WELCOME ALL!

- Workshop goals:

  ➡ Review and identify new scientific synergies between WFIRST High Latitude Survey and future planned facilities across wavelengths

  ➡ Ensure that we collectively take all the required steps to realize and facilitate these synergies, both in the planning stage (now!) or when the data arrive, i.e. that we can perform joint analysis (data format, data release, code sharing, infrastructure support, analysis support,…)

  ➡ It is a workshop so please leave time for discussions and most importantly, stimulate discussions!

- Logistic:

  ➡ Caltech Guest Wireless network

  ➡ Upload your talks before your session @ goo.gl/ECRSKw

  ➡ Collect notes @ https://tinyurl.com/wfirst-synergies-workshop

WFIRST HIGH LATITUDE SURVEY

Olivier Doré

Jet Propulsion Laboratory/California Institute of Technology

"*Cosmology with the WFIRST High Latitude Survey*" Science Investigation Team

www.wfirst-hls-cosmology.org

www.wfirst.gsfc.nasa.gov

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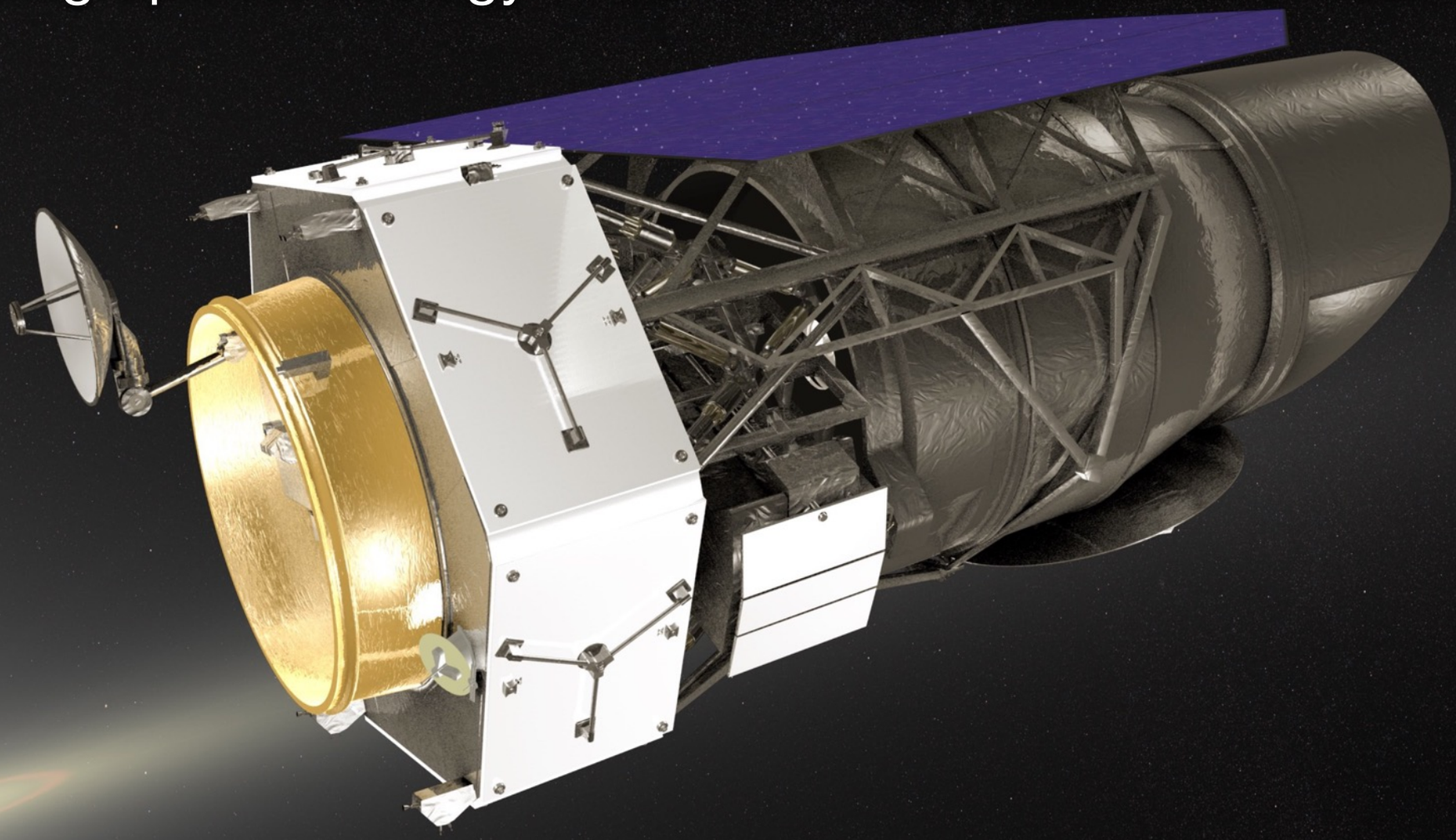
COSMOLOGY WITH THE HIGH LATITUDE SURVEY
SCIENCE INVESTIGATION TEAM

Olivier Doré (PI)	*JPL/Caltech*
Chris Hirata (WL lead)	*Ohio State U.*
Yun Wang (GRS lead)	*IPAC/Caltech*
David Weinberg (CL sub-lead)	*Ohio State U.*
Ivana Baronchelli	*IPAC/Caltech*
Rachel Bean	*Cornell*
Andrew Benson	*Carnegie*
Peter Capak	*IPAC/Caltech*
Ami Choi	*Ohio State U.U*
James Colbert	*IPAC/Caltech*
Tim Eifler	*JPL/U. Arizon*
Chen He Heinrich	*JPL*
Katrin Heitmann	*ANL*
George Helou	*IPAC/Caltech*
Shoubaneh Hemmati	*IPAC/Caltech*
Shirley Ho	*LBL/CCA*
Michael Hudson	*Waterloo*
Eric Huff	*JPL*
Albert Izard	*JPL*
Bhuvnesh Jain	*Penn*
Mike Jarvis	*Penn*
Alina Kiessling	*JPL*
Elisabeth Krause	*JPL/U. Arizon*

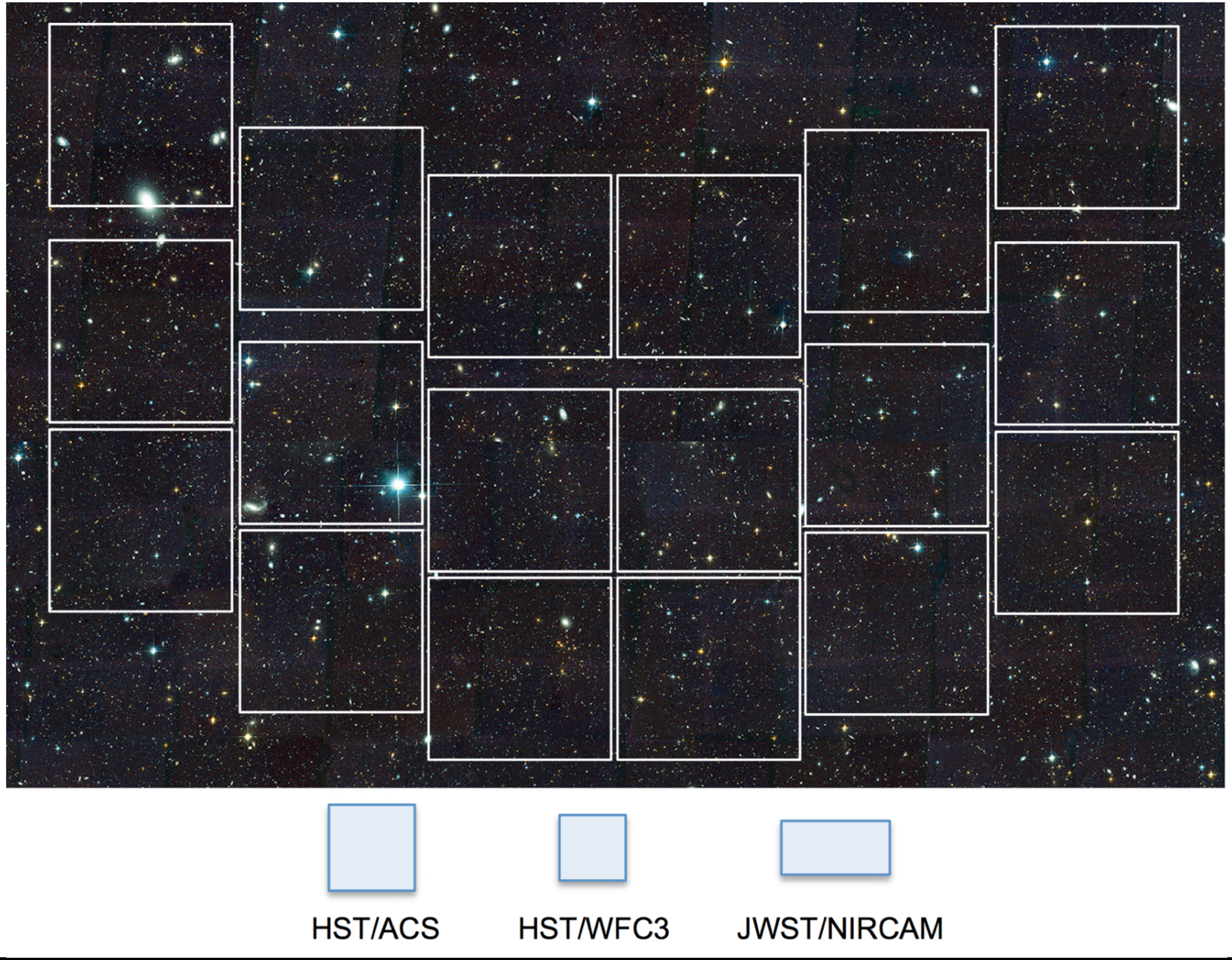
Alexis Leauthaud	*UCSC*
Robert Lupton	*Princeton*
Nial MacCrann	*Ohio State U.*
Rachel Mandelbaum	*CMU*
Elena Massara	*UCB*
Dan Masters	*JPL*
Alex Merson	*JPL*
Hironao Miyatake	*JPL*
Nikhil Padmanabhan	*Yale*
Alice Pisani	*Princeton*
Andres Plazas Malagon	*JPL*
Eduardo Rozo	*U. Arizona*
Lado Samushia	*U. Kansas*
Mike Seiffert	*JPL*
Charles Shapiro	*JPL*
Melanie Simet	*JPL*
Kendrick Smith	*Perimeter Institute*
David Spergel	*Princeton/CCA*
Masahiro Takada	*Kavli IPMU Tokyo*
Harry Teplitz	*IPAC*
Michael Troxel	*Ohio State U.*
Anja von der Linden	*Brookhaven*
Hao-Yi Wu	*Ohio State U.*
Ying Zu	*Ohio State U.*

WFIRST, THE NEXT NASA FLASHSHIP

- Top priority from the 2010 Astrophysics Decadal Survey
- Hubble sized telescope, donated by another government agency
- Hubble power and resolution, 100x the field of view
  ➡Hubble quality image over 100x more sky
- Dark energy, exoplanet, and wide-field survey capabilities
- Coronagraph technology to build the “Search for Life” foundation



0.28 SQ. DEG. FIELD OF VIEW



WFIRST STATUS

- WFIRST moving forward – Phase A entered in 2016
  - ➡ NASA “commits” to the mission

- Detector, coronagraph development
  - ➡ Reached TRL-6 in 2017
  - ➡ First payload procurements should happen soon

- Project answers to the WFIRST Independent External/Technical/Management/Cost Review (WIETR) accepted by NASA Science Mission Directorate (SMD) (Fall 2017).

- Coming Reviews:
  - ➡ SRR/MDR on-going this week
  - ➡ KDP-B April 2018

- Plan for a 2025 launch with a 5 year nominal mission (designed for 10 years)

- Troubles in the President’s *proposed* budget for FY19 released in February 18:
  - ➡ WFIRST is not cancelled!
  - ➡ Merely a first stage of negotiations between the two houses of Congress and the President's administration about the FY19 budget.
  - ➡ Negotiations will proceed over the next few months.
  - ➡ As of now, there is no change to the project office plan for WFIRST, and we expect that past strong Congressional support for WFIRST (from both major parties) will likely allow WFIRST to proceed as planned.

HOW TO SUPPORT WFIRST NOW

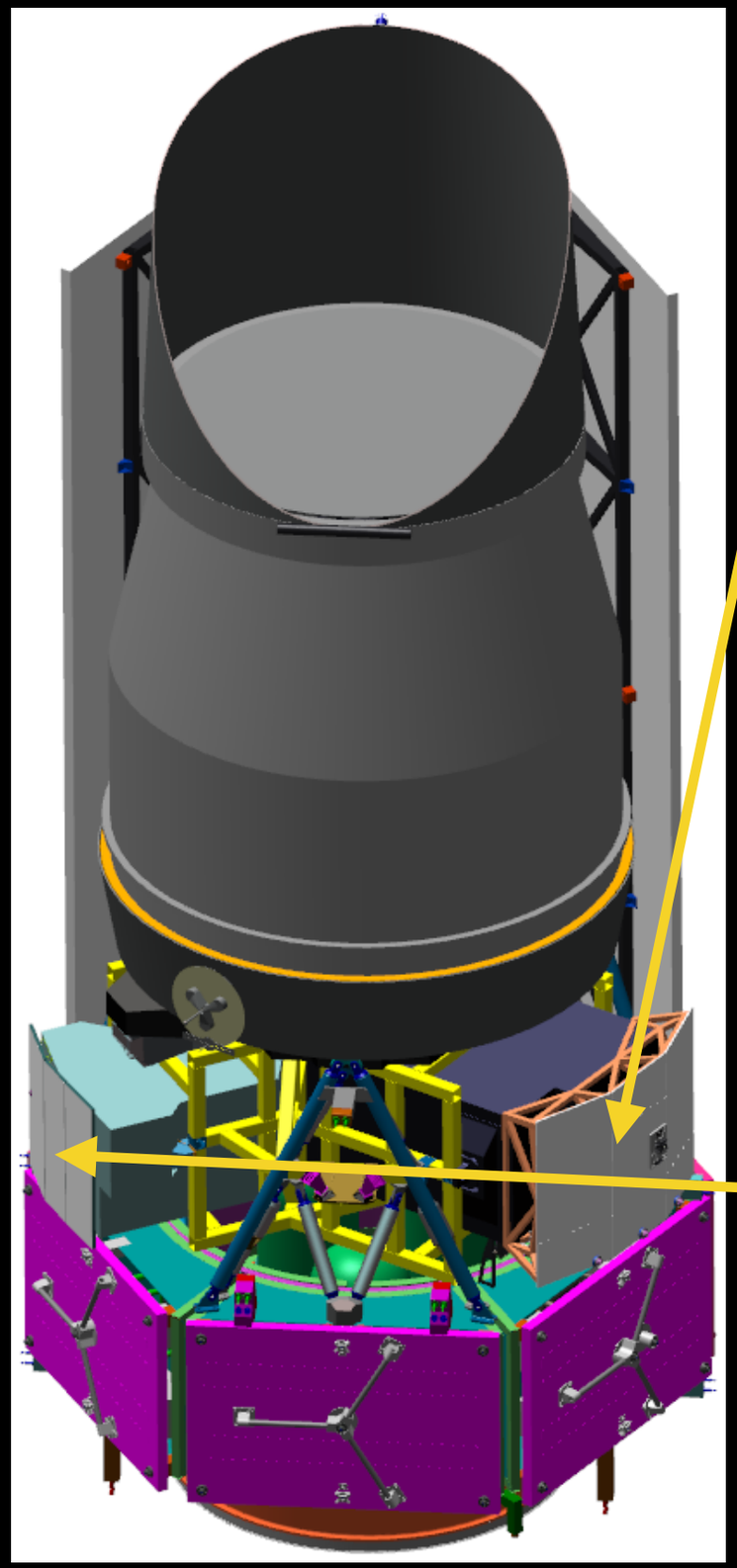
- Several efforts are organized by David Spergel and others. Contact David (or Olivier) to be added to a dedicated email list.

- Working to get Congress to support the Senate number for FY18 for WFIRST and to increase the top line for astrophysics to secure budget for WFIRST in FY19.
  - ➡ Initial response on the hill has been positive to this request. But many other requests to balance so it is important that we all work to support this mission.

- Several ways to support WFIRST:
  - ➡ If at university, please contact your Office of Government Affairs and encourage them to work to support WFIRST. A coalition of universities is being assembled to work together to restore the mission. There is already a group of universities working together with industry.
  - ➡ A number of researchers have drafted OpEd pieces for your regional papers. This is a very powerful way of informing Congress about WFIRST.
    - AURA has put together a web page with links to many of the articles that have appeared on WFIRST: https://aura-wfirst.org.

- A WFIRST day on Capitol Hill is organized.
  - ➡ Tentatively scheduled April 12 as a day to meet with local members of Congress and members of the Authorization and Appropriations committee.

WFIRST INSTRUMENT



- Wide-Field Instrument
  - ➡ Imaging & spectroscopy over 1000s of sq. deg.
  - ➡ Monitoring of SN and microlensing fields
  - ➡ 0.7-2.0 μm (imaging), ~1.0-2.0 μm (spec.) ?
  - ➡ 0.28 deg^2 FoV (100x JWST FoV)
  - ➡ 18 H4RG detectors (288 Mpixels)
  - ➡ 6 filter imaging, grism + IFC spectroscopy

- Coronagraph
  - ➡ Image and spectra of exoplanets from super-Earths to giants
  - ➡ Images of debris disks
  - ➡ 430 – 970 nm (imaging) & 600 – 970 nm (IFS spec.)
  - ➡ Final contrast of 10^{-9} or better
  - ➡ Exoplanet images from 0.1 to 1.0 arcsec
  - ➡ *Technology demonstration* for future missions to characterize exo-Earths (e.g., LUVOIR and HabEx)

WFIRST
A SURVEY, AN EXPERIMENT, AN OBSERVATORY

- Nominal 5 yrs mission

- Three Surveys:
  - ➡ ~2 yrs High-Latitude Survey (HLS)
    - Imaging, spectroscopy

  - ➡ ~6 months SNe search and IFC follow-up

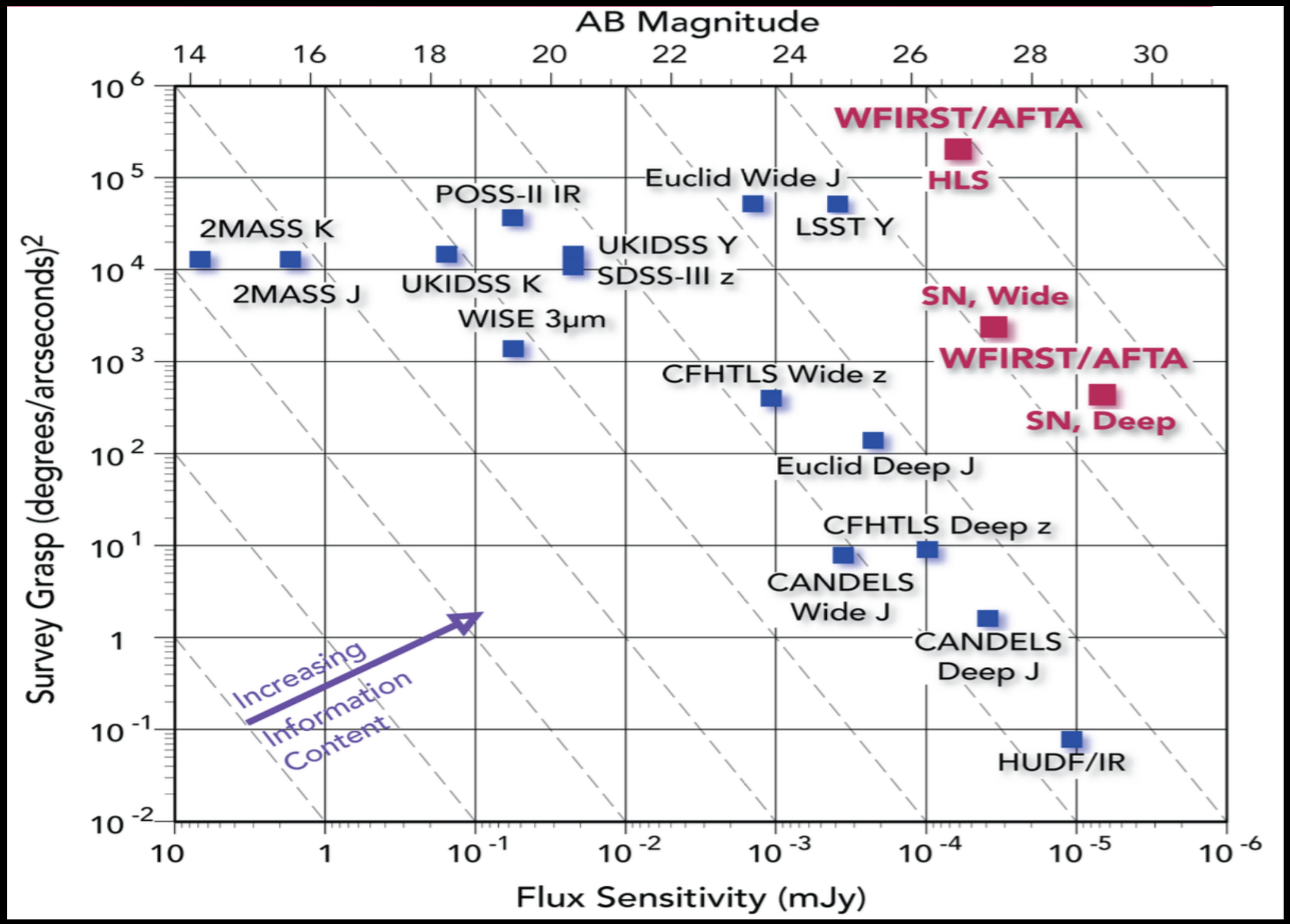
  - ➡ ~1 yr for repeated galactic bulge observations for micro-lensing

- Experiment:
  - ➡ 1 yr for coronograph

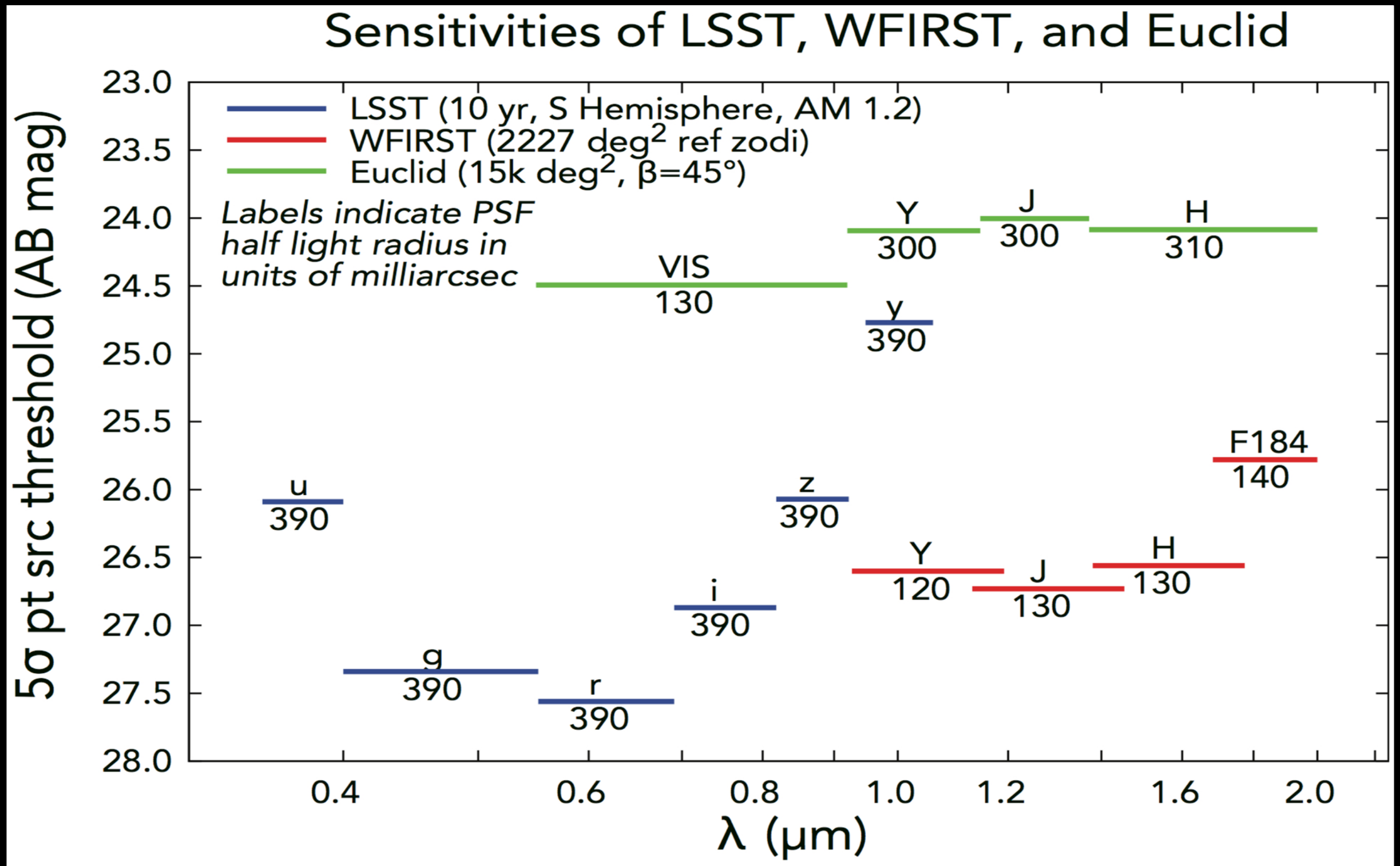
- 25% Guest Observer program

- All data public a few days after they are taken

WFIRST SURVEYS

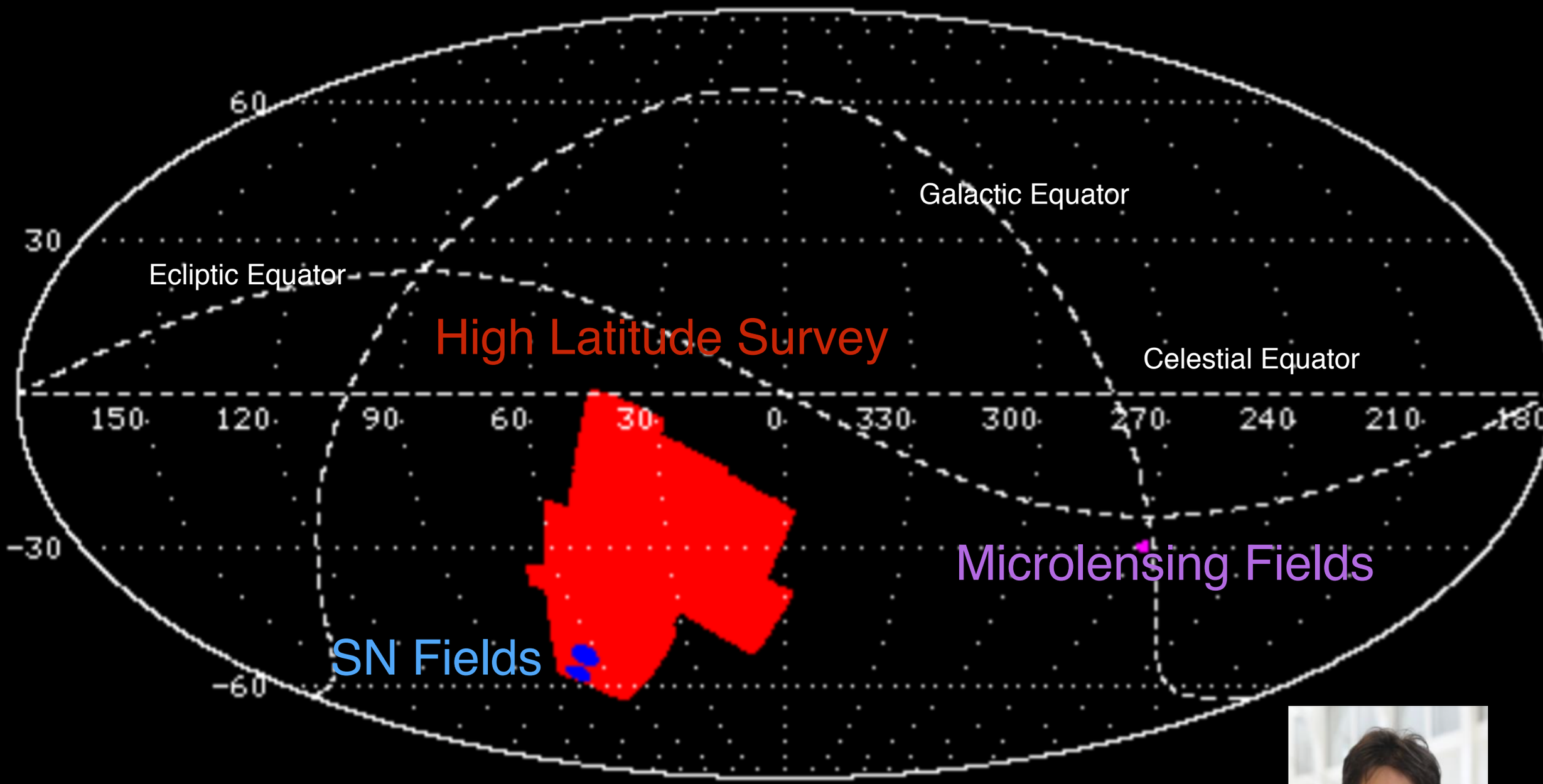


WFIRST HLS SENSITIVITY



HLS SKY COVERAGE

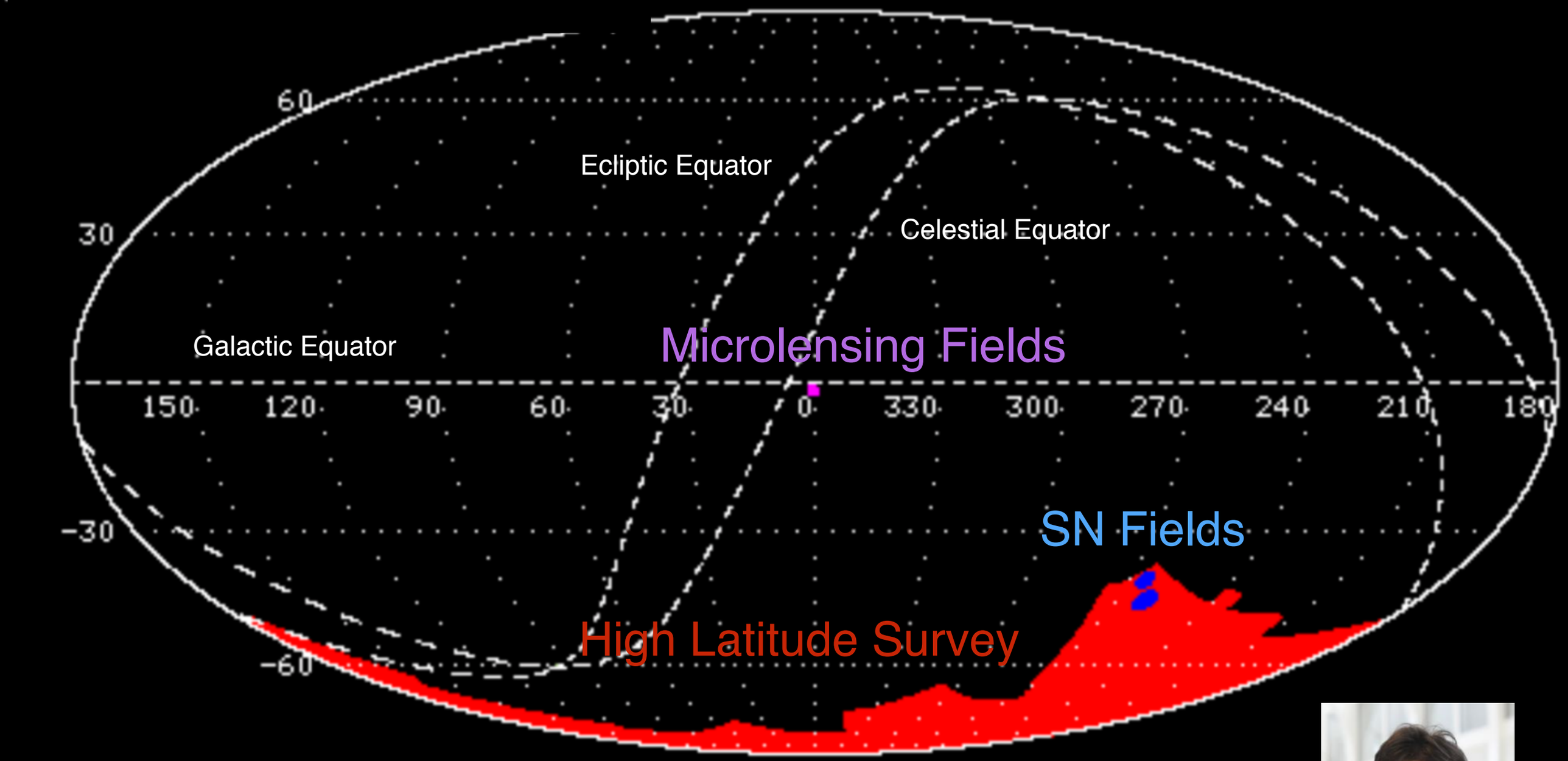
Equatorial Coordinates



Chris Hirata

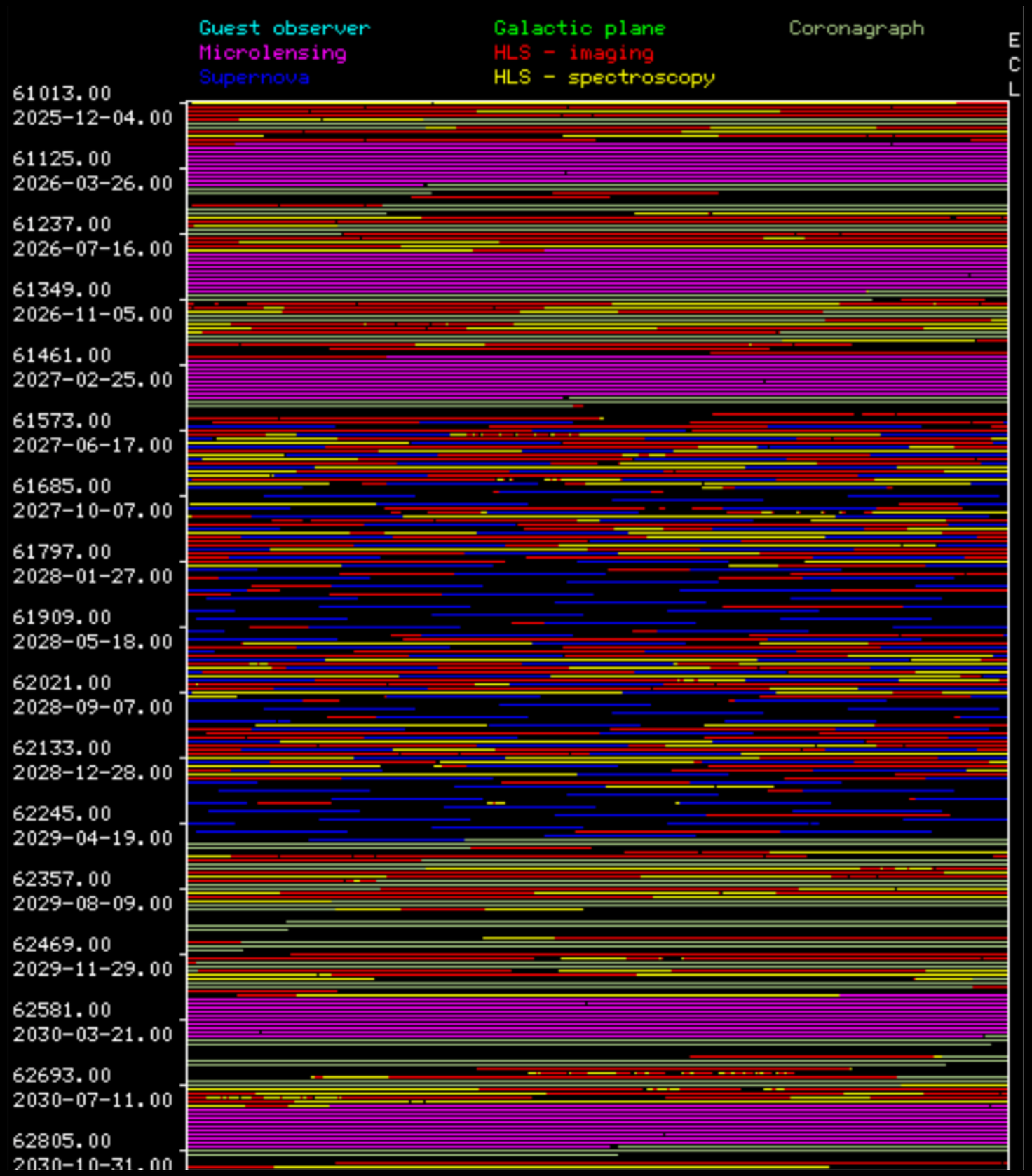
HLS SKY COVERAGE

Galactic Coordinates



Chris Hirata

REALISTIC OBSERVING TIMELINE



- Each row corresponds to 7 days.
- Color coded according to program.
- HLS is red and yellow.
- ~5 day cadence for SNe program (see *Dan Scolnic*'s talk).
- Blank areas are not allocated.
- Each field is observed 3 times in each filter and grism.

Chris Hirata

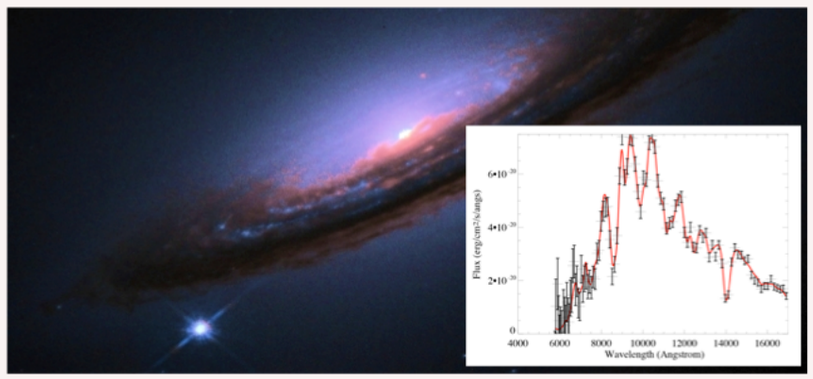
WFIRST DARK ENERGY PROGRAM

Supernova Survey

wide, medium, & deep imaging
+
IFU spectroscopy

2700 type Ia supernovae
z = 0.1–1.7

standard candle distances
z < 1 to 0.20% and z > 1 to 0.34%



High Latitude Survey

spectroscopic: galaxy redshifts

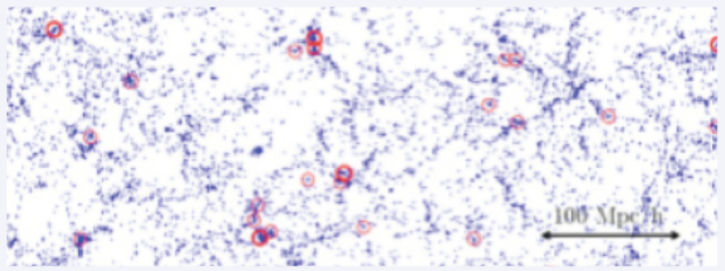
16 million Hα galaxies, z = 1–2
1.4 million [OIII] galaxies, z = 2–3

imaging: weak lensing shapes

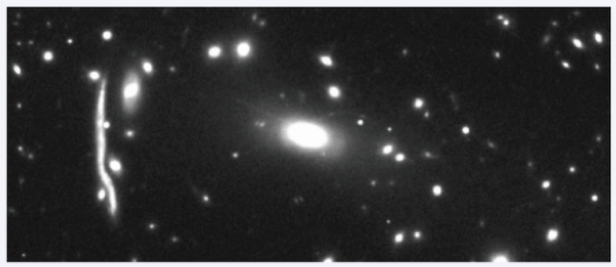
380 million lensed galaxies
40,000 massive clusters

standard ruler

distances	expansion rate
z = 1–2 to 0.5%	z = 1–2 to 0.9%
z = 2–3 to 1.3%	z = 2–3 to 2.1%

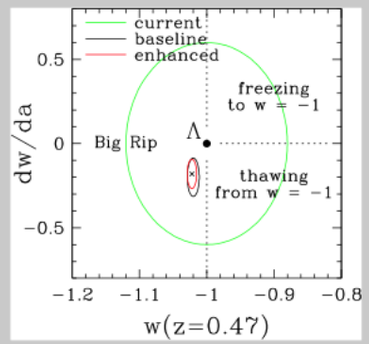


dark matter clustering
z < 1 to 0.21% (WL); 0.24% (CL)
z > 1 to 0.78% (WL); 0.88% (CL)
1.1% (RSD)



history of dark energy
+
deviations from GR

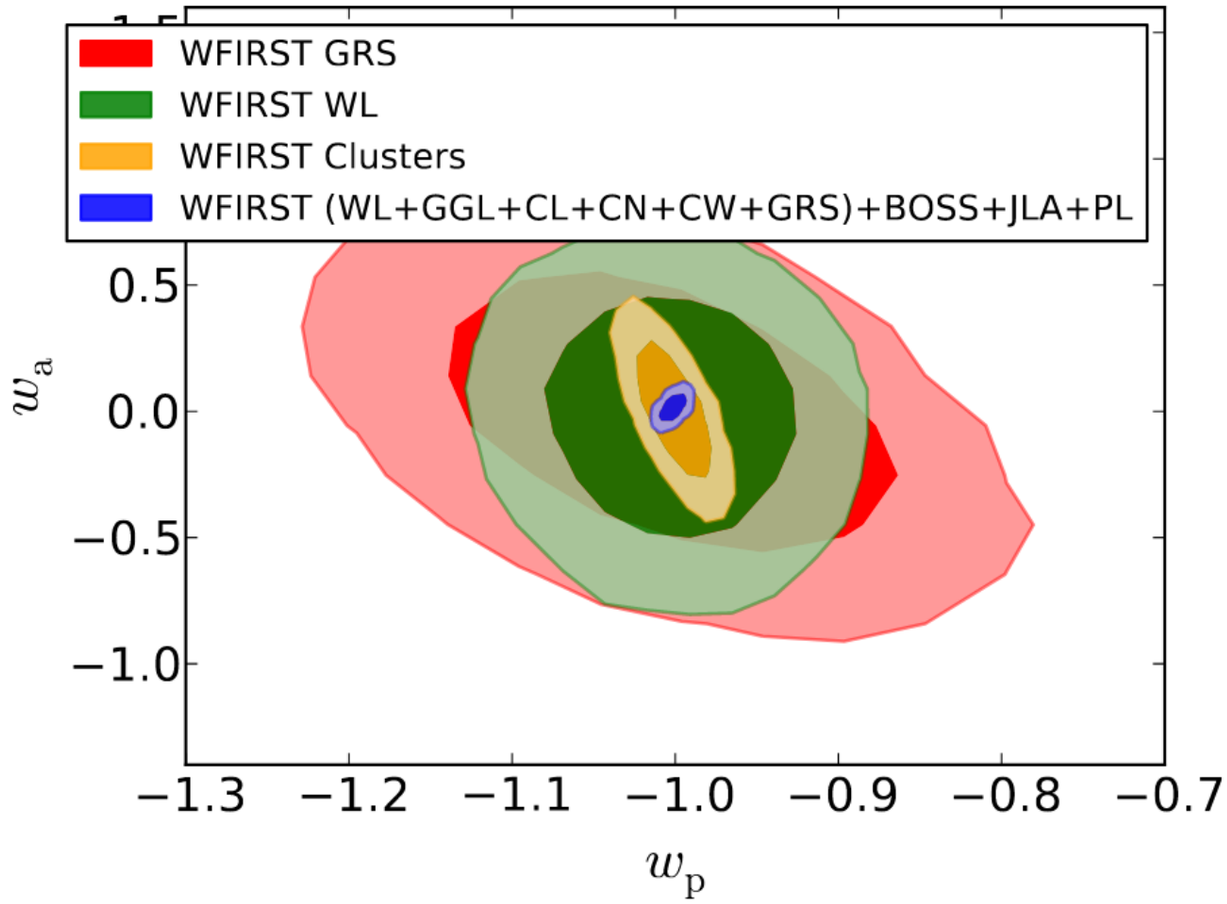
$w(z)$, $\Delta G(z)$, Φ_{REL}/Φ_{NREL}

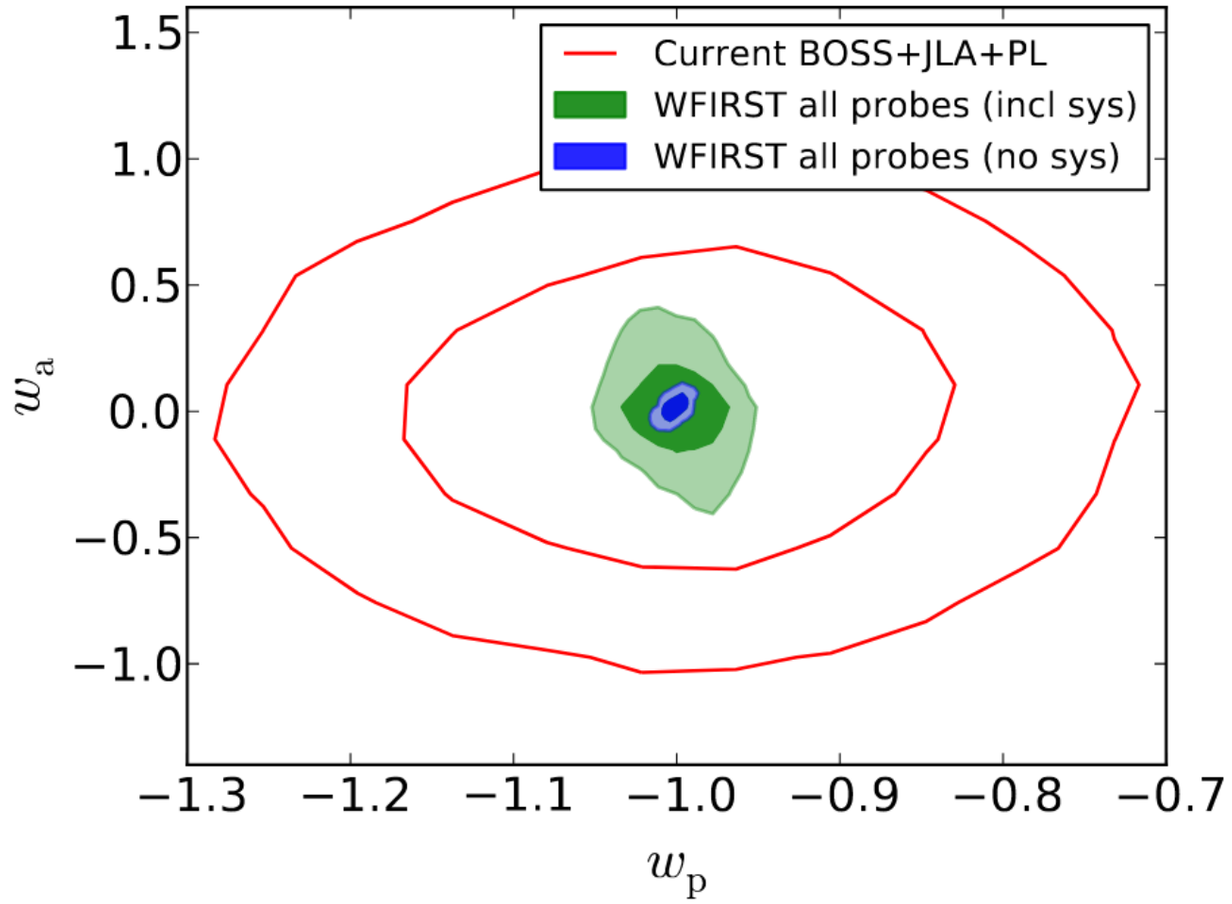


DE SURVEY COMPLEMENTARITY AT A GLANCE

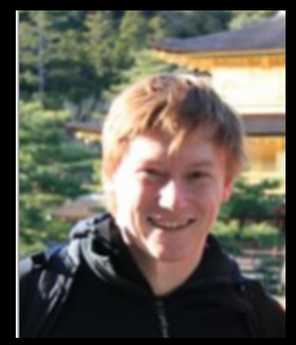
STAGE IV	LSST	WFIRST	Euclid	DESI
Start, duration	2022, 10 yr	~2025, 5 (-10) yr	2021, 6 yr	2019, 5 yr
Area (sq. deg.)	20,000 (S)	2,000 (S)	15,000 (N+S)	14,000 (N)
FOV (sq. deg.)	10	0.281	0.53	7.9
Diameter (m.)	6.7	2.4	1.3	4
Photometric Survey	6 bands (u,g,r,i,z,y)	6 bands (Z,Y,J,H,F,184,W149)	4 bands (VIS,Y,J,H)	
Photometric Galaxies (w/ shapes) (#/arcmin^{2})	~30 in 6 bands (ugrizy)	~68 in 4 bands (YJHF184)	~30-35, in 1 band (VIS)	
SN1a	10^{4}-10^{5}/yr z=0-0.7 photometric	2700 z=0.1-1.5 IFC spectroscopy		
Spectroscopic Survey		Grism R=550-800 1-2 μm	Grism R=250 1.1-2 μm	Fibers R=4000 0.36-0.98 μm
Spectroscopic Galaxies		ELGs z=0.5-1.8 (Ha/ ~20M) z=0.9-2.8 (OIII/ ~2M)	ELGs, z~0.7-2.1 (20M)	LRGs+ELGs z~0.6-1.7 (20-30M) QSOs/Lya 1.9<z<4 (1M)

WFIRST: A MULTI-PROBE MISSION





Eifler, Heinrich, Krause, Miyatake, Simet et al., 2018, *in prep*.



MULTIPLE SURVEYS/PROBES

- The era of multi-probes/multiple surveys:
  - ➡Rich insights will come from combining multiple probes (lensing, RSD, clusters) reliably.

- Cross-correlations: new information
  - ➡Multiple tracers of the same large scale structure might cancel sample variance (needs multiple high number density with different bias).
  - ➡Extra information in “off-diagonal” elements of (z, z’) covariance matrix.

- Multiple survey/probe brings robustness:
  - ➡Calibration
    - Redshift training for photo-z’s (see Dan Masters’ talk)
    - Intrinsic alignment model
    - De-blending / identifying blends (see Michael Schneider, Peter Melchior talks)
  - ➡Cross-correlations: systematics
    - Cancel uncorrelated systematics (e.g., PSF effects)
    - Identify contaminants (stars, other interlopers)

SYNERGIES WITH WFIRST FIRST OBSERVATIONS

- Start the SNe deep survey (~ 5 sq. deg., J=29.3, H=29.4)
- Overlap with LSST deep drilling fields
- Overlap HSC deep fields
- Spitzer data?
- eROSITA data?
- Other wavelengths?
- Targets for JWST/ELTs
- Important field:
  - ➡ Training for high latitude survey
  - ➡ Characterize Wide Field Instrument performance
  - ➡ Where to look? (see Peter Capak's presentation)

WFIRST WILL REVOLUTIONIZE THE NEXT DECADE

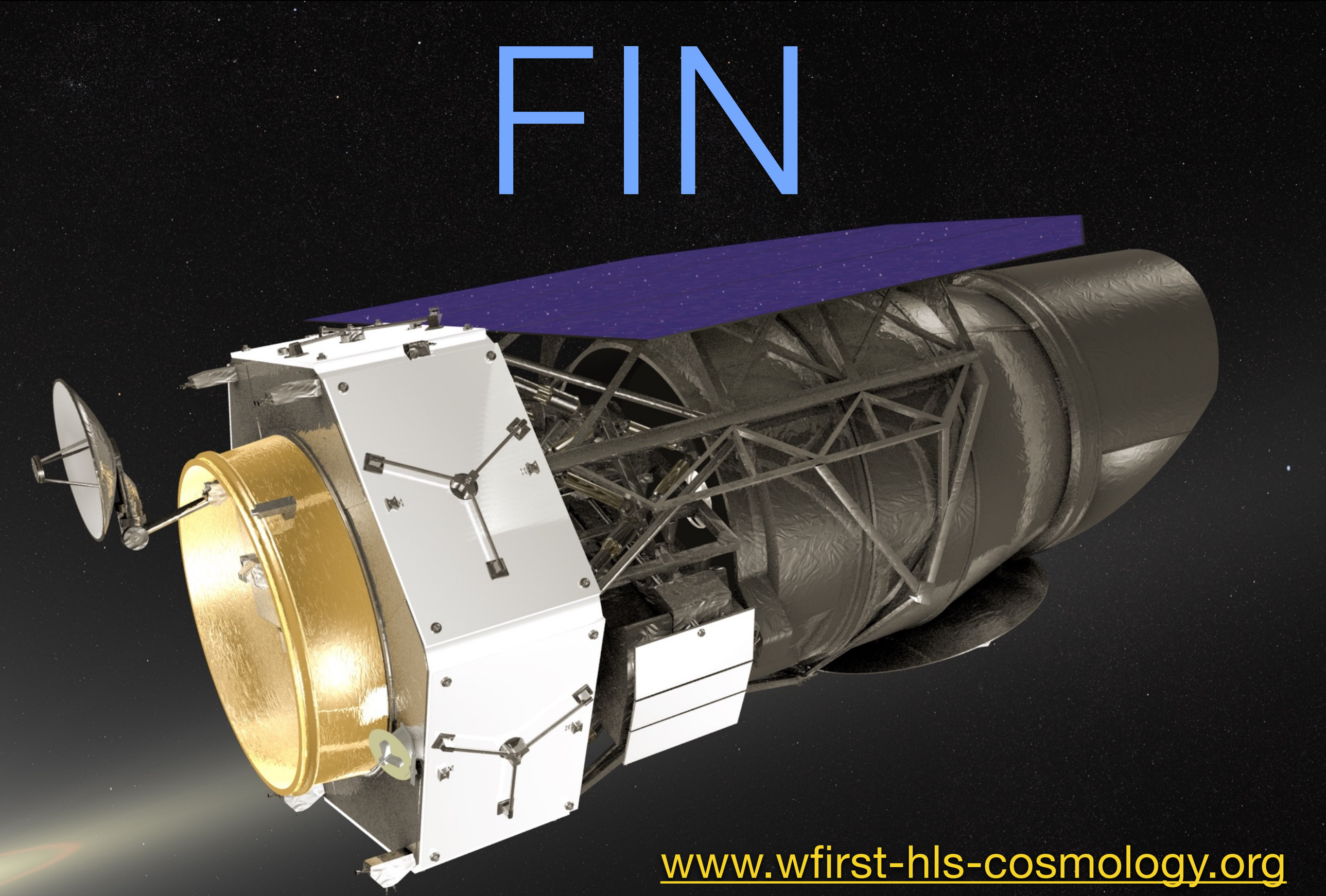
- WFIRST will be an extraordinary survey, experiment and observatory.

- An extremely versatile and powerful platform that will be able to address the relevant cosmological questions after LSST (yr1-2) and DESI
  - ➡E.g. WFIRST can do the 6 years of Euclid spectroscopy in 1 year.
  - ➡The details of the HLS will most likely be updated before launch.
  - ➡Extended mission proposal after the HLS can target specific questions.

- WFIRST can make unique contributions to understanding of Dark Energy

- For the astronomical community, it promises an enormous, broad-ranging scientific impact:
  - ➡The impact of SDSS multiplied by the imaging power of Hubble.

FIN



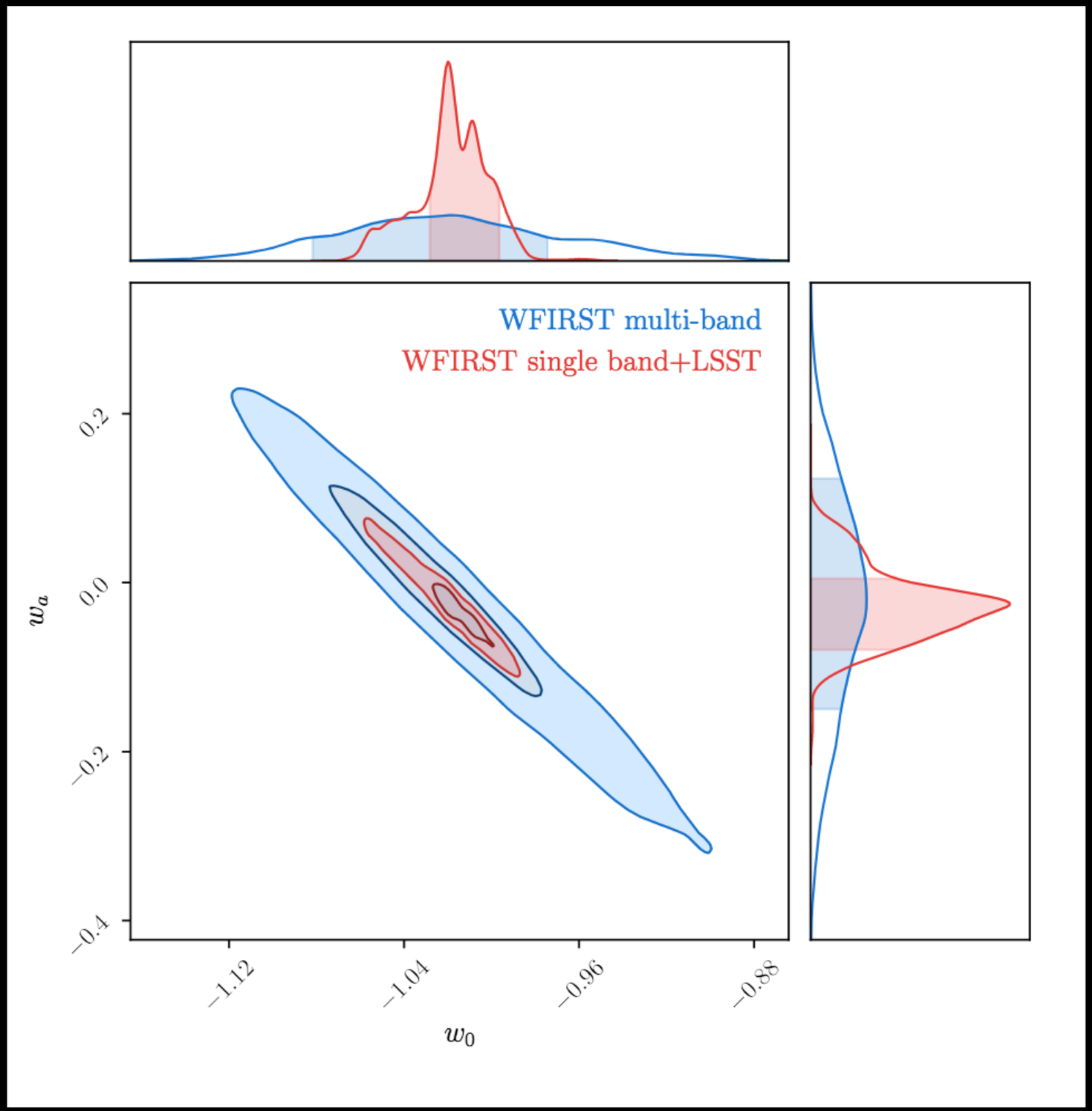
www.wfirst-hls-cosmology.org
www.wfirst.gsfc.nasa.gov

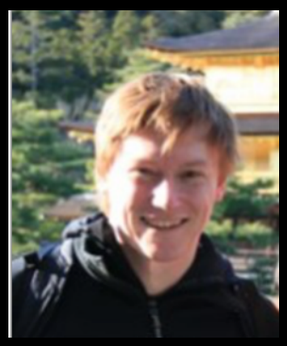
WFIRST BASELINE FILTERS

NAME	Wavelength [μm] (top of transmission curve)	Other names
R062	0.48-0.76	V, R, B, Orange
Z087	0.76-0.98	Z band
Y106	0.93-1.19	Y band
J129	1.13-1.45	J band
H158	1.38-1.77	H band
F184	1.68-2.00	F184
W146	0.93-2.0	W149
G150	~1.0-20	Grism
Dark	—	Dark

slides from Jason Kalirai

WFIRST AS A SINGLE BAND SURVEY

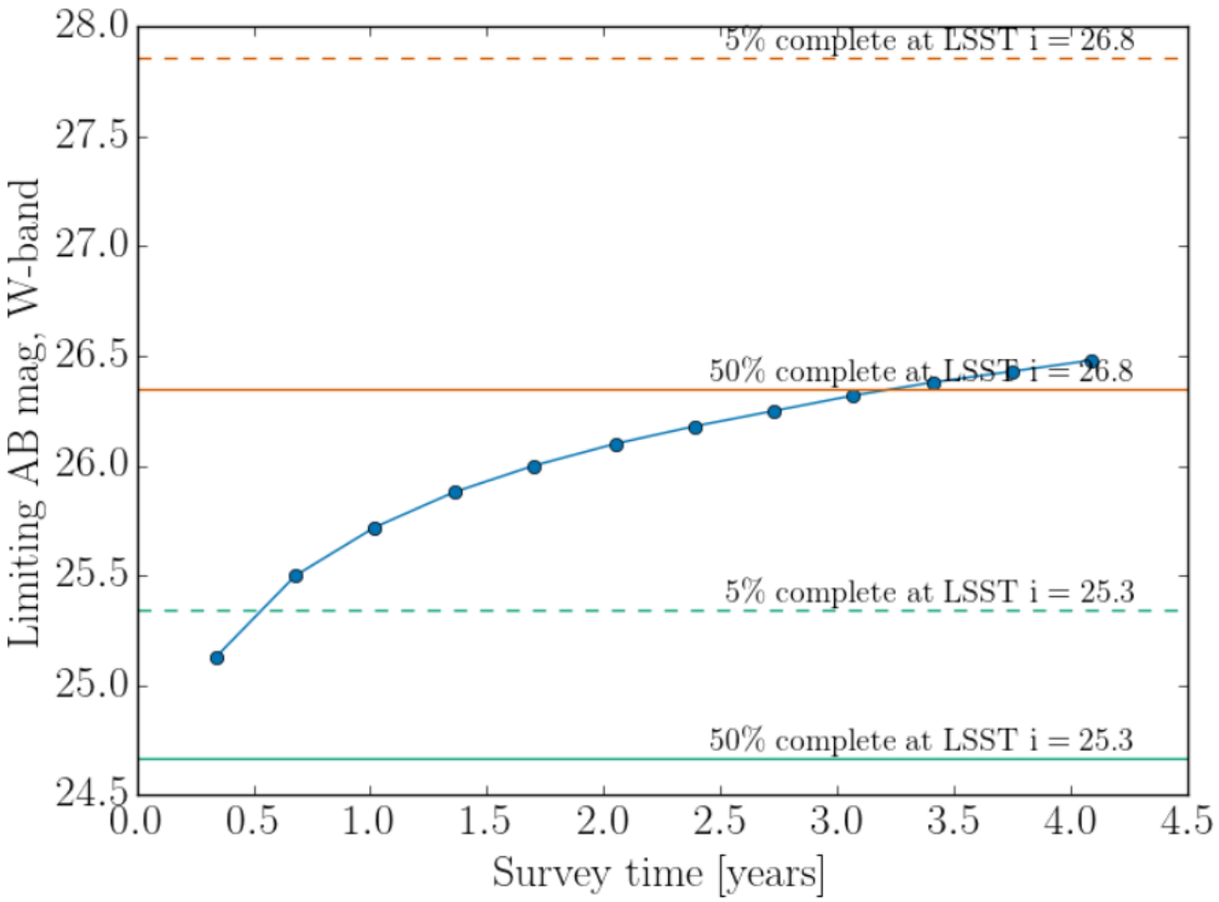




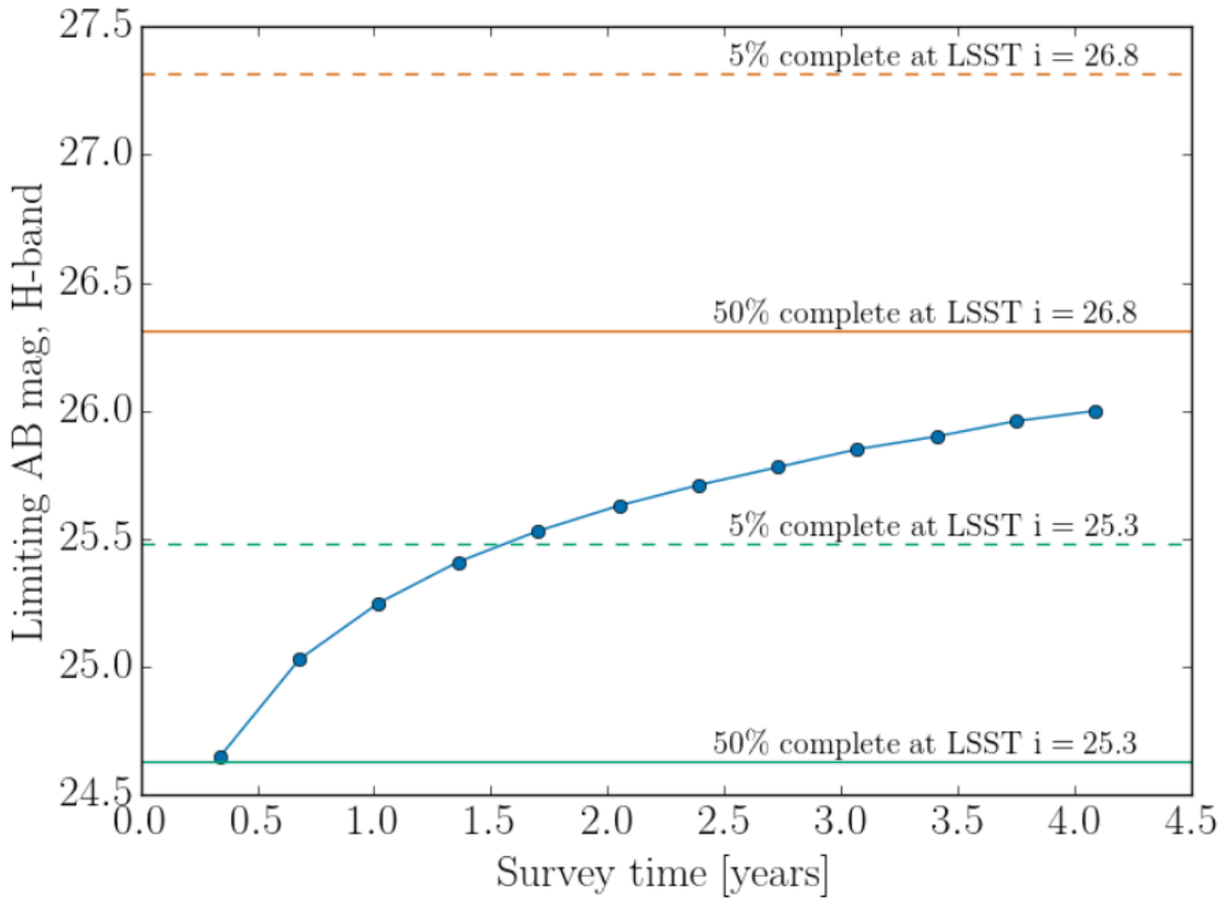
Tim Eifler et al. 2018, *in prep*.

WFIRST ONE BAND SURVEY

W BAND



H BAND



Tim Eifler et al. 2018, *in prep*.