The relative effect of filaments and nodes on the spin and star-formation of galaxies

Nicola Malavasi

with: Nabila Aghanim, Mathieu Langer, Daniela Galárraga, Marian Douspis

IAS Orsay - ByoPiC team

European Research Council
Established by the European Commission

EAS Virtual - 01/07/2020

The cosmic web

Credits: Horizon-AGN

Matter departs from voids → reaches walls

matter flows inside walls → reaches filaments

matter flows inside filaments → reaches clusters

The cosmic web

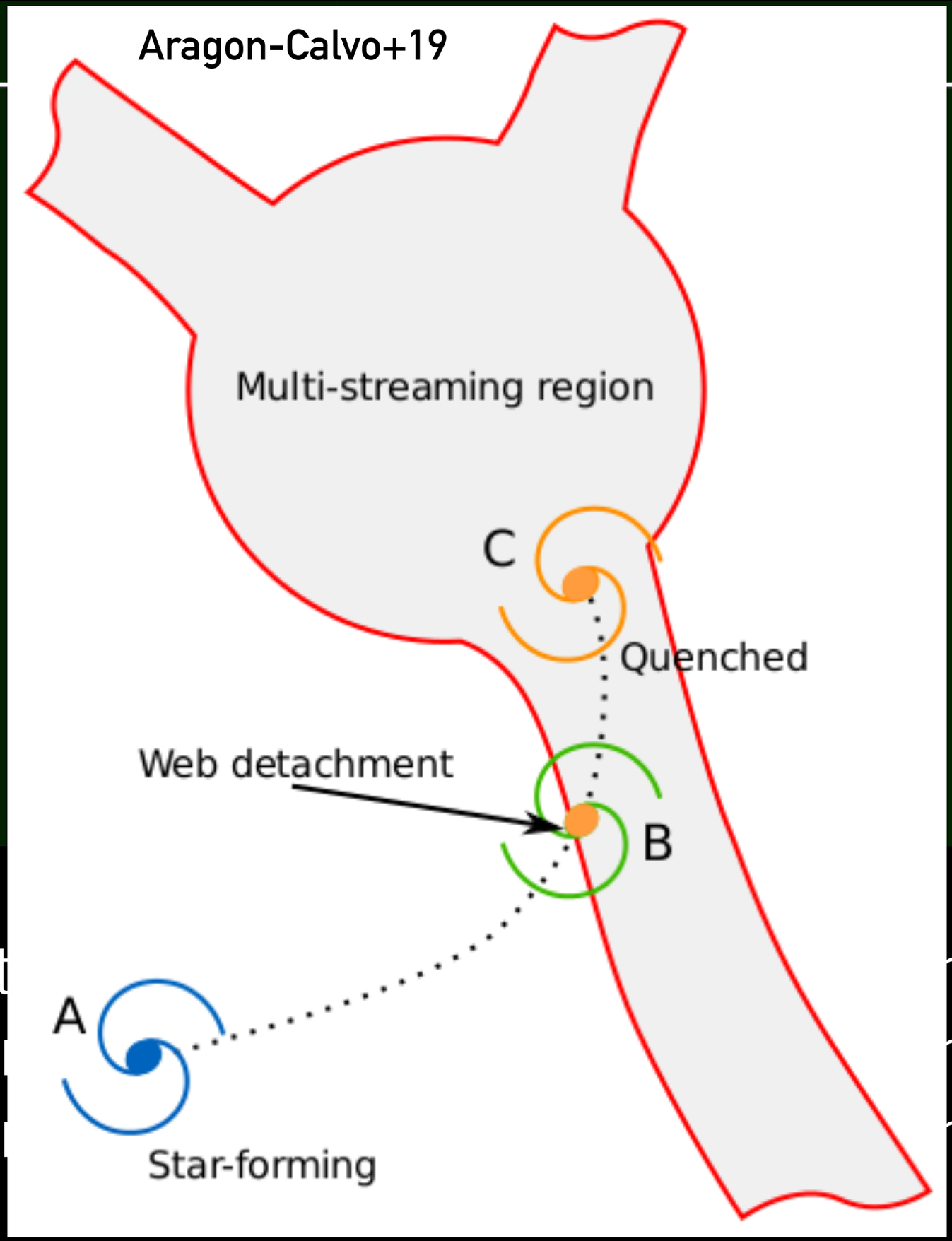
Credits: Horizon-AGN

Matter departs from voids → reaches walls

matter flows inside walls → reaches filaments

matter flows inside filaments → reaches clusters

The cosmic web



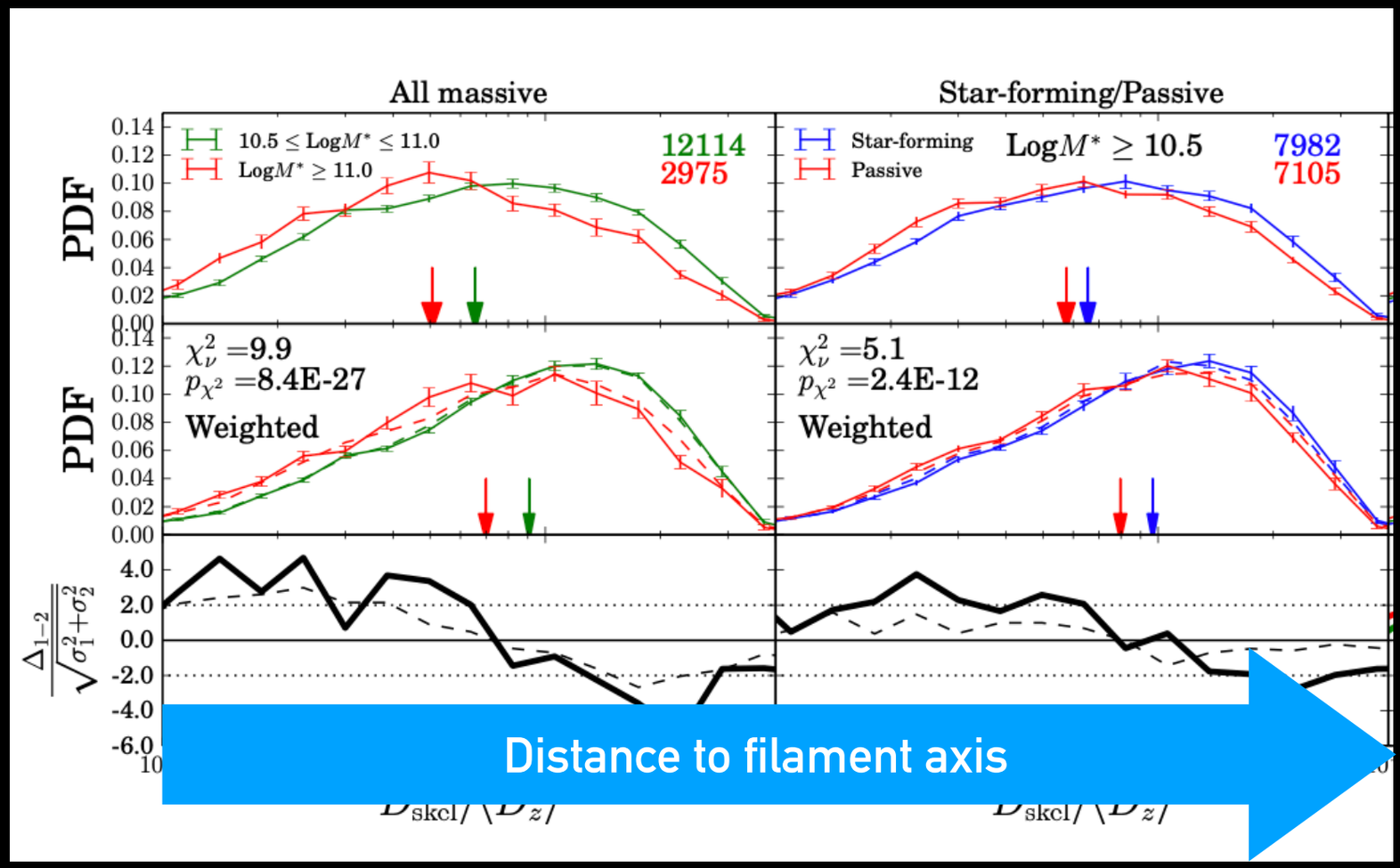
z=38.305

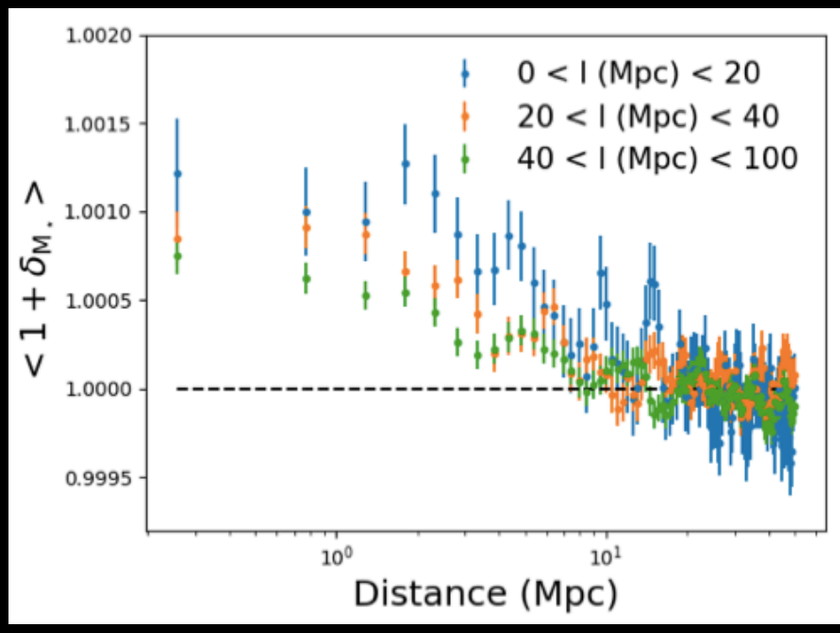
Matter depart nes walls
matter flows i nes filaments
matter flows i nes clusters

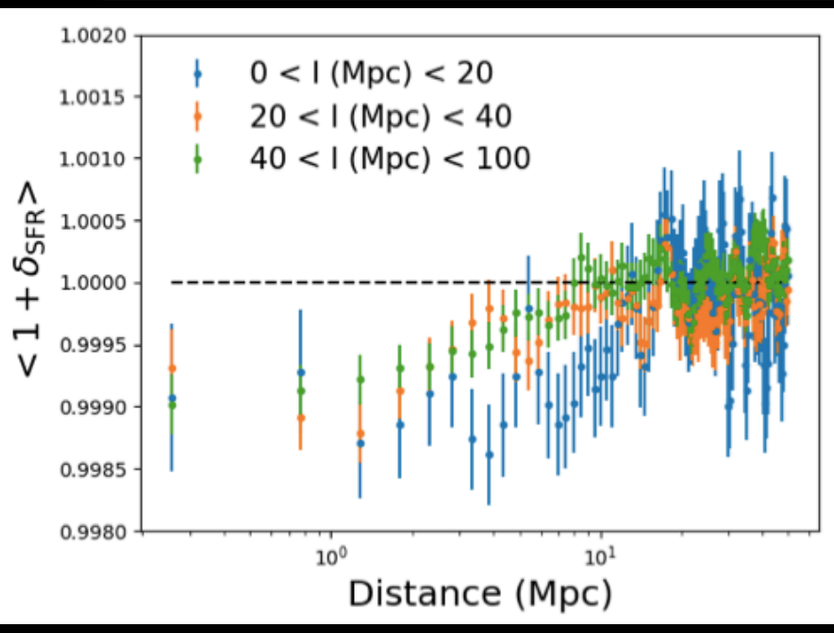
The cosmic web & galaxy evolution

Clusters and filaments affect SFR and M* of galaxies.

Malavasi+17: filaments detected in VIPERS. Massive and passive galaxies are closer to the axis of filaments.



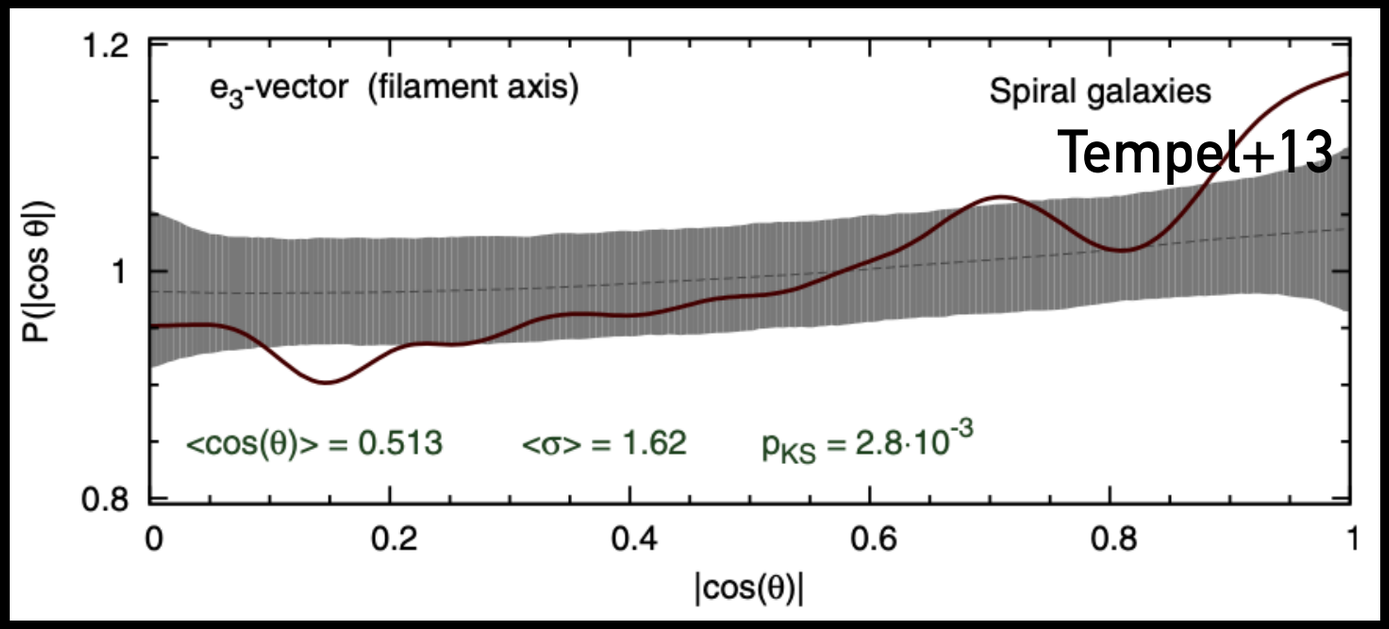




Bonjean+20: filaments detected in the SDSS (Malavasi+20). Gradients of mass and SFR from the axis of filaments.

Laigle+18, Kraljic+18, Salerno+20, Vulcani+19

THE EFFECT OF THE COSMIC WEB: SPIN



Perpendicular — Aligned

Cosine of angle between spin of spiral galaxies and axis of filaments.

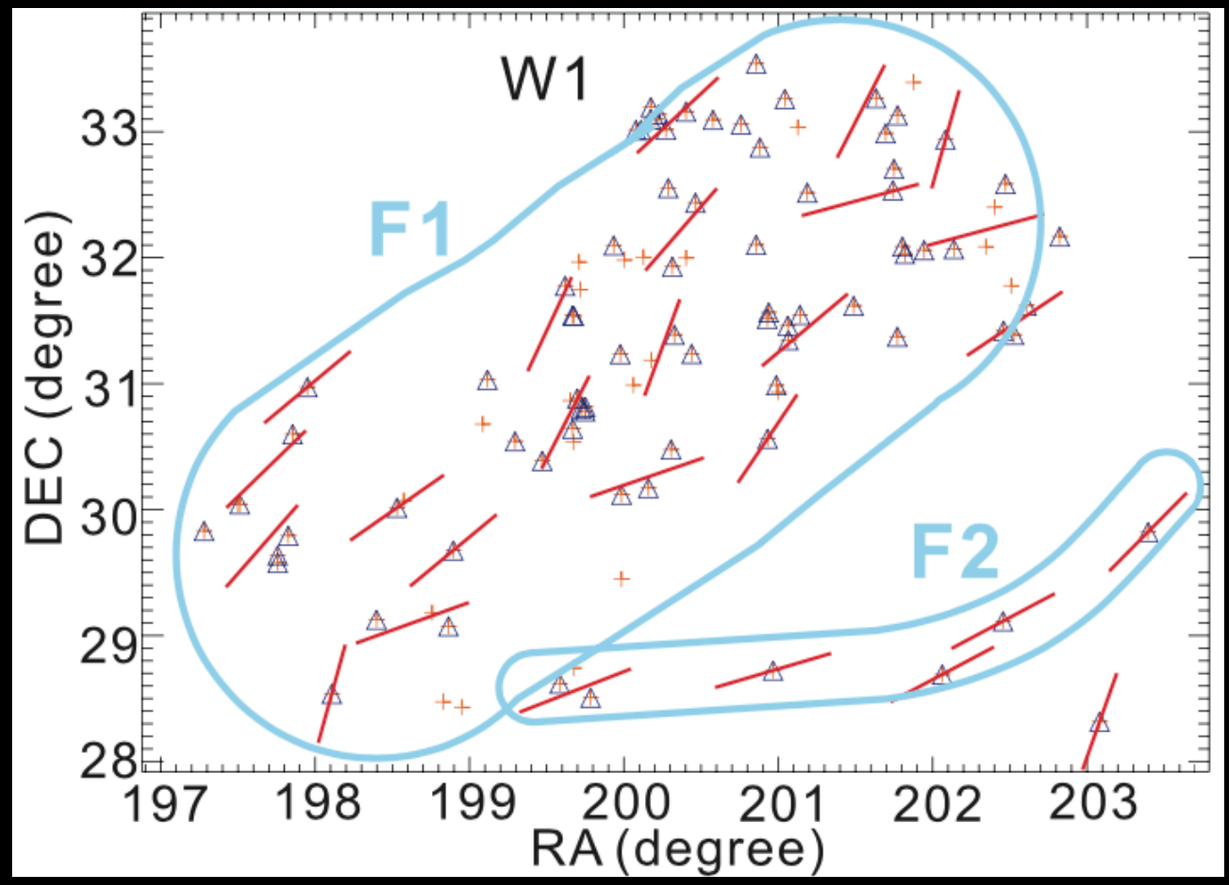
Filament influence on angular momentum of galaxies. The spin of galaxies is aligned or perpendicular with the direction of the filaments.

Codis+18, Ganeshaiah-Veena+19, Krolewski+19, Laigle+15, Welker+19

Our goal

- Which structures affects the most a given property? E.g. is SFR affected more by filaments or clusters?
- Understand which property better traces a given structure: e.g. is it better to use the quenched fraction or the spin to trace filaments?

E.g. use of the red sequence to improve cluster detection algorithms or use of the spin alignment to detect filaments.

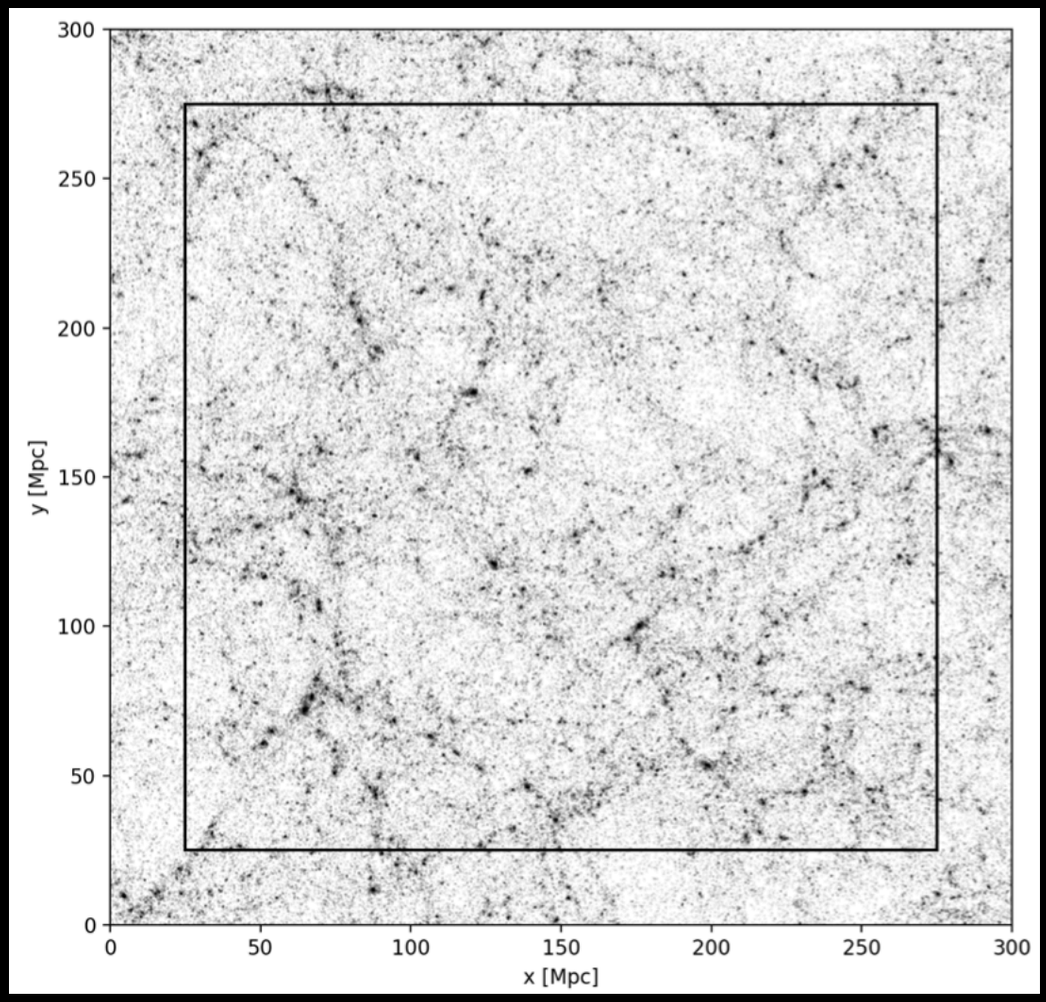


Rong+15: filaments detected around Coma with galaxy alignment.

The Illustris TNG simulation

- IllustrisTNG300-1 cosmological simulation (Nelson+19)
- ~276'000 halos
- ~300 Mpc^3 box
- $10^9 \leq M*[M_\odot] \leq 10^{12}$
- $z = 0$

	TNG300-1
Box size [Mpc^3]	302.6^3
DM resolution [$M_\odot/h$]	4.0×10^7
Density of tracers [Mpc^{-3}]	10.0×10^{-3}
Cosmology	*Planck* 2015
Number of filaments	5550
Min and Max filament lengths [Mpc]	[0.4, 65.6]
Mean filament length [Mpc]	10.9
Median filament length [Mpc]	8.8

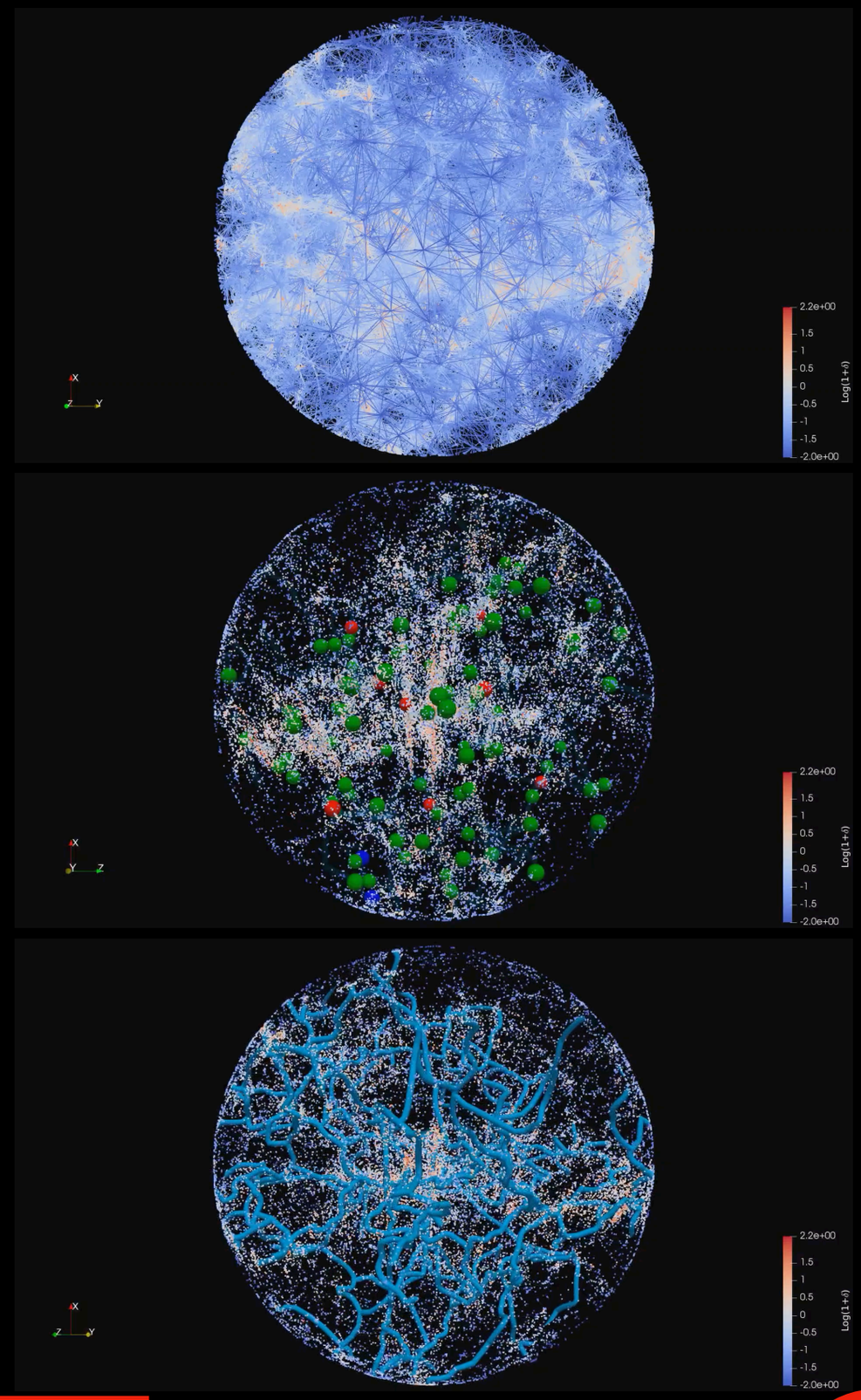


Halo selection and filament extraction described in Galárraga-Espinosa+20

The DisPerSE algorithm

Discrete Persistent Structure Extractor (DisPerSE, Sousbie11, Sousbie+11)

Powerful algorithm, works with discrete density fields, no smoothing necessary.

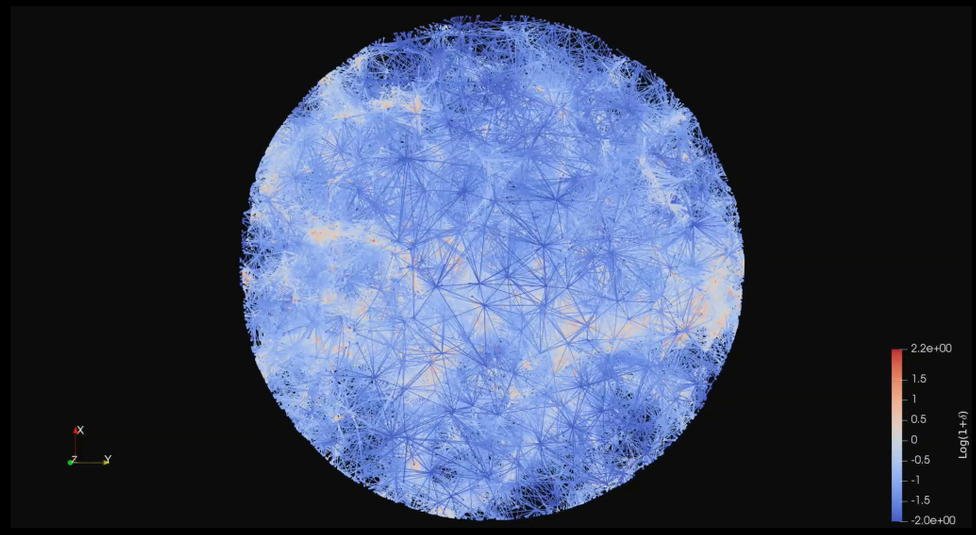


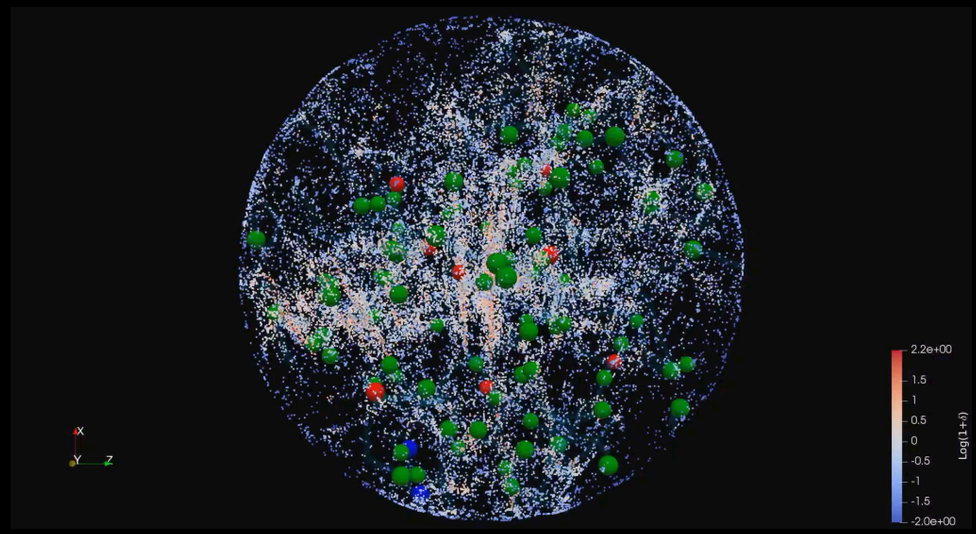
The DisPerSE algorithm

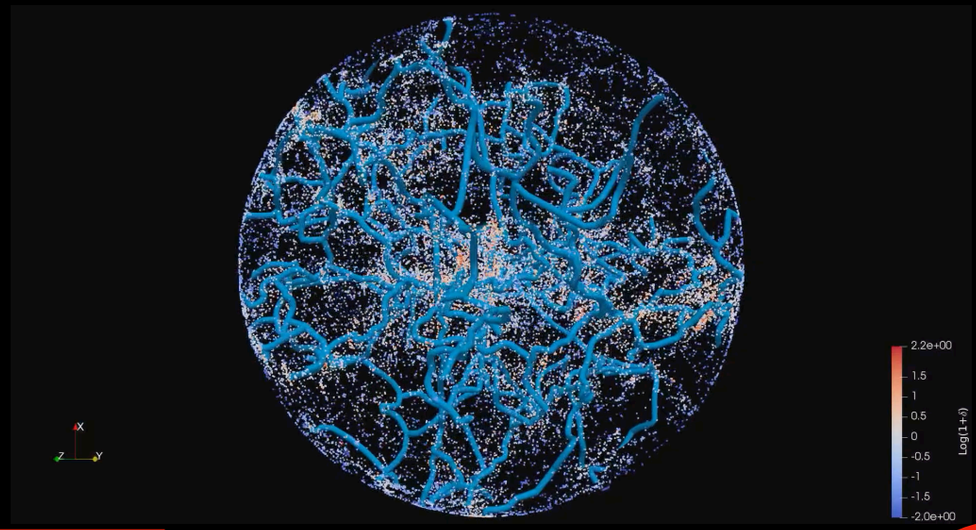
Measure of the density field (e.g. DTFE)

Computation of the discrete gradient
Detection of critical points (maxima, minima, saddles)

Connection of critical points with filaments
Persistence cut to eliminate spurious structures due to noise





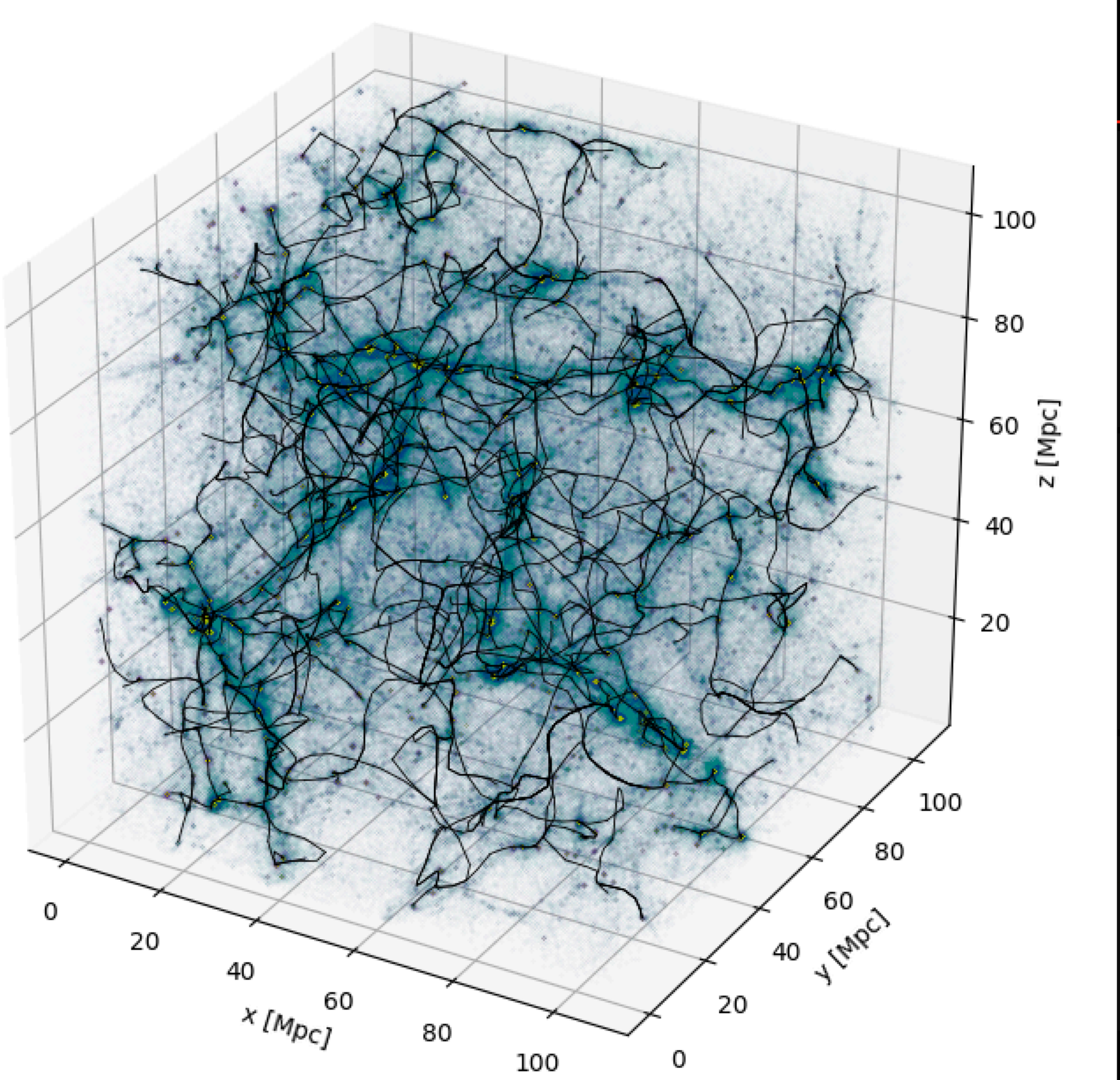


THE

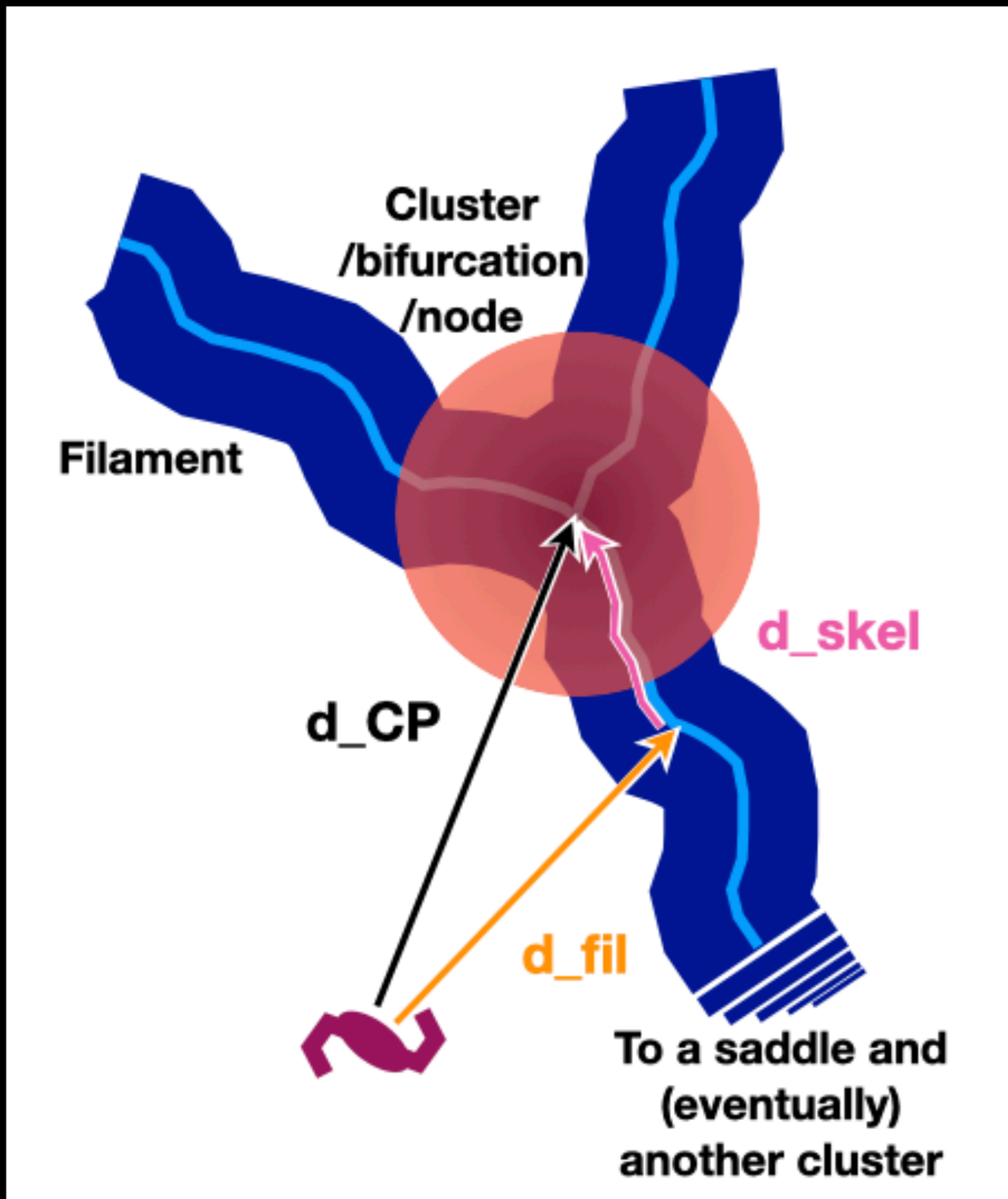
Comp

Dete

Persi

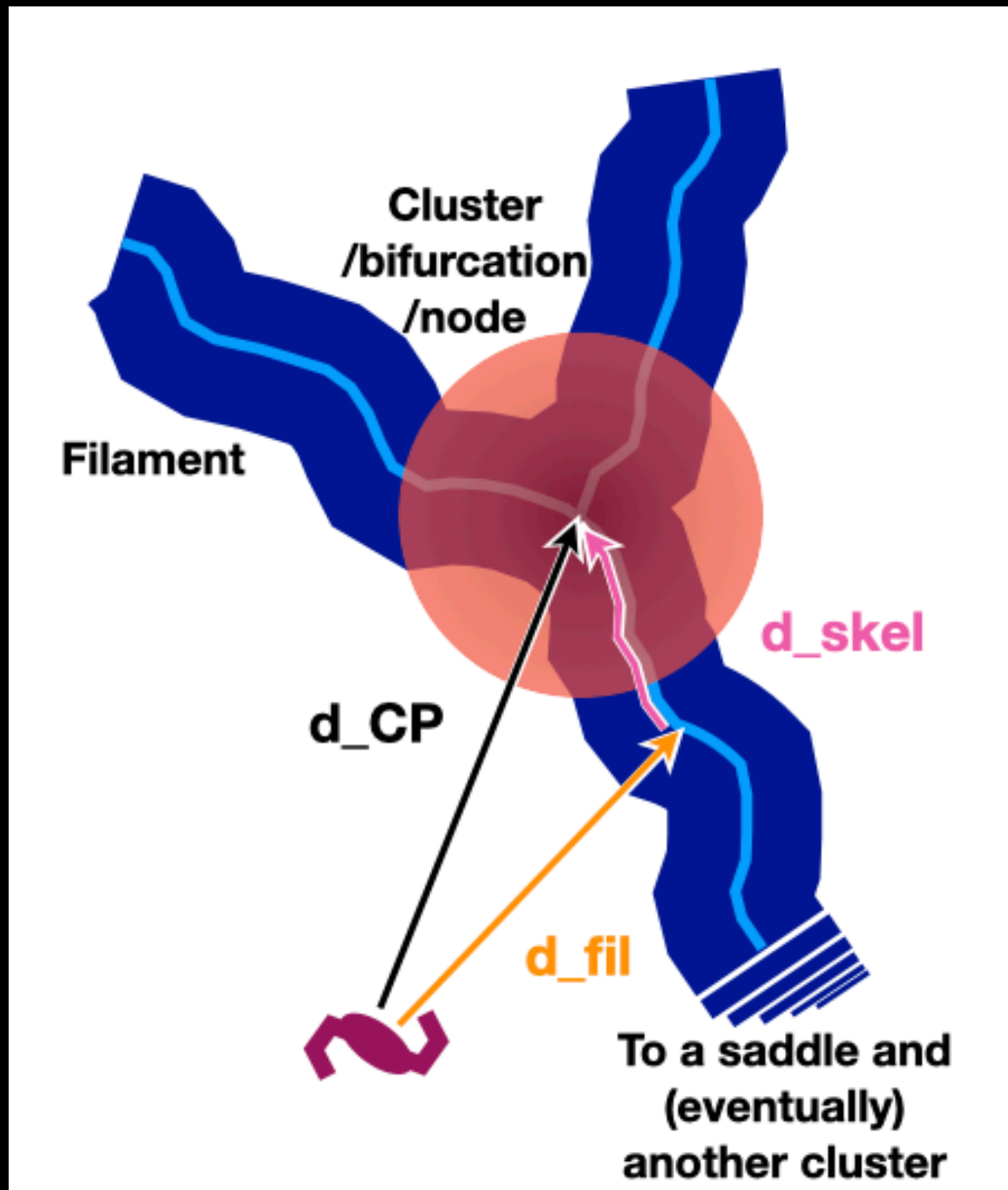


Quantities and distances



Quantities and distances

- Stellar mass M*
- Star-formation rate SFR
- Angle between filaments and halo spin θ – aligned (0°), perpendicular (90°), random (45°)

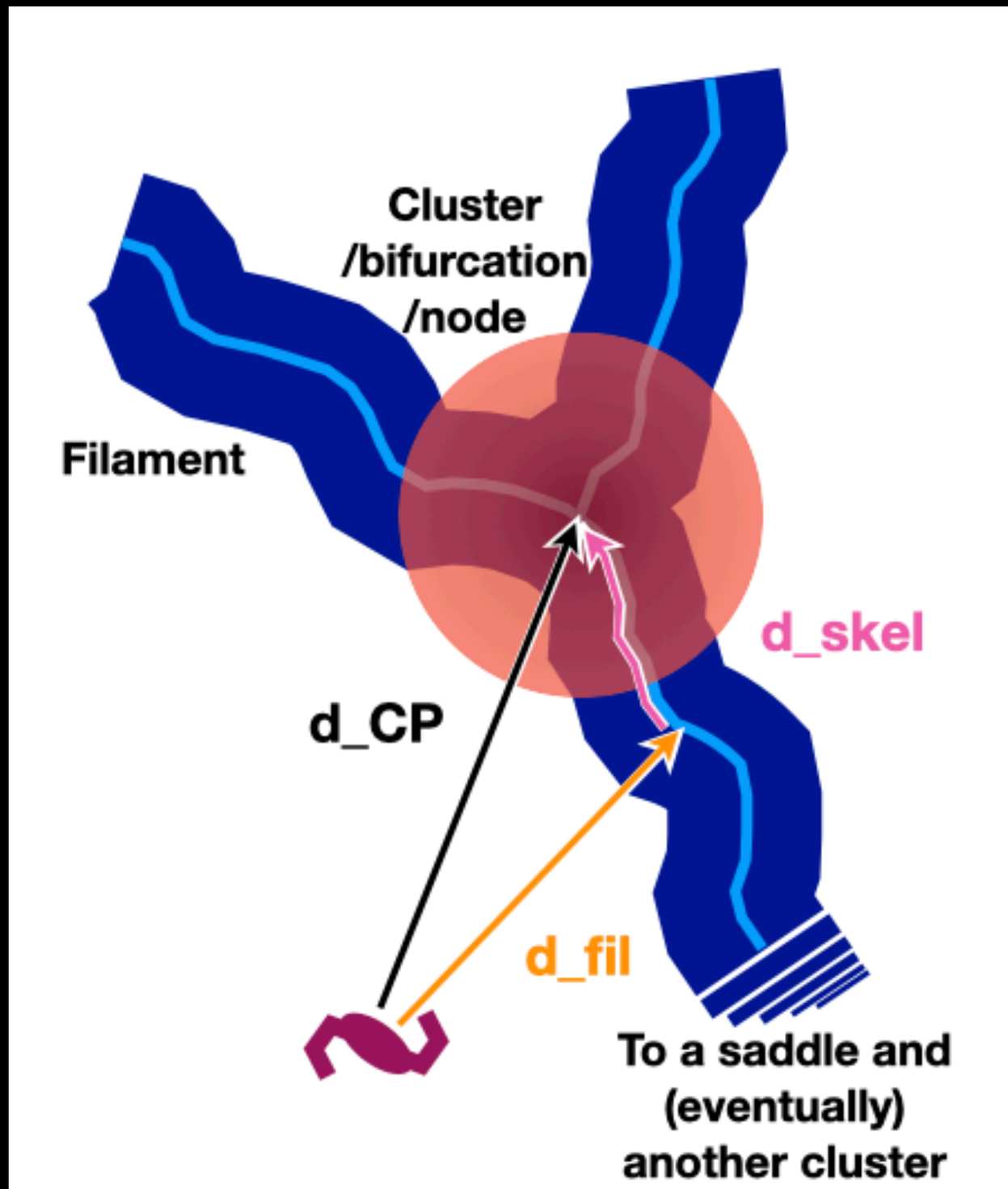


Quantities and distances

- Stellar mass M*
- Star-formation rate SFR
- Angle between filaments and halo spin θ – aligned (0°), perpendicular (90°), random (45°)

We focus on the following distances:

- Distance from the nodes
- Distance from the axis of filaments
- Distance from the nodes following the filaments (for haloes within 1 Mpc from filament axis)

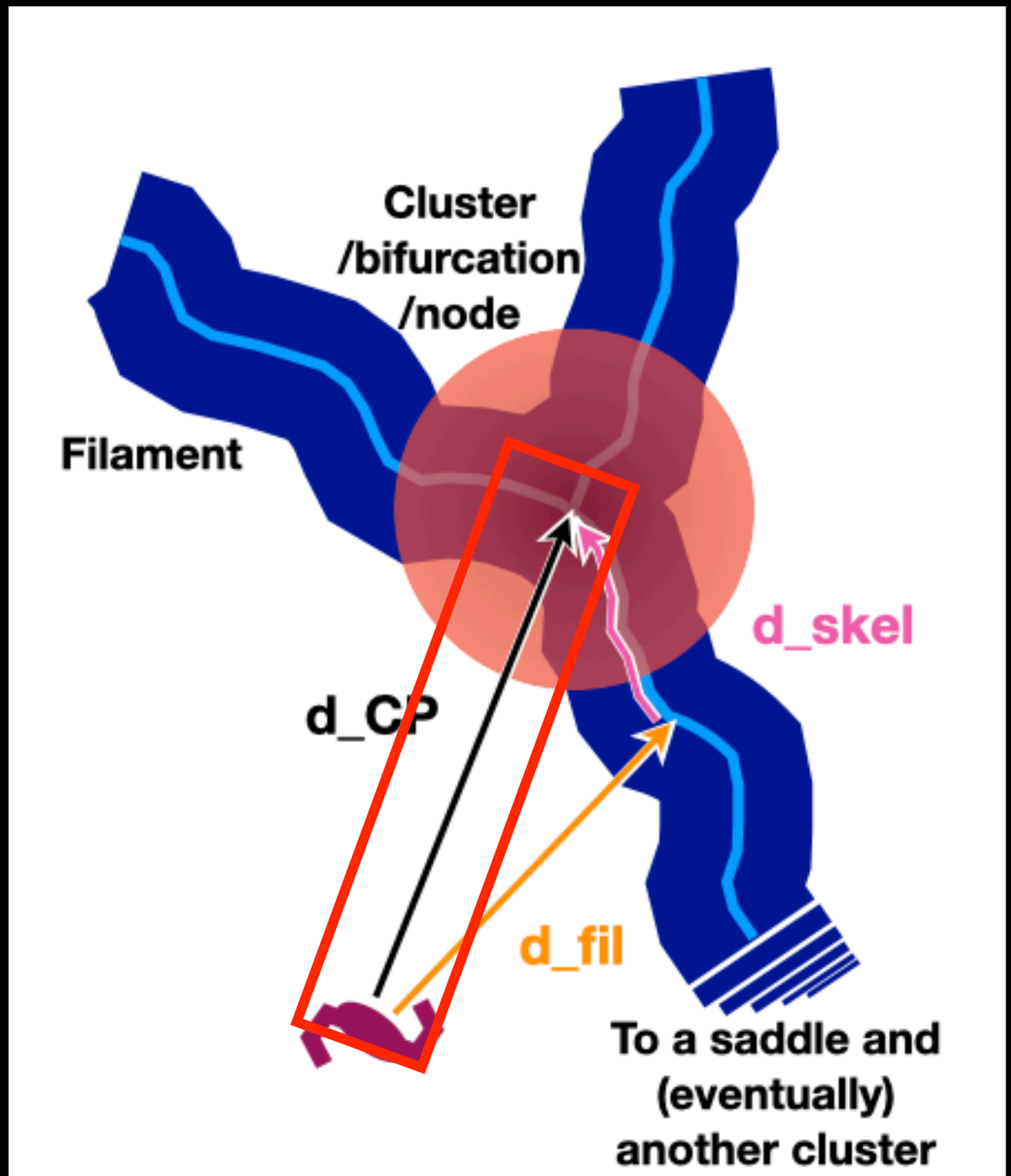


Quantities and distances

- Stellar mass M*
- Star-formation rate SFR
- Angle between filaments and halo spin θ – aligned (0°), perpendicular (90°), random (45°)

We focus on the following distances:

- Distance from the nodes
- Distance from the axis of filaments
- Distance from the nodes following the filaments (for haloes within 1 Mpc from filament axis)

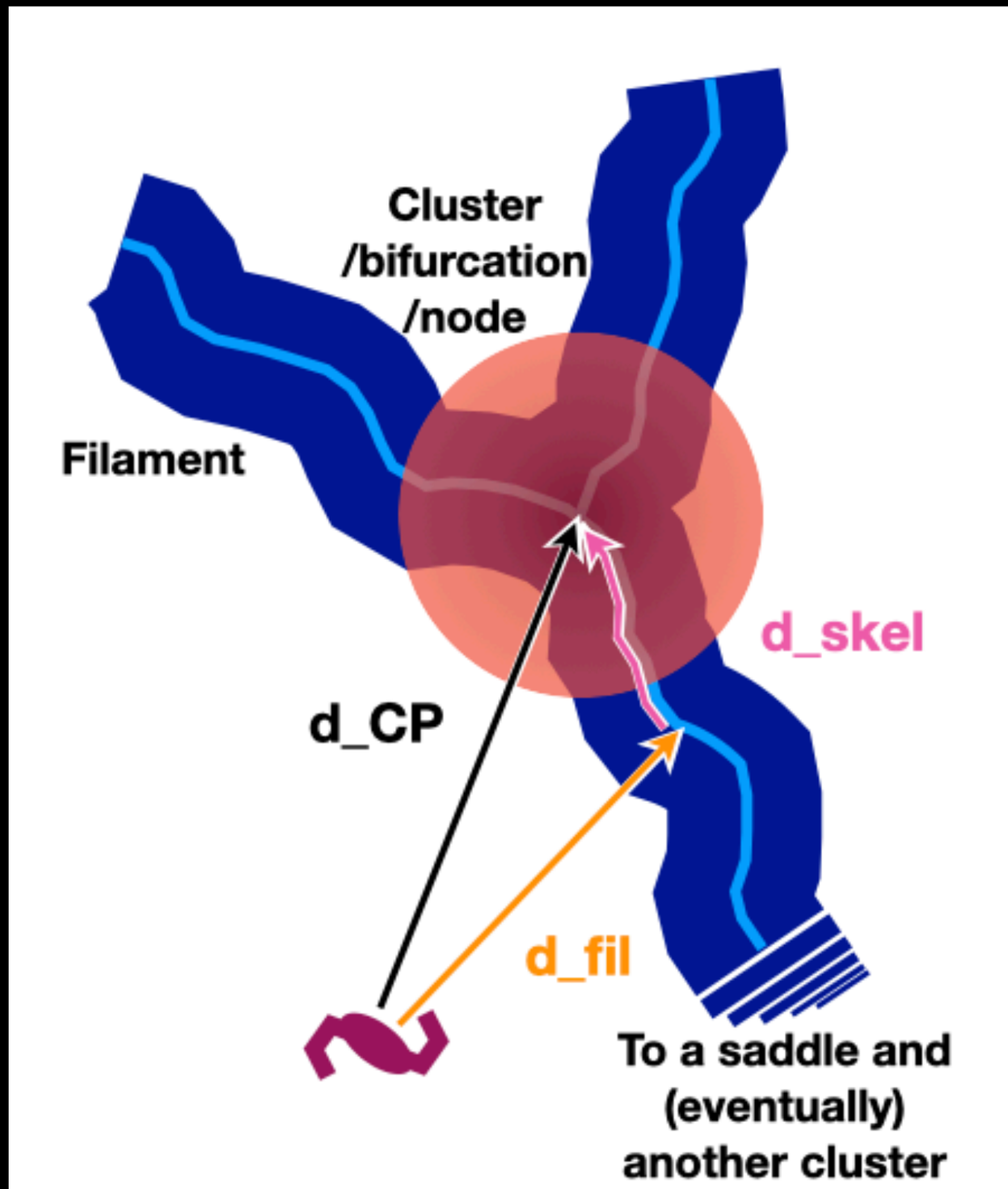


Quantities and distances

- Stellar mass M*
- Star-formation rate SFR
- Angle between filaments and halo spin θ – aligned (0°), perpendicular (90°), random (45°)

We focus on the following distances:

- Distance from the nodes
- Distance from the axis of filaments
- Distance from the nodes following the filaments (for haloes within 1 Mpc from filament axis)

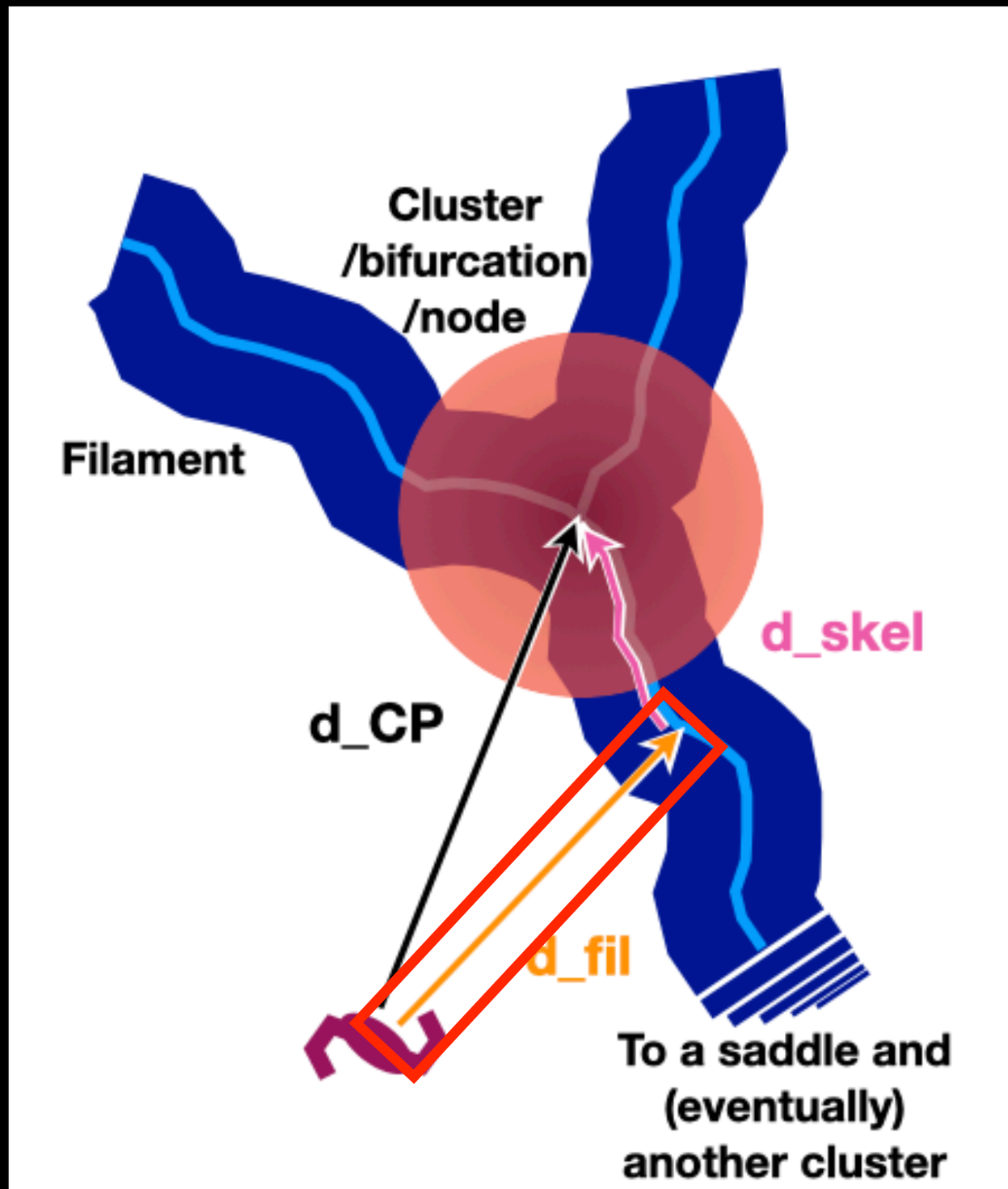


Quantities and distances

- Stellar mass M*
- Star-formation rate SFR
- Angle between filaments and halo spin θ – aligned (0°), perpendicular (90°), random (45°)

We focus on the following distances:

- Distance from the nodes
- Distance from the axis of filaments
- Distance from the nodes following the filaments (for haloes within 1 Mpc from filament axis)

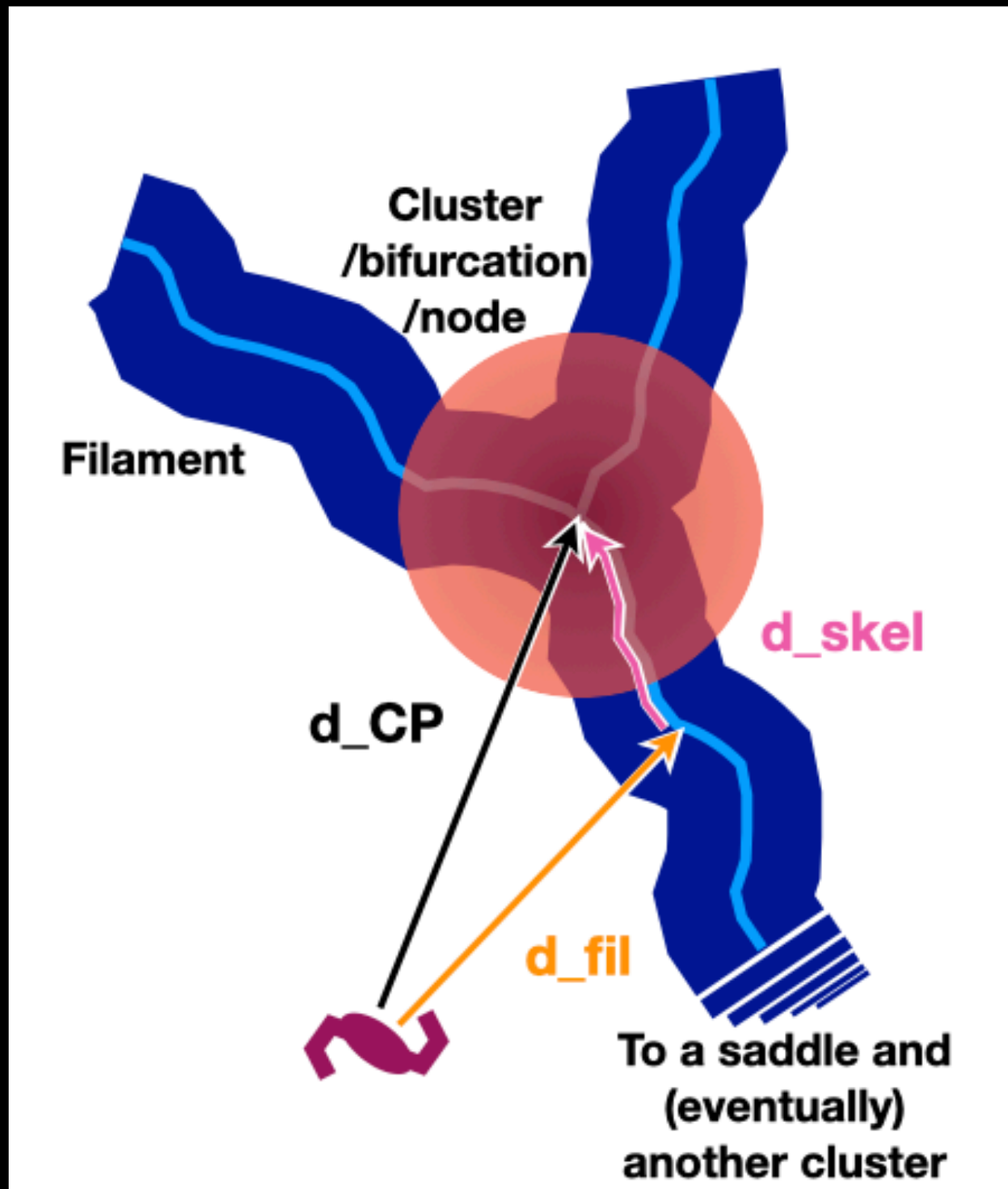


Quantities and distances

- Stellar mass M*
- Star-formation rate SFR
- Angle between filaments and halo spin θ – aligned (0°), perpendicular (90°), random (45°)

We focus on the following distances:

- Distance from the nodes
- Distance from the axis of filaments
- Distance from the nodes following the filaments (for haloes within 1 Mpc from filament axis)

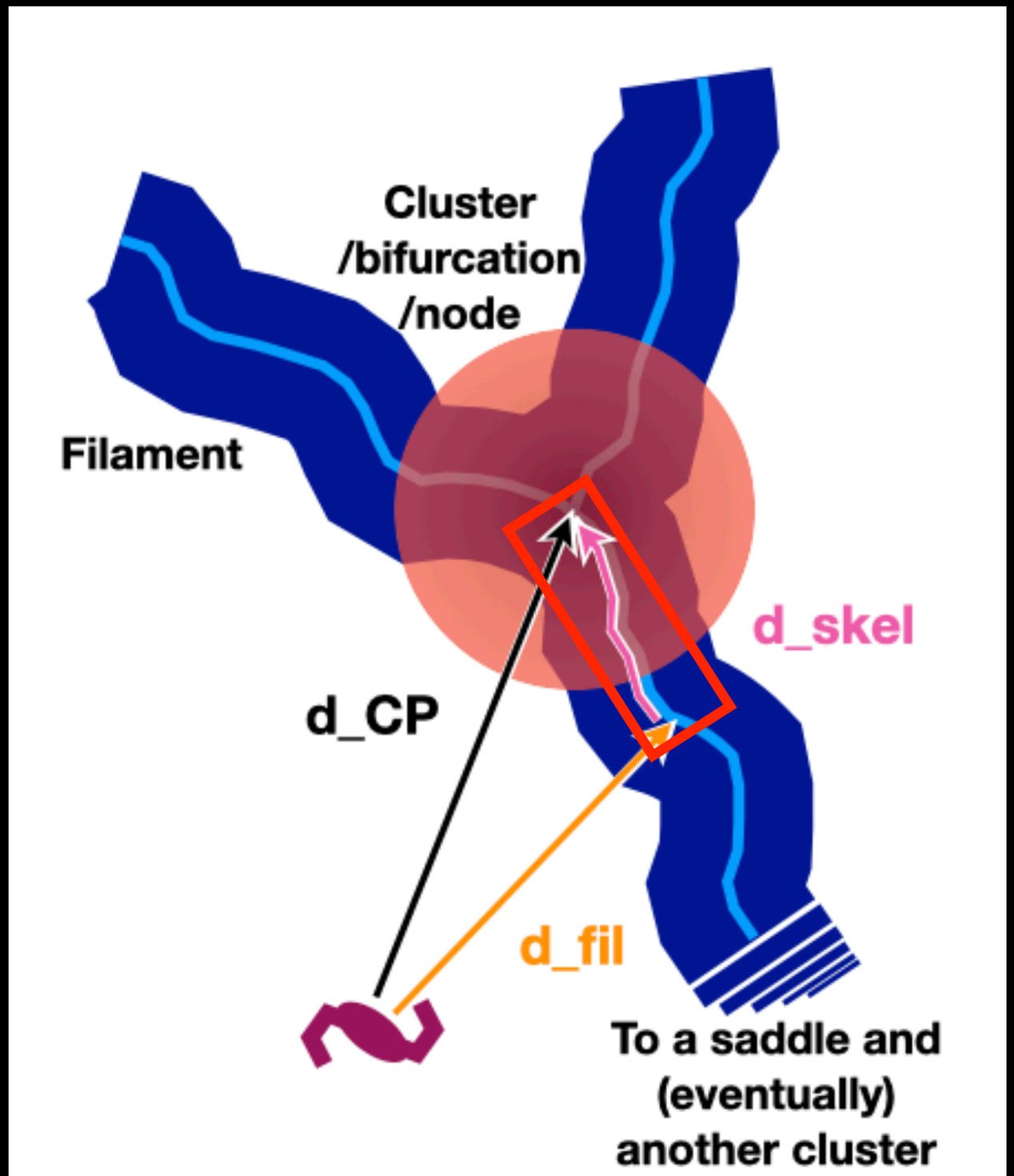


Quantities and distances

- Stellar mass M*
- Star-formation rate SFR
- Angle between filaments and halo spin θ – aligned (0°), perpendicular (90°), random (45°)

We focus on the following distances:

- Distance from the nodes
- Distance from the axis of filaments
- Distance from the nodes following the filaments (for haloes within 1 Mpc from filament axis)

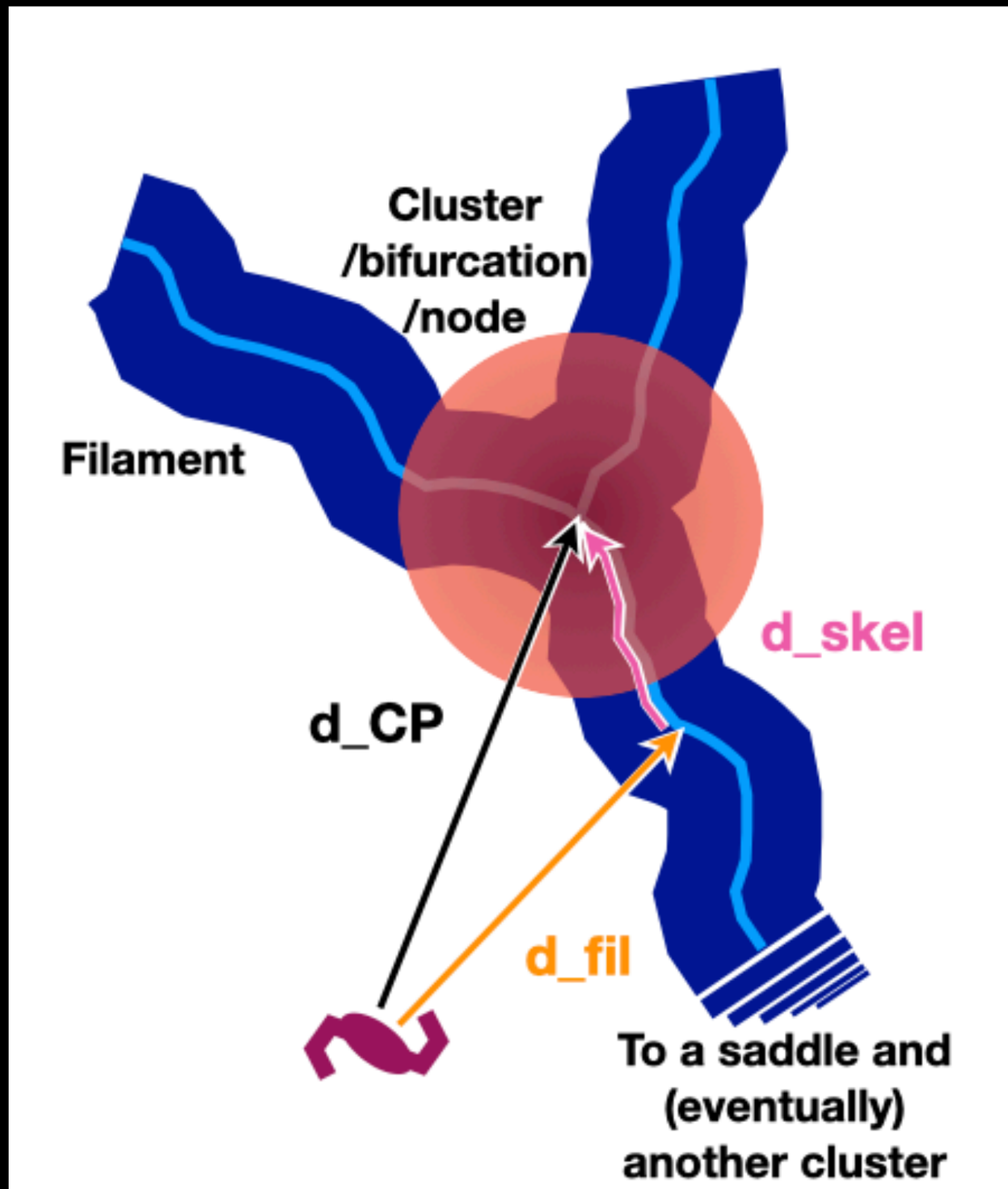


Quantities and distances

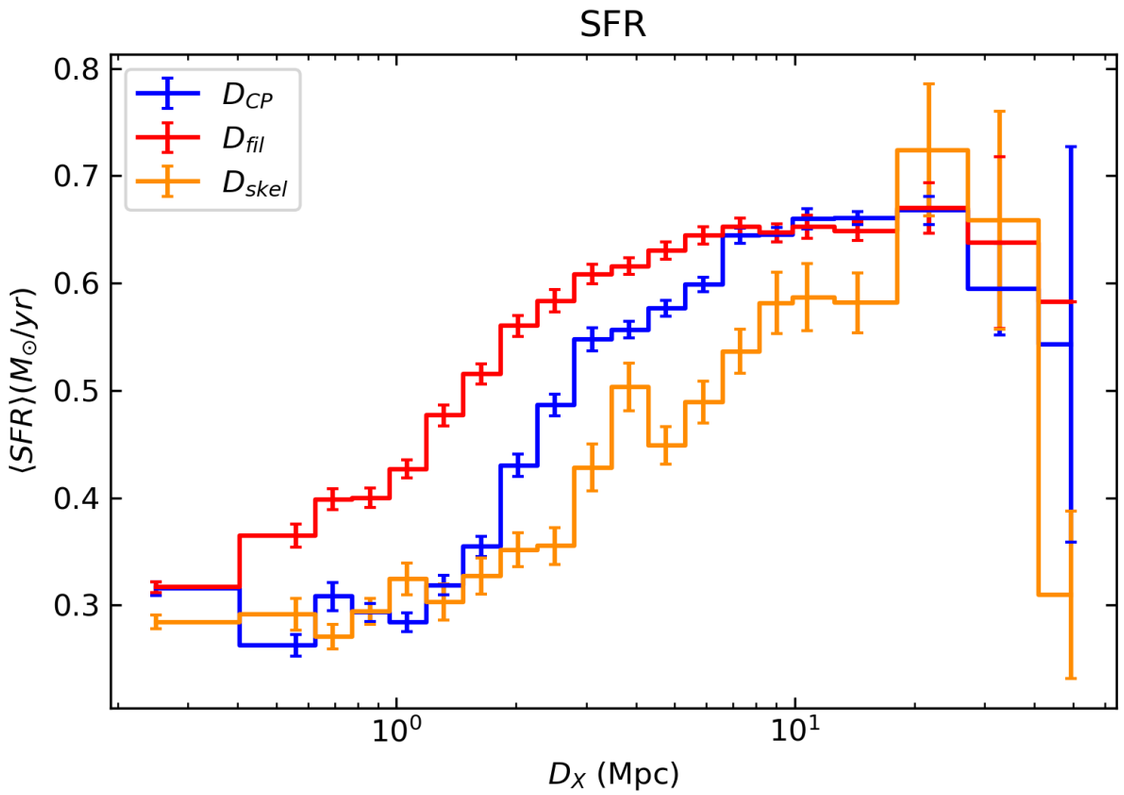
- Stellar mass M*
- Star-formation rate SFR
- Angle between filaments and halo spin θ – aligned (0°), perpendicular (90°), random (45°)

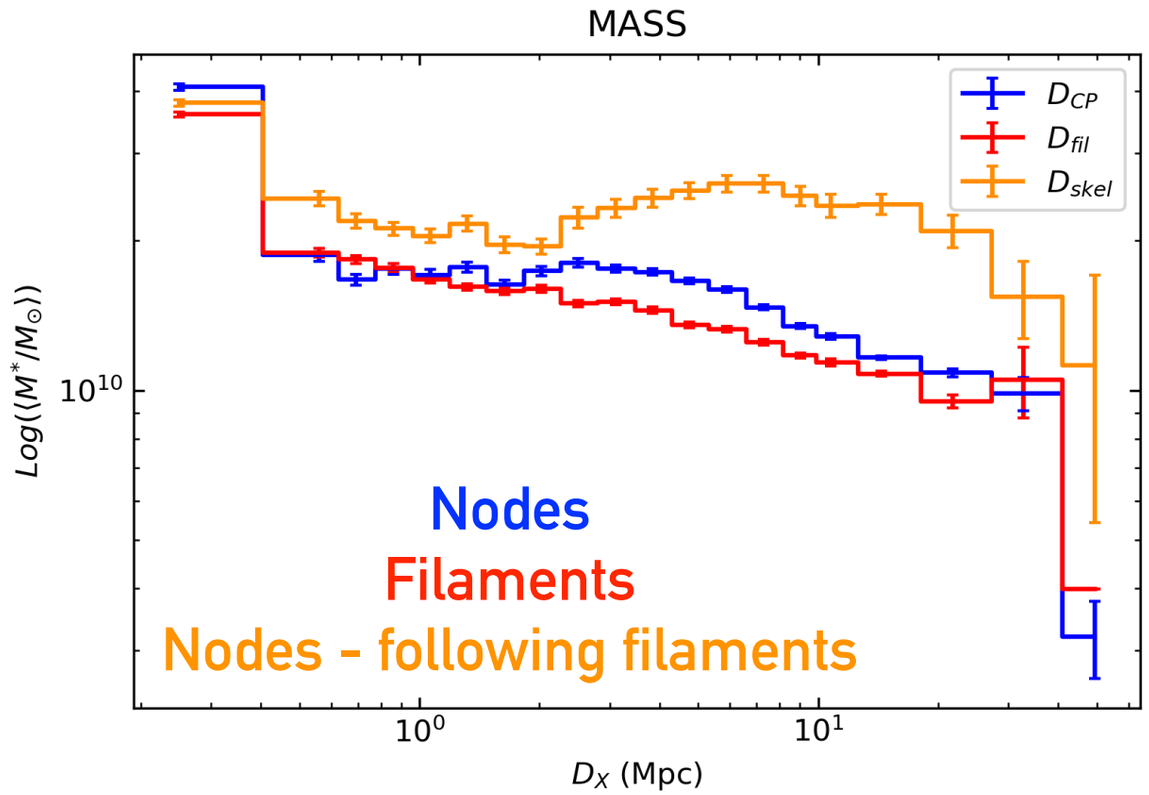
We focus on the following distances:

- Distance from the nodes
- Distance from the axis of filaments
- Distance from the nodes following the filaments (for haloes within 1 Mpc from filament axis)



Results – SFR and M*





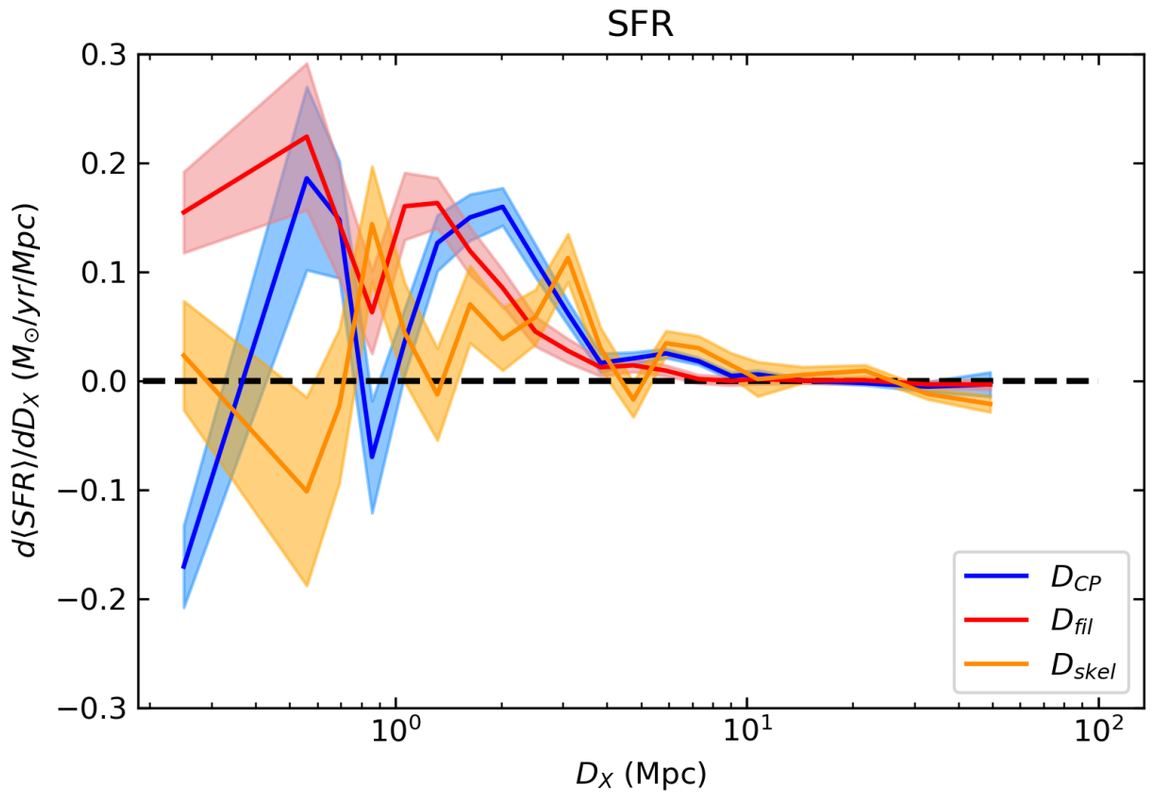
The value of $\langle SFR \rangle$

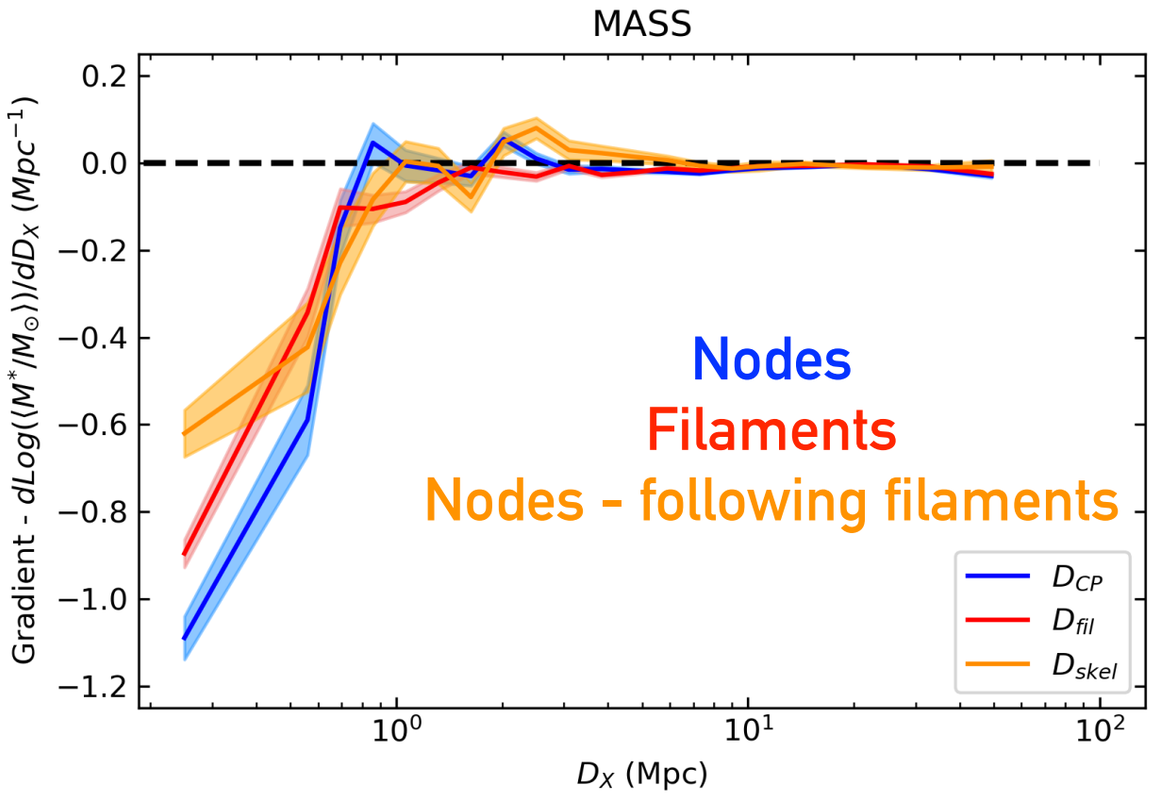
- Decreases towards all kinds of structures
- Is higher closer to filaments than closer to nodes – nodes are more effective at quenching
- Similar to nodes when moving towards them in filaments

The value of $\log(\langle M^*/M_\odot \rangle)$

- Increases towards all kinds of structures
- No difference between nodes and axis of filaments
- Slight difference in value when moving towards nodes in filaments

Results SFR and M*





The gradient of $\langle SFR\rangle$

- Positive but small for all structures
- No difference among the structures/distances

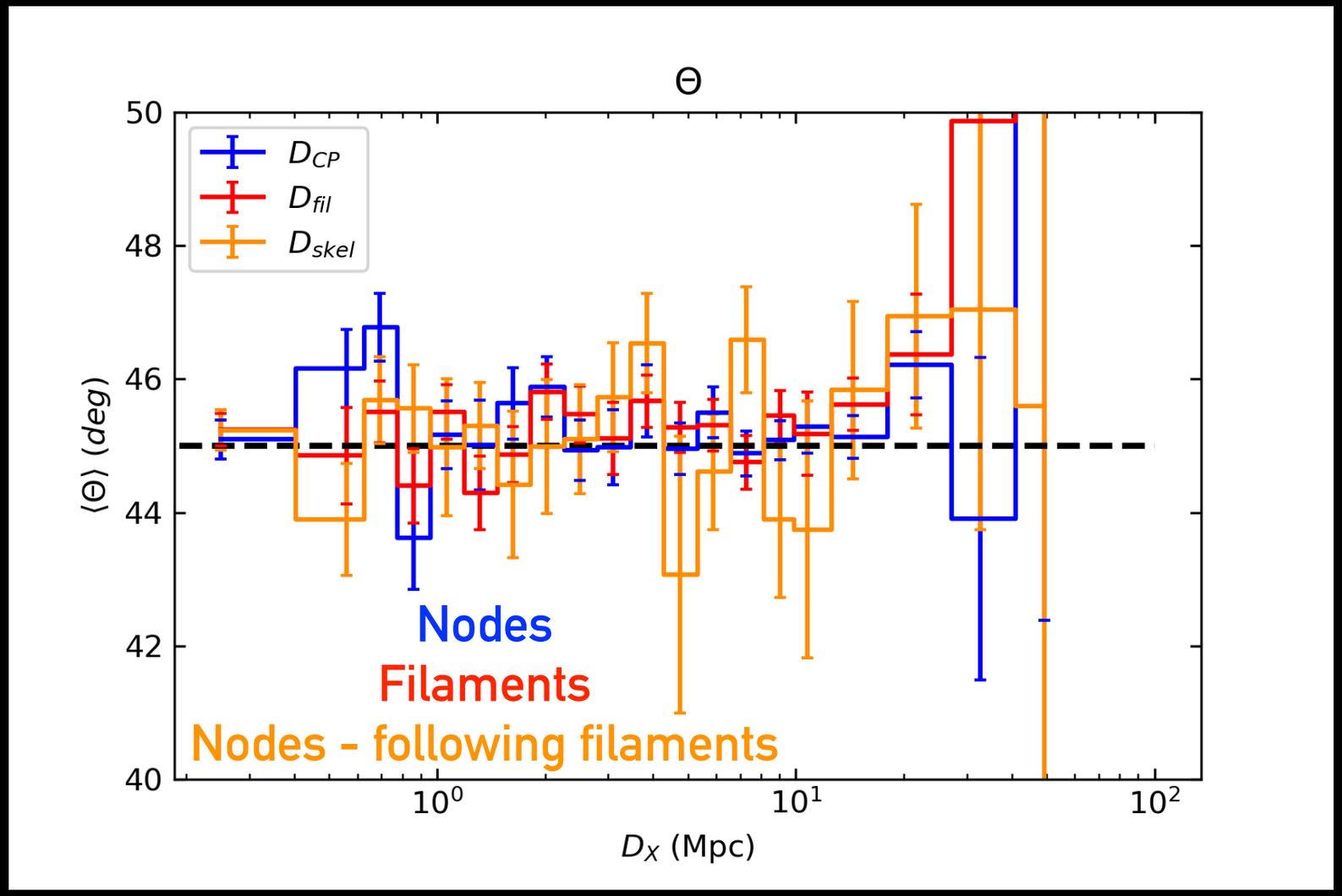
The gradient of $\log(\langle M^*/M_\odot\rangle)$

- Negative gradient close to structures that quickly goes to zero
- Small differences among structures: steepest gradient for nodes, least steep for nodes but within filaments

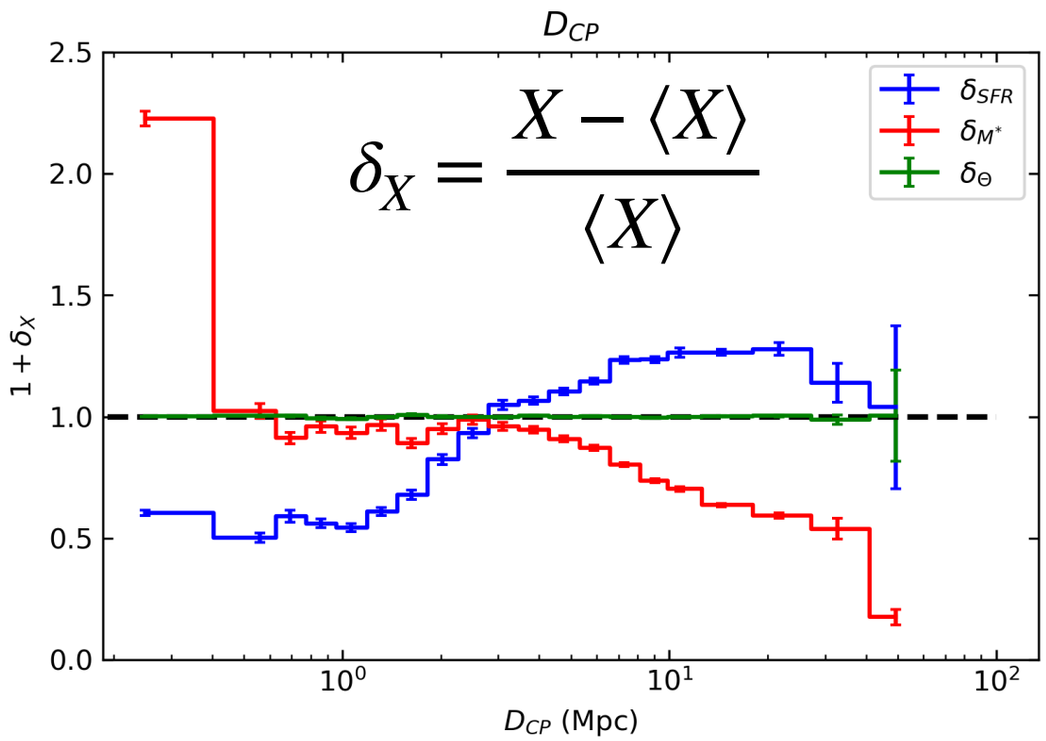
Results – spin

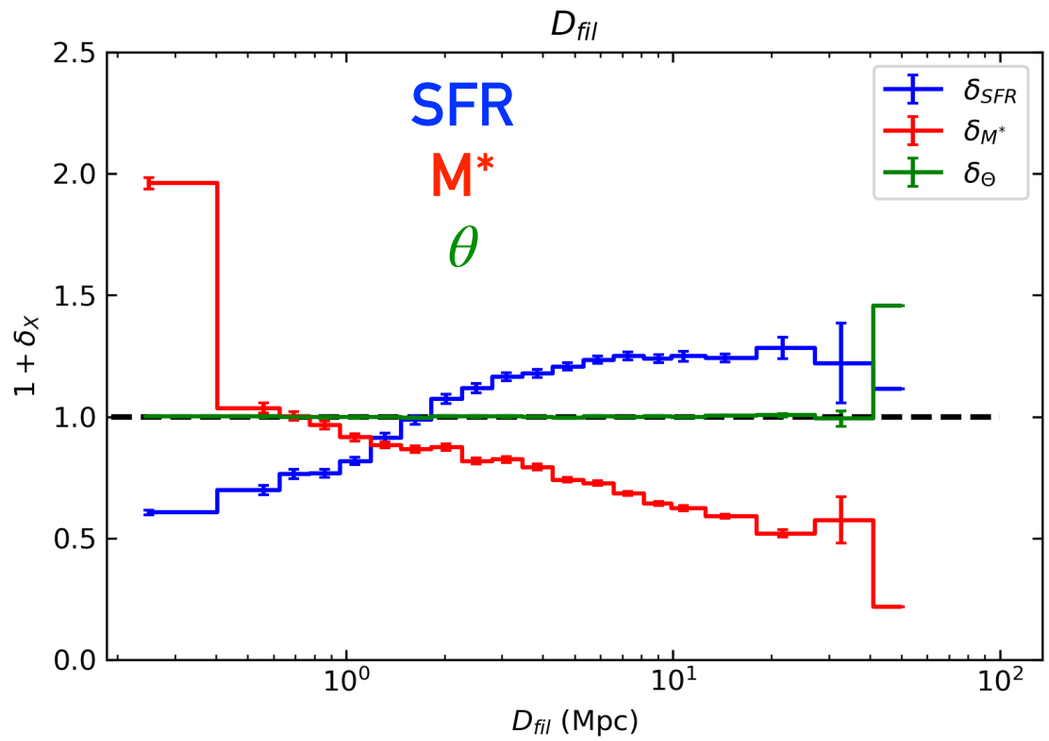
The **value** and **gradient** of $\langle\theta\rangle$

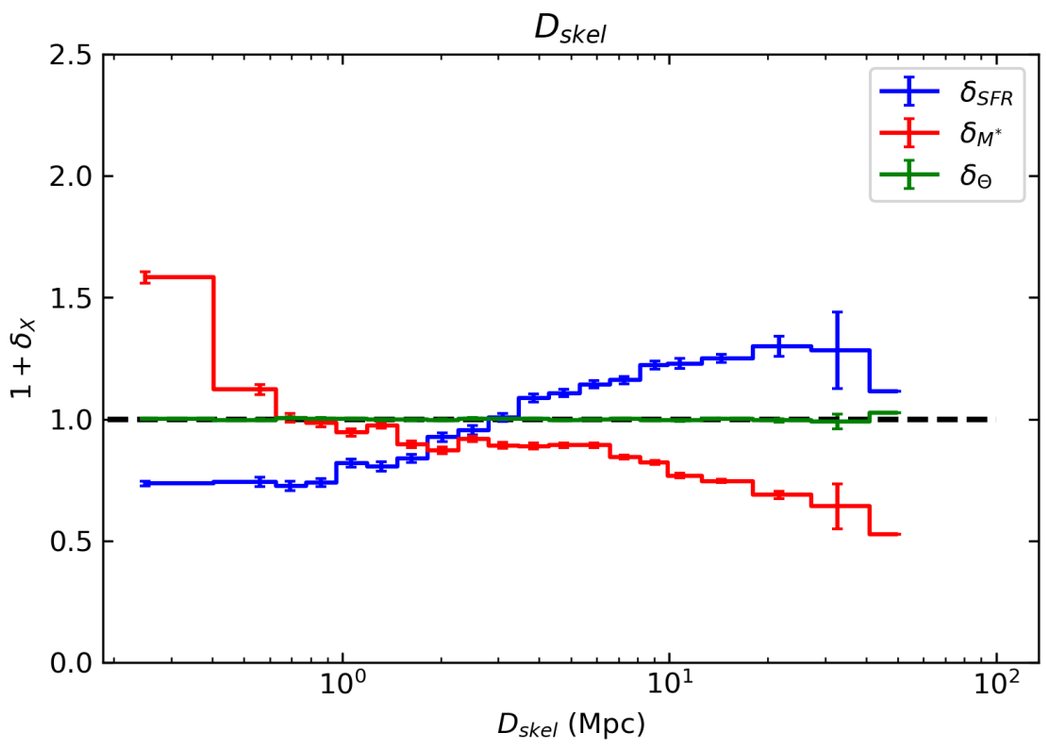
- No trend visible with any structure
- Value of θ is compatible with 45°
- Possible higher order effect, need more in-depth analysis



Results – distance to the same structure



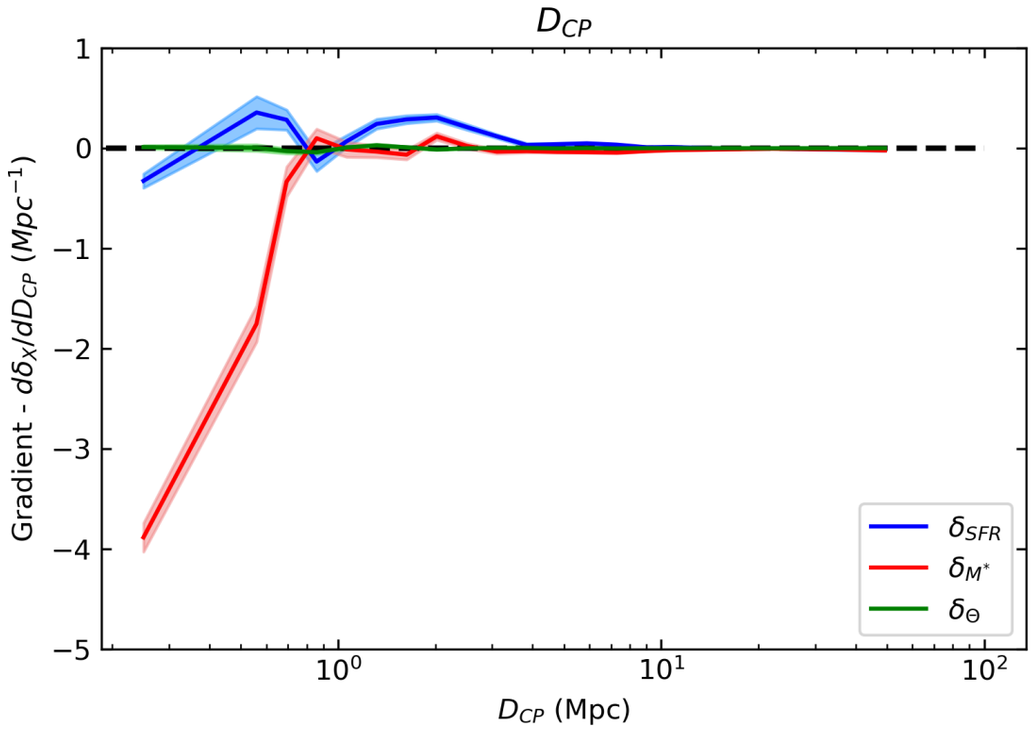


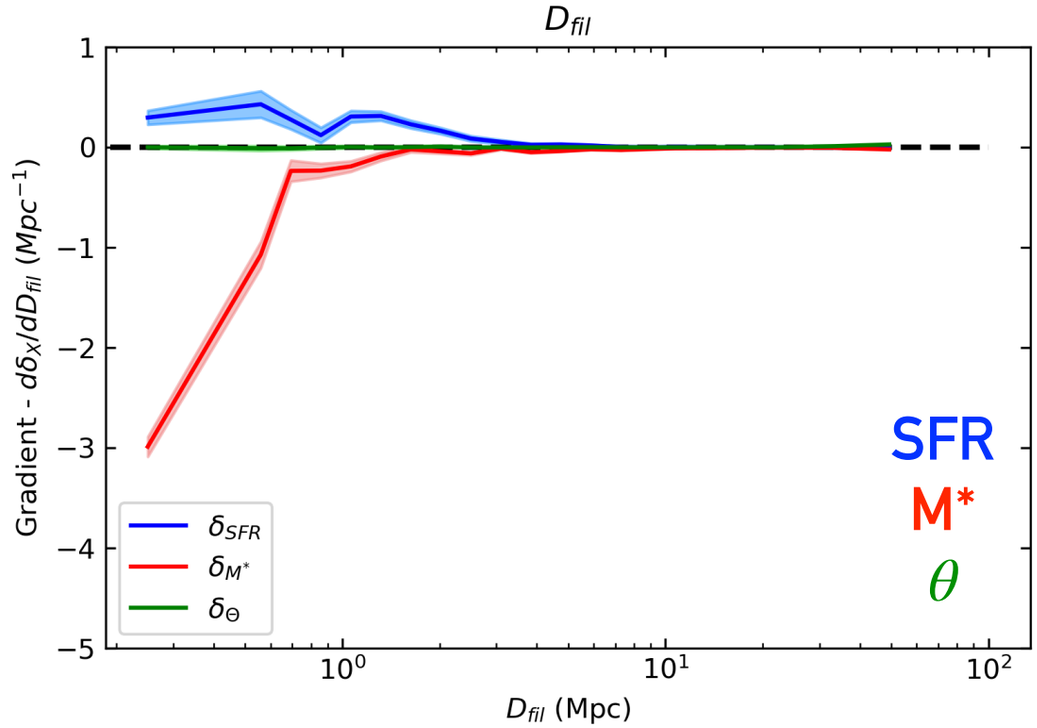


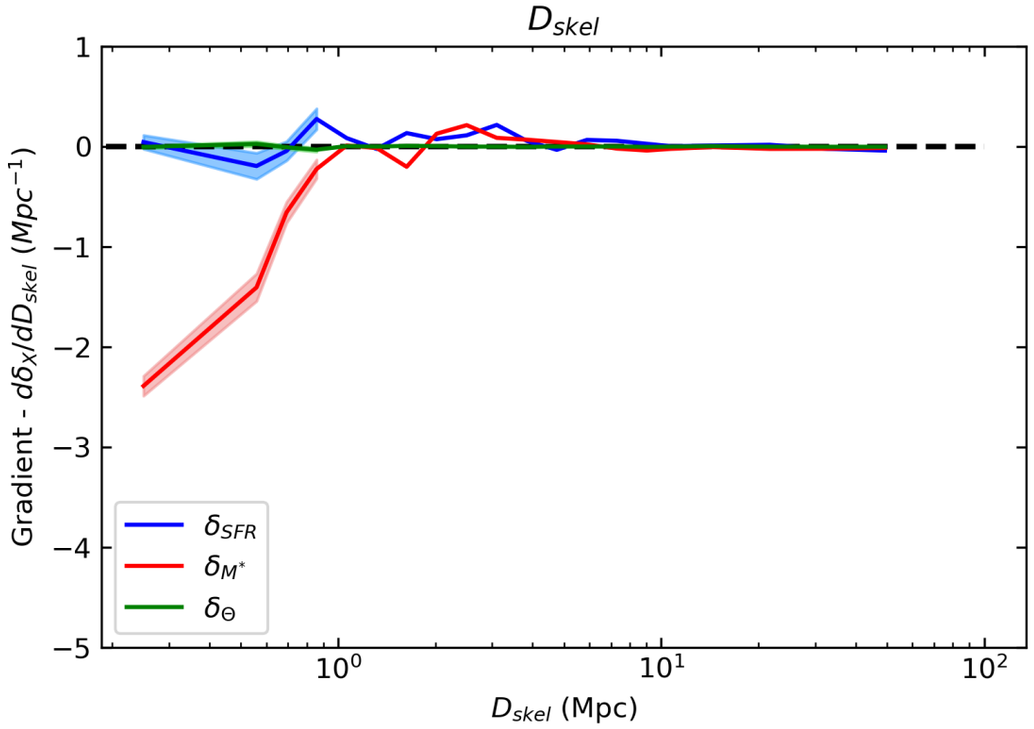
The **value** of quantities with respect to distances to the **same structure**

- δ_θ shows no variations
- δ_{SFR} shows smooth variation across the distance range, with stronger deviations from the average for densest structures
- δ_{M*} varies strongly close to structures, smoothly far away from them

Results – distance to the same structure







The **gradient** of quantities with respect to distances to the **same structure**

- δ_θ shows no variation
- δ_{SFR} shows very small positive gradient
- δ_{M*} shows very strong gradient close to structures

Conclusions

Very preliminary but promising analysis. Needs more in-depth exploration.

- **The effects of structures on spin are secondary with respect to the effects on M* and SFR.**
- **SFR seems to be a better predictor of structures due to its value, M* due to both its value and its gradient.**

Clusters and filaments are connected in the cosmic web and both concur to galaxy evolution.
In turn galaxy properties can be used to better trace structures.