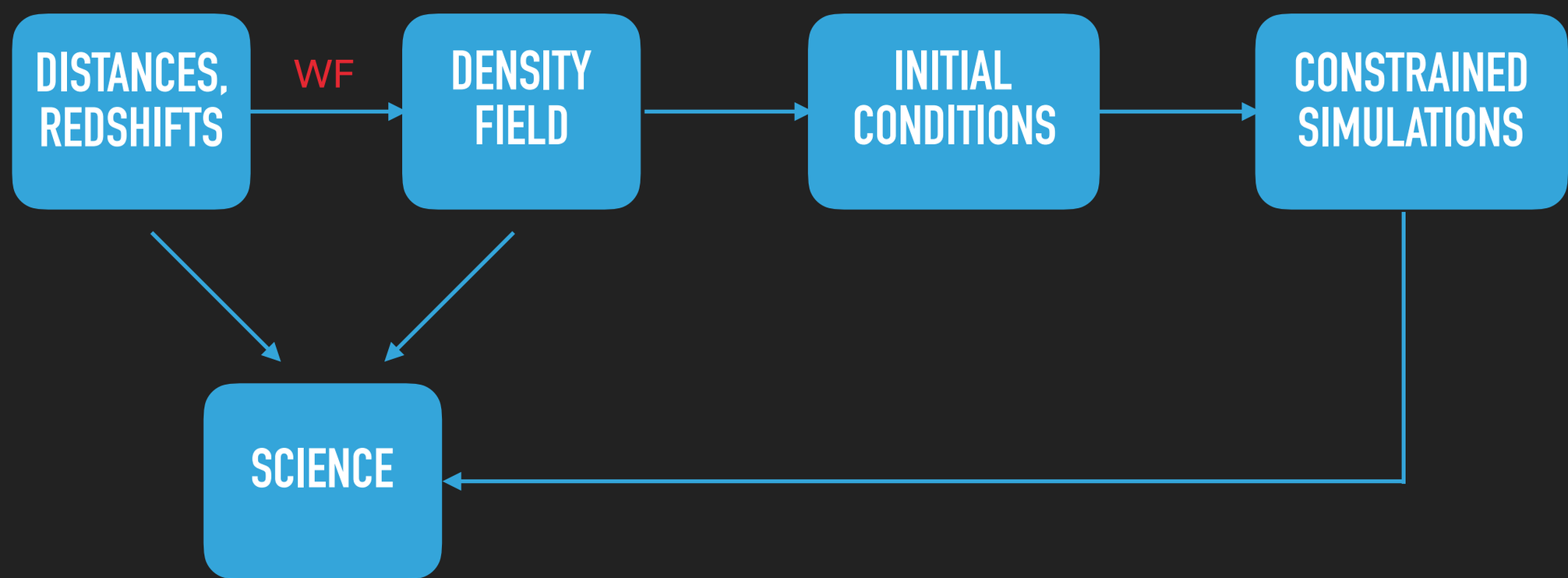
GRAZIANI R., COURTOIS H., HOFFMAN Y., TULLY B., SORCE J.

COSMIC FLOWS RECONSTRUCTION USING WF TECHNIQUE

CONTENTS

- Introduction
- Peculiar velocity field reconstruction
  - Cosmic-Flows
  - The Wiener Filter
- Statistical biases
  - Homogeneous Malmquist bias in distance
  - Distribution of radial peculiar velocities
- Results
- Outlook

THE WIENER FILTER RECONSTRUCTION AND THE CLUES PROJECT



CONTENTS

- Introduction
- Peculiar velocity field reconstruction
  - Cosmic-Flows
  - The Wiener Filter
- Statistical biases
  - Homogeneous Malmquist bias
  - Lognormal distribution of radial peculiar velocities
- Results
- Outlook

COSMIC-FLOWS DATA

- Database of galaxy distances : Cosmic Flows 3 ~17 000 entries
- TF, FP, RTGB, SBF, SNe, Cepheids
- Provides redshifts and luminosity distances.

TULLY, COURTOIS, SORCE, « COSMIC-FLOWS 3 », 2016

THE WIENER FILTER

$v_\alpha(k)$ is a linear function of $\delta(k)$

$$v_i^\alpha = \sum_{j=1}^{M} R_{ij}\delta_j + \epsilon_i \longrightarrow \delta_j^F = \sum_{i=1}^{N} F_{ij} v_i^\alpha$$

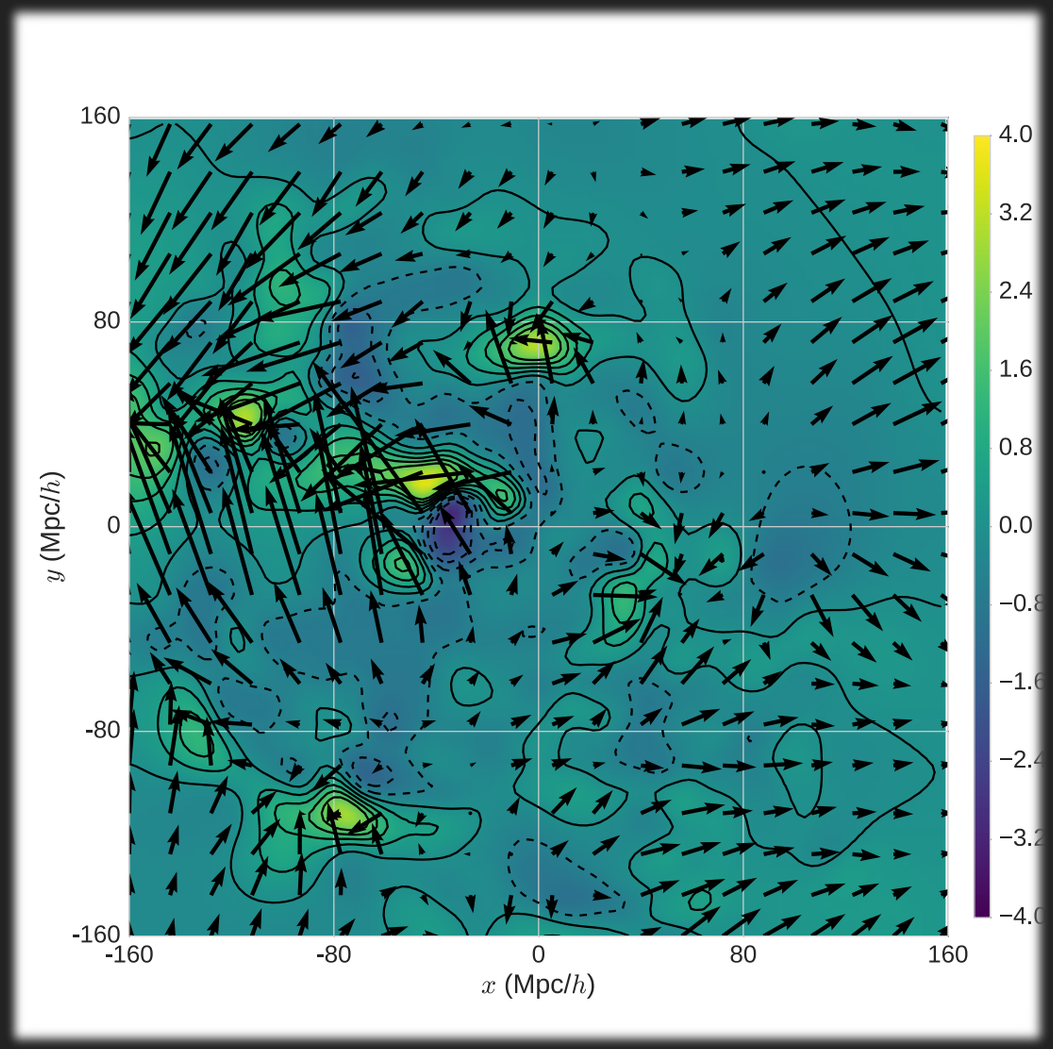
$$WF_{ij} = \sum_{k=1}^{N} < \delta_i v_j^\alpha >< v_j^\alpha v_k^\alpha >^{-1}$$

$< \delta_i v_j^\alpha >$ is known from $P(k)$

ZAROUBI ET AL., 1995 ; HOFFMAN, 2009 ; HOFFMAN AND RIBAS, 1991

MOCKS FROM CONSTRAINED SIMULATIONS

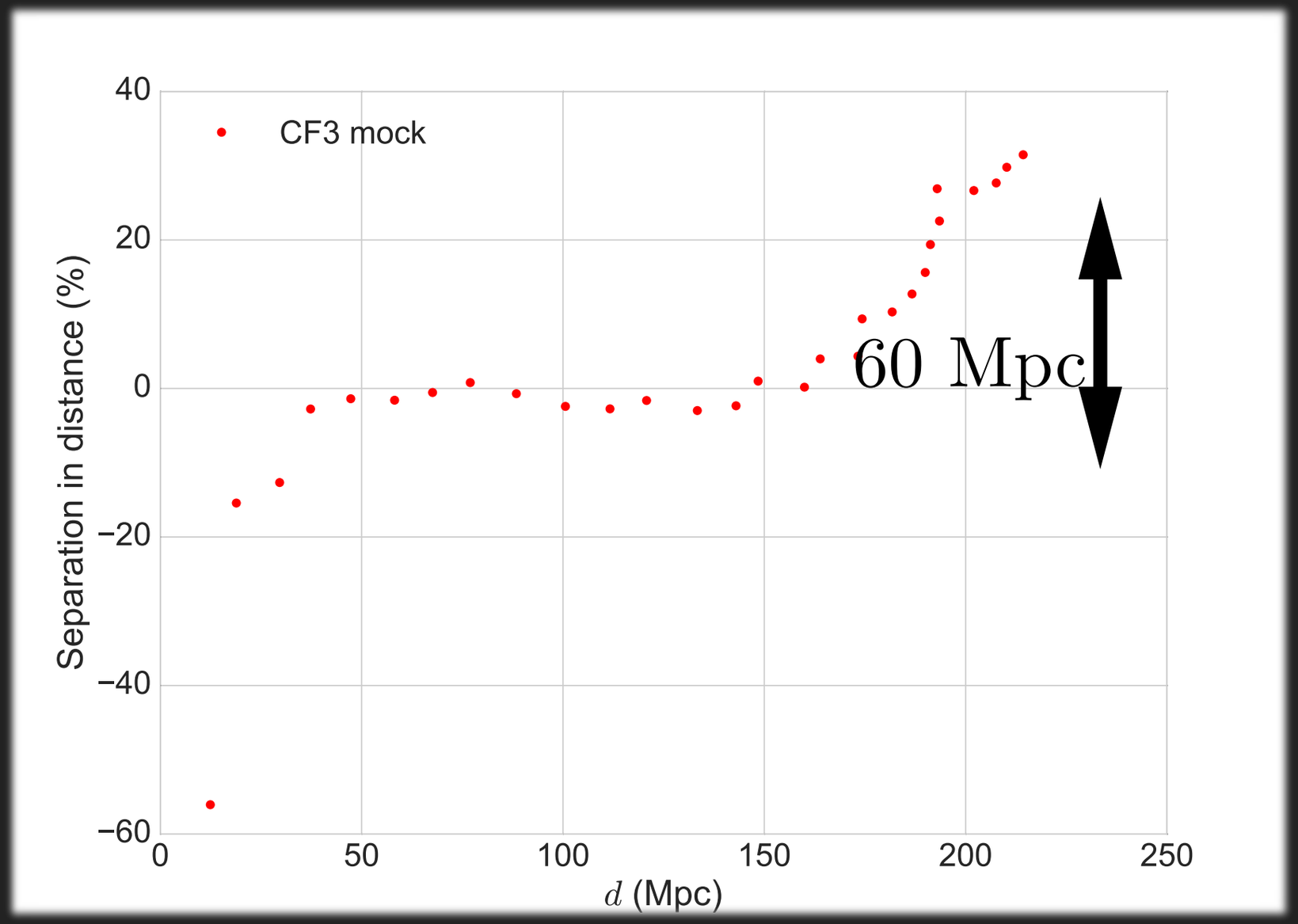
- Same angular distribution
- Same redshift distribution, distance distribution…



CONTENTS

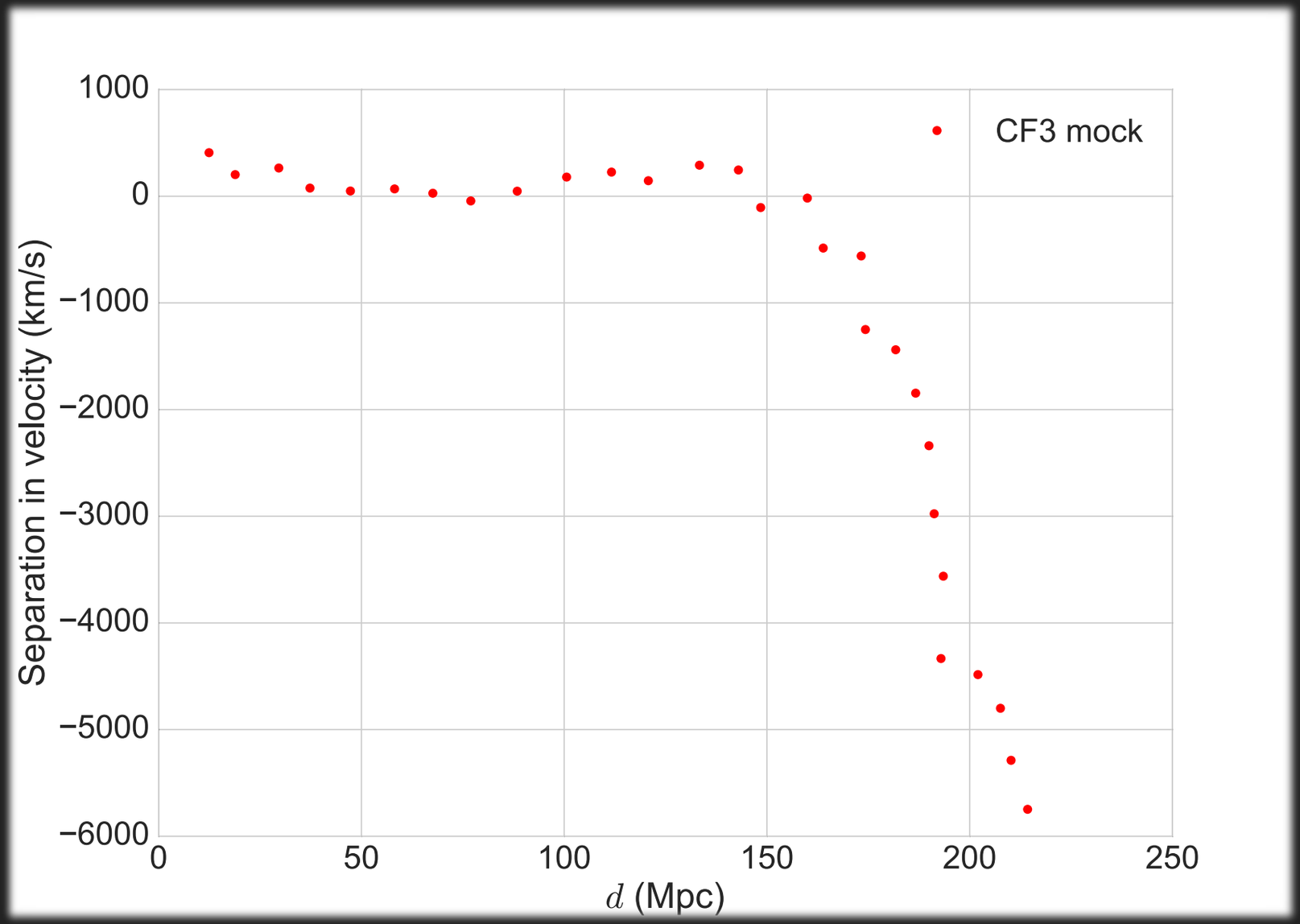
- Introduction
- Peculiar velocity field reconstruction
  - Cosmic-Flows
  - The Wiener Filter
- Statistical biases
  - Homogeneous Malmquist bias
  - Lognormal distribution of radial peculiar velocities
- Results
- Outlook

HOMOGENEOUS MALMQUIST BIAS



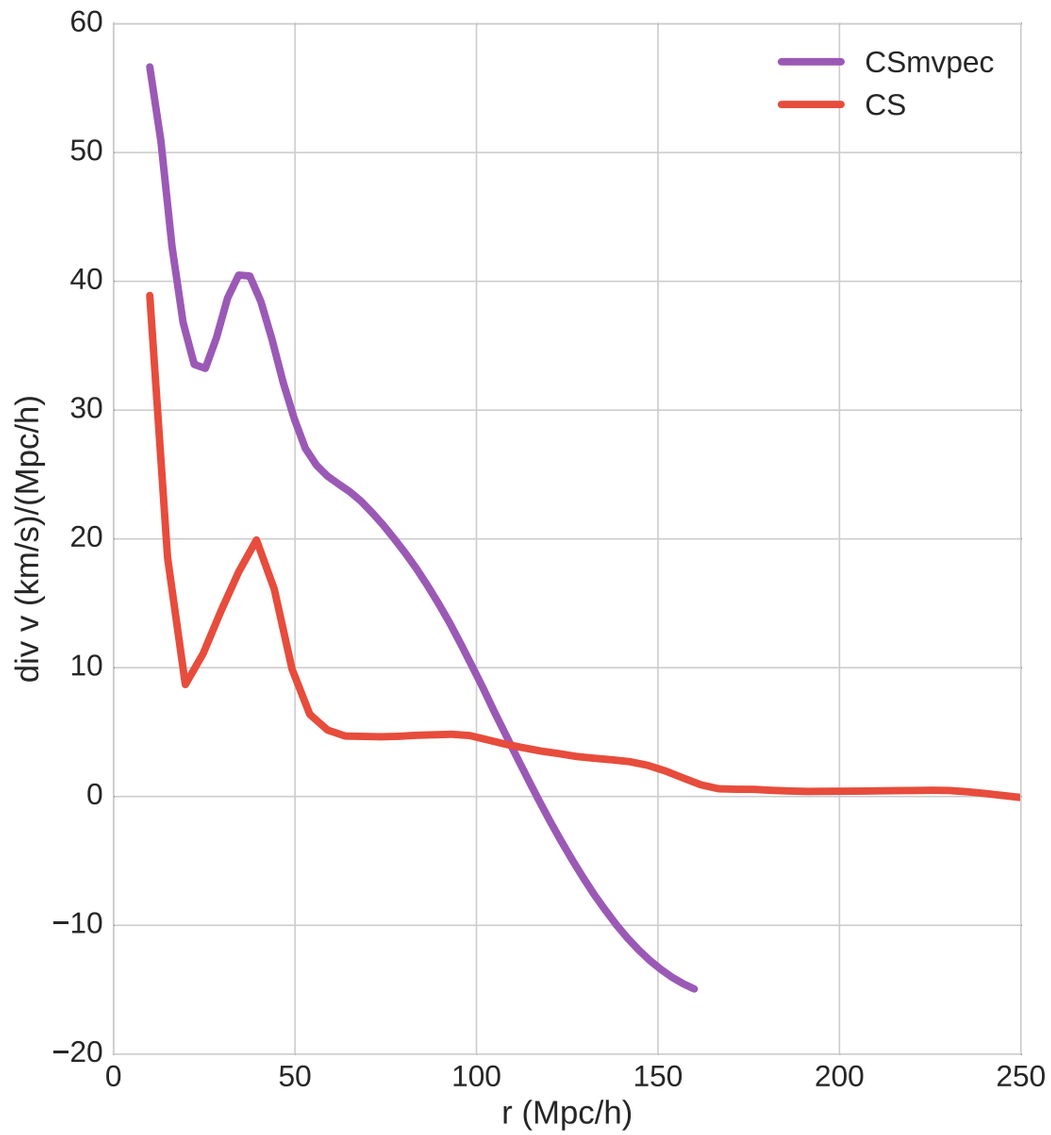
Difference between true and observed distances, in shells of observed distances.

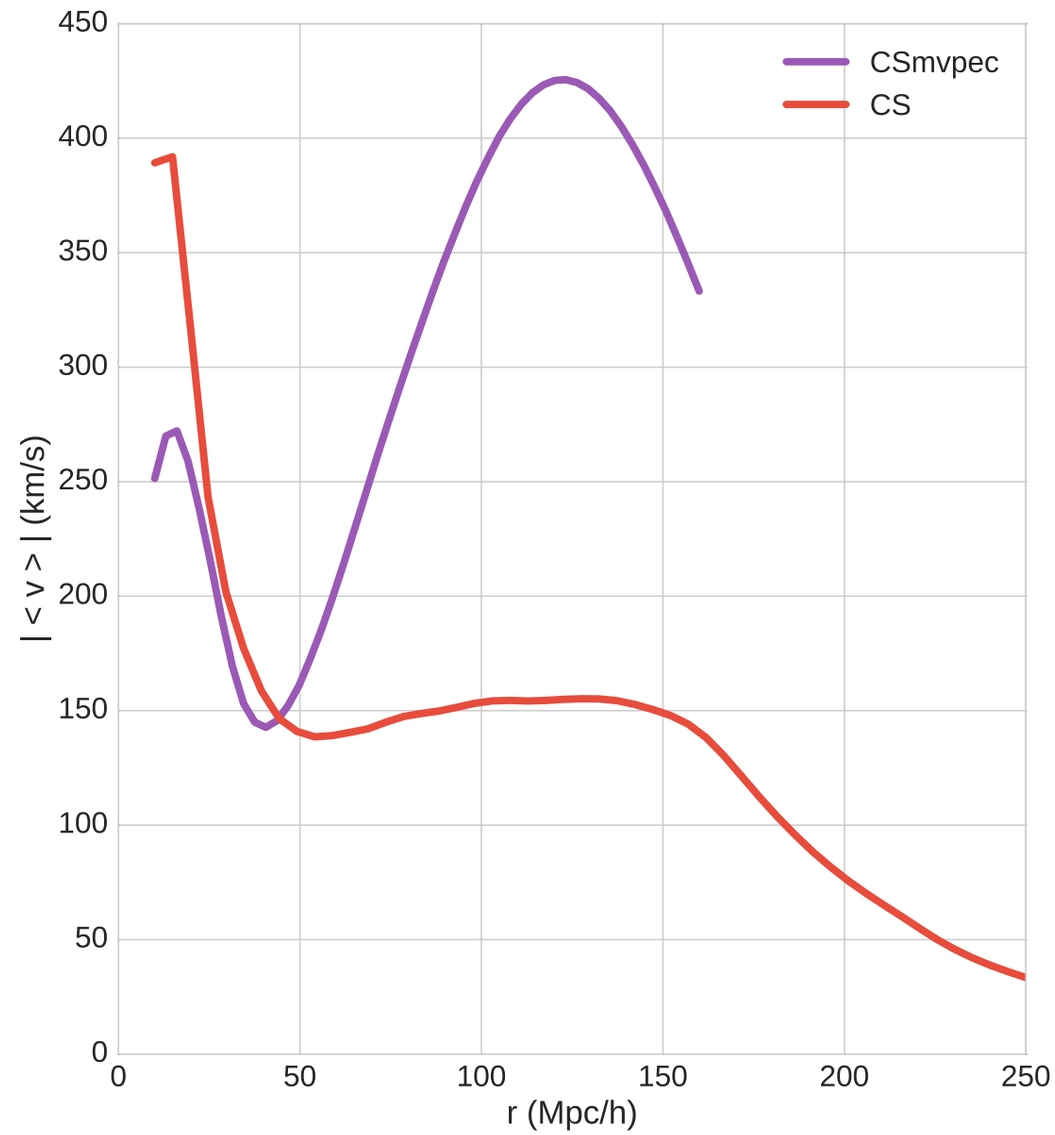
HOMOGENEOUS MALMQUIST BIAS



Difference between true and observed radial peculiar velocities, in shells of observed distances.

HOMOGENEOUS MALMQUIST BIAS

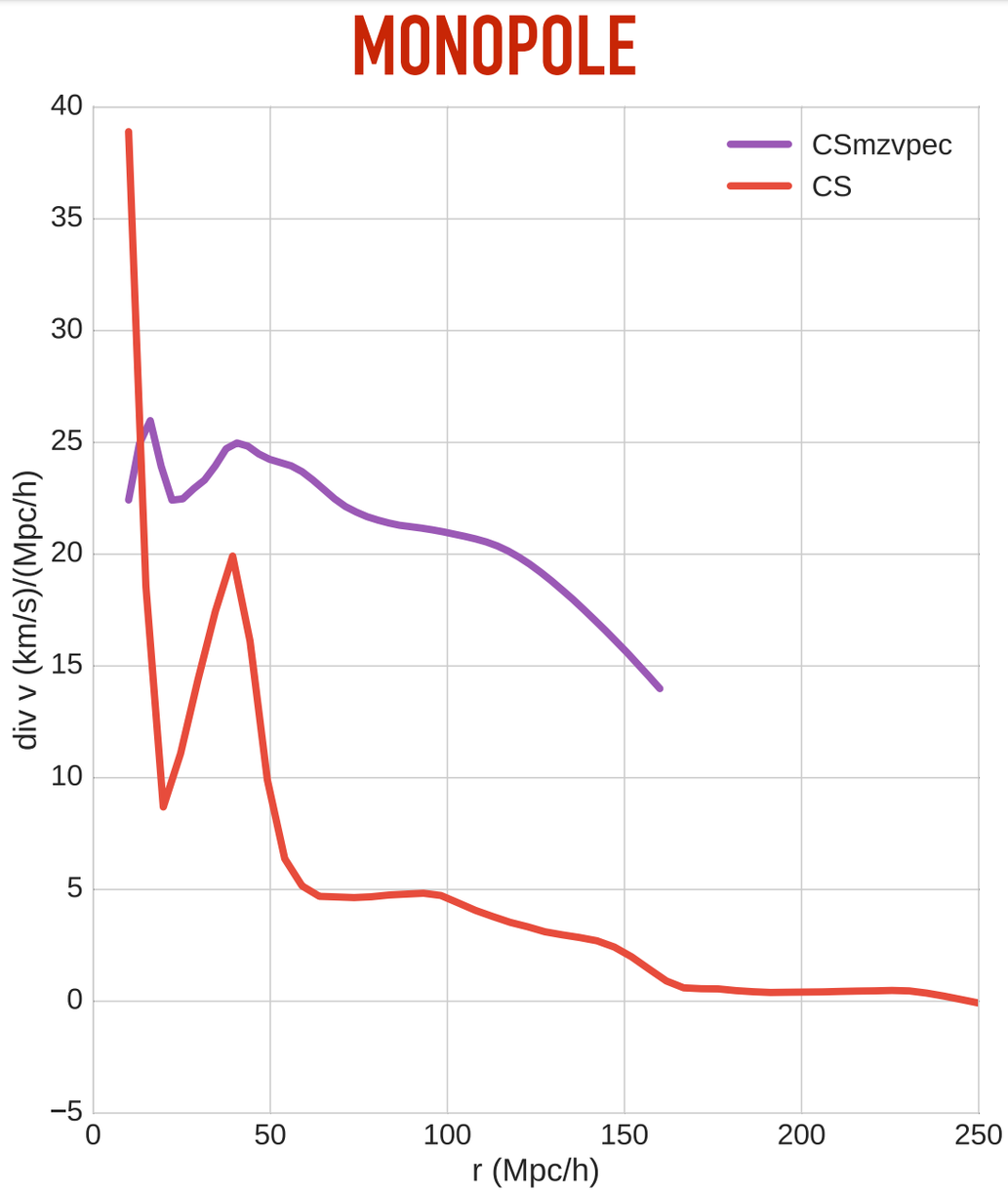


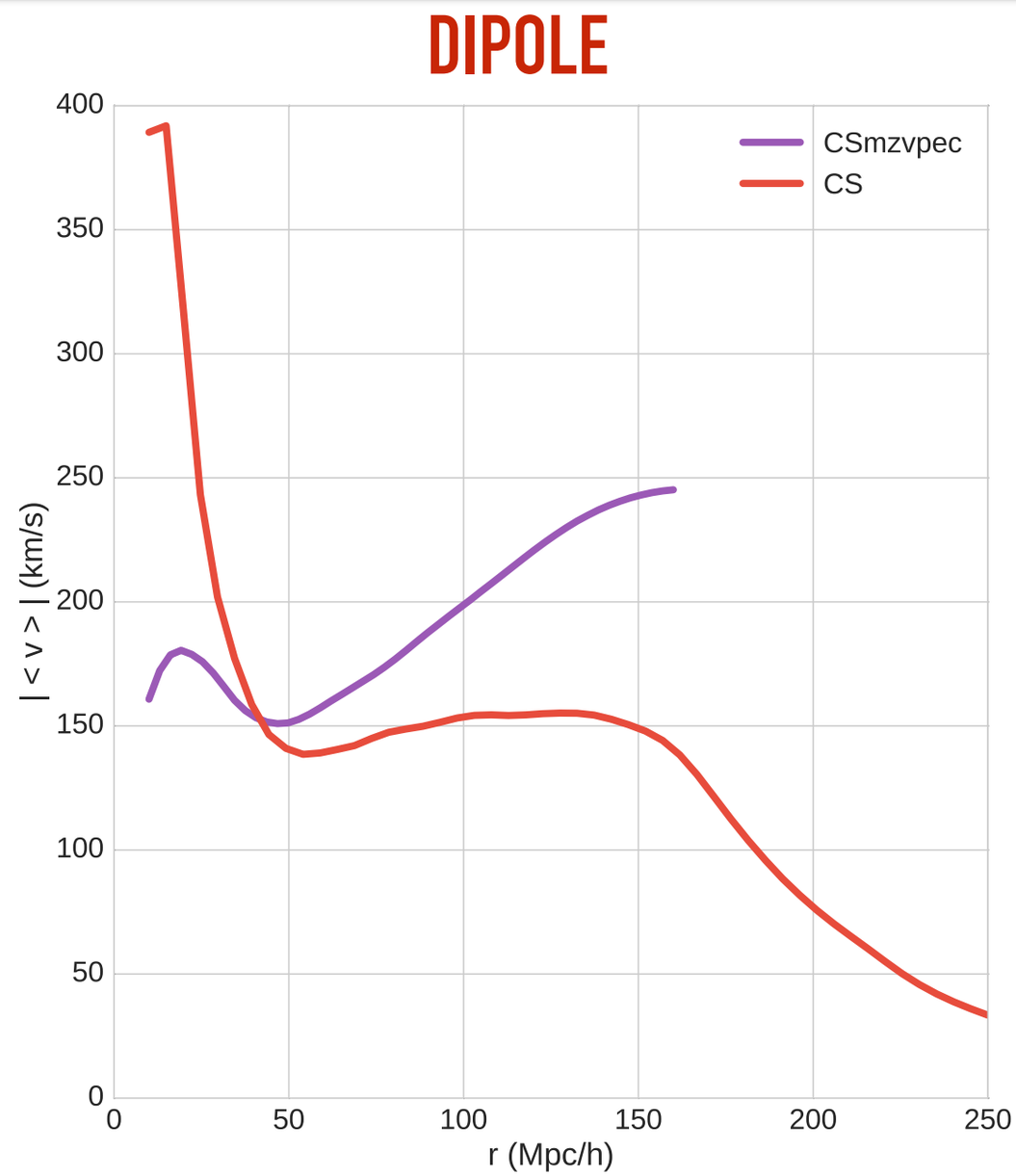


REDSHIFT SPACE

- $v^r(s) = v^r(r)\frac{dr}{ds} = v^r(r)\left(1 - \frac{1}{H_0}\frac{dv}{dr}\right)$
- At linear order :
  - $< \delta_i(r) v_j^\alpha(s) > = < \delta_i(r) v_j^\alpha(r) >$

REDSHIFT SPACE

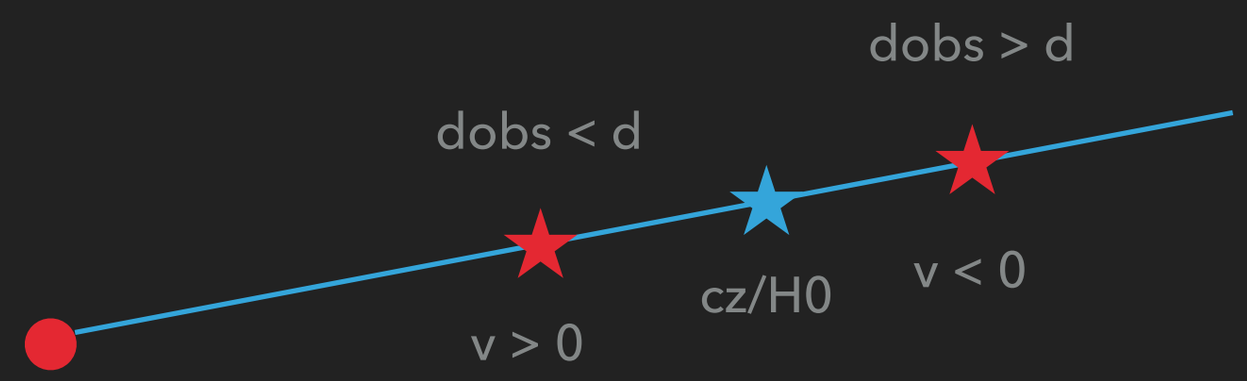




WHAT IS THE PROBLEM ?

$$v^r(r) = cz - H_0 d_c \implies \Delta v = H_0 \Delta d_c$$

$$\Delta v(v > 0) < \Delta v(v < 0)$$



-> Dominated by positive observed radial peculiar velocities

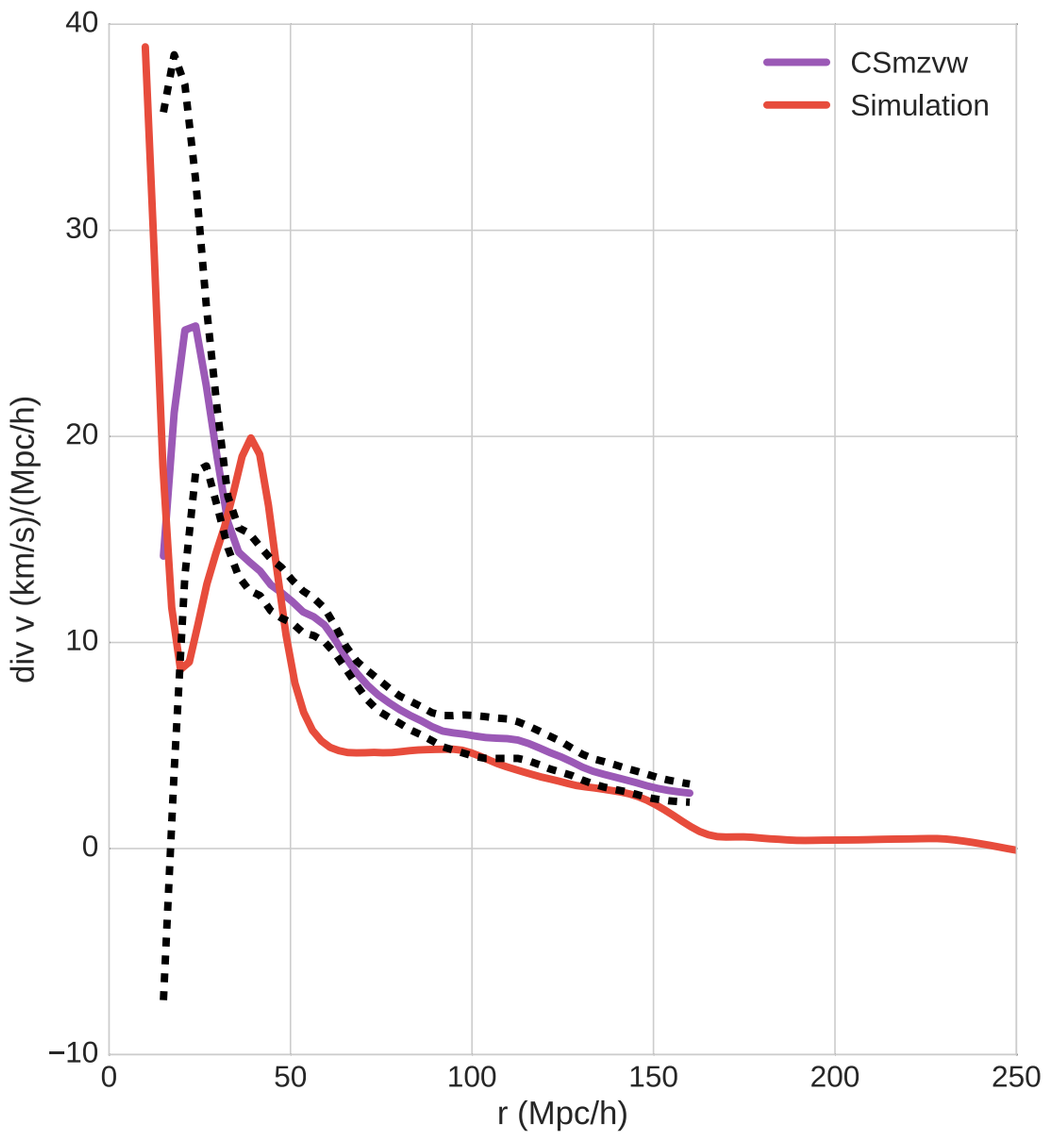
LOGNORMAL RADIAL PECULIAR VELOCITY ESTIMATOR

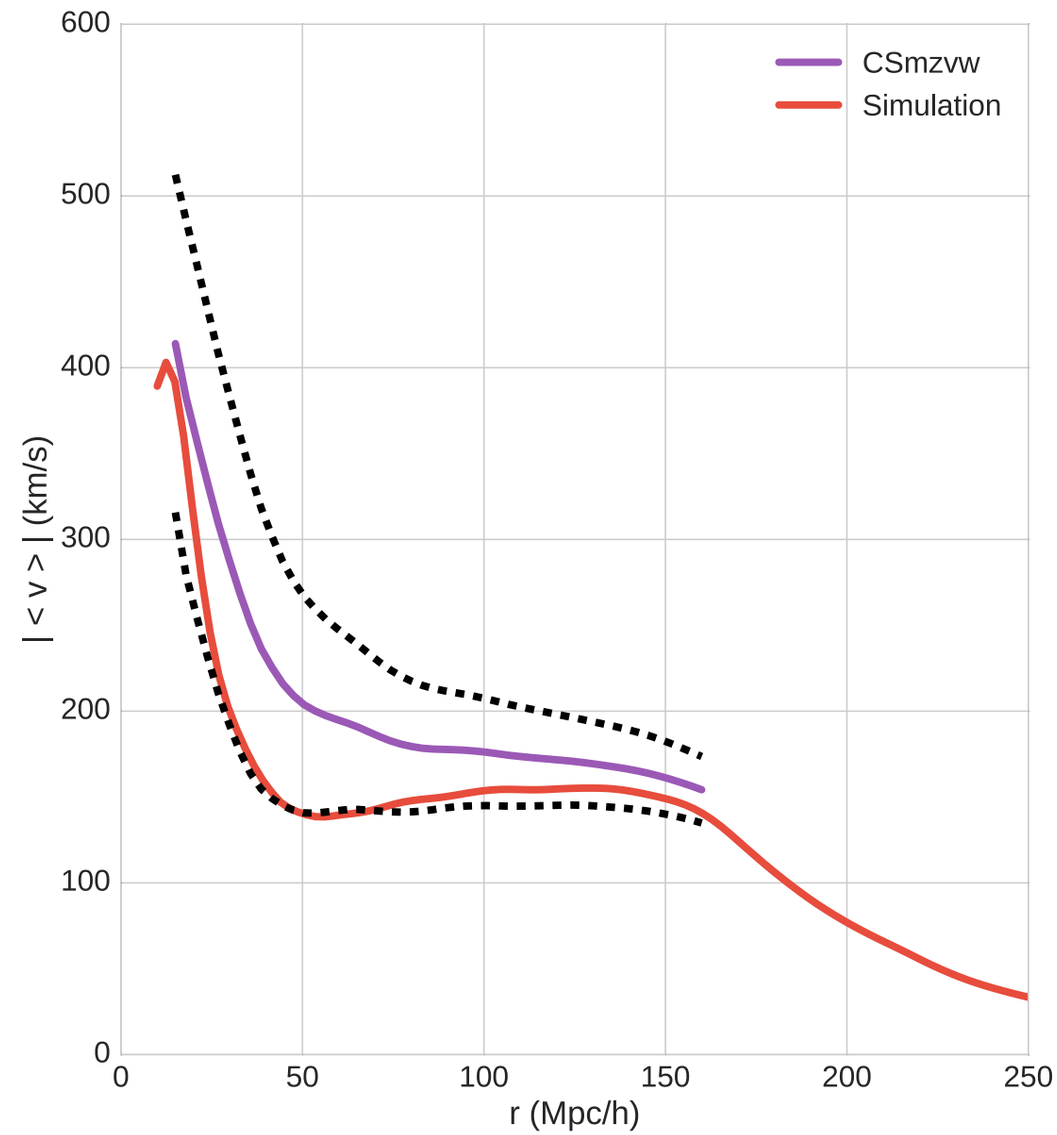
$$\hat{v}^r(r) = cz \log \frac{cz}{H_0 d_c} \implies \Delta\hat{v} = cz\Delta \log d$$

$$v \ll cz \implies \hat{v}^r \sim v^r$$

WATKINS AND FELDMAN, 2015

LOGNORMAL RADIAL PECULIAR VELOCITY ESTIMATOR

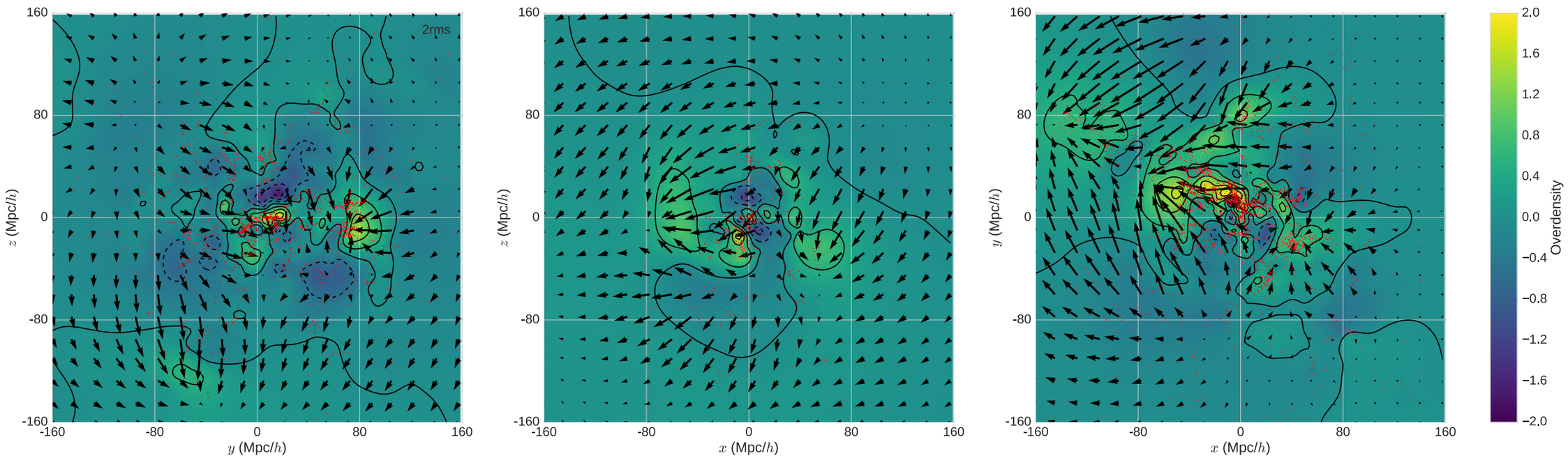




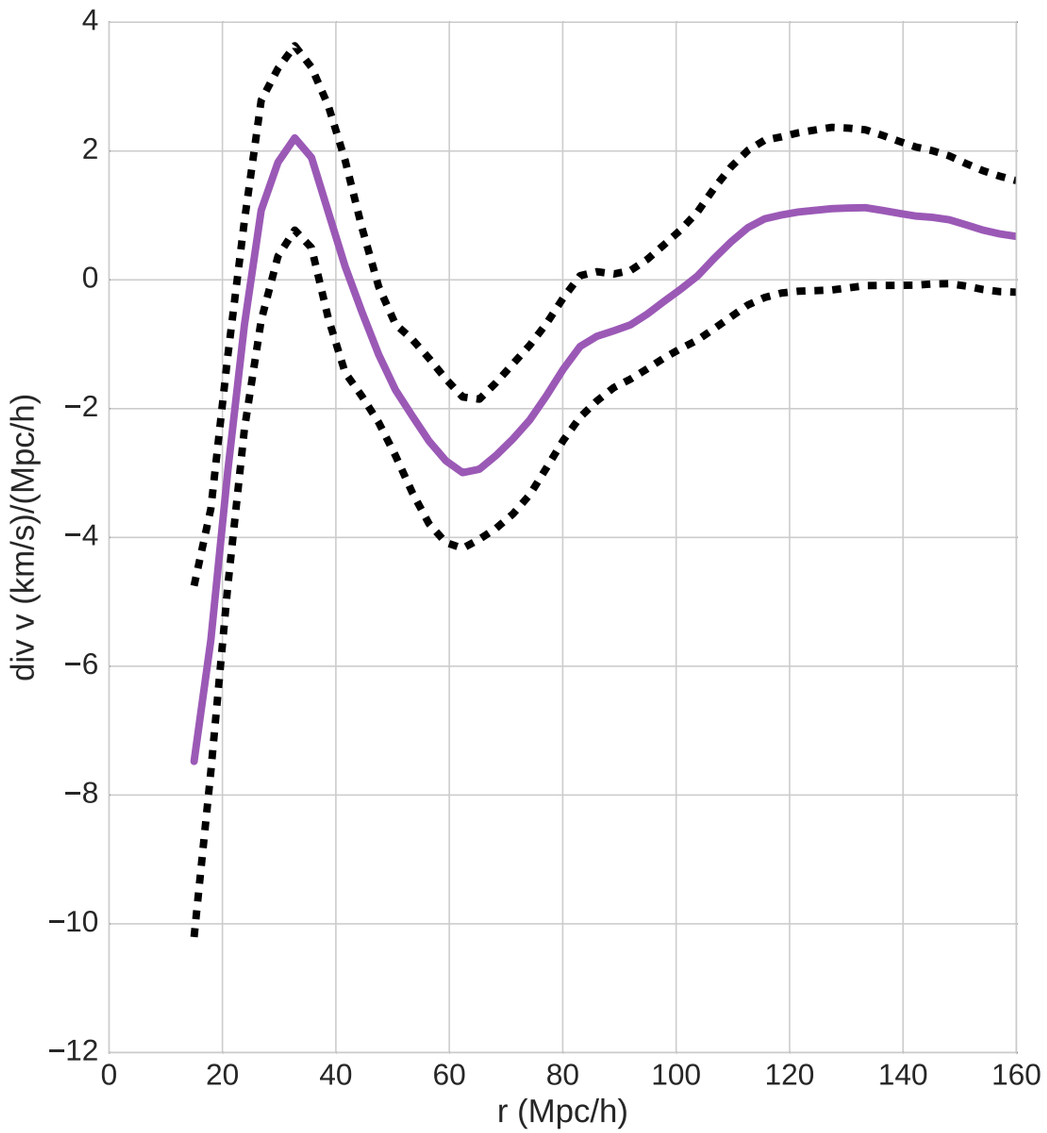
CONTENTS

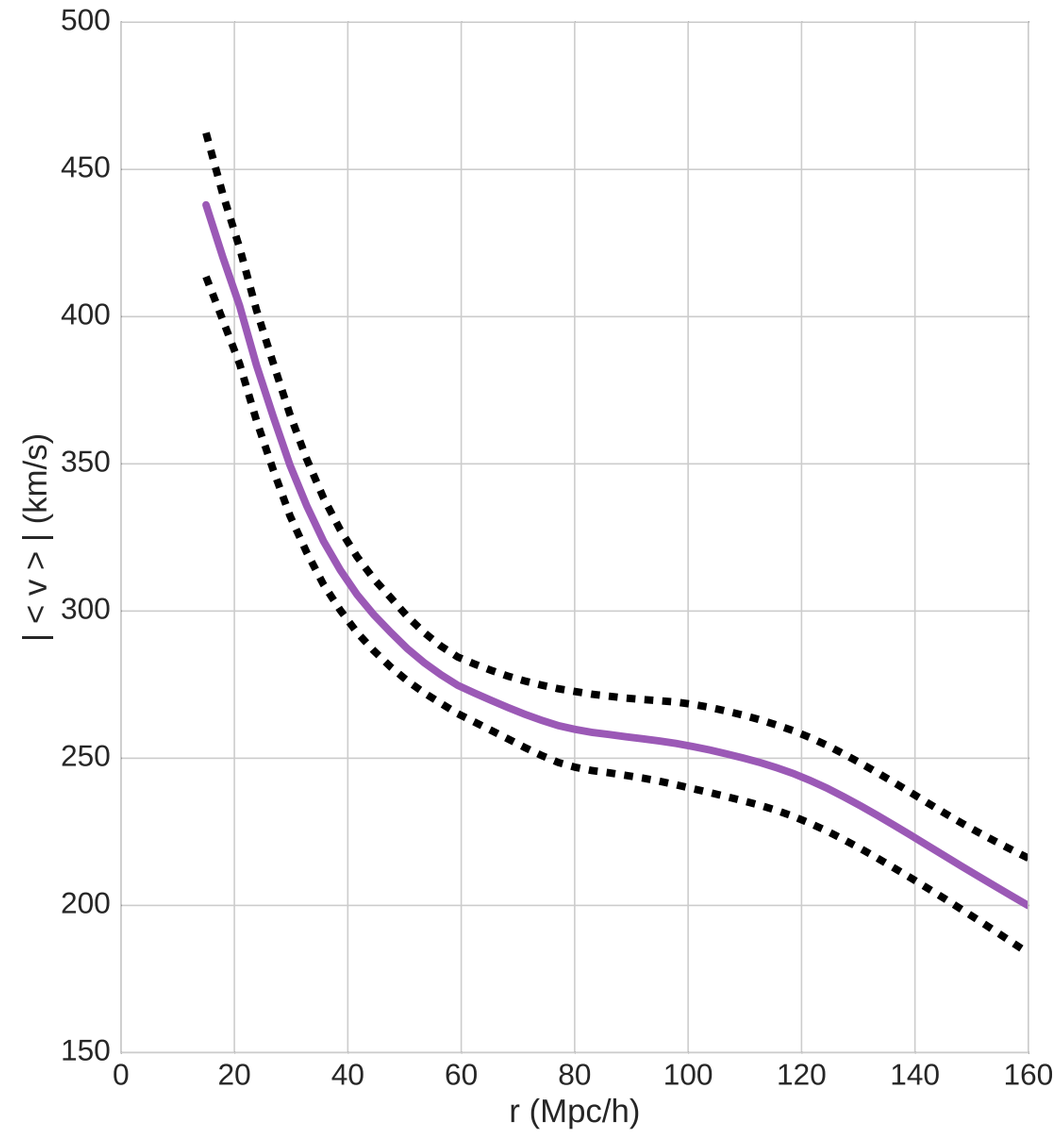
- Introduction
- Peculiar velocity field reconstruction
  - Cosmic-Flows
  - The Wiener Filter
- Statistical biases
  - Homogeneous Malmquist bias in distance
  - Distribution of radial peculiar velocities
- Results
- Outlook

CF2


2rms
160
80
0
-80
-160
-160
-80
0
80
160
z (Mpc/h)
y (Mpc/h)
x (Mpc/h)
2.0
1.6
1.2
0.8
0.4
0.0
−0.4
−0.8
−1.2
−1.6
−2.0
Overdensity

CF2


MONOPOLE
div v (km/s)/(Mpc/h)
4
2
0
−2
−4
−6
−8
−10
−12
0
20
40
60
80
100
120
140
160
r (Mpc/h)


DIPOLE
| < v > | (km/s)
500
450
400
350
300
250
200
150
0
20
40
60
80
100
120
140
160
r (Mpc/h)

WORKING ON CF3 ANALYSIS…

OUTLOOK

- What can we do with this reconstruction ?
  - Generate ICs for Constrained Simulations (CLUES)
  - Cosmography (Courtois, Hoffman, Tully, Pomarede)
    - V-Web classification
  - Estimation of Monopole and Dipole of the velocity field (Hoffman and al. 2016)
  - Estimation of cosmological parameters