Dark Energy with Euclid

...and Dark Matter and Tests of Gravity too

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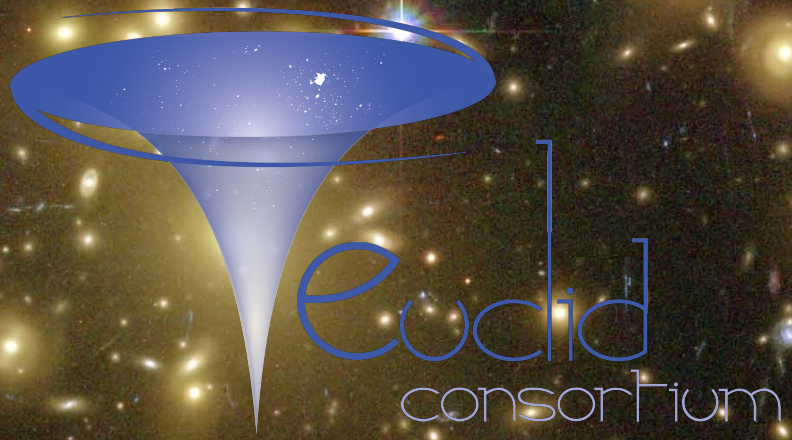
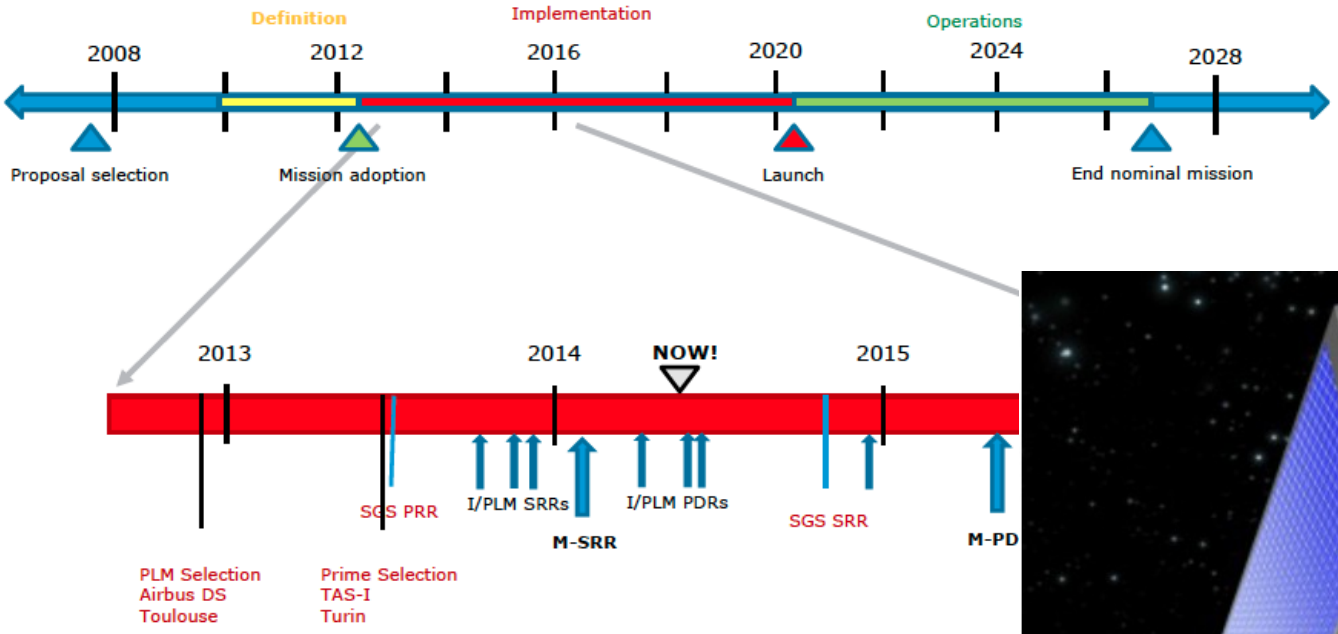


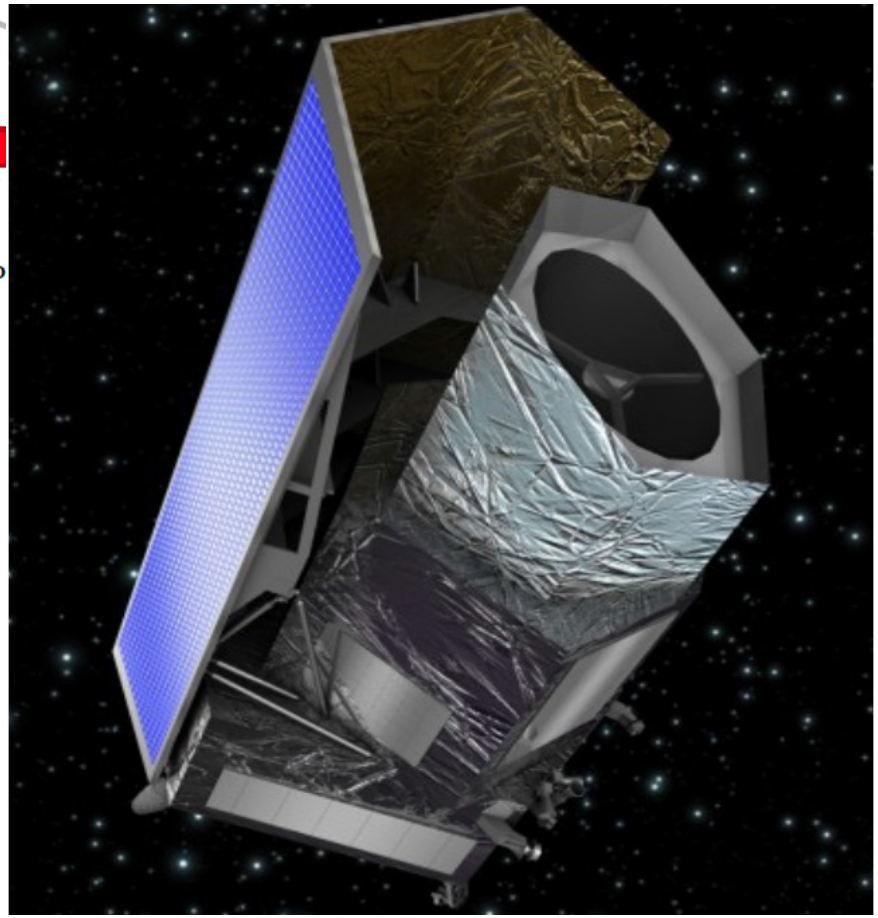
IPA, Queen Mary University

August 18th, 2014

Euclid timeline



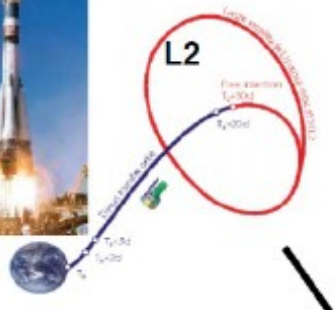
from R. Laureijs



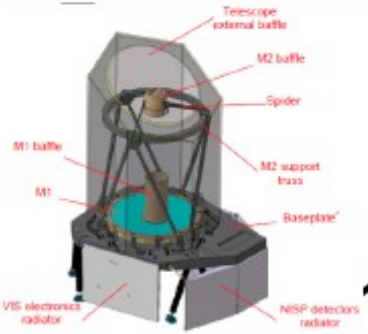
Euclid in one slide

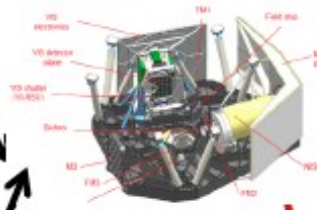
slide from Y. Mellier

Soyuz@Kourou
Q1 2020

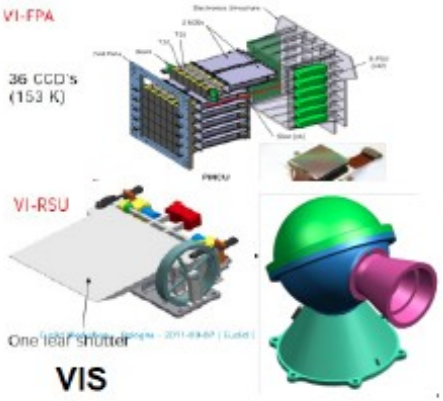


PLM+SVM: 2010-2019

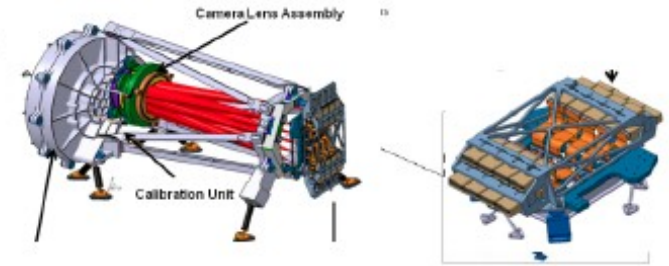




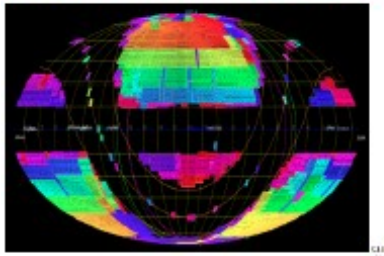
VIS imaging:
2010-2020
(VIS team)

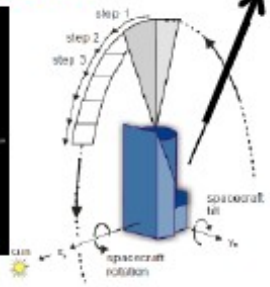


NIR spectro-imaging
2010-2020 (NISP team)



Surveys: 2010-2028 (Survey WG)

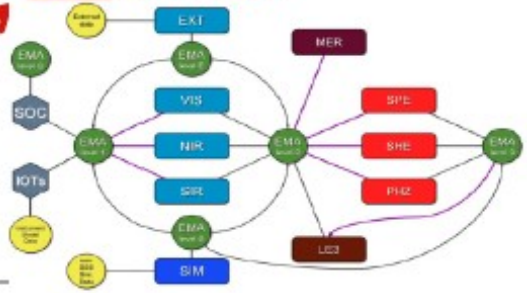




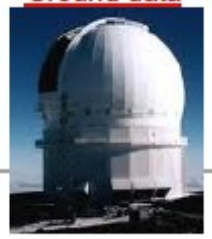
6 yrs - 15,000 deg²

- Commisionning – SV
- Euclid opération:
5.5 yrs:Euclid Wide+Deep
- +: SNIa, mu-lens, MW?

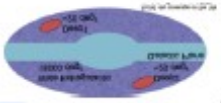
SGS: 2010-2028

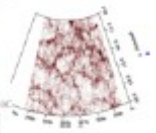


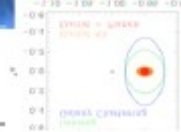
Ground data



SWG:
2019-2028







20-30 PB data processing (EC-SGS team) — Science analyses

Key numbers

slide from Y. Mellier

Ground based
Photometry and Spectroscopy (photo-z)

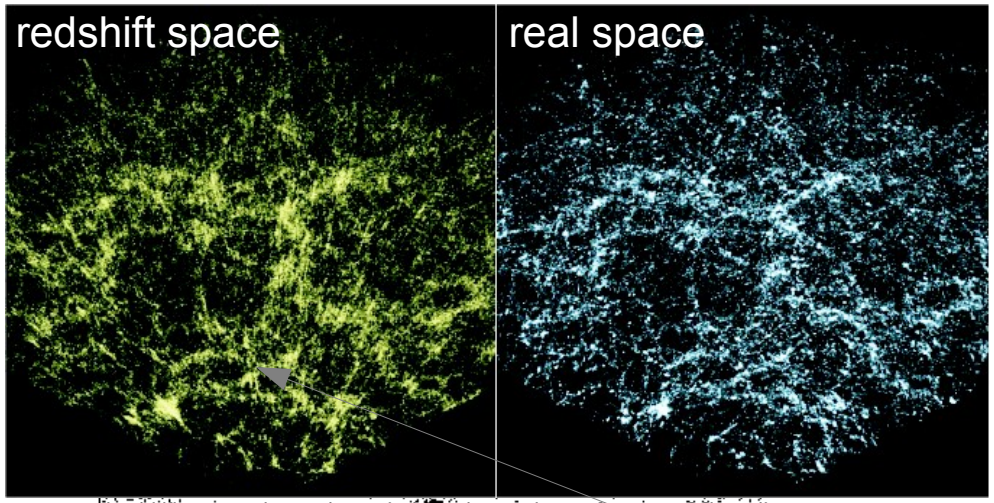
SURVEYS In ~6 years		
	Area (deg2)	Description
Wide Survey	**15,000 deg²**	Step and stare with 4 dither pointings per step.
Deep Survey	**40 deg²**	In at least 2 patches of > 10 deg² 2 magnitudes deeper than wide survey

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 0.1"/px	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=2.5x10⁷ galaxies	

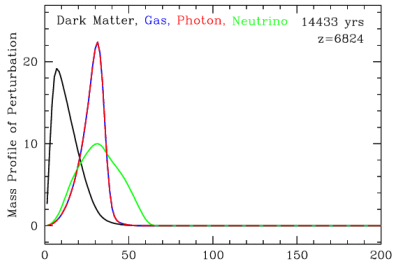
weak gravitational lensing

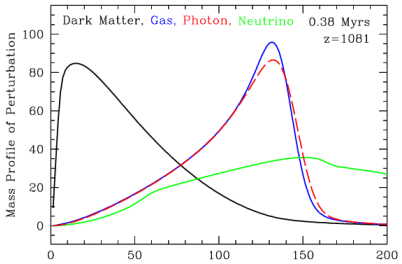
galaxy clustering

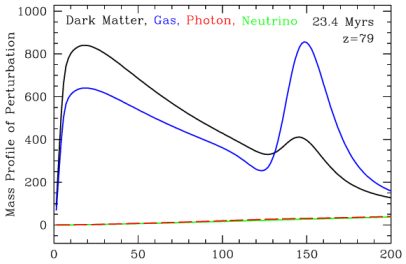
Galaxy clustering

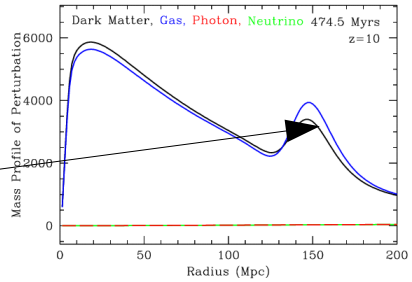


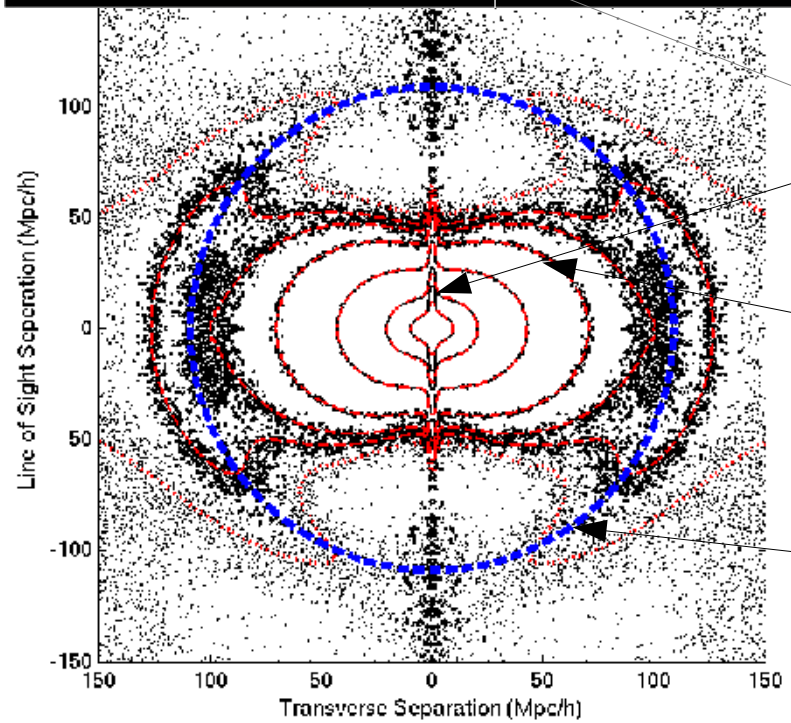
SubbaRao et al. (2008)











fingers of god

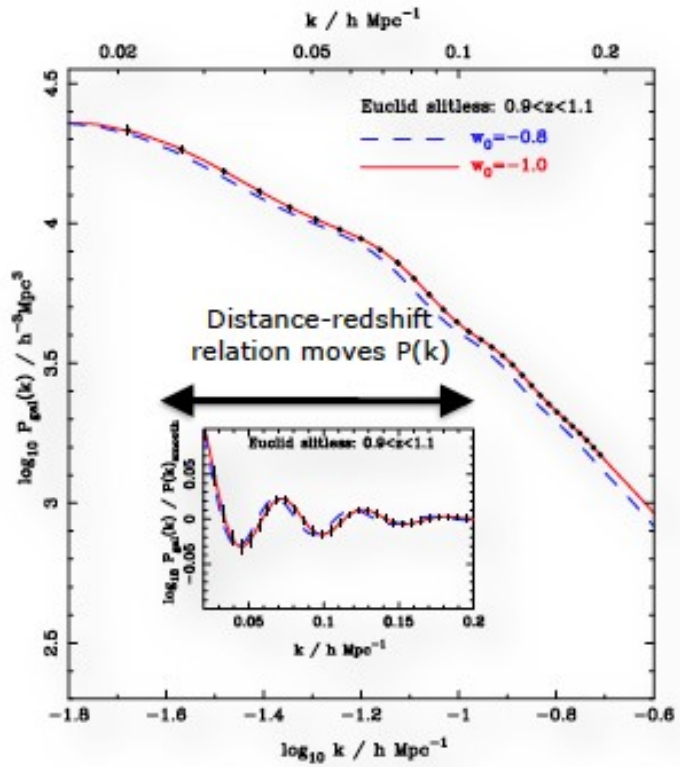
Kaiser effect

acoustic peak

Chuang et al. (2013)

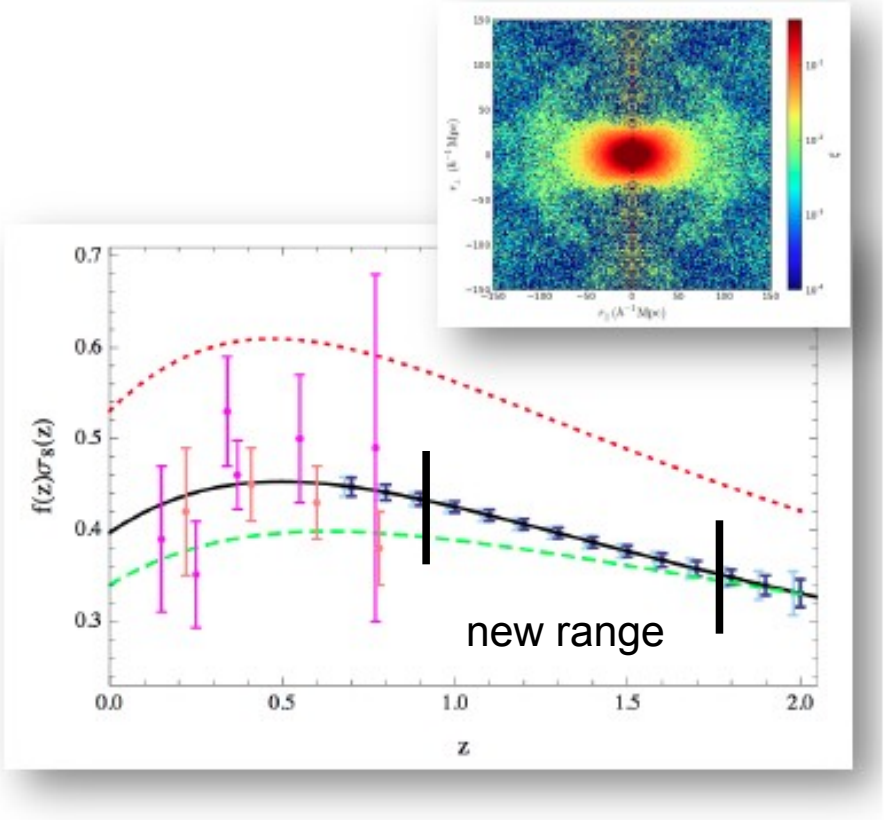
from D. Eisenstein

BAOs & RSDs



(BAO)

Baryonic Acoustic Oscillations in the galaxy power spectrum as a standard ruler (one Δz=0.2 redshift slice)



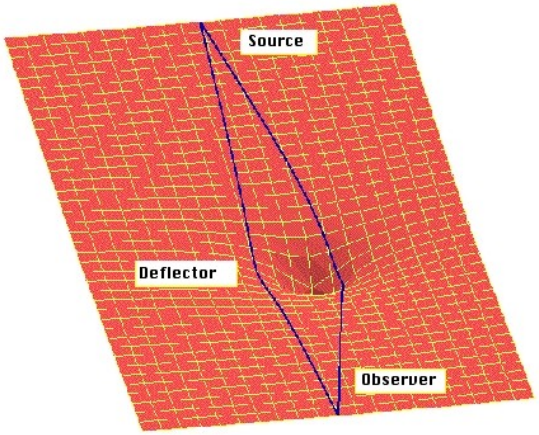
Anisotropy of the correlation function or power spectrum (RSD) as a measure of the growth of structure

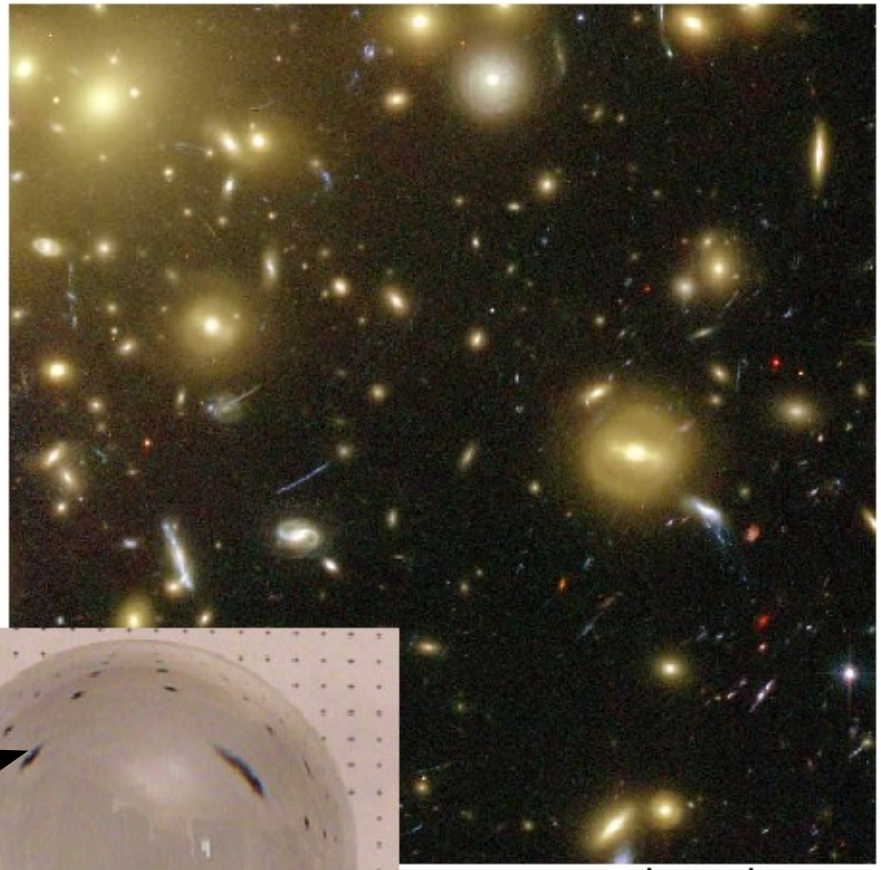
RSD: redshift space distortions

slide from G. Guzzo

Gravitational lensing

gravitational deflection of light

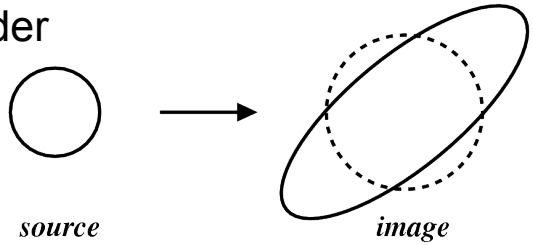




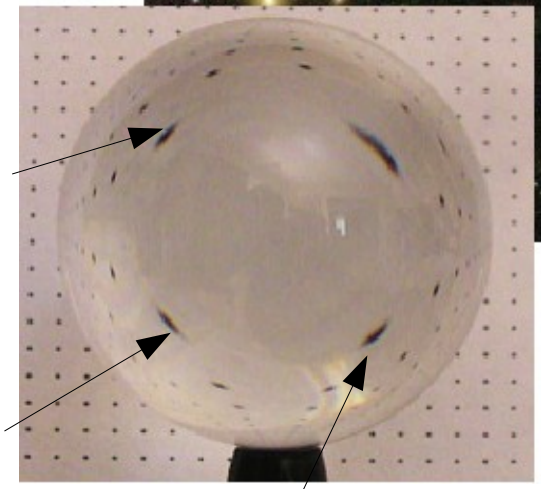
galaxy cluster
Abell 1689

lens mapping

to 1st order



shear

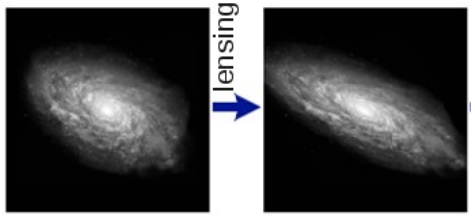


flux magnification

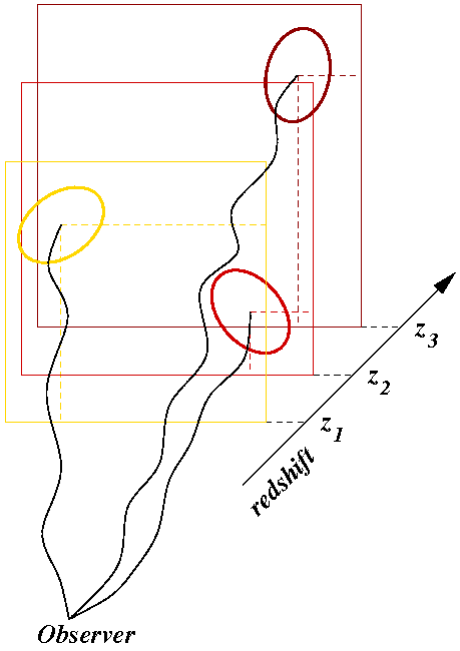
ball lens

size magnification

Weak lensing by the large-scale structure

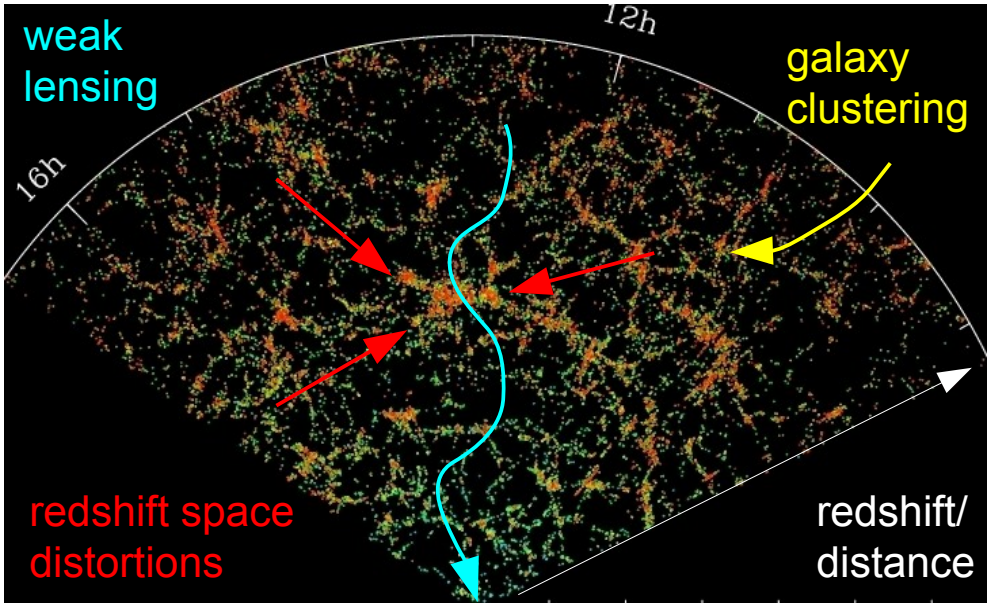


3D info via tomography



→ sensitive to spatial geometry and structure growth

Synergy of probes

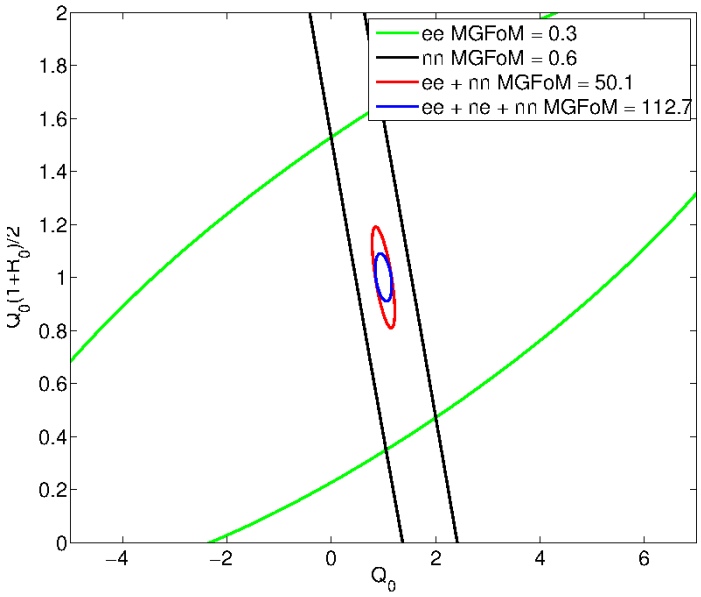


modified gravity parameters:

$$G_{eff} = G_{Newton} Q_0 a^3$$

$$\frac{\Phi}{\Psi} = R_0 a^3$$

- different sensitivities to cosmology
- different systematic effects
- include cross-correlations (same-sky surveys)
- add Euclid secondary probes & CMB



Kirk et al. (2013)
DES-like survey

Performance of Euclid

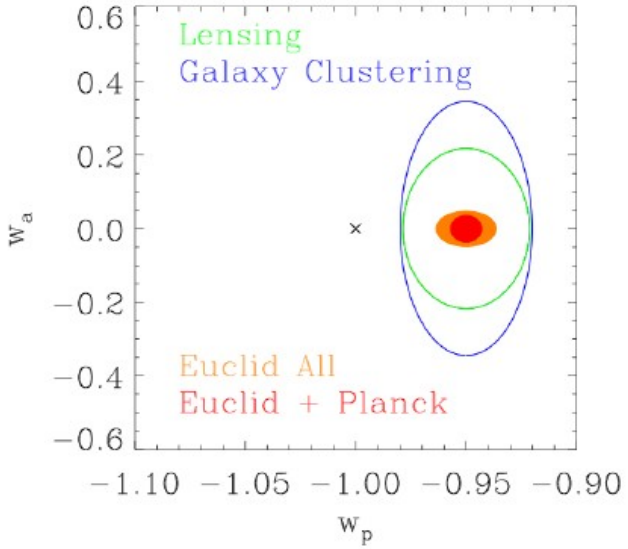
	Modified Gravity	Dark Matter	Initial Conditions	Dark Energy		
Parameter	γ	m_ν /eV	f_{NL}	w_p	w_a	**FoM** $= 1/(\Delta w_p \times \Delta w_a)$
Euclid primary (WL +GC)	0.010	0.027	5.5	0.015	0.150	430
Euclid All	0.009	0.020	2.0	0.013	0.048	1540
Euclid+Planck	0.007	0.019	2.0	0.007	0.035	4020 → **6000**
Current (2009)	0.200	0.580	100	0.100	1.500	~10
Improvement Factor	**30**	**30**	**50**	**>10**	**>40**	**>400**

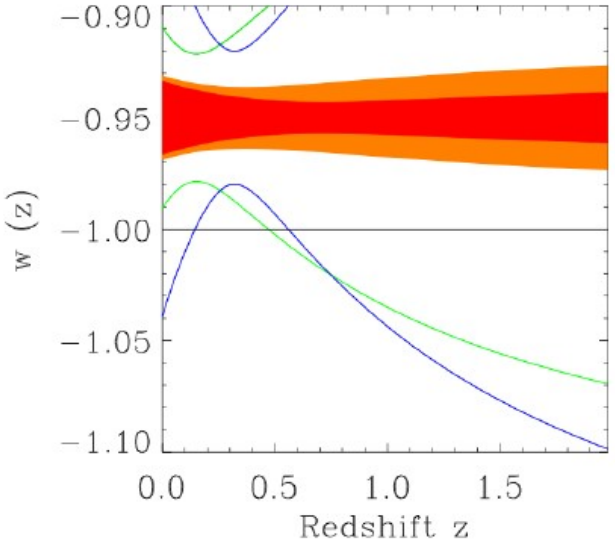
Laureijs et al. (2011)

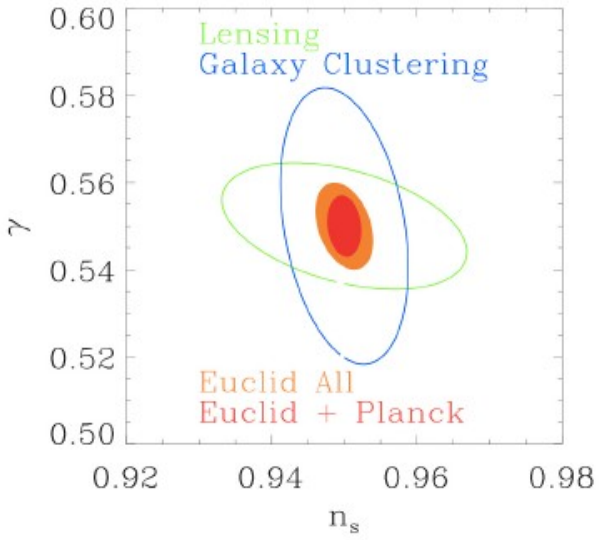
$$p_{DE} = w(z)\rho_{DE}c^2$$

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

$$\frac{d\ln G}{d\ln a} \approx \Omega_M(a)^\gamma$$

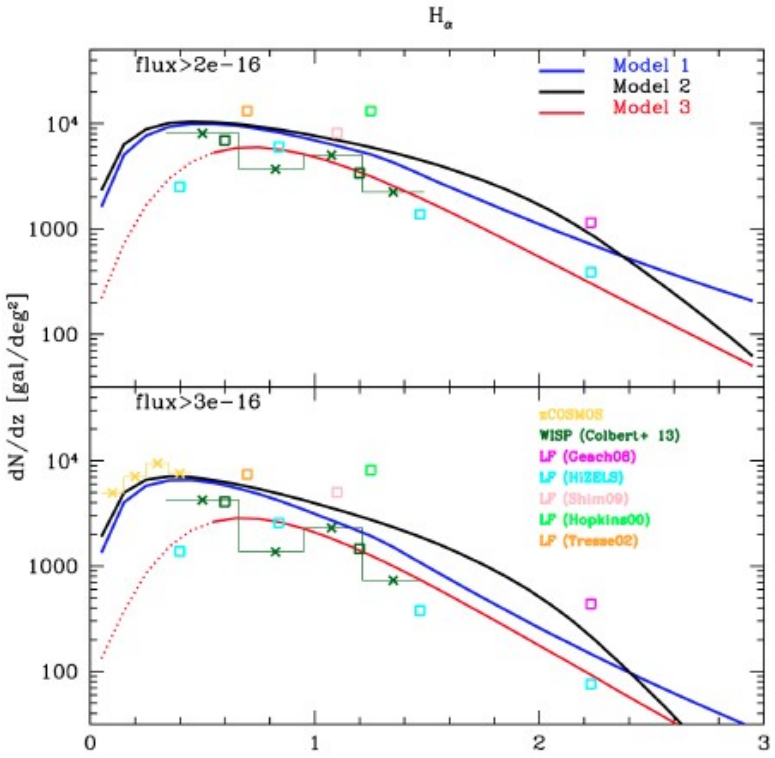






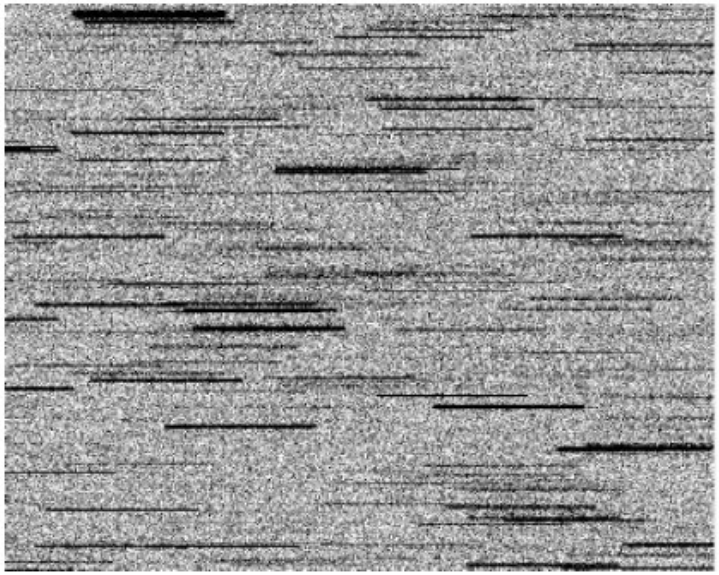
Challenges for clustering

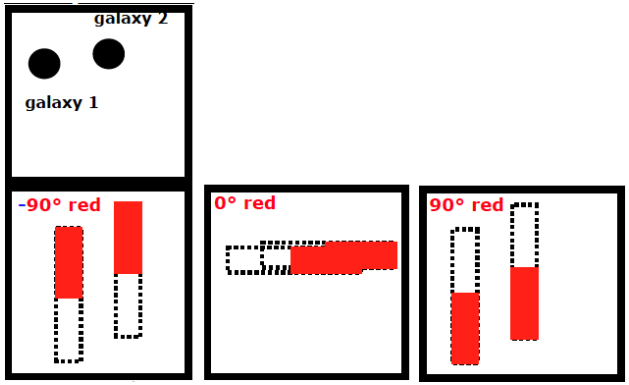
- untargeted observations with uncertain source numbers



from G. Guzzo

- slitless spectroscopy with significant confusion

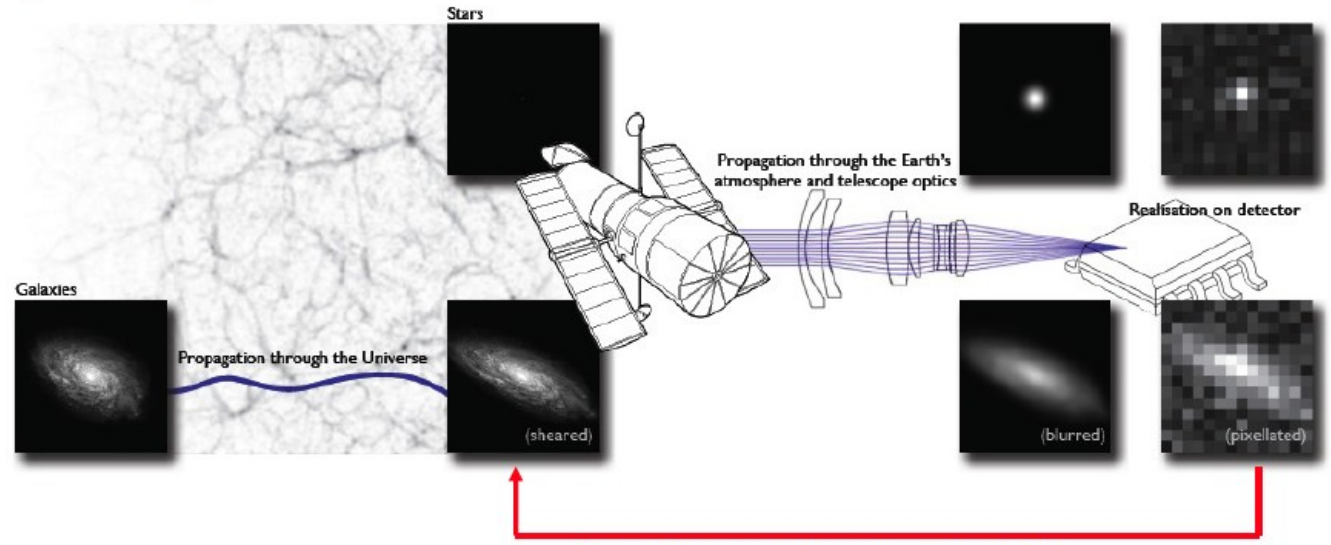




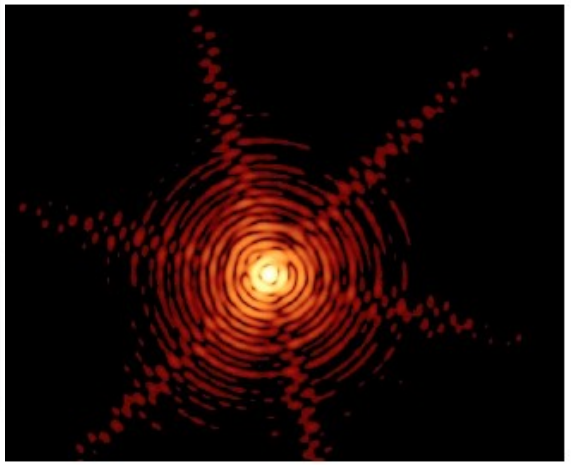
from O. LeFevre

Challenges for weak lensing

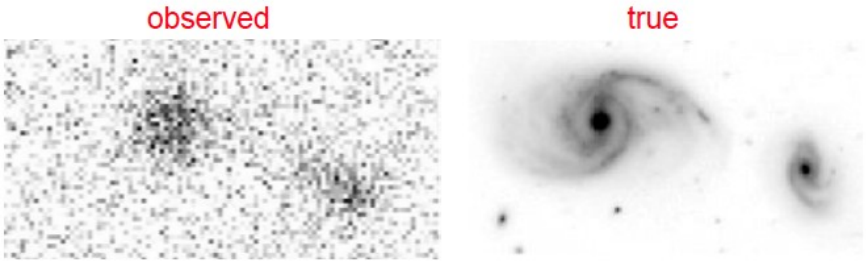
Figure from Kitching et al. 2012



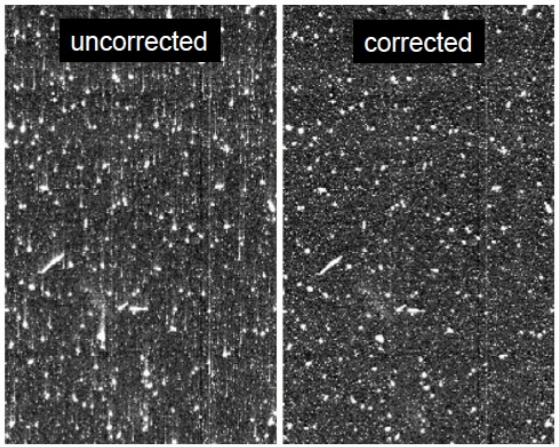
Euclid PSF



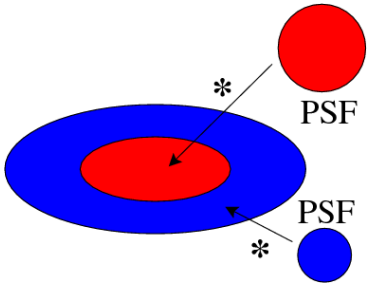
- low S/N shear estimation
- charge transfer inefficiency
- colour gradients



from H. Hoekstra



from R. Massey



Summary

- Euclid will map the full extragalactic sky from L2 in ~2021-2027
- primary probes: weak gravitational lensing & galaxy clustering
- high-res. optical imaging, NIR spectroscopy, NIR photometry
  + optical photometry from the ground

- unique capabilities for LSS weak lensing & mid-redshift clustering
- all measurements systematics-limited but Euclid probes synergetic and complementary to ground-based surveys
- expect excellent constraints on DE equation of state and other DE properties as well as DM properties, test of Einstein gravity, galaxy formation, etc.

Euclid Theory Review:
Amendola et al. (2012), astro-ph/1206.1225
Euclid Definition Study Report (Red Book):
Laureijs et al. (2011), astro-ph/1110.3193
http://sci.esa.int/euclid/