THE COSMIC WEB:
LARGE SCALE STRUCTURE IN DIFFERENT GEOMETRIC ENVIRONMENTS

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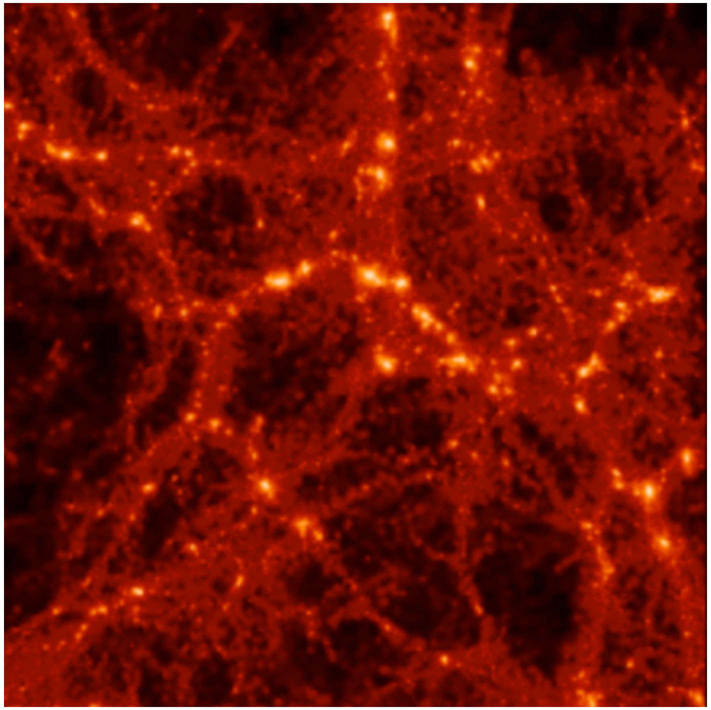
Contents

- Geometric Environments:
  - How to quantitatively classify them
- Application to Simulations:
  - Comparisons to Gaussian theory
- Application to Observational Datasets:
  - GAMA luminosity and mass functions as f(environment)
- Summary

Classifying the Geometric Environments



- VOIDS
- SHEETS
- FILAMENTS
- KNOTS

Tidal Tensor Prescription:

$$T_{ij} = \frac{\partial^2 \phi}{\partial q_i \partial q_j}$$

Second derivative of gravitational potential indicates whether point is near a potential minima or potential maxima.

Eigenvalues of T_{ij} determine geometrical nature of each point in space.

Number of positive eigenvalues corresponds to the dimension of the stable manifold.

- Extension of the **Zel'dovich approximation**
- Uses second derivatives of the **gravitational potential**

  e.g. Hahn et al. '06, Forero-Romero et al. '09

- 2 free parameters : λ_{th} Eigenvalue threshold, σ_s Smoothing scale.

Eigenvalues: $\alpha > \beta > \gamma$

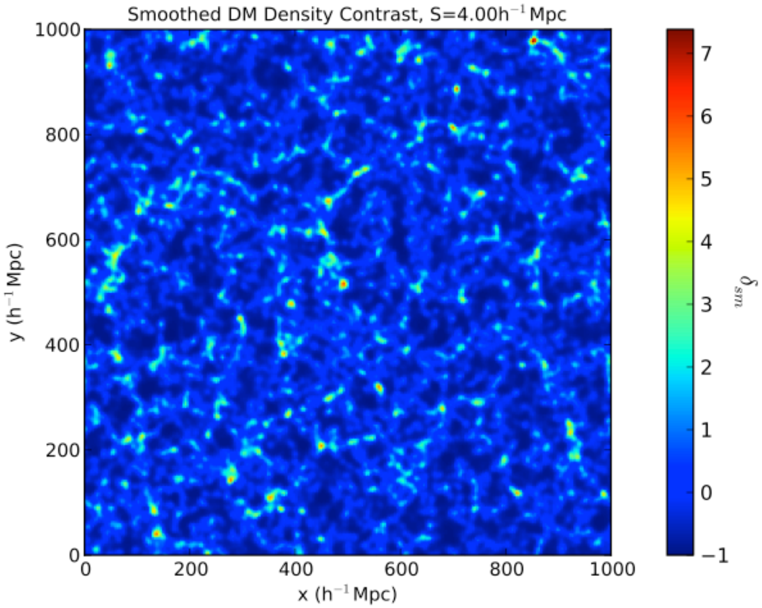
$\alpha, \beta, \gamma < \lambda_{th}$: Void

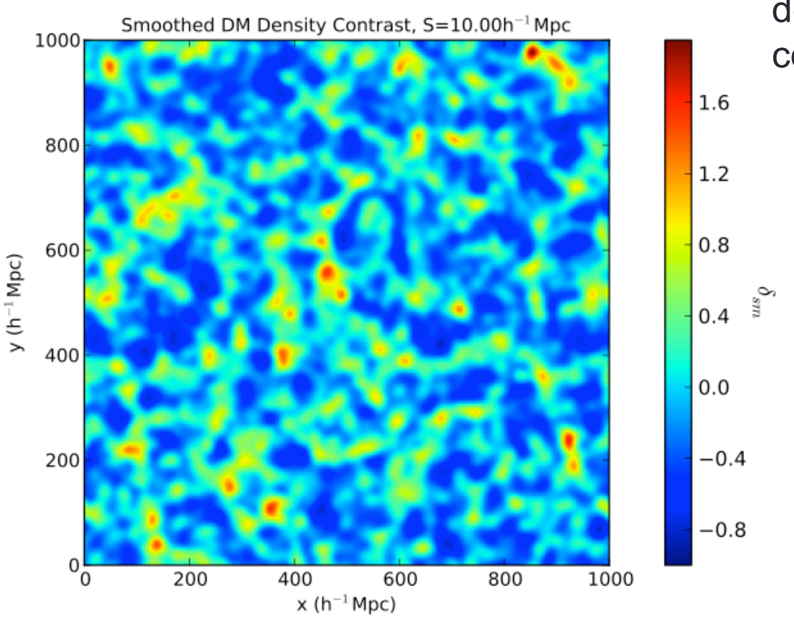
$\alpha > \lambda_{th}$: Sheet

$\alpha, \beta > \lambda_{th}$: Filament

$\alpha, \beta, \gamma > \lambda_{th}$: Knot

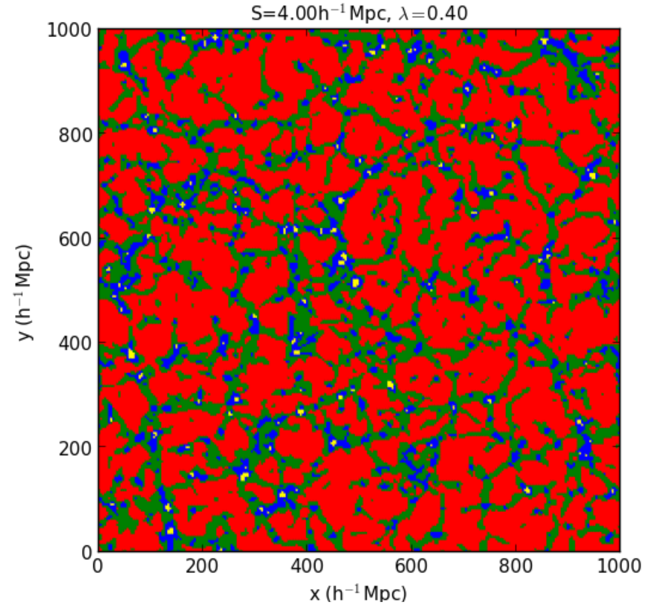
Application to Simulations

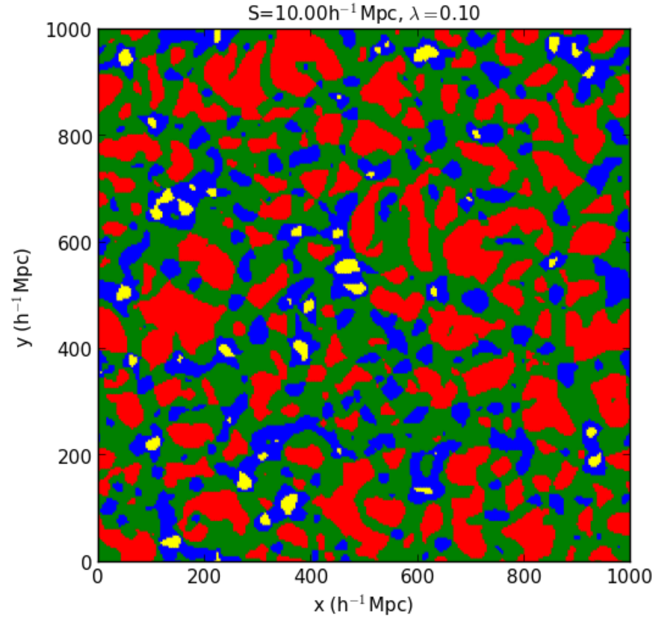


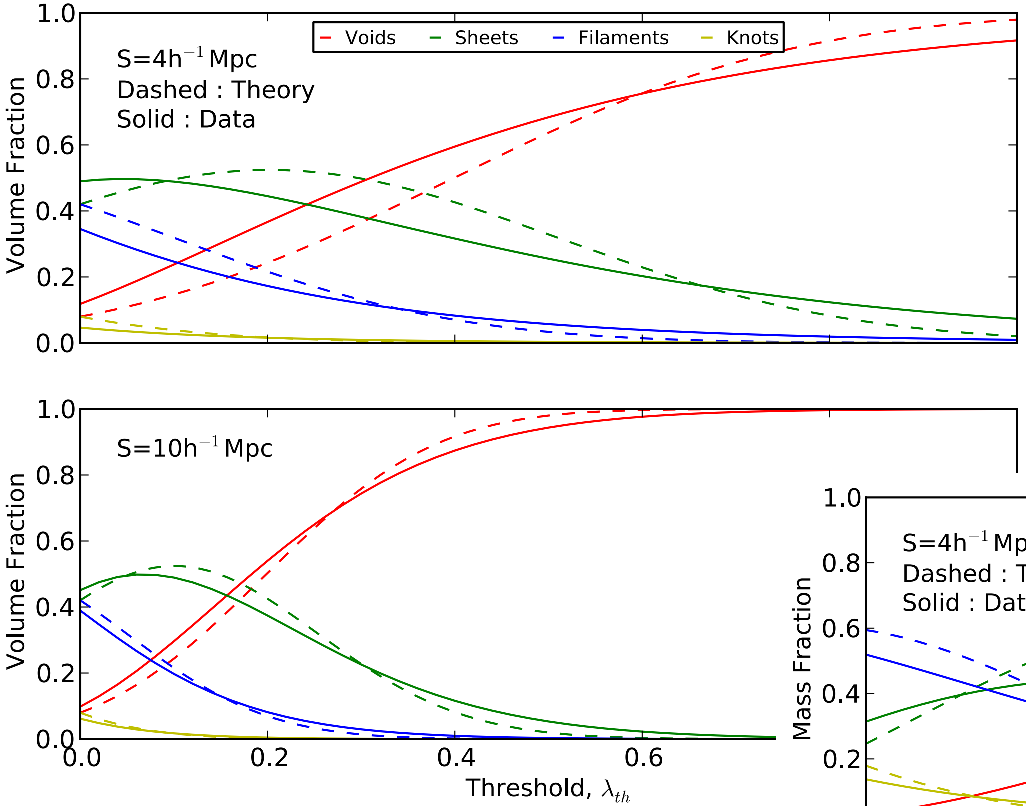


Smoothed density contrast

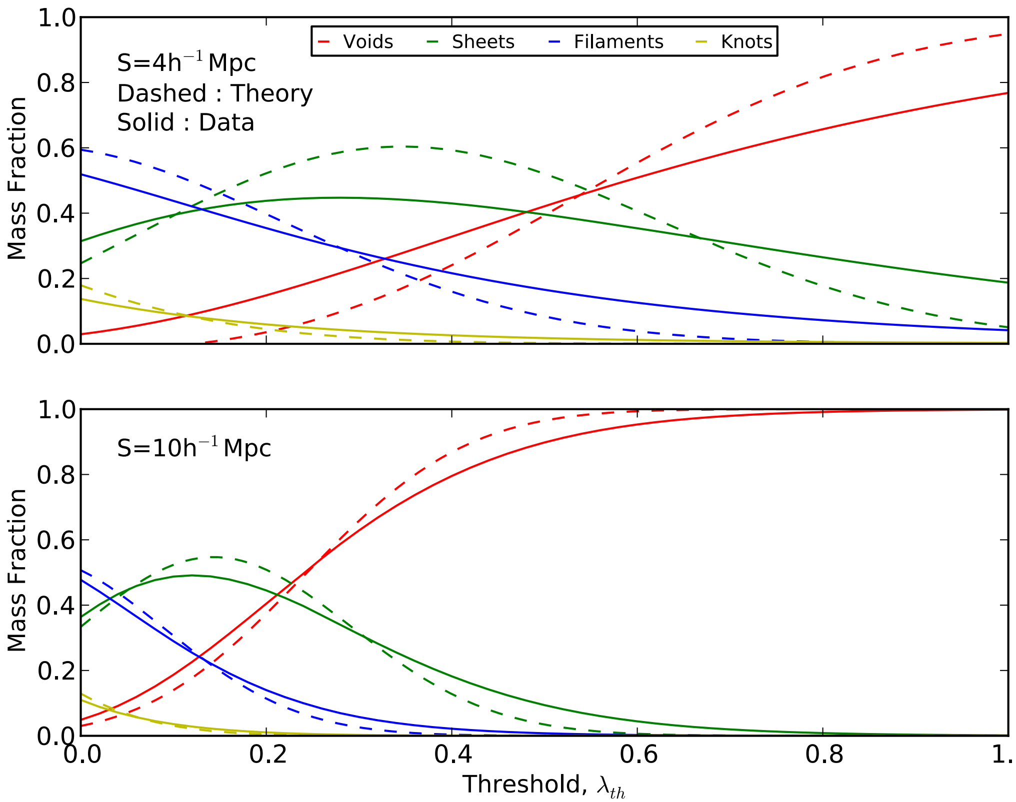
Resulting environments:
Voids
Sheets
Filaments
Knots







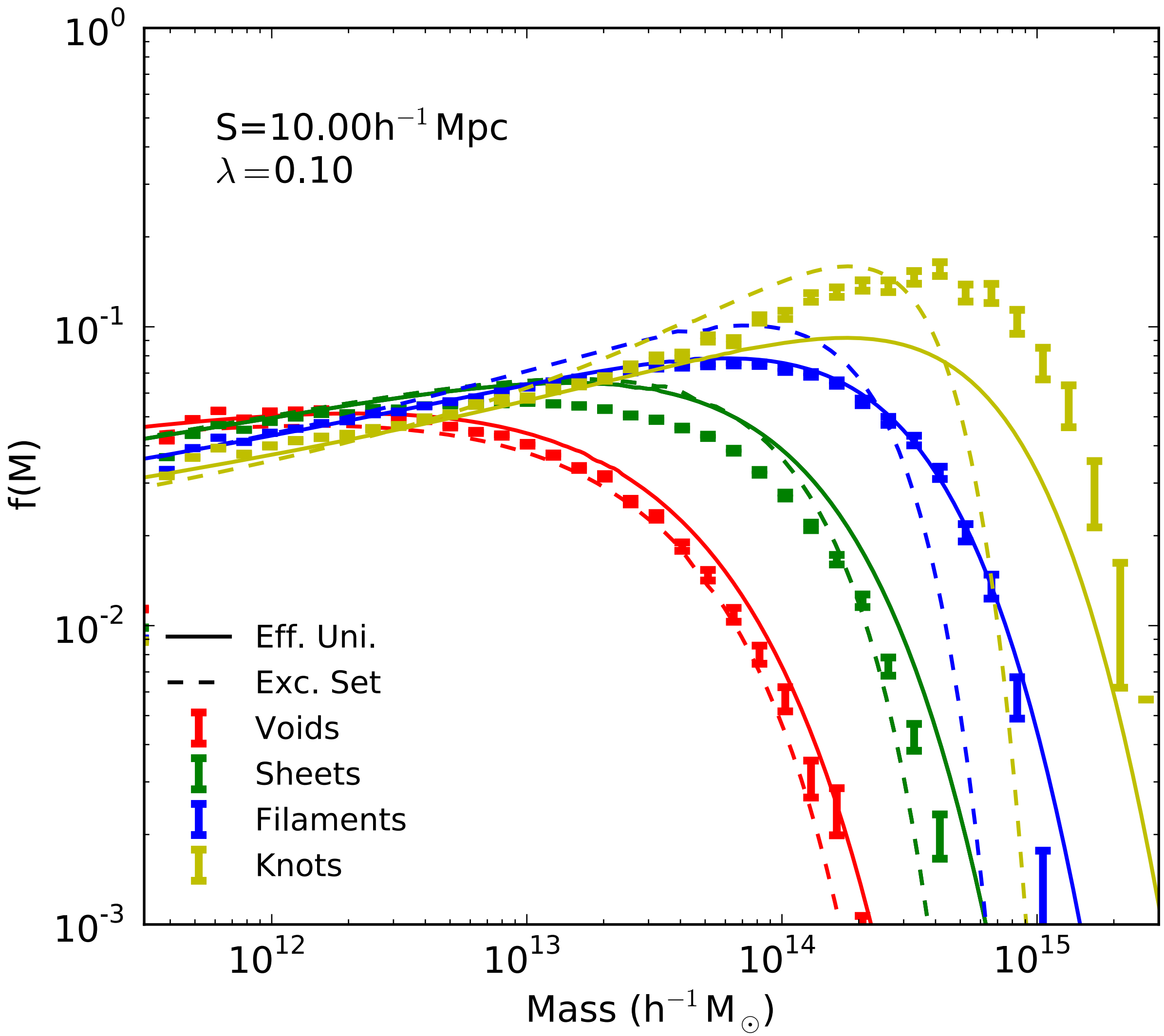
Volume Fraction f(threshold)



Mass Fraction f(threshold)

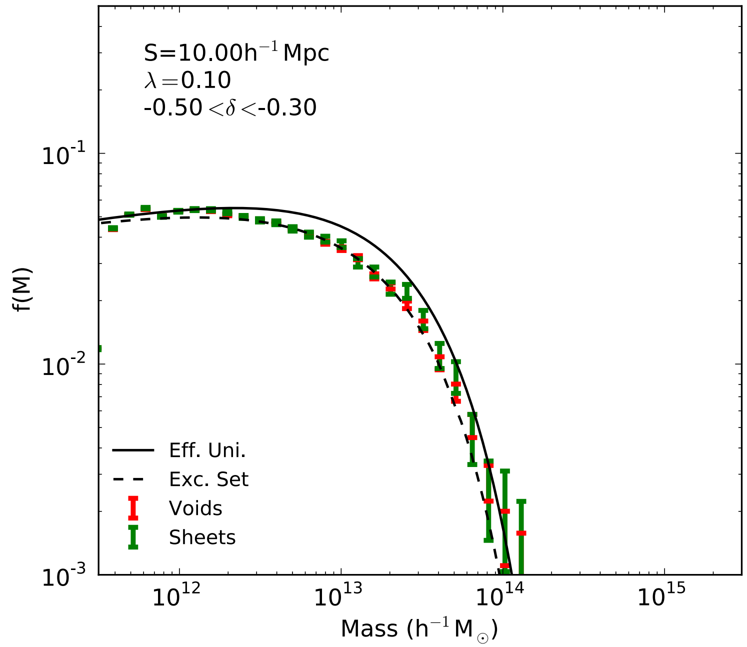
Alonso, Eardley & Peacock 2014 – arxiv: 1406.4159

The Conditional Halo Mass Function

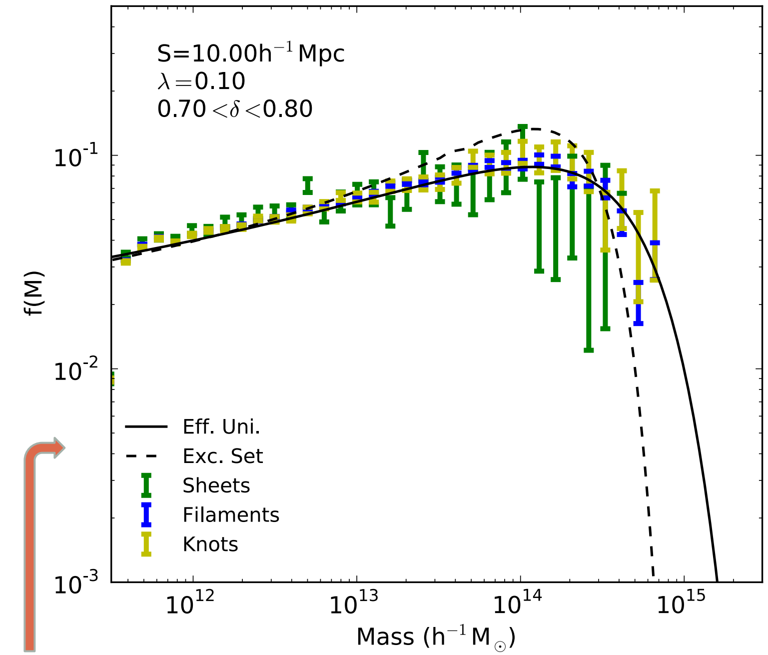


$$f(M) = M^2 F(M)/\rho_{av}$$

Alonso, Eardley & Peacock 2014

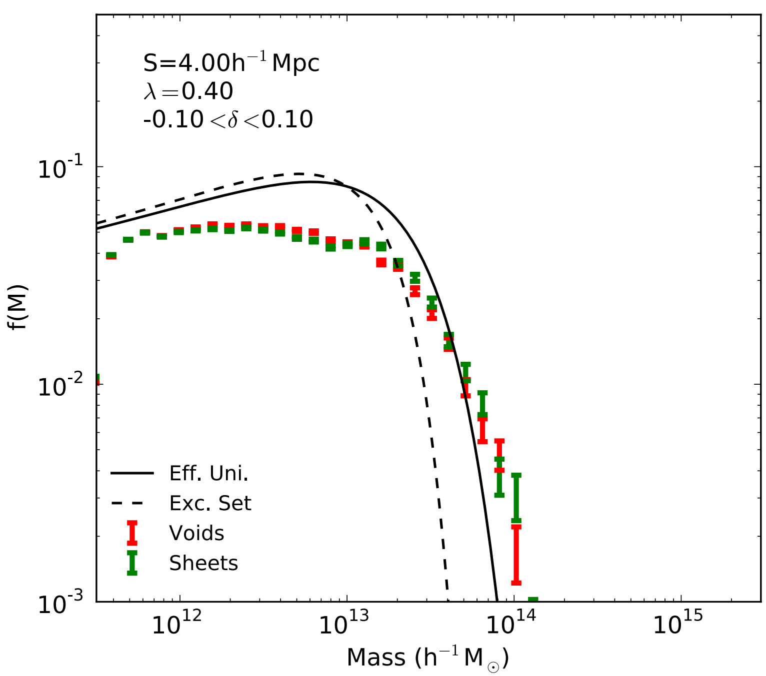


Large Smoothing

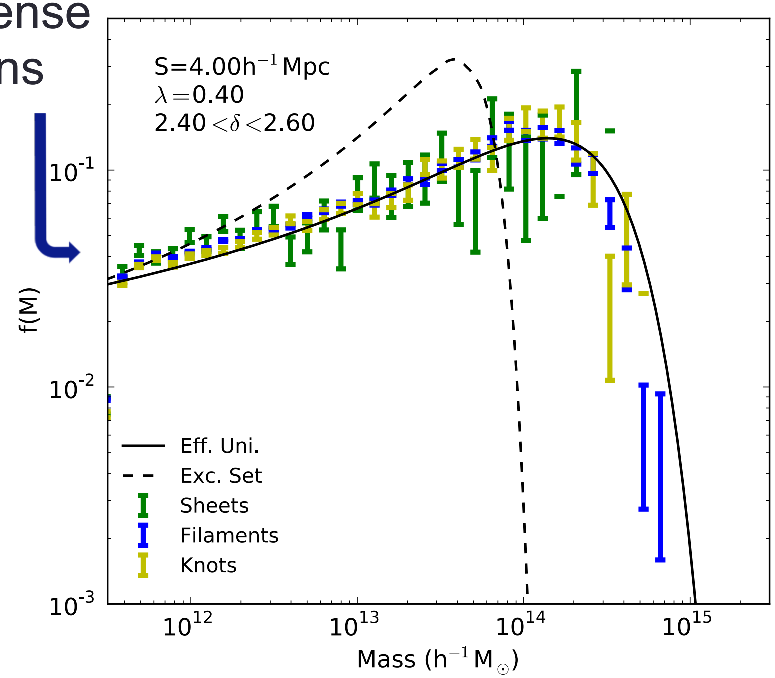


Under-dense regions

Over-dense regions



Small Smoothing



Halo mass function varies by geometric environment, but is only dependent on the local density.

How about real galaxies?

GAMA: Galaxy And Mass Assembly

http://www.gama-survey.org/

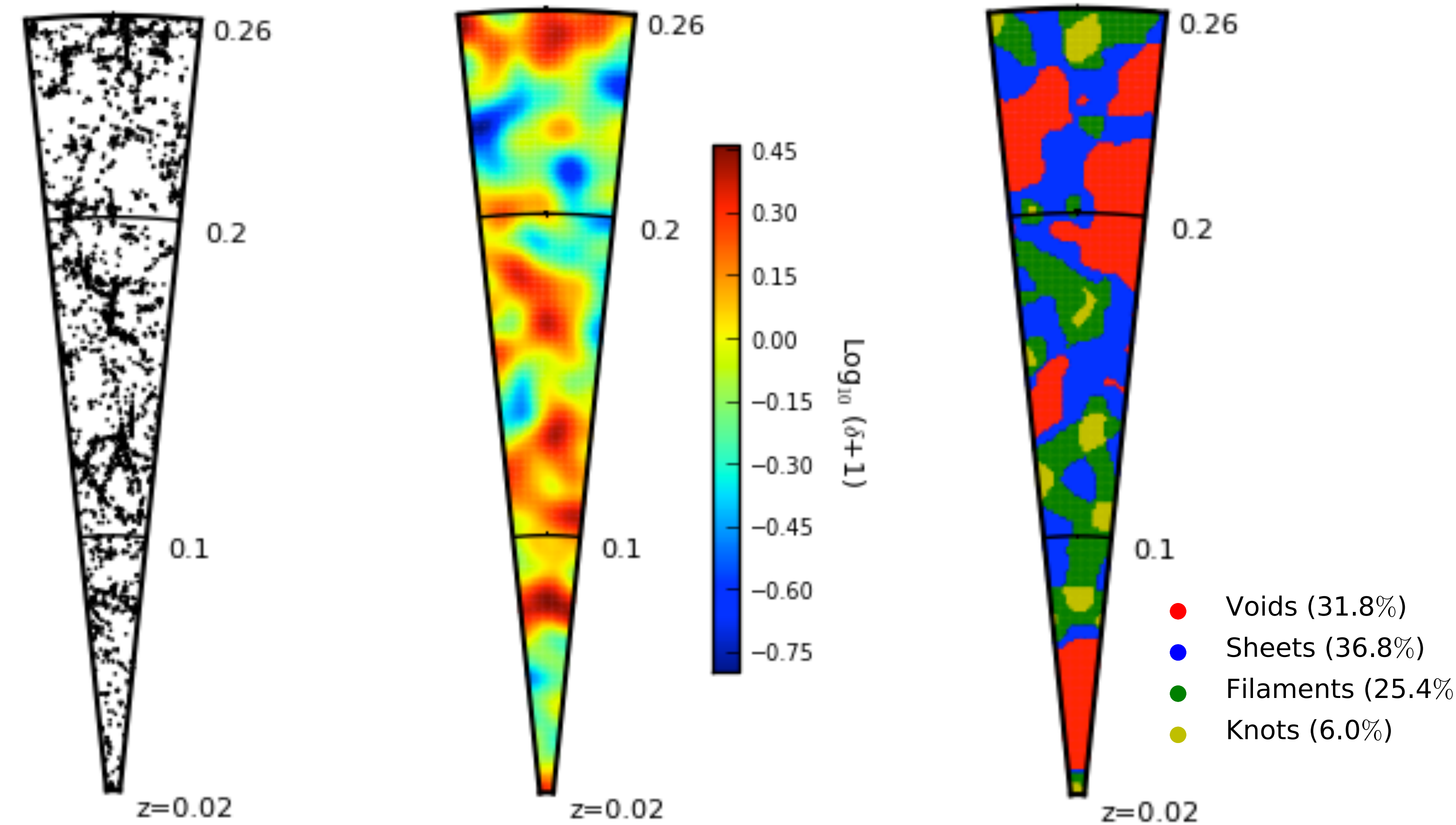
Spectroscopic survey of ~300,000 galaxies down to M_r<19.8 over ~290 deg^2 using the AAT.

z < 0.5

Three 5x12 deg^2 fields completed: G9, G12, G15

Redshift completeness > 98%

Application to Galaxy Surveys: GAMA



a) Galaxies

b) Smoothed density contrast $\sigma_s = 10h^{-1}\mathrm{Mpc}$

c) Environments $\lambda_{th} = 0.1$

Application to galaxy surveys:
Observational Issues

Galaxies not DM
Biased tracers

Redshift dependences
Bias(z)
D(z)
Lmin(z)

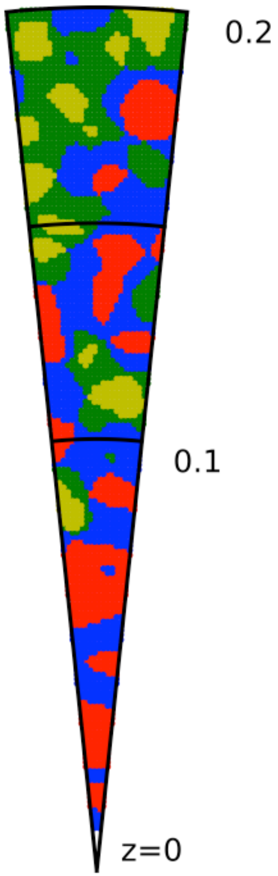
Incompleteness

Limited volume
Edge effects
Non-periodic volume

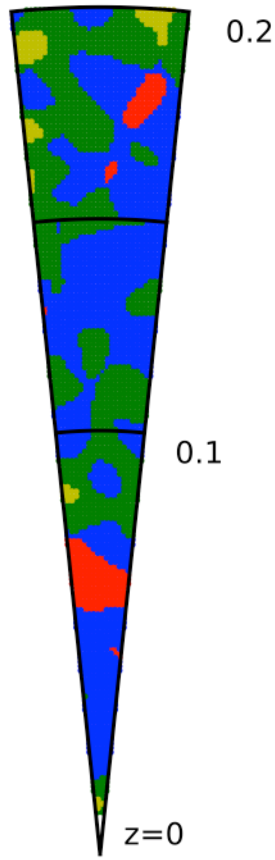
Application to galaxy surveys

How much does the limited survey volume affect results?

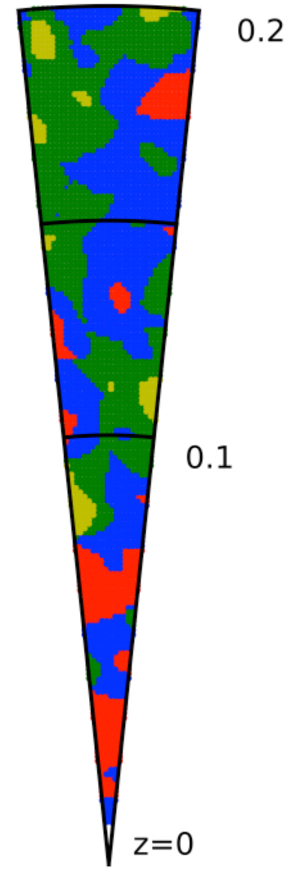
- Low redshift regions most affected
- Can be improved by 'reflecting' galaxies along survey boundaries



Survey volume
+ zero-padding

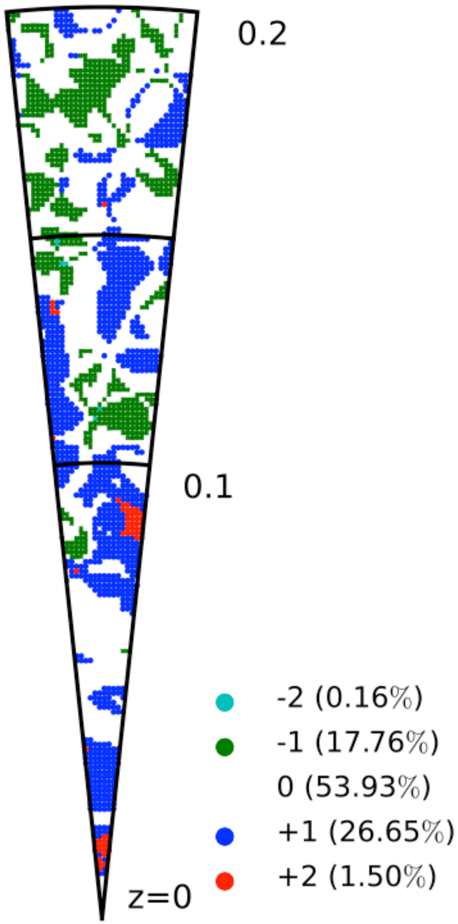


The "Truth" –
Full periodic
simulation used



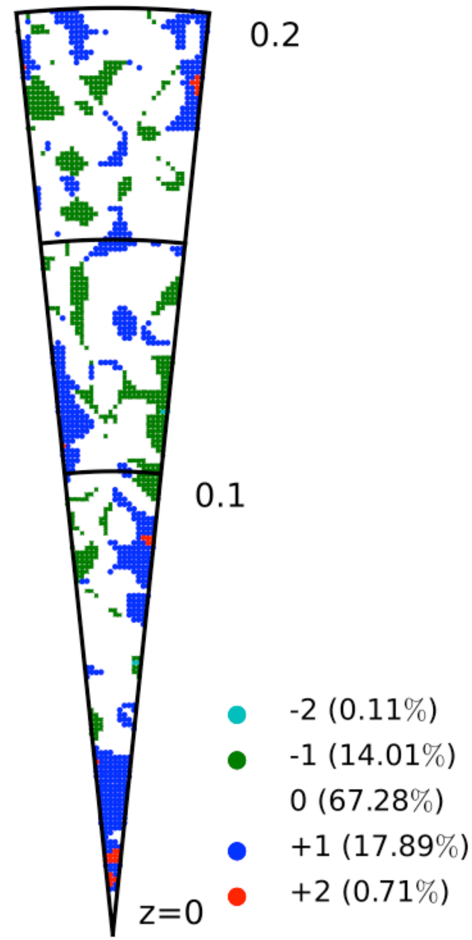
Survey volume
+ Reflections

Application to galaxy surveys



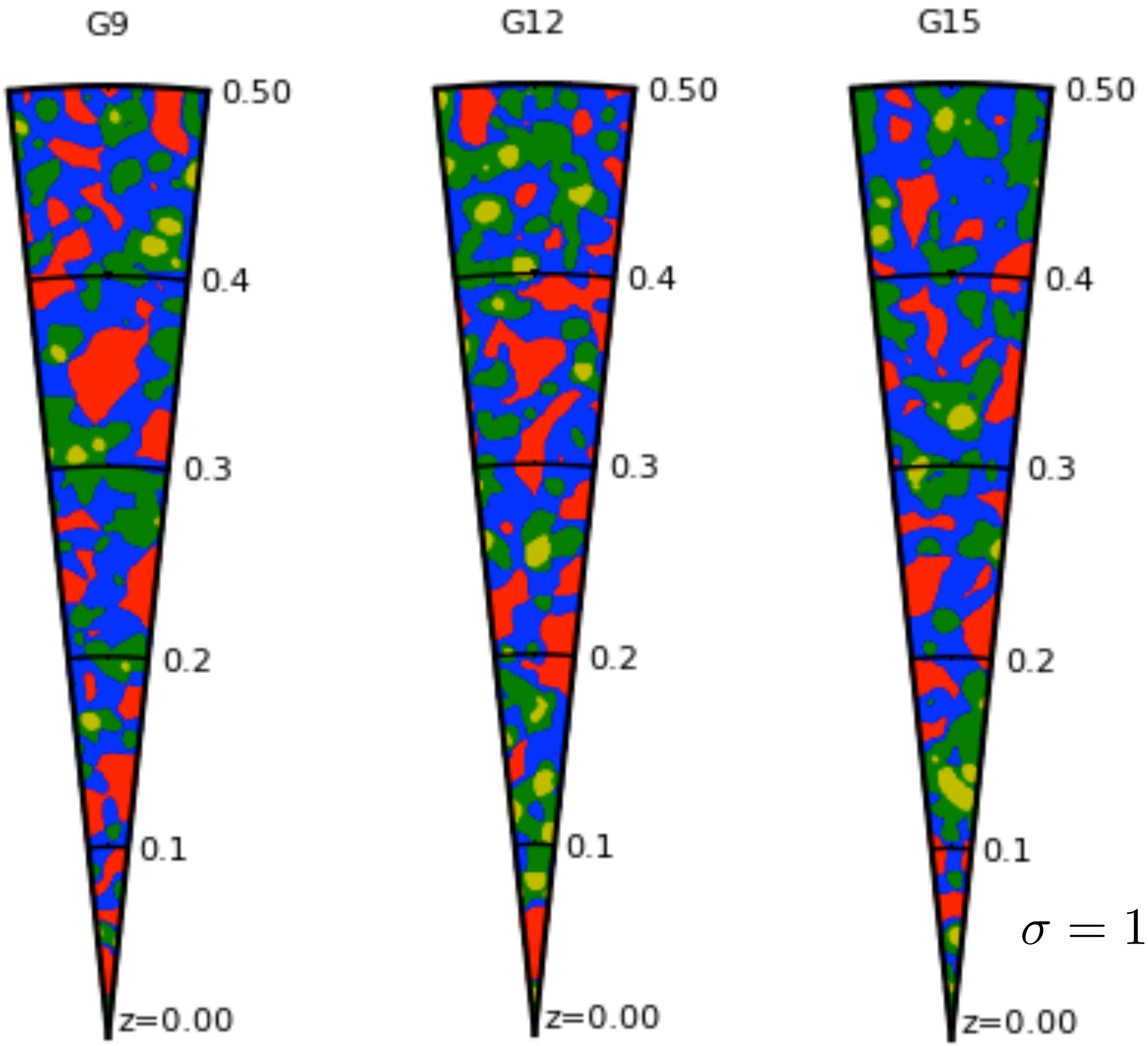
Survey volume
+ zero-padding

Regions which are classified differently when information outside the survey volume is discarded



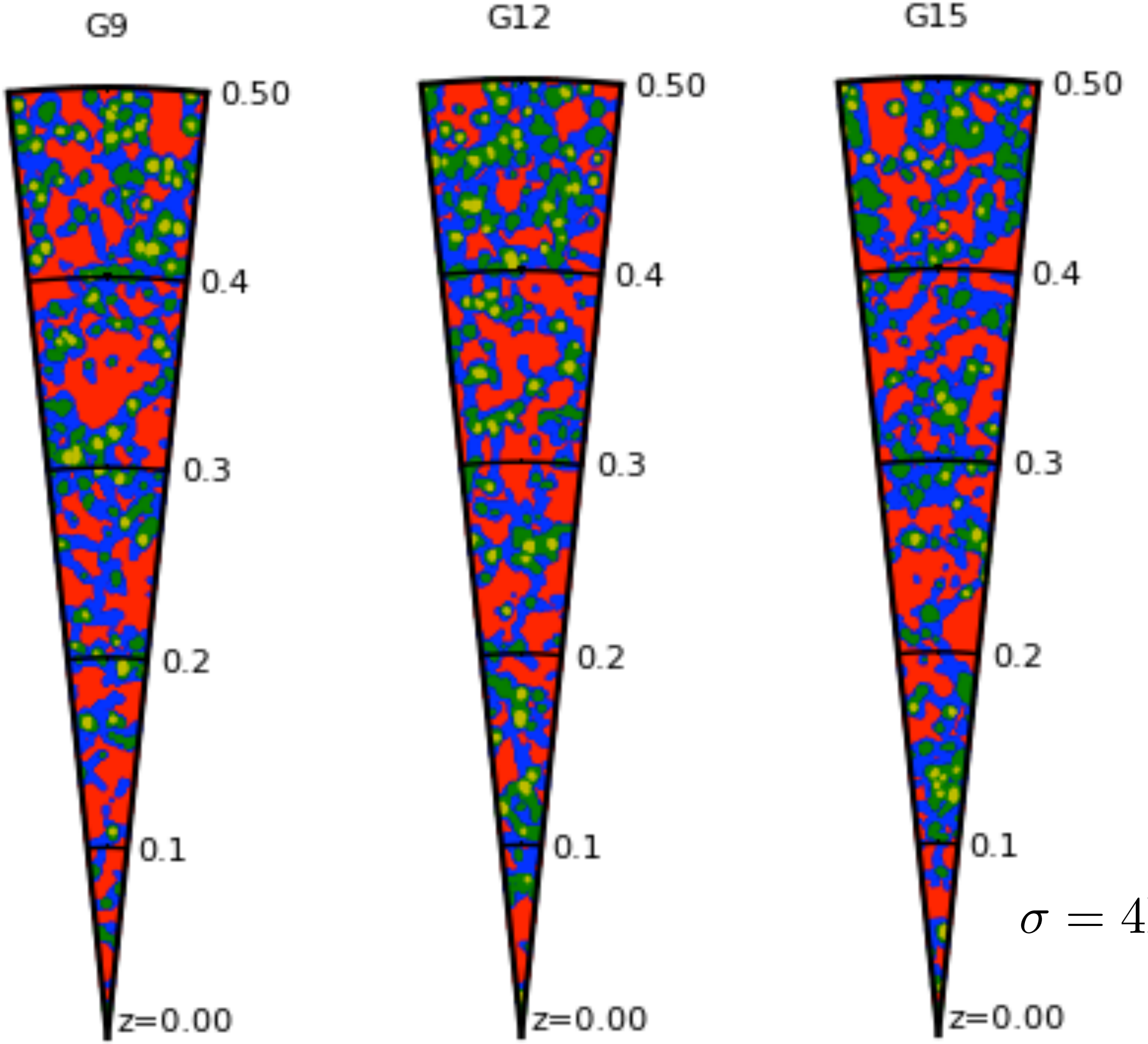
Survey volume
+ reflections

Application to Galaxy Surveys: GAMA Environments



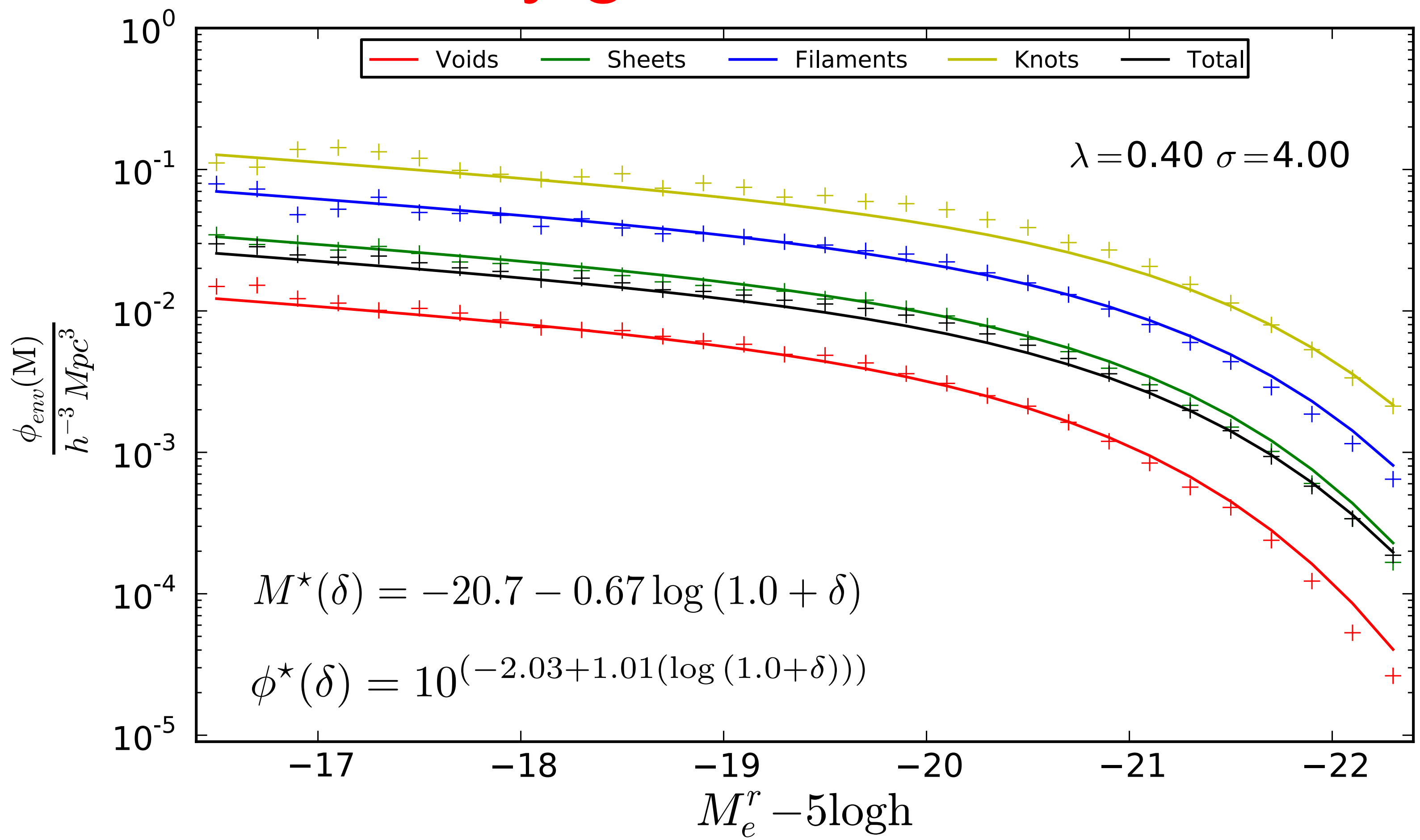
$$\sigma = 10\mathrm{h}^{-1}\mathrm{Mpc}$$

Application to Galaxy Surveys: GAMA Environments



$$\sigma = 4\mathrm{h}^{-1}\mathrm{Mpc}$$

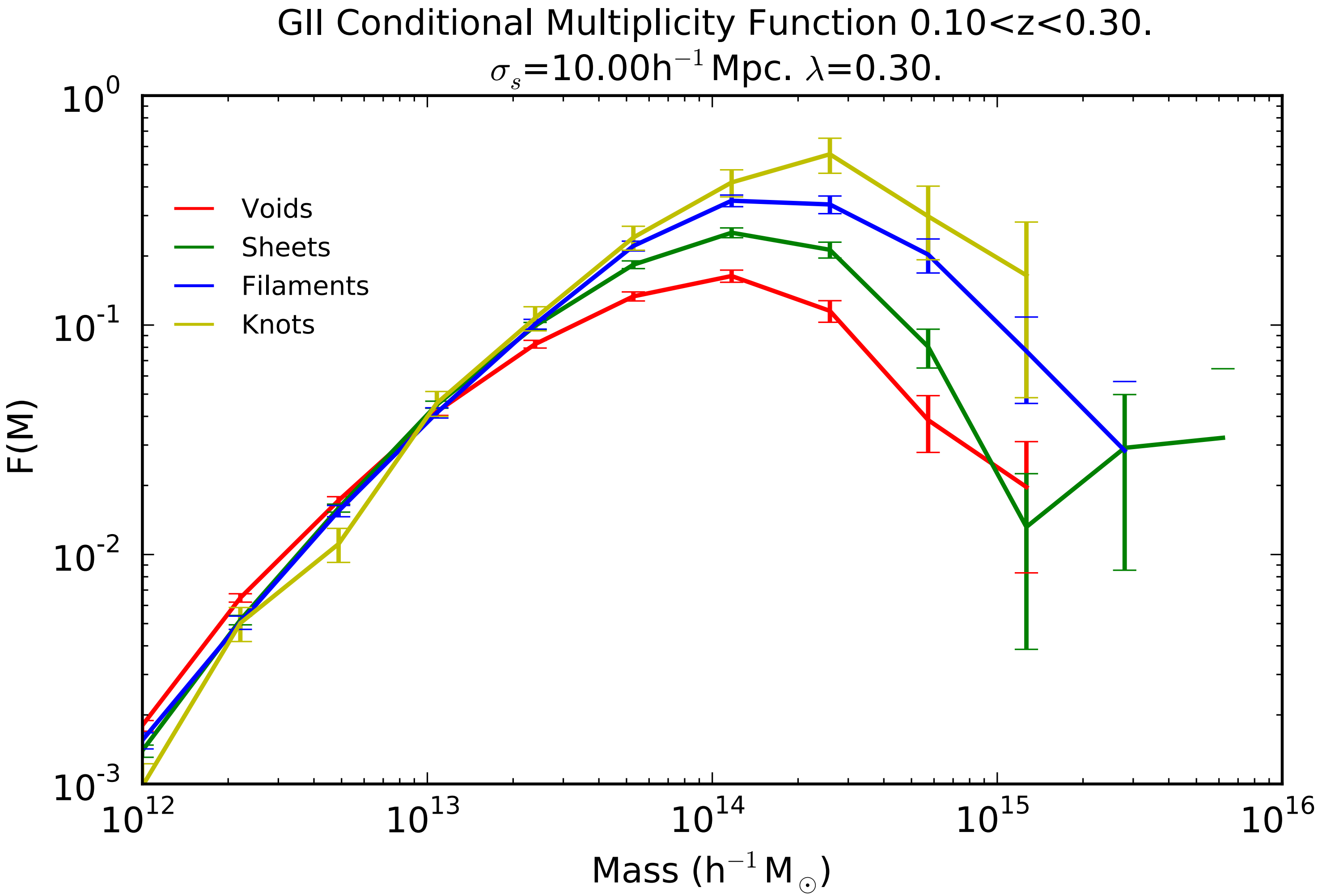
Modification of the galaxy luminosity function by geometric environment



$$\phi(M,\delta) = \frac{\ln 10}{2.5}\phi^\star(\delta)10^{0.4(M^\star(\delta)-M)(1+\alpha)}\exp(-10^{0.4(M^\star(\delta)-M)})$$

McNaught-Roberts et al 2014

Observed Mass Distribution as f(Environment)



SUMMARY

Geometric environments can be defined in simulated and observed datasets via the tidal tensor

Mass functions can be compared with Gaussian linear theory – no explicit dependence on geometric environments expected

Distributions of observed luminosities shows a similar lack of geometric dependence

Analysis can be extended to other properties of LSS – e.g. weak lensing and star formation histories

Thanks for listening! ☺

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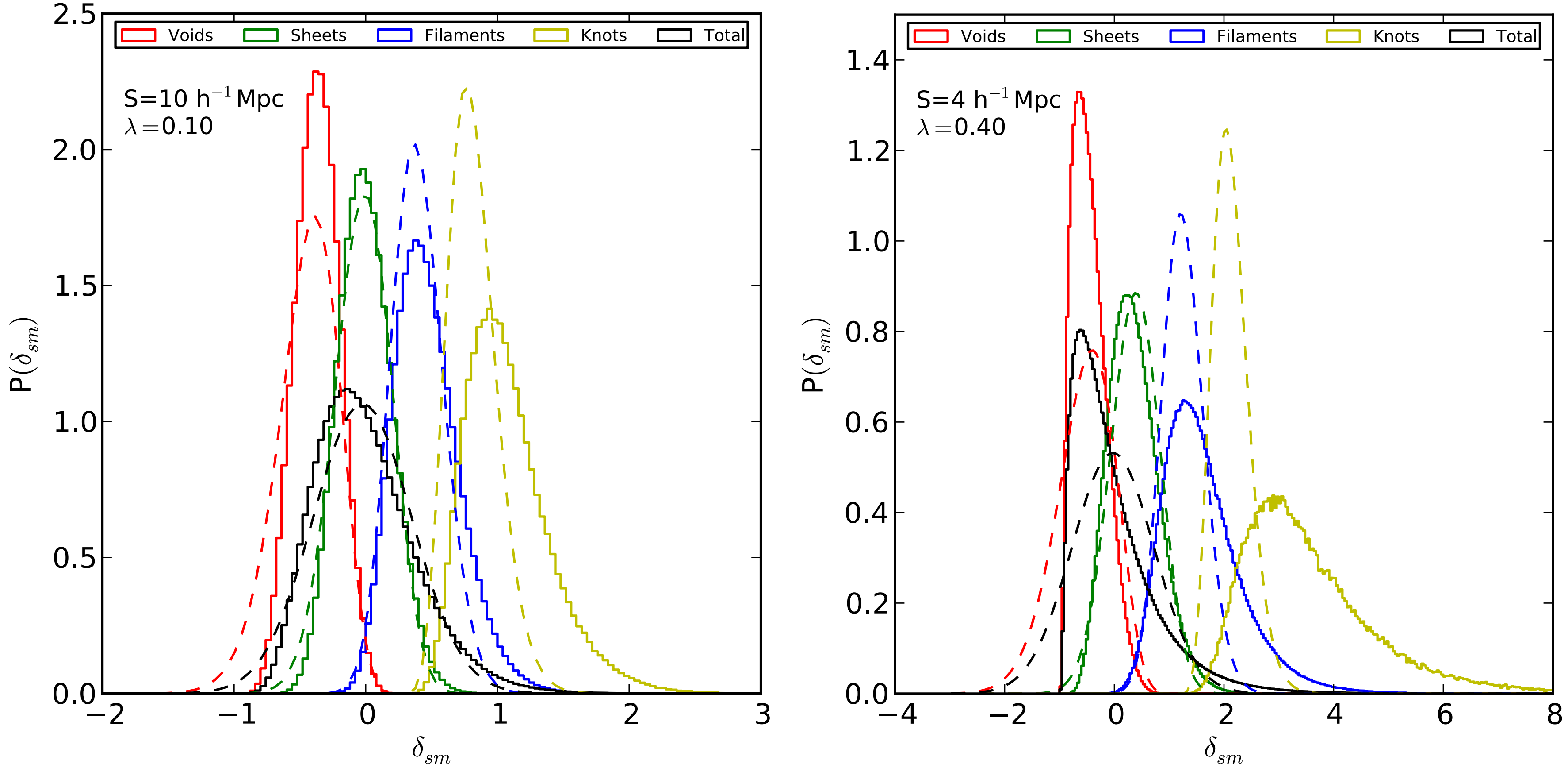
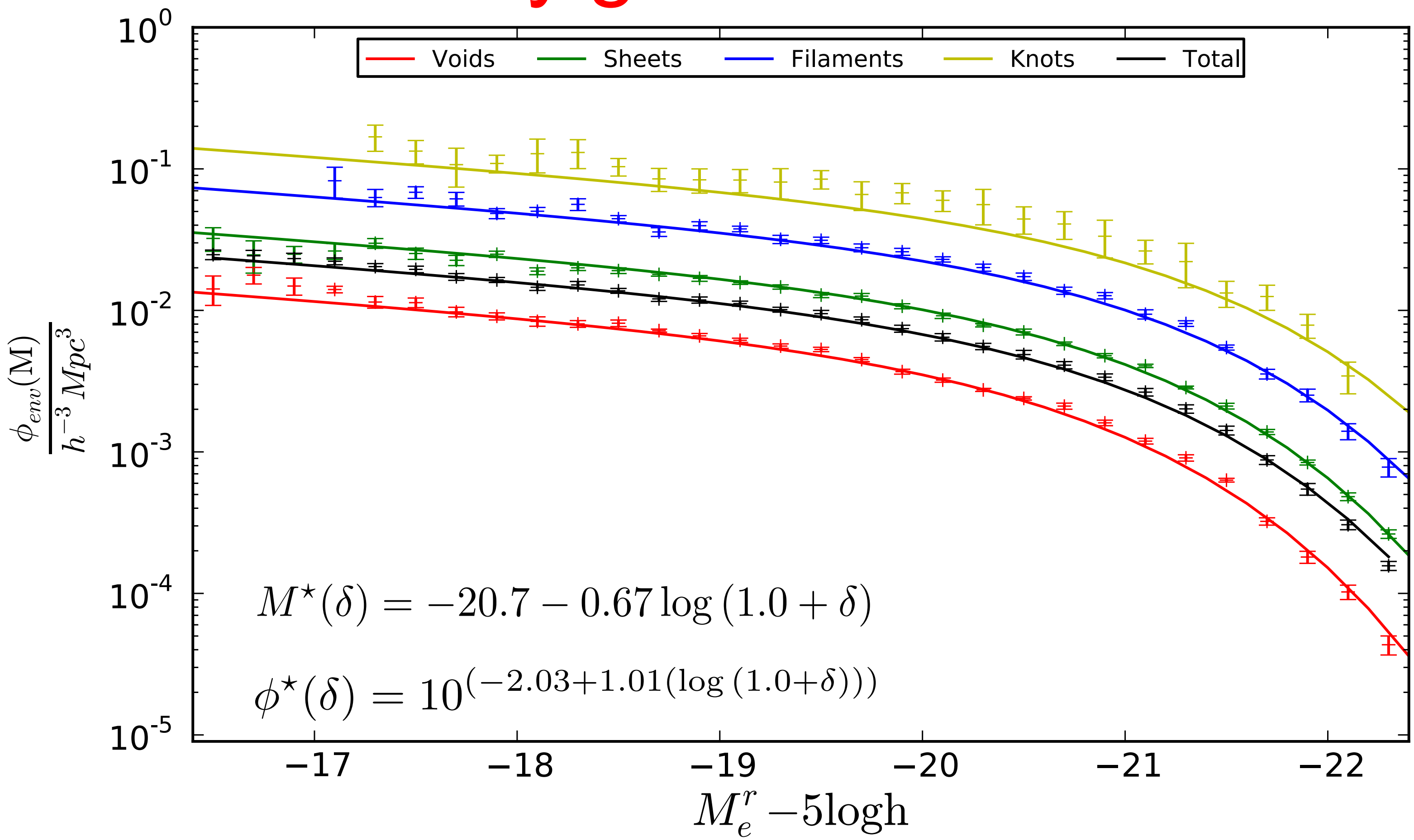


Density distributions

Modification of the galaxy luminosity function by geometric environment



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McNaught-Roberts et al 2014

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