SUBSTELLAR

Brown dwarfs with the Euclid space mission

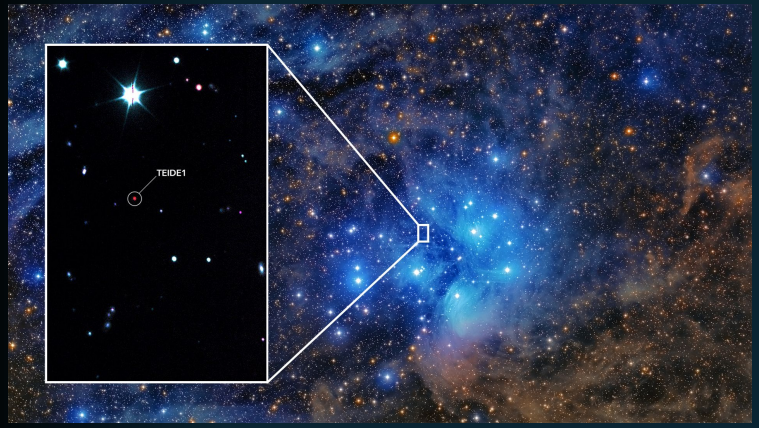
Maruša Žerjal, on behalf of Eduardo Martín

Substellar team

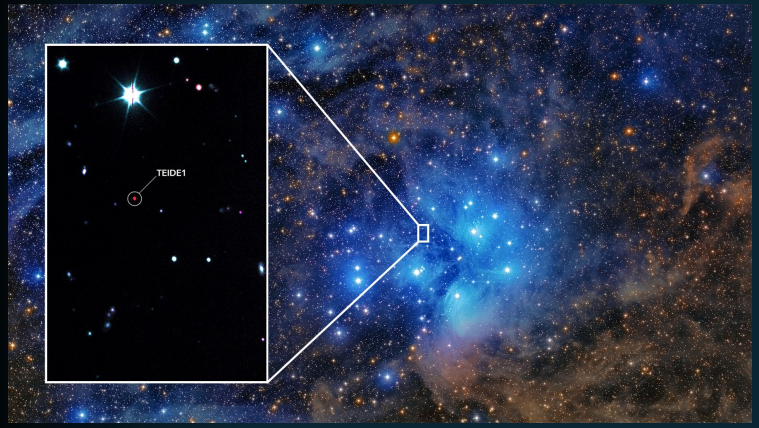
BD30, La Gomera, September 2025

Universidad de La Laguna

Funded by the European Union

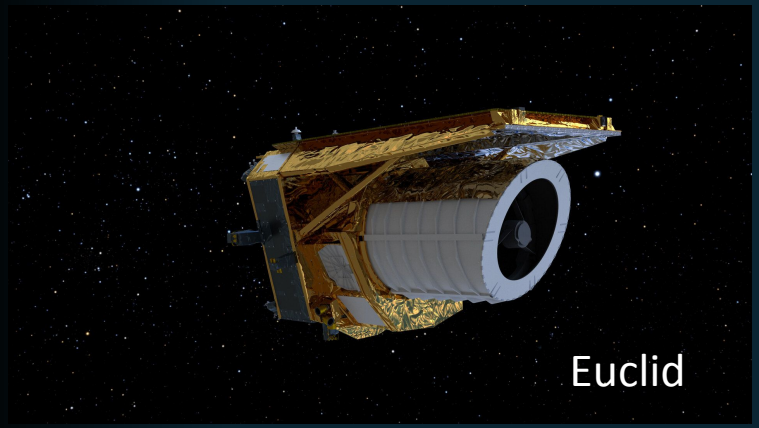


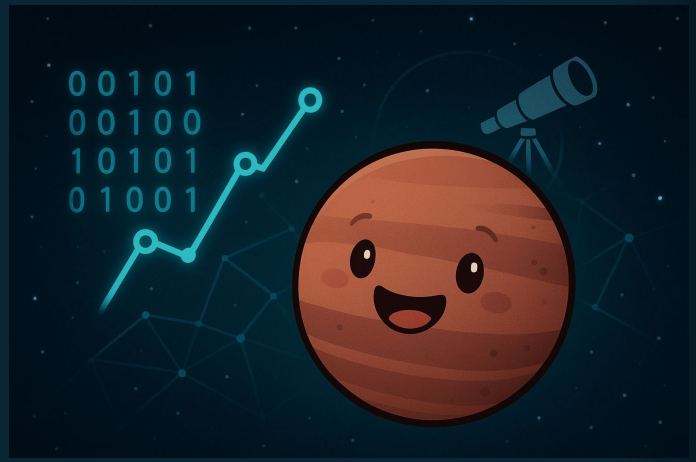
30 years after discovery…



30 years after discovery…

Brown dwarf science joins the world of Big Data





Open Questions

1) Are there unknown substellar objects lurking in our vicinity?

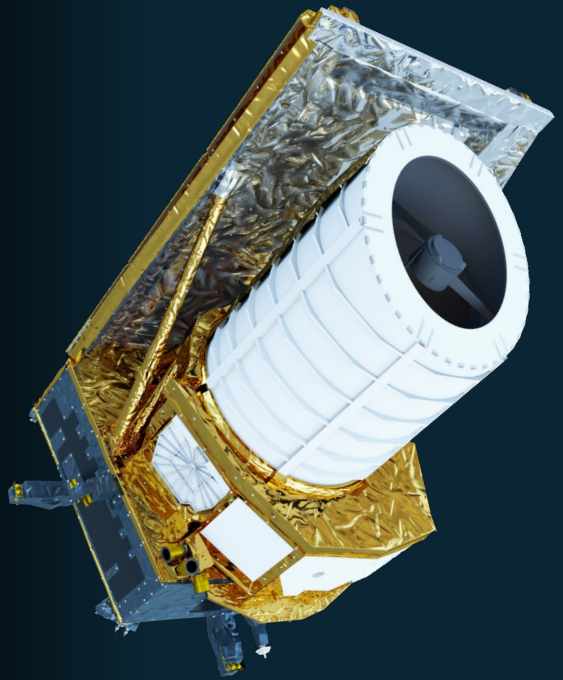
2) What halo brown dwarfs look like & how numerous?

3) What kind of planets orbit around substellar primaries?

4) Is there a substellar IMF cut off?

5) Does life thrive in habitable atmospheres of substellar objects?

Euclid space telescope



EUCLID

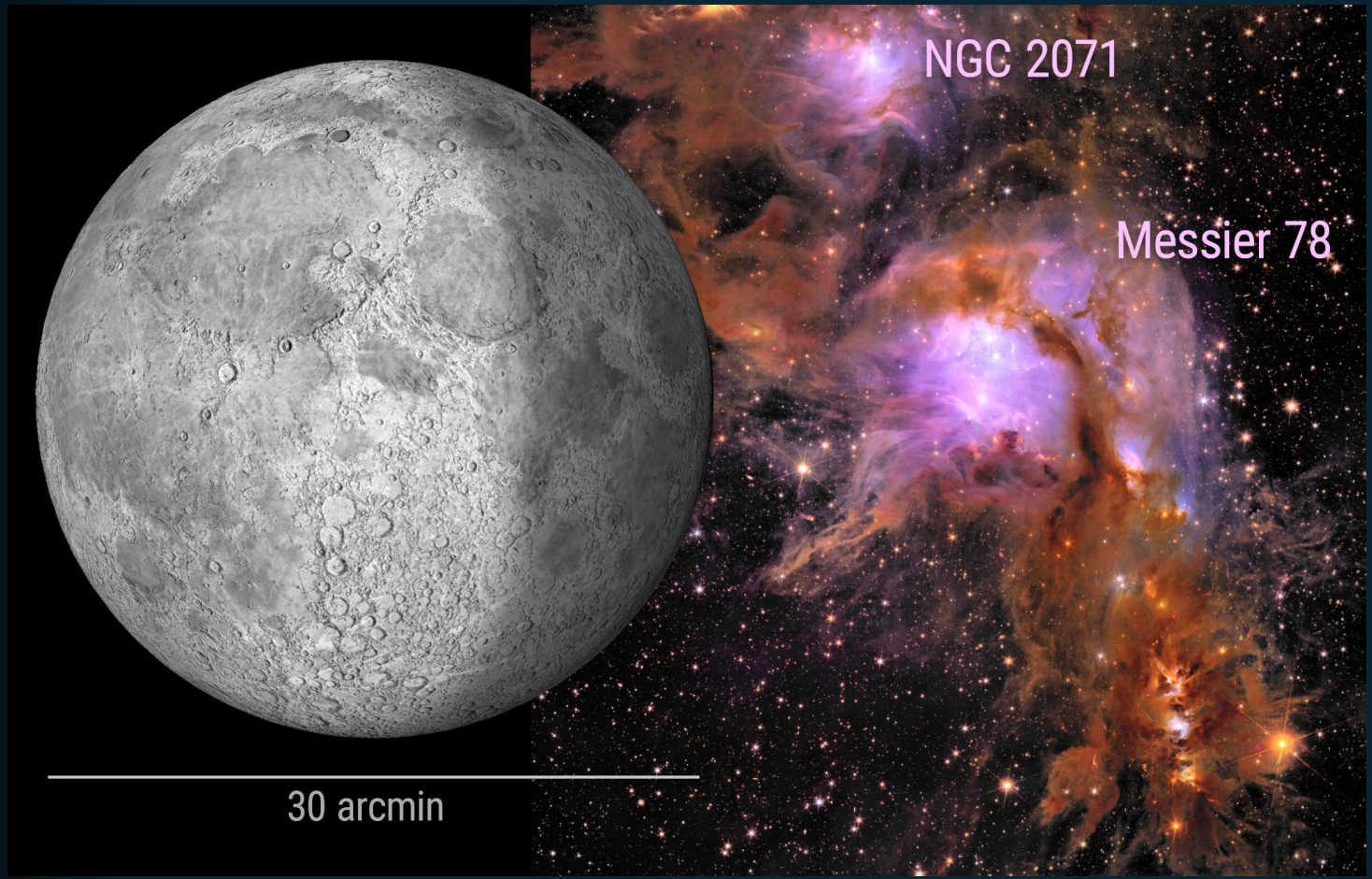
Wide-field telescope
1.2 m diameter primary mirror

Diffraction limited

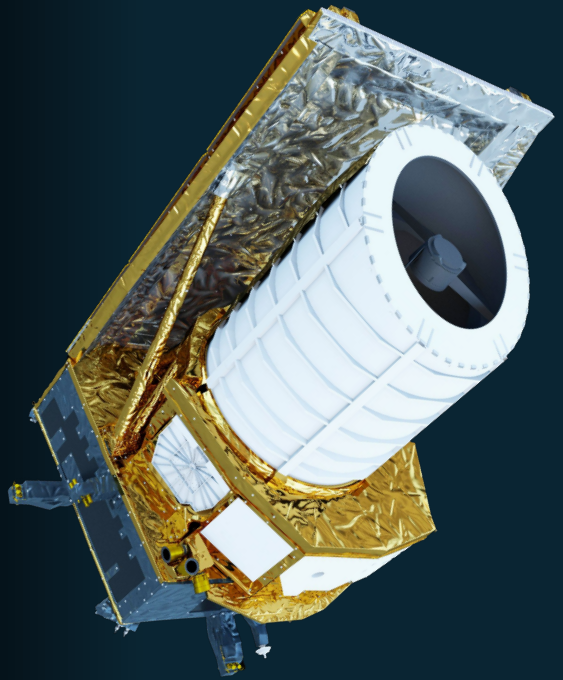
Visual Imager
0.55 - 0.9 μm band

Near-Infrared
GRISM Spectrometer 1.25 - 1.85 μm
Photometric Imager Y, J, H

LAUNCH
July 2023
6 year nominal survey


NGC 2071
Messier 78
30 arcmin

Euclid space telescope



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Data releases

- 2024: Early Release Observations (ERO)

- 2025: Q1 (62 square degrees)

- DR1 in preparation (~1900 square degrees)

Data releases

- 2024: Early Release Observations (ERO)

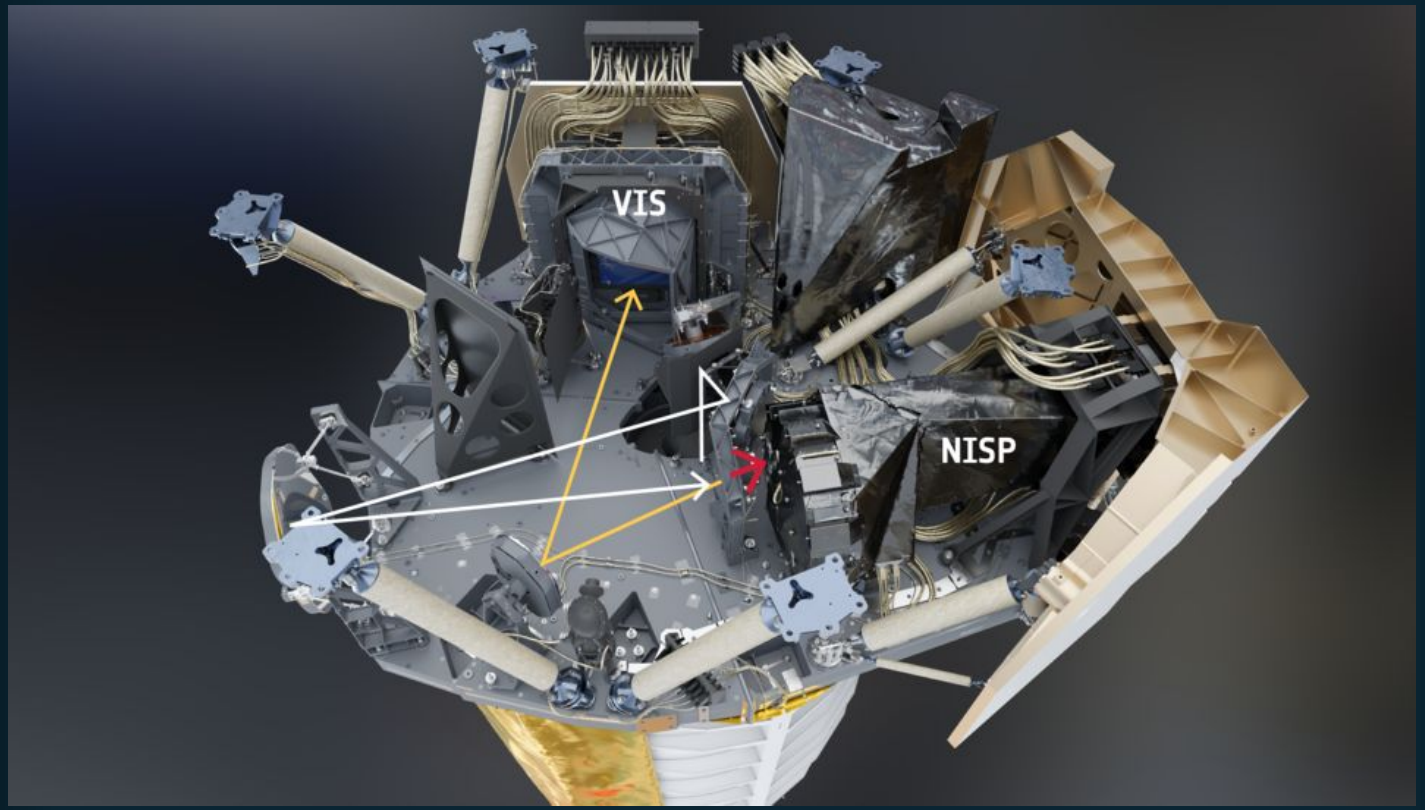
- 2025: Q1 (62 square degrees)

x30

- DR1 in preparation (~1900 square degrees)

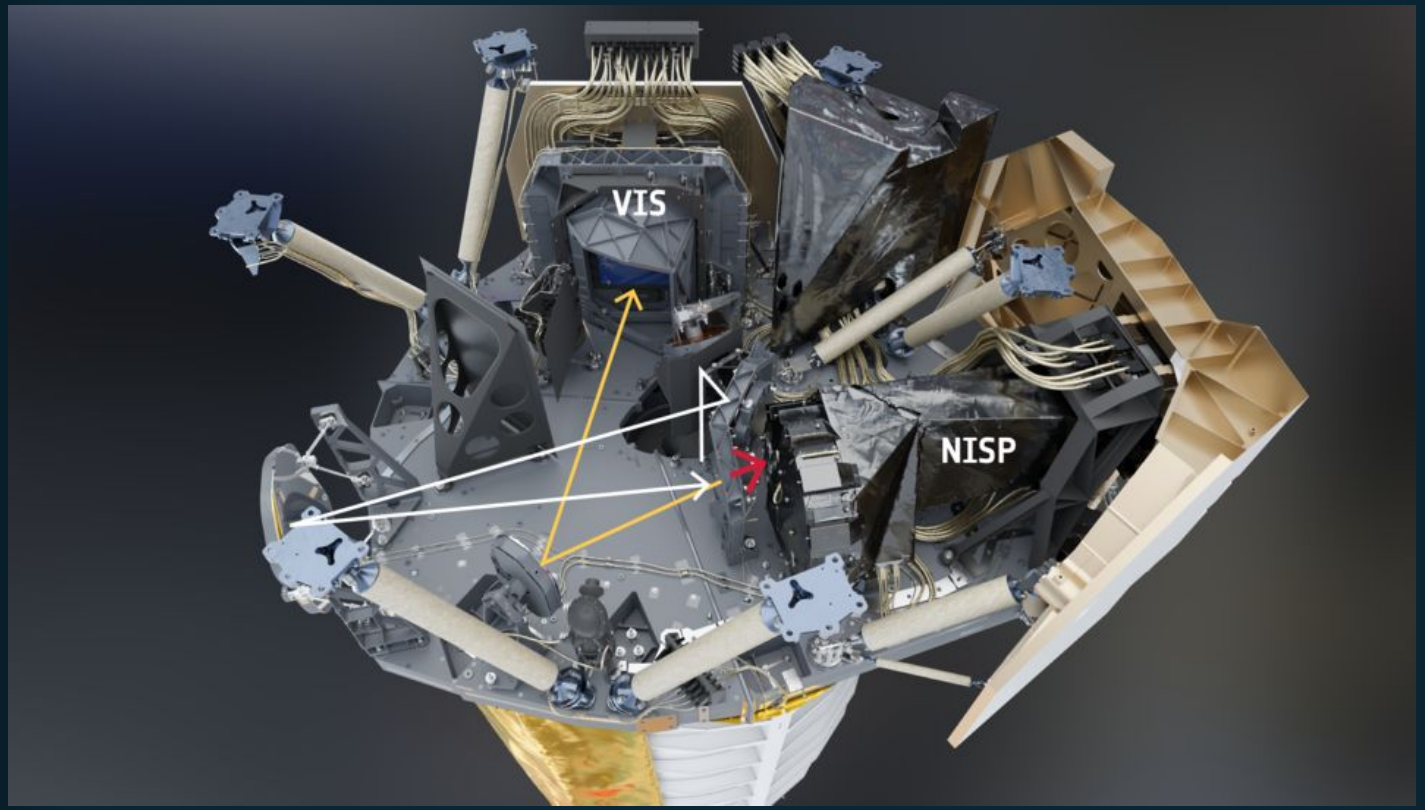
The VISible instrument (VIS)

Near-Infrared Spectrometer and Photometer (NISP)

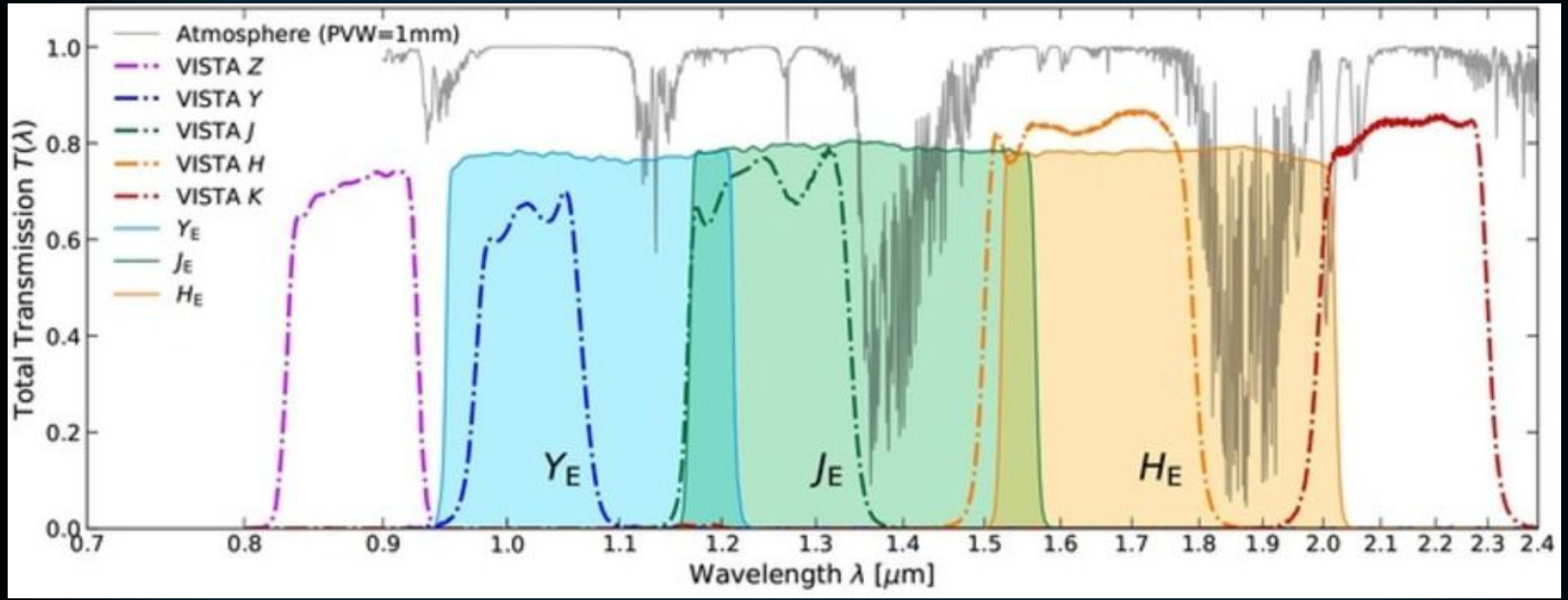


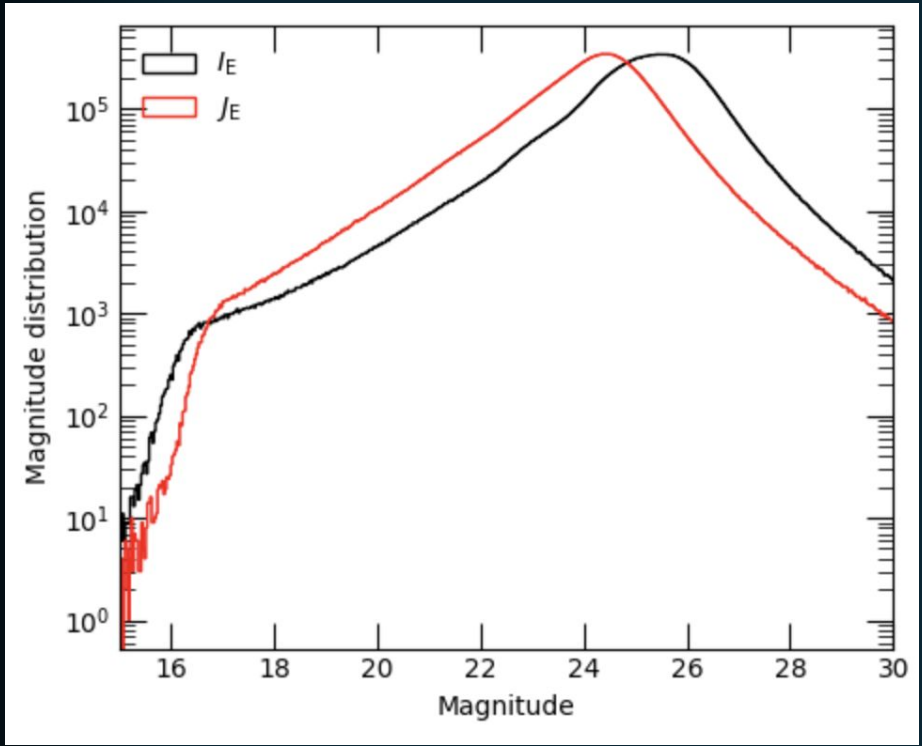
The VISible instrument (VIS)
0.1 arcsec

Near-Infrared Spectrometer and Photometer (NISP) 0.3 arcsec



NISP AB magnitude system

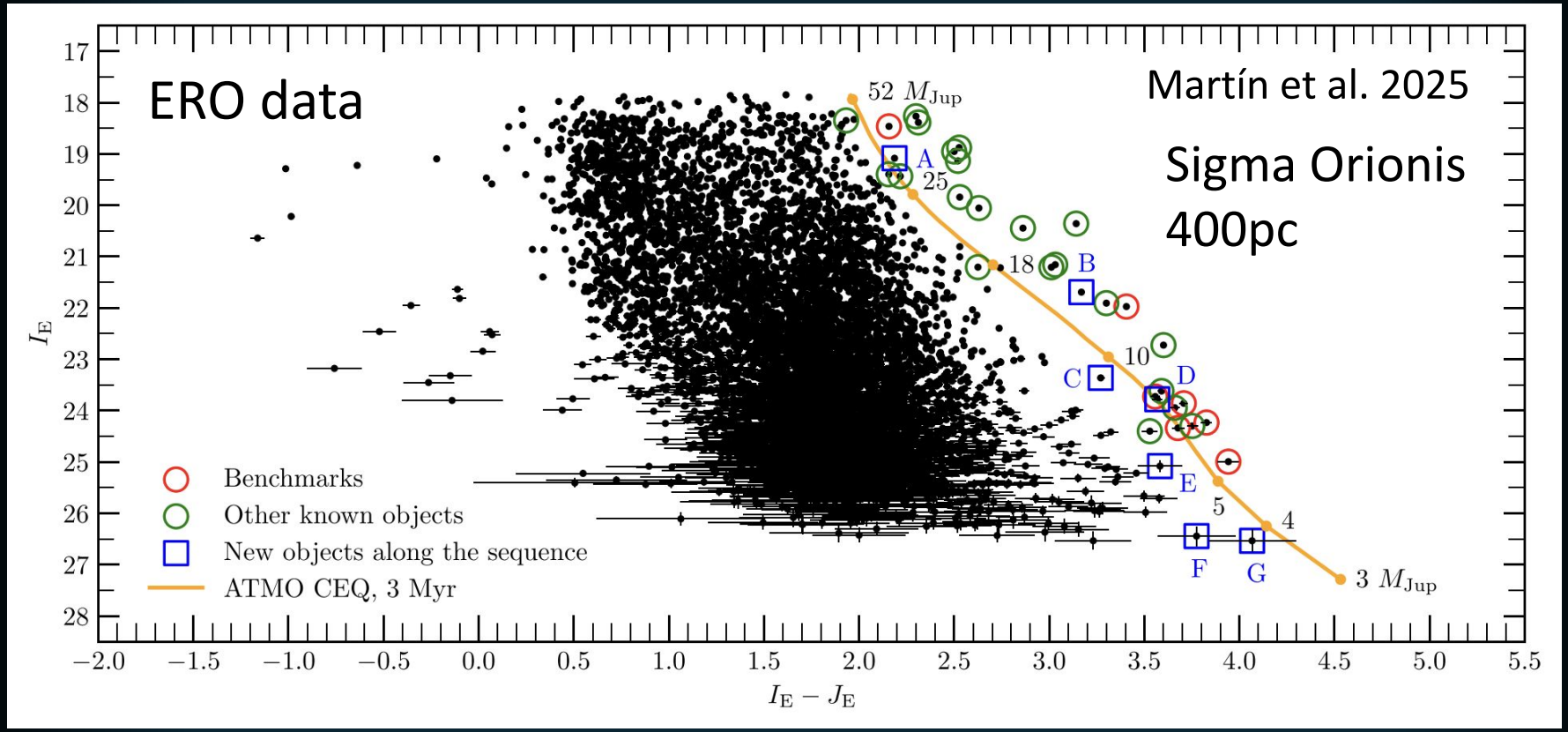




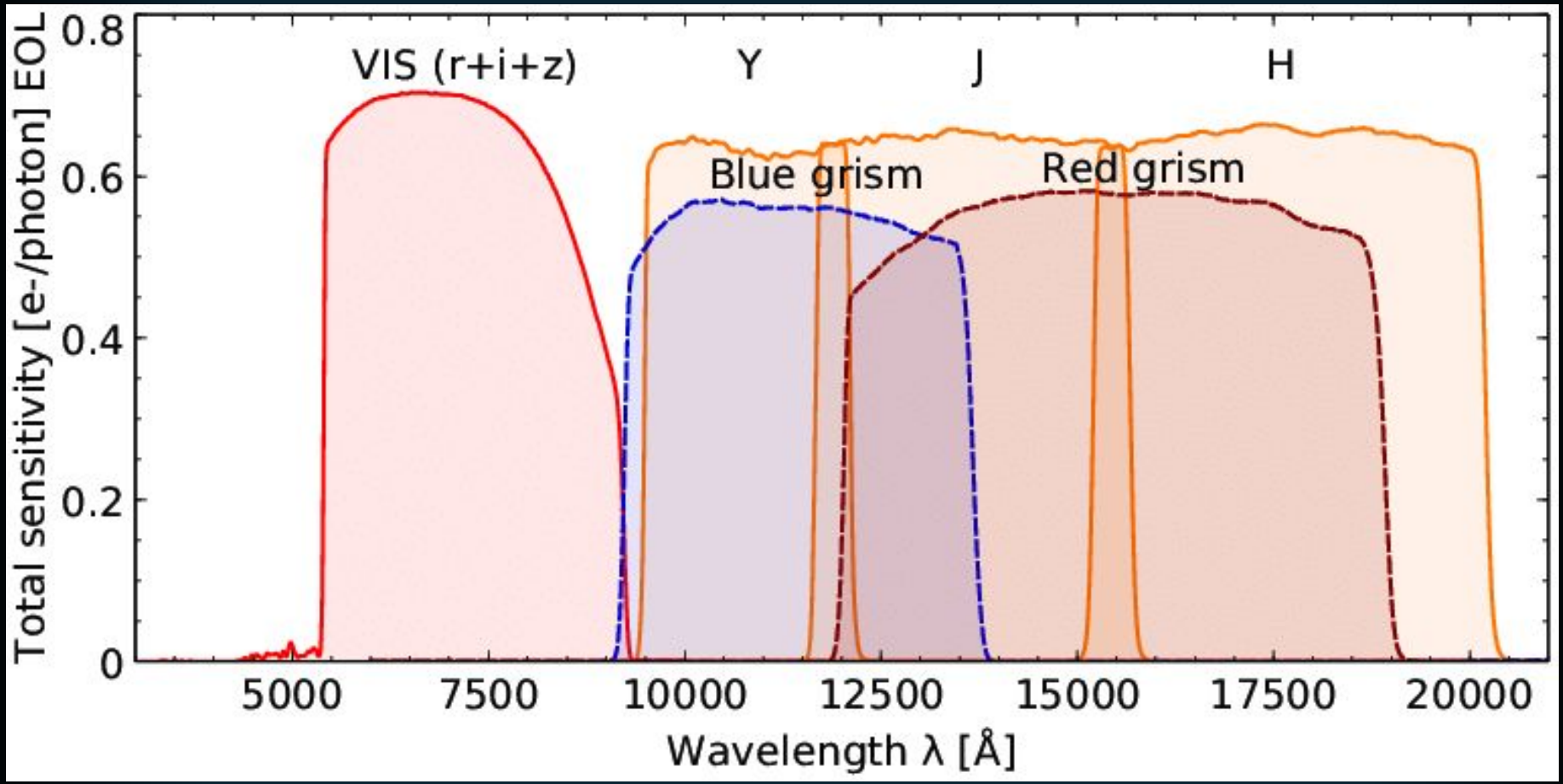
Completeness:

- 24.5 in NISP
- 25.5 in VIS
- Complementary with Gaia

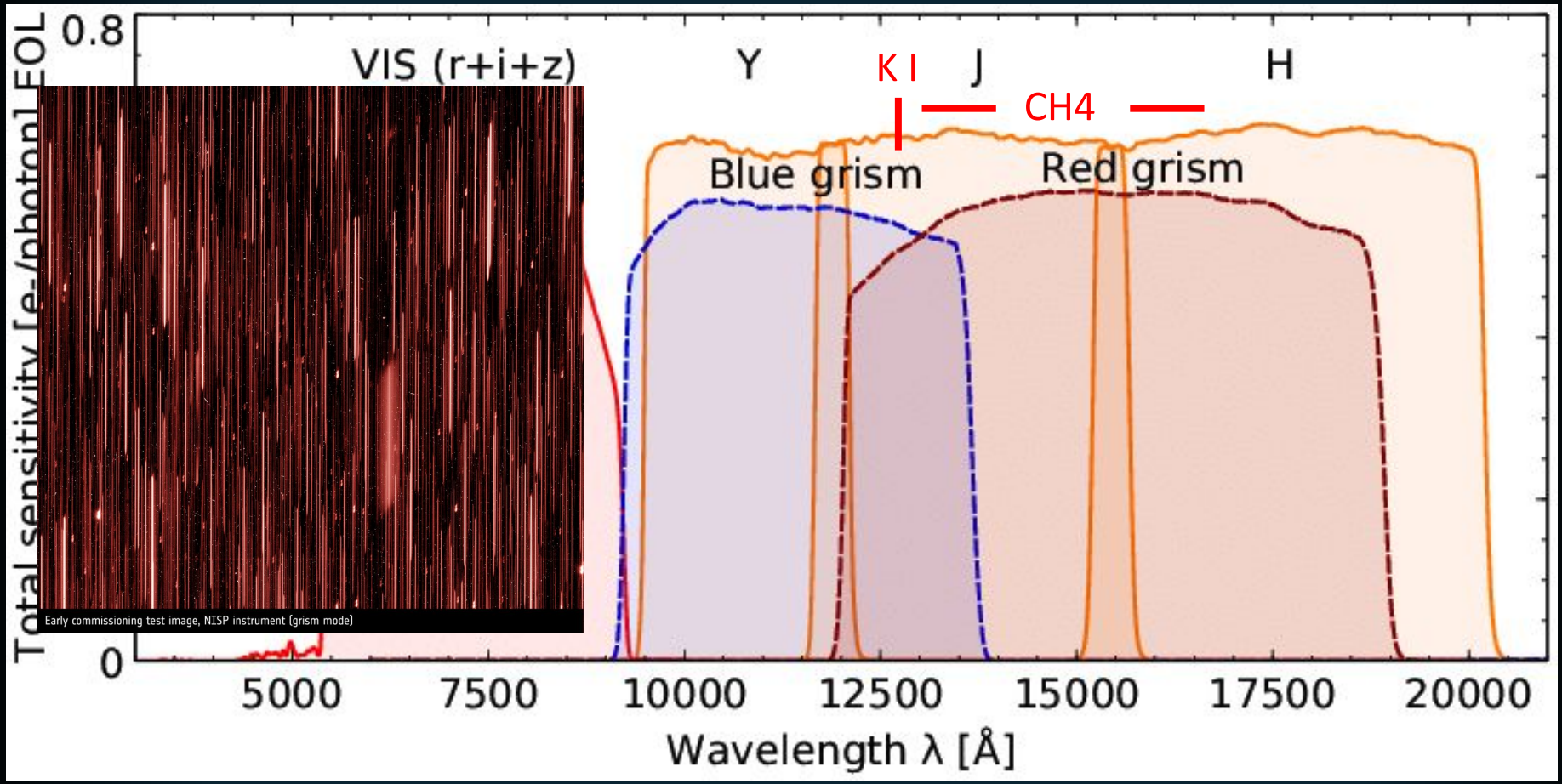
What this means in practice? Example:



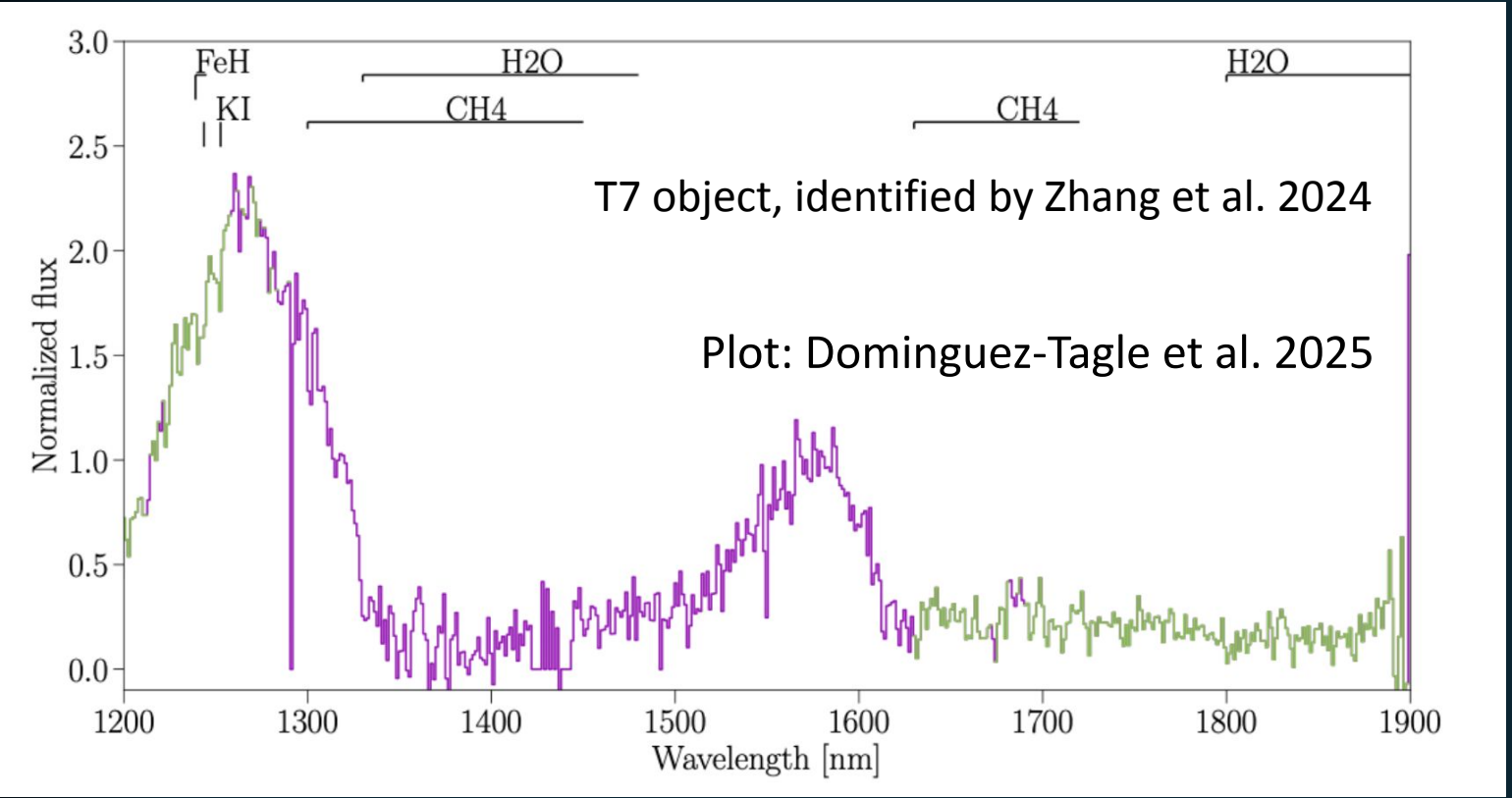
VIS


VIS (r+i+z)
Y
J
H
Blue grism
Red grism
Total sensitivity [e-/photon] EOL
0.8
0.6
0.4
0.2
0
5000
7500
10000
12500
15000
17500
20000
Wavelength λ [Å]

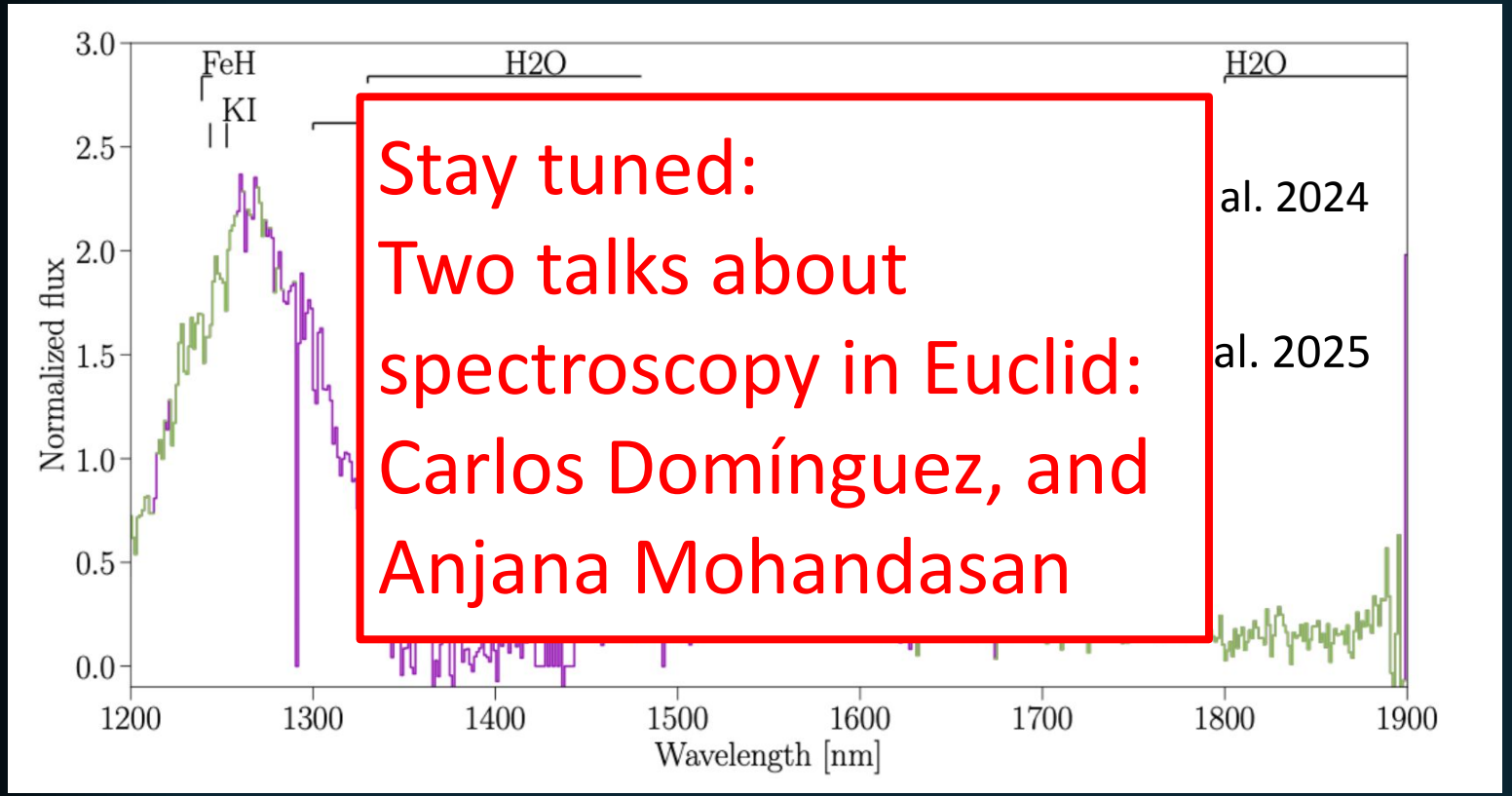
Spectrograph: slitless, R~450



Example UCD spectrum in Euclid



Example UCD spectrum in Euclid



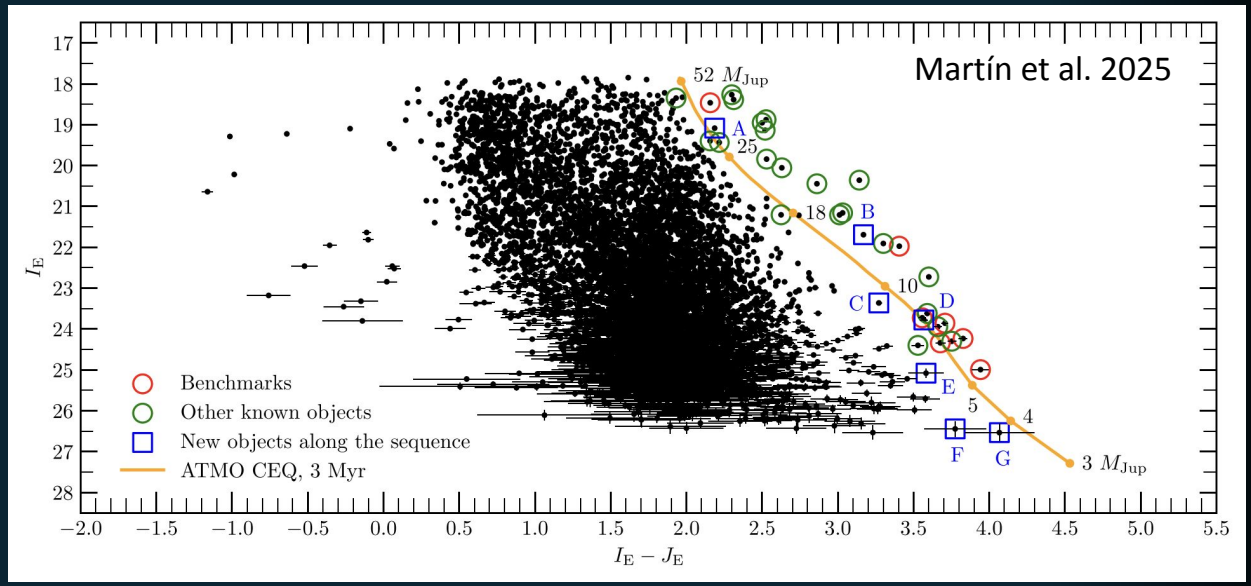
Stay tuned:
Two talks about spectroscopy in Euclid:
Carlos Domínguez, and Anjana Mohandasan

al. 2024

al. 2025

Early Release Observations (ERO) programme

Horsehead and Sigma Orionis (Martín et al. 2025)



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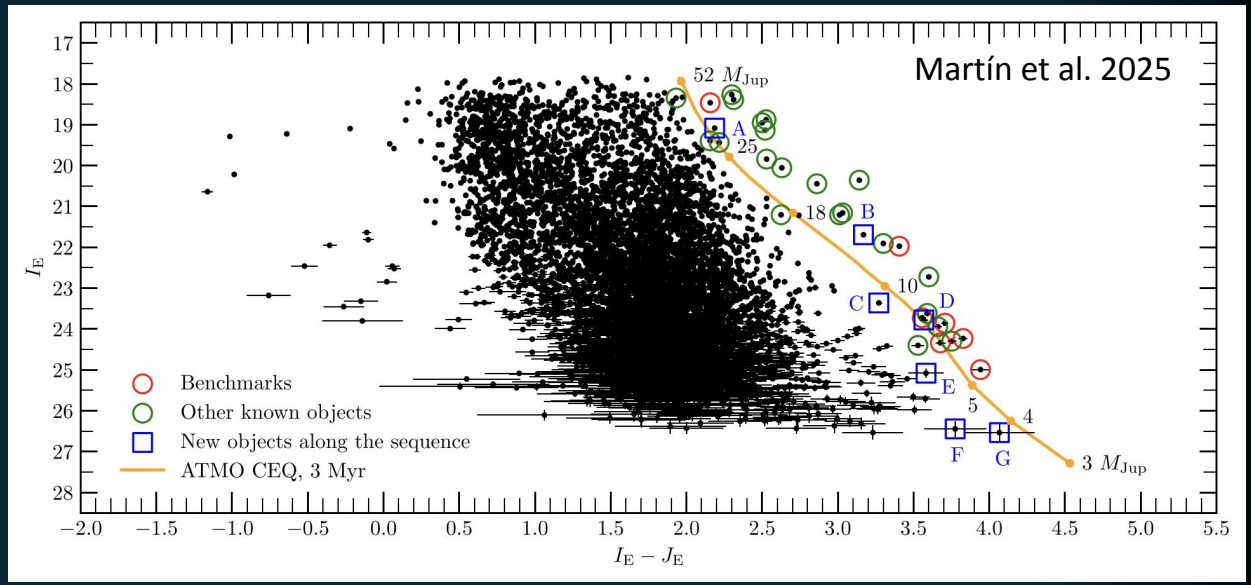
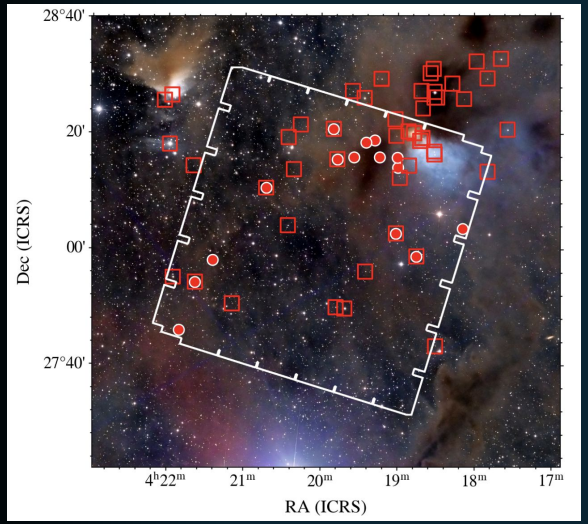


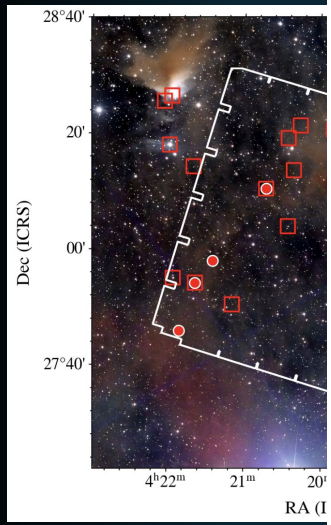
Ongoing work: Talk by S. Tsilia

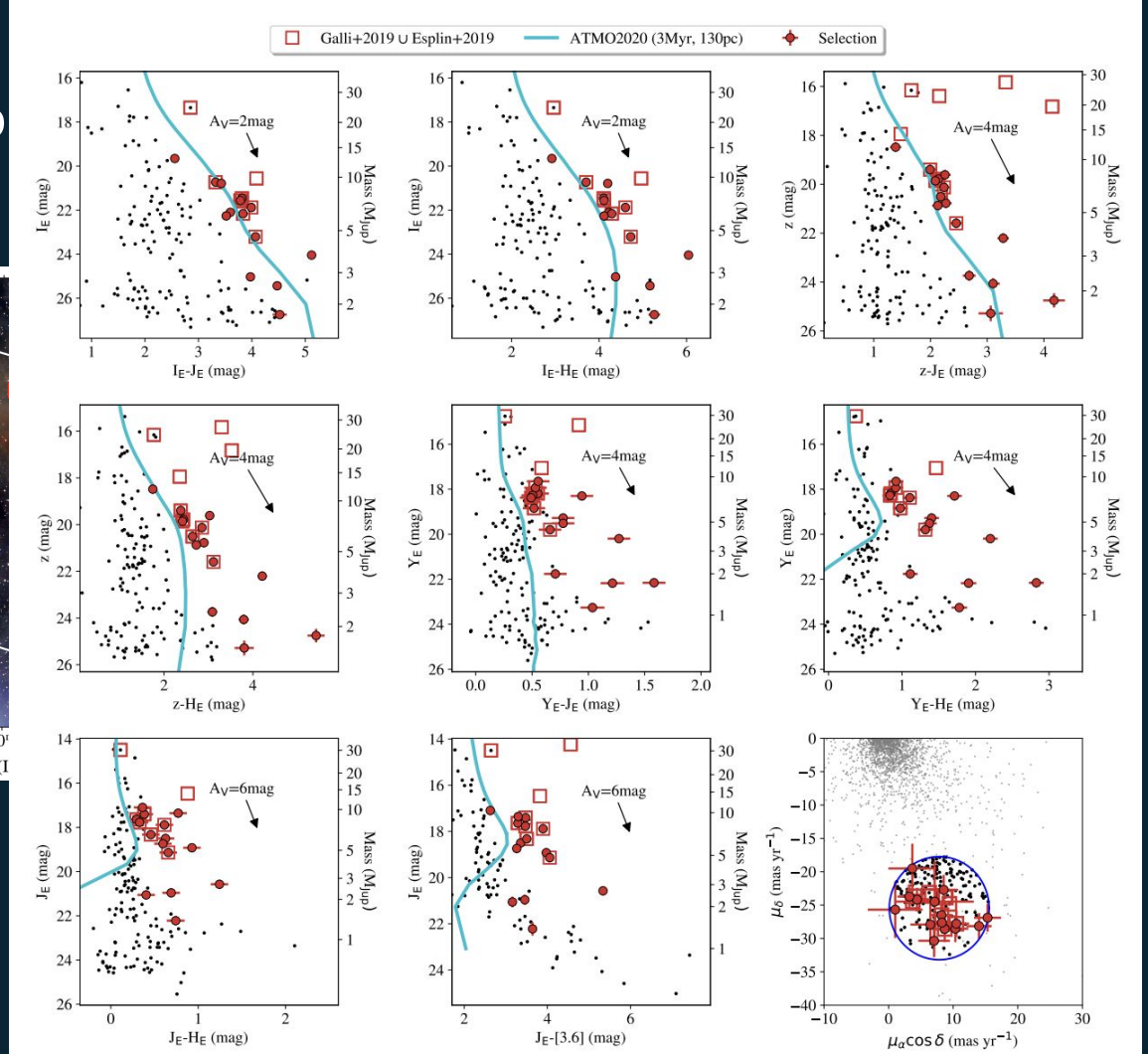
Taurus region LDN 1495 (Bouy et al. 2025)



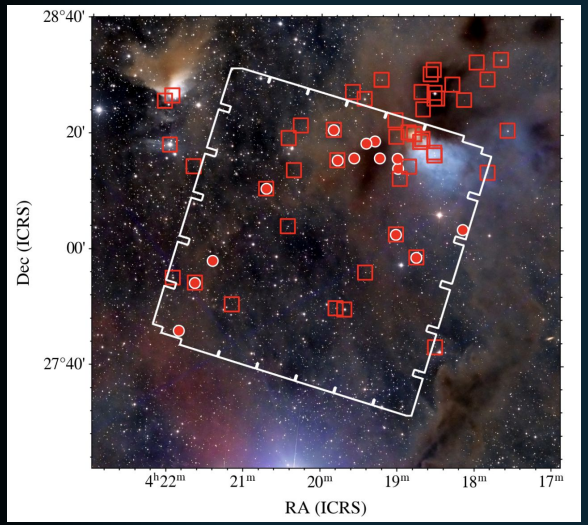
- 130 pc (Galli et al. 2019)
- Ancillary data ⟶ proper motions

Taurus regio





Bouy, H., et al.: A&A, 696, A80 (2025)



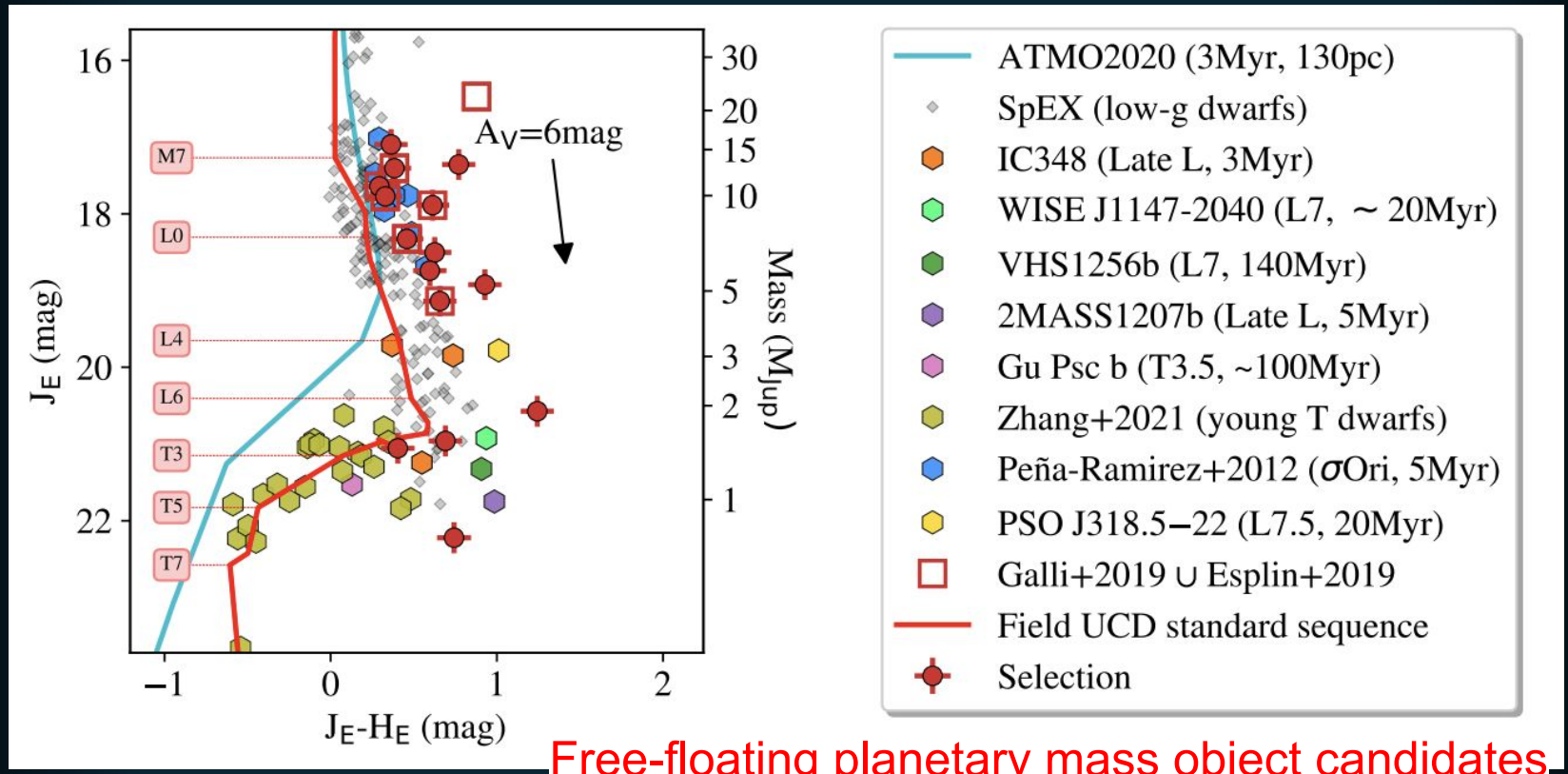
15 candidates (6 known)

Table 1. Candidate astrometry and photometry.

Object DANCe	RA (J2000) (deg)	Dec (J2000) (deg)
J041808.97+280336.5	64.53739	28.06013
J041845.30+275847.8 [(a)]	64.68875	27.97994
J041859.75+281410.4	64.74897	28.23622
J041900.12+281551.7	64.75052	28.26437
J041901.28+280248.2 [(a)]	64.75534	28.04671
J041914.29+281556.6	64.80956	28.26574
J041917.96+281851.5	64.82484	28.3143
J041924.83+281829.3	64.85345	28.30815
J041934.21+281558.3	64.89253	28.26619
J041947.39+281534.5 [(a)]	64.94745	28.25959
J041950.43+282048.4 [(a)]	64.96013	28.34679
J042043.02+281036.1 [(a)]	65.17927	28.1767
J042124.70+275805.9	65.3529	27.96831
J042138.50+275414.4 [(a)]	65.41042	27.904
J042150.63+274556.3	65.46095	27.76564

Notes. [(a)]Previously known member. The complete table including proper motions and photometric measurements is available in electronic form.

Taurus region LDN 1495 (Bouy et al. 2025)



Free-floating planetary mass object candidates

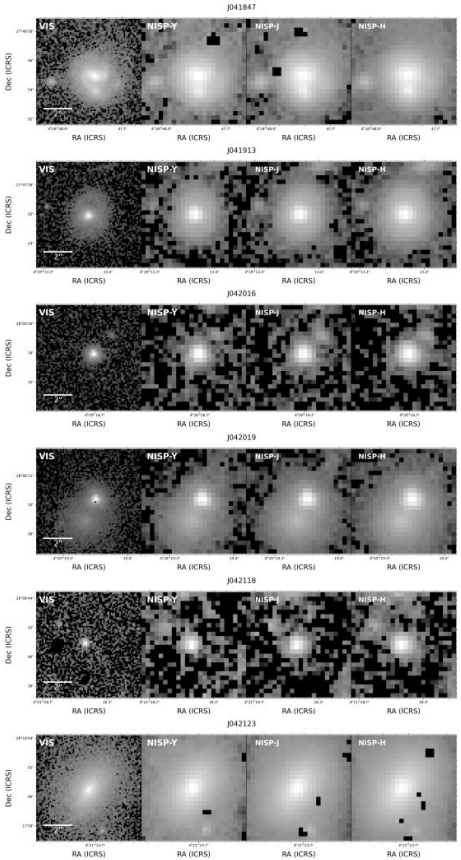


Fig. 9. *Euclid* images (log scale) of proto-brown dwarf candidates from Palau et al. (2012) and Morata et al. (2015). J041847 is clearly resolved as a spiral galaxy, possibly a galaxy merger. J041913 shows some extended emission that suggests that it is a galaxy. J042016, J042019, and J042118 have a neighbor within 3″ that might cause the radio emission. J042123 is resolved as an elliptical galaxy.

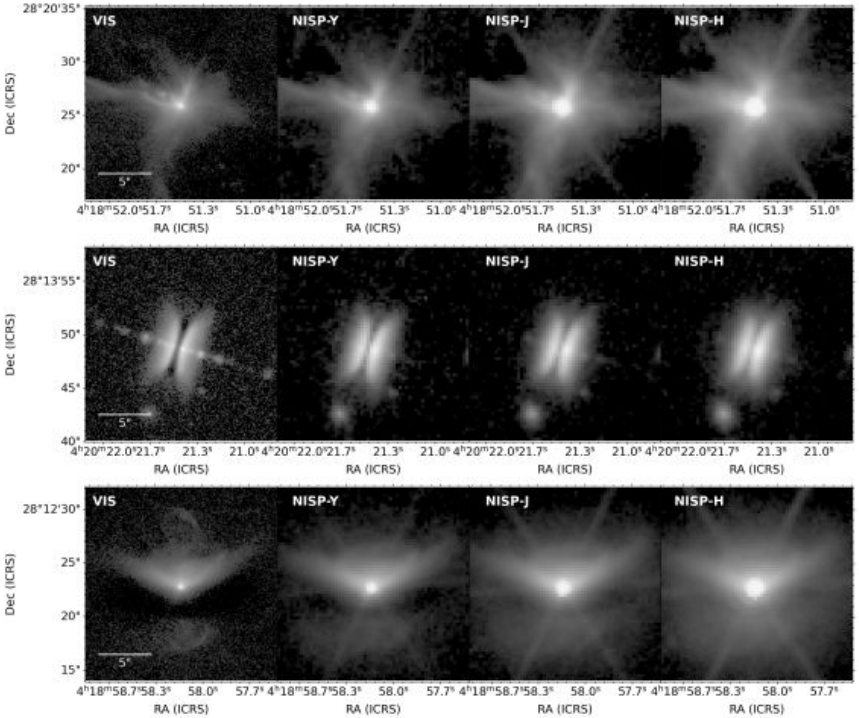


Fig. 8. *Euclid* images (log scale) of CoKu Tau 1 (top), 2MASS J04202144+2813491 (middle), and IRAS04158+2805 (bottom). The source core of CoKu Tau 1 is saturated in the NISP images. The edge-on disk and the collimated jet around 2MASS J04202144+2813491 are clearly resolved. A bipolar outflow is observed for the first time around IRAS04158+2805.

Bouy et al. 2025

3 more ERO regions in Orion

Messier 78

B30: Barrado et al., submitted

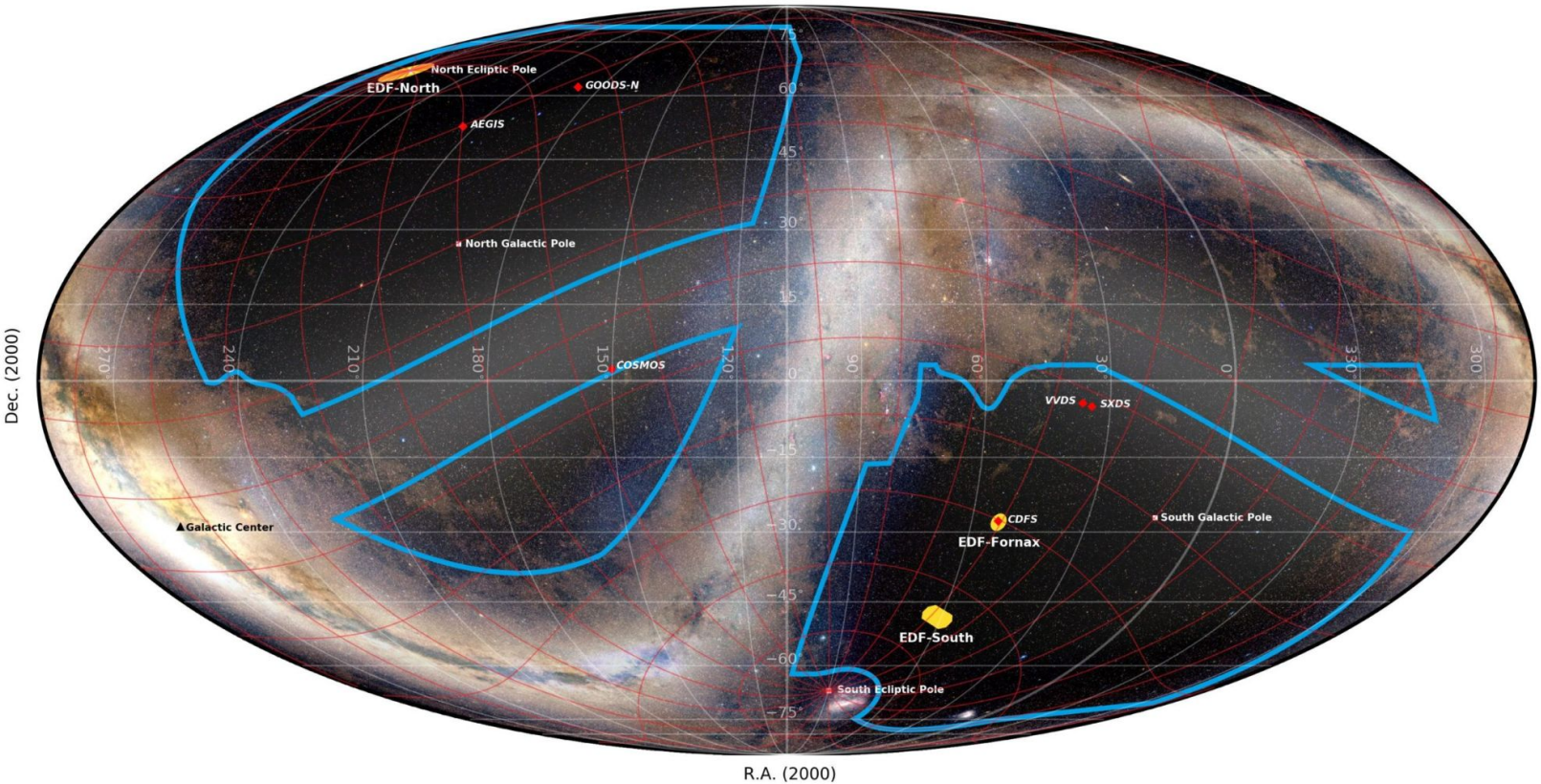
Messier 78, in prep.

LDN1641, in prep.

Observing programs

Nominal survey: Euclid Wide Survey

Euclid Deep Fields: three selected regions (Q1),
Repeated observations
2 magnitudes deeper
Variability



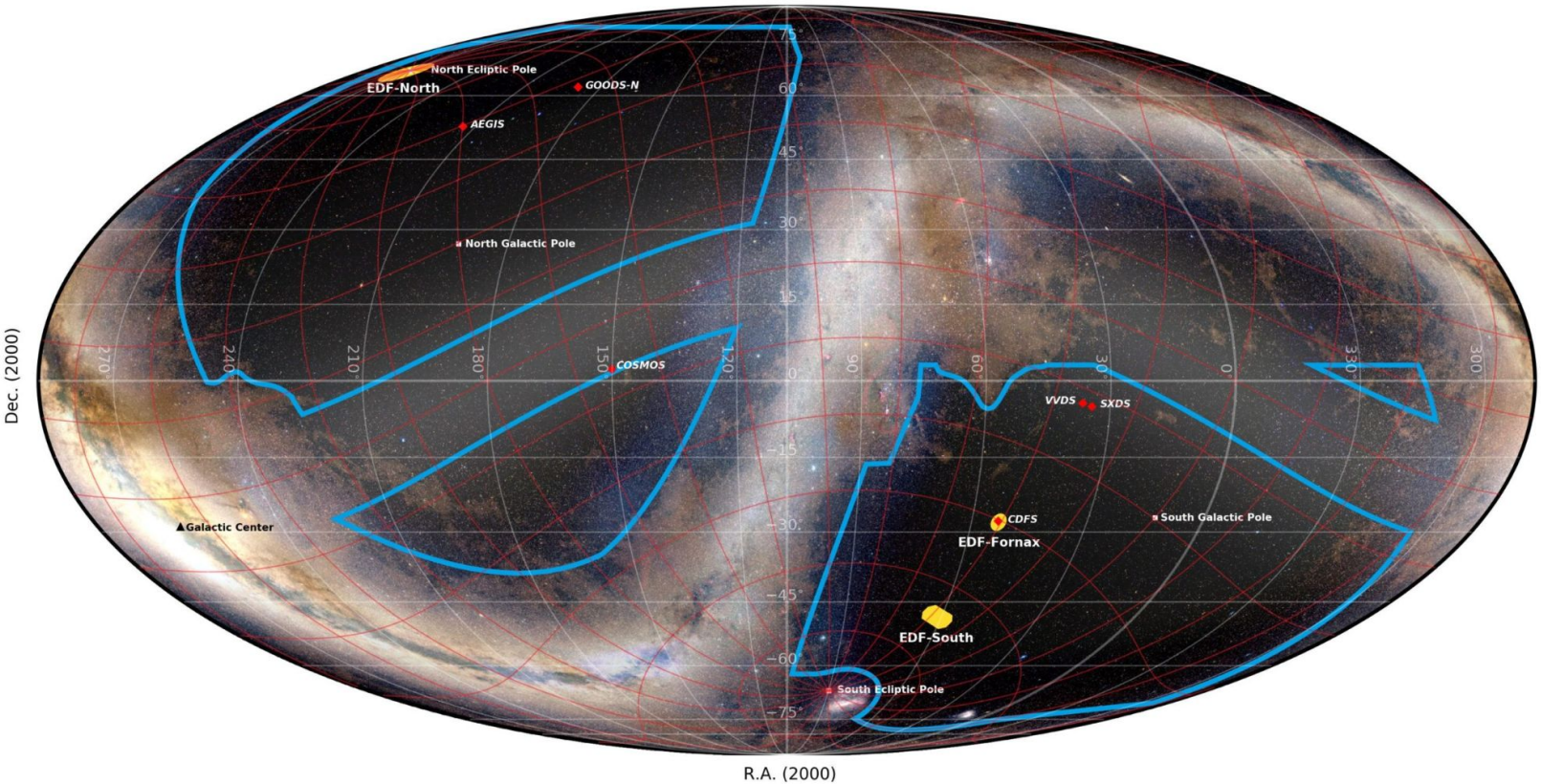
The 15,000 deg.^{2} Euclid Wide Survey, the 53 deg.^{2} Euclid Deep Survey, and the 6 deep auxiliary fields (6.5 deg.^{2}) [Mollweide Celestial]

Euclid Wide Survey region of interest : 16 Kdeg.^{2} compliant with a 15 Kdeg.^{2} survey

Euclid Deep Fields : North=20 deg.^{2}, Fornax=10 deg.^{2}, South=23 deg.^{2}

Euclid deep auxiliary fields (GOODSN=0.5, AEGIS=1, COSMOS=2, VVDS=0.5, SXDX=2, CDFS=0.5 deg.^{2})

Background image: Euclid Consortium / Planck Collaboration / A. Mellinger



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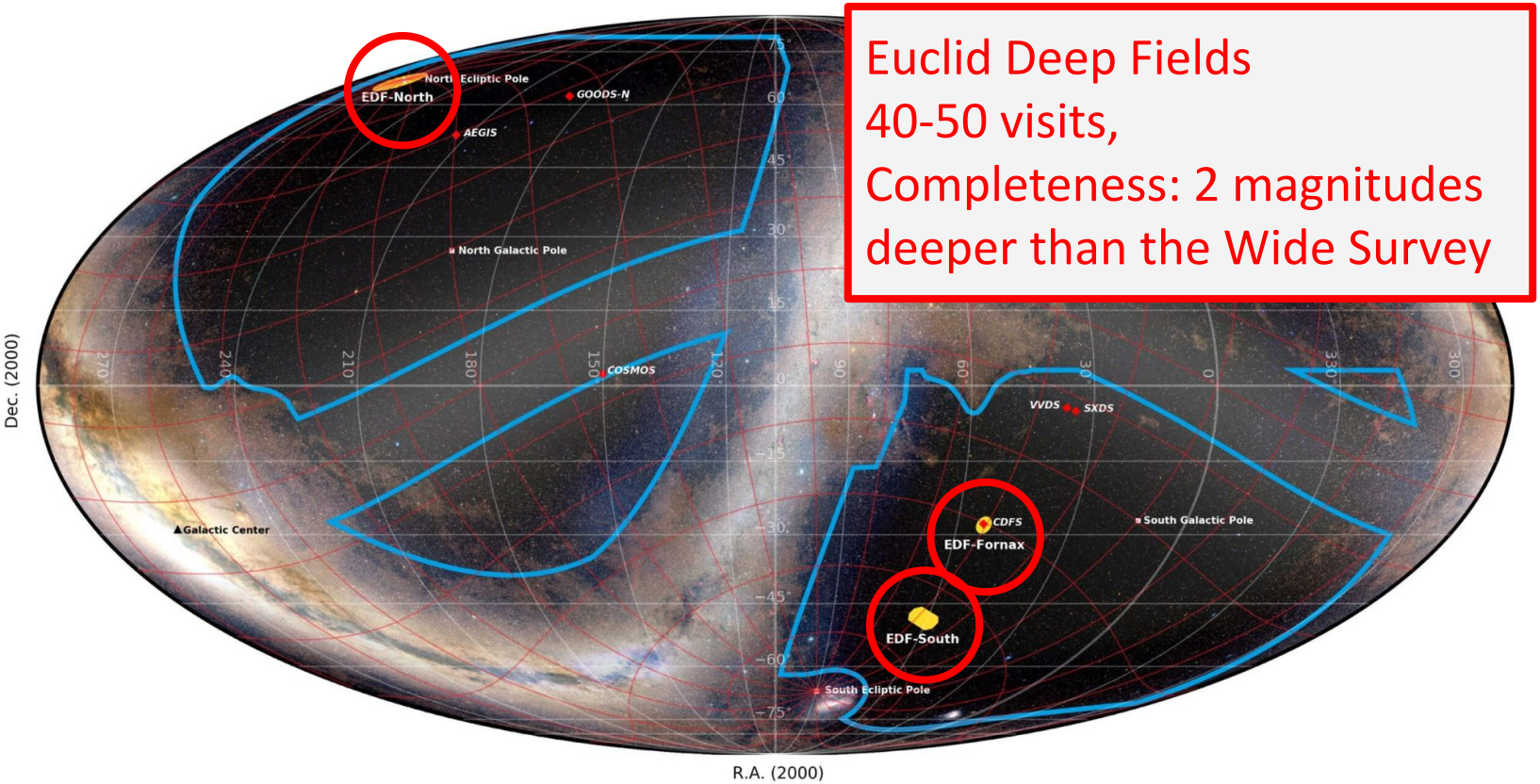
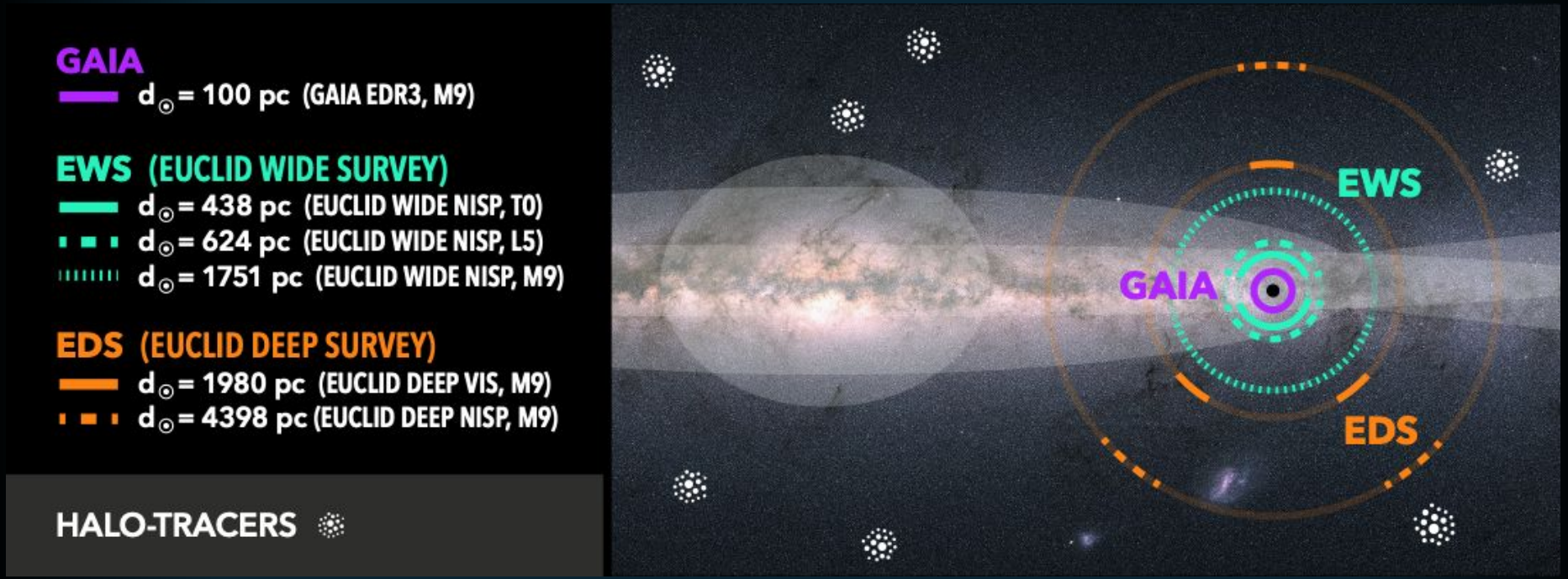

Euclid Deep Fields
40-50 visits,
Completeness: 2 magnitudes deeper than the Wide Survey
EDF-North
North Ecliptic Pole
GOODS-N
AEGIS
North Galactic Pole
COSMOS
Galactic Center
VVDS
SXDS
CDFS
EDF-Fornax
South Galactic Pole
EDF-South
South Ecliptic Pole
Dec. (2000)
R.A. (2000)
The 15,000 deg.² Euclid Wide Survey, the 53 deg.² Euclid Deep Survey, and the 6 deep auxiliary fields (6.5 deg.²) [Mollweide Celestial]
Euclid Wide Survey region of interest : 16 Kdeg.² compliant with a 15 Kdeg.² survey
Euclid Deep Fields : North=20 deg.², Fornax=10 deg.², South=23 deg.²
Euclid deep auxiliary fields (GOODSN=0.5, AEGIS=1, COSMOS=2, VVDS=0.5, SXDX=2, CDFS=0.5 deg.²)
Background image: Euclid Consortium / Planck Collaboration / A. Mellinger

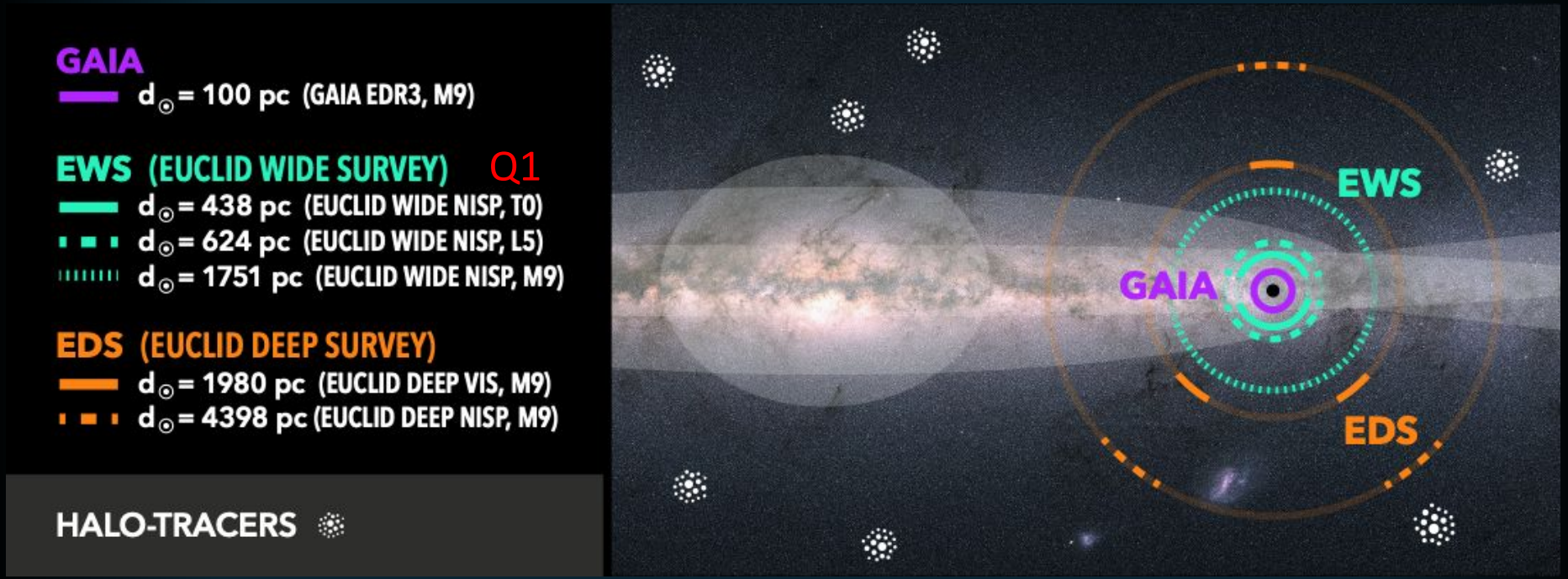
BREAKTHROUGH

Reach deeper, further & wider than ever before

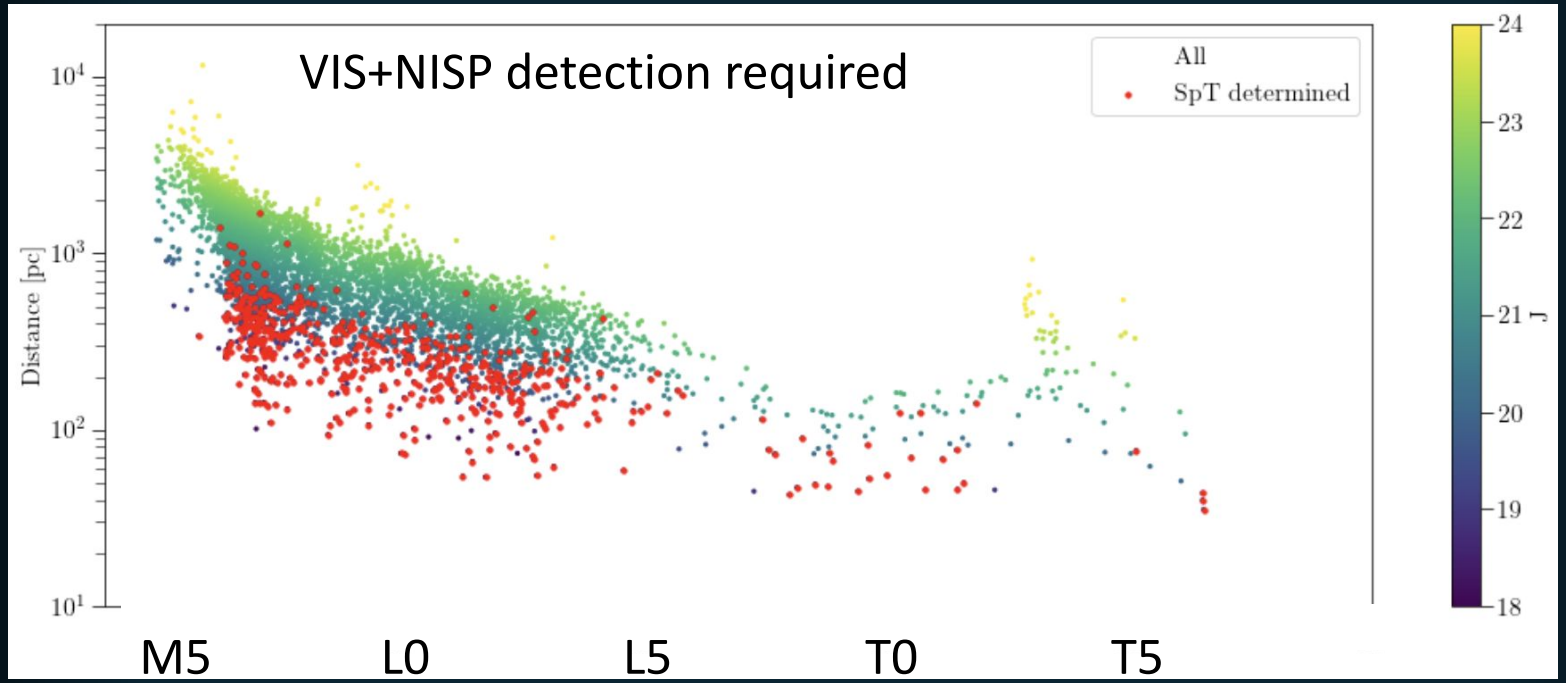


BREAKTHROUGH

Reach deeper, further & wider than ever before



First distance estimate in Q1 (in prep.)



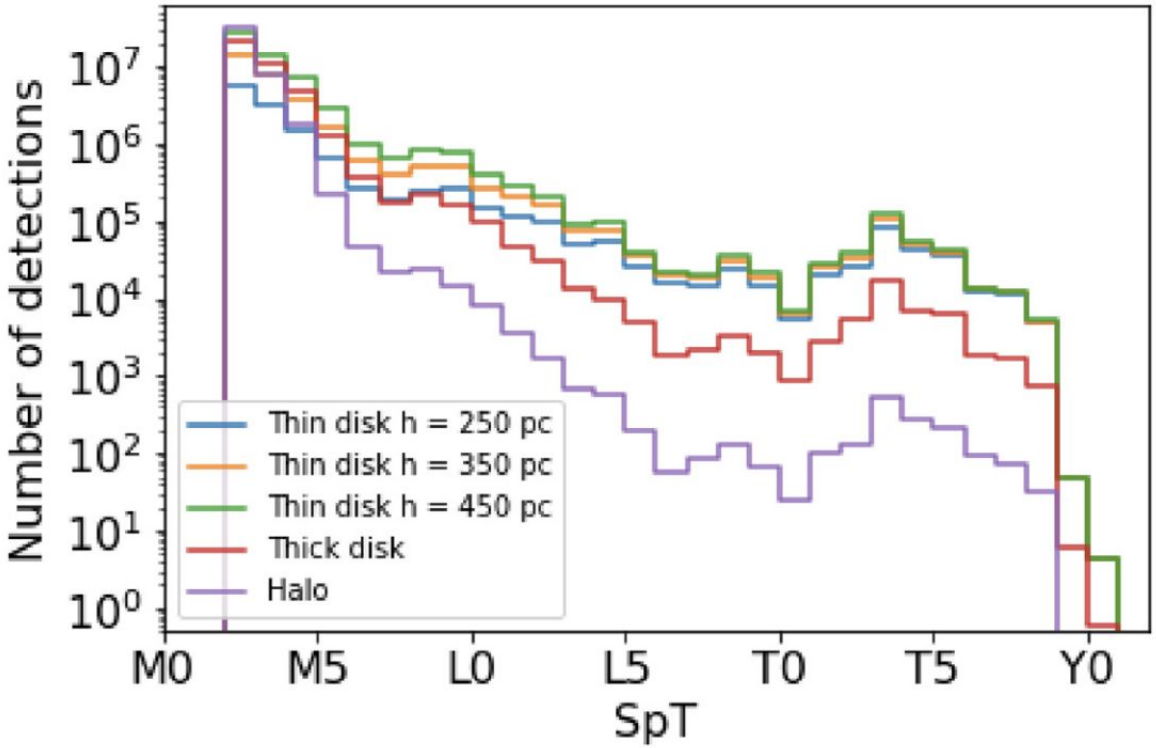


Figure 9. Simulated number counts of UCDs detected by the Euclid wide survey (15 000 deg^2) in the NISP *J* band for a constant galactic latitude of 45° for all objects.

Predicted numbers in the J band (Wide Survey):

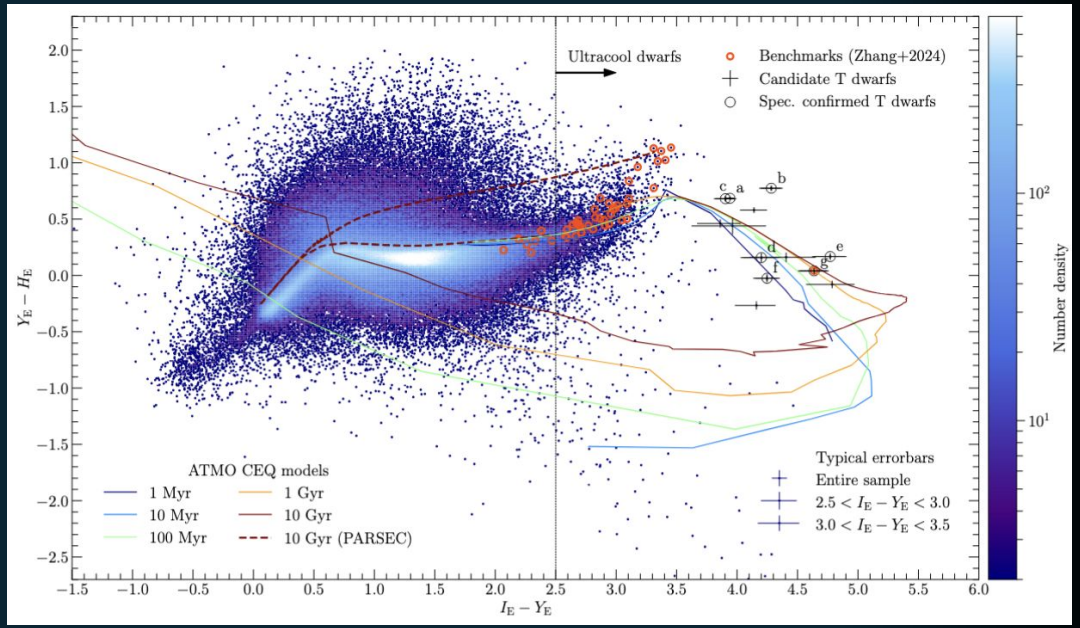
- L dwarfs: 2 million
- T dwarfs: 1 million
- Y dwarfs: a handful

All three NISP bands: Around 1 million

Solano et al. 2021: 2021MNRAS.501..281S

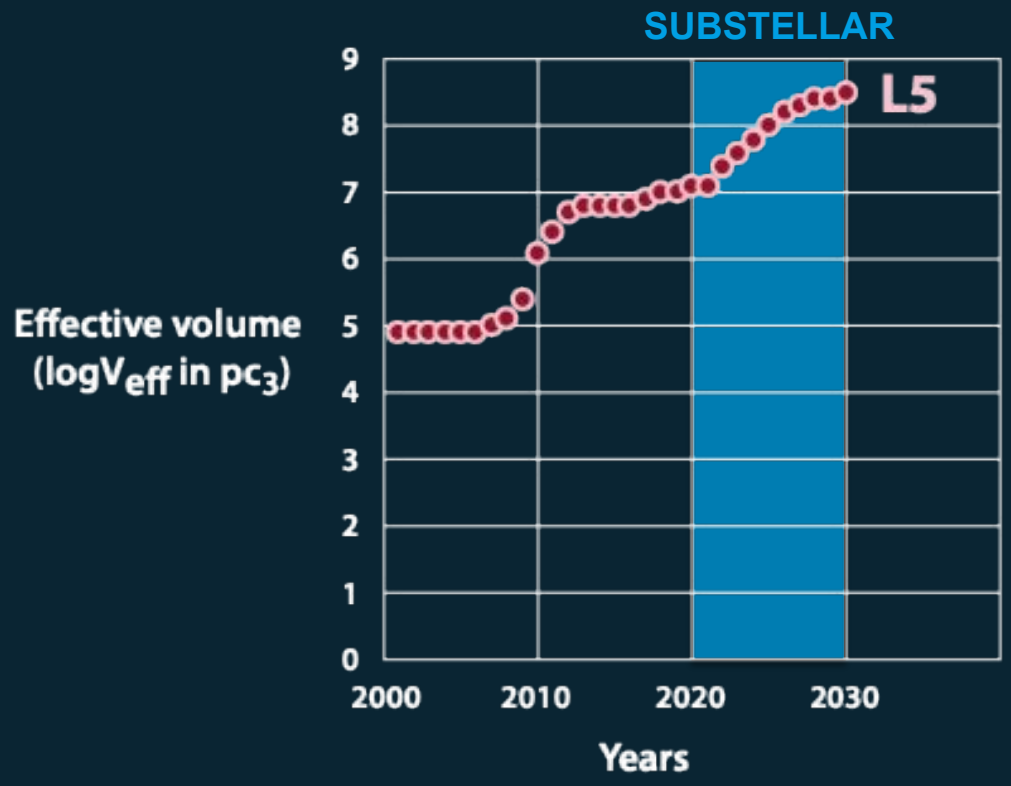
UCDs in the Q1 data release

- 5306 UCD candidates, but we didn't reach completeness limit
- Average density of ~100 UCDs per deg2 in Euclid
- → 1.4 million of UCDs at the end of the mission (at least), detection in all 4 bands (VIS)
- → 160,000 UCD candidates expected in DR1



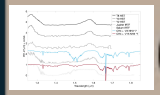
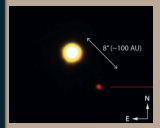
See my next talk

The SUBSTELLAR overarching vision

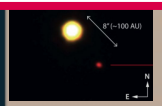


SUBSTELLAR > Euclid + JWST + Vera Rubin + Nancy Roman

STATE OF THE ART / CHALLENGE

	STATE OF THE ART	CHALLENGE
Substellar objects (with spectra)	 ($2x10^3$)	$2x10^6$ ($2x10^5$)
Substellar binaries (dynamical masses)	150 (40)	$2x10^4$ (400)
Substellar wide companions to stars	 50	1000
Planets around substellar primaries	10	100
Halo substellar objects	0	few $x10^2$

STATE OF THE ART / CHALLENGE

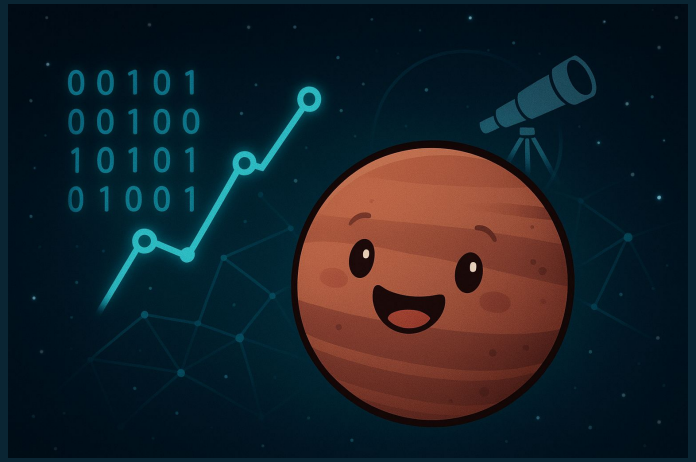
	STATE OF THE ART	CHALLENGE
Substellar objects	 ($2x10^3$)	$2x10^6$ ($2x10^5$)
Substellar wide companions to stars	 50	1000
Planets around substellar primaries	10	100
Halo substellar objects	0	few $x10^2$

Sara Muñoz Torres:
The first substellar binary in Euclid

Synergies

Vera Rubin Observatory

Nancy Grace Roman
Space telescope



Thank you for your attention!