Galaxy properties within cosmic web filaments

Clotilde Laigle
University of Oxford

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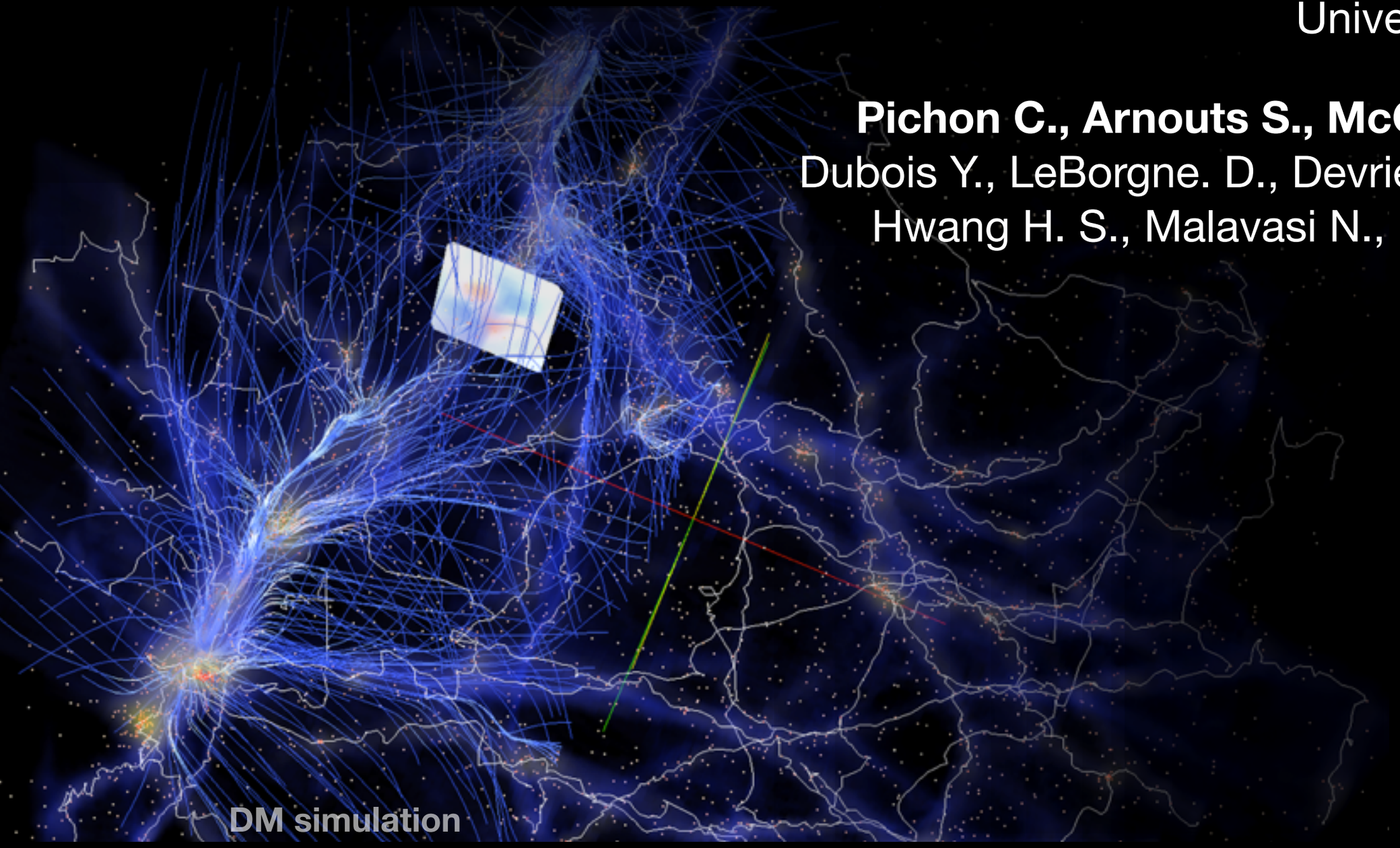
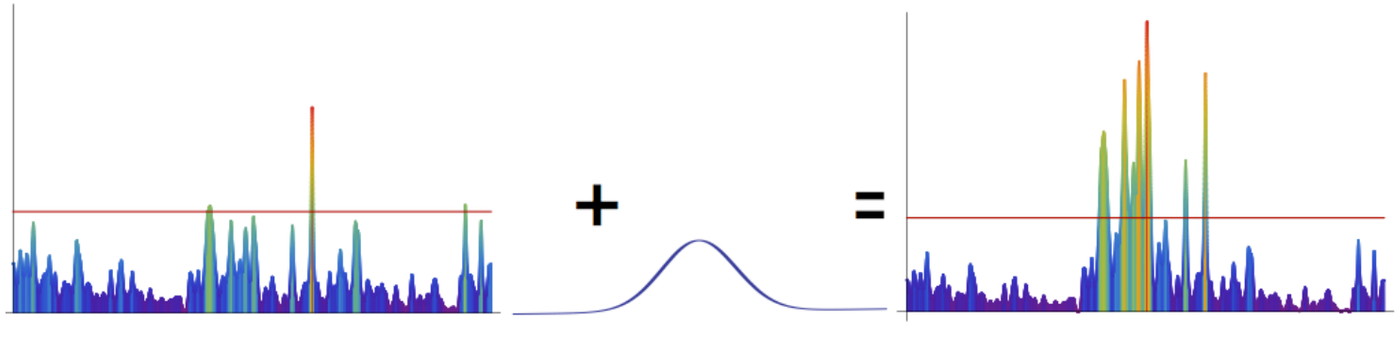


Local density versus tidal effects

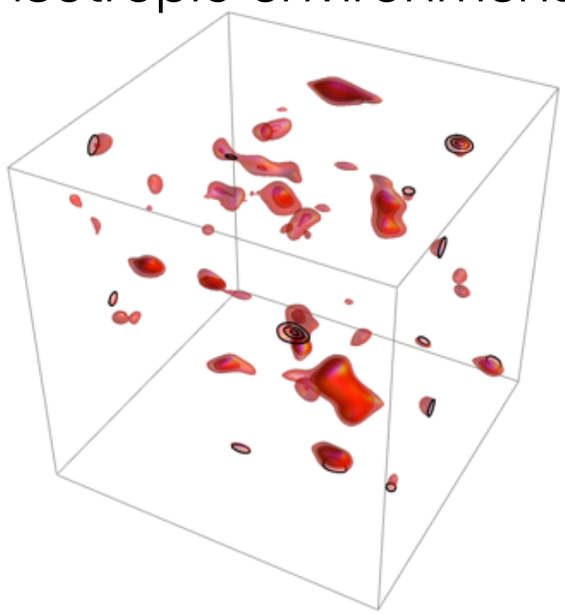
Enhancement of the abundance of massive halos/galaxies in denser environments



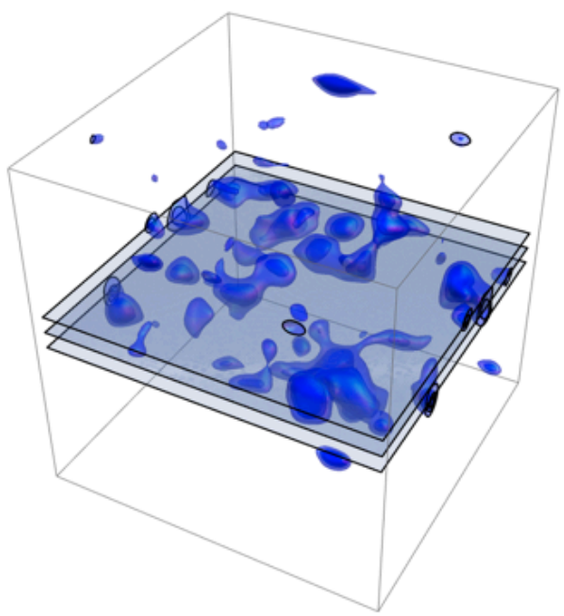
Density bias

See also:
Kaiser 84, White 88, Efstathiou+98,...

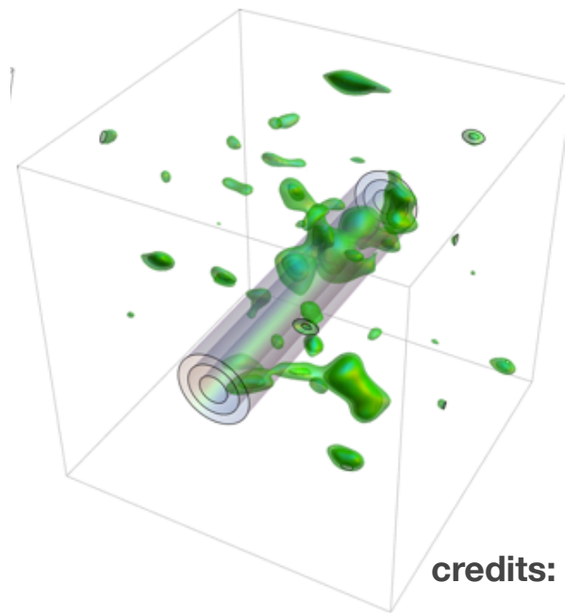
isotropic environment



Wall-like environment



filament-like environment



credits: C. Pichon

Density: trace of the hessian $\nabla^2\phi(\mathbf{x}) = 4\pi G\rho_0 a^2\,\delta(\mathbf{x})$

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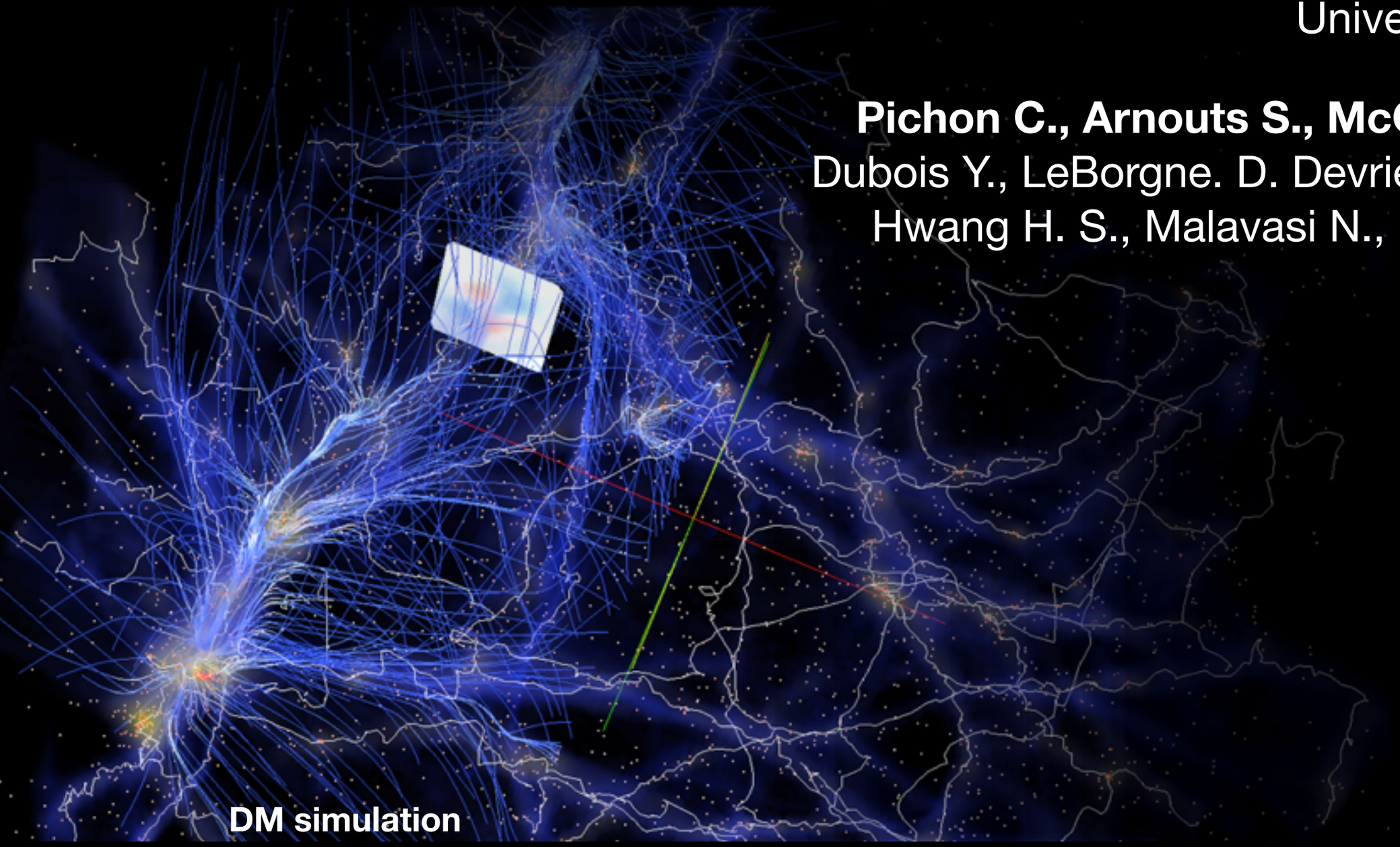


Local density versus tidal effects

Tidal effects

tidal tensor: traceless part of the hessian

$$T_{ij} = \left[\frac{\partial^2}{\partial_i \partial_j} - \frac{1}{3} \delta_{ij} \nabla^2 \right] \phi$$

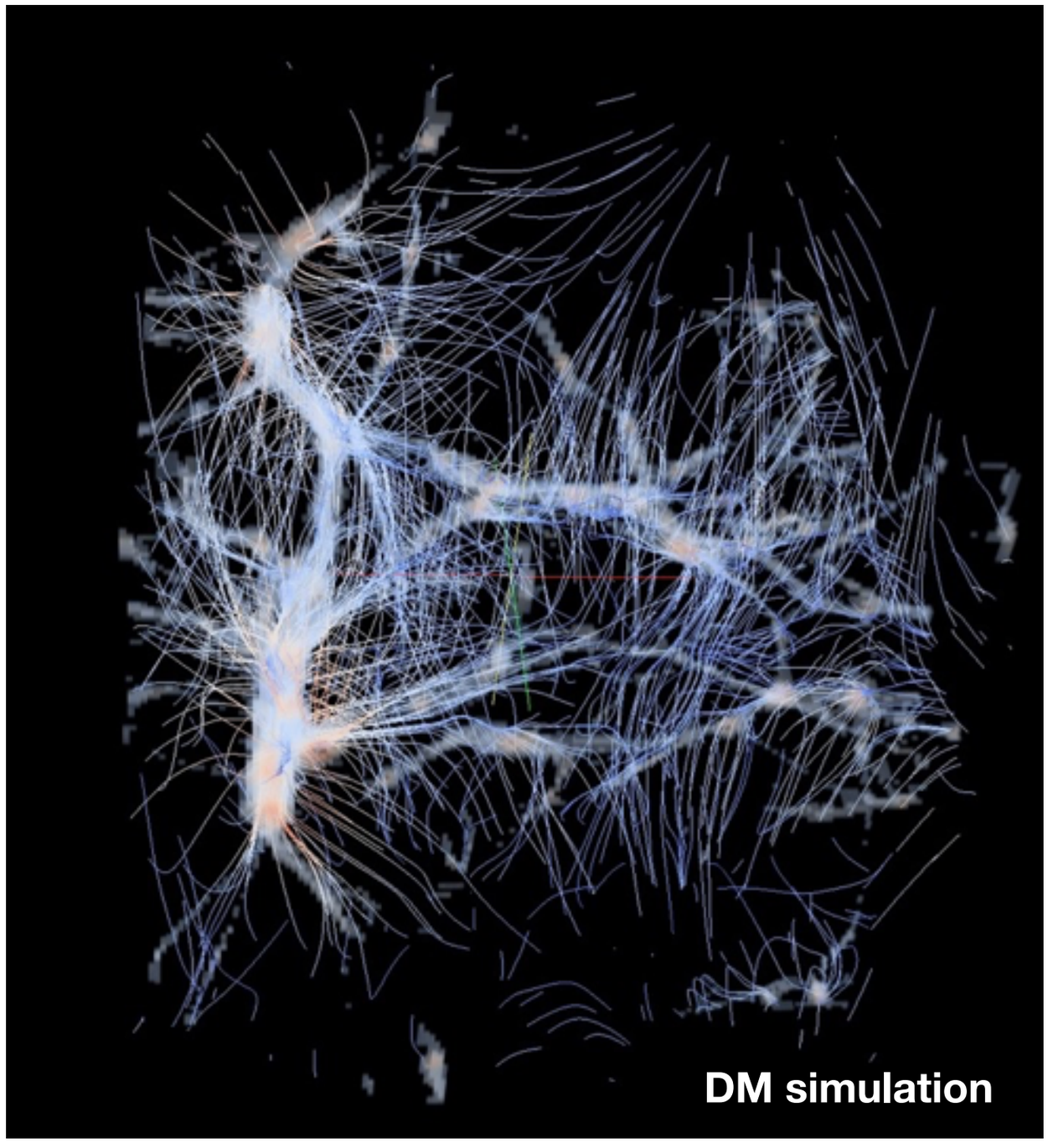
See e.g.:

Sheth et Tormen04, Croton+07, Dalal +08,Hahn+09,Wang+11, ...

- Tidal suppression of halo growth in the vicinity of a massive object

- Different formation histories for haloes in different environments

- dynamical connection between halo and the cosmic web



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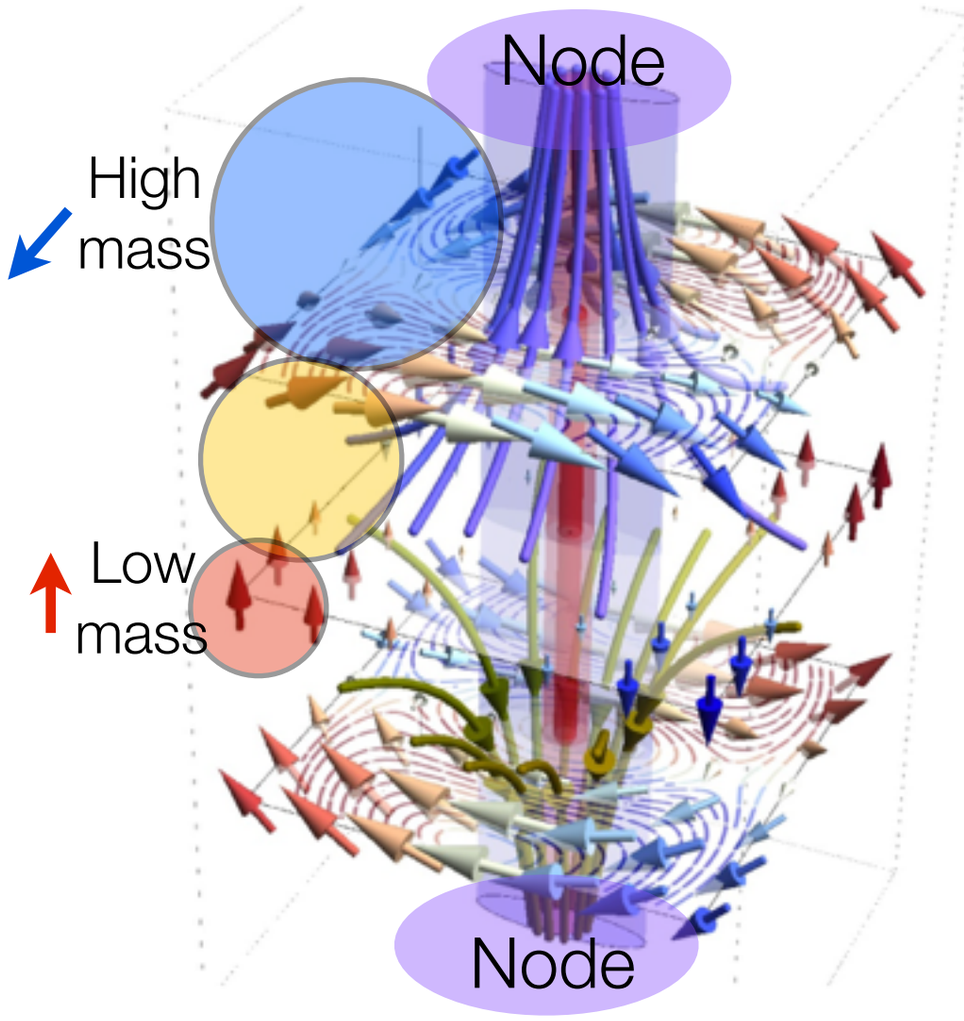
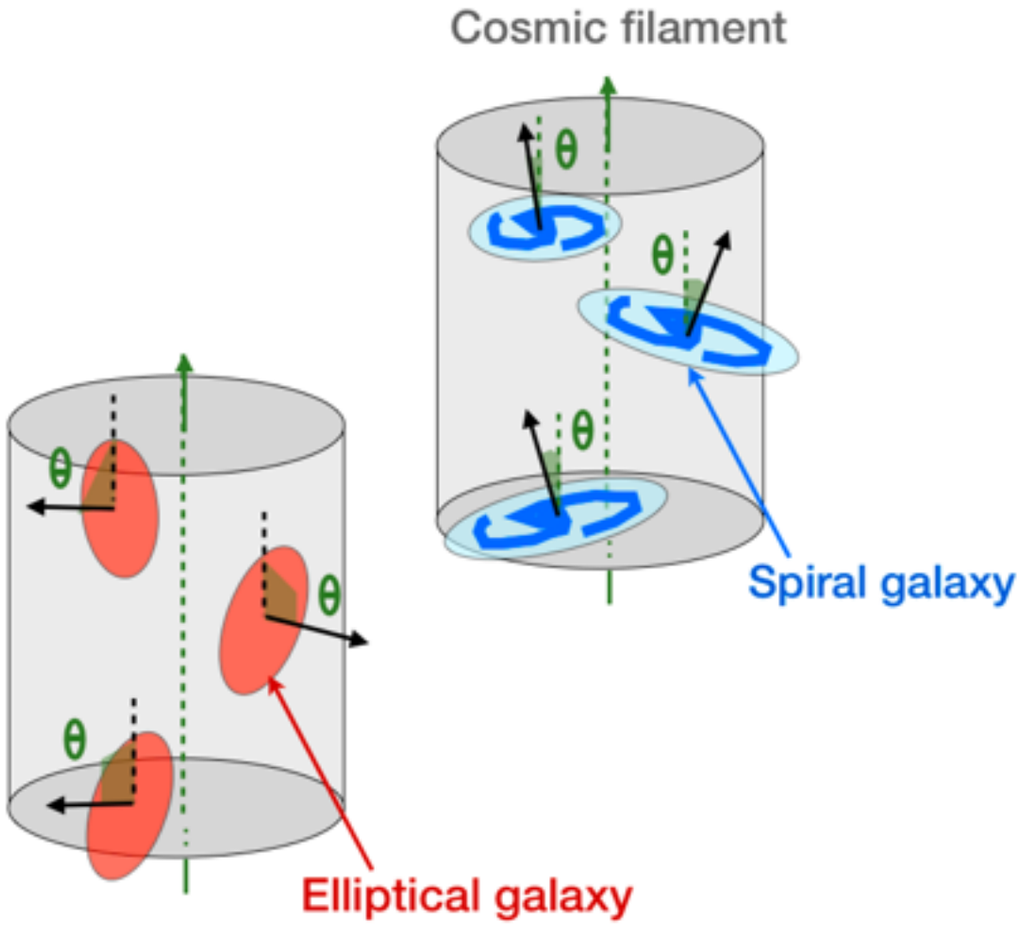
Codis+15

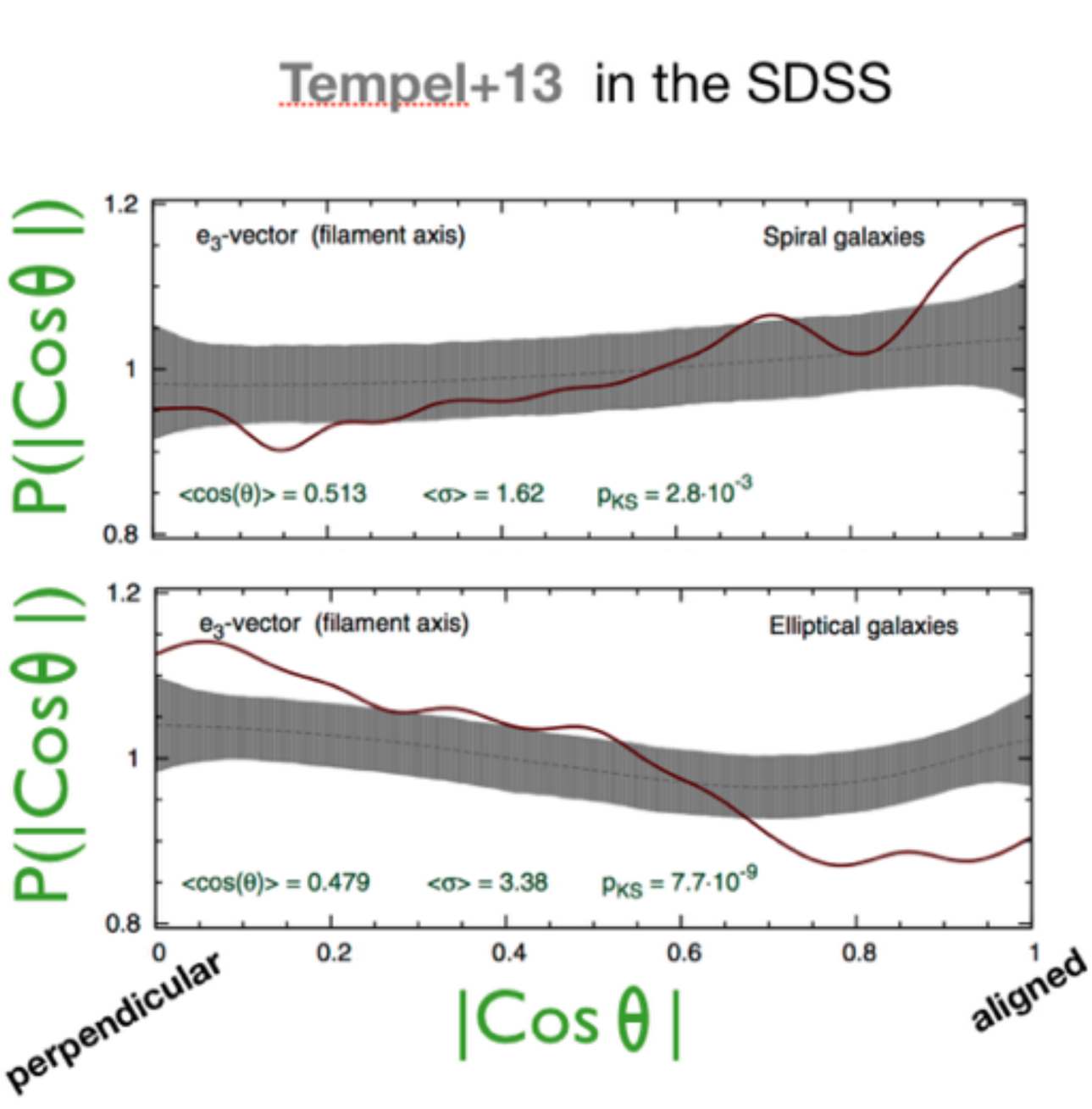
See also: **Laigle+15**



A critical ingredient: the anisotropy of the cosmic web

Dynamical connection between galaxies and cosmic web (TTT)



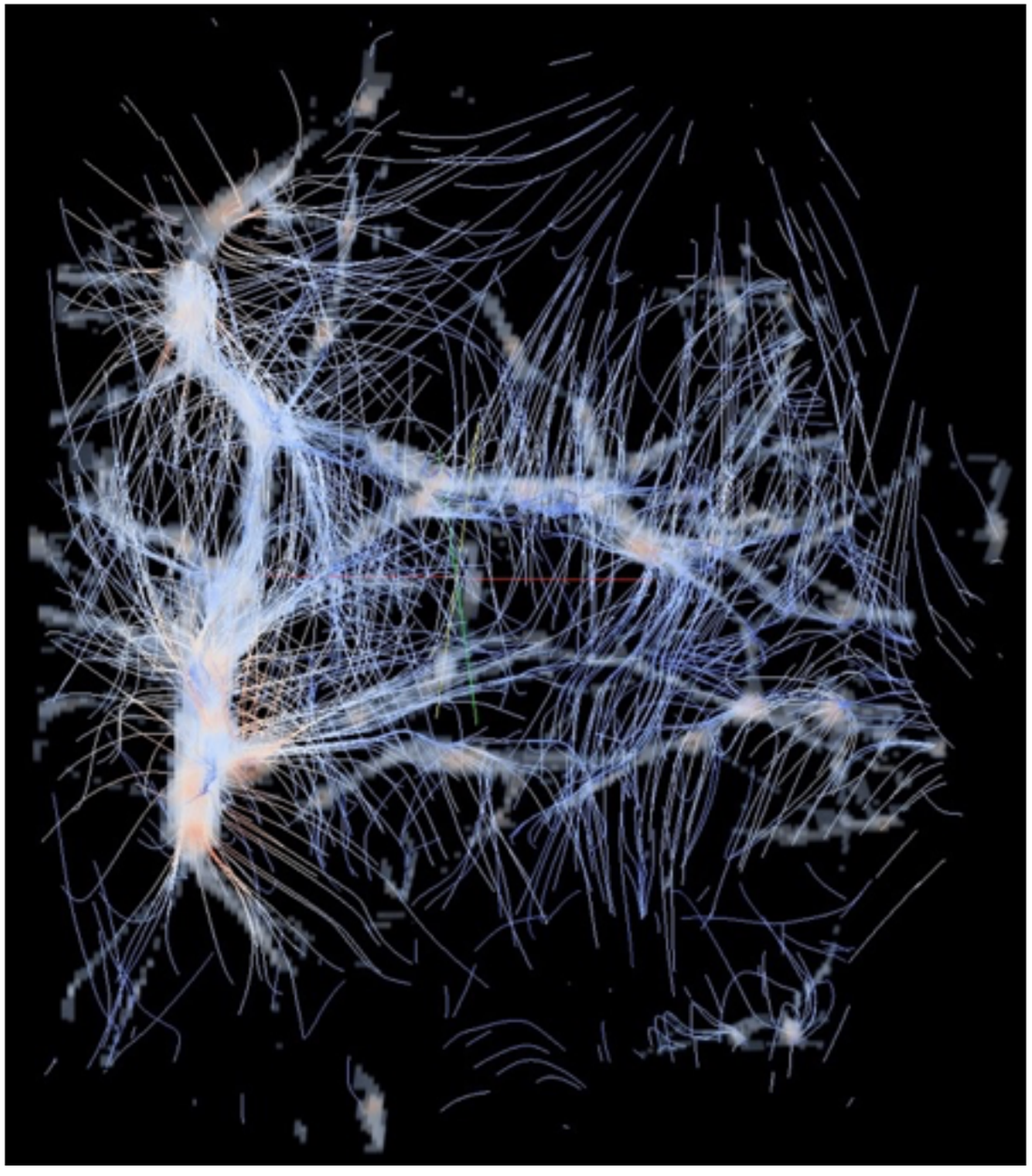


See also: **Aragon-Calvo+07**, **Hahn+07**, **Sousbie+08**, **Paz+08**, **Zhang+09**, **Codis +12**, **Libeskind+13, Laigle+15, Aragon-Calvo 13**, **Dubois+14**

INTRODUCTION

We look for an effect:

- distinct from the local density
- at larger scale than the group scale



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Tidal field drives:

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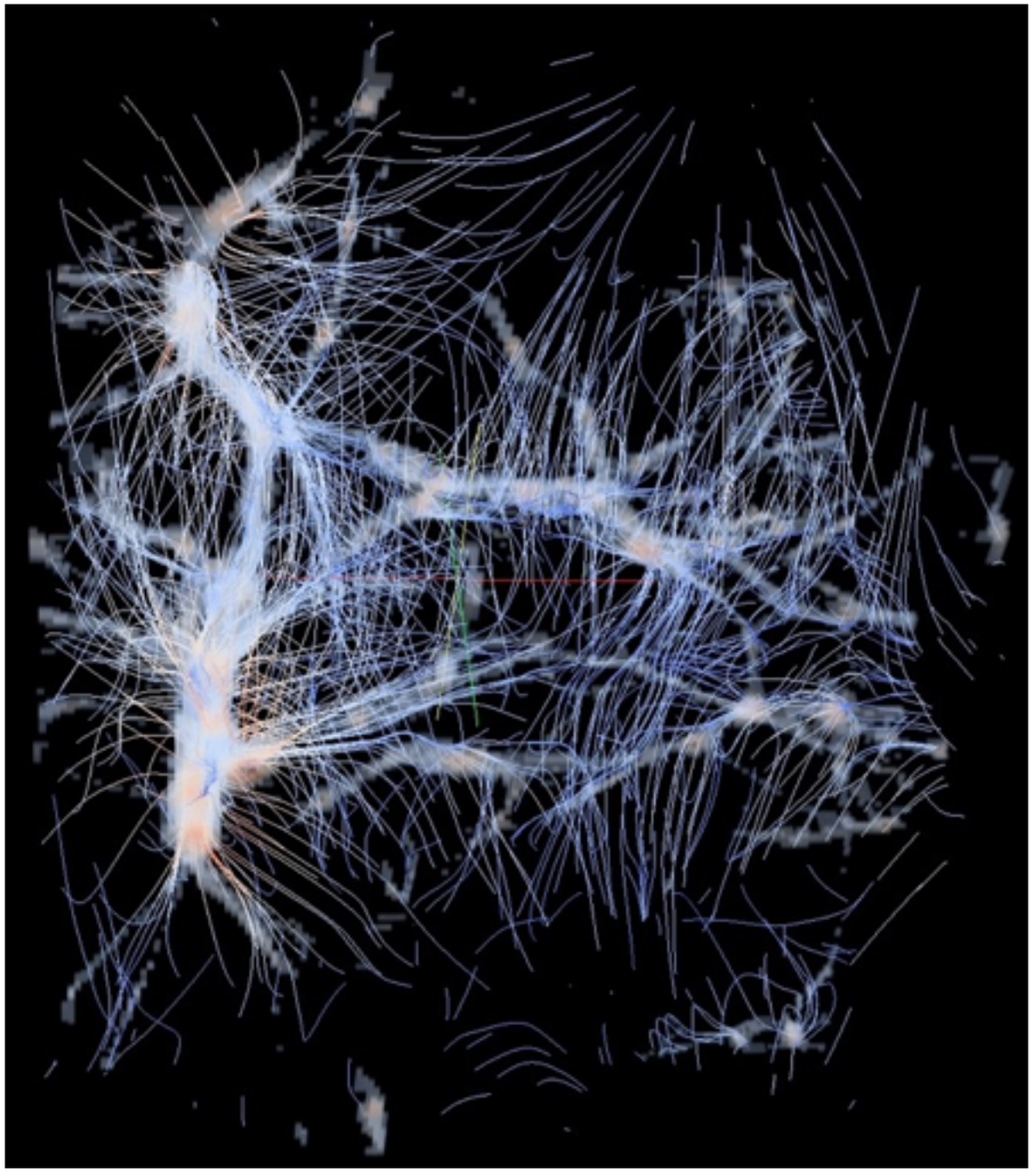
- a dynamical connection between galaxies/ haloes and the cosmic web

Crucial: the anisotropy of the environment



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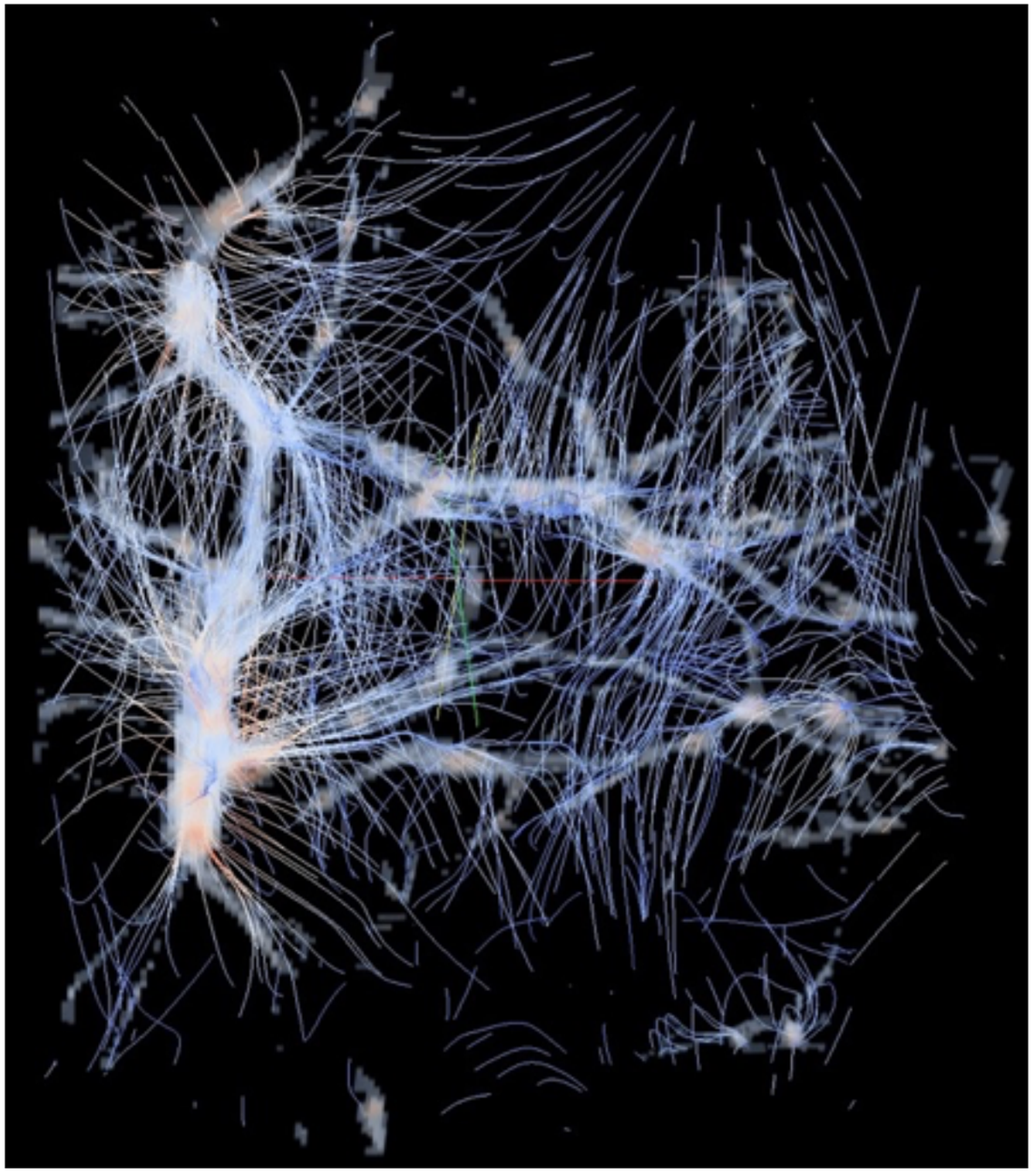

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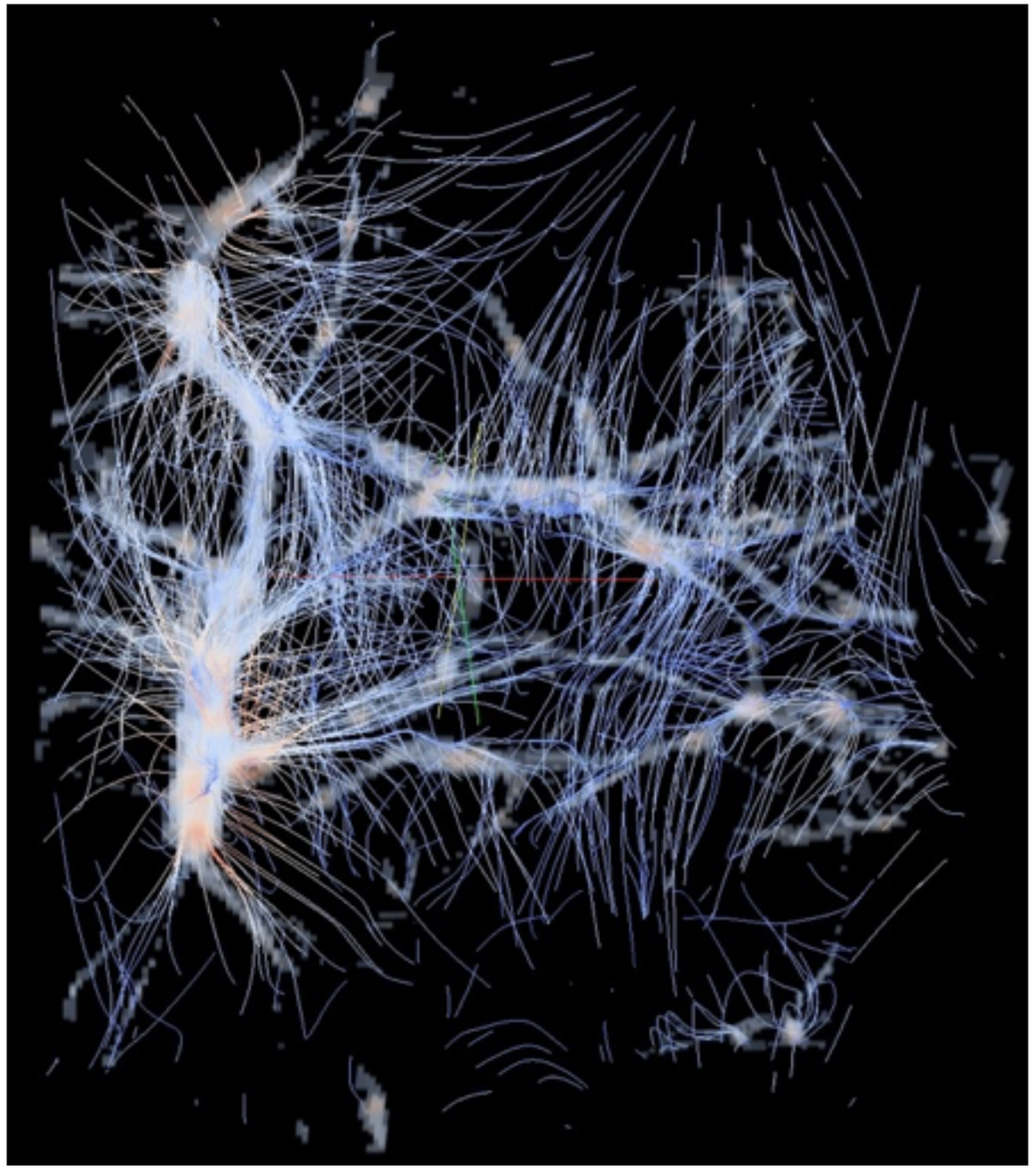
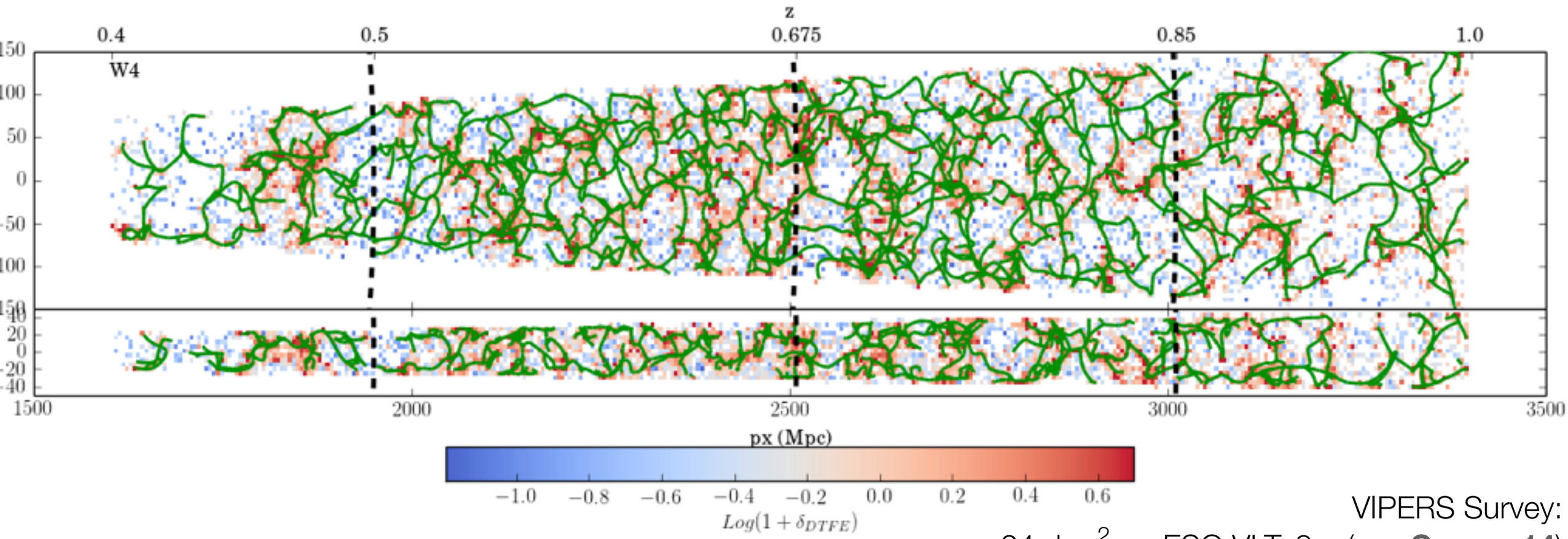
what is the impact for galaxies?

We will look for the evolution of galaxy properties (mass, colour-type) as a function of their distance to the filament



Reconstructing the cosmic web: galaxy distribution

Skeleton extraction in VIPERS W1, 0.4<z<1, i_{AB}<22.5, scale of ~10cMpc (**Malavasi+16**)



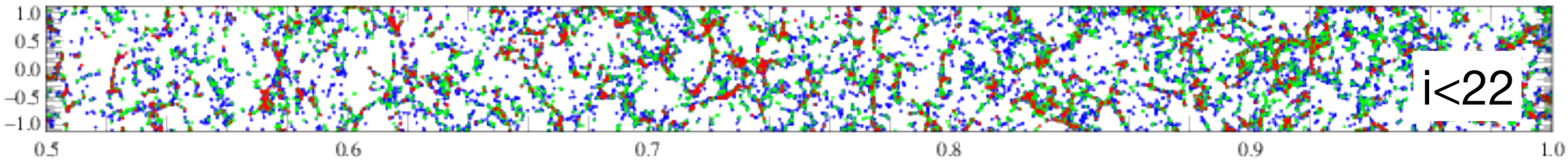
VIPERS Survey:
24 deg^2 on ESO VLT, 8m (see **Guzzo+14**)

Costly to probe the cosmic web at ~Mpc scale

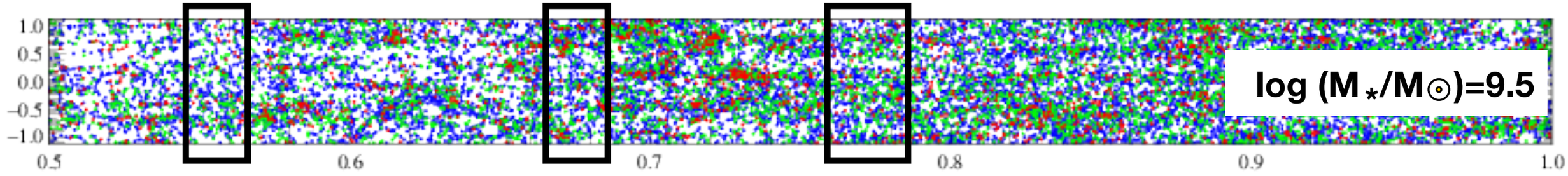
See also e.g.:
Kraljick+in prep., GAMA

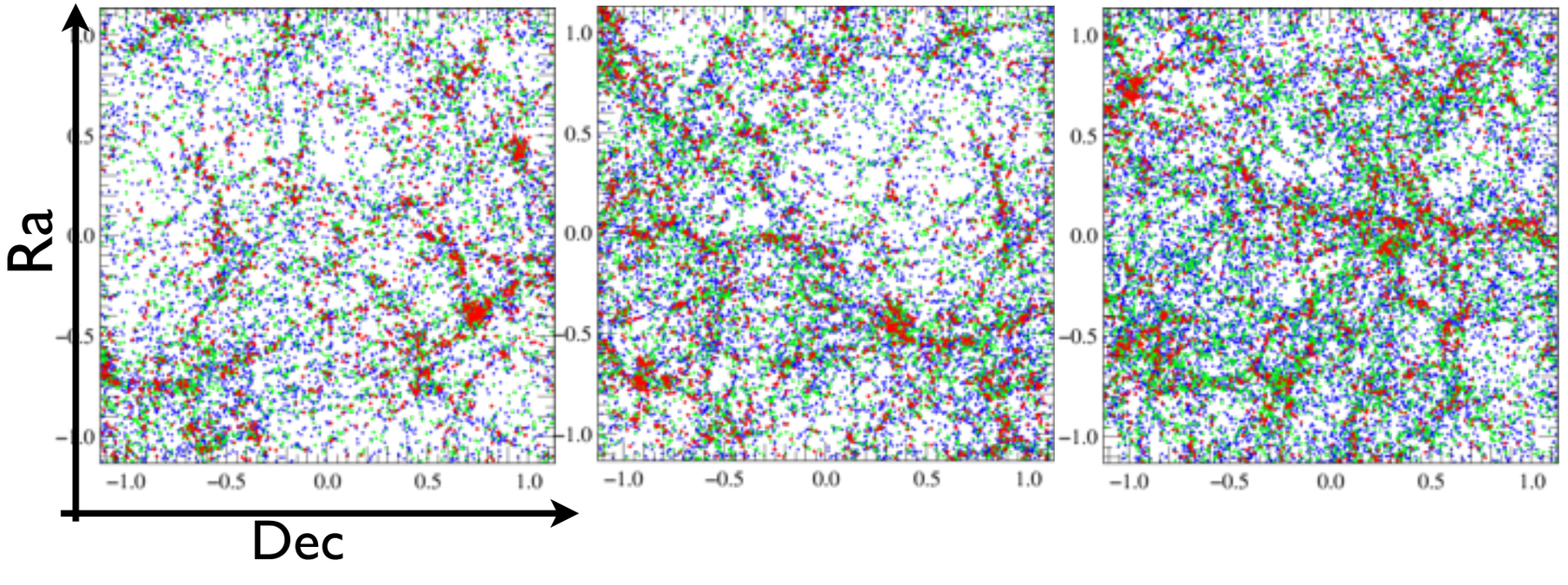
Spectroscopy versus photometry: complementary approach

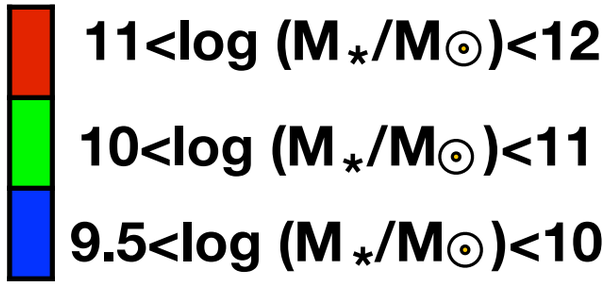
Spectroscopic surveys: redshift precisely known, but relatively poor sampling



Photometric surveys: redshift more uncertain, but good sampling and larger range

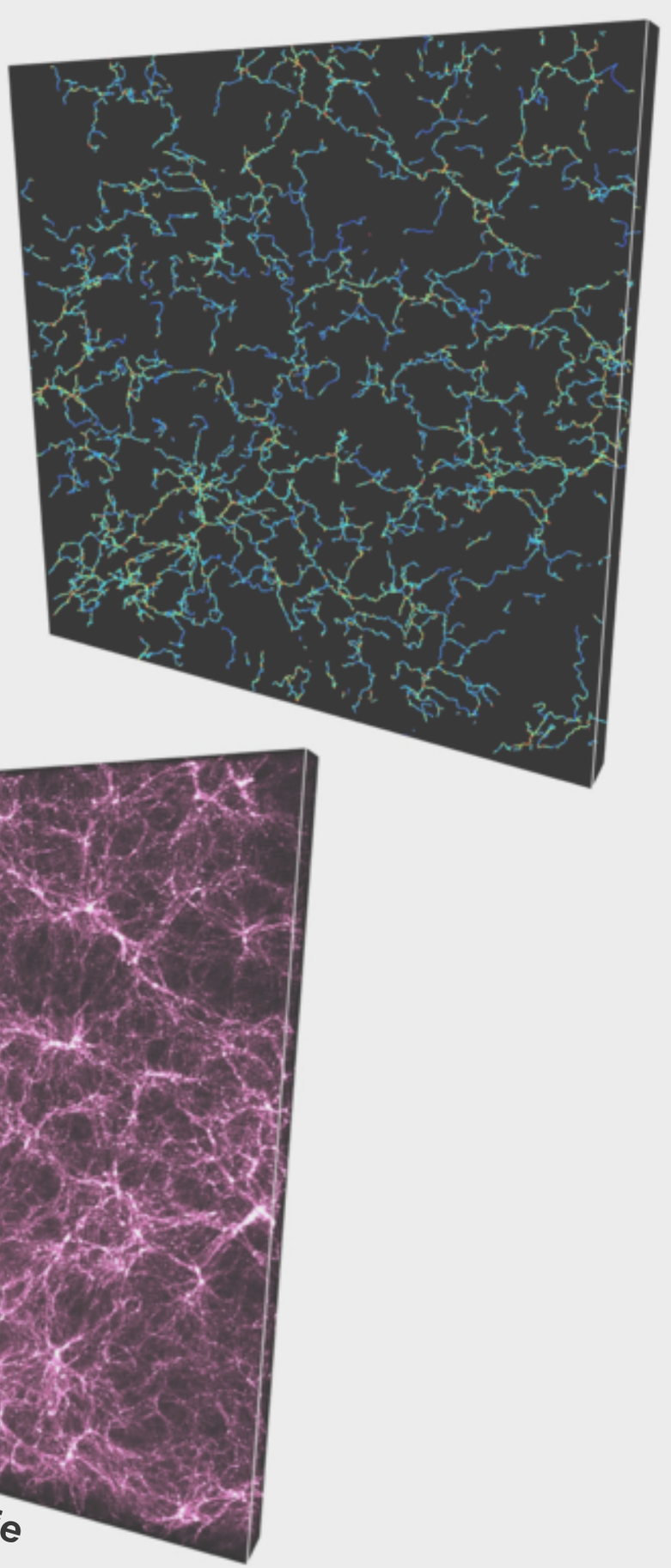






The persistent skeleton: a tracer of filaments **Sousbie+11**

- Filaments: a set of gradient lines connecting peaks
- Skeleton lines between peaks pass through one saddle point



credits: Sousbie

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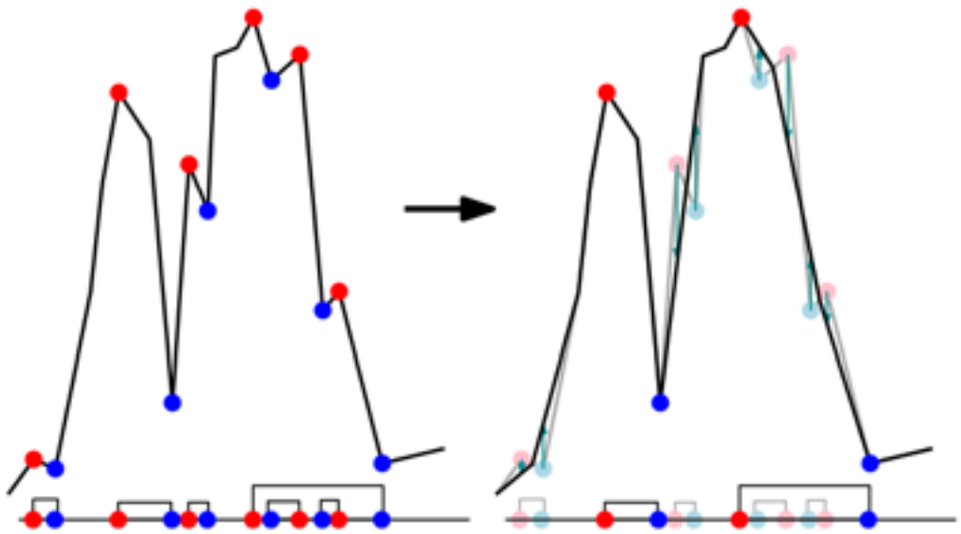
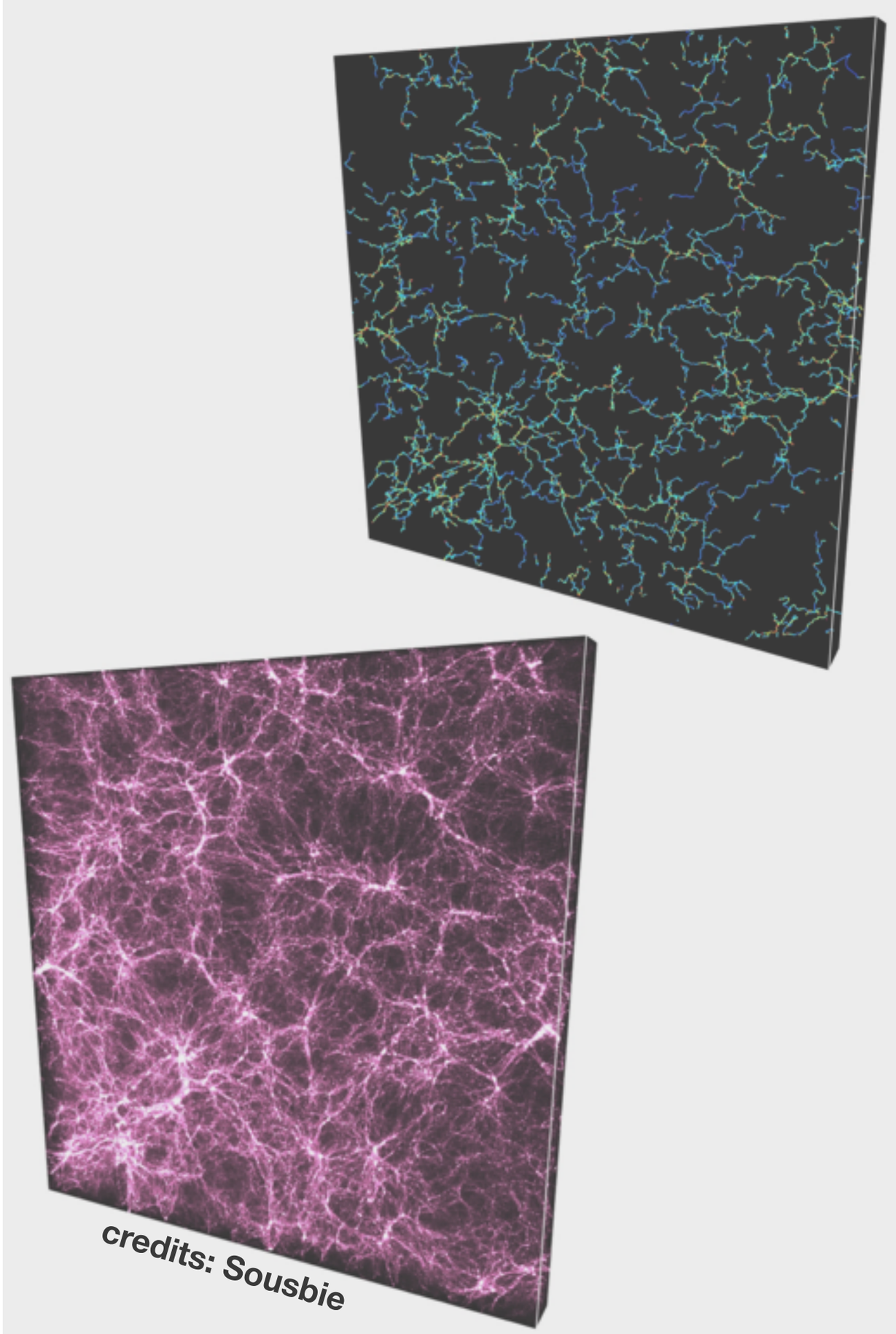
- Filaments: a set of gradient lines connecting peaks
- Skeleton lines between peaks pass through one saddle point
- Persistence allows to work with noisy datasets





credits: Sousbie

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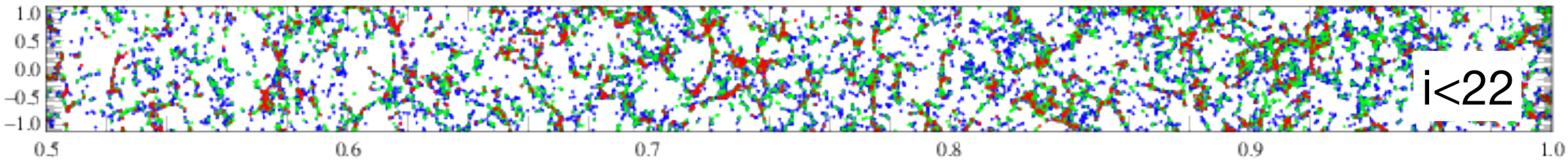
<u>Spectroscopic surveys</u>: redshift precisely known, but relatively poor sampling



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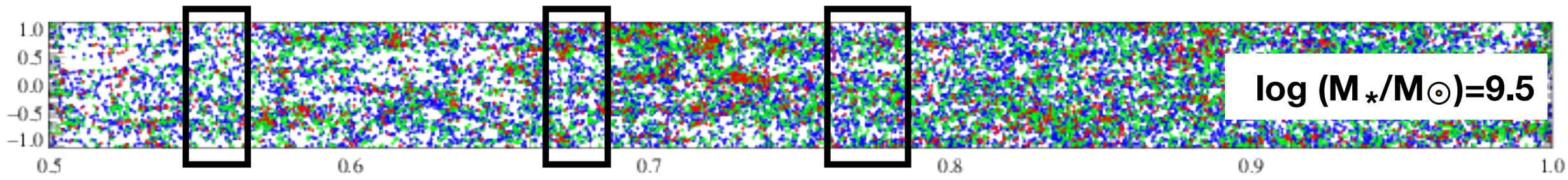
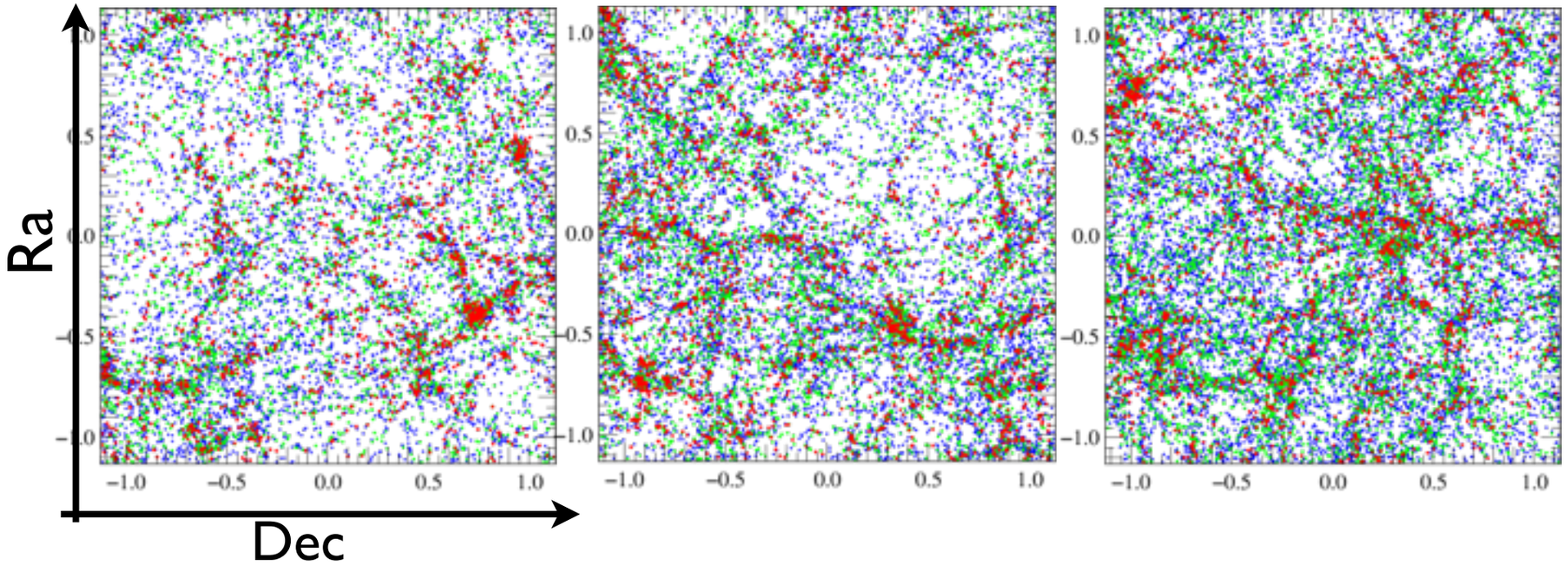




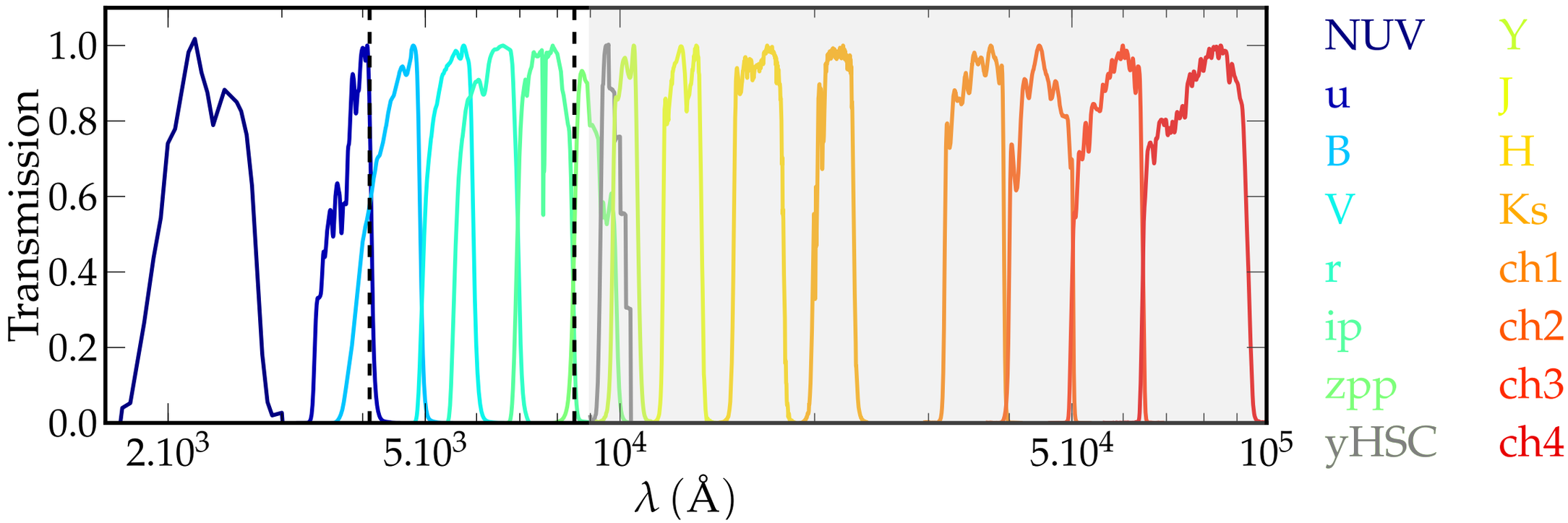
11<log (M*/M⊙)<12

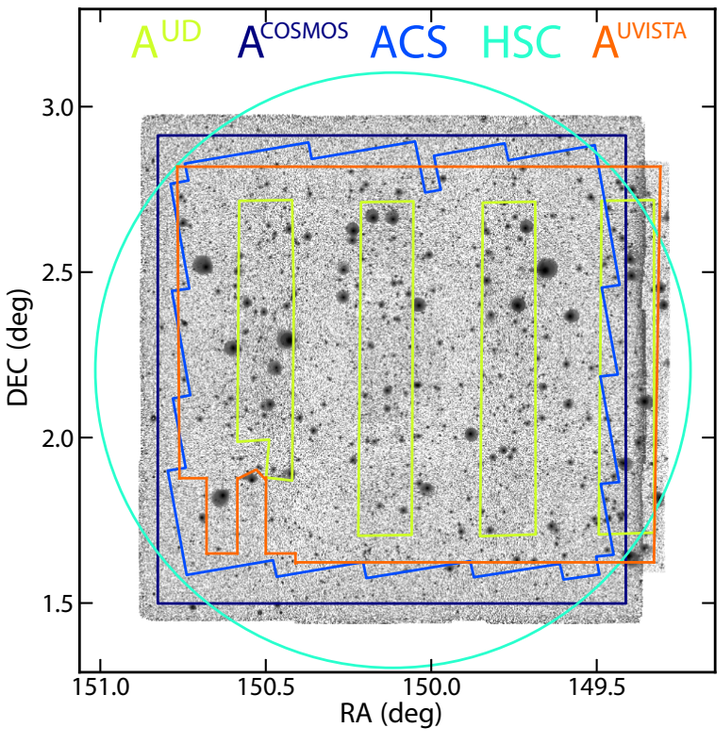
10<log (M*/M⊙)<11

9.5<log (M*/M⊙)<10

The COSMOS2015 catalogue

Laigle+16





30 photometric bands from NUV to FIR and 30 000 spectra
New IR (IRAC, Spitzer) and NIR (UltraVISTA DR2): crucial for accurate redshifts and masses at high-redshift

➡ Extraction of a new catalog

The COSMOS2015 catalogue

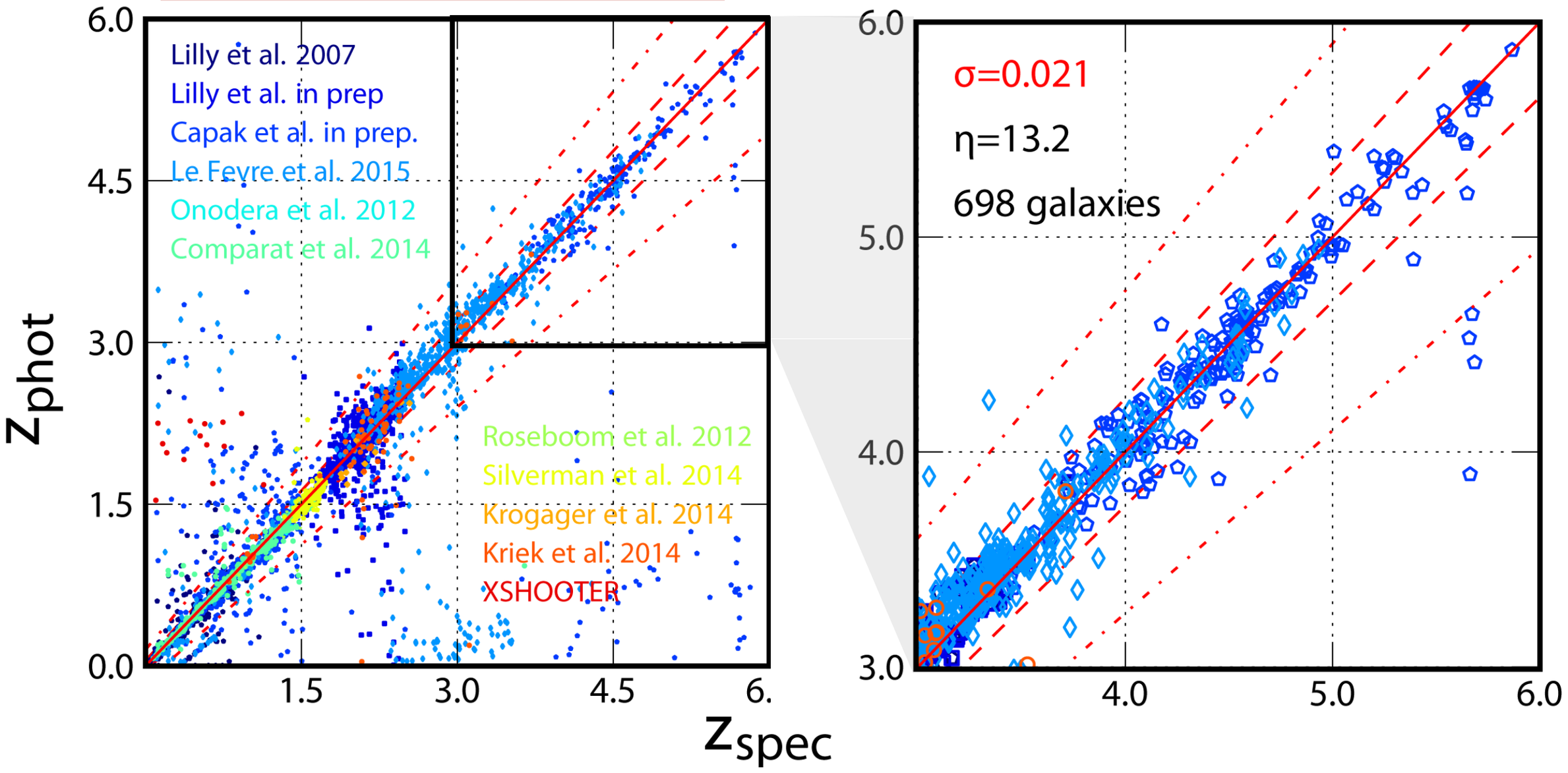
Laigle+16

Photo-z are computed with LePhare (**Arnouts+2002, Ilbert+2006**)

Comparison with spectroscopic redshifts

$\sigma = 0.008$, $\eta = 0.5\%$ at $i^+<21$

$\sigma = 0.021$, $\eta = 13.2\%$ at $z>3$



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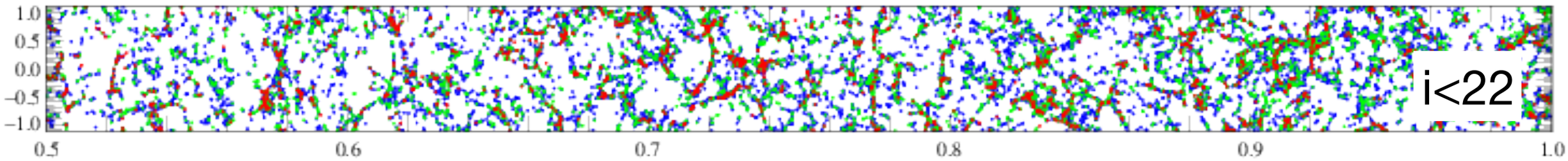

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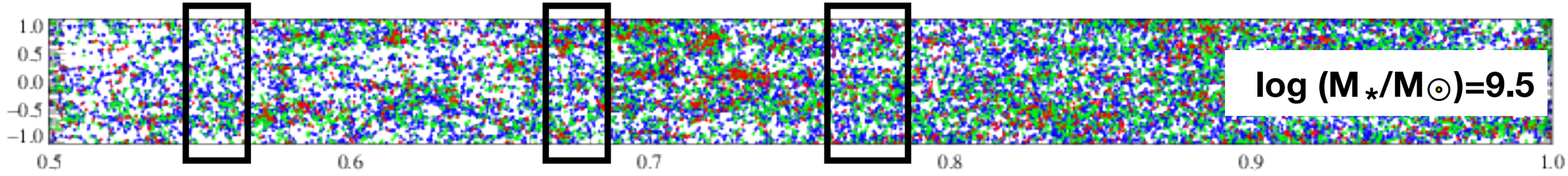
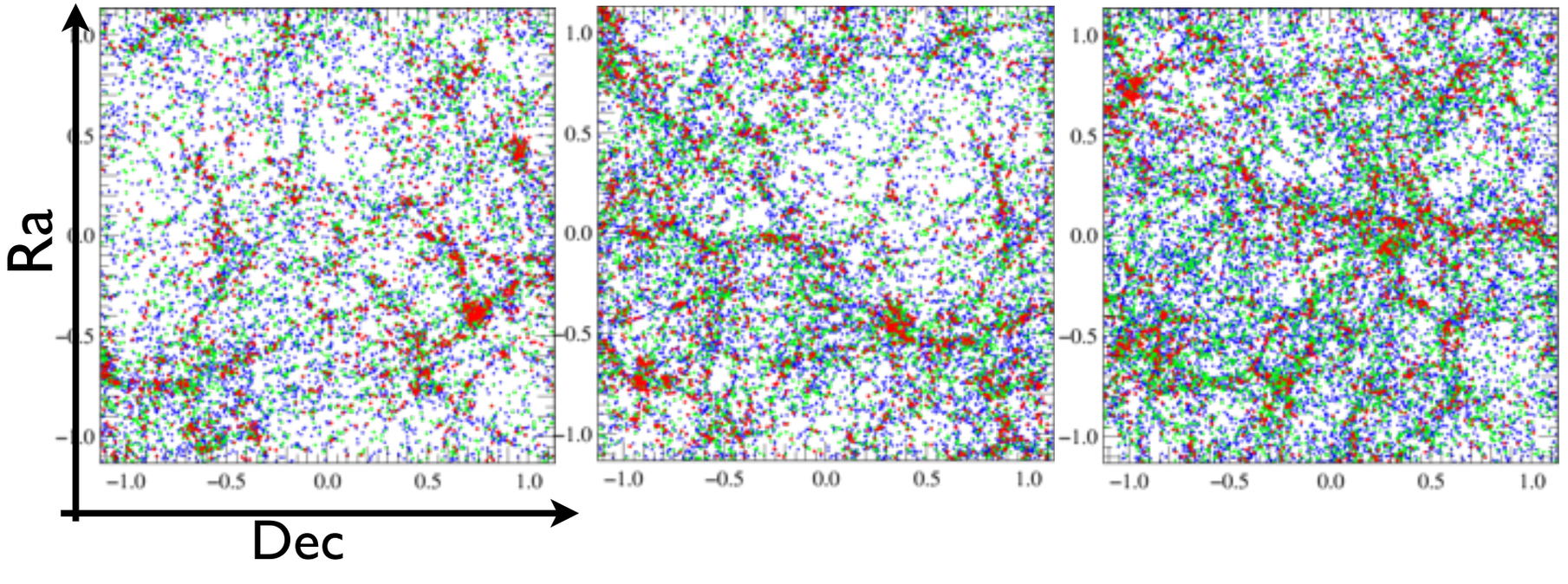




11<log (M*/M⊙)<12

10<log (M*/M⊙)<11

9.5<log (M*/M⊙)<10

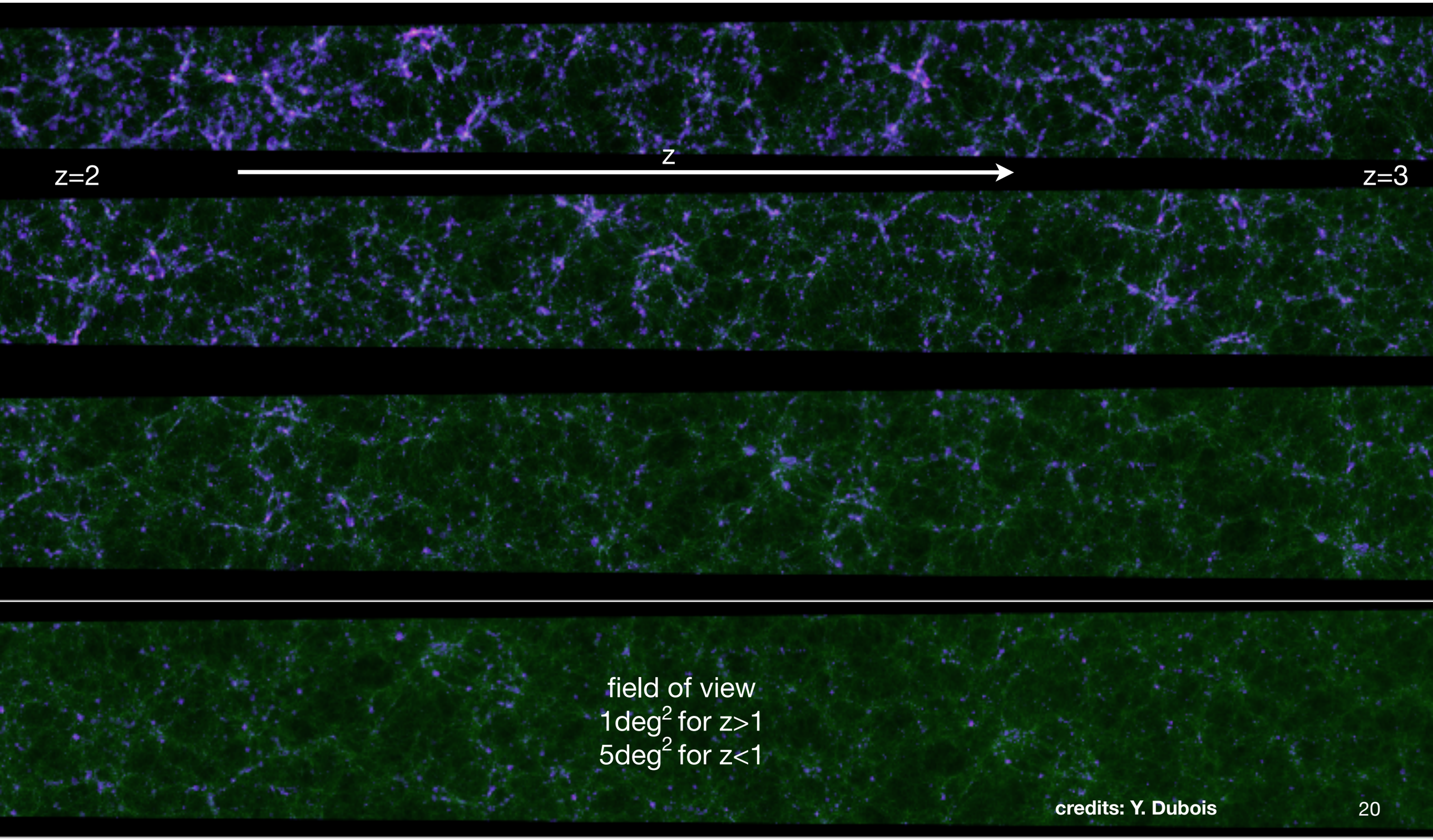
The Horizon-AGN simulation **Dubois+14**

- Run with RAMSES, not calibrated on the local Universe
- Cosmological volume (100 Mpc/h)
- Subgrid physics (below ~1kpc): stellar evolution and feedback, BH formation, BH growth, AGN feedback, gas cooling and heating
- Galaxies and haloes extracted with AdaptaHOP (**Aubert+04**)
- Photometry modeling and spectra production

Horizon-AGN provides realistic galaxy properties, distribution and clustering

The Horizon-AGN ligthcone

Dubois+14

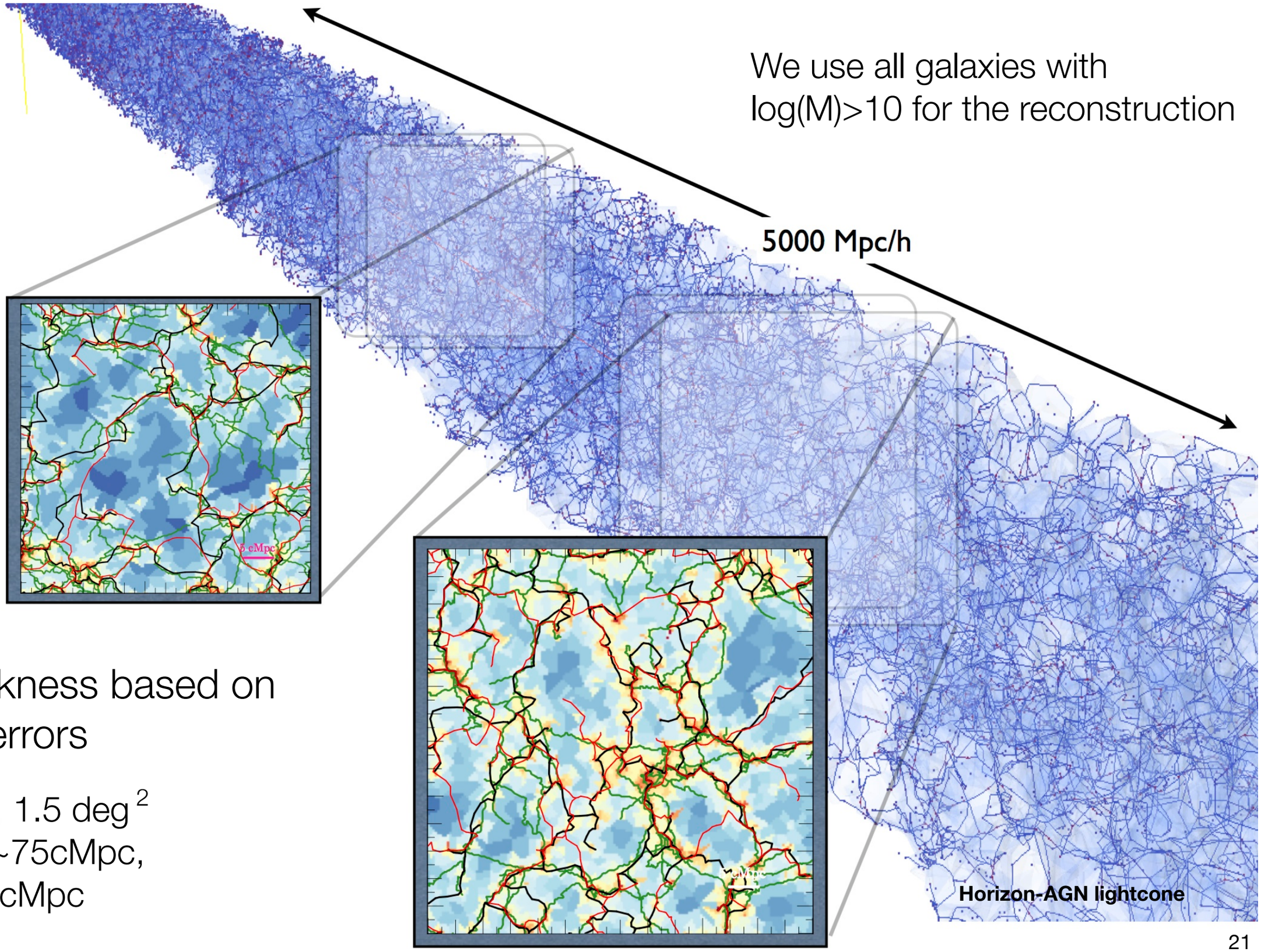


credits: Y. Dubois

Tracing the filaments with COSMOS2015

Laigle+ in prep.

We use all galaxies with log(M)>10 for the reconstruction

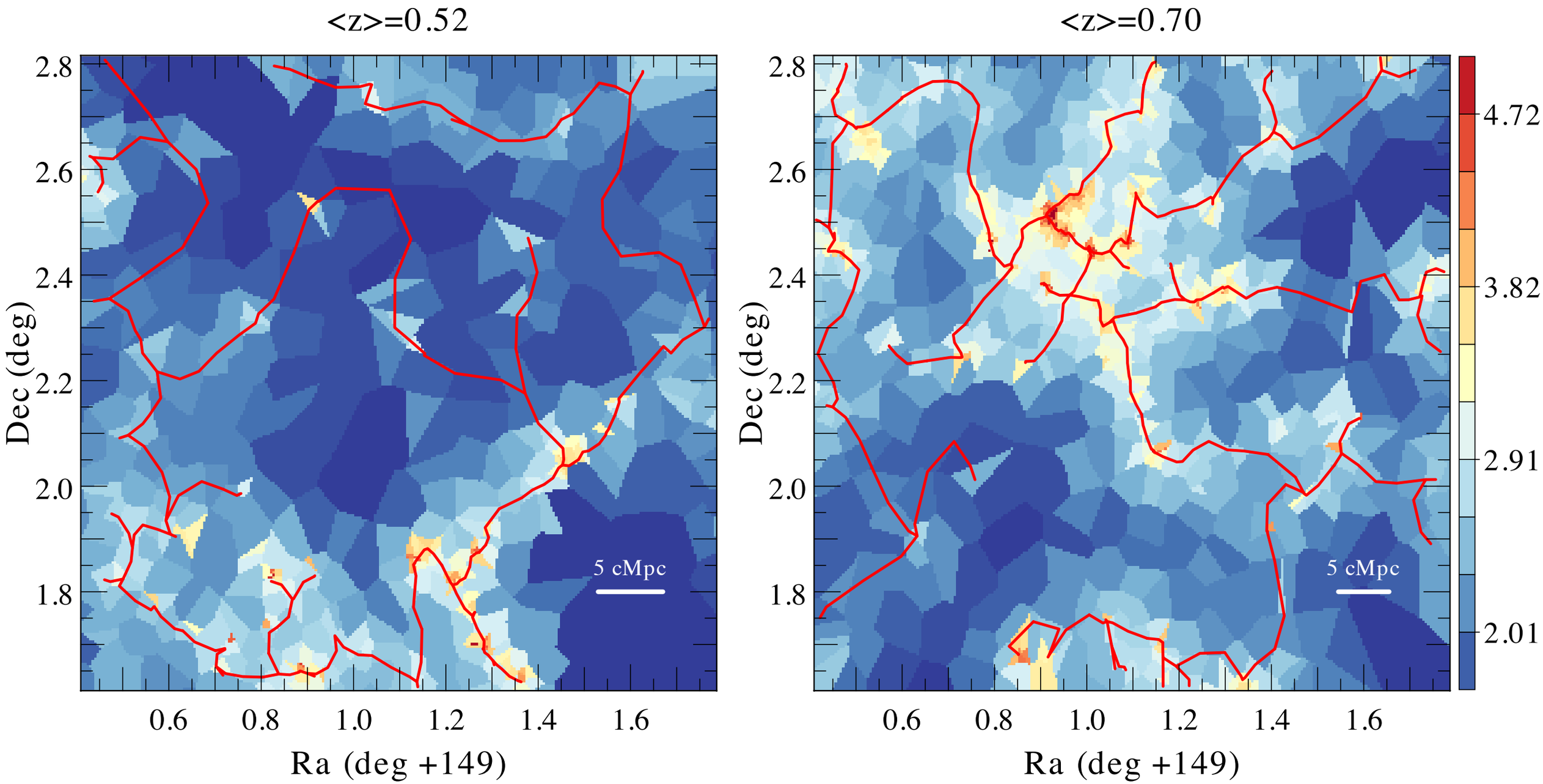


Slice thickness based on photo-z errors

$0.5<z<0.9$, 1.5 deg^2
thickness ~75cMpc,
width ~ 70cMpc

Tracing the filaments with COSMOS2015

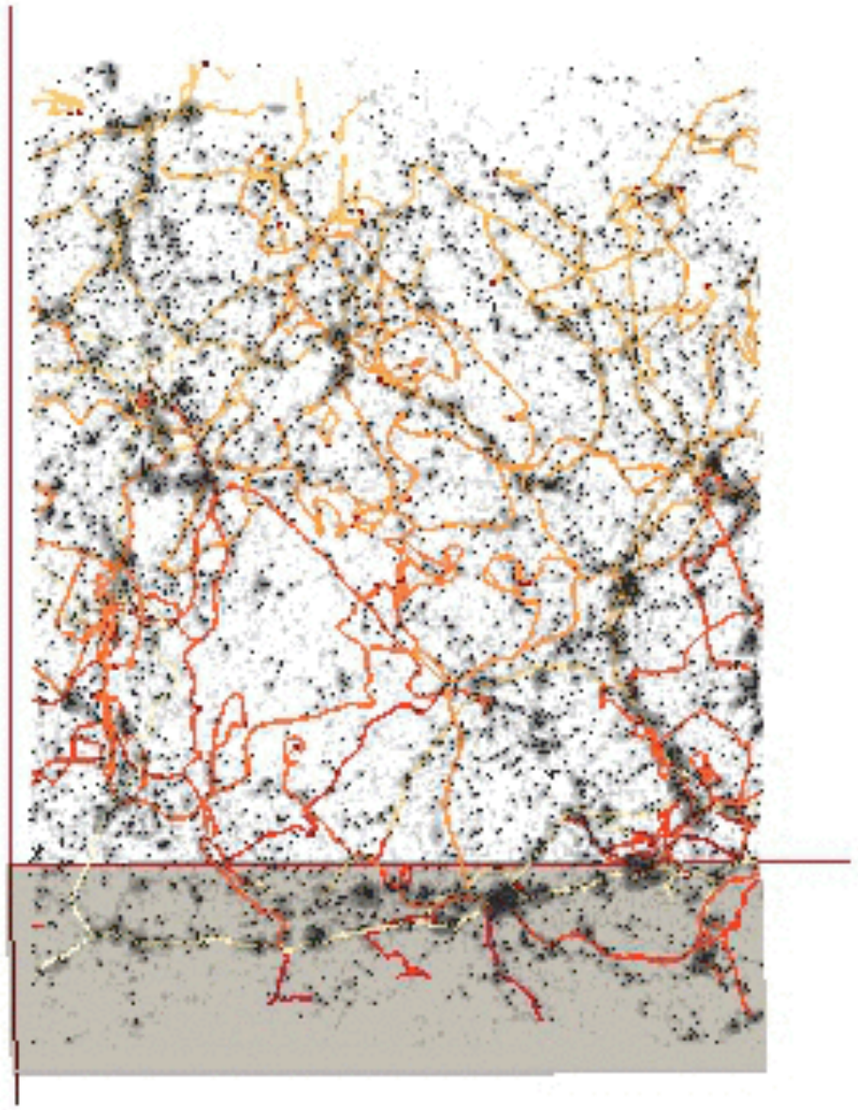
Laigle+ in prep.

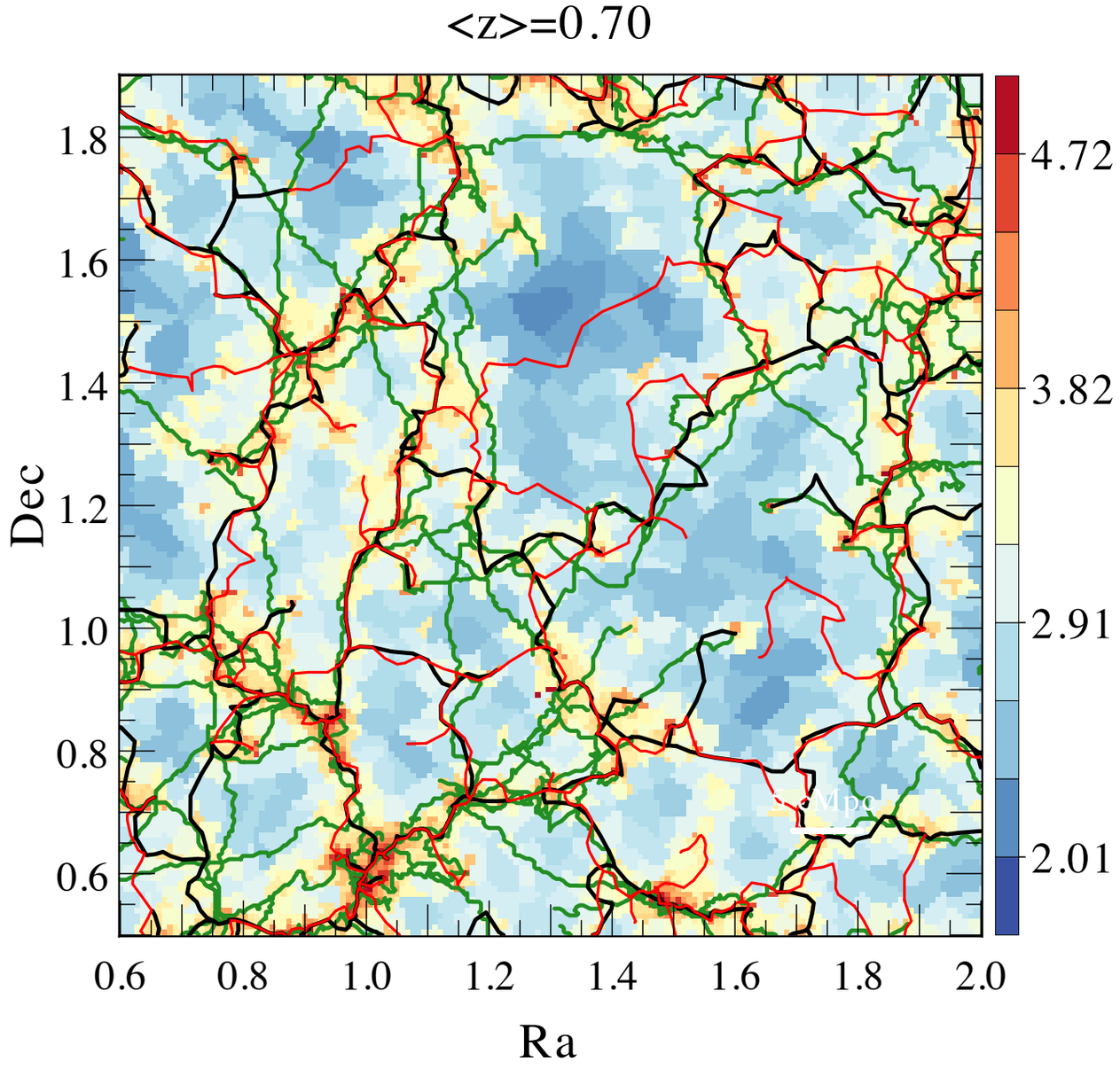


30 slices between 0.5 and 0.9, thickness 75 cMpc, persistence 2 sigma

Reliability of the 2D skeleton

Laigle+ in prep.





Tests on the Hz-AGN lightcone

projected 3D skeleton
2D skeleton from true redshift
2D skeleton from photo-z

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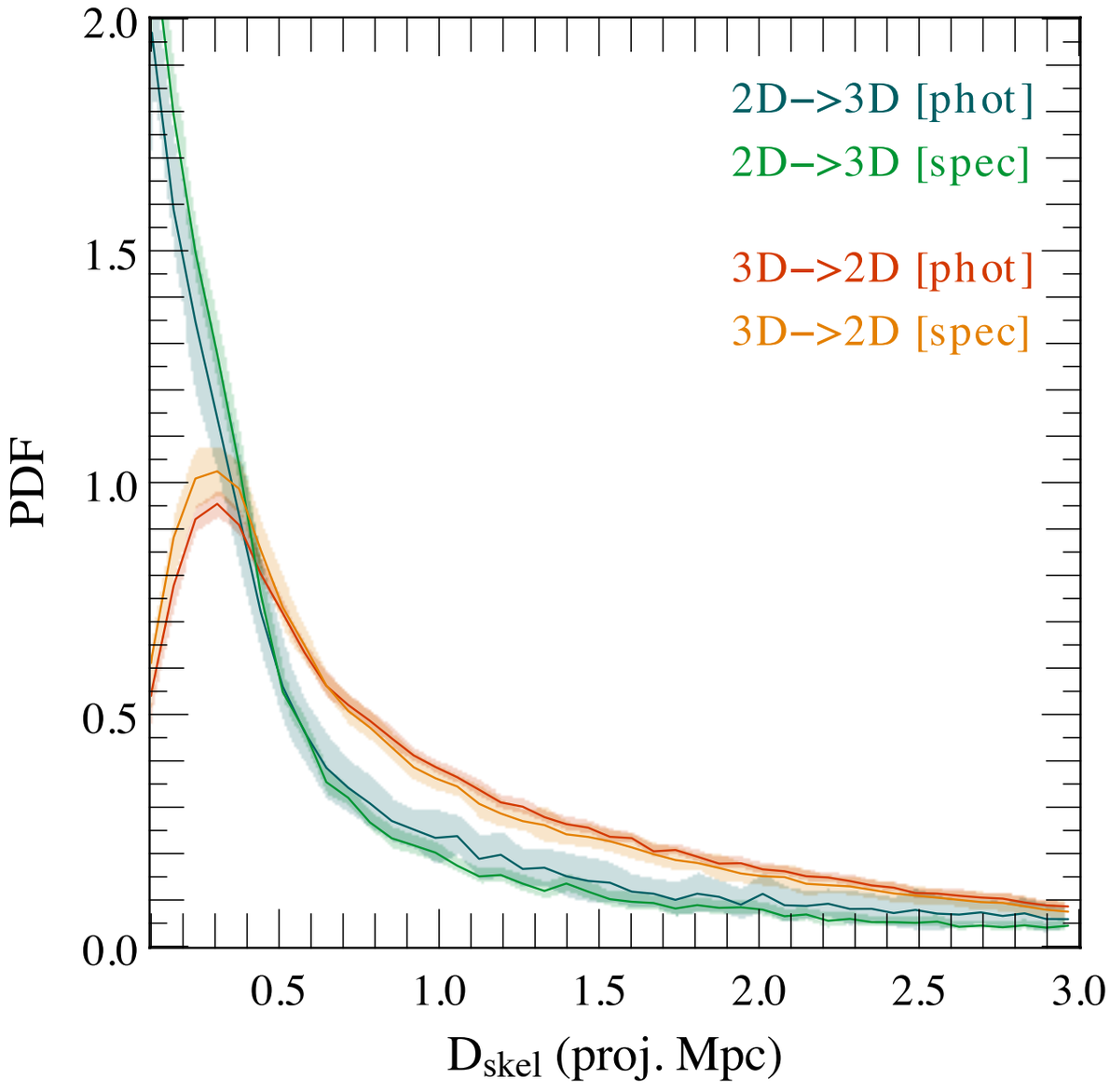

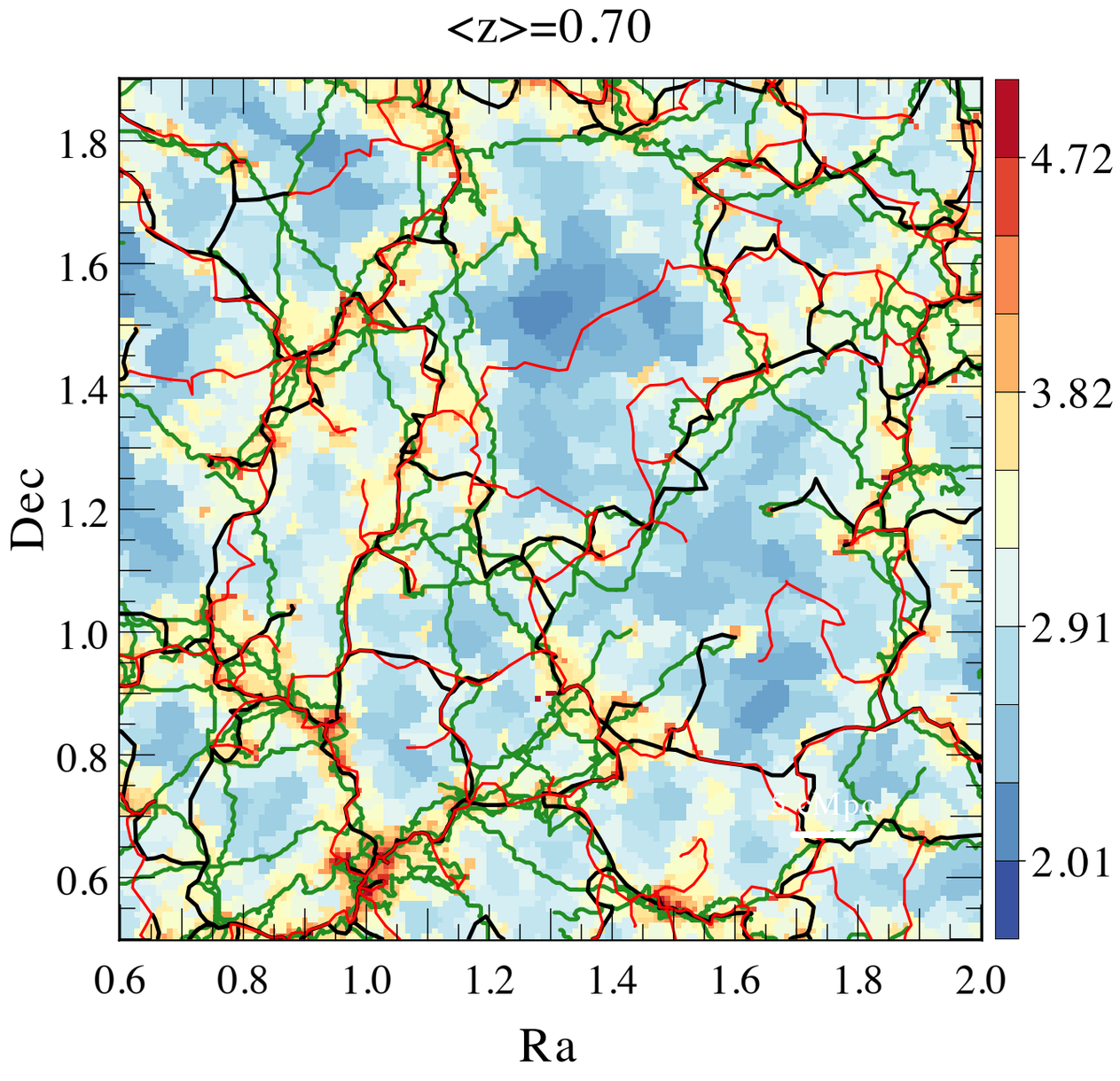

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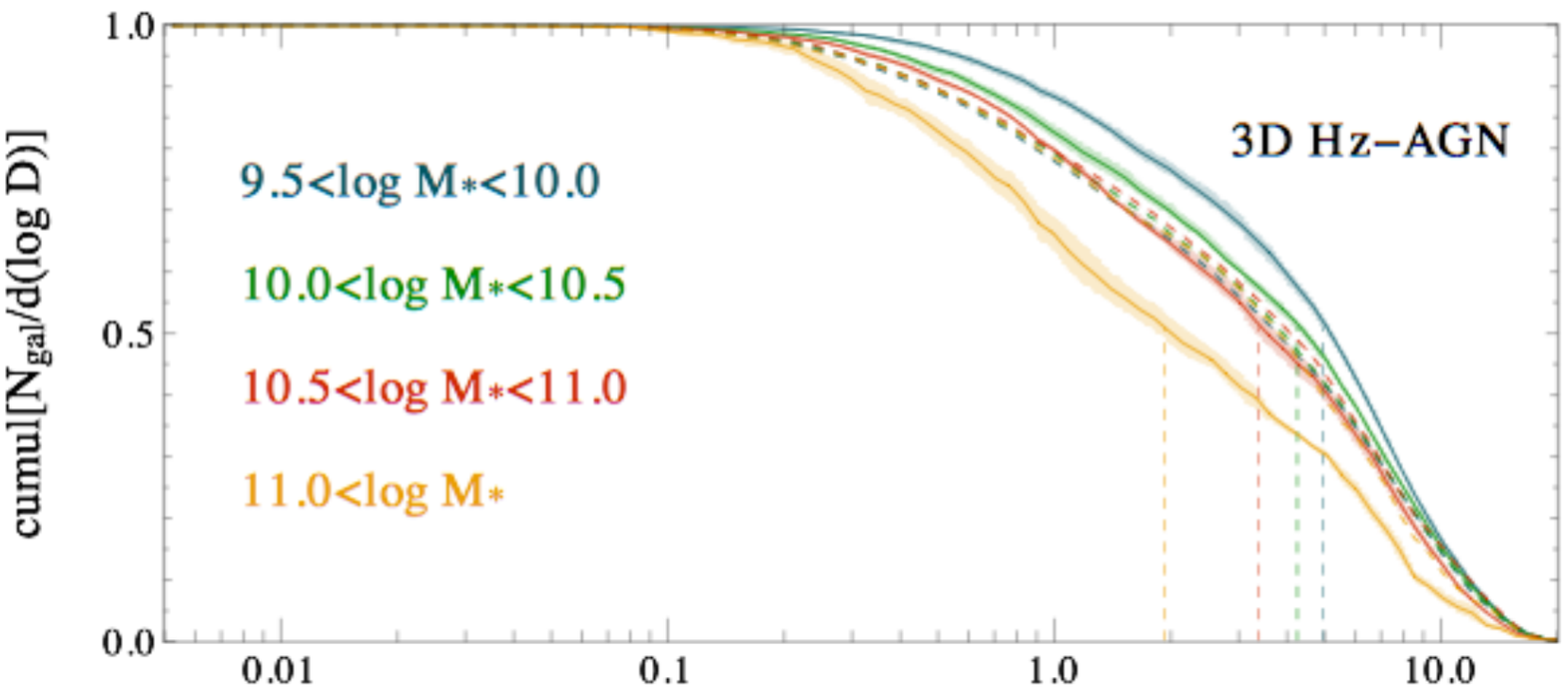
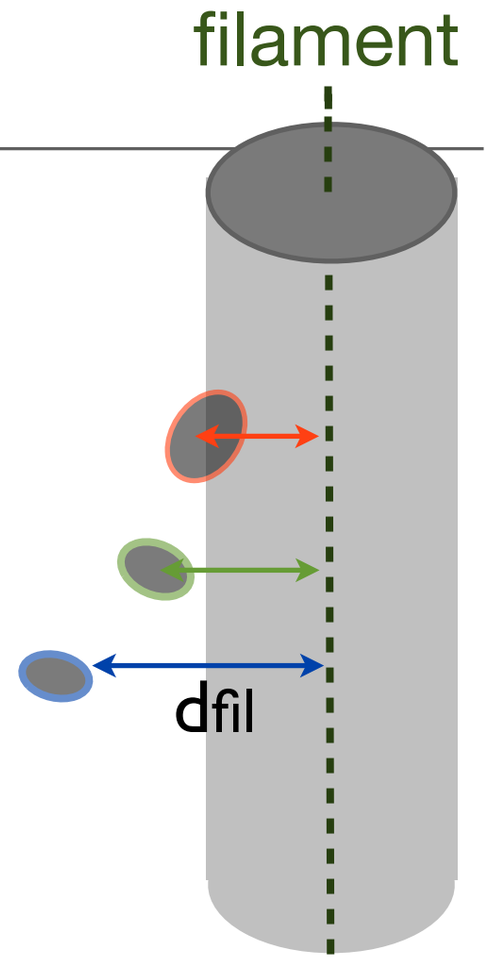
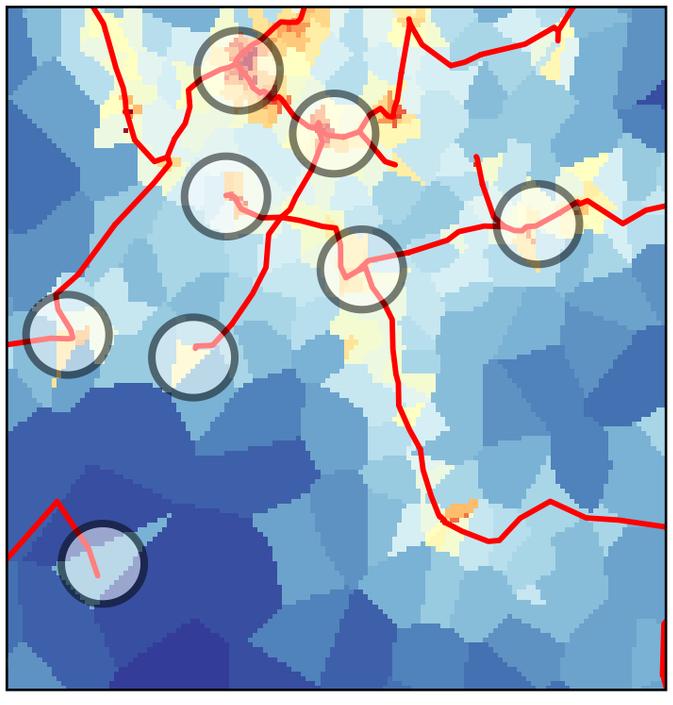
Mass gradients in 3D



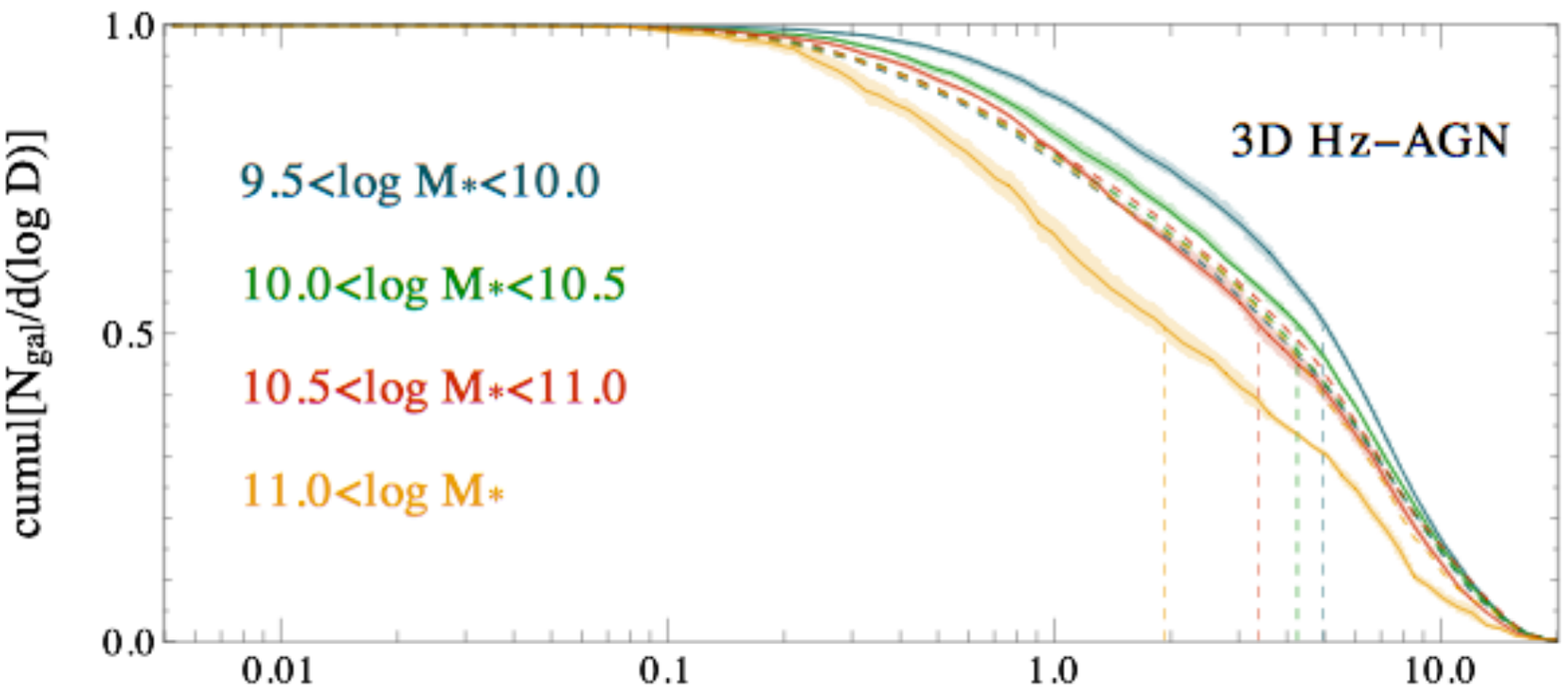


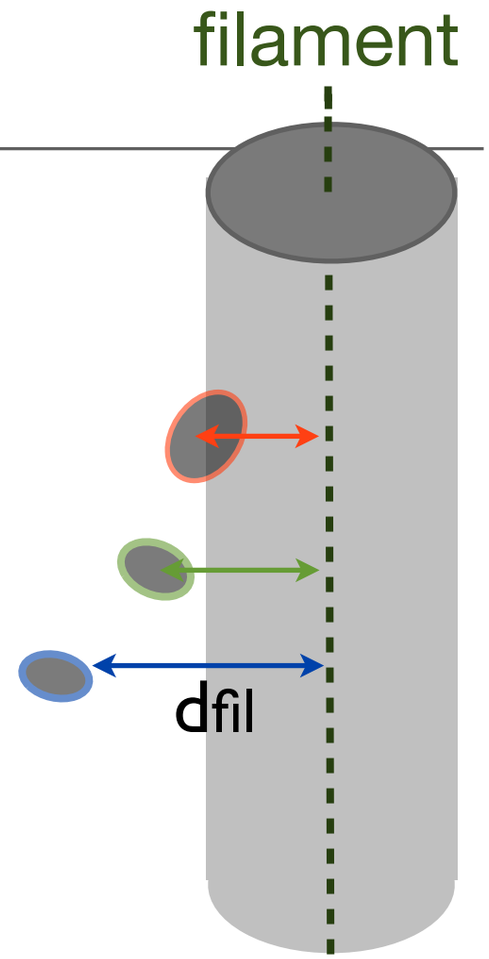


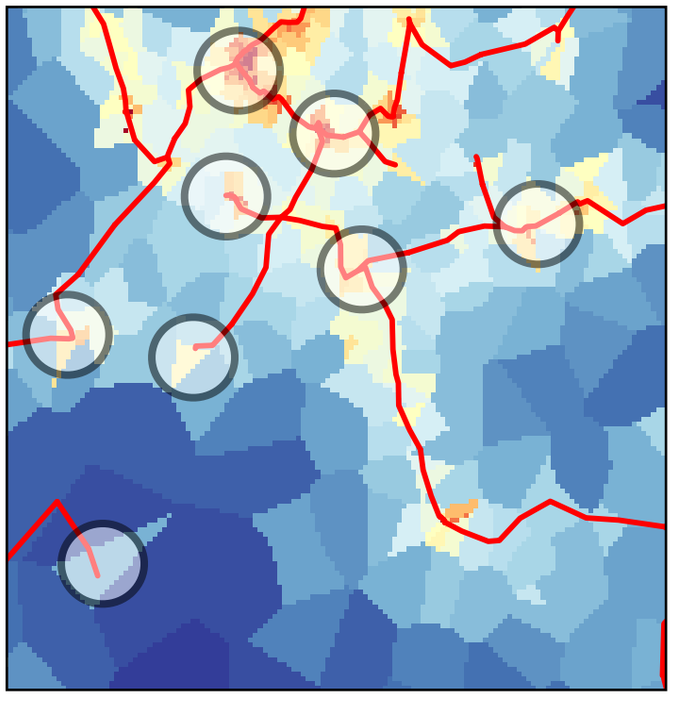
- Galaxies in the vicinity of nodes are removed from the analysis
- Each galaxy is down-weighted by the inverse of the density

➡ We measure an effect specific to the filaments

Mass gradients in 3D



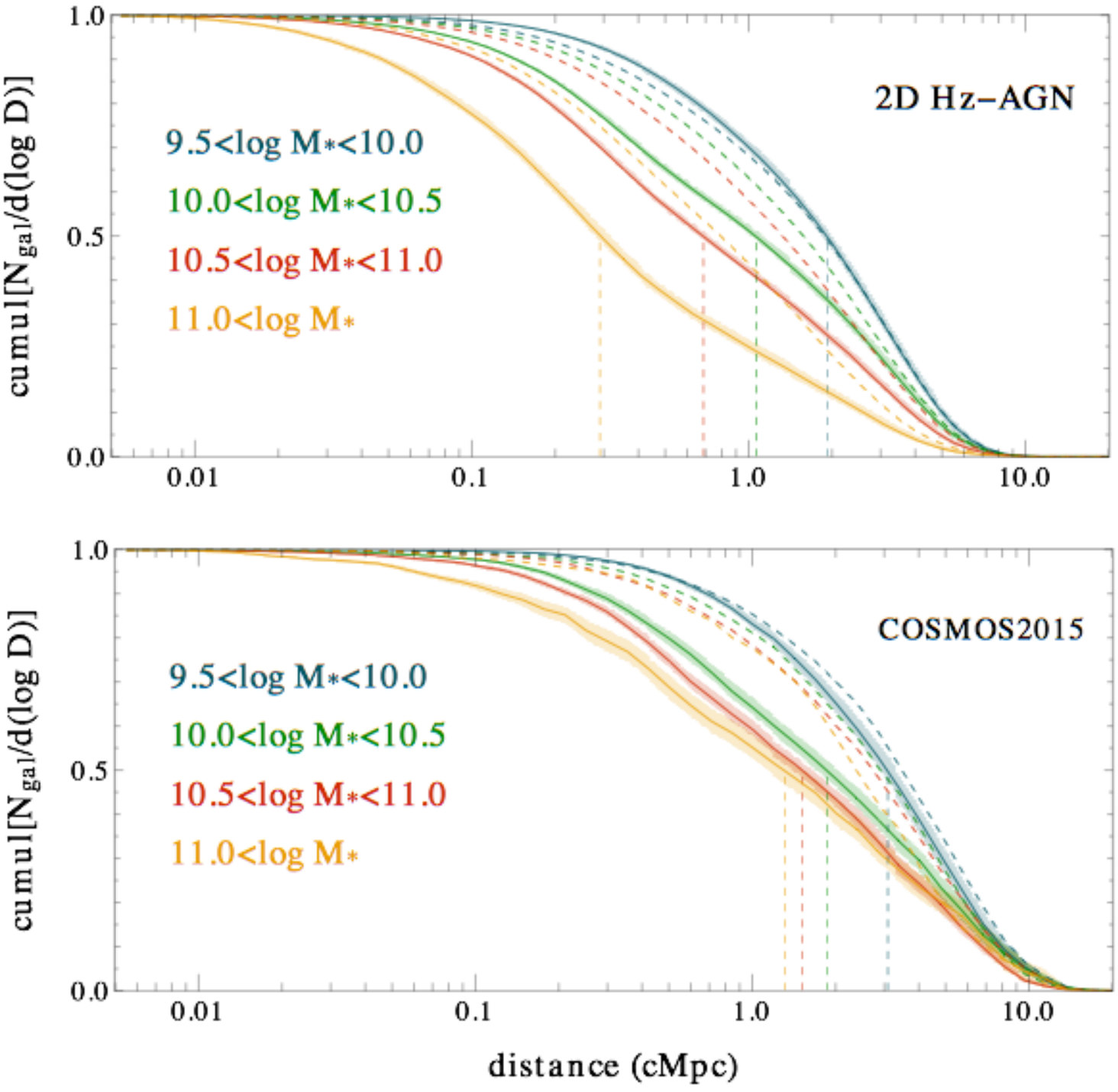


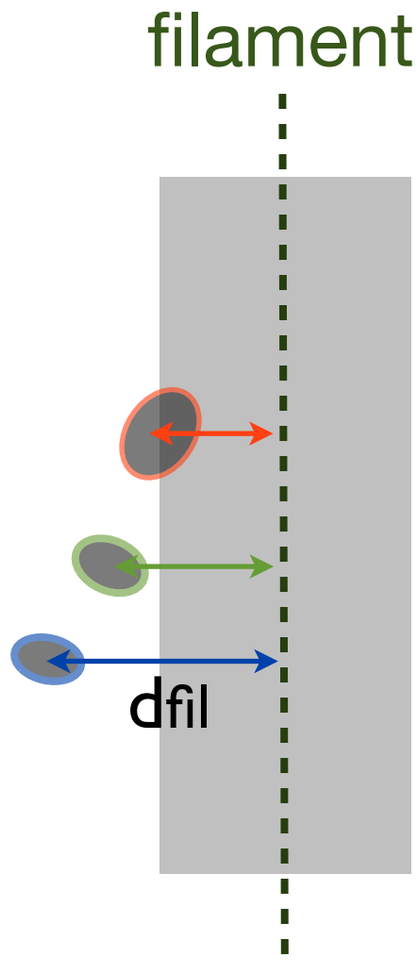


Can we measure it in projected 2D slices of thickness 75 cMpc with photometric redshifts and masses?

Mass gradients in 2D

Laigle+ in prep.





The contribution of node is down-weighted

Mass gradients towards filament found in 2D in simulated and observed data

Mass gradients in 2D

Galaxies with a background density of

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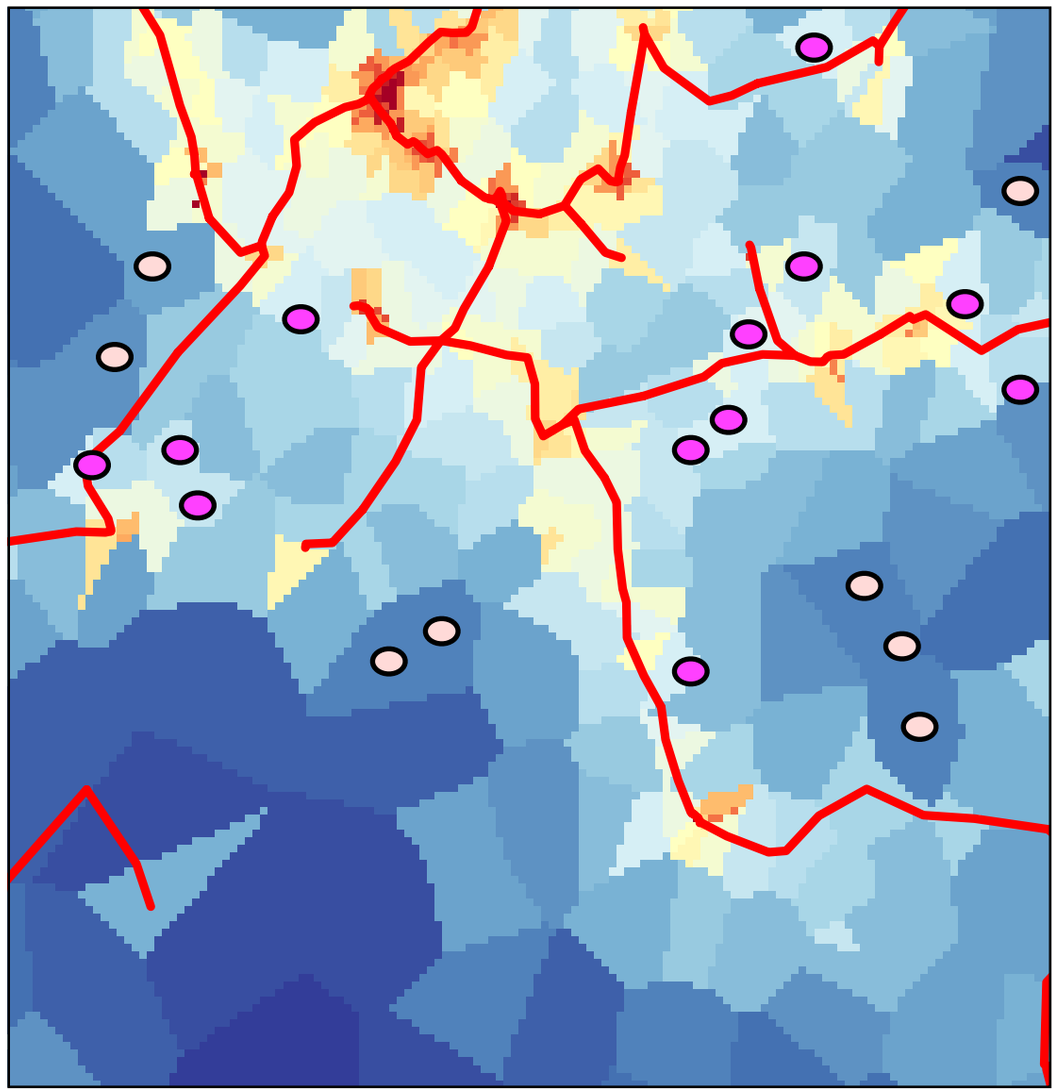
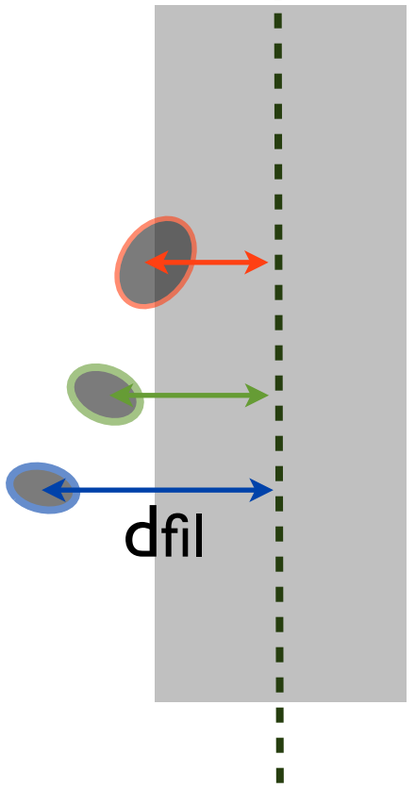


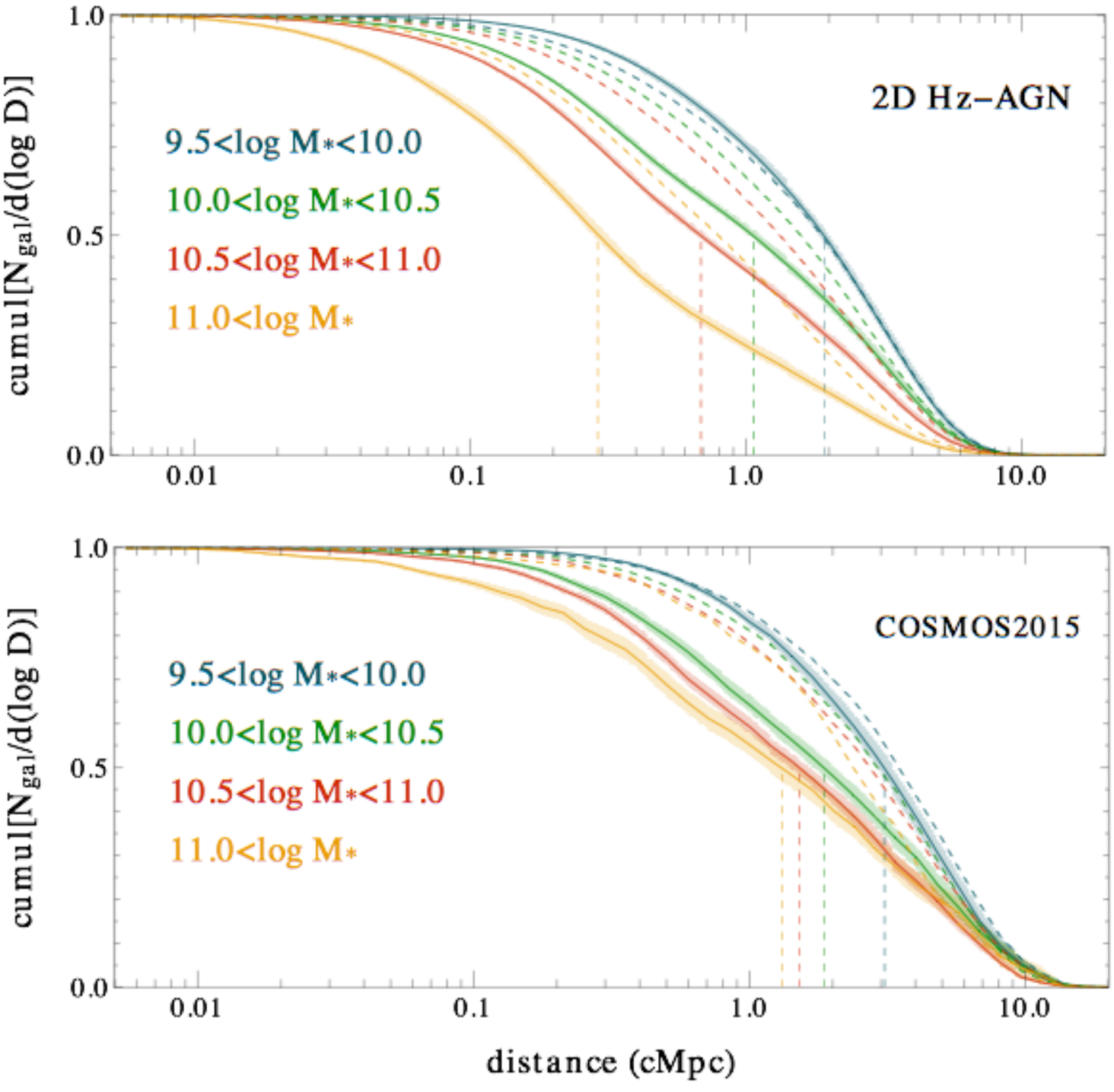
Mass gradients towards filaments: Is it an effect purely driven by the local mass-density relation?

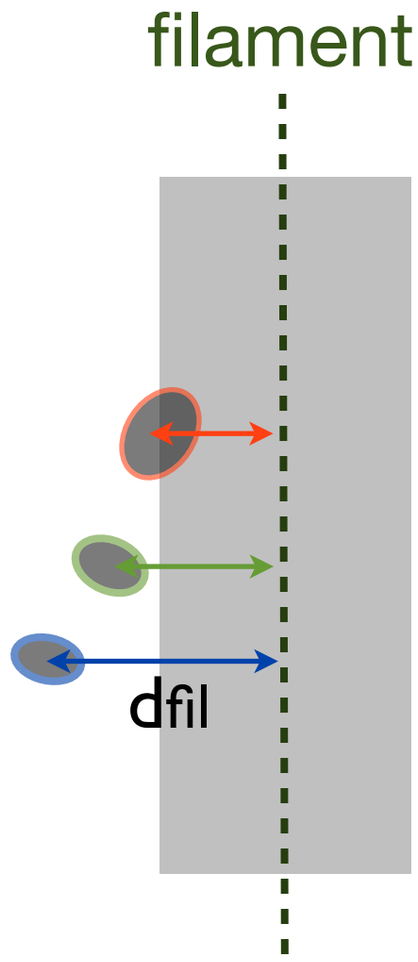


Reshuffling of galaxy masses w.r.t positions in given density bins (preserving the mass-density relation)

Mass gradients in 2D

Laigle+ in prep.

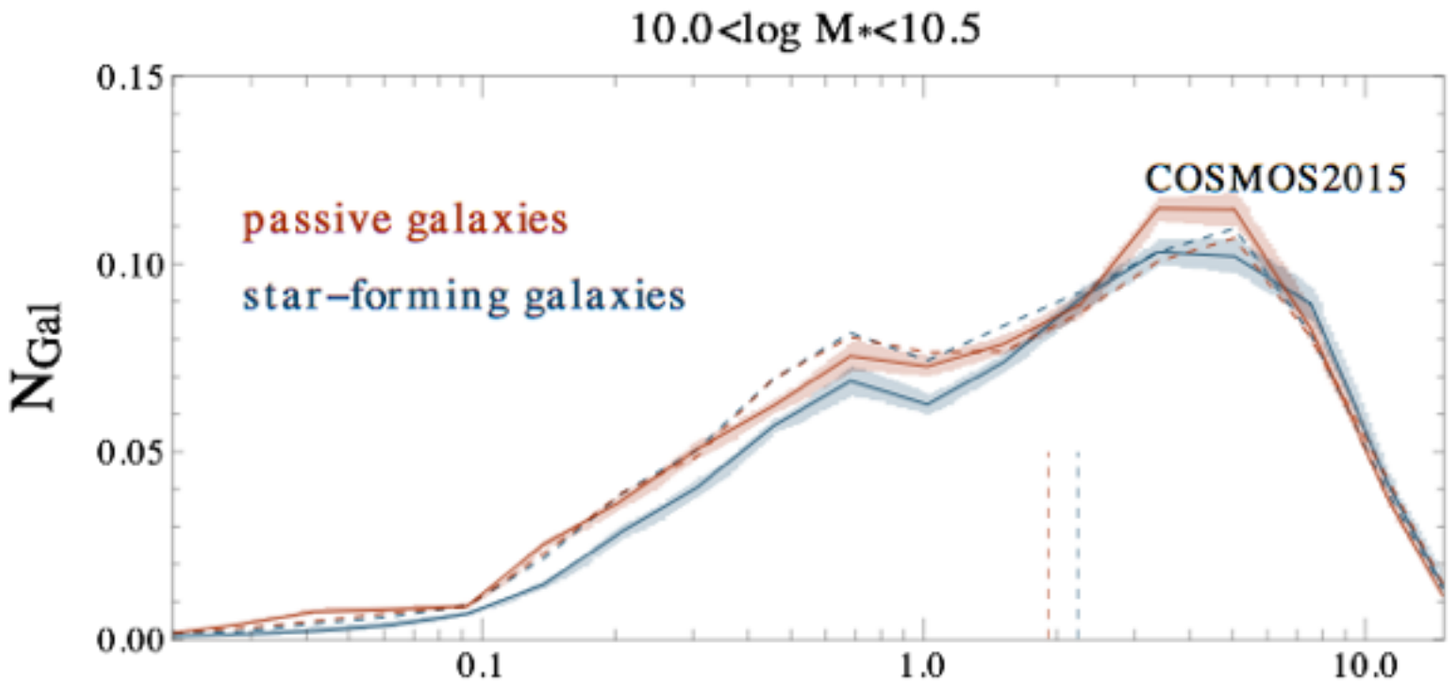


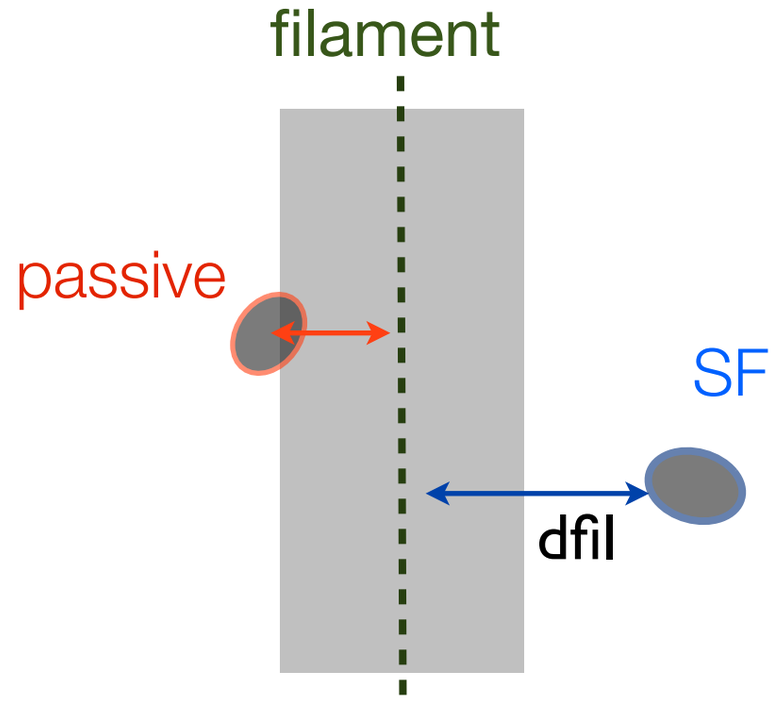


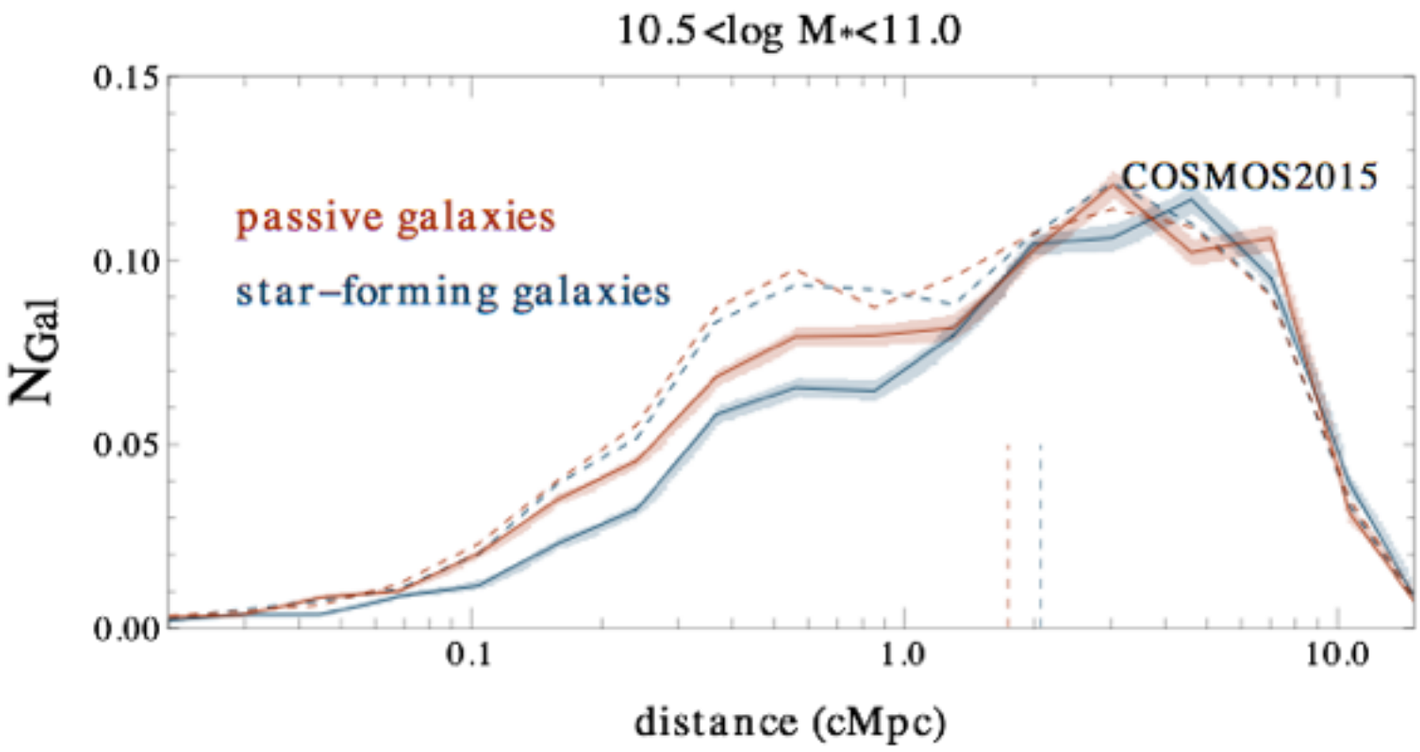
The contribution of node is down-weighted

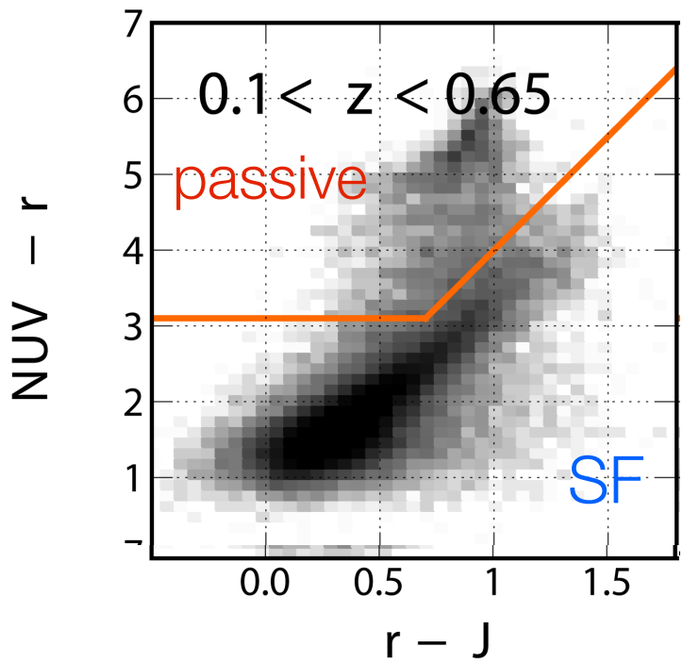
Mass gradients are partly explained by the local mass-density relation

Colors-type gradients in COSMOS2015









At a fixed mass, passive galaxies closer to filaments than star forming

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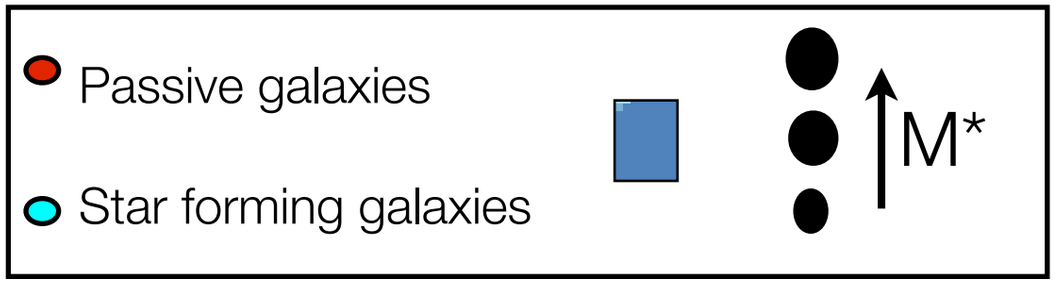
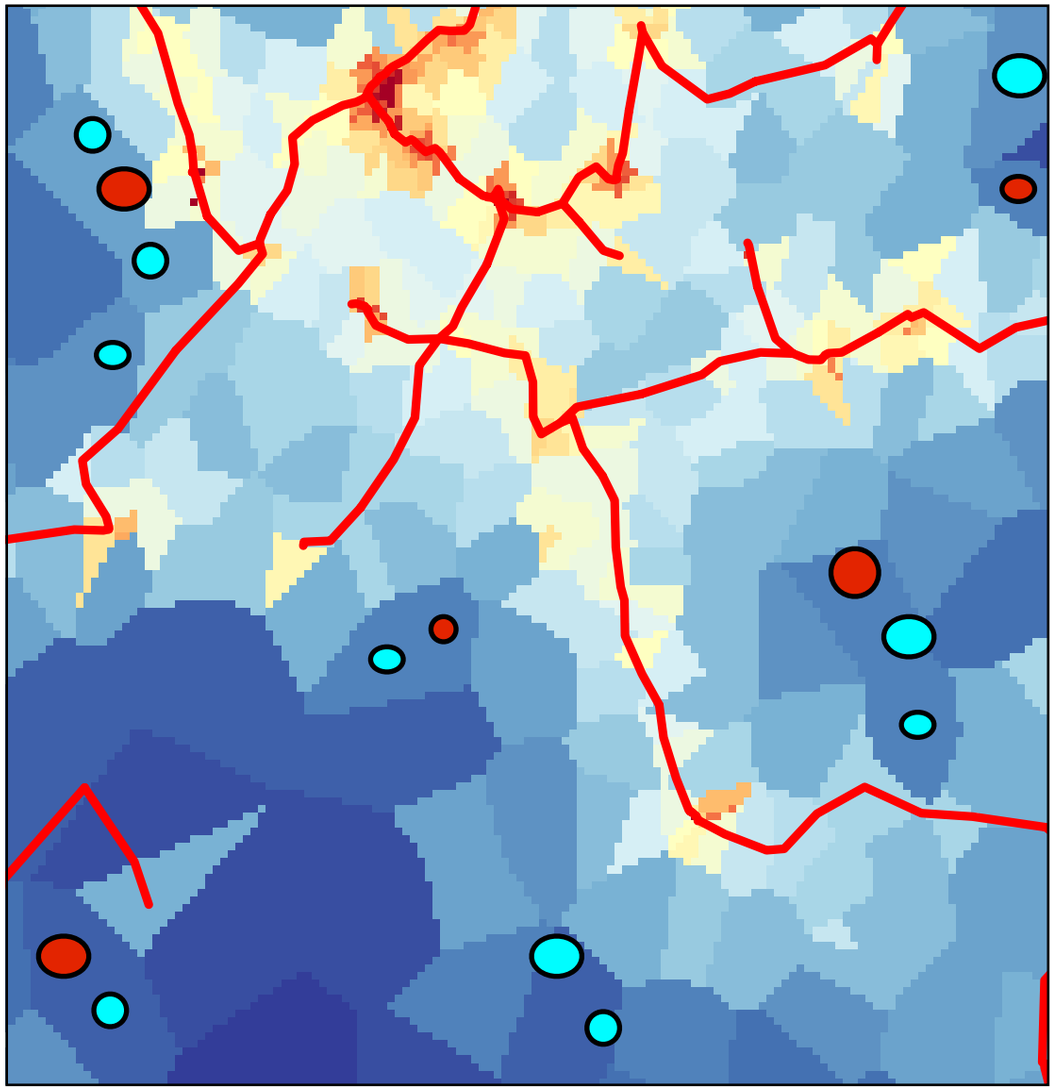
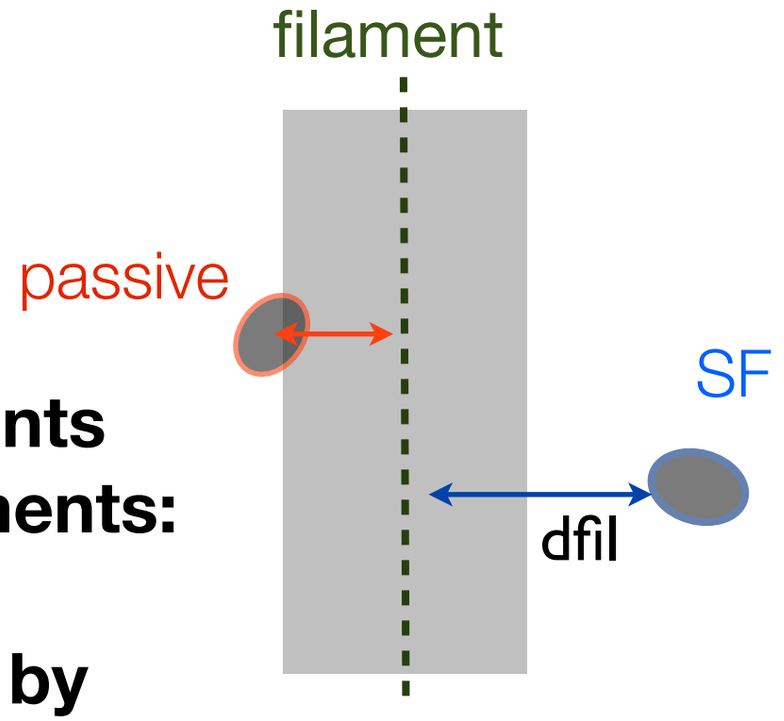


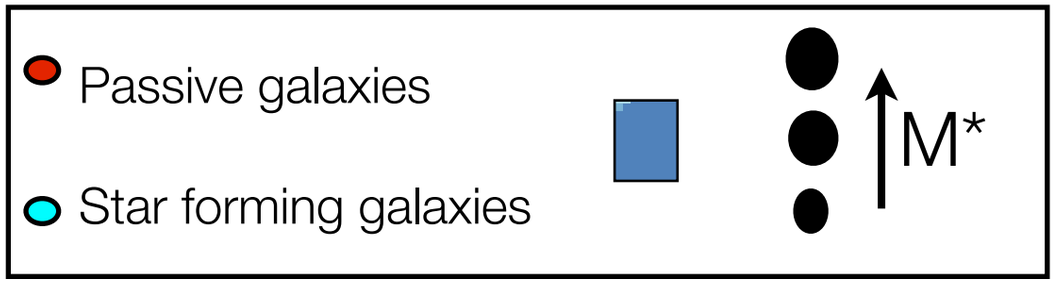


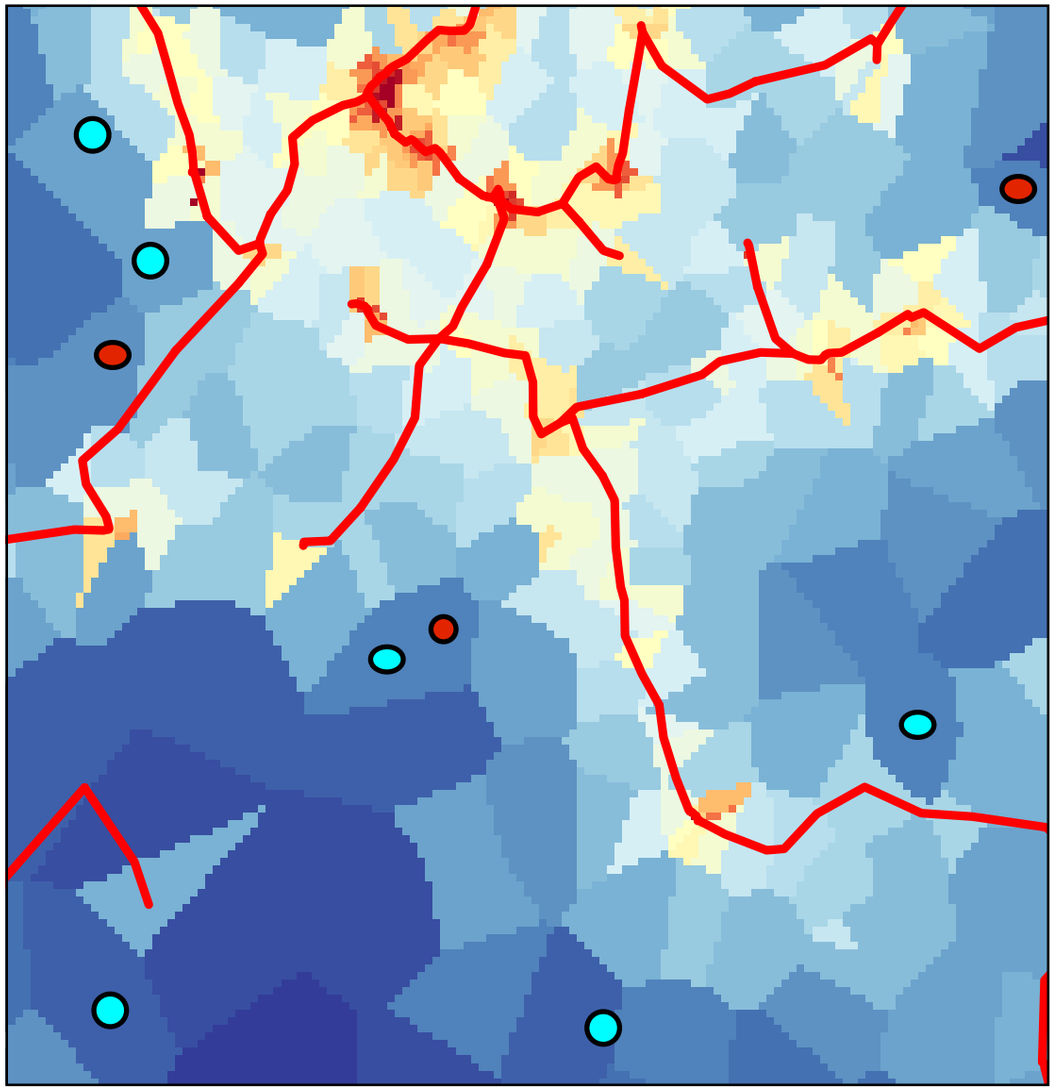


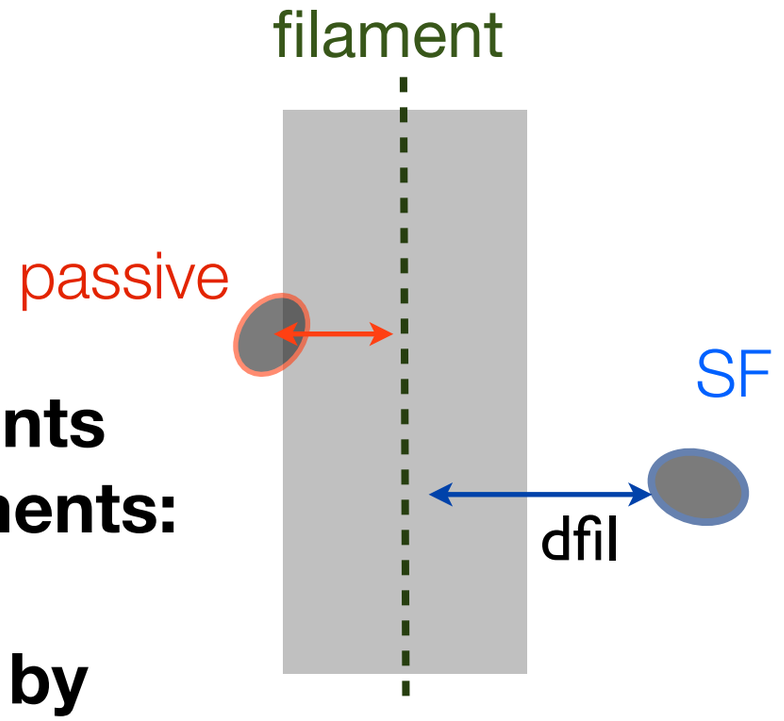
colour gradients towards filaments: Is it an effect purely driven by the local density?

Reshuffling of galaxy types w.r.t positions
in given density and mass bins
(preserving the mass-density relation)

Colors-type gradients in COSMOS2015







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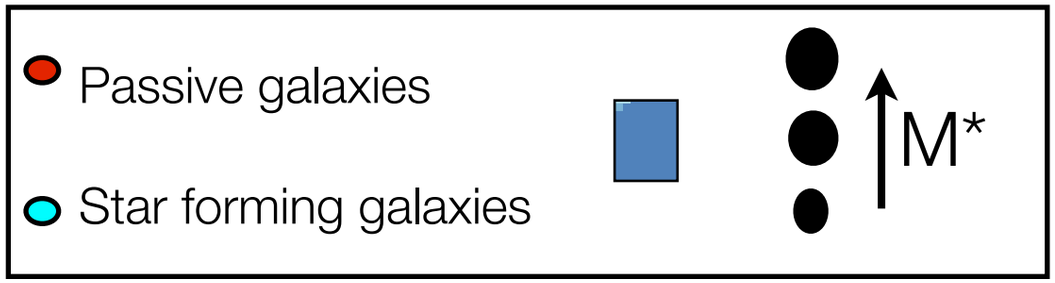

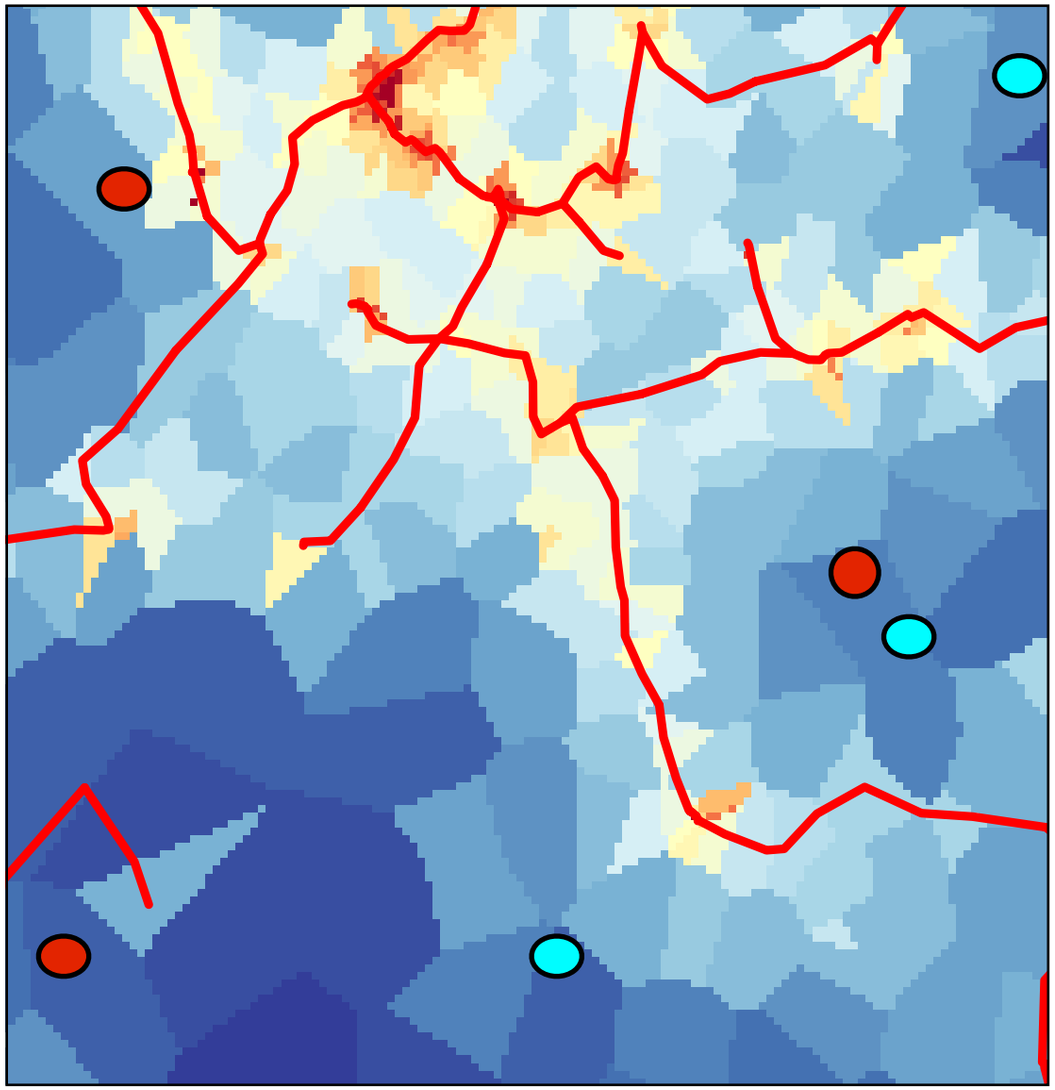

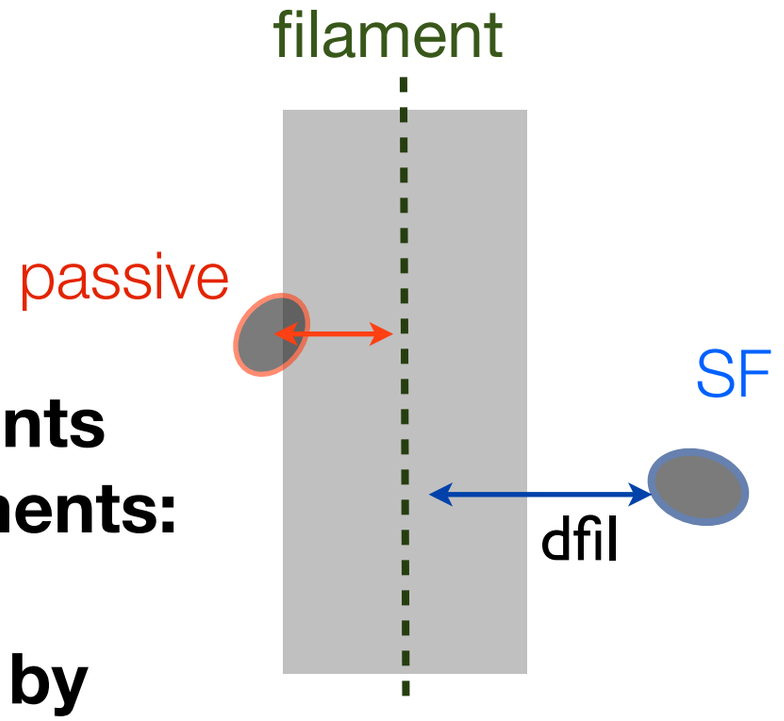

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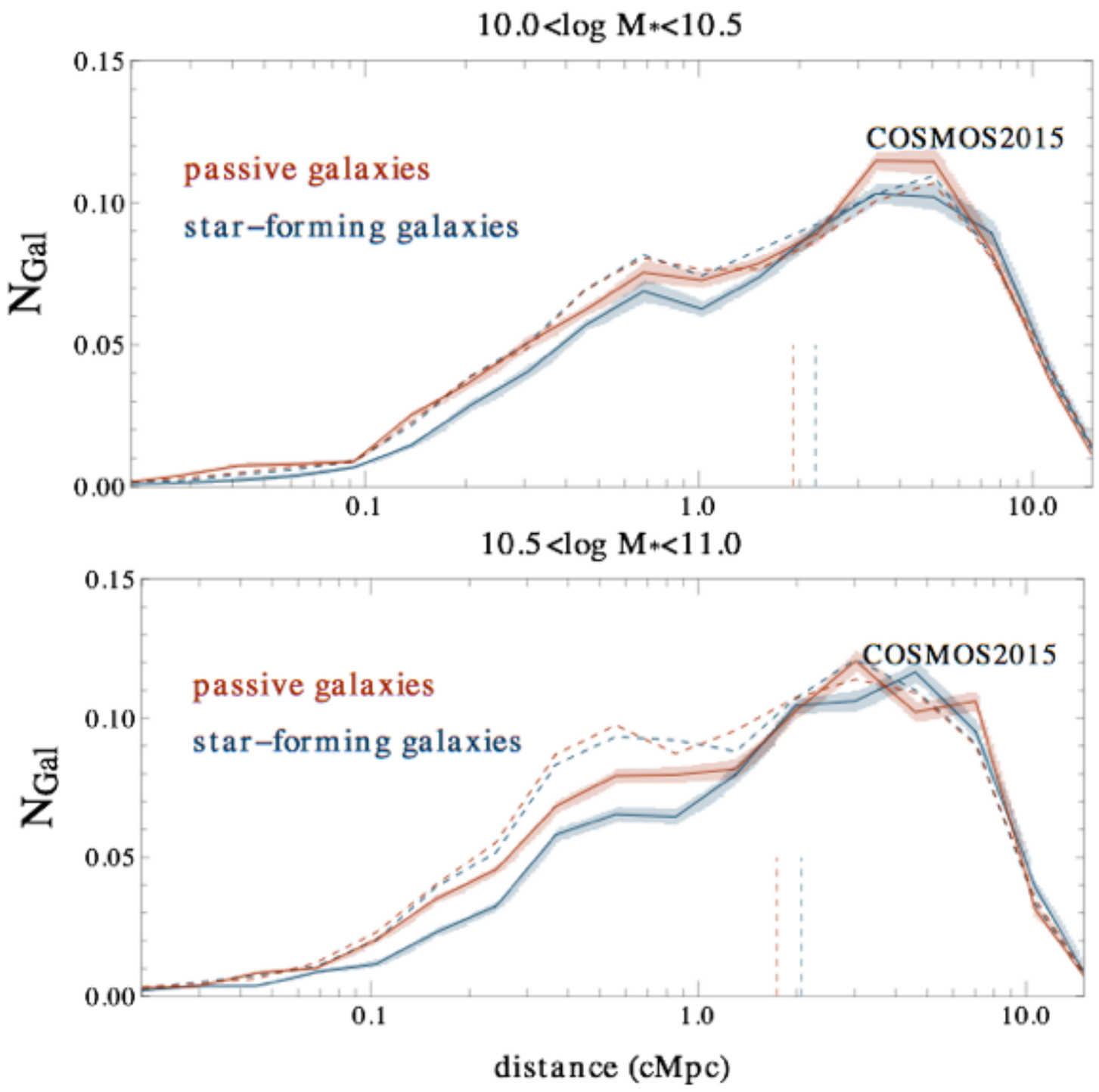
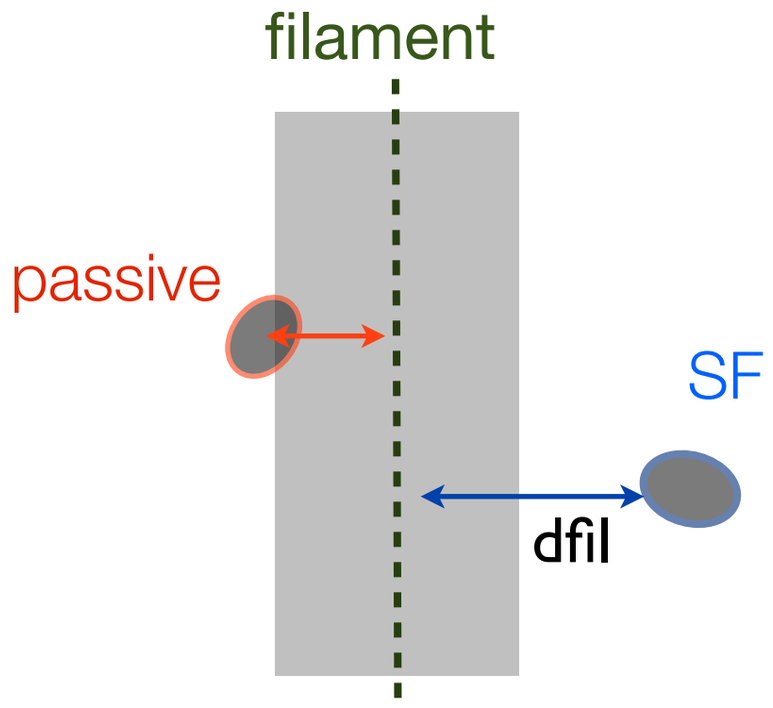




No trend detected for the reshuffled galaxies

The gradients are driven by the geometry of the cosmic web

At a fixed mass, passive galaxies closer to filaments than star forming

SUMMARY

1) We are able to extract reliably the cosmic web in 2D with photometric redshift and to measure an environmental signal

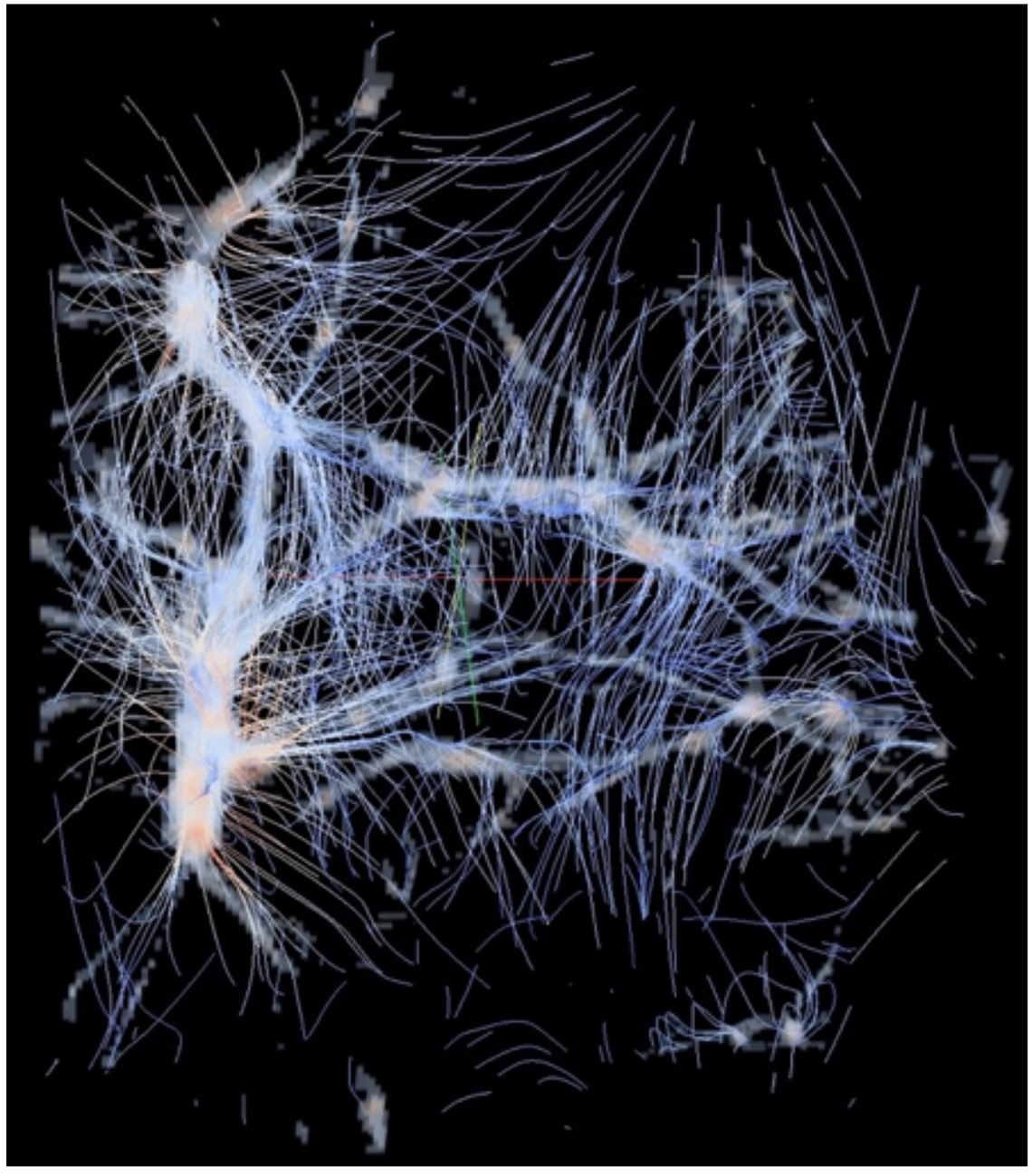
2) We find mass and colour-type gradients towards filaments for galaxies both in the simulations and in the observations

3) Those gradients can not be explained by the local density itself.

➡ **Crucial: the anisotropy of the environment**

Large-scale tidal field impacts both

halo/galaxy dynamics and galaxy mass assembly. Galaxy dynamics impacts star formation via the geometry of the gas inflow?



Next step:

Redshift evolution of the signal? Intrinsic alignment signal in 2D?