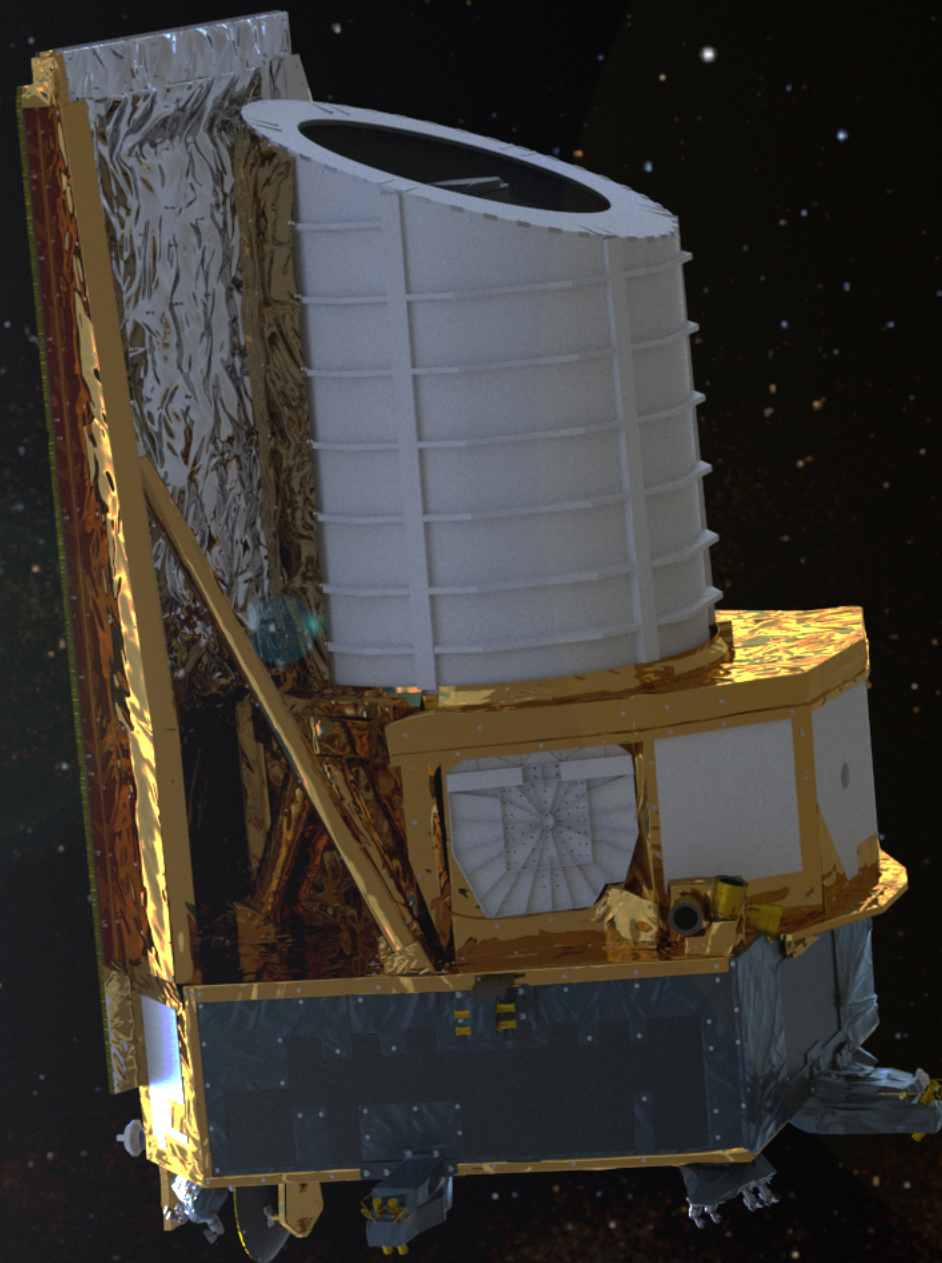




Istituto Nazionale di Fisica Nucleare



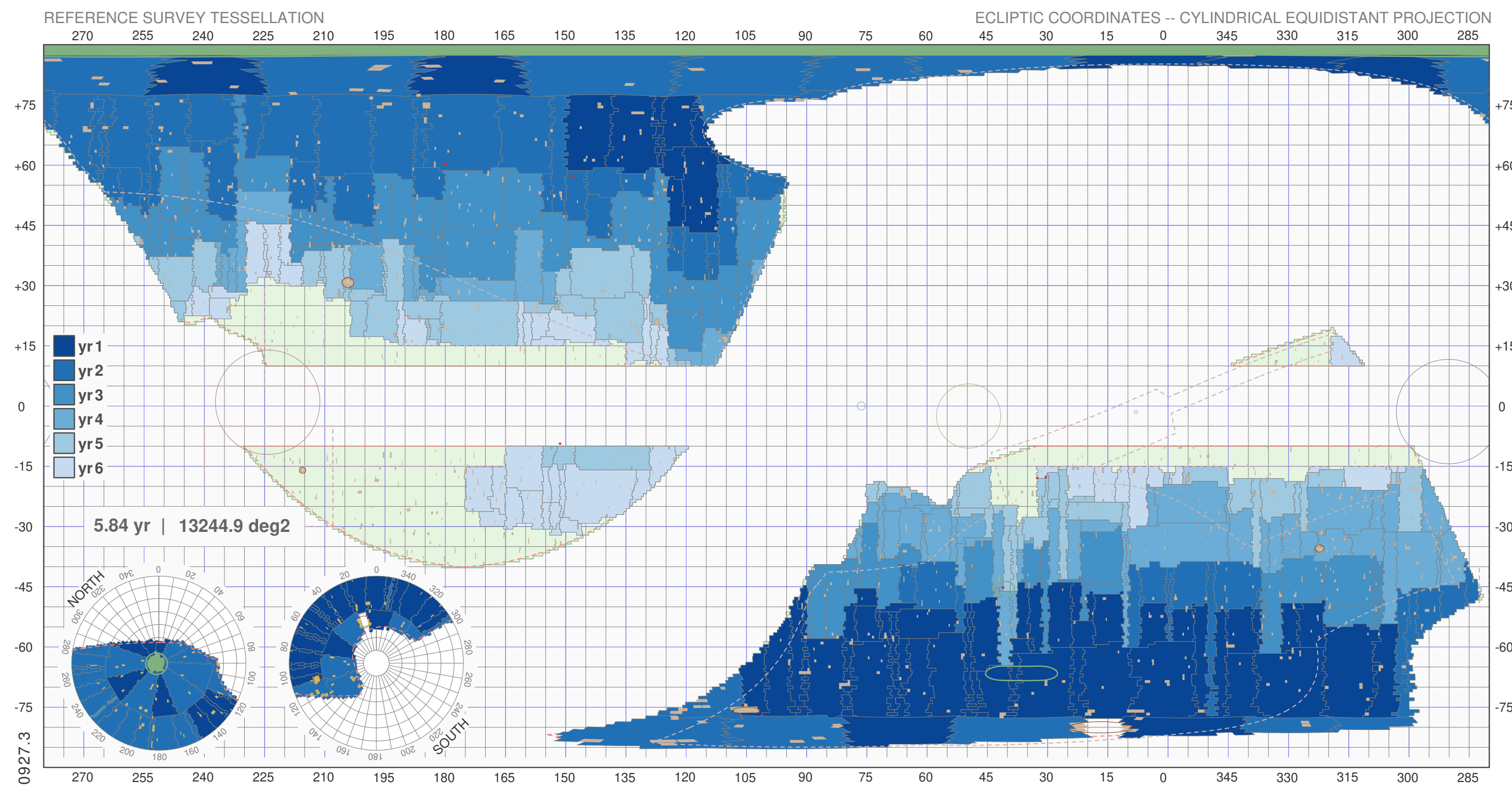
Stato della missione Euclid

Stefano Dusini
Incontro referee CSN2
Milano 1/9/2025



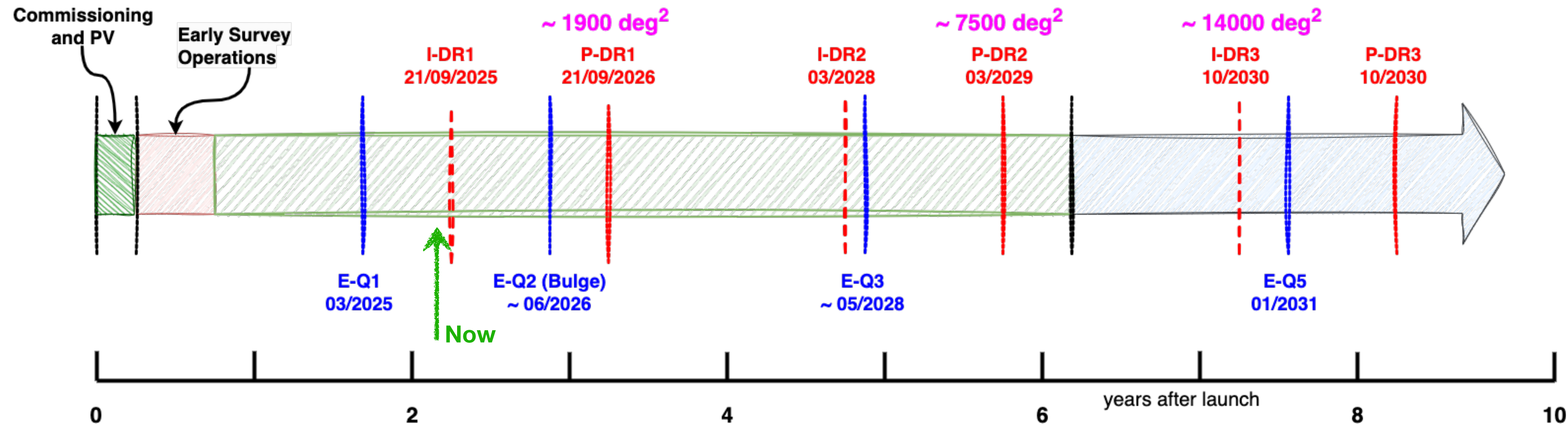
Status of Euclid mission

- **Euclid Spacecraft** and the two instruments **NISP** and **VIS** are working perfectly with a duty cycle ~99.5% 😊
- Sky area scanned (27/8): 3574 deg² , ~176k NISP images and ~83k VIS images 📡
- Fast ice formation on Folding Mirror #3 solved with second decontamination (June 2024) 🎉 😊
- Data acquired between the two decontaminations (March-June 2024) are not used for Euclid Science. Recovered in spring 2025.
- Some indication of slow formation of ice on NISP focal plane, expected not an issue.
- No sign of important degradation on VIS and NISP detectors. 😊



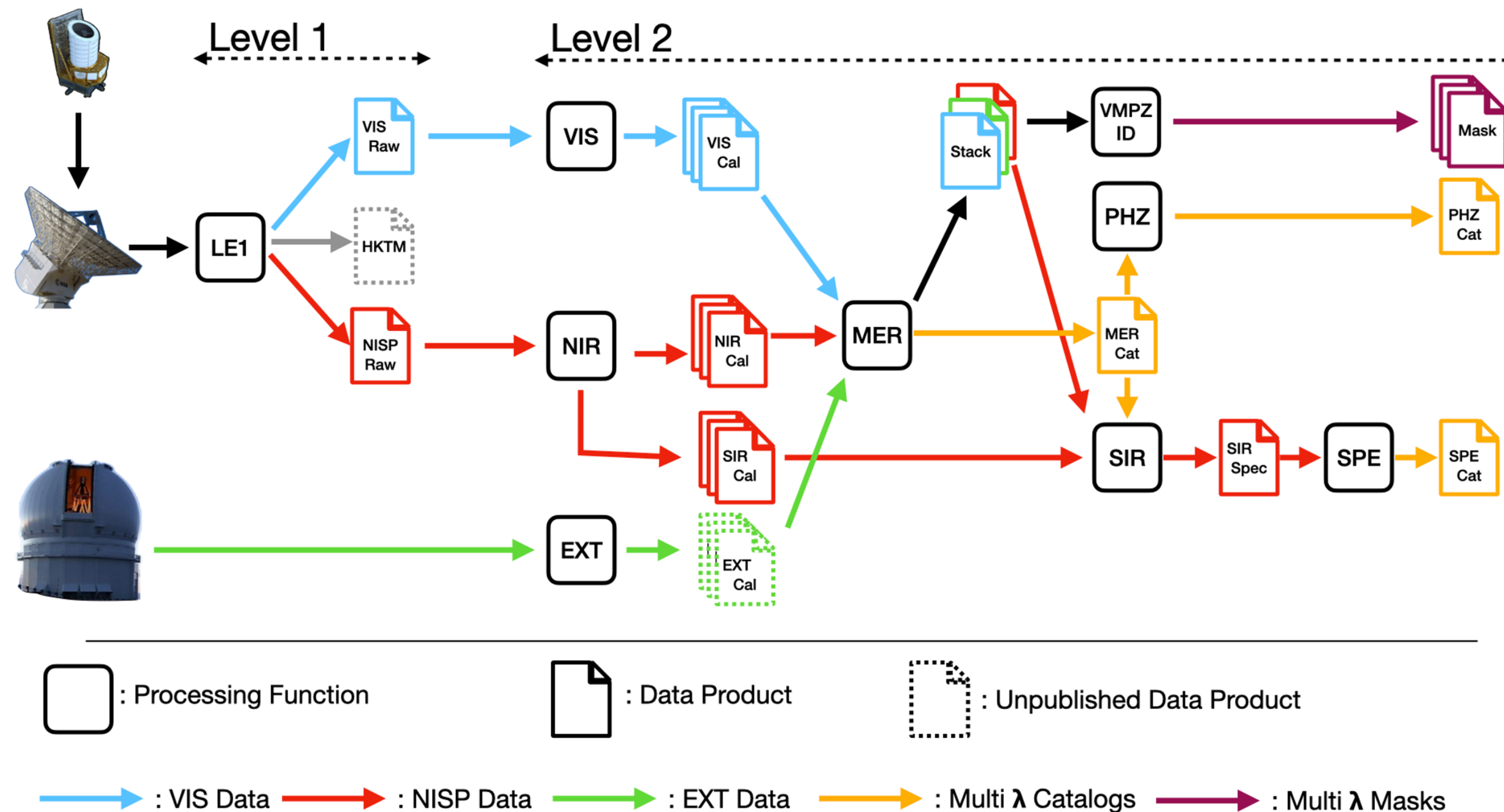
Time lost due to the ice formation and the reduced sky area of current 6 years survey (~ 13k deg²) could be recovered at the end of the mission.
-> Fuel for 14 years.

Euclid Data Release timeline

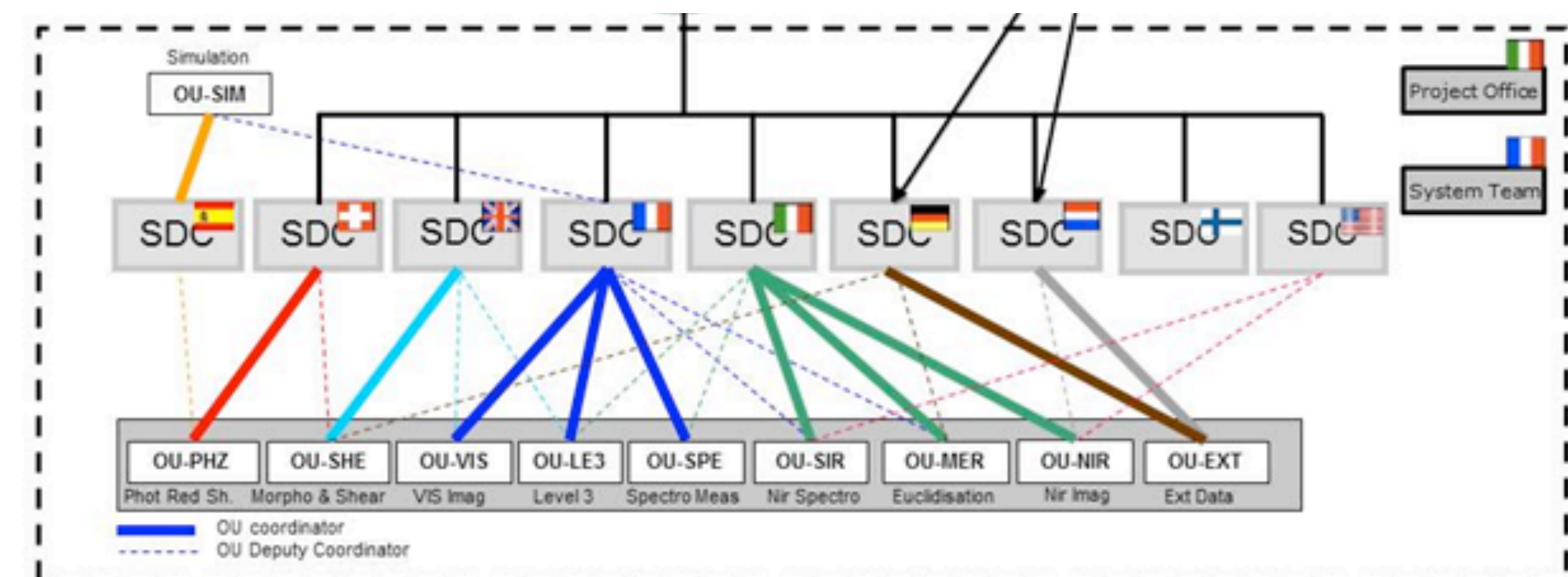


- In August 2025 Euclid Consortium (EC) and ESA revised the schedule of the Data Releases (DR).
- The **Internal Data Release (I-DR)**, i.e. to the EC working groups is **always 1 year before the public DR (P-DR)**.
- In the **new schedule DR2 and DR3** have been delayed by **9 and 4 month**, respectively.
- Delays in the I-DR will be absorbed by the Euclid Consortium, no delay in public release

Euclid Science Ground Segment (SGS)

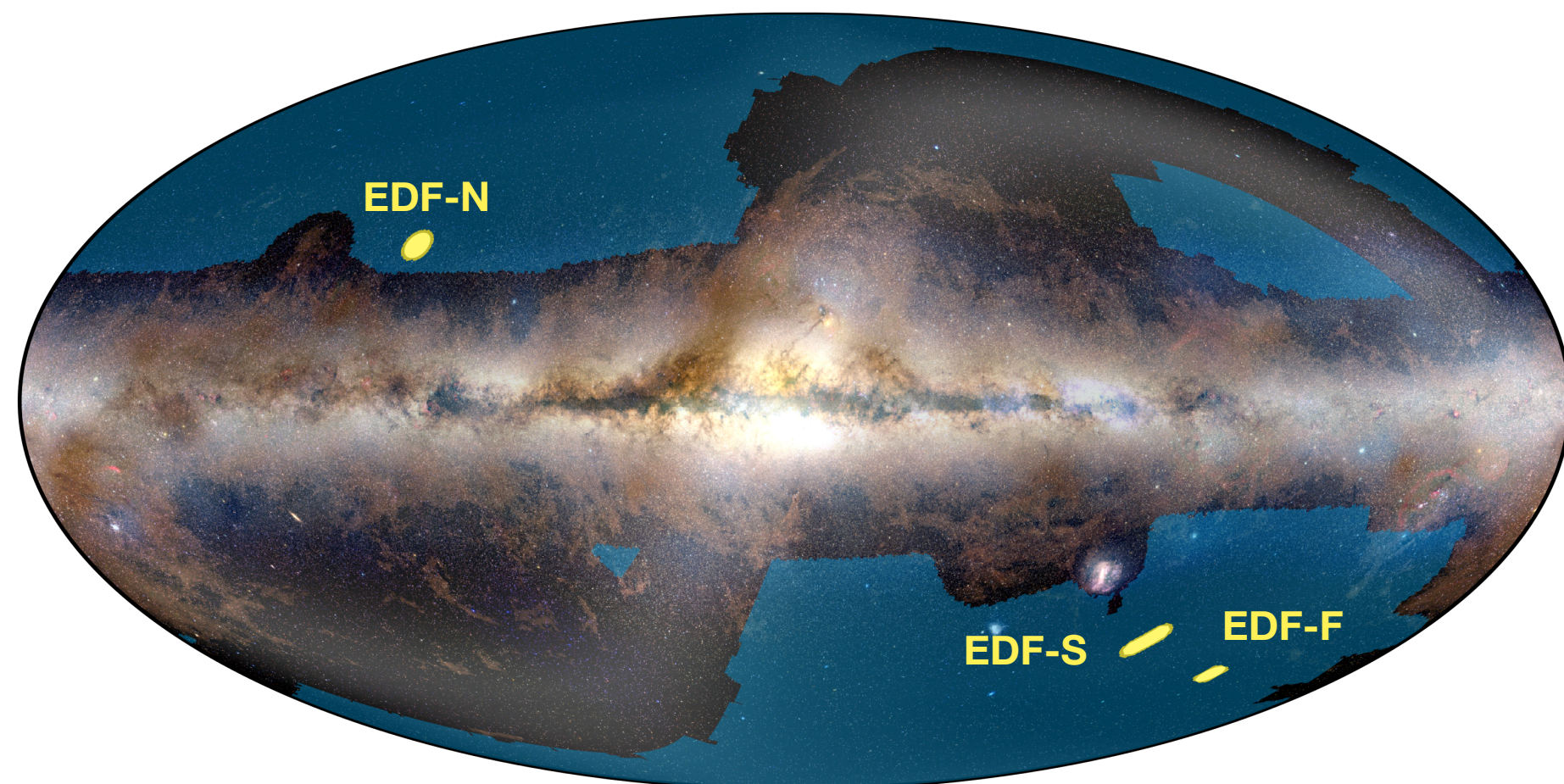


- Data processing activity is done in national Science Data Centre (SDC)
- Complex due to the need to merge different data sets (**VIS, NIR, EXT**)
- **Processing is following the data acquisition**
- **Data release are demanding** requiring regression test and reprocessing



The Q1 Data Release

- One pass of the **Euclid Deep Fields**
 - **63.1 deg²** of VIS, NISP and EXT (external) data
 - The best pass using the red grism
 - ~1/6 of overall Hubble Space Telescope
 - ~7 days of observation
- One pointing on the “Dark Cloud”



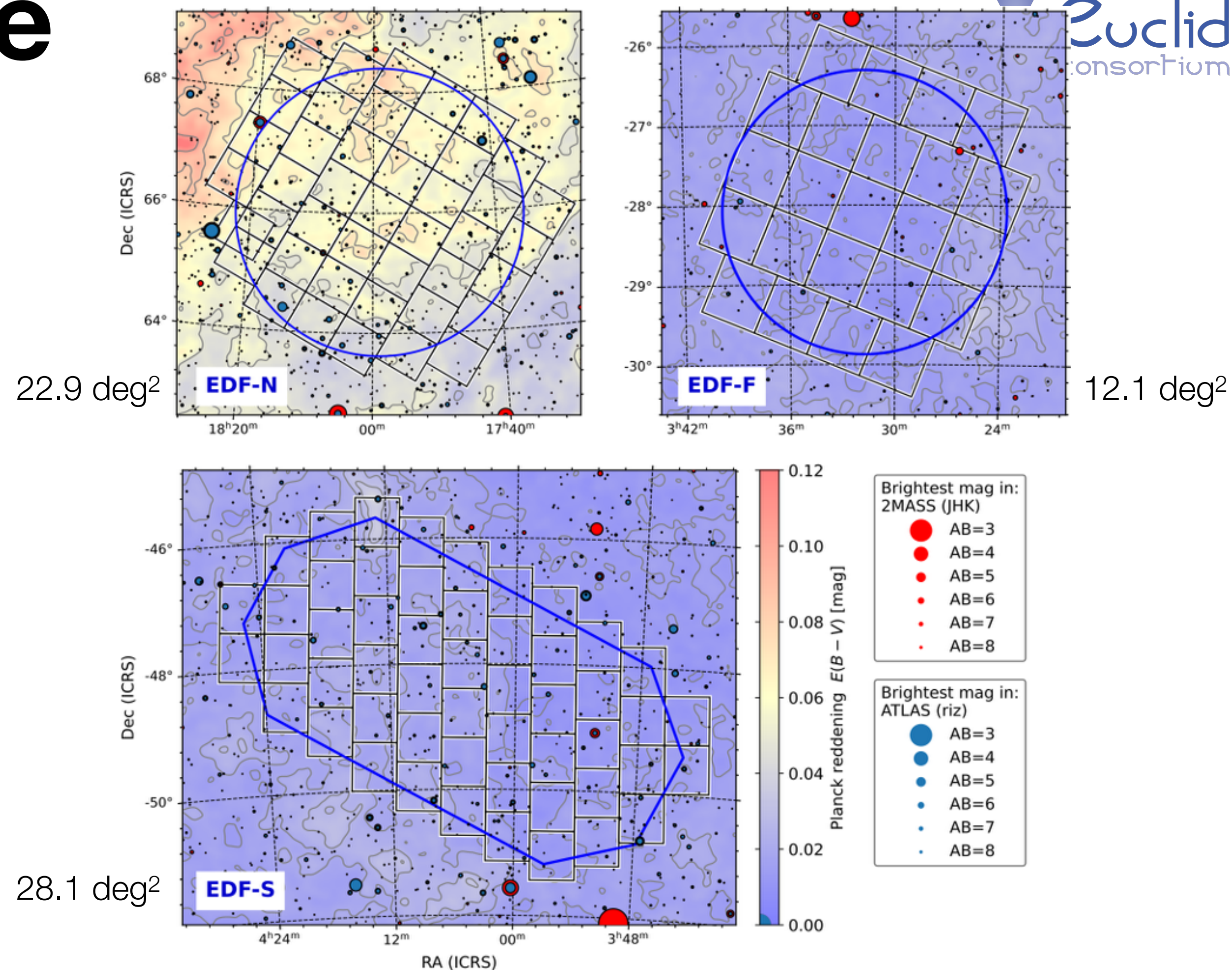
The Euclid Wide Survey and the Euclid Deep Survey

■ Euclid Wide Survey : 13,345 deg² in 6 years, avoiding the galactic plane (stars, dust) and the ecliptic plane (zodiacal light)

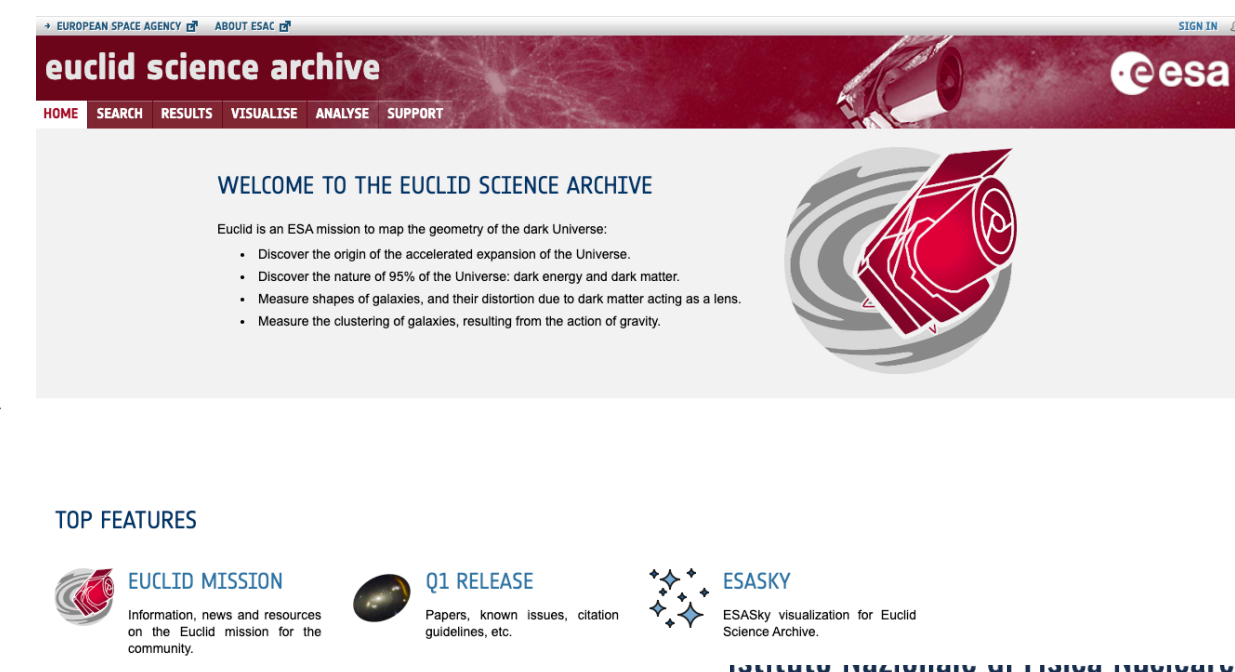
■ Euclid Deep Fields : North=20 deg² (top left), Fornax=10 deg² (bottom right), South=23 deg² [+ extended coverage]

⇒ The Euclid survey focuses on the two galactic caps to explore the extragalactic sky (total coverage = 2200 deg²/year) Background: Euclid Consortium / Planck Collaboration / A. Mellinger

40 Euclid Q1 paper submitted
mainly **Technical + Legacy Science**



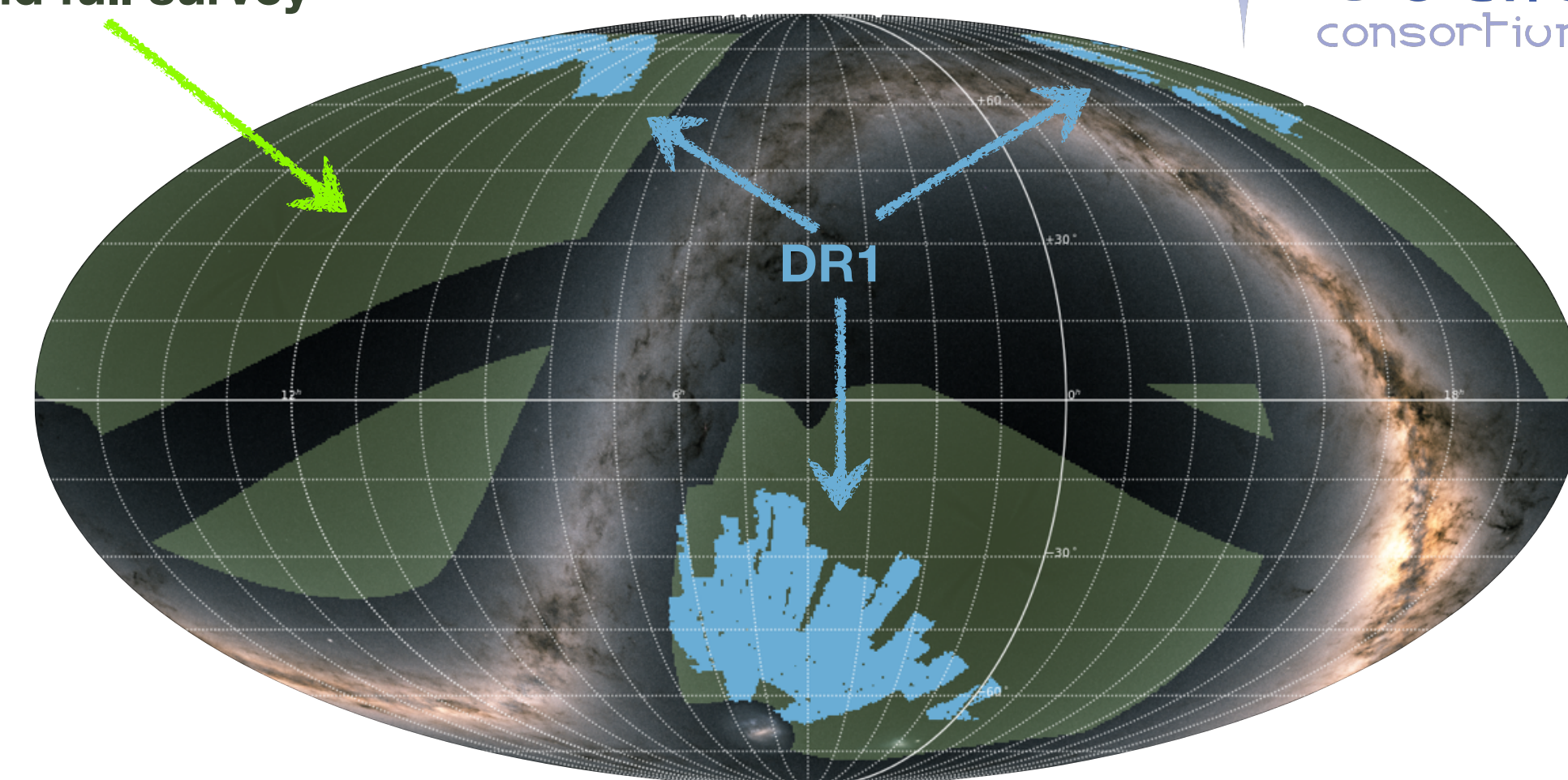
Data public available
<https://eas.esac.esa.int/sas/>



DR1 Data Release

- Content defined in [EUCL-EST-ME-8-020](#)
 - About **1900 deg² of Wide Survey** (~500 Nord, ~1400 South hemisphere)
 - Deep Field North : 8 pass red + 3 blue grism
 - Deep Field South : 10 pass red
 - Deep Field Fornax : 1 red + 1 blue
 - **All Level 1 (LE1) VIS and NISP raw images.**
 - **Valid and complete LE2 and LE3 data**
 - calibrated VIS, NIR and EXT, merged tiles, 1D spectra, redshifts, Photo-Z, shear...
 - Some calibration products
-
- **Data will be delivered to Euclid Consortium** for proprietary analysis starting **from 21/10/2025**, to the **public on 21/10/2026**
 - Due to the complexity of some data, in particular spectra, the freezing of the pipeline and the processing is in late.
 - **All LE1 and some LE2 will be delivered in October**
 - **rest of LE2 and LE3 end of 2025.**
 - **DR1 is x38 Q1** —> 1.4 PB of data including images, and 100 TB considering only the catalogs (my estimation)
 - Our plan is to **store part of the DR1 products at CNAF** to make them available via Euclid DataLake (Rucio+IAM).
We are now testing the system.

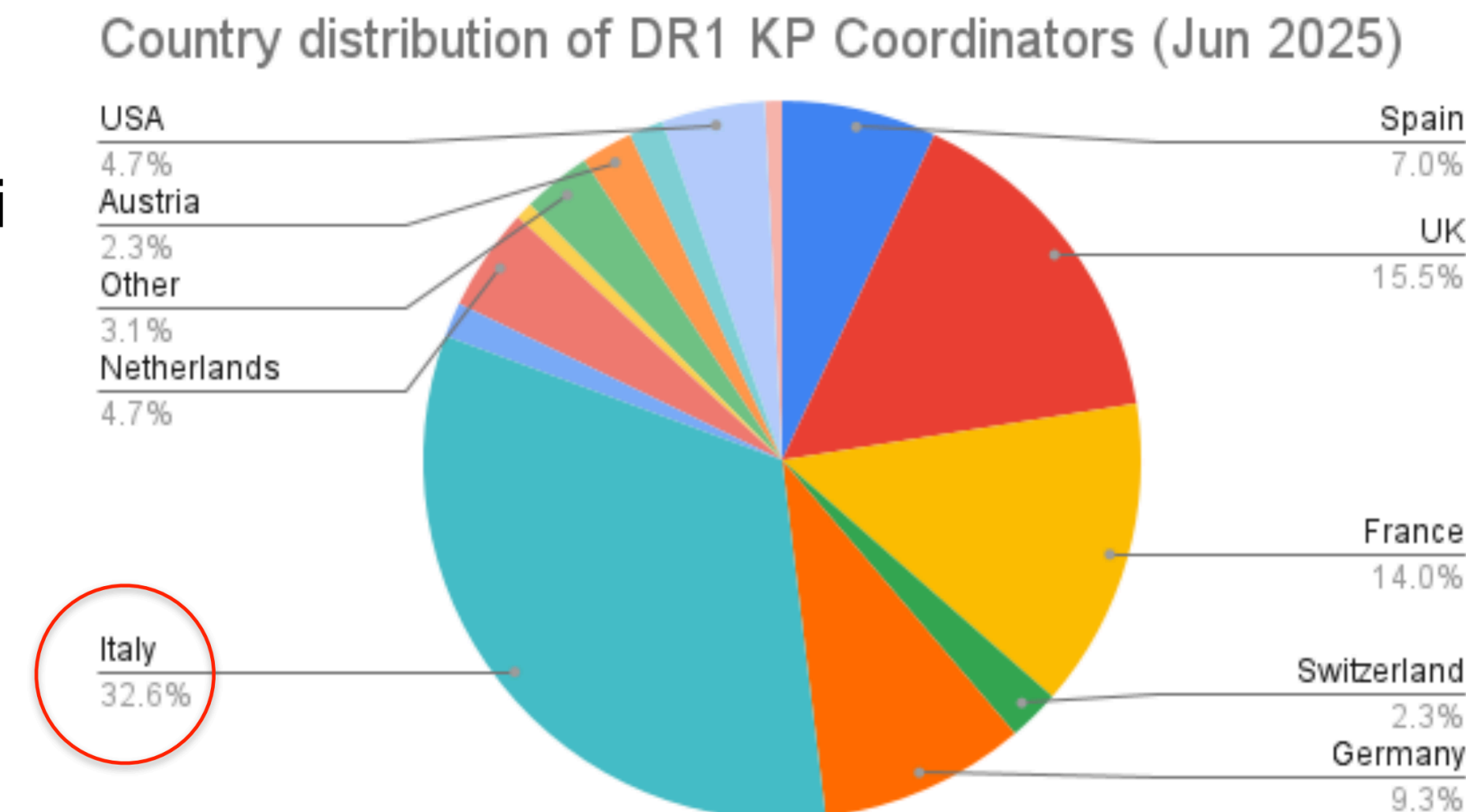
Euclid full survey



Data Analysis of DR1

L'analisi dei dati e la pubblicazione dei risultati sono organizzati in **Key e Standard Projects** (KP, SP).

- Per **DR1** in totale ci sono **74 KP**, e circa **30** sono prettamente di **cosmologia**
 - 42 dei 129 coordinatori sono Italiani,
 - 7 hanno l'affiliazione INFN (gr2 or gr4)
- Per la **DR1** si prevede di pubblicare > 300 articoli, ~100 con risultati cosmologici



ITA: 42 out of 129 coordinators

~ 7 associati INFN (gr. 2 o 4)

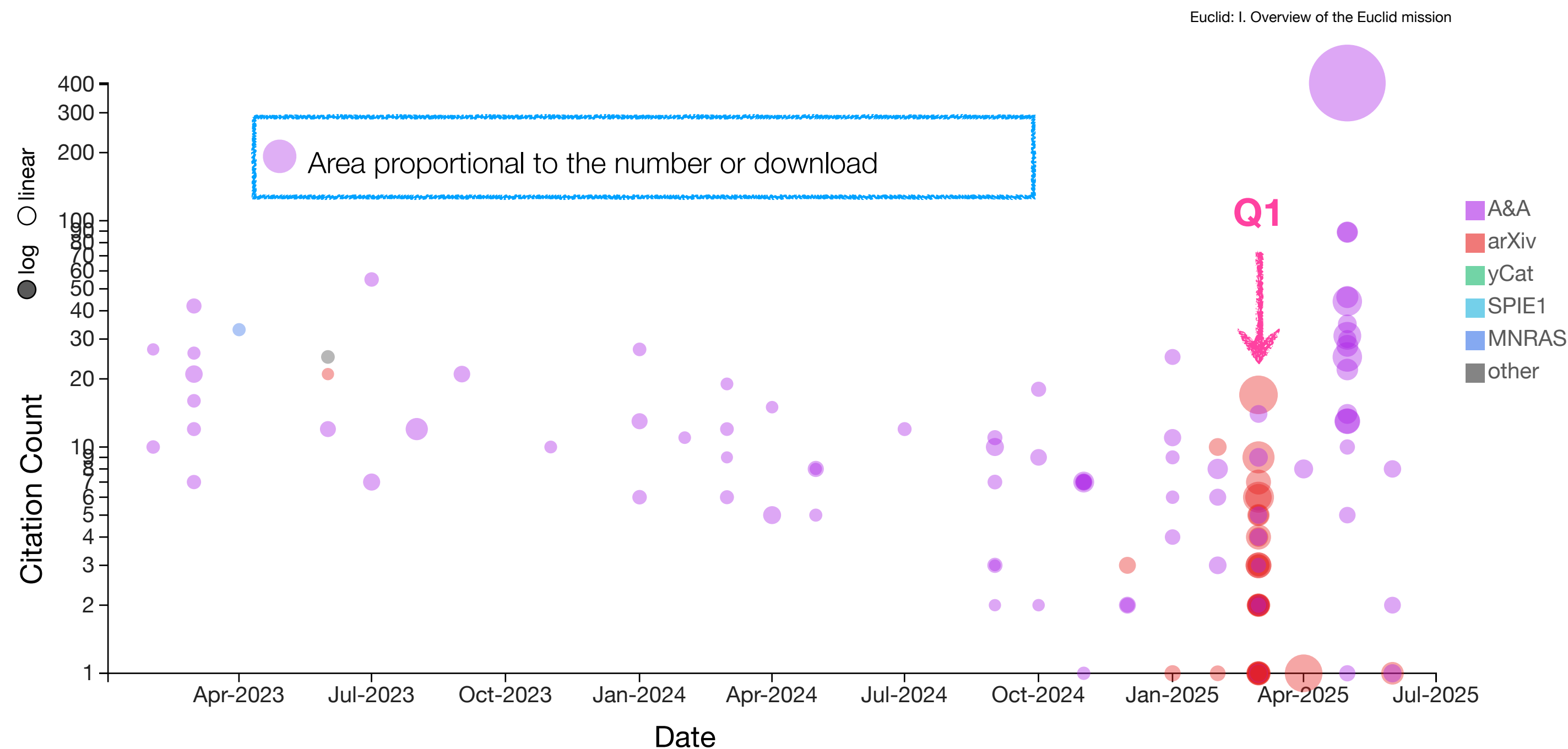
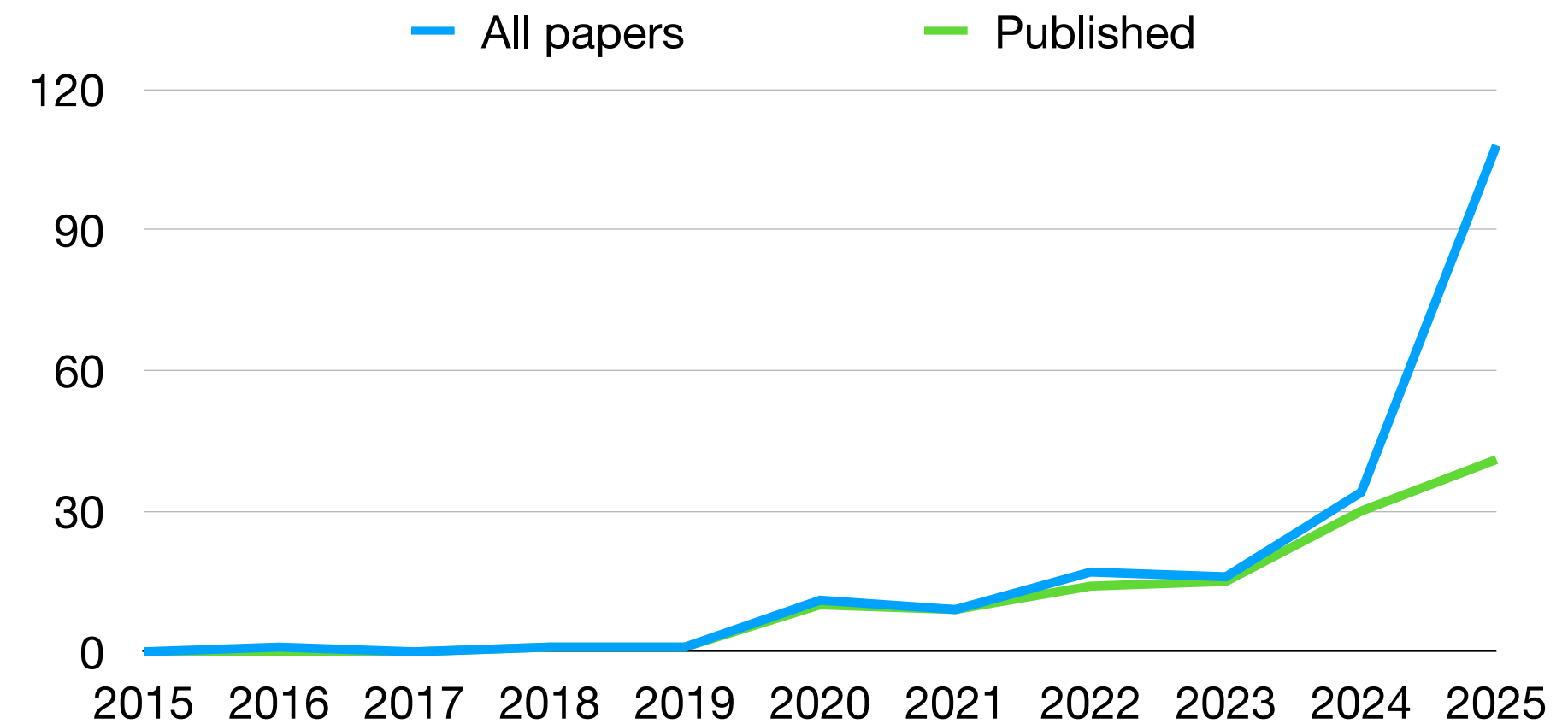
G. Guzzo, 7th Euclid Italian Meeting

- **Euclid non ha Common Funds** —> gli eventuali costi di pubblicazione sono a carico del primo autore.
- **Euclid pubblica** principalmente su ***Astrophysics & Astronomy***
- **open access** con un costo **150 euro oltre le 12 pagine + 8 appendice.**
- ASI puo' coprire il 50% di ogni pubblicazione
- Forte spinta alla "sintesi" e gli **articoli piu' lunghi verranno sottomesse a riviste senza fee**, ma.... per il 2026 chiediamo un contributo di 6.5 kEuro per spese di pubblicazione (SJ alla sottomissione)

Pubblicazioni

- Più di **200 articoli pubblicati** o sottomessi
- Dal lancio di Euclid (2023)
 - **73 articoli pubblicati**
 - **10 a prima firma INFN**, di cui **6 Gr2**
 - **42 con almeno una firma INFN** nei primi 10 autori

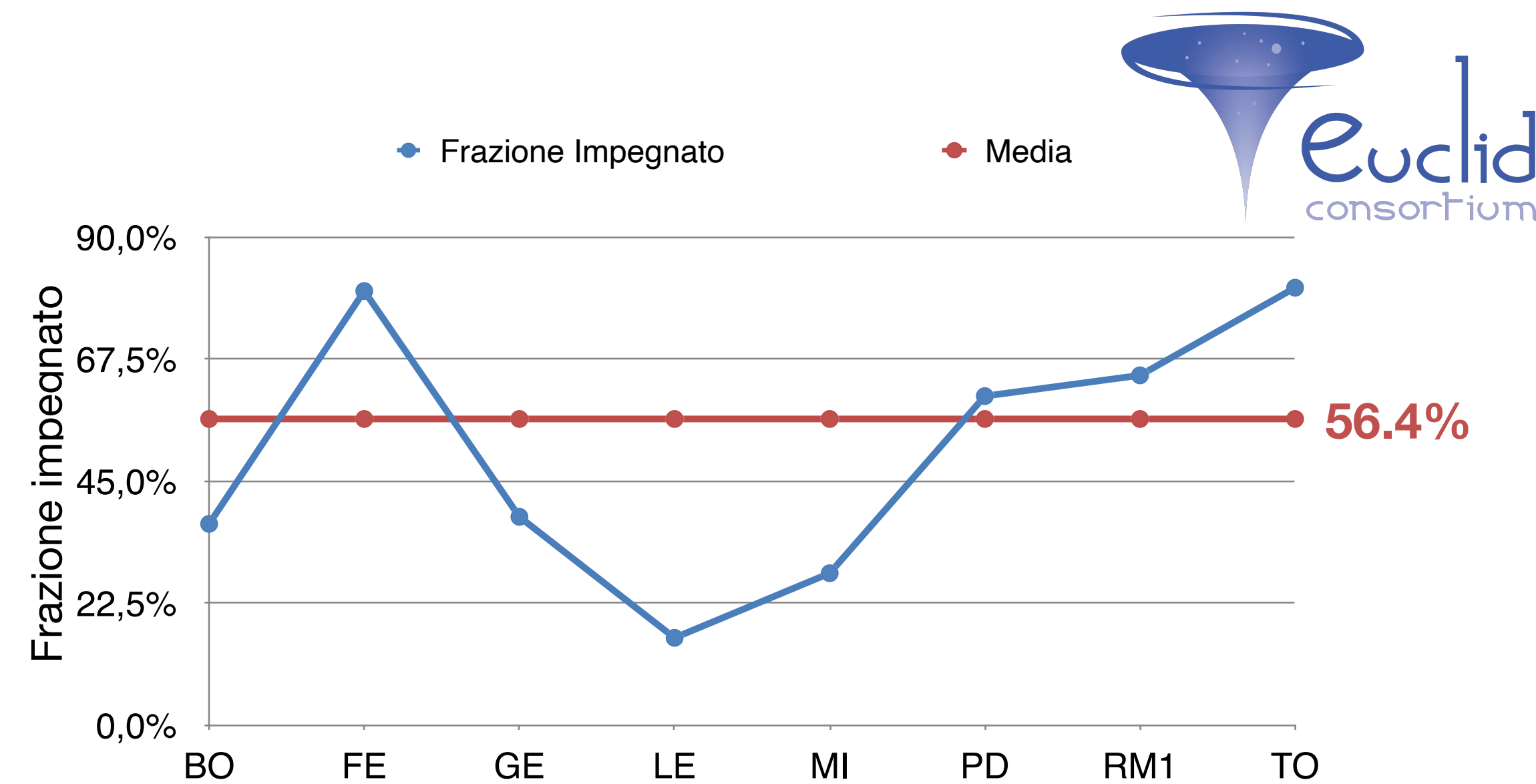
+ **40 Euclid Q1 paper** sottomessi alla rivista



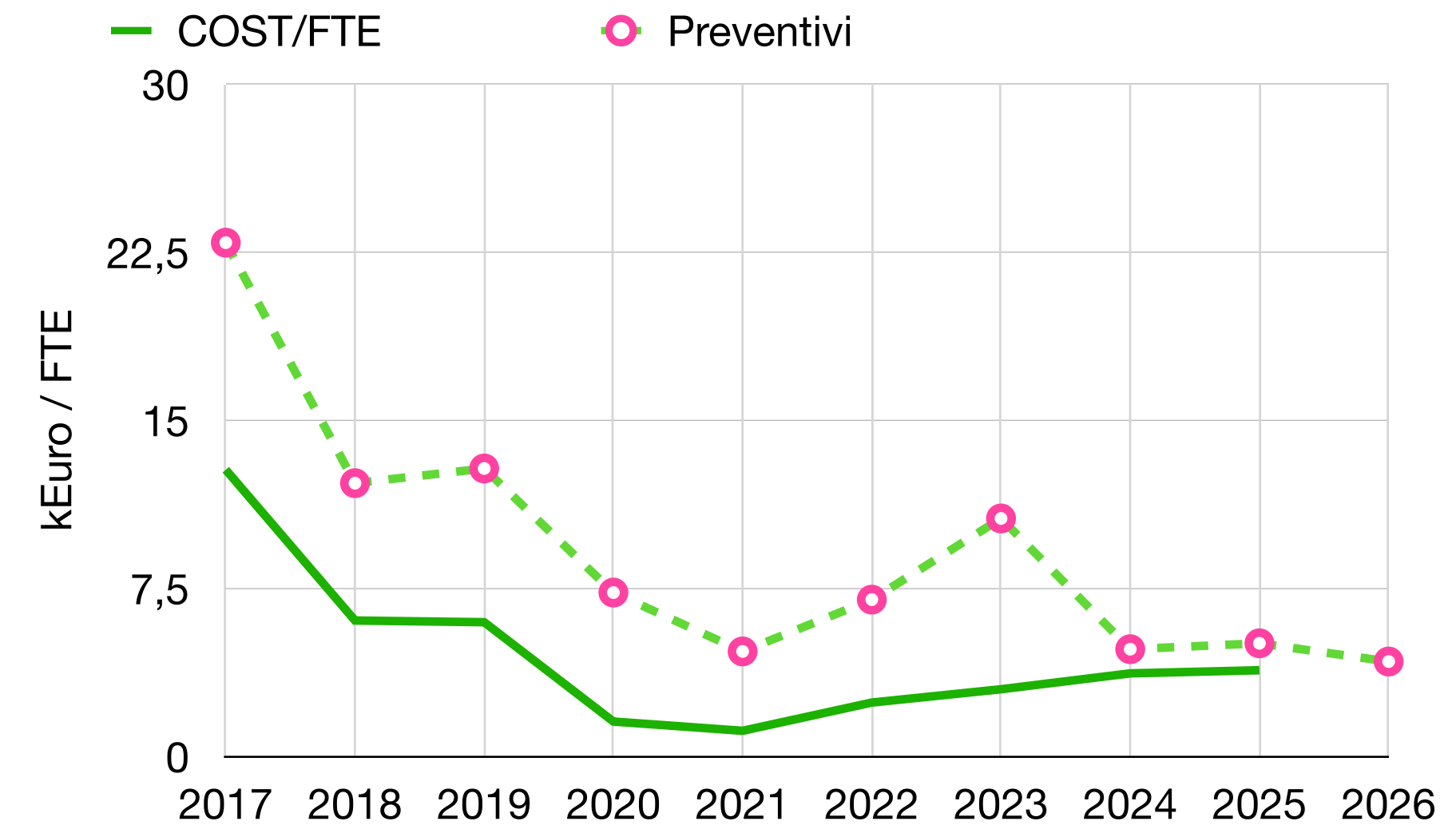
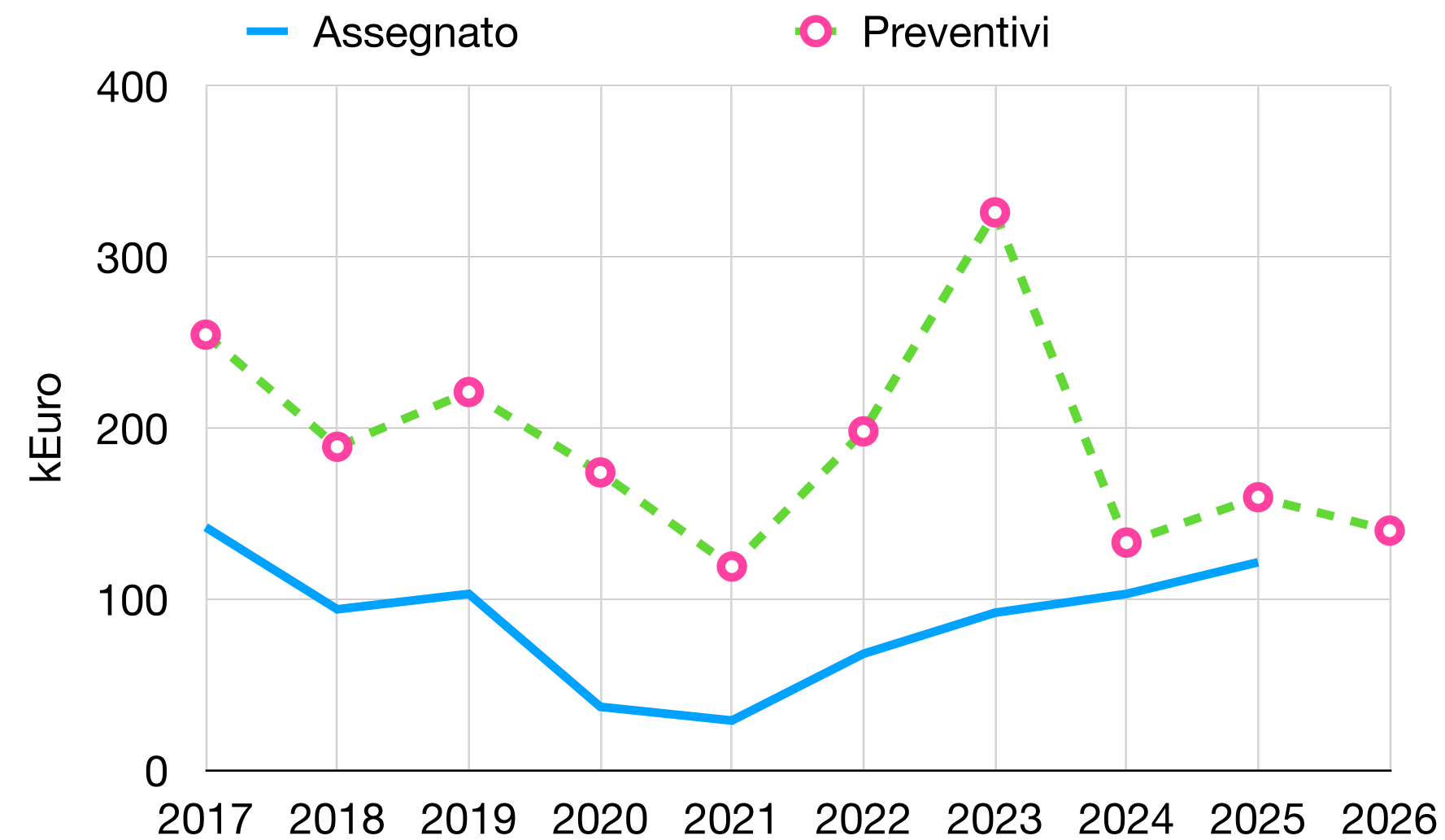
Stato finanziamenti

Profilo di spesa in linea al netto SJ con il numero di mesi 8/12

- **56.4%** (missioni) **impegnato** al 29/8
- Si prevede di spendere tutti i fondi assegnati nel 2025.
- Per **riunione di settembre definiremo la restituzione del SJ** e eventuali piccole restituzioni sui fondi ordinari

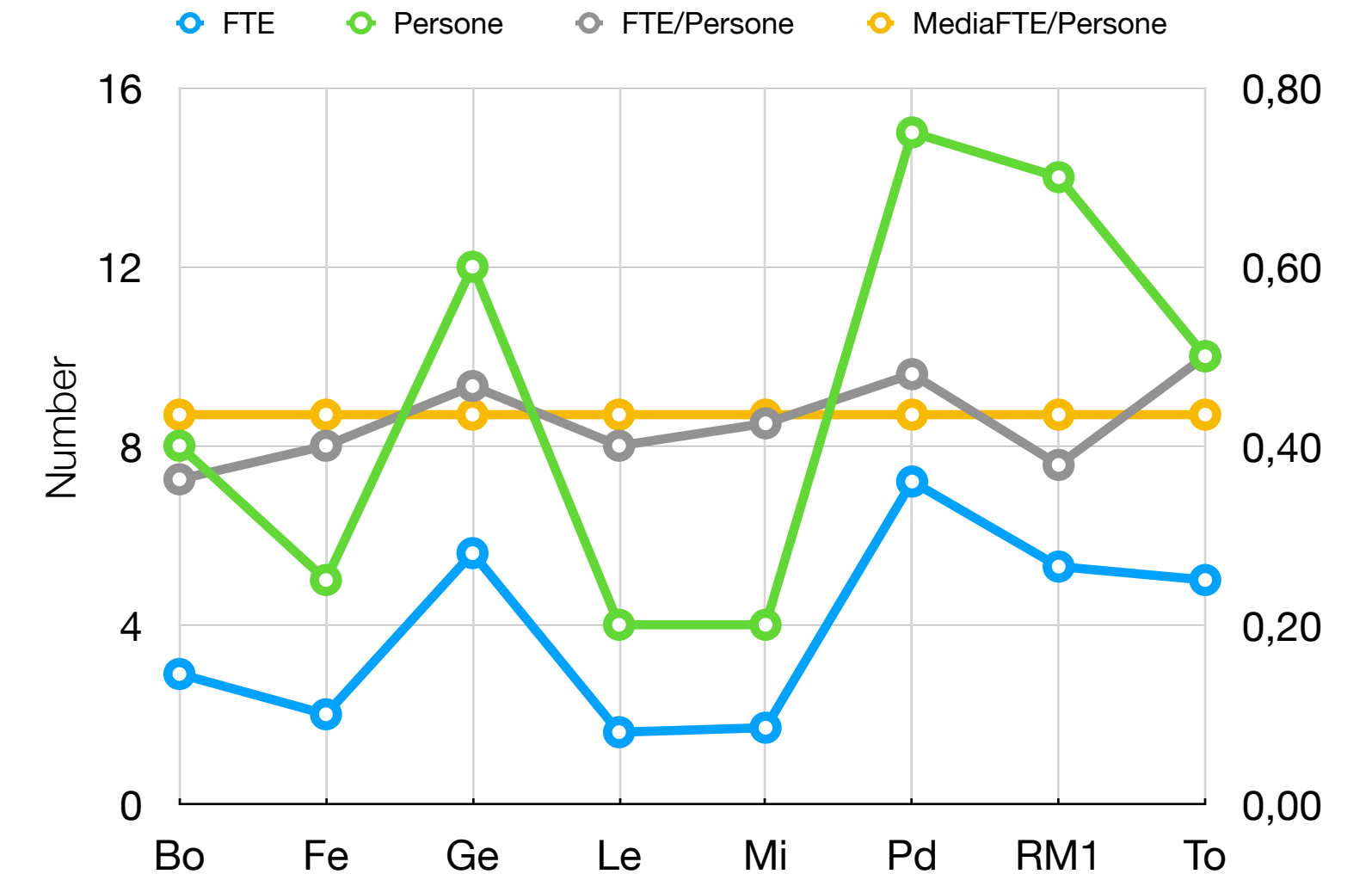
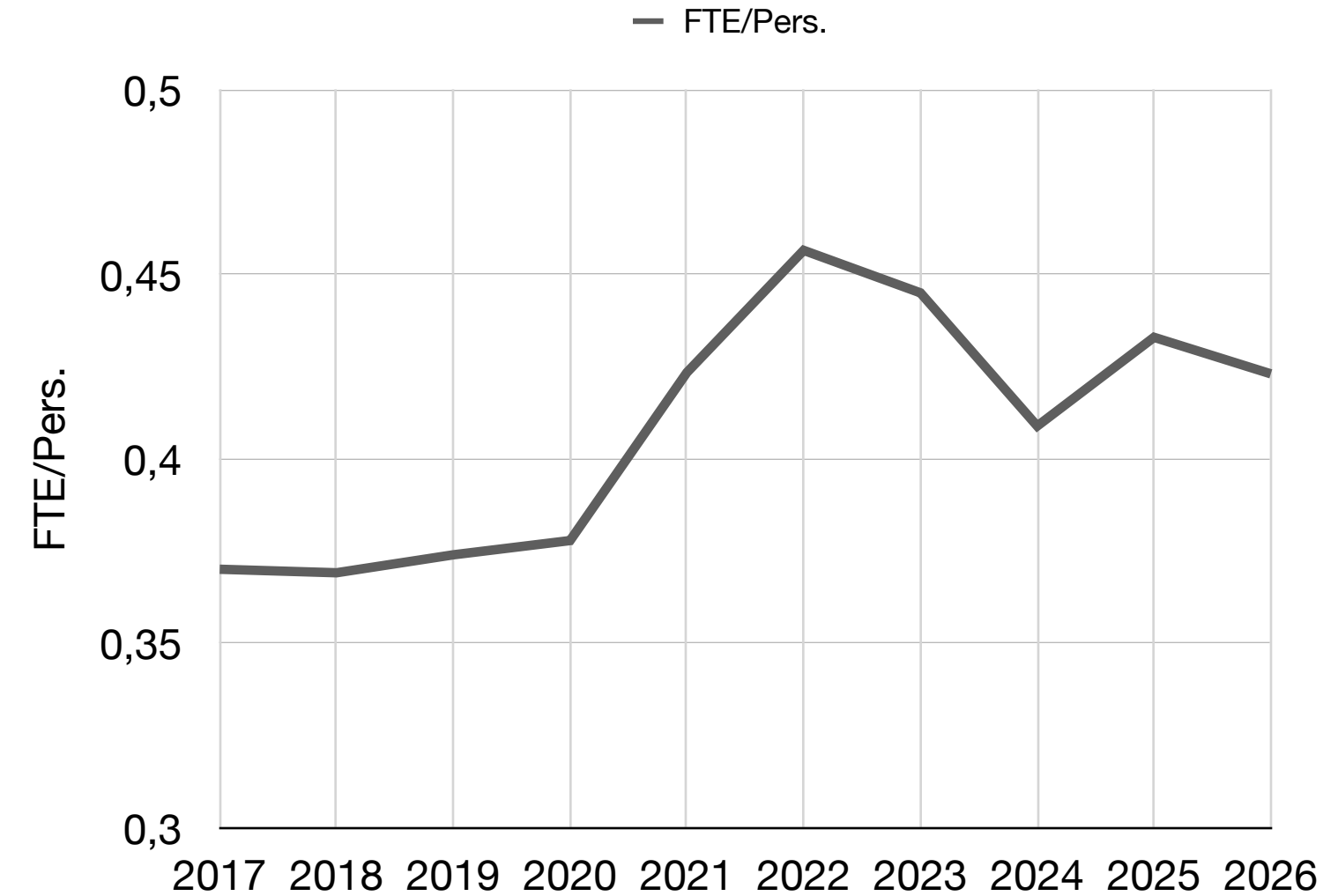
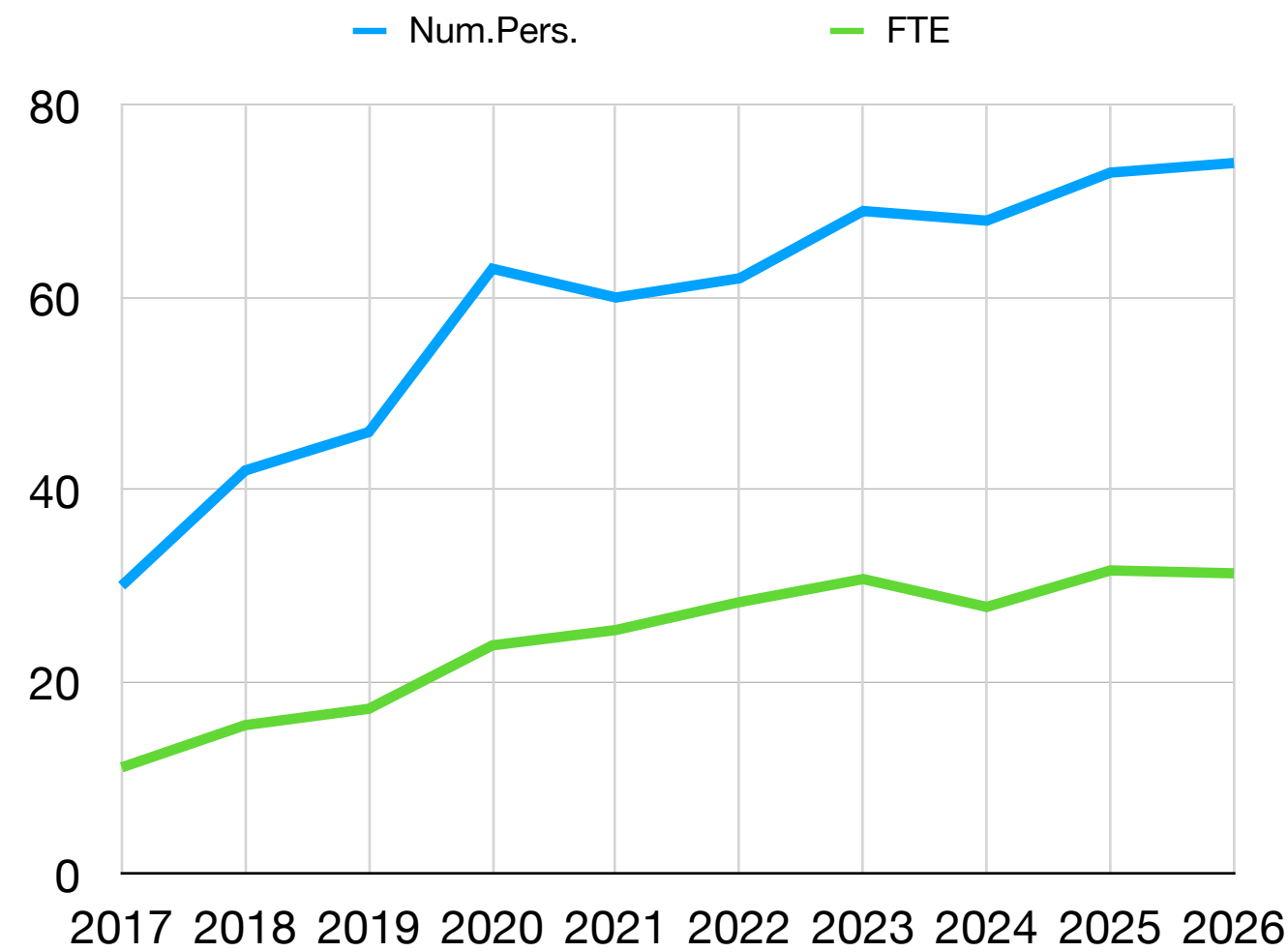


Per il 2026 leggero calo nelle richieste, al netto spese di pubblicazione, a fronte di una anagrafica stabile



Anagrafica

- La sigla Euclid è in una fase “stazionaria” con un fisiologico ricambio di persone,
- Numero ricercatori affiliati: **74**
- Totale FTE **31.3**
- FTE / Persone = **0.43**



Personale afferente a progetti sinergici

Nome e Cognome	Sigla	Dipendente/Associato/...	Contratto: tempo determinato/Indeterminato, borsista	ENTE	Tipo di supporto (PRIN, PNRR,)	nome attività	% totale sinergica	SIGLA 1	% Affinità 1	SIGLA 2	% Affinità 2	Note/Motivazione
Andrea Begnoni	Euclid Pd	Associato	PhD	UniPd	PNRR	CN1_Spoke2	100	Euclid	50	ET	50	Attività di Cross Correlazione LSS-GW
Stefano Davini	Euclid Ge	Dipendente	Primo Ricercatore	INFN Ge	PRIN	PRIN_20222JBEKN	10	Euclid	10			
Filippo Oppizzi	Euclid Ge	Associato	Assegnista	INFN Ge	PRIN	PRIN_20222JBEKN	100	Euclid	100			

Stefano Davini e Filippo Oppizzi sono presenti in anagrafica di Genova, mentre Andrea Begnoni per un fraintendimento non è in anagrafica.

Stato risorse umane

Triggerato dallo “Status Report” sono andato a guardare la composizione della sigla Euclid tra dipendenti e associati

Institution	Researcher				FTE				NOTE
	INFN		Associated		INFN		Associated		
	Staff	TD	Staff	TD/PhD	Staff	TD	Staff	TD/PhD	
BO	4	1	3	0	1	1	0.7	0	ASI
FE	0	0	4	1	0	0	0.9	1.5	
GE	2	1+1	3	5	0.5	2	0.9	3.2	ASI + PRIN
LE	0	0	6	0	0	0	1.1	0	
MI	0	0	3	1	0	0	1.5	0.2	
PD	3	1	8	3	1.3	1	2.7	2.7	ASI
RM1	0	0	8	5	0	0	2.9	2.6	
TO	0	0	2	3	0	0	5	5	
Total	9	4	37	18	2.8	4	15.7	15.2	

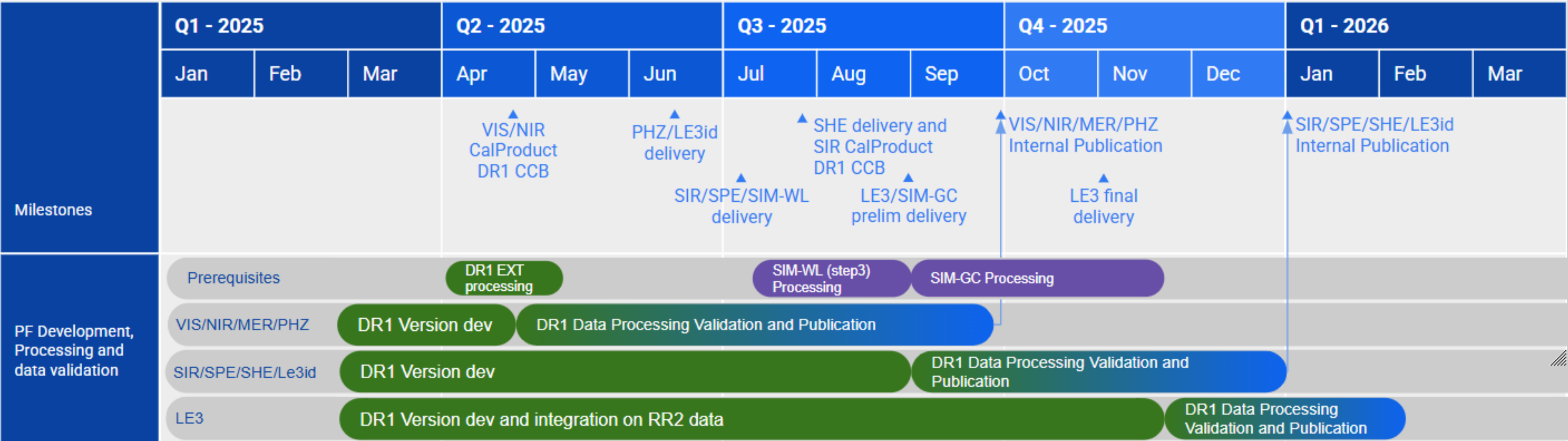
Personale entrato sullo strumento con background alte energie

3/4 TD pagati sui fondi esterni contratto ASI

Il concorso INFN in corso, sia teorico che sperimentale, non ha avuto “un occhio di riguardo” per la comunità cosmologica e astro.

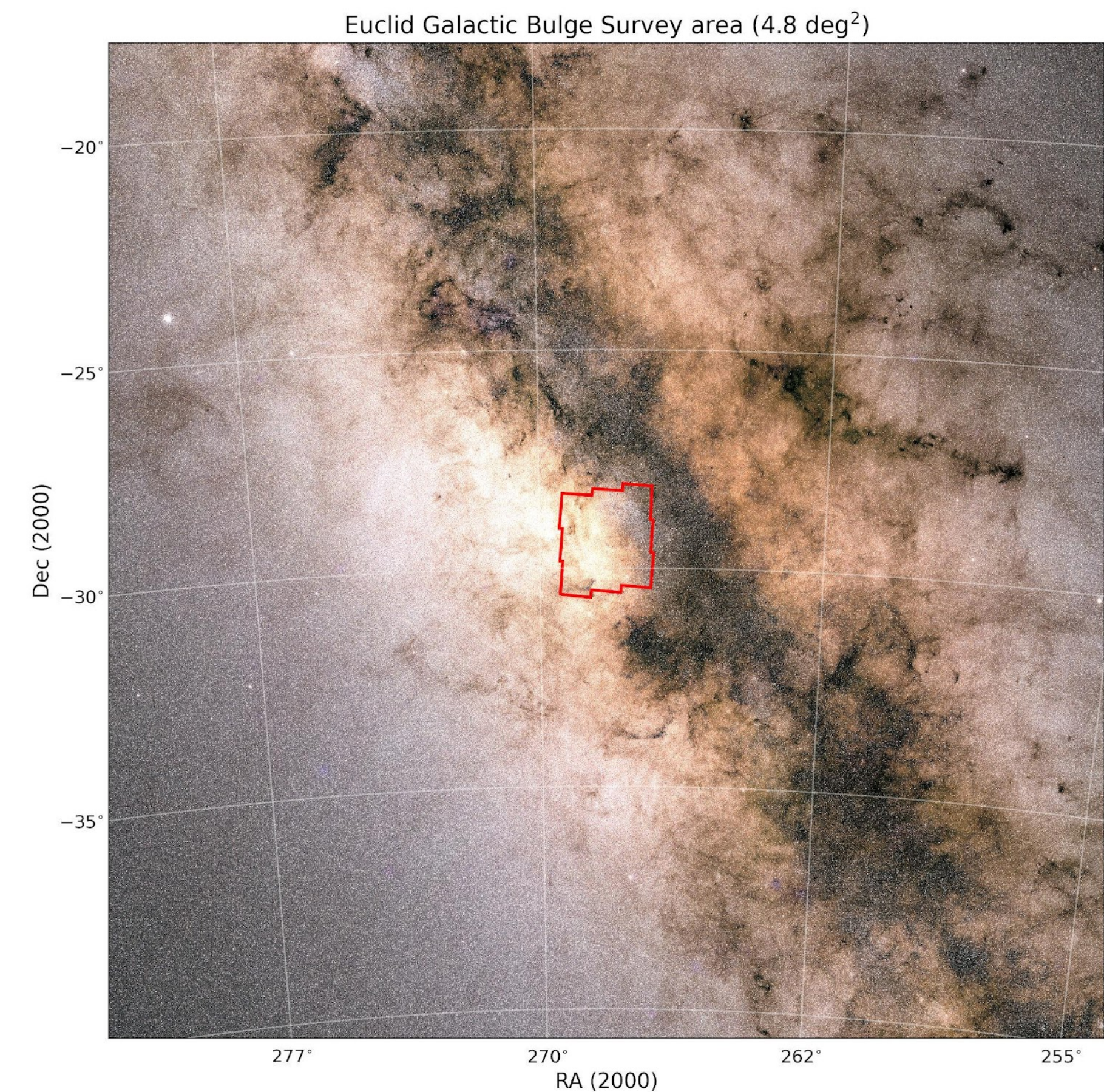
È difficile far crescere un comunica in questo contesto....

Backup



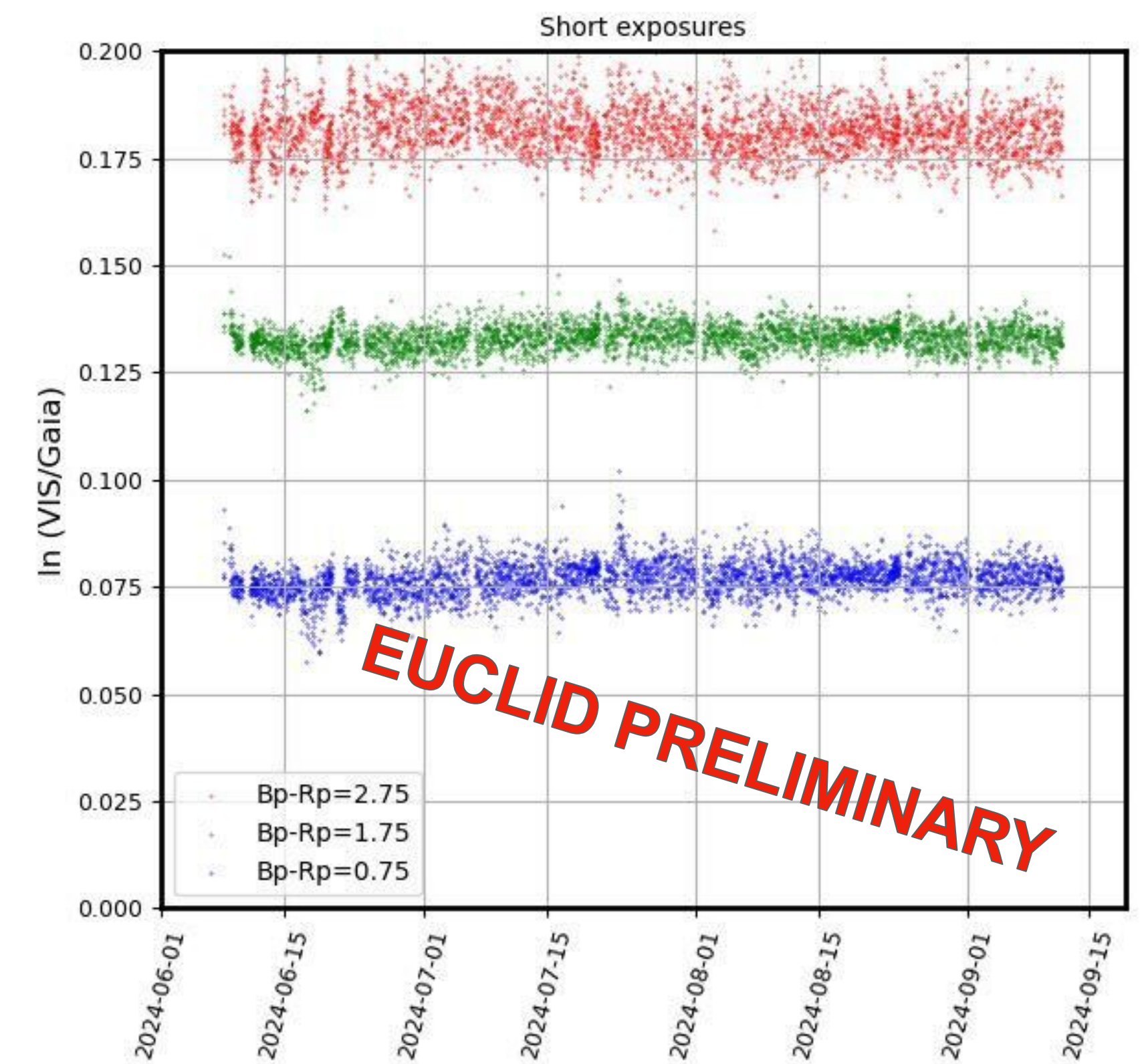
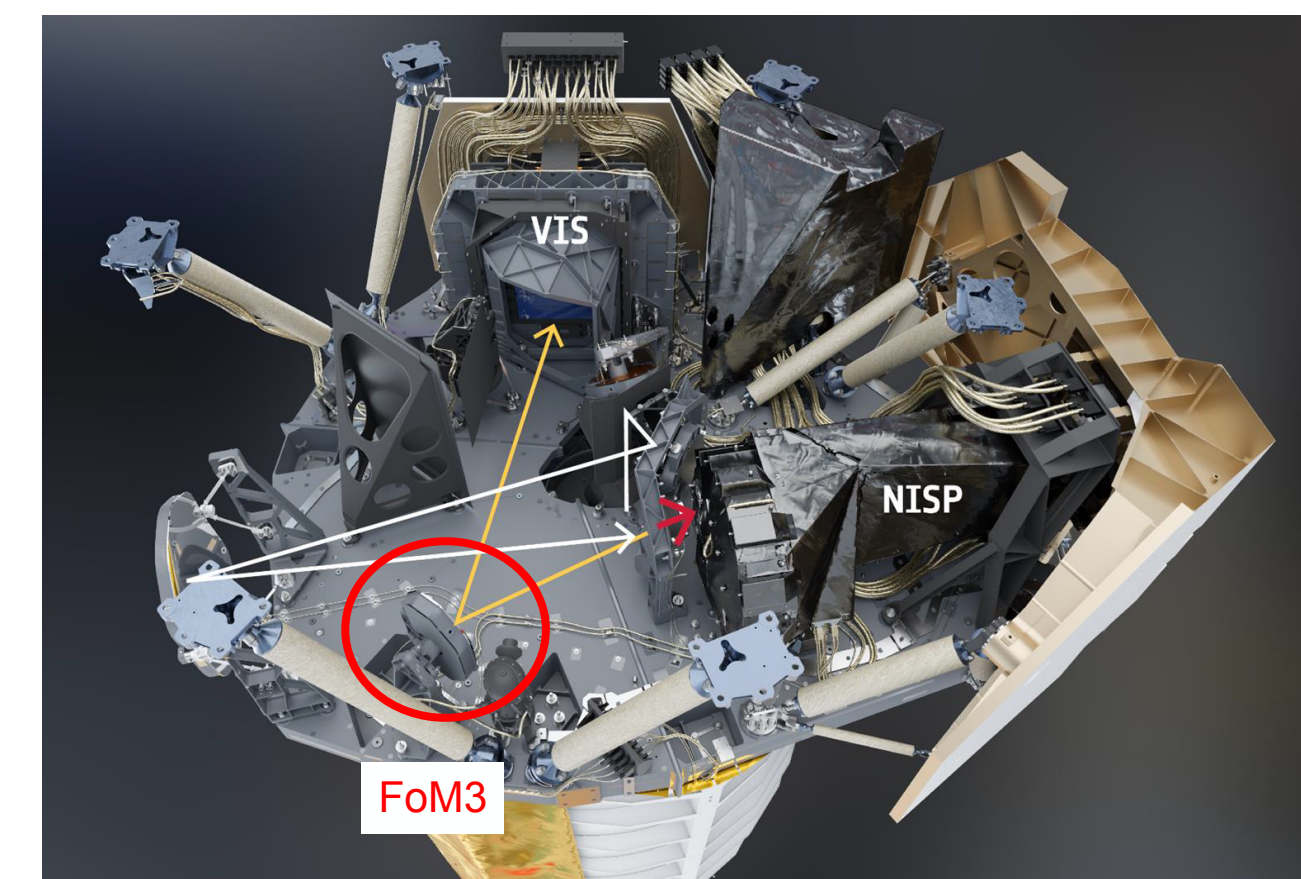
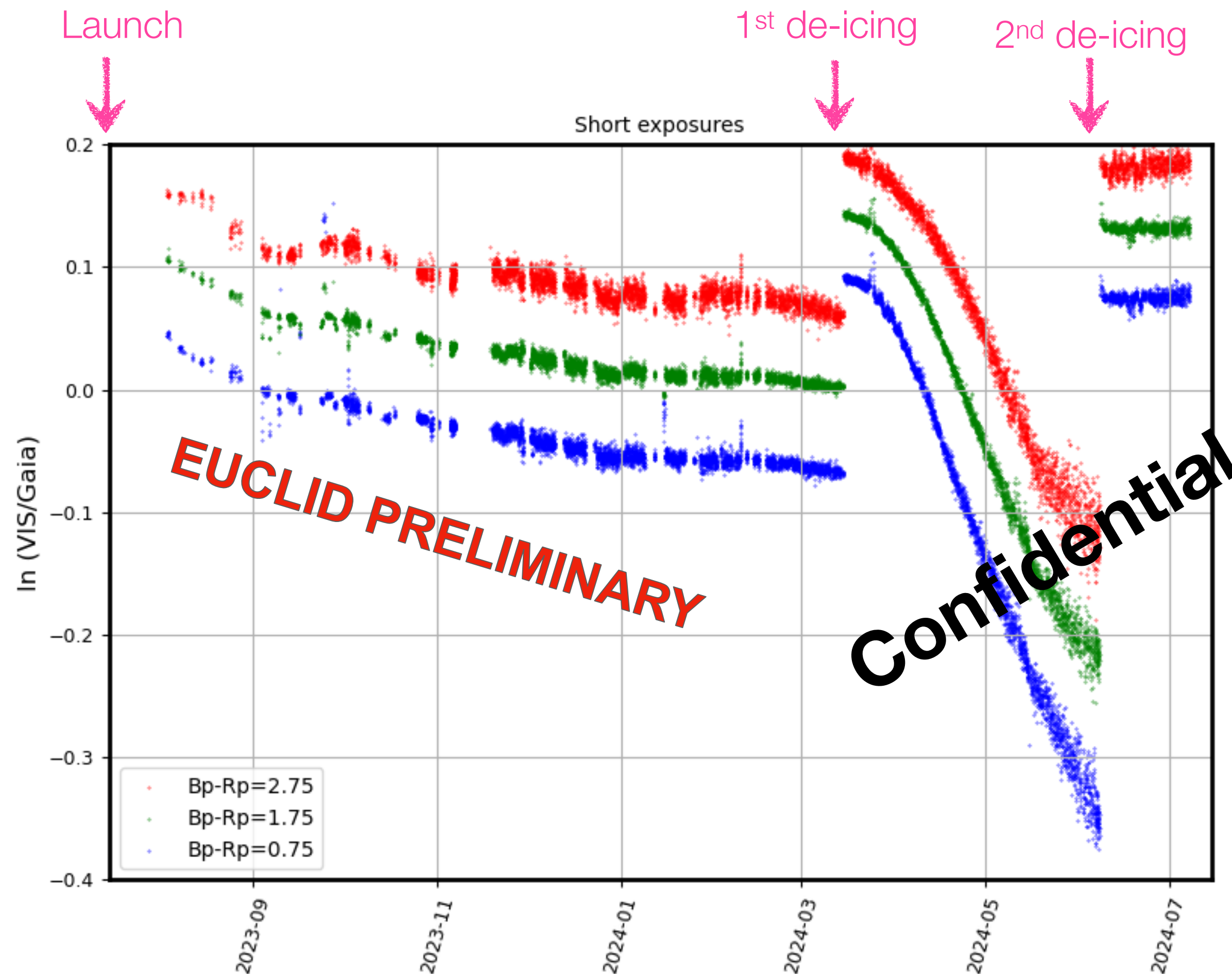
Observation of the Galactic Centre

- On March 23rd 2025 the Euclid acquired 4.8 deg² close to the Galactic Centre.
- Mainly for exoplanet search.
- The same area will be monitored by Roman for 5-year period from 2027 for its Galactic Bulge Time Domain Survey
- Euclid data will be released on Q2 in 2026



Ice contamination...

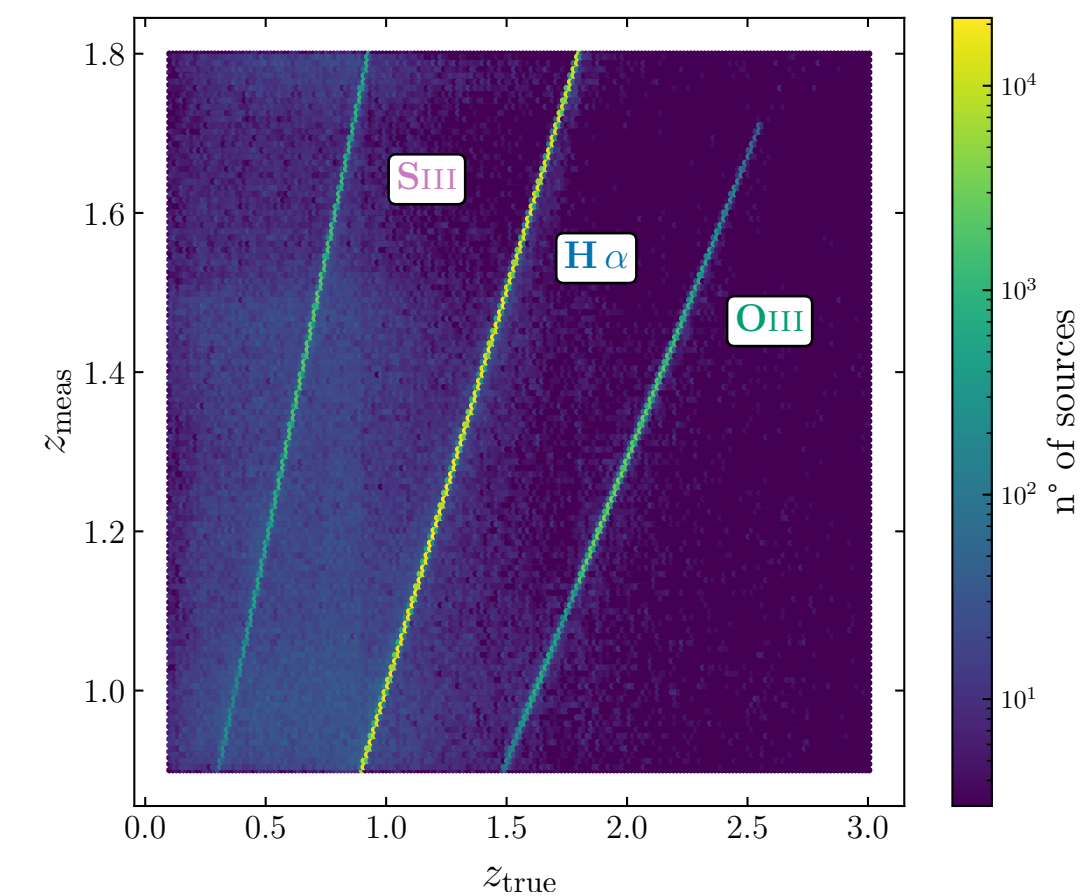
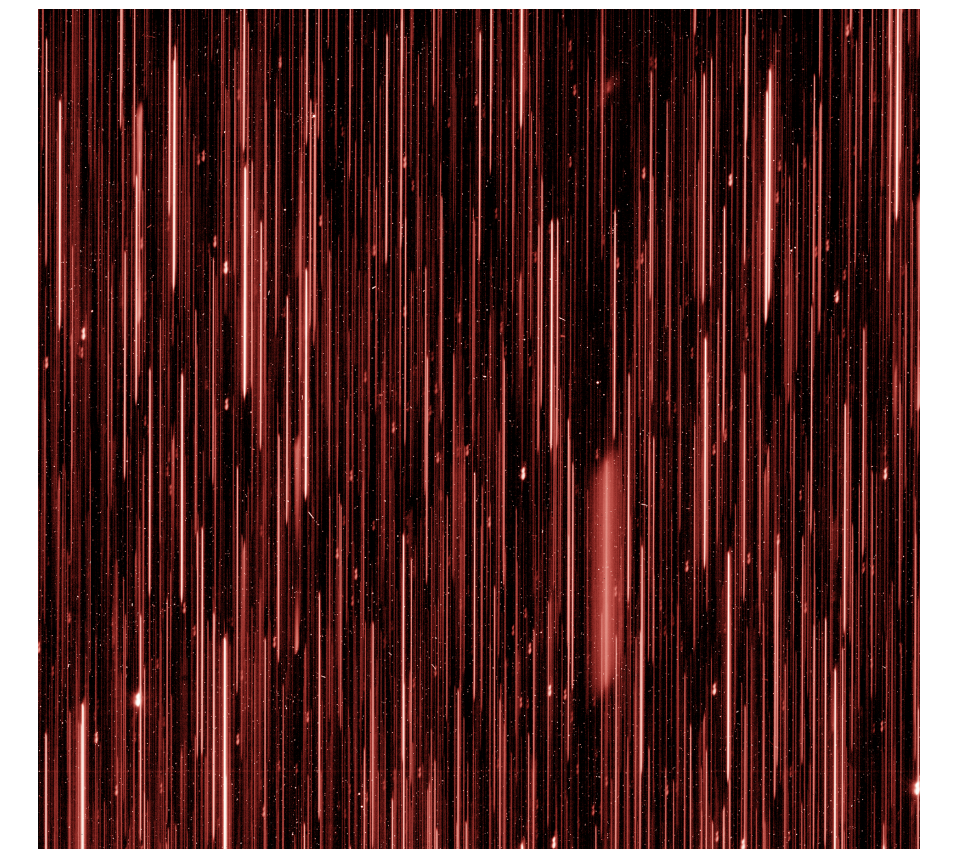
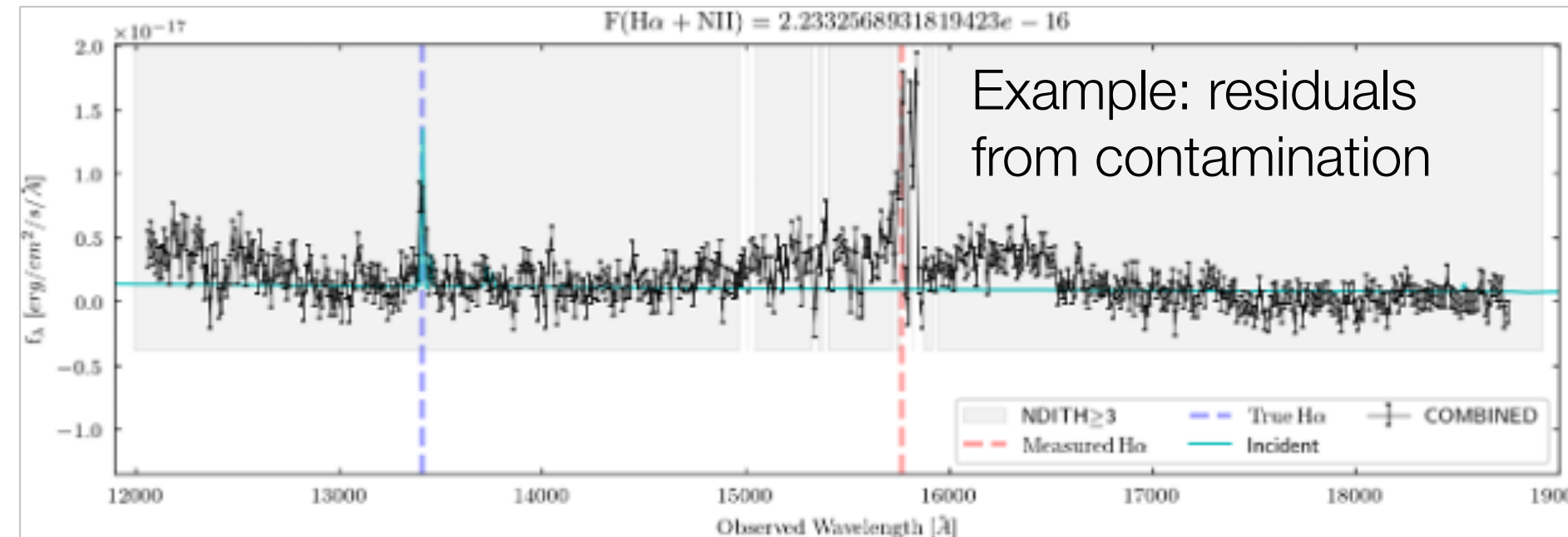
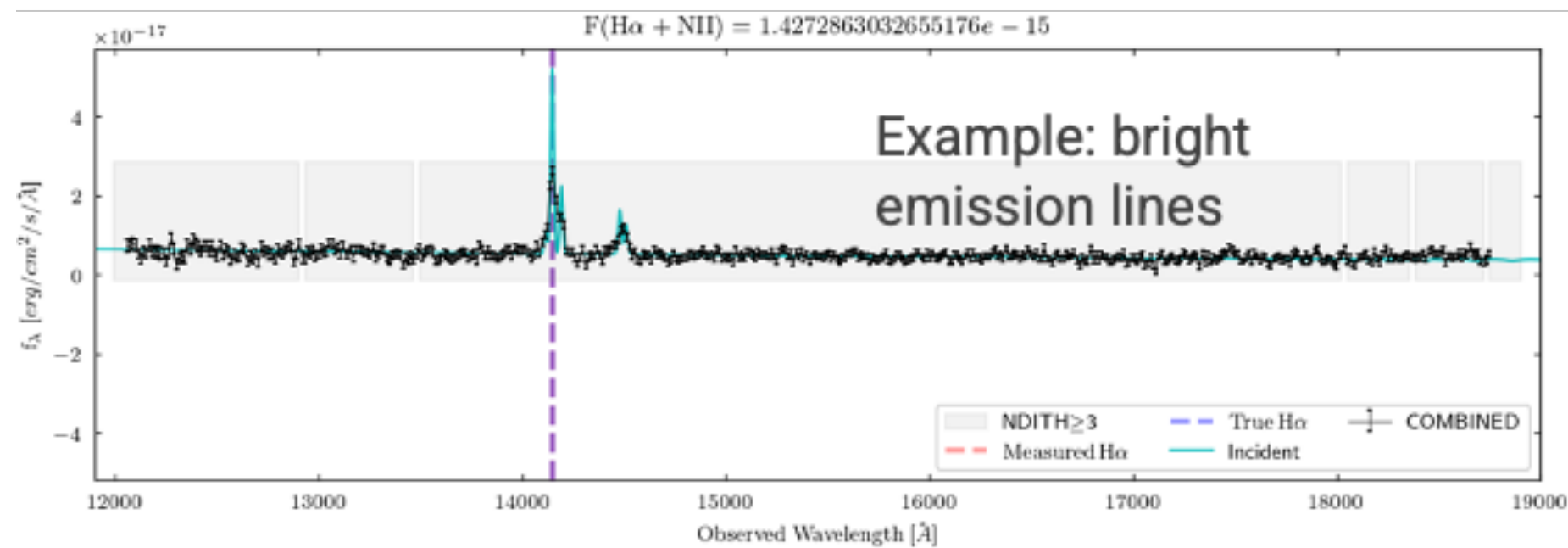
After the second decontamination of FoM3 the problem is over!!!



Credit: K. Kuijken

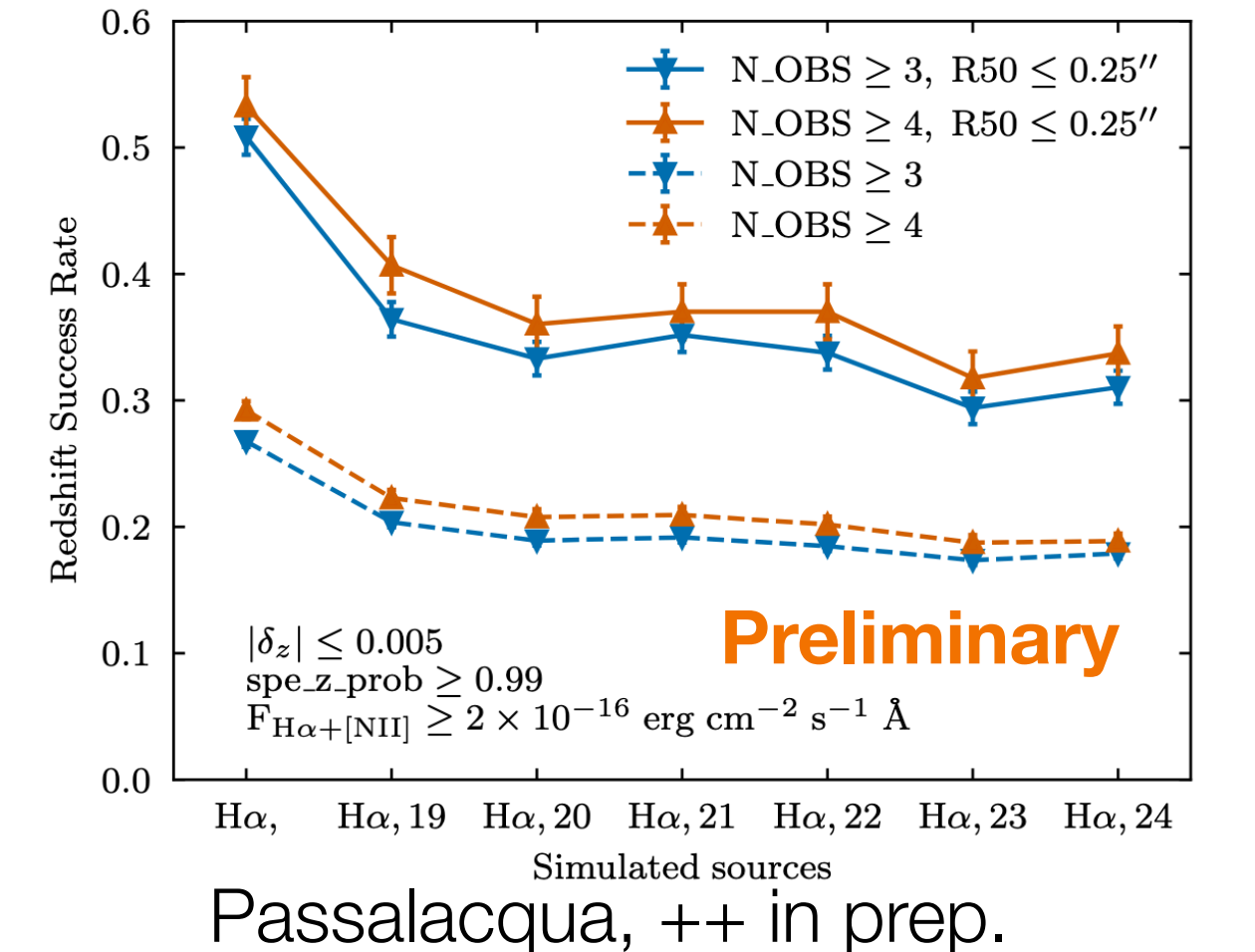
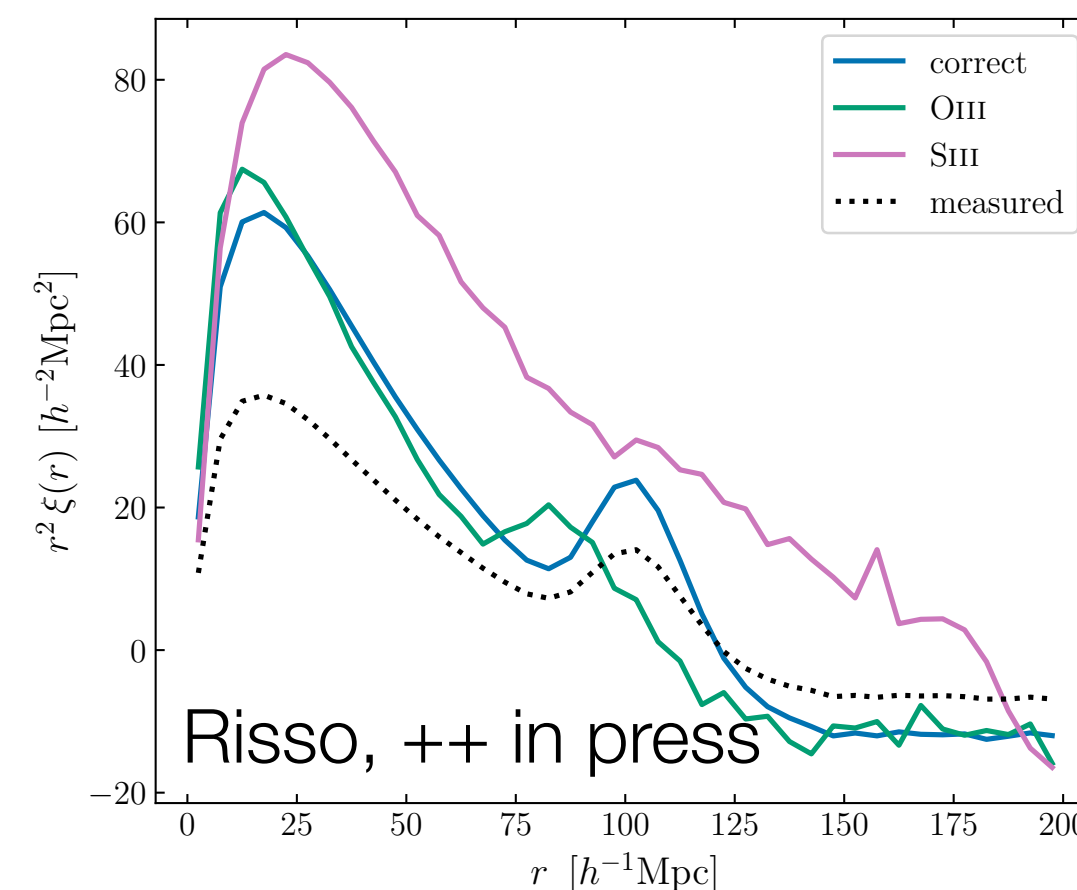
Spectra Reconstruction

- NISP is a slitless spectrometer $\rightarrow$ all the sources in the focal plane are dispersed
- Euclid use H_α line to measure the redshift of Line Emission Galaxies (LEG), which are $\sim 4\%$ of the total
- NISP spectra resolution is $\lambda/\Delta\lambda \sim 480$ and so the H_α line is blended with N_{II} doublet $\rightarrow$ no strong features to identify the correct line.
- Slitless spectroscopy complicate the problem because of contamination from other spectra or signal persistency from previous bright sources



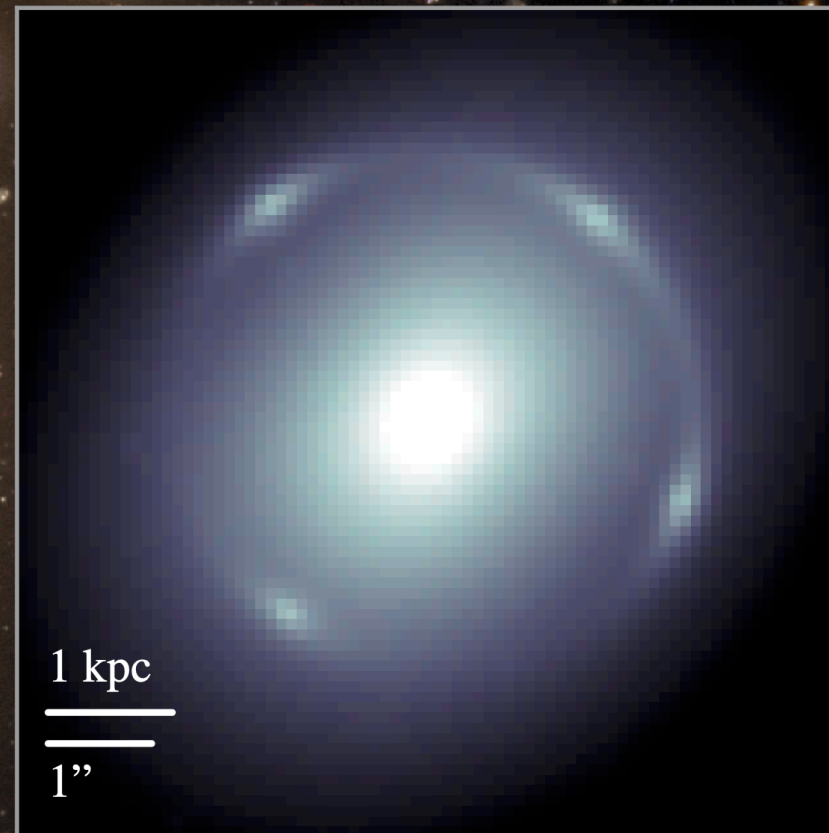
Mitigation activity

- Study the observed spectra to improve the spectra reconstruction and line identification (Granet, Scodeggio INAF Milano, Moresco UniBo)
- **Evaluation** of the effect of presence of “interlopers” (wrong z) in the galaxy clustering analysis (Risso INFN-Ge)
- **MC studies** to evaluate the effect of **spectra contamination** also through the **injection of simulated spectra** into real images (Passalacqua INFN-Pd)

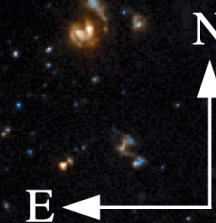


Highlights from Q1

Euclid Quick Data Release (Q1): The first catalogue of strong-lensing galaxy clusters", Bergamini et al., 2025, A&A special issue, submitted



20 kpc
20''



NGC 6505, about 590 million light-years from Earth, $z = 0.042$

The galaxy has been discovered in 1984 but nobody could observe the complete Einstein ring at the centre.

The lensed galaxy is 4.42 billion light-years, $z = 0.4058$

The estimated mass of the lens:

$$1.36^{+0.06}_{-0.09} \times 10^{11} M_{\odot}$$

Fraction of DM with in ring

$$f_{DM} = (11.1^{+5.4}_{-3.5}) \%$$

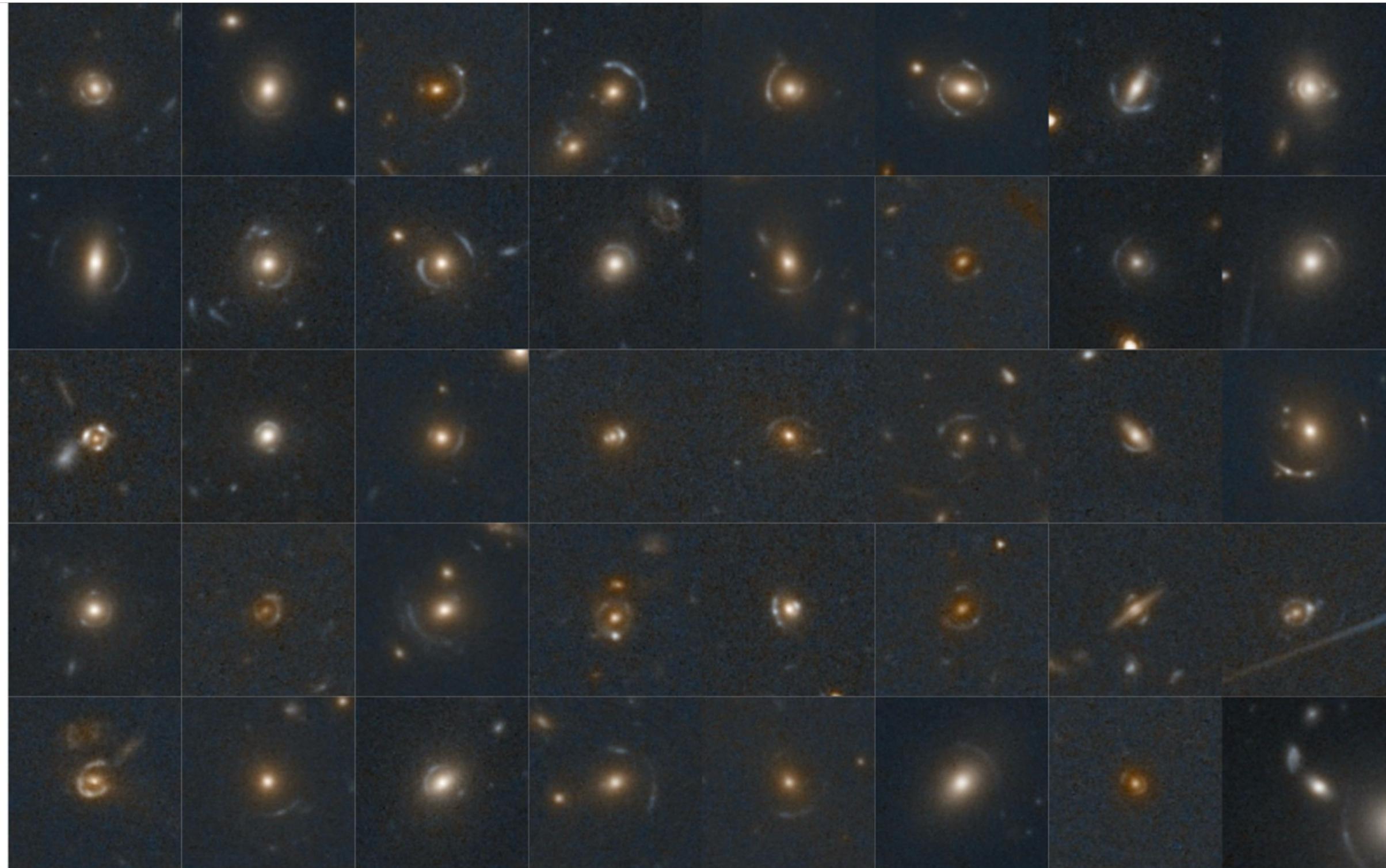
Euclid: arXiv:2502.06505



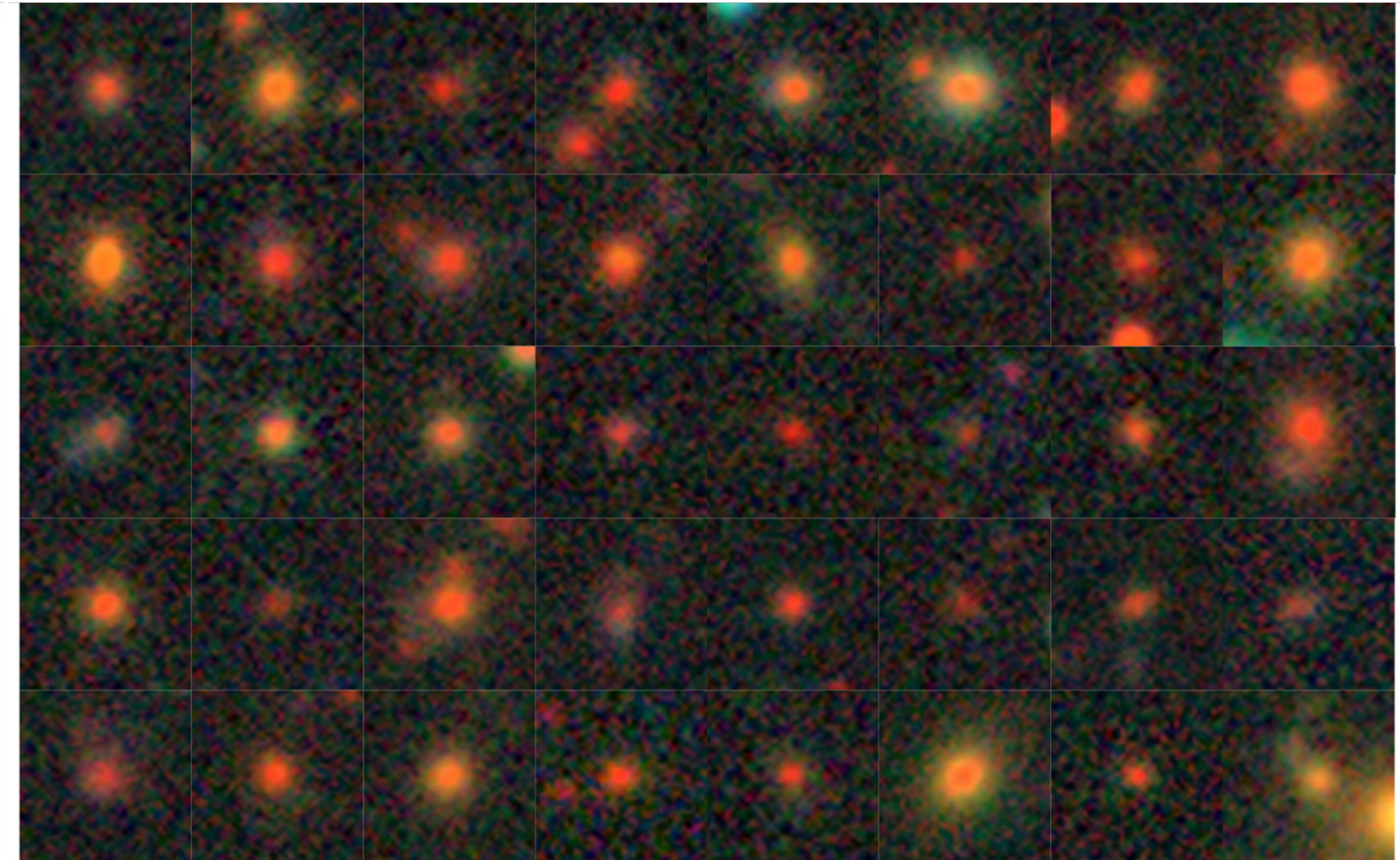
Euclid: a strong lens discovery machine

40 random lenses discovered by the SL Discovery Engine in Q1

Euclid

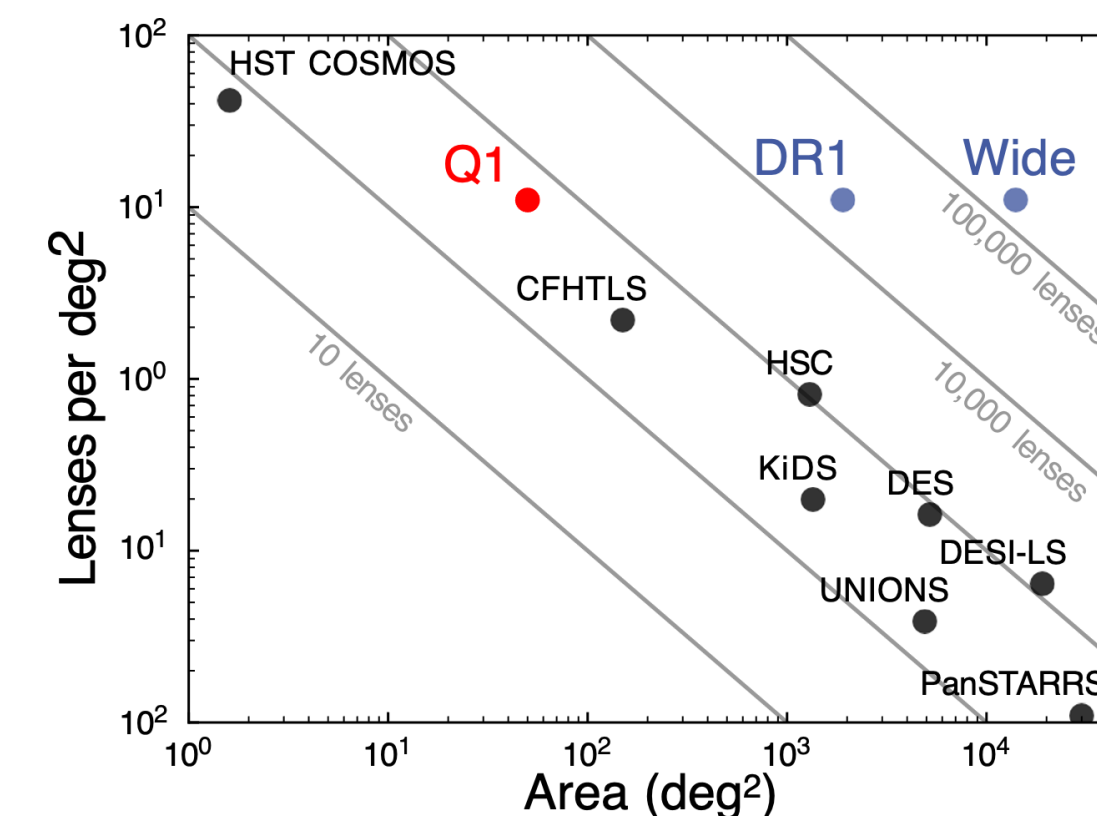


DES (4-meter telescope at the Cerro Tololo)

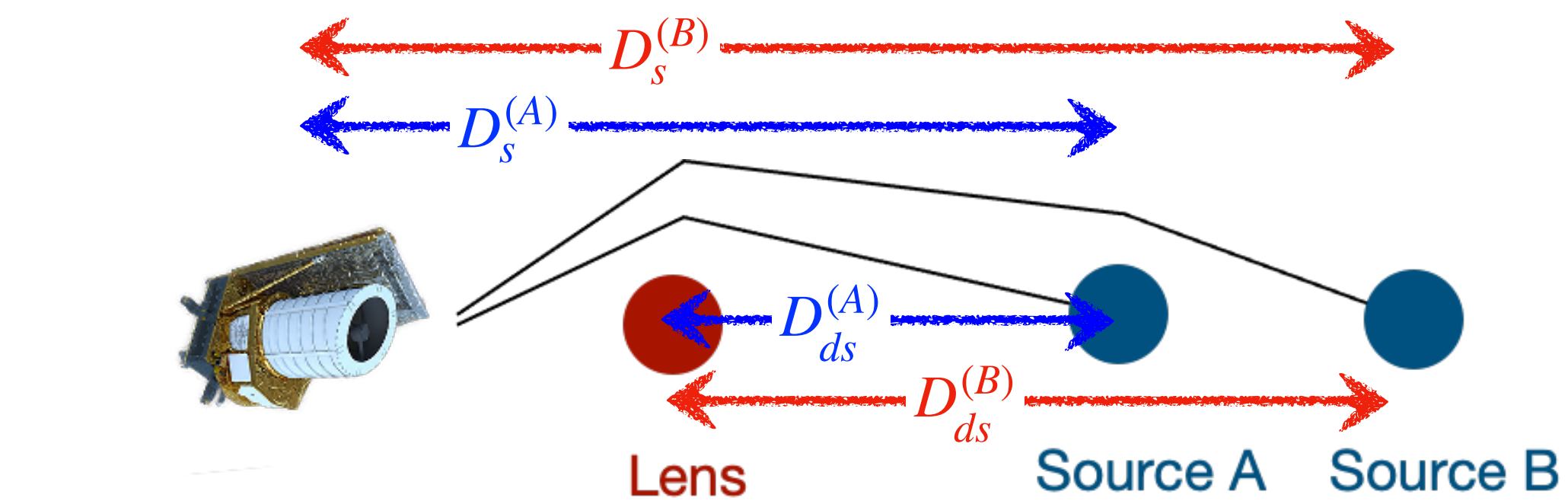


In **Q1** data there are
 ~ **500** galaxy-galaxy strong lens candidate
 ~ **80** strong lens clusters
 With Q1 Euclid doubled the number of
 observed Strong Lens

We expect to find at the end Euclid
 survey
 ~100 k galaxy-galaxy, galaxy-QSO
 ~ 10 k groups and clusters



Double Source Plane



Deflection
angle

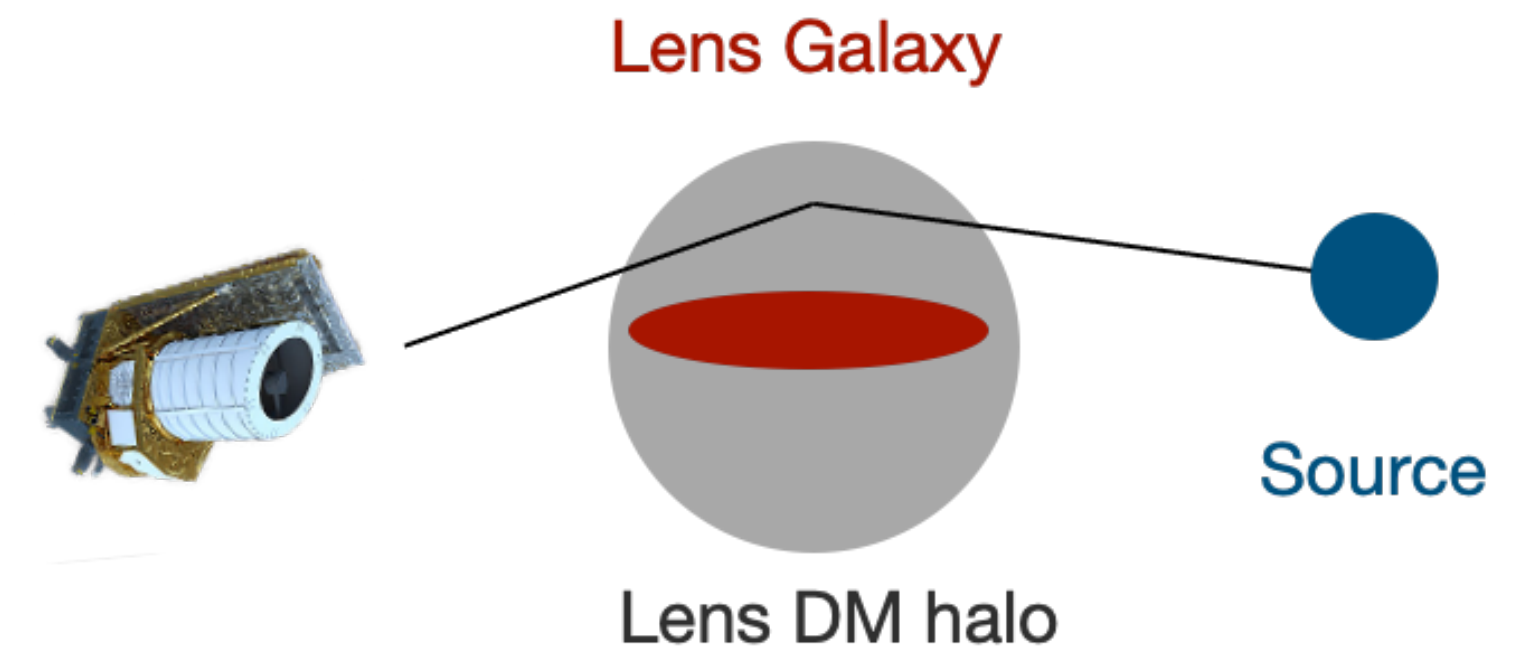
$$\alpha \propto \frac{D_{ds}}{D_s} \times M$$

Mass of the lens

$$\frac{\alpha_A}{\alpha_B} \propto \frac{D_{ds}^{(A)}}{D_s^{(A)}} \frac{D_s^{(B)}}{D_{ds}^{(B)}}$$

Correlate the redshift of
source with angular
diameter distance
Test expansion Universe

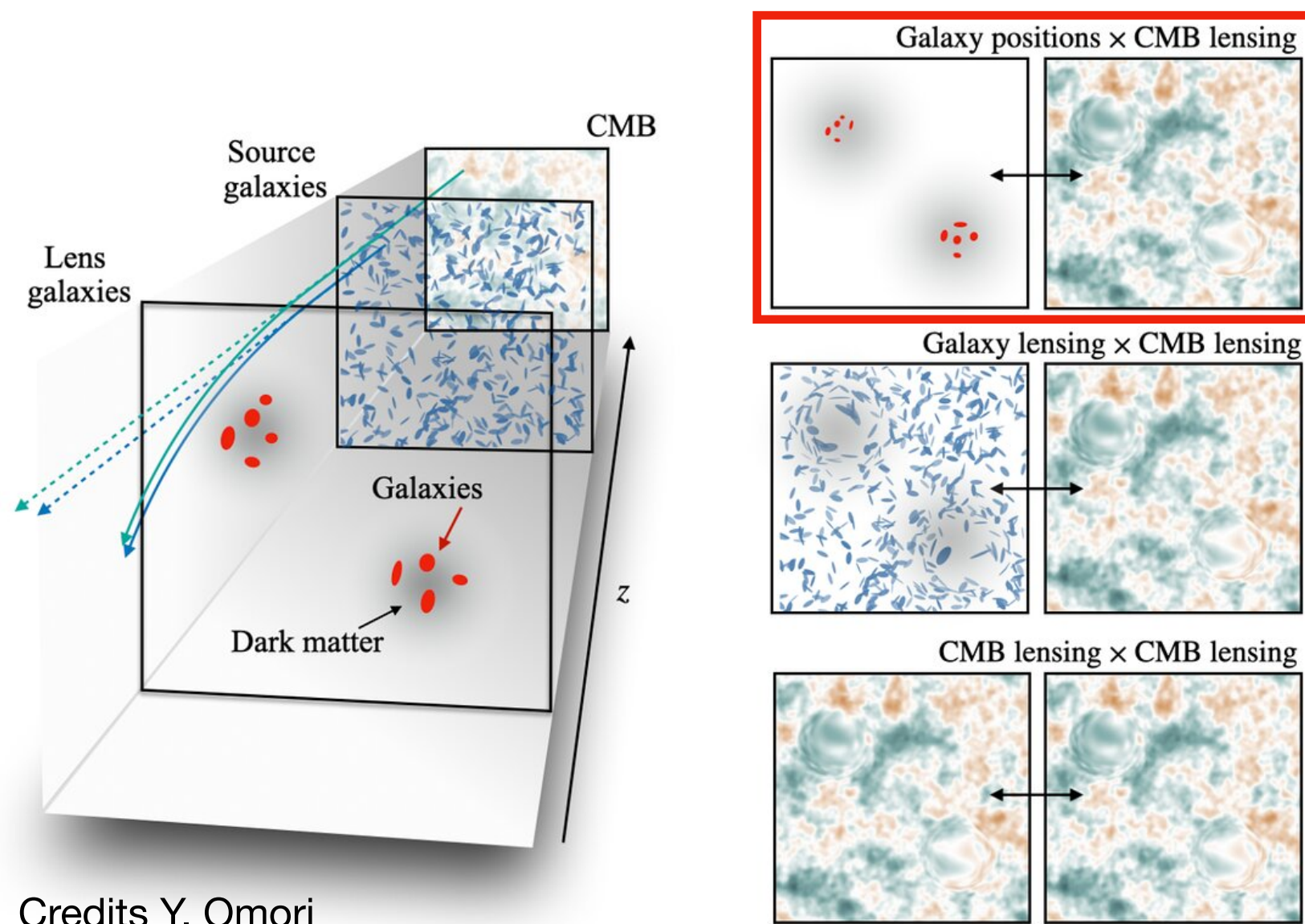
Edge-on lenses



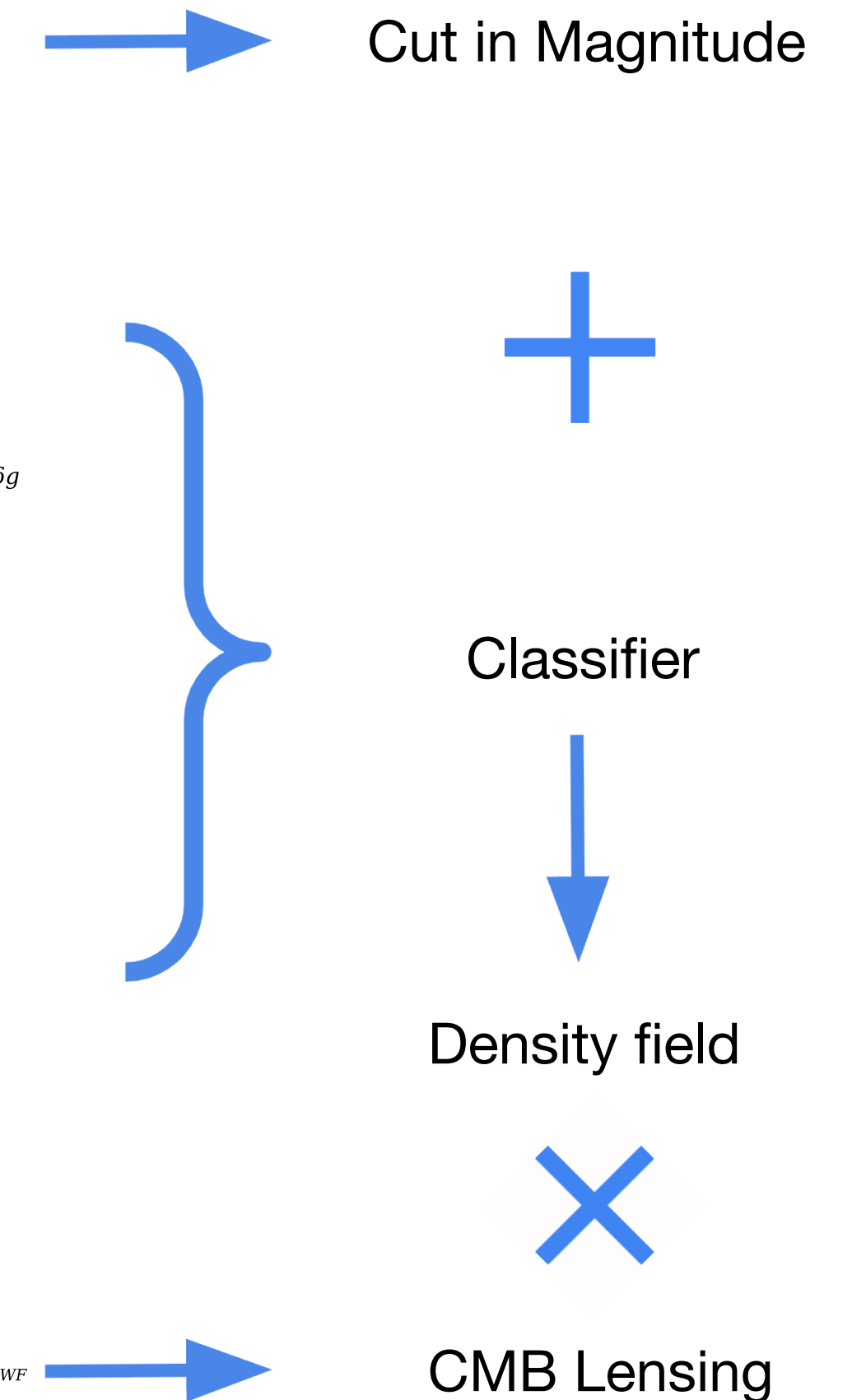
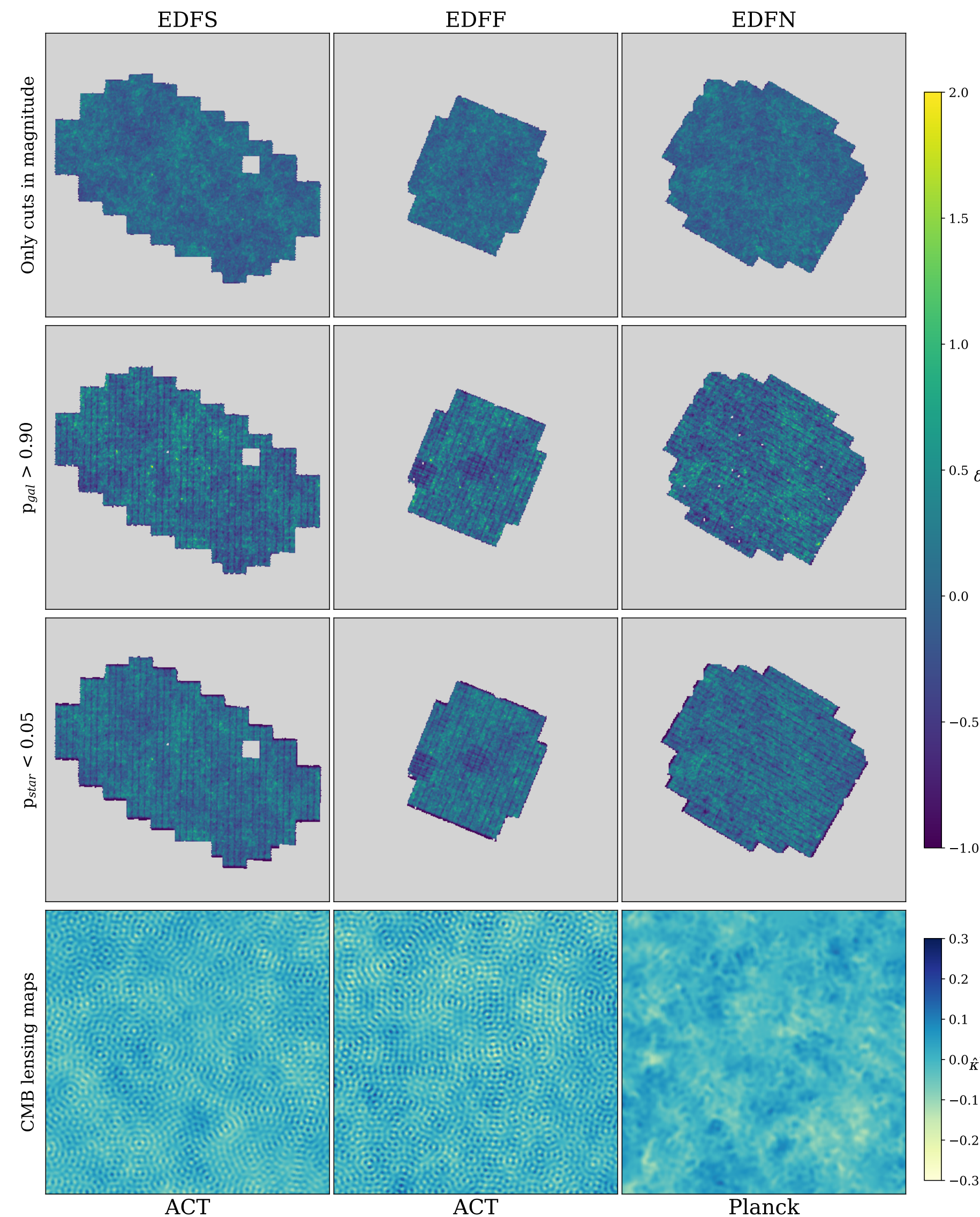
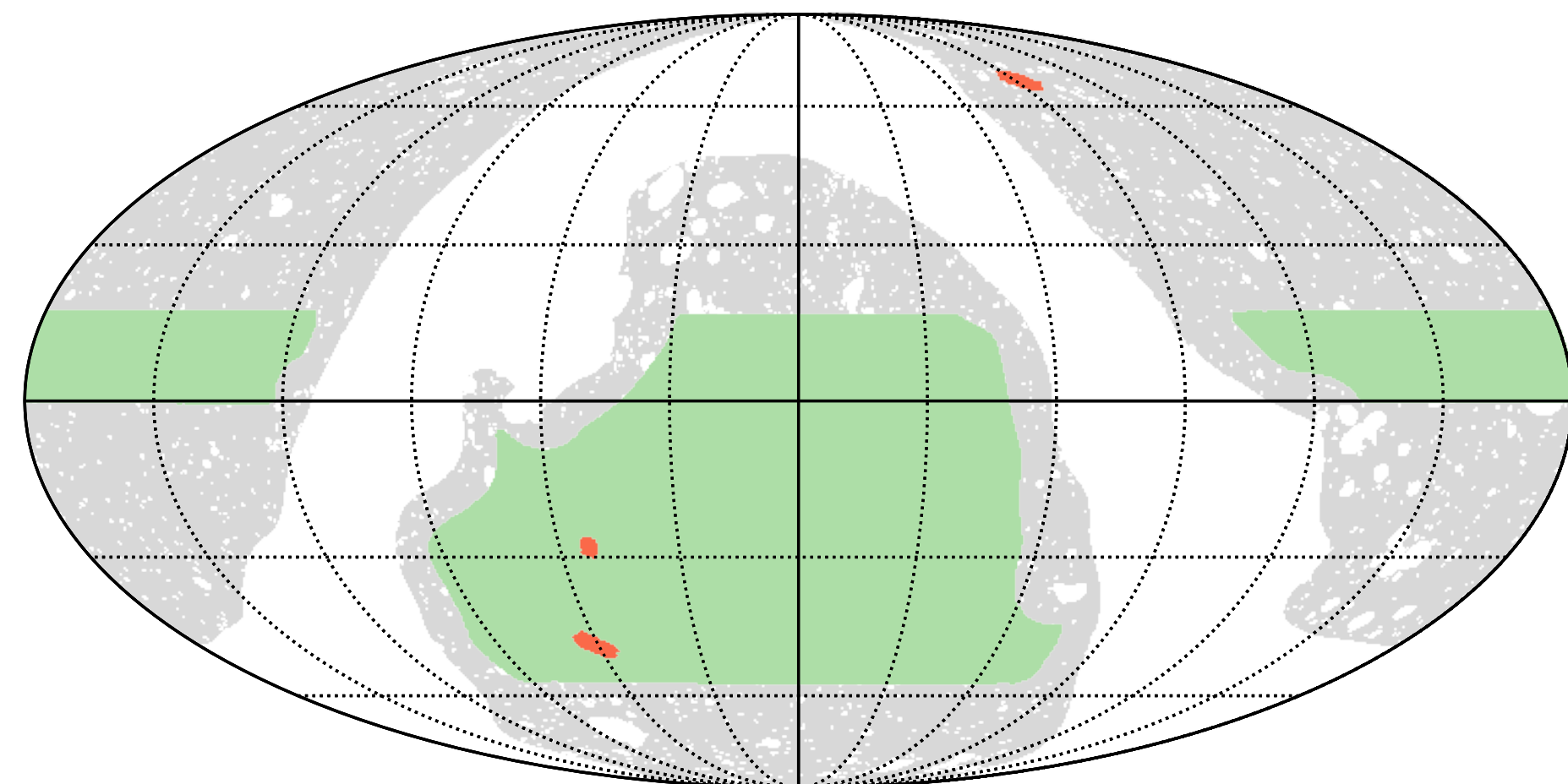
Test Dark Matter distribution around Galaxies

Q1 GC and x-correlation with CMB Lensing

First attempt of computing
Galaxy Clustering auto-spectrum, and
 cross-spectra with **CMB lensing**



Credits Y. Omori



Fabbian, Pagano, ++ in prep.

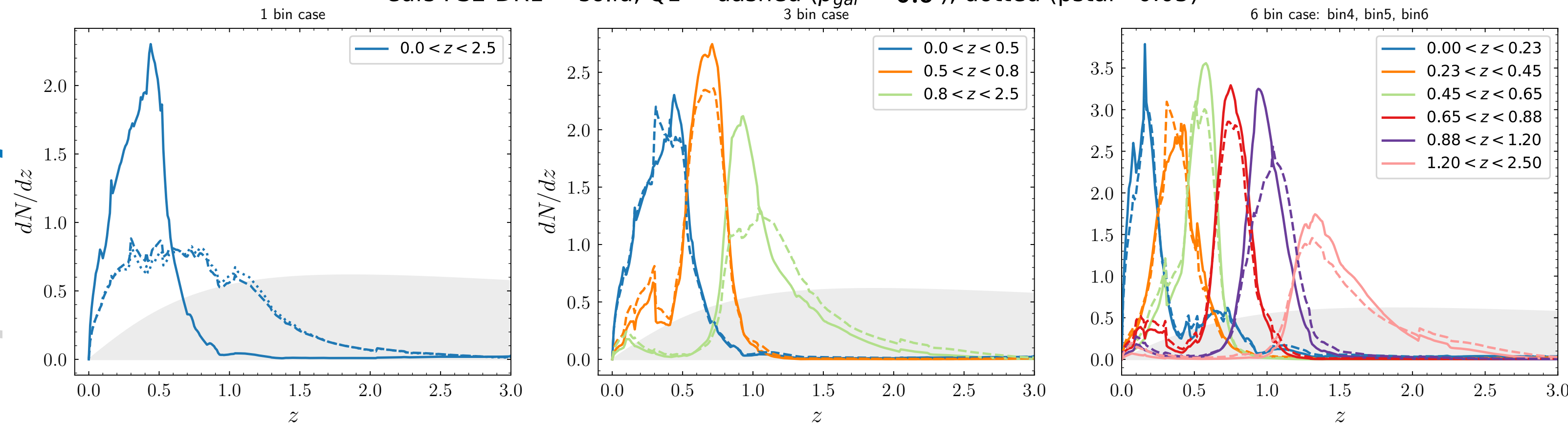


Q1 GC and x-correlation with CMB Lensing

Photometric redshift distribution

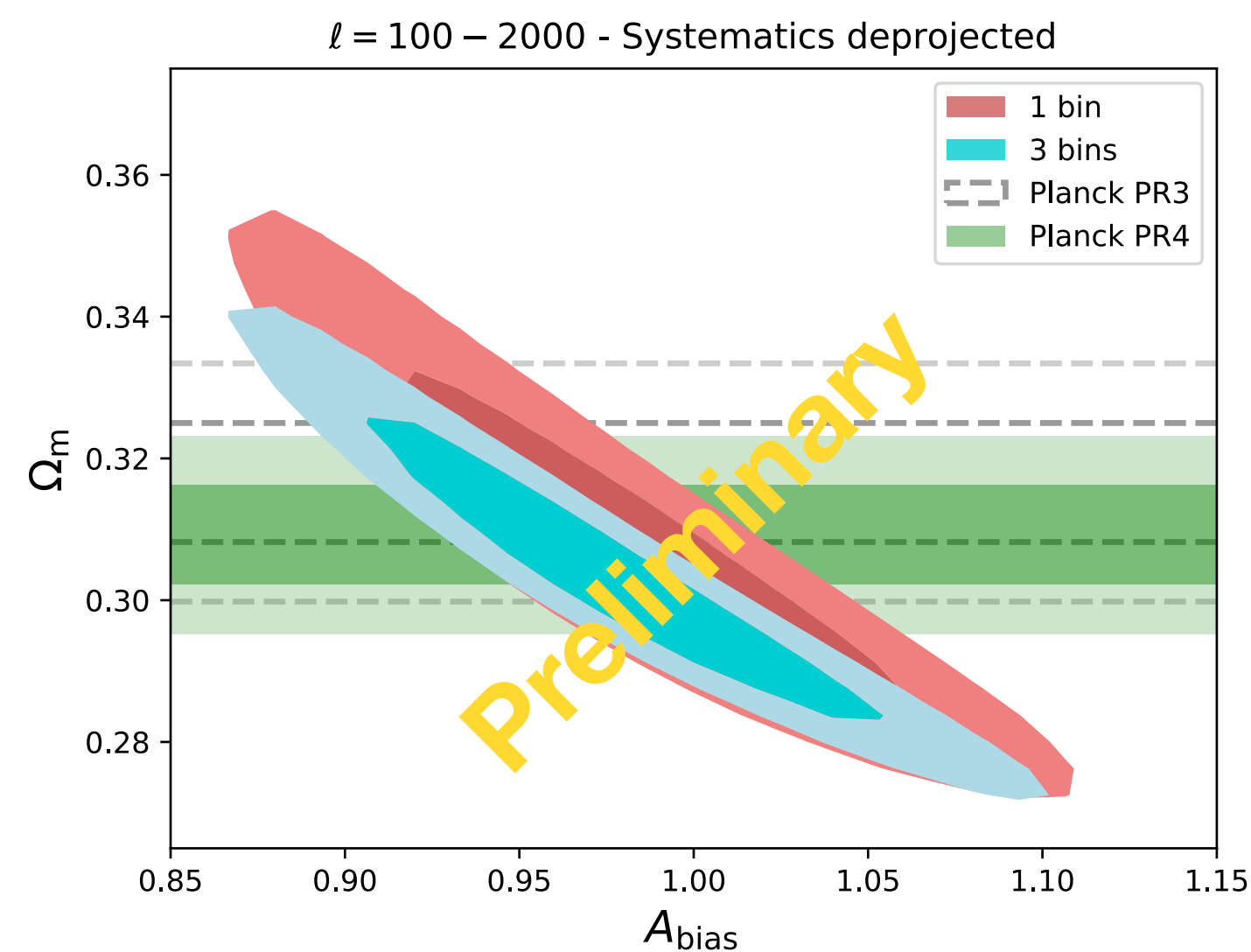
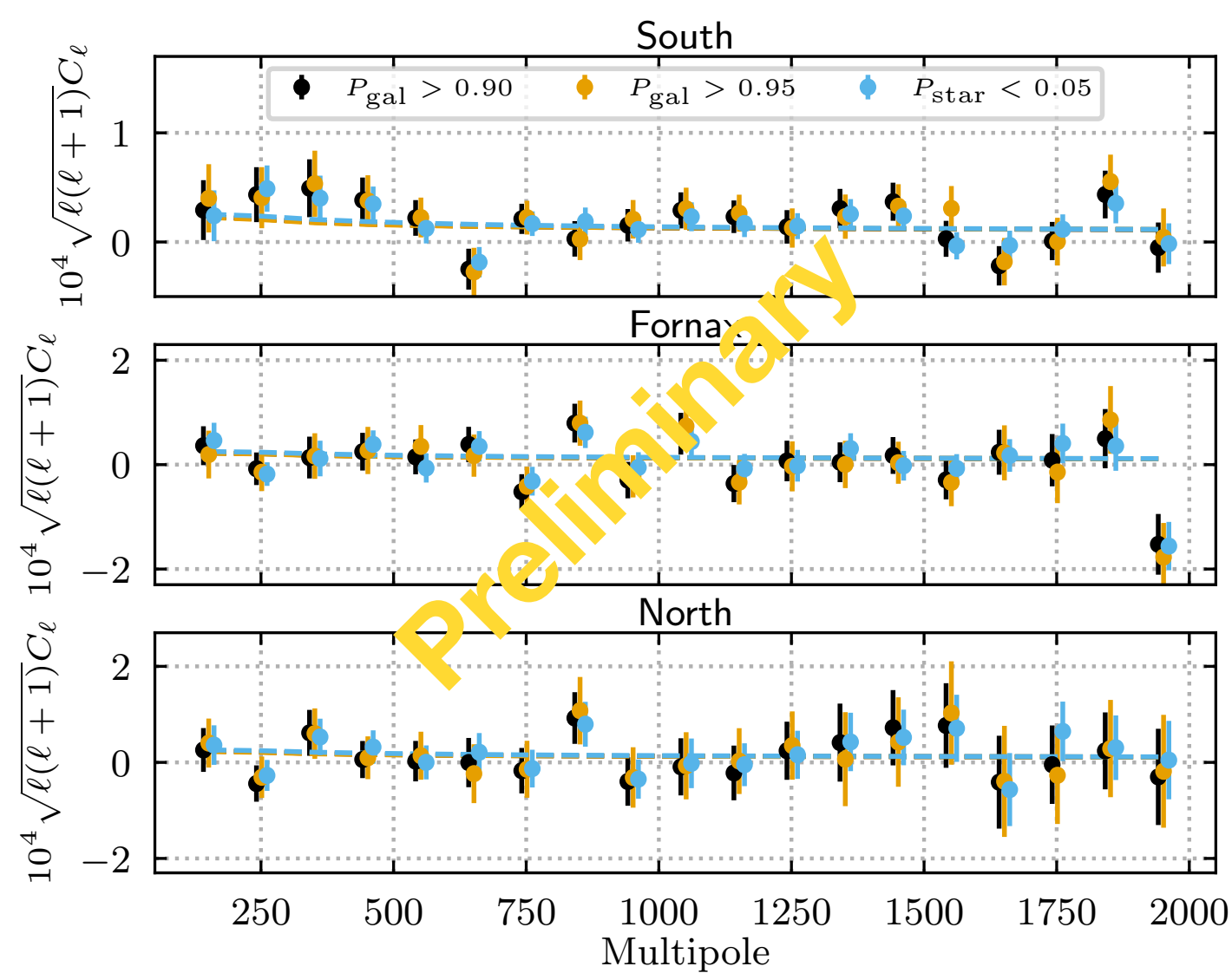
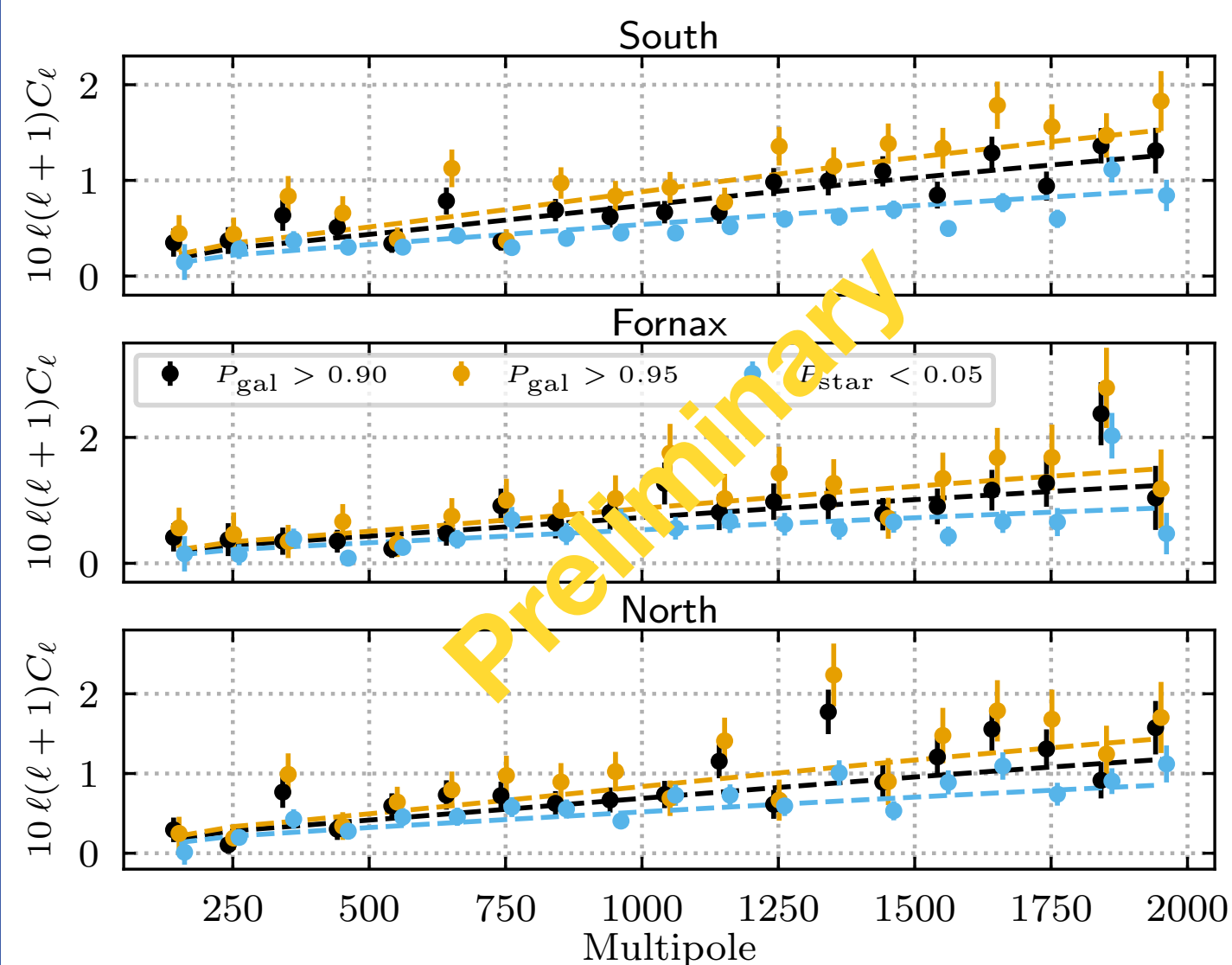
CMB Lensing Kernel

edfs FS2-DR1 = solid, Q1 = dashed ($p_{gal} > 0.9$), dotted ($p_{star} < 0.05$)



GG

KG



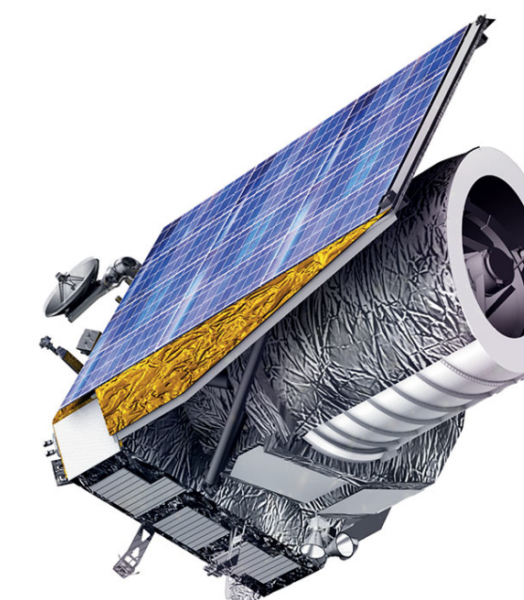
Q1 ~ 0.4% of Euclid final sky
x40 in statistics **in DR1**
x200 increase in the final statistics

INFN-CINACA resources used, thanks...

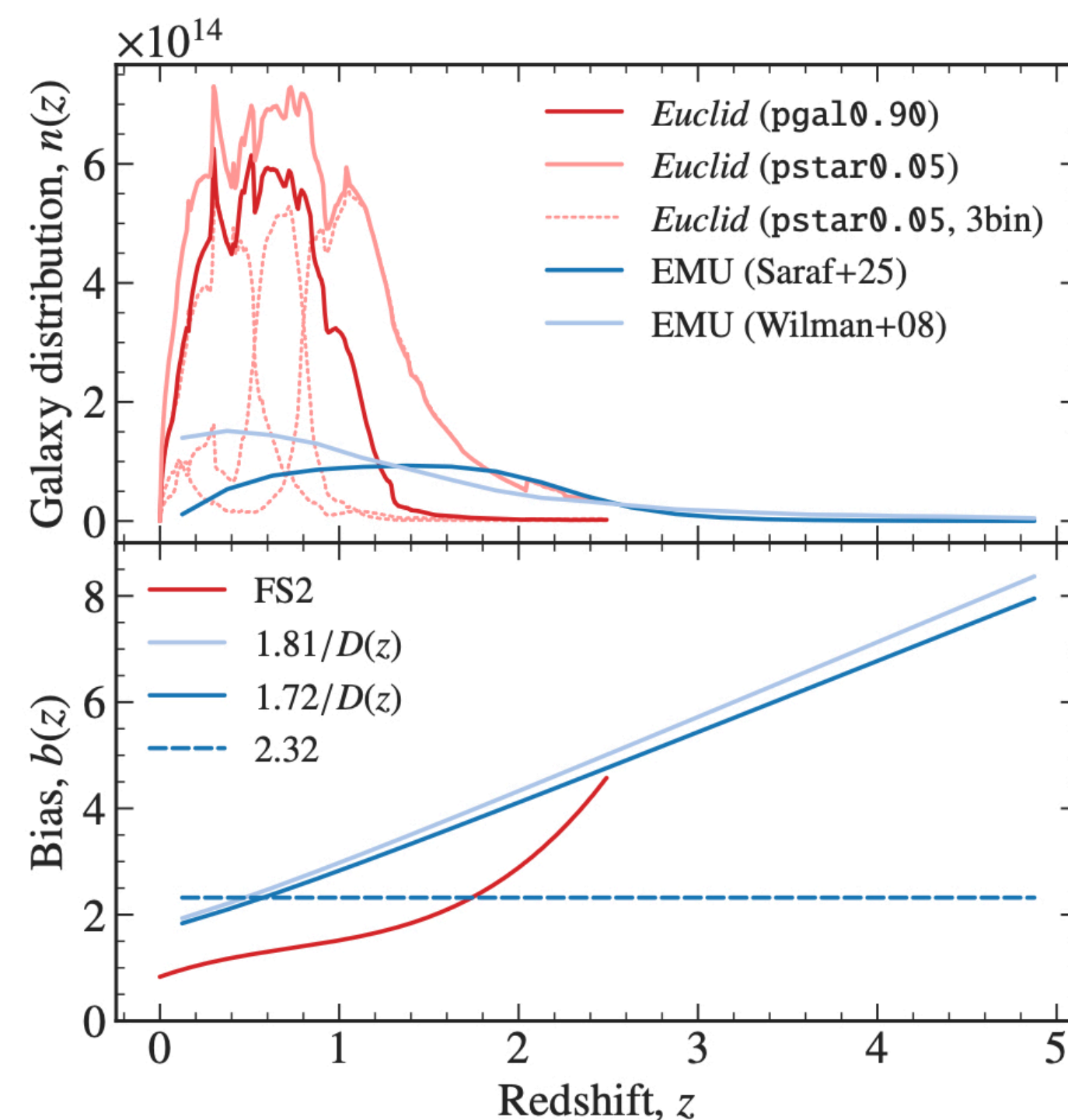
Fabbian, Pagano, ++ in prep.

Q1 GC and x-correlation with Radio

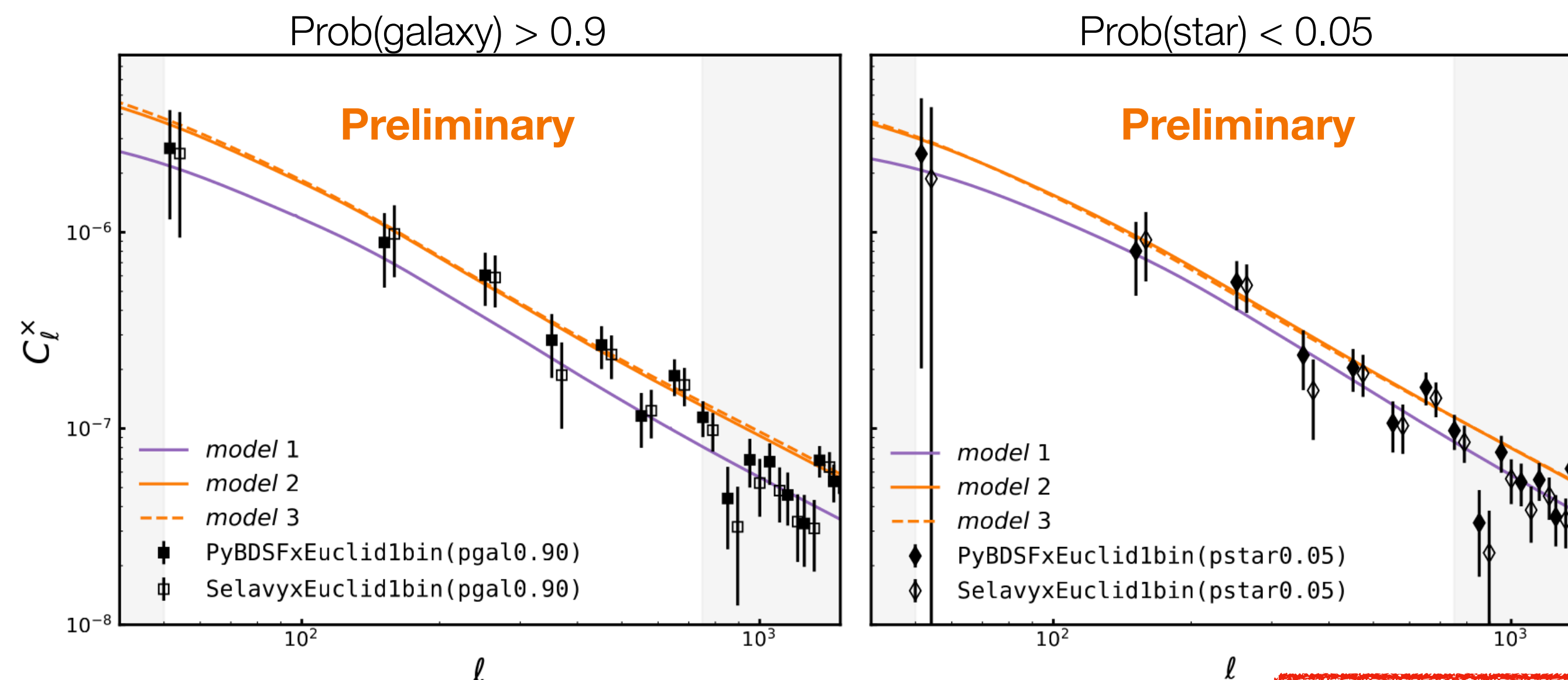
X-Correlation of Euclid Galaxy map with **Evolutionary Map of the Universe** (EMU)
proved by ASKAP, Australian SKA observatory Precursor.



- ✓ **Euclid Deep-South**, covered also by ASKAP
- ✓ Euclid **Photometric-Redshift**
- ✓ Redshift distribution in radio from models
- ✓ Dark Matter bias from Euclid Flagship-2 simulation and models in radio

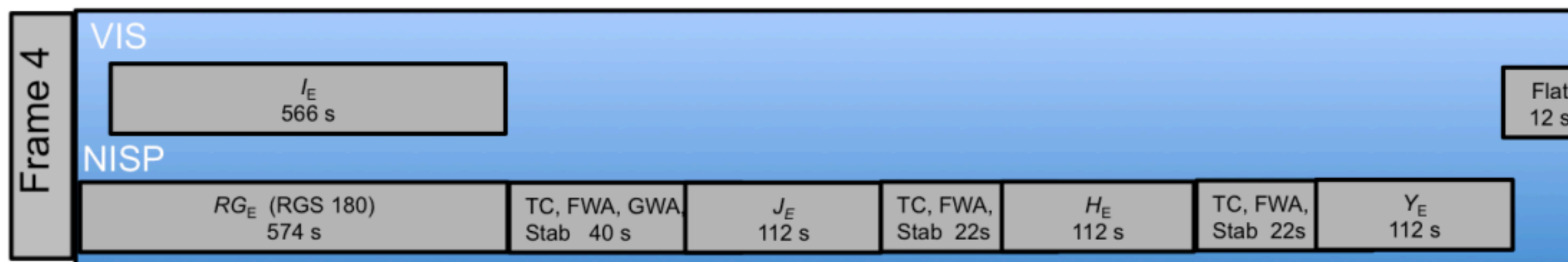
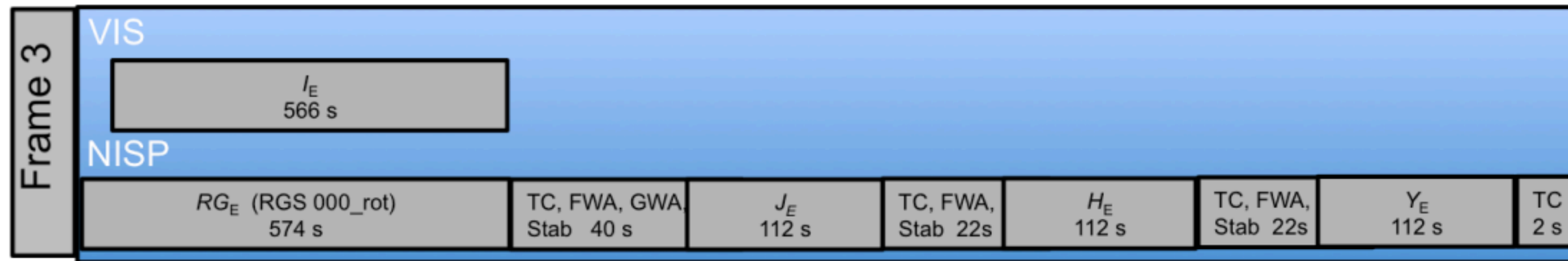
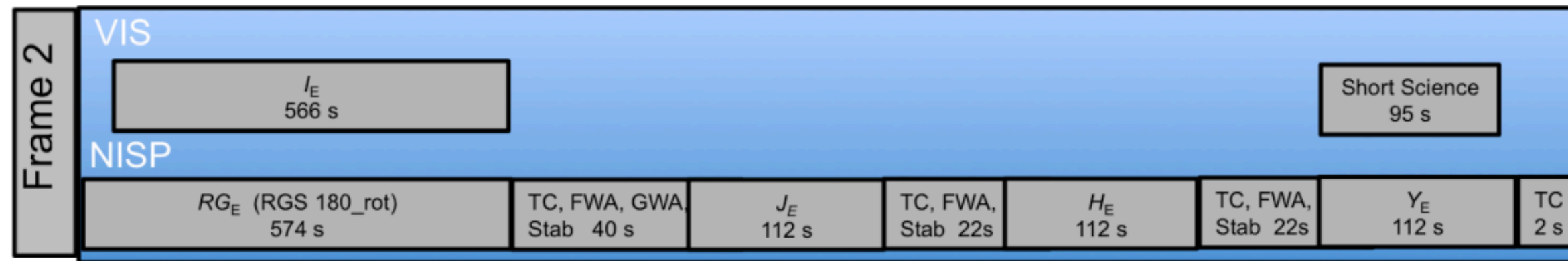
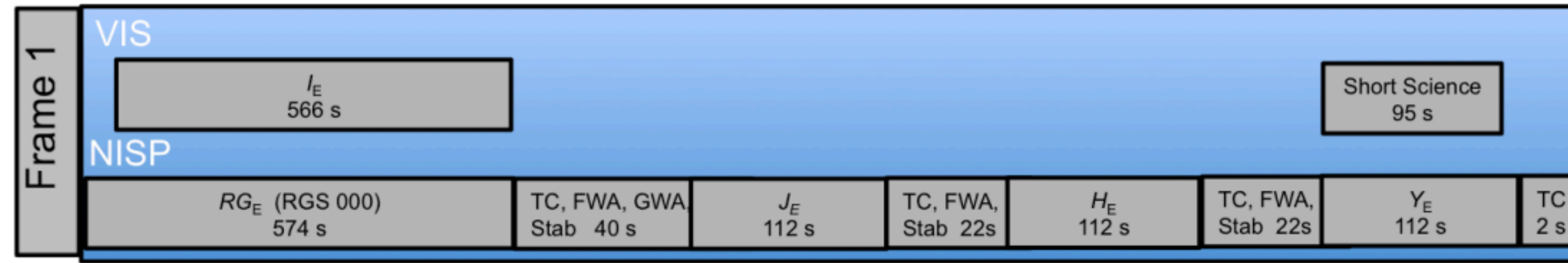


- Preliminary x-correlation spectrum
- The **models follow the data**, only the **amplitude is fitted**

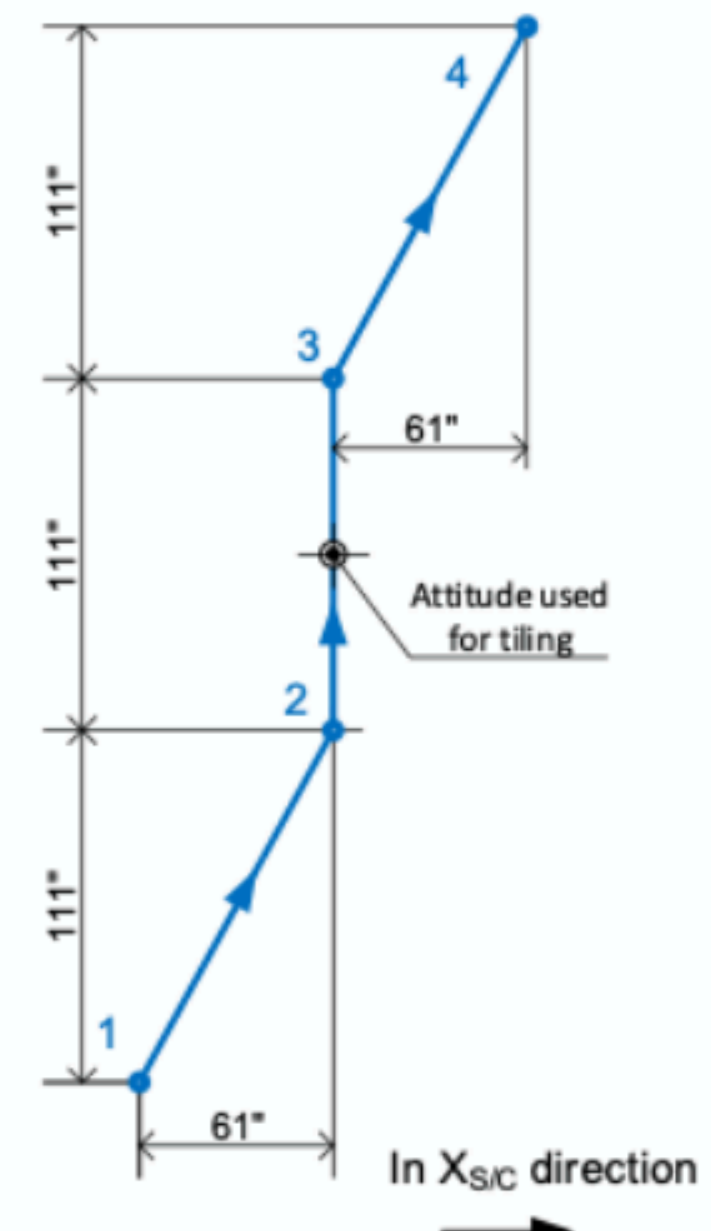
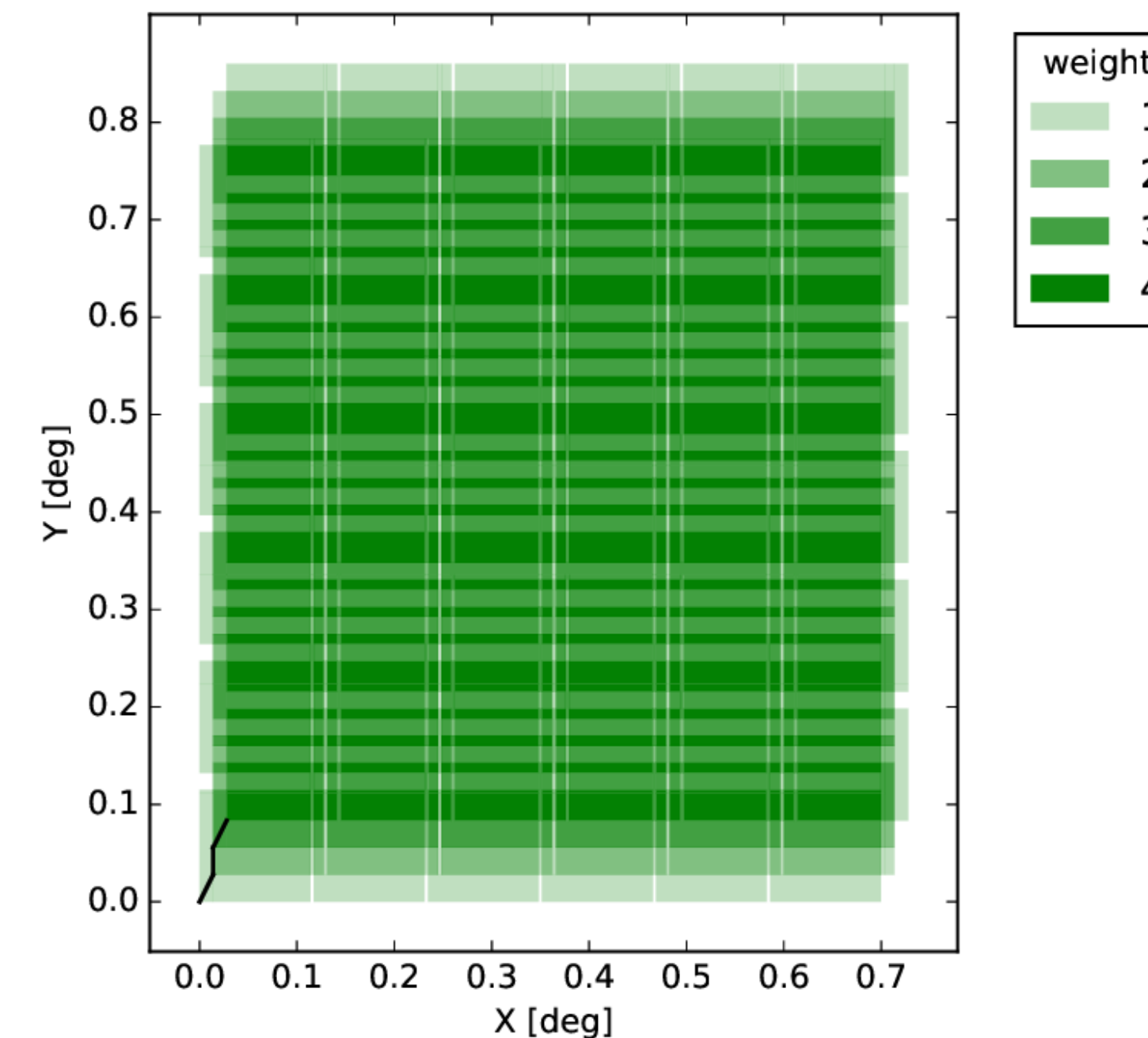
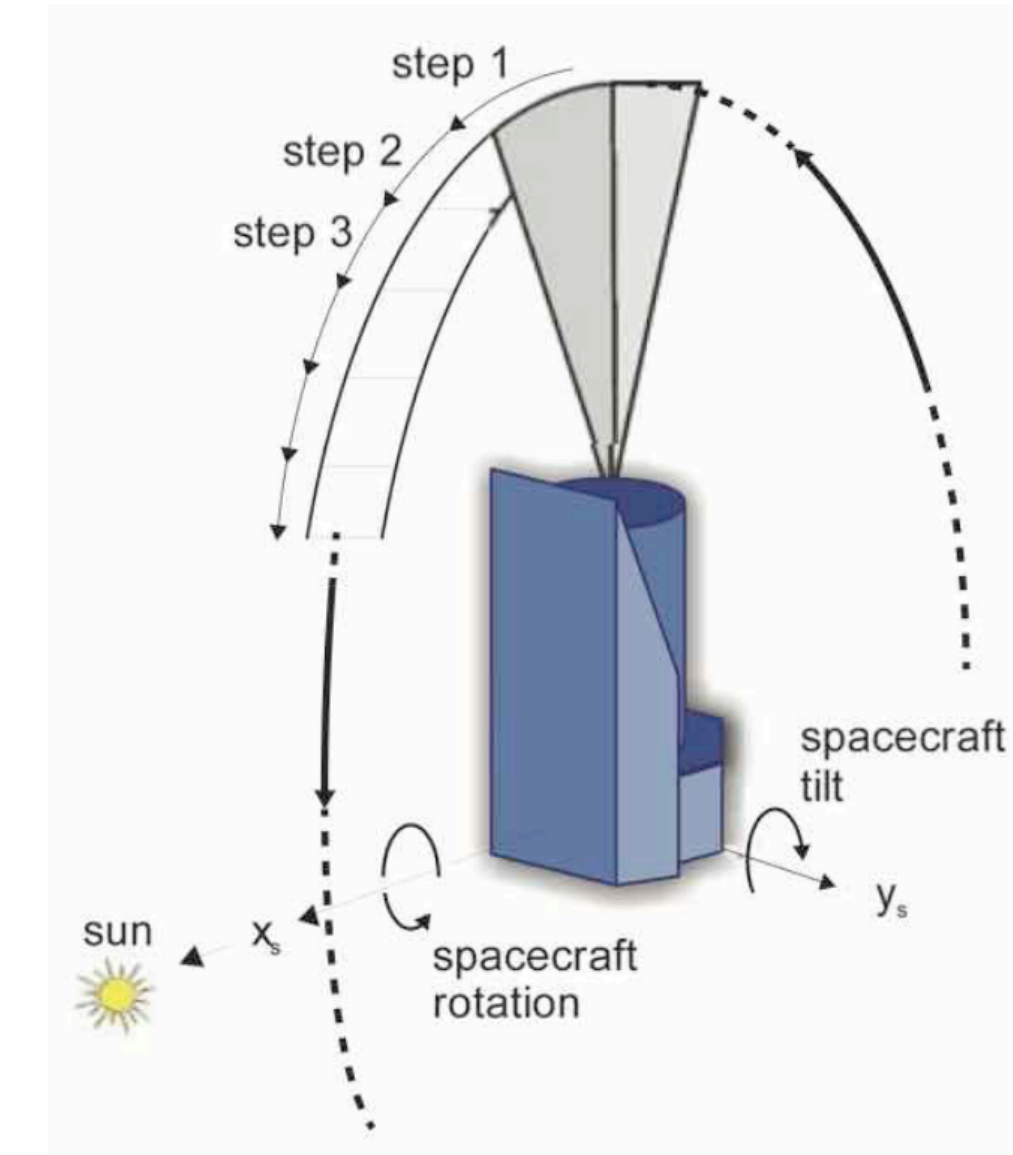
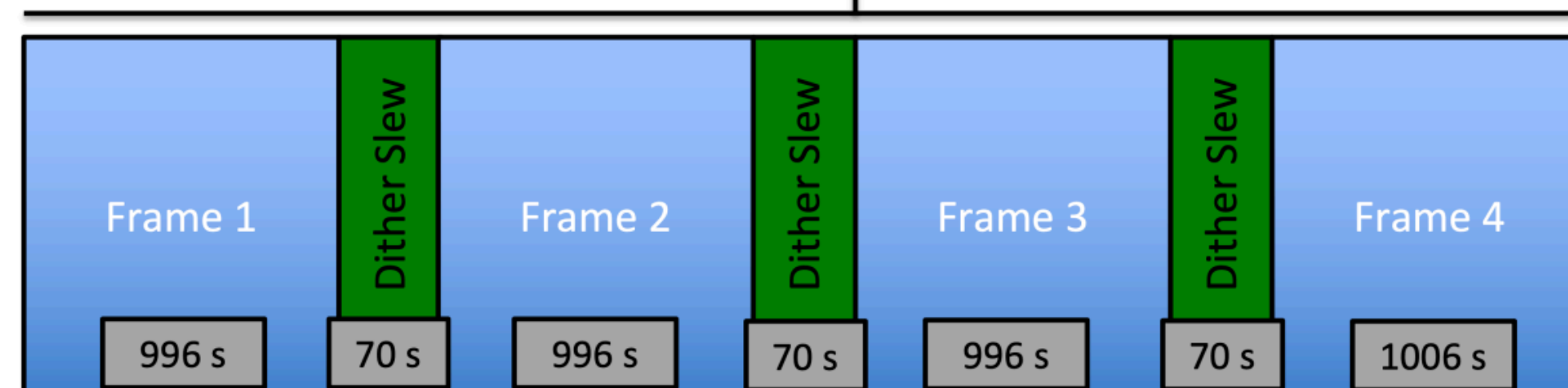


Camera, ++ in prep.

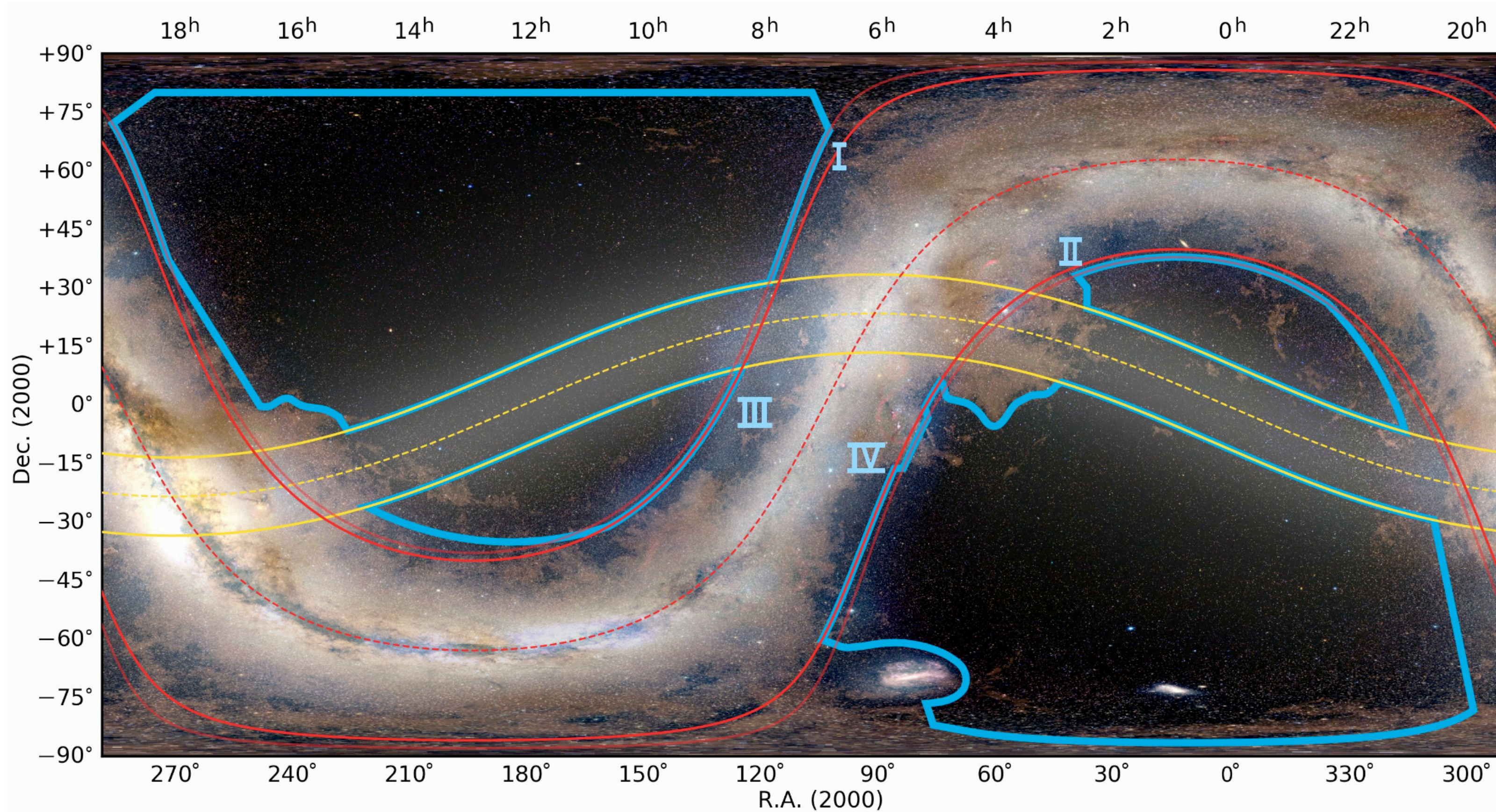
Euclid Observation sequence



ROS = 4204 s

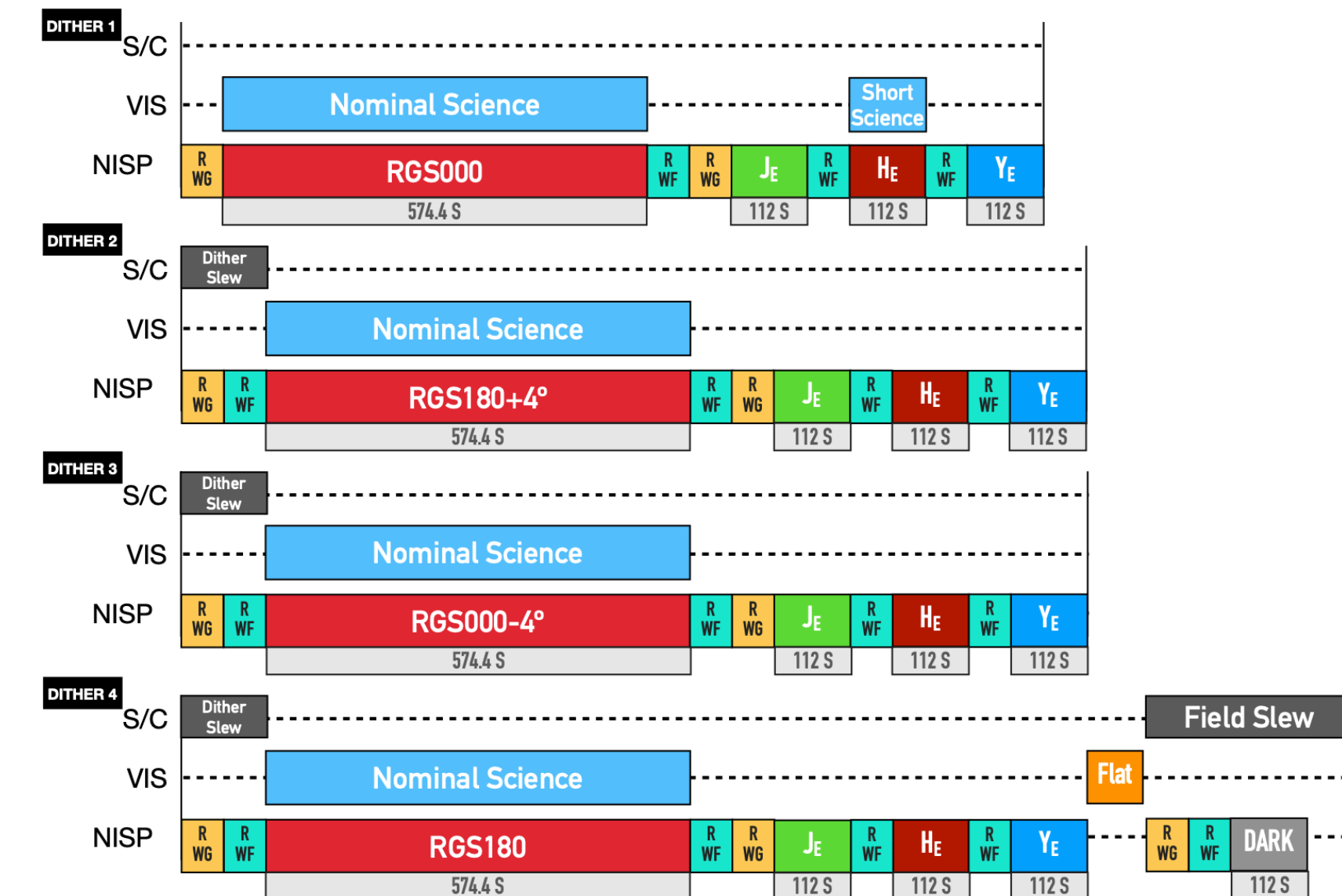
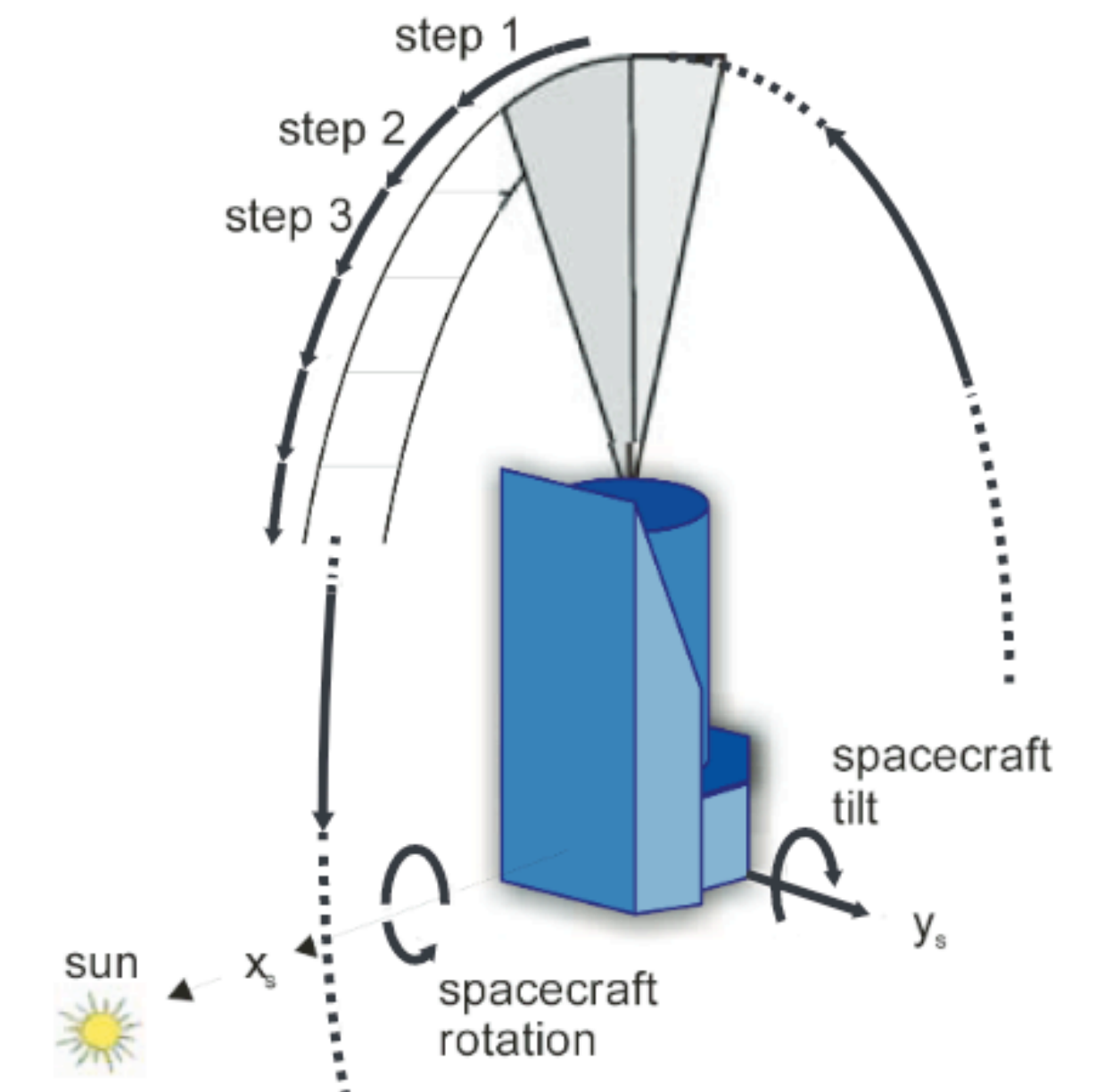


Euclid survey



The Euclid mission will last 6 years

- **~14000 deg²** (1/3 of the sky)
- **~1.5 billion photometric galaxies** (~ 50.000 gal per image)
- **~30 million of spectra** in the range $0.9 < z < 1.8$
- H α line flux limit $2 \times 10^{-16} \text{ erg}^{-1} \text{cm}^{-2} \text{s}^{-1}$

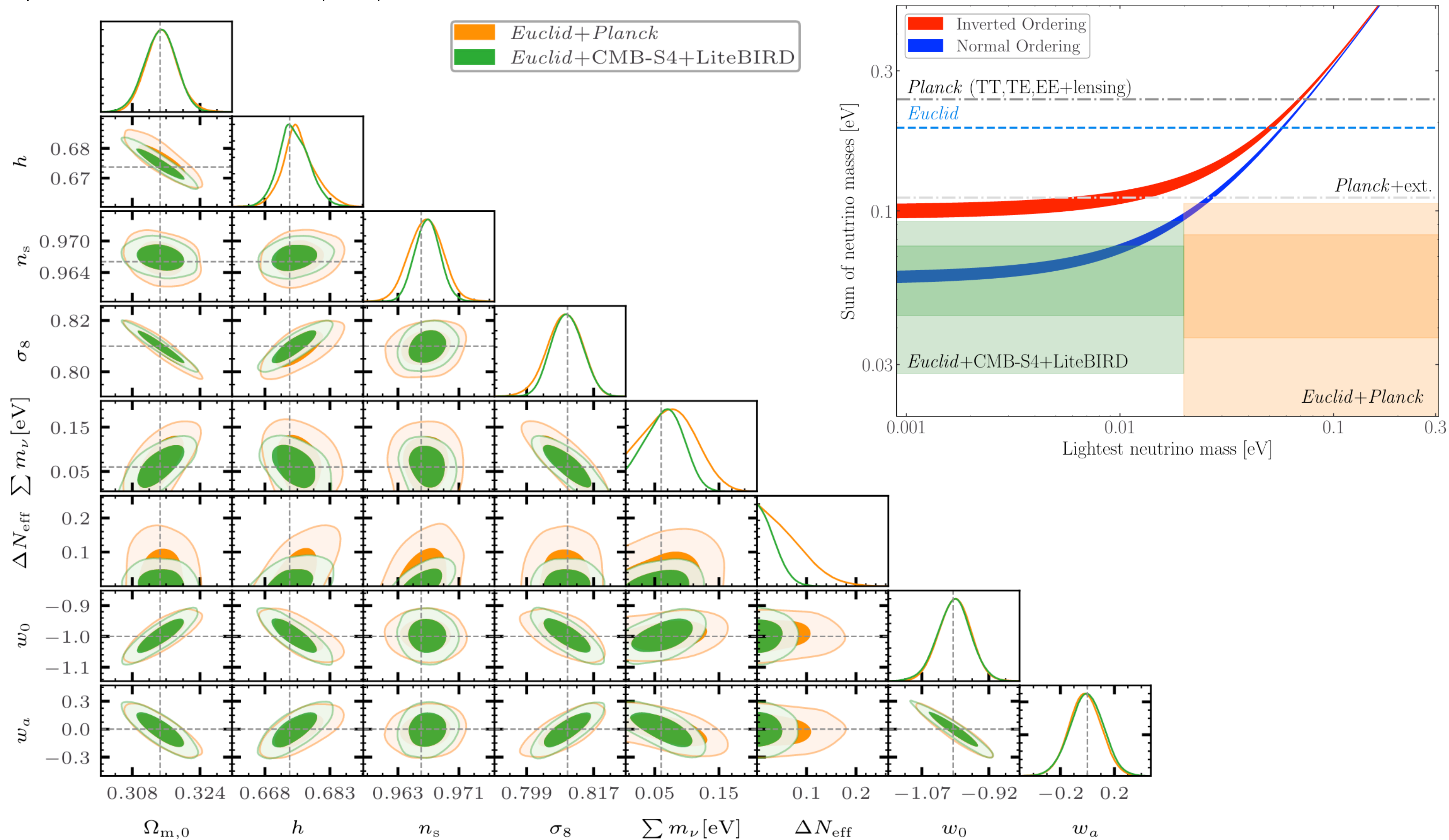


4 “dithers” for each pointing
~ 65 minute per point in the sky



Euclid preparation: Archidiano et. al (2024)

Neutrino Mass with Euclid





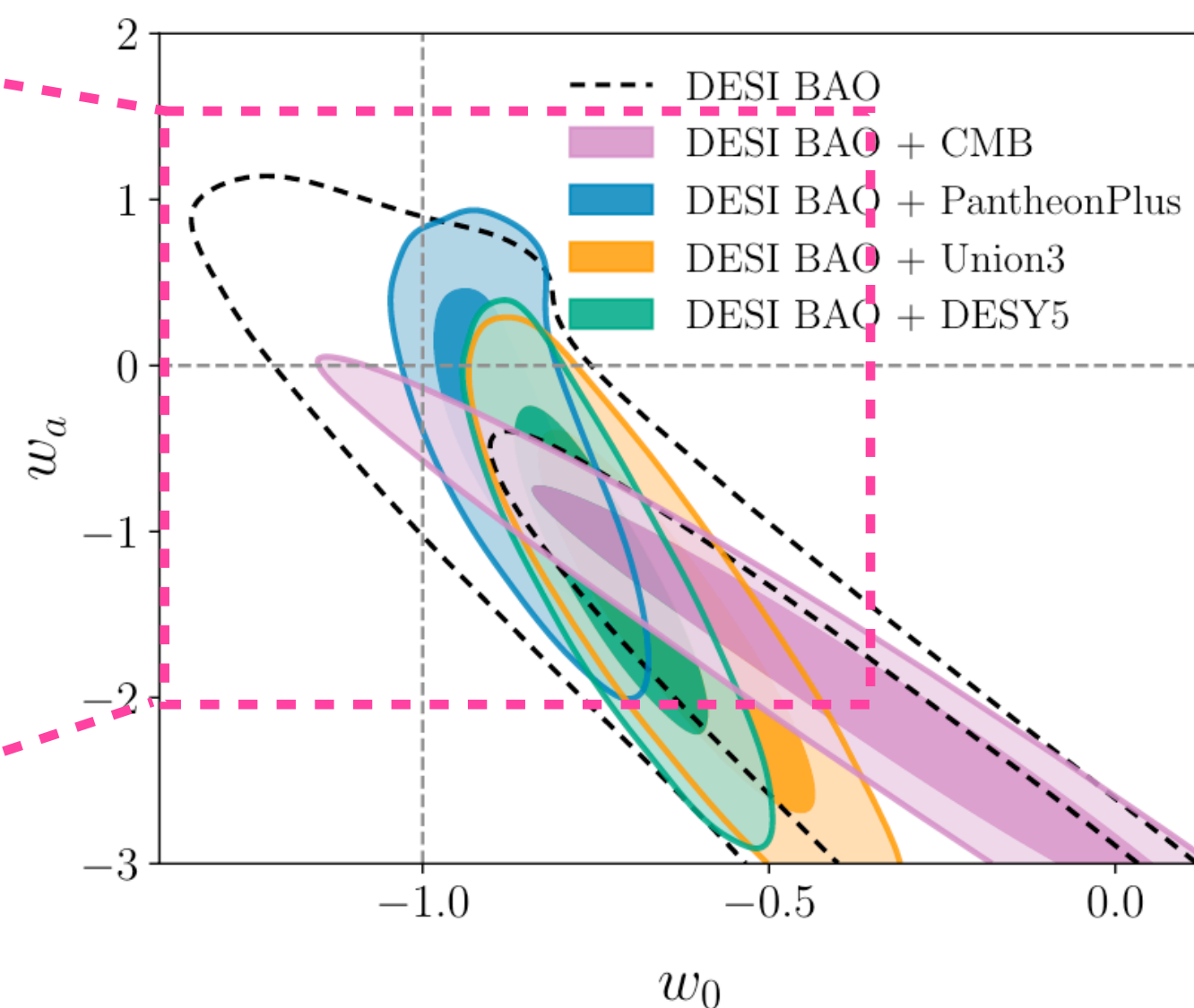
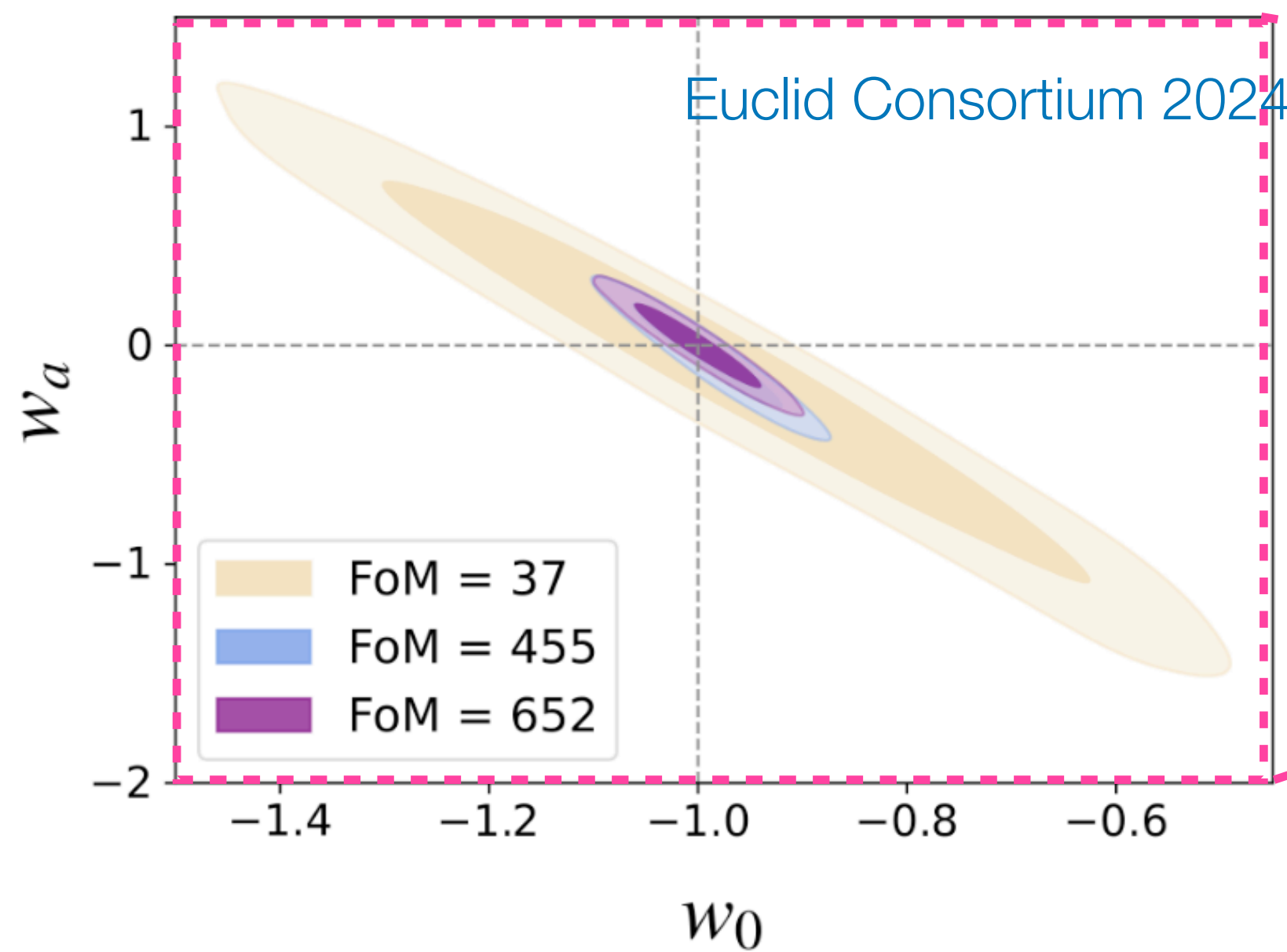
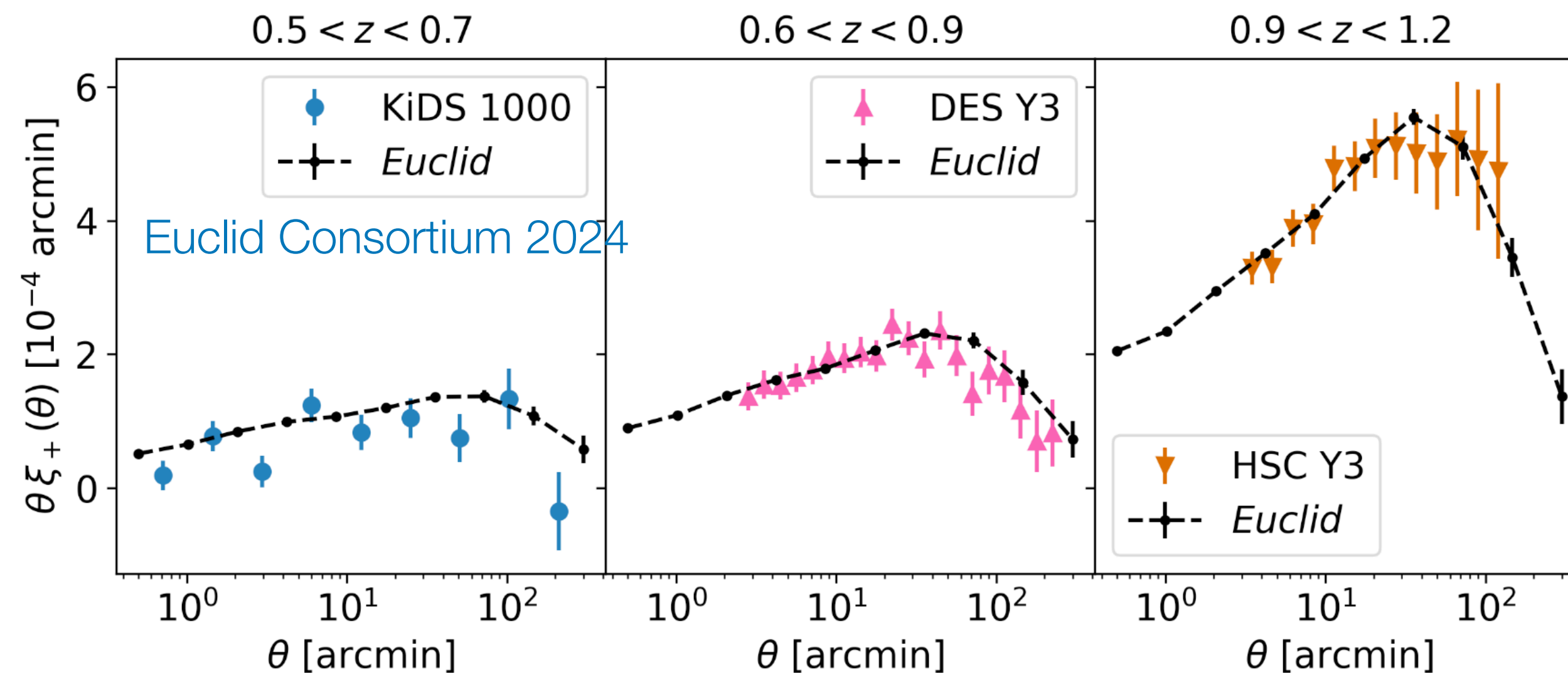
Expected sensitivity

Forecast shear auto-correlation functions, so called “3x2pt”

- Galaxy position : angular auto-correlation functions (galaxy position)
- Galaxy ellipticities : shear auto-correlation function
- position x ellipticity : cross-correlation

- w_0w_a CDM (GCsp)
- w_0w_a CDM (3x2pt)
- w_0w_a CDM (3x2pt + GCsp)

Sensitivity to matter distribution along the line-of sight and history of structure formation

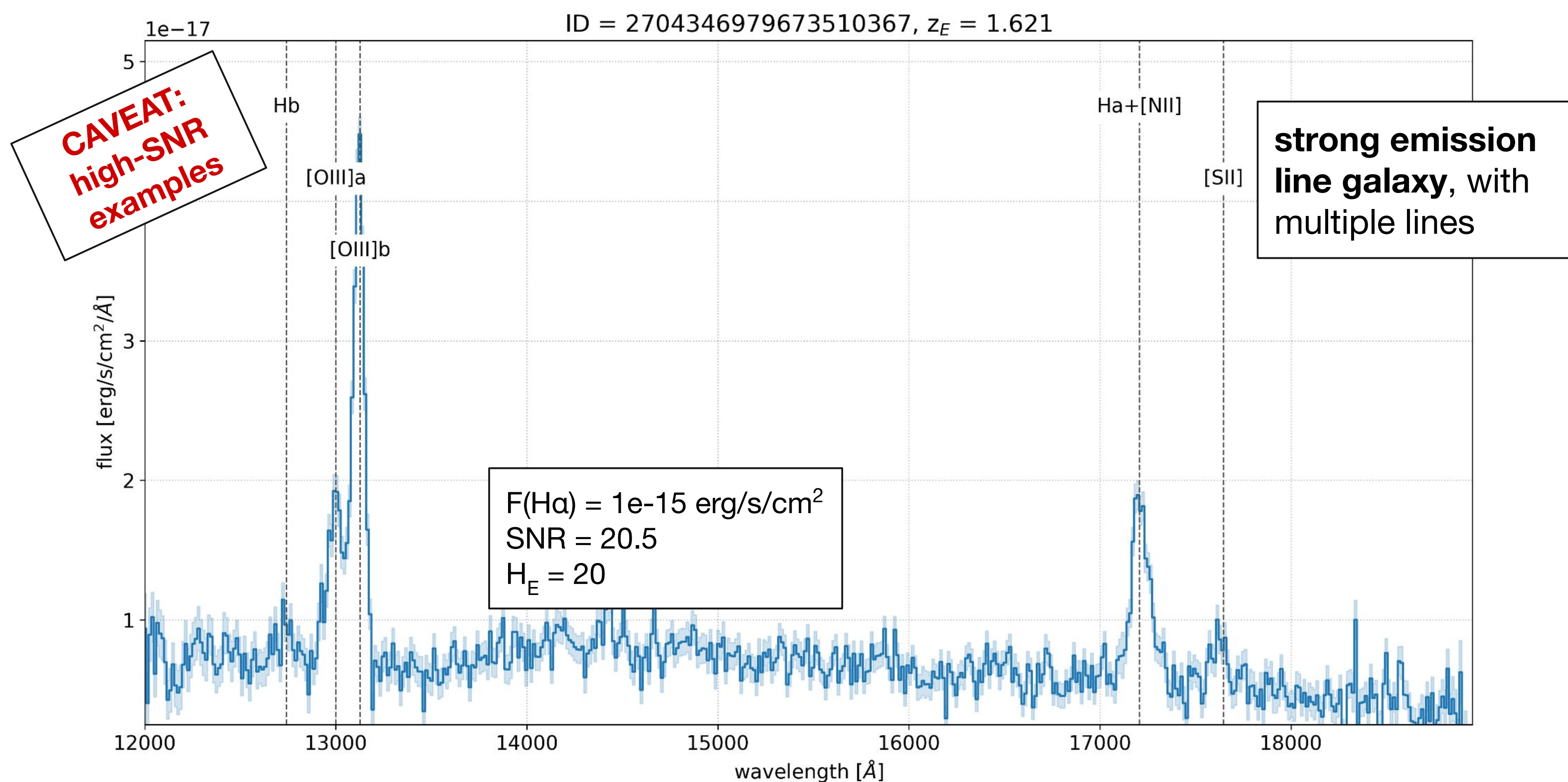
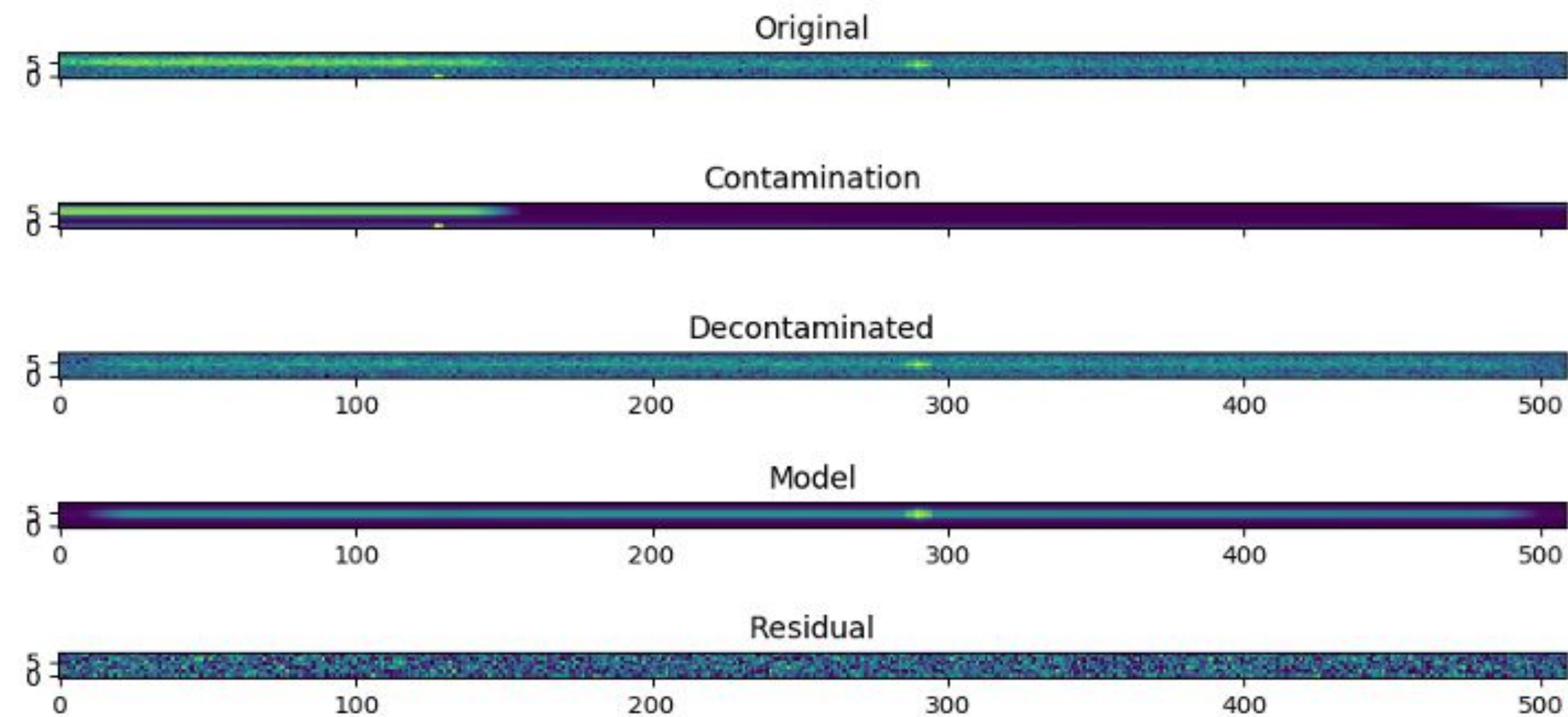


Sensitivity to Dark energy equation of state
 $w_0 \neq -1$ $\rightarrow$ departure from cosmological constant

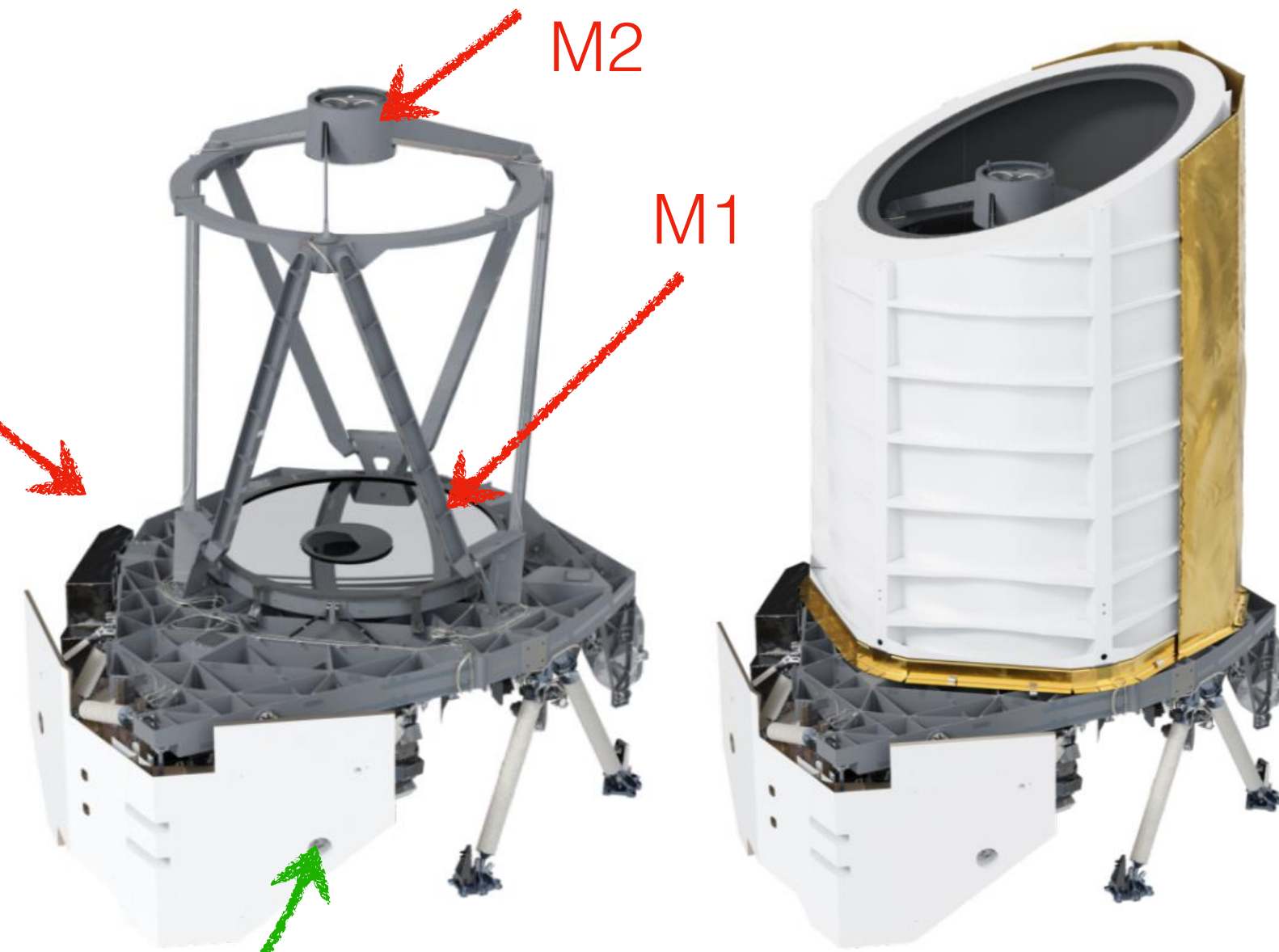
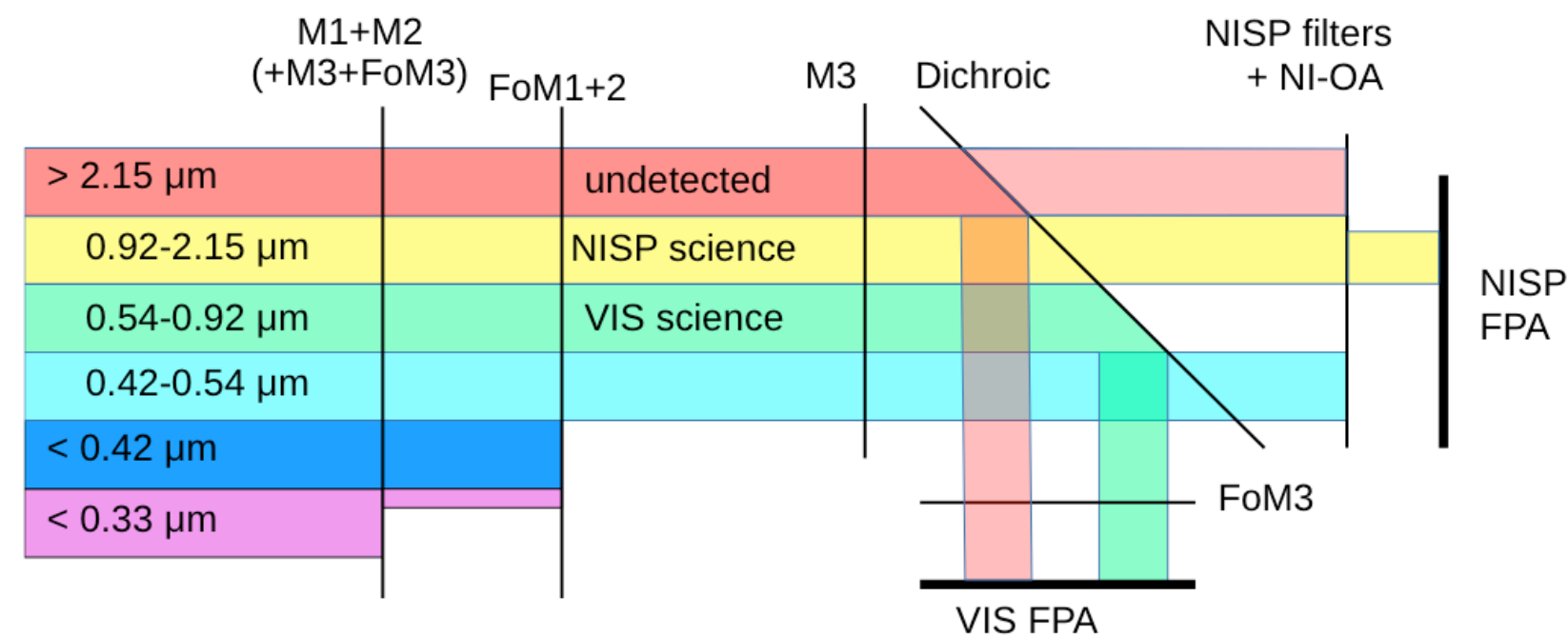
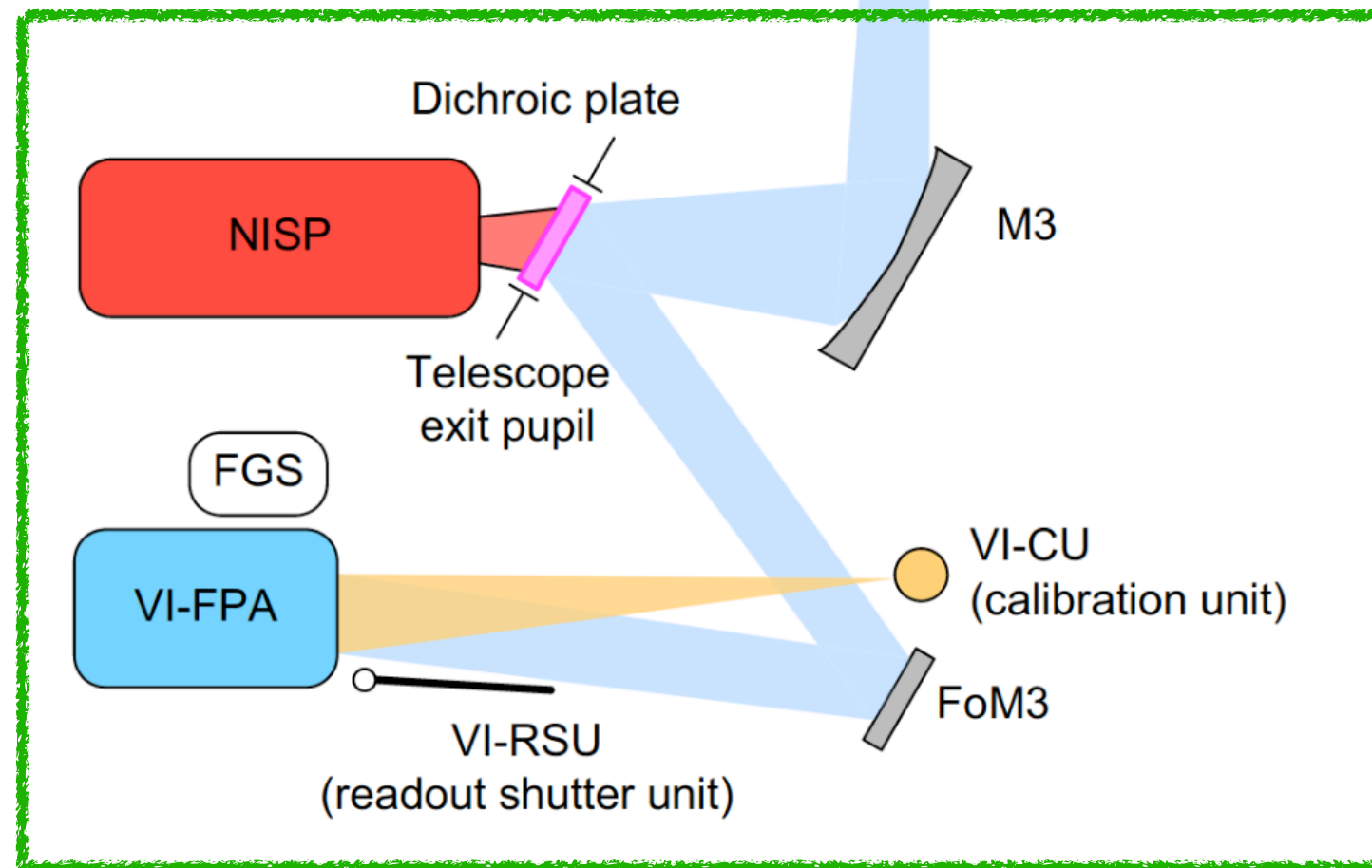
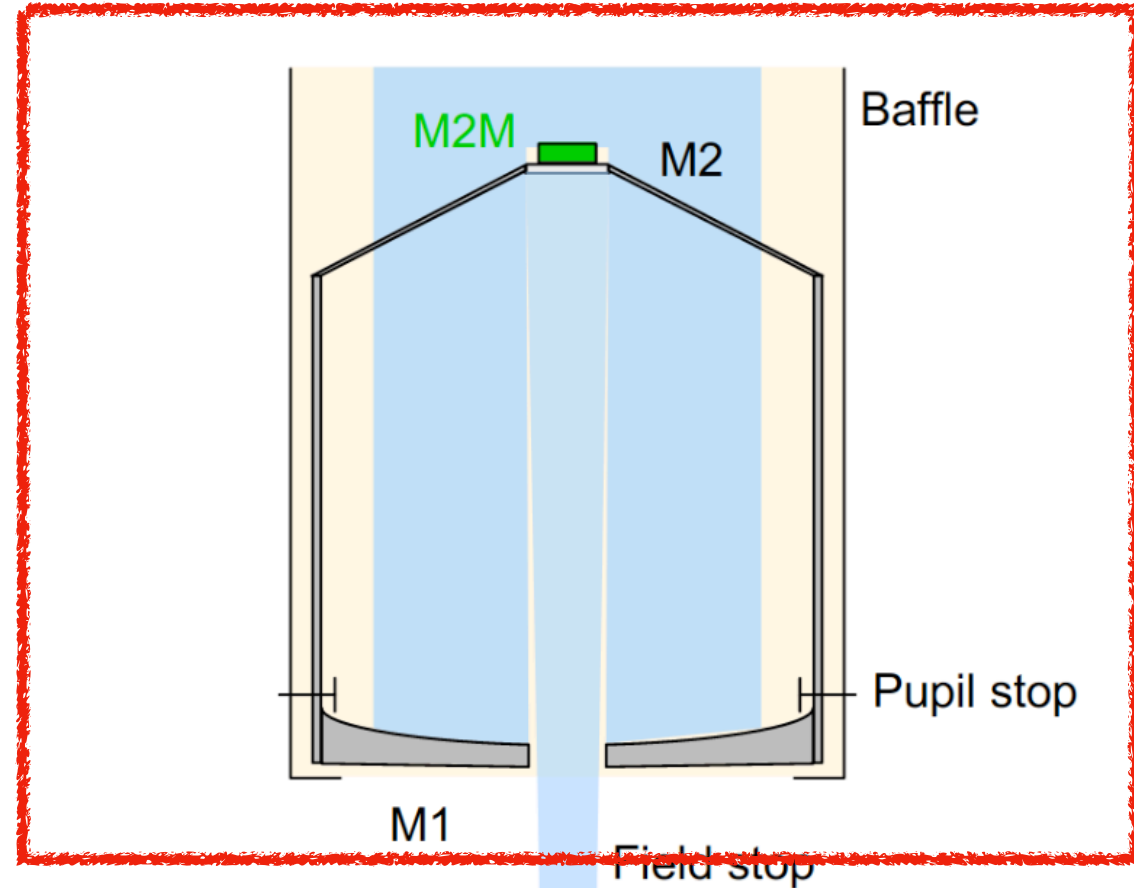
$$w(z) = w_0 + w_a \frac{z}{1+z}$$

DESI Collaboration 2024

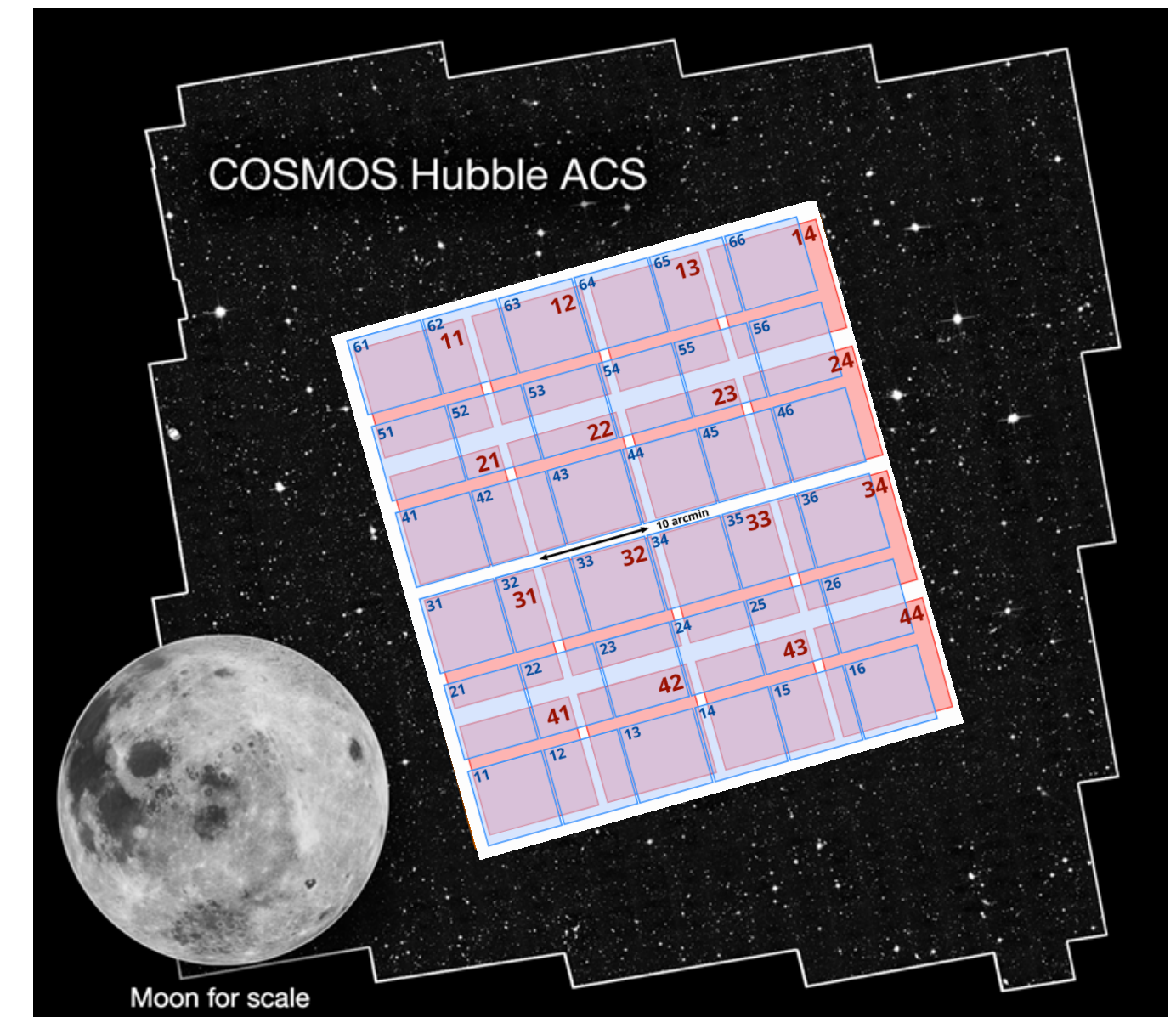
- The 4 spectra (RGS000, RGS180, RGS180+4, RGS180-4) of each identify sources (in VIS and NISP photo) are decontaminated by overlapping spectra and then combined
- Spectra are reconstructed to identify the lines, manly H α



Euclid Spacecraft



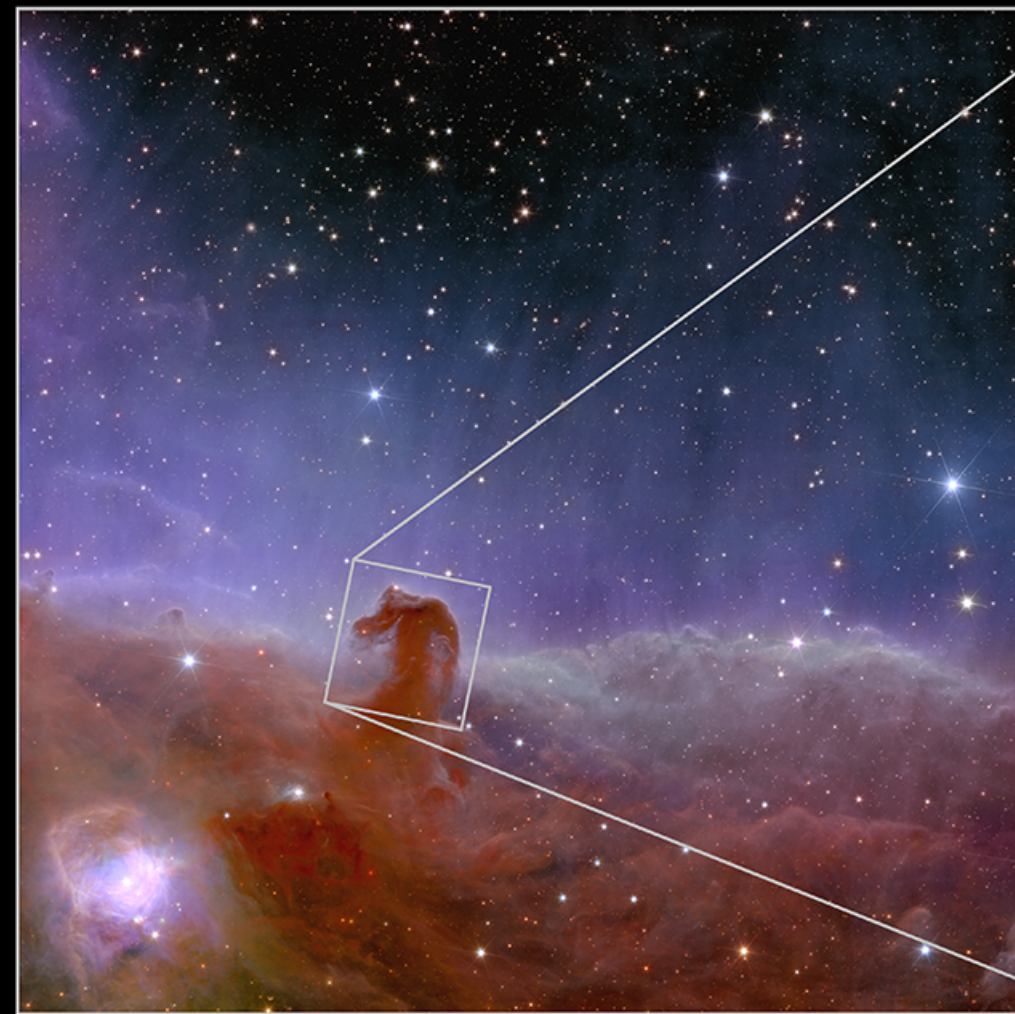
AIRBUS



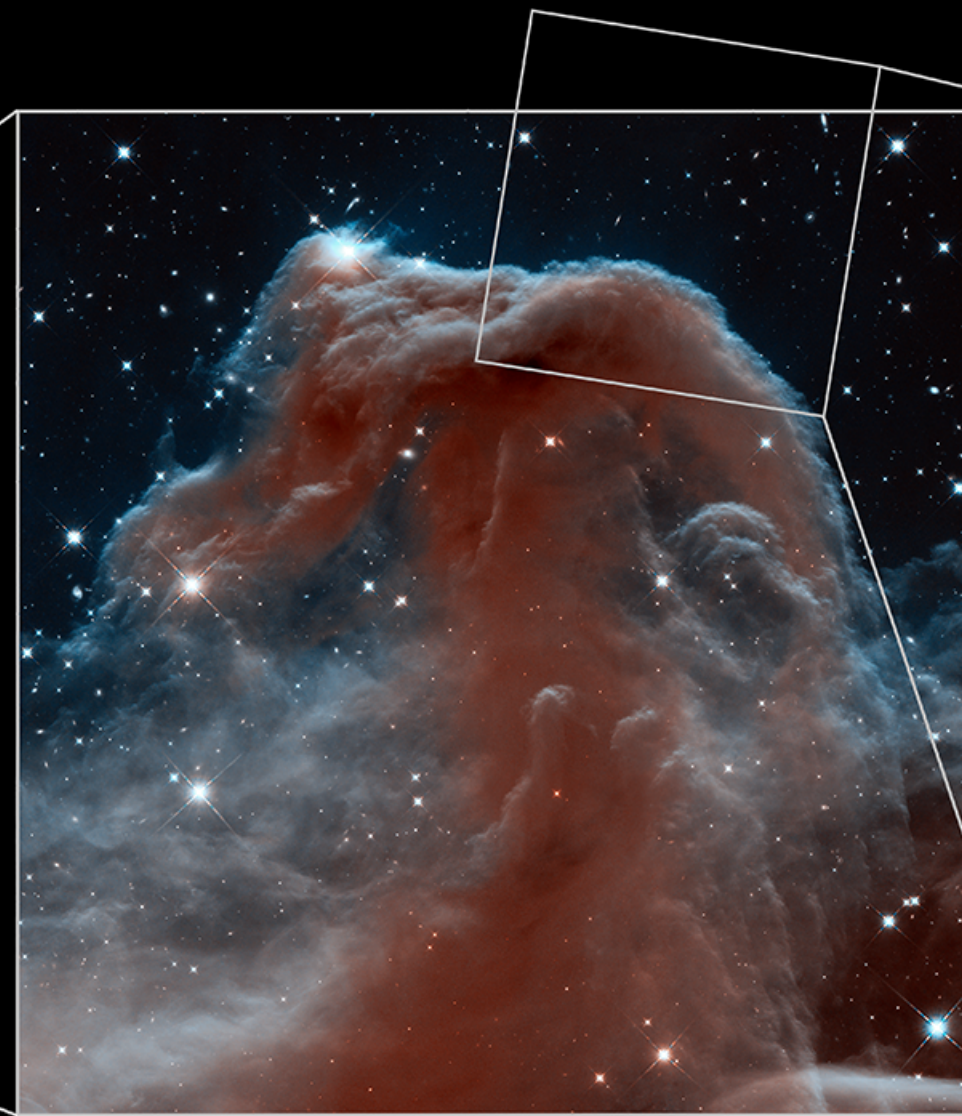
Optical telescope

- **1.2 m prim. aperture Korsch telescope**, 3 mirrors
- Mirror and structure in **Silicon Carbide** (rigidity and stability)
- **Wide field of view: 0.55 deg²** (180 times Hubble telescope)
- very low straylight —> **high contrast** images
- focal length: 24.5 m
- Passive temperature control : ~ 130 K

Euclid is a **wide angle telescope** designed to acquire large portion of the sky in single images



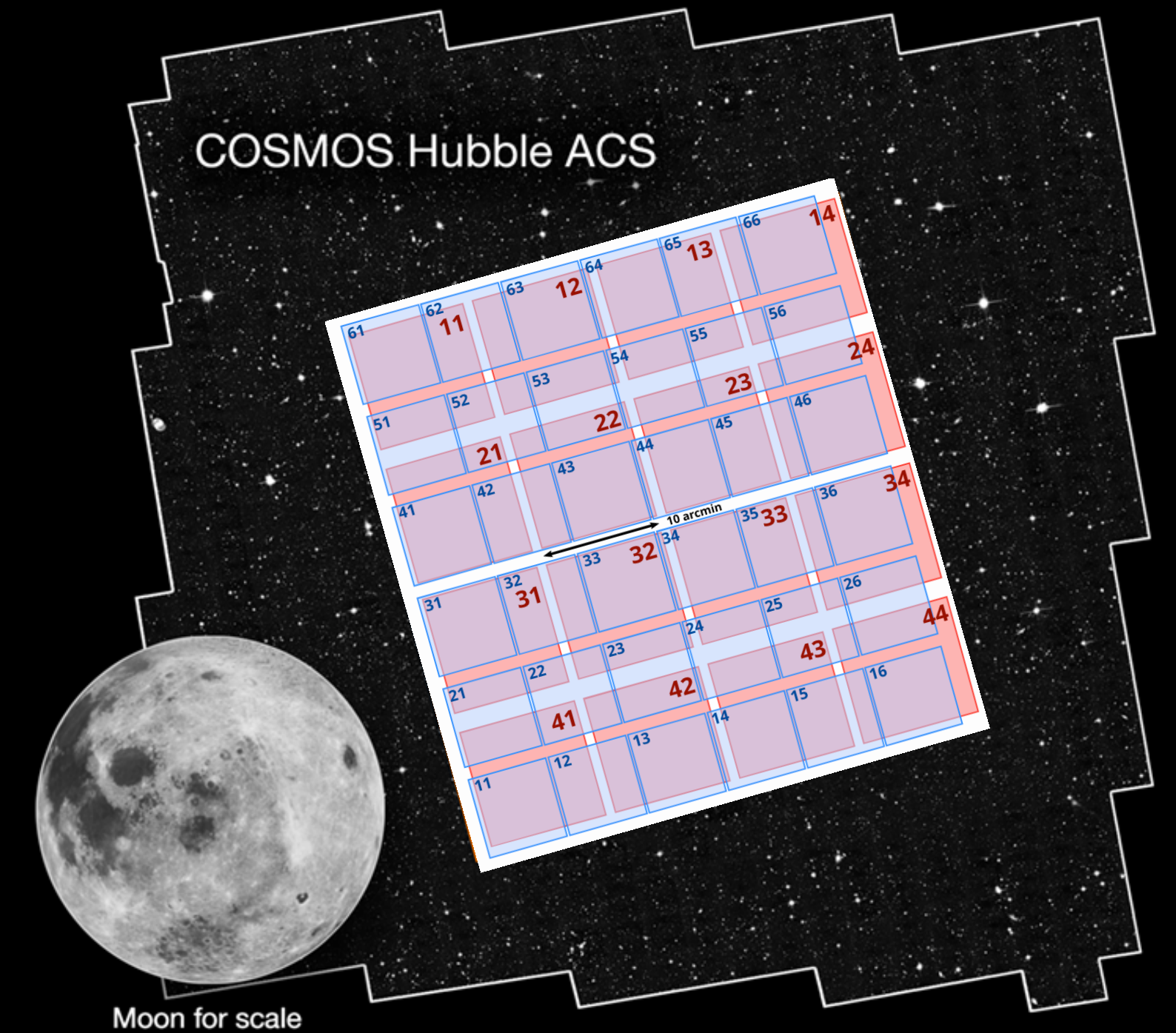
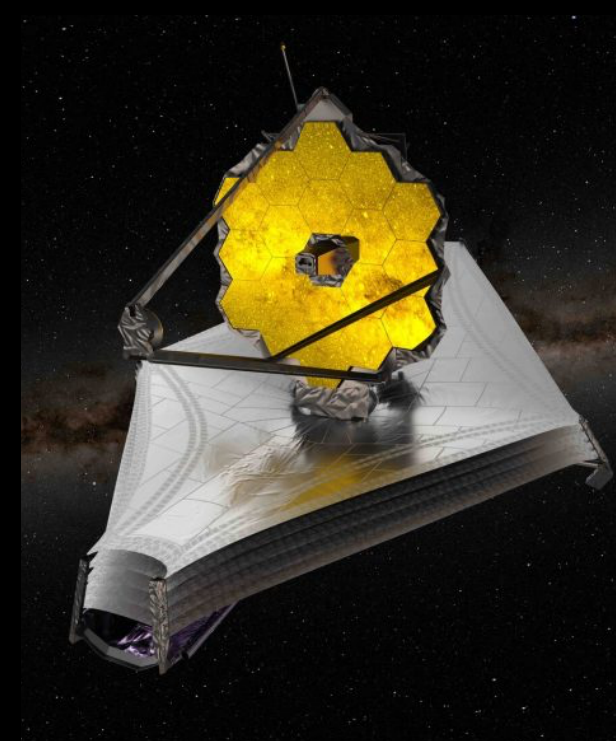
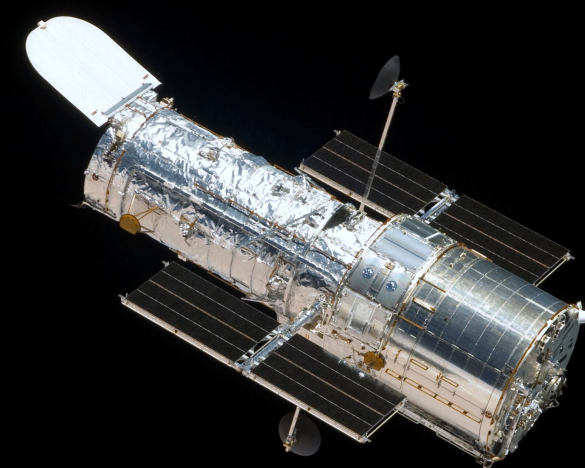
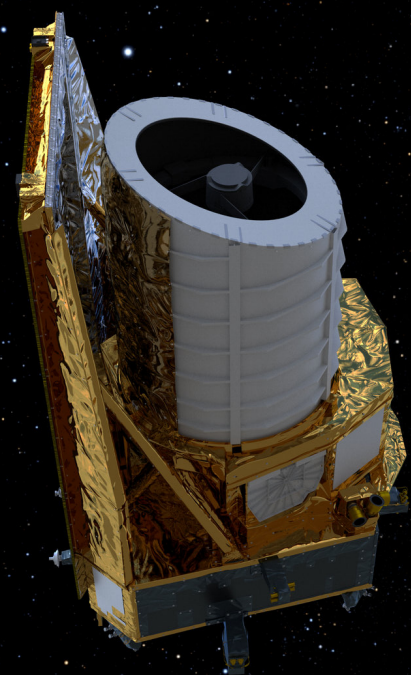
Euclid (Visible-Infrared)

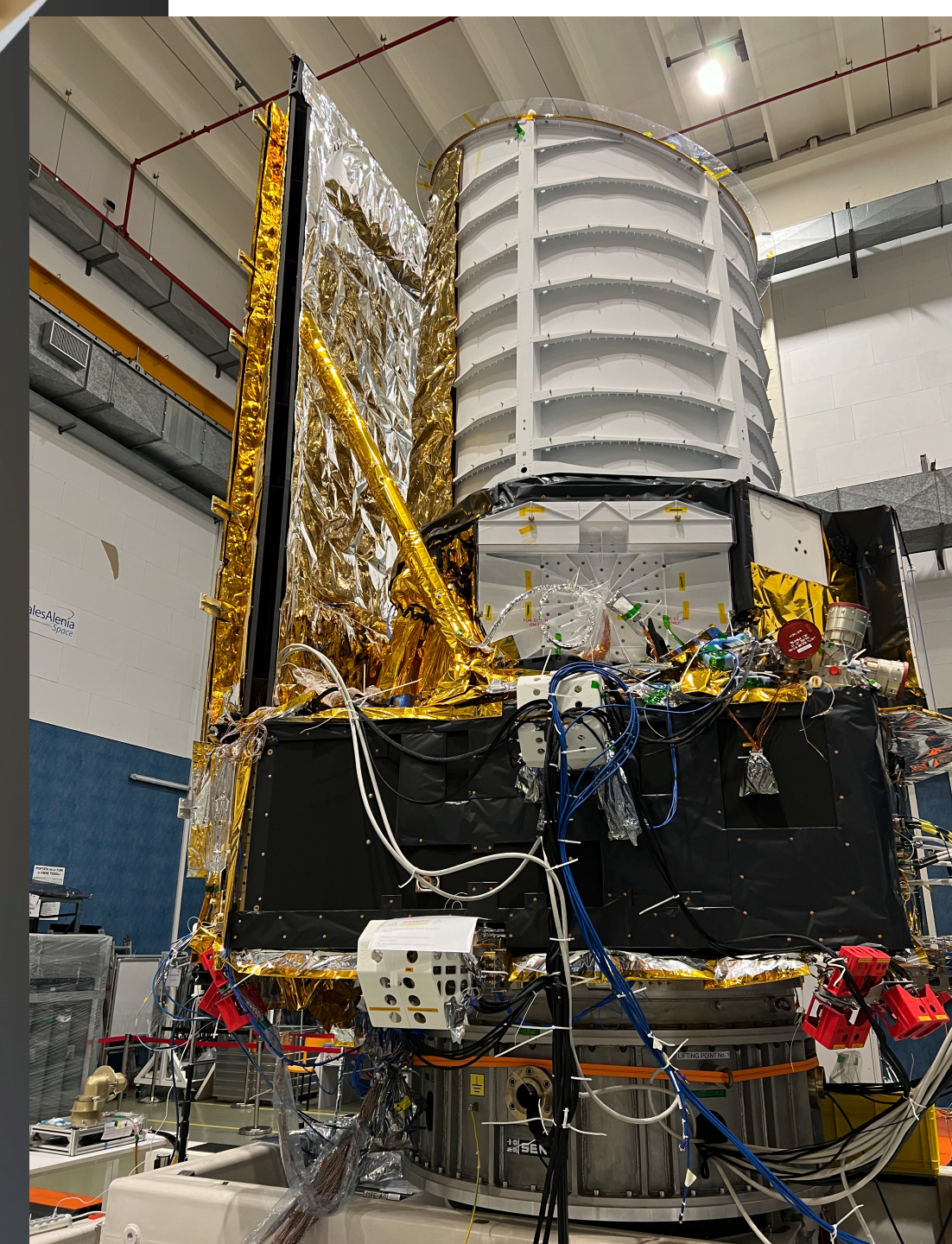
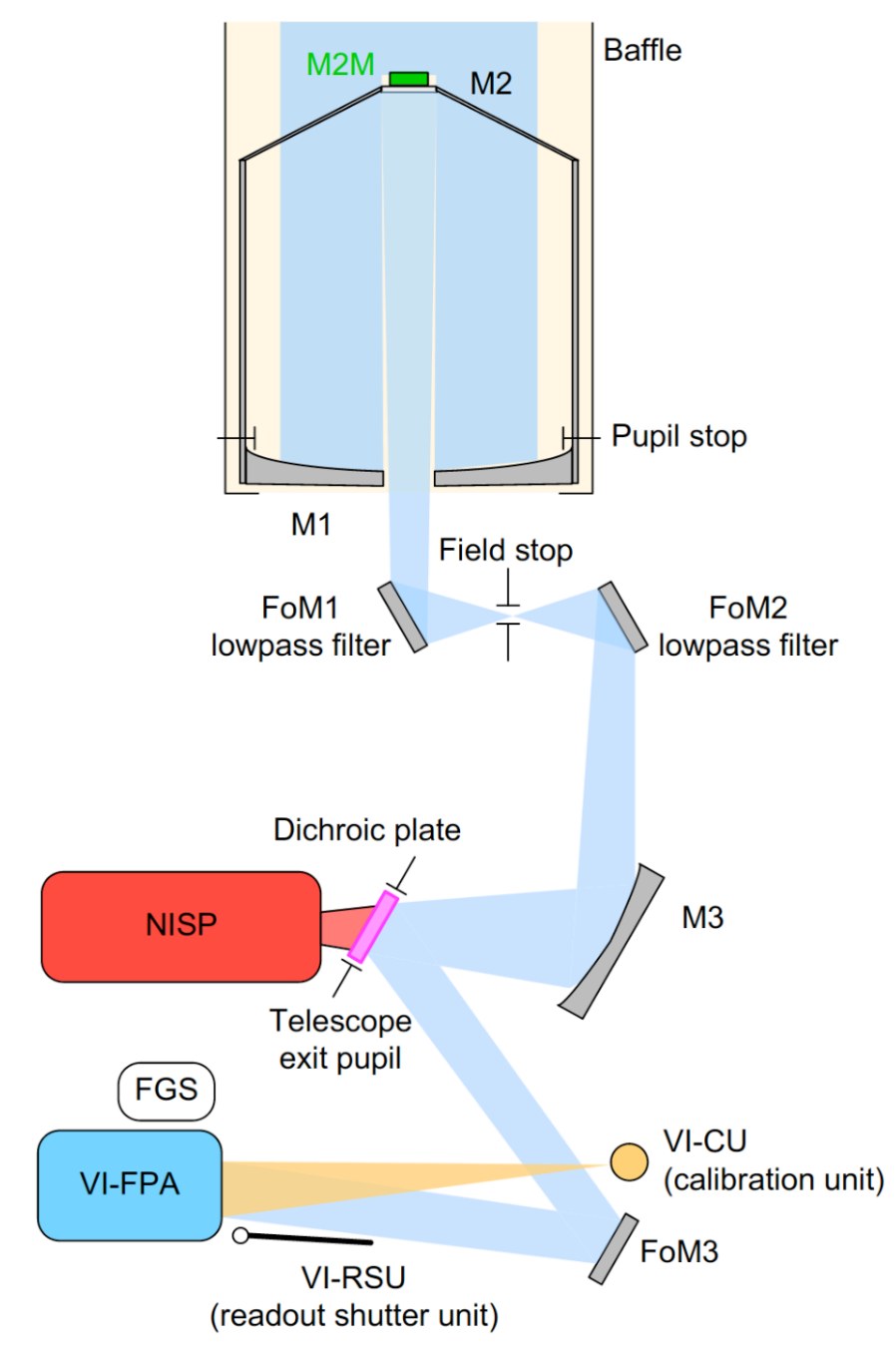
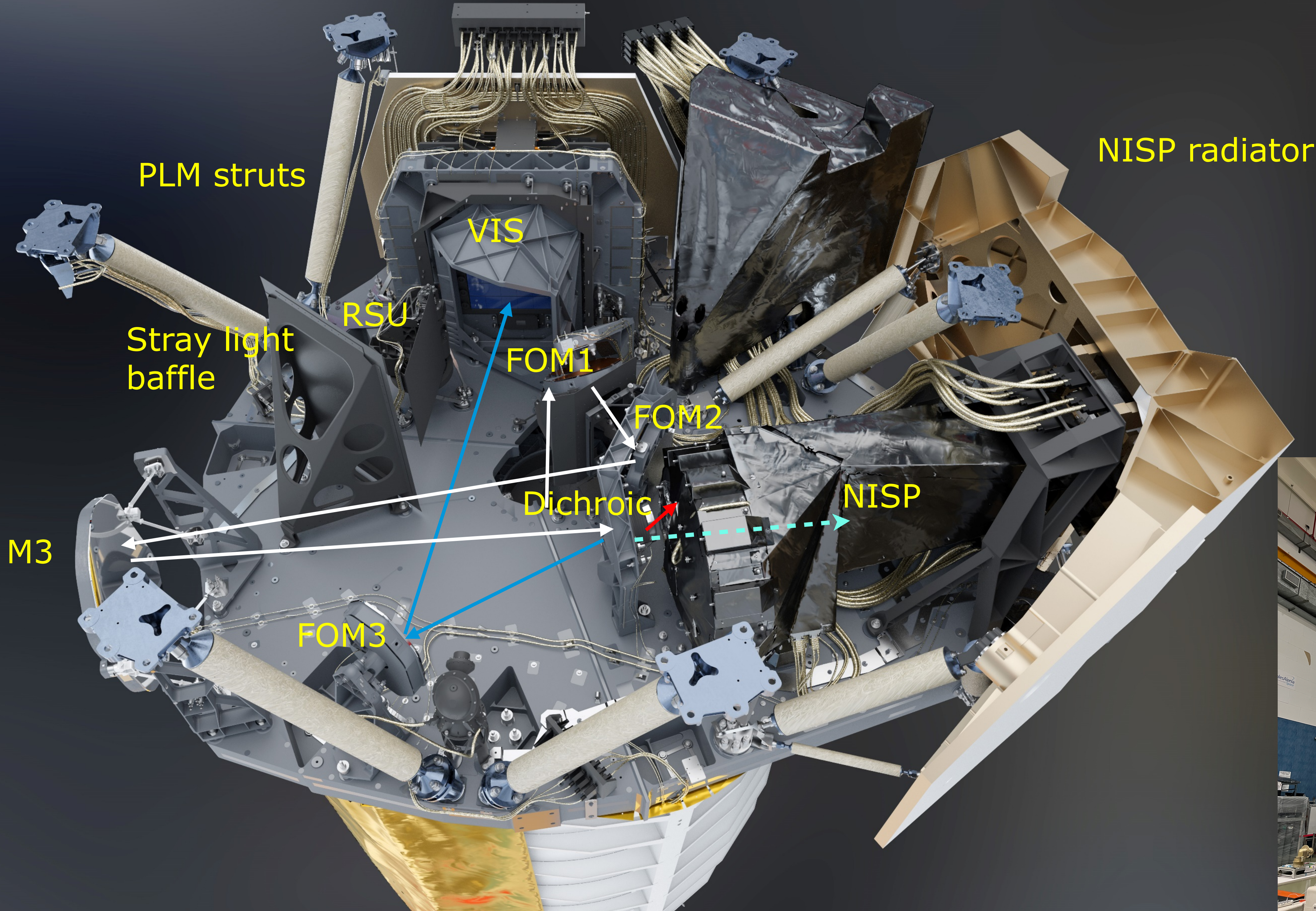


Hubble (Infrared)

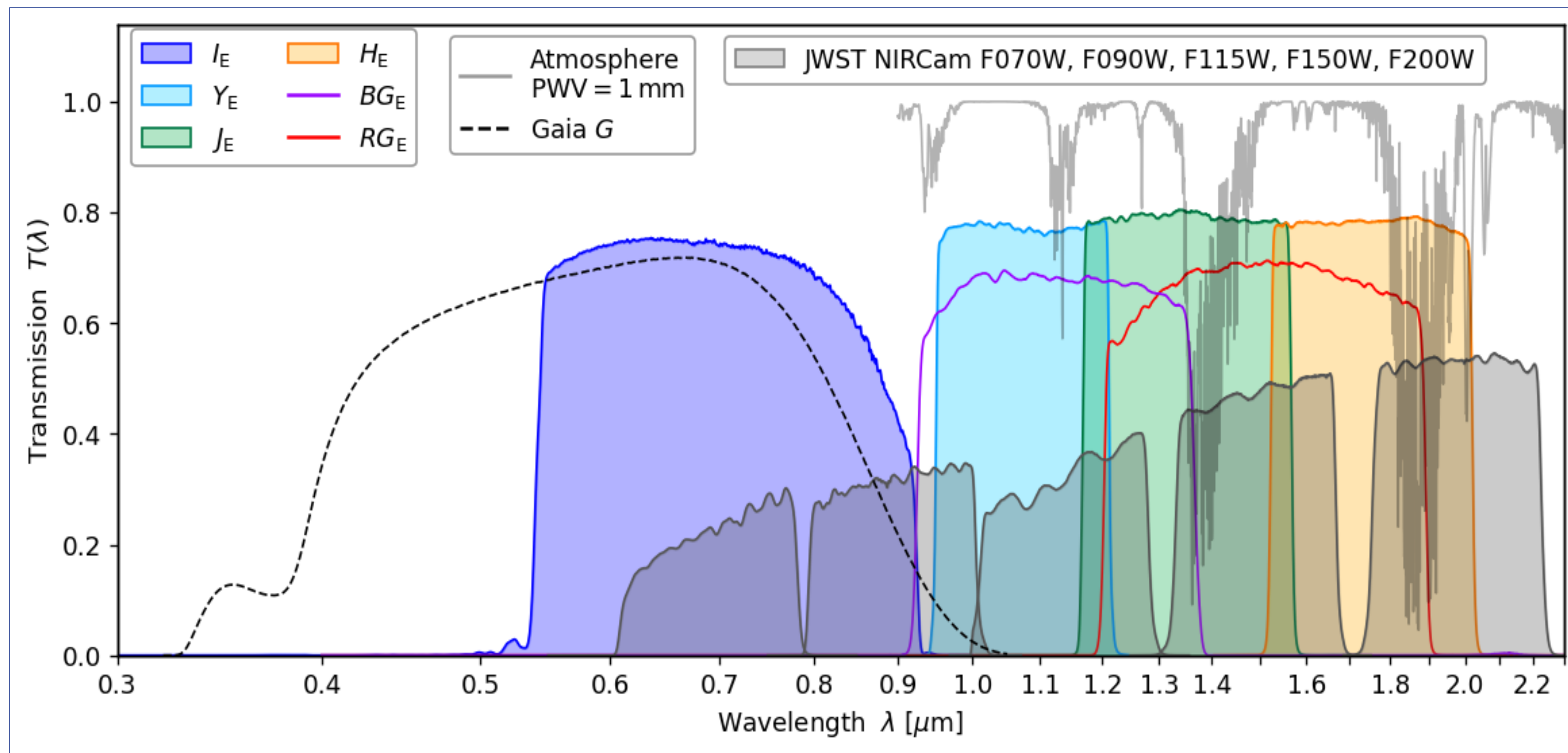


Webb (Infrared)



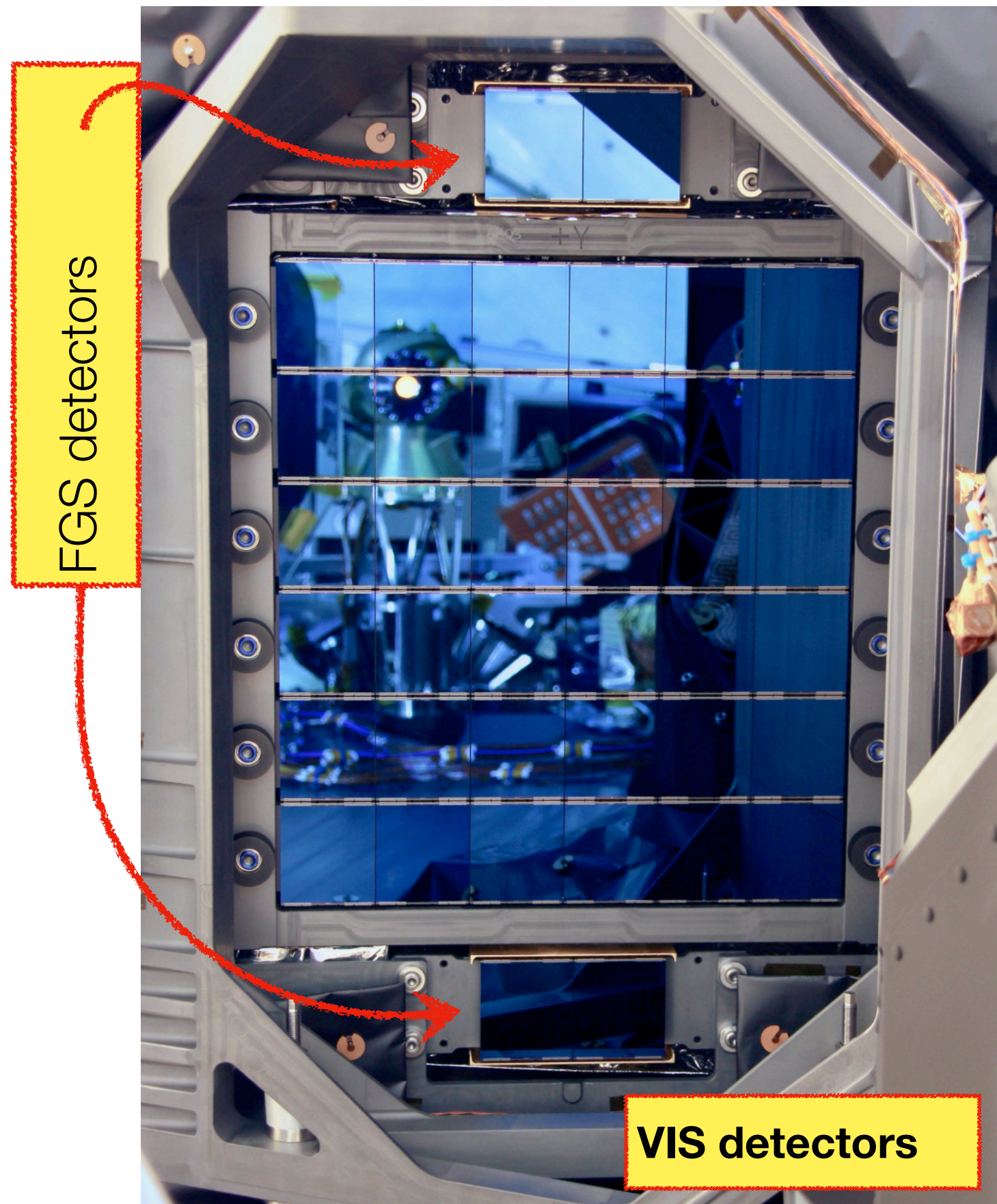
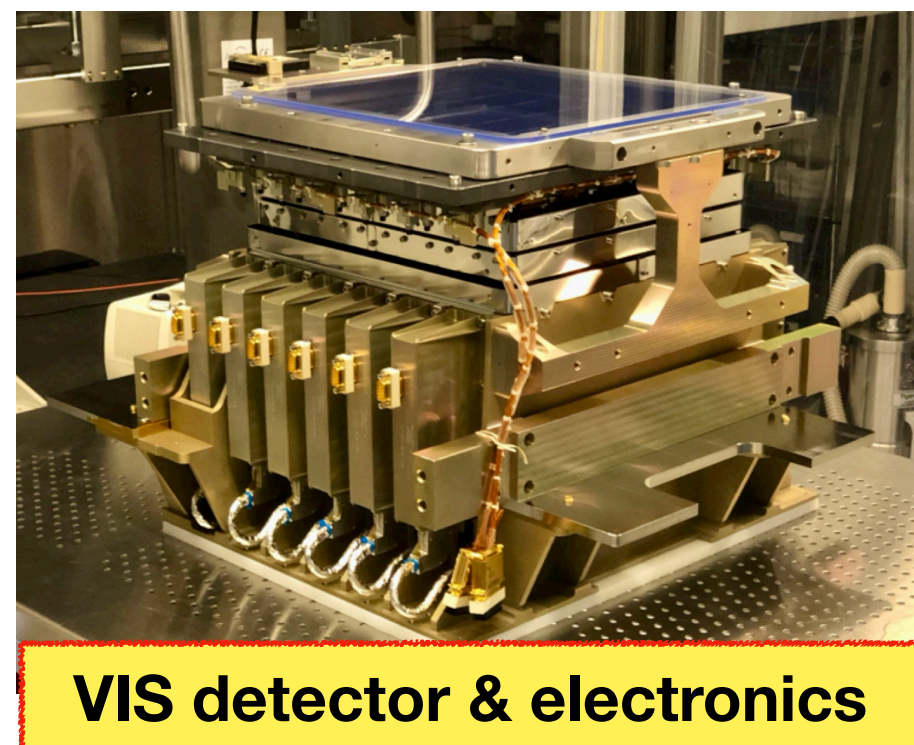


Euclid optical bandpass

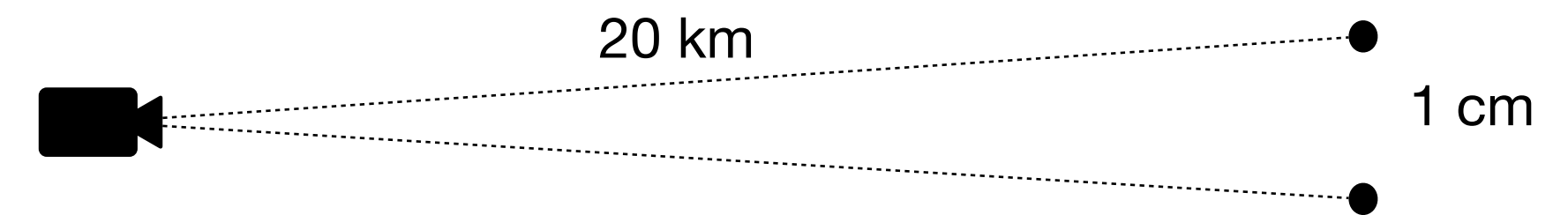


Good overlap with GAIA and JWST to cross-calibrate the observations

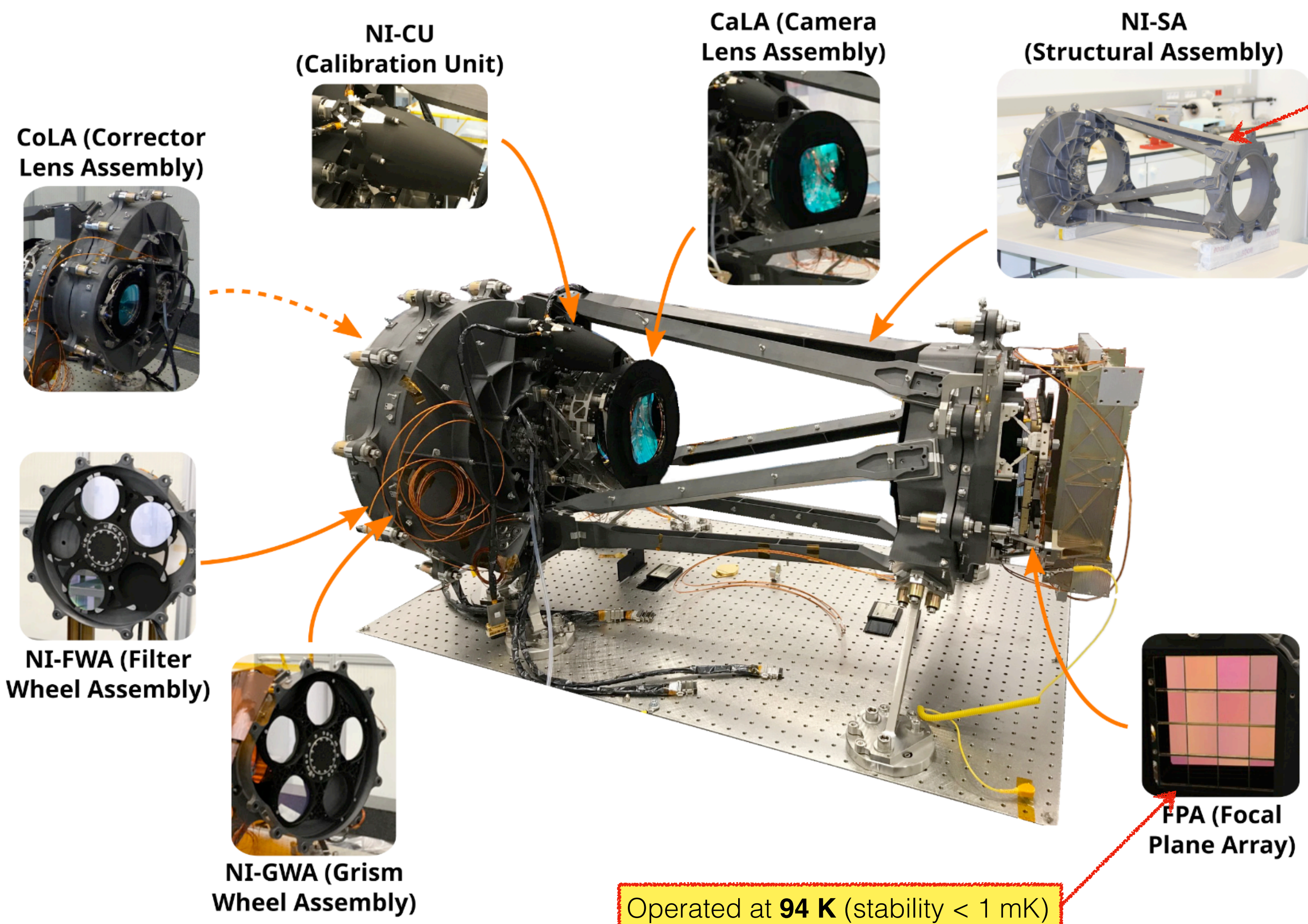
VIS: Visible Instrument



- 36 CCDs, **604 Mpixel**, 12 μm pixels size
- 34.3 x 30.4 cm^2 , 2nd largest camera after Gaia
- **0.1 arcsec** per pixel on sky,
- **0.54 deg^2 per field**
- Bandpass 550-900 nm
- Data volume **520 Gbit/day**
- Mag limit: Photo **$m_{\text{AB}} < 24.5 (10\sigma)$** ; Deep +2



NISP : Near Infrared Spectrometer and Photometer

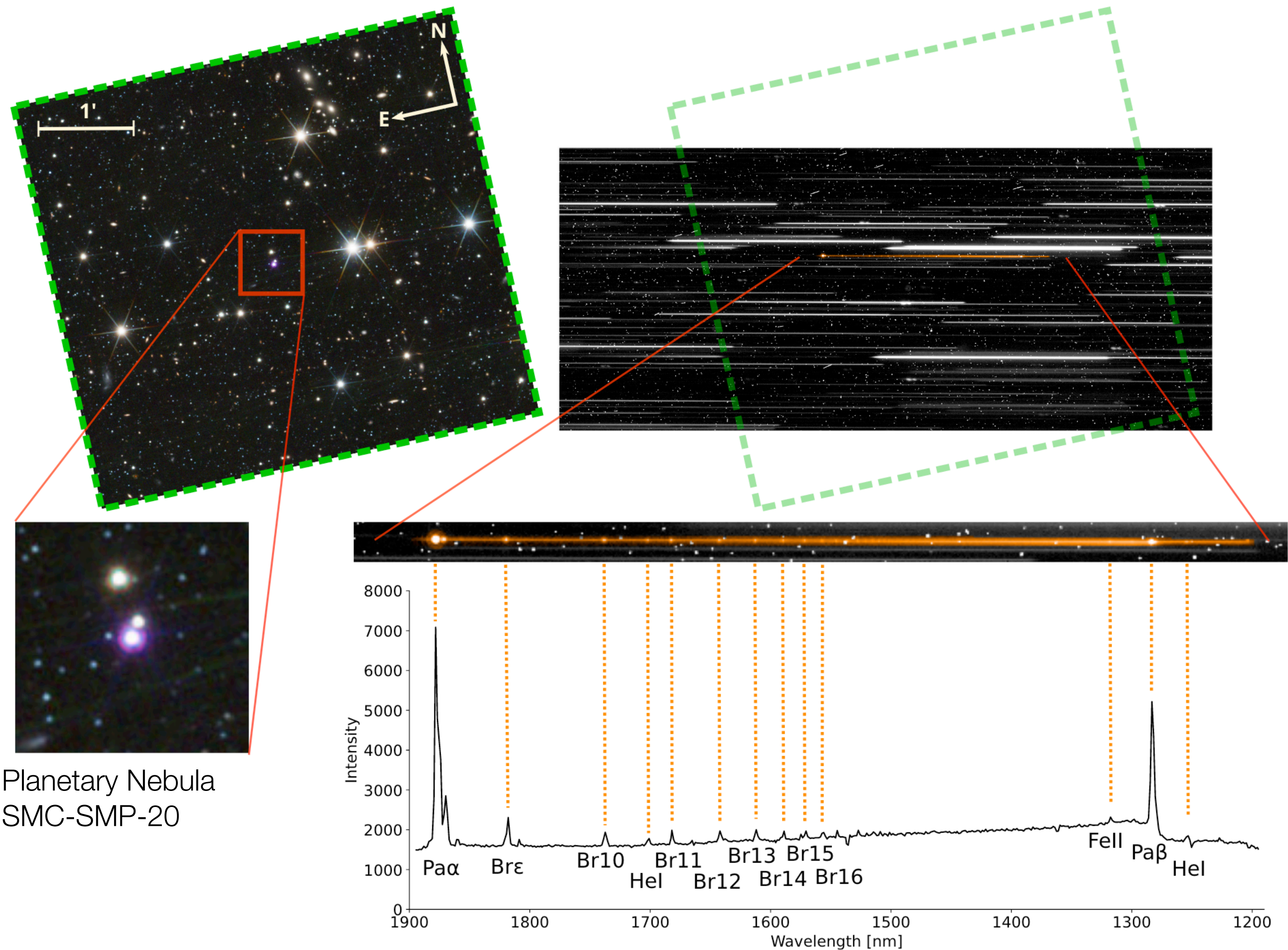


Structure in **SiC @ 135 K**, stability in operation ~ 2 mK

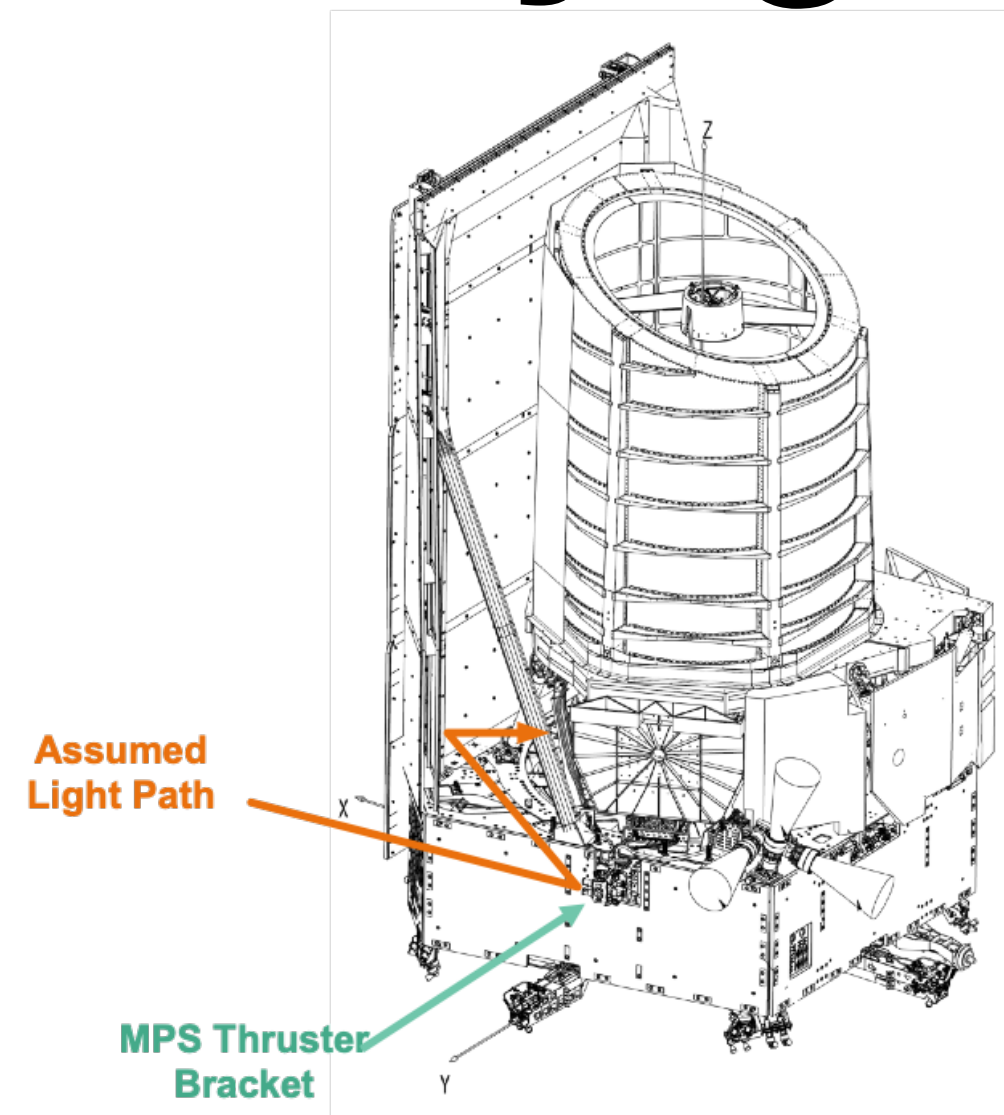
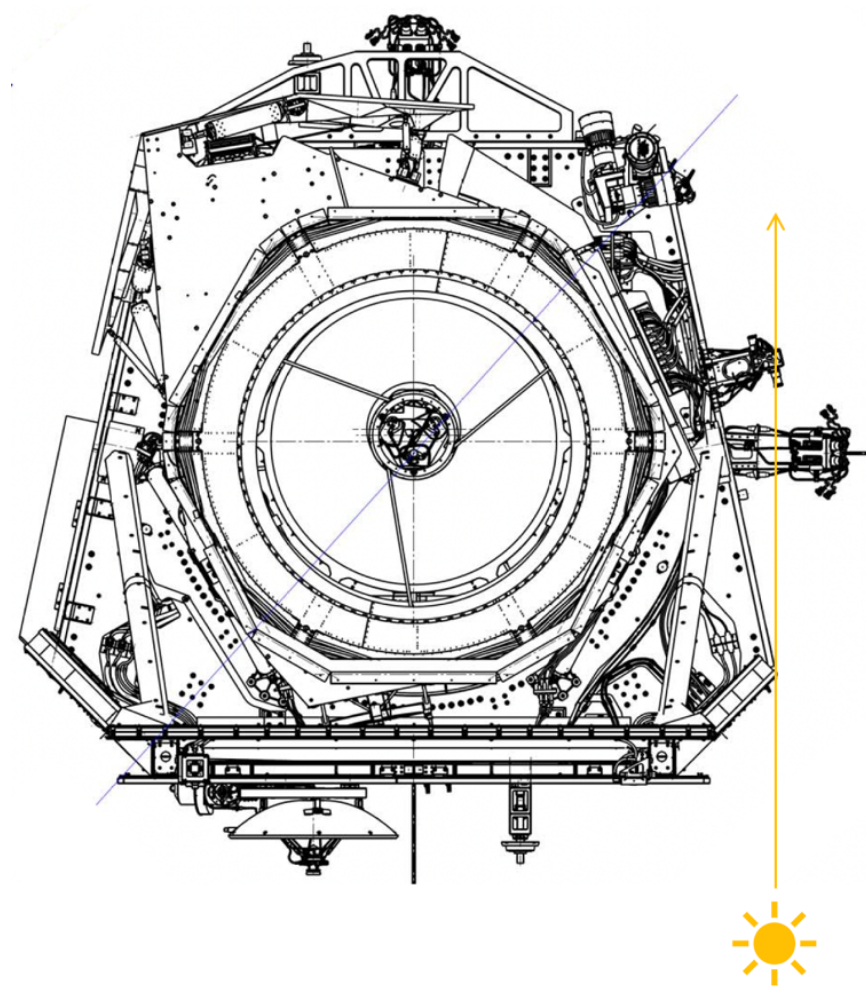
- 16 H2RG (HgCdTe) 2048 x 2048 pixels, 2 μm cutoff
- **67 Mpixel**, 18 μm pixel
- 0.3 arcsec pixel on sky, **0.55 deg² per field**
- Spectral resolution: **$\lambda/\Delta\lambda > 380$**
- 3 filter **Y, J, H**
- 4 grims: **1xB(920-1350 nm), 3xR(1250-1850)**
- Data partially reduced on-board
- Data volume **290 Gbit/day**
- Mag limit: Photo **$m_{AB} < 24.0$ (5σ)**;
- Spectro **$m_{AB} = 21.0$** ; Deep +2

Operated at **94 K** (stability < 1 mK)

NISP Slitless spectroscopy



Internal straylight



Assumed Straylight Path (MLI not shown)

