Inverno Astrofísico, Castelo-ES

28 de julho de 2018

A colaboração Brasil-Espanha de levantamento de dados cosmológicos: J-PAS

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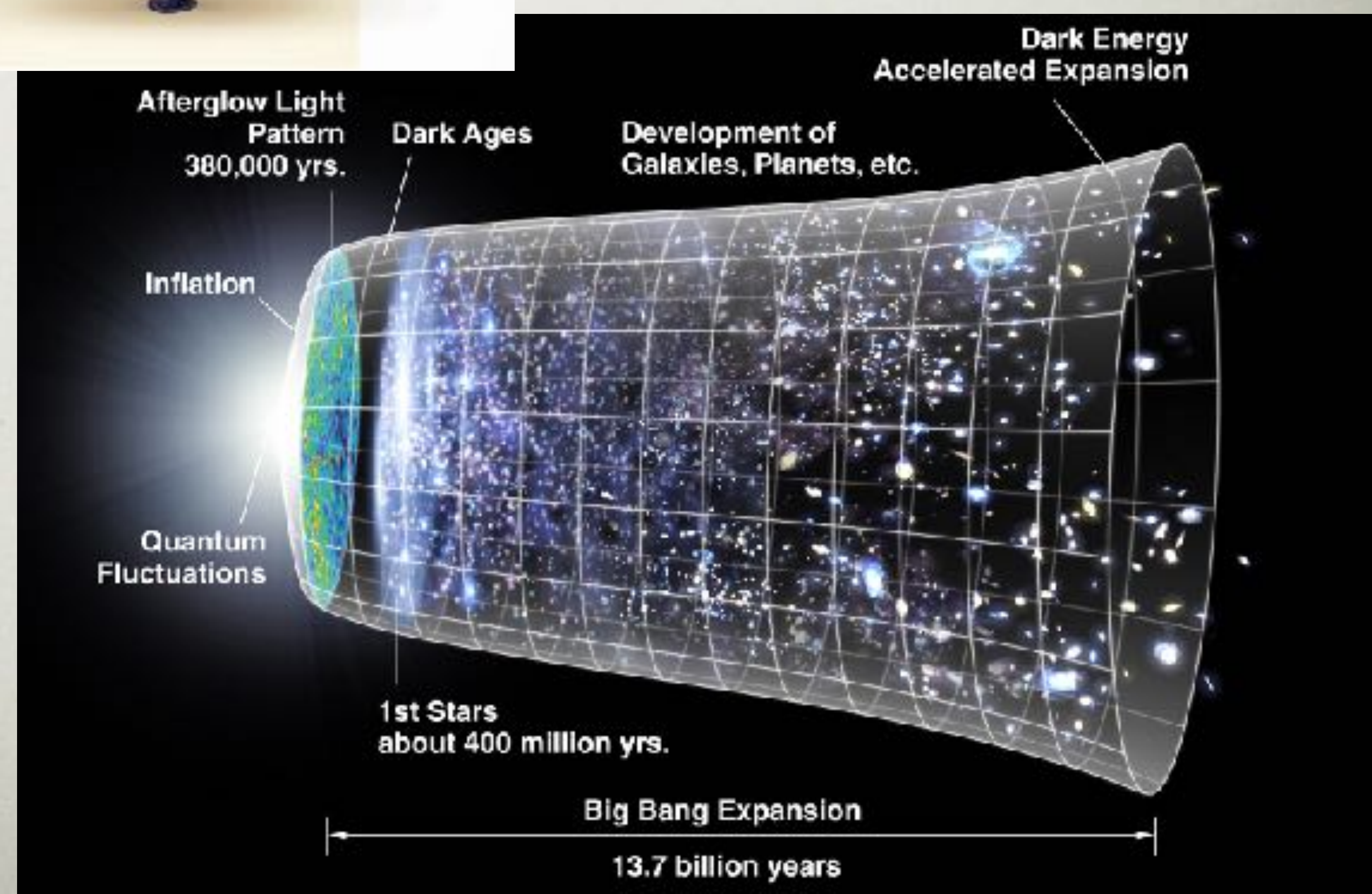
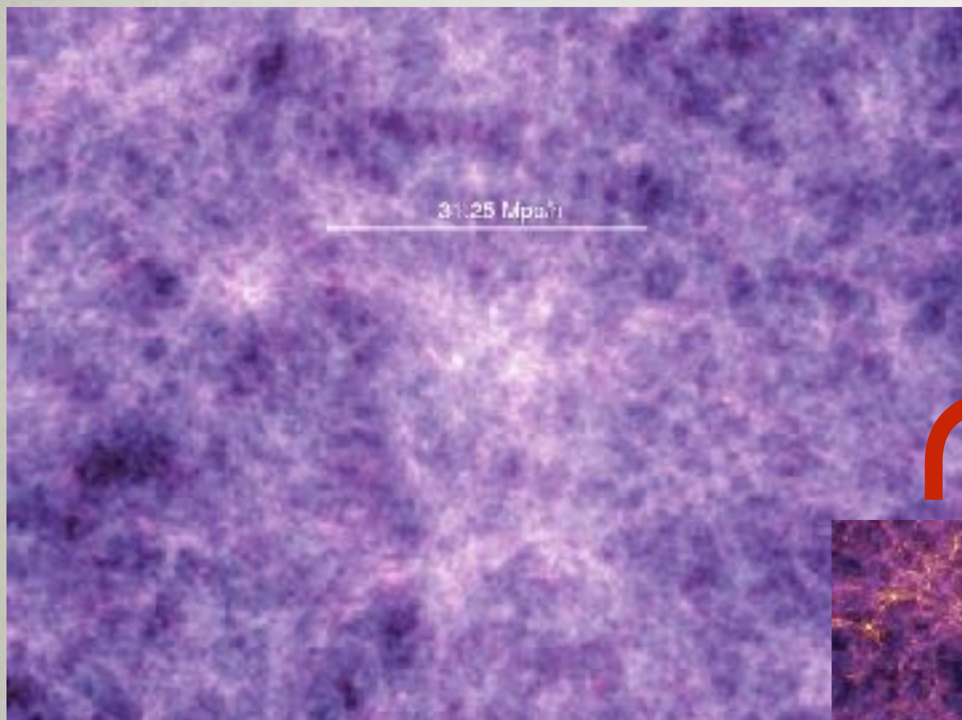
O que é a cosmologia (moderna)?

O que pretende descobrir?

1- A evolução do "tamanho" do universo

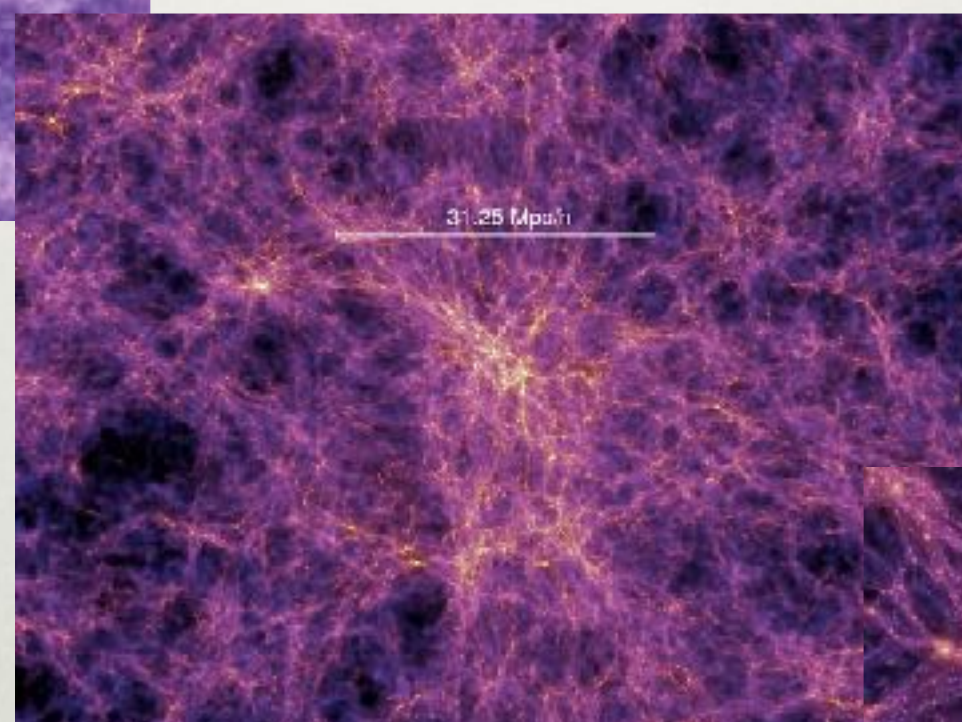


2- A evolução da estrutura em larga escala



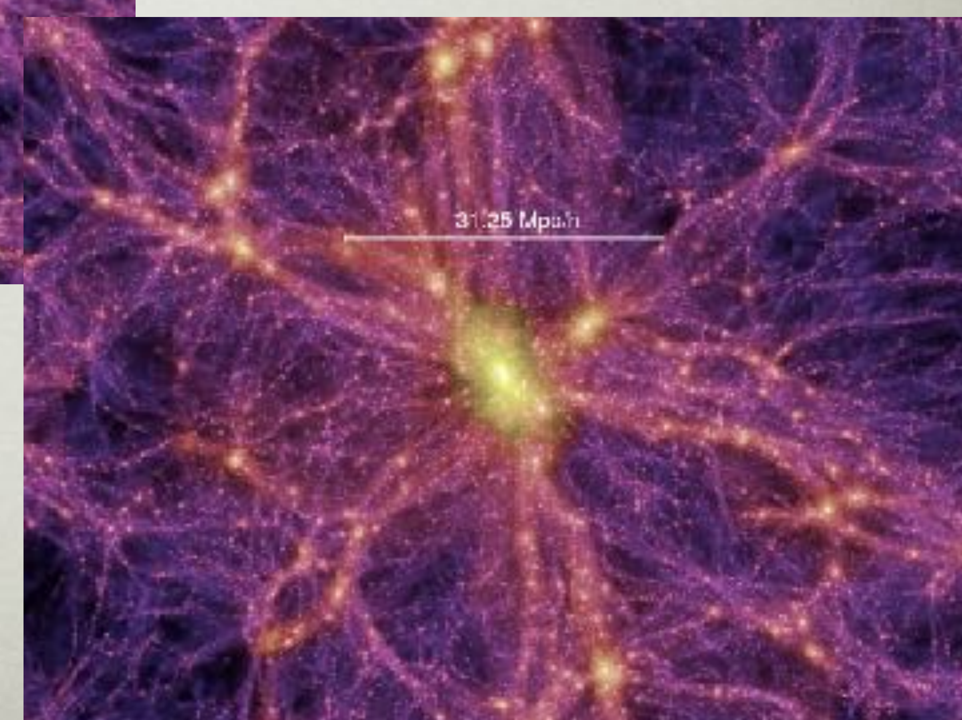
t = 0.21 Gyr

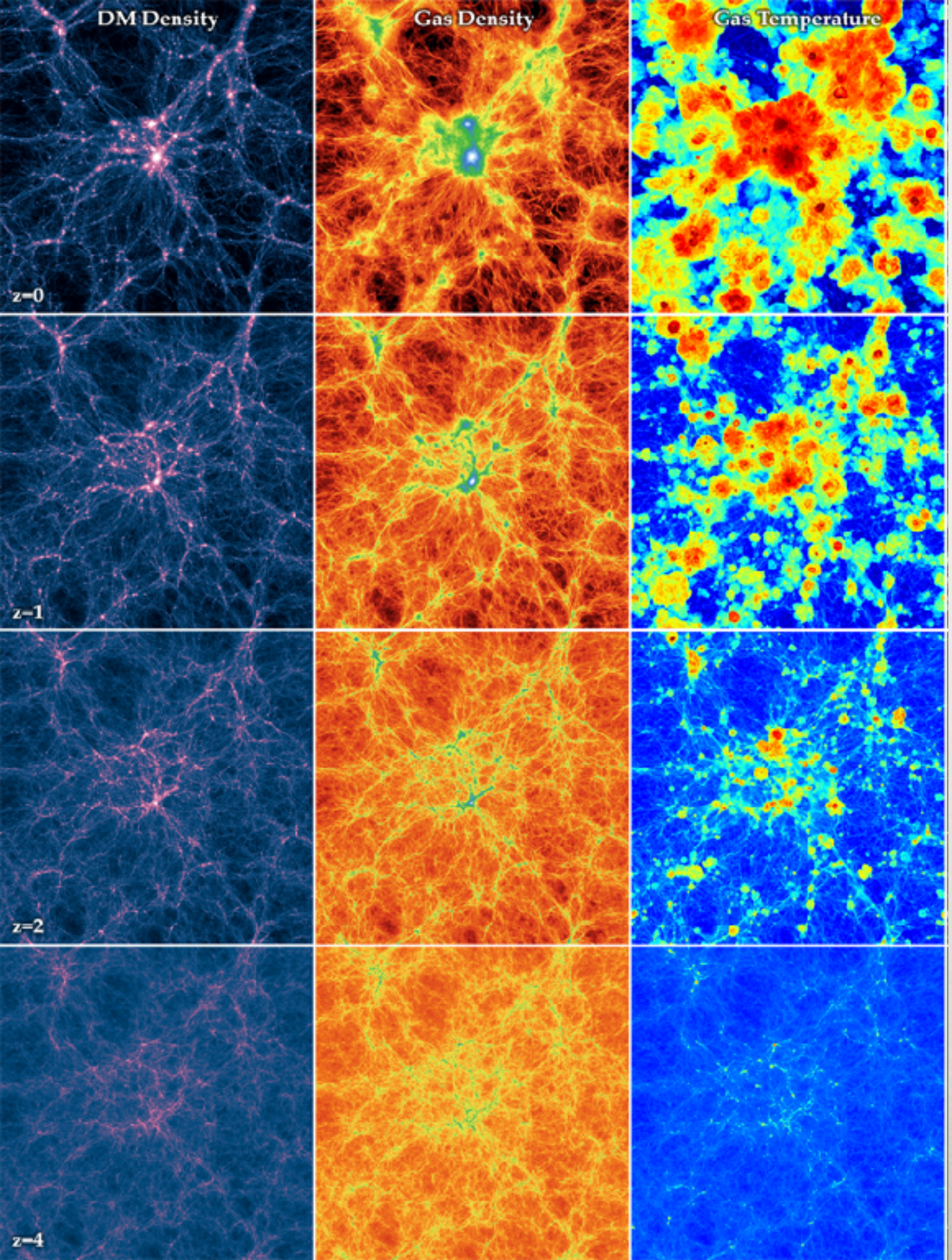
400,000,000 anos luz



t = 4.7 Gyr

t = 13.6 Gyr





How does the universe evolve?

Illustris simulation

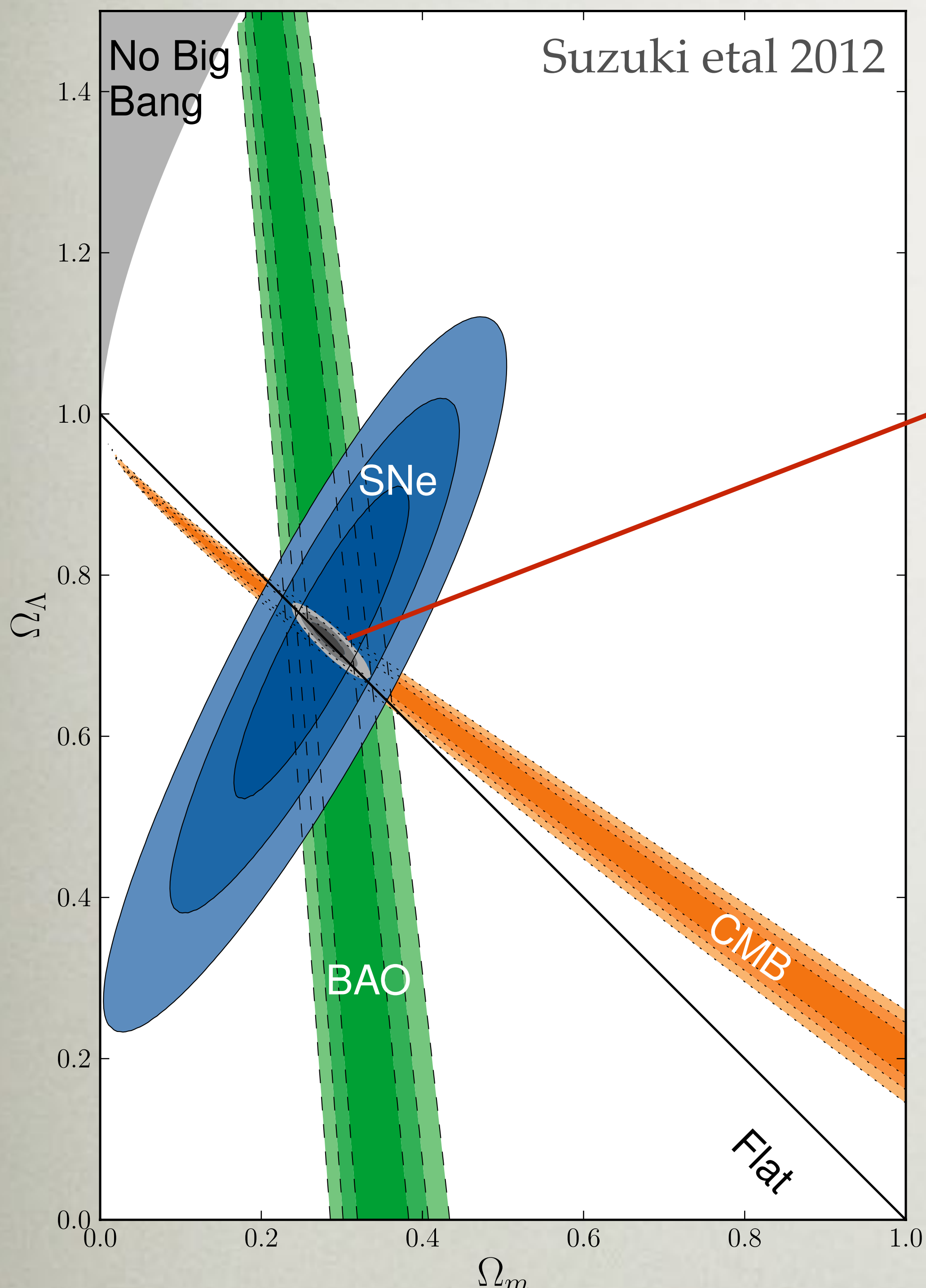
The largest was run on 8,192 compute cores, and took 19 million CPU hours.

Consequências?

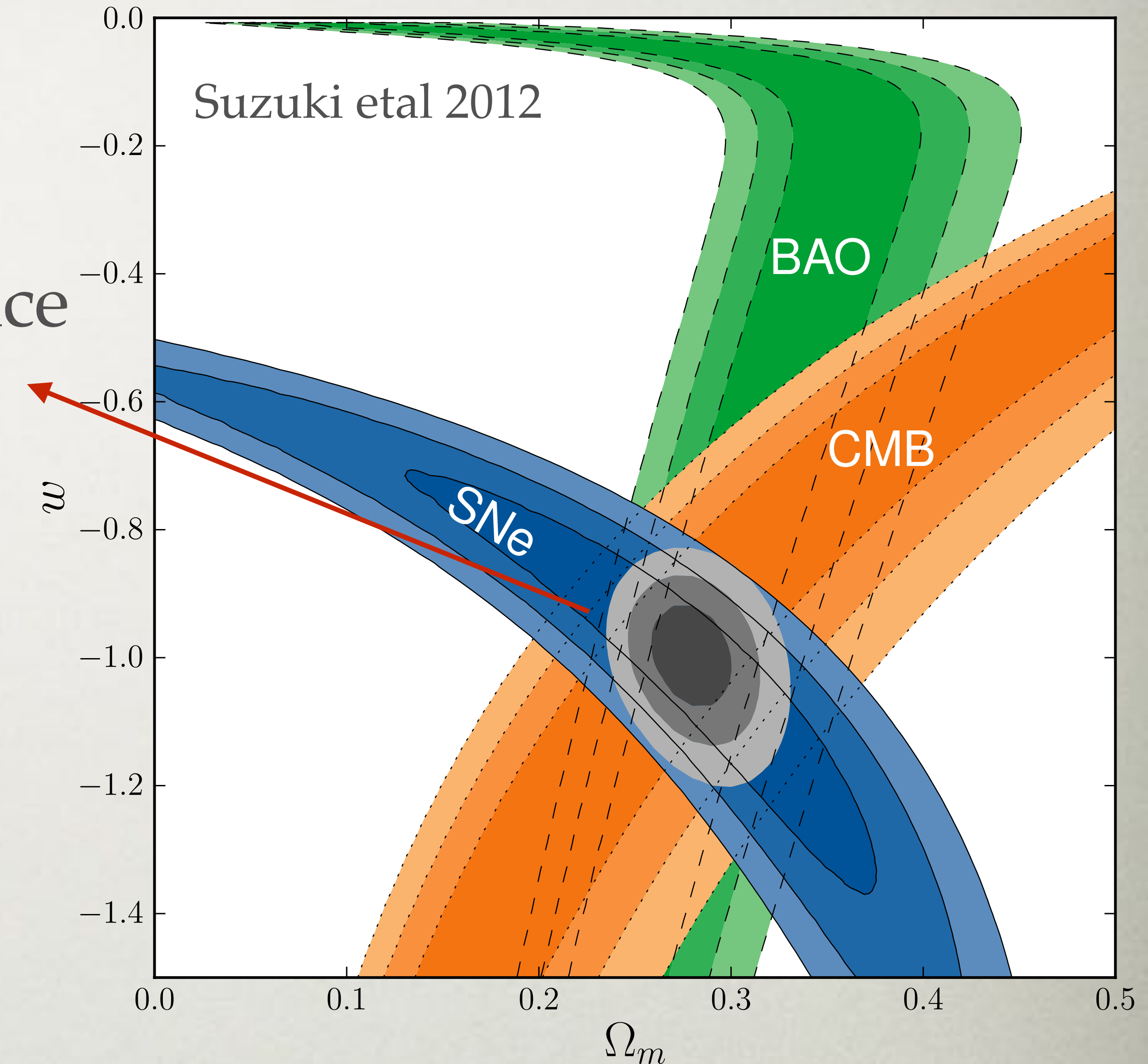
Inimagináveis!

Em particular, descobriremos a composição do universo e as leis da física que governam não somente nossa galáxia mas o universo inteiro.

Present understanding



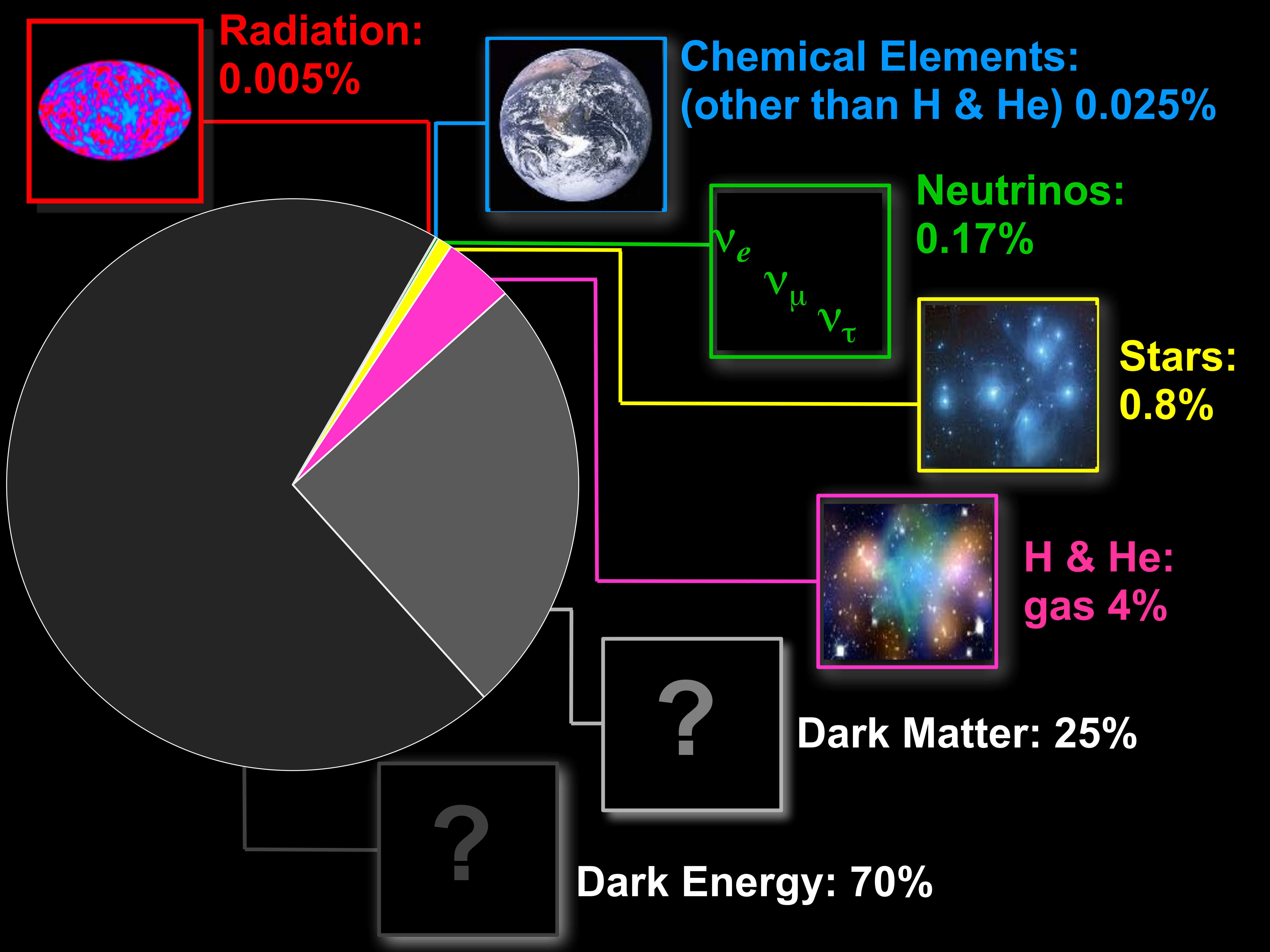
concordance
model



$$\Omega_M \simeq 0.3$$
$$\Omega_{\rm DE} \simeq 0.7$$
$$w_{\rm DE} \simeq -1$$

strong evidence for
dark energy

2011 Nobel Prize


Radiation:
0.005%
Chemical Elements:
(other than H & He) 0.025%
Neutrinos:
0.17%
ν_e ν_μ ν_τ
Stars:
0.8%
H & He:
gas 4%
?
Dark Matter: 25%
?
Dark Energy: 70%

Mysteries of the

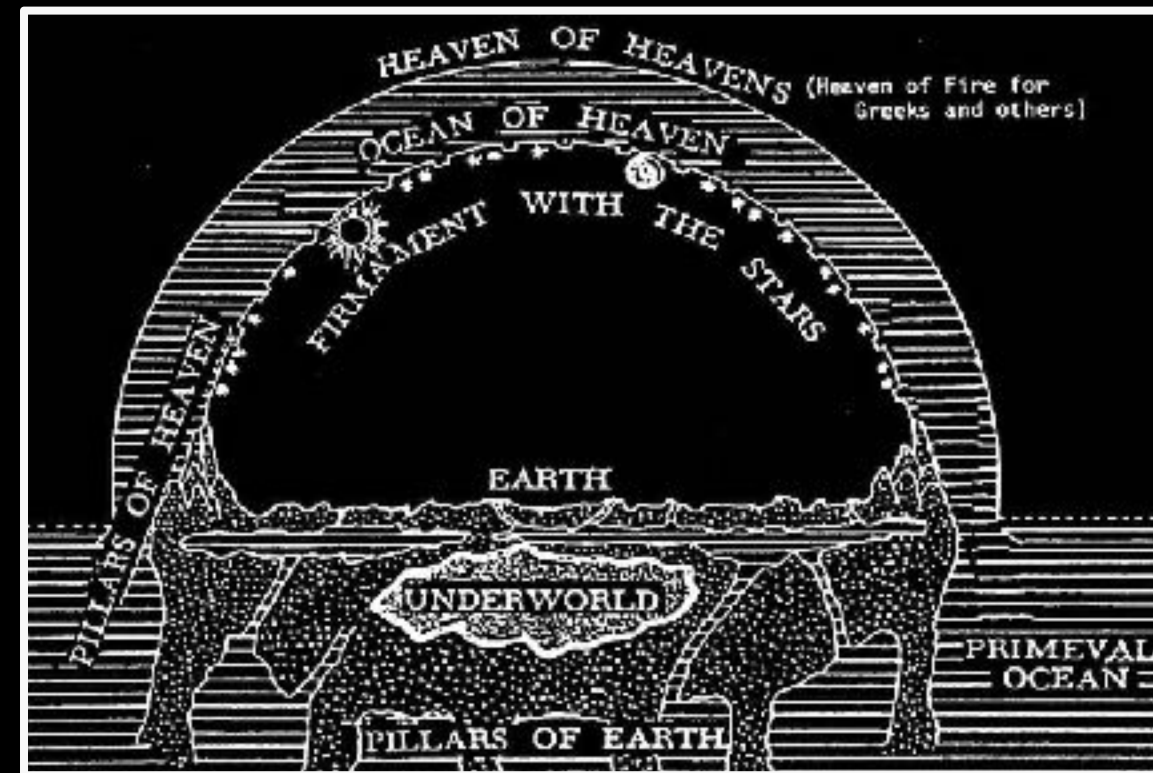
Dark Universe

Dark Matter	Dark Energy
Pulls Things Together	Pulls Things Apart
Attractive Gravity	Repulsive Gravity
New Particle Species?	Weight of Space?

Credit: Rocky Kolb

Old cosmological Models

Ancient Egypt



Ancient Middle East

Dark Ages (and Kansas today)

Ancient South Asia

Credit: Rocky Kolb

Near future in cosmology

We will observe a good fraction of all the galaxies in the observable universe. This will allow us to understand the nature of dark matter and dark energy.

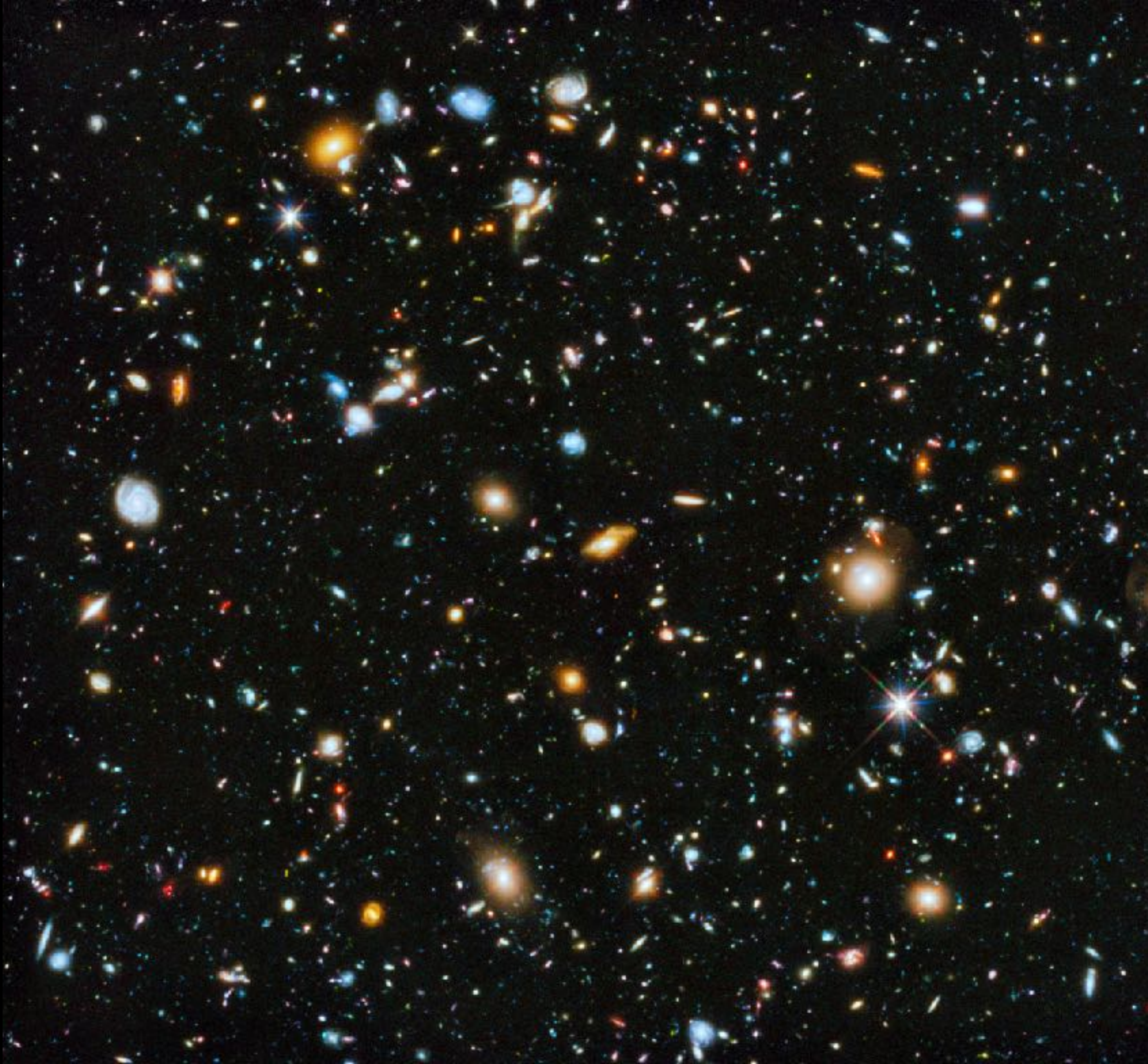
Two ways to observe galaxies:

I. **spectroscopy**: better data but less galaxies per year.
   Good for BAO.

II. **imaging**: only shape of galaxies but many galaxies per year.
   Good for weak lensing.

→ **lots of people, large collaborations**

Hubble Ultra Deep Field



10,000 individual galaxies

Para as escalas cosmológicas, as galáxias - e seus bilhões de estrelas e planetas - são… pontos!

How to observe galaxies?

Spectroscopy

How to observe galaxies? Spectroscopy

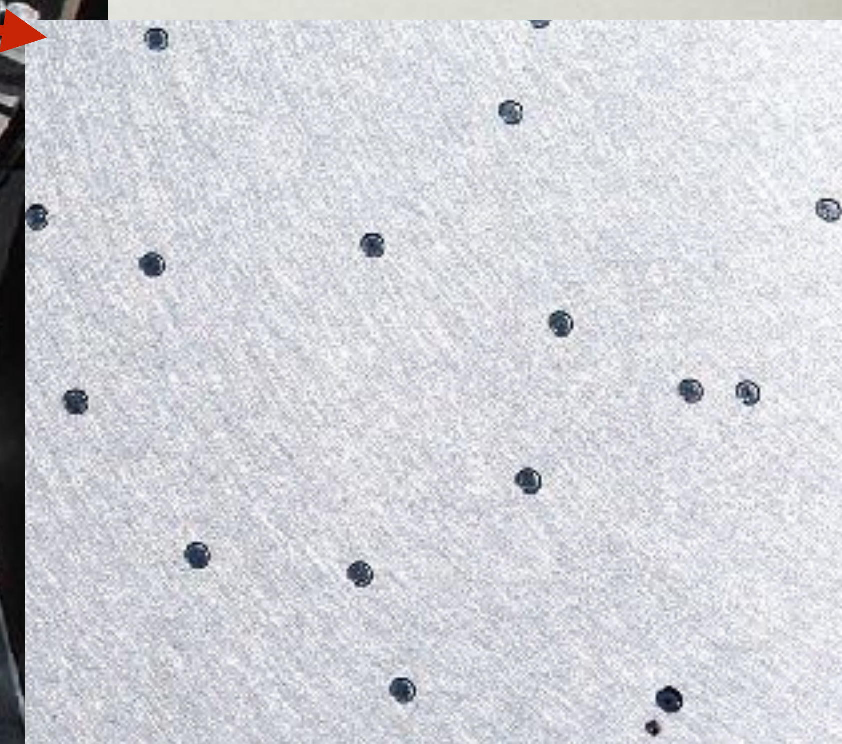
very precise redshifts —> very precise distances + peculiar velocities

excellent for BAO etc

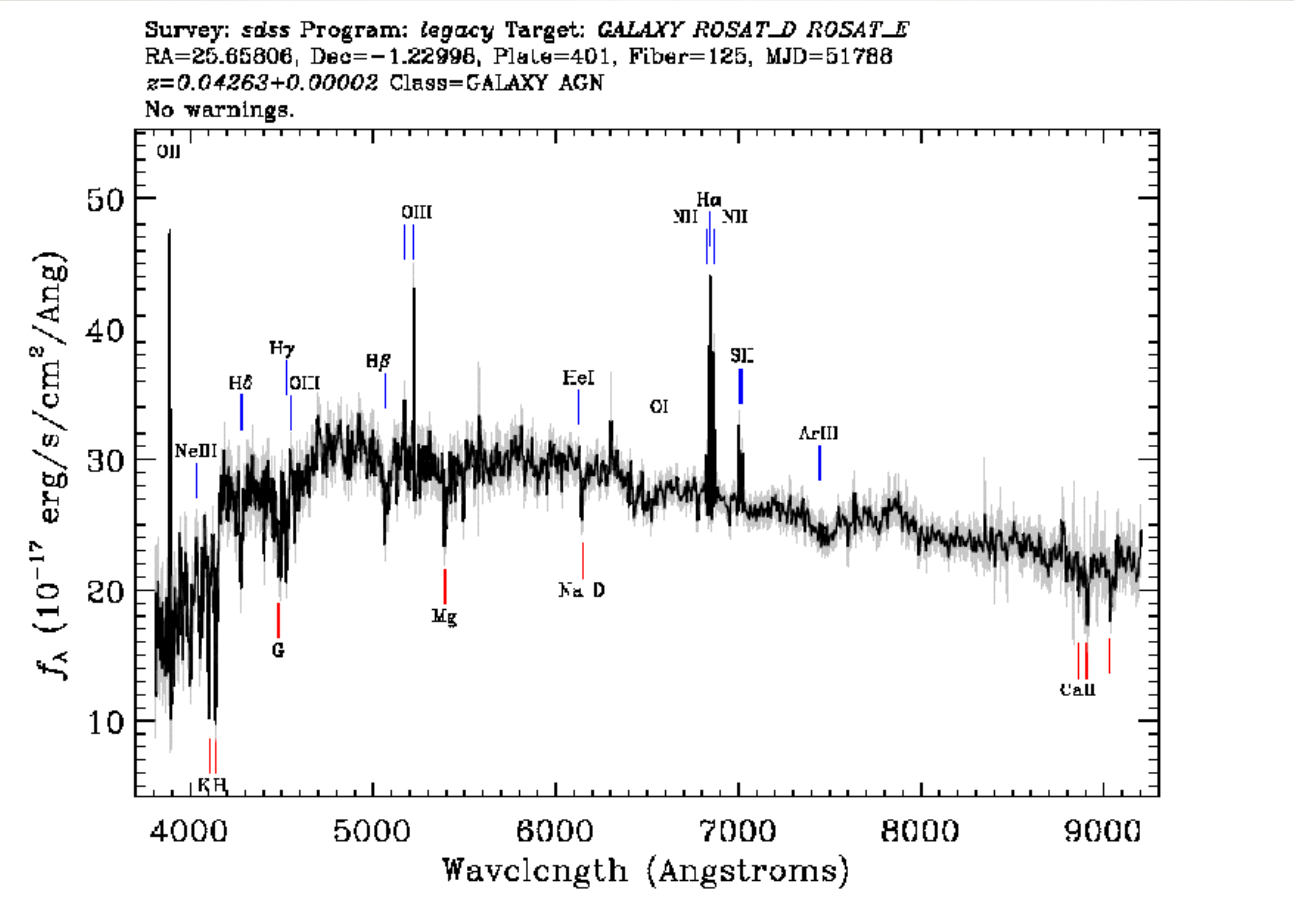
SDSS III can record 1000 spectra at once

…not so many!

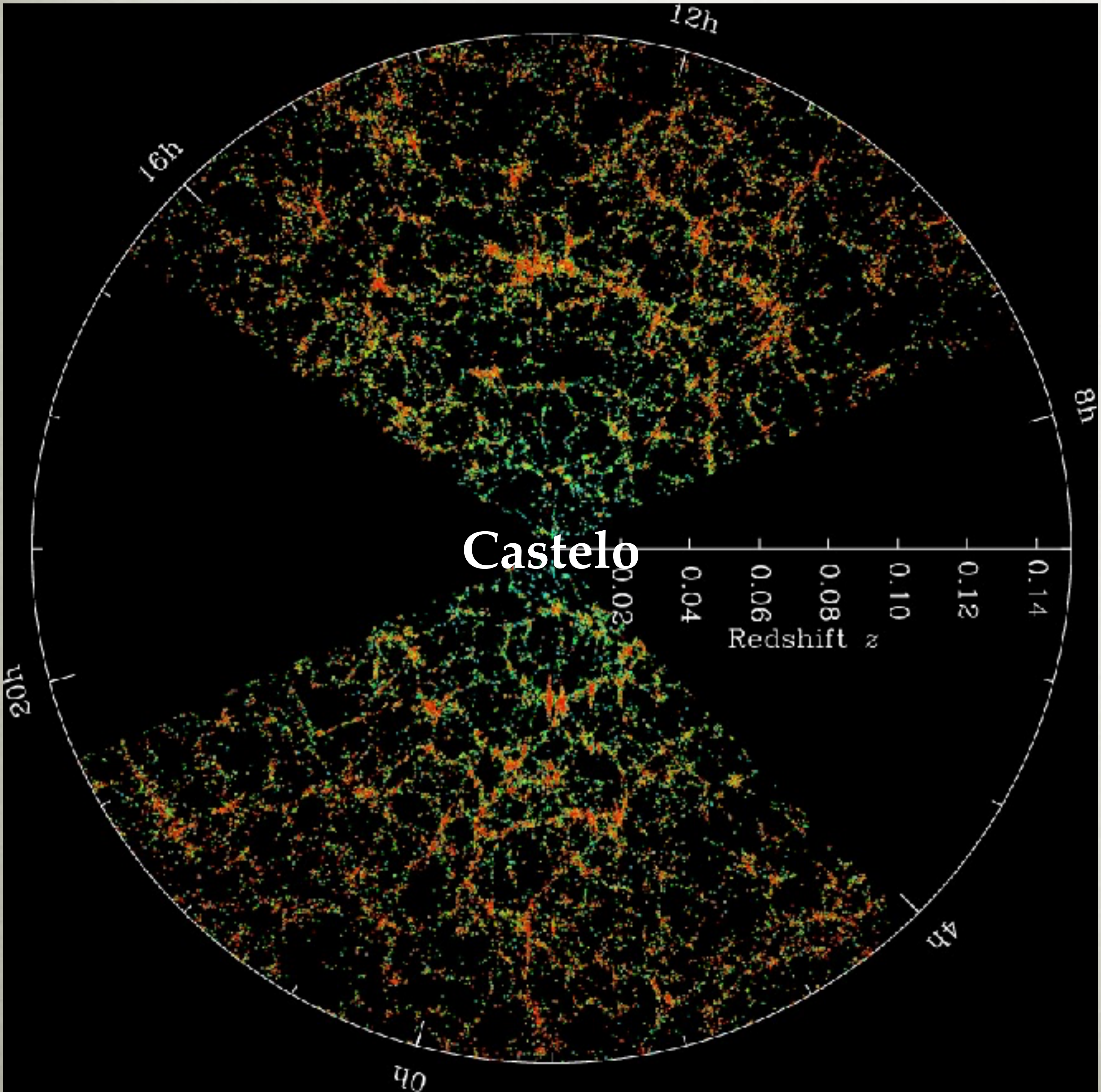
Credit: SDSS



How to observe galaxies? Spectroscopy



SDSS galaxies



Each point represents a galaxy, typically containing about 100 billion stars.

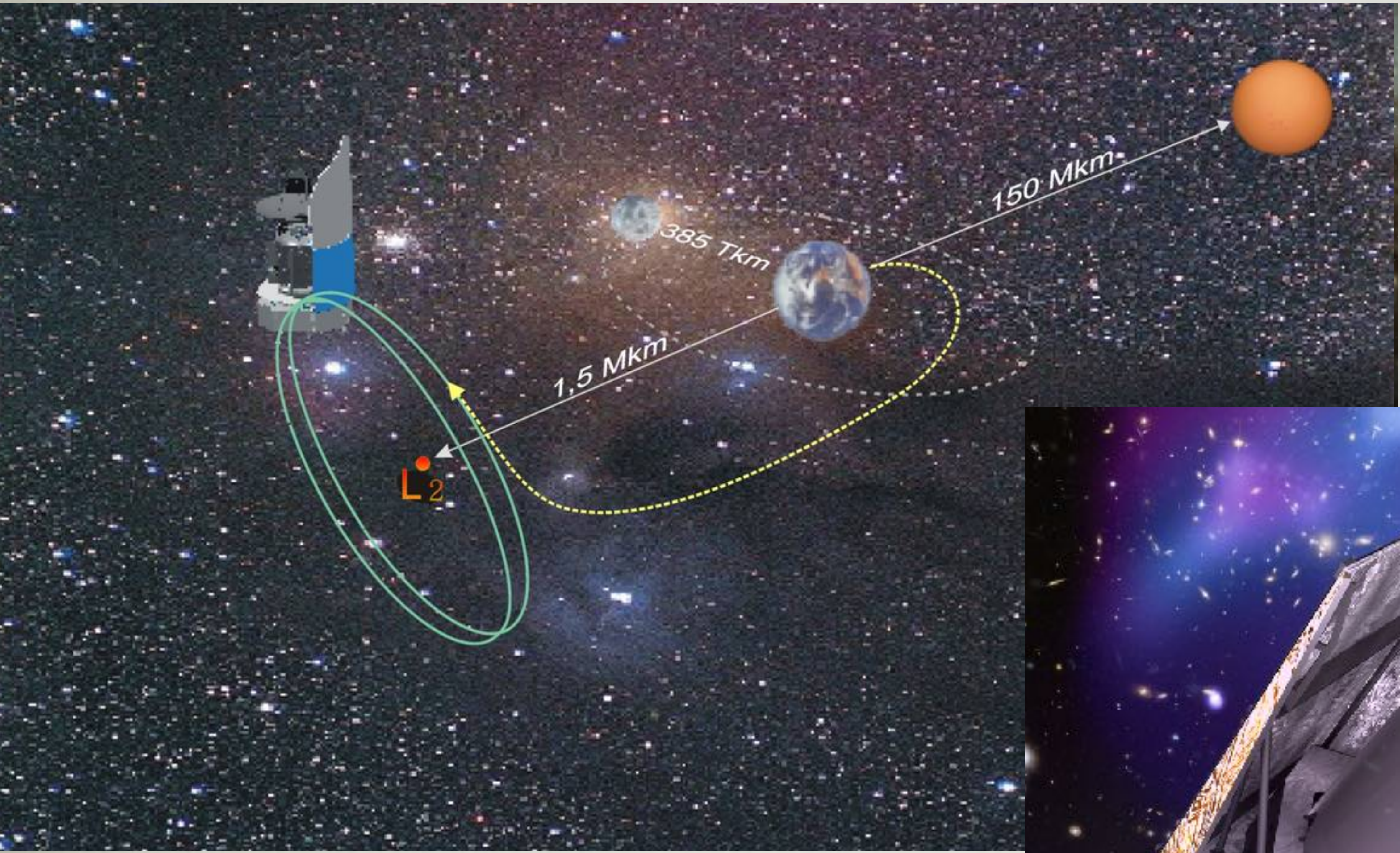
The outer circle is at a distance of two billion light years.

„limited“ depth

How to observe galaxies?

Imaging

Euclid: ESA medium class space mission selected in the Cosmic Vision program 2015-2025

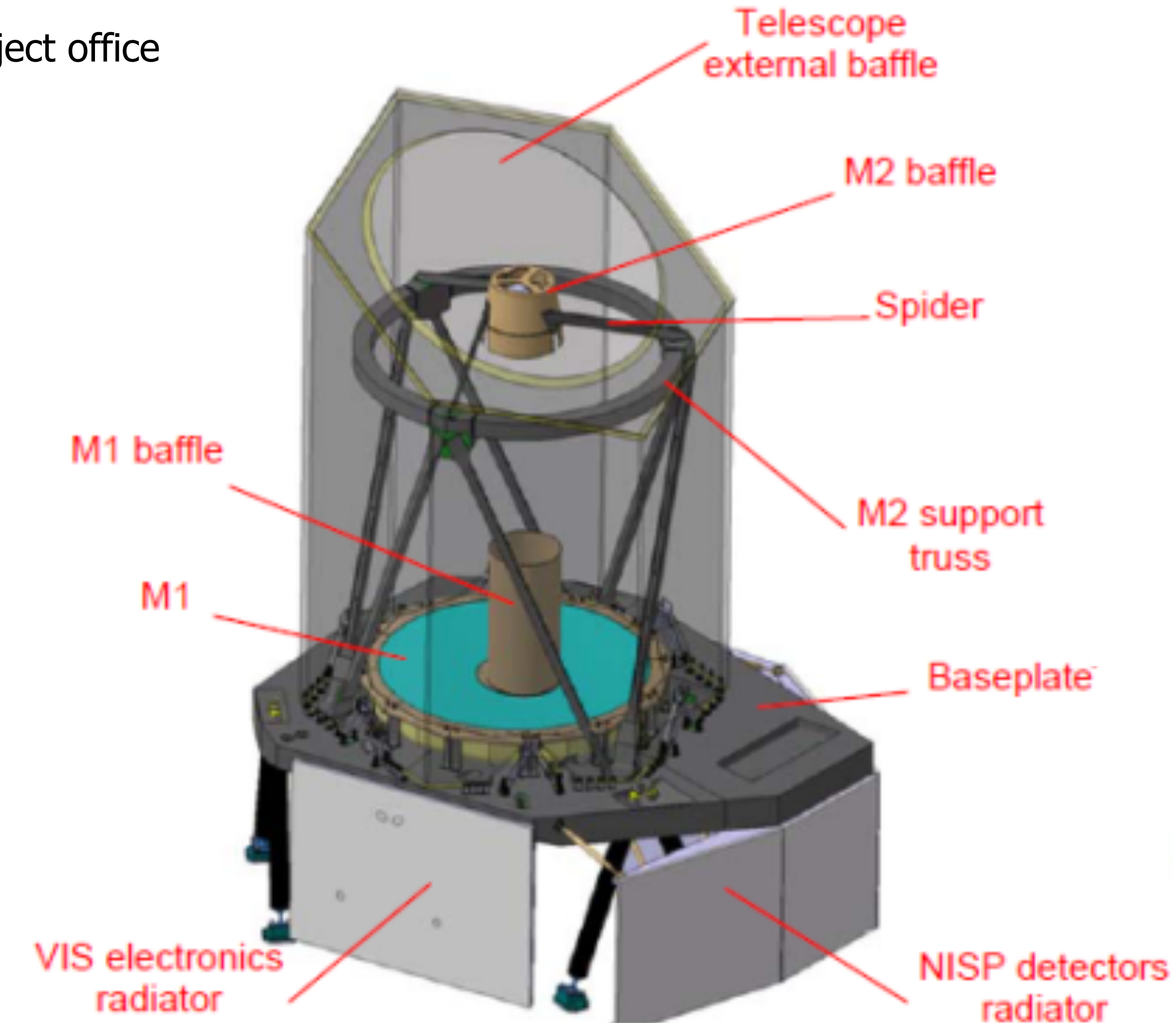


1.2m Korsch telescope

Telescope and instruments

The telescope feeds two instruments via a beam splitter.
Reflected light to VIS, transmitted light to NISP

Courtesy:
Astrium and ESA Project office



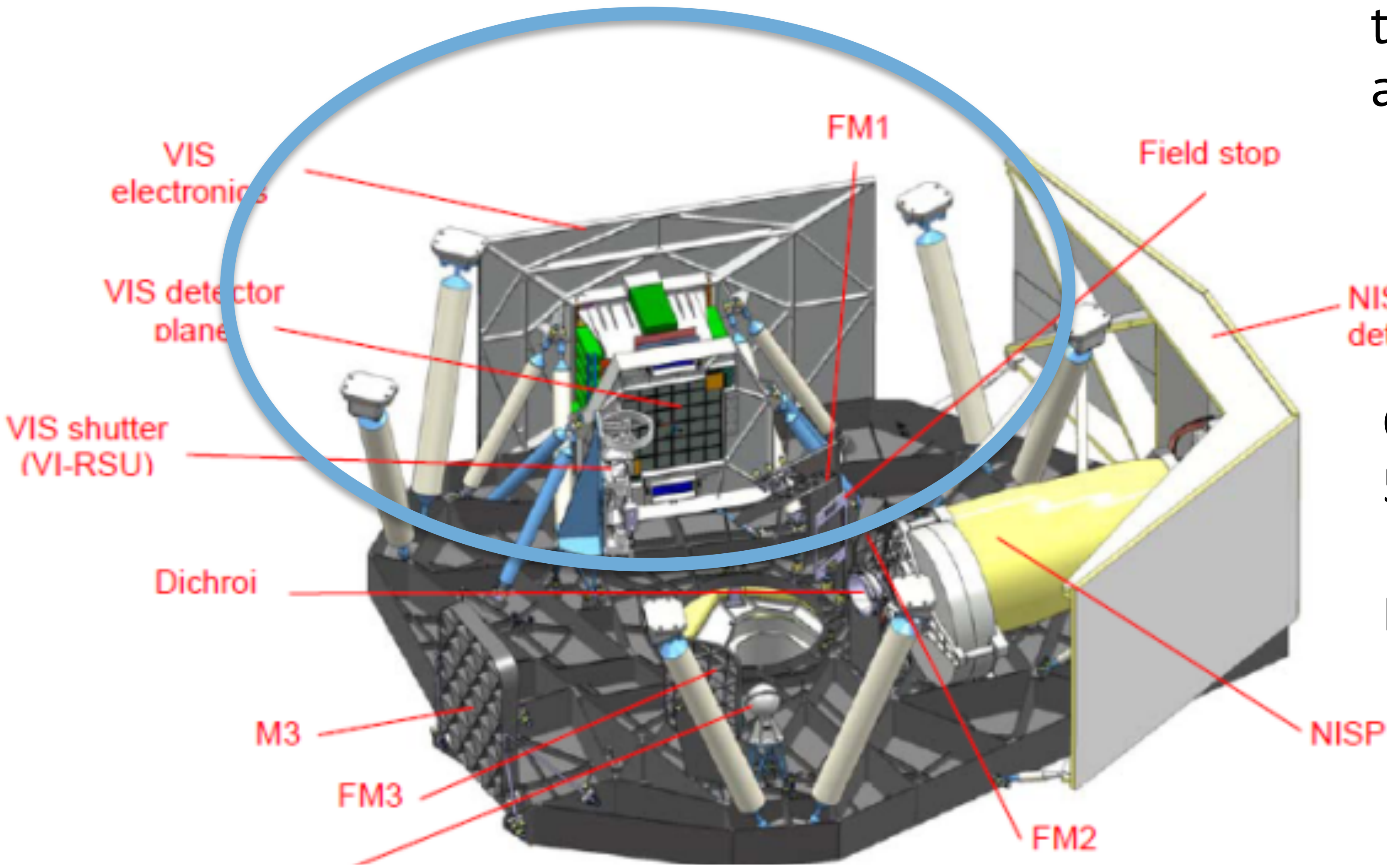
Same field of views, they will operate simultaneously in step-and-stare mode

Credit: V. Pettorino

VIS instrument

The VIS (visible band imager) instrument **measures shapes with high resolution**

Courtesy:
Astrium and ESA Project office



The VIS is equipped with 36 (4kx4k) CCDs, covering more than 0.5 deg^2 field with 0.1 arcsec pixels.

One wide visible band
550-900 nm

Data volume: 520Gbit/day

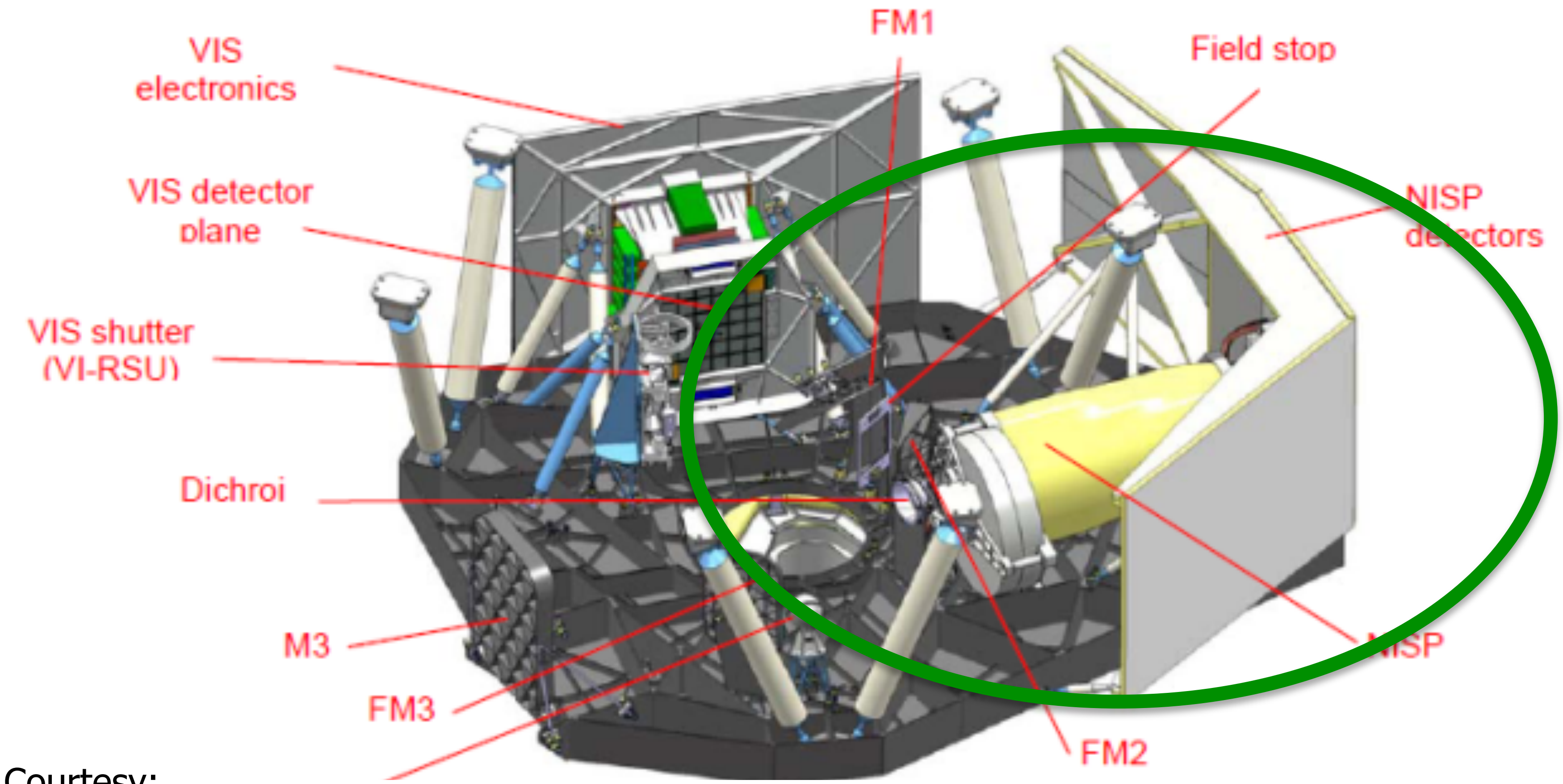
Credit: V. Pettorino

NISP instrument

The NISP instrument provides both **imaging and spectroscopy**

It has 16 infrared detectors, covering more than 0.5 deg^2 with 0.3 arcsec pixels.
Data volume: 180 Gbit/day
NISP performs photometry or spectroscopy in sequence selecting a filter or grism wheel respectively

The NISP **imaging photometer** mode contains 3 filters (Y,J,H) in the 1-2 micron wavelength range.



The NISP **slitless spectrometer** mode contains 4 grisms to provide spectra in two bands with orthogonal directions.

Courtesy:
Astrium and ESA

Credit: V. Pettorino

Main probes

Two (main) complementary probes:

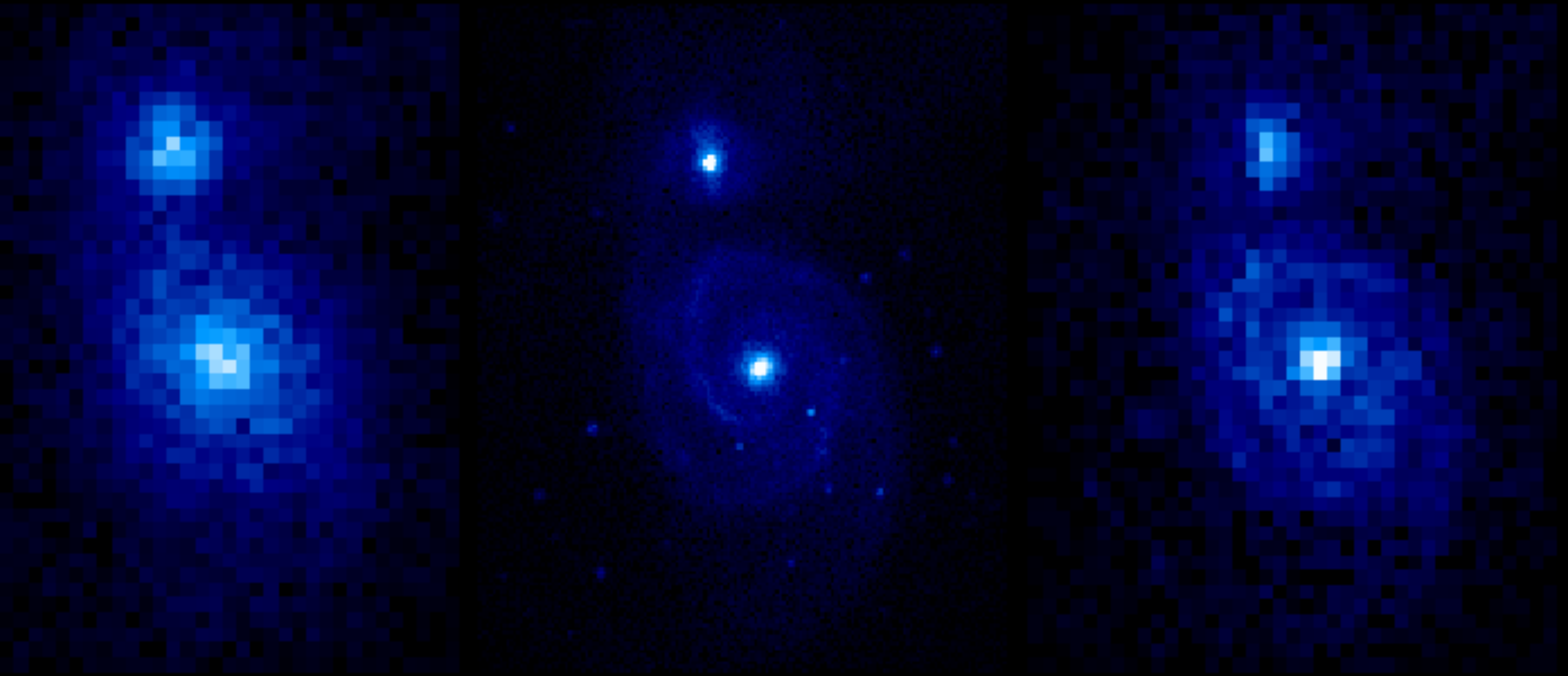
- **weak lensing**: shapes and distances (photometric redshift) of 2 billions galaxies to see the distribution of dark matter through weak lensing tomography.

- **galaxy clustering**: slitless spectrometer measures the 3-d distribution of galaxies as a function of time, measuring 50 millions of redshifts ($z<2$).

Same survey, independent probes, different systematics.

Euclid: optimized for shape measurements

M51



SDSS @ z=0.1 Euclid @ z=0.1 Euclid @ z=0.7

- Euclid images of z~1 galaxies: same resolution as SDSS images at z~0.05 and at least 3 magnitudes deeper.
- Space imaging of Euclid will outperform any other surveys of weak lensing.

Credit: L. Amendola

Objectives of Euclid

Understand the nature of dark energy, test gravity.

- measure background expansions, that is

$$w = p/\rho \qquad w(a) = w_0 + (1-a)w_a$$

- measure history of structure formation, that is

$$f_g \equiv \frac{\mathrm{d}\ln\delta}{\mathrm{d}\ln a} \simeq \Omega_M(z)^\gamma$$

From Euclid data alone: *FoM>400* and σ_γ*~0.02*

If data consistent with Λ:
„conclusive“ evidence for standard model *(selling ad :)*.

How to observe galaxies?

the third way… quasi-spectroscopy

How to observe galaxies?

quasi-spectroscopy (R~50) in every pixel

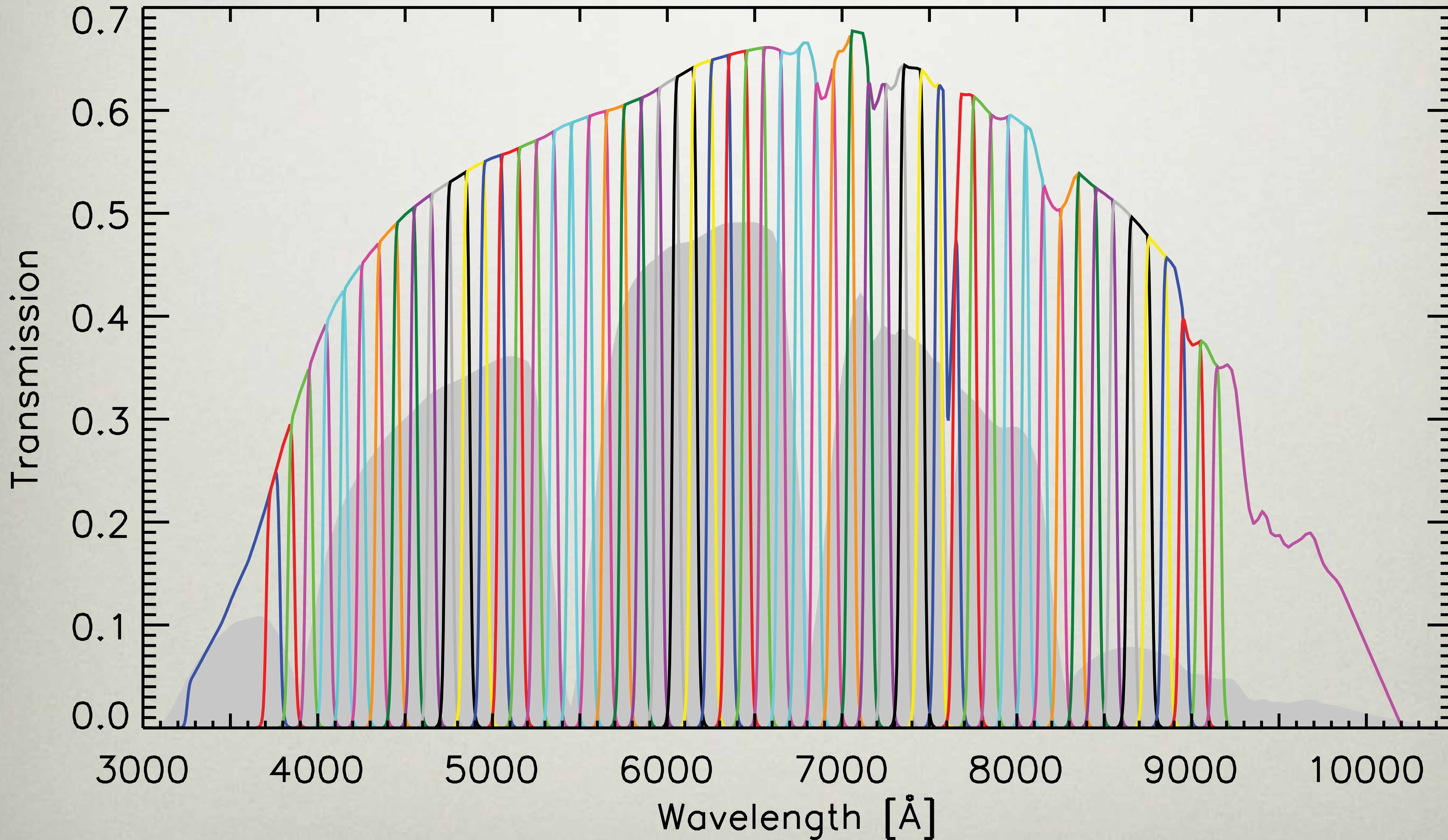


Figure 1. Transmission curves of the 54 narrow band and two medium-band overlapping J-PAS filters spanning the optical range (colour lines). The width of each narrow-band filter is ∼145 Å and they are spaced by 100 Å. For comparison, the five SDSS filters are shown with grey-shaded shape.

J-PAS: The Javalambre-Physics of the Accelerated Universe Astrophysical Survey

J-PAS was founded on the grounds of a MoU signed by CEFCA (Teruel, Spain), USP and ON.

SPAIN

- Fondo de Inversiones de Teruel
- Gobierno de Aragón
- Ministerio de economía y competitividad
- Araid
- CSIC

BRAZIL

- Ministério da Ciência, Tecnologia e Inovação
- FAPESP
- FINEP
- FAPERJ

R$ 100 milhões: R$1/galáxia.

Euclid é 20 vezes mais caro.

J-PAS: The Javalambre-Physics of the Accelerated Universe Astrophysical Survey

Redbook: arxiv.org/abs/1403.5237

The Javalambre-Physics of the Accelerated Universe Astrophysical Survey (J-PAS) is a narrow band, very wide field Cosmological Survey to be carried out from the Javalambre Observatory in Spain with a purpose-built, dedicated 2.5m telescope and a $4.7\square^\circ$ camera with 1.2Gpix. Starting in 2015, J-PAS will observe $8500\square^\circ$ of Northern Sky and measure $0.003(1+z)$ precision photometric redshifts for 9×10^7 LRG and ELG galaxies plus several million QSOs, about 50 times more than the largest current spectroscopic survey, sampling an effective volume of ~ 14 Gpc^3 up to $z = 1.3$. J-PAS will be the first radial BAO experiment to reach Stage IV.

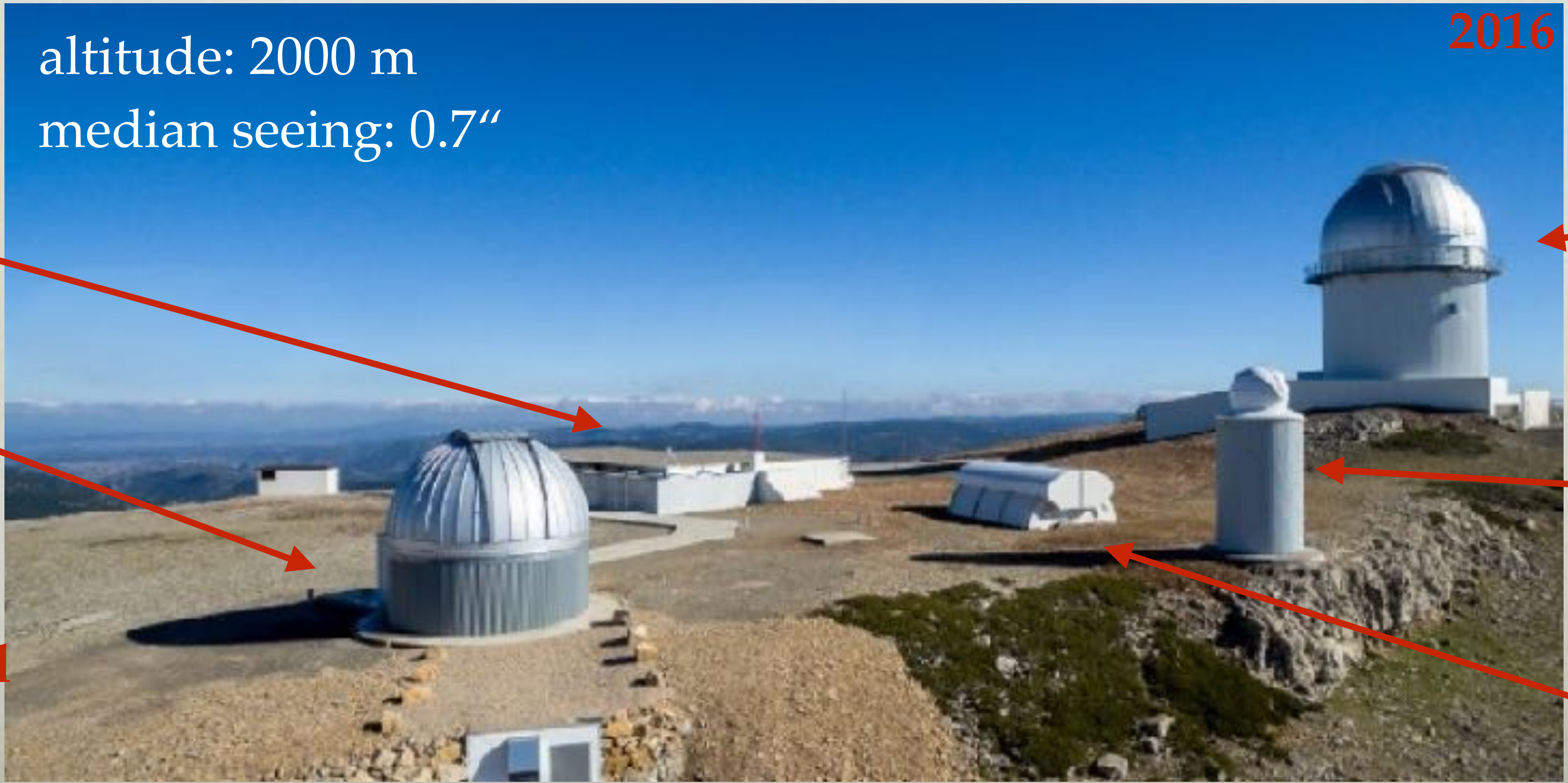
Thanks to J-PAS Brazil has joined the Euclid Consortium

Observatory

Teruel

Very dry:
good for astronomy
(and jamón serrano)

Observatory



control rooms, residence

T80

underground facilities

T250

seeing tower

extinction telescope

Very compact telescope

excellent étendue
(FOV · aperture)

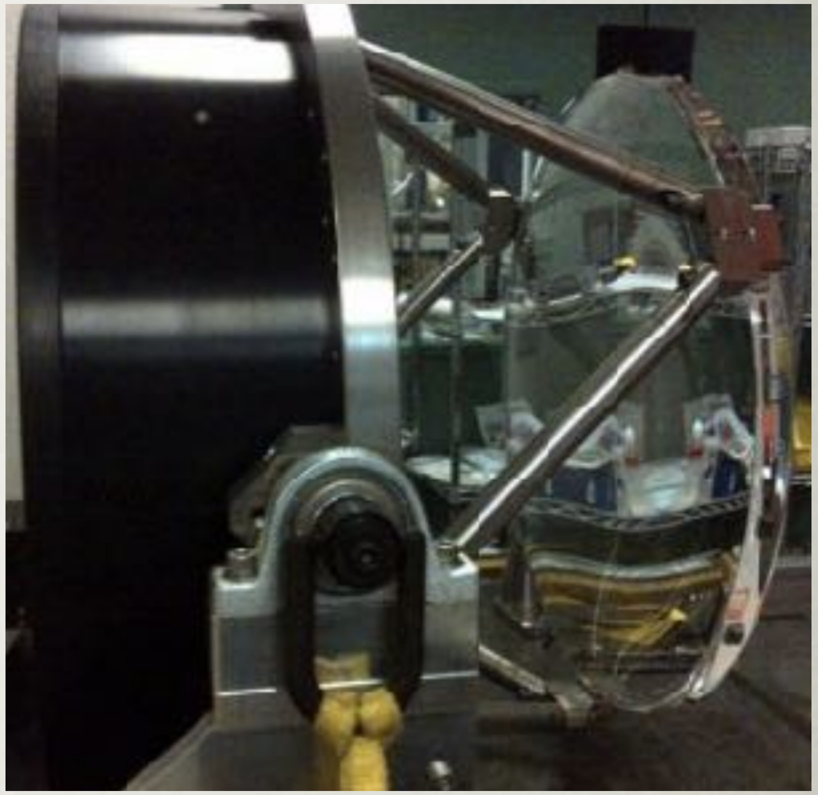
Table 1. Main technical speci

Optical configuration	Ritchey Chrétien li
M1 diameter	2.55m
FOV diameter	3deg (476mm phy
Effective collecting area	3.89 m^2
Etendue	26.5m^2deg^2
Focal length	9098mm
Plate scale	22.67 arcsec/mm
Mount	Altazimuthal
Focus	Cassegrain

weight: 45000 kg

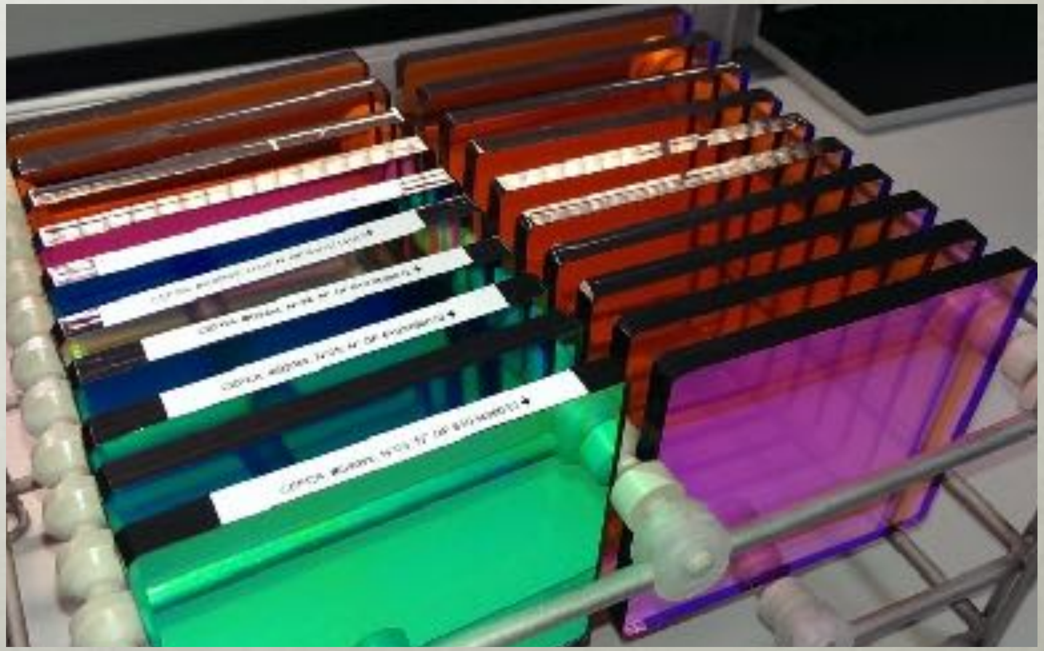
Complex design

3-lens aspherical field corrector



curved secondary mirror

JPCam



Maintenance

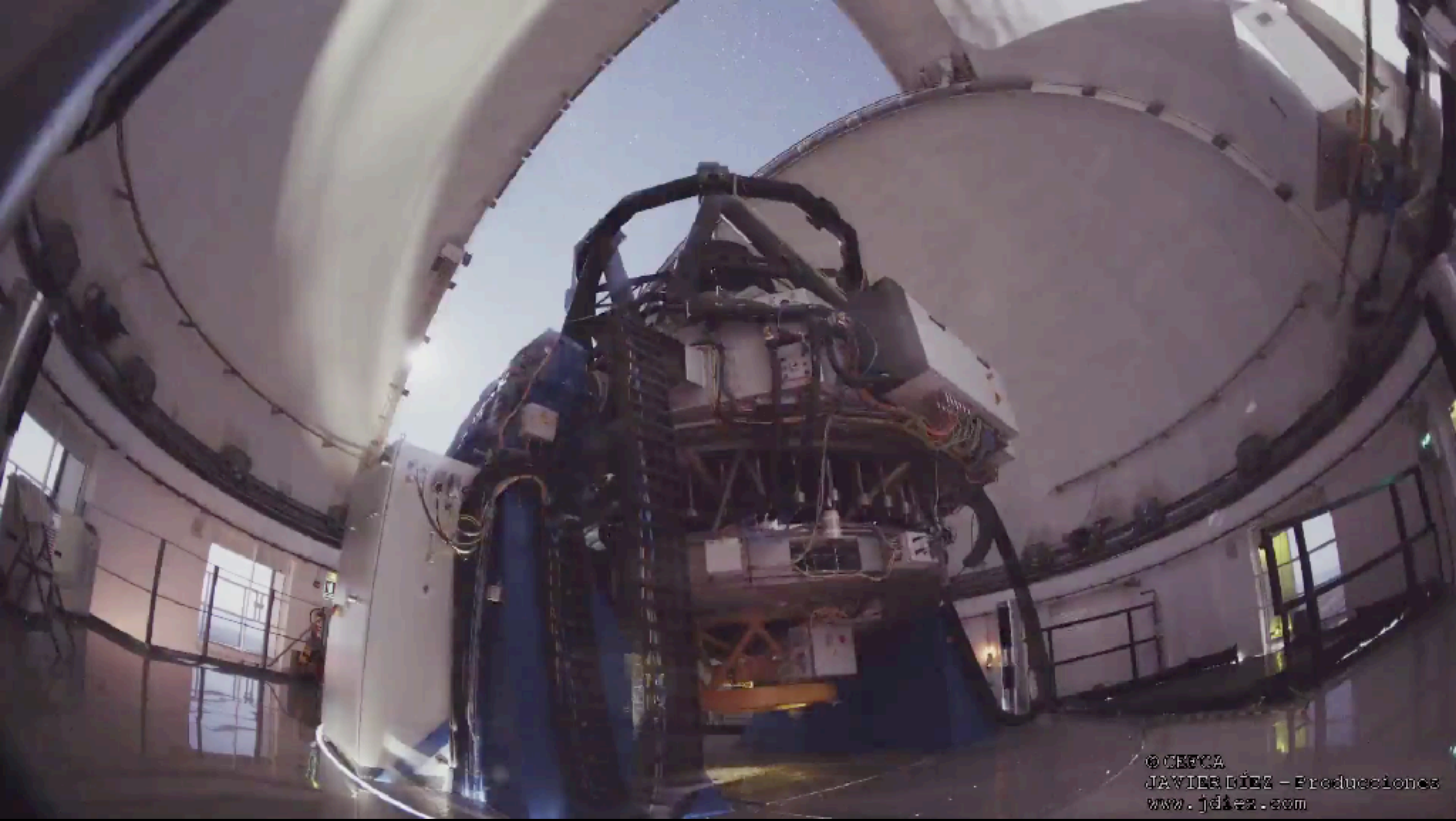
coating vacuum chamber for mirror aluminization

dirty mirror

Control room and storage

3 control rooms

Netapp cluster: 1.1 PB
Robotic tape library: 4PB
5000+MB/s bandwidth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Science

13th J-PAS Meeting in Teruel - September 2016

Science

The **main drivers** of J-PAS cosmological analysis are

Luminous Red Galaxies

Emission Line Galaxies

- The possibility of mapping the Large Scale Structure with **different probes** (LRGs, ELGs & QSOs), with very **high** redshift accuracy ($\Delta z/(1+z) < 0.003$) in a **wide redshift** range (**$z \in [0,3]$**), with the implications this has on BAO and RSDs measurements,
- The production of a **galaxy cluster catalogue** (with ~1e5 members), presumably the **deepest** until the arrival of *Euclid,* **up to z~1.3**,
- The production of a **SNIa catalogue**, and
- The study of **gravitational lensing**, providing **shear measurements** by its own, but also contributing to other Science, like **cluster mass estimates**

Credit: C. Hernández-Monteagudo

obrigado