Euclid Synergy with Rubin Observatory

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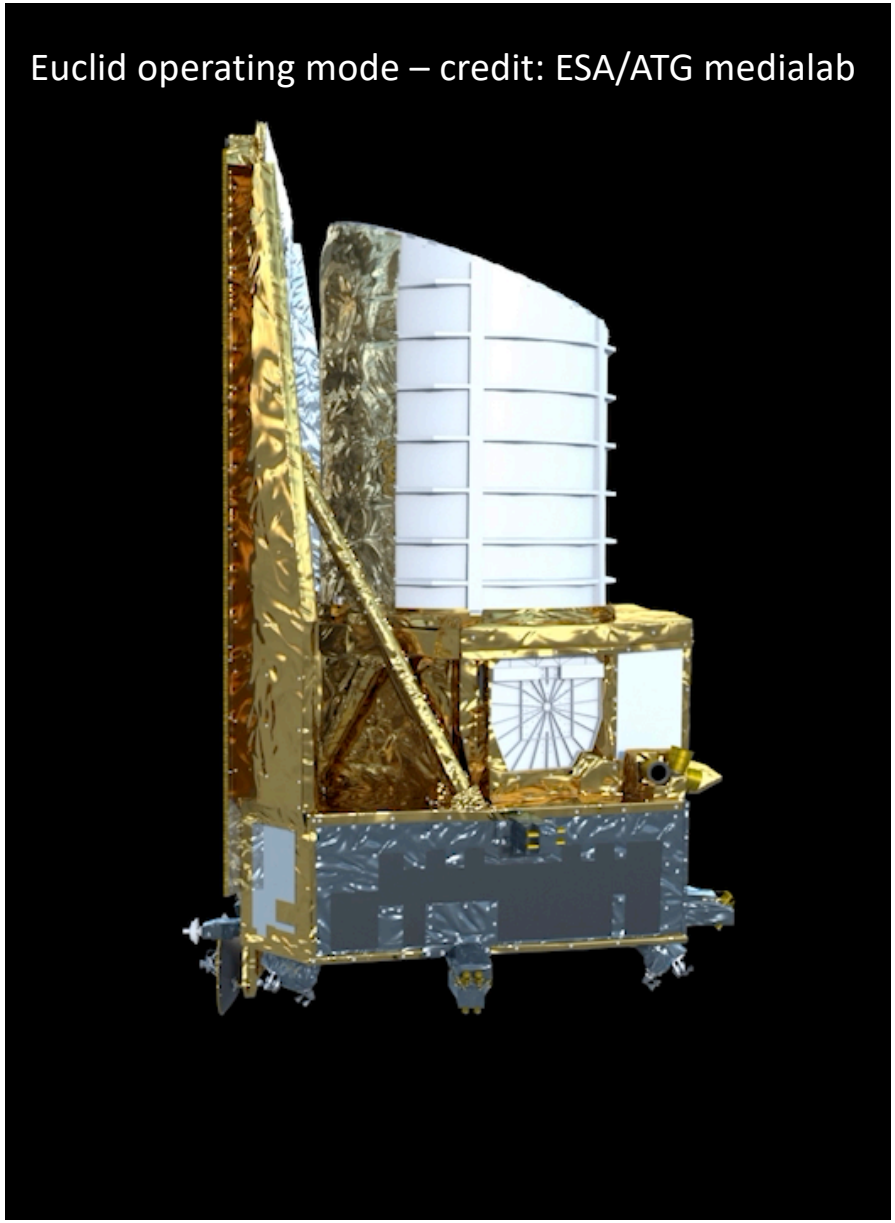
Euclid

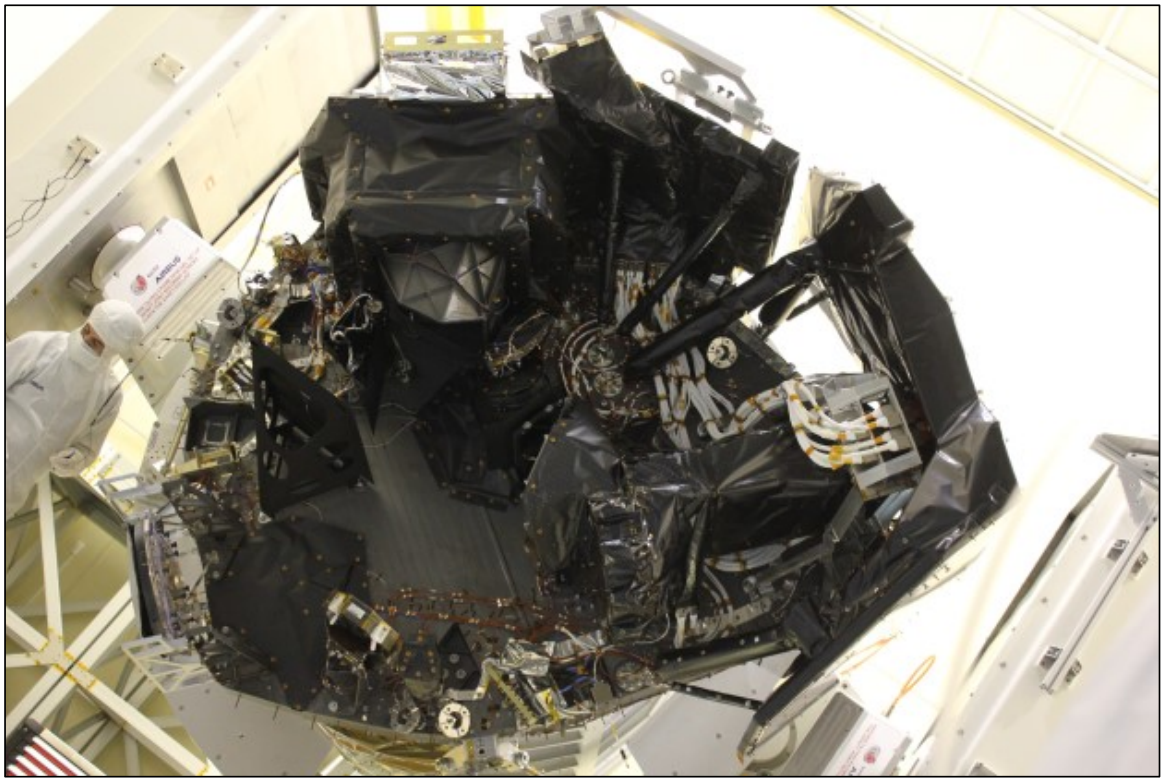
- ESA mission with focus on cosmology
  - Primary science: WL and BAO surveys
  - Huge legacy science potential
- 1.2 m telescope
- Launch planned for July – December 2022
- Nominal mission 6 years with possible 5-year extension
- Two wide-field instruments: VIS and NISP



Euclid Specifications

Euclid definition study report ("Red Book"), Laureijs et al 2011

- Wide survey 15,000 sq deg
- Wide survey depths
  - VIS imaging 10σ depth: 24.5
  - Y,J,H imaging 5σ depth: 24 mag (AB)
  - NIR spectroscopy at R~250: unresolved line flux 3.5σ depth: 3×10^{-16} erg $cm^{-2} s^{-1}$
- Deep survey 40 sq deg
  - 2 magnitudes deeper
- PSF sampled with 0.1" pixels (VIS), 0.3" pixels (NISP)



Both instruments integrated onto the payload module of the spacecraft.
Image Credit: Airbus Defence and Space – Toulouse, Dec 2020

Science synergies with Rubin/LSST

(what does Euclid bring?)

Cosmology and Dark Energy

- Weak lensing
  - superior shape measurement and deblending
  - Note that Euclid *requires* optical photometry for phot-z and PSF colour
- BAO spectroscopic redshifts
  - Photo-z calibration
- Other cosmological probes
  - Clusters masses (evolution with z)
  - SNe Ia (host galaxies)

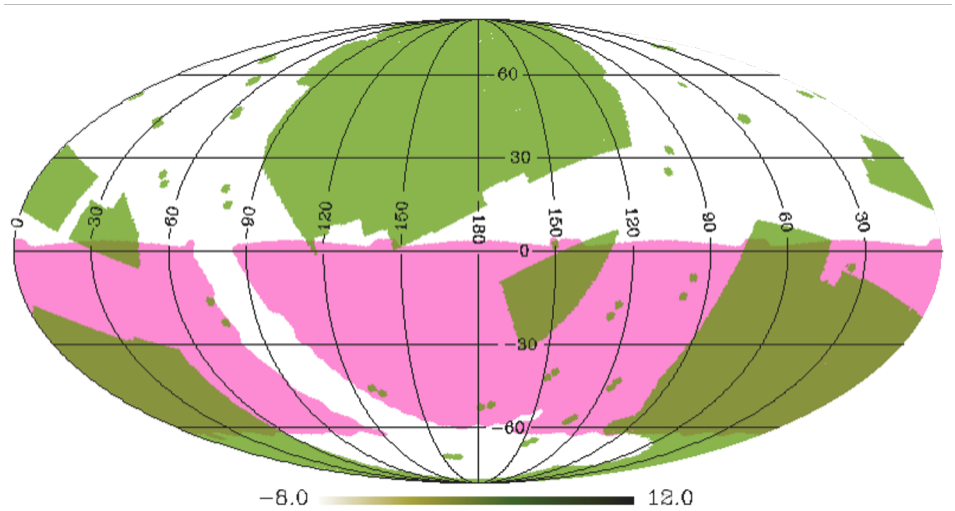
Legacy Science

- Solar System:
  - NIR colours , (sub-visit) astrometric shifts, spectra
- Milky Way and Local Group
  - star/galaxy separation, combined sensitivity to LSB features, e.g. stellar streams
- Galaxy evolution
  - galaxy stellar masses to z~3.5, very high-z galaxies, morphology, spectra
- Transients:
  - IR detections, host galaxy properties

See e.g. Jain et al 2015, Rhodes et al 2017

Survey overlap is key

- Strong case for maximising survey overlap
- Euclid responses to LSST survey optimisation process
  - e.g. Tri-Agency WG, Capak et al 2019
- But note important publication policies: need Derived Data Products (DDP) process!



LSST baseline Nov 2018

Euclid ~early 2020

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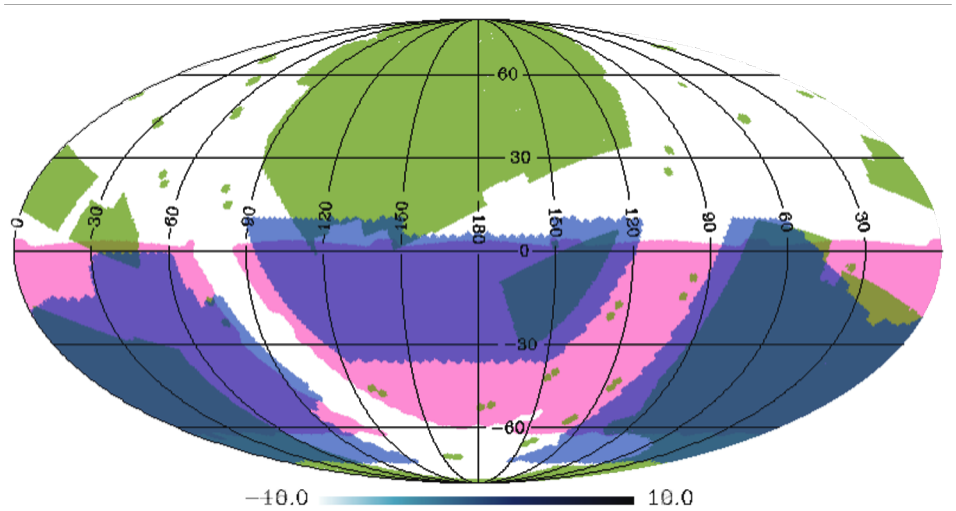
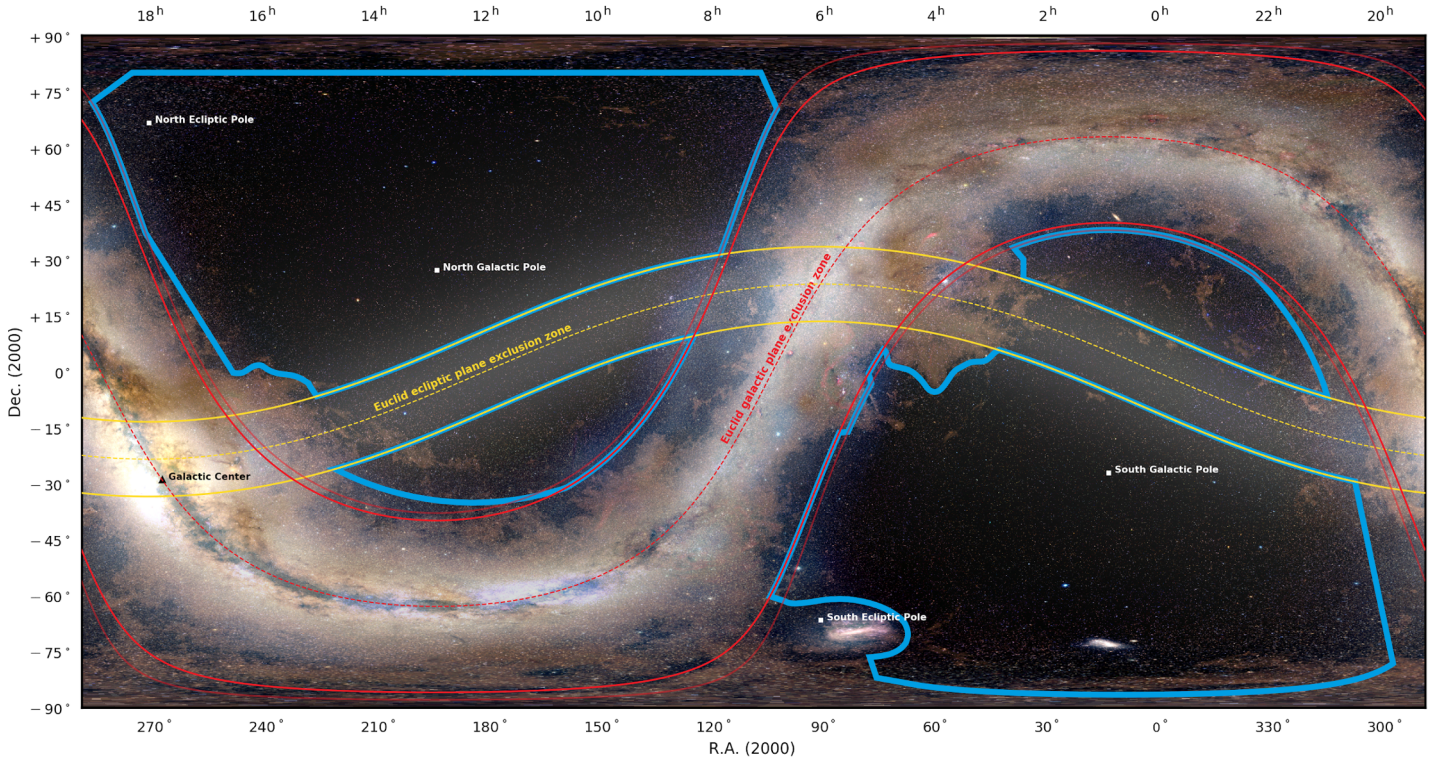


LSST + 4MOST extragalactic overlap area ~ 13 000 sq deg
LSST + 4MOST + Euclid overlap area ~ 6100 sq deg

Euclid Wide Survey : the region of interest

Slides from Jean-Charles Cuillandre

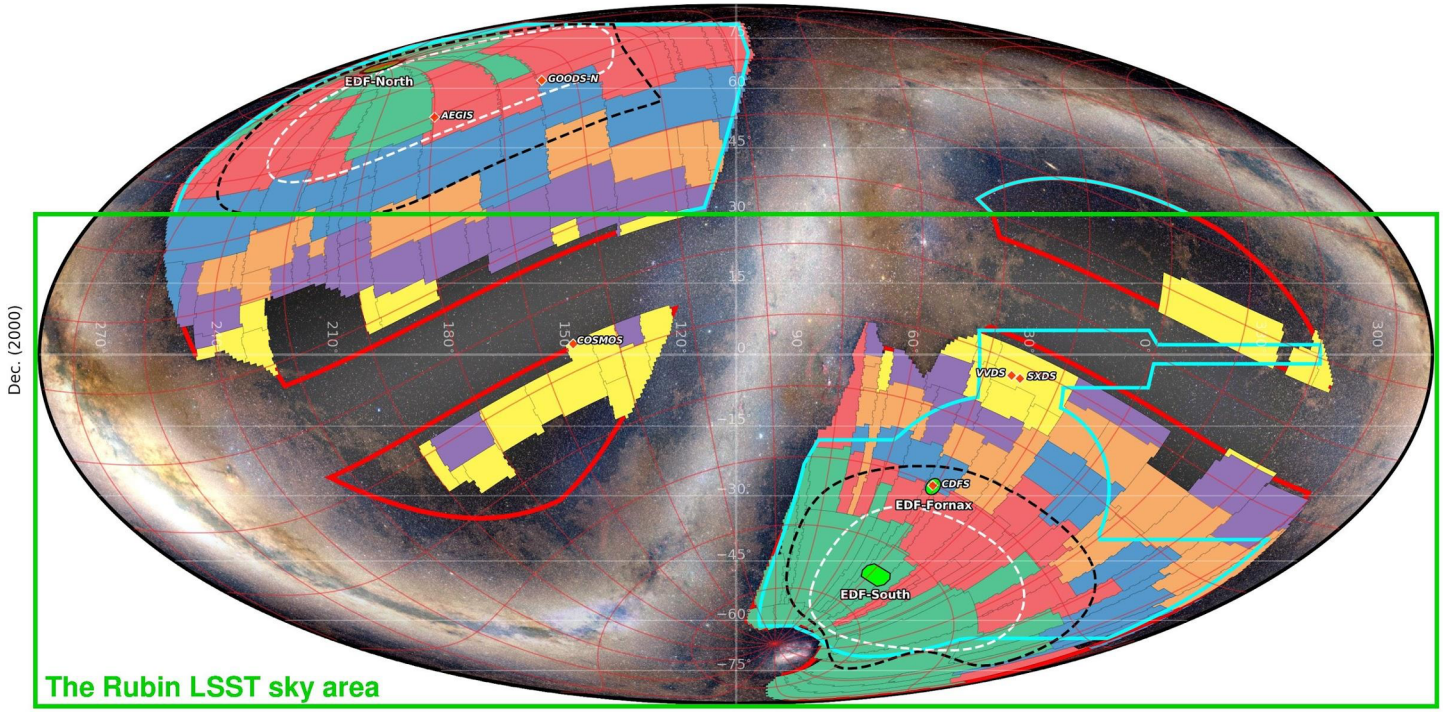


The Euclid Wide Survey based on ecliptic&galactic latitude thresholds + upper limits on stellar density & extinction (Gaia/Planck)

- Euclid Wide Survey region of interest : 17 Kdeg.^{2} compliant with a 15 Kdeg.^{2} survey
- Ecliptic plane [zodiacal light background] : +/- 10 deg. ecliptic latitude exclusion zone
- Galactic plane [stellar contamination] : +/- 23&25 deg. galactic latitude exclusion zone

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

The Euclid Wide Survey and the Rubin LSST sky area



65% of the Euclid Region of Interest (17,354 square degrees)

RSD 2020c ECTile realization of a Euclid Wide Survey within the 17 Kdeg.^{2} RoI : 14,668 deg.^{2} over 6 years in 216 patches

Euclid Wide Survey Region of Interest (RoI) : 17 Kdeg.^{2} compliant with a 15 Kdeg.^{2} survey

Best 2600 deg.^{2} (black) and 1300 deg.^{2} (white) SNR areas per galactic cap

Euclid Deep Fields (EDF, from north to south): 10+10+23 deg.^{2}

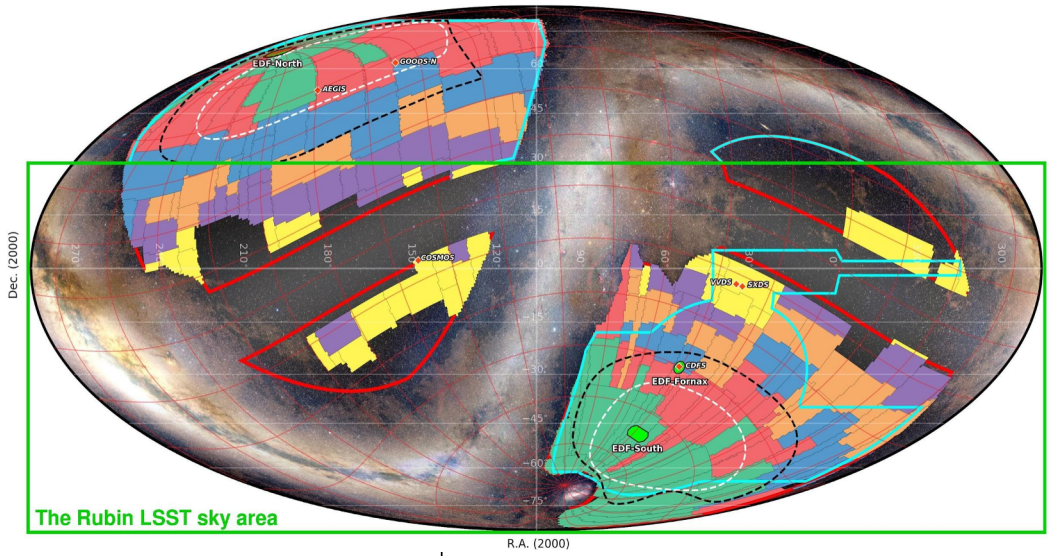
Euclid Wide Survey chronology (2.5Kdeg.^{2}/yr)

Year1 Year2 Year3 Year4 Year5 Year6

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

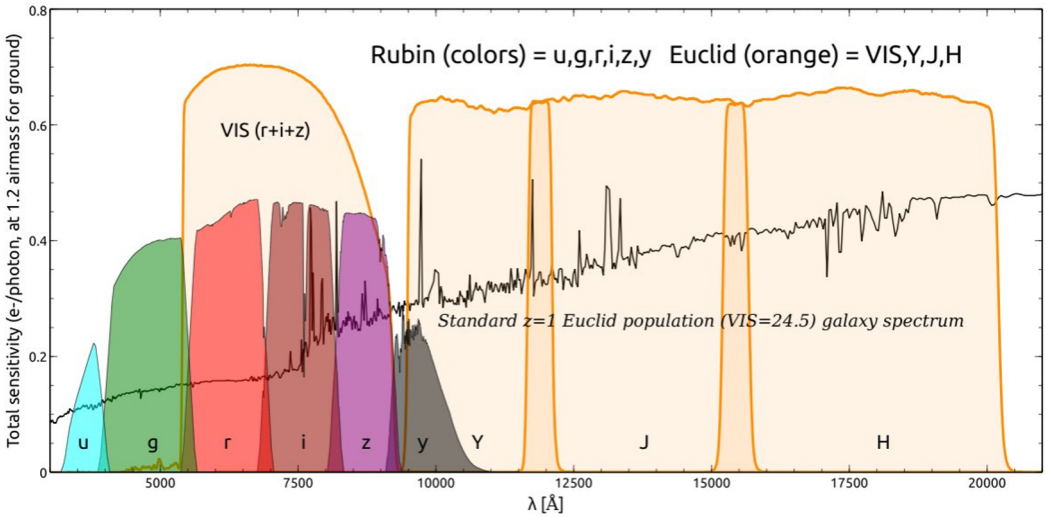
Euclid data releases

Assuming September 2022 Launch



- Jan 2023: End of commissioning
- Nov 2023: Q1
- Nov 2024: DR1 (2500 deg2) = year1 (green)
- Sep 2025: Q2
- Sep 2026: DR2 (7500 deg2) = year 1 to 3 (green+red+blue)
- Sep 2027: Q3
- Sep 2028: Q4 (TBC)
- Sep 2029: DR3 (15000 deg2) = year 1 to 6 (all colored areas)

Euclid performance as-built : deeper by 0.5 magnitude



Euclid (EOL) and Rubin (2018) Filter response curves

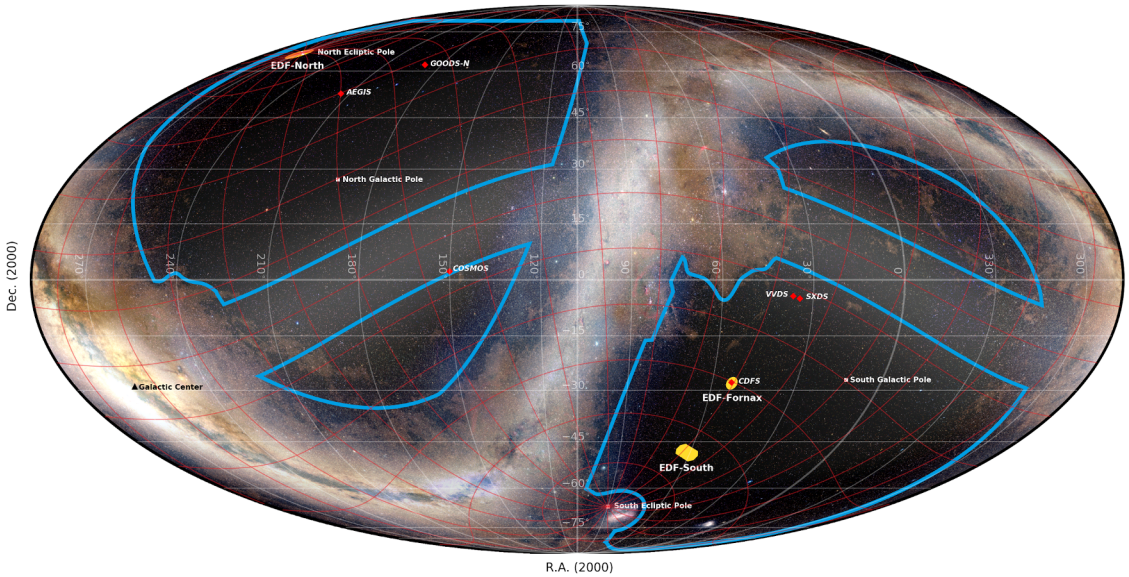
Euclid median SNR performance over the RoI for a VIS=24.5 extended source and a NISP Y, J, H 24th mag. star.
(Euclid Deep Survey: 2 mag fainter)

	VIS	*Y*	*J*	*H*	*S*
Minimum SNR	10.0	5.0	5.7	5.7	3.2
Median SNR	15.9	6.5	7.8	7.2	4.5
Maximum SNR	19.8	7.8	9.0	8.5	6.6
Median depth [AB mag]	26.2	24.3	24.5	24.4	–

Point source 5σ depth

Euclid Deep Survey : Rubin overlap on 2 fields (33 sq. deg.)

Location of the 3 Euclid Deep Fields



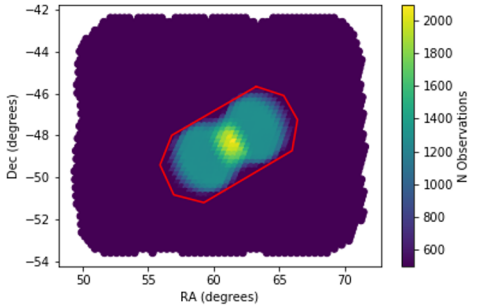
The Euclid Wide Survey (EWS) with the Euclid Deep Survey (EDF) and the deep Euclid Calibration Fields [Mollweide Celestial]

Euclid Wide Survey region of interest : 17 Kdeg.^{2} compliant with a 15 Kdeg.^{2} survey

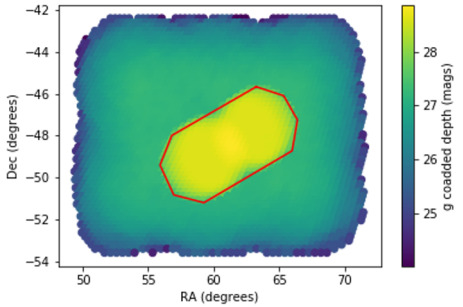
Euclid Deep Fields : North=10 deg.^{2}, Fornax=10 deg.^{2}, South=23 deg.^{2}

Euclid deep calibration fields marker (diamond not to scale)

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



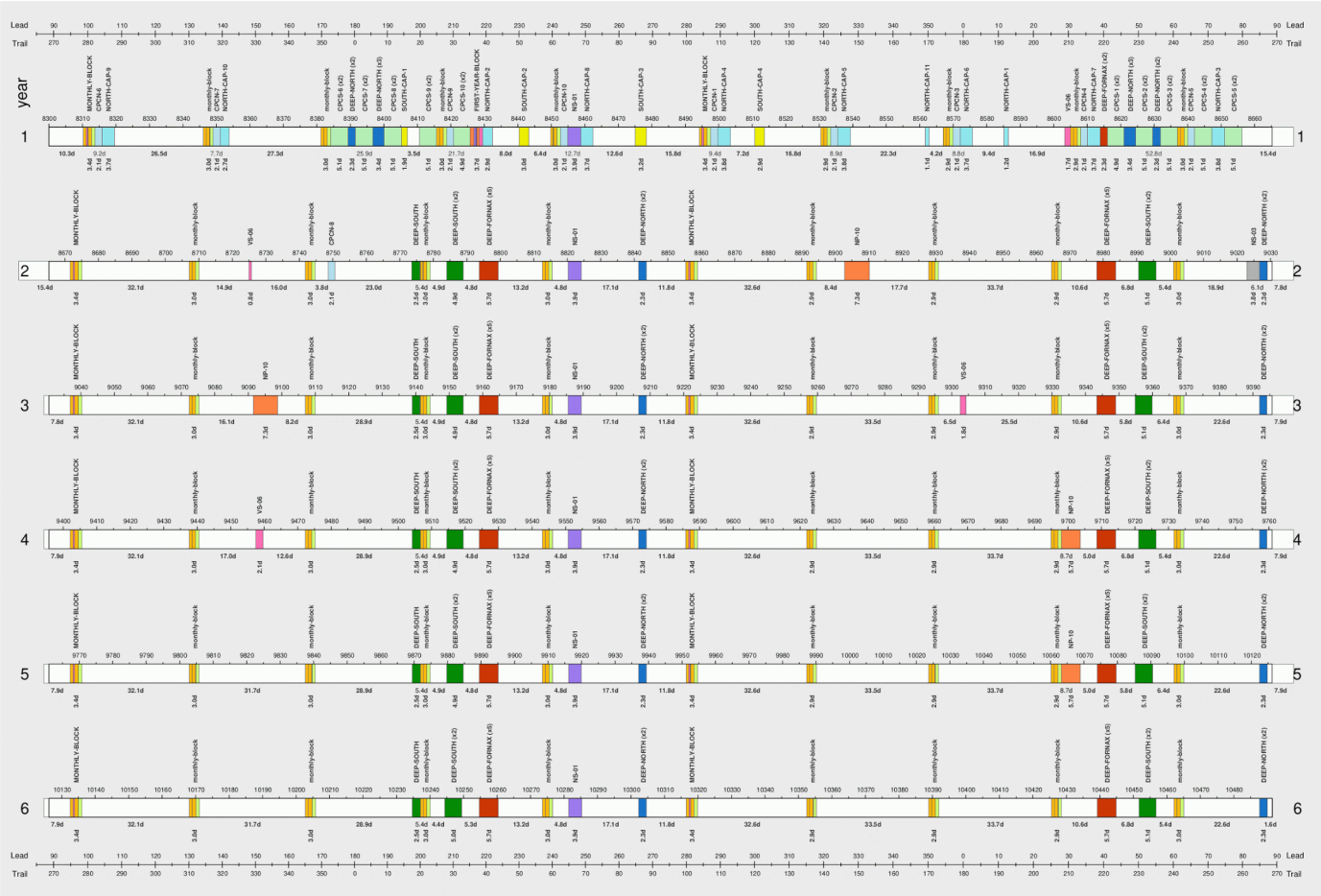
Two Rubin Deep Drilling Fields at half-depth on EDF-South



… or a uniform depth on EDF-South with an optimal Rubin dithering

EDF-South Rubin dithering (P. Yoachim)

Euclid Deep Survey : cadencing through the 6-year mission



Priority in Year 1 (2023) goes to EDF-North while EDF-Fornax (CDFS) and EDF-South reach full cadence in Year 2 (2024).

Depending on the launch date (currently September 2022), we will have a solid idea when EDF-Fornax and EDF-South ought to be observed.

The observing windows on the Euclid Deep Fields are 4 to 6-day long.

Plot from a 2020 ECSURV simulation

Conclusion

- Work ongoing to optimise survey overlap with LSST in space and time
- Science cases drive this
- Derived Data Products process is crucial!