Euclid ground-based support: the role of WHT/PAU

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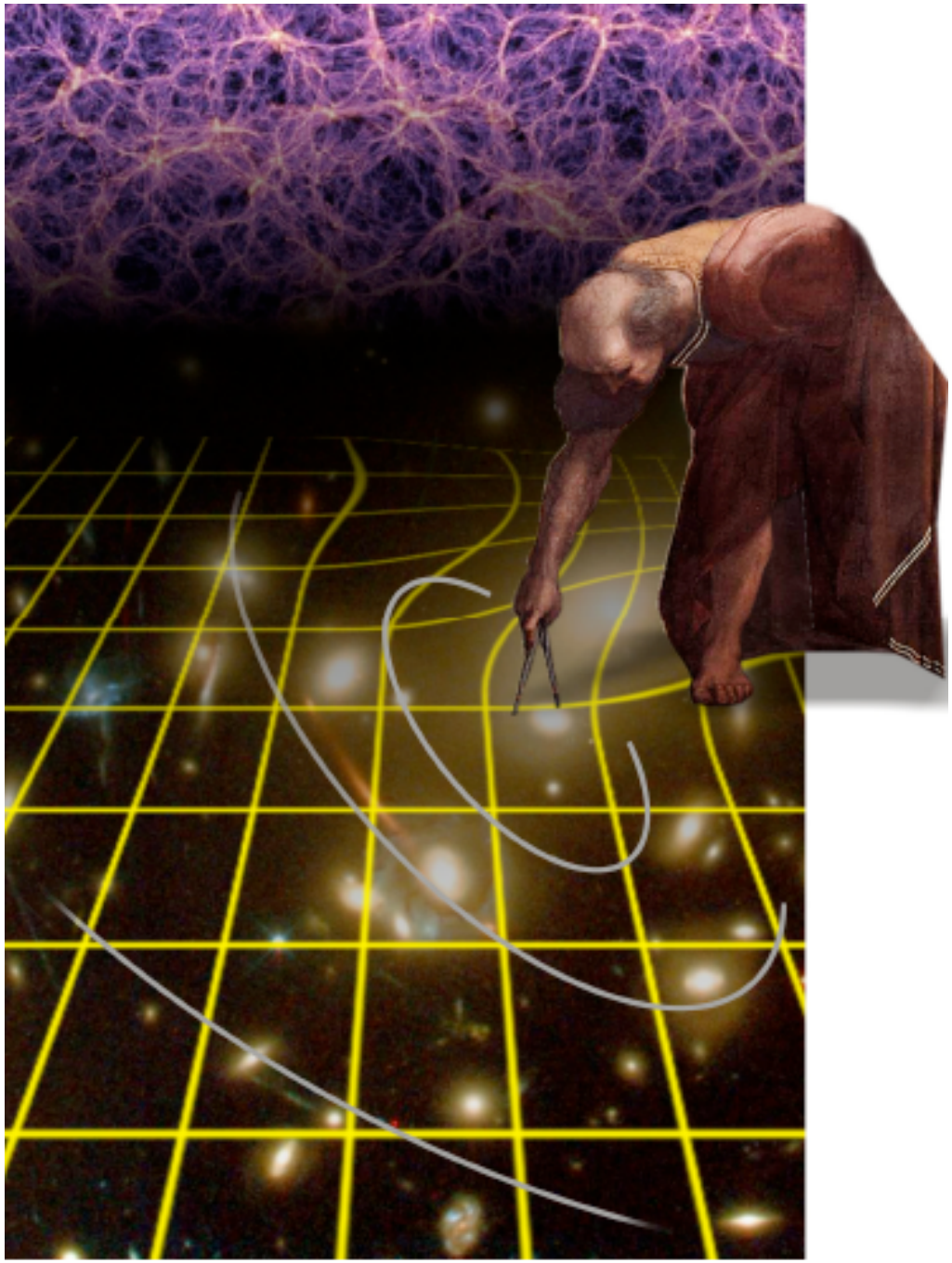
Euclid

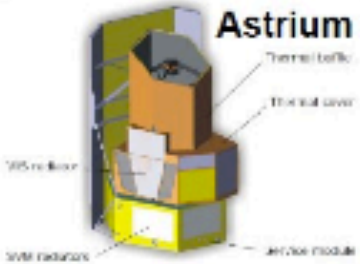
- Cosmology mission to study the accelerated expansion of the universe aka dark energy
- Selected by ESA on October 4th 2011
- M class mission
- M2 launch slot
- launch Q4 2019

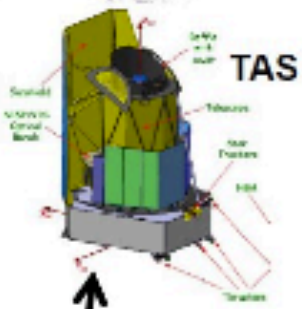


The Euclid mission

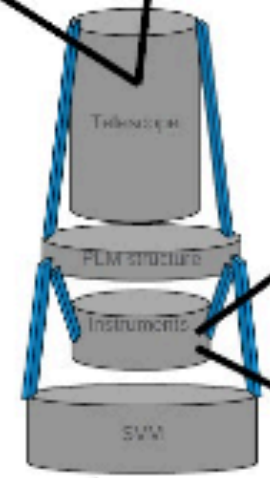
Euclid Consortium

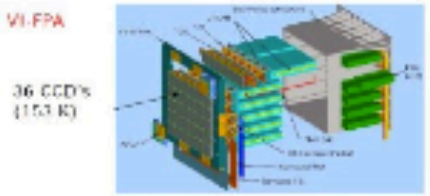
Euclid

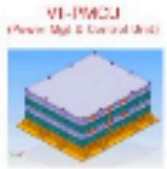




Soyuz@Kourou
Dec. 2019

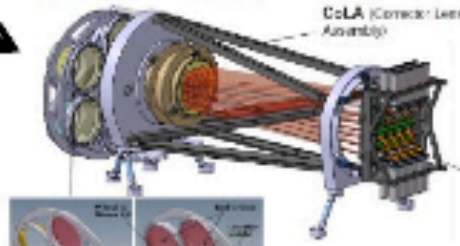


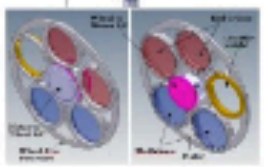




VIS

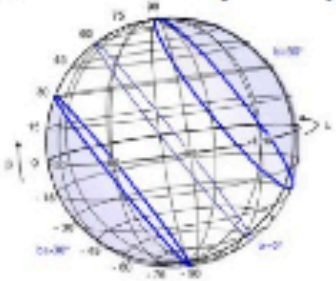
NISP

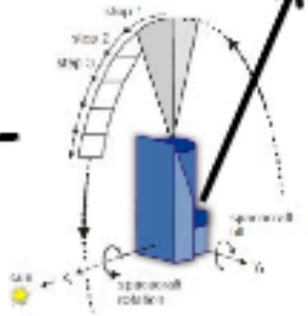




NI-GWA + NI-FWA

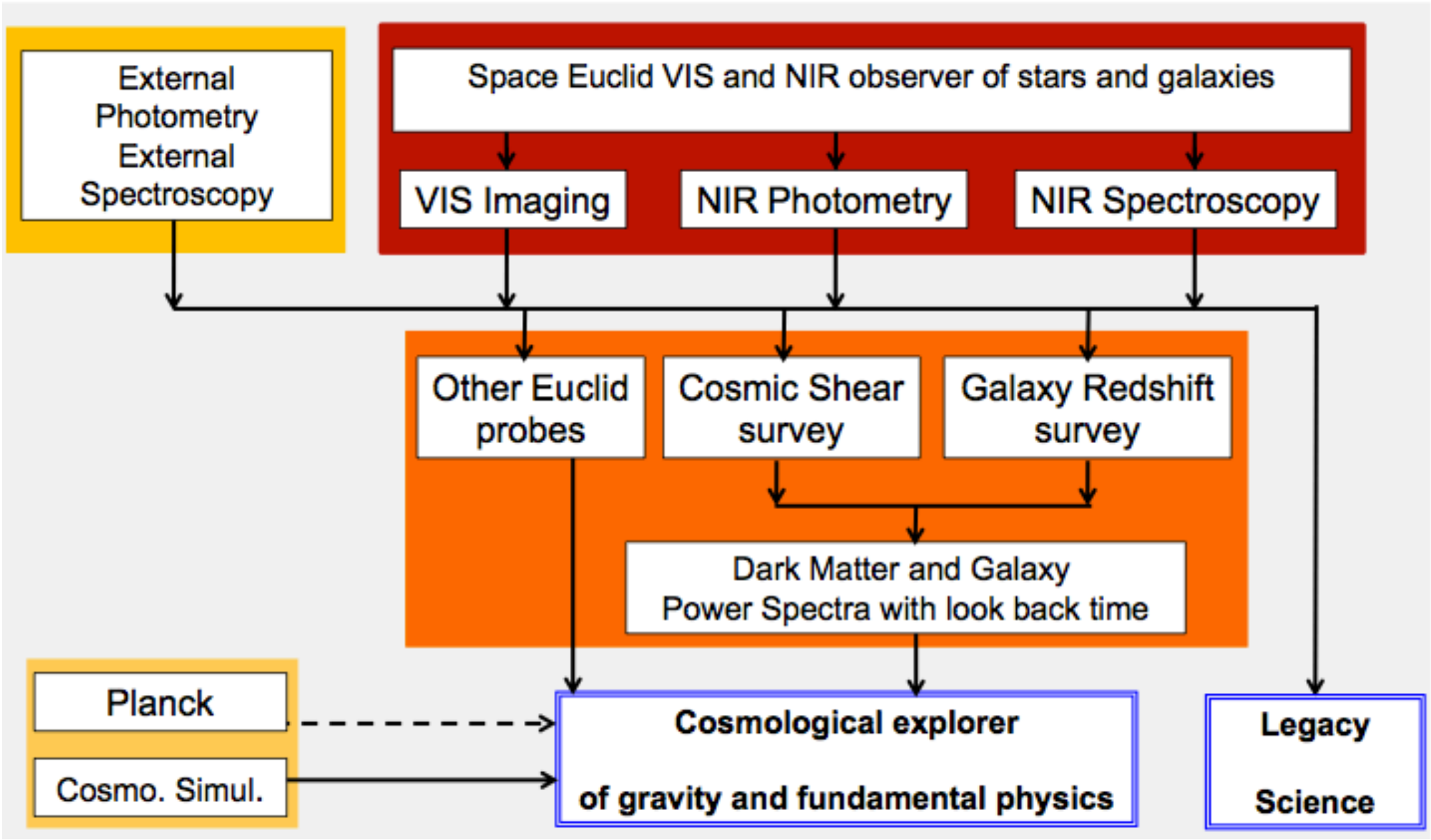
Avoid Galaxy+Ecliptic





The Euclid Machine

Euclid Consortium



Euclid main scientific objectives

Euclid Consortium

- Understand the origin of the Universe's accelerating expansion

- Probe the properties and nature of dark energy, dark matter, gravity, and

- Distinguish their effects decisively by:
  - Using at least 2 independent but complementary probes
  - Tracking their (very weak) observational signatures on the
    - geometry of the universe: Weak Lensing (WL) and Galaxy Clustering (GC)
    - cosmic history of structure formation: WL, Redshift-Space Distortion (RSD), clusters of galaxies (CL)
  - Controling systematic residuals to an unprecedented level of accuracy.

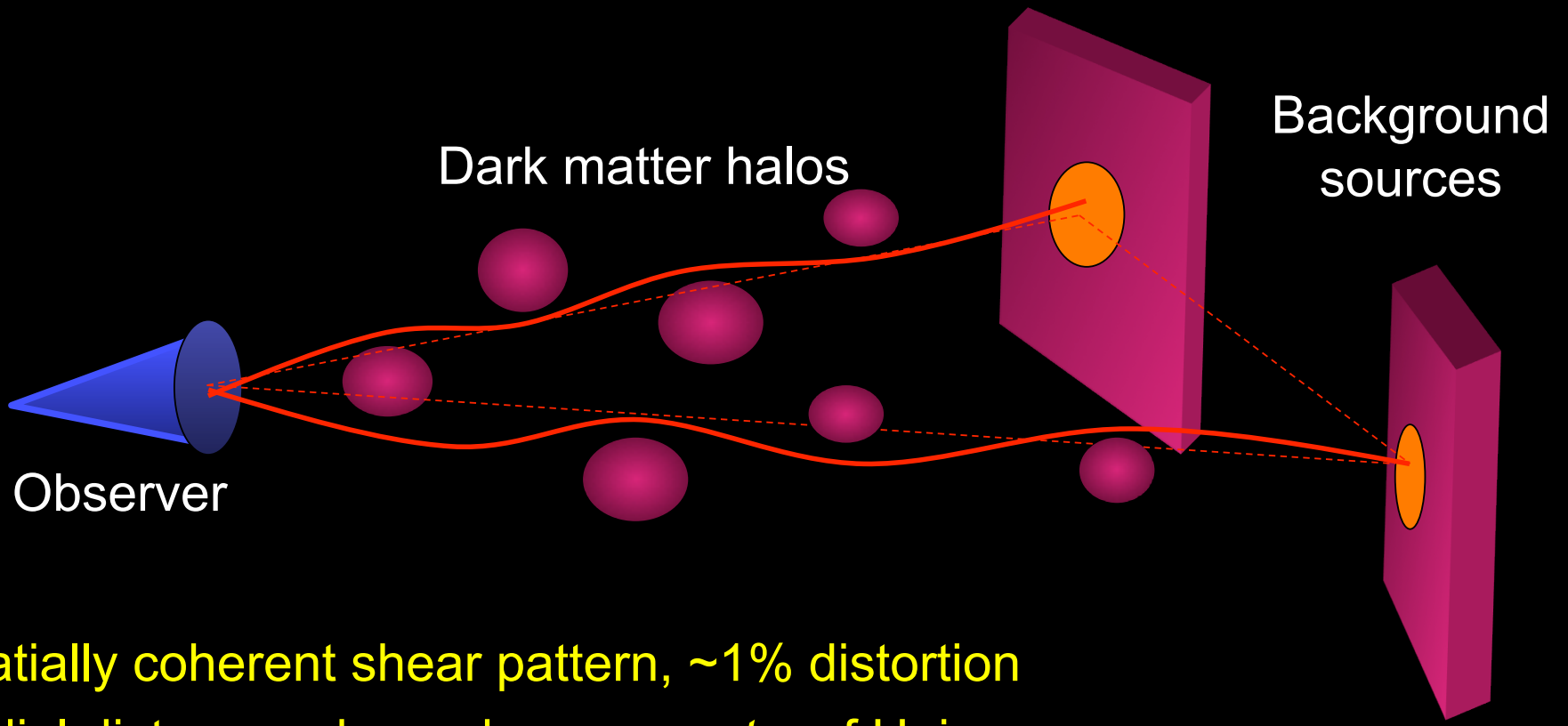
Euclid top science objectives

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_0 & w_a of 0.02 and 0.1 respectively)
Test of Gravity	- Measure the growth index, γ, to a precision better than 0.02 - Measure the growth rate to better than 0.05 for several redshift bins between $z = 0.5$ and $z = 2$ - Separately constrain the two relativistic potentials φ and ψ - 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 an 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 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 an error better than $\pm$ 2.

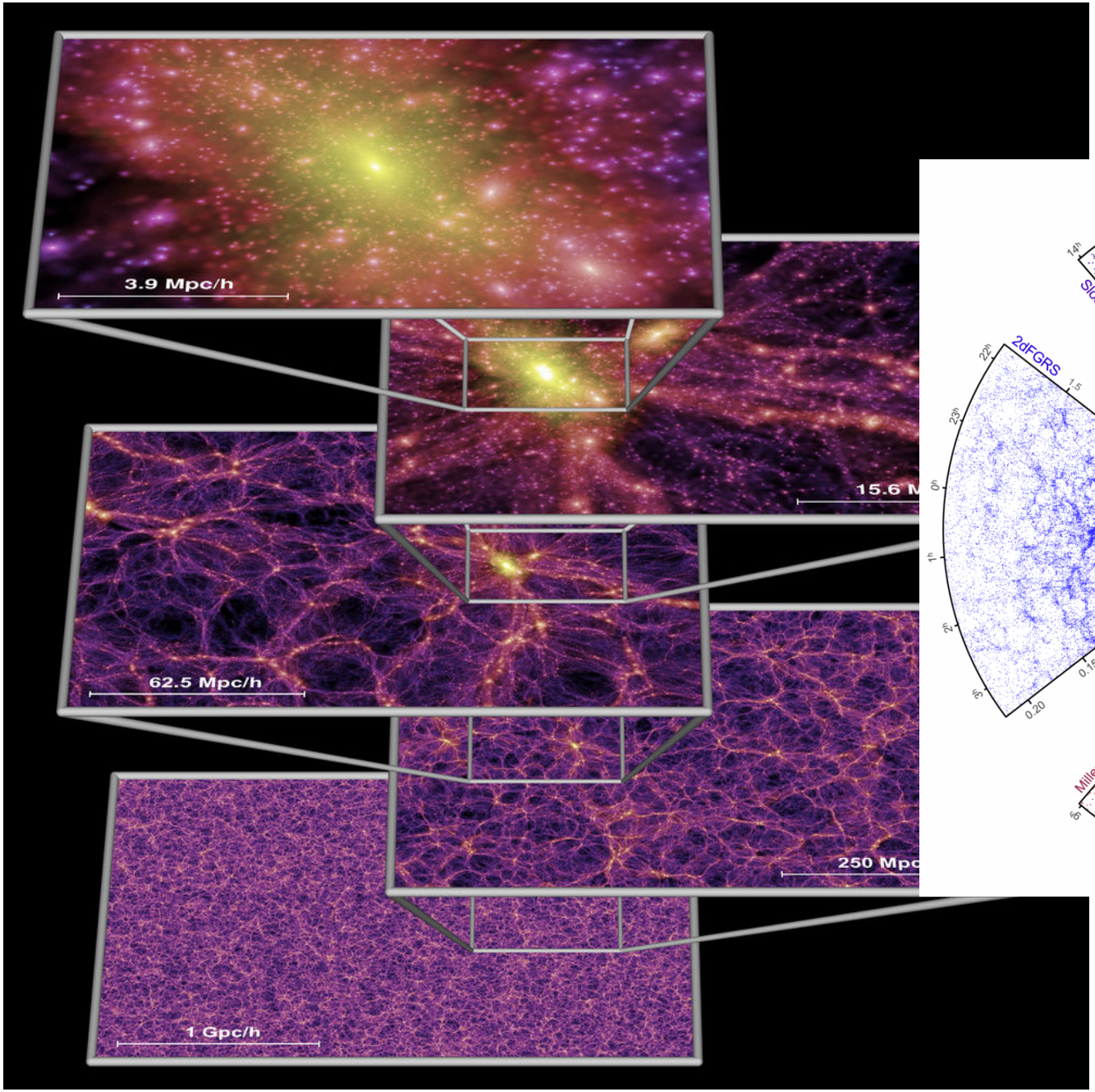
Euclid observational probes

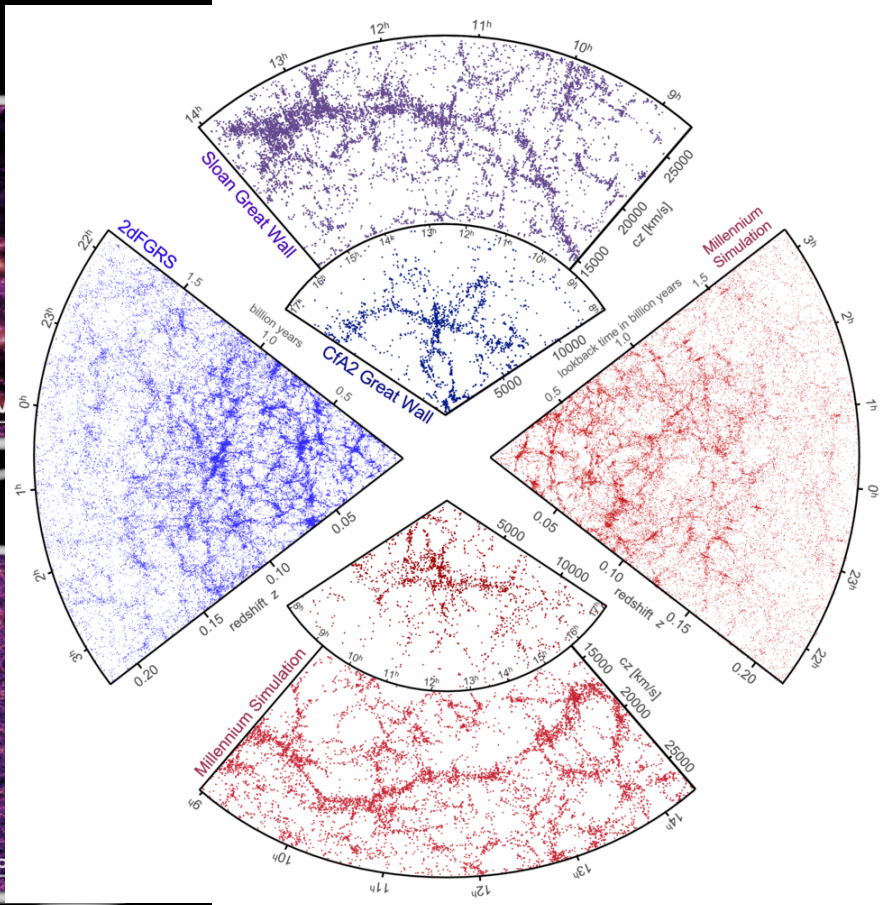
Observational Input	Probe	Description
Weak Lensing Survey	Weak Lensing (WL)	Measures the expansion history and the growth factor of structure
Galaxy Redshift Survey: Analysis of *P(k)*	Baryonic Acoustic Oscillations (BAO)	Measure the expansion history through D(z) and H(z) using the "wiggles-only".
	Redshift-Space distortions	Determine the growth *rate* of cosmic structures from the redshift distortions due to peculiar motions
	Galaxy Clustering	Measures the expansion history and the growth factor using all available information in the amplitude and shape of P(k)
Weak Lensing plus Galaxy redshift survey combined with cluster mass surveys	Number density of clusters	Measures a combination of growth factor (from number of clusters) and expansion history (from volume evolution).
Weak lensing survey plus galaxy redshift survey combined with CMB surveys	Integrated Sachs Wolfe (ISW) effect	Measures the expansion history and the growth
Weak lensing survey plus galaxy redshift survey combined with CMB surveys	Weak lensing on CMB anisotropies	Measures the high redshift expansion regime and growth of structures

II. Weak Lensing: Cosmic Shear

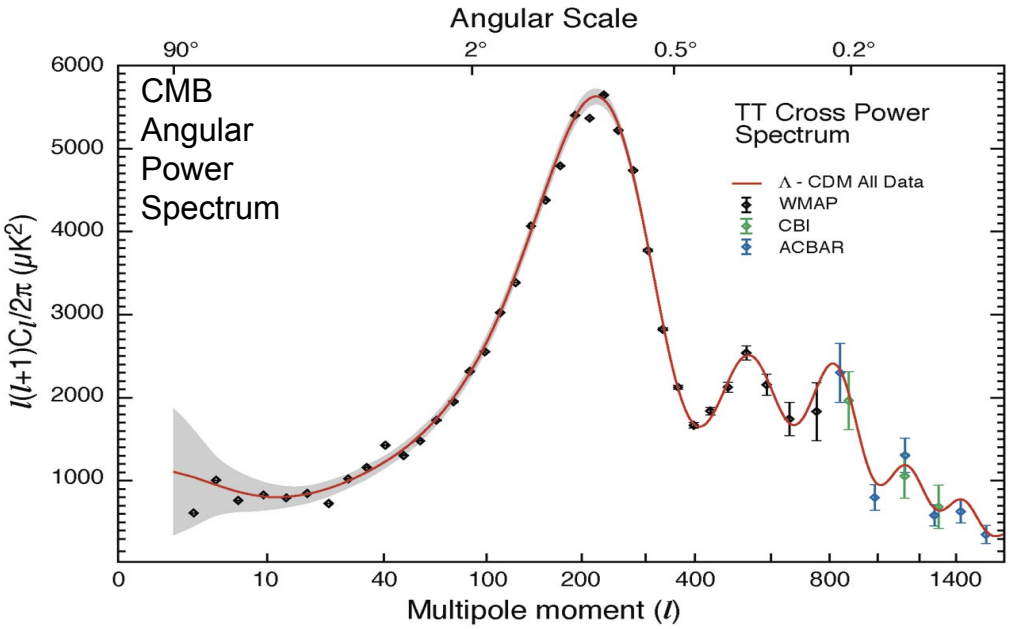


- Spatially coherent shear pattern, ~1% distortion
- Radial distances depend on *geometry* of Universe
- Foreground mass distribution depends on *growth* of structure

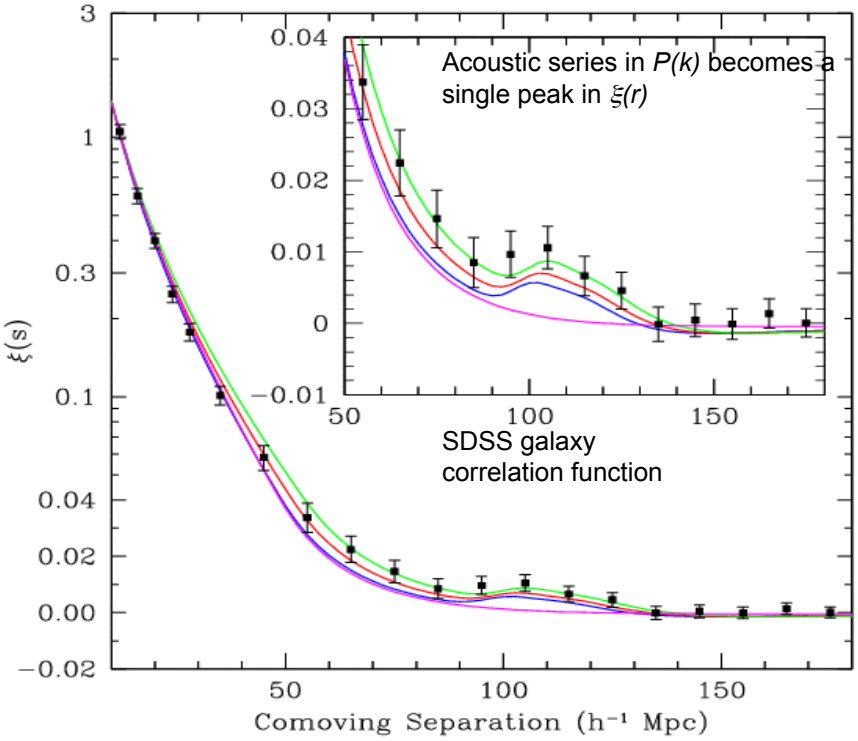

3.9 Mpc/h
15.6 M
62.5 Mpc/h
250 Mpc
1 Gpc/h


Sloan Great Wall
2dFGRS
CfA2 Great Wall
Millennium Simulation
Millennium Simulation
cz [km/s]
redshift z
billion years
lookback time in billion years

Baryon Acoustic Oscillations: CMB & Galaxies

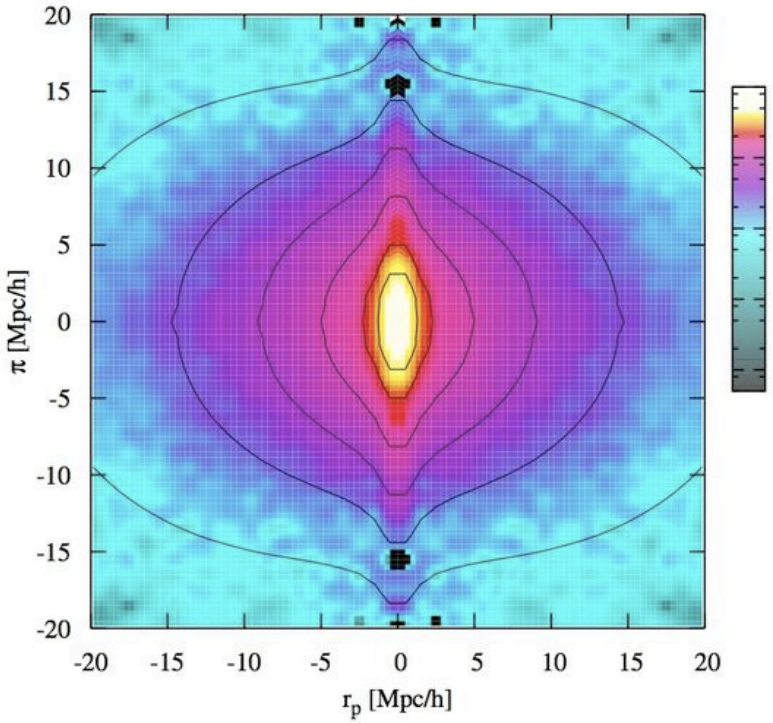


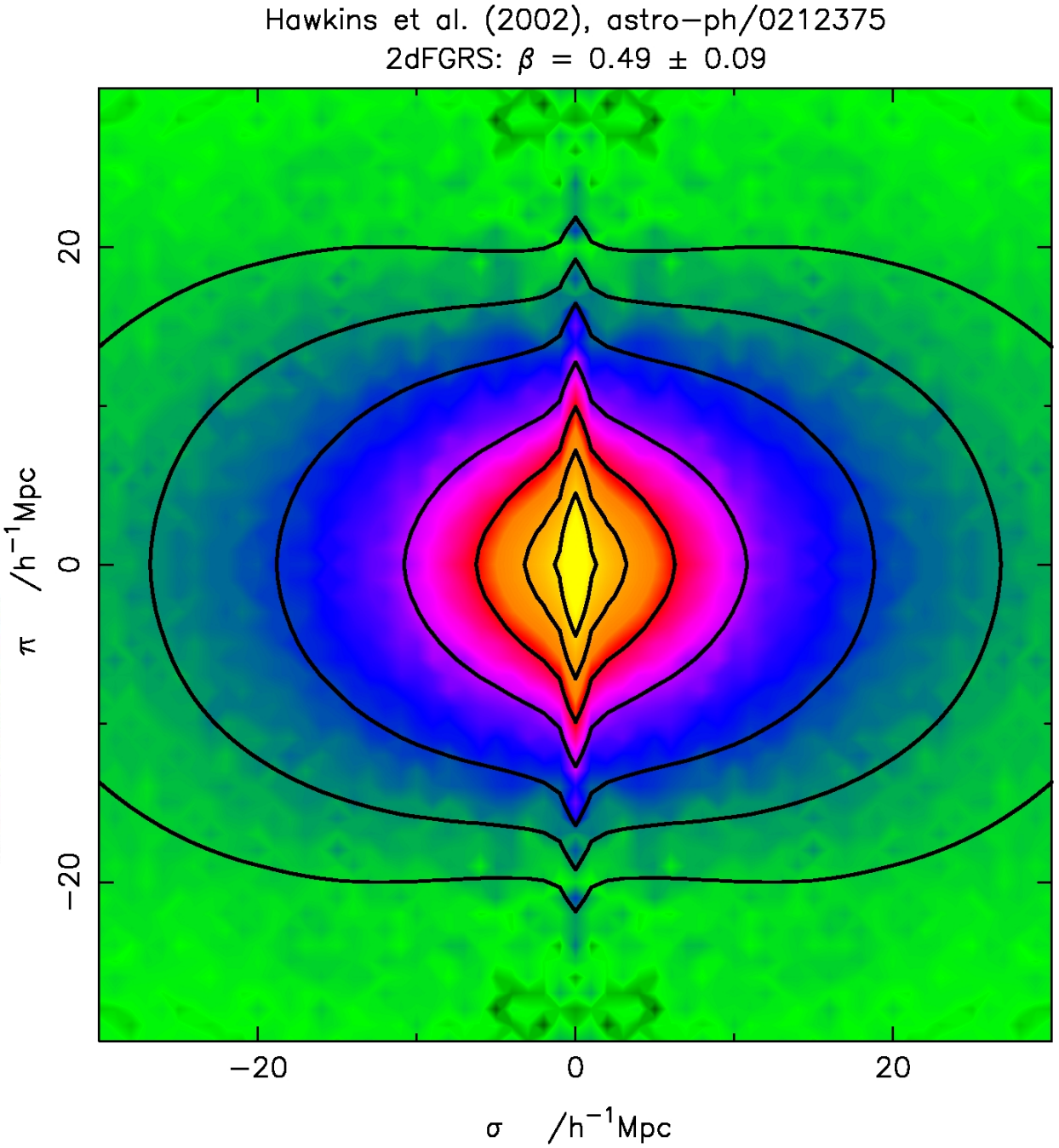
Bennett, etal



Eisenstein etal

Redshift Space Distortions





Euclid performance

	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**

Euclid L1 requirements

Req. ID	Parameter	Requirement	Goal
WL.1-1	Survey Area (A)	>15,000 deg^2	>20,000 deg^2
WL.1-2	Density of galaxies (Ng)	≥30 gals/$amin^2$	>40 gals/$amin^2$
WL.1-3	Median redshift (zm)	>0.8	
WL.1-4	Systematics (σ^2_{sys})	10^{-7}	
WL.1-5	Redshifts error (σ(z)/(1+z))	≤ 0.05	≤ 0.03
WL.1-6	Catastrophic failures (fcat)	10%	5%
WL.1-7	Bin mean redshift (δz)	<0.002	
GC.1-1	Survey Area (A)	>15,000 deg^2	>20,000 deg^2
GC.1-2	Galaxy sky density (sd)	3,500 / deg^2	5,000 / deg^2
GC.1-3	Redshift accuracy	σ(z)<0.001(1+z)	
GC.1-4	Systematic offset in redshift	<1/5 redshift accuracy	
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.1-8	Bias of all galaxies	>1	
GC.1-9	Bias of galaxies, upper quartile in redshift	>1.3	
GC.1-10	fraction of catastrophic failures	f<20%	
GC.1-11	fraction of catastrophic failures	known to 1%	
GC.1-12	mean redshift in 0.1 redshift bin	known to 0.1%	

Euclid complementary data

- WL-1.5 & WL-1.6 photometric redshift accuracy requires complementary data
- WL-1.4 systematics (σ^2_{sys})

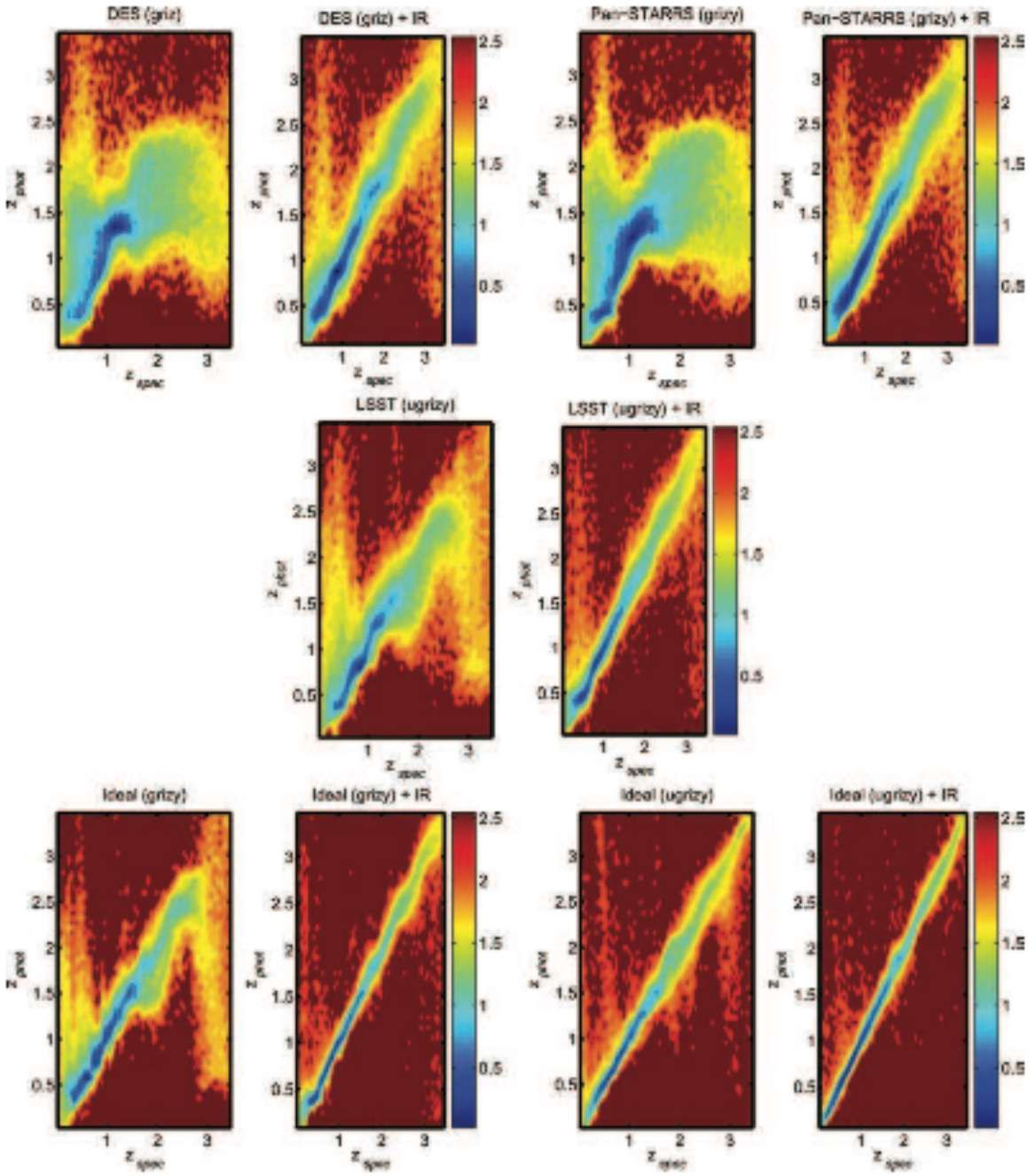
Euclid complementary data needs

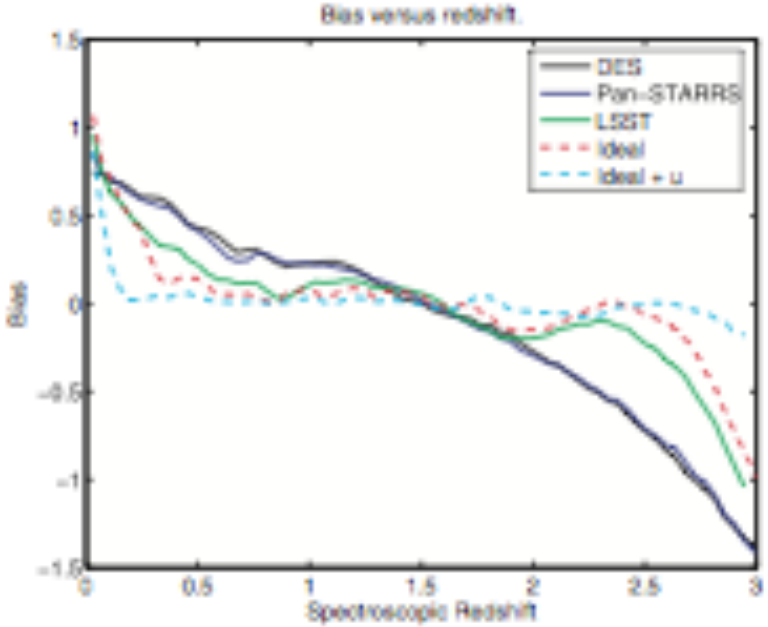
Photometric redshifts

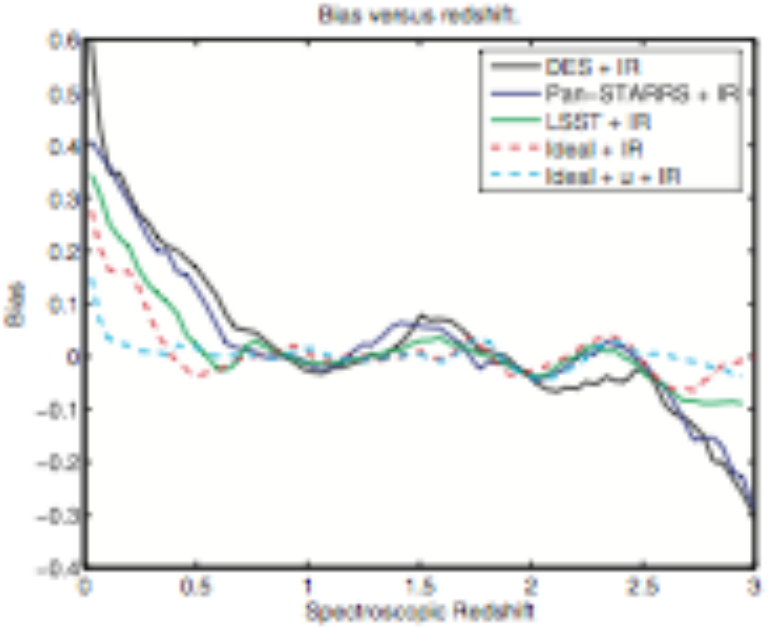
- Need wide area coverage with other bands => photometry
- Need spectroscopic training sets => spectroscopy

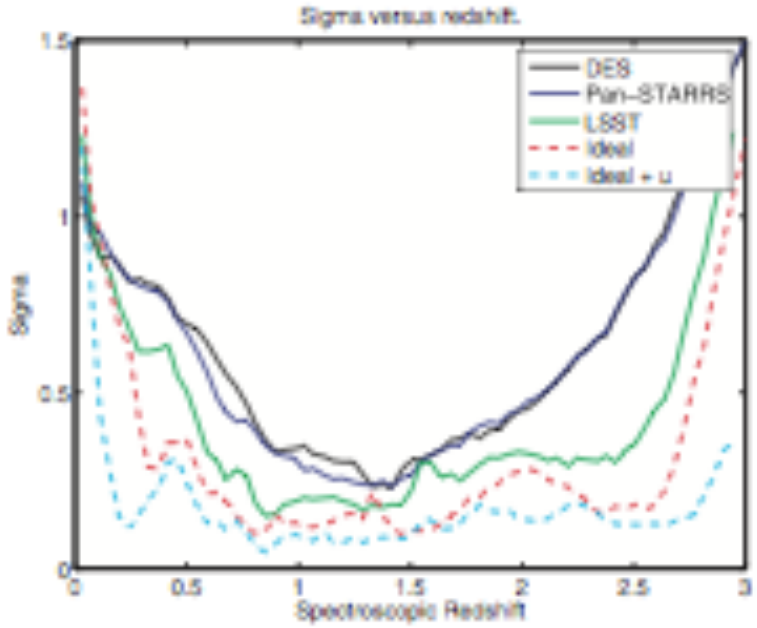
Photometric redshift simulations

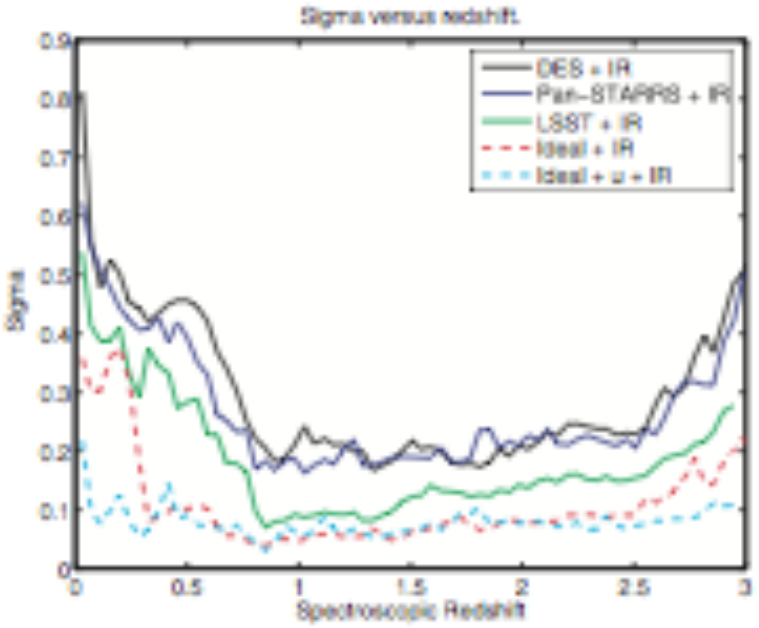
Abdalla et al 2008




Bias versus redshift.
DES
Pan-STARRS
LSST
Ideal
Ideal + u
Bias
Spectroscopic Redshift

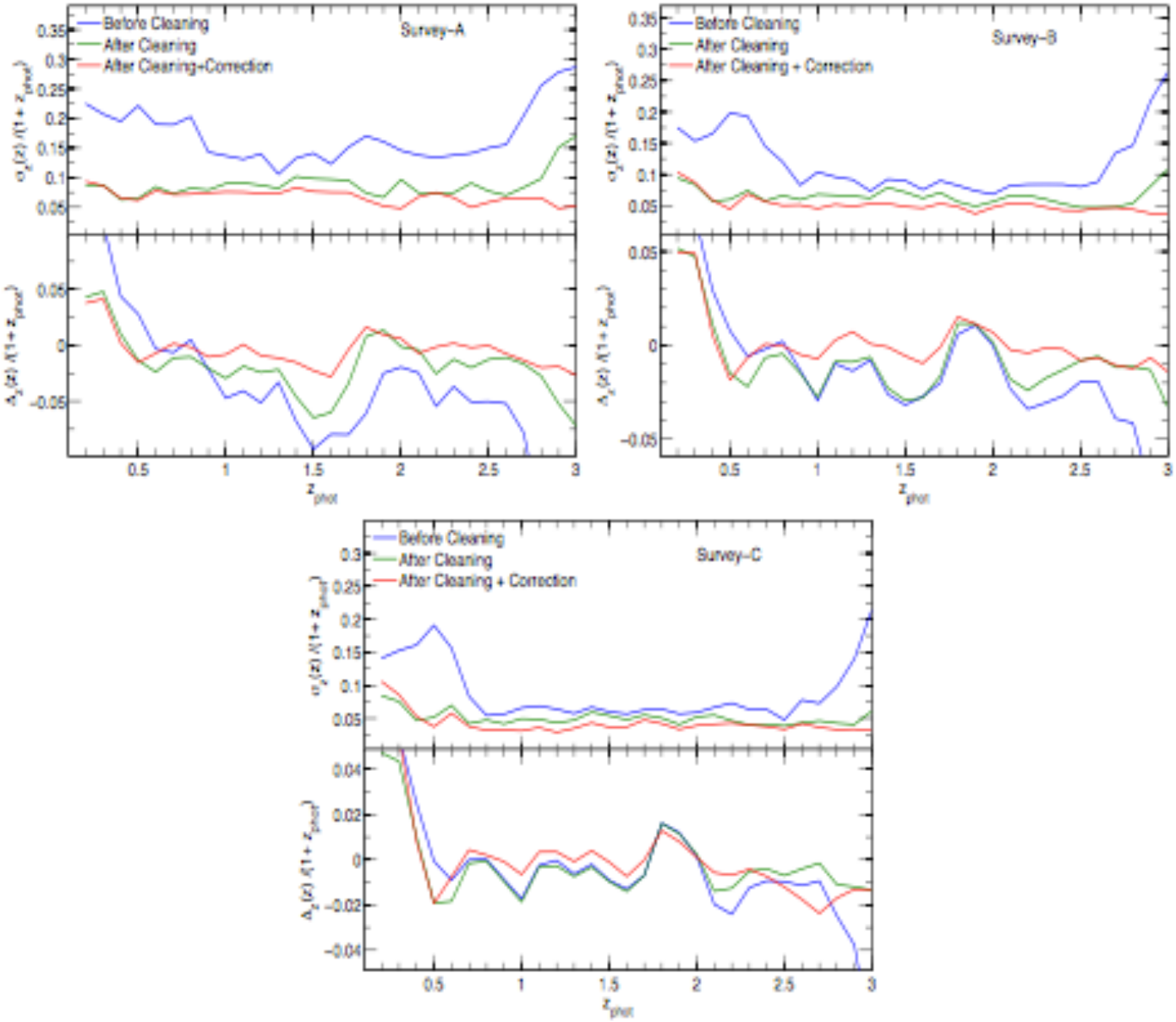

Bias versus redshift.
DES + IR
Pan-STARRS + IR
LSST + IR
Ideal + IR
Ideal + u + IR
Bias
Spectroscopic Redshift


Sigma versus redshift.
DES
Pan-STARRS
LSST
Ideal
Ideal + u
Sigma
Spectroscopic Redshift


Sigma versus redshift.
DES + IR
Pan-STARRS + IR
LSST + IR
Ideal + IR
Ideal + u + IR
Sigma
Spectroscopic Redshift

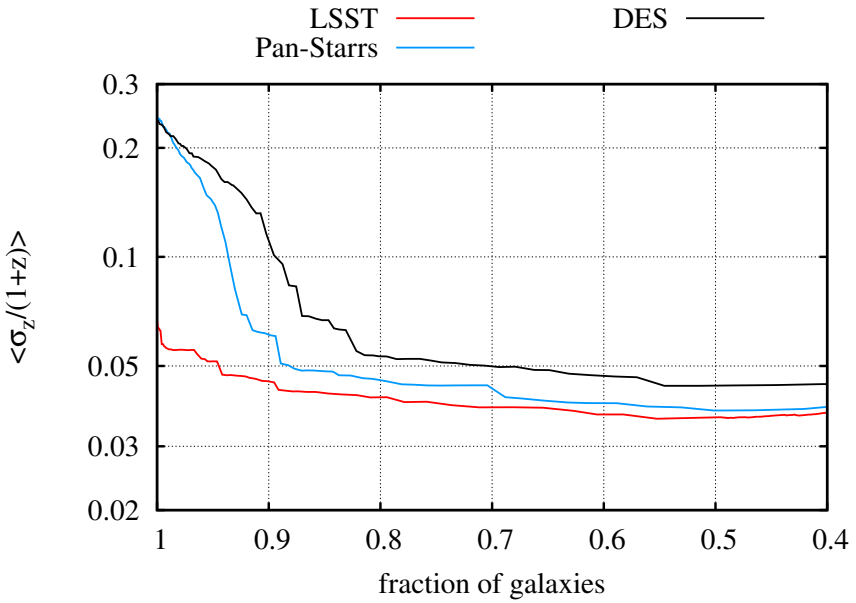
Photometric redshift simulations

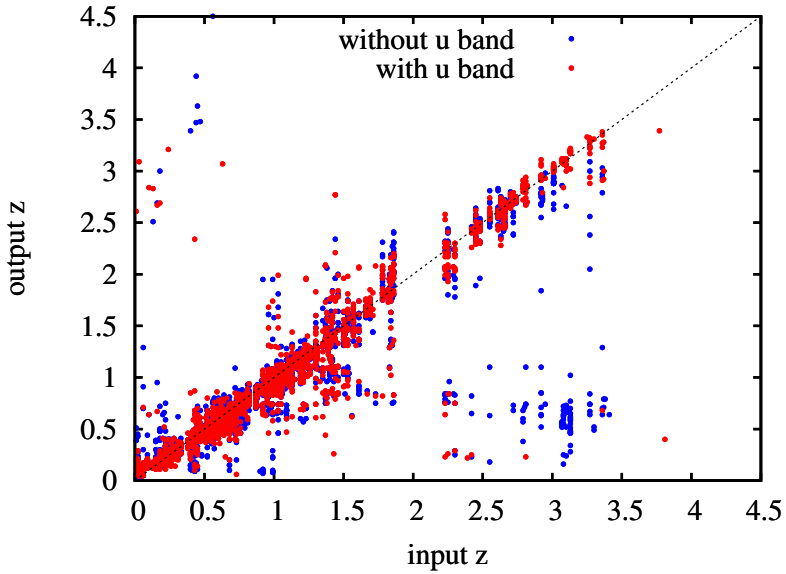
Bordoloi et al 2010

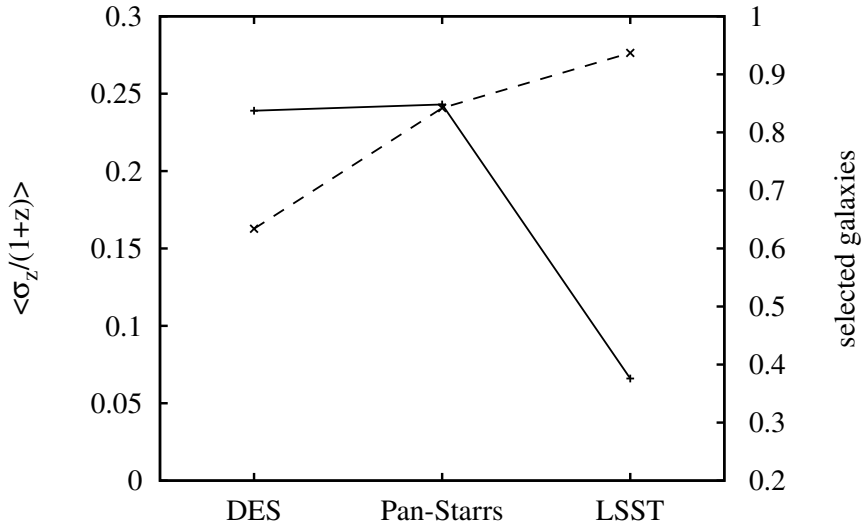


Photometric redshift simulations

Bellagamba et al 2012







Euclid complementary data options

Photometric redshifts

- Need wide area coverage at moderate depth i~24.5
- Default so far: DES and PanSTARRS data
- DES option seems secured
- PS option is more complicated
- Other possible options:
  - HSC
  - LSST
  - CFHT
  - WHT/PAU

Euclid complementary data options

Photometric redshifts

- WHT/PAU option
- Current corrector: 4 deg^2/hr/filter => 200 nights
- New corrector: 12 deg^2/hr/filter => 70 nights

Euclid complementary data options

Photometric redshifts

- Need for spectroscopc taining sets
- Main worry completeness and depth
- Cross-coorelation techniques
- Expensive spectroscopoic redshift: WHT/WEAVE, CAHA/ Hexa
- Regions of parameter space may only be accesible with photometris redshifts themselves:WHT/PAU

Euclid complementary data options

Systematics effects: intrinsic alignments

- WHT/PAU role
- Need redshifts in area where galaxy shears have been measured with sufficient area coverage and depth

Euclid complementary data needs summary

Photometric redshifts

- Need wide area coverage with other bands => photometry
  - wide area brod band survey
- Need spectroscopic training sets => spectroscopy
  - alternative with photo-z in some regons of parameters space

Systematics: intrinsic alignments

- Combined wide area lensing and spectroscopic survey with high compleness
  - Well suited for WHT/PAU