Euclid

COSMOLOGY MEASUREMENTS: HOW ?
A FRENCH PERSPECTIVE

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Outline

- Euclid: a mission with a goal
  - Precise requirements
- The key measurements
- The Survey machinery
  - Euclid; ancillary data
- Making the cosmology measurements
- Euclid is not alone
- The French position

Euclid = one goal

"Euclid is an ESA mission to map the geometry of the dark Universe"

Understand the origin of the accelerated expansion: Dark Energy or Modified Gravity ?

- All mission requirements are derived from this
- Euclid is not a multi-purpose observatory
- Euclid will do lots of other things (see: Legacy), but they piggyback on the Cosmology drivers

Very precise requirements: L0

- Predict physical effects and observables sensitive to dark energy and/or gravity
  - Cosmic history of expansion
  - Cosmic history of structure formation
    - DE equation of state, w_o, w_a
    - Growth rate of structure: γ
- Required accuracy of cosmological measurements to decisively identify the contributions of DE and/or gravity

R-L0	The Euclid Mission will by itself allow us to • understand the nature of the apparent acceleration of the Universe and • test gravity on cosmological scales from the measurement of the cosmic expansion history and the growth rate of structures.
R-L0.1	To determine the nature of the apparent acceleration, Euclid will distinguish effects produced by a cosmological constant from those produced by a dynamical dark energy. This must be done by achieving a minimum *FoM*$\geq$400 from Euclid data alone.
R-L0.2	To experience effects of gravity on cosmological scales, Euclid will probe the growth of structure and will separately constrain the two relativistic potentials, Ψ, Φ. This can be done by achieving an absolute 1σ precision of 0.02 on the growth index, γ, from Euclid data alone.

Key observables: probes

Probes sensitive to expansion history and/or growth rate of structures

- Weak Lensing: probes the distribution of matter
  - Expansion history
  - Growth rate
- Galaxy clustering
  - Gravity-induced clustering growth
- They are complementary
  - And can be also used to probe dark matter (e.g. neutrino) and inflation
- Other “secondary” probes: clusters, …

Measurements

Sector	Euclid Targets
Dark Energy	• Measure the cosmic expansion history to better than 10% for several redshift bins from $z = 0.7$ to $z = 2$. • Look for deviations from $w = -1$, indicating a dynamical dark energy. • Euclid *alone* to give $FoM_{DE} \geq 400$ (roughly corresponding to 1-sigma errors on w_p, & w_a of 0.02 and 0.1 respectively)
Test of Gravity	• Measure the growth index, γ, with a precision better a 1-sigma error of 0.02 • Measure the growth rate to better than a 1-sigma error of 0.05 for several redshift bins between $z = 0.5$ and $z = 2$ • 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 a 1-sigma 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 with respect to Planck alone by a factor 2. • Measure the non-Gaussianity parameter f_{NL} for local-type models with a 1-sigma error better than 2.

The survey machine

Telescope

VIS NISP

SGS

Survey 15000 deg²

Ext. | Multi-λ photometry

Photo-z | Image shapes…

Spectroscopic redshifts

Correl. Function | z_{spec} calib

Expansion: BAO…

Growth rate…

Dark Energy, Gravity, …

Making the cosmology measurements

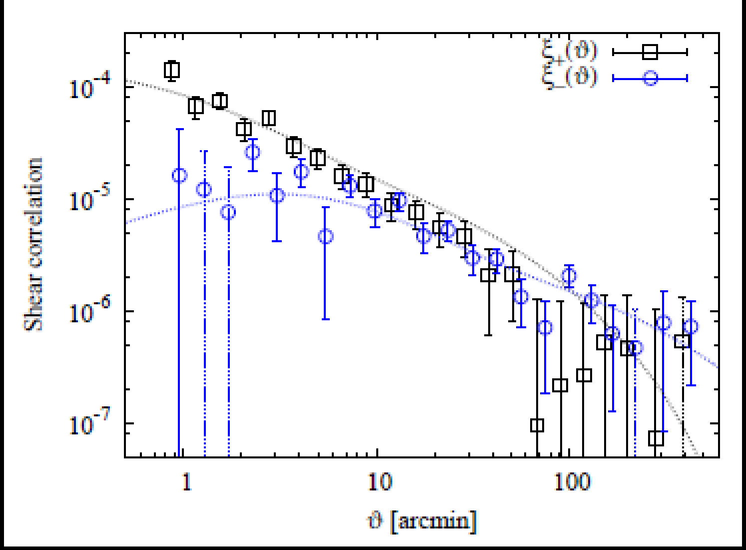
1. Assemble survey data
2. Well calibrated VIS and NISP data
3. Need external data
   - Visible photometry
   - Spectroscopic redshifts samples
4. Understand / map the survey selection function
5. Single probe measurements
6. Combine probes measurements
   - Primary, primary and secondary
7. Combine Euclid probes with other probes
   - Euclid + Planck…

Euclid is not alone: tough competition

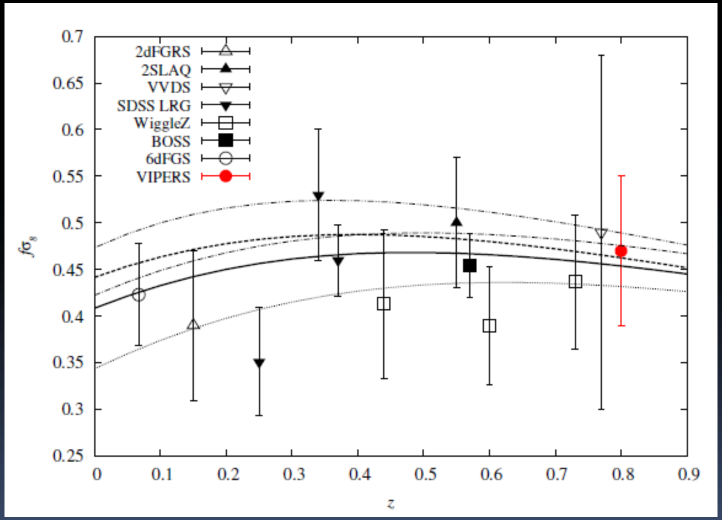
Survey	Probes	Deg²	z range	N gal/QSO	Date
BOSS	BAO, f_g, clusters	10000	0.3-0.8 (gal) 2.2-3 (QSO)	$1.5x10^6$ $1.6x10^5$	Now
VIPERS	f_g	25	0.6-1.2	10^5	Now
CFHT-Lens	Lensing	150	0.2-1.3	$4x10^6$	Now
eBOSS	BAO, f_g, clusters	7500	0.6-1 (gal) 1-3.5 (QSO)	$6x10^5$ $7x10^5$	2014
PFS-SUMIRE	BAO, f_g, clusters	1400	0.5-2	$5x10^6$	2018
4MOST	BAO, f_g, clusters	15000?	0.5-1.5?	$2x10^7$	2020
MS-DESI	BAO, f_g , clusters	~15000	0.5-1.6	$4x10^7$	2020
JPAS	Lensing, BAO, f_g, clusters	8600	0.5-1.5	$3x10^8$ (gal) $5x10^6$ (QSO)	2018
LSST	Lensing, BAO, f_g, clusters	18000	0.3-3	$>3x10^{10}$	2020
EUCLID	Lensing, BAO, f_g, clusters	15000	0.5-1.5 (lensing) 1-2 (clustering)	$1x10^{10}$ $5x10^7$	2020
WFIRST	?	?	?	?	?

The ‘french touch’

- Leading expertise all along the measurement chain
  - Experts in leading large imaging and spectroscopic surveys and their instrumentation
  - F-experience invaluable in designing and implementing VIS, NISP, SGS
- ‘Probe masters’: clustering, lensing, clusters
  - And ‘external’ probes (Planck…)
- Cosmology theory
- One challenge: coordinating the combination of probes
  - This must be done by the french community !



Best measurement of the WL shear (CFHTLens, Kilbinger et al. 2013)



Best measurement z~0.8 growth rate (VIPERS, de la Torre et al. 2013)

Responsabilities France, ground segment

Ground Segment

OU: 9 lead or co-lead

(for a total of 27)

Responsibilité		Country	Names
GS project office	GS manager	I	F. Pasian
	GS deputy manager, system lead	**F**	C. Dabin
	GS scientist	**F**	M. Sauvage
OU	OU-VIS VIS imaging	**F** / UK	McCracken / Benson
	OU-NIR imaging	G / I	A. Grazian / R. Bouwens
	OU-SIR spectro	I / / **F**	Scodeggio / Surace
	OU-EXT non Euclid	G / NL	Mohr / Gijs-Verdoes-Kleijn /
	OU-SIM simulations	SP / **F**	Serrano / Ealet
	OU-MER data merging	I / **F** / G	Fontana / Douspis / Koppenhoefer
	OU-SPE spectra	**F** / I	Le Fèvre / Mignoli
	OU-LE3 level 3	**F** / I / UK	J-L.Starck / S. Borgani / Abdalla
	OU-SHE shear	UK / UK / CH	Taylor / Schrabback / Courbin
	OU-PHZ photoz	CH / SP	Paltani / Castander

Responsibilities France, Science Working Groups

France:

9.5 lead / co-lead SWG

(over 35 total)

2 to be discussed (gone to a 'neutral' country…)

Coordination	WGs	Country	Names
COSMOLOGY	Leads	I / UK / NL	Guzzo / Percival / Hoekstra / Kitching
	Weak Lensing	UK / NL / F	Kitching / Hoekstra / Benabed
	Galaxy Clustering	UK / I	Percival / Guzzo
	Clusters	I / G / F	Moscardini / Weller / Bartlett
	CMB x-correlations	F / I	Aghanim / Baccigalupi
	Strong Lensing	F / I	**Kneib** / Meneghetti
	Theory	G / CH	Amendola / Kunz
	Additional science	F	Bartlett (coordinateur)
LEGACY	Leads	UK / NL	Warren / Brinchmann
	Primeval Universe	F / DK	Cuby / Fynbo
	Galaxies/AGN evol.	NL / F / I	Brinchmann / Elbaz / Cimatti
	Local Universe	I / UK	Poggianti / Warren
	Milky Way / resolved stellar pop.	NL / UK	Tolstoi / Warren
	Exoplanets	F / SP / UK	Beaulieu / Zapatero / Kerins
	Sne & Transients	UK(I) / F / IT	Hook / Tao / Capellaro
COSMO SIMULATIONS		F(CH) / SP	**Teyssier** / Fosalba