Dark Cosmology Centre

Mass measurement from the projected phase-space analysis

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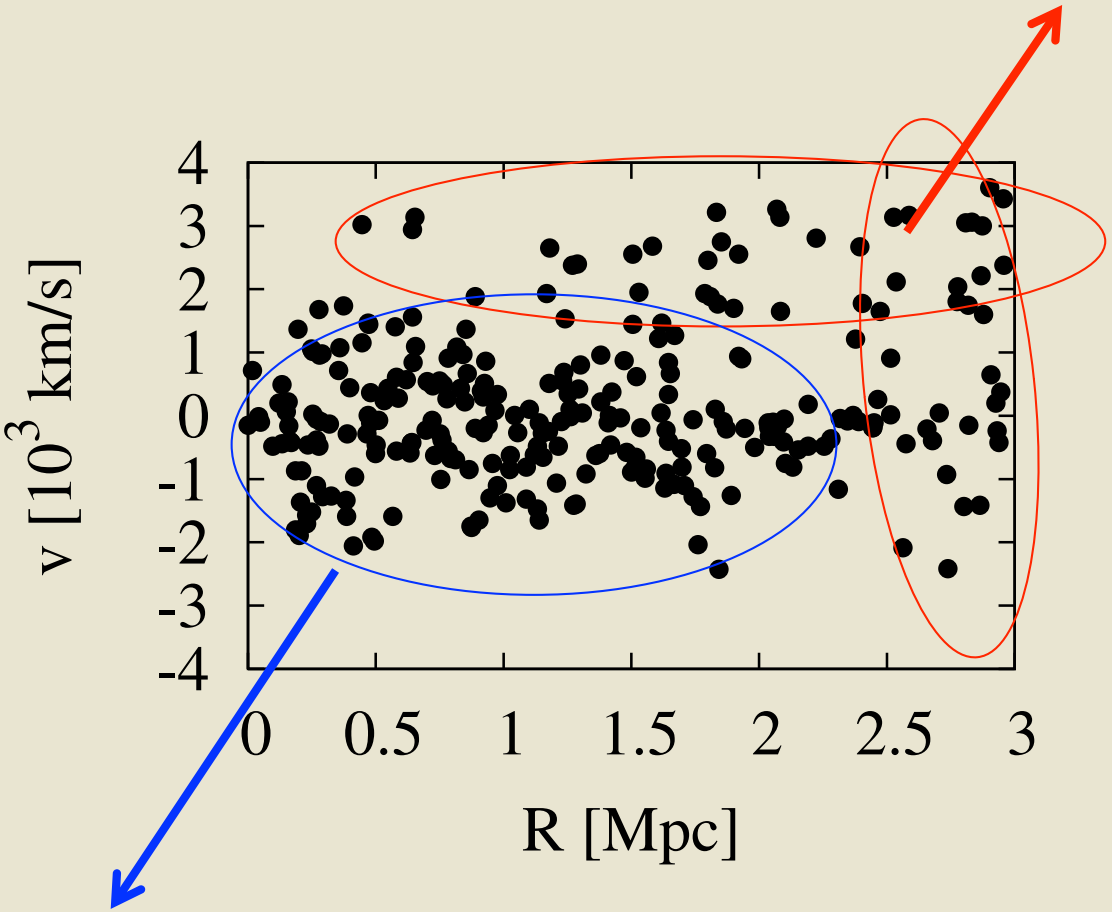
Halo Mass Project, Nottingham 2013

Outline

- Recognizing the problems
- Probabilistic approach to selection of members
- Dynamical equilibrium: anisotropic model of the distribution function
- Analysis of the projected phase space
- Expected scatter and bias
- Problem of asphericity (digression)
- Method: description of the algorithm
- Discussion

Recognizing the problems

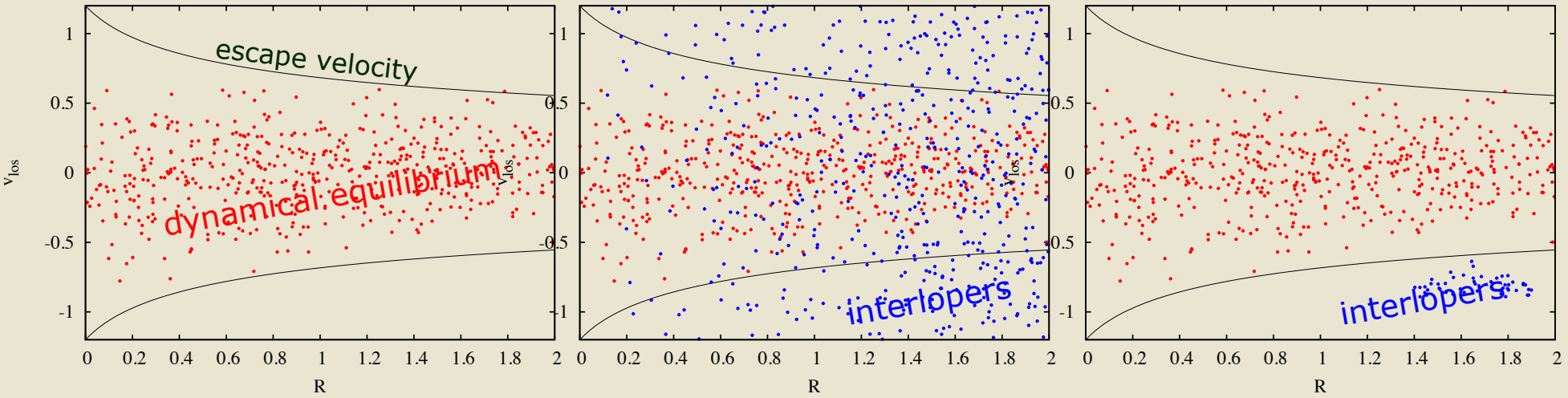
removal of interlopers/selection of members



mass inference

Two-component model of the projected phase-space density

isolated | uniform background (stacks) | irregular



$$wp_{eq}(R,v)+(1-w)p_{int}(R,v)$$

- equilibrium @ $|v|<[2\Psi(R)]^{1/2}$
- 0 @ $|v|>[2\Psi(R)]^{1/2}$

unrealistic

accurate for stacks

- equilibrium @ $|v|<[2\Psi(R)]^{1/2}$
- $\sim R$ @ $|v|>[2\Psi(R)]^{1/2}$

the most realistic for individual objects

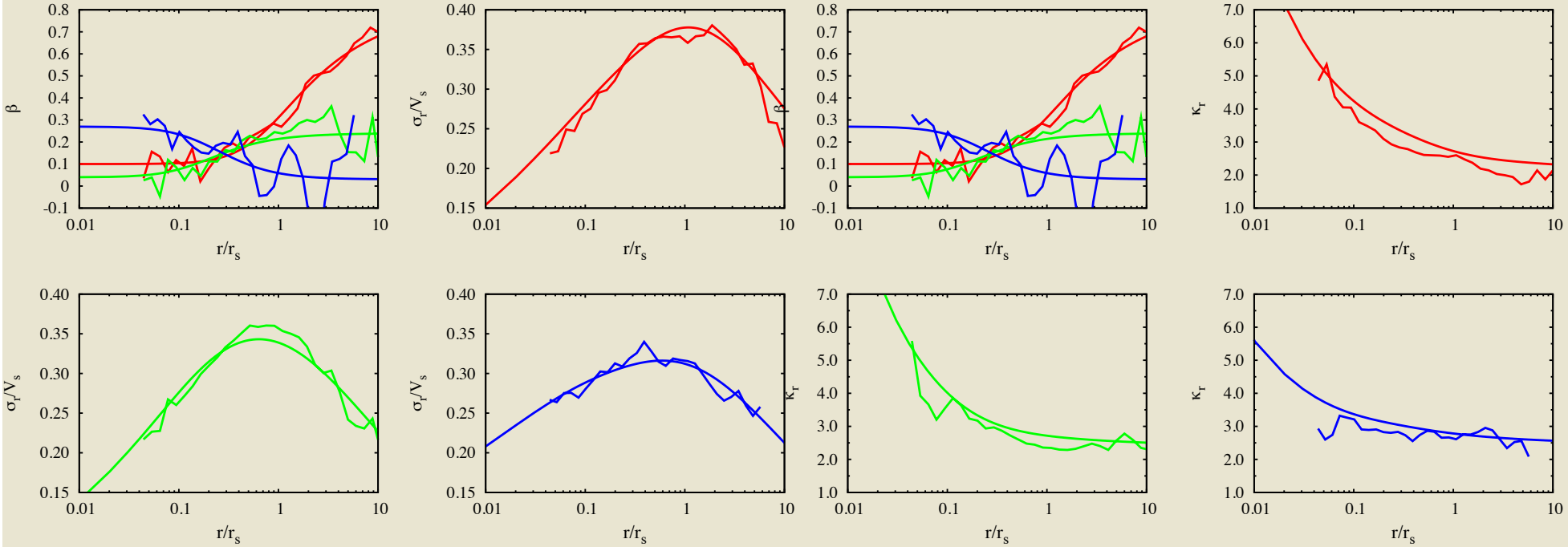
Equilibrium model: anisotropic distribution function

NFW

$$f_E(E)\left(1+\frac{L^2}{2L_0^2}\right)^{-\beta_\infty+\beta_0} L^{-2\beta_0}$$

$$\beta(r) = 1 - \frac{\sigma_\theta^2(r)}{\sigma_r^2(r)},$$

Wojtak et al 2008



Projected phase-space density

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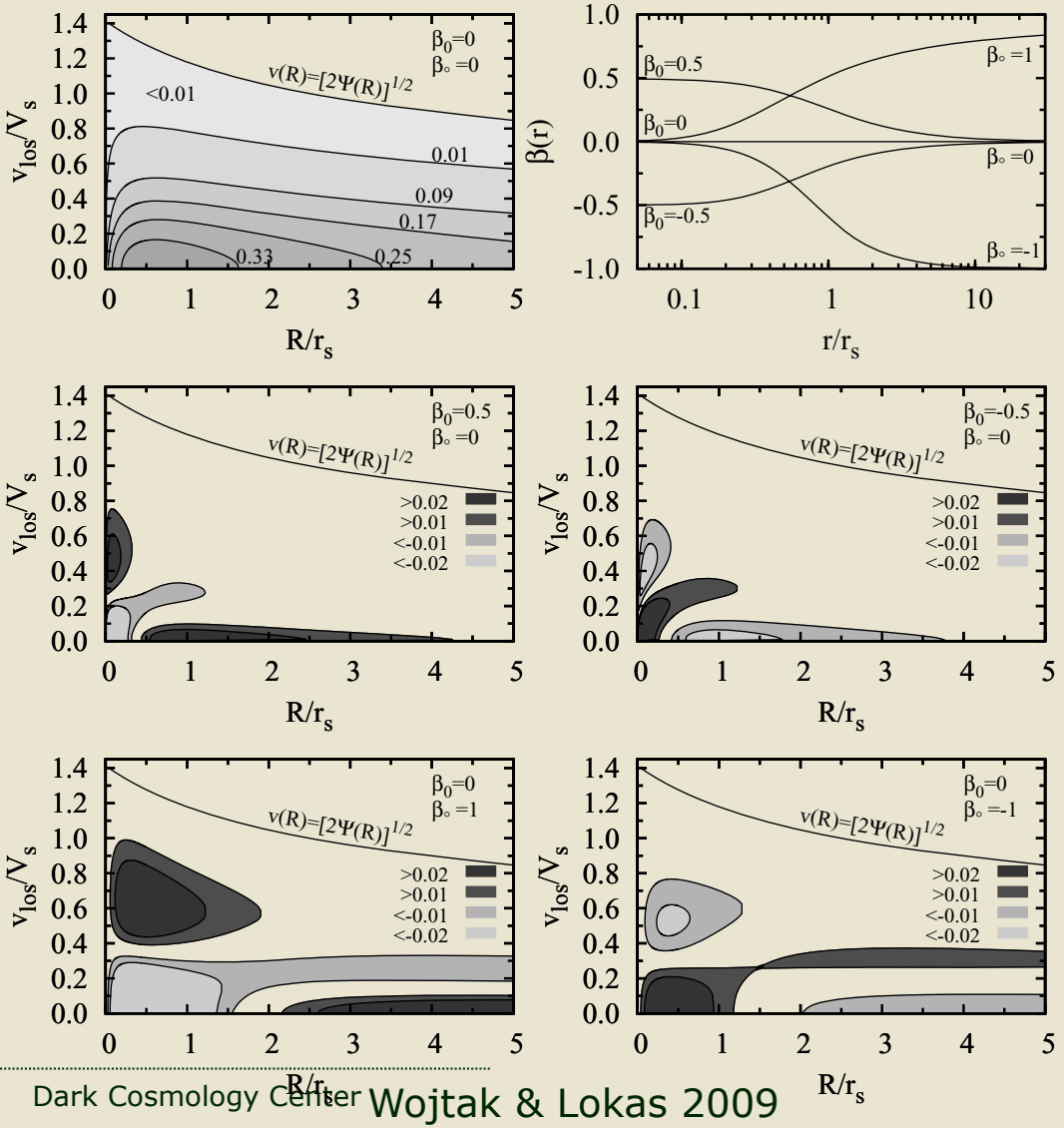
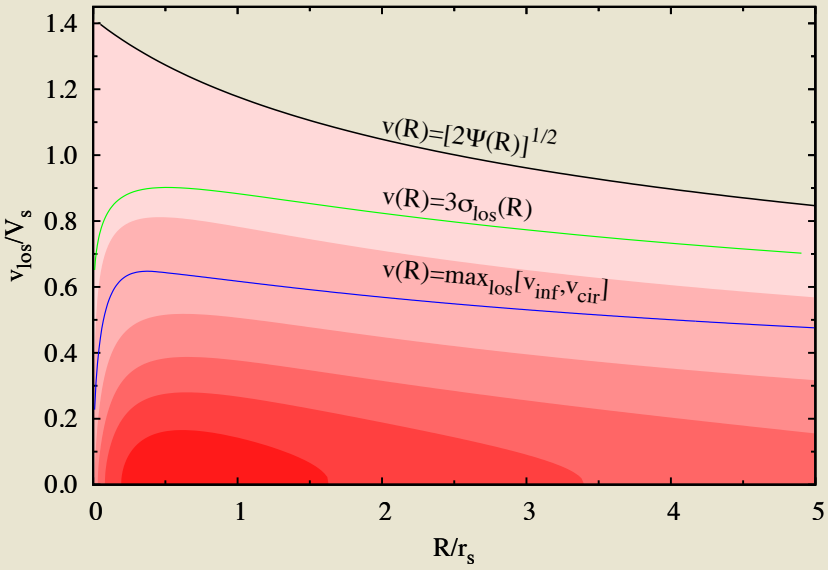
Breaking mass-anisotropy degeneracy



Maximum velocity profile used to separate interlopers



Wojtak & Lokas 2009

Projected phase-space analysis

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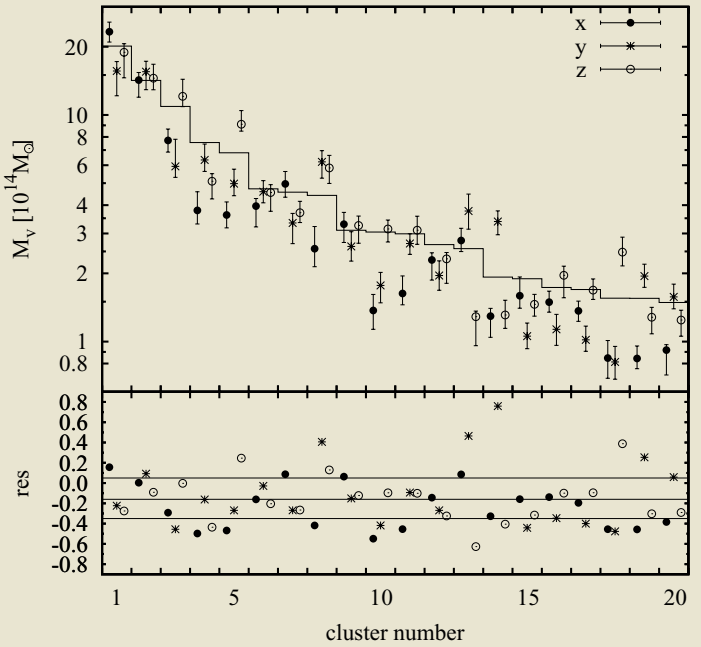
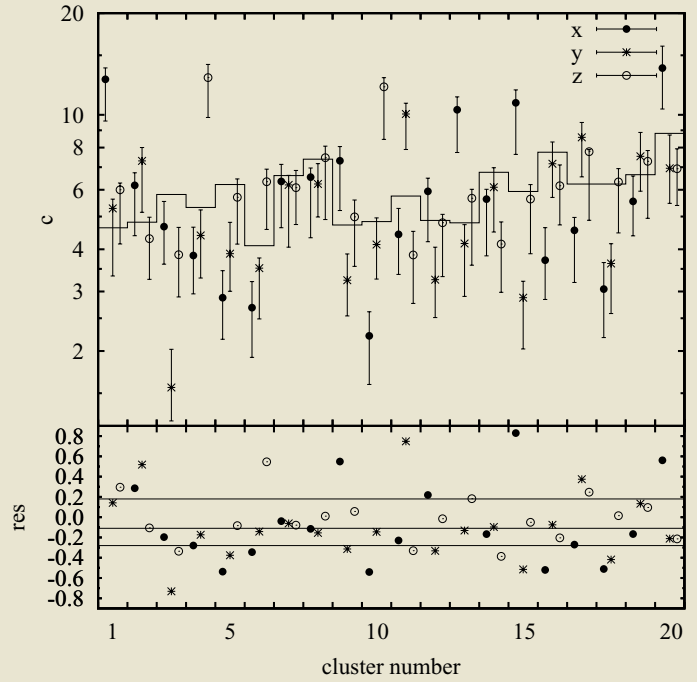
- no need of data binning
  $L \sim \Pi p(R_i, v_{los\ i} | \text{parameters})$
- breaking mass-anisotropy degeneracy
- degrees of freedom
  total mass profile, e.g. NFW
  tracer density profile, e.g. M/L~const
  anisotropy profile

- spherical symmetry

Virial mass (spherical overdensity)
- scatter of 30%
- typically underestimated

ASPHERICITY !





Cylindrical symmetry rather than spherical

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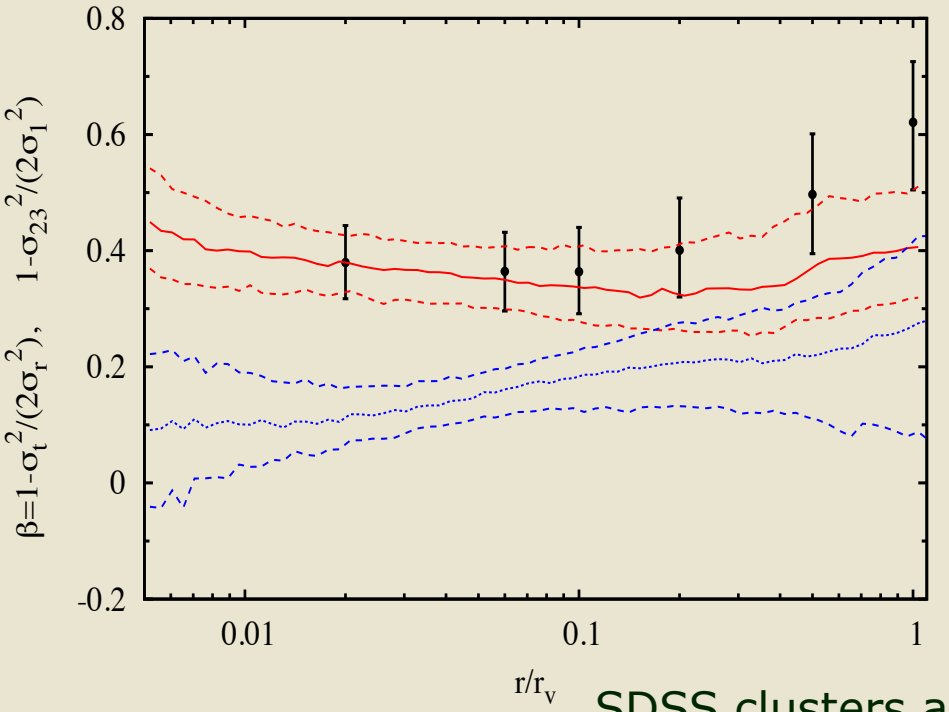


Cluster-like DM haloes
from Bolshoi simulation

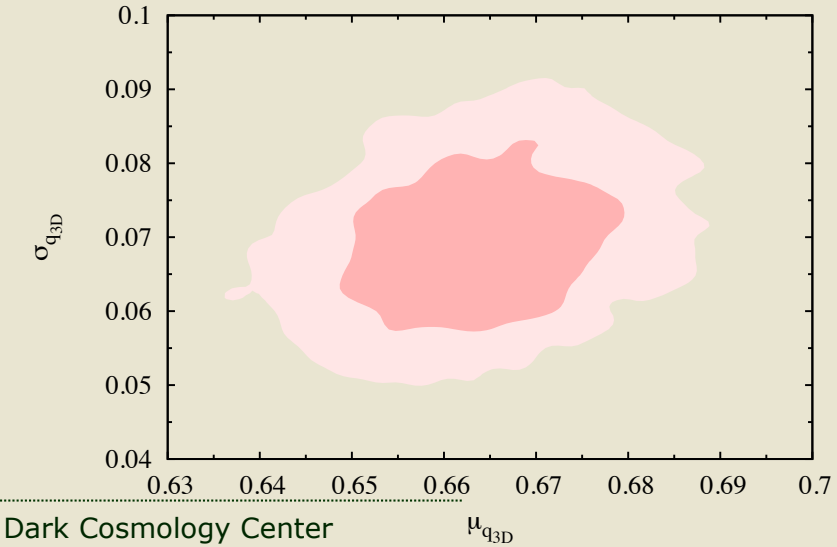
local values

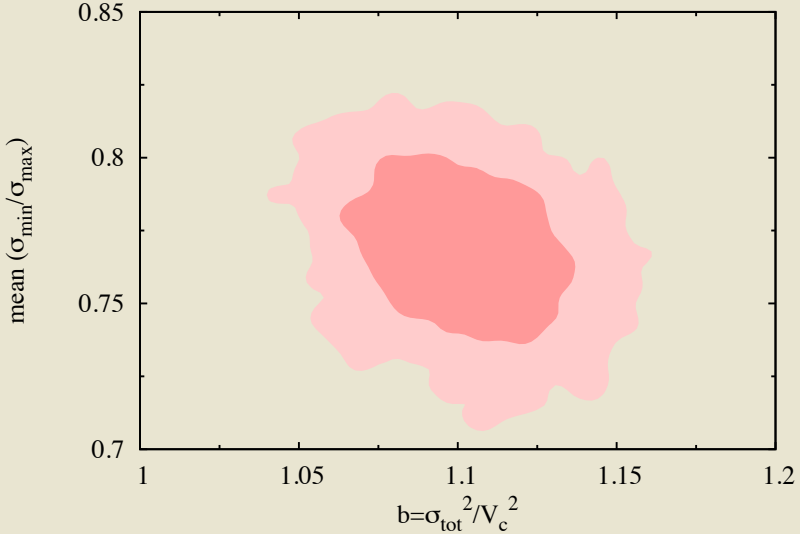
cylindrical symmetry

spherical symmetry

Wojtak et al 2013

SDSS clusters and rich groups of galaxies

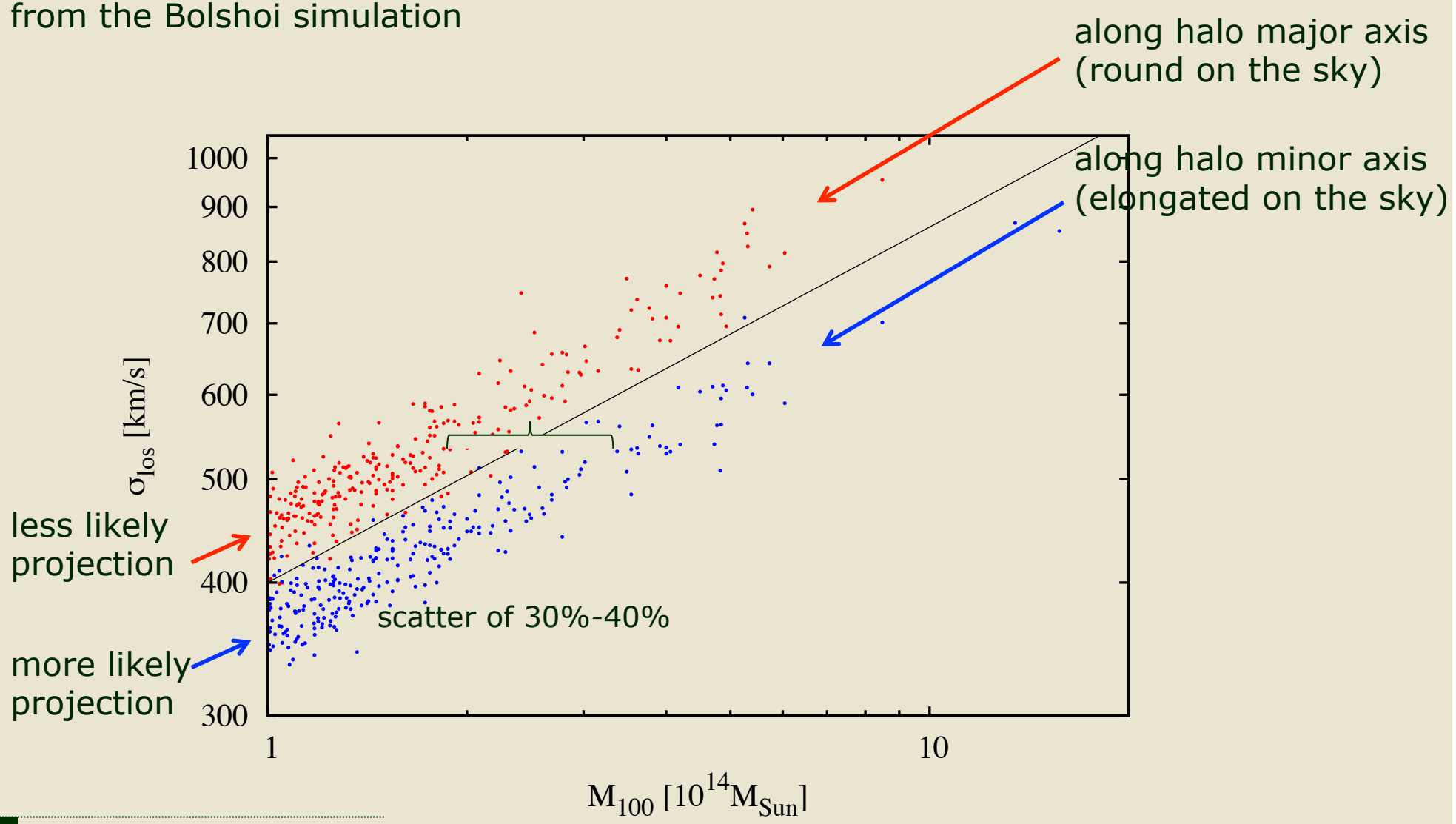




Wojtak et al 2013 (submitted)

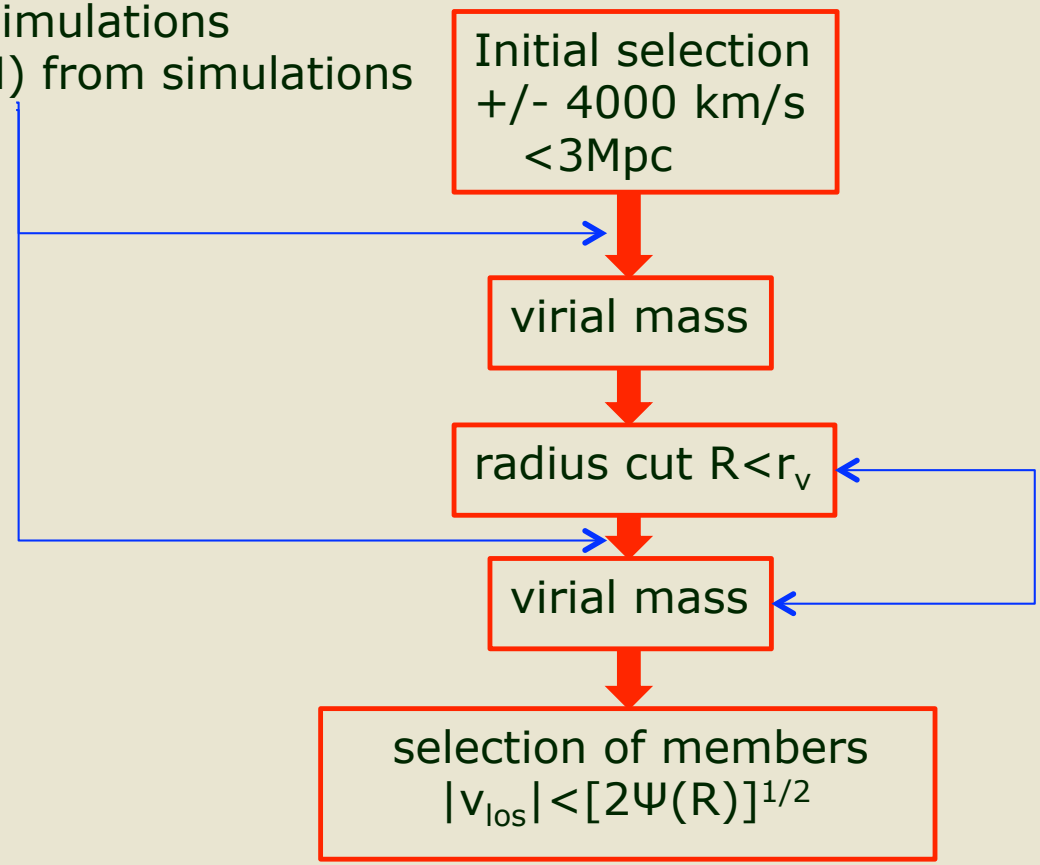
Velocity dispersion-mass relation in different projections

Based on subhaloes in ~500 cluster-like haloes from the Bolshoi simulation



Scheme of the analysis

- total mass profile: NFW
- galaxies: NFW
- β profile from simulations
- c(M) from simulations
- c(gal)/c(DM) from simulations



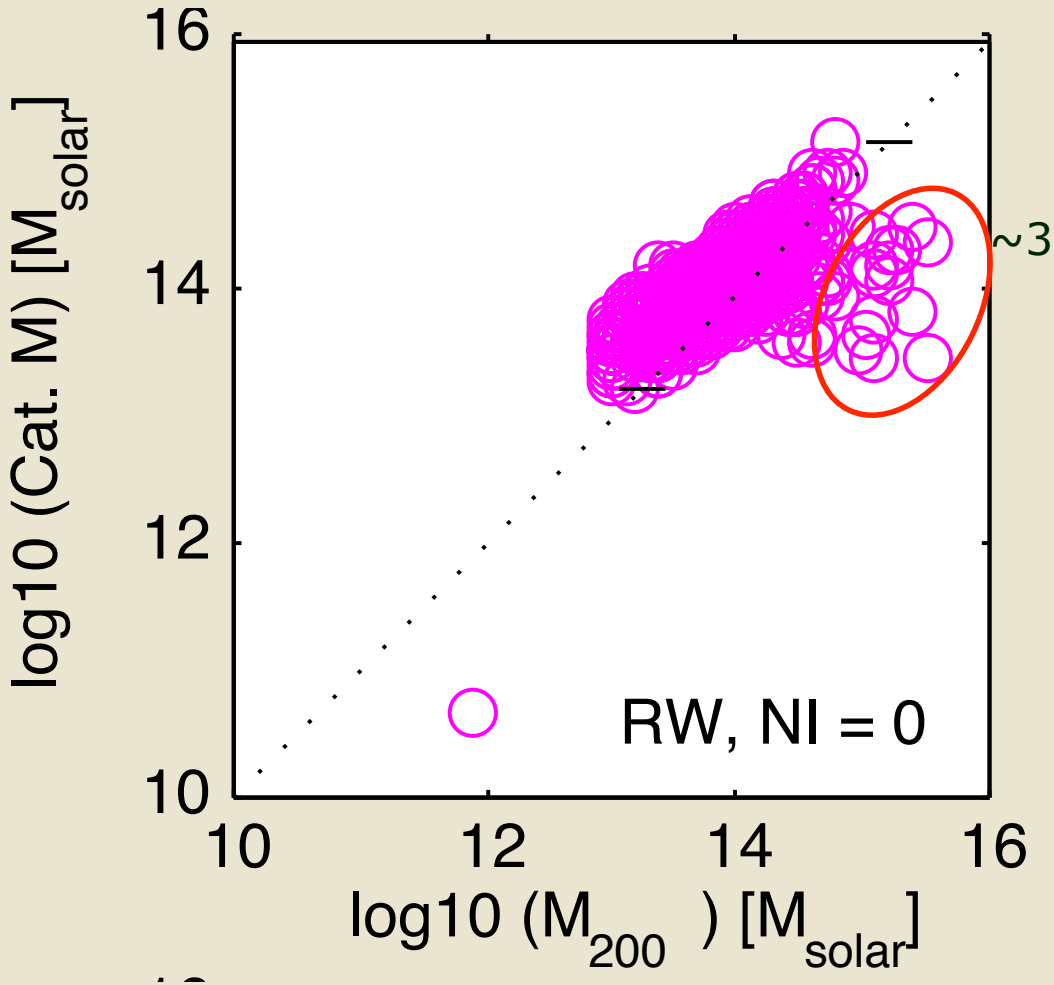
possible improvements

tighter velocity envelope than $|v_{los}|<[2\Psi(R)]^{1/2}$(?)

more iterations (?)

& $R<r_v$ (?)

First glance at the performance



~3% of catastrophic cases

Velocity diagrams stacked by mass

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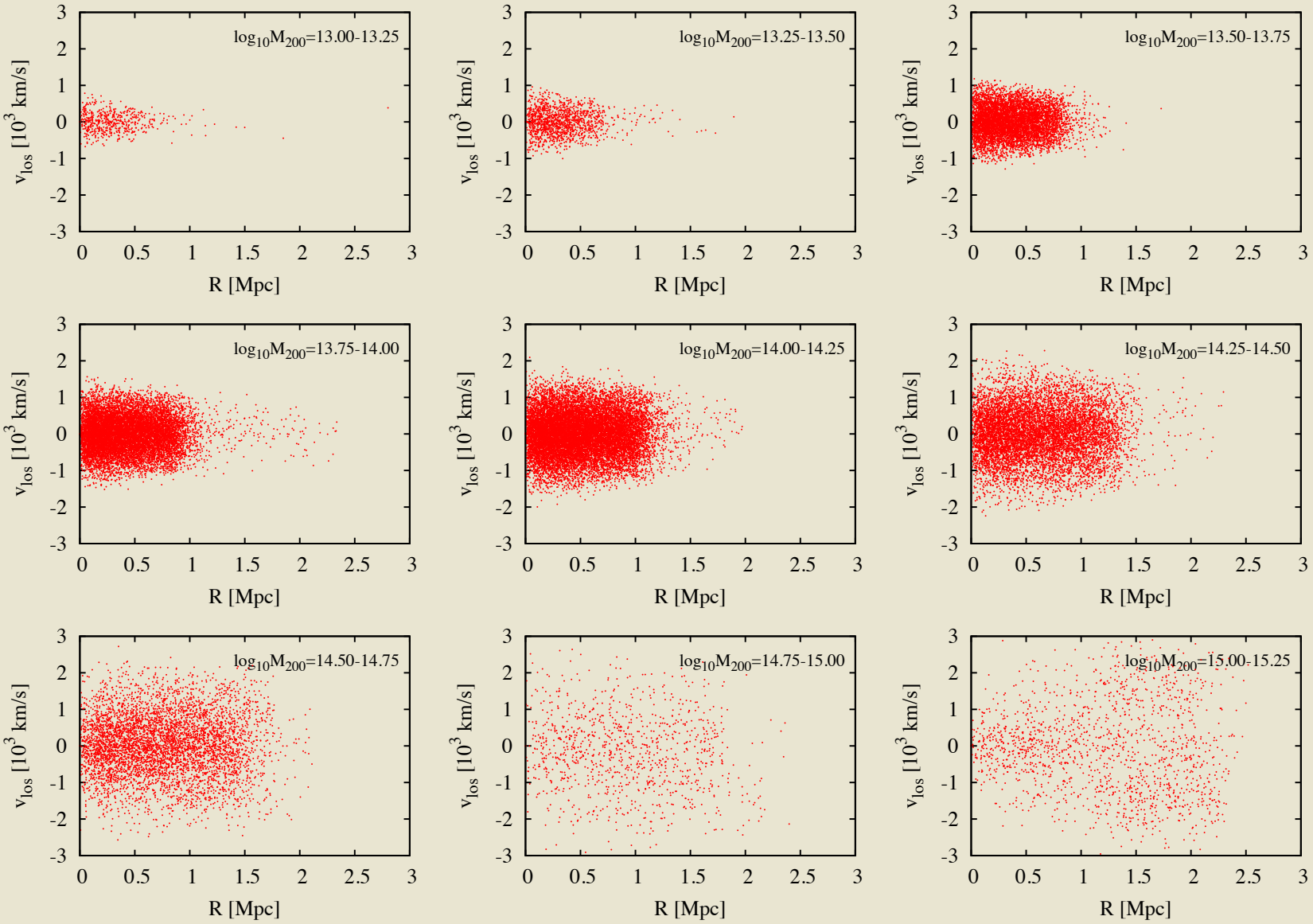

Velocity dispersion profiles stacked by mass

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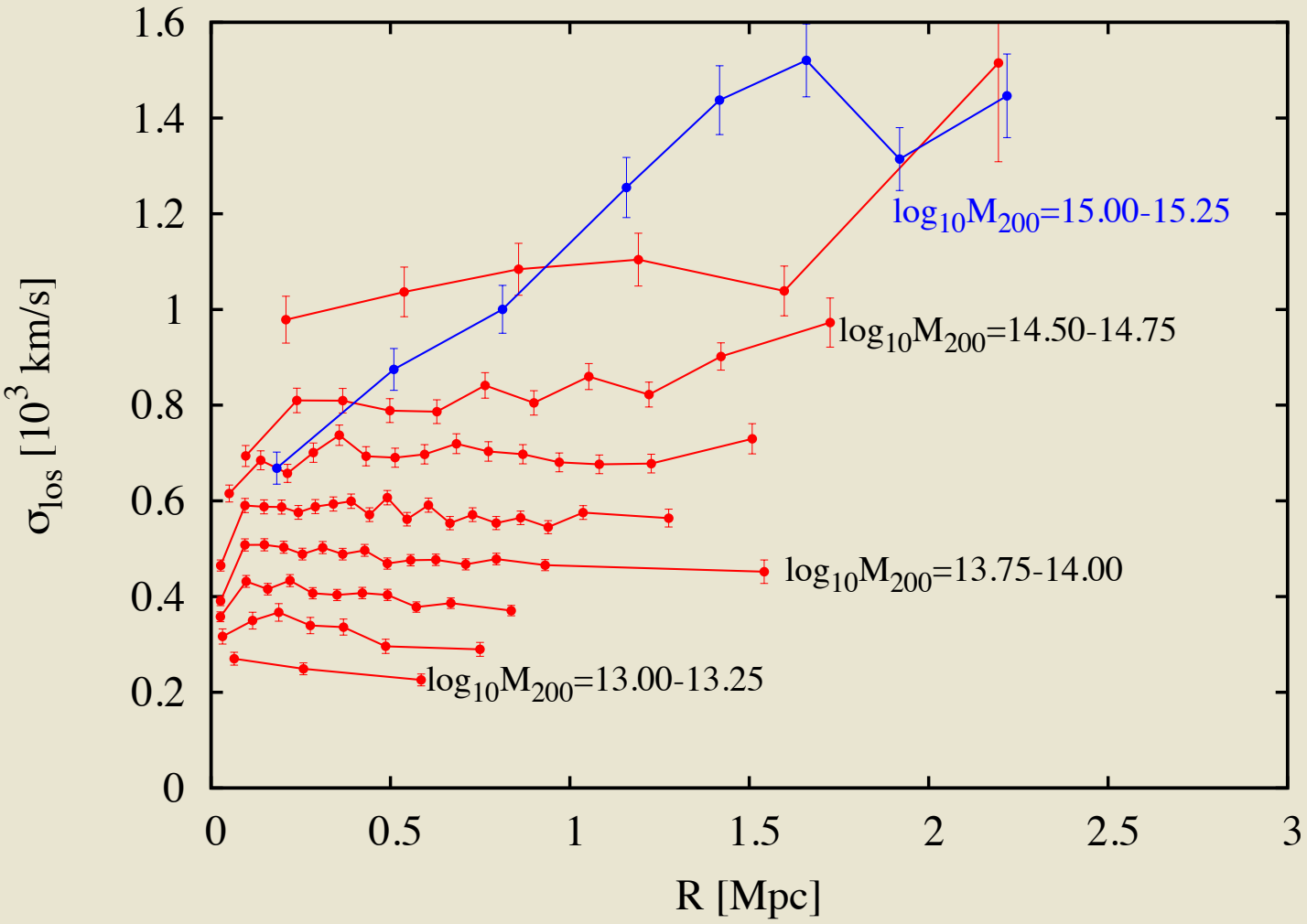

Summary

- Method based on
  probabilistic selection of members
  anisotropic and spherical model of the distribution function
  analysis of galaxy distribution in PPS
- Problems
  3% of catastrophic cases caused by strong structures along LOS
- Possible improvements
  tighter velocity envelope used to select members
  tighter initial cuts in positions and velocities
- Further perspective
  more parameters: concentration, anisotropy (if it makes sense ?)
  aspherical models
    attempt to measure mass as M(σ, elongation)