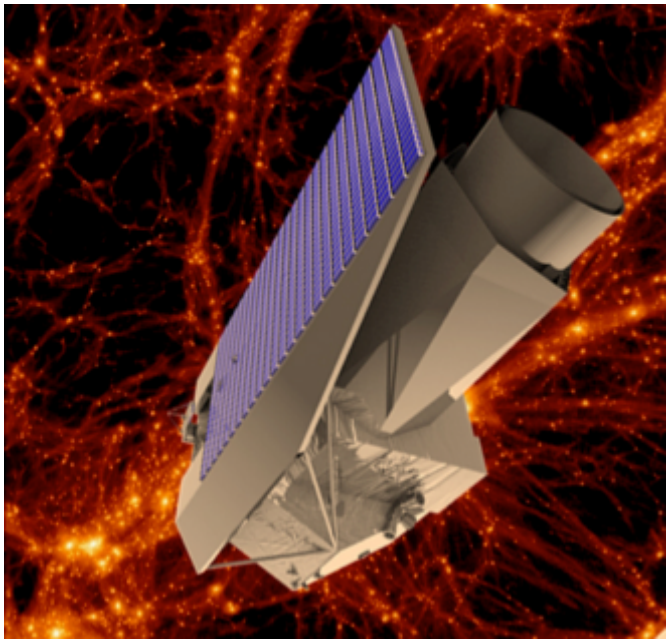


Euclid

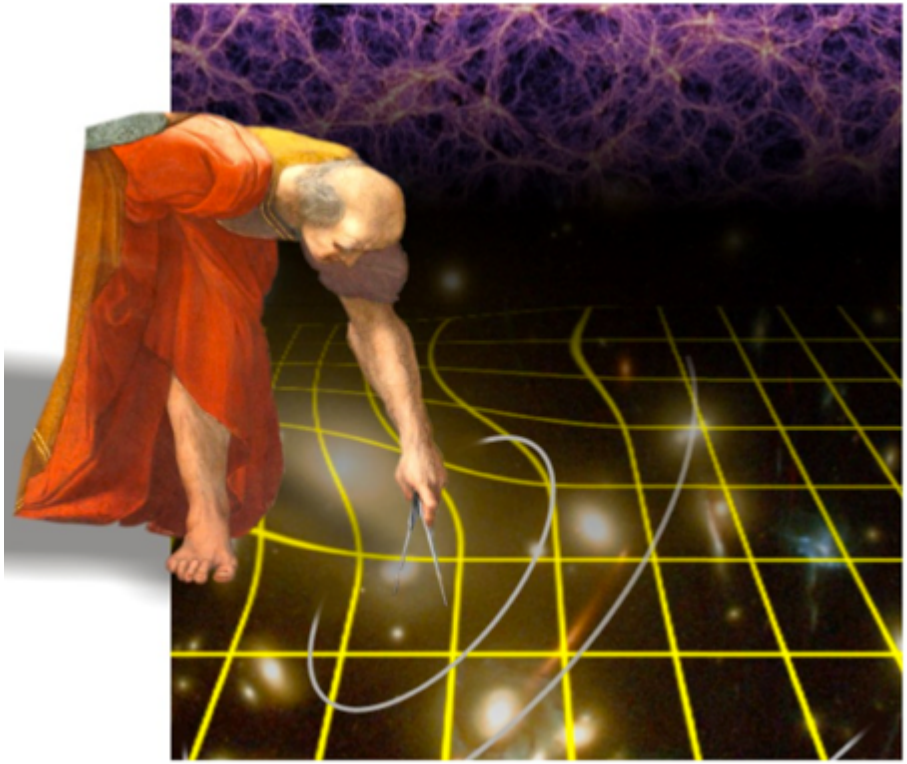
Mapping the geometry of the dark Universe

Conseil scientifique de l'IN2P3

25 Octobre 2012

A Ealet
(CPPM)

Participation of IN2P3 to an ESA space mission



OVERVIEW

Scientific objectives

The EUCLID mission

The instruments

The ground segment (data processing)

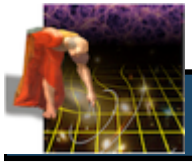
The organisation

The French participation

In2p3 contributions

Conclusion

Scientific objectives



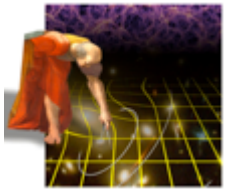
The goal ..

Understand the origine of the accelerated expansion of the Univers

Probe its nature
Distinguish different possible effects

Determine which are the best practical probes:
check degeneracies, complementarity, possible systematics,

Issue	Our Targets
Dark Energy	Measure the DE equation of state parameters w0 and wa to a precision of 2% and 10%, respectively, using both expansion history and structure growth.
Test of General Relativity	Distinguish General Relativity from the simplest modified-gravity theories, by measuring the growth factor exponent γ with a precision of 2%
Dark Matter	Test the Cold Dark Matter paradigm for structure formation, and measure the sum of the neutrino masses to a precision better than 0.04eV when combined with Planck.
The seeds of cosmic structures	Improve by a factor of 20 the determination of the initial condition parameters compared to Planck alone.



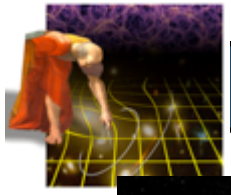
Main probes

Weak lensing (WL) :
two-point 3-dimensional cosmic shear measurements over 0<z<2

For 0<z<2 photo-z need both optical and NIR data.

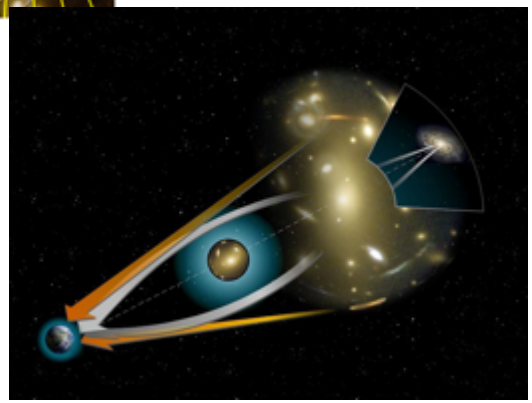
Galaxy clustering (GC) :
two-point 3-dimensional position measurements over the redshift range 0<z<2

3-dimensional distribution of galaxies from spectroscopic redshifts

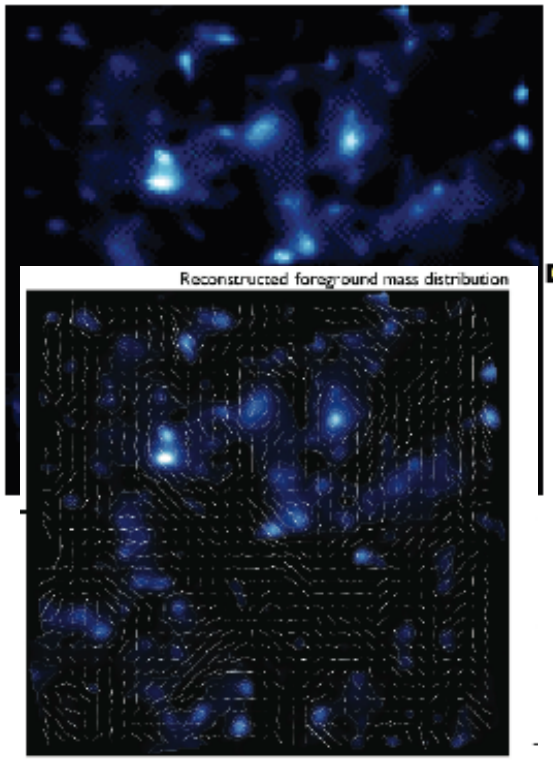


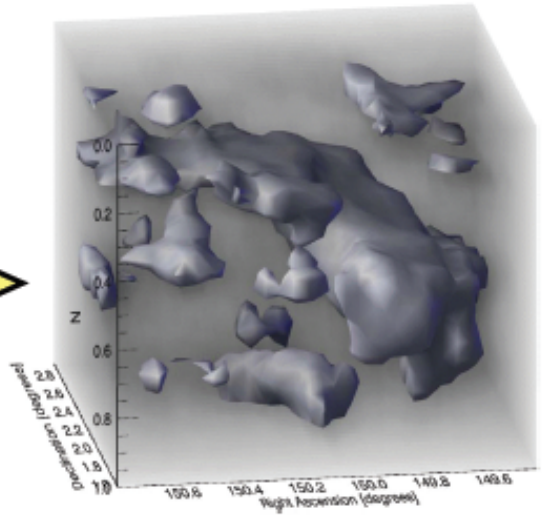
WL: Dark Matter and Lensing Tomography

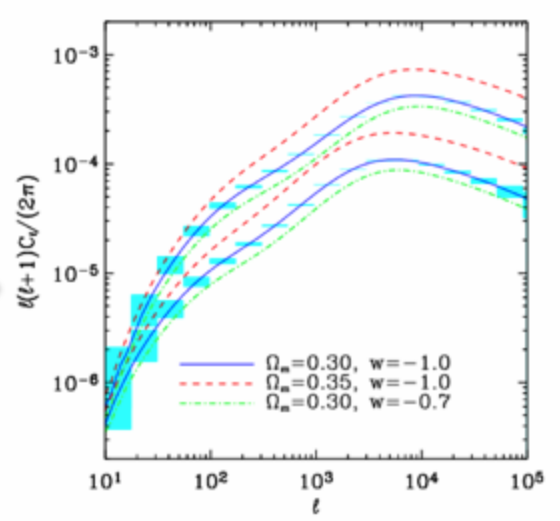
EUCLID CONSORTIUM



Density fluctuations in the universe affect the propagation of light rays, leading to correlations in the shapes of neighboring galaxies.





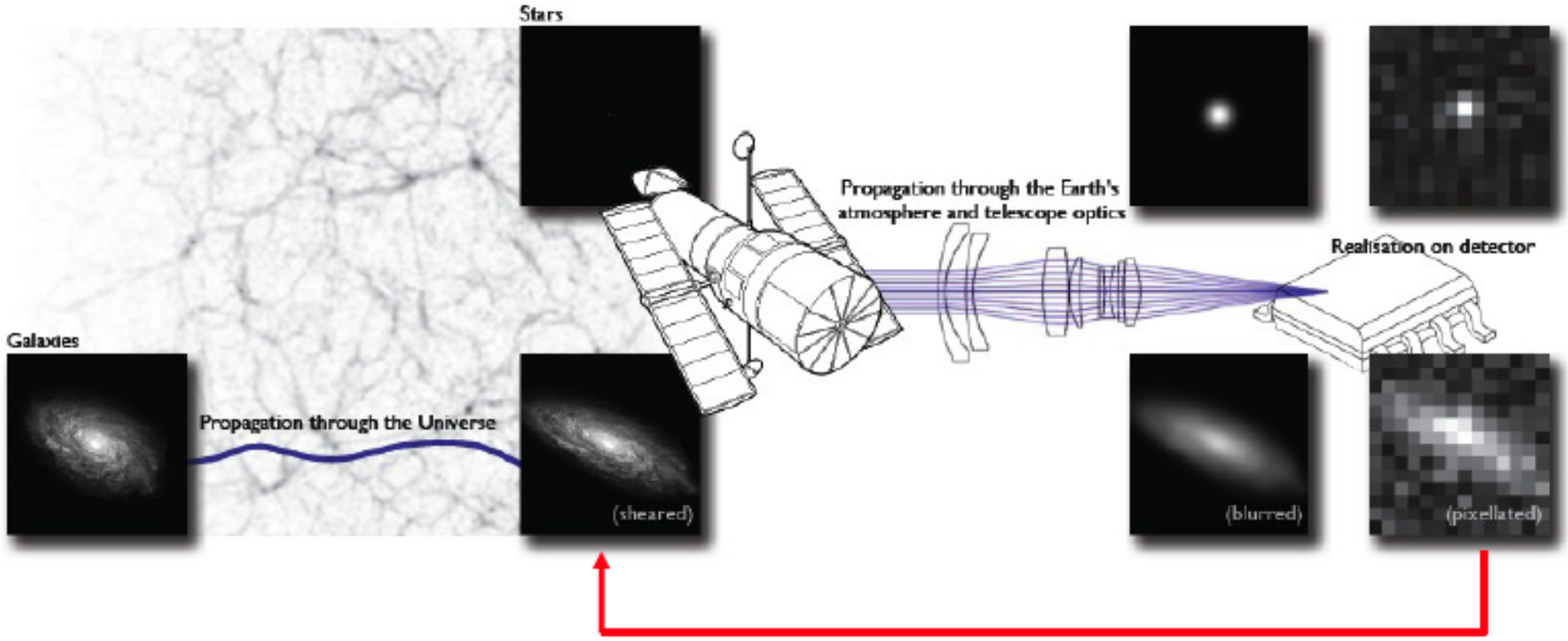


Statistics of shape correlations can directly map the **dark matter** in 3D
Weak lensing is sensitive to
-The expansion of Universe with z - H(z)
- The growth of structures with z - G(z)
The way these structures grow with cosmic time depend of **dark energy.**
This is a powerful observable to constrain DE , modified gravity…

Challenge 1: measuring very weak shear

Euclid Consortium

Figure from Kitching et al. 2012



Measuring very weak shear with the same accuracy on 2 billion galaxies, over 15,000 deg² and with the same instrument during 6 years

Euclid:optimised for shape measurements

Euclid Consortium

M51

Courtesy J. Brinchmann, Steve Warren

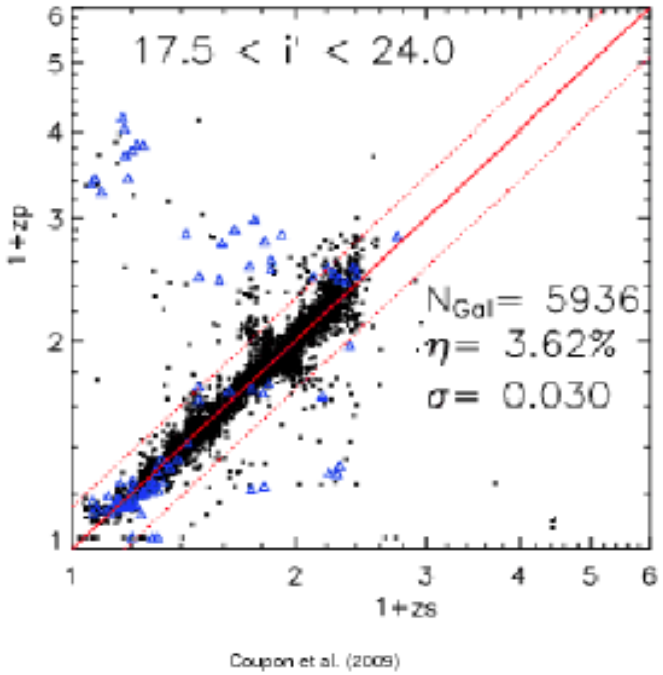
SDSS @ z=0.1 | Euclid @ z=0.1 | Euclid @ z=0.7

- Euclid images of z~1 galaxies: same resolution as SDSS images at z~0.05 and at least 3 magnitudes deeper.
- Space imaging of Euclid will outperform any other surveys of weak lensing.

Photometric redshifts with Euclid: need VIS+NIR

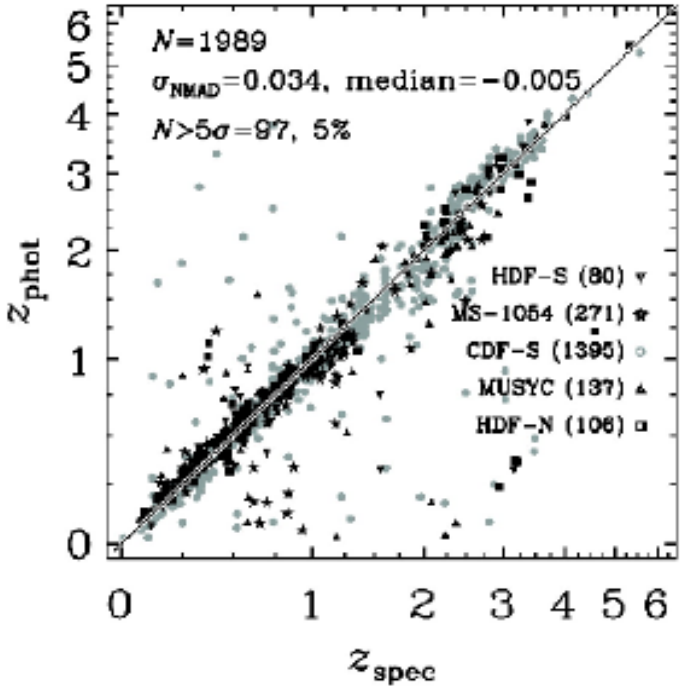
Euclid Consortium

Photo-*z* vs. spec-*z* (deep optical)



Courtesy:H. Hildebrandt

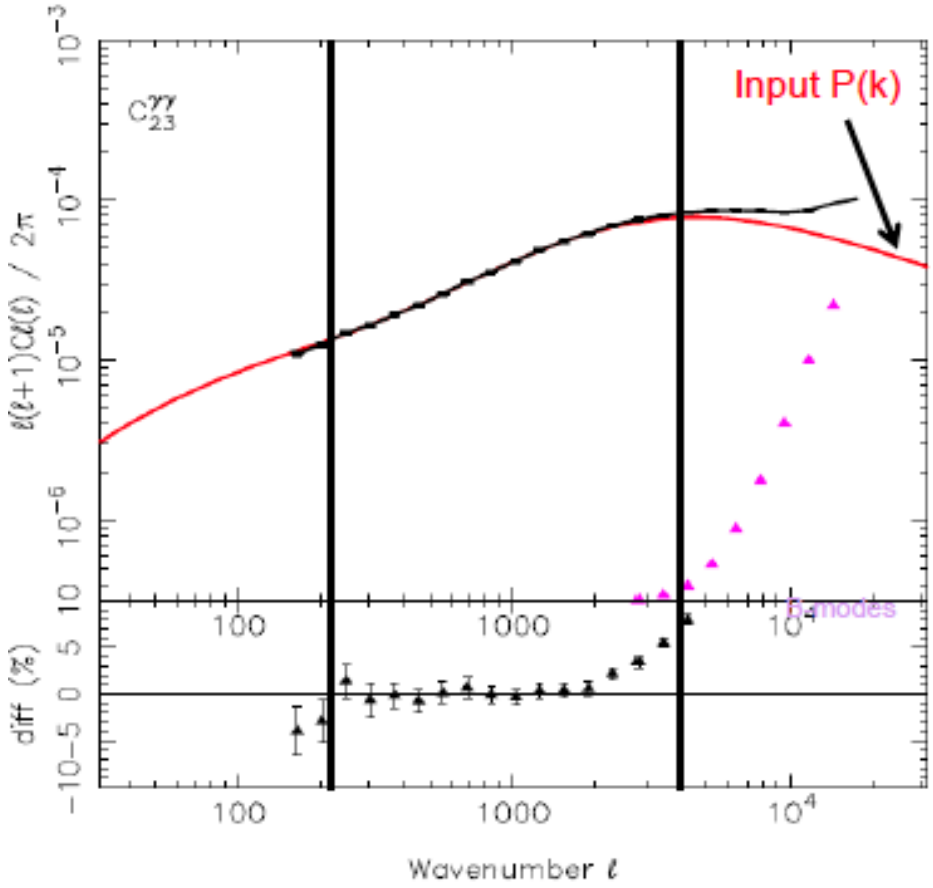
Photo-*z* vs. spec-*z* (deep optical+IR)



Euclid weak lensing will probe the lensed universe between redshift 0.2 and 3…
→ both visible and near infrared photometry are needed for photometric redshift

Need ground based photometry to have enough bands, enough depth over the whole 15 000 deg2 (North and South) : candidates Pan Starr 2, DES , Subaru, LSST??

Expected performance ….

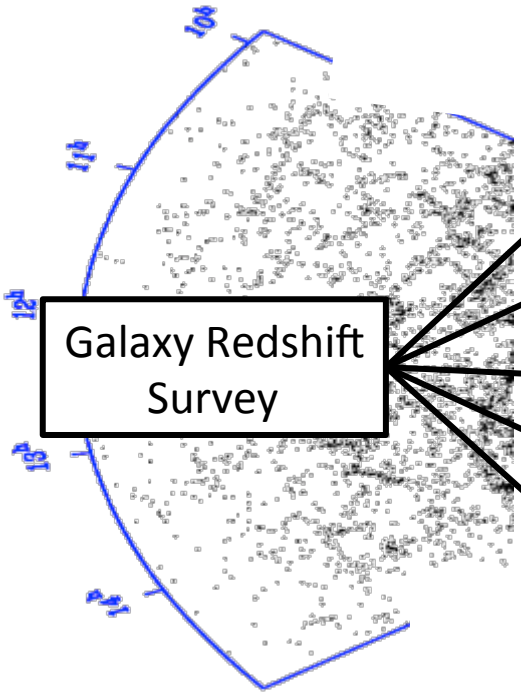


- Tomographic WL shear cross-power spectrum for $0.5 < z < 1.0$ and $1.0 < z < 1.5$ bins.

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

Challenge 2 : Galaxy clustering

EUCLID CONSORTIUM



Galaxy Redshift Survey

Comoving clustering → What are the constituents of matter?
e.g. neutrino mass, primordial P(k)

Standard Ruler (BAO) → What is the expansion rate of the Universe?
e.g. quintessence, Λ

Redshift-Space distortions → How does structure form within this background?
e.g. modified gravity, GR

Understanding acceleration

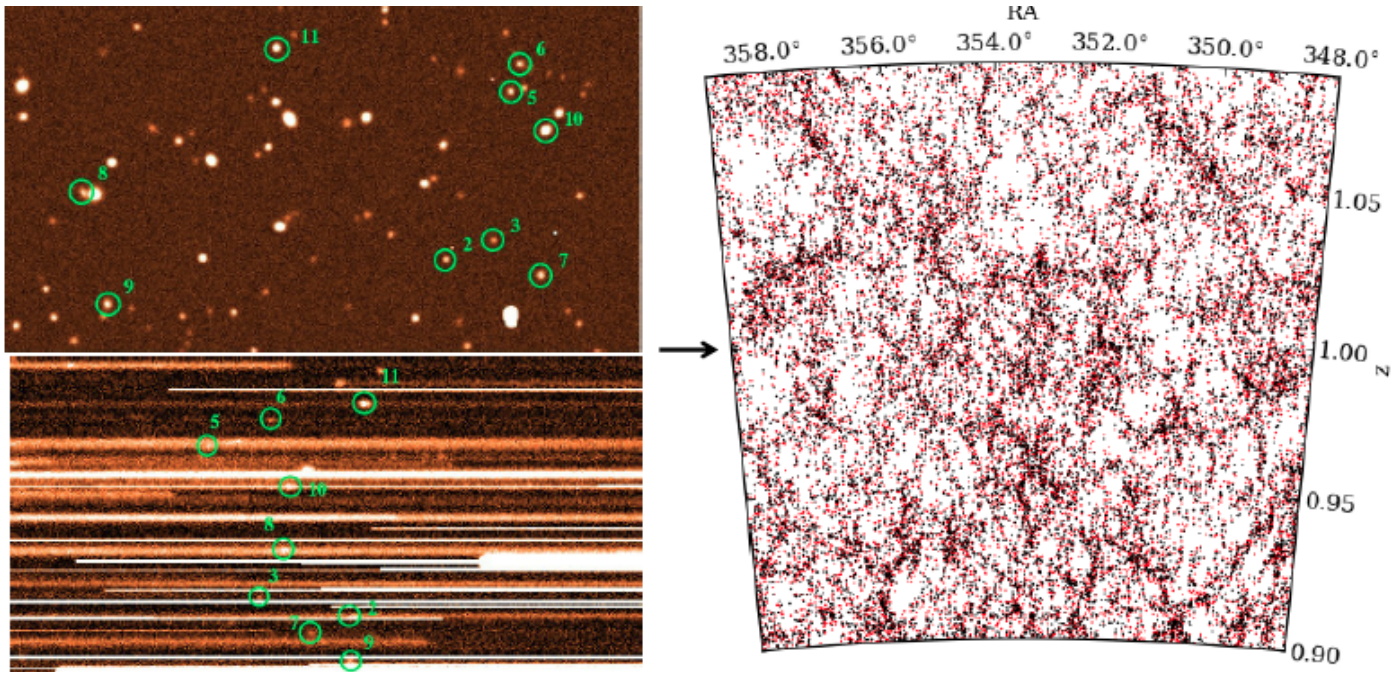
Large-scale density → Is the Universe homogeneous on large scales?
Copernican principle, Non-Gaussianity

Spectral analysis → How do galaxies form and evolve?
semi-analytic models, halo model

Spectroscopy method in space

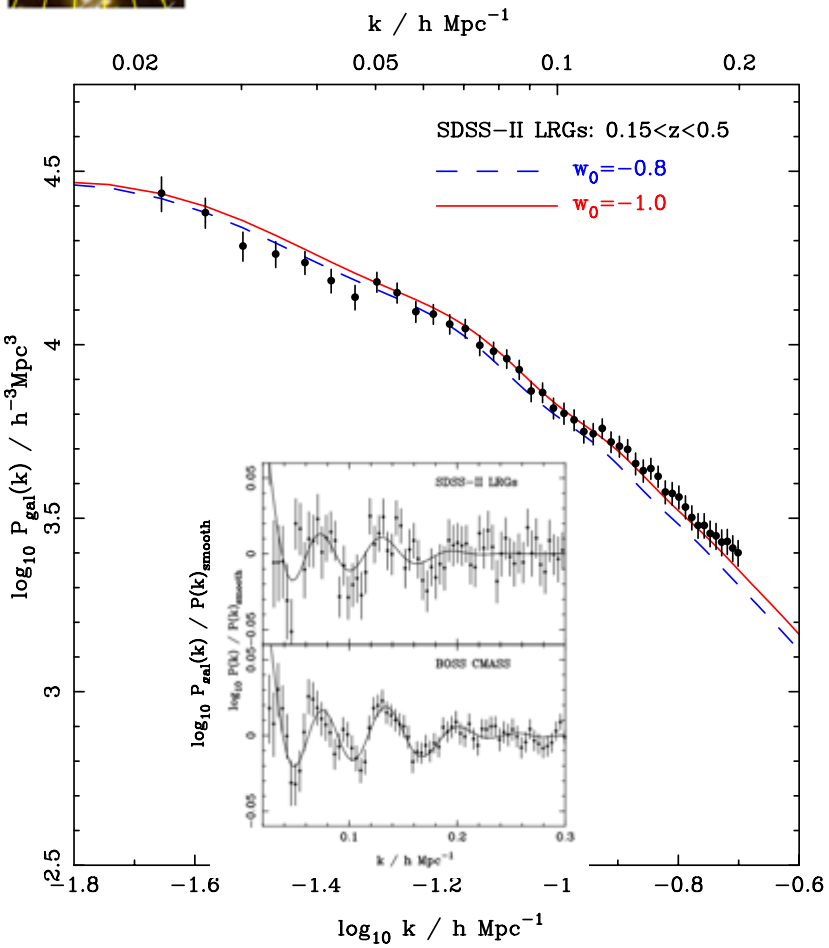
EUCLID CONSORTIUM

- Use slitless spectroscopy without target sample based on the selection in the IR of the Hα emission line in the range $0,7<z<2$
- Some heritage from HST (smaller area but same technic)
- Feasibility , density, completeness and purity demonstrated by end to end simulation



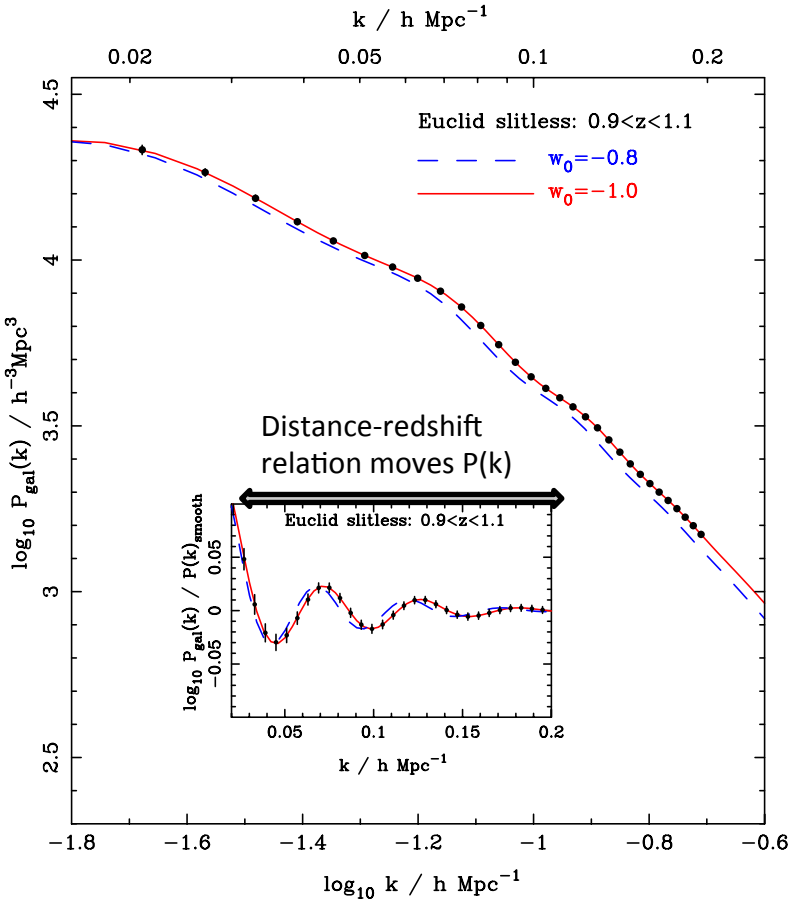
BAO in power spectrum:standard ruler

EUCLID CONSORTIUM



SDSS today

0.15<z<0.5



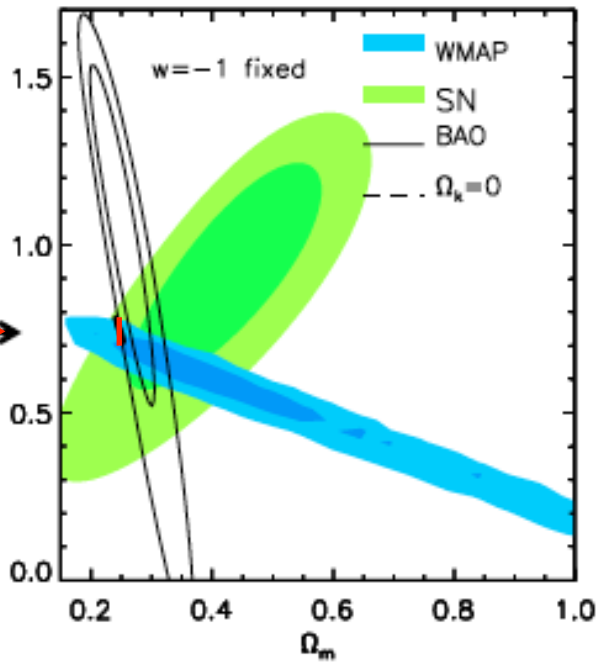
EUCLID expected

One of five redshift slices (0,7<z<2)
assuming slitless baseline in one slice
z~1

Euclid BAO predictions

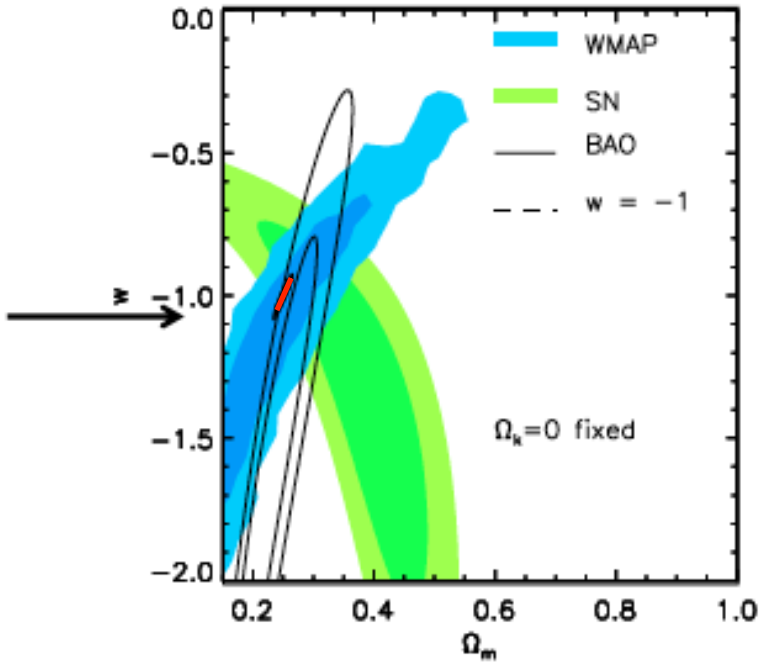
Euclid Consortium

ΛCDM models with curvature



EUCLID

flat wCDM models



Union supernovae

WMAP 5year

SDSS-II BAO Constraint on $r_s(z_d)/D_V(0.2)$ & $r_s(z_d)/D_V(0.35)$

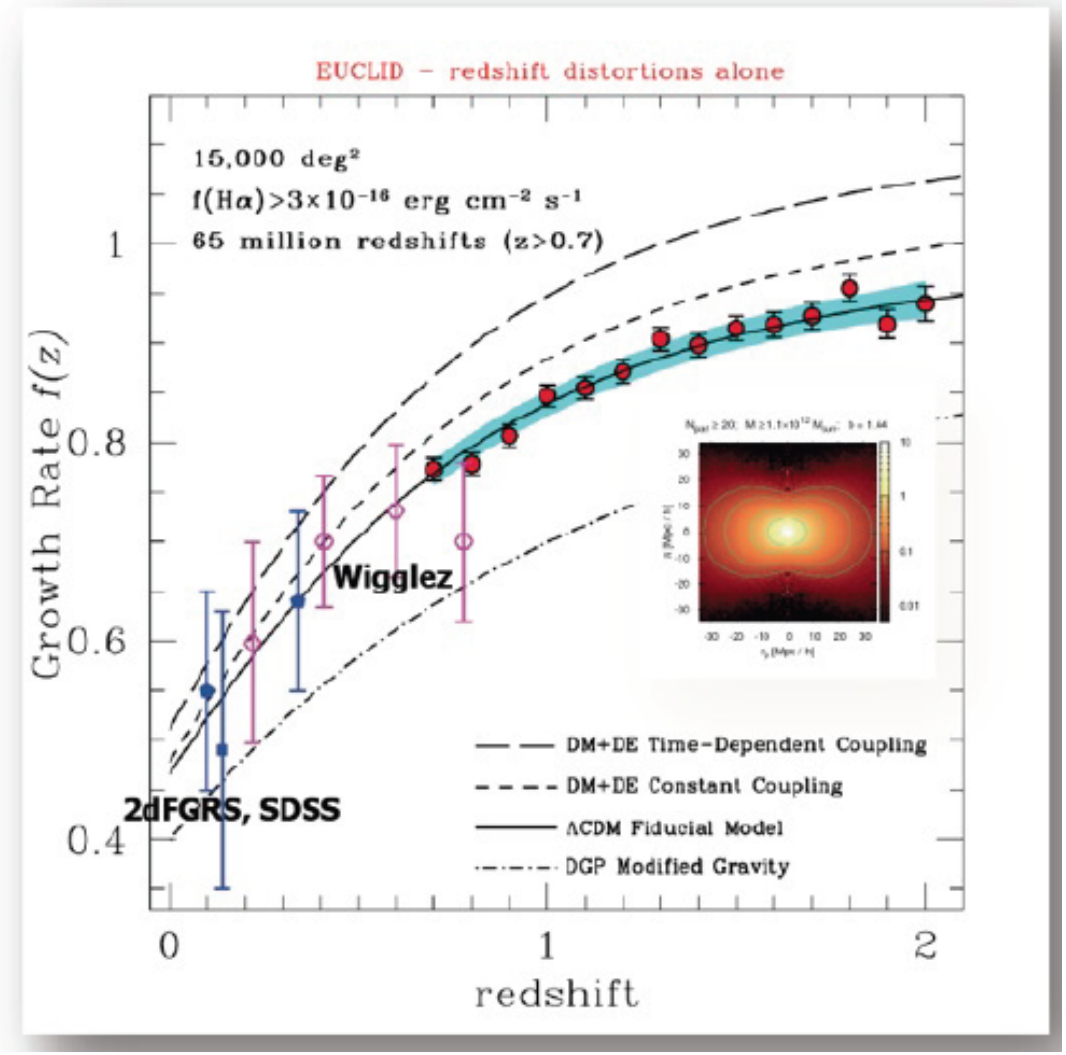
Courtesy Will Percival

Redshift space distorsion

EUCLID CONSORTIUM

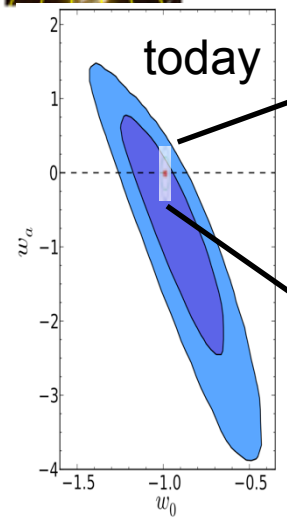
Anisotropy of the power spectrum
measure of the growth of structure

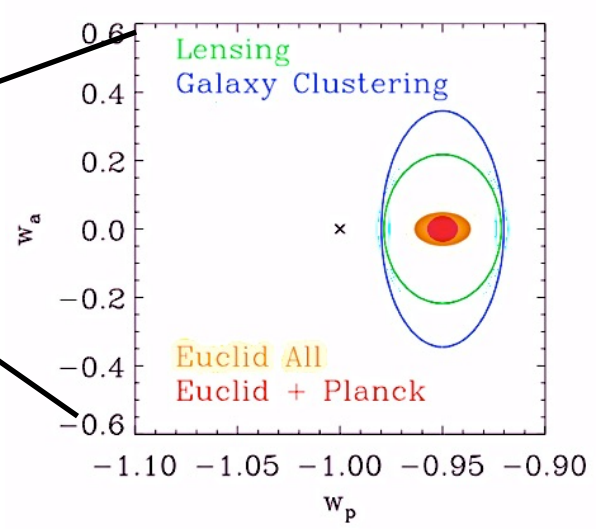
The growth factor or growth rate f(z) quantifies the efficiency with which cosmological structures can be build

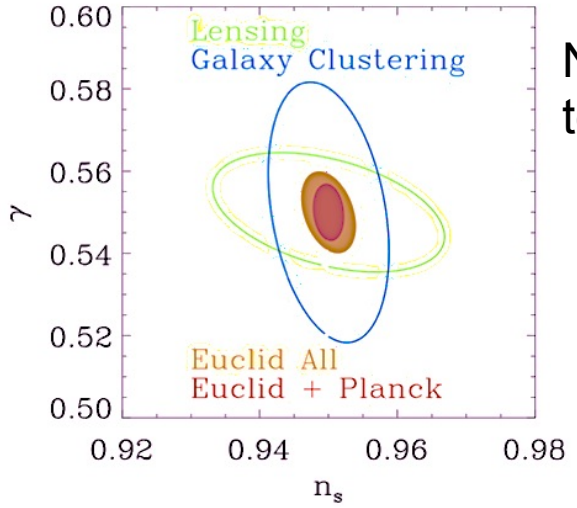


Combining WL +GC – constraining modifed gravity

EUCLID CONSORTIUM





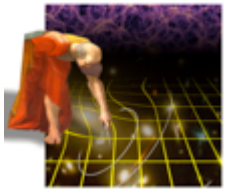


New possible test of gravity

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

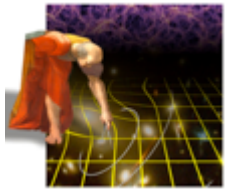
	Dark energy			neutrinos	Initial conditions	Modified gravity
Parameter	**w_p**	**w_a**	**FOM**	**$m\nu$ (eV)**	**F_{NL}**	**γ**
EUCLID +Planck	**0.007**	**0.035**	**4020**	**0.019**	**2.0**	**0.007**
Current	**0.1**	**1.5**	**11**	**0.58**	**100**	**0.2**
Improve factor	**>10**	**>50**	**>300**	**30**	**50**	**30**

These numbers have meaning only if we can control the systematic errors

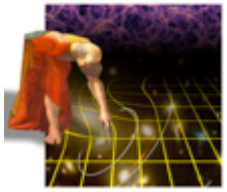


Additional cosmological probes

- Complementing ESA Planck data
  - tightening of parameters given baseline to last scattering surface
  - measurement of Integrated Sachs-Wolfe effect
  - measurement of the lensed CMB sky
- Type 1a Supernovae in the Deep Field
  - NIR light-curves and colours for 3,000 Type Ia SNe to z~ 1.2
  - Euclid spectroscopy would provide accurate redshifts for many of the host galaxies, although ground-based spectroscopic redshifts would still be required for subset
  - Euclid will be the first large- scale NIR search for SNe from space.



EUCLID
THE MISSION



EUCLID an ESA space mission

EUCLID CONSORTIUM

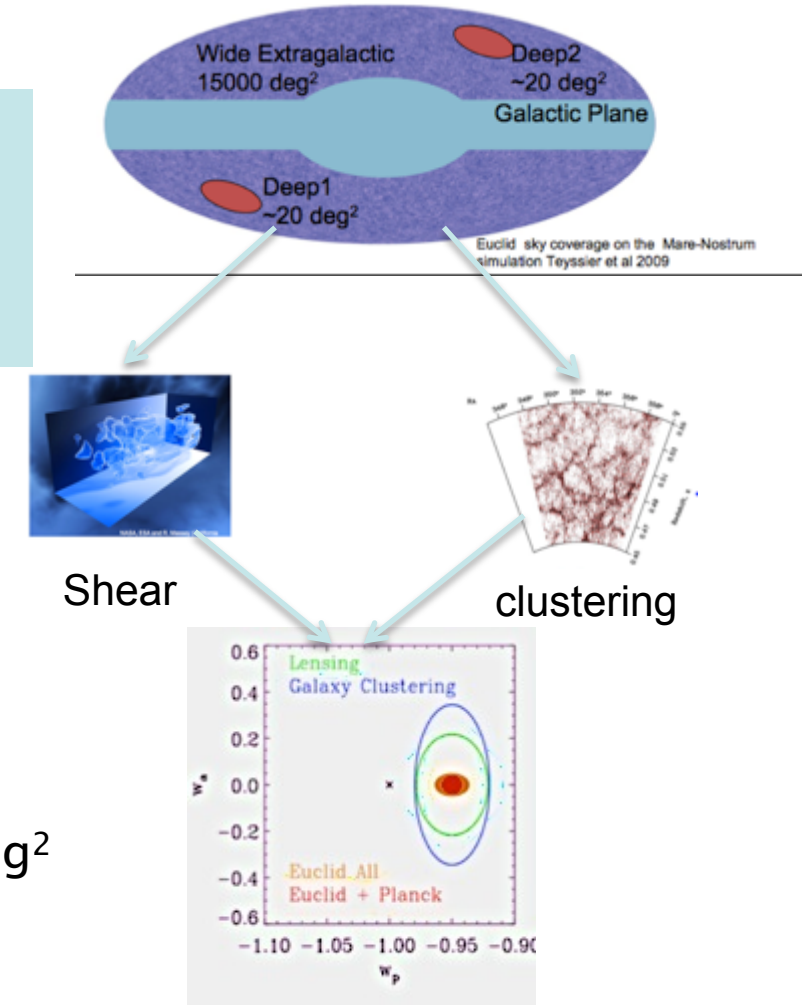
- EUCLID is a space mission with visible and Infrared observations of all sky, both in photometry and spectroscopy

- Near Infrared access (photometry, spectroscopy)
- Very stable image quality (small and stable PSF)
- Very low background
  - ⇒ Systematic control
  - ⇒ Homogeneity of selection in the full redshift range

- EUCLID is an ESA mission planned for an L2 orbit with 2 instruments (3 channels)

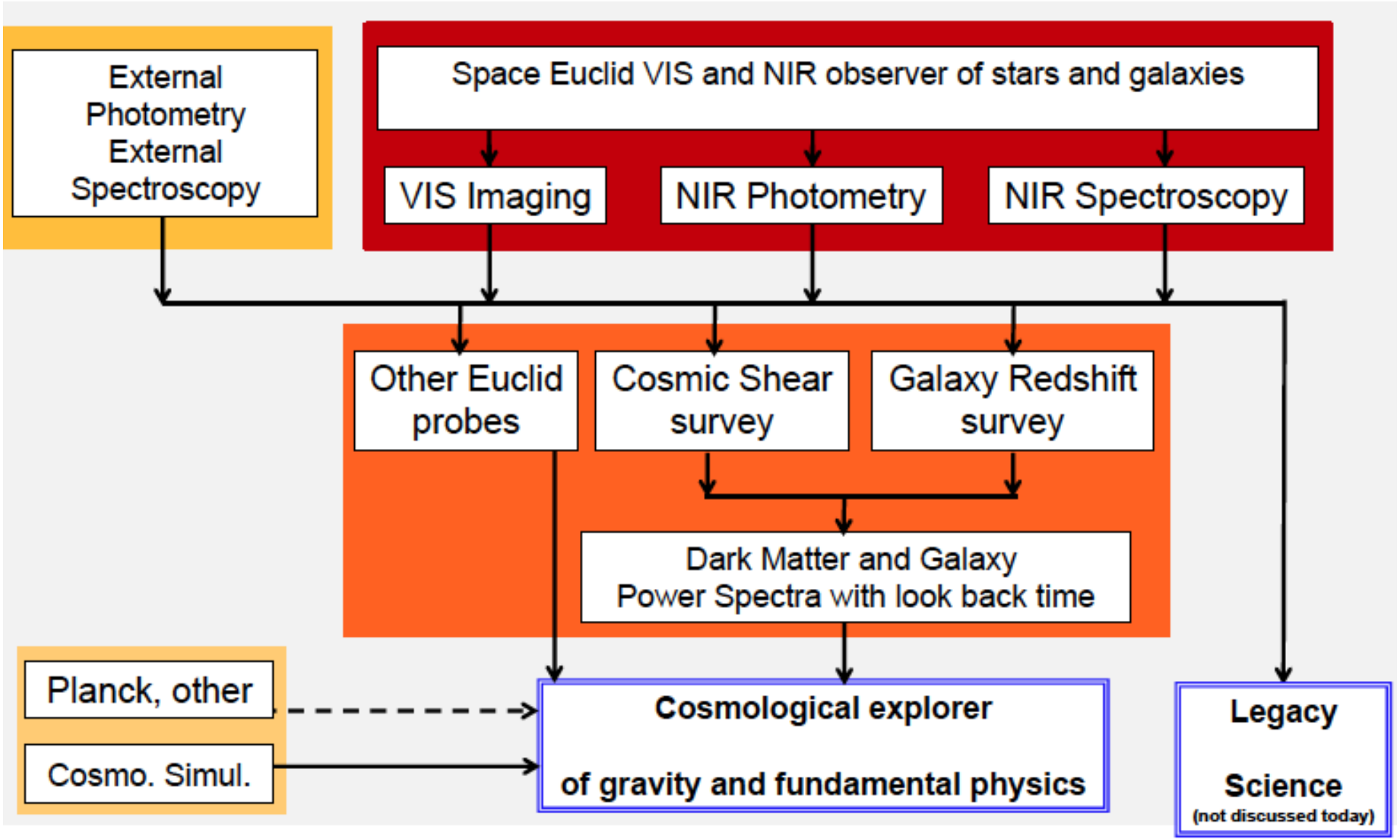
EUCLID was selected by ESA in Oct. 2011, Adopted in June 2012 in the cosmic vision program as the M2 mission to be launch in 2020

- EUCLID will have a wide survey of 15000 deg^2 and a deep survey of 40 deg^2



EUCLID: a big machine

EUCLID CONSORTIUM



Main requirements to design the mission

Euclid Consortium

	Wide survey	Deep survey
Survey		
size	15000 deg ^{2}	40 deg^2 N/S
VIS imaging		
Depth	n_{gal} > 30/arcmin^2 → M_{AB} =24.5 → <z> ~0.9	M_{AB} = 26.5
PSF size knowledge	$\sigma[R^2]/R^2<10^{-3}$	
Multiplicative bias in shape	$\sigma[m]<2\times10^{-3}$	
Additive bias in shape	$\sigma[c]<5\times10^{-4}$	
Ellipticity RMS	$\sigma[e]<2\times10^{-4}$	
NIP photometry		
Depth	24 M_{AB}	26 M_{AB}
NIS spectroscopy		
Flux limit (erg/cm^2/s)	3 10^{-16}	5 10^{-17}
Completness	> 45 %	>99%
Purity	>80%	>99%
Confusion	2 rotations	>12 rotations

- WL and systematics

$$\gamma^{obs} = (1+m)\times\gamma^{true} + c$$

$$C_l^{true} \approx \left[1+2\langle m\rangle\right]\times C_l^{obs} + \langle c\rangle^2$$

→ $m < 2\times10^{-3}$: multiplicative bias

$\sigma^2_{sys} \approx \langle c^2\rangle < 10^{-7}$: additive bias

→ Small PSF
→ Knowledge of the PSF size
→ Knowledge of distortion
→ Stability in time
→ External visible photometry for photo-z accurary: 0.05x(1+z)
(+ Methods to correct distortion)

- GC and GC systematics

→ Catastrophic z < 10%
→ <z>/(1+z)<0.002
→ Understand selection→Deep field
  - Completeness
  - Purity

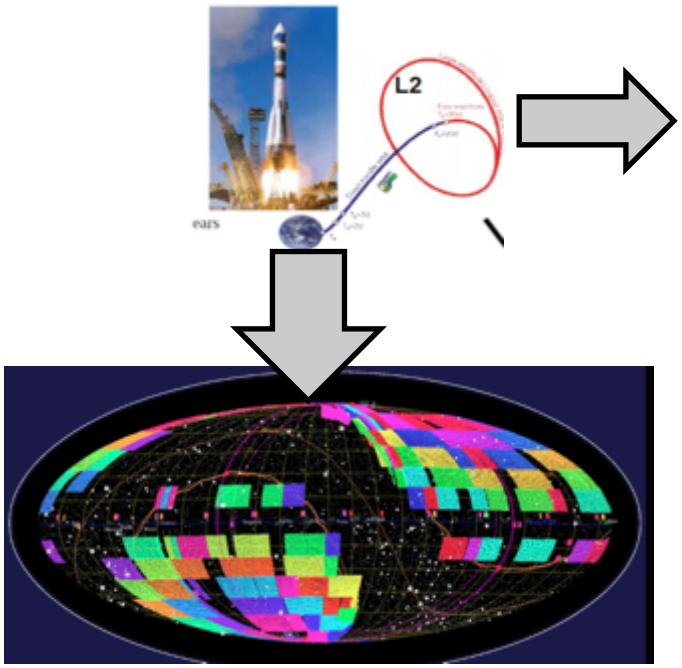
The EUCLID mission

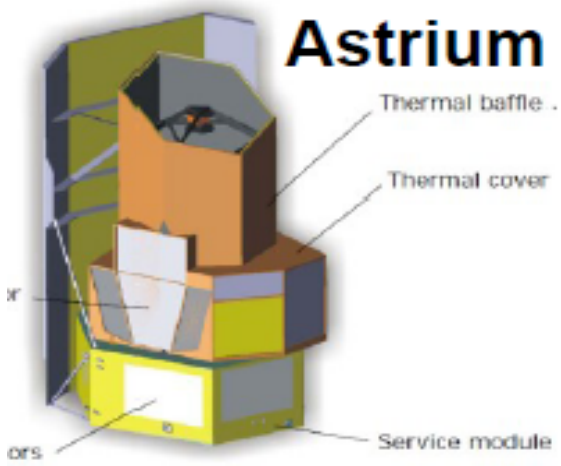
EUCLID CONSORTIUM

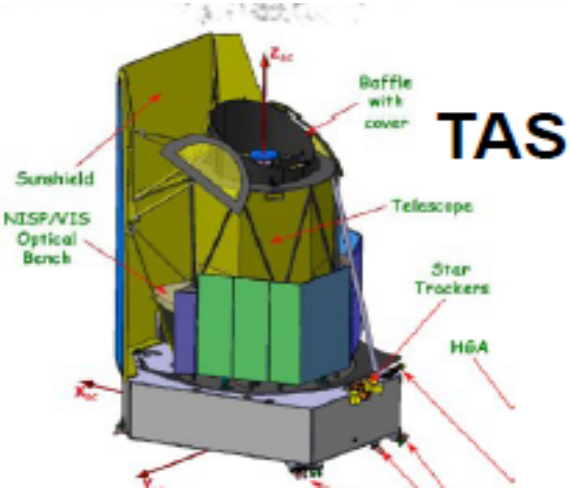
- Euclid is an ESA M mission with in-kind Member States contribution (MS)
- The MS contribution is provided through a scientific consortium

- ESA provides the telescope and detectors (via industry), the satellite, the launch by a Soyouz ST-2.1B and operation centers

- The consortium provides the 2 instruments (VIS and NISP) and the ground segment (data processing)







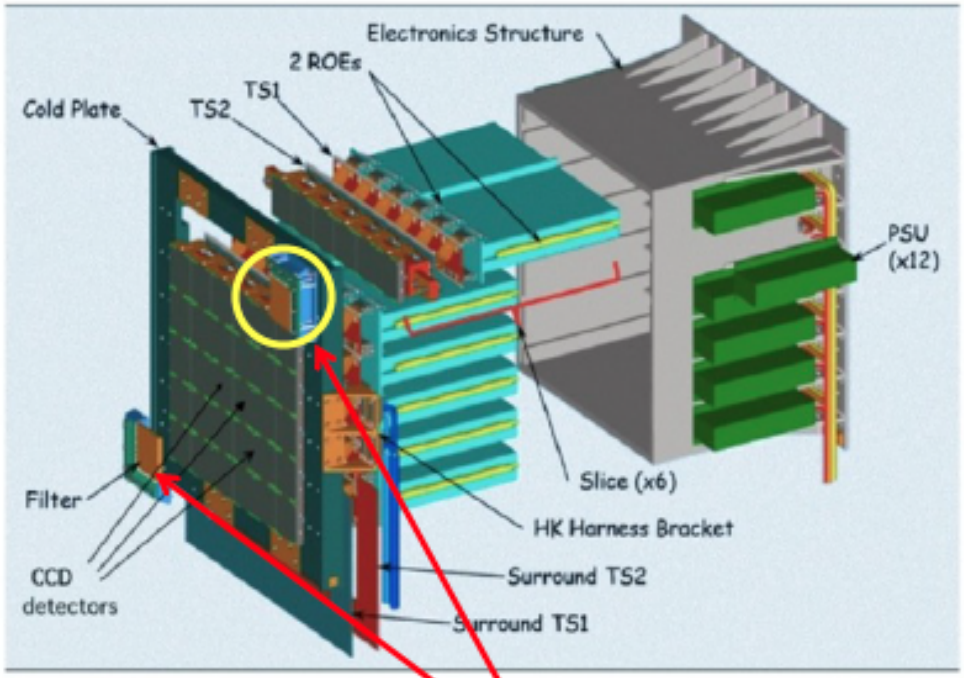
Telescope:
1.2 m Korsch , 3 mirror anastigmat, with a 0.45 deg. off-axis field , f=24.5m
Optically corrected and unvignetted FoV : 0.79 x1.16 deg^2

Prime contrator under selection

VIS Instrument

Euclid Consortium

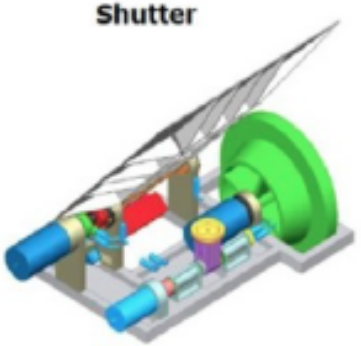
- large area imager – a 'shape measurement machine'
- 36 4kx4k CCDs with 12 micron pixels
- 0.1 arcsec pixels on sky
- bandpass 550-900 nm –
- limiting magnitude for wide survey of magAB = 24.5 for 10σ (extended)
- data volume – 520Gbit/day



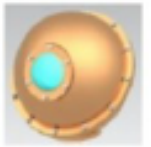
Focal Plane Assembly

Narrow band filters (color gradient) → Suppressed

Shutter

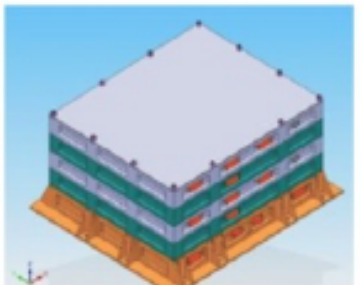


Cal Unit



WARM

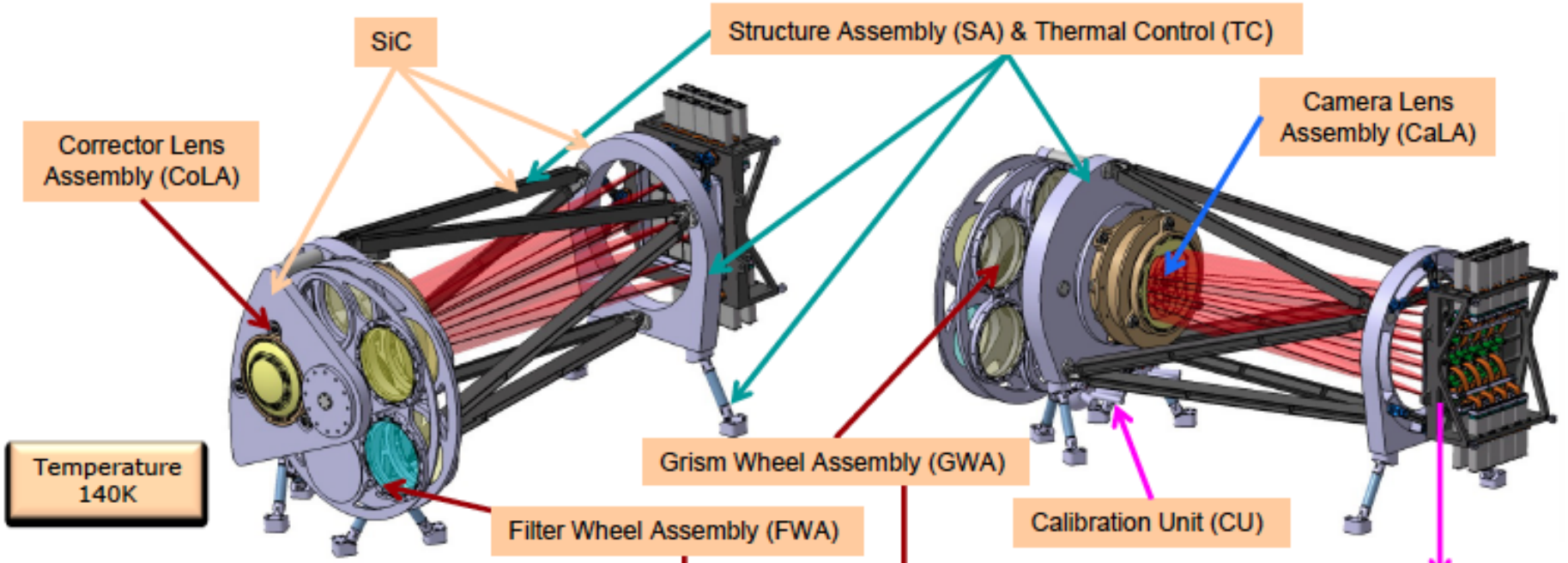
Power and Mechanisms Control Unit



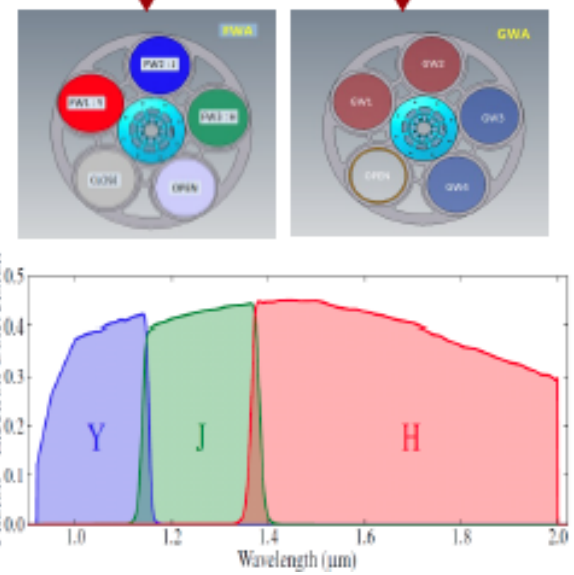
Command and Data Processing Unit

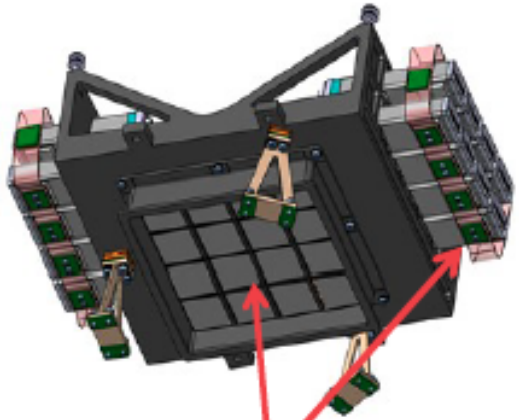
NISP instrument

Euclid Consortium



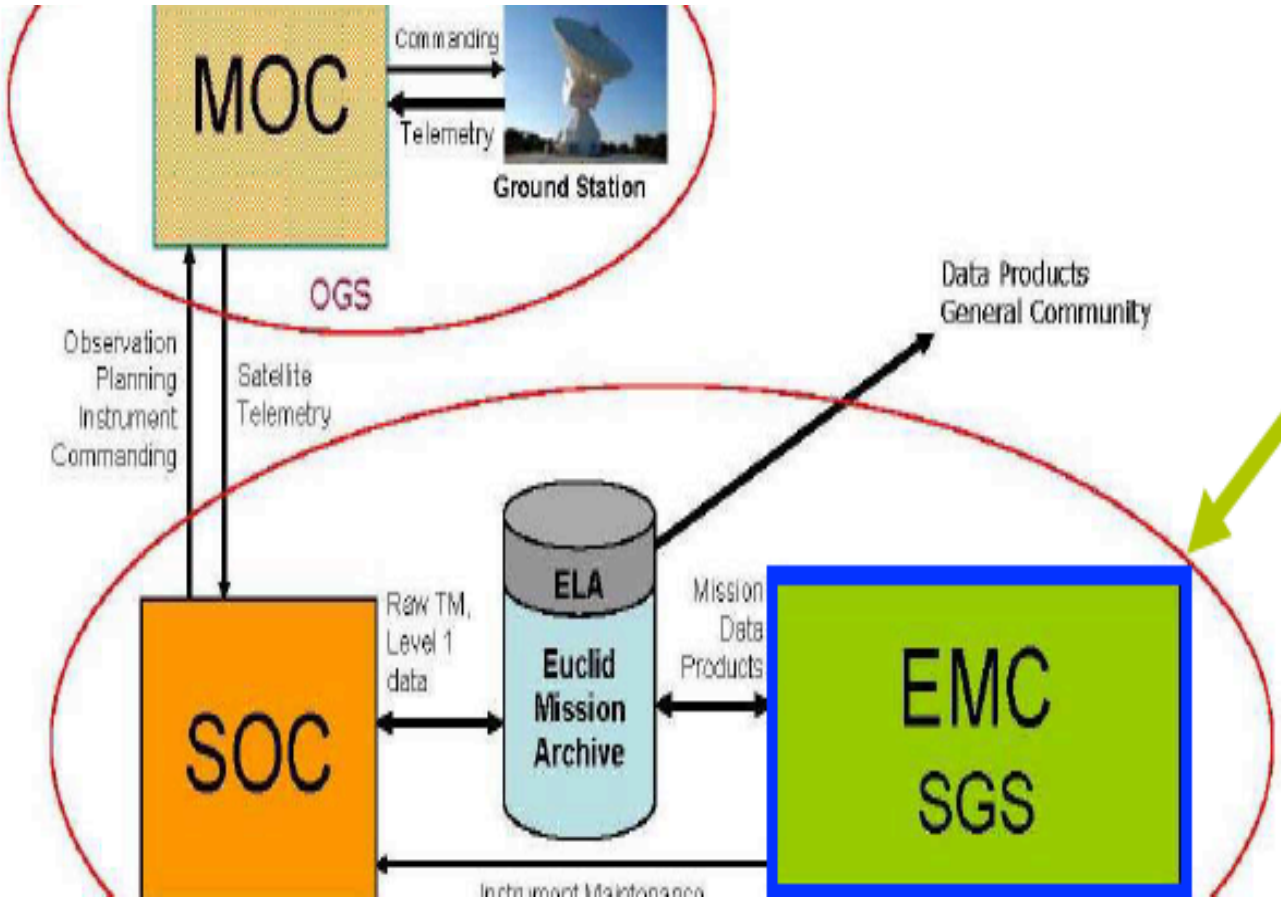
- 16 NIR 2kx2k H2RG detectors
- 0.3 arc/pixel
- 4 Grisms (2 blue, 2 red, rotated by 90 deg.) Resolution ~ 350
- 3 NIR filters Y,J,H (920-2000 nm)
- Telemetry= 180 Gbit/day





16 H2RG DETECTORS @ <100K+ ASIC Sidecar@140K (provided by ESA/NASA)

EUCLID ground segment overview



Schedule

Euclid Consortium

- October 4, 2011 : Euclid selected as ESA M2 Cosmic Vision
- Spring 2012 : Completion of the Definition phase (A/B1)

- June 20, 2012 : Adoption for the Implem. Phase (B2/C/D/E1)
- July 2012 : ITT release for Payload Module
- November 2012 : Kick off for the Payload contract
- December 2012 : ITT release for Service Module
- June 2013 : Kick off for the Service Module contract

- Q1 2014 : Instrument PDR
- Q3/Q4 2017 : Flight Model delivery

- Q2 2020 : Launch (L)
- <(L+6 months) : Start Routine Phase
- L+7 yrs : End of Nominal Mission
- L+9 yrs : End of Active Archive Phase

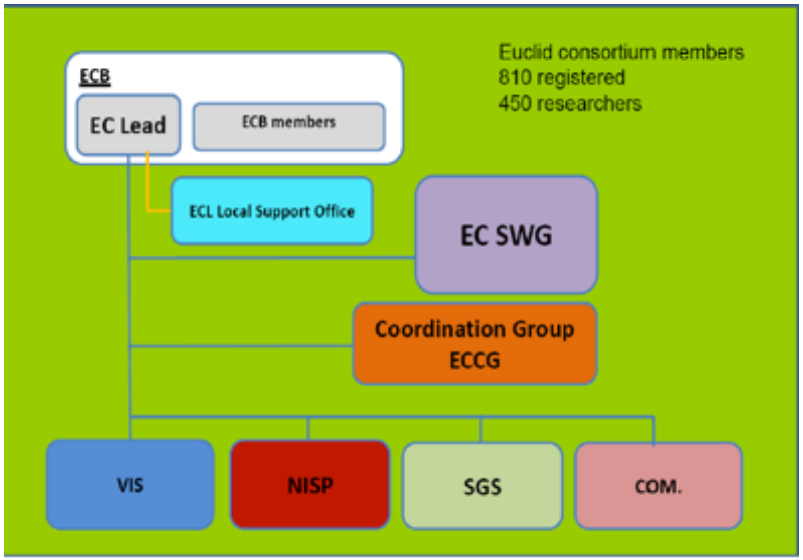
EUCLID organisation

EUCLID CONSORTIUM

- The project is managed by ESA with
  - -an ESA EUCLID science team (EST) (12 members)
  - - a strong scientific consortium

- The scientific consortium = 109 laboratories, 18 countries +NASA/ US

  Consortium organisation:
  - A core team around a Lead
  - A board (18 countries representatives)
  - 2 instrument teams (VIS,NISP)
  - 1 ground segment organisation (processing)
  - ~ 15 science teams
  - More than 900 members,
  - ~ 250 French members



- Total cost ~ 900 Meuros

  Consortium contribution ~ 35 % total cost

  France contribution ~ 30 % of the MS contribution

French participation

EUCLID CONSORTIUM

-IRFU
-CNRS/IN2P3 : APC, CCIN2P3, CPPM, IPNL
-CNRS/INSU : IAP, IAS, LAM, IRAP, Cassiope

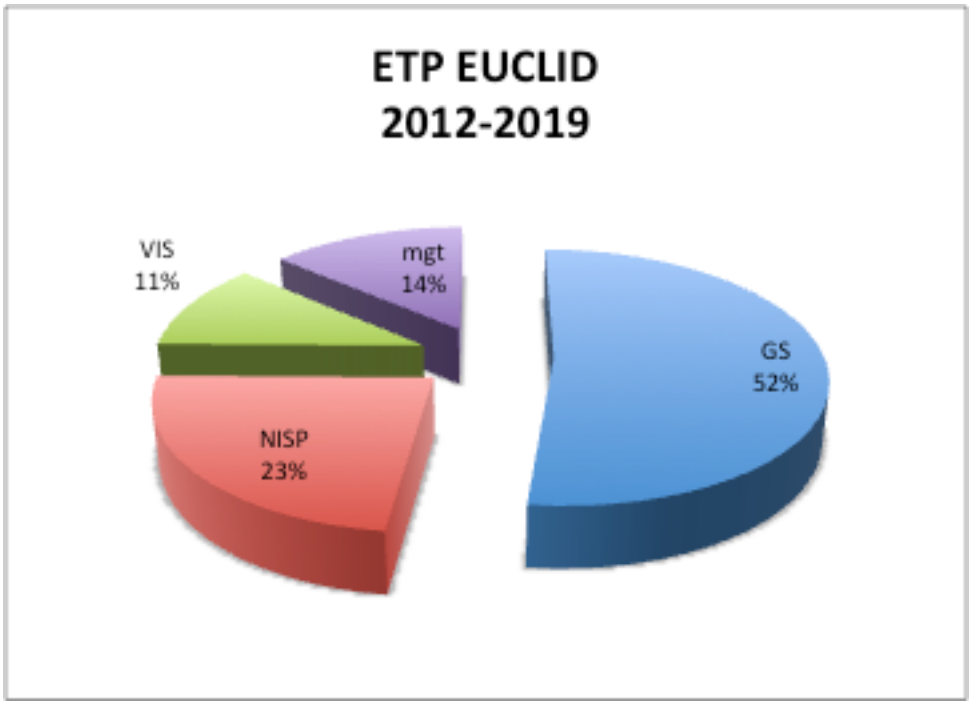
- French participation : IRFU, IN2P3, INSU
- Lab Personnel : ~500 FTE (2012- 2019, science and CDDs not included)
- CDDs ~ 150
- CNES : Funding +~ 80 FTE

French participation to Instruments :

- VIS : integration and calibration of the focal plan IRFU, IAS
- NISP : French management (CNES) + LAM, CPPM, IPNL,IRFU

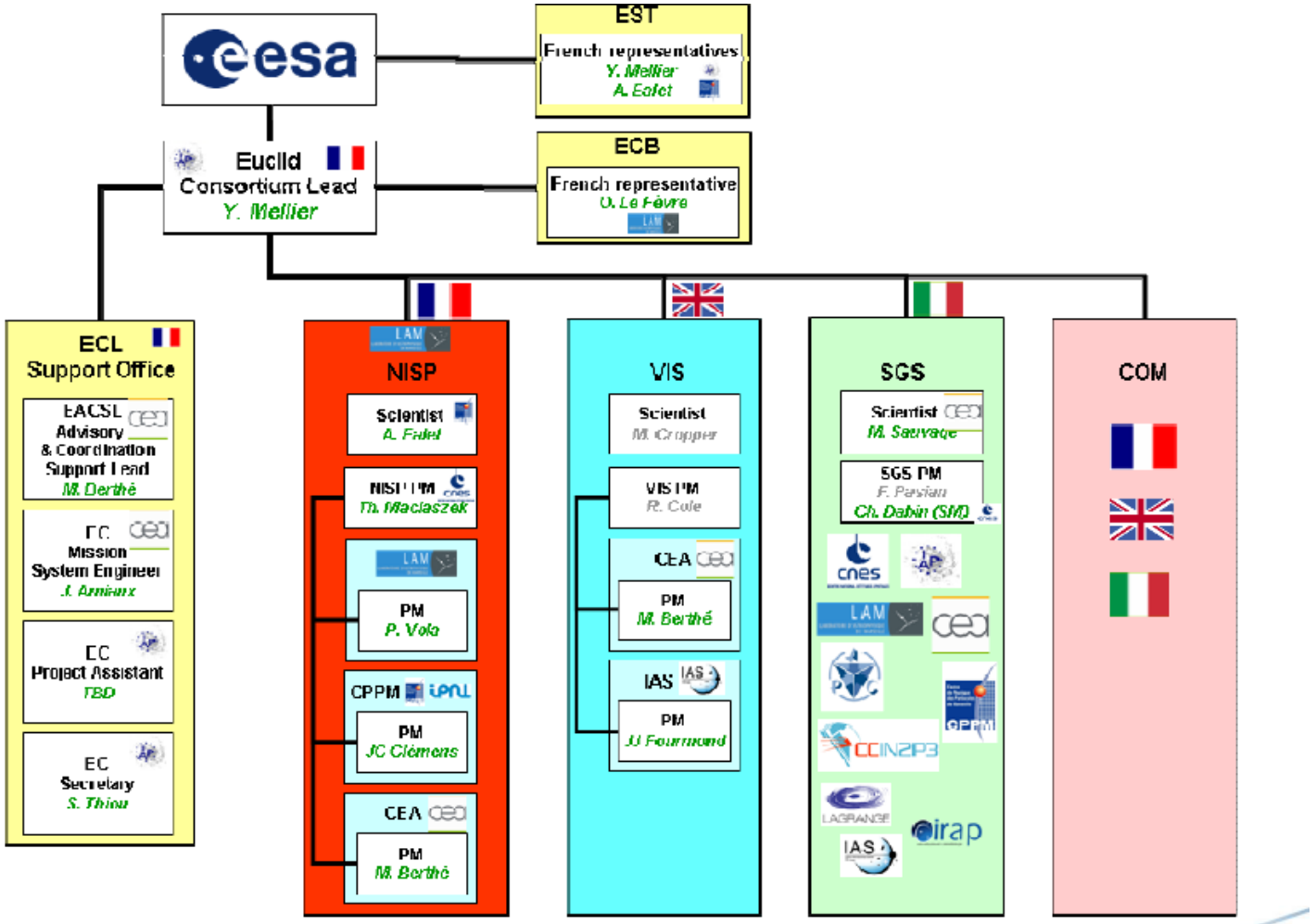
To Ground segment

- Data center for production : CCIN2P3 France (SDC - Fr)
- Data center for pipeline test : APC (FACe)
- SGS scientist (CEA)
- Leading system team (CNES)



French Responsabilities

EUCLID CONSORTIUM



Science activities

EUCLID CONSORTIUM

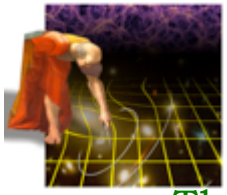
Science organisation: the science is organised with science groups:

France has 7 leads of Euclid science groups out of 30 (2 leads/group)

Science cosmology groups are in charge of requirements and of the final scientific validation

French scientific Coordination: national scientific committee:

19 members with identified responsibilities in EUCLID
Coordination should allow to link these activities to the data processing development.



IN2P3 activities in science

EUCLID CONSORTIUM

- Theory

Strong IN2P3 interest from all laboratories/theory groups on alternative models, interpretation and combination methods.

- Clustering

One of the primary goals …followed by the French BOSS group effort to develop expertise on galaxy power spectrum interpretation (neutrino mass, …)

- Lensing

Not only weak lensing but cosmic magnification and measure of strong lensing. IN2P3 is interested to participate at both aspects (APC, IPNL)

- Clusters

lead by APC, coordination of the development of this probe in different projects, such as X missions (XMM-Newton, Chandra et eRosita)

- Supernovae

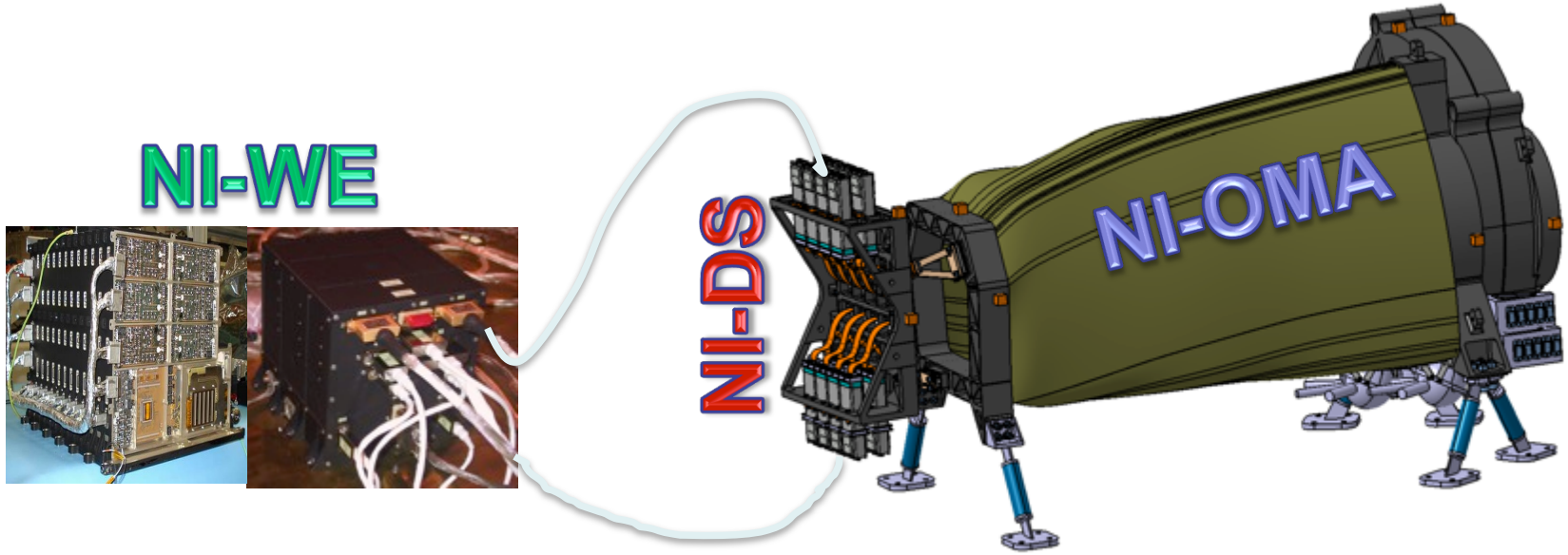
co-lead at CPPM
Strong IN2P3 activities including strong LPNHE expertise in survey strategy. Not part of the core science, but well-identified as potentially very interesting
Needs a dedicated deep survey to be proposed and is under study by EUCLID.

IN2P3 contribution to the NISP instrument

NISP : Instrument overview

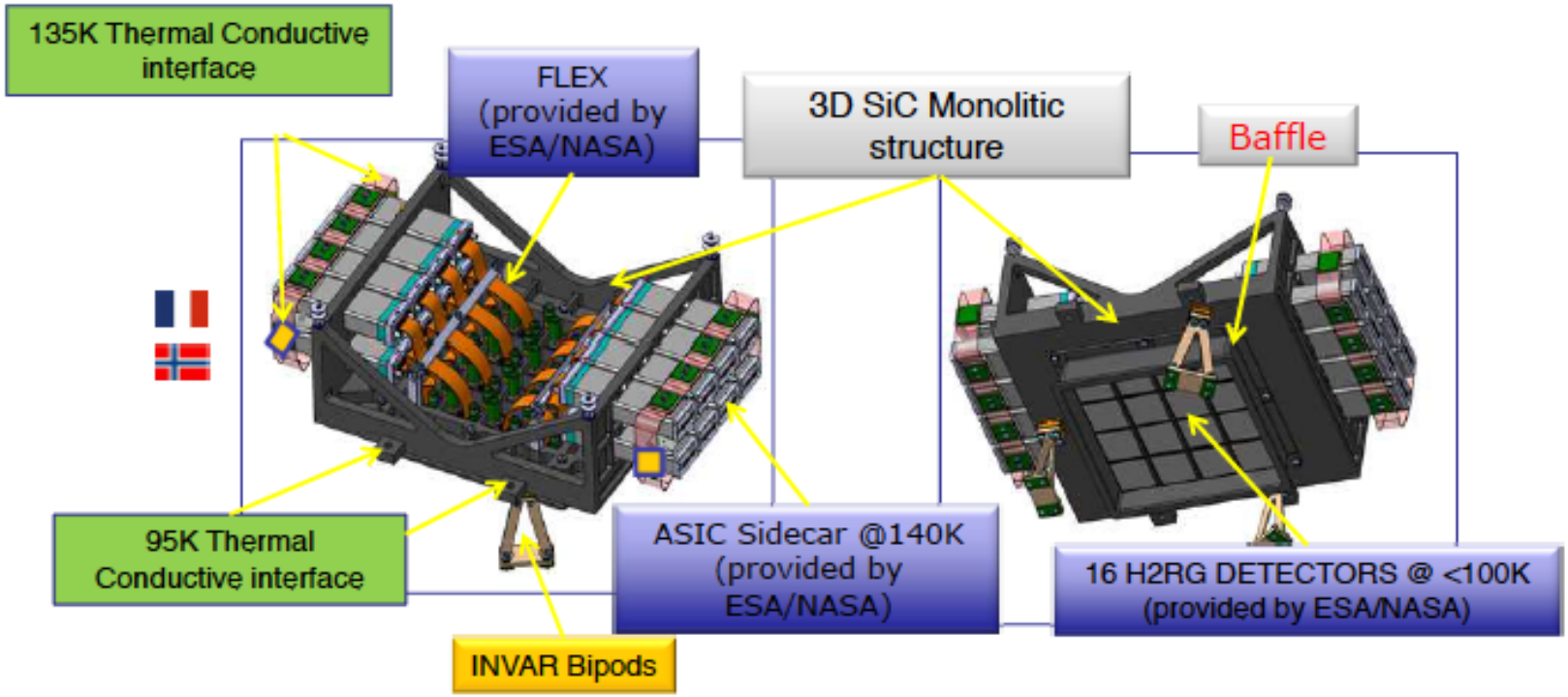
EUCLID CONSORTIUM

- **Large Field Photometer, Slitless spectrograph**
- 3 main parts :
  - **NI-OMA : Opto Mechanical Assembly in Cold PLM**
  - **NI-DS : Detection System mounted on NI-OMA**
  - **NI-WE : Warm Electronics in warm SVM**



Detection System (≈100K and 140K)

Euclid Consortium

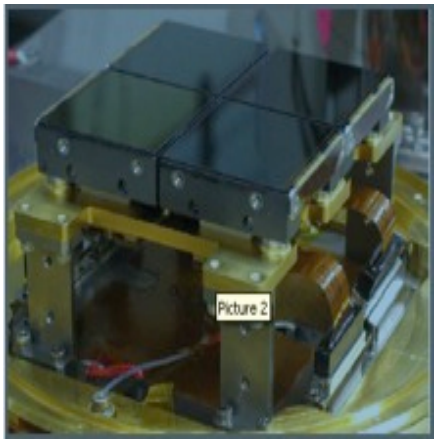


- NI-SCS (Sensor Chip System) : Sensor chip with SiC package + Flex + SIDECAR ASIC
  - Provided to the consortium by ESA (development and qualif) & NASA (flight + spare):

esa NASA

TELEDYNE

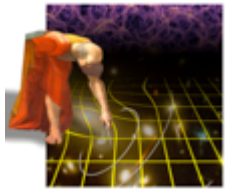
The H2RG detectors



The detector

The SIDECAR

- H2RG detectors for space applications are unique for low noise and IR performances
- developed by Teledyn, an US company
- Selected by ESA for EUCLID
- These detectors are mature, thanks to HST, JWST and SNAP/JDEM/WFIRST pre-activities
- The ASIC readout (sidecar) is a very new technology (only one is on HST)
- Very little expertise in Europe (ESO, ESA, JWST)
- French/IN2P3 expertise exists, thanks to the SNAP activities in 2004-2009



IR detector : history and expertise

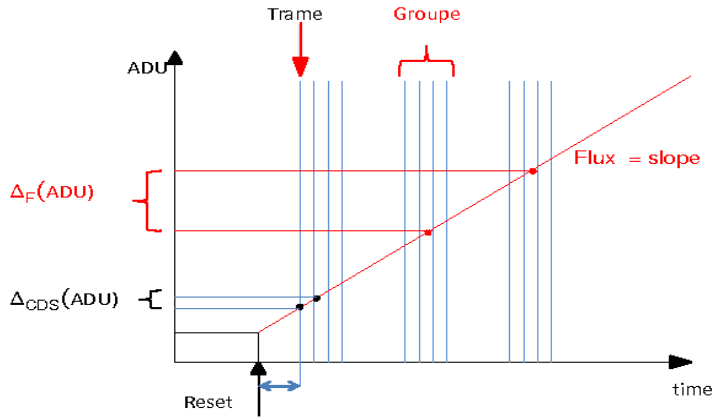
EUCLID CONSORTIUM

- Activities started at IPNL in 2004 in the context of SNAP with an H1RG, a set up with an in-house low noise readout electronic developed from the OPERA expertise.
- An H2RG given to France by LBNL in 2006 for the SNAP project and integrated into a spectrograph demonstrator by IPNL/CPPM with the IPNL readout card.
- A sidecar was bought for further studies in 2009
- An R&T CNES CPPM/IPNL in 2010-2012 to test SOFRADIR detectors (acquisition + test)
- 3 papers published (Smadja et al. 2009, 2010 and 2012) with new methods of calibration (IPC, non-linearity, noise measurement)

Exemple of noise measurement

EUCLID CONSORTIUM

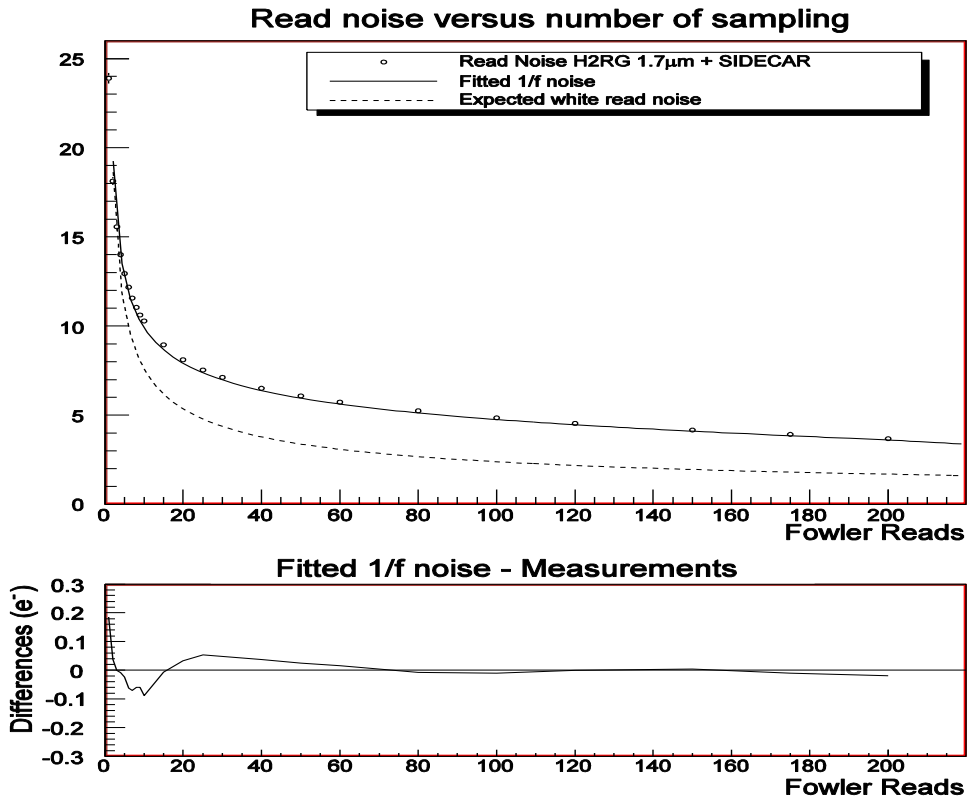
Lecture non destructive des pixels

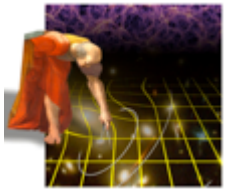


$\sigma(\Delta_{cds})$ = CDS (Correlated Double Sampling) différence entre 2 lectures (pas forcément consécutives). Bruit = σ (CDS) sans illumination

$\sigma(\Delta_F)$ = Fowler : bruit entre 2 groupes moyennés (pas forcément consécutifs)

Smadja et al. 2012





IR detectors : responsabilities in EUCLID

EUCLID CONSORTIUM

- **IN2P3 responsibility: reception, characterisation and calibration of detectors+sidecar on ground and on the NISP instrument.**
  - ✓ Pre development, and expertise with 'engineering' detectors+sidecar
  - ✓ Demonstrator model of the focal plan for 2014 with 4 detectors
  - ✓ Preparation of test facilities for flight detectors reception and test (CPPM) (clean room, cryostat)
  - ✓ Software for test and calibration (IPNL)
  - ✓ Integration of detectors into the instrument
- CPPM takes the responsibility (endorsed by CNES) to receive, caracterize and integrate the 16 flight detectors (+ 4 spares).
- NASA will select 16 flight detectors and deliver them to CPPM.
- ESA will buy all engineering detectors and ASIC for pre-development and pre-flight models

tests/charact./calib. life cycle

EUCLID CONSORTIUM

2013 2014 2015 2016 2017

EC & ESA specs.

TIS SCS qualification

SCA & SCE

TIS production

NASA selection

SCA & SCE

SCS

EC prelim. charac. plan

EC characterizations

FPA

EC calibrations

Clarification/updates

SCA & SCE

Predevelopments tests, DM , EQM etc..

Schedule :

- 2014 : demonstrator (1 FPA , 2 detectors, 4 MUX, test EMC)
- 2015 : qualification model (16 e. detectors , interface to flight electronic)
- 2015: flight detector: reception and test
- 2016 : start flight model
- 2017: test and instrument integration
- 2020 : launch

clarifications/modifications
Detector working group
ESA/NASA/EC

Detector characterization

EUCLID CONSORTIUM

The challenge : characterisation and calibration at few % level

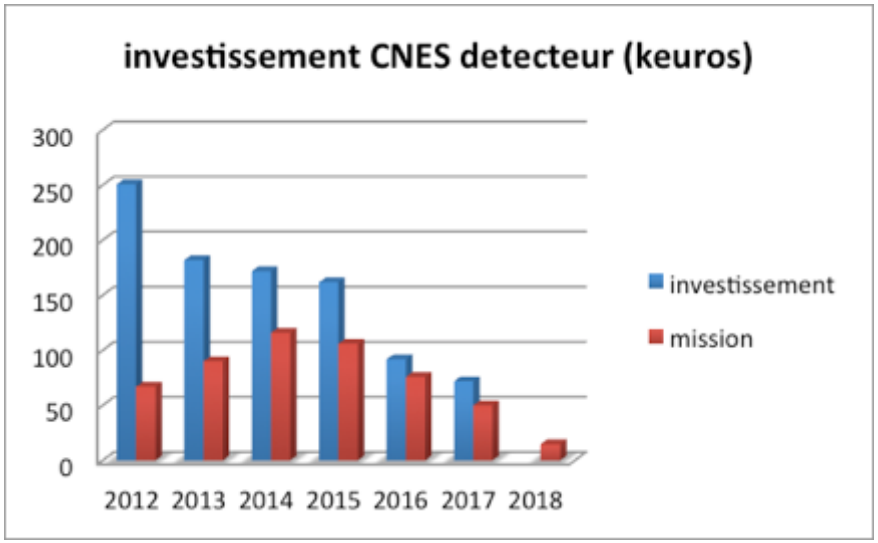
Each flight SCS (SCA+SideCar pair) will be characterized at CPPM using a Jade 2 card provided by Teledyn and acquisition sequences developed at IPNL.

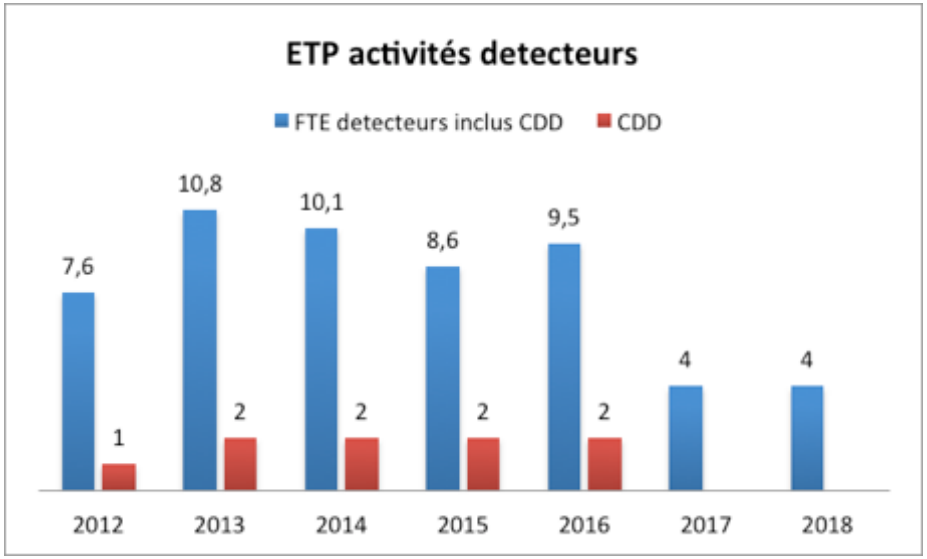
- Main tests are :
  - Quantum efficiency (with Copenhagen U.)
  - Gain
  - Non linearity
  - Noise and dark current
  - Interpixel capacitance …

- Dedicated clean rooms will be mounted in CPPM in 2013

- Predevelopment activities in 2013-2015 (noise, radiations..)
  - Pre activities to understand the full detection chain performance (impact of the on board electronic)
  - Cold test on proton beam are foreseen by the consortium to understand the detector degradation in the L2 radiation environment. These tests will be done by APC.

IN2P3 : ressource and manpower

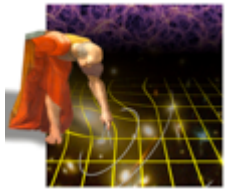




- Funding is provided by CNES through and IN2P3/CNES agreement
- The agreement includes CDD support.

- Manpower for CPPM and IPNL is now agreed with laboratories

IN2P3 contribution to the ground segment



Data processing on ground

EUCLID CONSORTIUM

The consortium provides the 'ground segment' (EMC SGS) and is responsible for the production and validation of the scientific data at all levels :

- Processing of the VIS et NISP instrument raw data up to cosmological analyses
- Adding external data if needed in adequate format
- Simulating data
- Producing data catalogs to be delivered to the community

Data will be released by ESA after a proprietary period

The final cosmological analysis and interpretation is under the responsibility of the consortium science groups

Ground segment organisation

EUCLID CONSORTIUM

Data processing is divided into Organisational Units (OUs) and science data centers (SDC) .

- The Organisational Units are trans-national: they should propose methods and algorithms for data processing.
- The Science Data Centers (SDC) are national entities: they ensure the production of EUCLID data

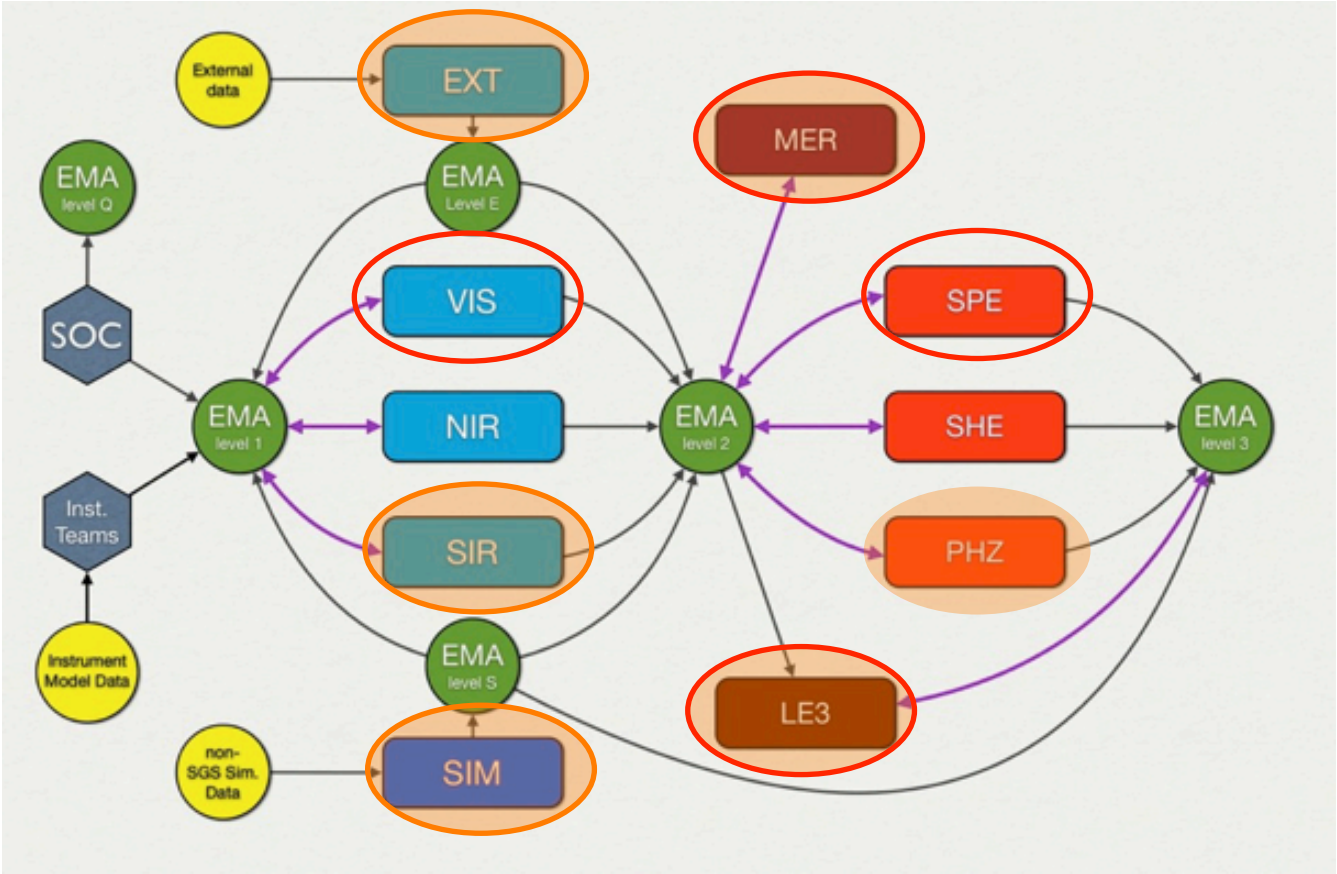
Data flow is organized inside OUs

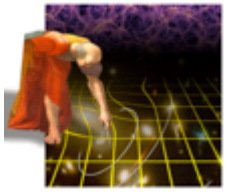
France is lead of :

- OU-VIS (VIS level 1) .
- OU-SPE (NISP level 2) ,
- OU-LE3 (level 3)

Co-lead of

- OU-SIR (NISP (level 1),
- OU-MER (external data)
- OU-SIM (simulated data)





In2P3 contribution in OUs

EUCLID CONSORTIUM

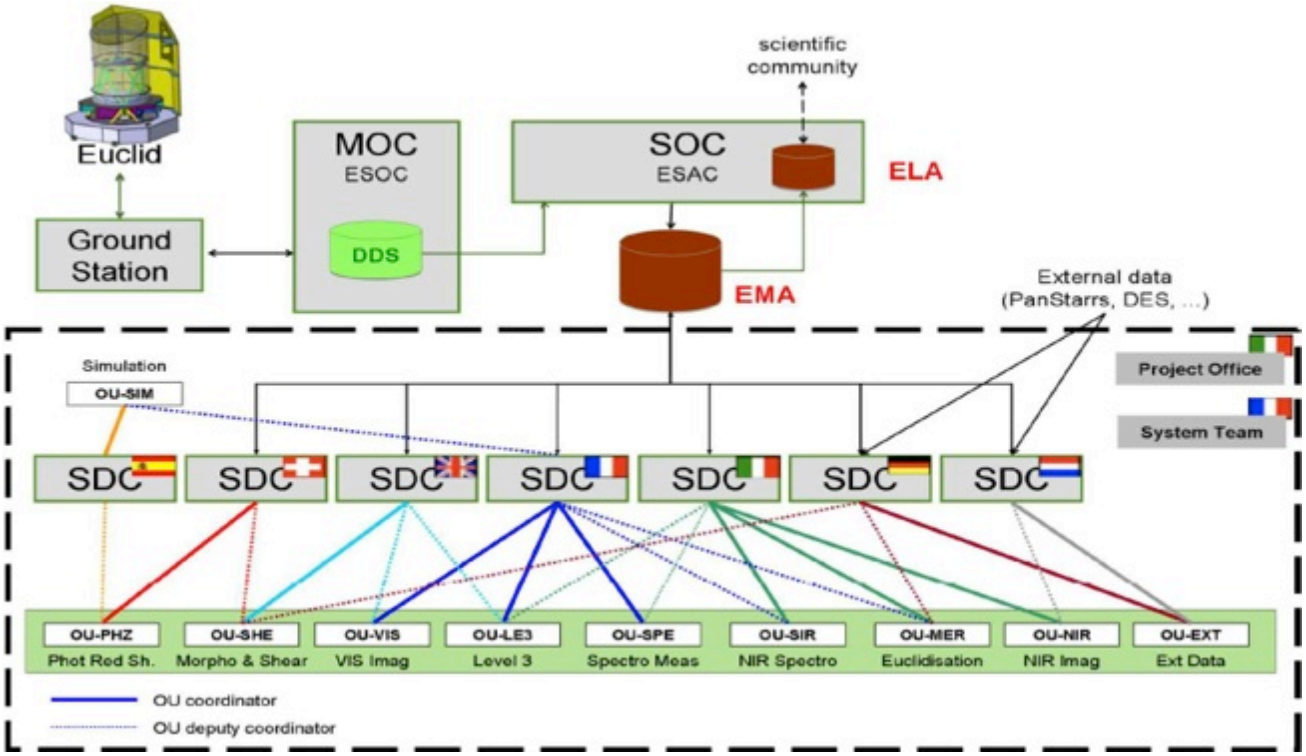
- OU-EXT-OU-MER-OU-PHZ (APC)
  - preparation of photo-z catalogs, using the full chain of data and external data such as DES, Pan-STARRS, LSST and SUBARU (all under agreement)

- OUSIM (CPPM,IPNL)
  - Co lead
  - Interaction with SWG-simu
  - Production of prototypes for VISand NISP pixel simulator
  - test and integration at SDC level
  - Preparation of data challenge

- OULE3 (APC)
  - Production of tools for scientific analysis for the cluster analysis
  - Interaction with SWGs – participation of IN2P3 at different levels

Ground segment organisation : SDC

EUCLID CONSORTIUM



Challenging:

- Data quantity
- Level of quality

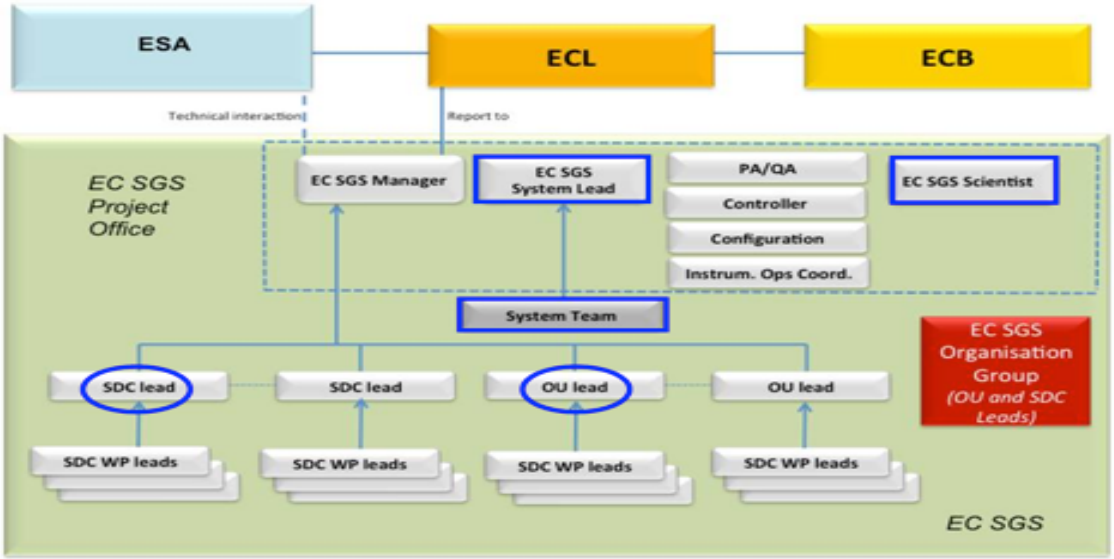
26 Pbytes /cycle/year (=> stockage)
10^{10} objects/year (=> data base)

Complexity:

Science Data Centers (SDC) in each country should ensure the production of EUCLID data

Very complex chain of data production to ensure the needed precision

French participation and SDC France



SDC-FR (CNES)

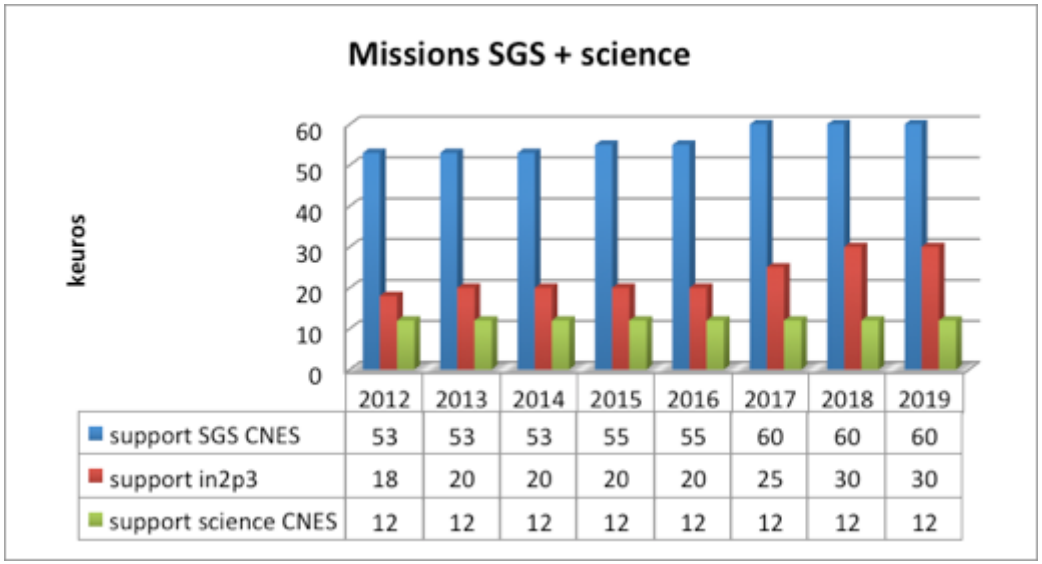
SDC-DEV (APC) | SDC-PROD (CCIN2P3)

-IN2P3 strongly supports the production of EUCLID data with the proposition to have CCIN2P3 as the SDC France – (letter of intent between CNES and IN2P3)
- APC Arago center is proposed as a meso-center for pipeline development

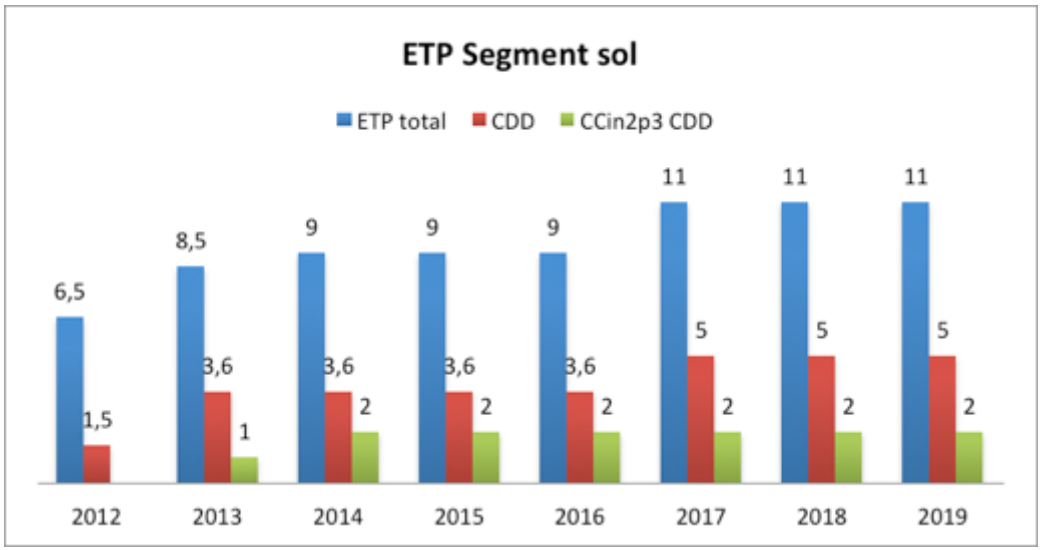
- First prototype activities just started , data challenge will follow
- Organisation (OUs-CNES-APC-CCIN2P3) to be tested and stabilised
- Large increase of activities expected in 2013-2018

IN2P3 ressource and manpower

EUCLID CONSORTIUM



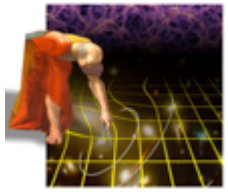
	2012	2013	2014	2015	2016	2017	2018	2019
support SGS CNES	53	53	53	55	55	60	60	60
support in2p3	18	20	20	20	20	25	30	30
support science CNES	12	12	12	12	12	12	12	12



- CNES mission support and CDD for SGS development

- Additional support from IN2P3 is needed to ensure the science group activites.

- Coordination and a development of OU-SDC-SWG activities has started in France and in IN2P3.



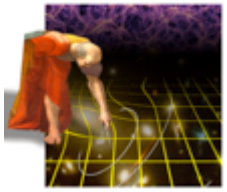
Overview of the IN2P3 contribution

EUCLID CONSORTIUM

Labo	Cherch. FTE (nbre)	ITA FTE 2013	CDD 2012-2013	Thésards
APC	1,6 (6)	1,9	1	
CPPM	1.8 (5)	5,5	2	2
IPNL	2.5 (6)	1.4	1	-
CC-IN2P3	0,1(1)	0,2	1	-
LPNHE	1(3)	-	-	-
Total	7,7 (19)	10	5	2

Nous demandons a l'IN2P3 les co-financement thèses (1-2/an) et post docs scientifiques et les missions pour couvrir les besoins futurs en science.

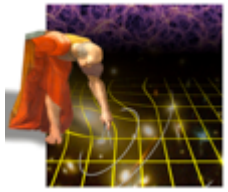
Nous soulignons aussi que des postes permanents seront à prévoir pour pérenniser l'expertise et stabiliser les CDD dans les laboratoires.



Conclusion

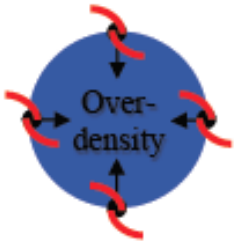
- ESA has selected the only space mission dedicated to understand the acceleration of the expansion of the Universe.
- It will give to the European community the opportunity to solve one of the most fascinating question of physic of the decade
- EUCLID is a large consortium (near 1000 members!) where France takes the leadership
- EUCLID include a strong contribution of all national agencies IN2P3, INSU, IRFU and is supported by the space agency CNES making France the biggest contributor to the mission.
- This proposition for IN2P3 is based on the expertise of the institute both technical with detector activities and on data processing by providing support and large infrastructure used in particle physics.

We ask a validation of this contribution and the support of the institute to prepare the scientific return of such an investment.



spares

Redshift Space Distortions



Actual shape

Apparent shape (viewed from below)

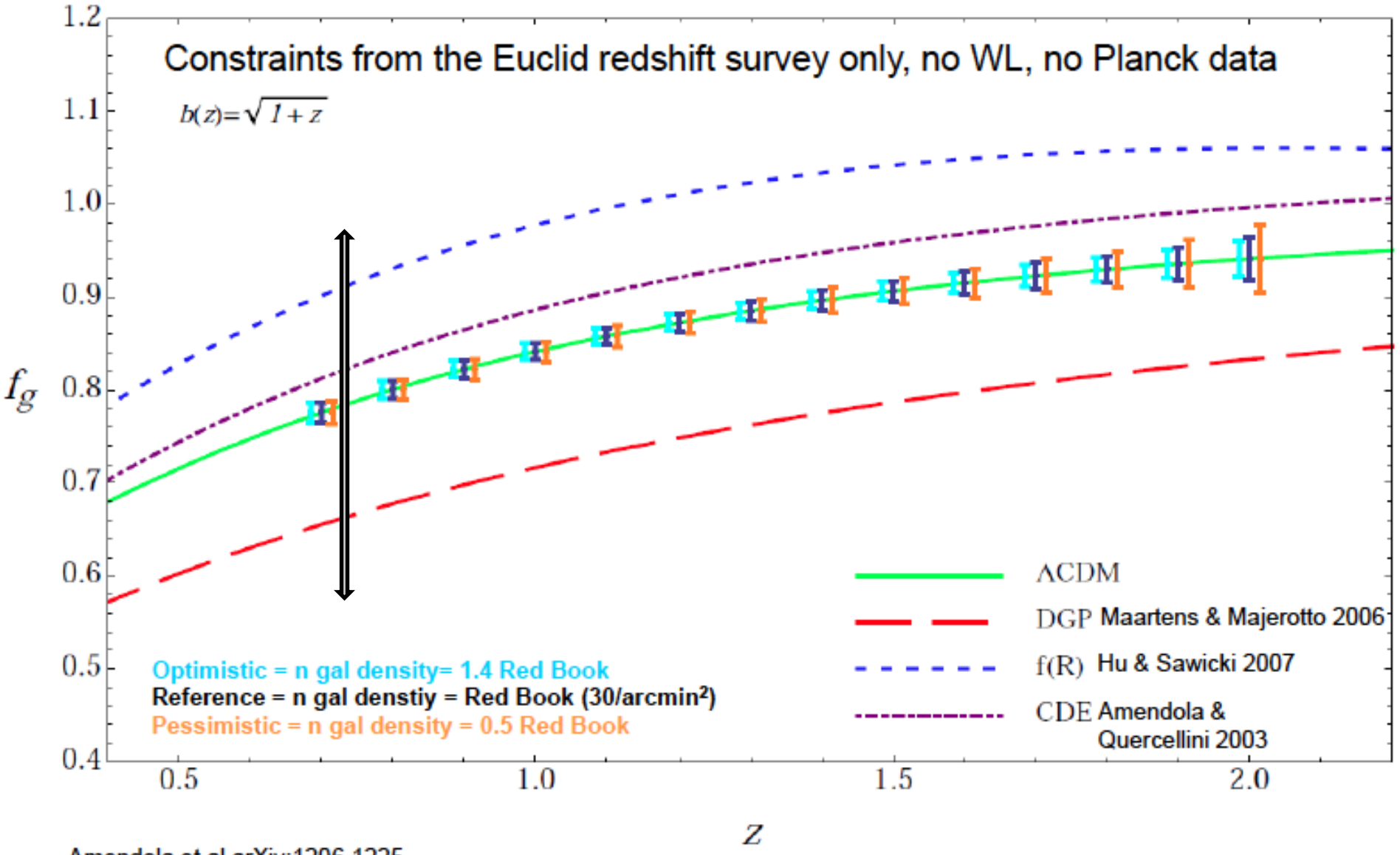
- Observed redshift depends on both Hubble expansion and additional "peculiar velocity"
- Galaxies move because cosmological structure is growing
- Resulting change in redshift is coherent with structure
- extra component depends on amplitudes of peculiar velocities

$$f(z)\sigma_8(z) \propto \frac{dG}{d\log a}$$

– where G is the linear growth rate

Biasing and Growth rate from GC data

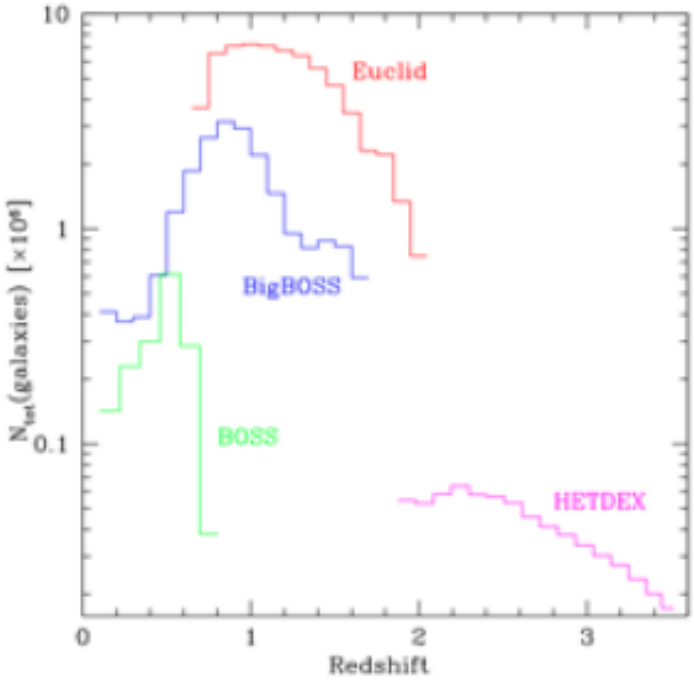
Euclid Consortium



Amendola et al arXiv:1206.1225

Galaxy redshift density

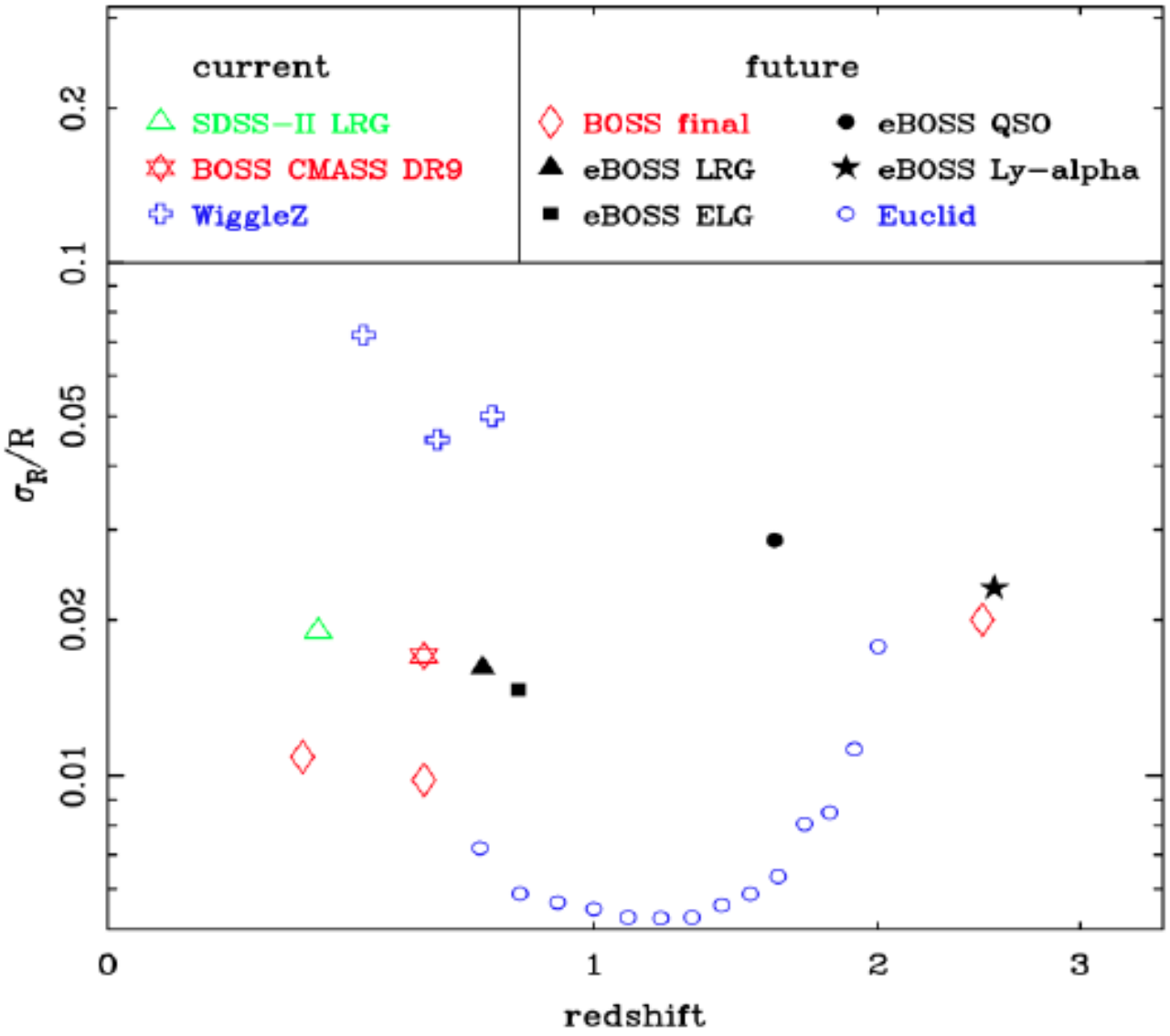
Euclid Consortium



Req. ID	Parameter	Requirement	Goal
GC.1-2	Galaxy sky density	3,500 / deg^2	5,000 / deg^2
GC.1-5	Redshift range	0.7<z<2.05	also gals z<0.7
GC.1-6	Median of redshift distribution	>1	>1.1
GC.1-7	Upper quartile of redshifts	>1.35	
GC.2.1-1	Flux limit	$\leq 3\times10^{-16}$ erg cm^{-2} s^{-1}	
GC.2.1-2	Completeness	>45%	
GC.2.1-3	Flux limit at all wavelengths	<120% of GC.2.1-1	

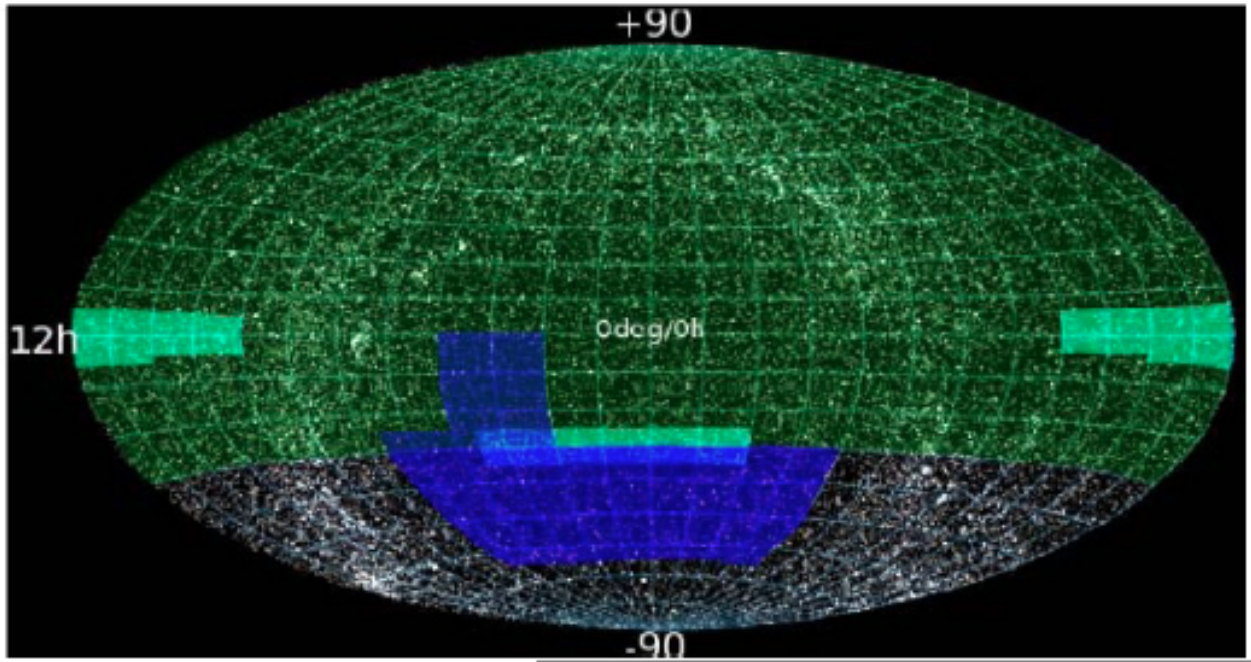
Euclid – BAO improvements

Euclid Consortium



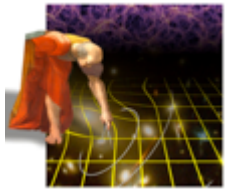
Euclid : Ground surveys

Euclid Consortium



External survey timelines	2011	2012	2013	2014	2015	2016	2017	2018
KiDS-VIKING	Survey underway		VIKING completed	KiDS completed, VIKING final release	, KiDS final release			
Pan-STARRS1	Survey underway		Survey completed		PS1 final release			
Pan-STARRS2				Survey start				
DES		Survey start		1st data release		Survey end	Final data release	
LSST								20207
HSC+WHT								

Survey	Area (sq deg)	U	G	r	i	z	Y	J	H	K
KiDS+VIKING	1500 Eq+SGC	24.8	25.4	25.2	24.2	23.1	22.3	22.0	21.5	21.2
Pan-STARRS1	15000 NGC+½ SGC		23.4	23.0	22.7	22.0	20.9			
PS2	15000 NGC+½ SGC		24.8	24.4	24.1	23.4	22.3			
DES	5000 ½ SGC		25.4	24.9	24.8	24.7	22.3			

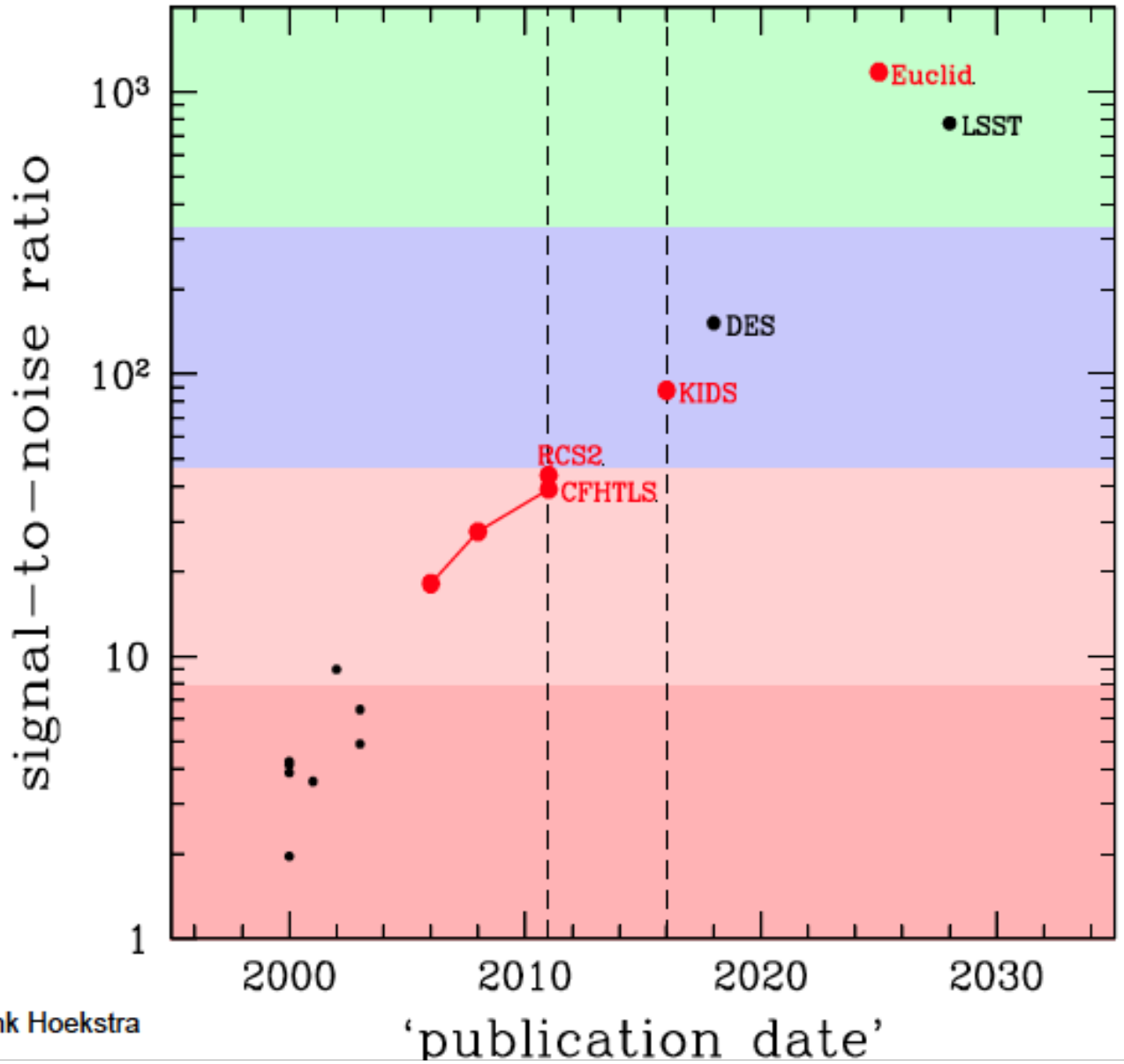


SURVEYS In ~5.5 years					
	Area (deg2)	Description			
Wide Survey	**15,000 deg²**	Step and stare with 4 dither pointings per step.			
Deep Survey	**40 deg²**	In at least 2 patches of > 10 deg² 2 magnitudes deeper than wide survey			
PAYLOAD					
Telescope	1.2 m Korsch, 3 mirror anastigmat, f=24.5 m				
Instrument	VIS	NISP			
Field-of-View	0.787×0.709 deg²	0.763×0.722 deg²			
Capability	Visual Imaging	NIR Imaging Photometry			NIR Spectroscopy
Wavelength range	550– 900 nm	Y (920-1146nm),	J (1146-1372 nm)	H (1372-2000nm)	1100-2000 nm
Sensitivity	24.5 mag 10σ extended source	24 mag 5σ point source	24 mag 5σ point source	24 mag 5σ point source	$3\ 10^{-16}$ erg cm-2 s-1 3.5σ unresolved line flux
	Shapes + Photo-z of n = 1.5 x10⁹ galaxies ?			**z of n=5x10⁷ galaxies**	
Detector Technology	36 arrays 4k×4k CCD	16 arrays 2k×2k NIR sensitive HgCdTe detectors			
Pixel Size Spectral resolution	0.1 arcsec	0.3 arcsec			0.3 arcsec R=250

Possibility to propose other surveys: SN and/or μ-lens surveys, Milky Way ?

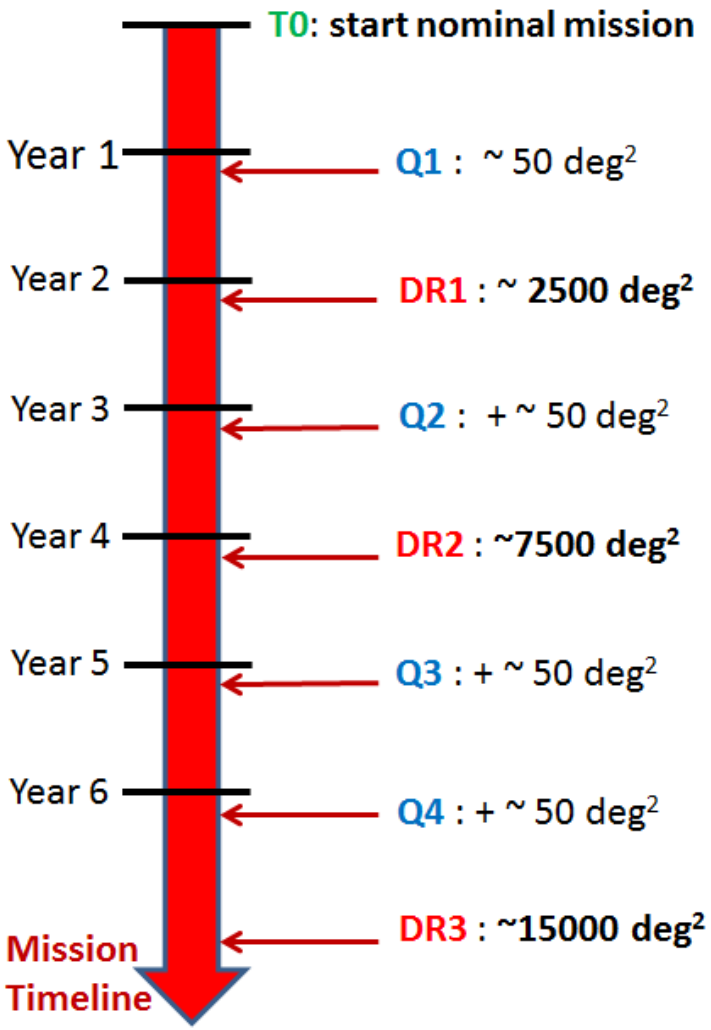
Improving S/N in shape measurements

Euclid Consortium



Courtesy Henk Hoekstra

New Data Release Plan from EST



EST (proposal)

- An annual cadence of L2 data releases is maintained
- Three (instead of six) full data releases of L1+L2+L3 data

- The Level Q releases could be thematic (to be decided):
  - Q1: high galactic latitude field
  - Q2: nearby galaxy cluster
  - Q3: galactic astronomy, all galactic fields from calibration observations
  - Q4: flexible – to be decided

Slitless spectroscopy in space

NIR Slitless spectroscopy would provide a uniform sample of galaxy redshifts based on the H-alpha line emission, with no need to specify a target sample

NIR observations are not possible from the ground due to the high background

a near-IR survey is much less affected by the dust extinction of our Galaxy

H-alpha is less affected by galaxy internal dust extinction than other lines in the blue (e.g. a factor of about 2 less than [OII]3727)

the most important emission lines to estimate gas dust extinction, metallicity and ionization properties are in the rest-frame optical (i.e. redshifted in the near-IR for $z>0.7$)

H-alpha is a primary estimator of the star formation rate

near-IR spectroscopy provides spectra in the rest-frame optical for $z>0.7$, hence allowing the best combination with ground-based optical surveys of low redshift galaxies (e.g. SDSS).