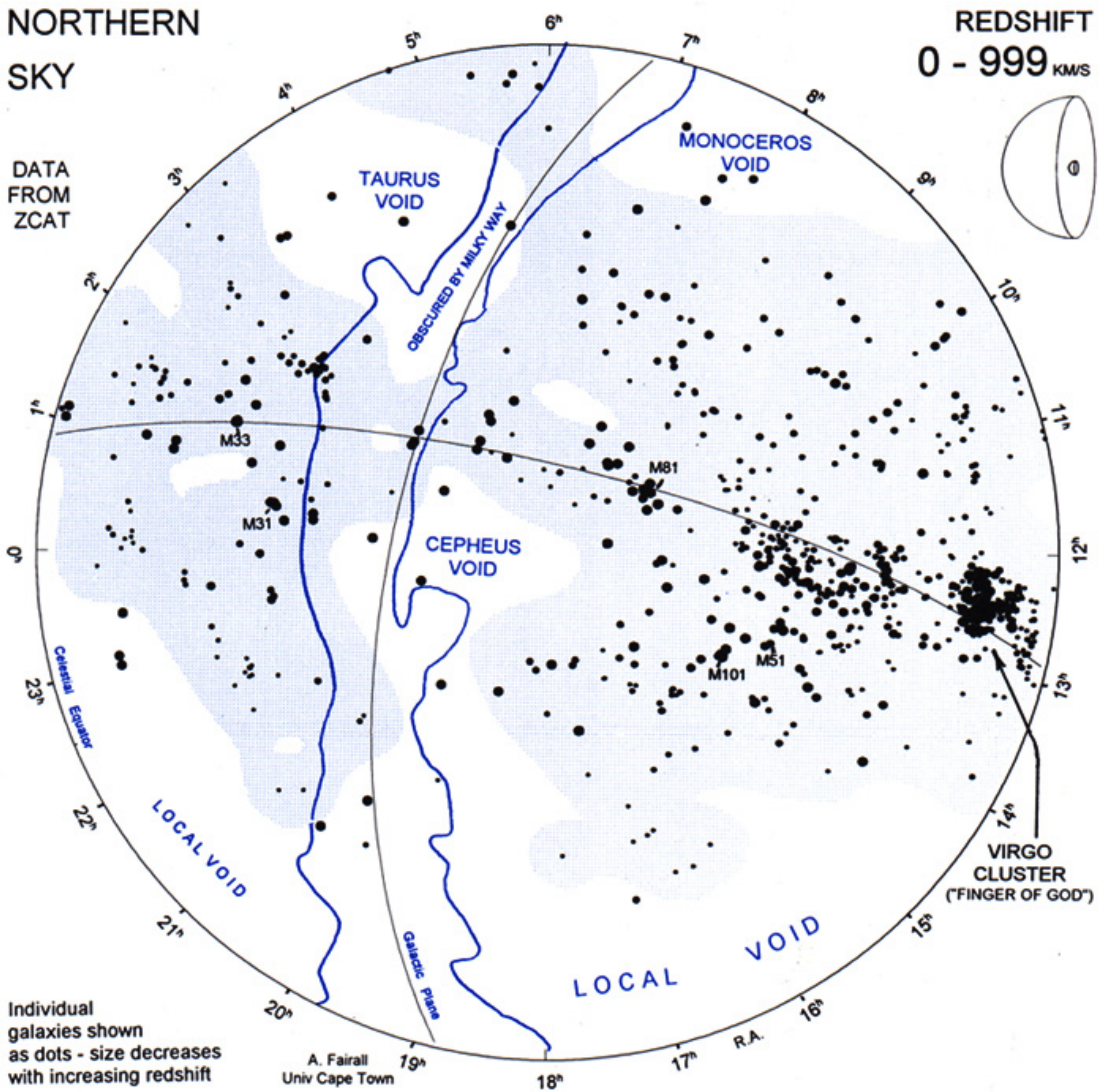
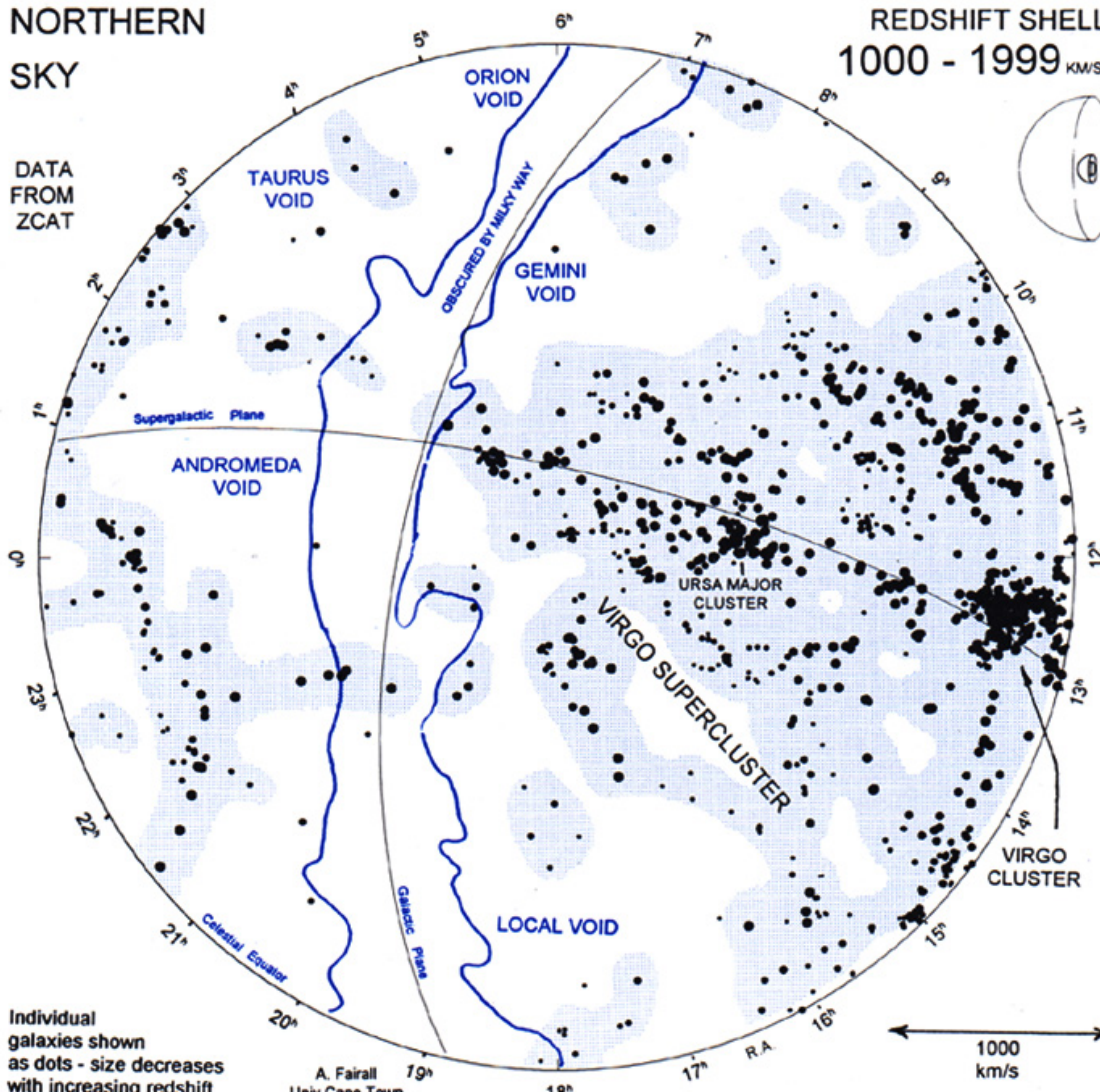
# Large scale distribution of galaxies

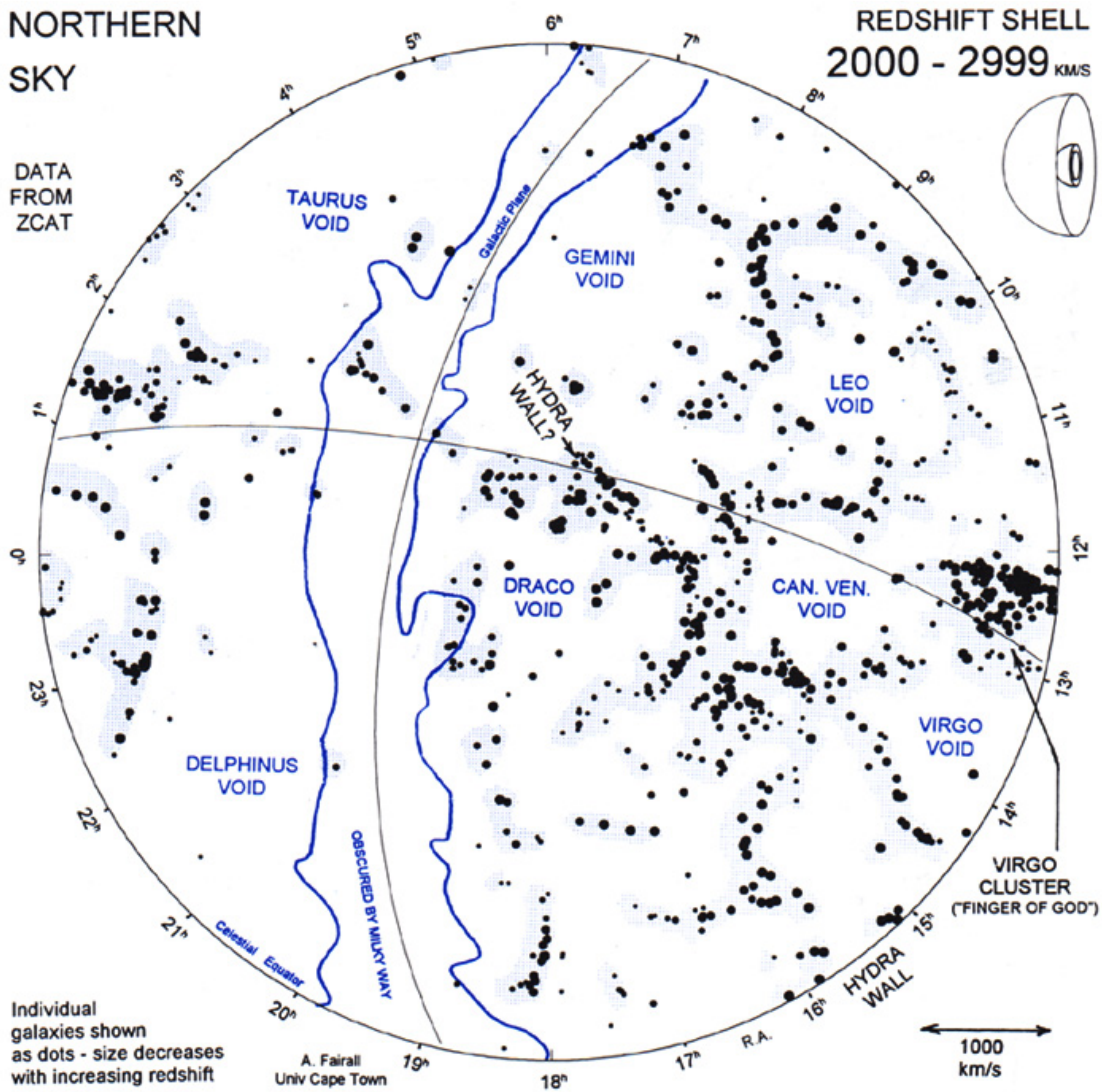
Projections on the sky
Pie diagrams
Motion of galaxies
Constrained simulations
Voids
Galaxies: effects of environment

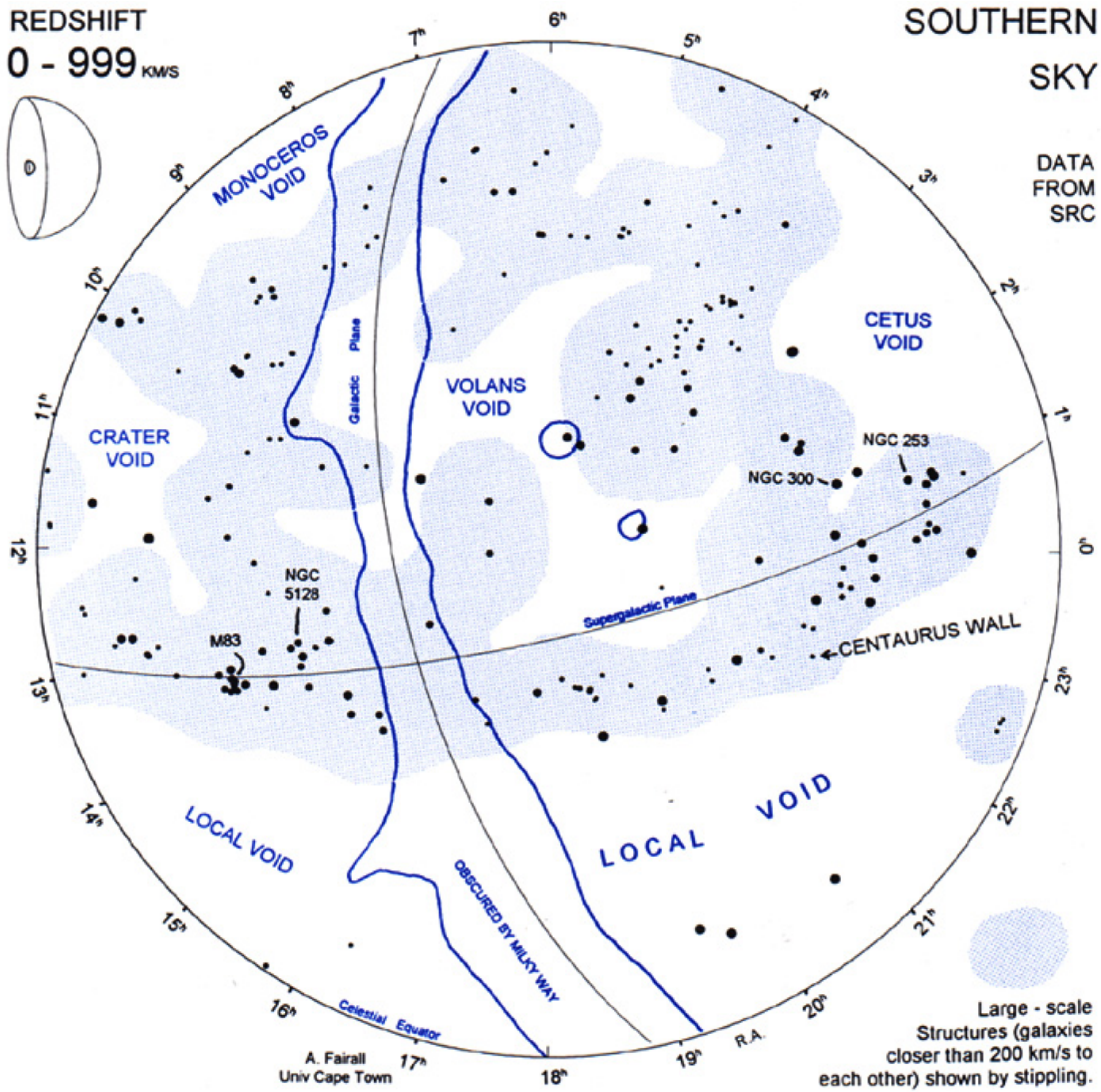
Projection

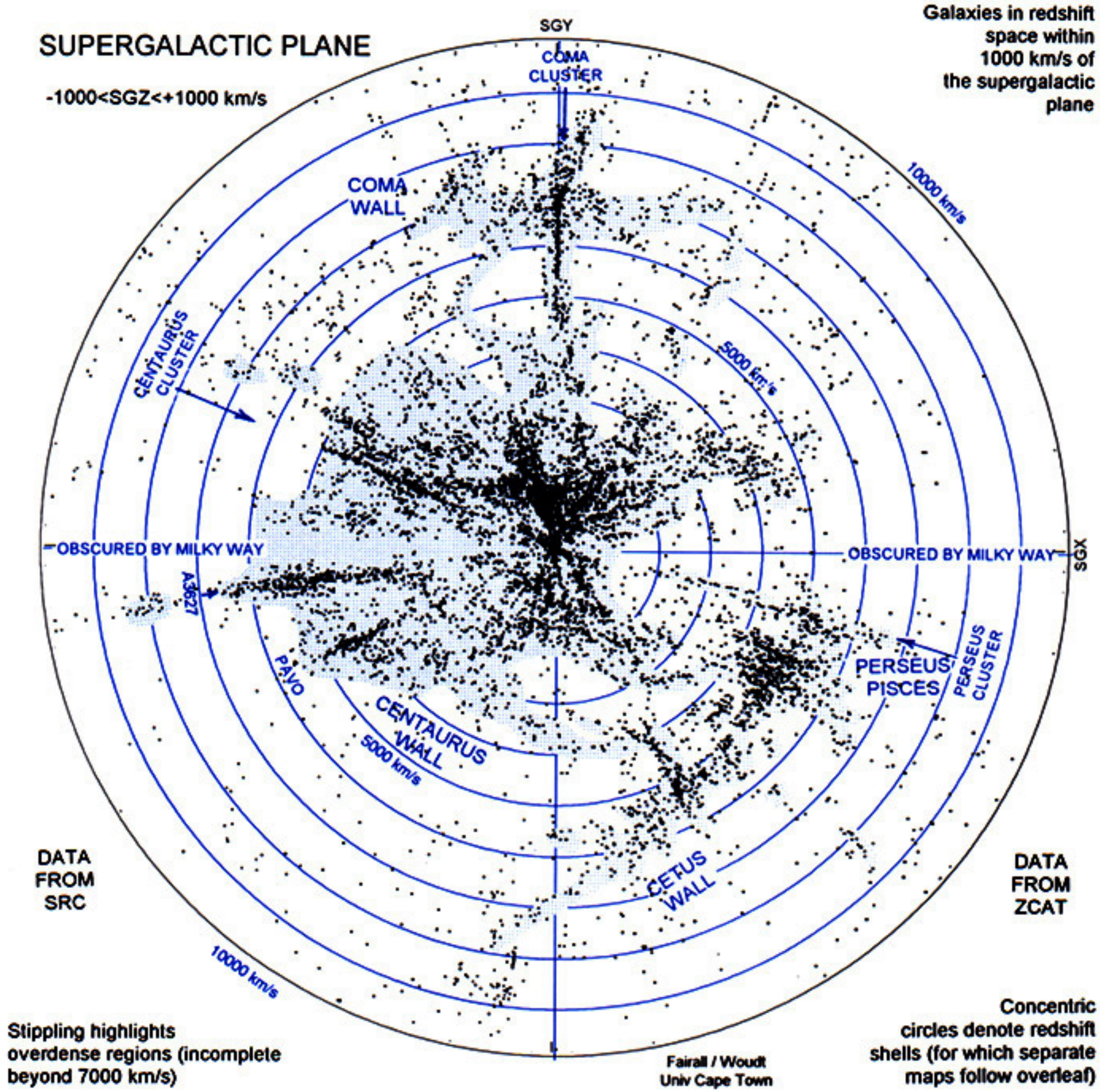


NORTHERN SKY
REDSHIFT 0 - 999 KM/S
DATA FROM ZCAT
TAURUS VOID
MONOCEROS VOID
OBSCURED BY MILKY WAY
CEPHEUS VOID
M33
M31
M81
M101
M51
VIRGO CLUSTER ("FINGER OF GOD")
LOCAL VOID
LOCAL VOID
Celestial Equator
Galactic Plane
R.A.
Individual galaxies shown as dots - size decreases with increasing redshift
A. Fairall Univ Cape Town


NORTHERN
SKY
REDSHIFT SHELL
1000 - 1999 KM/S
DATA
FROM
ZCAT
ORION
VOID
TAURUS
VOID
OBSCURED BY MILKY WAY
GEMINI
VOID
Supergalactic Plane
ANDROMEDA
VOID
URSA MAJOR
CLUSTER
VIRGO SUPERCLUSTER
VIRGO
CLUSTER
Galactic Plane
LOCAL VOID
Celestial Equator
R.A.
1000
km/s
Individual
galaxies shown
as dots - size decreases
with increasing redshift
A. Fairall
Univ Cape Town
0h
1h
2h
3h
4h
5h
6h
7h
8h
9h
10h
11h
12h
13h
14h
15h
16h
17h
18h
19h
20h
21h
22h
23h


NORTHERN
SKY
REDSHIFT SHELL
2000 - 2999 KM/S
DATA
FROM
ZCAT
TAURUS
VOID
GEMINI
VOID
Galactic Plane
HYDRA
WALL?
LEO
VOID
DRACO
VOID
CAN. VEN.
VOID
VIRGO
VOID
DELPHINUS
VOID
OBSCURED BY MILKY WAY
Celestial Equator
VIRGO
CLUSTER
("FINGER OF GOD")
HYDRA
WALL
R.A.
1000
km/s
Individual
galaxies shown
as dots - size decreases
with increasing redshift
A. Fairall
Univ Cape Town


REDSHIFT
0 - 999 KM/S
SOUTHERN SKY
DATA FROM SRC
MONOCEROS VOID
CRATER VOID
VOLANS VOID
CETUS VOID
Galactic Plane
Supergalactic Plane
NGC 253
NGC 300
NGC 5128
M83
CENTAURUS WALL
LOCAL VOID
LOCAL VOID
OBSCURED BY MILKY WAY
Celestial Equator
R.A.
0h
1h
2h
3h
4h
5h
6h
7h
8h
9h
10h
11h
12h
13h
14h
15h
16h
17h
18h
19h
20h
21h
22h
23h
A. Fairall
Univ Cape Town
Large - scale Structures (galaxies closer than 200 km/s to each other) shown by stippling.


SUPERGALACTIC PLANE
-1000<SGZ<+1000 km/s
Galaxies in redshift space within 1000 km/s of the supergalactic plane
SGY
COMA CLUSTER
COMA WALL
10000 km/s
CENTAURUS CLUSTER
5000 km/s
OBSCURED BY MILKY WAY
OBSCURED BY MILKY WAY
SGX
A3627
PAVO
CENTAURUS WALL
5000 km/s
PERSEUS PISCES
PERSEUS CLUSTER
CETUS WALL
10000 km/s
DATA FROM SRC
DATA FROM ZCAT
Stippling highlights overdense regions (incomplete beyond 7000 km/s)
Fairall / Woudt Univ Cape Town
Concentric circles denote redshift shells (for which separate maps follow overleaf)

# A SLICE OF THE UNIVERSE

VALÉRIE DE LAPPARENT,[2,3] MARGARET J. GELLER,[2] AND JOHN P. HUCHRA[2]



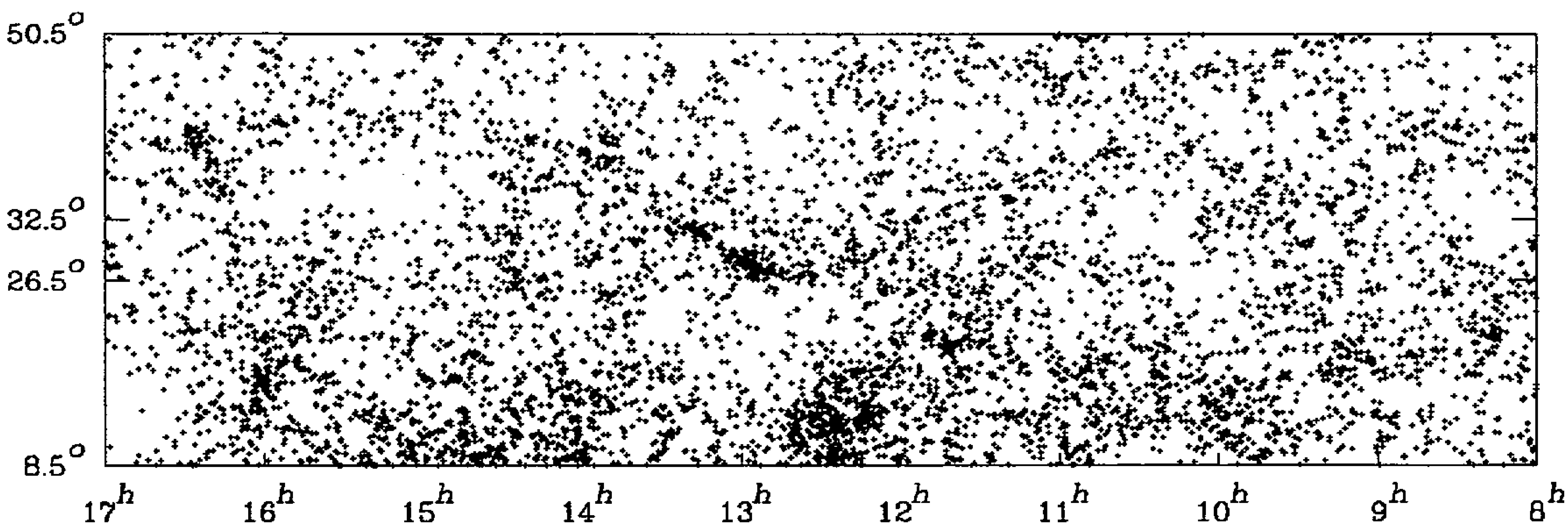
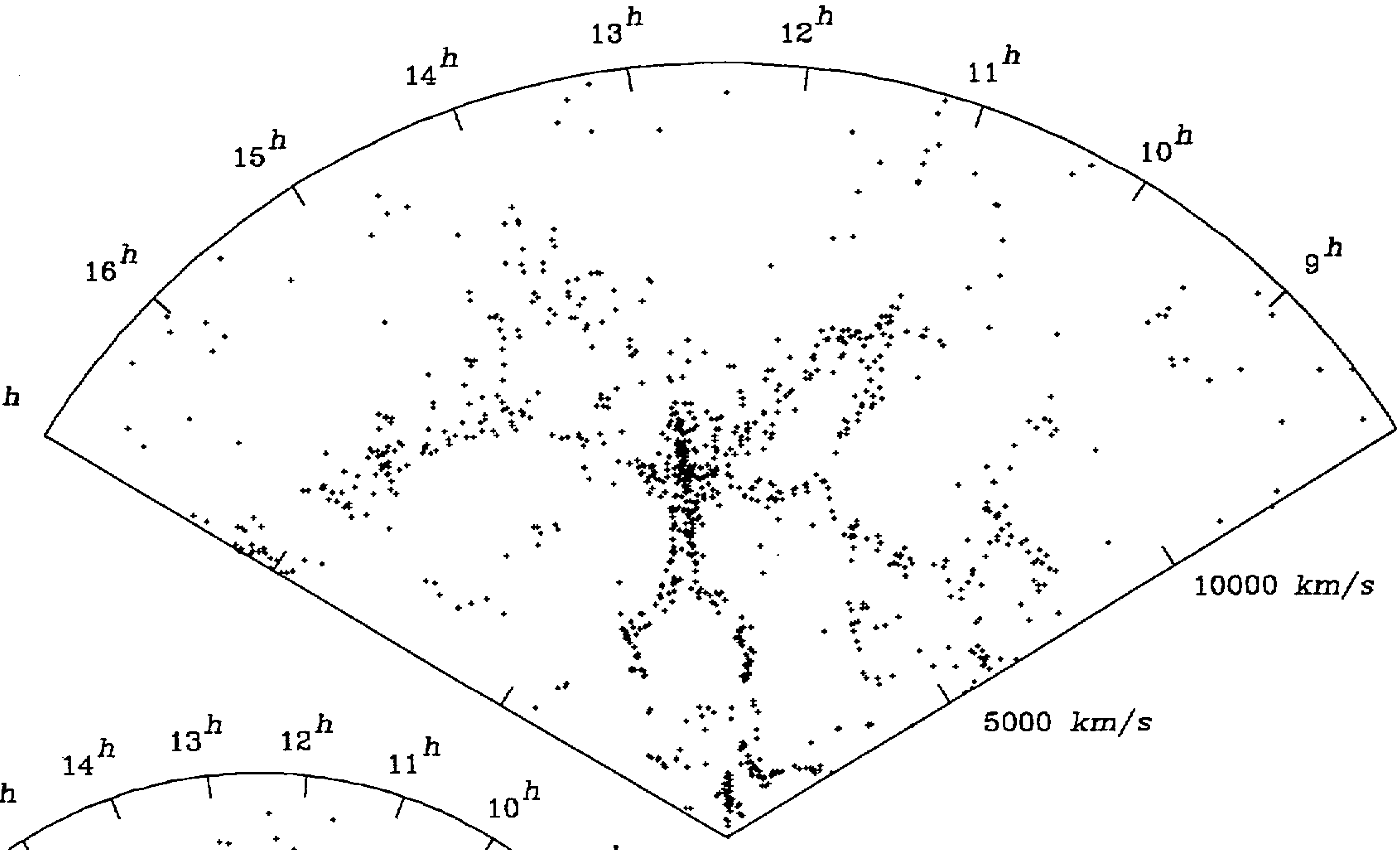



FIG. 1.—(*a*) Map of the observed velocity plotted vs. right ascension in the declination wedge 26°5 ≤ $\delta$ ≤ 32°5. The 1061 objects plotted have $m_B \leq 15.5$ and $V \leq 15{,}000$ km s$^{-1}$. (*b*) Same as Fig. 1*a* for $m_B \leq 14.5$ and $V \leq 10{,}000$ km s$^{-1}$. The plot contains 182 galaxies. (*c*) Projected map of the 7031 objects with $m_B \leq 15.5$, listed by Zwicky *et al.* in the region bounded by $8^h \leq \alpha \leq 17^h$ and 8°5 ≤ $\delta$ ≤ 50°5.



16^h
15^h
14^h
13^h
12^h
11^h
10^h
9^h
h
10000 km/s
5000 km/s
14^h
13^h
12^h
11^h
10^h
h

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# The supergalactic plane revisited with the Optical Redshift Survey

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A. Dressler[6] and J. P. Huchra[7]

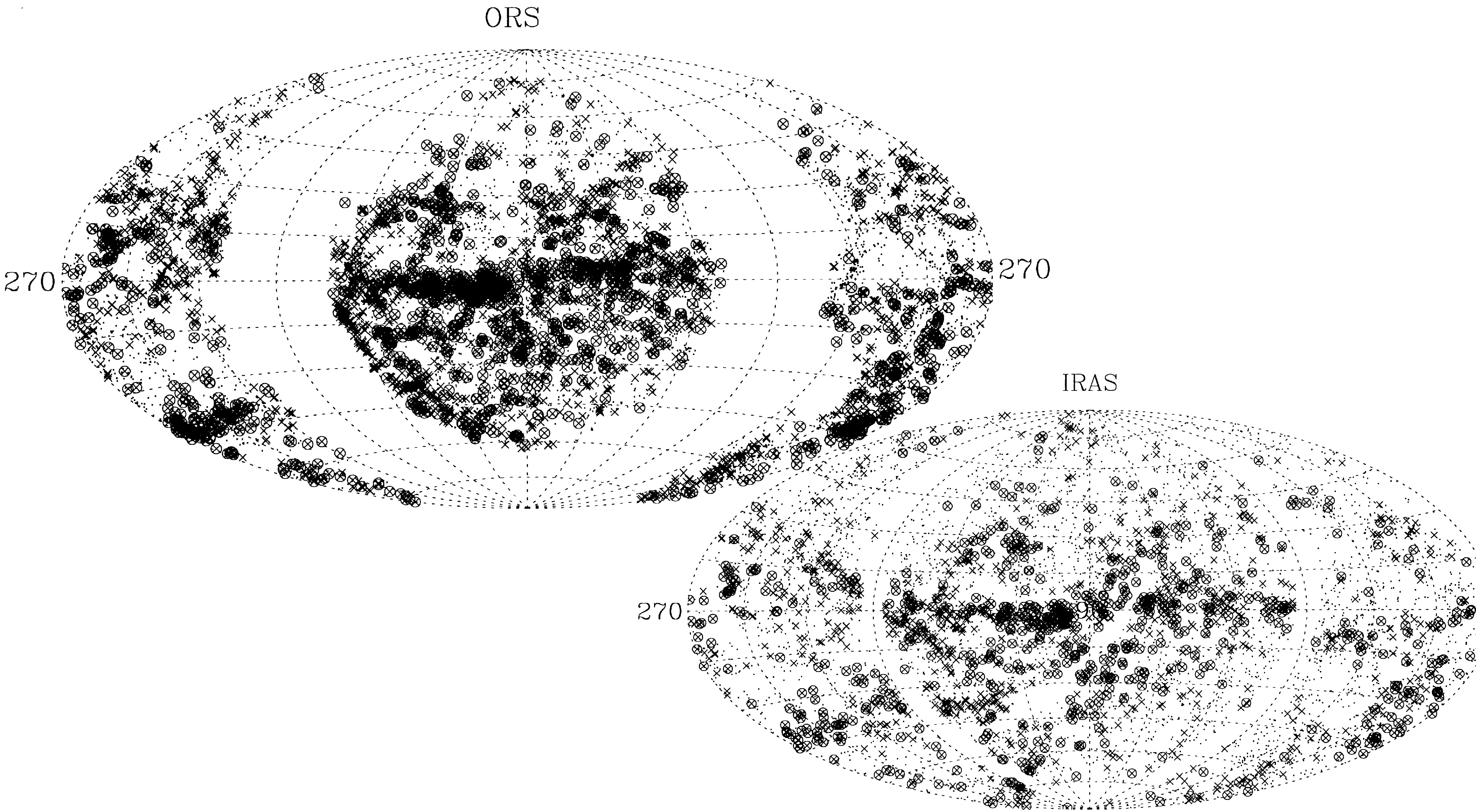



**Figure 1.** The distribution of galaxies projected on the sky in the *IRAS* and ORS samples. This is an Aitoff projection in supergalactic coordinates, with $SGL = 90°$, $SGB = 0$ (close to the Virgo cluster) in the centre of the map. Objects within 2000 km s$^{-1}$ are shown as circled crosses; objects between 2000 and 4000 km s$^{-1}$ are indicated as crosses, and dots mark the positions of more distant objects. Here we include only catalogued galaxies, which is why the zone of avoidance is so prominent in these two figures.

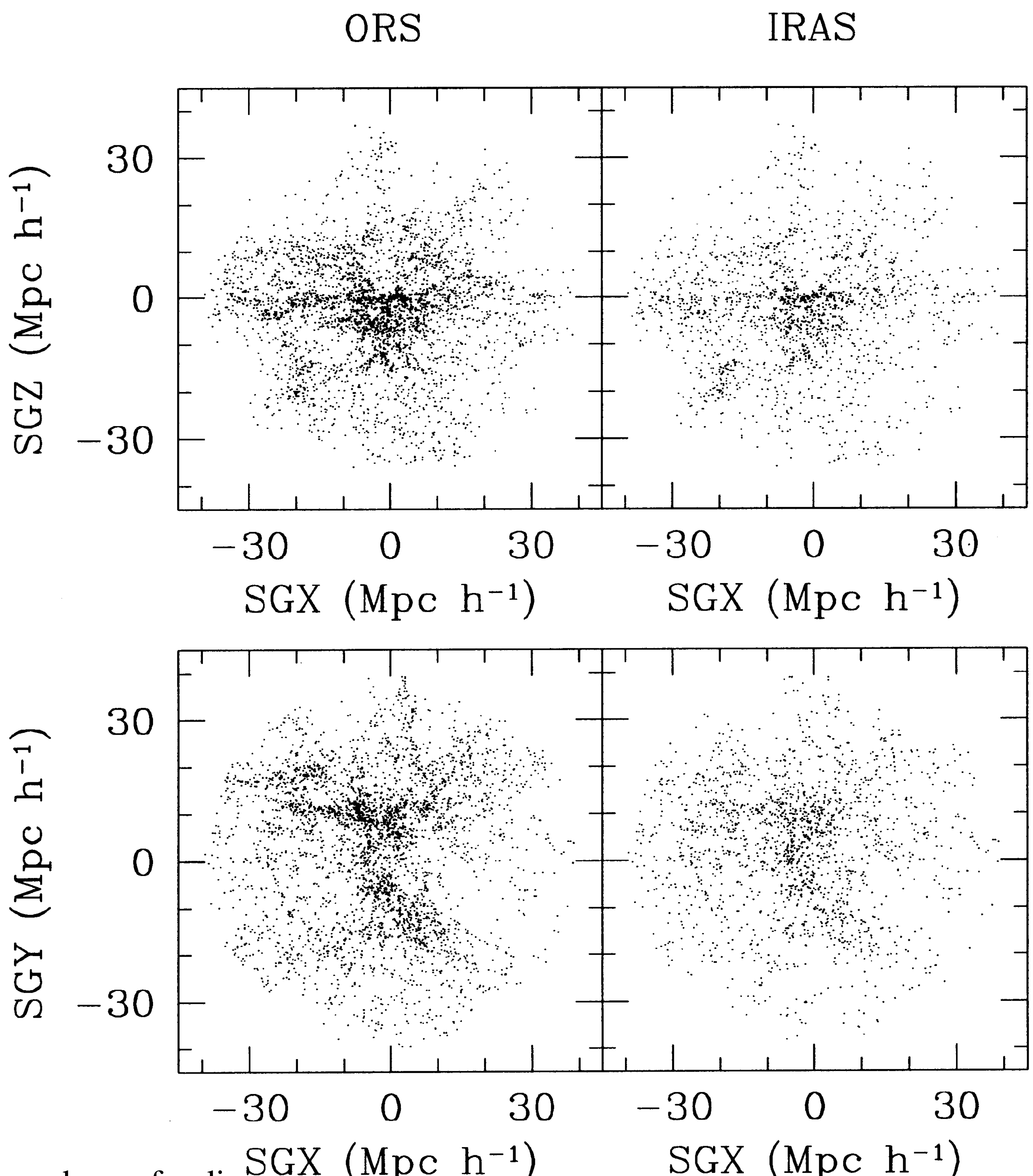
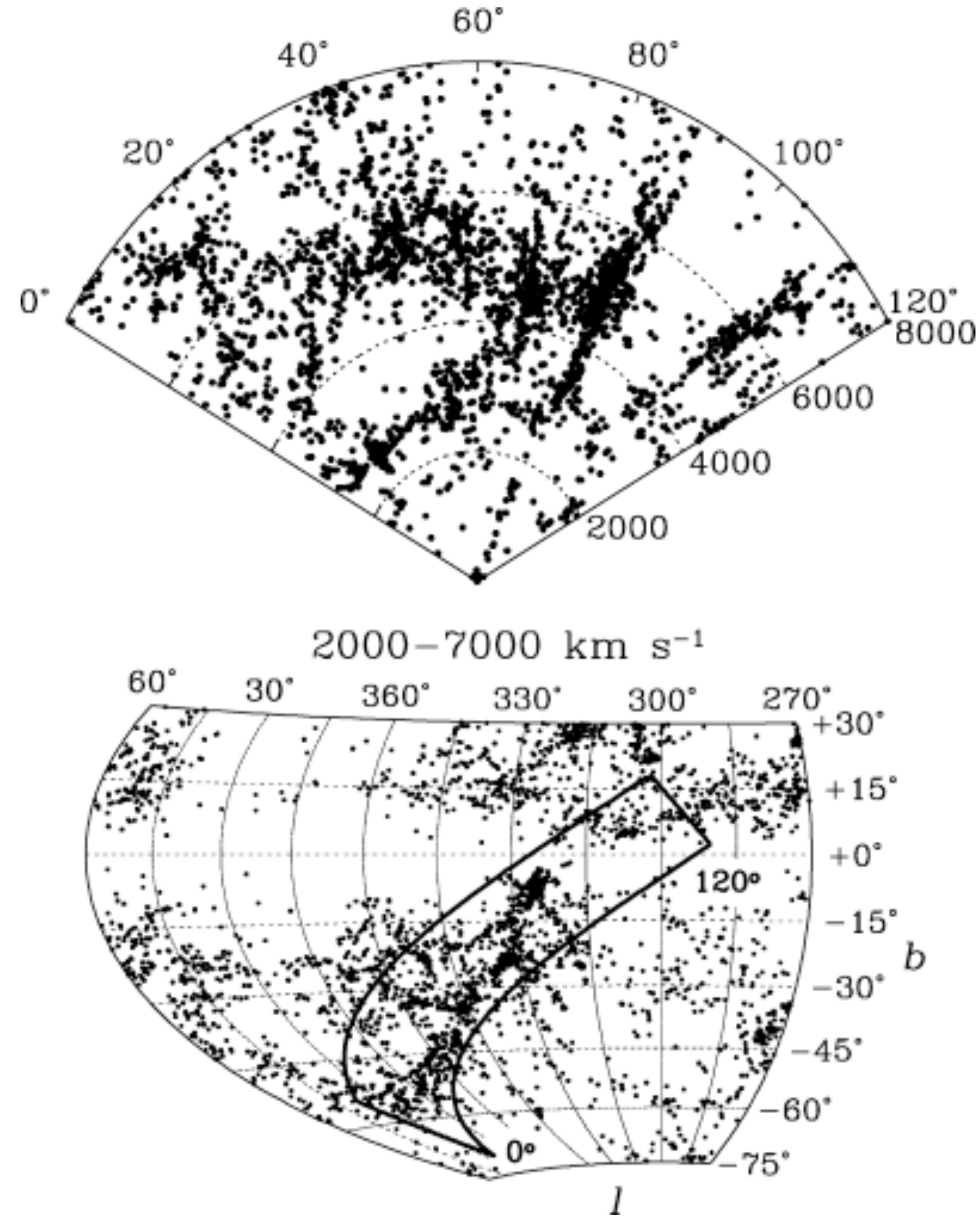


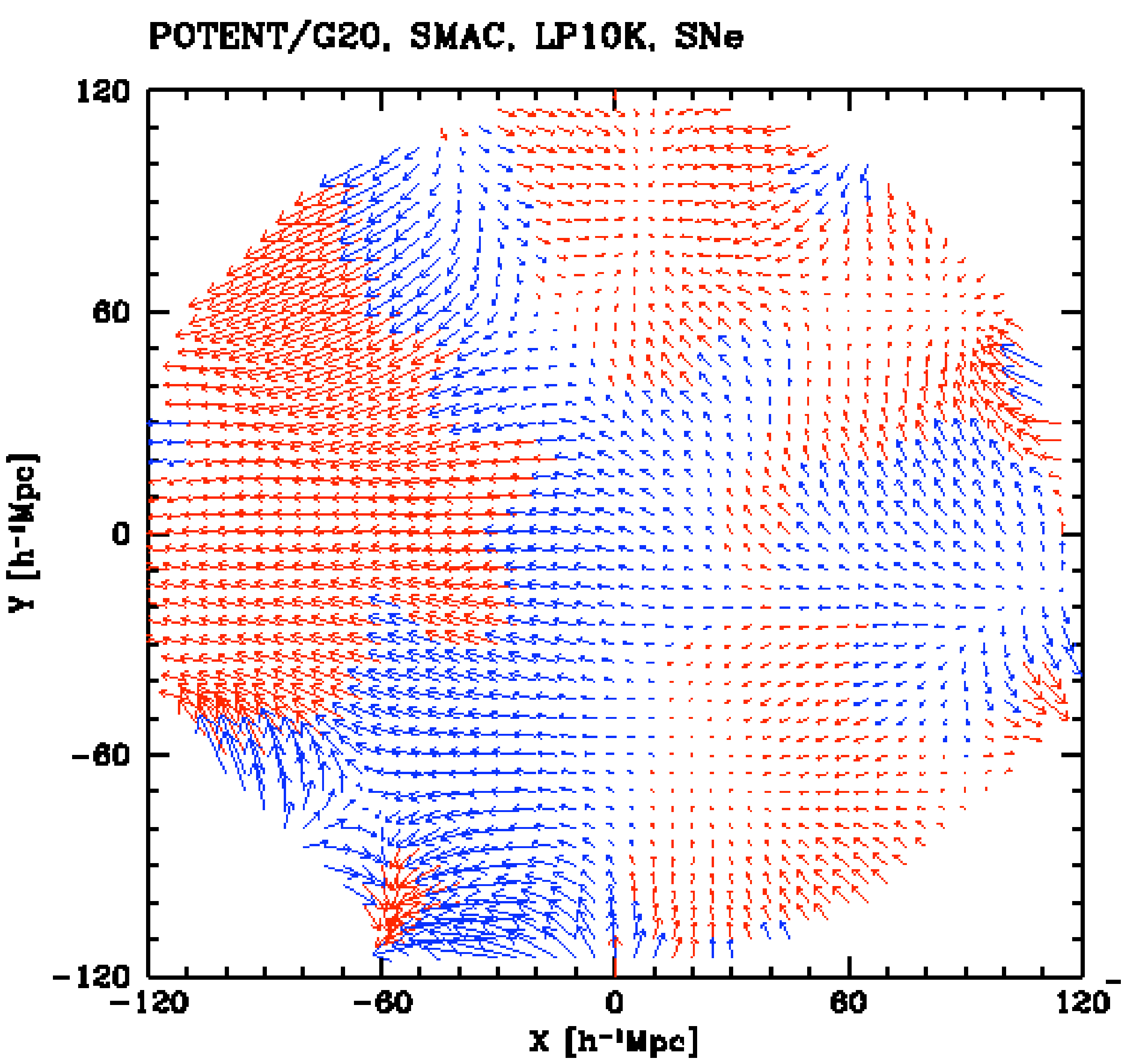

**Figure 2.** The distributions of ORS and *IRAS* galaxies in a sphere of radius of $40\,h^{-1}$ Mpc, projected on the standard ($SGX$–$SGZ$), ($SGX$–$SGY$) and ($SGY$–$SGZ$) planes. The SGP is visible edge-on as the linear feature at $SGZ = 0$ in the ($SGX$–$SGZ$) and ($SGY$–$SGZ$) projections ORS includes *IRAS* galaxies (real and mock) in the zone of avoidance (see text).

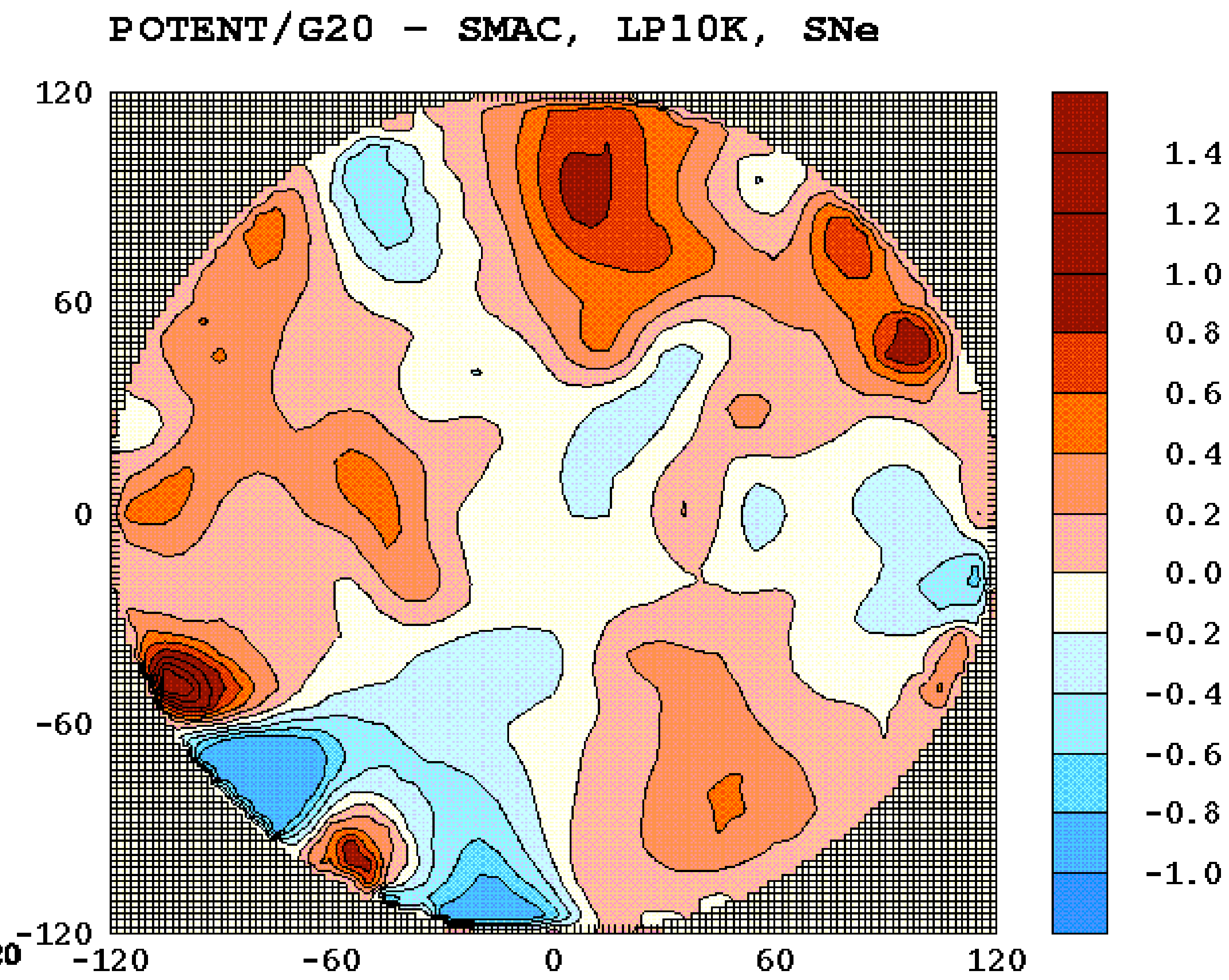
# Pie diagrams: structure of superclusters

**Figure 7.** The pieplot represents the radial distribution of galaxies along the projected rectangular strip shown in the lower panel. The strip covers a region 120°× 10°, orientated to lie along the filament. From the Norma cluster, lying 86° along the strip, the Norma supercluster is clearly seen as a wall of galaxies extending through the Pavo II cluster (at 71°) towards a point 20° along the strip. The Centaurus Wall appears as a smaller connection of galaxies, running almost parallel to the Norma supercluster at 2600 km s$^{1}$. The void lying between the Norma supercluster and the Centaurus Wall is an extension of the massive Microscopium Void.

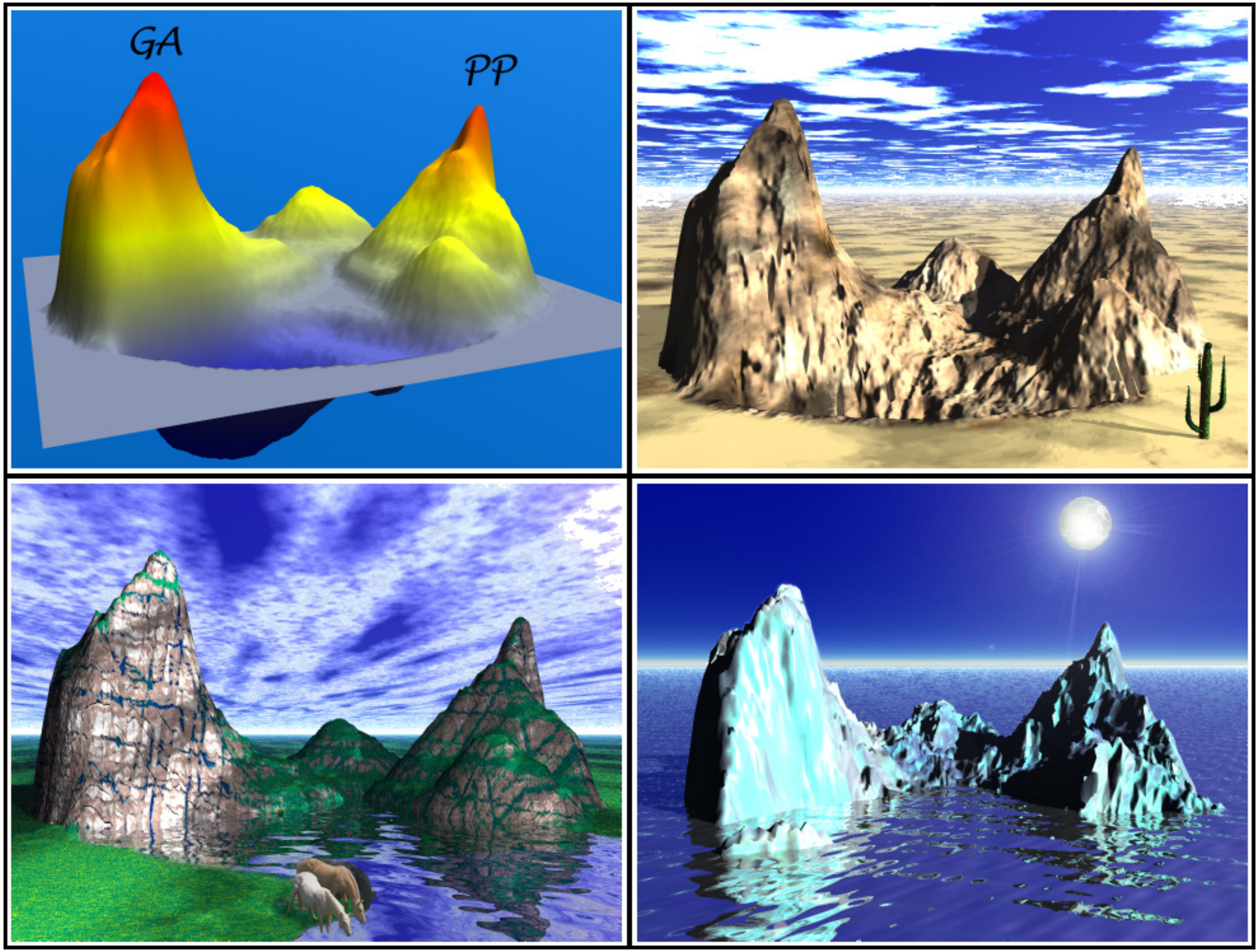


# Large scale distribution of galaxies and velocities



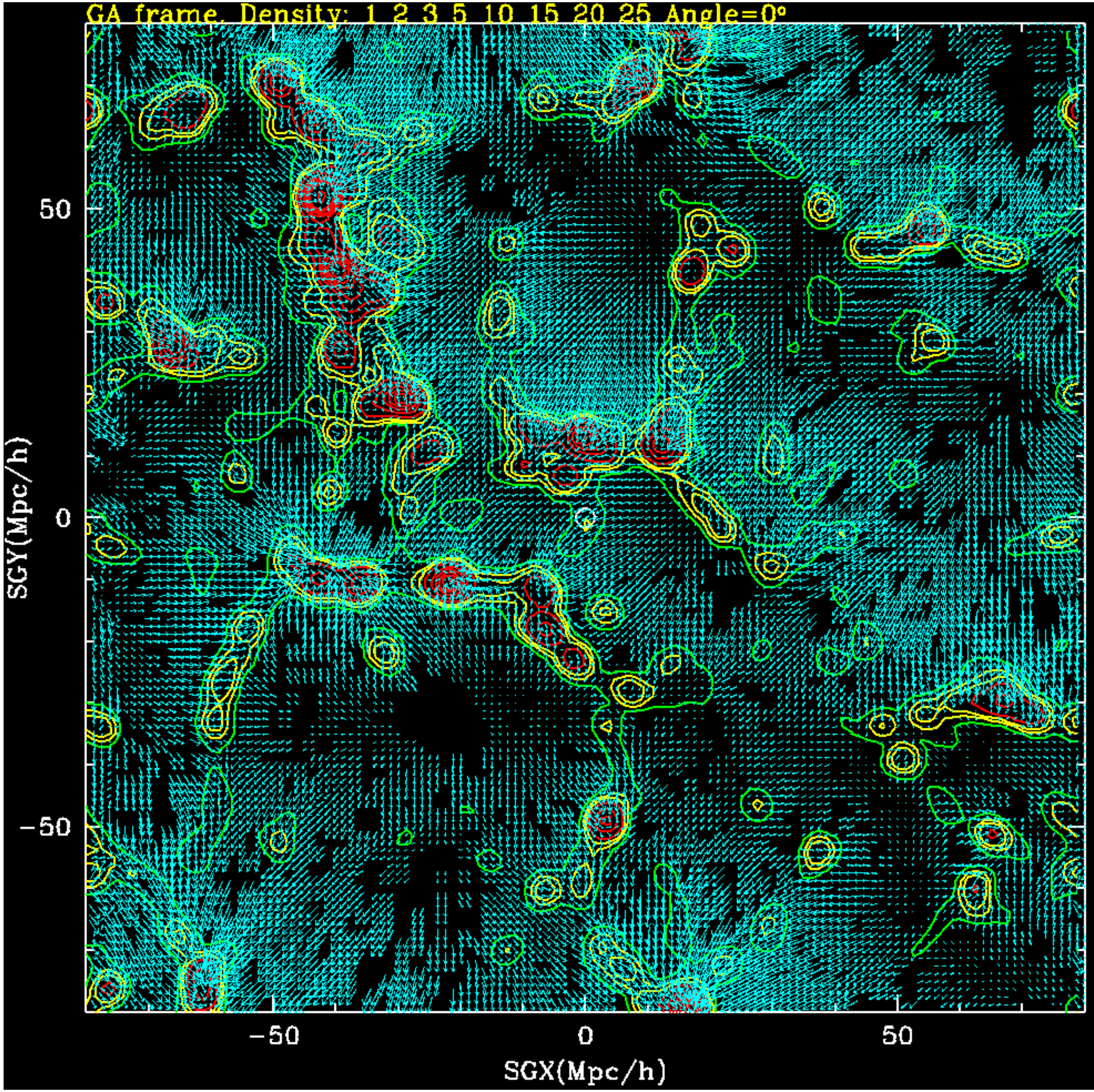



# Landscape of the MW neighborhood: 80Mpc



# Constrained simulations

Position of GA, Coma, Virgo, and Perseus-Pices. Our galaxy is a white circle at (0,0)




- Long waves (amplitudes and phases) are taken from observations.
- Small scale-perturbations and dynamics are for LCDM cosmological model
- N-body simulations at z=0

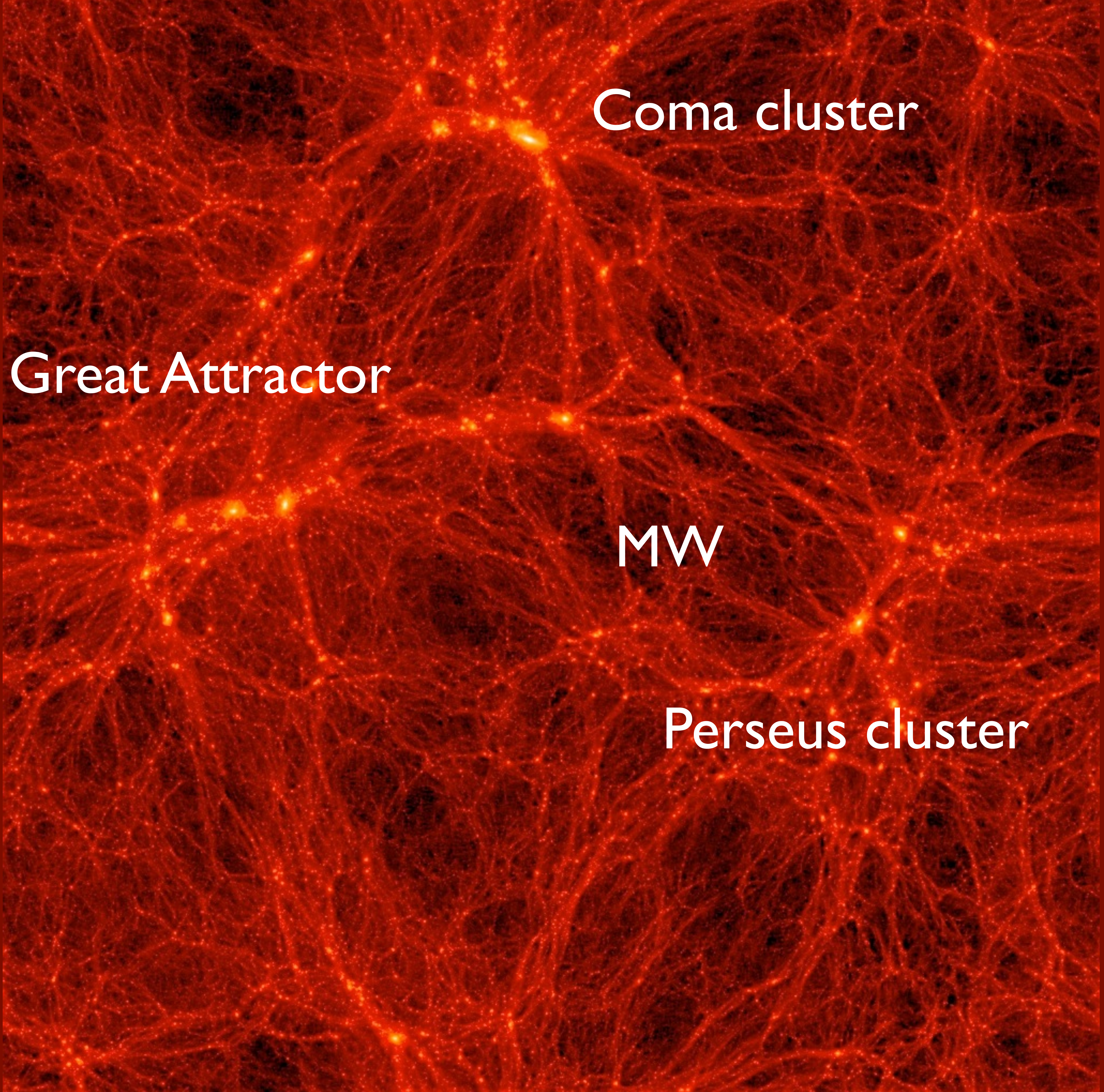
1G particles

Dynamical range 1e5

Constrained simulations

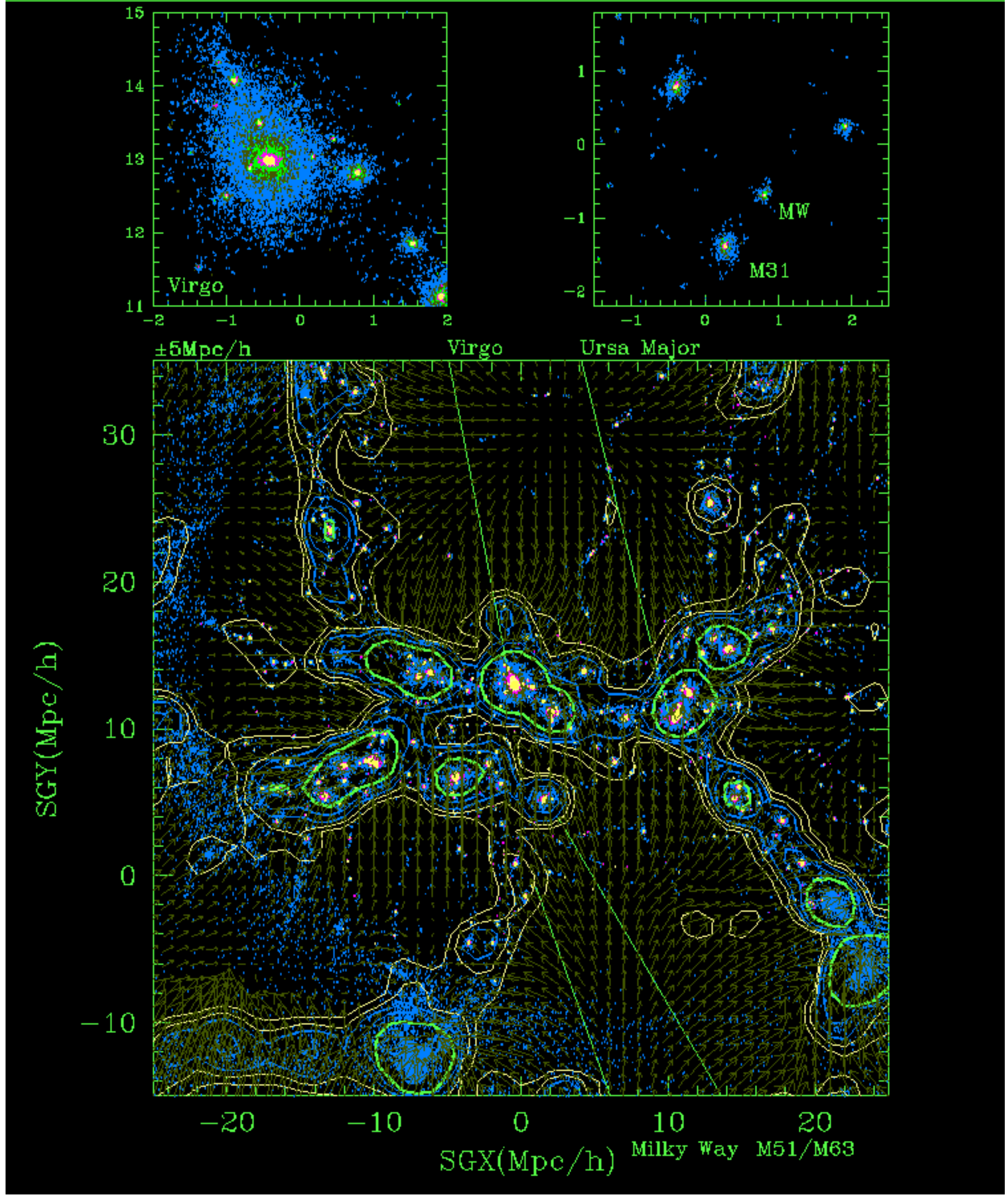
160 Mpc

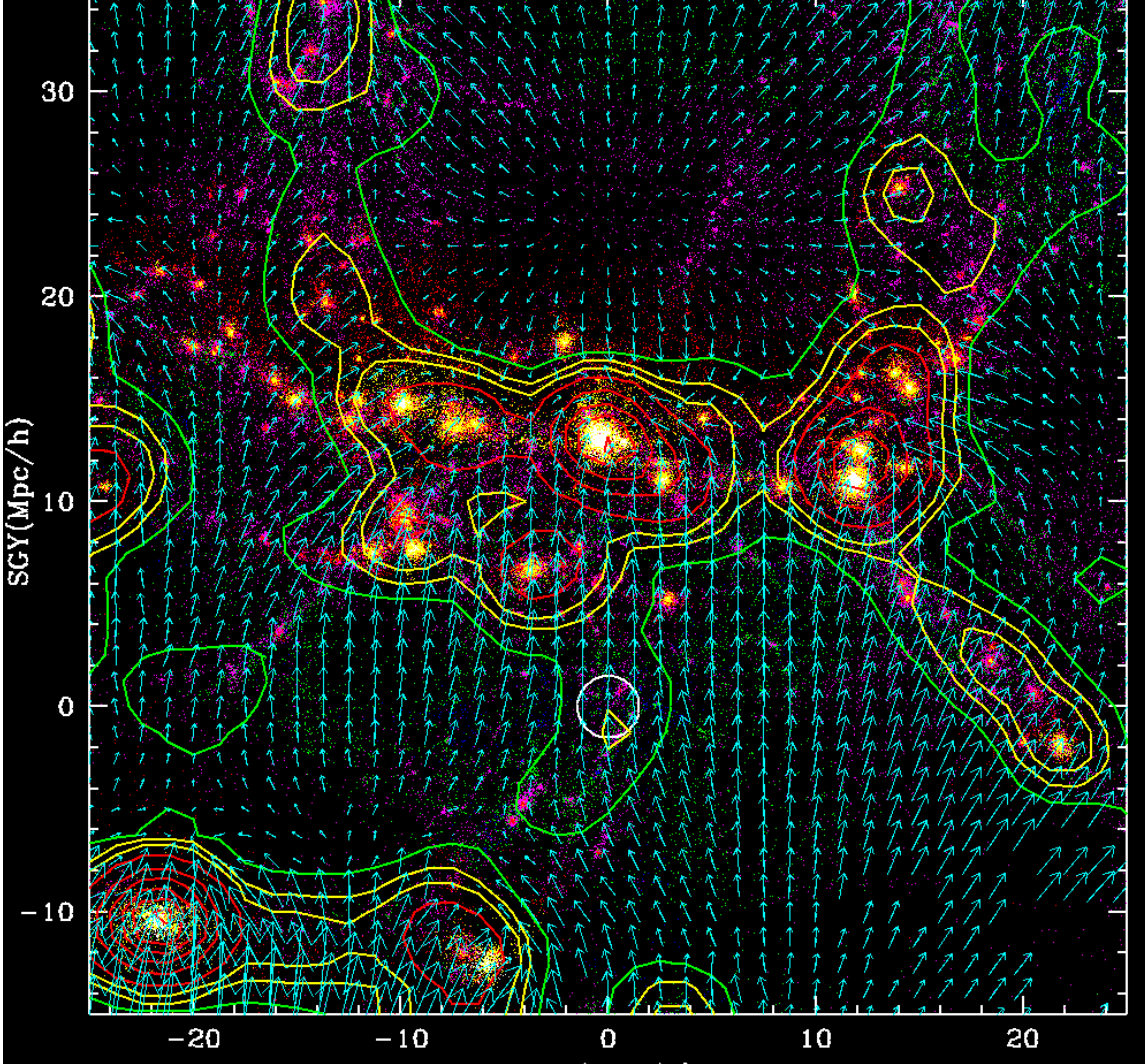
Klypin, Hoffman, Gottlober



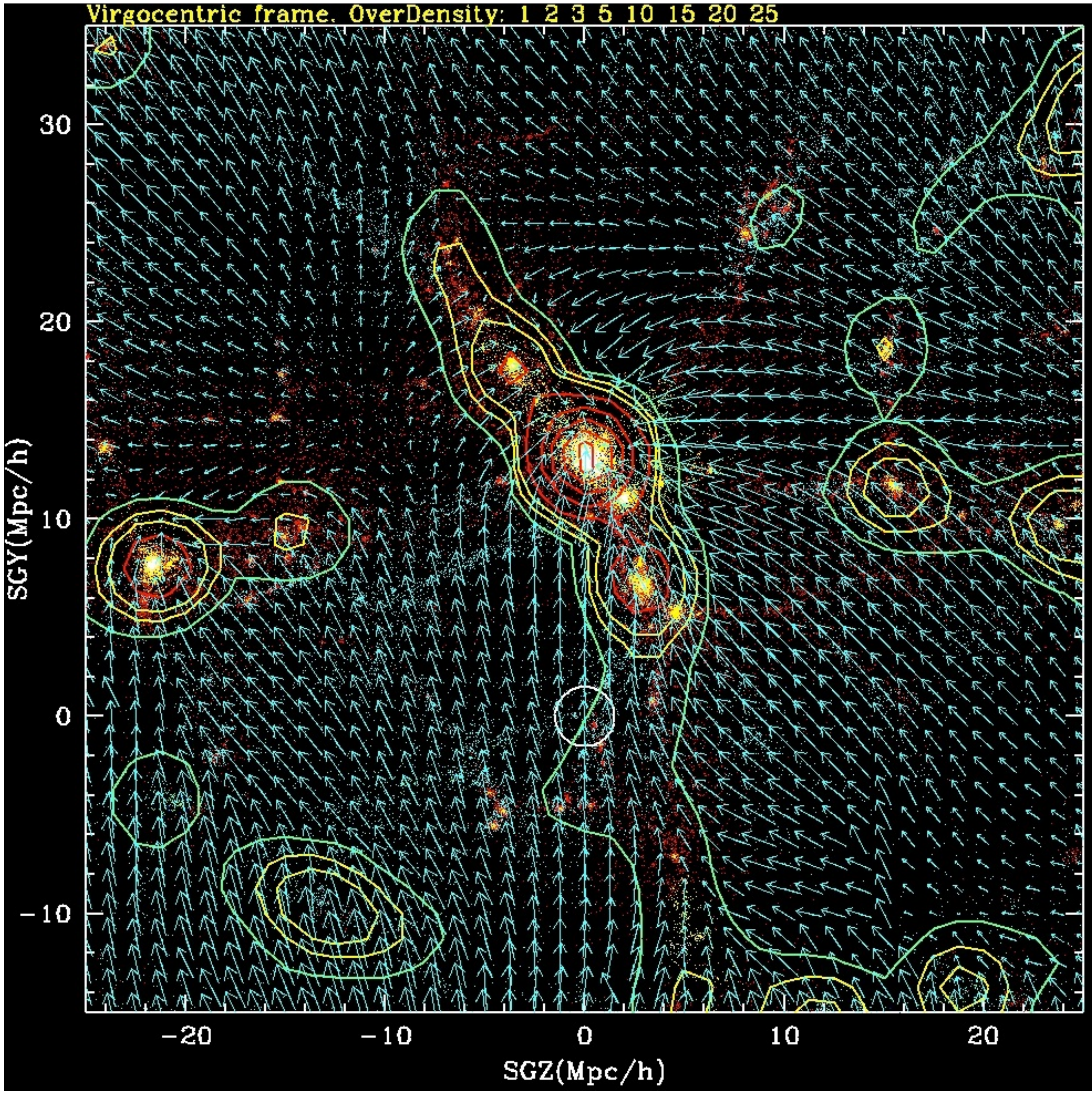
# Local Supercluster:

- Distribution of light and mass
- Peculiar velocities (deviations from the Hubble flow)
- Voids

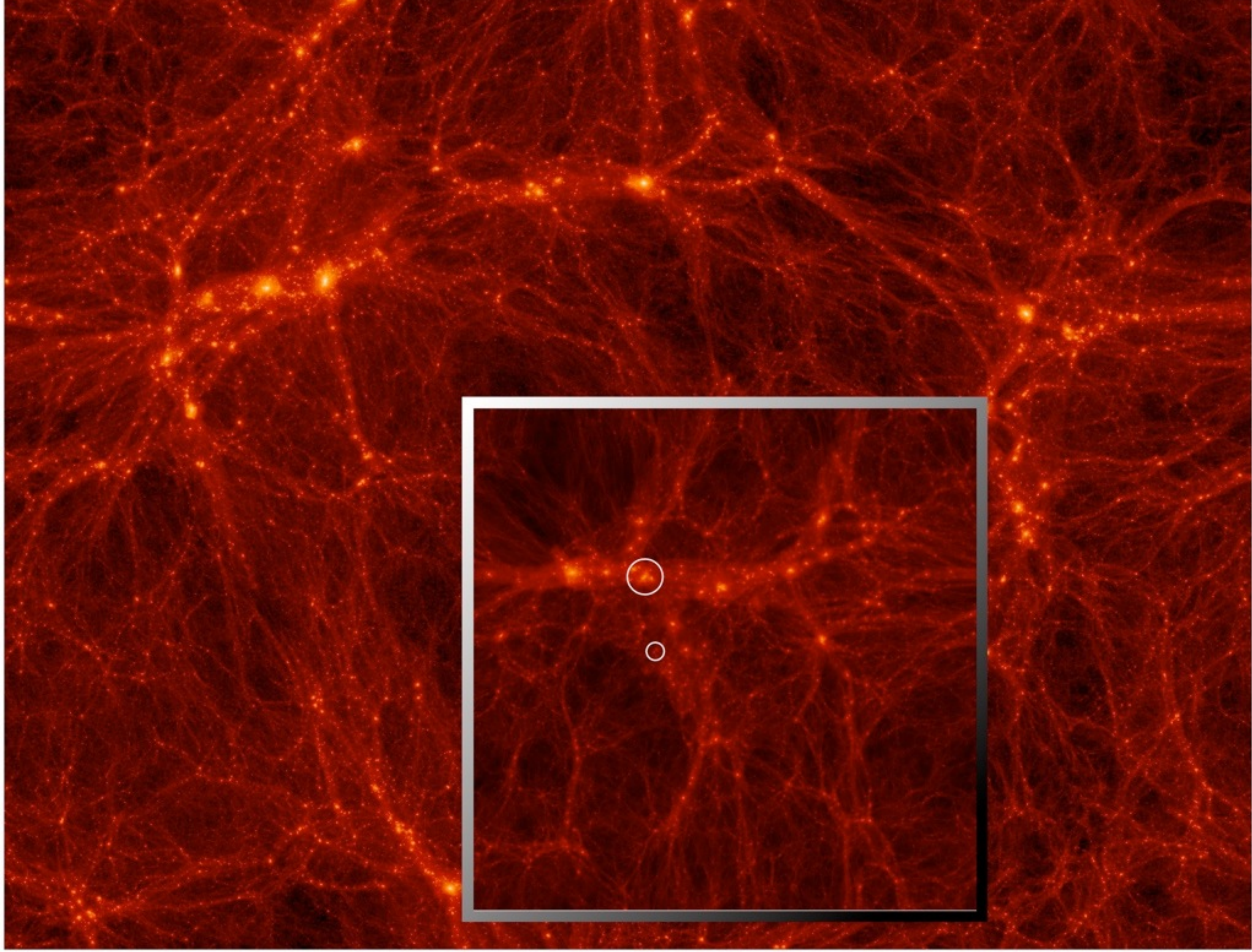

Virgo
MW
M31
±5Mpc/h
Virgo
Ursa Major
SGY(Mpc/h)
SGX(Mpc/h)
Milky Way
M51/M63



SGY(Mpc/h)
30
20
10
0
−10
−20
−10
0
10
20



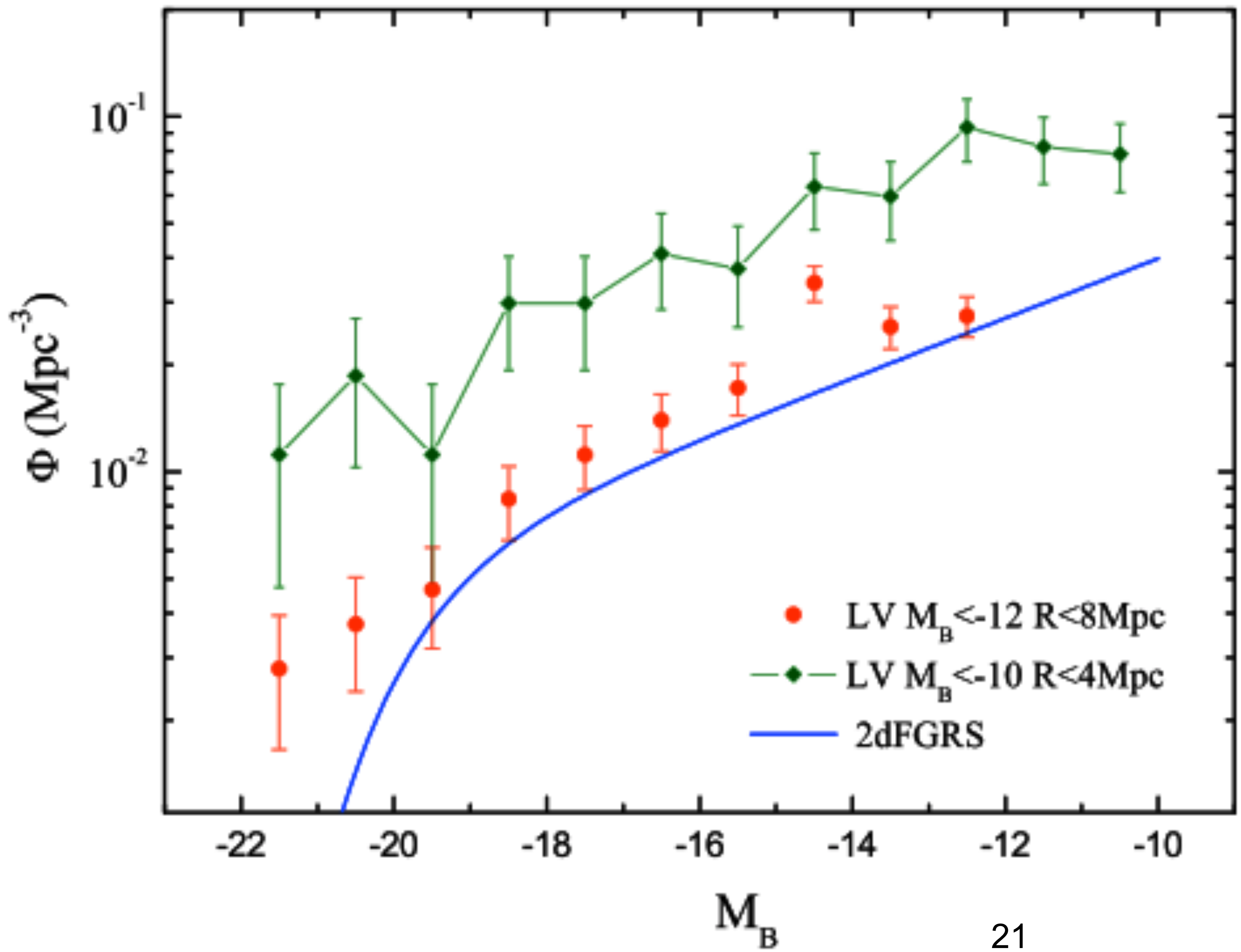
Virgocentric frame. OverDensity: 1 2 3 5 10 15 20 25
30
20
10
0
−10
SGY(Mpc/h)
−20
−10
0
10
20
SGZ(Mpc/h)



# *Galaxies in the Local Volume:*

- distances less than 10 Mpc
- 550 galaxies: Complete to M=-12
- Count voids: regions without galaxies

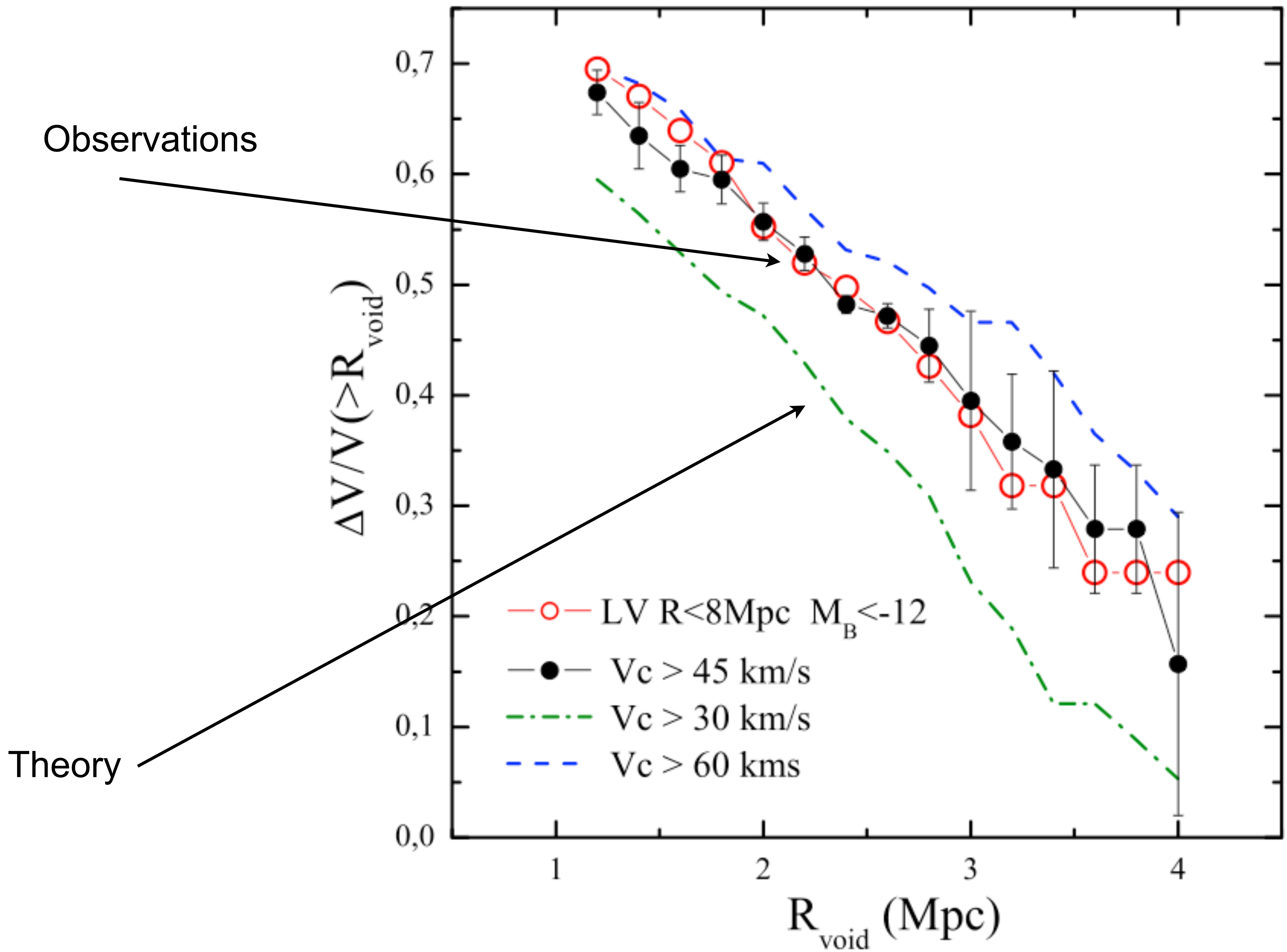
Tikhonov& Klypin 2008




Data: Karachentsev & Co

# Overabundance of dwarf halos

Tikhonov & Klypin 2008



# Peculiar velocities of local galaxies:

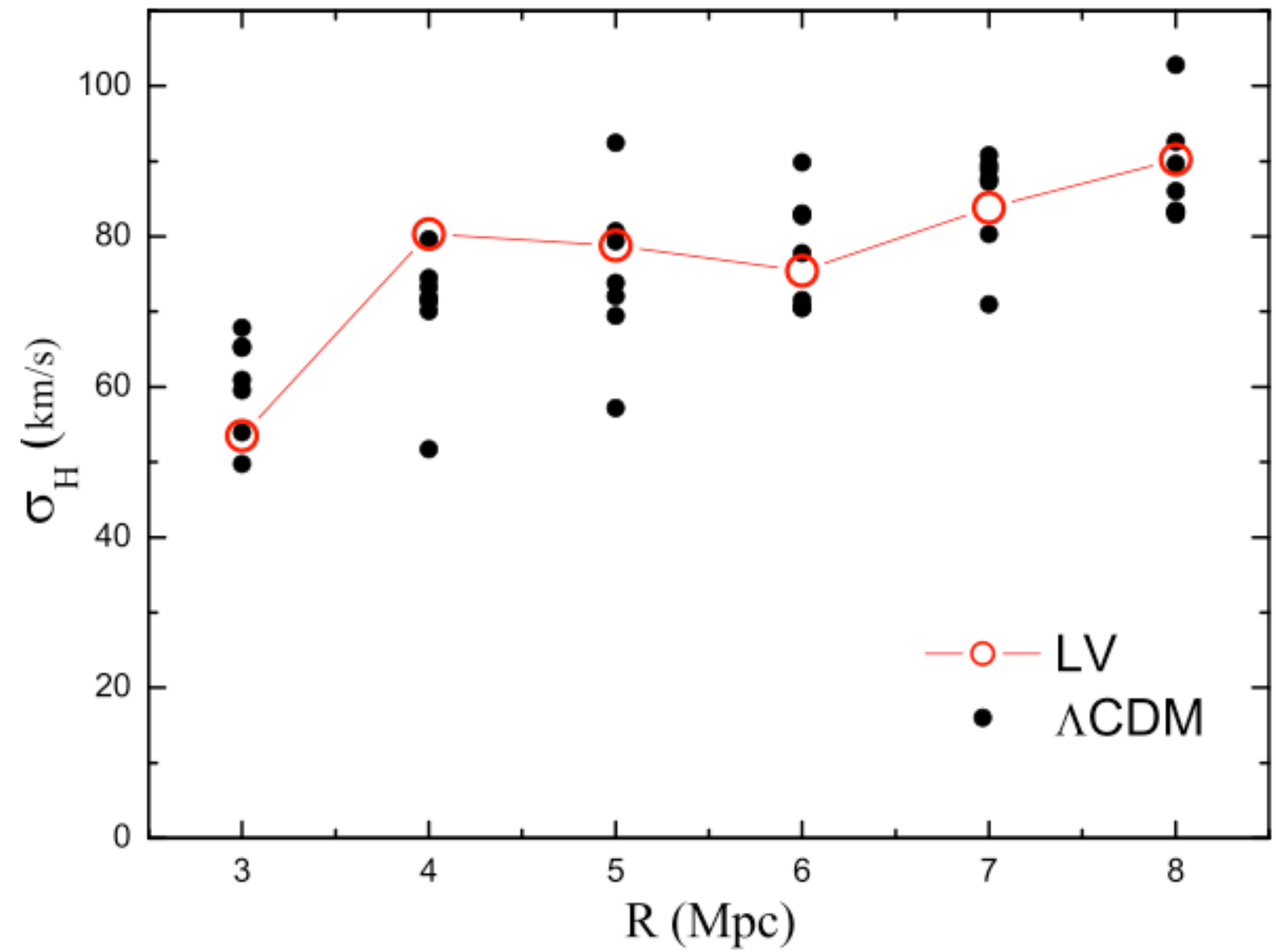



**Figure 2.** The rms radial velocity deviations from the Hubble flow $\sigma_H$ for galaxies in the Local Volume with distances from 1 Mpc up to R (full red curve with open circles). The estimates are corrected for the apex motion and for distance errors. Black filled circles show theoretical predictions for 7 LV candidates in the simulation $S_2$.

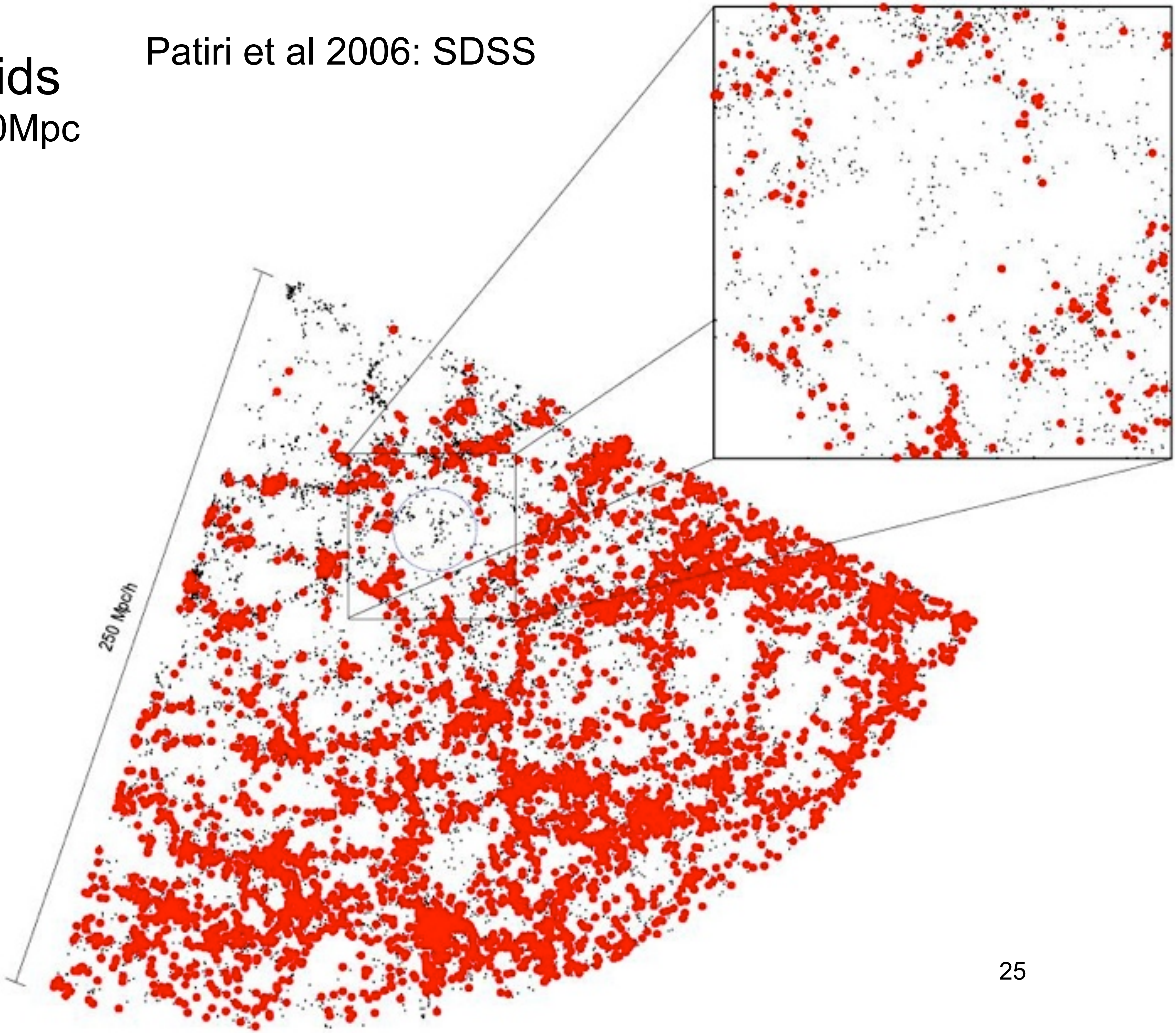
# Voids:

- Distribution of light and mass in giant voids

# Voids

R>10Mpc

Patiri et al 2006: SDSS



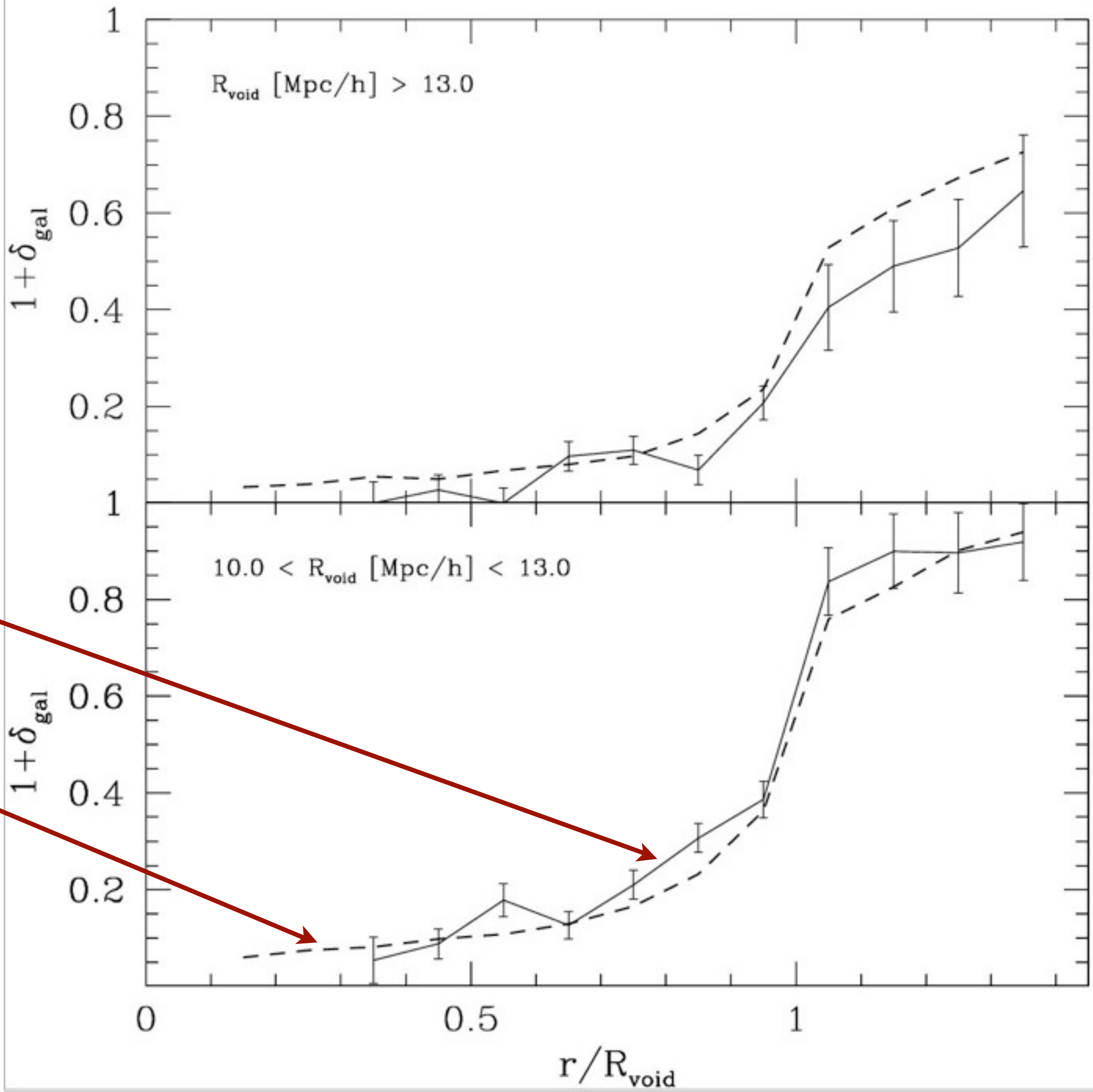
Number-density Profiles of Voids:

$n(R)/\langle n\rangle$

Patiri et al 2006

SDSS

LCDM

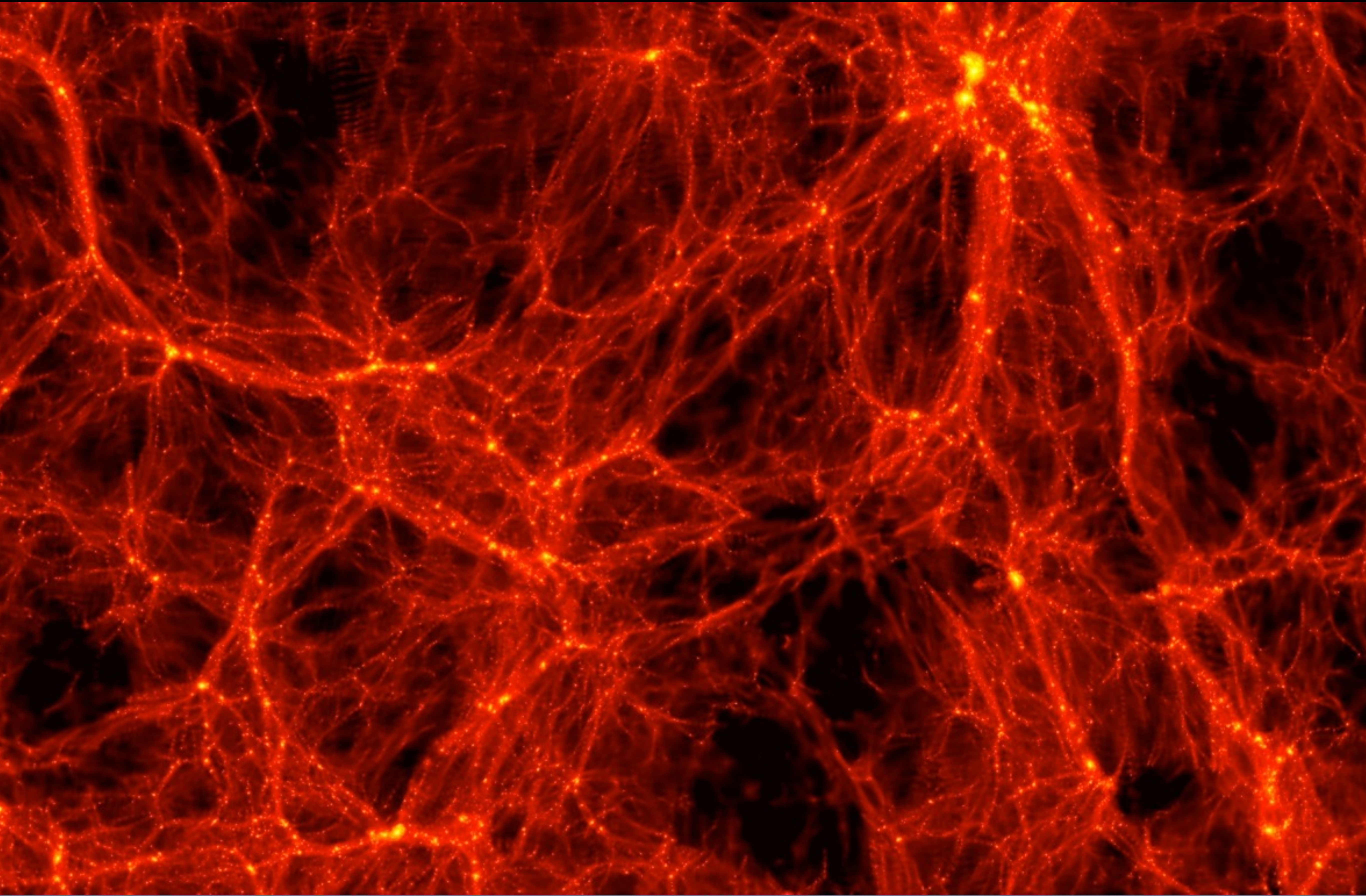


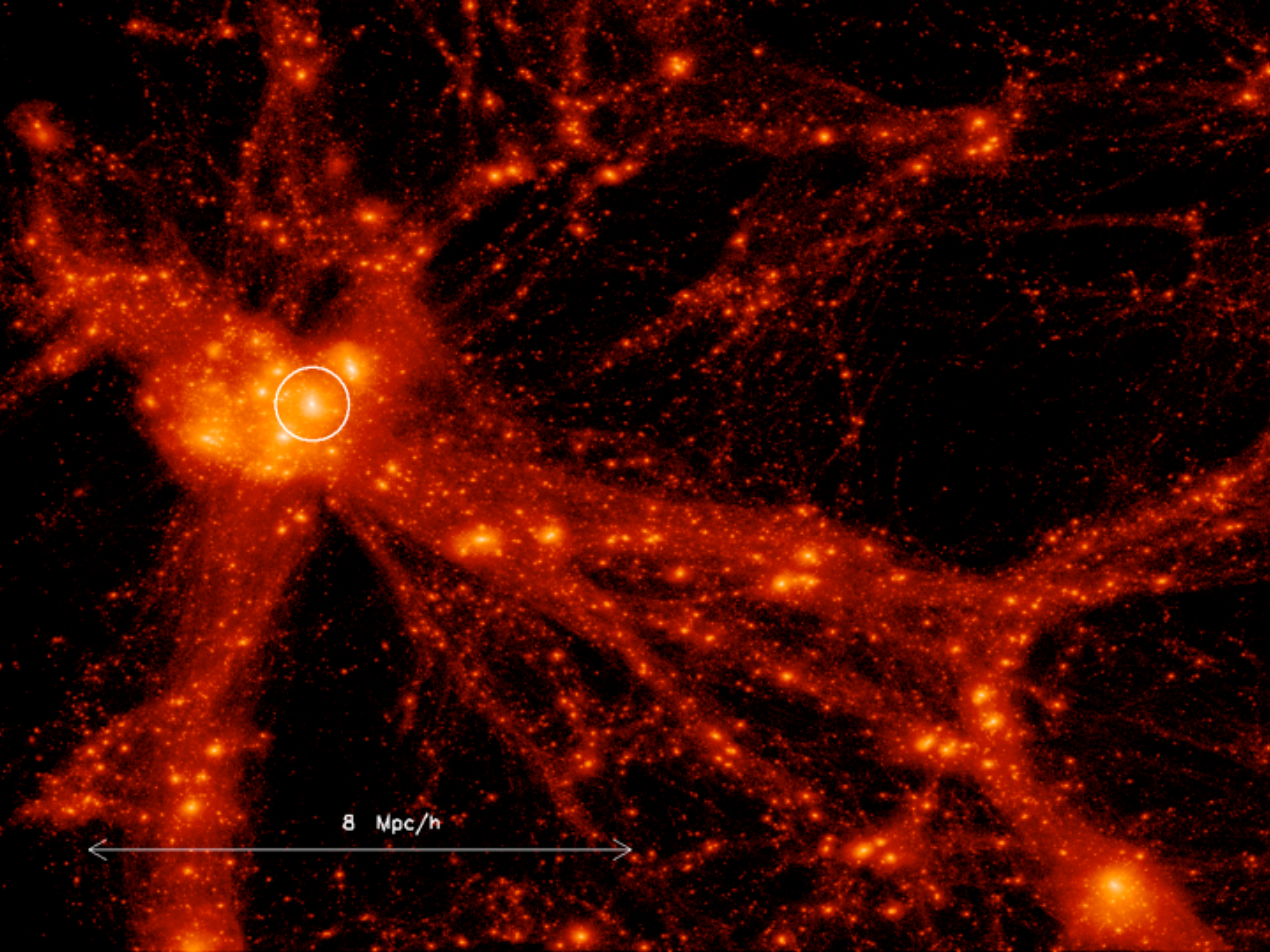
# Large Scale Structure and Galaxies:

- Morphology - density relation
- Effects of environment

# LSS: 300Mpc

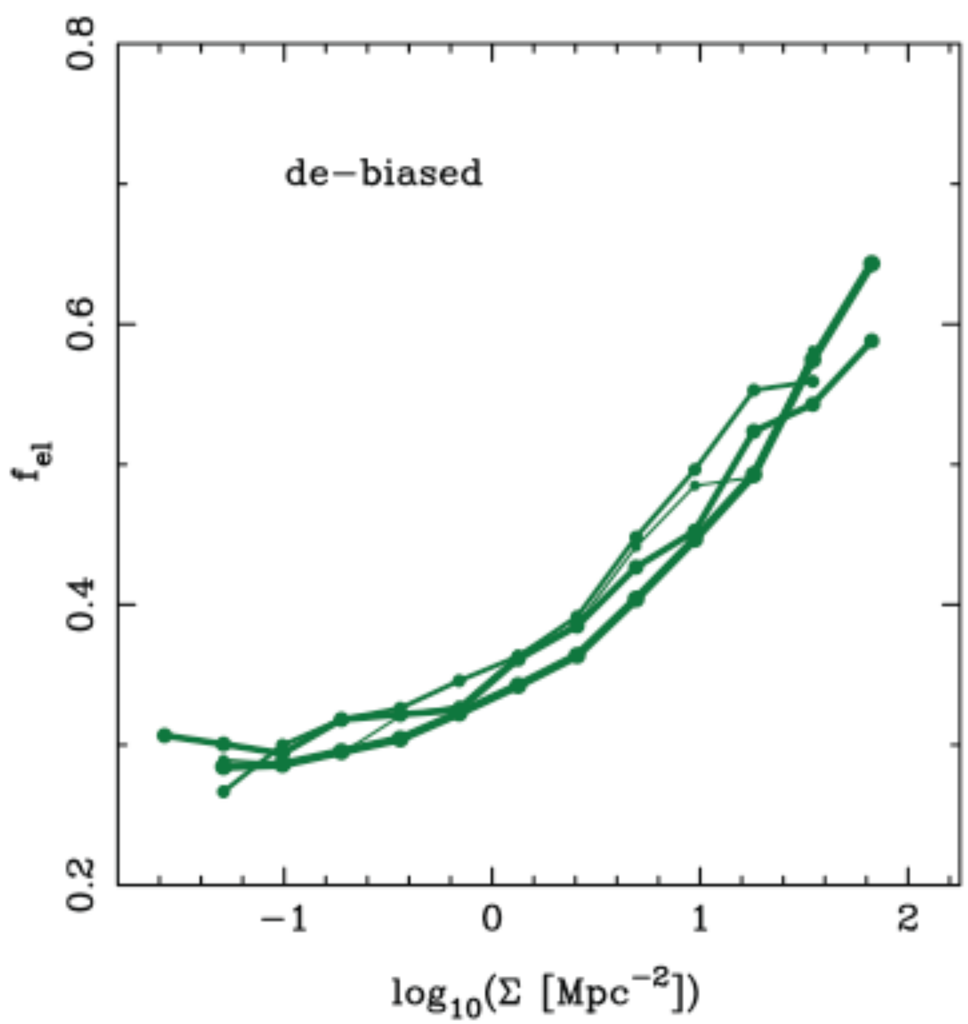
Ben Moore: PKDGRAV




8 Mpc/h

# Morphology -Density relation:

The local density for a galaxy is given by $\Sigma_N = N/(\pi d_N^2)$ where $d_N$ is the projected distance to the $N$th nearest neighbour that is more luminous than $M_r = -20$ (with a small evolution correction, see below). In our analysis we use an estimate of local galaxy density, $\Sigma$, determined by averaging $\log \Sigma_N$ for $N = 4$ and 5. In addition,




$$|c\,\Delta z| < 1000\,\mathrm{km\,s^{-1}}$$

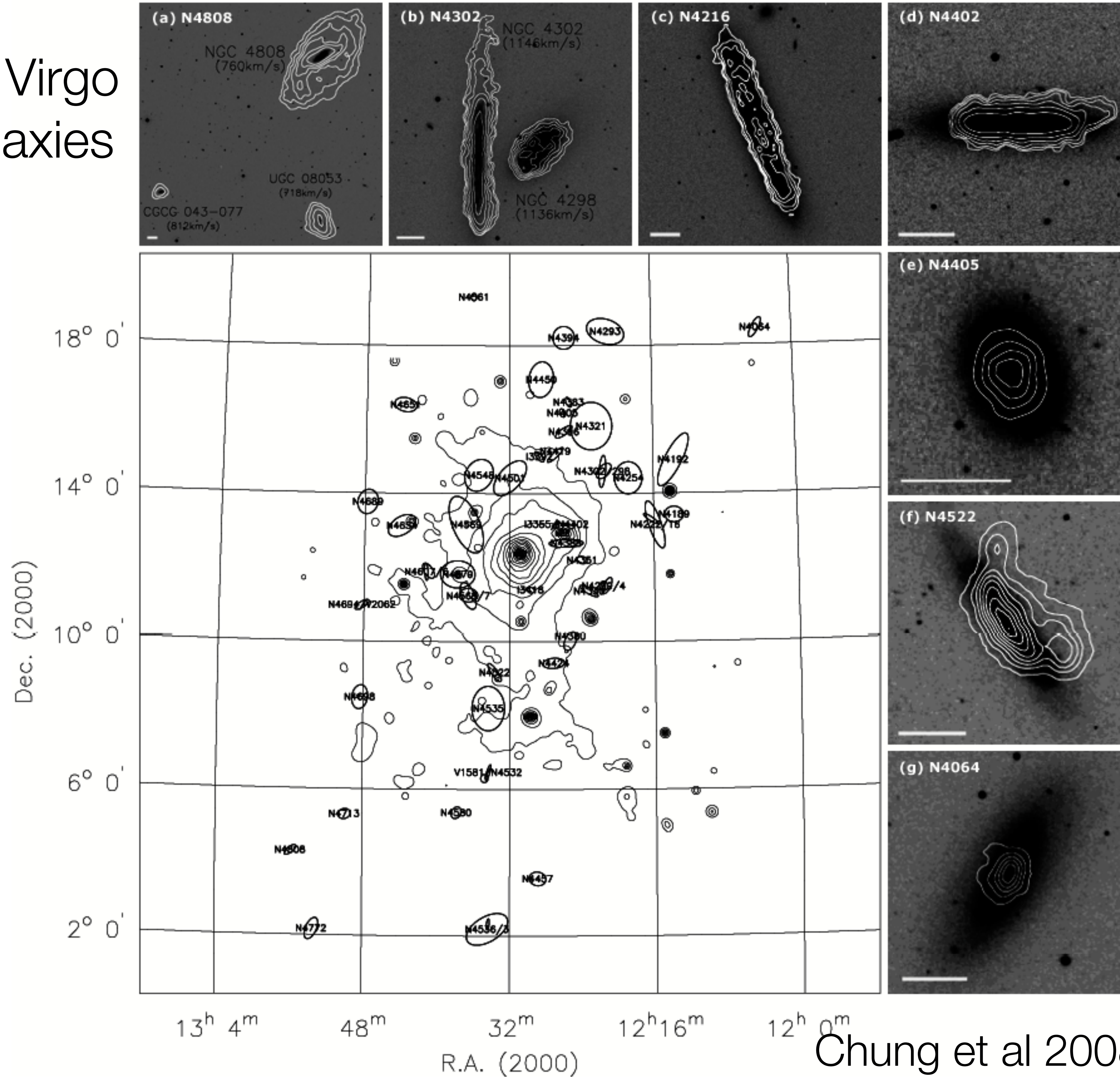
Fraction of early-type galaxies as the function of density

Bamford et al.

Mon. Not. R. Astron. Soc. **393,** 1324–1352 (2009)

# Gas stripping in Virgo cluster spiral galaxies

Spiral galaxies lose their gas and gradually get transformed into S0's




Chung et al 2008

The main effect in morphology-density relation is that galaxies in denser environments are more massive and more massive galaxies tend to be ellipticals and red regardless of their environment.

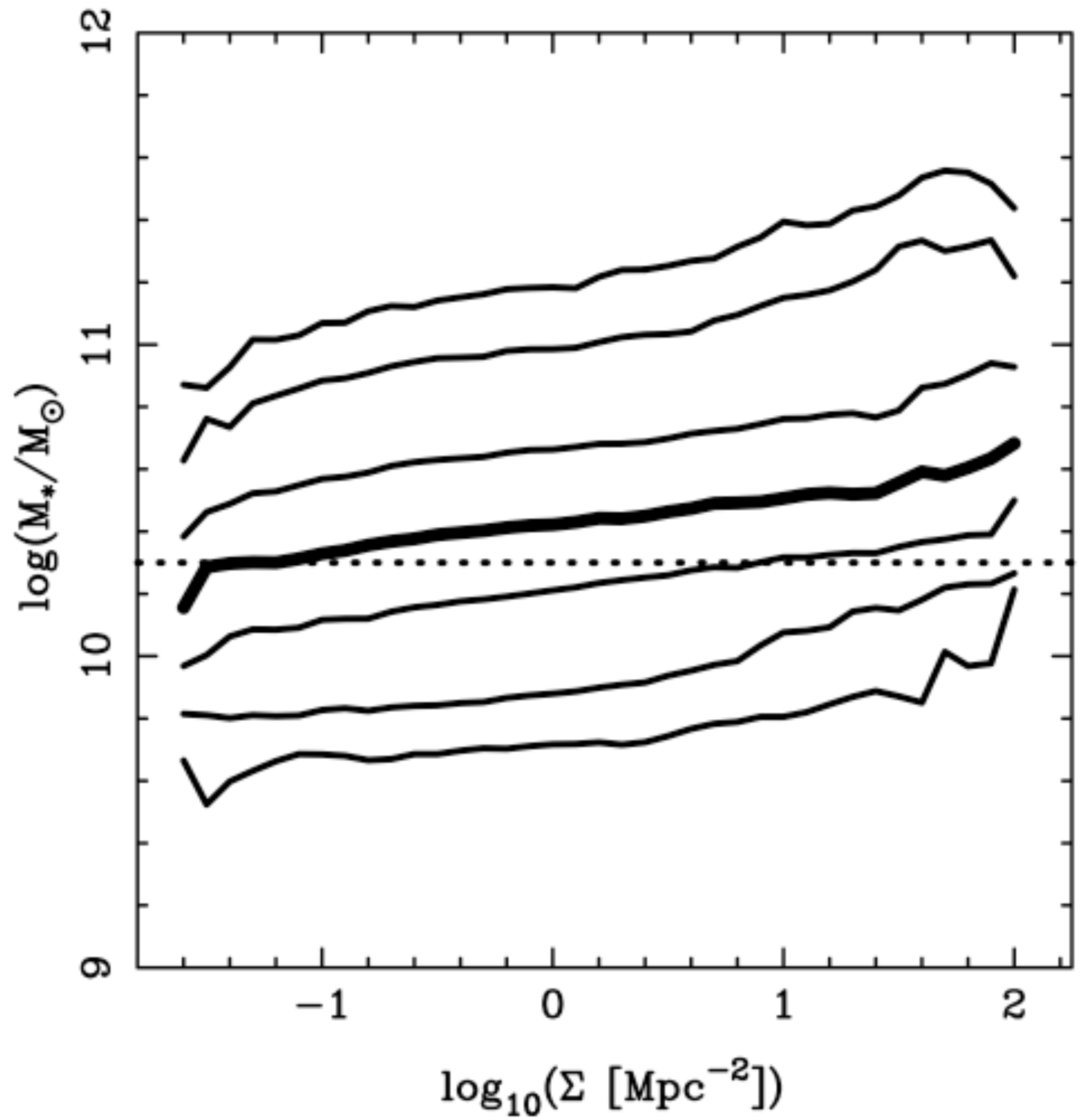
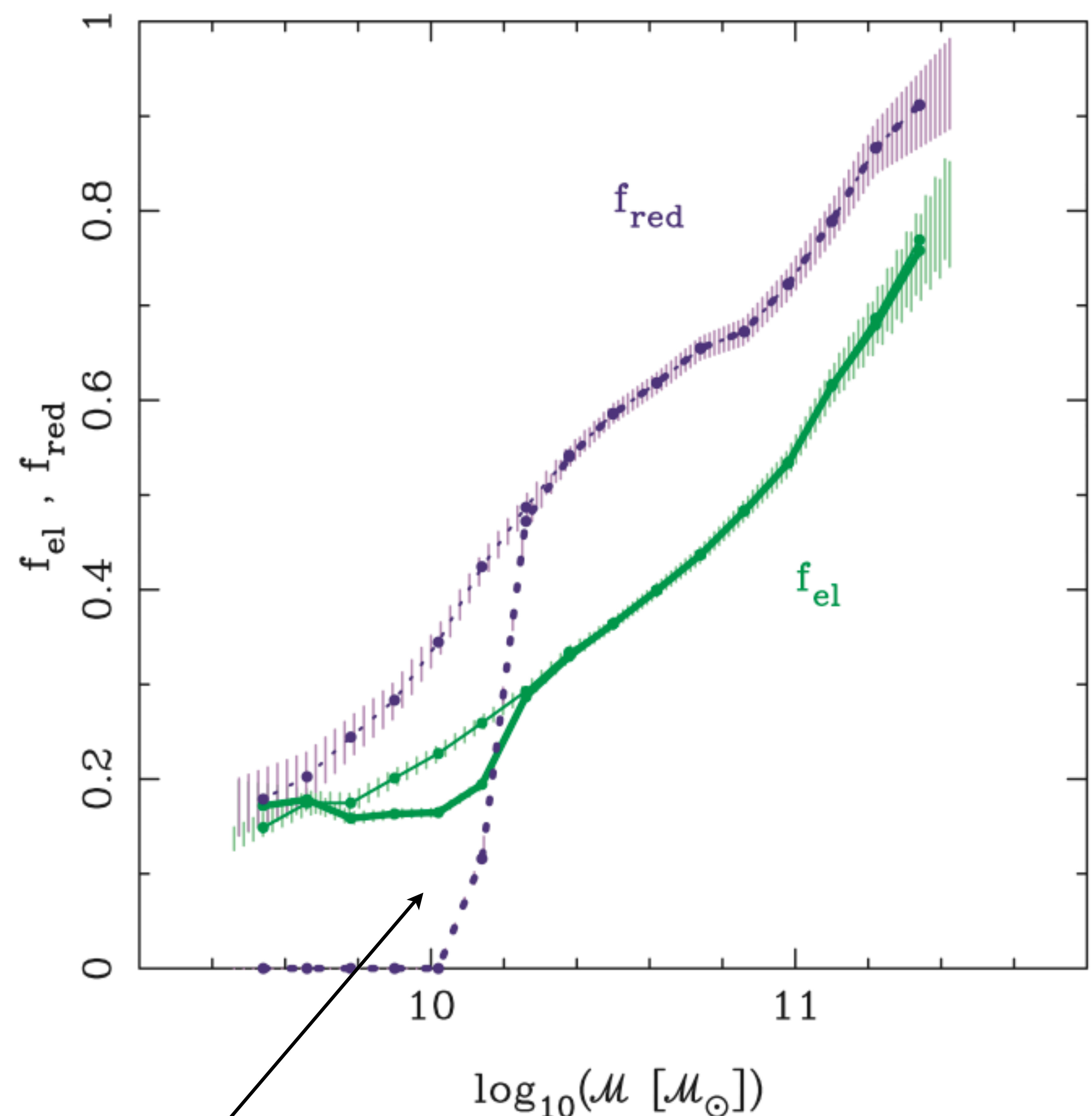



**Figure 10.** The distribution of stellar mass in our *luminosity-limited sample* as a function of (left) local galaxy density and (right) groupocentric distance. The lines trace the 1, 5, 25, 50 (thick), 75, 95 and 99 percentiles of the stellar-mass distribution in bins of environment. The stellar-mass distribution shifts steadily versus local density, while versus groupocentric distance most of the change in the stellar-mass distribution occurs within $\sim 0.2\ R_{\rm vir}$. The dotted horizontal lines indicate a stellar mass of $10^{10.3}\ \mathcal{M}_\odot$, below which our *luminosity-limited sample* becomes incomplete for red galaxies.

Fraction of red and early-type galaxies in low-density environment

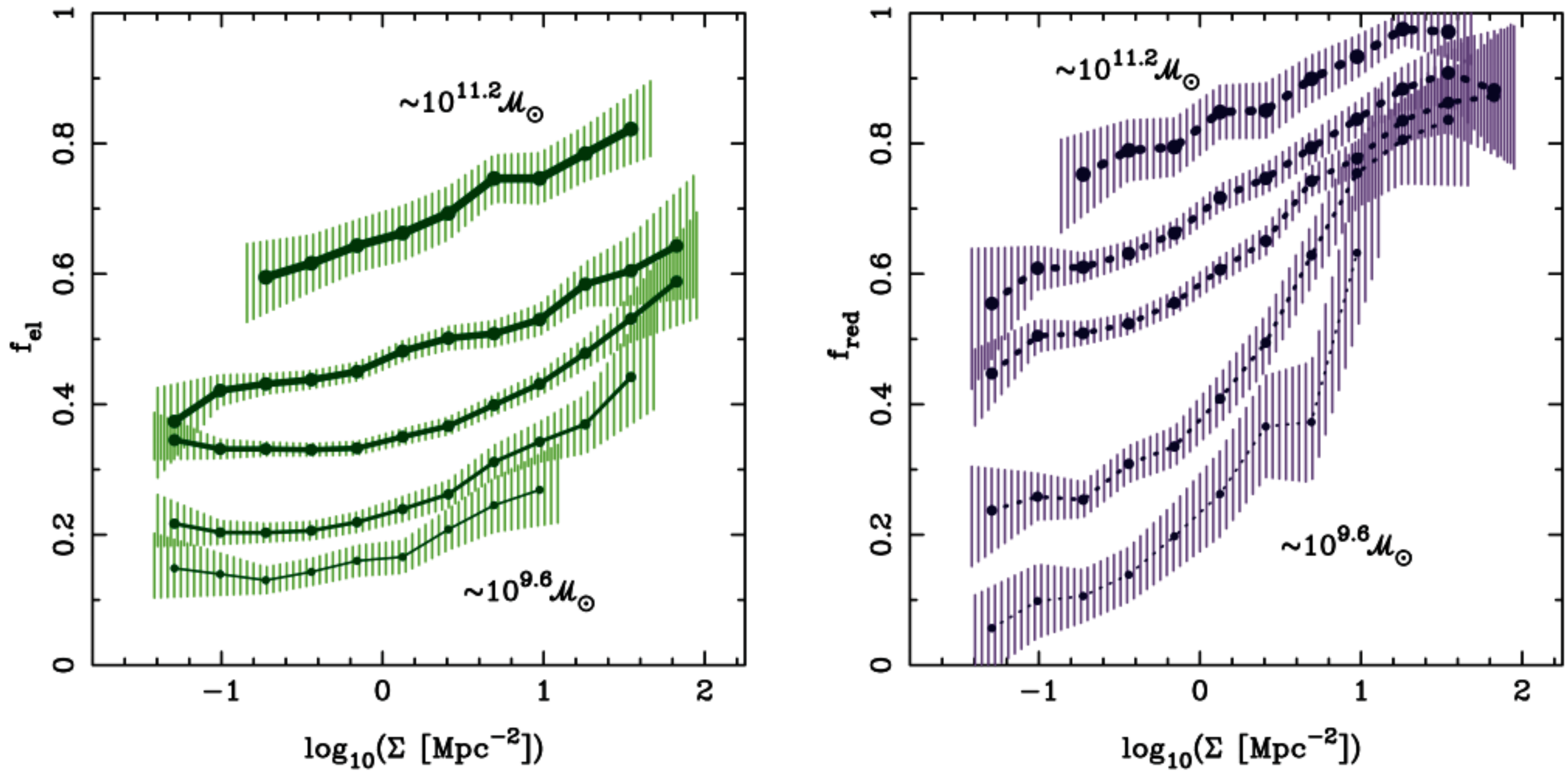
There are many ellipticals in the field where environment does not play a role




incompleteness

Stellar mass

# Fraction of ellipticals for different colors and stellar masses




## Small galaxies:

- in low density environments are preferentially blue spirals
- in high density they are red ellipticals

## Large galaxies:

- preferentially red  regardless of environment
- in high density they are red ellipticals