HI in Void Galaxies: probing the lowest density environments

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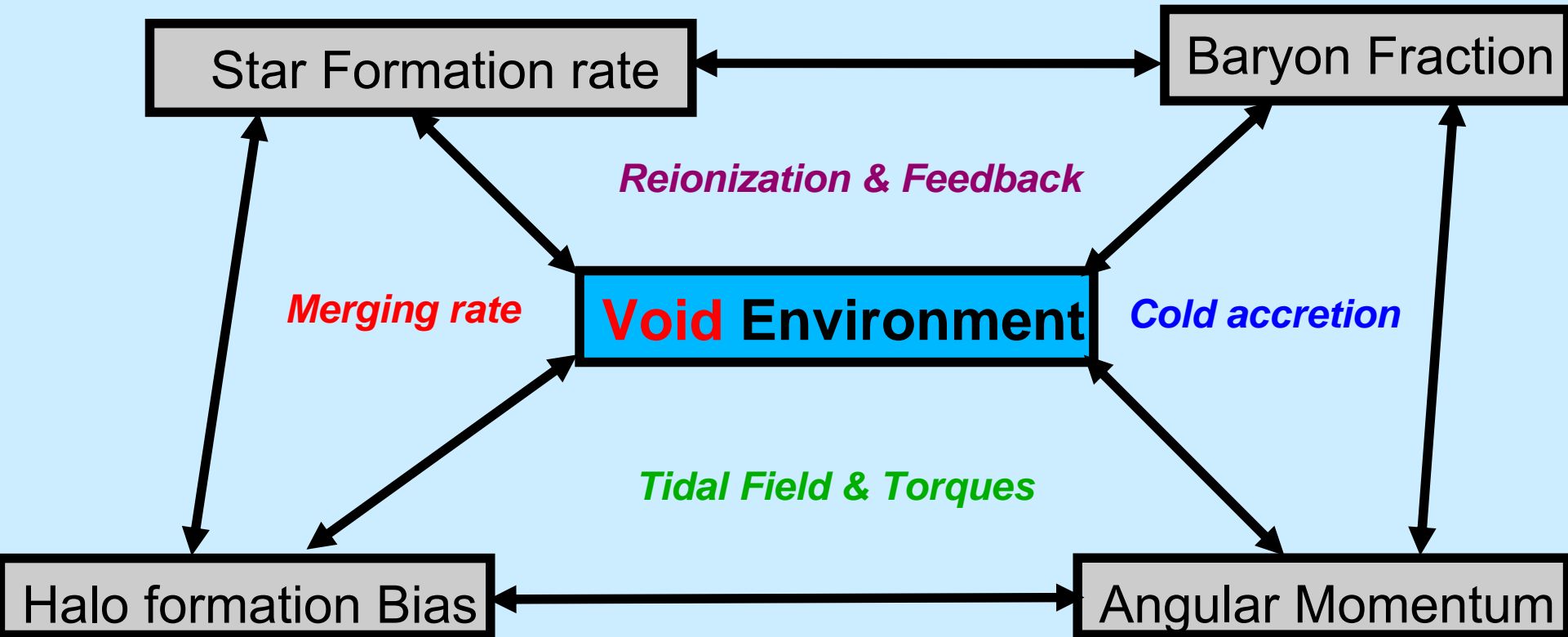Jacqueline van Gorkom Columbia University
Miguel Aragon-Calvo   Johns Hopkins Univ.
Jim Peebles   Princeton University
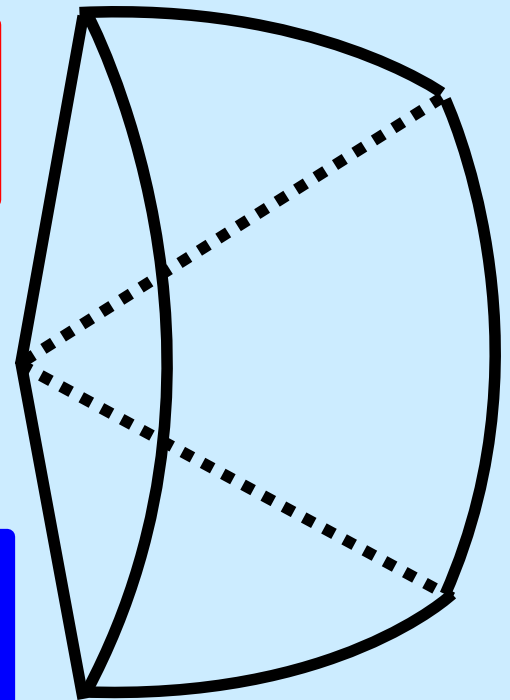
The complex picture of galaxy formation in ΛCDM

The Trouble with Void-Galaxies

- Voids are inhabited by small faint Galaxies
  ➡ restricted to nearby distances

Selecting/Finding Void galaxies requires
both deep and large fraction of the sky.

- Voids are large underdense regions
  ➡ covering large fraction of the sky
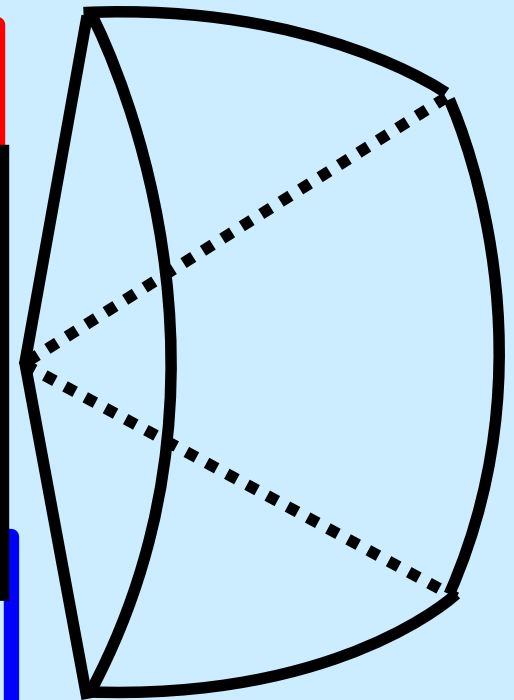
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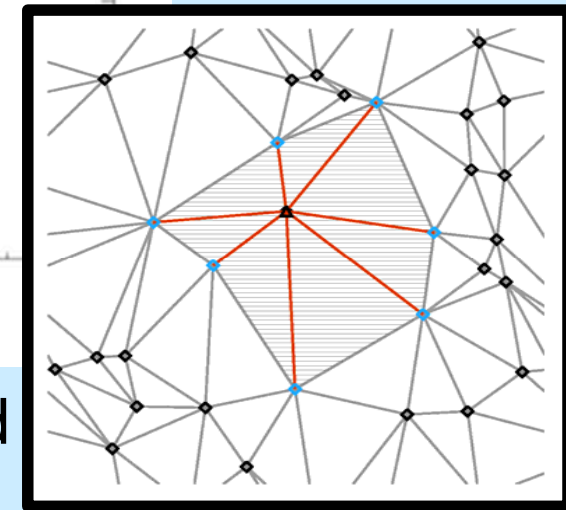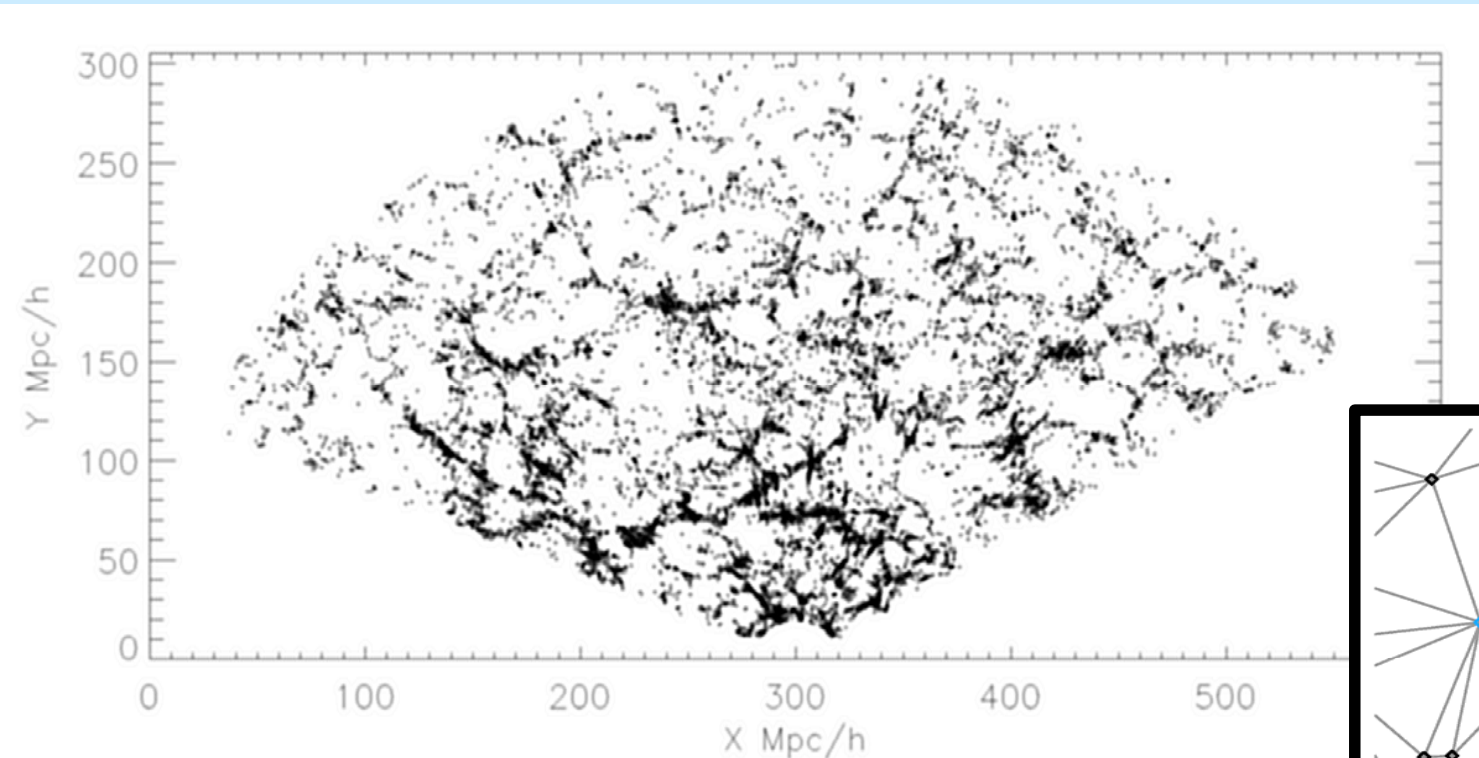
Selecting/Finding
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Optical Surveys:
SDSS-DR7 or 6dF-DR3

HI Surveys:
ALFALFA, APERTIF

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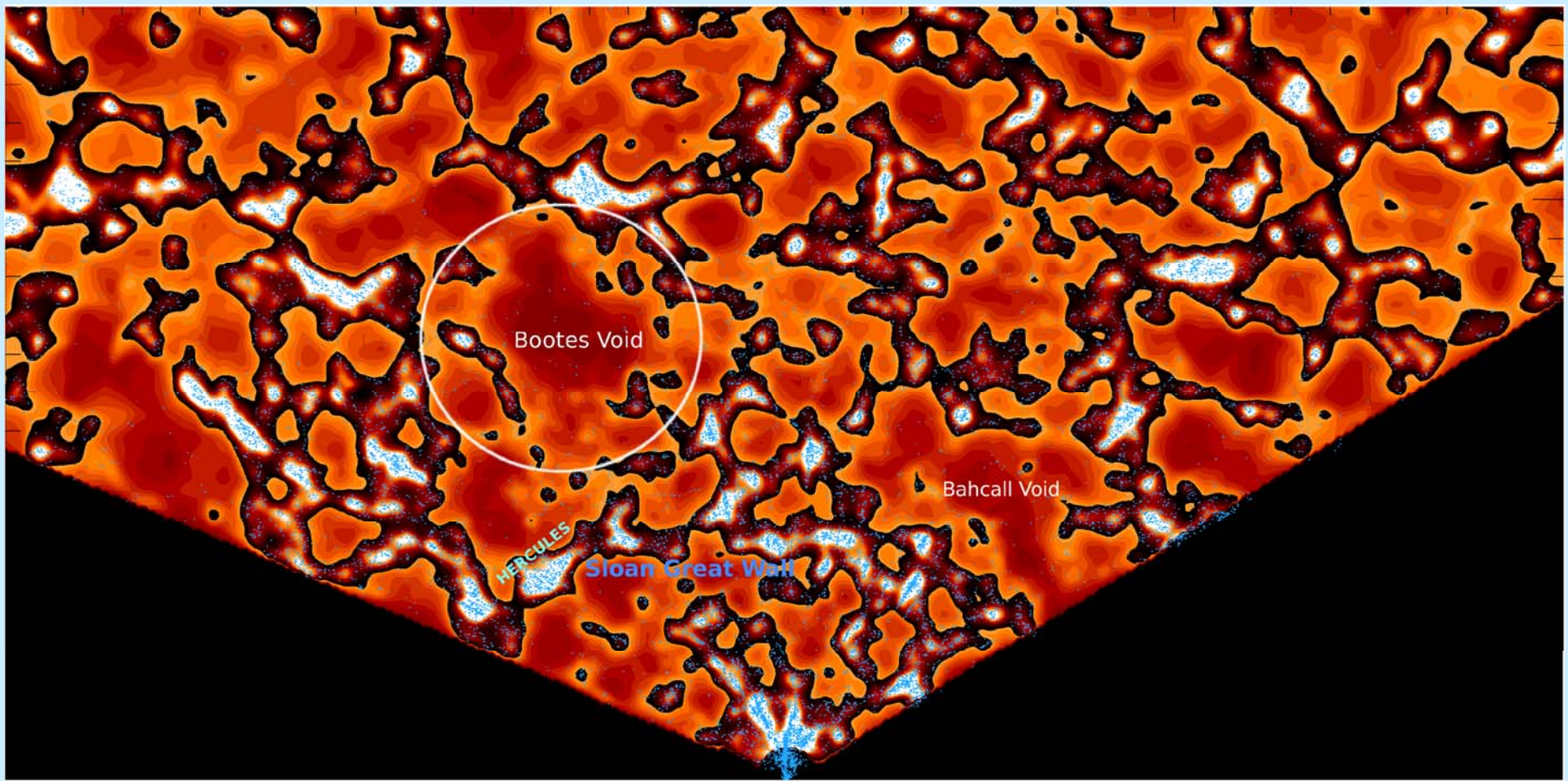
SDSS Density Reconstruction

Spatial Point Distribution → Density Field

Delaunay Tessellation Fields Estimator (Schaap 2000, A&A 363, 29)
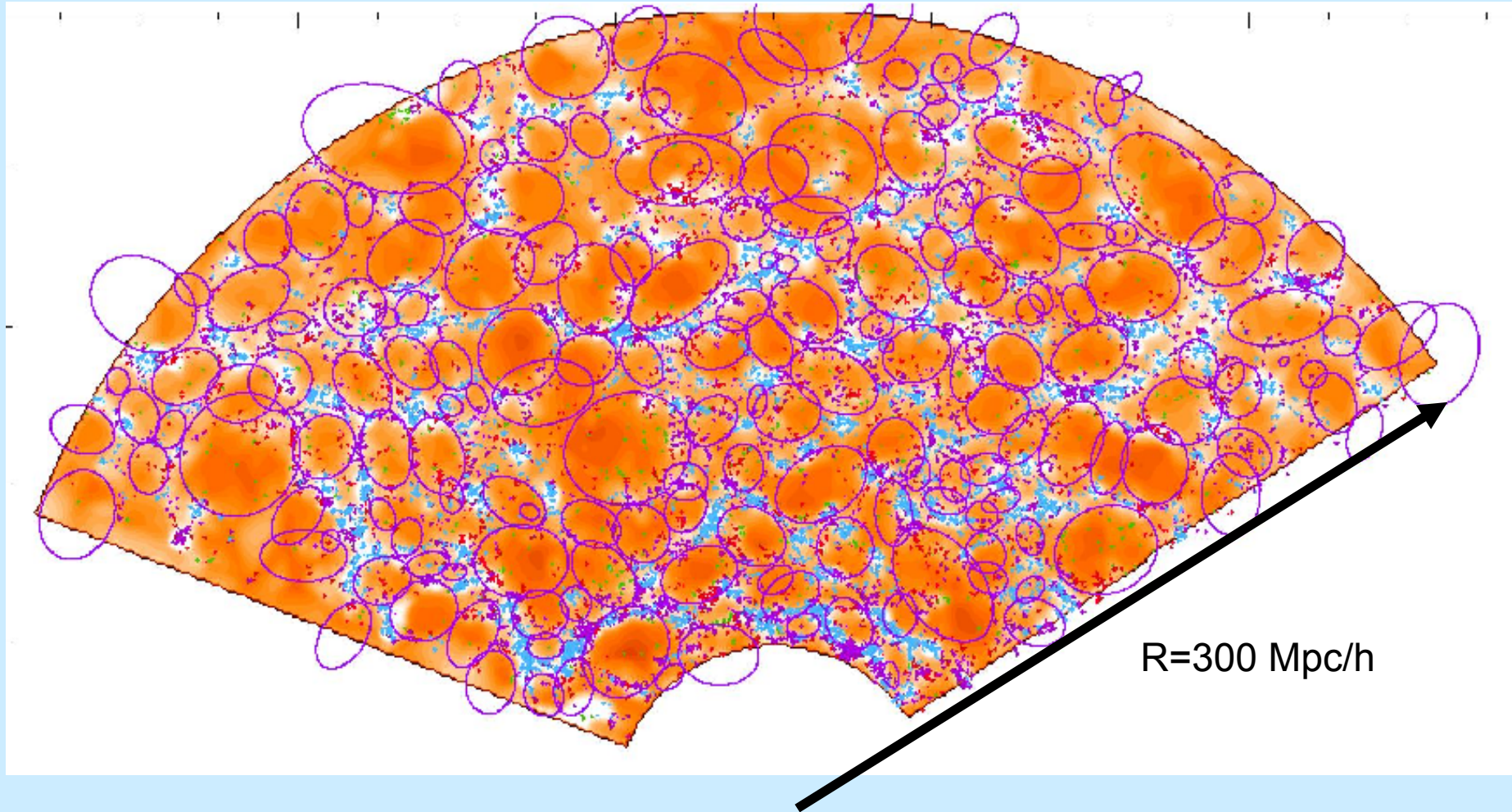Watershed Void Finder (Platen et al. 2007 MNRAS 380, 551)
Cosmic Spine formalism (Aragon-Calvo et al. 2007 A&A 474, 315)

SDSS density reconstruction

SDSS environments

R=300 Mpc/h

Void-Galaxy Sample

Geometrically Defined Sample

- Using the SDSS redshift catalogue

- Within a redshift range from
  0.01 < z < 0.025

- 250 galaxies with the lowest density values ~0.2 x cosmic mean

- Avoid galaxies that lie in front or behind clusters of galaxies
  (fingers of god)

- Ranked them according to the distance of the void-centers.
 Pick the most centrally located
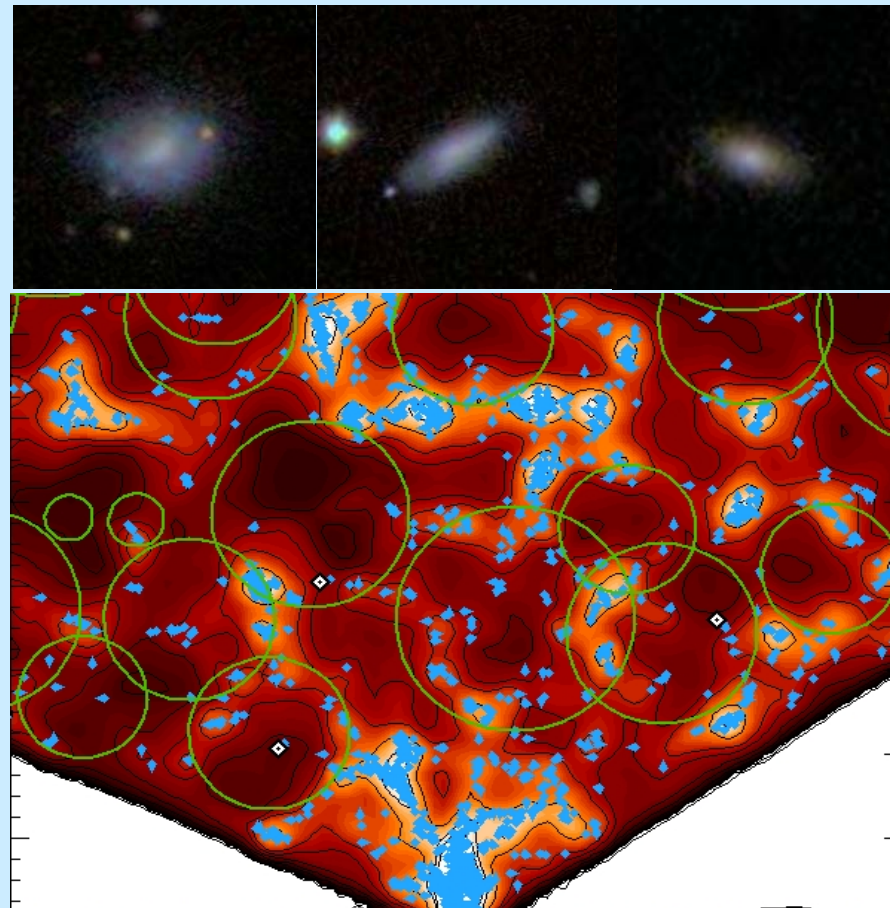
VOID_004 J121908.24+372644.1	VOID_005 J114303.01+404939.1	VOID_006 J102235.27+453821.2	VOID_008 J151211.61+243344.1	VOID_009 J153132.44+343055.8
VOID_013 J092252.91+513243.6	VOID_018 J141916.95+472839	VOID_022 J104807.05+430525.4	VOID_025 J141326.45+503841.7	VOID_029 J103913.14+310650.4
VOID_035 J085453.6+181924.7	VOID_036 J144338.46+322002.7	VOID_041 J145659.94+313308.5	VOID_051 J121716.54+124742.8	VOID_055 J114124.92+415221.9
VOID_061 J145314.6+462910.8	VOID_068 J093602.69+515638.6	VOID_069 J111029.61+134558.1	VOID_071 J142540.62+443835.3	VOID_078 J145909.32+324756.3
VOID_080 J122123.12+393659.4	VOID_088 J135836.3+292121.4	VOID_098 J153035.83+264408.5	VOID_114 J154452.18+362845.6	VOID_121 J105042.23+315119.6

HI Observation of VoidGalaxies

◆ Westerbork Synthesis Radio Telescope

◆ 12h integration, 25" resolution, 0.5 mJy/beam rms

◆ Voids within z < 0.025 [50-85 Mpc]

◆ Void galaxies: near the centers of voids

◆ 50 galaxies were selected out 250 candidates

◆ 38 have been observed

◆ Pilot sample (15) reduced
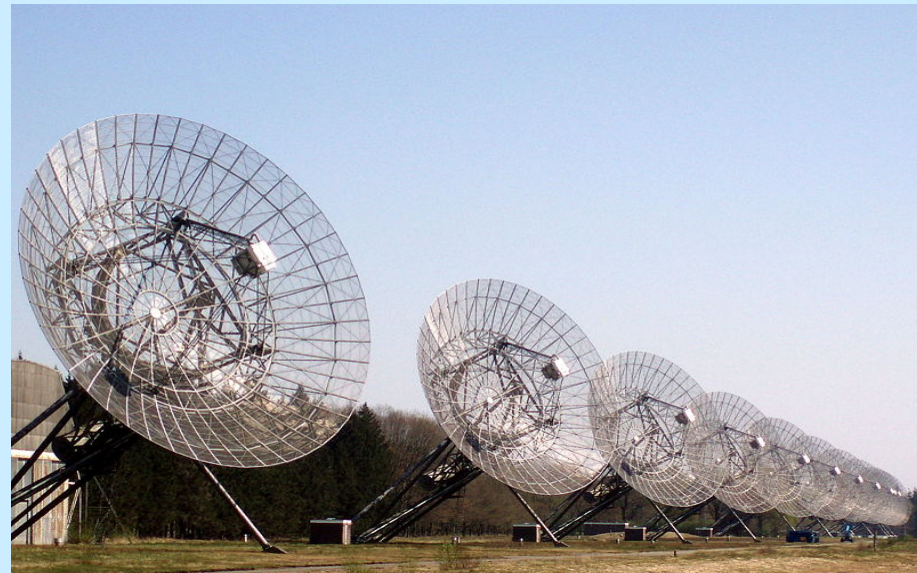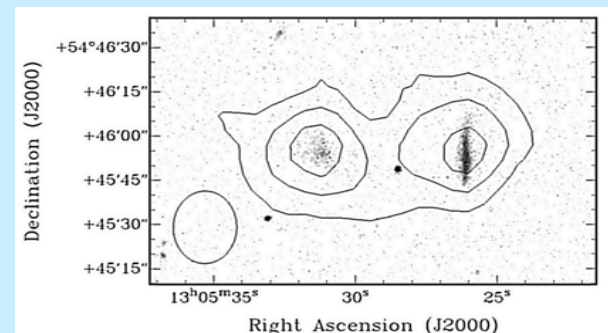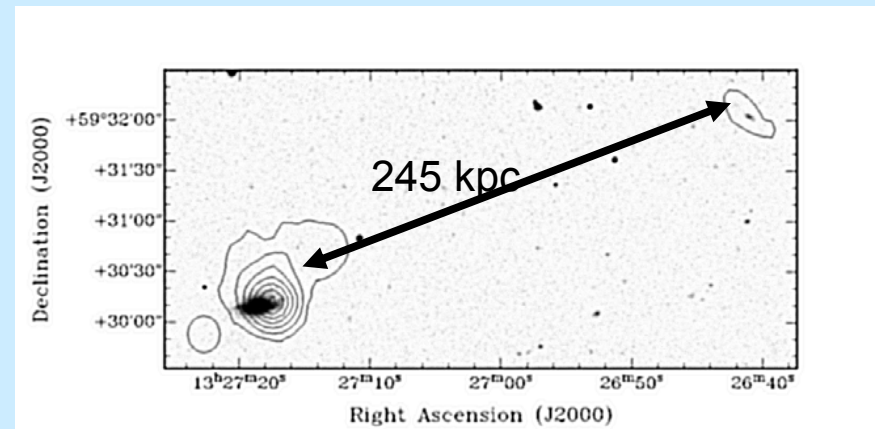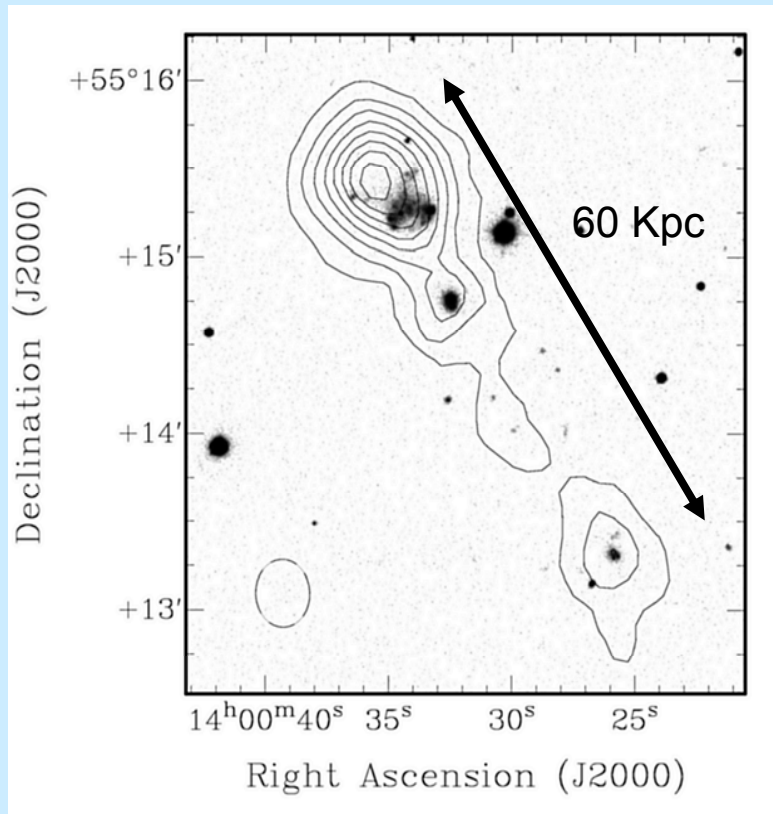
Pilot Project

14 out of 15 galaxies detected

$M_{stellar}$ 5 - 40 10^8 $M_\odot$
M_{HI} 5 - 40 10^8 $M_\odot$
M_{dyn} 5 - 40 10^9 $M_\odot$

5 new companions   with $M_{HI} \sim 5$ 10^7 $M_\odot$
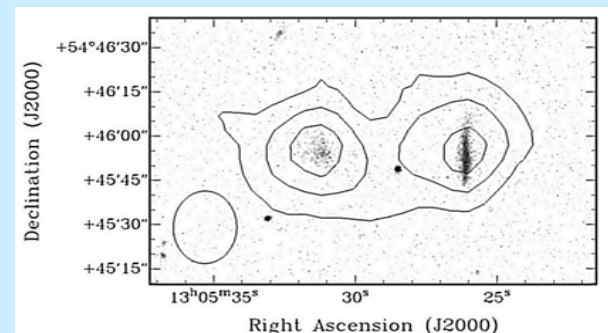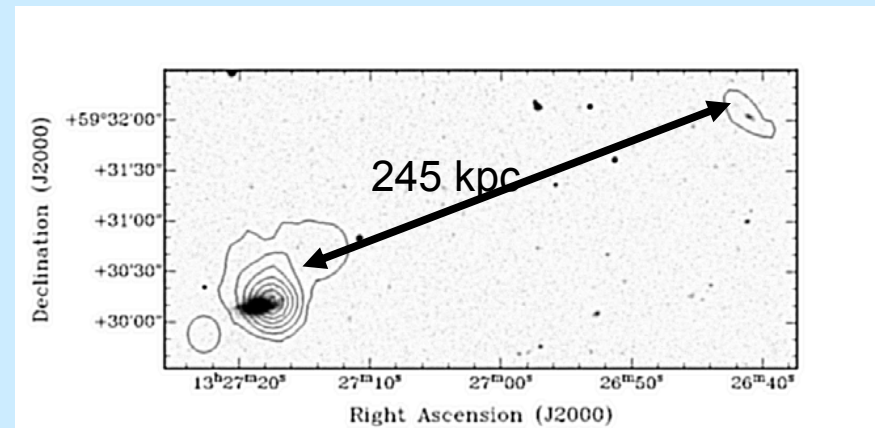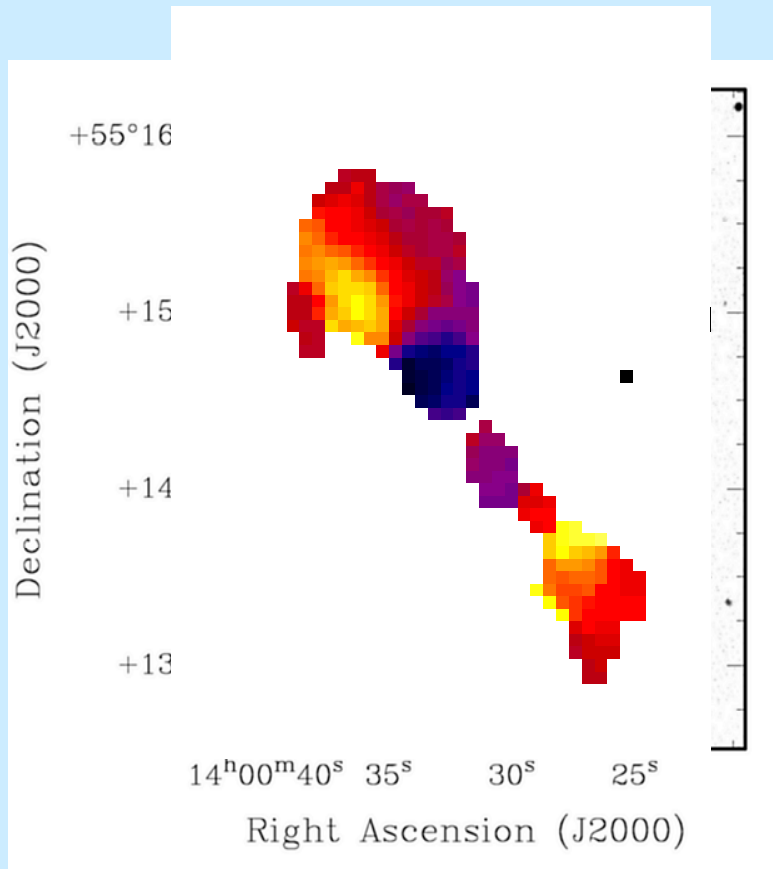
1 non-detection

13 Rotating Galaxies: 1 polar disk, 1warped,
  2 interacting, 2 with close companions
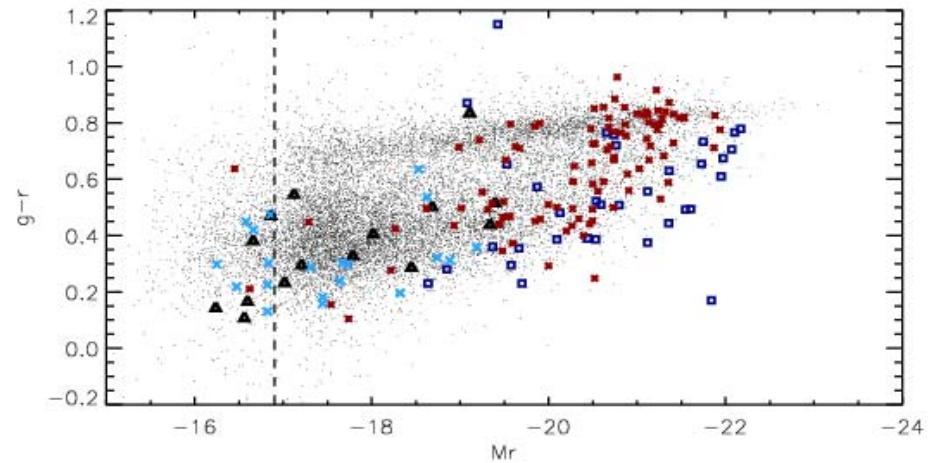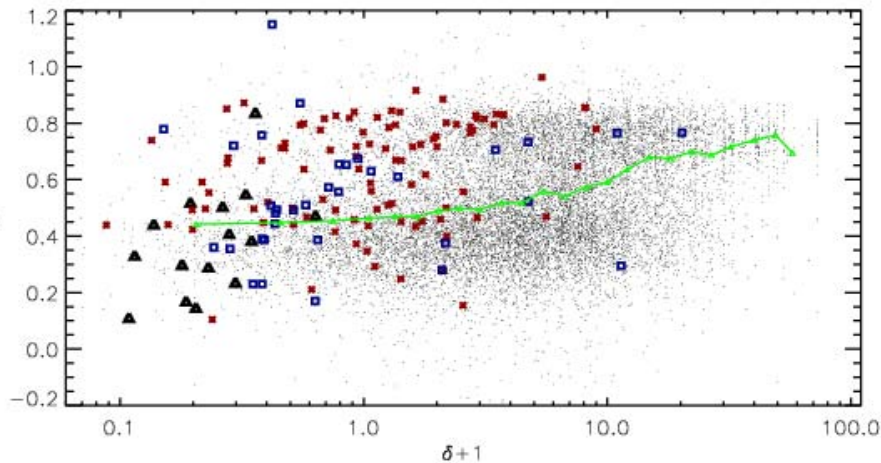
Interacting Void Systems

60 Kpc

245 kpc

Stanonik et al (2009), in preparation

Interacting Void Systems

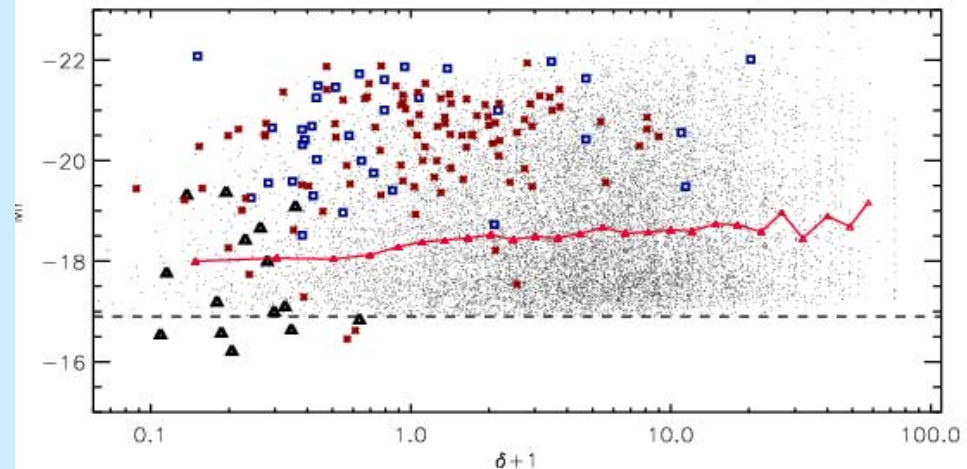Stanonik et al (2009), in preparation

Optical Properties of the Selection

Comparison to other VG samples:

Blue boxes:
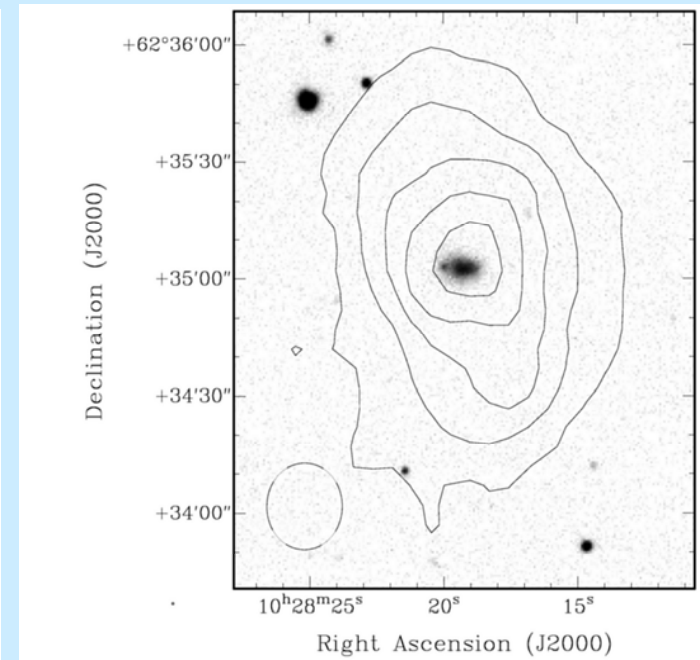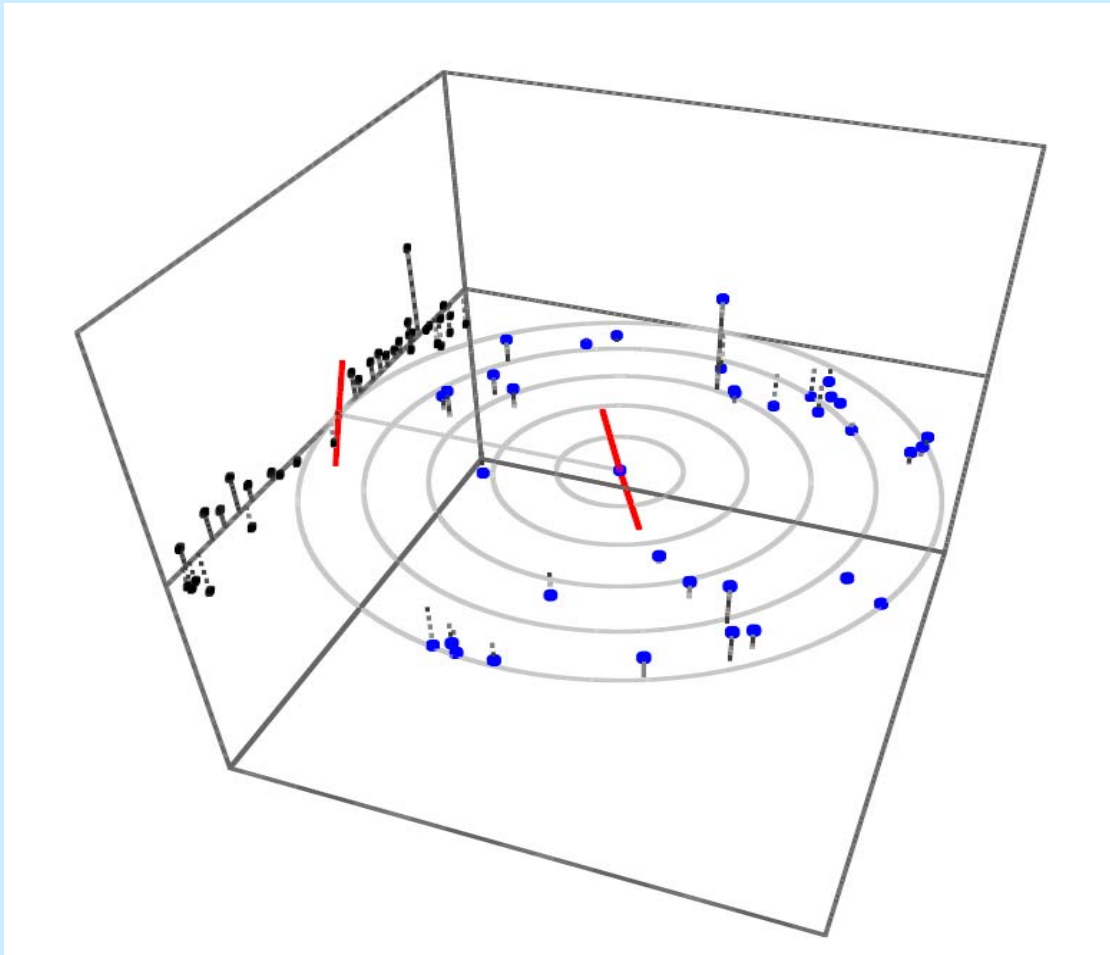Sample from Szomoru (1996)
Average redshift of z~0.05

Red crosses
Optical Selected sample of Grogin &
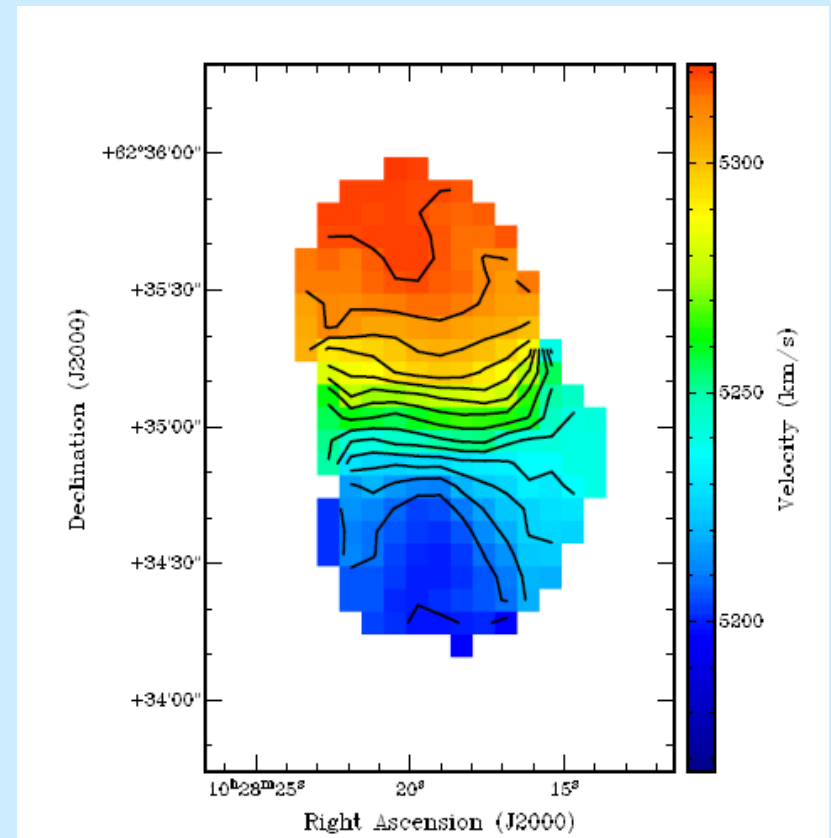Geller (2000). Same average distance
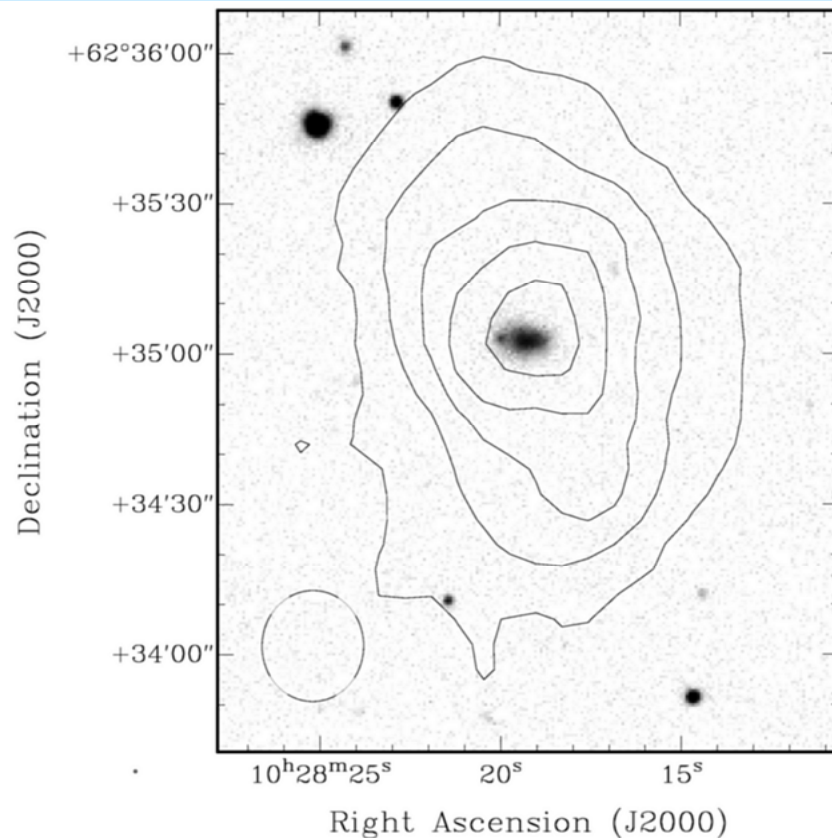<Mr> = -20, here <Mr> = -18

A Void galaxy in an 'Empty' Wall
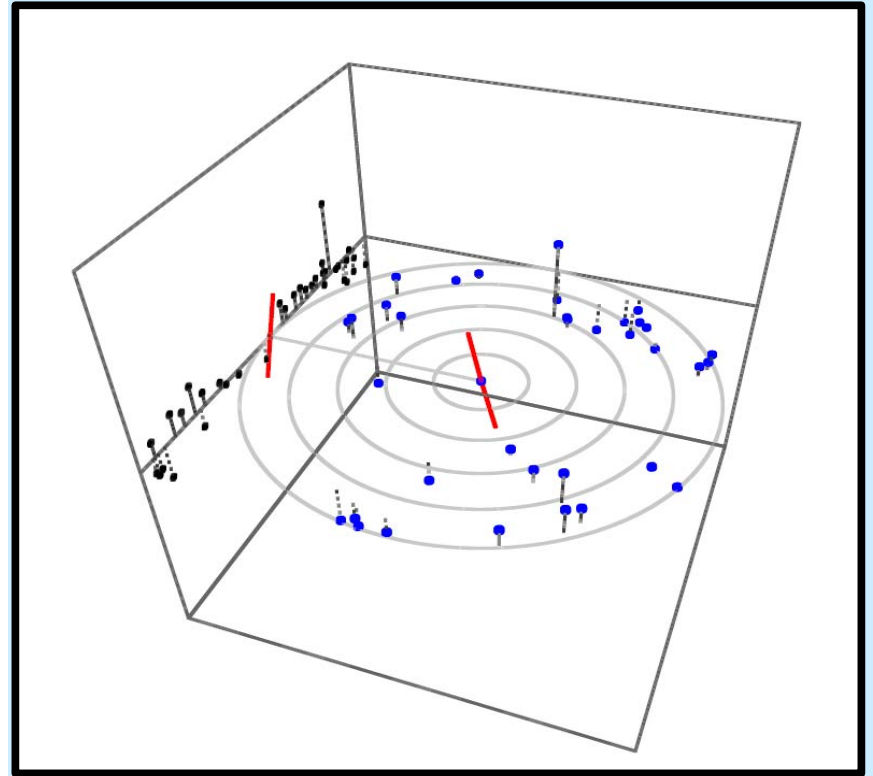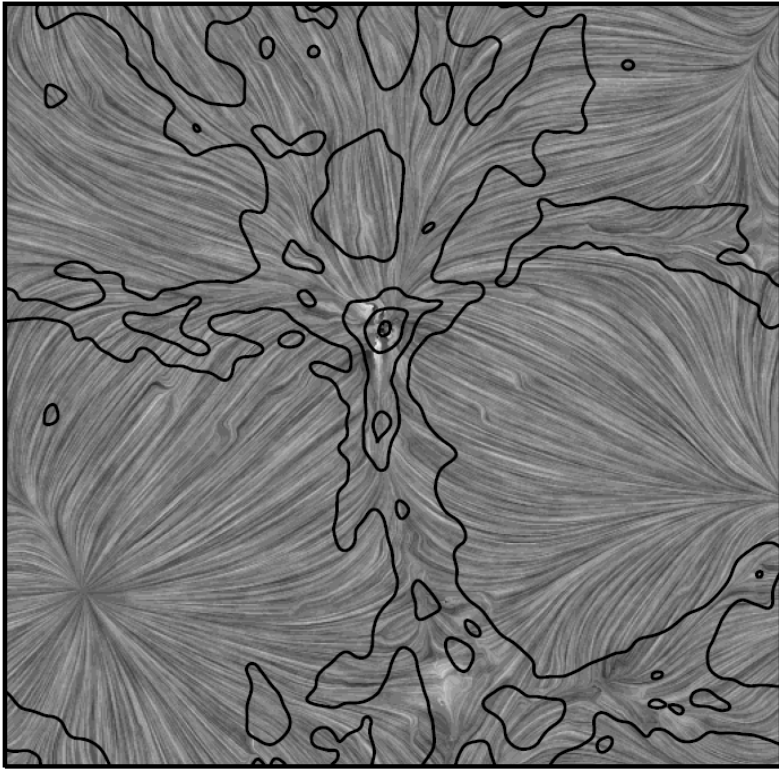
Galaxies within a distance of 10 Mpc

A void galaxy with a polar disk

Stanonik et al 2009 ApJ 696, L6

Cold Accretion out of Voids??

Galaxies within a distance of 10 Mpc

Summary

- The SpineWeb method was developed for finding Voids, Walls and Filaments

- The Method is based on Morphology & Topology of the density field; (almost) Parameter Free

- SDSS Density Field has been reconstructed (DTFE)

- SDSS Galaxies were Classified according to the Spine Web environment

- HI observation were carried out of void galaxies

- Pilot Data suggest that Void galaxies are building up their stellar component from remaining and infalling cold HI gas

- Polar Disk Galaxy found within a Large Scale Wall in between two large voids

Preliminary Conclusions

◆ Global properties such as HI-mass content, Tully-Fisher, etc relations seem to be no different than the trends in denser environments

◆ Despite having selected the most (globally) isolated galaxies, nearly half show signs of perturbed HI disks or signs of merging events. (Warp, Polar Disk, Merging)

◆ Five very faint nearby HI detected companion were discovered:

$$M_r = [-11.5, -14., -14.1, -14.9, -16.2]$$
$$M_{HI} = [\ 0.6,\ 0.6,\ 3.7,\ 1.4,\ 4.5\ ]\ 10^8\ M_\odot$$