

HACKATÓN CUÁNTICA

(Encuentro colaborativo, desarrollo y presentación de proyectos resultantes de la visualización y sonificación del Universo)

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ICE CSIC-IEEC



Port d'Informació Científica (PIC)

- Founded in 2003
 - Collaboration between **IFAE** and **CIEMAT**
 - **Spanish Tier-1 Large Hadron Collider (LHC - WLCG)**
- Supported projects:
 - Particle physics: LHC (**Atlas**, **CMS**, **LHCb**), neutrinos (**T2K** Japan)
 - Astrophysics: **MAGIC**, Cherenkov Telescope Array
 - Cosmology: **PAU**, **MICE**, **DES**, **Euclid (SDC-ES)**
- Resources:
 - **8426 cores, 11 PiB disk, 25 PiB tape, 10Gb LAN**
 - **2 x 10 Gbps WAN**, optical paths to **CERN** and **1 x 10 Gbps** to Observatorio del Roque de los Muchachos
 - **Hadoop cluster**: 16 nodes, 2 TiB RAM, 192 TiB HDD
 - **GPU** [proof of concept in training neural networks]

Port d'Informació Científica (PIC)

Network Storage



49,4 PB of data transferred last year (in and out)

Computing

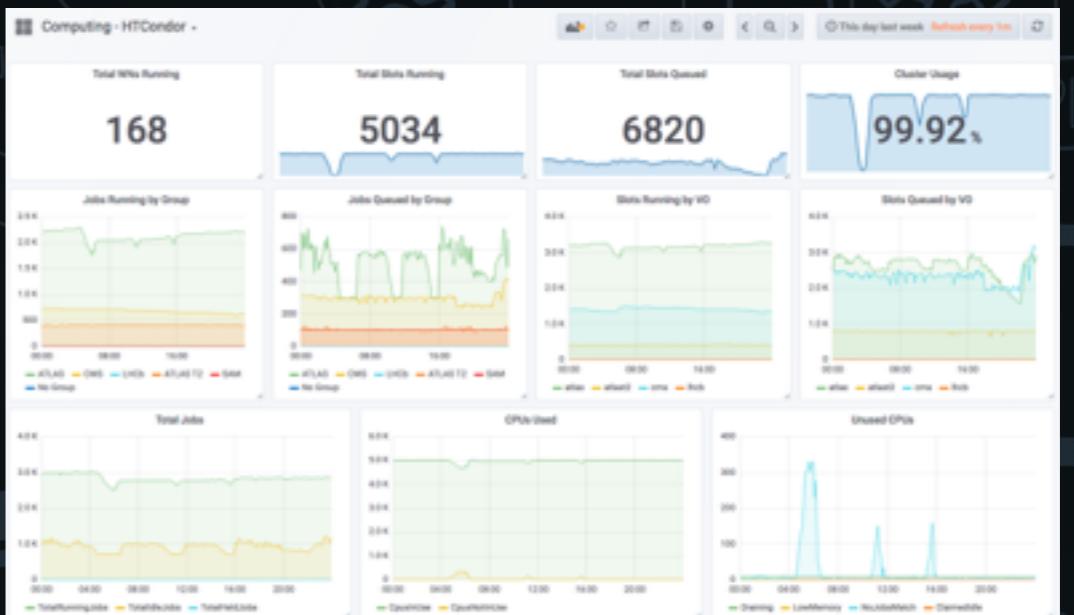


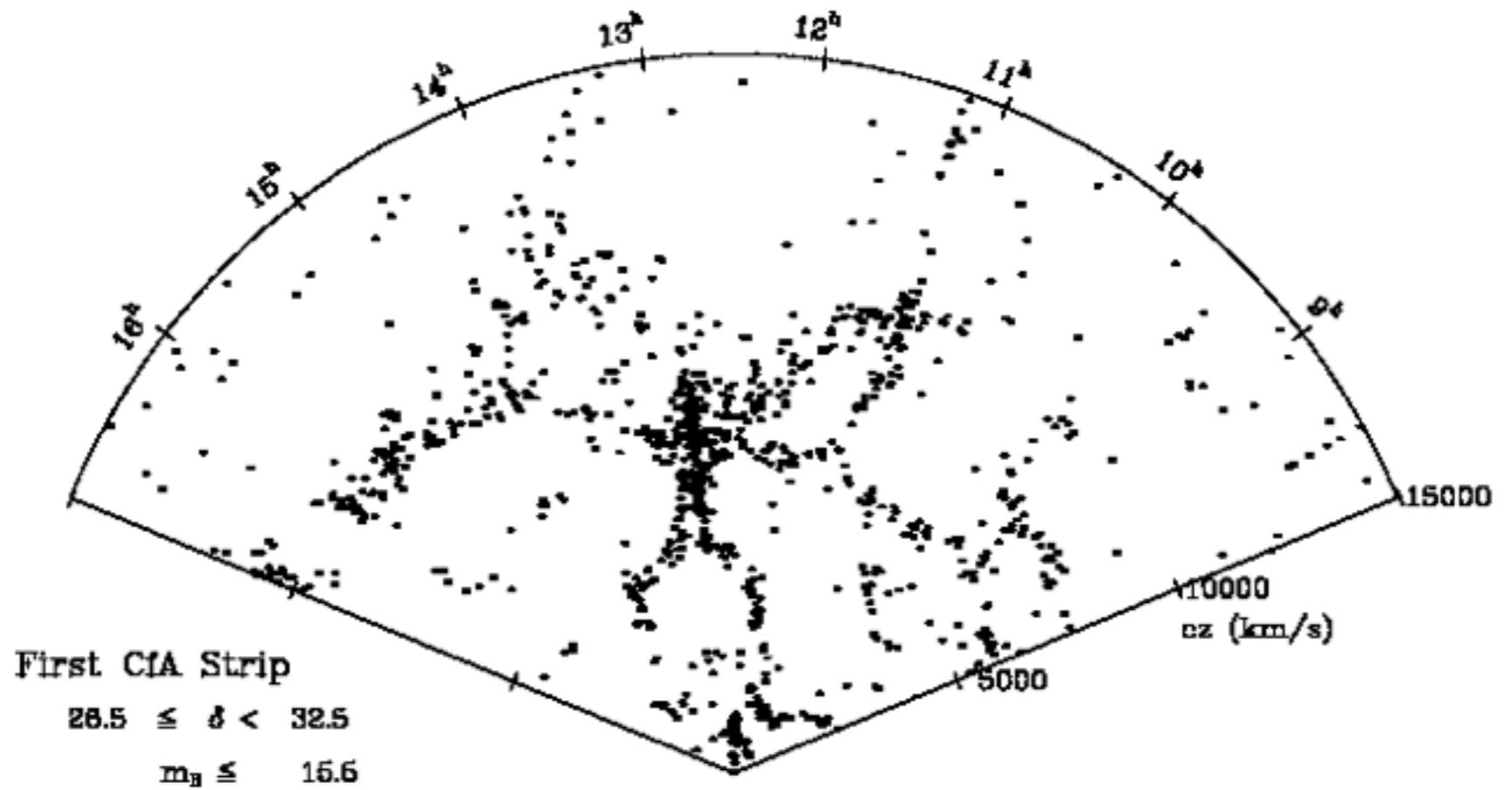
8426 cores computing farm

CCCB - Hackatón Cuántica - June 2019

Current capacity 25 PB

Monitoring





CfA survey: completed in 1982, ~14000 galaxies up to redshift $cz \sim 15000 \text{ km/s}$

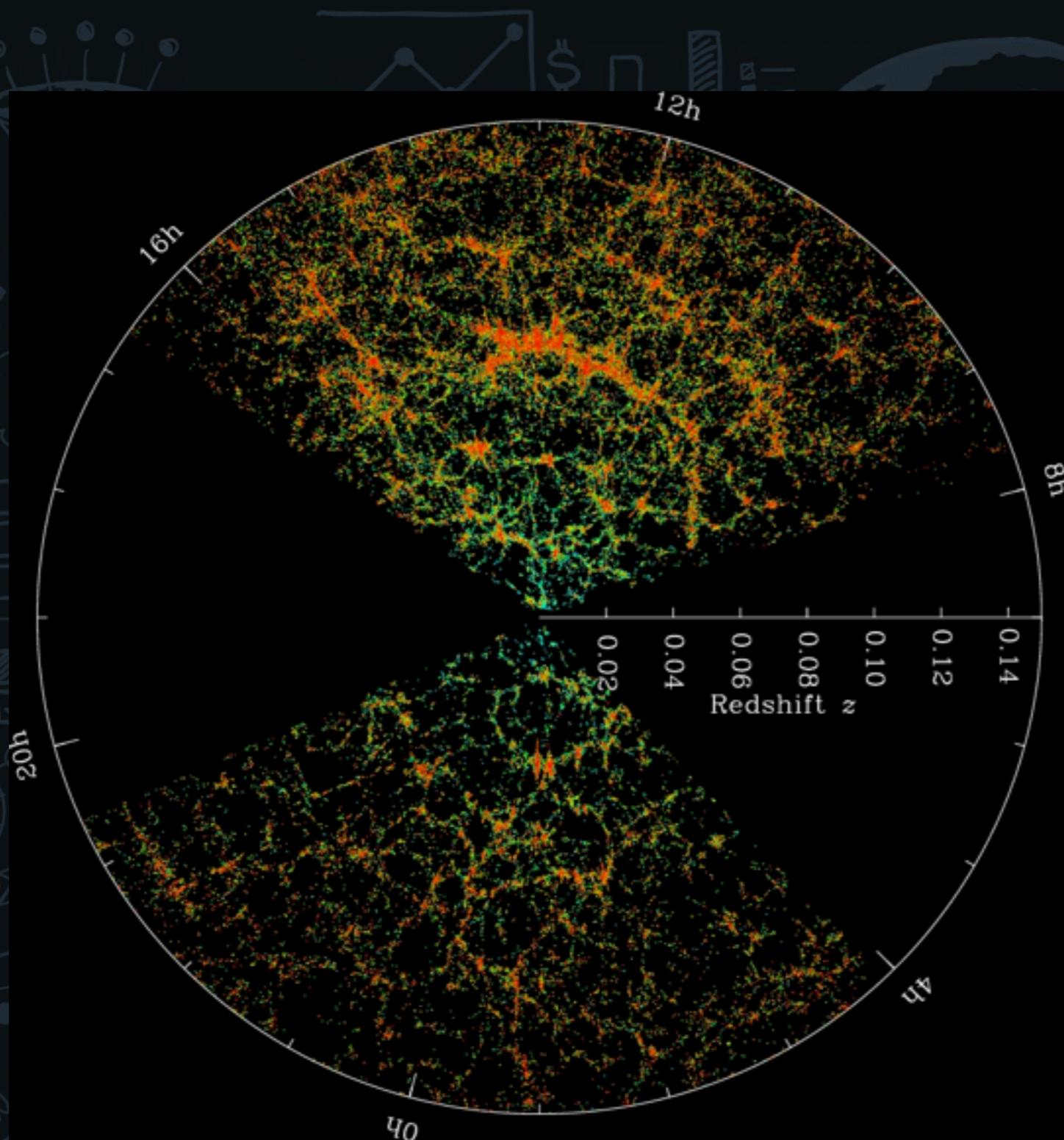
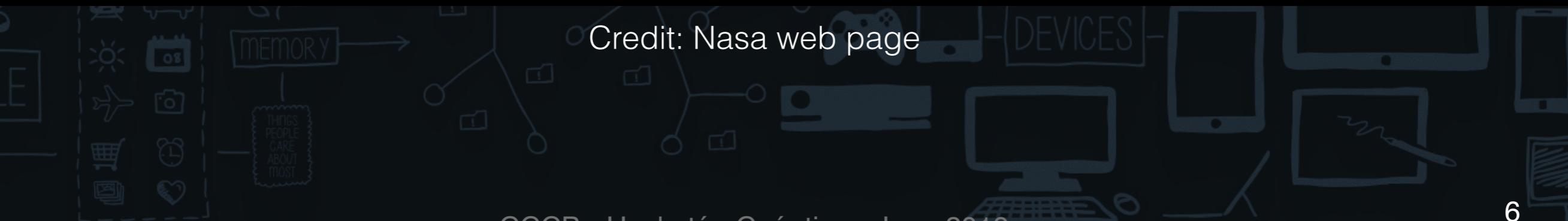
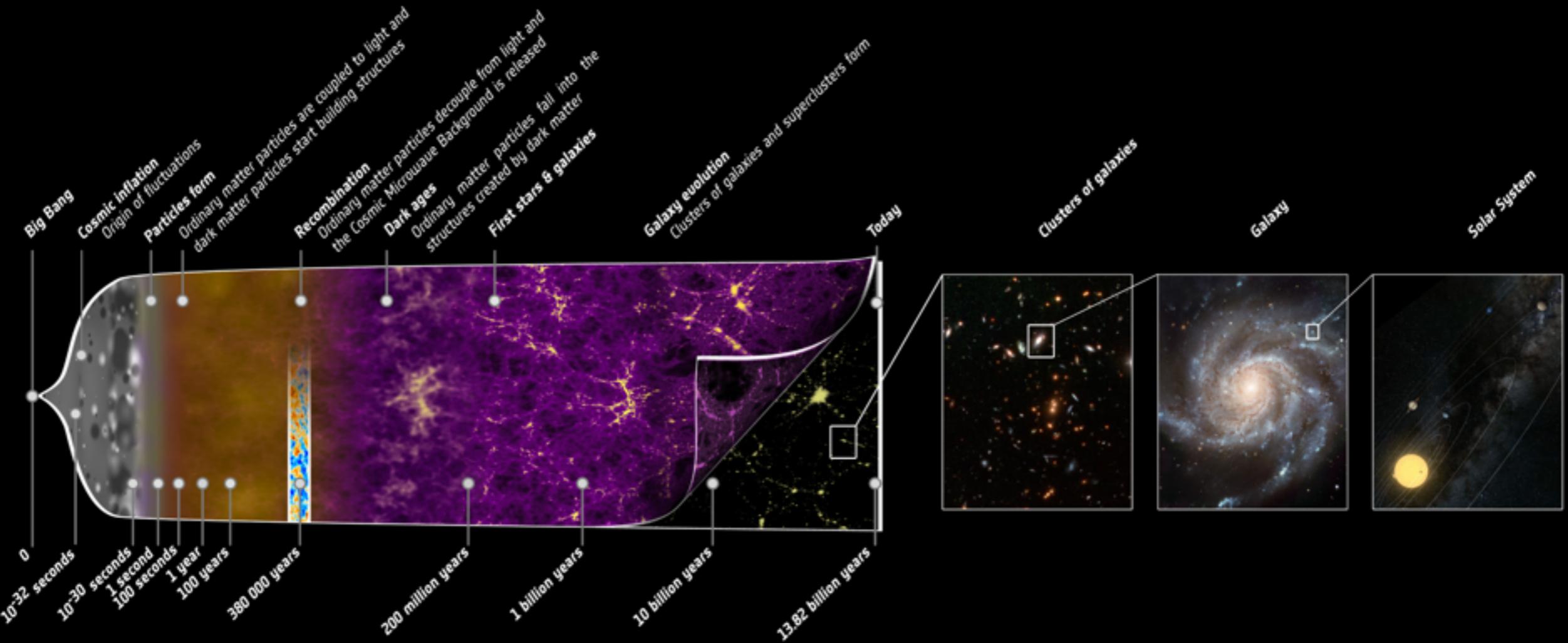


Image Credit: M. Blanton and SDSS

Story of Our Universe

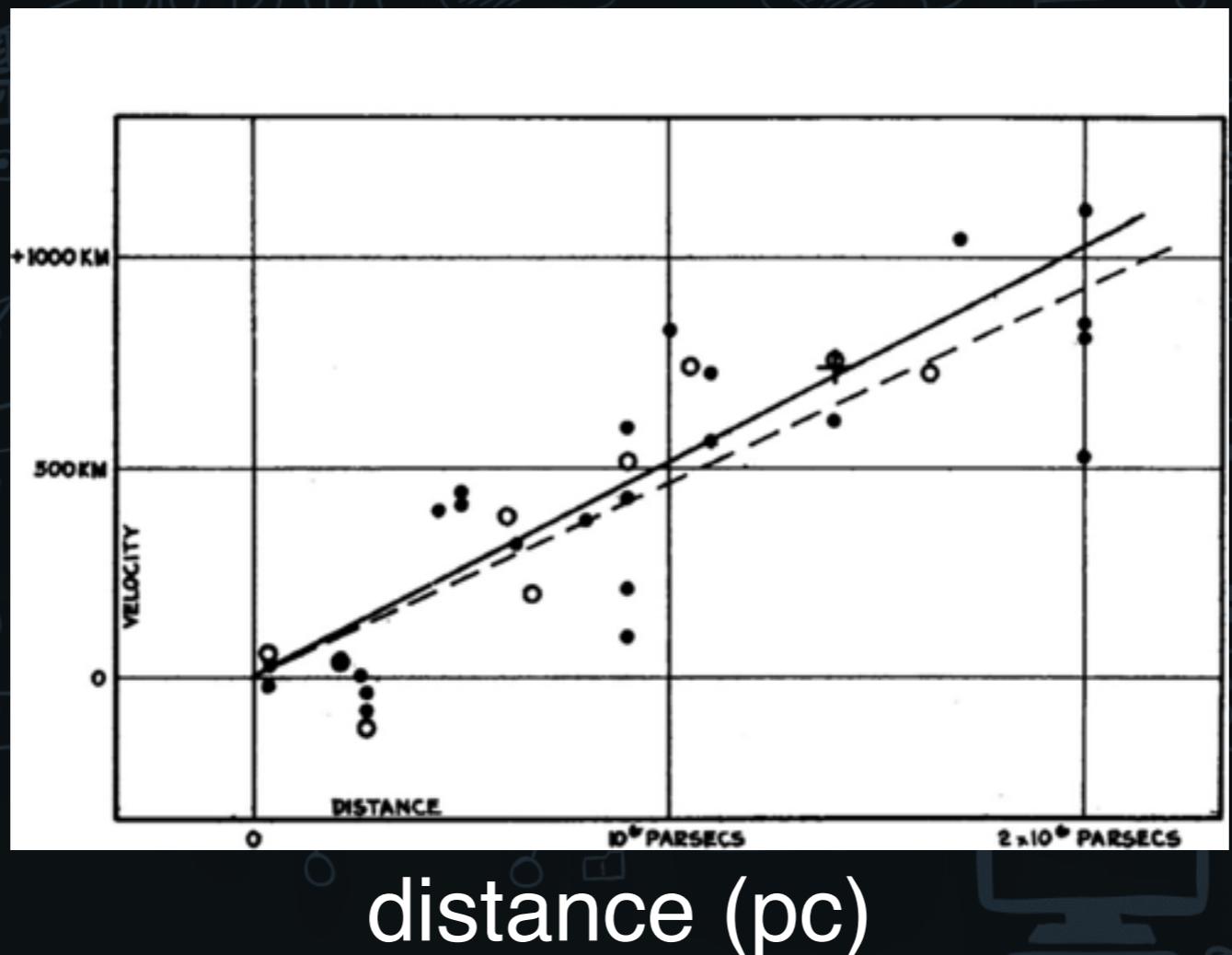


Cosmic inflation

- Is a theory in which there is an exponential expansion of the space in the early Universe (Alan Guth 1979)
- Presents a solution at the same time for the horizon problem (homogeneity problem) and the flatness problem
- **Quantum fluctuations** in the microscopic inflationary region, magnified to cosmic size, **become the seeds for the growth of structure in the Universe**

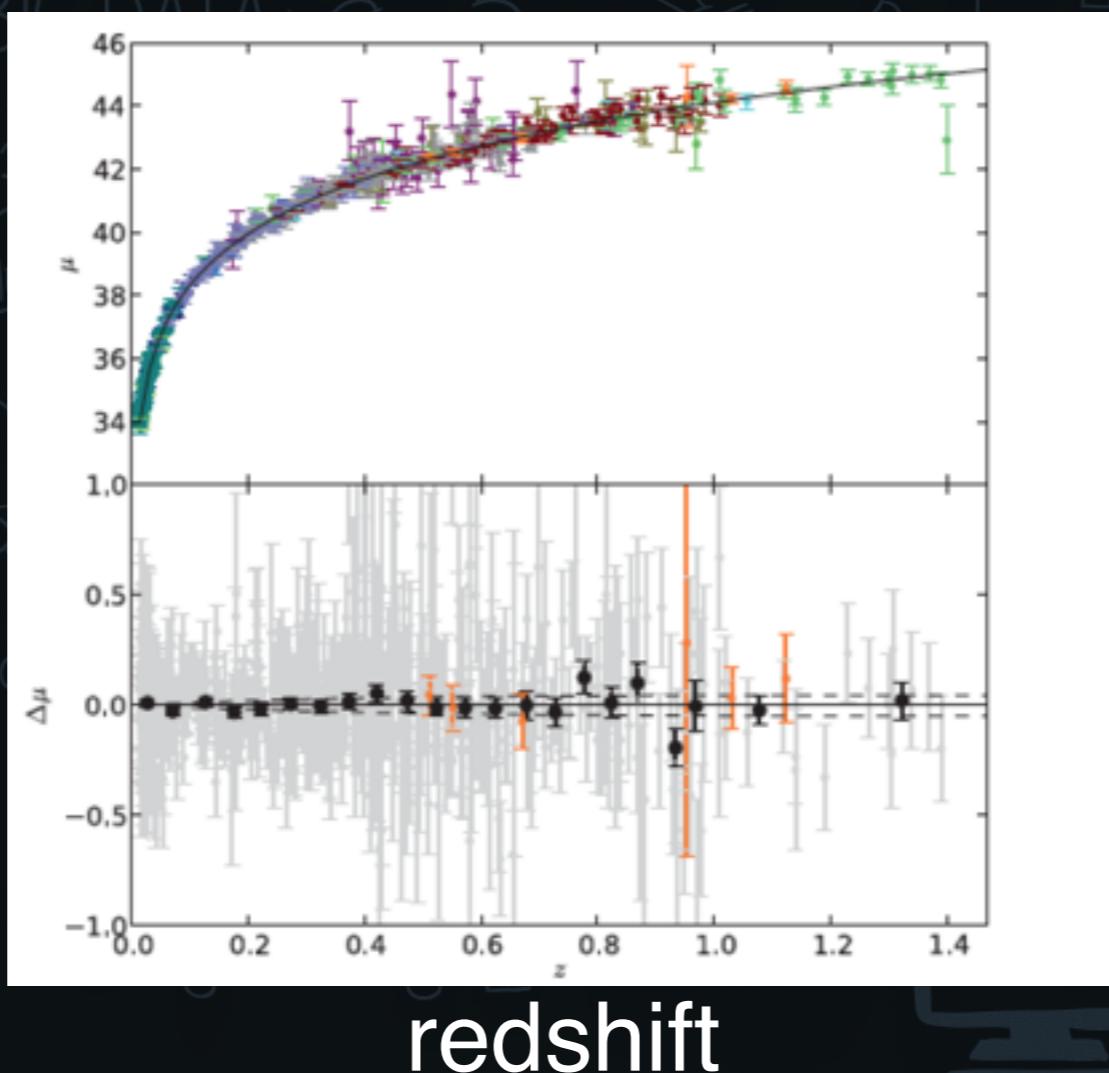
Expanding universe

- Cold facts:
 - **The Universe is expanding (Hubble - 1929)**
 - The Universe is expanding in an accelerating way (two independent groups - 1998)



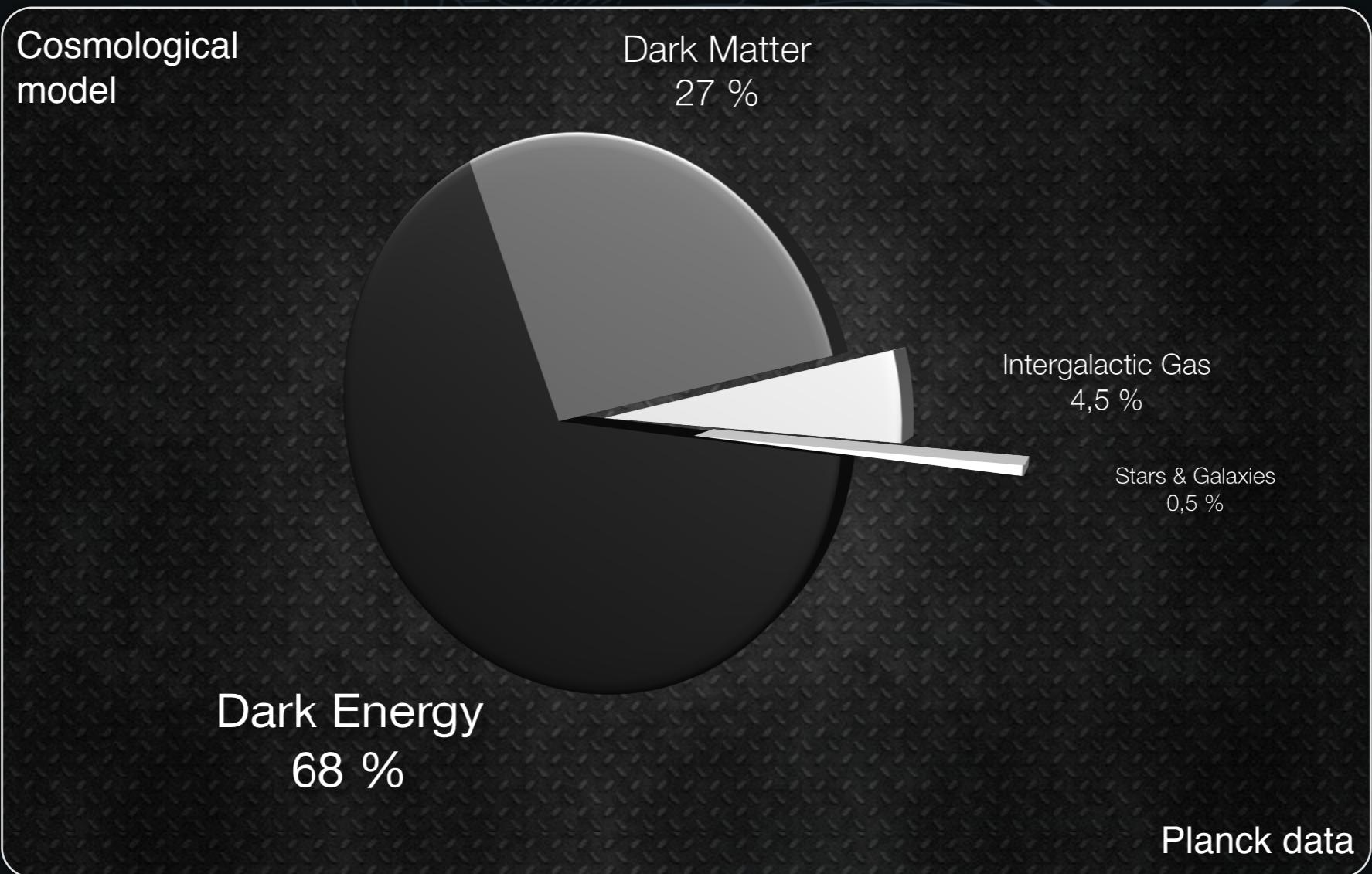
(Accelerating) expanding universe

- Cold facts:
 - The Universe is expanding (Hubble - 1929)
 - The Universe is expanding in an accelerating way (two independent groups - 1998)



Open questions

- Why in an accelerating way?
- What is the content of the Universe?



Galaxy surveys

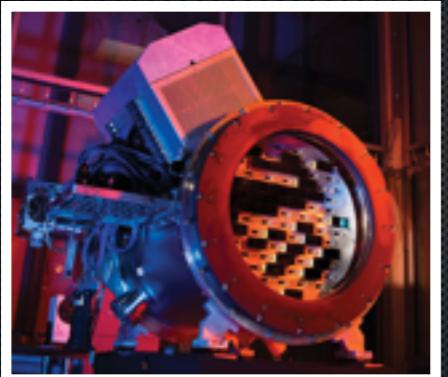


- Main goal: measure the positions of distant galaxies
- Measuring distances in Cosmology is difficult.
Instead we measure redshift:
 - displacement of spectral lines towards longer wavelengths (the red end of the spectrum) in radiation from distant galaxies
 - related to distance through the cosmological model
- Two methods to estimate the redshift of a galaxy:
 - spectroscopy: high precision spectra
 - photometry: low resolution spectra

"Our" galaxy surveys



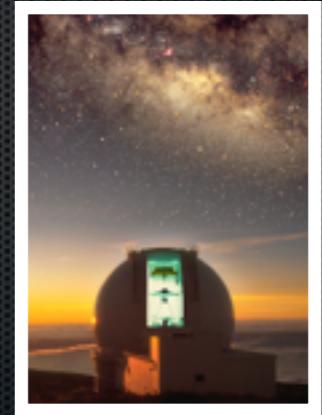
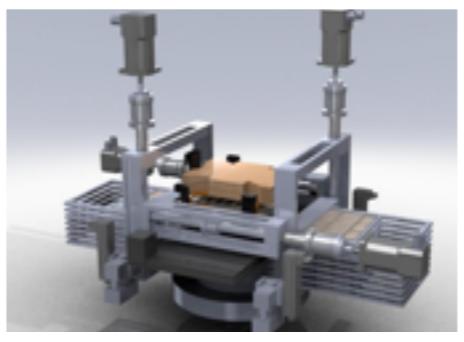
Dark Energy Survey



<https://www.darkenergysurvey.org/es/>



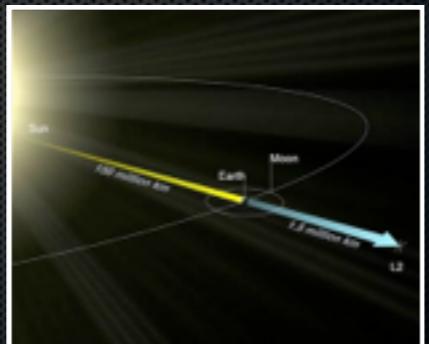
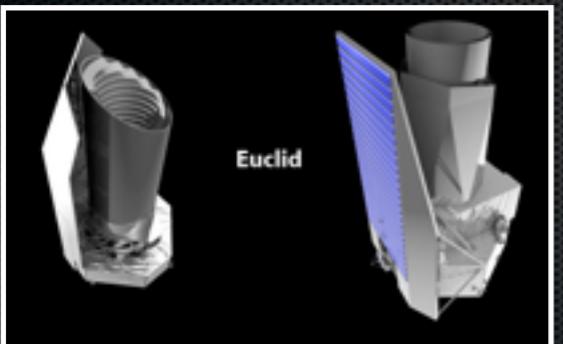
Physics of the
Accelerating Universe



<https://www.pausurvey.org/>



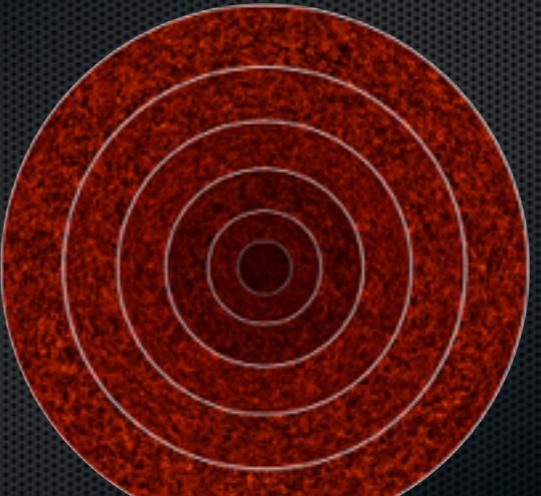
Euclid Mission



<http://sci.esa.int/euclid/>



Marenostrum Institut de
Ciències de l'Espai

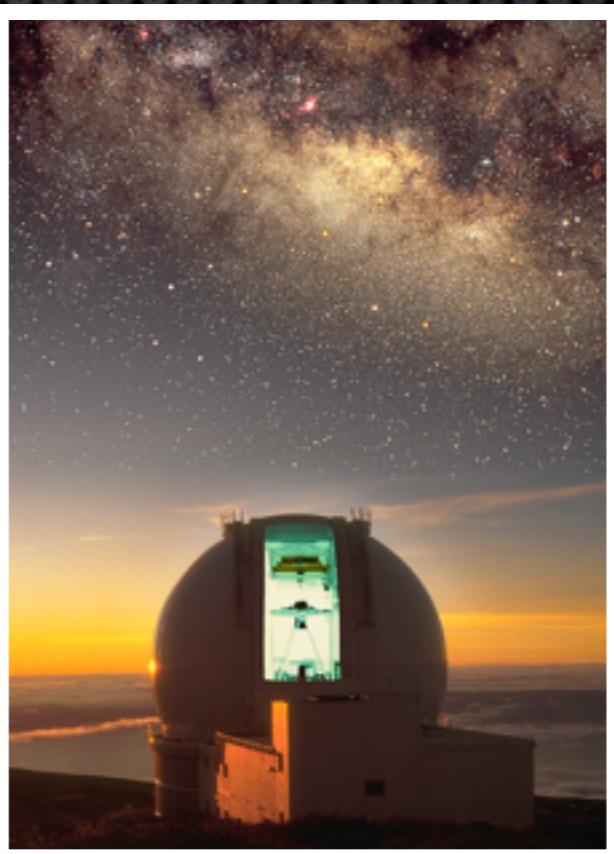
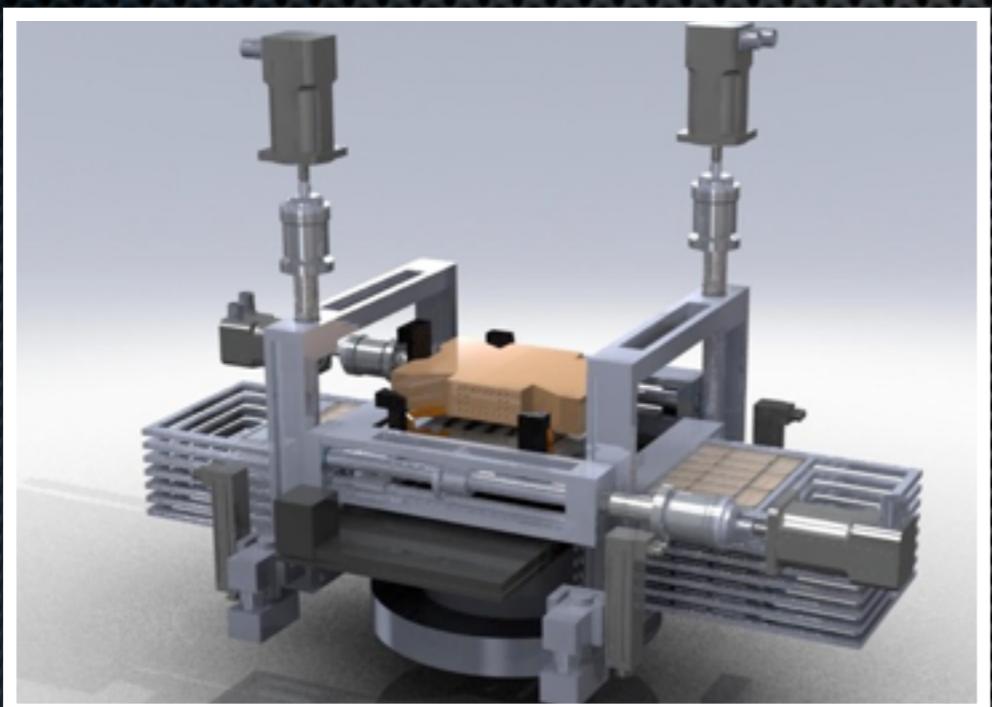


<http://maia.ice.cat/mice/>



Cosmology Surveys

Physics of the Accelerating Universe



10 billion light-years

100.000.000.000.000.000.000.000 meters



Cosmology Surveys

Physics of the Accelerating Universe

- 42 narrow + 5 five broad filters
- Very high accuracy photometric redshifts
- 120 deg^2

10 billion light-years

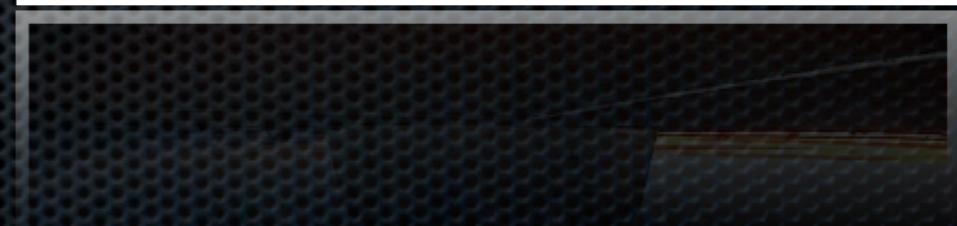
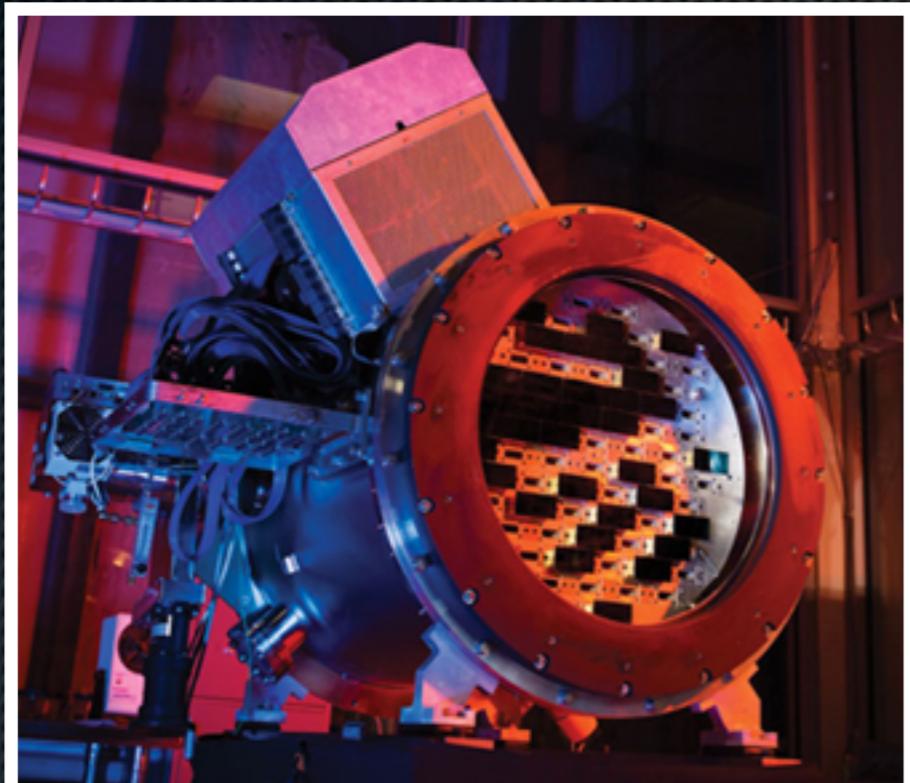
100.000.000.000.000.000.000.000 meters



DARK ENERGY
SURVEY

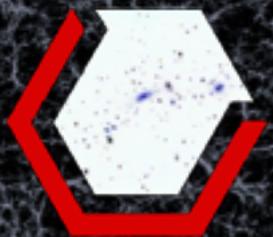
Cosmology Surveys

The Dark Energy Survey



10 billion light-years

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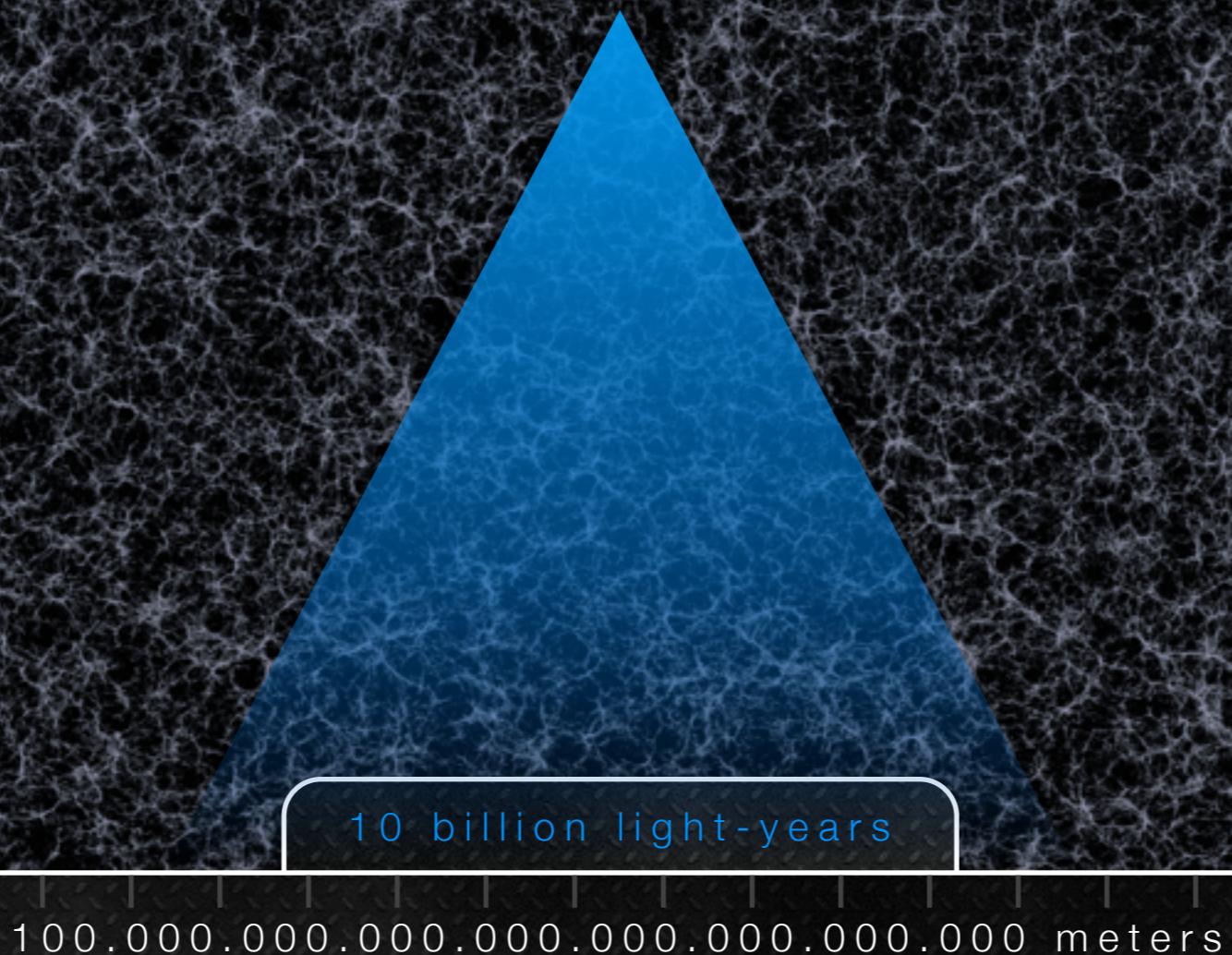


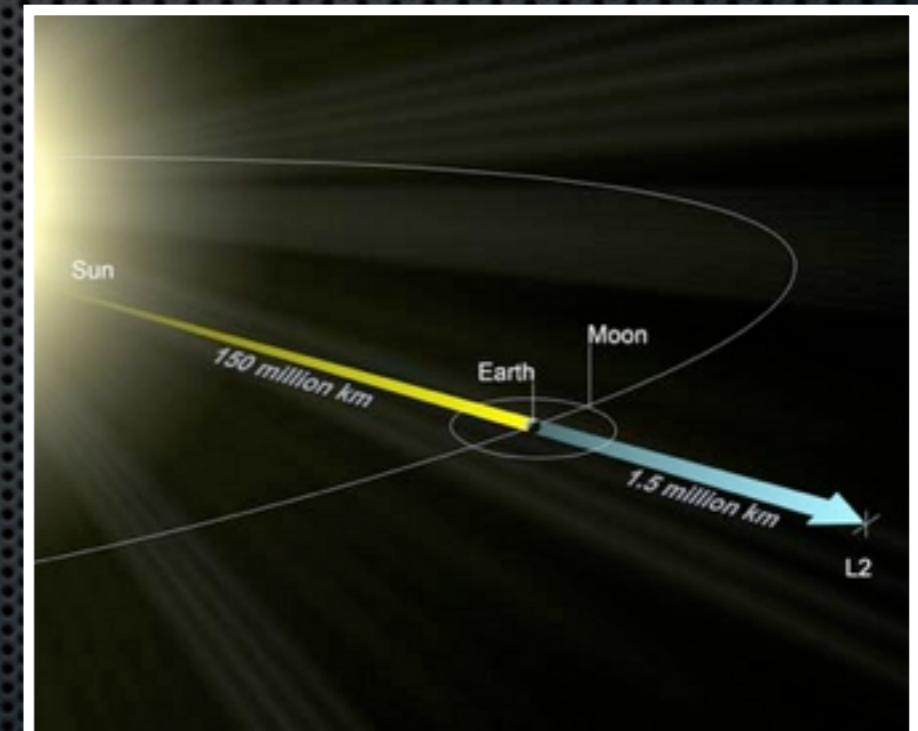
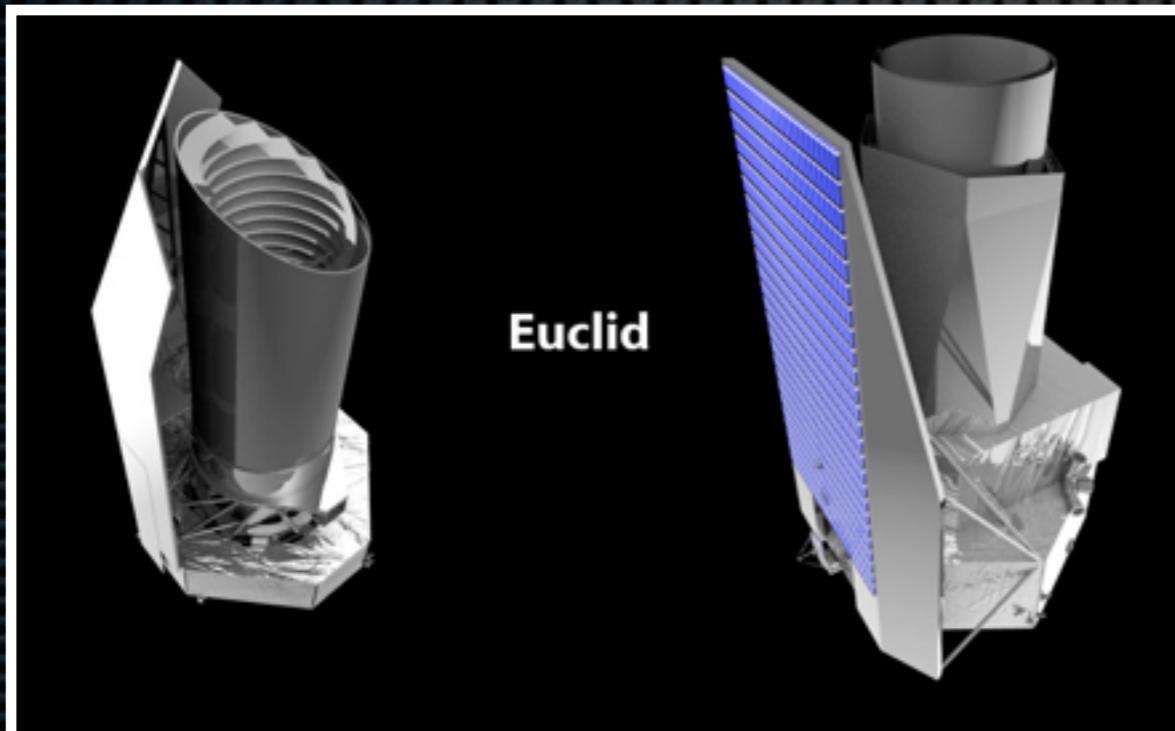
DARK ENERGY
SURVEY

Cosmology Surveys

The Dark Energy Survey

- 300M of galaxies
- 15000 galaxy clusters up to $z \sim 1.2$
- 1000 distant type-Ia SNe





10 billion light-years

100.000.000.000.000.000.000.000 meters



Cosmology Surveys Euclid Mission

- 10 billion astronomical sources
- spectroscopic redshifts for 50 million objects
- 15,000 deg²

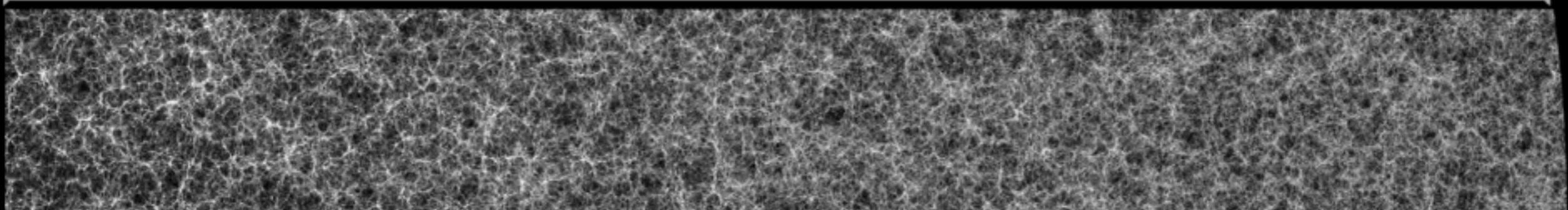
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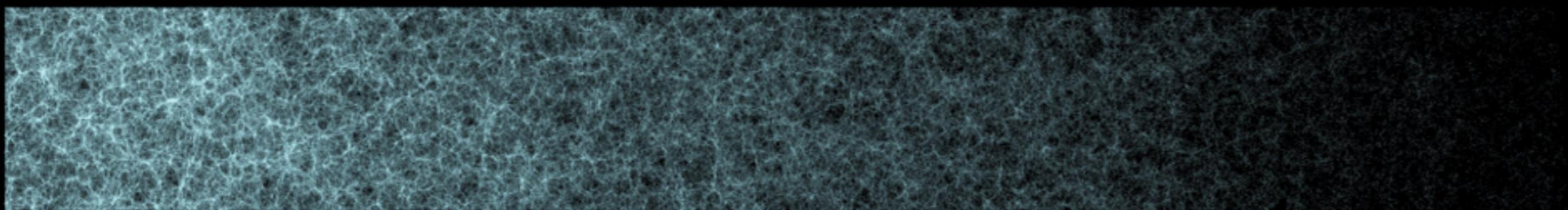
$z = 0$

All galaxies

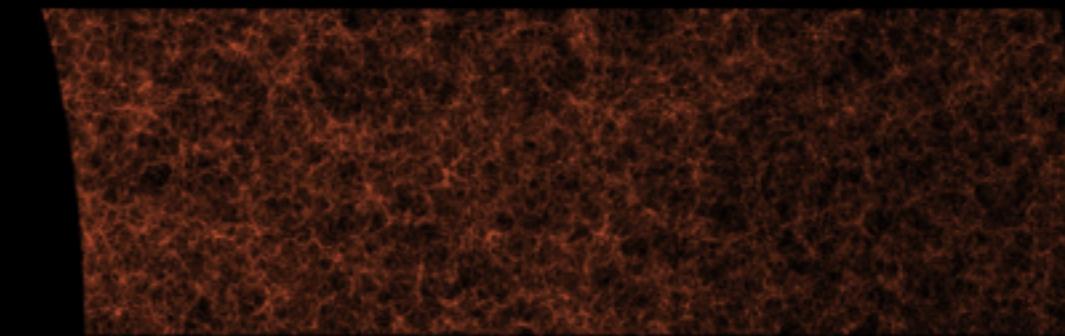
$z = 2.3$



$\text{VIS} < 24.5$



$\text{NISP H}\alpha > 1.\text{e}-16$



$z = 0.8$

$z = 1.9$

MICECAT2: generation (2015)

- Motivation: create a synthetic galaxy catalog to help calibrated other galaxy surveys using the simulation MICE GC produced at the BSC
- The galaxy catalog has to follow some of the global properties of the observed galaxy population



	fields	objects
input	10	330×10^6
output galaxies	125	500×10^6

(Big) data management

- After storing, reducing and calibrating the observed images one of the main outputs is a galaxy catalog, which contains their positions along with hundreds of other properties such as the luminosity, colour, morphology, etc

Project	Date	volume / night	Total volume	Number of objects (catalog)
SDSS	2000 - now	variable	116 TiB	2×10^6
MICE GC	2013	NA	42 TiB	5×10^8
DES	2013 - 2018	2.5 TiB	2 PiB	4×10^8
GAIA	2014 - 2019	40 GiB	1 PiB	1.1×10^9
Euclid	2020 - 2025	100 GiB	580 TiB	1.5×10^9
LSST	2022 - 2032	15 TiB	50 PiB	1×10^{10}

COSMO HUB

on Big Data

- Based on Apache Hive
- Distribution ✓
 - Query time range: seconds to minutes
 - 75% in < 3 min
- Exploration (Visualization)
 - Unlimited time
 - Full dataset plots (over all rows)
 - May use sampling
 - 1D histogram & 2D heatmap

<https://cosmohub.pic.es>