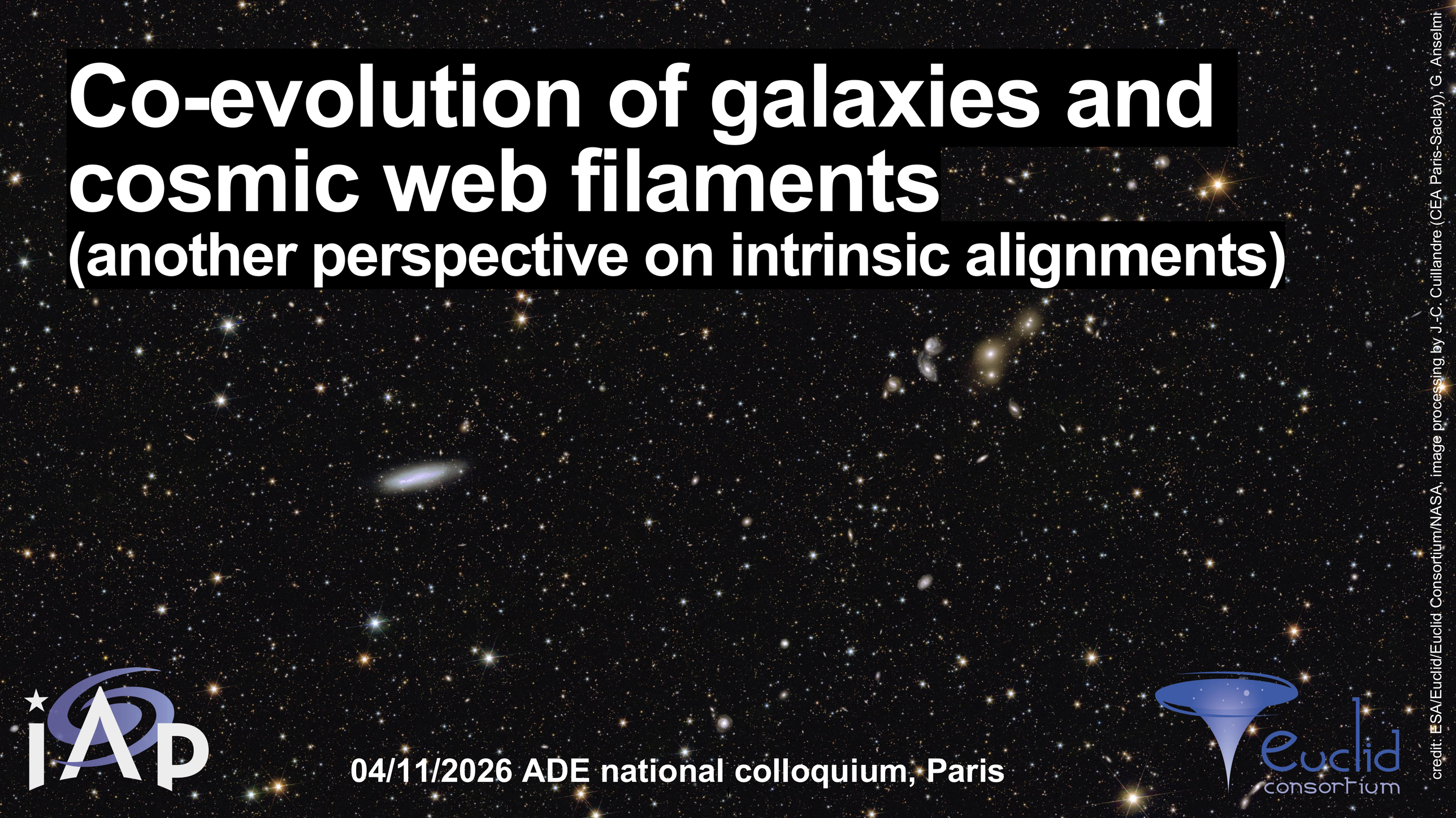
Co-evolution of galaxies and cosmic web filaments
(another perspective on intrinsic alignments)



04/11/2026 ADE national colloquium, Paris

credit: ESA/Euclid/Euclid Consortium/NASA, image processing by J.-C. Cuillandre (CEA Paris-Saclay), G. Anselmi



credit: ESA/Euclid/Euclid Consortium/NASA, image processing by J.-C. Cuillandre (CEA Paris-Saclay), G. Anselmi

Euclid: Measuring shapes for 1.5 billion galaxies (14000 deg^2)

See talk by M Sauvage

Shear power in tomographic redshift slices ➔ cosmological parameters

12 november 2026: DR1 Foundation: 1900 deg^2 of the Euclid Wide Survey

Euclid: Measuring shapes for 1.5 billion galaxies (14000 deg^2)

See talk by M Sauvage

Shear power in tomographic redshift slices ➔ cosmological parameters

We want to meet accuracy of $\sigma(w_0) = 0.01$ and $\sigma(w_a) = 0.1$

The error on w scales roughly as $\frac{\Delta w}{w} \approx 10 \frac{\Delta \gamma}{\gamma}$.

Weak Lensing: $\gamma \sim 0.01$.

This means that we have to measure shear to an accuracy and precision of $\sim 10^{-5}$. tiny!!!

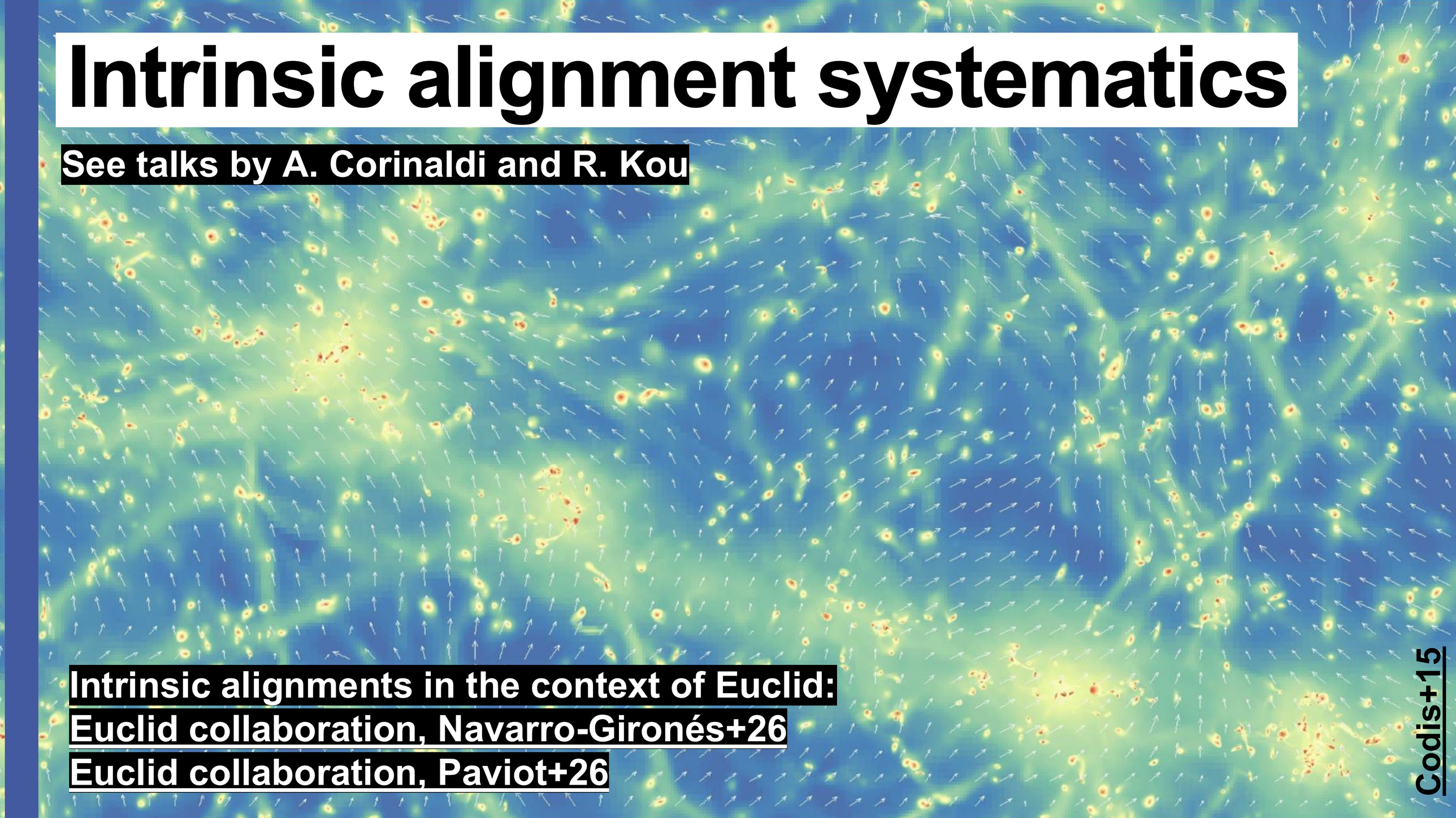
Statistical precision: $\frac{\Delta \gamma}{\gamma} \approx \frac{\sigma_e}{\gamma \sqrt{N}}$ where $\sigma_e \approx 0.3$ is the shape noise. We need $N = 10^9$ galaxies.

Error budget will be dominated by systematics

From a slide by A. Taylor

Intrinsic alignment systematics

See talks by A. Corinaldi and R. Kou



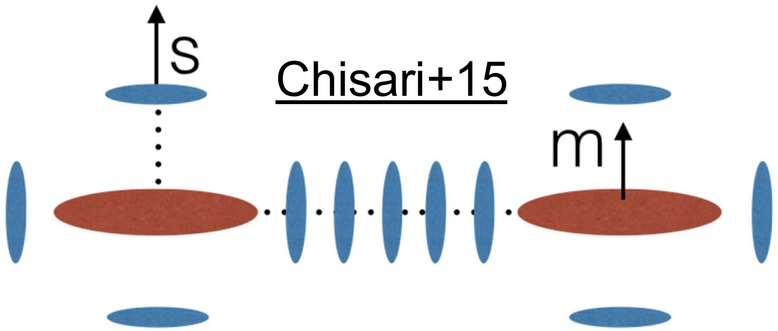
Intrinsic alignments in the context of Euclid:
Euclid collaboration, Navarro-Gironés+26
Euclid collaboration, Paviot+26

Codis+15

Intrinsic alignments

Cosmology

Pairwise alignments of galaxy shapes



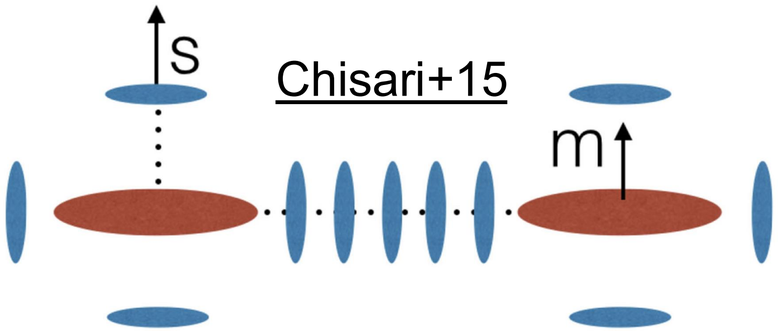
A contaminant for weak lensing analyses
See e.g. Joachimi+15 for a review

Known to depend on:
- Mass
- Galaxy colours
- Galaxy structural properties? e.g. Georgiou+25
- Etc.

Intrinsic alignments

Cosmology

Pairwise alignments of galaxy shapes

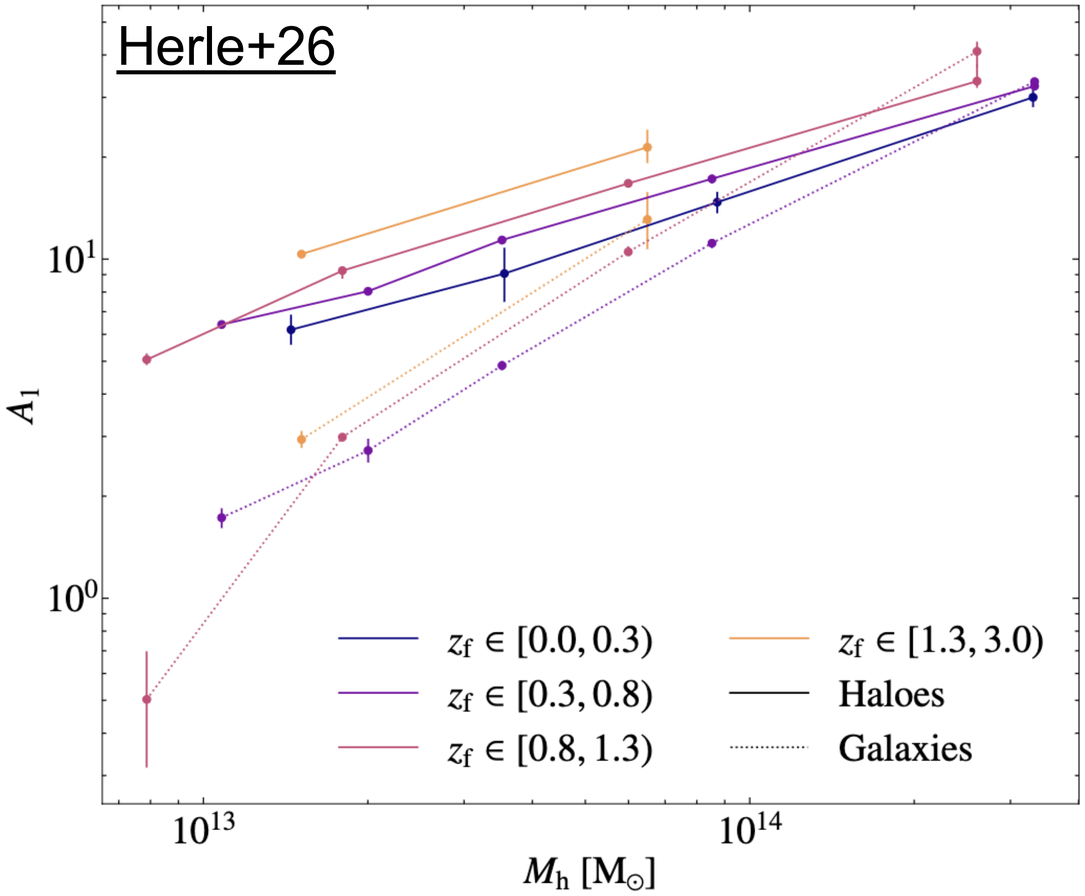


Chisari+15

A contaminant for weak lensing analyses
See e.g. Joachimi+15 for a review

Known to depend on:
- Mass
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- Etc.

Luminous Red Galaxies in FLAMINGO

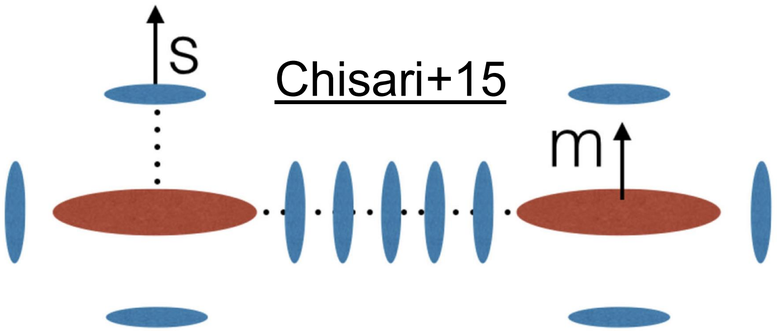


Intrinsic alignments in the cosmic web

Cosmology

Galaxy mass assembly

Pairwise alignments of galaxy shapes

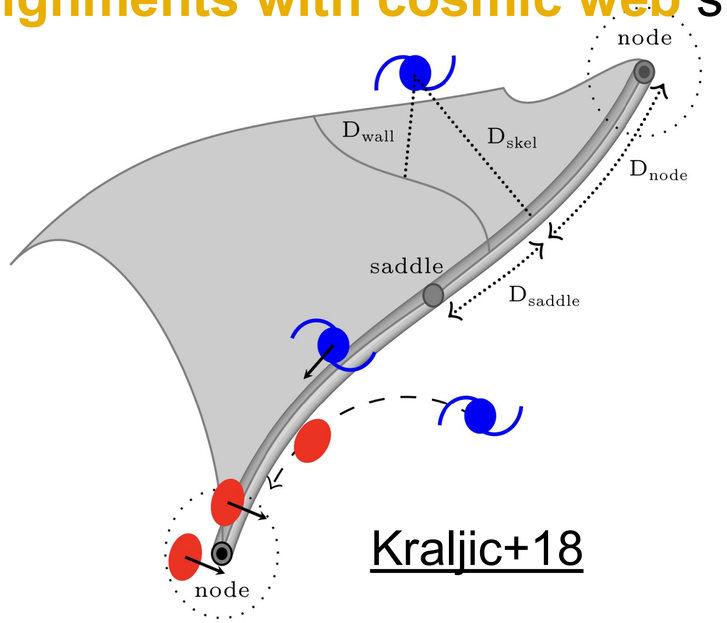


Chisari+15

A contaminant for weak lensing analyses
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Known to depend on:
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Galaxy **alignments with cosmic web** structures



Kraljic+18

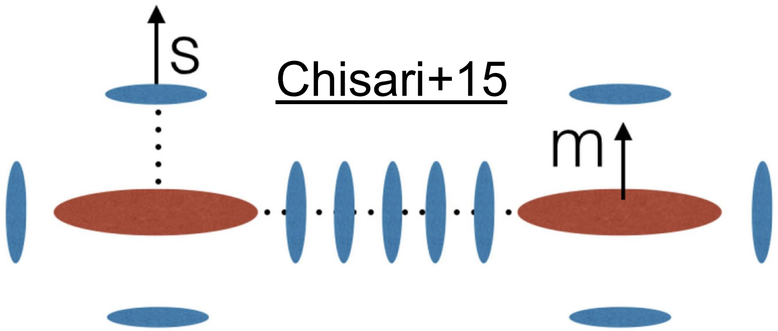
A fundamental to understand pairwise alignments

Intrinsic alignments in the cosmic web

Cosmology

Galaxy mass assembly

Pairwise alignments of galaxy shapes

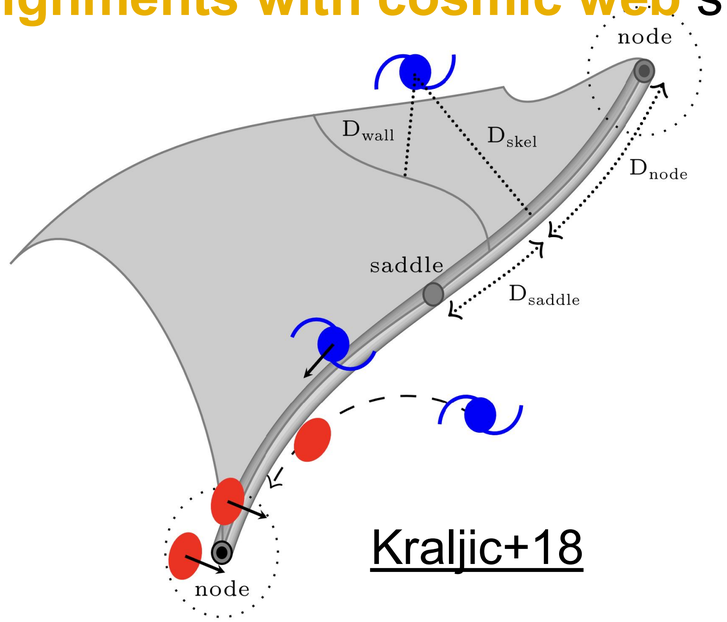


Chisari+15

A contaminant for weak lensing analyses
See e.g. Joachimi+15 for a review

Known to depend on:
- Mass
- Galaxy colours
- Galaxy structural properties? e.g. Georgiou+25
- Etc.

Galaxy alignments with cosmic web structures

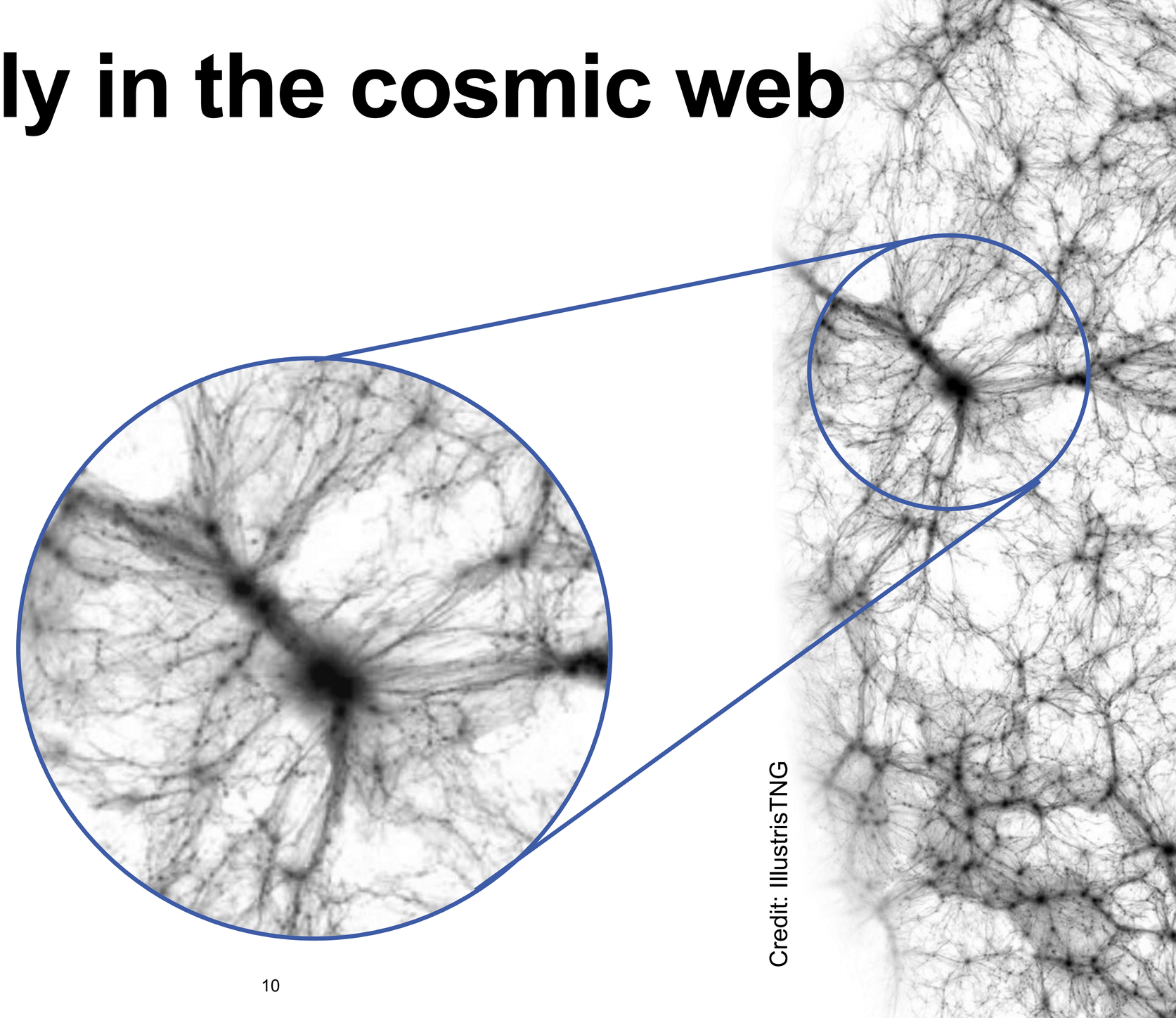


Kraljic+18

A fundamental to understand pairwise alignments

→ What do we learn from simulations?
→ Can we measure this alignment signal in observations?

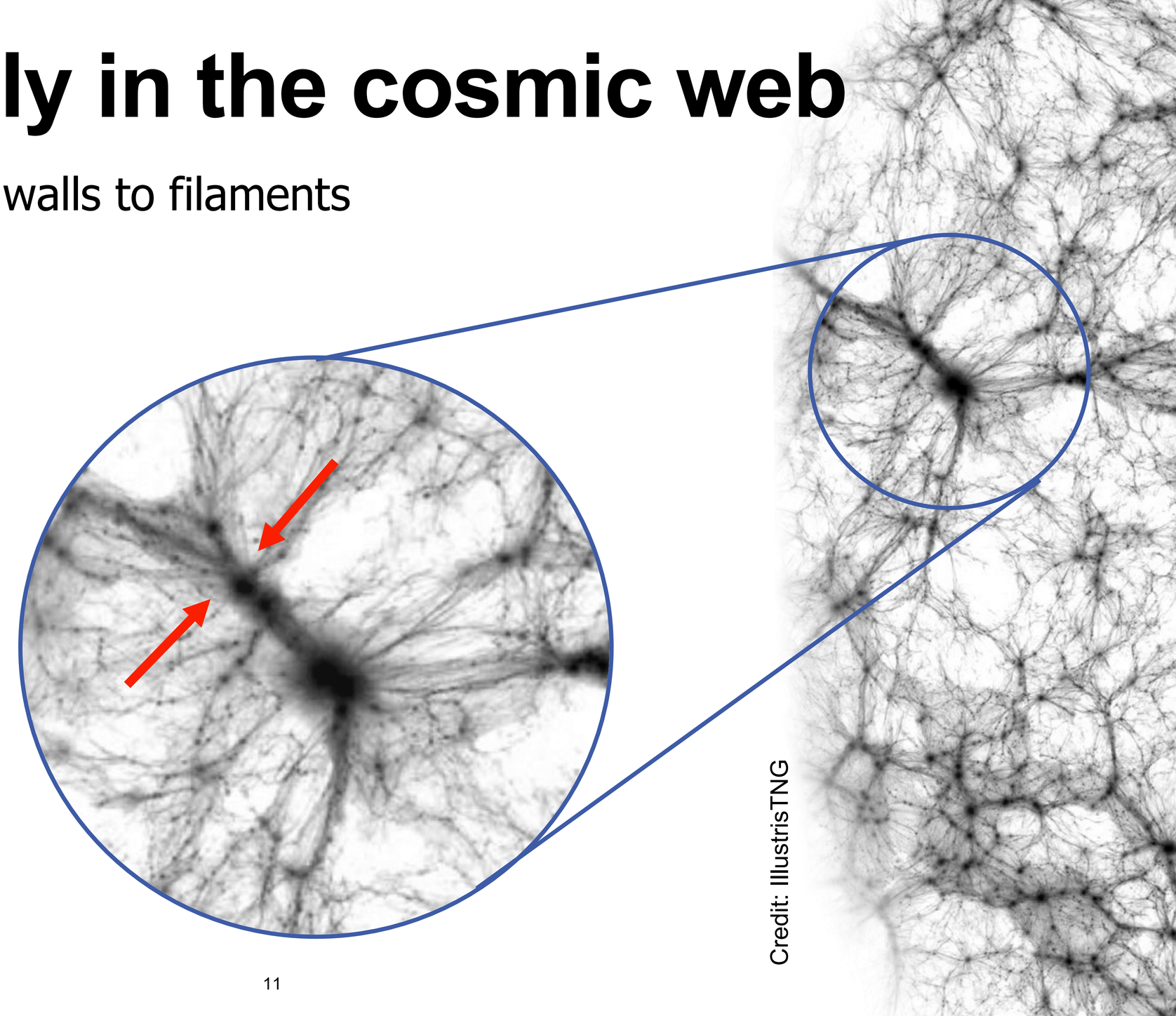
Mass assembly in the cosmic web



Credit: IllustrisTNG

Mass assembly in the cosmic web

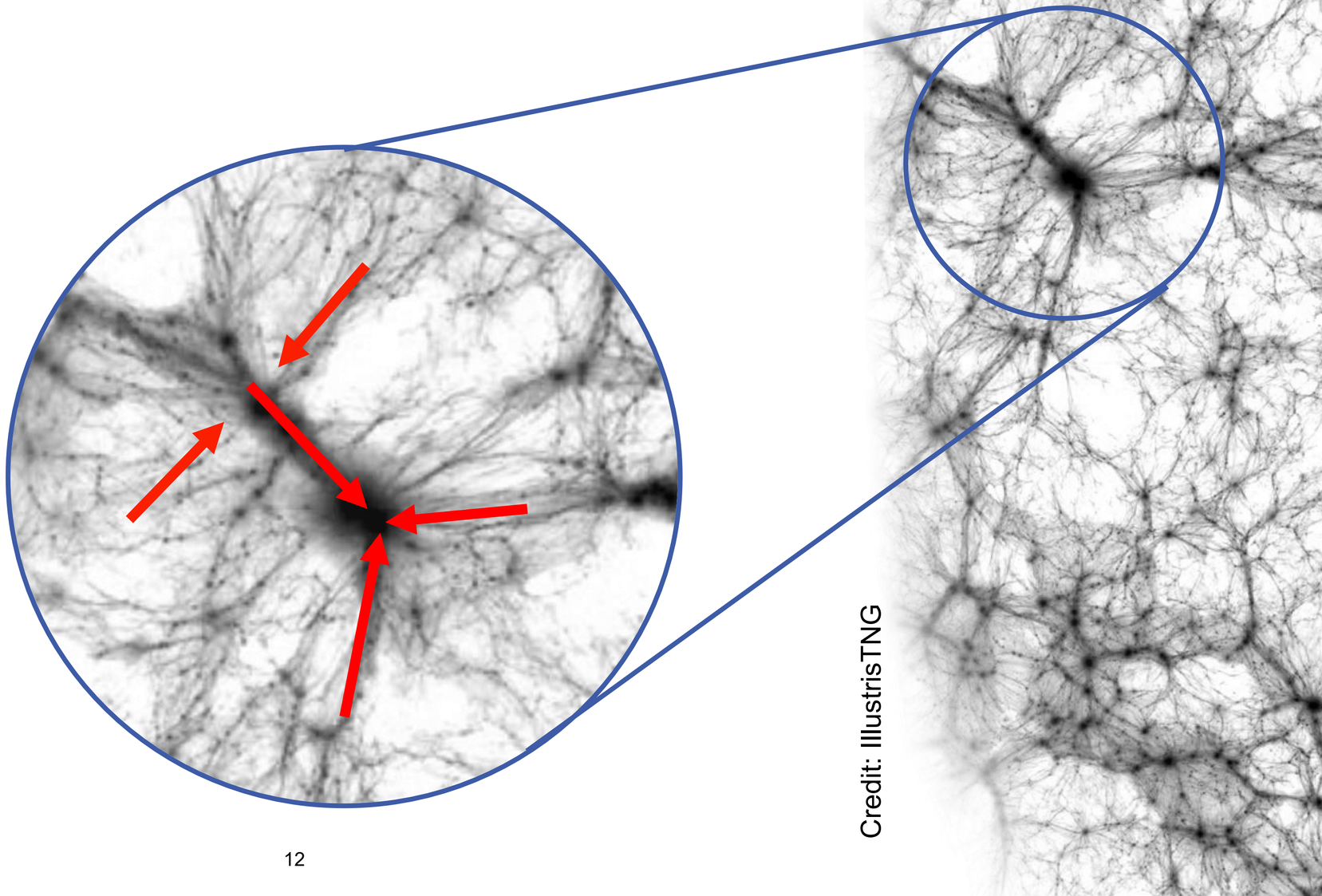
Matter flows from voids to walls to filaments



Credit: IllustrisTNG

Mass assembly in the cosmic web

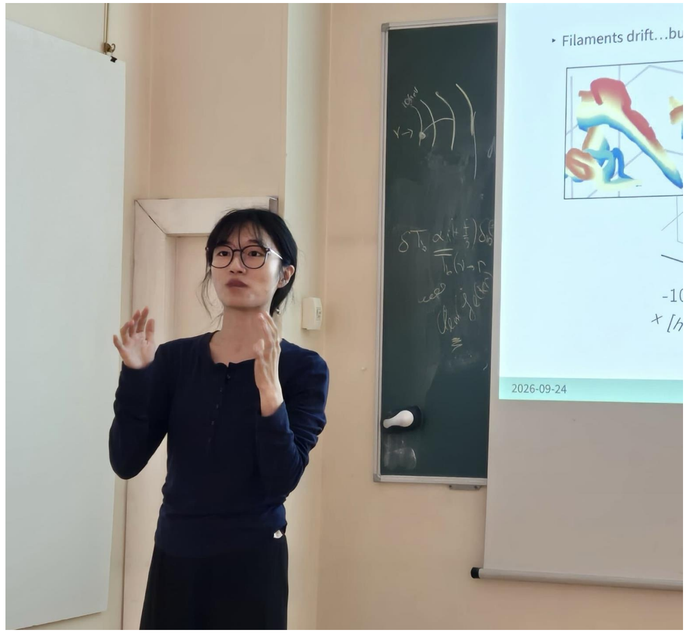
Matter flows from voids to walls to filaments and then to clusters

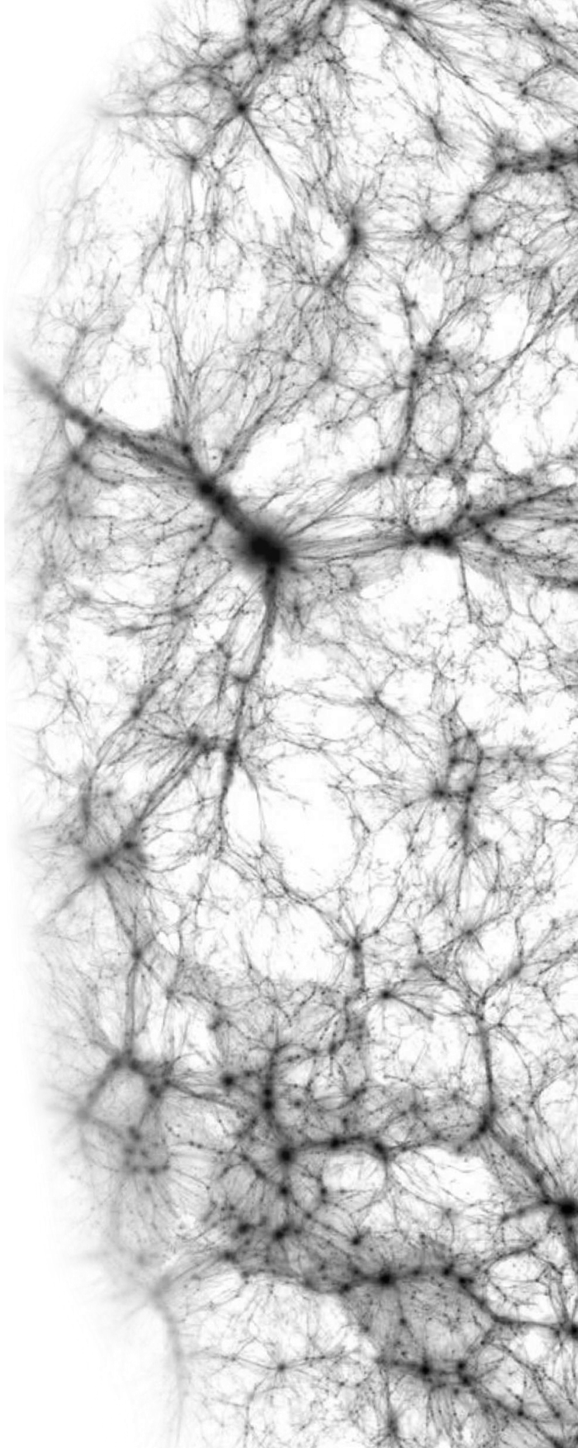


Credit: IllustrisTNG

1) How evolving filaments impact halo alignment?

The impact of evolving cosmic filaments on mass and spin evolution of dark matter halos Jhee, Song, Laigle+26





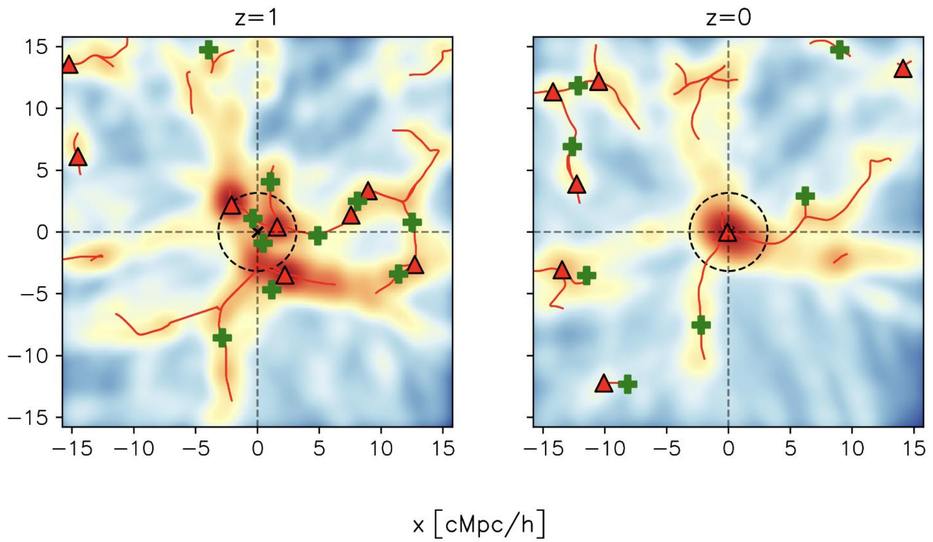
Result: a lagrangian analysis of filaments

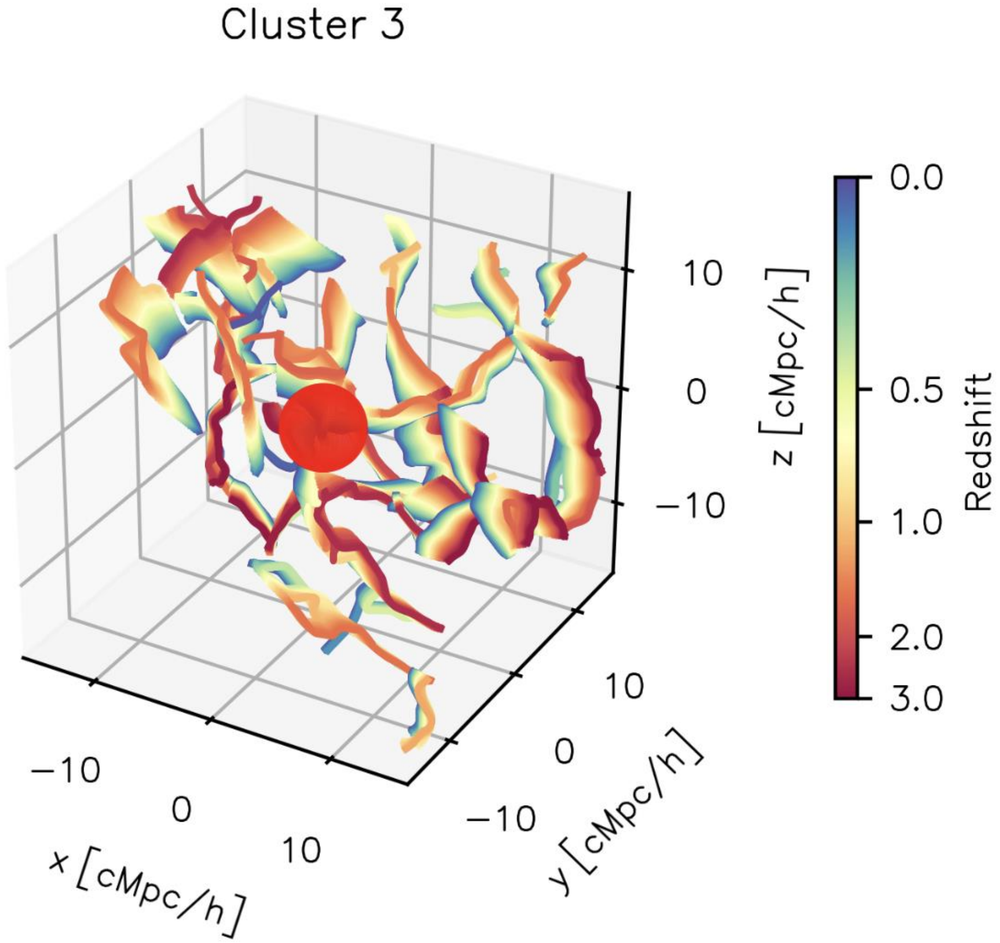
Jhee, Song, Laigle+26

Dark matter simulation,
Particle mass: $10^9\ M_\odot$
Select 30 Mpc/h regions around 3 massive clusters

- Filaments extracted with DisPerSE from the smoothed dark matter particle distribution.

- Development of a matching algorithm from spatial similarity to build a filament merger tree

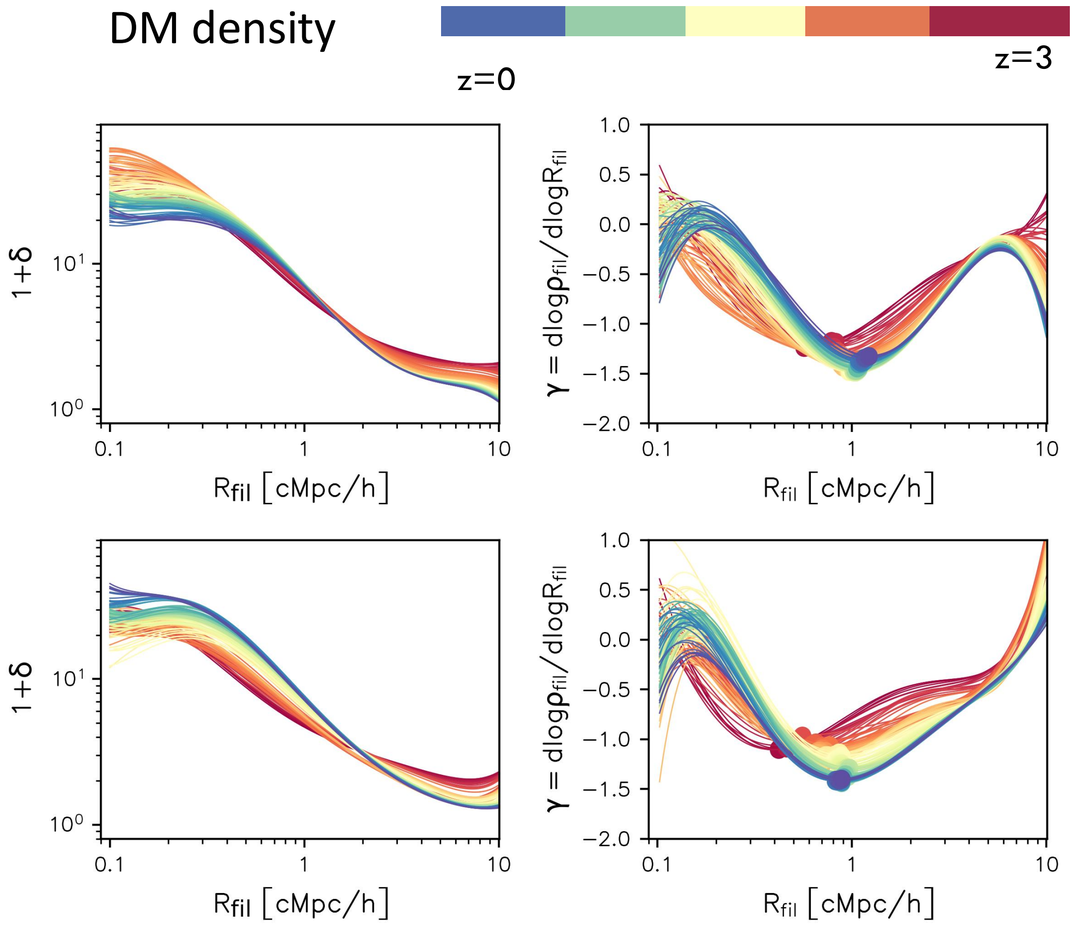


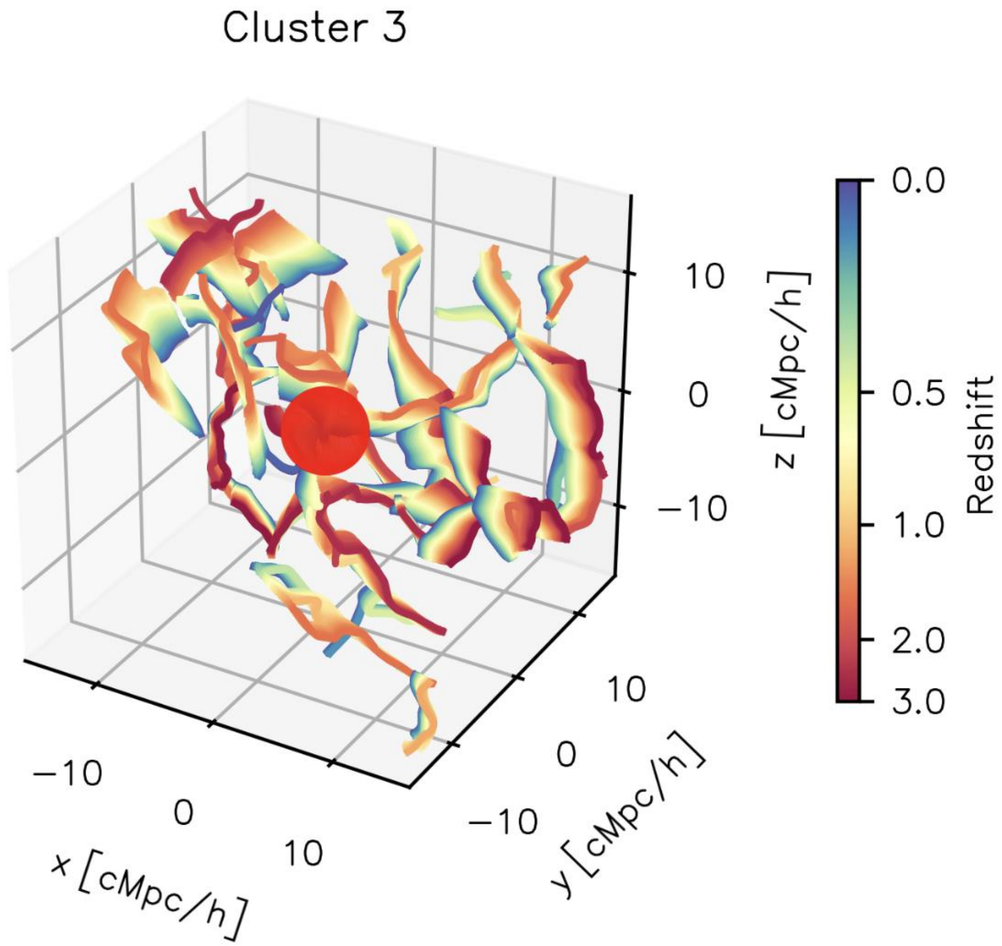


See also. Galarraga-Espinosa+24

Result: a lagrangian analysis of filaments

Jhee, Song, Laigle+26

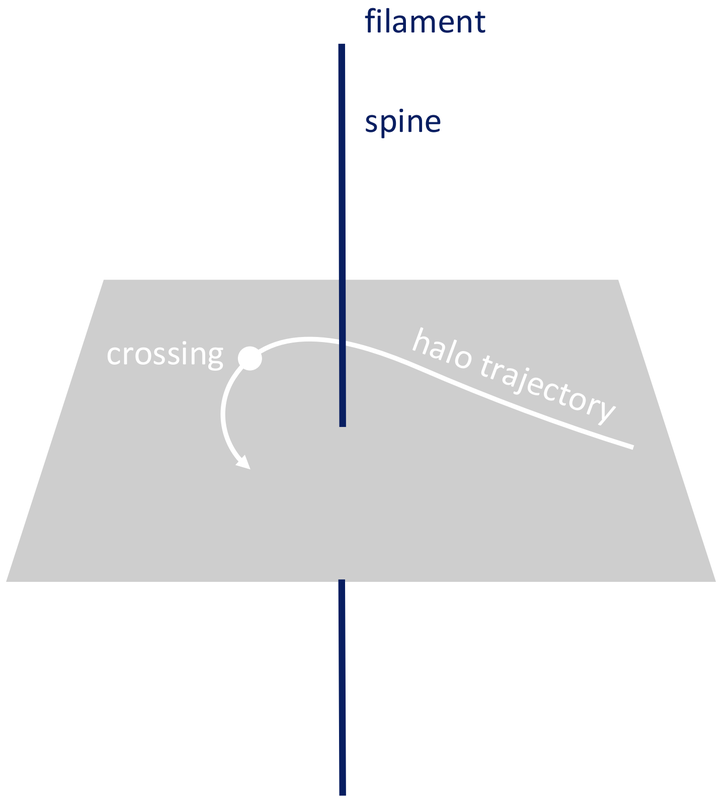


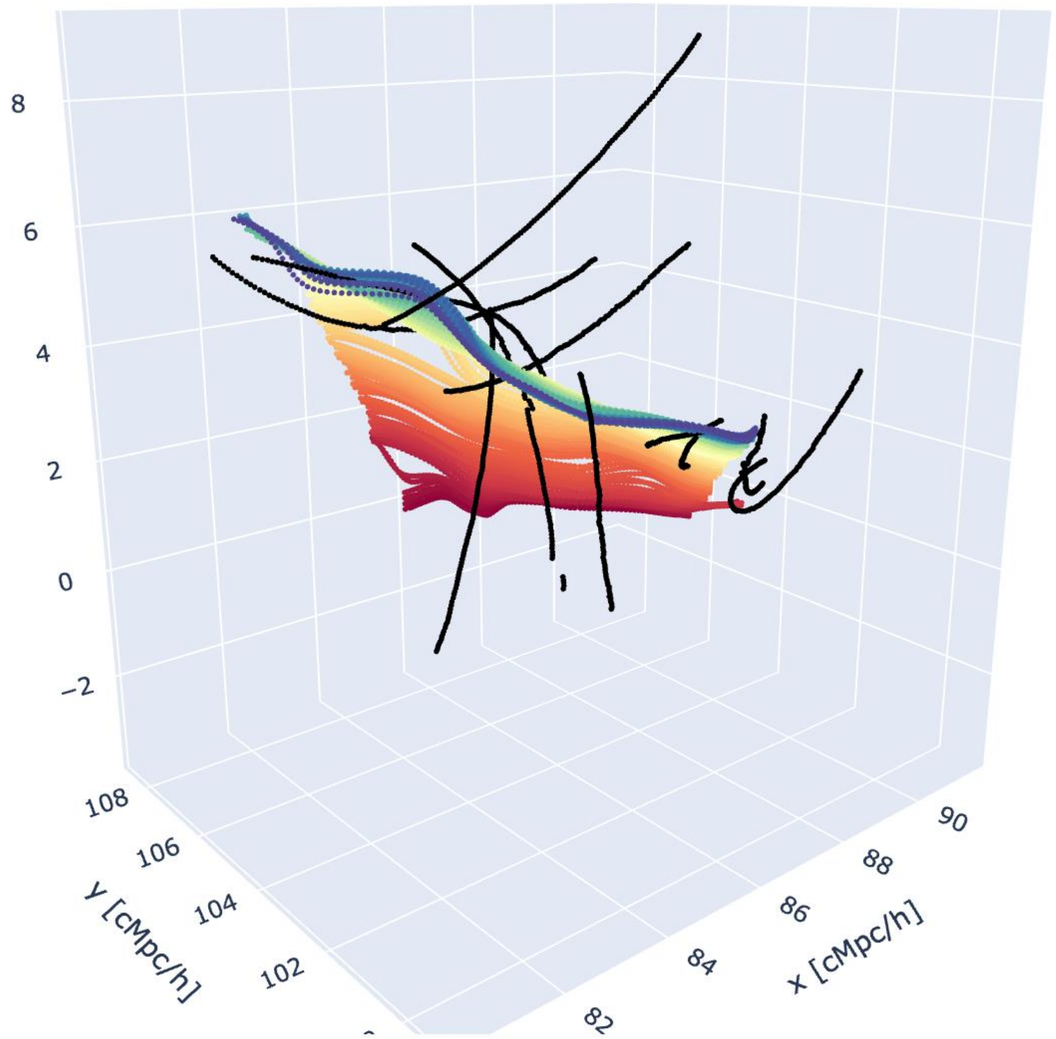


Filament drift speed ~300 km/s

Result: a lagrangian analysis of halos

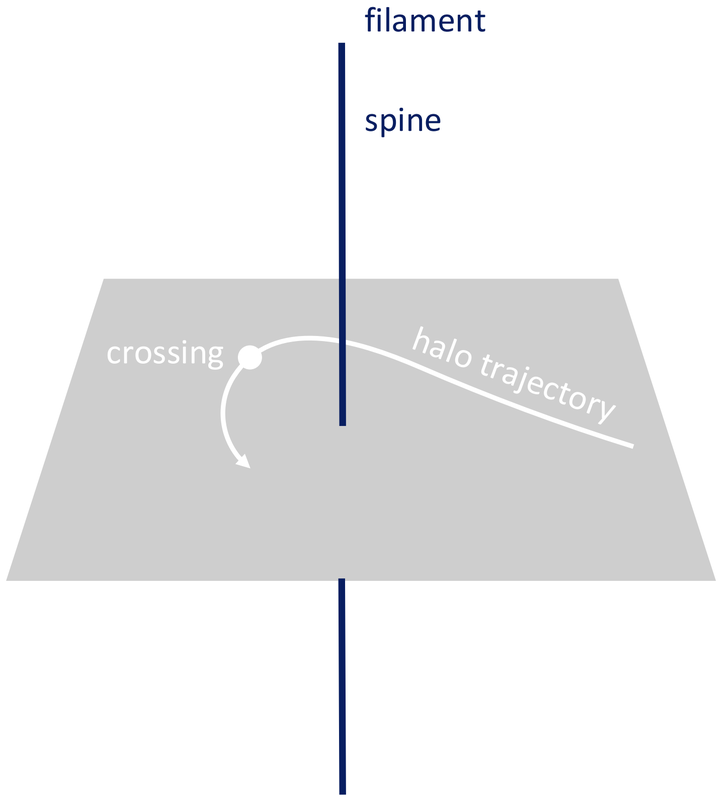
Jhee, Song, Laigle+26

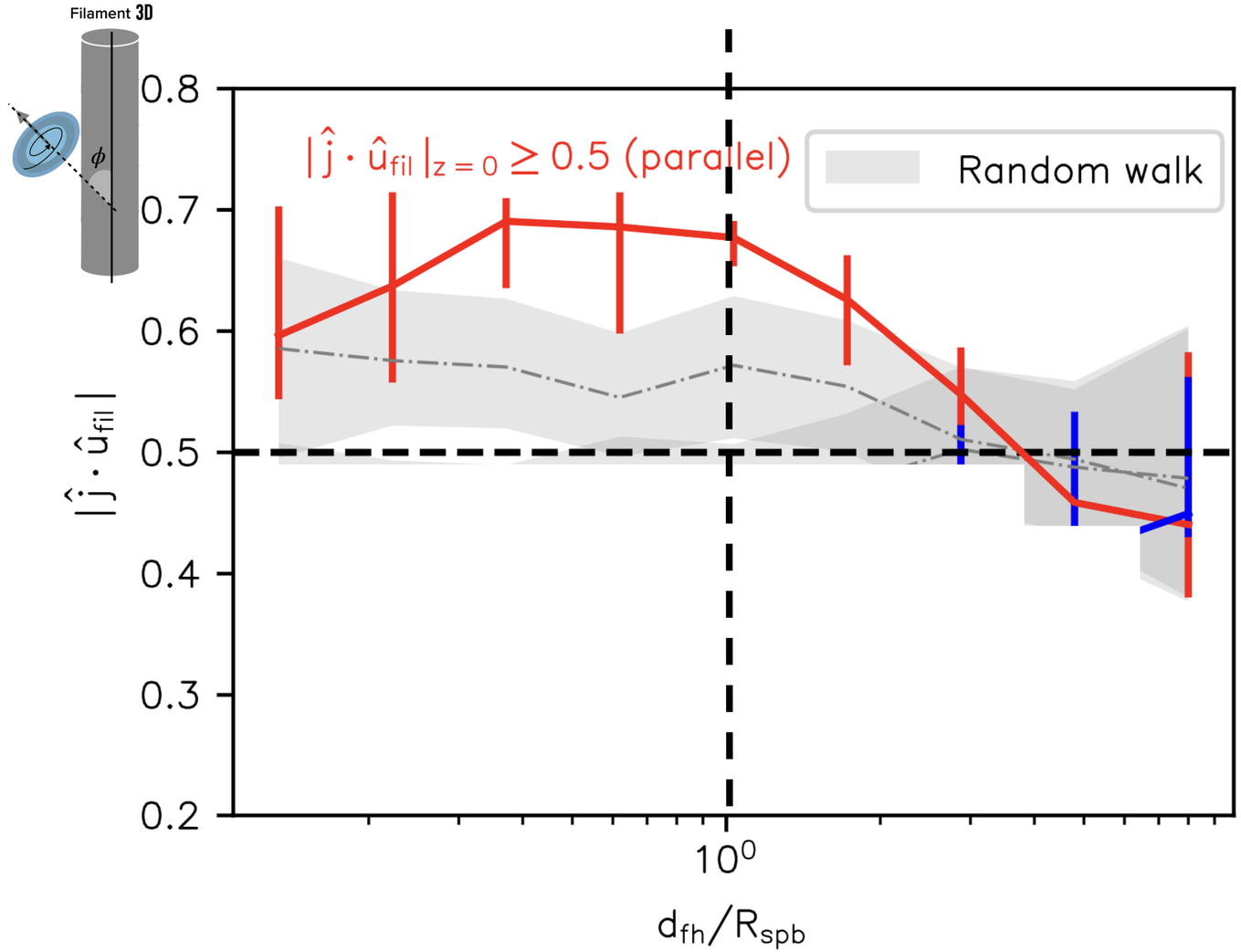




Result: halo spin reorientation in filaments

Jhee, Song, Laigle+26

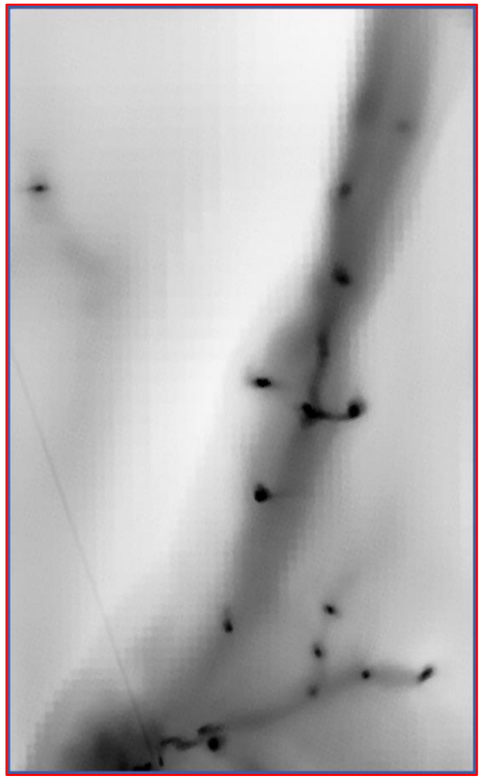




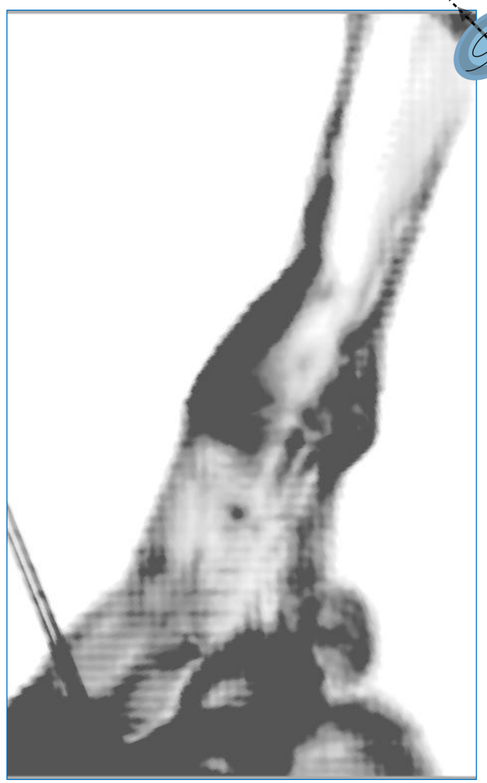
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Jhee, Song, Laigle+26

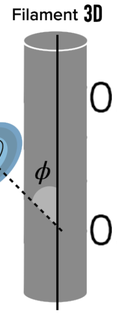
Laigle et al. 2015



Density



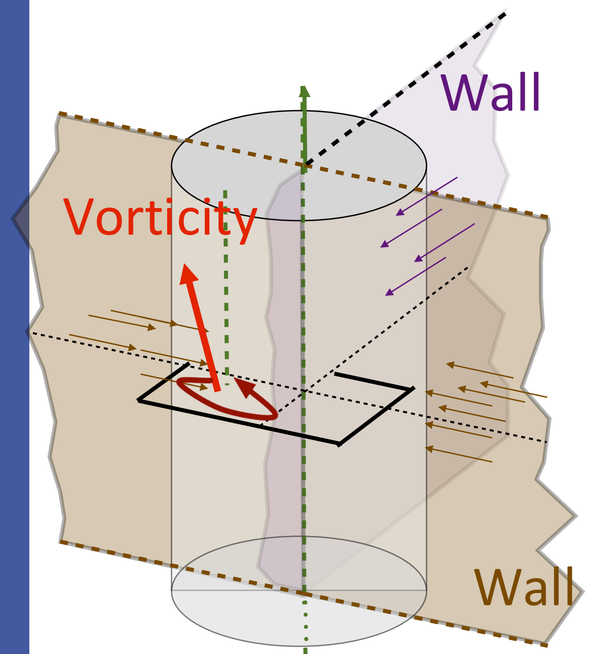
Vorticity

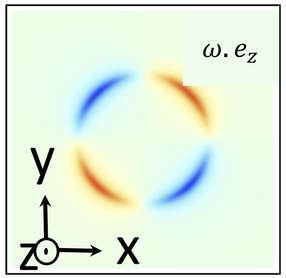


18

Result: halo spin reorientation in filaments

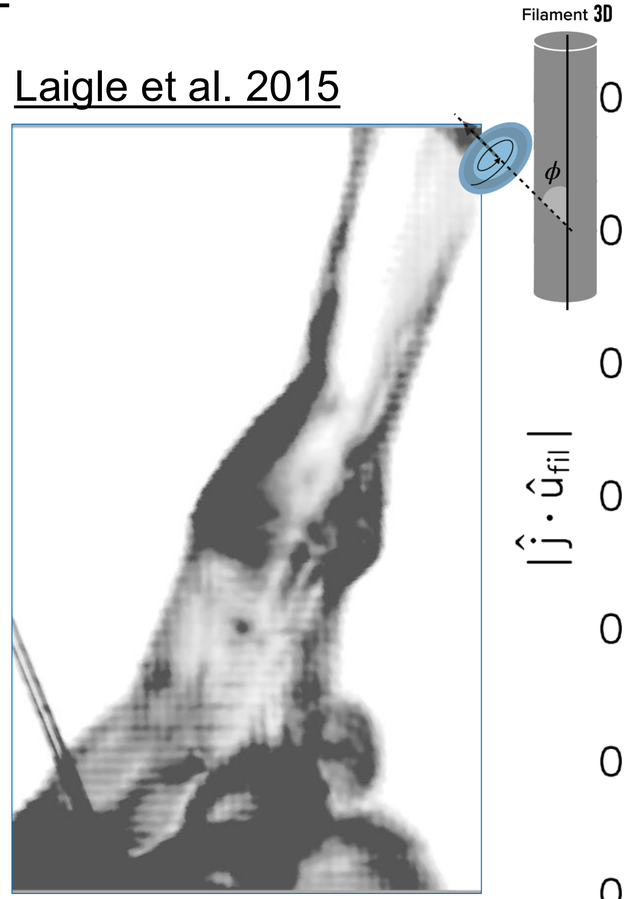
Jhee, Song, Laigle+26

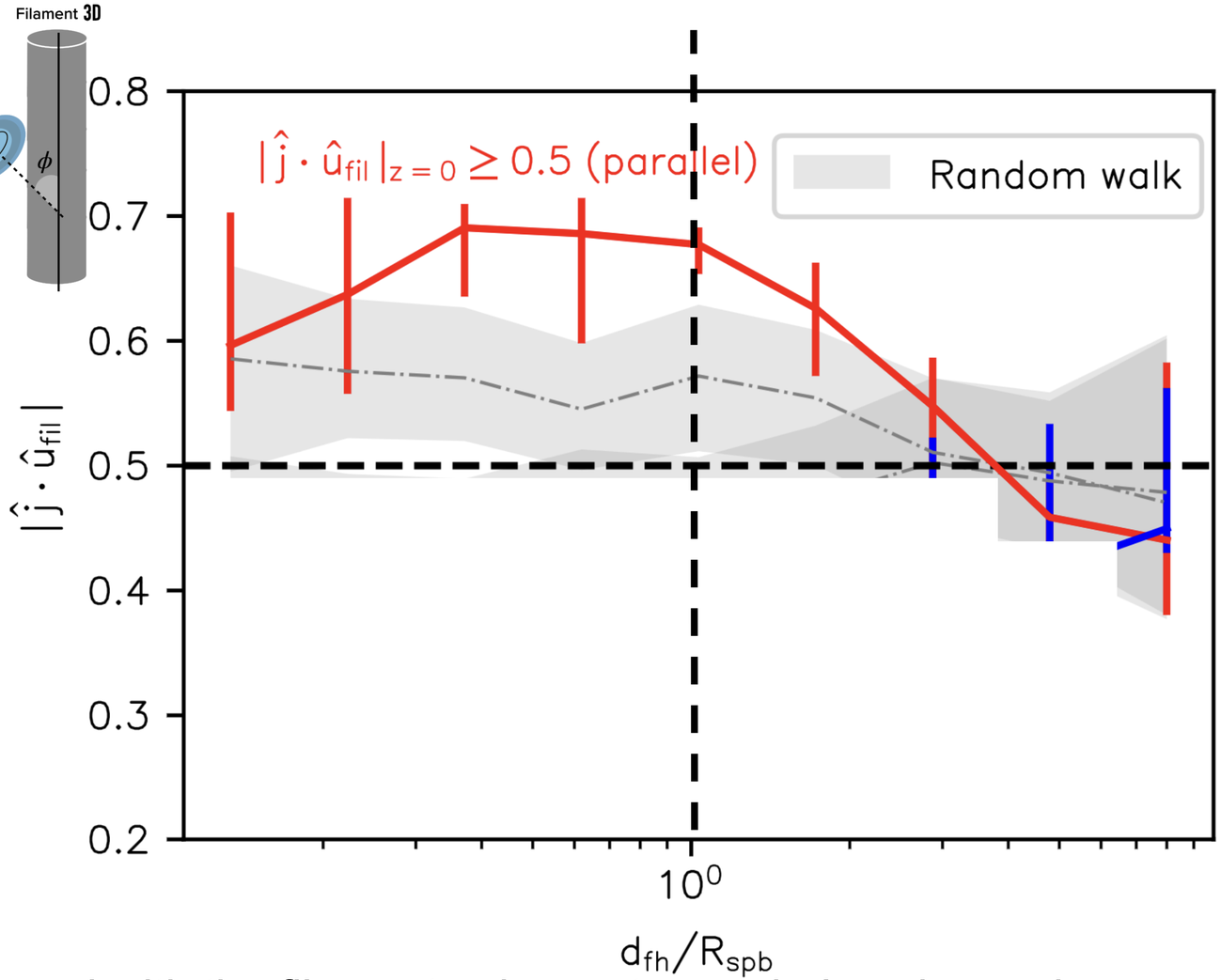




$\omega = \nabla \times \mathbf{v}$

Laigle et al. 2015

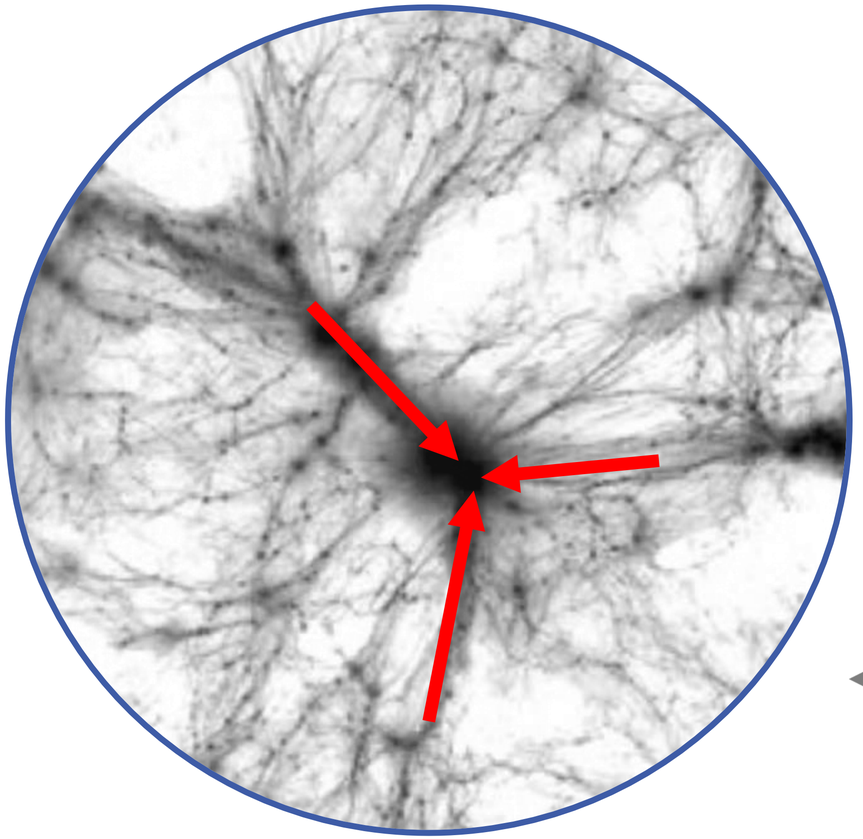


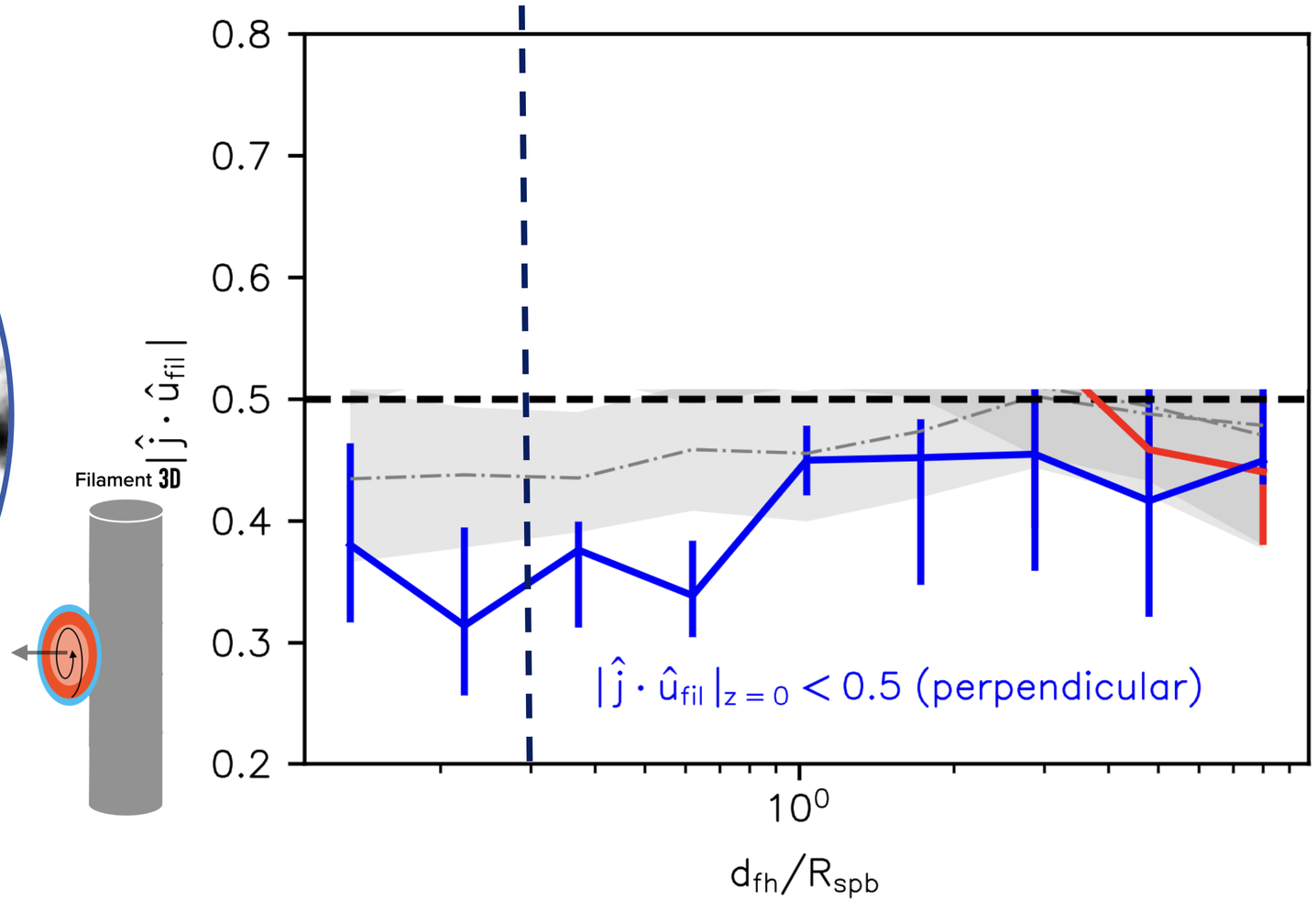


Vorticity aligned with the filament axis can torque halo spins and enhance a parallel alignment signal

Result: halo spin reorientation in filaments

Jhee, Song, Laigle+26





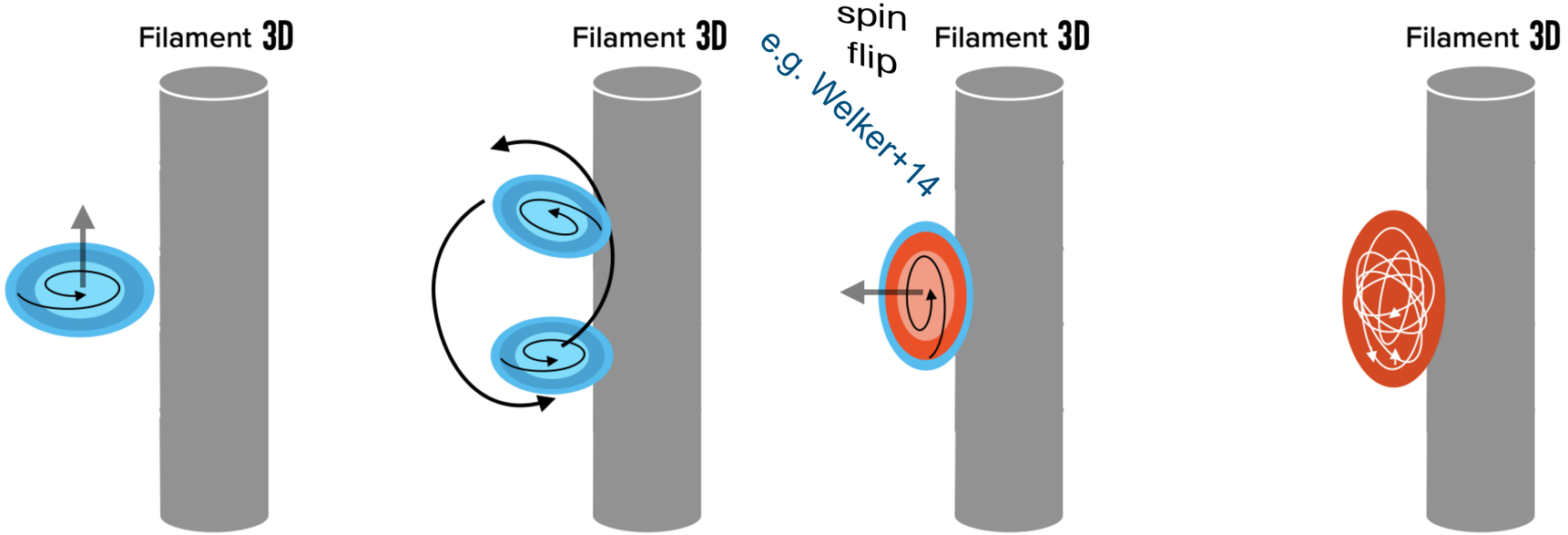
Deeper near filament spine, strong axial transport towards nodes could reorient spin

Intermediate summary: galaxy alignments in the cosmic web

Tidal torquing in the initial conditions (Schafer09)
Matter accreted as secondary infall spins up disk galaxies (e.g.Codis+12, Ganeshaia Veena+21)

Mergers along filaments can cause spin flip e.g. Welker+14

Tidal-stretching of dispersion-dominated objects



Barsanti+22

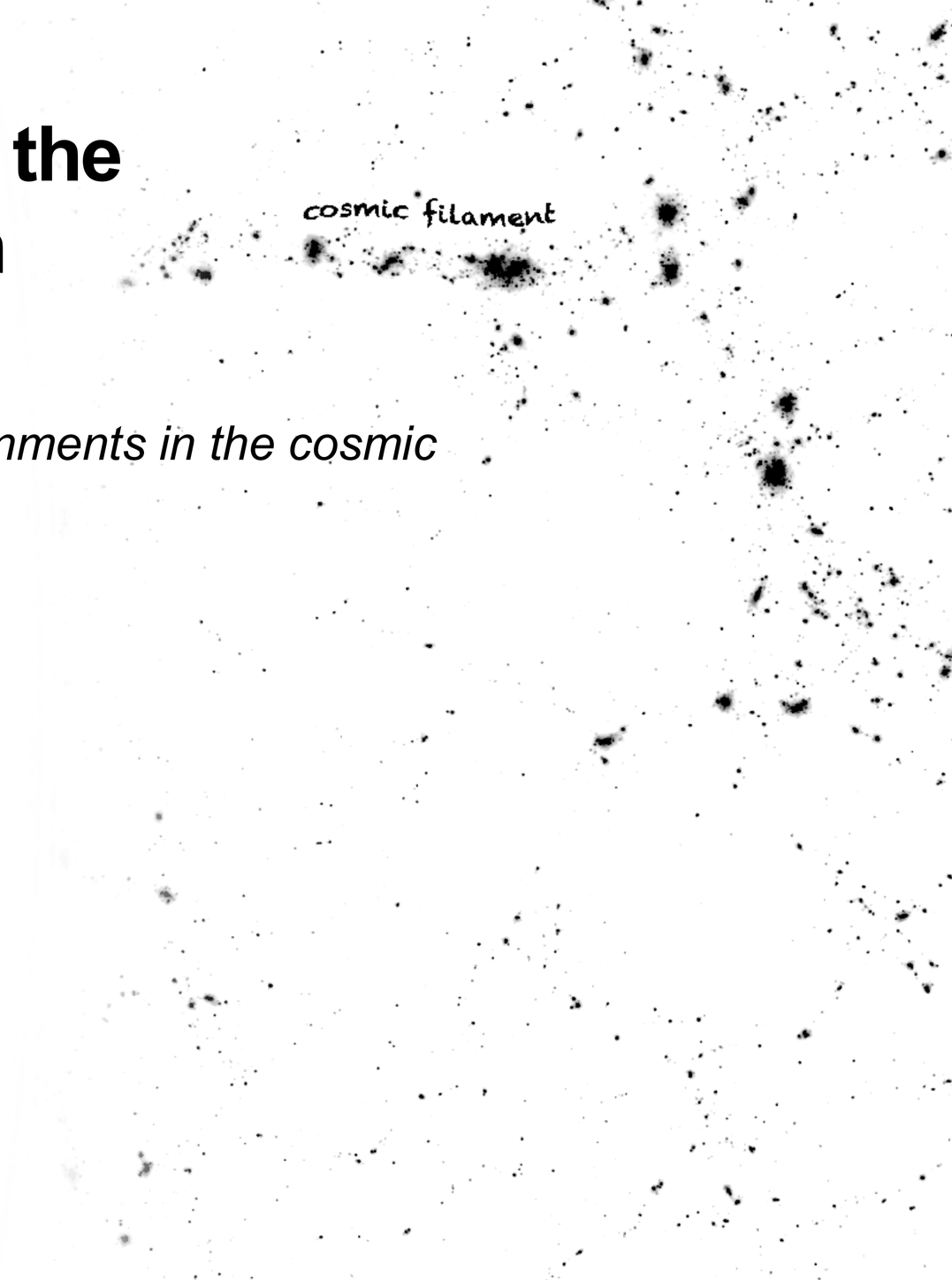
Full analysis of alignment pattern in HzAgn simulation: Codis+18
Different simulations predict different alignment patterns / mass threshold for alignment balance

2) Observationally, do we measure the alignment patterns of galaxies with cosmic filaments?

Euclid Quick Data Release (Q1). Galaxy shapes and alignments in the cosmic web Euclid collaboration, Laigle+26

+ M1 internship of Elsa Roy



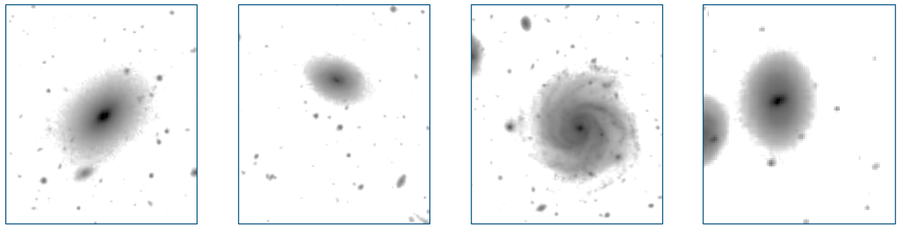


Euclid Quick Data Release 1

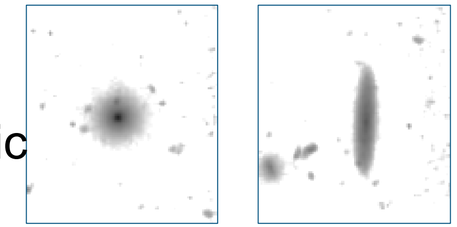
(Euclid Q1: EC, Aussel et al.+26)

Combination of

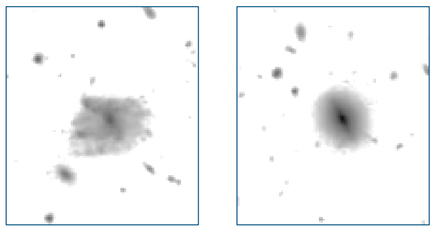
- ‘large’ coverage (63.1 deg^2)
- excellent resolution in VIS (FWHM $\sim$0.16”)
- depth in VIS/NIR + external data enable a study to $z = 1$

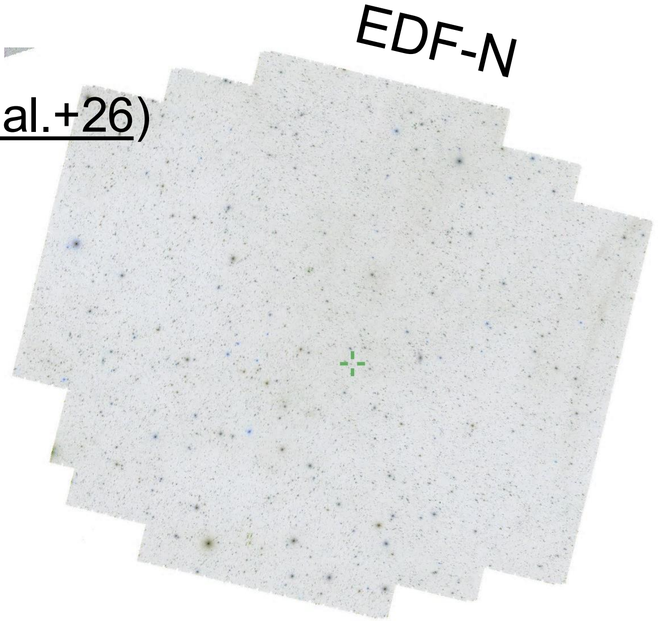


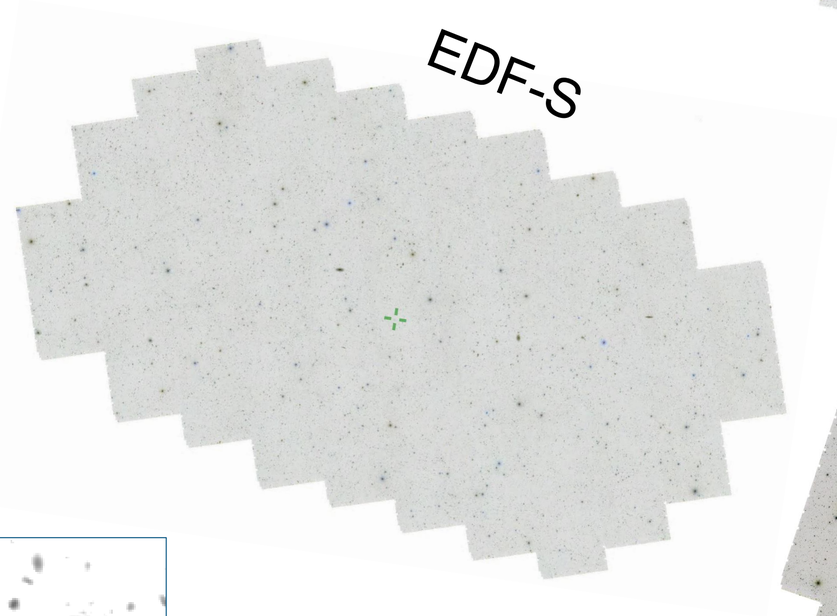
Shapes/
orientations
estimated from Sersic
fit

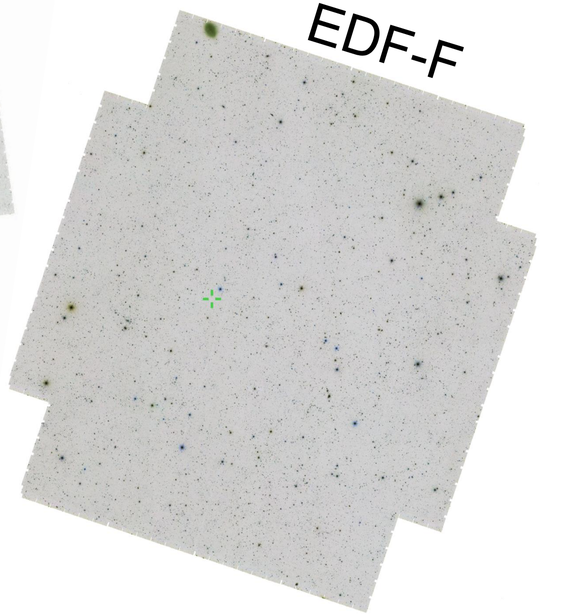


(Euclid Q1: EC, Quilley+26)

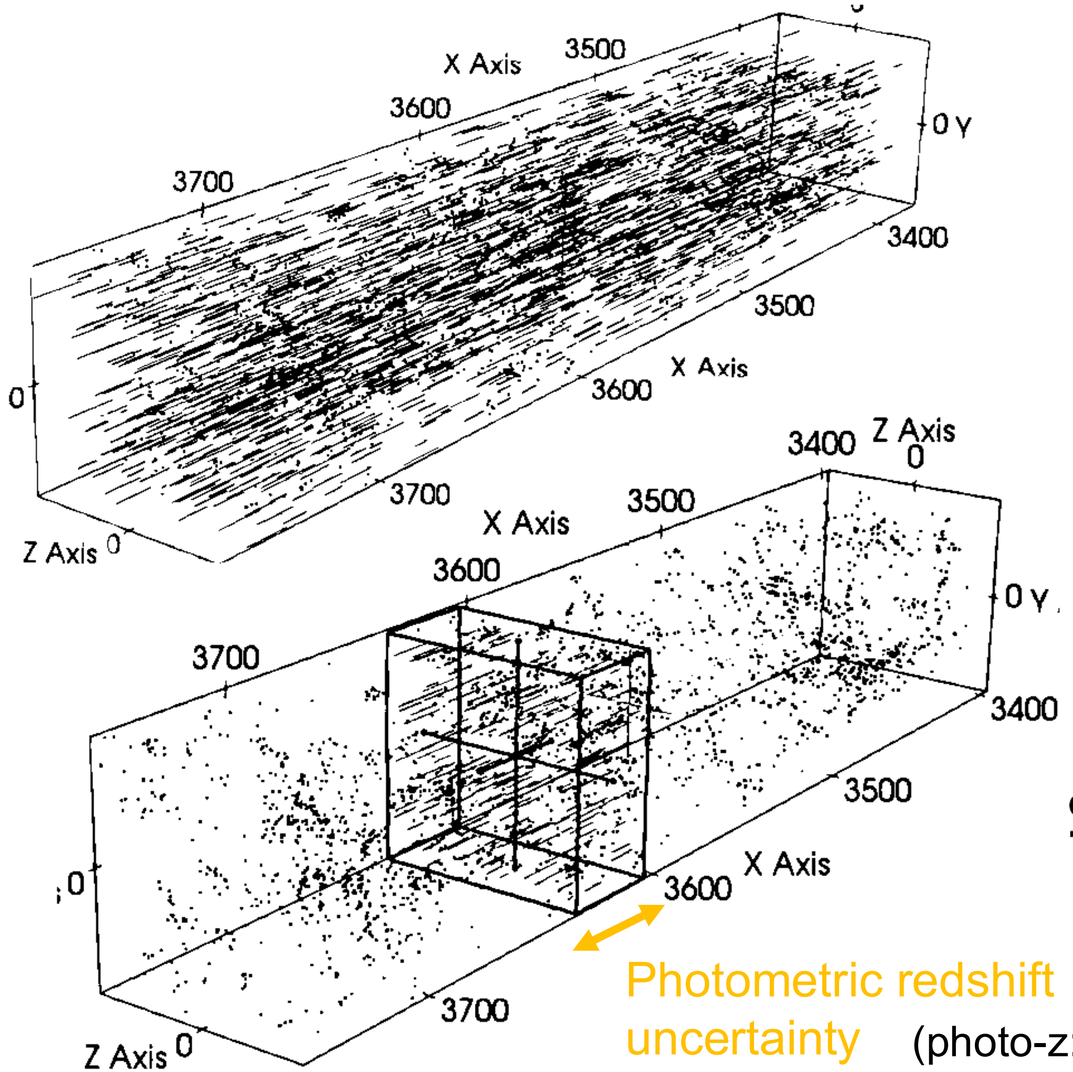


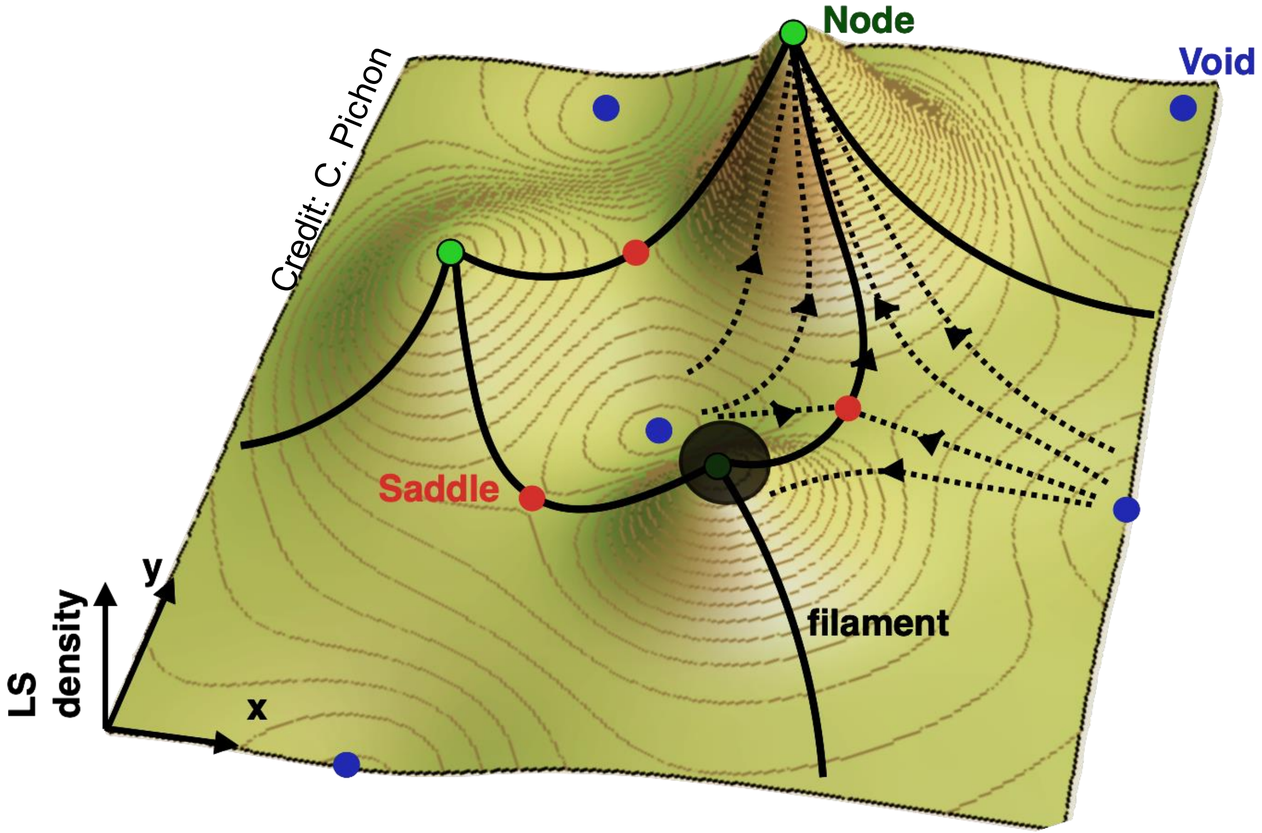






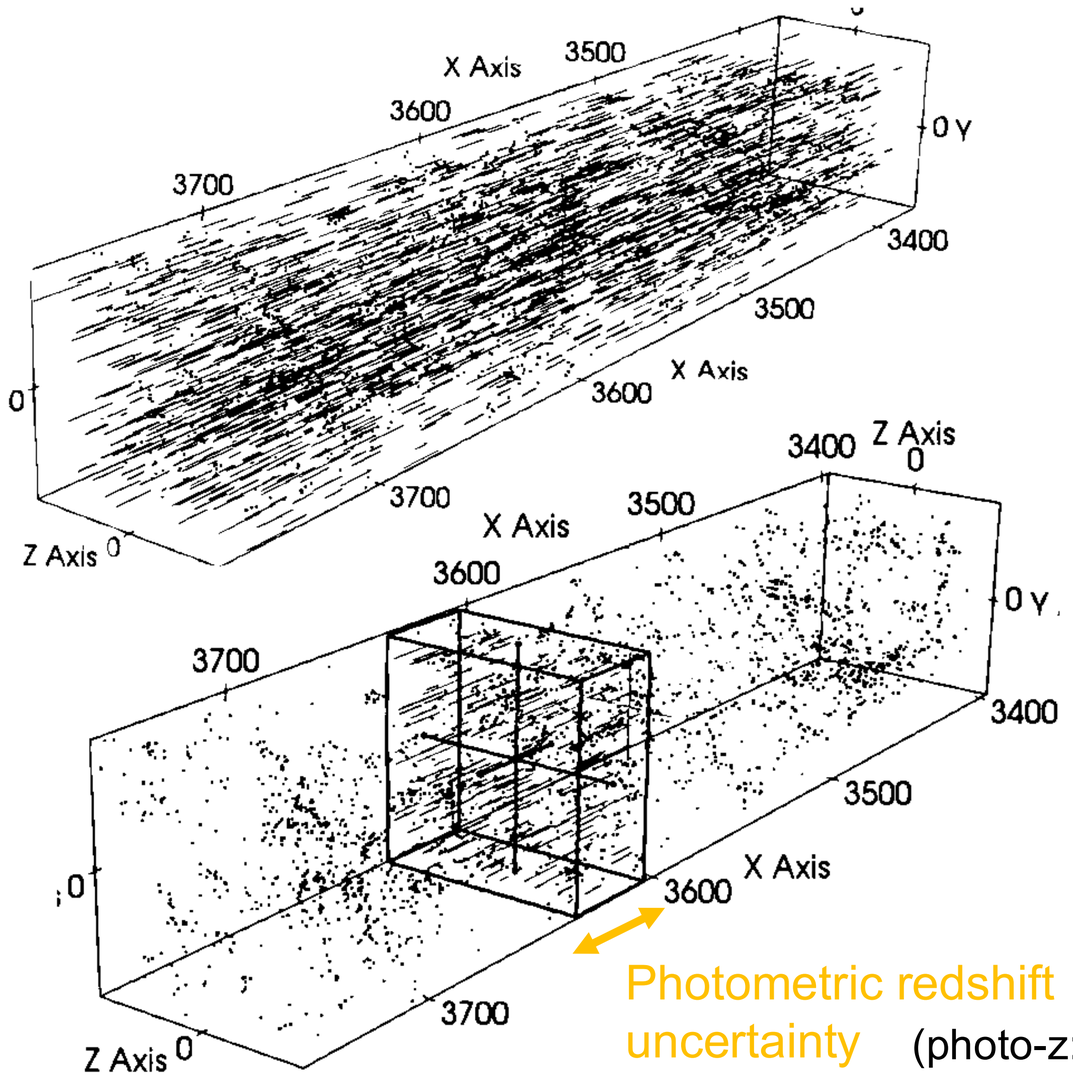
Cosmic filament extraction $0.5 < z < 0.9$

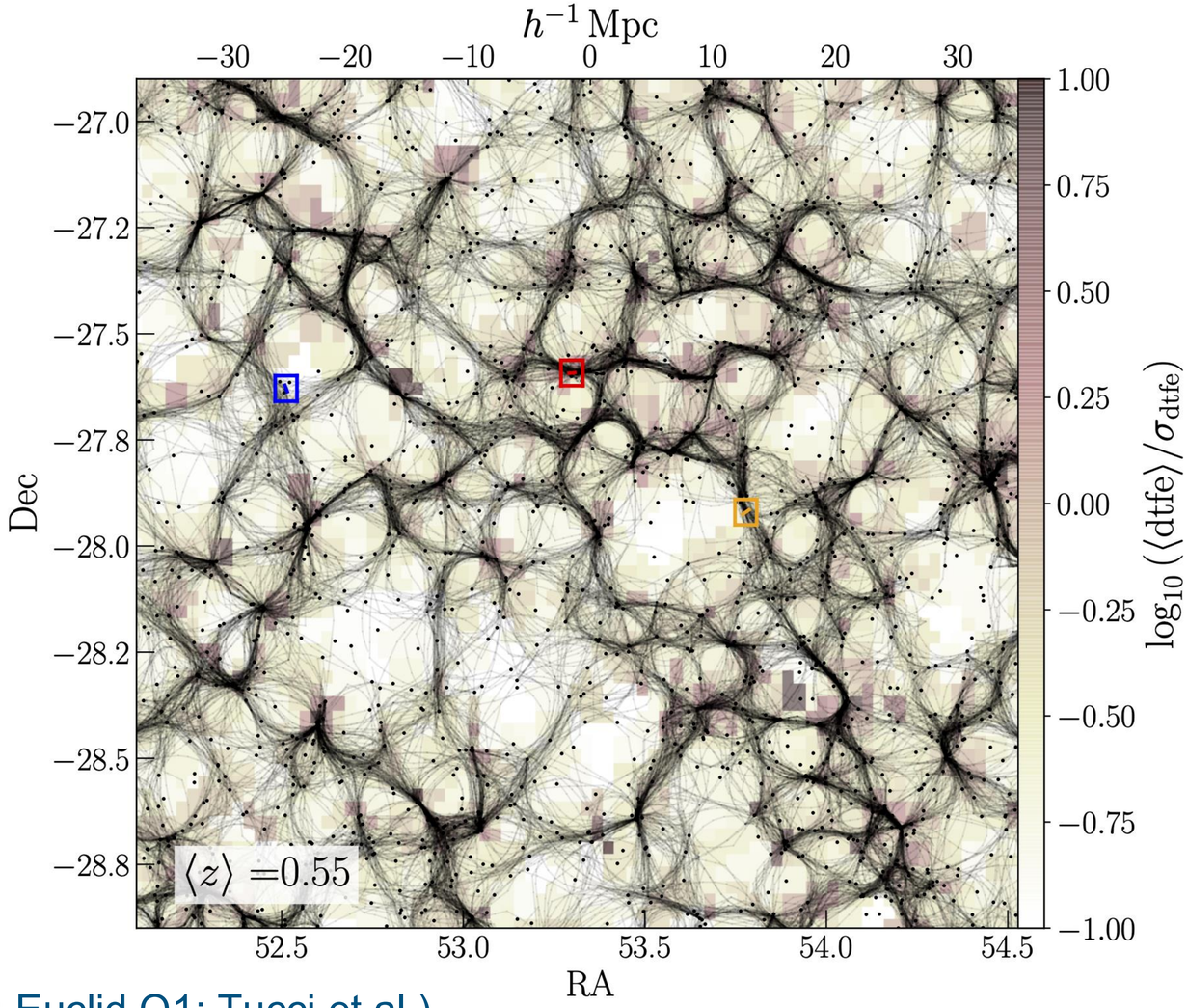




Photometric redshift uncertainty (photo-z: Euclid Q1: Tucci et al.)

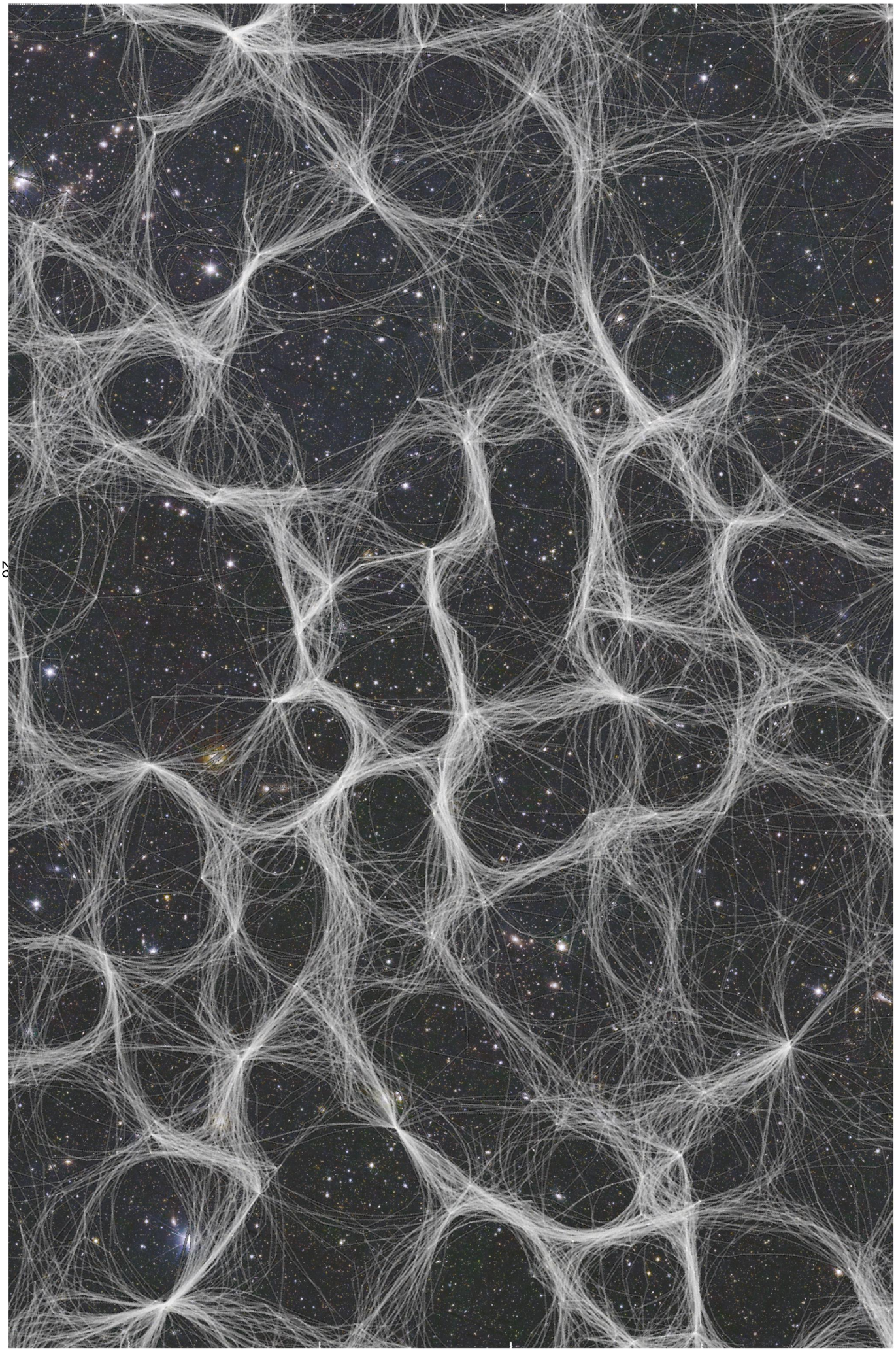
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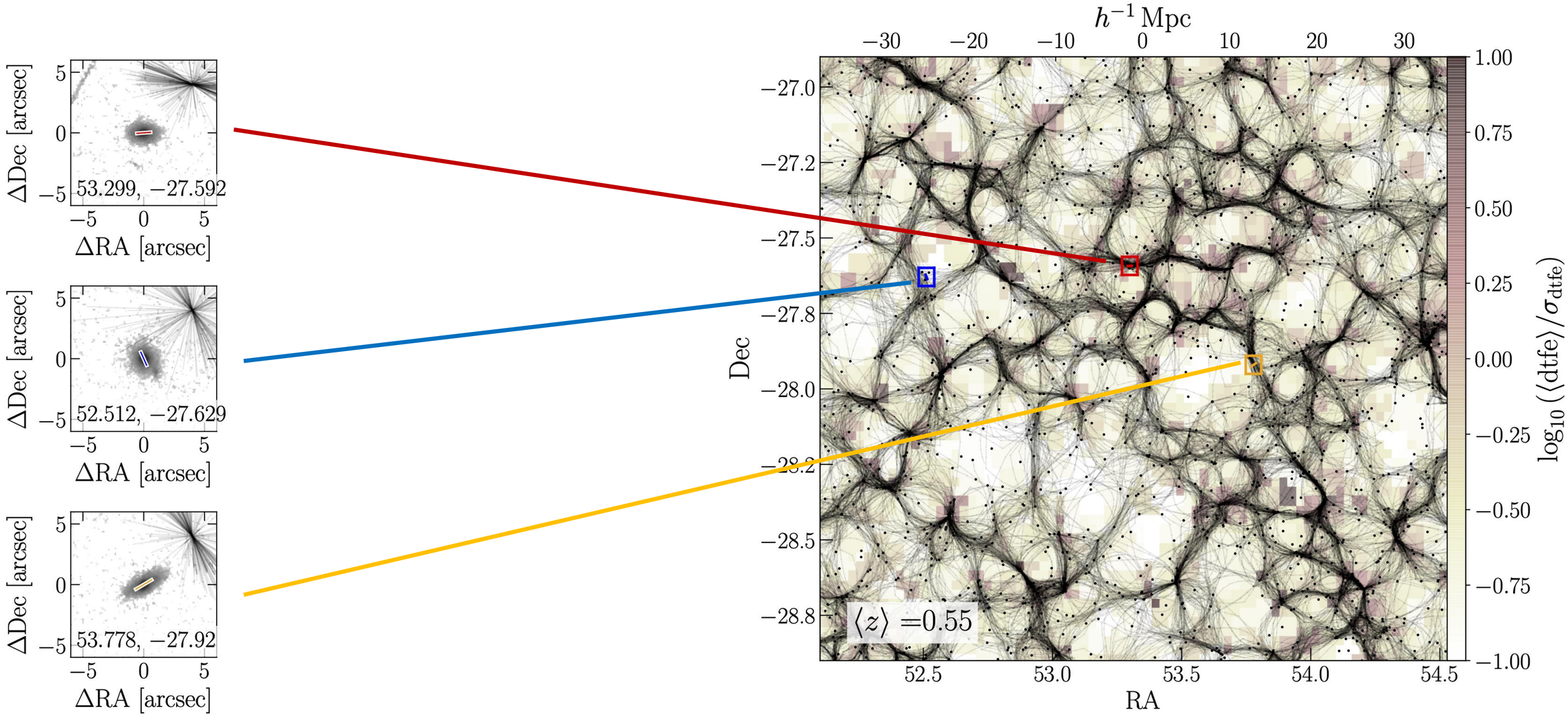


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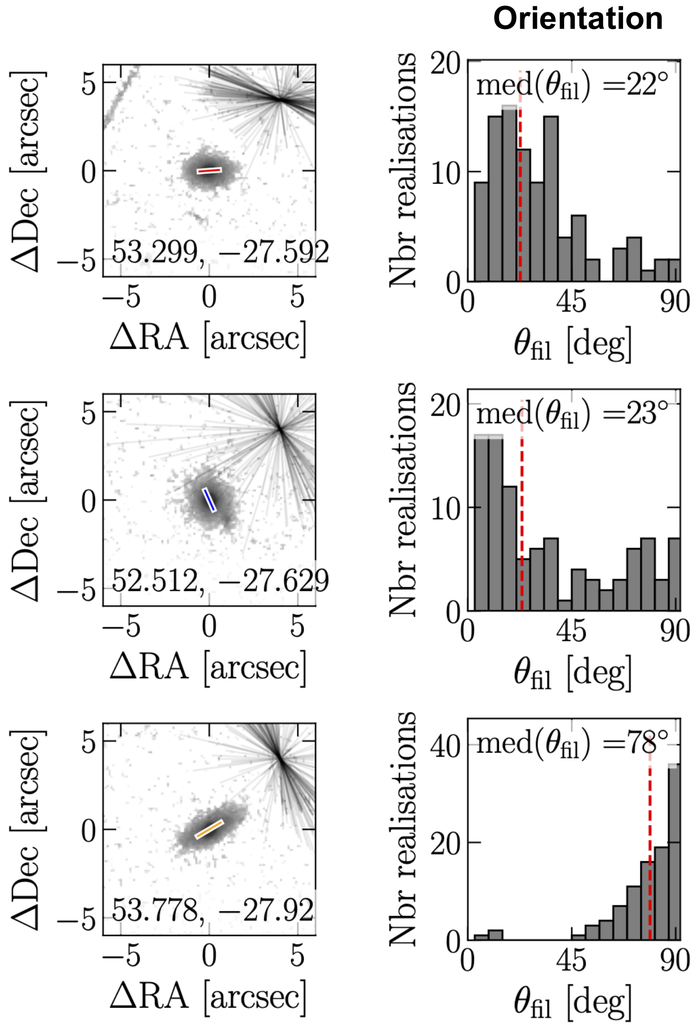
Credit: ESASky
S. Derriere, CDS, Observatoire astronomique de Strasbourg

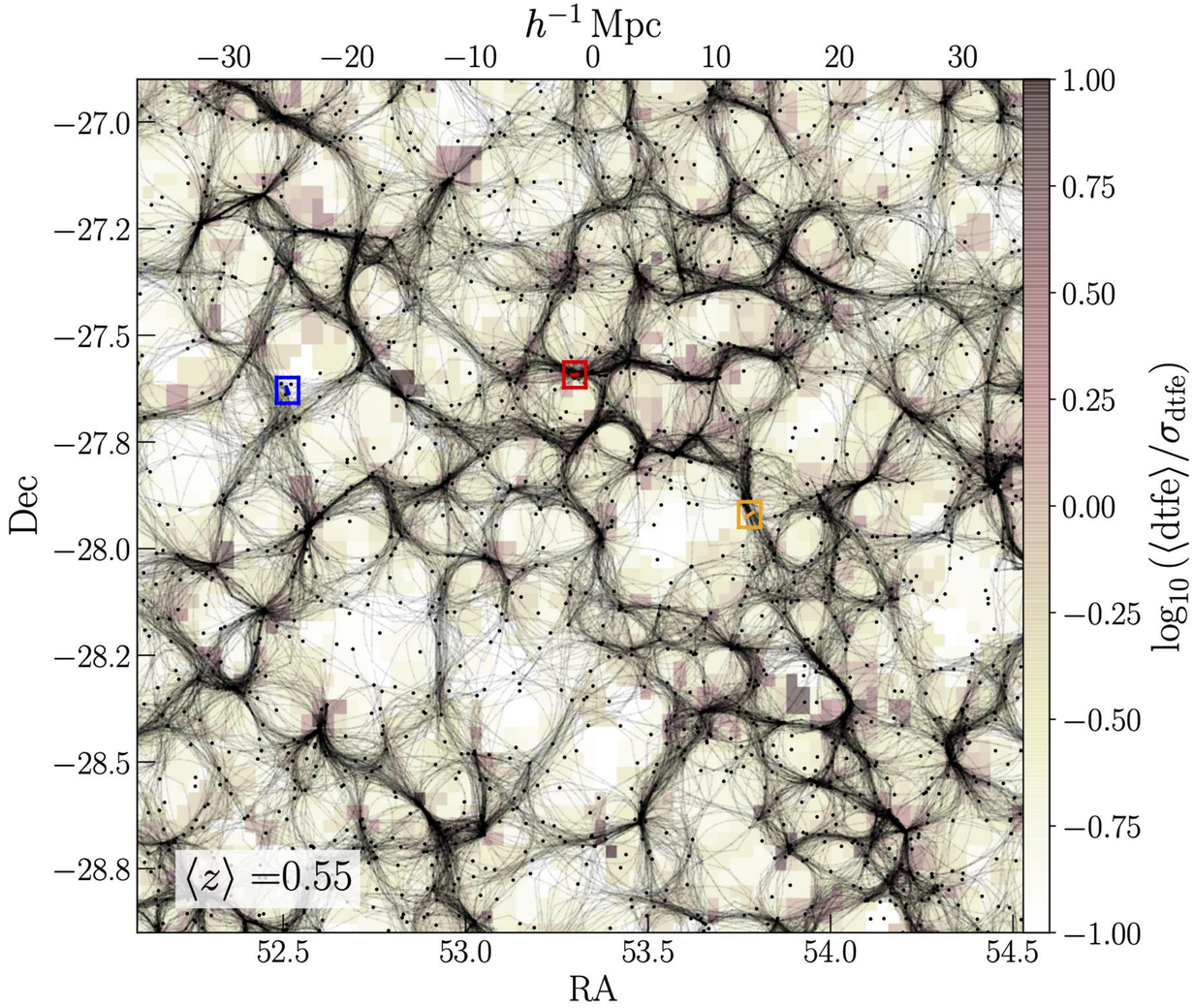


Results: Galaxy properties in the cosmic web

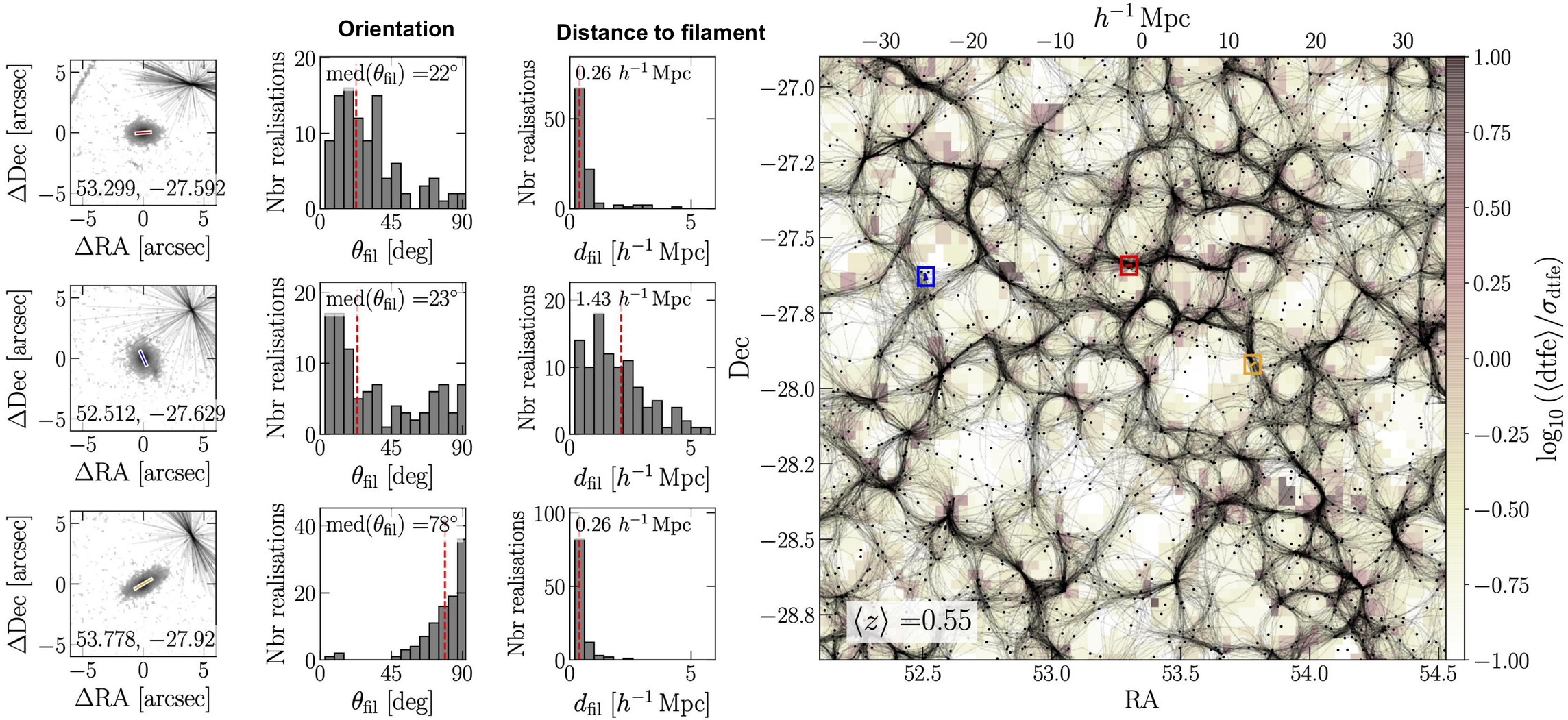


Results: Galaxy properties in the cosmic web

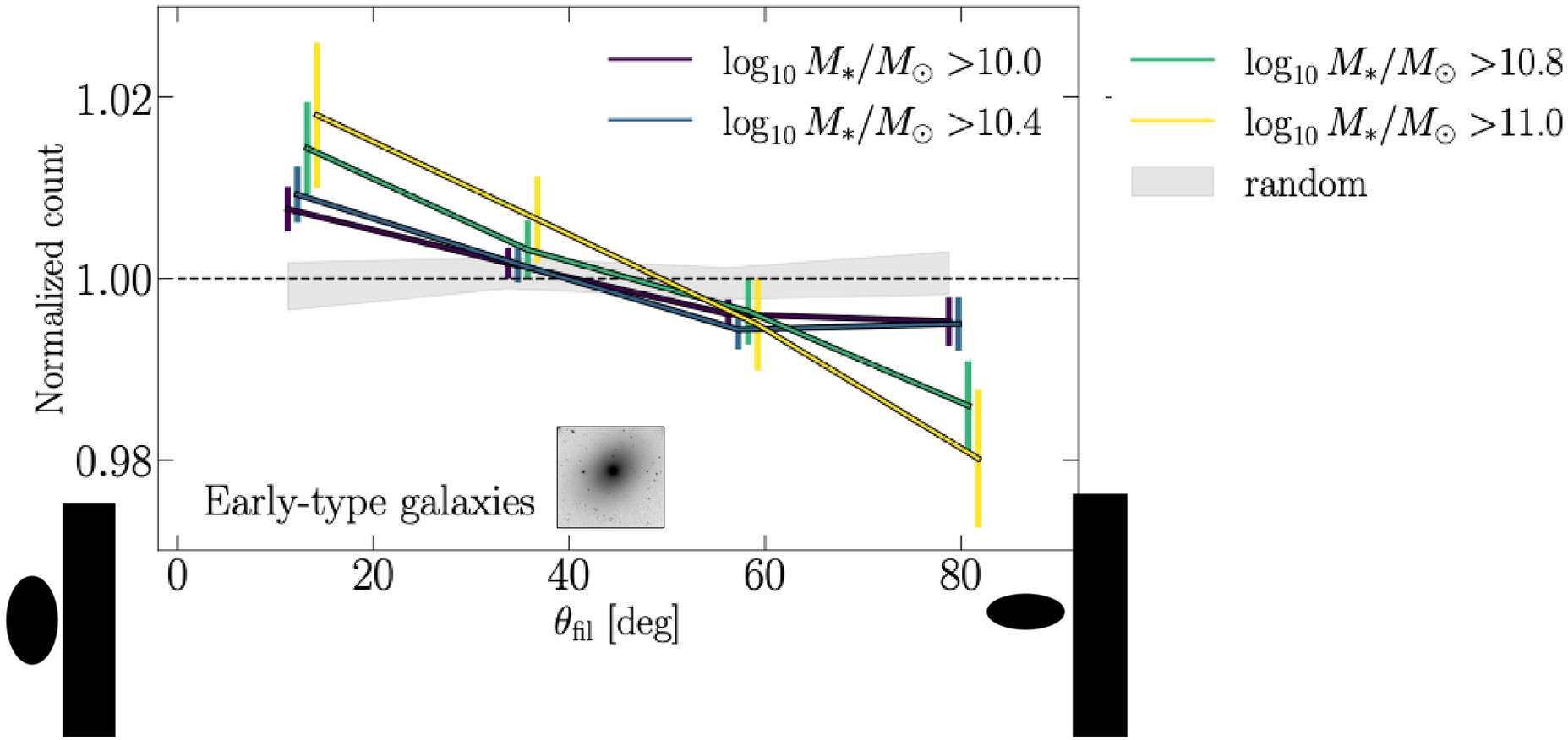




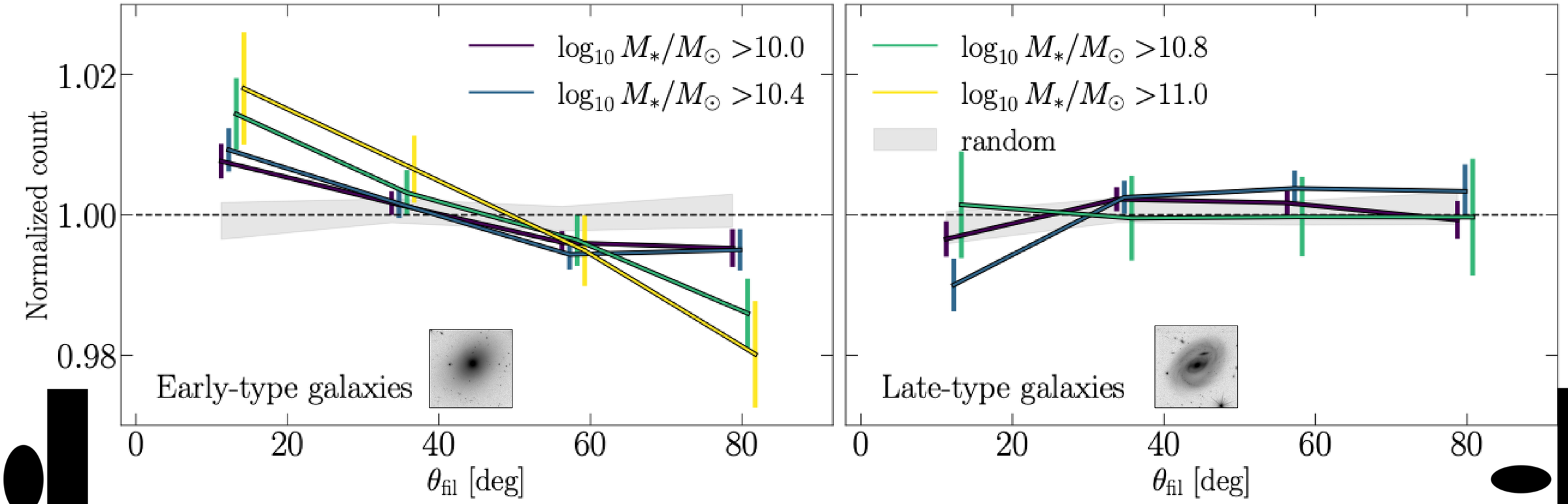
Results: Galaxy properties in the cosmic web



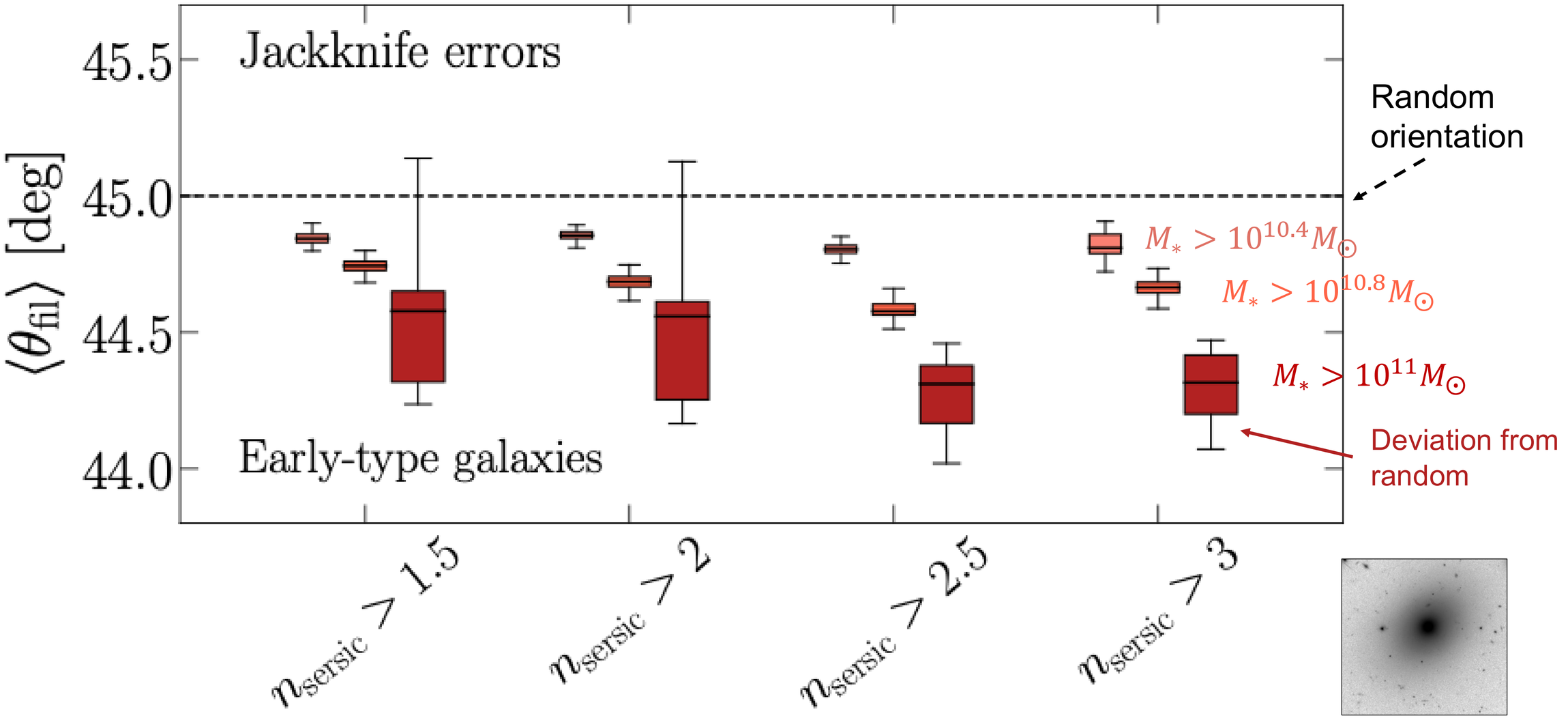
Results: alignment of galaxy shapes with filaments



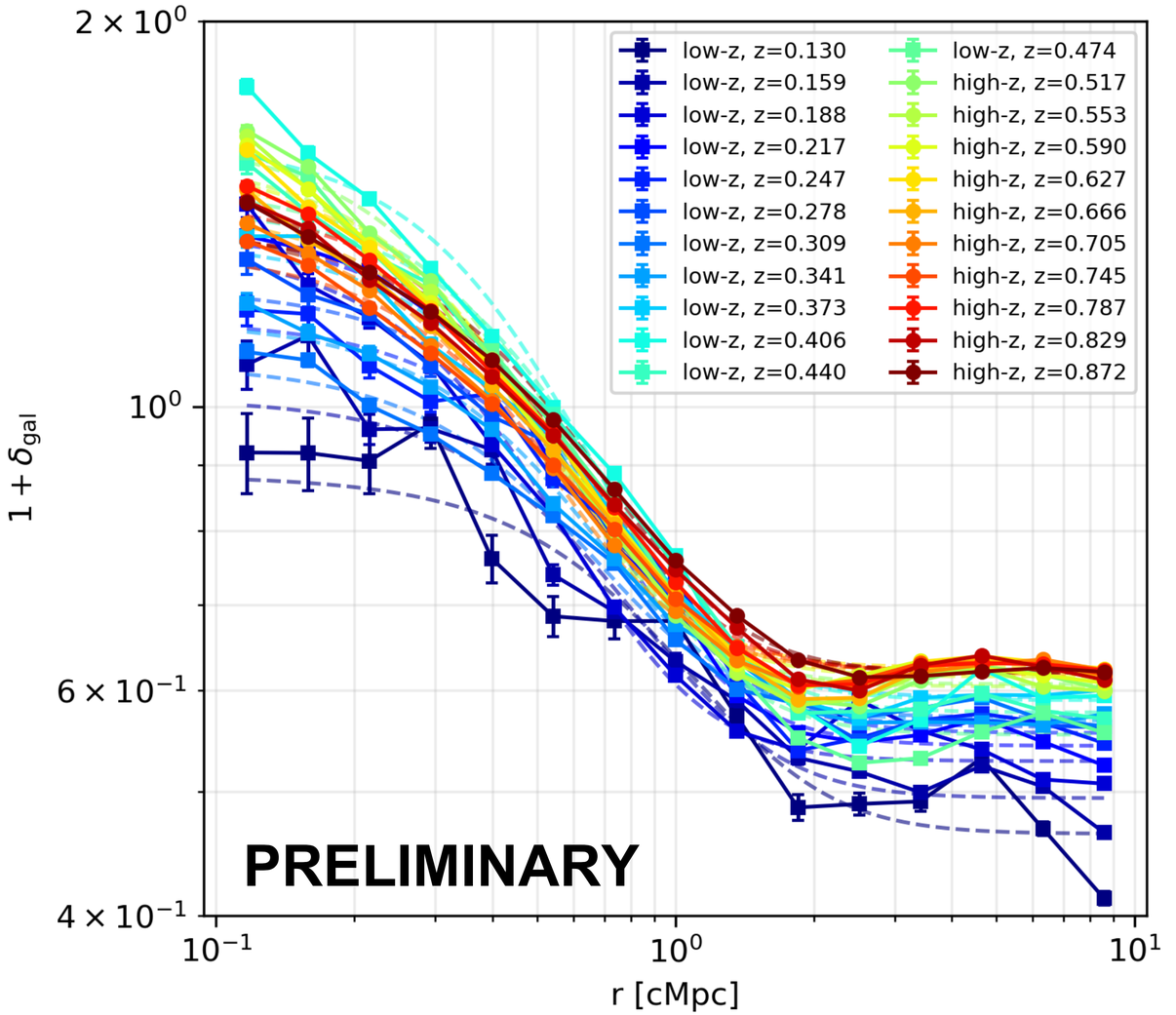
Results: alignment of galaxy shapes with filaments

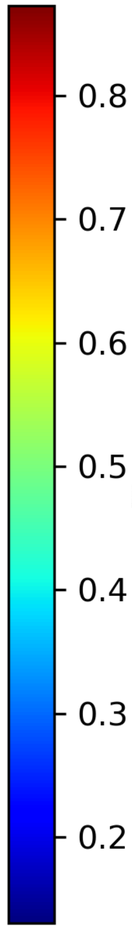


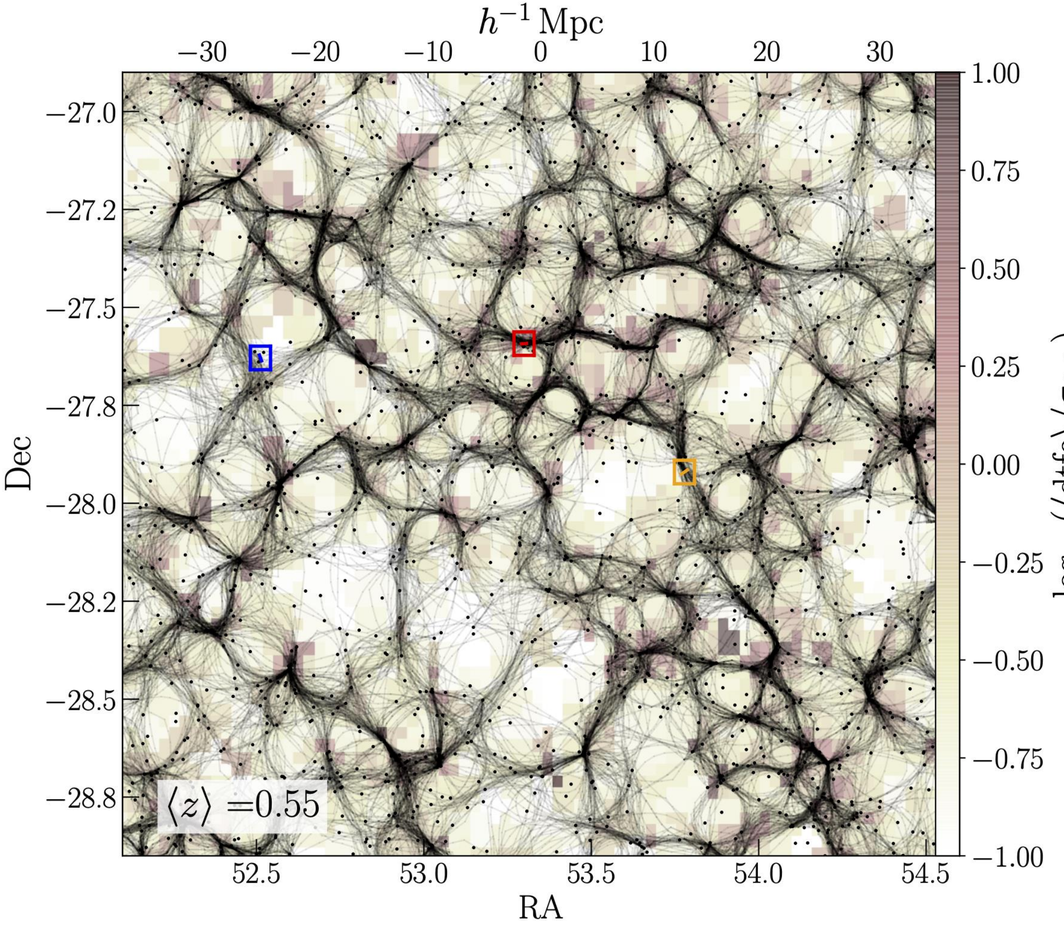
Results: Variations of alignments with Sersic index



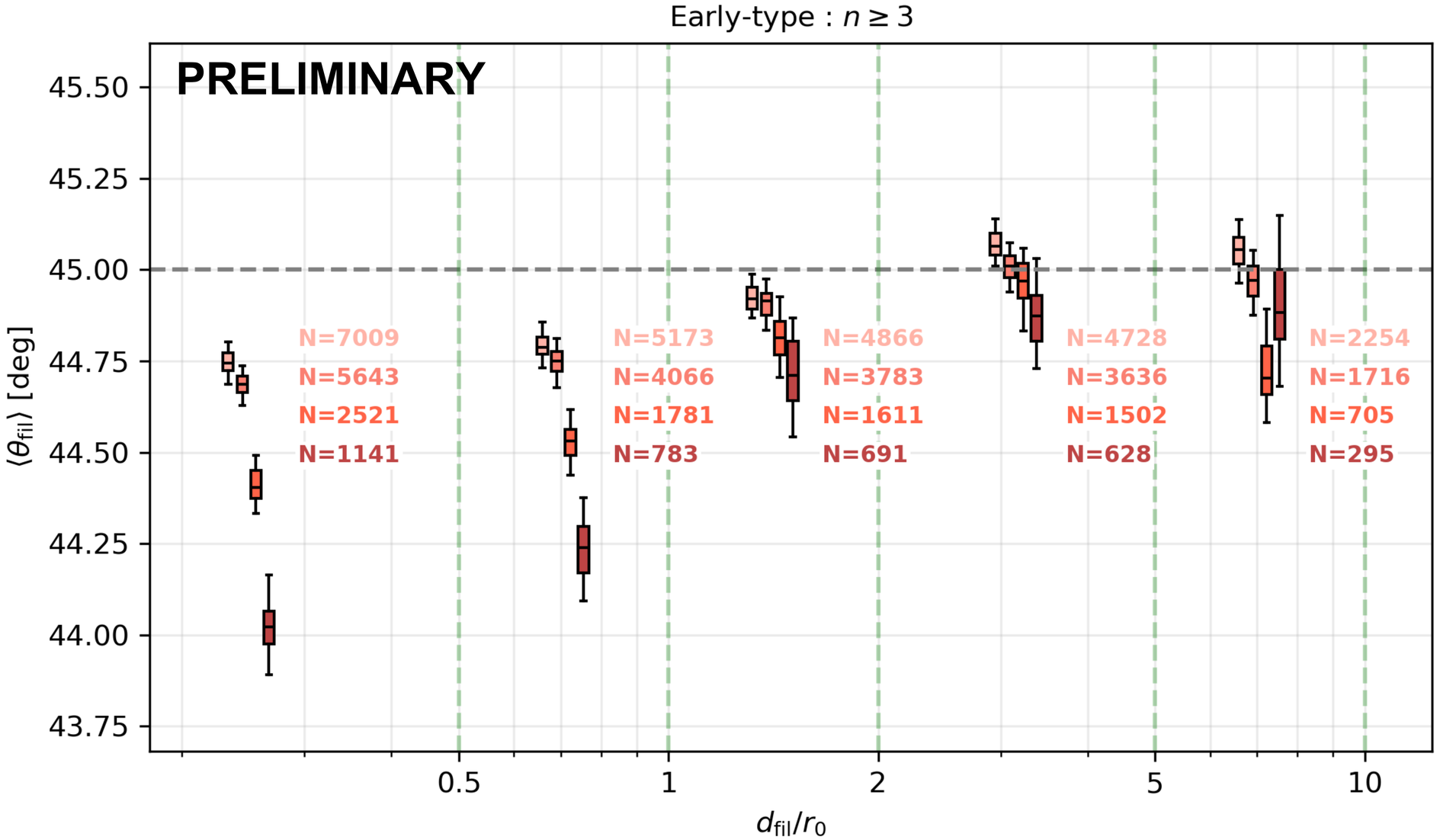
Results: projected filament density profile in Euclid Q1



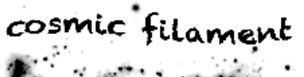




Results: most of the alignment signal is driven by galaxies inside filaments



Co-evolution of galaxies and cosmic web filaments
(another perspective on intrinsic alignments)



- Intrinsic alignments are a major source of systematics in weak lensing analysis
- The physics beyond intrinsic alignments can be addressed by understanding mass growth in the cosmic web
- From a lagrangian analysis on simulations we show that halos align at the filament edge
- In Euclid with photo-z, we made a first reconstruction of the cosmic web.
- We measure a tendency for early-type galaxies to align with the filaments. This increases with Sersic index
- Besides the study of alignments: in simulations we can characterize filament drift / core radius evolution: investigating the way these quantities depend on DE could be a promizing avenue

Perspectives on Euclid:

1. More statistics on DR1 data will allow to improve the significance of the results
2. Deeper data on EDF will enable the measurement of the alignment of late-type galaxies
3. Non-parametric morphological measurements will allow to refine the analysis