Euclid

The cosmology mission of our times

Euclid

- 2008 - [2023-2030] - 20xx

Euclid is **a space mission to map the Dark Universe**

- It is managed by ESA.
  https://www.cosmos.esa.int/web/euclid

- The instruments, the production of data, and the scientific analysis and interpretation is made by the researchers of the **Euclid Consortium** →~2000 people in Universities and research centers of ~15 countries.
  https://www.euclid-ec.org

- FCUL (IA) is an active member of the Euclid Consortium

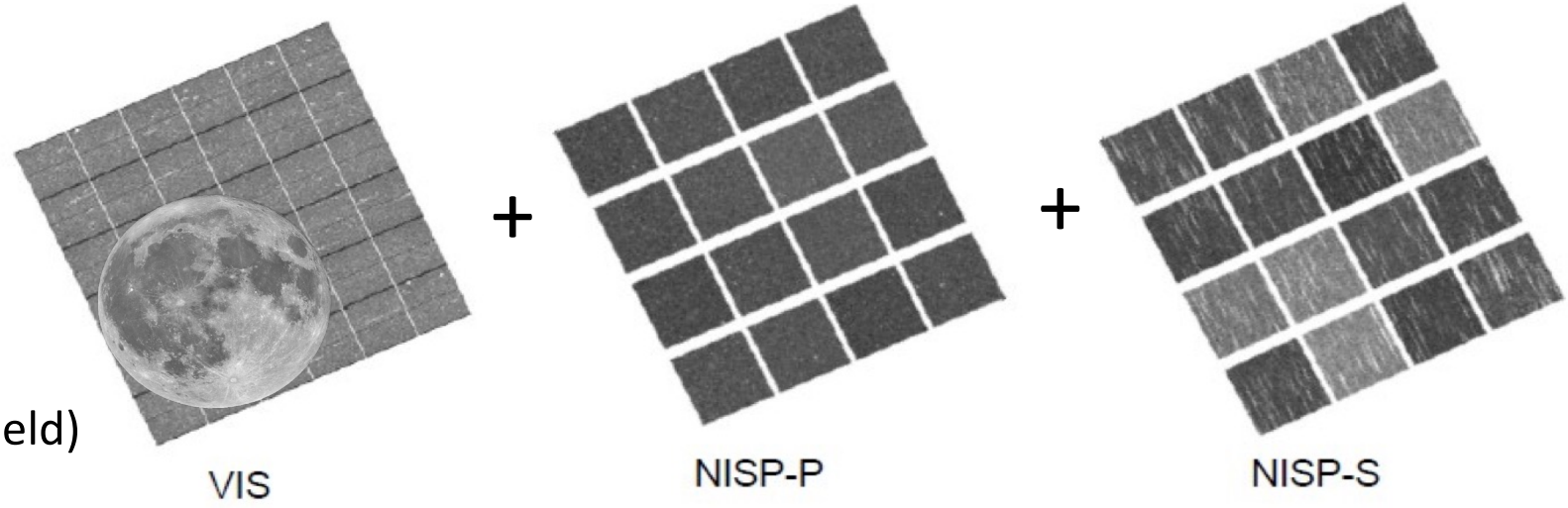
https://www.rtp.pt/play/p12254/e729446/tik-tak
(interview in Antena1, 20 Nov 2023)

https://divulgacao.iastro.pt/pt/feature/euclid-mapa-universo-invisivel/
(includes a video)

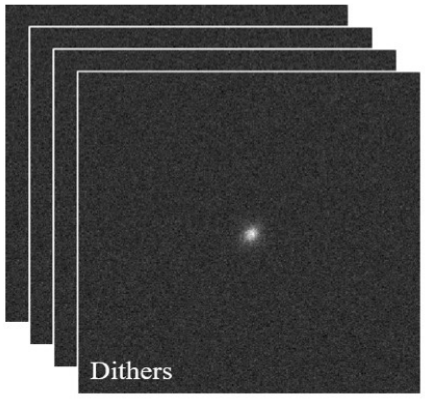
Euclid space mission:

a sequence of 30 000 science observations over the sky during 6 years (+ 20 000 observations for calibration purposes)

(wide field)



x 4

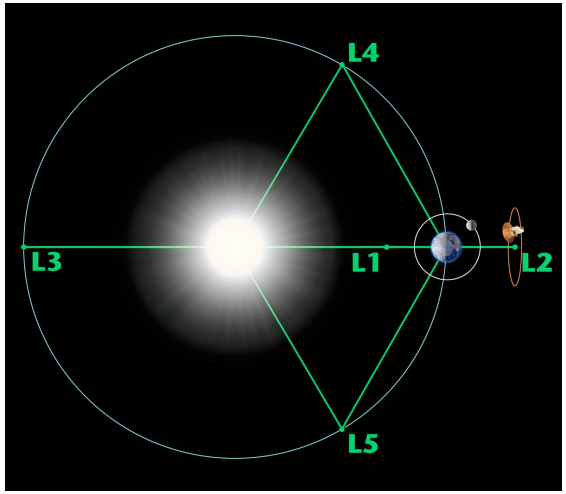


1 Euclid Observation = 1h 10’ + 5’ to turn to the next pointing

~ 20 observations / day

1 observations = 50 000 galaxies

30 000 observations → **1.5 billion galaxies**, in 15 000 deg^2



From an orbit around L2

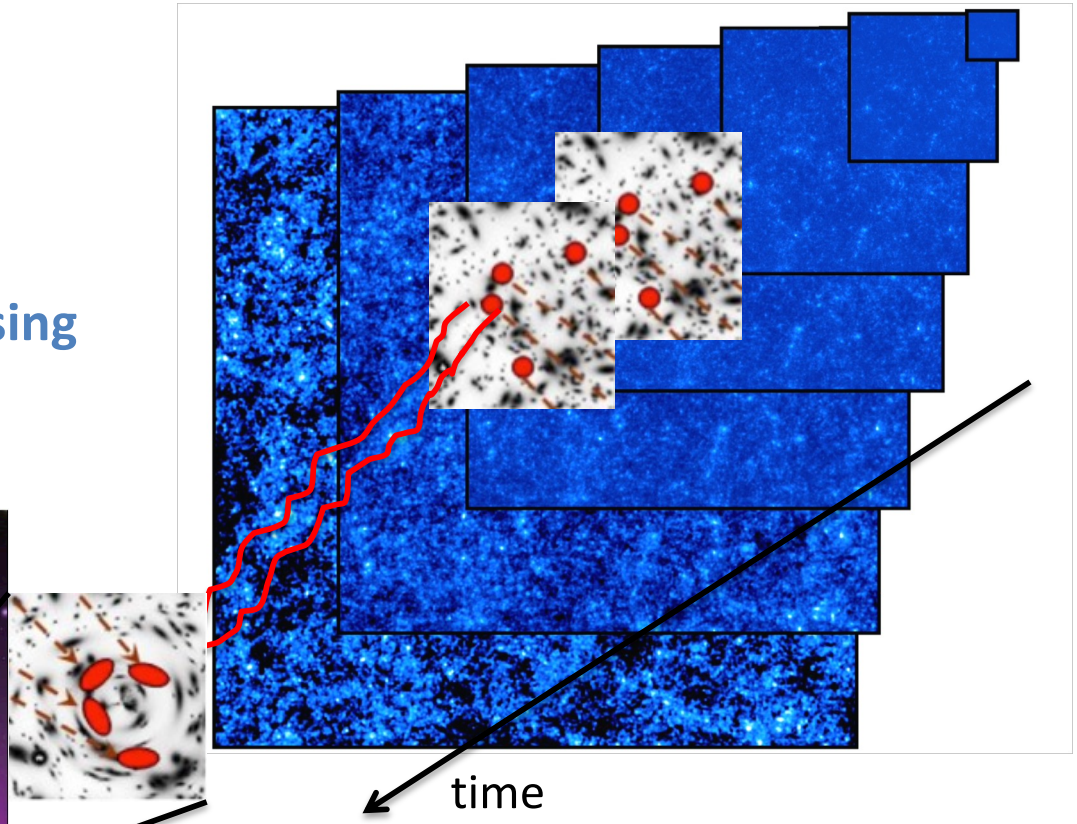
Euclid photometric survey:

weak gravitational lensing of distant galaxies

Euclid finds **source galaxies**
(far in the Universe, z > 0.7 - 2.0)

that are subject to **gravitational lensing**

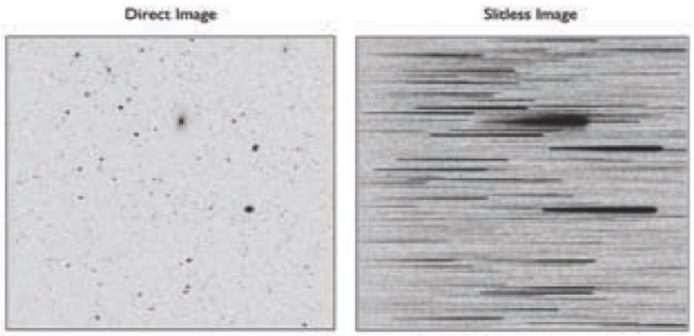
and observes their **distorted images**



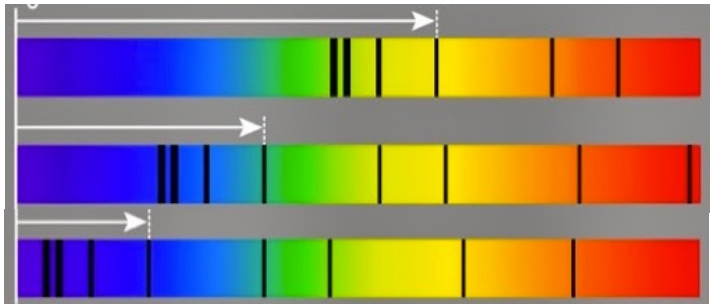
to infer the dark matter structures (the lenses) at various distances (different epochs in the evolution of the Universe) → discover the properties of dark energy.

Euclid spectroscopic survey:

galaxy clustering of distant galaxies

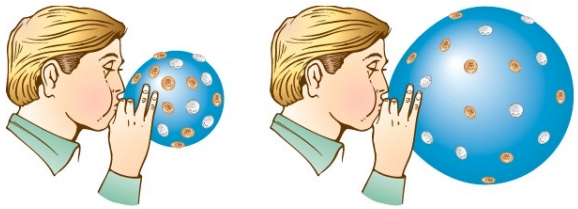


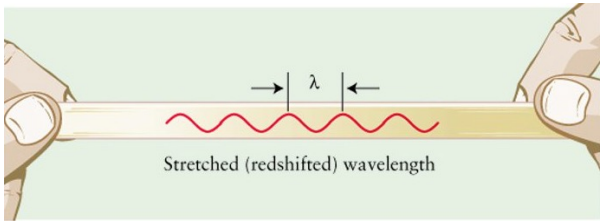
Euclid measures the **spectra** of the galaxies
(far in the Universe, z > 0.7 - 2.0)



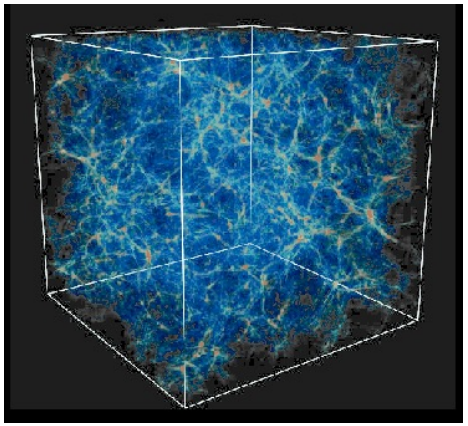
whose frequencies are shifted (the **redshift**)

by the **expansion** of the Universe
(and peculiar velocities)





to determine their
precise distances
(**3D positions**)

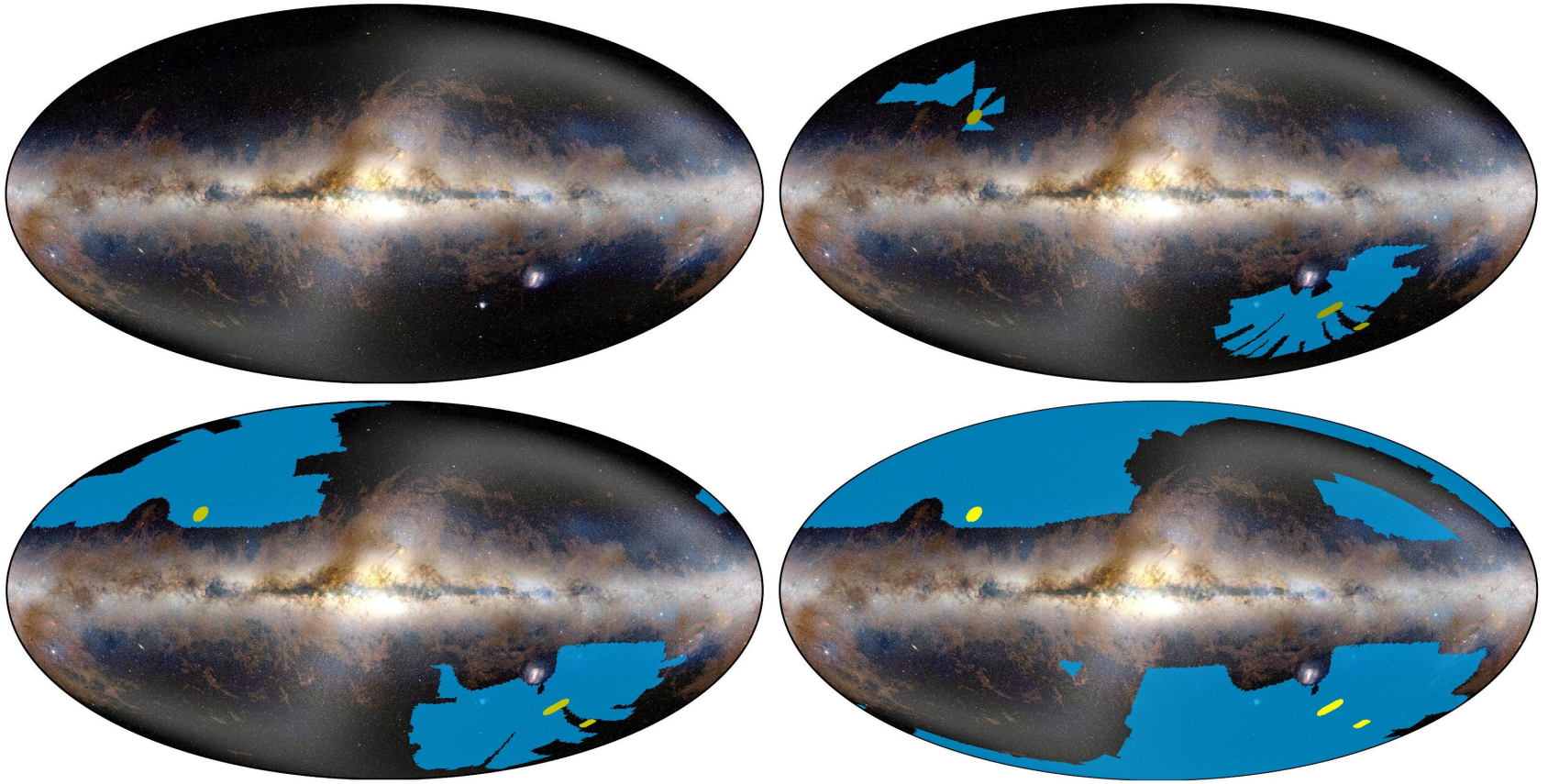


The combination of position (GC) and light propagation (WL) information allows us to test gravity.

Cosmological goals

Euclid will produce the largest 3D map of the dark matter large-scale structure

(time progression of the area coverage)



Euclid Survey sky coverage of the main data releases : DR1 (year 1), DR2 (year 1 to 3), DR3 (year 1 to 6)

Euclid Wide Survey : 13,345 deg^2 in 6 years, avoiding the galactic plane (stars, dust) and the ecliptic plane (zodiacal light)

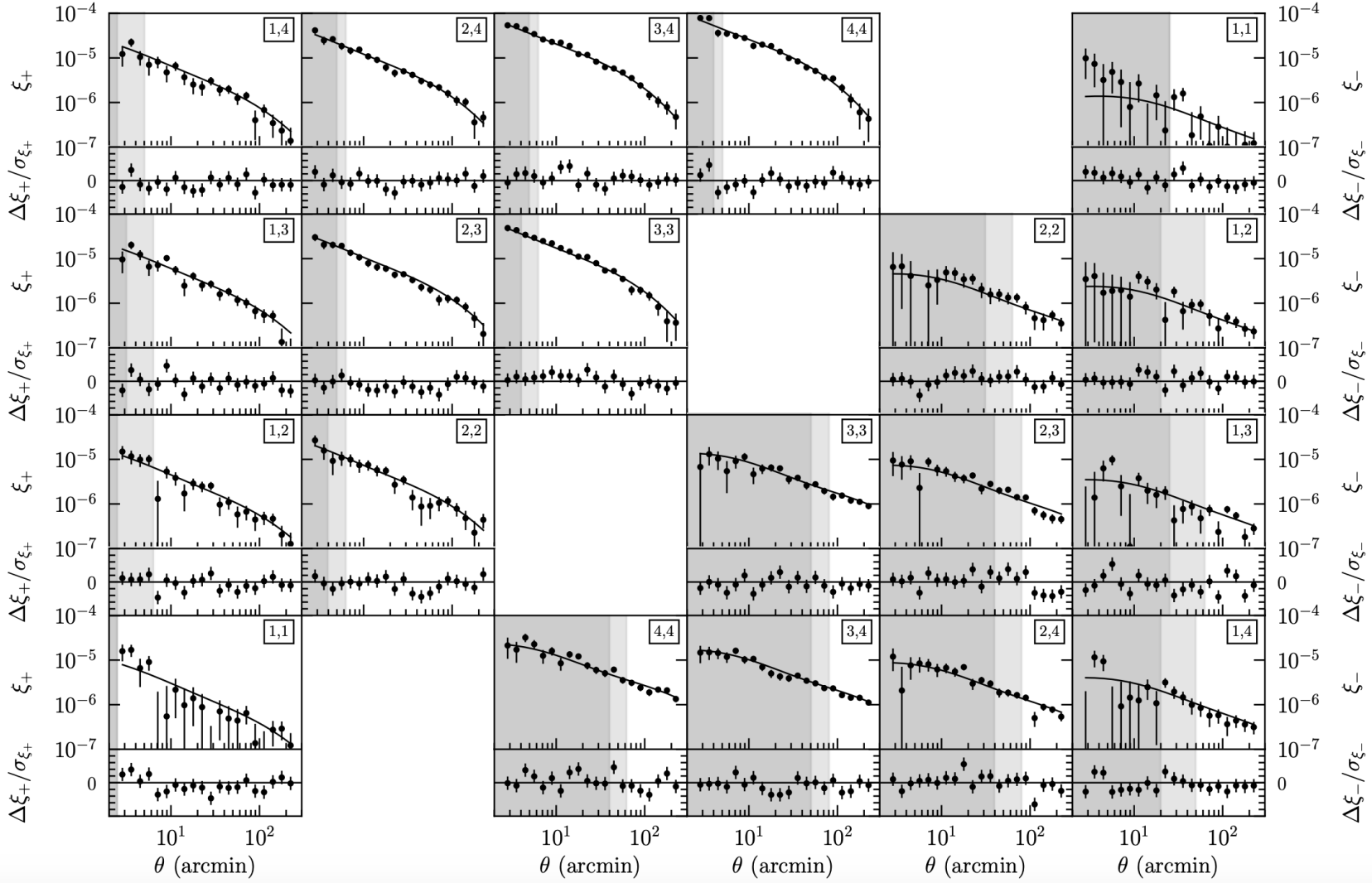
Euclid Deep Fields : North=20 deg^2 (top left), Fornax=10 deg^2 (bottom right), South=23 deg^2 [+ extended coverage]

⇒ The Euclid survey focuses on the two galactic caps to explore the extragalactic sky (total coverage = 2200 deg^2/year)

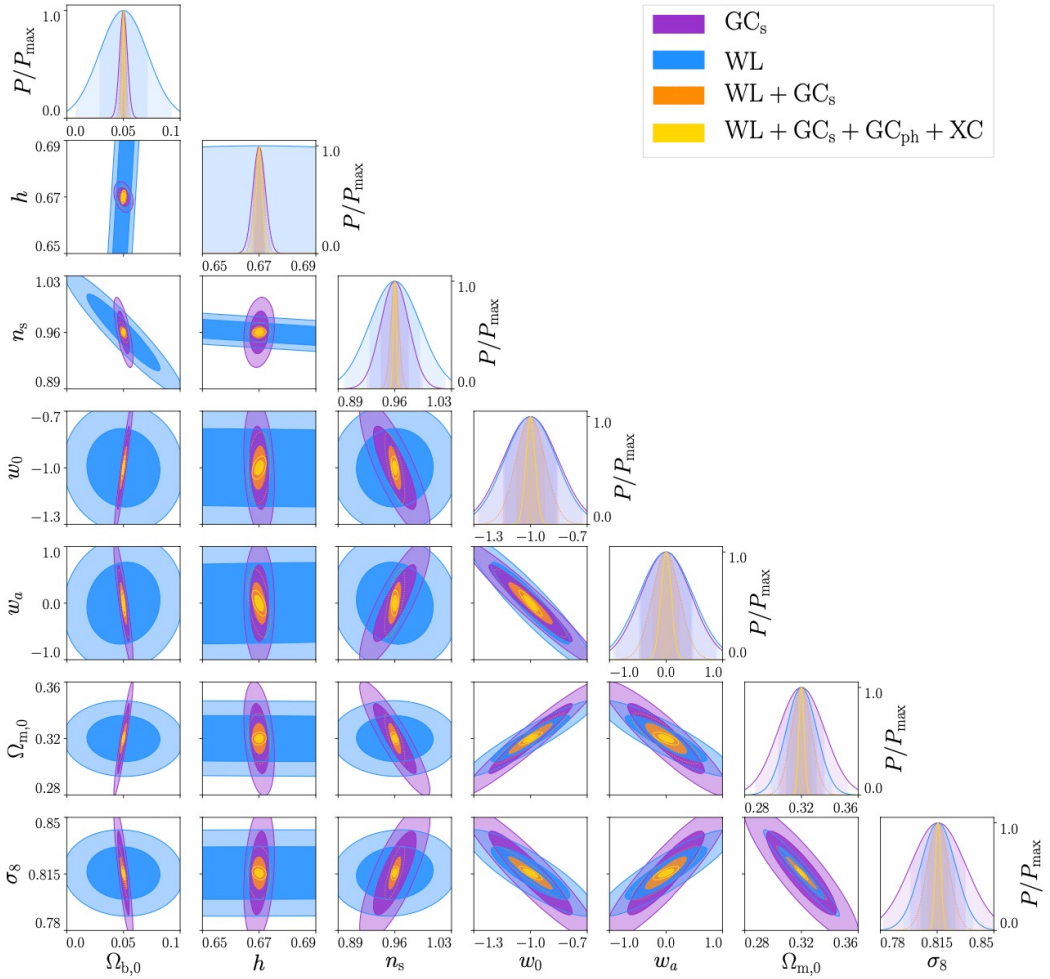
Background: Euclid Consortium / Planck Collaboration / A. Mellinger

The cosmological information is extracted in the form of **correlation functions**

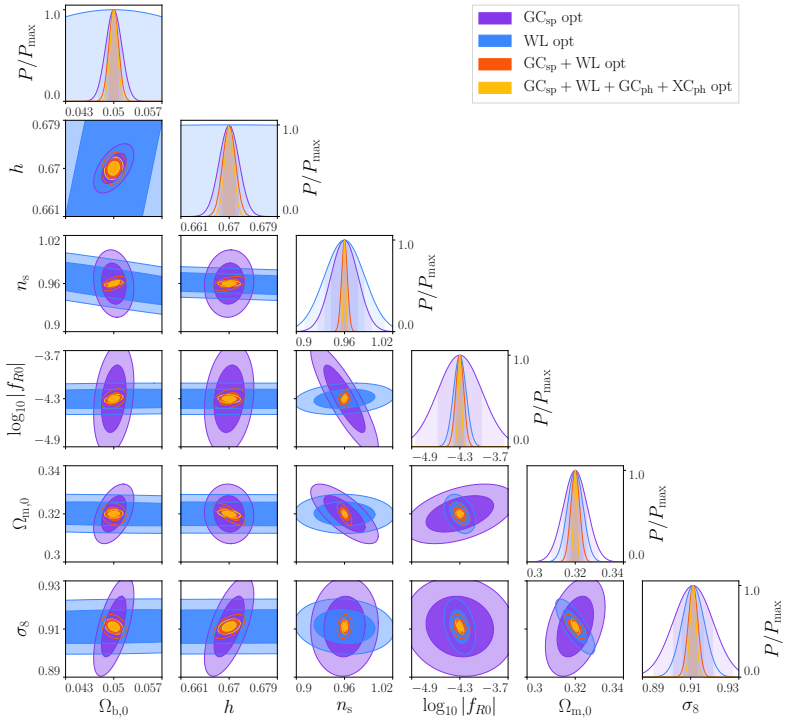
(Results from the ground-based 5000 deg^2 DES survey, Abbott et al 2022)



Comparing with theoretical models, we can **constrain the para meters of cosmological models** and discover the properties of the Universe



Euclid forecast for wCDM model



Euclid forecast for f(R)CDM model

The satellite

4.7m

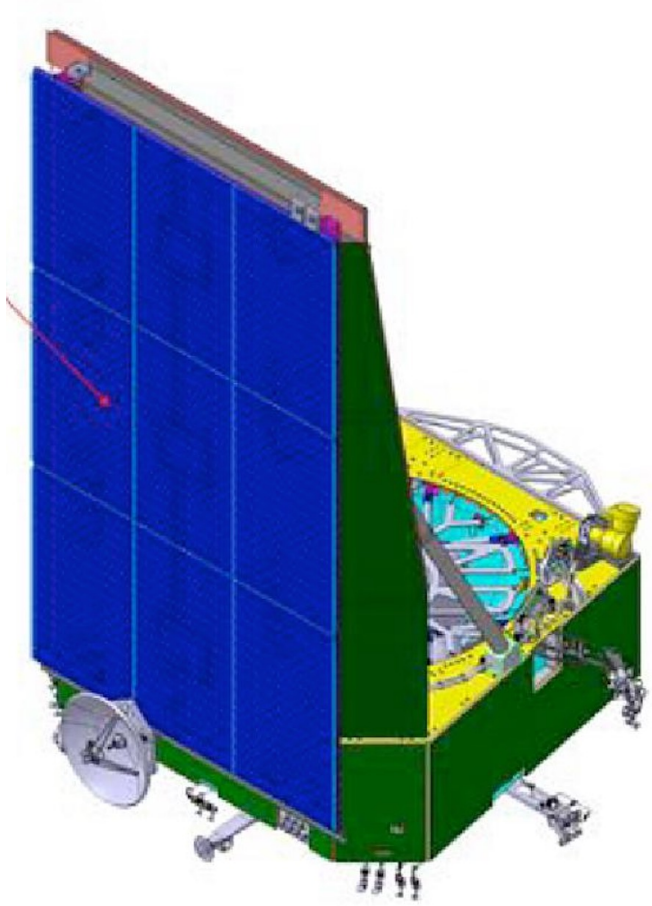
3.7 m

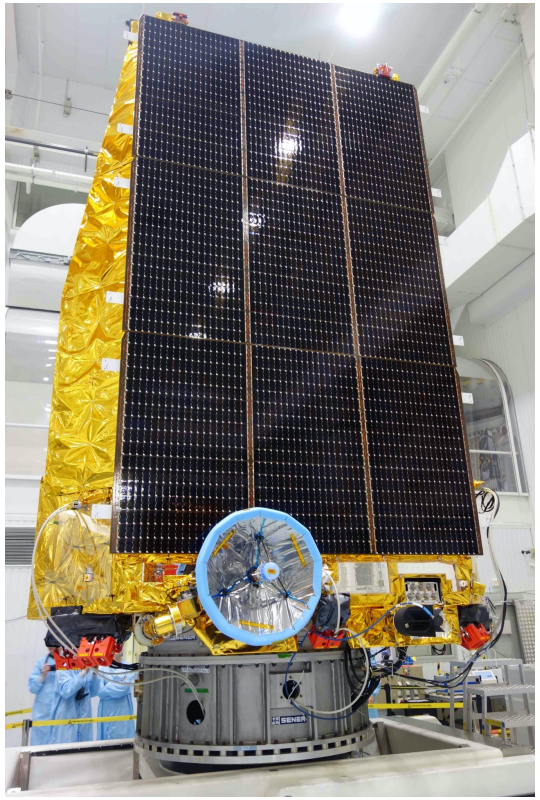
2 tons
including 210 Kg of propeller gas

Service module

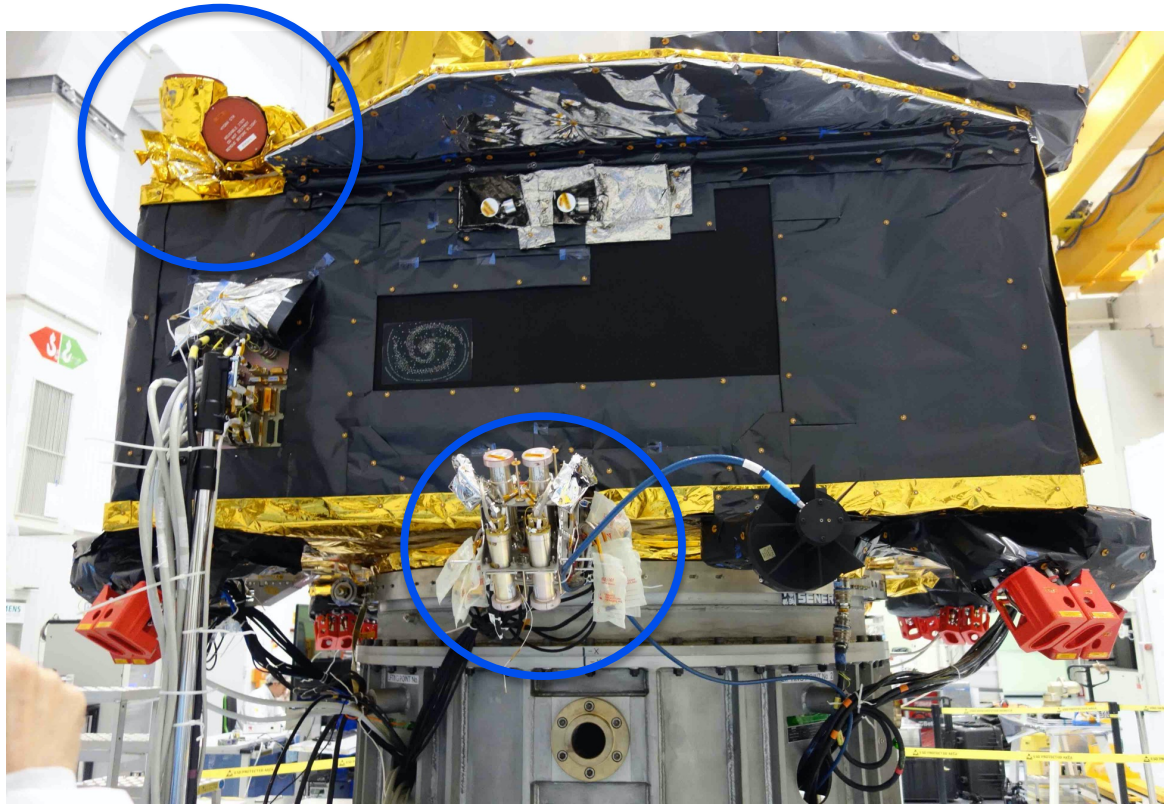
containing:

- Solar shield protecting the instruments from the Sun
- Siolar panels to provide electricity (2 kW)
- Antenna to send data to Earth (850 Gb /day at a rate of 55Mb/s)

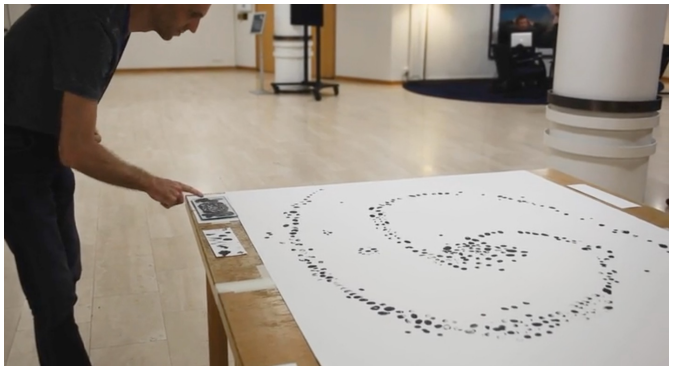


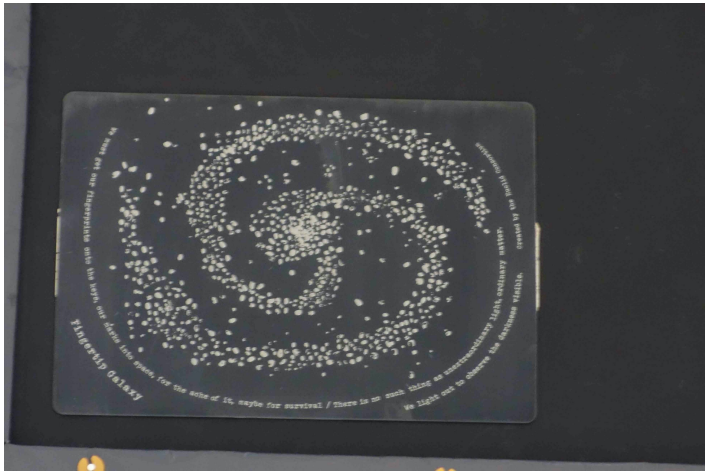


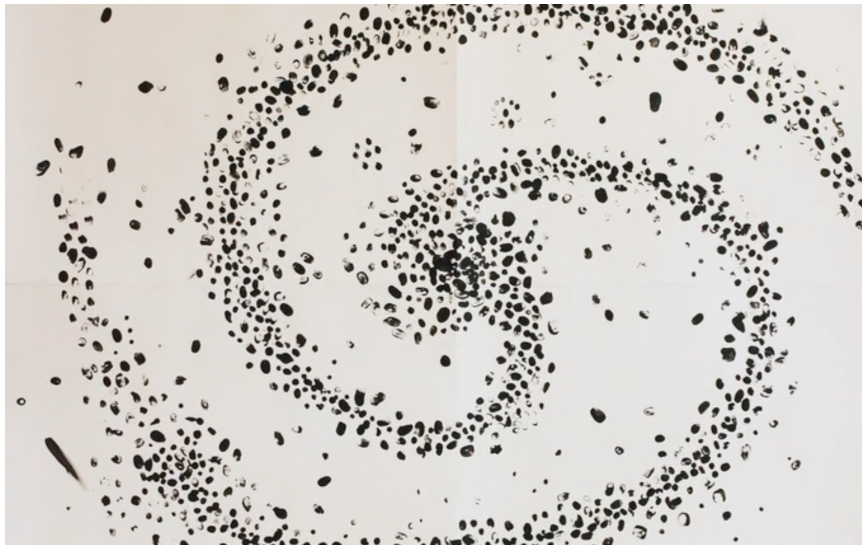
- Temperature control system
- Attitude and navigation control system – gas thrusters and reaction wheels



- Electrical systems and connections to the payload module
- The “fingerprint” galaxy







Excerpt from the **poem by Simon Barraclough**
(written for this occasion)

“We must get our fingerprint onto the keys, our marks into space, for the ache of it, maybe for survival.

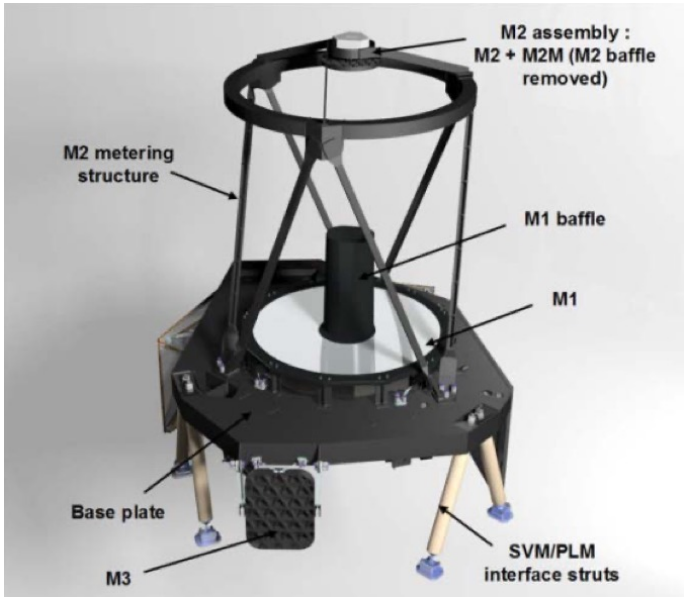
We light out to observe the darkness visible.

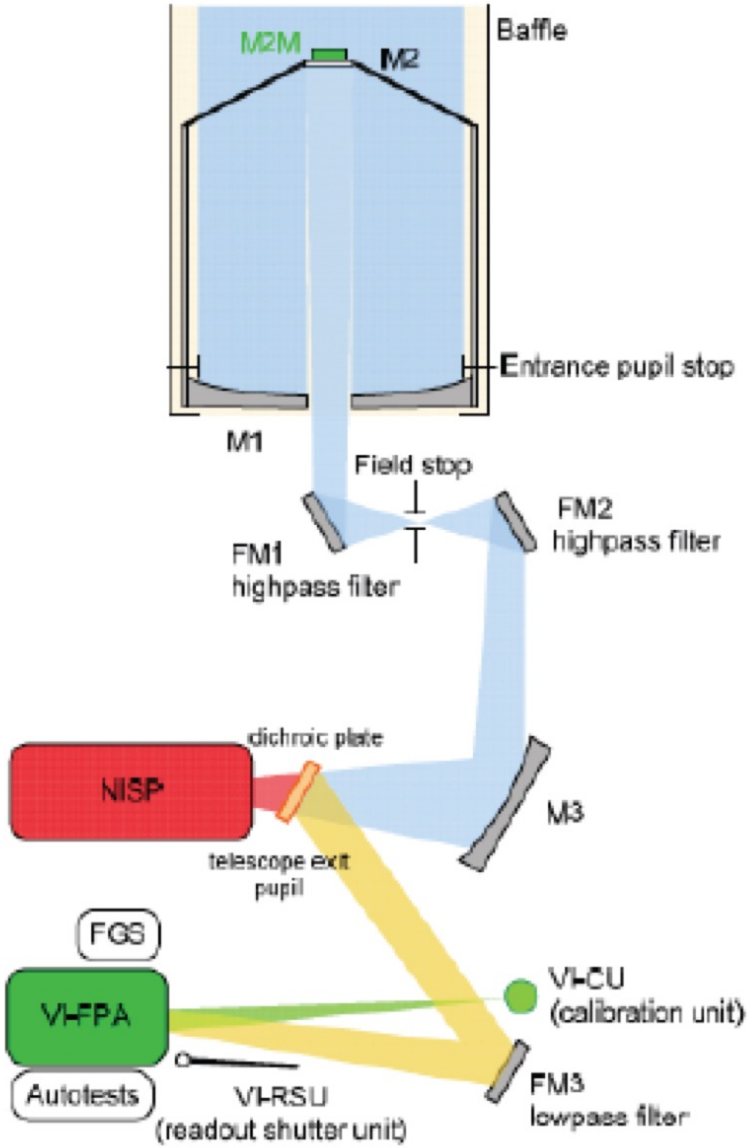
There is no such thing as unextraordinary light, ordinary matter.”

Payload module

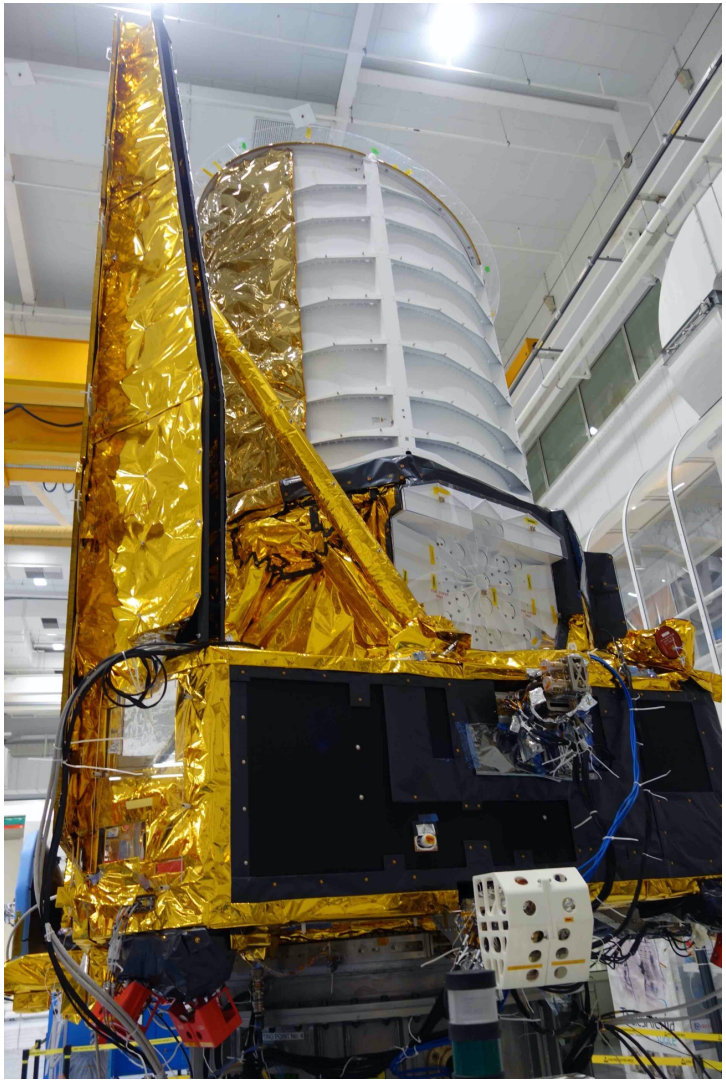
containing:

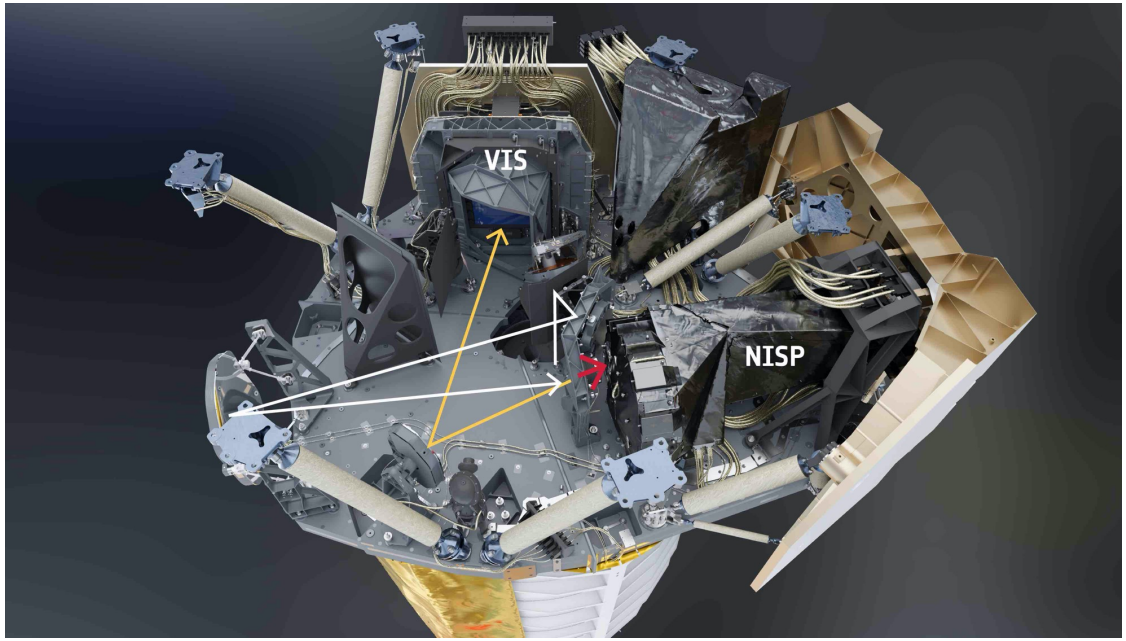
- The telescope (diameter 1.2 m) with a 3-mirror system

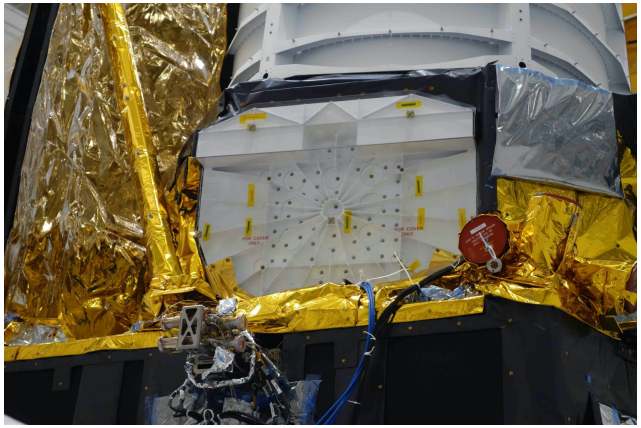




- The 2 scientific instruments

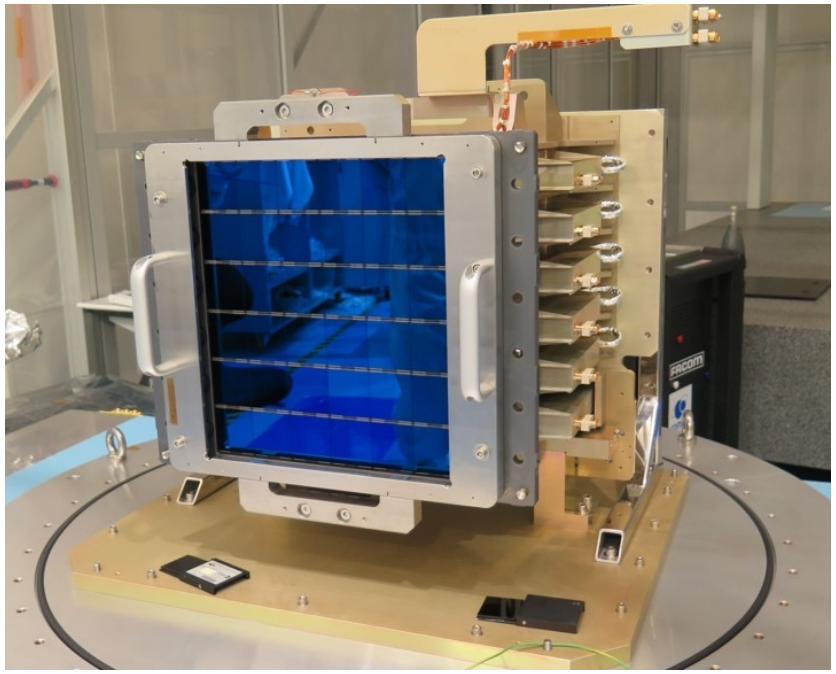






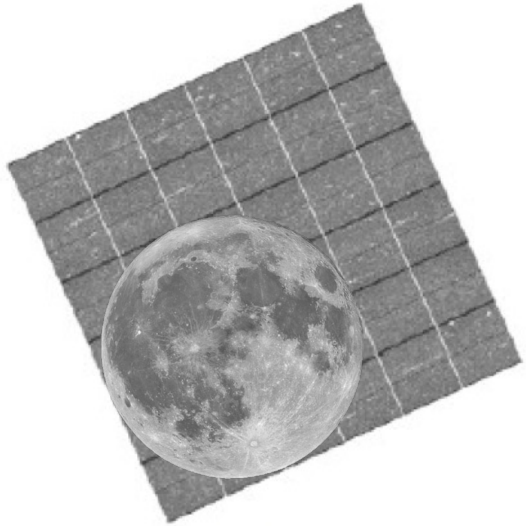
radiator

VIS (visible imager)



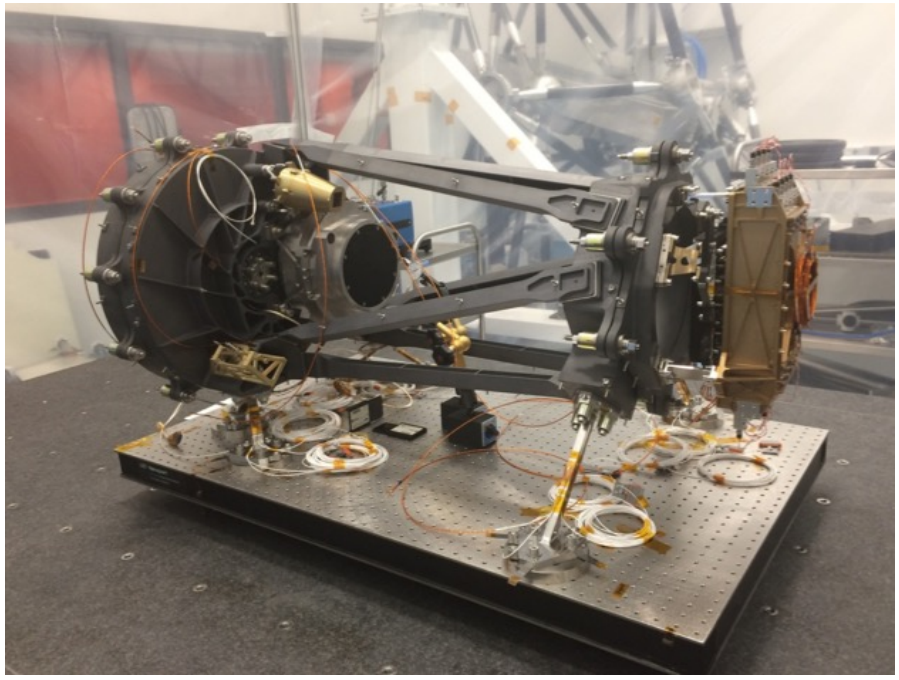
Digital camera with 36 CCDs and a total of 600 Mega pixels

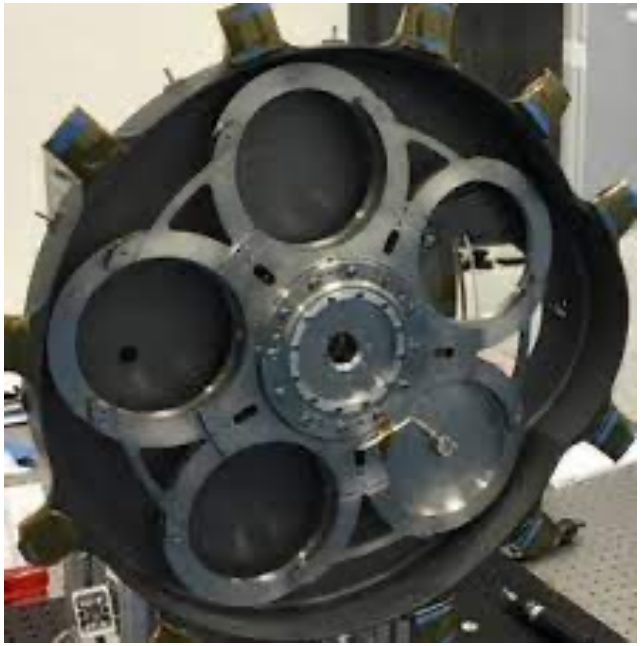
Field-of-view (FoV) of 0.54 deg^2



VIS

NISP (near infra-red photometer and spectroscoper)

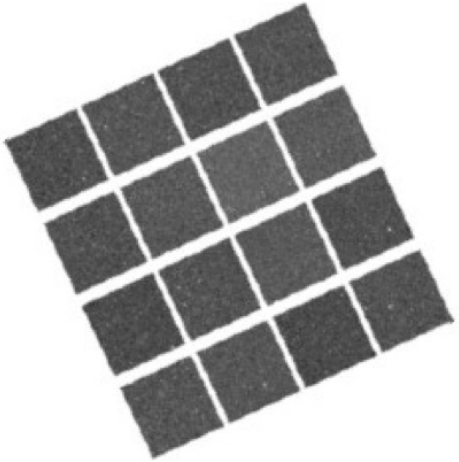




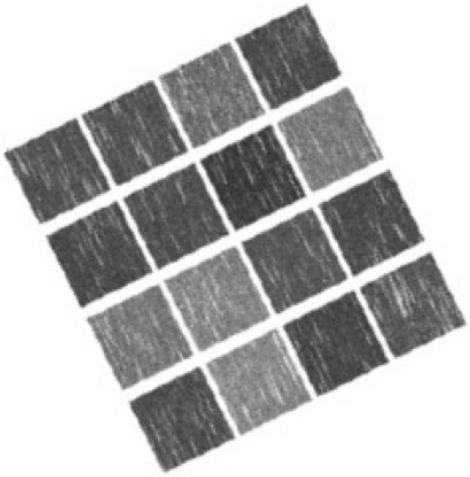
Digital camera with 16 CCDs and a total of 60 Mega pixels

Field-of-view (FoV) of 0.57 deg^2

Grisms wheel

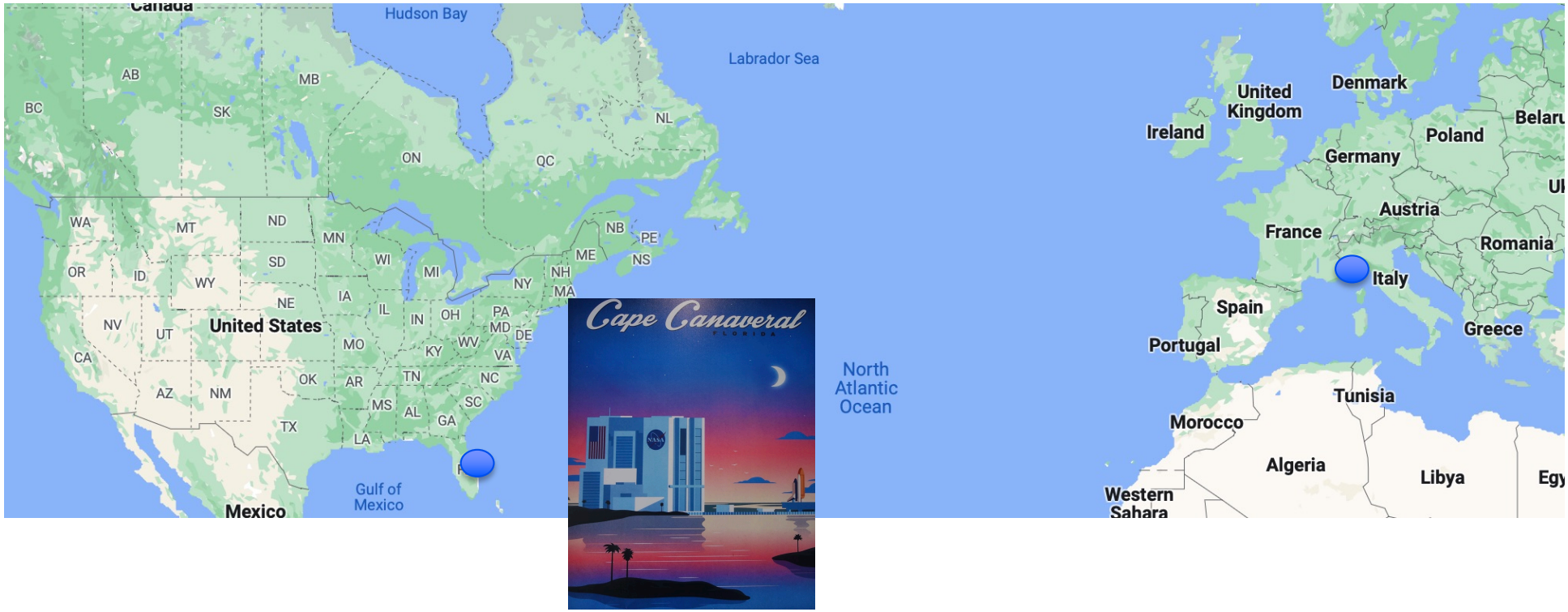


NISP-P



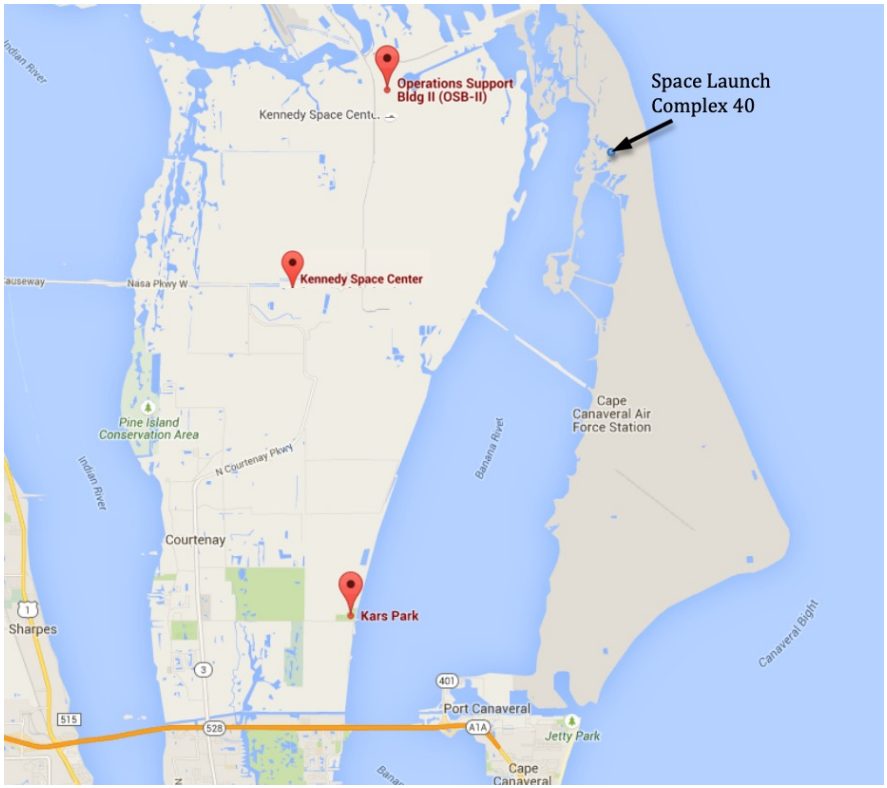
NISP-S

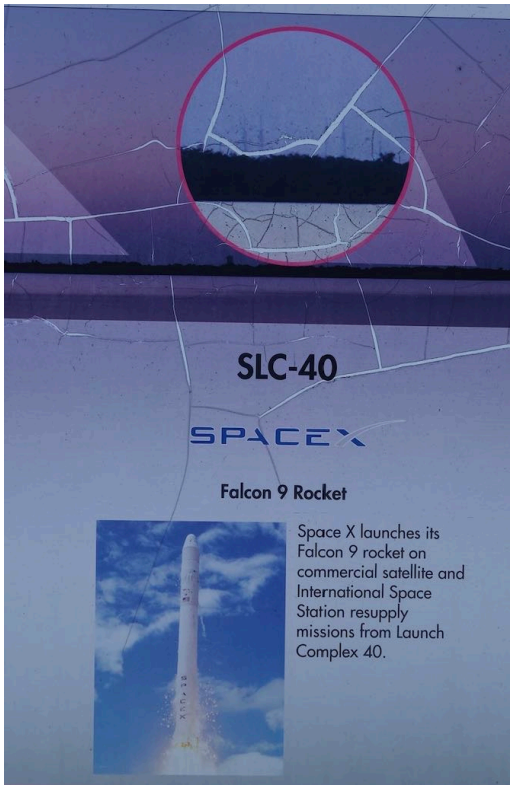
Getting ready for launch

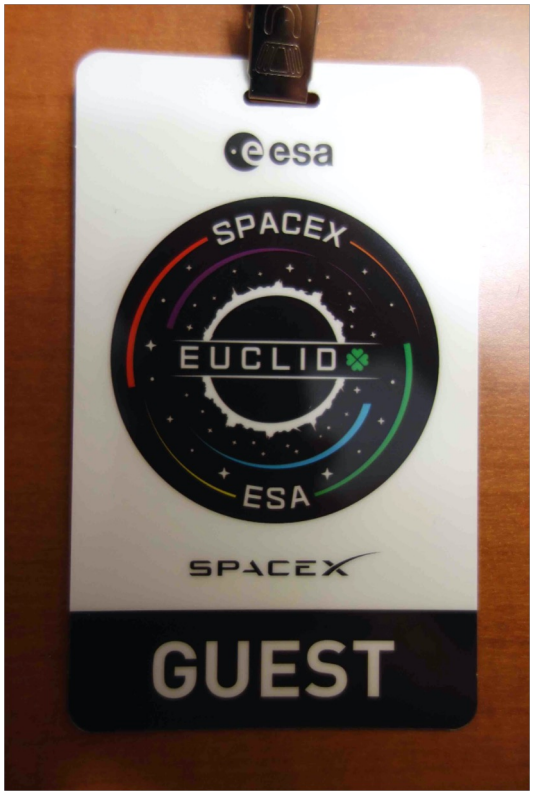


Launch: 1-July-2023

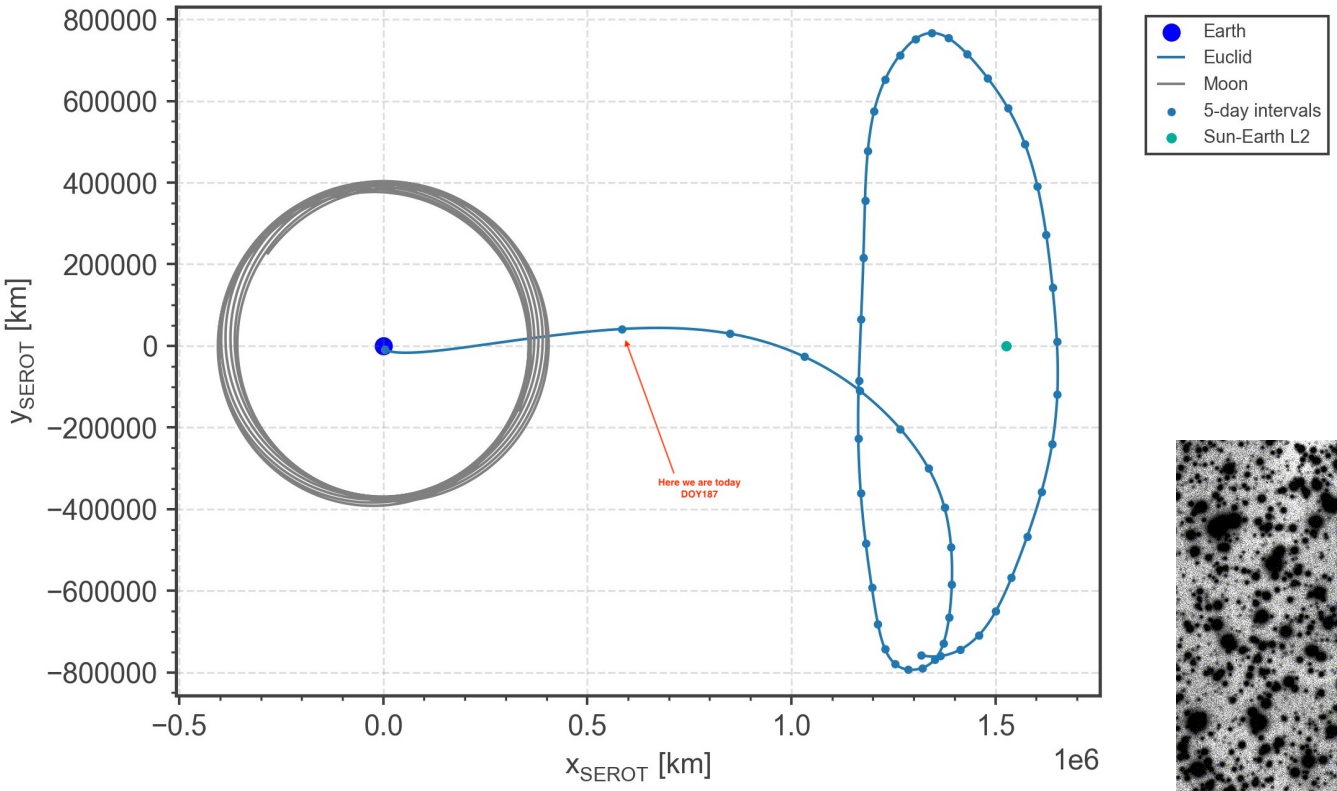
https://divulgacao.iastro.pt/pt/2023/06/27/euclid-lancado-telescopio-revelara-universo-invisivel/

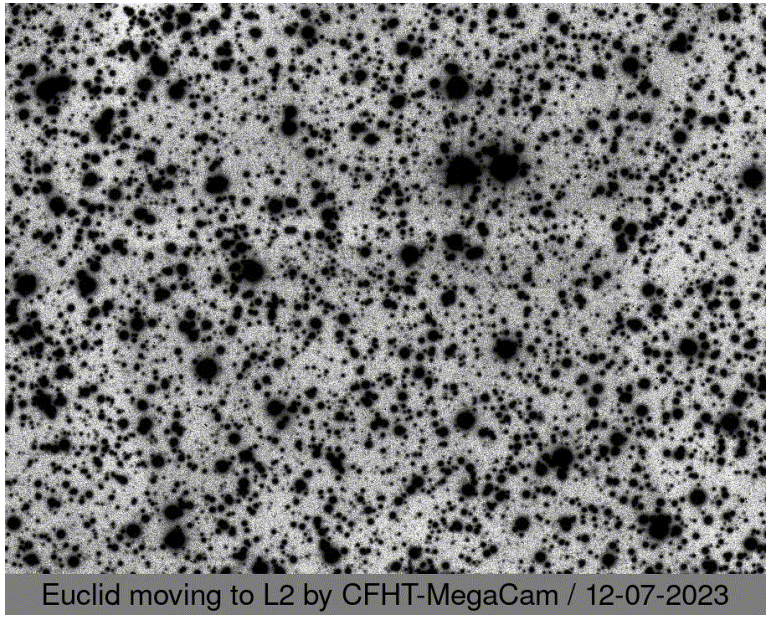






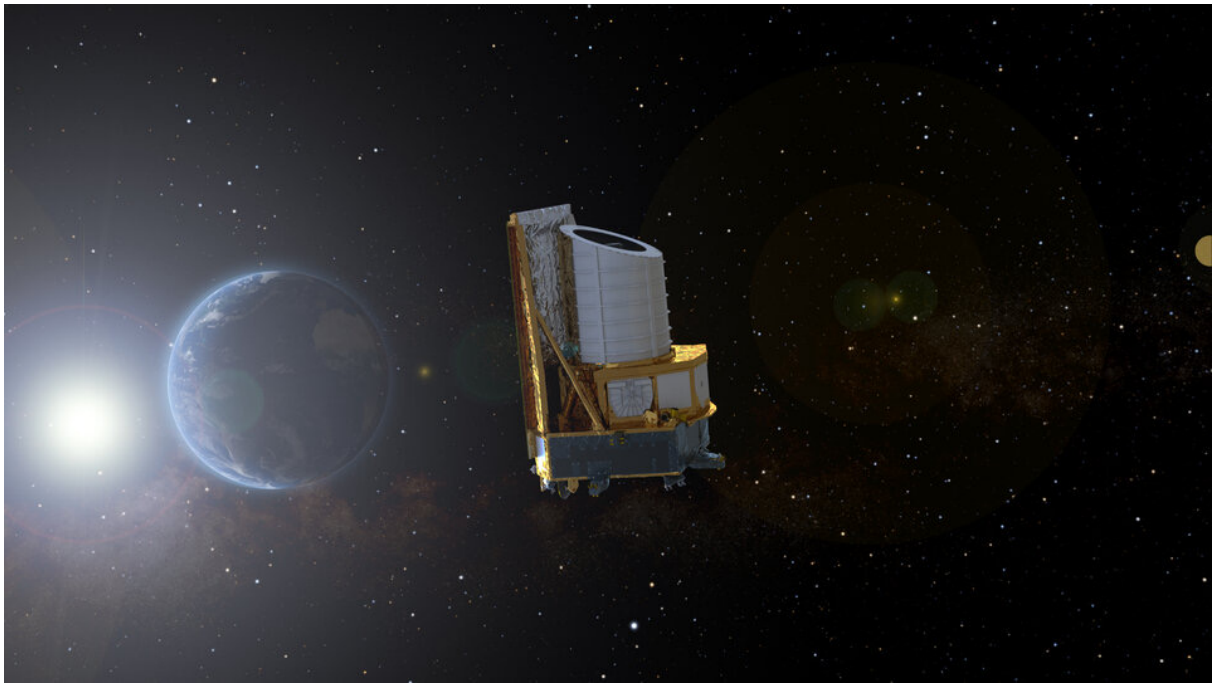
The journey to L2




Euclid moving to L2 by CFHT-MegaCam / 12-07-2023

- Turning-on the instruments
- Testing the communications
- Melting the ice – “outgassing” (gas trapped in non-metallic escapes) → freezes in the telecope cavities, interfering with the optical path → needs to be warmed up and escapes to space

The orbit

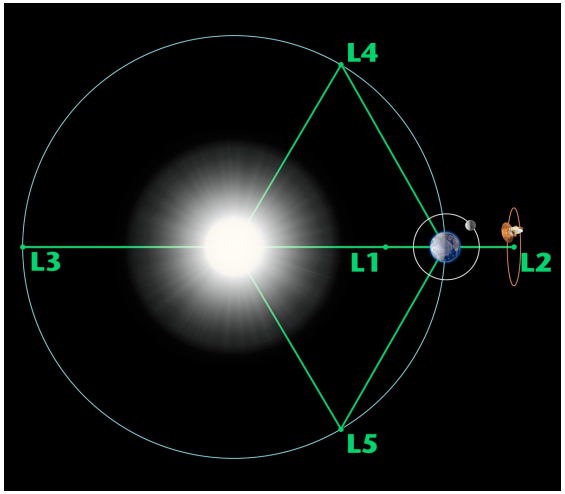


Lagrange point L2

Distance = 1.5 million Km from Earth

(5 light-seconds)

farther than the Moon



1 year orbit around the Sun

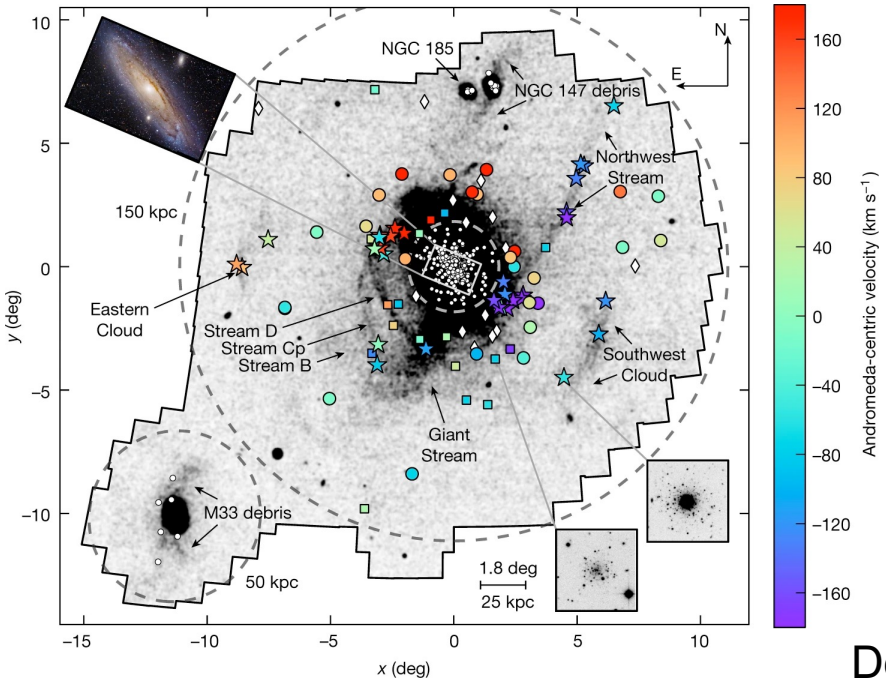
Early release observations: 7-November-2023

https://www.nationalgeographic.pt/ciencia/primeiras-imagens-astronomicas-missao-euclid-divulgadas-comentarios-ia_4402

(video shown on the screens in C8)

Astrophysical goals

	Euclid	Before Euclid
[1] Deep near-IR imaging: area of sky mapped to 24 mag AB in the near-IR	>14,500 deg^2(~10 deg^2 per day)	13.5 deg^2
[2] Massive galaxy clusters at z>1	~500,000	~1000
[3] High-redshift quasars, z>7	~100	10
[3] High-redshift quasars, z>8	~8	0
[4] Strong gravitational lenses (galaxy scale)	170,000	10,000
[5] High-redshift galaxies (z>6)	~390,000	~400
[6] H-alpha emitters at z>1	~30 million	<10,000
[7] Massive galaxies spectroscopically confirmed at z>1.5	few ×100,000	few × 100



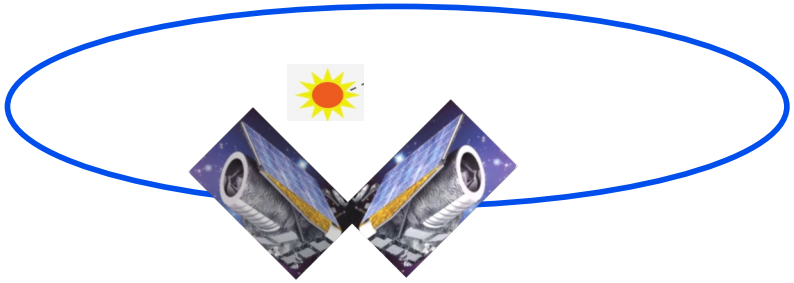
Detailed galaxy morphology, outskirts, contents

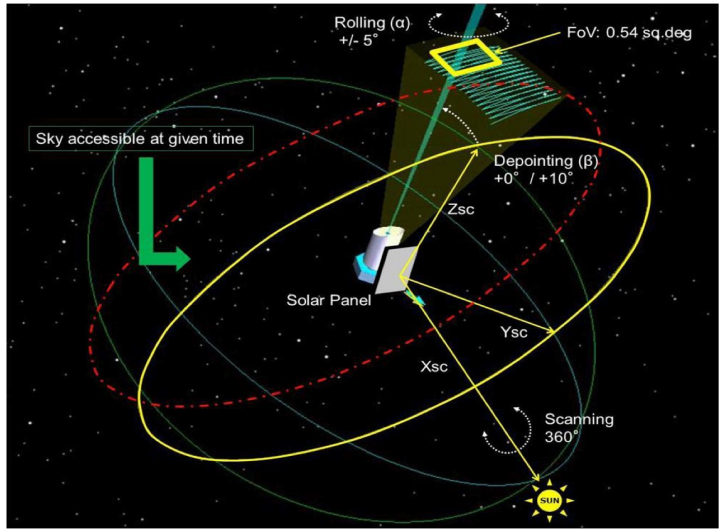
The sky survey: **14-February-2024** (until 2030)

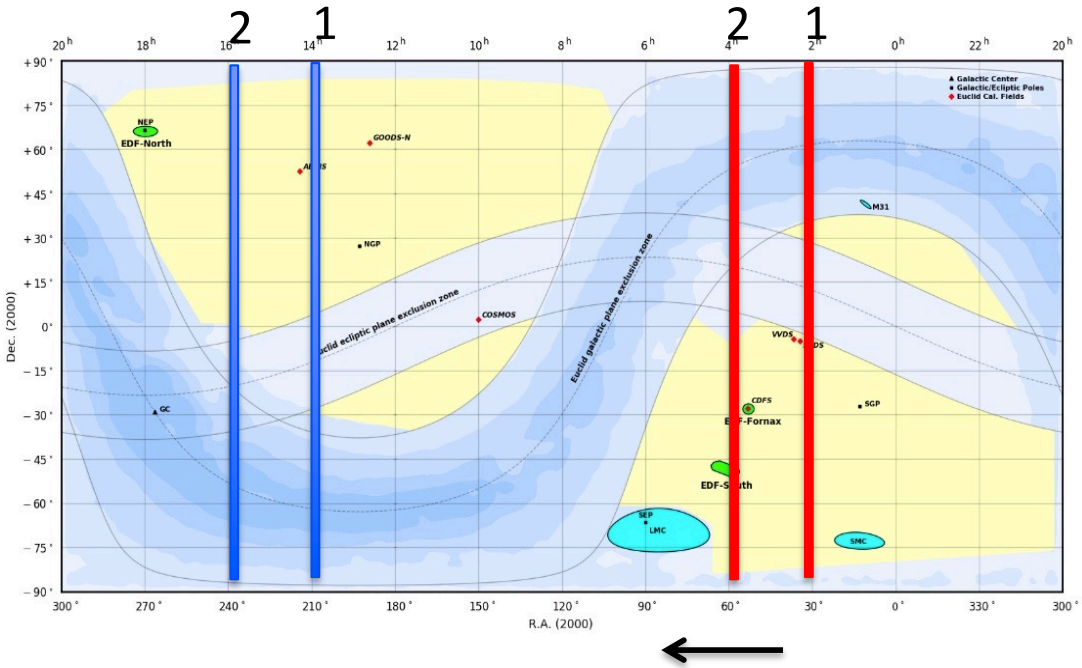
https://divulgacao.iastro.pt/pt/2024/02/14/euclid-rastreio-inicio/

The telescope cannot tilt much from the **orthgonal direction to the Sun for** thermal stability of the images.

It can also observe “upside-down”, **defining two visibility windows** in each moment.







orbital movement

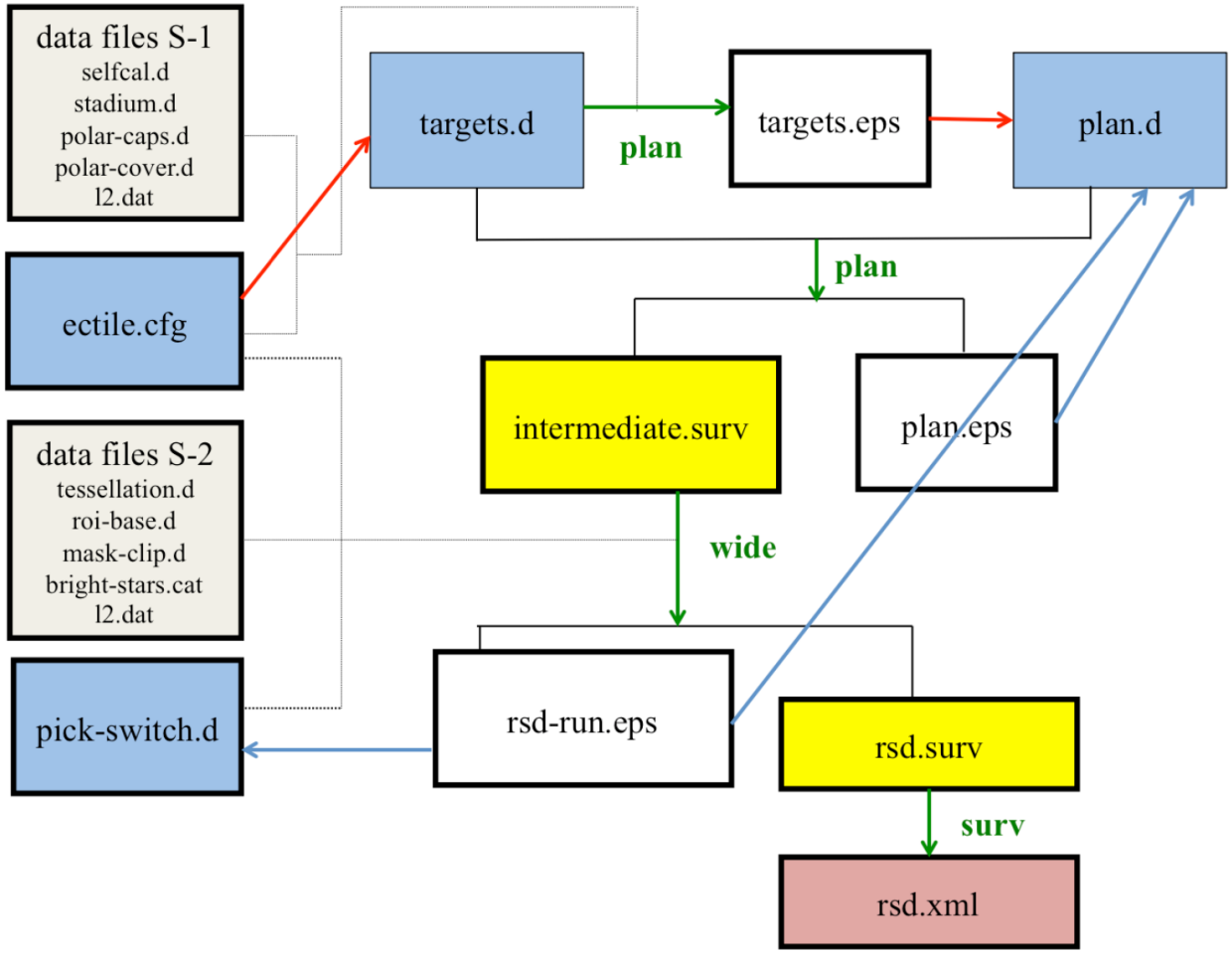
Stop-and-stare during 6 years

the windows move with orbit

Planning the mission

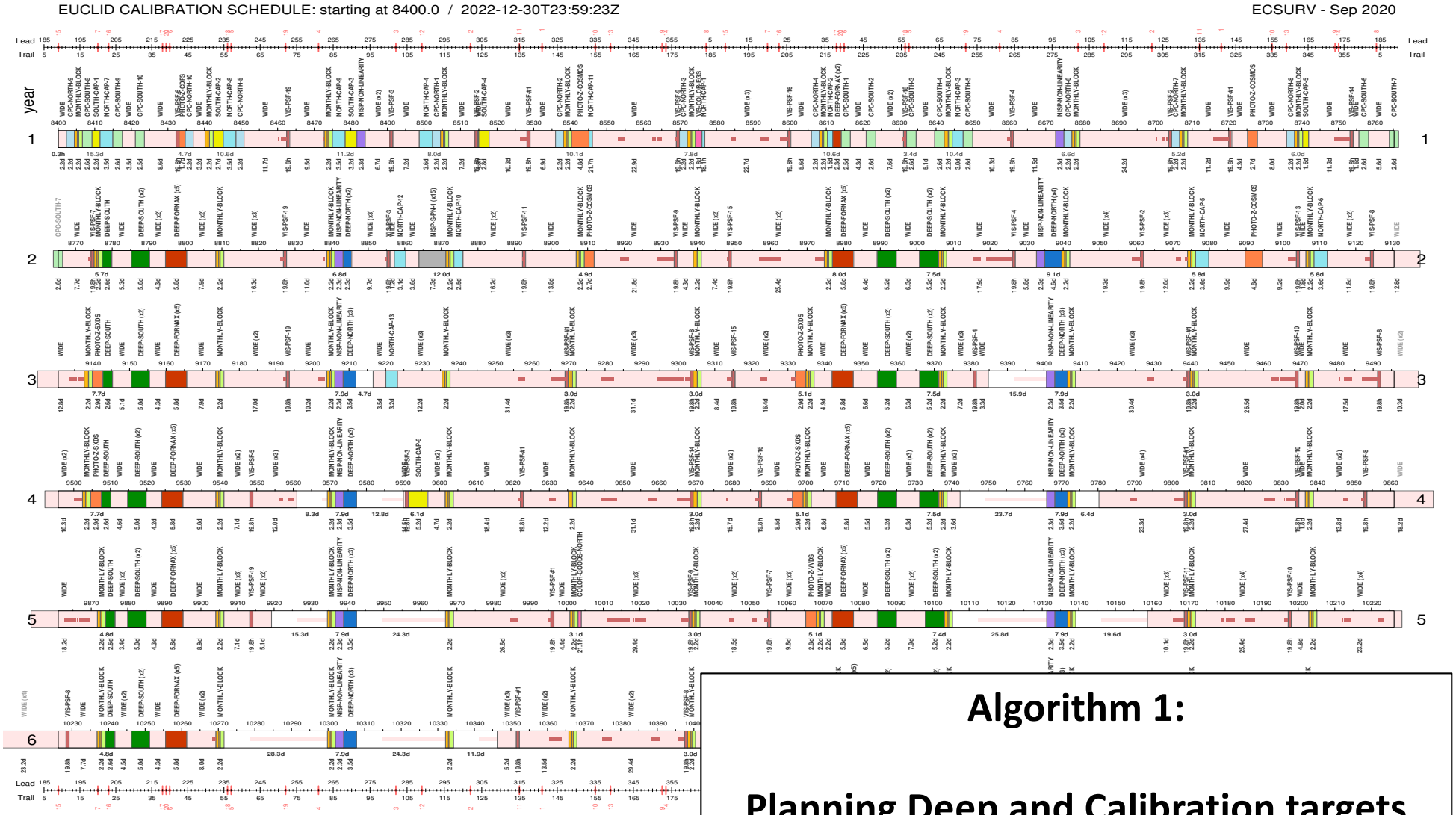
The observing sequence is built by the Survey Operations Support Team **– in the Faculty of Sciences of the University of Lisbon –**
We send our results to ESA that operates the telescope according to our sequence!

ECTile software



We first make a plan according to with the visibility of calibration and deep fields.

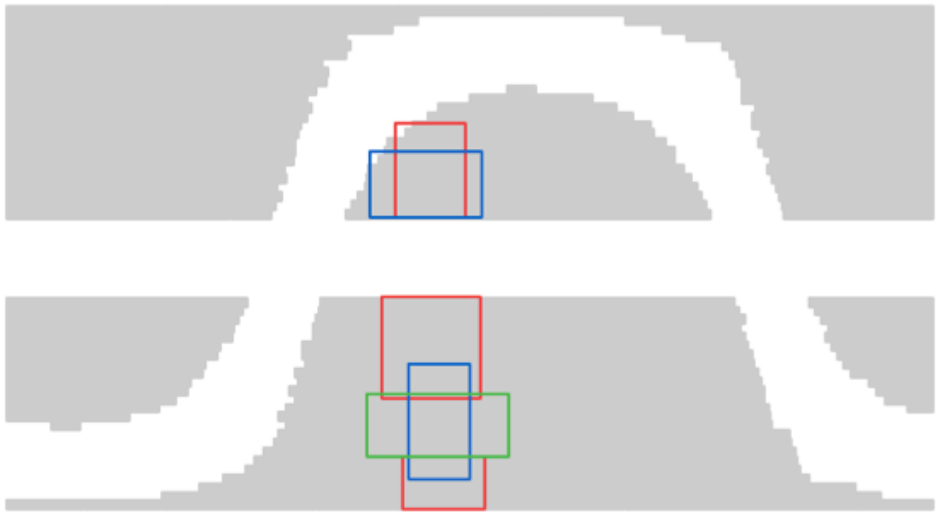
→ survey observations are interrupted to observe those targets.



Algorithm 1:

Planning Deep and Calibration targets

In the survey time intervals there is no time to observe a full window of visibility → definine “**patches”:**

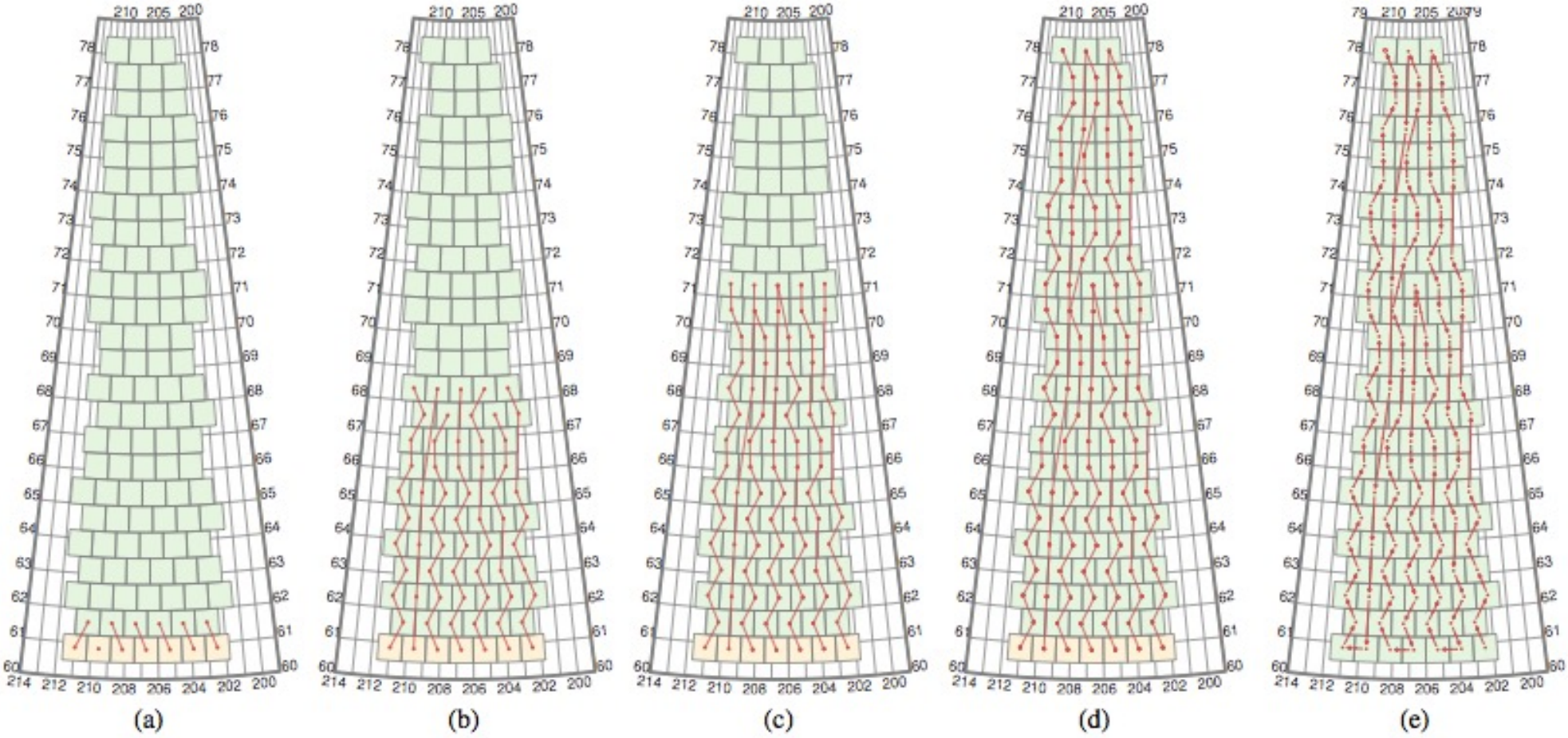


Algorithm 2:

Create and select patches

Fill the area from the poles to the equator

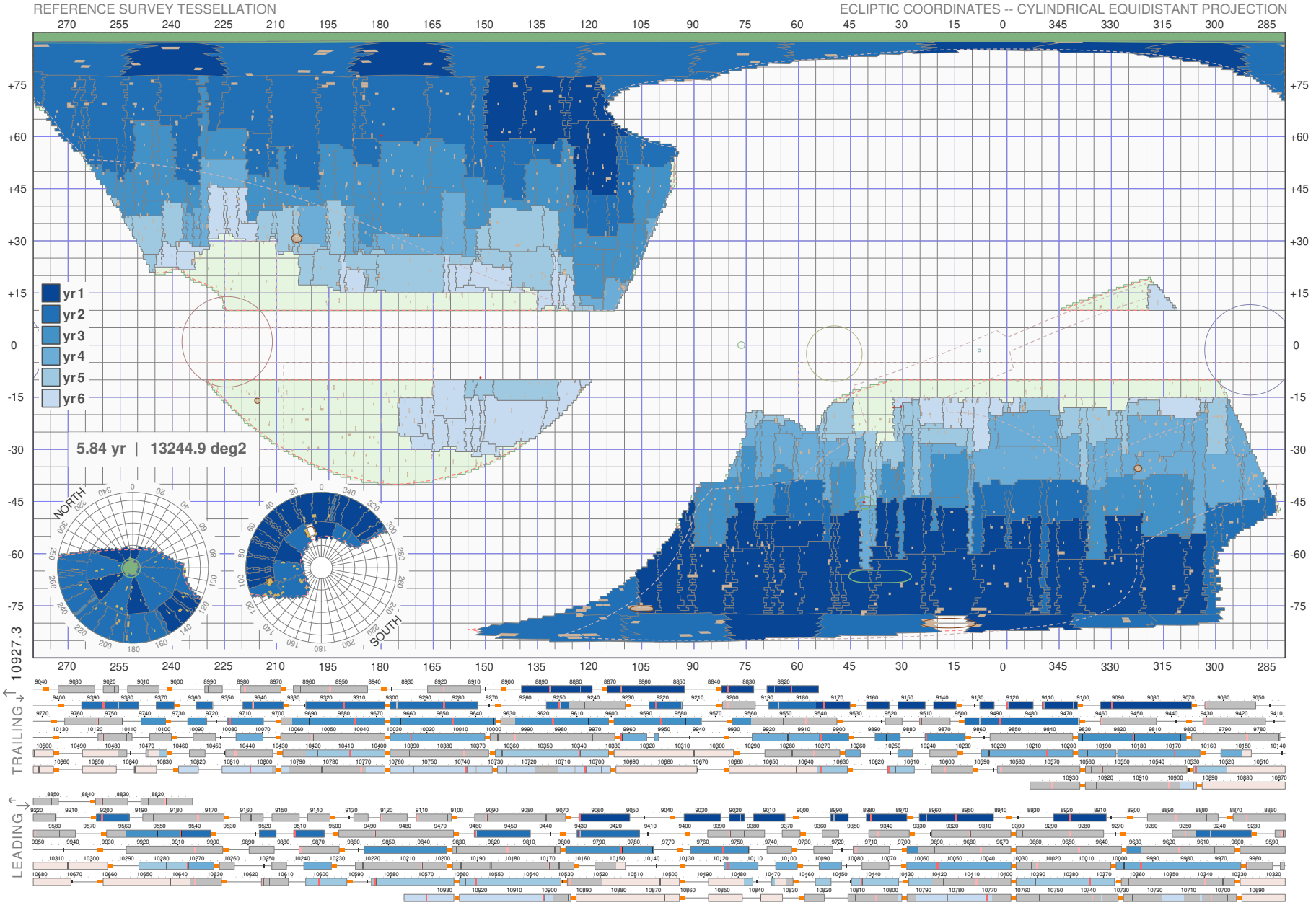
observing in sequence, avoiding large jumps to save gas and ensure homogeneity.



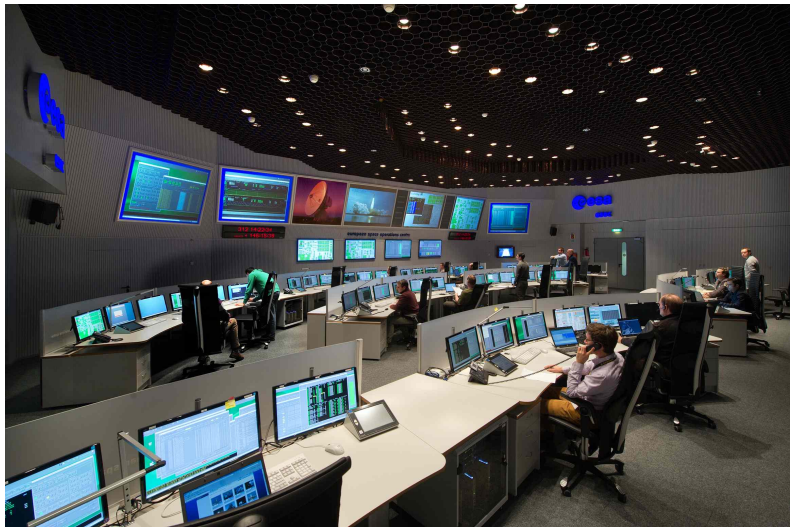
Algorithm 3:

Create a path within a patch

The result: a compact sequence of observations



Observing sequences will be updates, modified and sent regularly to ESA to operate the telescope, during the 6 years of the mission.



Opportunities for students

Euclid groups are working now on the development of cosmological models, measurement methods, theoretical modelling of astrophysical effects, simulations, etc, etc, to be applied to the Euclid data → **first data release DR1** (June 2025)

2024/25 is a training period (master) and after that interested students may have the opportunity to start a PhD abroad with the contacts made.