EUCLID

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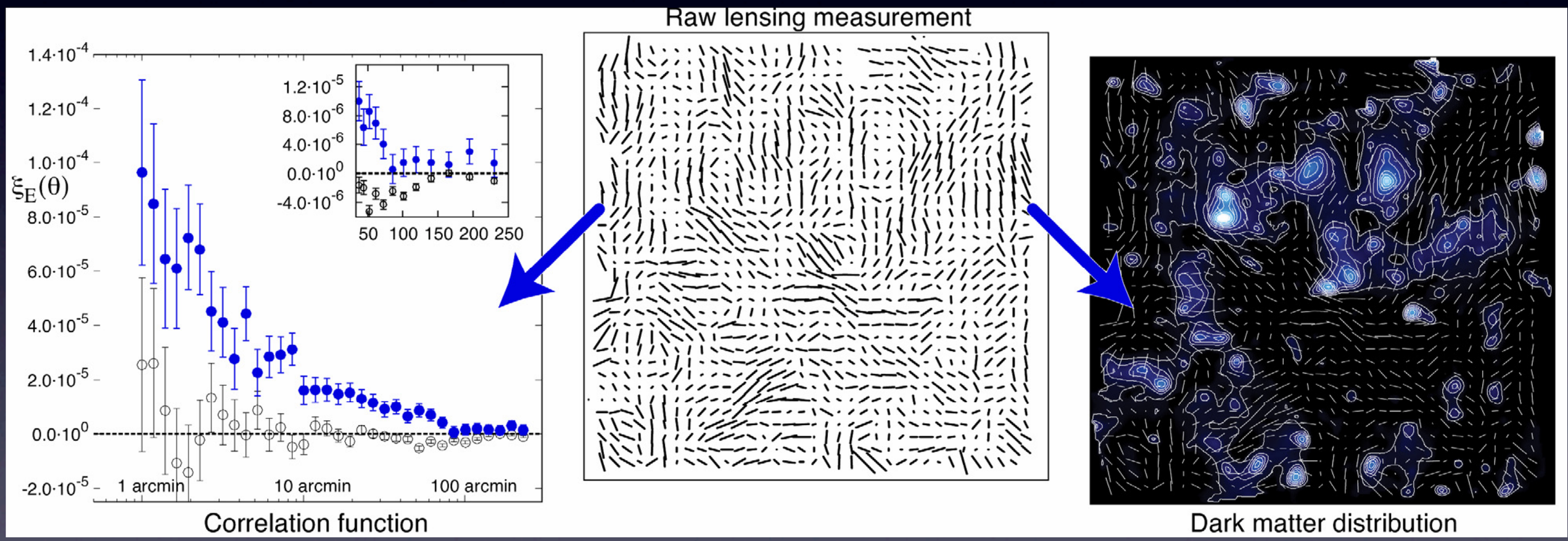
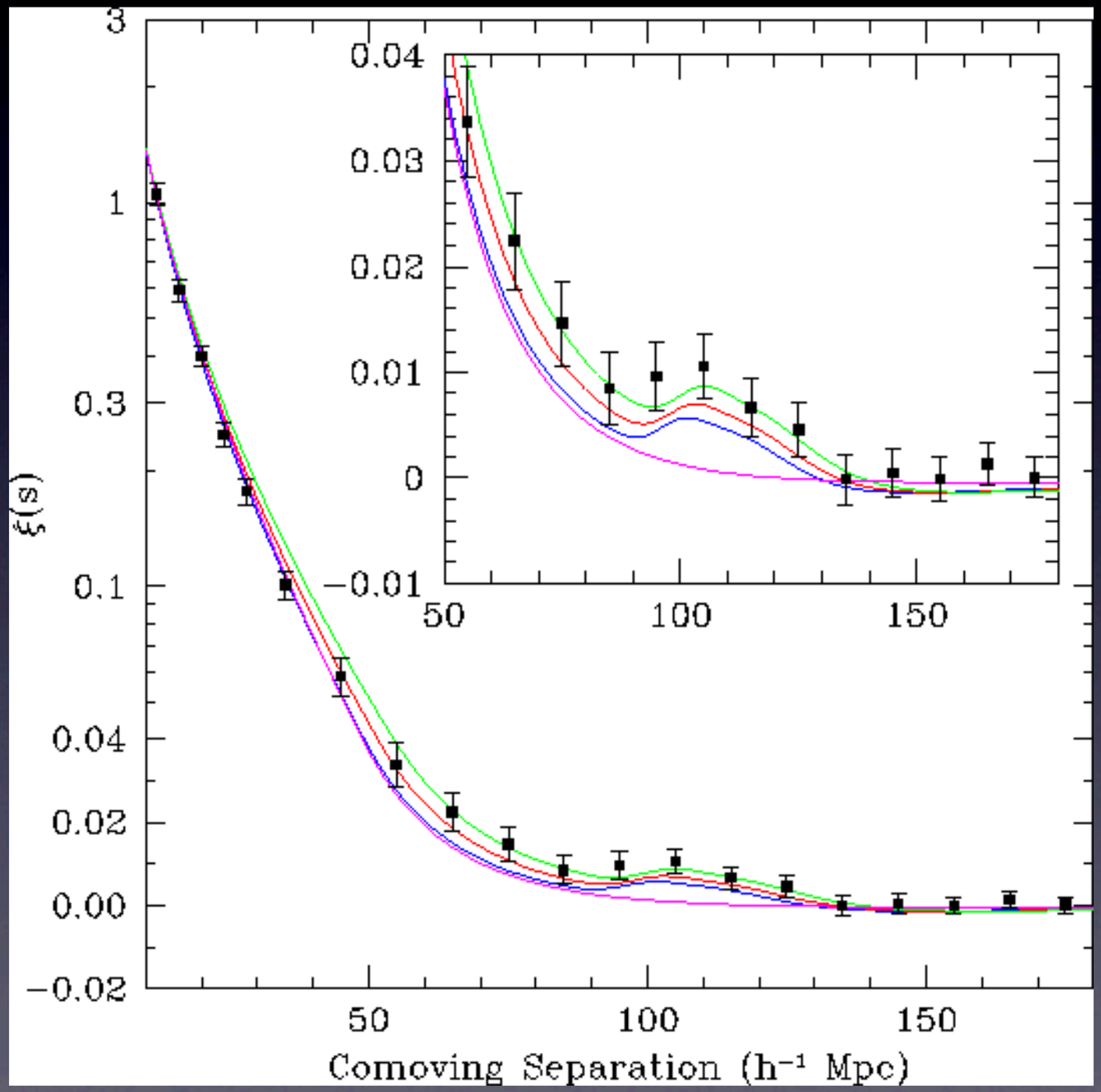
EUCLID : Science

- A high precision dark energy satellite mission
- Mainly two techniques to characterize dark energy:
  - Weak lensing
  - Baryon acoustic oscillations
- Launch 2018, 5-year mission

Lensing


Raw lensing measurement
$\xi_E(\theta)$
1.4·10^-4
1.2·10^-4
1.0·10^-4
8.0·10^-5
6.0·10^-5
4.0·10^-5
2.0·10^-5
0.0·10^0
-2.0·10^-5
1 arcmin
10 arcmin
100 arcmin
1.2·10^-5
8.0·10^-6
4.0·10^-6
0.0·10^0
-4.0·10^-6
50 100 150 200 250
Correlation function
Dark matter distribution

BAO


3
1
0.3
0.1
0.04
0.02
0.00
−0.02
ξ(s)
50
100
150
Comoving Separation (h⁻¹ Mpc)
0.04
0.03
0.02
0.01
0
−0.01
50
100
150

EUCLID : Science

- Legacy science
  - Galaxy formation & evolution
  - Milky way (complementing Gaia)
  - Supernovae
  - Exoplanets through microlensing

Science objectives

Sector	Euclid Targets
Dark Energy	(i) Euclid *alone* to measure w_p and w_a to 2% and 10% ($FoM_{DE} = 500$) (ii) Look for deviations from $w = -1$, indicating a dynamical dark energy. (iii) Measure the cosmic expansion history to better than 10% for several redshift bins from $z = 0.5$ to $z = 2$.
Test of Gravity	(i) Measure the growth index, γ_m, to a precision better than 2%. (ii) Measure the growth rate to better than 5% for several redshift bins between $z = 0.5$ and $z = 2$ (iii) Separately constrain the two relativistic potentials Φ and Ψ (iv) Test the cosmological principle
Dark Matter	(i) Detect dark matter halos between a mass scale of $>10^{15}$ to $10^8 M_\odot$ (ii) Accuracy of a few hundredths of an eV on the sum of neutrino masses, the number of neutrino species and the neutrino hierarchy. (iii) Measure the dark matter mass profile on cluster and galactic scales.
Initial Conditions	(i) Measure the matter power spectrum on a large range of scales in order to extract values for the parameters σ_8 and n to 1%; improve constraints on σ_8 and n by over a factor 30 and 2 respectively compared to Planck alone (ii) For extended models, improve constraints on n and α with respect to Planck alone by a factor 2. (iii) Measure the non-Gaussianity parameter f_{NL} to $\pm$ 10.

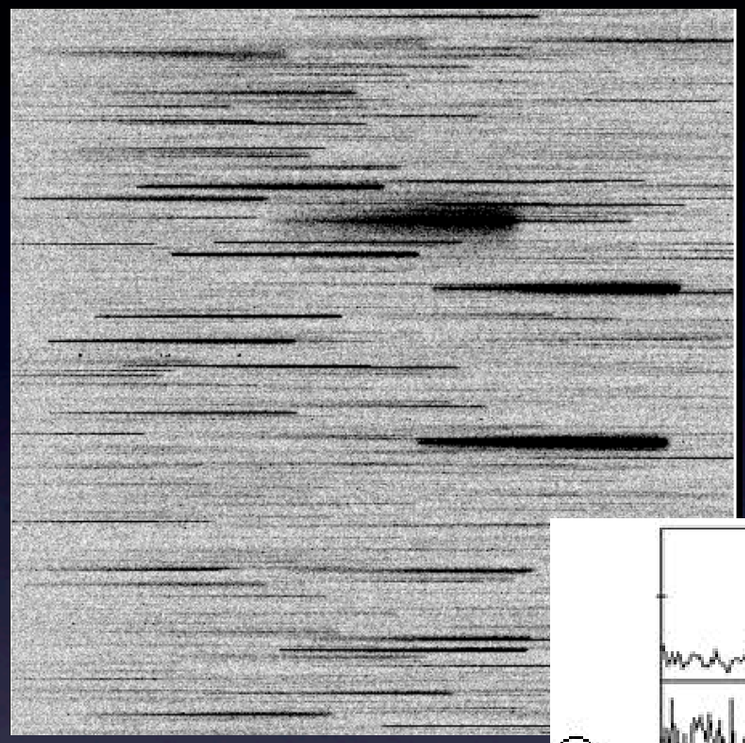
EUCLID : instruments

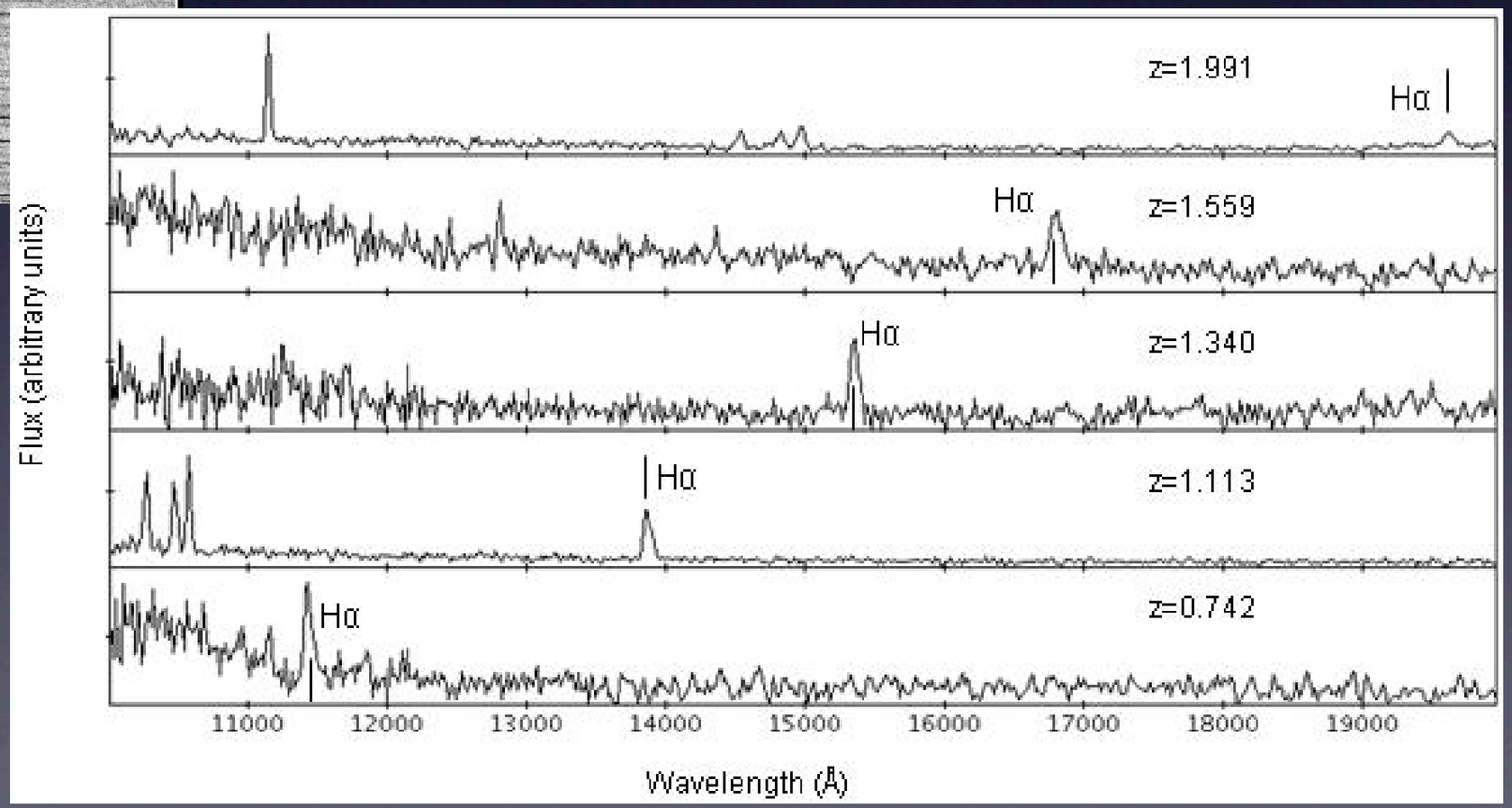
- 1.2 m telescope at L2
- Three on-board instruments
  - NIR and VIS imagers (.25 & .5 deg2 FOV)
  - NIR spectrograph (slitless, .4 deg2 FOV)
- Use of ground-based observations

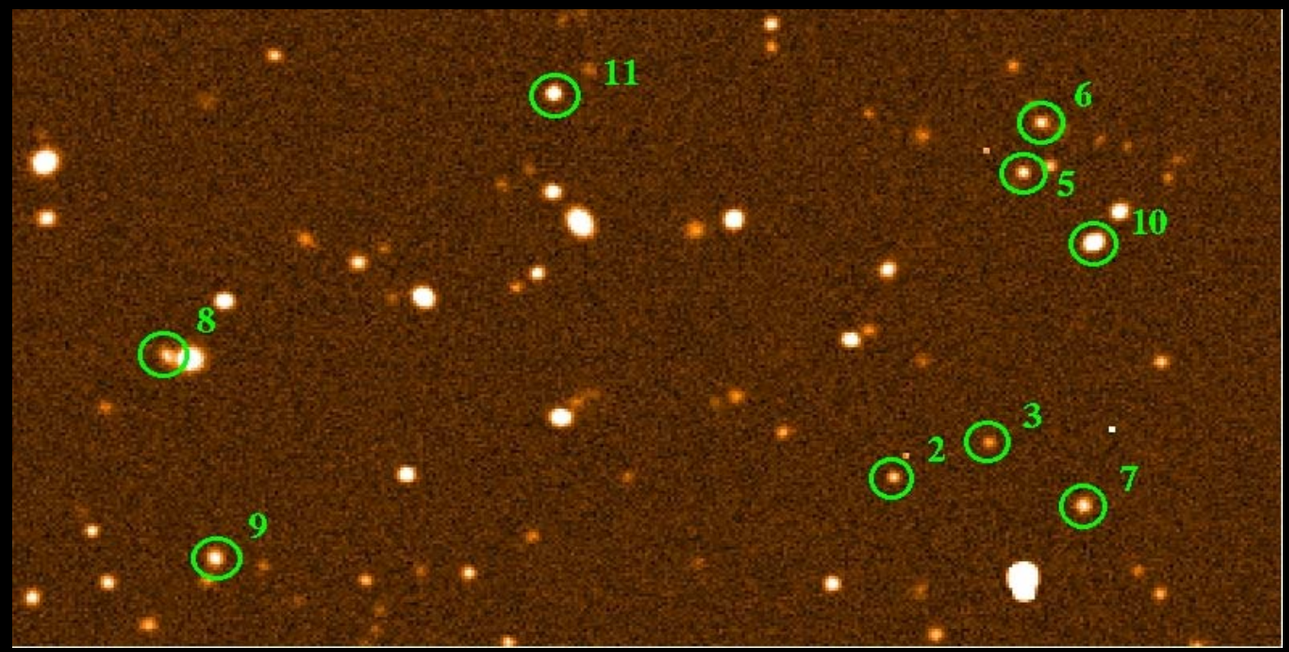
EUCLID instruments

- VIS imager : measure shape for weak lensing
- NIR imager (three bands) : for photometric redshifts of all observed objects — need visible measurements, from ground
- Spectrograph : for BAO. Baseline : low resolution and slitless : measure z from emission lines only. Need NIR images.

Slitless spectroscopy

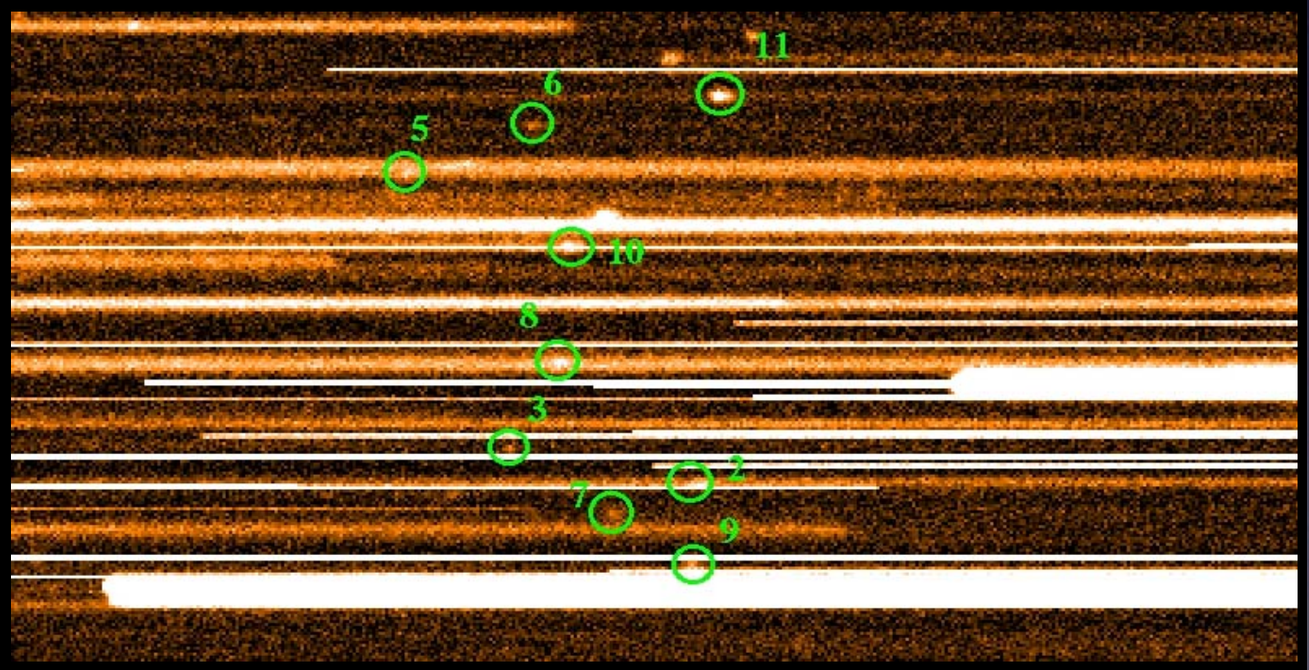




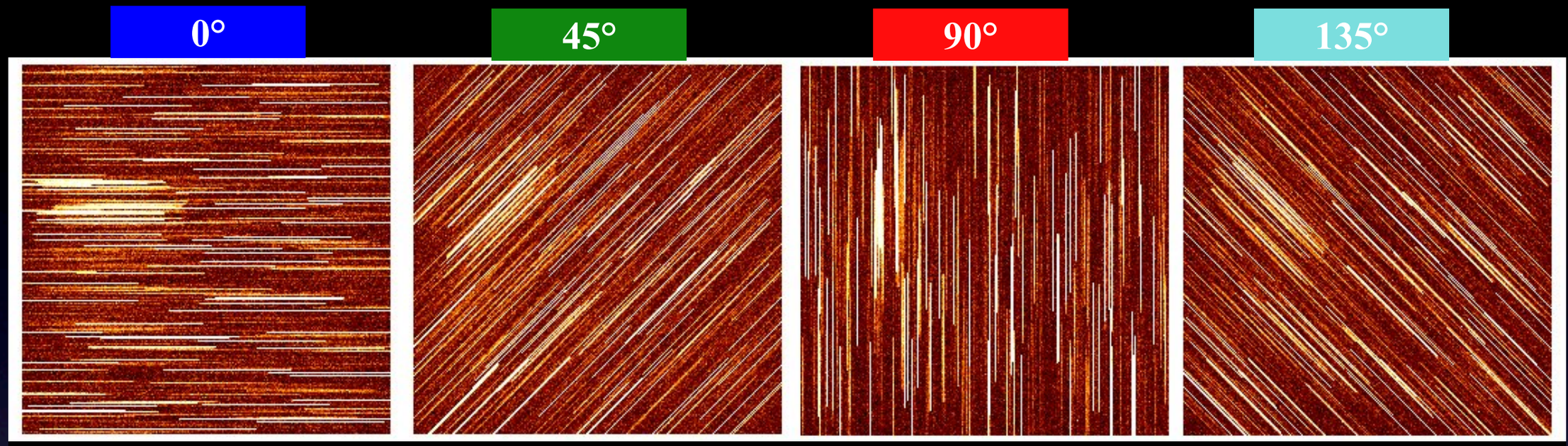


Direct Image

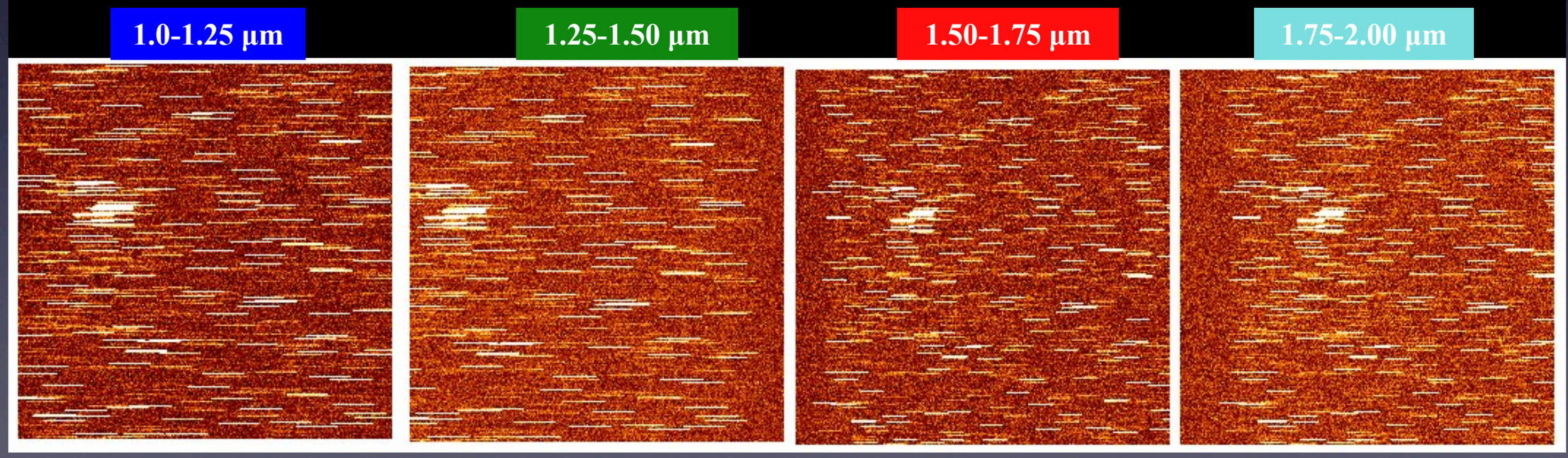
Slitless Dispersed Image



Mitigation of “confusion” (1): Multiple roll-angles



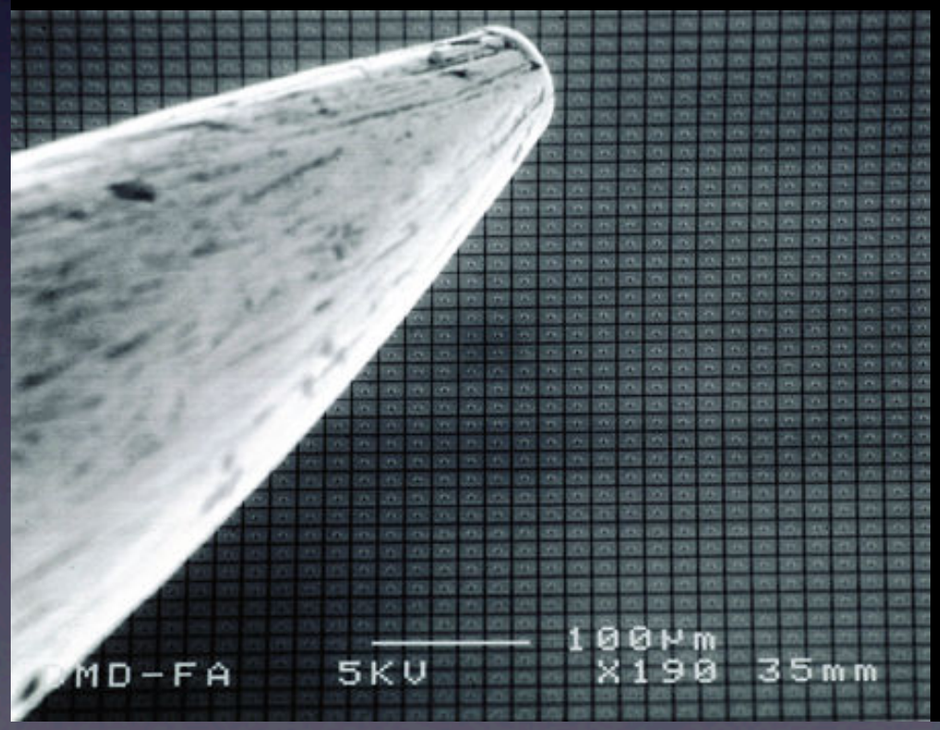
Mitigation of “confusion” (2): Multiple filters

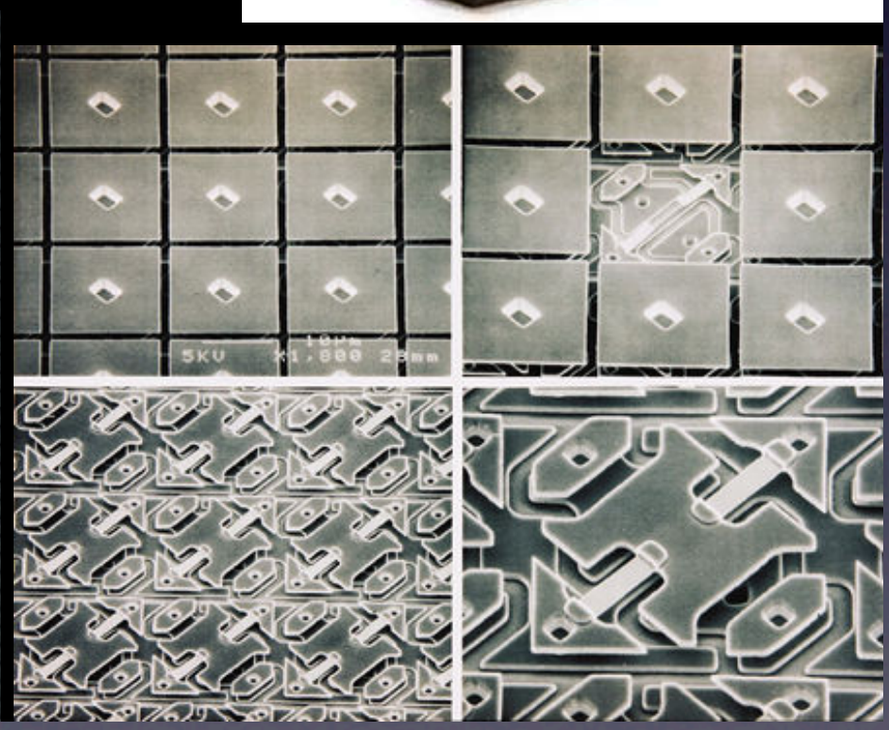


Non-baseline option : DMD spectrographs

TI "Cinema" DMD arrays of 2048×1080 independent mirrors (14 x 14 µm each)

➔ Never used in space
➔ Lab tests ongoing (Visitech+LAM+ESA)





Euclid people

- 25 institutes, 7 countries, ~140 people at the moment

Surveys & data

- Wide (20 000 deg2) imaging (3e9 sources at 10 sigma) + spectro (70e6 spectra)
- Deep (40 deg2) imaging + spectro
- External imaging : DES (5 000 deg2 southern), PanSTARRS (30 000 deg2 northern), LSST (20 000 deg2 southern)

Euclid processing

- Different and heterogenous data sets
  - Euclid + non Euclid (space+ground)
  - Types & goals : astrometry, photometry, morphometry…

Euclid processing

- Need very good space/ground intercalibration for photo-z, make processed data as homogeneous as possible
- High precision measurement requirements : work on data cubes of individual frames, not stacked images

Euclid processing

- Reference system = VIS imaging (0.1”/pixel, 0.5 deg2)
- Paving the sky with this system = « euclidisation »
- All data (other onboard instruments, external data) must be converted to that system and reduced according to Euclid specs.

Data volume of euclidisation

	Euclid	DES	PanSTARRS	LSST	Total
#images	1 400 000	160 000	70 000	4 000 000	5 630 000
Vol (PB)	1	3	4	300	
Sky cov (°2)	20 000	5 000	30 000	20 000	
#filters	4	5	4	6	
#sources	1,44E+10	4,50E+09	2,16E+10	2,16E+10	6,21 e10

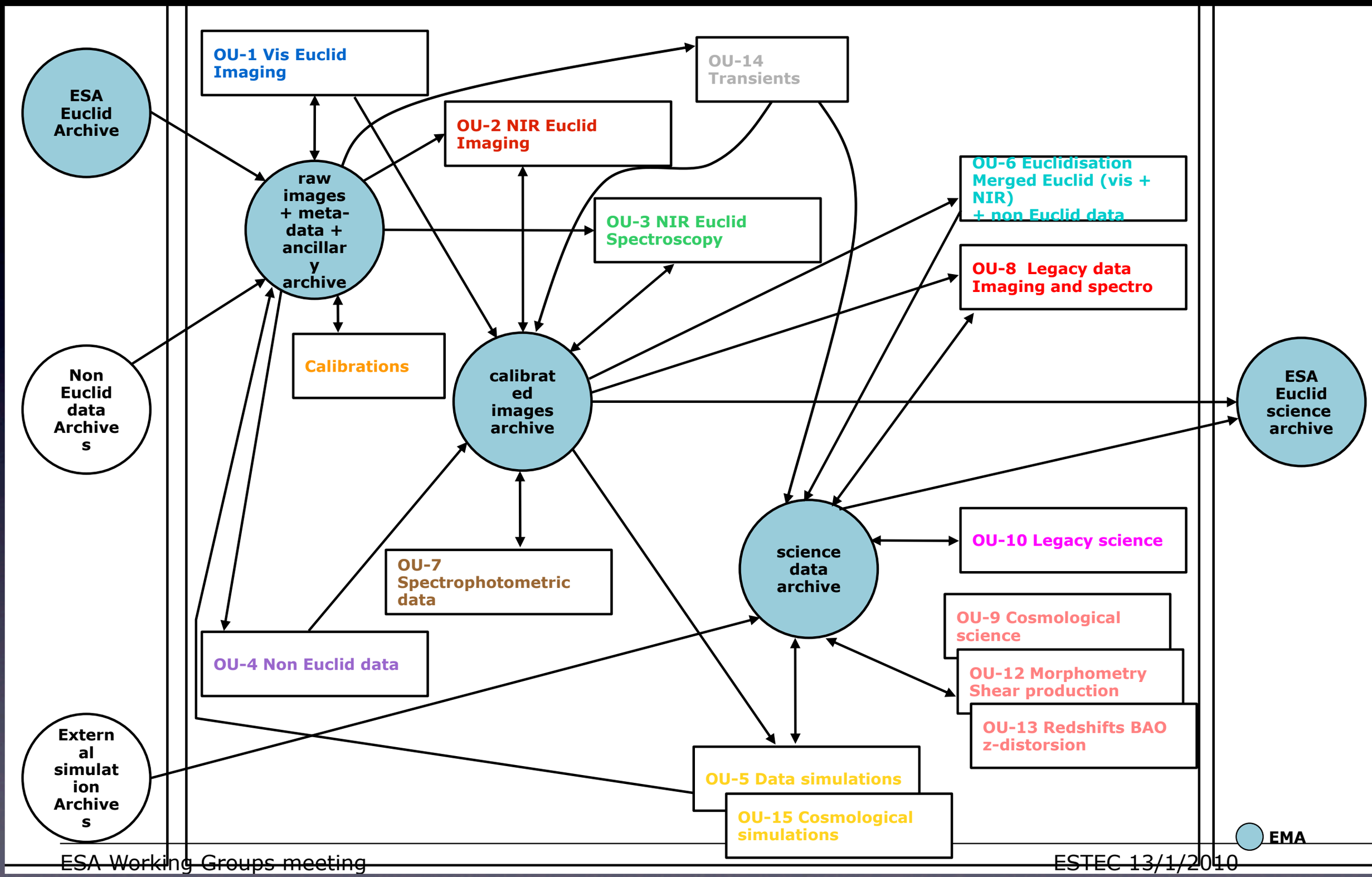
Functional breakdown

- Subdivision in OUs with associated SDCs
- Data reduction for 3 onboard instruments + ground data = OU-1 OU-2 OU-3 OU-4
- Final steps of euclidisation and merging is OU-6.

OU-6 and its SDCs - Euclid Vis/NIR/ground merging

Euclidisation, fusion, merged catalogues: delivers software, doc and data

- Coordinates and oversees SDC activities and cross-validations activities
- Gets requirements from SWG
- Defines algorithms, writes and validates prototypes
- Develops, validates and implements software in pipelines and SDCs
- Gets all ground/space Vis/NIR single images and meta-data produced by OU-1 to OU-4
- Defines the complet set of condfiguration files and sets the configuration parameters for all OU-6 processing steps
- **Processes all Vis-Im and NIR-Im photometric calibration images using standard Euclid software tools and computes the photometric zero points of each Euclid scientific image**
- Computes focal plane distortion, accurate astrometric of Euclid Vis-Im images with respect to external reference system (GAIA)
- Derive internal field-to-field photometric rescaling corrections of all Euclid Vis-Im images
- Computes focal plane distortion, accurate astrometric solutions, of all NIR-Im, NIR-Sp and External images with respect to internal Euclid Vis-Im reference system
- Derive internal field-to-field photometric rescaling corrections of Euclid NIR-Im and NIR-Sp and external images
- Euclidisation of all images in the Vis-Im reference system: astrometry, photometry, color term transformations
- Transforms (Rotate/Translates/Resamples/Regrids/Warps/Healpixs) all single images (Vis-Im, NIR-Im, NIR-Sp, External)
- Stacks Deep and Wide Imaging data (not Spectro data: for OU-7) when needed
- Produces all masks (Level 2), weightmap and flag map images attached to each combined (single or stacked) images
- Produces RA,DEC source catalogues in the same reference system for all single images
- Produces time series images for transient analysis
- Produces accurate PSF analysis, monitors PSF and models the PSF as function of instruments, observing conditions, etc…
- Applies the PSF homogenisation to images (single and stack images)
- Produces Deep, Wide, Transient sinlge and merged (multi-filter) catalogues
- Produces early simple morphology-based source classification
- Controls and validates all image and catalogue products
- Delivers data and meta-data products to EMA


ESA Euclid Archive
Non Euclid data Archives
External simulation Archives
OU-1 Vis Euclid Imaging
OU-14 Transients
OU-2 NIR Euclid Imaging
raw images + meta-data + ancillary archive
OU-3 NIR Euclid Spectroscopy
OU-6 Euclidisation Merged Euclid (vis + NIR) + non Euclid data
OU-8 Legacy data Imaging and spectro
Calibrations
calibrated images archive
ESA Euclid science archive
OU-7 Spectrophotometric data
science data archive
OU-10 Legacy science
OU-9 Cosmological science
OU-12 Morphometry Shear production
OU-13 Redshifts BAO z-distorsion
OU-4 Non Euclid data
OU-5 Data simulations
OU-15 Cosmological simulations
EMA

Euclid

Mapping the geometry of the dark Universe