THE VOID GALAXY SURVEY:
Galaxy Evolution and Gas Accretion in Voids

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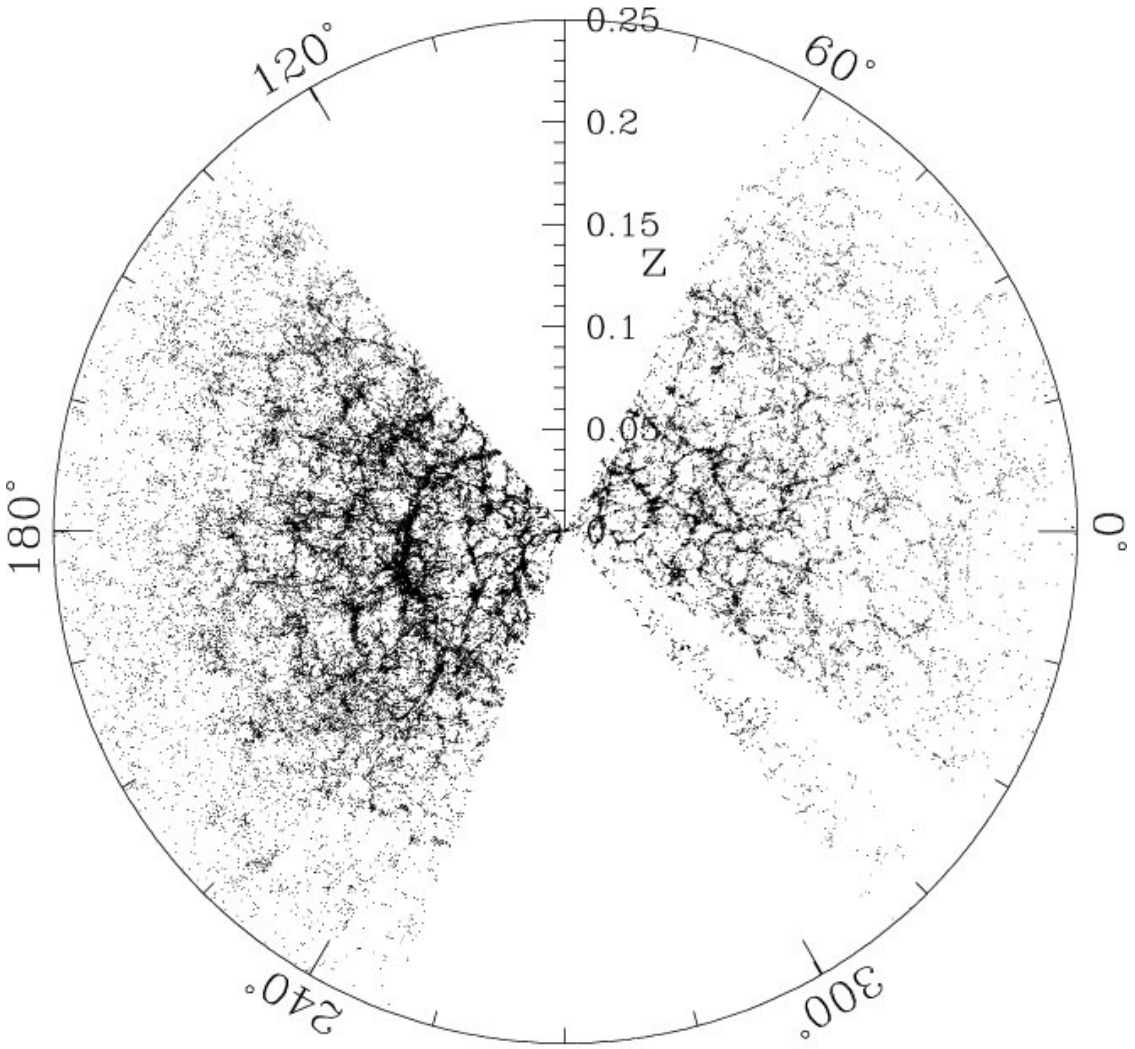
Large Scale Structure - Observations & Theory

Filaments, walls, clusters, voids

Dark matter only

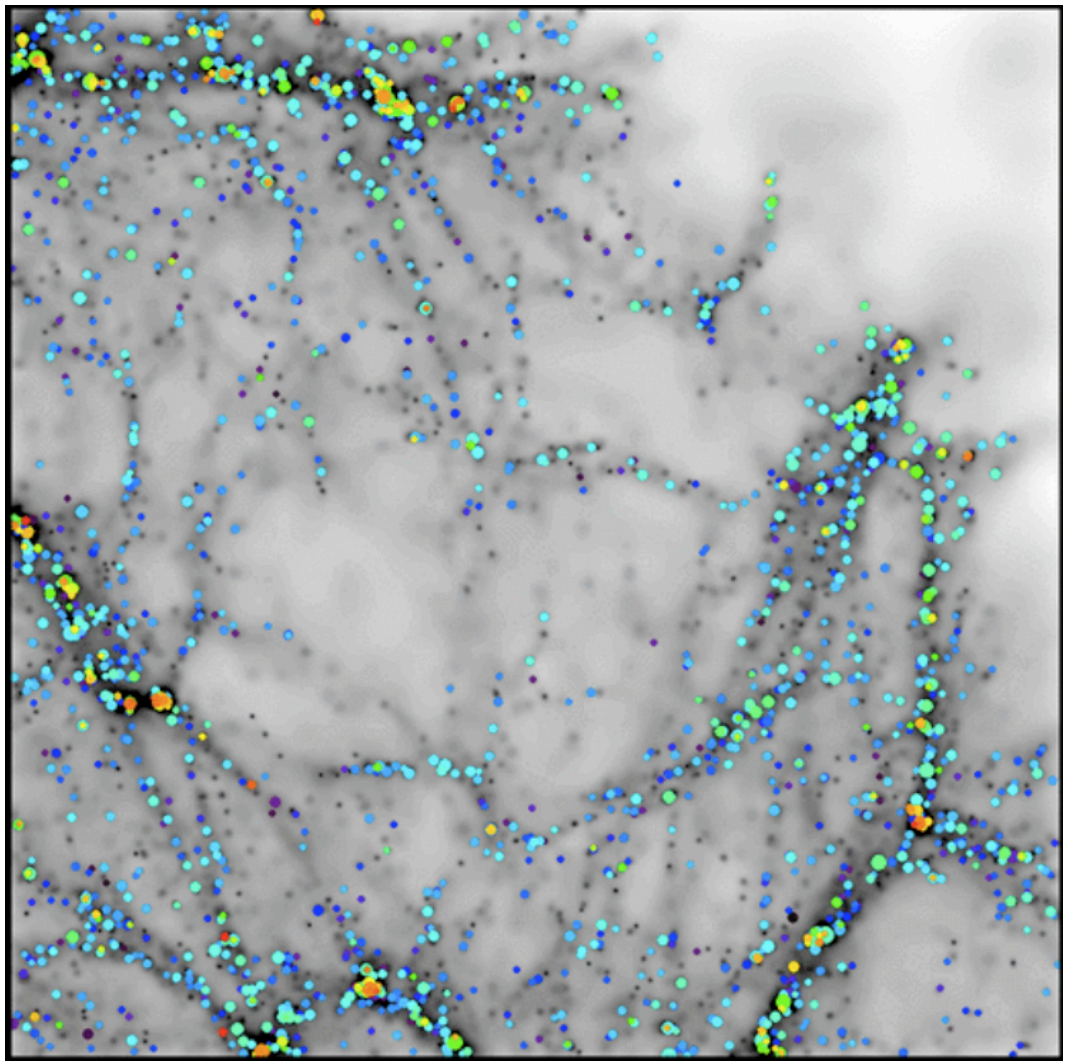


SDSS redshift survey

Millennium Simulation, Springel et al. 2005

Void Phenomenon

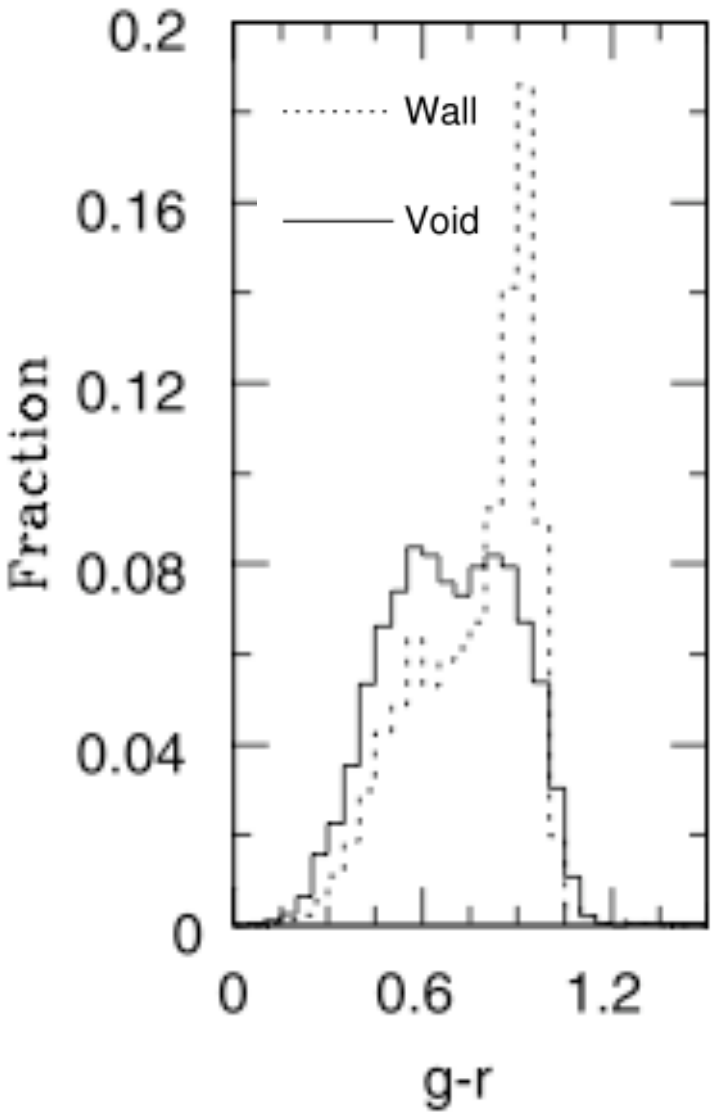
Simulated low mass dark matter halos fill the voids (Peebles 2001)

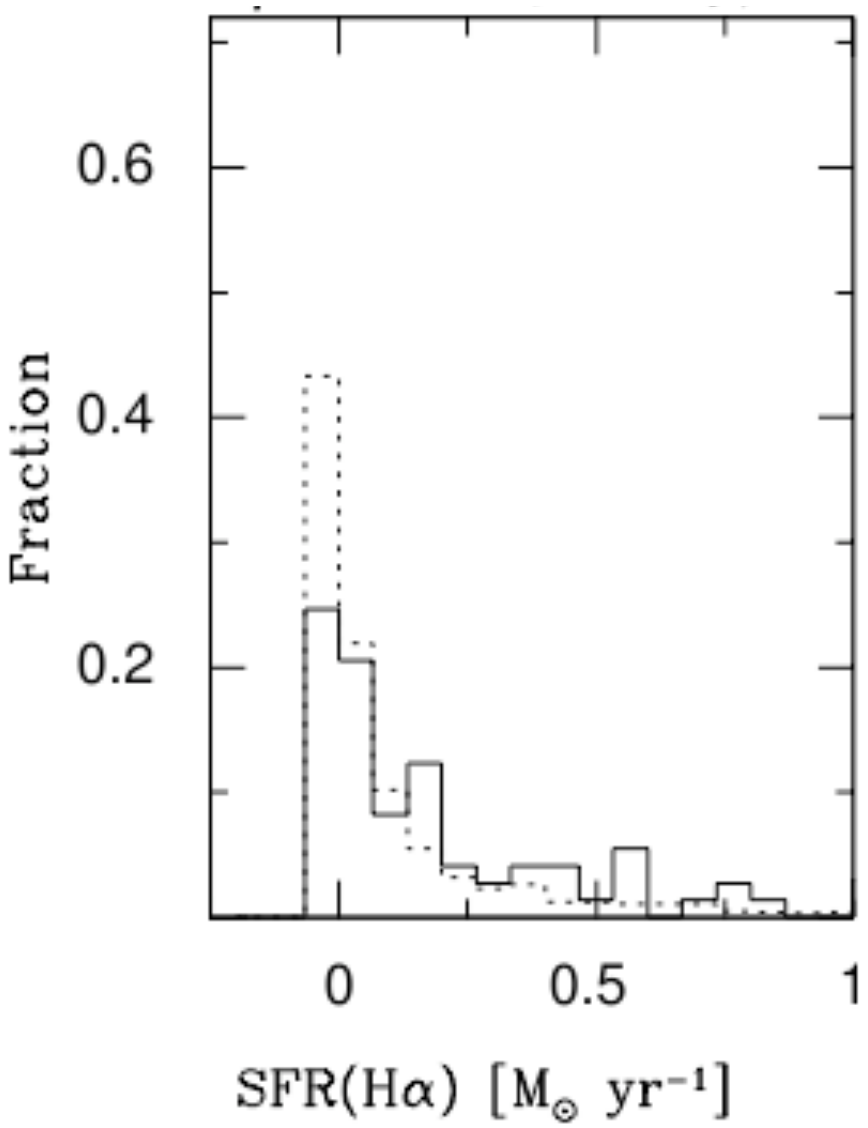


Simulation by Mathis & White 2002

Galaxy Growth in Voids

Bluer, with higher SFR

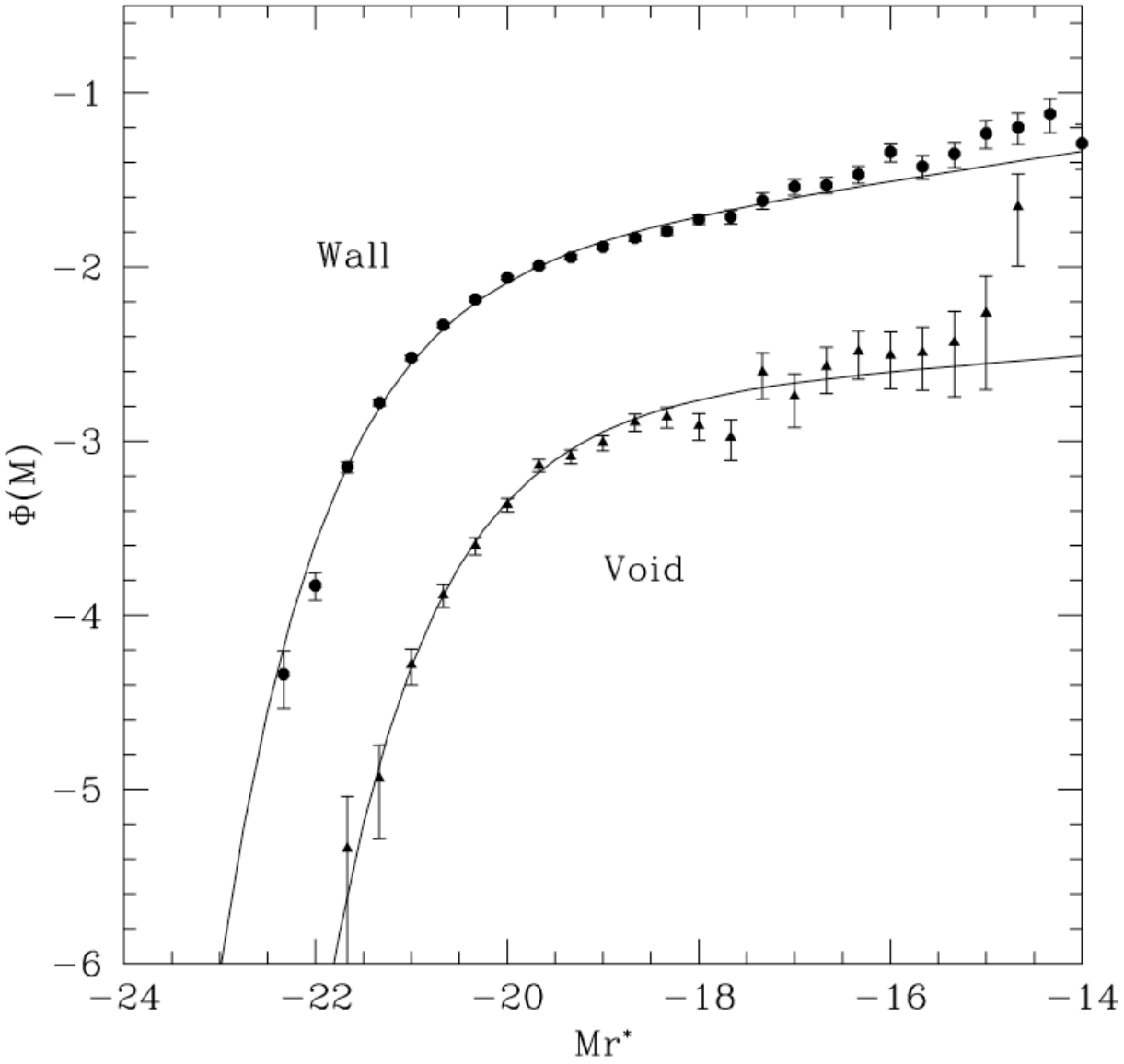




Rojas et al. 2004, 2005

Luminosity Function in Voids

Shifted vs. ‘wall’ environments

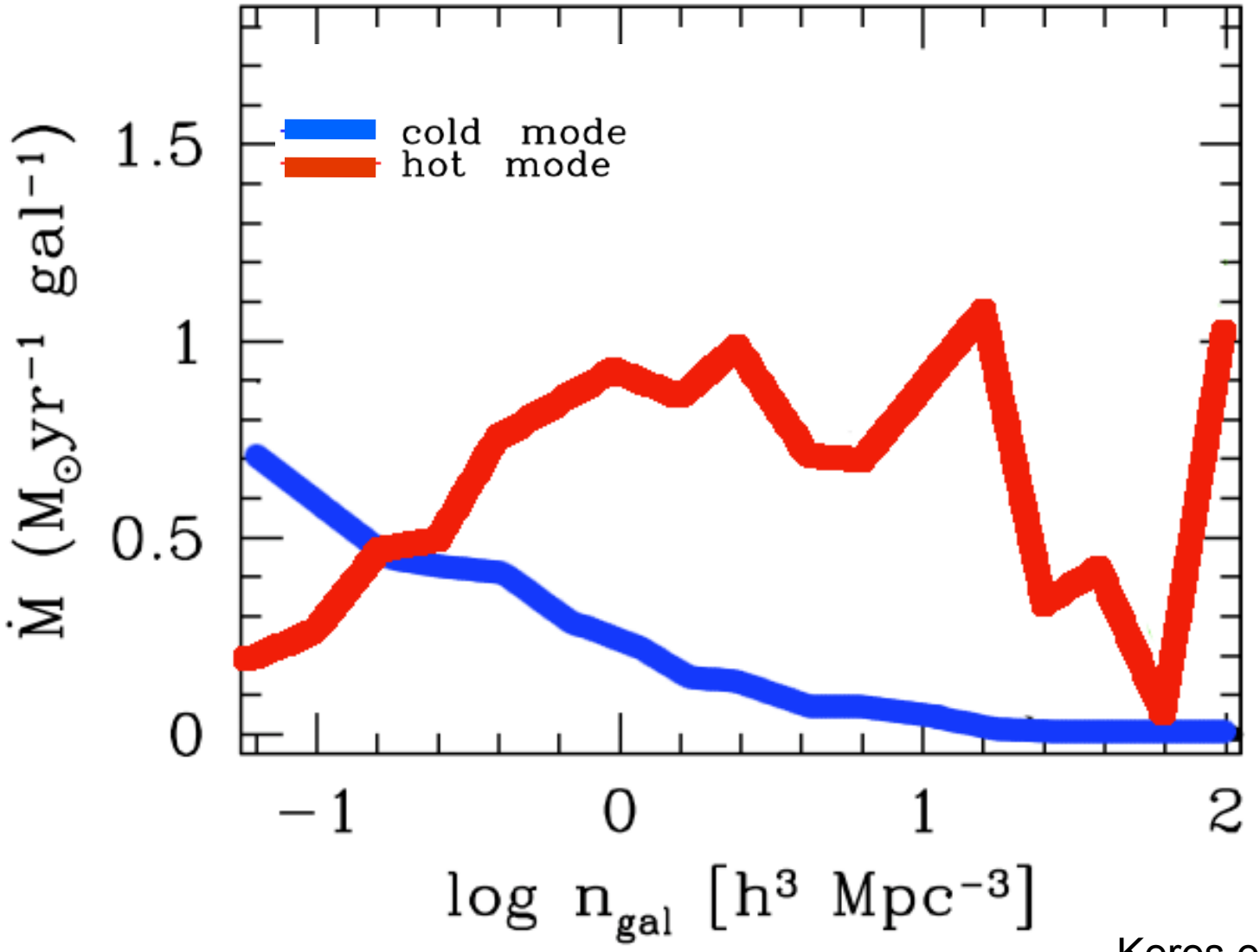


Voids as universes with lower Ω_M?

Hoyle et al. 2005

Galaxy Growth in Voids

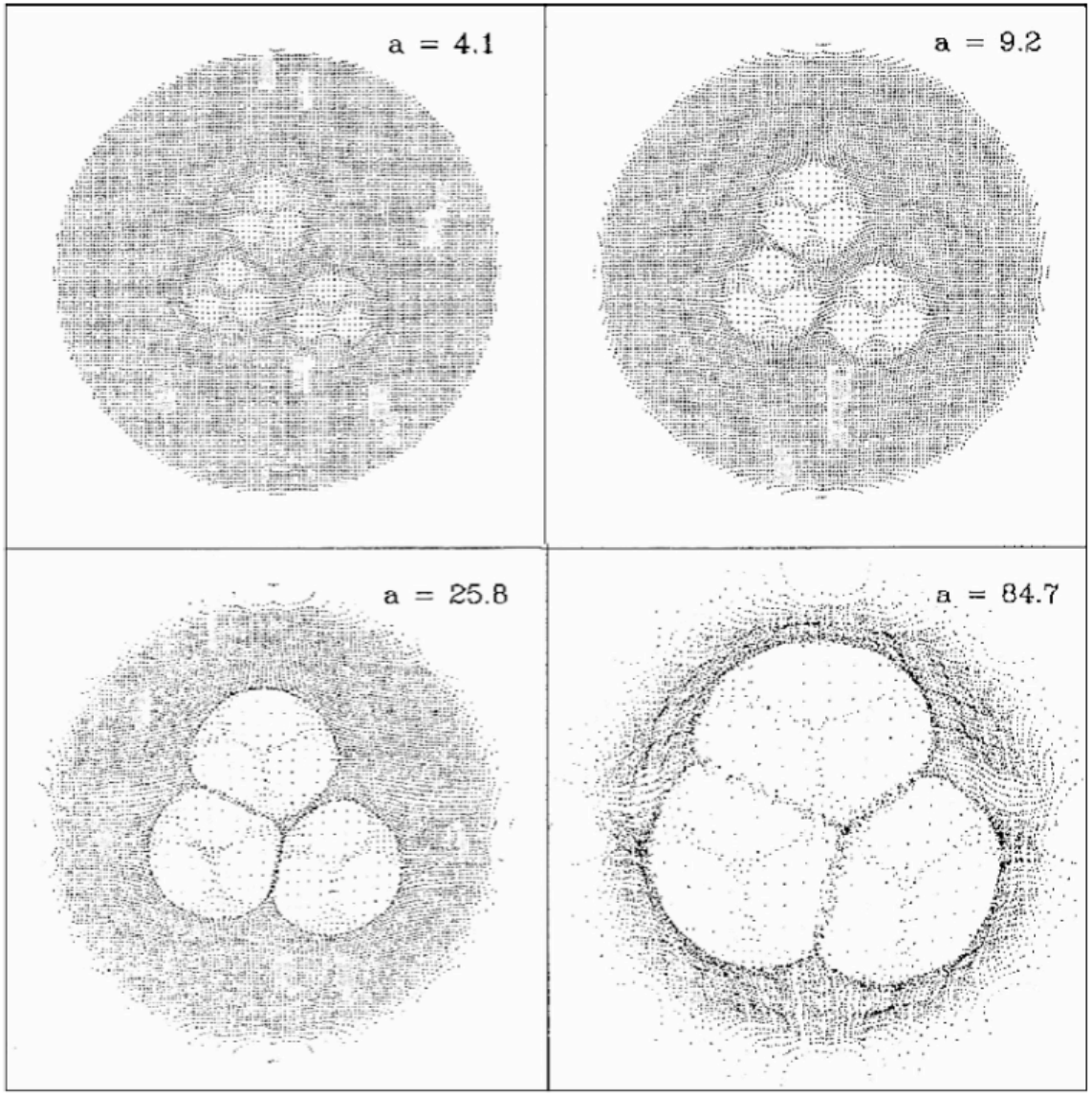
Cold mode accretion dominates



Keres et al. 2005

Substructure in Voids

Intervening substructure is diluted

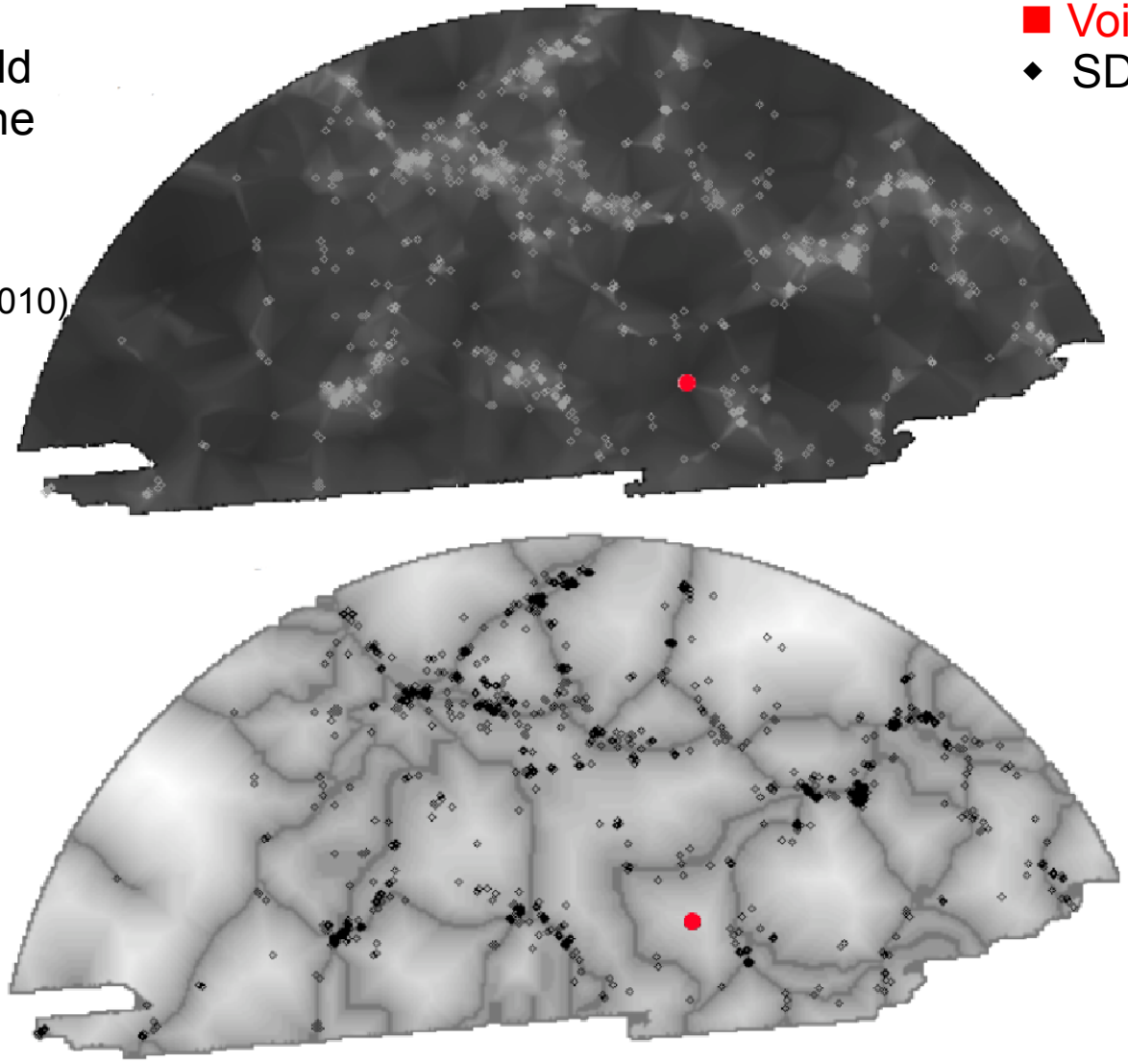


Dubinski et al. 1993

Topologically Identified Void Galaxies

Reconstructed DTFE density field with Cosmic Spine formalism

Van de Weygaert & Schaap 2007
Aragon-Calvo et al. 2010)



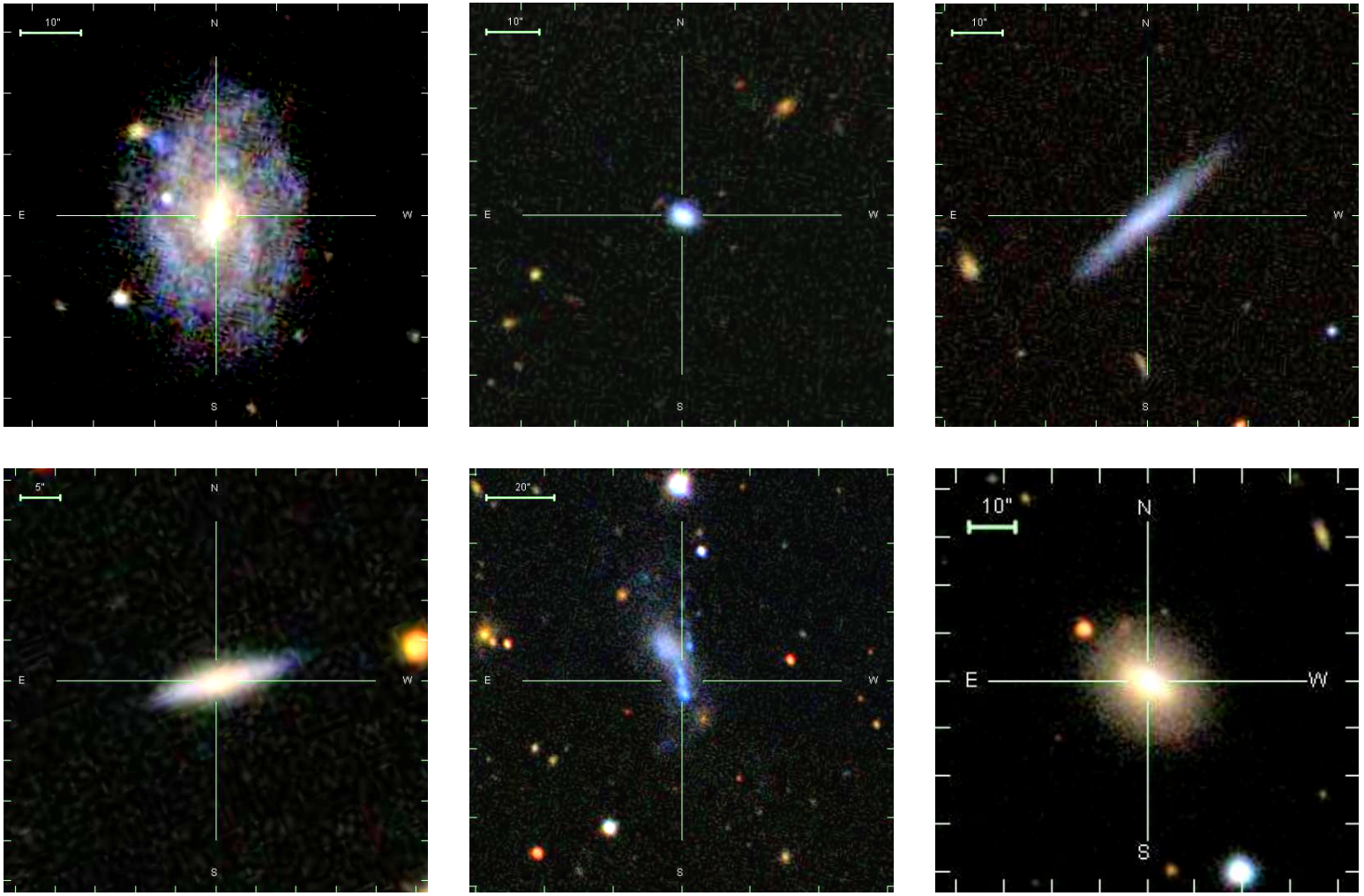
Watershed identified voids

Platen 2009

Kreckel et al. 2011

The Void Galaxy Survey (VGS)

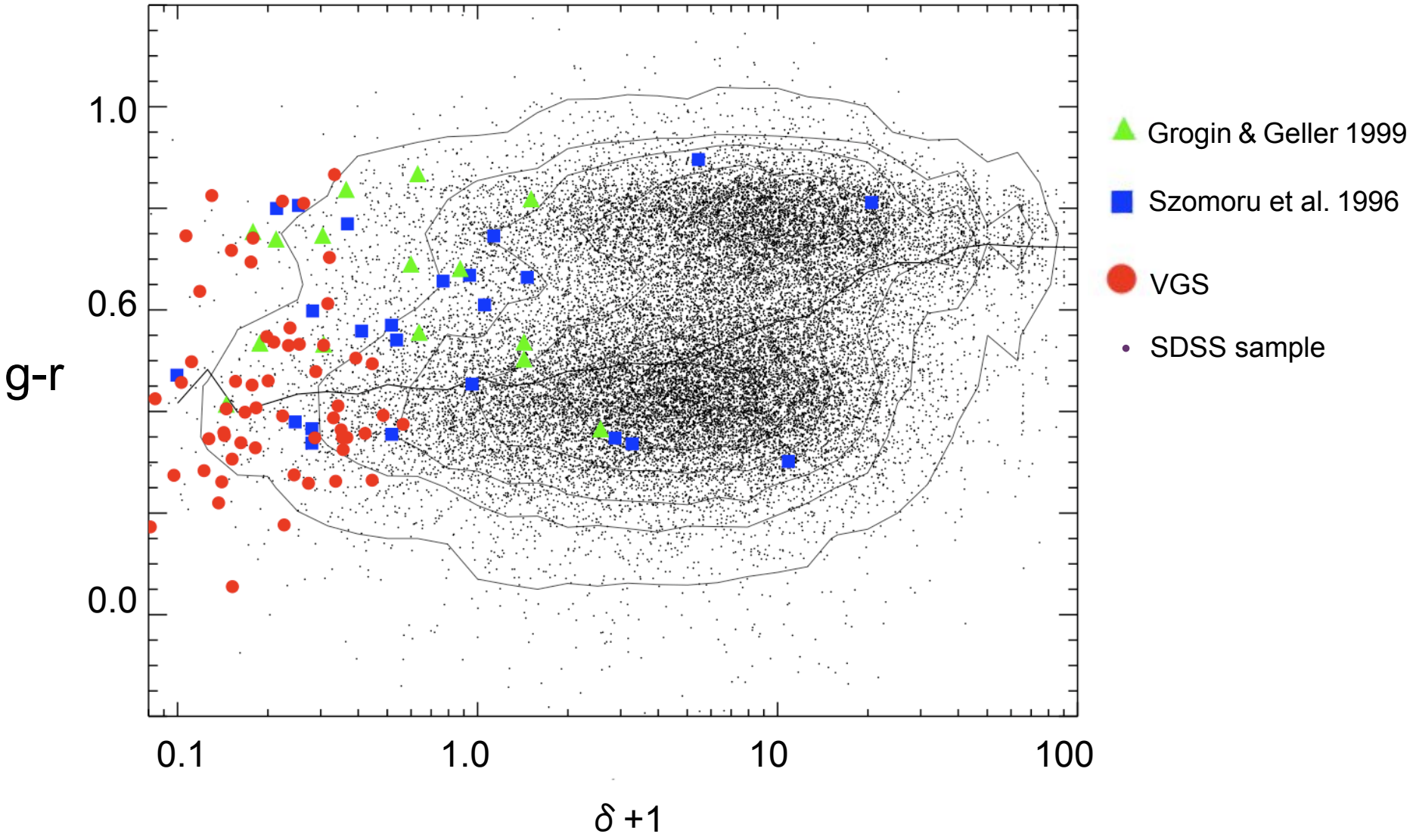
59 galaxies with a wide range of galaxy morphologies



SDSS color images, scaled to the same physical size 3kpc

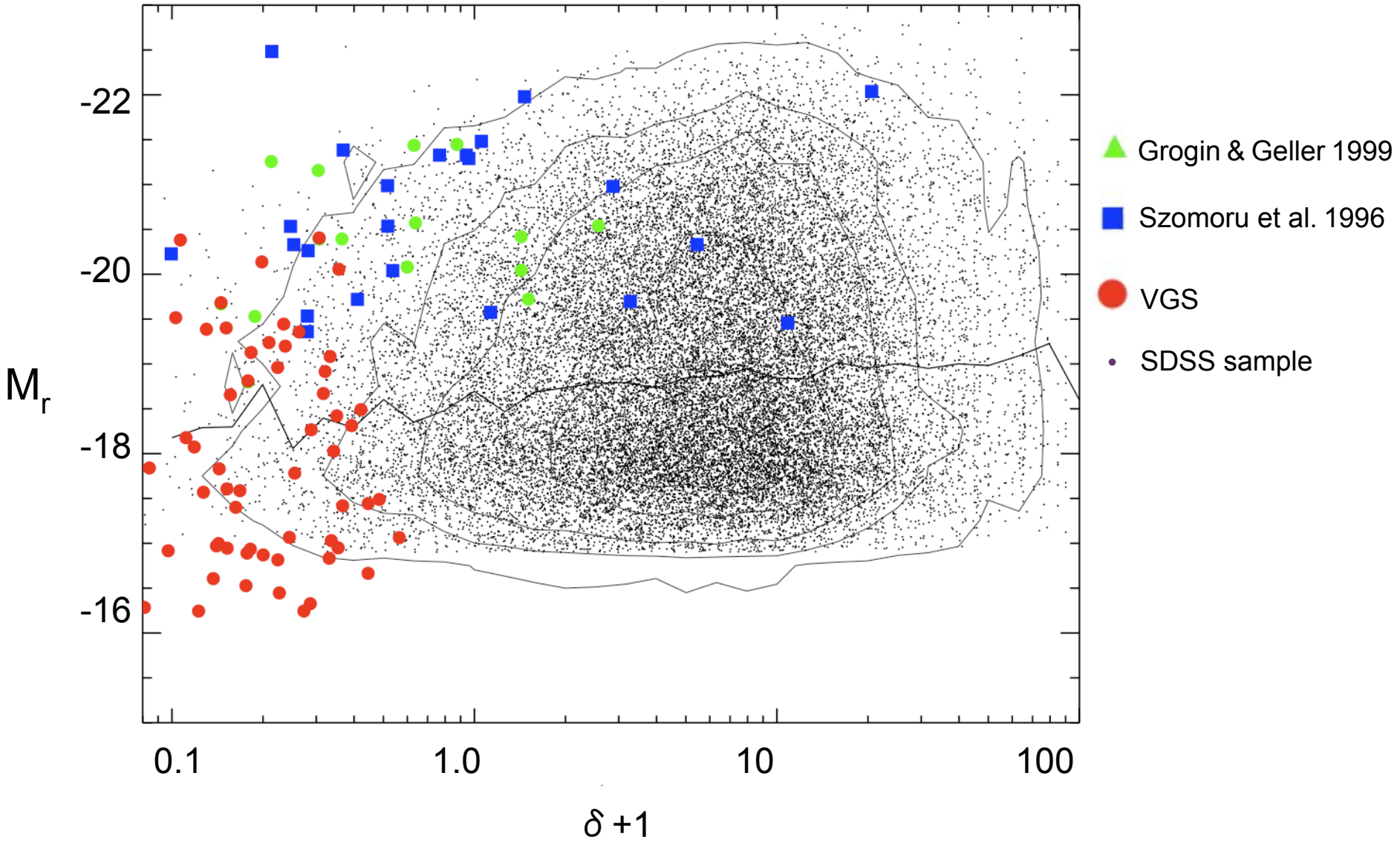
VGS

In the deepest underdensities with a range of colors...



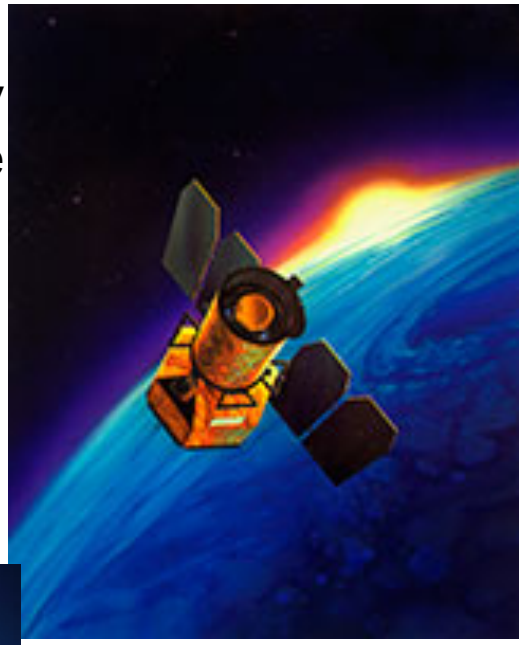
VGS

...and a range of magnitudes



The Void Galaxy Survey (VGS)

Near-UV
GALEX Telescope



21 cm
Westerbork
Synthesis
Radio
Telescope

H-α
MDM 2.4m Hiltner Telescope

3.6 & 4.5 μm
Spitzer

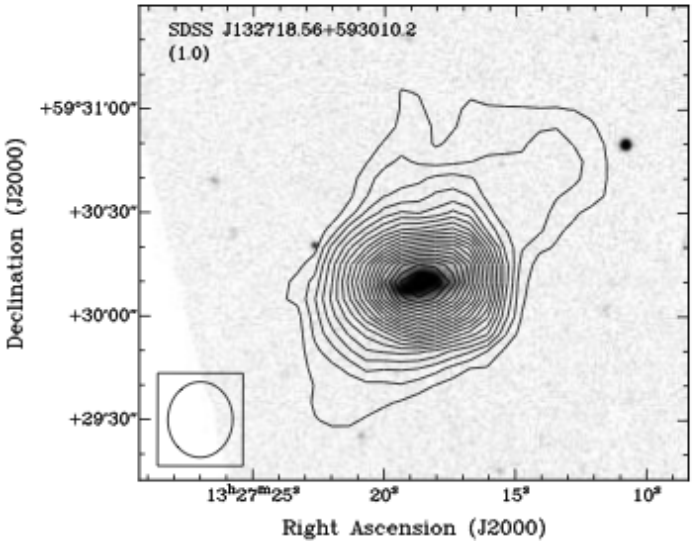
B & R –band
INT 2.5m

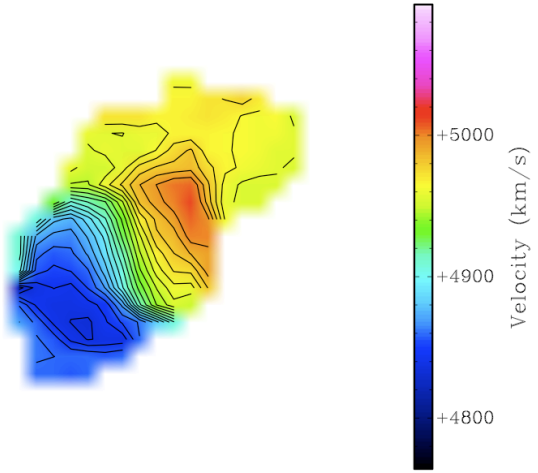
see also the next talk
by Burcu Beygu

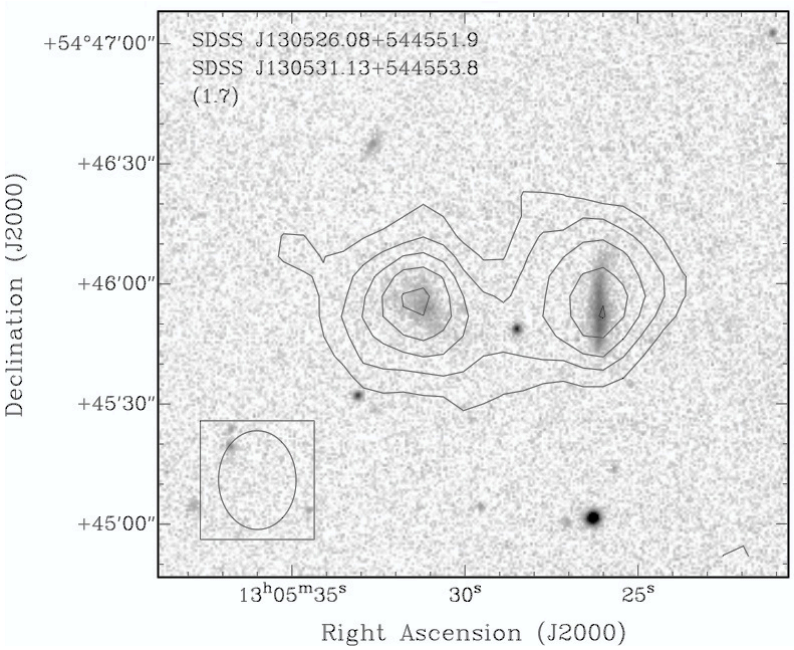
HI Observations

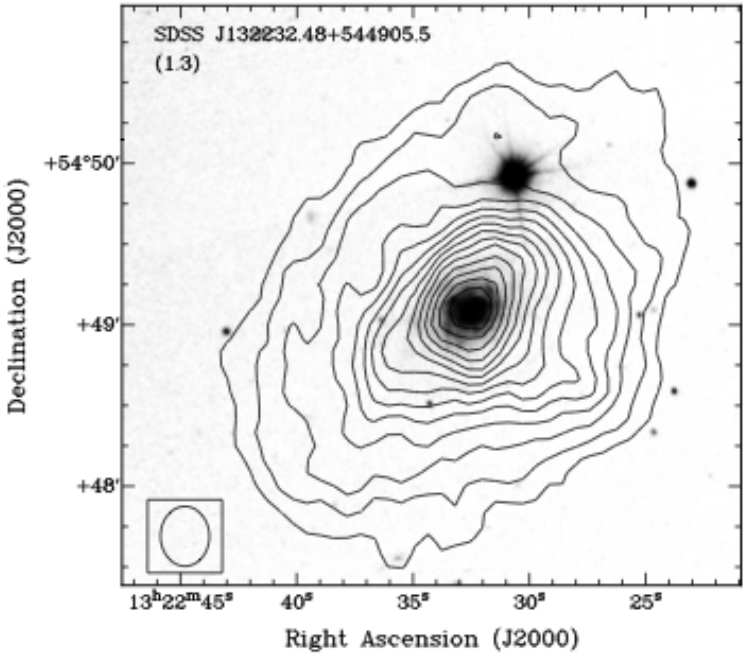
Kreckel et al. 2012

Extended, irregular and interacting systems.



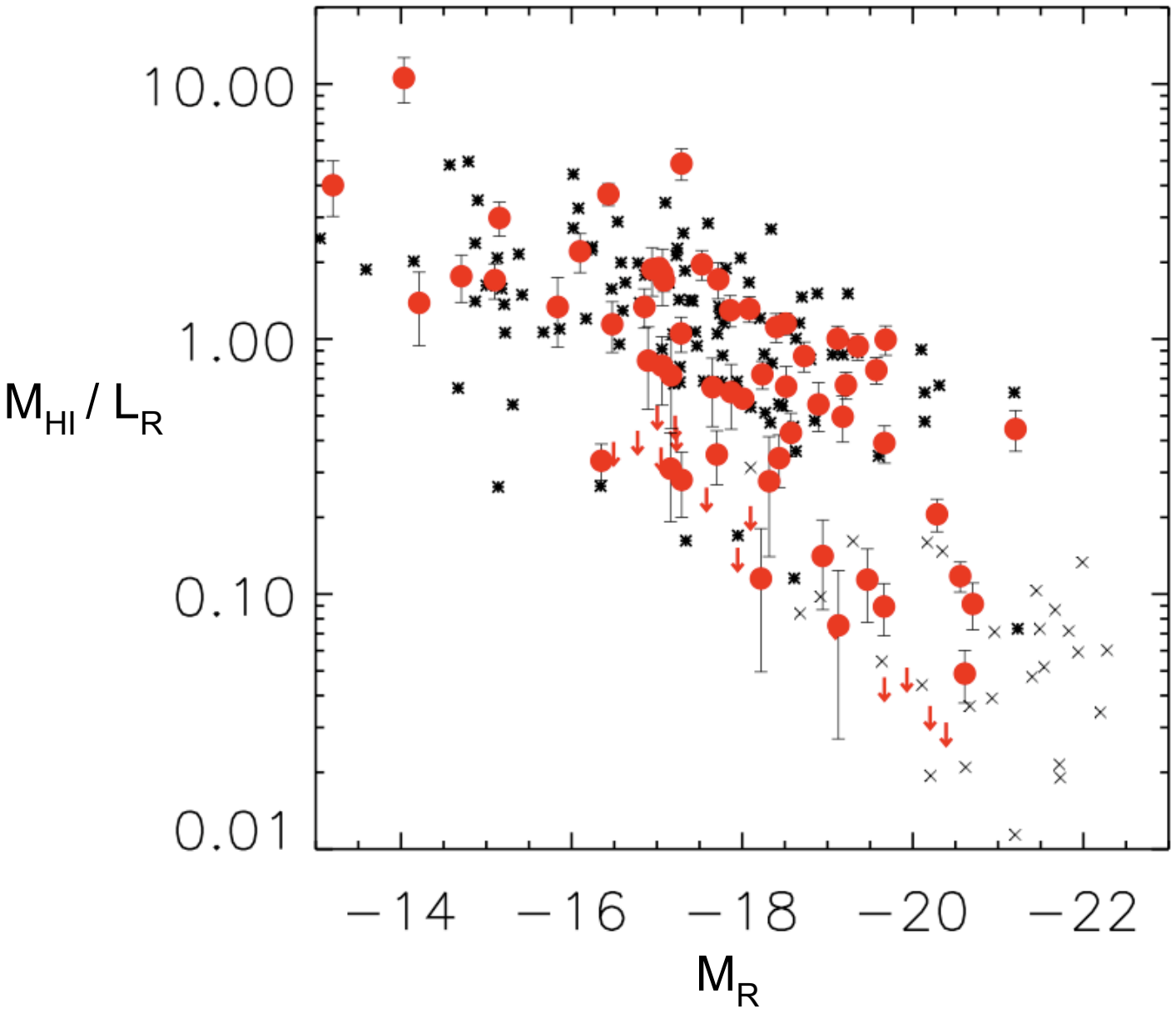






Integrated HI Content

The HI content is fairly typical for their size



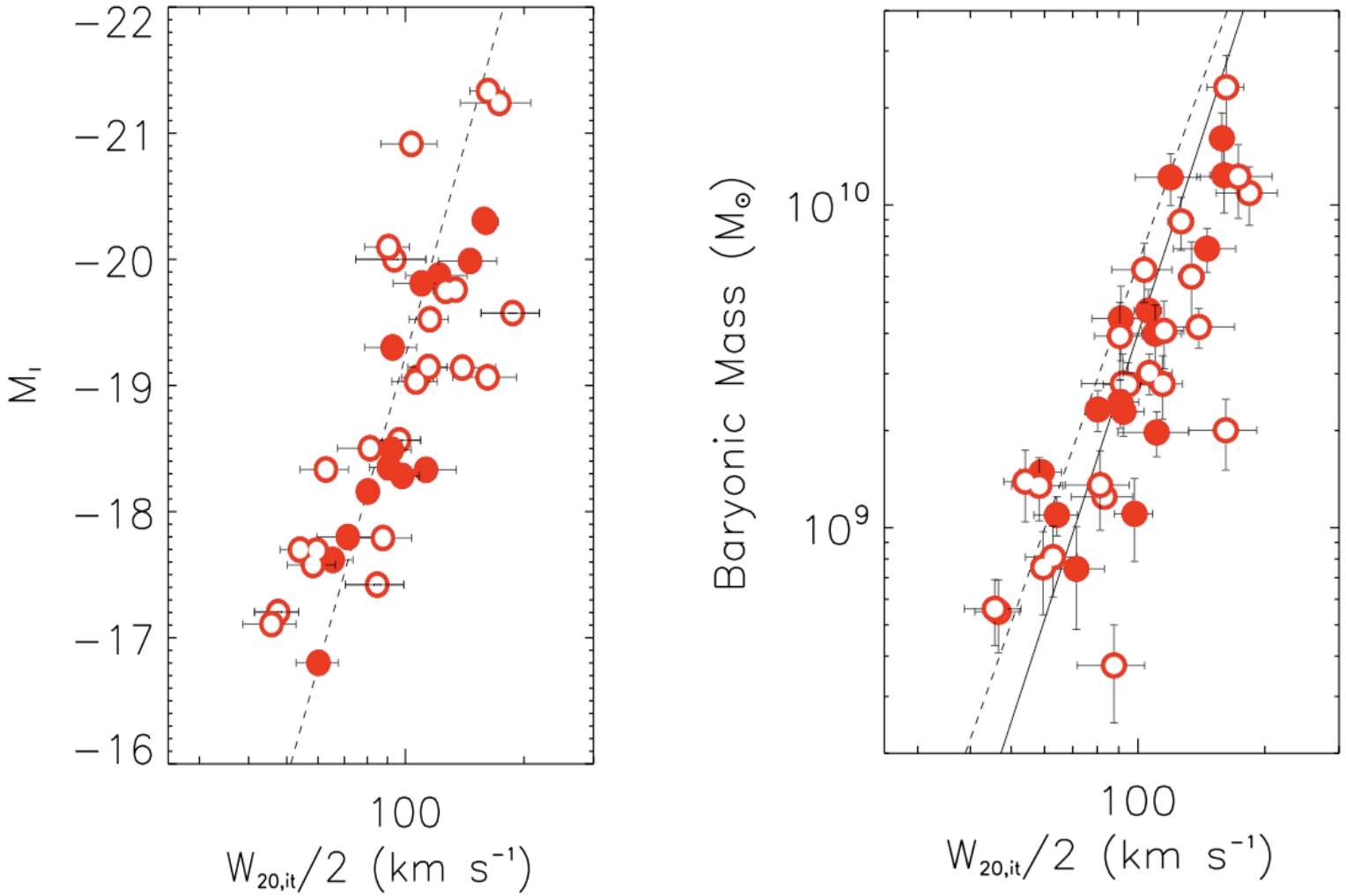
VGS

* WHISP
(Swaters et al. 2002)

x Ursa Minor
(Verheijen & Sancisi 2001)

Tully-Fisher Relation

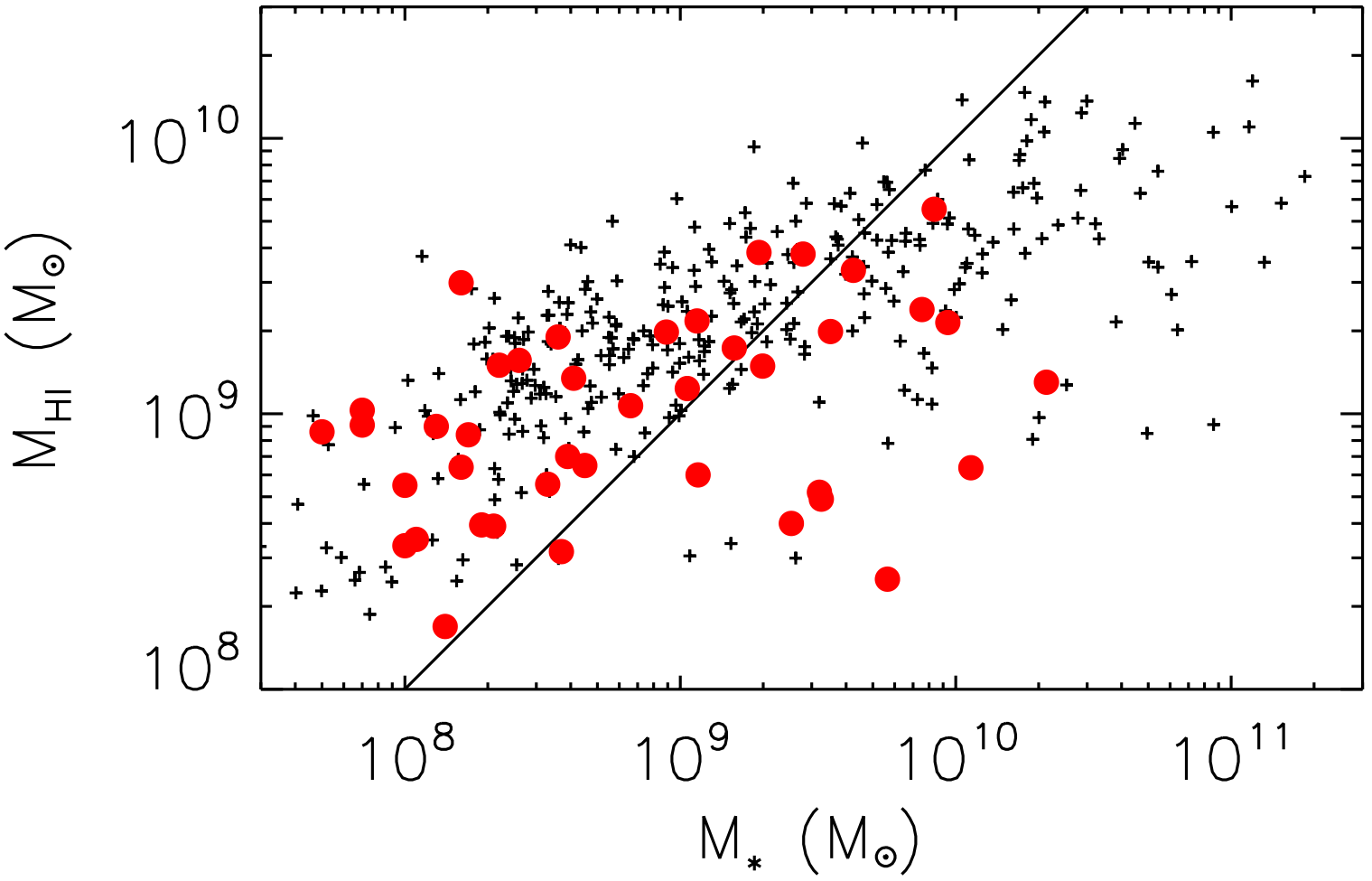
Follow the I-band Tully-Fisher relation



As compared with Geha et al. 2006 (dashed) and McGaugh et al. 2000 (solid)

HI and Stellar Masses by Environment

Very few galaxies in low density environments have large amounts of HI

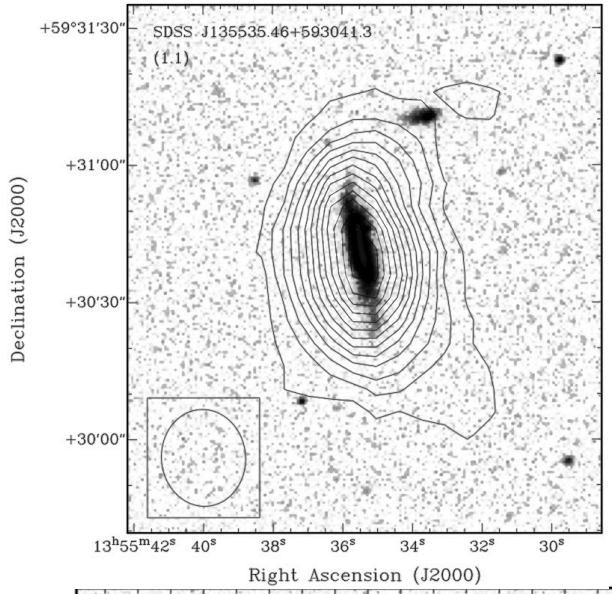


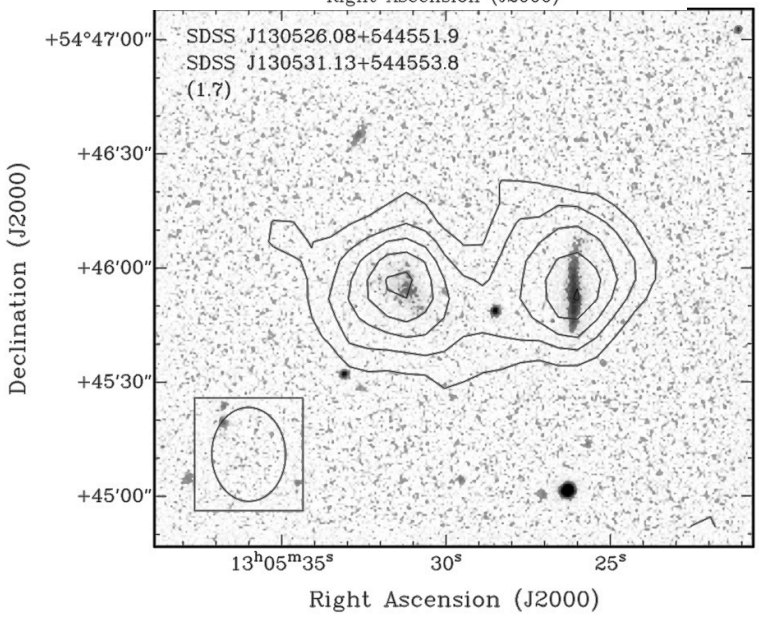
ALFALFA
average density

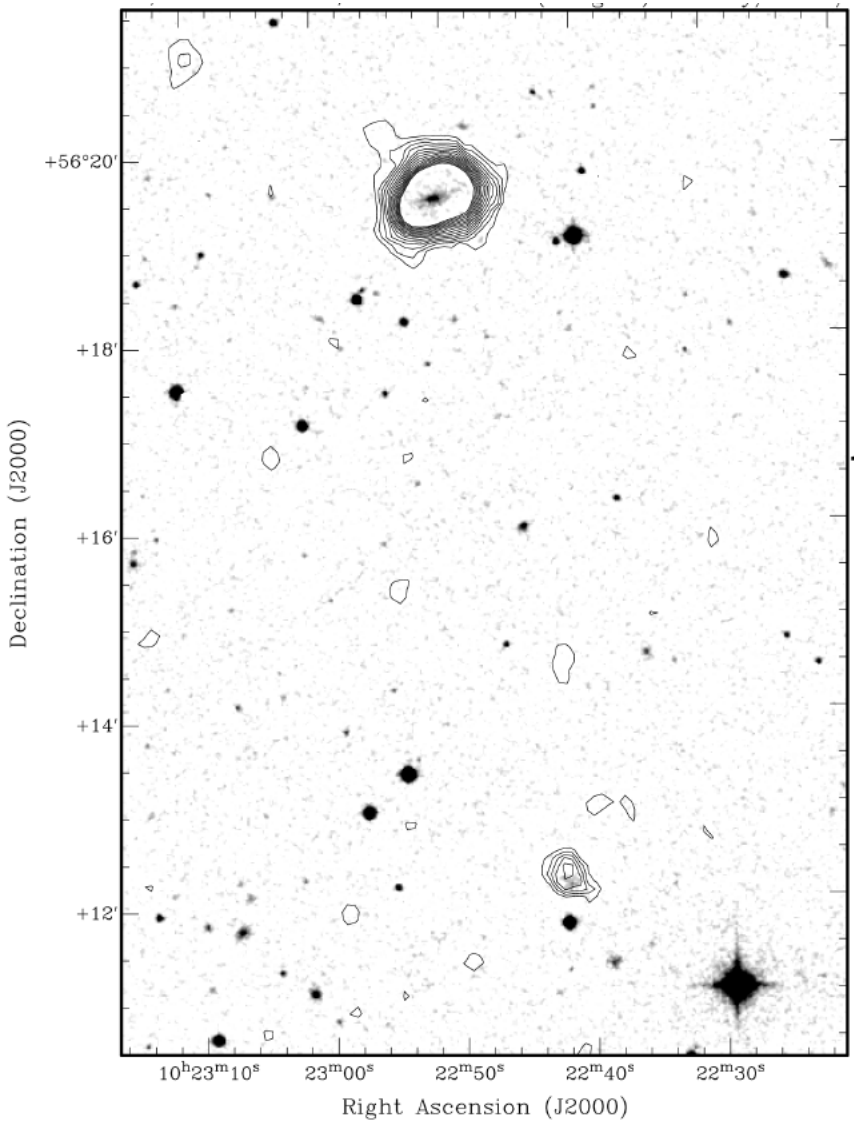
VGS
void galaxies

Lonely but not Alone

18 additional galaxies are detected in HI, most within 100 kpc and 100 km/s of the targeted VGS galaxy

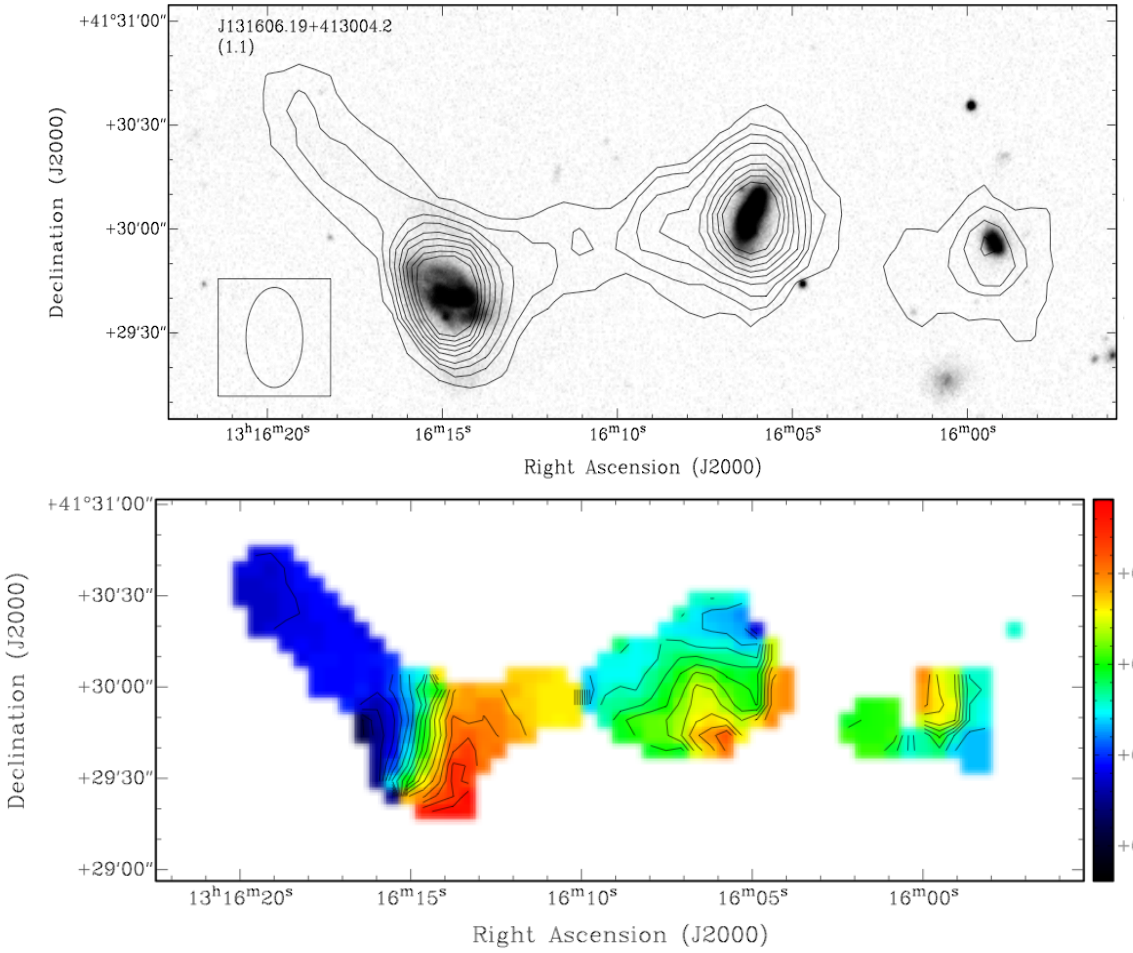






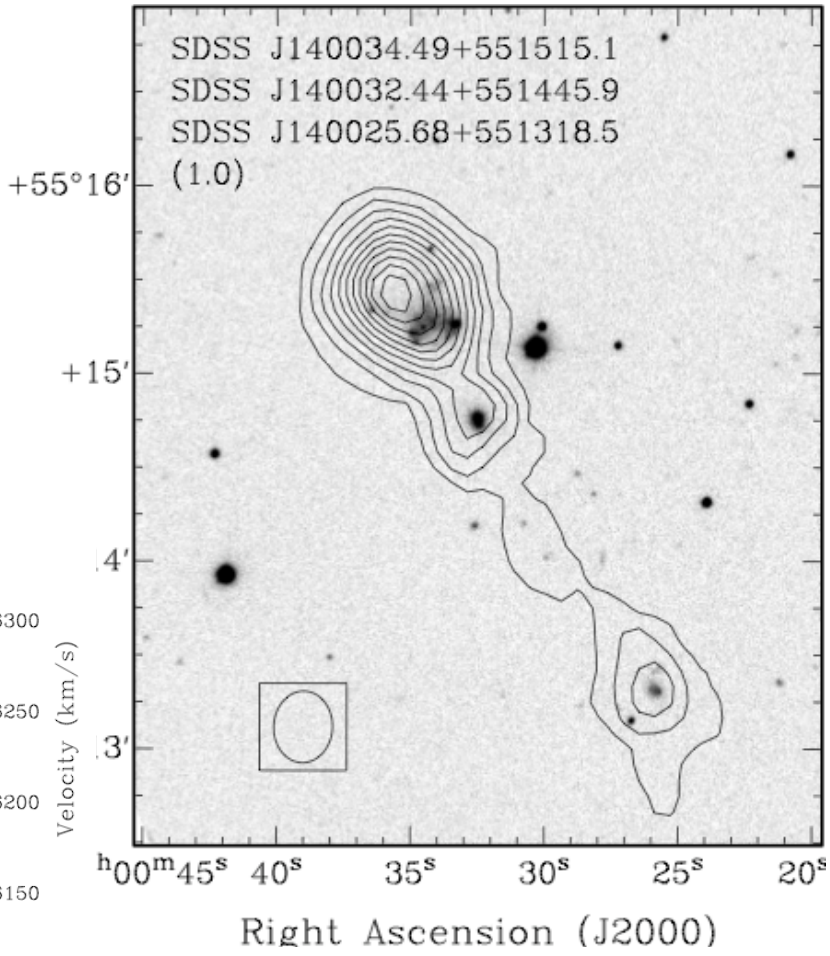
Observed Substructure in Voids?

Alignment between galaxies and connecting HI



VGS 31 system

Beygu et al., 2013
Rieder et al. 2013



Kreckel et al. 2011

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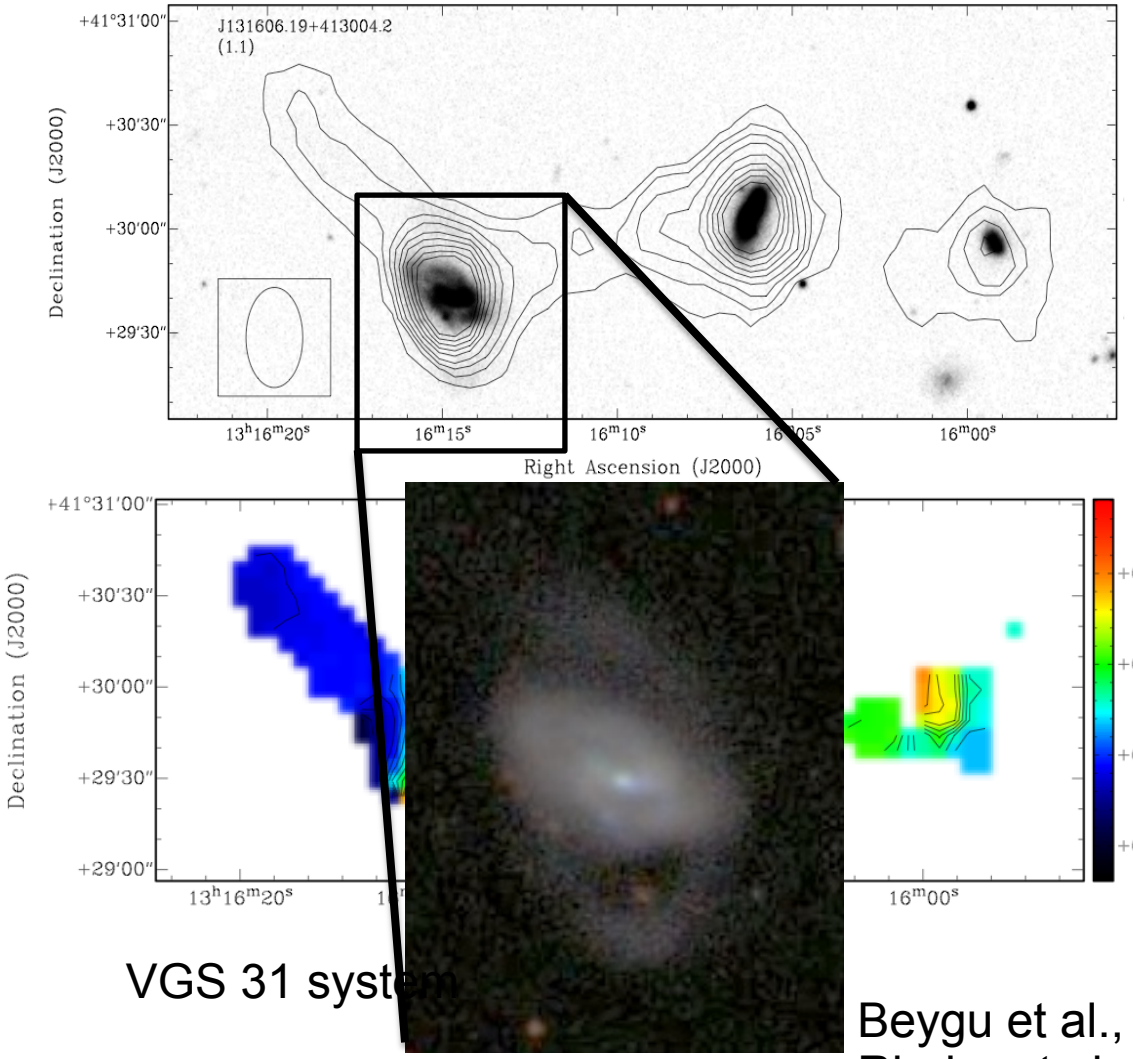

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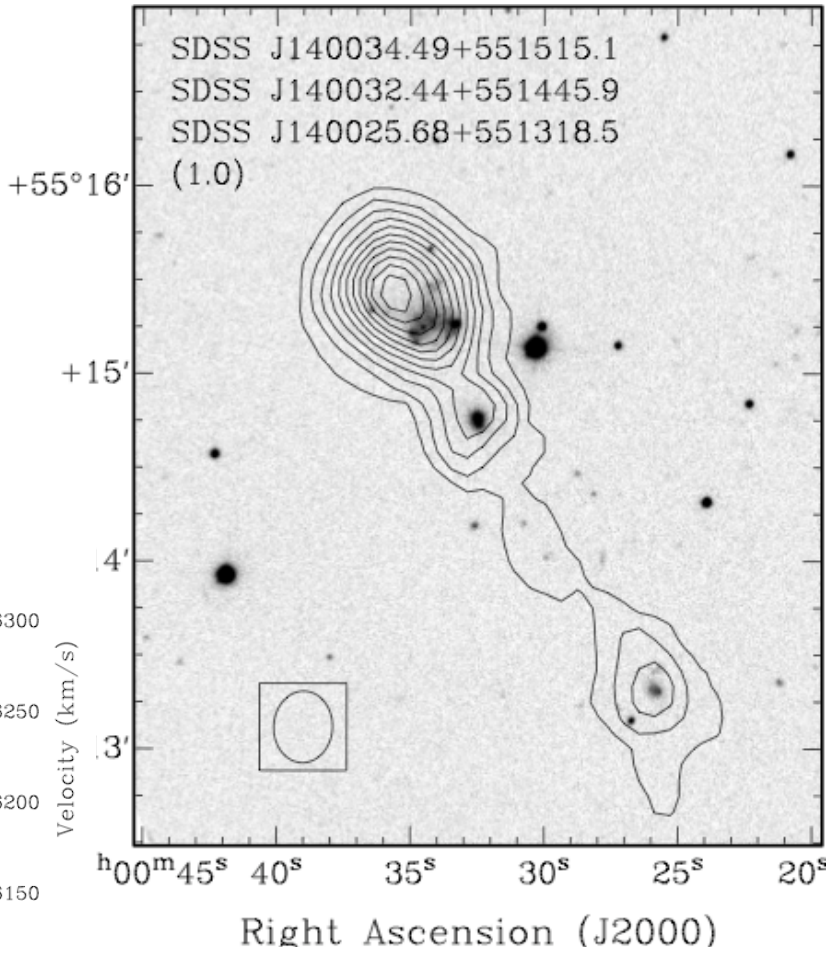

Kreckel et al. 2011

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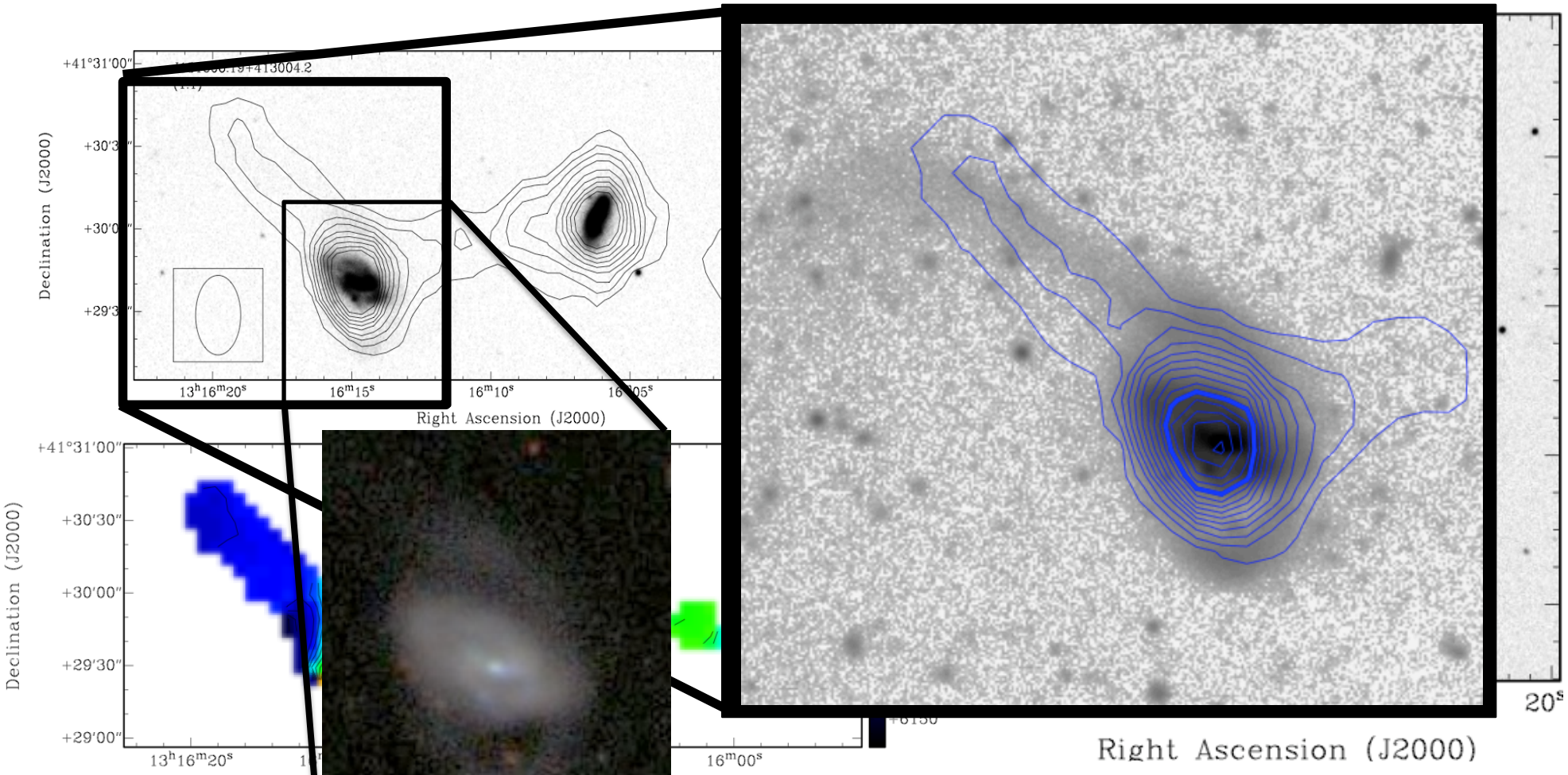


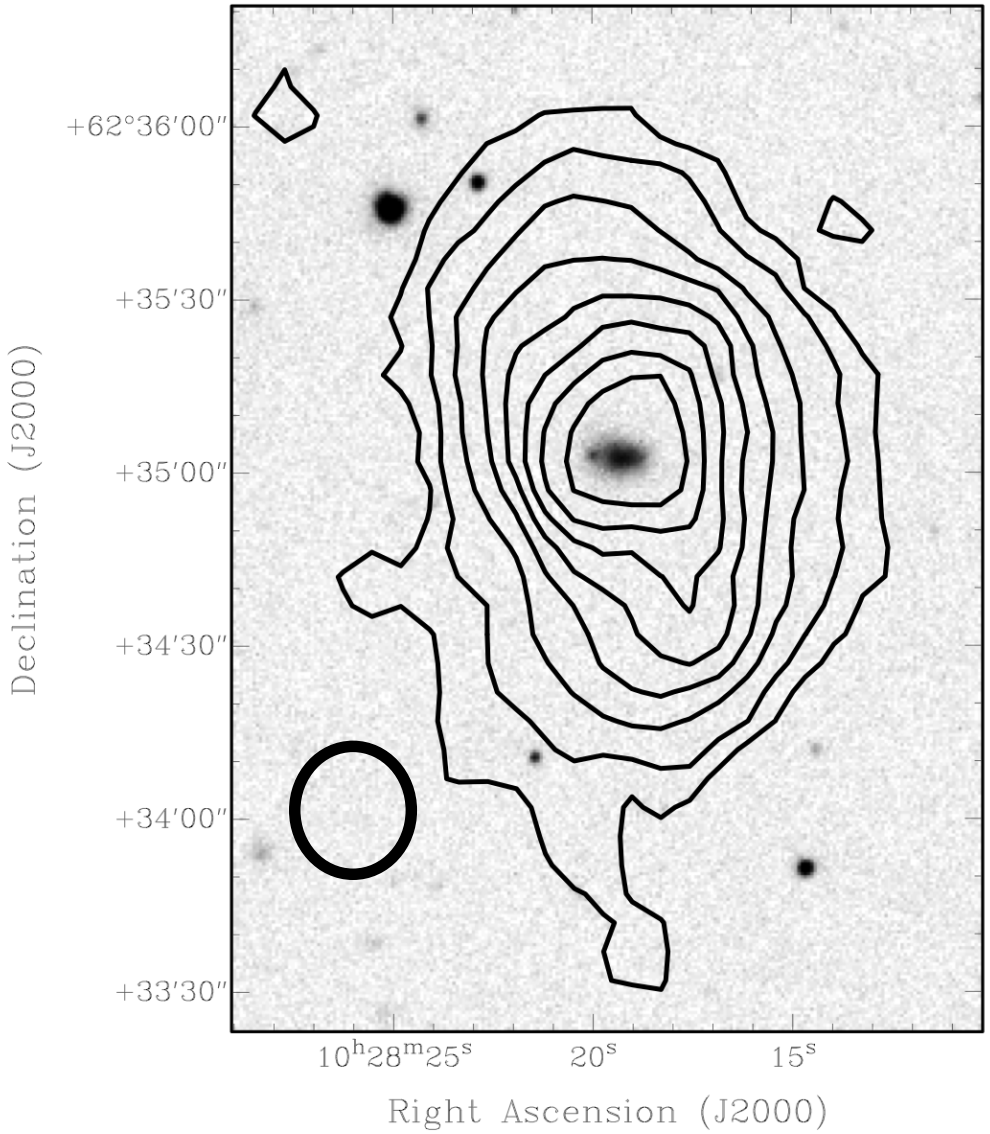
VGS 31 system

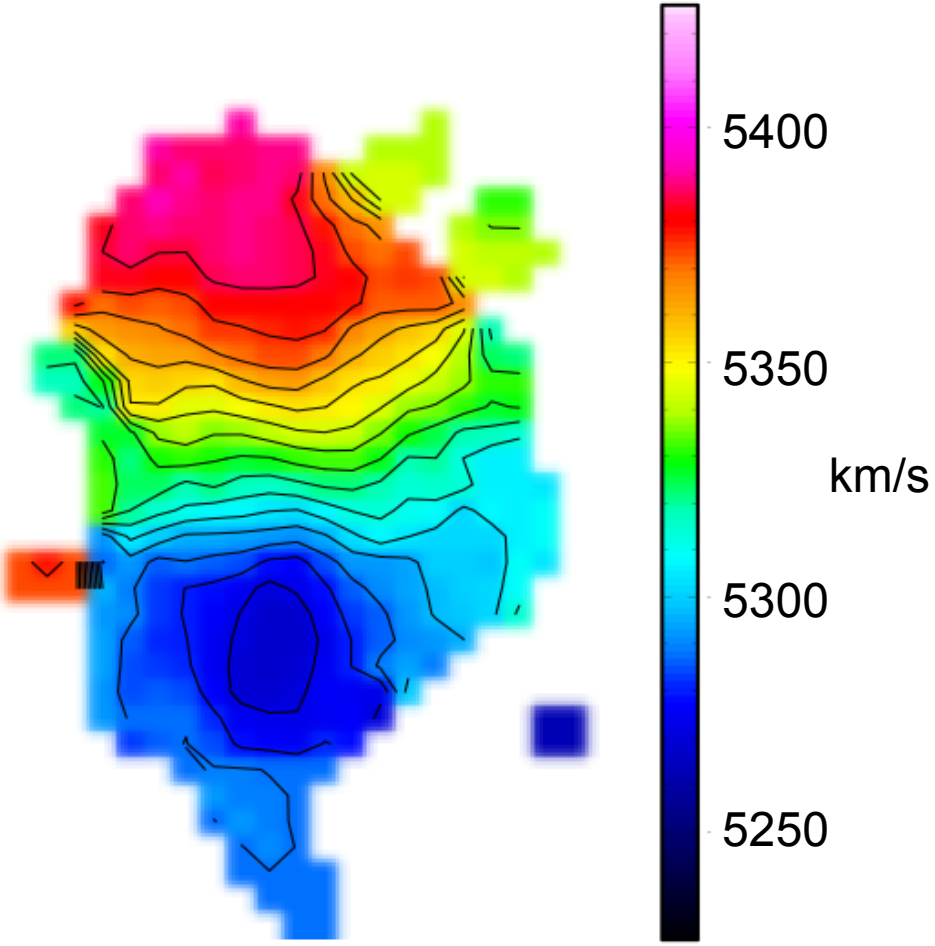
Beygu et al., 2013
Rieder et al. 2013

Kreckel et al. 2011

Gas Accretion in Void Galaxies

The massive, extended, star-poor gas disk and undisturbed central stellar disk suggest cold mode accretion as the most likely formation mechanism in this system

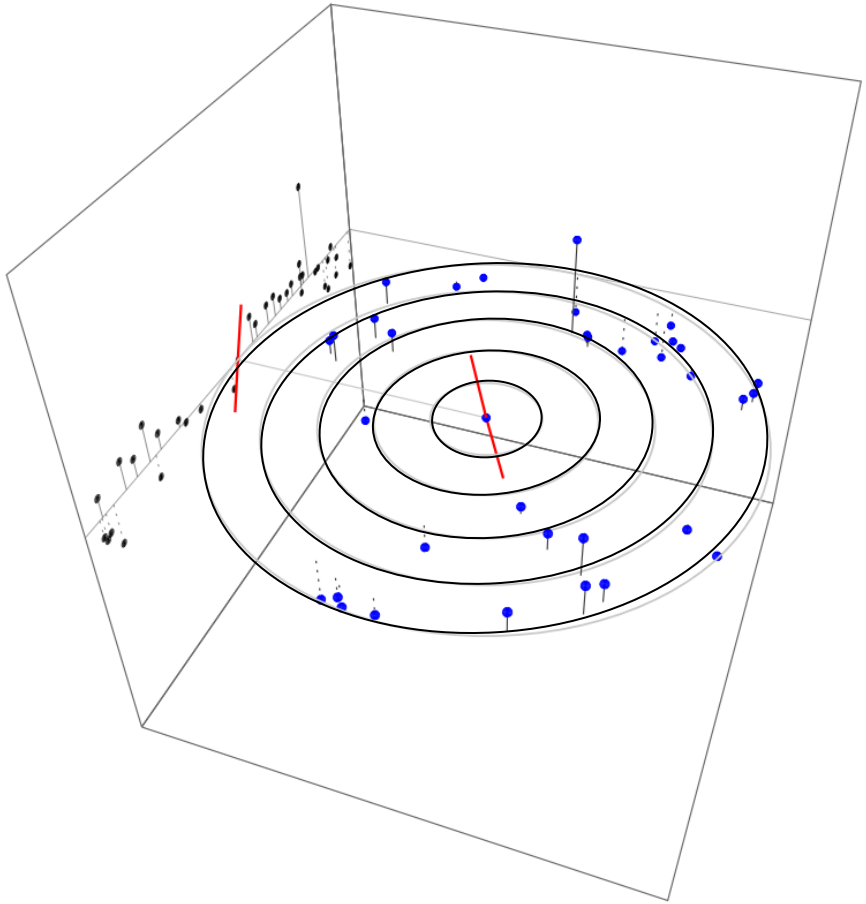


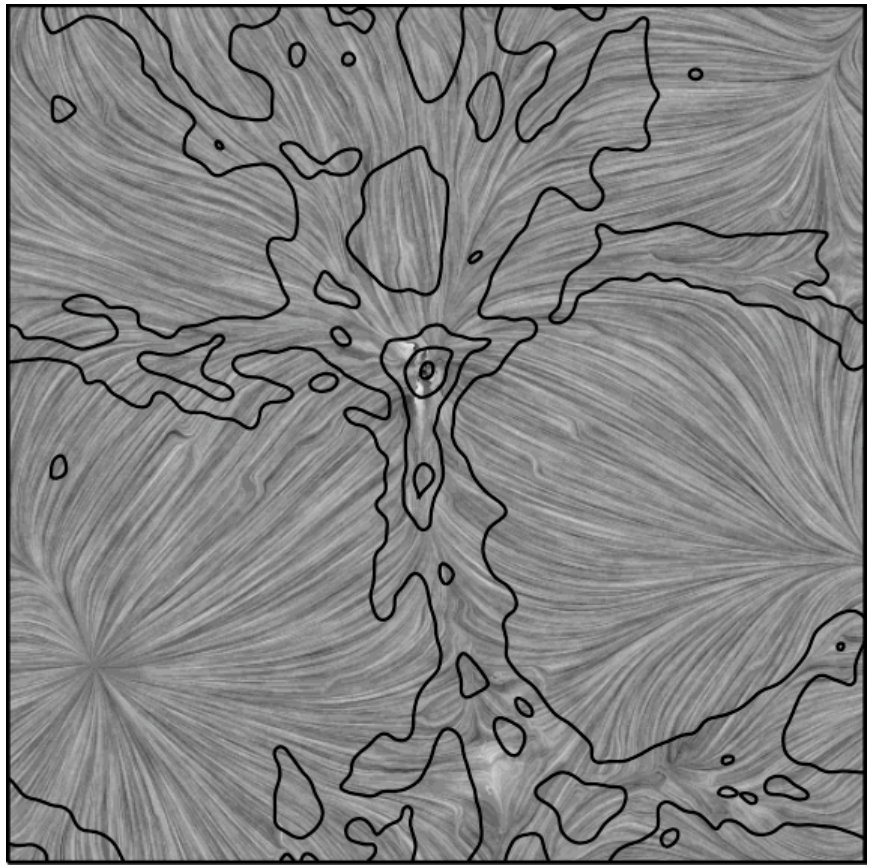


Stanonik et al. 2009

Gas Accretion in Void Galaxies

HI disk perpendicular to thin wall - accretion from out of the void?

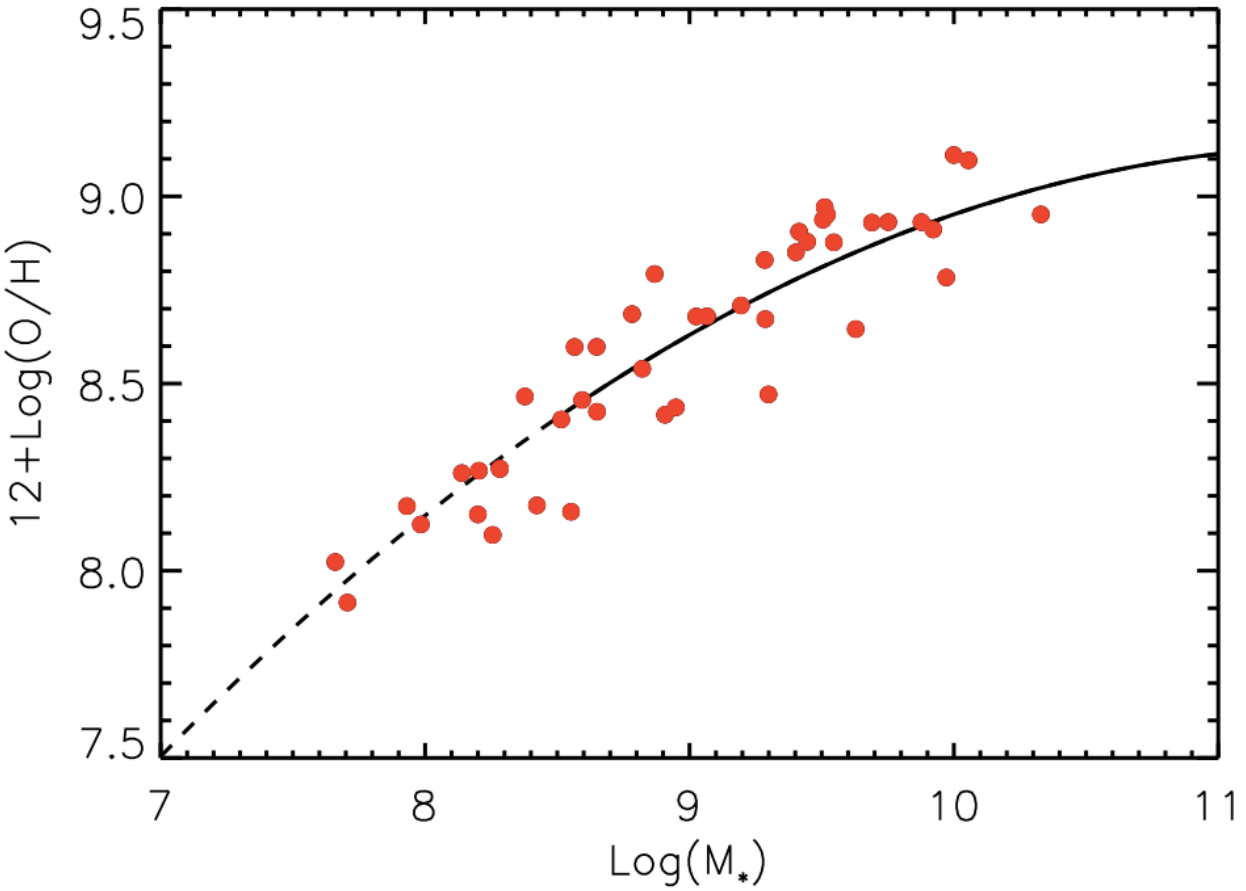


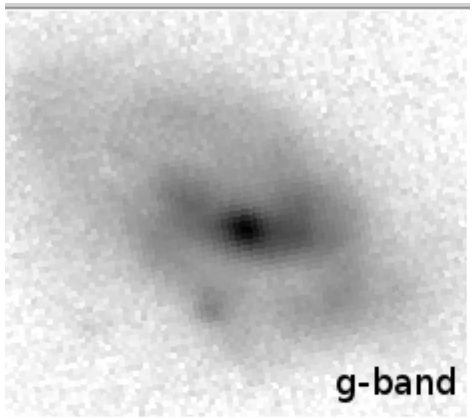


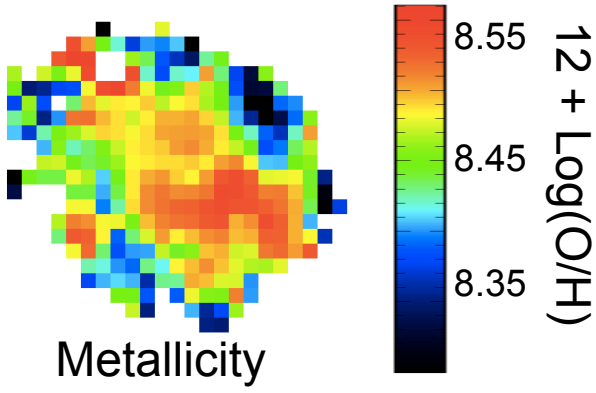
Stanonik et al. 2009

Gas Accretion & Gas Phase Metallicity

Nature vs nurture?



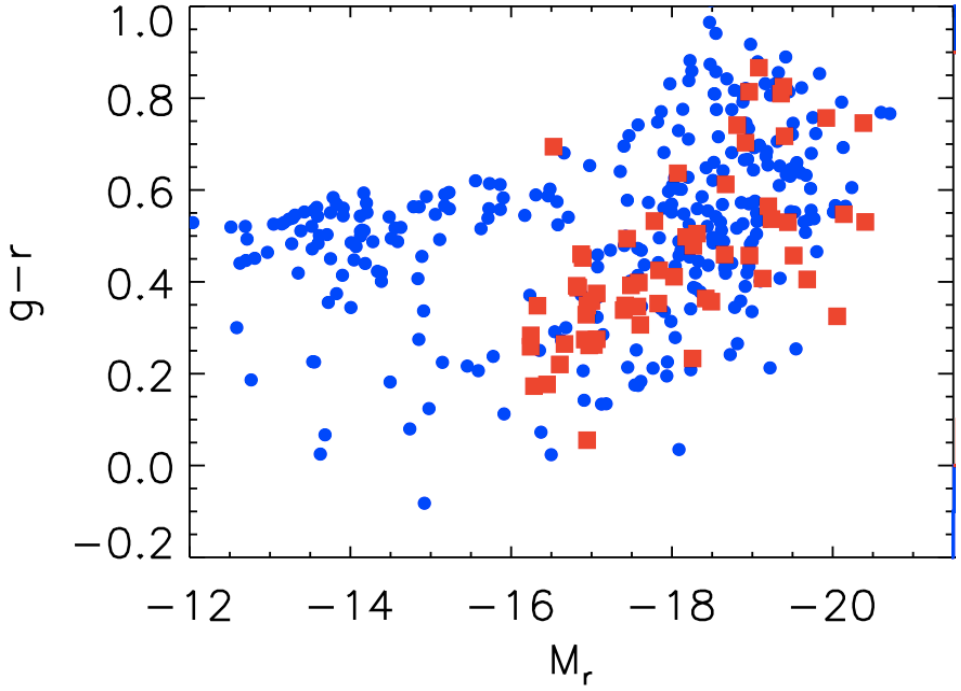


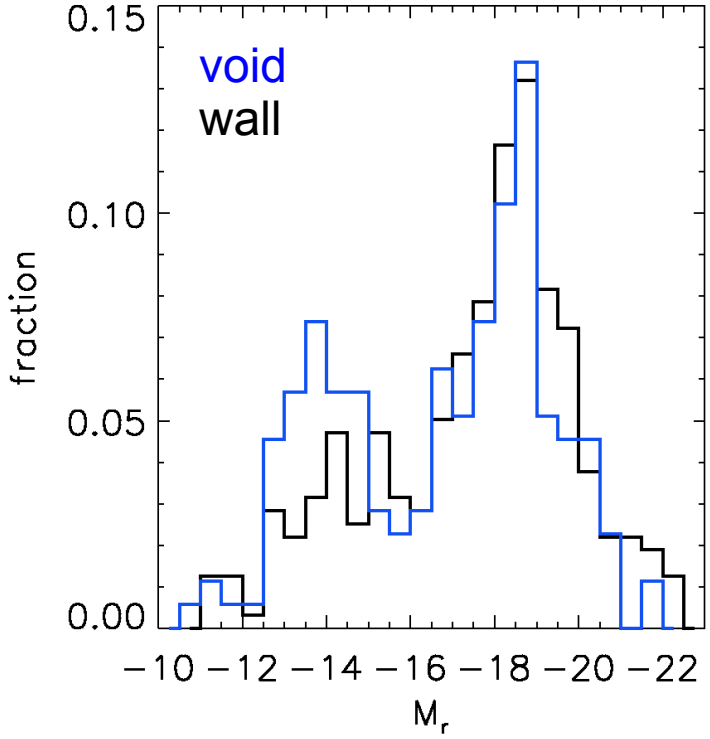


Kreckel et al. in prep

The Void Phenomenon – Hydrodynamic Cosmological Simulation

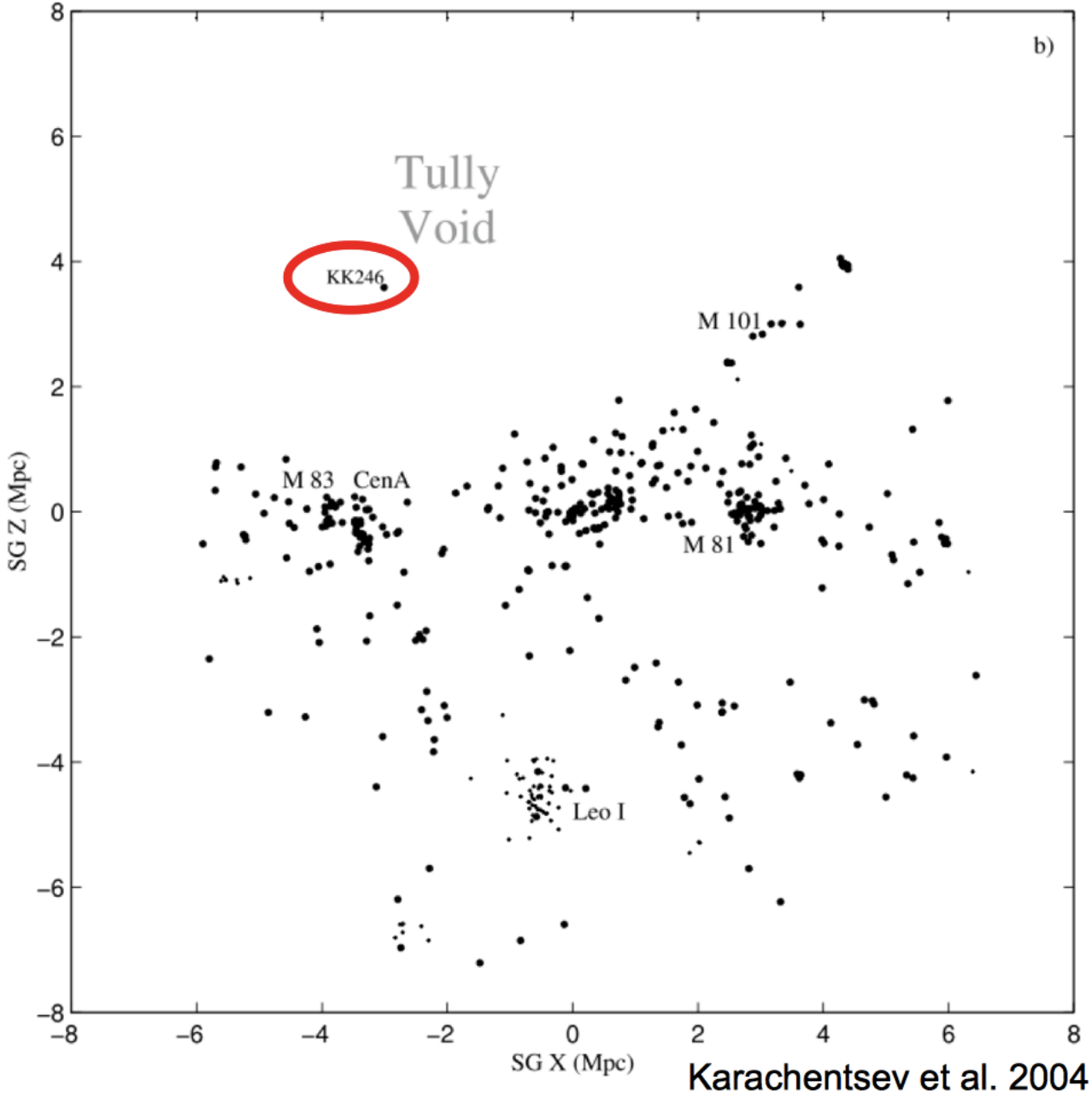
Local Void places some constraints, more observations needed





Kreckel, Joung, Cen 2011

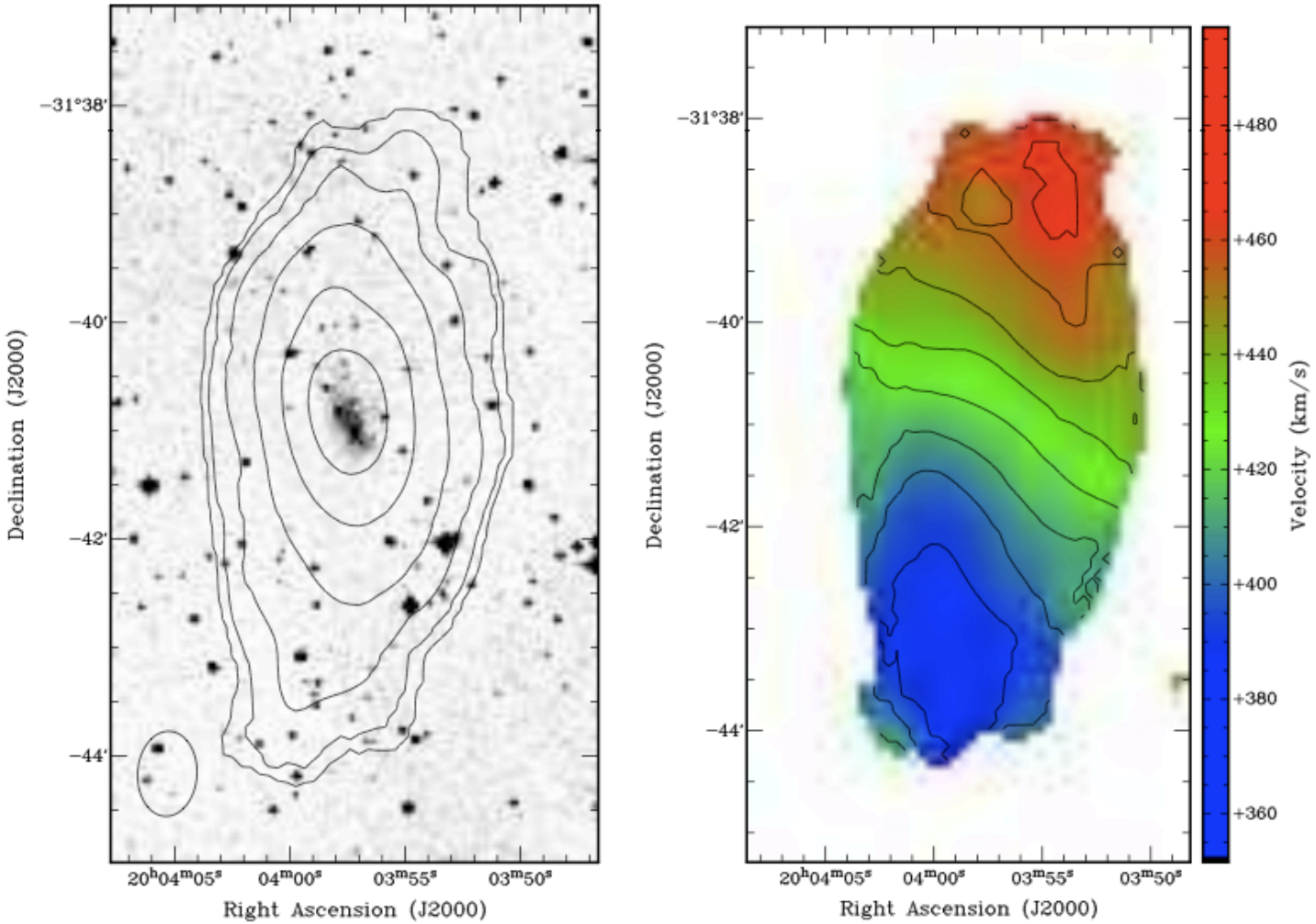
Local Volume Void Galaxy



Karachentsev et al. 2004

Gas Accretion in Void Galaxies

KK246 - Extended HI disk with anomalous gas accretion



Kreckel et al. 2011

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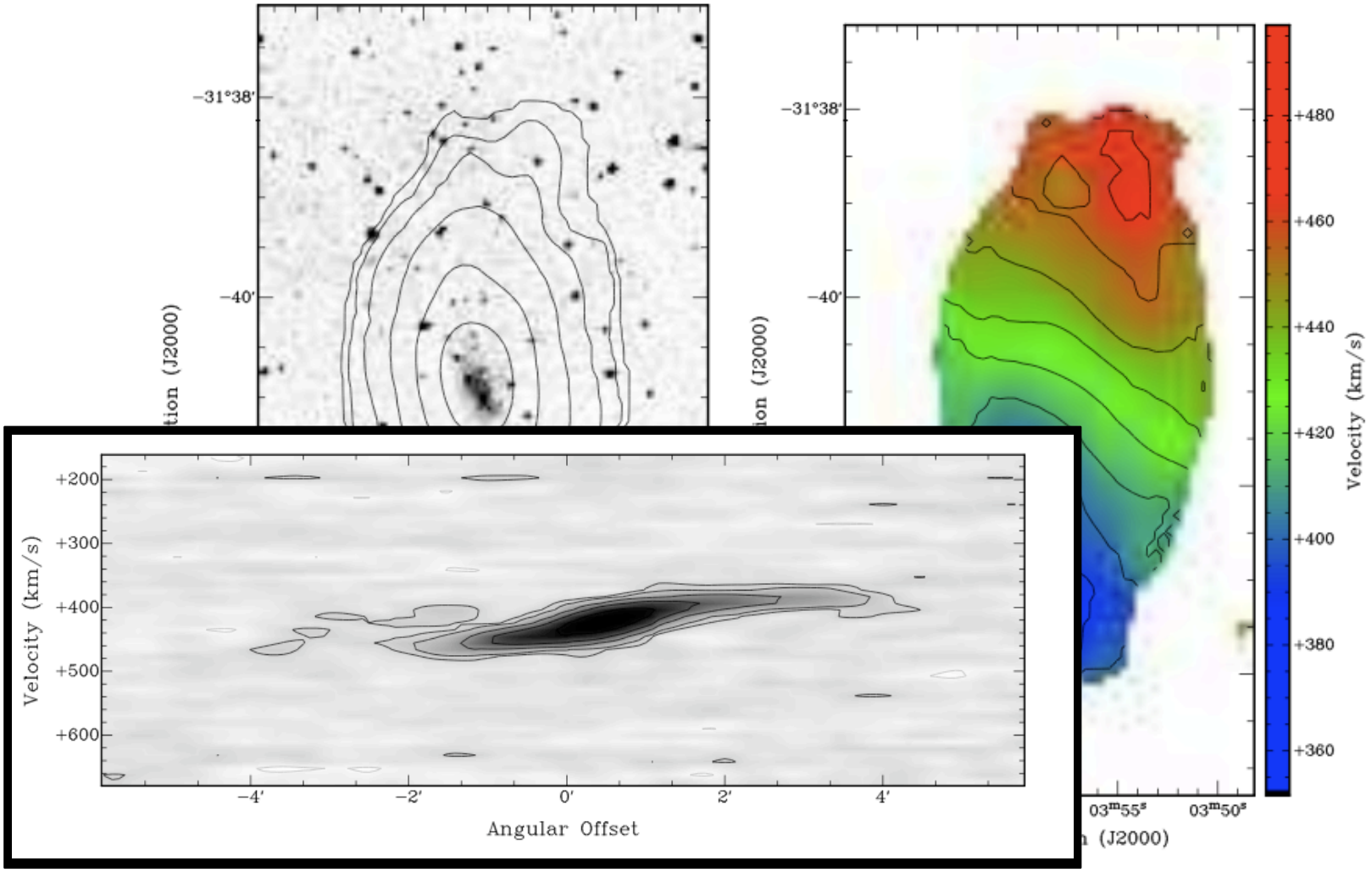
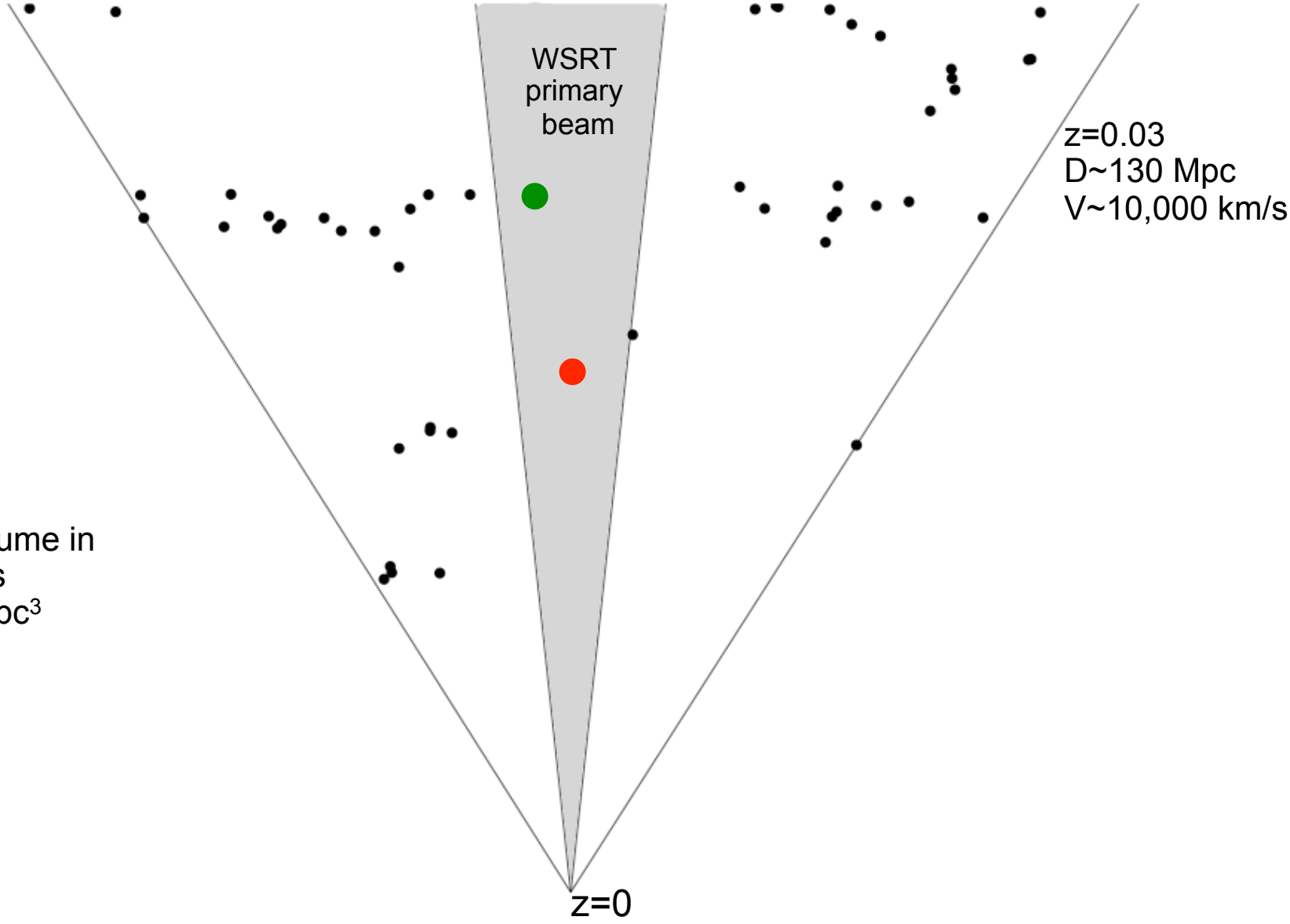


Kreckel et al. 2011

HI Constraints on the Void Phenomenon

No significant population of HI rich galaxies in the void



Total volume in
the voids
~500 Mpc^3

SUMMARY

- **59 VGS targets**, selected purely by environment
- Small, blue, **gas-rich** disk galaxies
- Evidence of **ongoing slow accretion** of cold gas
- Ideal for **cosmological tests** and studies of **galaxy evolution**