Euclid
A space mission to study the origin of the accelerating Universe

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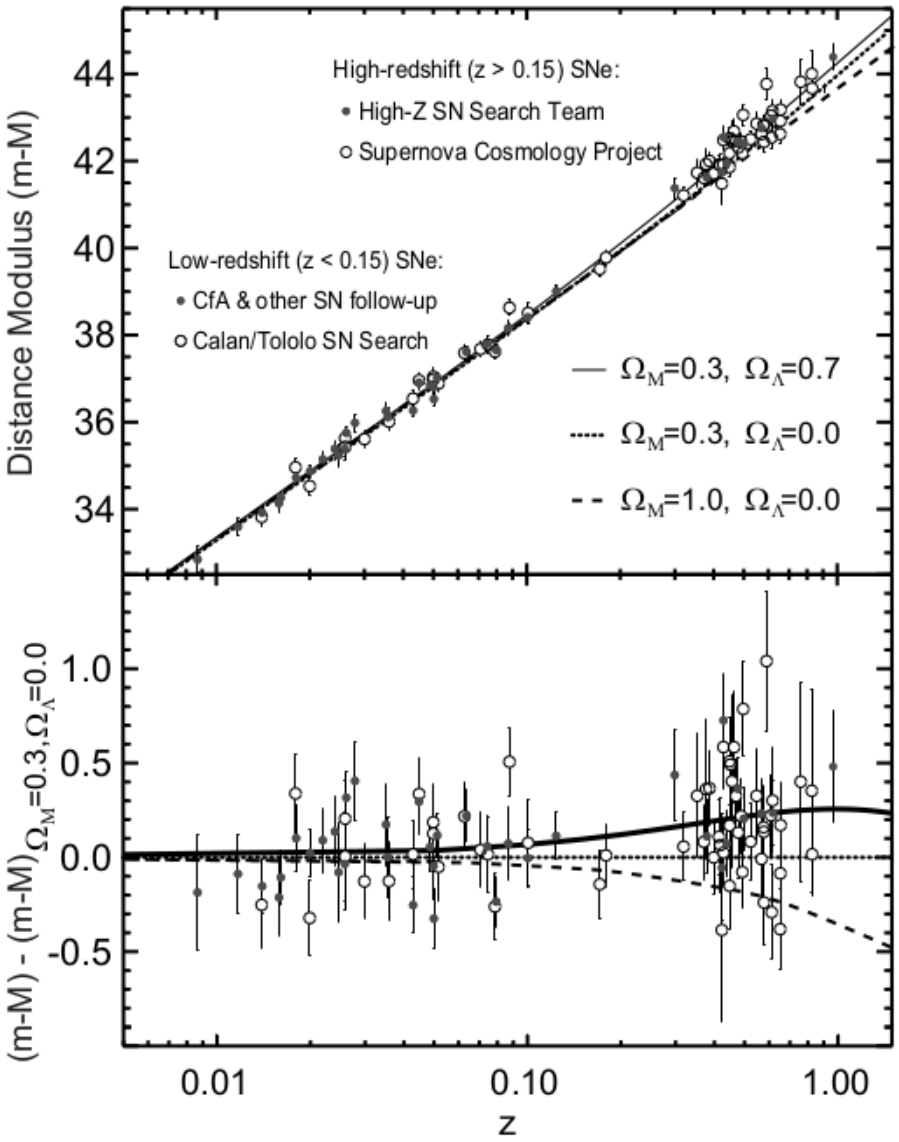
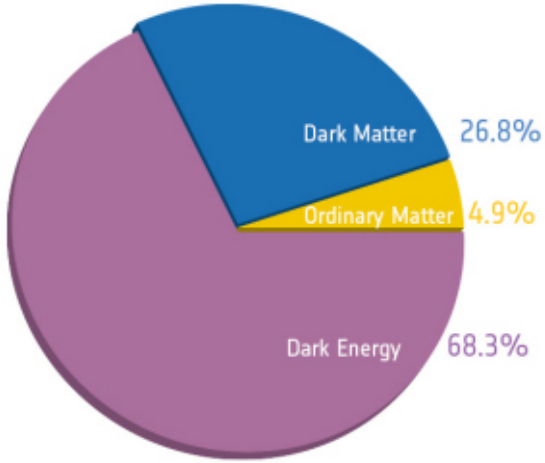
on behalf of the **Euclid Consortium** & **Euclid Italia**

Unveiling the known unknowns



Perlmutter & Schmidt (2003)

- ✓ accelerated expansion of the Universe
- ✓ precise determination of Universe constituents
- ✓ successful (?) model



ESA and the Planck Collaboration

<u>but</u> this unveiled several **known unknowns** (dark energy, dark matter), and possibly even more **unknown unknowns** (GR breakdown)

Key questions

- is **dark energy** merely a *cosmological constant*?
- is it a new kind of field that *evolves dynamically* with the expansion of the Universe?
- is dark energy instead a manifestation of a **breakdown of GR**?
- what are the nature and properties of **dark matter**?
- what are the initial conditions which seed the formation of cosmic structure?

The need of cosmological surveys

Large volumes to probe:

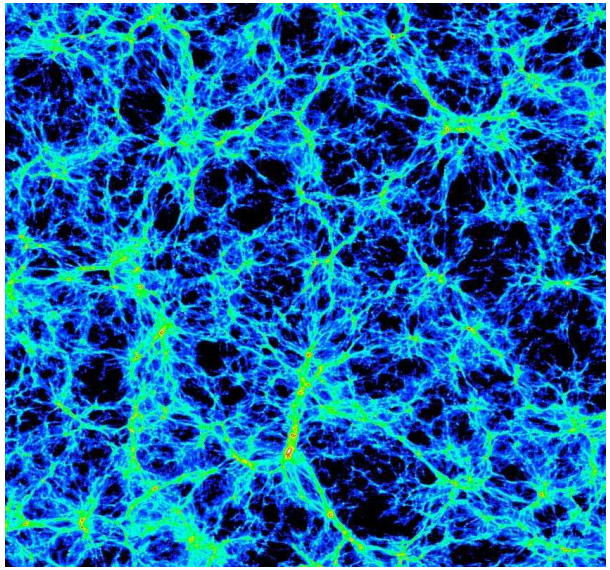
- expansion history of the Universe → geometry, H(z)
- growth of structures → growth rate, *f*(z)

Two missions for Cosmic Vision proposals (2007-2008)

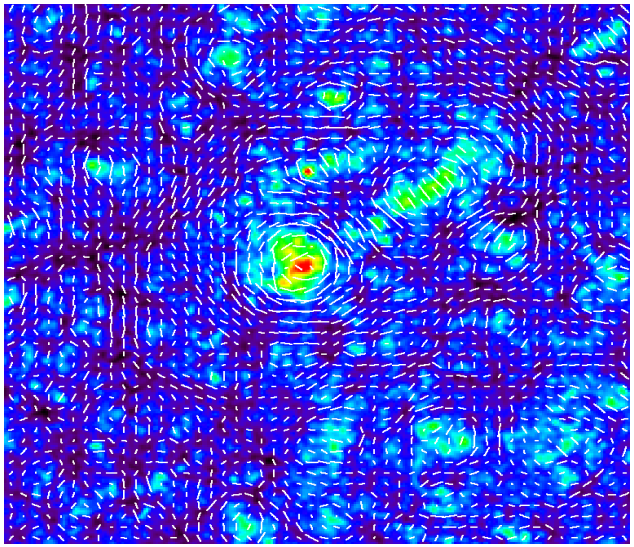
SPACE (PI Cimatti)

DUNE (PI Refregier)

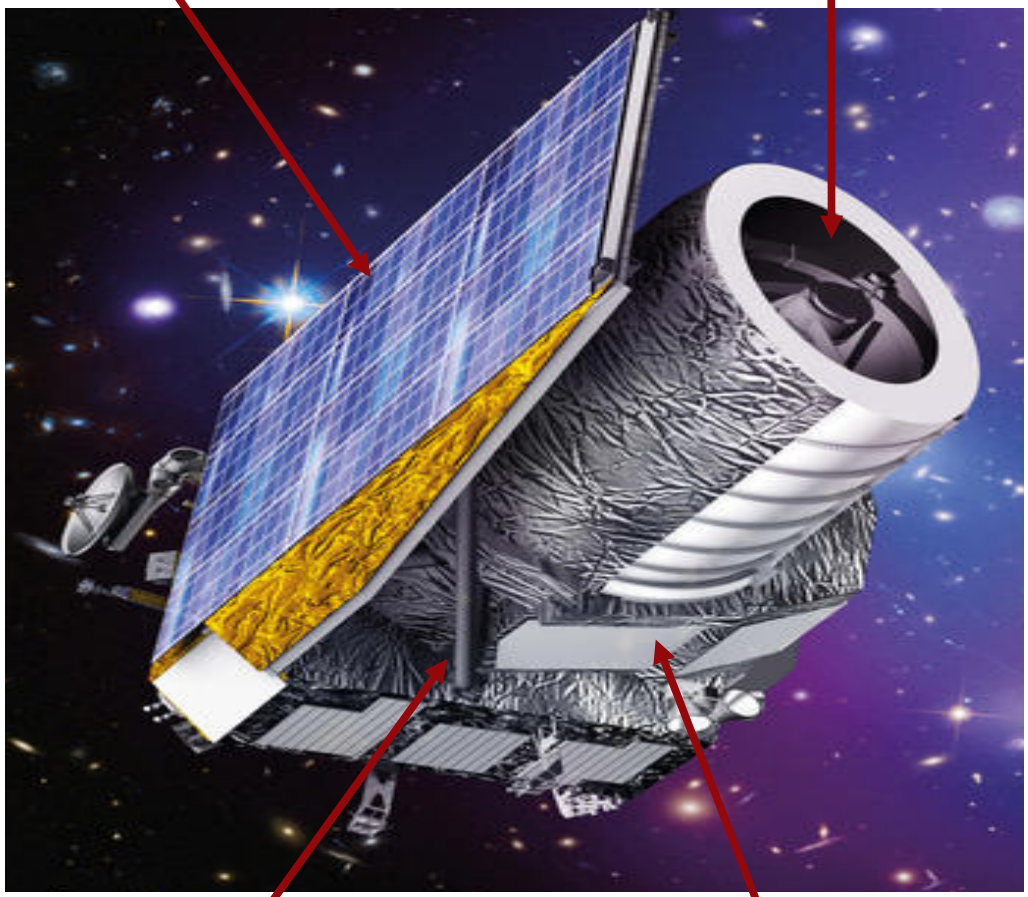
Galaxy clustering (BAO and RSD)



Weak gravitational lensing



ESA Euclid mission



Cosmic Vision 2015-2025
Medium-class mission (M2)

- 2008 – 2009: Assessment Phase
- 2010 – 2011: Definition Phase
- 2012: Adoption by ESA
- **2015: PDR → construction**
- 2021: launch (Soyuz, L2 orbit)
- Survey duration: 6 years

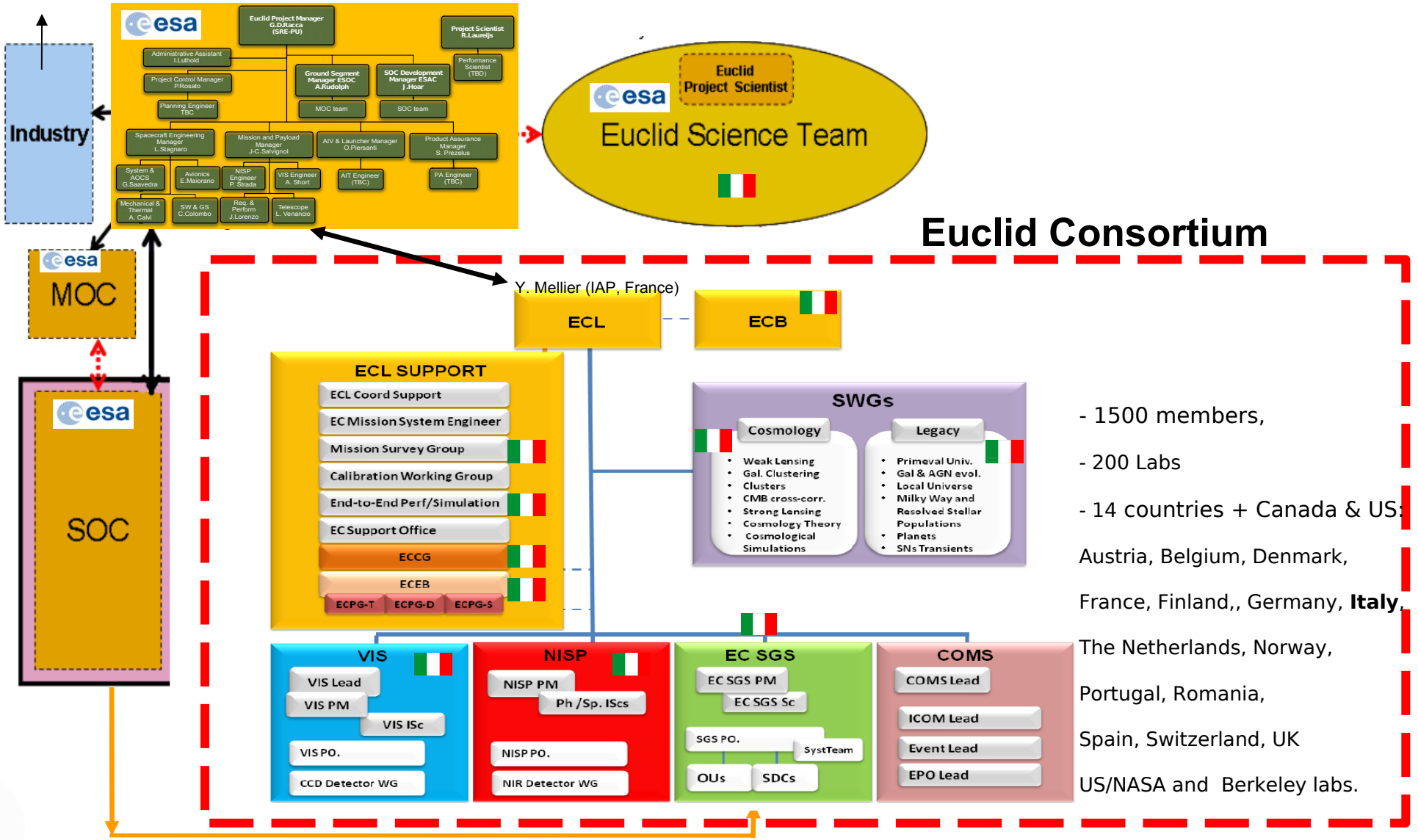
Partners: ESA + Euclid Consortium

The mission

Euclid structure

TAS : Prime Contractor
Airbus Defense & Space : payload module subcontractor

http://www.euclid-ec.org/



- 1500 members,
- 200 Labs
- 14 countries + Canada & US:

Austria, Belgium, Denmark, France, Finland,, Germany, **Italy**, The Netherlands, Norway, Portugal, Romania, Spain, Switzerland, UK US/NASA and Berkeley labs.

Imaging (VIS)

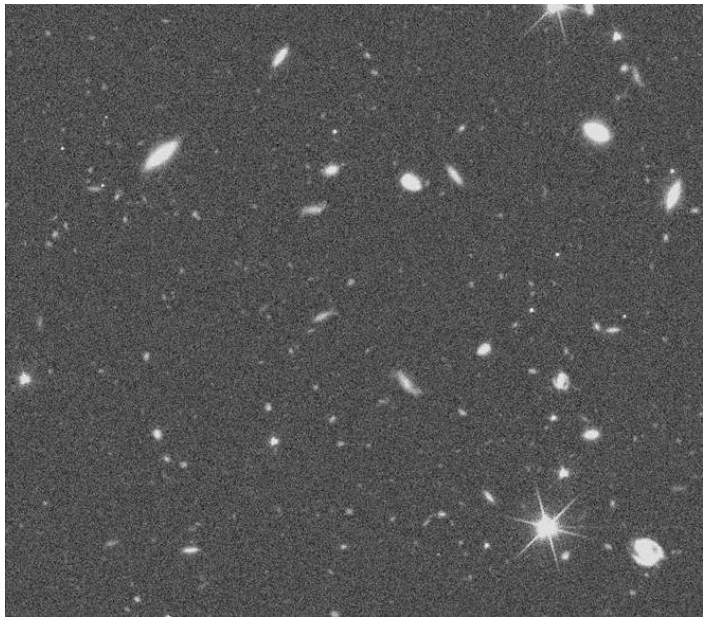
36 4kx4k E2V CCDs

FoV = 0.57 deg^2

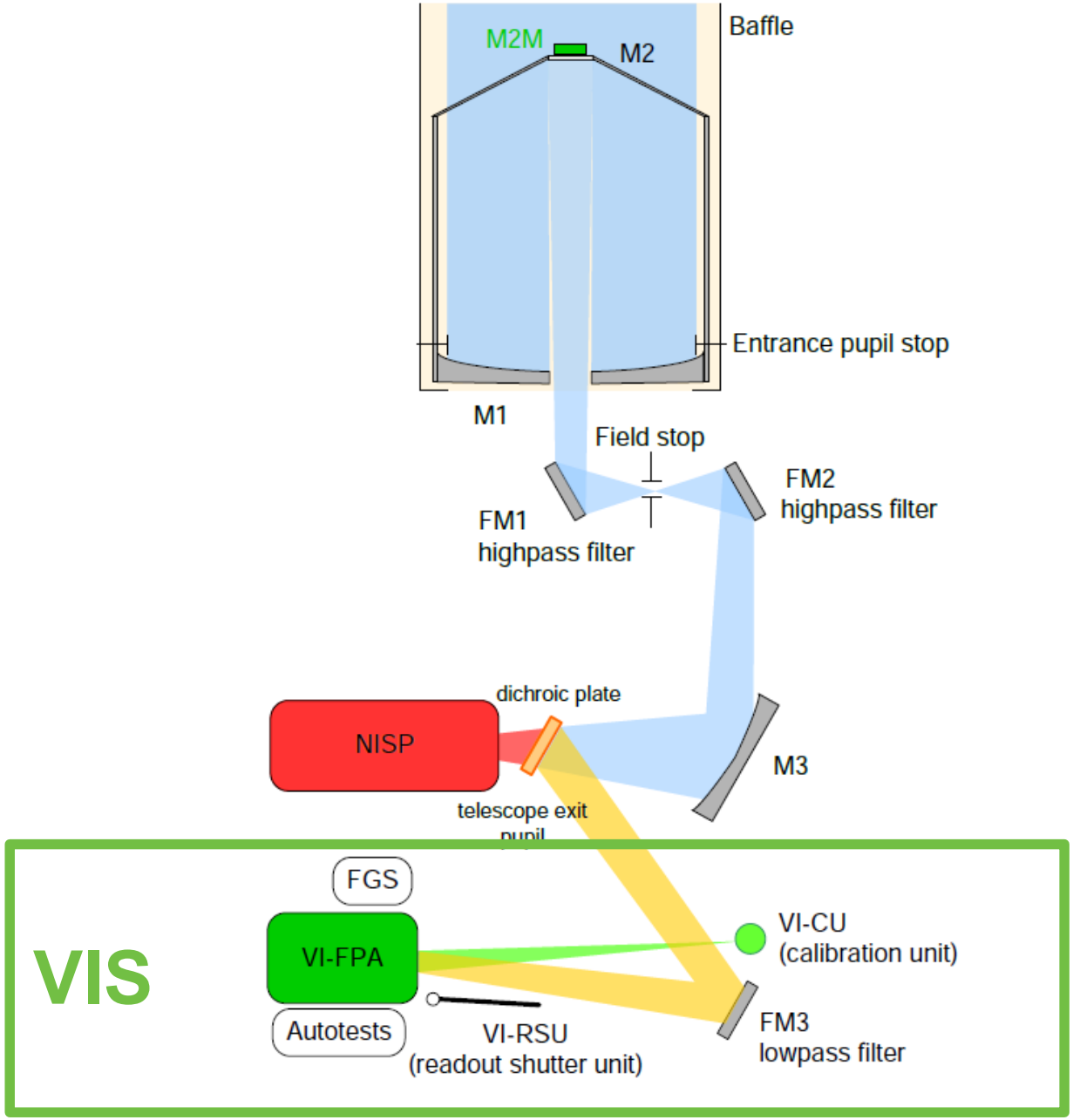
1 pixel = 12 μm = 0.1''

RIZ filter (0.55-0.92 μm)

mag_{lim} = 24.5 (AB) (10σ) (Wide)

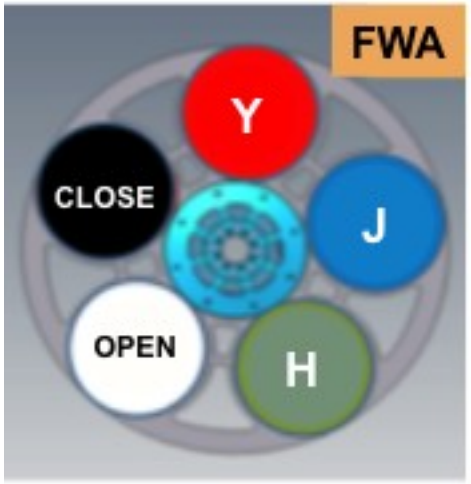


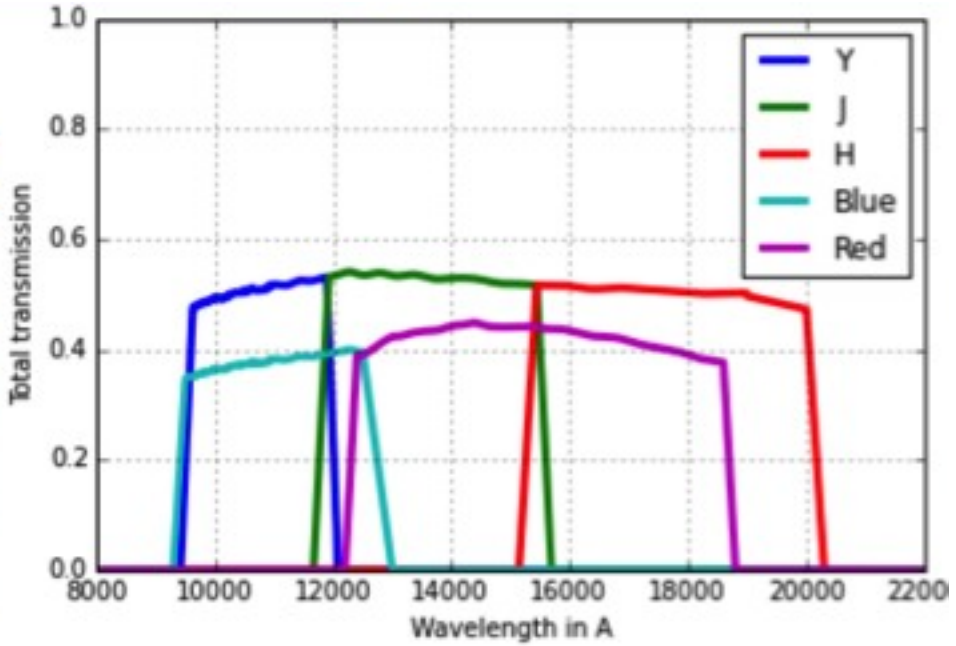
High-resolution images (VIS Team)



Imaging (NIR)

NISP-P

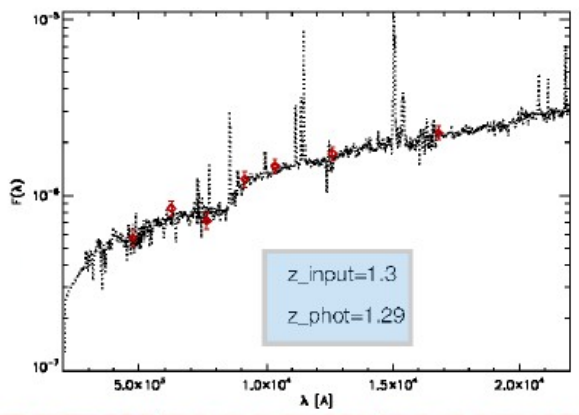


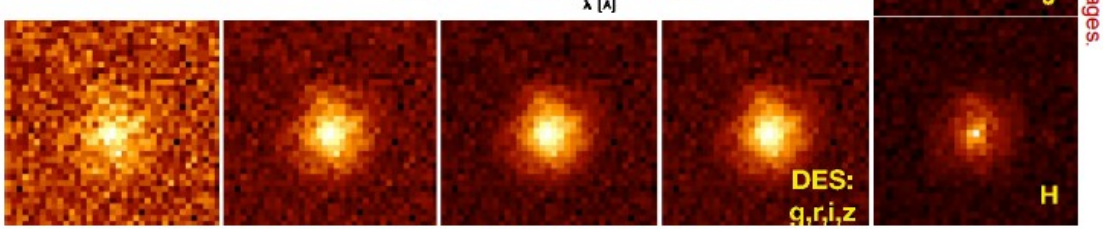


16 2kx2k H2RG HgCdTe detectors
0.3'' pixel
FoV = 0.53 deg^2

Filters: Y, J, H
mag_{lim} = 24.0 (AB) (5σ) (Wide Survey)

Requirements:
accuracy = 0.05x(1+z)





Visible data obtained from ground based telescopes

NIR slitless spectroscopy

3 grisms 1.25–1.85 μm at 3 different orientations

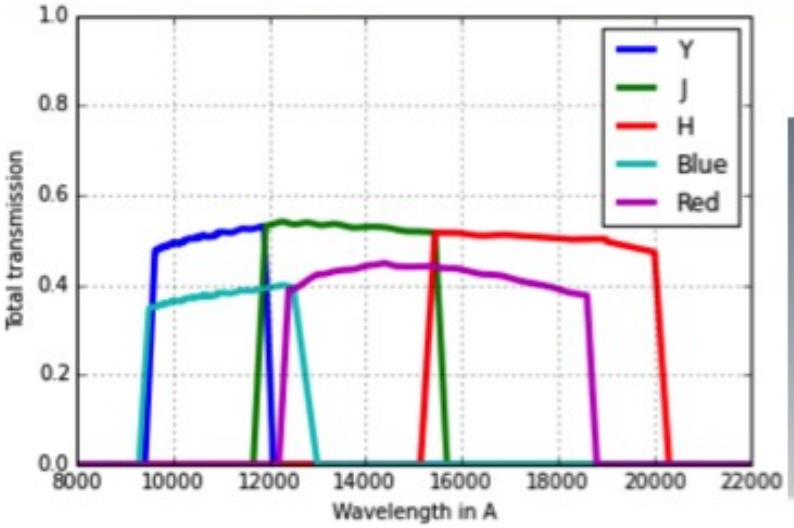
1 grism 0.92–1.25 μm in Deep Survey

$\lambda/\Delta\lambda$ ~380 (for a 0.5'' source)

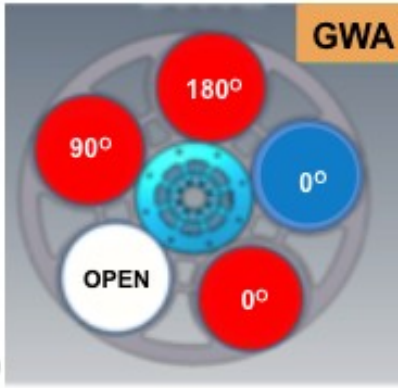
Line limiting flux ~ 2×10^{-16} ergs cm^{-2} s^{-1} (Wide Survey)

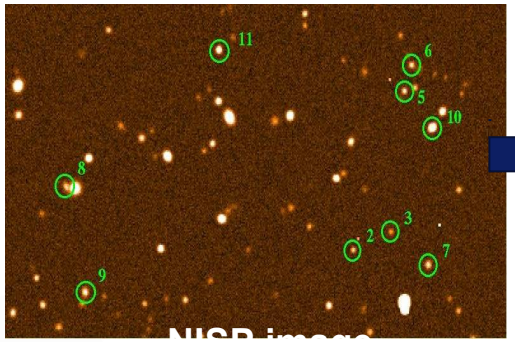
Continuum limiting mag H~19.5 (AB) (Wide Survey)

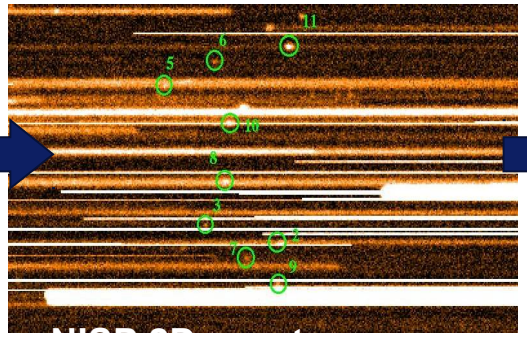
Mostly Hα emission at 0.7 < z < 1.8

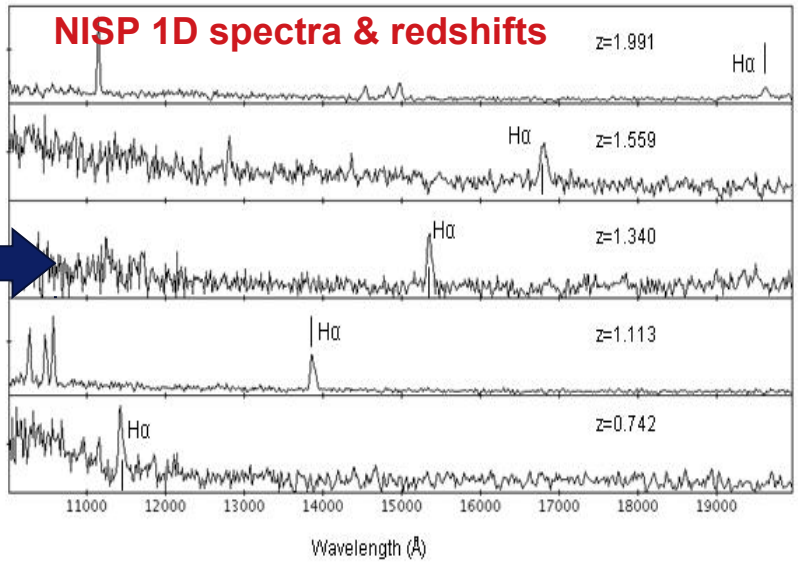


NISP-S

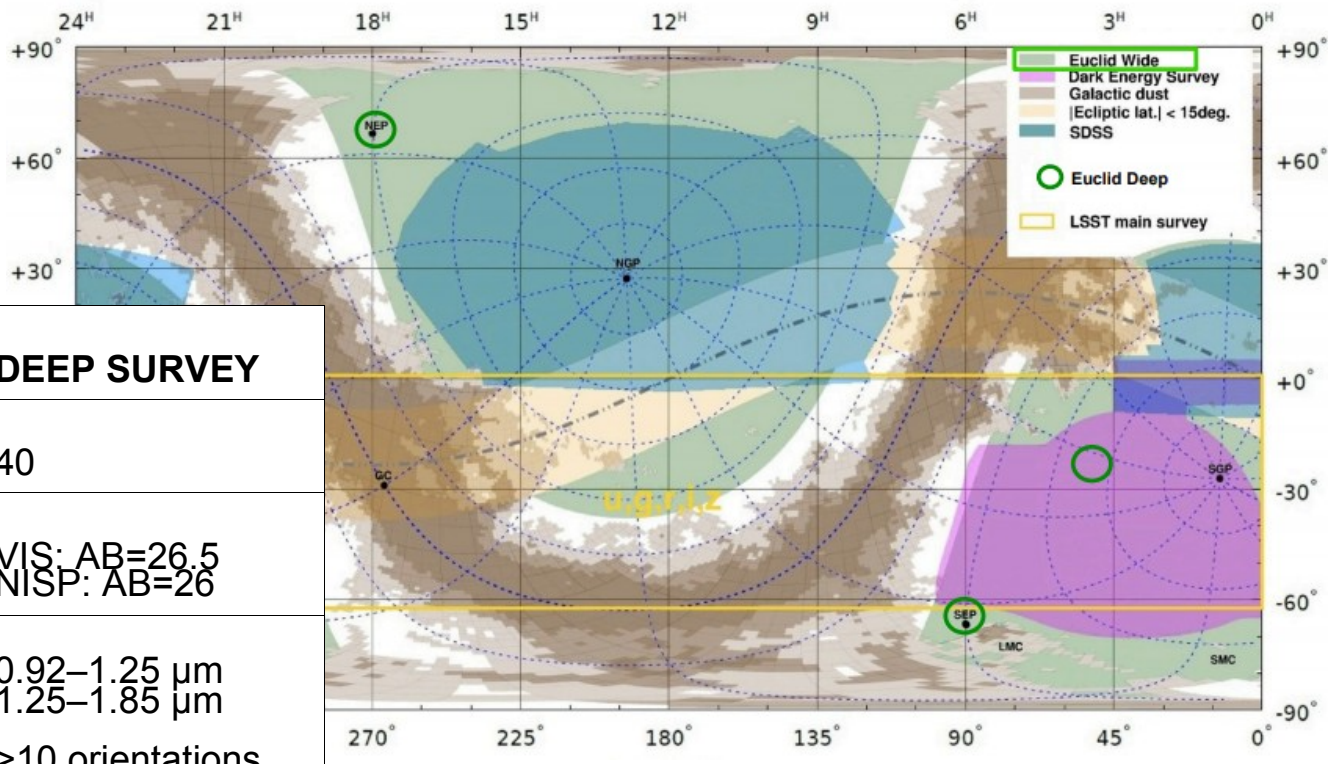








Euclid surveys



J.-C. Cuillandre and the Survey WG

	WIDE SURVEY	DEEP SURVEY
AREA deg²	15,000	40
IMAGING	VIS: AB=24.5 NISP: AB=24	VIS: AB=26.5 NISP: AB=26
SPECTRO	1.25–1.85 μm 3 orientations F(line)>2×10^{-16} cgs H ~ 19.5 (AB)	0.92–1.25 μm 1.25–1.85 μm >10 orientations F(line)>6×10^{-17} cgs H ~ 21.5 (AB)

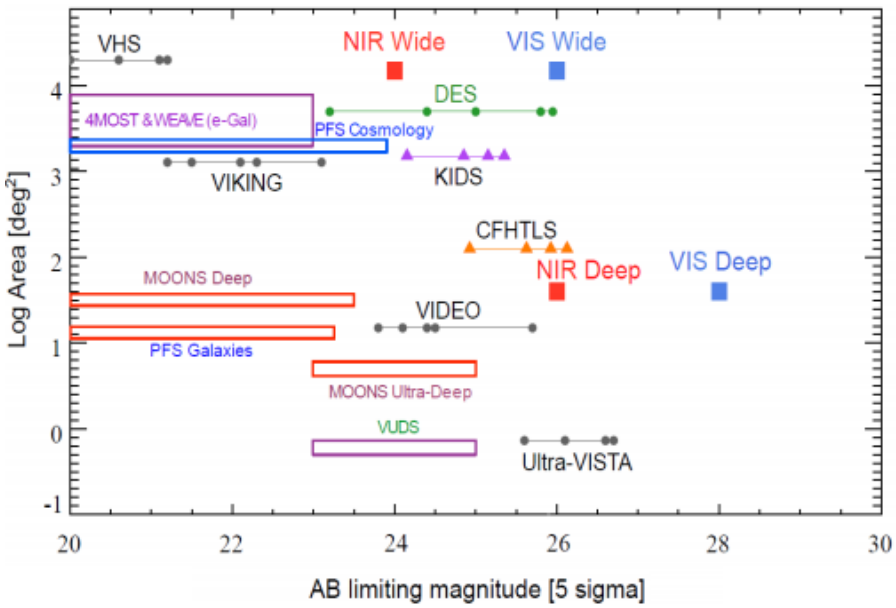
Wide Survey (**15,000 deg²** in ~5.5 years)

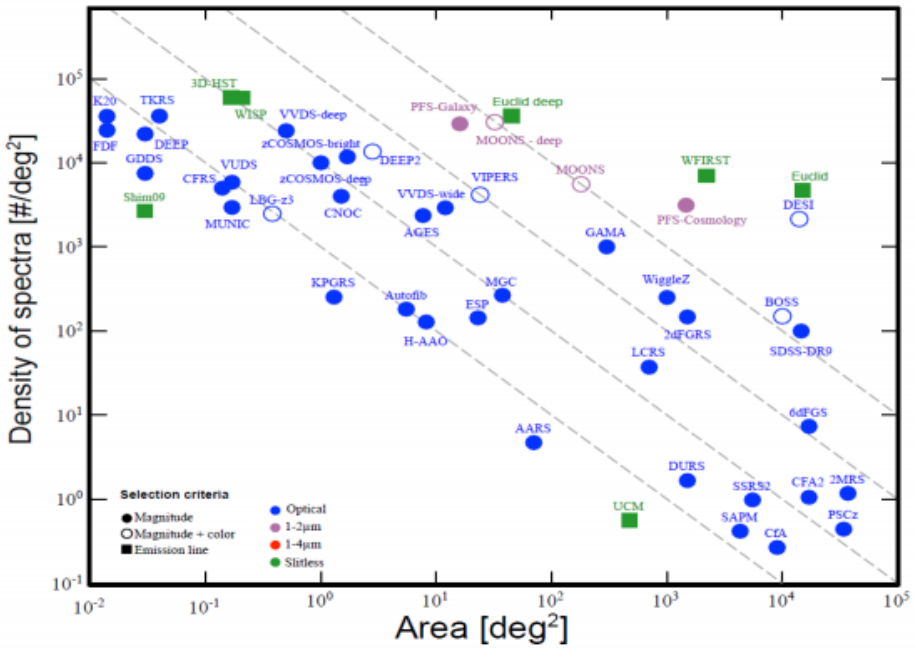
→ **1.5 billion** galaxies with images, SEDs, photo-z

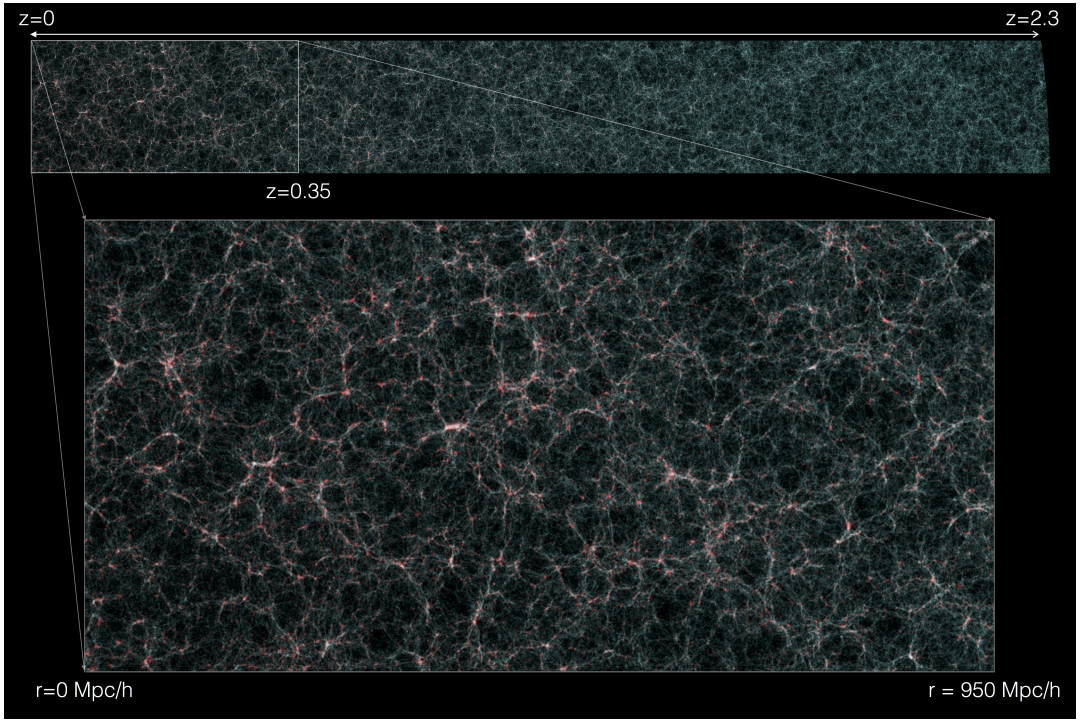
→ **35 million** galaxies with spectra and spectro-z

Deep Survey (**40 deg²**, 2 mag deeper, + bluer grism, several grism orientations)

Putting Euclid in the context







Largest simulations to-date
needed to assess performances

Euclid Flagship mock galaxy catalogue
2 Trillion particles N body simulation down to z=0
100+ redshift slices
(Cosmological Simulations WG)

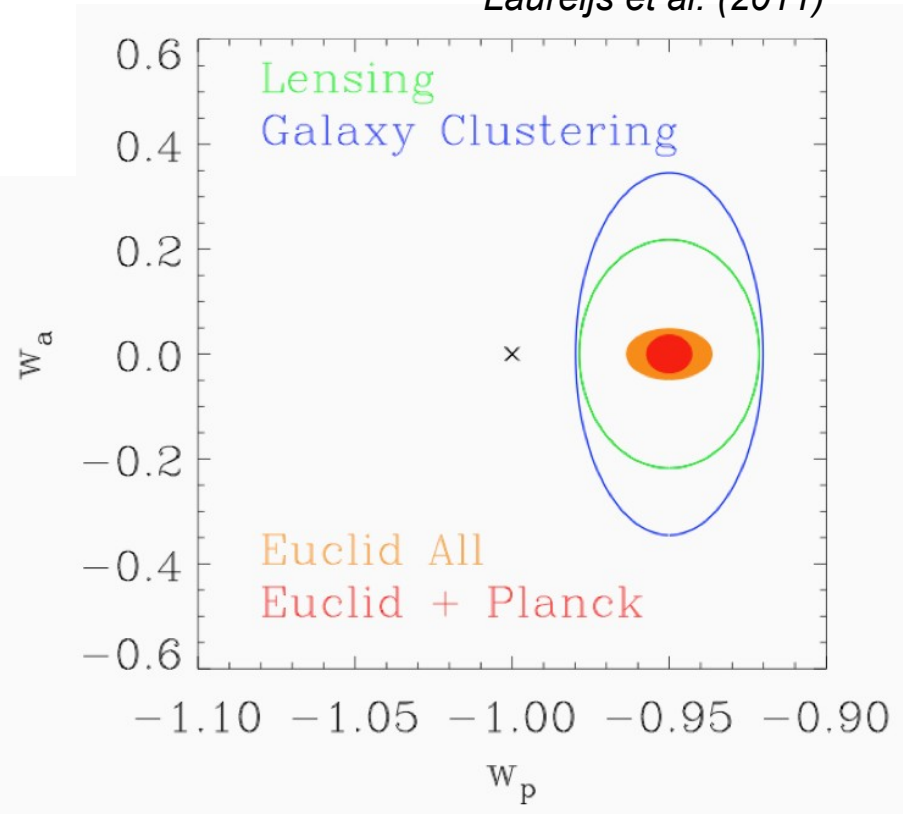
The science

Main cosmological probes

Complementarity between probes is the key

Galaxy clustering
+
Weak lensing

Laureijs et al. (2011)



- Keep systematics under control
- Maximize accuracy and scientific return
- Break degeneracy between parameters
- Strong synergy with CMB analysis (Planck)

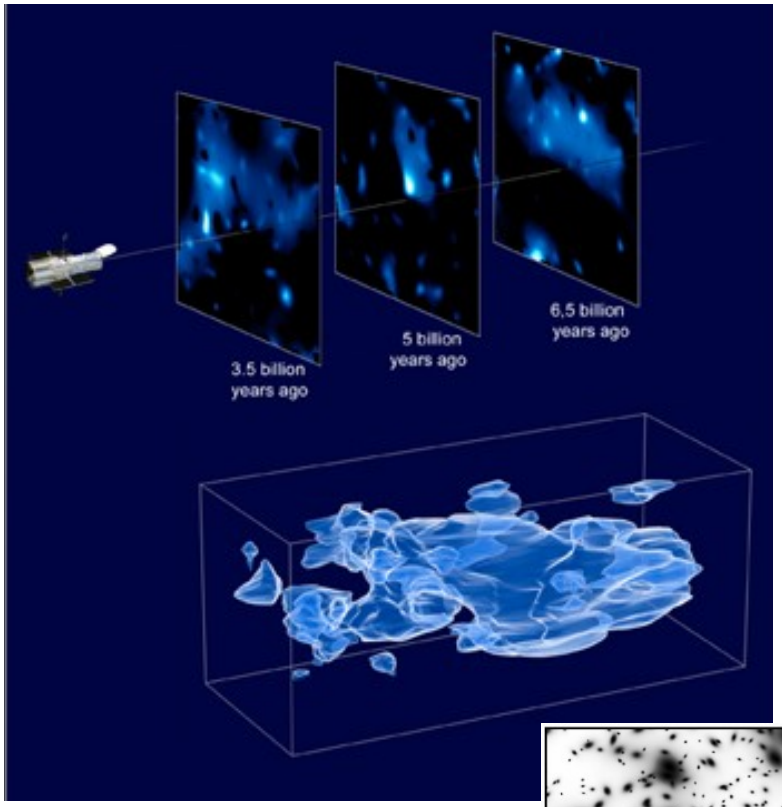
Weak lensing

Cosmic shear over 0<z<2

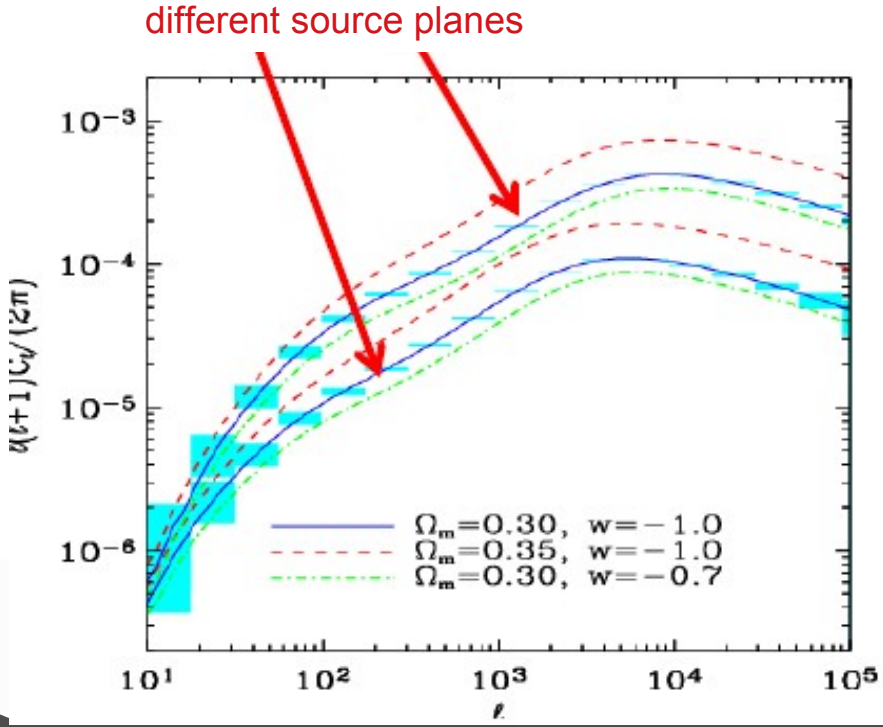
1.5 billion galaxies shapes, shear and phot-z (u,g,r,i,z,Y,J,H)

0.05 (1+z) accuracy over 15,000 deg^2

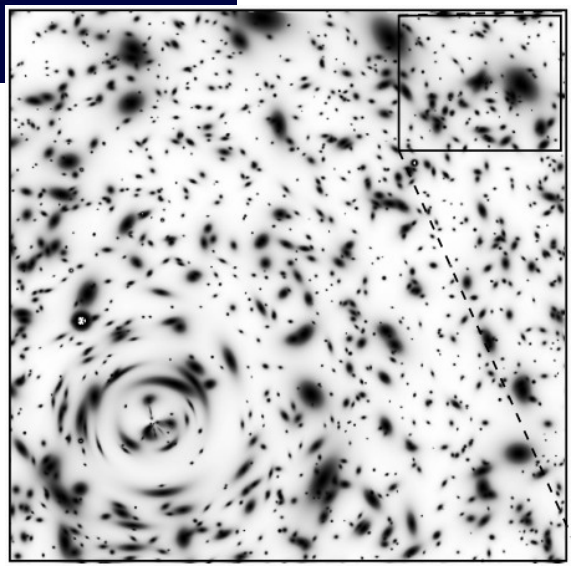
requirements
- high-quality imaging (VIS)
- high-quality photo-z (NISP+ground)
- control of systematics



ESA



ellipticity
↕
local shear



from Y. Mellier

Galaxy clustering

3-D positions of galaxies over 0.7<z<1.8 :

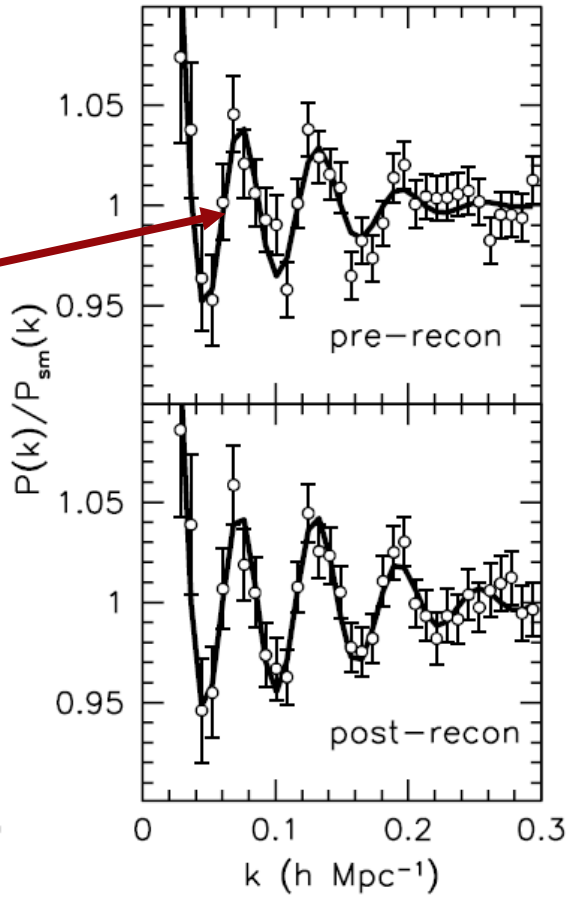
35 million spectroscopic redshifts

0.001 (1+z) accuracy over 15,000 deg^2

requirements
- accurate redshifts
- wide redshift range
- large volume
- large sample

Power spectrum P(k)

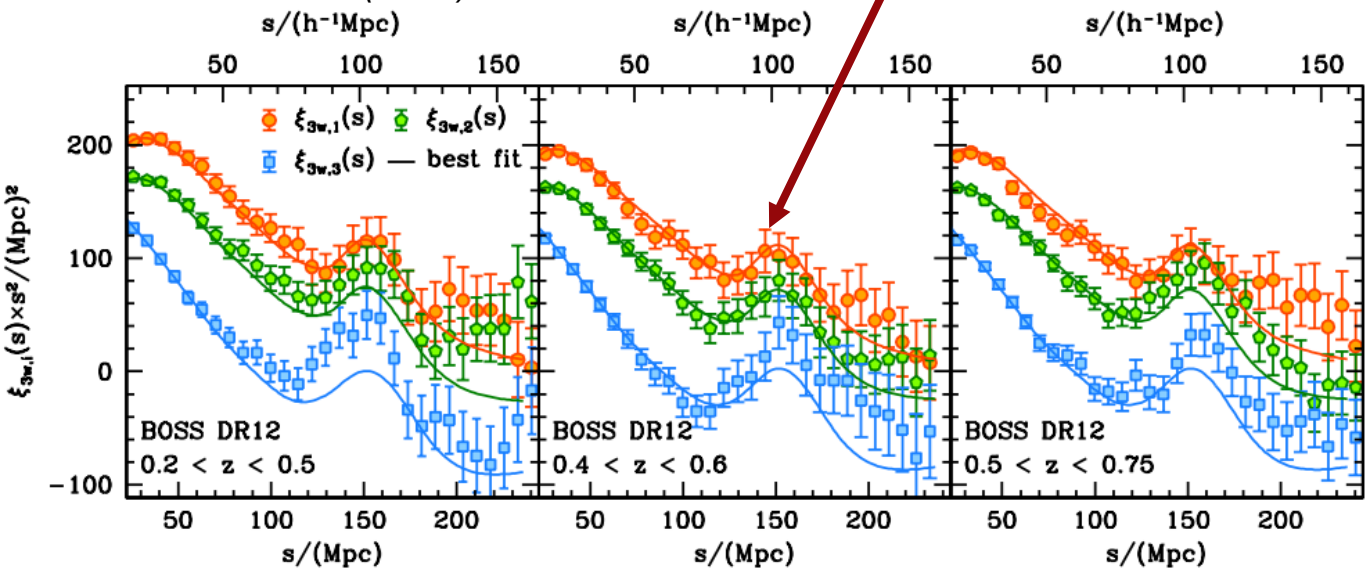
Anderson et al. (2014)



BAO imprint

Correlation function ξ(r)

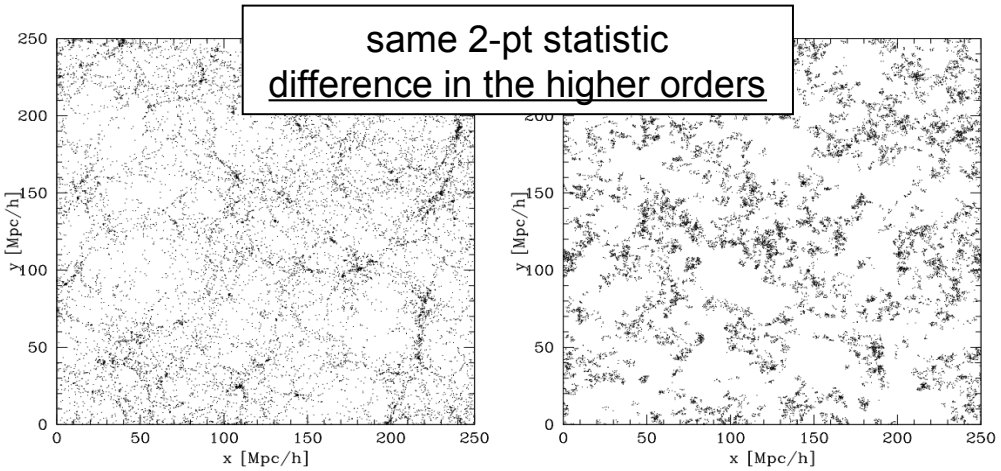
Sanchez et al. (2016)



Additional probes

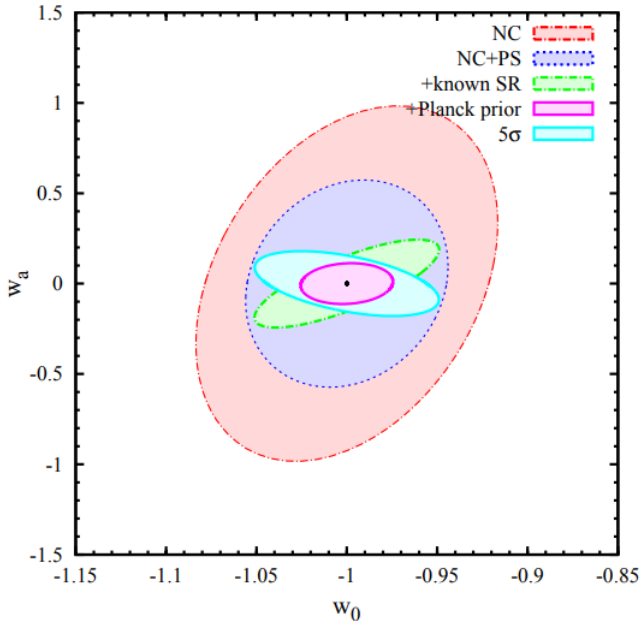
Higher order correlation functions

Bispectrum and three-point correlation function allows to exploit additional information



Sefusatti & Scoccimarro (2005)

Sartoris et al. (2015)



Cluster of galaxies

Several hundreds at 1<z<2, probes of growth of structures and DE
DM mapping and halo density profiles

Integrated Sachs-Wolfe effect

Correlation of LSS with CMB sensitive to growth and DE

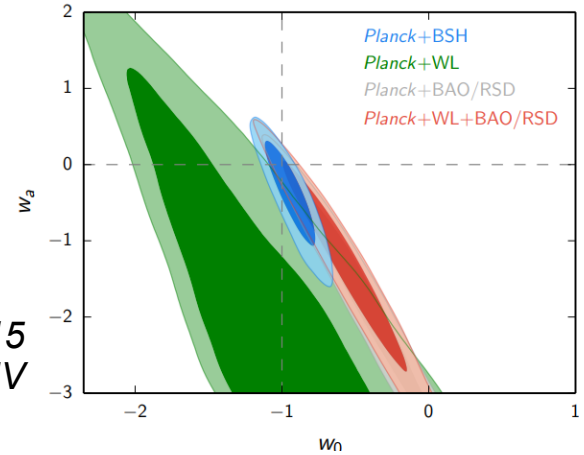
Euclid impact on cosmology

Dark energy EoS parametrization

$$w(z) = w_0 + w_a \frac{z}{1+z}$$

Figure of merit

$$FoM = \frac{1}{\Delta w_0 \, \Delta w_a}$$

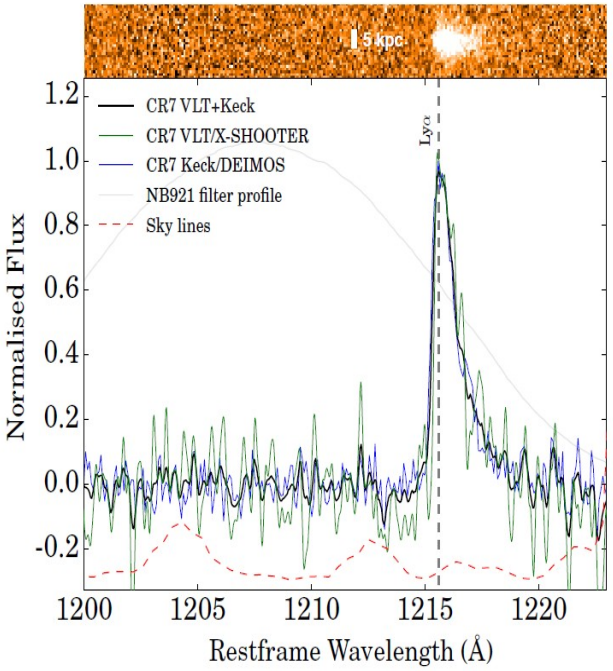


Planck 2015 XIV

	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**

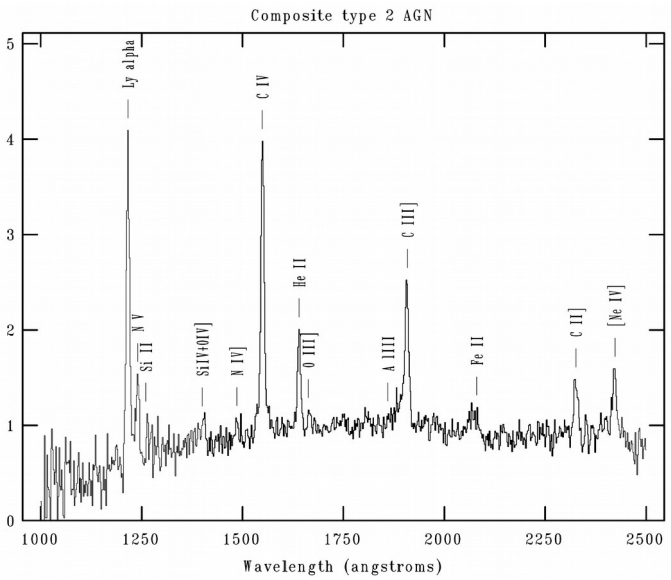
Laureijs et al. (2011)

Deep survey and legacy science

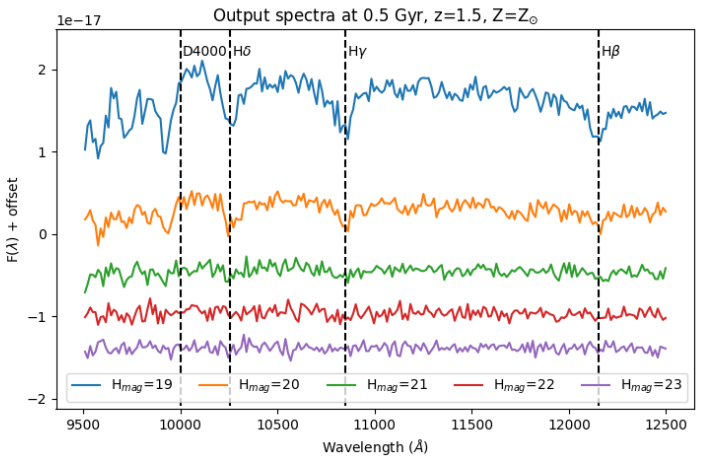


Sobral et al. (2015)
Hu et al. (2016)
Bagley et al. (2017)
Hu et al. (2017)

Mignoli et al. (2017)

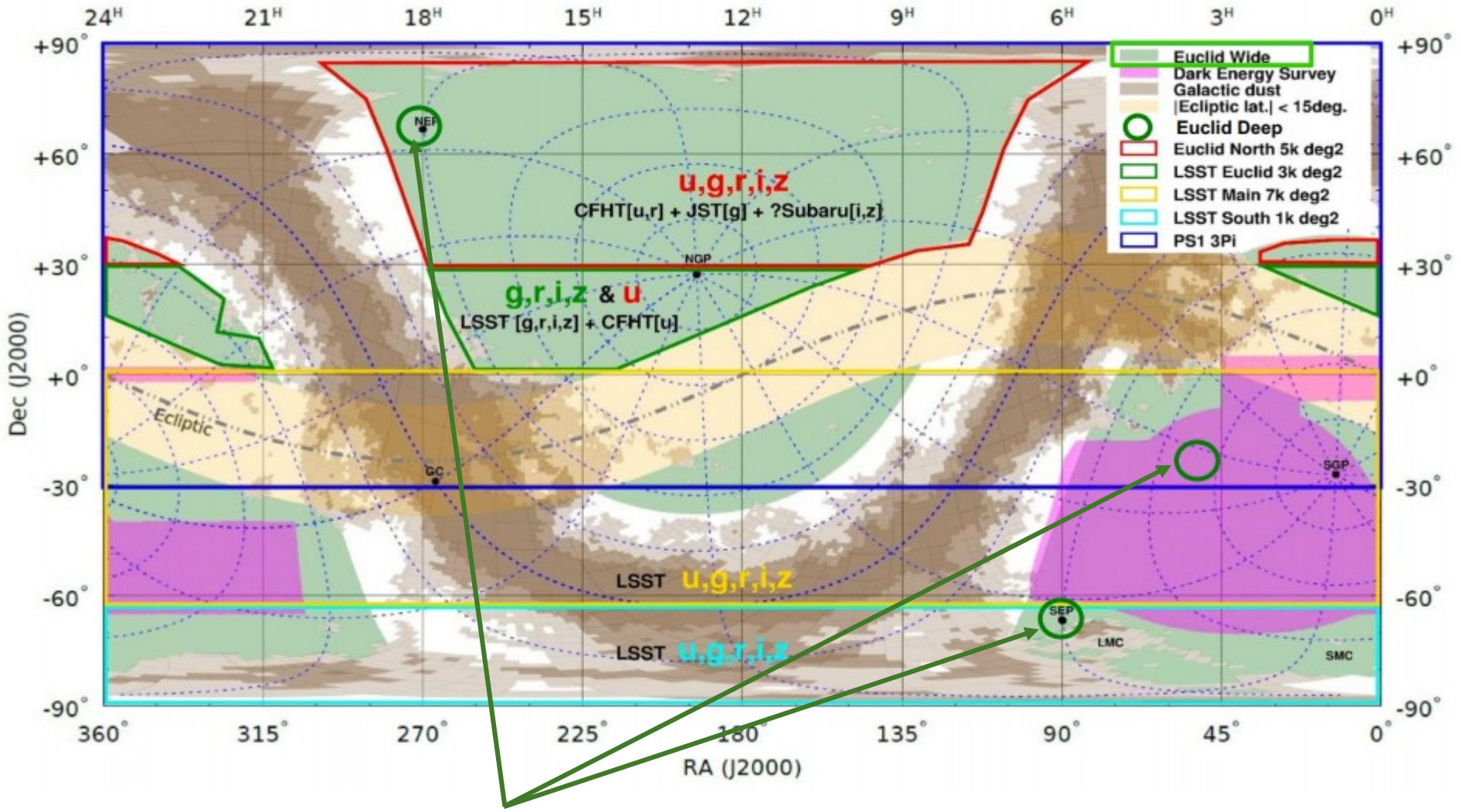


Tranin, Cimatti, Moresco, Pozzetti et al. (Blue Grism Working Group)



- Galaxy formation and evolution
- Probing the “cosmic noon”
- High-redshift universe (Lyα emitting galaxies at z>6.5, AGN at z>5)
- Environment and clustering studies. Connection with DM haloes
- Detection of massive and passive galaxies (passive galaxies at 1.4<z<2.3)
- Stellar physics

Synergies with VST

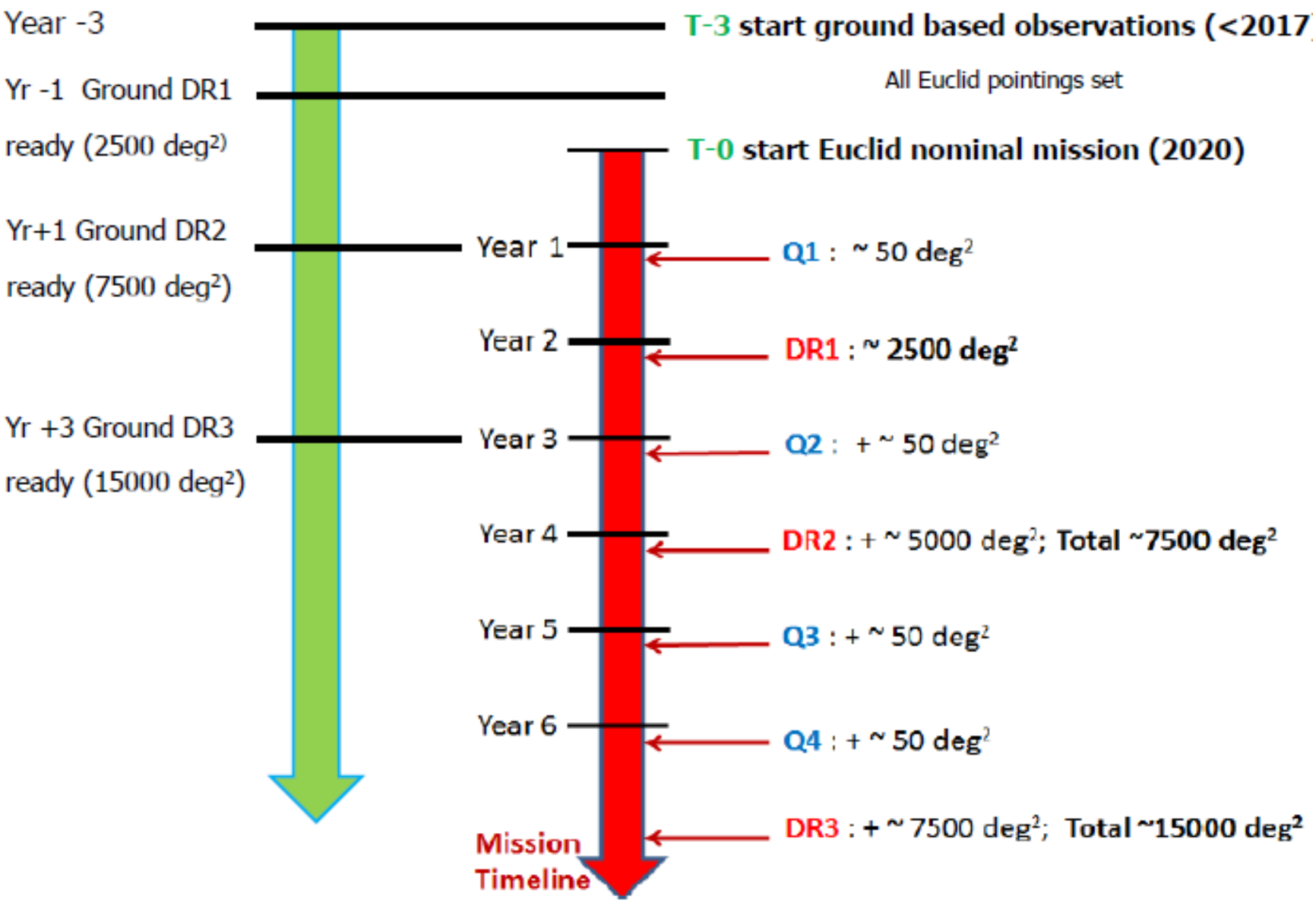


interesting for the Deep Survey (3 fields, tot~40 deg^2)

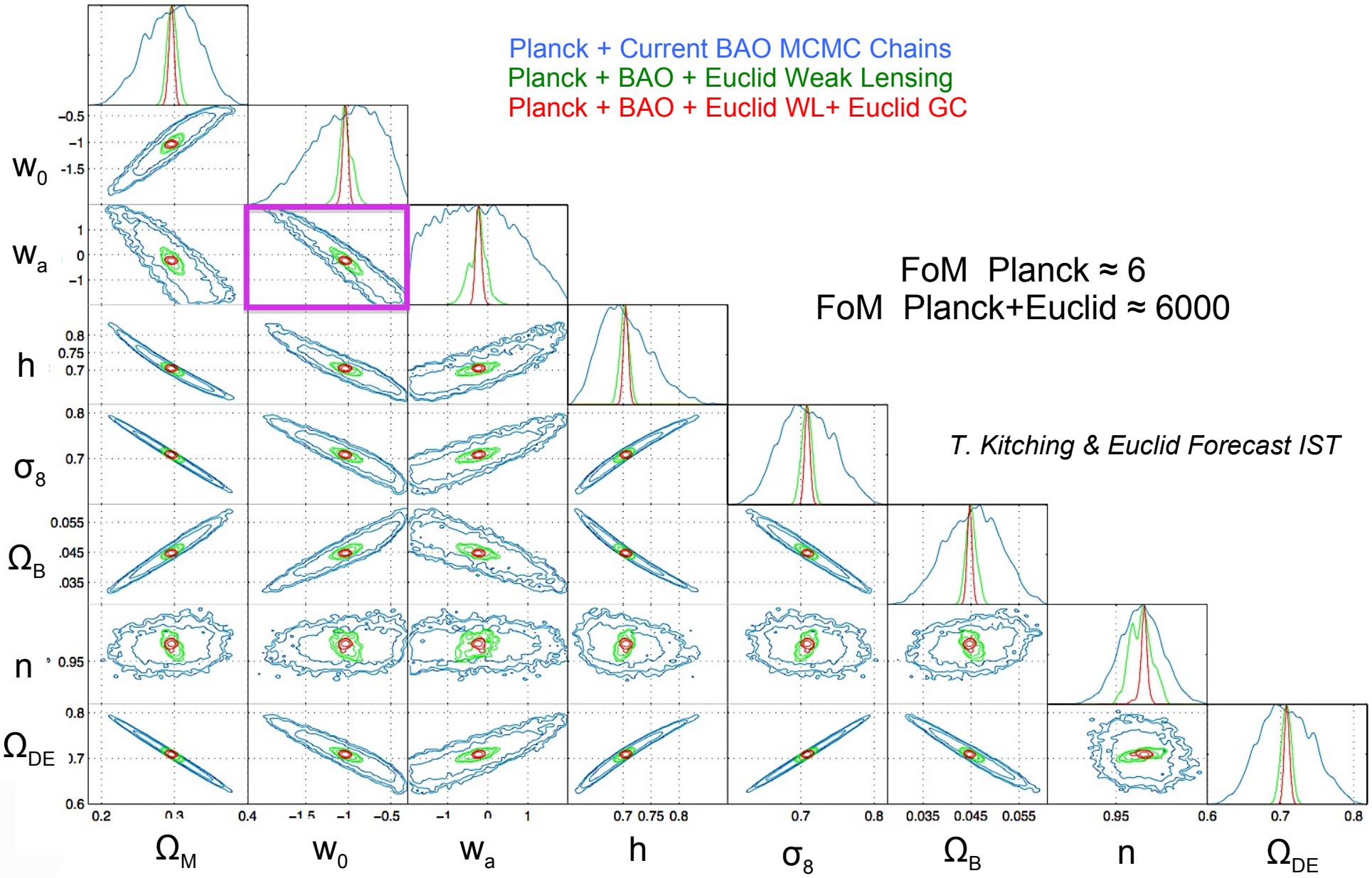
photometric redshifts
SED characterization
galaxy properties

Backup slides

Data releases



Euclid impact on cosmology



Constraints on expansion and growth