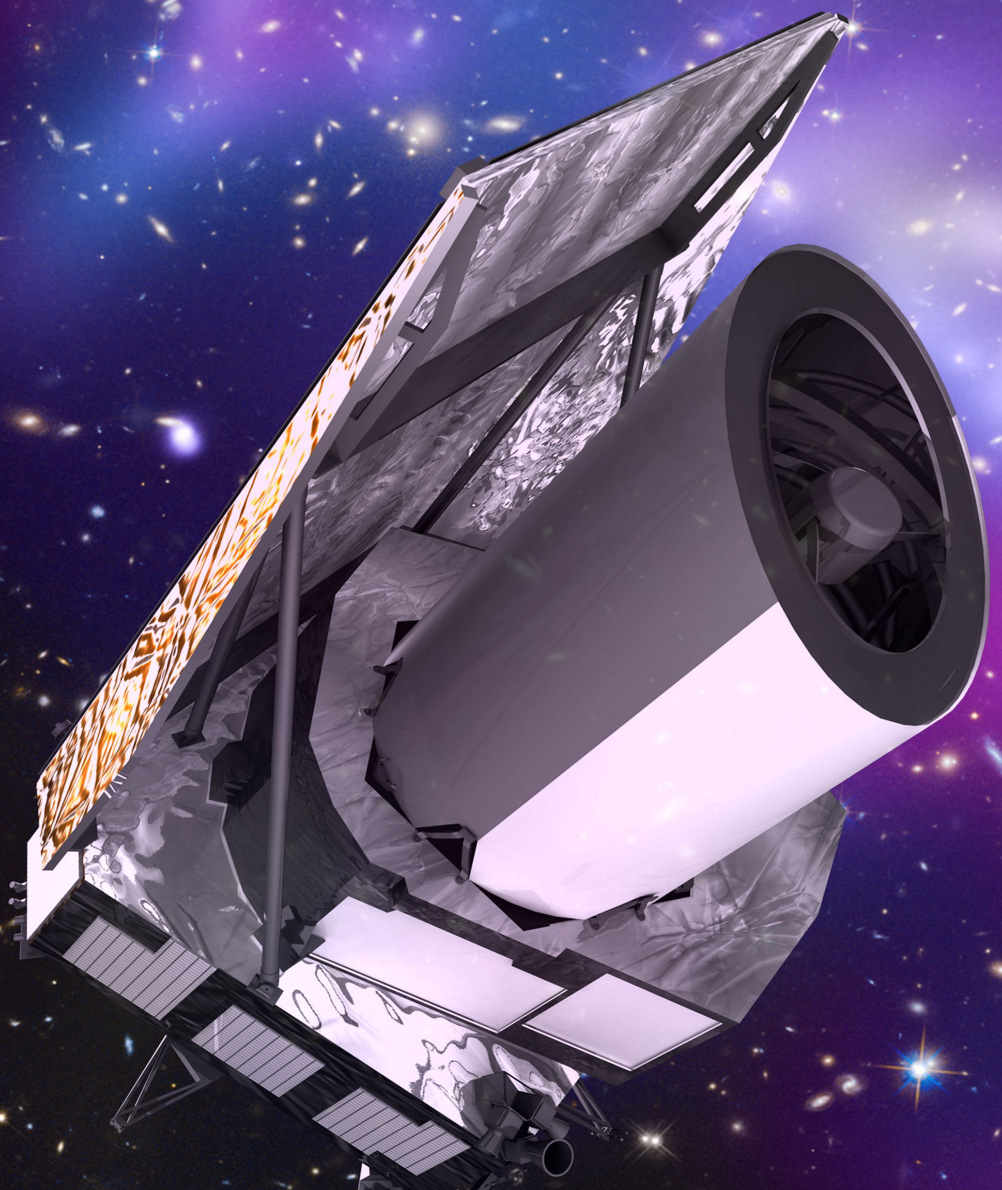
Euclid



Euclid (Artist impression, ESA)

Tim Schrabback (AifA Bonn)

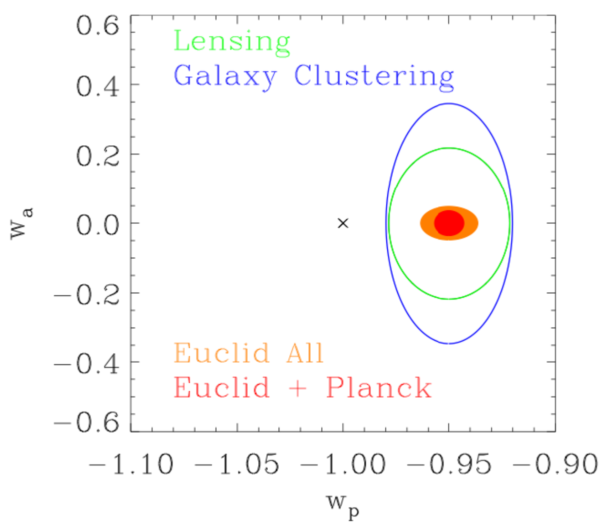
ISSI meeting, Bern, Dec. 18th, 2018

Euclid: Context & science goals

- **ESA** M-Klasse mission (M2) from the „Cosmic Vision“ programme
- **Official mission goal: „Study the geometry of the dark universe“:**
  - **Constrain the nature of dark energy** via: Gravitational lensing, galaxy clusters, BAOs, Redshift space distortions
  - Distribution of dark matter
  - Constrain the sum of the neutrino masses
  - Constrain initial conditions (non-Gaussianity etc.)

Source: Euclid Redbook

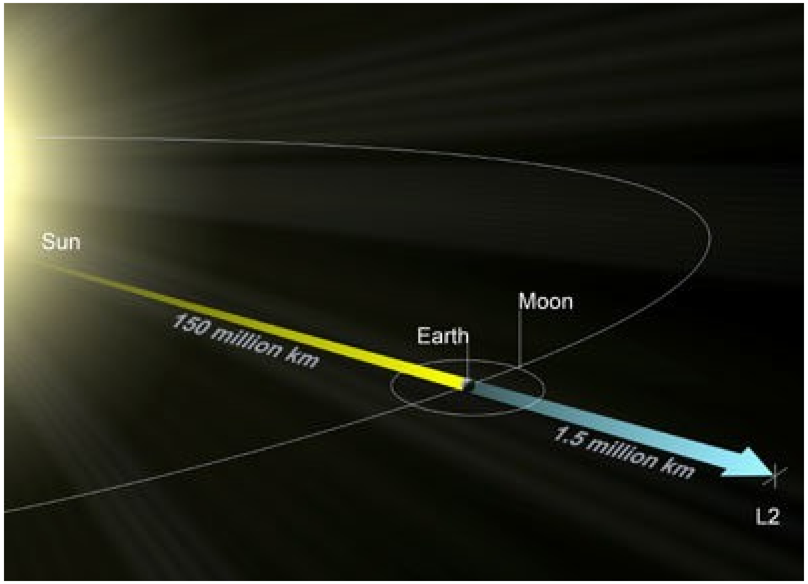
	Modified Gravity	Dark Matter	Initial Conditions	Dark Energy		
Parameter	γ	m_ν/eV	f_{NL}	w_p	w_a	FoM
Euclid Primary	0.010	0.027	5.5	0.015	0.150	430
Euclid All	0.009	0.020	2.0	0.013	0.048	1540
Euclid+Planck	0.007	0.019	2.0	0.007	0.035	4020
Current	0.200	0.580	100	0.100	1.500	~10
Improvement Factor	**30**	**30**	**50**	**>10**	**>50**	**>300**



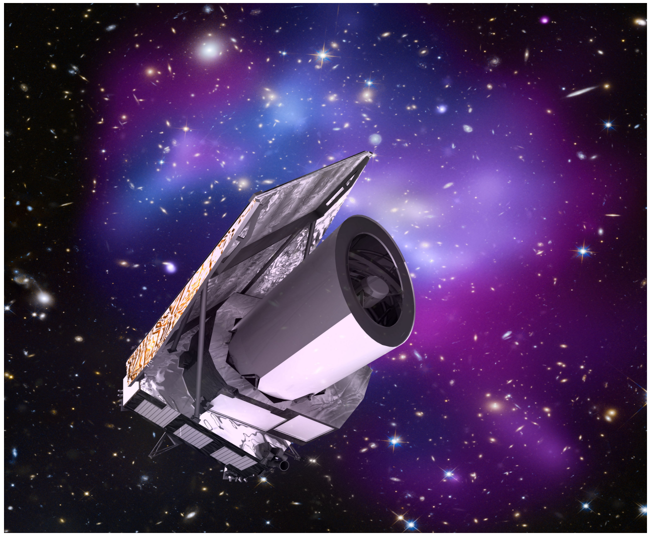
Euclid: Mission overview

- Should be launched onboard of a Soyuz-2 from Kourou (French-Guiana) under control of ESA
- Halo orbit around the 2nd Sun-Earth Lagrange point (L2)
- Mission duration: 6.25 years
- Total mass: 2,100 kg, Payload: 855 kg
- Length: 4.5m, Diameter: 3.1m
- Telescope: 1.2m Korsch, Silicon-Carbide mirror

Liftoff of Soyuz flight VS01 on 22.10.2011 (Source: ESA)

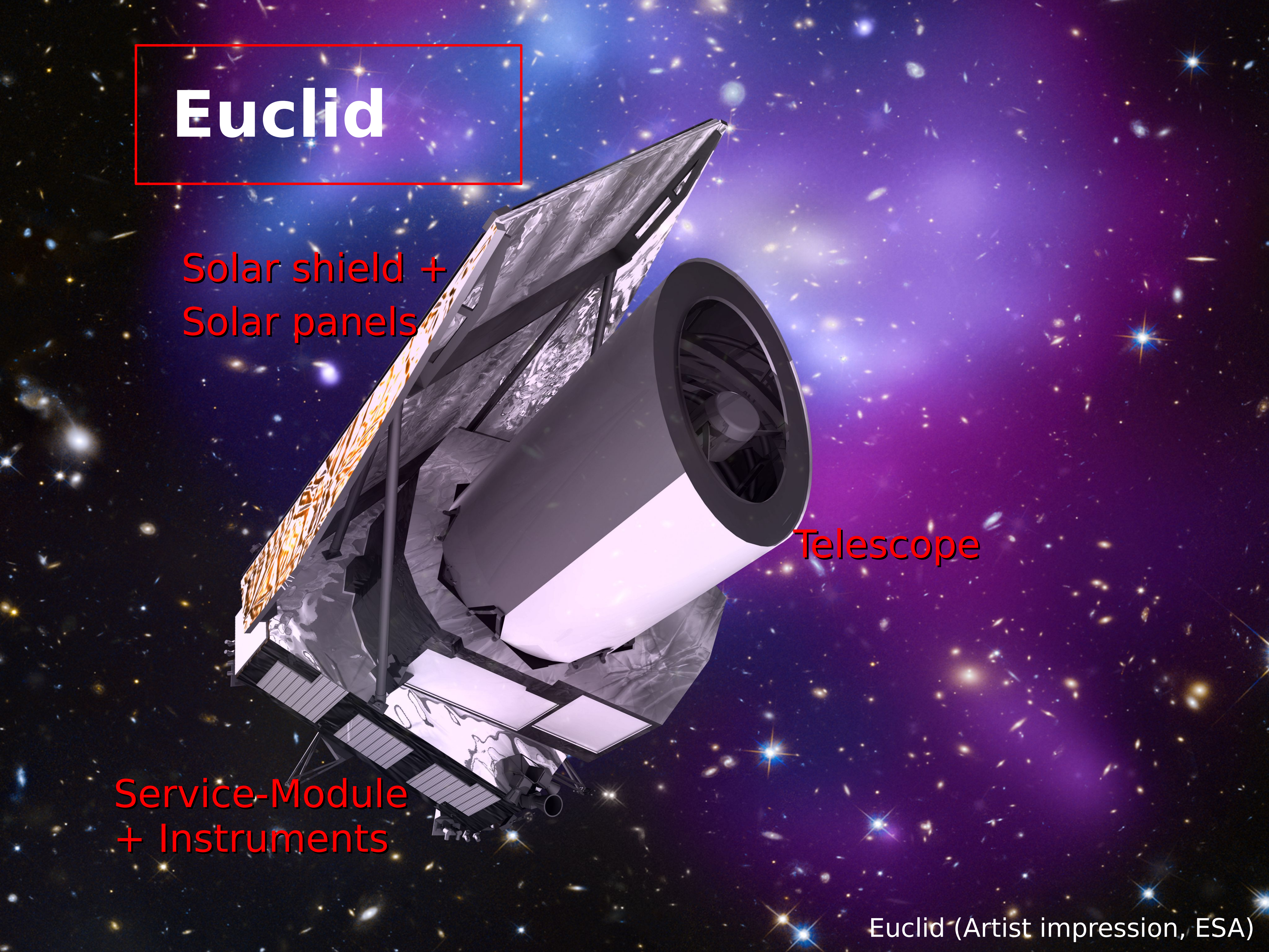


L2 (Source: ESA)



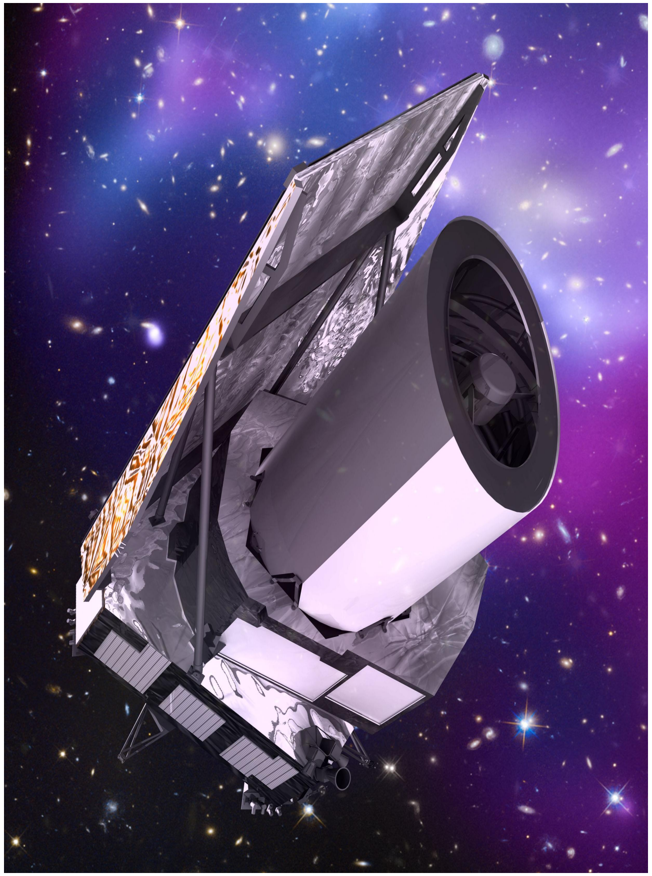
Euclid Artist Impression (Source: ESA)

Euclid



Euclid (Artist impression, ESA)

Euclid: Hardware



Euclid Artist Impression
(Source: ESA)

Satellite & Service module

- Main contractor: **Thales Alenia Space**
- Includes: Engine, Pointing control, sun shield, solar panels, energy supply, communication, thermal control

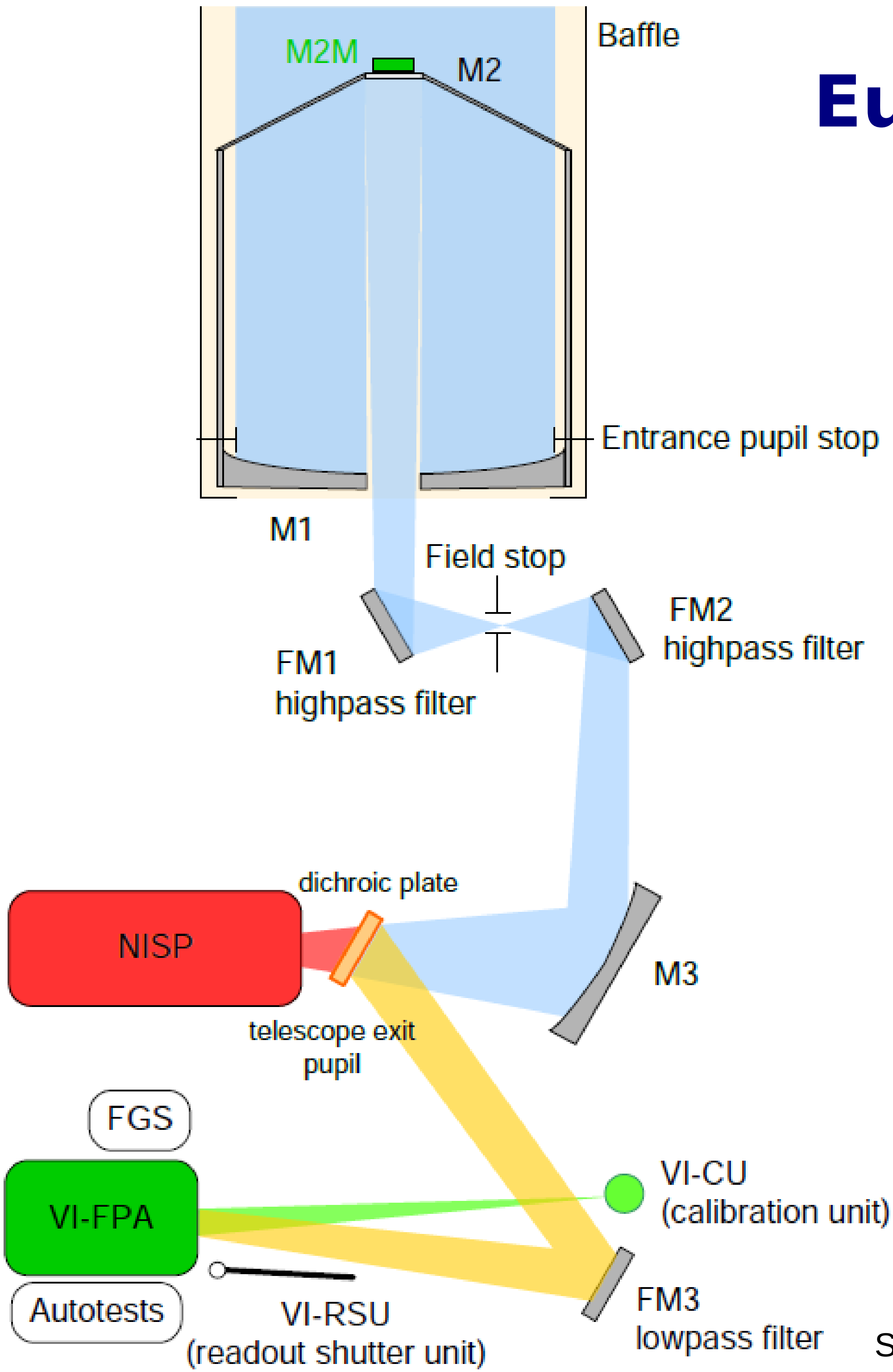
Payload module

- Main contractor: **Airbus Defence and Space division** (previously called Astrium)
- Includes: Telescope, Optics, Fine Guidance sensors, thermal control of the PLM

Instruments

- Mainly responsible for the construction: Euclid Consortium, to a large fraction funded via national space agencies
- VIS: Optical Camera; NISP: NIR camera & slitless spectrograph

Euclid: Optics overview



M1, M3: ellipsoidal mirror

M2: hyperbolic mirror

Advantages: Fairly flat focal plain, good suppression of straylight

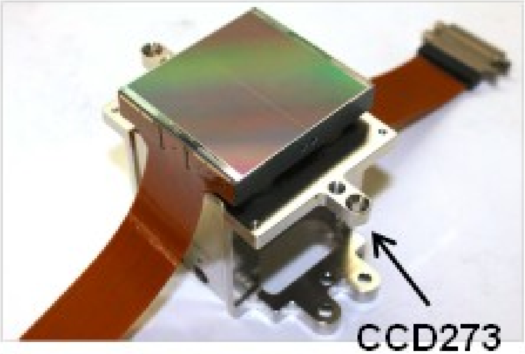
Source: Airbus Defence and Space.

Euclid: Instruments

Field of view: ~ 0.7 deg x 0.7 deg

Visible (VIS) instrument:

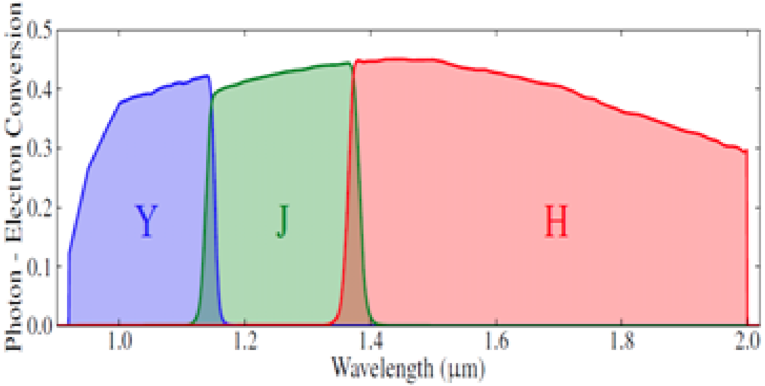
- 6×6 e2v CCDs with 4096×4096 pixels (~570 Mpix)
- Pixel size: 0.1“x0.1“
- Broad optical band pass: 550-900 nm
- PSF FWHM: ~0.16-0.18“
- Primary aim: WL shape measurements down to VIS~24.5 AB mag (10sigma)



Source: Euclid Consortium

Near Infrared Spectrometer and Photometer (NISP):

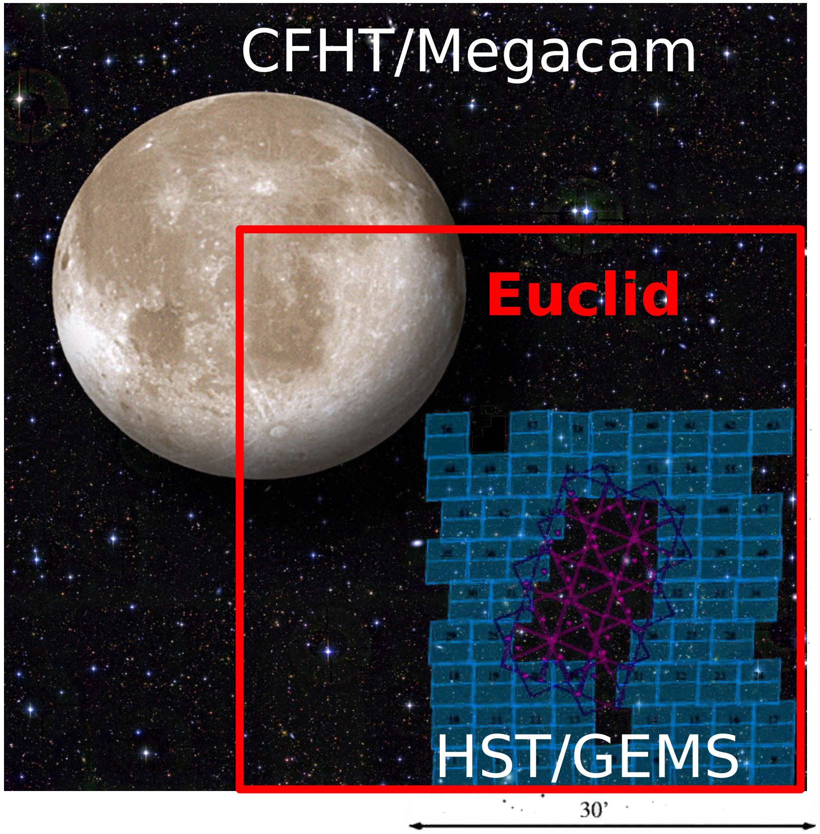
- 4×4 Teledyne TIS H2RG detectors with 2000×2000 pixels
- Pixel size: 0.3“x0.3“
- NIR Y, J, H photometry to ~24.0 AB mag (5sigma) → Photometric redshifts
- Slitless NIR spectroscopy → Spec-zs for BAO



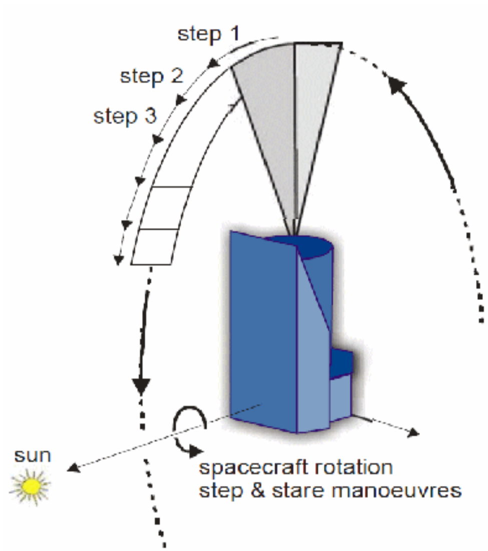
NISP throughputs through the Y, J and H filters

Source: Euclid Consortium

Advantages for WL measurements



- Space-based resolution (~0.2")
- Large field of view (144x HST/ACS):
  0.7 deg x 0.7 deg
- Excellent thermal stability
  (solar aspect angle~90 deg)
  → Very good PSF stability
- Deep NIR photometry → accurate photo-zs



Source:: Euclid Redbook

Euclid: Surveys

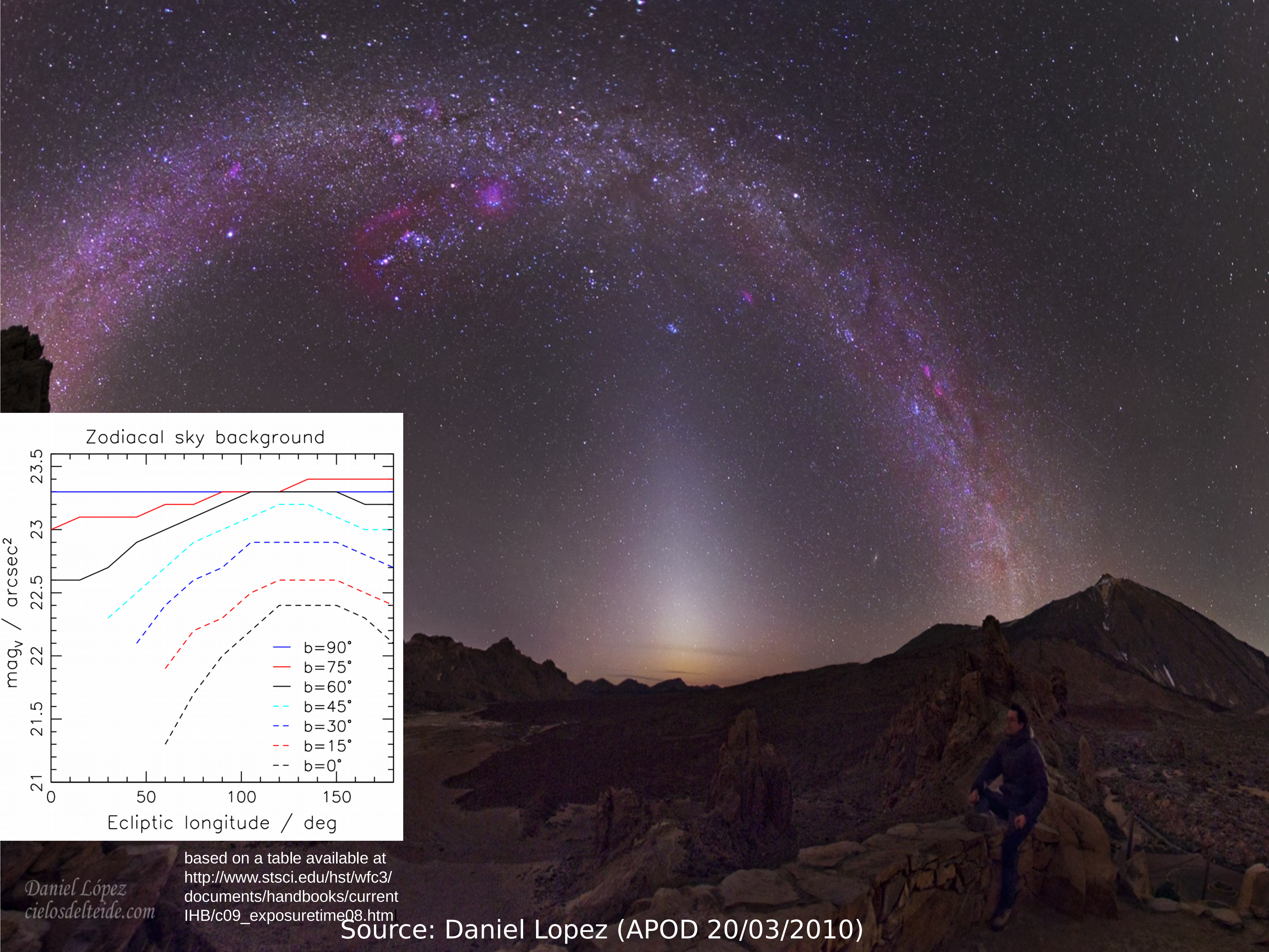
Wide Survey:

- **15.000 deg^2**, avoiding low ecliptic and low galactic latitudes
- 4 exposures per pointing , VIS+NISP-Spectra in parallel
- Depth: VIS=24.5mag (10σ), NIR: Y,J,H= 24.0mag (5σ)
  → WL shape measurements for ~1.5 x 10^9 galaxies
- NISP: Spec-zs for about 50 x 10^6 galaxies ($0.7<z<2$)
- A lot of legacy science (galaxy evolution, galactic halo stars, etc.)

Deep Survey:

- **40 deg^2**, probably 3 fields including NEP & near SEP
- **40x the exposure time of the Wide Survey** → 2 mag deeper
- Needed for the WL noise bias calibration
- Further legacy, e.g. targets for JWST

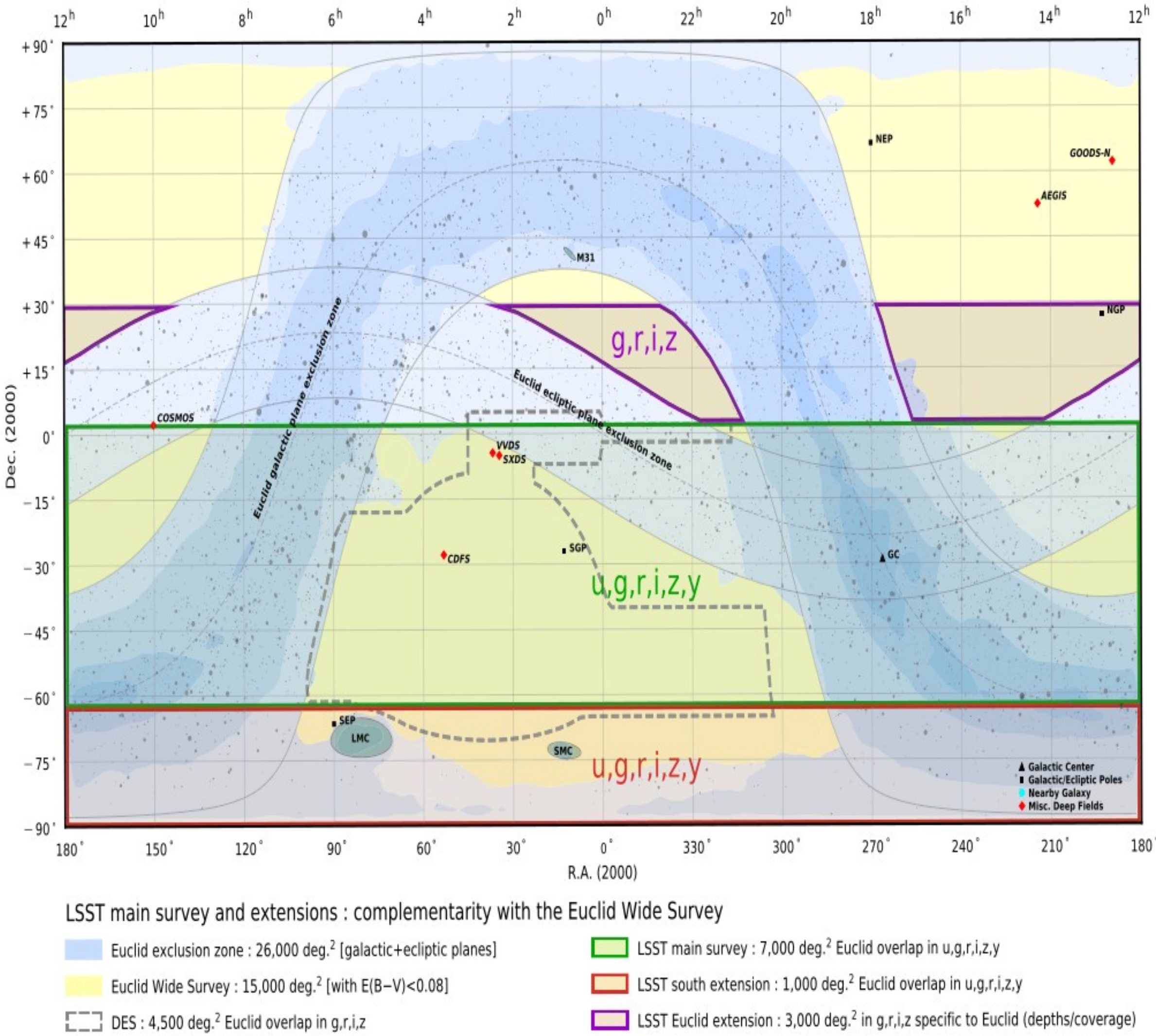
+ further calibration fields (PSF, spec-z+HST calibration fields, etc.)



based on a table available at http://www.stsci.edu/hst/wfc3/documents/handbooks/currentIHB/c09_exposuretime08.htm

Source: Daniel Lopez (APOD 20/03/2010)

Optical photometry for Euclid



Rhodes+2017

- **South**: DES, potentially LSST
- **North**:
  - CFIS: (u)r
    http://www.cosmostat.org/projects/cfis
  - JST/T250: g

https://oajweb.cefca.es/news/show/135

  - PS : i+z

Needed for

- Photo-zs
- Galaxy+stellar SED estimates for the PSF modelling + correction (e.g.Cypriano et al. 2010; Duncan et al. in prep)

Some of the further ingredients

Spectroscopic calibration:

- Calibrate the true redshift distribution in colour cells (Masters et al. 2015; 2017):
- Large spectroscopic programmes with Keck+VLT

Spectrophotometry of stars:

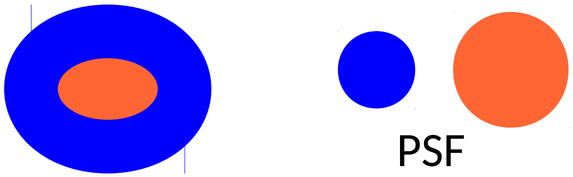
- Needed for the PSF modelling (Eriksen & Hoekstra 2018; Duncan et al. in prep.)
- Default plan to establish this through GAIA data (limited to relatively bright stars)

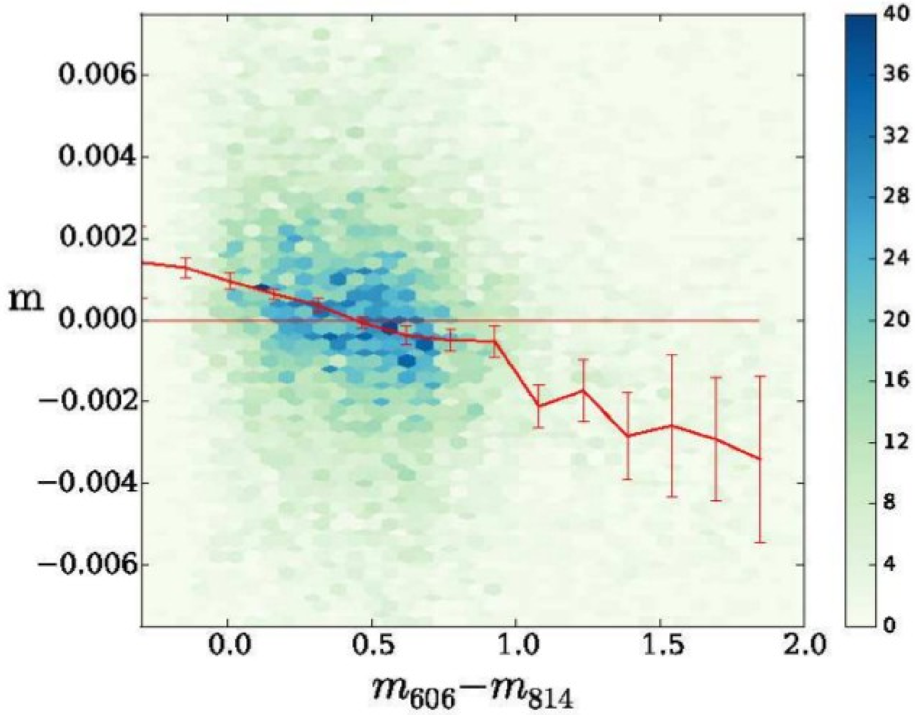
Archival HST data:

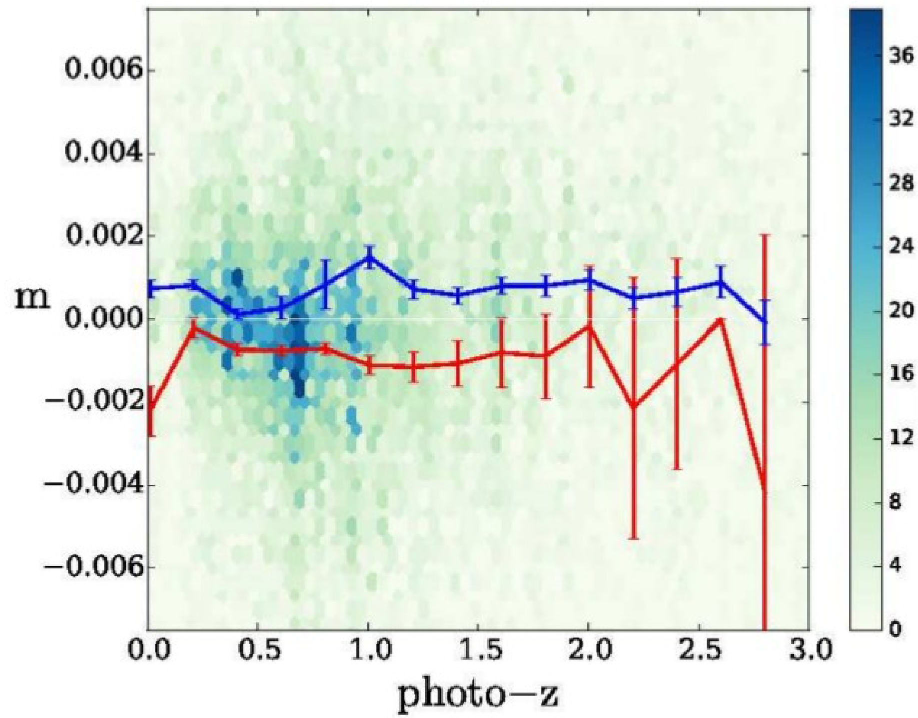
- Input to image simulations, initial training data for shape measurement methods
- Statistical correction for the impact of color gradients

Statistical correction for the impact of colour gradients

Er, Hoekstra, Schrabback, et al. 2018, MNRAS, 476, 5645





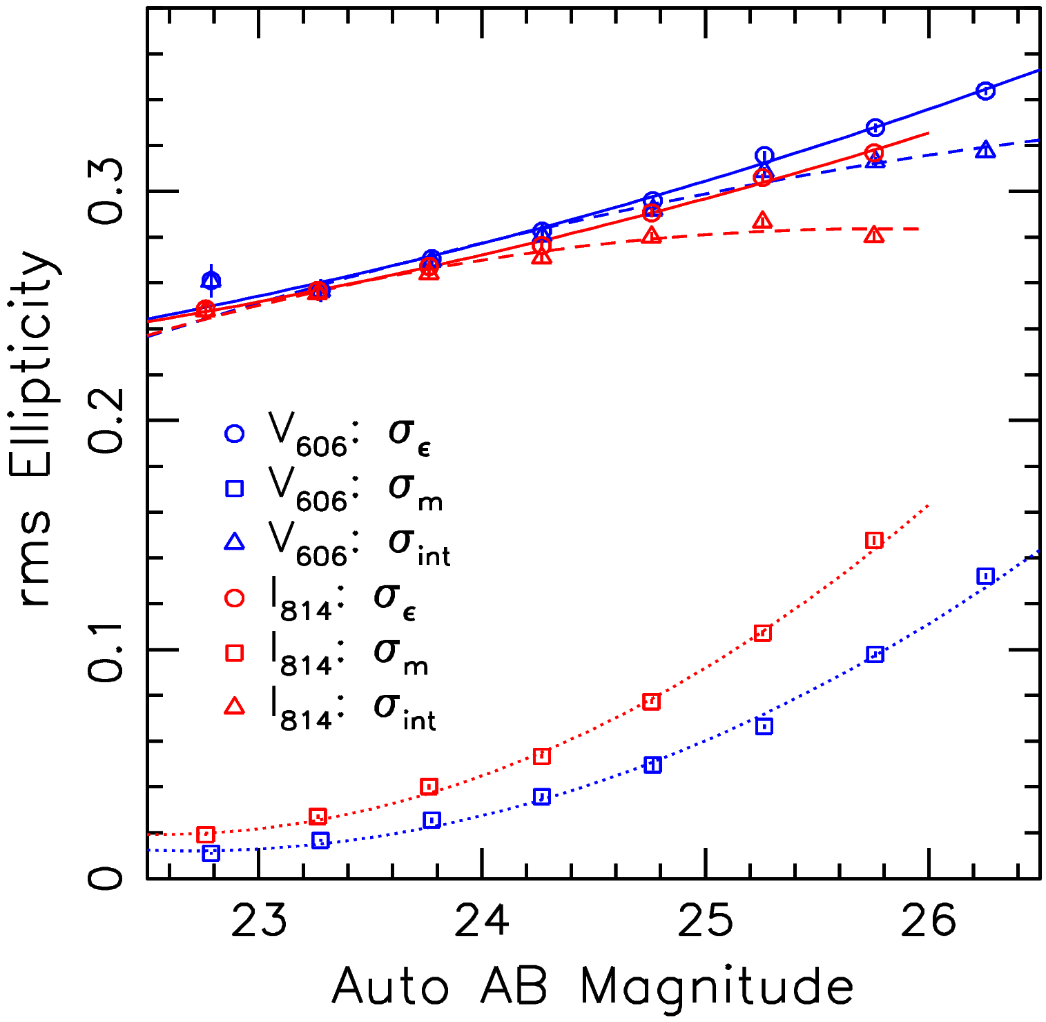


- Need a correction as function of redshift and galaxy properties
- Plan to revise the analysis using more & deeper HST stacks & actual Euclid shape measurement techniques

See also Voigt et al. 2012; Semboloni et al. 2013

Galaxy shape distribution

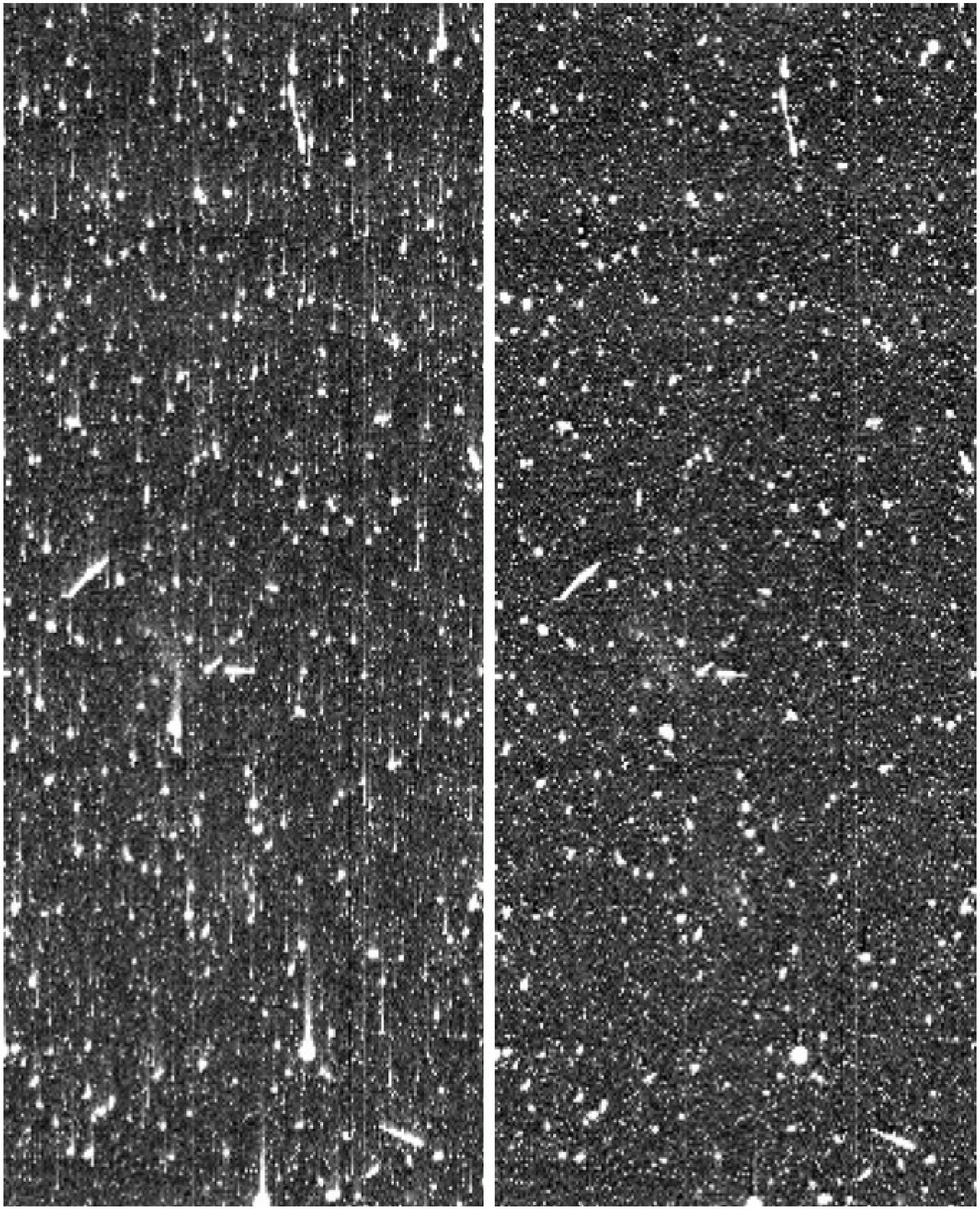
- Measurement of the **intrinsic galaxy ellipticity dispersion** based on our initial reduction of CANDELS V606W+F814W images
- For the first time showed that this is clearly magnitude and band-pass dependent



Schrabback, Applegate et al. 2018, MNRAS 474, 2635

Correction for charge transfer inefficieny

- Massey et al. 2010; 2014
- Israel et al. 2015



CTI in HST/ACS data
Massey et al. 2010

The Euclid Consortium: >1200 members

- Instrument building + support
- Science working groups
- Ground segment

- Euclid PI and Consortium Lead: Yannick Mellier

More than 120 institutes/institutions...

TarGet
AARHUS UNIVERSITY

Aix*Marseille université

UAM UNIVERSIDAD AUTONOMA
Berkeley UNIVERSITY OF CALIFORNIA

UCIRVINE
Universidad Politécnica de Cartagena

THE UNIVERSITY OF CHICAGO

UCL

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UNIVERSITÀ DEGLI STUDI FIRENZE
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UNIVERSITY of HAWAI'I MĀNOA

UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386

university of groningen

UiO : Institute of Theoretical Astrophysics
University of Oslo

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University of Southampton

US University of Sussex
THE UNIVERSITY OF TEXAS AT AUSTIN

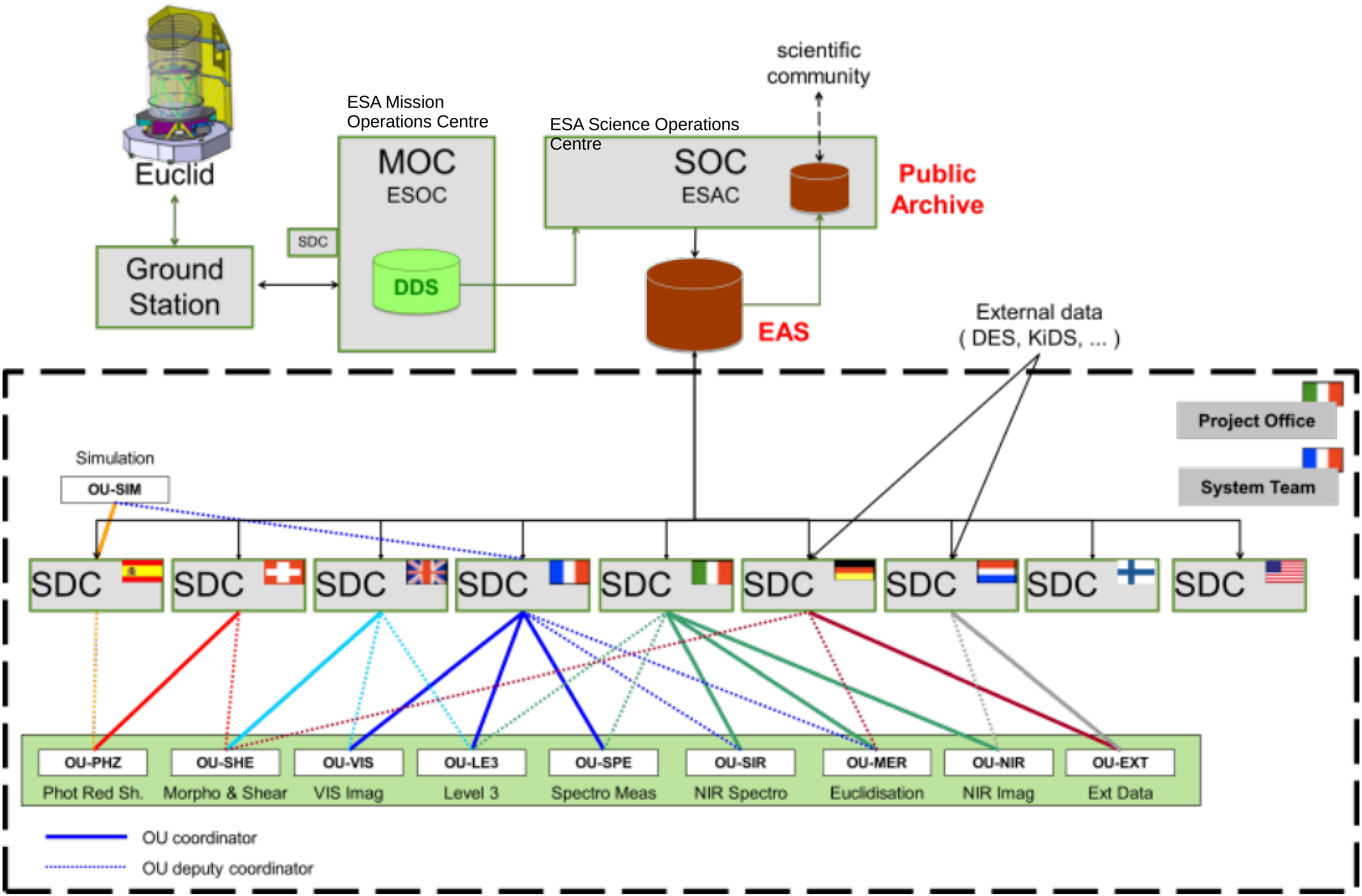
UNIVERSITÀ DEGLI STUDI DI TRIESTE

Yale University

Universität Zürich UZH

Turun yliopisto
University of Turku

Euclid Science ground segment



Some possible synergies for Euclid+CSS-OS

Photometry:

- Stable Near-UV to NIR photometry, well matched in depth
- All at similar resolution → Much lower impact of blends on shapes+photo-z (especially useful to separate blends at different redshifts)

Colour gradient correction:

- CSS-OS could provide colour gradient corrections for Euclid for individual galaxies

Euclid PSF modelling:

- Could the CSS-OS slitless optical spectra provide well-calibrated spectrophotometry for stars to fainter magnitudes than GAIA?

Some further Euclid-related technical WL papers

- Euclid WL requirement flow-down: Cropper et al. 2012; Massey et al. 2013
- Impact of faint sources: Hoekstra 2017; Martinet et al. (in prep.)
- Machine learning shape estimation: Tewes et al. 2018
- Bayesian Fourier Domain method: Bernstein et al. 2016
- Empricial PSF modelling: Schmitz et al. (in prep.)