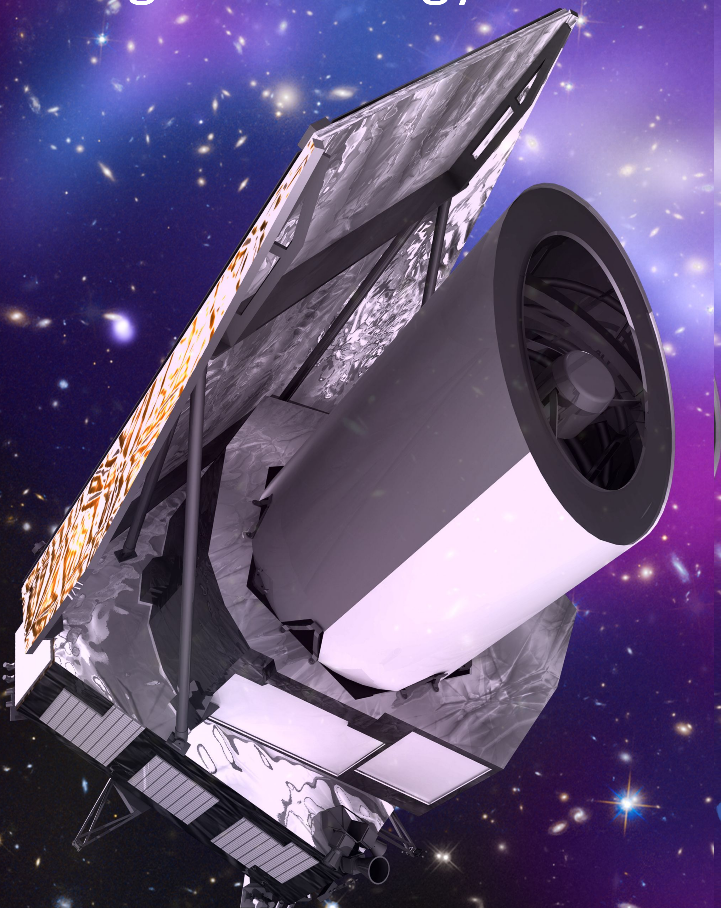
Cosmology with the EUCLID satellite

Mapping the large structures of the Universe
Probing dark energy



A.Ealet (CPPM/IN2P3)
on behalf the Euclid consortium

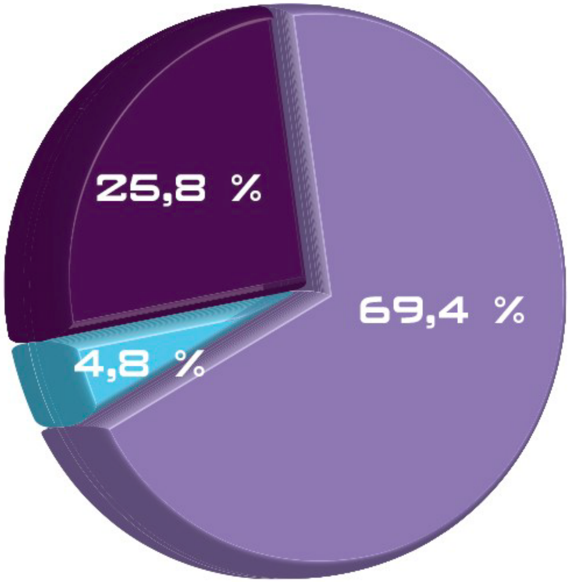
April 25 2017

Pont-2017

The post Planck Universe ΛCDM

Post Planck Universe

- 69.4 % dark energy
- 25.8 % dark matter
- 4.8 % baryons

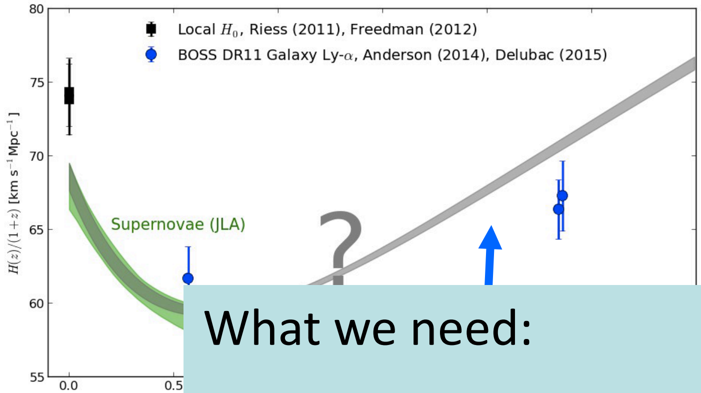


$\Rightarrow$ Confirmation ΛCDM

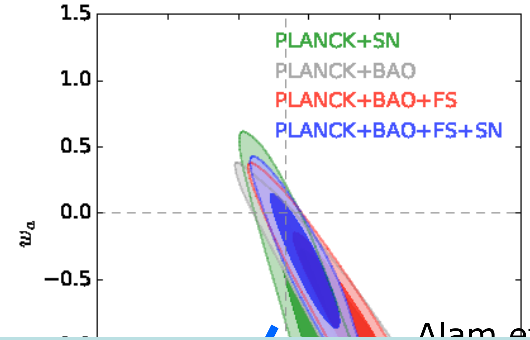
$\Rightarrow$ **Cosmological constant Ω_Λ confirmed by Planck , supernovæ and BAO (baryonic acoustic oscillation)**

$\Rightarrow$ **No indication for a more complex explanation than Ω_Λ, that can explain the acceleration of the expansion of the Universe**

Nature of dark energy…. Where we stand…



No indication
Or no sensitivity?



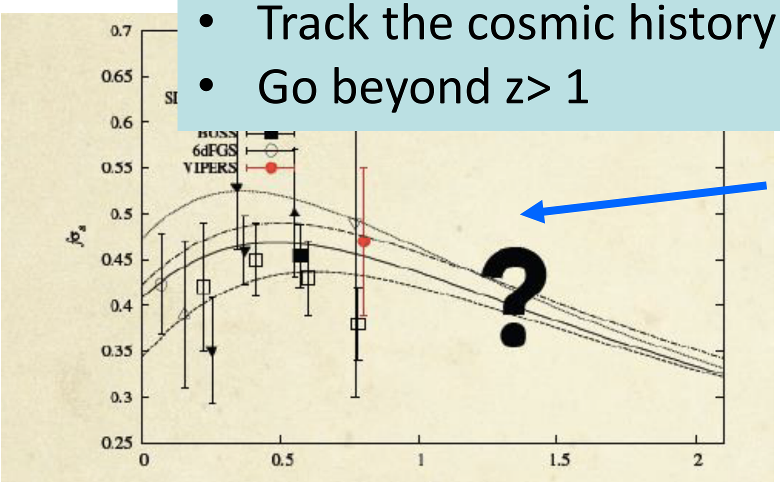
Alam et al 2016

What we need:

- Reduce by 1 order the errors on DE equation of state.
- Test the geometry of the Universe
- Track the cosmic history of structure formation
- Go beyond z> 1

Trans
Accel

– a)



Does gravity self consistent with the accelerated expansion? (modified gravity)

=> Verify that growth of structures consistent with LCDM ?

Exploring the DM/DE transition period : H(z)/D(z)

1

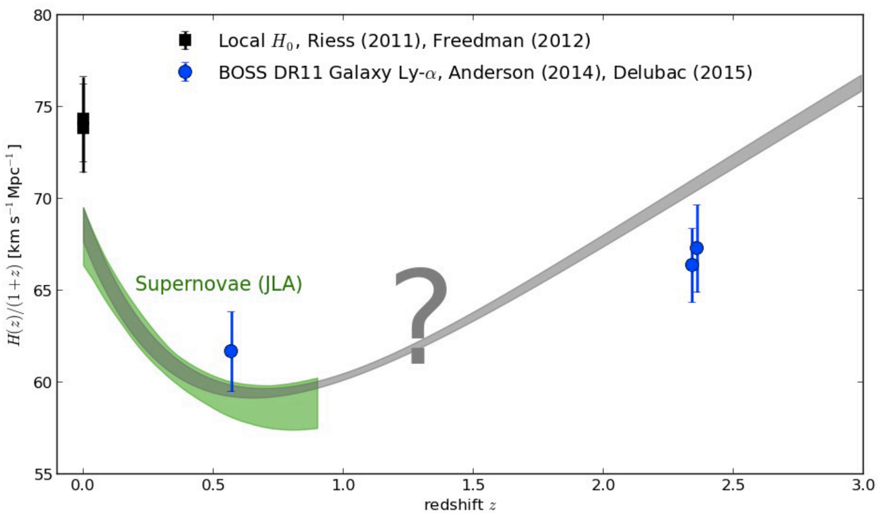
Expansion Rate (BAO):

$$H(z) = H_0 \left[\Omega_M (1+z)^3 + \Omega_{DE} \frac{\rho_{DE}(z)}{\rho_{DE}(0)} + \Omega_K (1+z)^2 \right]^{1/2}$$

2

Distance (SN, BAO, CMB):

$$D(z) = \frac{1}{(|\Omega_K| H_0^2)^{1/2}} S_K \left[(|\Omega_K| H_0^2)^{1/2} \int_0^z \frac{dz'}{H(z')} \right]$$



Euclid: Exploring the cosmic history with structure formation

3

Growth and growth rate (WL, Clusters, RSD):

$$G'' + \left(4 + \frac{H'}{H}\right) G' + \left[3 + \frac{H'}{H} - \frac{3}{2}\Omega_{\mathrm{M}}(z)\right] G = 0$$

$$G = D_1/a \quad ; \quad f = d \ln(D) / d \ln(a)$$

4

Measuring the metrics: use probes that explore the 2 potentials

$$ds^2 = -(1 + 2\psi)\, dt^2 + (1 - 2\phi)\, a^2(t)\, dx^2$$

It is fundamental to have
access to both potentials
To distinguish effects

- Small scalar perturbations:

$$ds^2 = -(1+2\psi)\,dt^2 + (1-2\phi)\,a(t)d\vec{x}^2$$

- Non relativistic particules are sensitive to: ψ
- Relativistic particules are sensitive to: $\psi + \phi$

- Standard GR + no anisotrotic stress: $\psi = \phi$

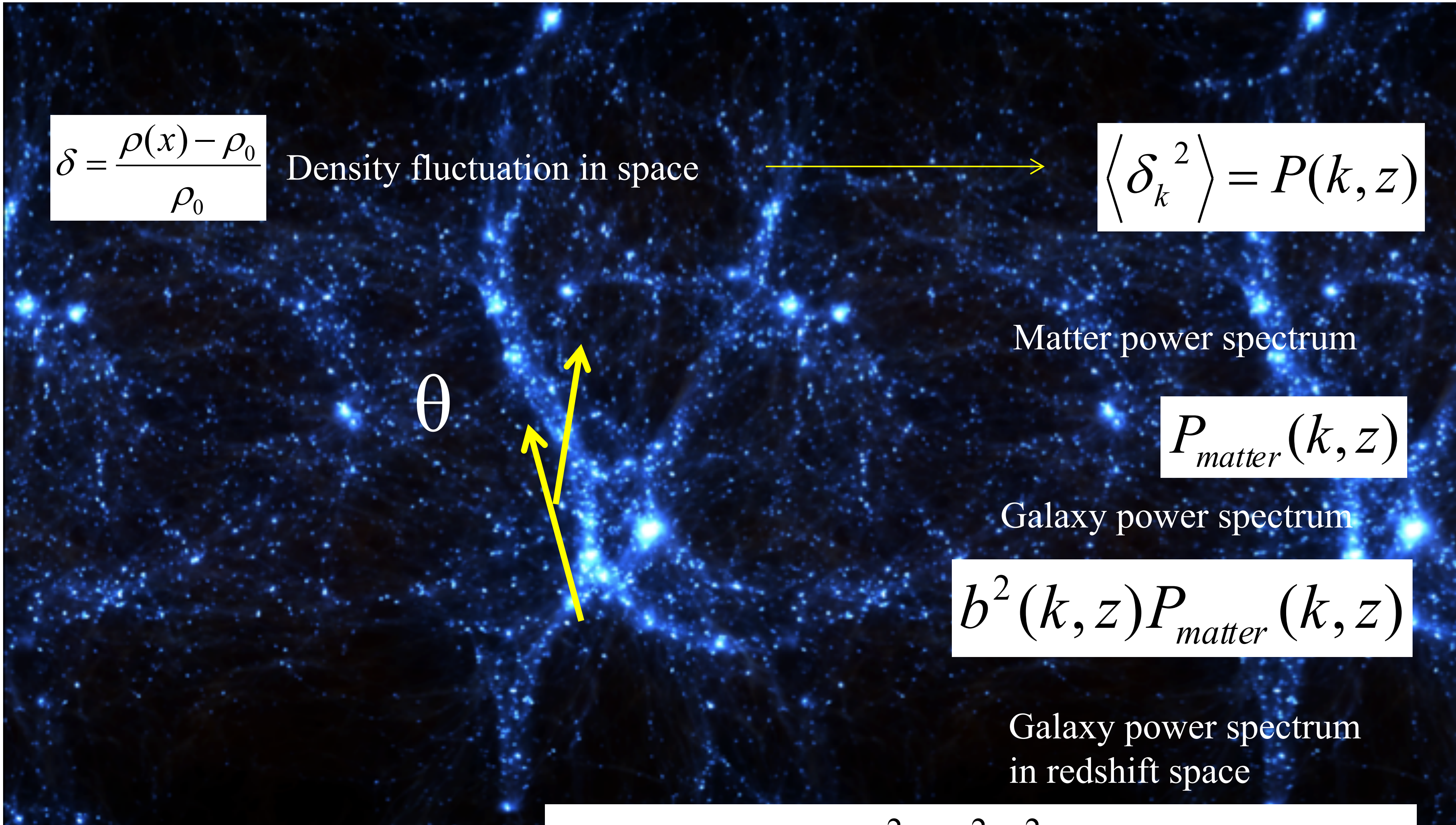
→ Poisson equation $k^2\phi = -4\pi G a^2 \sum \rho_i \Delta_i$

- Modified Gravity or Dynamical DE: $\psi = R\phi$

→ Poisson equation: $k^2\phi = -4\pi G Q a^2 \sum \rho_i \Delta_i$

$Q(k,a)$, $R(k,a)$: imprints on clustering of DM, Gal and DE

Measurements = power spectrum



$$\delta = \frac{\rho(x) - \rho_0}{\rho_0}$$

Density fluctuation in space

$$\left\langle \delta_k^{\;2} \right\rangle = P(k,z)$$

θ

Matter power spectrum

$$P_{matter}(k,z)$$

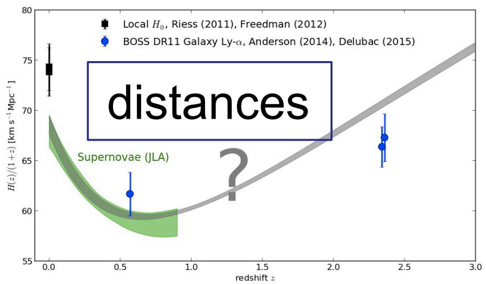
Galaxy power spectrum

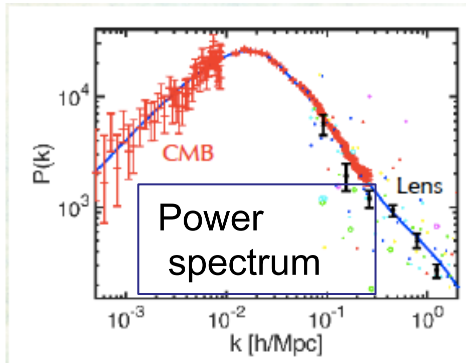
$$b^2(k,z)P_{matter}(k,z)$$

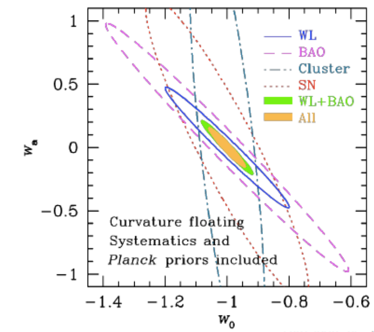
Galaxy power spectrum
in redshift space

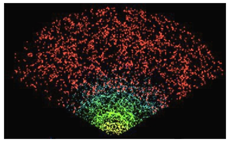
$$(1+\beta(k,z)\cos^2\theta)^2 b^2(k,z)P_{matter}(k,z)$$

A multi probe approach



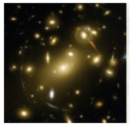






- *Clustering /Large scale structure (LSS) (BA0, RSD…)*
  distance + ordinary matter power spectrum
  + growth of structures (access to ϕ)

Spectroscopy
Redshift survey



- *Weak gravitational shear.*
  distance + dark matter power spectrum,
  growth of structure (access to (ϕ+ψ)

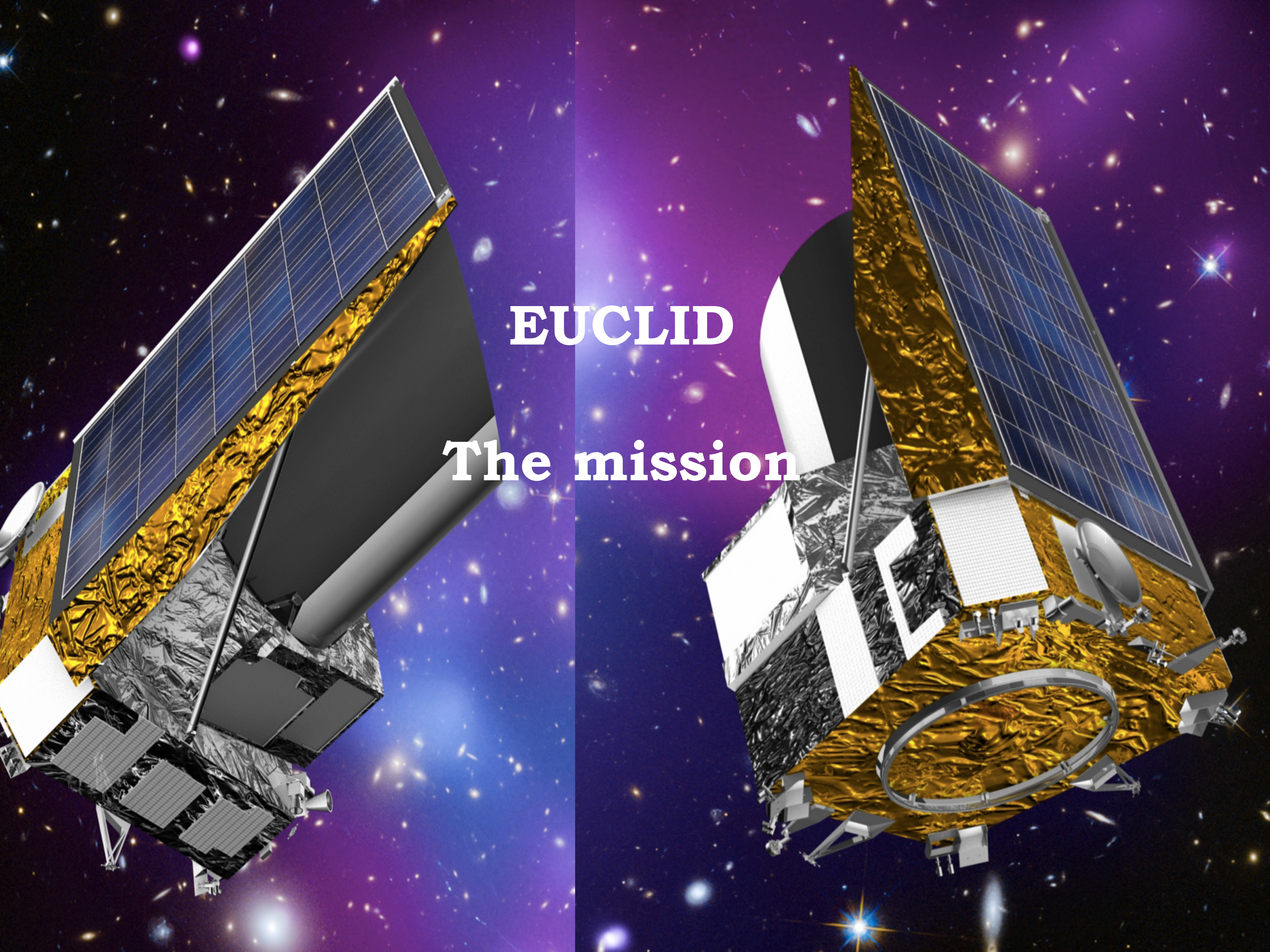
Imaging
Photometry

- *Galaxy cluster / Voids*
  count, power spectrum

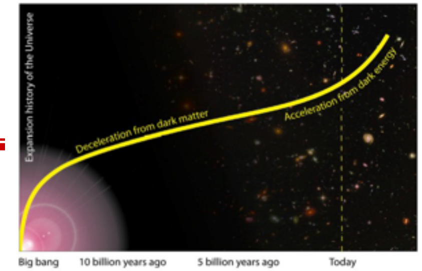
Photometry+
spectroscopy

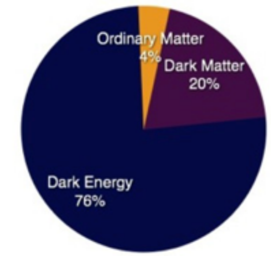
EUCLID

The mission



Euclid objectives





Use one mission and same data to achieve previous objectives

- **Nature of dark energy**
  - Distinguish effects of Λ and dynamical DE: *w(a)* → slices in redshift
  - From Euclid data alone, get FoM=1/(Δw_a x Δw_p) > 400→ ~1% precision on *w*'s.
- **Nature of gravity on cosmological scales**
  - Probe growth of structure → slices in redshift ,
  - **Study of 3 power spectra**: lensing, galaxy, velocity → biasing
  - Separately constrain the potentials (ψ,ϕ) as function of scale and time
  - Distinguish effects of GR from MG models with high confidence level:

    → Absolute 1-σ of 0.02 on the growth index, γ , from Euclid data alone.

    → Use WL and RSD → differently sensitive to ψ and ϕ

Mission objectifs

Goal → -reduce by 1 order the errors on DE equation of state. (FOM GC+WL > 400)

-Test the geometry of the Universe

-Track the cosmic history of structure formation

Method → *Observations of both expension H(z) and growth of structure f(z) on large sky and different epochs*

Key issues → Systematic Errors -> observational strategy, reduction,simulation

→ Interpretation -> analysis, multi probe interpretation

Multi probes →

- Galaxy Clustering : BAO, RSD, growth of structure
- Weak Lensing : growth of structure
- Cluster counts /voids .....
- Supernovae : standard candle

Euclid strategy and space

Strategy: use a multi probes approach sensitive to H(z) and f(z)

⇒ Reduce statistical errors by a full sky coverage
  ⇒ wide field instruments
  ⇒ Same survey, same data, better control of all errors.

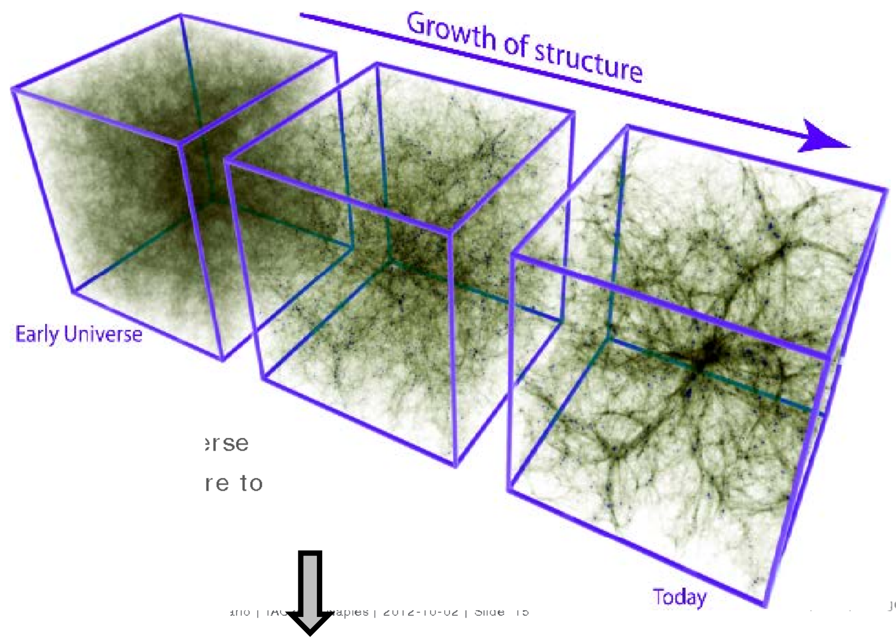
⇒ Control systematic errors using space advantages :

  ⇒ High image quality
  ⇒ Ultra High PSF stability over 6 years
  ⇒ Infrared access to redshift > 1
  ⇒ Low sky background (1000 less than ground)

(Doing the same observation on VLT/VISTA than Euclid would have taken 640 years)

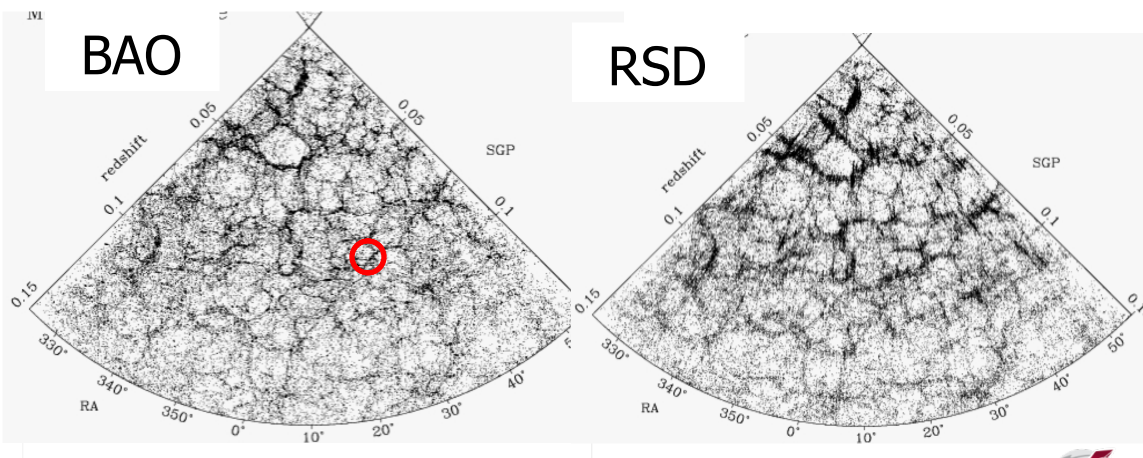
Primary: Galaxy Clustering: BAO + RSD

- 3-D position measurements of galaxies over 0.9<z<2



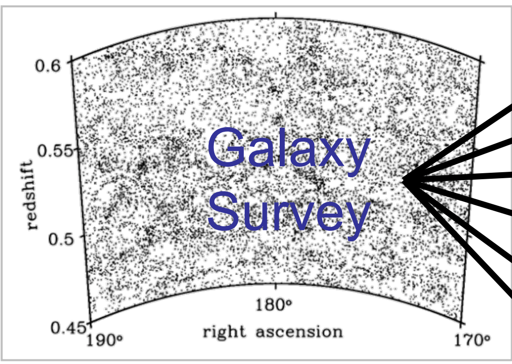
- Probes expansion rate of the Universe (BAO) and clustering history of galaxies induced by gravity (RSD); ψ, $H(z)$.

- Need high precision 3-D distribution of galaxies with spectroscopic redshifts from spectroscopy in NIR range.



35 million spectroscopic redshifts with 0.001 (1+z) accuracy over 15,000 deg^2

Primary probe 1: Euclid Redshift Survey



Baryon Acoustic Oscillations → What is the expansion rate of the Universe?

Alcock-Paczynski effect → What is the expansion rate of the Universe?

Understanding Dark Energy

Redshift-Space Distortions → How does structure form within this background? — Understanding energy-density, gravity

Comoving clustering → What are the neutrino masses, matter density? — Understanding energy-density

Large-scale shape → What is f_{nl}, which quantifies non-Gaussianity? GR-horizon effects — Understanding Inflation, GR

ISW effect → Does the potential change along line-of-sight to CMB — Understanding DE, GR

Primary probe 2: Weak Lensing

Cosmic shear over 0<z<2

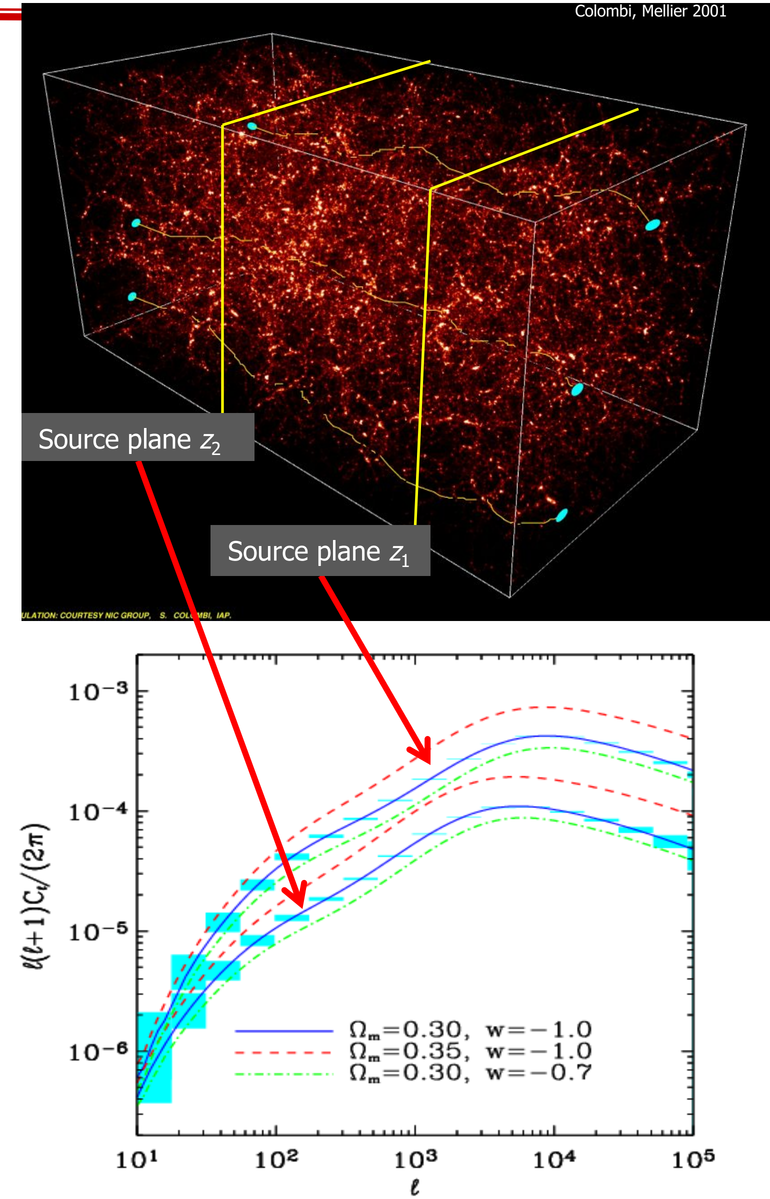
•Probes distribution of matter (Dark +Luminous): expansion history, lensing potential $\phi+\psi$.

→ Shapes+distance of galaxies: shear amplitude, and bin the Universe into slices.

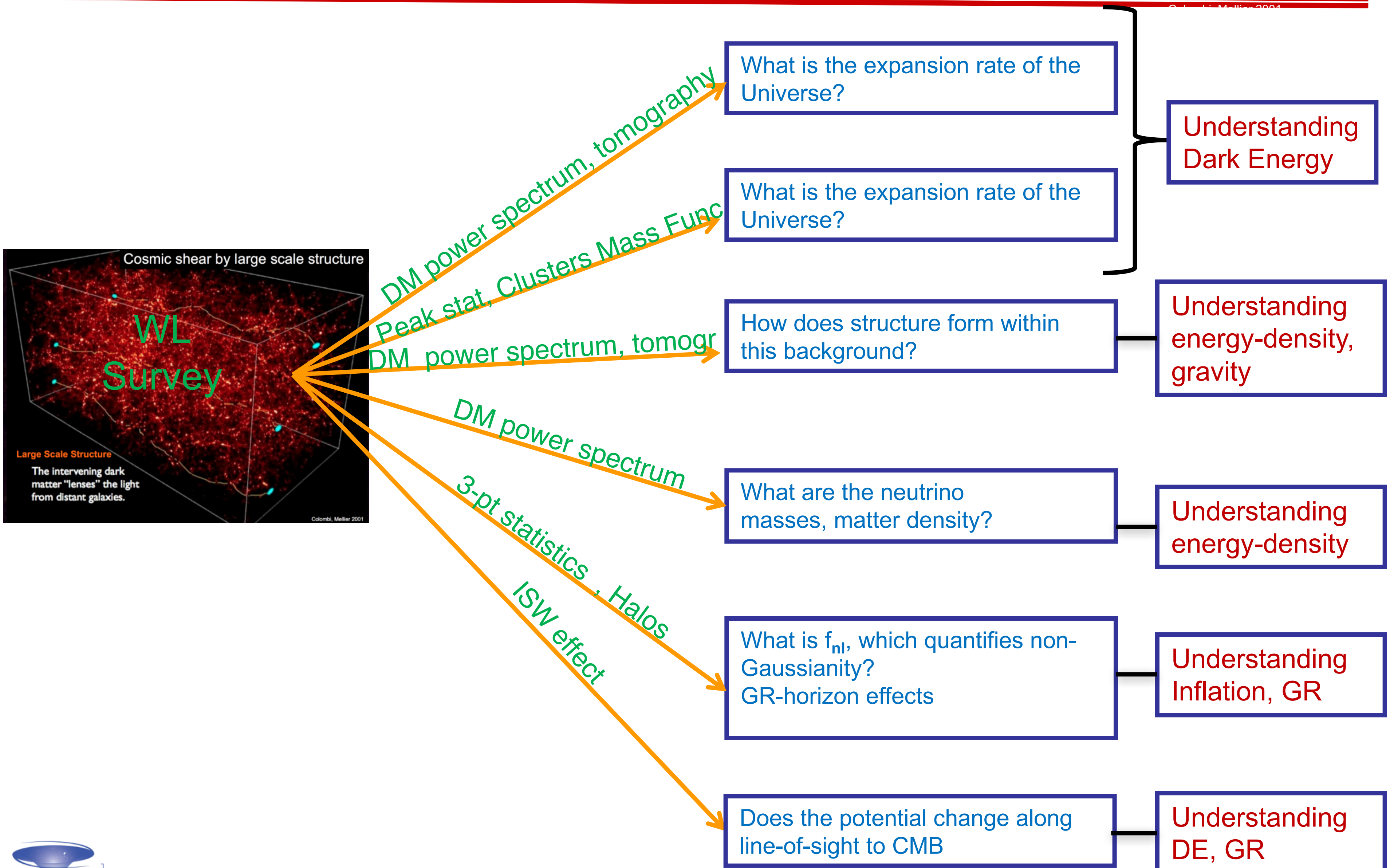
→ "Photometric redshifts" sufficient for distances

Shape measurement and photo-z's from optical an NIR data

1.5 billion galaxies over 15,000 deg^2
+shape and photo-z's



Cosmology Weak Lensing survey



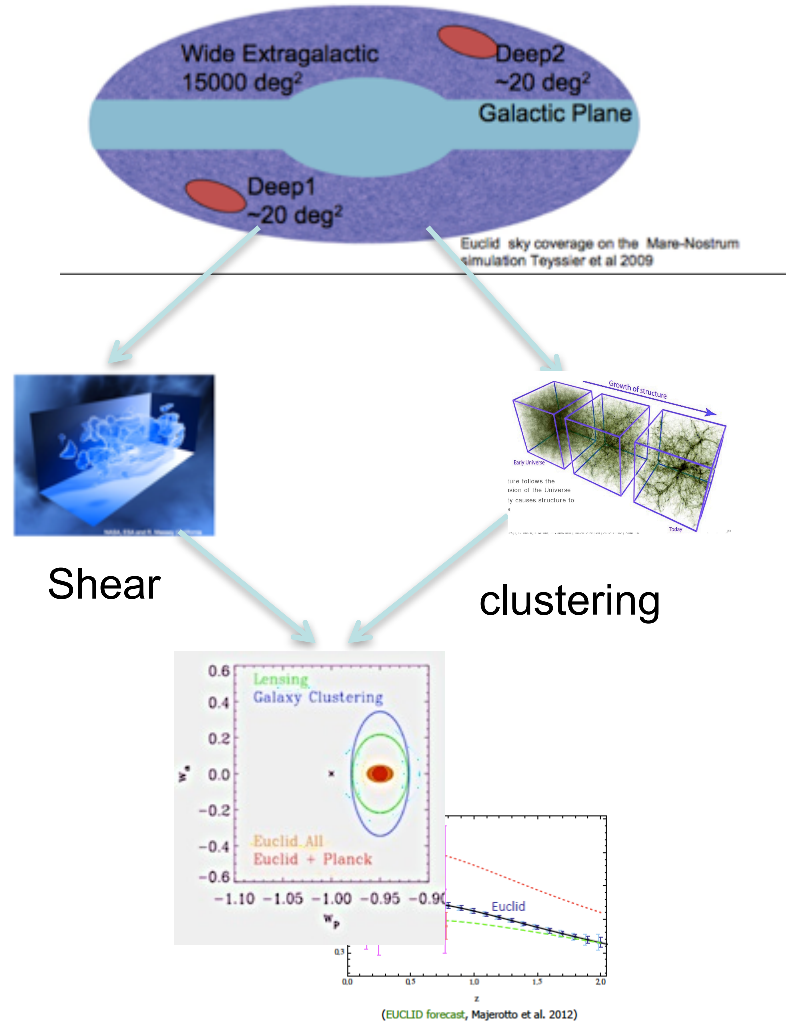
Euclid: an ESA space mission

Euclid was selected by ESA in Oct. 2011, Adopted in June 2012 in the cosmic vision program as the M2 mission to be launched in 2020

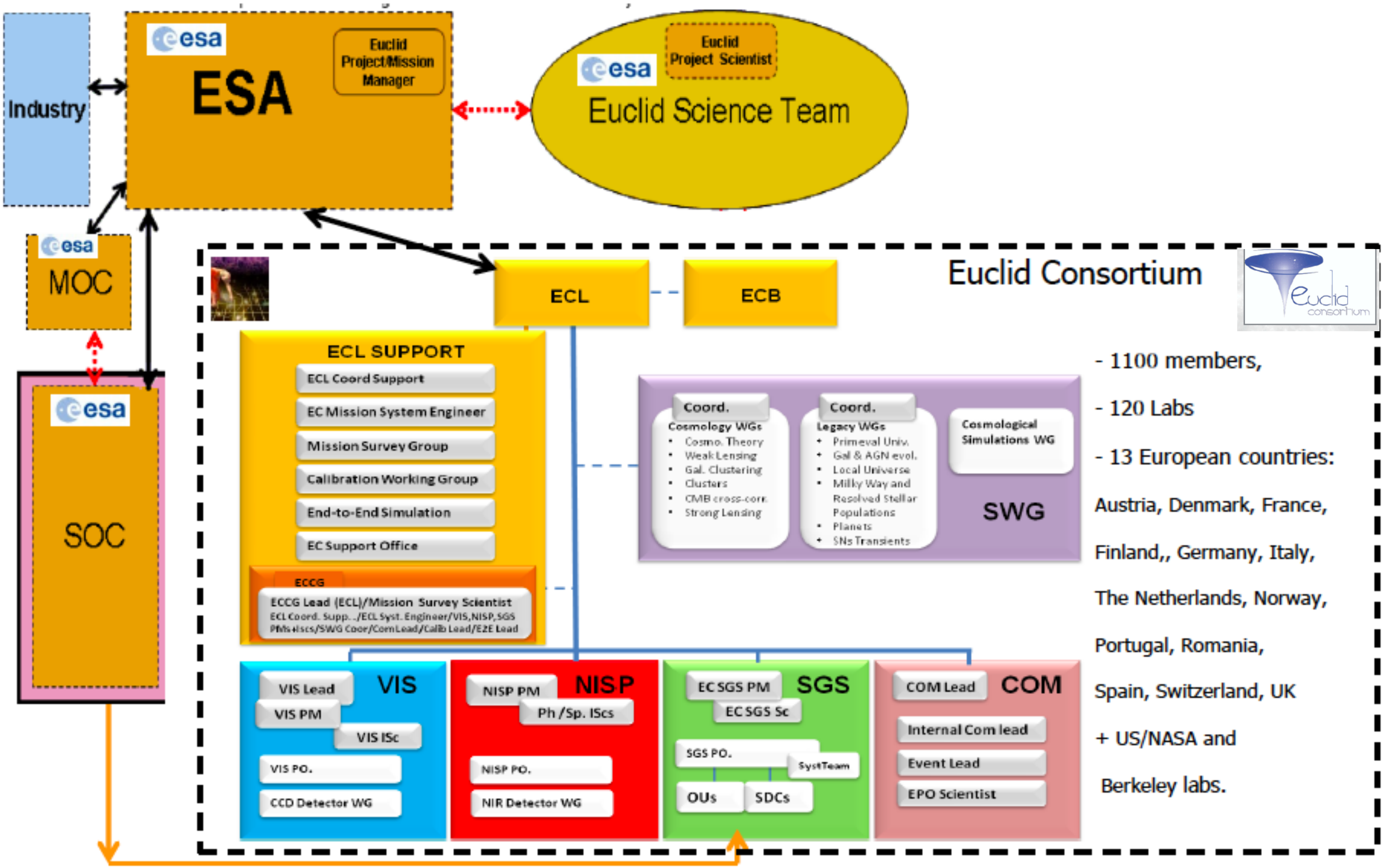
- Euclid is an ESA mission with a strong scientific consortium
- ESA provides the telescope and detectors (via industry), the satellite, launch and operation centers
- Countries provide the 2 instruments (VIS and NISP) and the ground segment (SGS)

- The ground segment and related computing is a very expensive and challenging aspect of the project

- EUCLID is under implementation an starting the construction of instrument and telecope
- For a launch end 2020

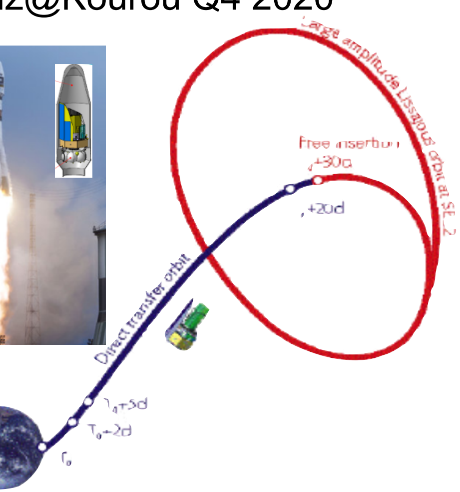


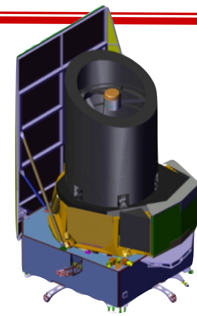
Euclid: organisation



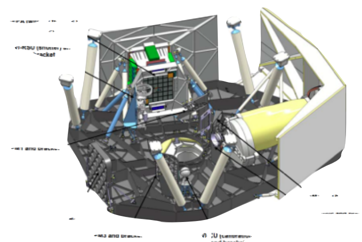
The ESA Euclid mission in one view

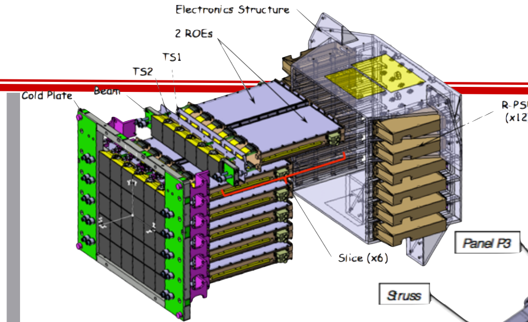
Soyuz@Kourou Q4 2020

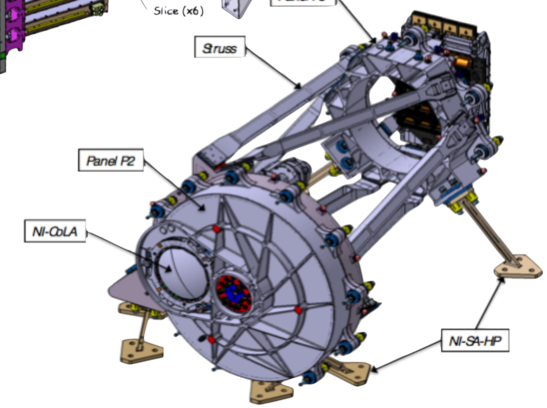


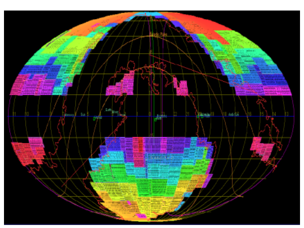


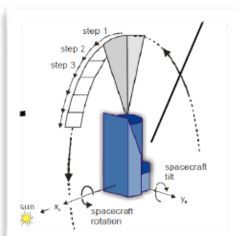
⌀ 1.2m





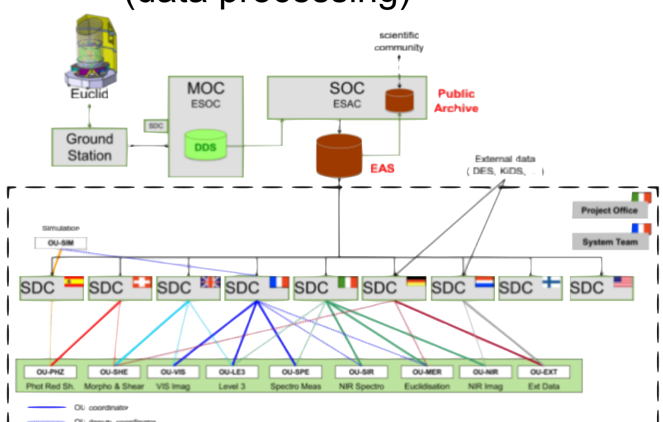




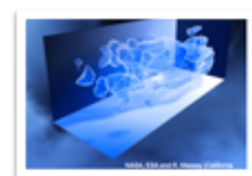


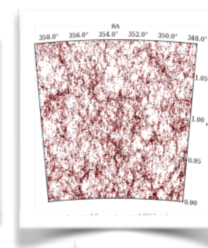
Survey:
6 years - 15000 deg^2

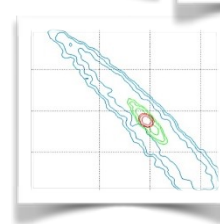
Science Ground Segment (data processing)



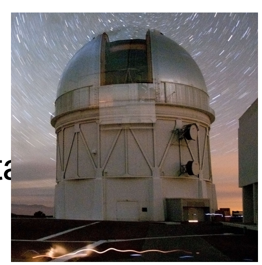
Science Working Groups
Cosmology and legacy analysis







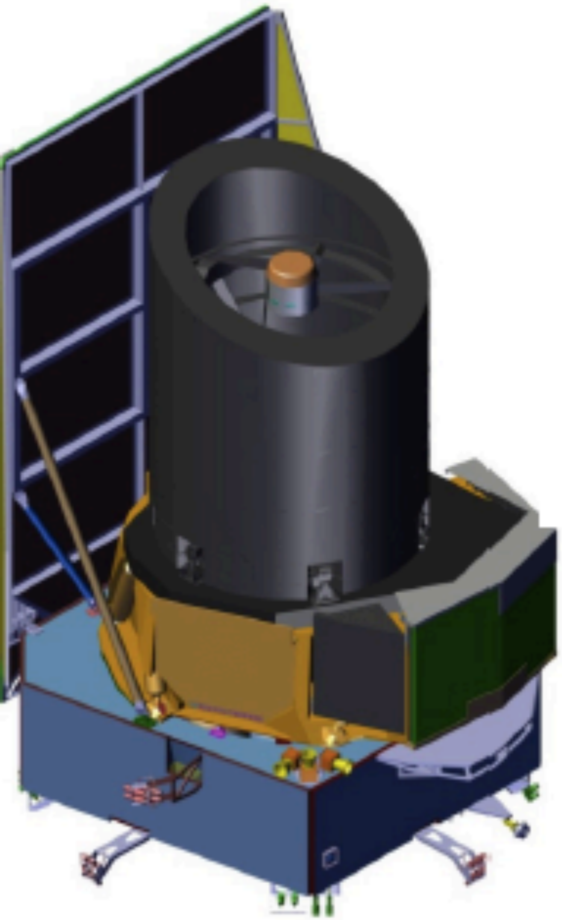
Ground-based photometric and spectroscopic data

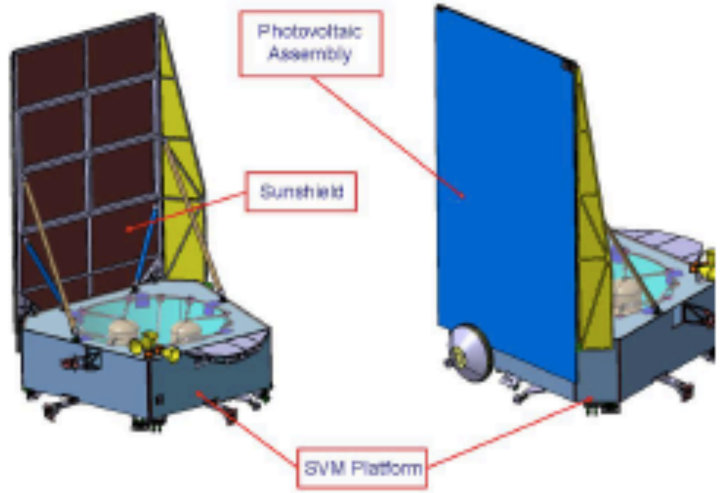


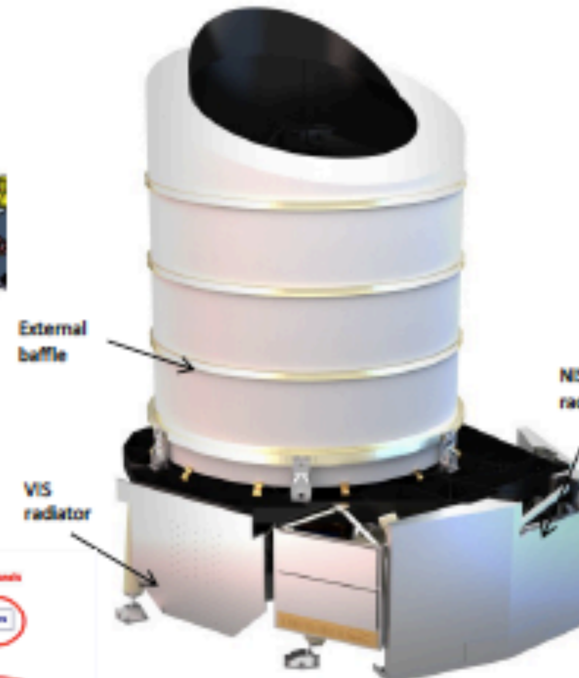
1

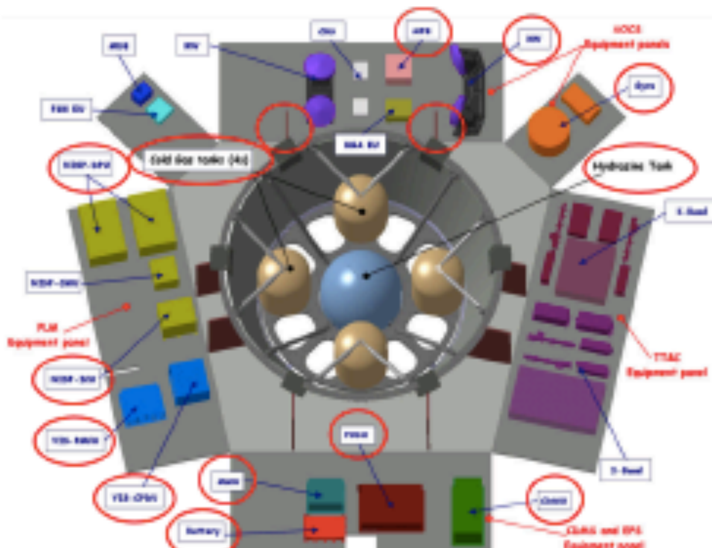
Euclid – Spacecraft Configuration

From Thales Alenia Italy, Airbus DS, ESA Project office and Euclid Consortium









- Total mass satellite :

  2 200 kg
- Dimensions

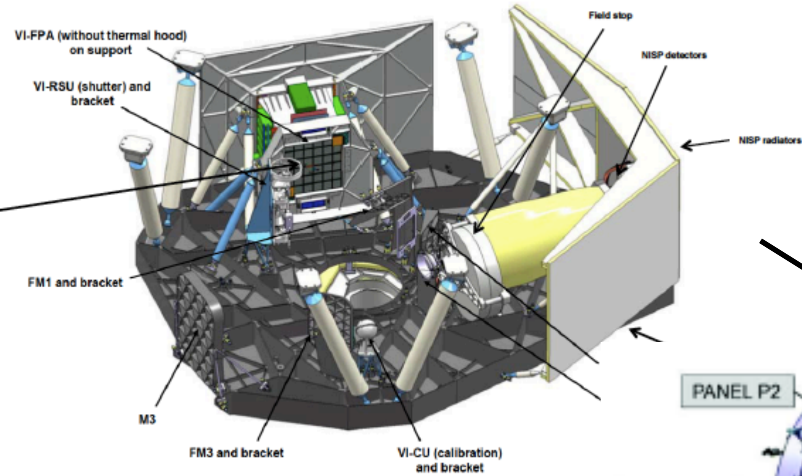
  4,5 m x 3m x 3 m

- Télescope 1,2 m: FoV: 0.54 deg²
- Miror in Silicon Carbide= ultra-stable:

Temp.: -150 deg. Stability +:- 0.05 deg.

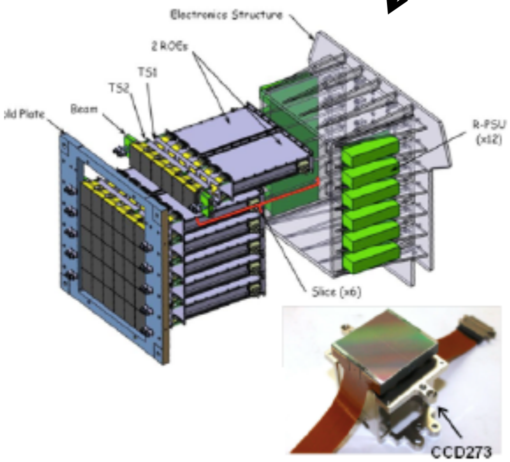
The instruments

VIS

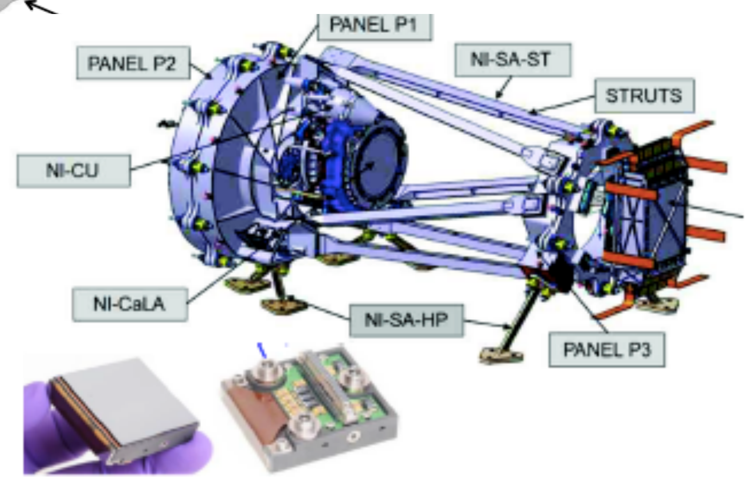


Common VIS and NIR FoV $= 0.54$ deg^2

NISP



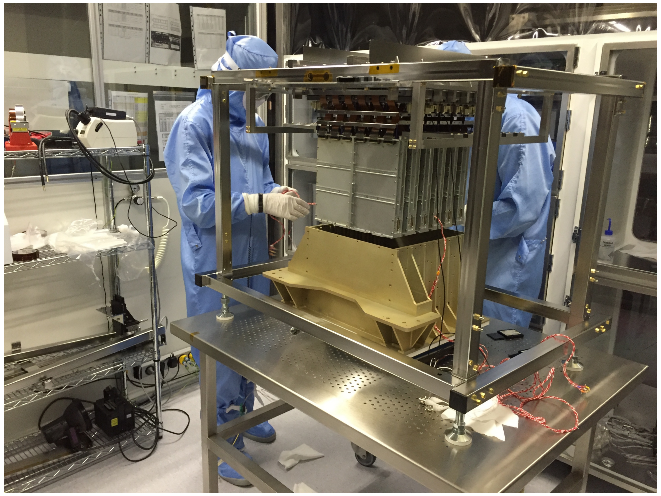
36 CCDs,4kx4k, 12 micron pixels
0,1 arcsec pixel on sky
1 filter Y(R+I+Y)
Bandpass 550-900 nm
Data volume 520 Gbit/day
Mass 135 Kg

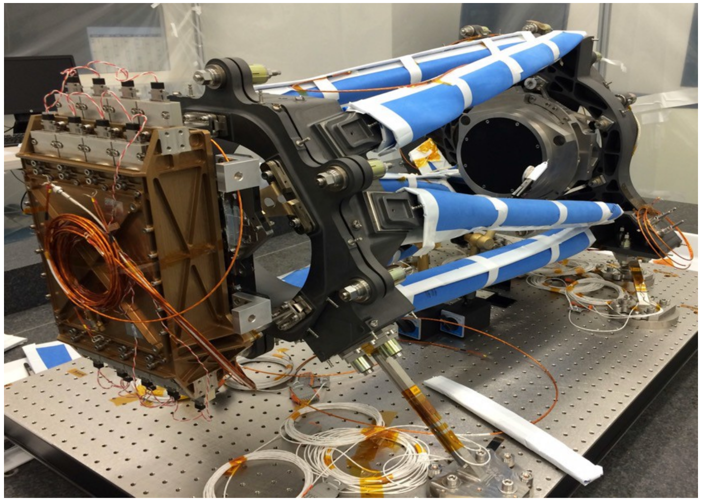


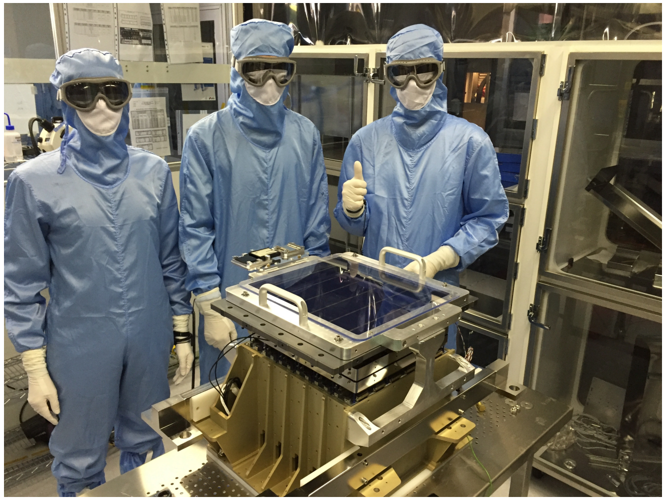
16 2kx2k, H2RG, 18 micron pixels
0,3 arcsec pixel on sky
3 filters Y,J,H
4 grisms 1B(920-1350),3 R(1250-1850)
Data Volume 290 Gbit/day
Mass 159 Kg

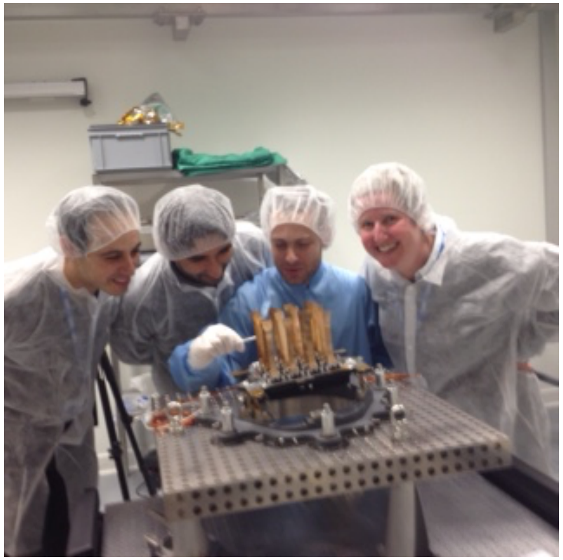
Euclid is under construction

- **VIS**
- **NISP**

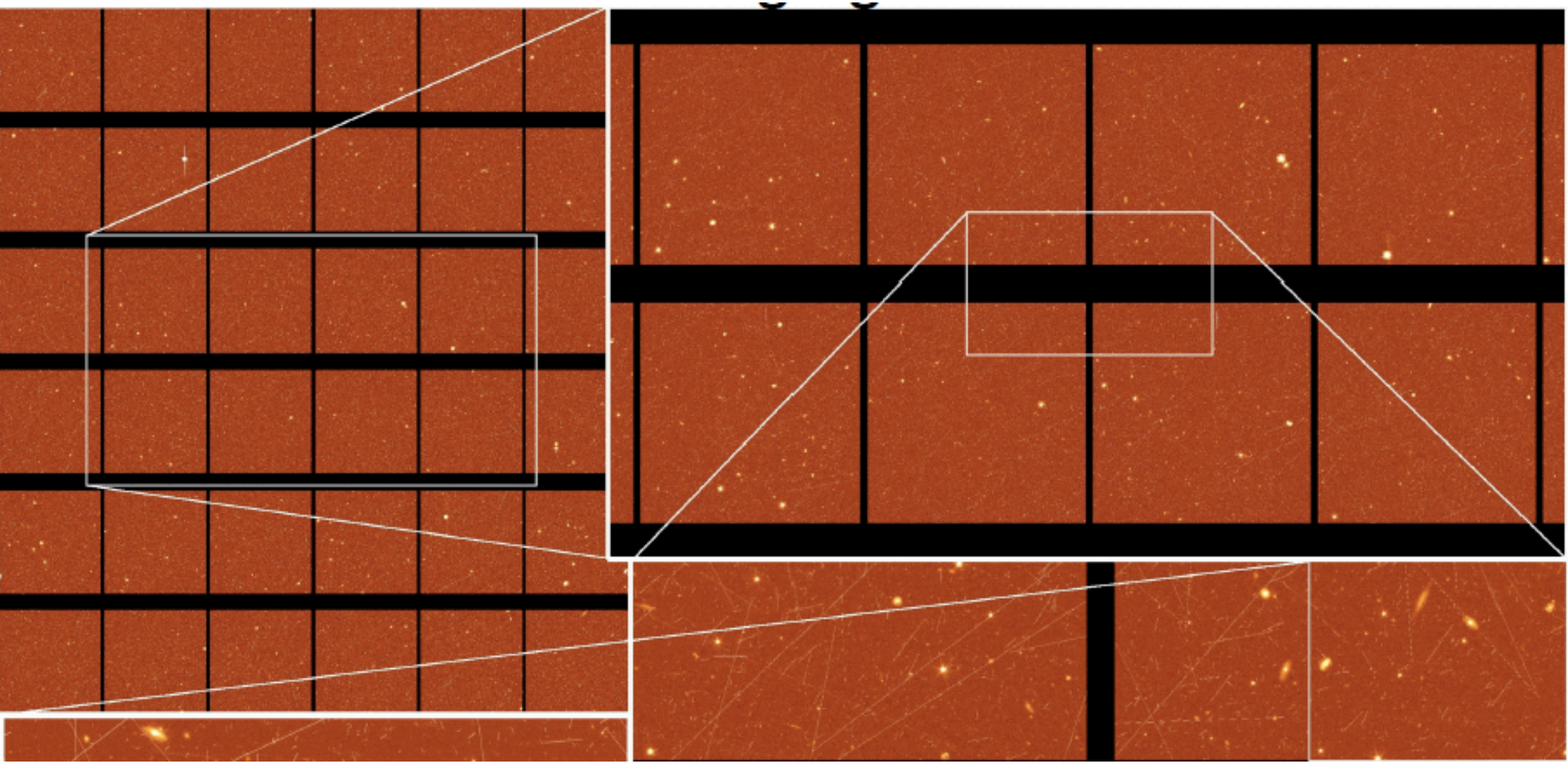




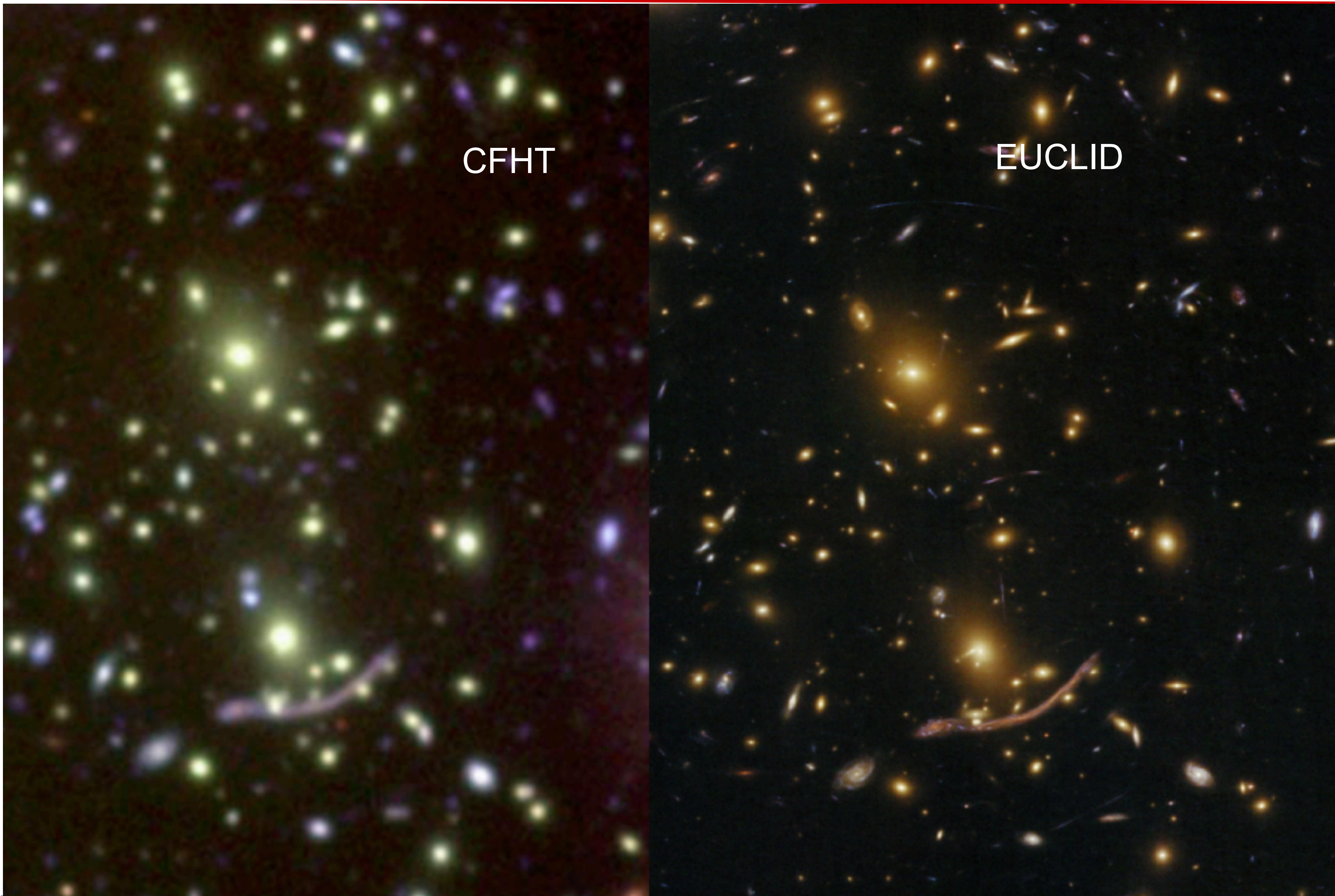




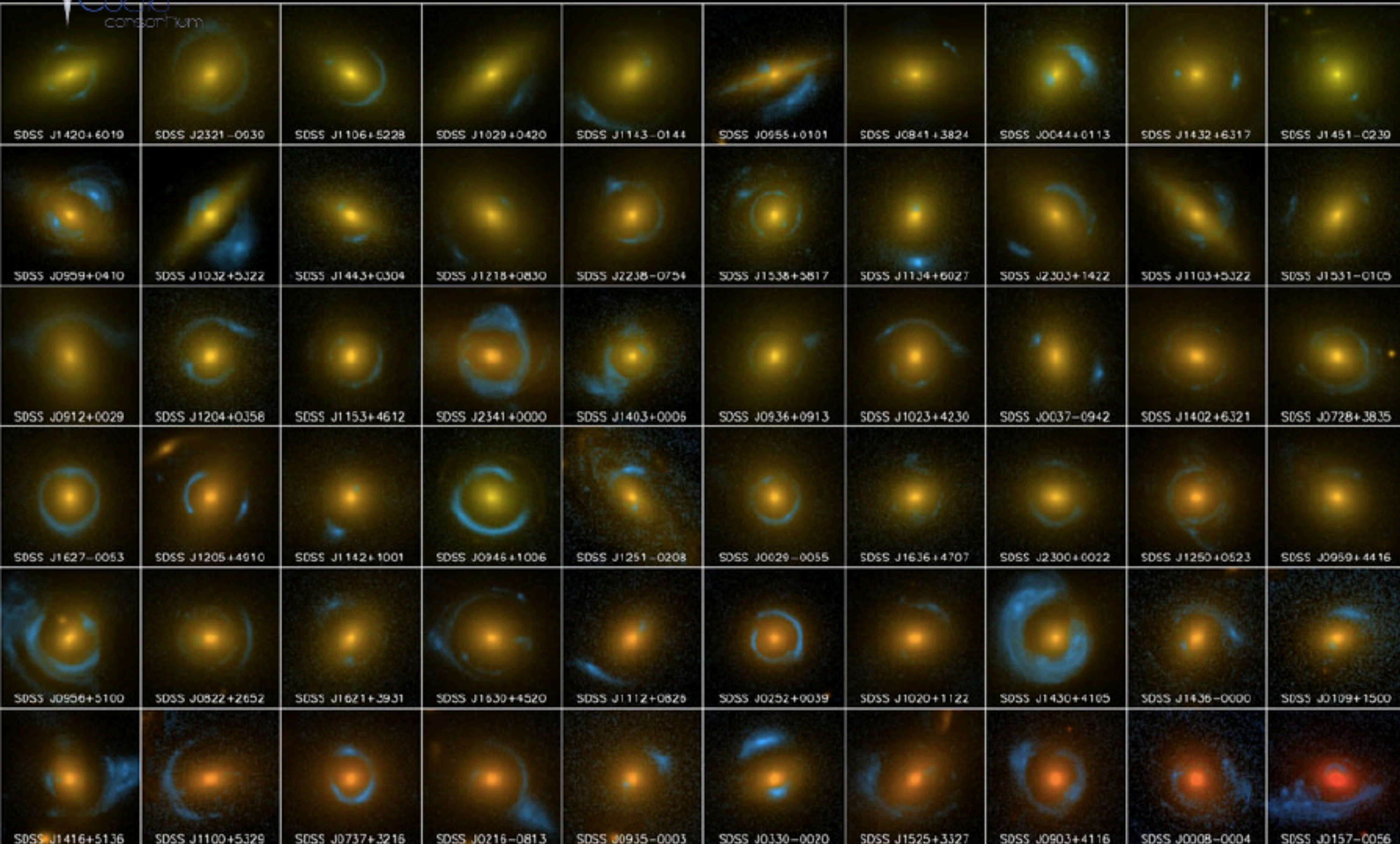
Euclid in simulation =VIS CCDs



Euclid is under simulation

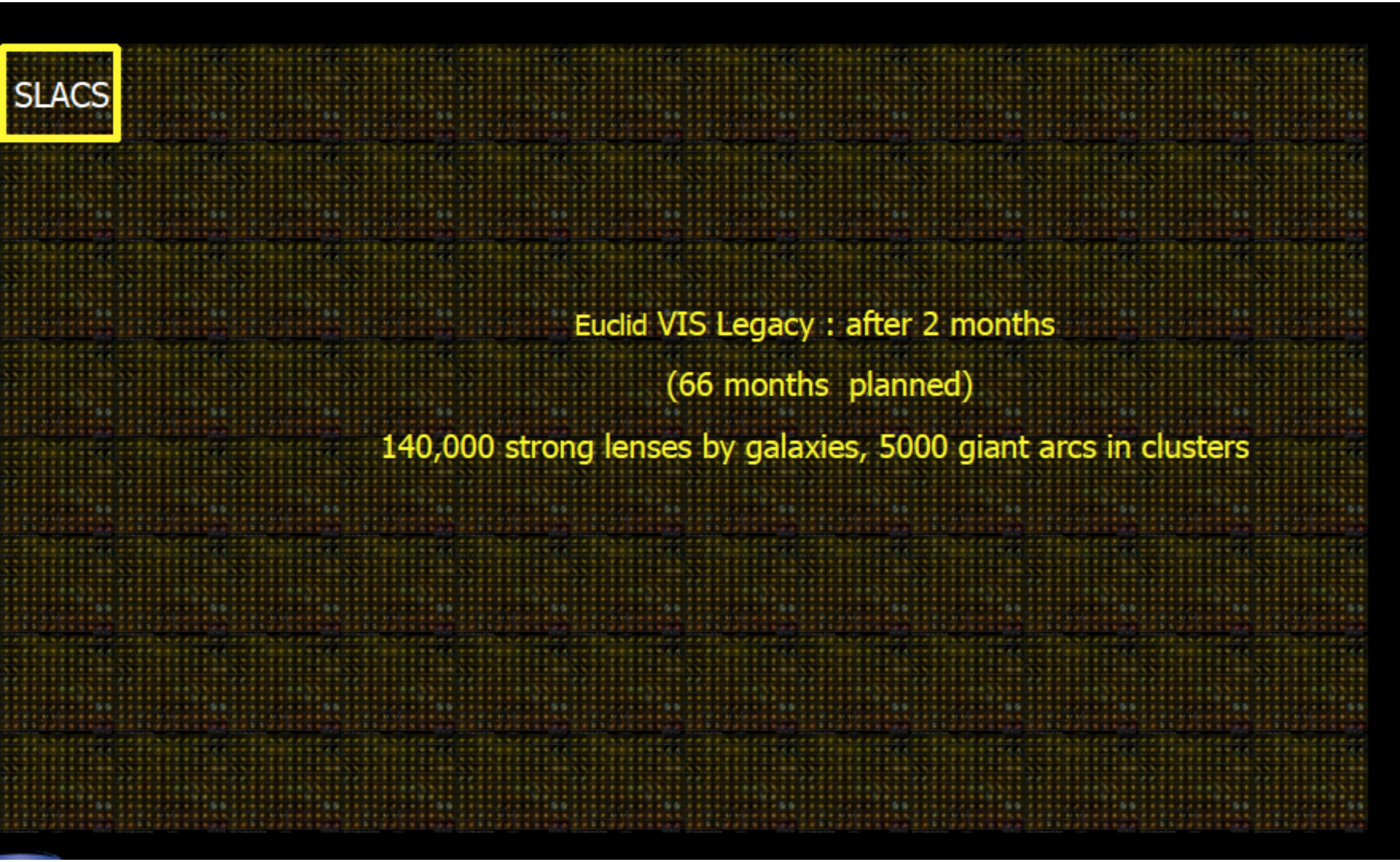


SLACS (~2010 - HST): gravitational lensing by galaxies

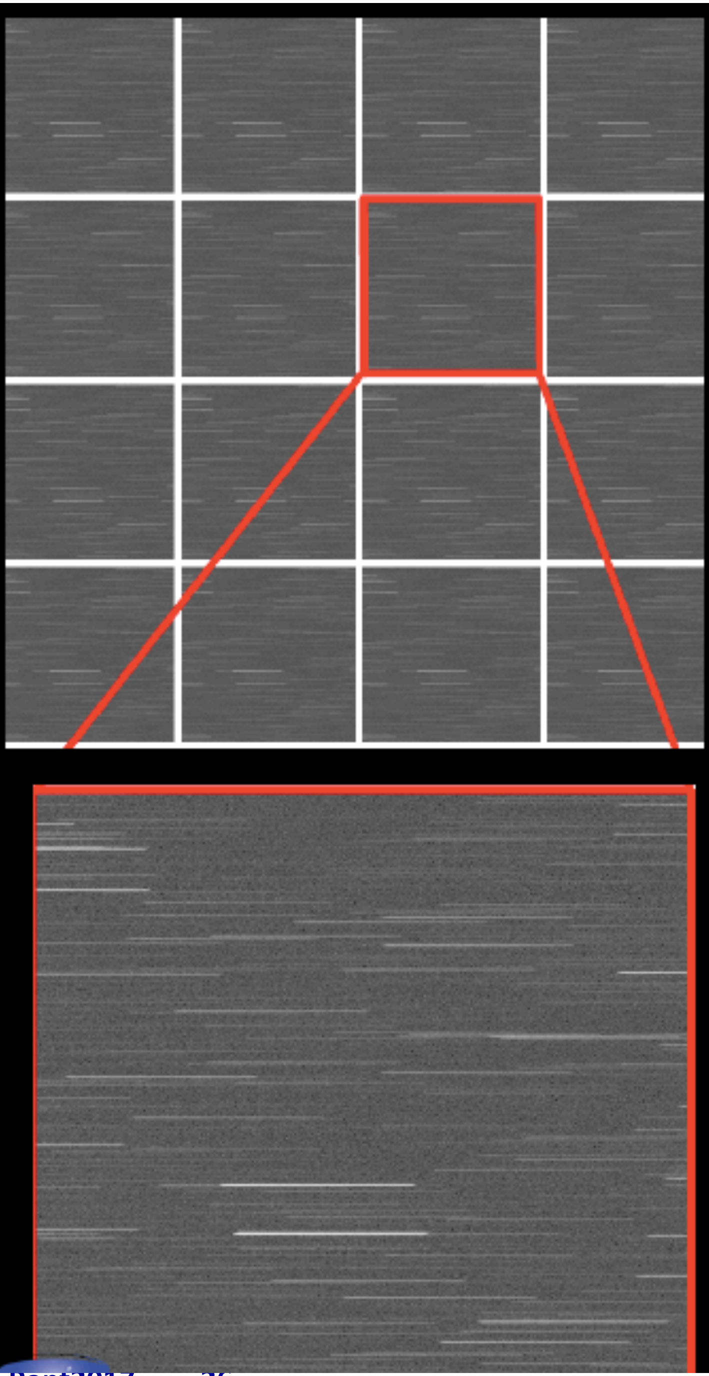


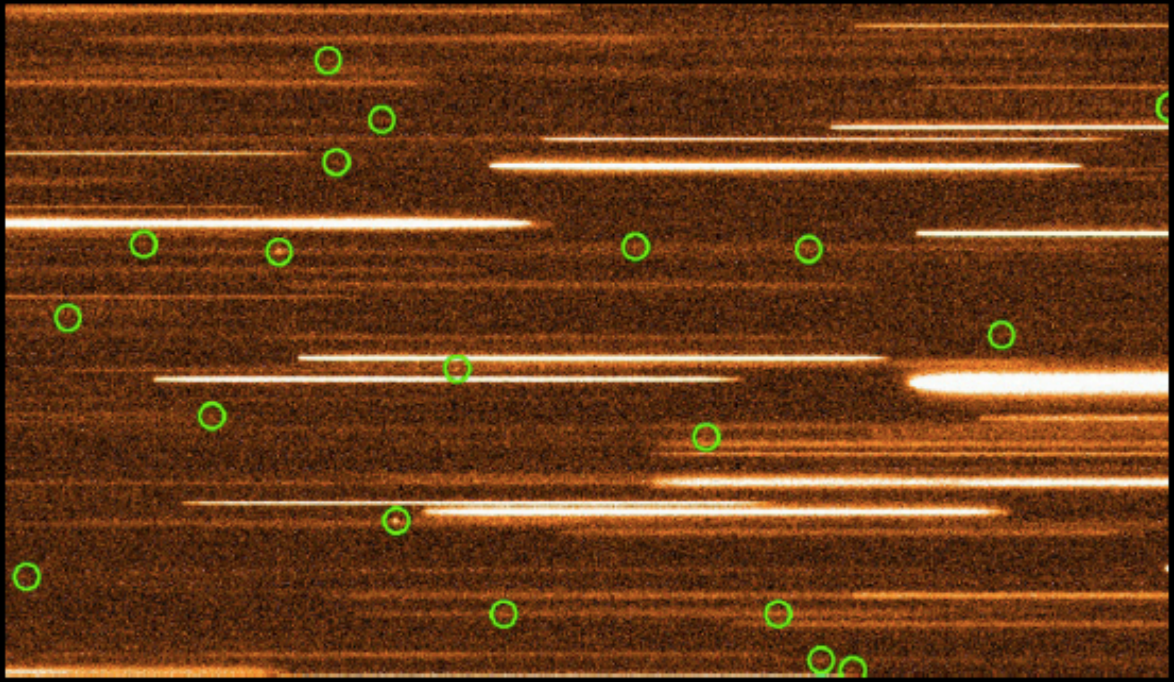
SLACS: The Sloan Lens ACS Survey — www.SLACS.org

olton (U. Hawai'i IfA), L. Koopmans (Kapteyn), T. Treu (UCSB), R. Gavazzi (IAP Paris), L. Moustakas (JPL/Caltech), S. Burles (MIT)


SLACS
Euclid VIS Legacy : after 2 months
(66 months planned)
140,000 strong lenses by galaxies, 5000 giant arcs in clusters

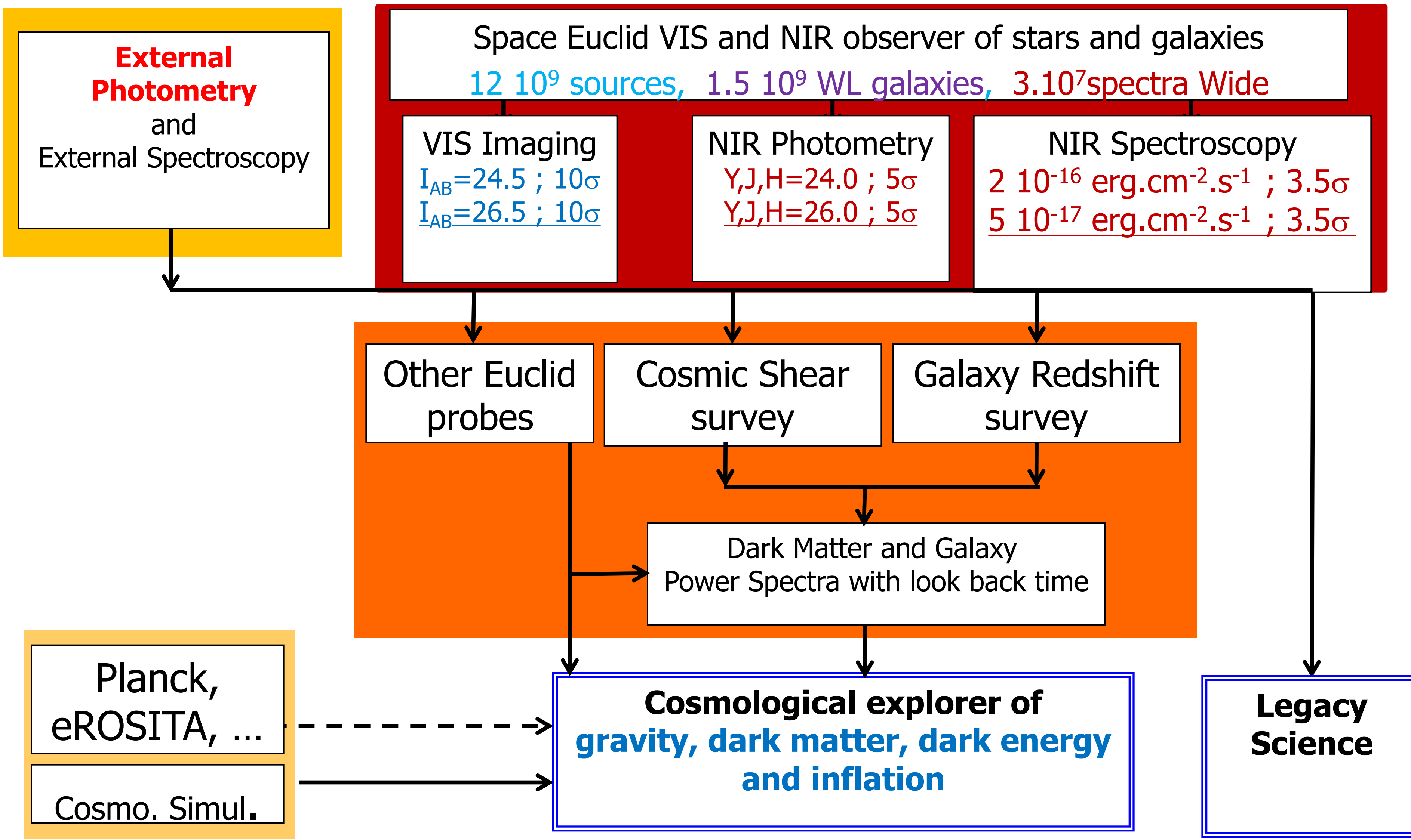
NISP-spectroscopy for Euclid (2015)



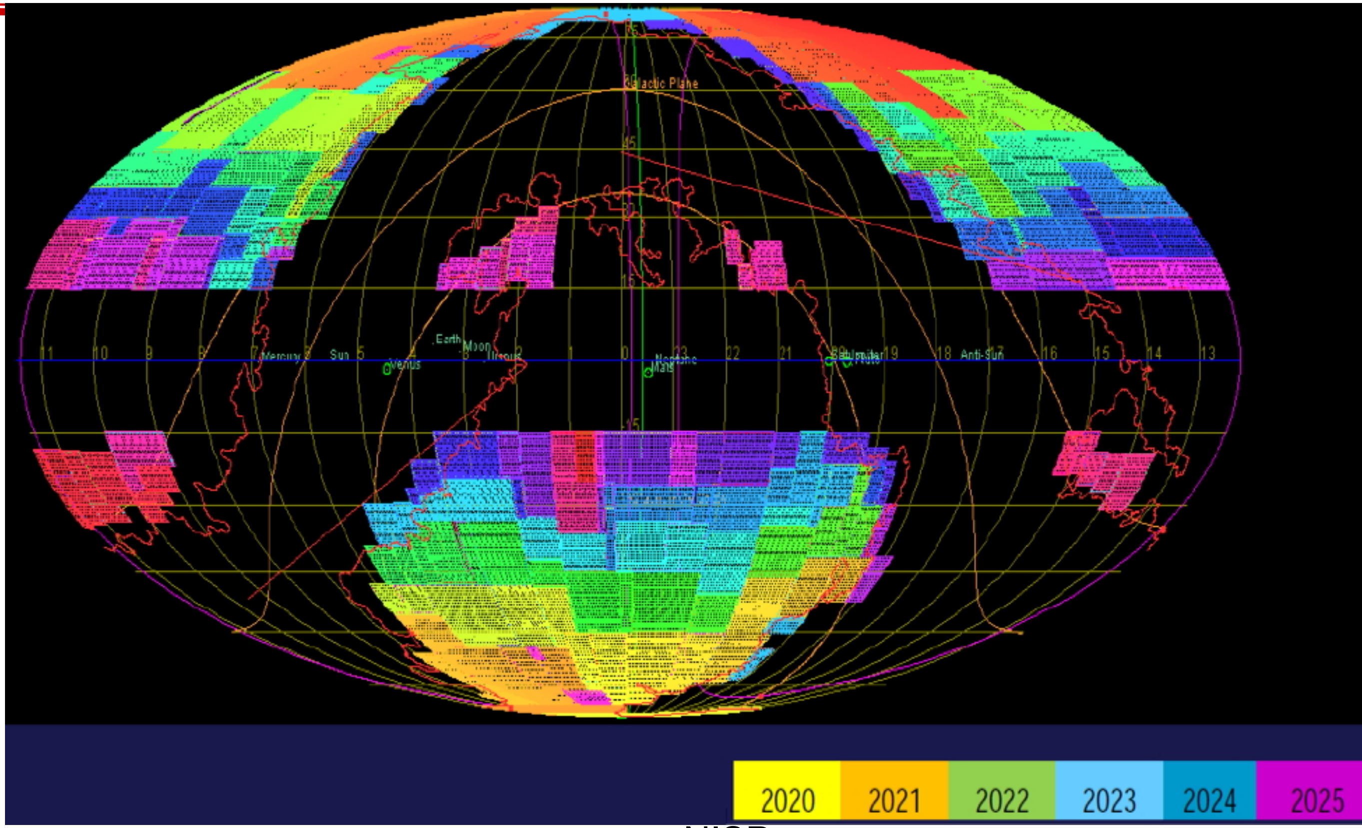


35 million spectra with at least 3 exposures taken with 3 different orientations and a total exposure time of 4000 sec.

Euclid Survey Machine: 15,000 deg^2 + 40 deg^2 deep



Euclid wide survey



Euclid is a cosmological survey mission, but unlike CMB experiments, it will only do its survey once!

Survey strategy is constrained by the number of times we can point the satellite!

- **12 billion source**
- **1.5 billion for WL**
- **35 millions with spectroscopy**

VIS:

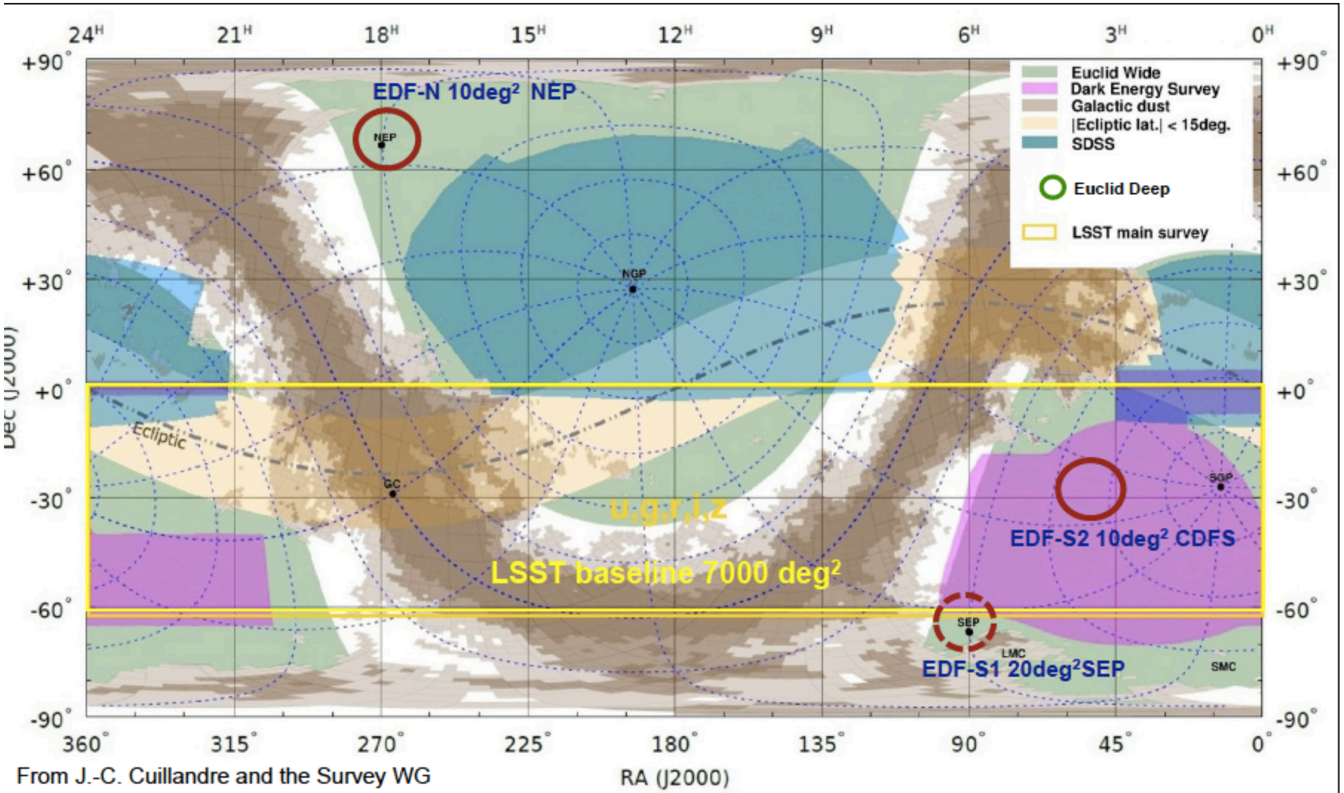
- Imaging
- 36 4k x 4k CCD
- 0.54 deg^2 per field
- 0.1" pixels on the sky
- limiting magnitude: 24.5 AB @10σ
- 520 Gbit/day

NISP:

- Imaging and slitless grism spectroscopy
- 16 2k x 2k NIR arrays
- 0.55 deg^2 per field
- 0.3" pixels on the sky
- limiting magnitude: 24 H @5σ
- 2 10^{-16} $erg.cm^{-2}.s^{-1}$; 3.5σ
- 240 Gbit/day

Visible and infrared imaging, as well as infrared spectroscopy are obtained "simultaneously"

Euclid deep surveys and external data



Deep survey

- 10 million source
- 1.5 millon for WL
- 150 000 with spectroscopy

External data

Mandatory ground basesd imaging in 4 bands for the WL photoz-s of all WL galaxies

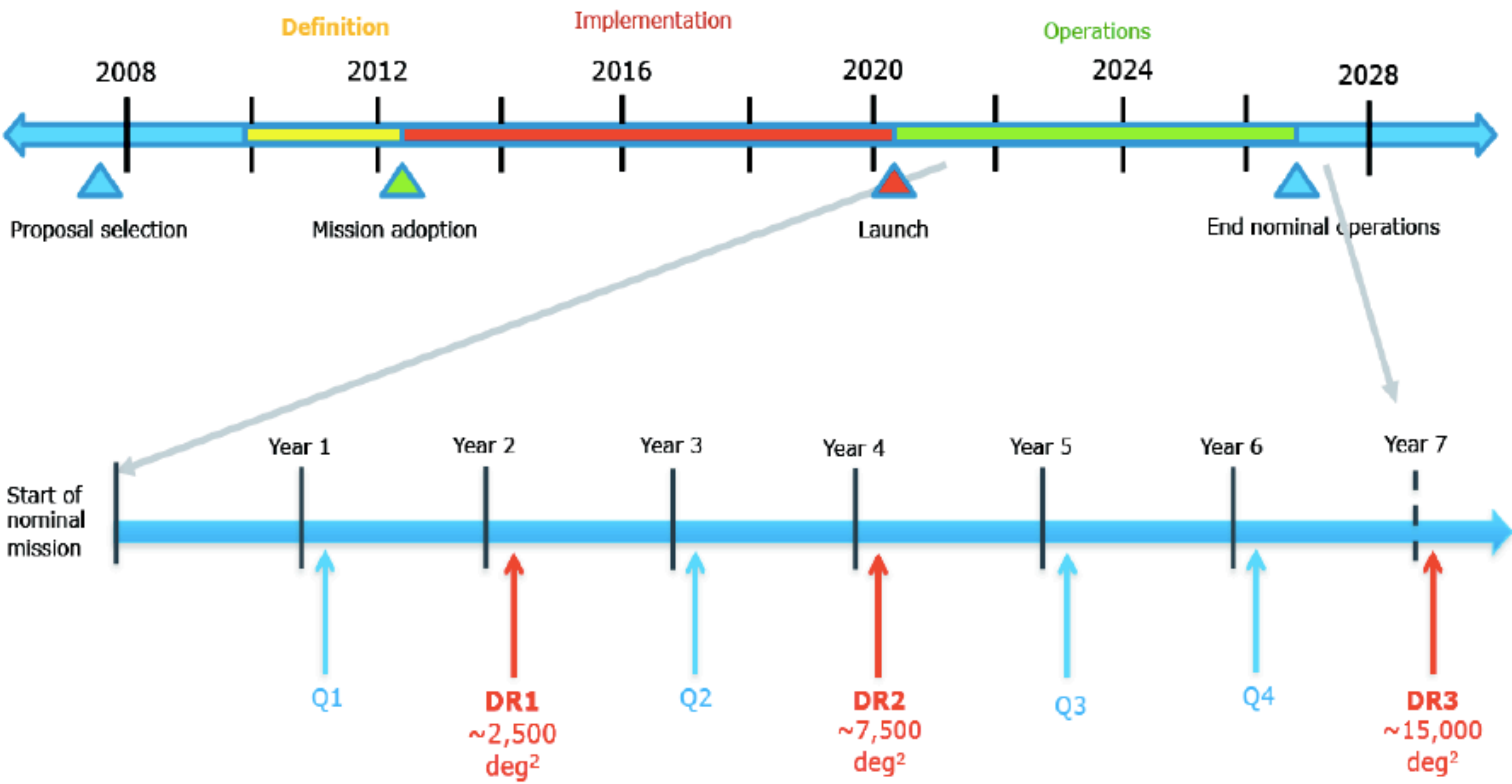
- 1x10 deg^2 North Ecliptic pole (EDF-N) + 1x20 deg^2 South Ecliptic pole (EDF-S1)

+ 1x10 deg^2 at CDFS (EDF-S2)

- VIS limiting magnitude: 26.5 AB @10σ
- NISP limiting magnitude 26 H @ 5σ

+Spectro 5 10^{-17} $erg.cm^{-2}.s^{-1}$; 3.5σ

Data release



Science with Euclid will start in 2022 with Q1 and in 2023 with DR1

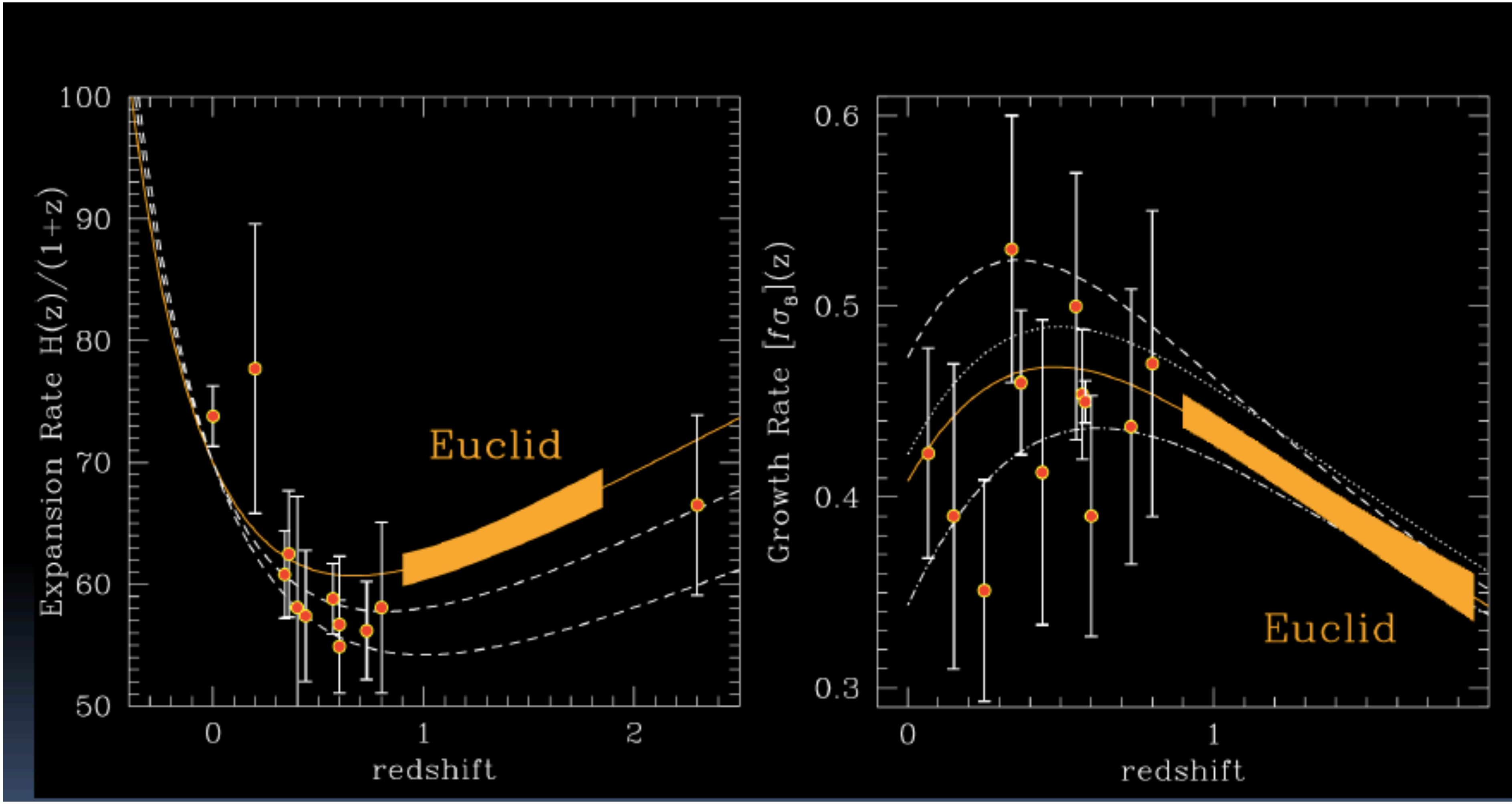
EUCLID
Science Performances forcasts

Euclid : the core program

- Use 5 cosmological probes, with at least 2 independent, and 3 power spectra
- Explore the dark universe: DE, DM (neutrinos), MG, inflation, biasing
- Explore the transition DM-to-DE-dominated universe periods
- Get the percent precision on w and the growth factor γ
- Perfect complementarity with Planck: probes and data, cosmic periods
- Synergy with New Gen wide field surveys: LSST, WFIRST, e-ROSITA, SKA
- Provide 150,000 strong lenses → propoerties of DM haloes at dwarf galaxies, galaxies, groups, clusters of galaxies scales in the range of redshift $0. < z < 2$

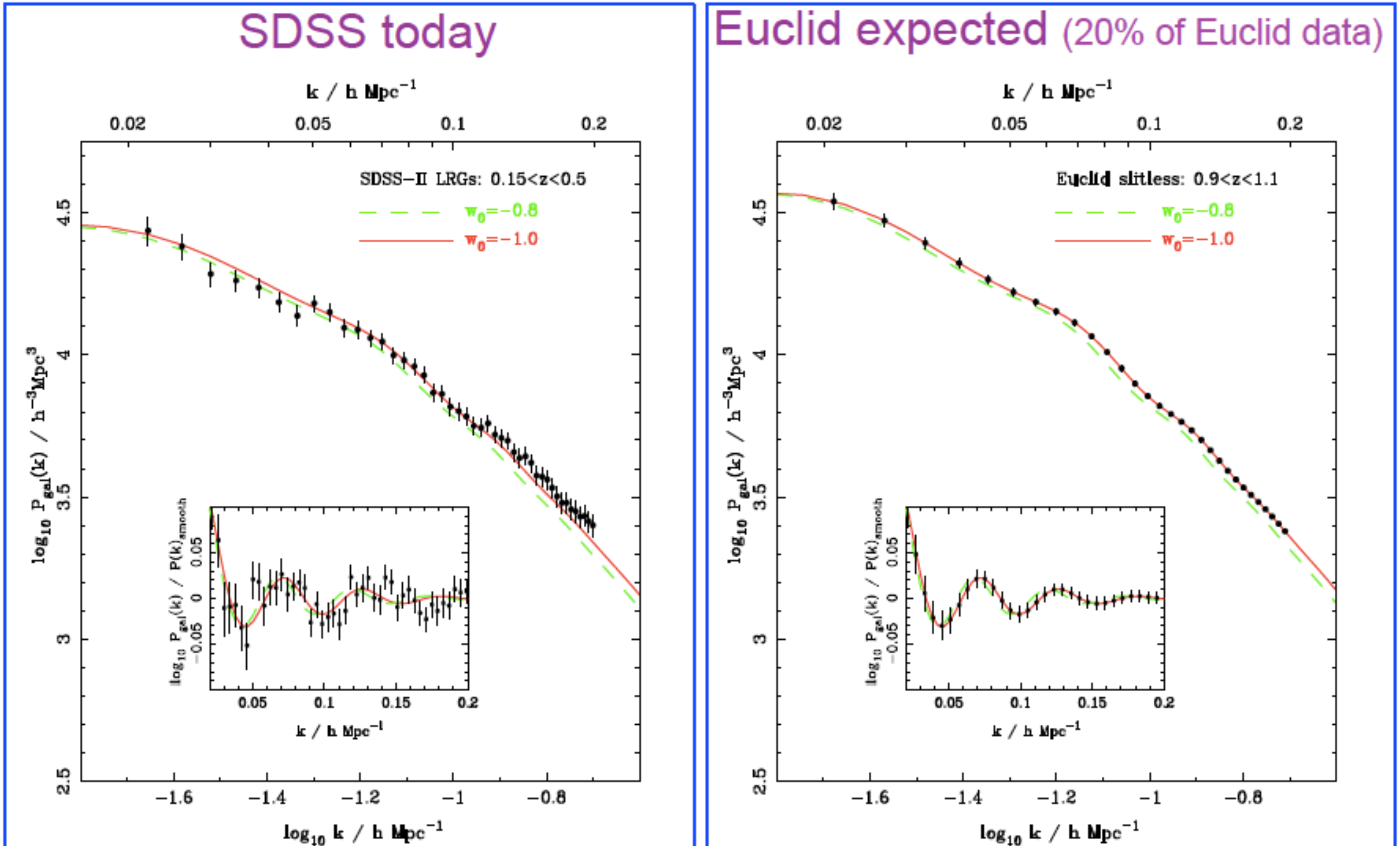
EUCLID: Exploring the DM-DE transition period

Euclid can explore the transition area with redshift survey only

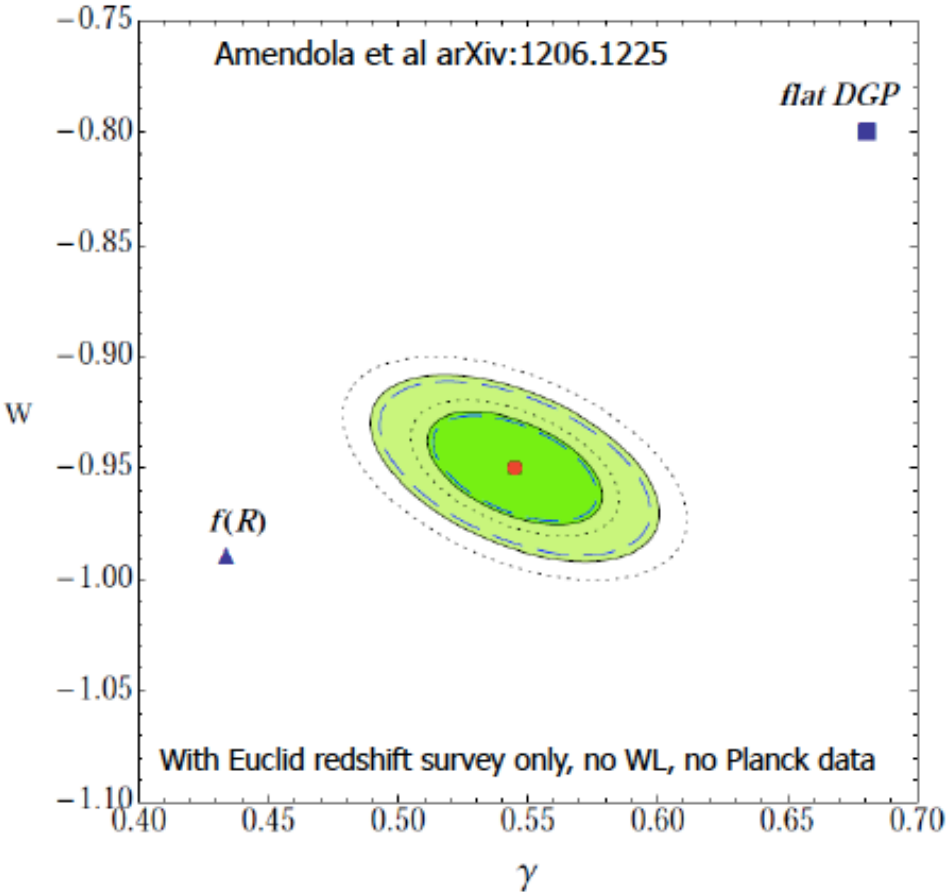


Credit: G.Guzzo

EUCLID : galaxy power spectrum



Performance using clustering only

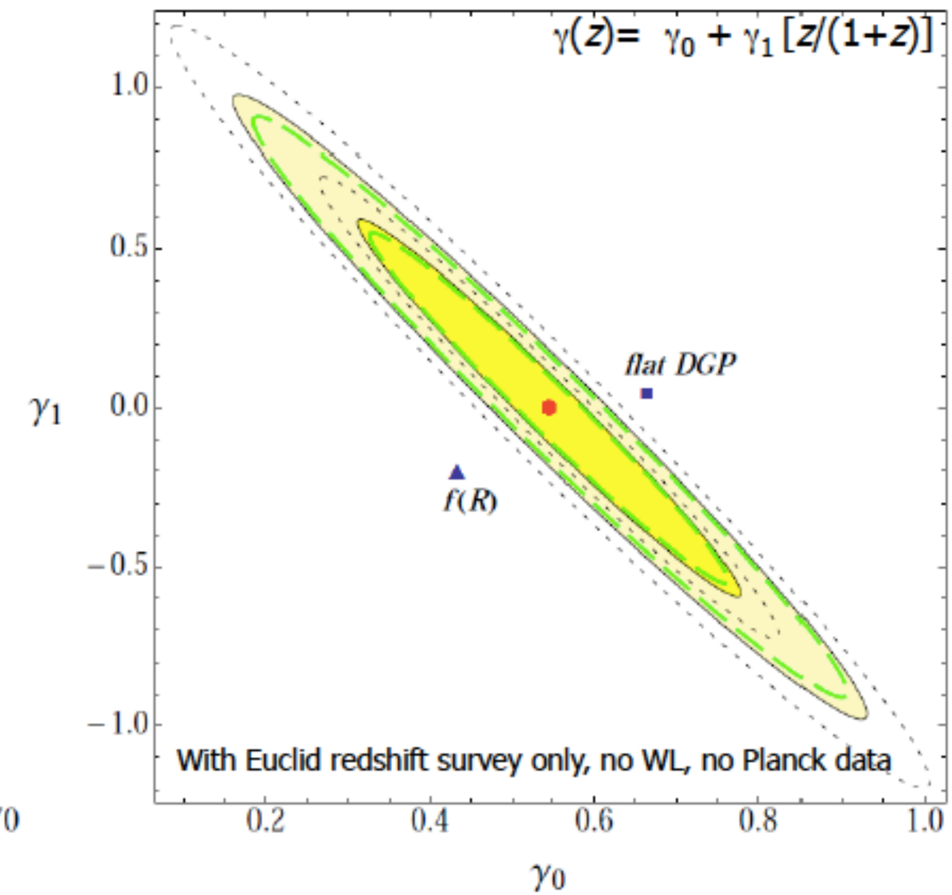


1/2−σ marginalised probability regions, constant γ and *w*

Reference = green regions

Optimistic = blue long-dashed ellipses

Pessimistic= black short-dashed ellipses



1−σ, 2−σ marginalised probability regions for γ_0 and γ_1

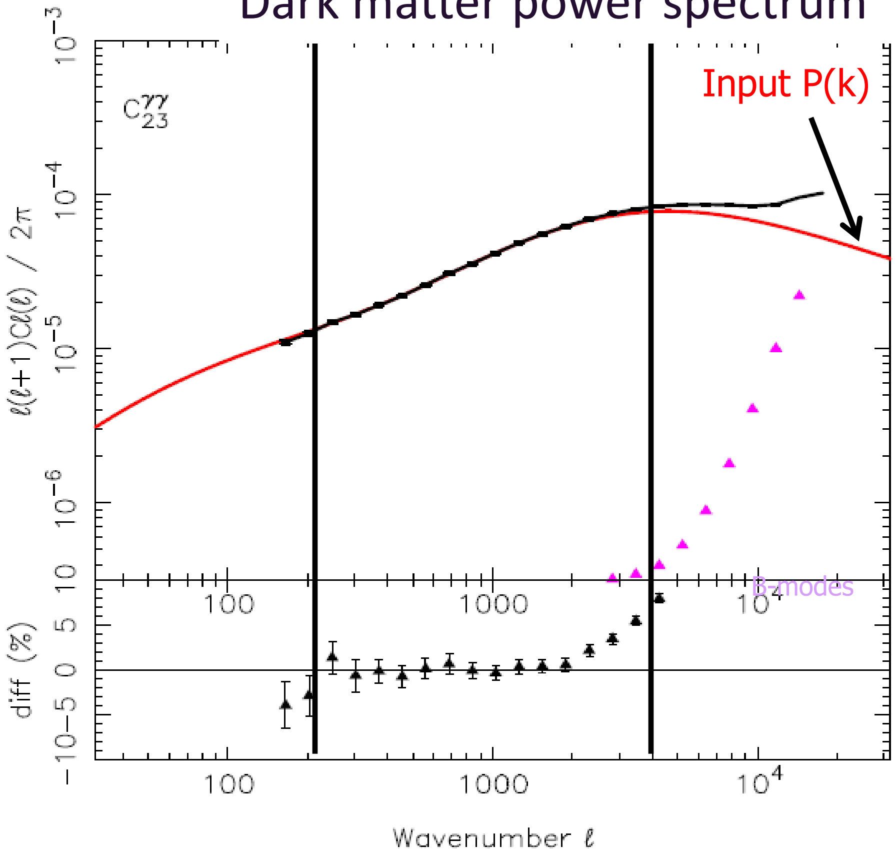
Reference = yellow regions

Optimistic = green long-dashed ellipses

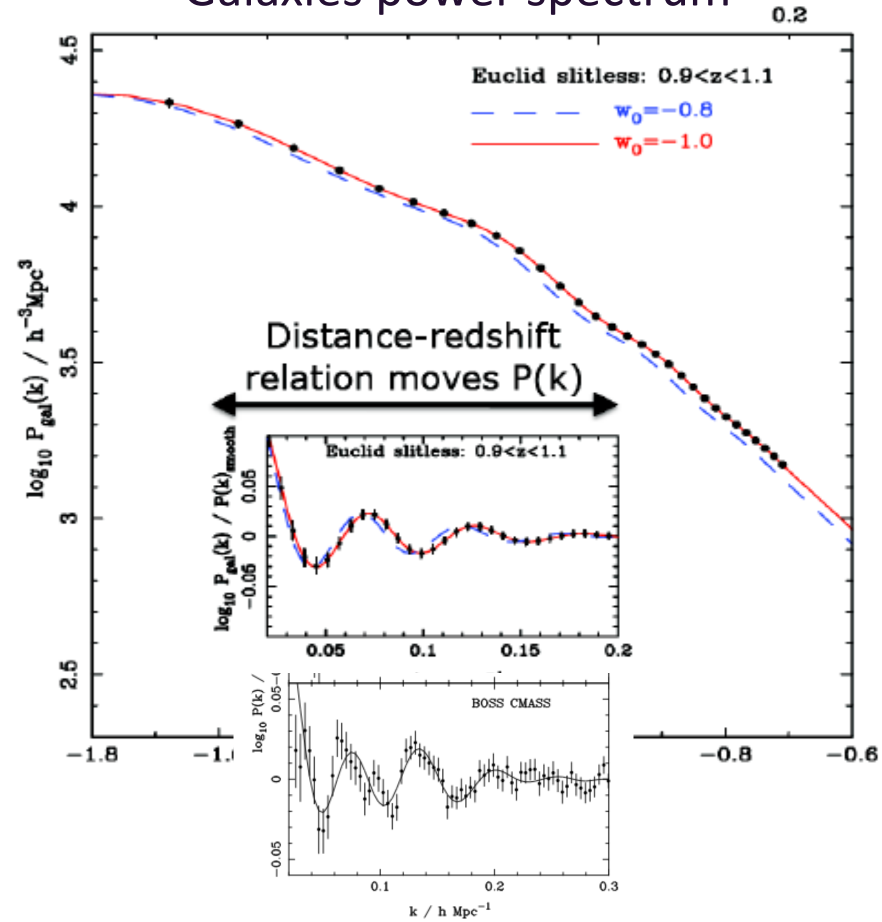
Pessimistic= black doted ellipses

Euclid: Combining WL and GC power spectrum

Dark matter power spectrum



Galaxies power spectrum



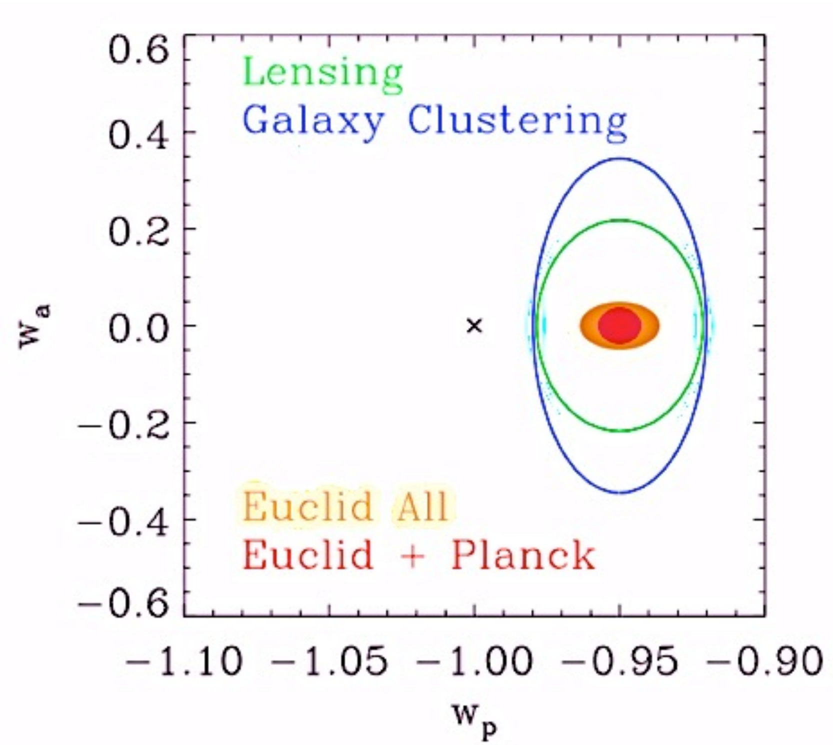
• Tomographic WL shear cross-power spectrum for 0.5 < z < 1.0 and 1.0 < z < 1.5 bins.
• Percentage difference [*expected* – *measured*] power spectrum: recovered to 1% .

• Percentage difference [*expected* – *measured*] power spectrum: recovered to 1% .

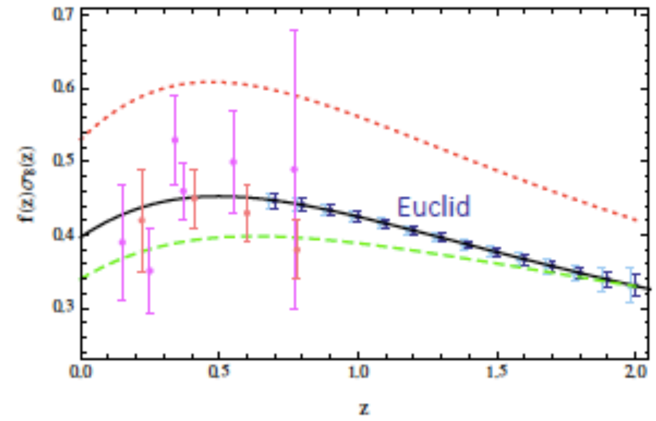
• $V_{eff} \approx 19\ h^{-3}\ Gpc^3 \approx$ 75x larger than SDSS
• Redshifts 0.9<*z*<1.9

Dark Energy analyses

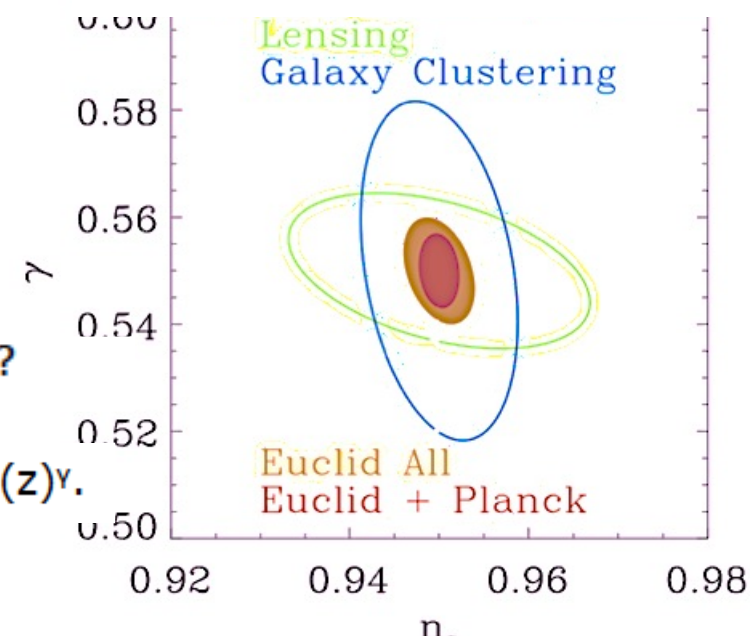
Variation in time



Growth rate



(EUCLID forecast, Majerotto et al. 2012)



$f \sim \Omega^{\gamma}$; $\gamma = 0.55$?

The growth rate well described by $f(z)=\Omega_m(z)^{\gamma}$.

Euclid Forecast for the Primary Program

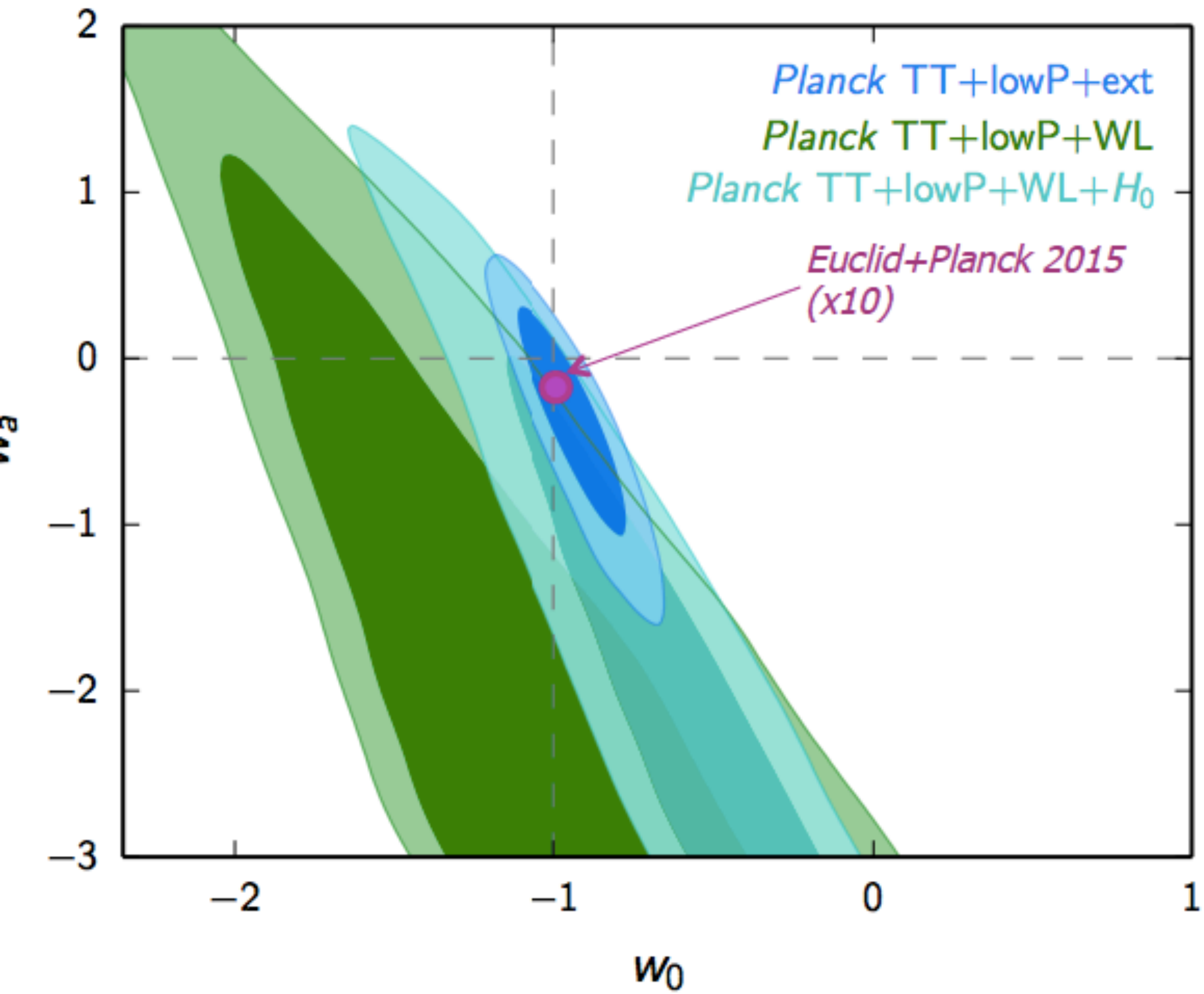
Ref: Euclid RB arXiv:1110.3193	Modified Gravity	Dark Matter	Initial Conditions	Dark Energy		
Parameter	γ	m_ν /eV	f_{NL}	w_p	w_a	FoM $= 1/(\Delta w_0 \times \Delta w_a)$
Euclid primary (WL+GC)	0.010	0.027	5.5	0.015	0.150	430
EuclidAll (clusters,ISW)	**0.009**	**0.020**	**2.0**	**0.013**	**0.048**	**1540**
Euclid+Planck	0.007	0.019	2.0	0.007	0.035	**6000**
Current (2009)	**0.200**	**0.580**	**100**	**0.100**	**1.500**	**~10**
Improvement Factor	**30**	**30**	**50**	**>10**	**>40**	**>400**

- DE equation of state: $P/\rho = w$, and $w(a) = w_p + w_a(a_p - a)$
- Growth rate of structure formation: $f \sim \Omega^{\gamma}$;

Assume systematic errors are under control

- From Euclid data alone, get FoM=$1/(\Delta w_a \times \Delta w_p) > 400$→ ~1% precision on w's.
- **Notice neutrino constraints -> minimal mass possible ~ 0.05 eV!**

Euclid Post-Planck Forecast for the Primary Program



Dark Energy		
w_p	w_a	FoM $= 1/(\Delta w_0 \times \Delta w_a)$
0.015	0.150	430
0.013	**0.048**	**1540**
0.007	0.035	**6000**
0.100	**1.500**	**~10**
>10	>40	>400

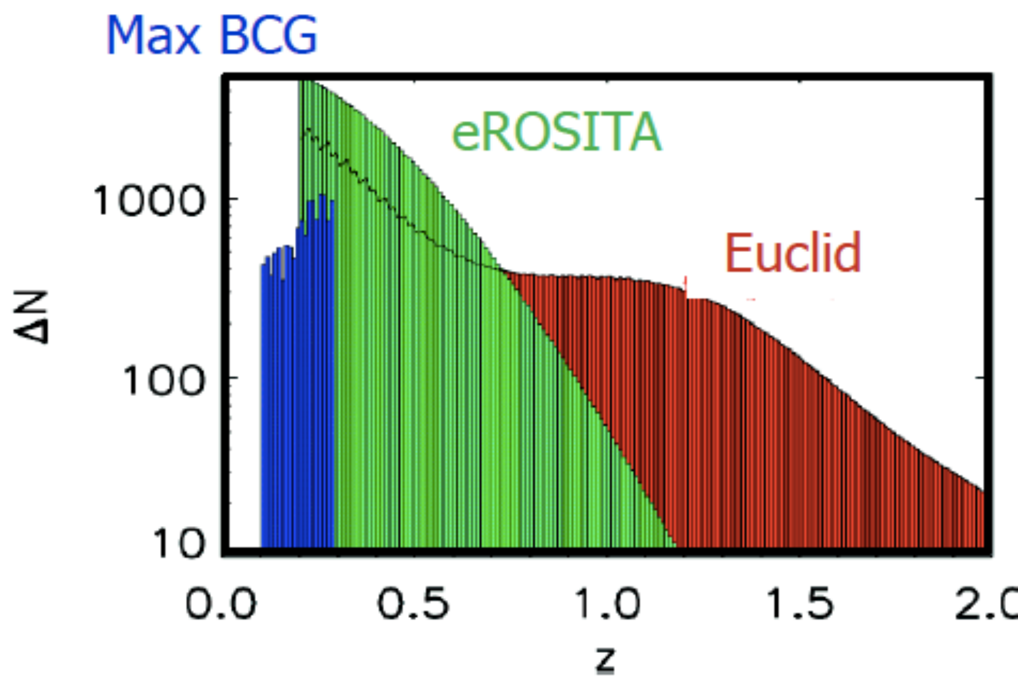
DE equation of state: $P/\rho = w$, and $w(a) = w_p + w_a(a_p - a)$

From Euclid data alone, get FoM=1/(Δw_a x Δw_p) > 400→ ~1% precision on w's.

Clusters of galaxies

important probe for Dark energy!

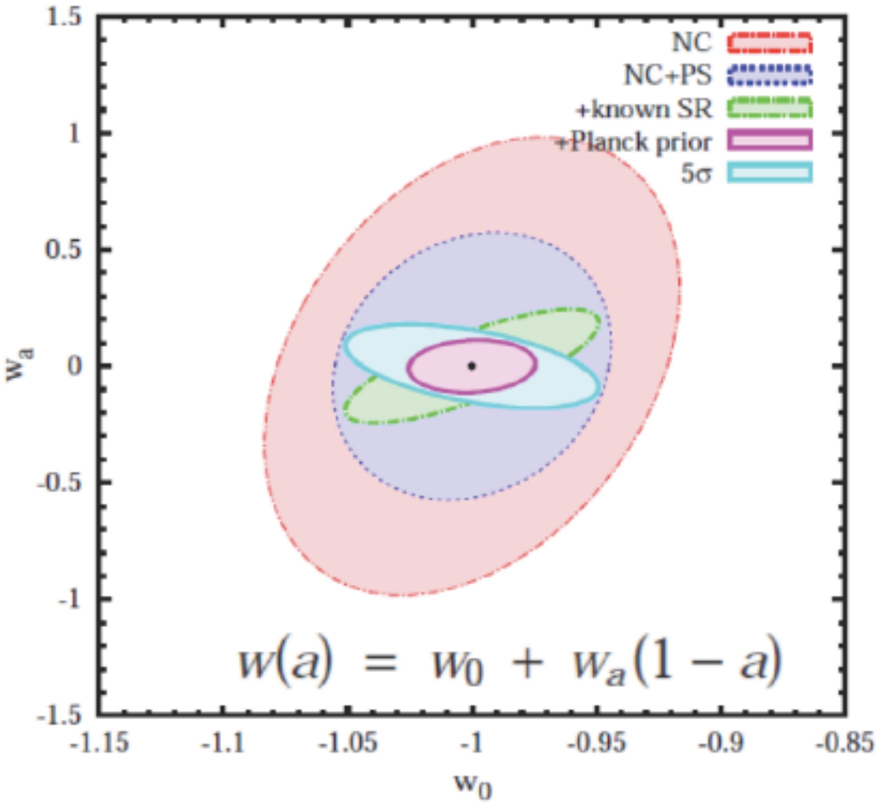
- Probe of peaks in density distribution
- Nb density of high mass, high redshift clusters very sensitive to
  - primordial non-Gaussianity and
  - deviations from standard DE models
- Euclid data will get for free:
  - Λ-CDM: all clusters with M>2 .10^{14} Msol detected at 3-σ up to z=2
    - → 60,000 clusters with 0.2<z<2 ,
    - → 1.8 10^4 clusters at z > 1.
  - ~ 5000 giant gravitational arcs
    - → accurate masses for the whole sample of clusters
    - → dark matter density profiles on scales >100 kpc



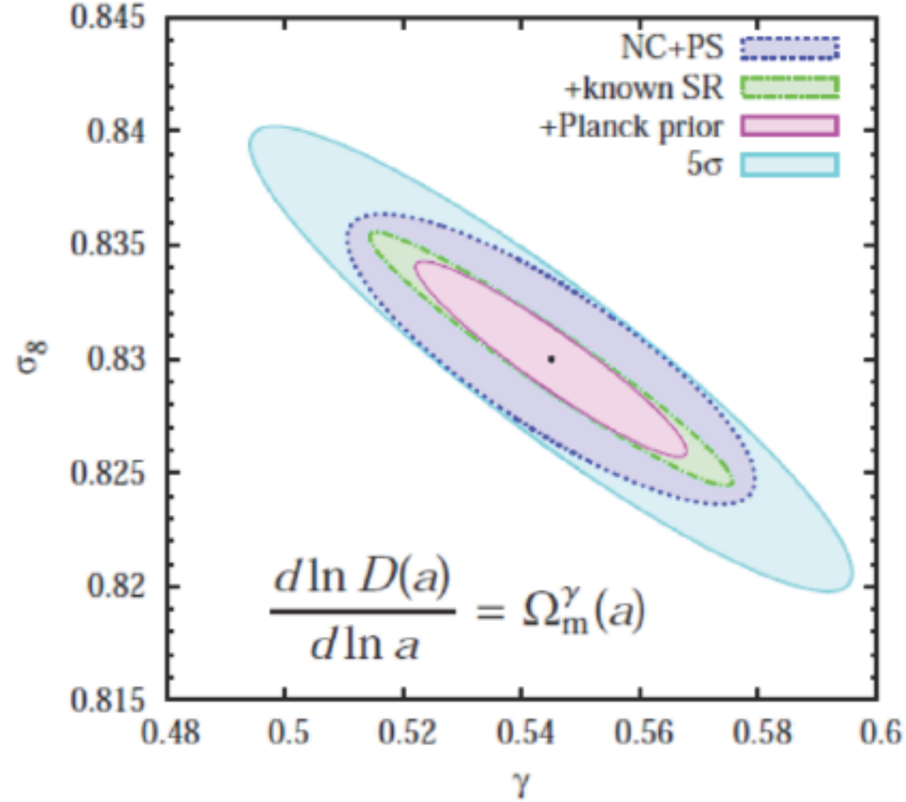
→ Synergy with Planck and eROSITA

Cosmology with clusters of galaxies in Euclid

Constraints on homogeneous dark energy



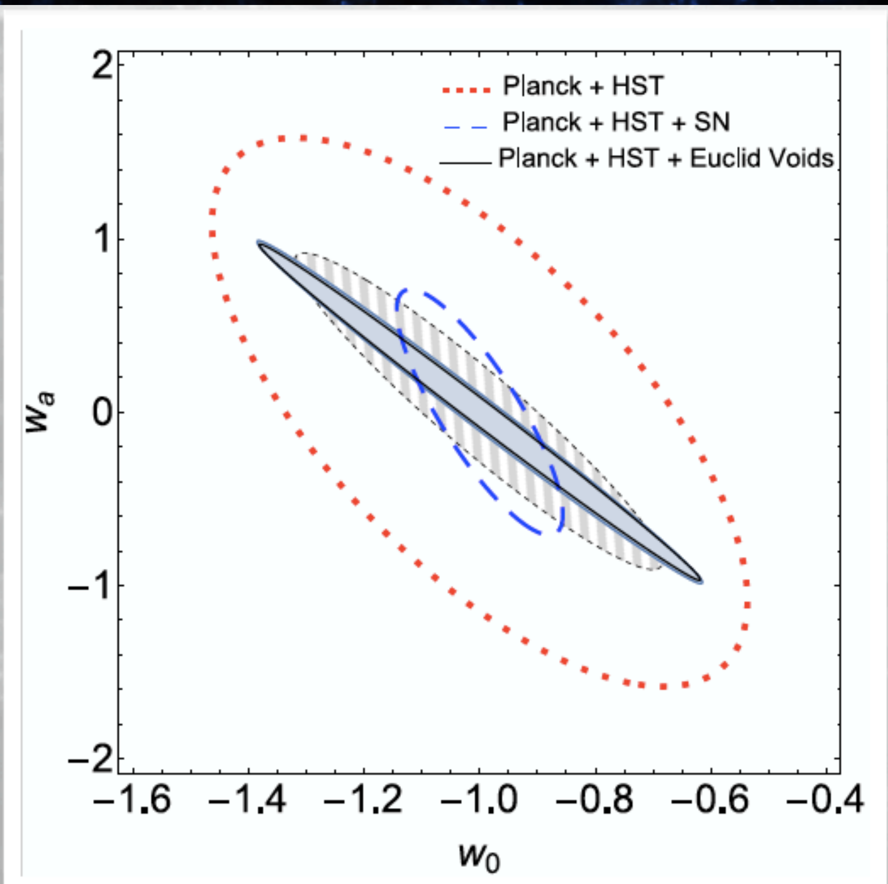
Constraints on fluctuations and growth rate



Sartoris et al. 2015 arXiv:1505.02165

NC: Cluster Number counts ; **PS**: Cluster Power Spectrum, **SR**: Cluster Scaling Relation

Cosmology with voids in Euclid



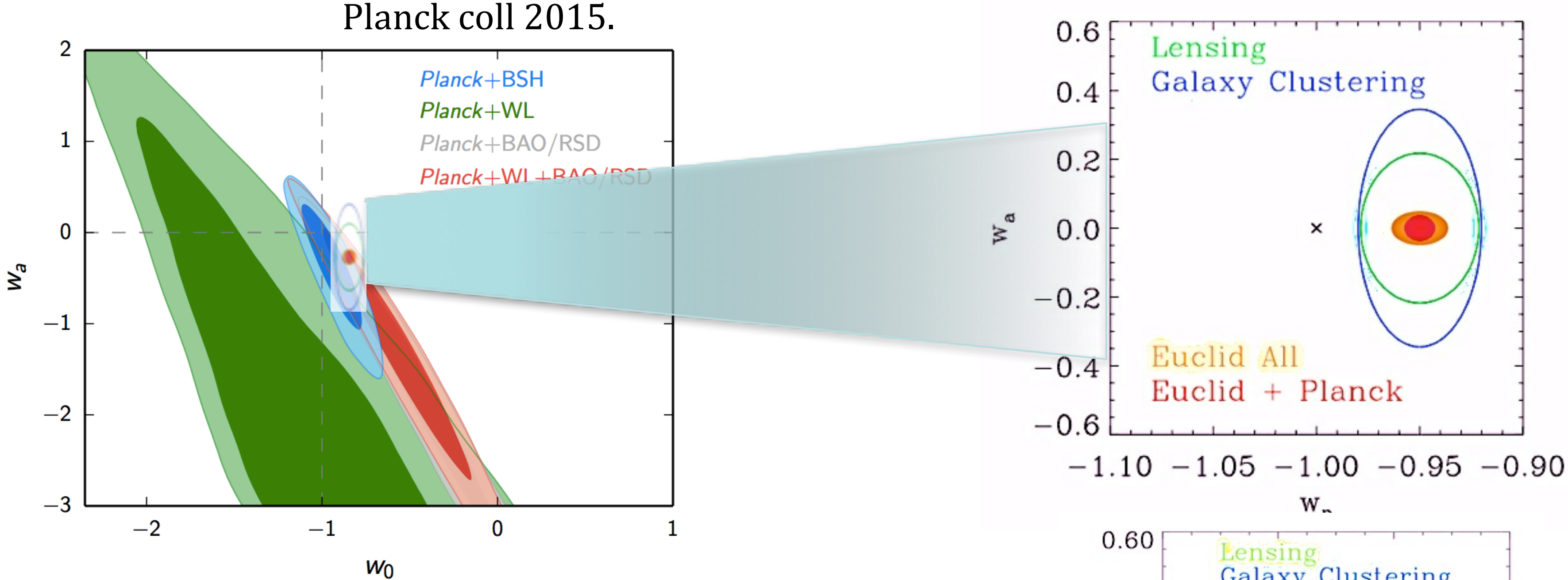
Pisani et al. 2015 (Phys. Rev. D; arXiv:1503.07690)

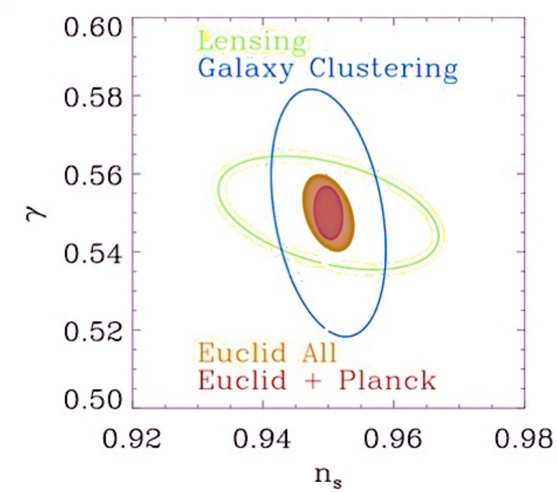
important probe for Dark energy!

We expect 1 Million of voids !

Need to combine all probes….

Planck coll 2015.



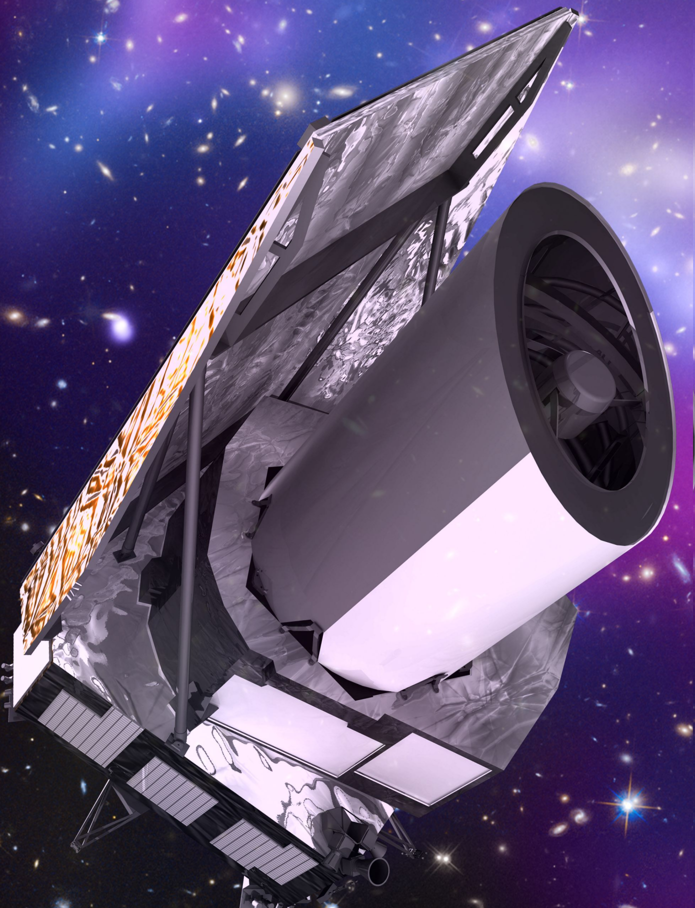


$f \sim \Omega^{\gamma}$; $\gamma = 0.55$?

The growth rate well described by $f(z)=\Omega_m(z)^{\gamma}$.

Euclid
Launch in 2020
First data for cosmology in 2023
Survey completed by 2026
Final results for 2027

euclid consortium



We need to be prepared to explore Dark Energy and the matter of the Univers in the next decade

Thank you

4

Euclid Top Level Science Requirements

Sector	Euclid Targets
Dark Energy	• Measure the cosmic expansion history to better than 10% in redshift bins $0.7 < z < 2$. • Look for deviations from $w = -1$, indicating a dynamical dark energy. • Euclid *alone* to give $FoM_{DE} \geq 400$ (1-sigma errors on w_p, & w_a of 0.02 and 0.1 respectively)
Test Gravity	• Measure the growth index, γ, with a precision better than 0.02 • Measure the growth rate to better than 0.05 in redshift bins between $0.5 < z < 2$. • Separately constrain the two relativistic potentials ψ , ϕ • Test the cosmological principle
Dark Matter	• Detect dark matter halos on a mass scale between 10^8 and $>10^{15}$ M_{Sun} • Measure the dark matter mass profiles on cluster and galactic scales • Measure the sum of neutrino masses, the number of neutrino species and the neutrino hierarchy with an accuracy of a few hundredths of an eV
Initial Conditions	• Measure the matter power spectrum on a large range of scales in order to extract values for the parameters σ_8 and n to a 1-sigma accuracy of 0.01. • For extended models, improve constraints on n and α wrt to Planck alone by a factor 2. • Measure a non-Gaussianity parameter : f_{NL} for local-type models with an error < +/-2.

Laureijs et al 2011

- DE equation of state: $P/\rho = w$, and $w(a) = w_p + w_a(a_p - a)$
- Growth rate of structure formation: $f \sim \Omega^\gamma$;
- FoM=$1/(\Delta w_a \times \Delta w_p) > 400$ → ~1% precision on w's.

Euclid forecast: neutrinos and relativistics species

Amendola et al 2013	General cosmology					
fiducial →	$\Sigma = 0.3\,\mathrm{eV}^a$	$\Sigma = 0.2\,\mathrm{eV}^a$	$\Sigma = 0.125\,\mathrm{eV}^b$	$\Sigma = 0.125\,\mathrm{eV}^c$	$\Sigma = 0.05\,\mathrm{eV}^b$	$N_{\mathrm{eff}} = 3.04^d$
EUCLID+Planck	0.0361	0.0458	0.0322	0.0466	0.0563	0.0862
	ΛCDM cosmology					
EUCLID+Planck	0.0176	0.0198	0.0173	0.0218	0.0217	0.0224

[a] for degenerate spectrum: $m_1 \approx m_2 \approx m_3$; [b] for normal hierarchy: $m_3 \neq 0$, $m_1 \approx m_2 \approx 0$
[c] for inverted hierarchy: $m_1 \approx m_2$, $m_3 \approx 0$; [d] fiducial cosmology with massless neutrinos

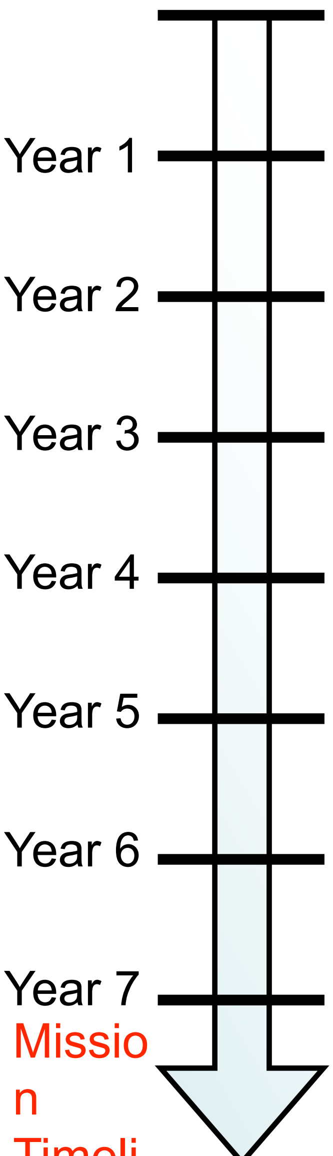
- **If Σ >0.1 eV**

→ Euclid spectroscopic survey will be able to determine the neutrino mass scale independently of the model cosmology assumed.

- **If Σ <0.1 eV**

→ the sum of neutrino masses, and in particular the minimum neutrino mass required by neutrino oscillations, can be measured in the context of the Λ-CDM

Euclid data release schedule



T0: Start of nominal mission (2021)

QR1: ~50 deg^2

DR1: 2500 deg^2 (first year)

QR2: + ~50 deg^2

DR2: +5000 deg^2, total 7000 deg^2

QR3: + ~50 deg^2

QR4: + ~50 deg^2

DR3: +7500 deg^2, total 15000 deg^2

Early 2028…

Mission Timeline

QR: Quick Releases

- No cosmology relevant data products.
- Focussed releases (e.g. highly observed sky fields, catalogs of objects).

DR: Data Releases

- Full release of the Euclid pipeline data products.
- Validated by Science Working Groups (accompanying papers).
- Cosmology relevant.
- Will contain ground-based data but do not supersede actual releases by ground-based teams.
- DR1: first year of data delivered at end of year 2.
- DR2: first 3 years of date delivered at end of year 4
- DR3: all data delivered 1 year after the end of the survey.

4

Euclid+ground: photo-z of 1.5 billion galaxies

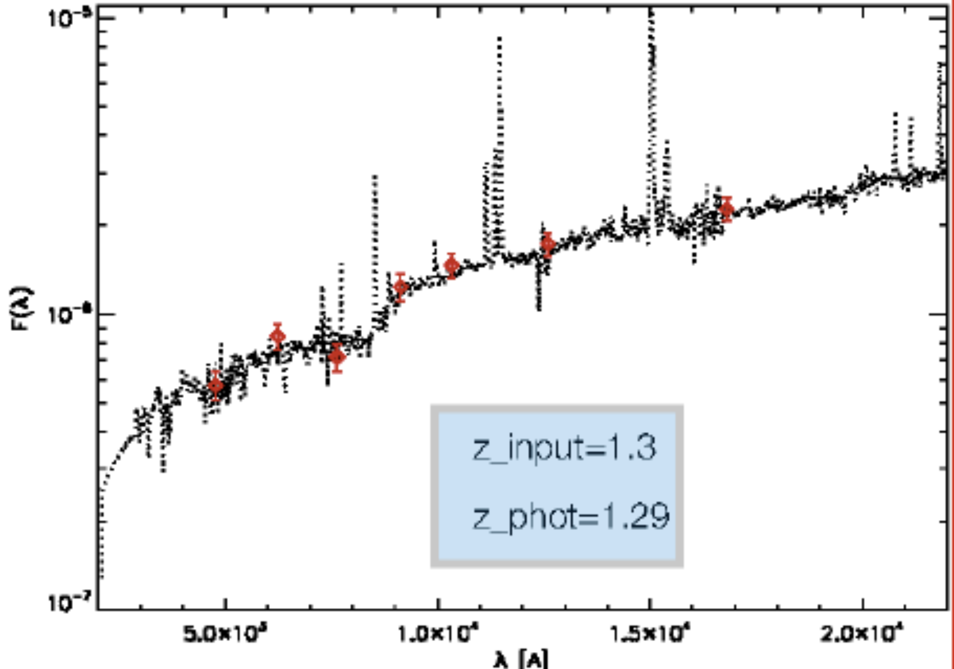
Critical: need ground based imaging over 15,0000 deg² in 4 bands

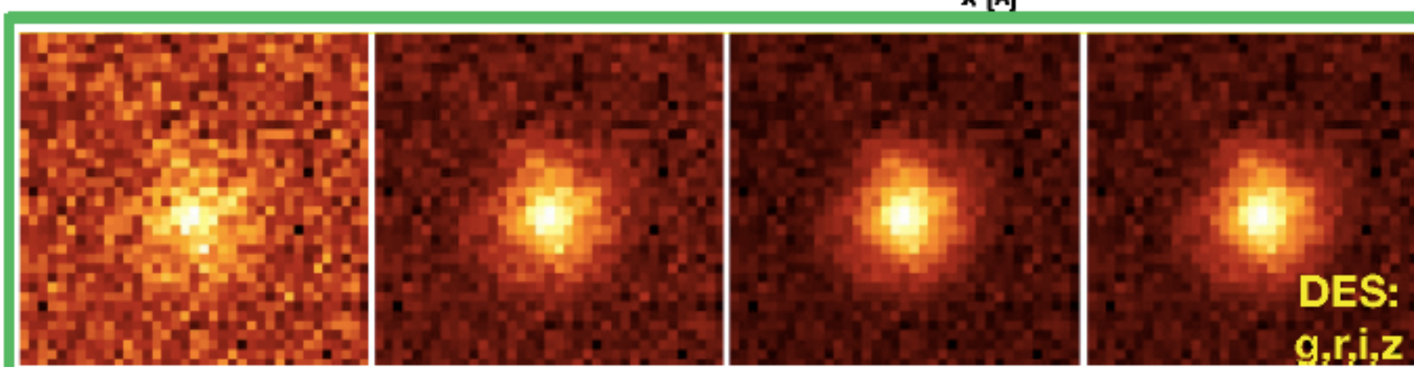
Courtesy Euclid SWG Photo-z and OU-PHZ

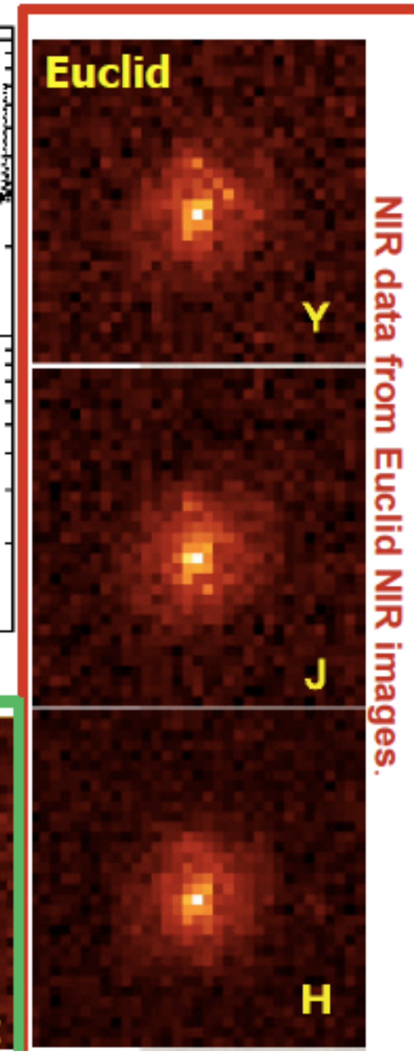
Requirements:

- get photo-z for ~all WL galaxies
- cover the whole Euclid sky (15000 deg²)
- accuracy: 0.05x(1+z)

→ 4 optical bands needed







Euclid Wide and Deep Surveys

- **Euclid Wide:**
  - 15000 deg^2 outside the galactic and ecliptic planes
  - 12 billion sources (3-σ)
  - 1.5 billion galaxies with
    - Very accurate morphometric information (WL)
    - Visible photometry: (u), g, r, i, **z** , (R+I+Z) AB=24.5, 10.0 σ +
    - NIR photometry : Y, J, H AB = 24.0, 5.0σ
    - Photometric redshifts with 0.05(1+**z**) accuracy
  - 35 million spectroscopic redshifts of emission line galaxies with
    - 0.001 accuracy
    - Halpha galaxies within 0.7 < **z** < 1.85
    - Flux line: 2 . 10^{-16} $erg.cm^{-2}.s^{-1}$; 3.5σ

- **Euclid Deep:**
  - 1x10 deg^2 at North Ecliptic pole + 1x20 deg^2 at South Ecliptic pole

    + 1x10 deg^2 South Equatorial field
  - 10 million sources (3-σ)
  - 1.5 million galaxies with
    - Very accurate morphometric information (WL)
    - Visible photometry: (u), g, r, i, **z** , (R+I+Z) AB=26.5, 10.0 σ +
    - NIR photometry : Y, J, H AB = 26.0, 5.0σ
    - Photometric redshifts with 0.05(1+**z**) accuracy
  - 150 000 spectroscopic redshifts of emission line galaxies with
    - 0.001 accuracy
    - Halpha galaxies within 0.7 < **z** < 1.85
    - Flux line: 5 . 10^{-17} $erg.cm^{-2}.s^{-1}$; 3.5σ

Euclid challenges

Shape measurements/systematics

Control of both multiplicative and additive biases

Photometric redshifts:

Ground based photometry in 4 bands : 15,000 deg^2 (i.e. north and south)

Numerical simulations with power spectrum to a 1% accuracy :

Resolution

Underlying physics: e.g. numerical simulations with baryons

Numerical simulation of a large number of DE, GR models

10^3 to 10^5 simulations to estimate covariance matrices

High order statistics:

Potentials of high order statistics for DE science + Systematics

Need Spectroscopics surveys to

Calibrate deep photo-z and

Understand BAO and RSD samples