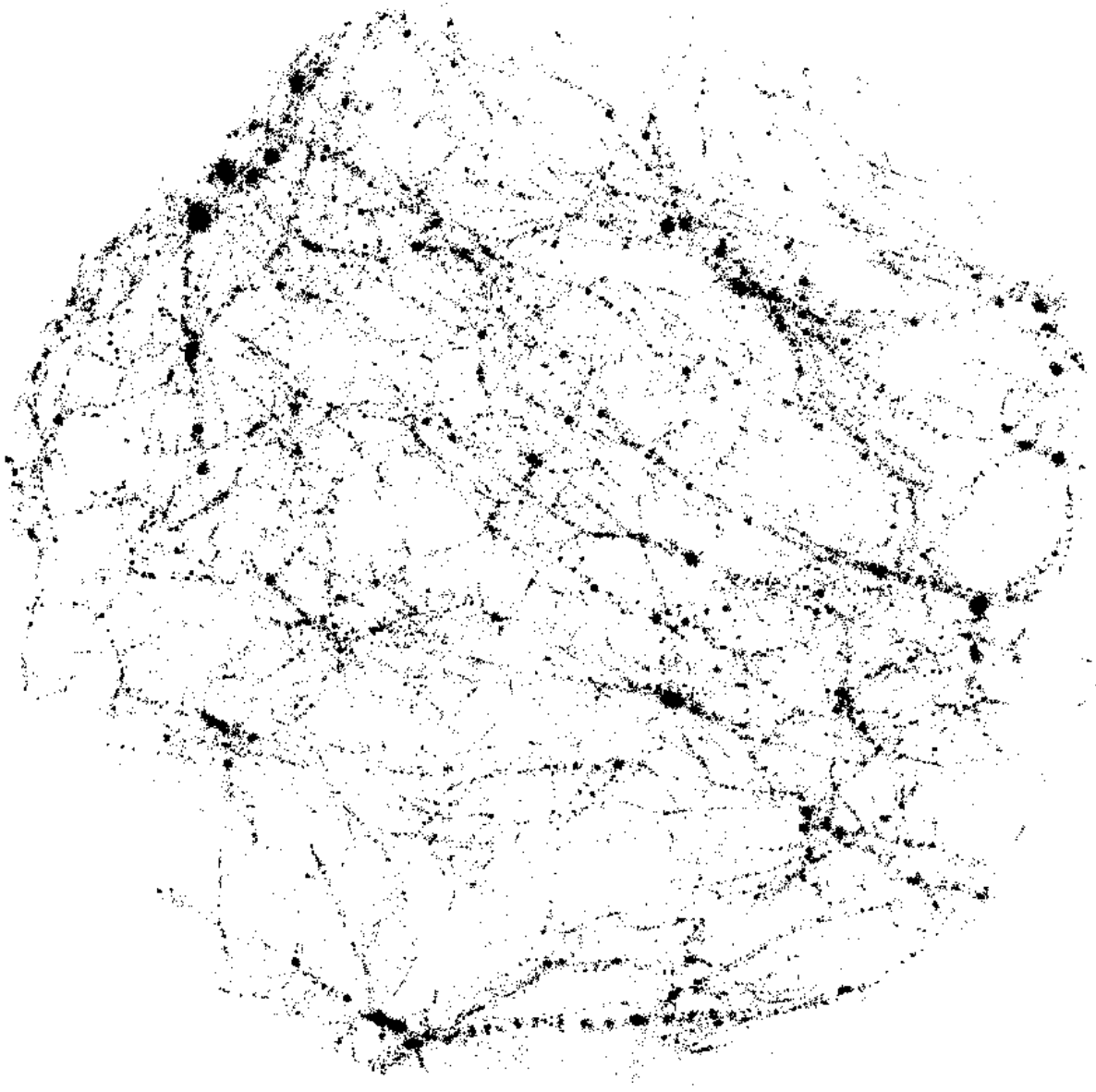


Gottlöber et al. 2003

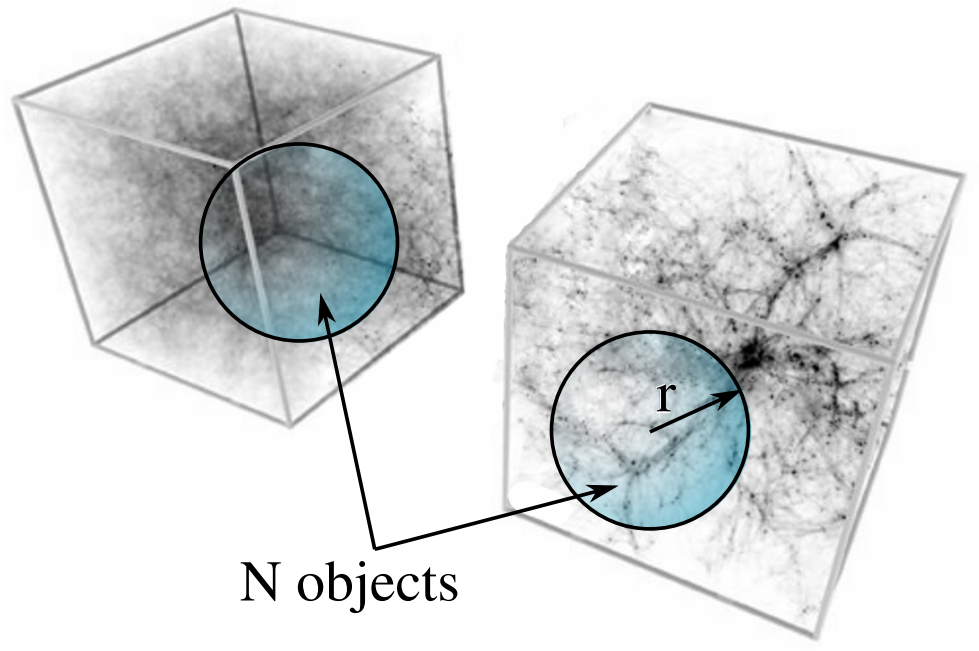
Enter the Void:
Statistics of small-scale clustering

Federico Dávila Kurbán

IATE

April 10th 2019

Introduction: Void Probability Function (VPF)



- Count Probability Distribution Function (CPDF), $P_N(V)$

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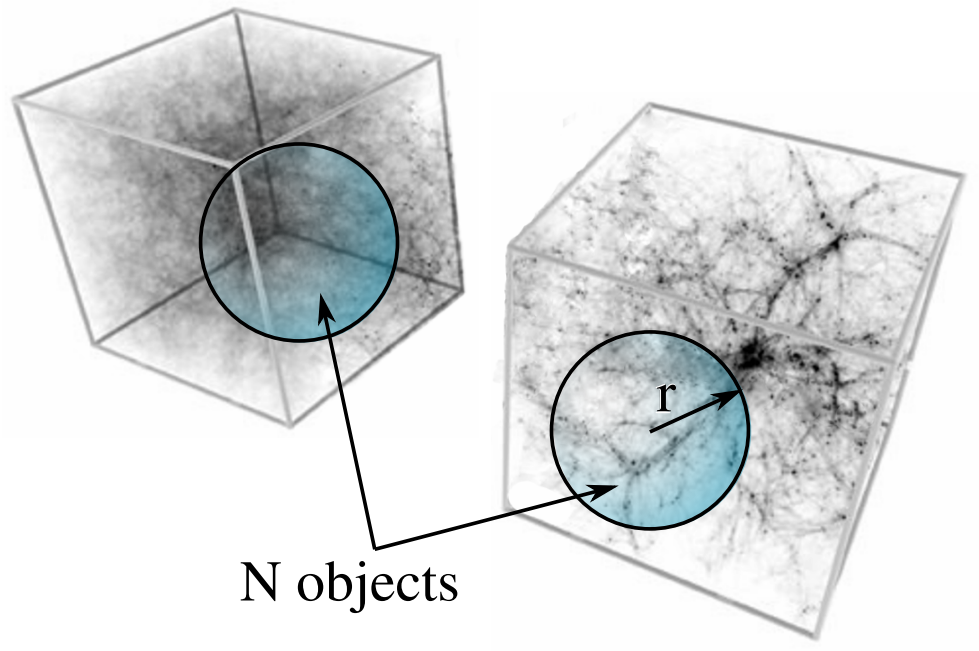

- Count Probability Distribution Function (CPDF), $P_N(V)$
- $N = 0 \rightarrow P_0(V) \rightarrow \boxed{VPF \equiv P_0(R)}$

Introduction

- $P_0(R) \leftrightarrow \xi_p(R)$ (White 1979):

$$\boxed{P_0(R) = exp\left\{ \sum_{p=1}^{\infty} \frac{[-\bar{N}(R)]^p}{p!} \bar{\xi}_p(R) \right\}} \qquad (1)$$

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Introduction: Enter the Reduced Void Probability Function

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- Si $\chi = 1 \rightarrow$ No clustering
- Si $\chi < 1 \rightarrow$ Yes clustering

- $\chi(\bar{N}\bar{\xi} \ll 1) = 1 + ... \rightarrow$ Constant term is dominating
- $\chi(\bar{N}\bar{\xi} < 1) = 1 - \frac{1}{2}\bar{N}\bar{\xi} + ... \rightarrow$ Gaussian term is dominating

Characteristics of the RVPF

$$\chi(\bar{N}\bar{\xi}) = \sum_{p=1}^{\infty} \frac{S_p}{p!}(-\bar{N}\bar{\xi})^{p-1}$$

- Different clustering models can be distinguished when $\bar{N}\bar{\xi} > 1$. This happens when $R >\sim \frac{Mpc}{h}$ (Croton et al. 2004)
- On small scales $\bar{N}\bar{\xi}$ is very small and non-gaussian contributions cannot be appreciated

- The VPF is only a good discriminator in the weakly non-linear regime (Croton et al. 2004)

Objectives

Short term goal:

- Compare the *Void Probability Function* (VPF) inside voids identified in the Illustris simulation (Invoid VPF) with the VPF of the entire box (Box VPF)

Long term goal:

- Eventually, perform the same comparison in observational catalogues and compare results.

Previous Results

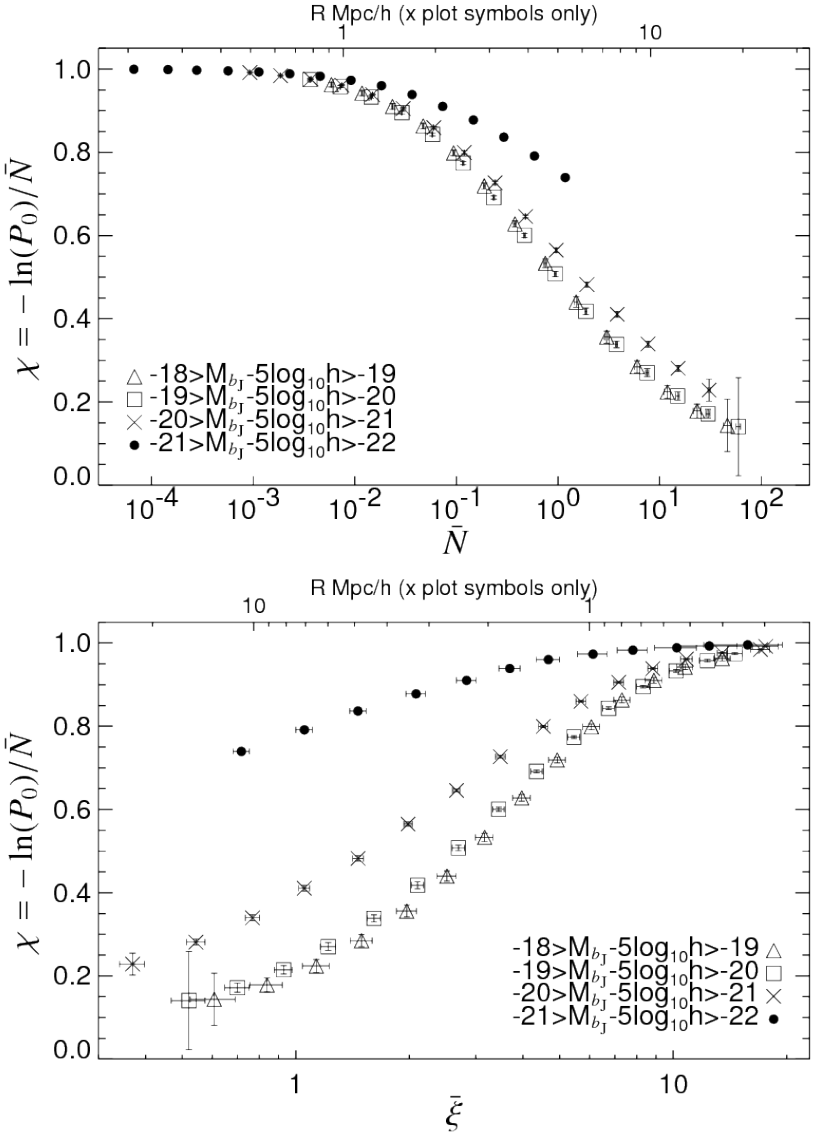


Figure 1: Croton et al. 2004. VLC from 2dFGRS

Previous Results

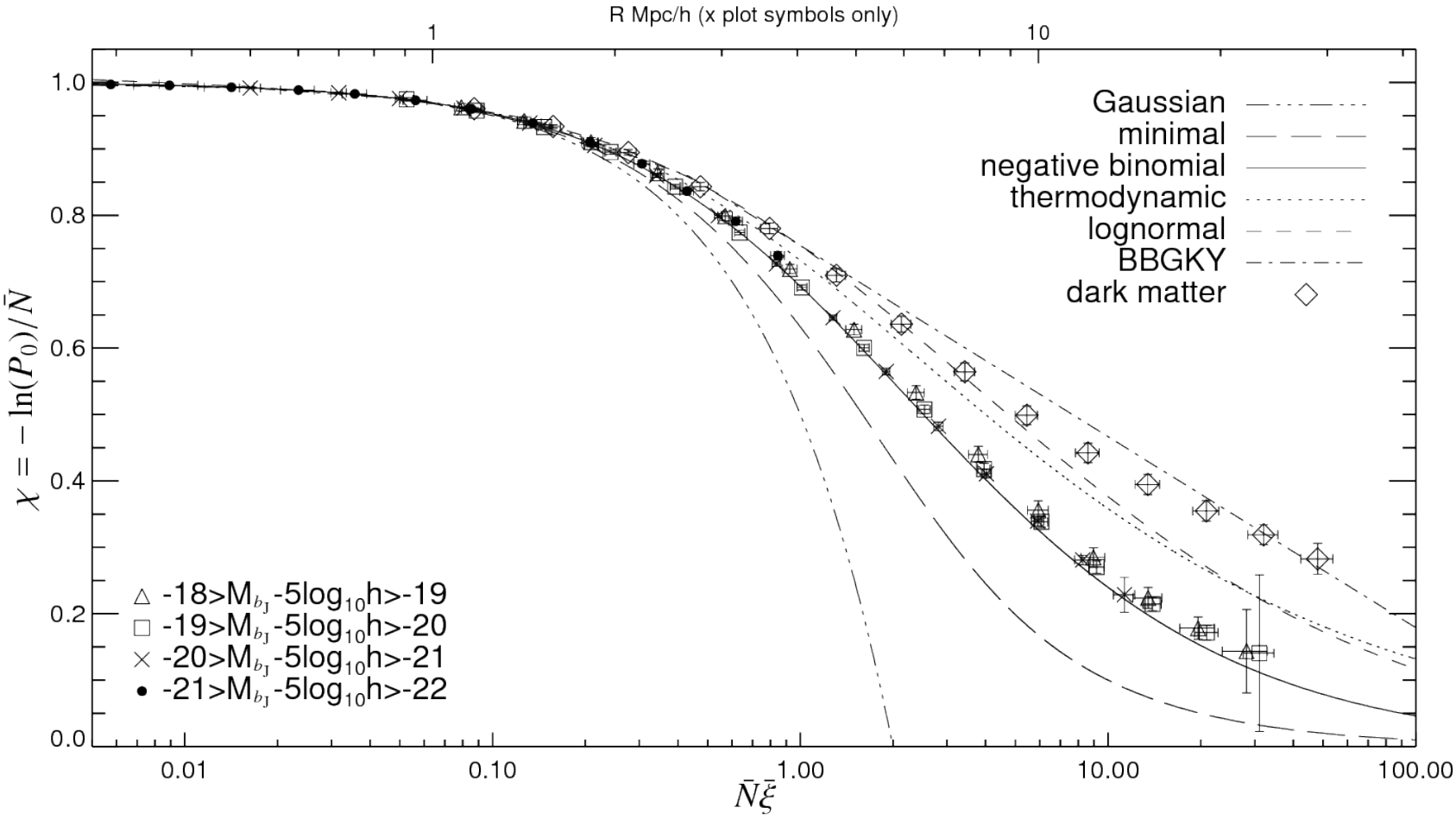


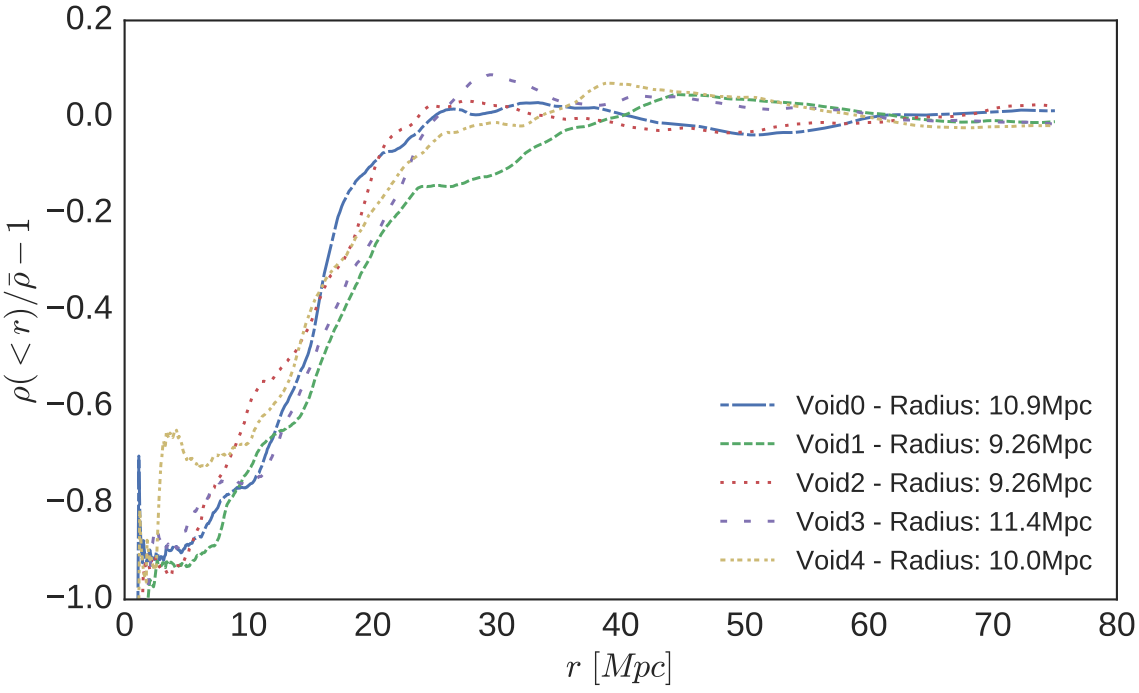
Figure 2: Croton et al. 2004. VLC from 2dFGRS

My Results: Sample

- We used *subhalos* (galaxies) in the Illustris simulation as tracers
- We selected those with $10^9 M_\odot < M < 10^{13} M_\odot$

Method I

- **VPF Invoid**: We generated spheres contained within the 5 identified voids and count the amount of tracers (galaxies)



- We studied $0.4Mpc < R < 9Mpc$, in 25 log-spaced bins.
- We generated 5000 spheres per bin, randomly centered.

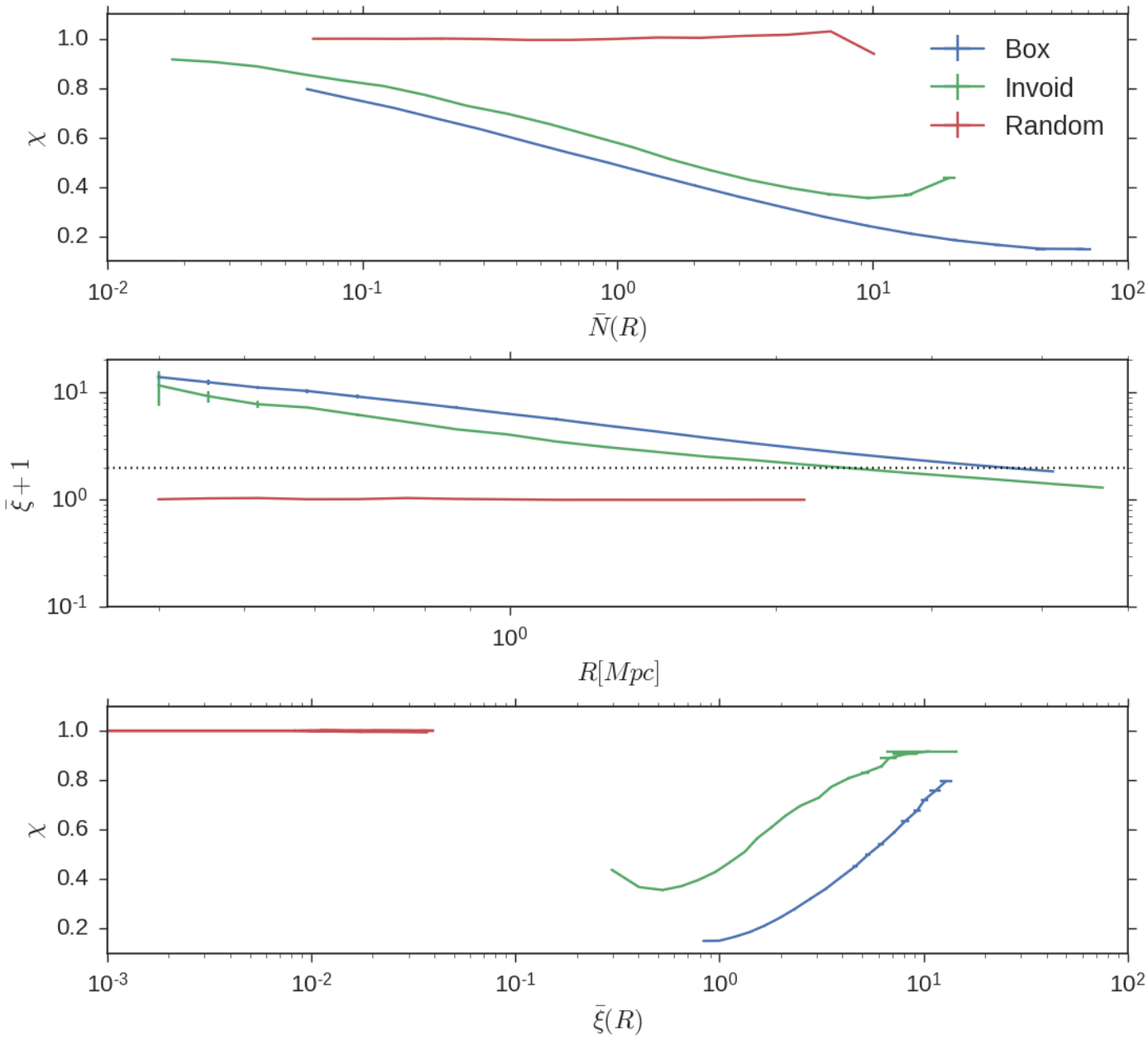
Method II

- **VPF Box**: idem *invoid*, but centered randomly throughout the simulation.
- **VPF Random**: idem the above, using a random sample in a volume identical to that of Illustris.

- **Dilution**: in all cases, from the mass selection of the sample we diluted it so that we are left with 1 million galaxies.

- **Errors**: we calculated Jackknife errors. For the *invoid* calculation we performed 5 realizations, and for the box calculation, 20.

Results



Previous Results

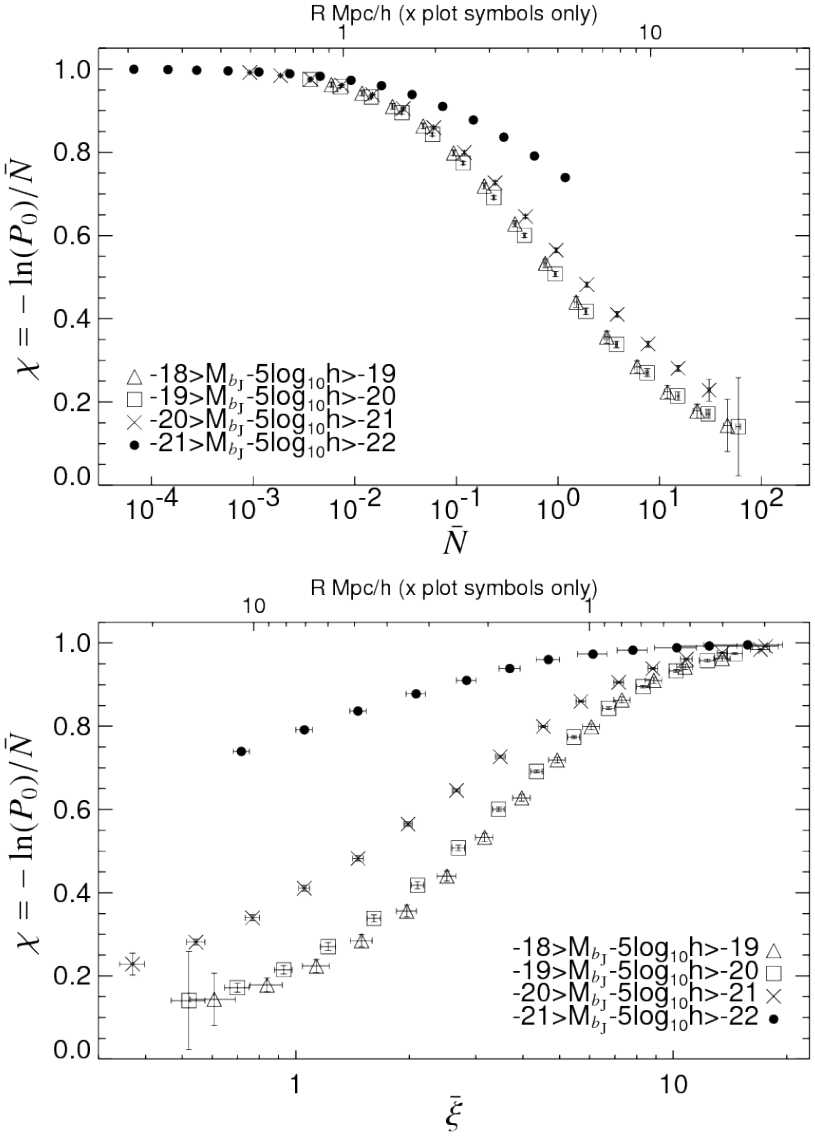
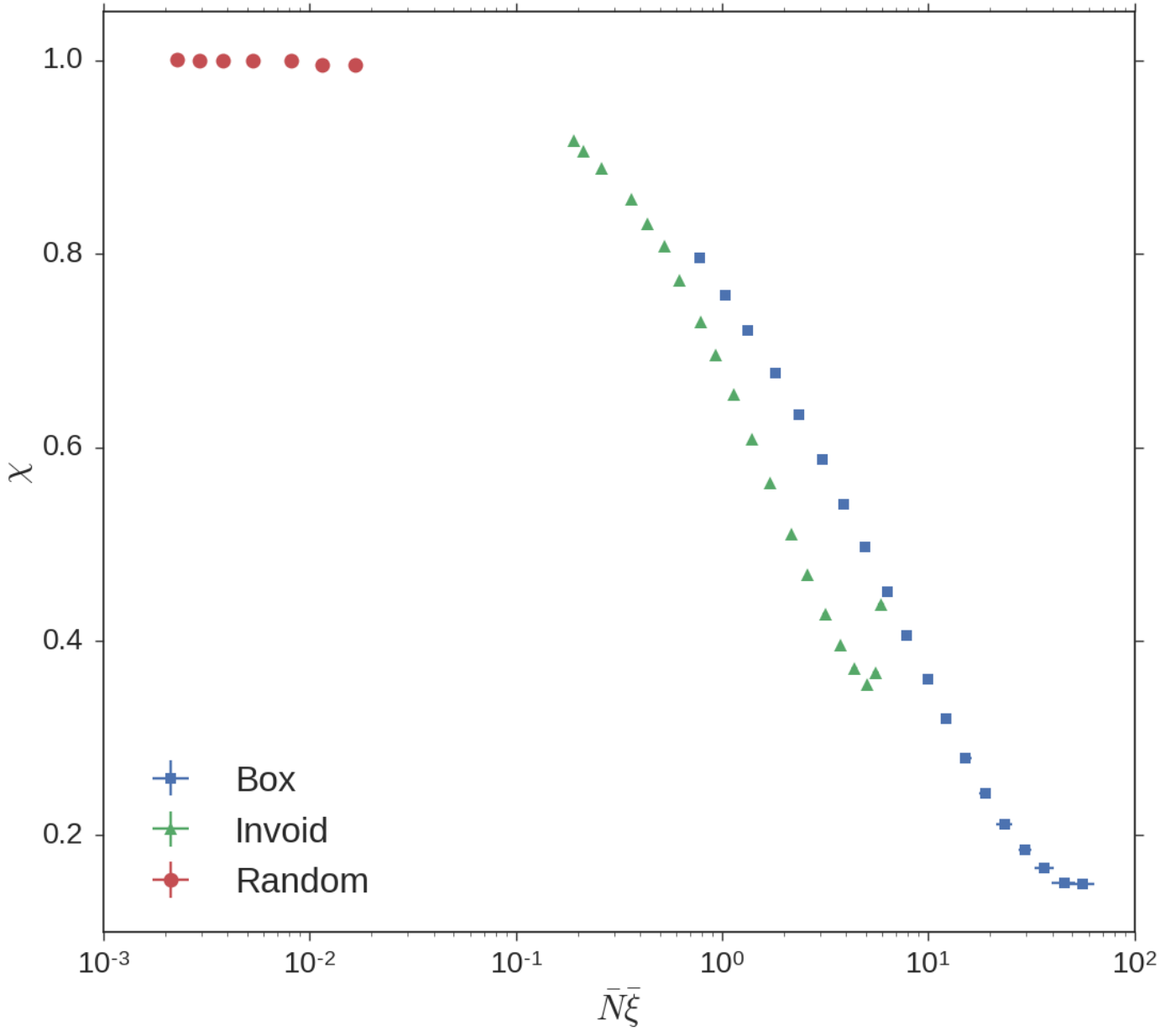
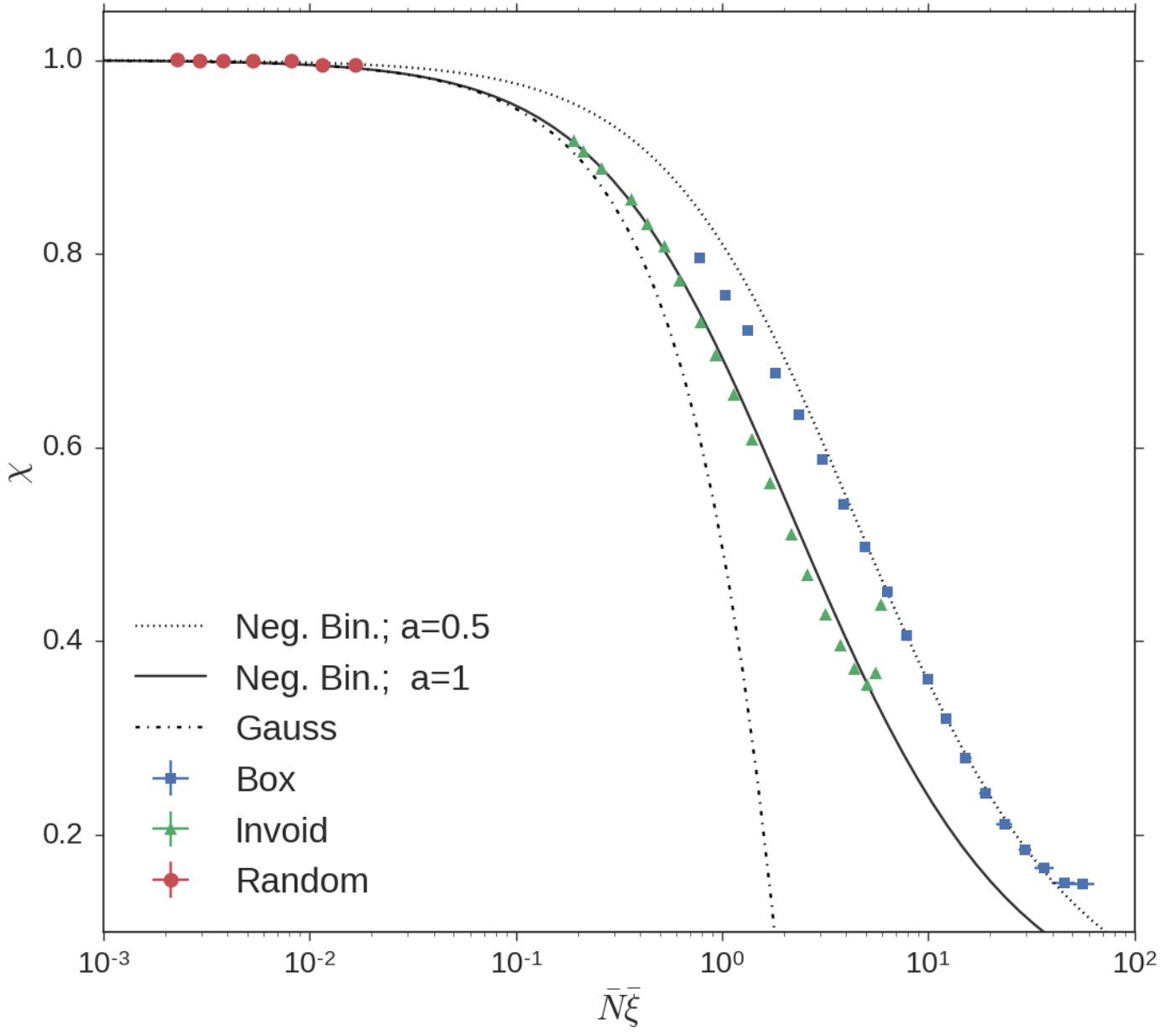


Figure 3: Croton et al. 2004. VLC from 2dFGRS

Results


1.0
0.8
0.6
0.4
0.2
χ
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
$\bar{N}\bar{\xi}$
Box
Invoid
Random

Results


1.0
0.8
0.6
0.4
0.2
χ
Neg. Bin.; a=0.5
Neg. Bin.; a=1
Gauss
Box
Invoid
Random
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
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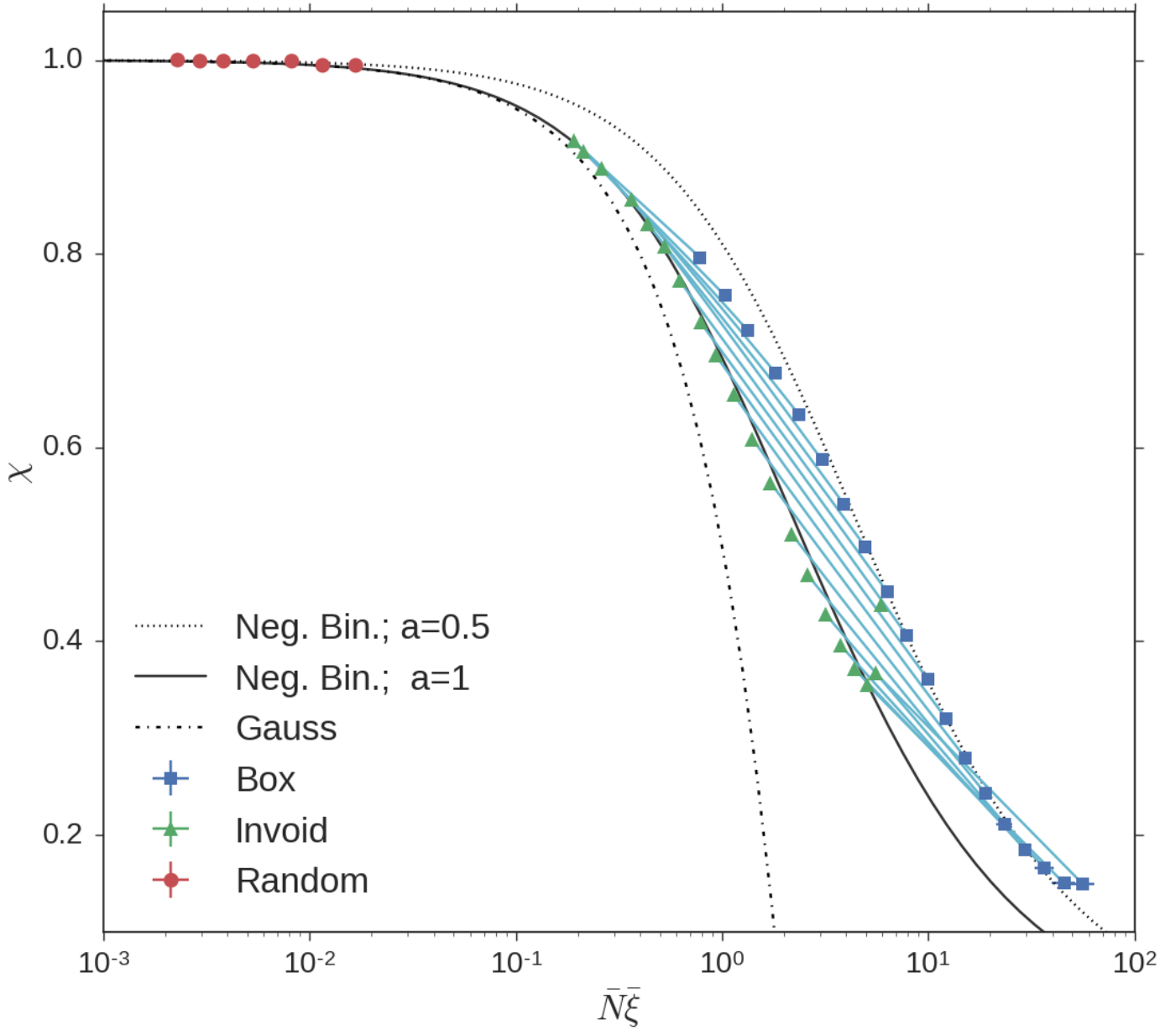
Results


1.0
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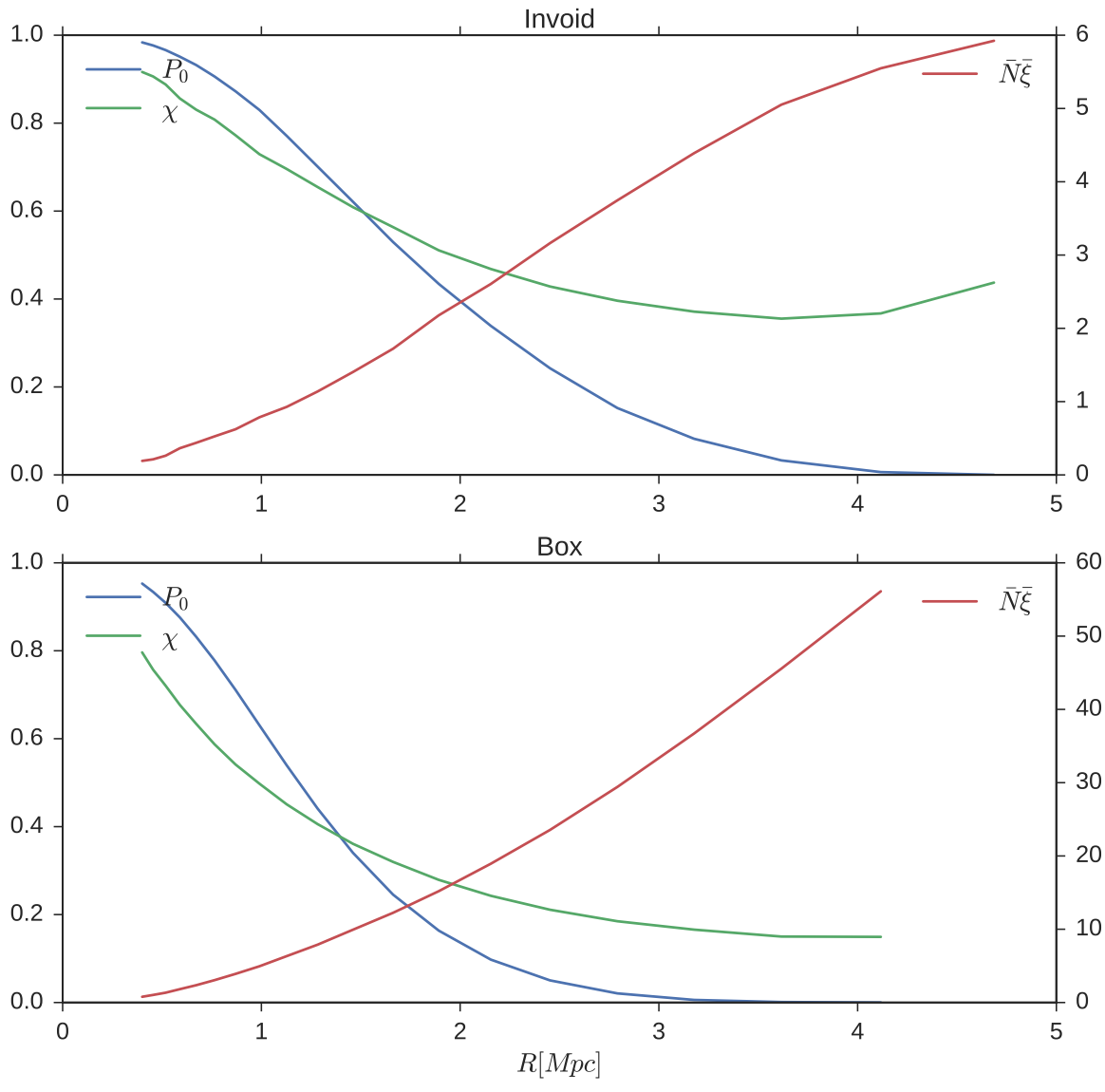
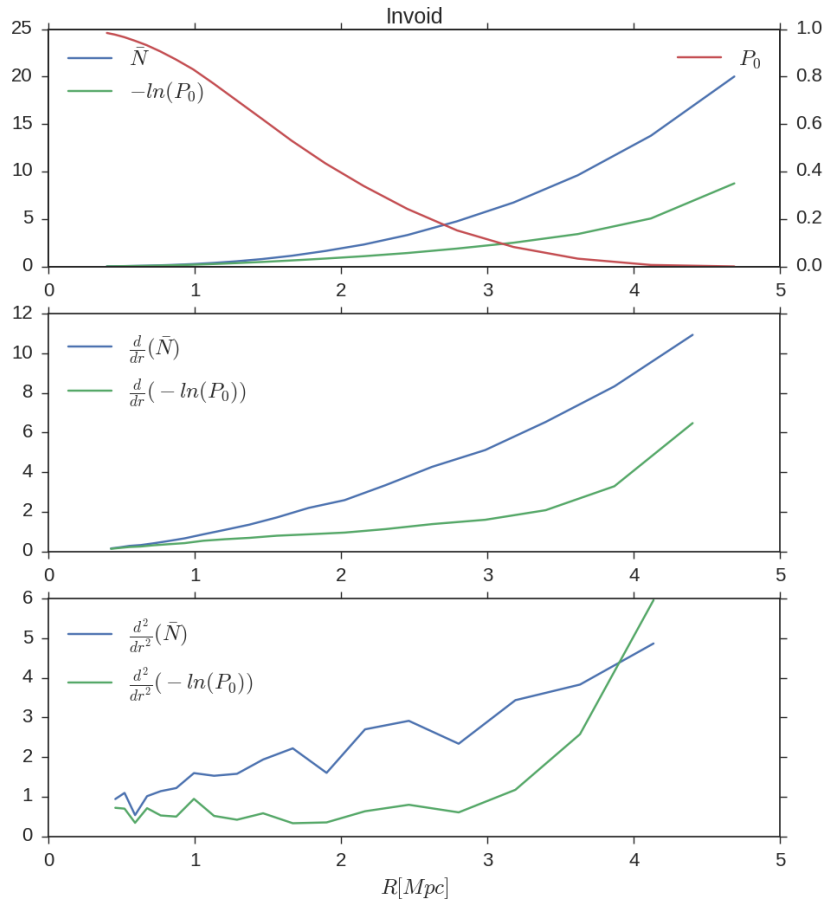
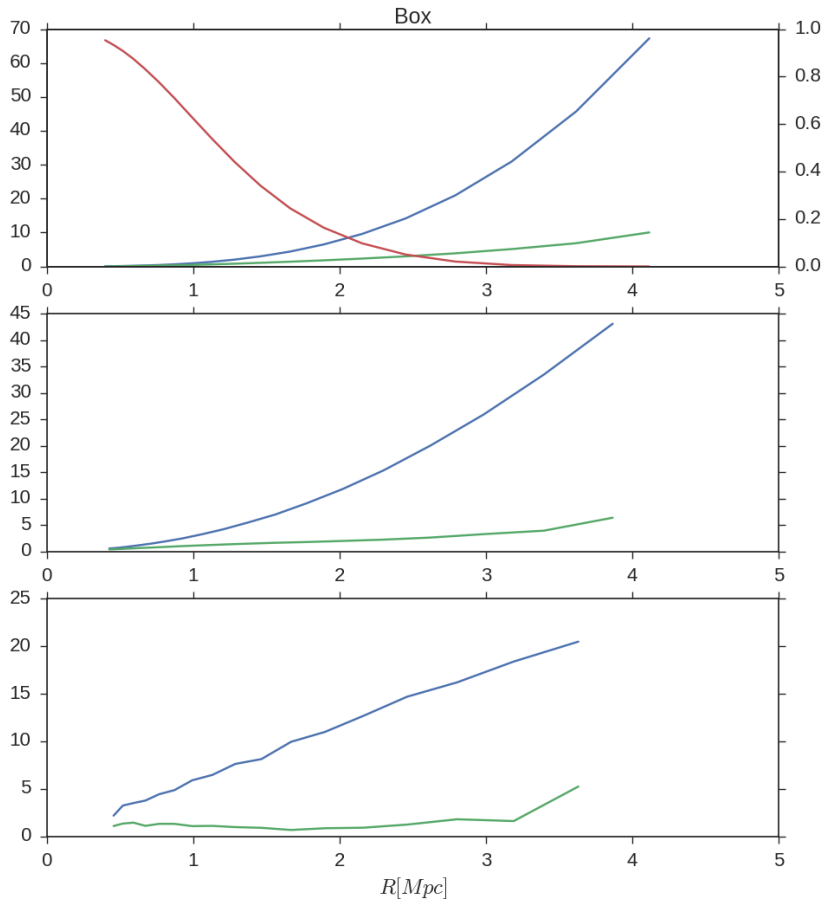

Invoid
P_0
χ
$\bar{N}\bar{\xi}$
Box
P_0
χ
$\bar{N}\bar{\xi}$
$R[Mpc]$


Invoid
$\bar{N}$
$-ln(P_0)$
P_0
$\frac{d}{dr}(\bar{N})$
$\frac{d}{dr}(-ln(P_0))$
$\frac{d^2}{dr^2}(\bar{N})$
$\frac{d^2}{dr^2}(-ln(P_0))$
$R[Mpc]$


Box
$R[Mpc]$

Some ideas on where to go to next:

- Try other clustering models
- Fit curves and calculate S_p
- Use recently released Illustris TNG

Thank you for listening!