COSMIC VOIDS IN COSMOLOGICAL SIMULATIONS

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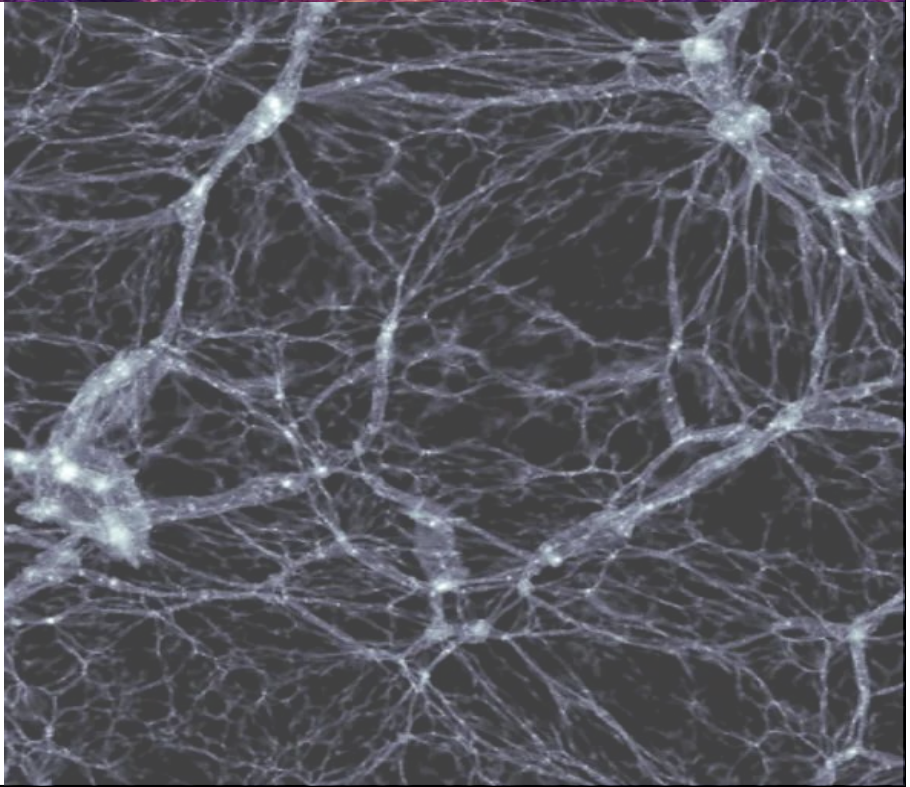
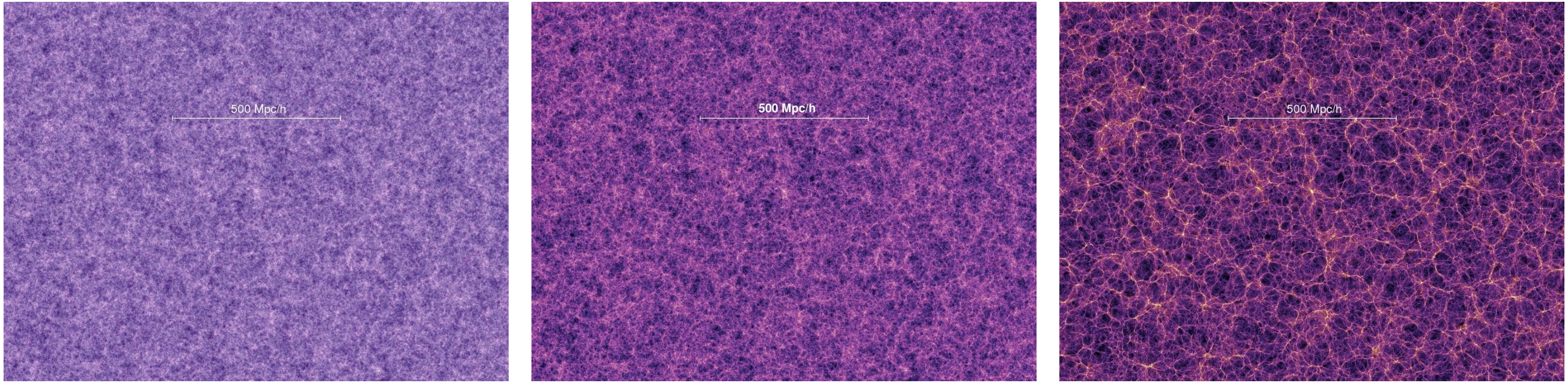


1. INTRODUCTION

- Structures in the Universe have been formed by the gravitational instability of primordial fluctuations (Gaussian distributed).

- This generates a process of collapse into more dense structures, originating the known **Cosmic Web** (non-Gaussian distributed).

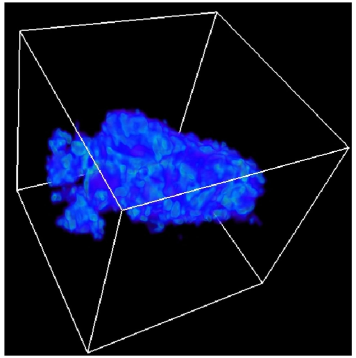
z = 20 z = 5 z = 0



1. INTRODUCTION

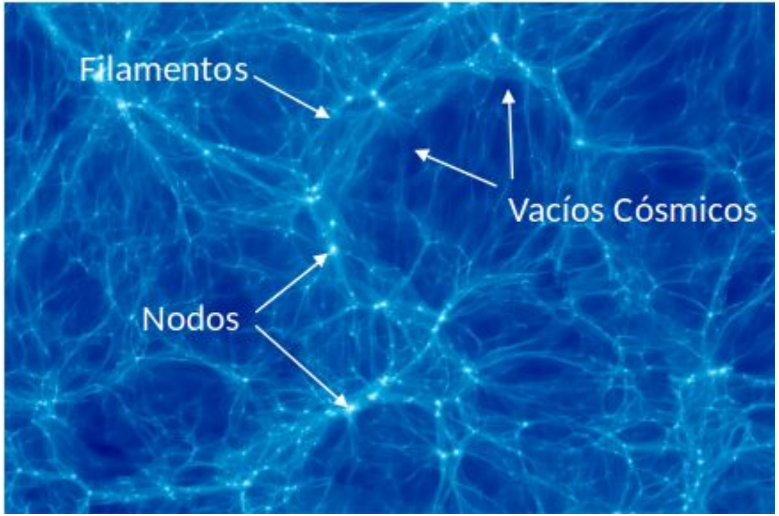
Cosmic voids are vast spaces between filaments with a very low mean density filling up most of the volume in the Universe.

They are expected to emerge in regions of negative initial density fluctuations, and subsequently expand as the matter around them collapses.



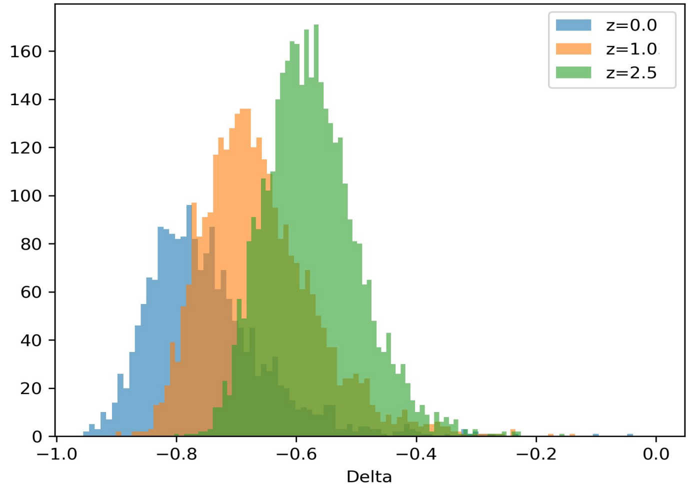
Voids show an irregular morphology and are far from being spherical.

Ricciardelli.E et al. (2013)

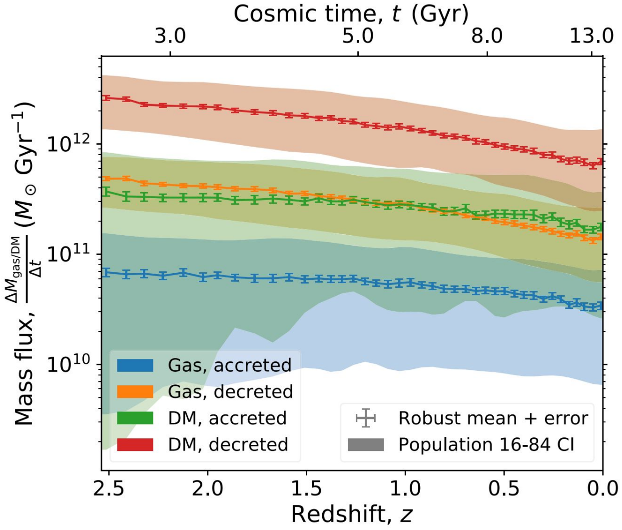


Cosmic Voids

- As the dynamics of cosmic voids are dominated by their expansion, they experience a reduction in their gas and dark matter content.



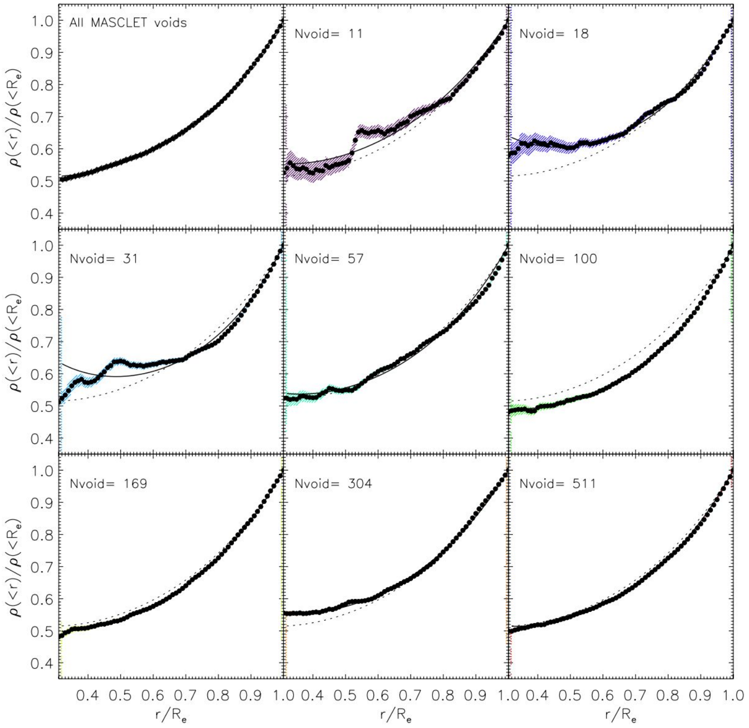
- Voids also experience mass inflow over cosmic history, accreted from overdense regions.



Vallés-pérez. D et al. (2021)

Cosmic Voids

- Their mass profile leads to a universal density profile in voids of any size, density, morphology and redshift.



Ricciardelli.E et al. (2016)

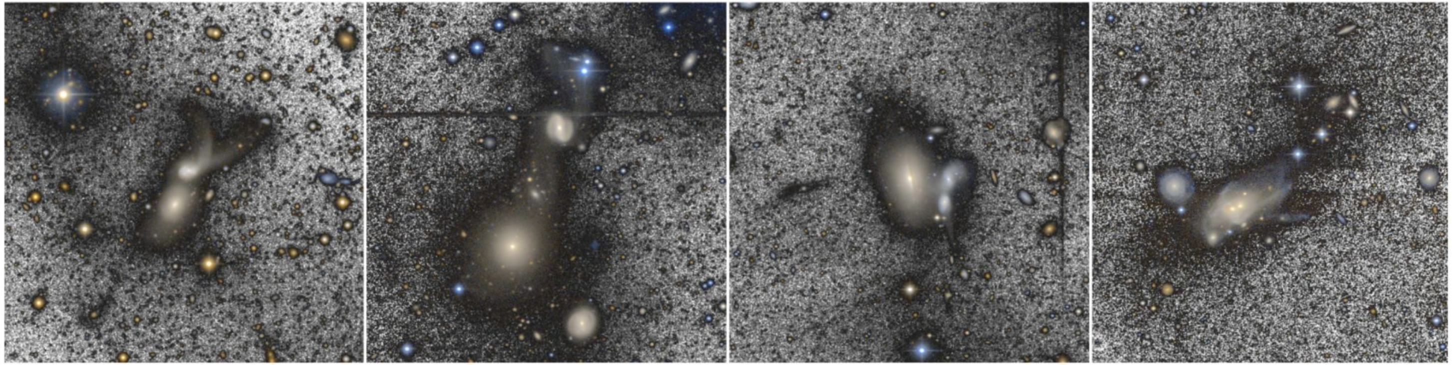
2. CAVITY collaboration

CAVITY is a survey aimed to study galaxies in voids using IFS data.

Calar Alto Void Integral-field Treasury surveY

Determine how environment affects the mass assembly of void galaxies and how galaxy formation and its properties depend on the large-scale environment.

Sample of 1115 observable galaxies in 15 voids.



Credit: Javier Román

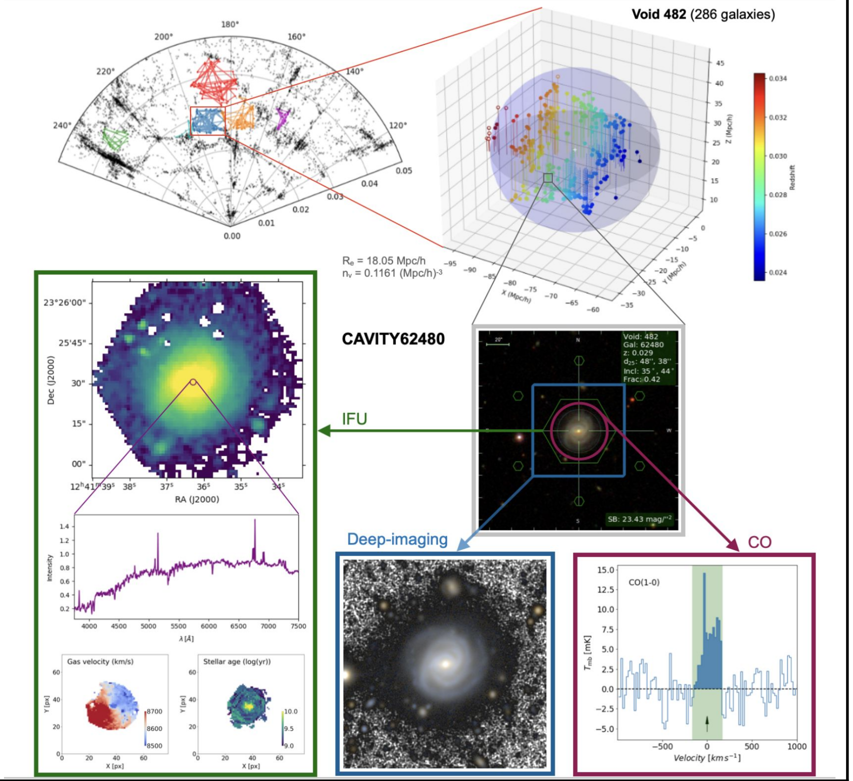
2. CAVITY collaboration

The void 482 has been selected, where each dot corresponds to a different galaxy, colour-coded by redshift.

The middle right panel zooms an example galaxy.

- ➢ The green rectangle corresponds to the IFS data.
- ➢ The blue rectangle panel shows a coloured image using the INT g- and r-band deep imaging.
- ➢ The purple rectangle corresponds to the integrated CO(1-0) spectrum.

Pérez. I. et al. (in prep)



3. Cosmic void from Cosmological simulations

VACíos CÓSmicos: modelos teóricos, simulaciones numéricas y comparación con las observaciones (**VACOS**)

IPs: Susana Planelles & Vicent Quilis

- We aim at simulating and identifying galaxies in voids.

  Voids represent a pristine laboratory to study the evolution of galaxies as they largely unaffected by the processes modifying galaxies in denser environments and this should affect their star formation histories (SFHs).

- This can help us to understand what are the main drivers of galaxy formation.

- Comparison with observations.

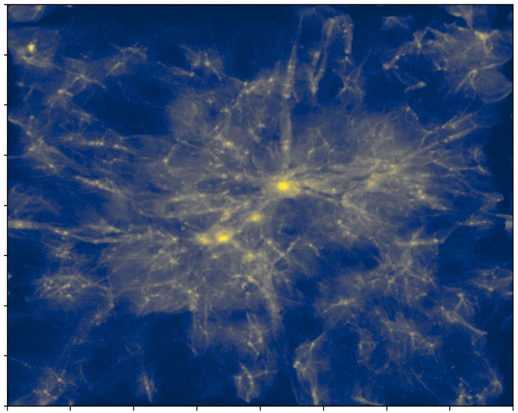
3. Cosmic void from Cosmological simulations

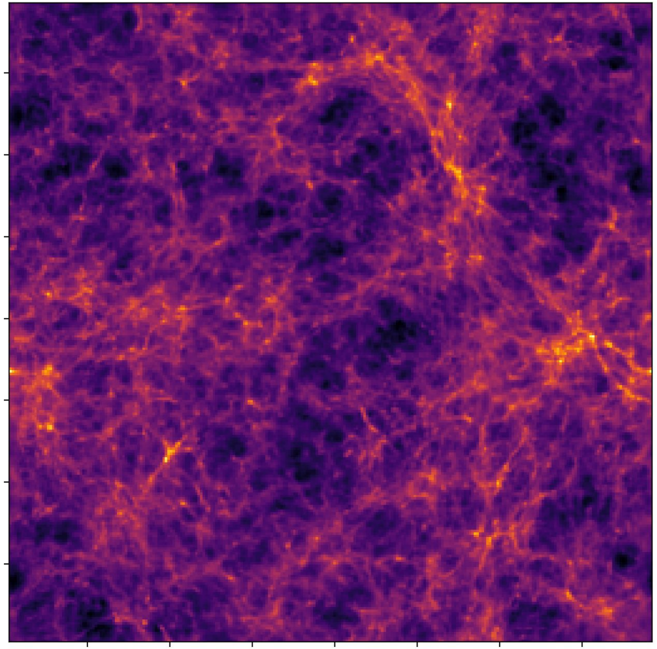
3.1. MASCLET simulation

Mesh Adaptive Scheme for CosmologicaL structurE evoluTion (**MASCLET**) (Quilis. V, 2004)

Eulerian AMR hydrodynamical and N-body simulation.

It can refine the computational grid in the underdense regions, in contrast to the usual overdense parts of the simulated volume.





3. Cosmic void from Cosmological simulations

3.2. Void finder

The void finder identifies voids starting from the cell with least density and highest velocity divergence $\nabla \cdot \boldsymbol{v}$

Then, the underdense region is expanded by adding two cells in each coordinate direction until reaching the void wall, defined from the sharp increase of the density gradient.

Therefore, the volume expansion is stopped when at least one of the following conditions applies:

$$\nabla\delta > \nabla\delta_{\mathrm{thre}}$$

$$\delta > \delta_{\mathrm{max}}$$

$$\nabla \cdot \boldsymbol{v} < 0$$

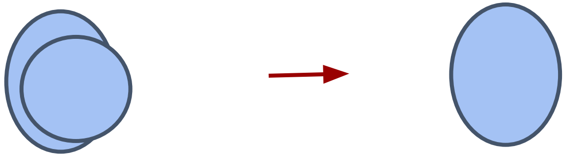
Ricciardelli.E et al. (2013)

3. Cosmic void from Cosmological simulations

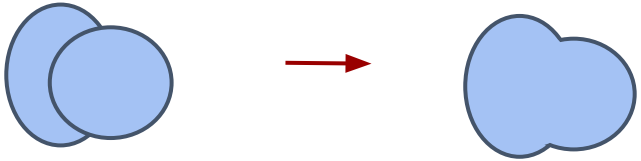
3.2. Void finder

In a second step we perform a crossmatch to identified which voids are overlapped.

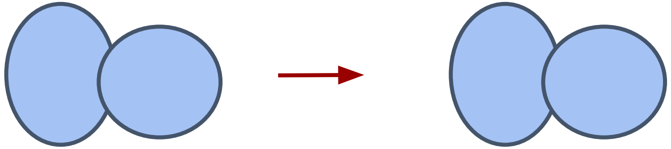
➢ If the overlapped volume between two voids is bigger than Fmax: we keep the bigger void and remove the smaller



➢ If the overlapped volume between two voids is between Fmin and Fmax: we join both voids.



➢ If the overlapped volume between two voids is lower than a Fmin: we keep the two voids separated

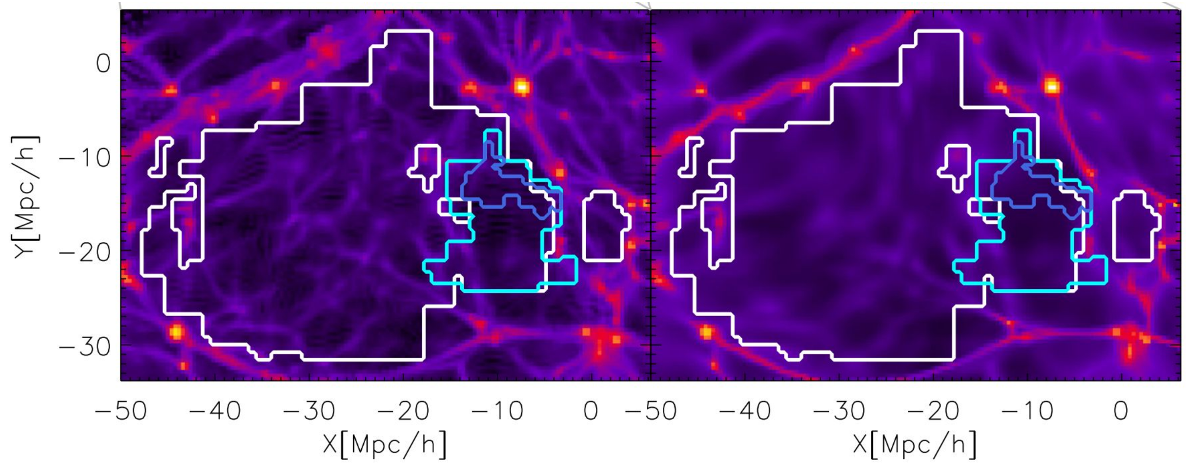


3. Cosmic void from Cosmological simulations

3.2. Void finder

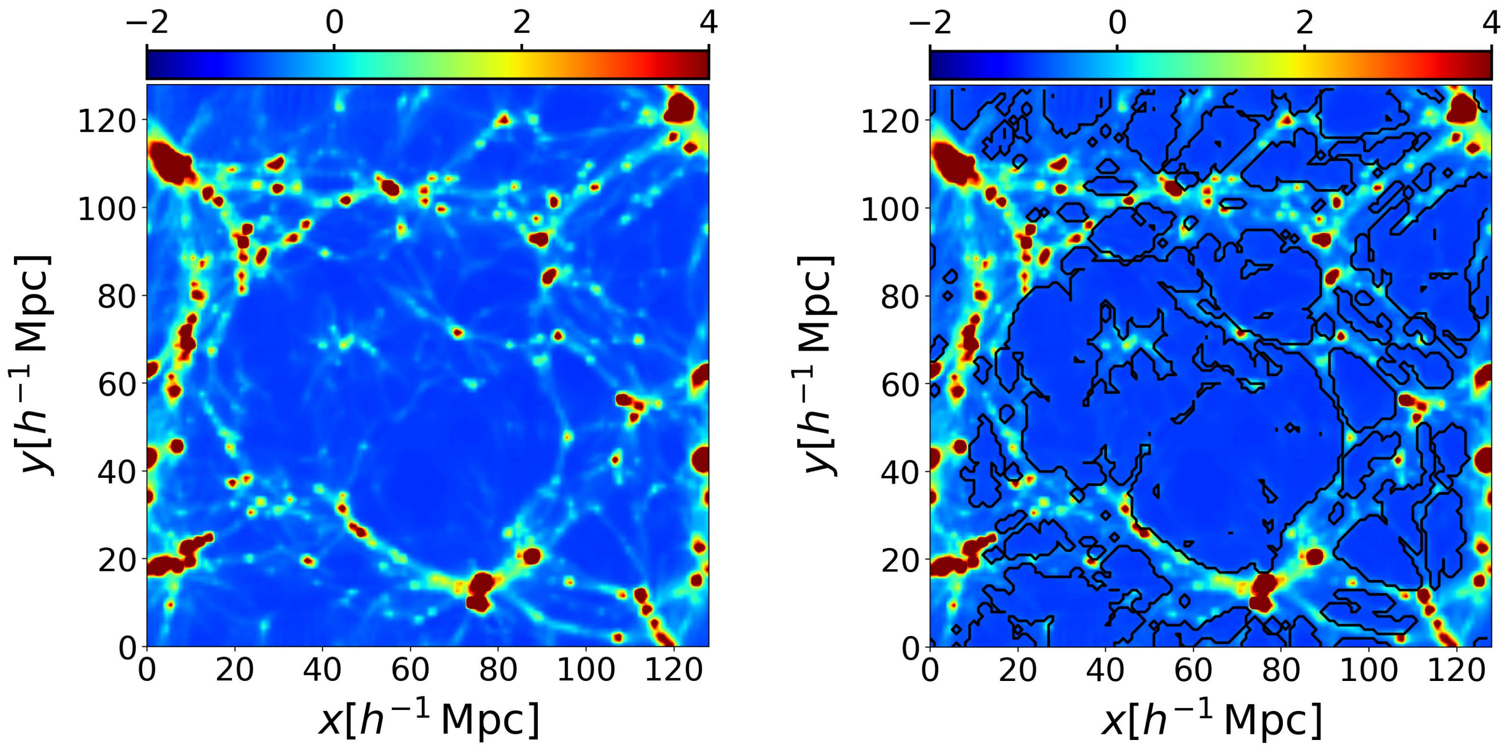
We can take into account the hierarchical structure of voids running the void finder on different grids of different resolution.

Parent voids can be found in the base level or a grid coarser, while subvoids can be found at different refinement levels.



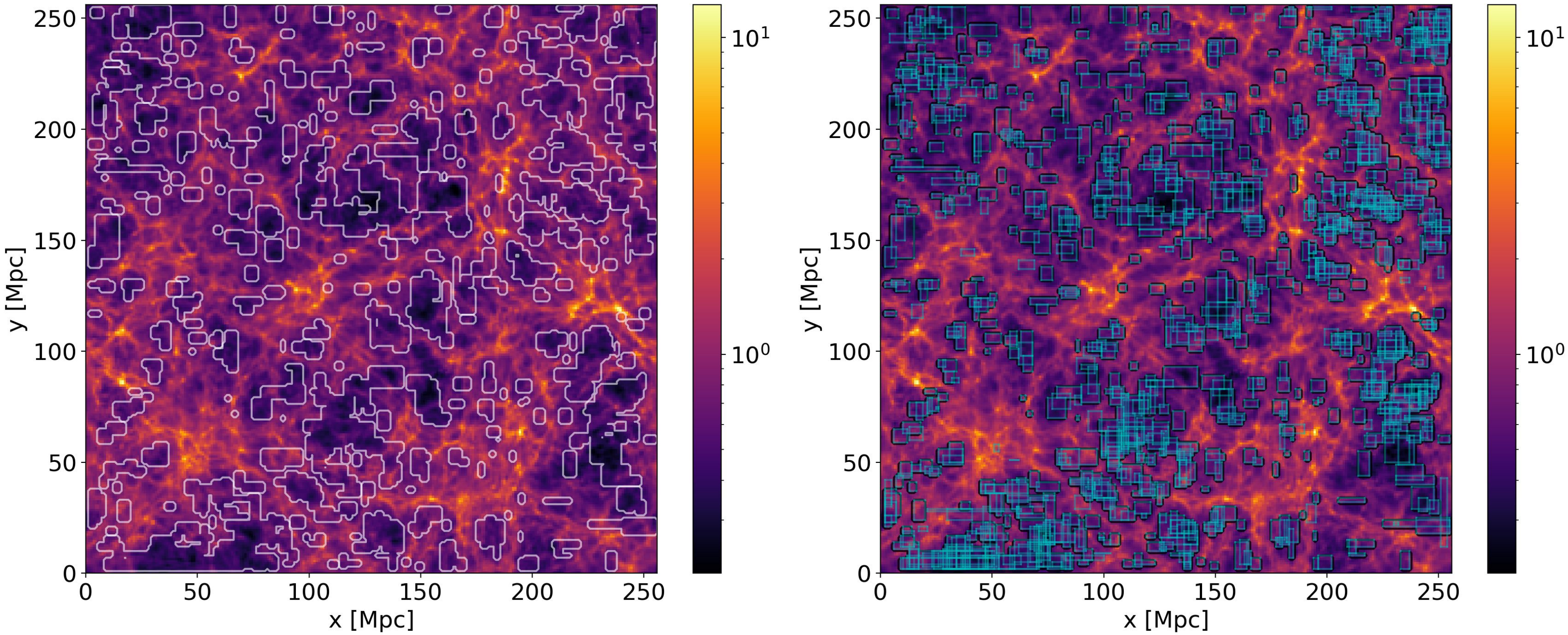
Ricciardelli.E et al. (2013)

4. Preliminary results



4. Preliminary results

z = 4



4. Preliminary results

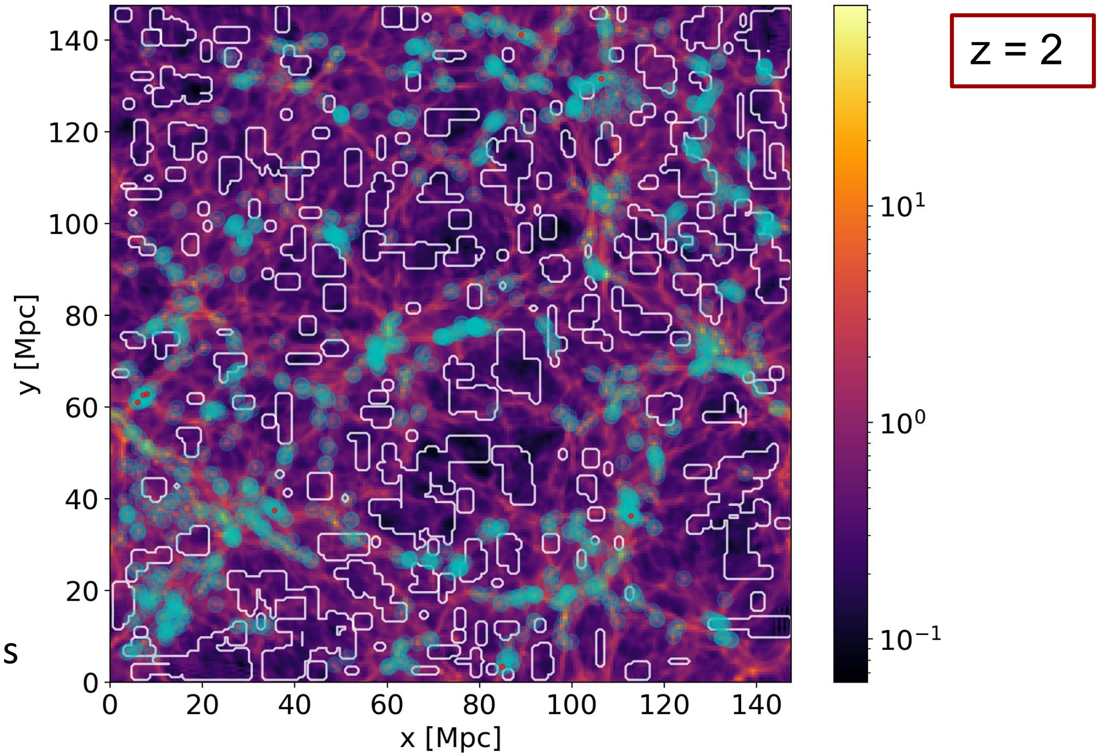
ASOHF halo finder
(Planelles. S & Quilis. V, 2012)

Number of DM haloes: 33680

- ➢ DM haloes in voids: 85
- ➢ DM haloes in shells: 462

Number of stellar haloes: 513

Not stellar haloes found yet inside voids



Future work

- Analysis of simulations at lower redshifts.
- Statistics and comparison of void galaxies with galaxies in denser regions.
- Comparison with observations, stellar population models in our simulated galaxies…

THANK YOU FOR YOUR ATTENTION

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