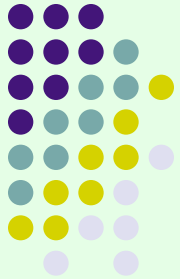

Low-Density Structures in the Local Universe

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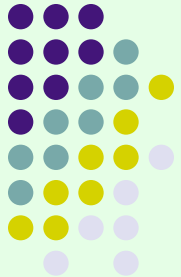
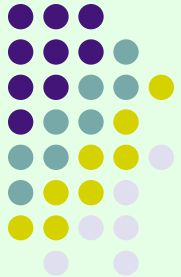
2013



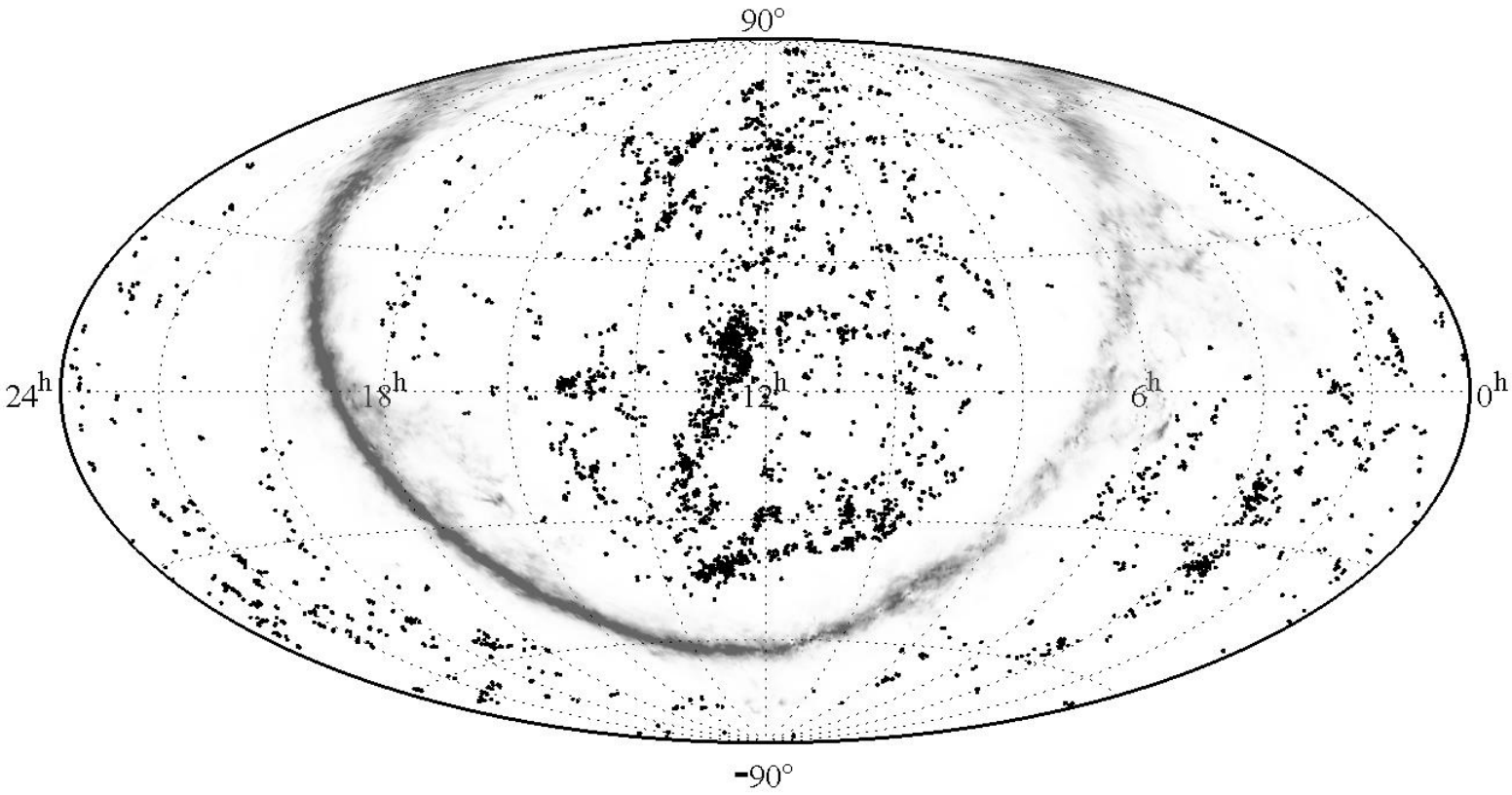
Important cosmologic information is written not only in the high density peaks of the "Cosmic Web" (clusters and groups of galaxies) but also in low density regions, which remain to be poorly studied so far.

The study of "tops" of the LSC and the neglect of its "roots" renders the prevailing approach rather asymmetric.

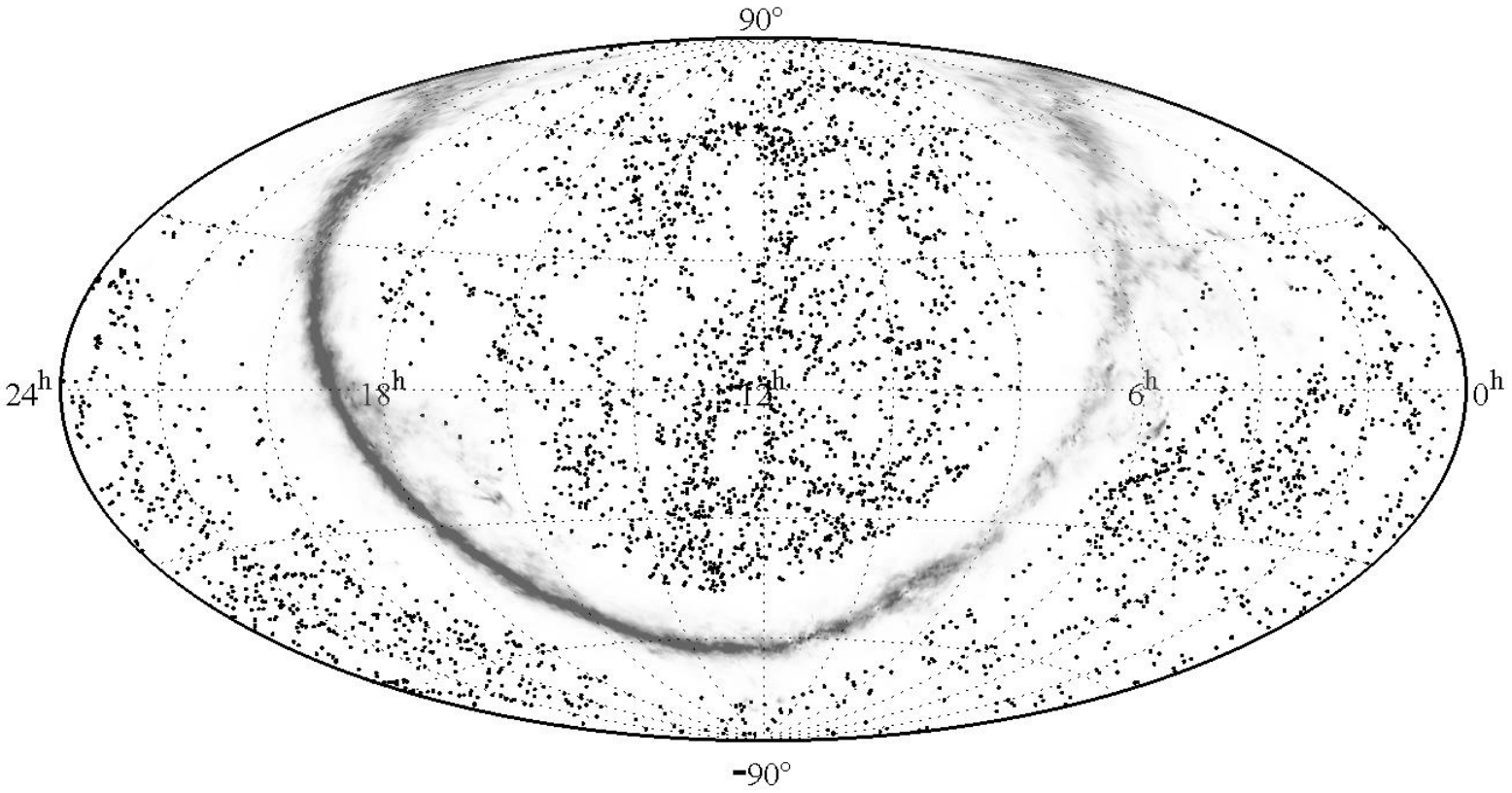


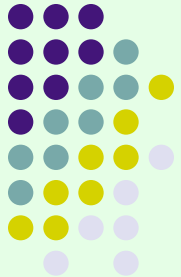
In the Local universe, among 7596 galaxies with radial velocities $V_{LG} < 3500$ km/s, absolute magnitudes $M_K < -18.4$ mag, and Galactic latitudes $|b| > 15°$ there are 3168 field galaxies (i.e. 42%) that avoid pairs, groups and clusters.

Distribution of 4428 clustered galaxies in equatorial coordinates. The region of significant Galactic extinction is shown by a gray ragged stripe.



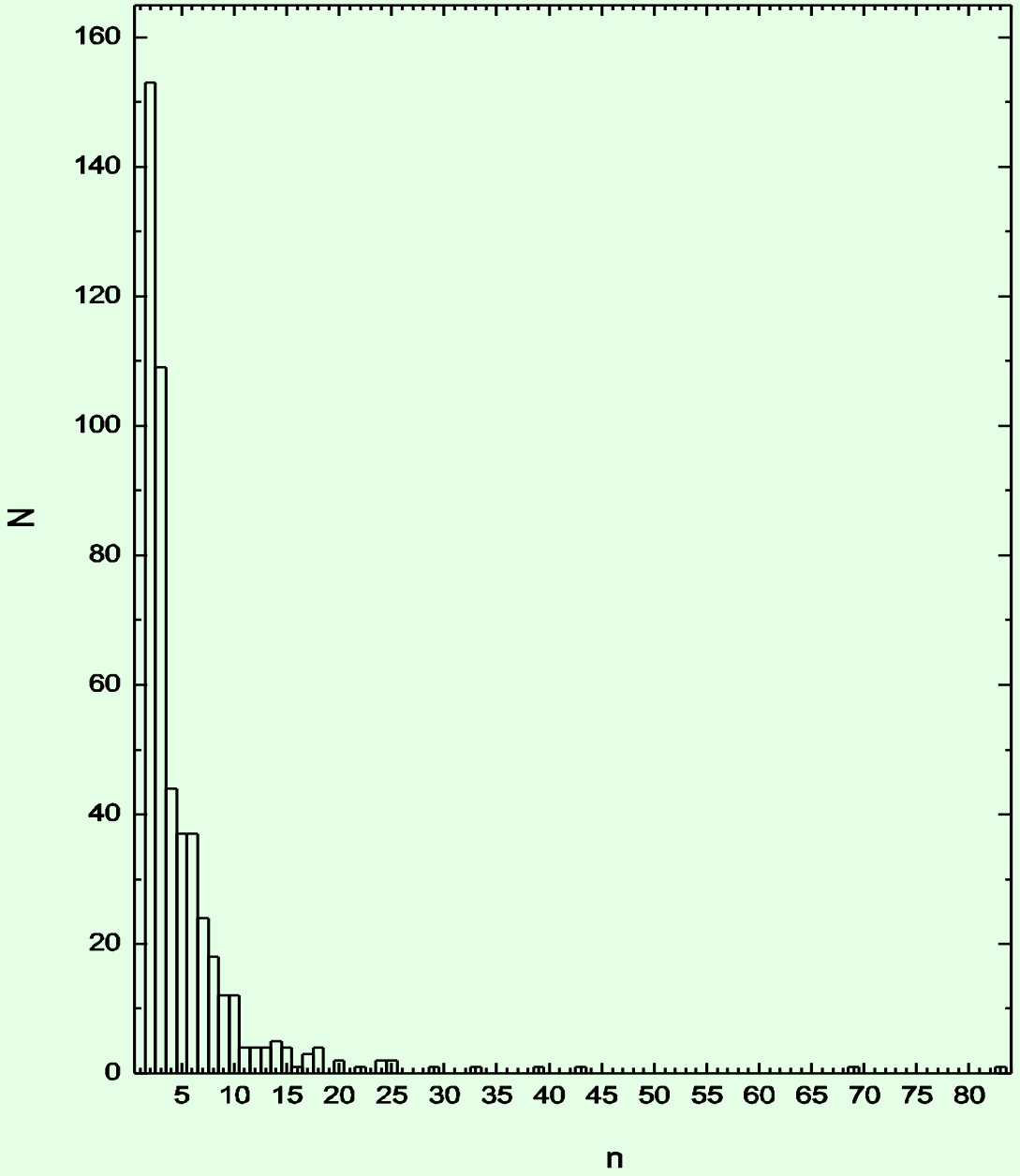
Distribution of 3168 non-clustered galaxies in equatorial coordinates.



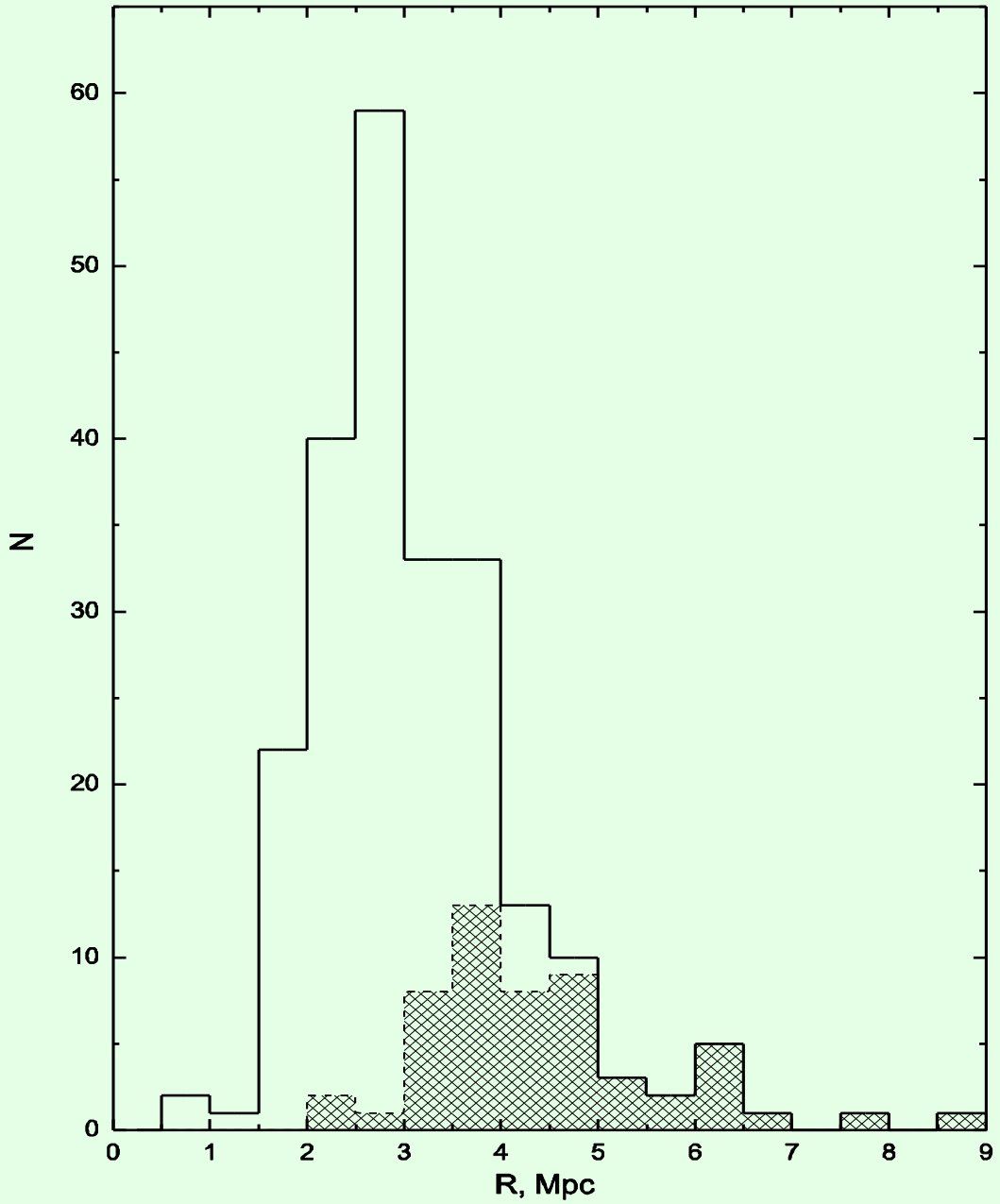


Two-thirds of the field galaxies have their nearest 3D-neighbor within r_0= 2.8 Mpc. Applying to the field galaxy sample a percolation algorithm with the radius of 2.8 Mpc, we found 226 diffuse agglometares with number of members n >= 4.

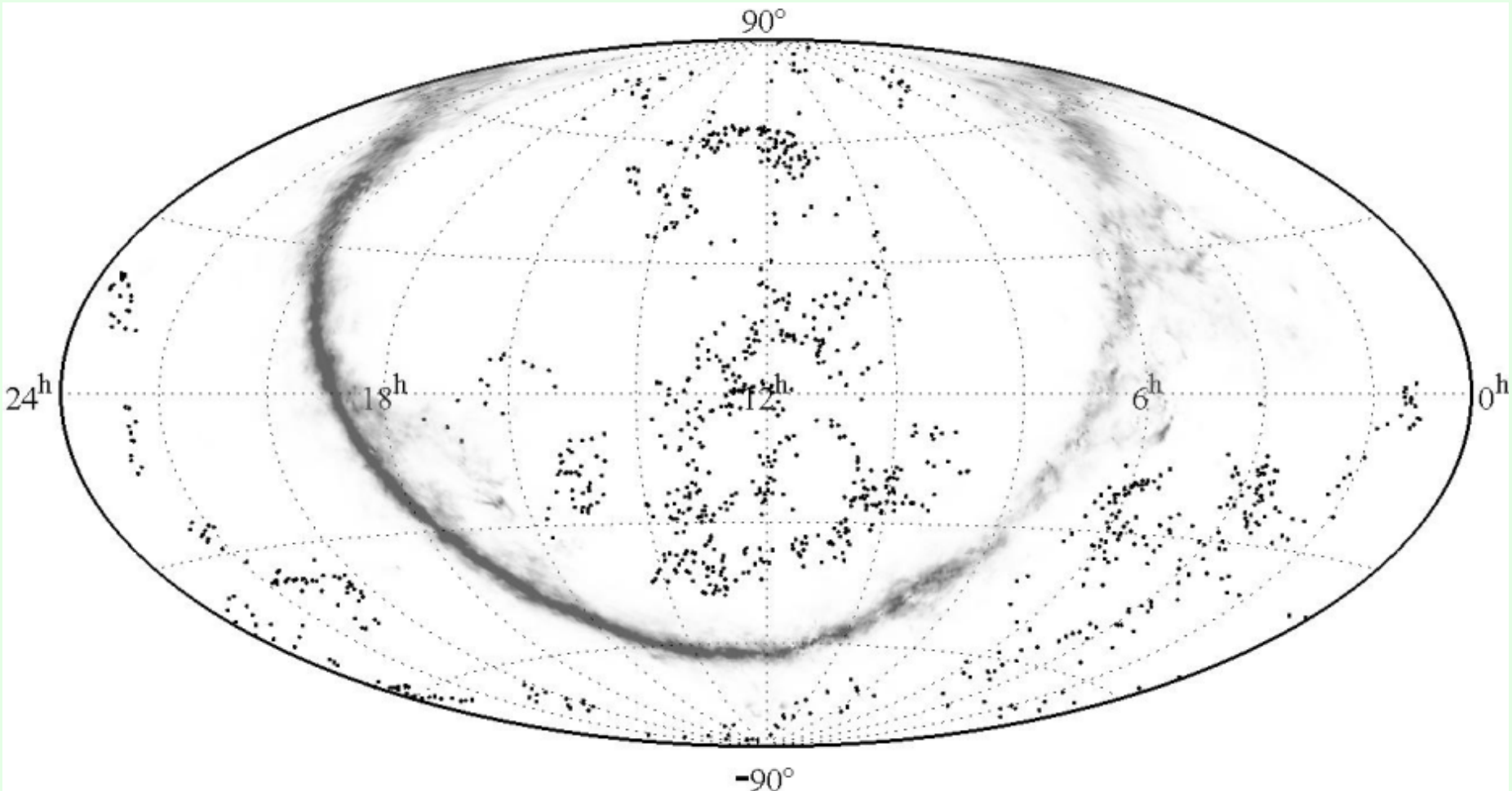
Number of low density agglomerates, identified by percolation, depending on number of galaxies in them.



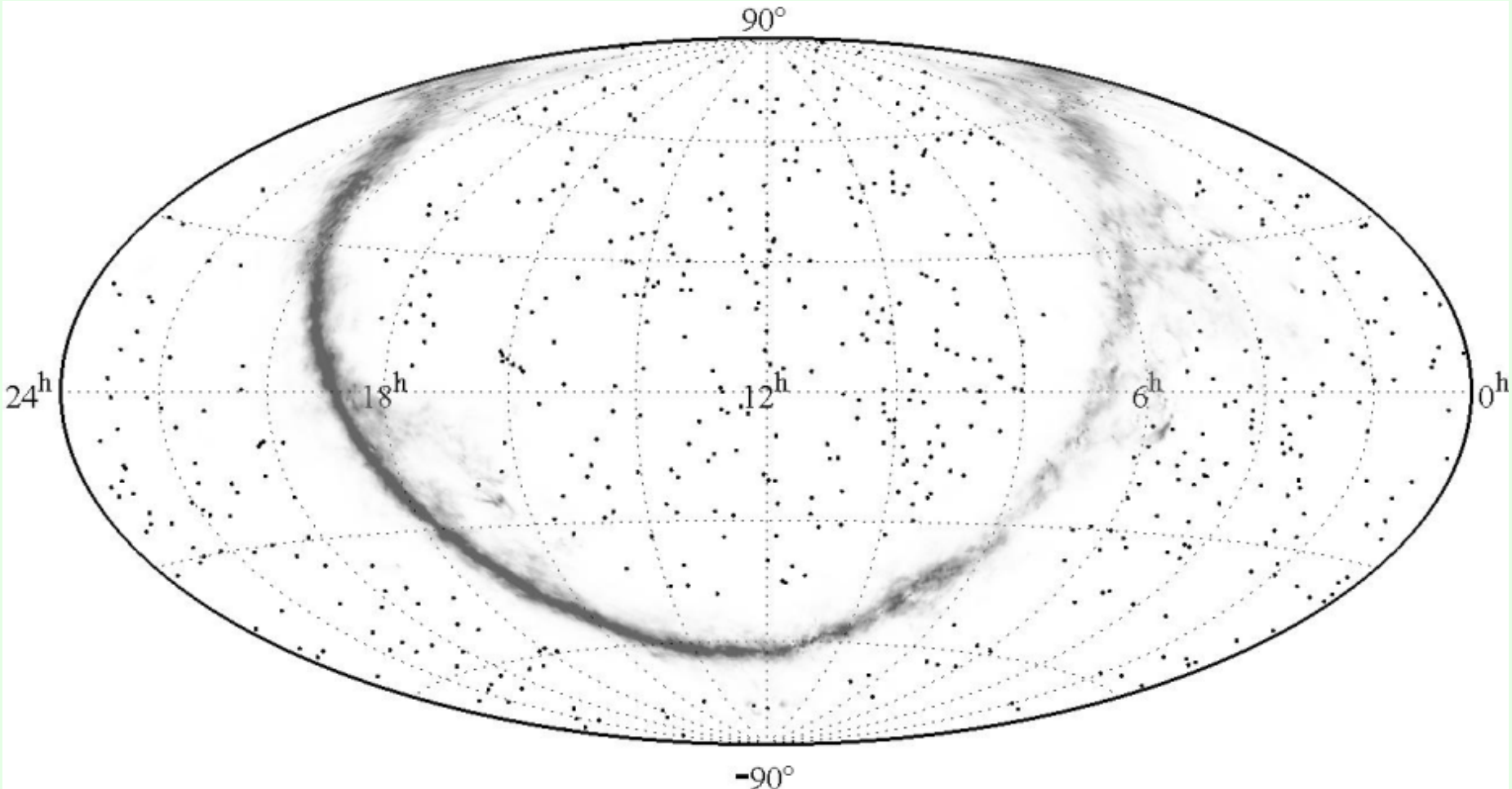
Distribution of 226 agglomerations with n >=4 members, as well as 54 most populated structures with n >=10 by the average mutual separation of their members. The medians of these distributions are 2.9 Mpc and 4.2 Mpc, respectively, i.e. the linear dimensions of these structures are comparable to the virial radius of rich clusters of galaxies.



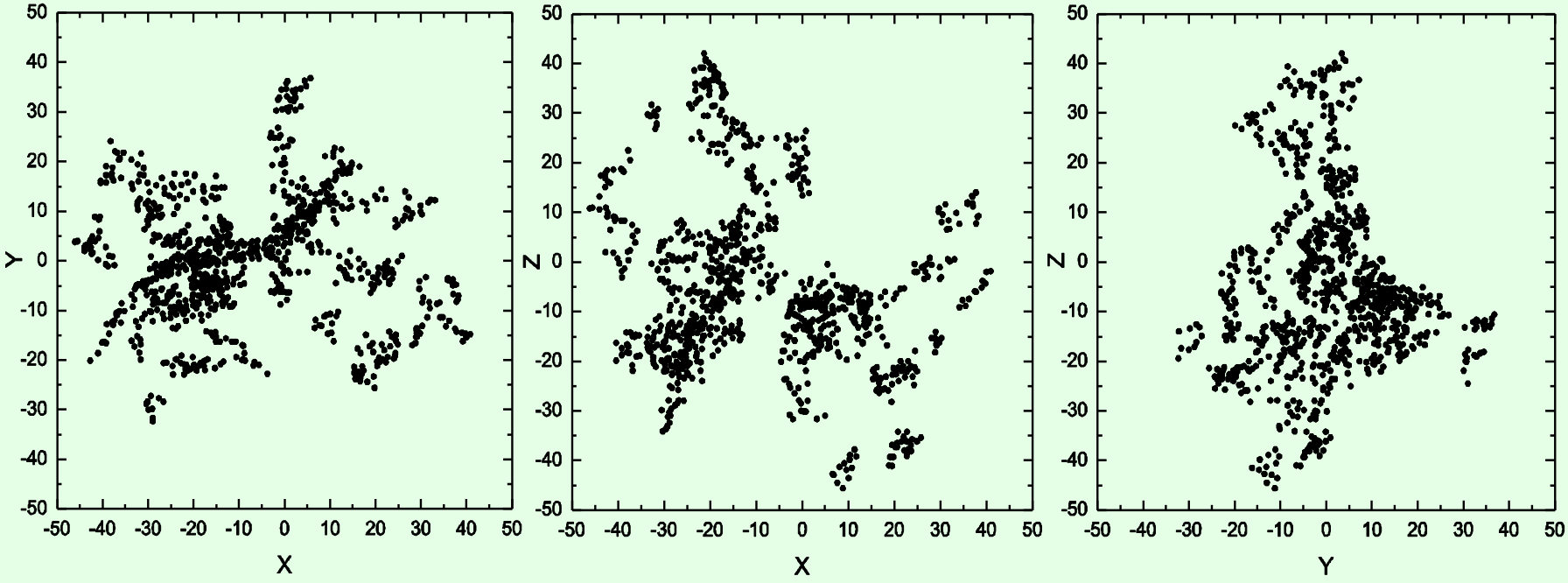
The sky distribution of 989 galaxies belonging to the agglomerates with n >= 10 members.



For a comparison, this panel displays a similar distribution of 543 single galaxies, not subjected to percolation (n=1). The characters of these distributions are strikingly different, once again suggesting that the low density regions are hosting some non-virialized extended structures, which comprise a significant number of galaxies.

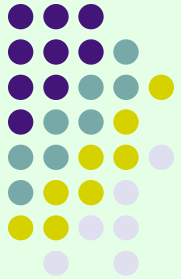


The flocky nature of the distribution of galaxies belonging to the agglomerates with populations of n >=10 is also clearly visible here, in the Cartesian equatorial coordinates. The spottiness of these projected distributions is partly caused by the presence of the extinction region in the Milky Way. However, the filamentary structure of a great many agglomerates can not be caused by the effect of galactic extinction only.



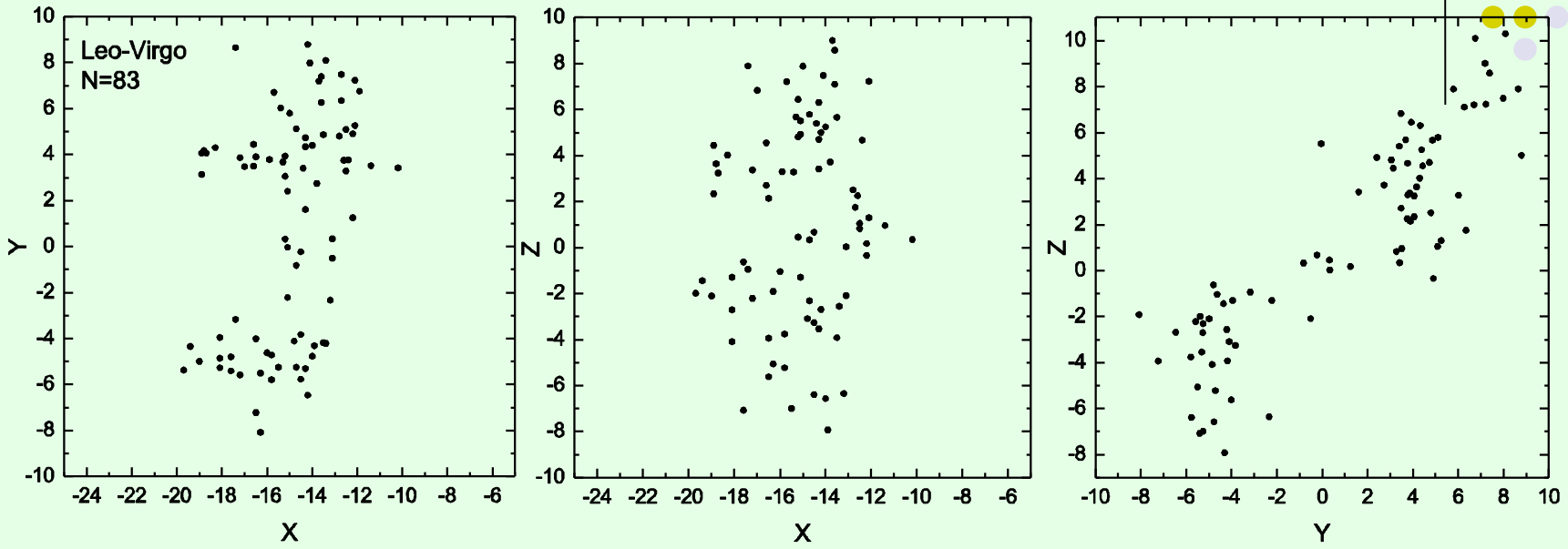
Parameters of the most populated local agglomerates

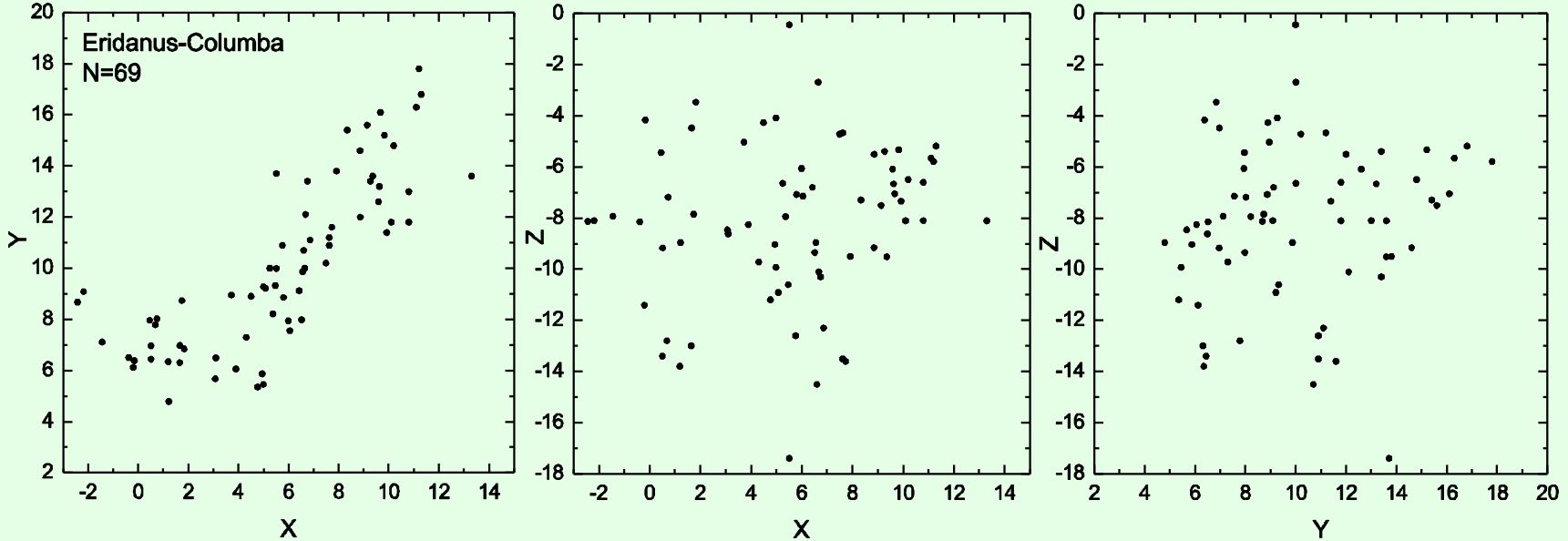
Agglomerate	RA Dec	n	$\langle V_{\rm LG}\rangle$, km/s	σ_v, km/s	$\langle r_{12}\rangle$, Mpc	L_K, $10^{11}\,L_\odot$	$M_{\rm vir}$, $10^{14}\,M_\odot$	$M_{\rm vir}/L_K$	n (E,S0)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Leo–Virgo	$11^h.7$ $+4°$	83	+1210	158	8.7	3.4	2.4	700	9
Eridanus–Columba	$4^h.3$ $-36°$	69	+1080	273	7.6	3.0	6.2	2050	13
Centaurus	$13^h.3$ $-32°$	43	+2310	182	6.5	4.3	1.6	360	4
Microscopium	$21^h.0$ $-39°$	39	+2670	110	6.2	3.0	0.8	270	3
Crater–Corvus	$11^h.9$ $-17°$	33	+1510	180	4.8	1.7	1.7	1000	1
Libra–Hydra	$15^h.1$ $-20°$	29	+2300	153	6.2	2.3	1.6	690	2
Virgo	$12^h.4$ $+2°$	25	+2070	217	4.7	2.0	2.4	1210	1
Tucana–Grus	$22^h.5$ $-59°$	25	+3170	109	4.1	5.1	0.6	110	2

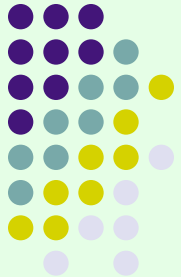


These 8 non-virialized agglomerates are characterized by a median dispersion of radial velocities ~170 km/s, a typical linear dimension ~6 Mpc, integral K-band luminosity ~3 10^{11} $L_{\odot}$, and a formal virial-mass-to-luminosity ratio ~700 $M_{\odot}$ /$L_{\odot}$. The mean density contrast for the considering agglomerates is only ~5, and their crossing time is ~(30-40) Gyrs.

The structure of 2 most populated low-density agglomerates in projections of equatorial Cartesian coordinates (in Mpc).



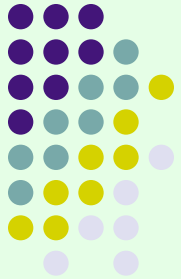




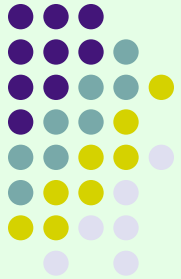
Large-scale flows of galaxies related to motions of filaments and walls can lead to phantom phase groupings of galaxies, if only the kinematic distances are used to find low-density agglomerates.

Such kind false "phase caustics" can be easily confused with scattered physical associations of galaxies. Therefore, some or even most of the discussed agglomerates in the low density regions can prove to be phantom structures.

NEARBY COSMIC VOIDS

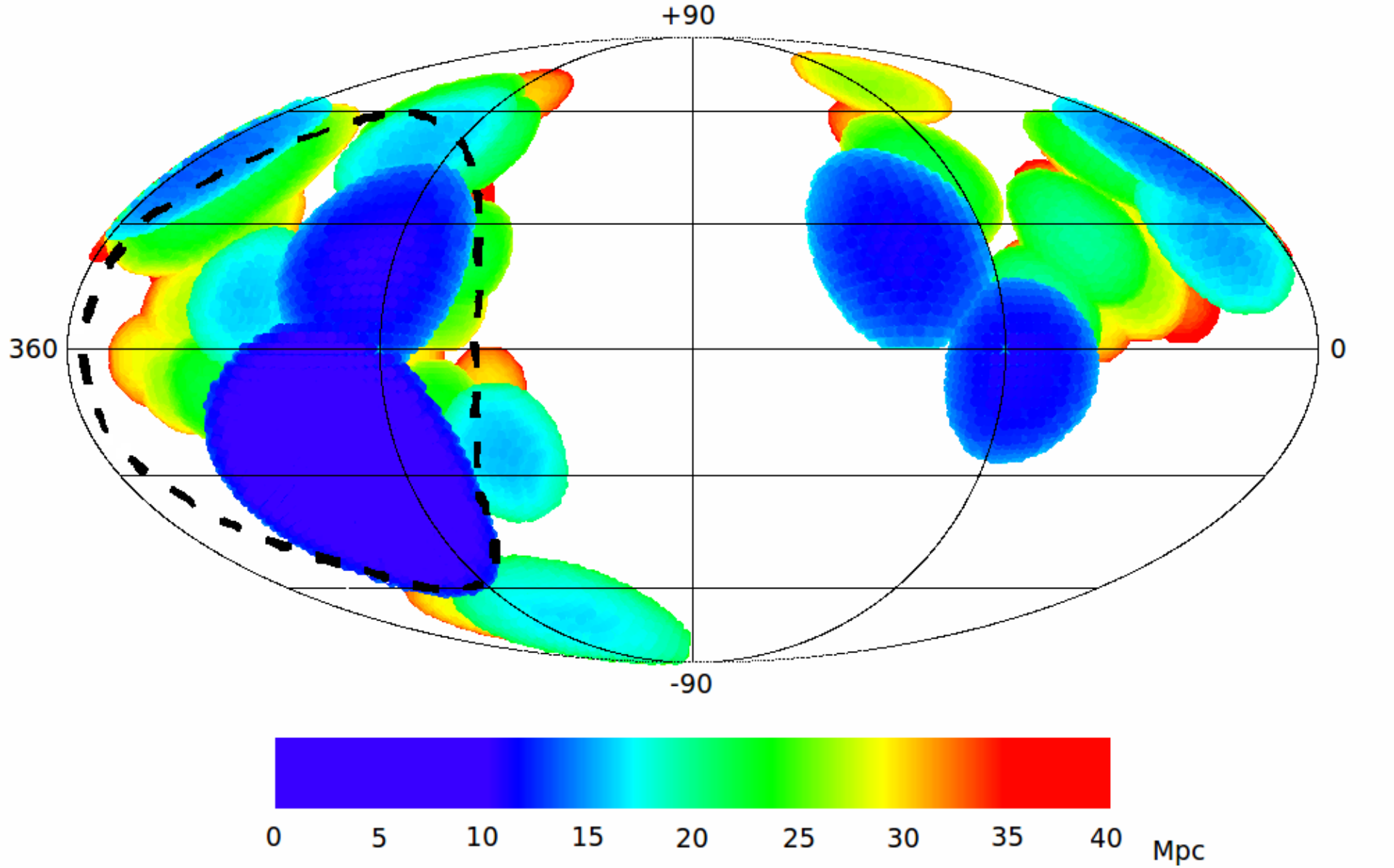


We searched for spherical volumes containing no galaxies with luminosities brighter than the Magellanic Clouds in the Local Supercluster and its vicinity. Within a distance of 40 Mpc from us, 89 cosmic voids were found with the diameters of 24 to 12 Mpc, which are free of galaxies with absolute magnitudes brighter than $M_K < -18.4$.

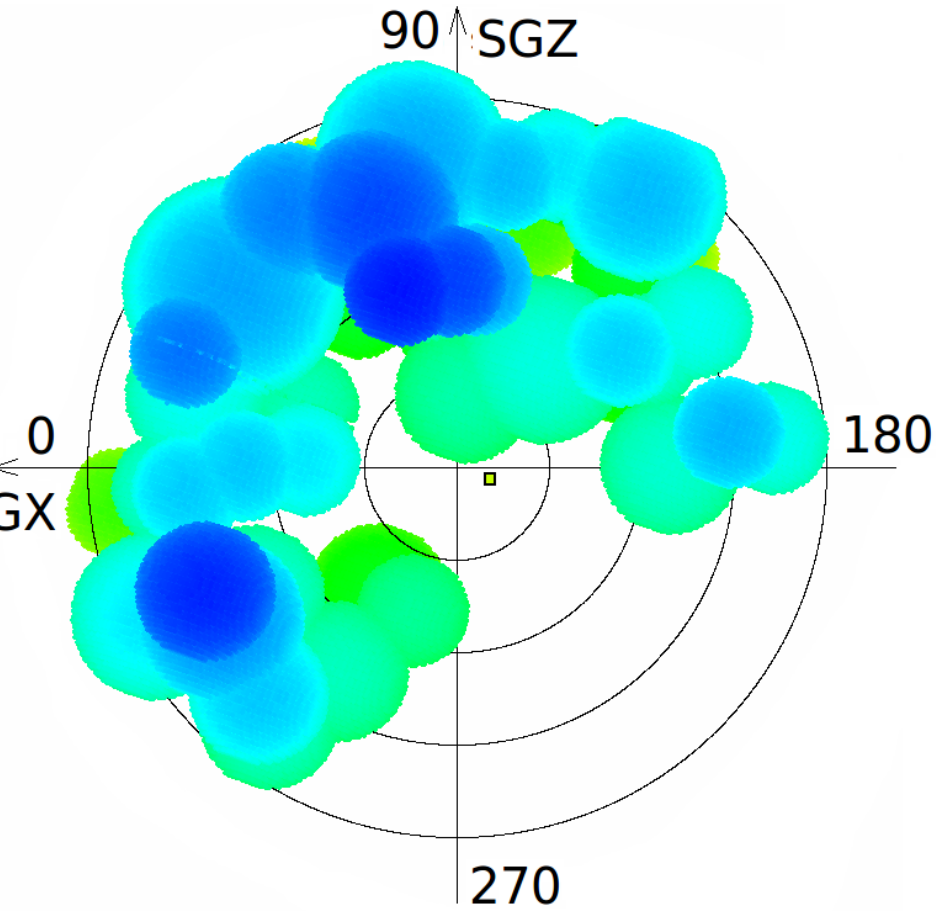


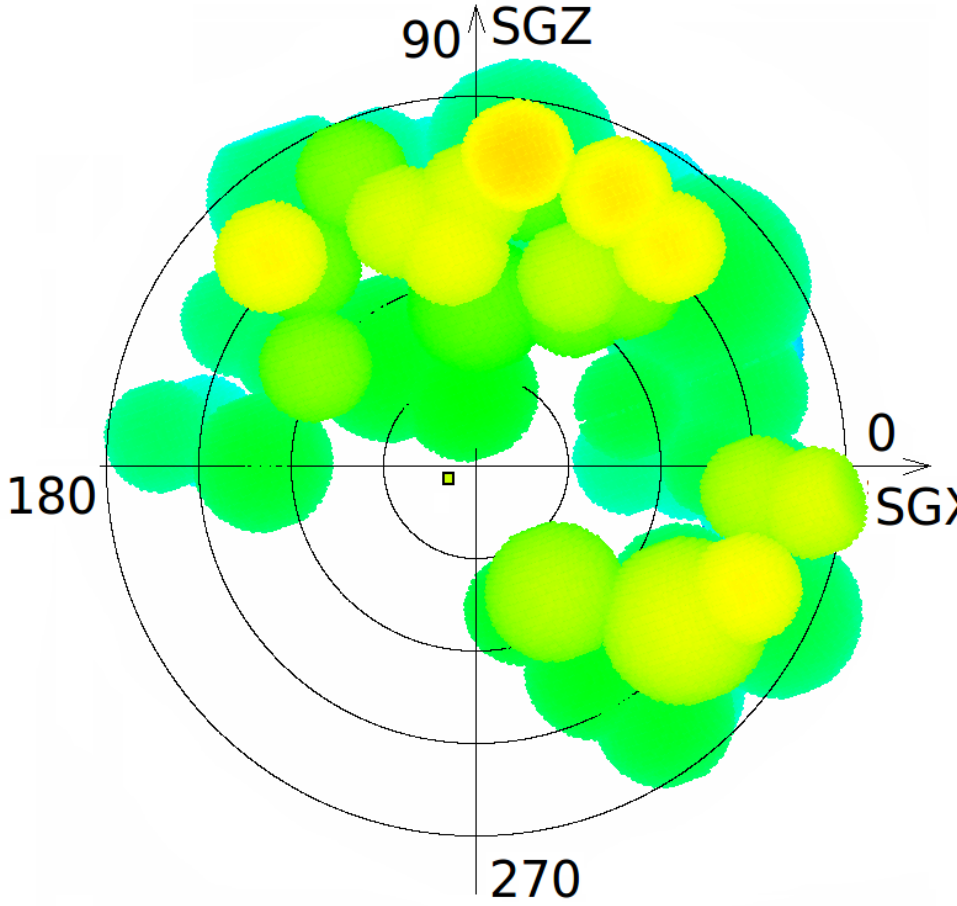
It was found that 93% of spherical voids overlap, forming three more extended percolated voids (hypervoids). The largest of them, HV1, has 56 initial spherical cells and extends in a horseshoe shape, enveloping the Local Volume and the Virgo cluster. The Local Void = Tully Void, in the Hercules - Aquila region is the closest part of the HV1.

HV1

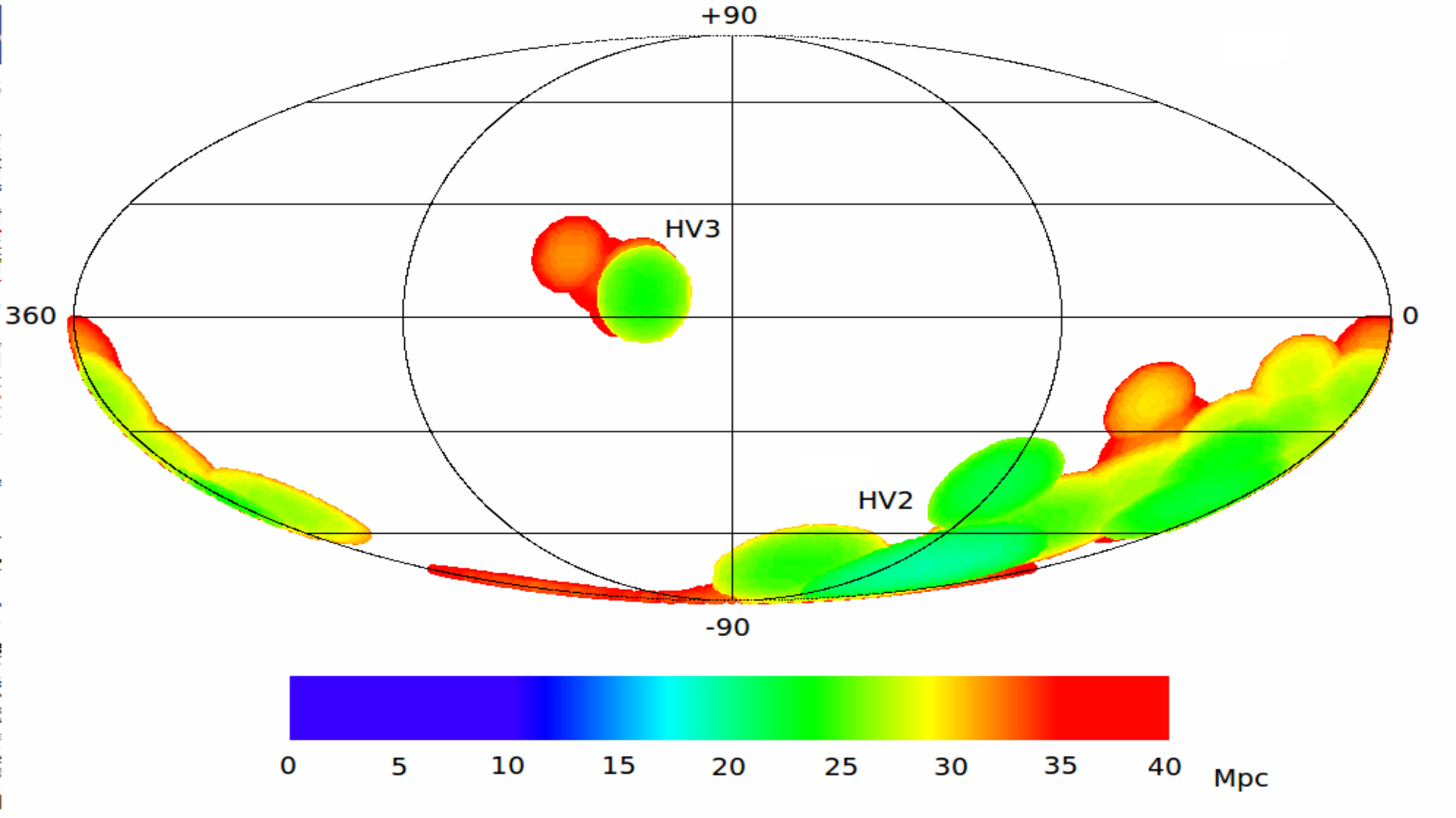


Projection of the HV1 hypervoid on the supergalactic SGX - SGZ plane.





Hypervoid HV2 contains 22 spherical voids in the Eridanus constellation, and the third compact hypervoid (HV3) comprises 6 spherical cells in the Bootes. The total volume fraction of these voids incorporates at least 30% of the Local Universe.



Properties of three local hypervoids

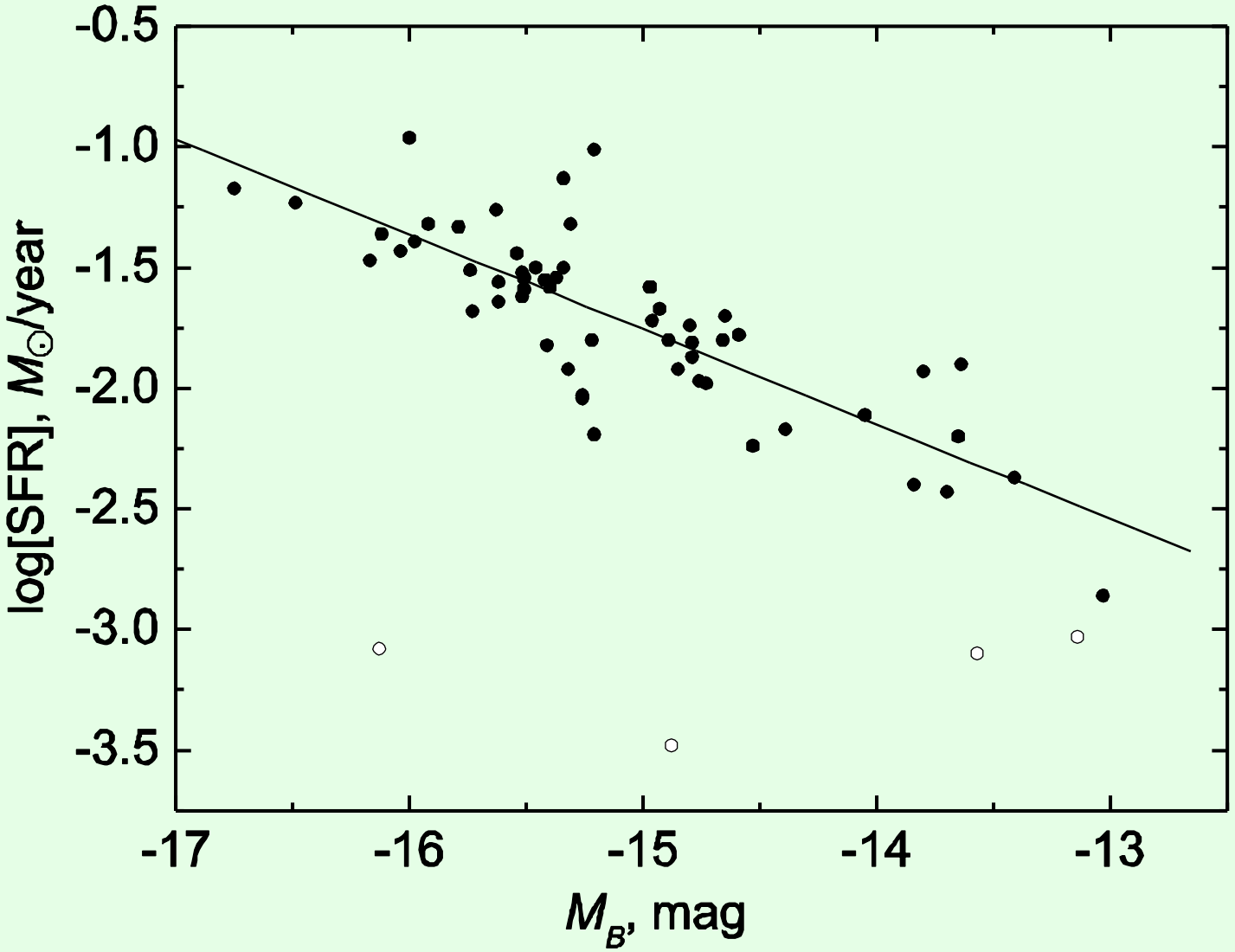
	HV1	HV2	HV3
Number of voids	56	22	5
Volume, Mpc^3	68469	23767	3440
D_{min}, Mpc	1.4	19.4	23.8
D_c, Mpc	13.8	30.5	35.8
D_{max}, Mpc	46.9	47.6	45.6
RA_c, deg	22.2	2.4	14.2
Dec_c, deg	+32	-51	+10
Sky region	Pegasus	Eridanus	Bootes

Among 2906 dwarf galaxies excluded from the initial sample (N=10502) under the search for spherical volumes, only 68 are located in the voids we have detected.

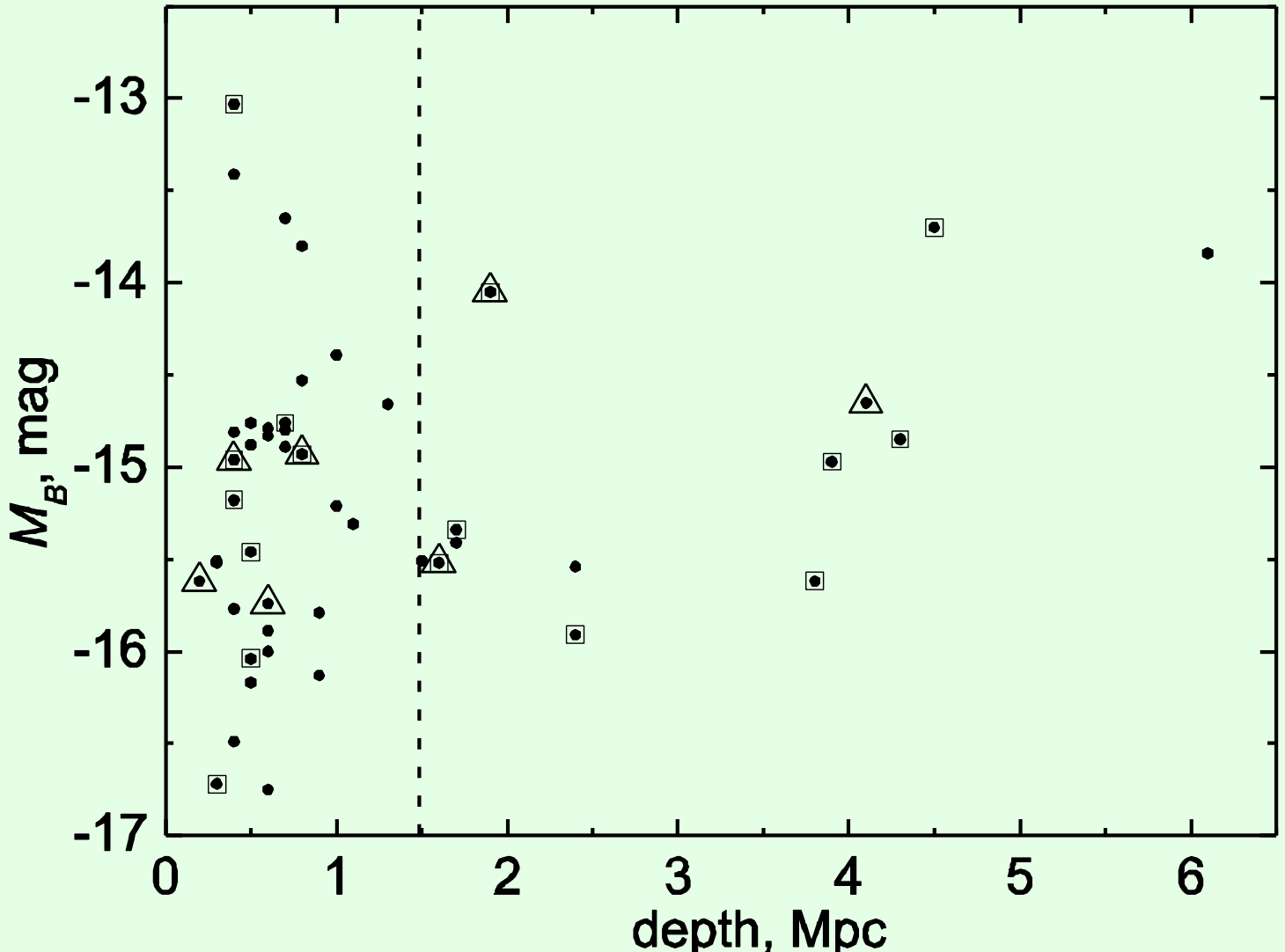
They are characterized by the late morphological types (85% are Ir, Im, BCD, Sm), absolute magnitudes M_B ranging from -13.0 to -16.7, moderate star formation rates (log SSFR ~ -10 yr^{-1}) and gas reserves per luminosity unit 2 - 3 times larger than in other dwarf galaxies located in denser environments.

The dwarf population of the voids shows a certain tendency to sit shallow near the surfaces of cosmic voids.

Relationship between the star formation rate SFR and absolute magnitude for 60 dwarf galaxies in the voids. The unfilled circles show the galaxies with upper estimates of FUV- fluxes.

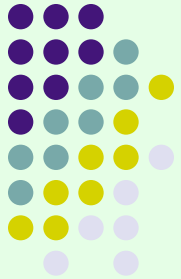


Distribution of 48 dwarf galaxies in the nearby (D < 40 Mpc) voids by absolute magnitude M_B and the bedding depth under the surface of hypervoid. Squares trace the objects common with catalog of Local Orphan Galaxies (LOG).



Perhaps, cosmic voids do not contain ultra-faint dwarfs with luminosities fainter than $3 \times 10^7 L_\odot$ and hydrogen masses lower than $1 \times 10^7 M_\odot$.

The nearest representatives of the void population: KK246 and ALFAZOA J1952+1428 have $M_B = -13.7$ and -13.5 mag, respectively.



Thank you!