The Local Dimension: A method to quantify the Cosmic Web

Prakash Sarkar

IIT Kharagpur, India

Collaborator: Dr. Somnath Bharadwaj
Dr. Biswajit Pandey

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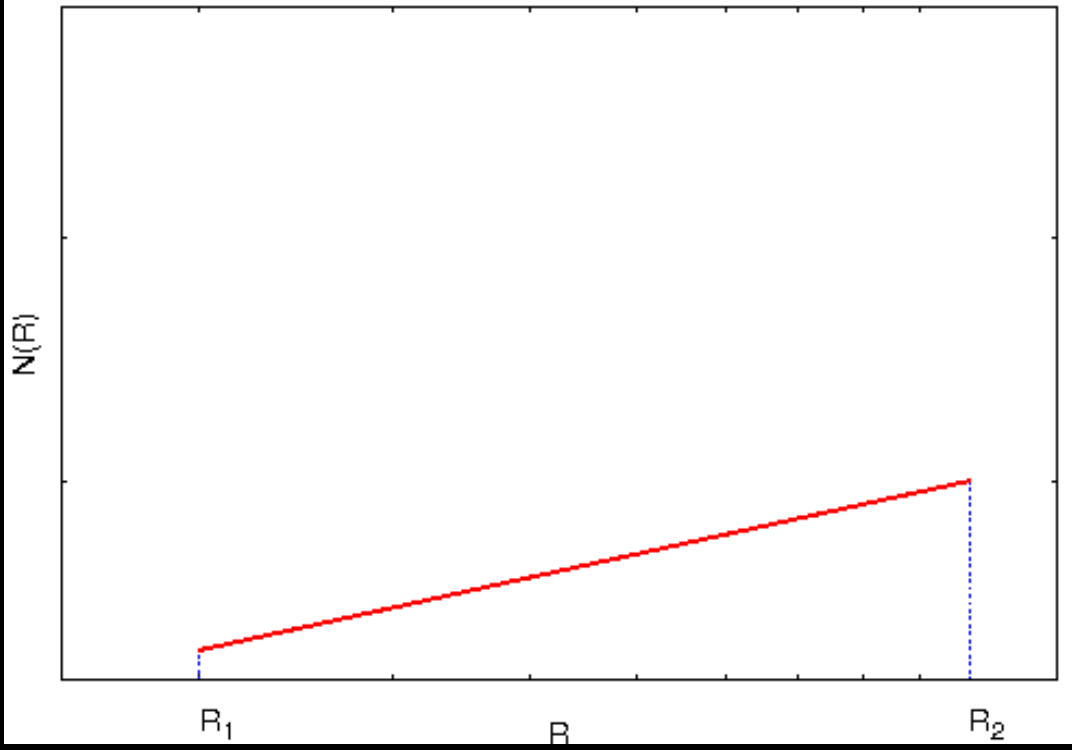
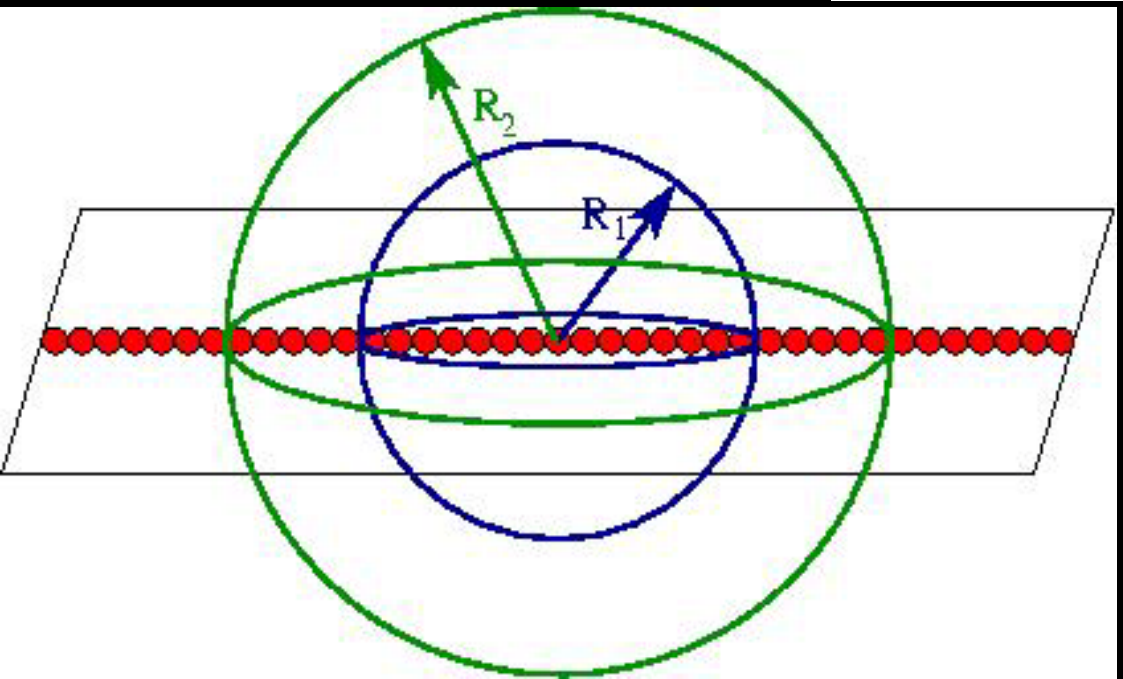
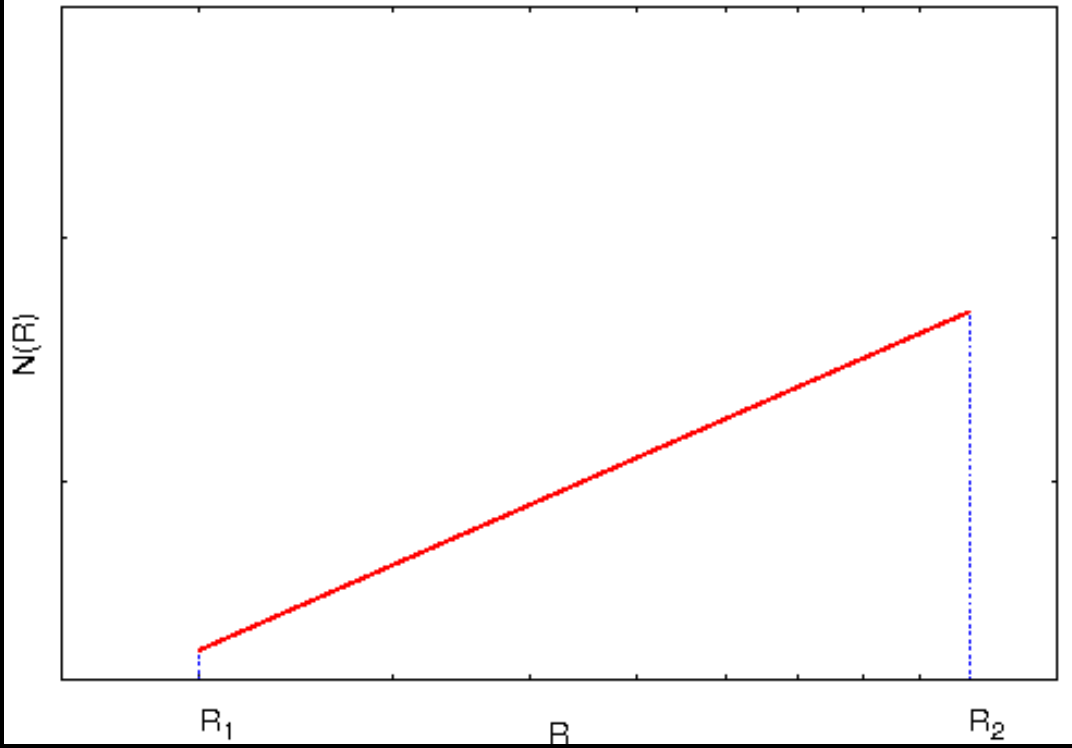
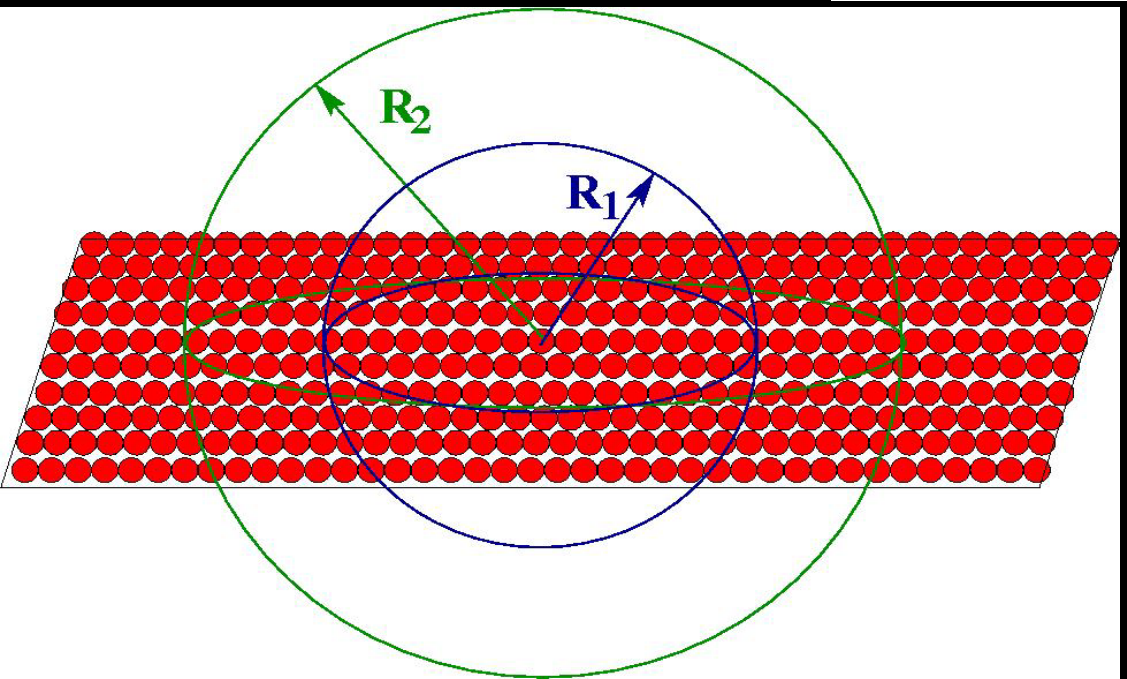
$$N(R) \propto R$$



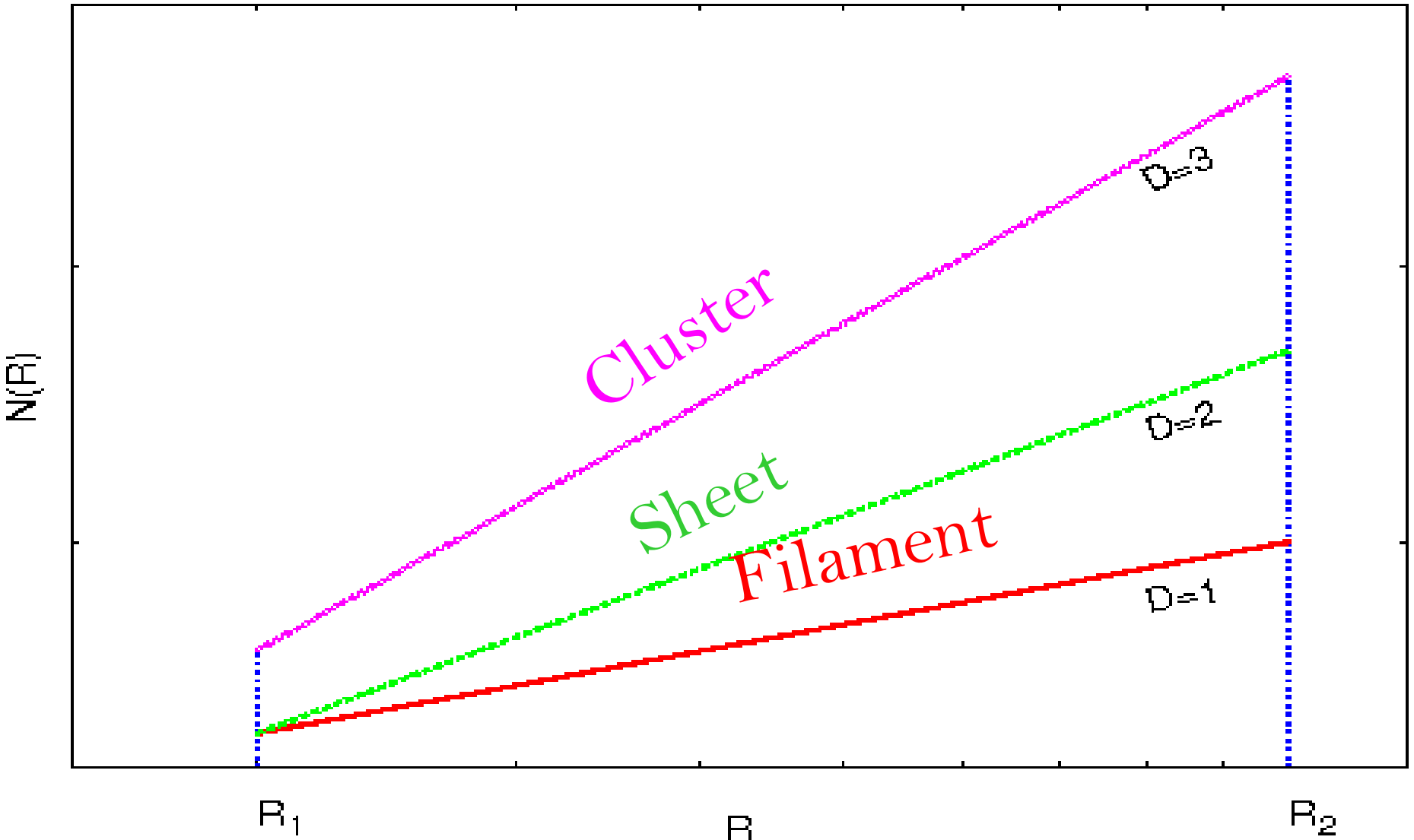


$$N(R) \propto R^2$$





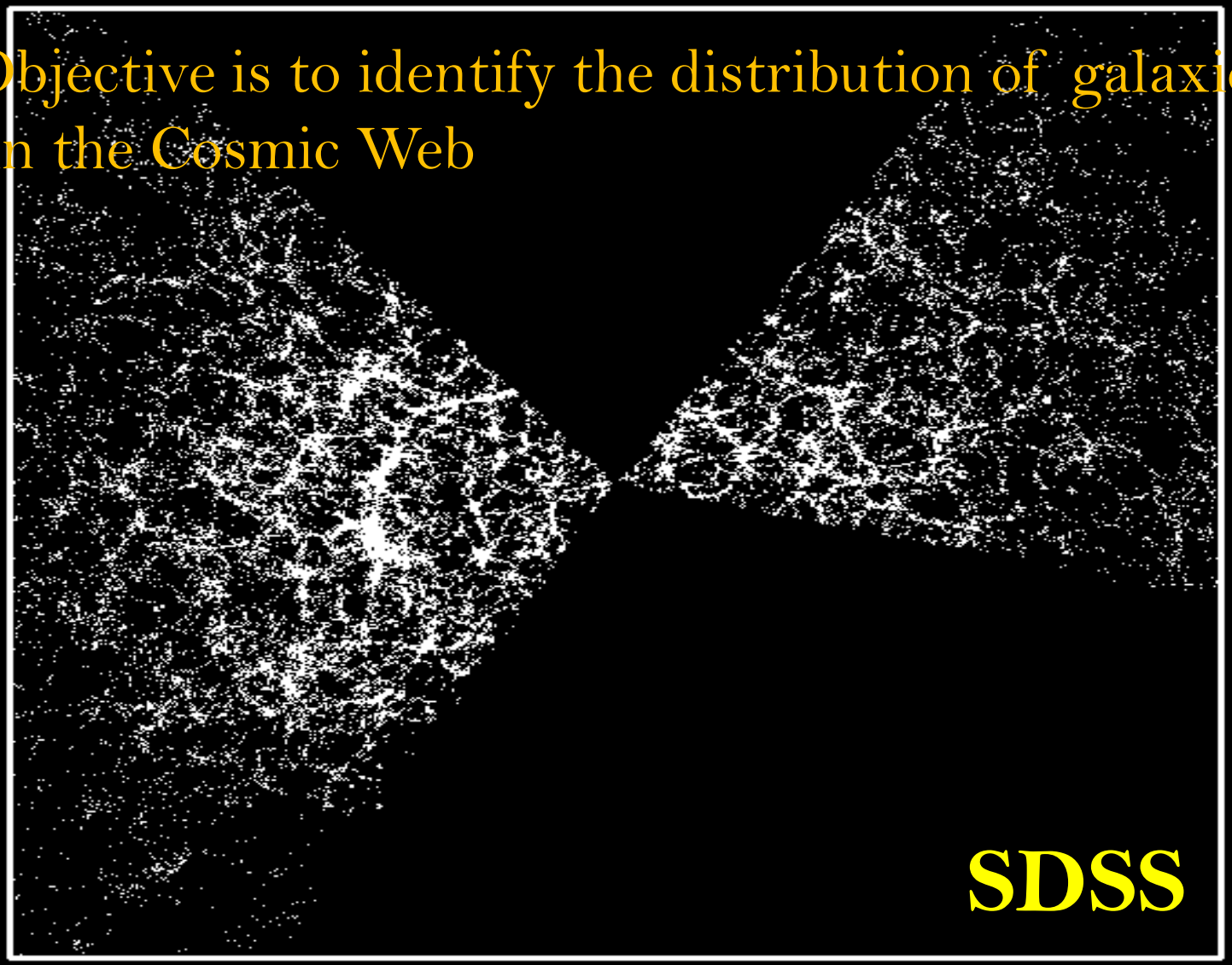
$N(R) \propto R^D$

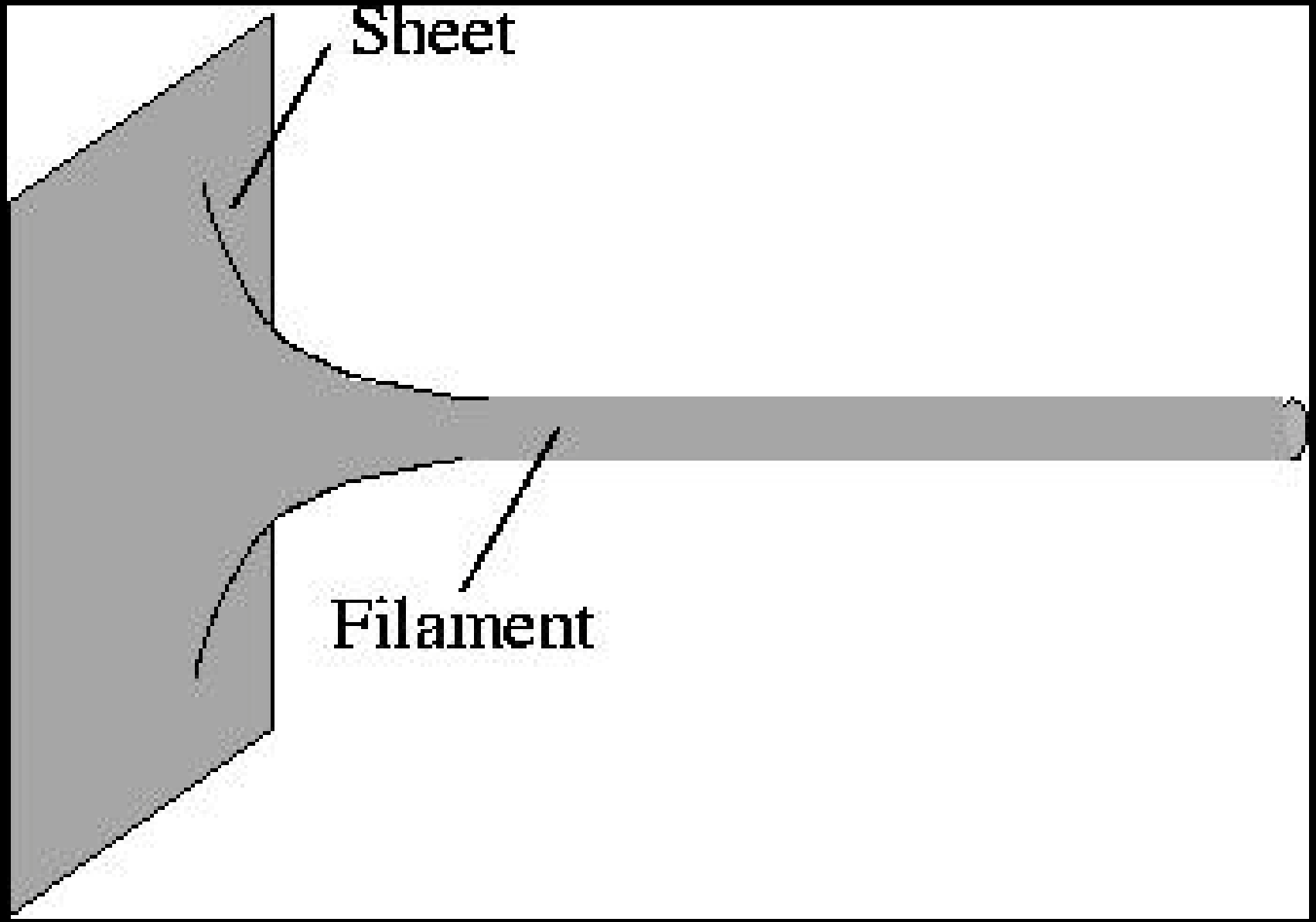


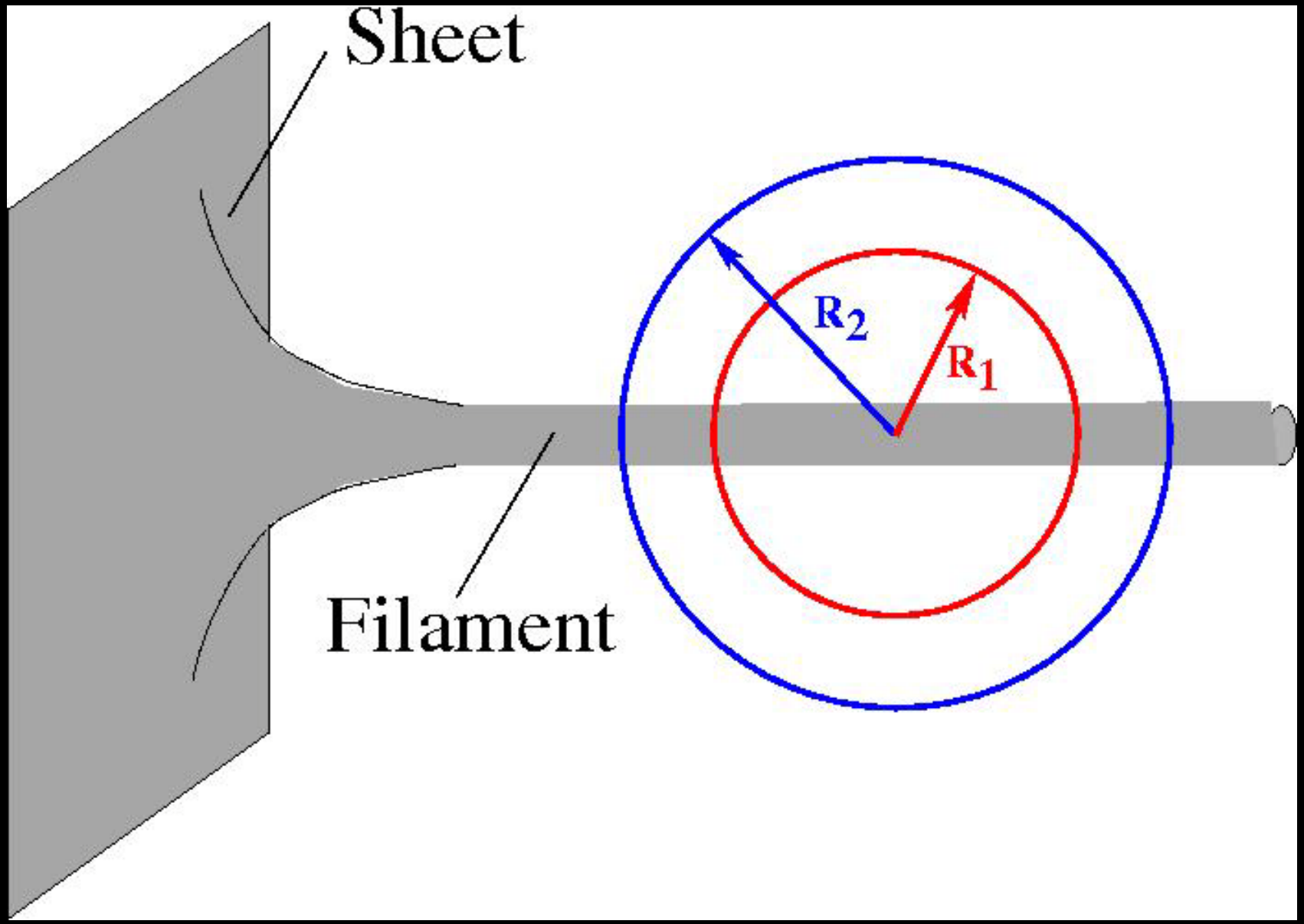
The Local Dimension: A method to quantify the Cosmic Web

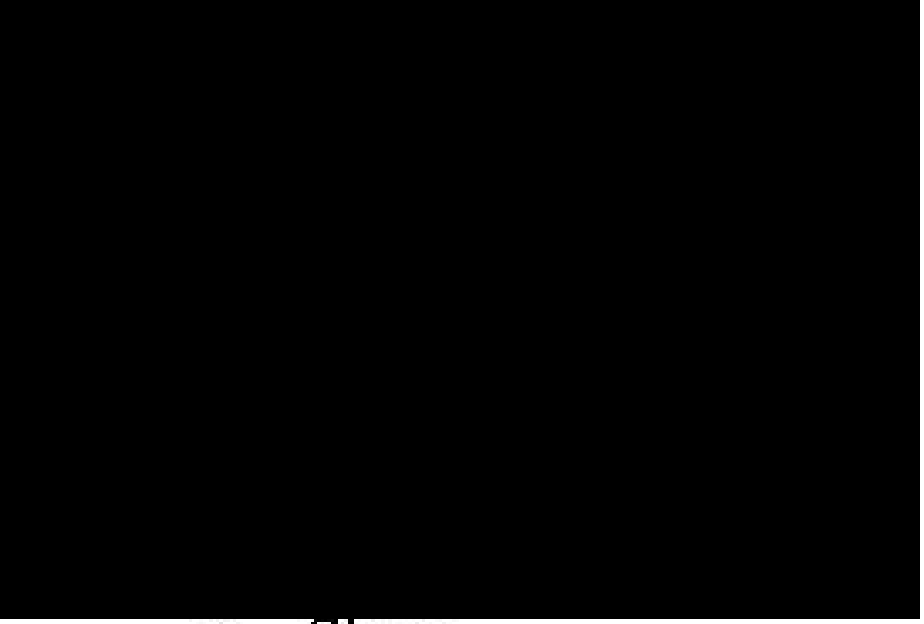
SDSS

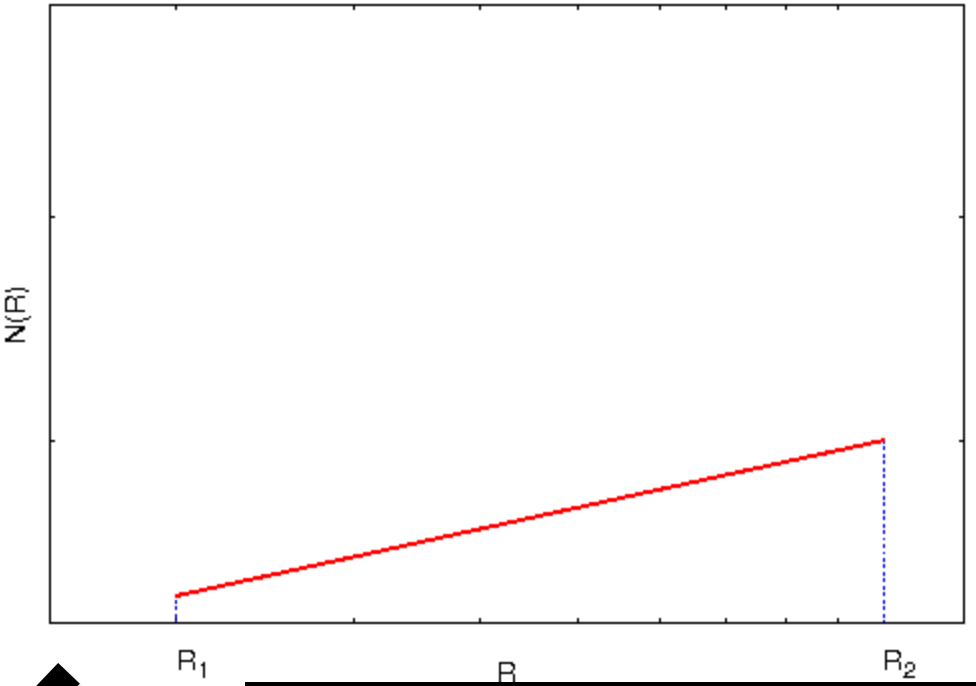
Objective is to identify the distribution of galaxies in the Cosmic Web

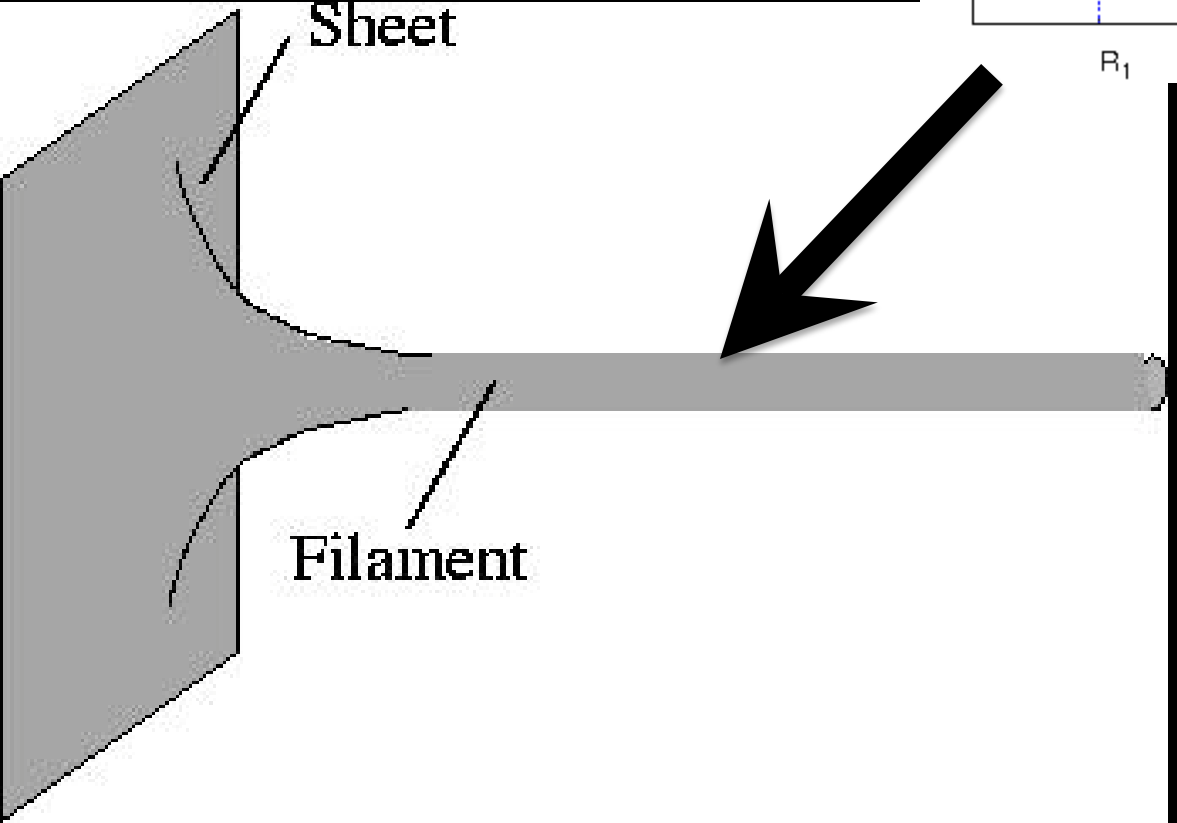


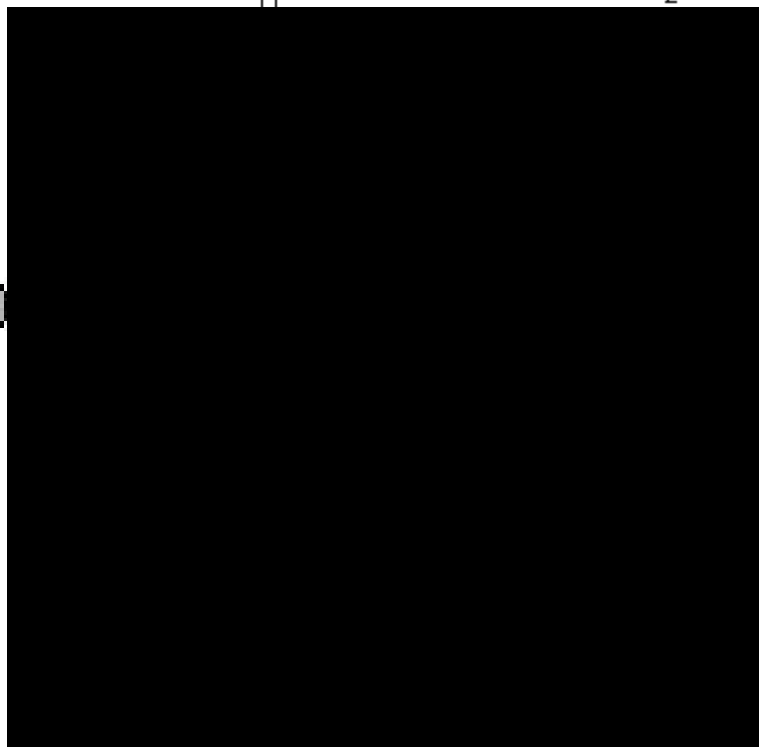

Sheet
Filament

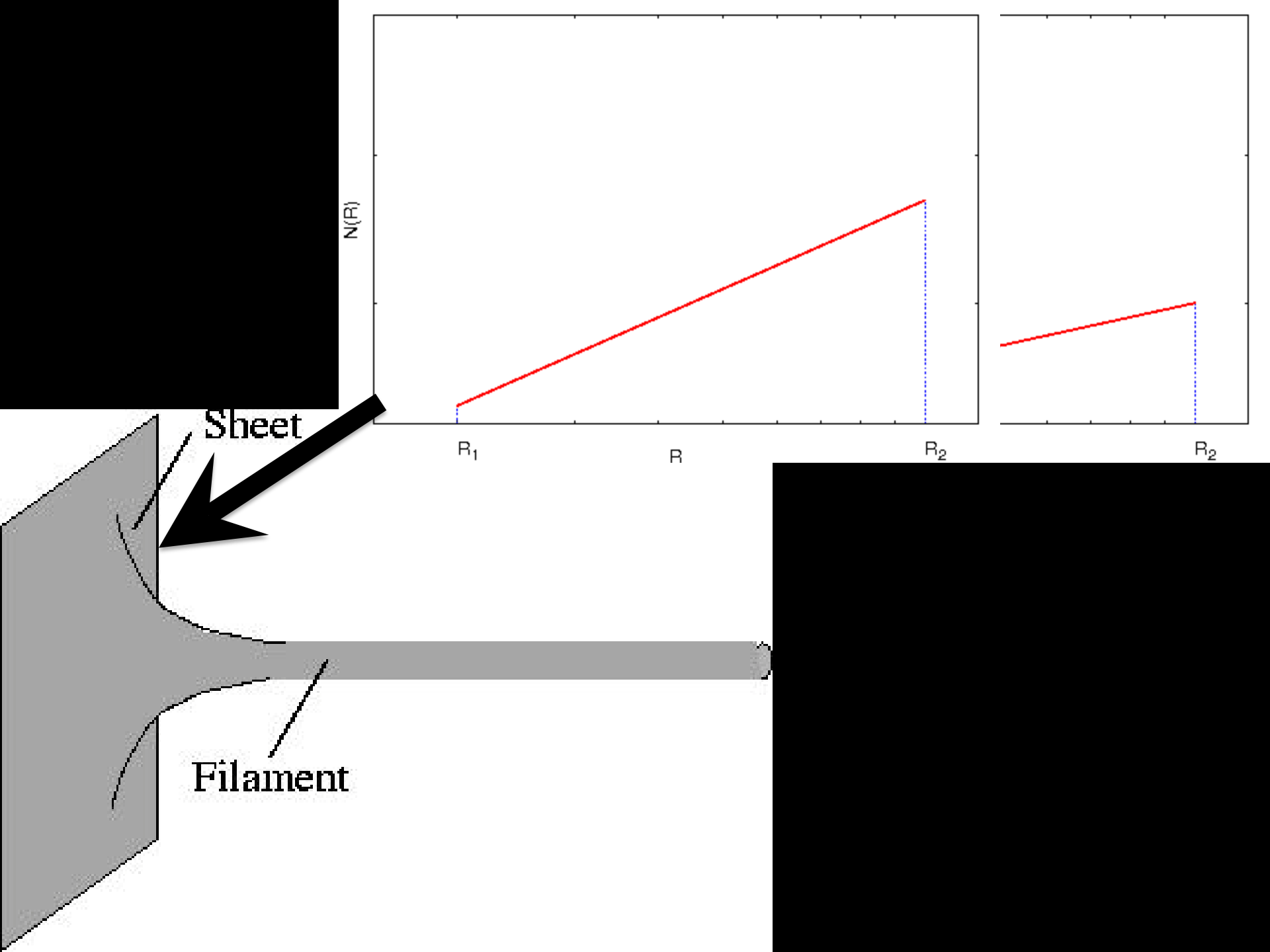

Sheet
R_2
R_1
Filament



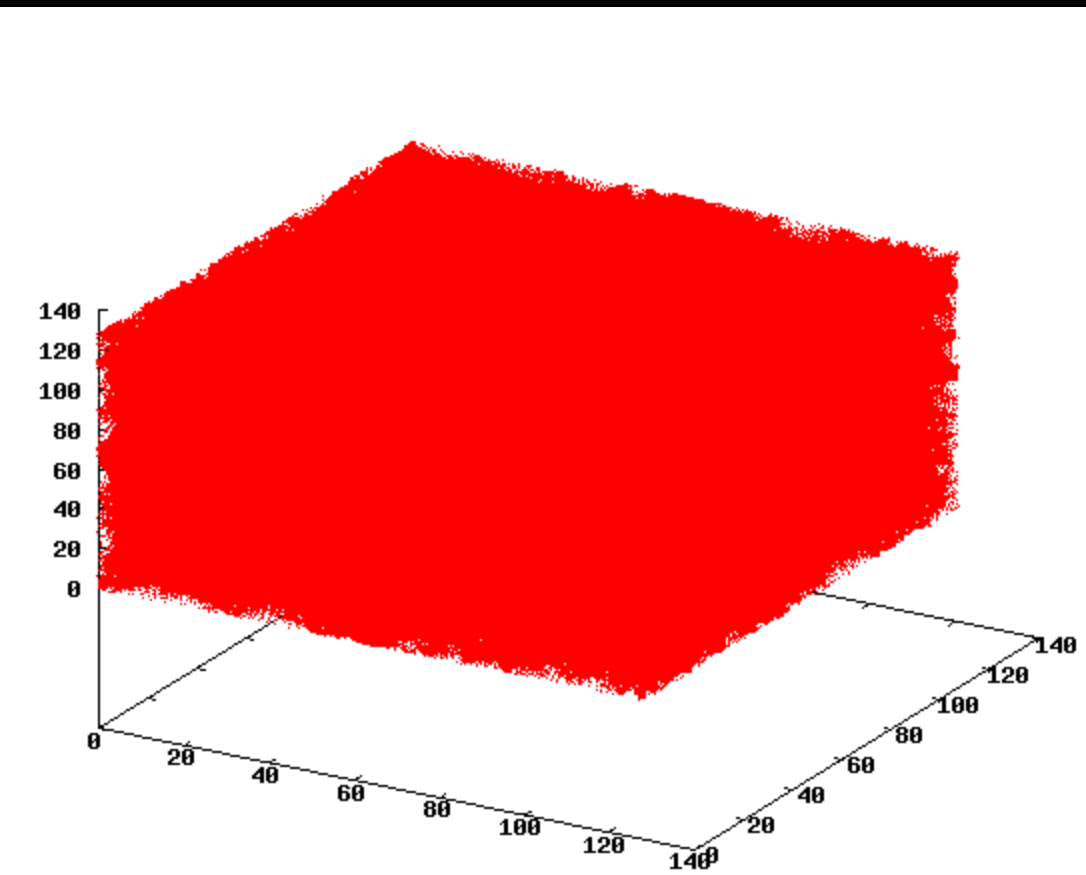

N(R)
R1
R
R2


Sheet
Filament

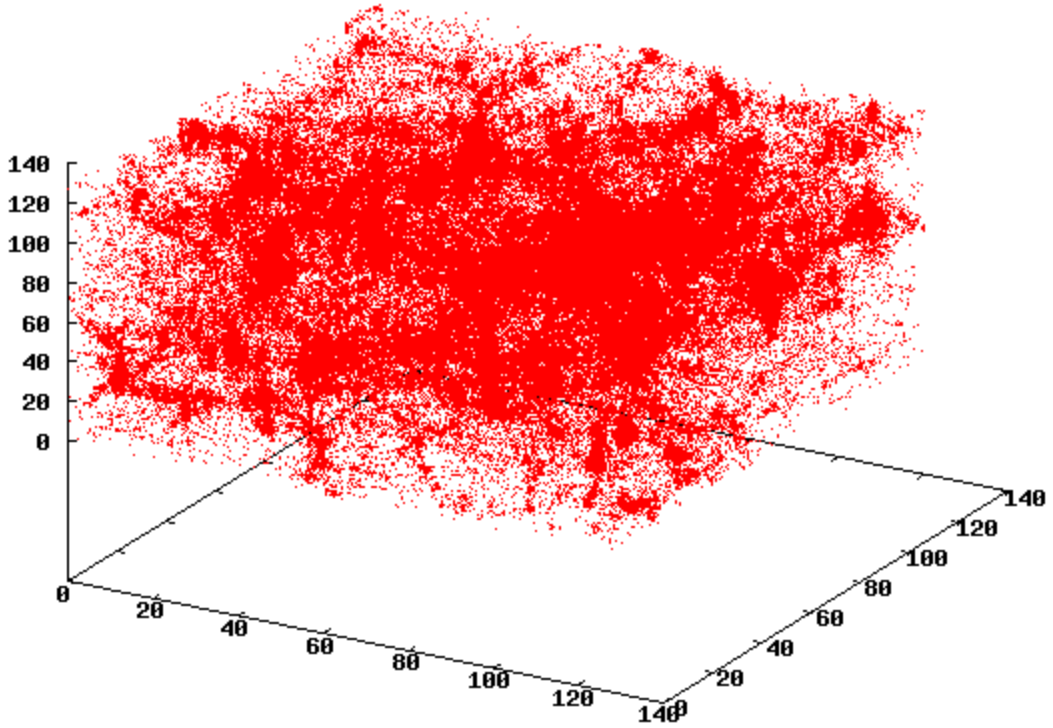


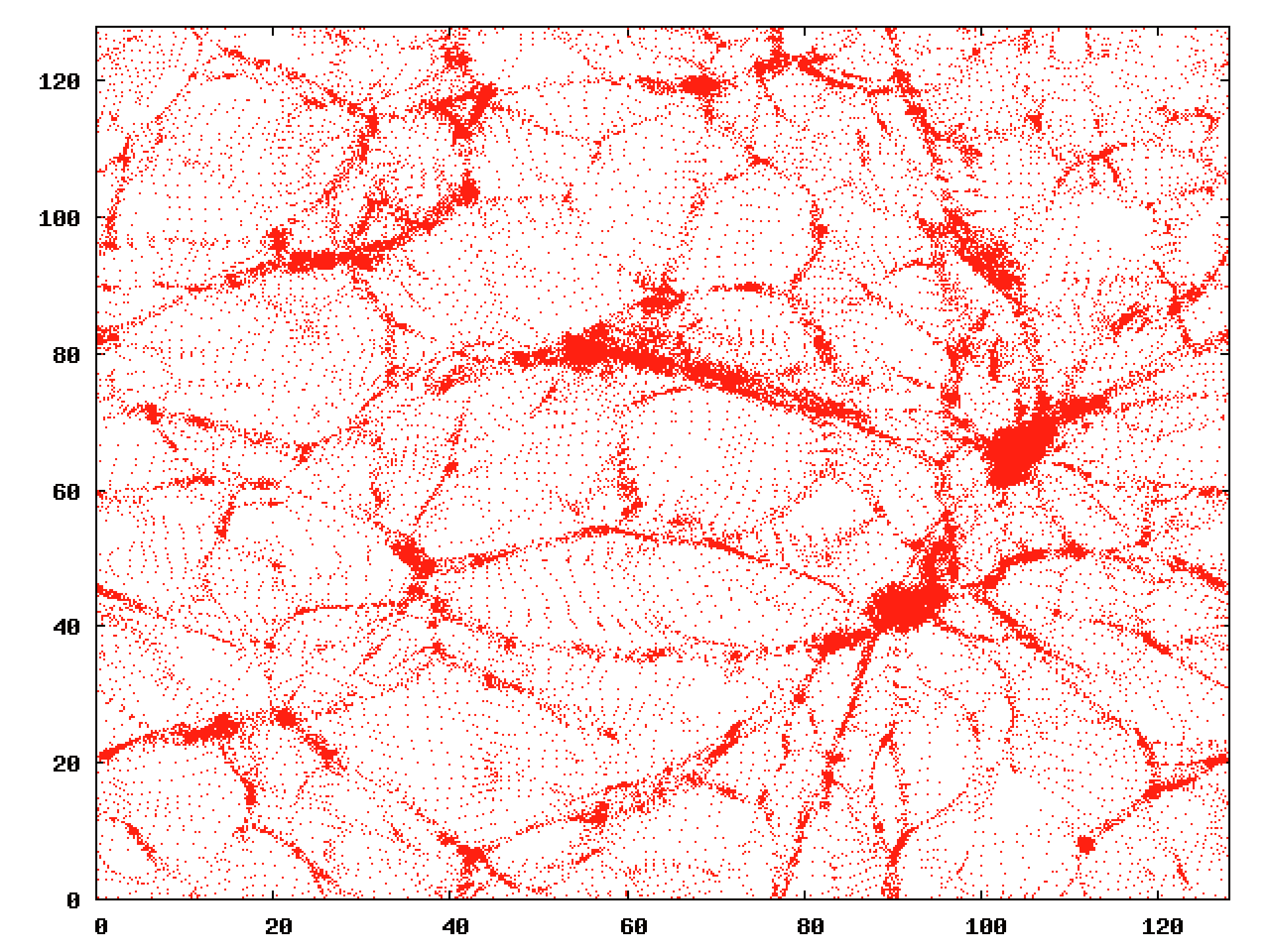

N(R)
R1
R
R2
R2
Sheet
Filament

256^3 particles
256^3 grids
0.5 Mpc grid spacing



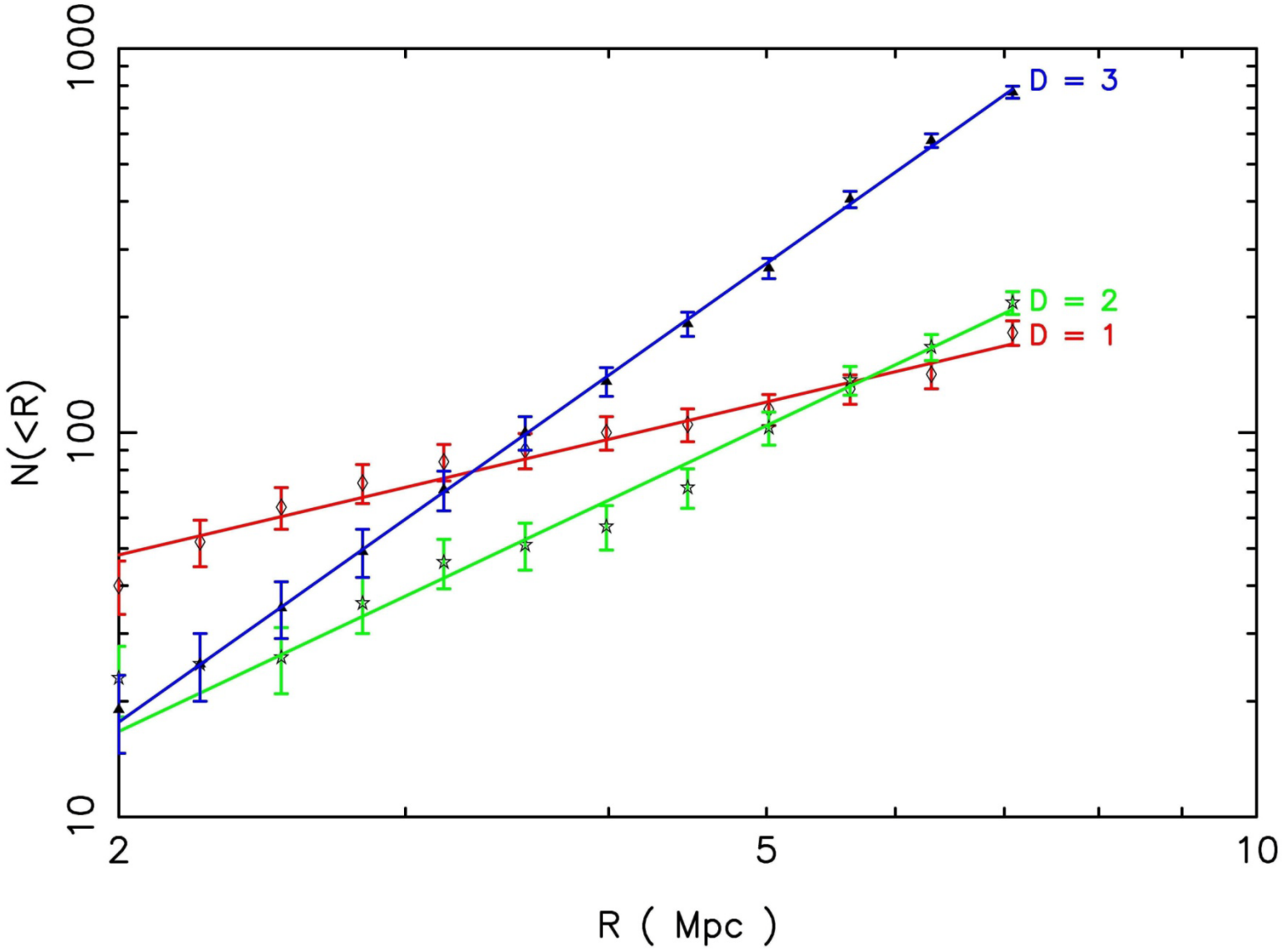
210000 particles




120
100
80
60
40
20
0
0
20
40
60
80
100
120

- Considering each and every galaxies as center
- Apply the analysis in length scale 2 Mpc to 10 Mpc.

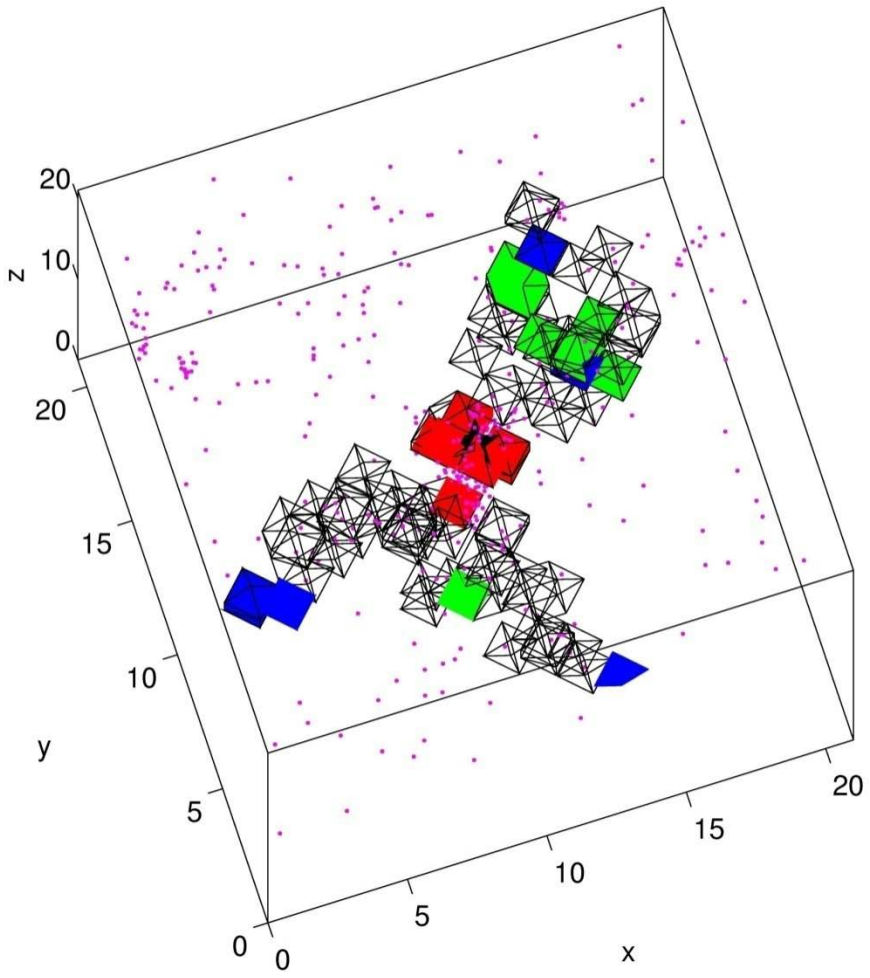
$$\frac{\chi^2}{\nu} \leq 1.2$$


1000
100
10
N(<R)
2
5
10
R (Mpc)
D = 3
D = 2
D = 1

Results for N-body simulation

~ 70000 galaxies
as center with 7%
Variance across the
10 samples

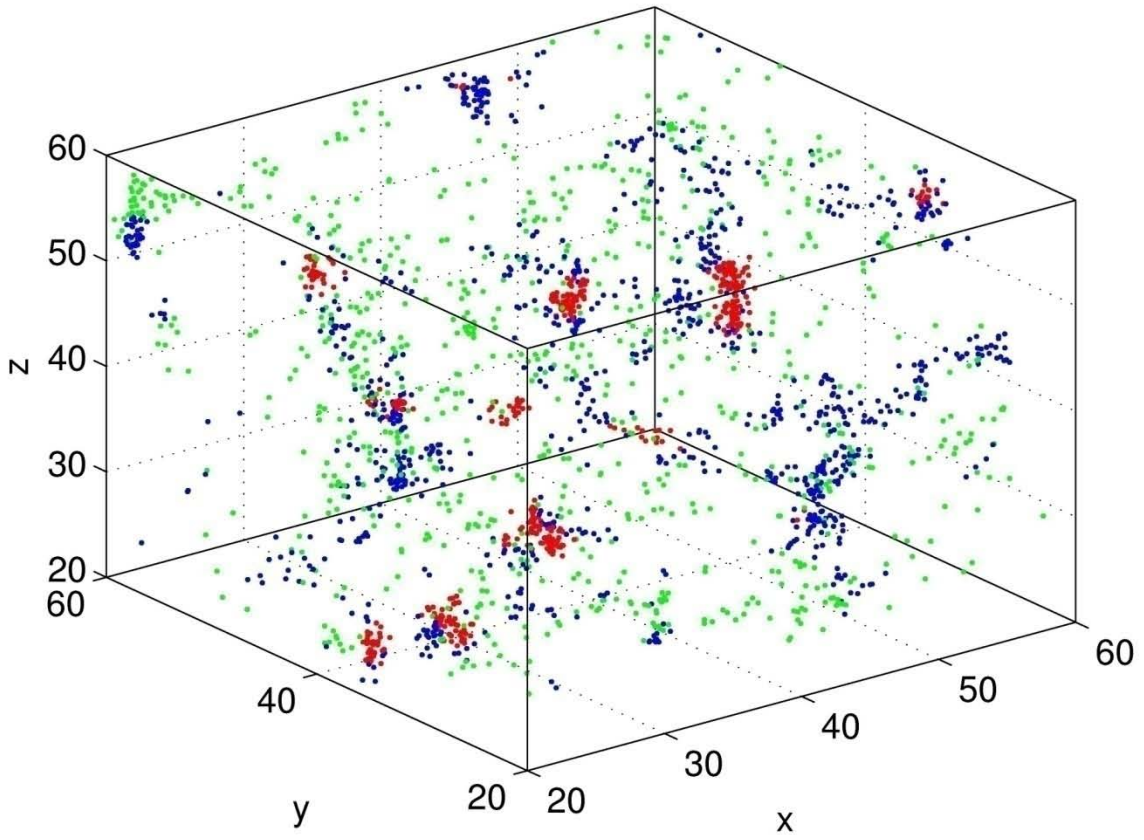
D=1
D=2
D=3
Unknown



D=1

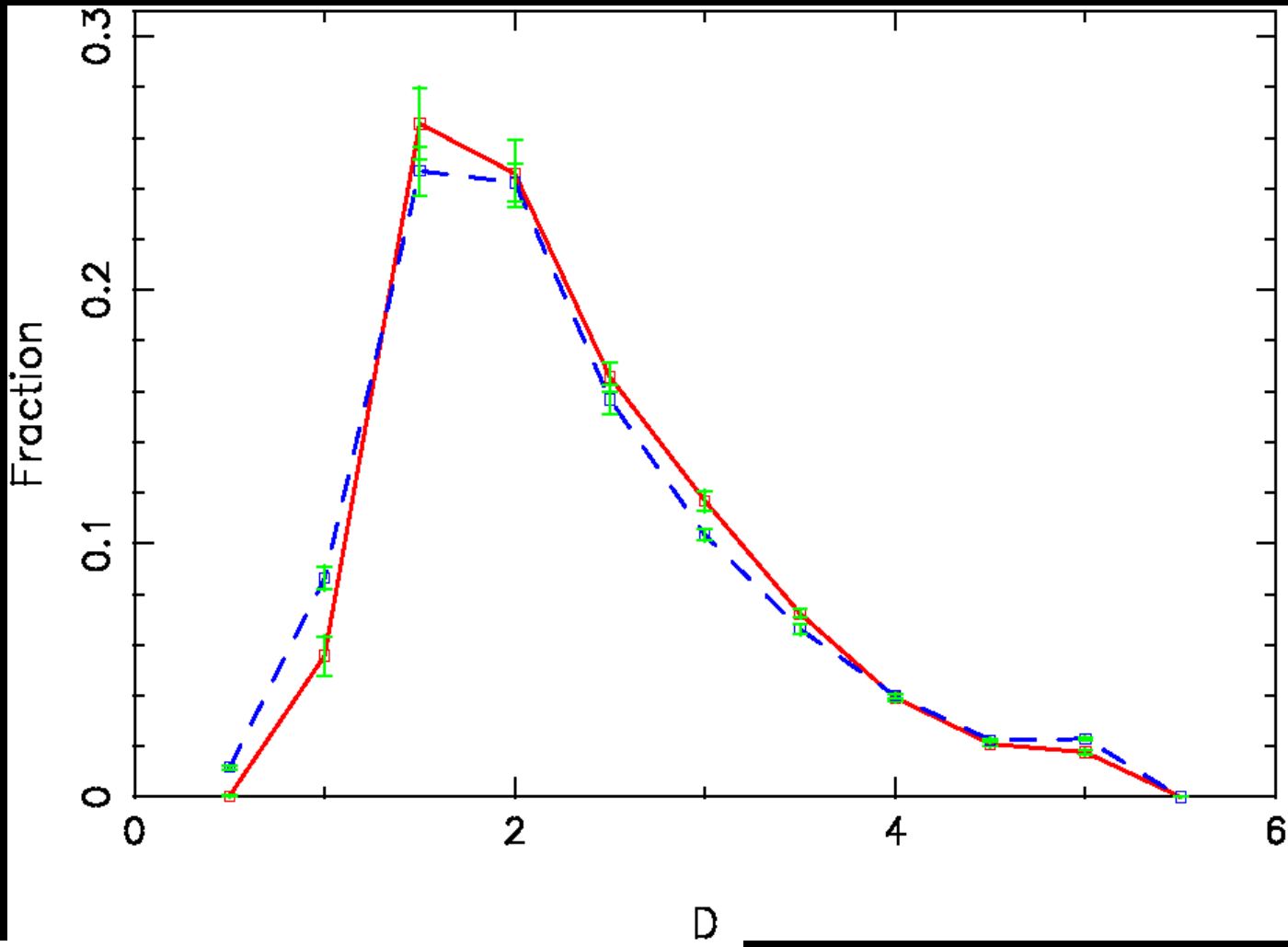
D=2

D=3



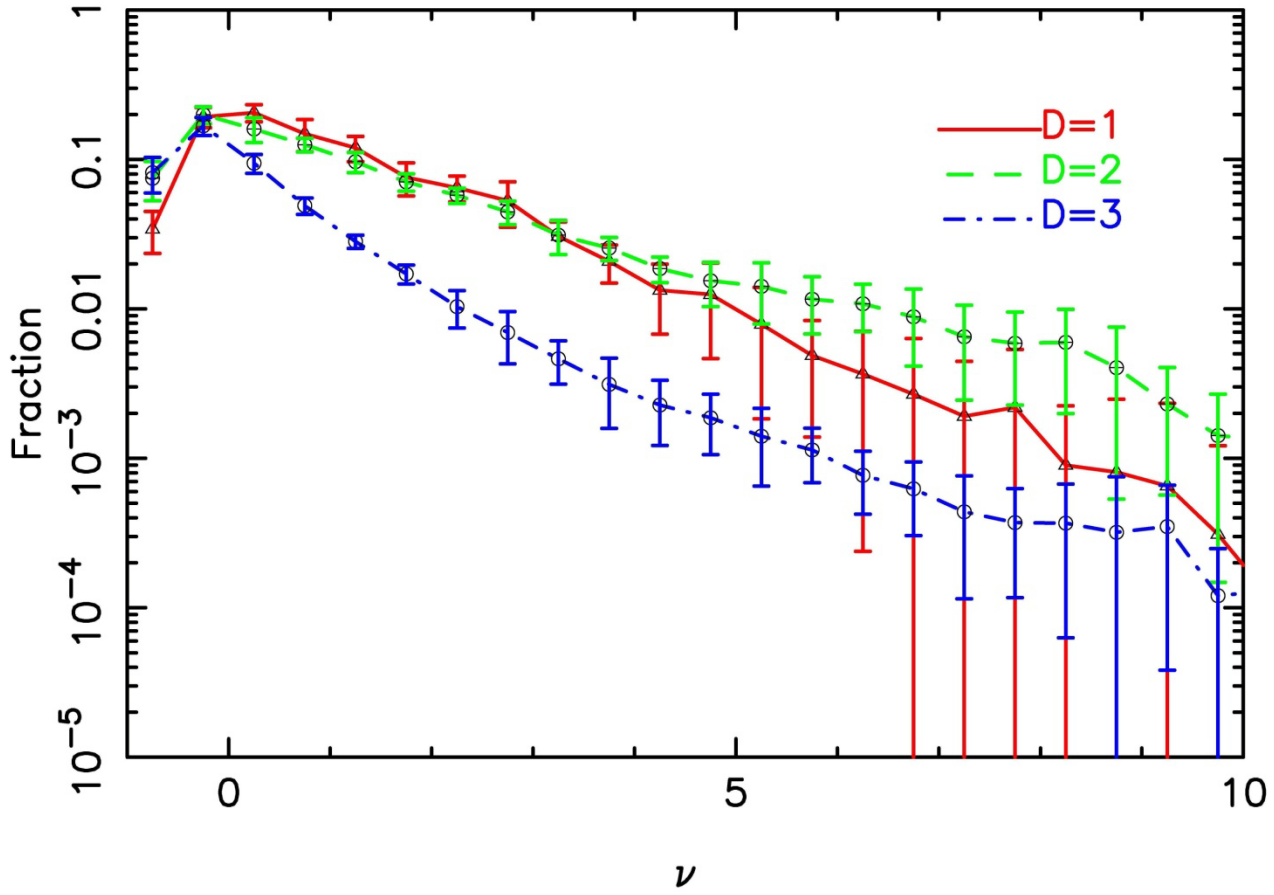
FRACTION OF CENTERS WITH PARTICULAR D VALUES

Binned as ±0.25



Done for length scale 2-10 Mpc

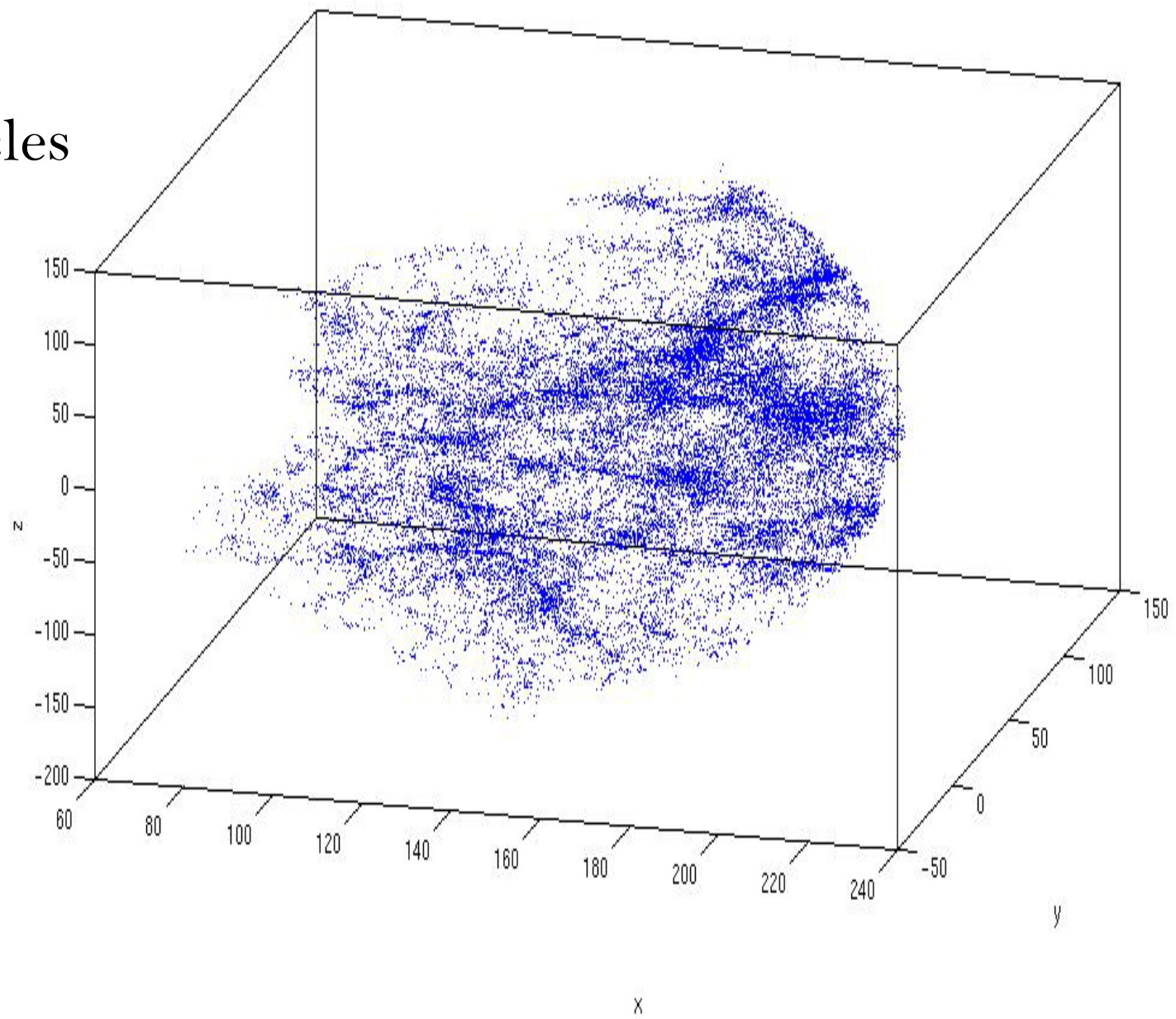
Done for length scale 2-5 Mpc



$$\nu = \frac{\delta}{\sigma^2}$$

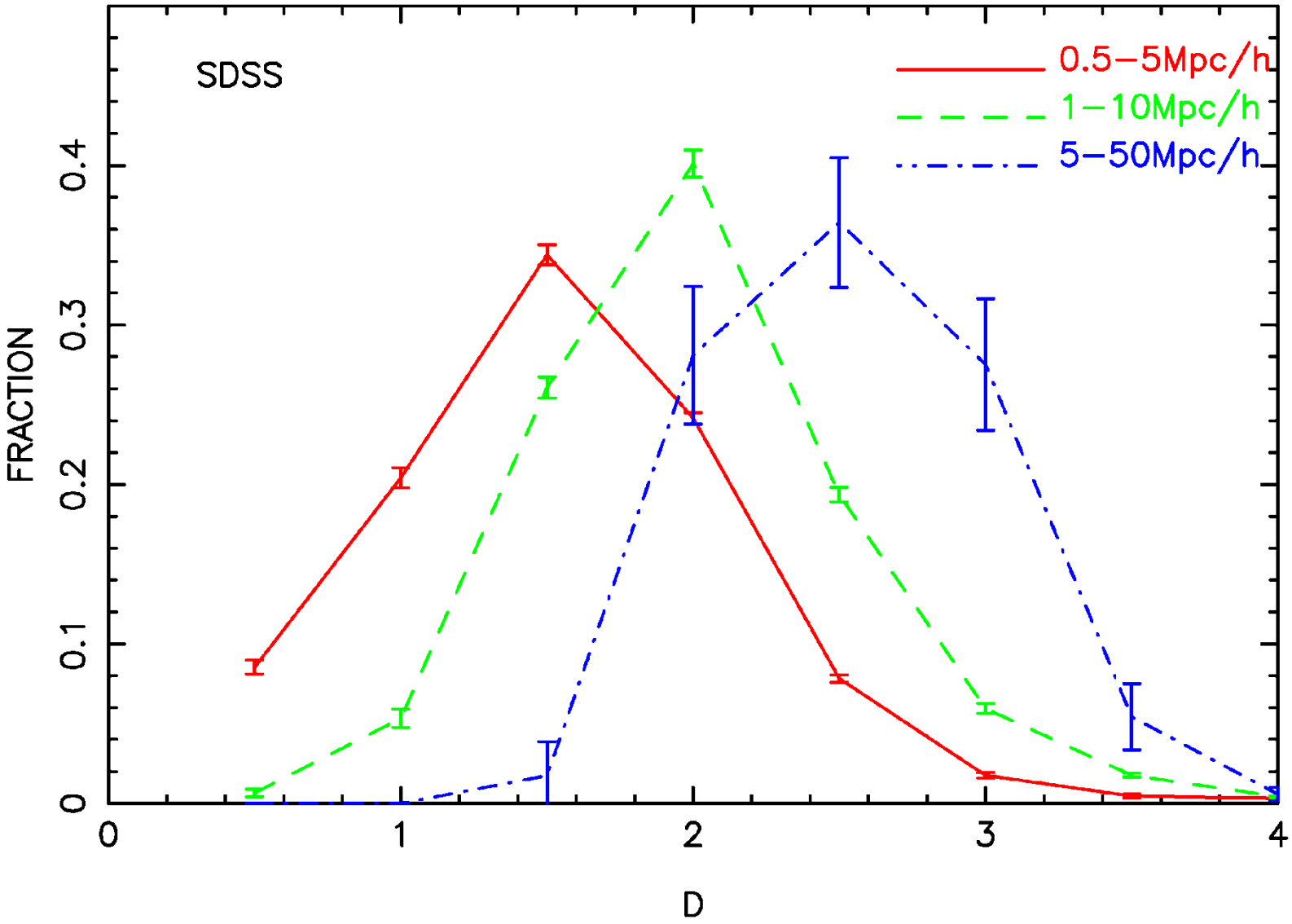
Volume limited subsample of SDSS DR6

32740 particles

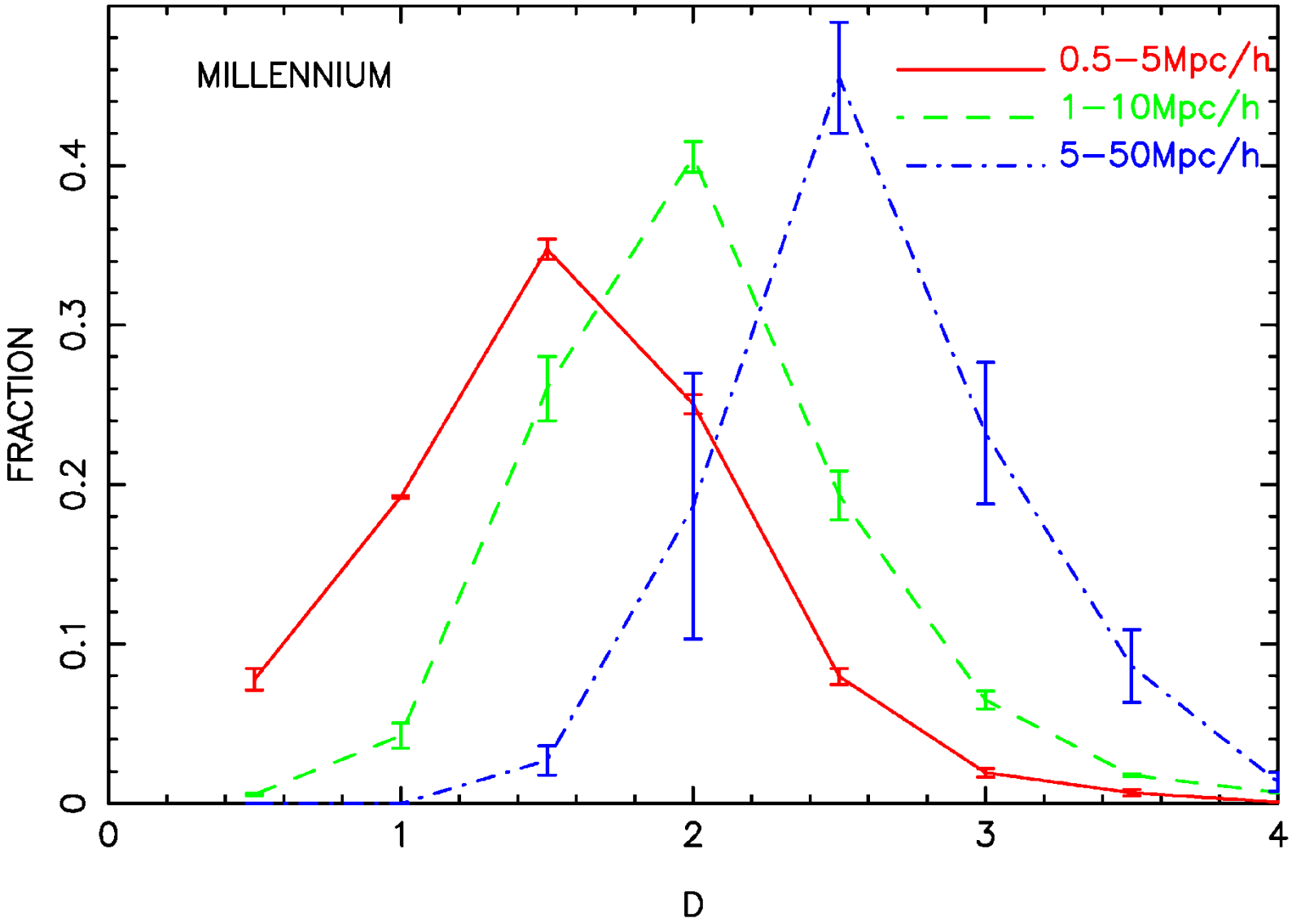


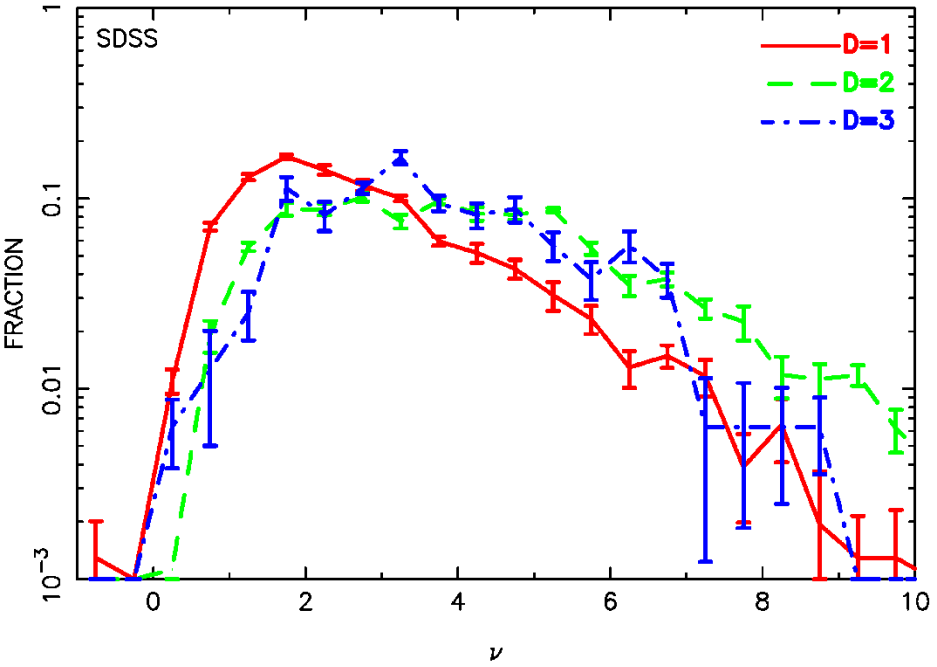
- We have considered the relative distribution of different structures in decade of 10. So we have done this analysis for 3 length scale 0.5-5 h^{-1} Mpc, 1-10 h^{-1} Mpc and 5-50 h^{-1} Mpc

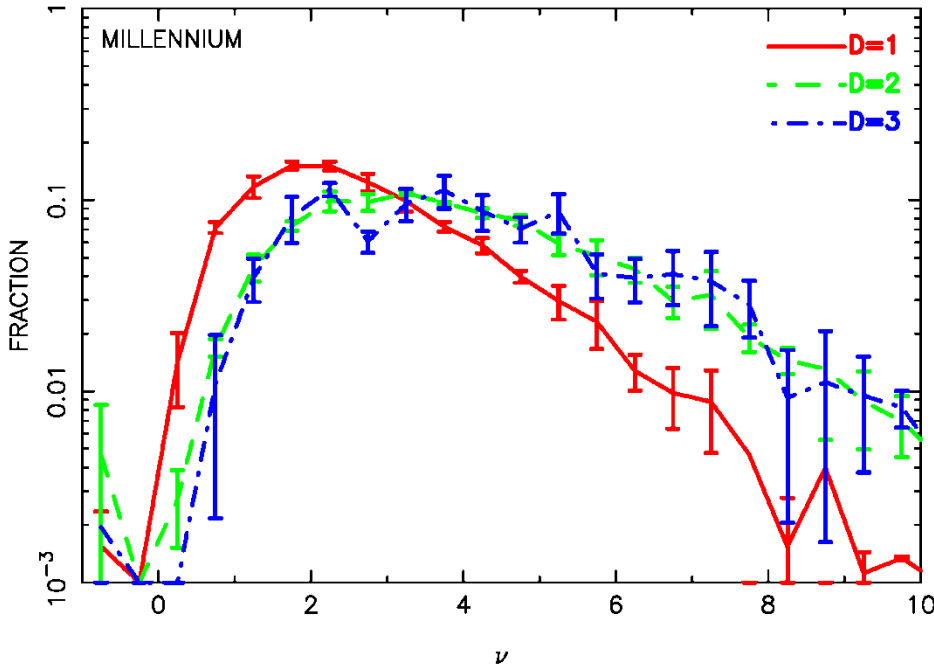
Fraction of centers with particular D value

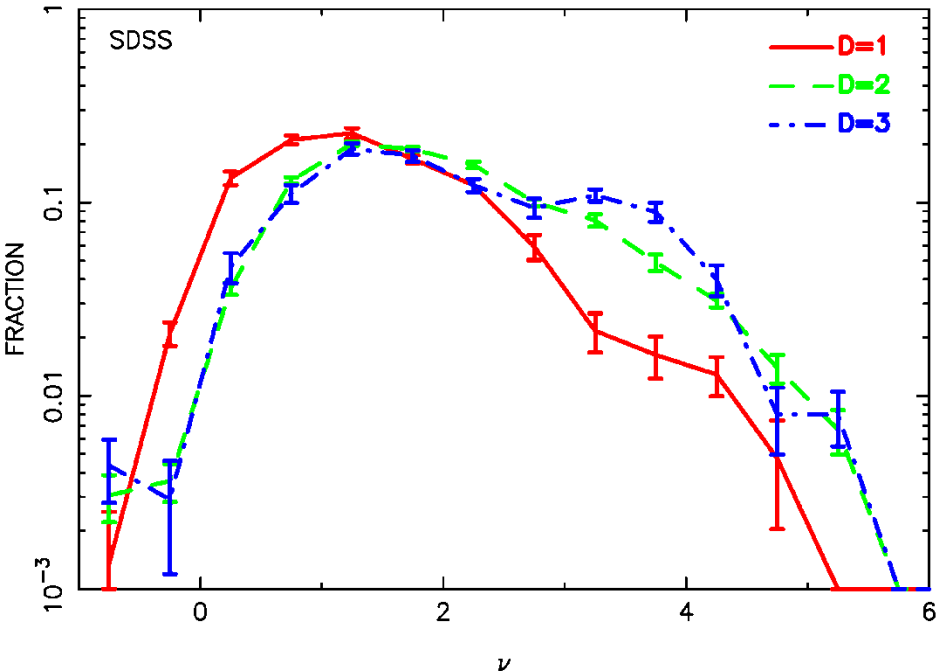


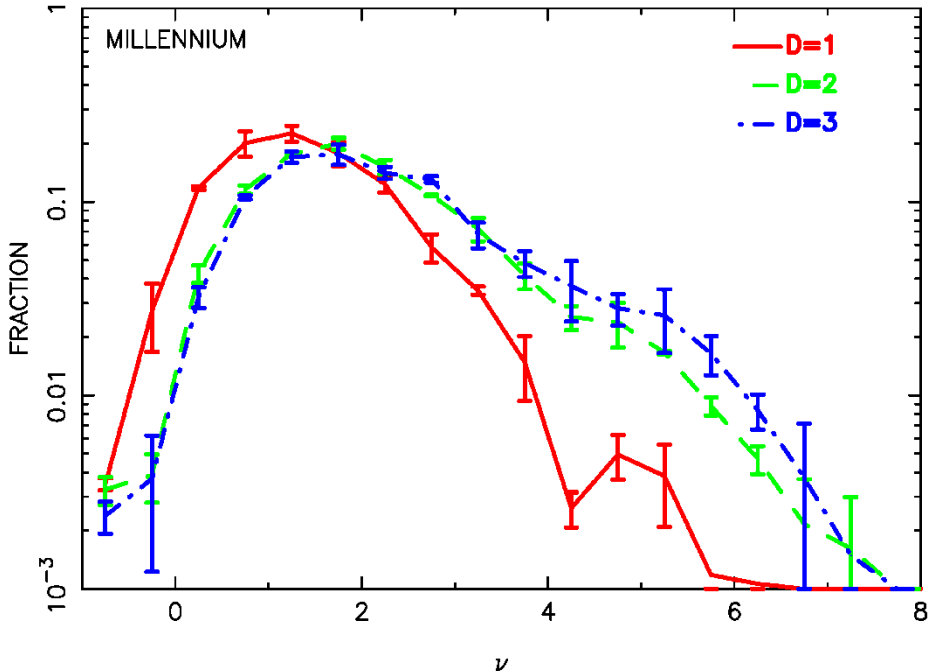
Fraction of centers with particular D value




SDSS
D=1
D=2
D=3
FRACTION
1
0.1
0.01
10^{-3}
0
2
4
6
8
10
ν


MILLENNIUM
D=1
D=2
D=3
FRACTION
1
0.1
0.01
10^{-3}
0
2
4
6
8
10
ν


SDSS
D=1
D=2
D=3
FRACTION
1
0.1
0.01
10^{-3}
0
2
4
6
ν


MILLENNIUM
D=1
D=2
D=3
FRACTION
1
0.1
0.01
10^{-3}
0
2
4
6
8
ν

Conclusion

- Local Dimension provides a robust method to quantify the shapes that make up the cosmic web.
- At scale 0.5-5 h^{-1} Mpc filaments and sheet dominates, at 1-10 h^{-1} Mpc sheet dominates while at 5-50 h^{-1} Mpc sheet and cluster dominates
- Filaments dominates the under-dense region while sheet and cluster dominates at over-dense region
- SDSS and Millennium shows the same results

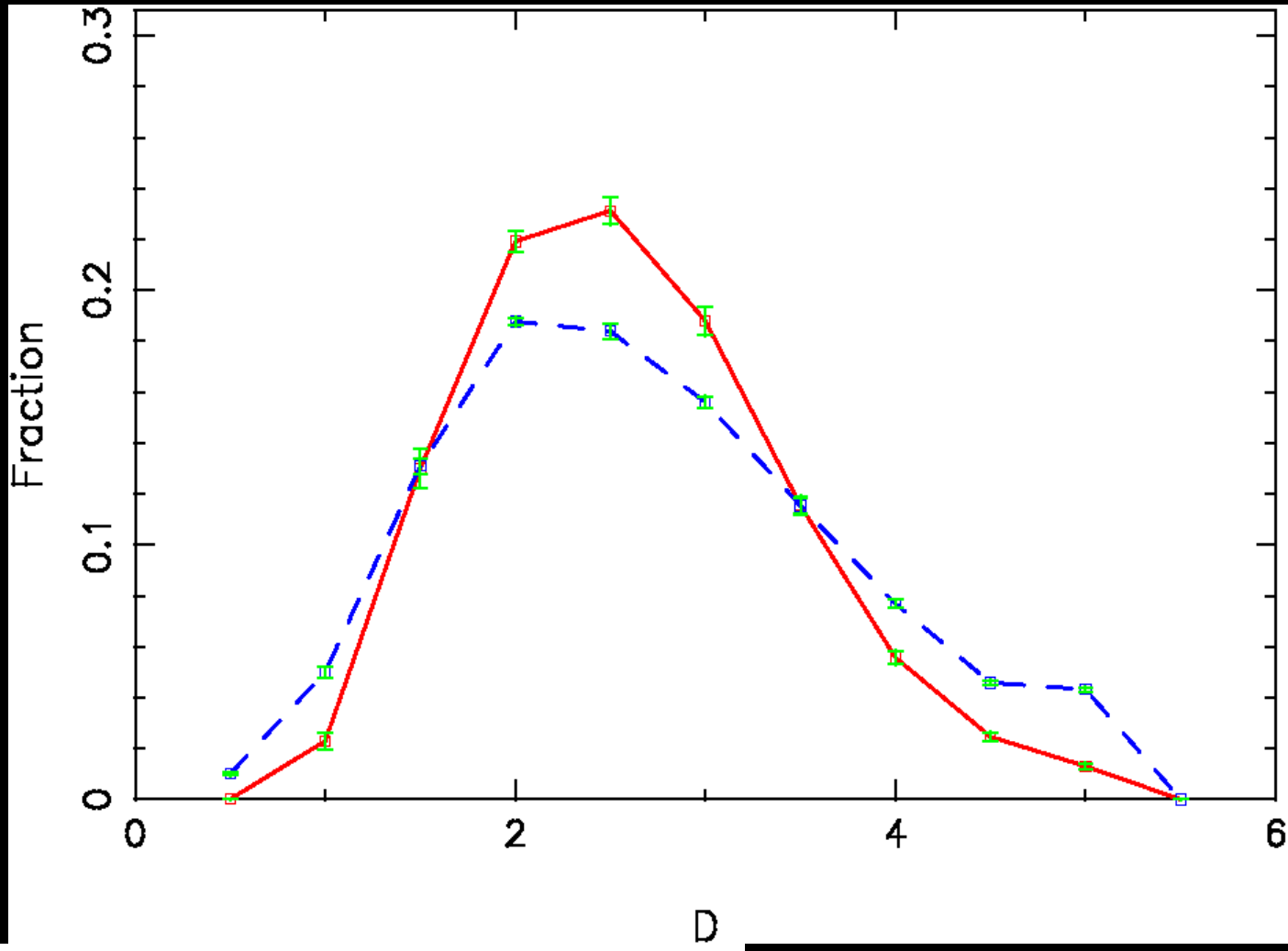
Thank you

- LCDM power spectrum with parameters

$(\Omega m0, \Omega\Lambda 0, h, ns, \sigma 8)=(0.3, 0.7, 0.7, 1, 1)$

FRACTION OF VOLUME WITH PARTICULAR D VALUES

Binned as ±0.25



Done for length scale 2-10 Mpc

Done for length scale 2-5 Mpc