The phase-space structure of nearby dark matter as constrained by the SDSS main galaxy sample

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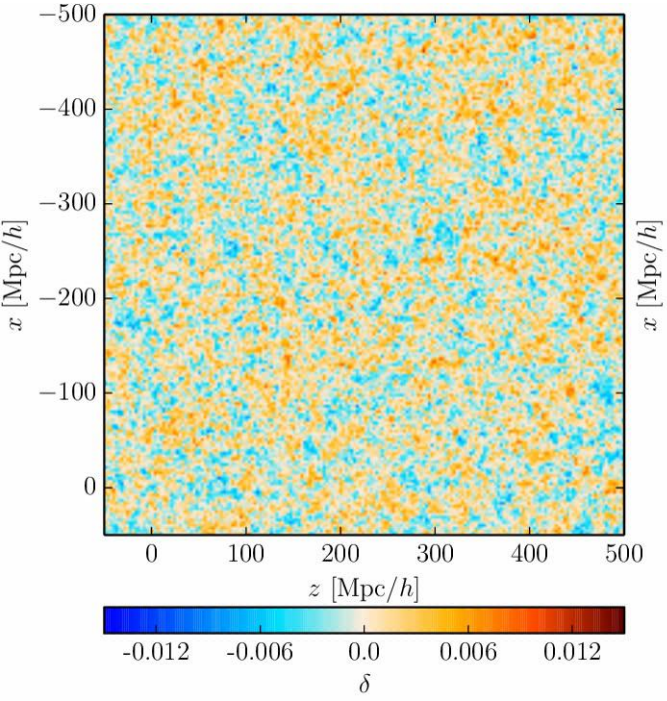
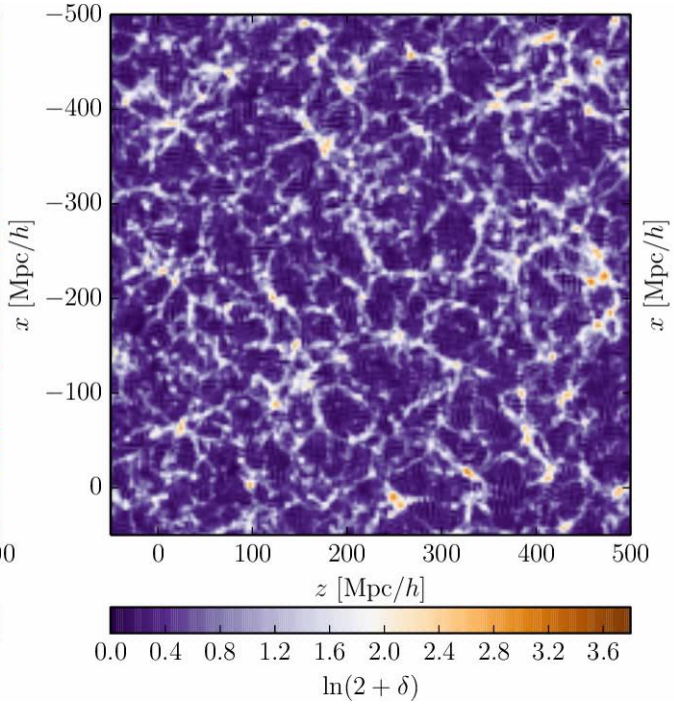
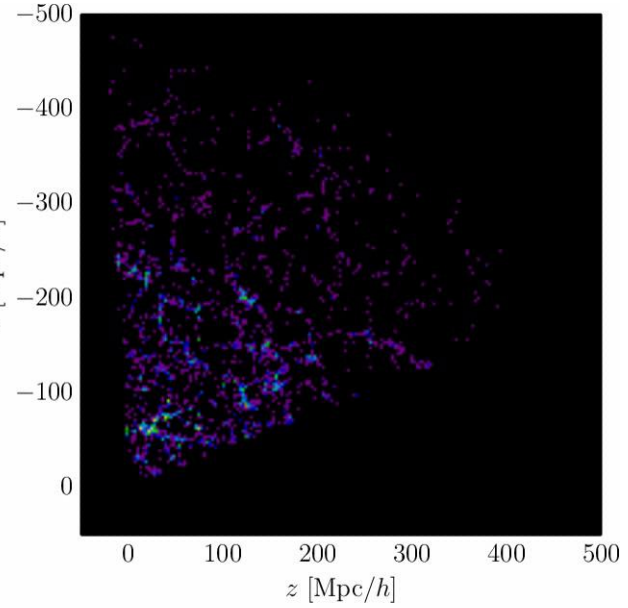
The BORG SDSS run



Initial conditions



Final conditions



Observations

334,074 galaxies, ≈ 17 millions parameters, 3 TB of primary data products,
12,000 samples, ≈ 250,000 data model evaluations, 10 months on 32 cores

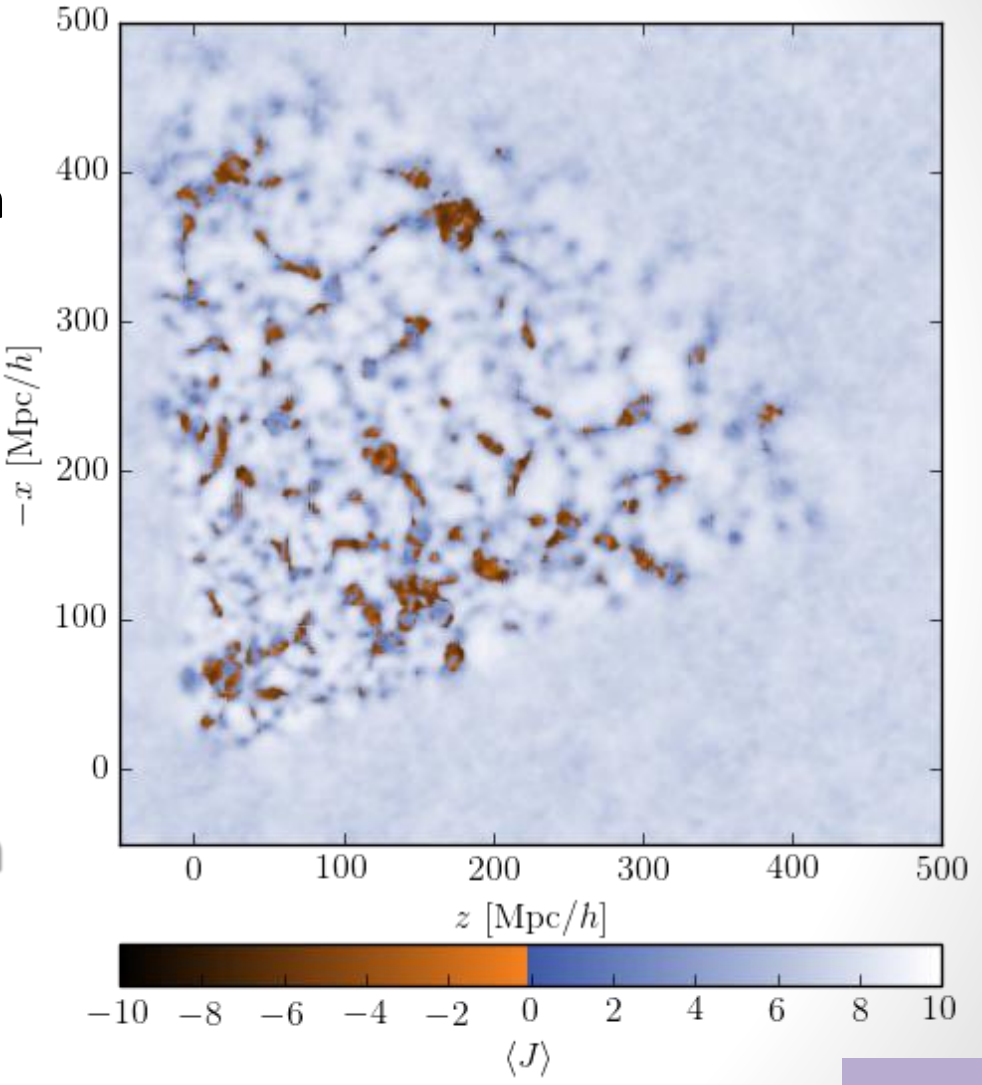
Jasche, FL & Wandelt 2015, arXiv:1409.6308

Inference of the dark matter phase-space sheet

- The dark matter phase-space sheet has been studied so far in simulations

e.g. Neyrinck 2012, arXiv:1202.3364
Abel, Hahn & Kaehler 2012, arXiv:1111.3944
Shandarin, Habib & Heitmann 2012, arXiv:1111.2366

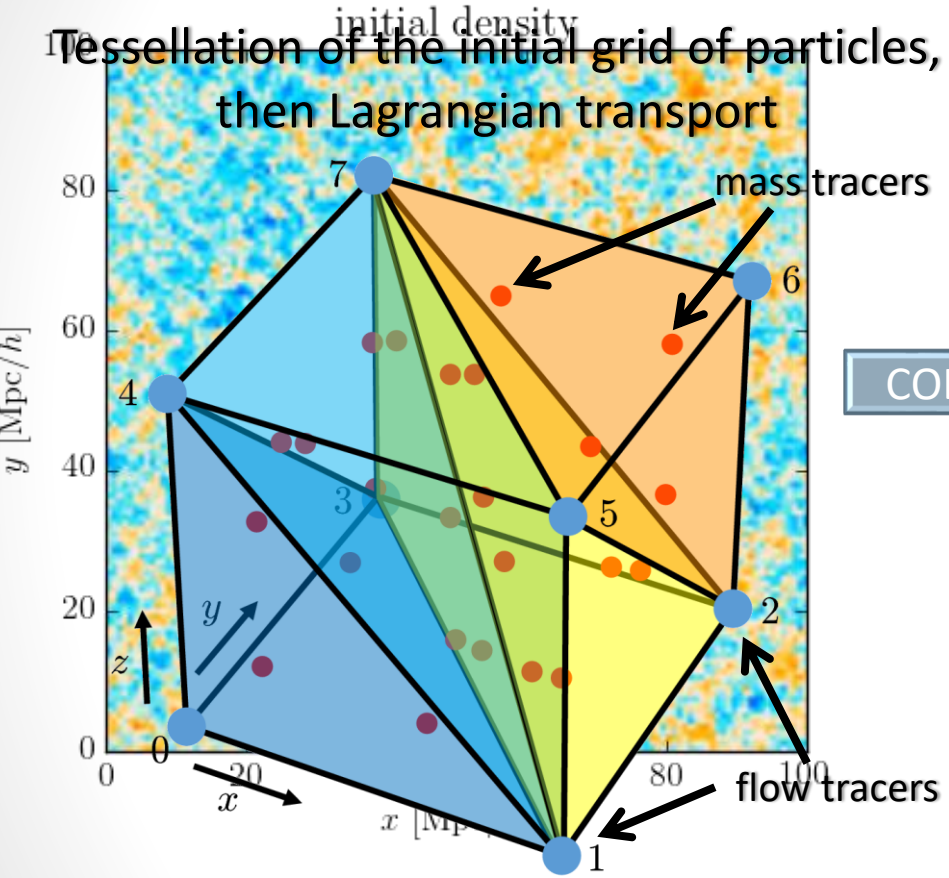
- BORG infers **Lagrangian dynamics** in real data
- Identified structures have a direct **physical interpretation**



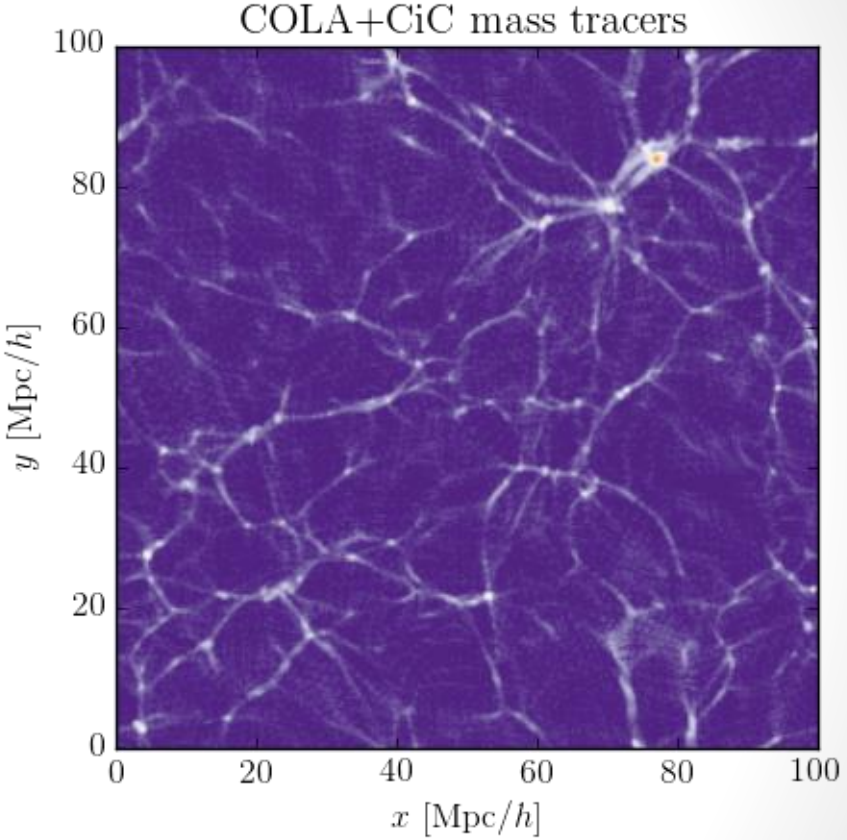
FL, Jasche, Lavaux & Wandelt 2016, arXiv:1601.00093

Non-linear filtering improves density samples

Tessellation of the initial grid of particles, then Lagrangian transport



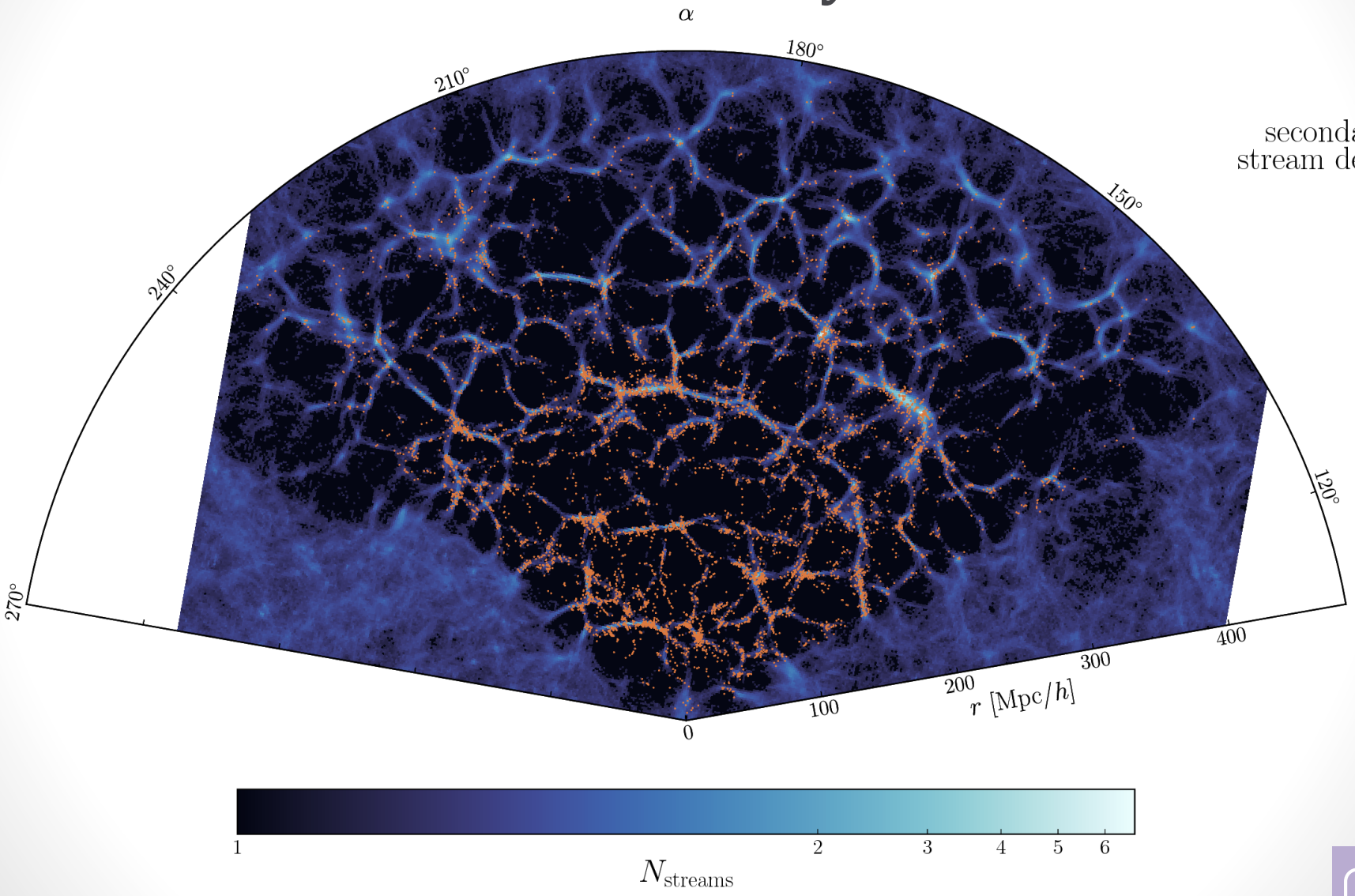
COLA



Abel, Hahn & Kaehler 2012, arXiv:1111.3944
Hahn, Abel & Khaeler 2013, arXiv:1210.6652
Hahn, Angulo & Abel 2015, arXiv:1404.2280

FL, Jasche, Lavaux & Wandelt 2016, arXiv:1601.00093

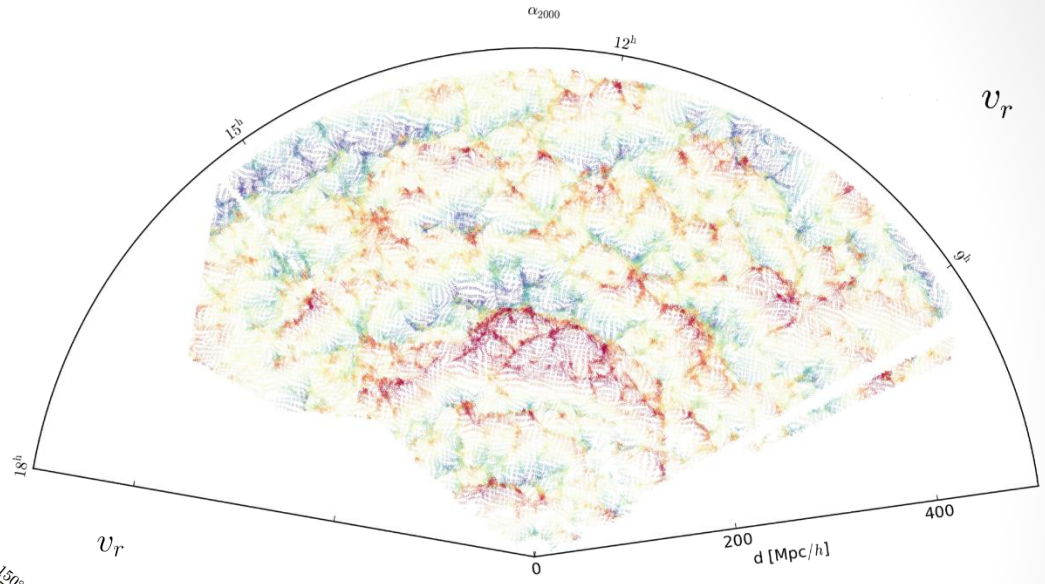
Dark matter stream density



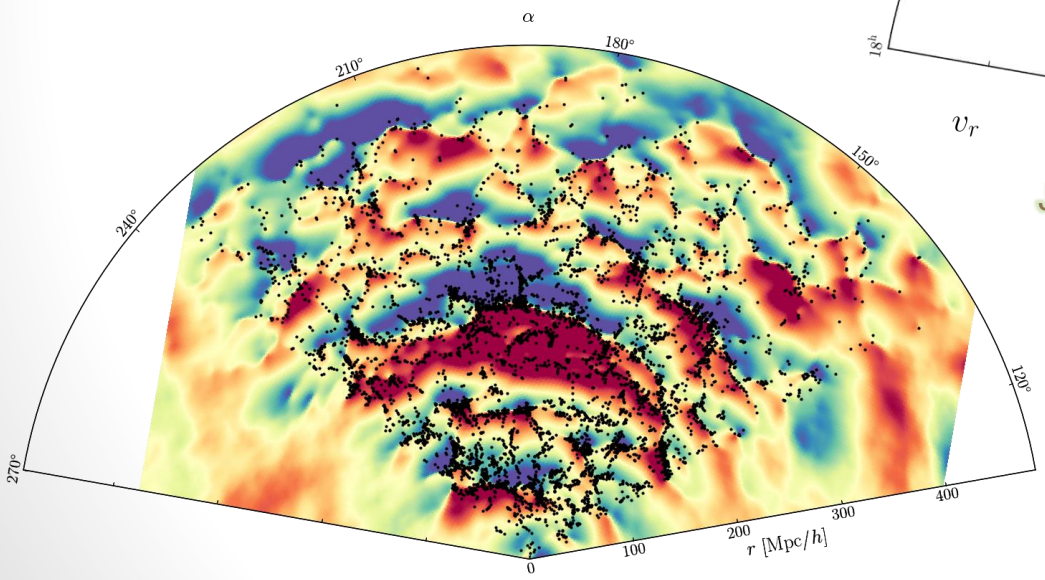
Lagrangian transport of the velocity field

see Hahn, Angulo & Abel 2015, arXiv:1404.2280

Velocity field: 2014 vs 2016

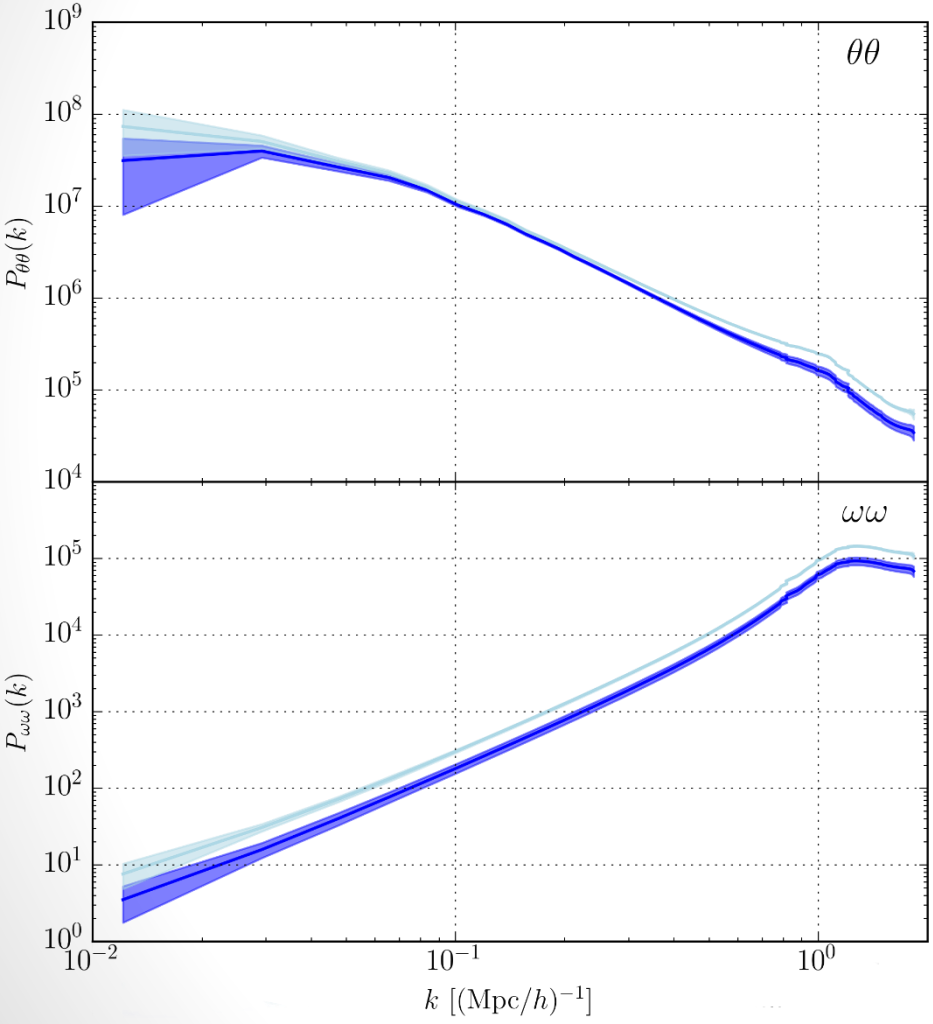


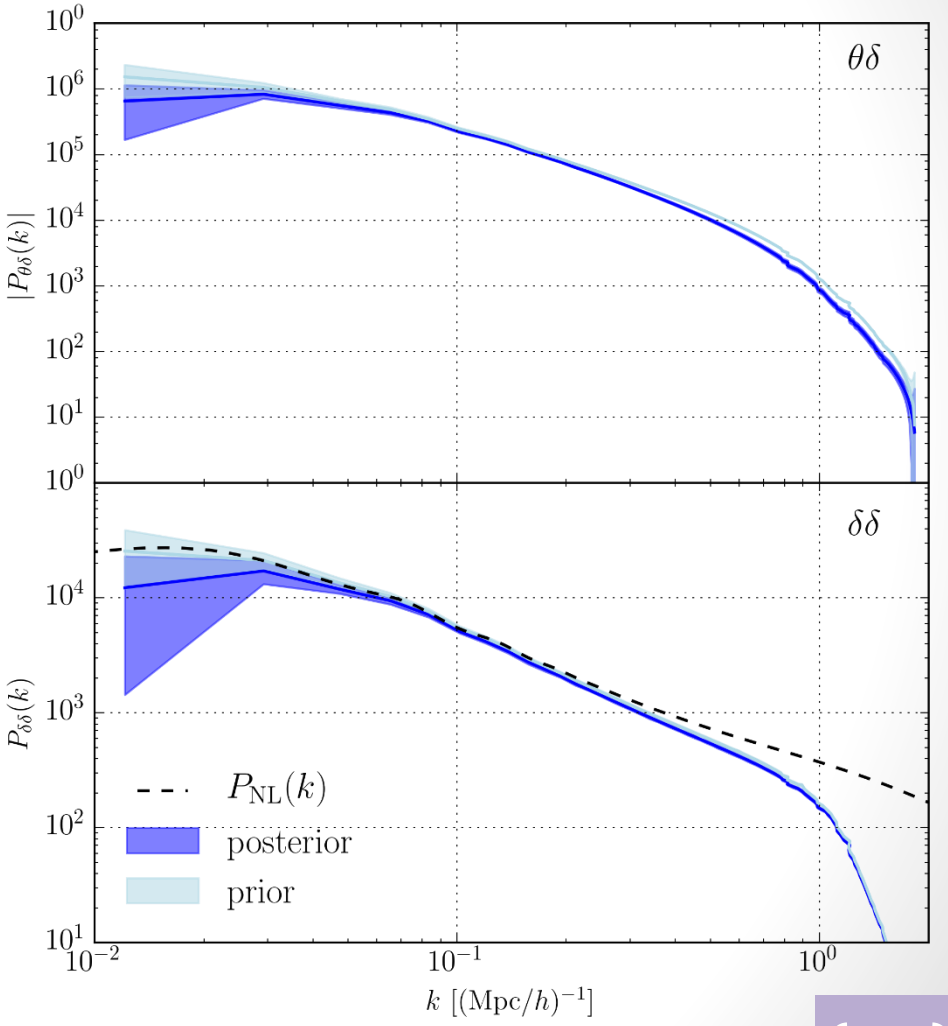
Jasche, FL & Wandelt 2015, arXiv:1409.6308



FL, Jasche, Lavaux & Wandelt 2016, arXiv:1601.00093

Inferred velocity fields are accurate in spite of the approximate inference model





Cosmic web classification procedures

void, sheet, filament, cluster?

- The **T-web**:

uses the sign of μ_1, μ_2, μ_3: eigenvalues of the tidal field tensor, Hessian of the gravitational potential: $T_{ij}(\mathbf{x}) = \partial_i \partial_j \Phi(\mathbf{x})$

Hahn *et al.* 2007, arXiv:astro-ph/0610280

- **DIVA**:

uses the sign of $\lambda_1, \lambda_2, \lambda_3$: eigenvalues of the shear of the Lagrangian displacement field: $R_{\ell m}(\mathbf{q}) = \partial_m \Psi_\ell(\mathbf{q})$

Lavaux & Wandelt 2010, arXiv:0906.4101

- **ORIGAMI** :

uses the dark matter "phase-space sheet" (number of orthogonal axes along which there is shell-crossing)

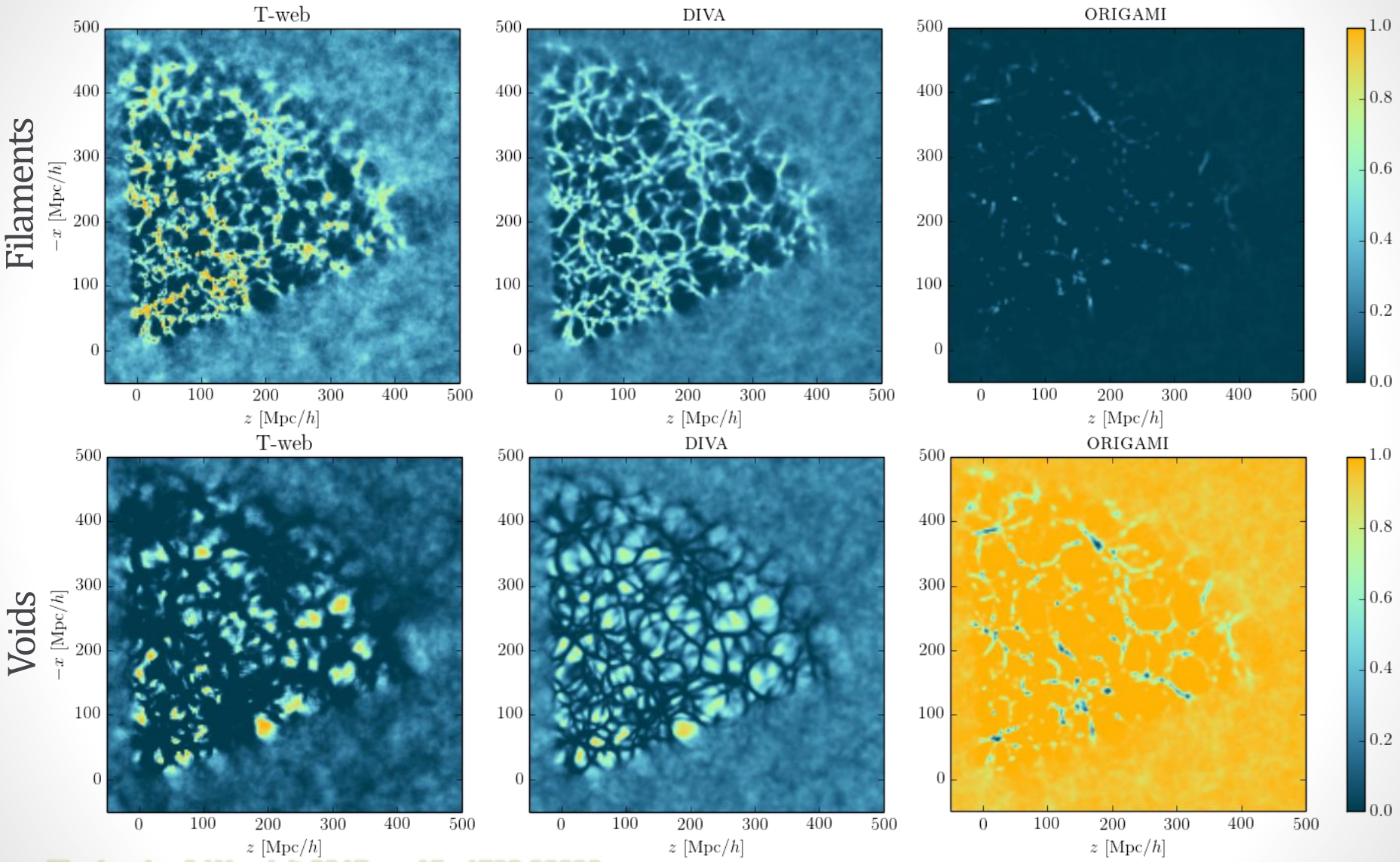
Falck, Neyrinck & Szalay 2012, arXiv:1201.2353

Lagrangian classifiers

now usable in real data!

and many others…

Comparing classifiers



FL, Jasche & Wandelt 2015a, arXiv:1502.02690

FL, Jasche, Lavaux & Wandelt 2016, arXiv:1601.00093