Tracing high redshift cosmic web with quasar systems

Maret Einasto (Tartu Observatory)
with
Erik Tago, Heidi Lietzen, Changbom Park, Pekka Heinämäki,
Enn Saar, Hyunmi Song, Lauri Juhan Liivamägi and Jaan Einasto

The Zeldovich Universe 2014

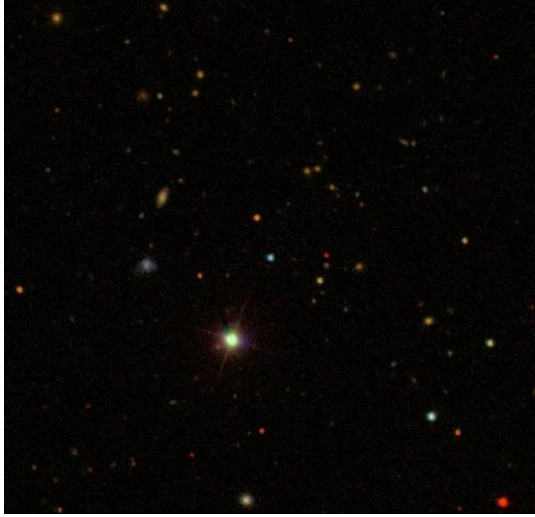
To understand how the cosmic web formed and evolved
we need to describe it
at low and high redshifts.

We use data about quasars to get information about the cosmic structures at redshifts
$1.0 < z < 1.8$.

Quasars have low space density and short lifetime –
rare events in group size haloes with masses $\approx 10^{12} M_{\odot}$.

What information we obtain about the cosmic web from their distribution?

We study clustering properties of quasars and random samples with
Friend-of-Friend (FoF) method



In FoF systems each object has at least one neighbour at a distance smaller or equal than the linking length l.

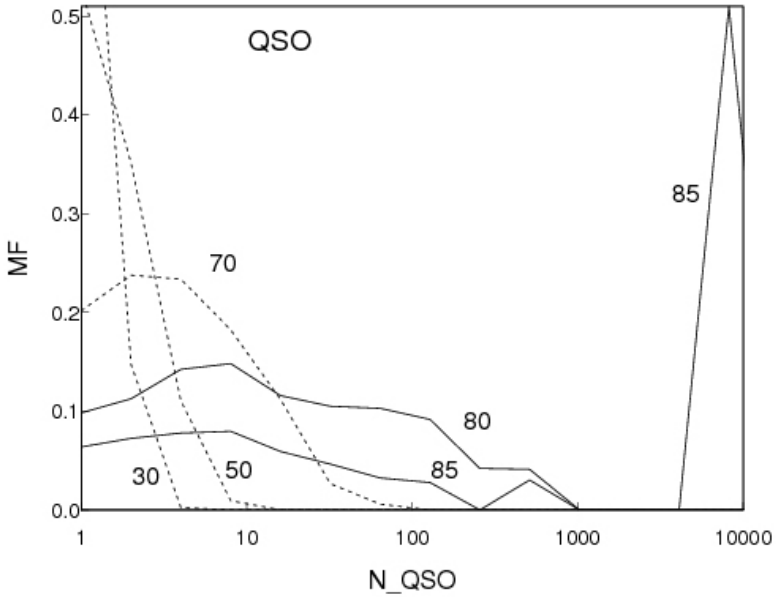
- determine systems of quasars at a series of linking lengths

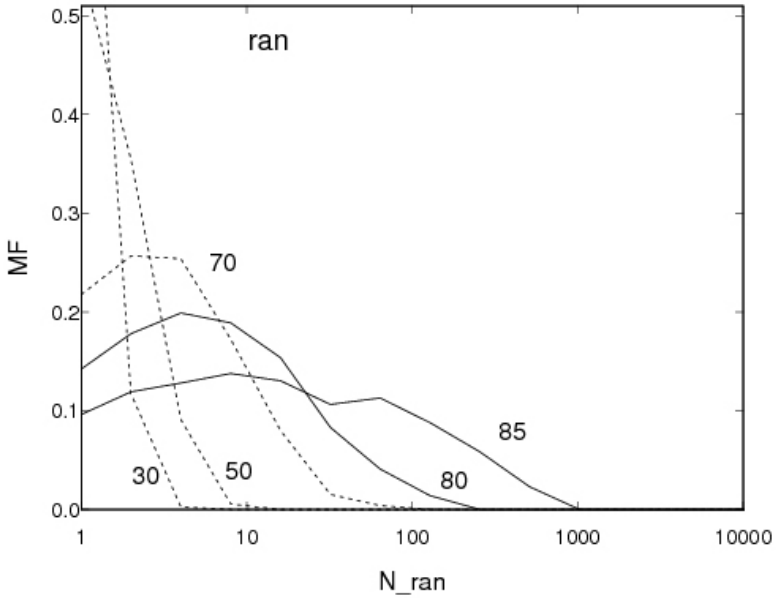
- analyse quasar system properties and their large-scale distribution

- present quasar system catalogues.

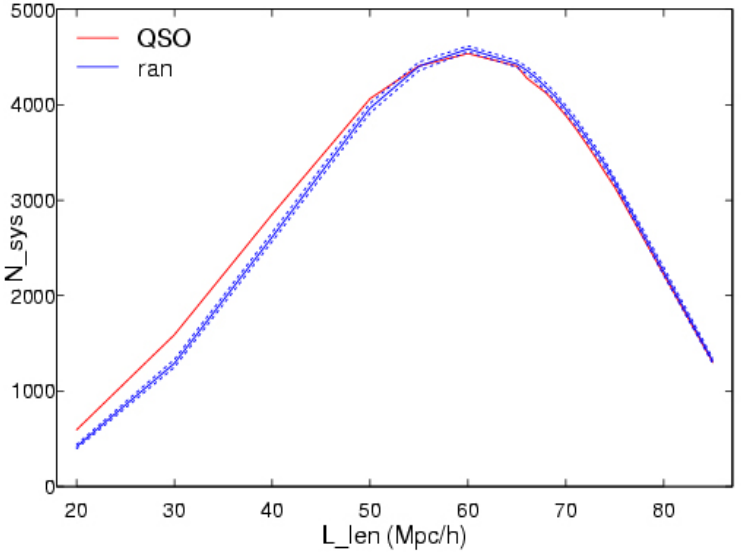
Our sample: SDSS DR7 QSO catalogue (Schneider et al., 2010)
redshift interval $1.0 < z < 1.8$,
i - magnitude limit $i <= 19.1$,
sky coordinates: $-55 < \lambda < 55$, $-33 < \eta < 35$,
N = 22381
Random samples: the same sample limits and number of points

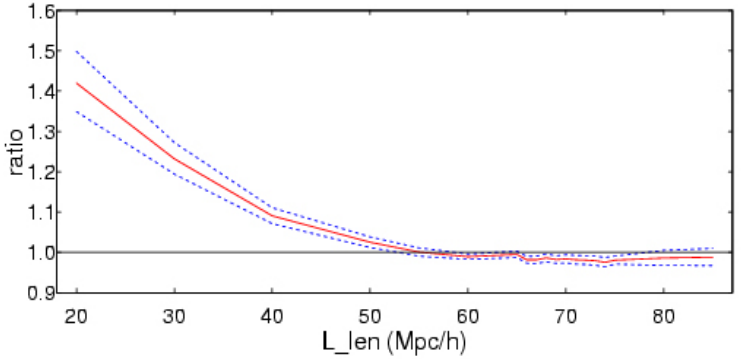
FoF results





Multiplicity functions.

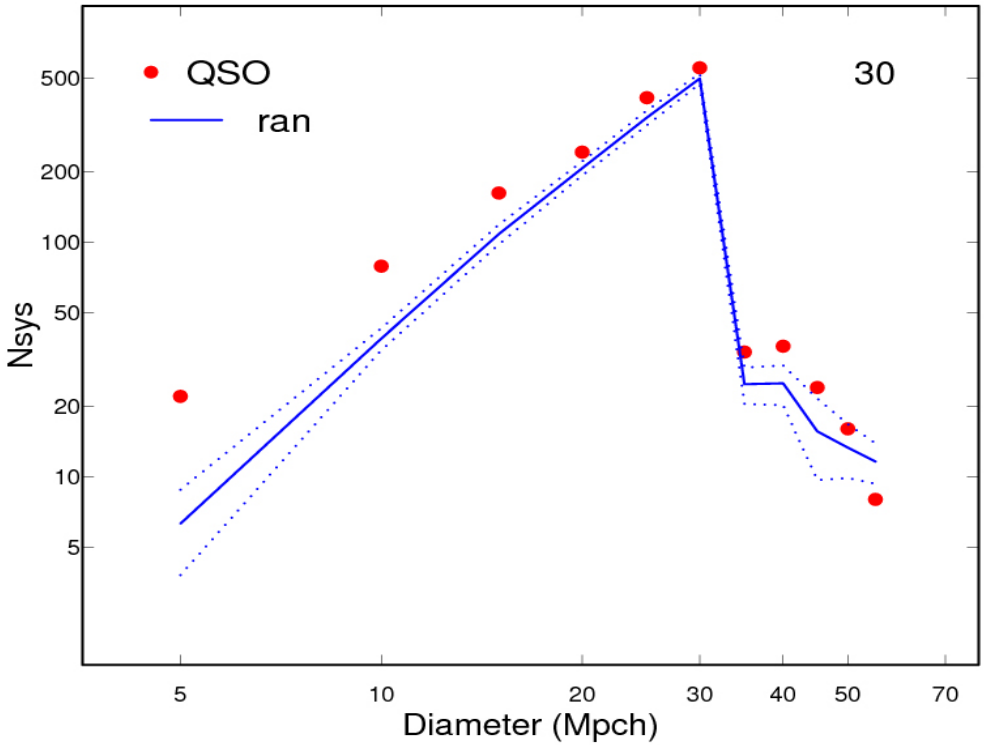


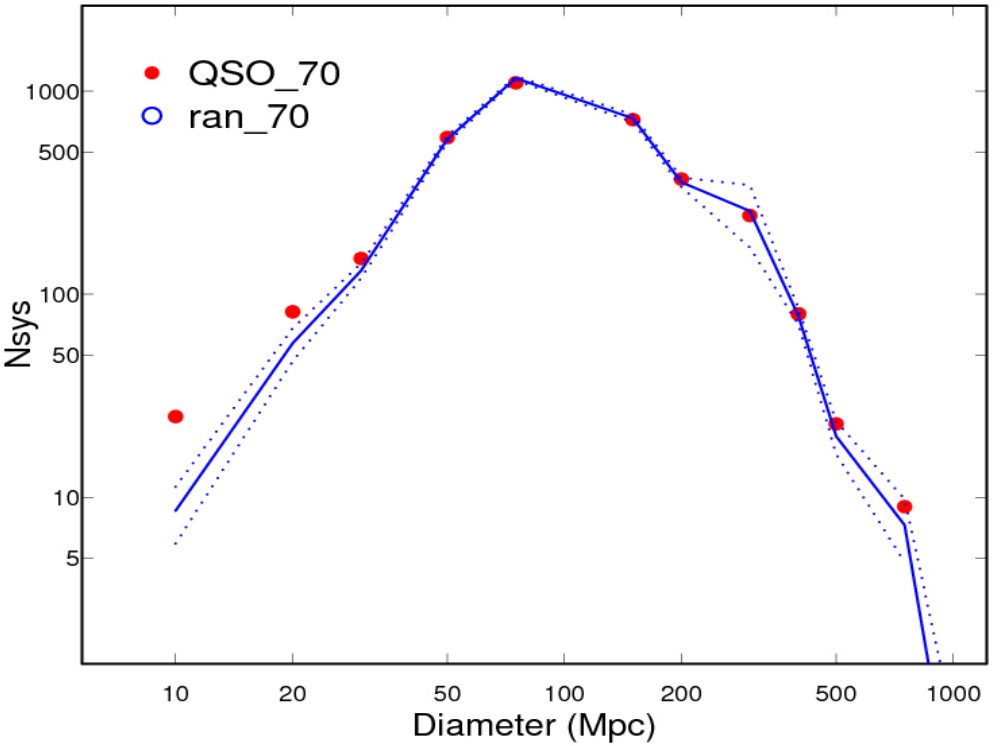


Number of systems.

FoF: differences between quasar and random systems at the linking lenghts $l \leq 30$ Mpc and $l \geq 80$ Mpc (percolation of quasar systems).

Diameters of quasar and random systems



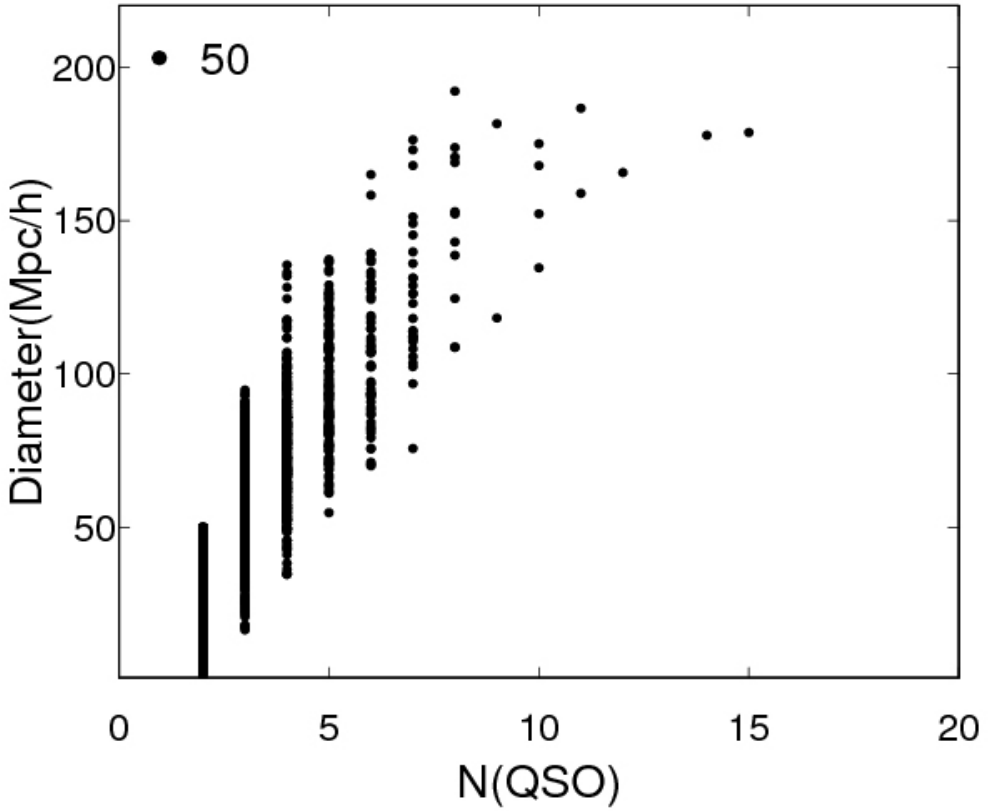


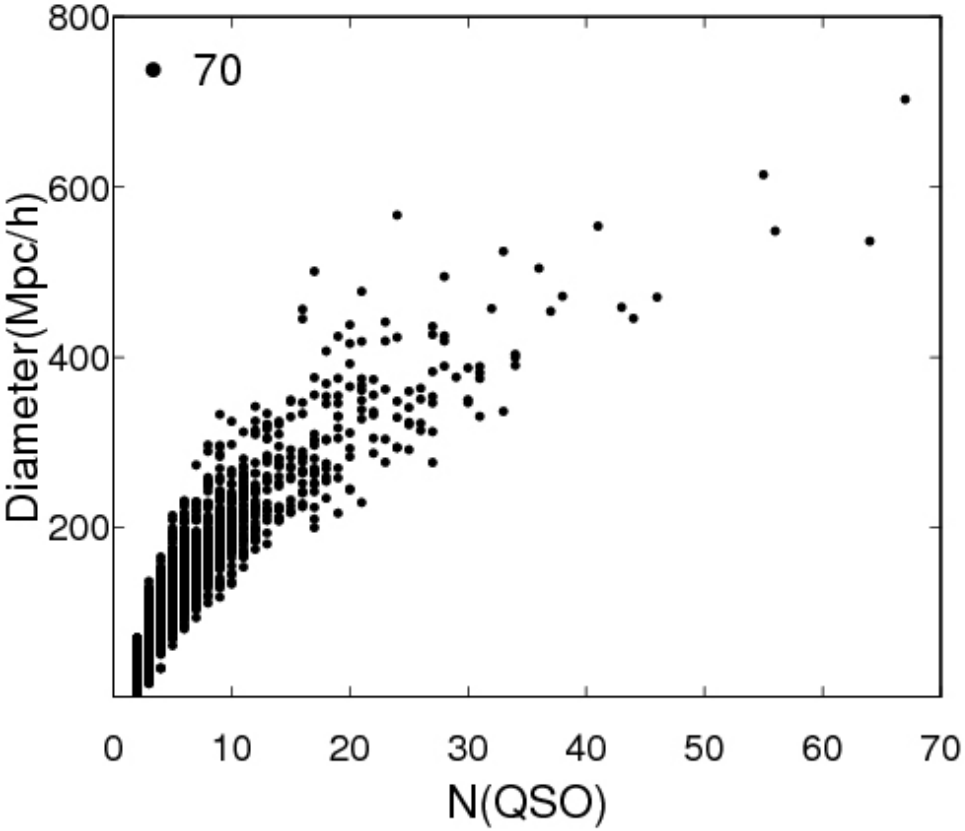
N of quasar and random systems of different diameter, l = 30 and 70 Mpc/h.

The number of quasar systems with diameters < 30 Mpc is larger than the number of random systems at all linking lengths.

The largest quasar systems at l = 70 Mpc/h with sizes 500 – 700 Mpc/h are similar to random systems.

Number of quasars in systems vs. system diameters.



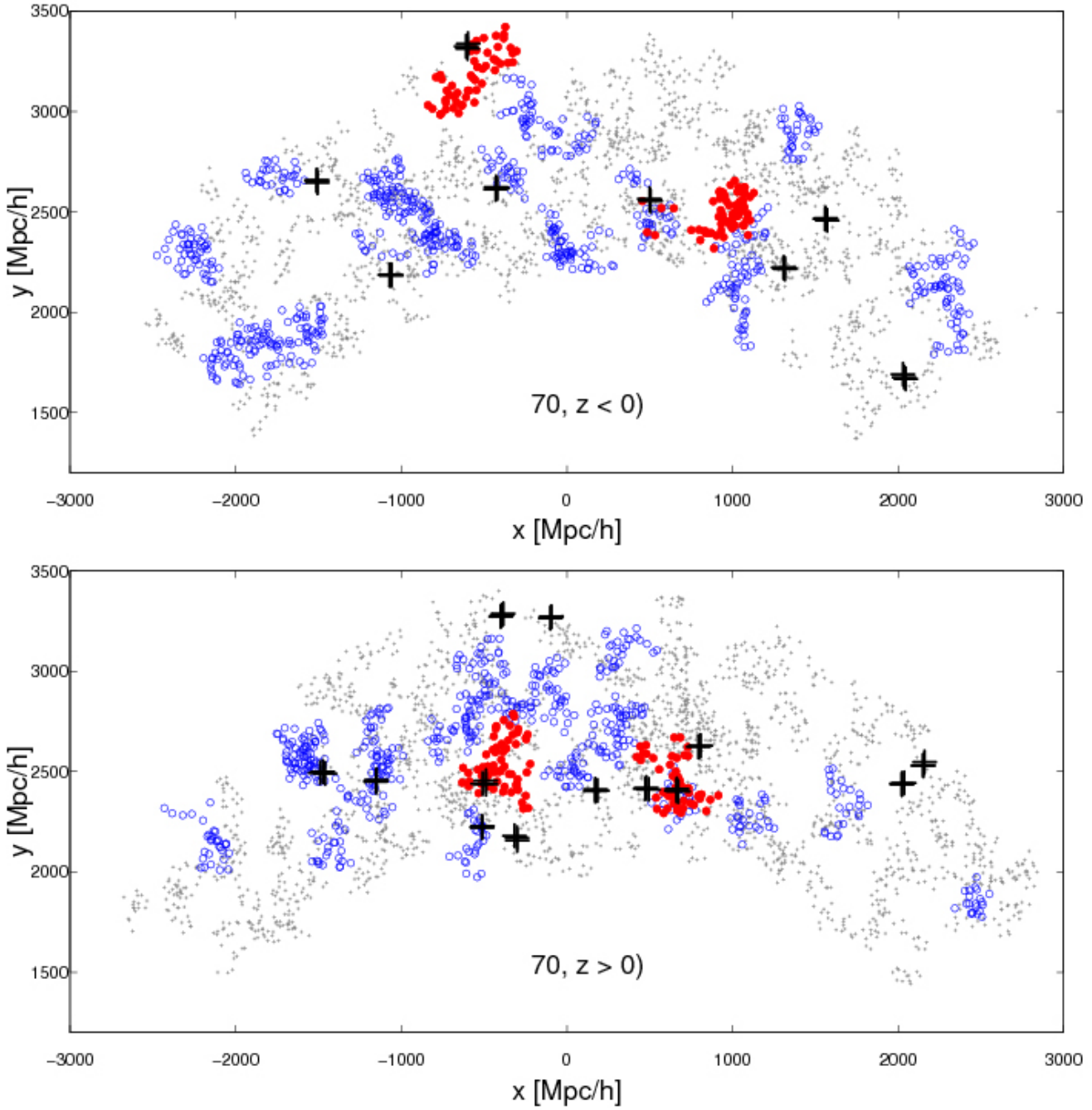


At l = 20 – 50 Mpc the sizes and space density of quasar systems, $\approx 10^{-7}$ $(h^{-1}\ \mathrm{Mpc})^{-3}$, are comparable to the sizes and density of local galaxy superclusters.

At l = 70 Mpc - sizes are as the sizes of local rich superclusters and supercluster complexes (like SGW).

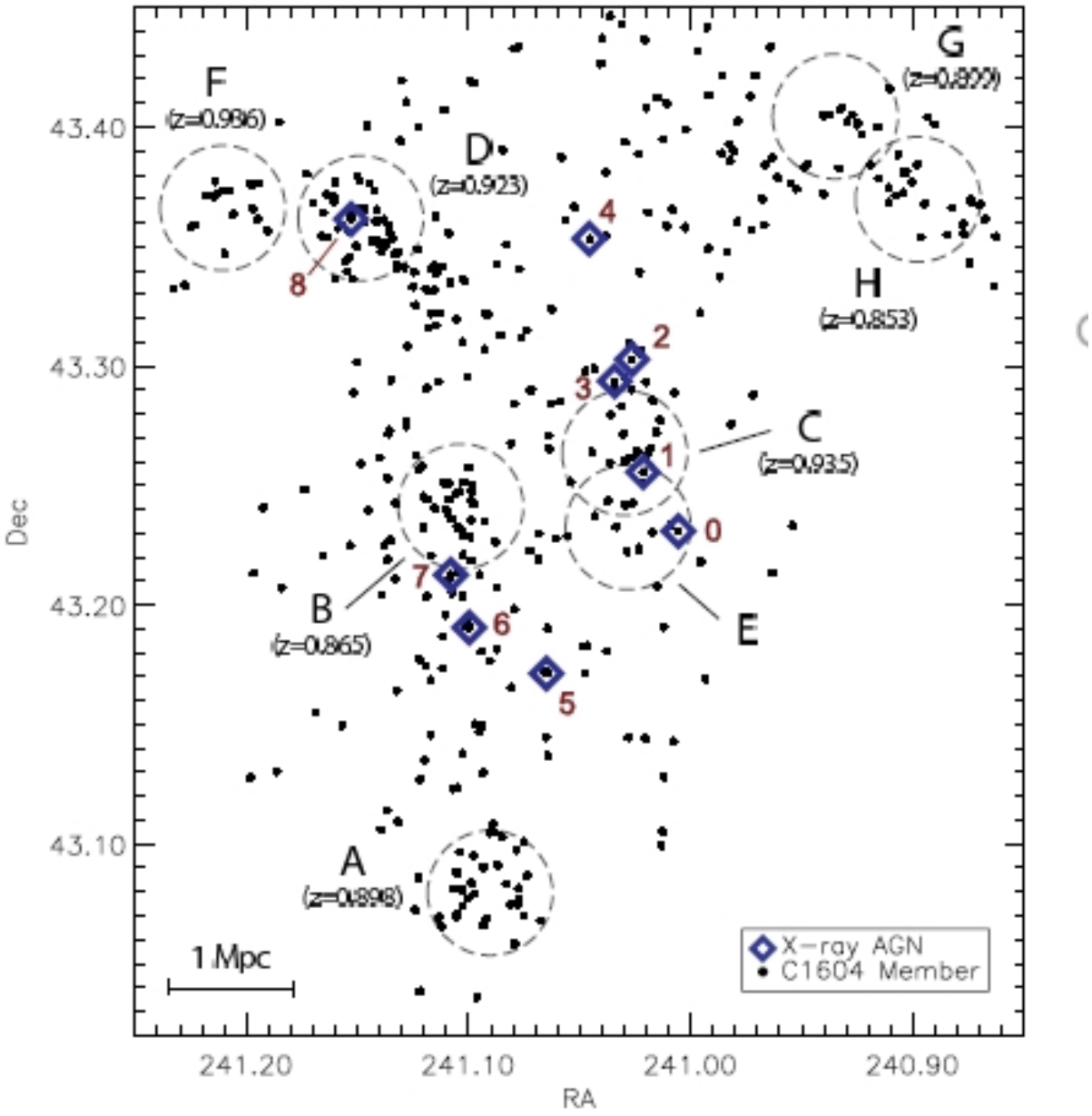
The largest quasar system at 70 Mpc: the same as HUGE-LQG (Clowes et al. 2013)

Cosmic web at redshifts $1 \leq z \leq 1.8$



Red circles: l = 70 Mpc/h, $N_{QSO} > 50$, black crosses: l = 20 Mpc/h, $N_{QSO} = 3$.

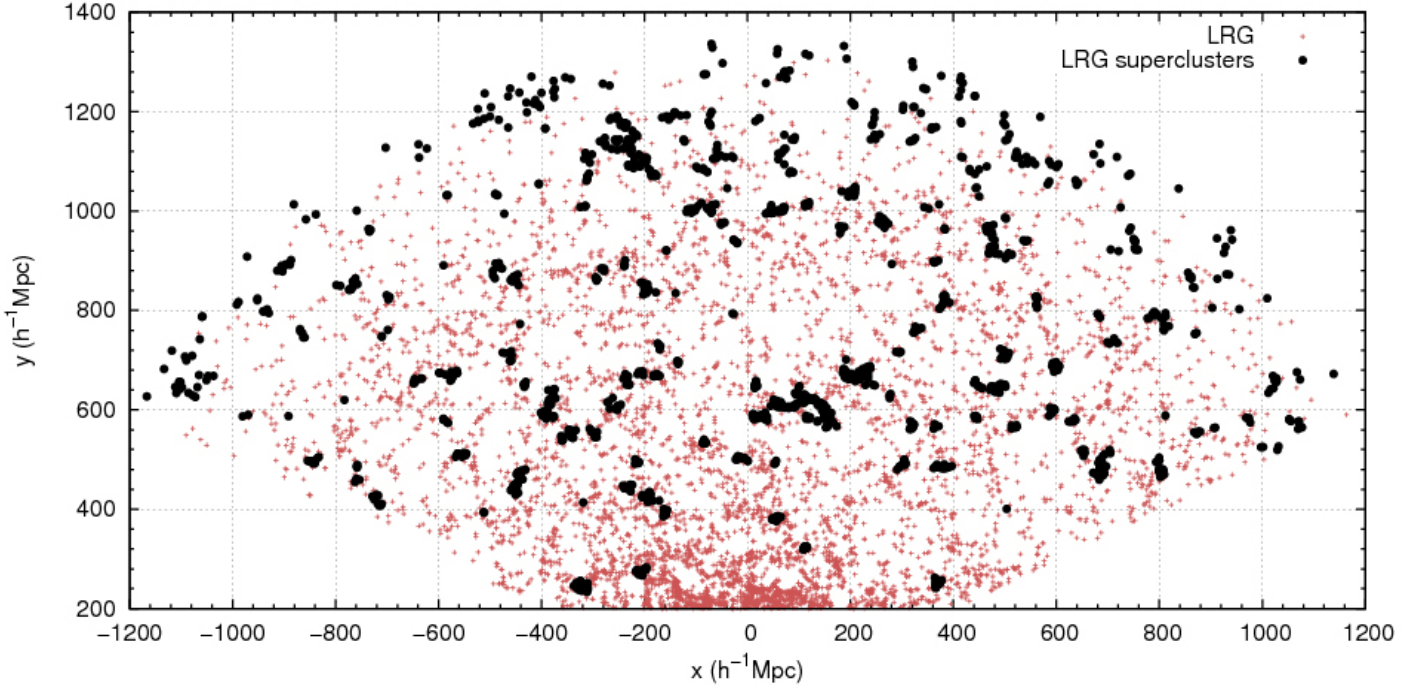
Quasar systems as markers of galaxy superclusters



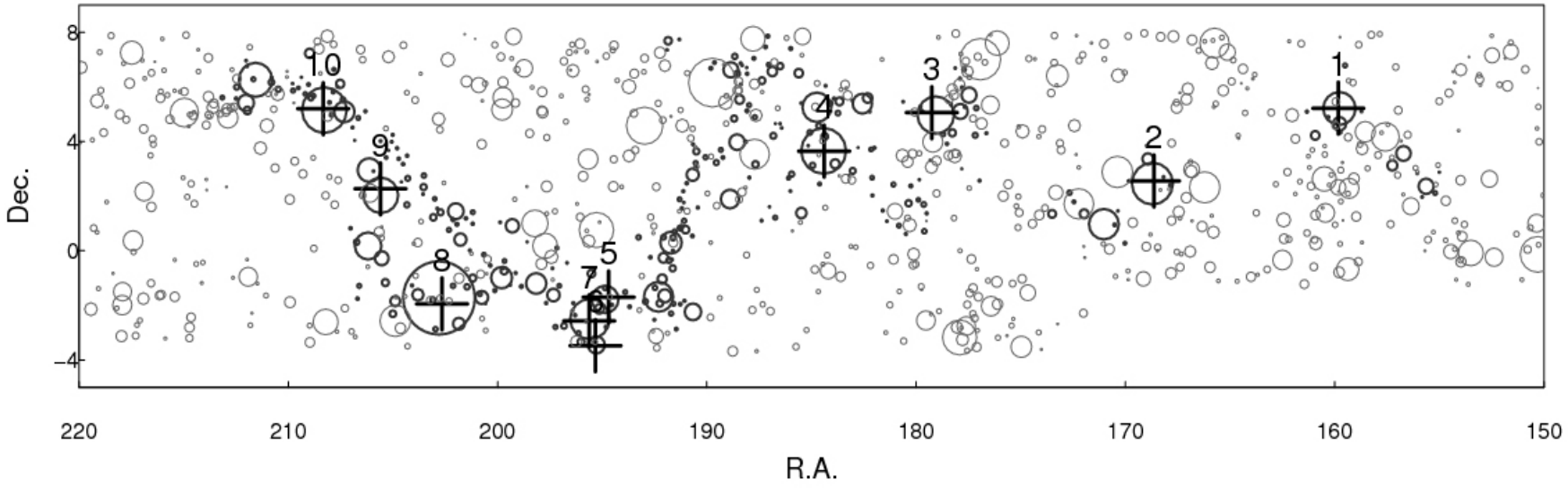
AGNs in poor groups and outskirts of clusters in the supercluster Cl 1604 at z ≈ 0.9

(Kocevski et al. 2009)

Are huge systems real physical systems violating homogeneity?



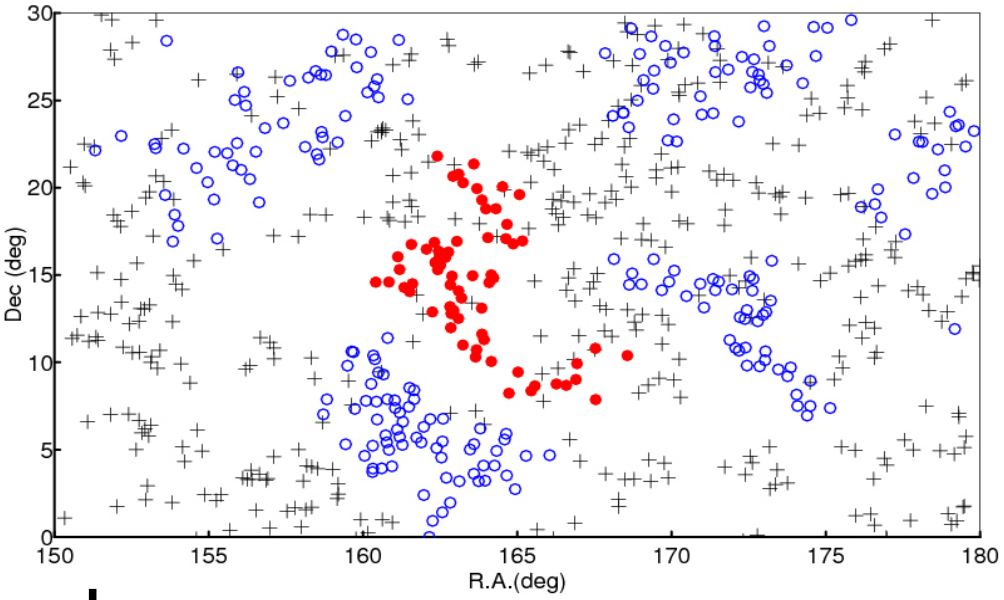
Luminous Red Galaxies and their superclusters.



The Sloan Great Wall

Systems penetrating the whole sample volume ☺

Summary



Quasar systems as
markers of galaxy superclusters
and supercluster complexes
give us a snapshot of
the high-redshift cosmic web

Quasar system catalogues: database to search for high-redshift superclusters of galaxies and to trace the cosmic web at high redshifts.

www.aai.ee/~maret/QSOsystems.html

Einasto et al. 2014, AA, accepted


Thank you!