WFIRST & Euclid

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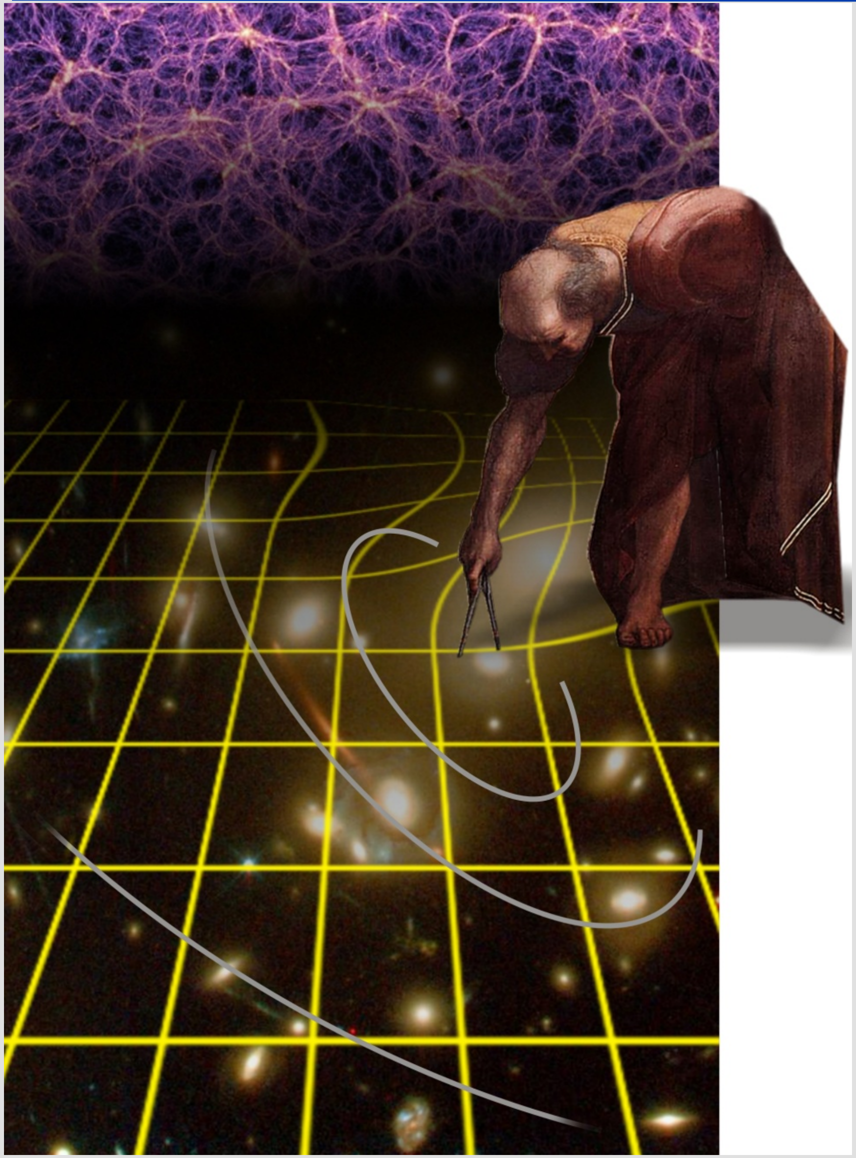
The Missions



Euclid

Mapping the geometry of the Dark Universe

2004: Dark Universe Mission proposed as a Theme to ESA's Cosmic Vision programme

Oct 2007: DUNE and SPACE jointly selected for an ESA Assessment Phase

April 2010: Formation of single Euclid Consortium

2010-2011: Definition phase

July 2011: Final Euclid Proposal- Red Book

Oct 2011: Cosmic Vision Approval of Euclid

June 2012: Official selection of Euclid and start of implementation

2012-2019: Implementation phase

2019: launch

2020-2026 :science operations

Euclid goals

Understand the nature of Dark Energy and Dark Matter by:

•Measuring the DE equation of state parameters w_0 *and* w_a to a precision of 2% and 10%, respectively, using both expansion history and structure growth.

•Measuring the growth factor exponent γ with a precision of 2%, enabling to distinguish General Relativity from the modified-gravity theories

•Testing 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.

•Improving by a factor of 20 the determination of the initial condition parameters compared to Planck alone.

scientific goals outlined in NWNH Panel Reports:

- How did the universe begin?
- Why is the universe accelerating?
- What is dark matter?
- What are the properties of neutrinos?

Euclid concept

- **Optimized for two complementary cosmological probes:**
  - **—Weak Gravitational Lensing**
  - **—Baryonic Acoustic Oscillations**
  - **Additional probes: clusters, redshift space distortions, ISW**
- **15,000 square degree survey**
  - **—Imaging (WL):**
    - **High precision imaging at visible wavelengths**
    - **Photometry/Imaging in the near-infrared**
  - **—Near Infrared Spectroscopy (BAO)**
- **SN, exoplanet microlensing not part of science goals now**
  - **—Possible, but not planned**

Euclid Mission Baseline

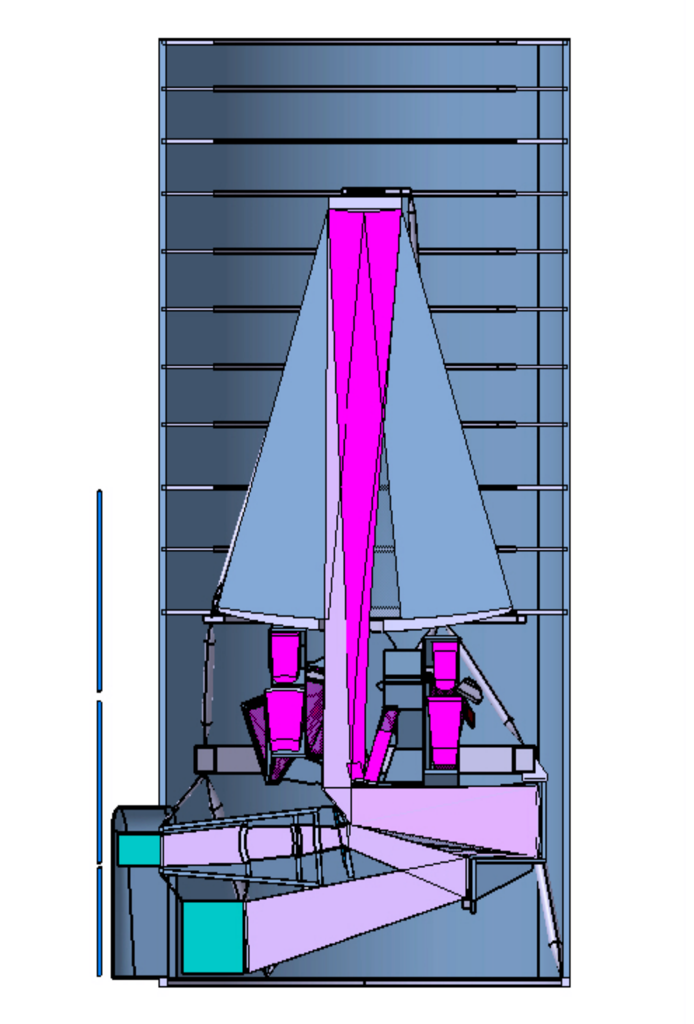
Mission elements:

- L2 Orbit
- 6.25 yr primary mission
- Telescope: three mirror astigmat (TMA) with 1.2 m primary
- Instruments:

– VIS: Visible imaging channel: 0.5 deg^2, 0.10" pixels, 0.16" PSF FWHM, broad band R+I+Z (0.5-0.9mu), 36 CCD detectors, 2/36 CCDs have narrower filter, galaxy shapes

– NISP: NIR channel: 0.5 deg^2, 16 HgCdTe detectors, 1-2mu:

  - Photometry: 0.3" pixels, 3 bands Y,J,H, photo-z's
  - Spectroscopy: slitless, R=500, redshifts



One of two possible telescope designs, both obstructed

Impact on Cosmology

	Modified Gravity	Dark Matter	Initial Conditions	Dark Energy		
Parameter	γ	m_ν/eV	f_{NL}	w_p	w_a	FoM
Euclid Primary^	0.01	0.027	5.5	0.015	0.150	430
Euclid All	0.009	0.02	2	0.013	0.048	1540
Euclid+Planck	0.007	0.019	2	0.007	0.035	4020
Current*	0.2	0.58	100	0.1	1.5	~10
Factor Improvement	**30**	**30**	**50**	**>10**	**>50**	**>300**

$f = d\ln\delta_m / d\ln a \propto \Omega_m^{\gamma}$

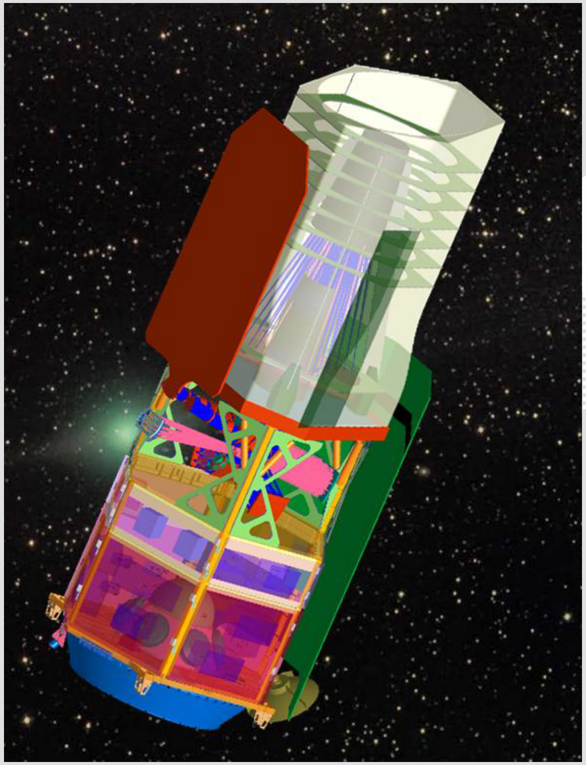
$w(a)=w_p+w_a(a_p-a)$

$FoM=1/(dw_p dw_a)$

Primary: Five year survey with weak lensing and galaxy clustering from 15,000 deg^2 of optical/NIR imaging and slitless spectroscopy (RIZ > 24.5, YJH > 24) and DES/PS2 ground-based data

All: Including RSD, ISW and clusters from same survey data

WFIRST =



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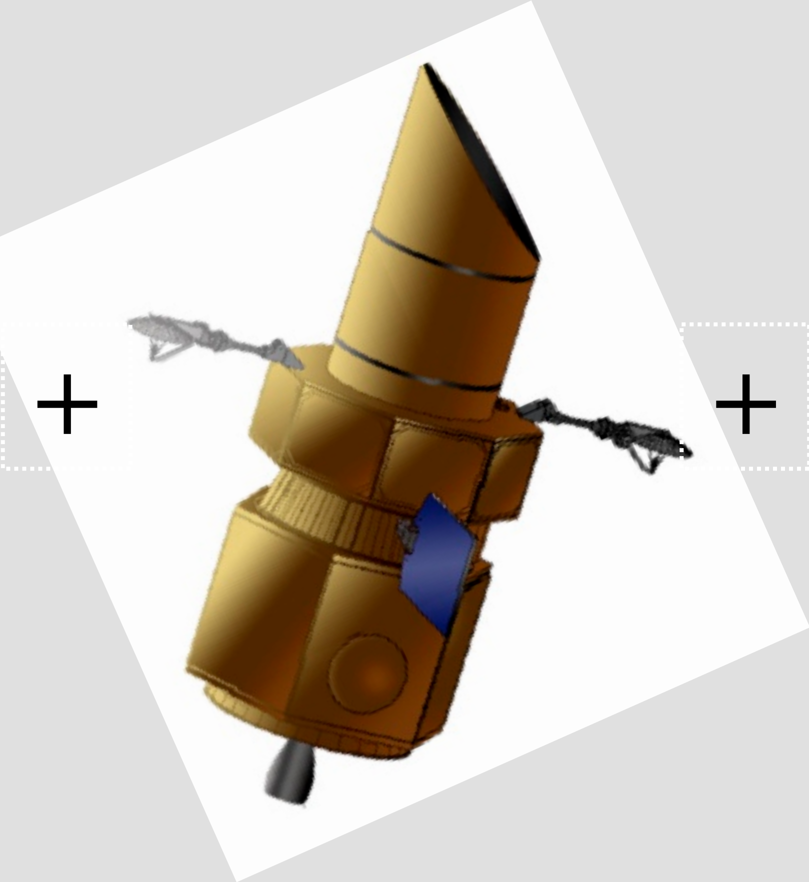

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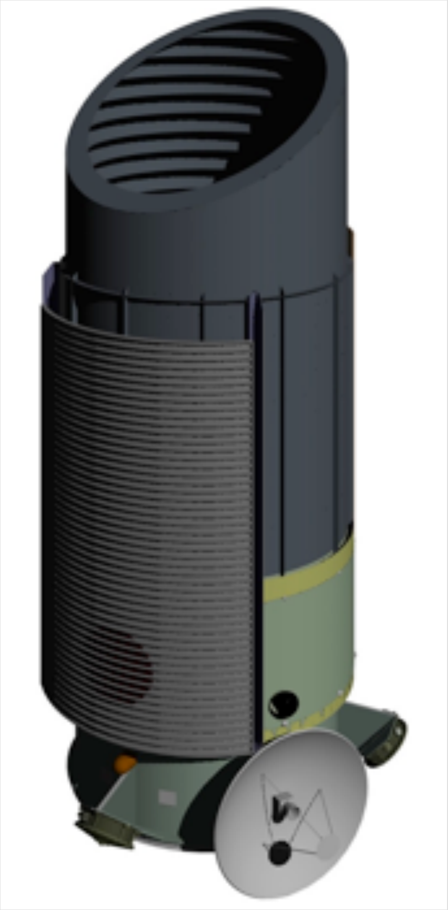


JDEM-Ω

MPF

NIRSS

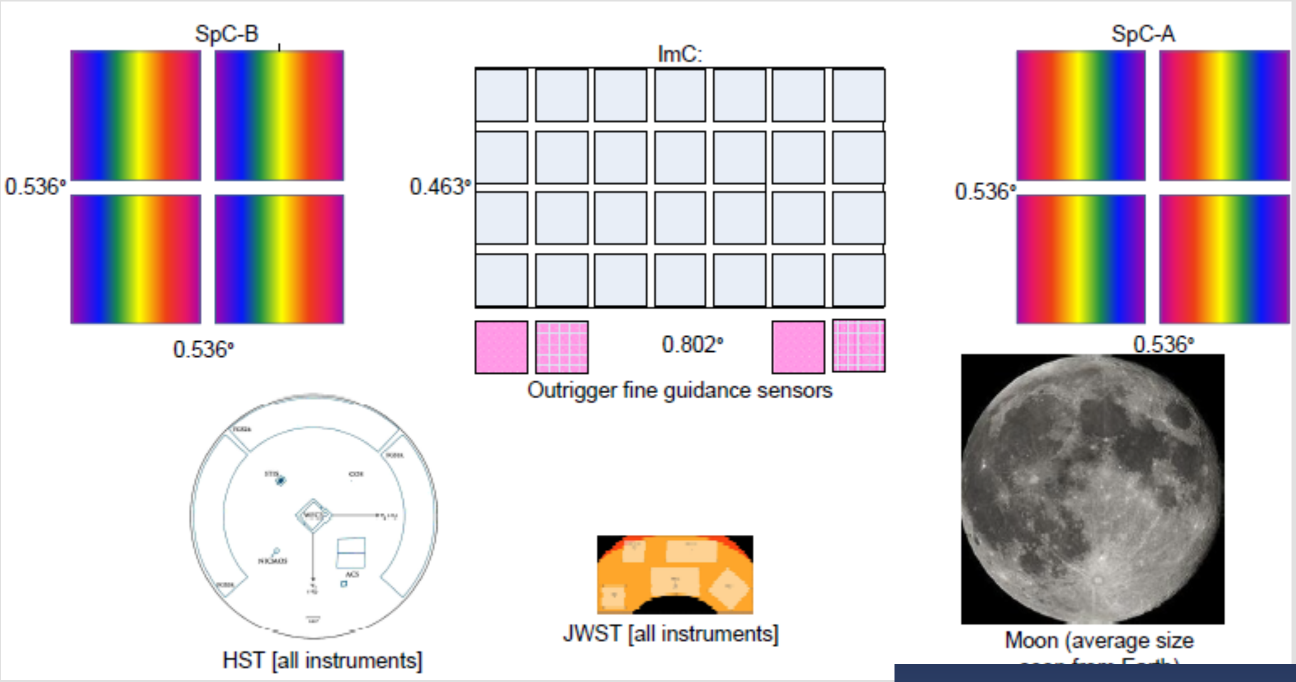
WFIRST – Science Objectives

1) Complete the statistical census of planetary systems in the Galaxy, from habitable Earth-mass planets to free floating planets, including analogs to all of the planets in our Solar System except Mercury.

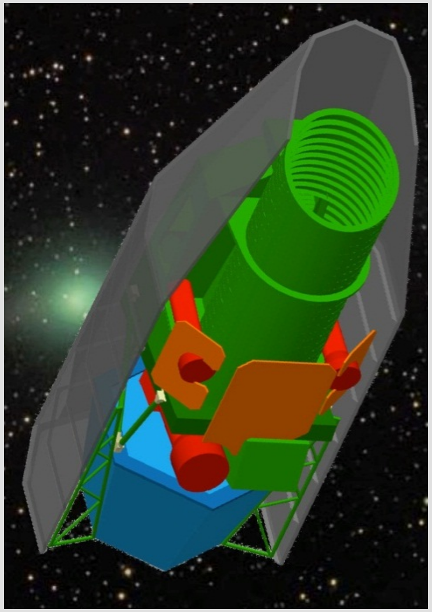
2) Determine the expansion history of the Universe and its growth of structure in order to test explanations of its apparent accelerating expansion including Dark Energy and possible modifications to Einstein's gravity.

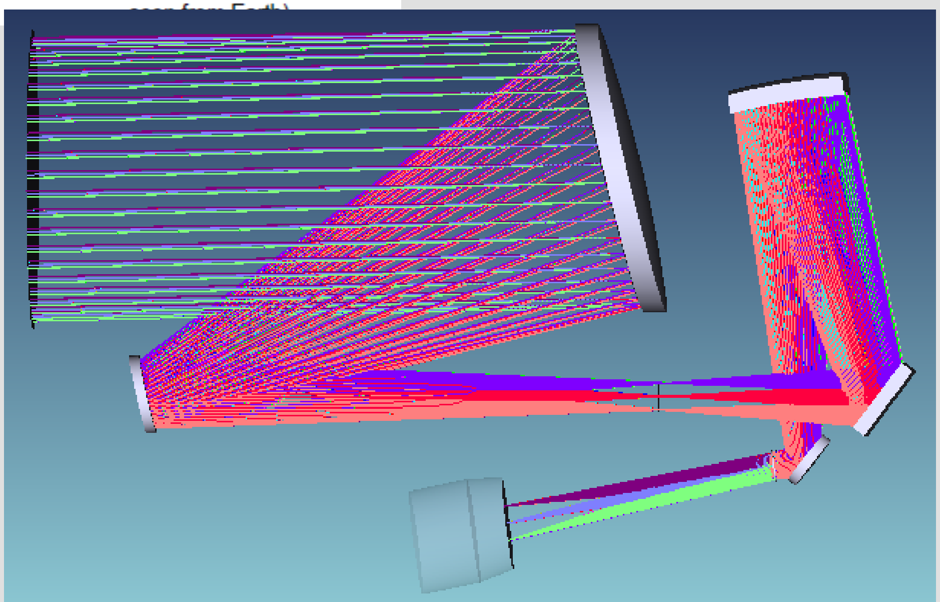
3) Produce a deep map of the sky at NIR wavelengths, enabling new and fundamental discoveries ranging from mapping the Galactic plane to probing the reionization epoch by finding bright quasars at z>10.

WFIRST – A **Survey** Telescope



WFIRST Focal plane





Off-axis design gives high throughput and excellent point spread function

WFIRST and Euclid Do not Work Alone

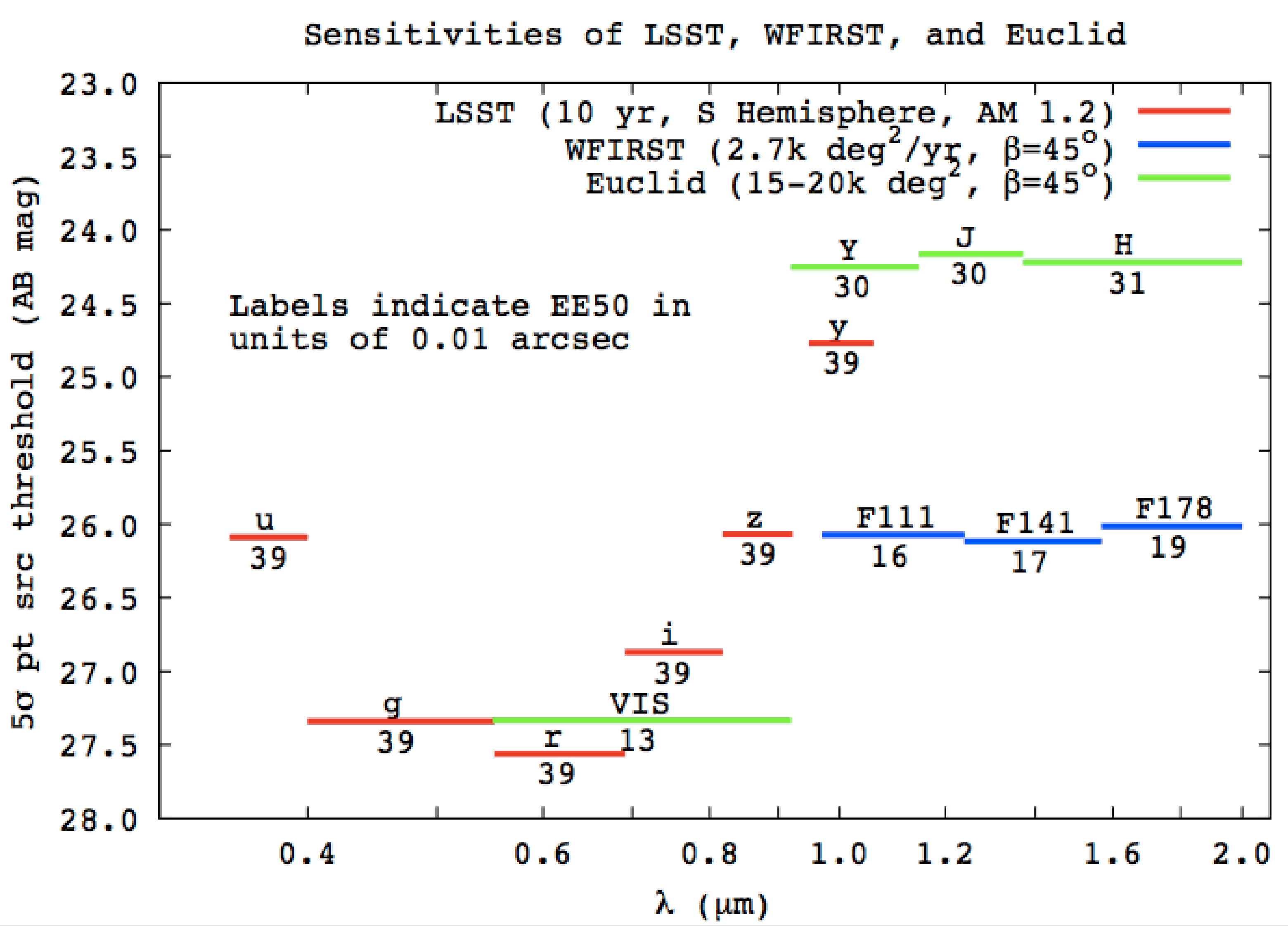
- Both require optical ground based photometry for photo-zs
- Euclid gets shapes in one optical filter that is not very useful for photo-z
- WFIRST does not take optical data in deep survey mode
  - DES, LSST in South
  - HSC, PS2 in North

- Both require significant number of spectroscopic redshifts for photo-z calibration
  - PFS or another facility?

Comparison

	WFIRST IDRM	Euclid
Aperture	1.3m unobstructed (equivalent to 1.5m obstructed)	1.2 m obstructed
Wavelength range	760nm-2μm	500nm-2μm
Pixel size	018” NIR imaging 0.45” NIR spectro	0.1” optical imaging 0.3” NIR imaging and spectro
Science goals	DE and modified gravity, exoplanet microlensing, IR surveys	DE and modified gravity, dark matter
Lifetime	5 years primary, 10 years goal	6.5 years primary
Instruments	1. NIR imaging instrument with filter wheel (0.29 deg^2) and prism 2. 2 NIR spectrographs (0.26 deg^2)	1. Optical imager (VIS) with fixed filter (s) (0.5 deg^2) 2. NIR instrument (NISP) with filter wheel and grism (0.5 deg^2)
More info?	http://wfirst.gsfc.nasa.gov/science/WFIRST_Interim_Report.pdf	http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=48983

Survey Comparison



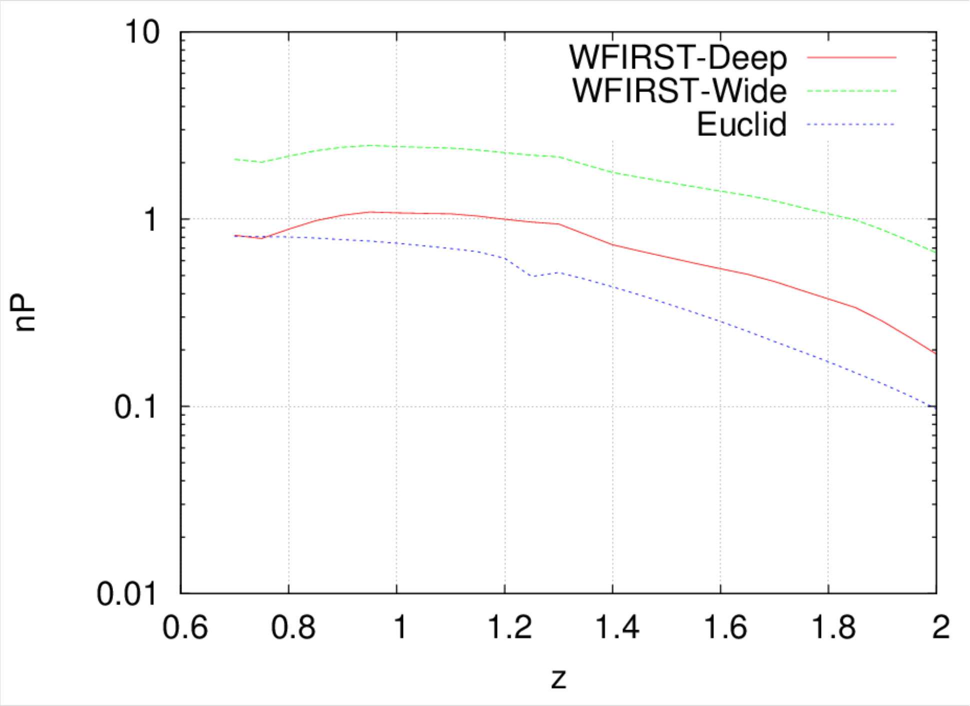
Plot courtesy of Chris Hirata

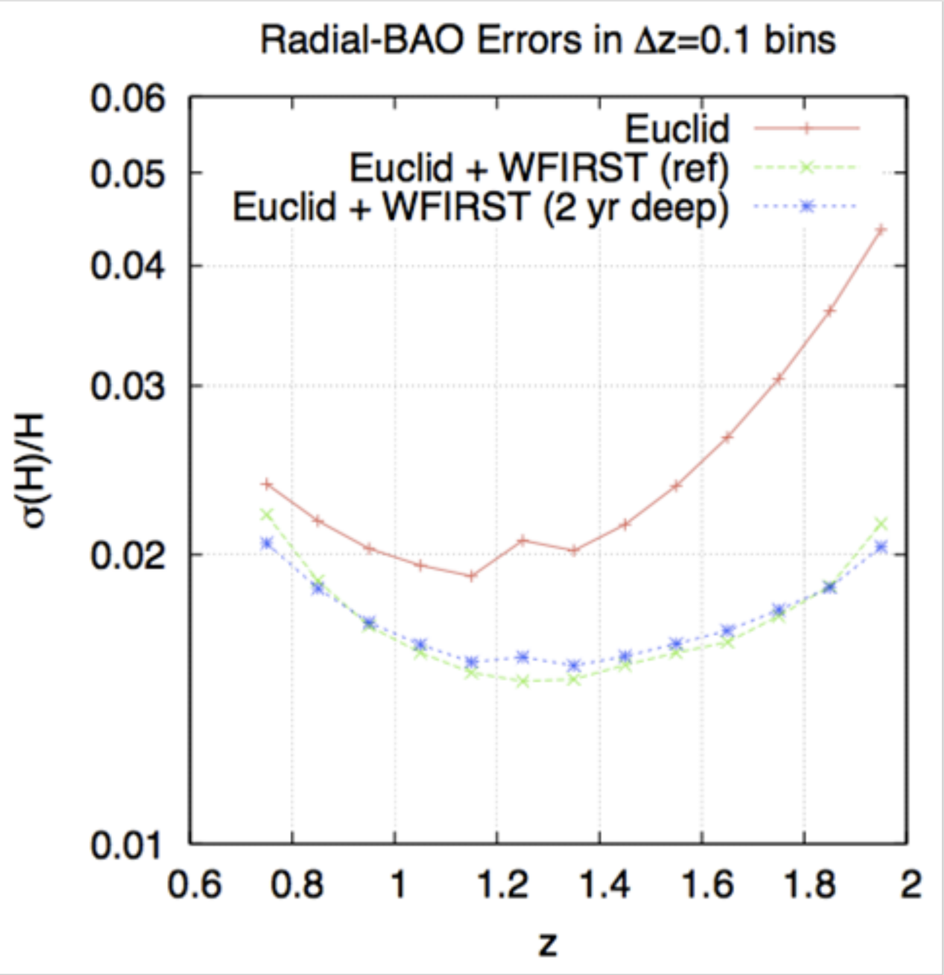
WL Comparison

	WFIRST	Euclid
Shape bands	2 NIR bands with shapes	Single wide riz band w/ possible second band on 2/36 CCDs for calibration or calibration with HST data
N_eff	~30	~30
Area	2700 square degrees	15,000 square degrees
Sampling	2 bands well sampled with 5 random dithers	Single band usually well sampled with 4 random dithers but ~50% of sky has only 3 exposures (almost well sampled)*
Ellipticity noise	May be slightly improved due to NIR, but effect is small	Typical optical WL value
Redundancy	Yes	No

* Well sampled is defined in Rowe, Hirata, Rhodes (2011)

BAO Comparison





Plots courtesy of Chris Hirata

BAO Comparison

	WFIRST	Euclid
Line flux	Hα emission line flux at 2.0 μm ≥1.5x10^{-16} erg/cm2-s (DEEP) or 3.1x10^{-16} erg/cm^2-s (WIDE)	3x 10^{-16} erg cm^{-2} s^{-1} 3.5σ unresolved line flux
Area	13,700 square degrees (wide+deep)	15,000 square degrees
Imaging	Simultaneous imaging over different area	Simultaneous optical imaging over same area

“Other” Comparison

μlensing:

- Euclid could do this, with some loss of sensitivity in optical
- Observing time and baseline are critical
- Some questions remain about number of allowed slews

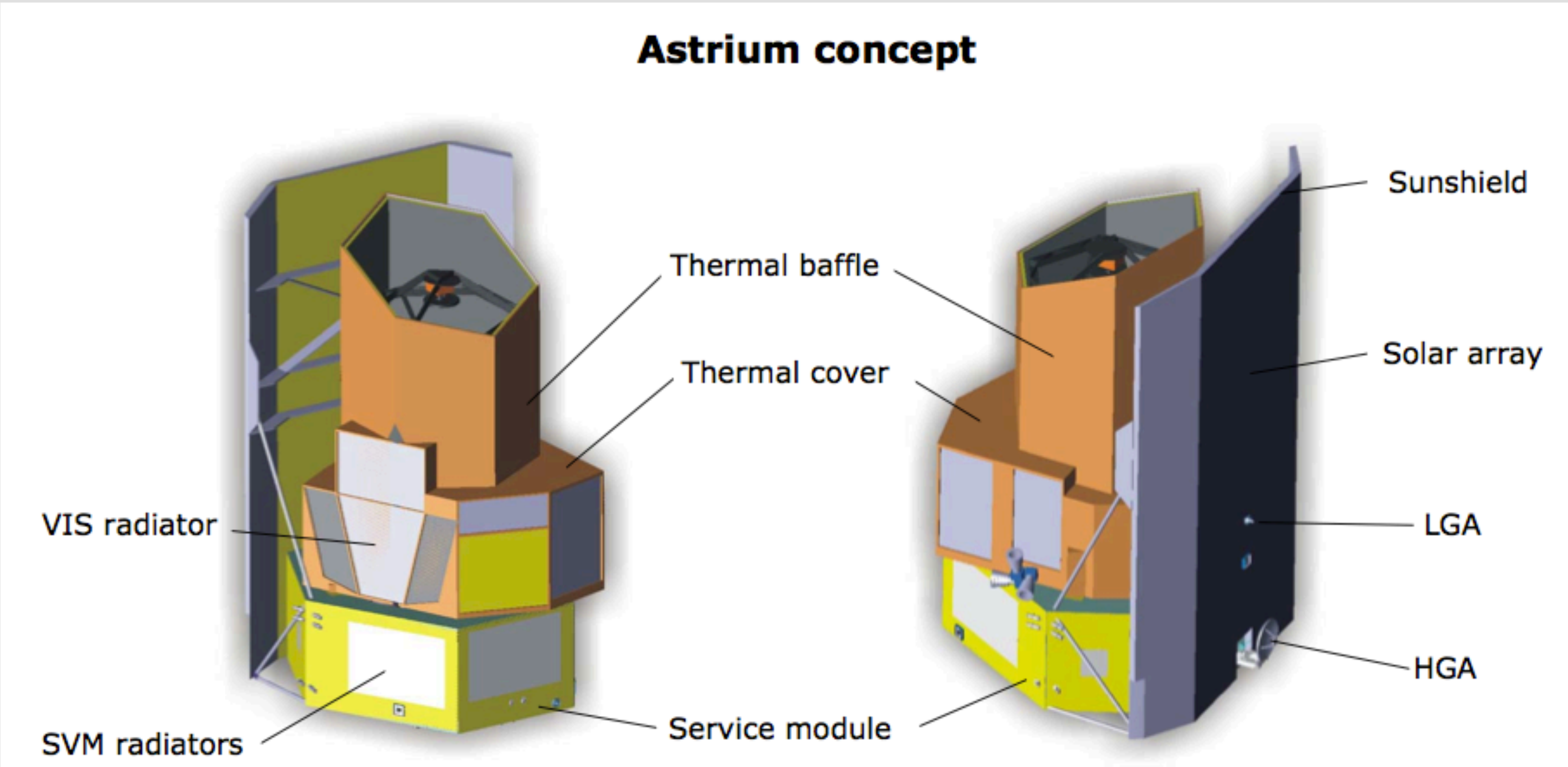
SN:

- Euclid does not have an observing cadence that makes this efficient in one (of two) industrial design
- Even assuming reaction wheels follow up with grism is not optimal
- Would require dedicated survey time (deep and calibration fields not sufficient

NIR survey:

- Euclid surveys a larger area with a lower depth and poorer resolution

Euclid spacecraft preliminary design



Euclid spacecraft preliminary design