



The Wide Field Infrared Survey Telescope (WFIRST)

Alex Merson

Jet Propulsion Laboratory/California Institute of Technology/IPAC
(on behalf of the WFIRST Cosmology with the HLS SIT)

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HLS Science Investigation Team Members

Ivano Baronchelli (Caltech/IPAC)

Rachel Bean (Cornell)

Andrew Benson (Carnegie)

Peter Capak (Caltech/IPAC)

Ami Choi (OSU)

James Colbert (Caltech/IPAC)

Olivier Doré (JPL/Caltech, PI)

Tim Eifler (JPL/Caltech)

Chen He Heinrich (JPL/Caltech)

Katrin Heitmann (ANL)

George Helou (Caltech/IPAC)

Shoubaneh Hemmati
(IPAC/Caltech)

Shirley Ho (LBL)

Eric Huff (JPL)

Albert Izard (JPL)

Bhuvnesh Jain (Penn)

Mike Jarvis (Penn)

Alina Kiessling (JPL/Caltech)

Elisabeth Krause (Stanford)

**Chris Hirata (OSU,
Weak lensing lead)**

Alexie Leauthaud (UCSC)

Robert Lupton (Princeton)

Niall MacCrann (OSU)

Rachel Mandelbaum (CMU)

Elena Massara (LBL)

Dan Masters (JPL)

Alex Merson (JPL/IPAC)

Hironao Miyatake (JPL/Caltech)

Nikhil Padmanabhan (Yale)

Alice Pisani (Princeton)

Andres Plazas Malagon (JPL/Caltech)

Eduardo Rozo (U. Arizona)

Lado Samushia (U. Kansas)

Mike Seiffert (JPL/Caltech)

Charles Shapiro (JPL/Caltech)

Melanie Simet (UCR/JPL)

David Spergel (Princeton, CCA)

Harry Teplitz (Caltech/IPAC)

Michael Troxel (OSU)

Anja von der Linden
(Stony Brook University)

**Yun Wang (Caltech/IPAC,
Galaxy redshift survey lead)**

**David Weinberg (OSU,
Galaxy clusters lead)**

Hao-Yi Wu (OSU)

Ying Zu (OSU)

~40 members

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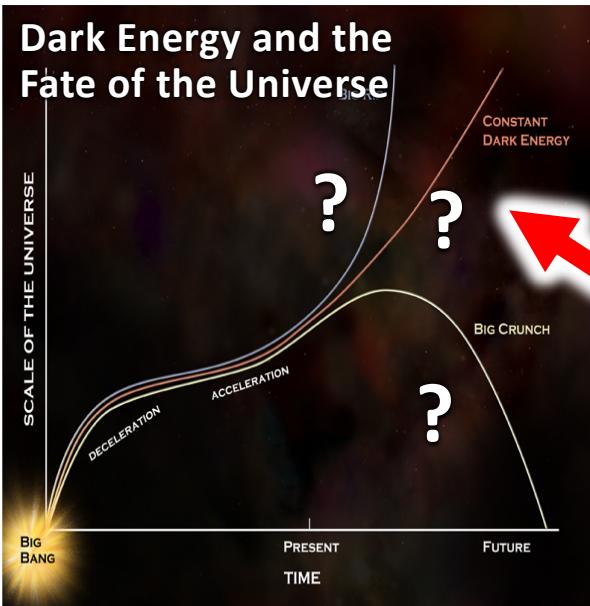
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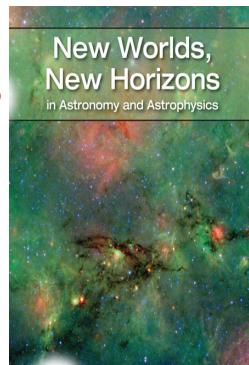
Ying Zu (OSU)

~22 also members of
Euclid Consortium

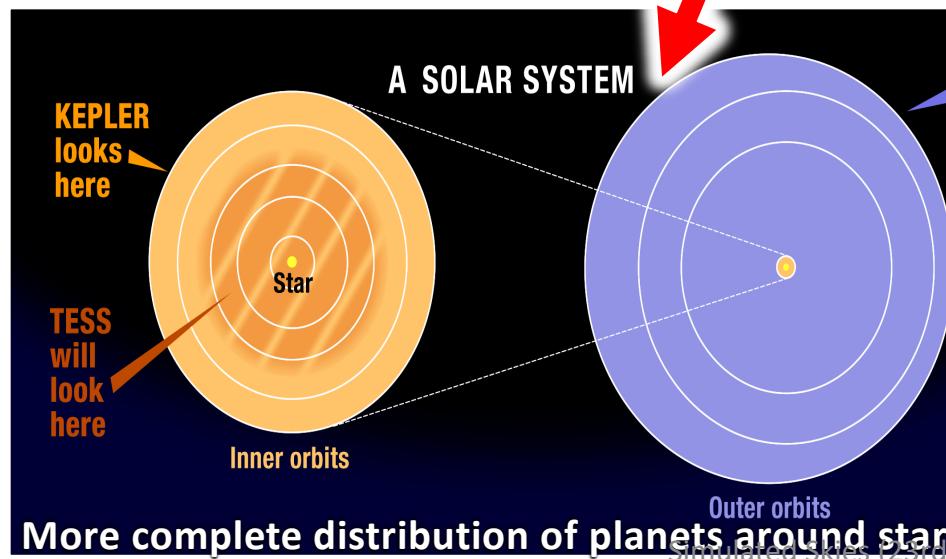
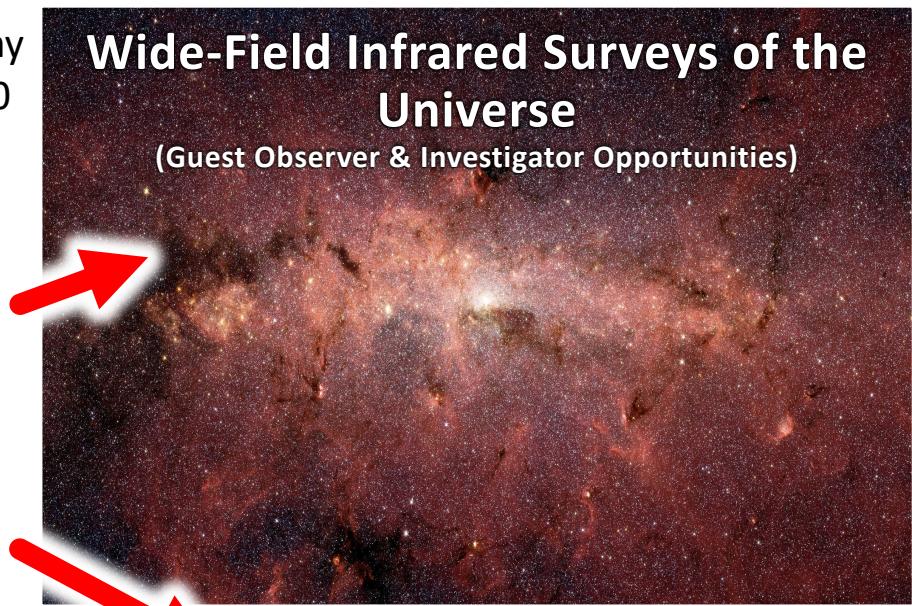
WFIRST Scientific Objectives



National Academy
of Sciences 2010
Decadal Survey



Wide-Field Infrared Surveys of the Universe
(Guest Observer & Investigator Opportunities)



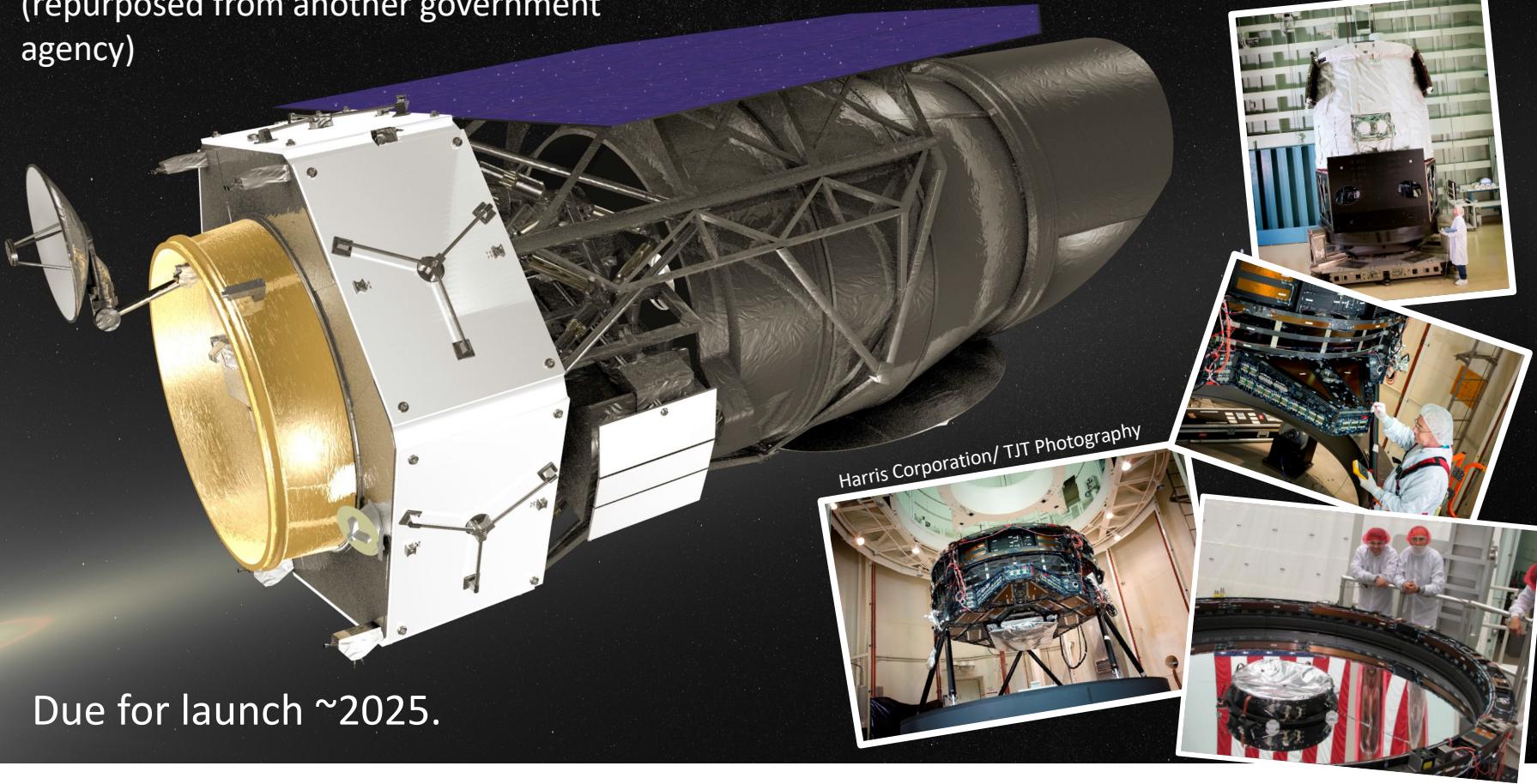
More complete distribution of planets around stars

Simulated Skies (23rd-25th April 2018)



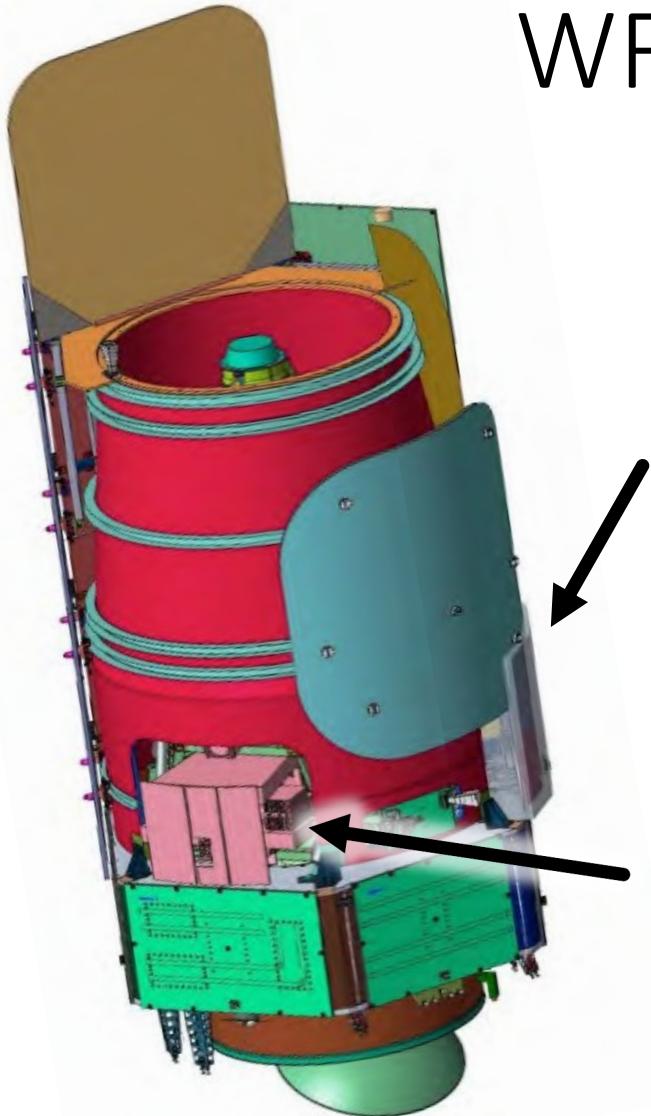
WFIRST: the next NASA flagship mission

- Top priority for large space-based telescope.
- 2.4m Hubble-sized telescope (repurposed from another government agency)
- Dark energy and exoplanet mission with wide-field survey capabilities.



- Due for launch ~2025.

WFIRST Instruments



Wide Field Instrument

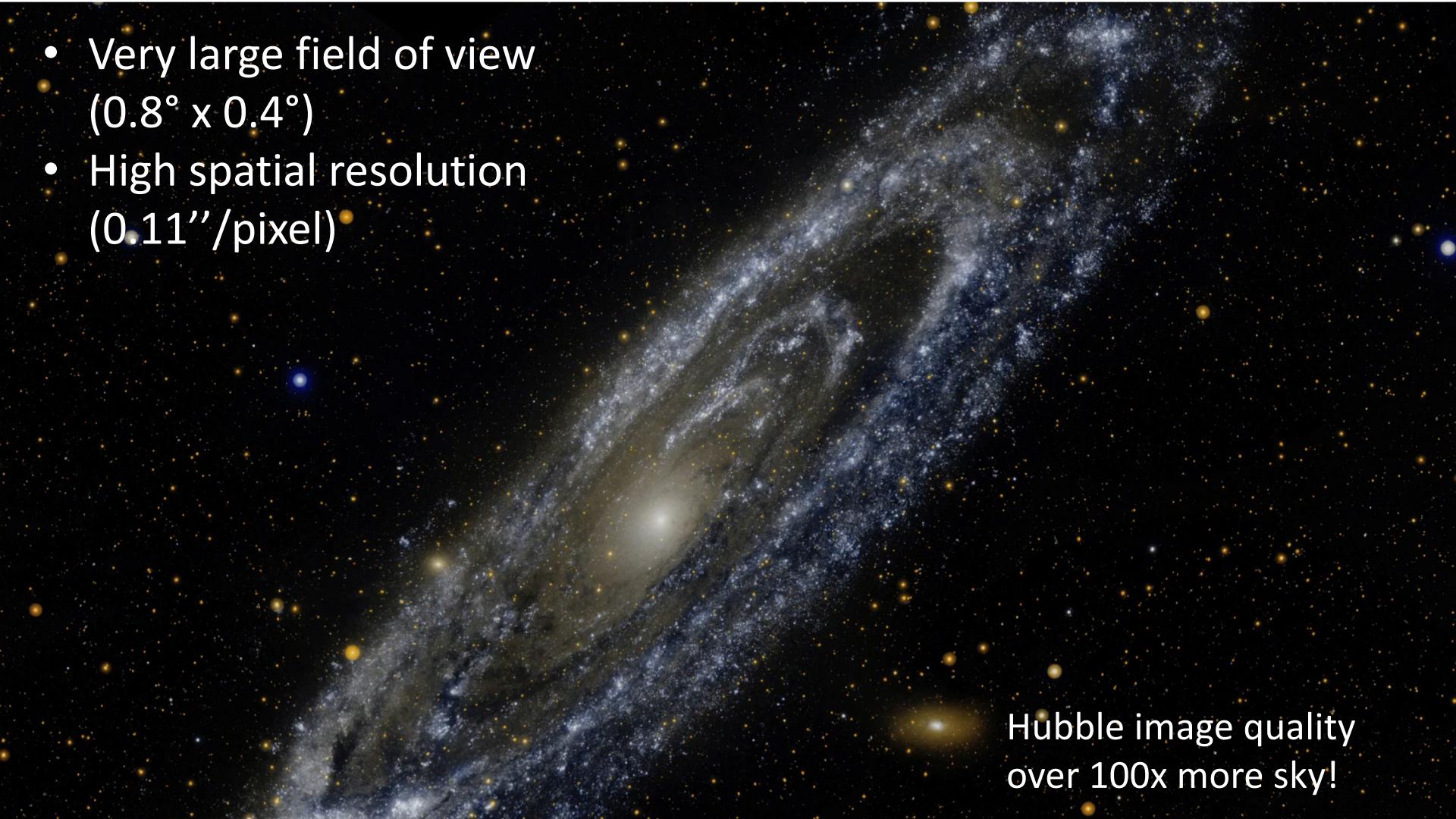
- Imaging & spectroscopy over 1000s sq.deg.
- Monitoring of SN and microlensing fields
- Near-IR filter imaging, grism + IFC spectroscopy
- 0.7-2.0 μm (imaging), ~1.0-2.0 μm (spec.)
- 0.28 deg² FoV (100x Hubble and JWST FoV)
- 18 H4RG detectors (288 Mega pixels)

Coronagraph (technology demonstration)

- Imaging and spectroscopy of exoplanets (Jupiter/Neptune-like exoplanets)
- Imaging of debris discs
- 430-970 nm (imaging), 600-970 nm (spec.)
- Planet/star flux ratio of 10^{-9} (or better)
- Exoplanet imaging from 0.1 – 1.0 arcseconds

WFIRST = wide field + high resolution

- Very large field of view
($0.8^\circ \times 0.4^\circ$)
- High spatial resolution
($0.11''/\text{pixel}$)



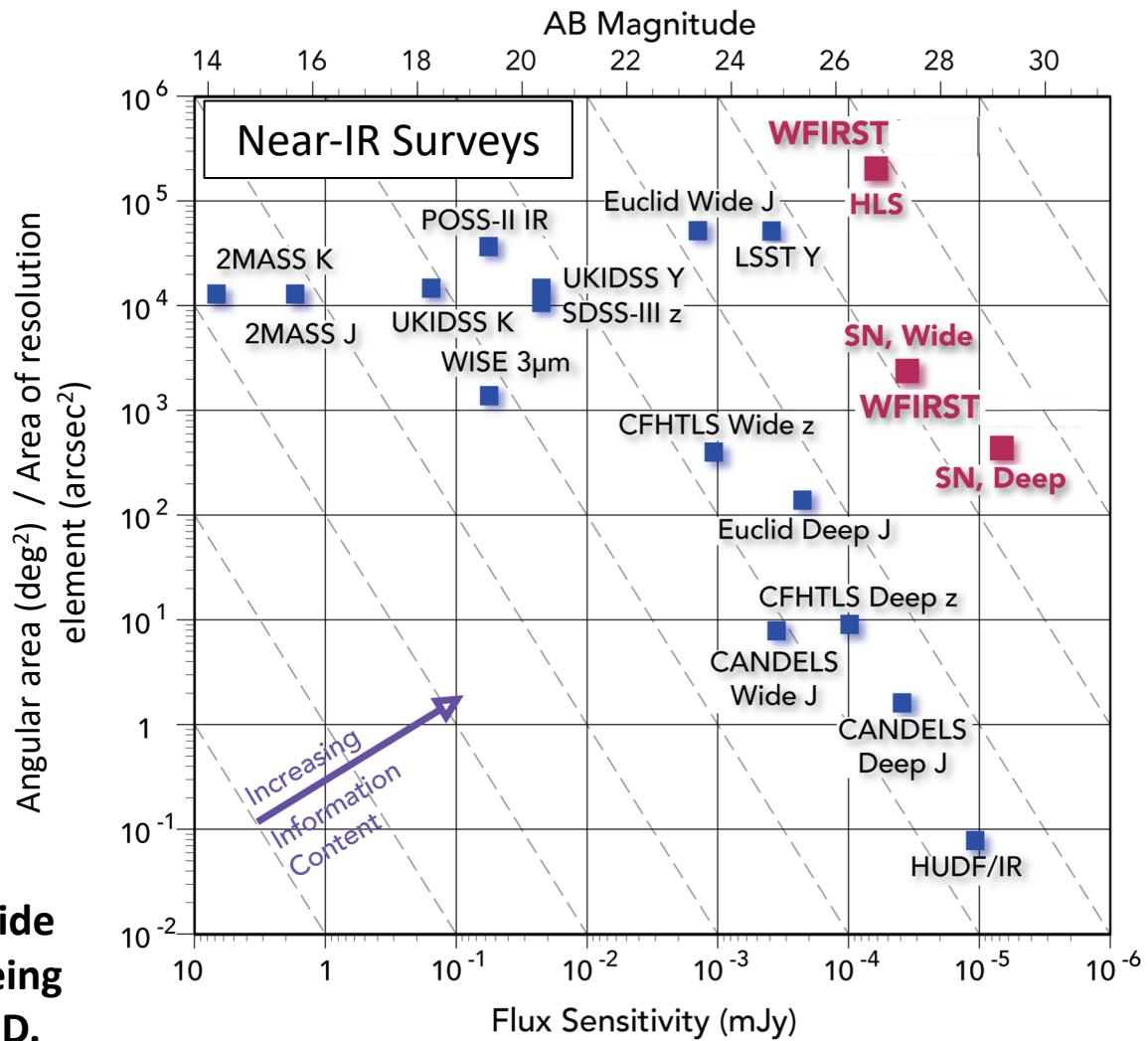
Hubble image quality
over 100x more sky!

WFIRST Surveys

Figure: wfirst.gsfc.nasa.gov

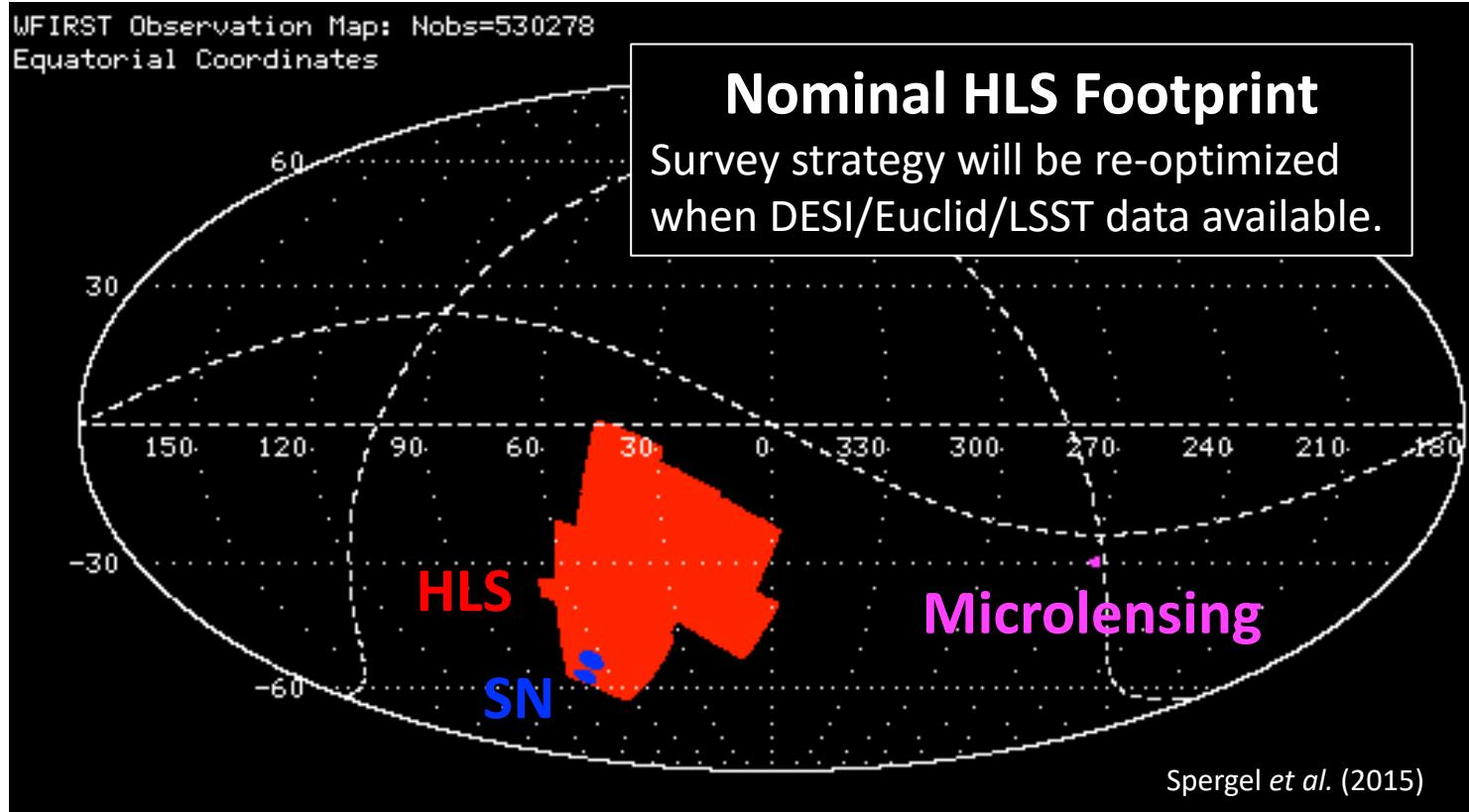
5 year nominal mission:

- High Latitude Survey (HLS) [1.5 years]
 - Imaging
 - Slitless spectroscopy
- SN monitoring [6 months]
- 25% GO Program (100% in extended mission)
- Coronagraph observations & technology demonstration [TBD]
- Repeat observations of Galactic bulge (microlensing events) [~ 1 year]



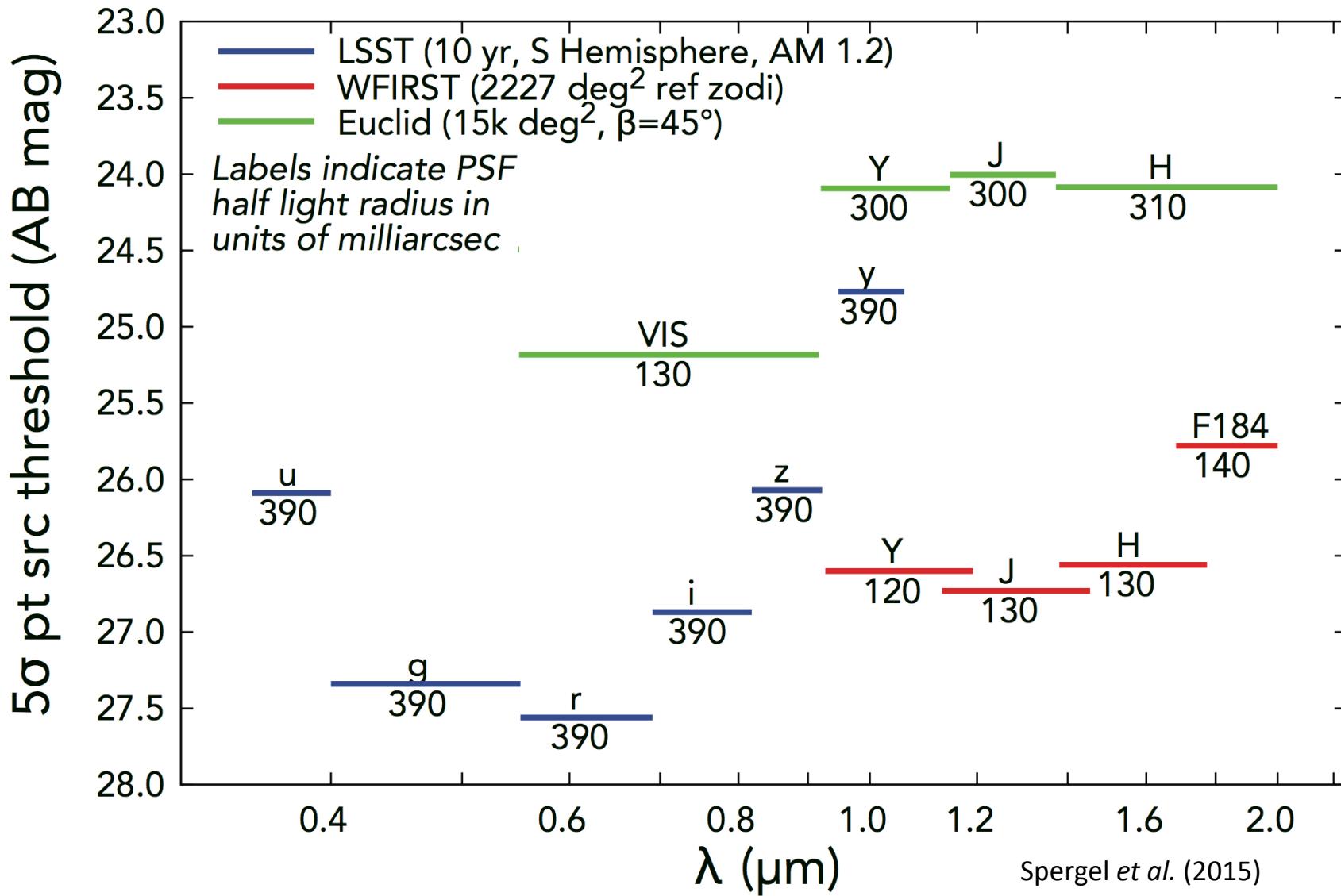
All data to be made public worldwide within few days of observations being taken, i.e. NO PROPRIETARY PERIOD.

WFIRST High Latitude Survey (HLS)



- Nominally 1.5yr over $\sim 2,000 \text{ deg}^2$ in southern sky (c.f. Euclid: $15,000 \text{ deg}^2$ over 6yr)
- Cosmological probes: (i) near-IR spectroscopic galaxy clustering (BAO+RSD)
 $f > 1 \times 10^{-16} \text{ ergs/s/cm}^2$ (c.f. Euclid: $2 \times 10^{-16} \text{ ergs/s/cm}^2$)
(ii) gravitational weak lensing shear measurements
Y, J, H, (F184) to AB ~ 26.5 (5σ point src) (c.f. Euclid VIS AB ~ 24.5)

Sensitivities of LSST, WFIRST, and Euclid



WFIRST Dark Energy Science Outline

Supernova Survey

wide, medium, & deep imaging
+
IFU spectroscopy

2700 type Ia supernovae
 $z = 0.1\text{--}1.7$

High Latitude Survey

spectroscopic: galaxy redshifts

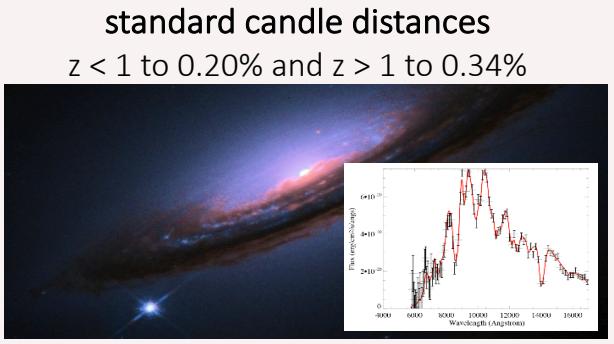
20 million H α galaxies, $z = 1\text{--}2$
1.4 million [OIII] galaxies, $z = 2\text{--}3$

imaging: weak lensing shapes

380 million lensed galaxies
40,000 massive clusters

standard ruler
distances expansion rate

$z = 1\text{--}2$ to 0.5% $z = 1\text{--}2$ to 0.9%
 $z = 2\text{--}3$ to 1.3% $z = 2\text{--}3$ to 2.1%



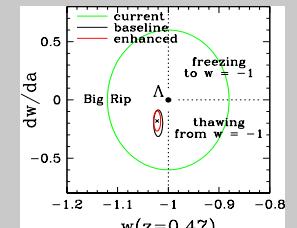
dark matter clustering

$z < 1$ to 0.21% (WL); 0.24% (CL)
 $z > 1$ to 0.78% (WL); 0.88% (CL)
1.1% (RSD)



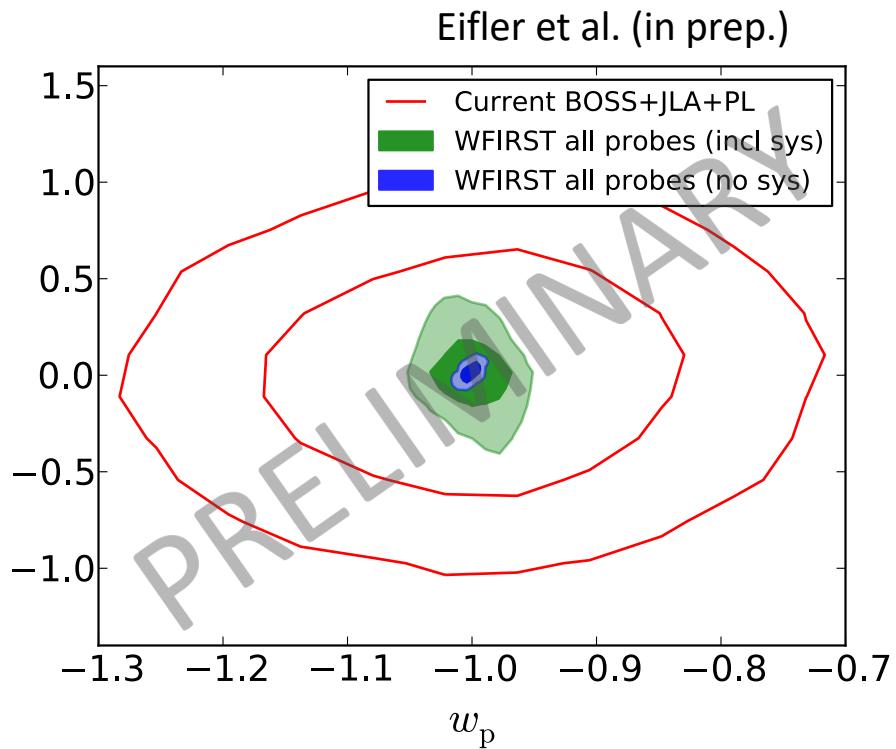
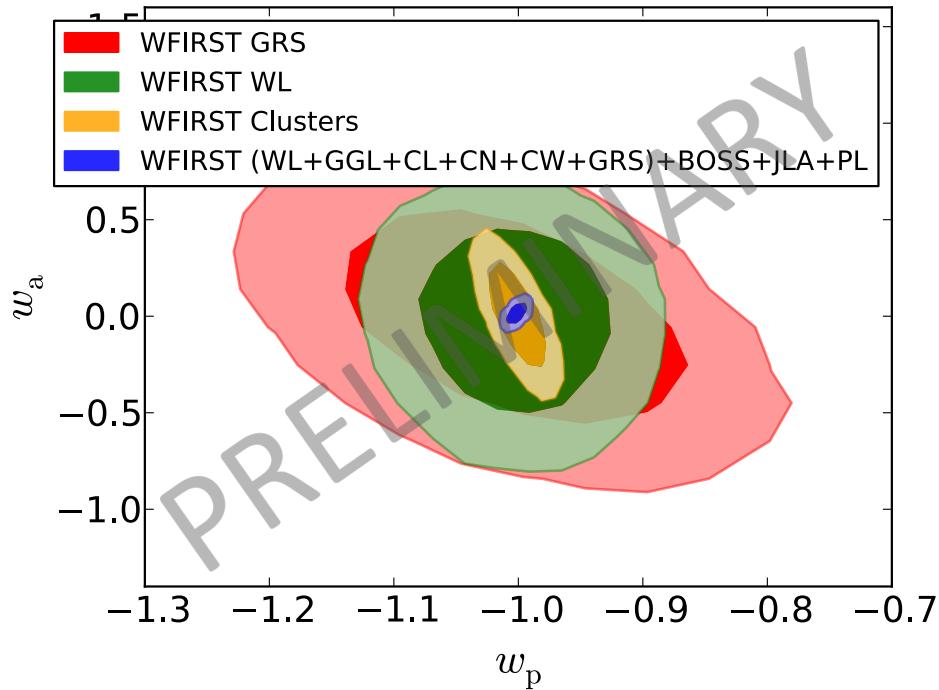
history of dark energy
+
deviations from GR

$w(z)$, $\Delta G(z)$, $\Phi_{\text{REL}}/\Phi_{\text{NREL}}$



Spergel *et al.*
(2015)

Multi-probe Cosmology



- Demonstration of power of **multi-probe mission**.
- WFIRST strategy **optimized to address systematics** and maximize robustness of results (c.f. Euclid optimized for statistical precision).

Stage IV Dark Energy Surveys Comparison

	DESI	Euclid	WFIRST	LSST
Start, duration	2019, 5yr	2021, 6yr	~2025, 5(-10)yr	2022, 10yr
Area (sq. deg.)	14,000 (N)	15,000 (N+S)	2,000 (S)	20,000 (S)
FOV (sq.deg.)	7.9	0.53	0.281	10
Mirror diameter (m)	4	1.3	2.4	6.7
Spectroscopic Survey	Fibers R=2000-5500 0.36-0.98 μm	Grism R=250 1.25-1.85 μm	Grism R=461 λ 1-2 μm	
Spectroscopic Galaxies	LRGs + ELGs $z \sim 0.6-1.6$ (20M-30M)	ELGs: $z \sim 0.9-1.8$ (~30M)	ELGs: $z \sim 1-2$ Ha (~20M) $z \sim 2-3$ [OIII] (~2M)	
Photometric Survey		4 bands (YJH+VIS)	4 bands (YJH+F184)	6 bands (ugrizY)
Photometric Galaxies (/w shapes) (#/arcmin ²)		~30 in 1 band (VIS)	~45 in 3 bands (YJH)	~30 in 6 bands (ugrizY)
SN1a			2700 $z=0.1-1.5$ IFU spectroscopy	10k-100k/yr $z=0-0.7$ photometric



Summary

- WFIRST is a **dark energy + exoplanet mission** with **wide-field capabilities**.
- WFIRST is a **2.4m telescope** that will provide **Hubble-like imaging** resolution but over **100x more sky**.
- WFIRST will nominally be a 5yr mission, but can be extended to 10yrs.
- WFIRST **High Latitude Survey** will be optimized for dark energy studies:
 - Nominally 1.5 years over $\sim 2,000 \text{ deg}^2$.
 - $\sim 22\text{M}$ ELGs observed with slitless spectroscopy over $1 < z < 3$.
 - Shape information for $\sim 380\text{M}$ galaxies ($\sim 45 \text{ galaxies/arcmin}^2$) in YJH +F184.
 - Designed to be **synergistic with DESI/Euclid/LSST**.
- WFIRST will have unique DE program providing distances for ~ 2700 SNe.
- WFIRST is designed as **multi-probe mission optimized to address systematics**.
- WFIRST = a **survey + an observatory** (25%++ GO) + an **experiment** (tech. demo.)
- WFIRST data will be made public straight away with **NO PROPRIETARY PERIOD**.

Cosmology with the HLS Science Investigation Team 2018 Report: [arXiv1804.03628](https://arxiv.org/abs/1804.03628).

www.wfirst.gsfc.nasa.gov www.wfirst-hls-cosmology.org