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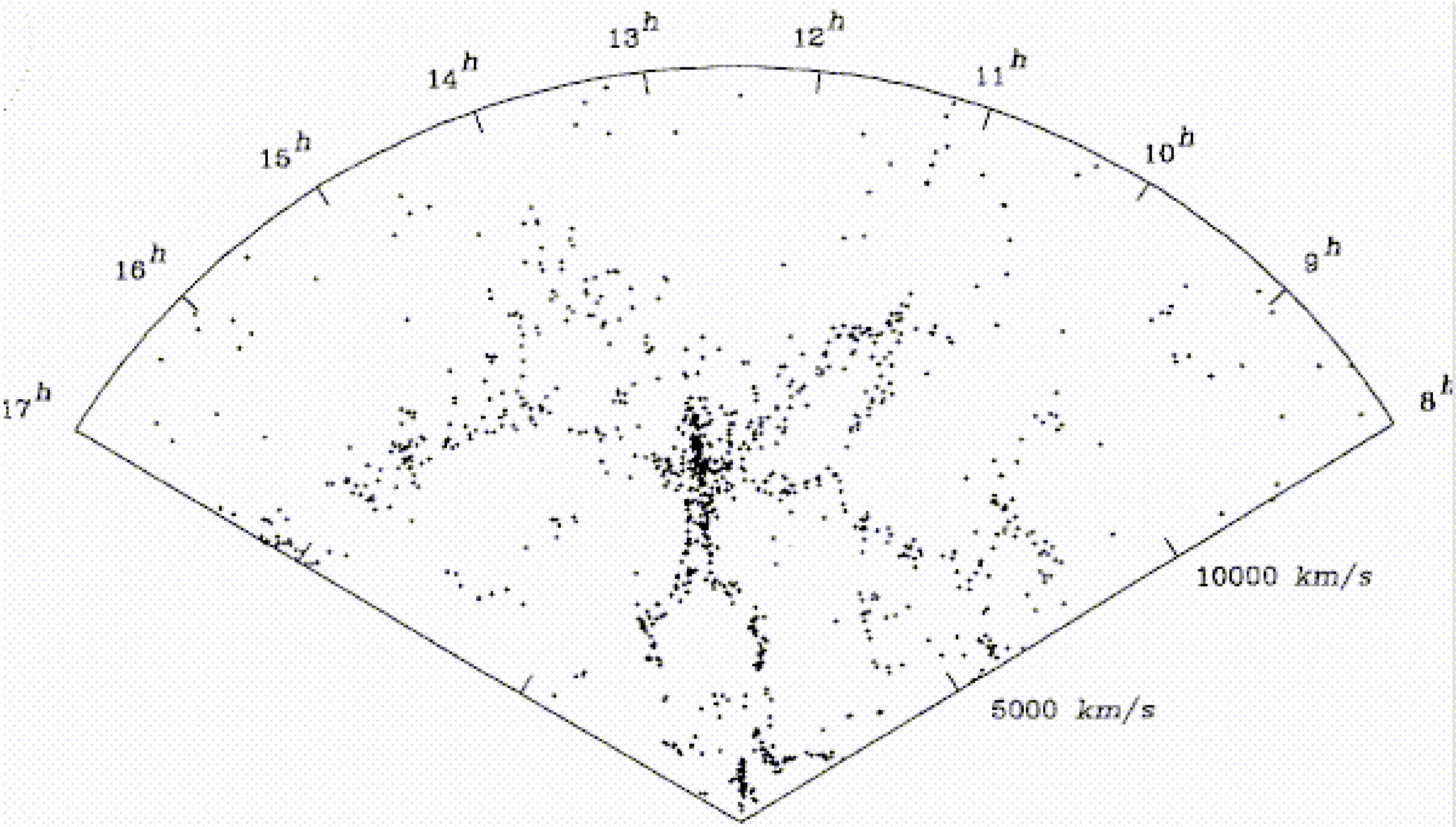
Effects of Large Scale Structure on Properties of Galaxies

with Lei Hao (SHAO), Michael Vogeley (Drexel)

CfA survey map

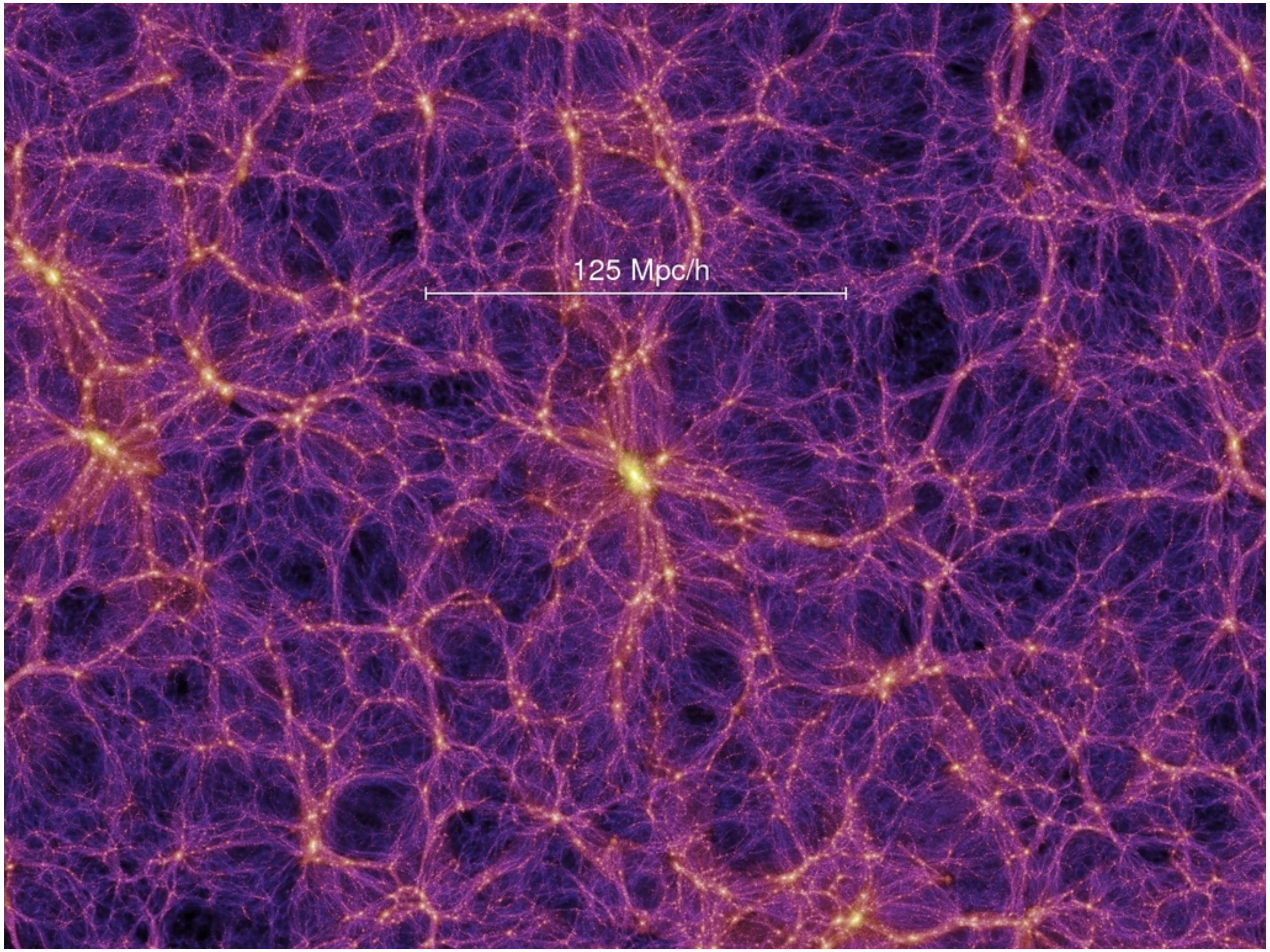


de Lapparent, Geller & Huchra 1986

Motivation

- Cosmic Web (Bond, Kofman, Pogosyan 1996)
  - Filaments (where galaxies live)
  - Clusters (intersection of filaments)
  - Voids (all the volume in between)

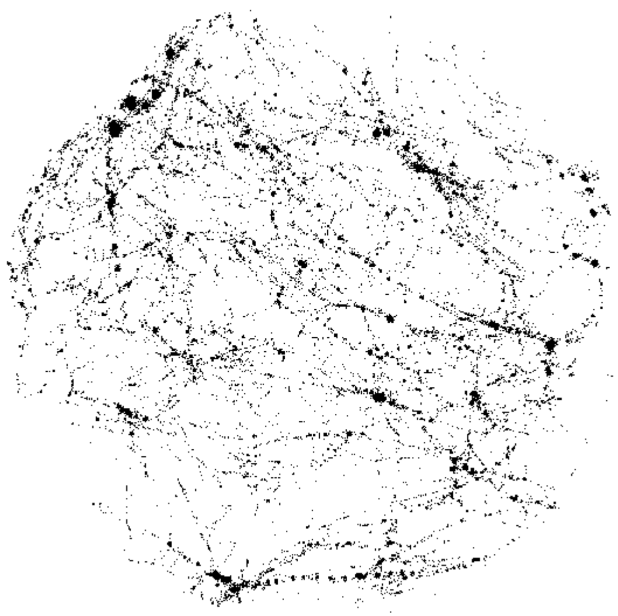
Motivation (Cosmic Web)



Springel et al. 2005

Motivation

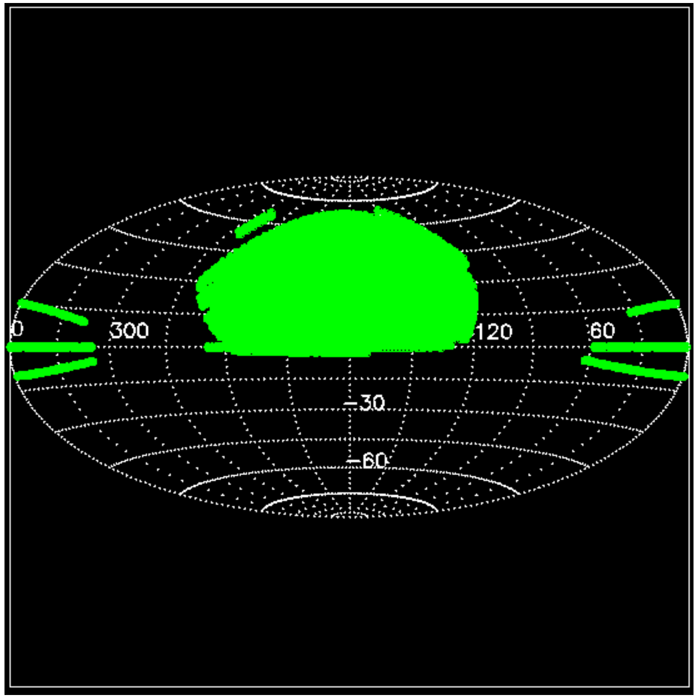
- Void Phenomenon (Peebles 2001)
  - Where are the void galaxies?

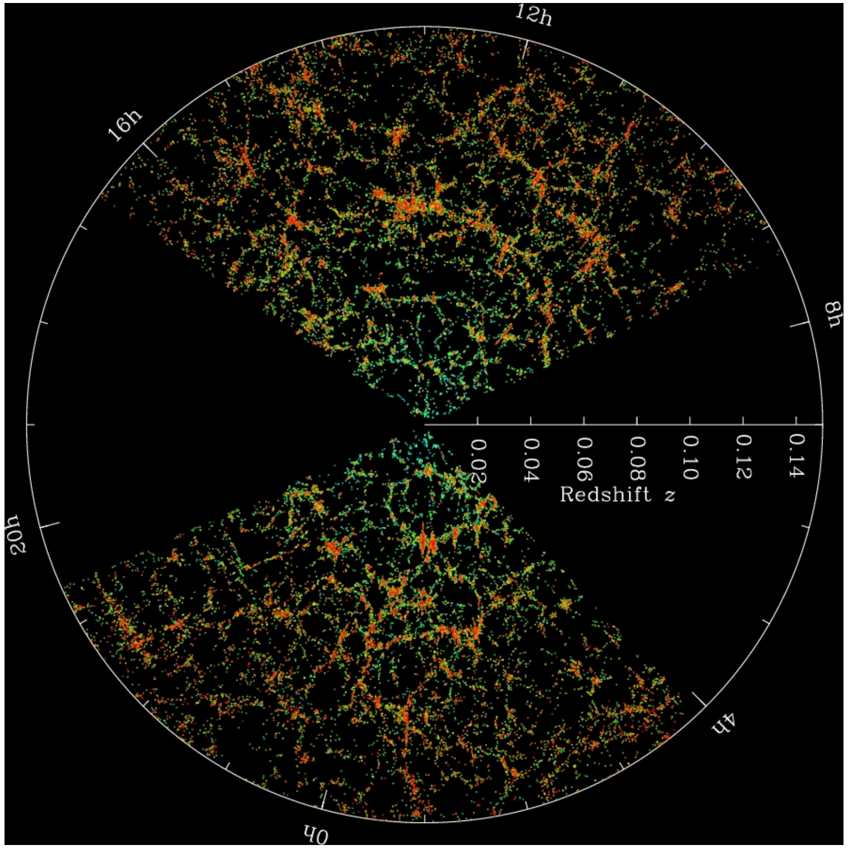


Gottloeber et al. 2003

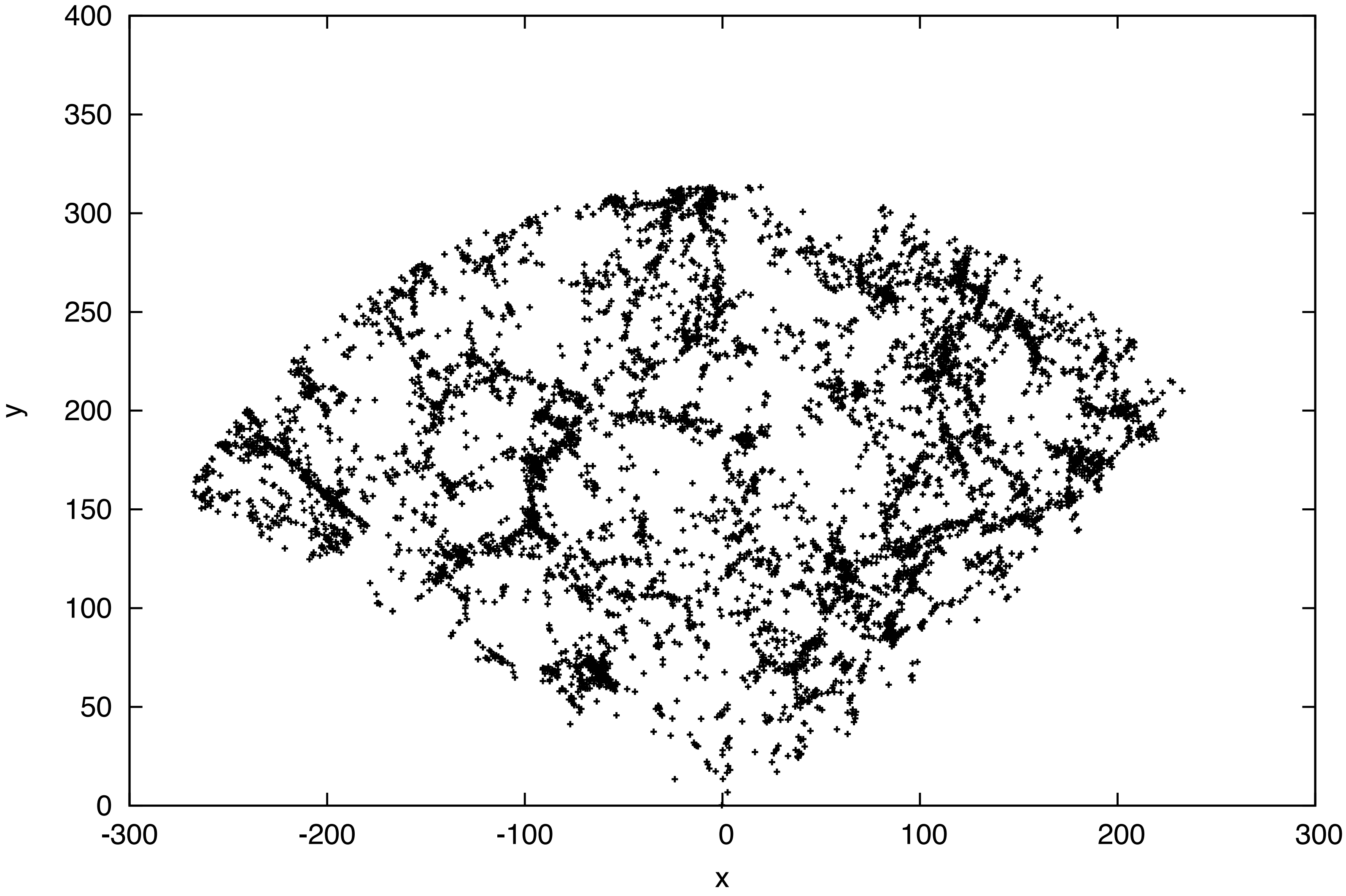
Sloan Digital Sky Survey (DR7)

- 8,032 sq. degrees
- r < 17.77
- 707,817 unique galaxies



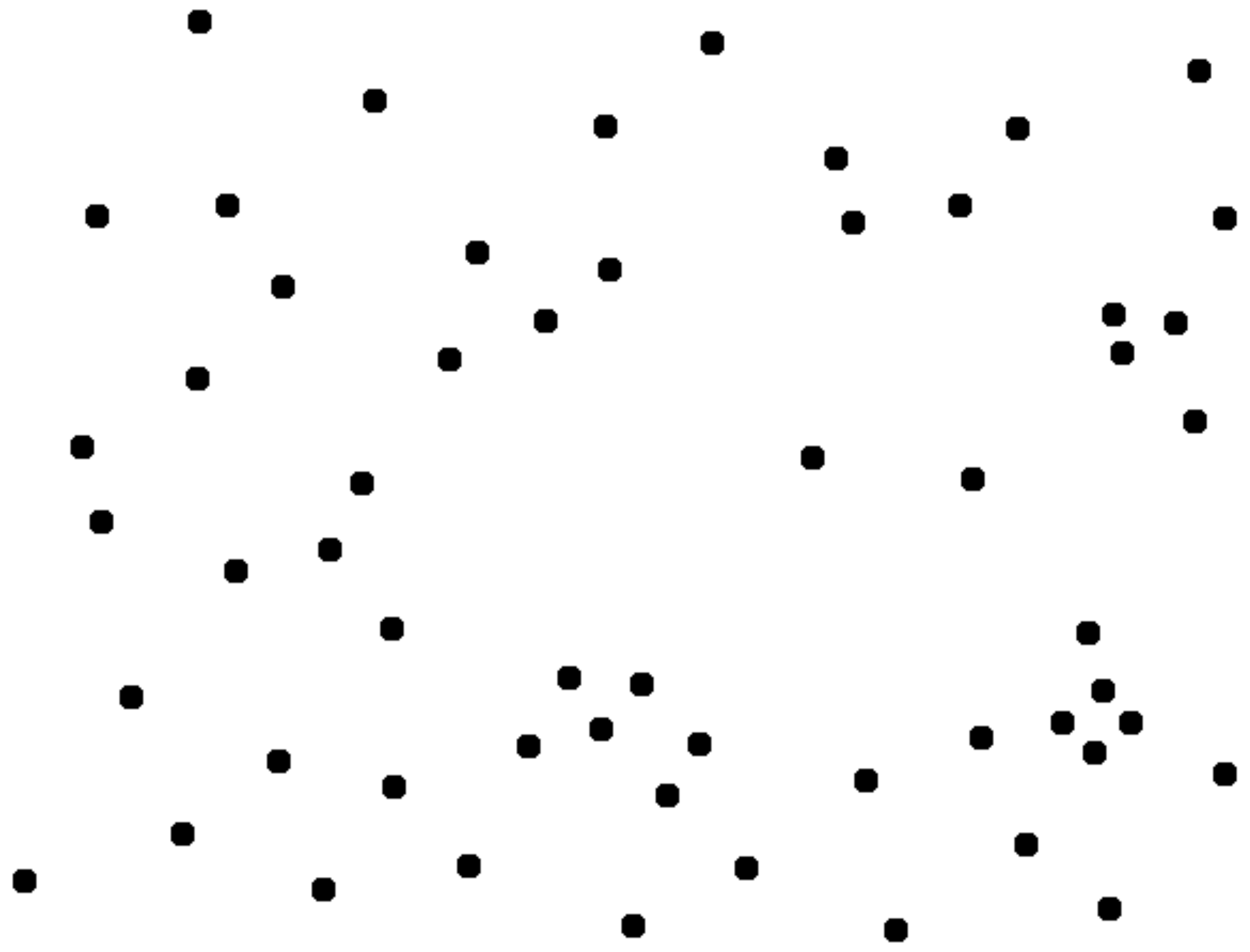


Galaxy based Void Finding

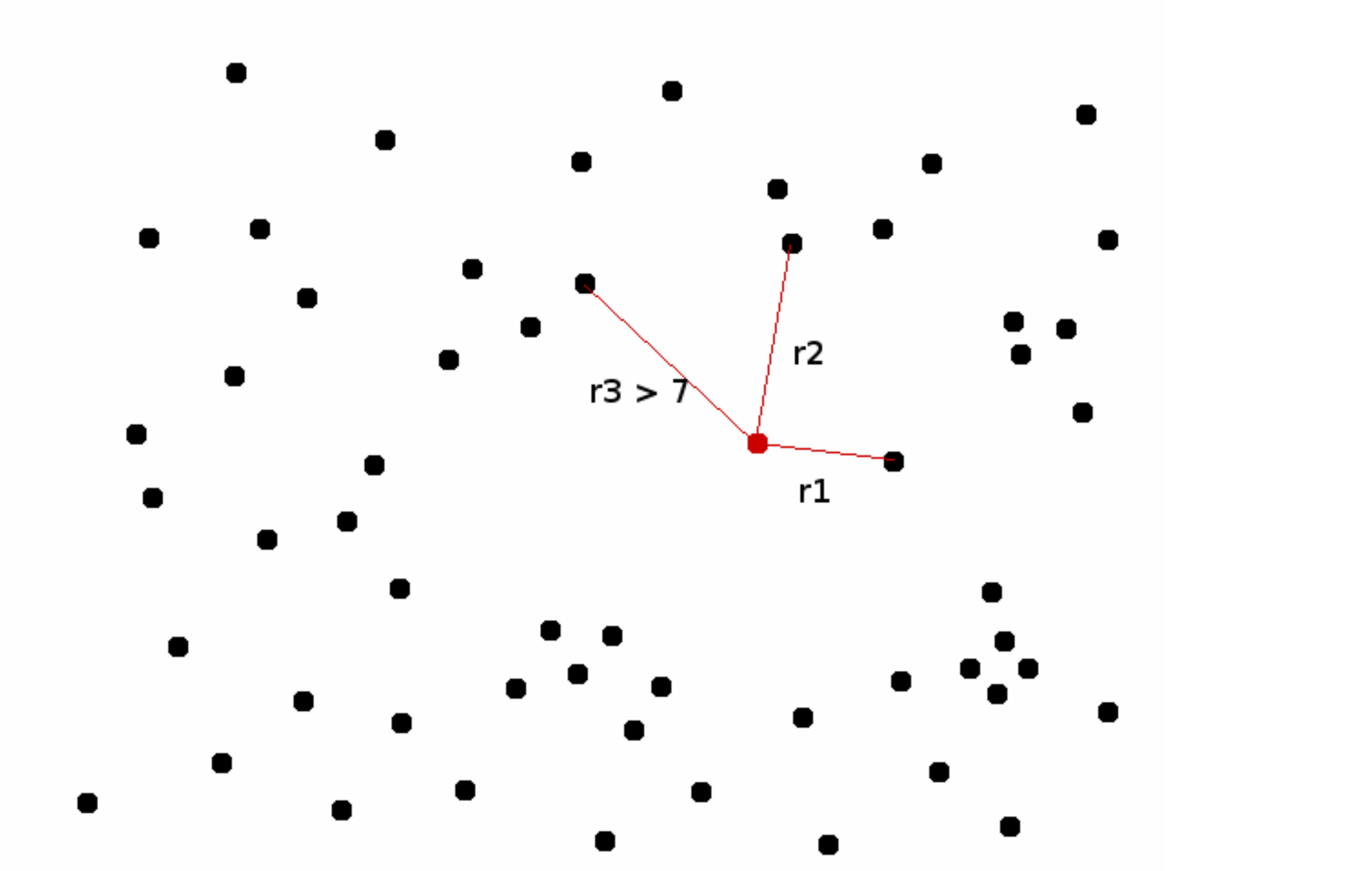


Redshift slice 10 h^{-1} Mpc thick

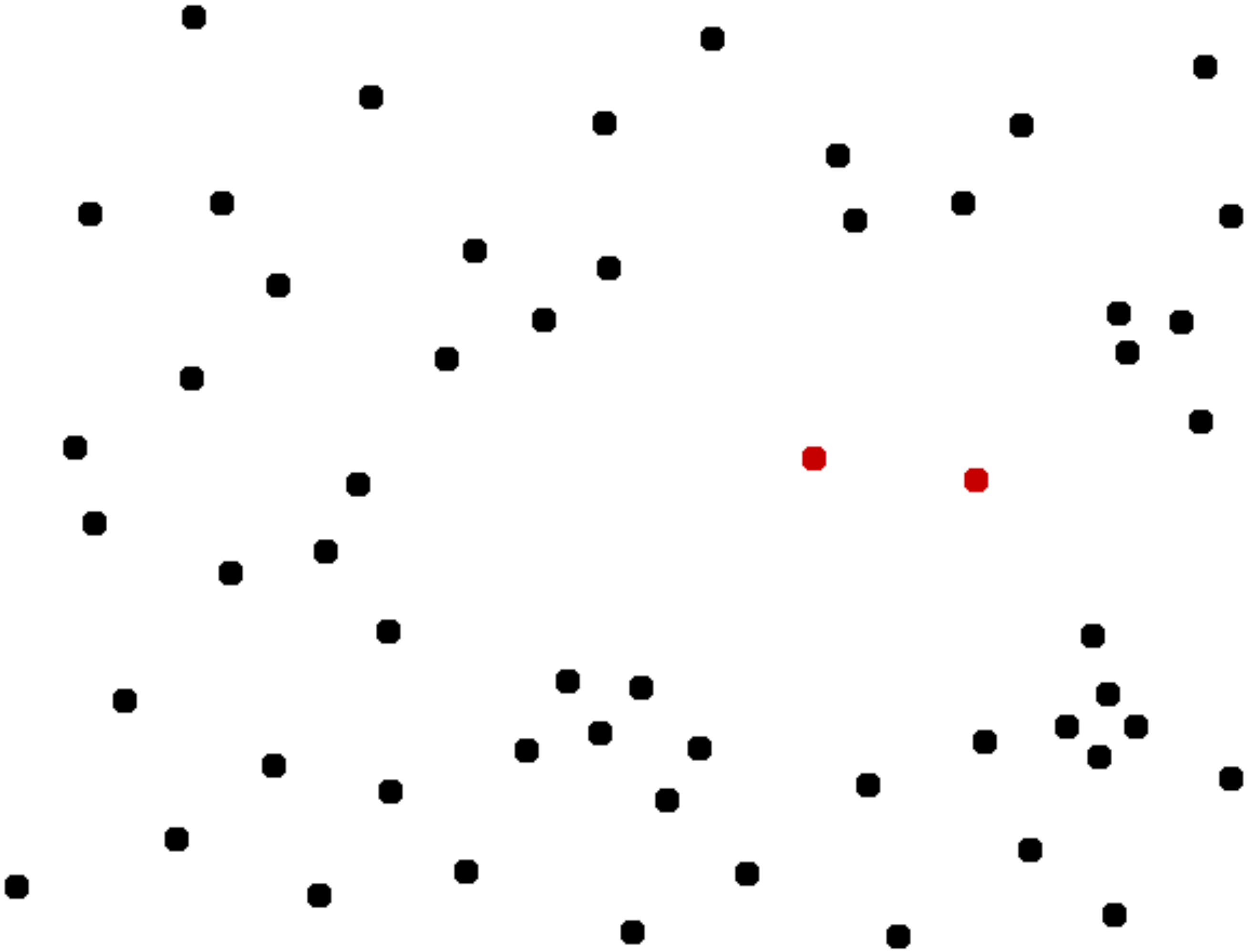
Galaxies



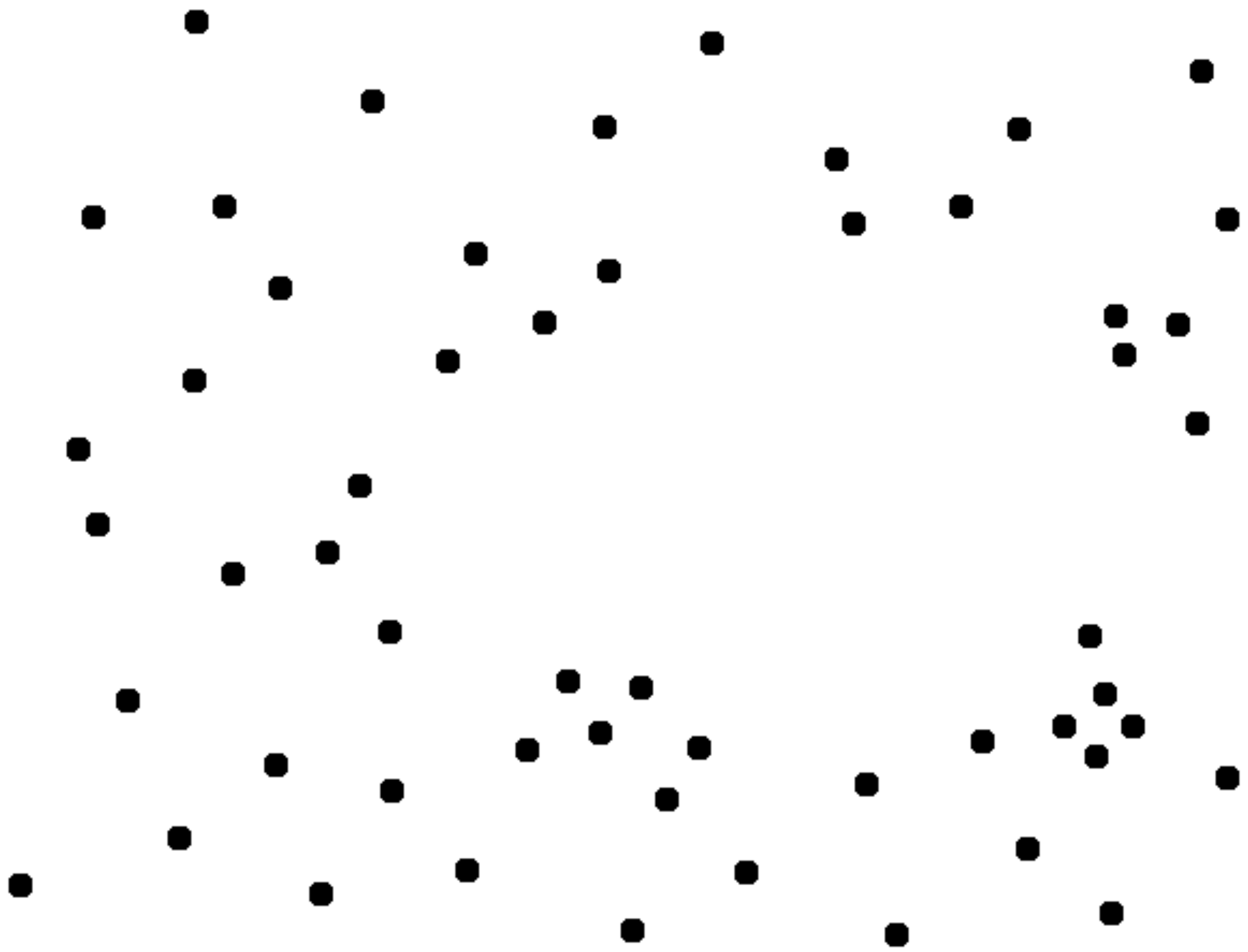
3 Nearest Neighbors



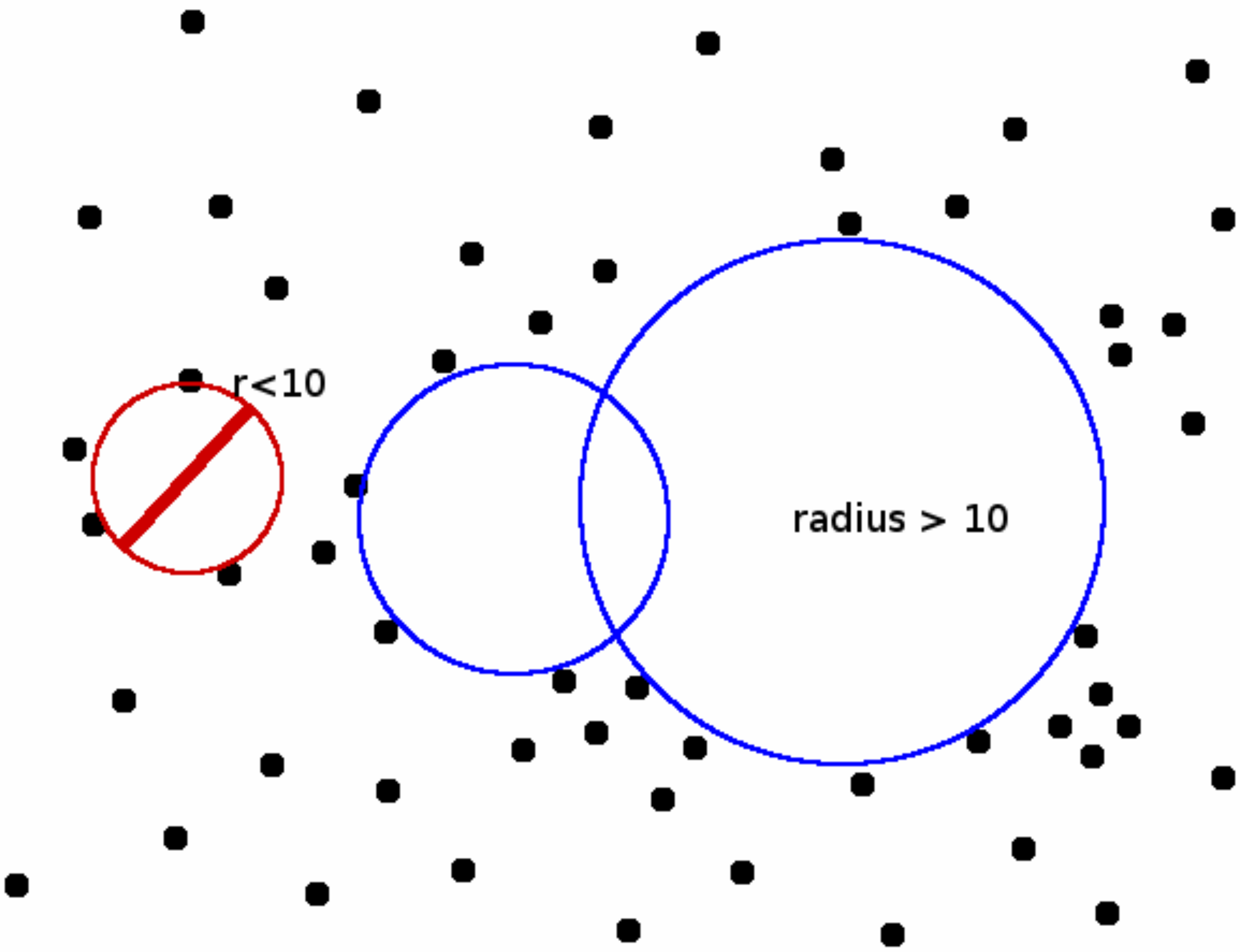
Potential Void Galaxies



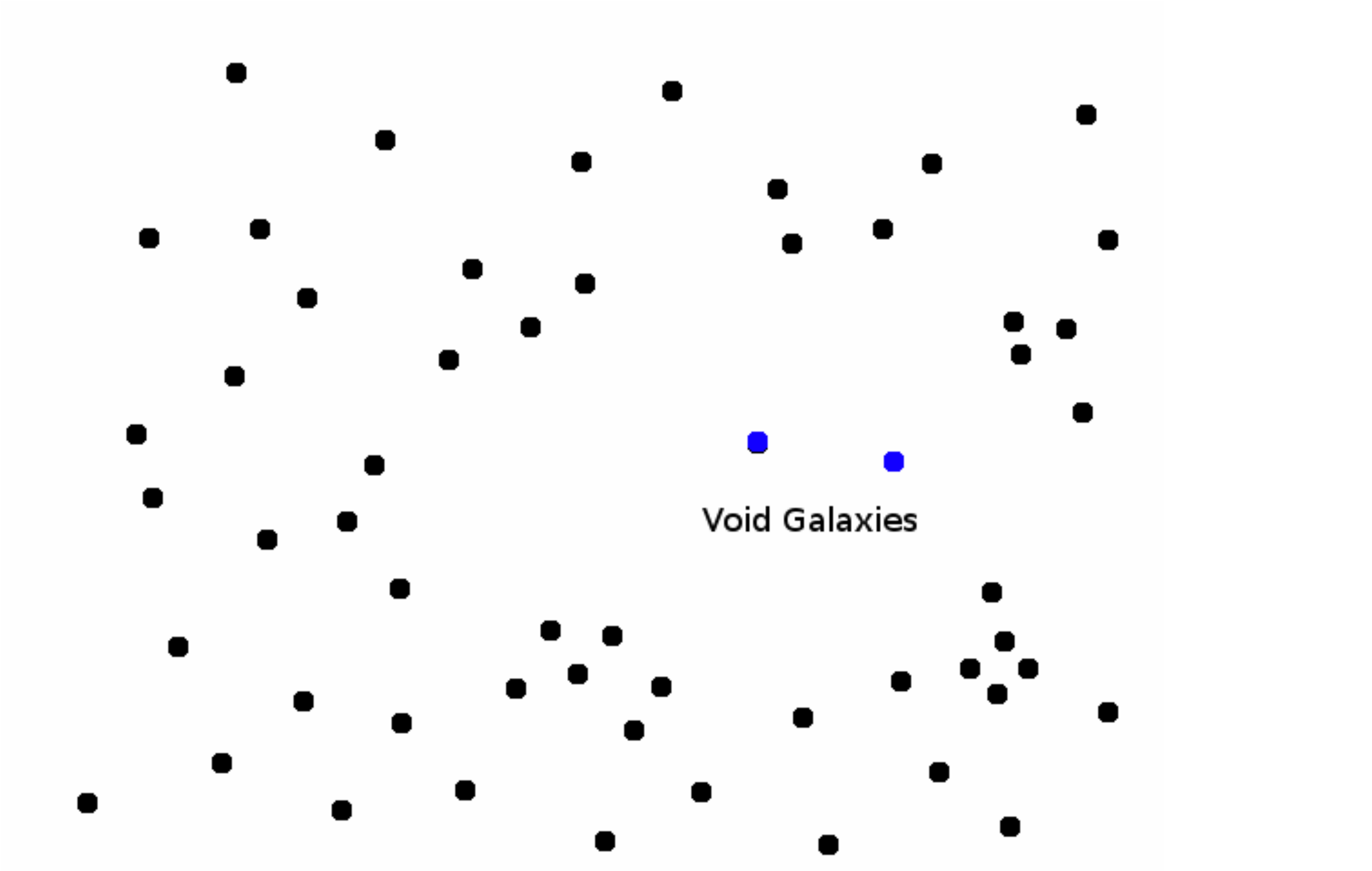
Walls Only



Maximal Spheres



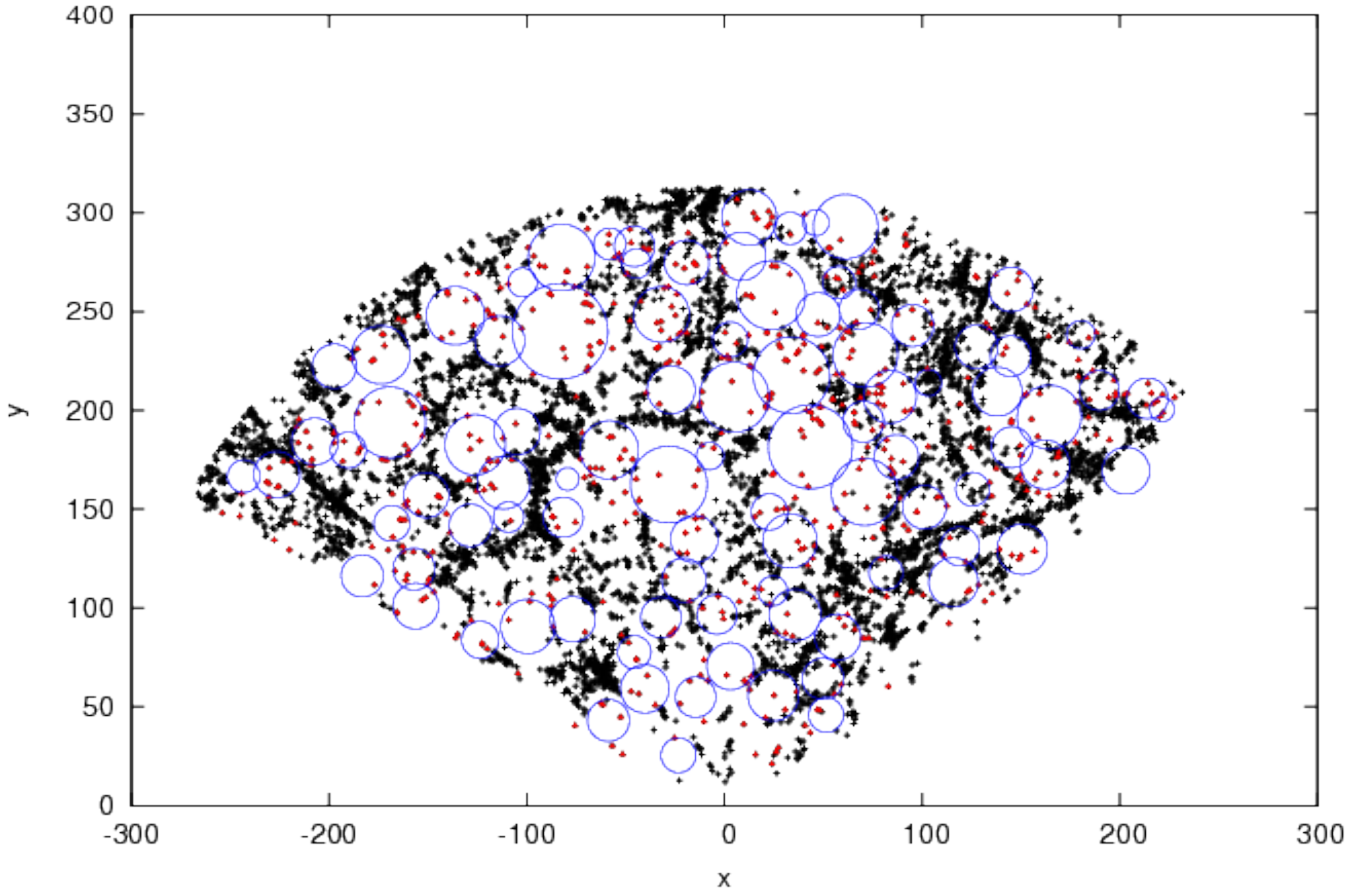
Void Galaxies



Void Catalog (Pan et al. 2012)

- SDSS DR7
  - 120,606 volume limited galaxies
  - $z < 0.107$
  - $M < -20.1$
- VoidFinder (galaxy based)
  - 1,055 voids ($r > 10\ h^{-1}$ Mpc)
  - 8,046 void galaxies $M < -20.1$
  - 79,947 void galaxies $m < 17.77$
  - Voids fill 63% of the volume

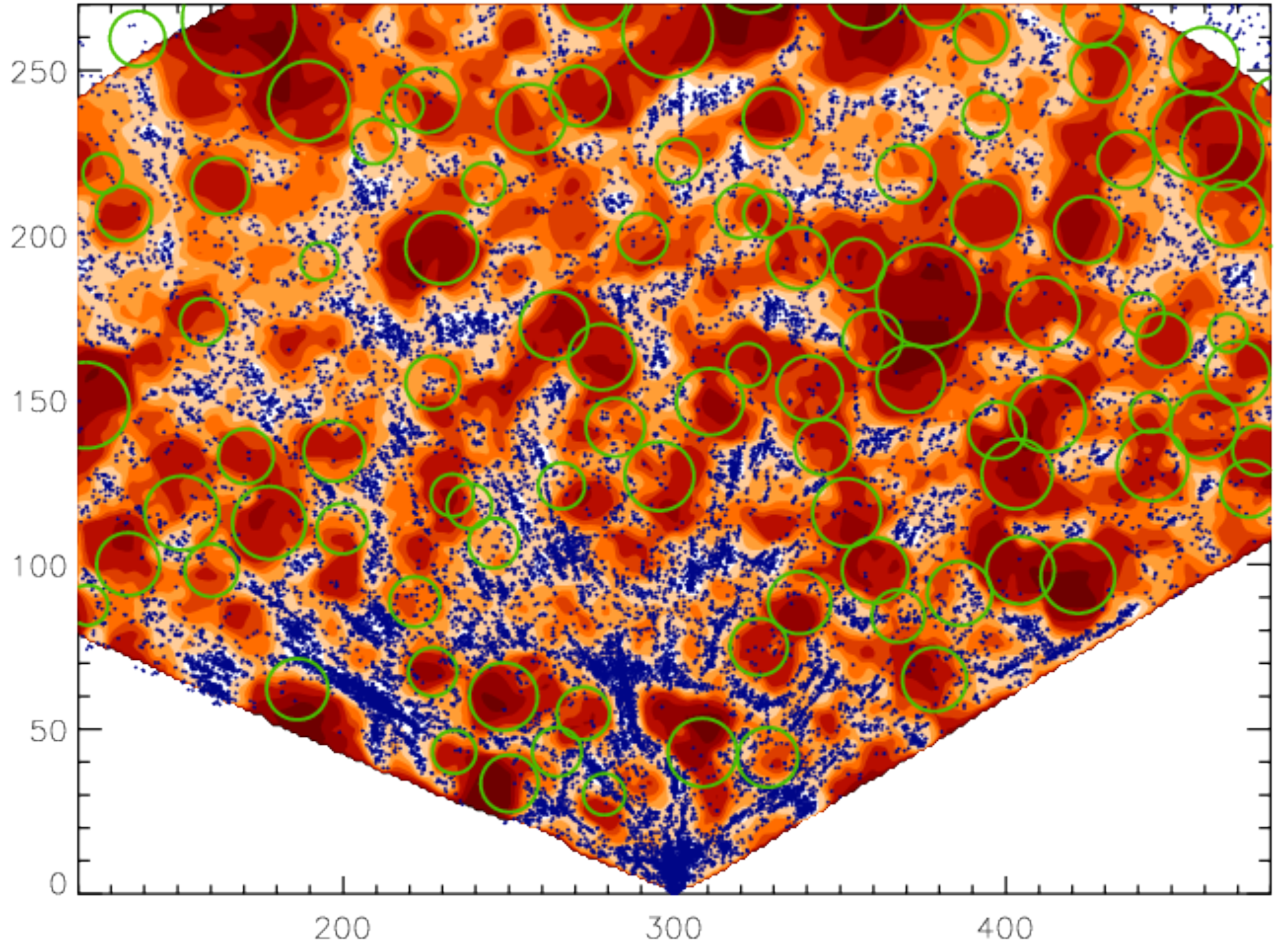
Voids (Slice of Sloan)



Redshift slice 10 h^{-1} Mpc thick

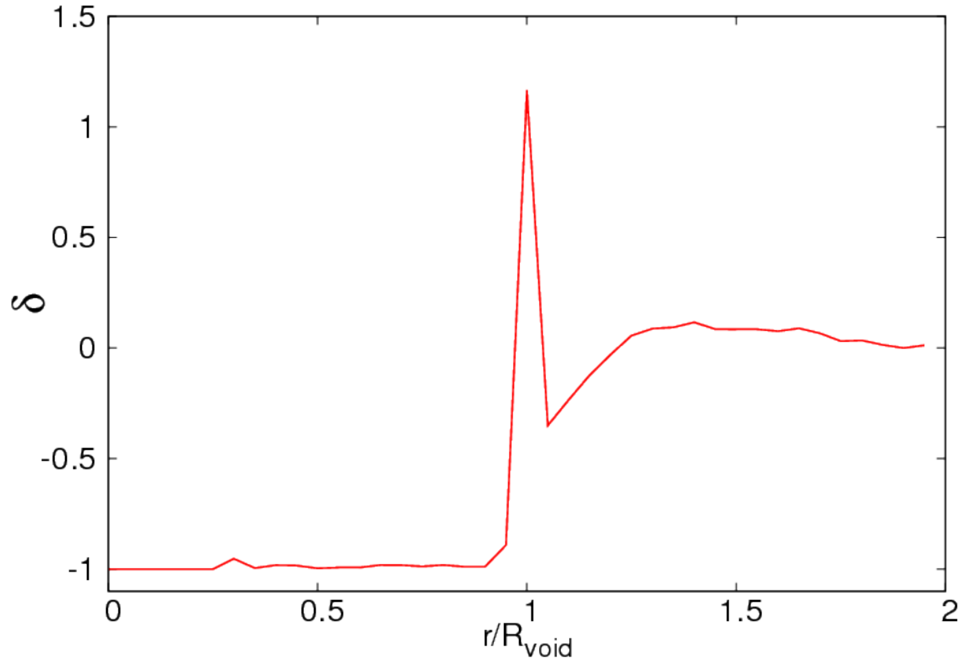
Pan et al. 2012

Voids (Slice of Sloan)

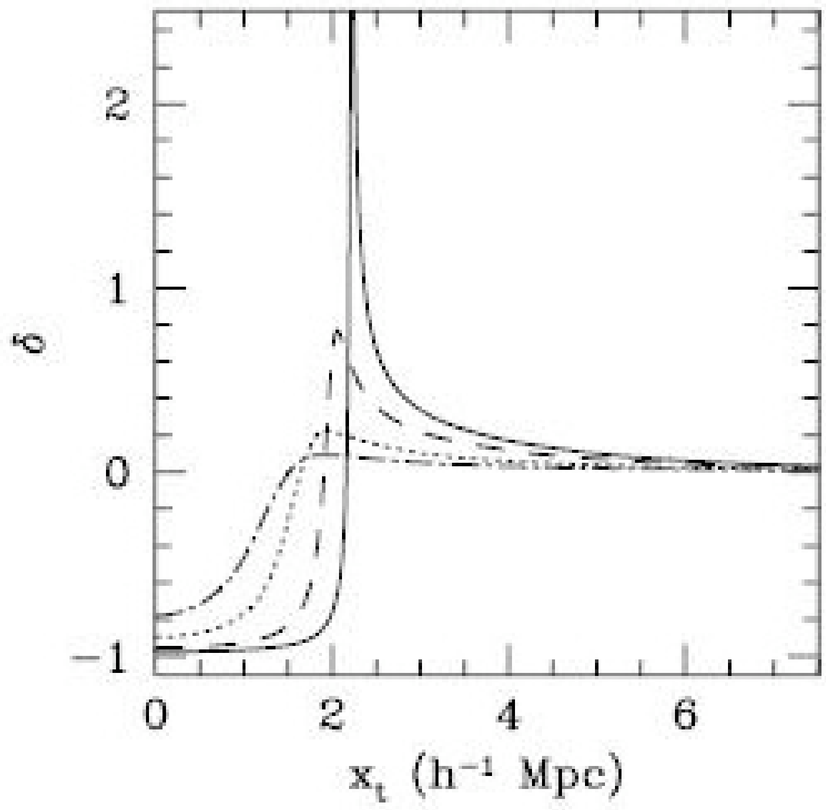


A comparison with DTFE shows similar voids identified by both algorithms.

Voids (Dynamically Distinct)

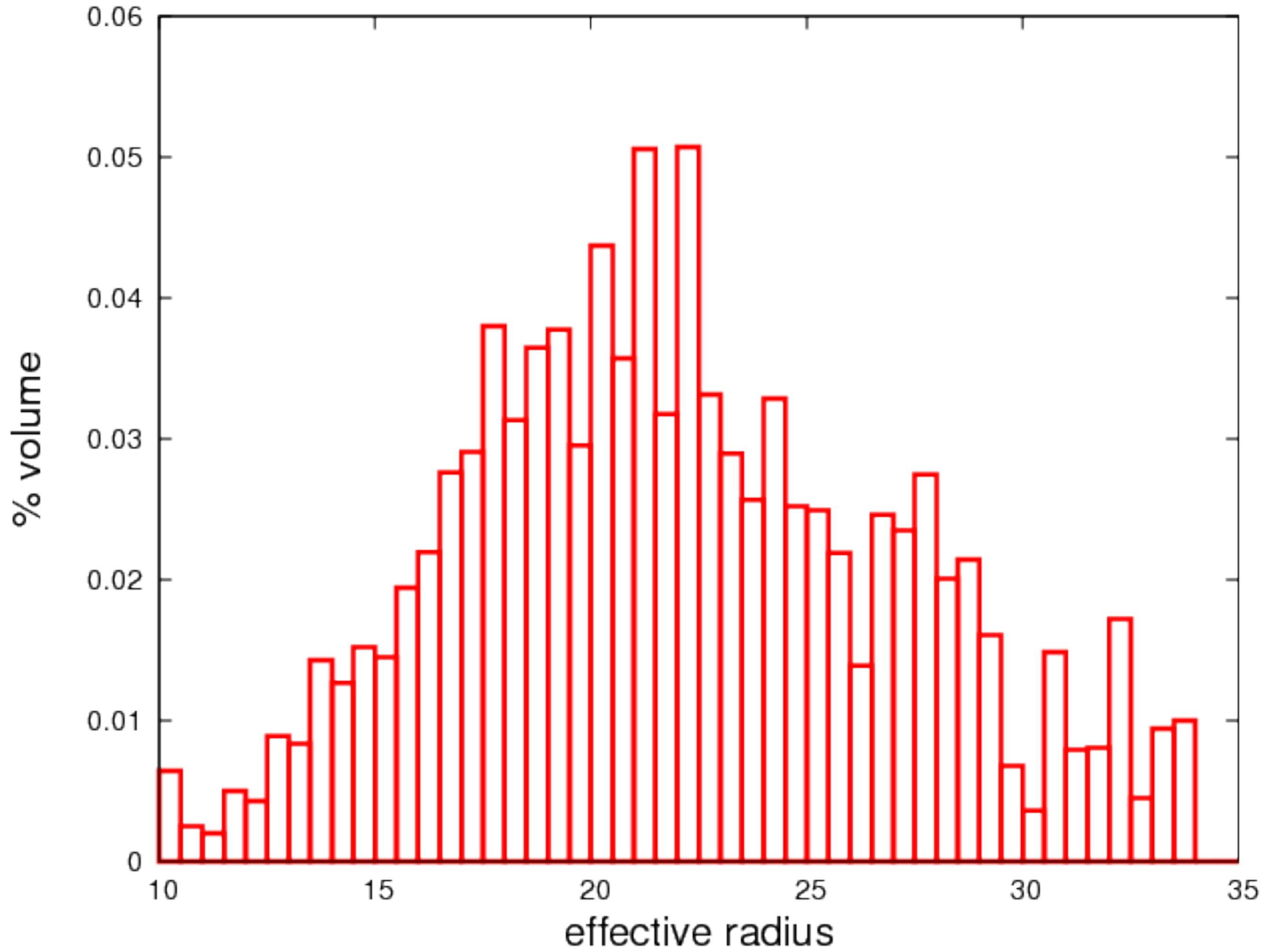


Voids are very empty in the centers, as predicted by gravitational instability. (Pan et al. 2012)



Sheth and van de Weygaert 2004

Voids



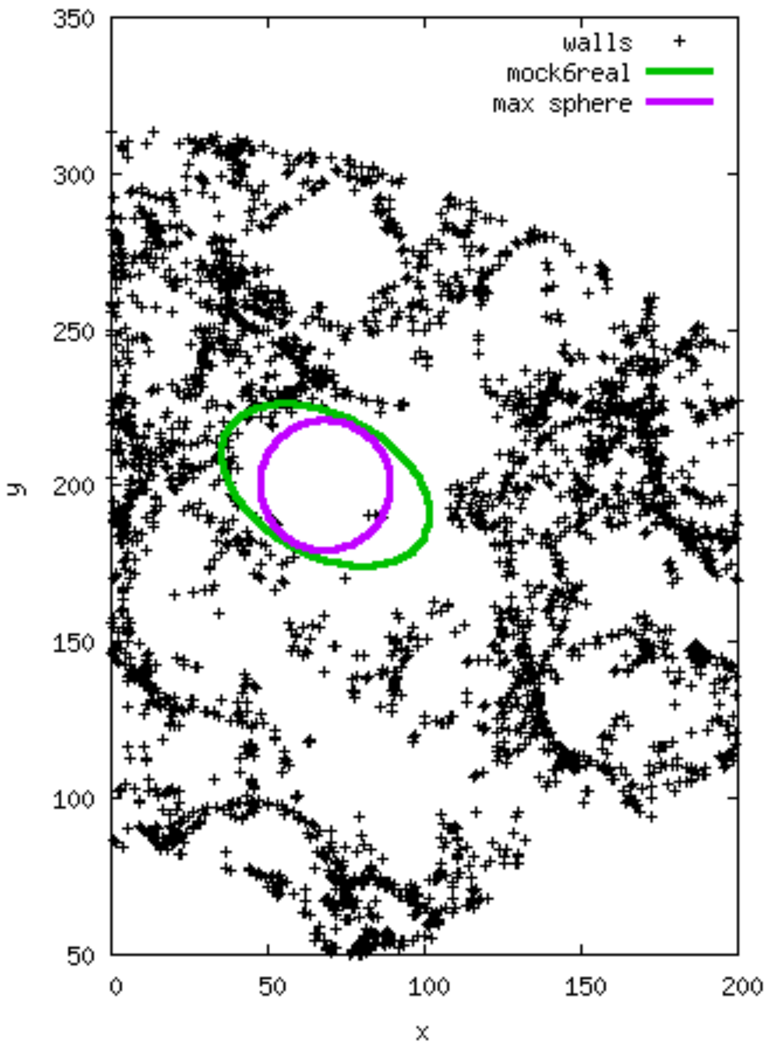
Majority of volume filled by median sized (17-27 Mpc) voids.

Pan et al. 2012

Science with Voids

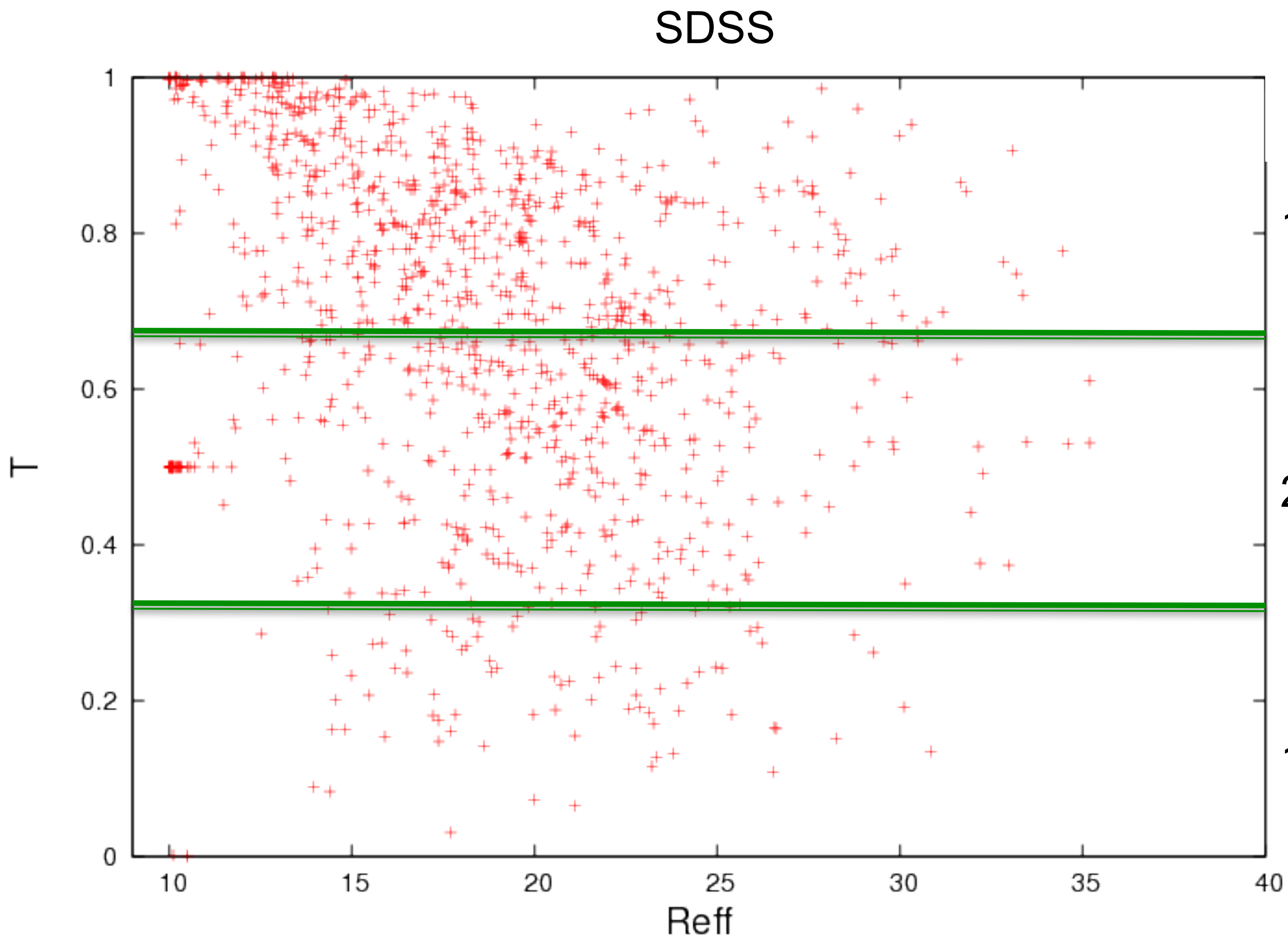
- Ellipticity
  - Redshift space distortions
- Void Galaxies
  - Two point correlation
  - AGNs in Voids
  - Void metallicity

Void Shapes (Ellipsoid)



Voids can be elliptical
Best fit ellipsoid of one of the most elliptical voids in the sample.

Void Shapes (Prolate vs. Oblate)



$$T = \frac{1-\left(\frac{b}{a}\right)^2}{1-\left(\frac{c}{a}\right)^2}$$

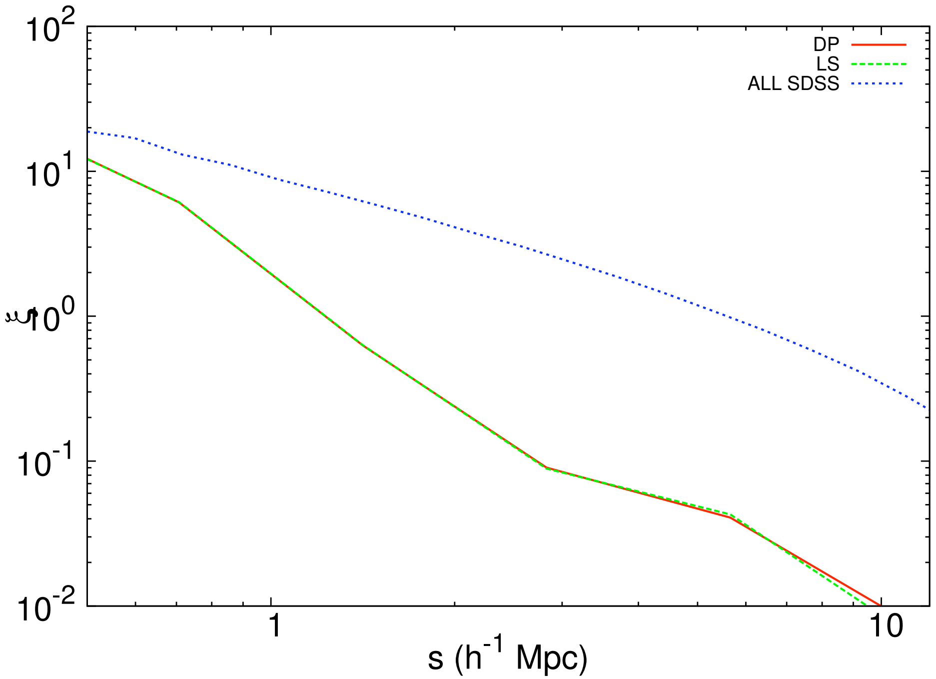
a > b > c

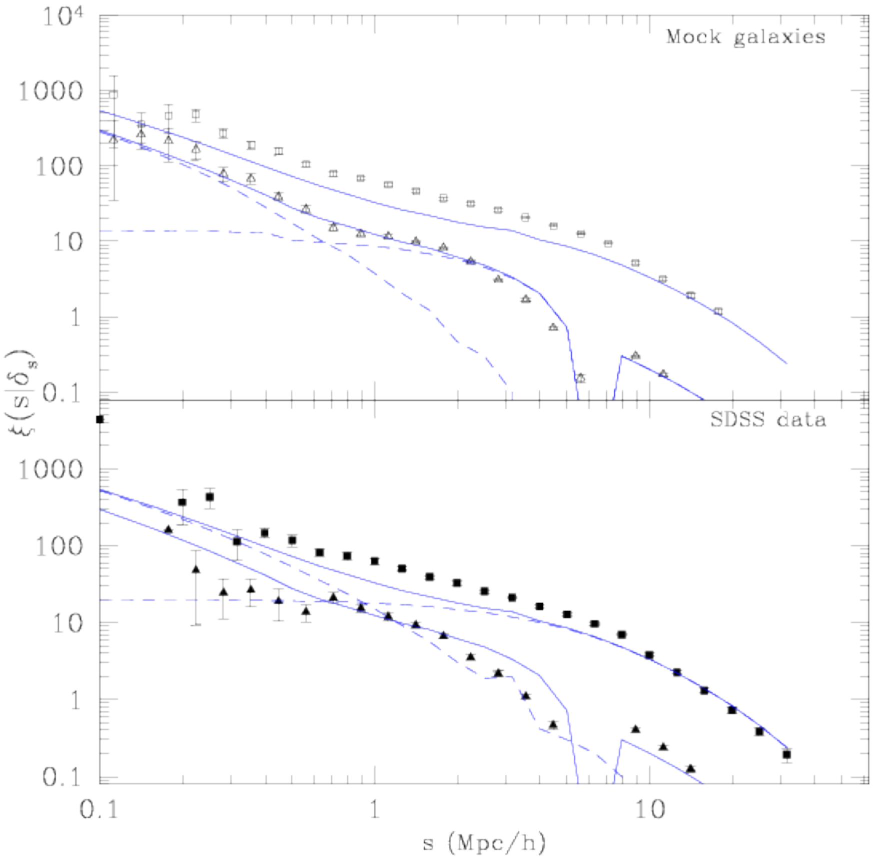
1 > T > 2/3 Prolate

2/3 > T > 1/3 Triaxial

1/3 > T > 0 Oblate

Void Galaxies (2 point correlation)

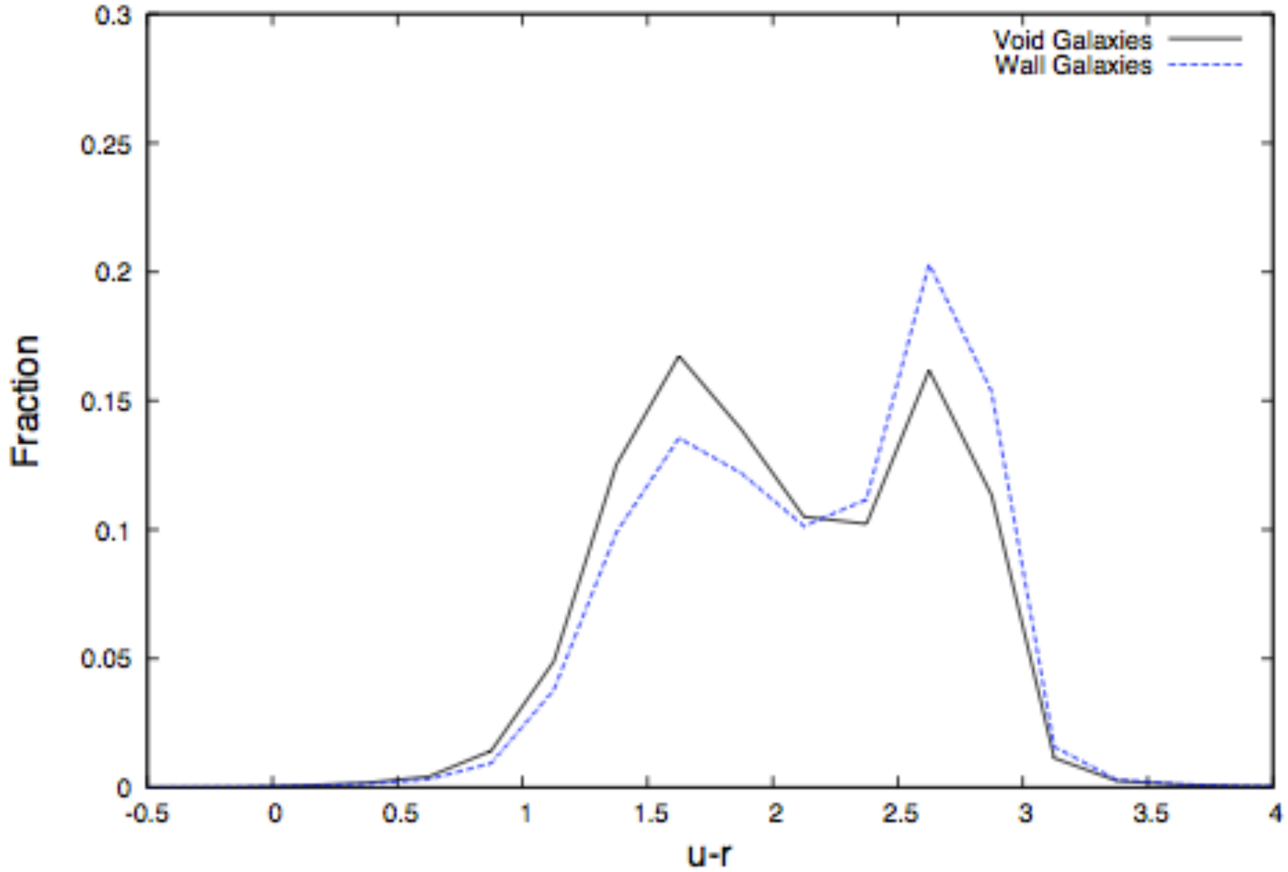




Note, galaxies in voids are LESS clustered than typical galaxies.

Abbas and Sheth (2006) found a similar result

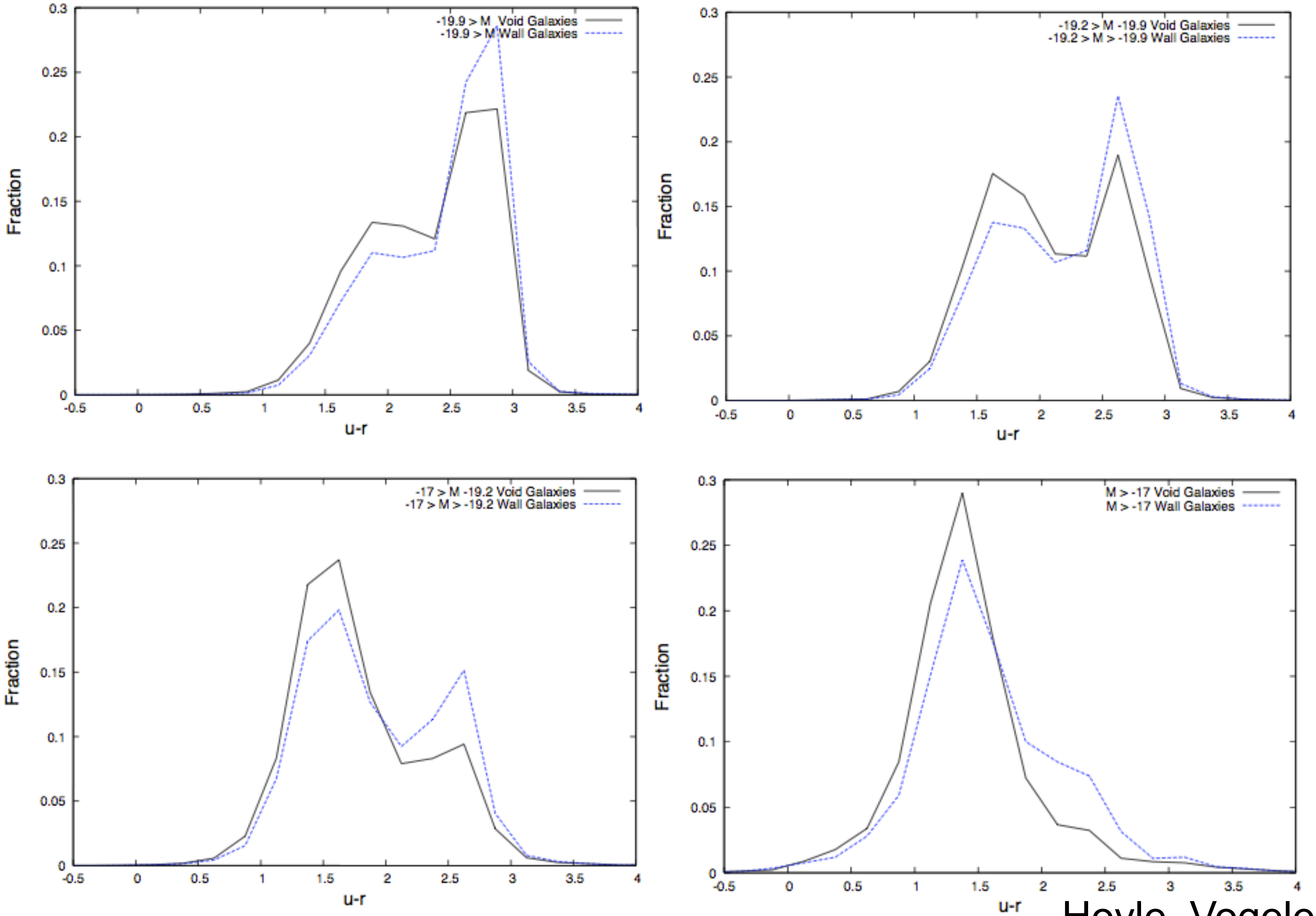
Void Galaxies (Properties)



There are more red galaxies in walls than voids.

Hoyle, Vogeley, Pan 2012

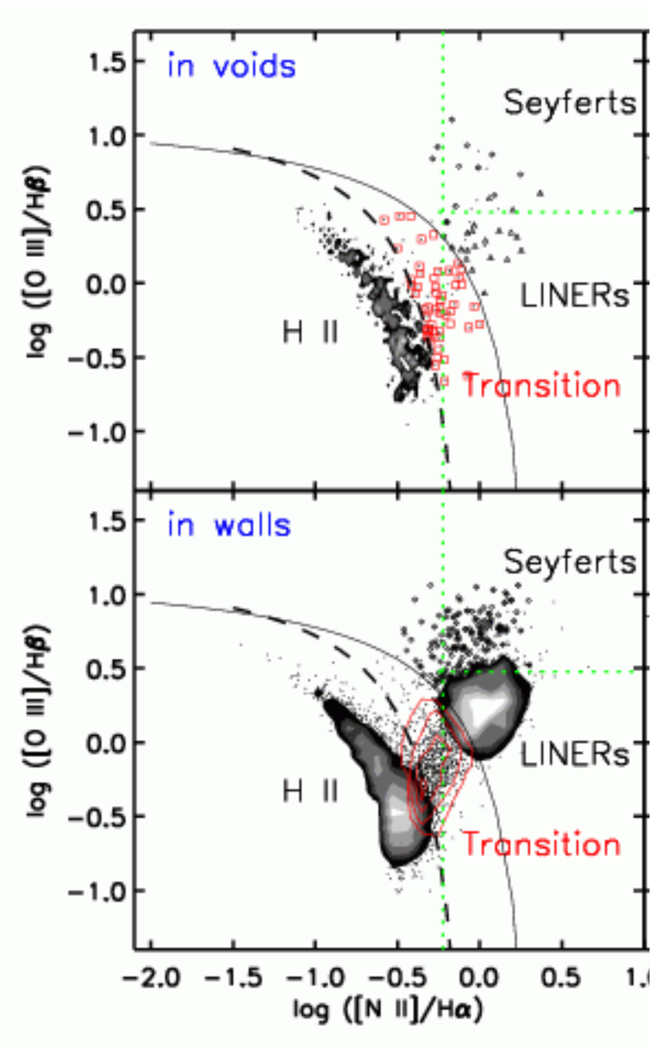
Void Galaxies (Properties)



More red galaxies in walls at all magnitudes

Hoyle, Vogeley, Pan 2012

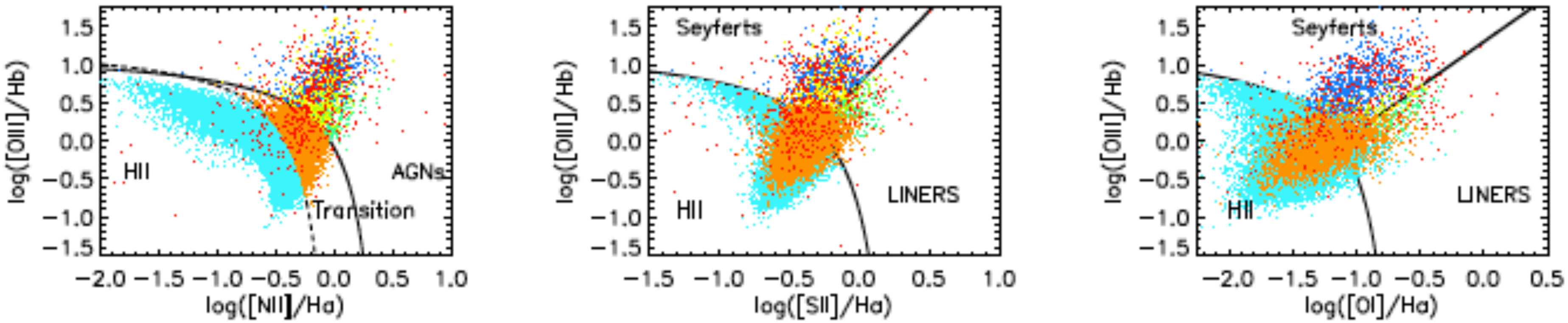
AGNs in Voids



All types of AGNs found in voids, suggest evolutionary sequence.

Constantin, Hoyle, Vogeley 2008

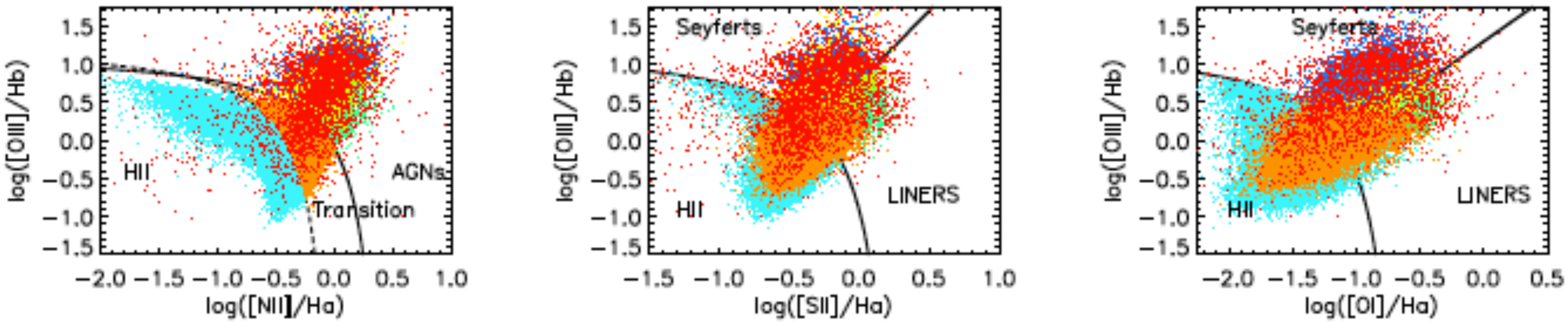
AGNs in Voids (Pan et al. in prep)



(g) mag limited void galaxies

(h)

(i)



(j) mag limited control sample

(k)

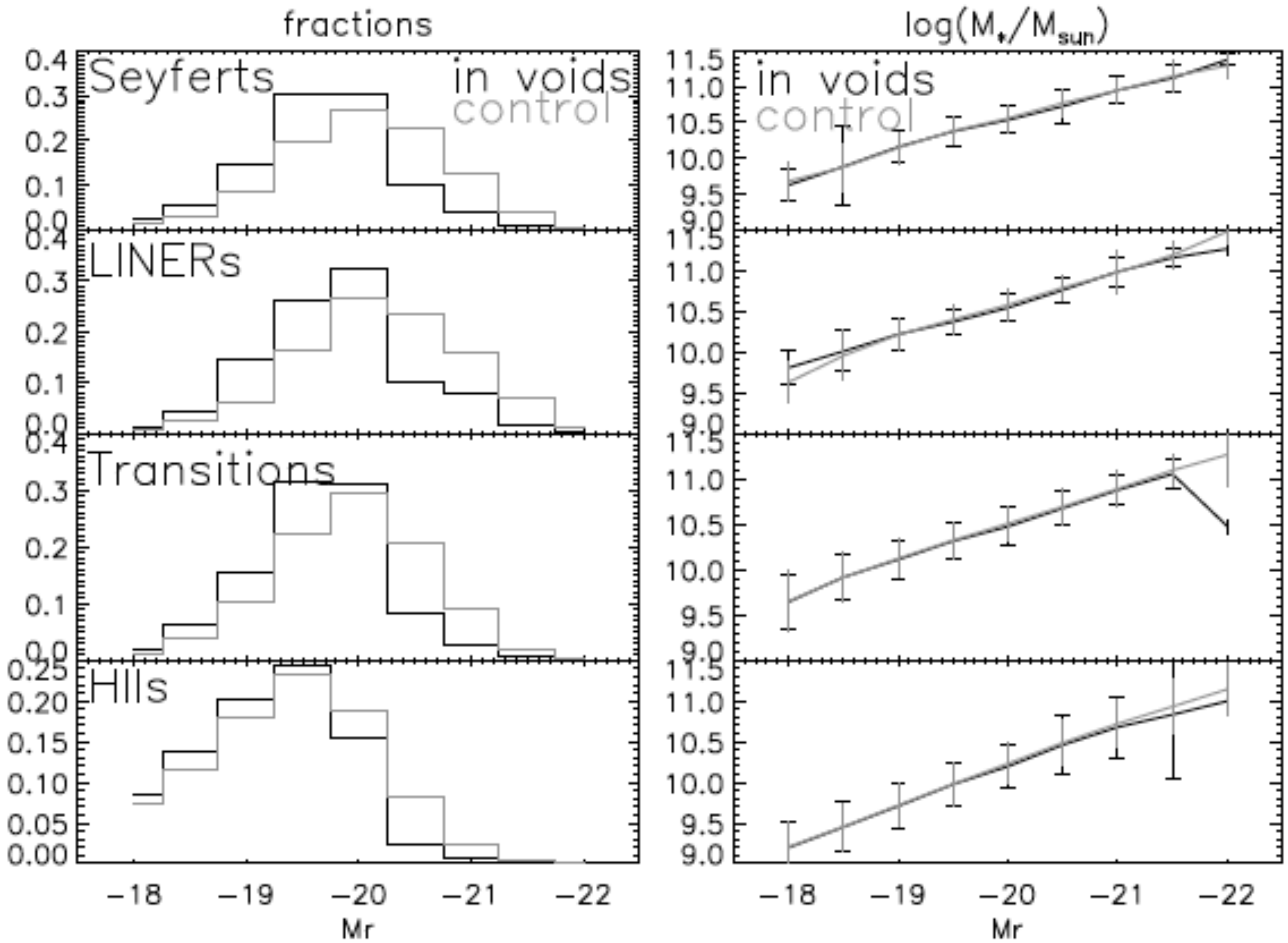
(l)

AGNs in Voids

Table 1: Object Sample Statistics

magnitude limited sample	in voids		control	
	N	F(%)	N	F(%)
emission	57947	76.1	204456	56.5
type I	631	0.8	3728	1.0
Seyfert II	838	1.1	4352	1.2
LINER II	333	0.4	2149	0.6
S-L	490	0.6	2408	0.7
L-S	100	0.1	622	0.2
composite	6244	8.2	28396	7.8
HII	37768	49.6	117001	32.3
no class	1334	1.8	6217	1.7
emweak	6601	8.7	30652	8.5
mismatch	3607	4.7	8931	2.5
no emission	18221	23.9	157581	43.5
total	76168	100.0	362037	100.0

AGNs in Voids



(a) maglim limited void galaxies

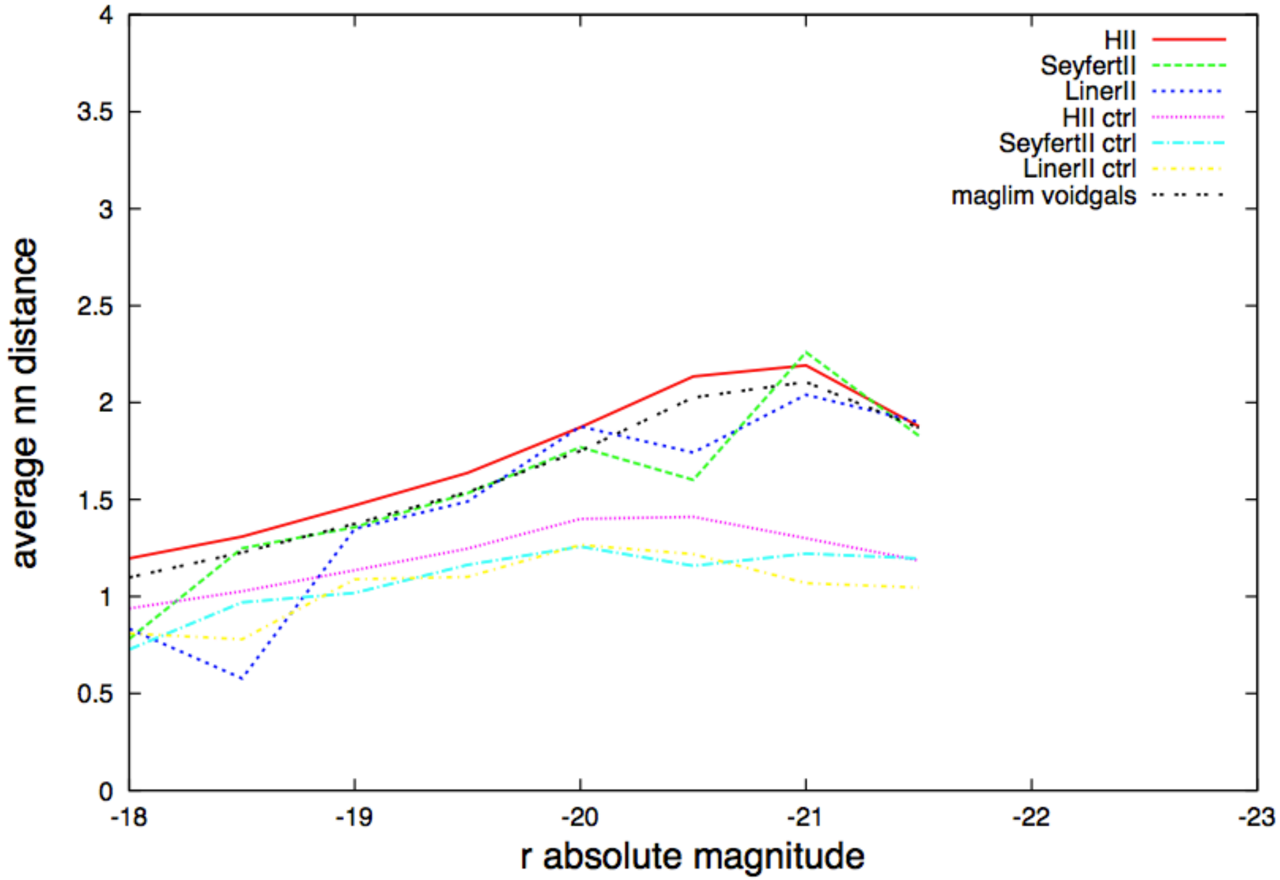
AGNs in Voids

Table 9: Host properties – rband absolute magnitude (Mr)

magnitude limited sample	in voids	control	D[a]	PROB[b]
Seyfert	-19.8	-20.2	0.311	0.00e+0
LINER	-19.9	-20.5	0.377	0.00e+0
composite	-19.7	-20.0	0.286	0.00e+0
star forming	-19.1	-19.4	0.123	0.00e+0
emission line galaxies	-19.2	-19.6	0.189	0.00e+0

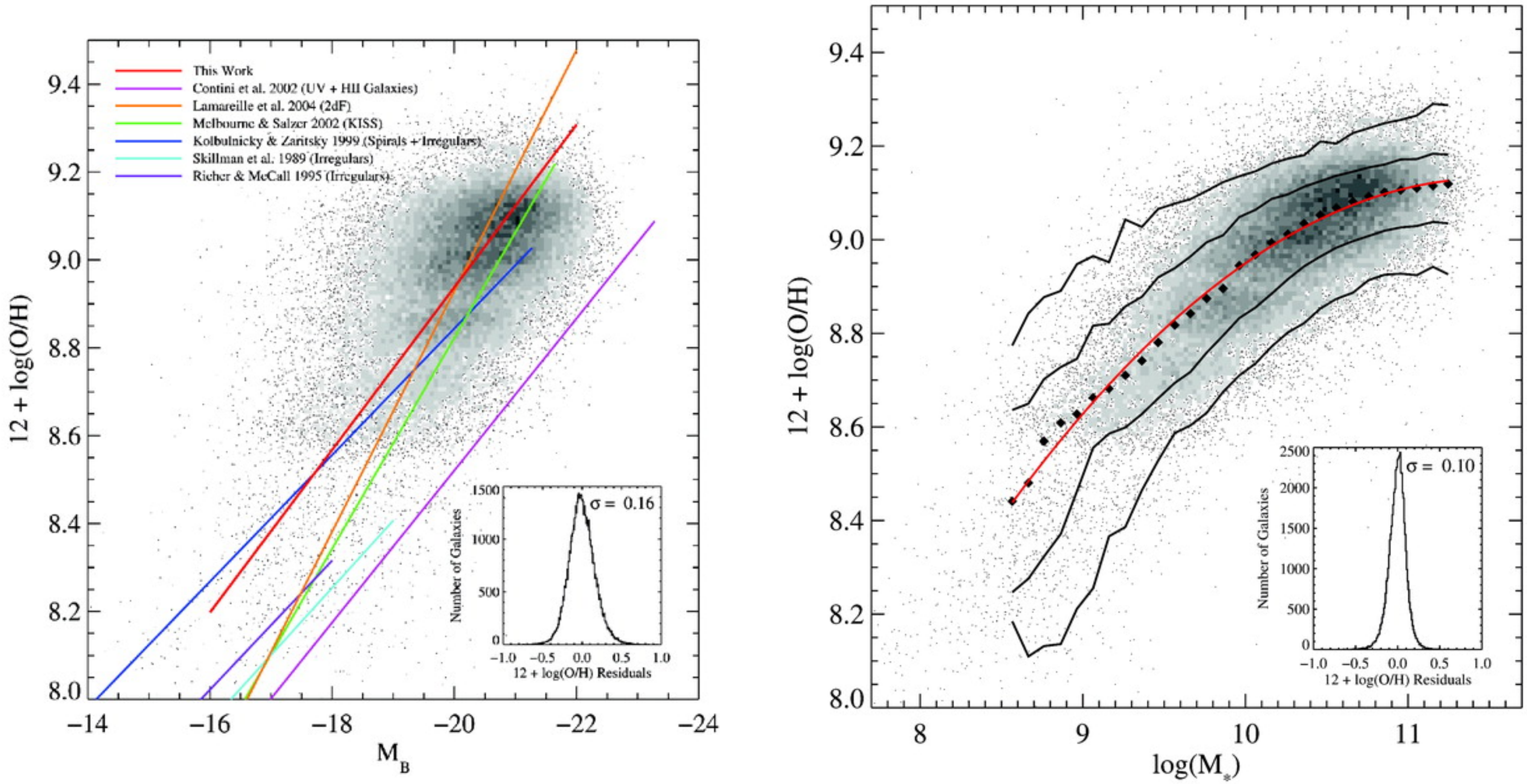
Hosts of all types of emission line galaxies are dimmer in voids than the walls.

AGNs in Voids



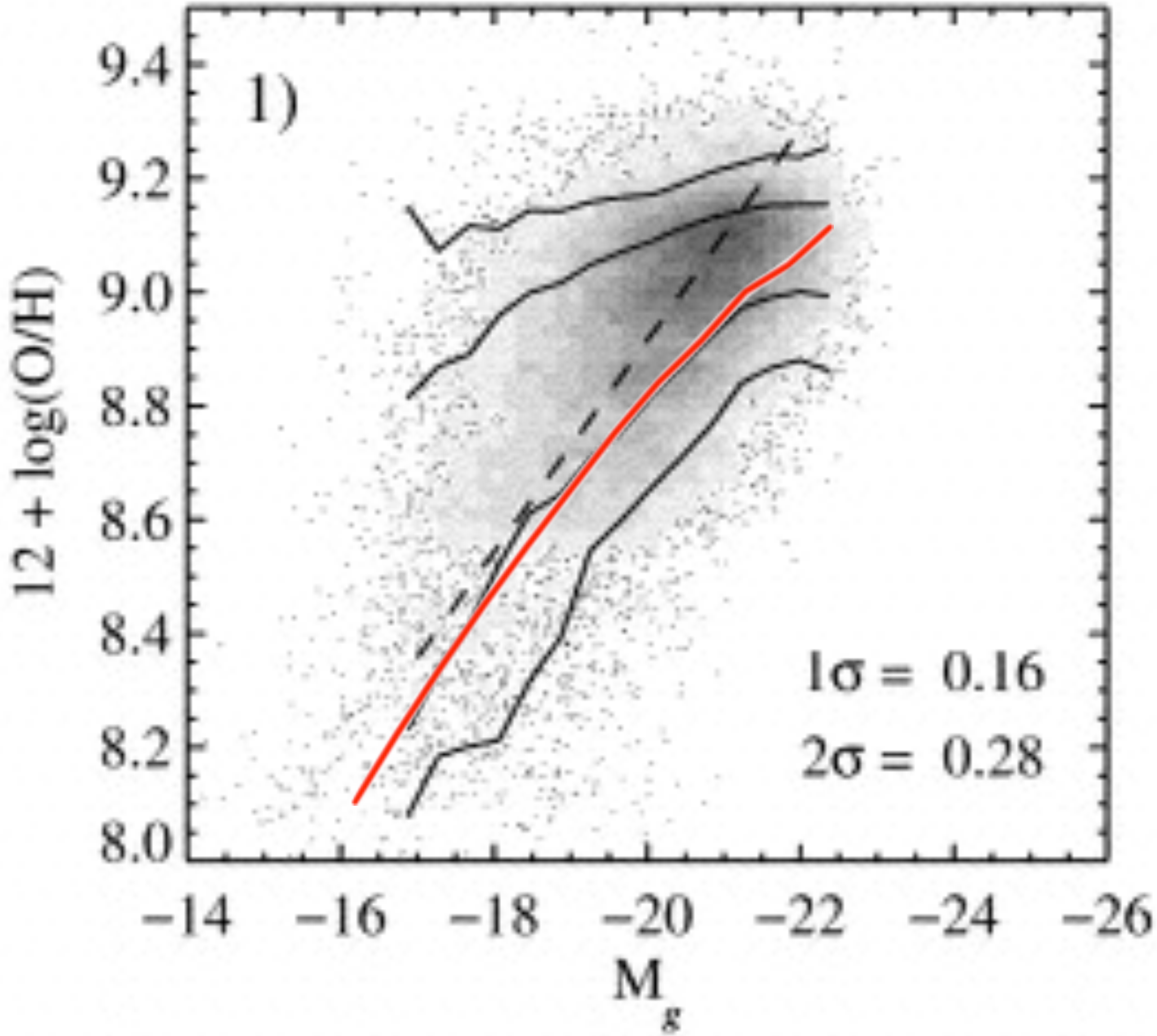
Void galaxies have larger distances to nearest neighbors, consistent with AGNs in voids.

Galaxy metallicity



Tremonti et al. 2004 calculated the metallicity-luminosity relation as well as the mass-metallicity relation

Void Galaxy metallicity



Red line shows preliminary results of void galaxy metallicities compared to Tremonti et al. 2004

Conclusions

- SDSS DR7 void catalog to z<0.107
  - Median void radius ~21 h^{-1} Mpc
  - Filling factor of voids (~63%)
- Voids are more prolate than oblate
- Void galaxies are less clustered than wall galaxies
  - Bluer, more star formation
- AGNs of all types exist in voids
  - Similar abundance to walls
  - Trace a dimmer population of galaxies
- Void galaxies more metal poor (?)