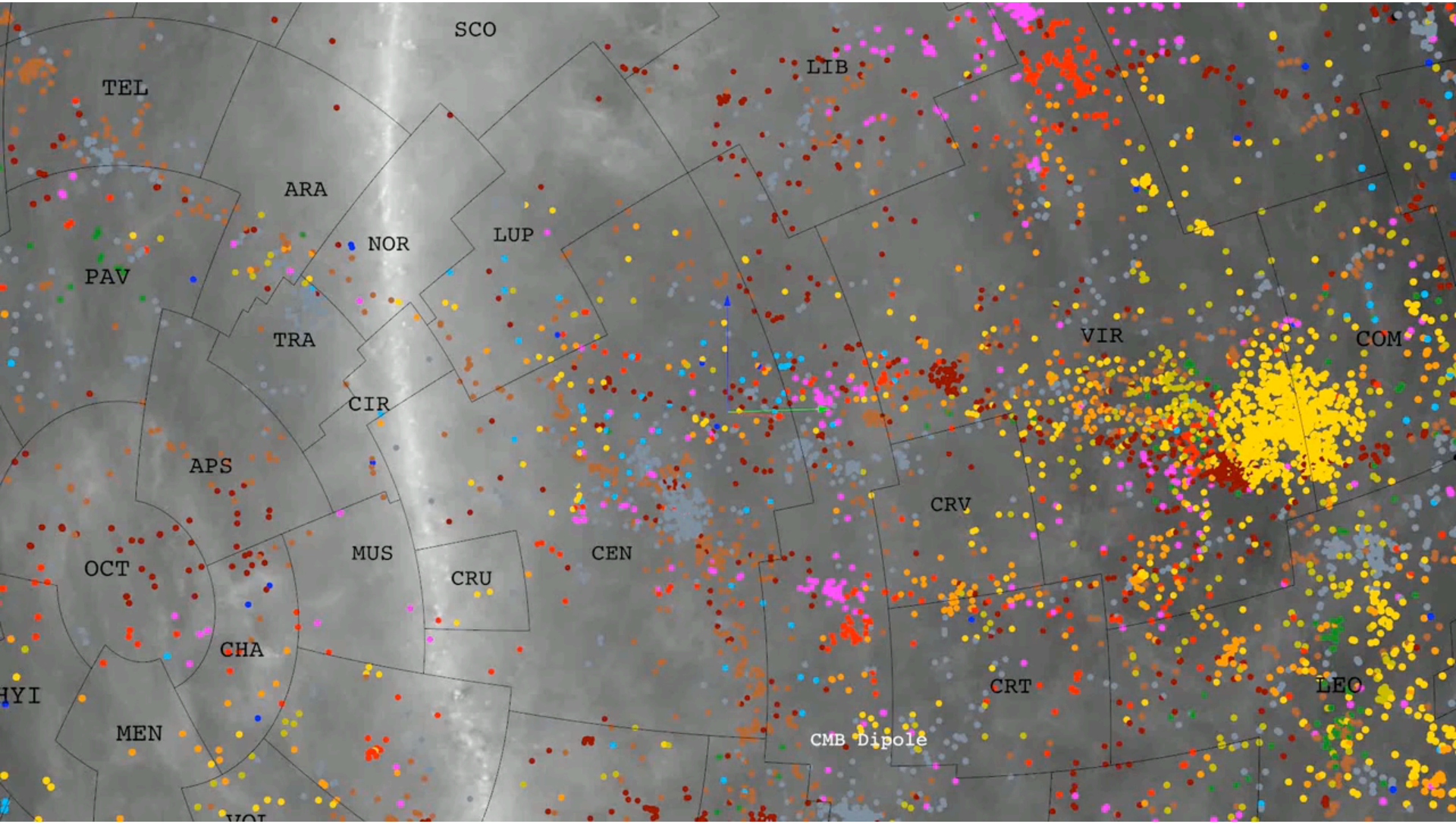
UGCA 281

Brent Tully
University of Hawaii

Galaxy Groups within 3500 km/s

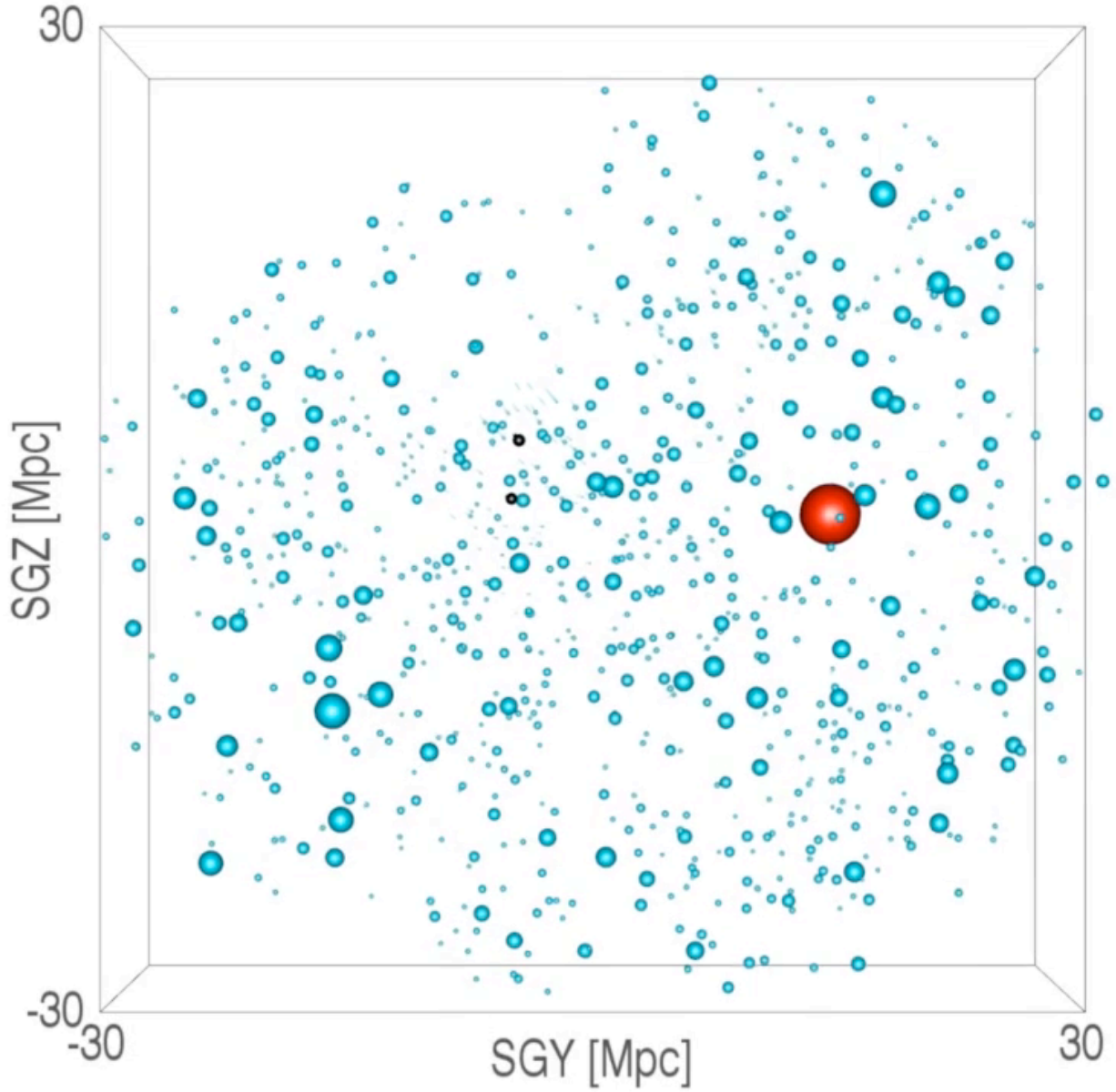
Ehsan Kourkchi & Brent Tully

15,000 galaxies



Dynamics of the Local Supercluster

Ed Shaya, Brent Tully & Yehuda Hoffman



Basic Theory

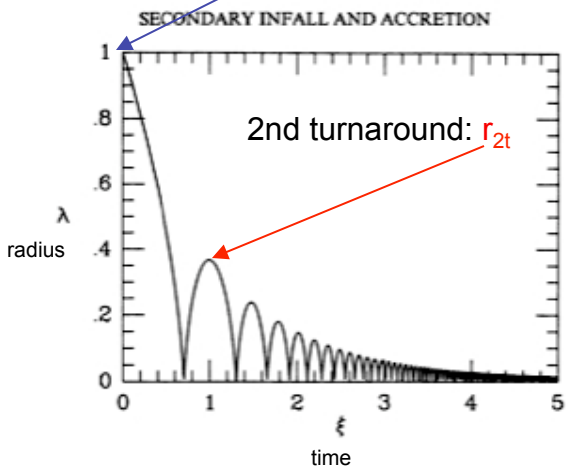
spherical collapse

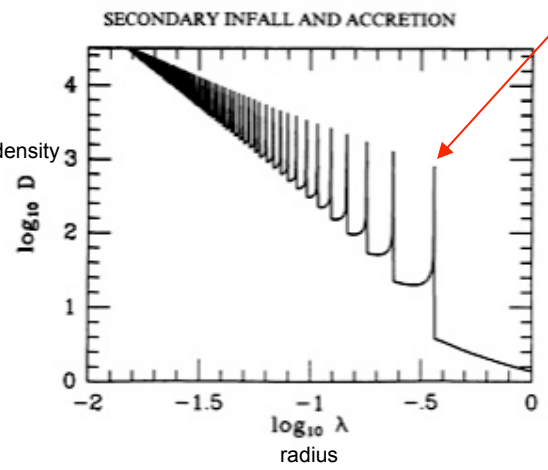
Bertschinger 1985, ApJS, 58, 39

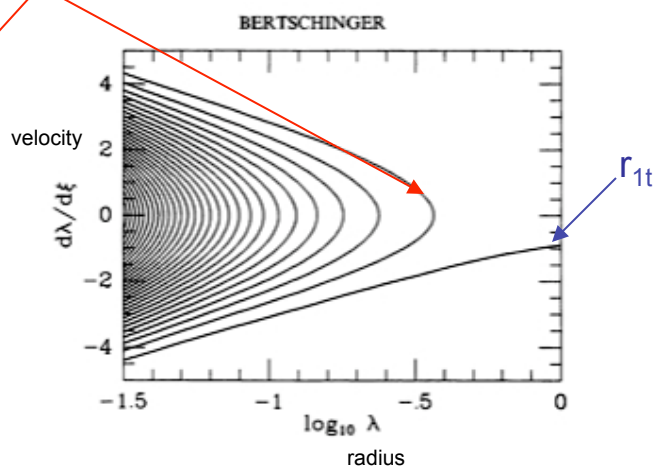
Friedmann Equation: $H^2 - (8\pi/3)G\rho - \Lambda/3 = -kc^2/R^2$

$t = 2/(3H) \Rightarrow \boxed{t \sim 1/\rho^{1/2}}$

1st turnaround today: r_{1t}







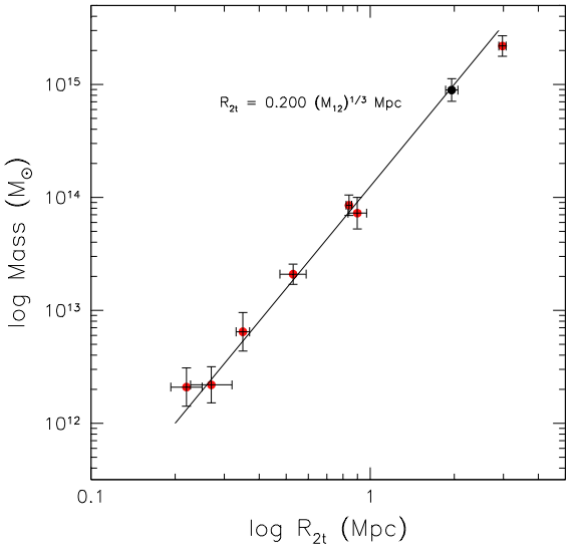
$t \sim (r^3/M)^{1/2}$
so $r_1/r_2 = (M_1/M_2)^{1/3}$
or $r_{2t} \sim M^{1/3}$

$M \sim \sigma_p^2 r$
so $(r_1/r_2)^3 \sim \sigma_1^2 r_1/\sigma_2^2/r_2$
or $r_{2t} \sim \sigma_p$

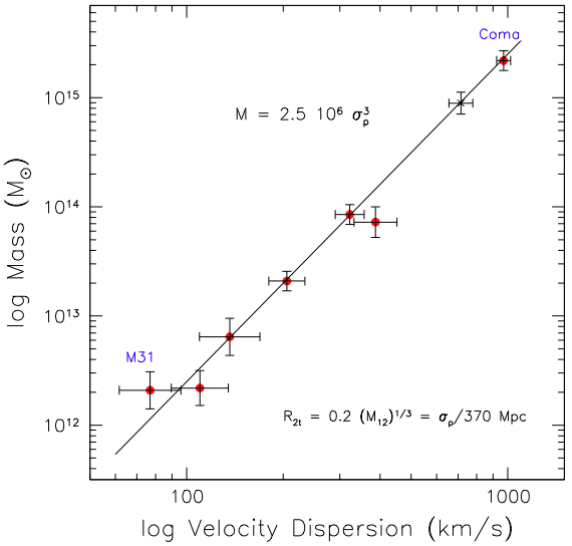
→

$M \sim \sigma_p^2 r$
if $r_{2t} \sim \sigma_p$
then $M \sim \sigma_p^3$

From big to small …. Correlations

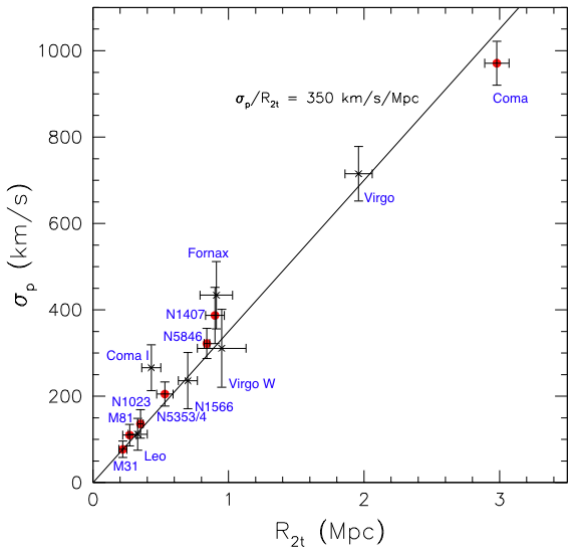


$r_{2t} \sim M^{1/3}$



$M \sim \sigma_p^3$

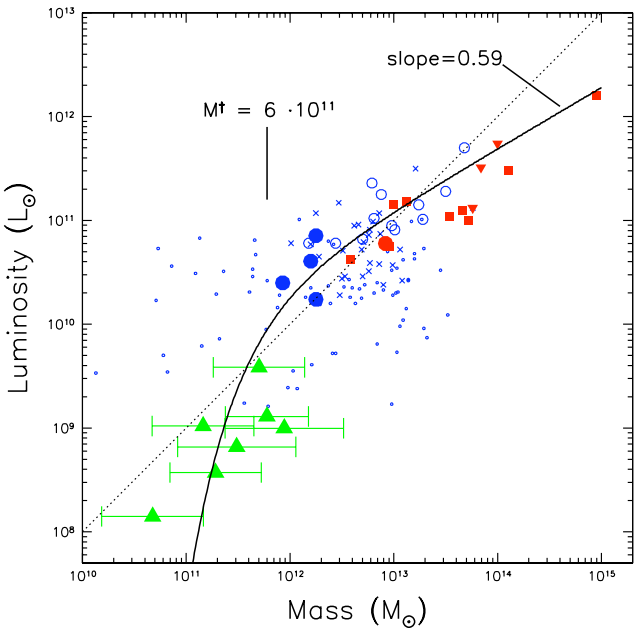
$r_{2t} \sim \sigma_p$



Tully 2015, AJ, 149, 54

Conversion from Luminosity to Mass

M/L from virial analysis of groups
Tully 2005, ApJ, 618, 214

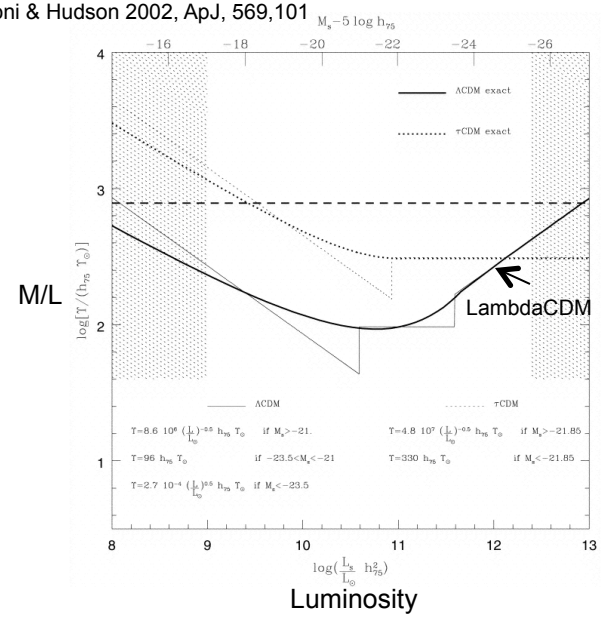


M/L values increase with halo mass, but how?

Input:

- Virial mass to K band luminosity measurements for well studied groups (Coma, Virgo, nearby groups studied by Makarov and Karachentsev)
- Numerical action models of infall into the Virgo Cluster and the dynamics in and around the Local Group

Compare halo luminosity function with Press-Schechter mass function
Marinoni & Hudson 2002, ApJ, 569,101

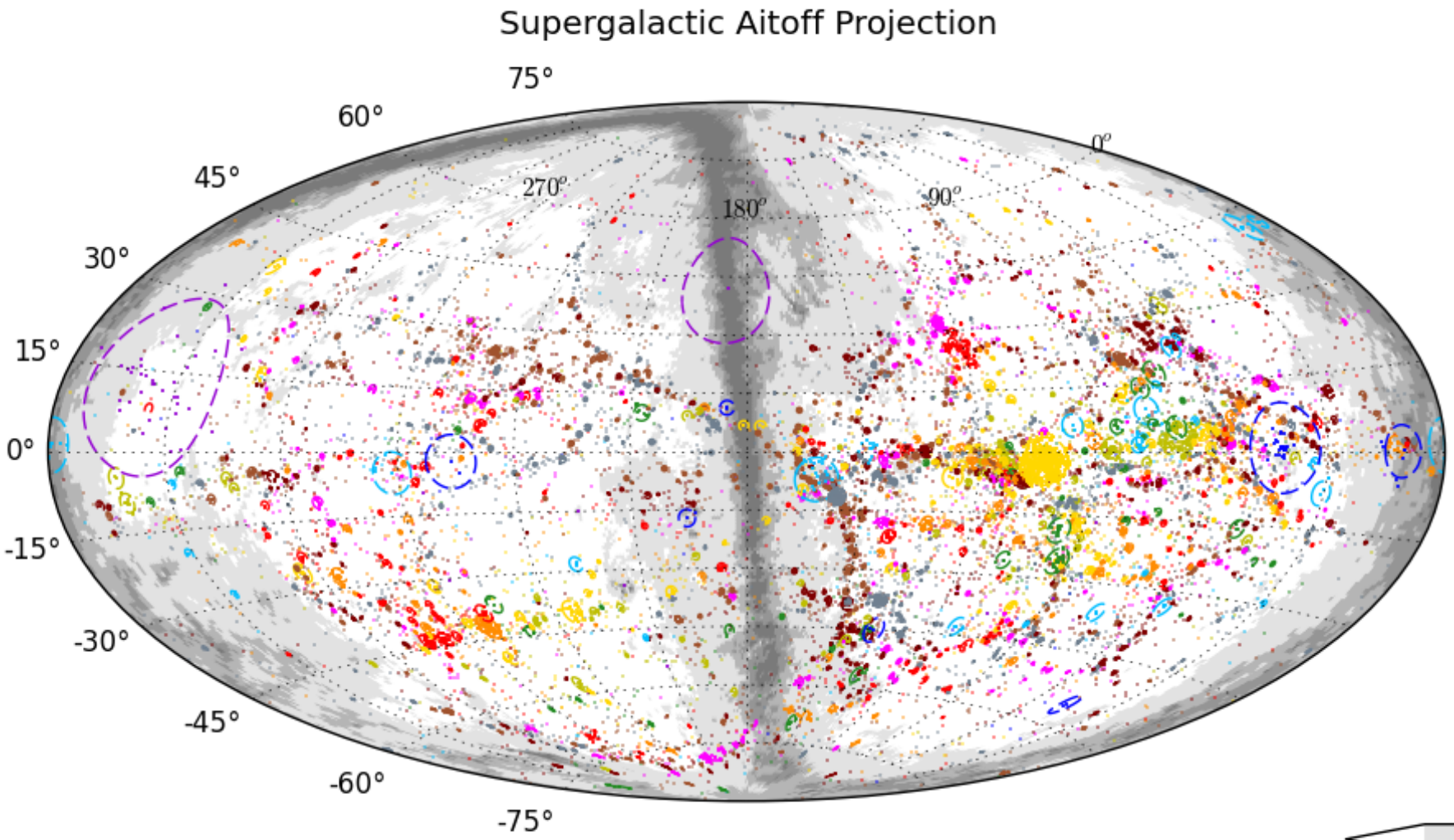


$$\frac{M_v^{exp}}{L_{K_s}} = \begin{cases} 32 \times L_{10}^{-0.5} & L_{K_s} < 10^{10} \\ 32 \times L_{10}^{0.15} & 10^{10} \leq L_{K_s} \leq 10^{13} \\ 91 & L_{K_s} > 10^{13} \end{cases}$$

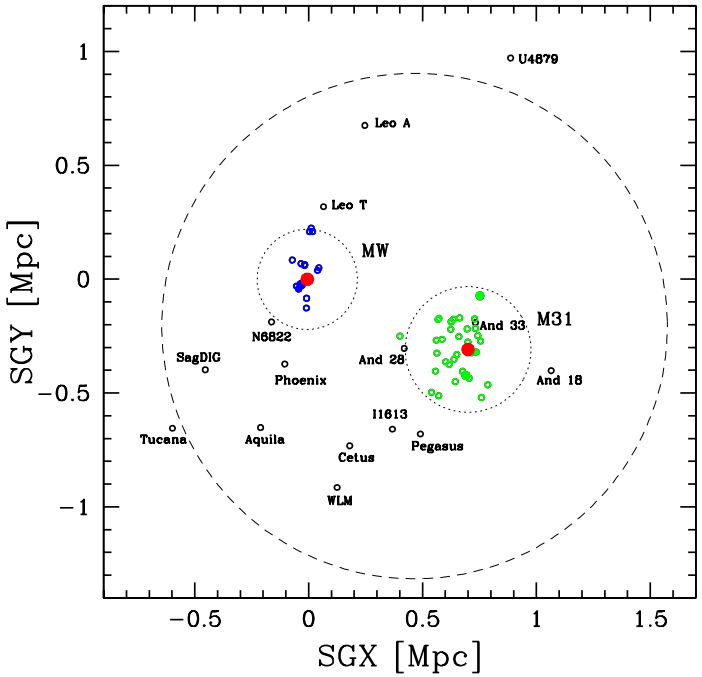
Data

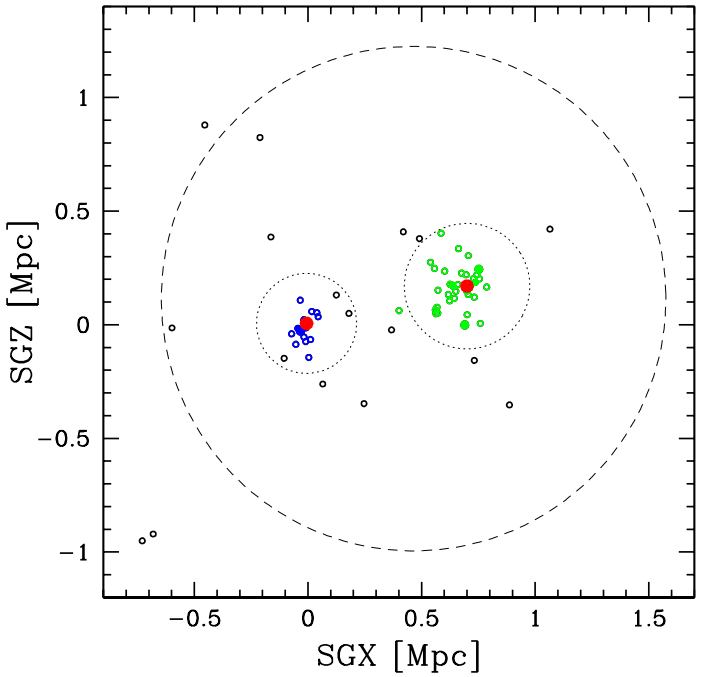
15,000 galaxies V<3,500 km/s

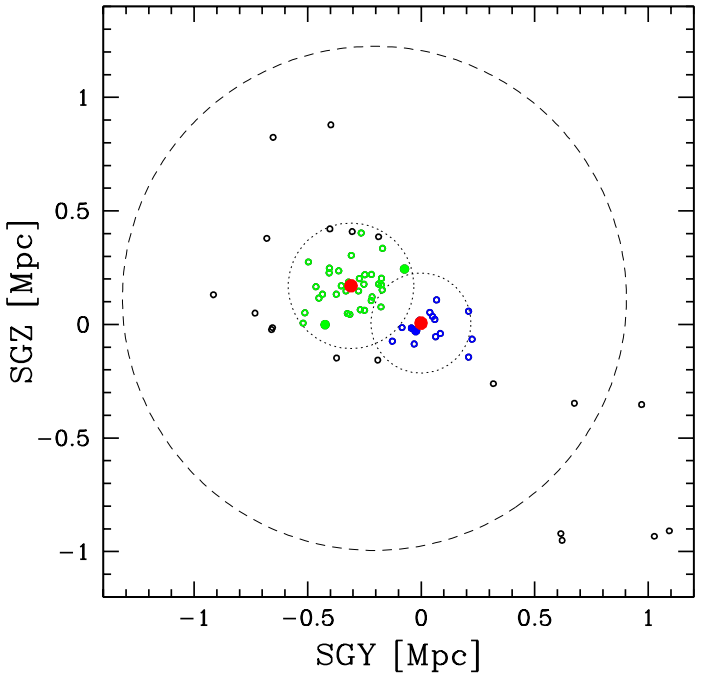
- all-sky 2MASS K<11.75 (2 mag fainter than L* at distance limit)
- HI surveys (low surface brightness galaxies)
- Karachentseva & Karachentsev dwarfs (local inventory)
- HST TRGB for 400 galaxies (50% of galaxies within 10 Mpc)



Local Group


U4879
Leo A
Leo T
MW
N6822
SagDIG
Phoenix
And 33
M31
And 28
And 18
I1613
Tucana
Aquila
Cetus
Pegasus
WLM
SGY [Mpc]
SGX [Mpc]


SGZ [Mpc]
SGX [Mpc]


SGZ [Mpc]
SGY [Mpc]

Association

Local Group

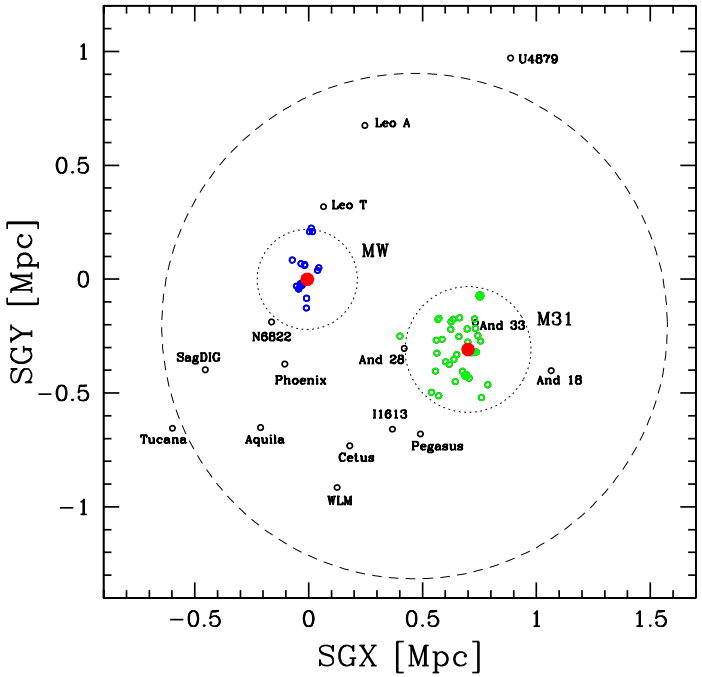
16 Groups

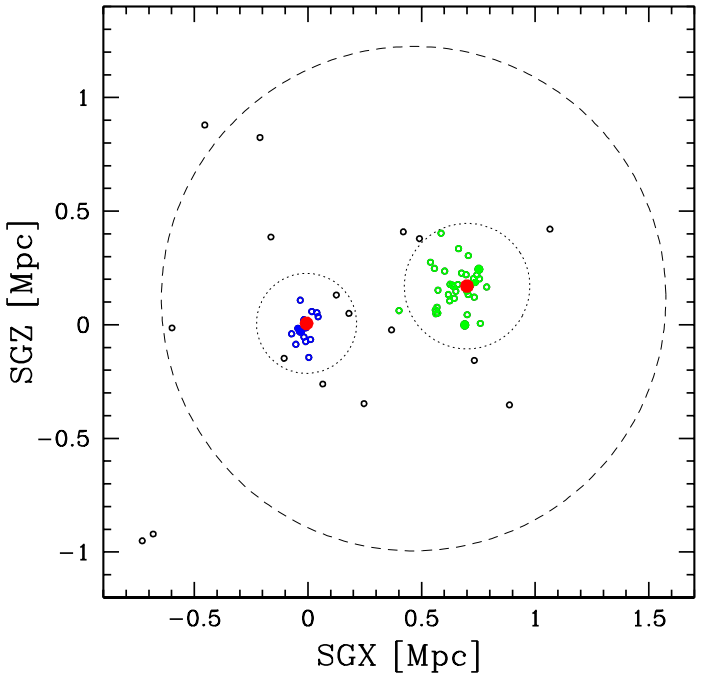
MW, M31

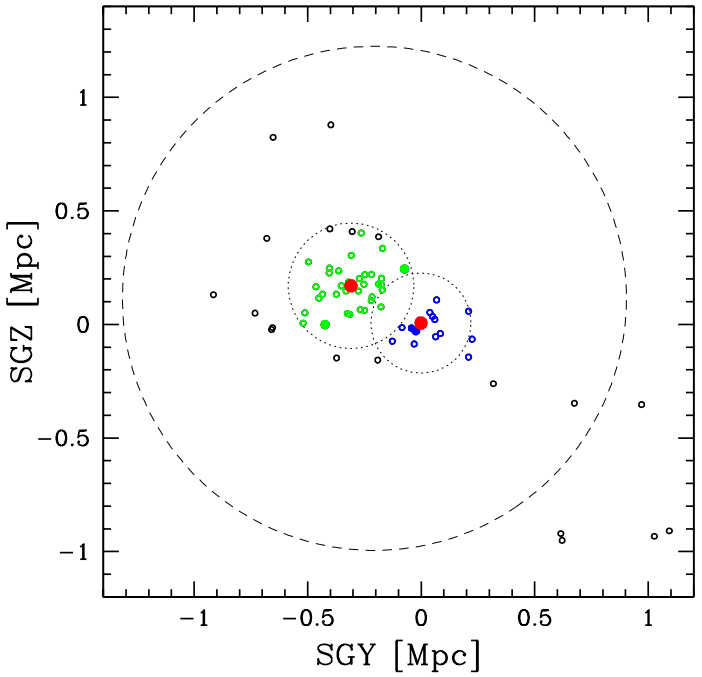
N6822, I1613, WLM

Leo A, Leo T, Phoenix, SagDIG, Tucana, Aquarius

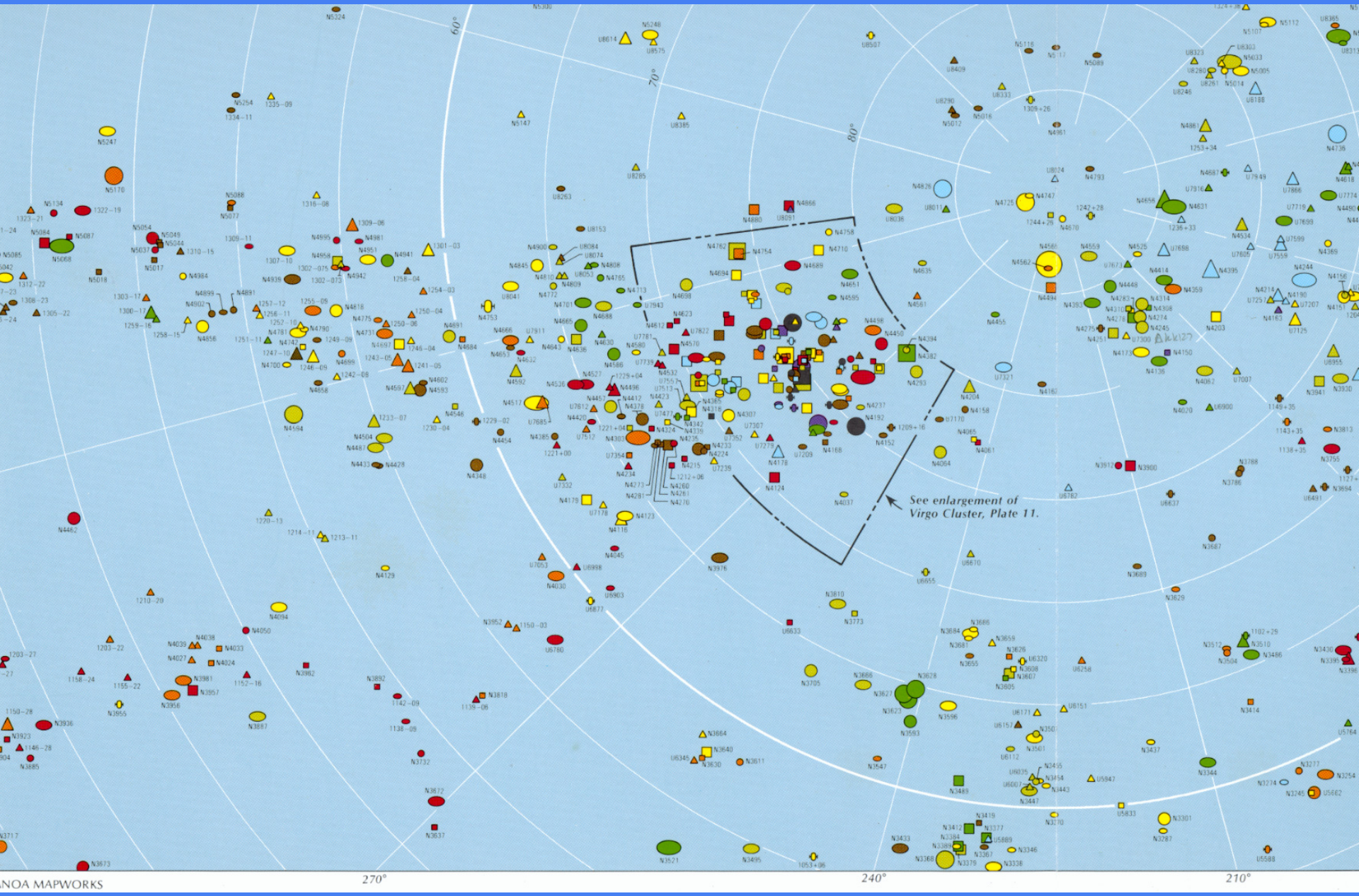
Cetus, Pegasus, And 18, And 28, And 33



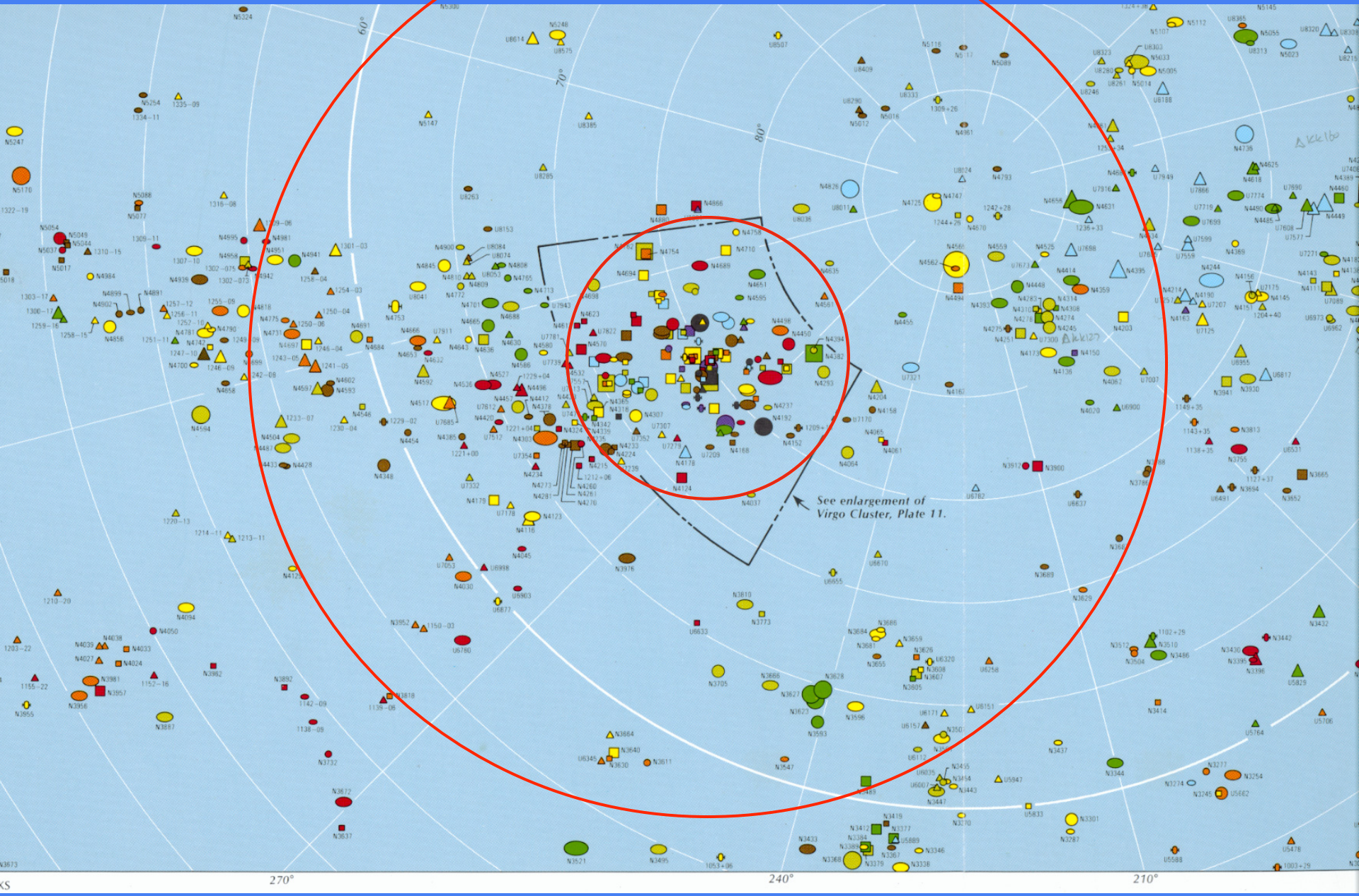




Virgo region

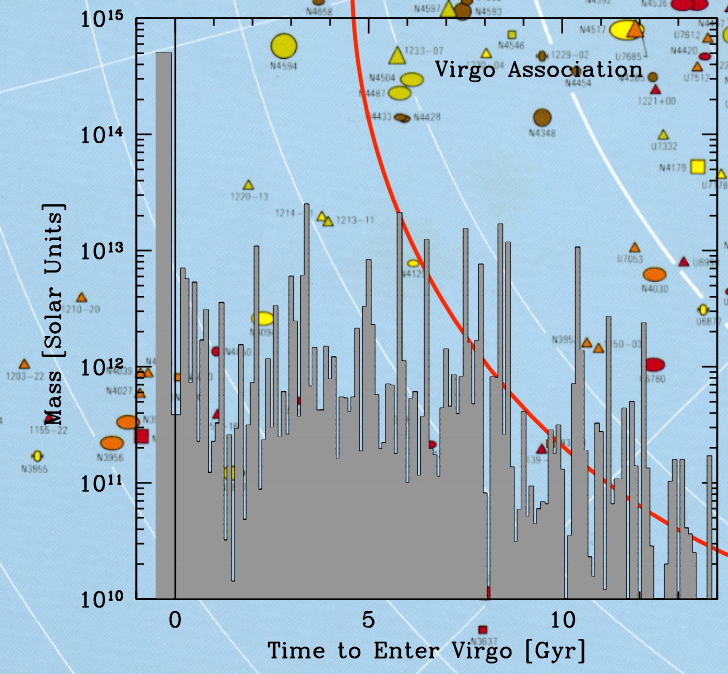


Virgo zero velocity surface
~ 7 Mpc radius

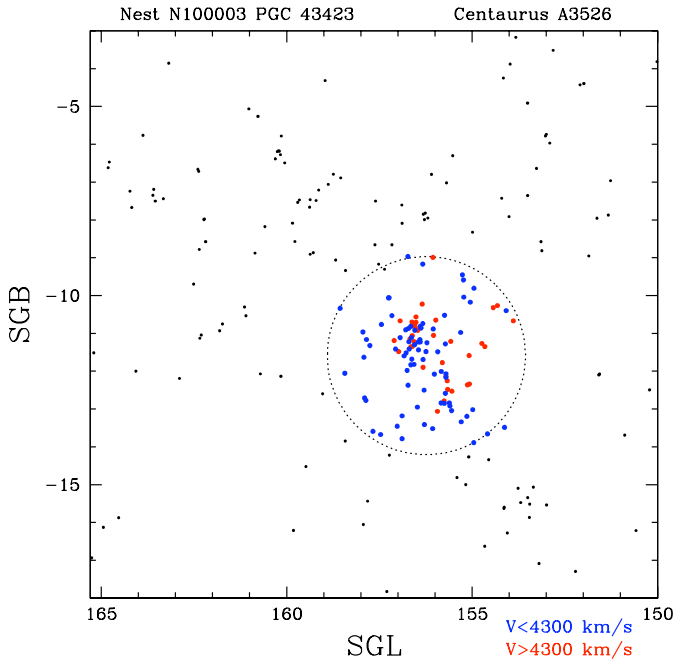


Virgo zero velocity surface
~ 7 Mpc radius

Virgo growth in next $1/H_0$
60% by number
50% by luminosity
40% by mass

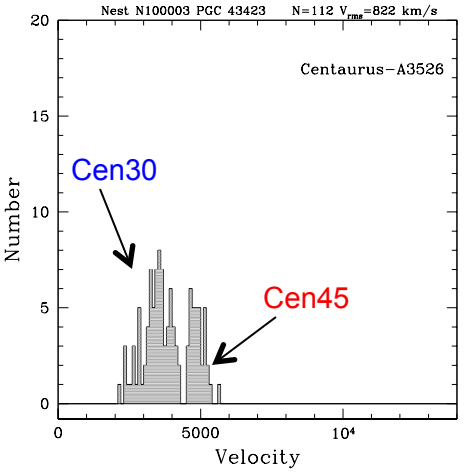


Extreme Velocities



Centaurus Cluster

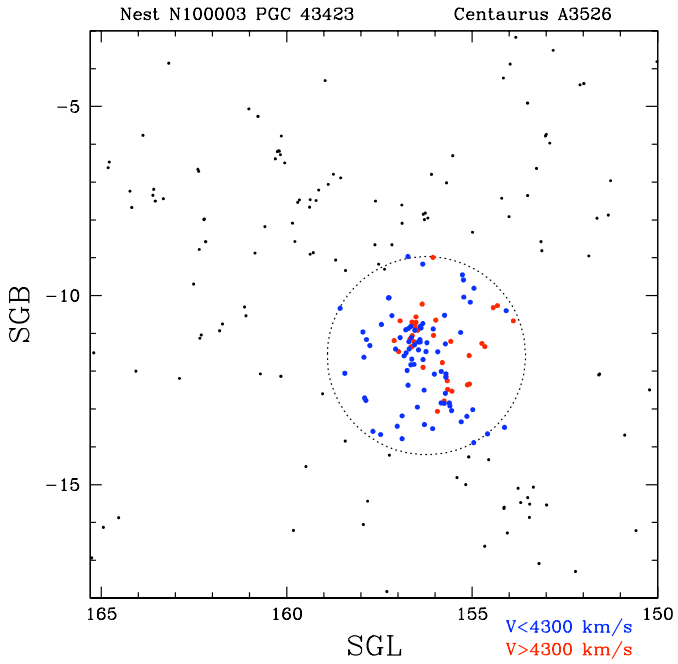
2 kinematic components overlap spatially

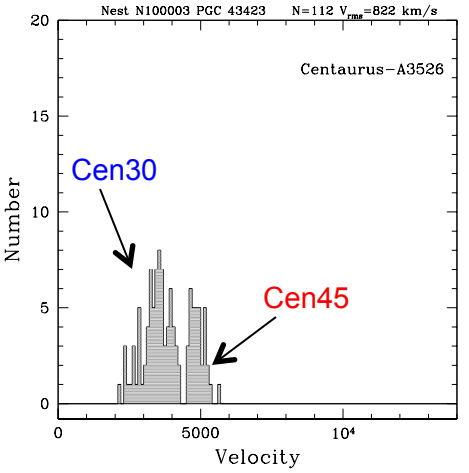


Extreme Velocities

Centaurus Cluster

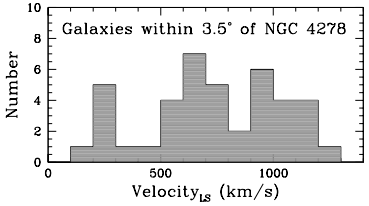
2 kinematic components overlap spatially

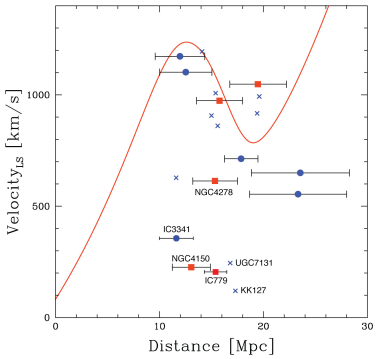


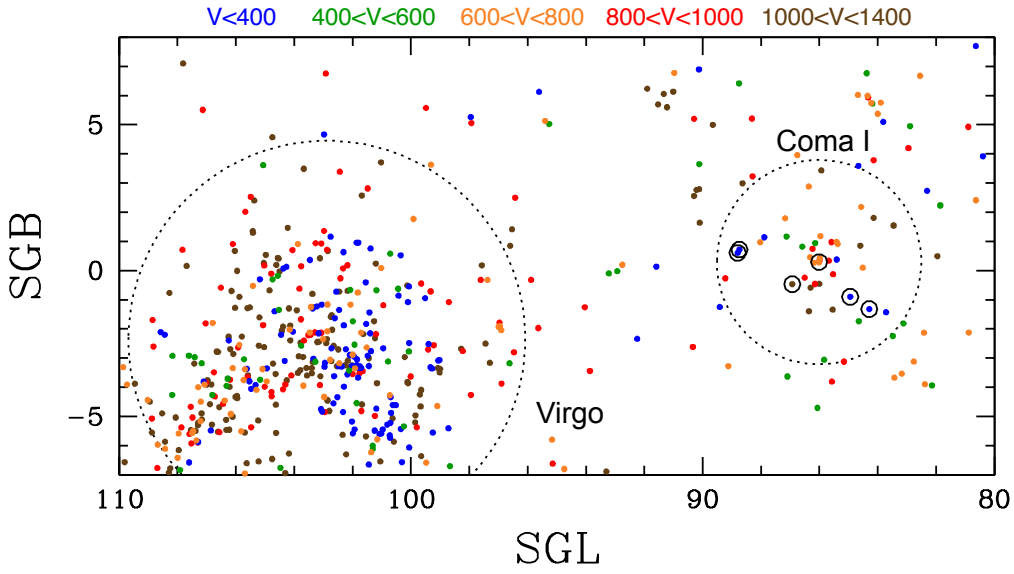


Coma I Group

Anomalous blueshifted members

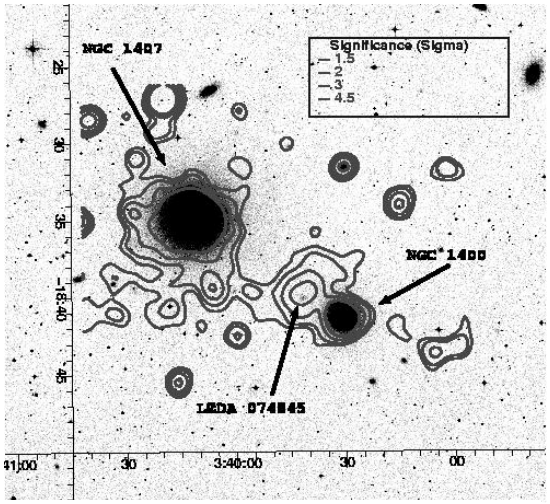






Quasi-fossil …. NGC 1407 Group

The NGC 1407 Group is part of the Fornax-Eridanus complex that is bound with 3-4x$10^{14}M_{\odot}$ and will collapse within the next Hubble time



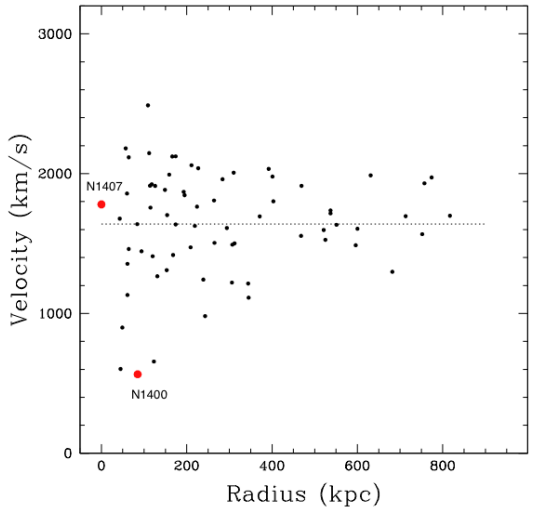
D = 25 Mpc

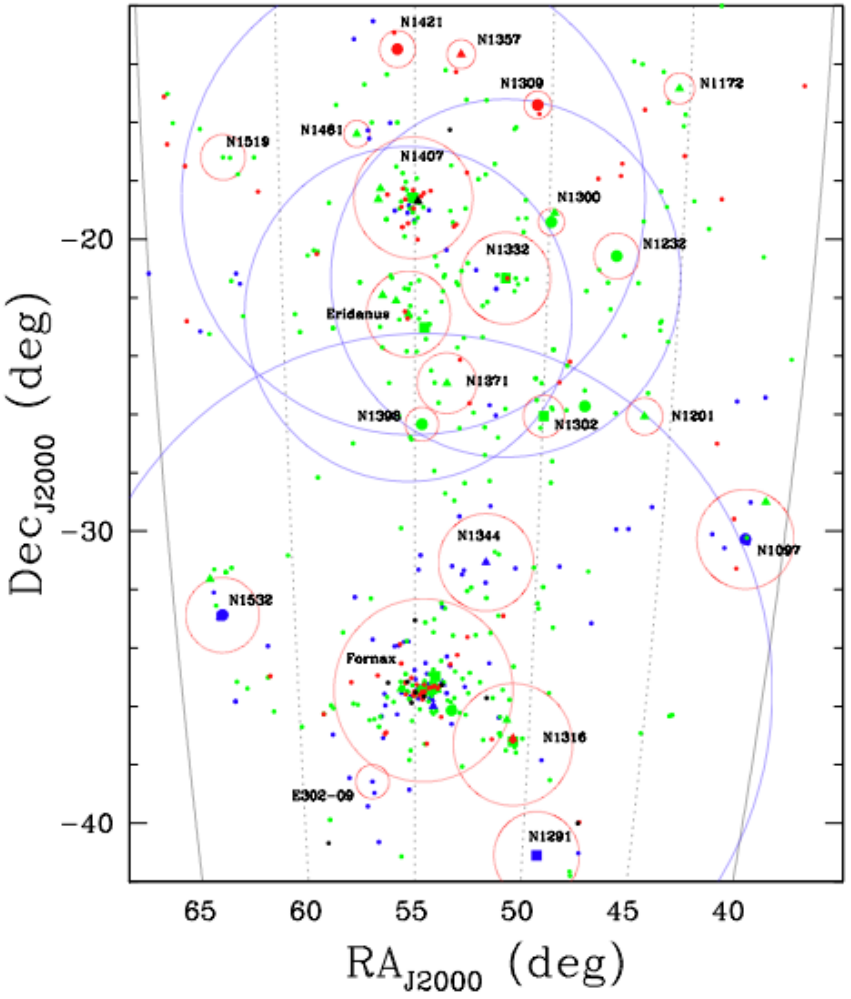
R_{2t} ~ 900 kpc

σ_p = 387 km/s

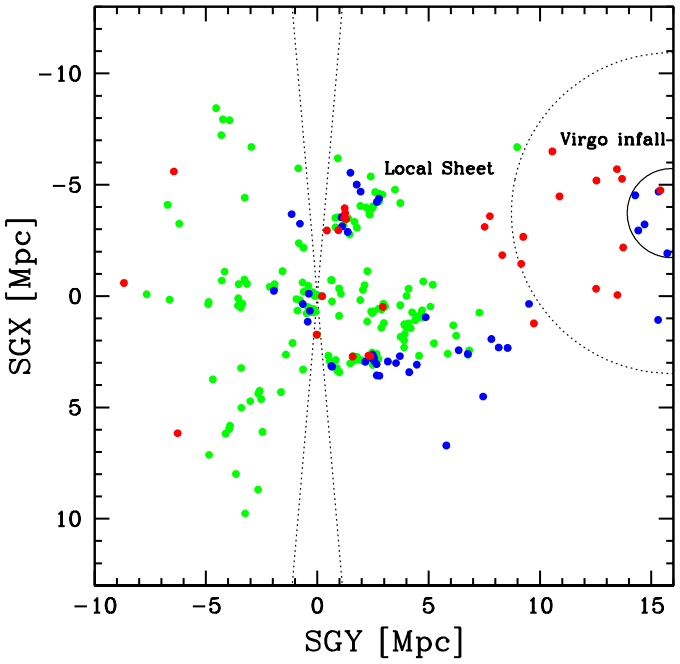
$M_v = 7x10^{13}\ M_{\odot}$

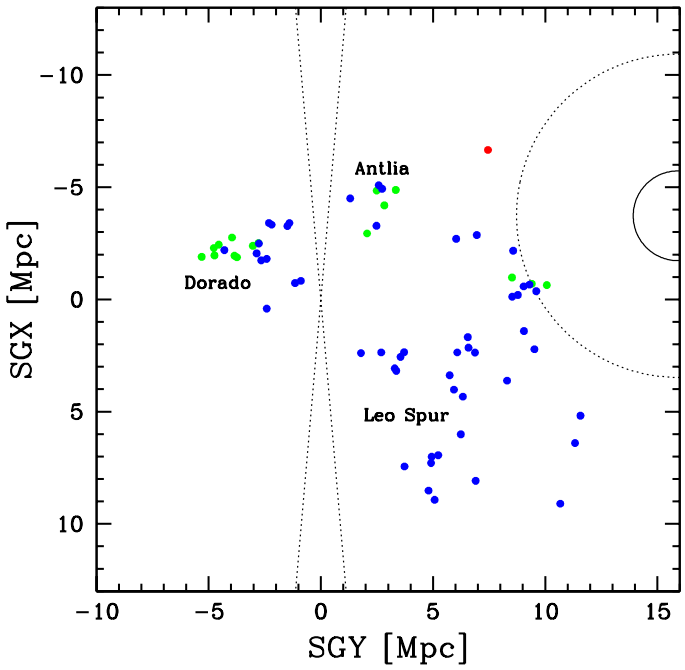
The 2nd brightest galaxy, NGC 1400, is blueshifted 1220 km/s w.r.t. NGC 1407 !

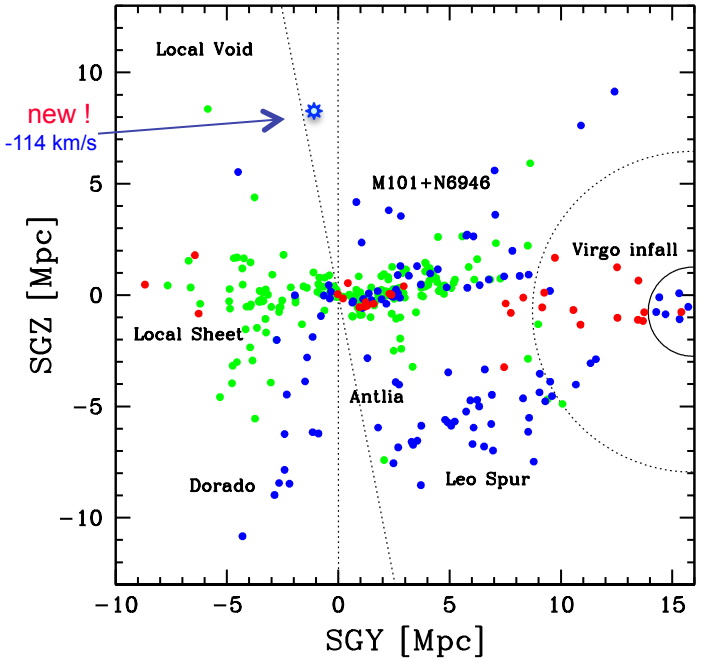




Trentham, Tully, Mahdavi 2006, MNRAS, 369, 1375

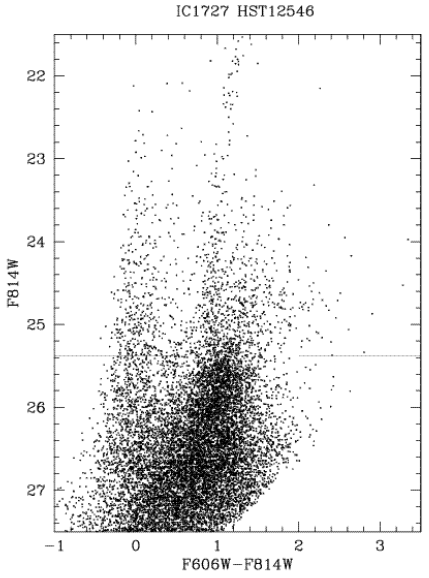


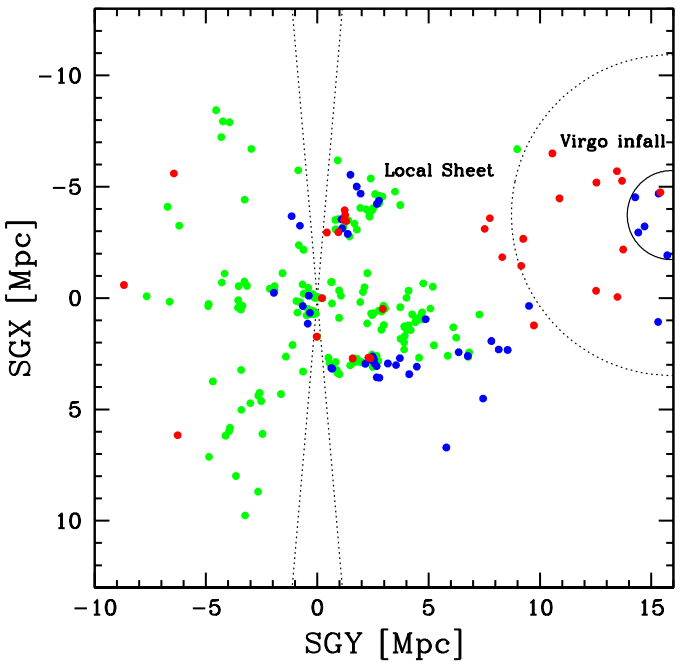


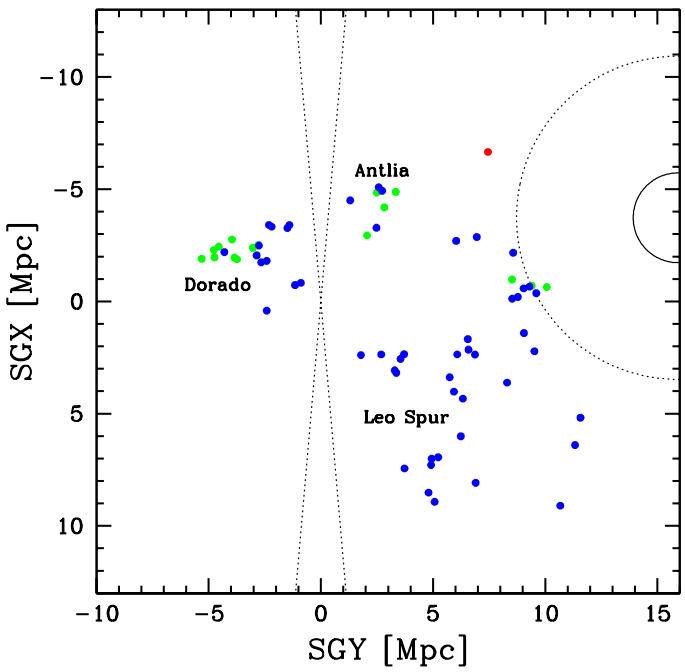


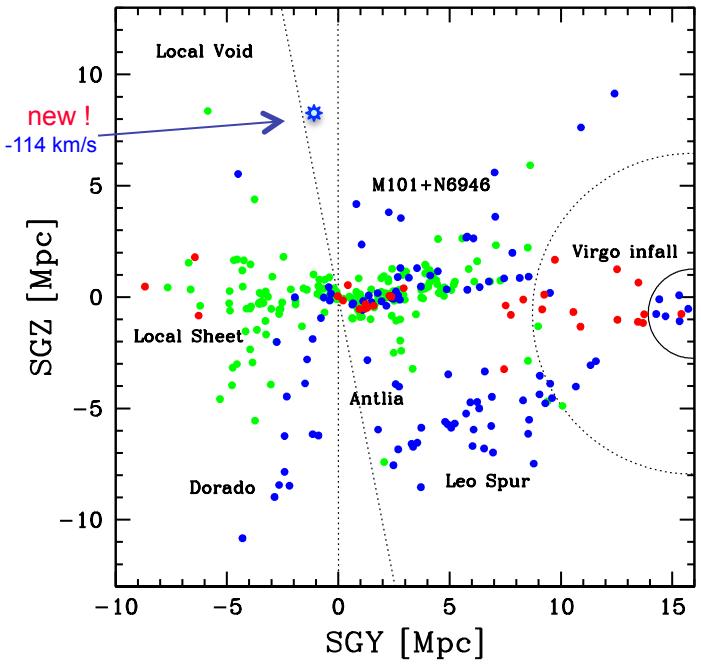
excellent TRGB coverage locally

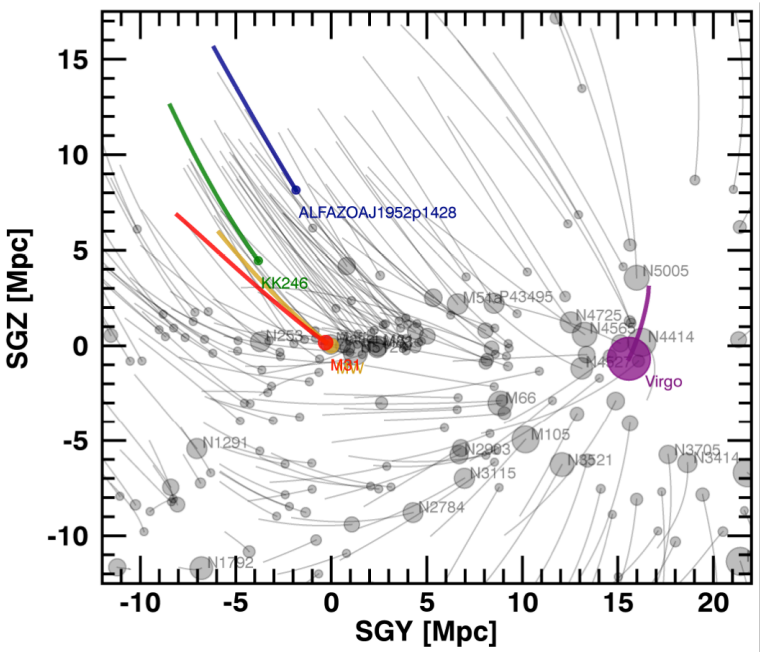
V_{LS} > +100 km/s
-100 to +100 km/s
V_{LS} < -100 km/s

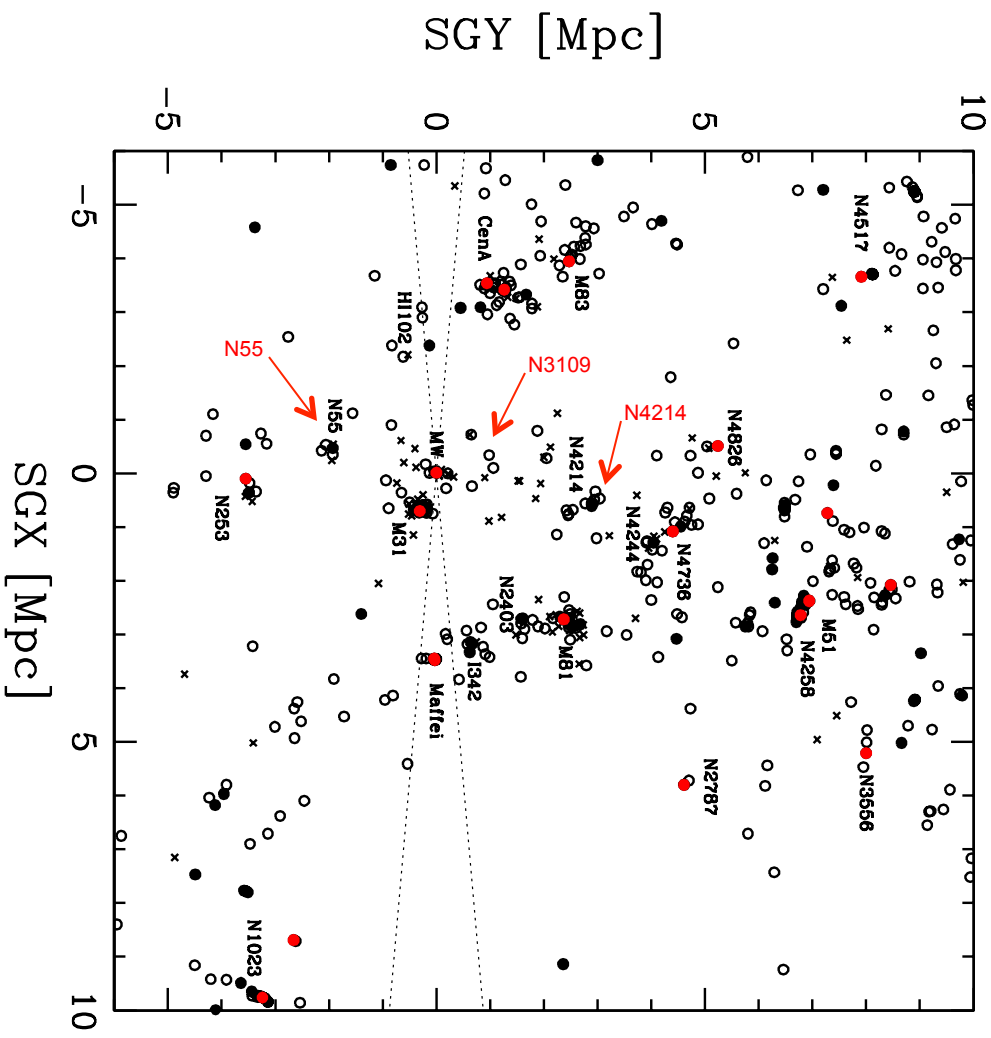



Local Sheet
Virgo infall
SGX [Mpc]
SGY [Mpc]


Antlia
Dorado
Leo Spur
SGX [Mpc]
SGY [Mpc]

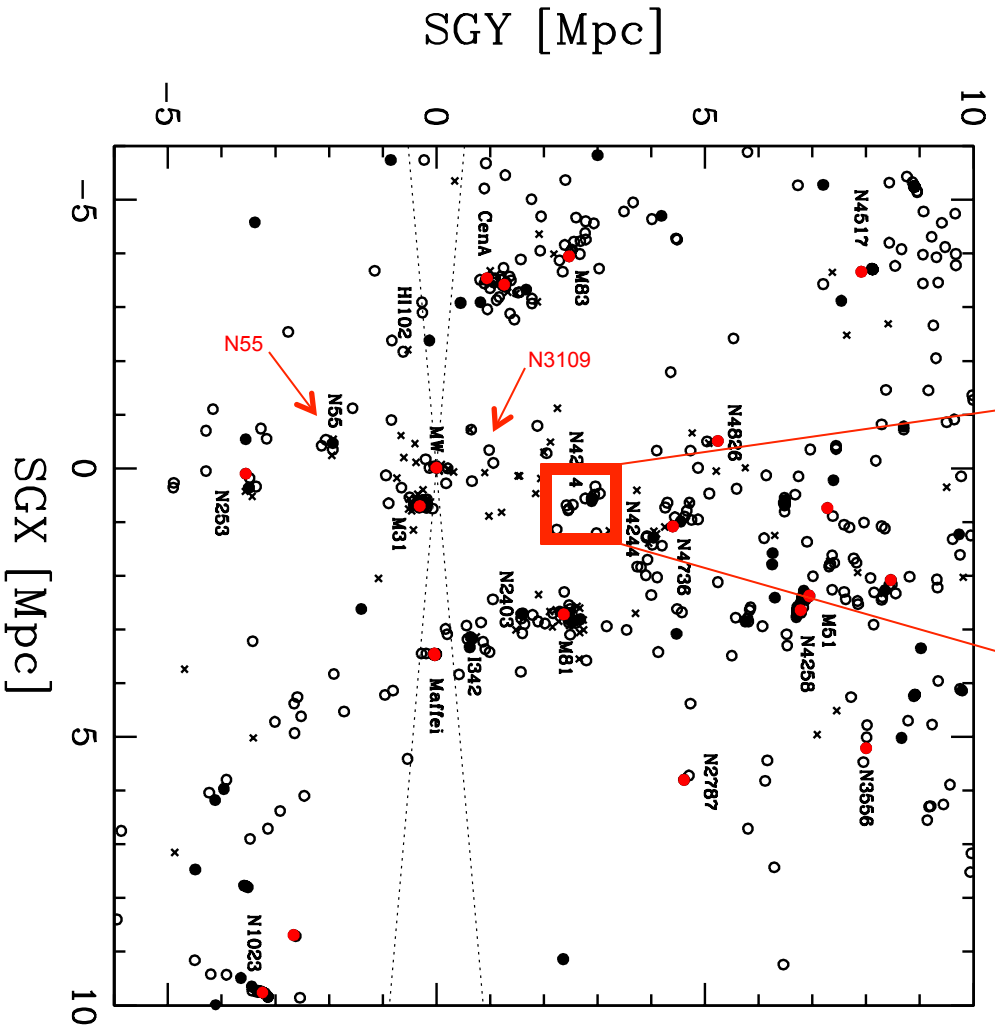

Local Void
new !
-114 km/s
M101+N6946
Virgo infall
Local Sheet
Antlia
Dorado
Leo Spur
SGZ [Mpc]
SGY [Mpc]


ALFAZOAJ1952p1428
KK246
M31
Virgo
N5005
N4414
M66
M105
N1291
N3115
N2784
SGZ [Mpc]
SGY [Mpc]

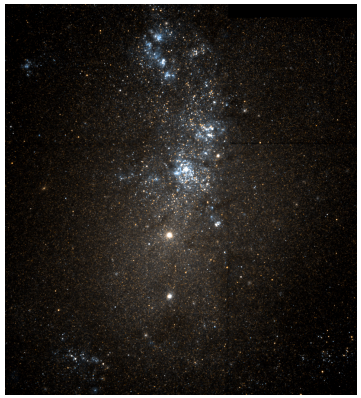


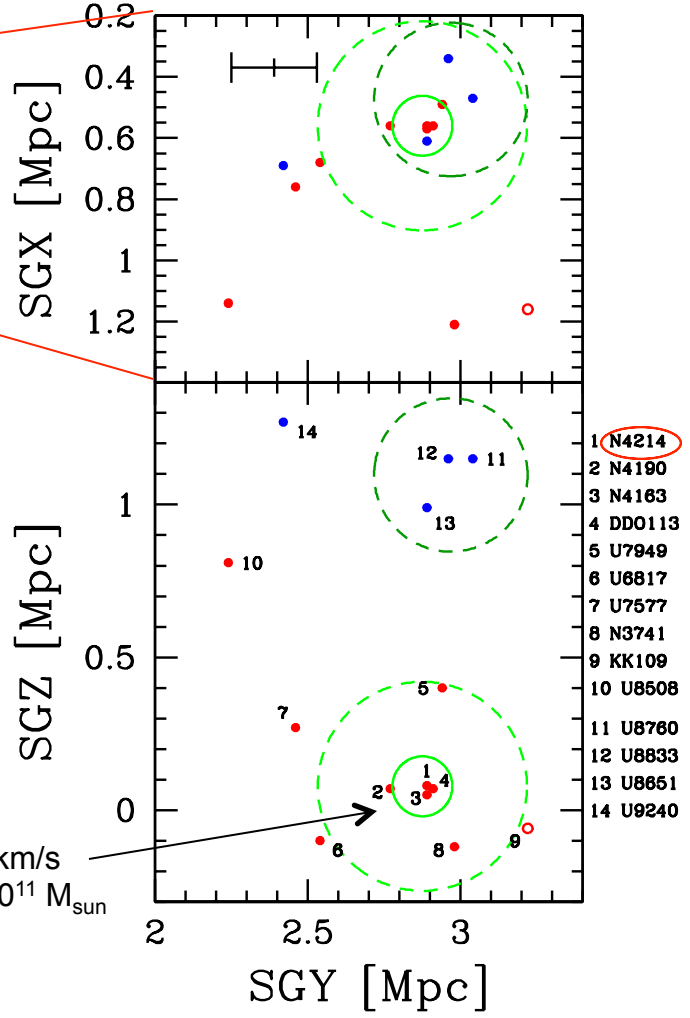
Relative accuracy of TRGB distances ~200 kpc

Dwarf Associations



NGC4214





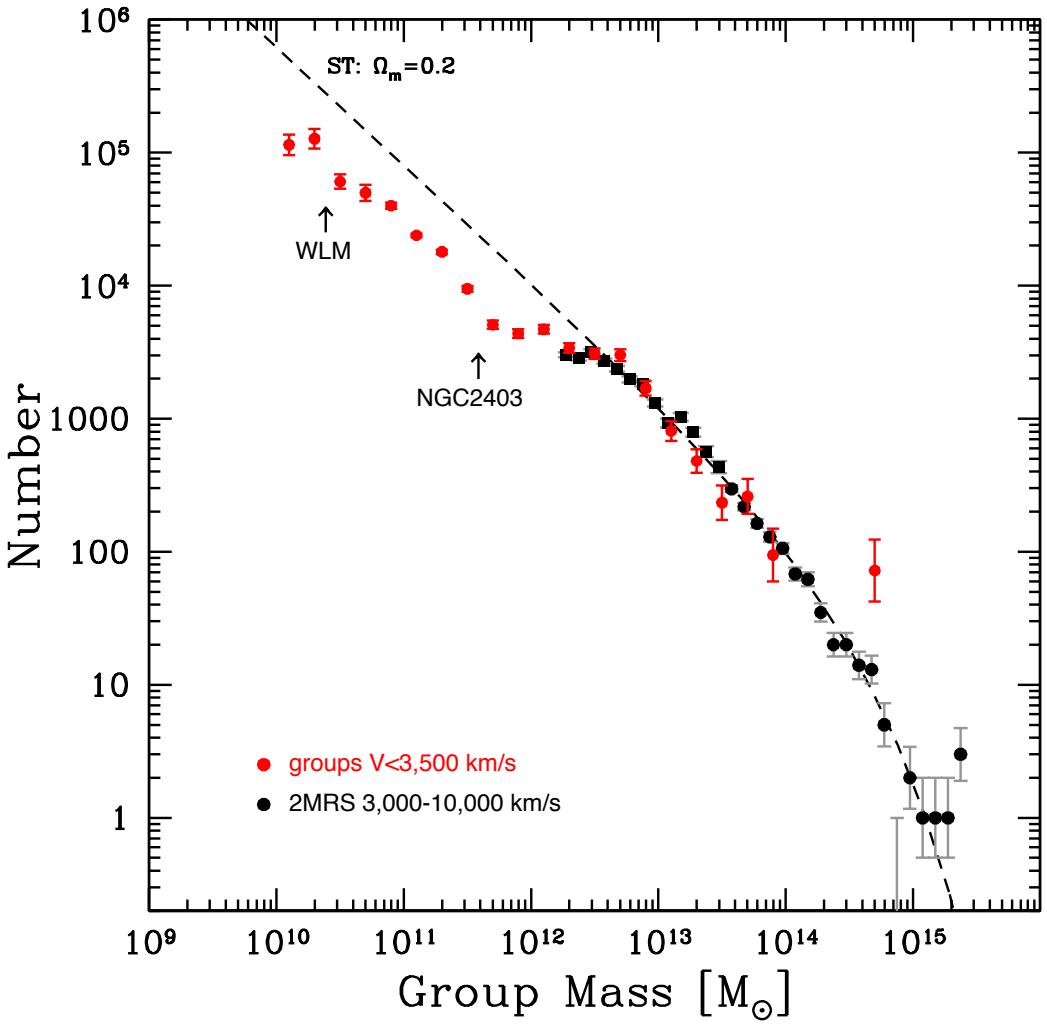
Relative accuracy of TRGB distances ~200 kpc

σ_v=49 km/s
M~2x10^{11} M_{sun}

Dwarf Associations

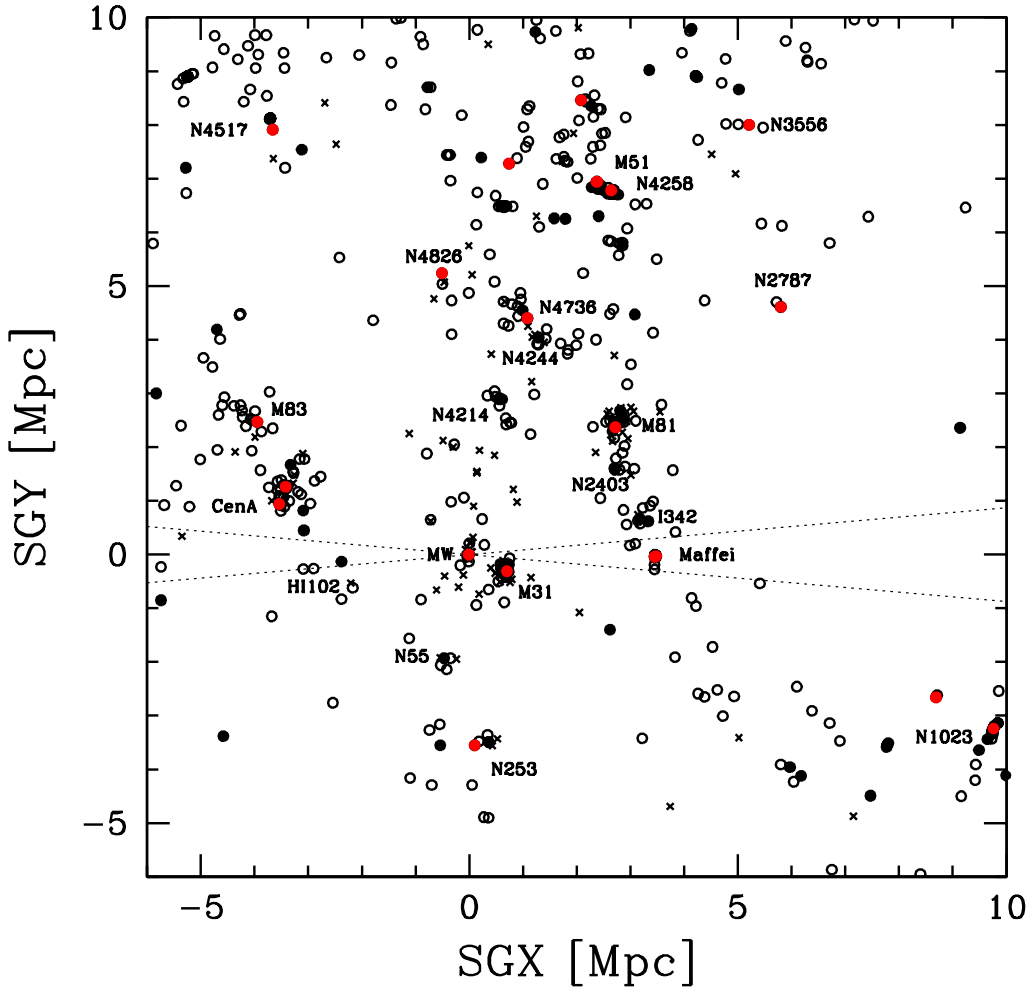
Sheth-Tormen fit: thanks to Melody Wolk, Julien Carron, Istvan Szapudi

Mass Function

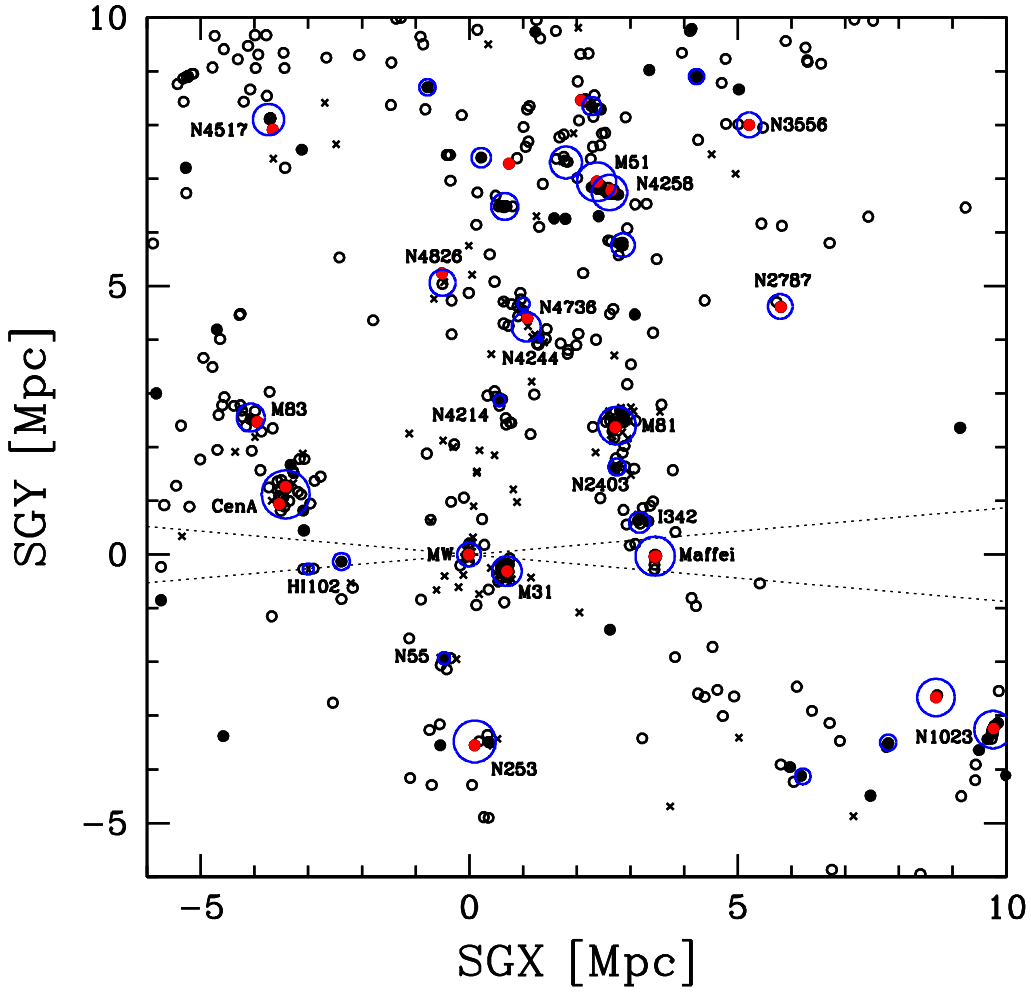


All groups, including N_{gp}=1, masses inferred from luminosities
red: V<3500 km/s sample; black: 2MASS K<11.75, 3-10k km/s

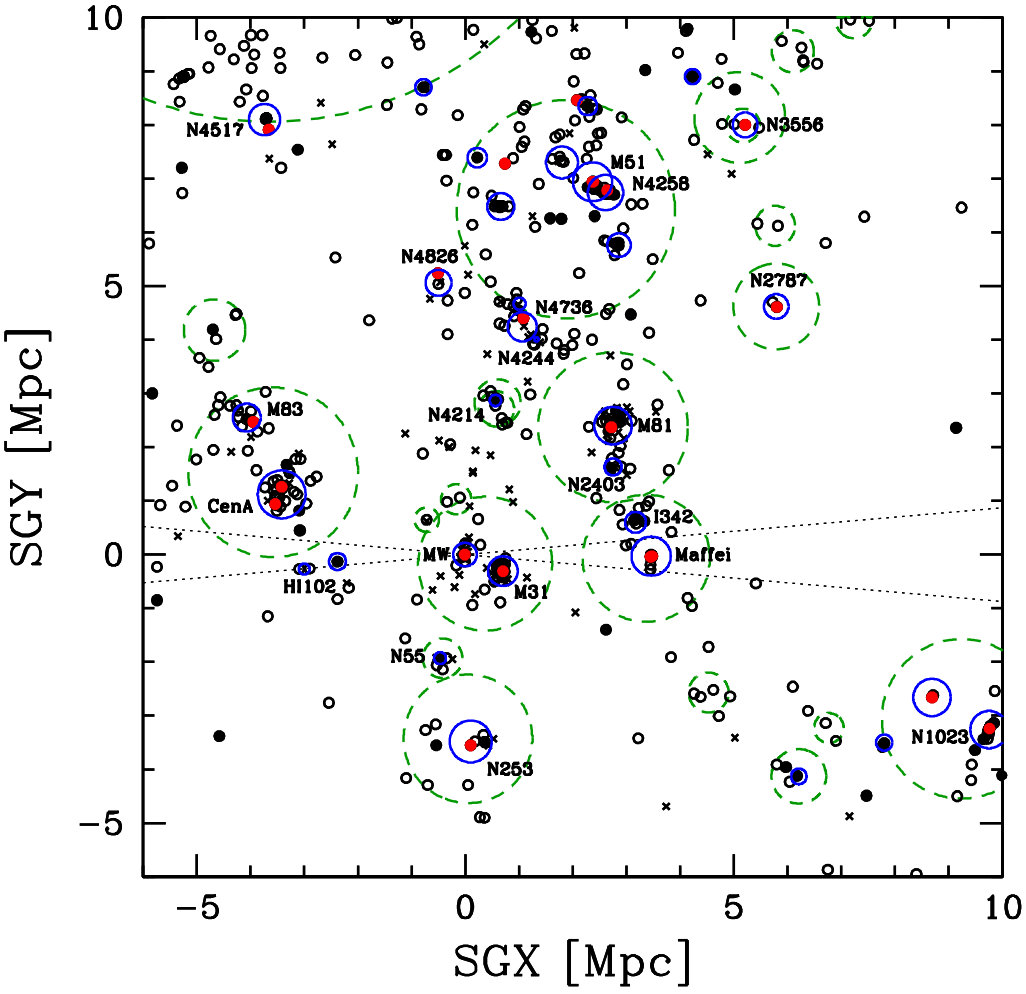
Future merging



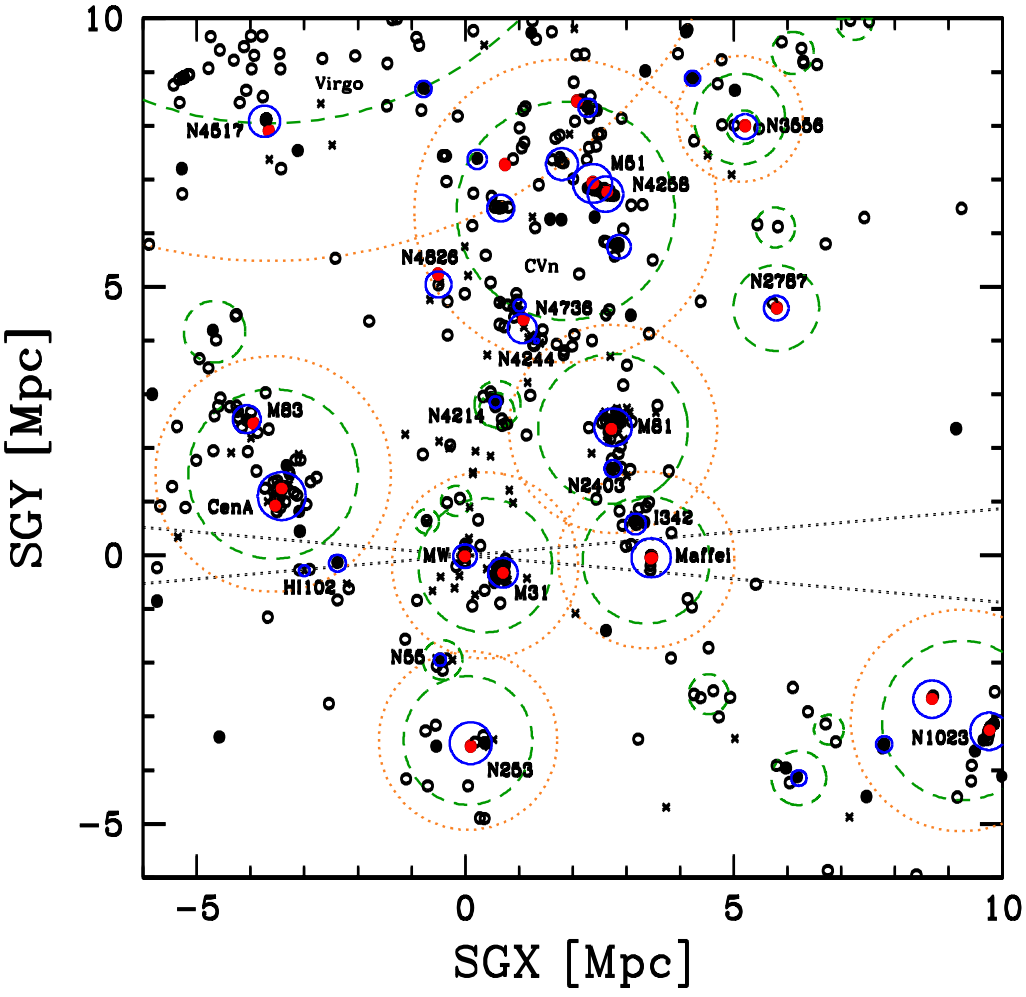
Future merging



Future merging



Future merging



Map of Universe in 10^{37} years if protons are unstable