Tracing high redshift cosmic web

with quasar systems

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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 $i <= 19.1$,
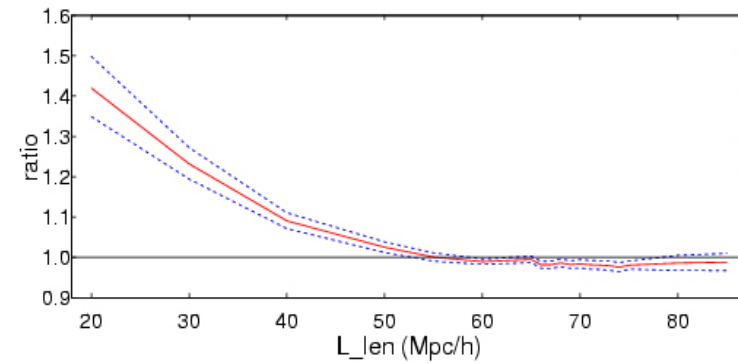sky coordinates: $-55 < \lambda < 55$, $-33 < \eta < 35$,
$N = 22381$
Random samples: the same sample limits and number of points
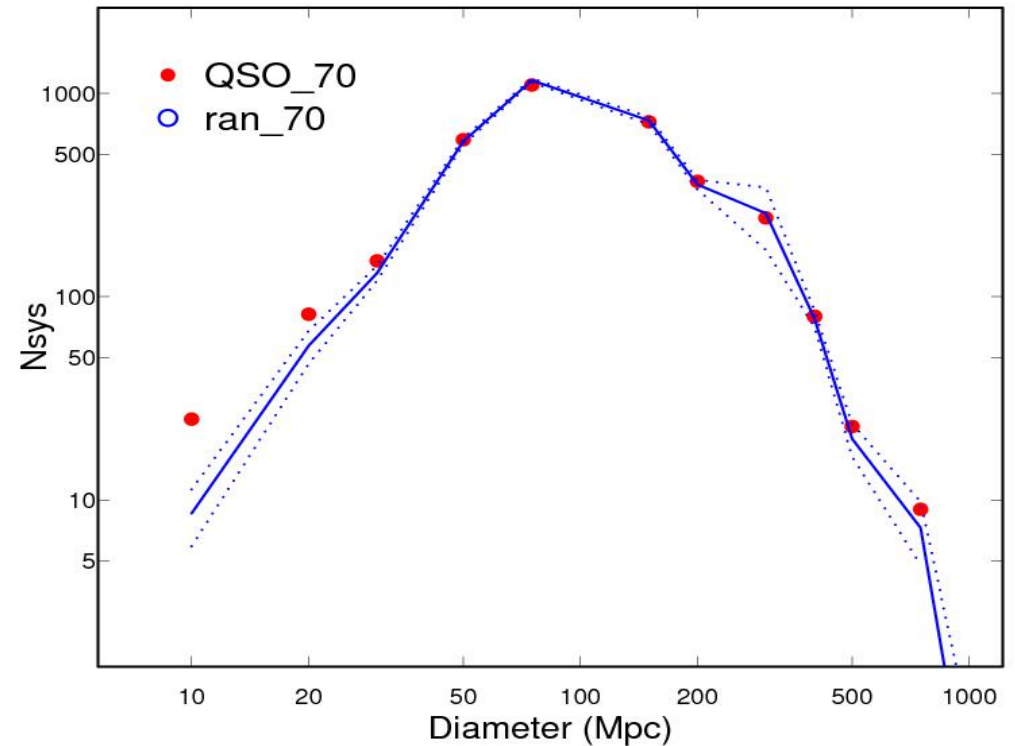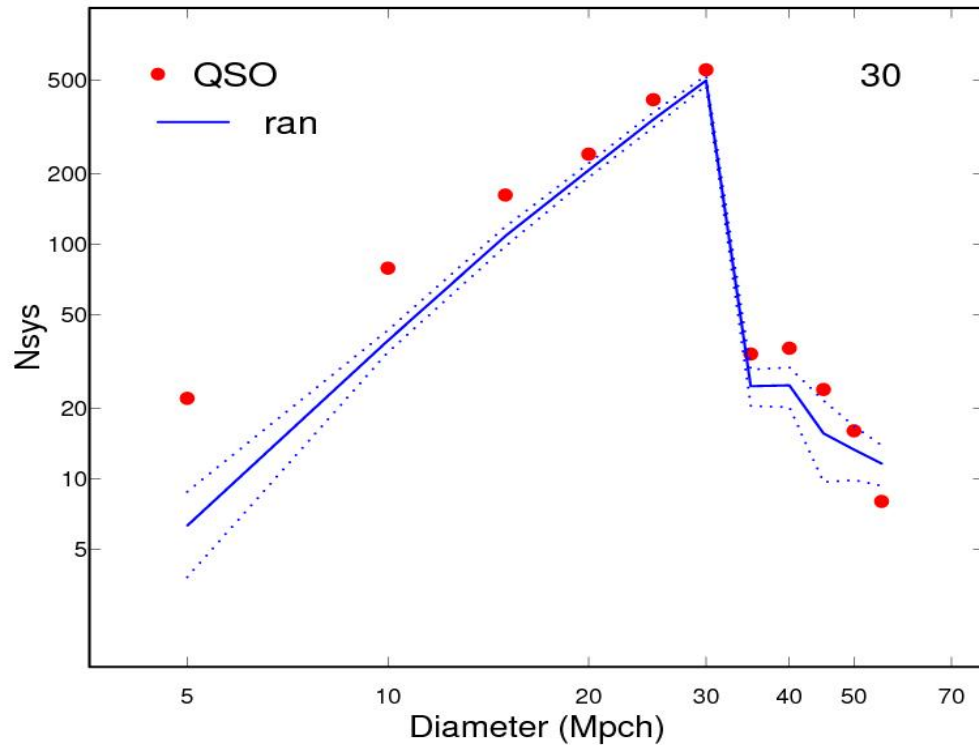
FoF results
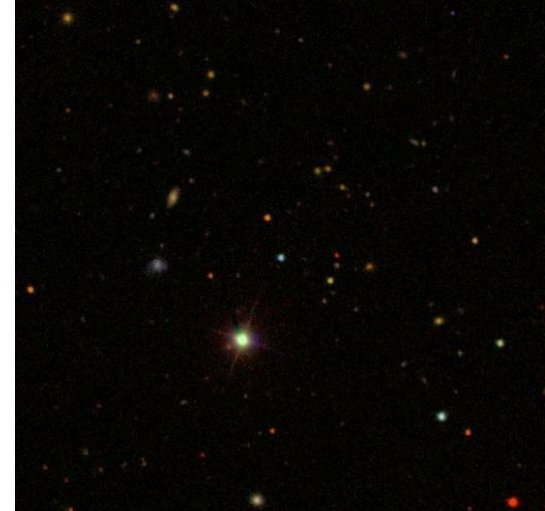
Multiplicity functions.
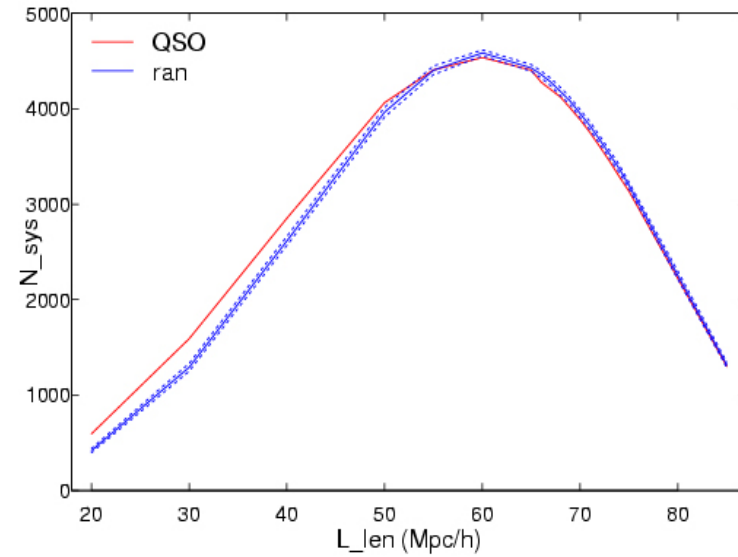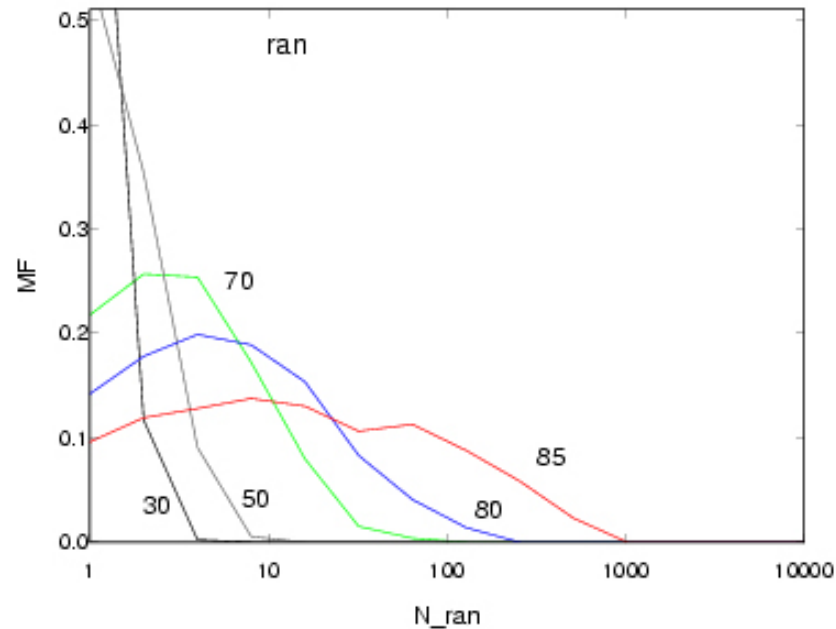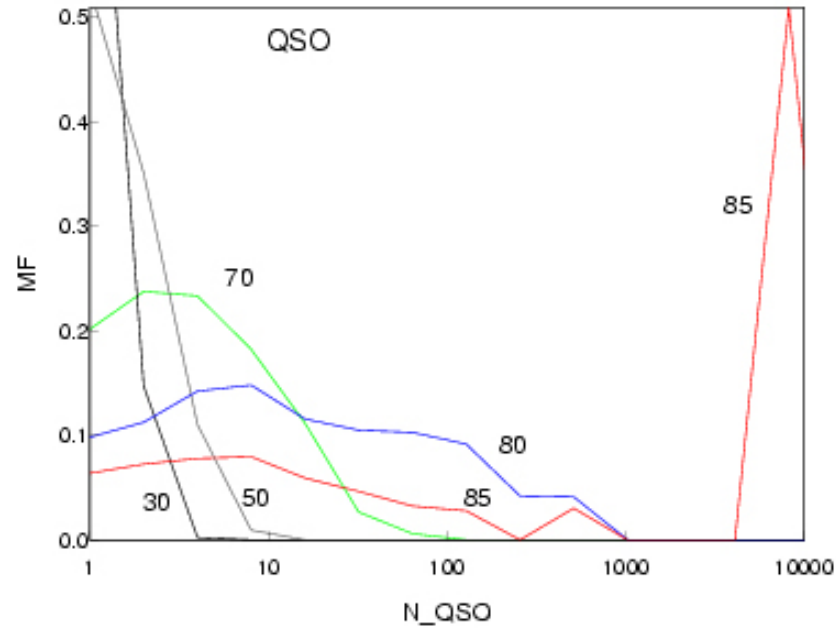
The number of systems.

FoF: differences between quasar and random systems at the linking lenghts l ≤ 30 Mpc and l ≥ 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.

Large systems at l = 70 Mpc/h with sizes of 500 – 700 Mpc/h can be found also in the random catalogues.

# Number of quasars in systems N_{QSO} vs. system diameters.
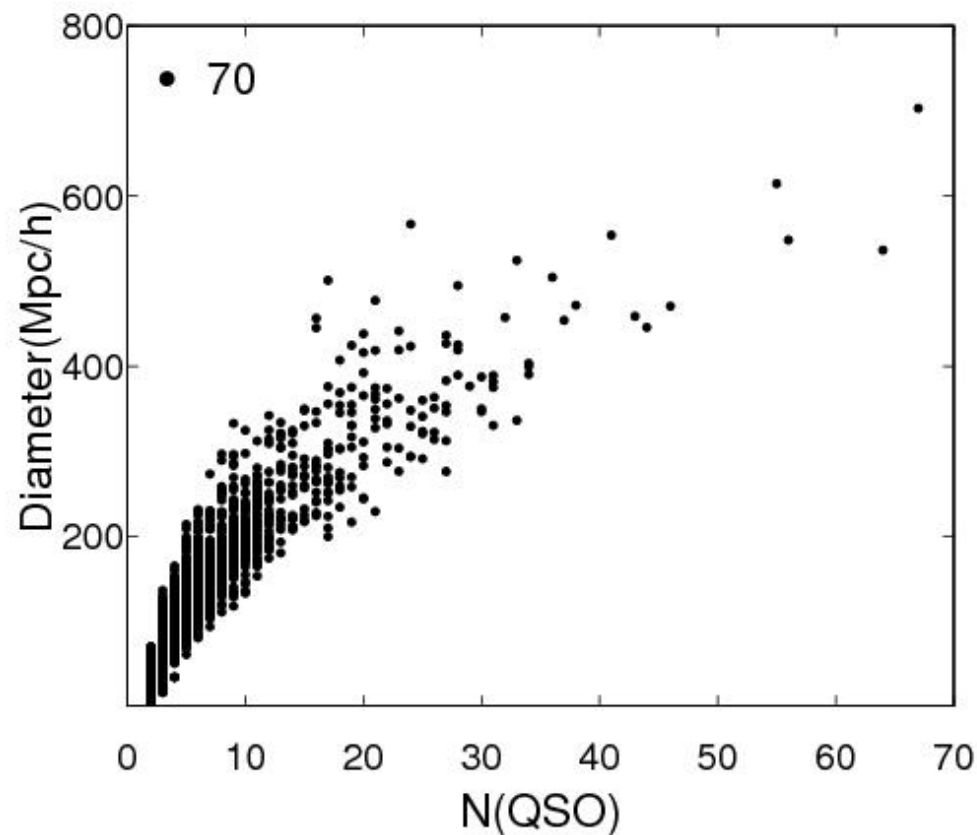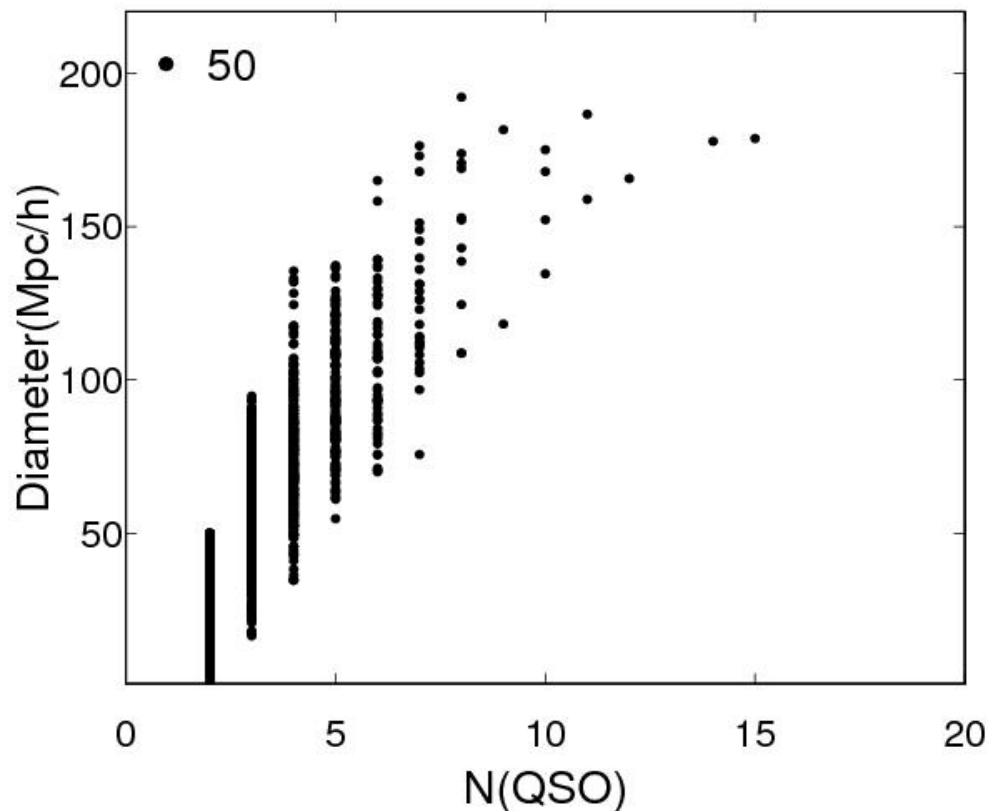
At l = 20 − 50 Mpc the sizes and space density of quasar systems, ≈ 10^{-7} $(h^{-1}$ Mpc$)^{-3}$, comparable to the sizes and density of local galaxy superclusters.

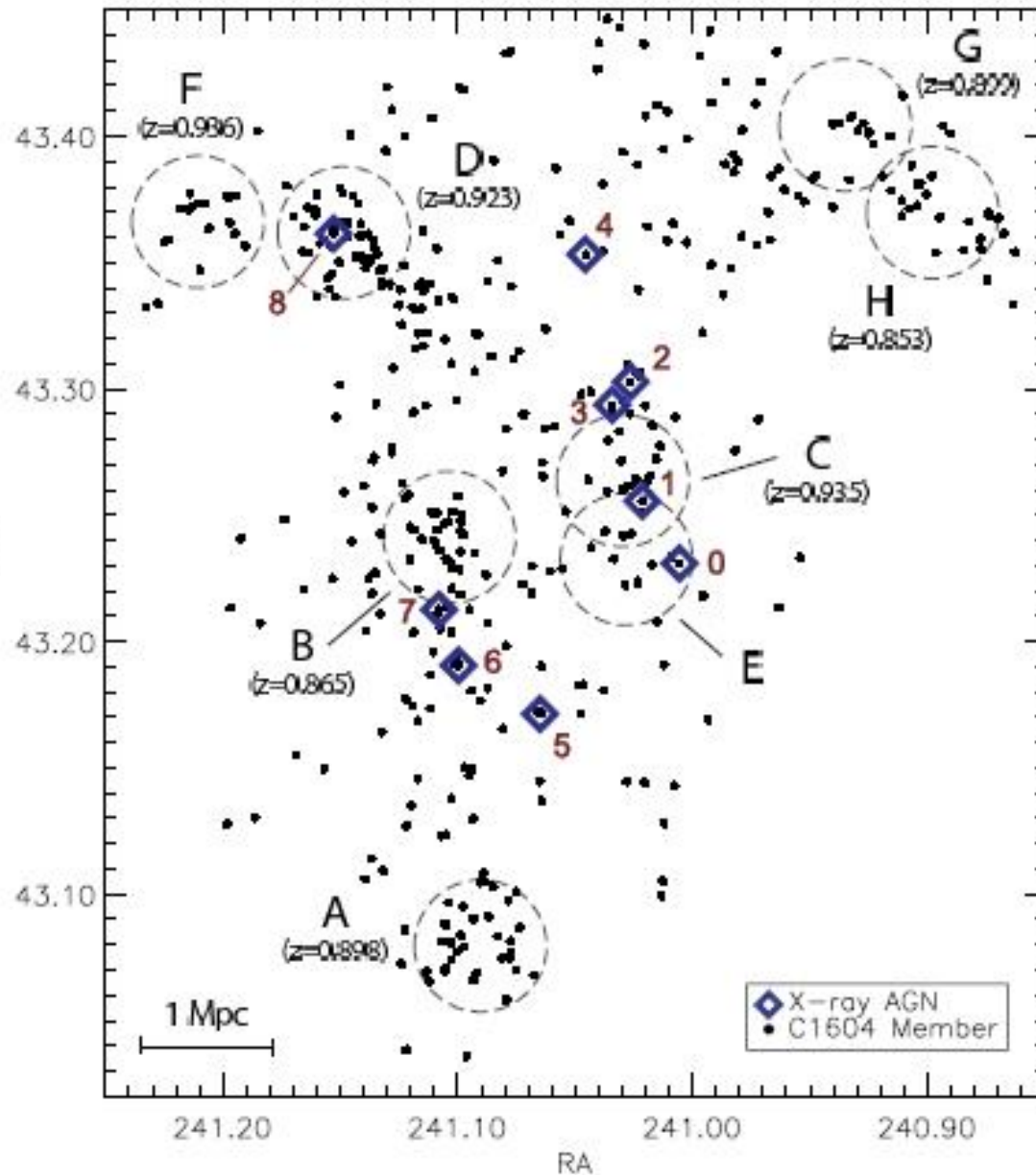At l = 70 Mpc - sizes as the sizes of local rich superclusters and supercluster complexes (like SGW)

The largest quasar systems the same as LQGs by Clowes et al. 2012, 2013

Cosmic web at redshifts $1 \le z \le 1.8$
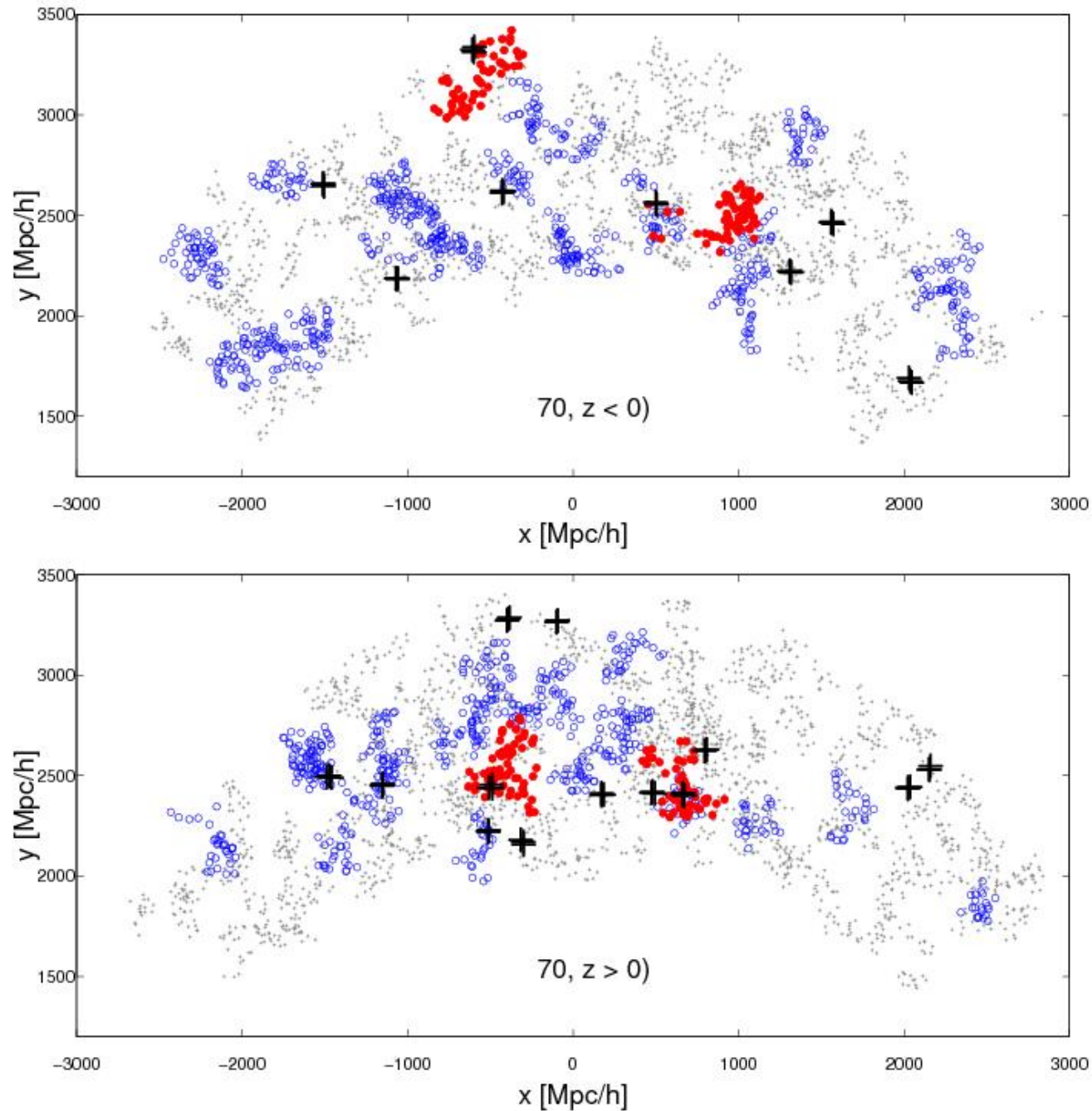
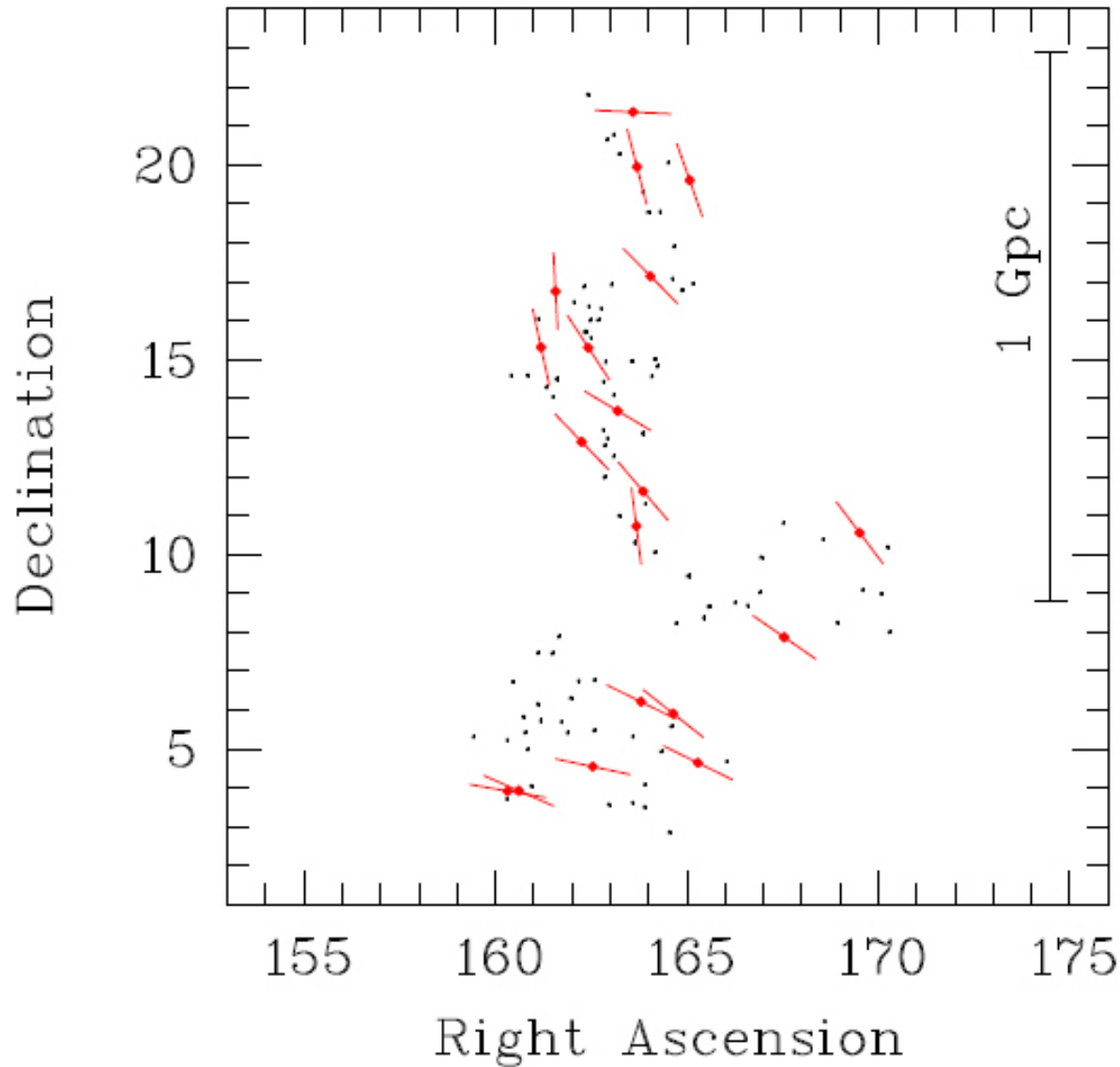Red circles: $l = 70$ Mpc/h, $N_{QSO} > 50$, black crosses: $l = 20$ Mpc/h, $N_{QSO} = 3$.

Quasar systems as markers of galaxy superclusters
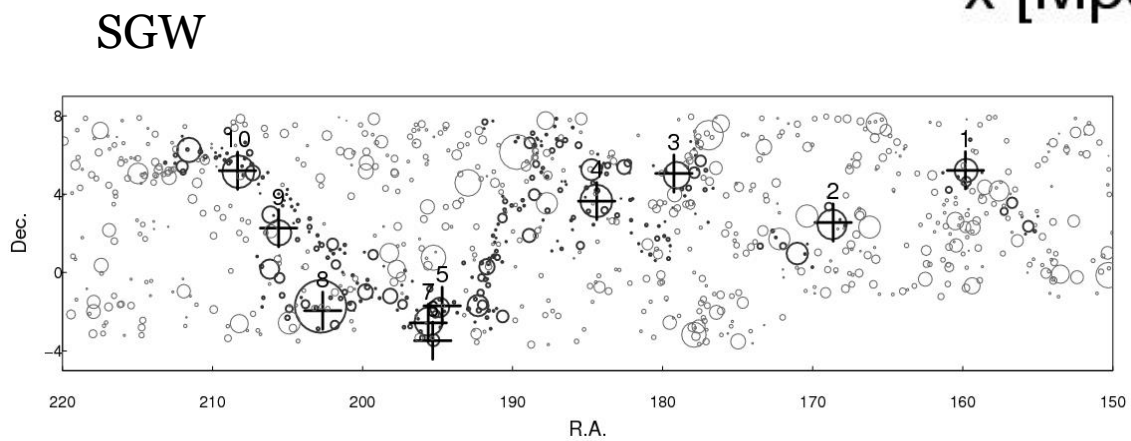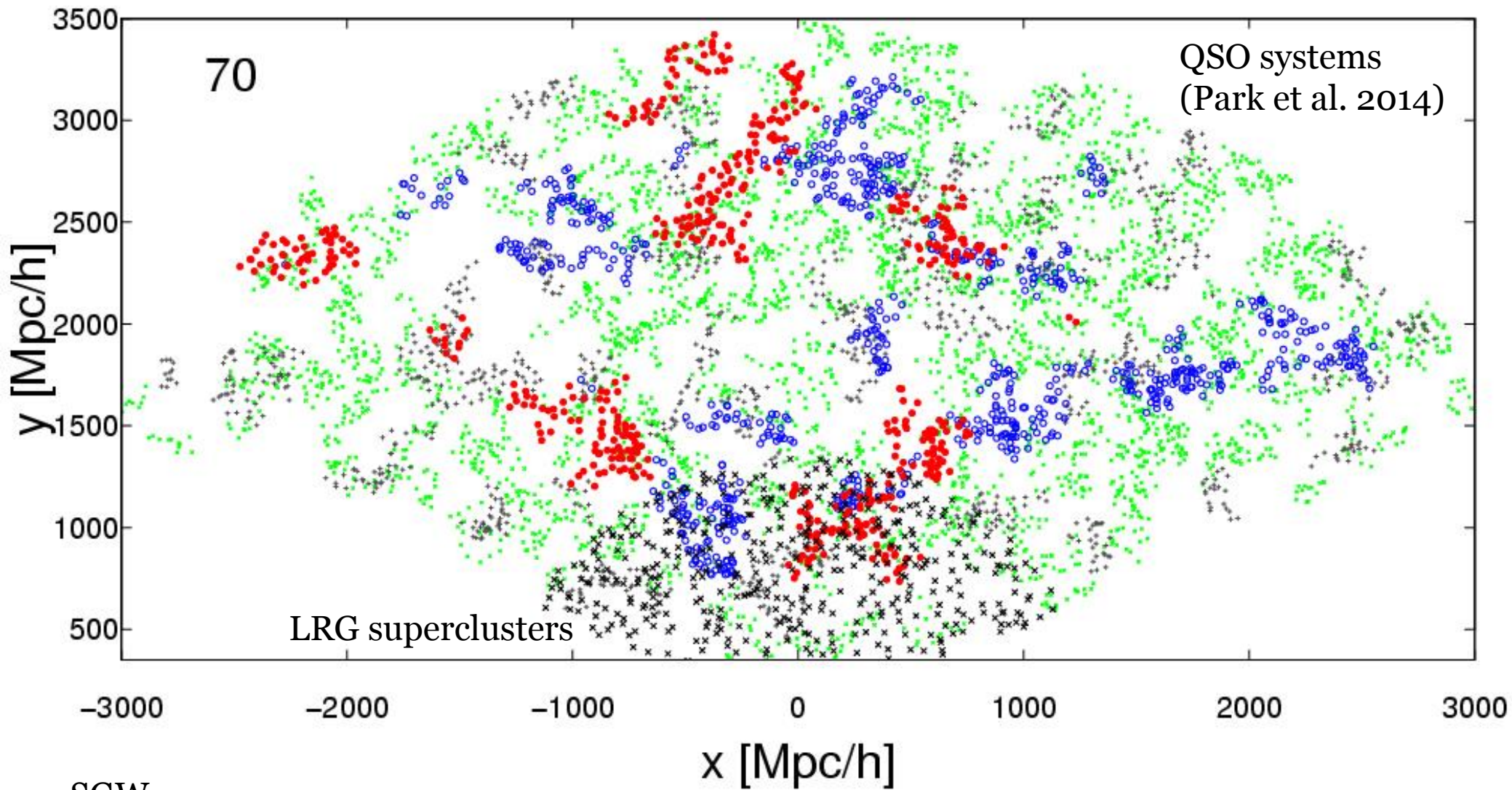

AGNs in poor groups and
outskirts of clusters
in the supercluster
Cl 1604 at z ≈ 0.9
        (Kocevski et al. 2009)
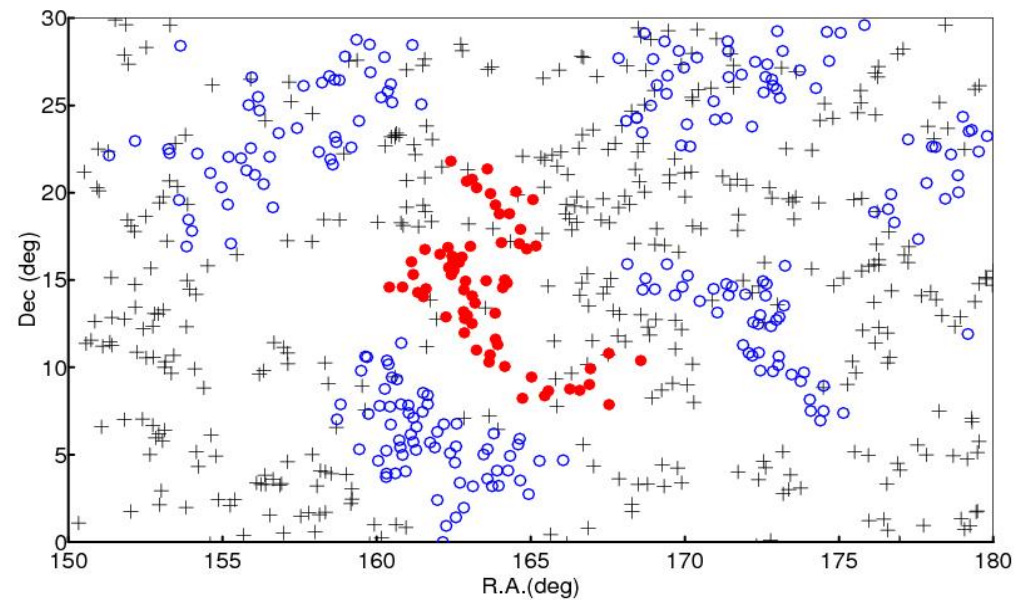
Quasar systems as markers of galaxy superclusters

Polarization vectors of quasars indicate that quasar spin axes are parallel to their host large-scale structures (Hutsemékers et al. 2014).

70

QSO systems
(Park et al. 2014)

LRG superclusters

SGW

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, 568, A46

Thank you!