

Free-Streaming Dark Radiation Recombination shifted by primordial magnetic field
Recombination shifted by varying effective electron mass in a curved universe
Early Dark Energy by primordial magnetic field Lambda Cold Dark Matter
Late Dark Energy with field Cold Dark Matter decaying into Dark radiation and Warm Dark Matter Phenomenological
Chevallier-Linder-Polarski parametrization The Majorana self-interacting Dark Radiation Emergent Dark Energy
scattering on Dark Matter Early Modified Gravity
Free-Streaming plus self-interacting Dark Radiation Lambda Warm Dark Matter Generalized Phenomenological
Cold Dark Matter decaying into Dark Radiation Emergent Dark Energy Fraction of Cold Dark Matter decaying into Dark Radiation
Self-interacting neutrino radiation and WDM Recombination shifted by varying effective electron mass Late Dark Energy
plus free-streaming Dark Radiation New Early Dark Energy Self-Interacting Dark Radiation

Which one is the **true** cosmological model?

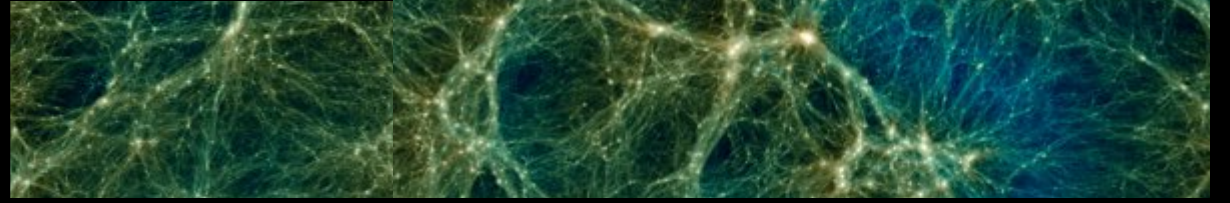
Observations from
telescopes



Cosmological
simulation



Outline



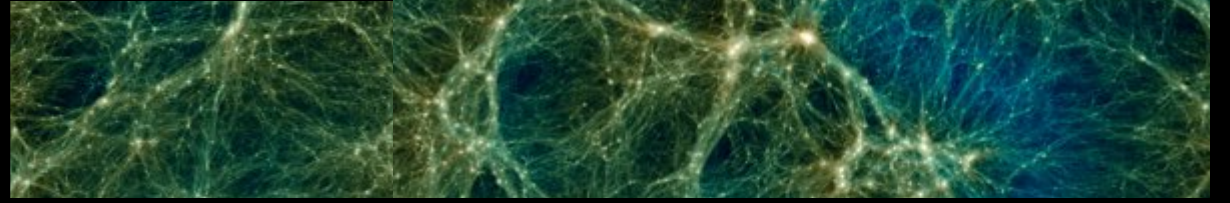
What is a cosmological simulation?

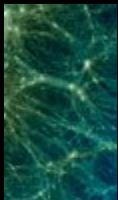
How do we construct one?

Comparison with observations?

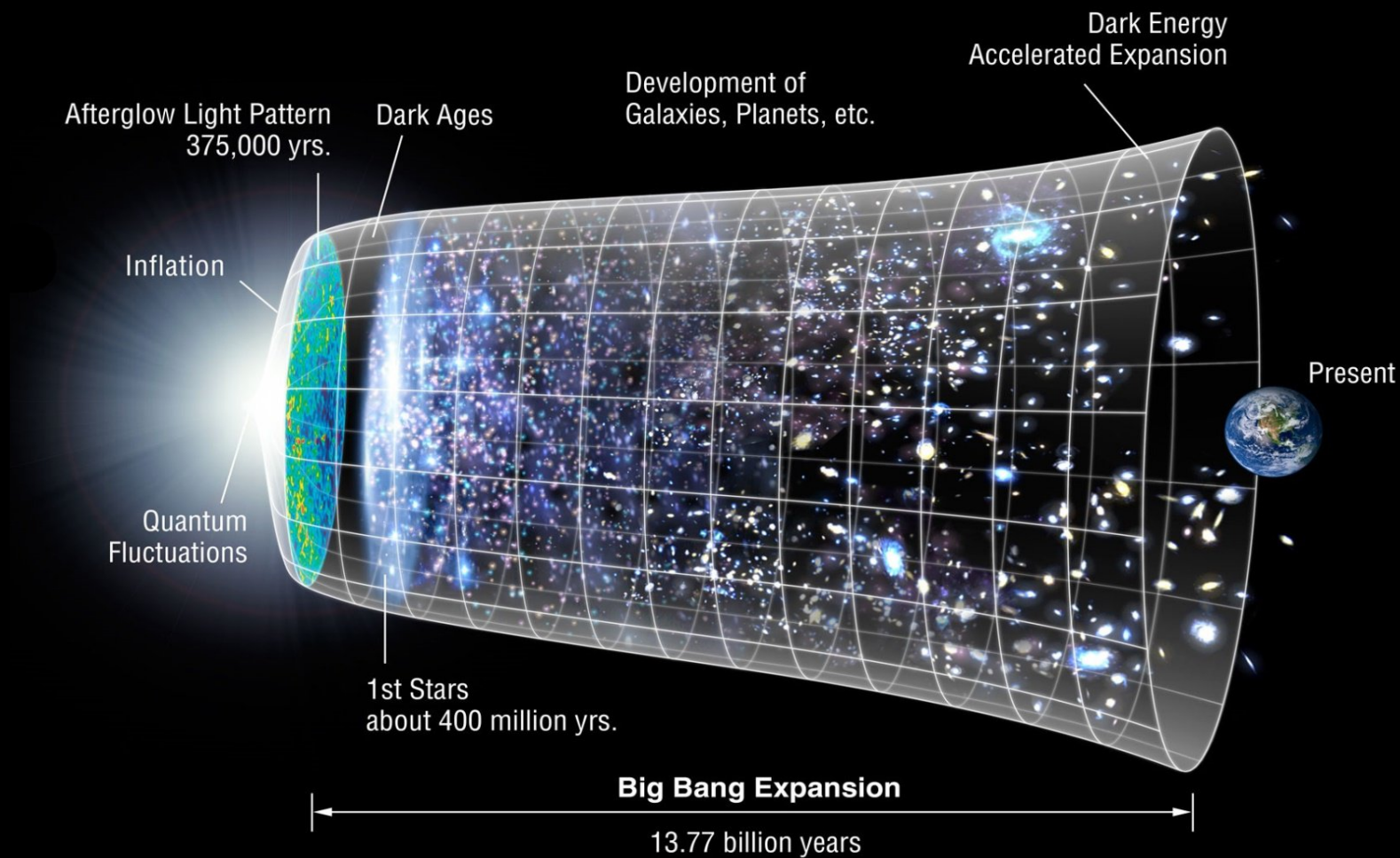


What is a cosmological
simulation?



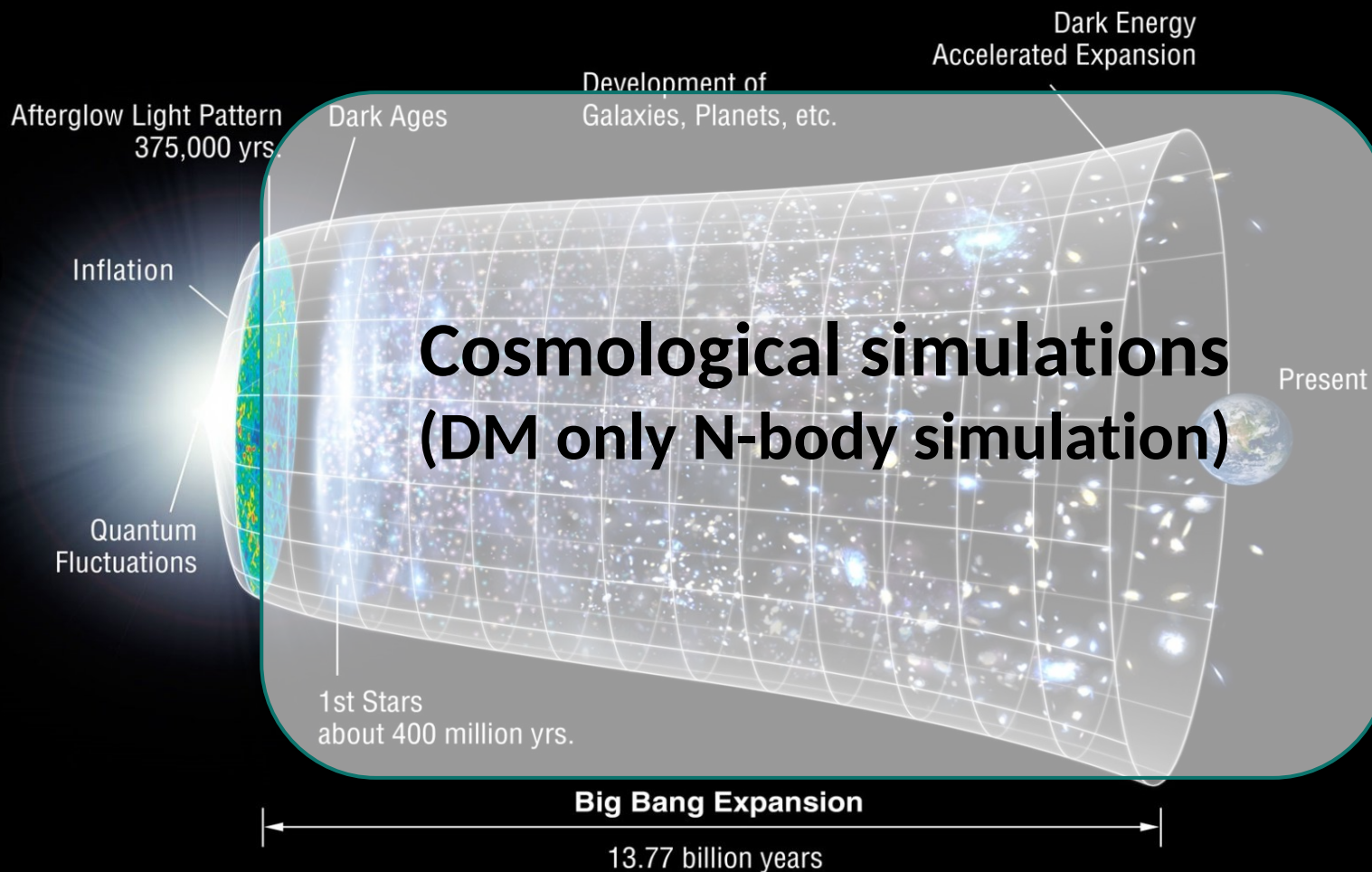
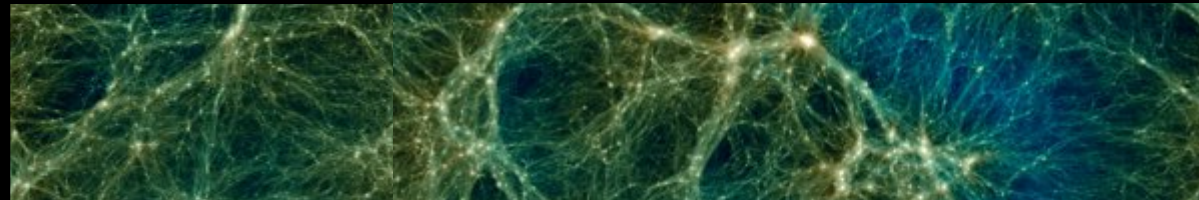


What is a cosmological simulation?





What is a cosmological simulation?





How do we construct
one?

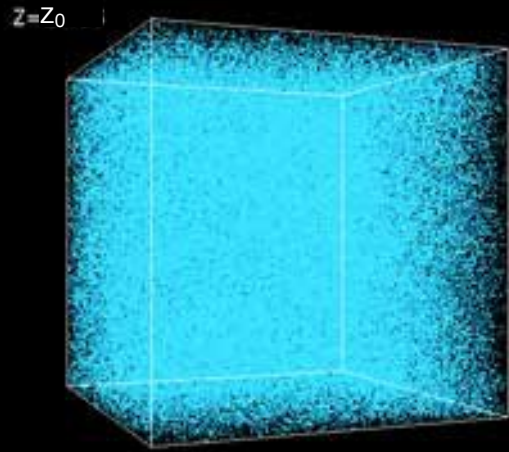




How do we construct
one?

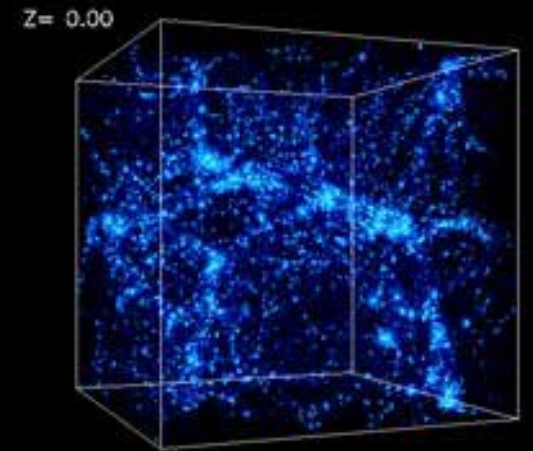


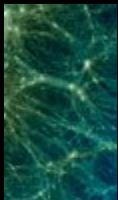
Initial conditions



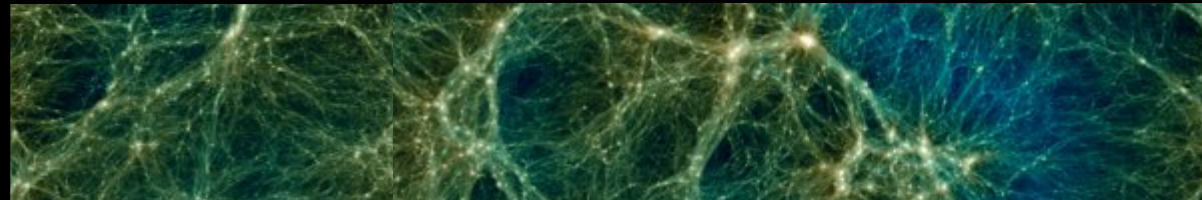
Box of size L with
 N particles

Today



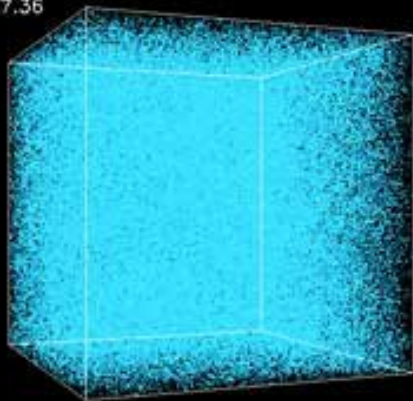


How do we construct one?

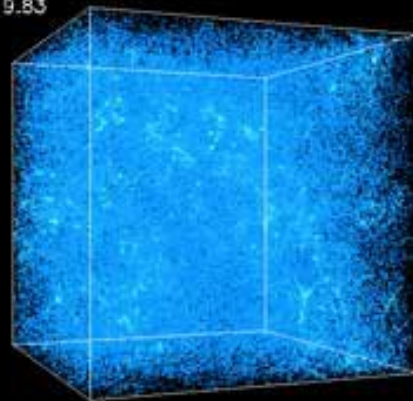


Big Bang

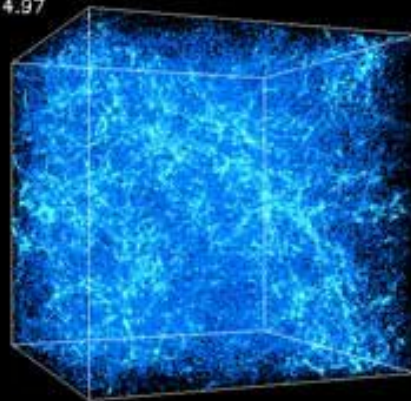
$Z=27.36$



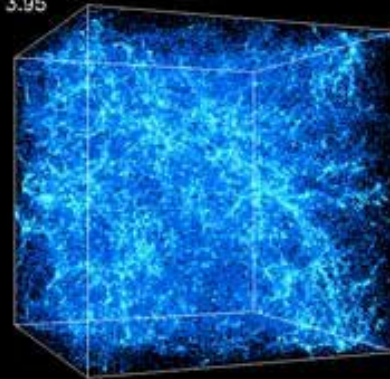
$Z=9.83$



$Z=4.97$



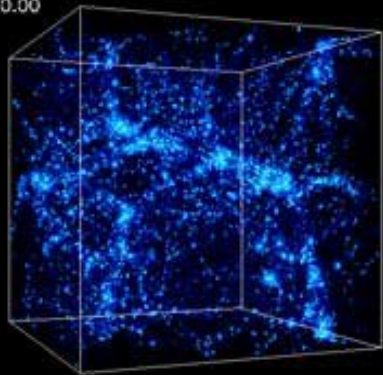
$Z=3.95$



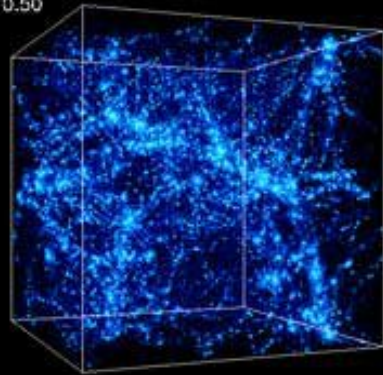
T I M E

← *Today*

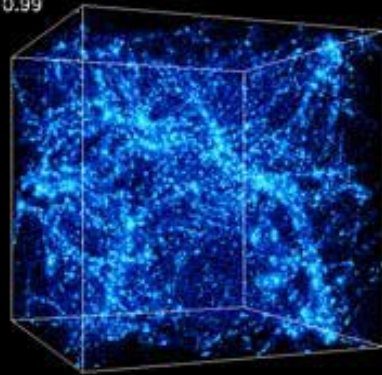
$Z=0.00$



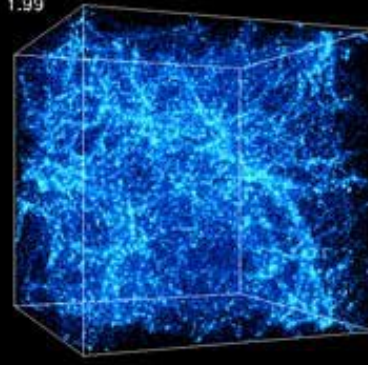
$Z=0.50$



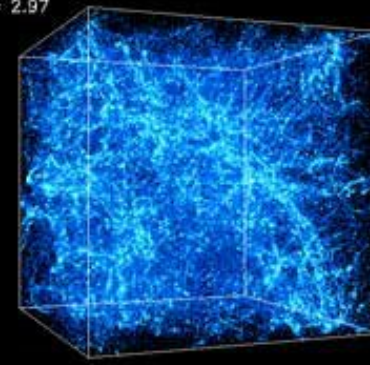
$Z=0.99$



$Z=1.99$

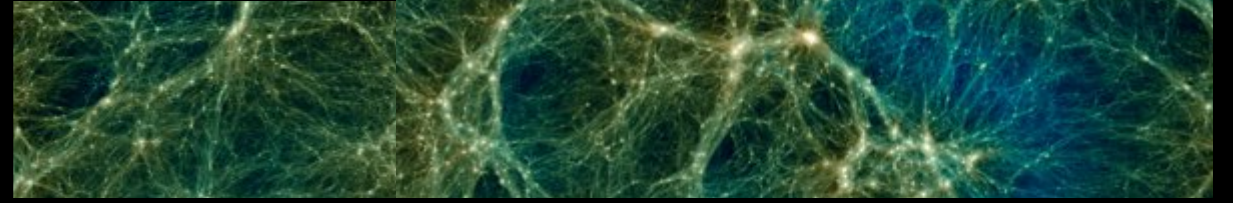


$Z=2.97$



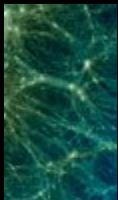


How do we construct
one?

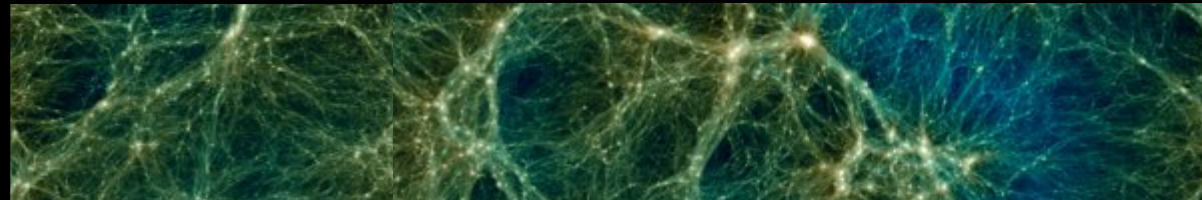


Uchuu Simulation





How do we construct one?



Uchuu is a 2.1 trillion DM only *N*-body simulation that uses Λ CDM-Planck15 cosmology.

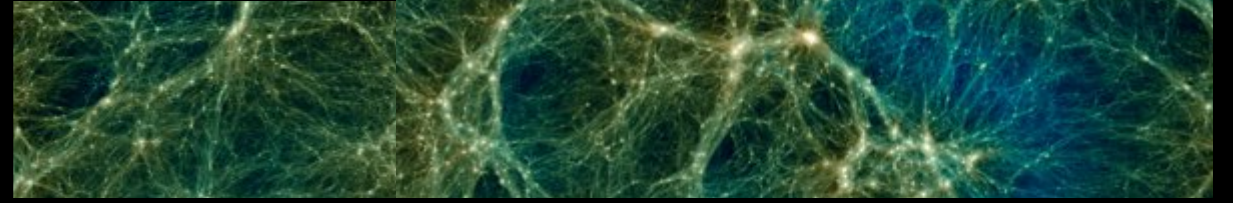
L_{box} (Mpc/h)	N_{part}	M_{part} (Msun/h)
2000	12800^3	3.27×10^8

It was produced at the **ATERUI II supercomputer in Japan (NAOJ)**.

In total we have made publicly available **125TB** generated from more than **4PB** of raw data.



How do we construct one?



The **skun6 server (IAA-CSIC)** hosts Uchuu data releases and provides a **fast download** speed through the **RedIRIS** High Speed Data Transfer Service.

The **Uchuu-BigData platform at CESGA** provides **quick access** and covers a wide range of **use cases**:

- processing large volumes of information in parallel
- processing high velocity streams of data in real-time
- processing heterogeneous data from different sources (structured and unstructured)

How do we construct one?

Uchuu is publicly available (and free) to anyone who wants to access the data

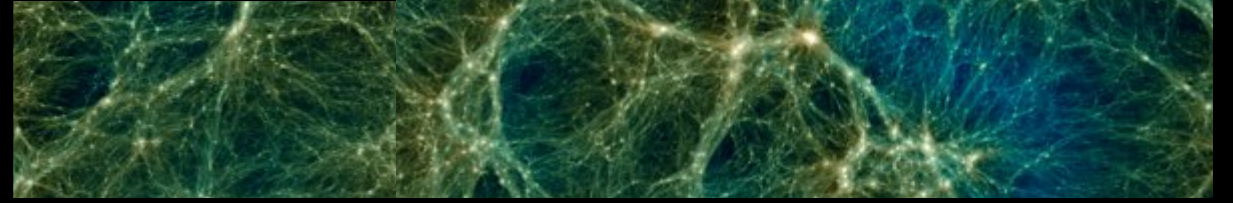


Skies and Universes

+info: <http://www.skiesanduniverses.org/Simulations/Uchuu/>



Comparison with
observations?





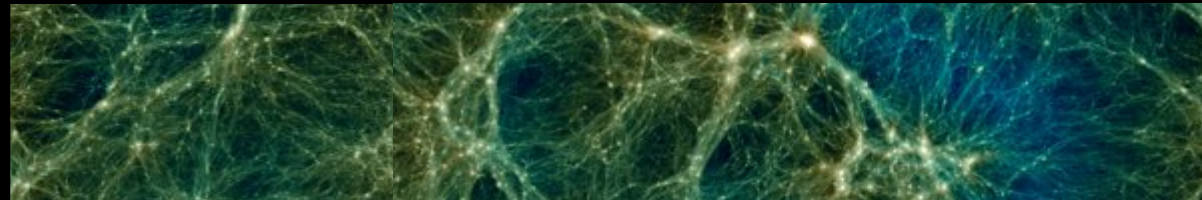
Comparison with observations?



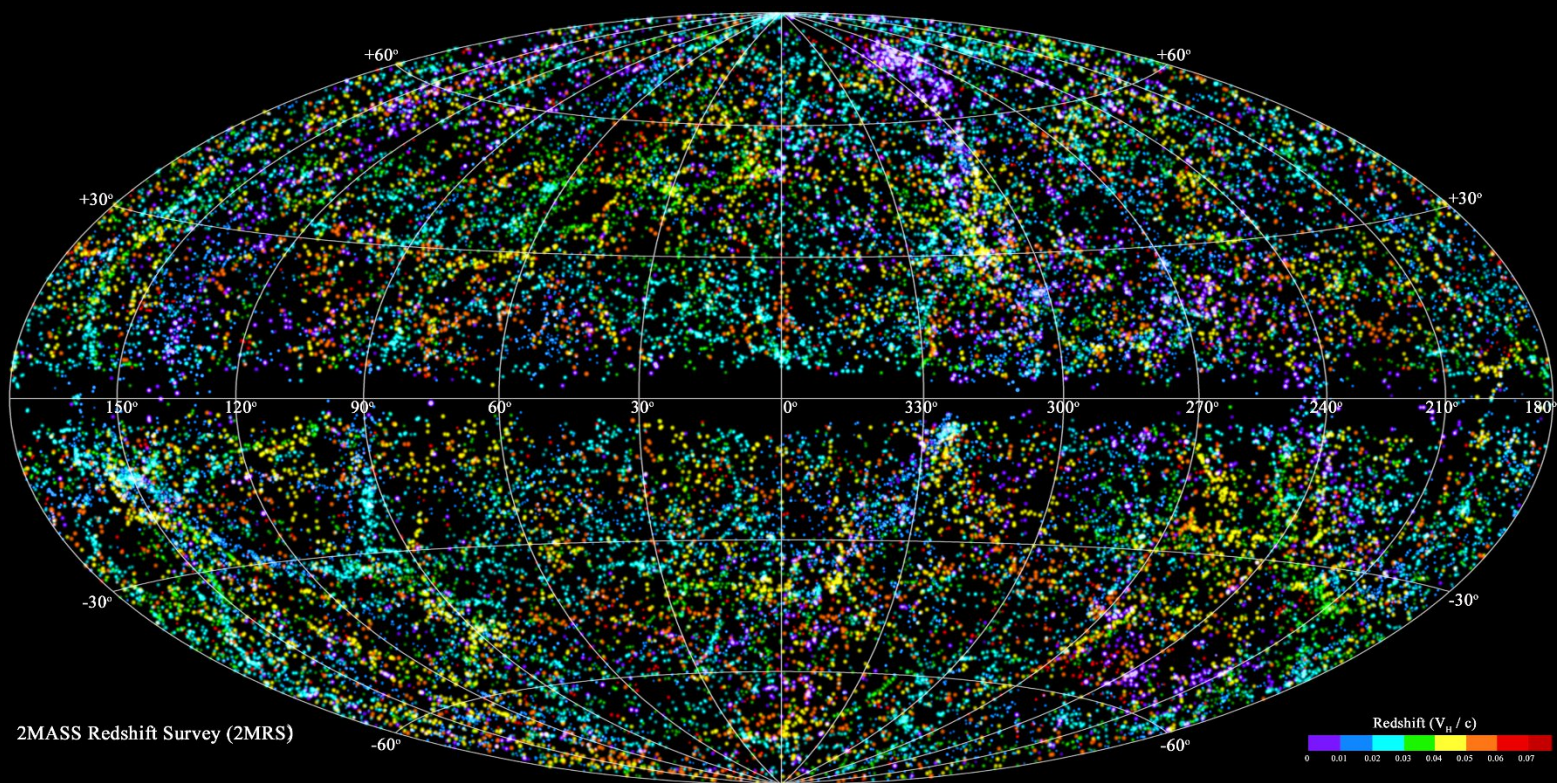
Lightcone  A sky mock built with cosmological simulations



Comparison with observations?



Lightcone  A sky mock built with cosmological simulations

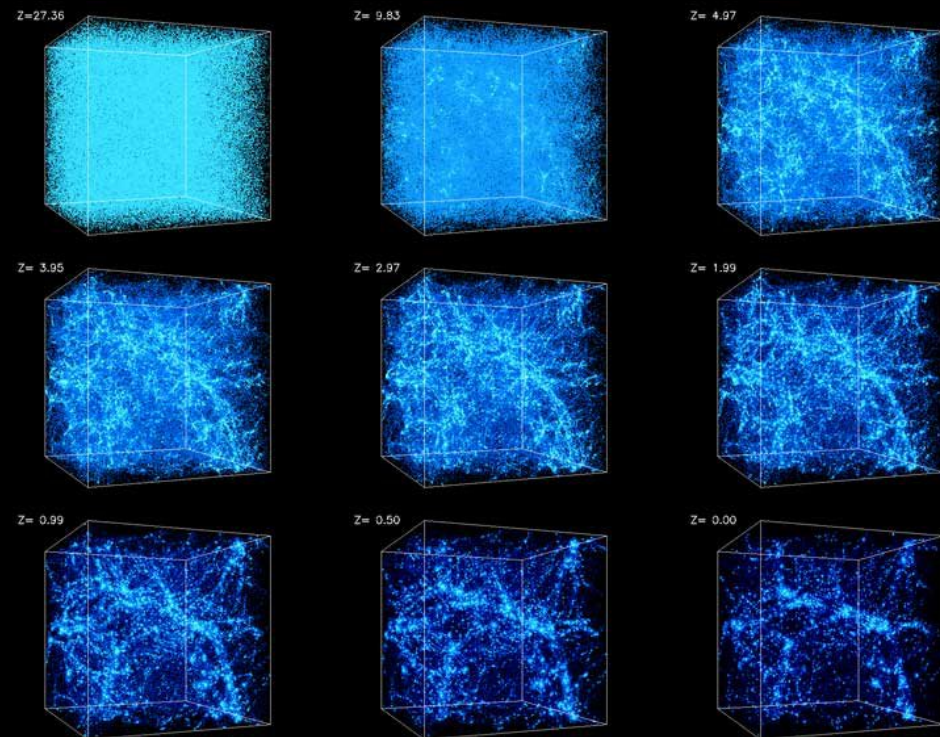




Comparison with
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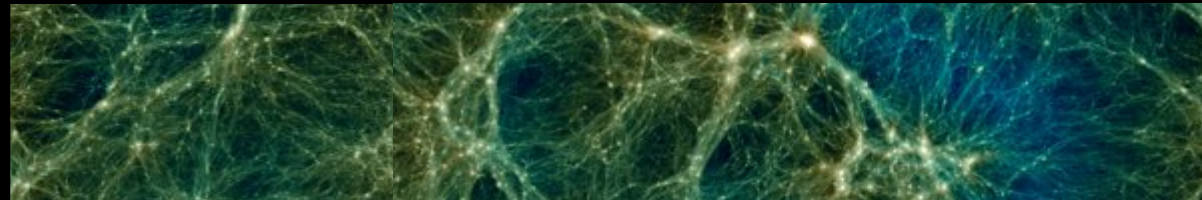


Lightcone  A sky mock built with cosmological simulations

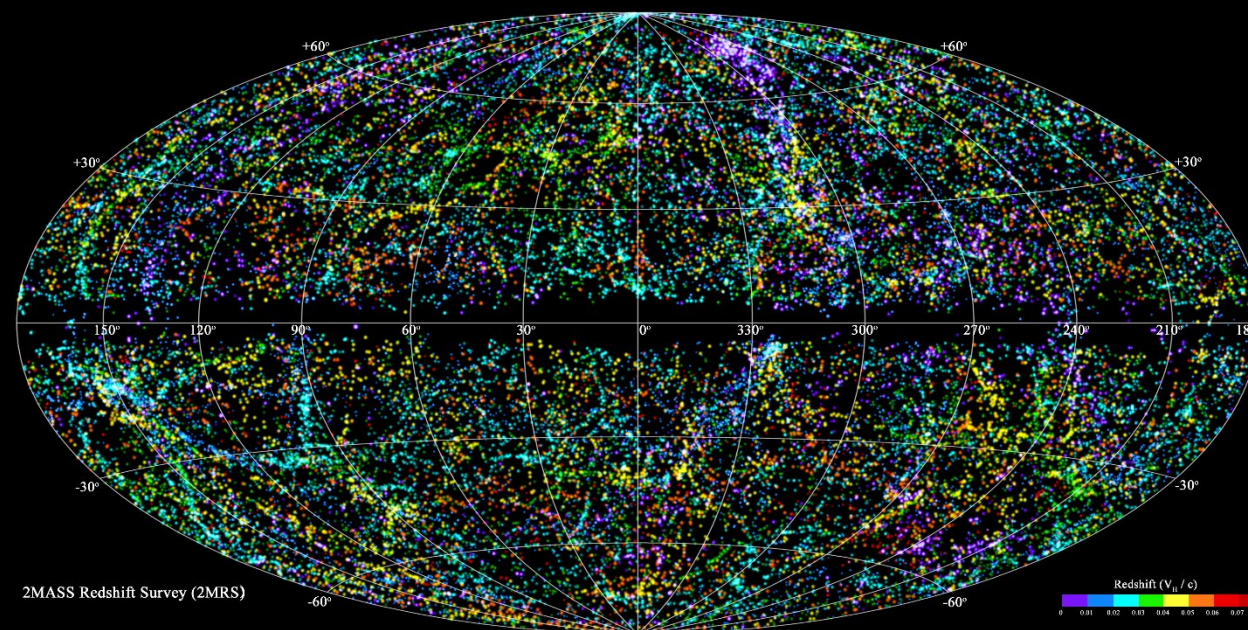
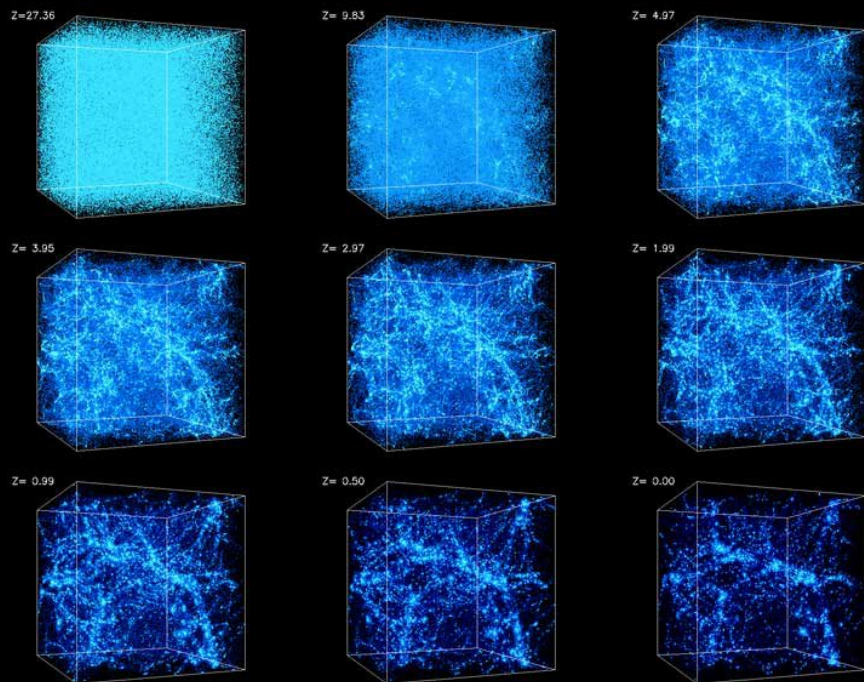




Comparison with observations?

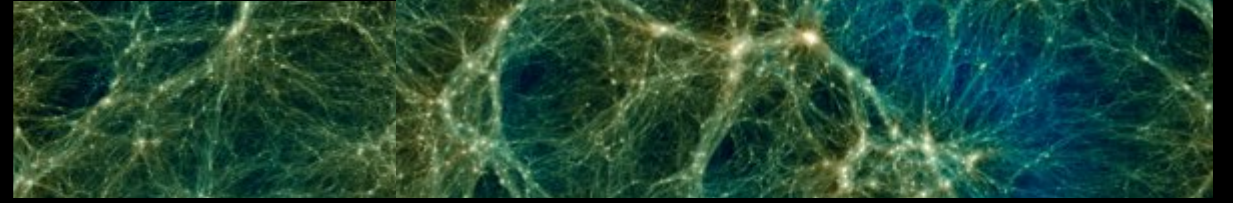


Lightcone  A sky mock built with cosmological simulations

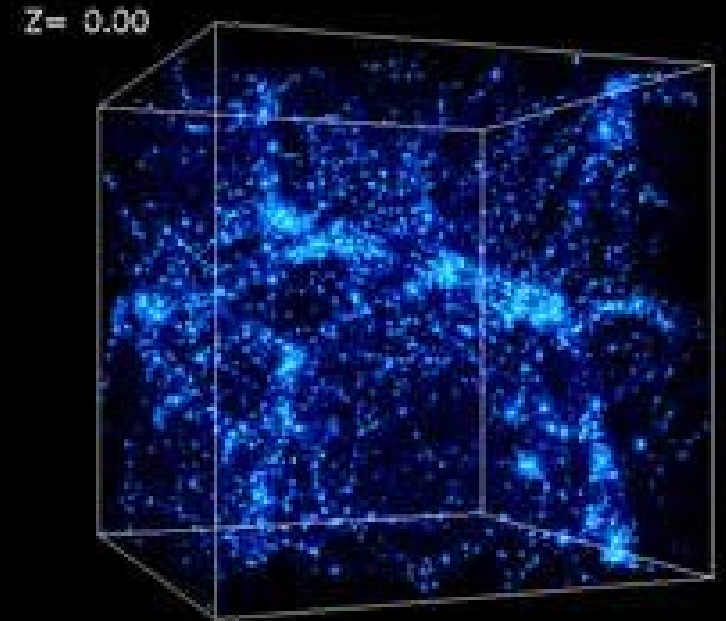
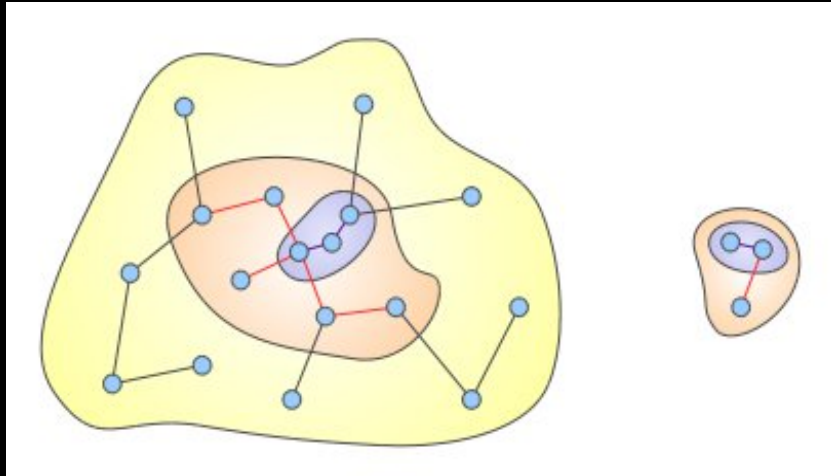




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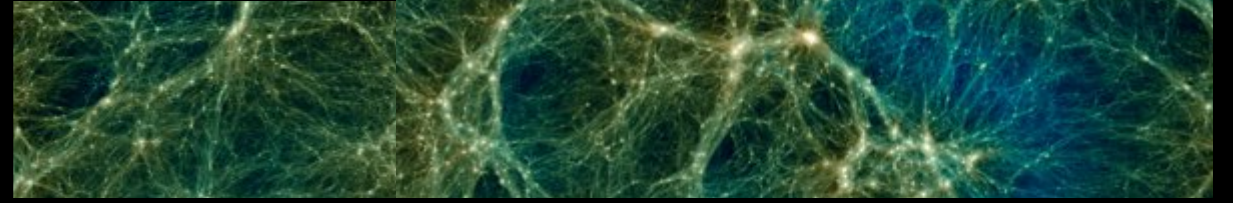


1.- We identify the Dark Matter (DM) halos in each Uchuu box

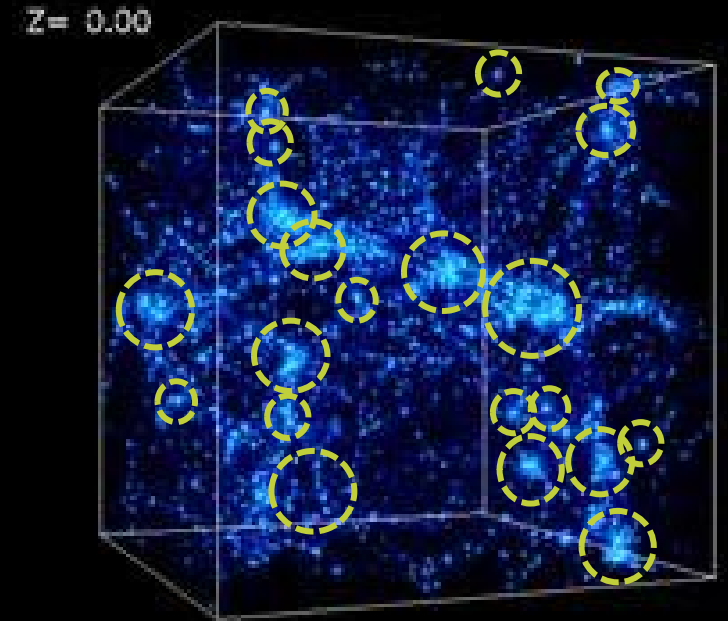
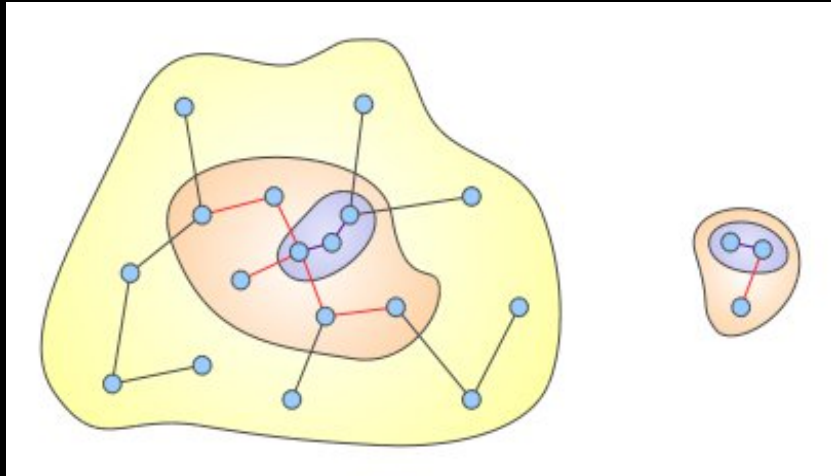




Comparison with observations?

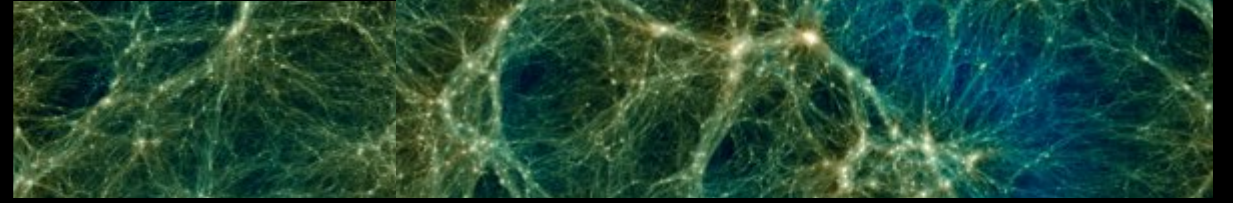


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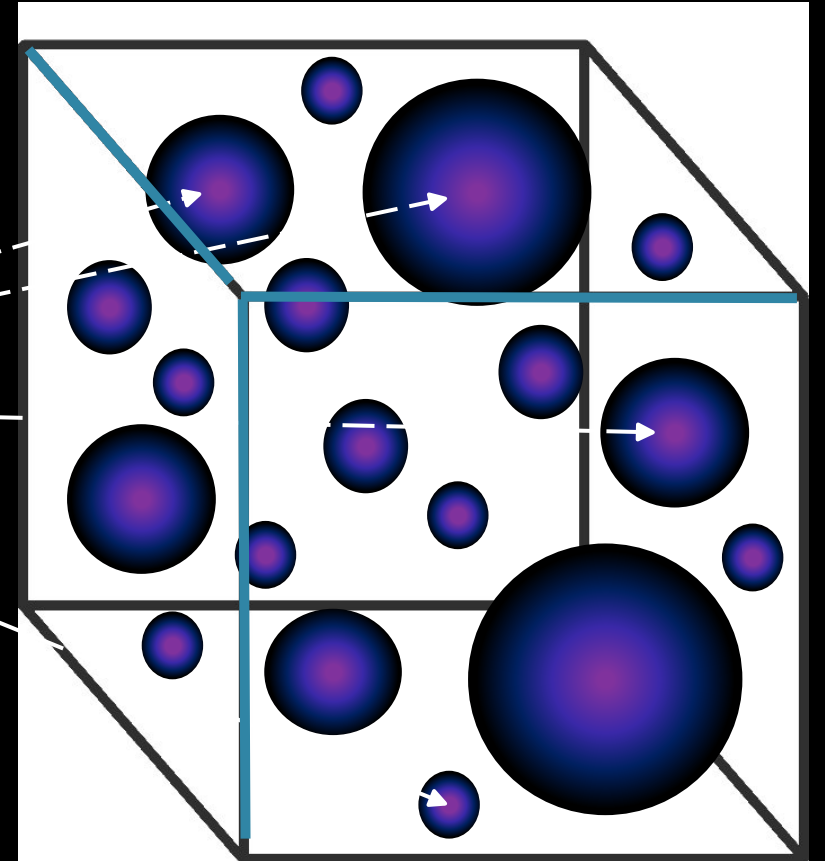
**Comparison with
observations?**



2.- We add galaxies to those DM halos

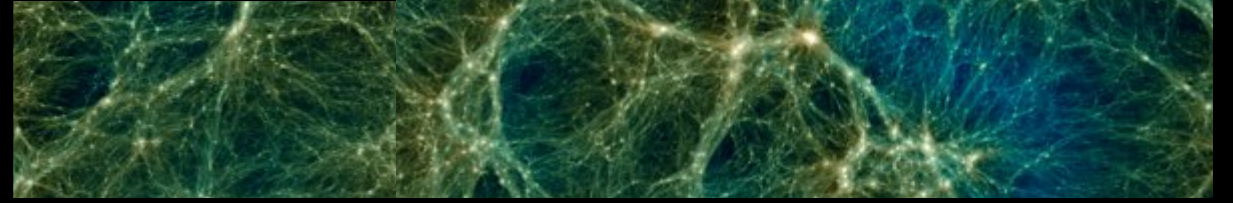


Galaxy mass \propto DM halo size





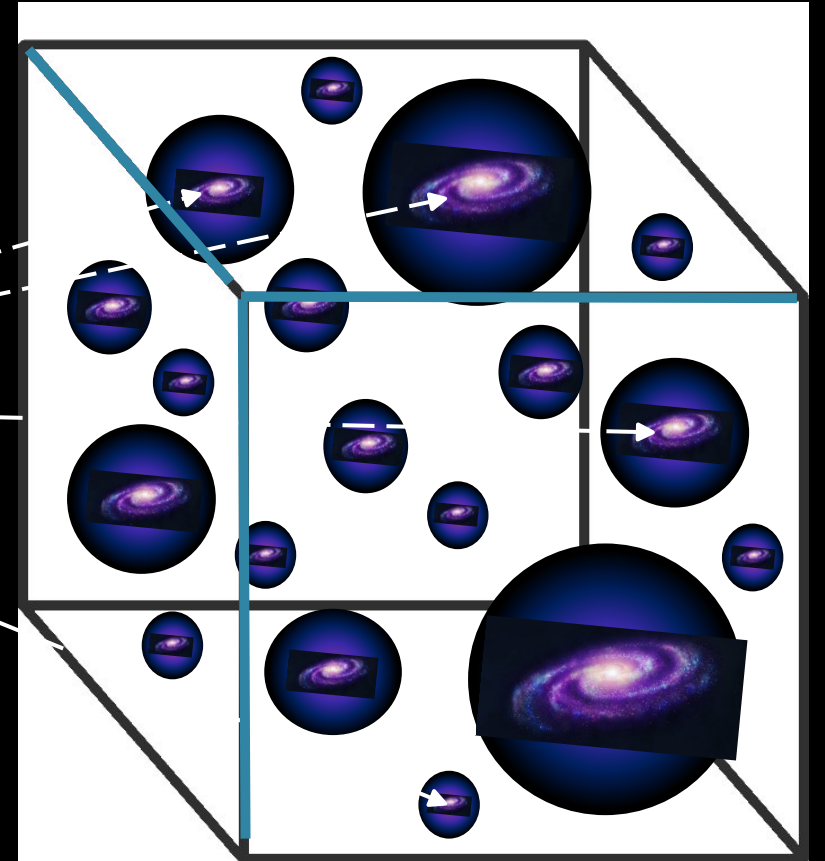
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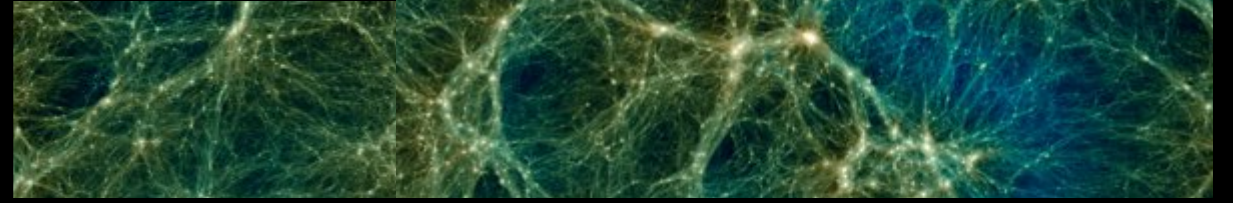


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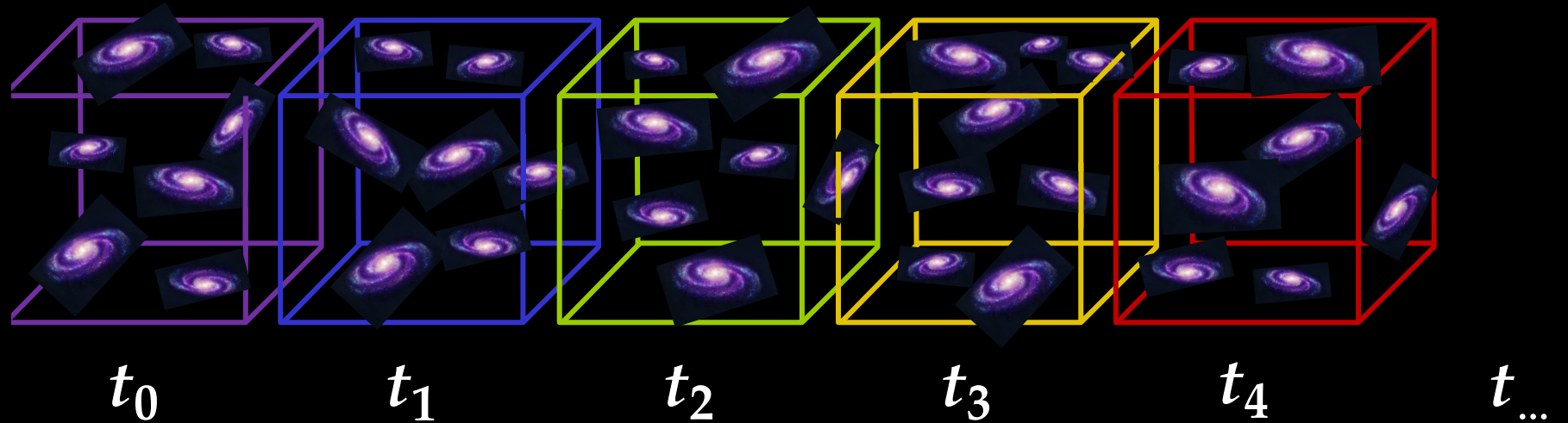


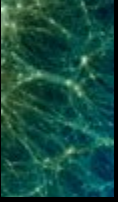


Comparison with observations?

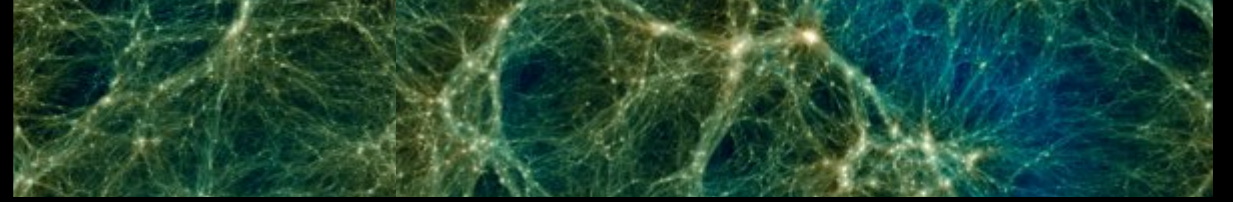


3.- We join the boxes thus reproducing the clustering evolution with redshift

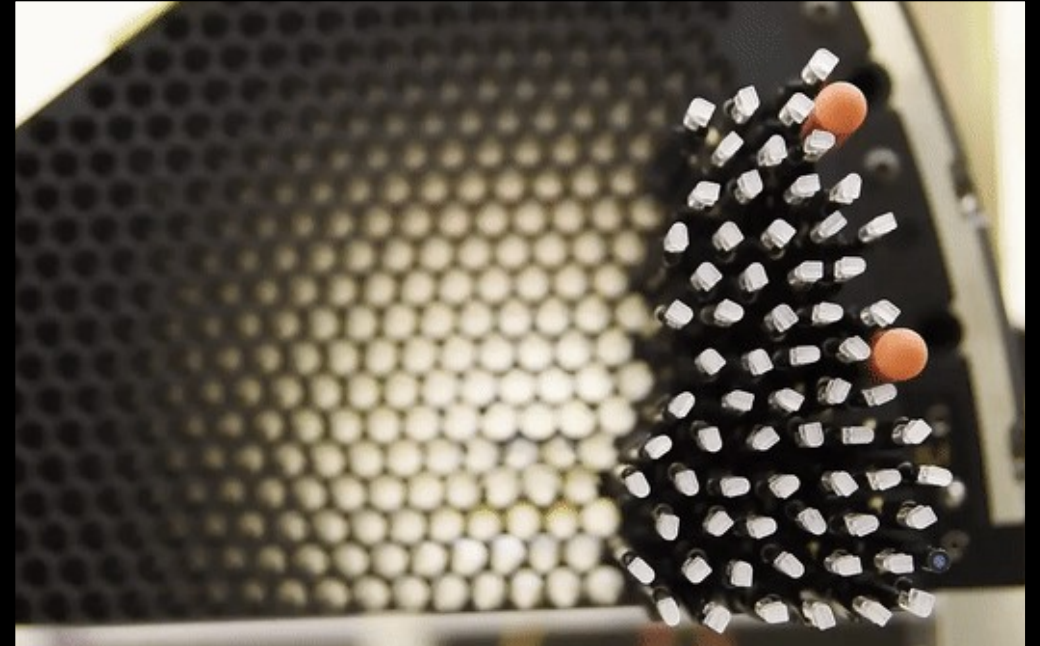


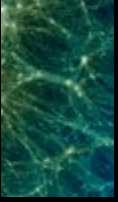


Comparison with
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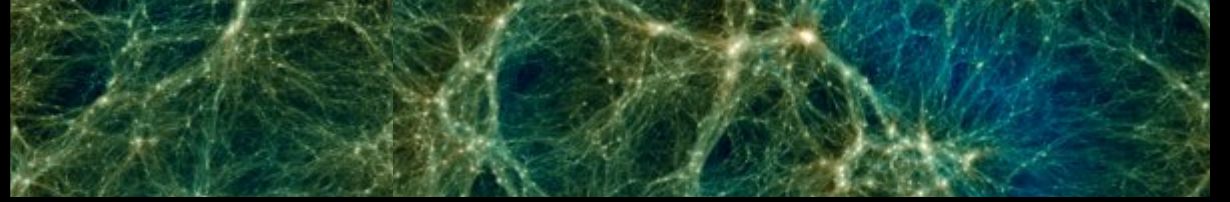


4.- We add all the observational systematics





**Comparison with
observations?**



5.- Comparison of the resulting lightcone with observations

is not consistent

is consistent



Comparison with observations?



5.- Comparison of the resulting lightcone with observations

is not consistent

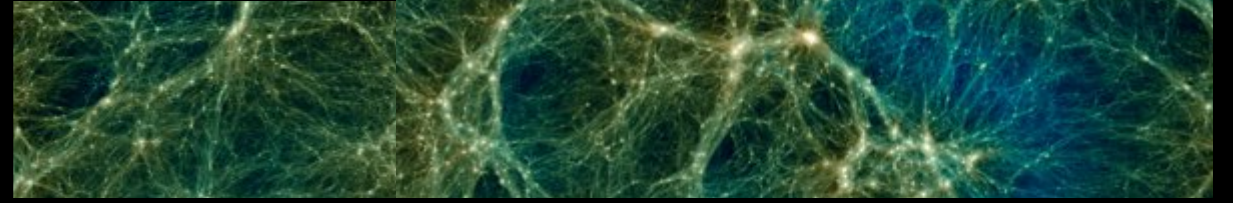
The cosmological model
assumed in the simulation is
incorrect

**We have ruled out the
cosmological model**

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Comparison with observations?



5.- Comparison of the resulting lightcone with observations

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The cosmological model
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correct

**We have found a “true”
cosmological model
candidate**



Comparison with observations?



5.- Comparison of the resulting lightcone with observations

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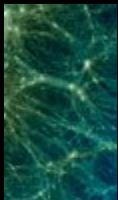
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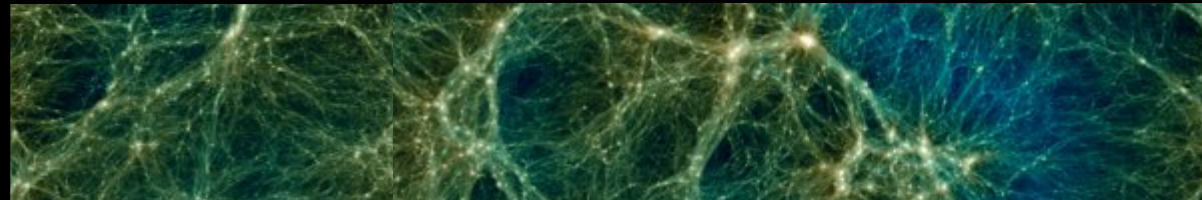
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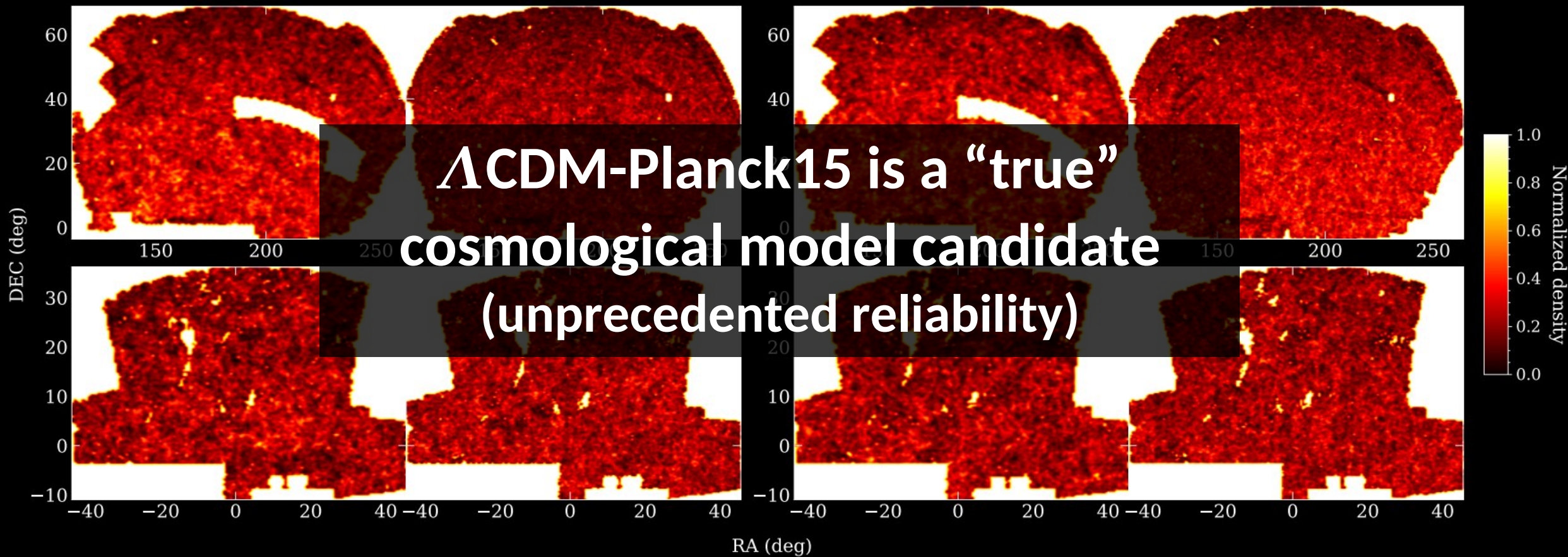


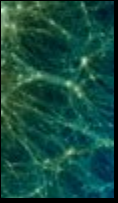
Comparison with observations?



Real observed data

Uchuu lightcone



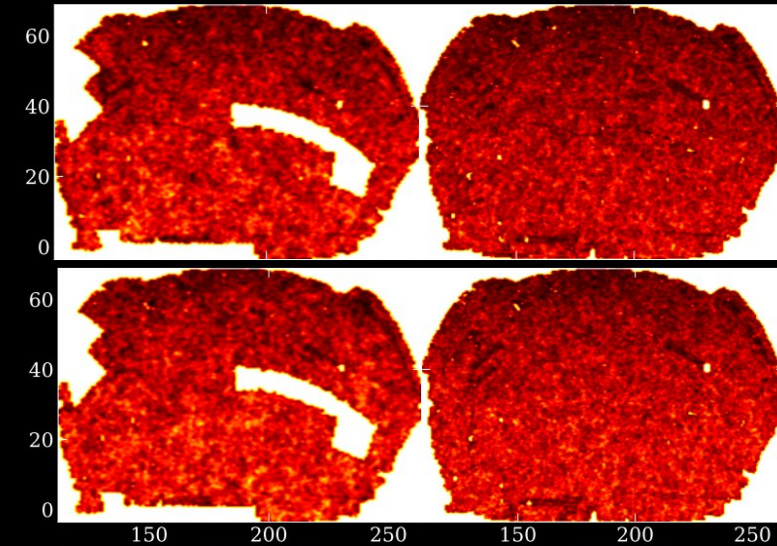


Conclusions



1.-

3.-



2.-



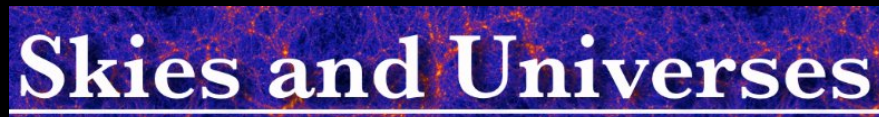
4.-

We have defined Λ CDM-Planck15 as a “true” cosmological model candidate with **unprecedented reliability**

A high-fidelity sky mock of galaxies in the Λ CDM cosmology

Julia F. Ereza

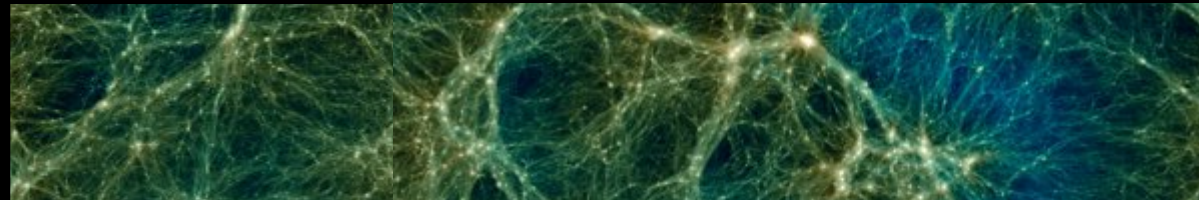
Uchuu Simulation is a Granada - Durham effort made by J. F. Ereza, F. Prada, A. Klypin, Tomoaki Ishiyama, Chi An Dong-Páez, C. Hernández-Aguayo, A. Smith, C. Baugh, S. Cole, C. Frenk, B. Li, P. Norberg, C.-Z. Ruan, P. Zarrouk







How do we construct
one?



Uchuu Simulation

Ω_m	Ω_L	Ω_b	h	σ_8	n_s
0.3089	0.6911	0.0486	0.6774	0.8159	0.9667

L_{box} (Mpc/h)	N_{part}	M_{part} (Msun/h)	Z_{init}
2000	12800^3	3.27×10^8	127