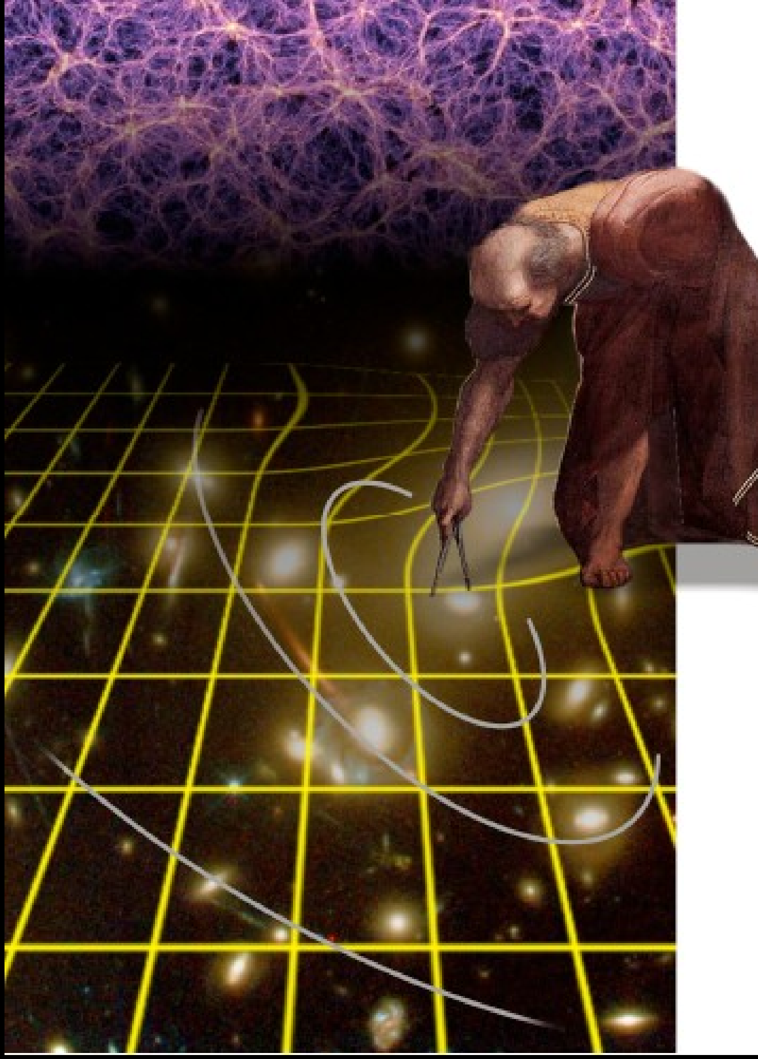
Preparing for Euclid:

a space mission to map the universe

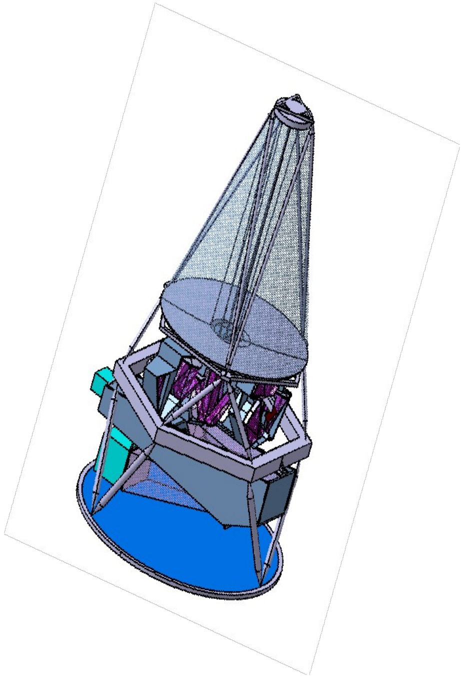


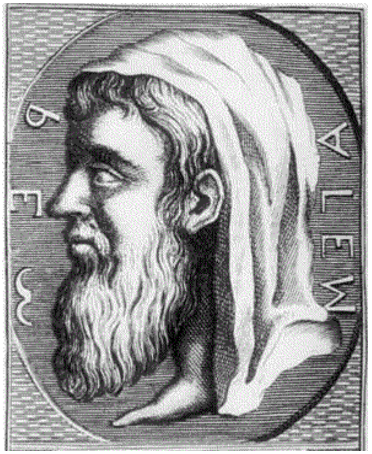
Francisco Javier Castander, ICE (IEEC/CSIC), Barcelona

on behalf of the Euclid Consortium


Benasque 13 – Cosmo 1

Euclid: The ESA Mission to Map the Dark Universe





Francisco Javier Castander (ICE, Barcelona)
on behalf of the Euclid Consortium

ESA Cosmic Vision 2015-2025 programme

Process Timeline

Call for science themes	April 2004
Cosmic Vision 2015-2025 Themes	2005
Call for Proposals (M & L missions)	March 2007
Proposals due	June 2007

ESA Cosmic Vision 2015-2025 programme

Proposed Cosmology M missions

DUNE

All-sky optical imaging for gravitational lensing

SPACE

All-sky near-IR spectra to H=22 for BAO

ESA Cosmic Vision 2015-2025 programme

Process Timeline

Call for science themes	April 2004
Cosmic Vision 2015-2025 Themes	2005
Call for Proposals	March 2007
Proposals due	June 2007
Pre-selection	October 2007

ESA Cosmic Vision 2015-2025 programme

- In October 07: ESA selects DUNE & SPACE for a joint assessment study and appoints a Concept Advisory Team

ESA Cosmic Vision 2015-2025 programme

- In May 08: The Concept Advisory Team (CAT) reports their conclusions to ESA advisory structure

=> Euclid is borned

Euclid

A geometrical probe of the universe proposed for Cosmic Vision

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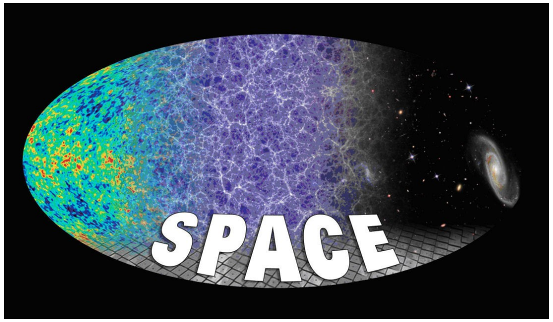


All-sky optical imaging for gravitational lensing

All-sky near-IR spectra to H=22 for BAO

The Euclid Concept

- Named in honour of the pioneer of geometry
- Euclid will survey the entire extra-galactic sky (20 000 deg^2) to simultaneously measure two dark energy probes:
  - **Weak lensing (DUNE)**:
    - Diffraction limited galaxy shape measurements in one broad visible R/I/Z band.
    - Redshift determination by Photo-z measurements in 3 YJH NIR bands to H(AB)=24 mag, 5σ point source
  - **Baryonic Acoustic Oscillations (SPACE)**:
    - Slitless spectroscopic redshifts for galaxies with emission lines fluxes H brighter than 4×10^{-16} erg/s/cm2 (default)
    - DMD spectroscopic redshifts for 33% of all galaxies brighter than H(AB)=22 mag, $\sigma_z < 0.001$ (back-up)
- With constraints:
  - Aperture: max 1.2 m diameter
  - Mission duration: max ~5 years

Other Probes

- Besides its two principal dark energy probes, Euclid will obtain information on:

  - **Galaxy clustering: the full power spectrum P(k)**
    - Determination of the expansion history and the growth factor using all available information in the amplitude and shape of P(k)

  - **Redshift-space distortions**:
    - Measures the growth rate (derivative of growth factor) from the redshift distortions produced by peculiar motions.

  - **Clusters of Galaxies**
    - Measures a combination of of growth factor (from number of clusters) and expansion history (from volume evolution).

  - **Integrated Sachs-Wolfe Effect**
    - Measures the expansion history and the growth.

Euclid's Primary Science Objectives

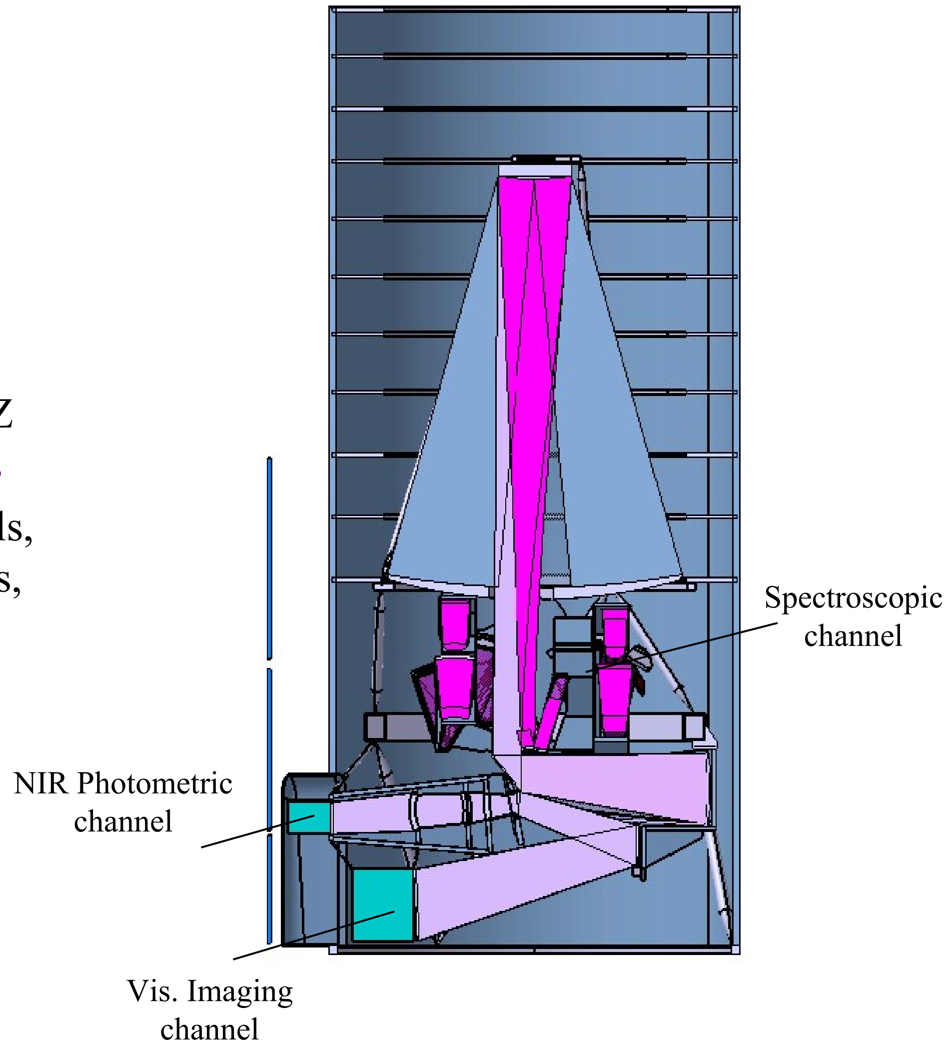
Issue	Target
The nature of Dark Energy	**Measure the DE parameters w_n and w_a to a precision of 2% and 10%, respectively, using both expansion history and**
The nature of Dark Matter	**Test the Cold Dark Matter paradigm for structure formation, and measure the sum of the neutrino masses to a precision 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**
Testing General Relativity	**Distinguish General Relativity from the simplest modified-gravity theories, by measuring the growth factor exponent γ with a precision of 2%**

Euclid Mission Implementation

Euclid

Mission elements:

- L2 Orbit
- 4-5 year mission
- Telescope: three mirror astigmat (TMA) with 1.2 m primary
- Instruments:
  - Visible imaging channel: 0.5 deg^2, 0.10'' pixels, 0.23'' PSF FWHM, broad band R+I+Z (0.55-0.92mu), CCD detectors, galaxy shapes
  - NIR photometry channel: 0.5 deg^2, 0.3'' pixels, 3 bands Y,J,H (1.0-1.7mu), HgCdTe detectors, Photo-z's
  - NIR Spectroscopic channel: 0.5 deg^2, R=400, 0.9-1.7mu, slitless spectroscopy, redshifts
- Data rate Max 840 Gbits/day (compressed)



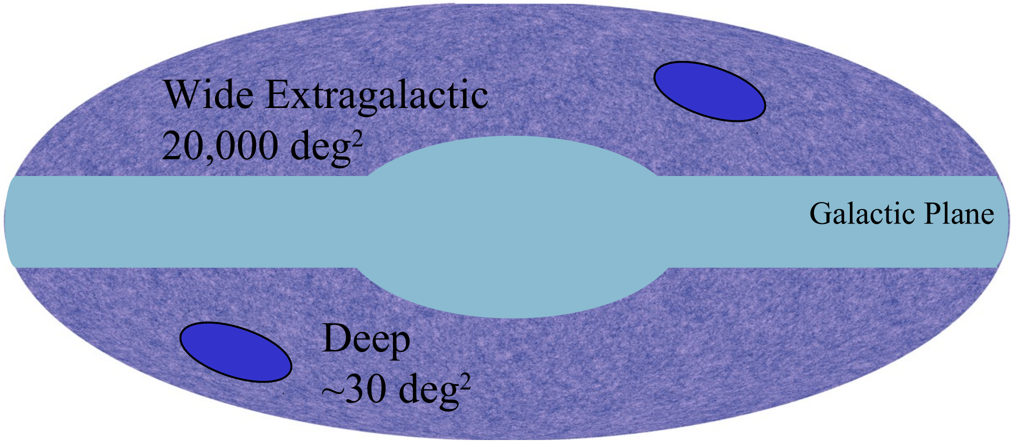
Euclid Surveys

Wide Survey: entire extra-galactic sky (20 000 deg^2)

- Imaging for Weak lensing:
  - Visible: Galaxy shape measurements in R+I+Z<24.5 (AB,10σ), 40 resolved galaxies/$amin^2$, median resdshift of 0.9
  - NIR photometry: Y,J,H<24 (AB, 5σ PS), photometric redshifts rms 003-0.05(1+z) with ground based complement
- Spectroscopy for BAO:
  - Spectroscopic redshifts for 33% of all galaxies with H(AB)<22 mag, σ_z<0.001

Deep Survey: ~30 deg^2, visible/infrared imaging to H(AB)=26 mag and spectroscopy to H(AB)=24 mag

Galactic surveys: Other surveys in the galactic plane under discussion



ESA Cosmic Vision 2015-2025 programme

Process Timeline

Call for science themes	April 2004
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Call for Proposals	March 2007
Proposals due	June 2007
Pre-selection	October 2007
Call for Assessment Studies M missions	July 2008

ESA Cosmic Vision 2015-2025 programme

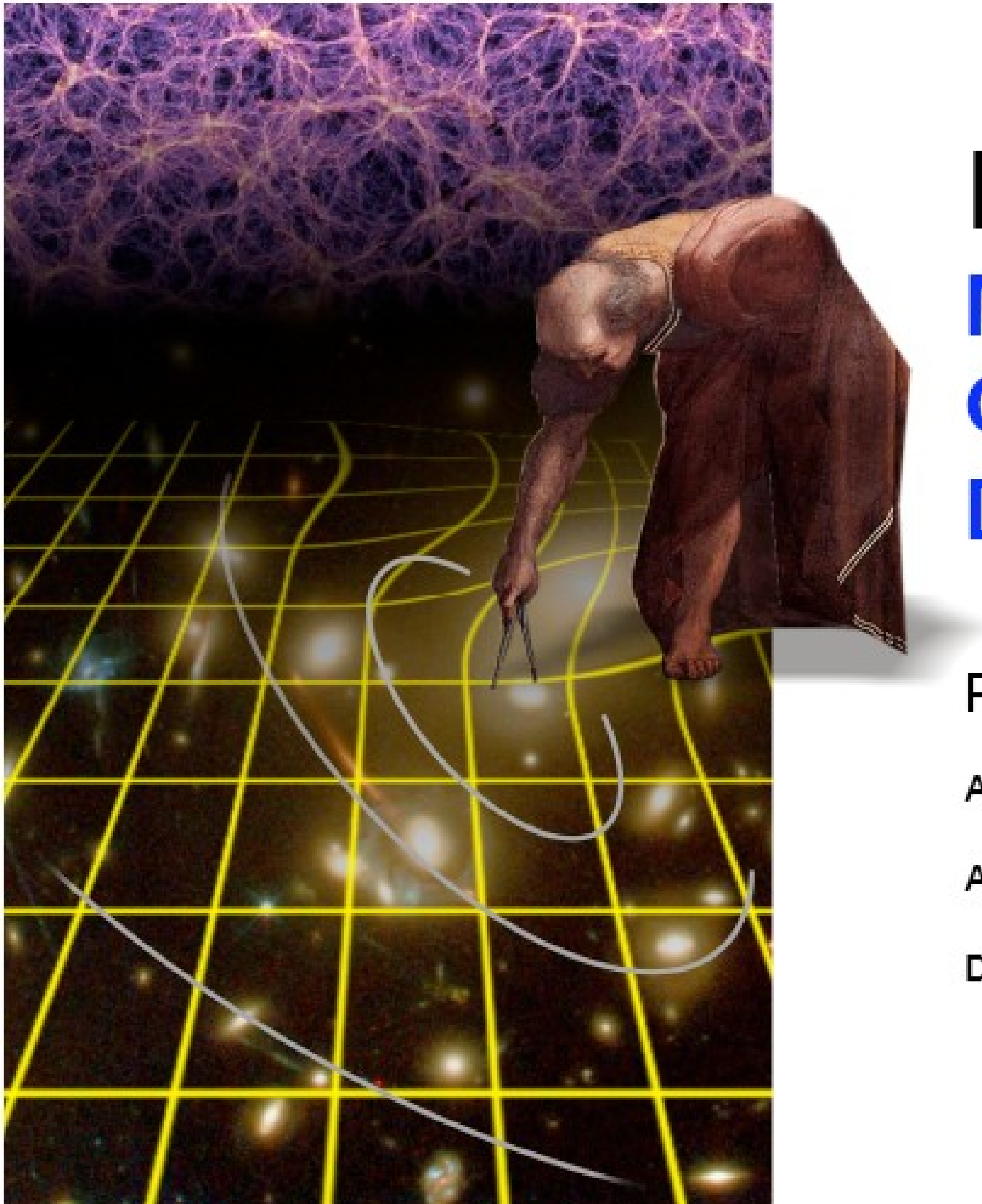
- July 08: a call for assessment studies is launched for the six preselected M class missions (~300 M euros cost to ESA)

Euclid	Cosmology
Plato	Extrasolar planets
Solar Orbiter	Sun
Cross-Scale	Plasma Physics
SPICA	IR
Marco Polo	Asteroid mission return

ESA Cosmic Vision 2015-2025 programme

Process Timeline

Euclid stakeholders meeting	December 2008
Joint mission with US: IDECS	February 2009
US pulls out: Euclid resurrects	April 2009
Euclid-DES/PS letter of understanding	September 2009
Submission of Assessment Study: YB	September 2009
ESA internal review	Oct-Nov 2009
M missions presentations	December 2009



Euclid

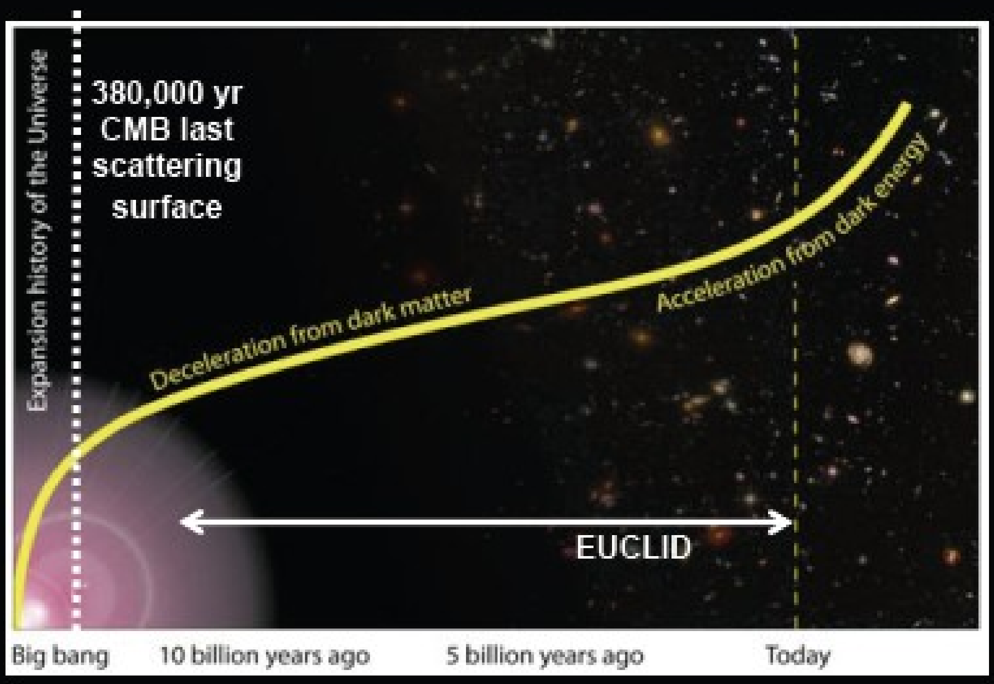
Mapping the Geometry of the Dark Universe

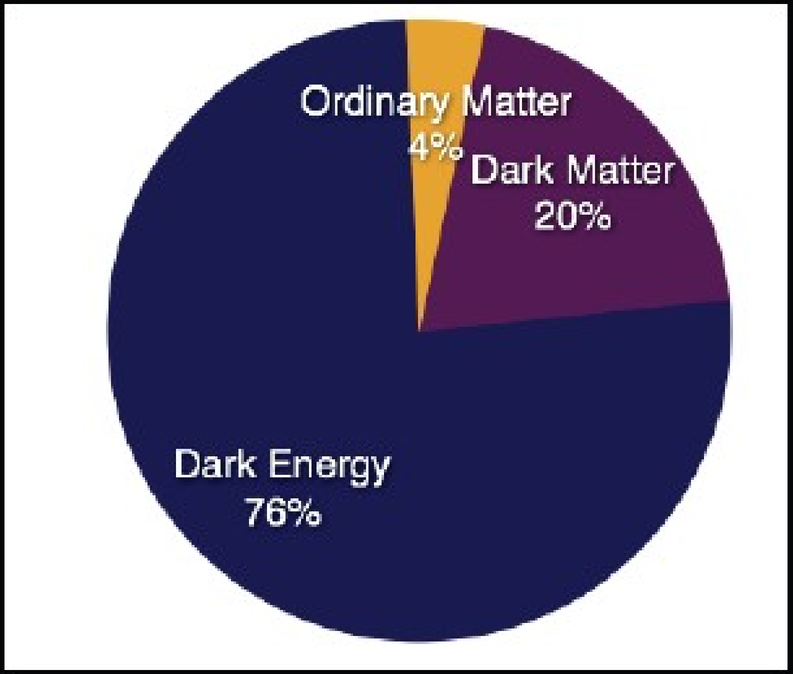
Presentations by

A. Refregier (CEA Saclay)
Imaging Survey
A. Cimatti (Univ. Bologna)
Spectroscopic Survey
D. Lumb (ESA)
Mission implementation

Outstanding questions in cosmology

- the nature of the Dark Energy
- the nature of the Dark Matter
- the initial conditions (Inflation Physics)
- modifications to Gravity





Euclid concept

- High-precision survey mission to map the geometry of the Dark Universe
- Optimized for two complementary cosmological probes:
  - Weak Gravitational Lensing
  - Baryonic Acoustic Oscillations

  Additional probes: clusters, redshift space distortions, ISW
- Full extragalactic sky survey with 1.2m telescope at L2:
  - Imaging:
    - High precision imaging at visible wavelengths
    - Photometry/Imaging in the near-infrared
  - Near Infrared Spectroscopy
- Legacy science for a wide range of areas in astronomy
- Survey Data public after one year

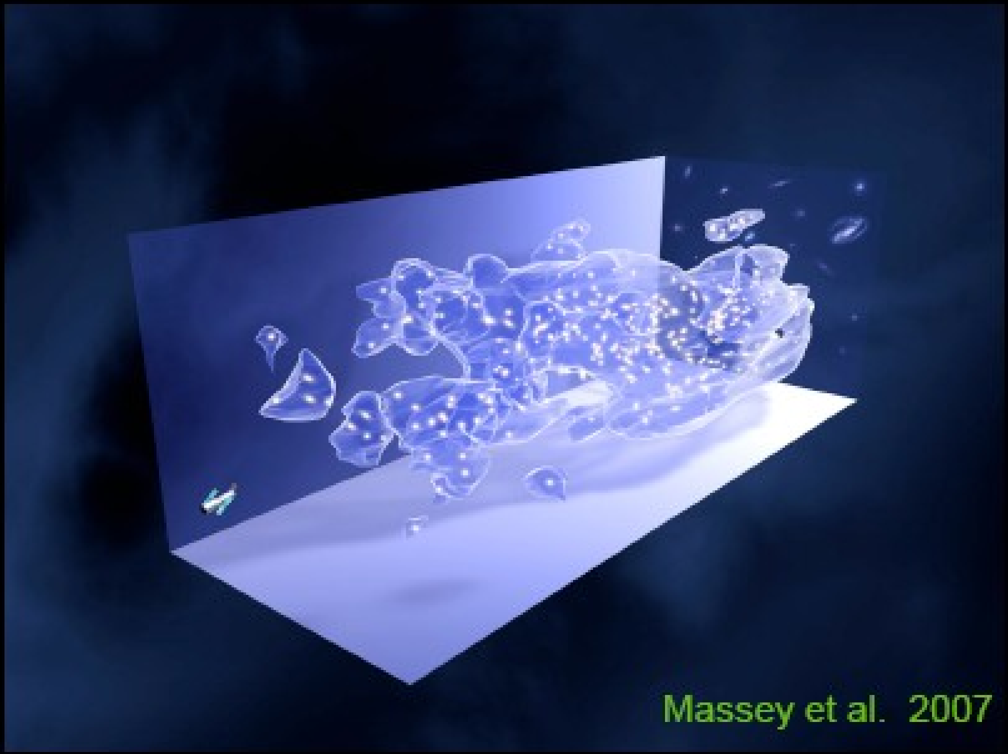

Imaging the Dark Universe with Euclid

Weak Gravitational Lensing

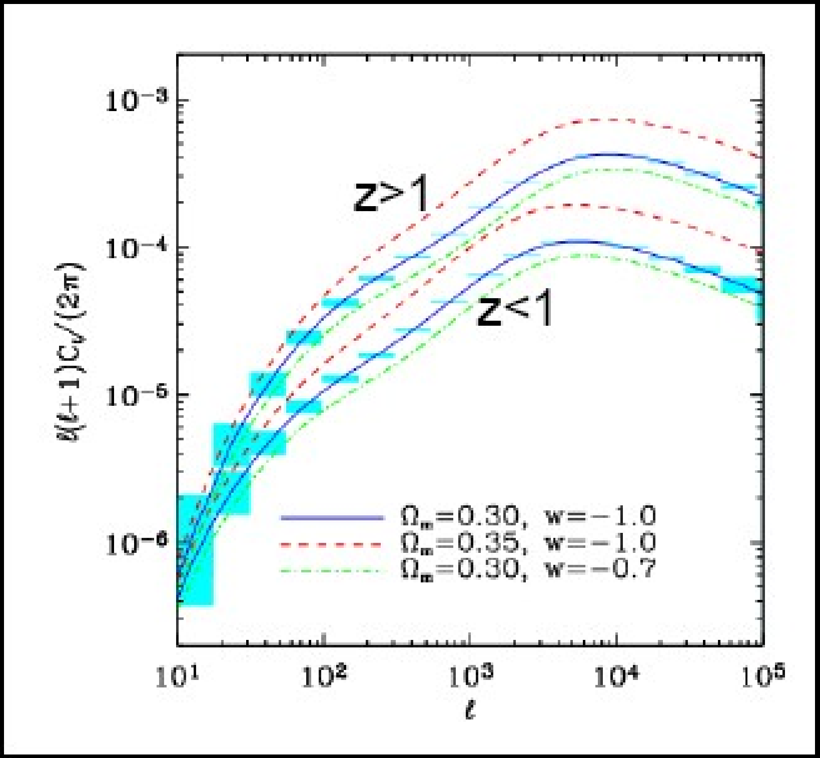
Weak Lensing:

- Map the 3D distribution of Dark Matter in the Universe
- Measures the mass without assumptions in relation between mass and light
- Very sensitive to Dark Energy through both geometry and growth

→ Need measurements of galaxy shape and photometric redshifts



Massey et al. 2007



Current status of Dark Energy

Dark Energy:

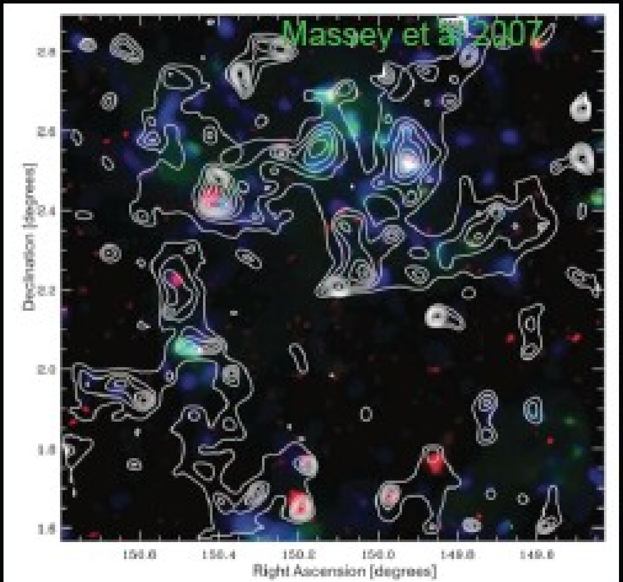
- Affects cosmic geometry and structure growth
- Parameterised by equation of state parameter:

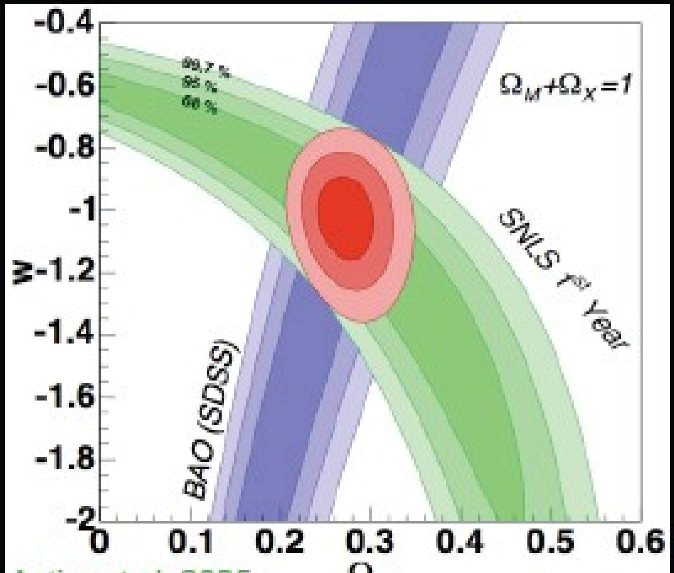
$w(z)=\rho/p$,   constant $w=-1$ for cosmological constant

Current constraints: 10% error on constant w

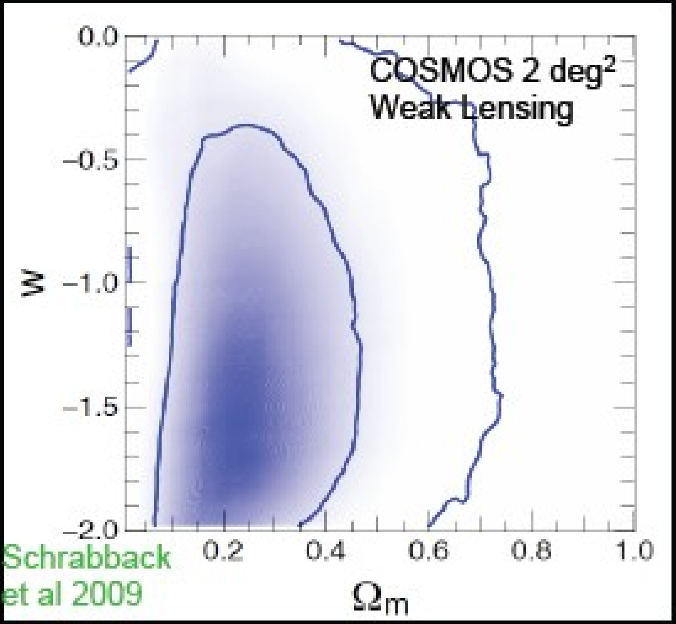
For definite answers on DE: need to reach a precision of 1% on (varying) w and 10% on $w_a=dw/da$

→ Objective for Euclid imaging





Astier et al. 2005



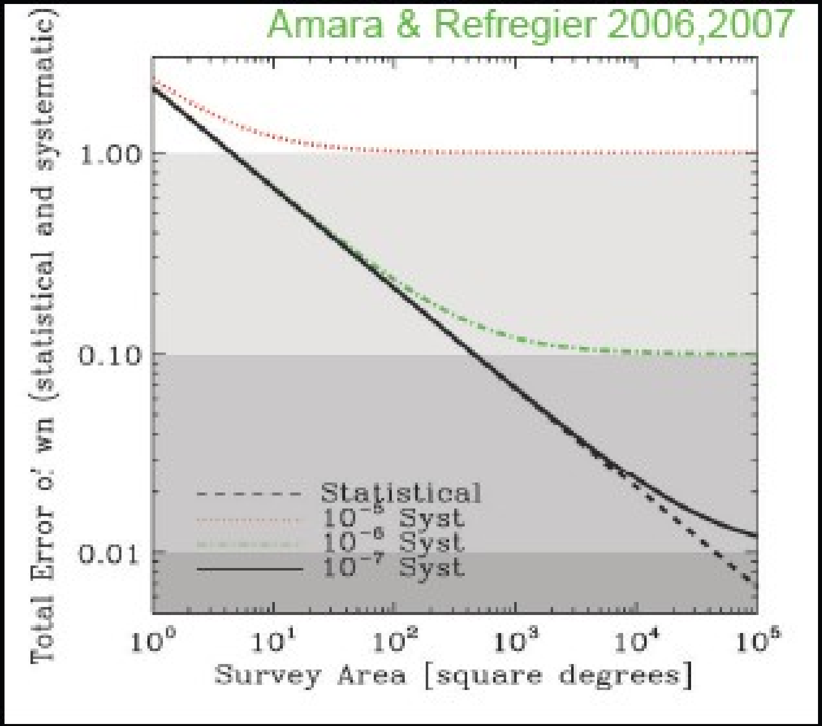
Schrabback et al 2009

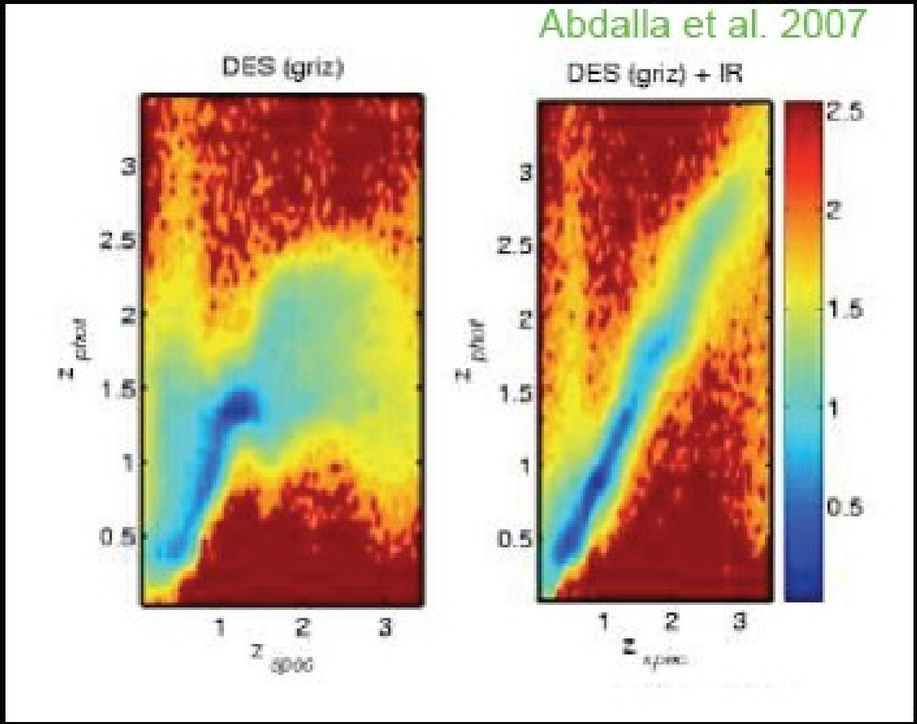
Requirements for Weak Lensing

Statistics: optimal survey geometry: wide rather than deep for a fixed survey time, → need 20,000 deg^2 to reach ~1% precision on w

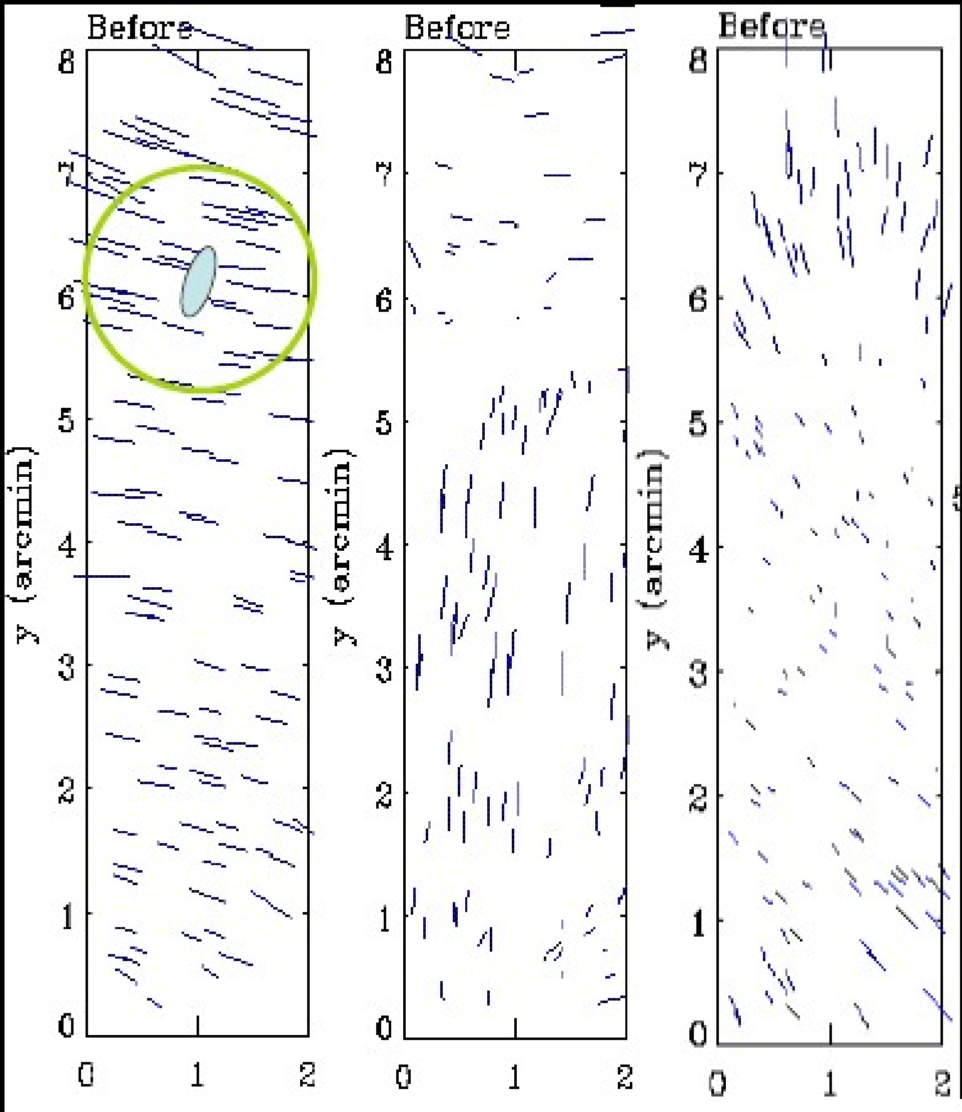
Redshift bins: good photo-z for redshift binning and intrinsic alignments → need deep NIR photometry

Systematics: must gain 2 orders of magnitude in systematic residual variance → need about 50 bright stars to calibrate PSF





The need for space



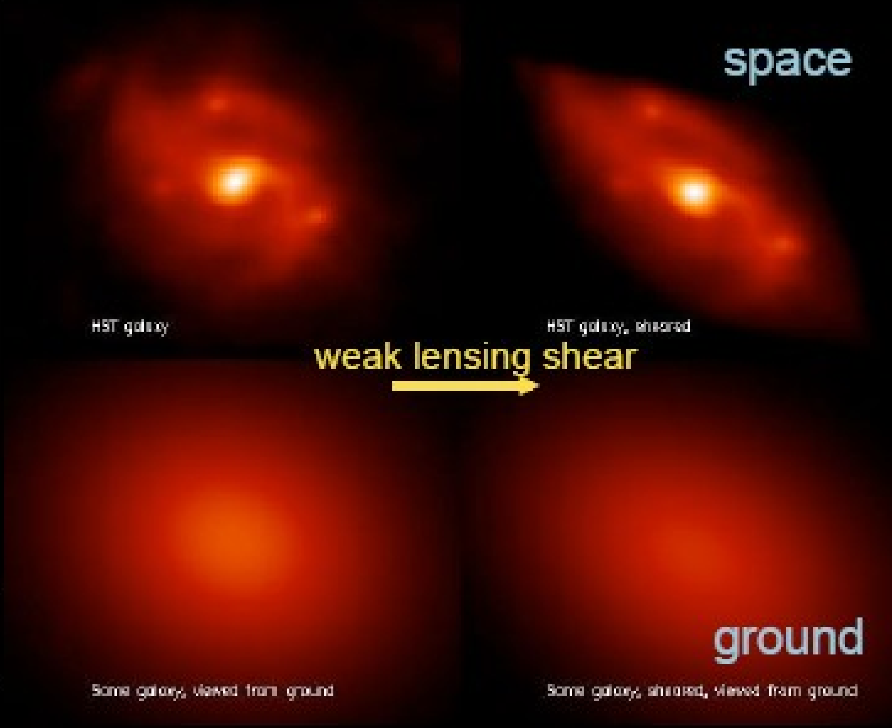
Ground PSF calibration and deconvolution

Euclid in space compared to ground:

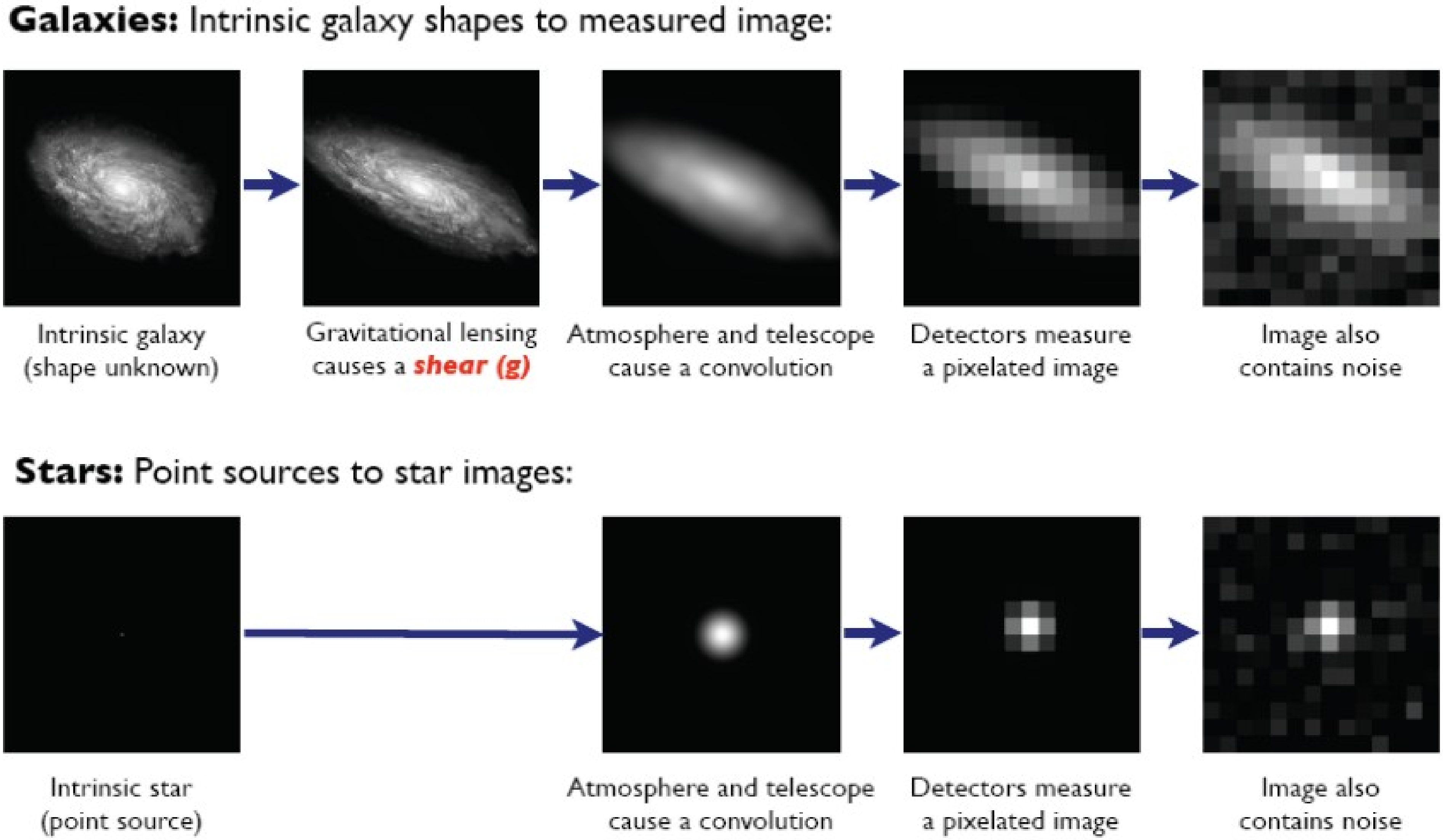
No atmospheric seeing, absorption, windshake, etc

- PSF size 5x smaller
- PSF stability 10x better
- NIR photometry 3 mag deeper

→ Needed to meet WL requirements



The Forward Process.



borrowed from C. Heynmans

Imaging instrument and control of systematics

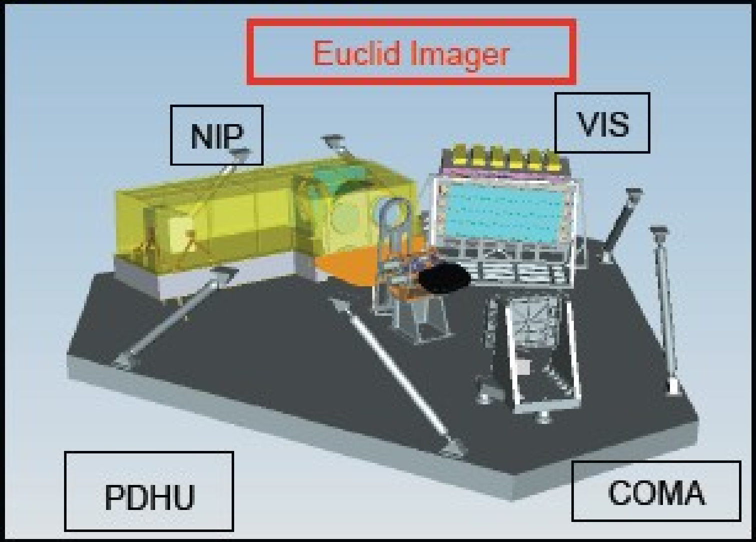
Imaging instrument: optimised for weak lensing

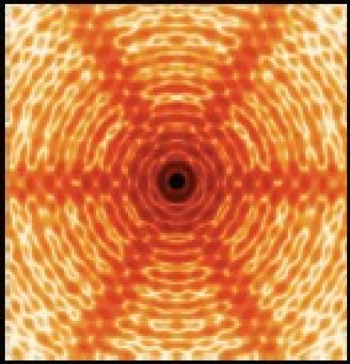
- Visible imaging channel: 0.5 deg^2, 0.10'' pixels, 0.16'' PSF FWHM, broad band R+I+Z (0.55-0.92mu), CCD detectors, galaxy shapes
- NIR photometry channel: 0.5 deg^2, 0.3'' pixels, 3 bands Y,J,H (1.0-2.0mu), HgCdTe detectors, photo-z's

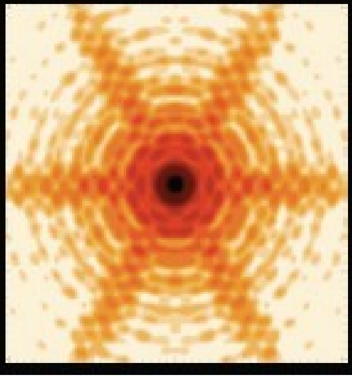
Control of systematics:

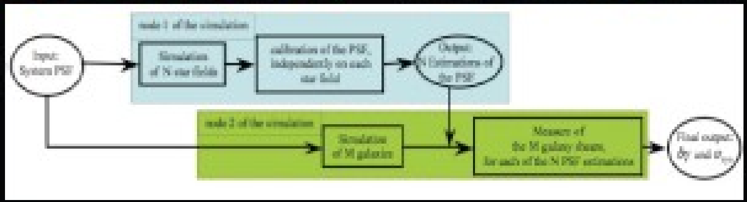
- Tight requirements on PSF ellipticity and stability, thermo-elastic distortions, attitude control, detector performance
- Instrument performance simulations
- Integrated data handling and calibration chain

Euclid Imaging Consortium (EIC):
130 people, 25 institutes, 7 countries









Euclid Imaging Surveys

Wide Survey: Extragalactic sky (20,000 $deg^2 = 2\pi$ sr)

- Visible: Galaxy shape measurements to $RIZ_{AB} \leq 24.5$ (AB, 10σ) at 0.16” FWHM, yielding 30-40 resolved galaxies/$amin^2$, with a median redshift $z \sim 0.9$
- NIR photometry: Y, J, H ≤ 24 (AB, 5σ PS), yielding photo-z’s errors of 0.03-0.05(1+z) with ground based complement (PanStarrs-2, DES. etc)
- Concurrent with spectroscopic survey

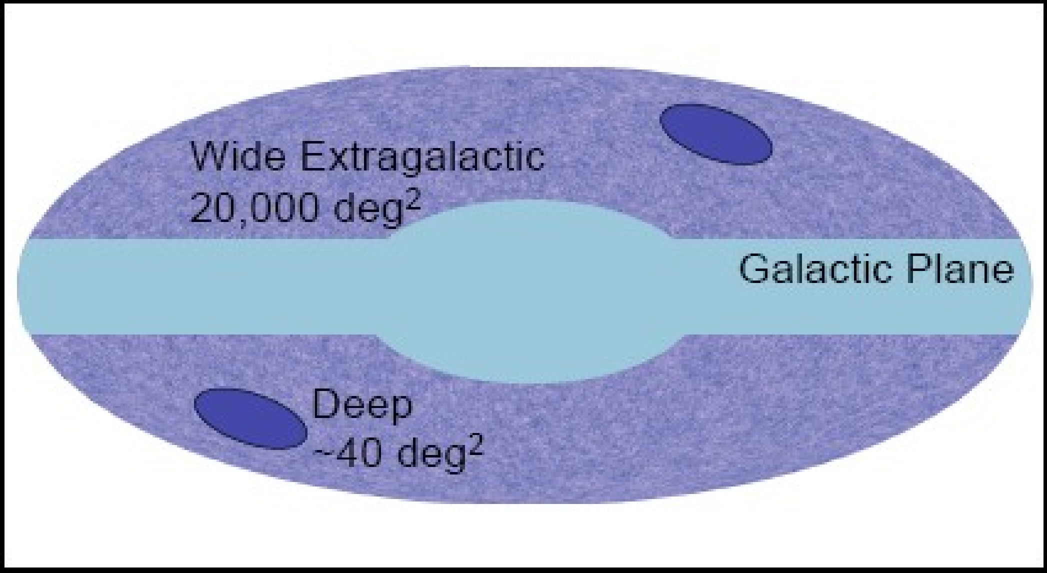
Deep Survey: 40 deg^2 at ecliptic poles

- Monitoring of PSF drift (40 repeats at different orientations over life of mission)
- Produces +2 magnitude in depth for both visible and NIR imaging data.

Possible additional Galactic surveys:

- Short exposure Galactic plane
- High cadence microlensing

extra-solar planet surveys could be easily added within Euclid mission



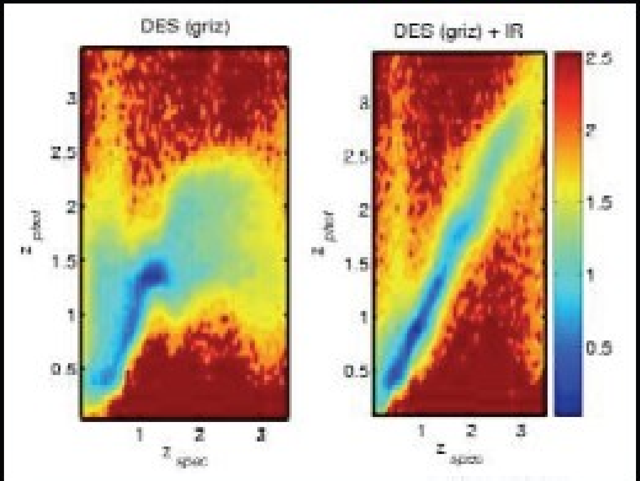
Ground-Space Synergy

To achieve photometric redshift precision of $\sigma(z)/(1+z)$=0.03(goal)-0.05(rq't), combine Euclid visible/NIR photometry with visible photometry from the ground

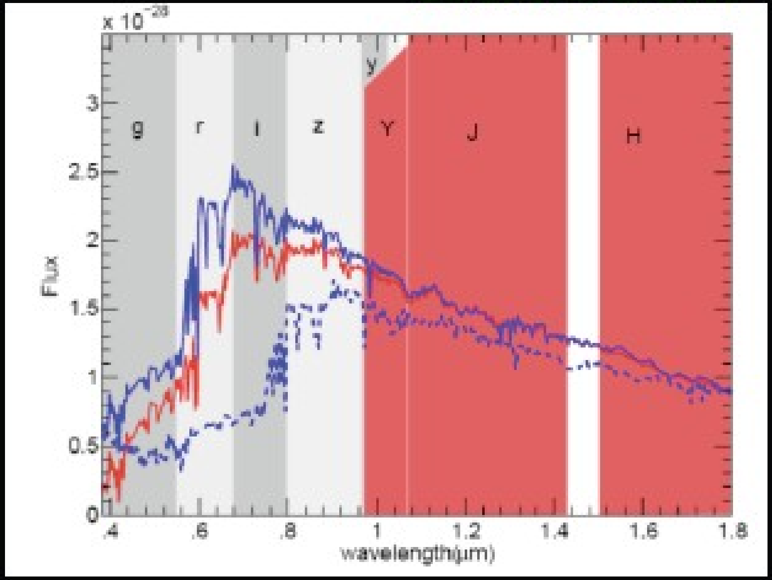
DES+Pan-STARRS2 will provide necessary depth and combined sky coverage, LSST+PS4 would provide even better photo-z's

→ see letters of support from DES and PS projects

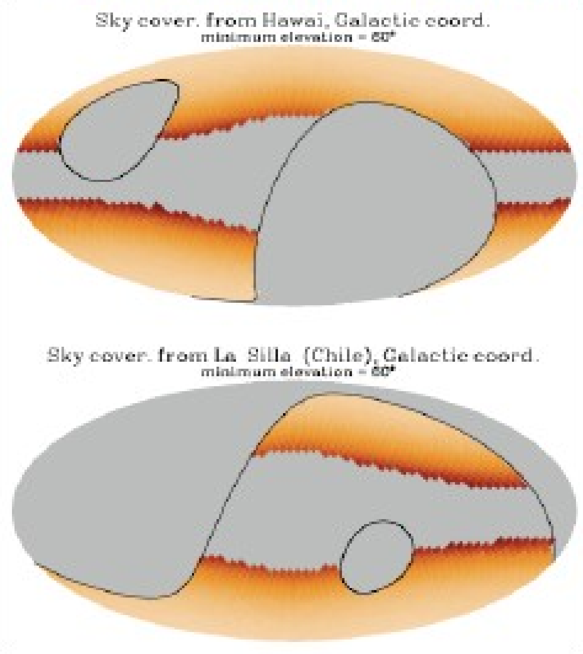
Abdalla et al. 2007



Bordoloi et al. 2009

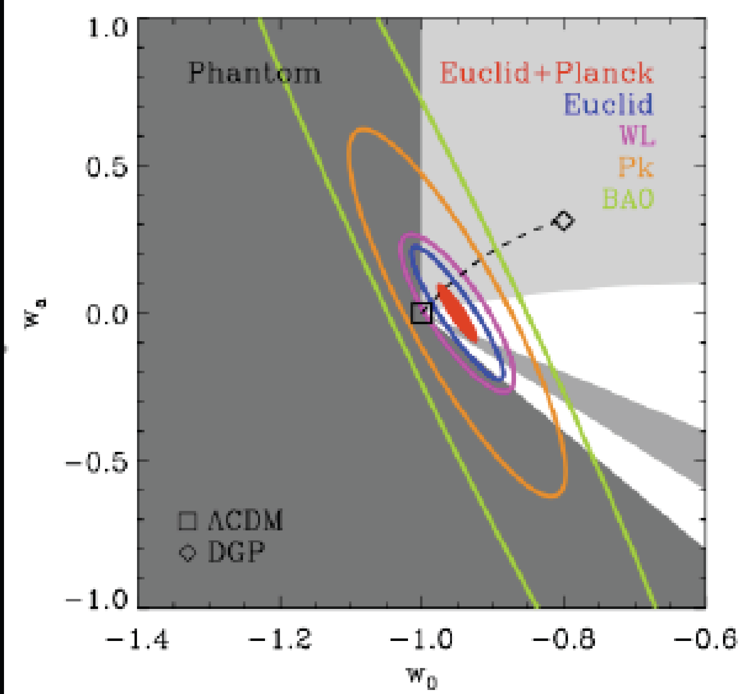


Paulin-Henriksson et al. 2009



Impact on Cosmology

	Δw_p	ΔW_a	$\Delta\Omega_m$	$\Delta\Omega_\Lambda$	$\Delta\Omega_b$	$\Delta\sigma_8$	Δn_s	Δh	DE FoM
Current+WMAP	0.13	-	0.01	0.015	0.0015	0.026	0.013	0.013	~10
Planck	-	-	0.008	-	0.0007	0.05	0.005	0.007	-
Weak Lensing	0.03	0.17	0.006	0.04	0.012	0.013	0.02	0.1	180
Imaging Probes	0.018	0.15	0.004	0.02	0.007	0.0009	0.014	0.07	400
Euclid	0.016	0.13	0.003	0.012	0.005	0.003	0.006	0.020	500
Euclid +Planck	0.01	0.066	0.0008	0.003	0.0004	0.0015	0.003	0.002	1500
Factor Gain	13	>15	13	5	4	17	4	7	150



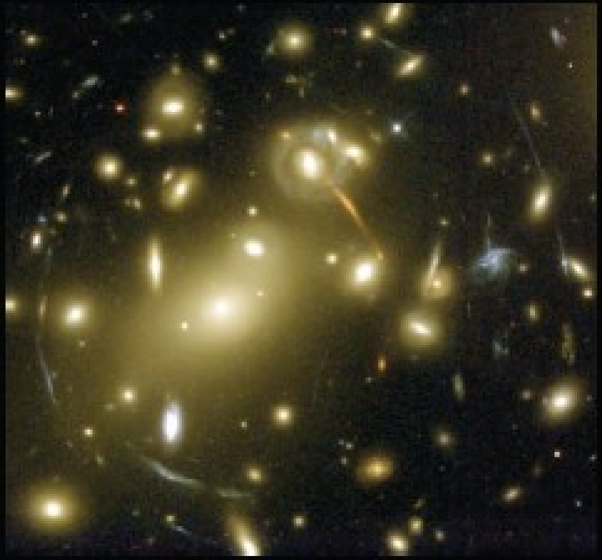
Euclid Imaging will challenge all sectors of the cosmological model:

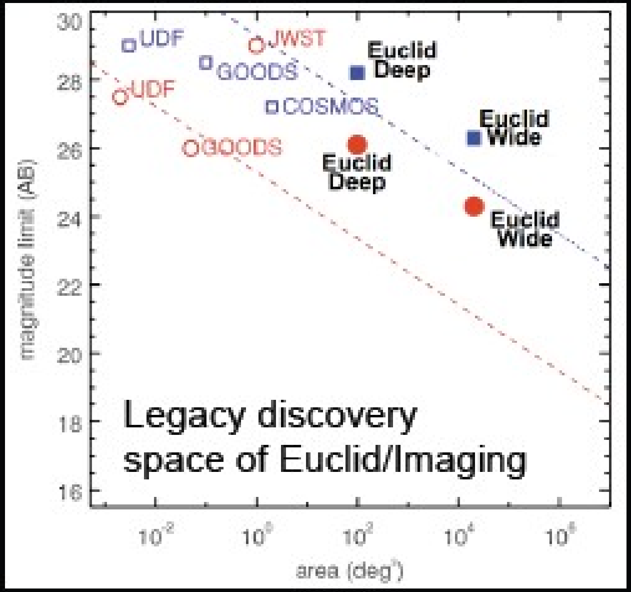
- Dark Energy: w_p and w_a with an error of 2% and 13% respectively (no prior)
- Dark Matter: test of CDM paradigm, precision of 0.04eV on sum of neutrino masses (with Planck)
- Initial Conditions: constrain shape of primordial power spectrum, primordial non-gaussianity
- Gravity: test GR by reaching a precision of 2% on the growth exponent γ ($d\ln\delta_m/d\ln a \propto \Omega_m^\gamma$)

→ Uncover new physics and map LSS at 0<z<2: Low redshift counterpart to CMB surveys

Imaging Legacy Science

- Map relation between Galaxy Mass and Light: correlation of WL mass map with galaxy distribution and properties/morphologies
- Constrain physical drivers of star formation: galaxy morphology and NIR properties; SNe rate (Detection of ~3000 Type Ia and Type II supernovae in deep survey)
- High-z objects: Using the Ly-dropout technique in MD survey, detect 10^{3-4} star forming galaxies at z~8, 10^{2-3} at z~10, ~10 at z~12; also detect 10^{2-4} quasars at z~7, and 10^{1-3} at z~9
- Galaxy Clusters: NIR detection of several 100 Virgo-like clusters and several 1000 10^{13} M_{sun} at z>2, mass detection of 40,000 clusters at z~0.3-0.7, well matched to Planck and eRosita cluster sample
- Strong-Lensing systems: ~10^5 Galaxy-galaxy lenses, ~10^3 galaxy-quasar lenses, 5000 strong lensing arcs in clusters
- Exo-planets: make census earth mass planets through microlensing





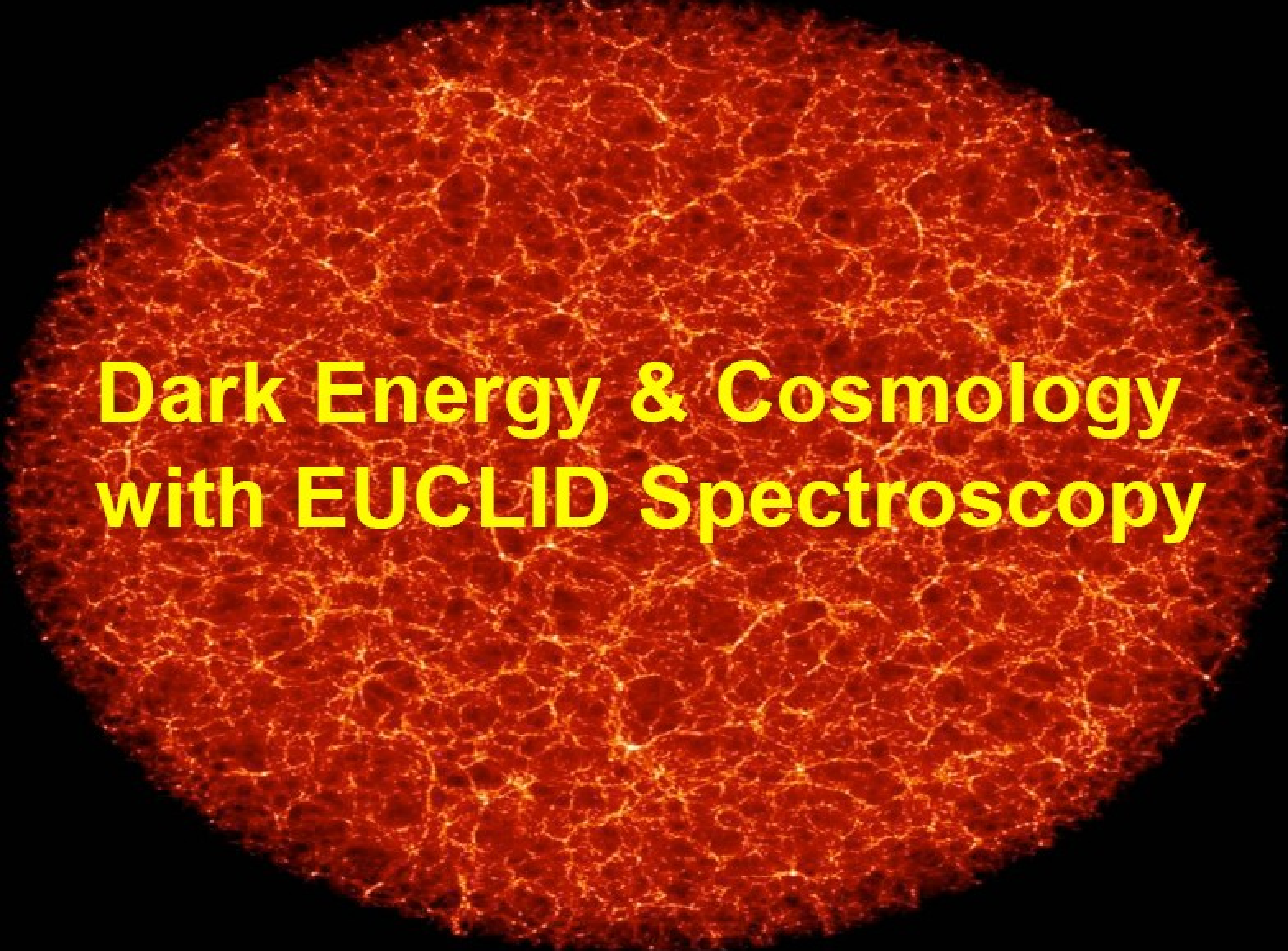
Imaging the Dark Universe

- Euclid concept: high-precision survey mission, optimised for Weak Lensing and BAO, tight control of systematics, strong link between science and instrumentation, matched survey speeds, synergy with ground based surveys

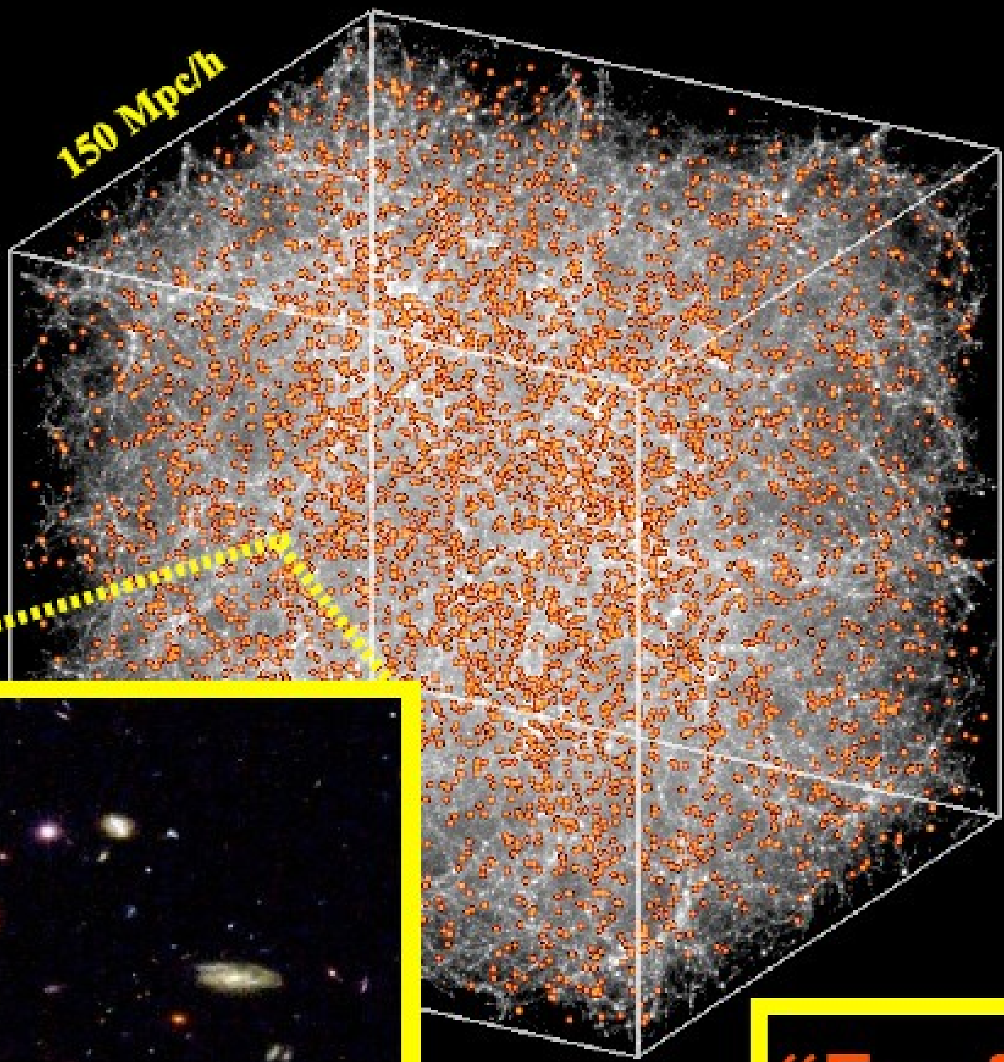
- Euclid imaging will achieve definite constraints on Dark Energy and challenge all sectors of the cosmological model

- Euclid imaging will provide unique legacy science: galaxy evolution, high-z objects, clusters, strong lensing, and with a survey extension exoplanets and Milky Way

- Euclid has received broad support from the European science community: ESA/ESO WG on Fundamental Cosmology, Astronet, National agencies


Dark Energy & Cosmology
with EUCLID Spectroscopy

3-D Evolutionary Map of the Universe

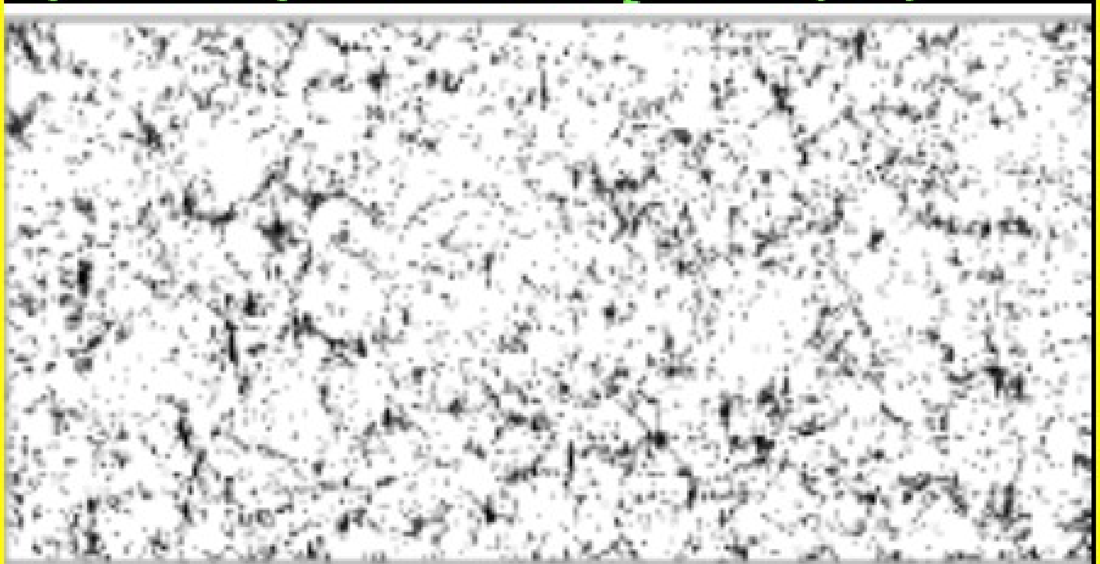


- For each galaxy: RA, Dec, Redshift
  ➔ **3-D map**
- Boxes at different redshifts:
  ➔ **Evolution**

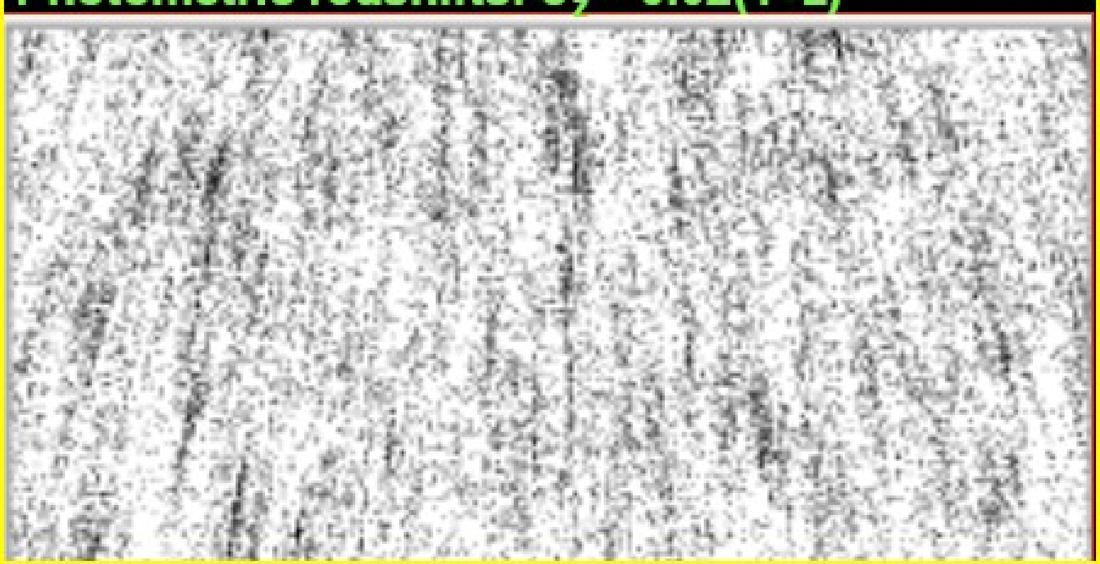
"For free":
Galaxies, AGNs

WHY SPECTROSCOPY ?

Spectroscopic redshifts: $\sigma_z = 0.001(1+z)$



Photometric redshifts: $\sigma_z = 0.02(1+z)$

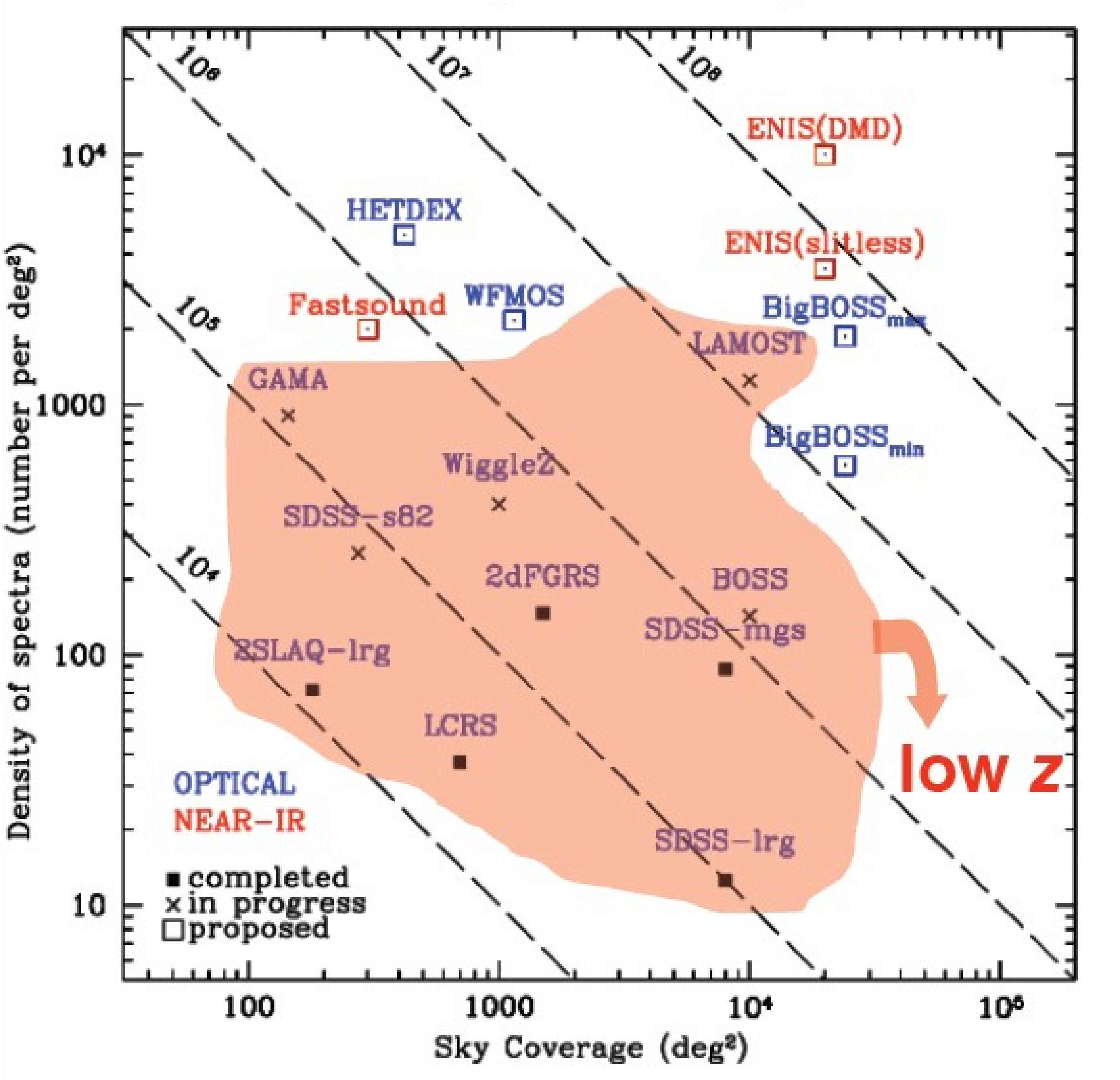


WHY FROM SPACE ?

- No atmosphere
- ≈ 500x less background
- Stable PSF
- Homogeneous data
- Easy to reach $z \approx 2+$
- Clean selection function
- Unbeatable speed
- Multi-probe experiment

WHY NEAR-IR ?

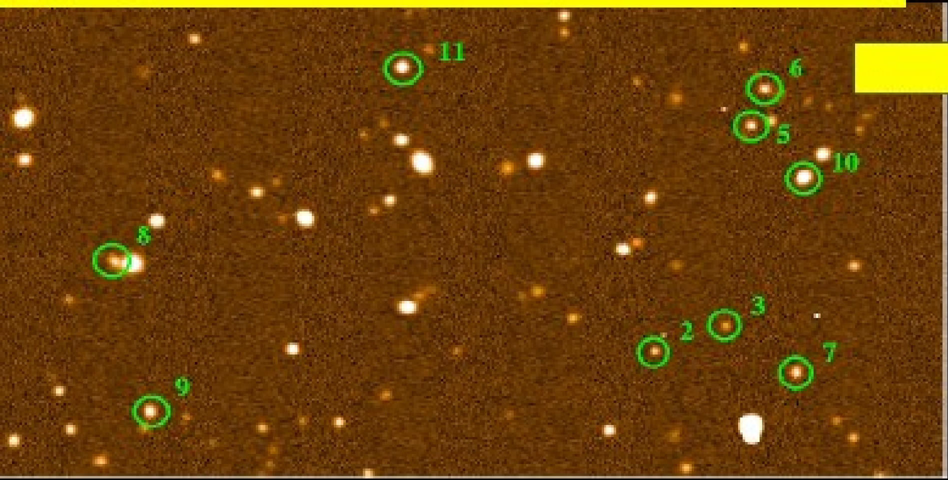
- $0.5 < z < 2$ with Hα
- Less dust extinction
- Higher legacy value



ENIS(DMD)
HETDEX
ENIS(slitless)
Fastsound
WFMOS
BigBOSS$_{max}$
LAMOST
GAMA
BigBOSS$_{min}$
WiggleZ
SDSS-s82
2dFGRS
BOSS
SDSS-mgs
2SLAQ-lrg
LCRS
low z
OPTICAL
NEAR-IR
SDSS-lrg
completed
in progress
proposed
10^6
10^7
10^8
10^5
10^4
Density of spectra (number per deg^2)
Sky Coverage (deg^2)

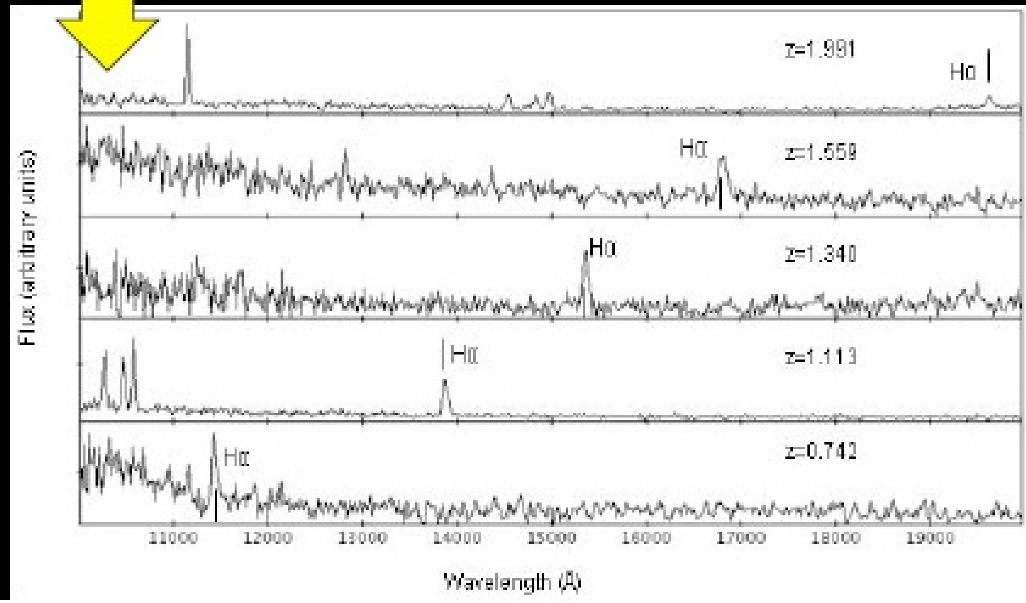
$\lambda/\Delta\lambda$=500
1-2 μm
FoV=0.5 deg^2

Slitless spectroscopy (baseline)

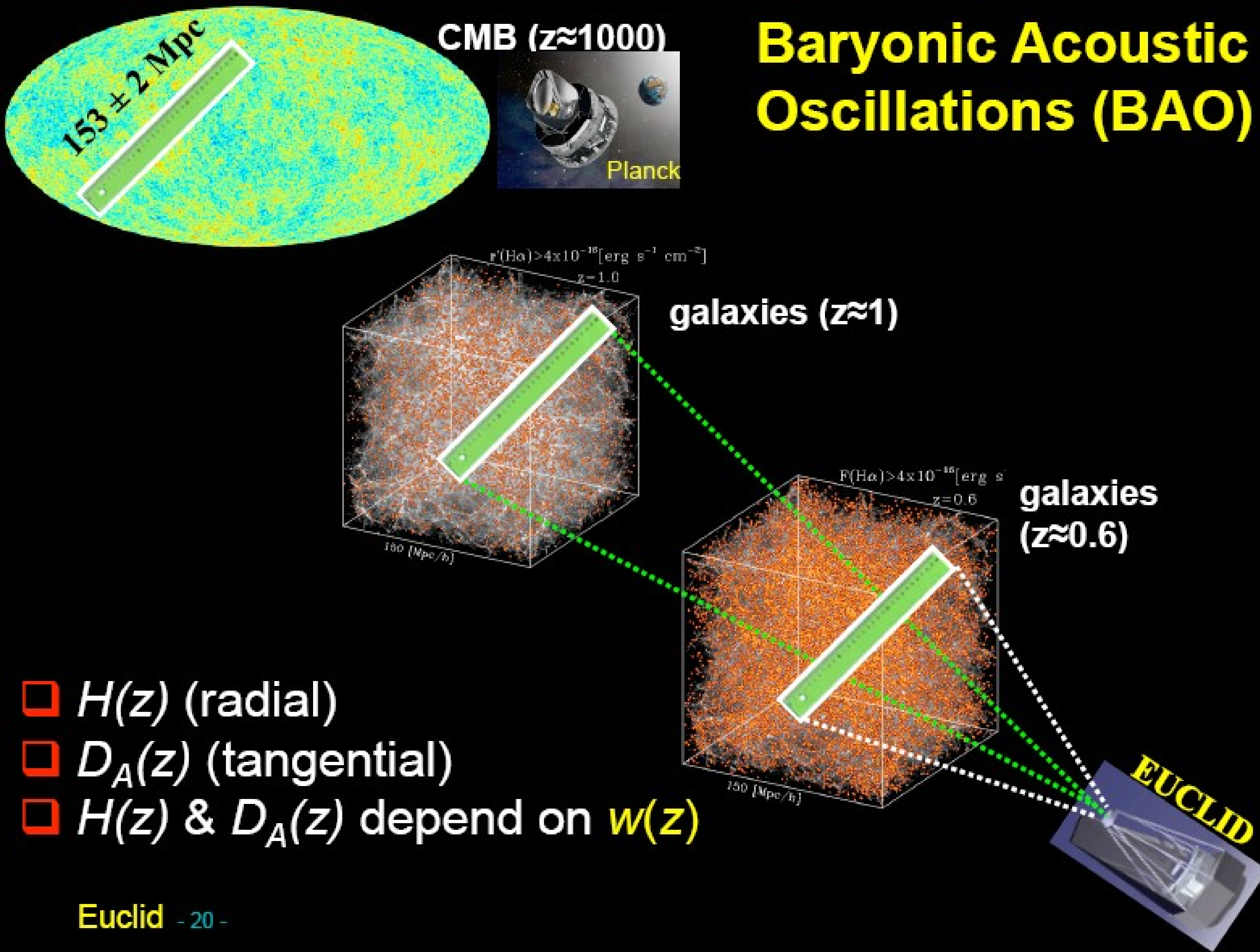


simulated NIS data

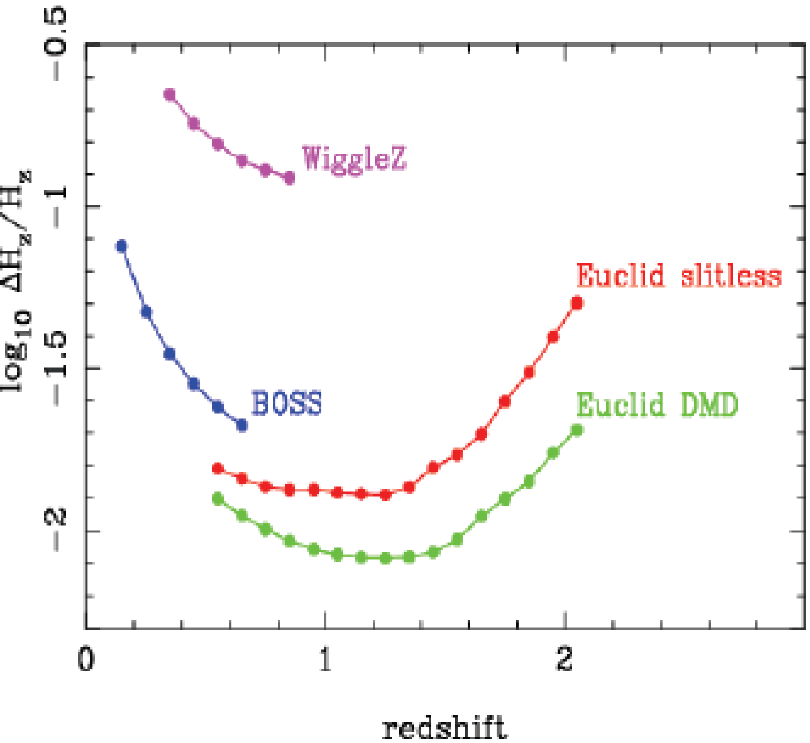
- Star-forming galaxies
- 0.5<z<2 (Hα)
- F_{line}> 4x10^{-16} erg/s/cm^2 (H<19.5)
- $\sigma_z \leq$ 0.001(1+z)
- Redshift success rate ≥ 50%
- N(gal) ≈ 7 x 10^7
- Sky coverage = 20,000 deg^2
- Mission duration ≤ 5 years

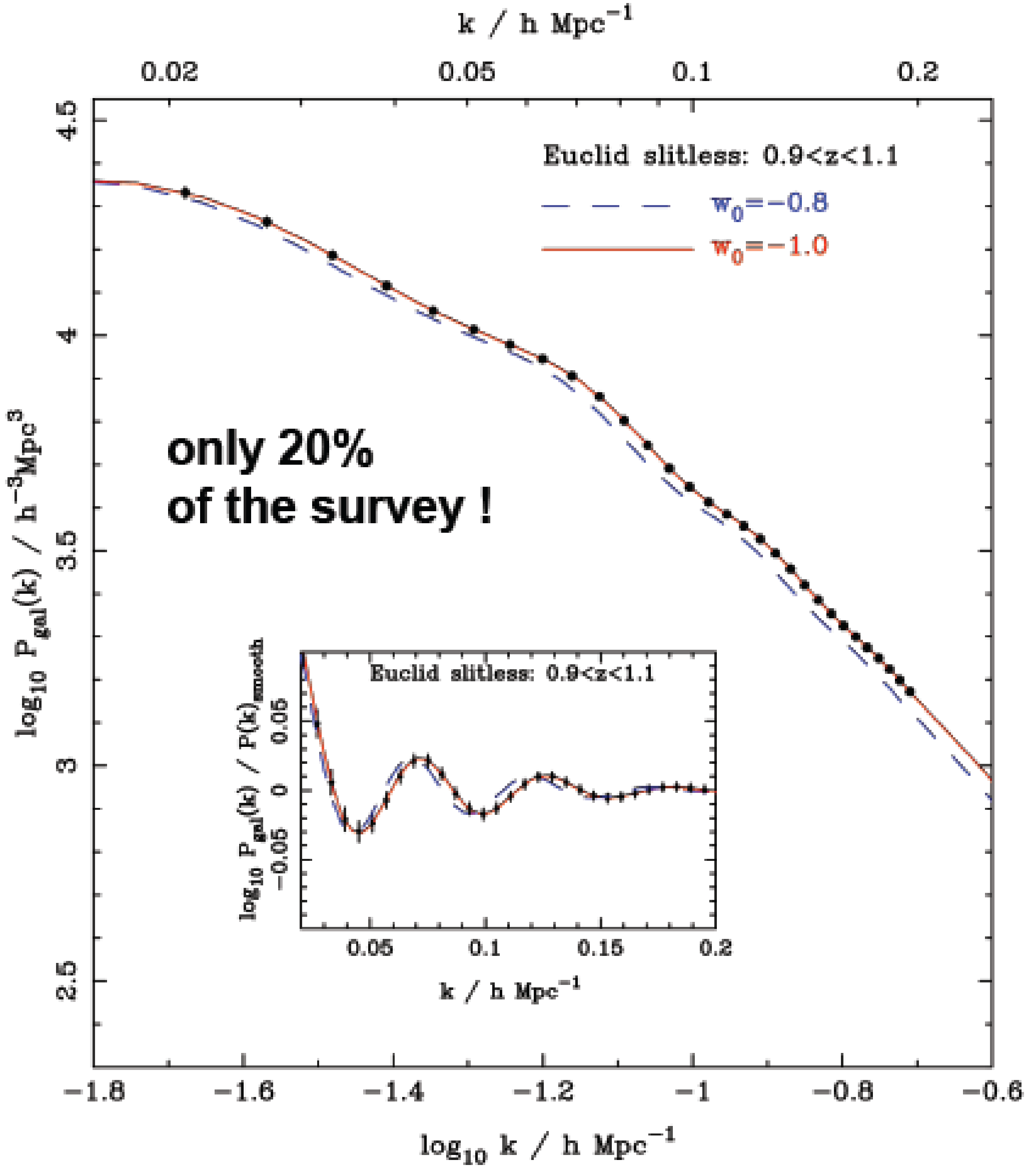


Baryonic Acoustic Oscillations (BAO)



- $H(z)$ (radial)
- $D_A(z)$ (tangential)
- $H(z)$ & $D_A(z)$ depend on $w(z)$



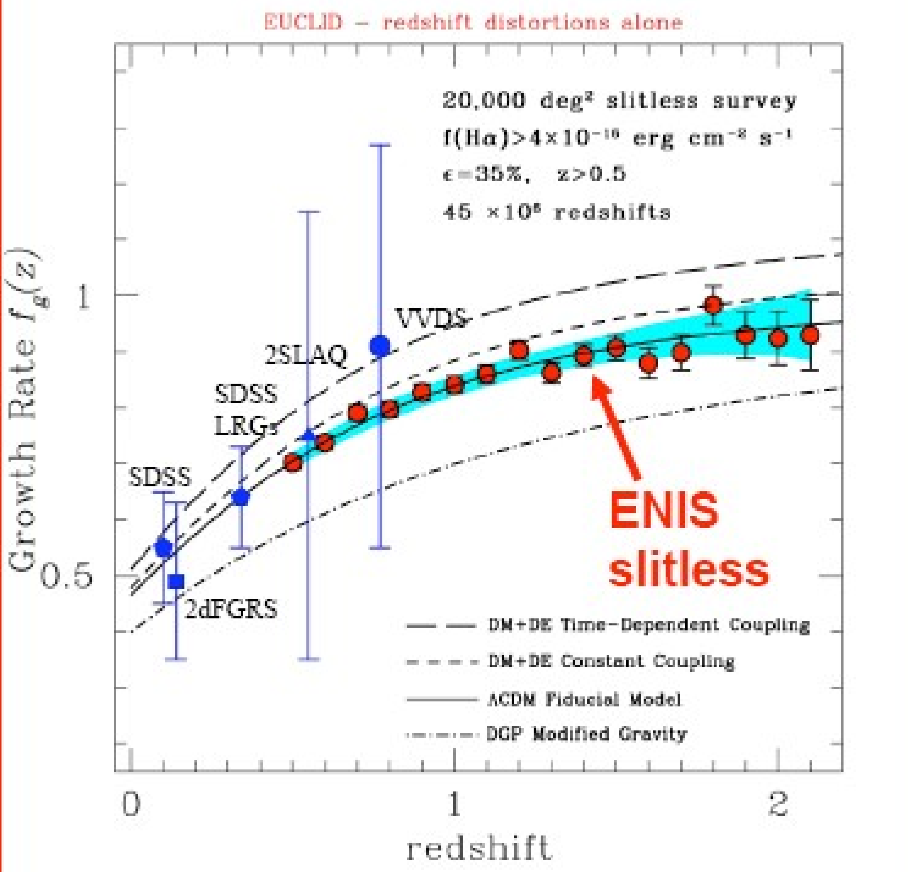


- $V_{eff} \approx 19\ h^{-3}\ Gpc^3 \approx$ 75x larger than now (i.e. SDSS) !
- dw_p, dw_a = 2%, 17% (with Planck) (FoM≈300)
- FoM(imaging+spectroscopy+Planck)≈ 1500 (150x better than now !)

More cosmology with the ENIS dataset

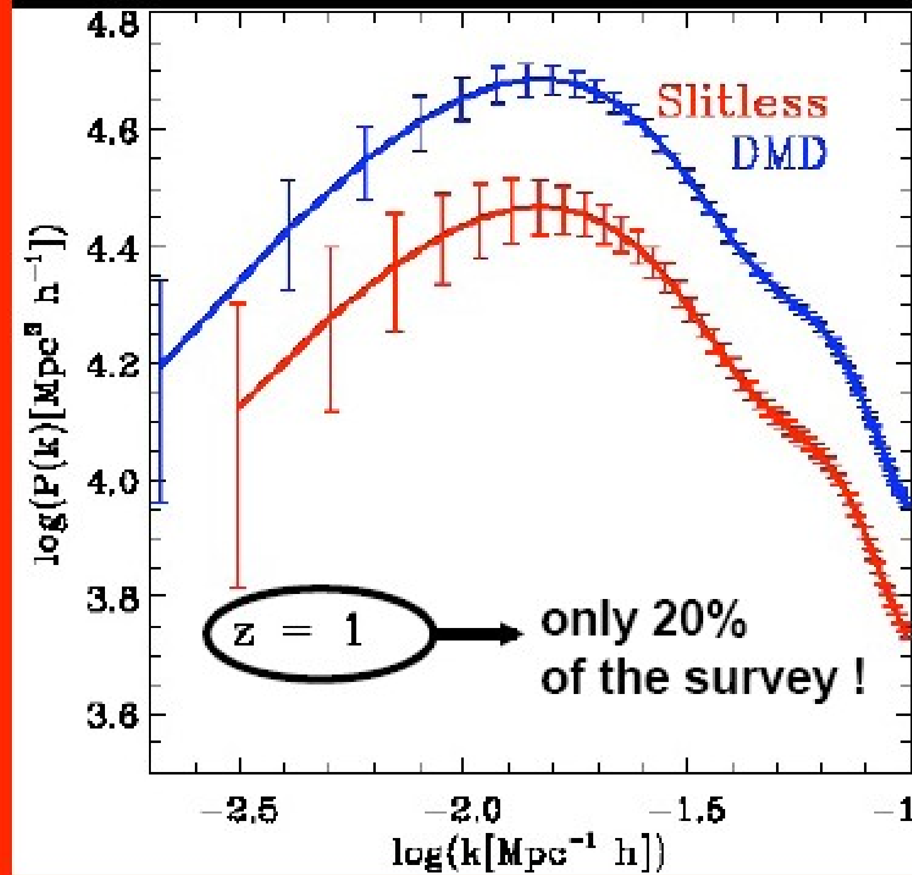
Redshift Space Distortions

Anisotropy of radial vs tangential clustering
<u>Impossible with photometric redshifts !</u>
Test of Modified Gravity theories
Break degeneracies for models with same H(z)

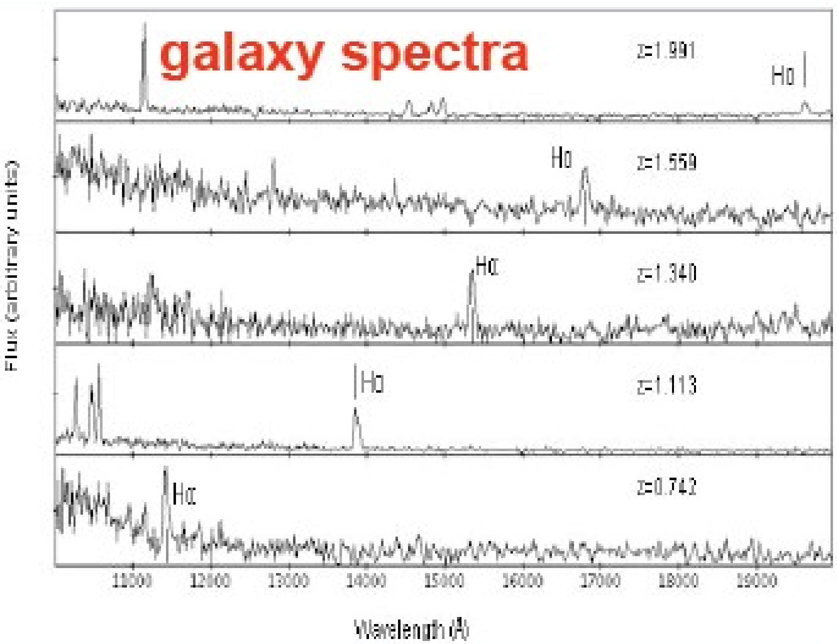


Full Power Spectrum P(k)

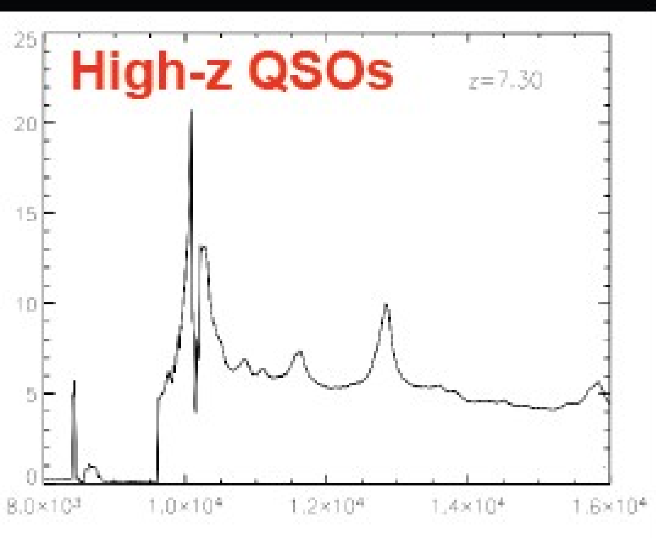
Primordial fluctuations
Models of inflation
Complementary to CMB

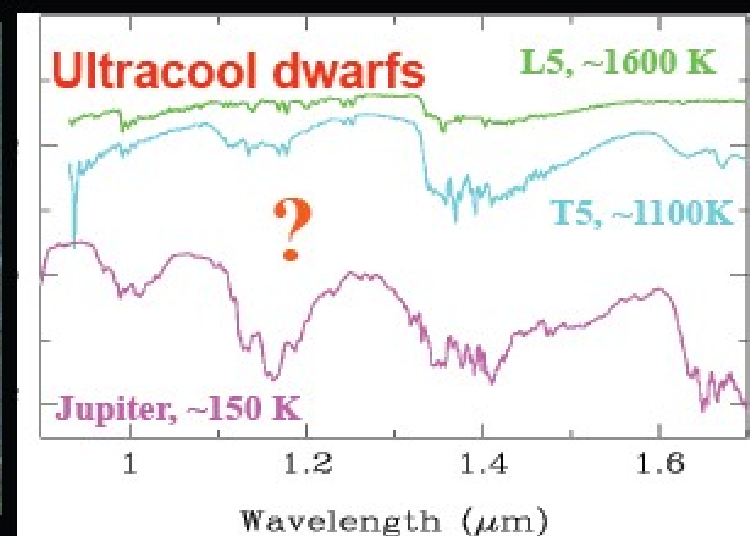


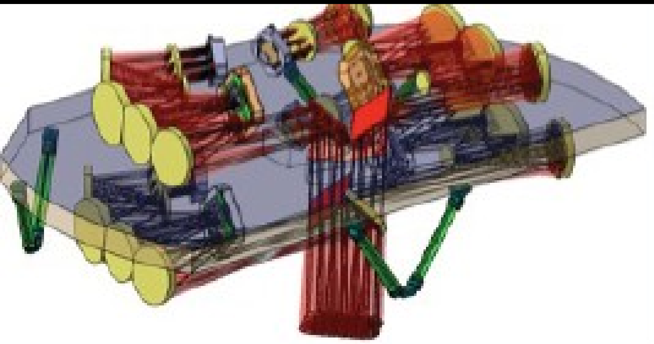
Immense Legacy Value !

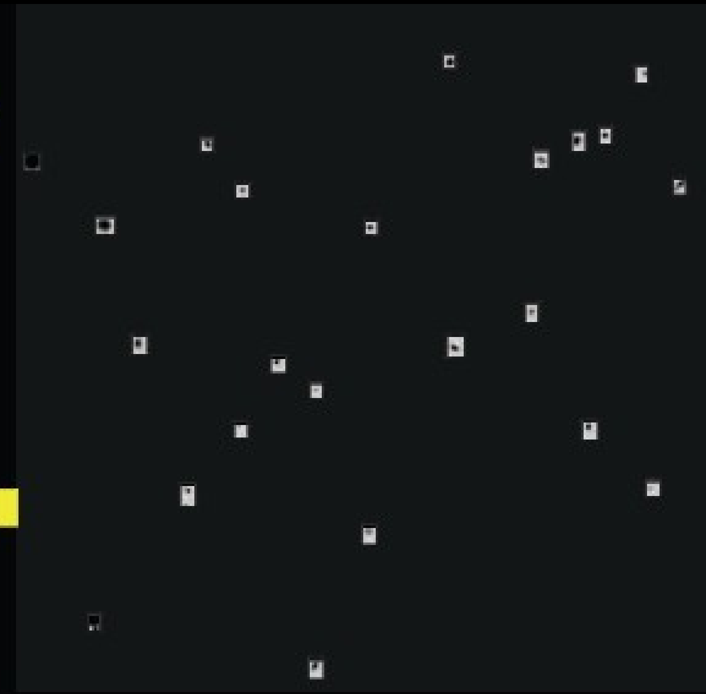


- ≈70 million galaxies & AGNs: >1000x more redshifts than now at **z** ~1 and >70x than SDSS !
- Statistical studies with unprecedented statistics
- ≈ 10,000 clusters of galaxies at **z** < 1
- Clustering and halo statistics
- The largest unbiased survey for high-z QSOs
- Most luminous objects at **z** > 7 in *Deep Survey*
- Our Galaxy (ultracool dwarfs, IMF…), **+GAIA**
- **Synergies: VIS/NIP, multi-λ surveys, JWST**



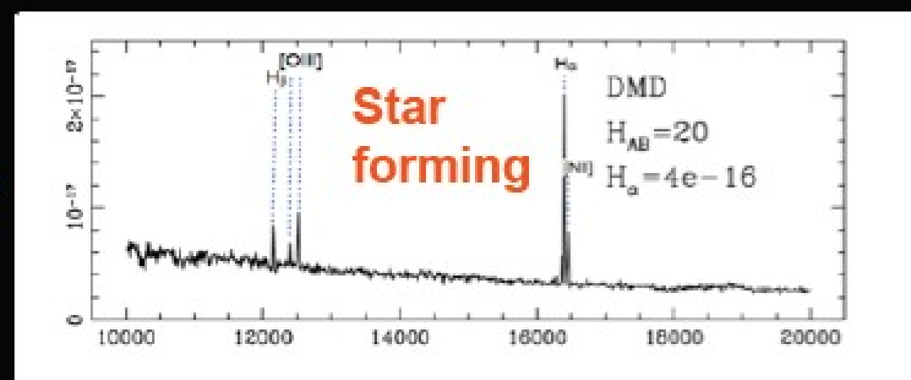


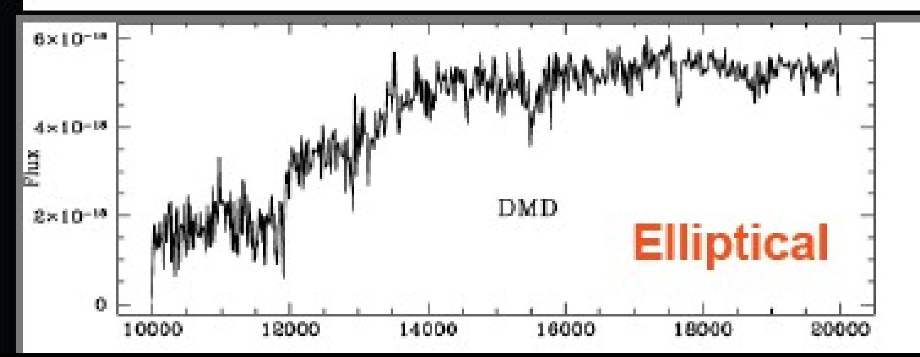




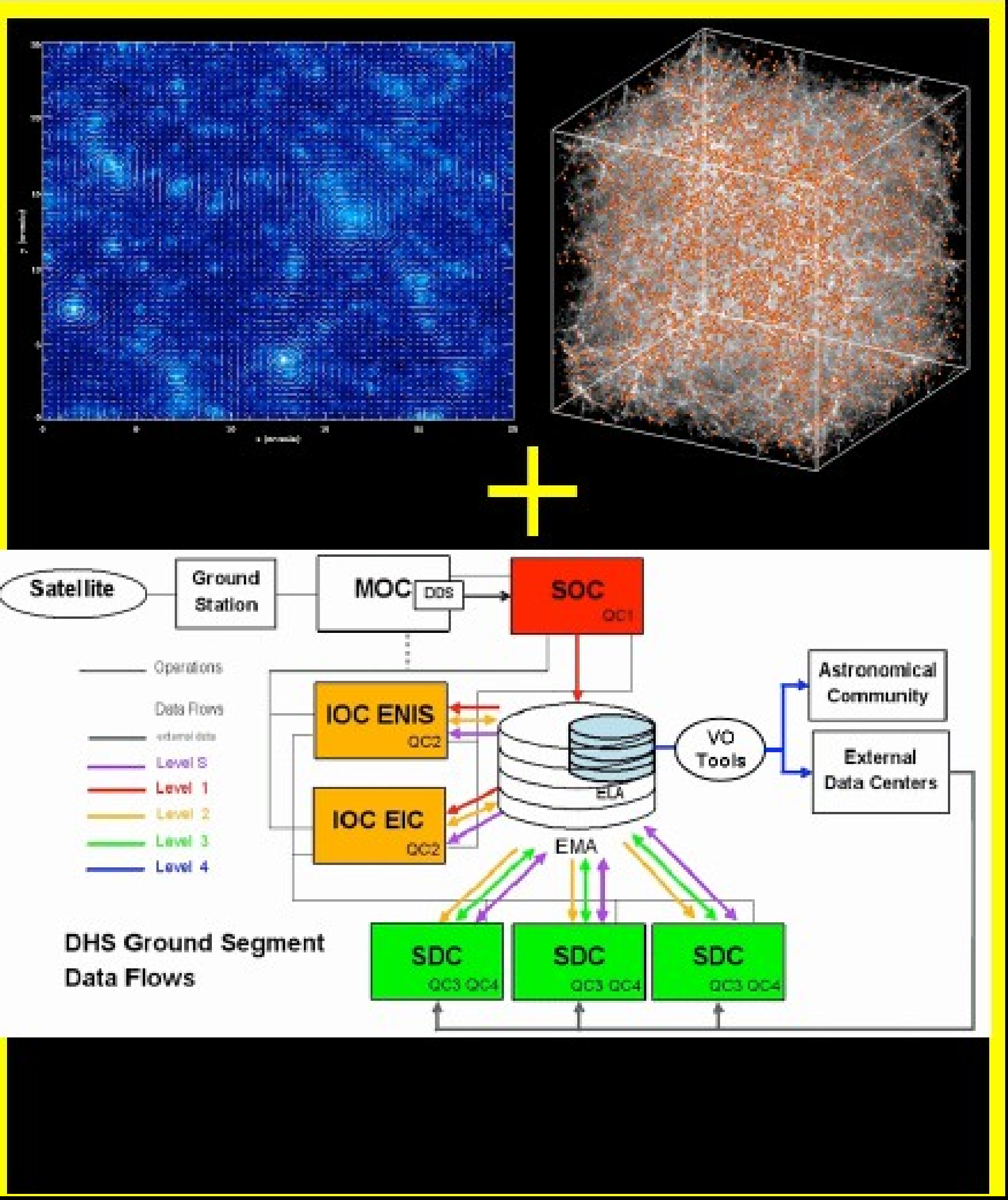
DMD "slit" spectroscopy (<u>optional</u>)

- Deeper spectra (H<22)
- All galaxy types (+E/S0)
- +Clusters at z>1
- N(gal) ≈ 2×10^8
- 0 < z < 2.5 (Wide Survey)
- $V_{eff} = 50\ h^{-3}\ Gpc^3$
- $>10^6$ galaxies at 2<z<10 (Deep Survey)
- Extra gain of cosmology & legacy value





Why EUCLID ?



- **"The" high precision Dark Energy & Cosmology mission**

- **Essential and unbeatable synergy of imaging + spectroscopy:**

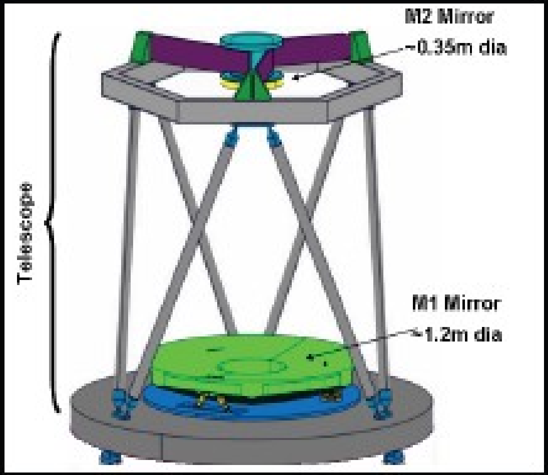
  - control of systematic errors
  - complementary mapping of the same large scale structure
  - complementary tests of Gravitation
  - dark vs luminous matter clustering

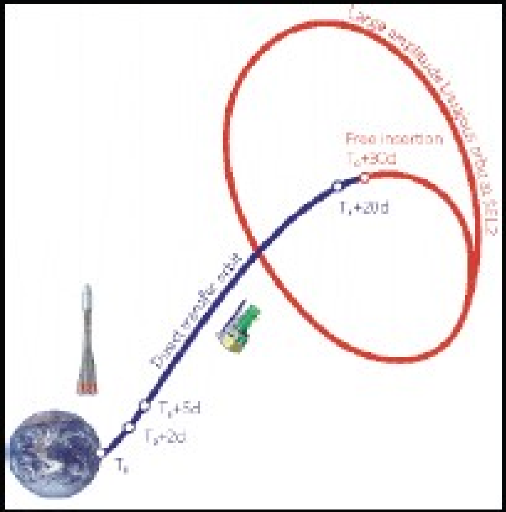
- **Immense legacy value**

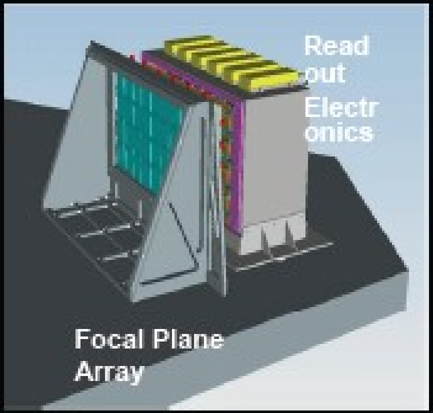
- **EUCLID (ima+spec) will impact the whole astrophysics and cosmology for decades to come**

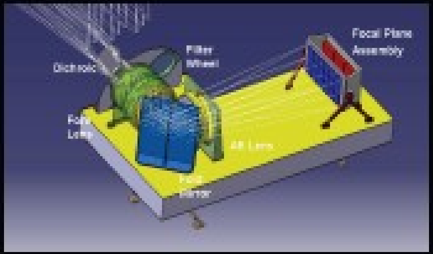
Mission Implementation

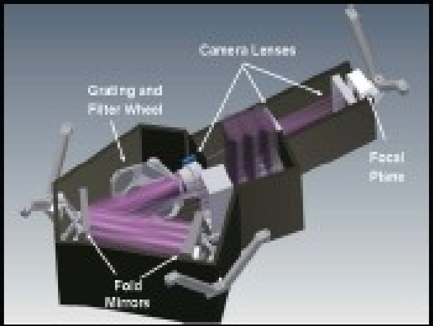
David Lumb, ESTEC SRE-PA











Mission Introduction - Requirements

Driving Science Requirements

Wide Extragalactic Survey

20 000 °²

Properly Sample Galaxies

PSF <0.2 arcsec

Ellipticity < 20%

Stable <0.02% rms

Red shifts $\sigma_z/(1+z) \leq 0.001$

VIS, NIP imaging instruments

NIS spectrometer

Same FOV & Dithered

System Requirements

L2 orbit

4.5 yrs Science mission

Step and Stare observation strategy

850Gbit/day = K band Cebreros

Pointing Stability

RPE < 25mas (500seconds)

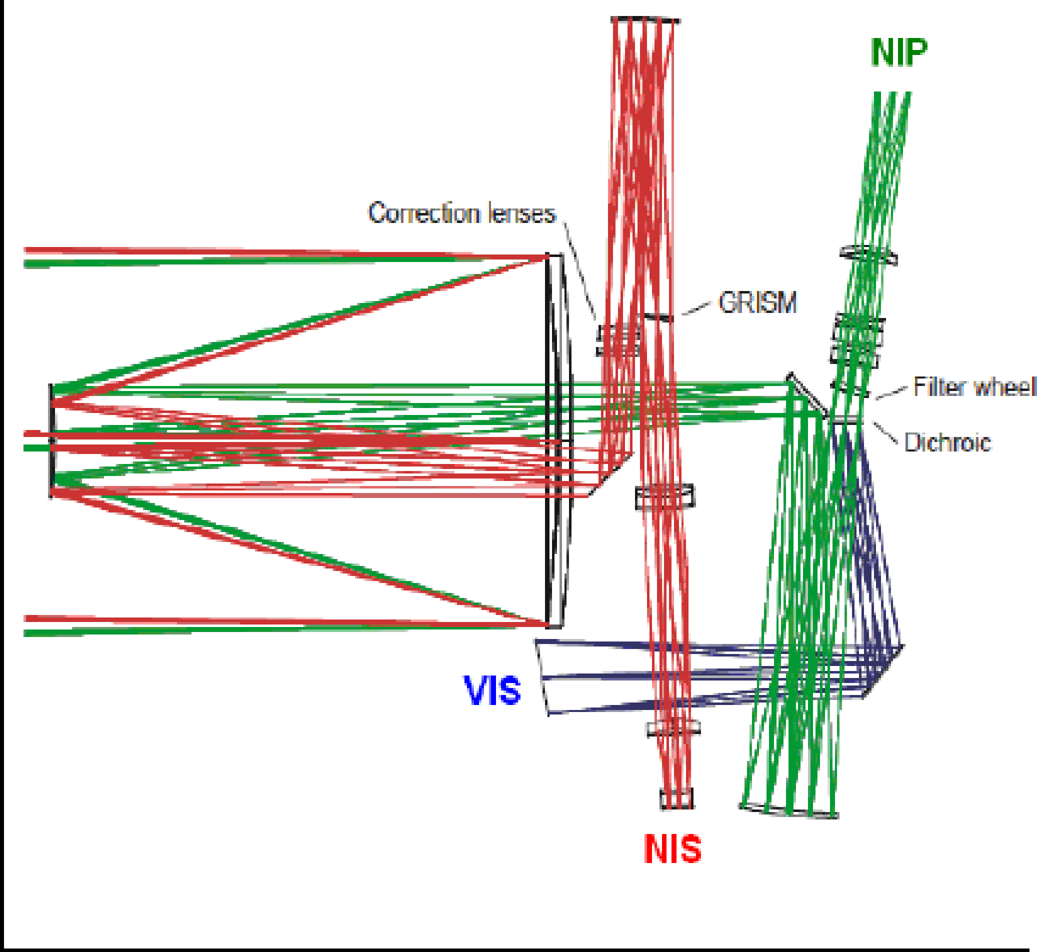
APE < 10 as

AME < 100mas

36 CCDs and 26 NIR arrays

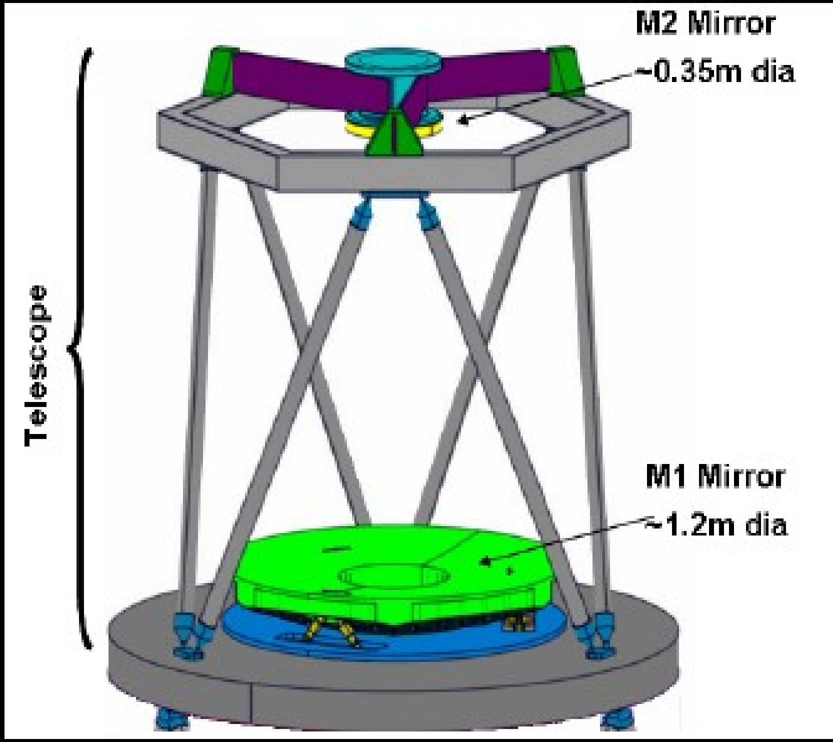
Telescope (1 / 2)

- High resolution imaging across a wide waveband, simultaneously with a spectroscopic channel
- Similar fields of view with >0.5 degree^2, and focal scale tuned to existing CCD and NIR detectors
- A common design provided by ESA SRE-P for both industries and consortia
- Teams arranged folding to accommodate a compact Payload Module



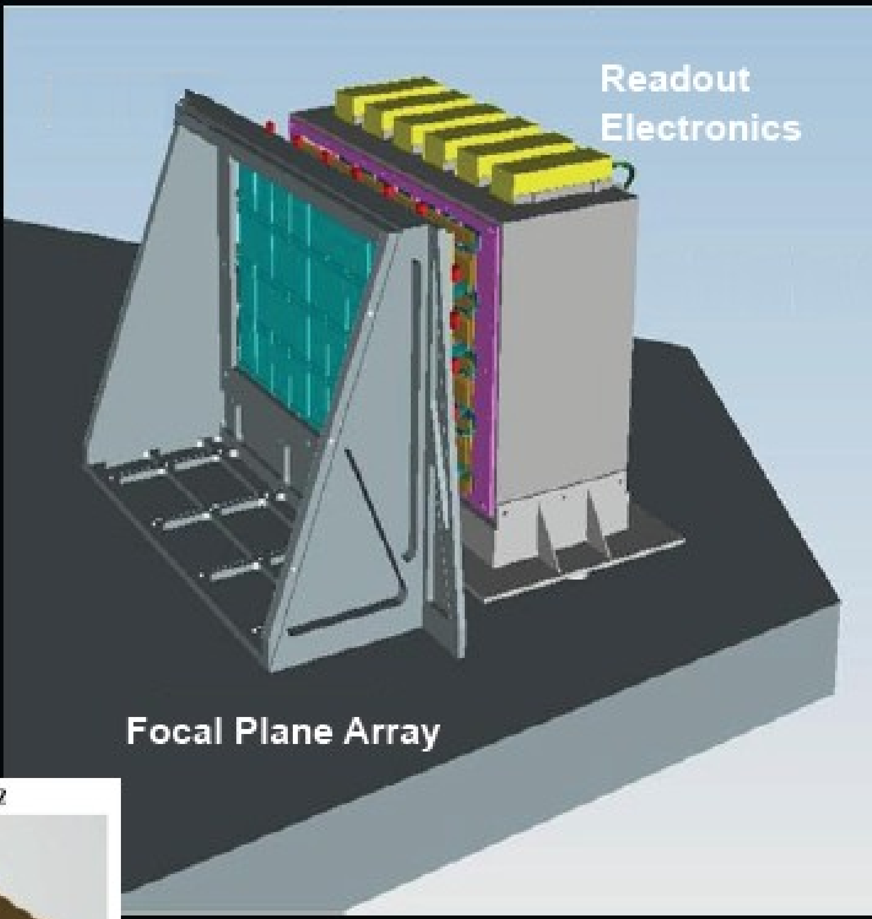
Telescope (2 / 2)

- A **1.2m diameter** Korsch-type telescope with diffraction limited imaging performance
- One industry solution is **SiC** (at 150K) passive thermal control
- Complementary approach uses actively controlled **Zerodur** at the maximum temperature (240K) for acceptable internal background
- Stability **~20µm** on focus required for PSF stability (**~10's mK**)



VIS

- Part of Weak Lensing Science package
- 1° x 0.5 ° field of view covered by 36 CCDs (*e2v CCD203 heritage Solar Dynamics Observer)*
- Broad **r, i, z** waveband (550-920nm)
- 150K passively cooled
- Each field covered by 4 exposures of ~500s and small spacecraft dither manoeuvre to fill gaps
- 0.1 arcsec pixels to over-sample PSF
- Prototype proximity electronics development already started

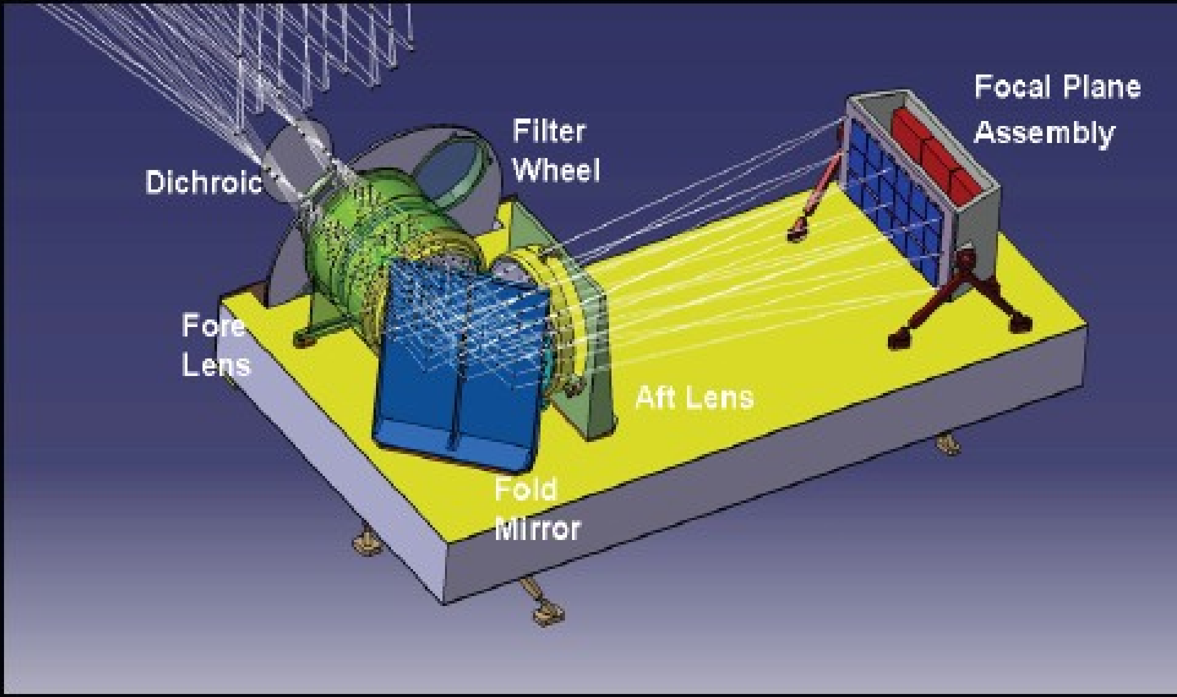


Existing

4k x 4k

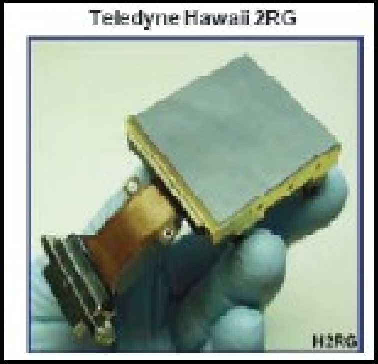
NIP

- **Also part of Weak Lensing Science package**
- **1° x 0.5 ° field of view co-aligned with VIS**
- **Covered by 18 NIR detectors (*Teledyne Hawaii HgCdTe*)**
- ***0.3 arcsec pixels***
- ***Passively cooled ~100K***
- **3 Filter bands Y, J, H each observed ~100s during each of the 4 exposures of VIS**



Existing

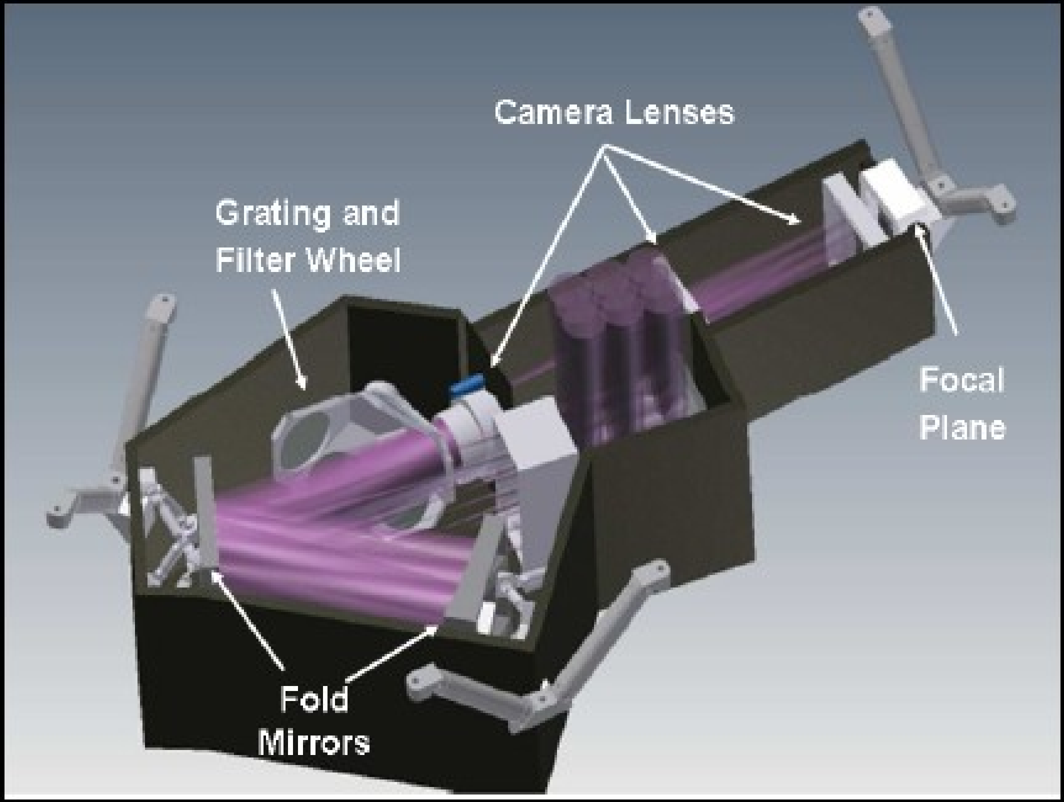
2k x 2k



– Provides the Near-IR photometric z that is infeasible from ground and essential for tomography

NIS

- **Slitless spectrometer, R~500 from 1 to 2 µm**
- **Field of View comparable with Imaging Channel (but displaced ~1.5°)**
- **2 pixels/resolution element requires 2x4 Hawaii detector arrays**
- **Passive cooled to ~100K**
- **Cryogenic lenses and filter wheel with JWST heritage**
- **Source confusion minimised with grating orientation changed per field dither**

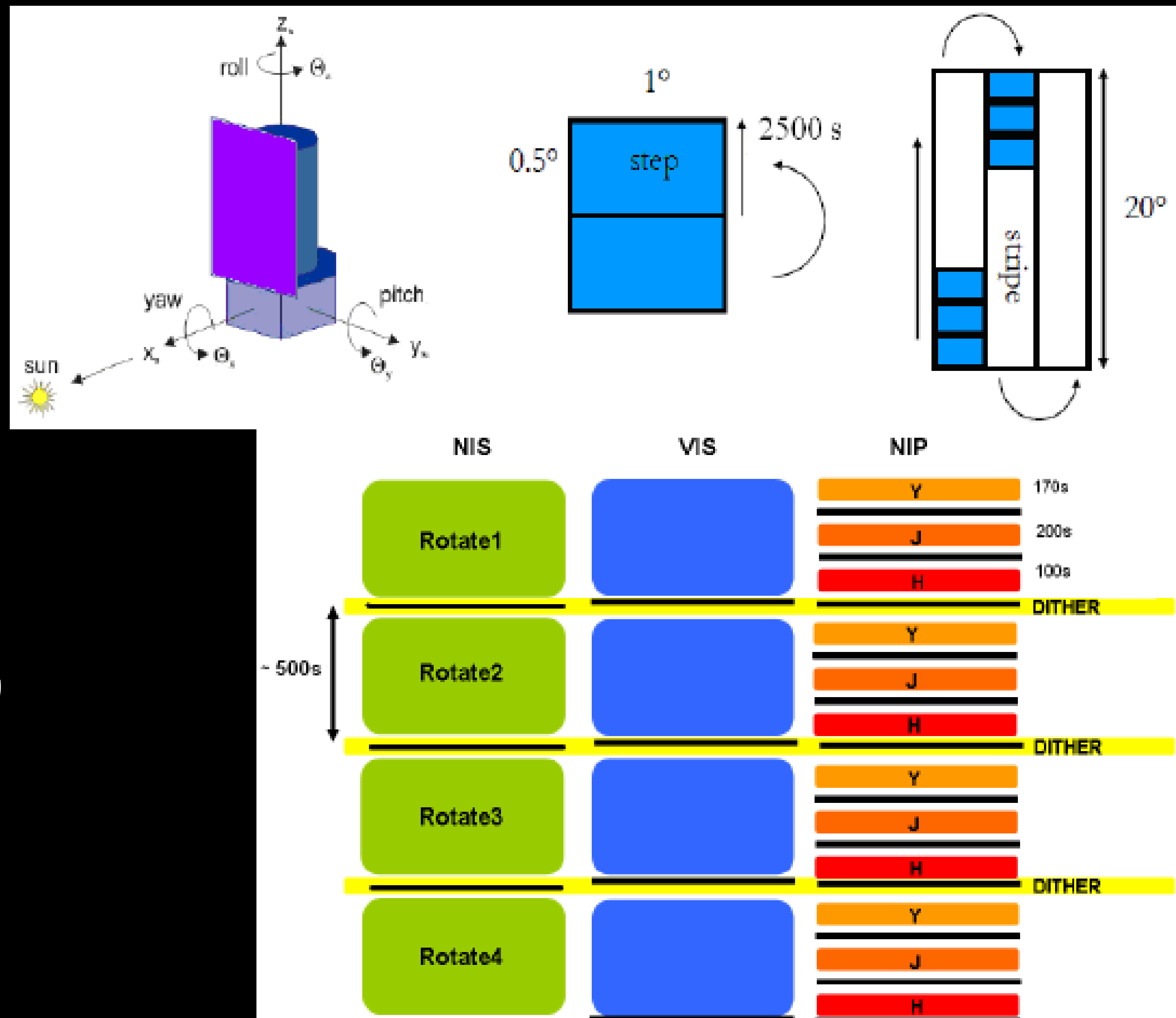


System Design – (1) Pointing & Stability

- Relative Pointing Error budgeted as 25 marcsec/ 500s exposure
- Requires a Fine Guidance Sensor (*in VIS focal plane*) and low noise actuators (*GAIA cold gas or DLR magnetic RW*)
- Absolute Pointing Acquisition <10 arcsec to guarantee correct field overlaps (*Standard state of art star tracker*)
- Absolute Measurement Accuracy 0.1 arcsec – to ensure zero wavelength scale (*combination of star trackers and VIS science data stream)* but needs budget for VIS-to-NIS stability

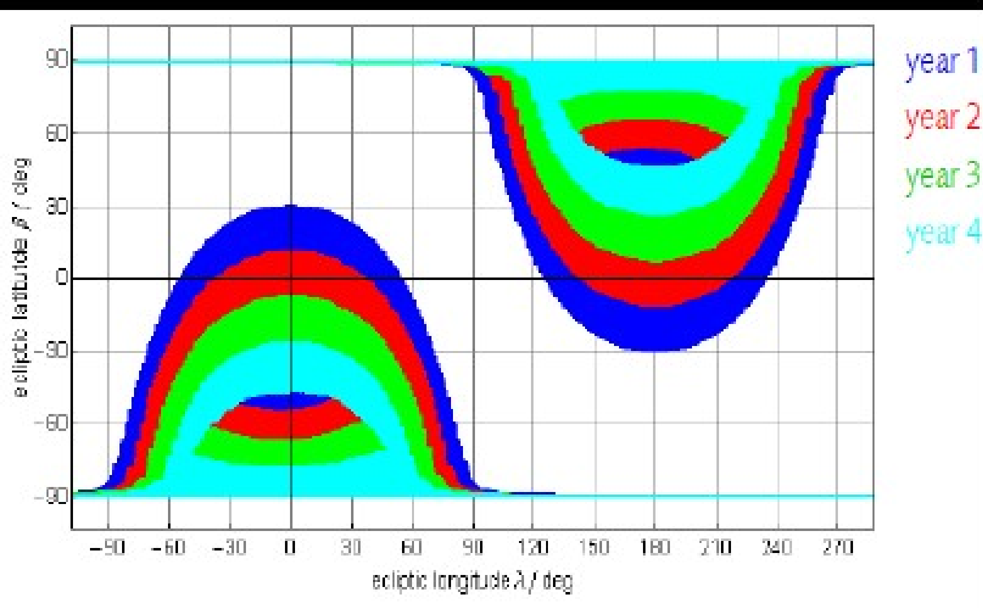
System Design – (2) Sky Scanning Strategy

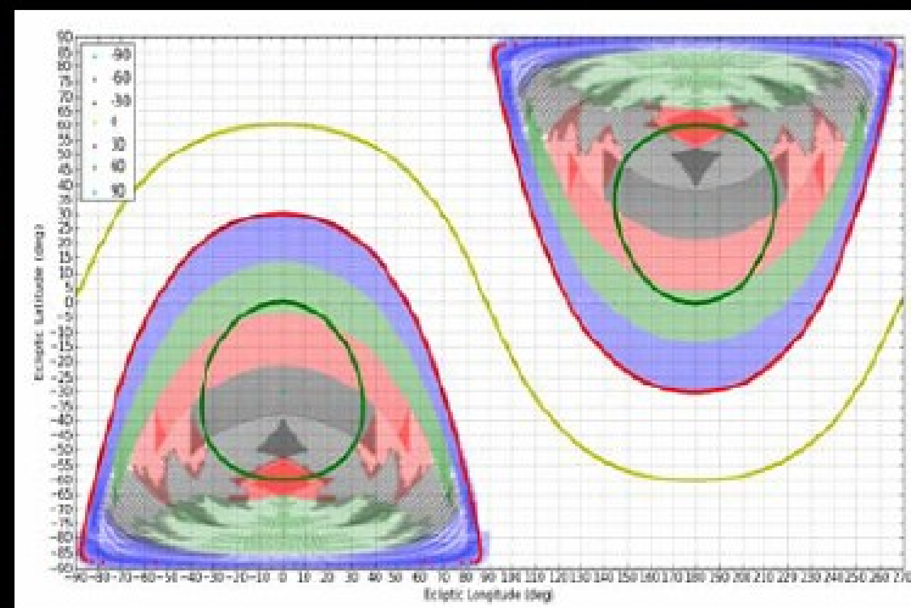
- **Keep Sun Aspect Angle <30°, pointing scans orthogonal to the sun direction**
- **Each field observed ~2500s, then *step and stare* along a strip 20°/ day**
- **Each field composed of 4 *dithered* pointings to overlap the chip gaps**



System Design – (3) Mission Profile & Sky Coverage

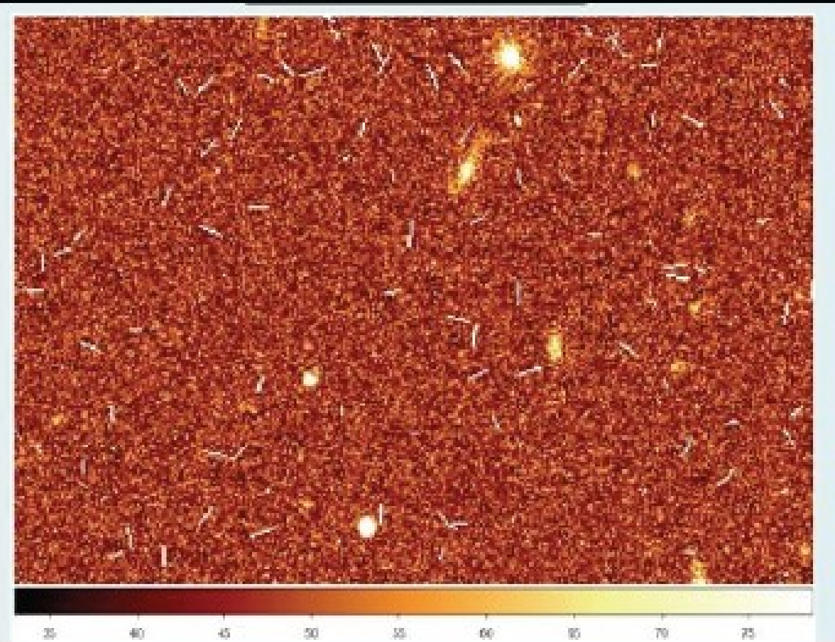
- Launch with Soyuz – Fregat from Kourou. Direct injection SEL2 (thermally stable). Sized for 5 years science mission
- Both industries confirm complete coverage of 20,000 sq deg assuming reasonable efficiency of dither & slews ~75%





System Design – (4) Data

- **VIS 600Mpixels**, all data sent to ground for CR rejection and processing. Compression tested ~2.8 lossless with RICE algorithm
- NIP and NIS data are sampled during accumulation for noise reduction and CR removal *comparable GAIA DHS*
- **100Mpixels total in NIR** (but multiple filters and lower compressibility)
- **36 Fields/day = 850 Gbit** compressed



- K band (26GHz) from L2 - first ESA mission & need to upgrade ground segment & on-board transponders (in progress)
- Rapid quick-look check for data quality (reschedule lost fields while SAA is within bounds)

GS / Distributed Mission Archive 5Pb

- **Allows quality control at all levels**
  - Operational feedback & monitoring to SOC/MOC
  - all aspects propagation as systematic errors ← IOCs ↔ SDCs
- **Connect instrument & science teams**
  - Exchange & verify results
  - Connect to Ground based observations & external data – *agreements with (e.g.) PanStarrs / DES*
  - Connect simulated data
- **Euclid Legacy Archive**
  - Science ready data -> VO
  - Re-processing raw data to the ELA – additional studies
- **Building upon experience in ESA missions**
  - Planck and Gaia, but also XMM and Integral

Budgets

	Mass (kg)	*Power (W)*
Payload Module	855	350
Service Module	691	595
Propellant	150	
Adapter / or Power losses	100	58
Margin 20%)	309	201
Total	2105	1204

Radiometric Performance

	VIS	NIP	NIS
Plate Scale	0.1″	0.3 ″	R=500 2pixels
Magnitude (AB)	24.5	24 5	19.1 (4 10^{-16} erg.cm^{-2}.s^{-1})
SNR	14.3	7.1	5 (spectral element)
Radiometric aperture	1.3″	0.5 ″	3×5 pixels

Review Recommendations

- **Mission considered feasible**
- **Schedule too optimistic with lean development model assumptions**
- **Mass is at limit of Soyuz & design uncertainties of payload demand higher margin**
- **DMD slit spectrometer not compatible with M-class TRL**
- **Attention should be given to** : ***NIR detectors procurement, improved interface definition for testing, pointing performance***
- **Lacking thermomechanical analysis to confirm the stability w.r.t. sun angles (scanning law)**

ESA Cosmic Vision 2015-2025 programme

- End of December meeting ESA presented their cost & timeline evaluation

Euclid	~500	Q4 2018
Plato	~480	Q4 2018
Solar Orbiter	~450	Q3 2018
Cross-Scale	~600	Q2 2019
SPICA	~100	Q1 2019
Marco Polo	~620	Q4 2019

ESA Cosmic Vision 2015-2025 programme

Process Timeline

M mission down-selection — February 2010

Euclid, Plato & Solar-Orbiter were pre-selected for the two M mission slots (M1/M2) for expected launch in 2017/2018 with a budget of ~475 Meuros cost to ESA

ESA Cosmic Vision 2015-2025 programme

Process Timeline

M mission down-selection	February 2010
EOAT appointment	March 2010
Euclid Consortium	April 2010

ESA Cosmic Vision 2015-2025 programme

Euclid Optimization Advisory Team

- input on the Science Management Plan
- Advise on the optimization of the mission

ESA Cosmic Vision 2015-2025 programme

Euclid Optimization Advisory Team

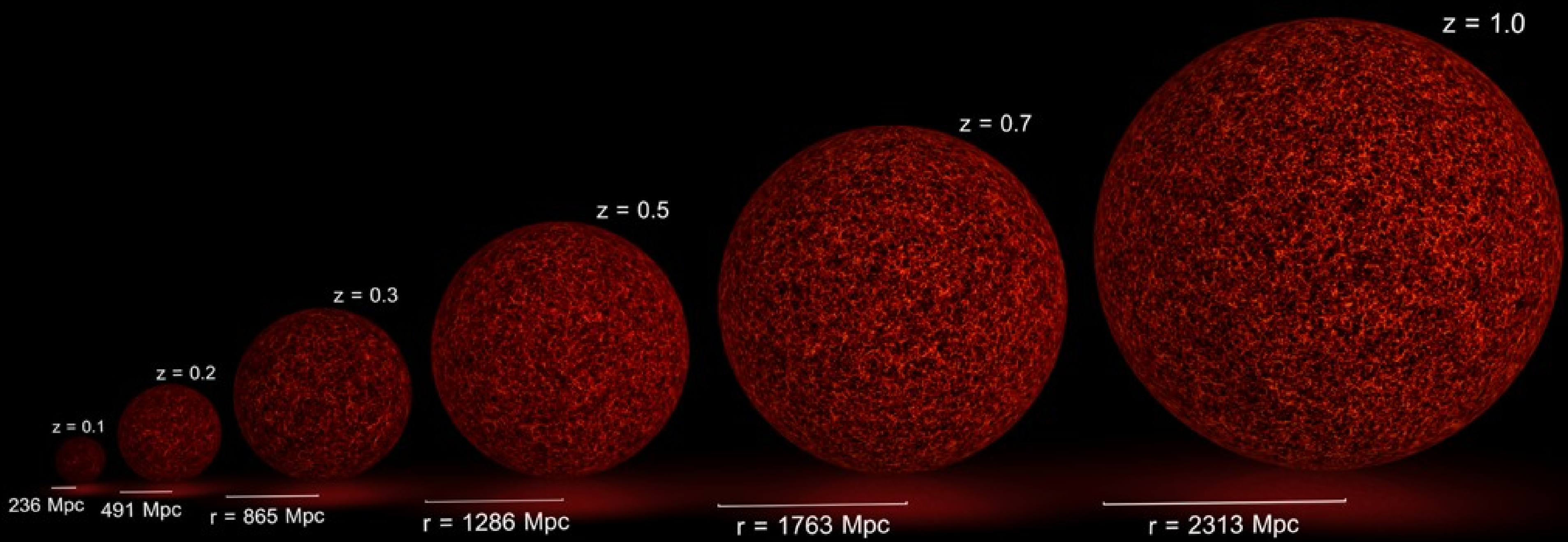
- Eight/Nine questions
  - Q1: radiometric performances
  - Q2/Q3: PSF
  - Q4/Q5: Tiling
  - Q6: Spectroscopy slitless implementation
  - Q7: Calibration requirements
  - Q8: Deep survey
  - Q9: filter in the optical

ESA Cosmic Vision 2015-2025 programme

Process Timeline

Release AO for EC & ILS	July 2010
Proposals due	October29, 2010
ESA internal Evaluation	Nov 2010-Jan 2011
Advisory Bodies Recommendations	Jan-Feb 2011
M-class mission selection	June 2011
MLA decision	Nov 2011
Implementation Phase	2012-2017
Mission Launch	2017-2018

MICE simulations



MICE

Marenostrum Institut
de Ciències de l'Espai
Simulations

MICE ⇨ Project to develop very large numerical “cosmological” simulations in the **Marenostrum** supercomputer (Barcelona). Provide future surveys with mocks (DES, PAU, Euclid).

10.000 processors, 20 TB RAM , 100 Teraflops

GADGET N-body simulations with 10^9- ~10^{11} dark-matter particles in volumes 1-500 h^3 Gpc^3 ⇨ ***dynamical range of 5 orders of magnitude in scale***

People

MICE collaboration : P.Fosalba (PI), F.Castander, M.Crocce, E.Gaztañaga, M.Manera

External : C.Baugh , A.Cabré, A. Gonzalez, J.Carretero, V.Springel

project web: www.ice.cat/mice

MICE

Marenostrum Institut de Ciències de l'Espai Simulations

N	Box (Mpc h^{-1})	Mass ($M_{sun}\ h^{-1}$)
800^3	1200	$2.4\ 10^{11}$ (20 realizations)
1024^3	768	$2.9\ 10^{10}$
1024^3	384	$3.6\ 10^{9}$
1024^3	179	$3.7\ 10^{8}$
2048^3	3072	$2.4\ 10^{11}$
2048^3	7680	$3.7\ 10^{12}$
4096^3	3072	$3.0\ 10^{10}$

Where do we stand ?

Millennium Run : 2160^3 particles, m = 9 10^8 M_{sun} h^{-1} in L = 500 Mpc h^{-1} (Springel et al. 2006)

MICE 3072 has ~ 200 times the volume of the Millennium Run, with same particle load

MICE 7680 equal 17 Hubble Volume Simulations (and 500 times SDSS volume)

Cluster abundance and Large Scale Clustering (e.g. BAO to % accuracy)
Lightcone to z =1 and projected density maps (Lensing, ISW, etc)

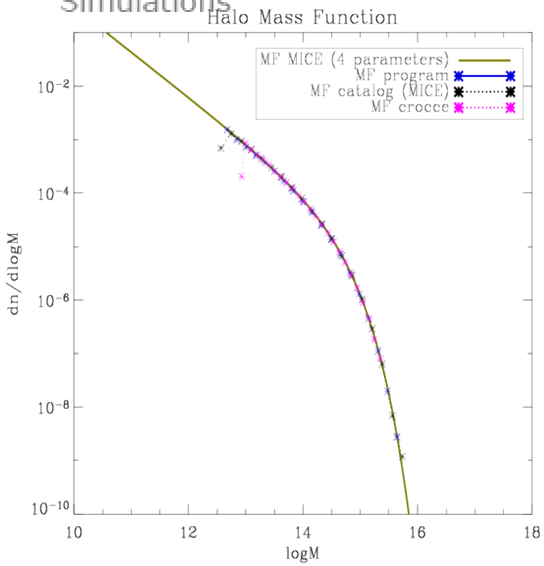
MICE
Marenostrum Institut de Ciències de l'Espai Simulations

Mock galaxy catalogue

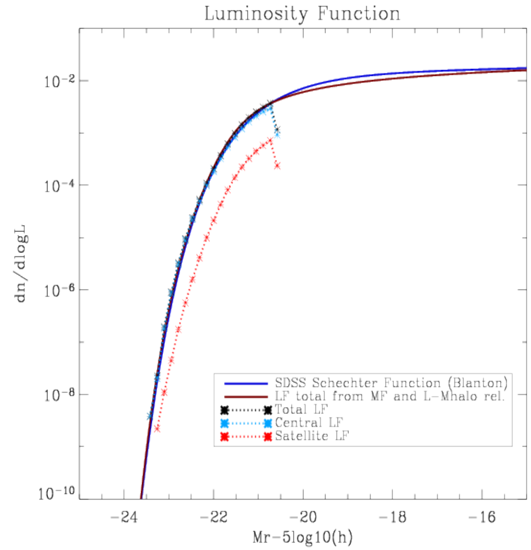
- Generating mock galaxy catalogues from N-body halos using HOD prescription and assign lensing
- Constraints
  - Luminosity function
  - Colour-magnitude diagram
  - Clustering as a function of colour and luminosity

MICE Mock galaxy catalogue

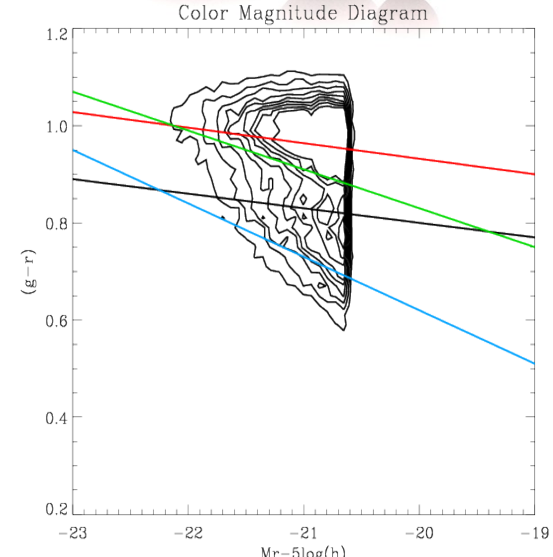
Marenostrum Institut de Ciències de l'Espai Simulations



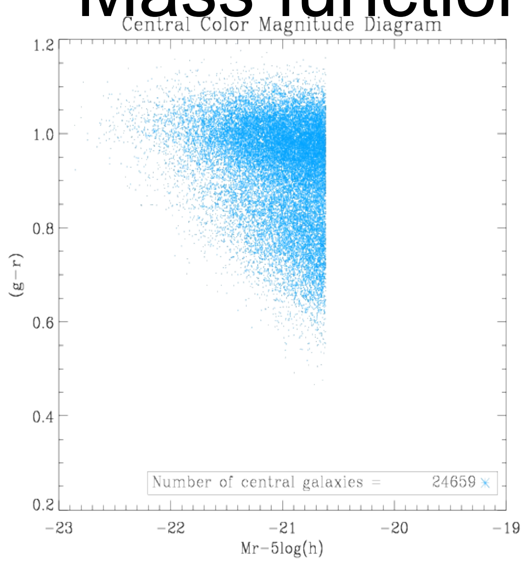
Mass function

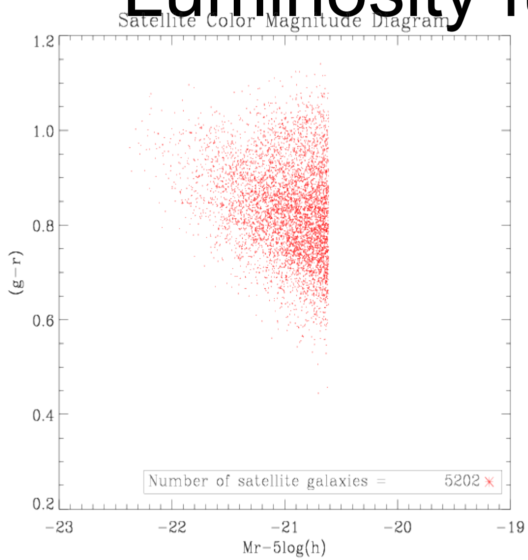


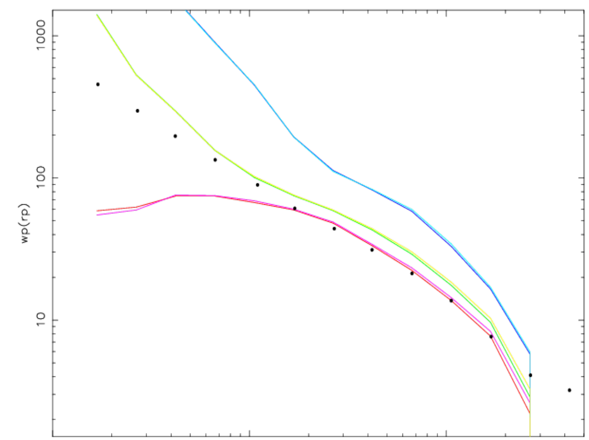
Luminosity function



CM diagram







Clustering


Benasque 13 – Cosmo 1