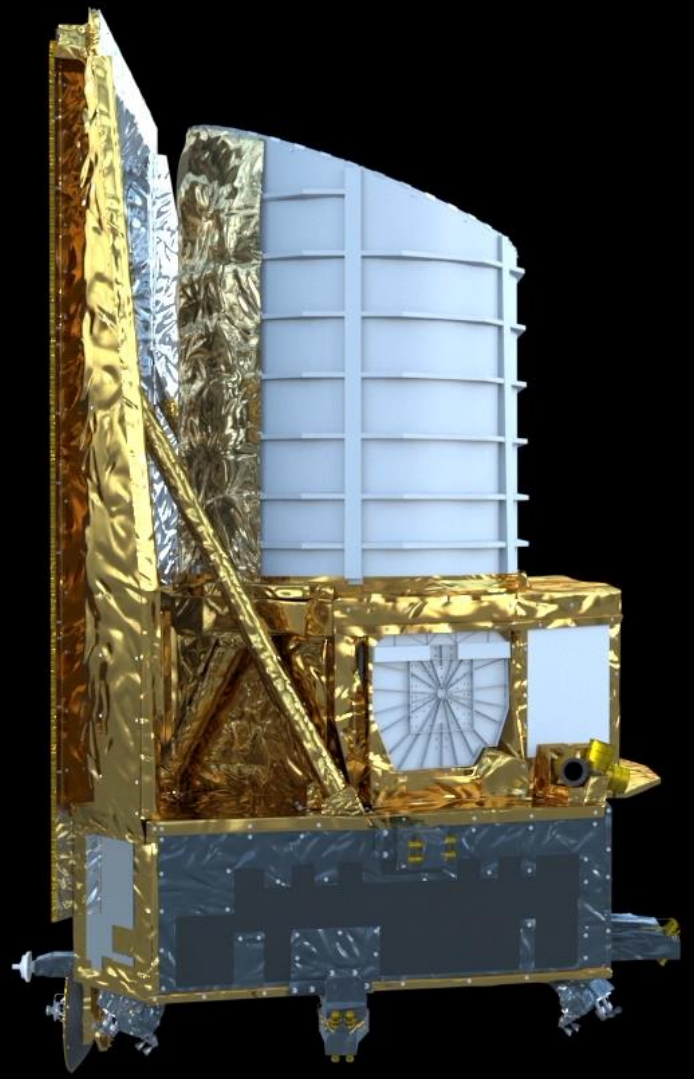
Euclid Update



Jason Rhodes (Jet Propulsion Laboratory, California Institute of Technology)

January 4, 2019

PCOS @ AAS

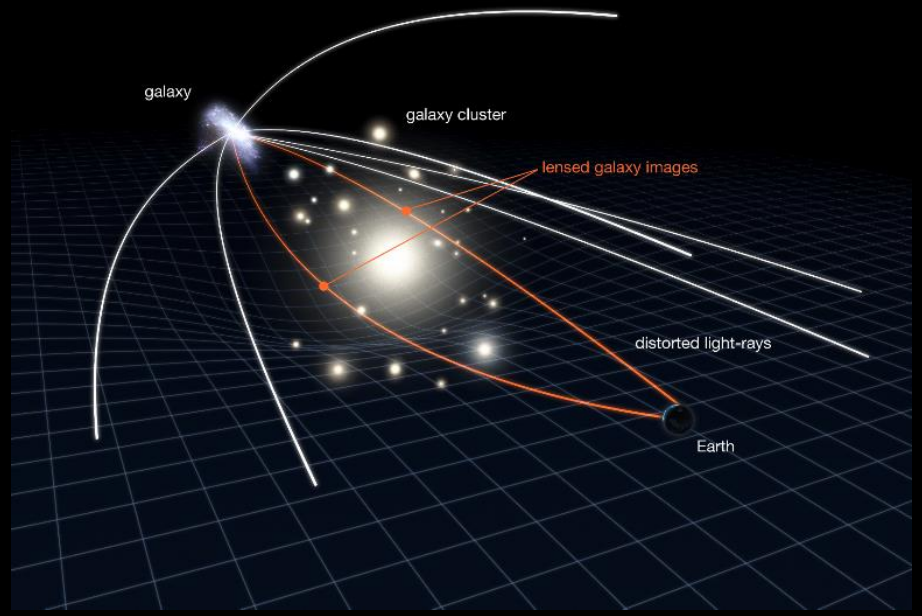
Euclid: a surveying space telescope of the European Space Agency

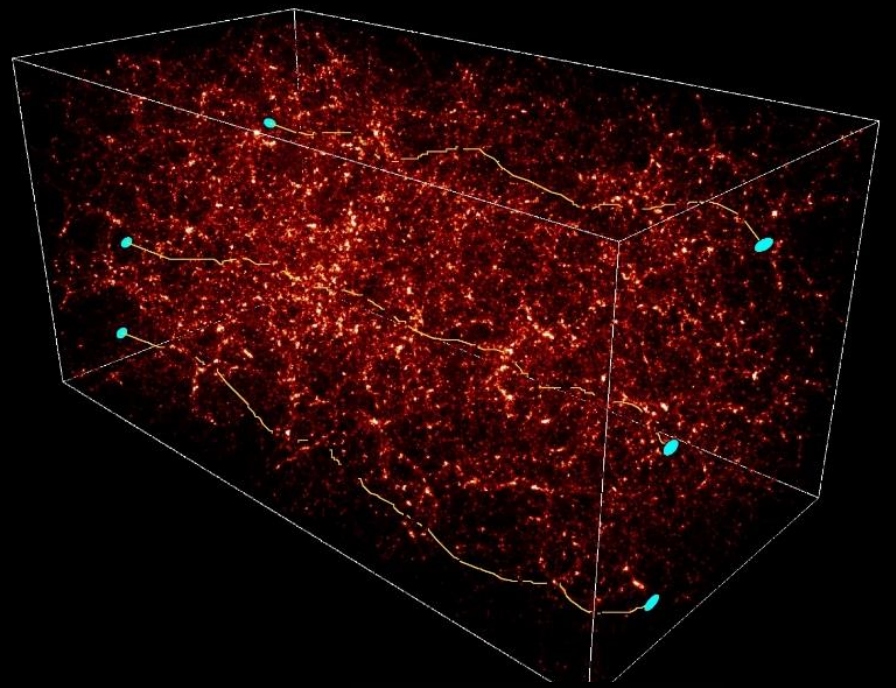
Prime Science Objectives: quantify Dark Energy [$w(a)$], Modified Gravity [γ], Dark Matter [m_ν], and the Universe's Initial Conditions [f_{NL}]

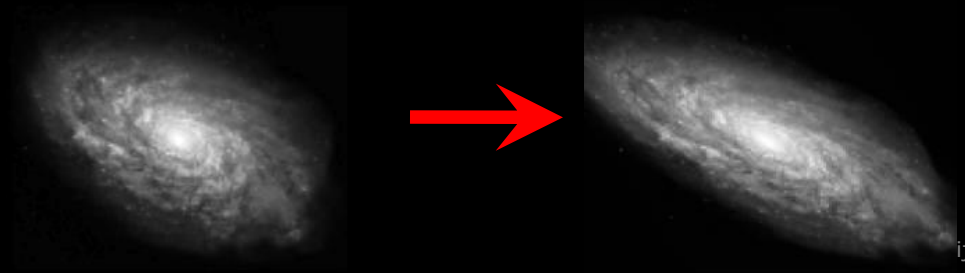
make a decisive measurement of the accelerated expansion of the Universe

Euclid is designed to measure two cosmological probes:

- Weak Lensing (WL)

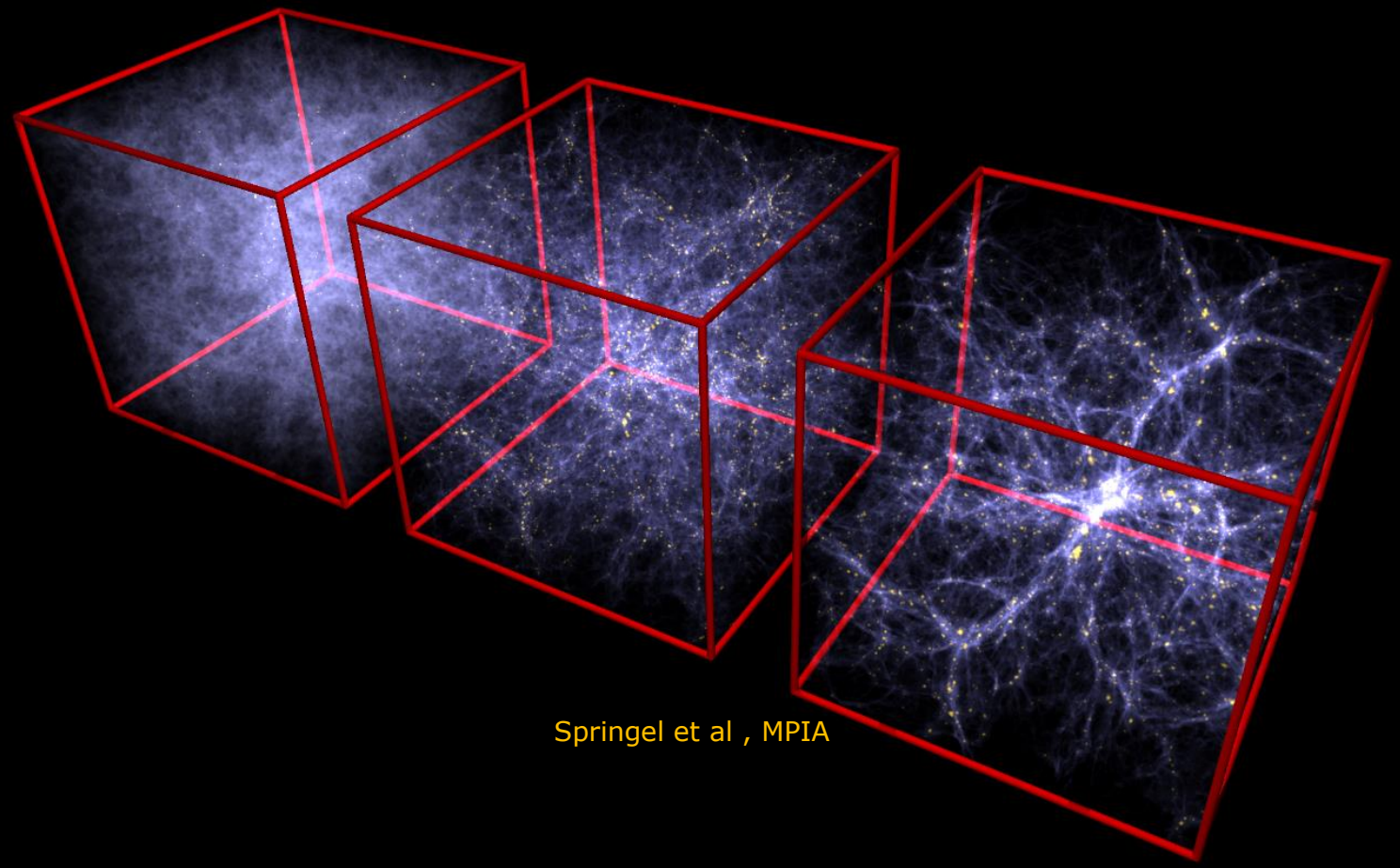




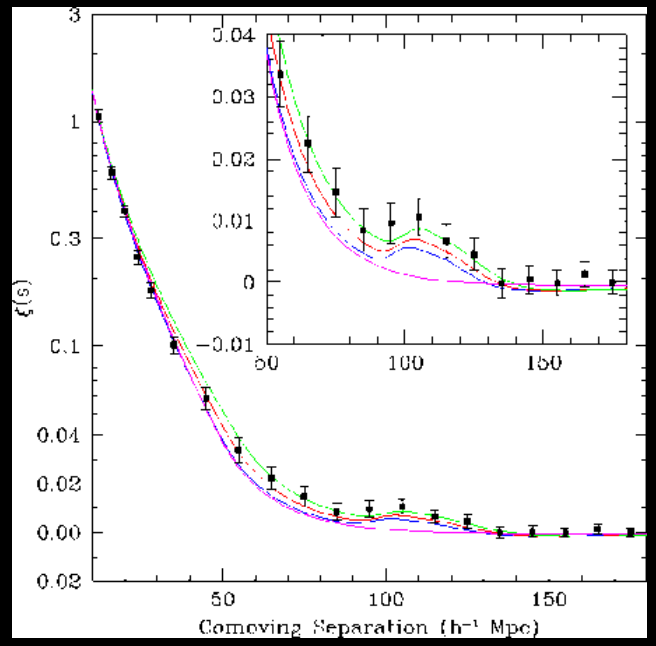


Euclid is designed to measure two cosmological probes:

- Galaxy Clustering (GC)



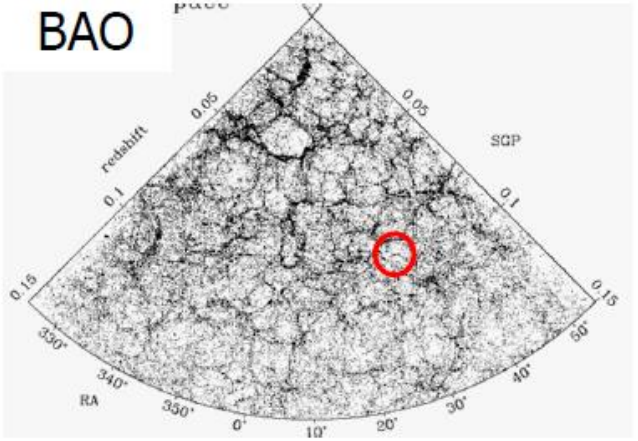
Springel et al , MPIA

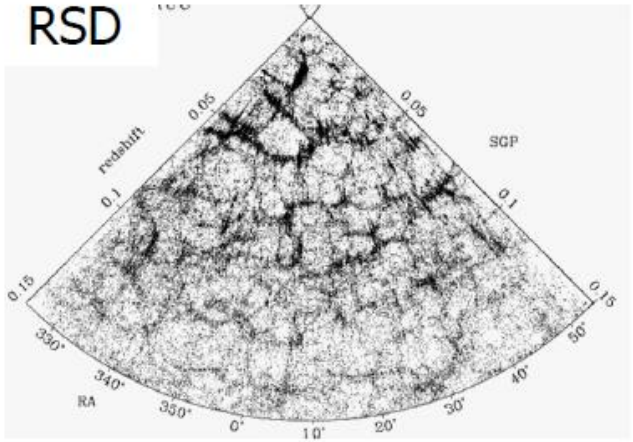


Euclid Primary Probes

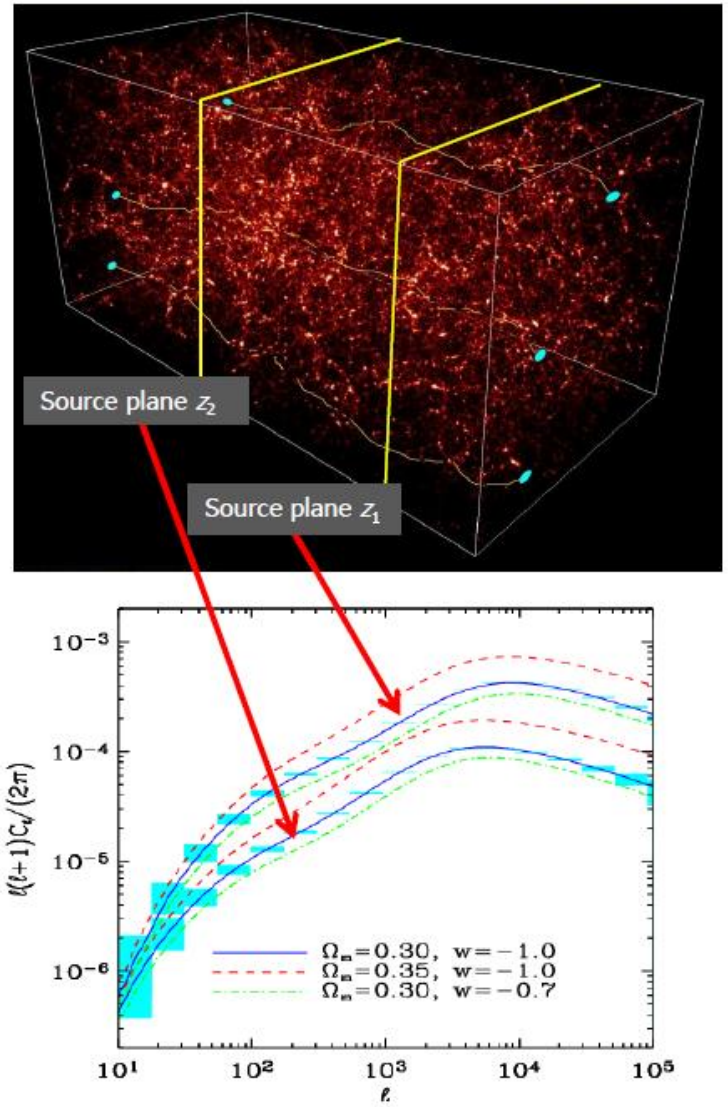
BAO, RSD and WL over 15,000 deg^2

50 million galaxies with redshifts

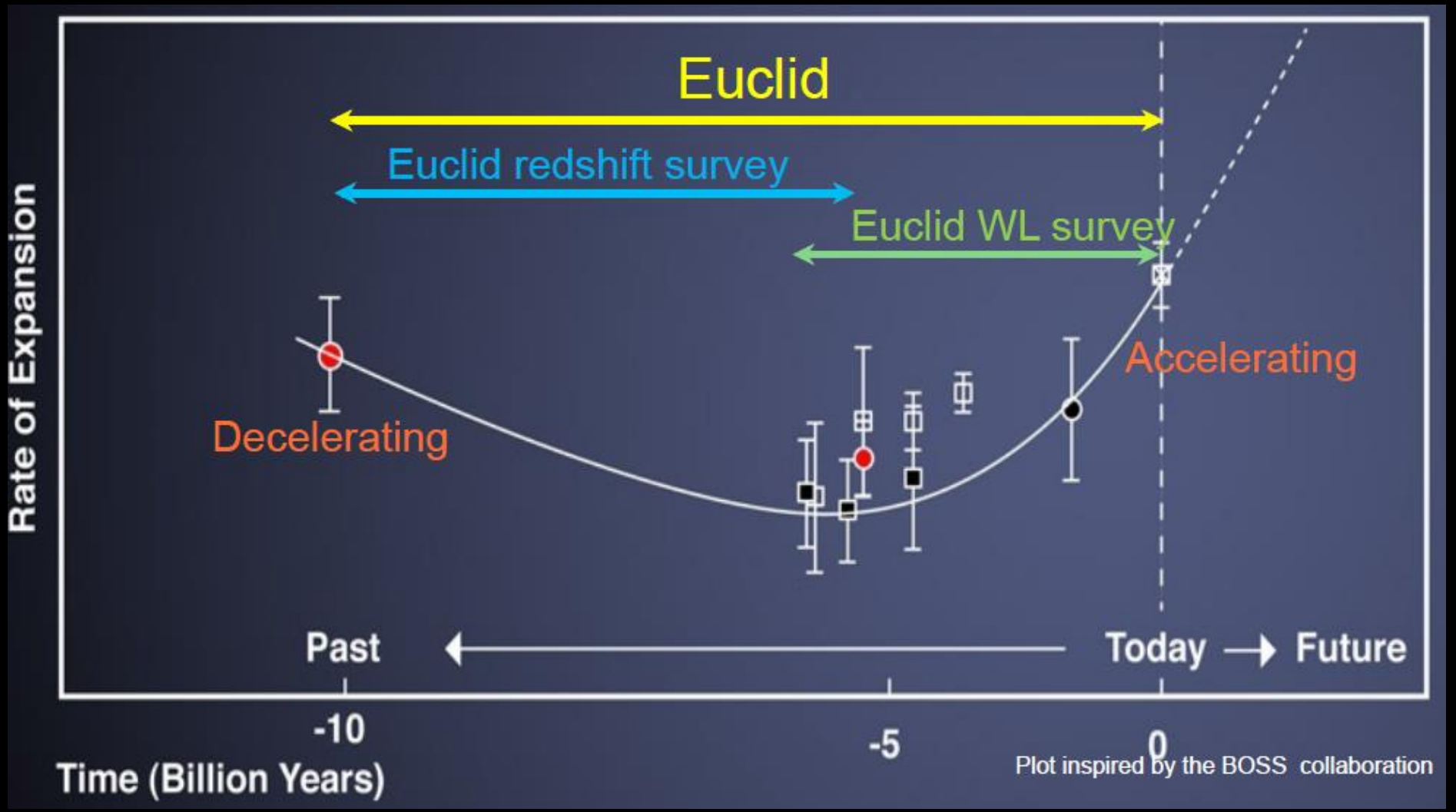




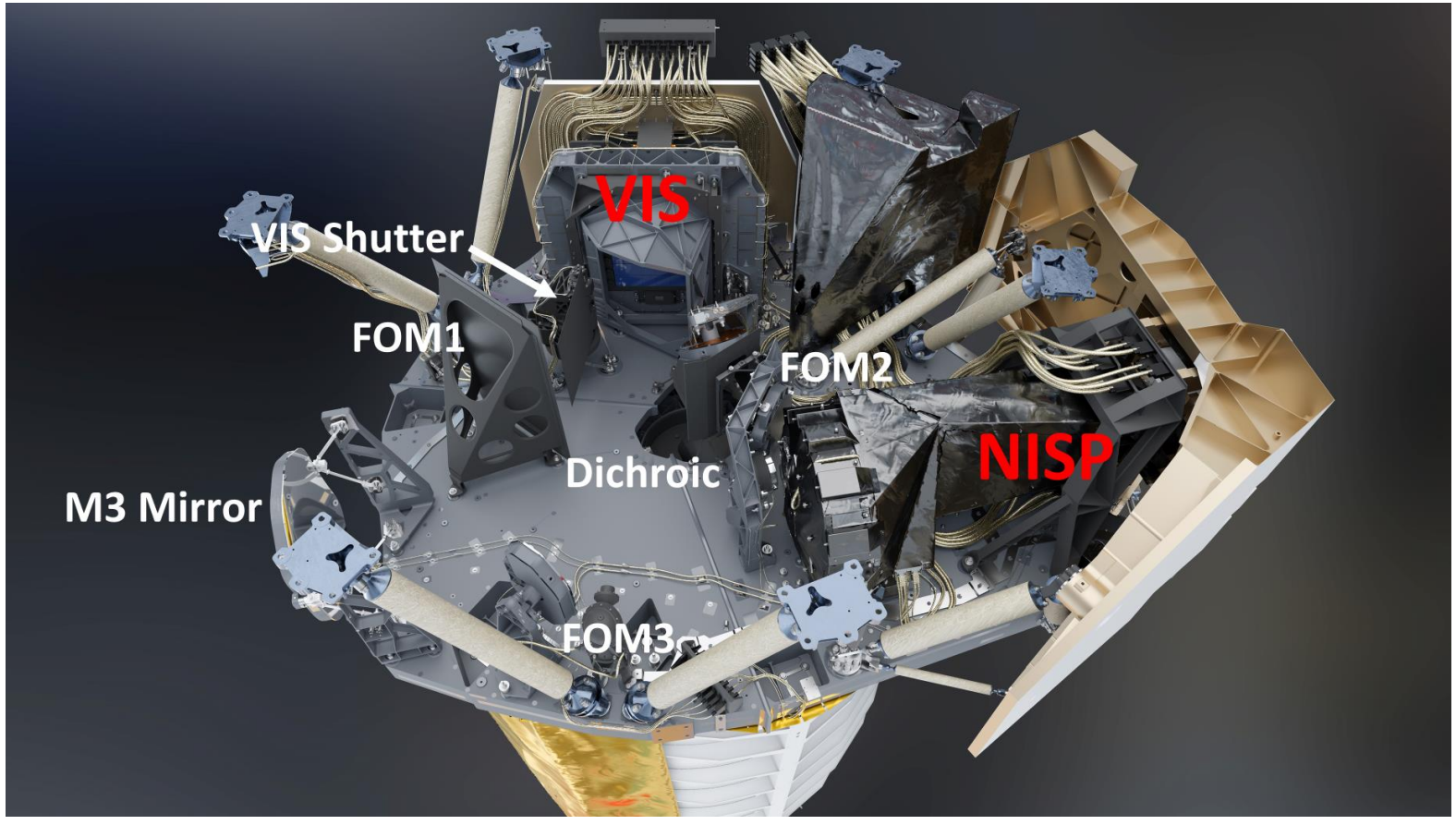
1.5 billion sources with shapes, 10 slices



Combining probes



From Y. Mellier



Near-Infrared Spectrometer and Photometer (NISP)

FOV:
0.78 x 0.73 deg
16 H2RGs
0.3” / pixel

Visual Imager (VIS)

FOV:
0.79 x 0.70 deg
36 4kx4k e2v CCDs
0.1” / pixel

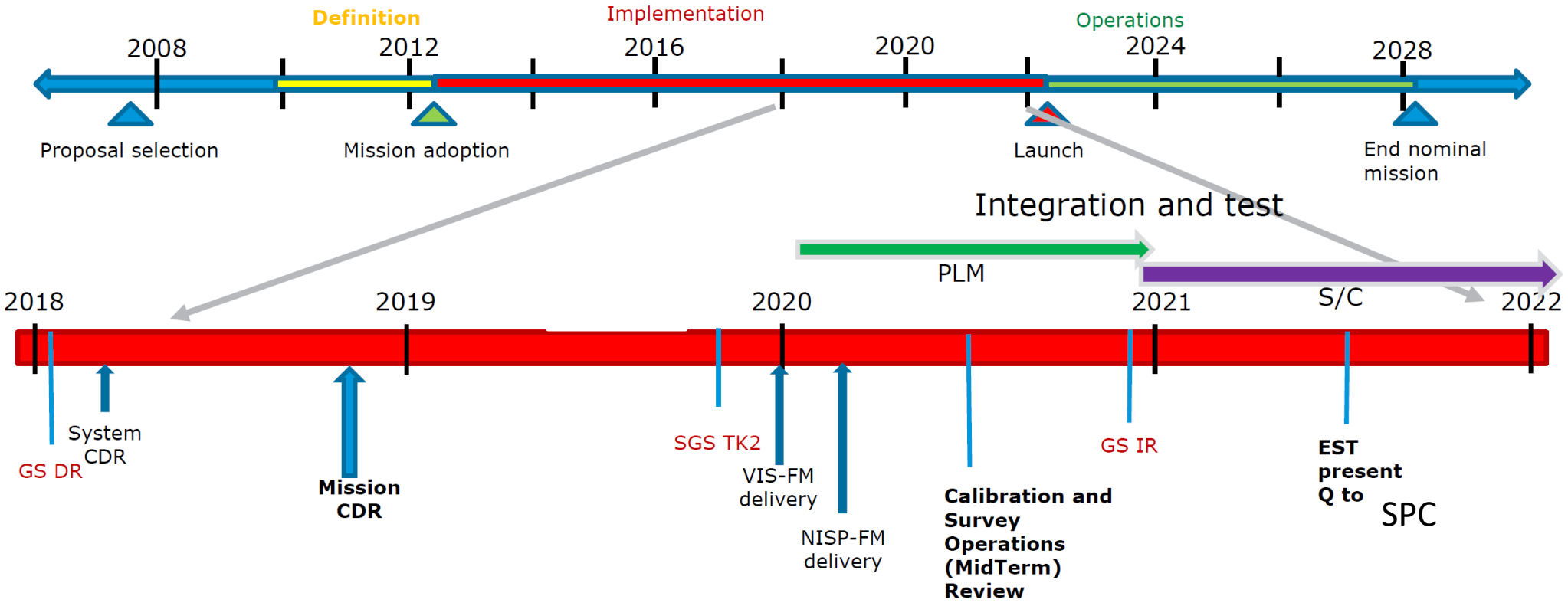
Launch:
on Soyuz
from Kourou,
Mid 2022

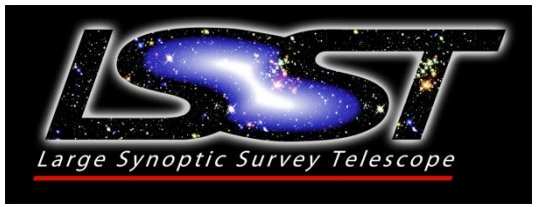
Mission Lifetime:
6+ years
@ L2

Aperture:
1.2m

Euclid Timeline

Overview mission timeline





Proposed lifetime	2022 - 2032	2022 - 2028	2025 - 2031
Mirror size (m)	6.5 (effective diameter)	1.2	2.4
Survey size (sq deg)	20,000	15,000	2,227
Median z (WL)	0.9	0.9	1.2
Depth (AB mag)	~27.5	~24.5	~27
FoV (sq deg)	9.6	0.5 (Vis) 0.5 (NIR)	0.28
Filters	u-g-r-i-z-y	Y-J-H-Vis	Y-J-H-F184
Cosmological probes	WL, LSS, SN	WL, LSS	WL, LSS, SN

The Euclid survey : 3 distinct components

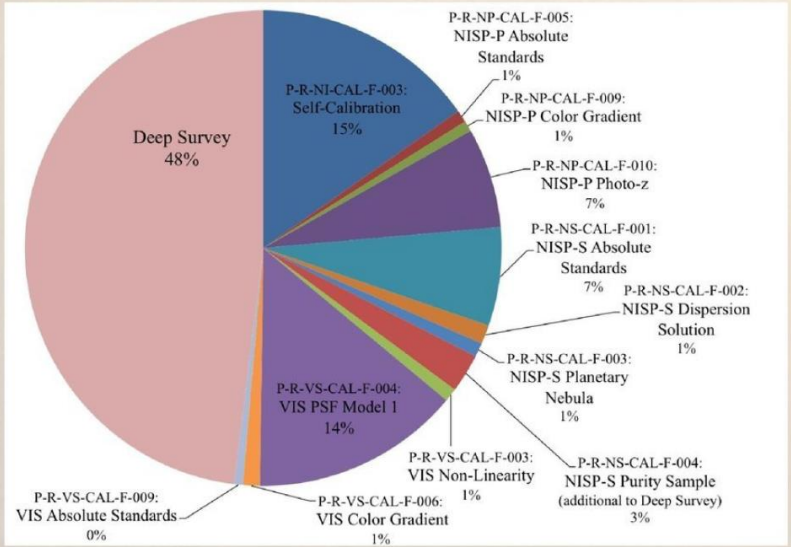
Mission core science goal requirements

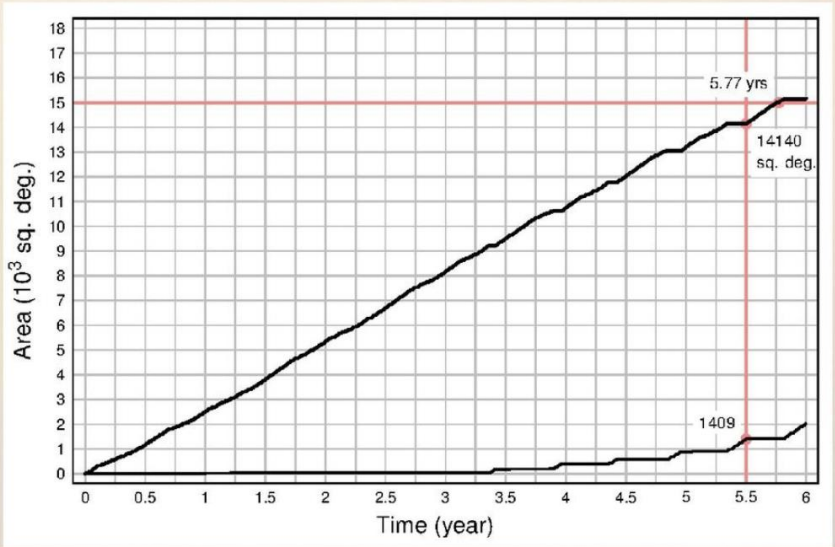
Calibrations + Deep Survey + Wide Survey

Misc. locations, many repeats
+
Time constraints

40 sq.deg. in 3 split fields
+
Time constraints

15,000 sq.deg. in 6 years



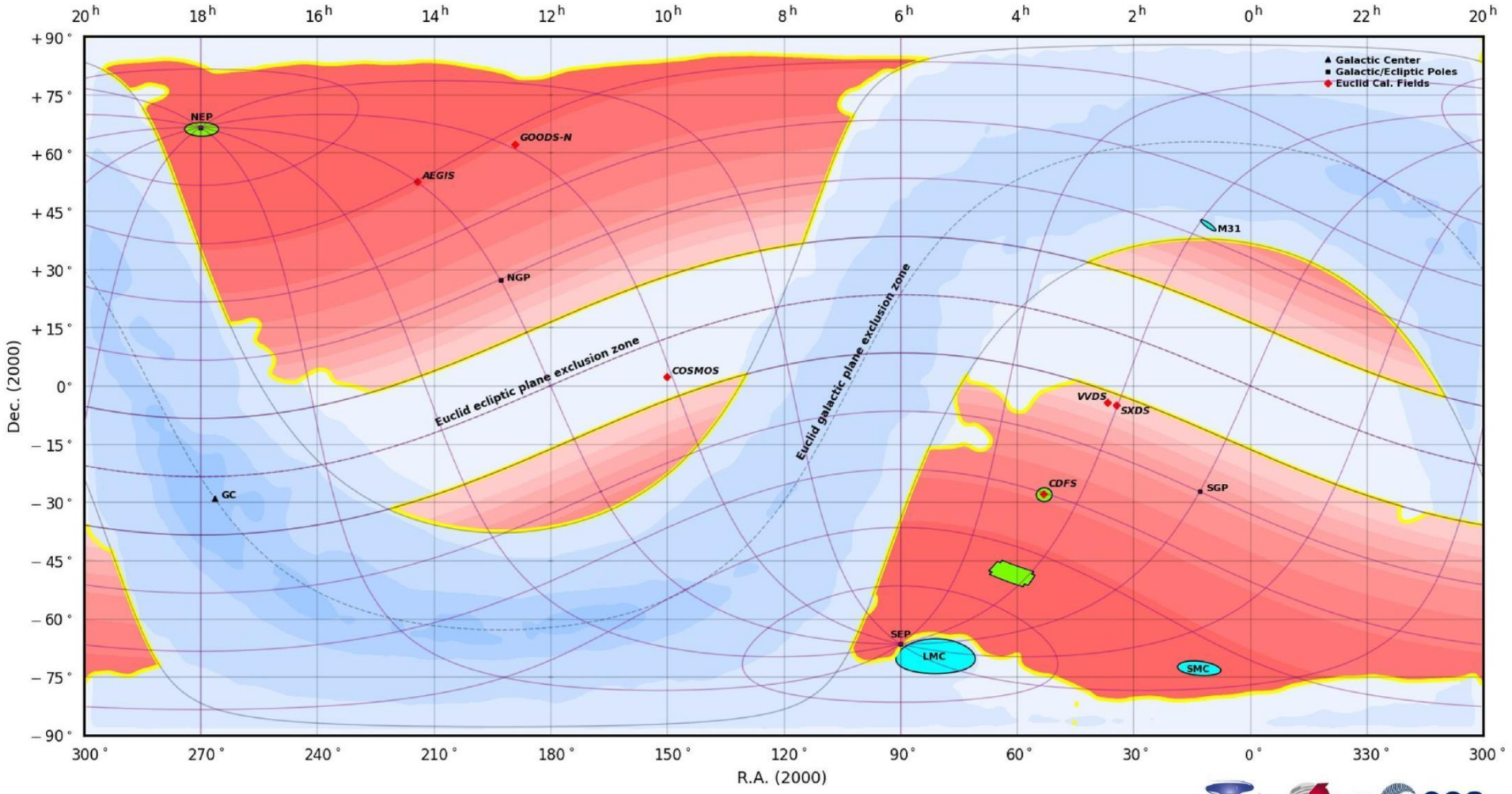


Scheduling priorities: 1) Calibrations, then 2) Deep (=calibration), and then 3) Wide

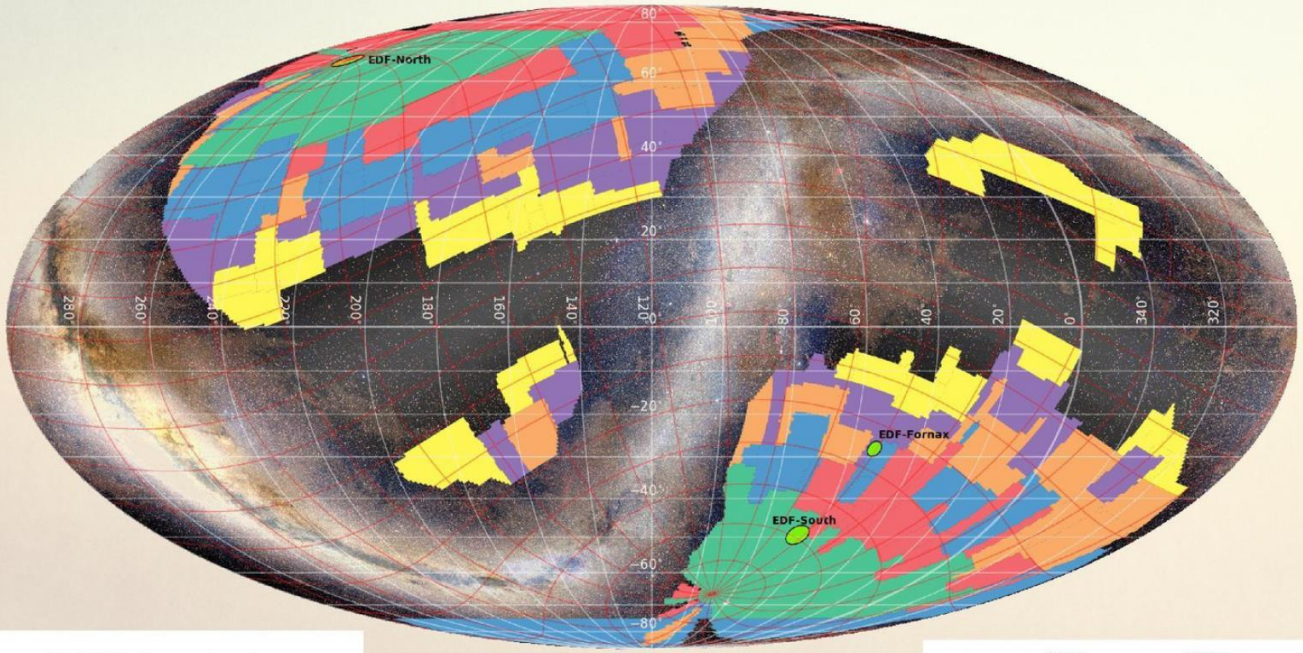
Slide from Jean-Charles Cuillandre

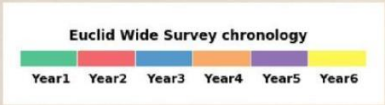
Euclid Survey

From R Scaramella and JC Cuillandre

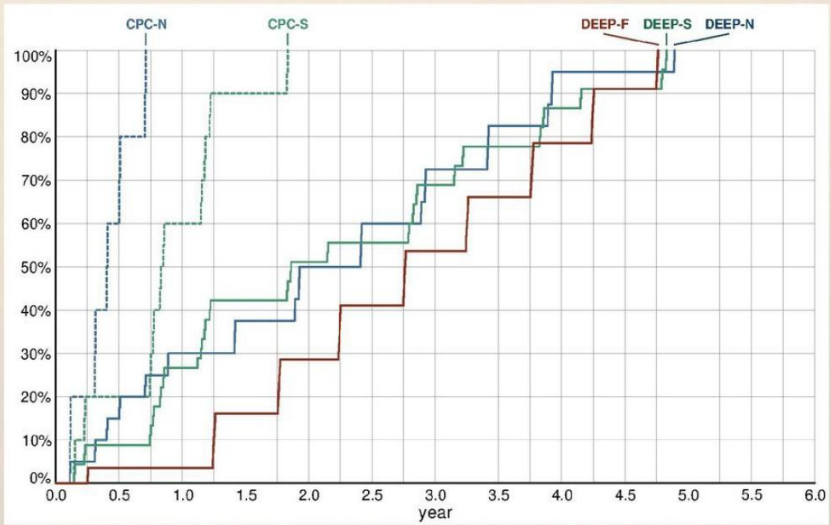


The Euclid Survey : sky coverage chronology





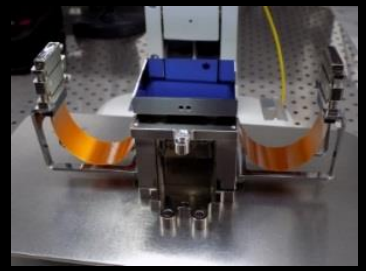
Wide survey : patches over 6 years



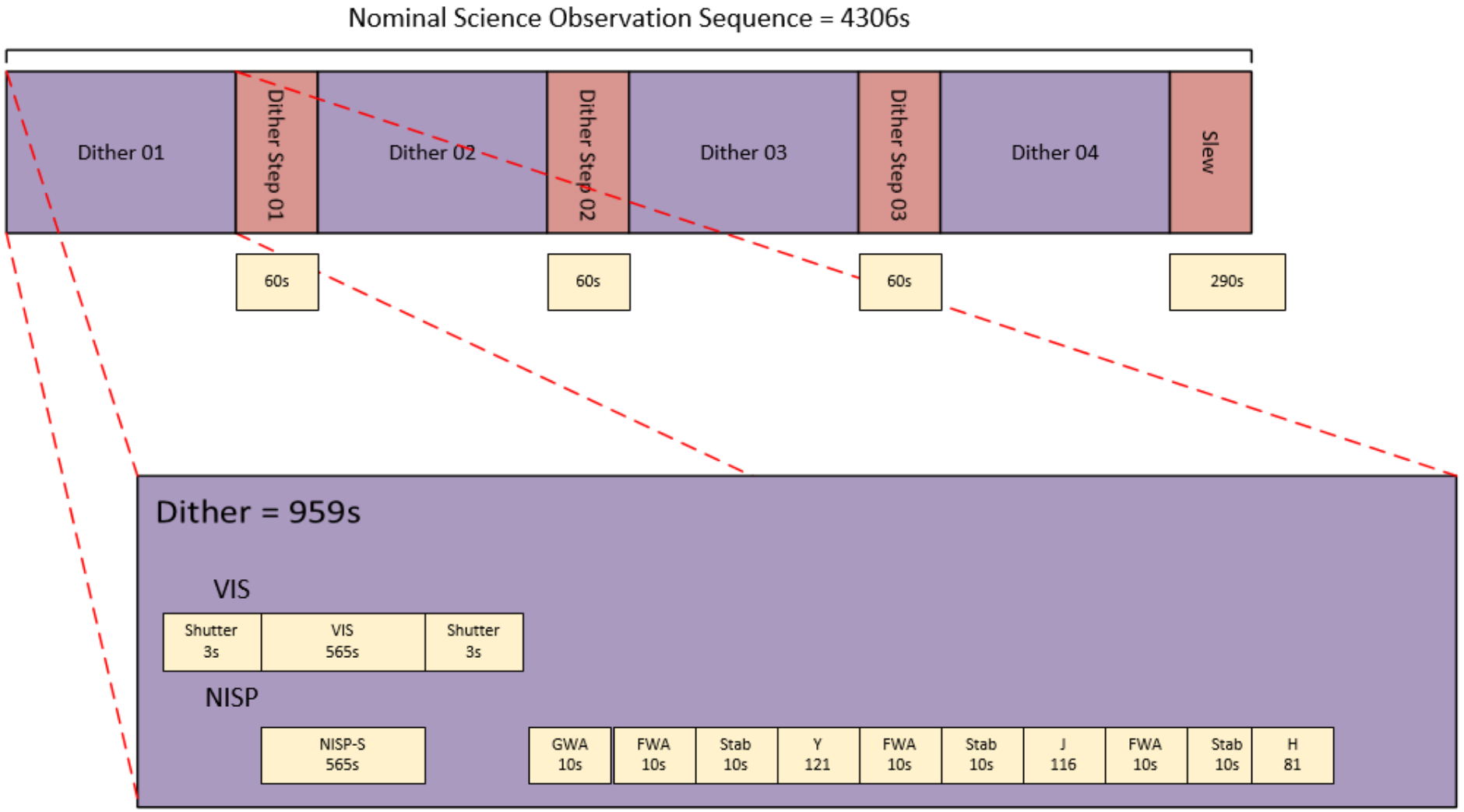
Deep fields : coverage first, depth second

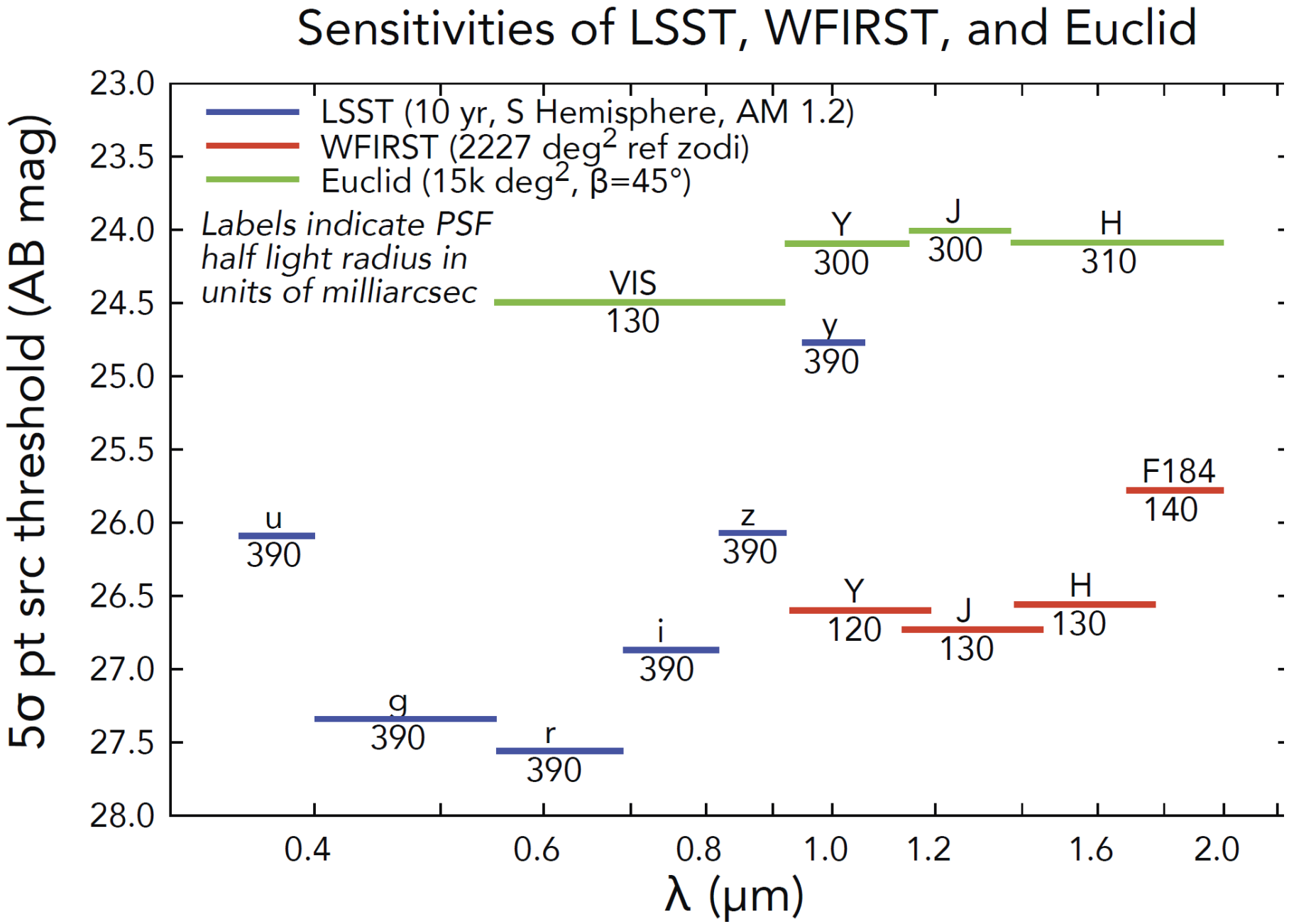
Euclid Collecting Information

- Euclid carries two types of sensors
  - 36 CCDs (4kx4k pixels) – visible channel
  - 16 HgCdTe CMOS (2kx2k pixels) – infrared channels
- Quantum efficiencies of the sensors are > 80-90%, low noise
  - About 8 out of 9 photons are registered with low instrumental noise – this is necessary to go deep, with acceptable integration
- One block observation gives consists of 4 dithers of
  - 1 VIS exposure – 36 x 16 Mpix
  - 1 Spectroscopy field – 16 x 4 Mpix
  - 3 imaging photometry (Y,J,H) – 3 x 16 x 4 Mpix
- Survey Speed: 20-22 block observations per day



Nominal Euclid Survey Exptimes




Sensitivities of LSST, WFIRST, and Euclid
LSST (10 yr, S Hemisphere, AM 1.2)
WFIRST (2227 deg^2 ref zodi)
Euclid (15k deg^2, β=45°)
Labels indicate PSF half light radius in units of milliarcsec
VIS 130
Y 300
J 300
H 310
y 390
u 390
g 390
r 390
i 390
z 390
F184 140
Y 120
J 130
H 130
5σ pt src threshold (AB mag)
λ (μm)
23.0
23.5
24.0
24.5
25.0
25.5
26.0
26.5
27.0
27.5
28.0
0.4
0.6
0.8
1.0
1.2
1.6
2.0

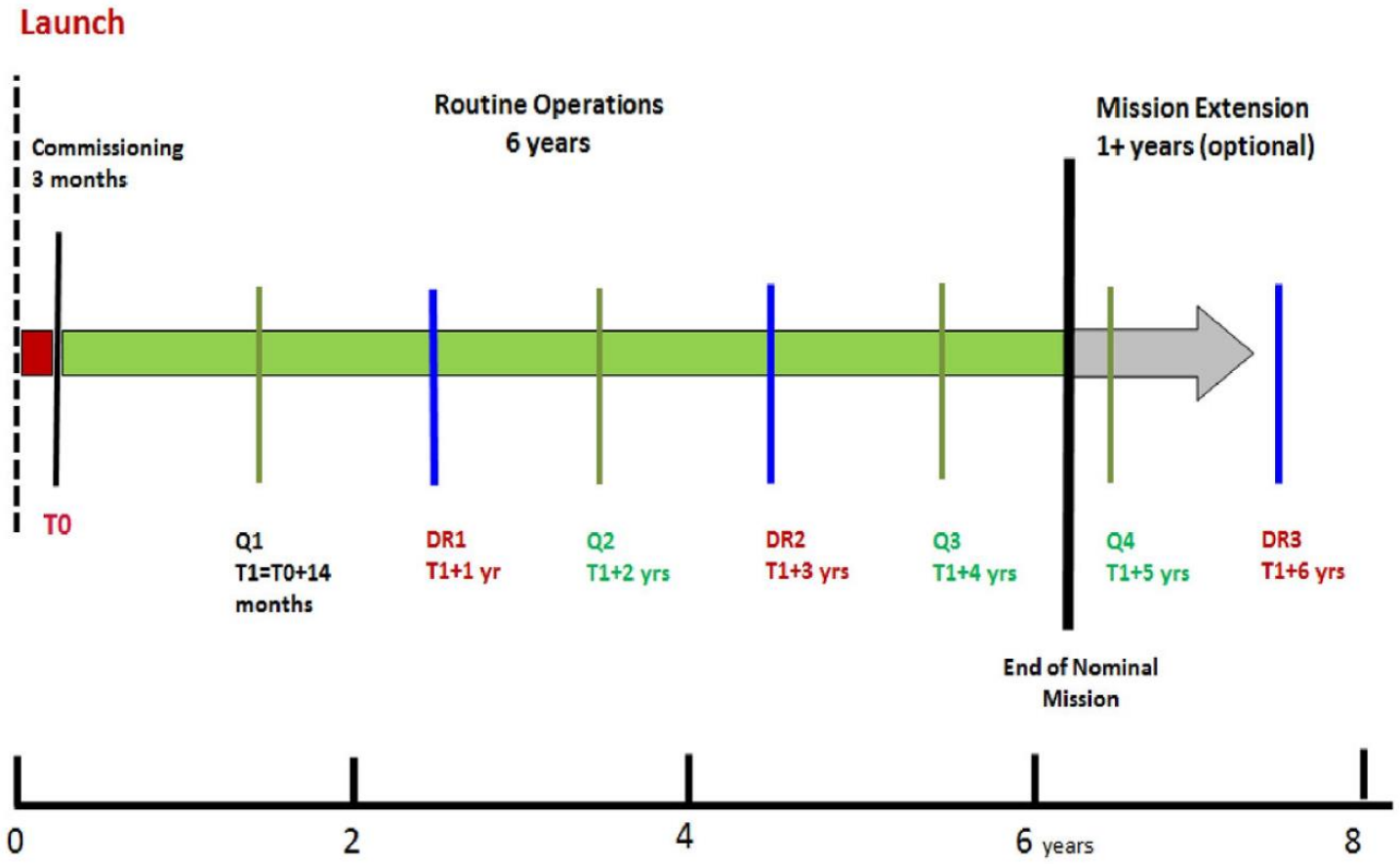
Euclid Collecting Information: huge legacy content

- 12 billion sources ,3-σ
- 50 million redshifts;
- A mine of images and spectra for the community for several decades;
- A reservoir of targets for JWST, GAIA, E-ELT, TMT, ALMA, Subaru, VLT, etc…
- Synergy with LSST, e-ROSITA, SKA

Objects	Euclid	Before Euclid
Galaxies at 1<z<3 with precise mass measurement	~$2x10^8$	~$5x10^6$
Massive galaxies (1<z<3))	Few hundreds	Few tenss
Hα Emitters with metal abundance measurements at z~2-3	~$4x10^7/10^4$	~$10^4/10^2$?
Galaxies in clusters of galaxies at z>1	~$2x10^4$	~10^3 ?
Active Galactic Nuclei galaxies (0.7<z<2)	~10^4	<10^3
Dwarf galaxies	~10^5	
T_{eff} ~400K Y dwarfs	~few 10^2	<10
Lensing galaxies with arc and rings	~300,000	~10-100
Quasars at z > 8	~30	None

Euclid Data Releases

External Data Availability vs DR dates



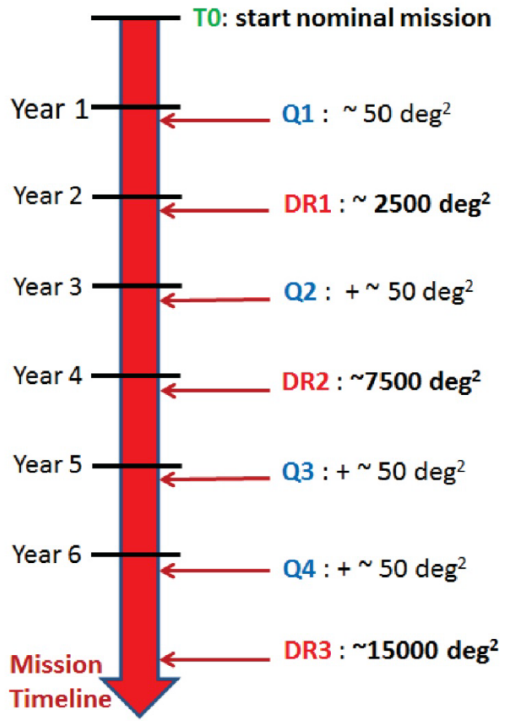
Delivery milestones

2022/6 Euclid launch (assumed)
2022/10 start survey
2023/12 Ground based for DR1 (2.5kdeg^2)
2024/12 DR1
2025/12 Ground based for DR2 (7.5kdeg^2)
2026/12 DR2
2028/10 End Nominal Mission
2027/12 Ground based for DR3 (15kdeg^2)
2029/12 DR3

Euclid NASA Science Center at IPAC

ENSCI and the US Community

- ENSCI work pre-launch will prepare us to support US community research
  - Presence at IPAC booth at AAS
  - Website and Helpdesk
  - User Panel (starting 2019)
- Science potential of archive is enormous
  - Imaging at 0.1-0.3" pixels, ~24mag Vis, Y, J, H over 15,000 deg^2
  - >2B galaxy photo-z; ~50M grism redshifts
  - ~1000 multiply-imaged QSO and ~300K strongly lensed galaxies
- Expect a flood of proposals after first public data release
  - Spitzer and WISE were each ~40% of ADAP in their first year

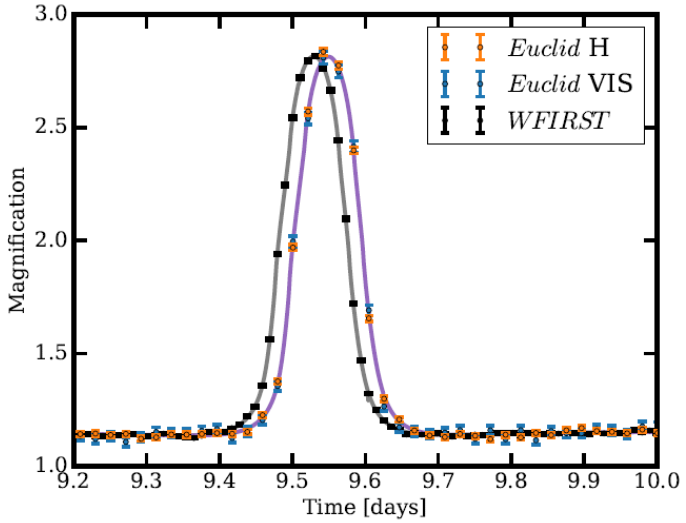


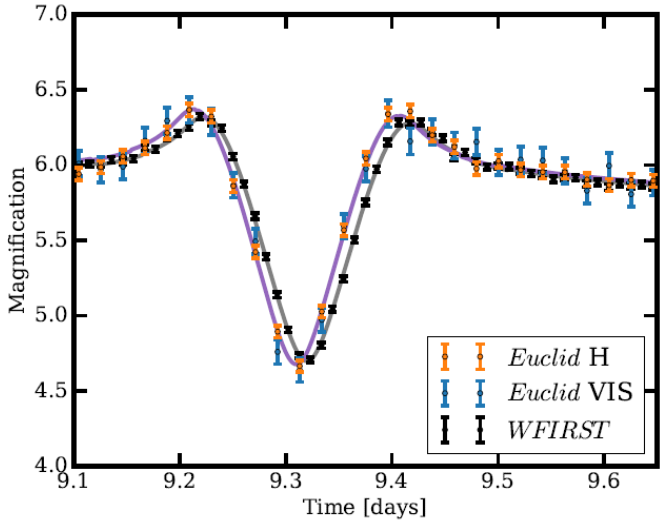
Euclid Structures- how to join

- Euclid Consortium (EC) >1500 members
  - About 100 from US
  - ~10 science working groups
  - Possible to join: compelling contribution to Euclid, support of science working group lead(s), sufficient funding to cover engagement
- Euclid Consortium Board (ECB), ~ 20 member governing body of EC appointed by
  - Jason.d.rhodes@jpl.nasa.gov is US rep
- ESA Euclid Science Team (EST), 13 member ESA body that 'safeguards' science requirements, ensures mission success, defines additional surveys
  - Jason.d.rhodes@jpl.nasa.gov is US rep
- Thoughts, ideas, questions, please contact me

Euclid and WFIRST Microlensing Parallax

- Euclid and WFIRST will see measurably different lightcurves for bound and free-floating planets
- Needs high-cadence Euclid observations (~30 min) simultaneous with WFIRST
- Can measure parallaxes for a wide range of events
- Expect ~1 FFP parallax for every 6 days of Euclid observations (Bachelet & Penny 2019)
- Expect ~1 bound-planet parallax for every 1 day of Euclid observations





Penny+2019 Astro2020 White Paper

The left plot is free floating planet; right plot is Earth sized bound planet at 1 AU around a0.1M_{sun} star