

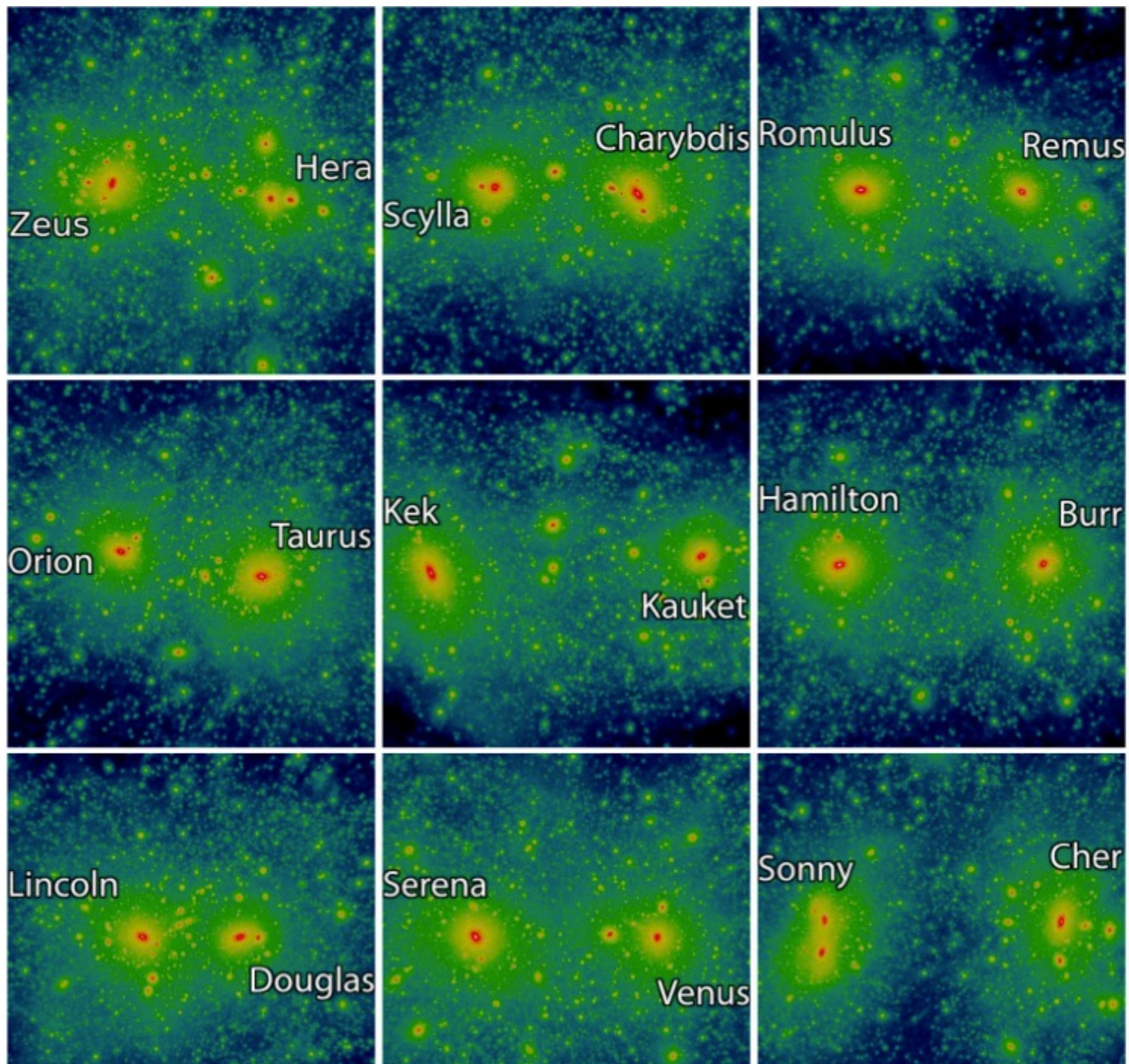
The Place of the Local Group in the Cosmic Web

in collaboration with

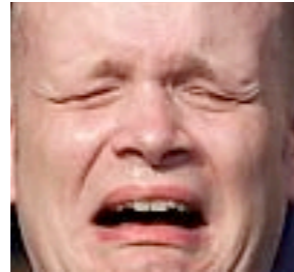
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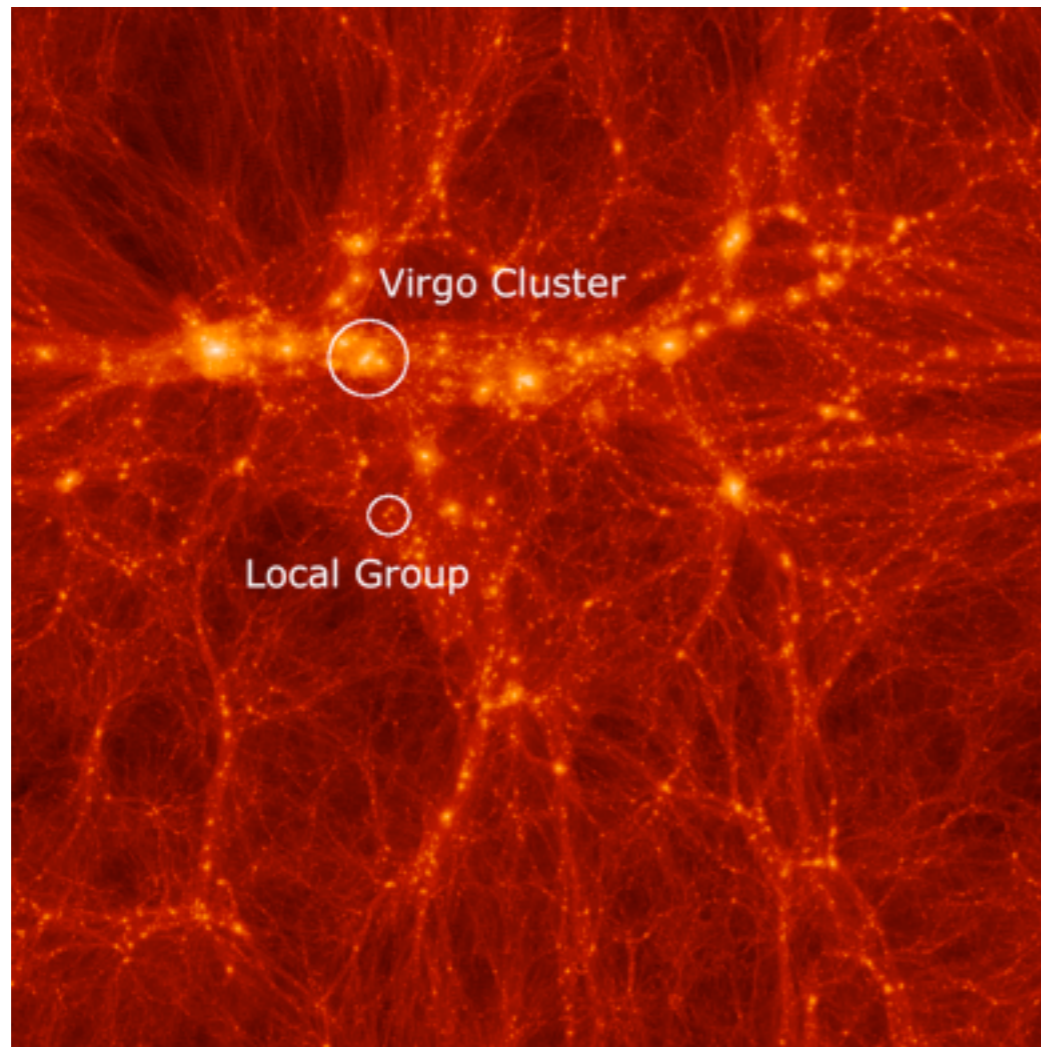
Why getting into that trouble?



Because context is important



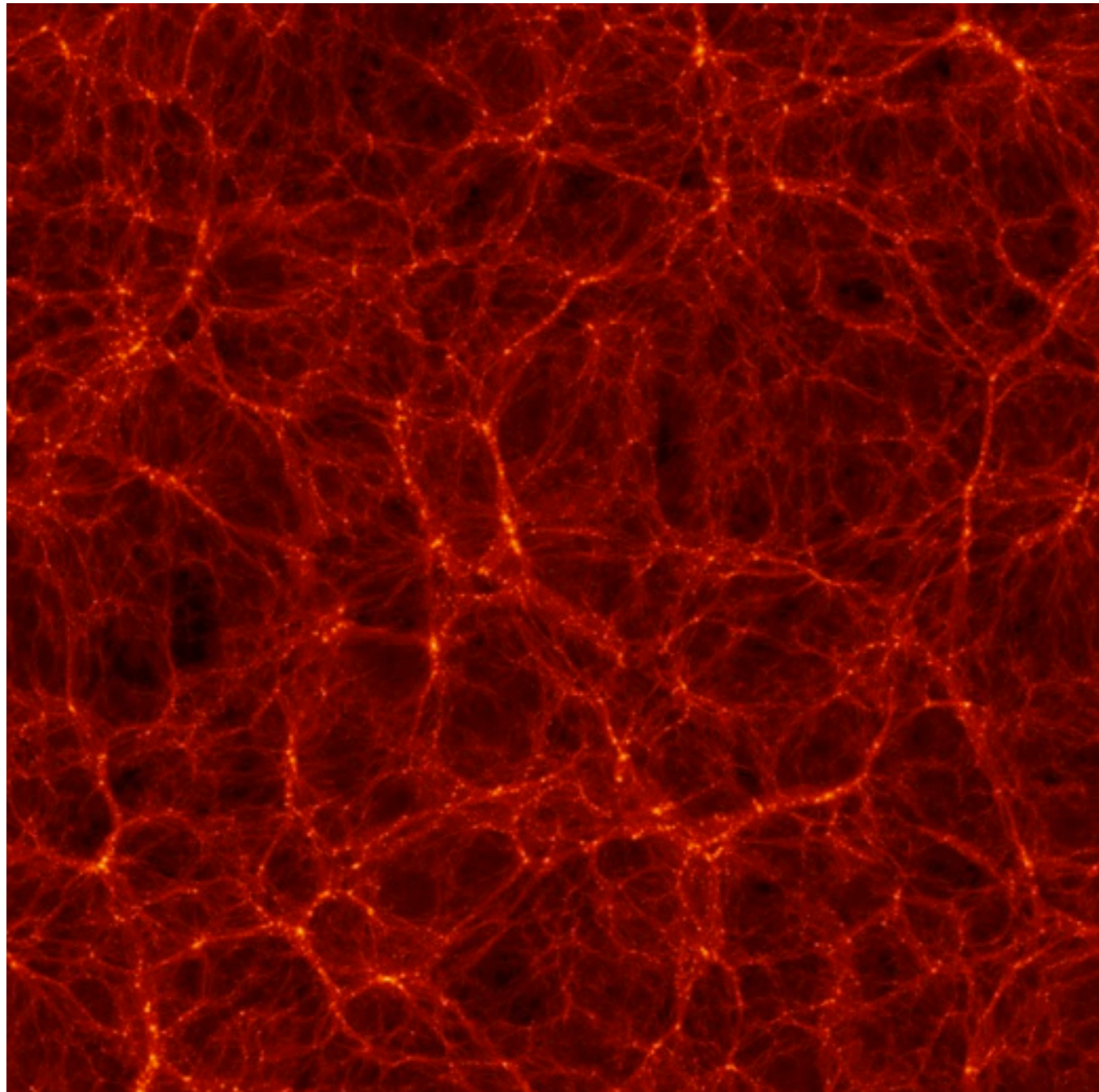
(CLUES - Constrained Local UniversE Simulations)



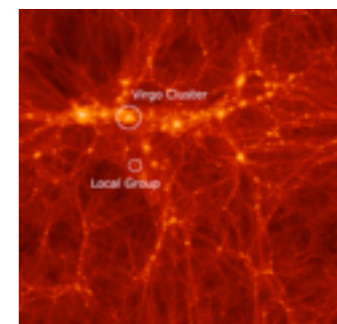
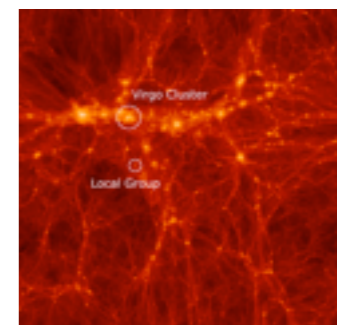
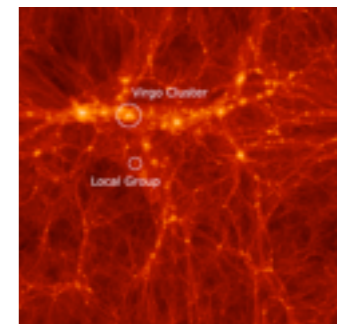
Gottloeber, Hoffman, Yepes 1005.2687

- Large Scales (5-7 Mpc) are fixed
- Small scales are random.
- 200 low res realizations until a LG is found.
- LG defined by mass and negative radial velocity).

Random & Constrained Simulations



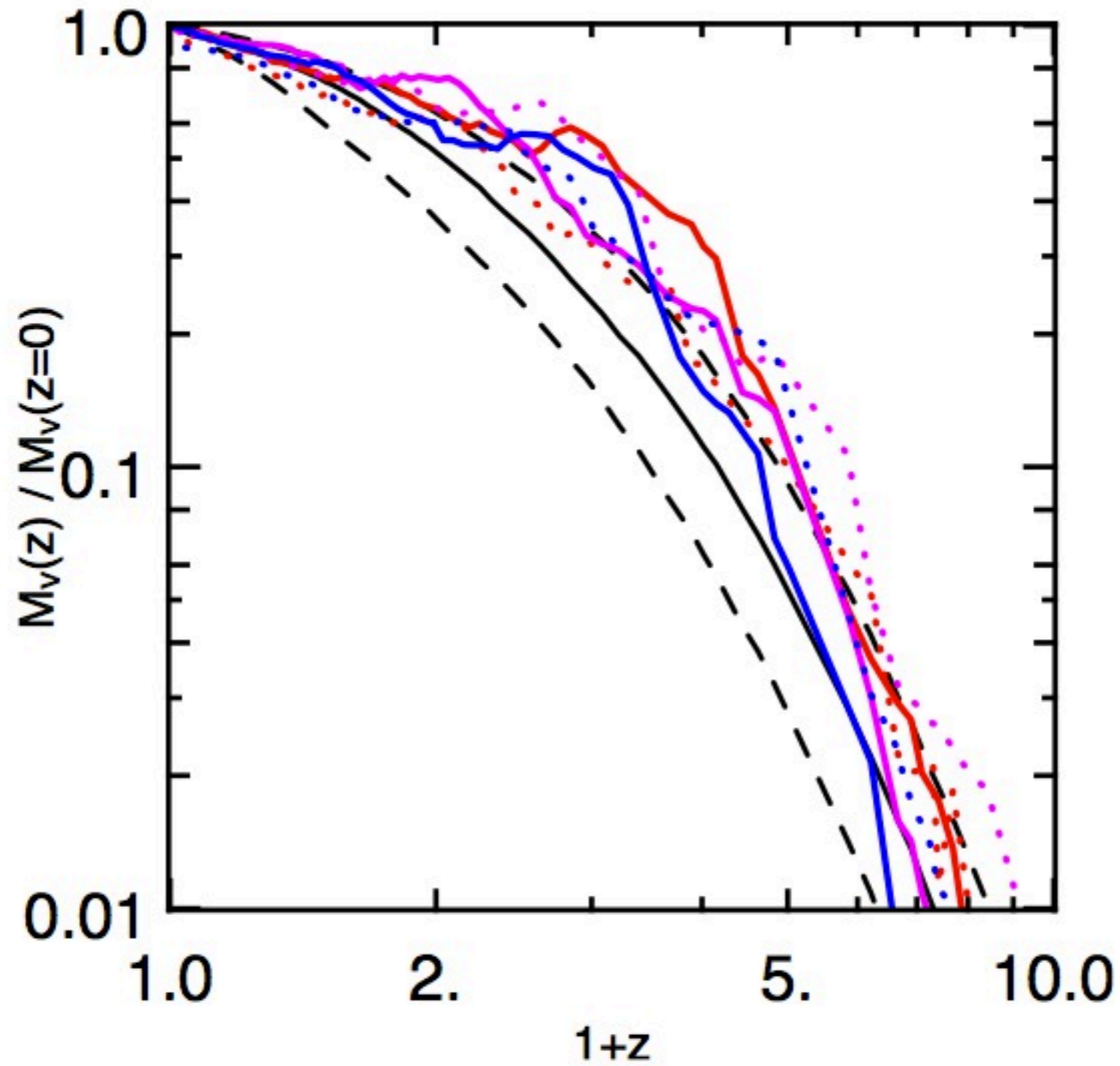
BOLSHOI
&
CLUES



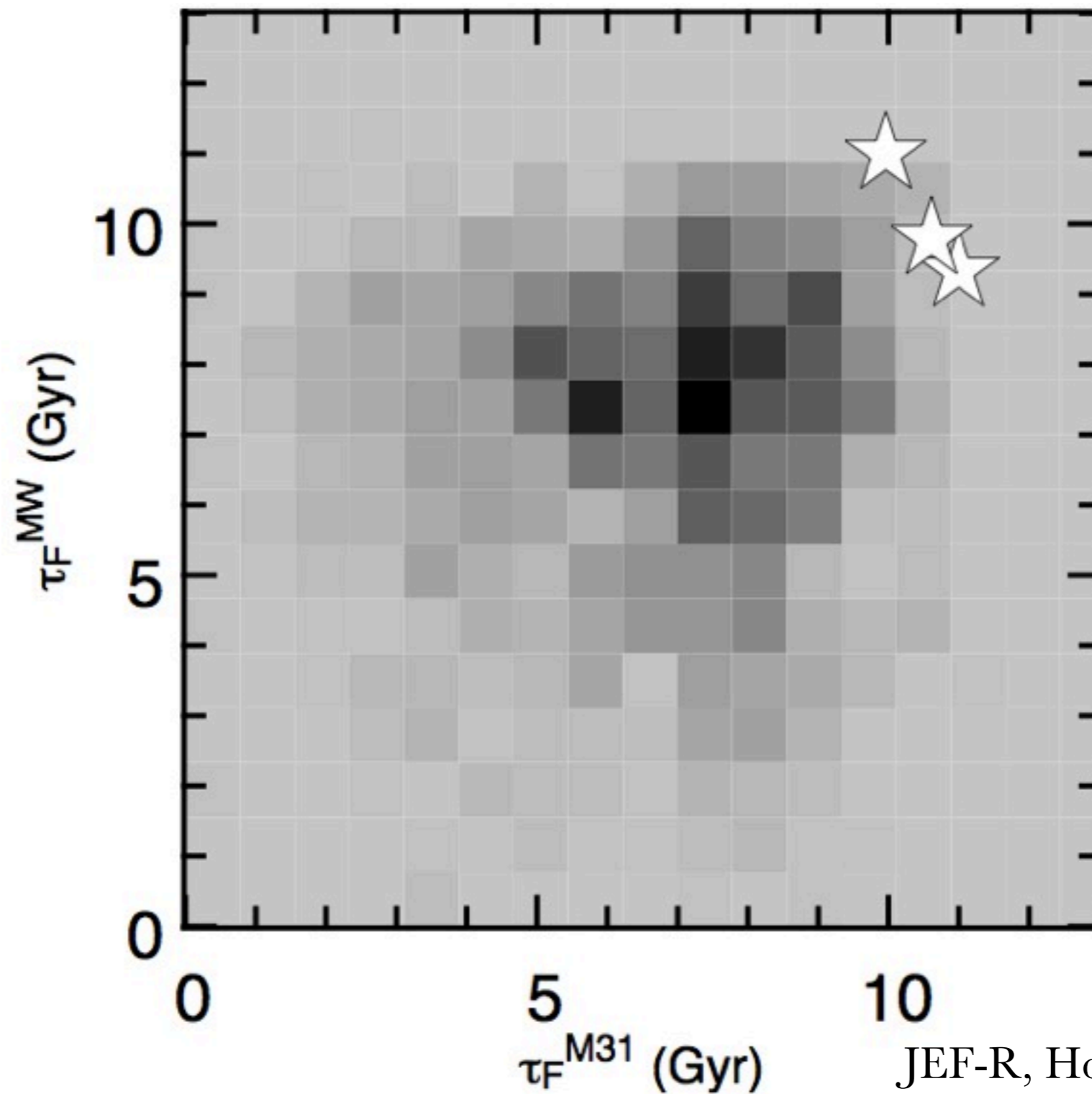
5 conditions to define Isolated Pairs

- Each halo has a mass between $5 \cdot 10^{11} M_{\text{sun}}$ and $5 \cdot 10^{12} M_{\text{sun}}$.
- The distance between centers of the halos is smaller than 1.0 Mpc (Ribas et al. 2005)
- The relative radial velocity is negative.
- Absence of massive halos inside 3Mpc around each halo (Tikhonov & Klypin 2009)
- Absence of massive halos ($>5 \cdot 10^{13} M_{\text{sol}}$) around 7Mpc (Karachentsev et al. 2004)

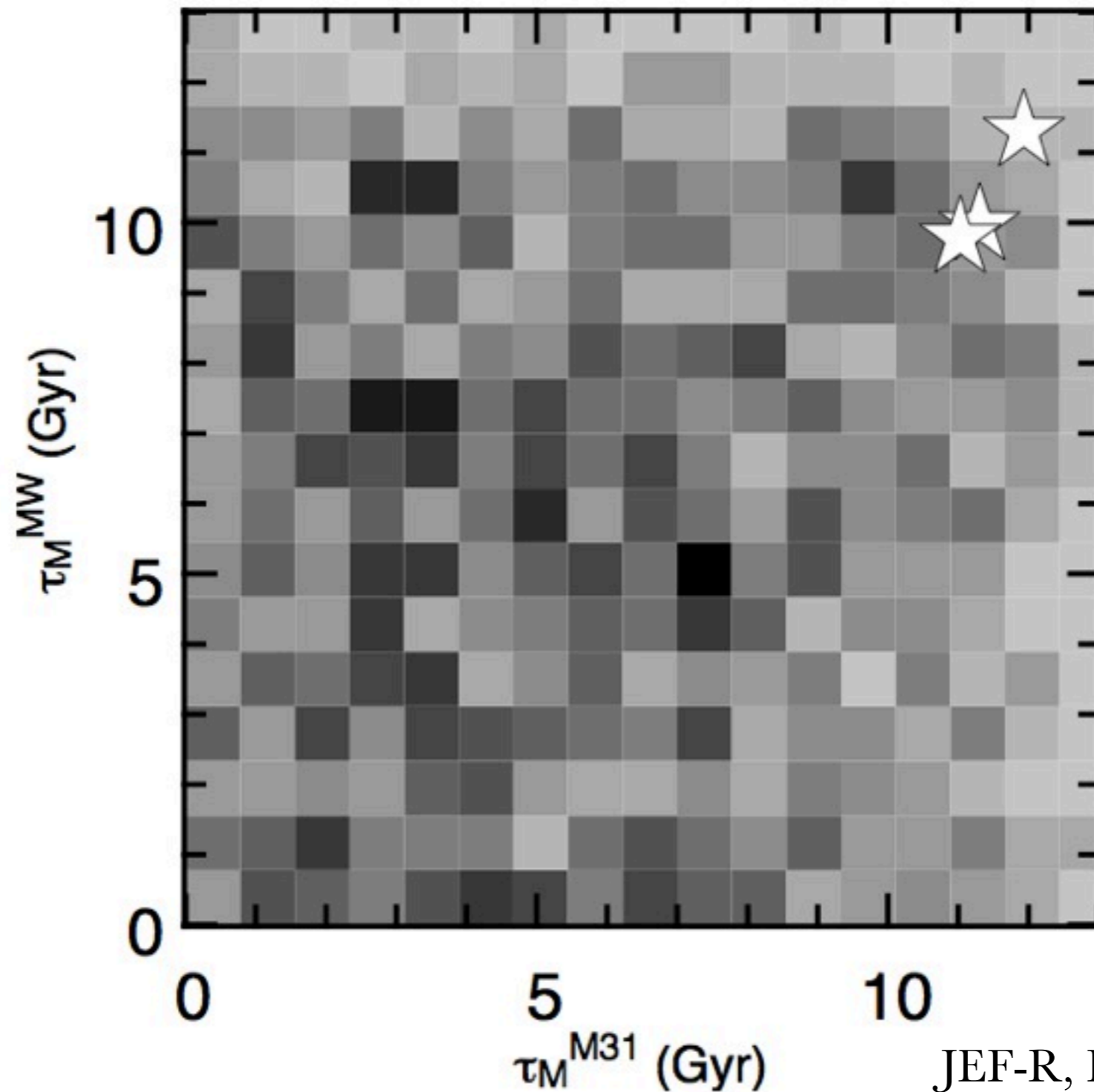
biased LG assembly in constrained simulations



biased LG assembly in constrained simulations (formation time)



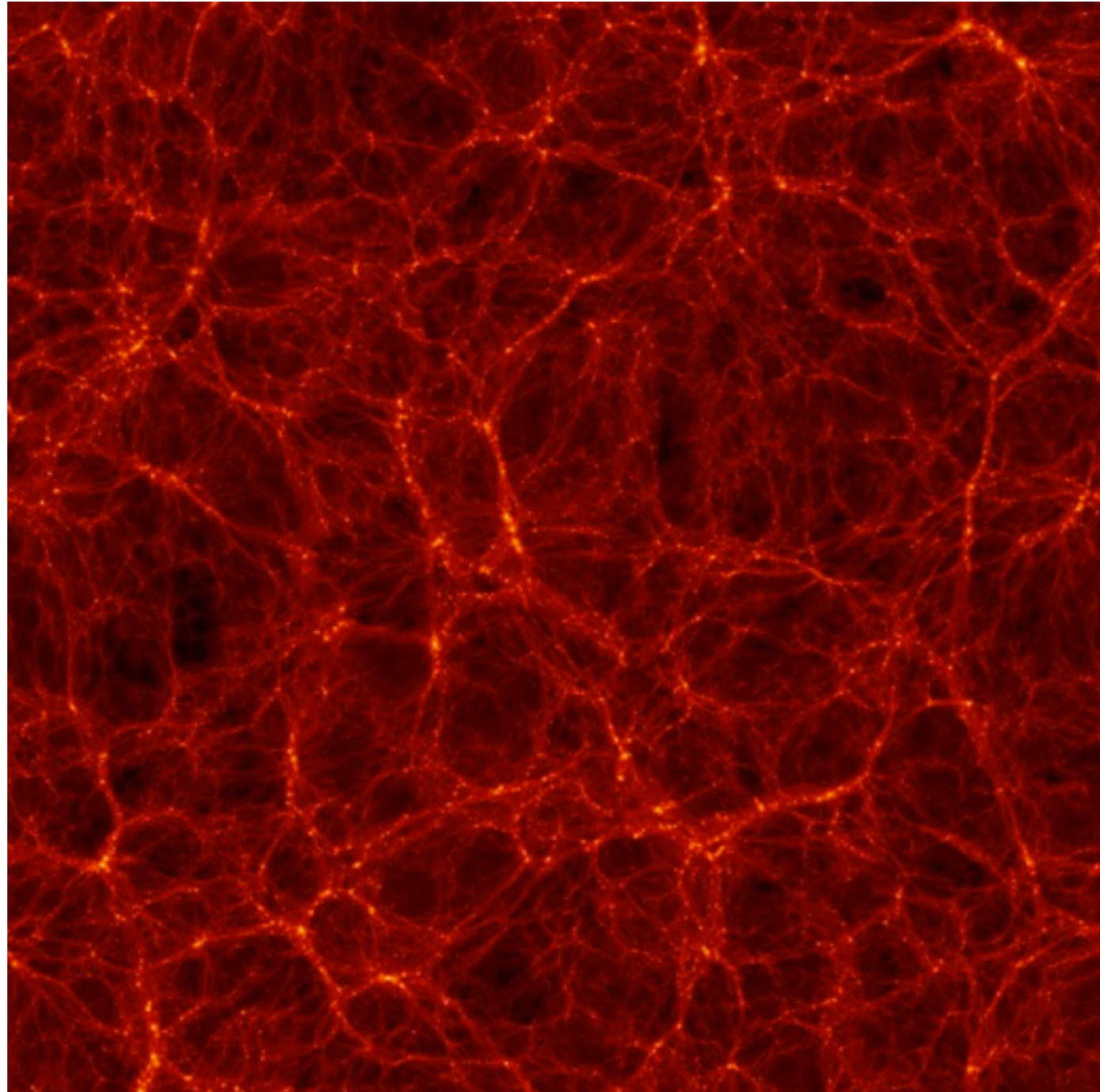
biased LG assembly in constrained simulations (last major merger)



Conclusion #1

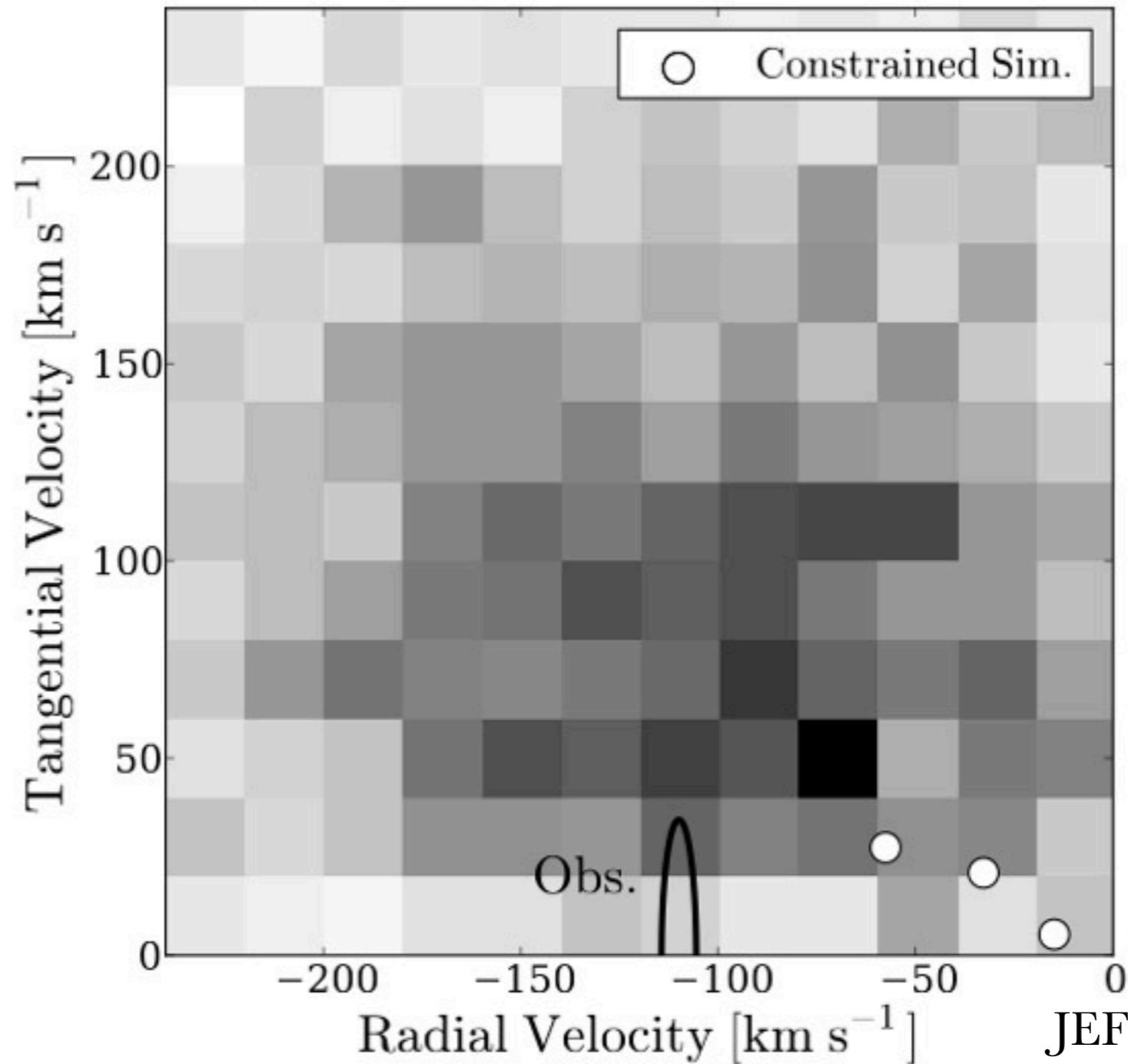
**Constraints (large scales + meso scales)
produce special Local Groups**

Use Bolshoi to study in detail the Isolated Pairs



1st step: kinematics (Sohn, Anderson & van der Marel 2012)

the not-so-common LG kinematics in LCDM



JEF-R, Hoffman, Bustamante,
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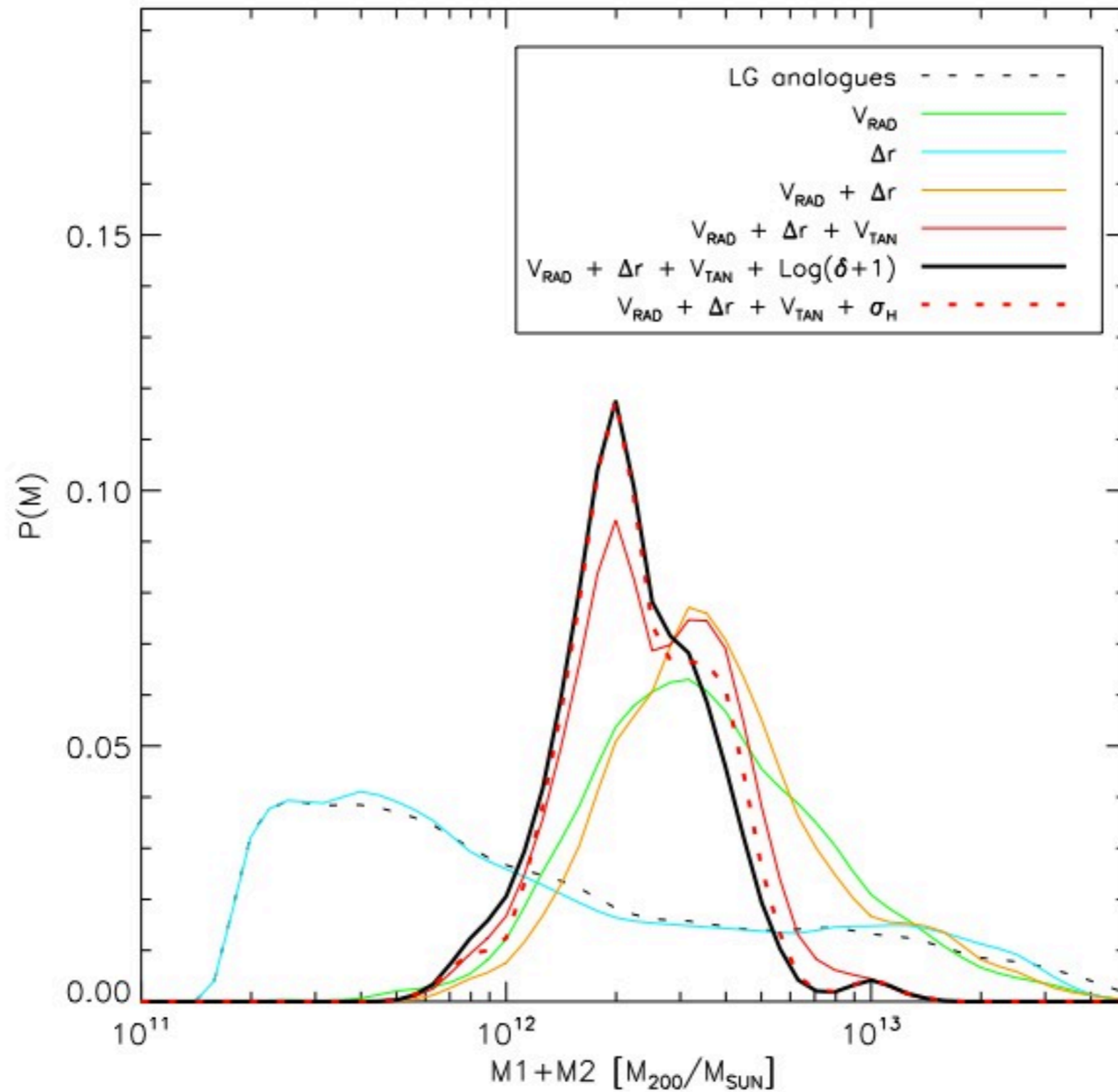


small numbers to construct a new LG sample

Physical property	(%) Pairs consistent with observations ($1-\sigma$) (full sample)
$v_r - v_t$	(0.4%) 8/1923
$e_{\text{tot}} - l_{\text{orb}}$	(15%) 298/1923
$\log_{10} \lambda$	(13%) 257/1923
$r_t = v_t / v_r$	(12%) 242/1923

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kinematics impose a strong mass selection effect



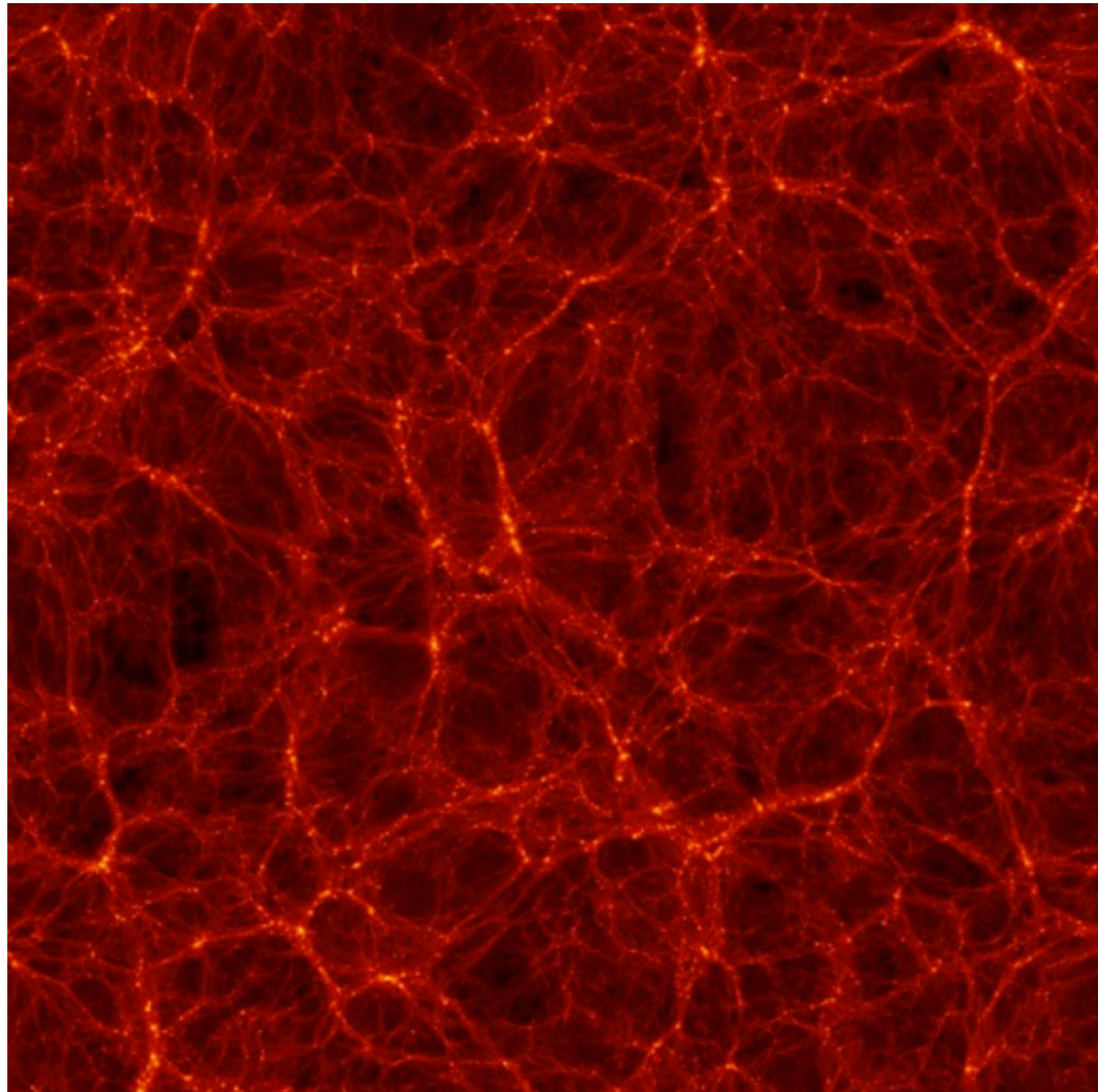
Conclusion #2

The LG kinematics are not common in LCDM.

Conclusion #3

Requiring consistency with observations imposes a tight constraint on the LG mass.

Use Bolshoi to study in detail the Isolated Pairs



2nd step: environment (Forero-Romero et al. 2009)

Data publicly available

CosmoSim

The CosmoSim database provides results from cosmological simulations performed within different projects: the [MultiDark project](#), the [BolshoiP project](#), and the [CLUES project](#).

MULTIDARK

Multimessenger Approach
for Dark Matter Detection

The Spanish MultiDark Consolider project supports efforts to identify and detect matter, including dark matter simulations of the universe.

[MDR1](#)
[MDPL](#)
[Bolshoi](#)

BolshoiP

Cosmological Simulations

The BolshoiP project contains a simulation like Bolshoi, with the same box size and resolution, but with Planck cosmology.

[BolshoiP](#)

CLUES

Constrained Local Universe Simulations

The CLUES project deals with constrained simulations of the local universe, partially with gas and star formation.

[Clues3_LGDM](#)
[Clues3_LGGas](#)

Please visit the linked sites for more information about the projects and about the appreciated form of acknowledgment, if the data is used in a scientific publication or proposal. The MultiDark simulations MDR1 and MDPL as well as the Bolshoi simulation are also available via the [MultiDark database](#).

[Register to CosmoSim](#)



CosmoSim.org is hosted and maintained by the Leibniz-Institute for Astrophysics Potsdam (AIP).



It is a contribution to the German Astrophysical Virtual Observatory.

The MultiDark and Bolshoi

what is the environment of these LG pairs?

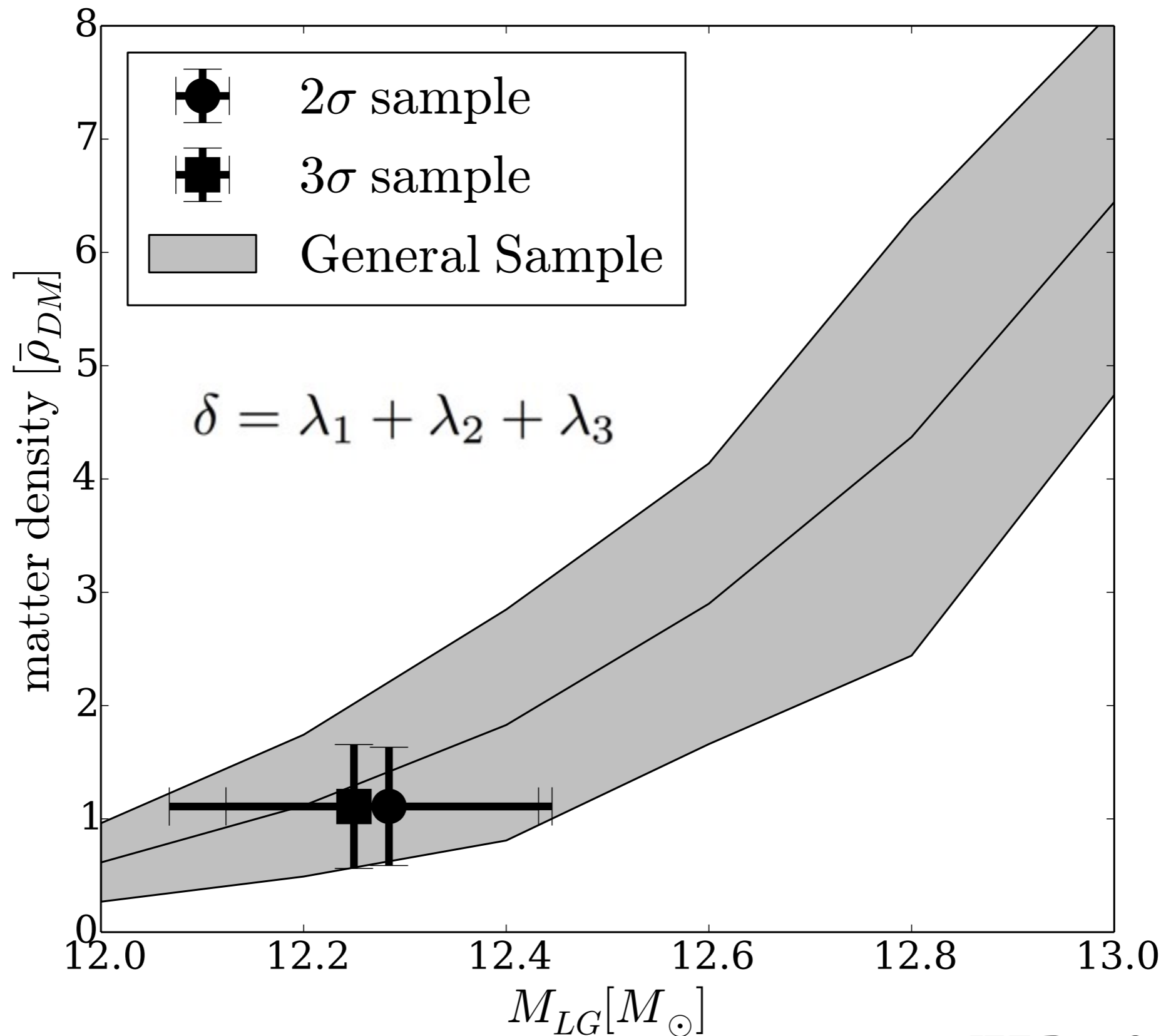
$$T_{ij} = \frac{\partial^2 \phi}{\partial r_i \partial r_j}$$

$$\delta = \lambda_1 + \lambda_2 + \lambda_3$$

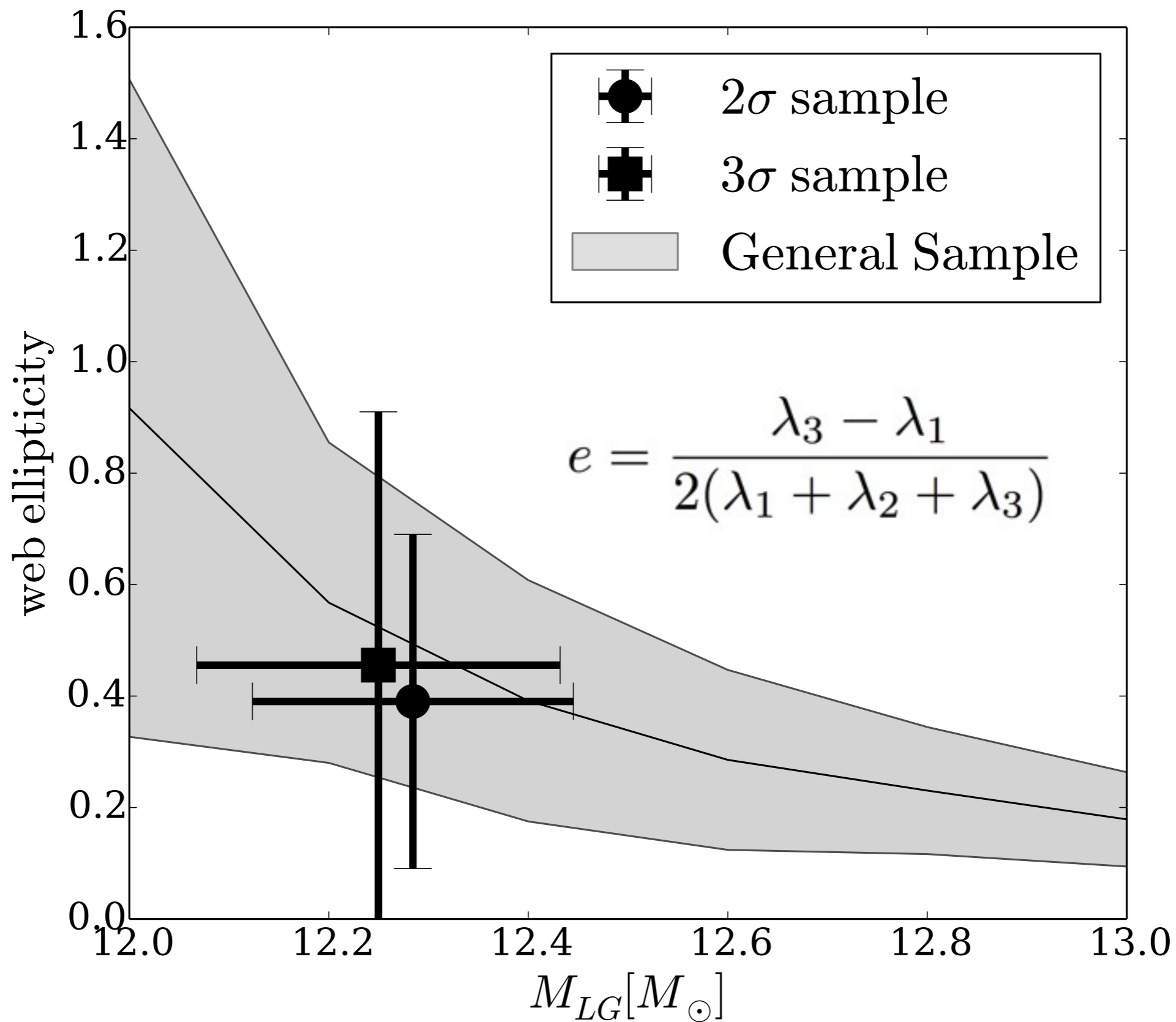
$$e = \frac{\lambda_3 - \lambda_1}{2(\lambda_1 + \lambda_2 + \lambda_3)} \quad p = \frac{\lambda_1 + \lambda_3 - 2\lambda_2}{2(\lambda_1 + \lambda_2 + \lambda_3)}$$

defined over a grid of 1Mpc/h + 1Mpc/h gaussian smoothing

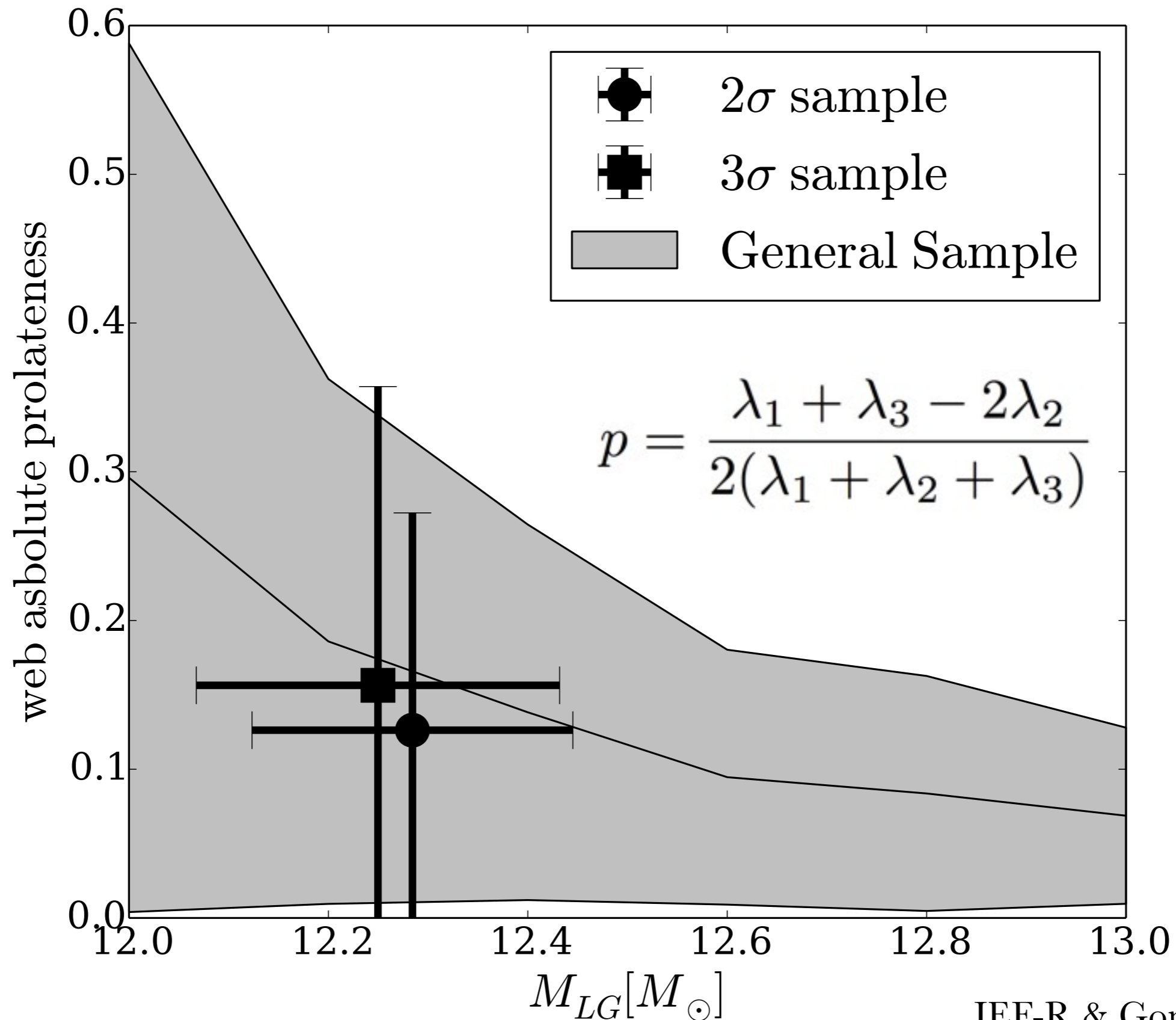
local matter over-density around pairs

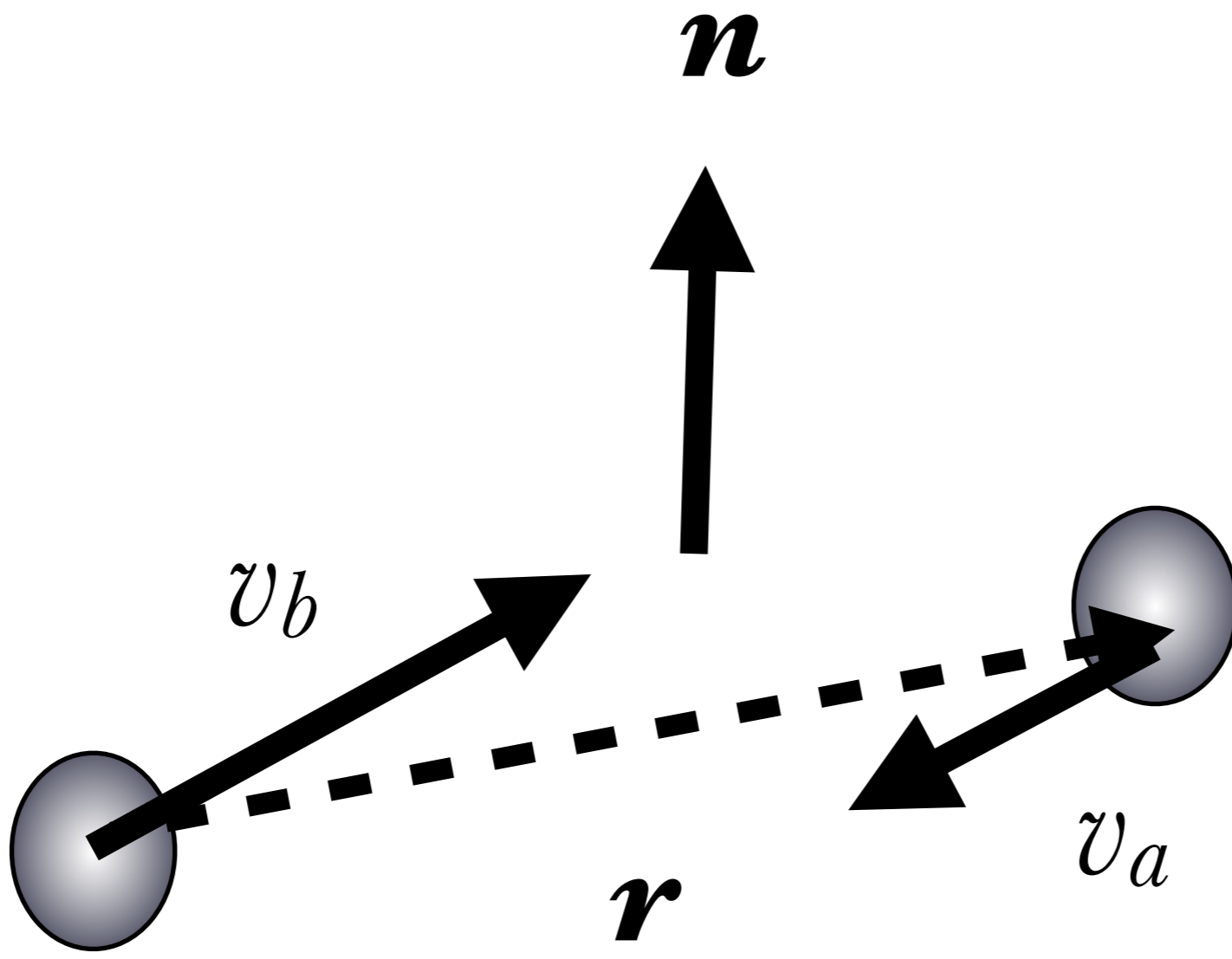


T-web ellipticity around pairs



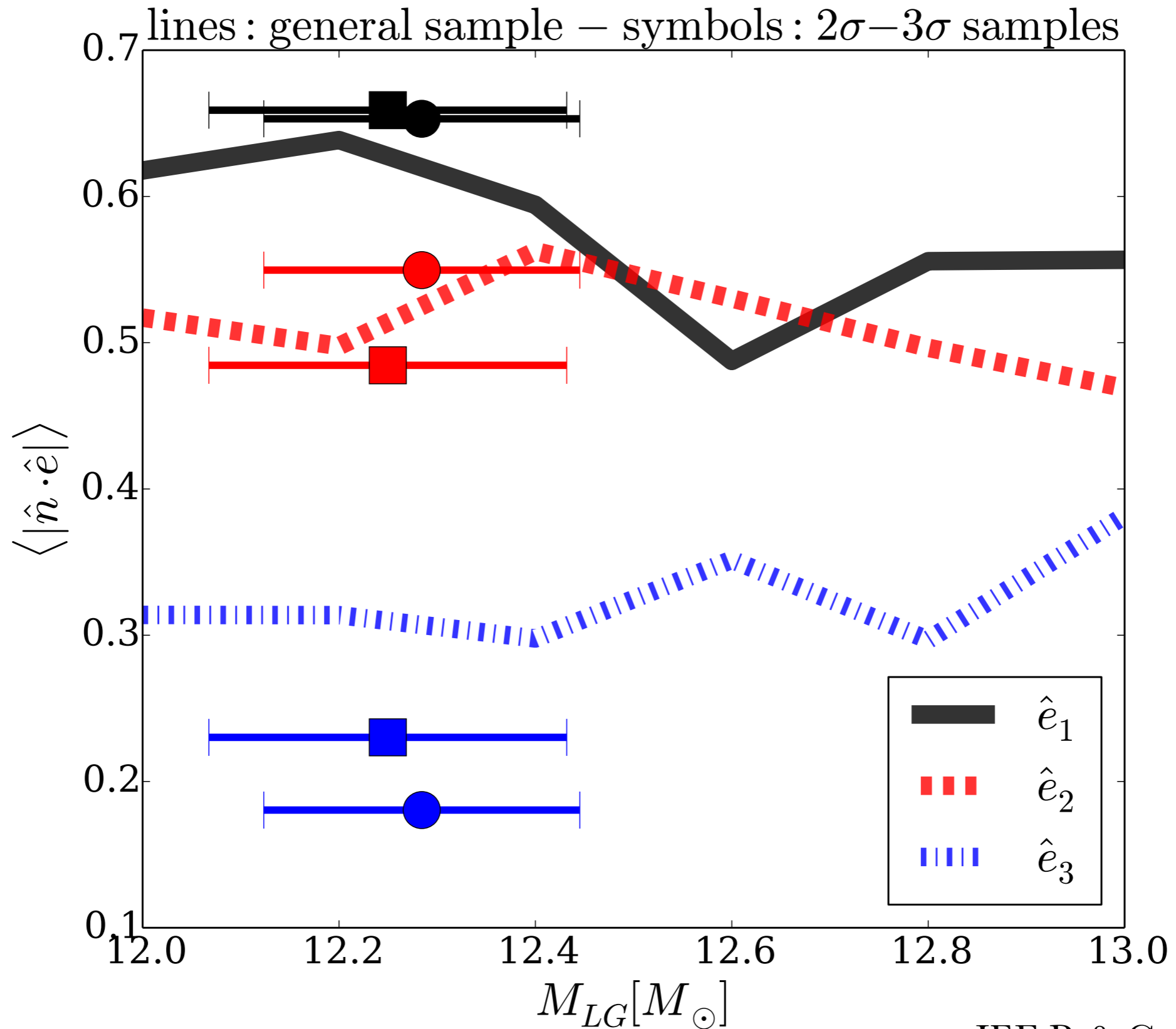
T-web prolateness around pairs



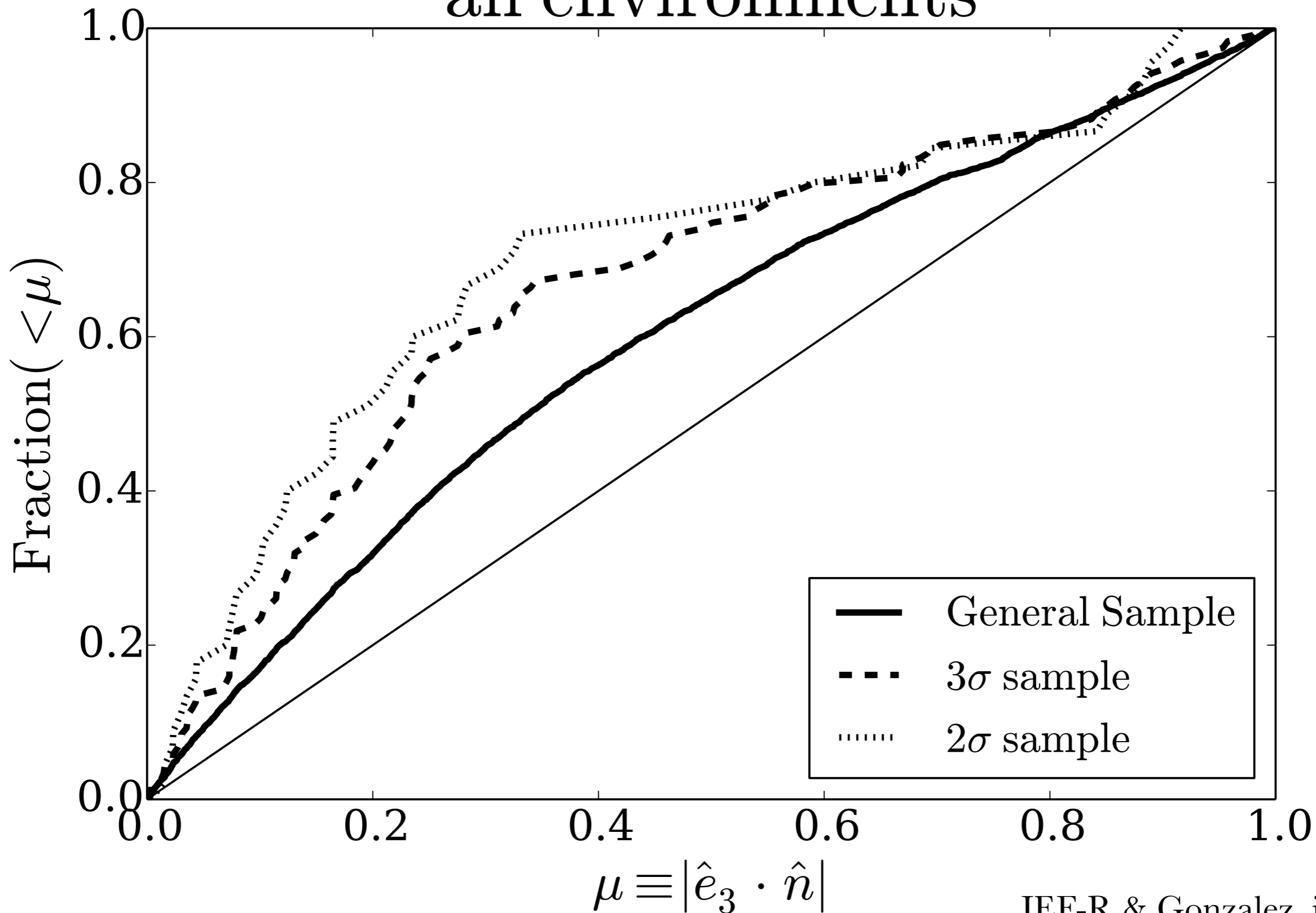


CM Frame

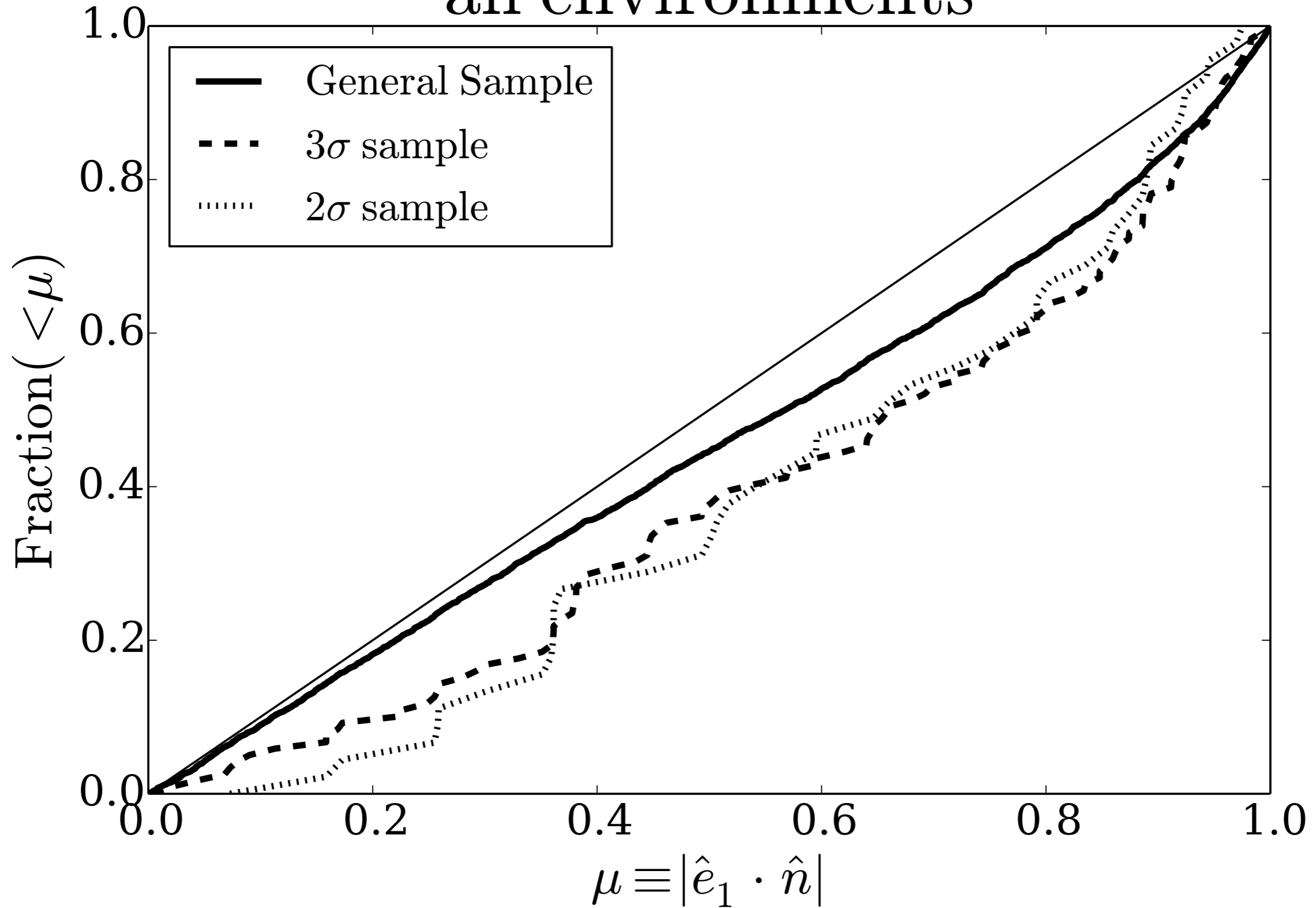
strong T-web alignments for pairs



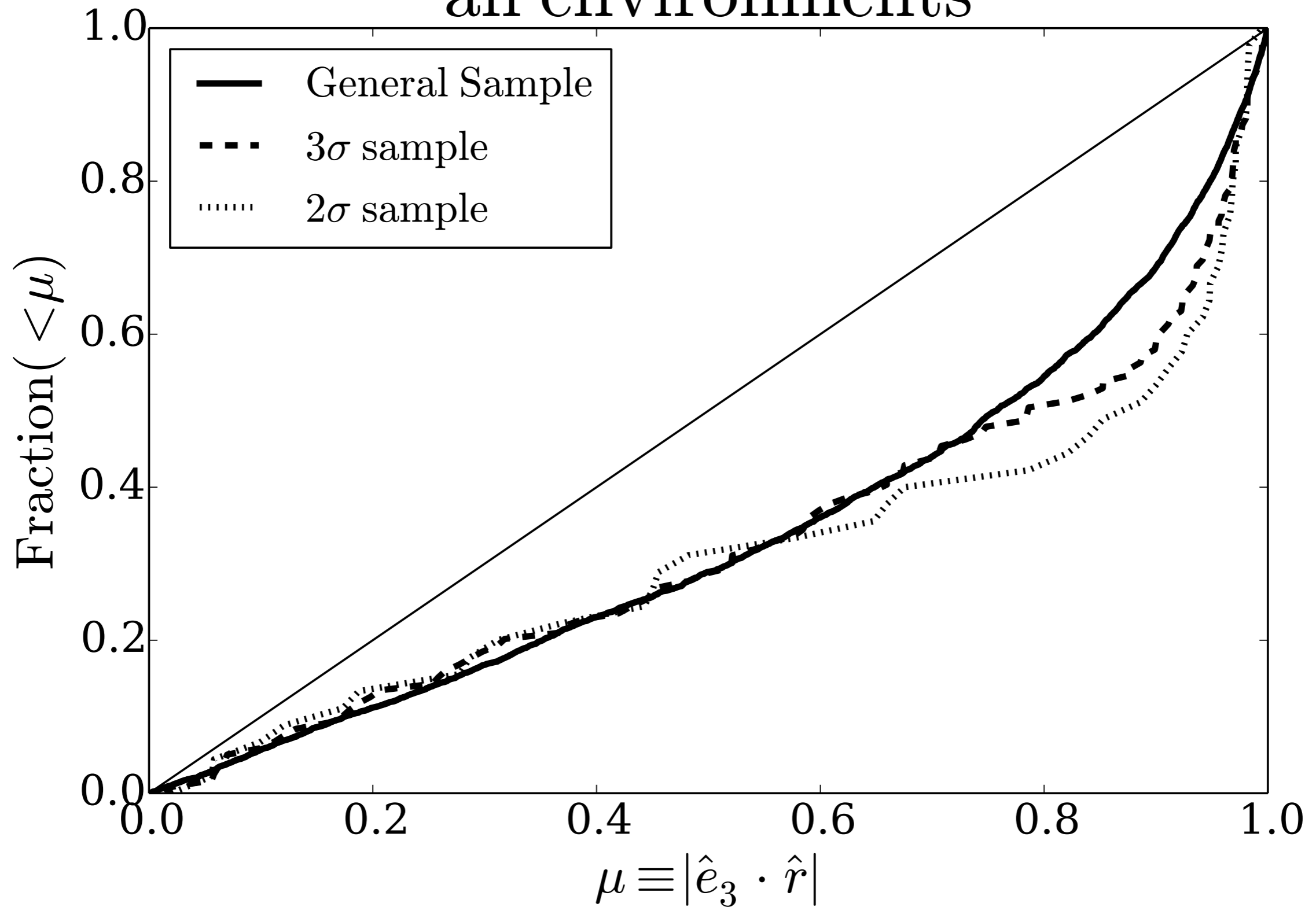
strong anti-alignment of \mathbf{n} with \mathbf{e}_3
all environments



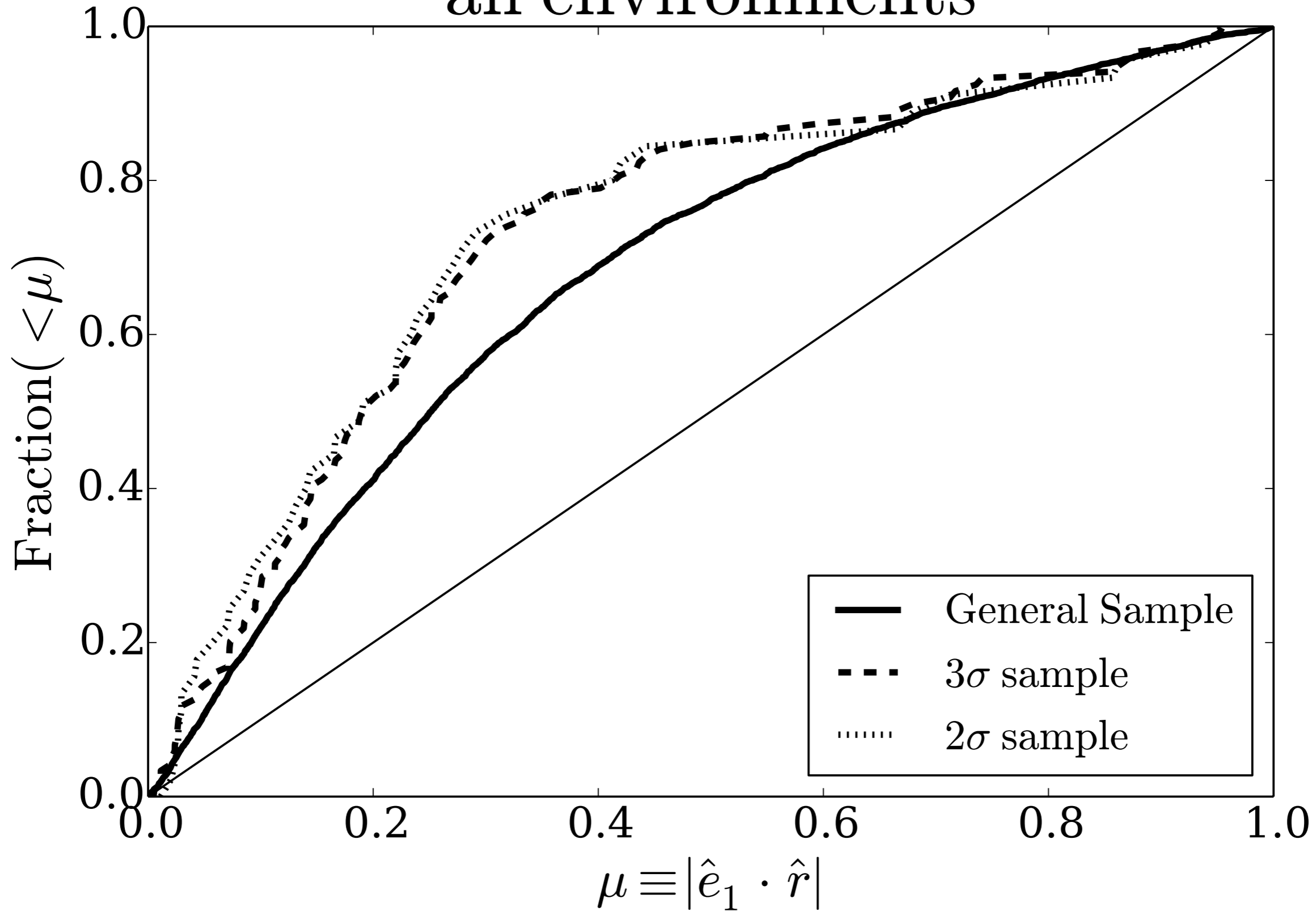
weak alignment of \mathbf{n} with \mathbf{e}_1 all environments



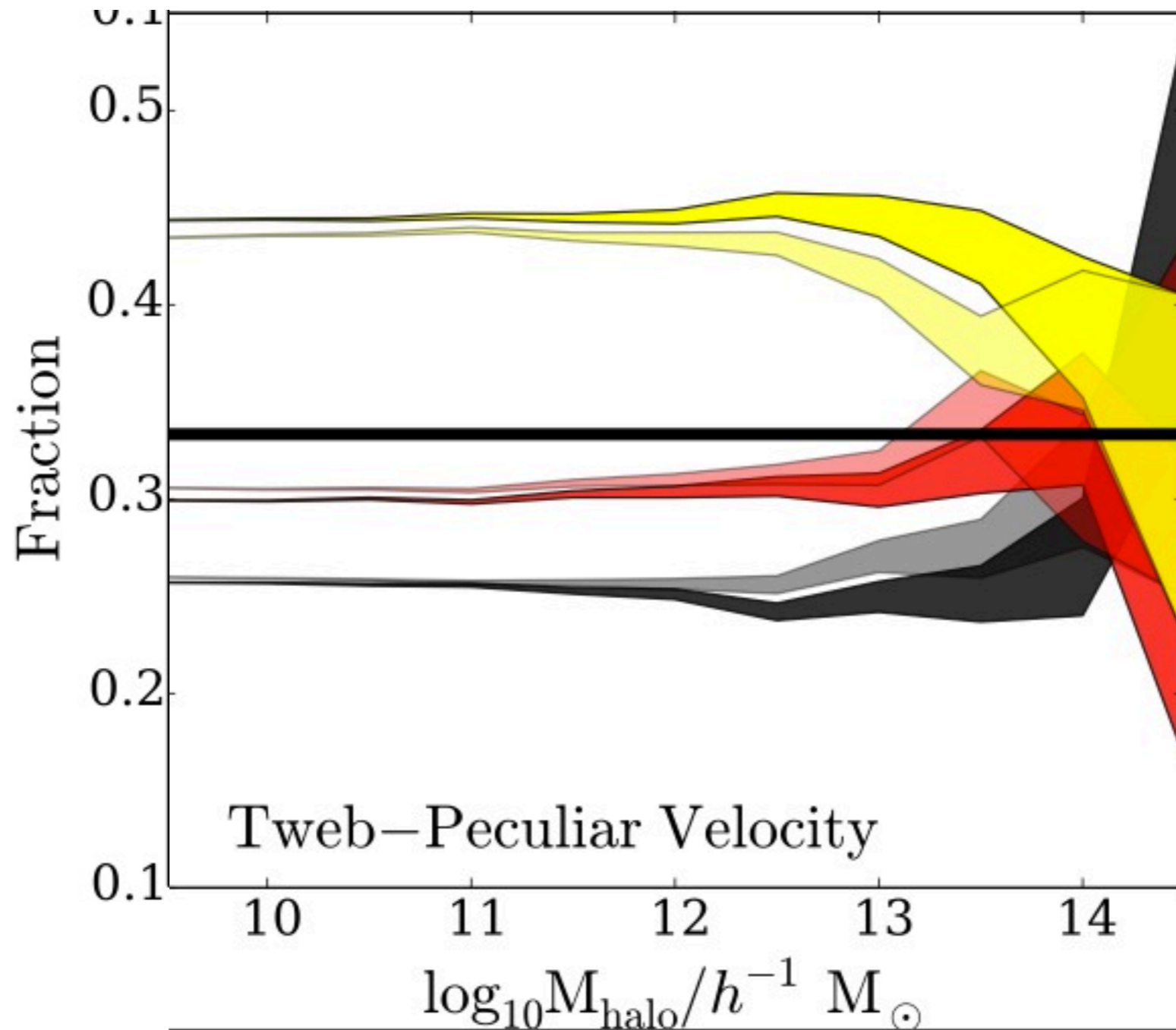
strong alignment of \mathbf{r} with \mathbf{e}_3 all environments



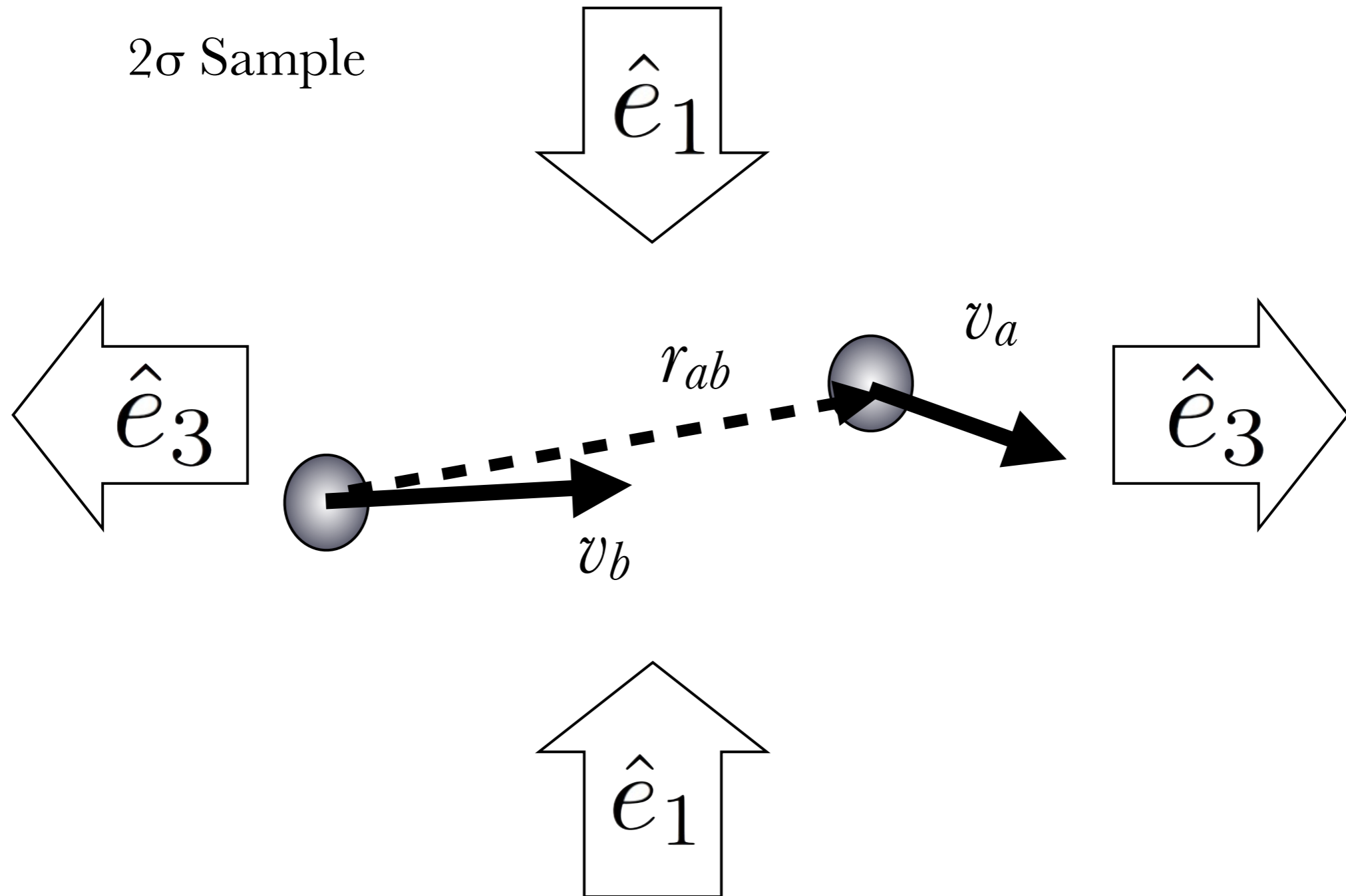
strong anti-alignment of \mathbf{r} with \mathbf{e}_1 all environments



alignment of peculiar velocities with e_3



Conclusion #4



Conclusions

- Density field constraints (large scales + meso scales) produce special Local Groups.
- The LG kinematics are not common in LCDM
- LG kinematics impose a tight constraint on the LG mass.
- In the T-web context, LG is most probably located in a filament with the \mathbf{r} vector along the direction defined by \mathbf{e}_3 .

Sample	Peak <i>n</i> (%)	Filament <i>n</i> (%)	Sheet <i>n</i> (%)	Void <i>n</i> (%)
2σ	4 (8.7)	24 (52.2)	17 (36.7)	1 (2.2)
3σ	10 (8.3)	58 (48.3)	47 (39.2)	5 (4.2)
General	1312 (23.9)	1472 (26.9)	1769 (32.3)	927 (16.9)