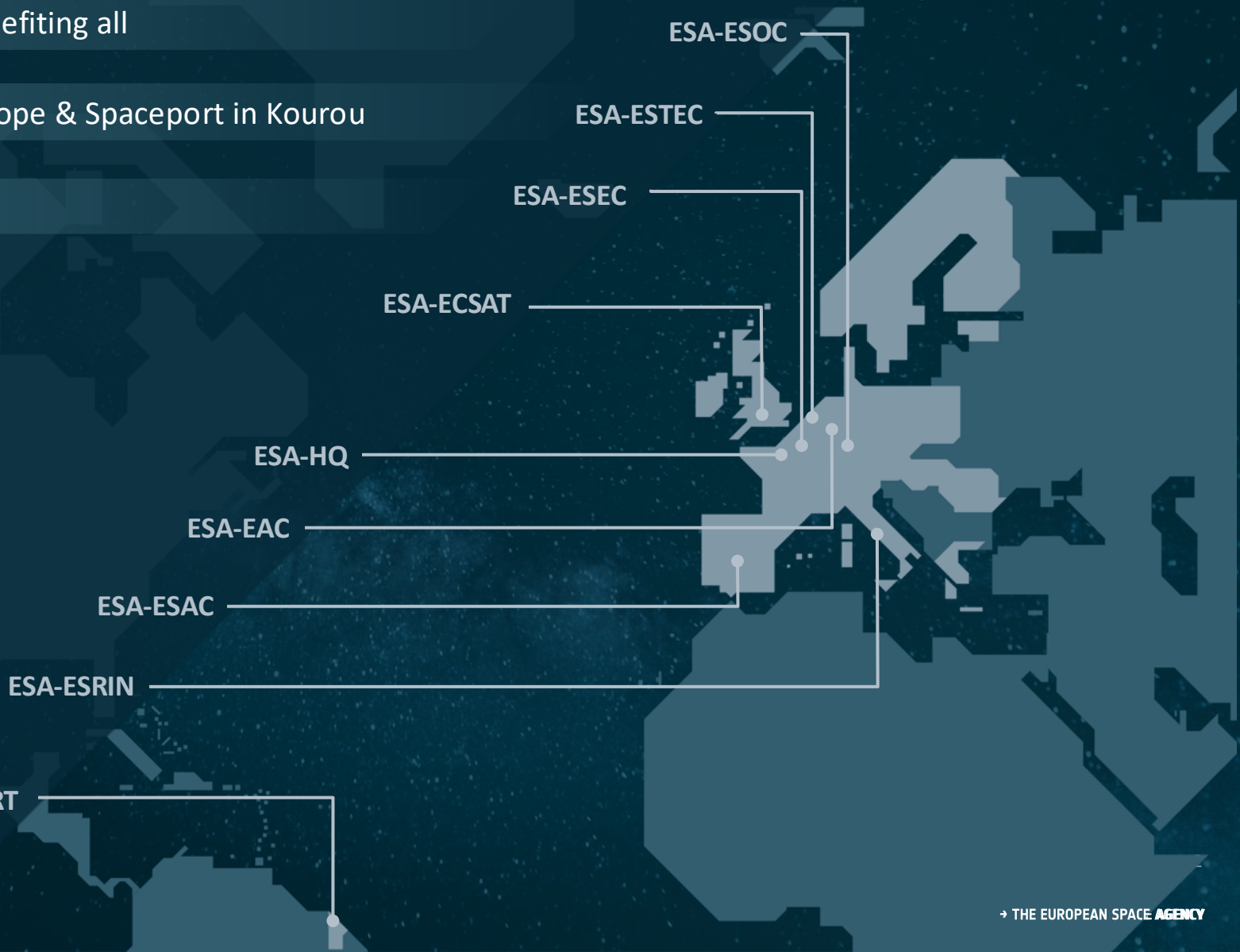
# Overview of the ESA Euclid mission in the context of ESA Science

Valeria Pettorino, ESA Euclid Project Scientist, ESA/ESTEC

10/06/2025

| | |
|---|---|
| **WHO** | 23 Member States, 2500+ staff members and total workforce of 6000+ |
| **WHY** | For the peaceful use of space, benefiting all |
| **WHERE** | HQ in Paris, seven sites across Europe & Spaceport in Kourou |
| **BUDGET** | €7.79 billion |




50th anniversary this year

1975: merge of European Space Research Organization and European Launcher Development Organization

# INSIDE ESA

## Four pillars. One ESA.

SCIENCE

SPACE TRANSPORTATION

EARTH OBSERVATION

NAVIGATION

COMMERCIALISATION, INDUSTRY & COMPETITIVENESS

HUMAN & ROBOTIC EXPLORATION

OPERATIONS

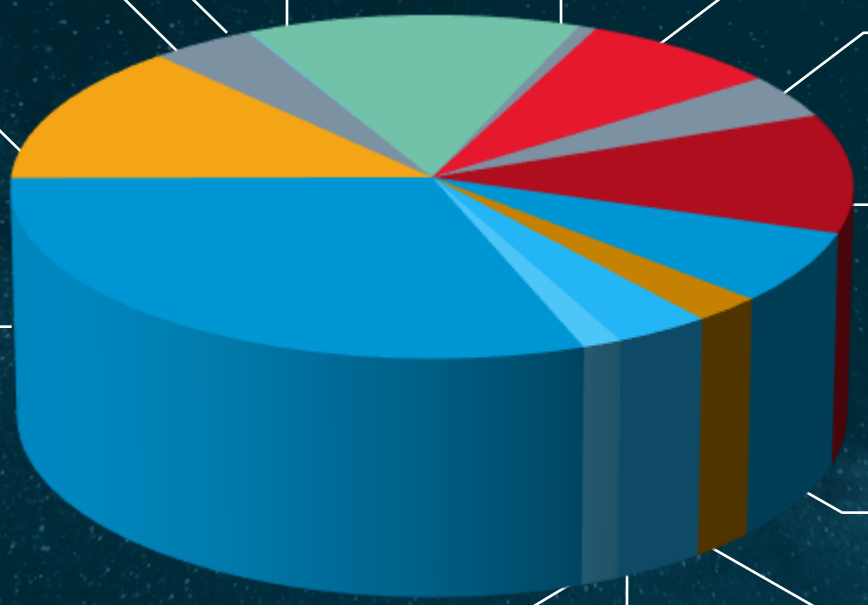
TECHNOLOGY

CONNECTIVITY & SECURE COMMUNICATIONS

SPACE SAFETY

# Annual budget* 2024 (by domain)

TOTAL: €7.79 B** (+10% vs. 2023)



NAVIGATION
€1051.1 million, 13.5%

PRODEX
€56.6 million, 0.7%

EUROPEAN COOPERATING STATES AGREEMENT
€5.9 million, 0.1%

ASSOCIATED WITH GENERAL BUDGET
€330.1 million, 4.2%

SPACE TRANSPORTATION
€1032.7 million, 13.3%

SCIENTIFIC PROGRAMME
€632 million, 8.1%

BASIC ACTIVITIES
€322.9 million, 4.1%

HUMAN & ROBOTIC EXPLORATION
€873.8 million, 11.2%

EARTH OBSERVATION
€2372.4 million, 30.5%

CONNECTIVITY & SECURE COMMUNICATIONS
€525.7 million, 6.8%

COMMERCIALISATION, INDUSTRY & COMPETITIVENESS
€111.8 million, 1.4%

TECHNOLOGY
€196.7 million, 2.5%

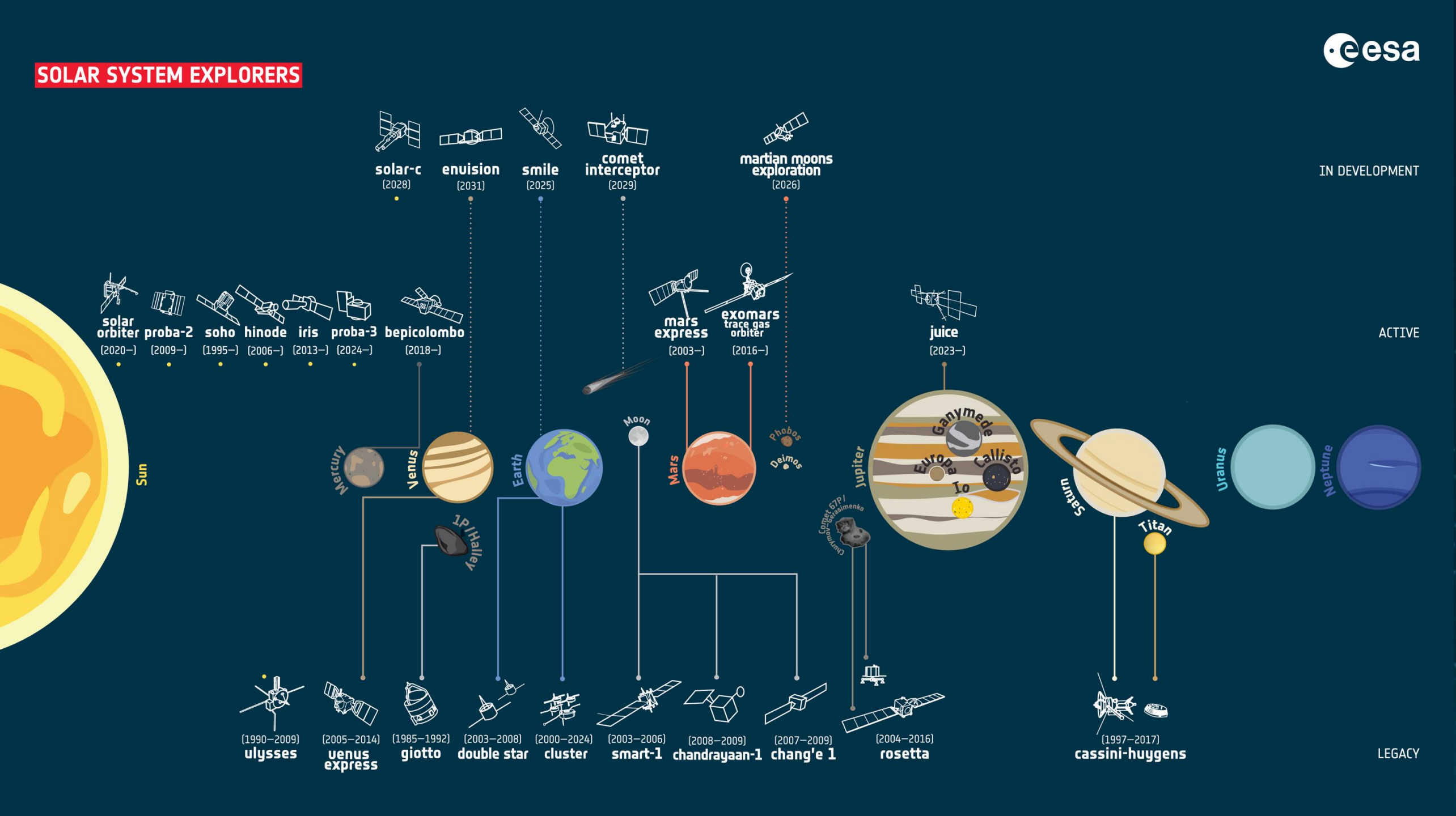
SPACE SAFETY
€273.4 million, 3.5%

*Adopted budget, not final budget **Includes activities implemented for other institutional partners

# SCIENCE & EXPLORATION

- What is the origin of the Solar System and stars?
- What is the history of our Universe and the fundamental forces governing it?
- Are we alone?

# SOLAR SYSTEM EXPLORERS



# COSMIC OBSERVERS

esa

IN DEVELOPMENT

ACTIVE

LEGACY

ariel (2029)



roman (2026)



arrakihs (2030)

plato (2026)

new athena (~2037)

lisa (~2035)

webb (2021–)

euclid (2023–)

hubble (1990–)

cheops (2019–)

xrism (2023–)

xmm-newton (1999–)

einstein probe (2024–)

microwaves

sub-millimetre

infrared

optical

ultraviolet

x-rays

gamma rays

gravitational waves

lisa pathfinder (2015–2017)

planck (2009-2013)

herschel (2009-2013)

iso (1995-1998)

akari (2006-2011)

hipparcos (1989-1993)

gaia (2013–2025)

corot (2006–2014)

iue (1978-1996)

exosat (1983–1986)

hitomi (2016)

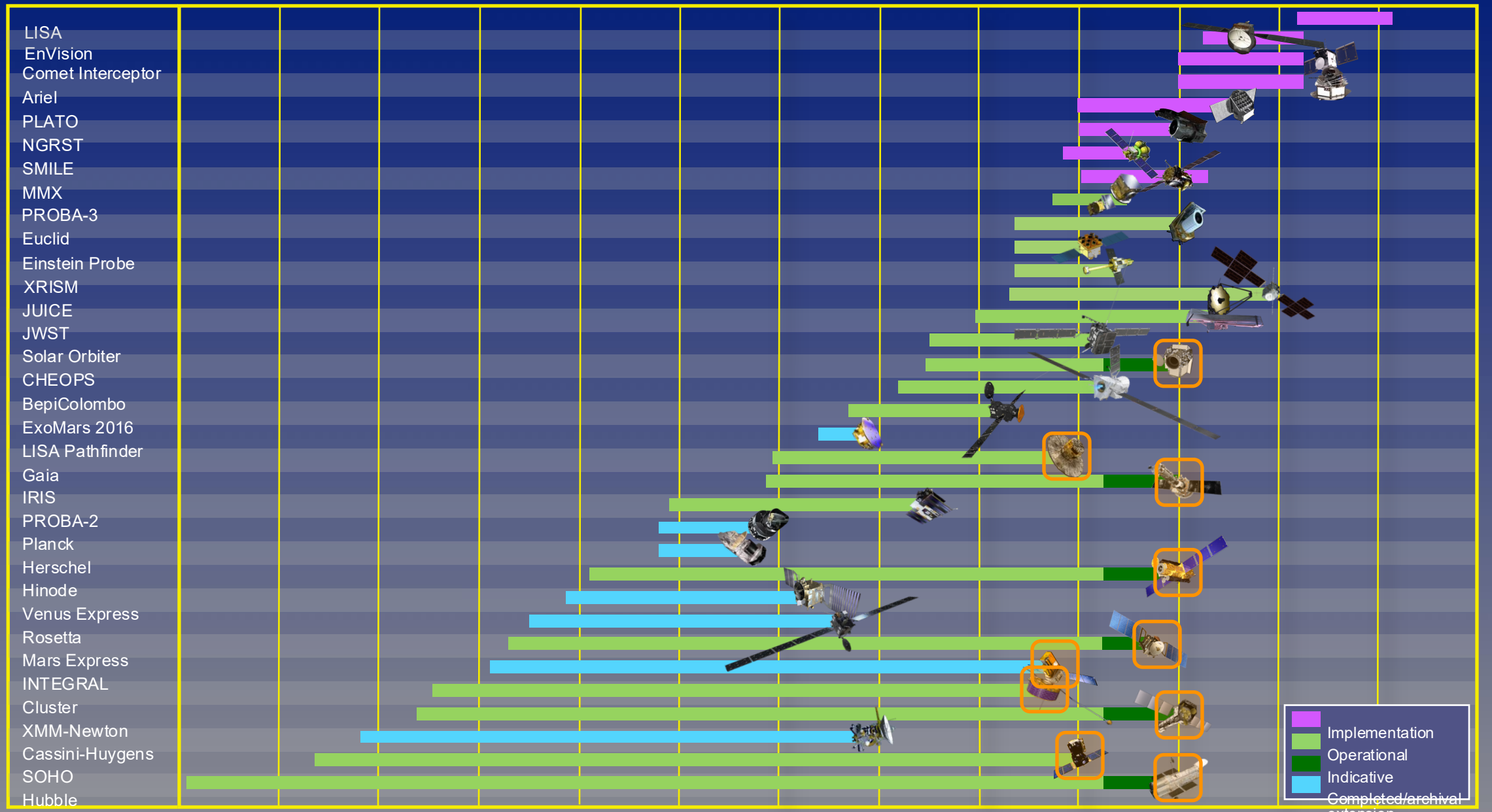
suzaku (2005–2015)

cos-b (1975–1982)

integral (2002–2025)

microscope (2016–2018)

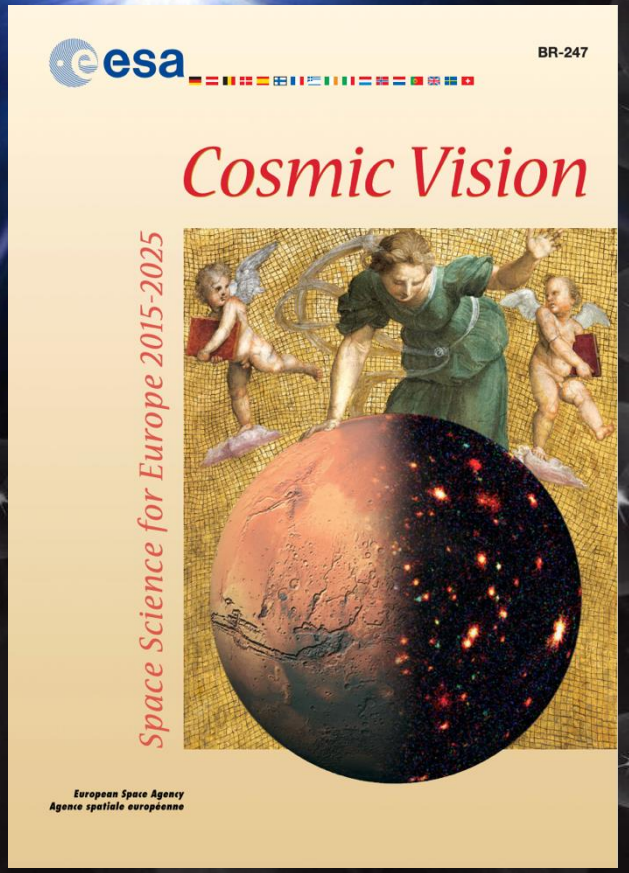
# ESA Space Science Missions




Latest update: January 2024

Courtesy of Gaitee Hussain, ESLAB 2025

# ESA Cosmic Vision 2015 - 2025




- what are the conditions for planet formation and the emergence of life?
- how does the Solar System work?
- what are the fundamental physical laws of the Universe?
- how did the Universe originate and what is it made of?

**COSMIC VISION** (launches spanning 2019 - 2037)

esa

## SMALL/FAST

**S1 - CHEOPS**
[2019]

**SMILE**
[2025]

**F1 - Comet Interceptor**
[2029]

**F2 - ARRAKIHS**
[2030]

## MEDIUM

**M1 - Solar Orbiter**
[2020]

**M2 - Euclid**
[2023]

**M3 - PLATO**
[2026]

**M4 - Ariel**
[2029]

**M5 - Enuision**
[2031]

## LARGE

**L1 - JUICE**
[2023]

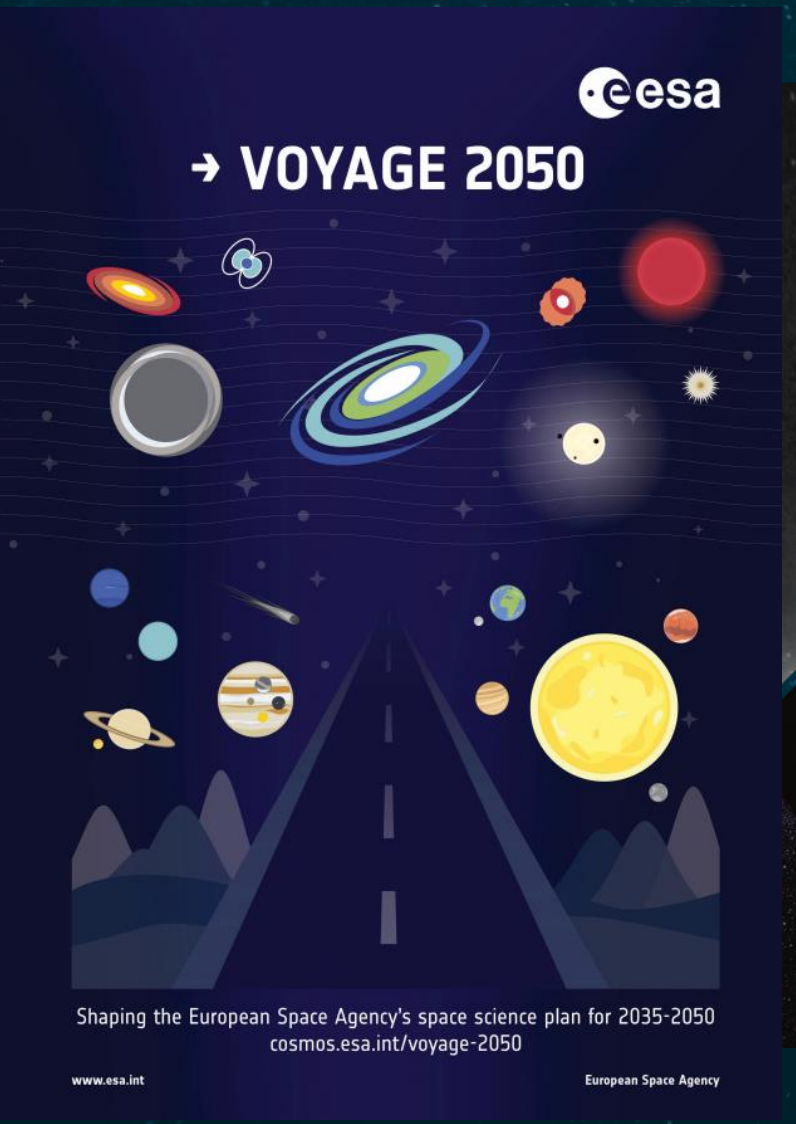
**L2 - New Athena**
[2037]

**L3 - LISA**
[2035]

in study
in development
in operations

Courtesy of Gaitee Hussain, ESLAB 2025

# Large missions science themes for ESA's future: Voyage 2050




## 3 Science Themes for Voyage 2050 Large missions

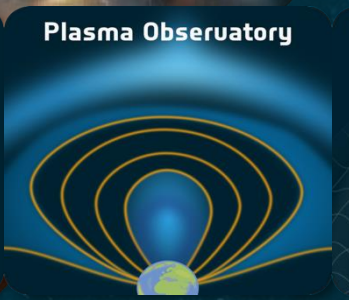
Moons of the giant planets

From temperate exoplanets to the Milky Way

New physical probes of the early Universe

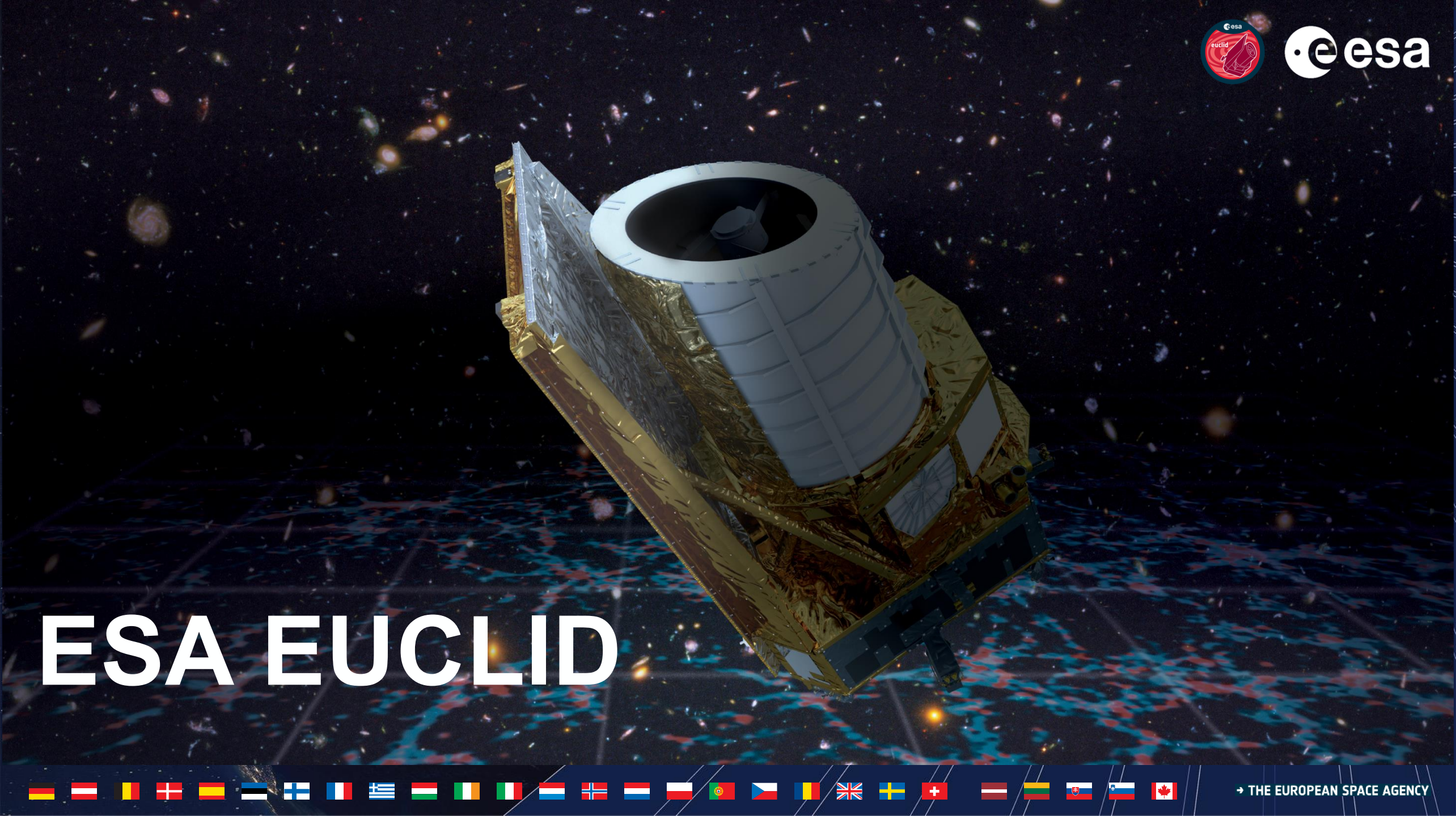
**Medium size missions candidates:** M7 mission candidates

M7

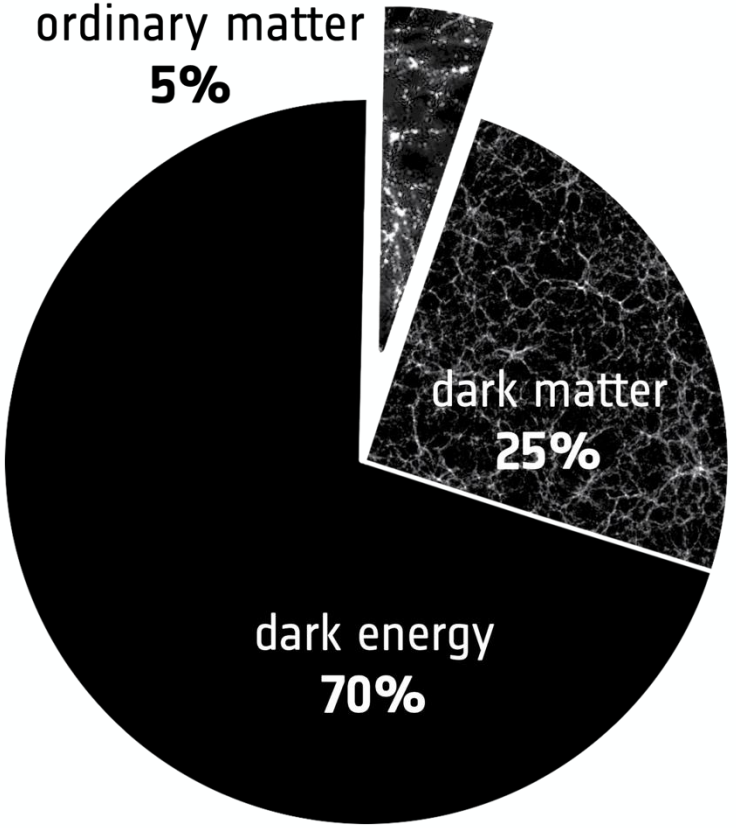





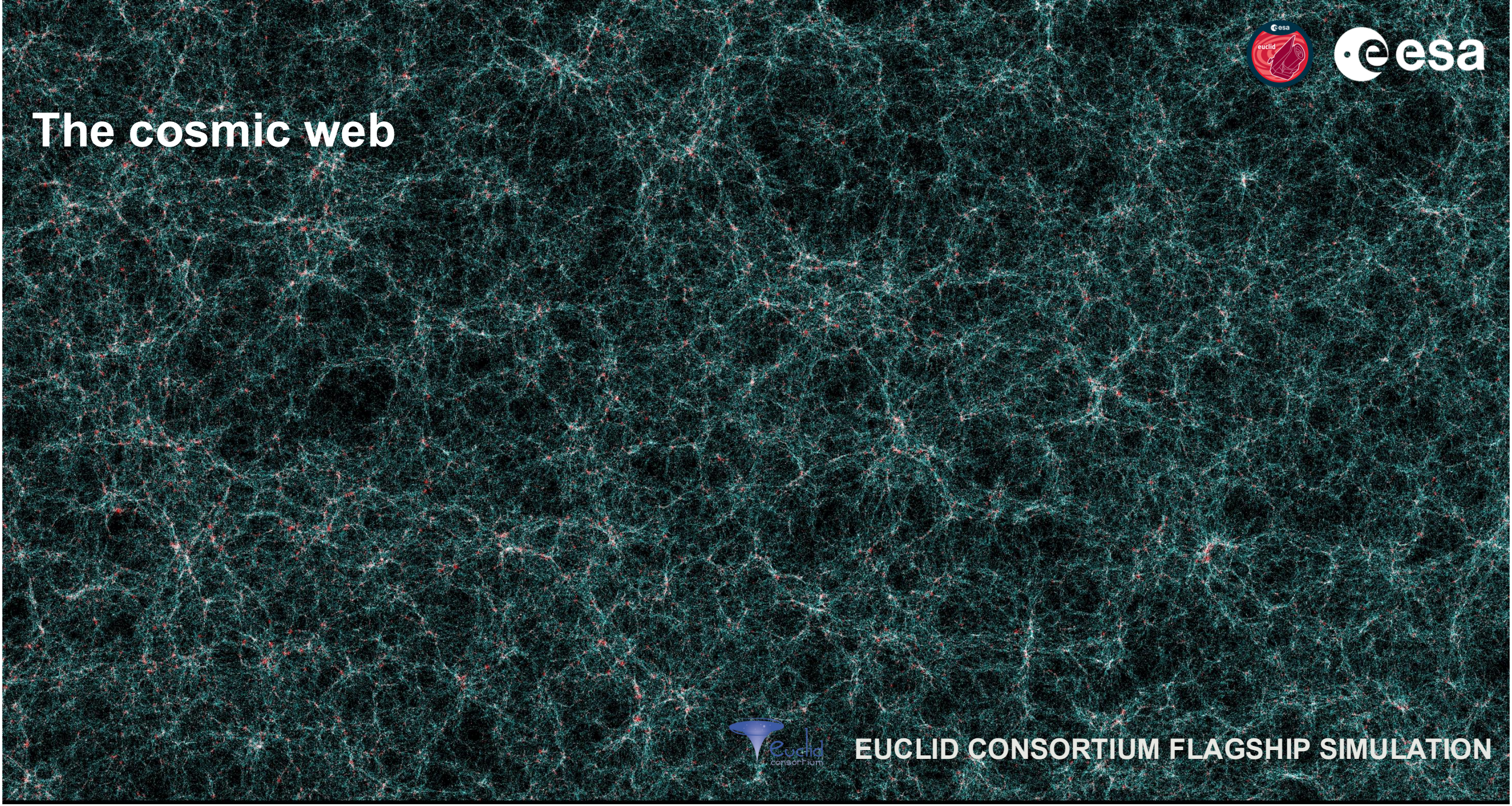
Call for one Medium-size (M8) mission opportunity (to be launched around 2041) and for one Fast mission (F3, to be launched around 2034), plus proposals for mini-Fast (mini-F) mission concepts


ESA EUCLID
→ THE EUROPEAN SPACE AGENCY

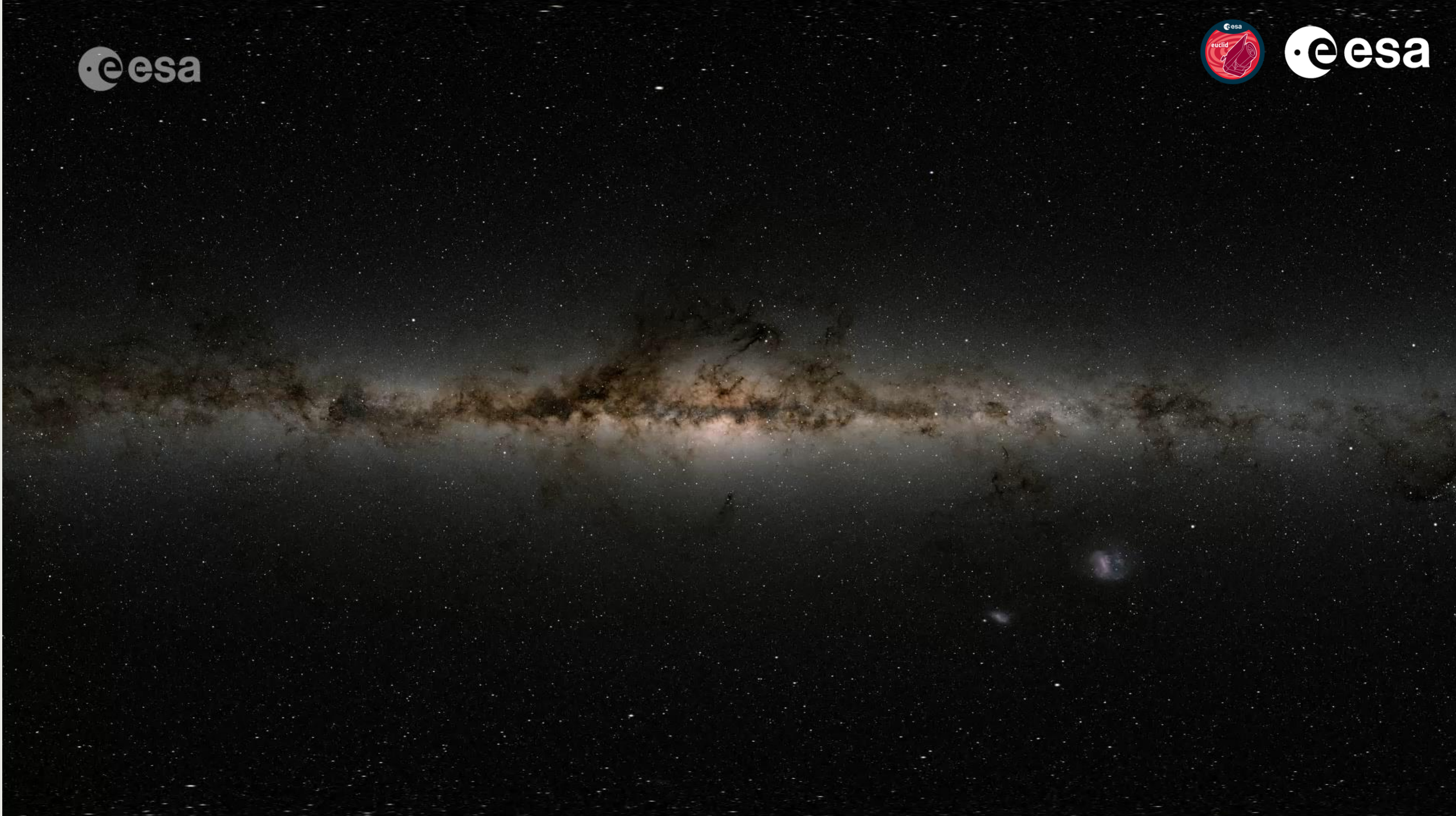
# What is the universe made of?



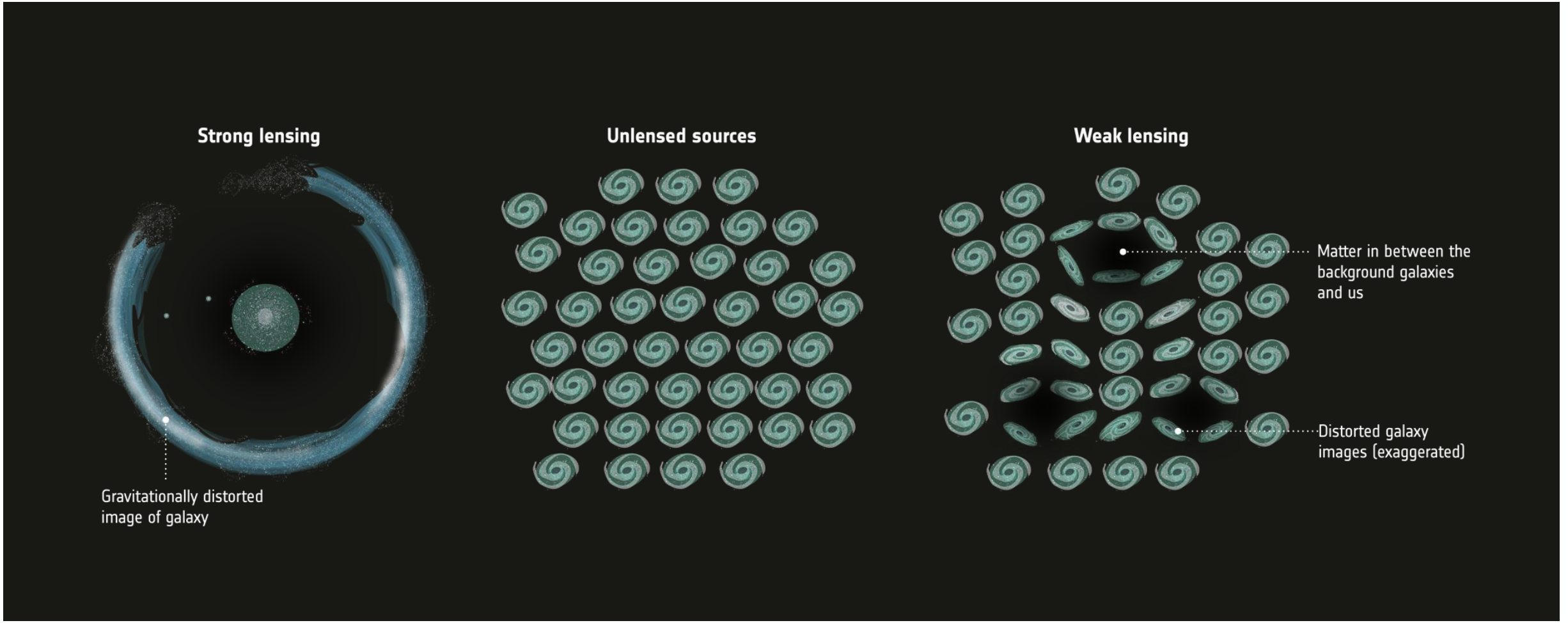
# The cosmic web



EUCLID CONSORTIUM FLAGSHIP SIMULATION



# Gravitational lensing




*credit: Yuzheng Kang/Euclid Consortium*


FROM SPACE
credit: Yuzheng Kang/Euclid Consortium

# Euclid instruments


*[Credit: ESA / acknowledgement ATG Europe]*

DATA DOWNLOAD: 106 GB/DAY

## Visible instrument (VIS)

**Galaxy shapes**

**A mosaic of 600 megapixels**

## Near-Infrared Spectrometer and Photometer (NISP)

**Distances**

# Status of the Euclid mission

*What is the nature of dark energy? What is the nature of dark matter?*

*What is the structure and evolution of the cosmic web? Is our understanding of gravity complete?*

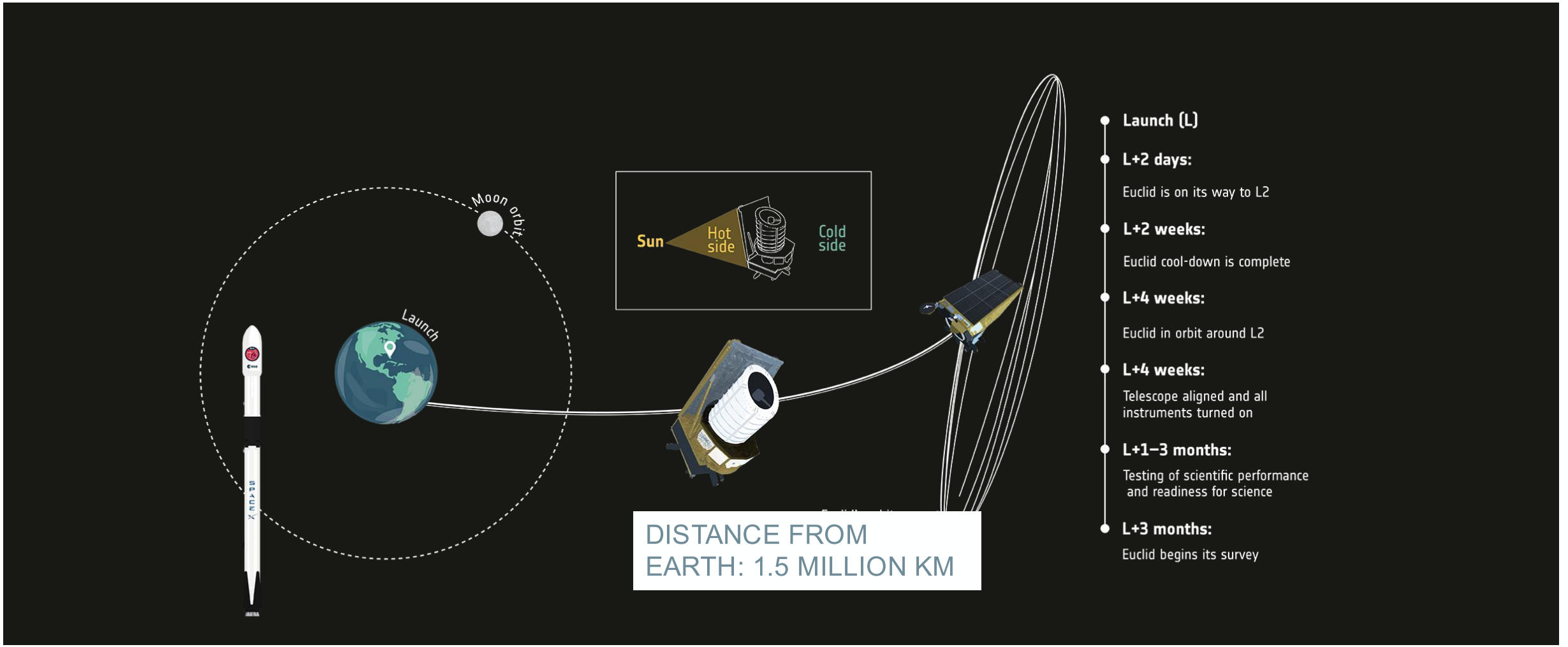
**2007 selection of proposals**

**2012 mission adoption and start of the implementation phase**

**Launch 1st July 2023**


LIFTOFF
STARTUP
T - 00:00:06

# Euclid journey



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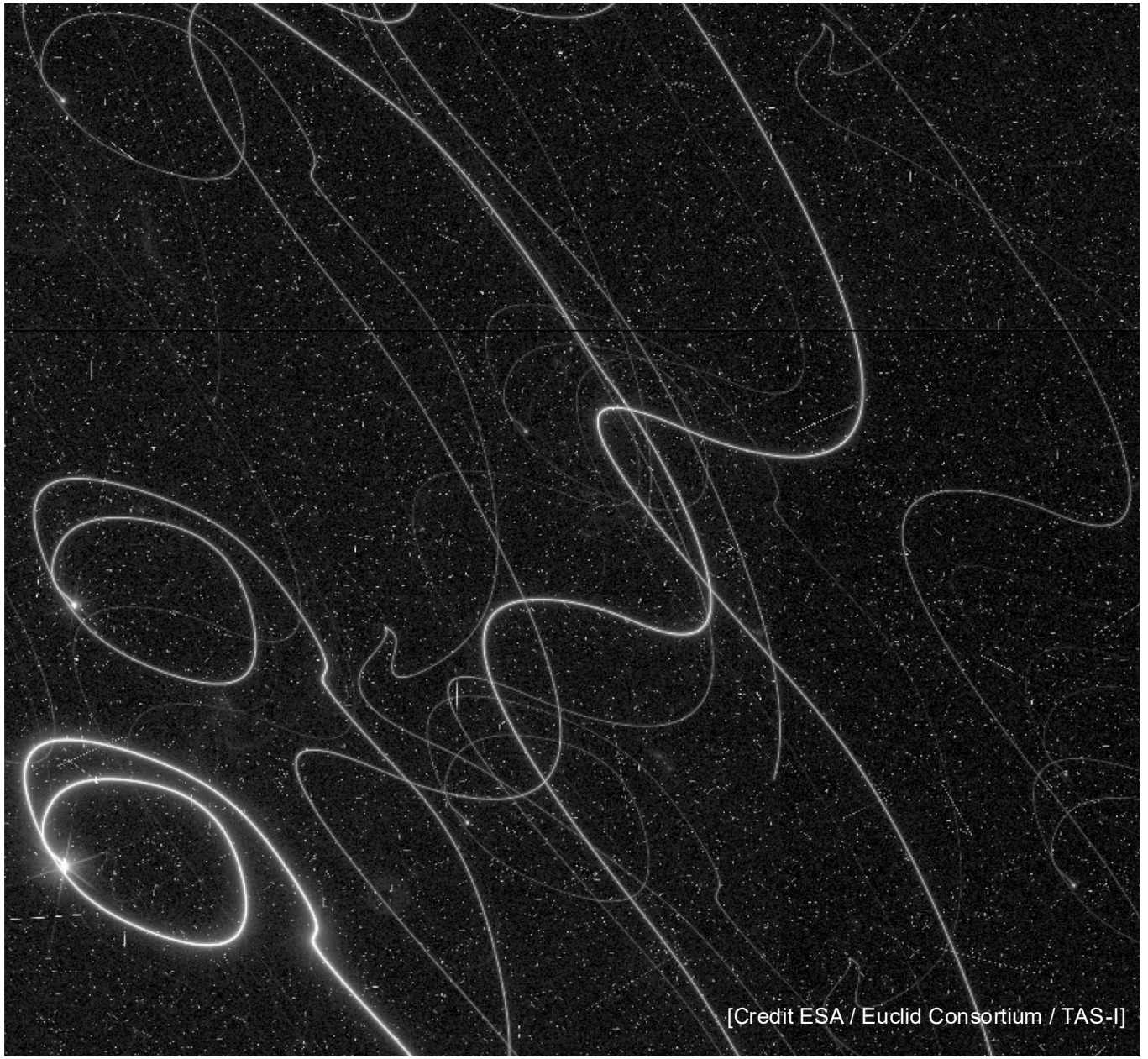
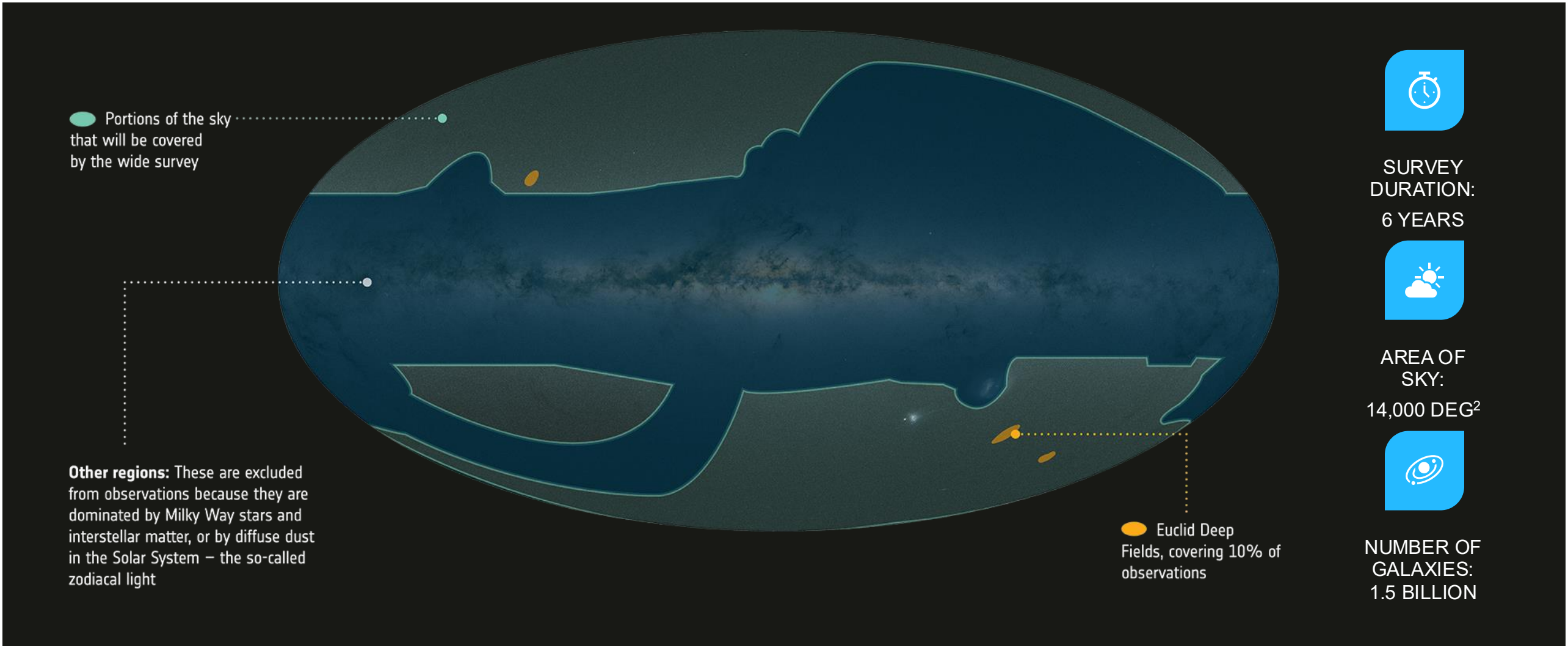
# STAY STILL

# while taking

# a picture



# A map of the sky



# An ESA-led collaboration


ESA Euclid (survey status, data) www.cosmos.esa.int/web/euclid
Euclid Consortium: www.euclid-ec.org

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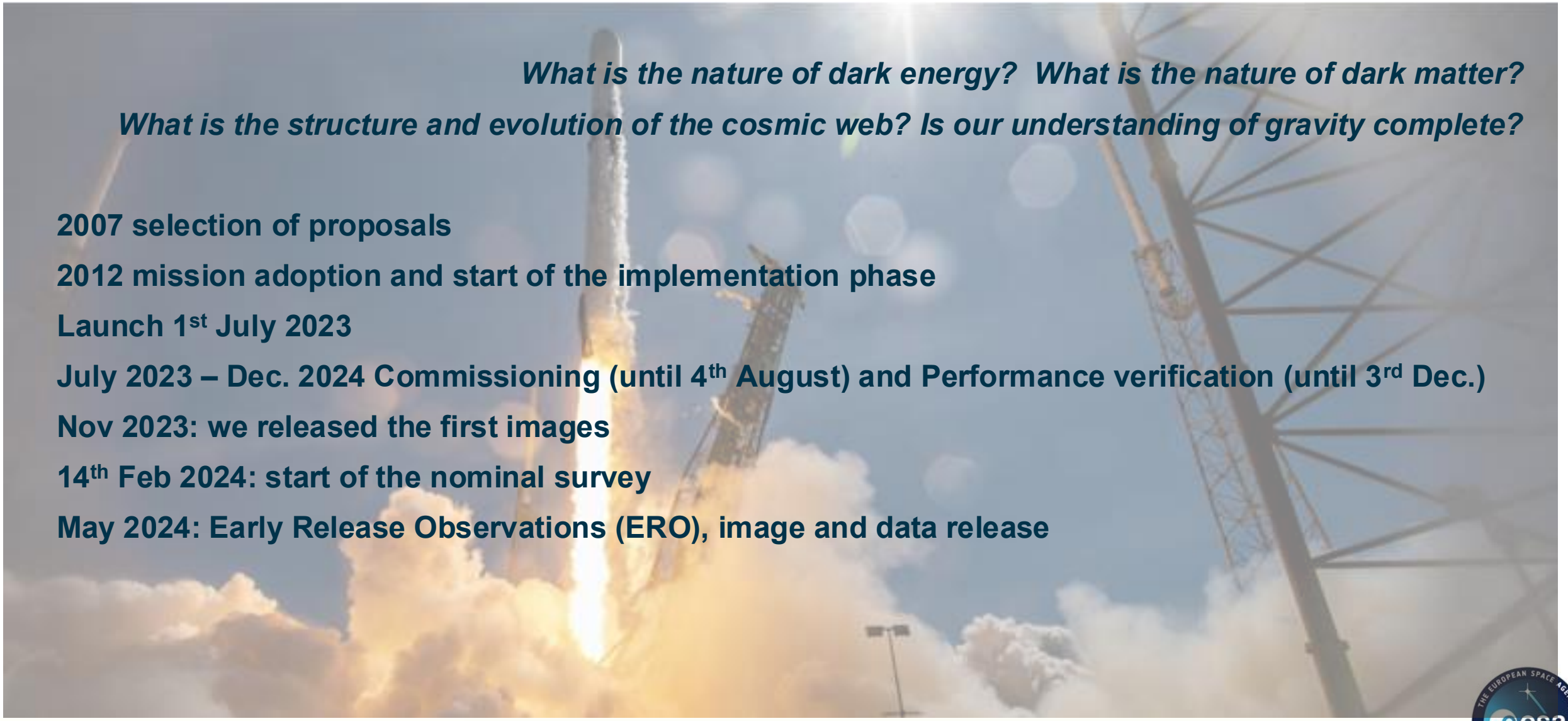

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**Nov 2023: we released the first images**

**14th Feb 2024: start of the nominal survey**

**May 2024: Early Release Observations (ERO), image and data release**

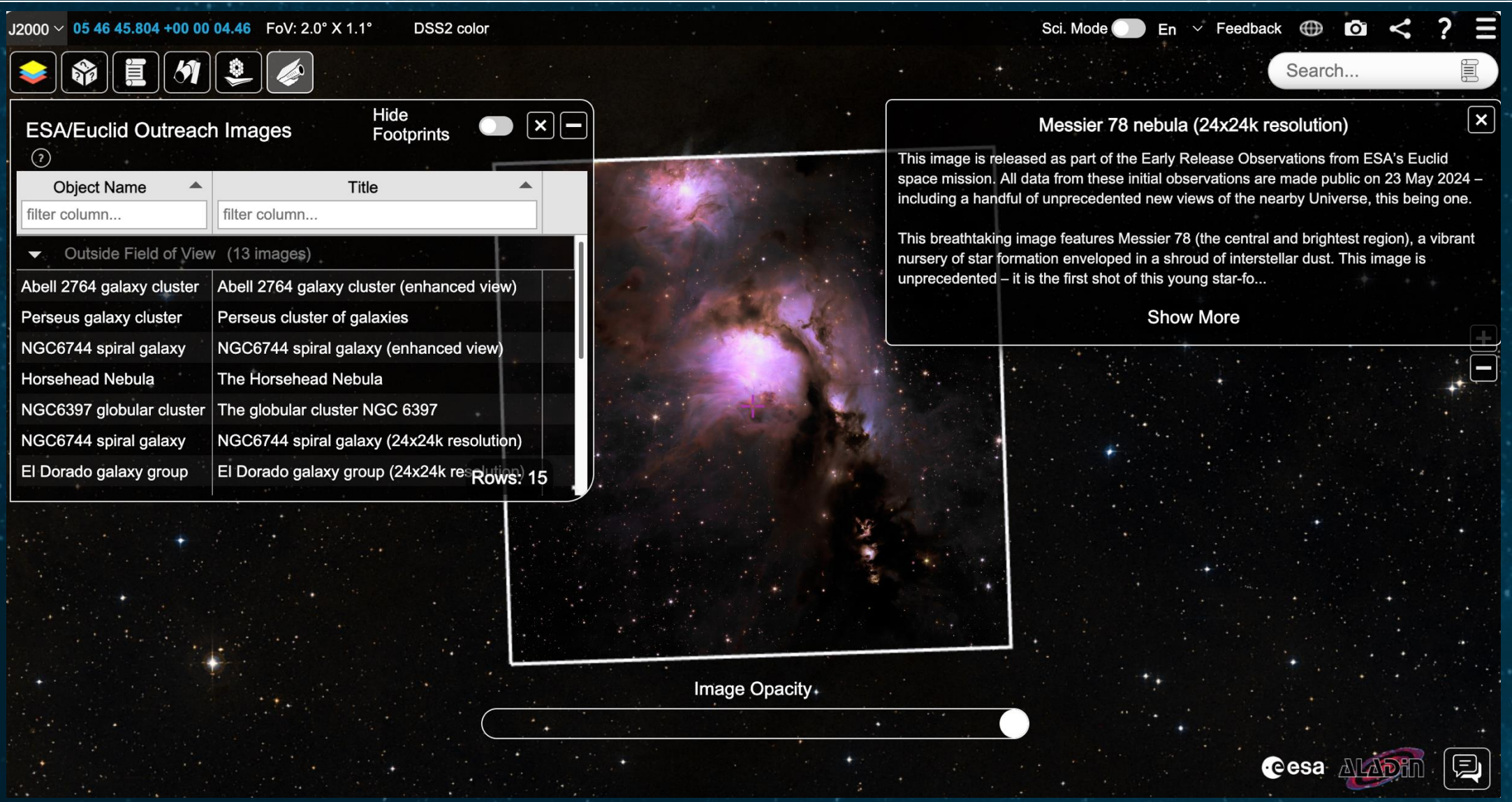

Young star-forming region of Messier 78
EARLY RELEASE OBSERVATIONS
Credit: ESA/Euclid/Euclid Consortium/NASA, image processing by J.-C. Cuillandre (CEA Paris-Saclay), G. Anselmi

# Early Release Observations

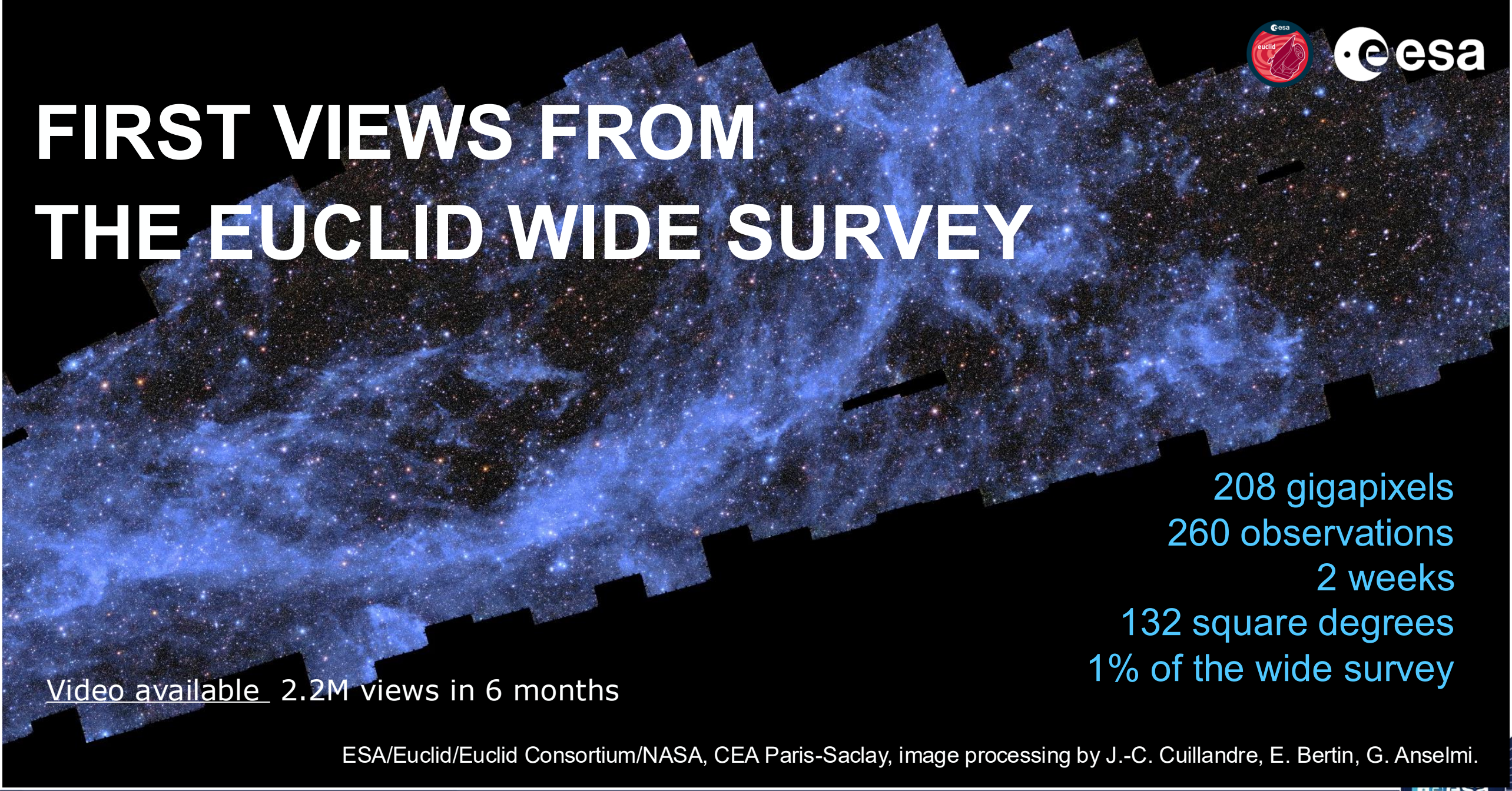
sky.esa.int

Credit: ESA/Euclid/Euclid Consortium/NASA, image processing by J.-C. Cuillandre (CEA Paris-Saclay), G. Anselmi

https://sky.esa.int/



# FIRST VIEWS FROM THE EUCLID WIDE SURVEY



208 gigapixels
260 observations
2 weeks
132 square degrees
1% of the wide survey

Video available 2.2M views in 6 months

ESA/Euclid/Euclid Consortium/NASA, CEA Paris-Saclay, image processing by J.-C. Cuillandre, E. Bertin, G. Anselmi.

# Euclid: A complete Einstein ring in NGC 6505

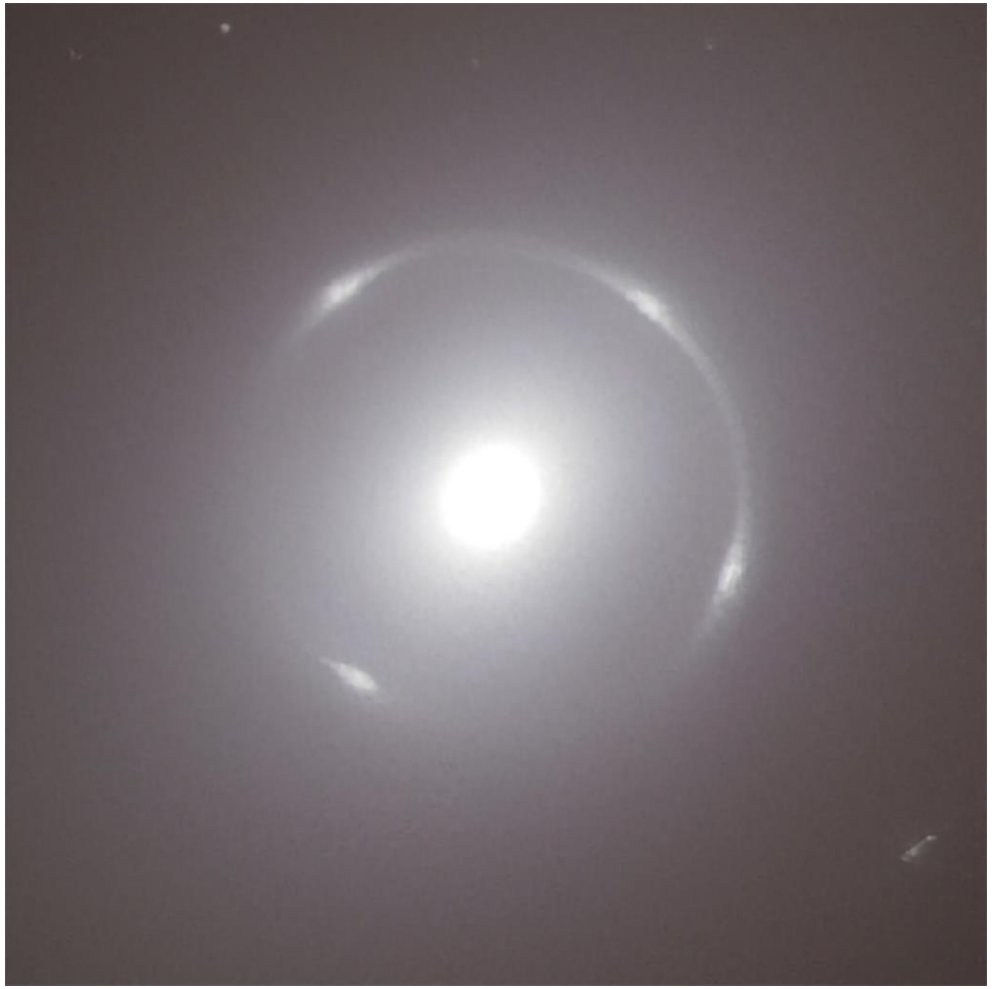
- Scientists (B.Altieri, ESA archive scientist) discovered a complete Einstein Ring within galaxy NGC 6505, within the images of the testing phases observed in September 2023

- NGC 6505 is a well-known galaxy only around 590 million light-years from Earth, and Euclid's discovery of a complete Einstein ring here was unexpected.

- Combining the strong lensing measurements with analysis of the spectroscopic data, Conor etal 2025 estimate a dark matter fraction inside the Einstein radius of about 11%.

- ESA press release (+ Euclid Consortium, NASA): https://www.esa.int/Science_Exploration/Space_Science/Euclid/Euclid_discovers_a_stunning_Einstein_ring

- In the news (The Guardian, CNN, APOD, etc)



C. M. O'Riordan et al (2025, *Astronomy & Astrophysics*. DOI: 10.1051/0004-6361/202453014)

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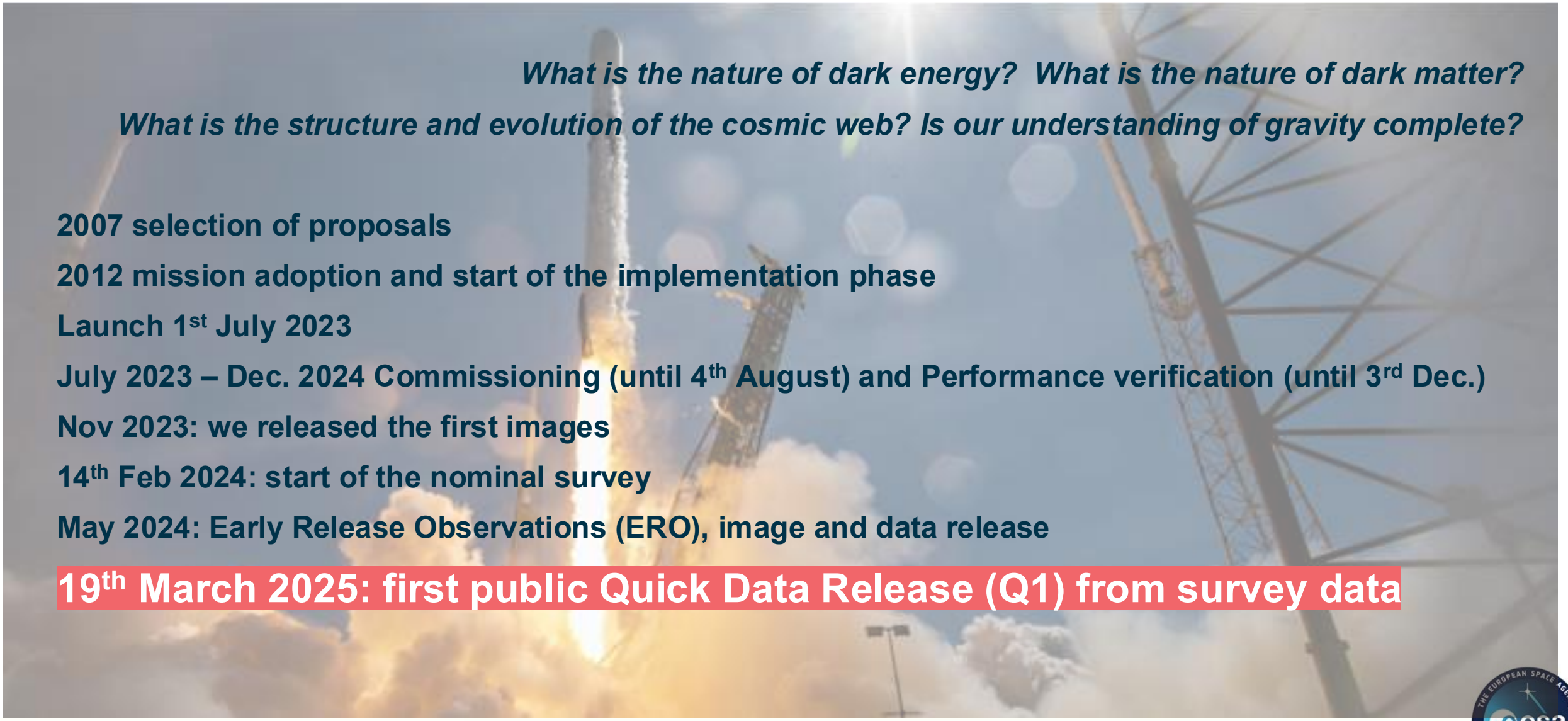

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**May 2024: Early Release Observations (ERO), image and data release**

**19th March 2025: first public Quick Data Release (Q1) from survey data**

# The Q1 Euclid data release

**19th March 2025: first survey data release**

**Time**: 1 week of observations

**Area**: 63.1 deg2 of the Euclid Deep Fields (EDFs).

**Data**: 35 TB, with visible and near-infrared imaging and spectroscopic data, ground-based photometry, masks.

**Sources**: 26 millions galaxies, for a total of almost 30 millions of sources.

**Scientific papers**: 27 scientific papers + 7 reference papers describing the complex processing

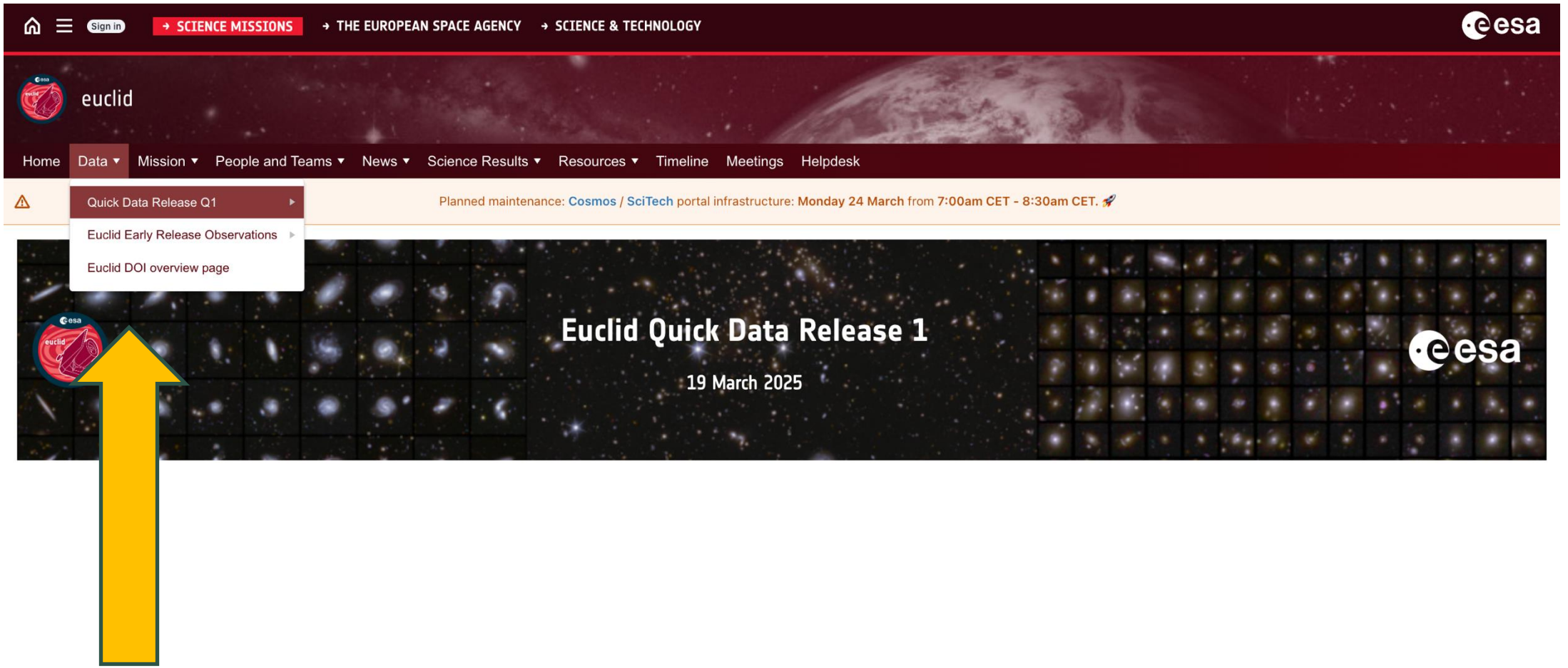
**Data Access**: available through the Euclid science archive at ESAC, with tools for querying and visualizing data and through ESA Datalabs, including tutorials.

**Q1 Data Release Overview**: Aussel et al 2025

with a detailed description of the data processing pipeline, including calibration, stacking, and catalog extraction.

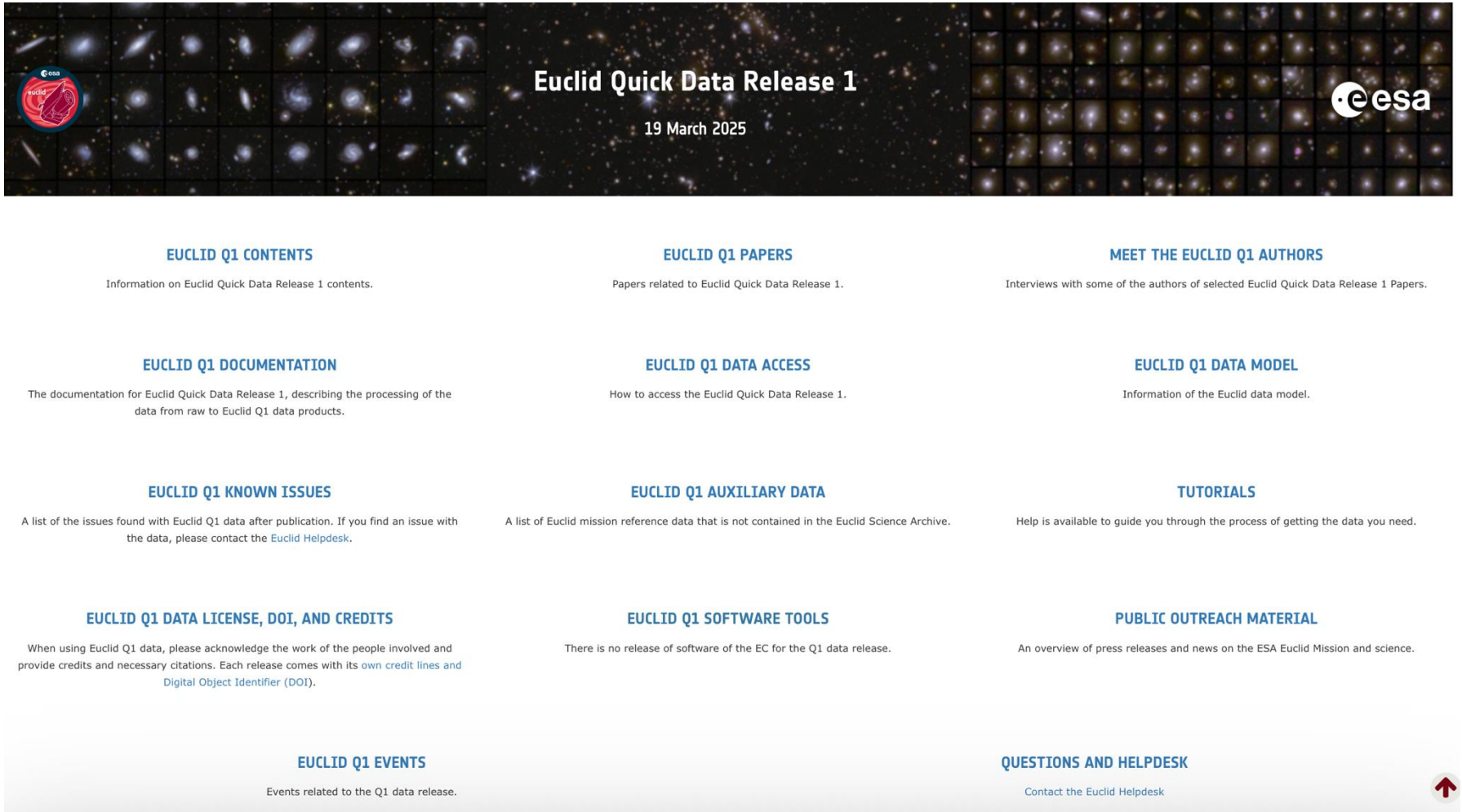
# Where to start

https://www.cosmos.esa.int/web/euclid/home



# Where to start

https://www.cosmos.esa.int/web/euclid/euclid-q1-data-release

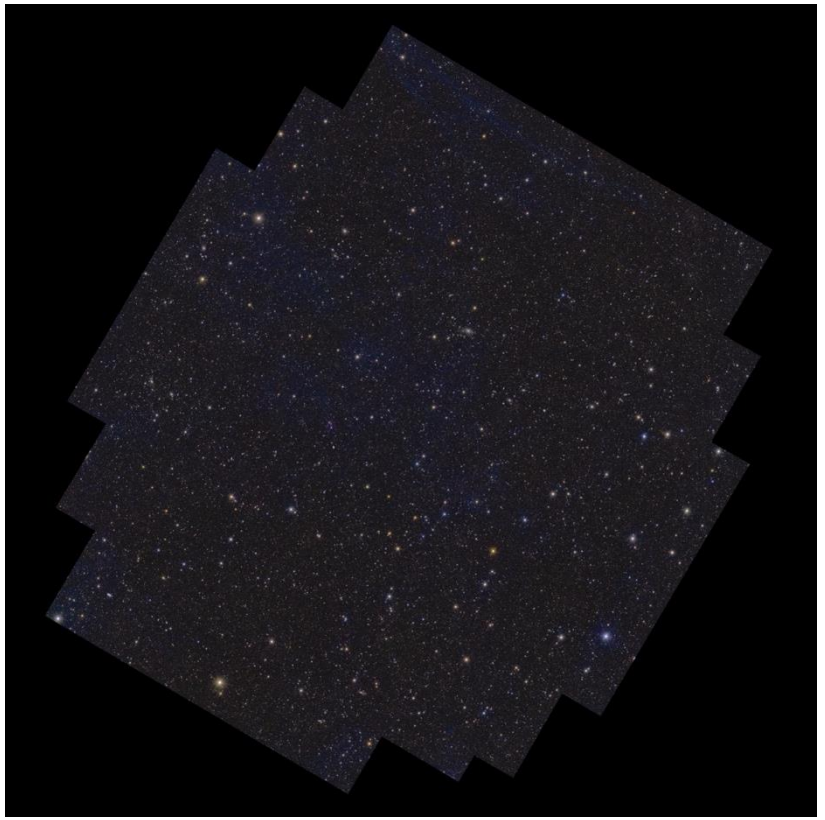



*Jos De Bruijne, Cristina Hernandez De La Torre,*
*Sandor Kruk, Bruno Altieri, Sara Nieto, Anna Rudolsfen, VP*

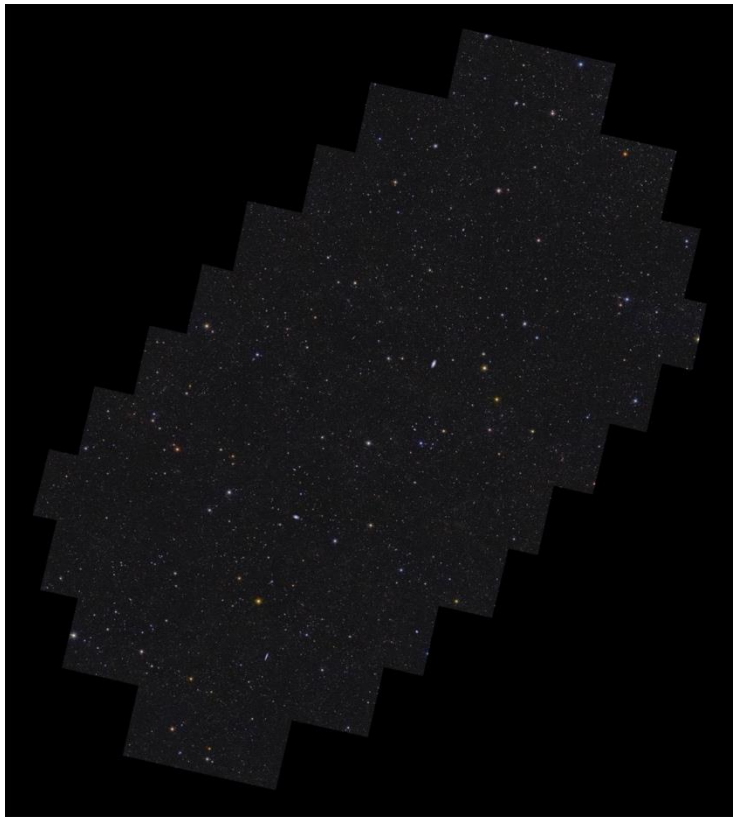
# The Euclid deep fields

https://sky.esa.int/

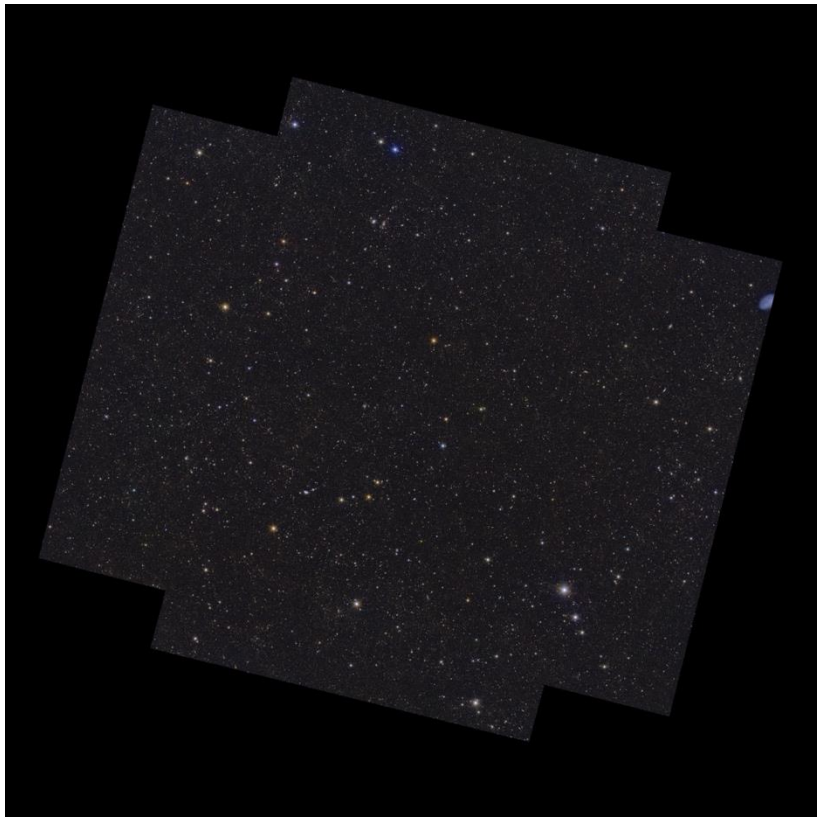
A single visit over the Euclid Deep Fields



**Euclid Deep Field North**
22.9 deg2



**Euclid Deep Field South**
28.1 deg2



**Euclid Deep Field Fornax**
12.1 deg2

Credits: ESA/Euclid/Euclid Consortium/NASA, image processing by J.-C. Cuillandre, E. Bertin, G. Anselmi

# Q1 broad scientific areas

The area released in Q1 is not large enough for cosmological studies, but it is illustrative of how Euclid data are useful for a variety of purposes in astronomy.

**Galaxy Morphology**: *Walmsley et al, Huertas-Company et al, Siudek et al, Quilley et al*

**Star-forming galaxies**: *Enia et al, Girardi et al, Bisigello et al*

**Passive galaxies and galaxy quenching**: *Corcho-Caballero et al*

**Active Galactic Nuclei evolution**: *Matamoro Zatarain et al, Roster et al, Steven et al, Margalef-Bentabol et al, La Marca et al, Tarsitano et al*

**Cosmic environment**: *Cleland et al, Laigle et al, Gouin et al*

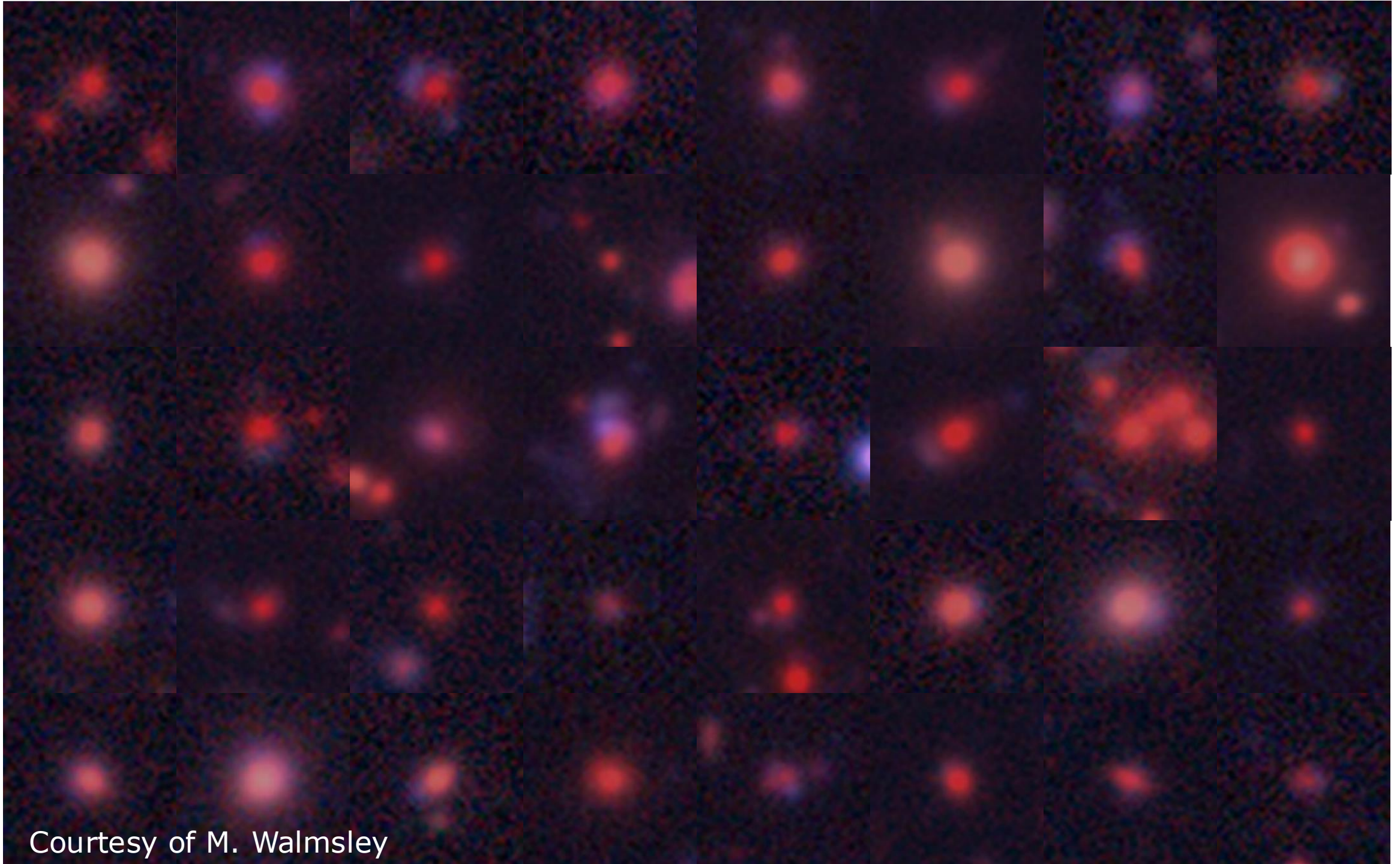
**Strong Lenses**: *Walmsey et al, Rojas et al, Lines et al, Li et al, Holloway et all, Busillo et al*

**Galaxy Clusters**: *Bergamini et al, Mai et al*

**Transients:** *Duffy et al*

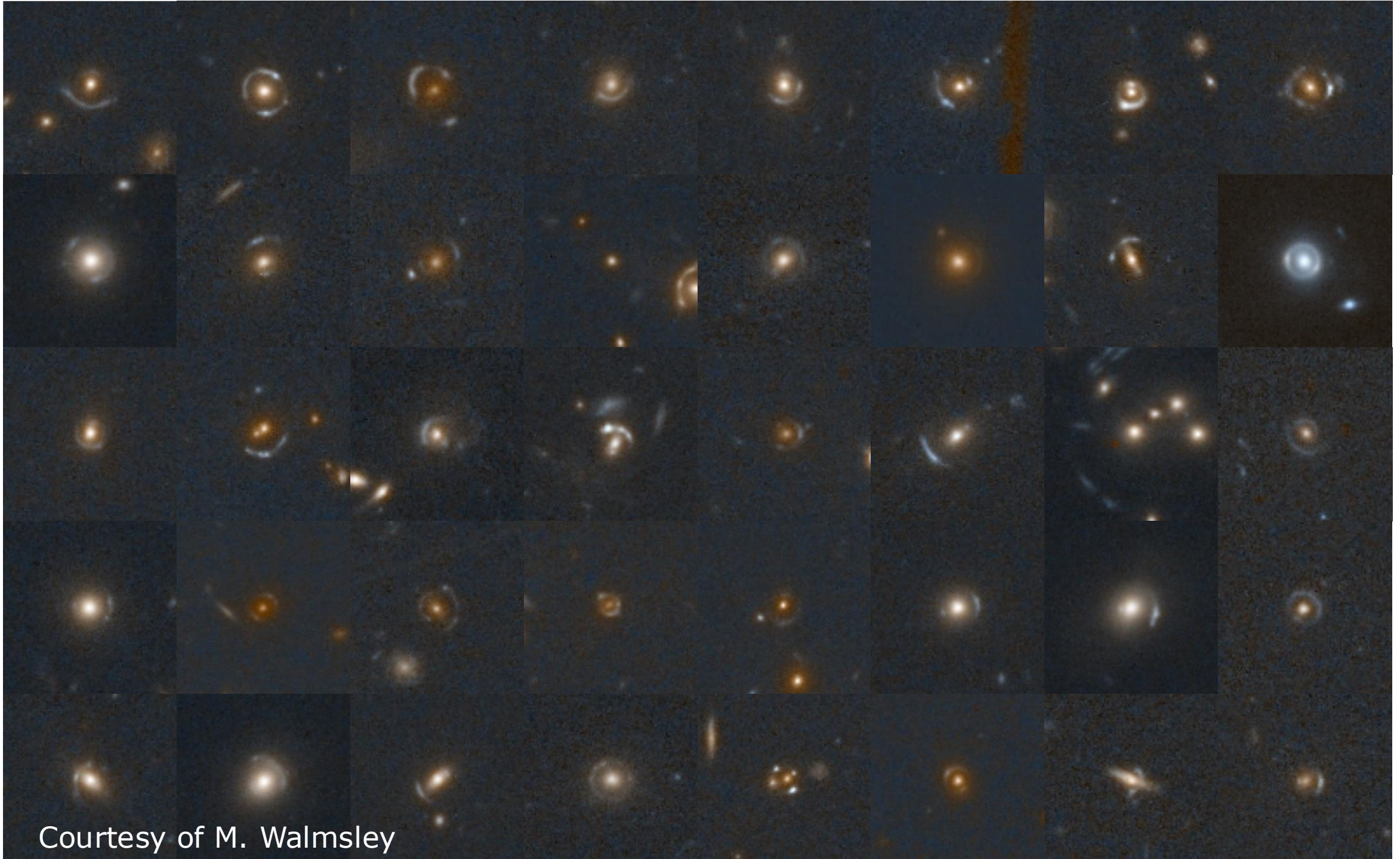
**Nearby galaxies**: *Marleau et al*

Images from Legacy Survey (South, DECam)



Courtesy of M. Walmsley

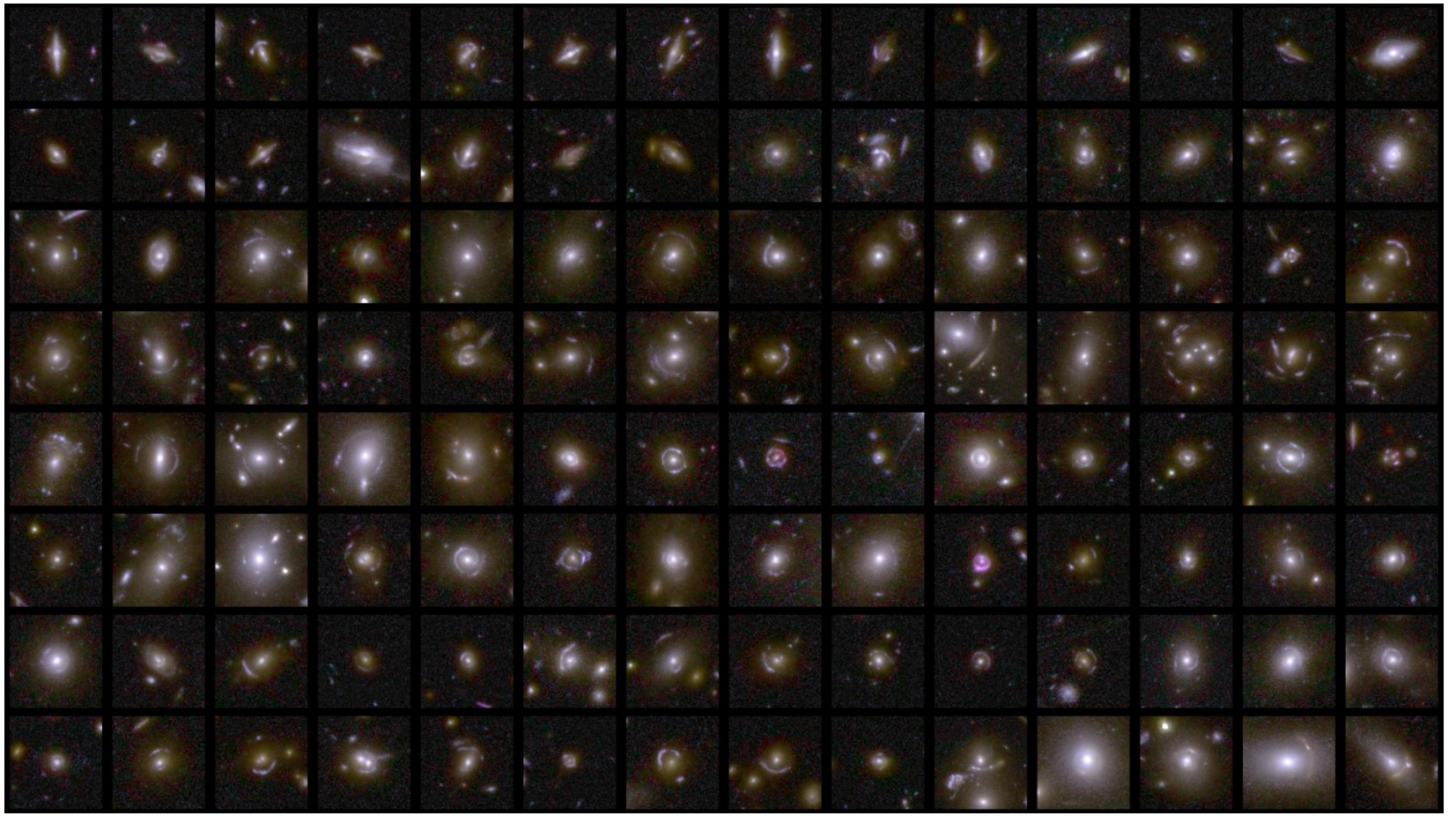
Images from Euclid Deep Field South



Courtesy of M. Walmsley

# Strong lenses

*Related papers: Walmsey et al, Rojas et al, Lines et al, Li et al, Holloway et all, Busillo et al*



Credits: ESA/Euclid/Euclid Consortium/NASA, image processing by M. Walmsley, M. Huertas-Company, J.-C. Cuillandre

A first catalogue of 500 galaxy-galaxy strong lens candidates was created, almost all of which were previously unknown (***Walmsey et al***).

This type of lensing happens when a foreground galaxy and its halo of dark matter acts as a lens, distorting the image of a background galaxy along the line of sight towards Euclid.

# Galaxy morphology

*Related papers: Walmsley et al, Huertas-Company et al, Siudek et al, Quilley et al*

Credits: ESA/Euclid/Euclid Consortium/NASA, image processing by M. Walmsley, M. Huertas-Company, J.-C. Cuillandre

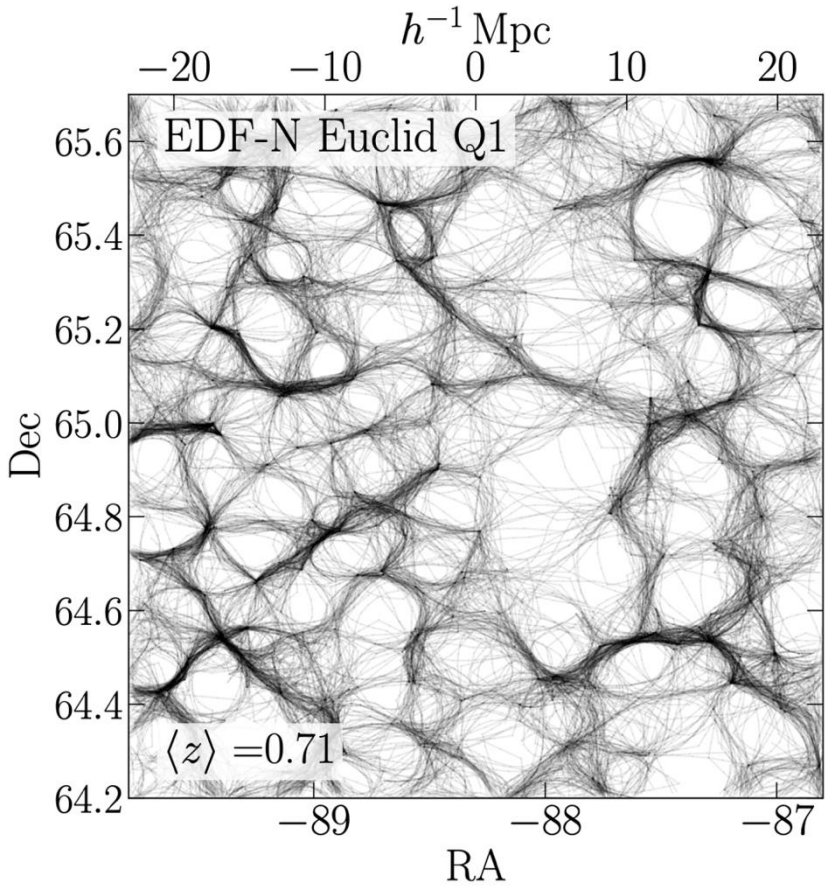
As part of the data release, a detailed catalogue of more than 380 000 galaxies was published, which have been classified according to features such as spiral arms, central bars, and tidal tails that infer merging galaxies.

Galaxy Zoo & deep learning

Trace the abundance of stellar bars over time, which is influencing bulge growth and star formation: identified 7711 barred galaxies (***Huertas-Company et al***)

# Cosmic environment

*Related papers: Cleland et al, Laigle et al, Gouin et al*




*The cosmic web plays a crucial role in cluster properties.*

***Gouin et al** show that clusters predominantly made up of elliptical galaxies are more strongly connected to filaments than those dominated by disk galaxies. The more massive a cluster is, the stronger its connection to these cosmic filaments.*

***Laigle et al** measure variations of morphologies depending on their proximity to these cosmic filaments. Shapes and orientation changes also depending on how close the galaxy is to filaments*

***Cleland et al** studies how the environment plays a significant role in transforming galaxies from star-forming to passive.*

Laigle et al, https://arxiv.org/abs/2503.15333, Fig. B3
Visualisation of the cosmic web reconstruction based on the Q1 data in the EDF-North.

# What's next

**Cosmology DR1 data release** in October 2026

| Quick Release 1 | | Data Release 1 |
|---|---|---|
| **Time**: 1 week | ⇨ | 1 year of observations |
| **Area**: 62.1 deg2 | ⇨ | ~1900 deg2 |
| **Data**: 35 TB | ⇨ | ~2.5 PT data |
| **Papers**: 34 | ⇨ | first results on cosmology! |

# Early Career Opportunities at ESA

**Calls open to nationals of ESA member & cooperating states only**

**Student internships (3-6 months)**
- applications due ~Oct
- master students (penultimate/final year)

**National trainee programme (1+1 year)**
- timelines determined by national agencies
- master students (final year/recent graduates) from Belgium, Estonia, Germany, Ireland, Luxembourg, Portugal & Switzerland

**ESA graduate programme (1 year)**
- applications due ~Jan/Feb for start in Sep
- master students (final year/recent graduates)

**ESA co-funded research for PhD students & postdocs (1-1.5 years)**
- applications accepted throughout the year

**ESA Research Fellowships for postdocs (2+1 years)**
- Call in the fall

**ESA Junior Professionals (4 years)**
- Call in May, for graduates with 2-3 years of professional experience (including PhD)

# ESA Graduate Trainee Opportunities

https://www.esa.int/About_Us/Careers_at_ESA/Graduates_ESA_Graduate_Trainees

# ESA Science Research Fellowship


**What?**

- **independent postdoctoral fellowship for ESA State nationals**
- research project covering any topic in space science
- 2 + 1 years (proposal for 3rd year extension)

**Where?**

- ESTEC (Netherlands), ESAC (Spain) or STScI (USA)

**Why?**

- **100% research time** (optionally <20% functional work, e.g. archive/data science, citizen science, operations, calibration, communication)
- insights into ESA environment & activities
- mentoring from senior ESA Science Faculty members
- training available (e.g. spacecraft design, soft skills, management)
- 3500-4600€ net monthly salary (depending on location & experience)
- comprehensive health coverage

Website: https://www.cosmos.esa.int/web/space-science-faculty/opportunities/research-fellowships

contact: fellowship@cosmos.esa.int

# Research opportunities at the ESA Science Directorate

https://www.cosmos.esa.int/web/space-science-faculty/opportunities

**Visiting the Faculty**

Collaboration visits


Archival Research Visitor Programme


**Early-career research**


Research Fellowships in Space Science and Exploration for postdoctoral researchers


ESA co-funded PhD studentships via the Open space innovation platform (OSIP)


Traineeships for undergradute or Master's students

# ESA SCIENCE Newsletter

The newsletter contains calls for proposals, announcements of opportunity, news on developments of the Science Programme, research fellowship announcements, calls for memberships, job announcements, major mission updates, conference announcements, etc.

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- Software engineering
- Ground segment systems & operations
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- Earth observation & environmental science
- Planetary & space science
- Life & material sciences

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