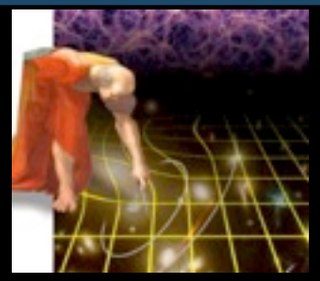


Euclid

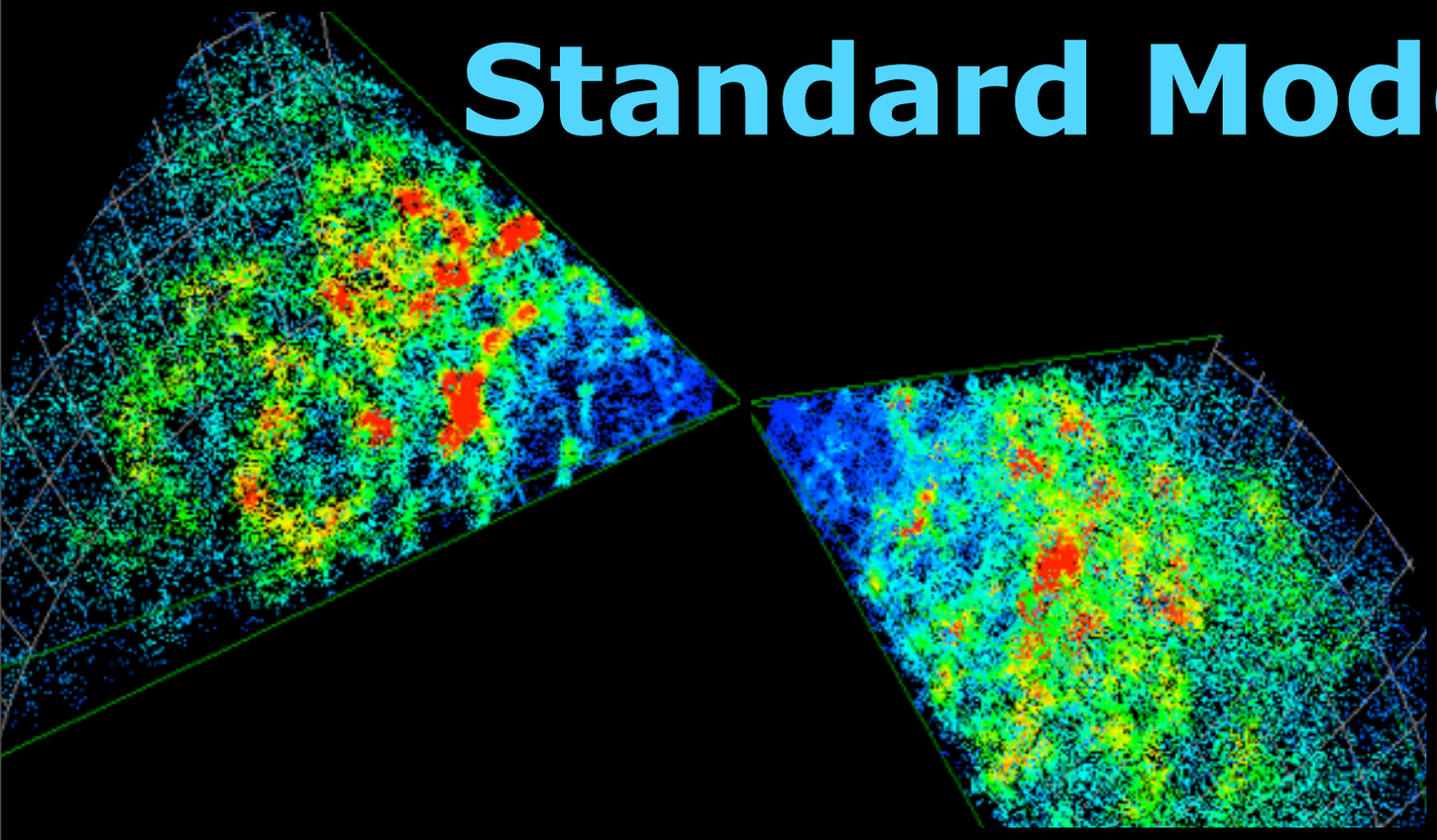
Andy Taylor

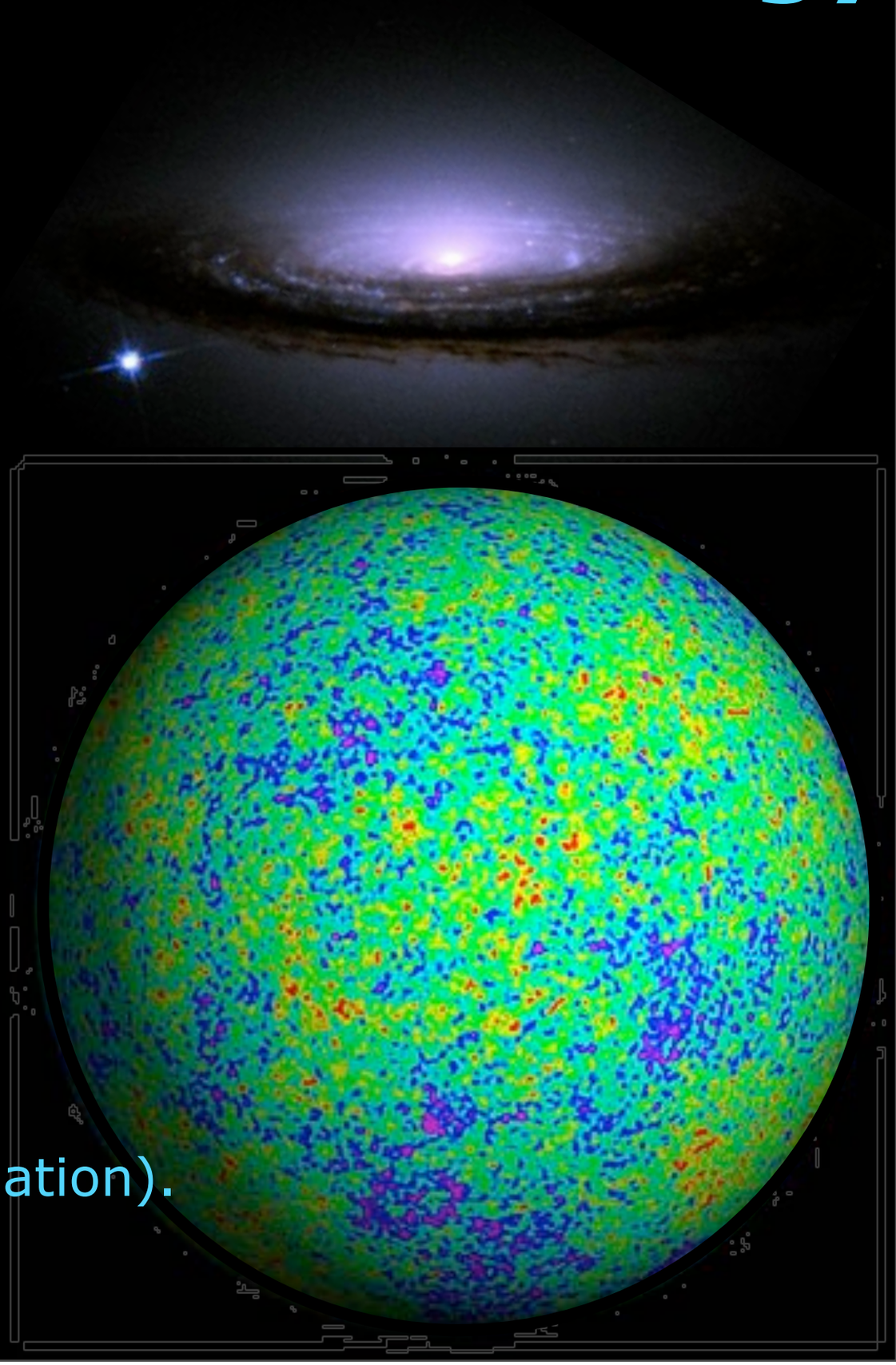
Institute for Astronomy, University of Edinburgh,

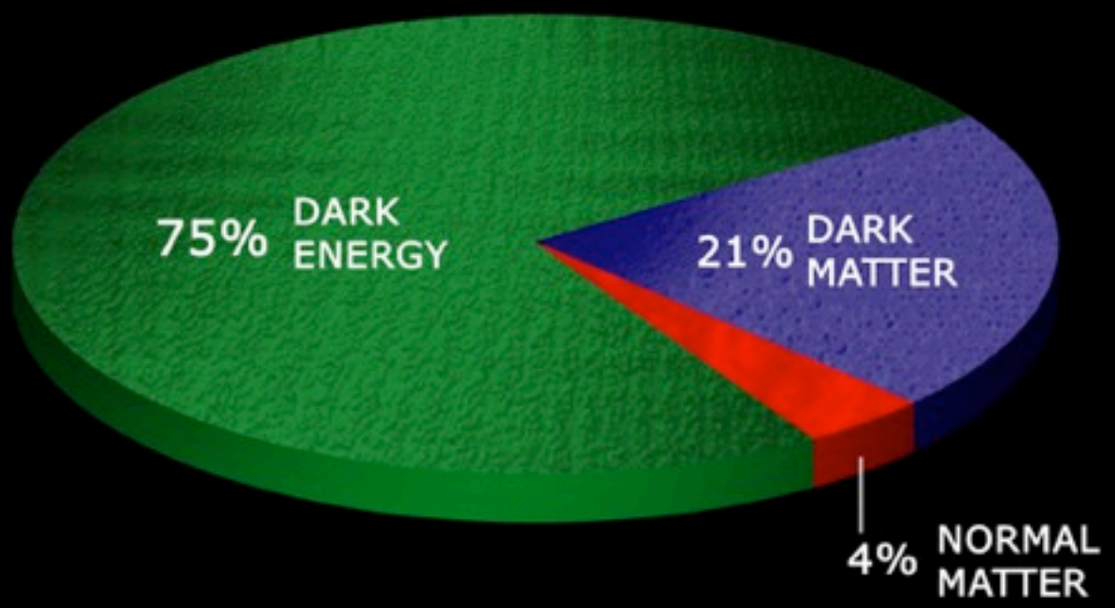
Royal Observatory, Blackford Hill, Edinburgh, UK

(Euclid Simulations: Teyssier et al 2008)

Standard Model of Cosmology



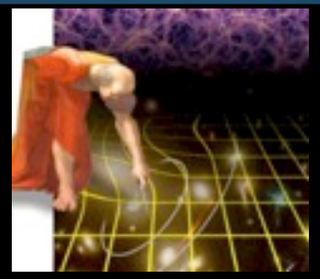




+ Einstein Gravity & Initial Conditions (Inflation).

EUCLID

Euclid: Key Cosmological Questions



1. Dynamical Dark Energy:

Is the dark energy simply a cosmological constant, or is it a field that evolves dynamically with the expansion of the Universe?

2. Modified Gravity:

Is the apparent acceleration due to a breakdown of Einstein Gravity on the largest scales?

3. Dark Matter:

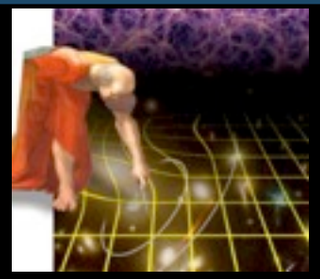
What is dark matter? What is the absolute neutrino mass scale and what is the number of relativistic species in the Universe?

4. Initial Conditions:

What is the power spectrum of primordial density fluctuations, which seeded large-scale structure, and are they described by a Gaussian probability distribution?

Euclid Primary Science Probes

EUCLID



3-D Weak Lensing:

Galaxy images are distorted (sheared), γ, by ~1%.

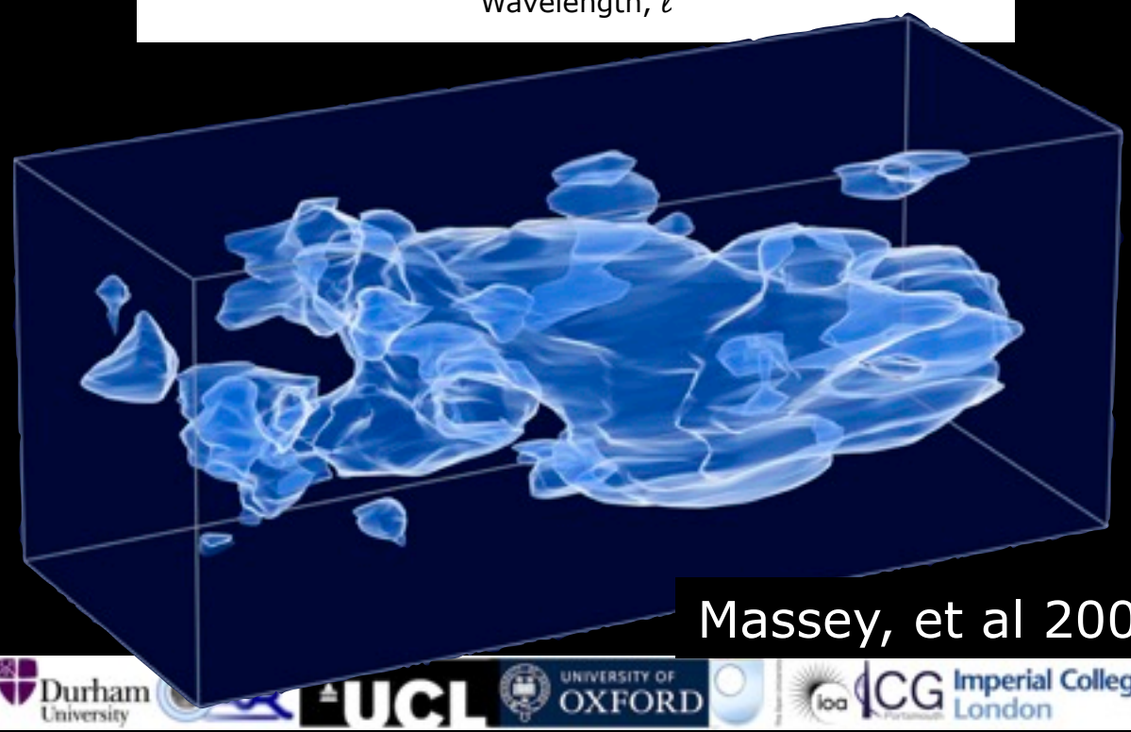
Measure shear and redshifts

➡ projected mass maps, κ (convergence).

Kiessling, Taylor, Heavens, 2010

Measure power spectrum

$C^{\beta\beta}(\ell,z)$



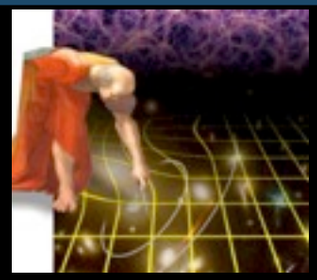
Invert to see 3-D mass maps and evolution of structure.

Massey, et al 2007

Euclid Primary Science Probes

EUCLID

3-D Weak Lensing:

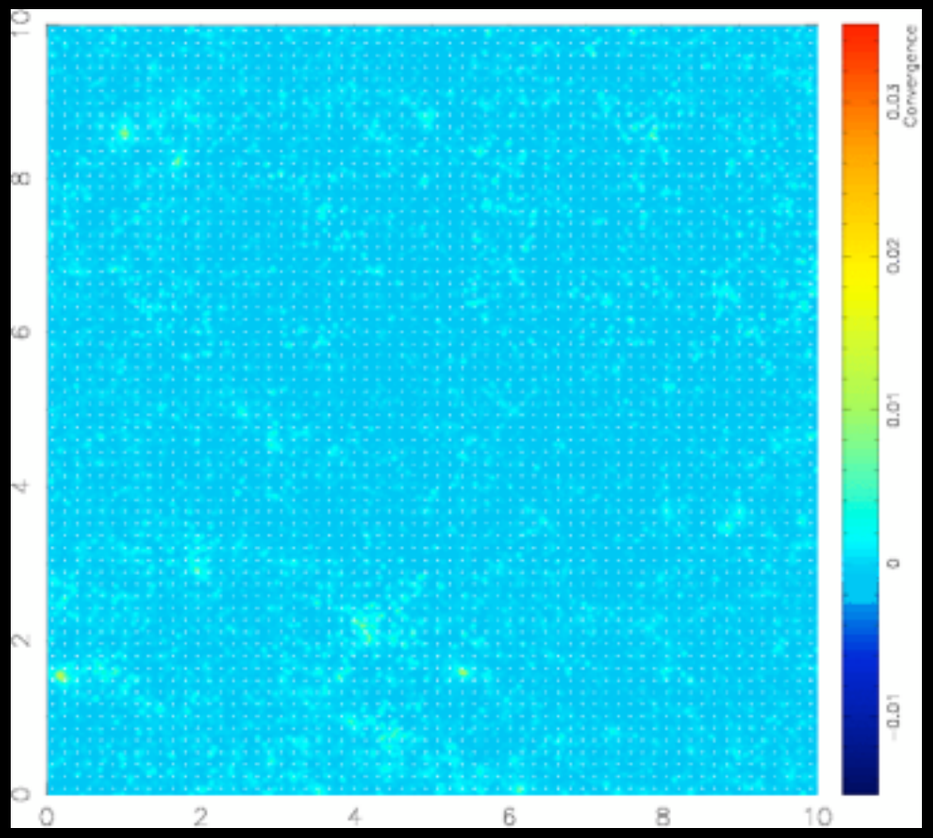


Galaxy images are distorted (sheared), γ, by ~1%.

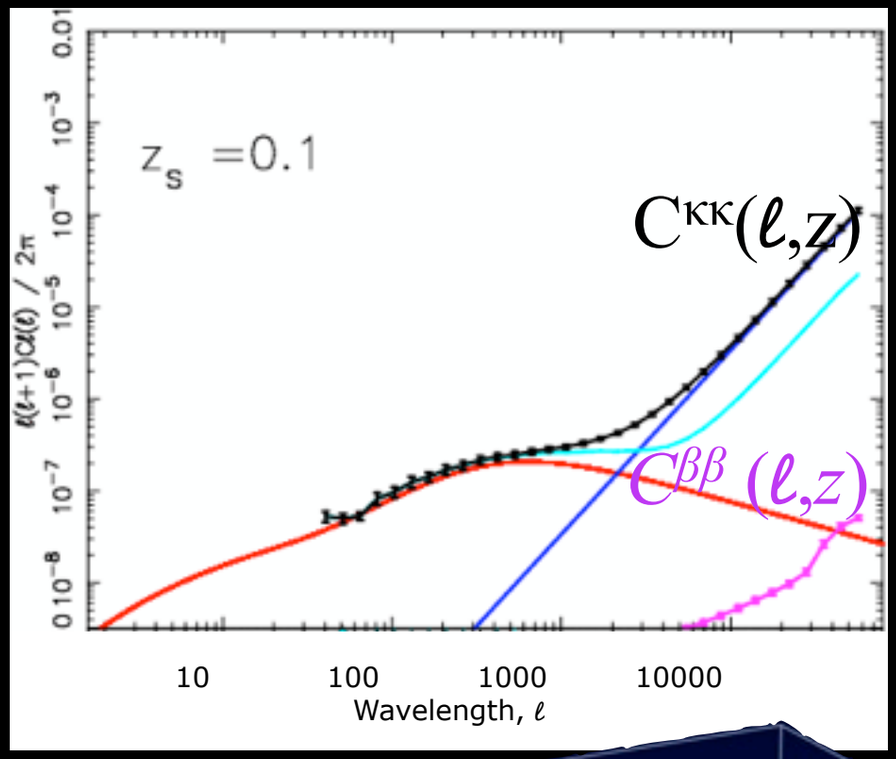
Measure shear and redshifts

➡ projected mass maps, κ (convergence).

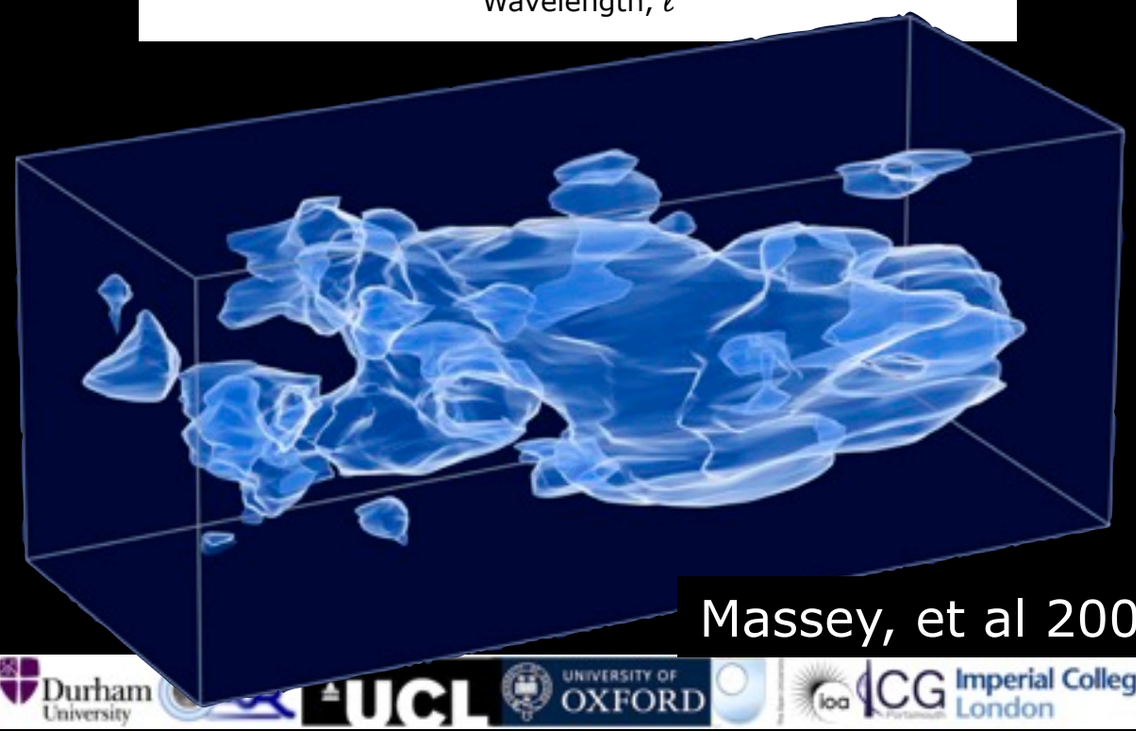
Kiessling, Taylor, Heavens, 2010



Measure power spectrum



Invert to see 3-D mass maps and evolution of structure.



Massey, et al 2007

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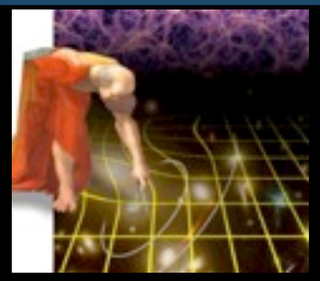
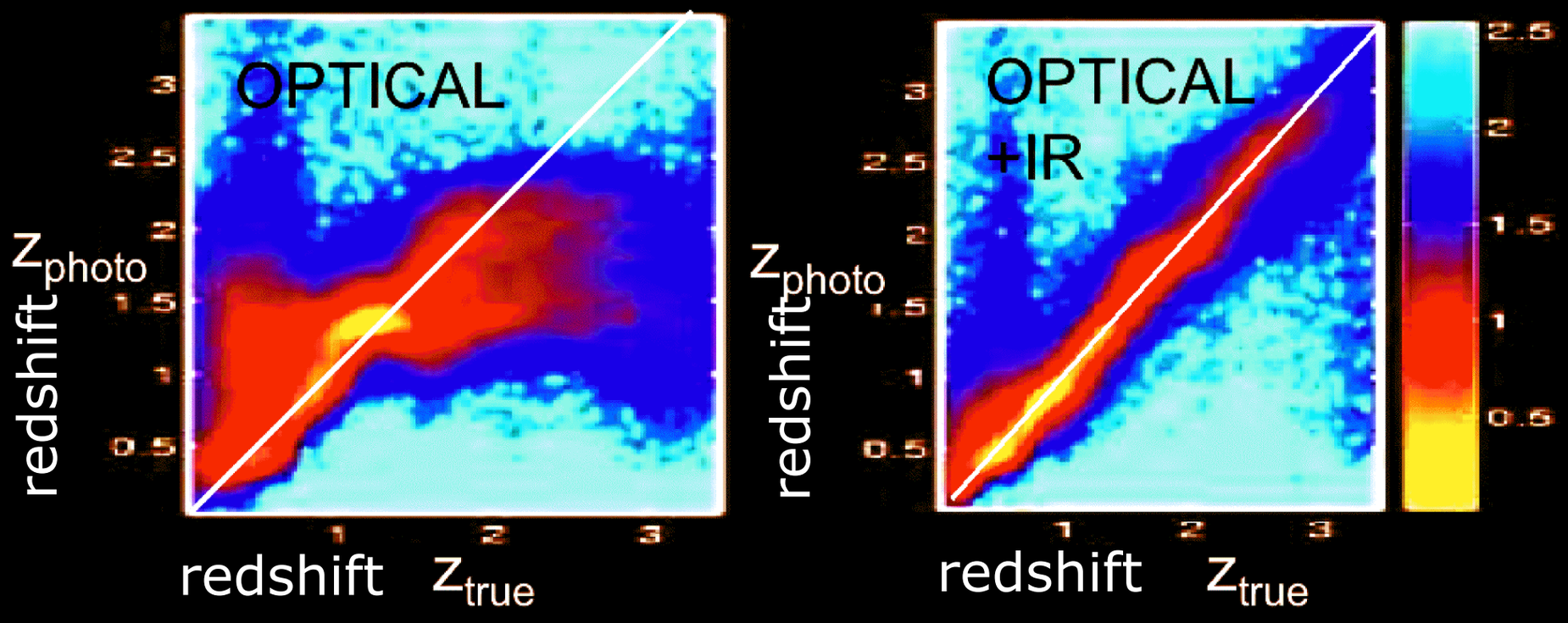
Photometric Redshifts



- Need Infrared Photometry from space.
- Galaxy distances (redshifts) measured by modelling intensity in passbands.
- Bands griz can be done from ground (e.g. Pan-STARRS, DES).



Abdalla et al (2008)

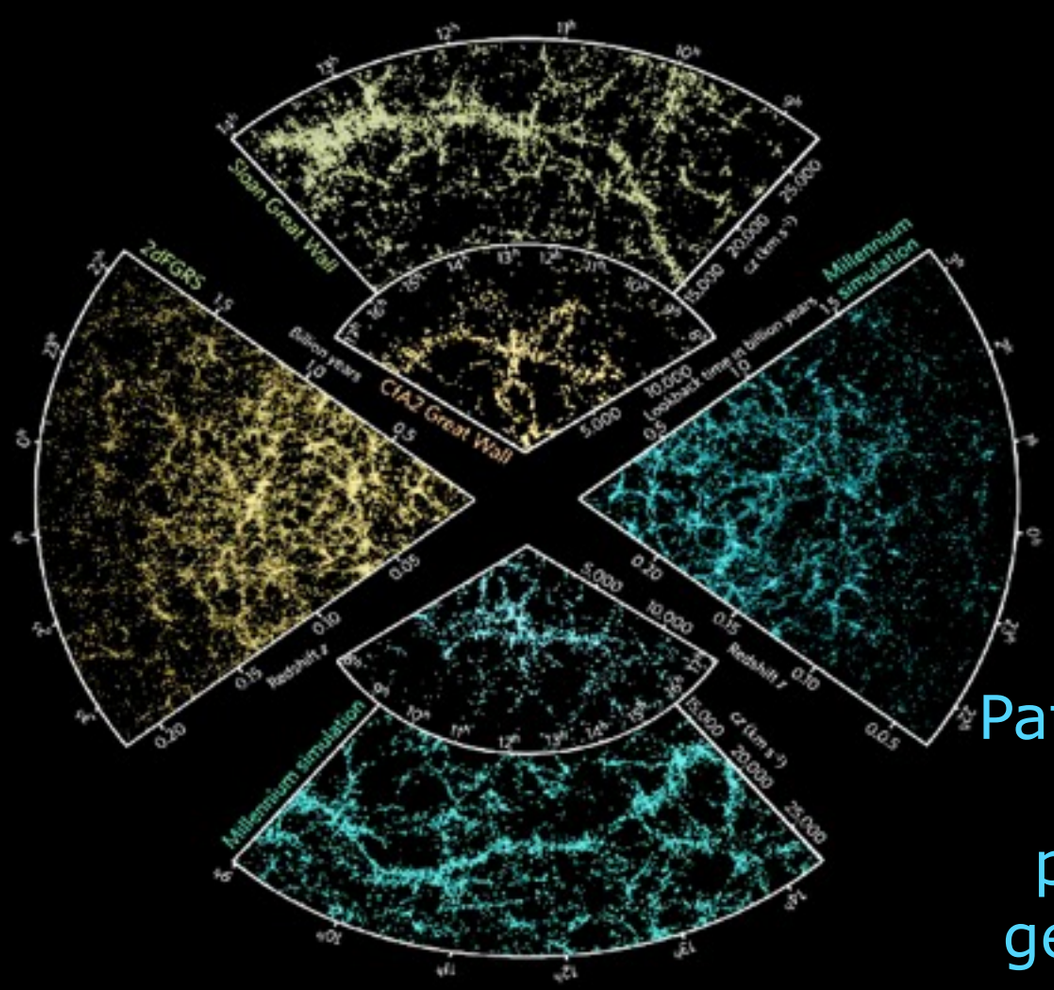
- Required accuracy reached by adding IR (Y,J,H) from Euclid.

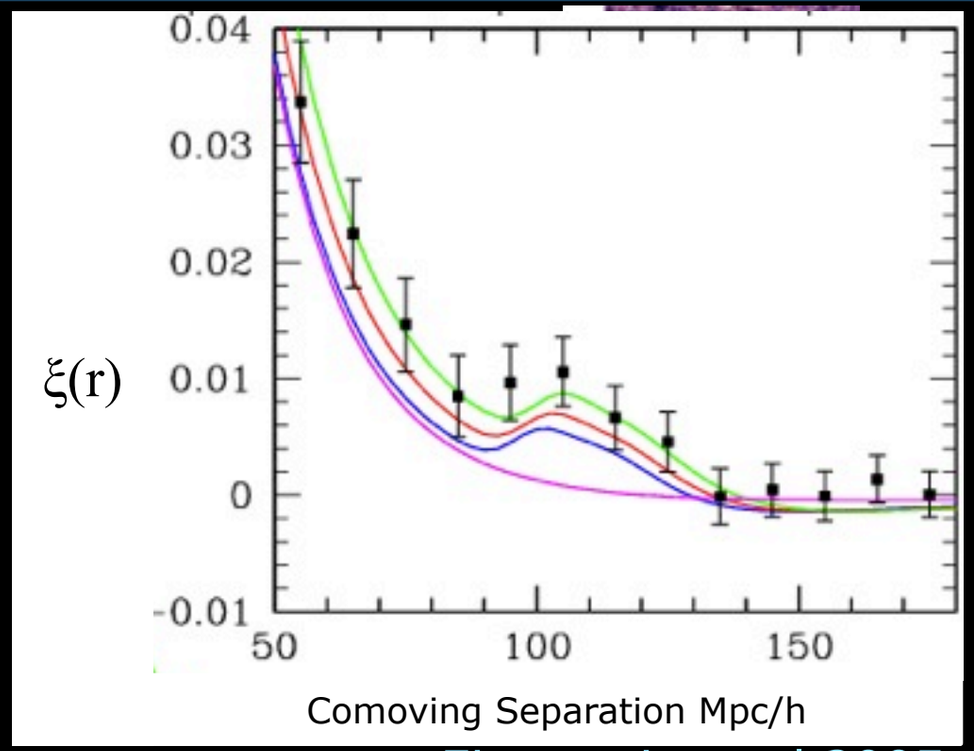
Euclid Primary Science Probes

EUCLID

Galaxy Clustering:

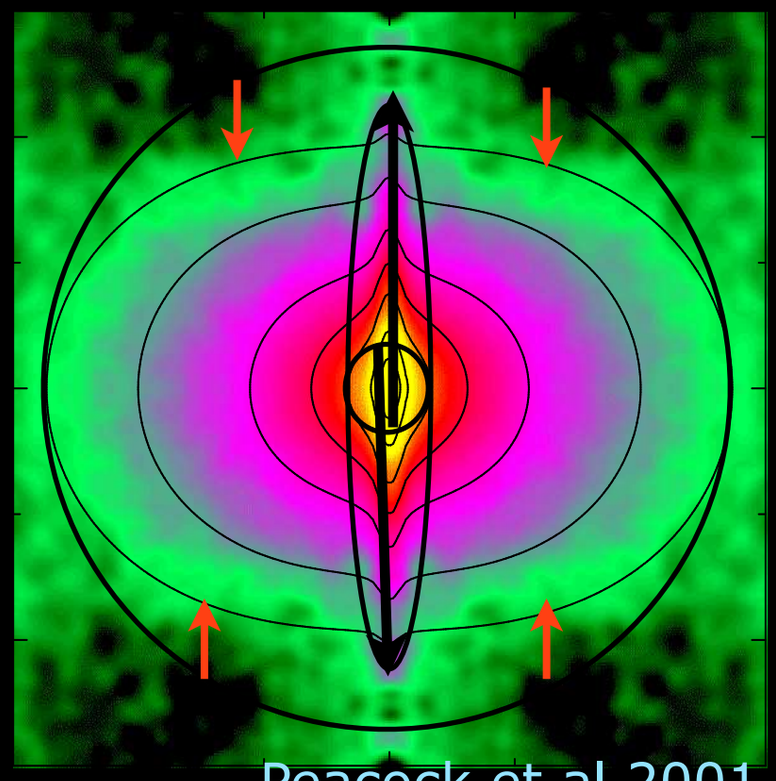
- Clustering pattern imprinted with plasma sound-wave at ~150Mpc.
- Baryonic Acoustic Oscillation from recombination - Standard Ruler.





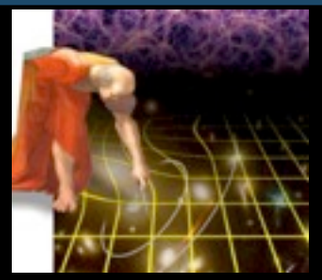
Eisenstein et al 2005

Pattern also distorted by gravitational peculiar velocities generated by mass.



Peacock et al 2001

Parameterise post-ΛCDM Universe:



1. Dynamical Dark Energy:

Model dark energy by varying equation of state,

$$w(a) = P/\rho c^2 = w_p + w_a(a_p\text{-}a)$$

2. Modified Gravity:

Parameterise deviation to growth rate, γ=0.55 for GR, of matter clustering,

$$\delta \propto a^f, \qquad f = \Omega_m{}^\gamma,$$

3. Dark Matter:

Add the contribution from a species of massive neutrinos with mass,

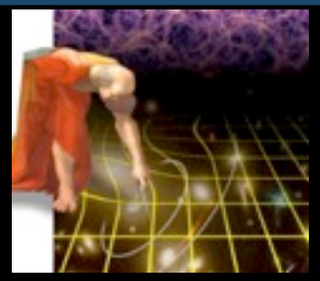
$$m_\nu.$$

4. Initial Conditions:

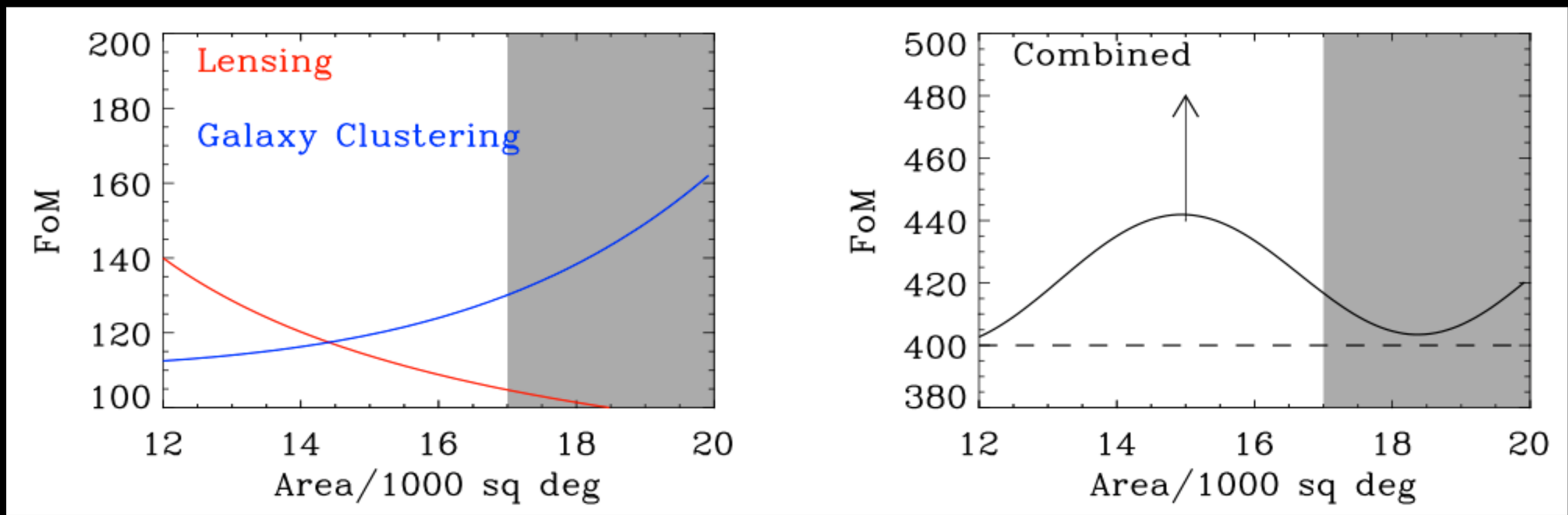
Departures from primordial Gaussianity of matter clustering parameterized by

$$f_{NL}.$$

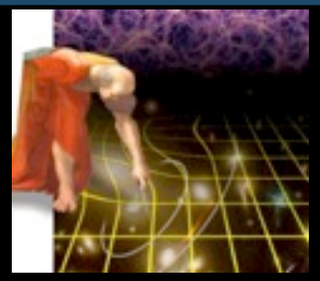
Optimise Primary Euclid Science



- Combining Weak Lensing and Galaxy Clustering maximises Euclid Primary Science: $\mathrm{FoM} = 1/[\Delta w_p \times \Delta w_a]$.



Euclid: Key Cosmological Questions

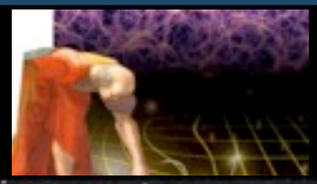


Predicted accuracy of post-ΛCDM parameters:

	Modified Gravity	Dark Matter	Initial Conditions	Dark Energy		
Parameter	γ	m_ν/eV	f_{NL}	w_p	w_a	*FoM*
Euclid Primary	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
Current	0.200	0.580	100	0.100	1.500	~10
Improvement Factor	**30**	**30**	**50**	**>10**	**>50**	**>300**

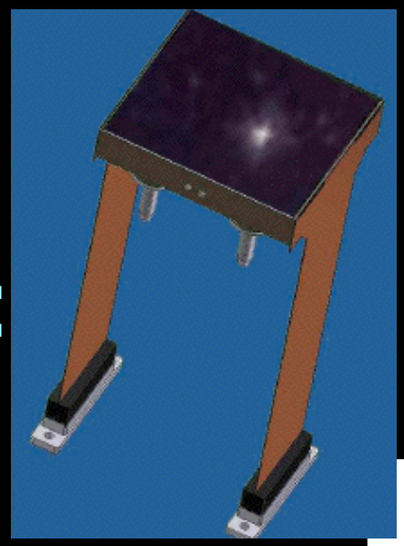
Primary = WL + GC
All = Primary + Cluster Counts & ISW

Euclid Instruments



- To do this we require:

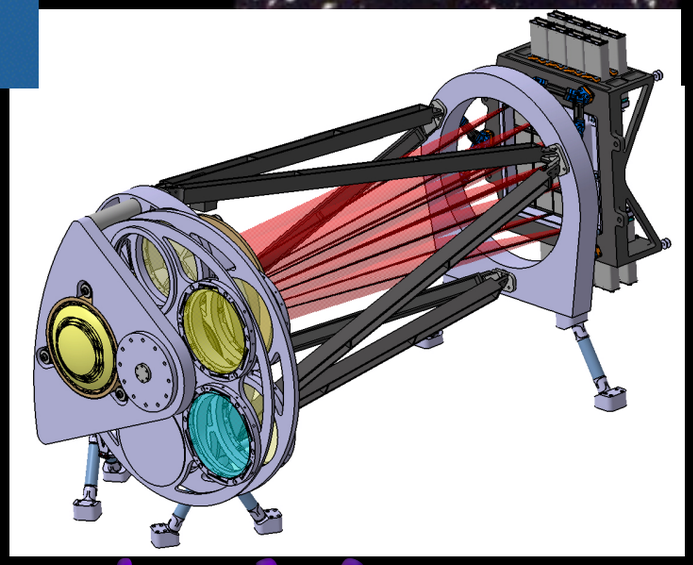
- Visible Image Channel (UK):
  - 36 4069x4069 CCD273 detectors.
  - Broad-band R+I+Z (550-900nm)



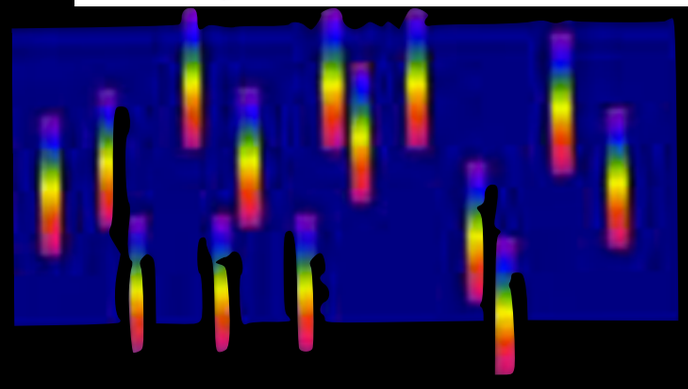
VIS

- Near Infrared Spectroscopy (Fr):
  - Wavelength range 0.9-2.0μm
  - Slitless spectroscopy

NISP

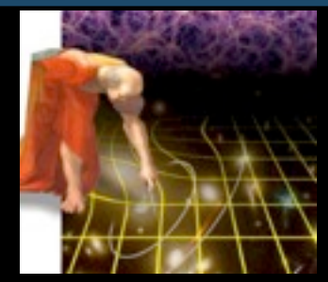


- Near Infrared Photometry (Fr):
  - 16 NIR HgCdTe detectors.
  - 3 bands Y,J,H (1.0-1.7μm)

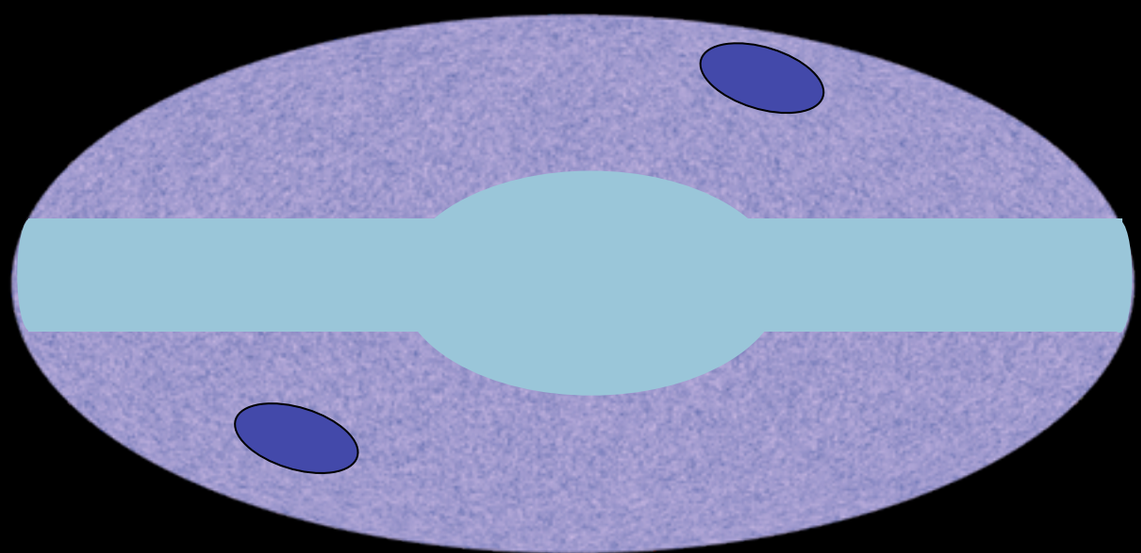


- Beam splitter sends images to VIS and NISP Instruments.

Euclid Mission



- Launch date 2019. L2 orbit.
- 6-year primary mission, 7-yr total.
- Telescope 3 mirrors with 1.2m primary.
- 0.18 arcsecond Point Spread Function.
- 0.1 arcsec pixels (VIS)
- 0.5 square degree field of view.
- Wide Survey - 15,000 sq deg:
  VIS = 24.5, median z = 0.9
  NISP = 24
- Deep Survey - 40 sq deg:
  VIS = 29
  NISP = 26.



Primary Euclid Science Measurements

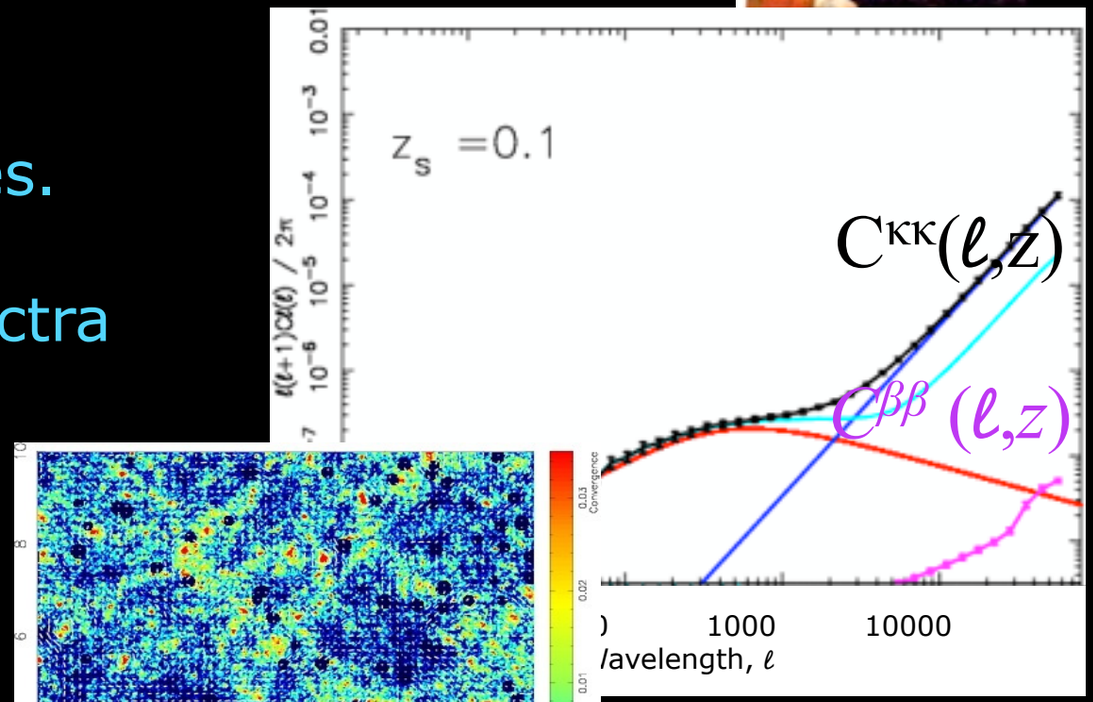
EUCLID

3-D Weak Lensing:

- Images and redshifts to 1.5 Billion galaxies.
- Measure ~165 auto- and cross-power spectra

  $C^{\kappa\kappa}(\ell,z,z')$, $C^{\beta\beta}(\ell,z,z')$, $C^{\kappa\beta}(\ell,z,z')$

  to sub-percent accuracy.
- Accurate 2-D and 3-D mass mapping.



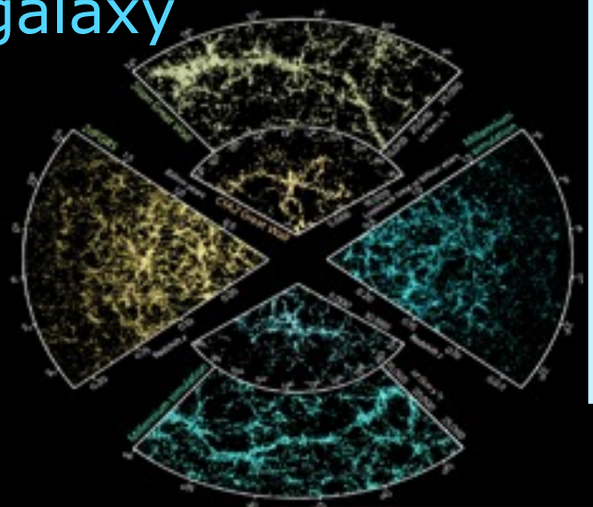
Kiessling, ANT, Heavens, 2010

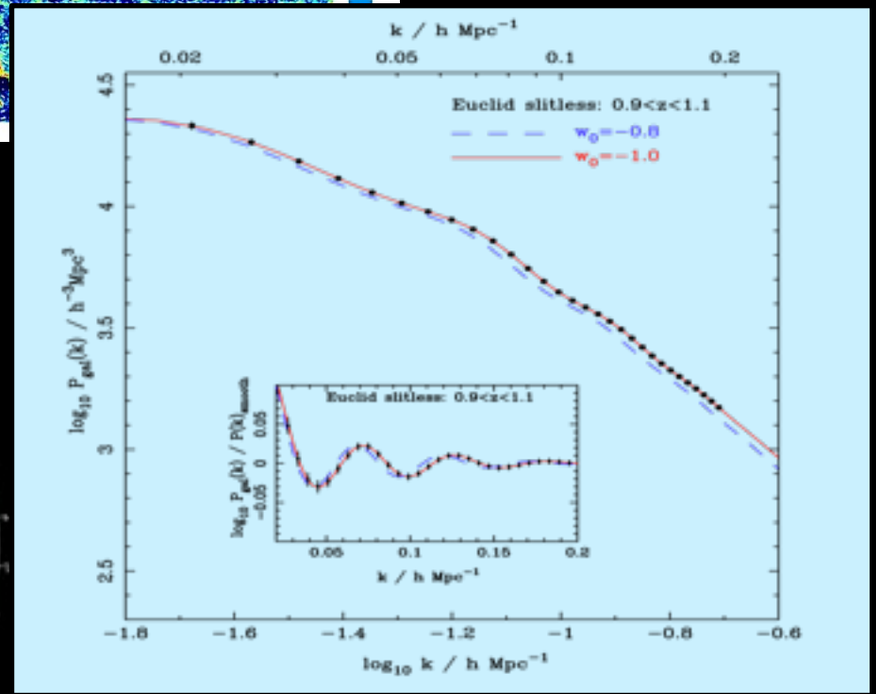
Galaxy Clustering

- Redshifts for 50 Million galaxies.
- Measure the redshift-space galaxy power spectrum:

  $P(k,z)$

  BAO & redshift-distortion.

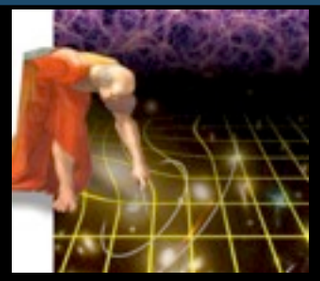




Percival, Baugh et al 2010,
Euclid Red Book 2010

Institute for Astronomy · Durham University · UCL · University of Oxford · ICG Imperial College London

Primary Euclid Science Measurements



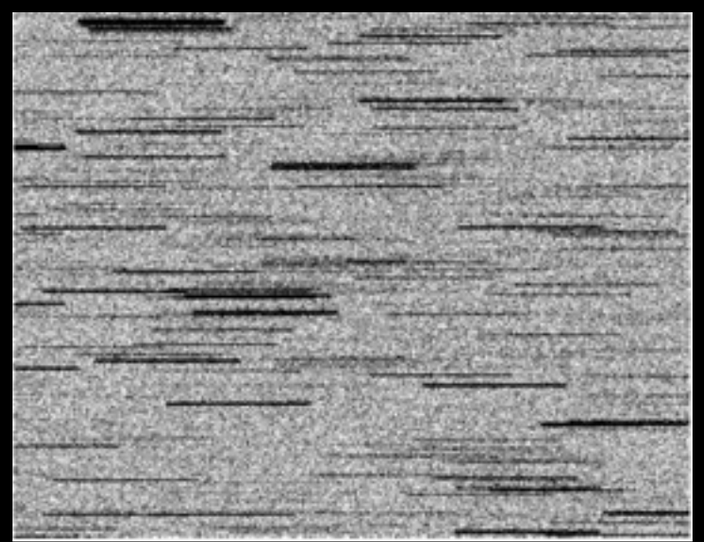
- Weak Lensing 3-D shear power:

$$C'(\ell,z,z') = (1+m)^2 C(\ell,z,z') + \sigma^2_{sys}$$

Calibration bias Uncorrected Systematics

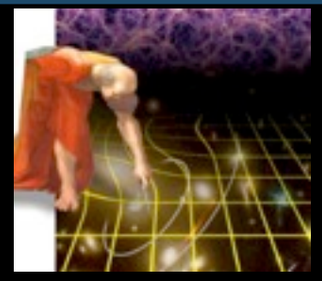
  - Require: $m < 2 \times 10^{-3}$ and $\sigma^2_{sys} < 10^{-7}$

- Photo-z's:
  - Require $\Delta z \leq 0.05(1+z)$, <10% failures.



- Galaxy Clustering:
  - Slit-less Spectroscopy (Hα emission in star-forming galaxies).
  - Sky density 3,500/sq deg.
  - Redshift Completeness >45% (slitless confusion).

Euclid Data Processing



Science Working Groups set Requirements

WL SWG

GC SWG

...

Operational Units define algorithms

OUs

OUs

OUs

OU...

Science Ground Segment (SGS)

Science Data Centres Implement and run analysis

SDC-FR

SDC-IT

SDC-UK

SDC...

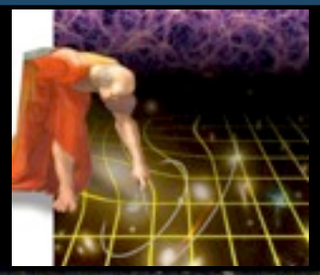
Science Working Groups coordinate Science Exploitation

WL SWG

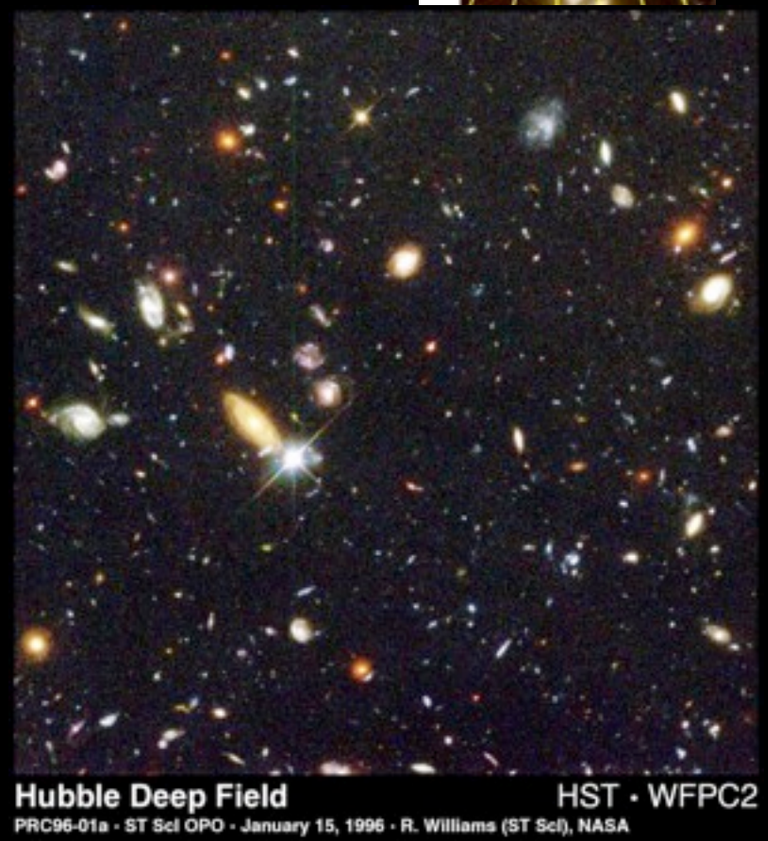
GC SWG

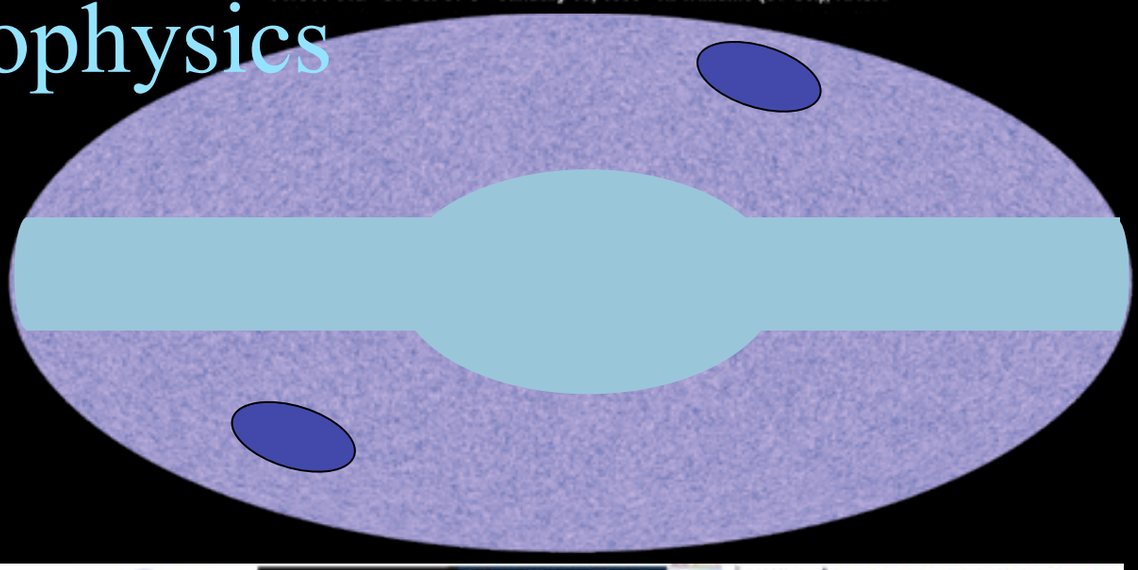
...

Euclid Legacy Science

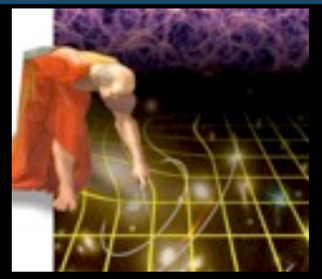


- Legacy SWGs Coordinated by Steve Warren (IC).
- High-redshift Universe: z>7 Galaxies and Quasars:
  Detect Lyman Break Galaxies (LBG).
- Co-evolution of galaxies and AGN
- Near-field Cosmology and Astrophysics
- Strong Lensing





Prominent UK Roles in Euclid



- UK has major scientific leadership of Euclid Weak Lensing and a significant role in Galaxy Clustering.

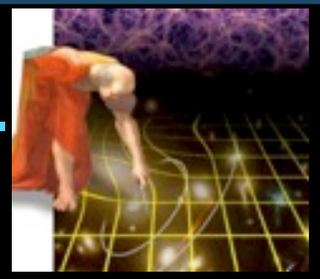
- Euclid Consortium Board/ESA Science Team:
  - Mark Cropper (MSSL) - VIS Instrument Scientist, UK PI.
  - Bob Nichol (Ports) - Galaxy Clustering Scientist.

- 3 of the 6 Science Working Group Coordinators:
  - Tom Kitching (UoE) - Weak Lensing
  - Will Percival (Ports) - Galaxy Clustering
  - Steve Warren (IC) - Legacy Science

- Euclid Science Ground Segment:
  - Andy Taylor (UoE) - Weak Lensing OU-SHE Lead, UK SGS Lead.
  - Filipe Adballa (UCL P&A) - LE3 Science-Ready Products co-deputy lead.
  - Neville Shane (MSSL) - VIS raw reduction deputy lead.

Euclid Summary

EUCLID



- Euclid will be *the* major optical/NIR mission for a generation.

- Need space for:
  Small, stable PSF, NIR photo-z channels for Weak Lensing.
  Large homogeneous volume for Galaxy Clustering.

- Survey optimised for primary, dark energy science.

- VIS and NISP Instruments for imaging, photometry and spectroscopy.

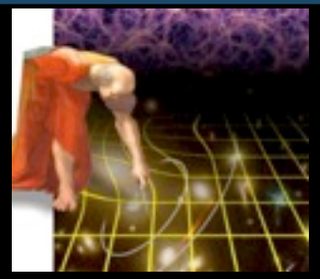
- UK has very prominent role in Weak Lensing:
  WL SWG, VIS Inst, VIS reduction, 3-D Shear Catalogue,
  3-D Shear power spectra, 3-D mass maps.

  and a significant role in Galaxy Clustering:
  GC SWG, Slitless corrections, Galaxy redshift-space power spectrum.

- Additional significant roles in Legacy Science.

- Euclid Red Book available online: Laureijs et al 2010.

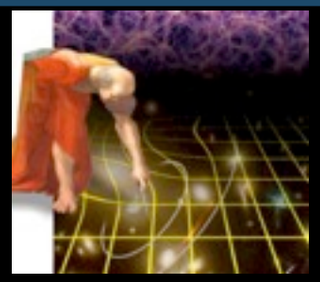
Institute for Astronomy · Durham University · STFC · UCL · University of Oxford · loa · ICG · Imperial College London



END

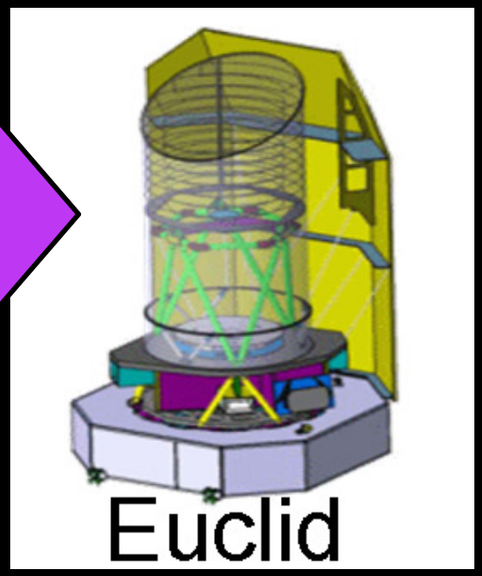
Overview of Euclid Data Handling

EUCLID



ESA

Ground Station



Mission Operations Centre (MOC)

Science Operations Centre (SOC)

Euclid Legacy Active

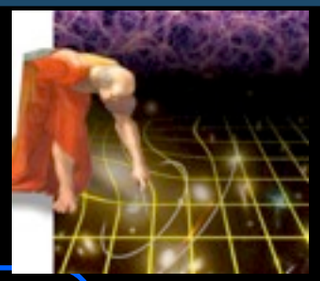
Euclid Mission Active

Euclid Consortium

Euclid Science Ground Segment

Institute for Astronomy · Durham University · UCL · University of Oxford · ICG · Imperial College London

Euclid Science Ground Segment Structure



EXT
MER
PHZ
VIS INST
VIS
SHE
WL LE3
SDC UK
WL SWG
OUs
NISP
NIR
SPE
GC LE3
SDCs ...
GC SWG
SIR
SIM

UK Lead
Deputy-Lead

UK co-Lead

Science Ground Segment (SGS)

(Non-UKSA Funded)