Euclid & AGN: a promising entanglement

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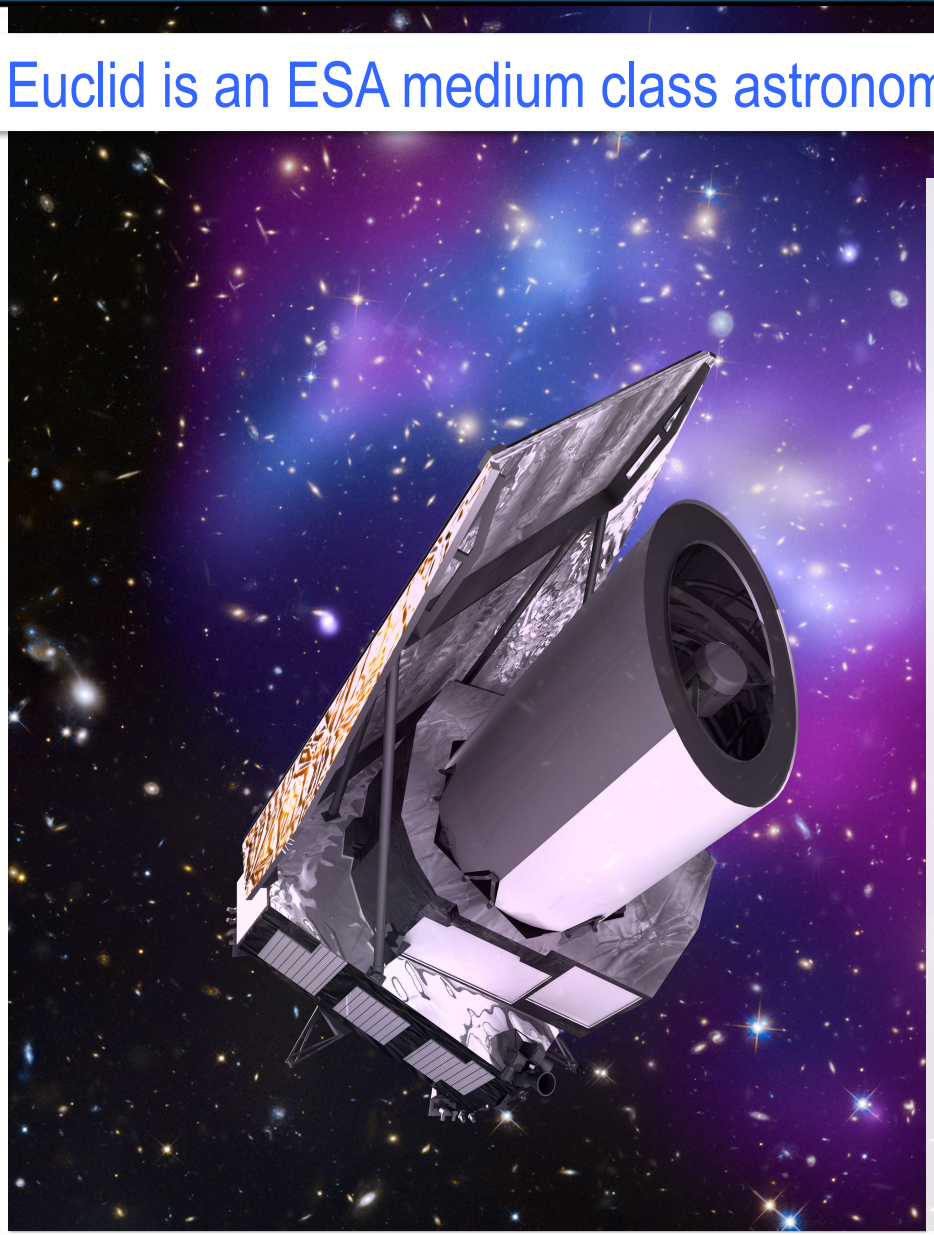
Euclid is an ESA medium class astronomy and astrophysics space mission.



- **Satellite** (Thales Alenia Space)
- **1.2m telescope** (Airbus Defence and Space)
- **Instruments**
  - VIS imager (0.79ºx0.71º FoV)
  - NISP imager (0.76ºx0.72º FoV)
  - NISP spectrograph (slitless)
    - **RED GRISM** : 1.25 - 1.85 μm
    - **BLUE GRISM**: 0.92 - 1.30 μm
- **Launch:** 2020 **Duration:** 6-7 yrs
- **Euclid Consortium (EC):** includes >1100 members, >120 Institutes, 14 EU countries + NASA & US

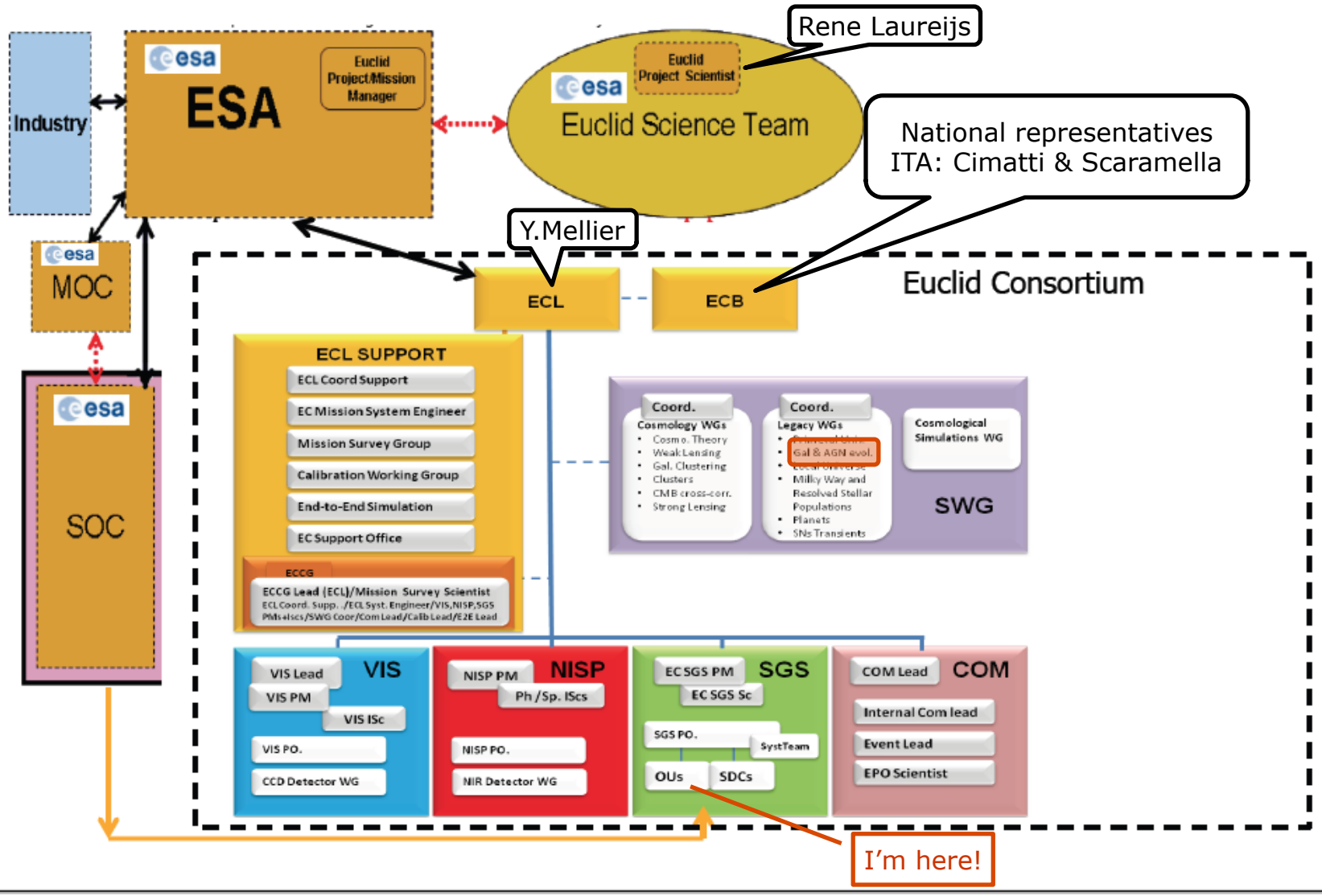
The **Euclid Consortium (EC)** is an organisation that brings researchers in theoretical physics, particle physics, astrophysics and space astronomy, engineers, technicians, and management and administrative staffs working in public research laboratories. Together with the European Space Agency (ESA) and aerospace industries they are part of the **Euclid Collaboration** contributing to the **Euclid Mission**.


2012
Euclid Mission Conference
2012
Copenhagen 15 – 16 May
Space Science Center
esa
ASTRIUM
AN EADS COMPANY
ThalesAlenia
Space

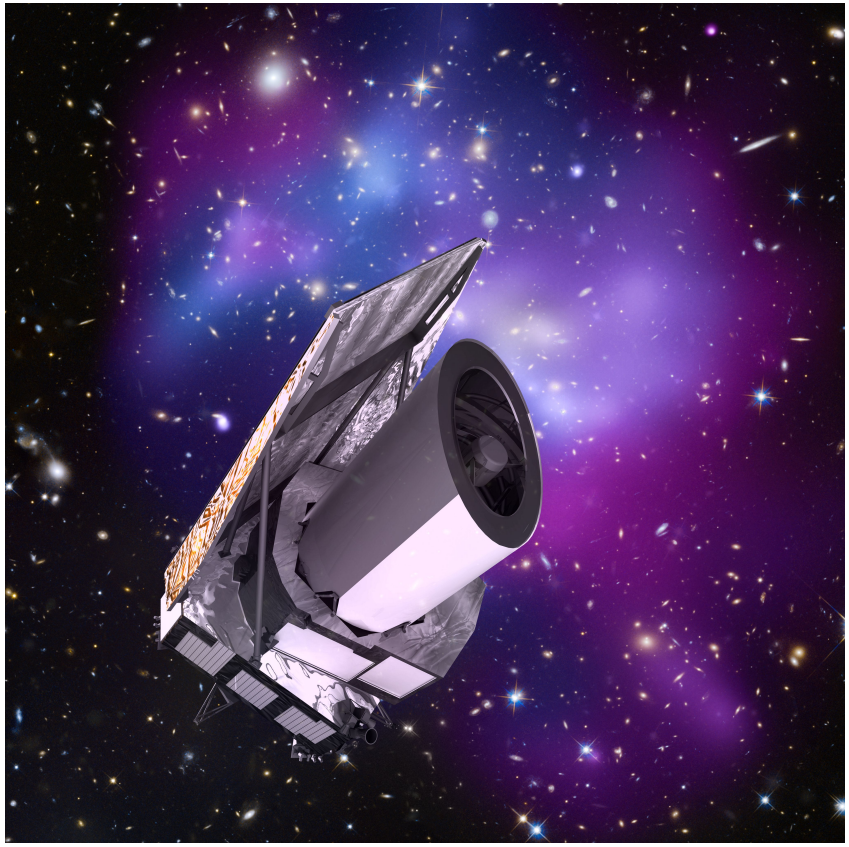

Euclid Consortium Meeting 2013
Leiden Observatory,
Leiden, Netherlands, 13 - 15 May 2013
esa
ASTRIUM
SRON
Dutch Space
TNO
2013

14 European countries contribute to EC activities (Austria, Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Portugal, Romania, Spain, Switzerland and UK), NASA and few US laboratories are also members of the Euclid Consortium.
More than 120 Institutes are contributing to the Euclid missions.
In total, 1100+ members are registered in the EC, of which ≈ 2/3 are scientist.

Euclid Consortium



Satellite and Service Module (SVM)



- The Satellite is built by *Thales Alenia Space*. It comprises the Service Module (SVM) and the Payload Module (PLM).
- The SVM (*Thales*) sub-systems include the sunshield, the star trackers & gyros, the thrusters, the slews control systems, the Attitude and Orbital Control system, the solar panel and electric power system, the thermal regulation and the downlink communication system.
- The PLM (*Airbus Defence and Space, ex-Astrium*) comprises the telescope, the Fine Guidance Sensor (FGS), the Optical Bench, the Dichroic for visual & near-IR simultaneous measurements, the VIS and NISP instruments (delivered by the Euclid Consortium) and the detectors (delivered by ESA).

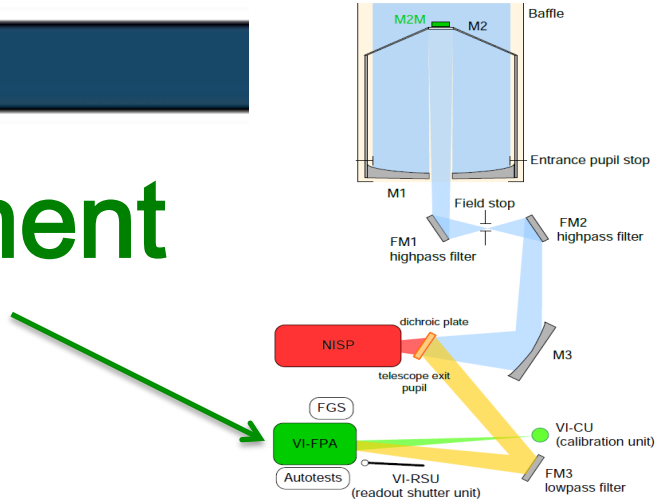
The "Observatory"

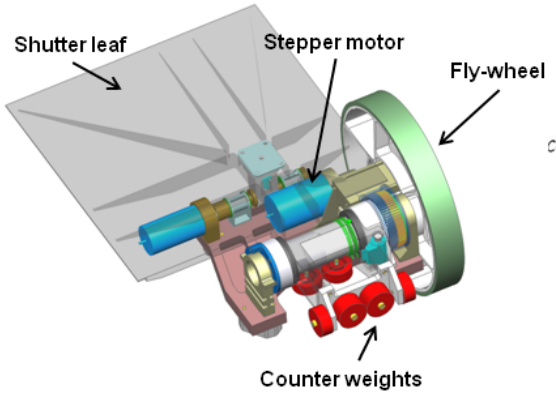
- The telescope:
  - Korsch 3-mirror anastigmat (TMA), 1.2 m primary mirror, FoV > 0.54 deg^2
- Visual Imager (VIS):
  - 36 CCDs (CCD273 e2v), Pixel 0.1x0.1 arcsec, single filter $0.55 < \lambda < 0.99$ micron
- Near-IR Slitless-spectrometer/Photo-Imager (NISP)
  - 16 HgCdTe sensors (H2RG Teledyne), Pixel 0.3x0.3 arcsec $0.92 < \lambda < 2.0$ micron
  - Imaging: 3 filters Y, J, H
  - Spectroscopy: slitless red grism (wide) + blue grism (deep)

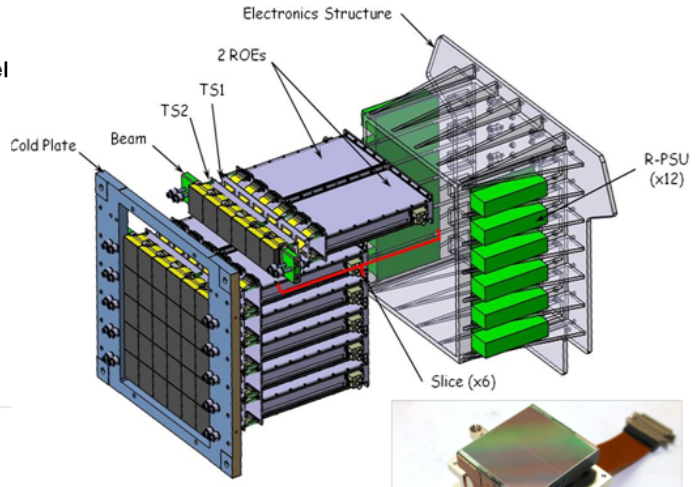
The VIS Instrument

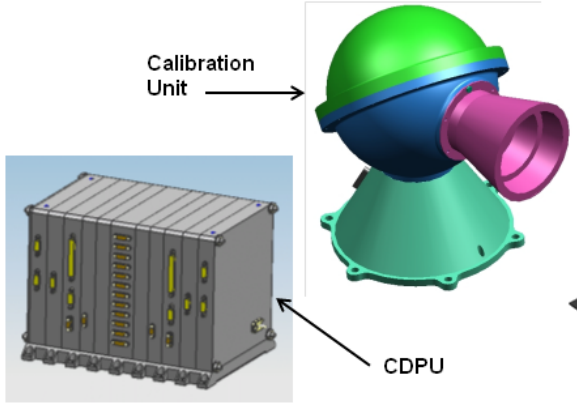
VIS: large area imager
A shape-measurement machine

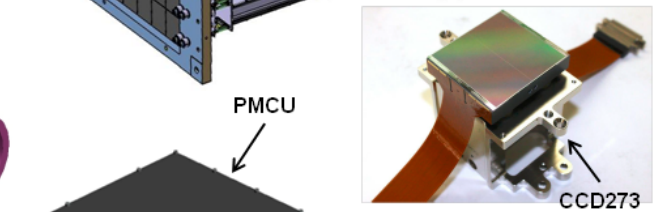
- 36 4096×4096 e2v CCDs
- pixel 12x12μm=0.1”x0.1”
- FoV 0.57 deg^2
- single broad band filter
  $0.55 < \lambda < 0.99$ micron
- image quality 0.23” FWHM
- Spatially stable PSF carefully modeled (PCA)
- limiting magnitude (10σ ŝ)
  m_{AB}≈24.5-24.9 (wide survey)
- 4 dithered exposures (565s)
  50% of sky covered by four
  47% of sky covered by three
- Data volume 520Gbit/day

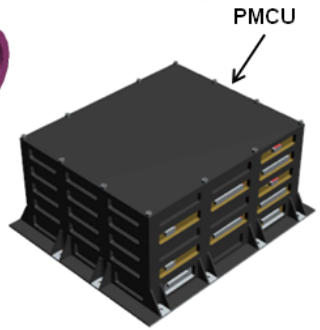


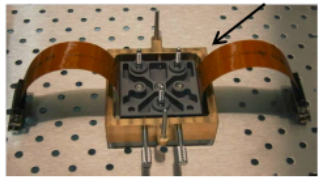




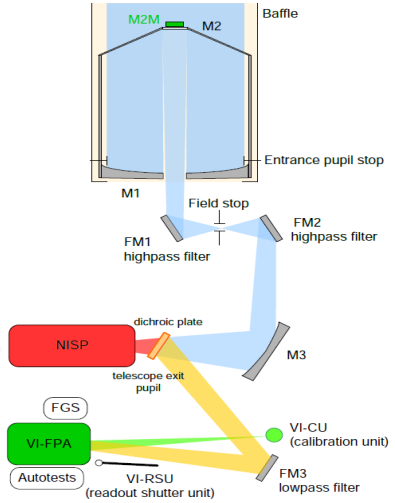






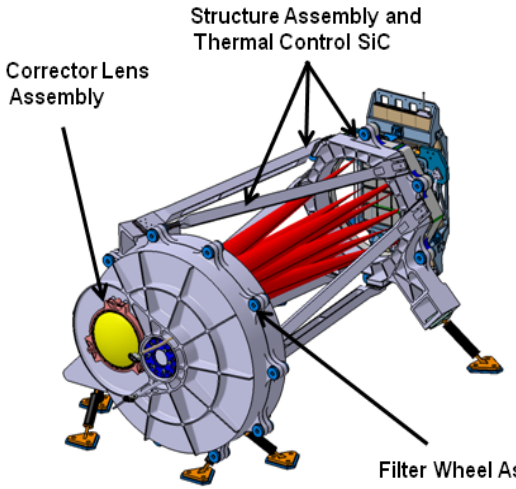


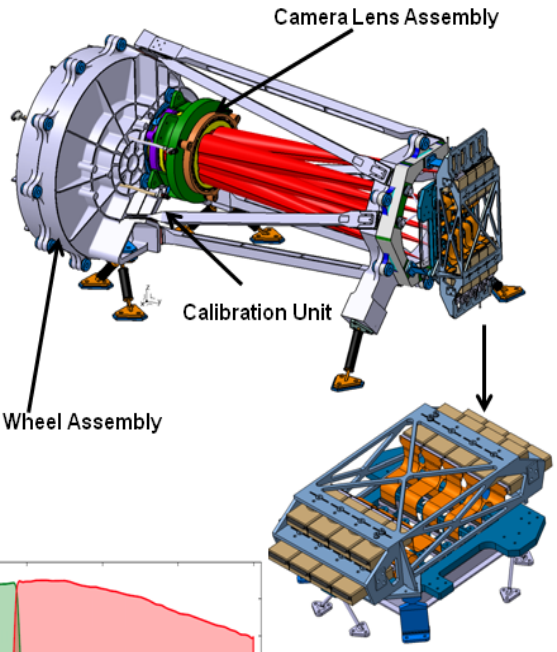
The NISP Instrument (1)

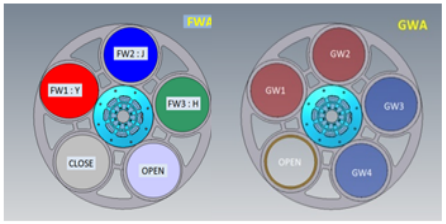


NISP: Near Infrared
Spectrometer **& Photometer**

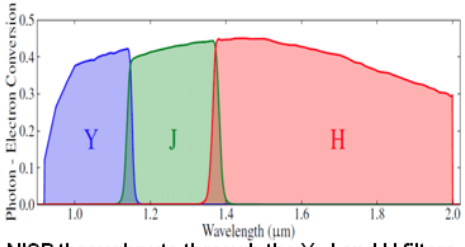
- 16 2k×2k H2G detectors
- pixel 18x18μm=0.3”x0.3”
- FoV 0.53 deg^2
- 3 NIR filters: Y,J,H
  1000 < λ < 2000 nm
- image quality 0.3” FWHM
  (undersampling)
- limiting magnitude (5σ ★)
  m_{AB}≈24 (Y,J,H wide survey)
- 4 dithered exposures
  (Y: 4x120 J:4x115 H:4x80)
- Data volume 180Gbit/day







Filters and grisms positions in wheels



NISP throughputs through the Y, J and H filters

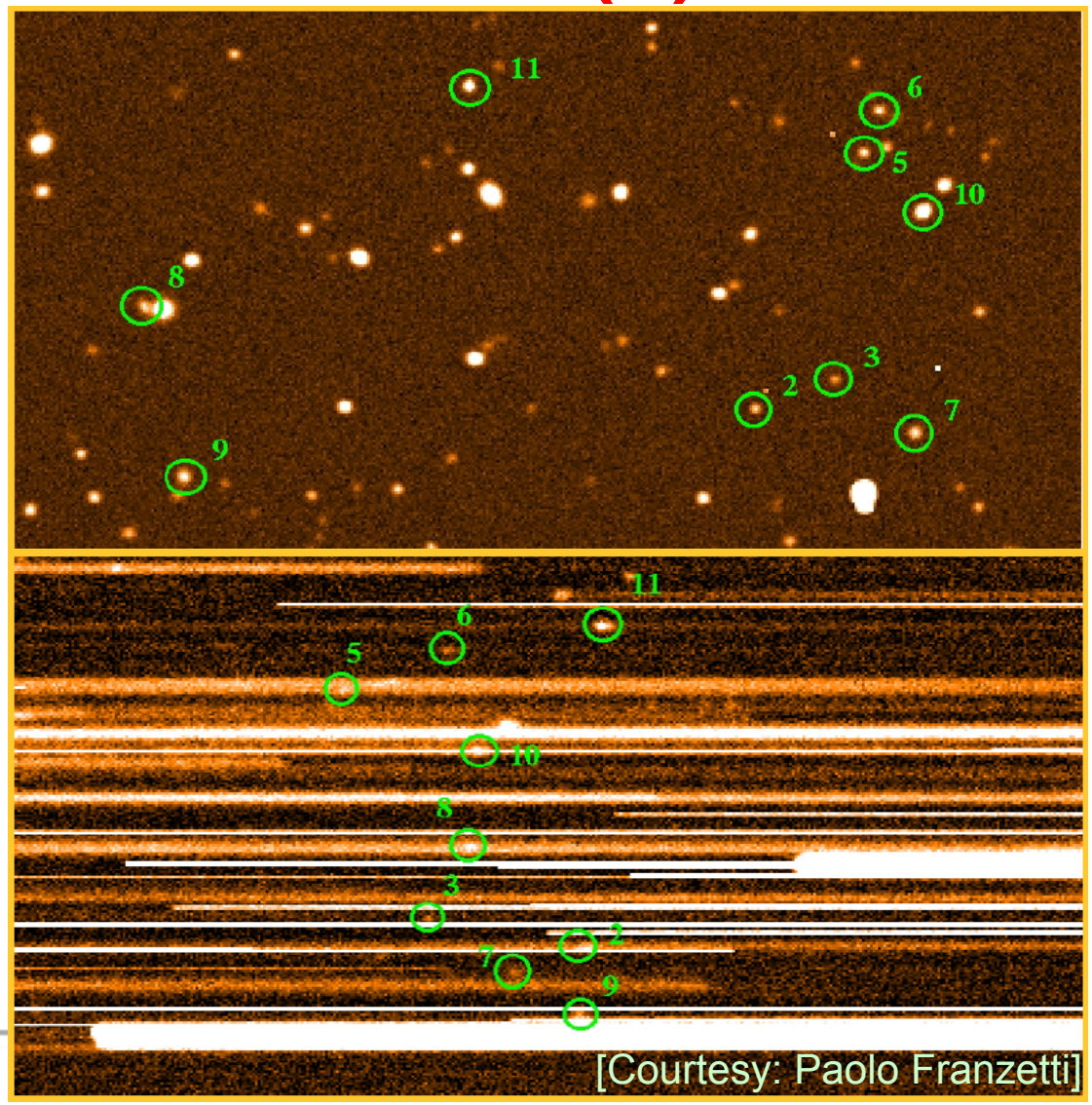
The NISP Instrument (2)

NISP: Near Infrared Spectrometer & Photometer

• slitless spectroscopy

• 4 low resolution grism (R~250)
3 "red" grisms 1.25 - 1.85 μm
1 "blue" grism 0.92 - 1.30 μm
• WS: 3 red x 4 different orientations to decontaminate
• DS: 3 red+1 blue x 16 angles
• FoV 0.53 deg^2
• Hα redshifts
• Line flux limit 3x10^{-16} cgs (WS: 3-5σ unresolved line)

Main problem: ***Contamination***, overlap of object spectra



[Courtesy: Paolo Franzetti]

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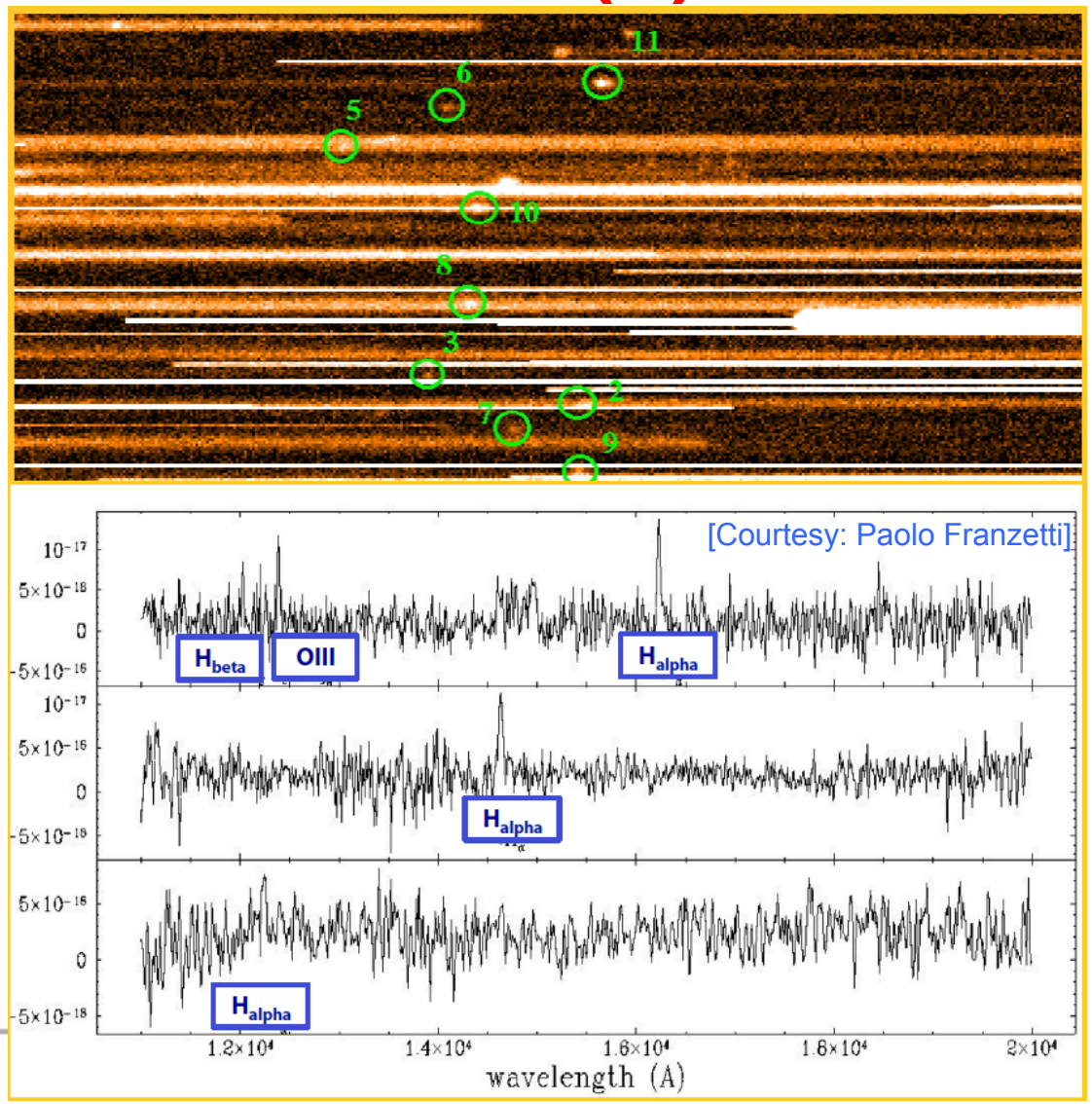
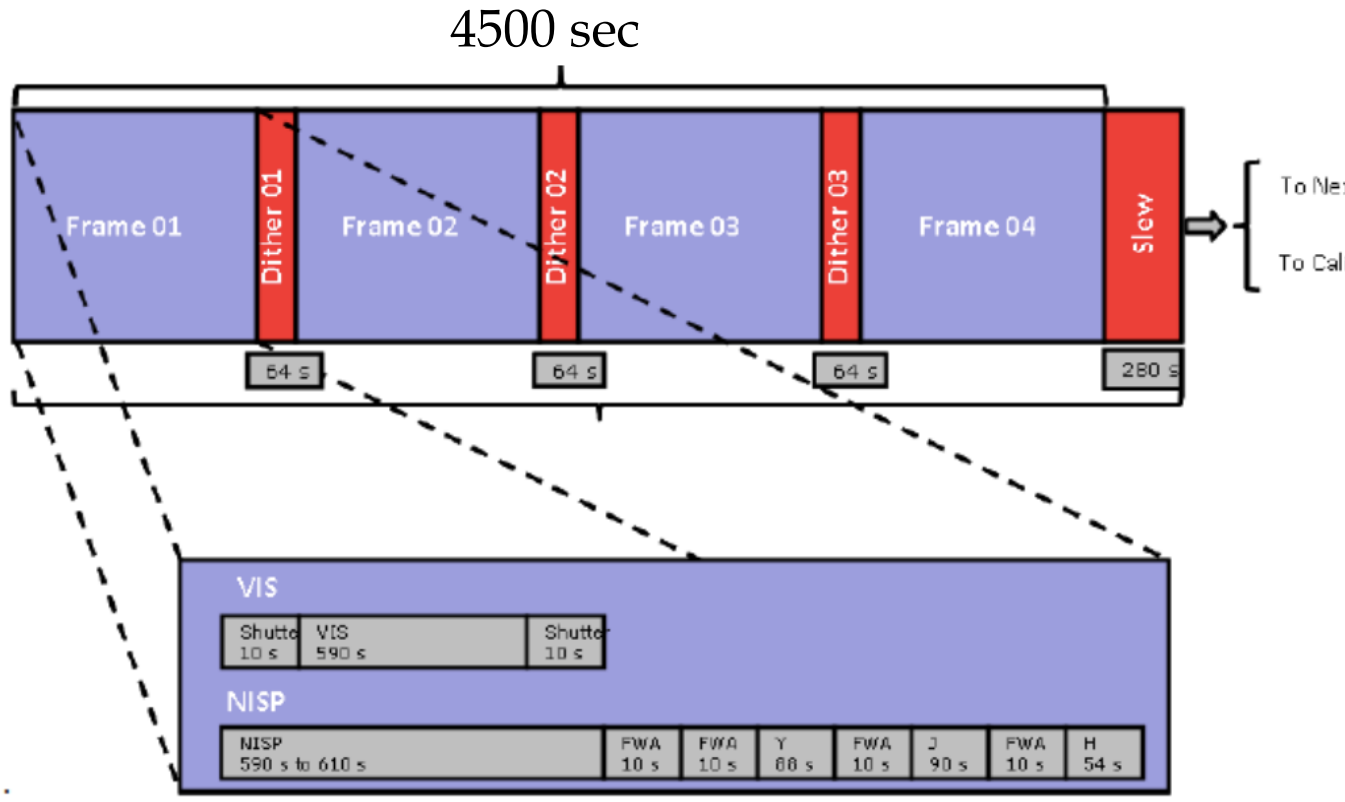


Observation Sequence

Step-and-Stare Pointing Strategy

- Each field is 0.54 deg^2
- ≈4500s dwell time per field
- Each field dithered 4 times dither step ~100 arcsec
- Each dither includes 1 VIS full observation, 1 NISP-Spectro full observation (in parallel with VIS), and 3 NISP-Photo observations (Y, J, H band in sequence)
- 60,000 fields, slews 180,000 dither slews
- 6 year



Euclid Surveys

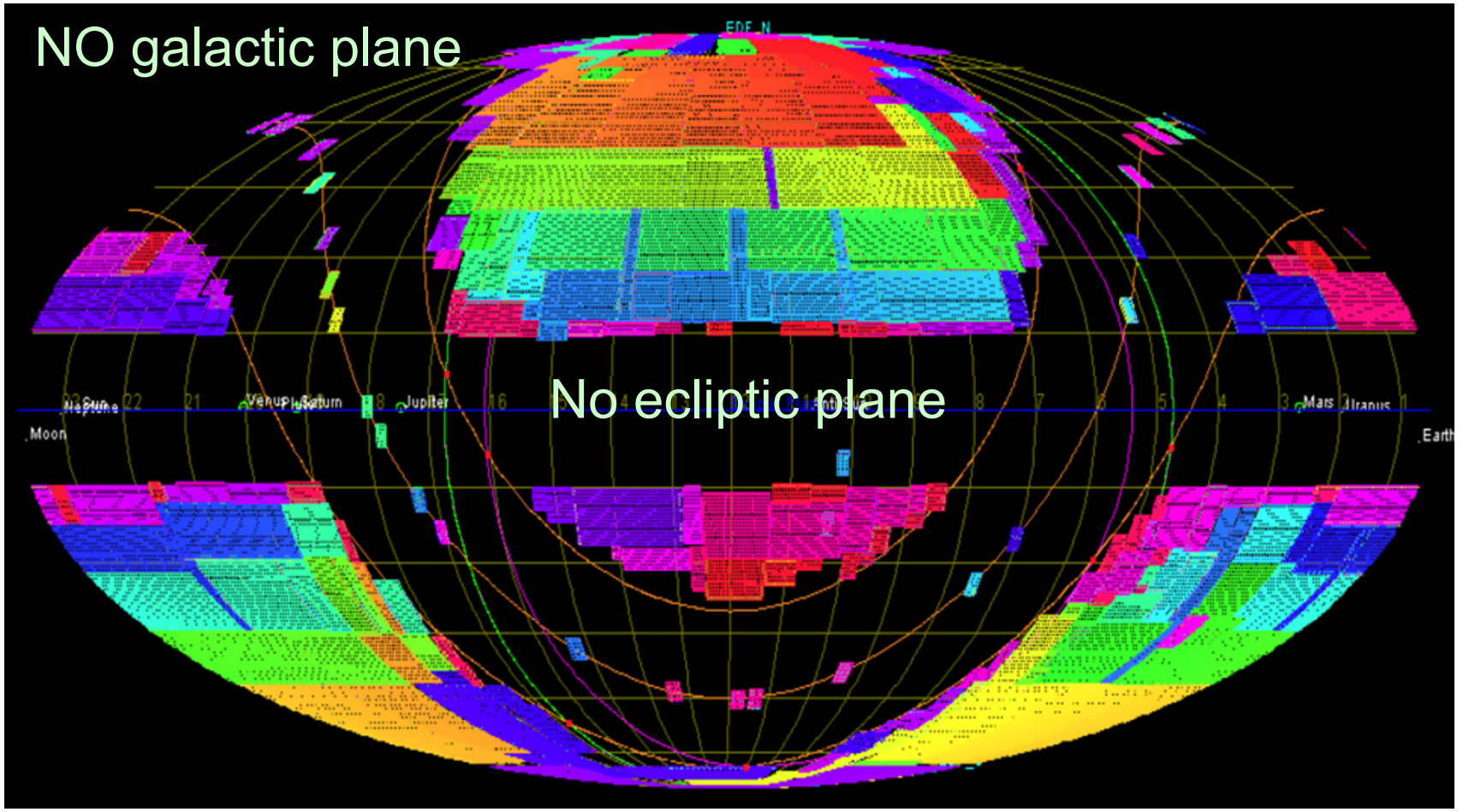
WIDE SURVEY

- Euclid's *Primary* survey
- 15,000 deg^2
- Entire extragalactic sky
- VIS to $m_{AB} \approx 24.9$
- NISP to Y,J,H≈24 (AB)
- only 4 red grism spectra (1.25 - 1.85 μm)
  (0.9 < z < 1.9 for Hα)
  (1.5 < z < 2.7 for [OIII])
  (2.35<z< 3.96 for [OII])
- Hα line flux to ~3×10^{-16}

DEEP SURVEY

- Euclid's *Additional* survey
- Legacy Science+Calibrations
- ~40 deg^2
- Two mag deeper
- 16 red+blue grisms spectra (0.92-1.30+1.25-1.85 μm)
  (0.4 < z < 1.9 for Hα)
  (0.8 < z < 2.7 for [OIII])
  (1.5 < z < 4.0 for [OII])
  (6.5 < z < 15(!) for Lyα)
- Easier Spectra decontamin!

Sky Coverage (after 6 years)



Each color represents a full year of observation

Main Scientific Objectives

- Euclid is a space-based cosmology experiment.

  "The mission is designed to understand the origin of the Universe's accelerating expansion and to derive the nature and the properties of Dark Energy, Dark Matter and explore the possibility of non-standard gravity".

- Two main cosmological probes, both independent and complementary + additional cosmological tools
  - Weak gravitational Lensing (WL)
  - Baryonic Acoustic Oscillations (BAO)

  ✦ Redshift Space Distortion (RSD)

  ✦ Galaxy Clusters and the Integrated Sachs-Wolf effect

Euclid Scientific Requirements

Optimize the mission for WL and BAO

- Wide Survey > 15,000 deg^2
- WL
  - Shapes and shear of galaxies
  - Very high image quality and stability; minimize systematics
  - Redshift range 0<z<2; accuracy dz/z~0.04 → photo-z
- BAO
  - Hα redshift for >3500-5000 galaxies/deg^2
  - z-range 0.7<z<2; accuracy dz/z~0.001 → NIR spectro-z

VIS

VIS+NISP

NISP

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Besides cosmology, Euclid will provide an exceptional dataset: 2x10^9 galaxies with photo-z and morphology; ~10^8 galaxies (and ~10^6 AGN) with redshifts (+em.lines)

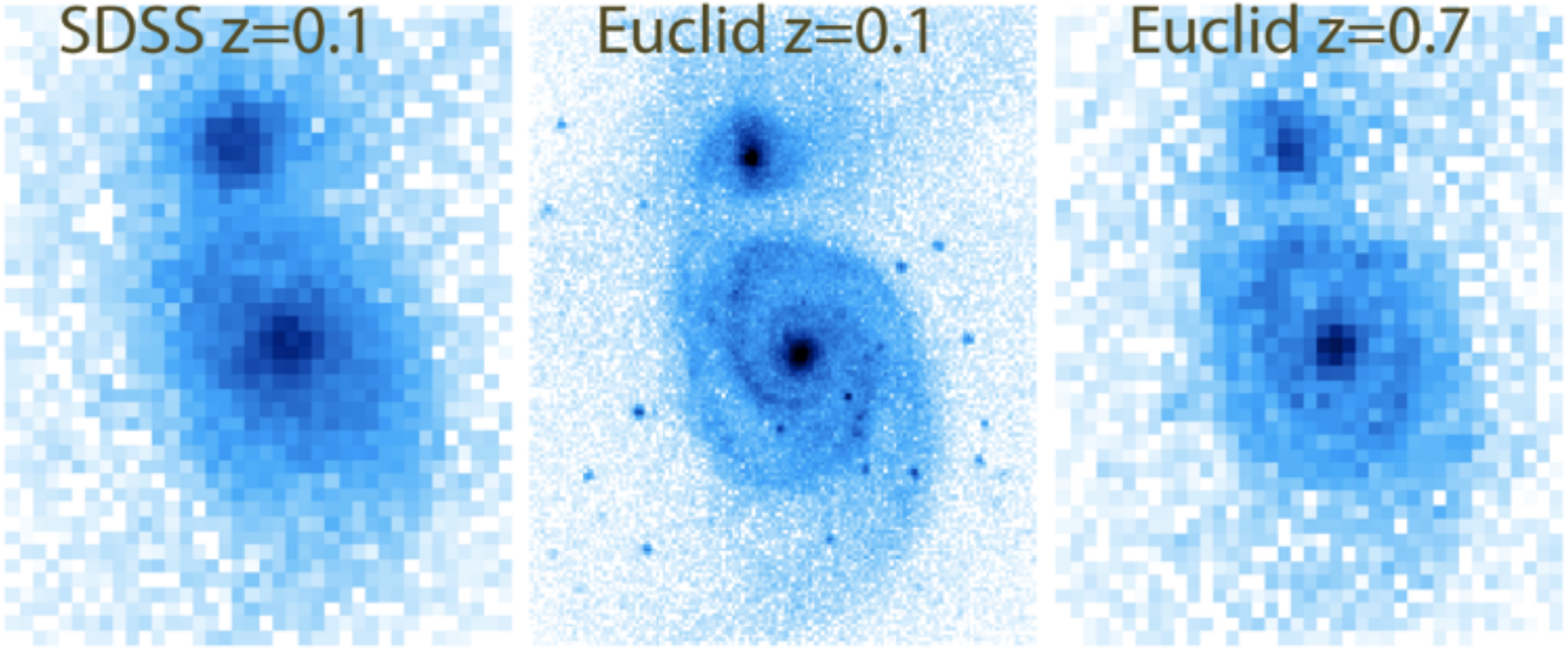
Euclid Legacy Science

- Surveys easy to use/access for the general astronomers have major and lasting impact (e.g. IRAS, SDSS, H(U)DF).
- Early in the mission, legacy will be the main generator of scientific results and will be useful for the image of the mission as perceived by the scientific community.
- The number of legacy science papers will significantly exceed that of cosmology papers.
- With a good data archive and a Deep Survey optimized as much as possible for legacy science, Euclid will likely be a cornerstone of extra-galactic astronomy for almost a decade.

Legacy Science Working Groups

- Extra-solar planets
- Miky Way and Resolved Stellar Populations
- Local Universe
- Galaxies and AGN Evolution
- Primeval Universe
- Clusters of Galaxies
- Supernovae and transients
- Strong Lensing
- CMB Cross-correlations
- Cosmological Theory
- Cosmological Simulations

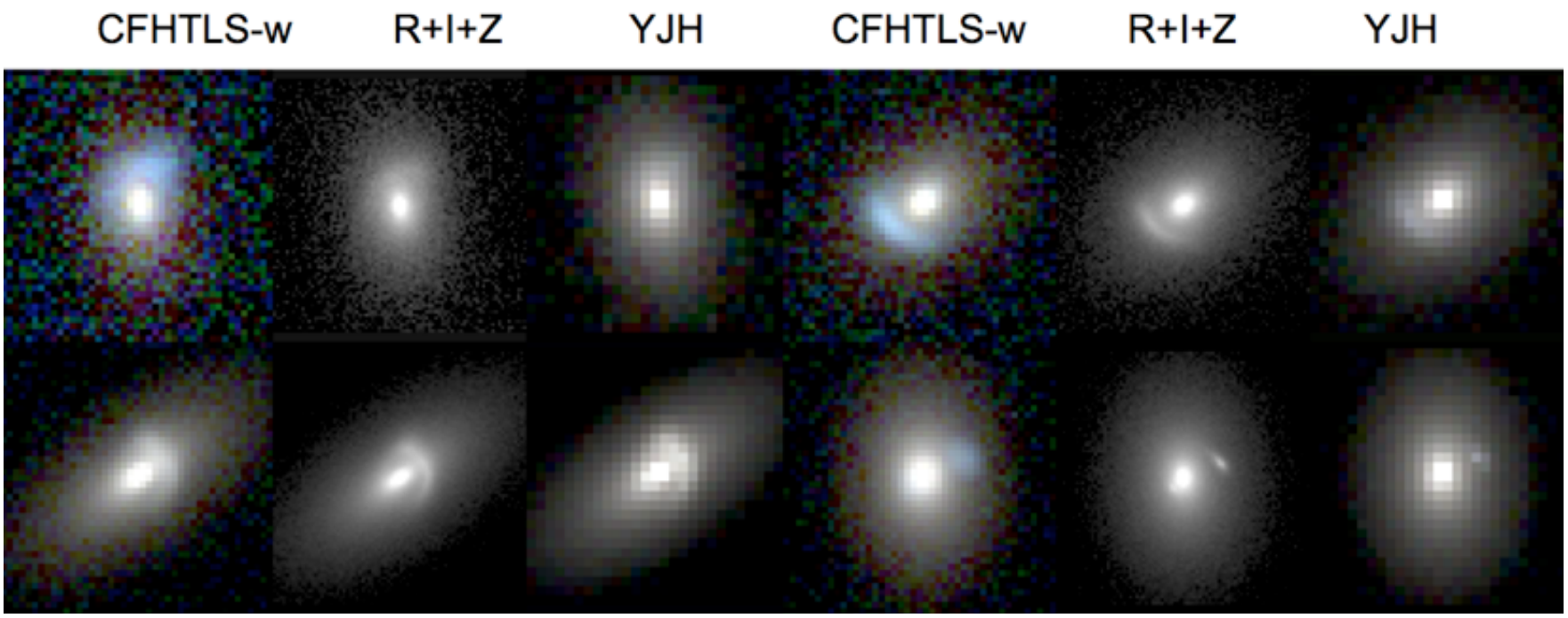
AGN Science with Euclid: VIS



✓ Morphologies of ~10^9galaxies and associated science

AGN: hosts of type2 AGN – Hubble type, mergers, satellite.

AGN Science with Euclid: VIS



✓ Strong Lensing: ~1-2x10^5 expected galaxy-galaxy lenses
~ 10^3 expected QSO-galaxy lenses
~ a few QSO acting as lenses?

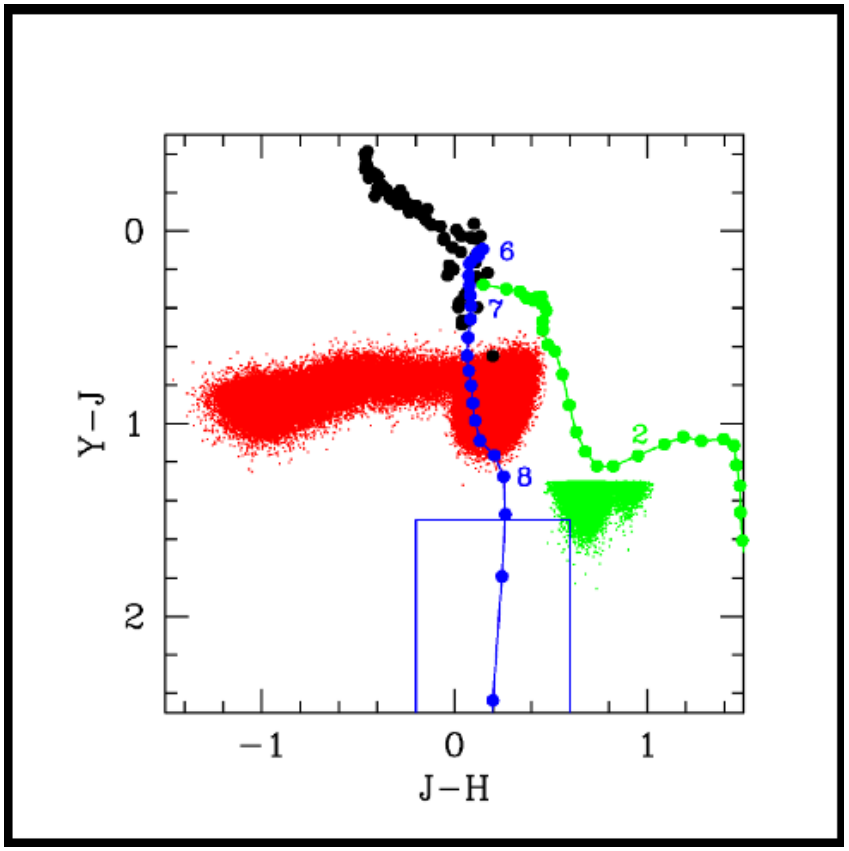
AGN Science with Euclid: NISP-P

Bright High-z Quasars

Euclid-NISP YJH data:

Expected ~30 z>8 QSOs

Euclid should be able to immediately get spectra of the brightest and follow-up the faint ones from ground-based observatories



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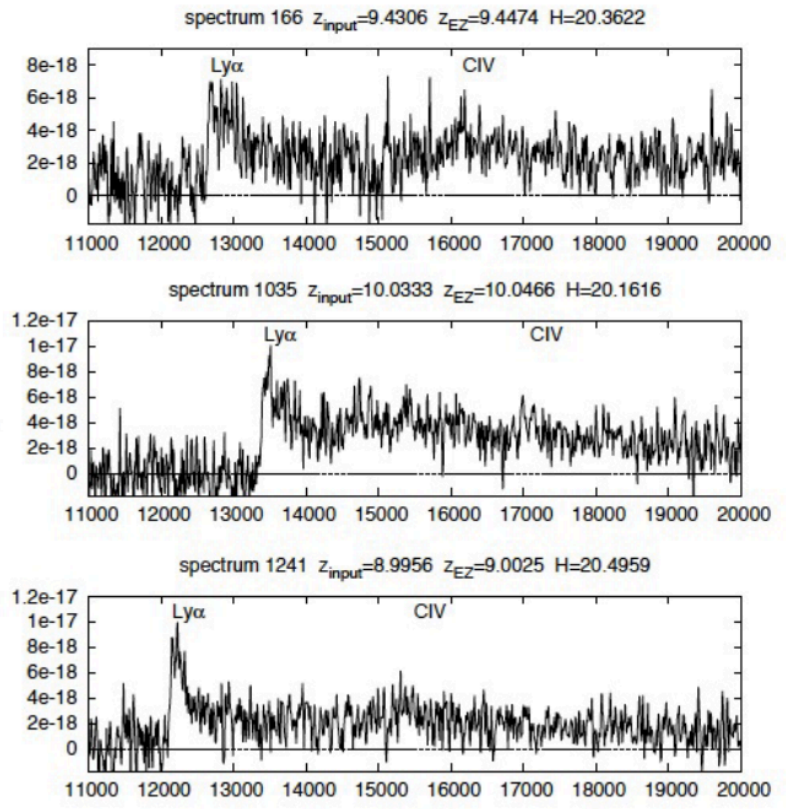


Roche et al (2011)

AGN Science with Euclid: NISP+VIS

Deep Survey

Probing the bright end of the galaxy (and AGN) LF at high z

Selection with Euclid-only data:

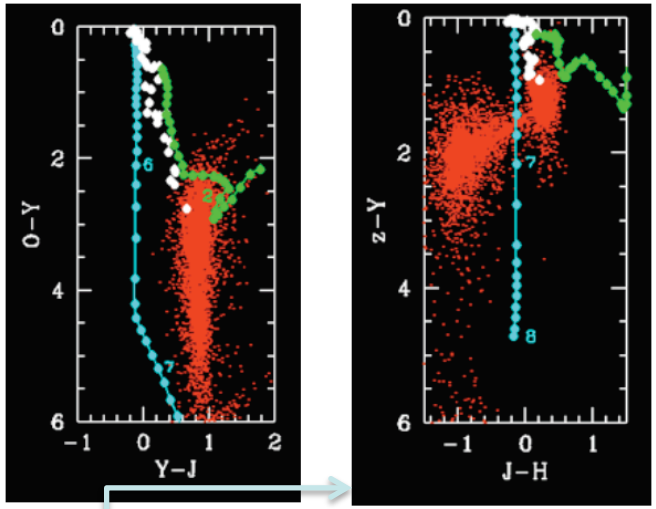
J < [25.5-26] at [8-5] σ

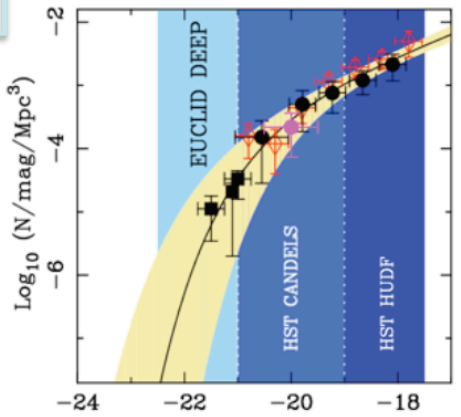
[700-4000] galaxies at z =7 ± 0.5

[150-1000] galaxies at z = 8 ± 0.5

Additional z band data (AB = 27 - 5σ) highly desirable for discriminating z=7 galaxies from T-dwarfs.

• Spectroscopy: Lyα emission of ~100 brightest objects from the photometric sample





AGN Science with Euclid: NISP-S

HINL

Emission Lines	Wide Survey	Deep Survey
Hα	**0.9 < z < 1.9**	0.4 < z < 1.9
→ [OIII] λ5007	1.5 < z < 2.7	0.8 < z < 2.7
[OII] λ3727	2.4 < z < 4.0	1.5 < z < 4.0
→ [NeV] λ3426	2.6 < z < 4.4	1.7 < z < 4.4
MgII λ2800	3.5 < z < 6.6	2.3 < z < 6.6
→ CIV λ1549	8.1 < z < 12	4.9 < z < 12
Lyα	-----	6.5 < z < 15

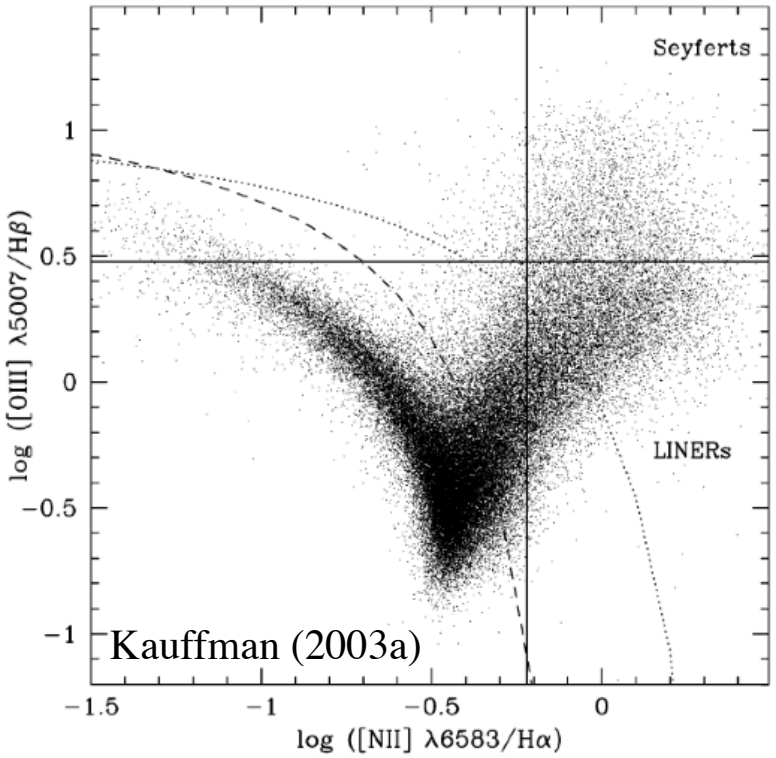
The Euclid spectroscopy of extragalactic objects is limited to emission lines. AGN are the best targets!

- Detection of broad lines in NISP spectra → Type 1 AGN selection
- Detection of high ionization narrow lines → Type 2 AGN selection

➢ **REMEMBER! 15,000 deg²: if the (otherwise selected) AGN is within the survey area → OPT + Y,J,H photometry + NIR spectrum**

AGN Science with Euclid: NISP-S

SDSS: Diagnostic Diagram for type2 AGN 0.02<z<0.3



Euclid: Diagn.Diagram at z>1

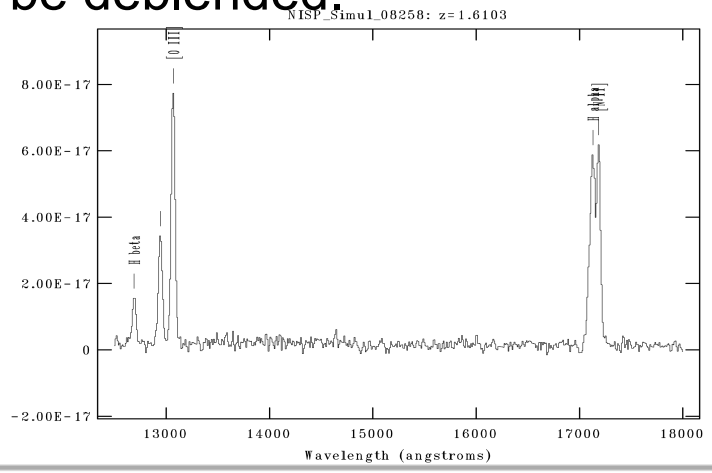
Ha+[OIII]

- WS: 1.5<z<1.9 DS: 0.8<z<1.9

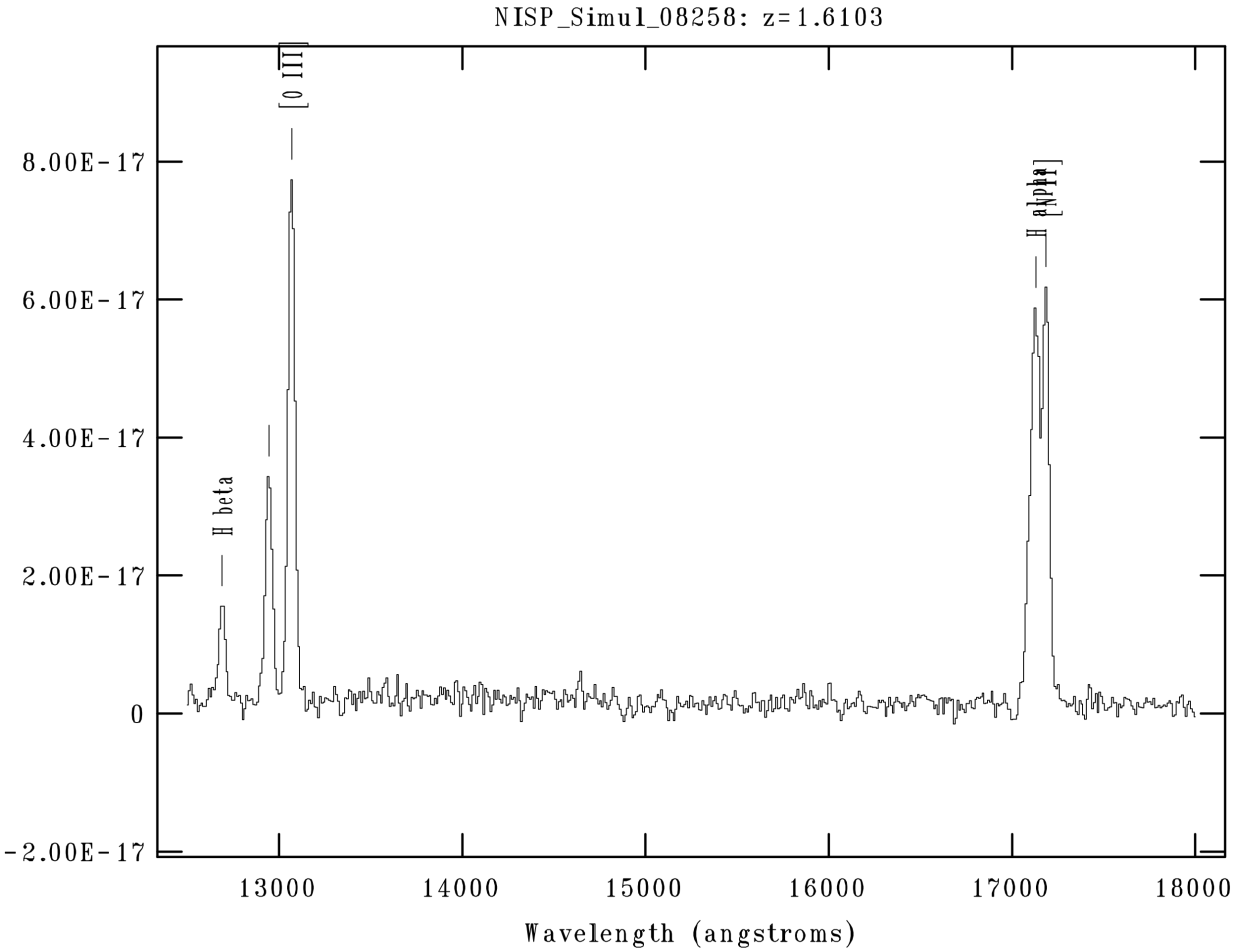
[OIII]+[OII]

- WS: 2.4<z<2.7 DS: 1.5<z<2.7

But low resolution R~250: Hα/[NII] to be deblended.



A NISP-simulated type2 AGN



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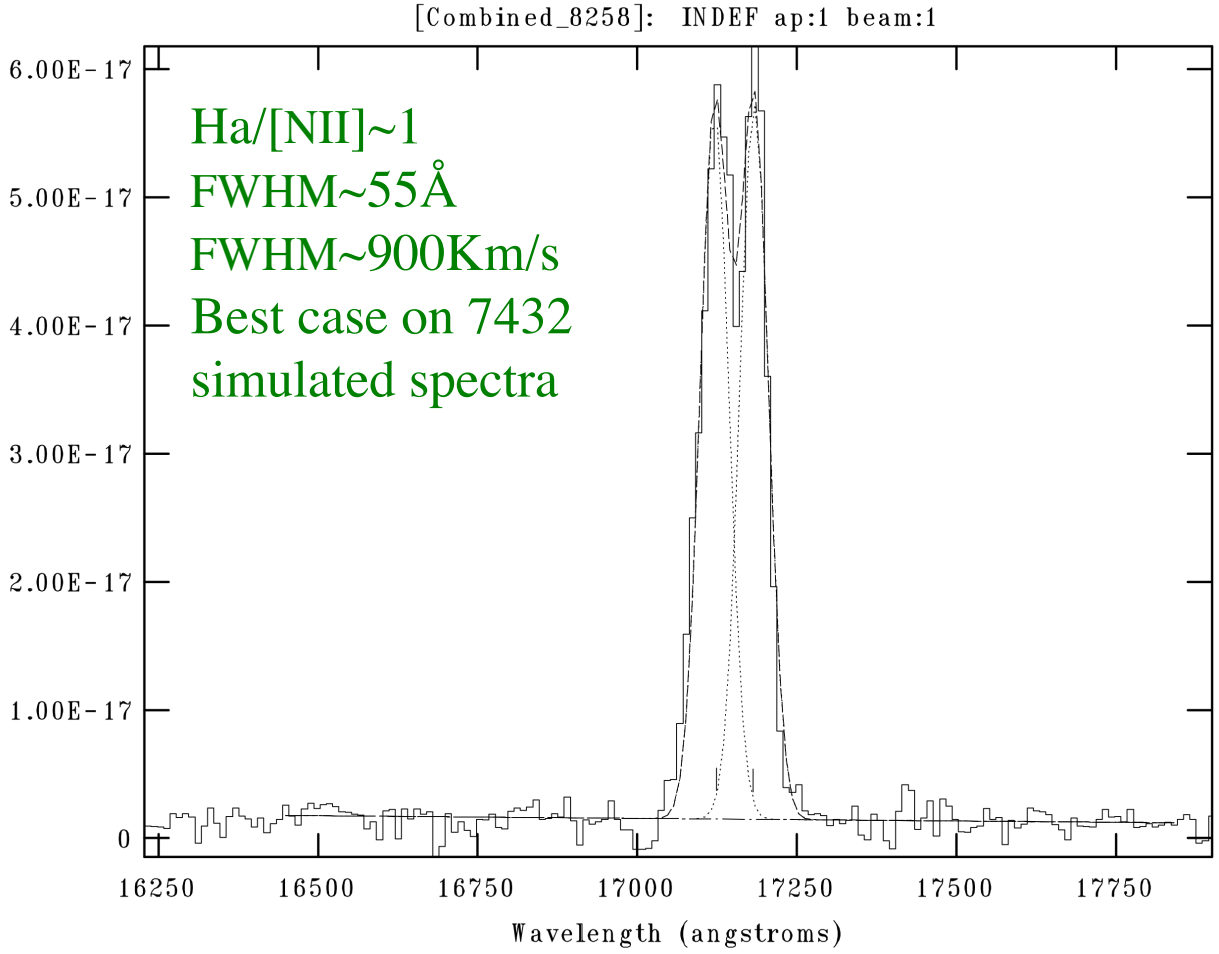
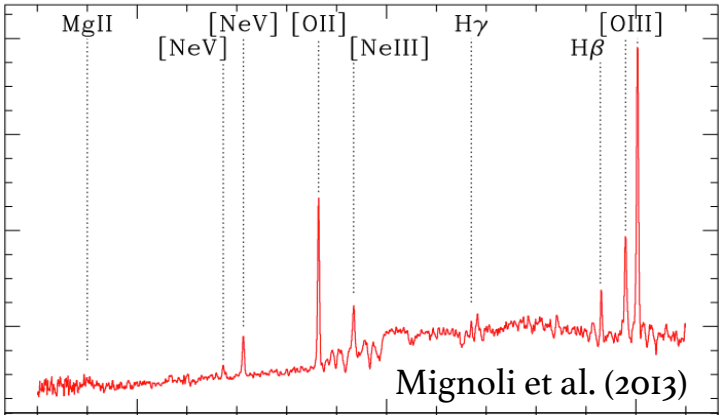


Type2 AGN selection via HINL

94 type2-AGN with 0.65< *z* <1.20 selected in COSMOS by detection of the high-ionization [Ne v] λ3426.

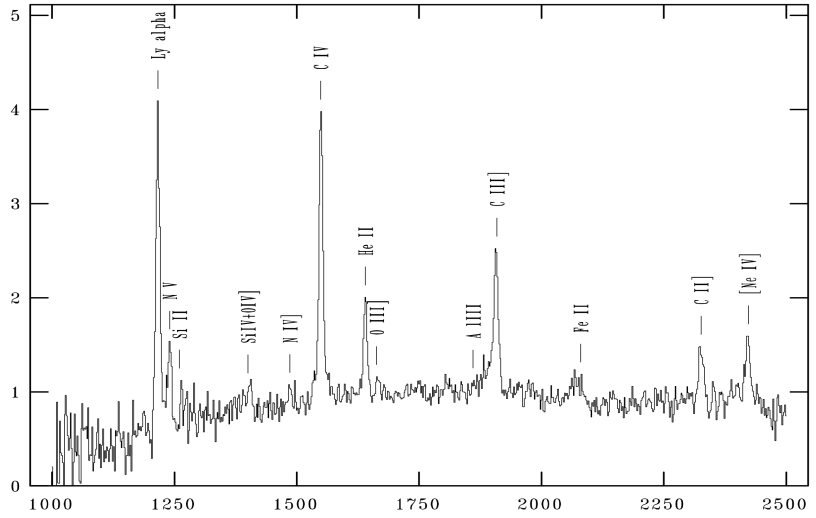
30/deg^2 of them with EW_{obs}>20Å



Expected 500-1000 type2-AGN in Euclid Deep Survey (1.7 < *z* < 2.5) by detection of the high-ionization [Ne v] λ3426.

~100 type2-AGN with 1.5< z <3.0 selected in COSMOS by detection of the high-ionization C IV λ1549.

60/deg^2 of them with EW_{obs}>40Å



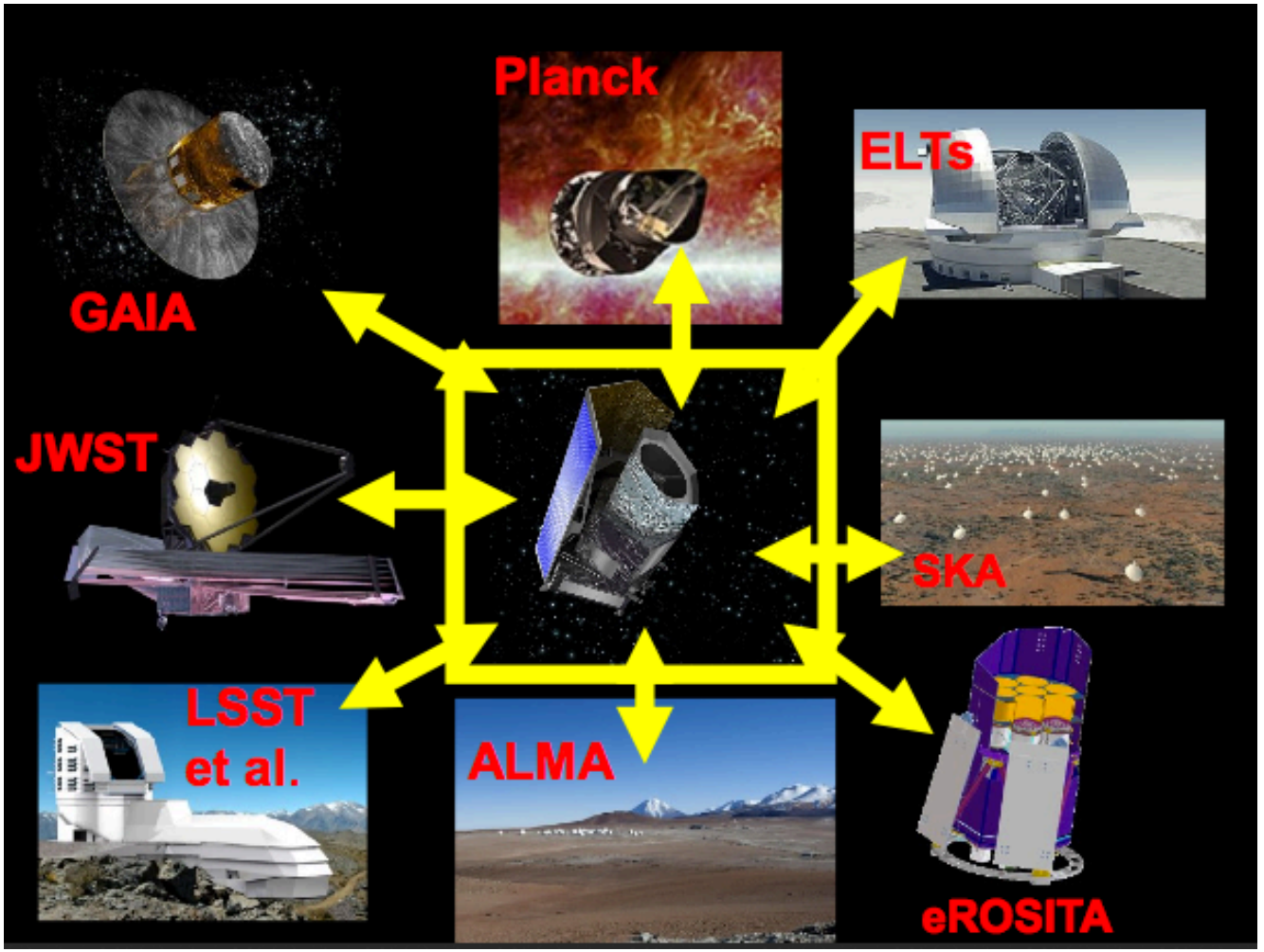
Possible selection of type2-AGN in Euclid Deep Survey by detection of Narrow Line C IV λ1549 at z > 4.9.

Synergies

Euclid:
~12 billion sources
(OPT,Y,J,H+morph)
~50 million redshifts

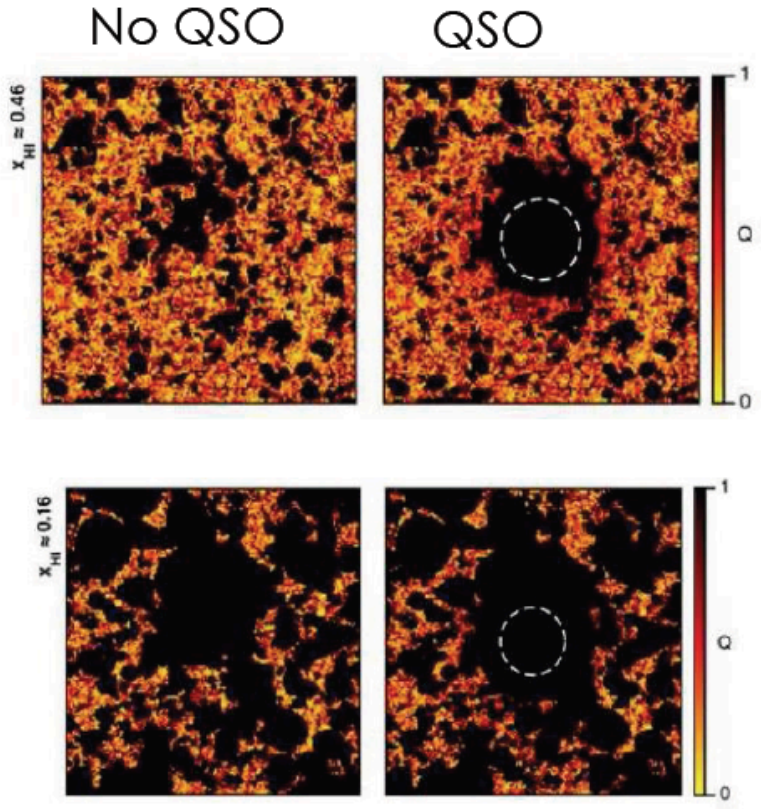
A reservoir of target for follow-up with JWST, E-ELT, ALMA

Synergy with LSST, E-ROSITA, SKA



Synergy with SKA: Epoch of Reionization

- Euclid will find QSOs at the EoR → Targets for SKA to observe the redshifted 21cm (21cm tomography as cosmological probe).
- Mapping the regions around high-z QSO (feedback, IGM & reionization process)



Geil & Wythie (2008)

Synergy with eRosita: optical/IR imaging follow-up of x-ray selected sources

- **Two-ways synergy with eRosita:**
  - eRosita → X-ray data for a large fraction of Euclid AGN at 0.9<z<1.9 (Wide survey)
  - EUCLID --> redshift for almost all the eRosita X-ray sources (good match X-ray fluxes opt/NIR mags)

See Brusa's talk

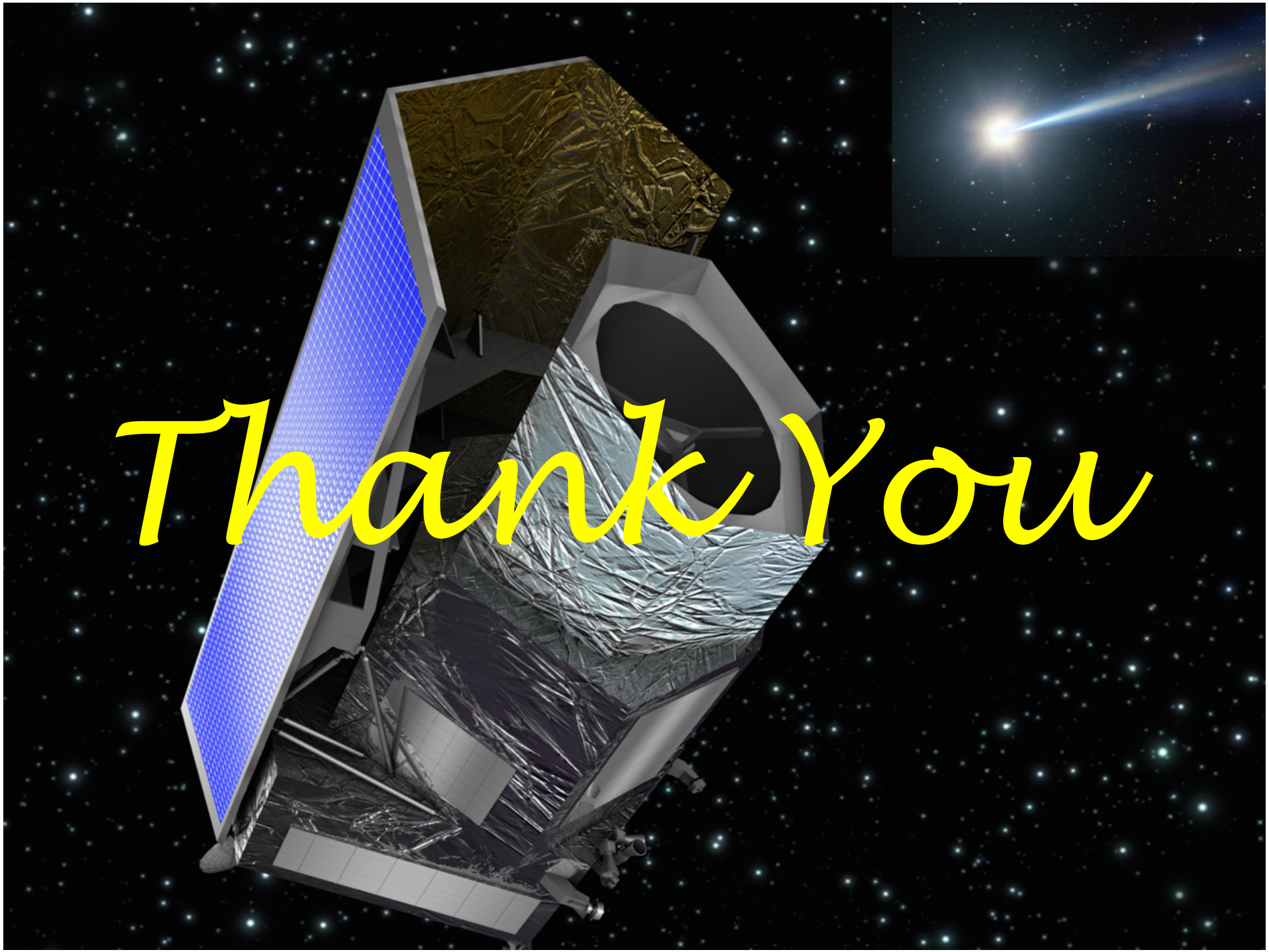
- Maybe stronger science case: **galaxy clusters**

Survey	Lat	Date	Ω	u	g	r	i	z	Y	J	H	K
SDSS	+30	-'10	10000	21.6	22.6	22.4	21.6	20.1	-	-	-	-
PS1	+20	'10-'12	30000	-	22.6	22.4	22.1	21.1	-	-	-	-
SkyMapper	-30	11-	30000	-	22.5	22.0	20.9	20.6	-	-	-	-
KIDS+VIKING	-20	11-	1500	24.8	25.4	25.2	24.2	22.4	21.6	21.4	20.8	20.5
DES+VHS	-30	'12-'16	5000	-	24.6	24.1	24.3	23.8	21.5	20.2	20.1	19.5
ATLAS+VHS	-20	11-	4500	22.0	22.2	22.2	21.3	23.8	21.5	20.5	19.9	19.3
HSC	+20	'12-'16	1500	-	25.5	25.2	25.5	24.3	23.3	-	-	-
PS2	+20	14-	10000	-	24.5	24.5	24.5	24.5	-	-	-	-
GAIA	-	'13-	41253			20						
Euclid	-	'19-'24	15000			24.5			24.0	24.0	24.0	-
LSST	-30	'20-'30	18000	24.0	26.0	26.0	26.0	26.0	26.0	-	-	-

From eRosita Science Book

Summary

- Euclid is an ESA medium space mission (~2020-2027).
- Three instruments / Two surveys
  - VIS IMAGER (wide opt filter) to $m_{AB} \approx 24.9$ [WS 15,000 deg^2]
  - NISP IMAGER (YJH) to $m_{AB} \approx 24$ [WS 15,000 deg^2]
  - NISP SPEC (slitless) [1.25-1.85μm 15,000 deg^2 / 0.9-1.85μm 40 deg^2]
- Euclid is cosmology experiment but…
  will provide a huge (15,000 deg^2) astronomical database:
  - 2×10^9 galaxies with photo-*z* and morphology;
  - ~10^8 galaxies (and ~10^6 AGN) with NIR spectra (*z*+em.lines)
- Euclid Legacy science for AGN is promising especially in the Deep Survey (40 deg^2: $m_{AB} \approx 26.5$ ◆ YJH≈26 ◆ B/R grisms)
- Synergy with other facilities (eROSITA,Athena,SKA,SPICA..) is potentially extremely rewarding for AGN science.


Thank You