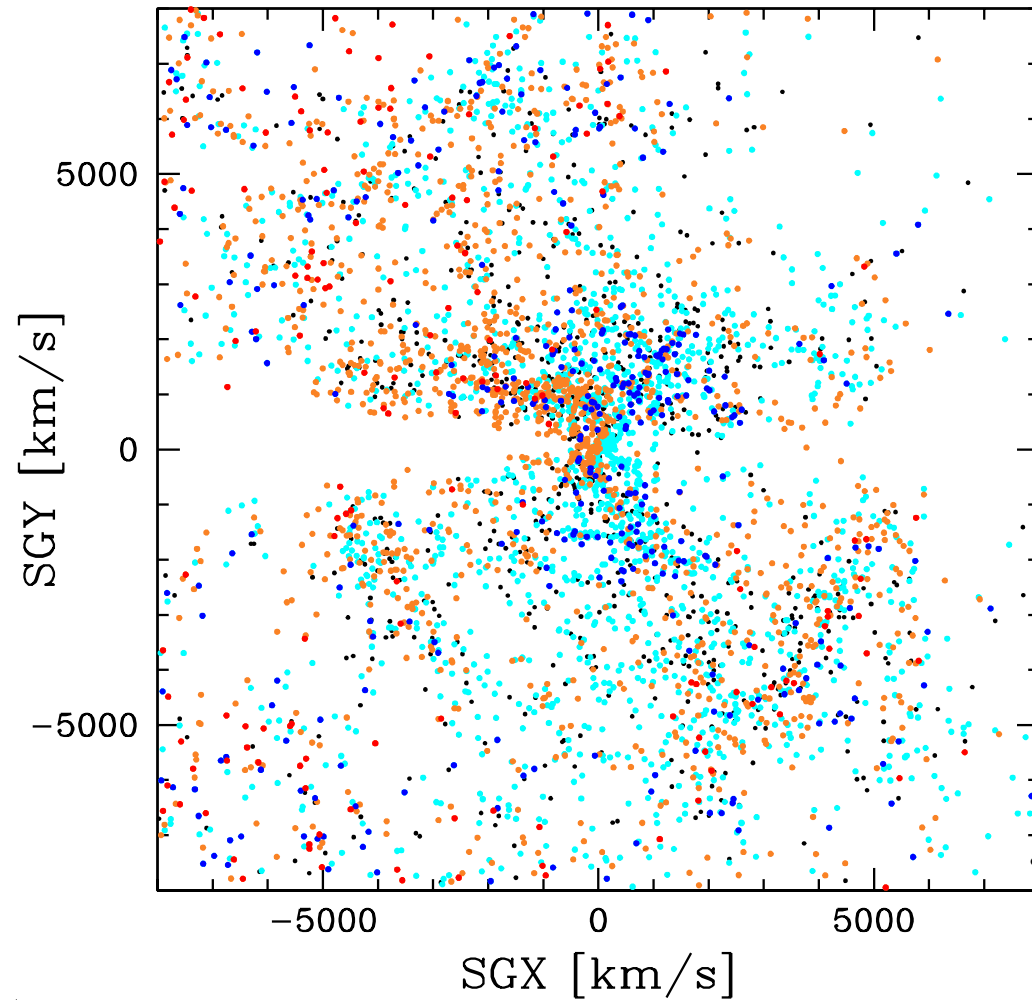


Cosmicflows-3



Brent Tully
Helene Courtois
Jenny Sorce

Cosmic Flows Program

- Measure distances d
 - Peculiar velocities: $V_{\text{pec}} = V_{\text{obs}} - H_0 d$
 - Infer 3D velocities and density field
- Project to initial conditions
 - Simulate evolution to present conditions

Helene Courtois, Yehuda Hoffman, Daniel Pomarede

Ehsan Kourkchi, Po-Feng Wu

Karachentsev, Rizzi, Shaya

Gottloeber, Hoffman, Klypin, Yepes (CLUES collaboration)

Sorce, Kitaura, Libeskind

Cosmic Flows Program

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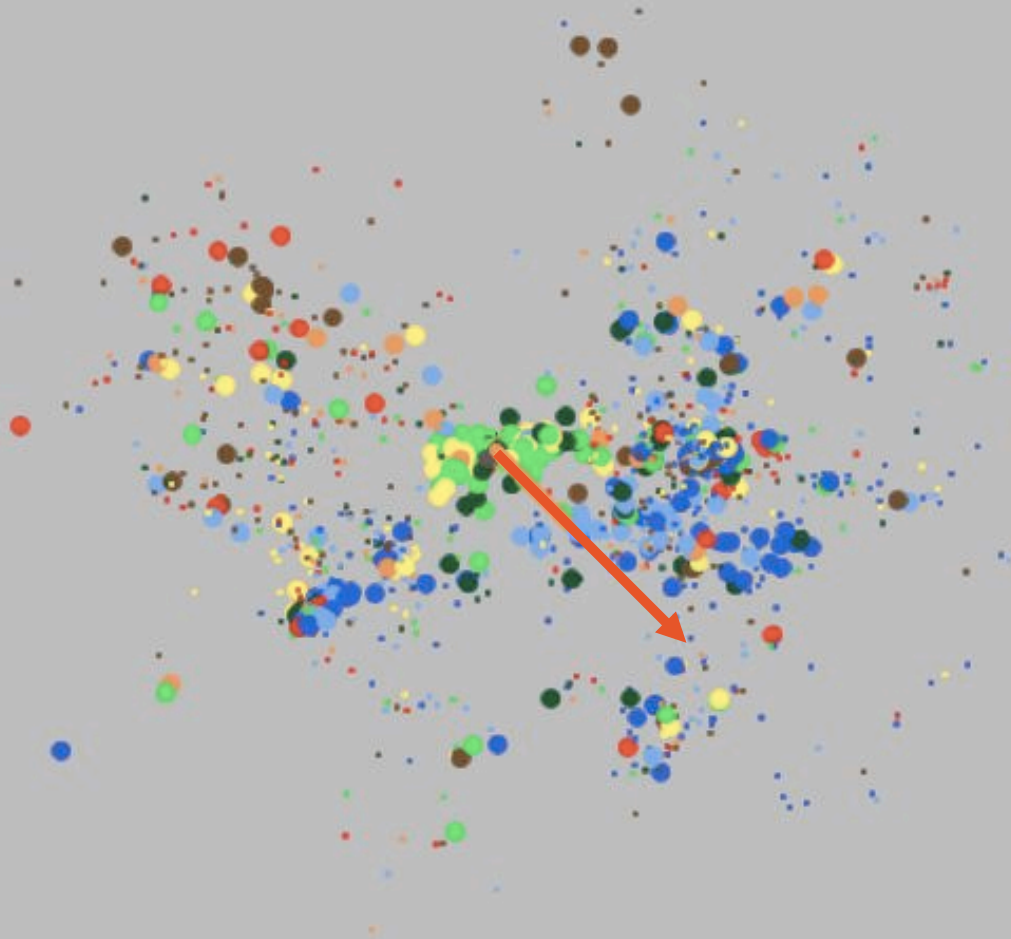
Gottloeber, Hoffman, Klypin, Yepes (CLUES collaboration)
Sorce, Kitaura, Libeskind

errors increase with distance
 $\Rightarrow V_{\text{pec}}$ uncertainties
large at large distances

strong constraints nearby;
diminishes with distance

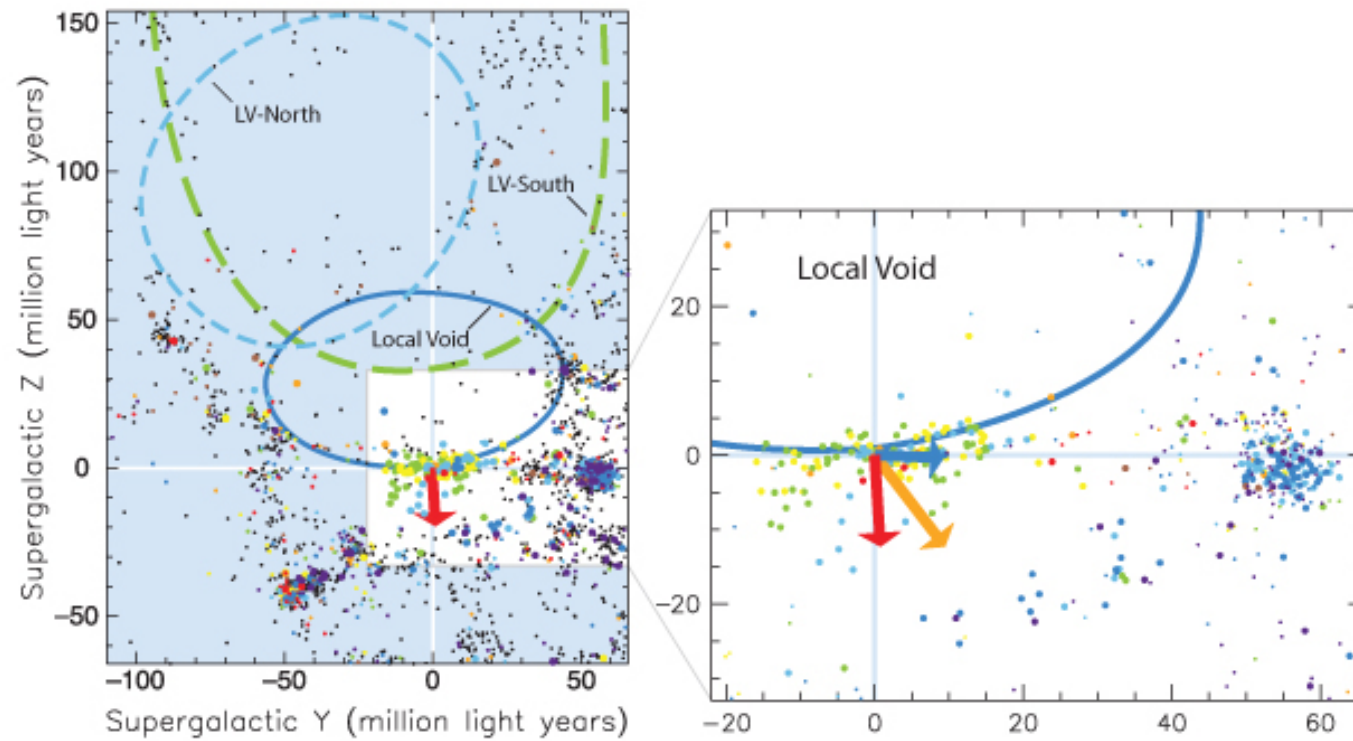
Most important result from Cosmicflows-1

BT, Shaya, Karachentsev, Courtois,
Kocevski, Rizzi, Peel [2008, ApJ,
676, 184]



The MW has a motion of 323
km/s w.r.t. 1800 galaxies
with measured distances
within 3000 km/s

green/yellow $V_{pec} \sim 0$
red $V_{pec} > +100$
blue $V_{pec} < -100$



1. tiny peculiar velocities within Local Sheet
2. discontinuity in peculiar velocities passing to adjacent structures
3. 185 km/s motion toward Virgo Cluster
4. 260 km/s motion away from Local Void

Cosmicflows-1: 1797 distances within 3300 km/s

catalog in Extragalactic Distance Database: <http://edd.ifa.hawaii.edu>

Tully et al. 2008, ApJ, 676, 184

Contributions to Cosmicflows-2

1209

297 TRGB: Tip of the Red Giant Branch

133 TRGB Literature

31 RR Lyr, Horiz Br, Eclip Bin, Maser

60 Cepheid Period-Luminosity

382 SBF: Surface Brightness Fluctuation

306 SNIa: Type Ia Supernova

1508 FP: Fundamental Plane

5998 TF: Luminosity-Linewidth

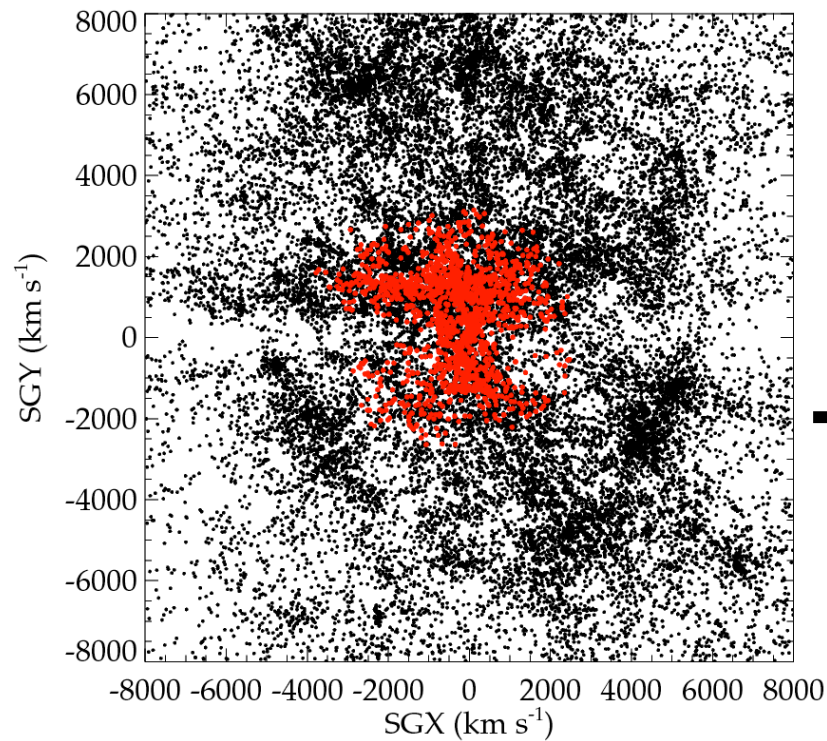
8315 distance measures within 30,000 km/s

Cosmicflows-1 => Cosmicflows-2

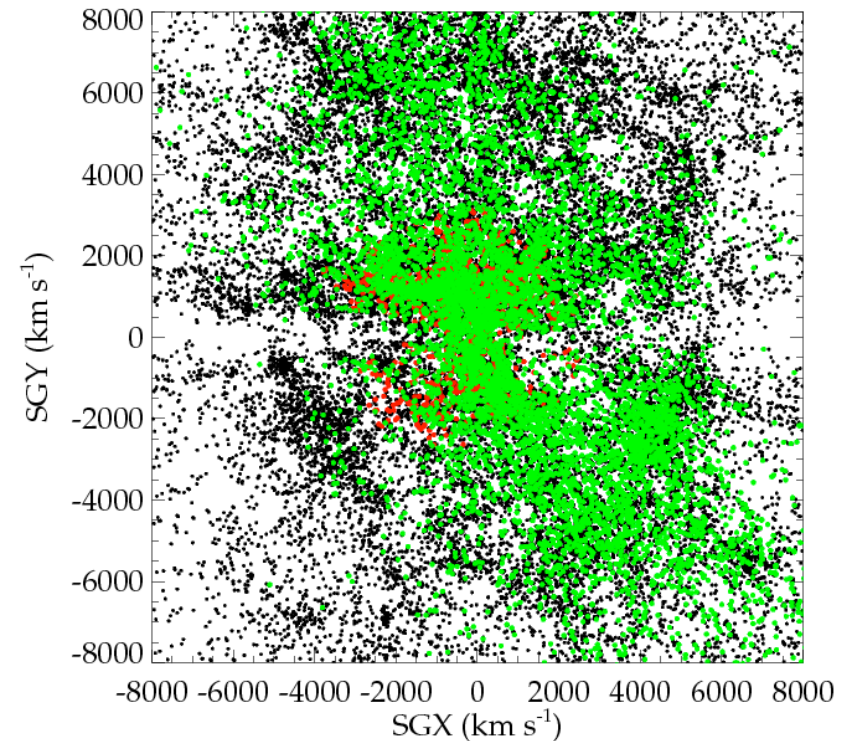
CF1: 1800 galaxies
 $V < 3,000 \text{ km/s}$



CF2: 8000 galaxies
 $V < 30,000 \text{ km/s}$



2008



2013

Contributions to Cosmicflows-2

297 TRGB: Tip of the Red Giant Branch

133 TRGB Literature

31 RR Lyr, Horiz Br, Eclip Bin, Maser

60 Cepheid Period-Luminosity

382 SBF: Surface Brightness Fluctuation

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1508 FP: Fundamental Plane

5998 TF: Luminosity-Linewidth

8315 distance measures within 30,000 km/s

new to Cosmicflows-3

Incremental:

TRGB: 297 => 384

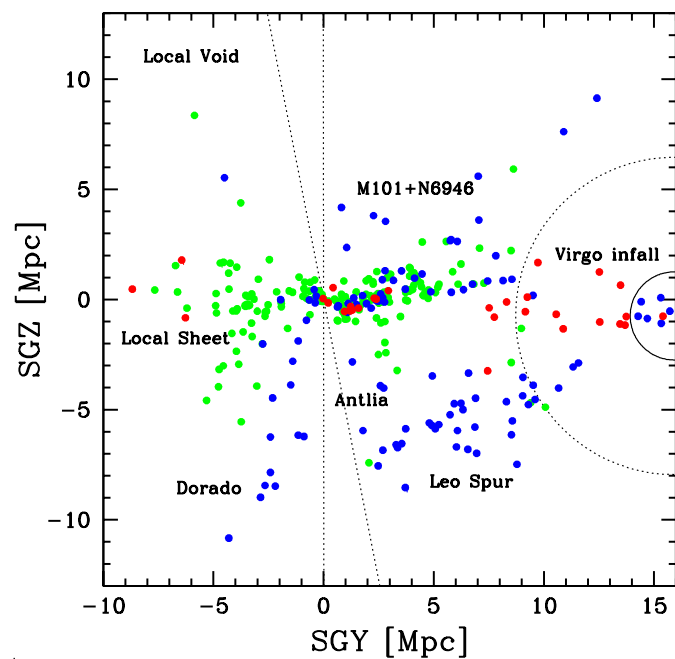
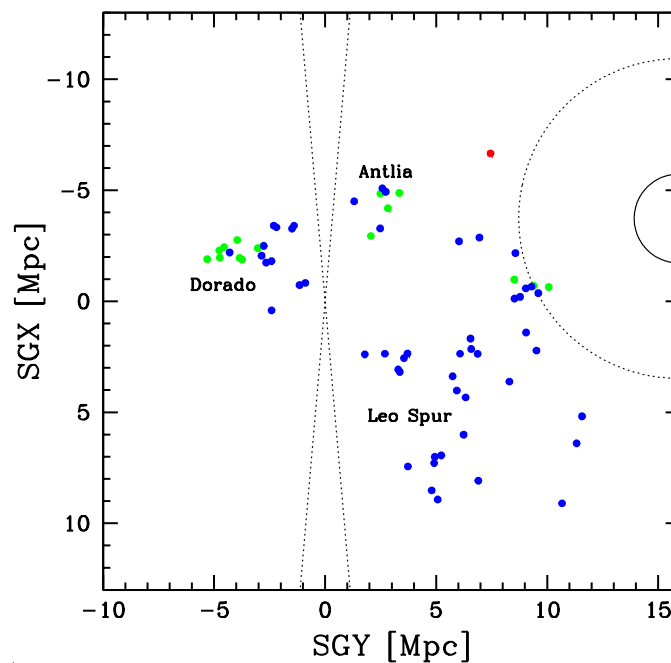
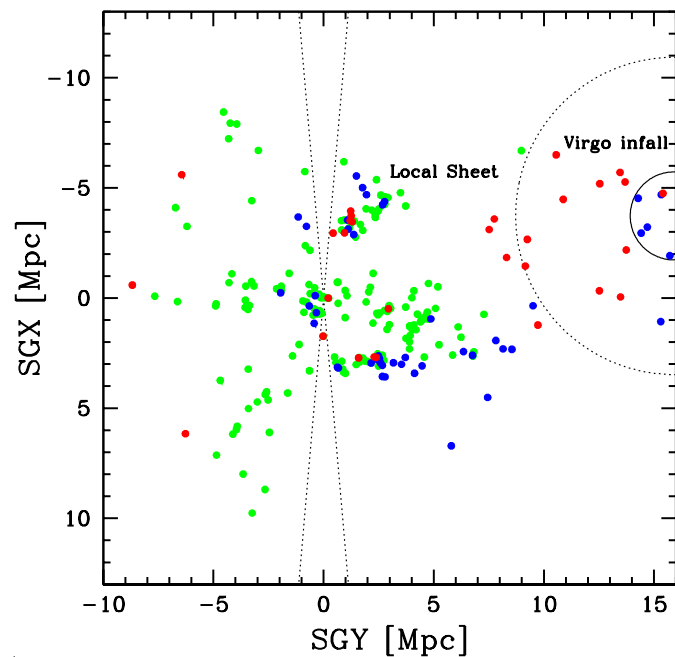
SNIa: 306 => 390

All new:

Spitzer TF: 2257

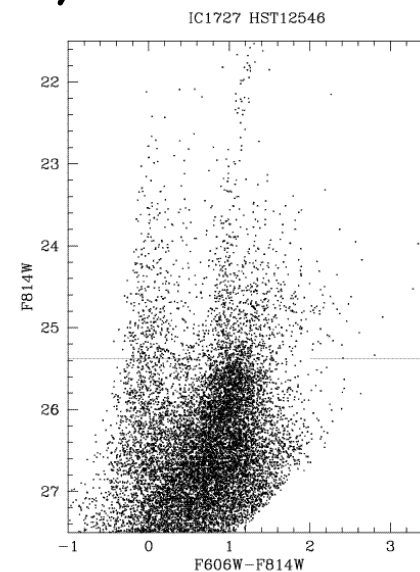
6dFGS FP: 8885

17,669 distance measures within 30,000 km/s



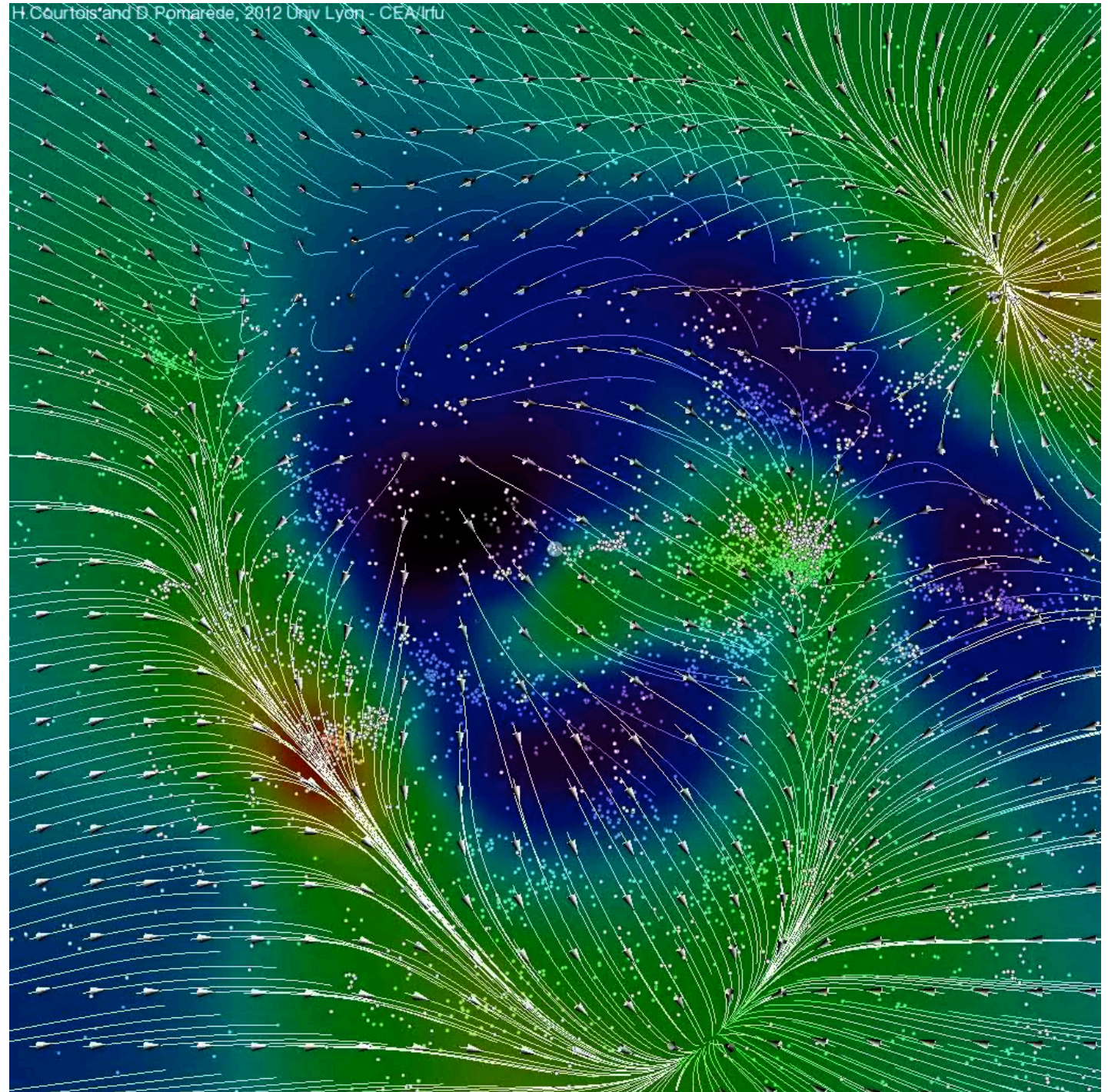
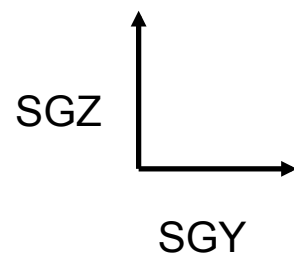
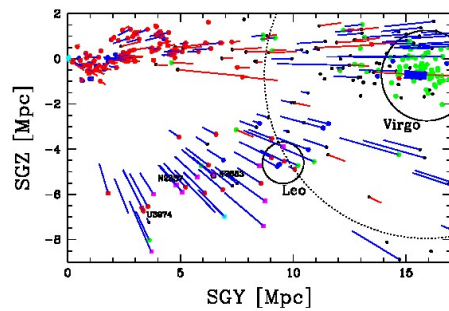
excellent TRGB coverage locally

$V_{LS} > +100$ km/s
 -100 to $+100$ km/s
 $V_{LS} < -100$ km/s



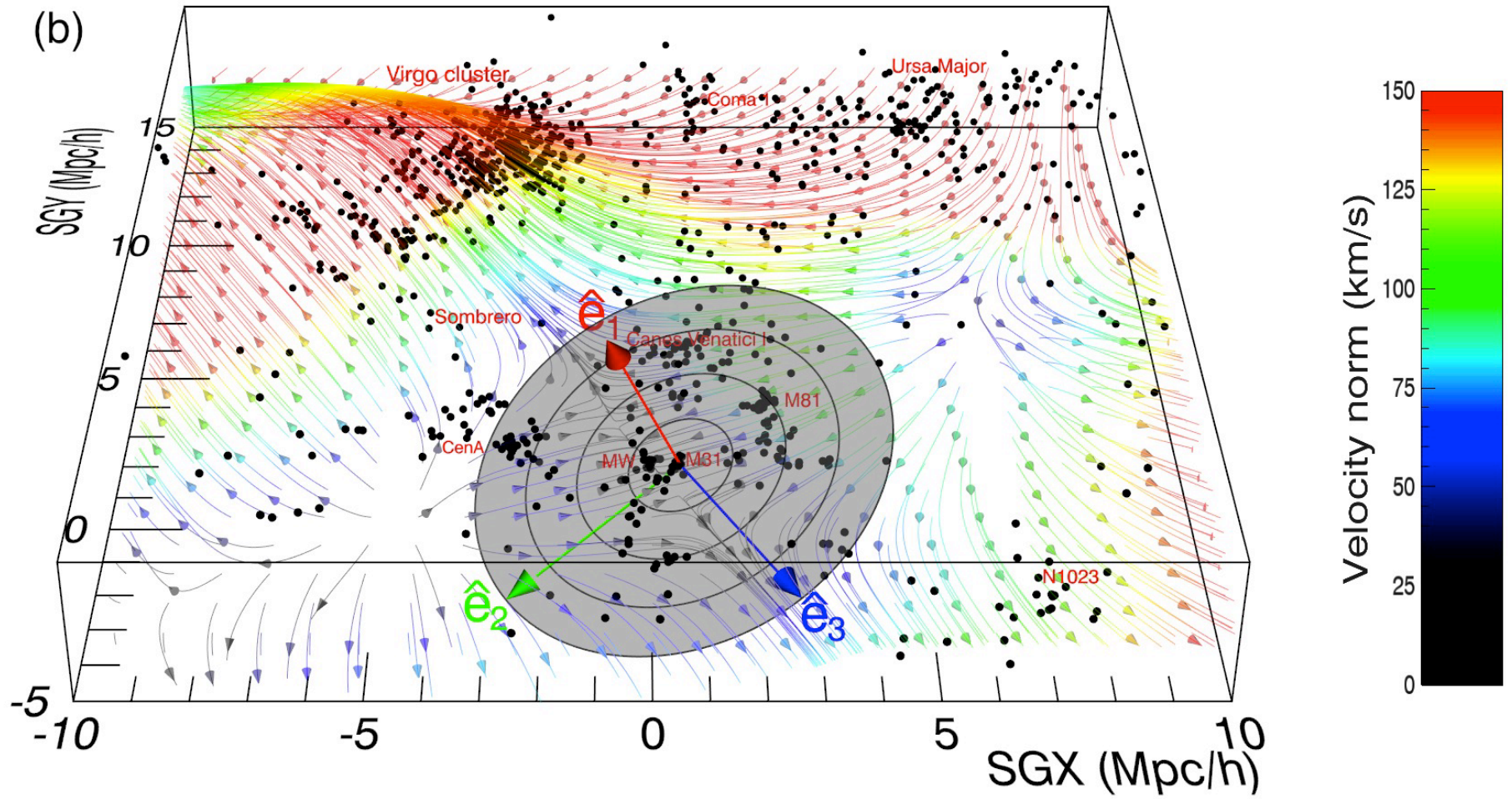
Wiener Filter reconstructions of
3D velocity fields and density
maps. Results from
cosmicflows-1

Courtois, Pomarede, Hoffman
2013, AJ, 146, 69
Expulsion from the Local Void.

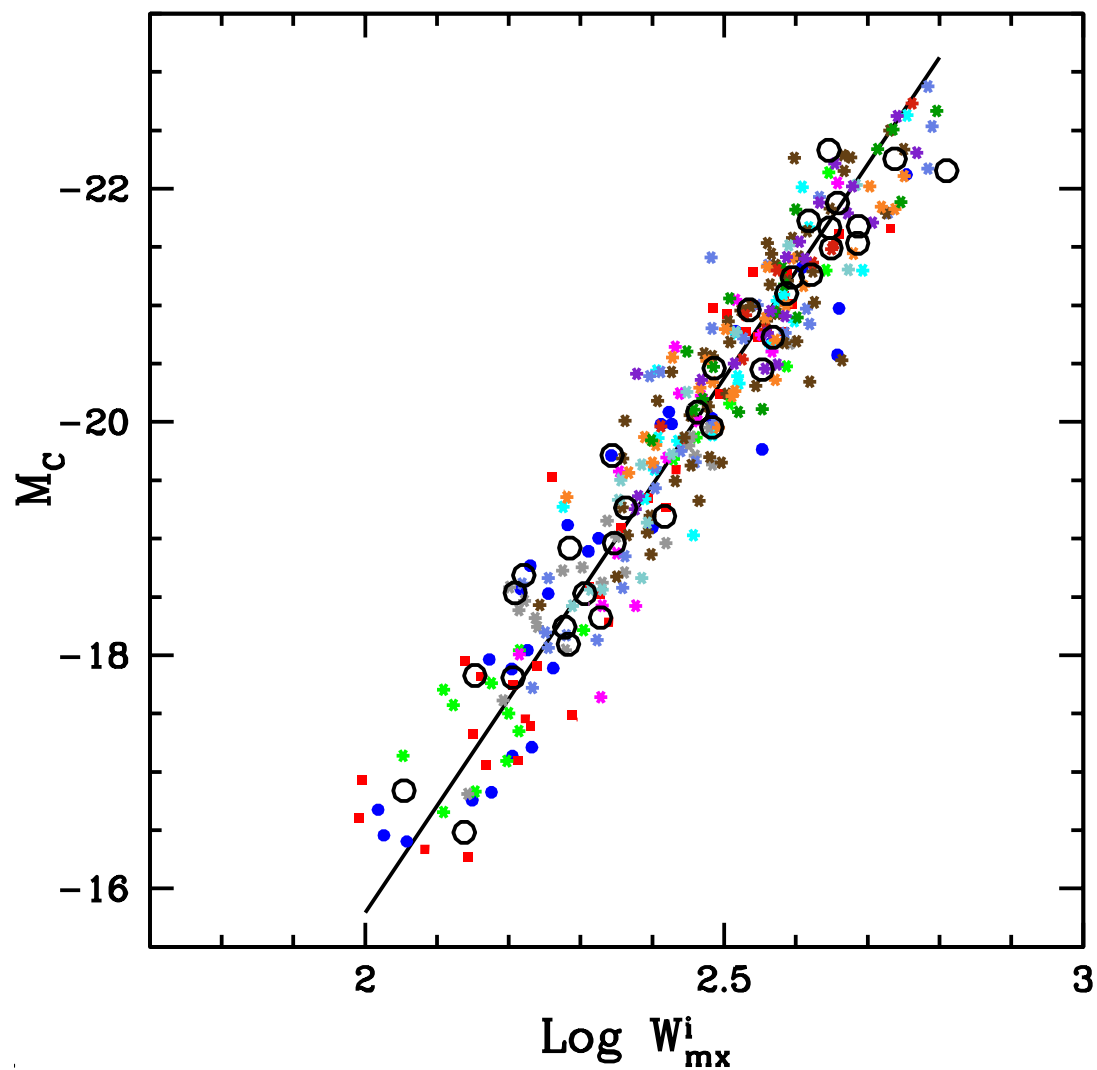
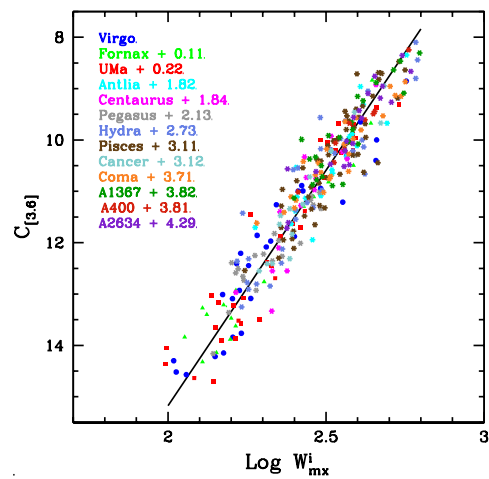
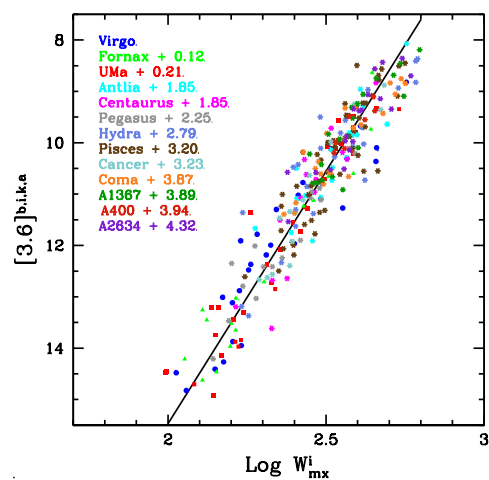


Virgo Infall

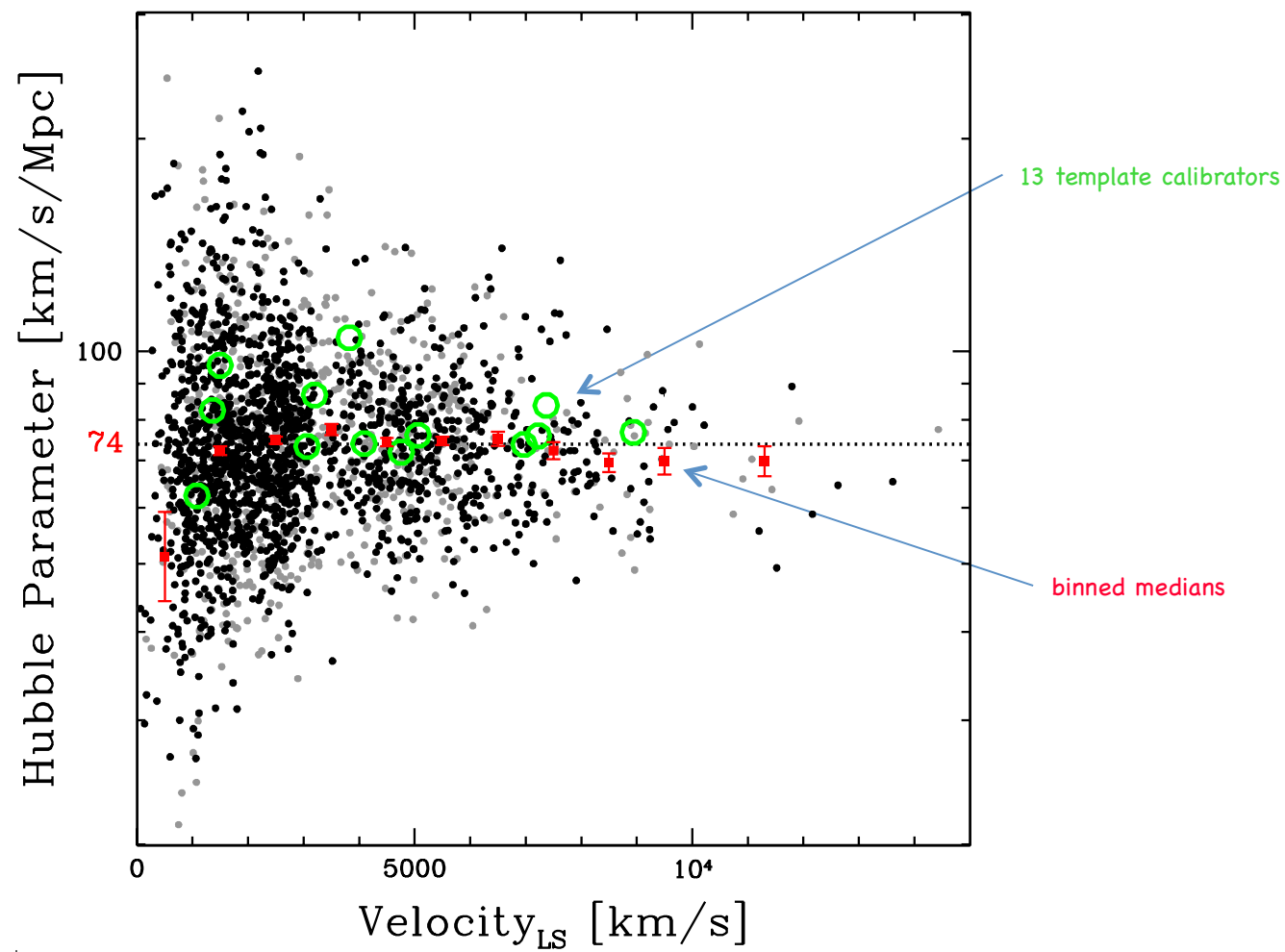
Wiener Filter Reconstruction



Spitzer Luminosity vs HI Linewidth

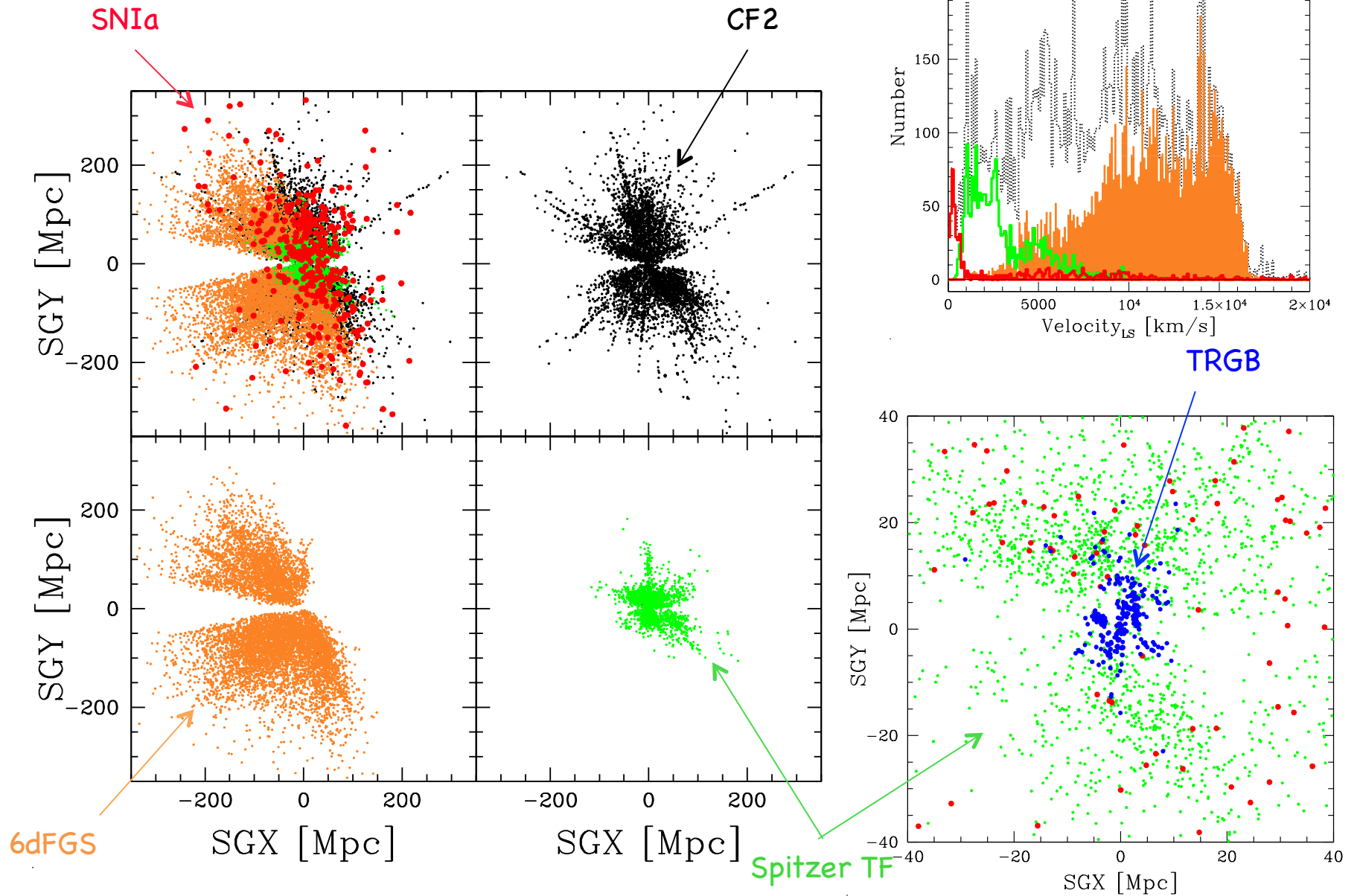


Properties of 2257 galaxies of Spitzer sample

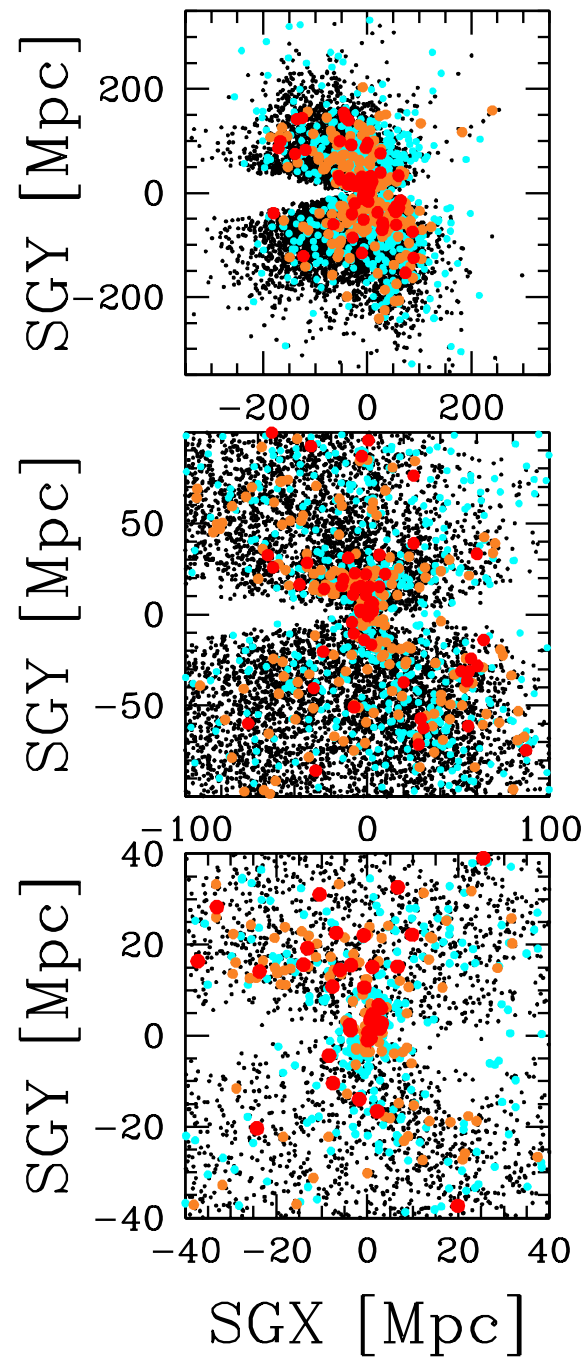


$$H_i = V_i/d_i$$

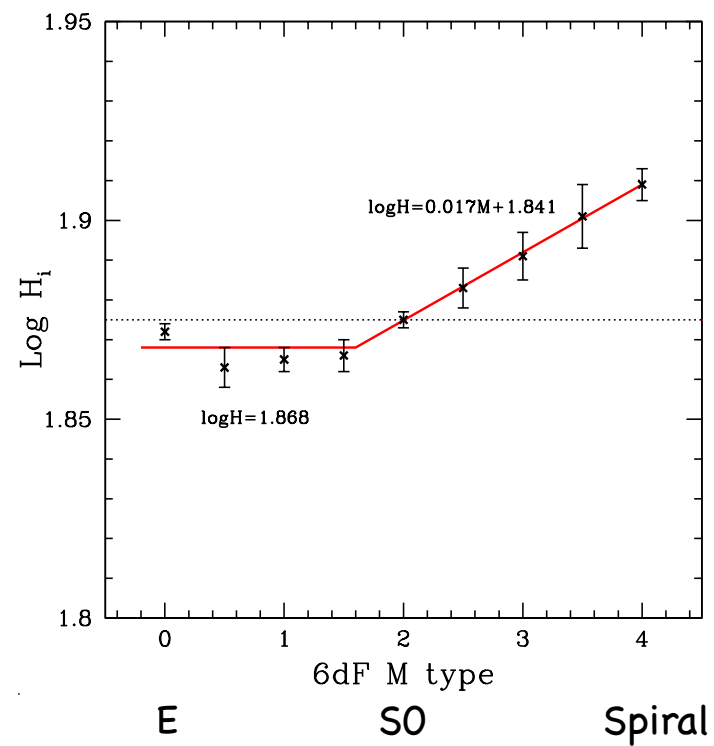
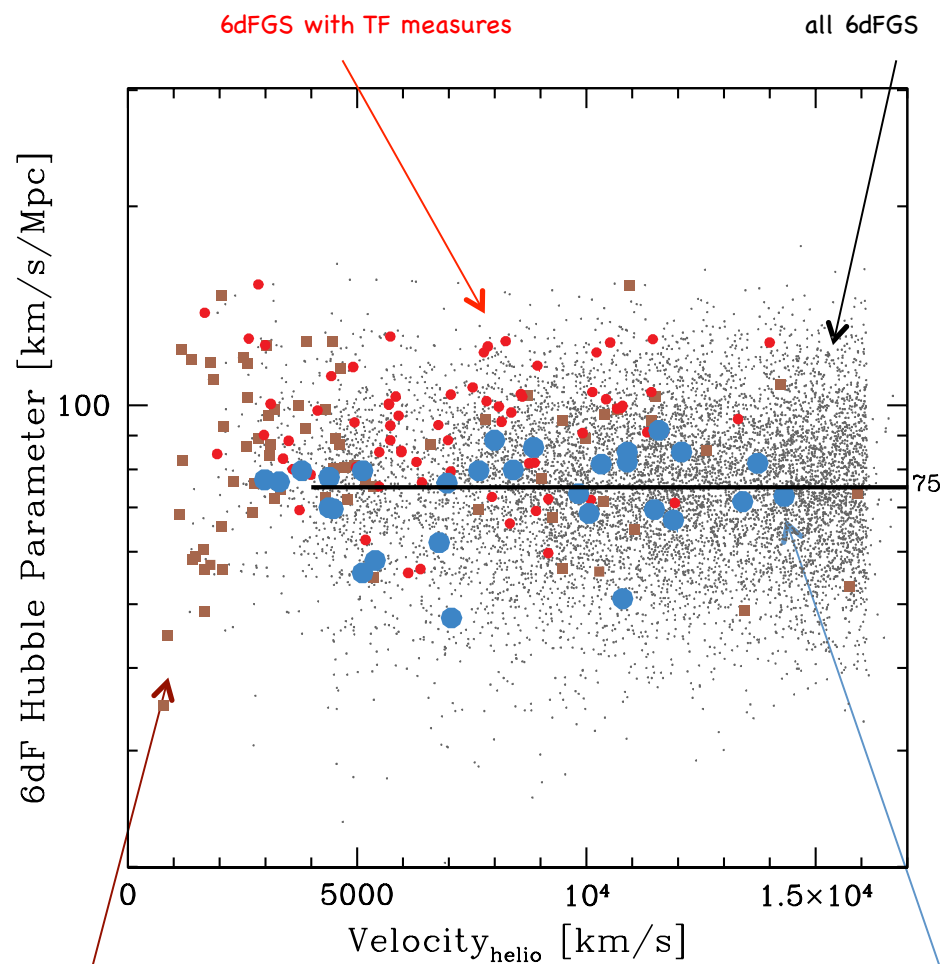
6dFGS FP & other Components of CF3



Distances: quality

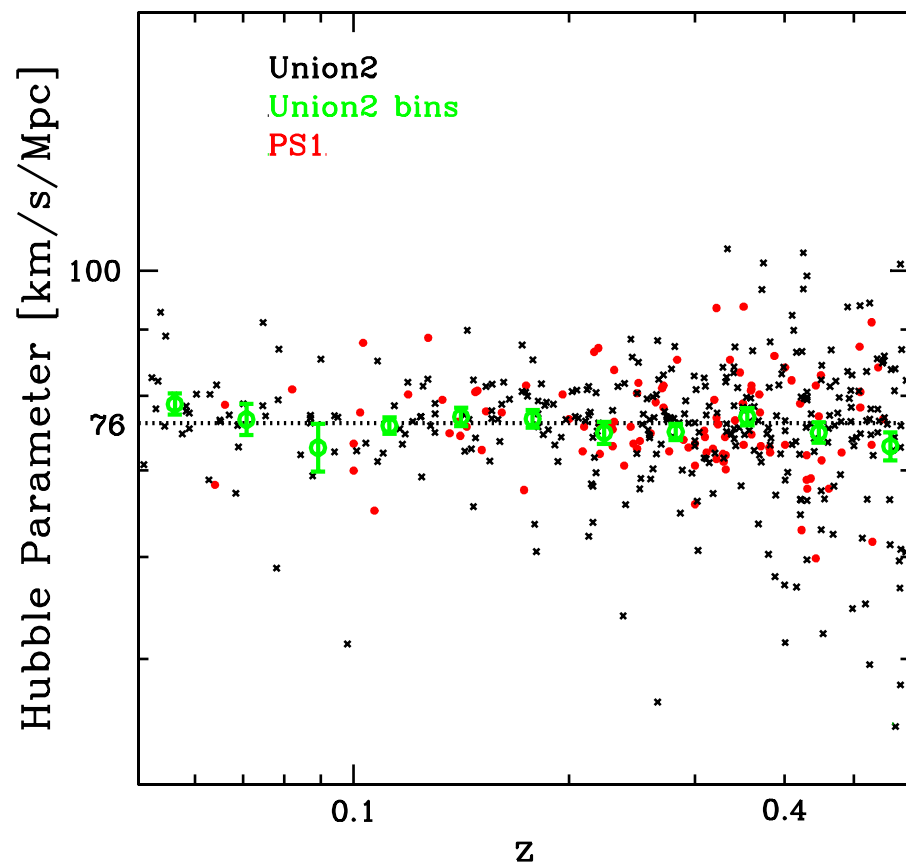
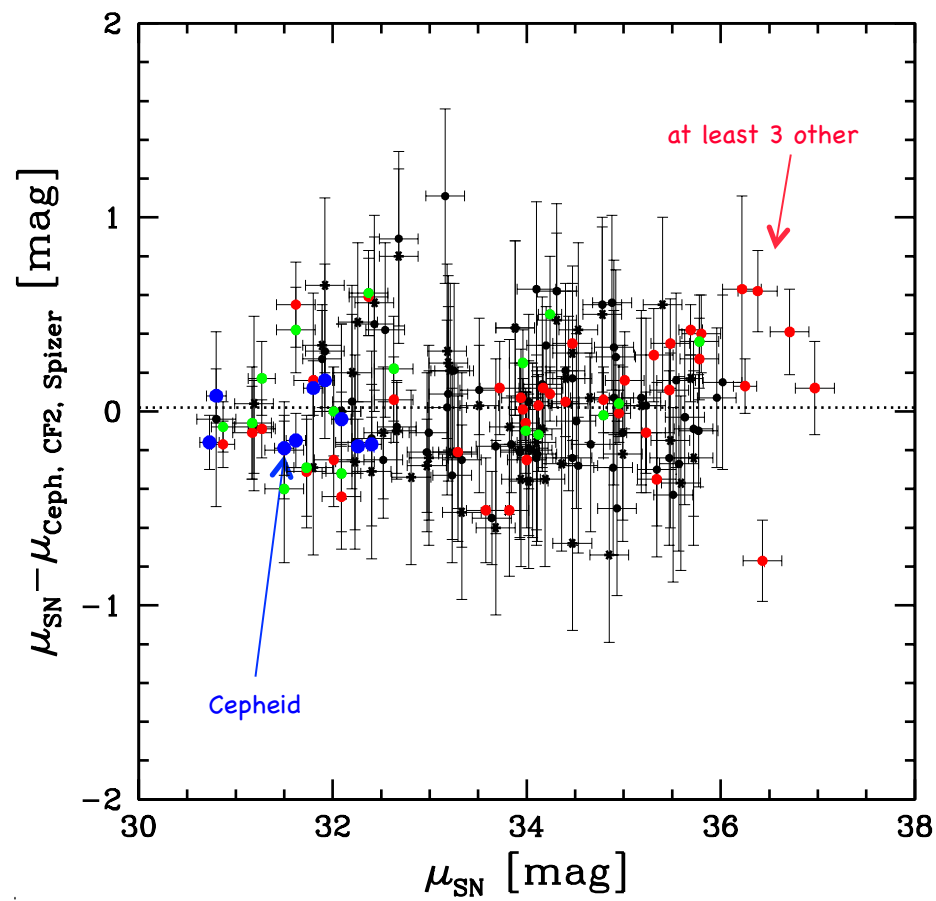


6dFGS FP morphology adjustment



means for 29 groups

SN Ia zero point and H_0

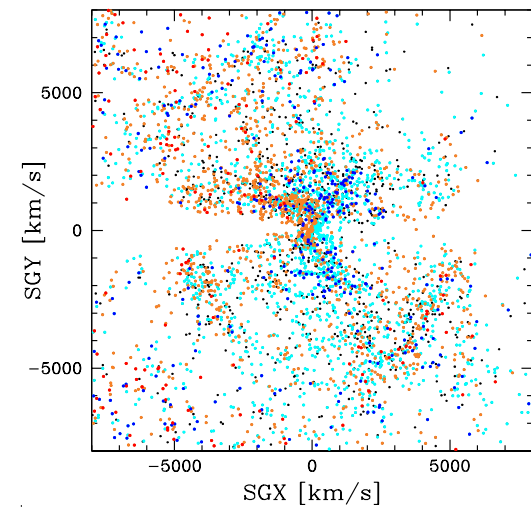
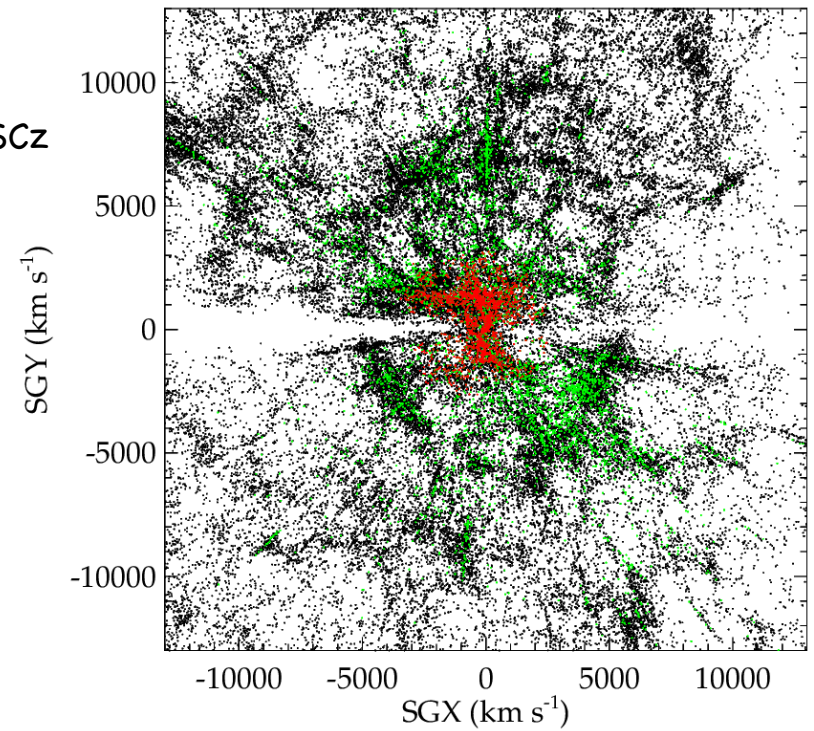
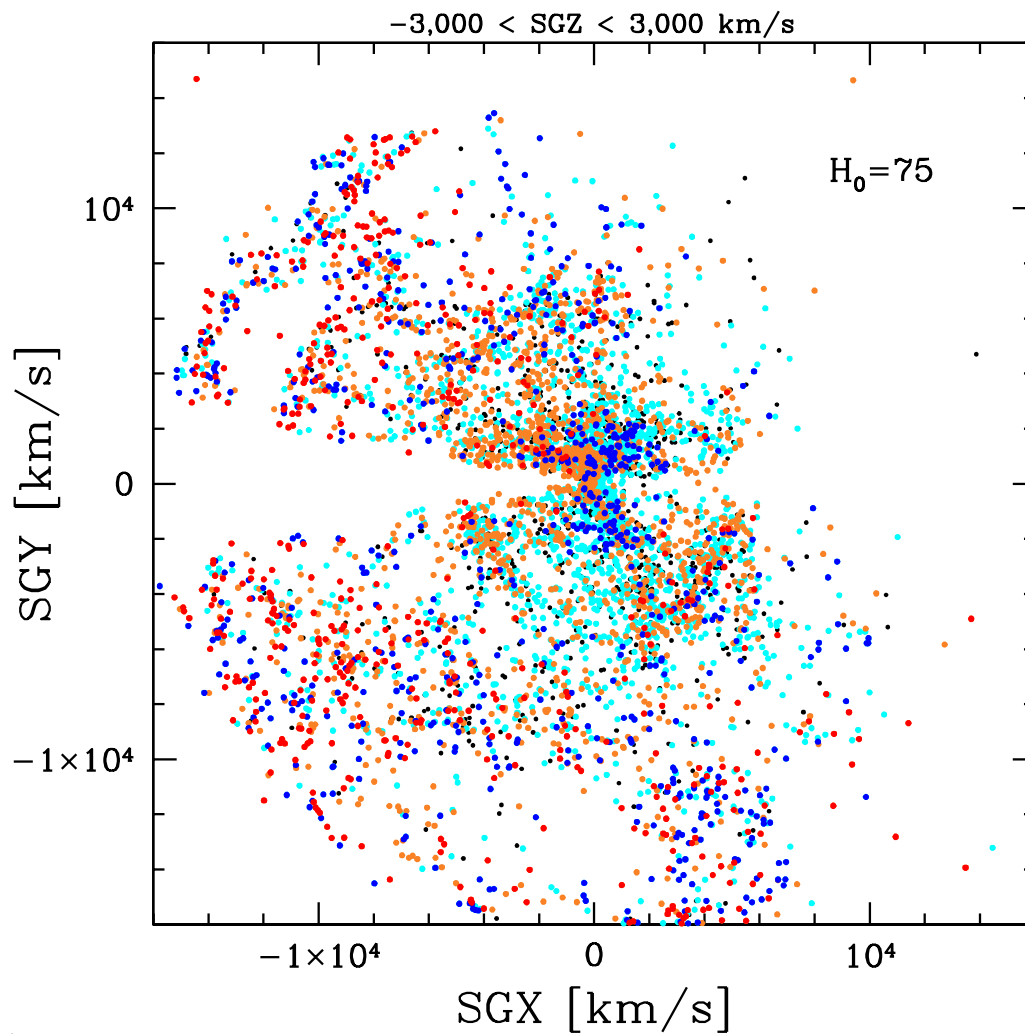


$$H_0 = 76.2 \pm 3.4 \text{ rms} \pm 2.7 \text{ sys}$$

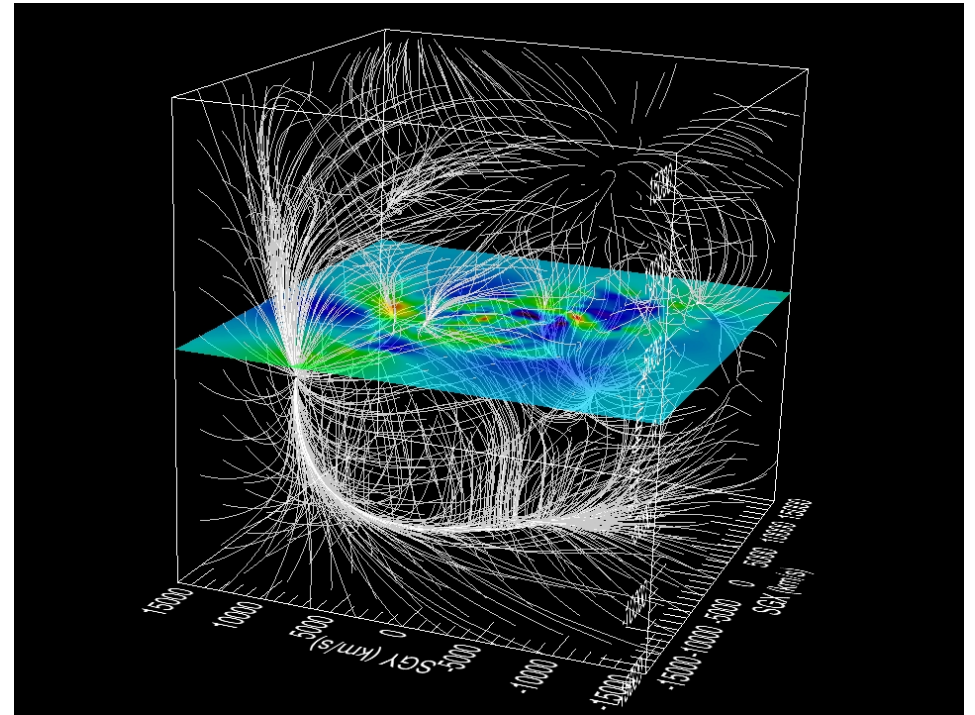
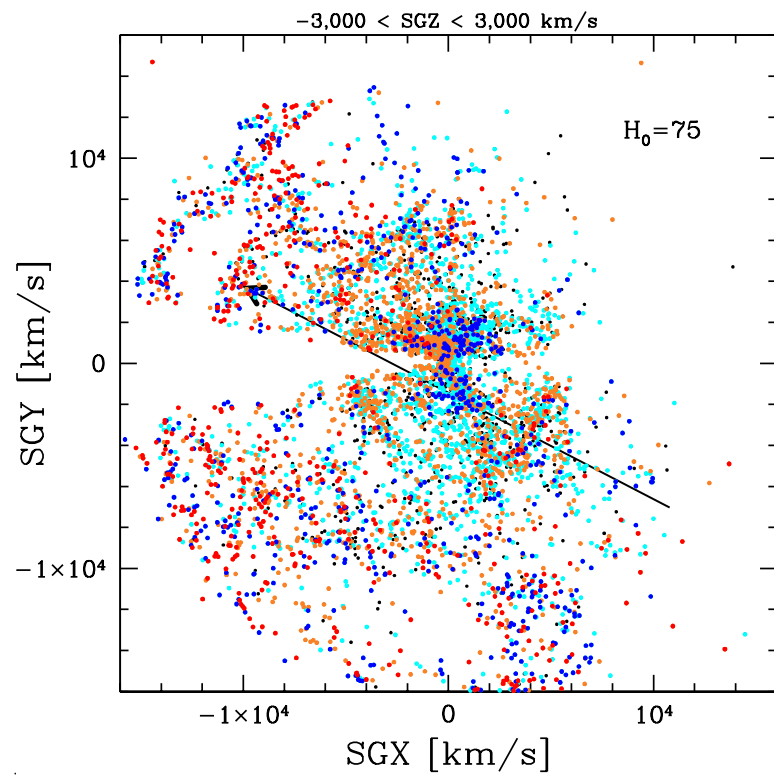
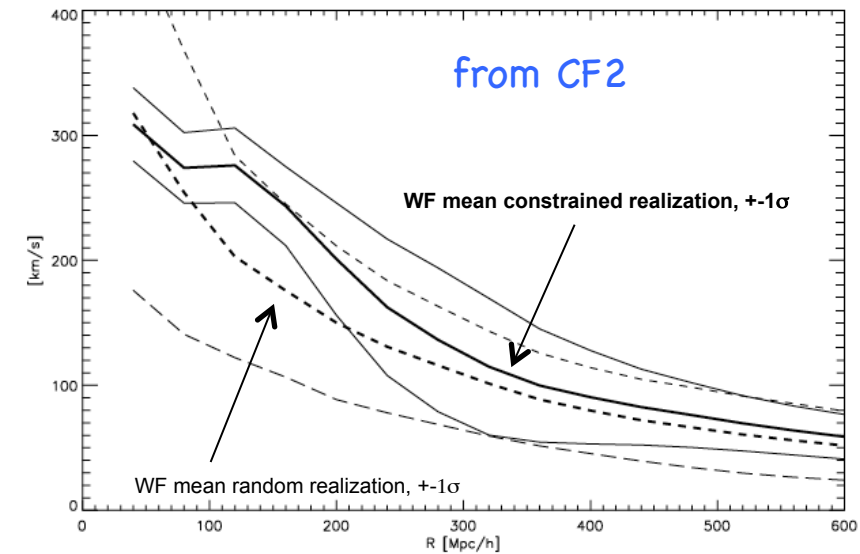
CF3 Peculiar Velocities

CF1, CF2
2MASS XSCz

red, orange $> +100$ km/s
cyan, blue < -100 km/s

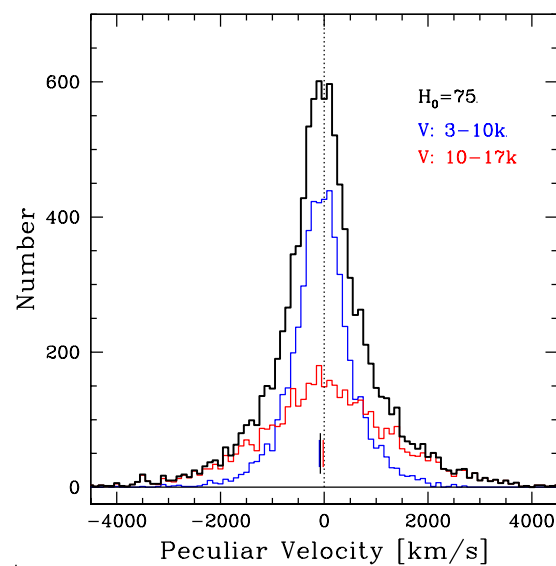
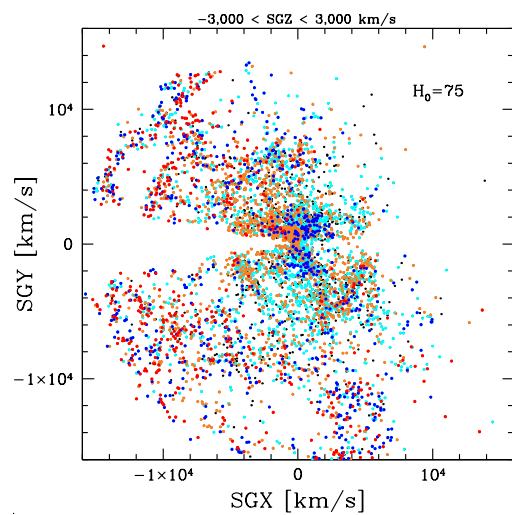


Bulk Flow



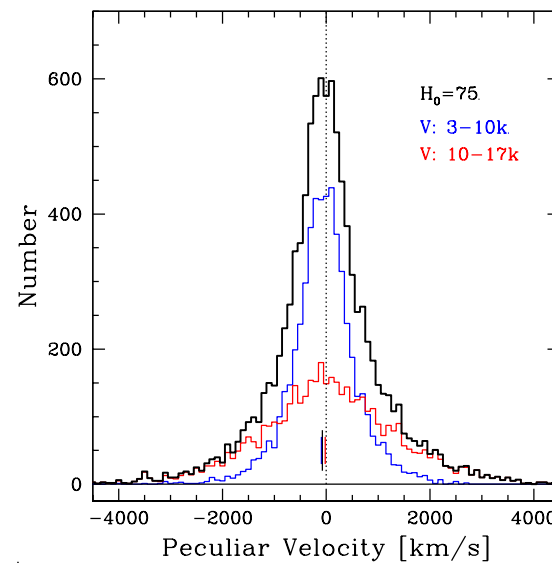
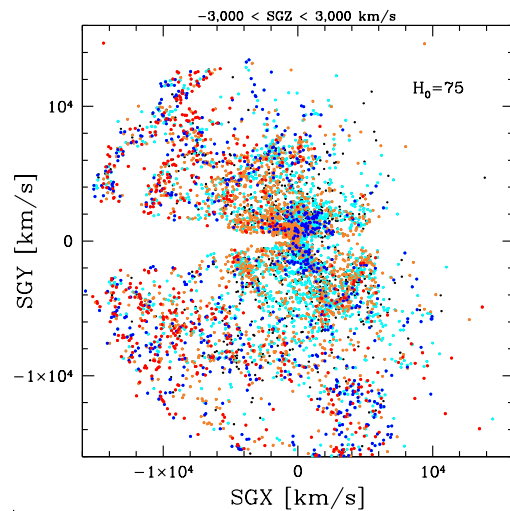
minimizing the monopole

$H_0=75$ ± 2 if out/in $< \pm 100$ km/s

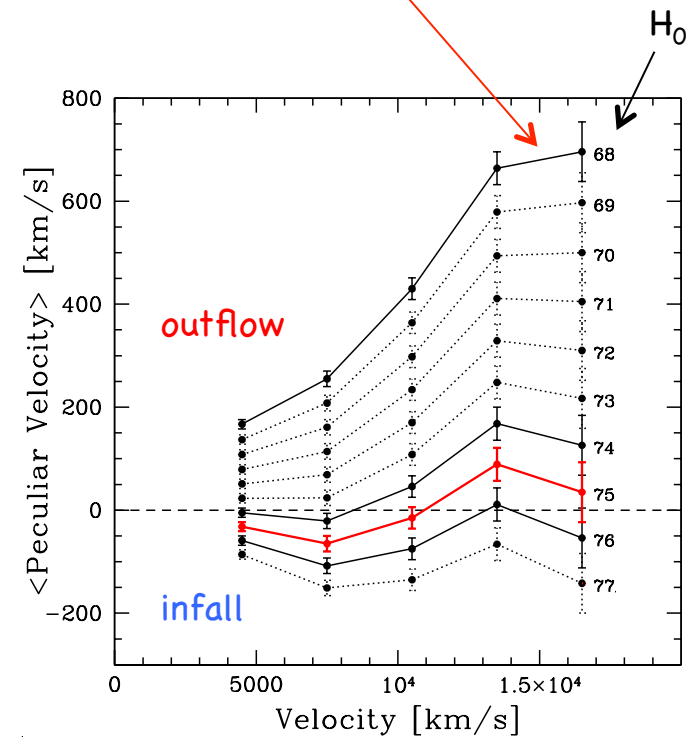


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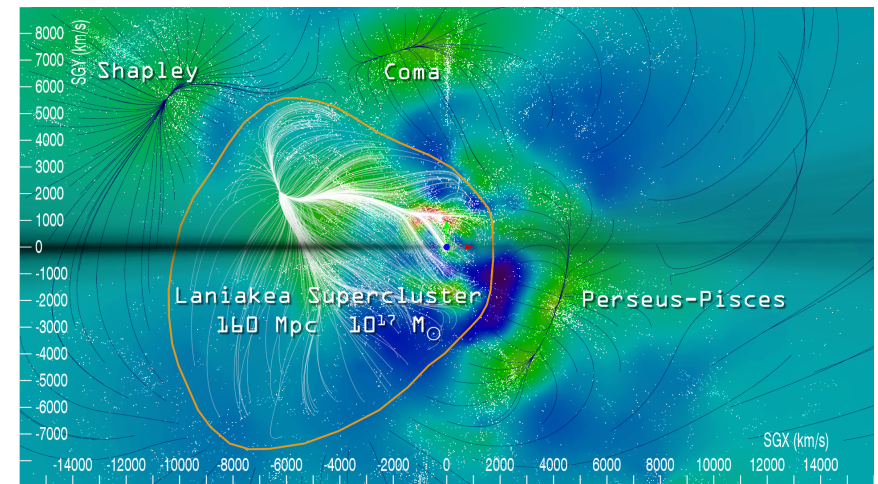
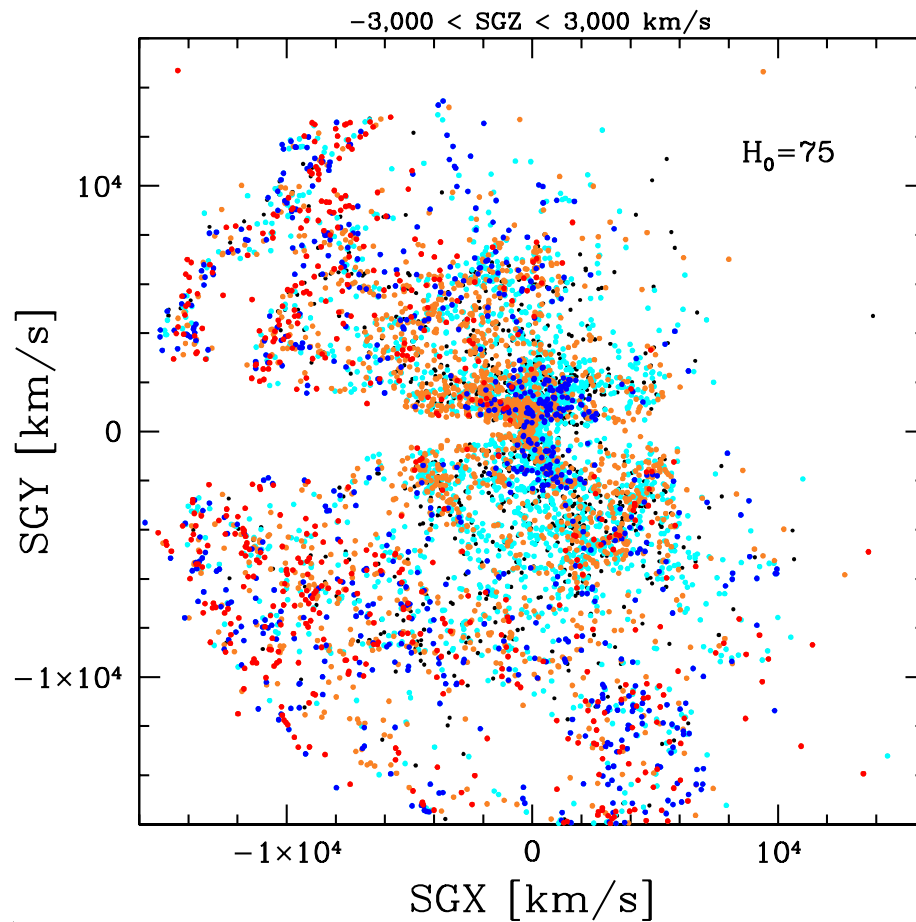
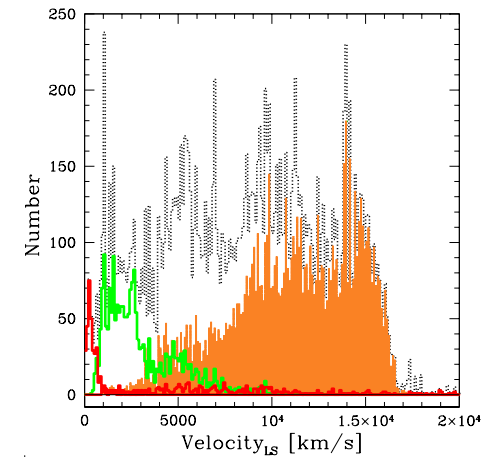
If $H_0=68 \Rightarrow 700$ km/s outflow at $0.05c$!!



increase H_0 1 unit $\Rightarrow -40$ km/s infall
decrease H_0 1 unit $\Rightarrow +40$ km/s outflow

Cosmicflows-3

18 thousand distances !



Laniakea Supercluster