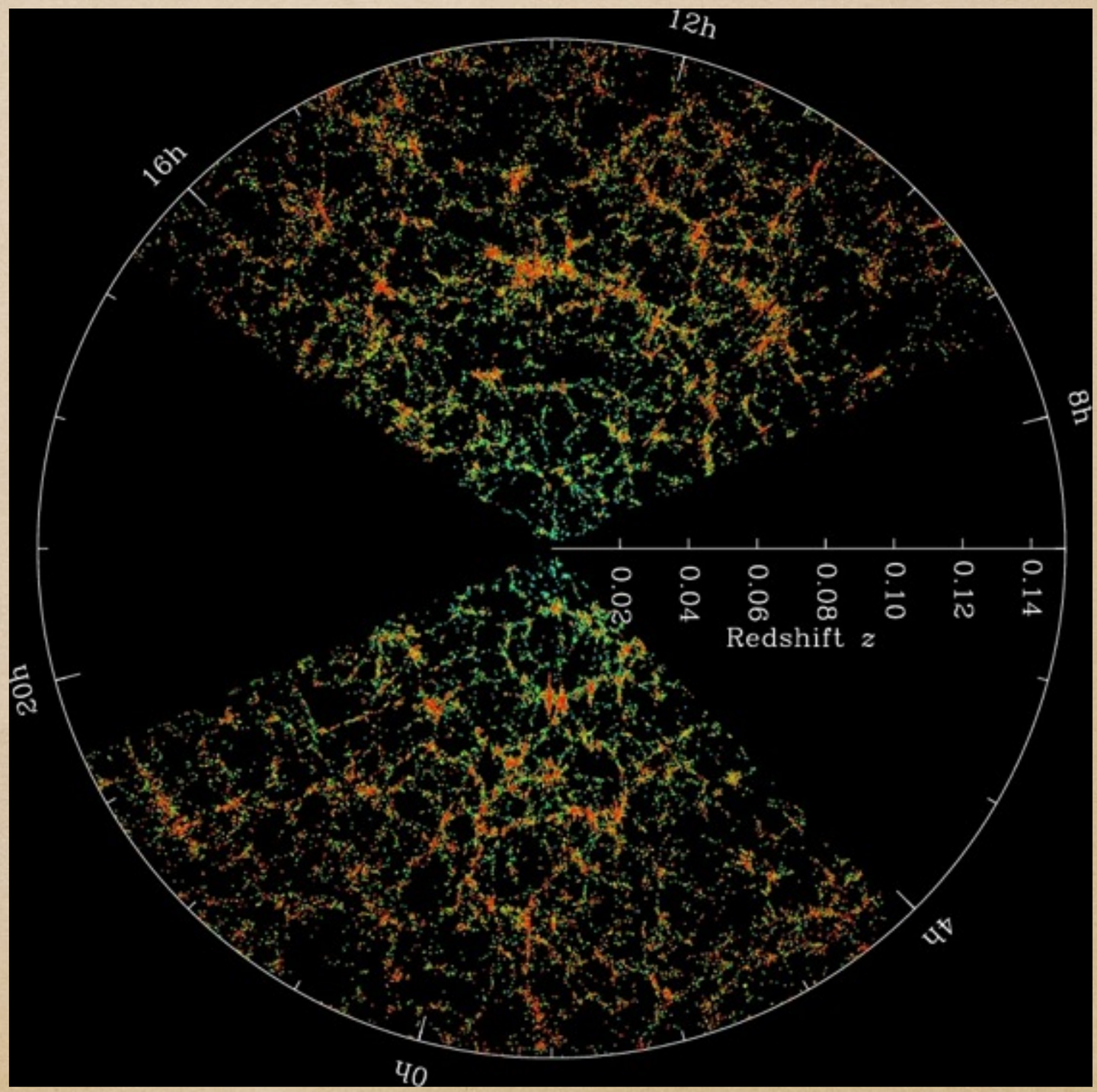
Adaptive density estimator for galaxy surveys

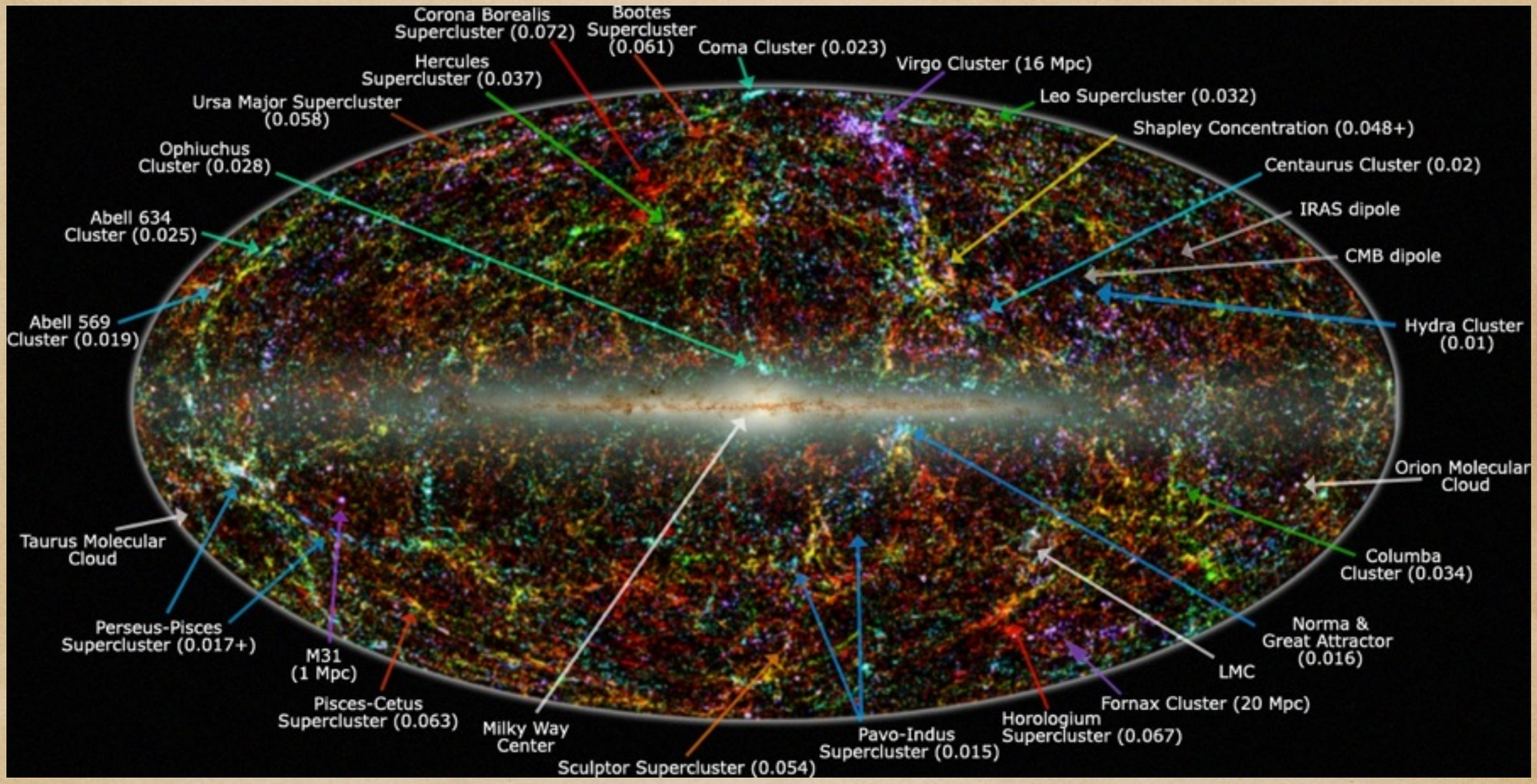
Enn Saar, Tartu Observatory

Tallinn, 26.06.2014

The Bright Universe

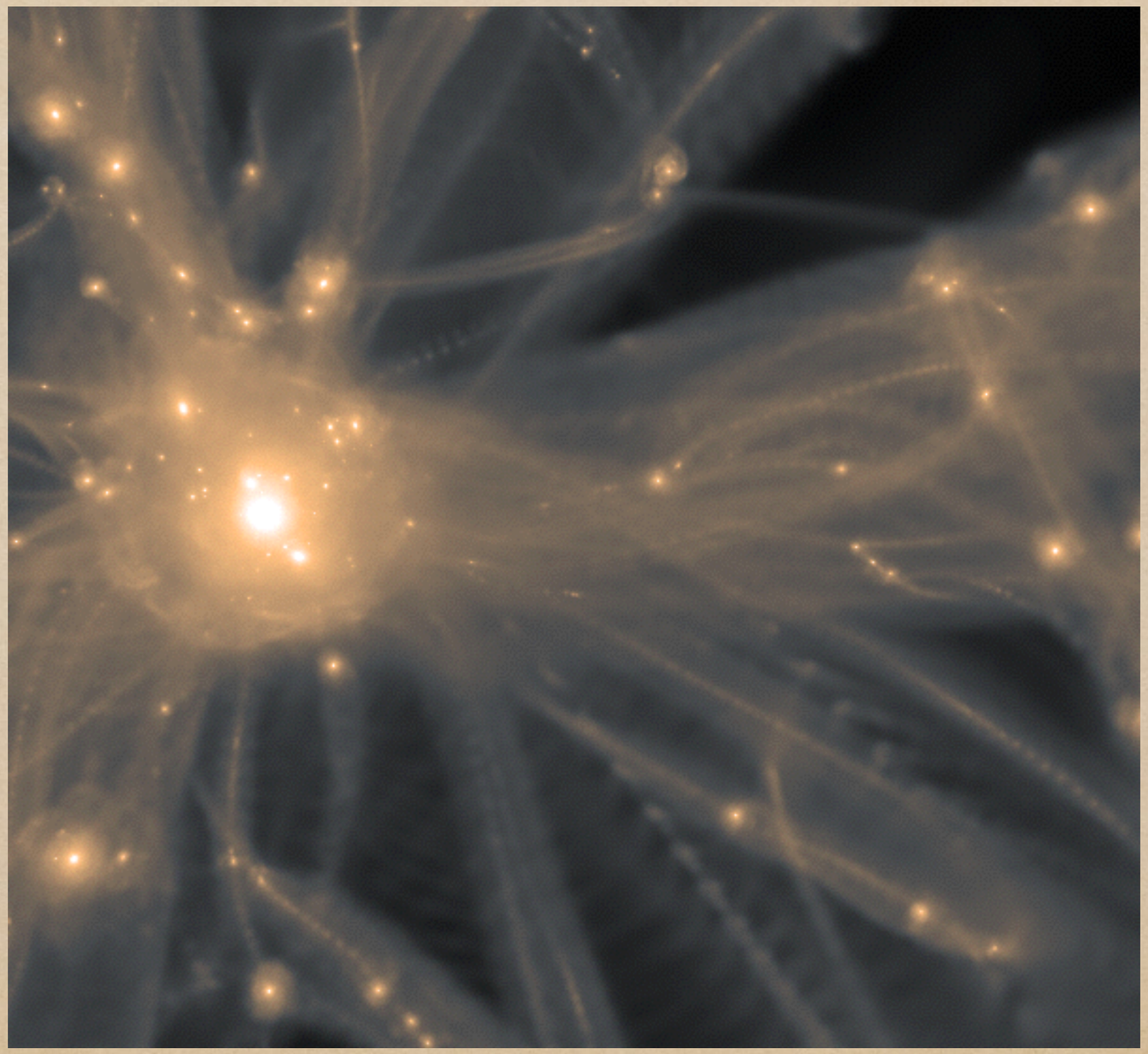
SDSS




Corona Borealis Supercluster (0.072)
Bootes Supercluster (0.061)
Coma Cluster (0.023)
Virgo Cluster (16 Mpc)
Hercules Supercluster (0.037)
Leo Supercluster (0.032)
Ursa Major Supercluster (0.058)
Shapley Concentration (0.048+)
Ophiuchus Cluster (0.028)
Centaurus Cluster (0.02)
Abell 634 Cluster (0.025)
IRAS dipole
CMB dipole
Abell 569 Cluster (0.019)
Hydra Cluster (0.01)
Orion Molecular Cloud
Taurus Molecular Cloud
Columba Cluster (0.034)
Perseus-Pisces Supercluster (0.017+)
Norma & Great Attractor (0.016)
M31 (1 Mpc)
LMC
Pisces-Cetus Supercluster (0.063)
Fornax Cluster (20 Mpc)
Milky Way Center
Horologium Supercluster (0.067)
Pavo-Indus Supercluster (0.015)
Sculptor Supercluster (0.054)

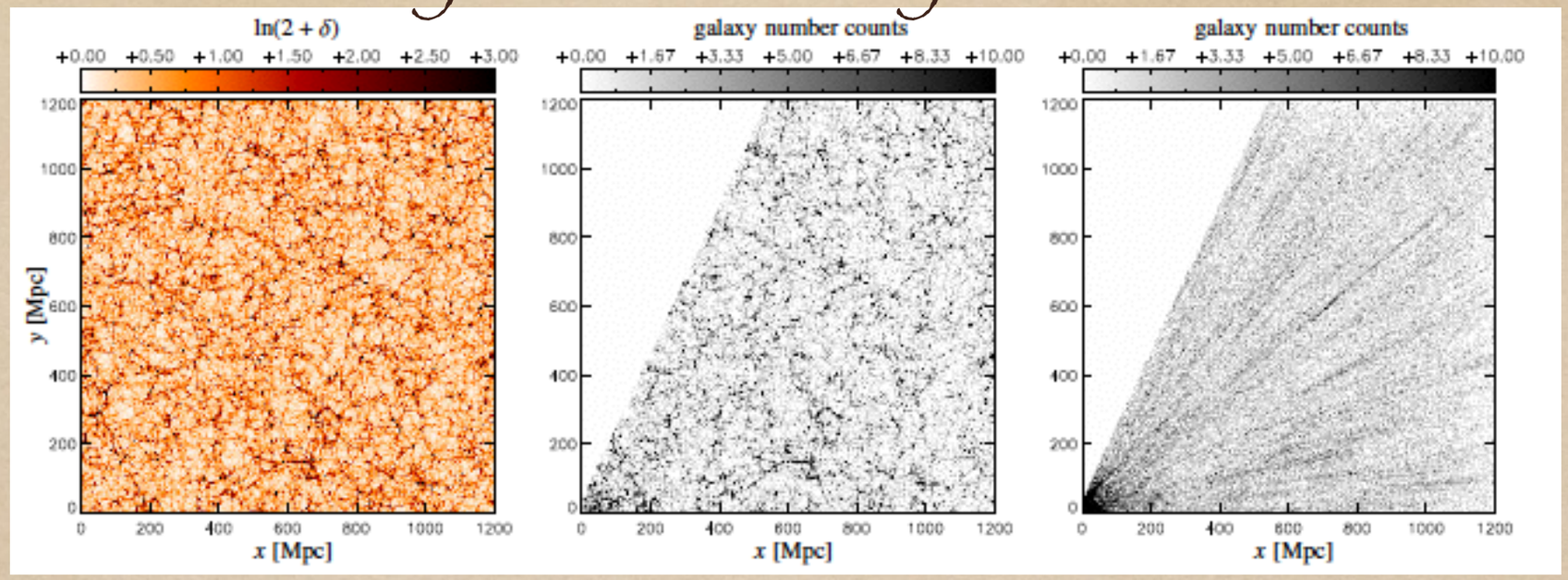
2MASS sky

The Dark Universe



Tom Abel

Bayesian density builder



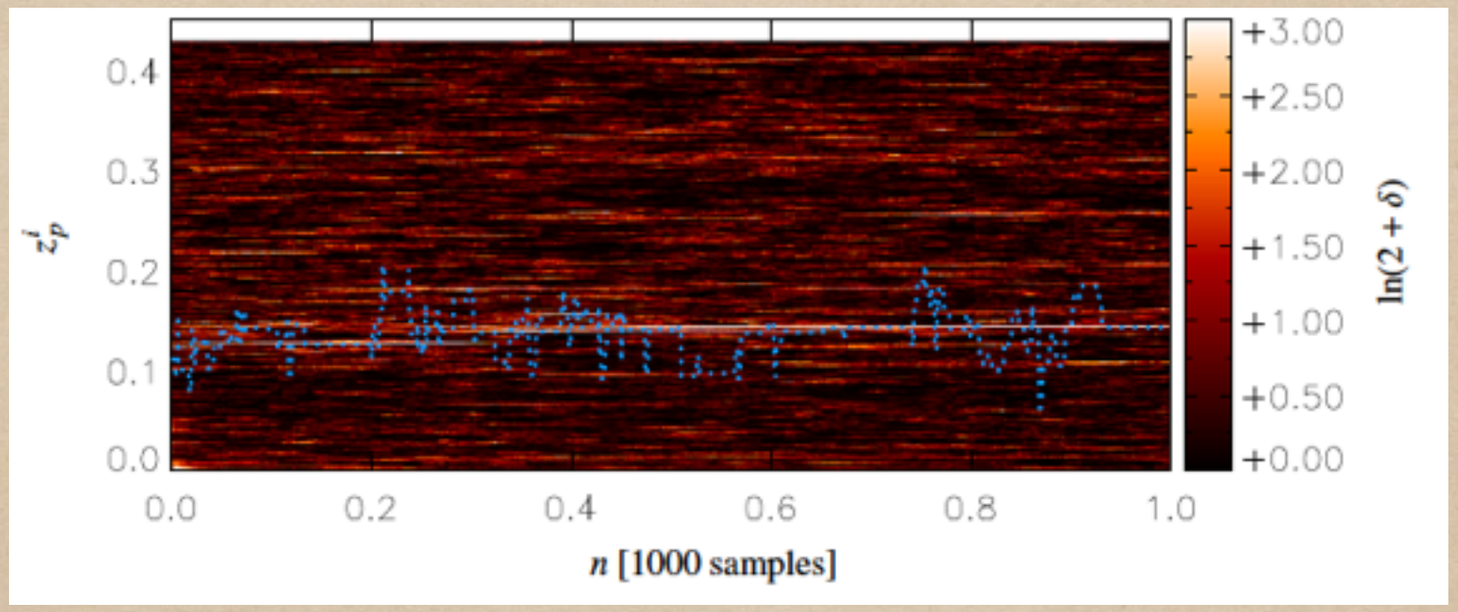
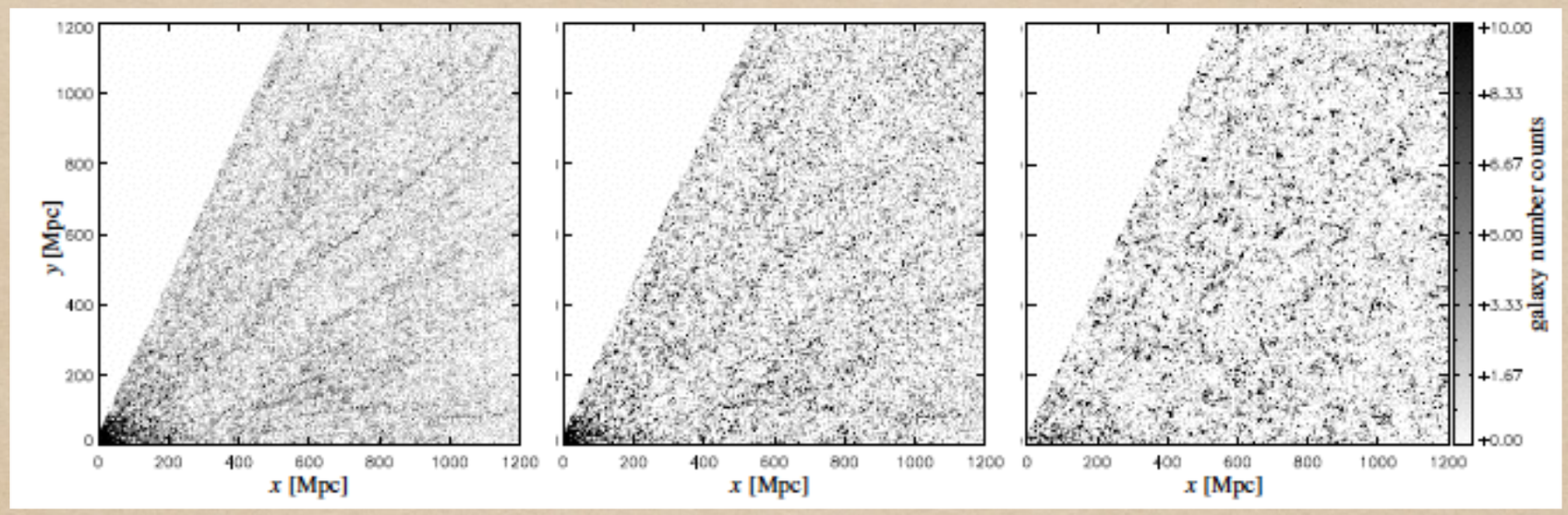


Photo-z & covariance matrix prior

Jens Jasche
Benjamin Wandelt

(2011)

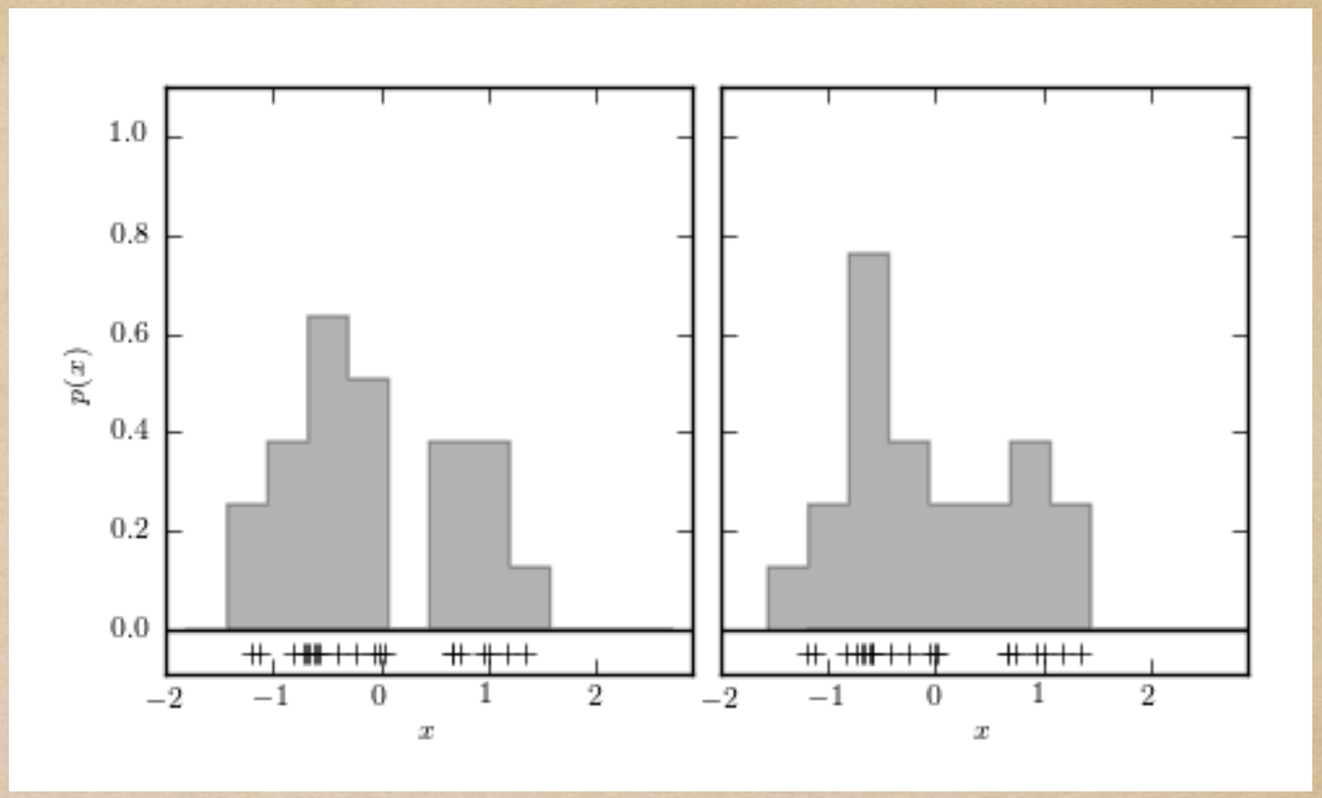

y [Mpc]
x [Mpc]
galaxy number counts
0
200
400
600
800
1000
1200
+10.00
+8.33
+6.67
+5.00
+3.33
+1.67
+0.00

1 5 100

Smoothing

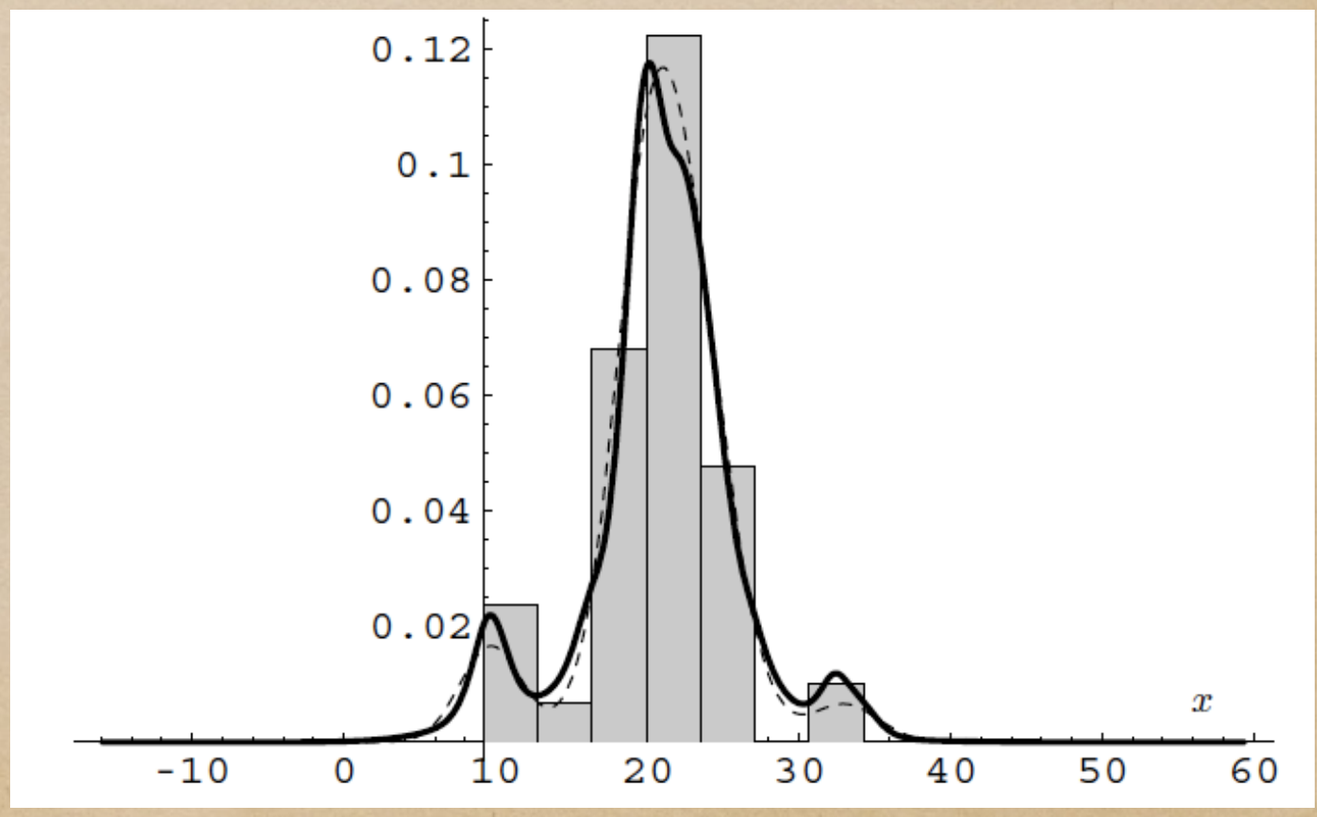
- Clusters — lensing, X-ray, SZ
- Filaments — X-ray, SZ, UV, luminosity density
- Voids — ISW
- Sheets?

Binning



Kernel smoothing

Error estimates



Kernel methods

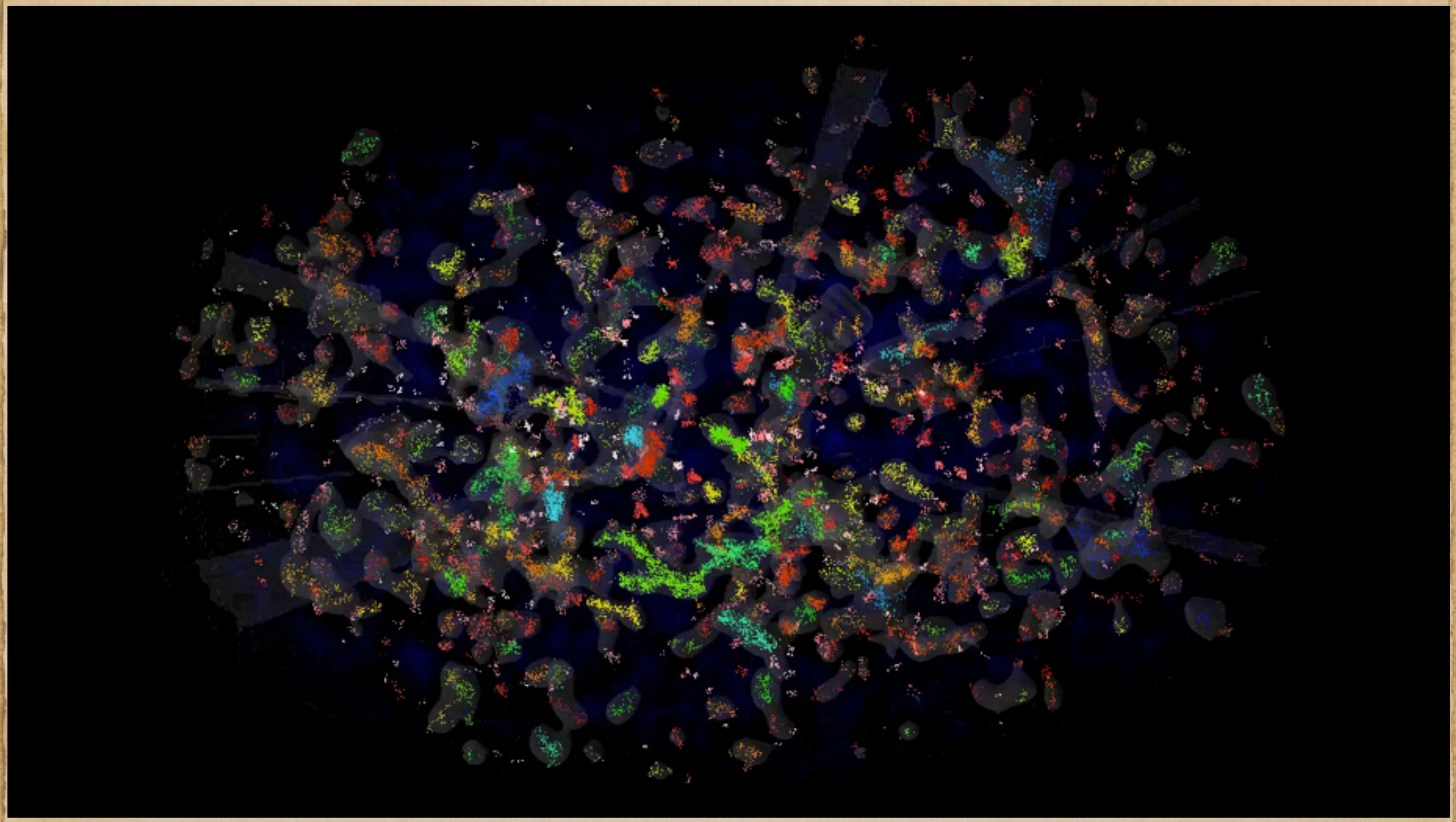
$$\rho(x) = \frac{1}{a}\sum_i K\left(\frac{x - x_i}{a}\right)$$

$$K(x) > 0, \int K(x)dx = 1, \int xK(x)dx = 0, \int x^2K(x)dx < \infty$$

Error estimates:

crossvalidation

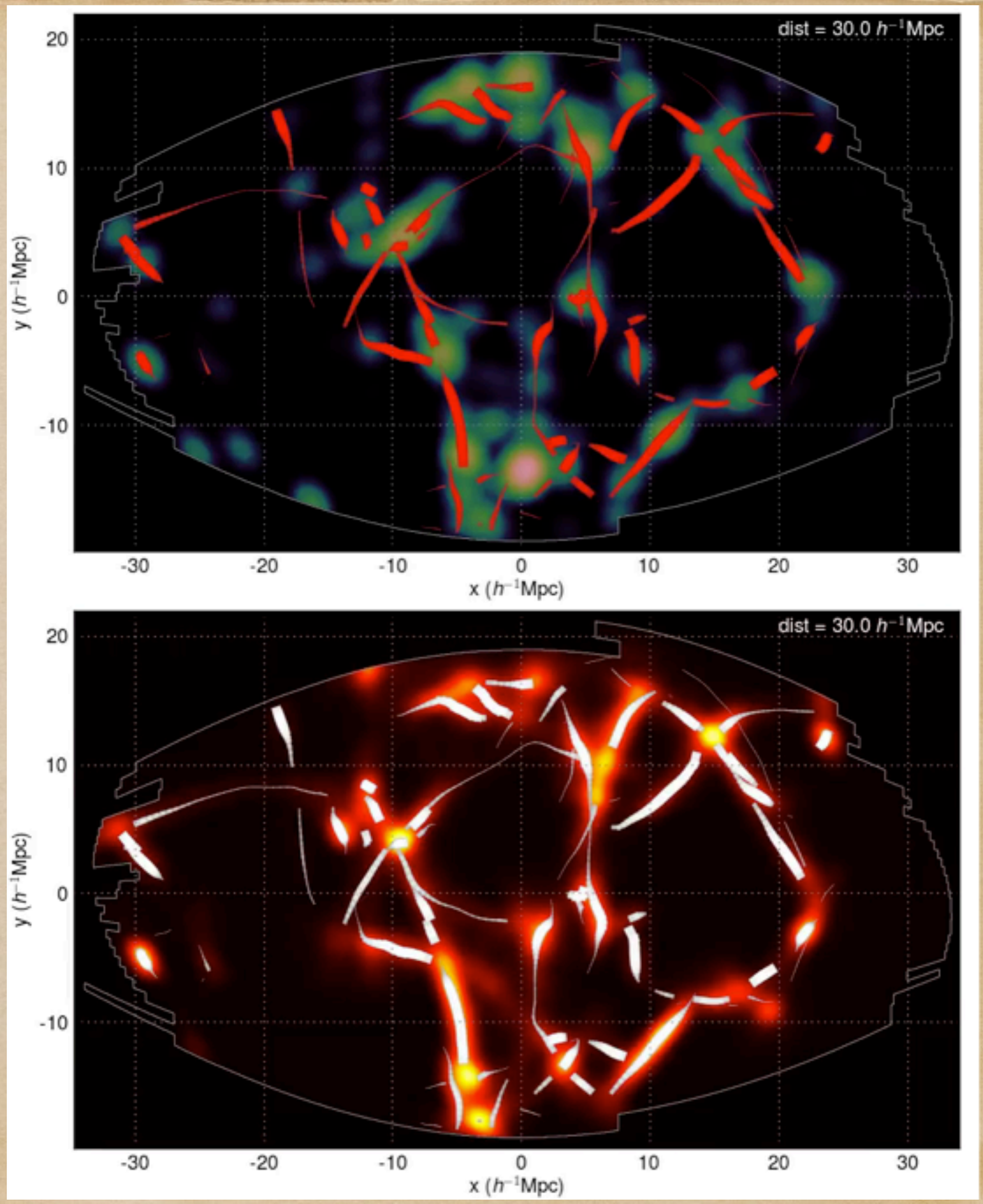
smoothed bootstrap



SDSS superclusters

Juhan Liivamägi

Filamentary densities

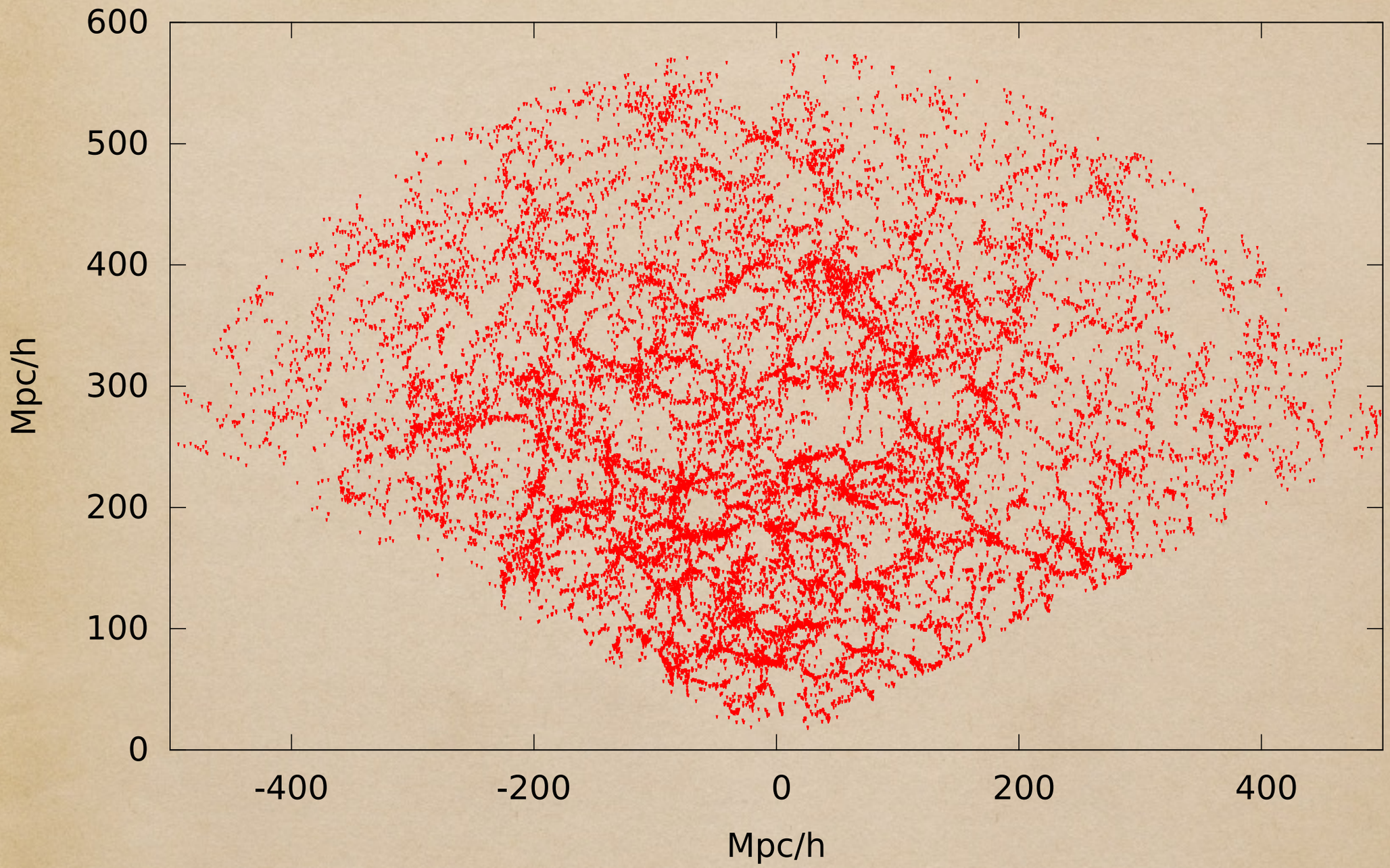


Juhan Liivamägi

Adaptive estimation

$$\rho(x_k) = \sum_{i \in galaxies} \frac{1}{a_i} K\left(\frac{x_k - x_i}{a_i}\right)$$ sandbox

$$\rho(x_k) = \sum_{i \in galaxies} \frac{1}{a_k} K\left(\frac{x_k - x_i}{a_k}\right)$$ balloon



Sloan survey slice

Anisotropic adaptive kernels

$$\rho(x) = \frac{1}{(2\pi|\Sigma|)^{D/2}} \sum_i \exp[-\frac{1}{2}(x - x_i)^T \Sigma^{-1}(x - x_i)]$$

$$\Sigma_i = \sum_j w(x_i, x_j, R)(x_j - x_i)(x_j - x_i)^T$$

j (over galaxies)

$$w(x_i, x_j, R) = \frac{1}{\sqrt{2\pi}R} \exp[-\frac{1}{2R^2}(x_i - x_j)^2]$$

Output

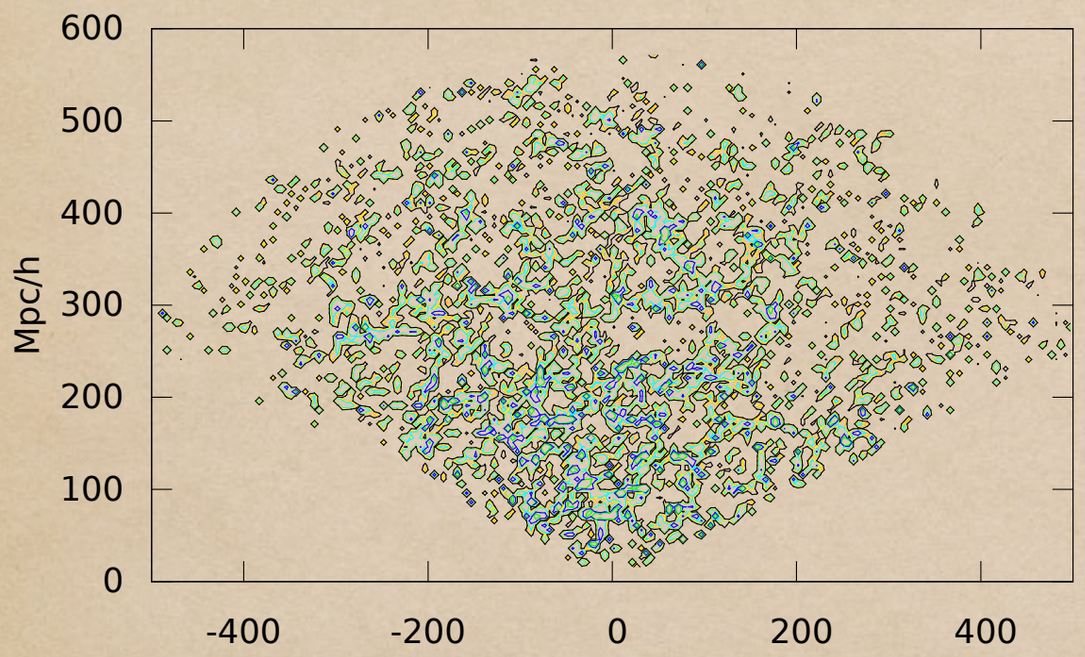
- adaptive density
- three eigenvectors (two independent)
- three scale factors (eigenvalues)
- two ellipticities (filament & sheet indices)

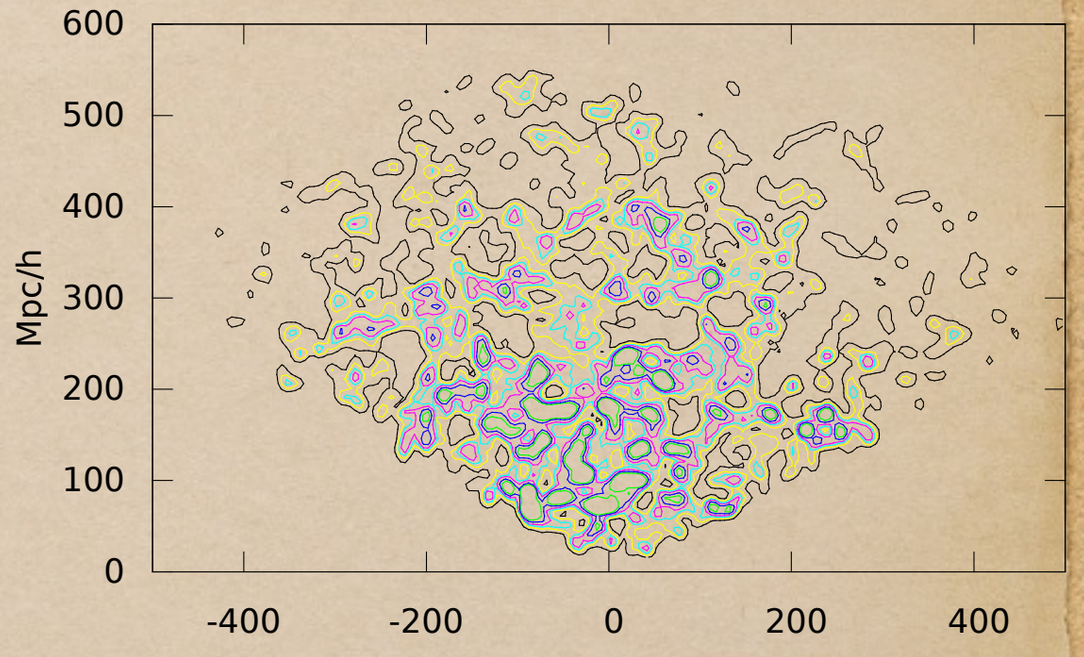
2-D Densities

Adaptive

Gaussian

5





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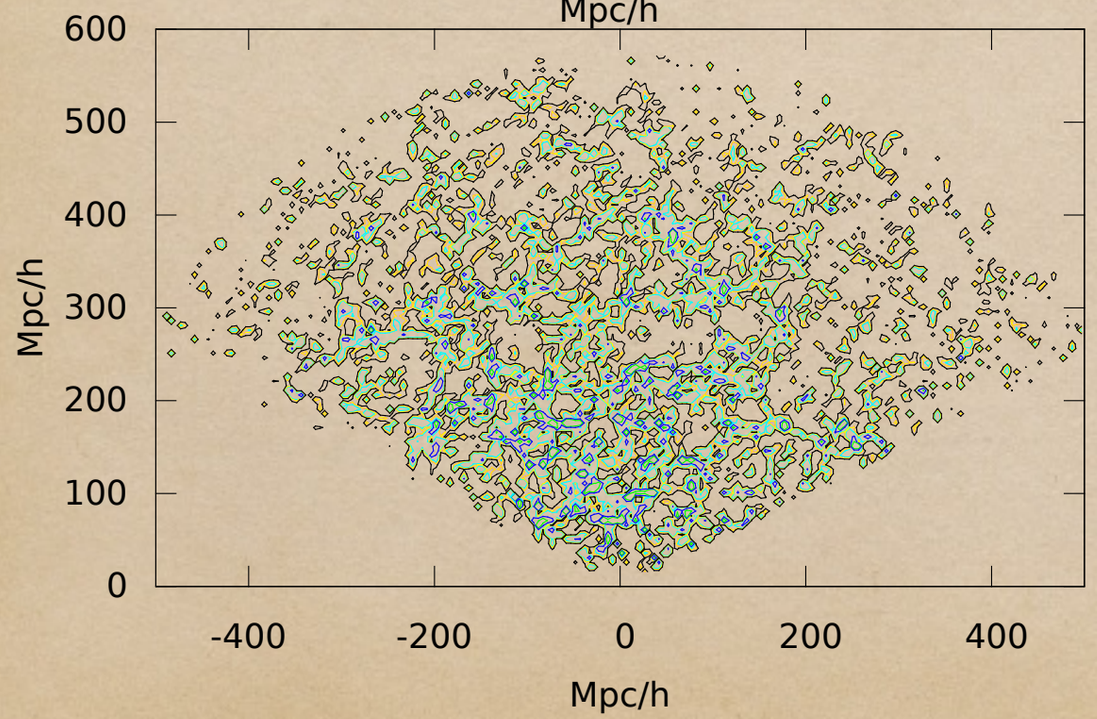
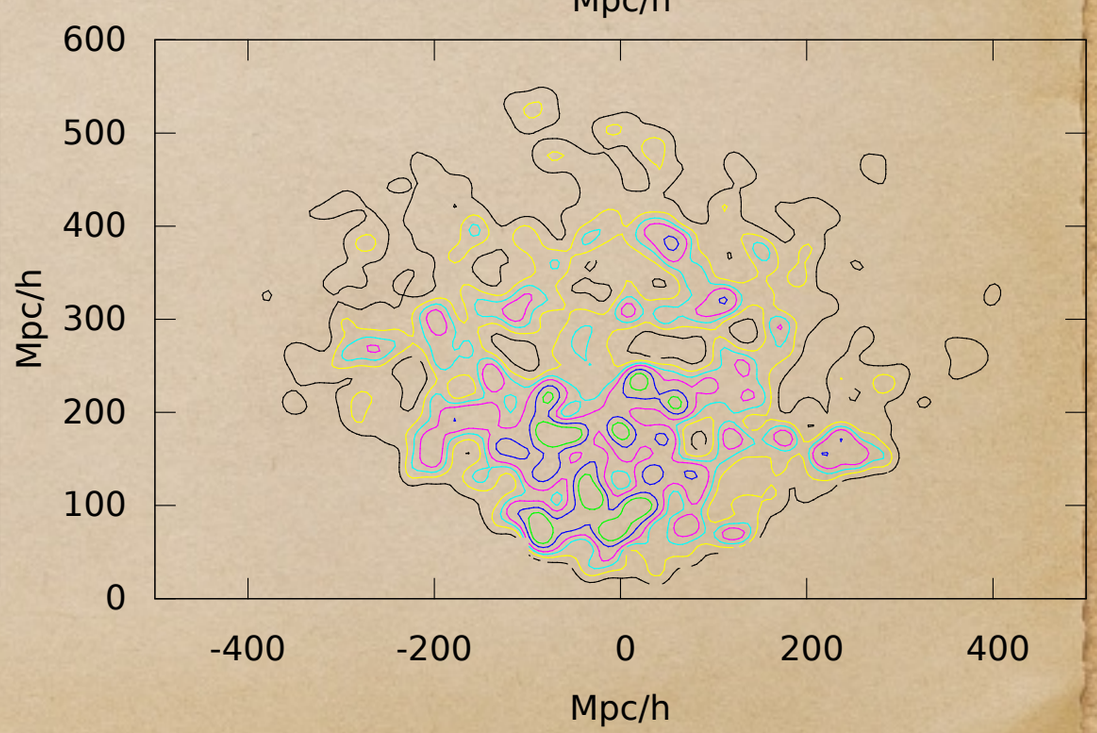
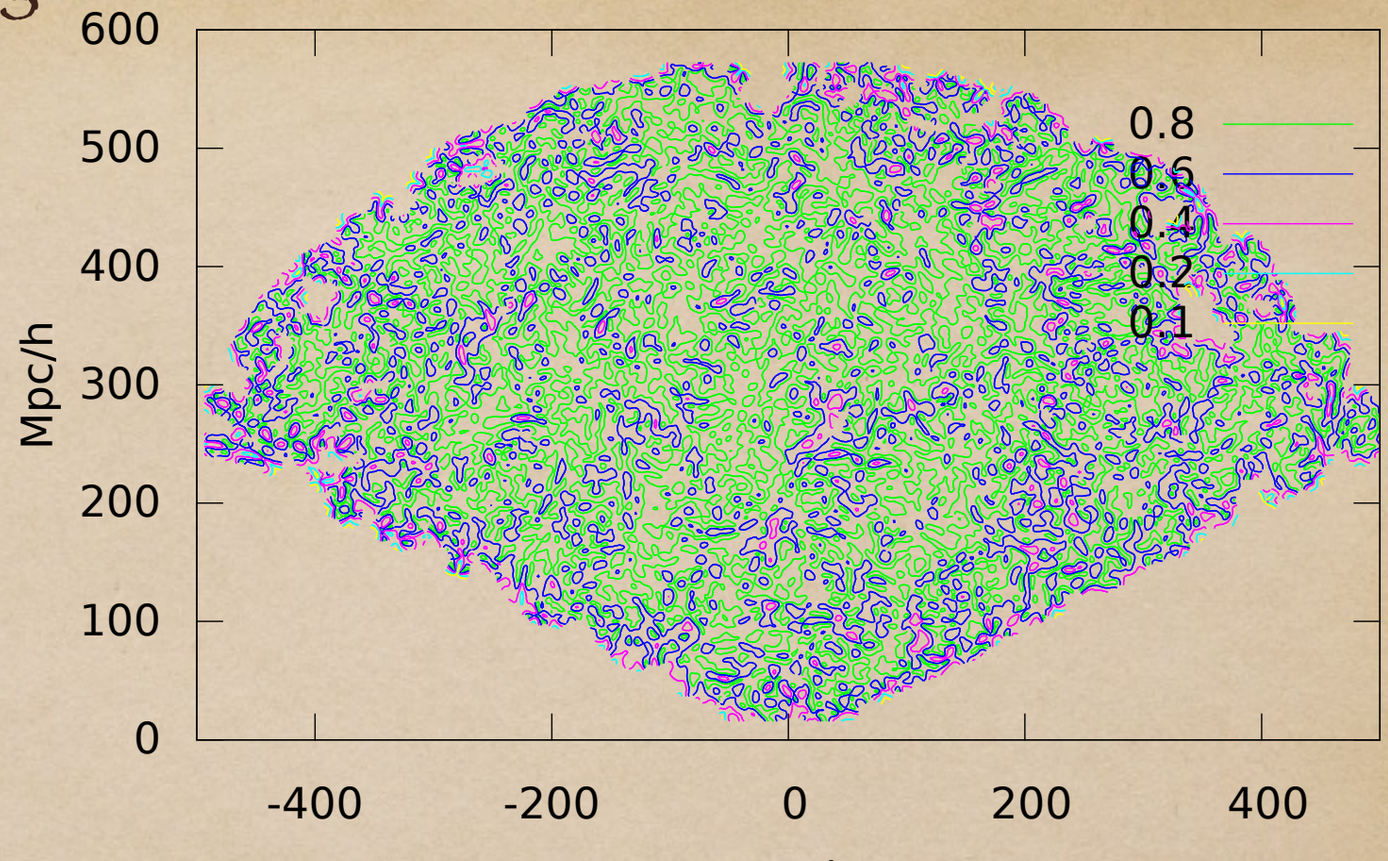


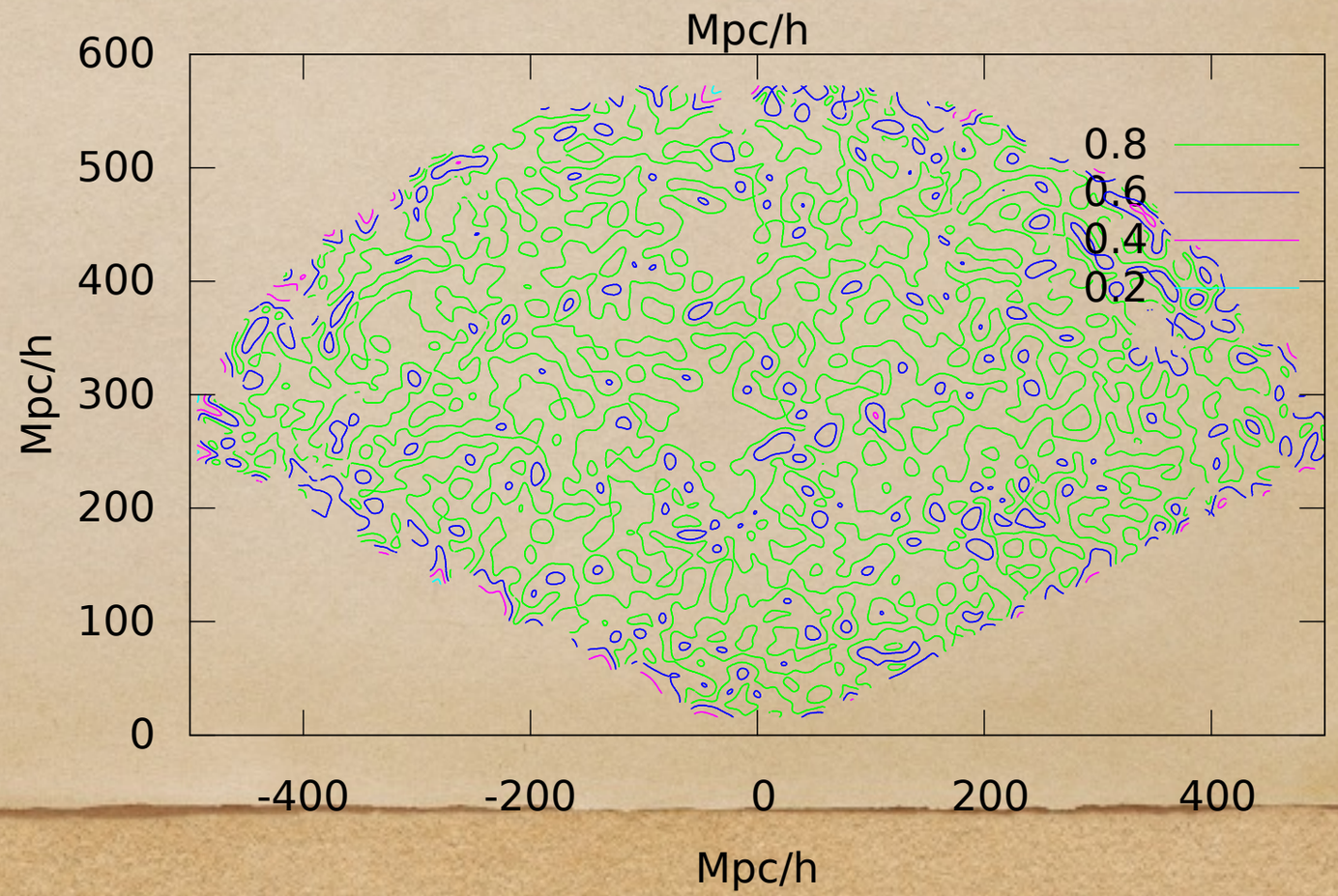


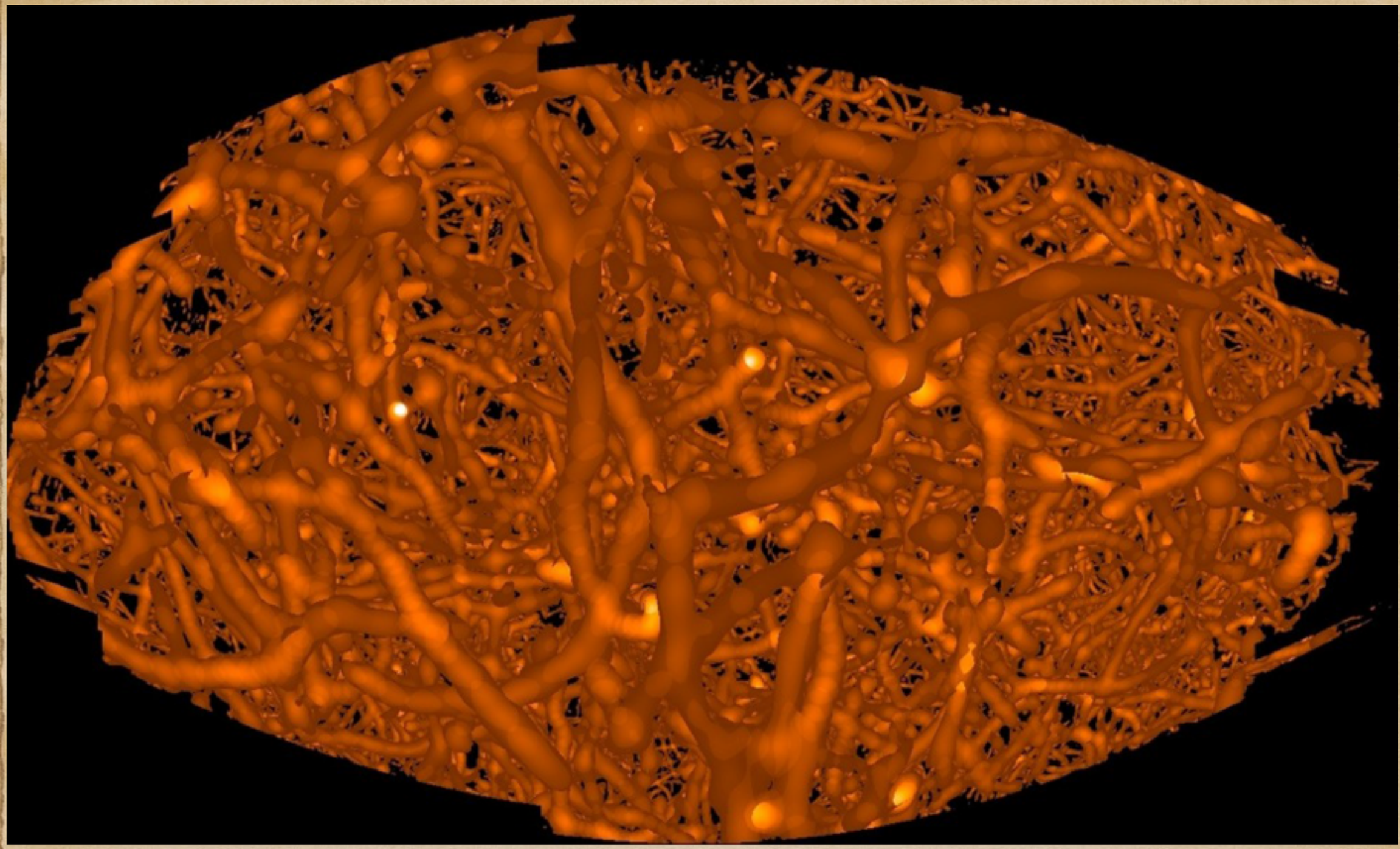
Axis ratios

R=5



R=10





Filament sky

by Juhan Liivamägi