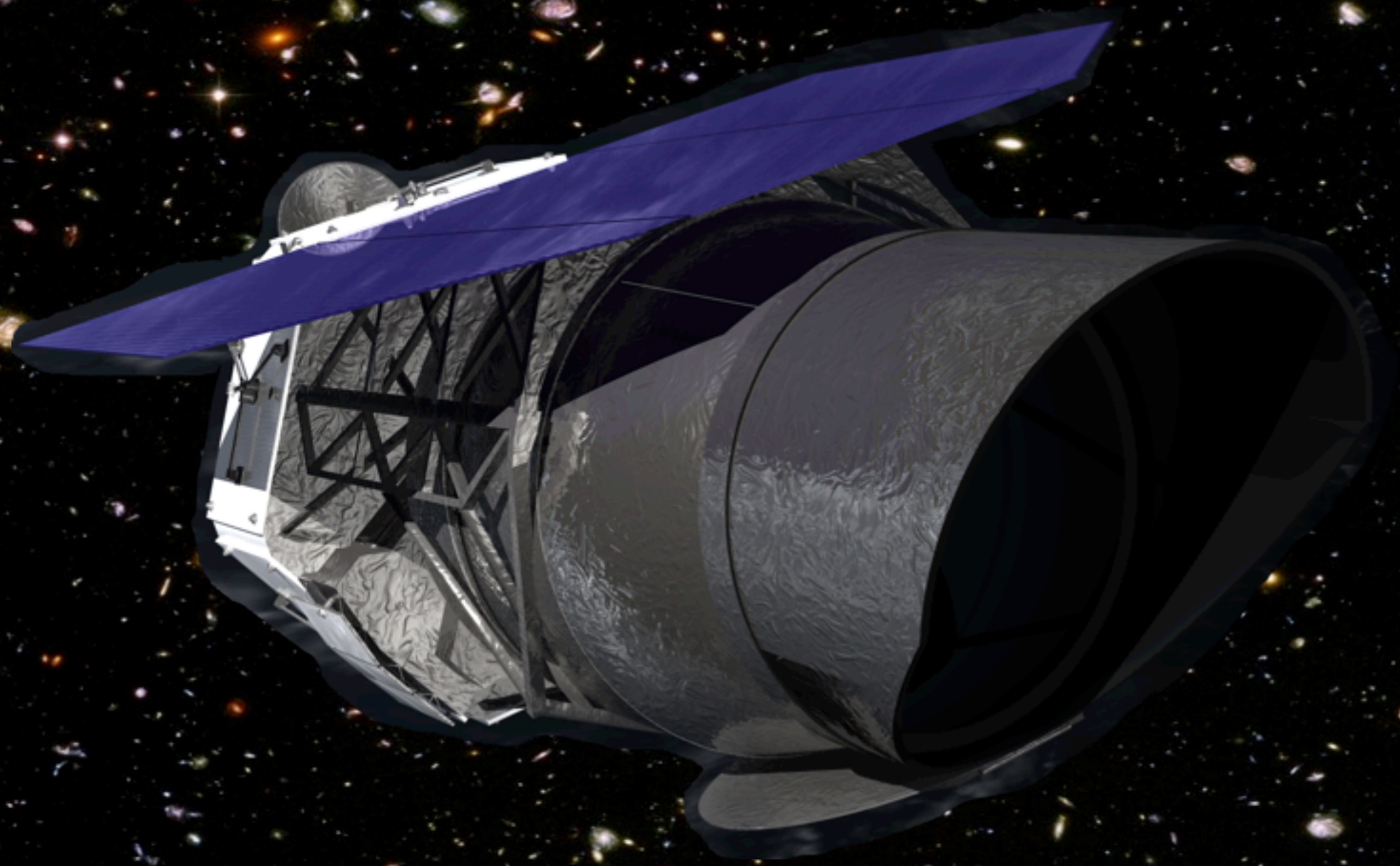


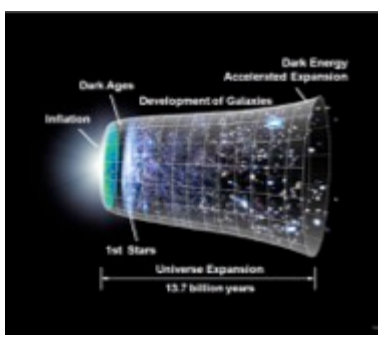
WFIRST Science and Status
Far IR STDT, May 13, 2016

Neil Gehrels/GSFC
Project Scientist

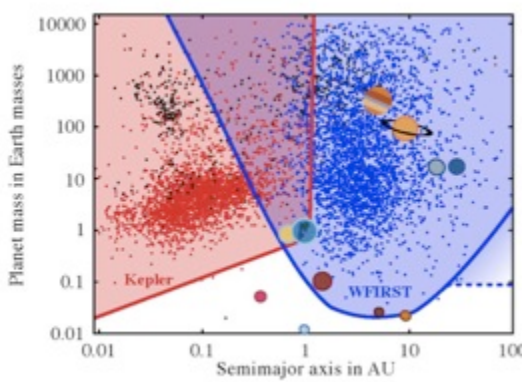
Introduction

- WFIRST highest ranked large space mission in 2010 Decadal Survey
  - Study Dark Energy, Exoplanet Census, NIR Sky Survey
- Use of 2.4m telescope enables
  - Hubble quality imaging over 100x more sky
  - Imaging of exoplanets with 10^{-9} contrast with a coronagraph

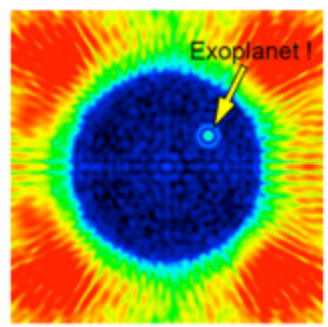
Dark Energy



Exoplanets

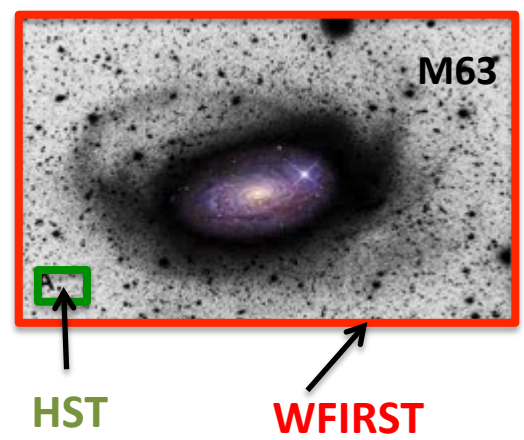


Microlensing

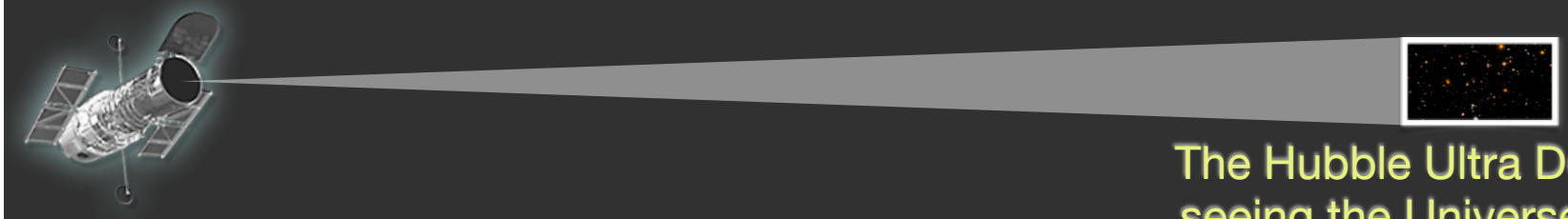


Coronagraph

Astrophysics



Hubble - A Spectacular Start



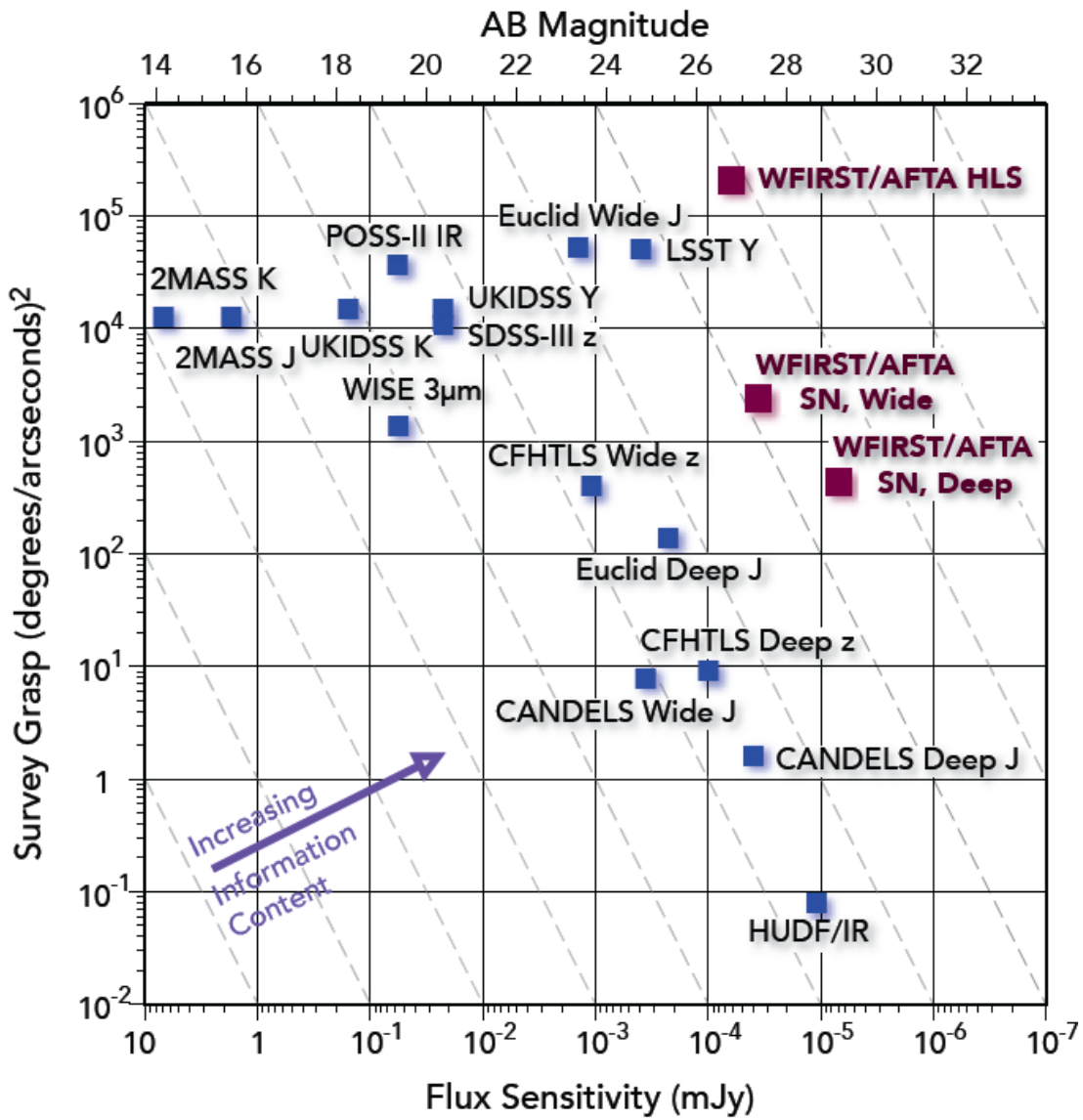
The Hubble Ultra Deep Field seeing the Universe, 10,000 galaxies at a time

WFIRST - Hubble X 100

A WFIRST Deep Field

A New Window on the Universe - **1,000,000** galaxies at a time

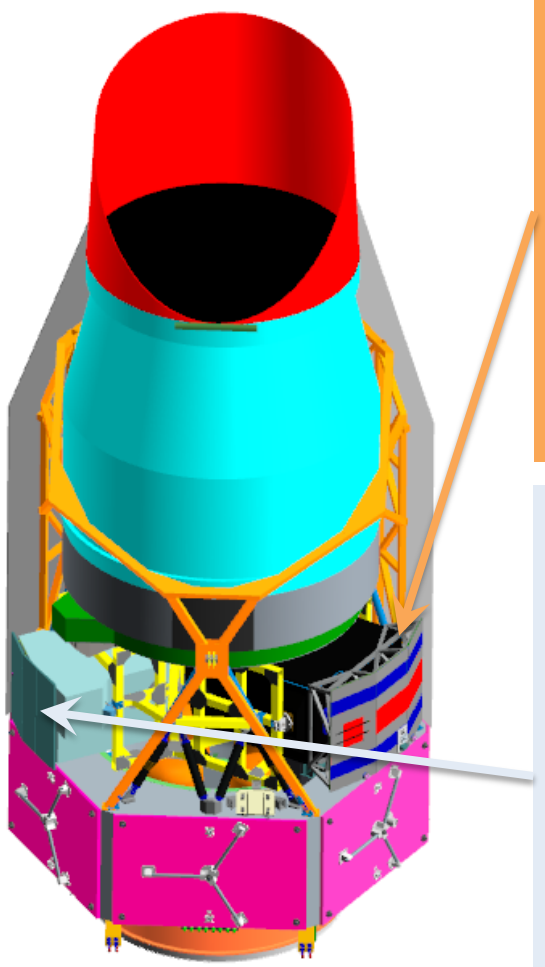
Unprecedented Near IR Capabilities



Science Objectives

- Produce Hubble quality infrared sky images and spectra over 1000's of square degrees of sky
- Determine the expansion history of the Universe and the growth history of its largest structures in order to test possible explanations of its apparent accelerating expansion including Dark Energy and modifications to Einstein's gravity.
- Complete the statistical census of planetary systems in the Galaxy, from the outer habitable zone to free floating planets
- Directly image giant planets and debris disks from habitable zones to beyond the ice lines and characterize their physical properties.
- Provide a robust guest observer program utilizing a minimum of 25% of the time over the 6 year baseline mission and 100% competed in following years.

WFIRST Instruments



Wide Field Instrument

- *Imaging & spectroscopy over 1000s of sq. deg.*
- *Monitoring of SN and microlensing fields*
- Near infrared bandpass
- Field of view 100 x HST and JWST
- 18 H4RG detectors (288 Mpixels)

Coronagraph

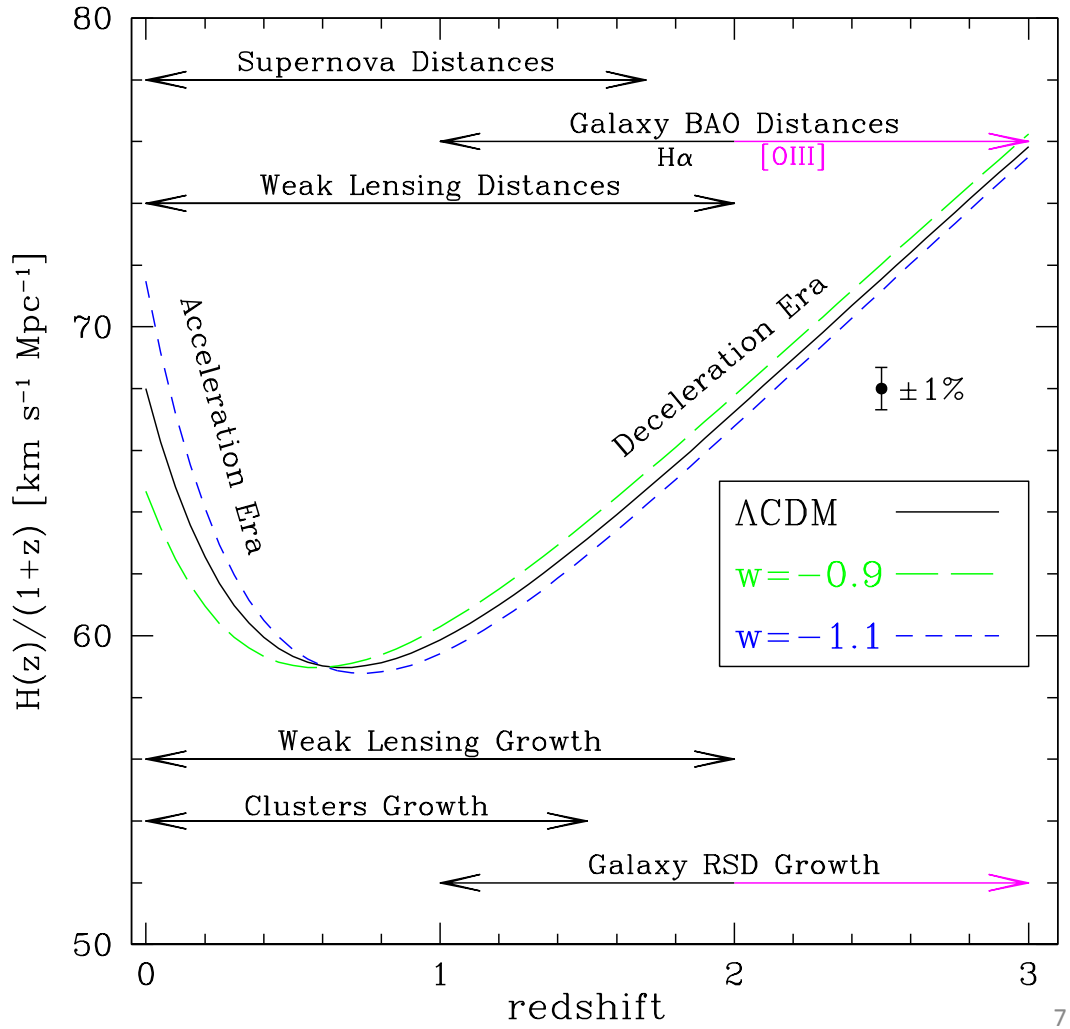
- *Image and spectra of exoplanets from super-Earths to giants*
- *Images of debris disks*
- Visible bandpass
- Contrast of 10^{-9} or better
- Exoplanet images from 0.1 to 1.0 arcsec

Premier Dark Energy Observatory

WFIRST
WIDE-FIELD INFRARED SURVEY TELESCOPE
DARK ENERGY • EXOPLANETS • ASTROPHYSICS

- WFIRST combines all techniques to determine the nature of Dark Energy.
- Only observatory doing such comprehensive observations
- High precision measurements will be optimally combined for the best measurement

WFIRST Probes of Expansion and Growth



Weinberg & SDT 2015

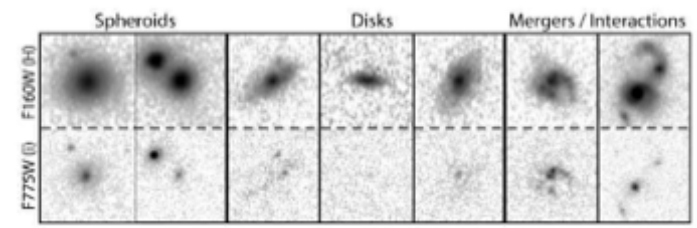
Premier Dark Energy Observatory

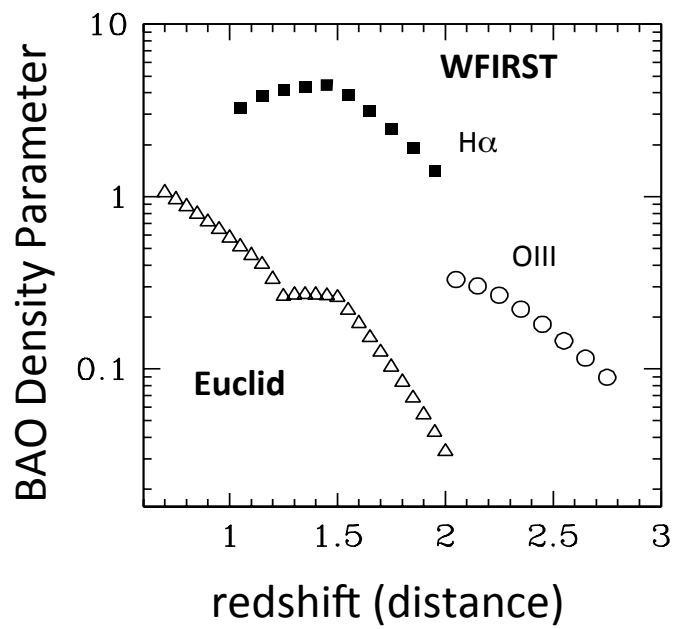
- WFIRST will be the first mission to fully exploit the powerful IR band for dark energy measurements.

- It will be much more sensitive and have higher angular resolution than any other dark energy instrument.

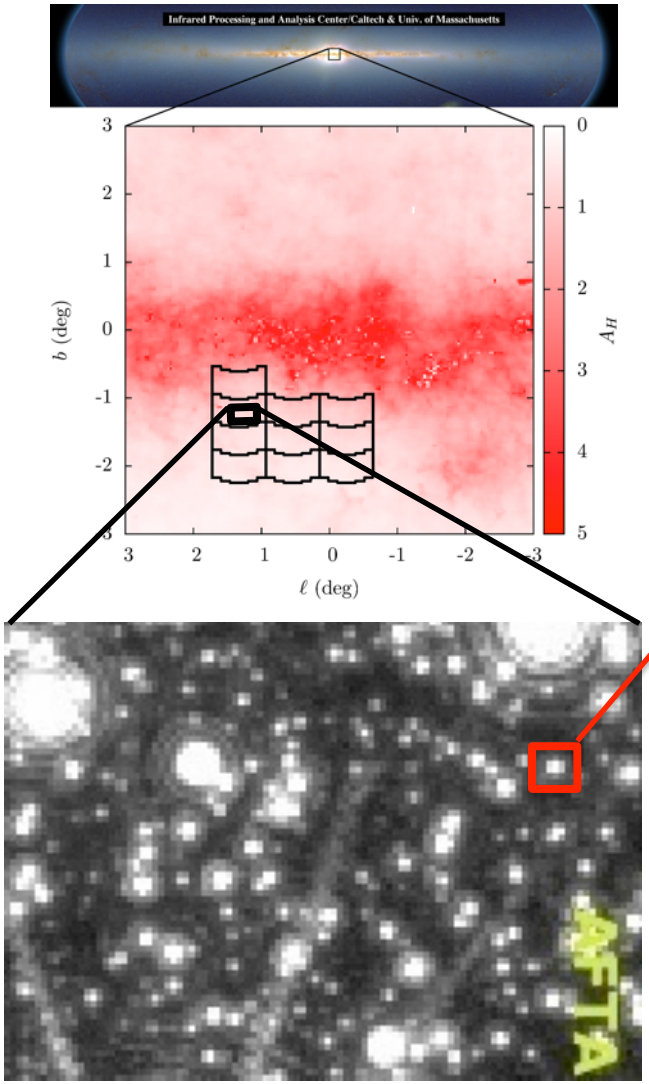
IR

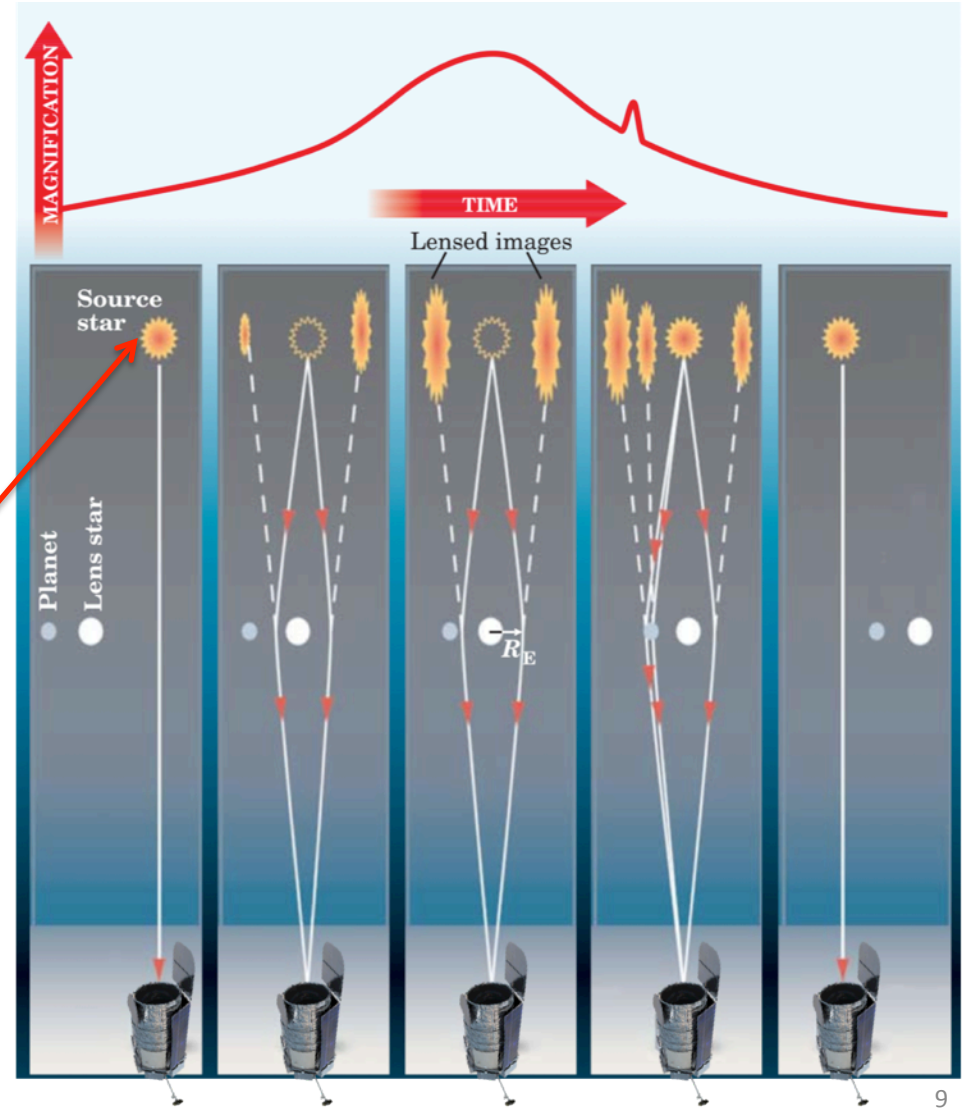
Optical

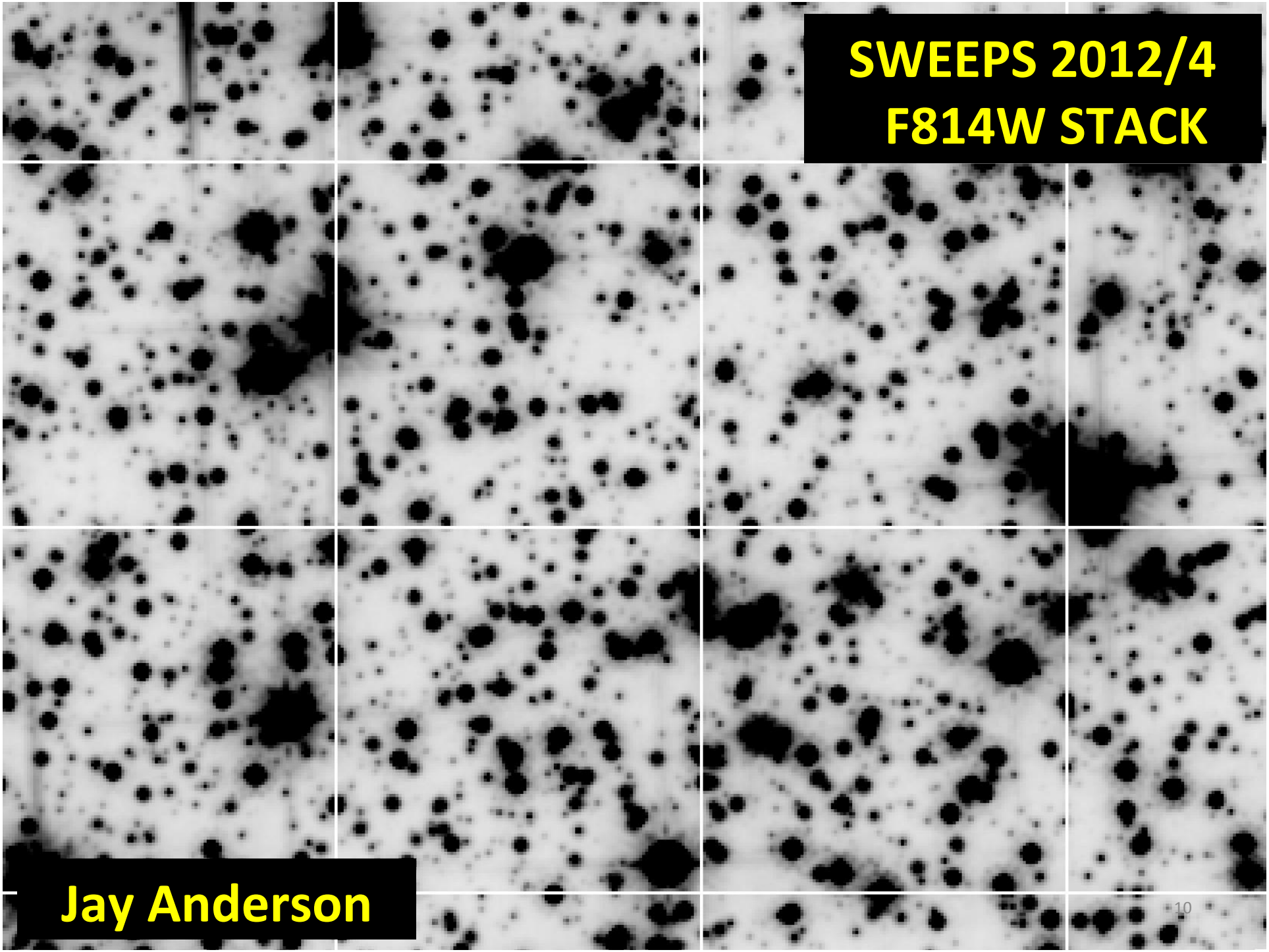


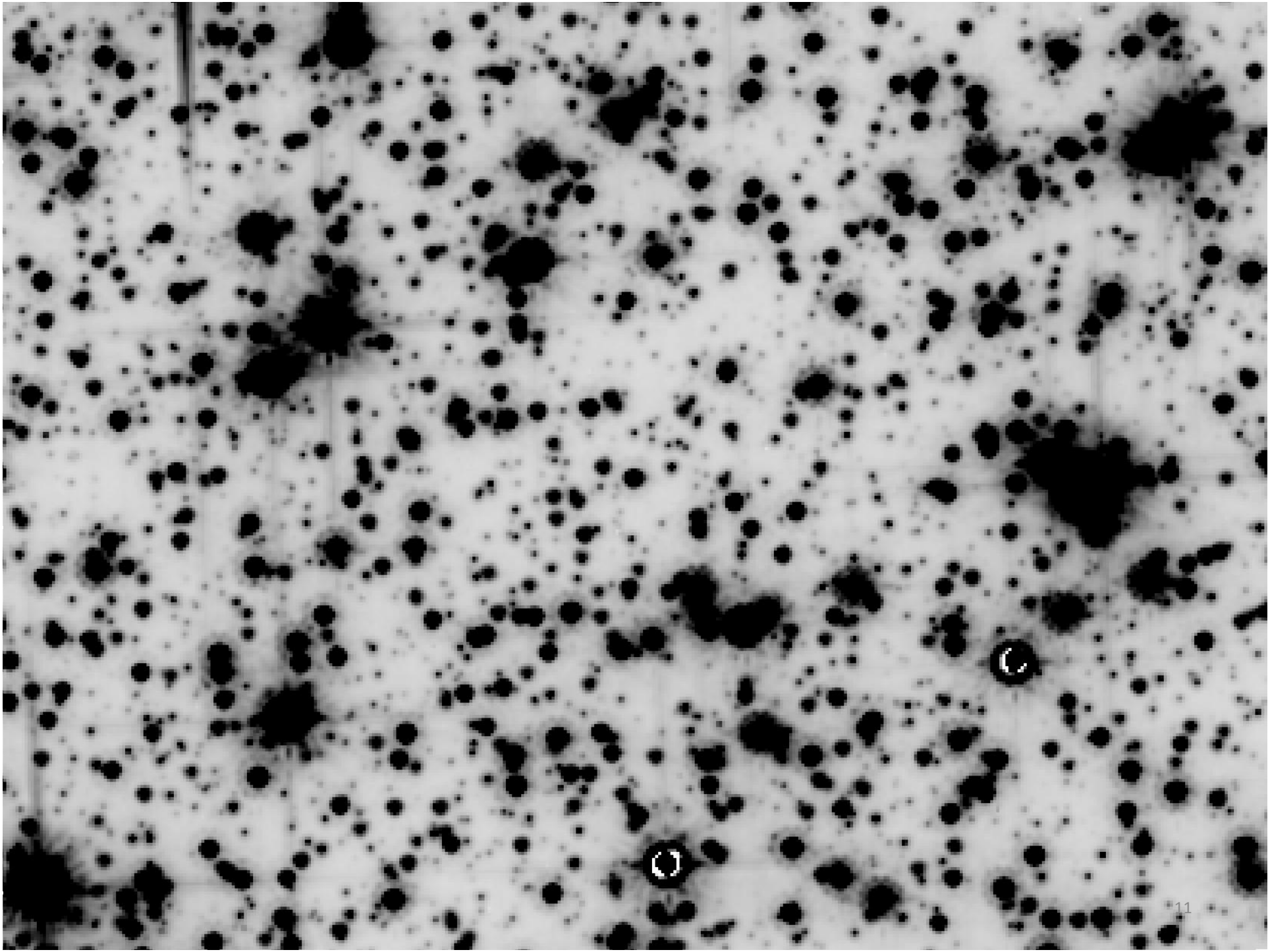


Detecting Planets with a Microlensing Survey






SWEEPS 2012/4
F814W STACK
Jay Anderson


C
O

Microlensing Exoplanet Survey

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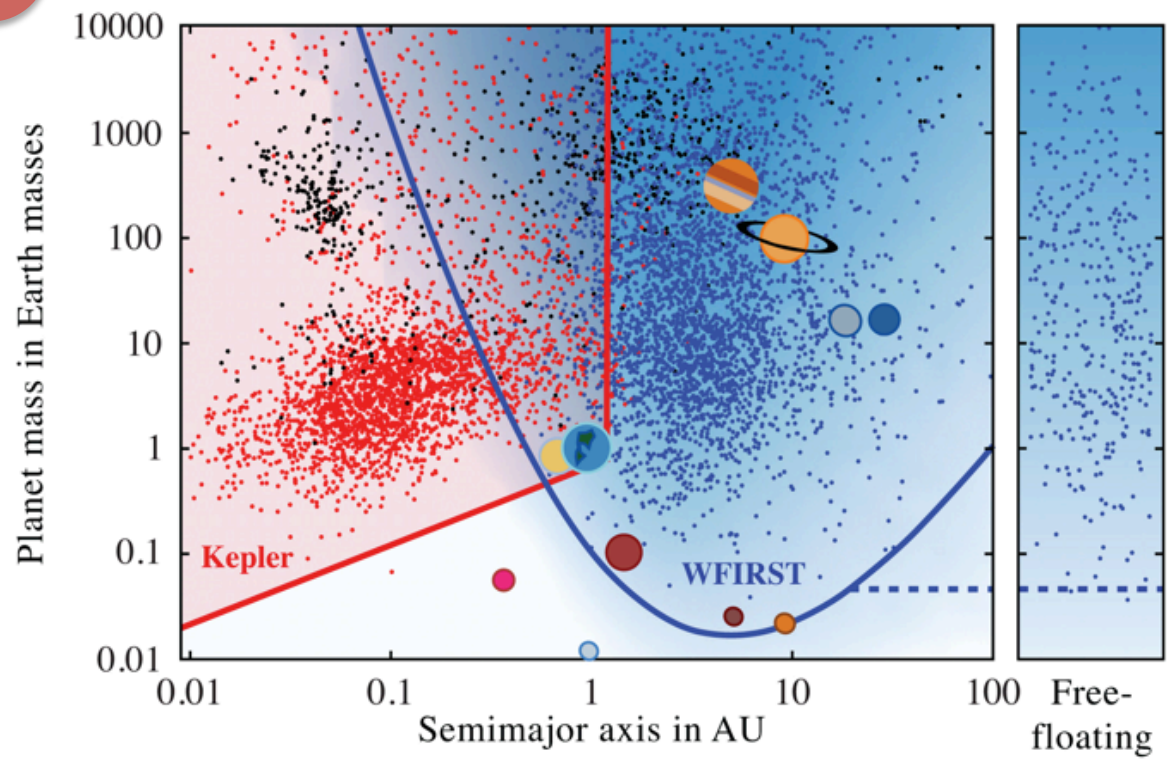
WFIRST complements Kepler, TESS, Plato

Kepler

WFIRST

- 2600 planets
- 370 Earth mass & less
- **100's free-floaters**

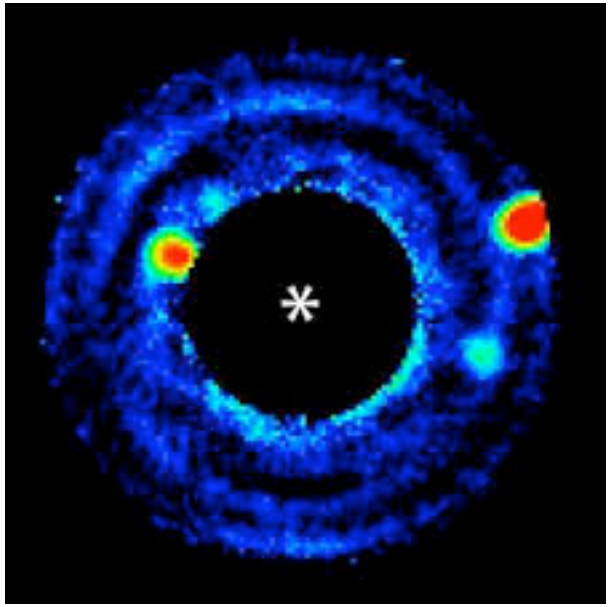


M. Perry

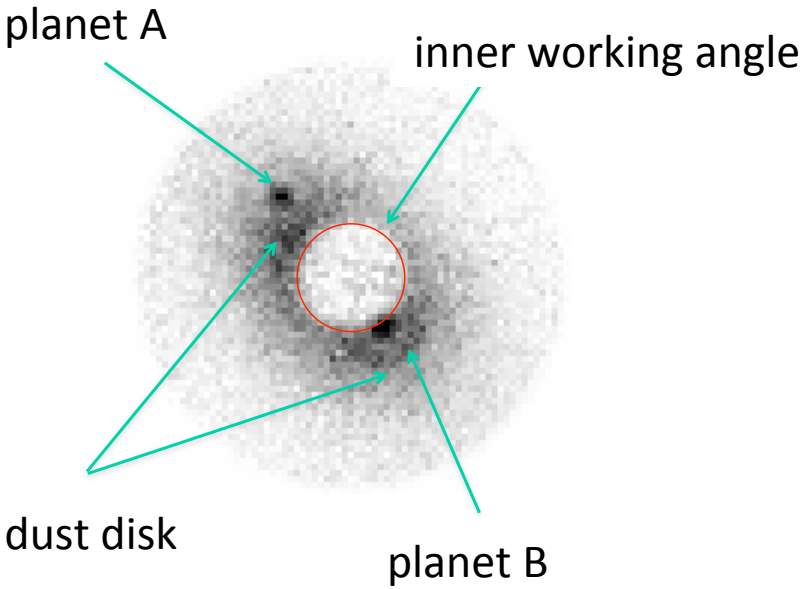
Pioneering High Contrast Exoplanet Coronagraph

- Imaging at high contrast provides for direct detection and spectroscopy (characterization) of exoplanets

Concept



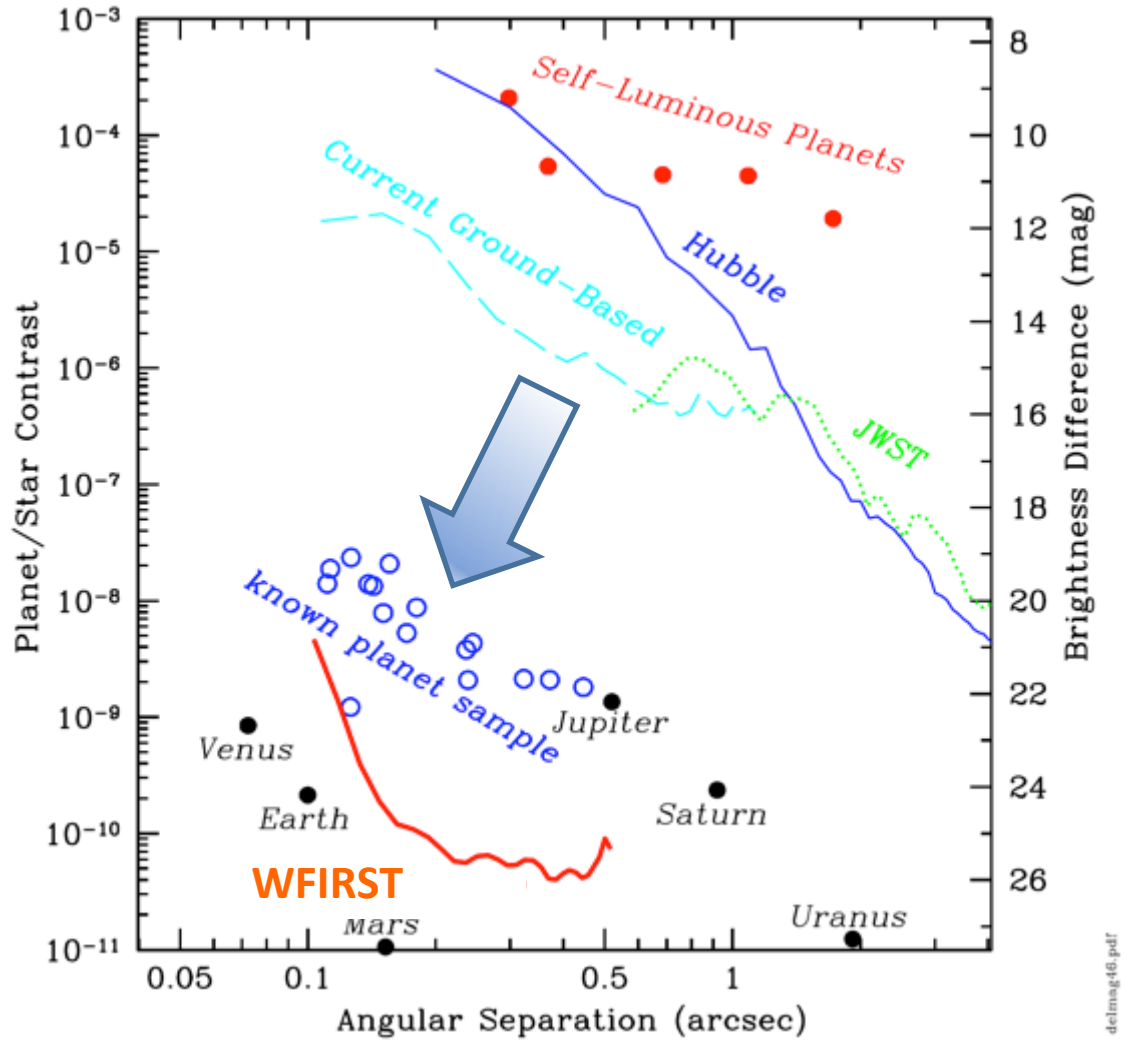
WFIRST Simulation



Greene 2015

WFIRST Brings Humanity Closer to Characterizing exo-Earths

- WFIRST advances key elements needed for a future coronagraph to image an exo-Earth
  - ✓ Coronagraph
  - ✓ Wavefront sensing & control
  - ✓ Detectors
  - ✓ Algorithms
- WFIRST performance predictions are exciting



Traub & SDT 2015

25% of WFIRST is GO Time

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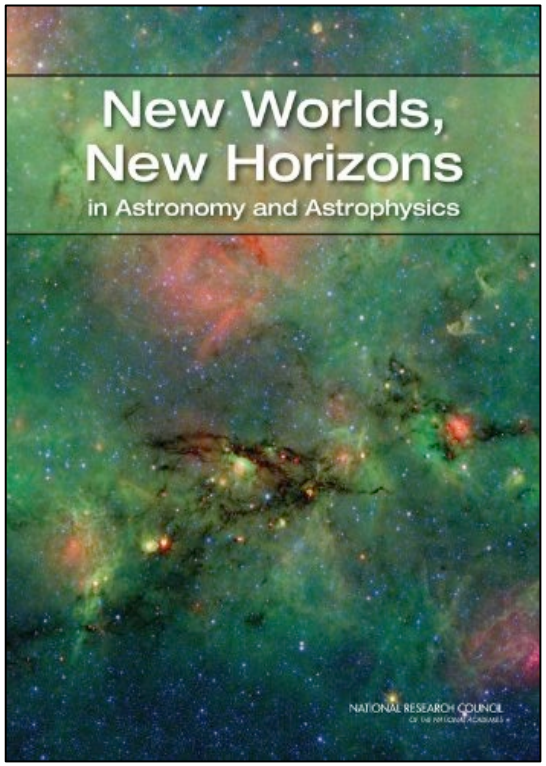
Frequently discussed

#1 Large-Scale Priority - Dark Energy, Exoplanets

#1 Medium-Scale Priority - New Worlds Tech. Development

WFIRST covers many other NWNH science goals



5 Discovery Science Areas

ID & Characterize Nearby Habitable Exoplanets ✔

Time-Domain Astronomy ✔

Astrometry ✔

Epoch of Reionization ✔

Gravitational Wave Astrometry

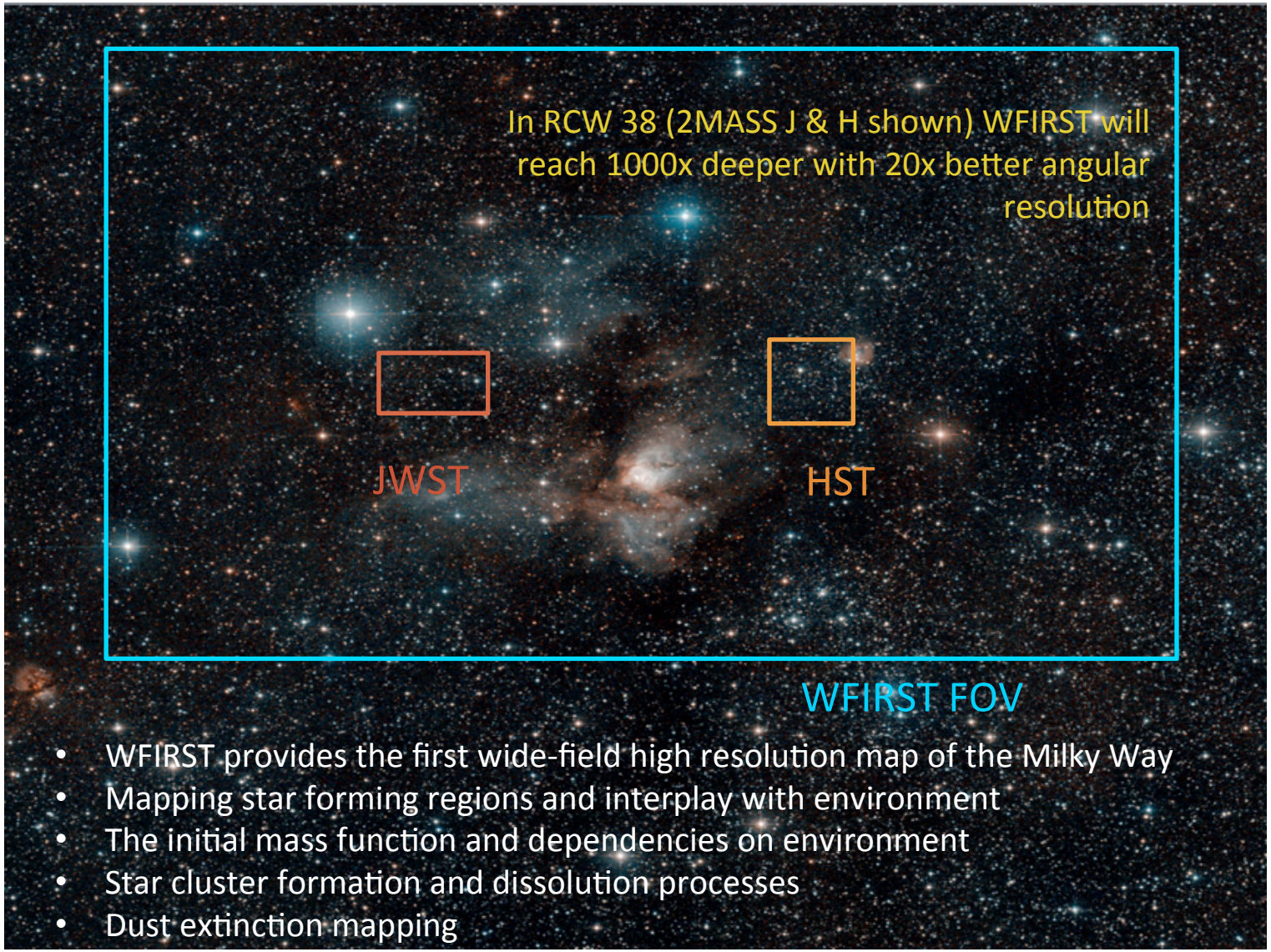
20 Key Science Questions

Origins **(7/7 key areas)**

Understanding the Cosmic Order **(6/10 key areas)**

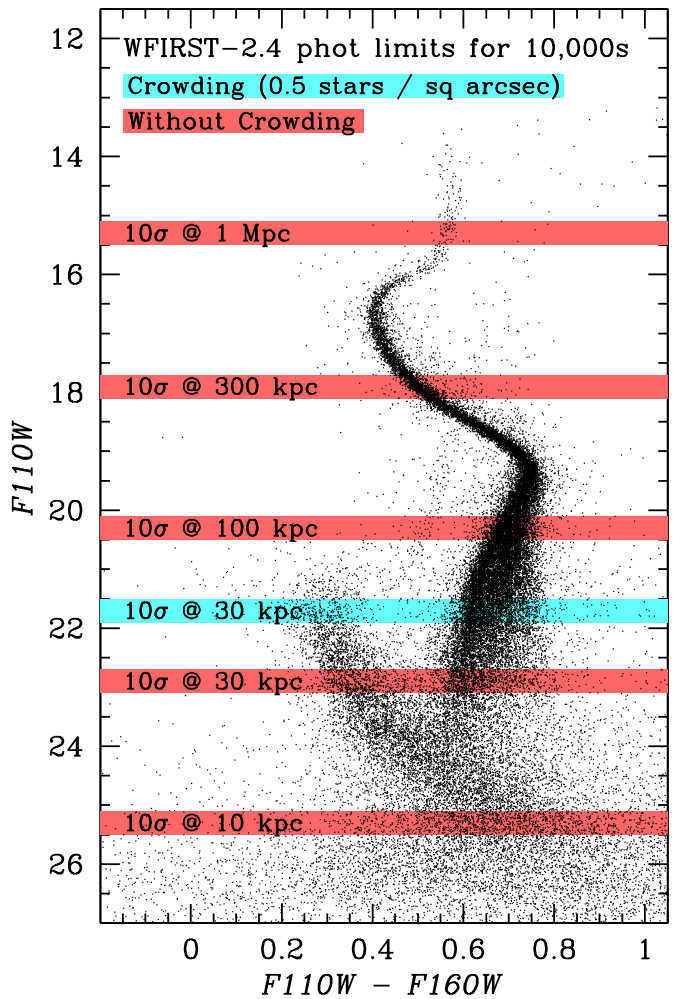
Frontiers of Knowledge **(3/4 key areas)**

Mapping the Relation Between Star Formation and its Environment



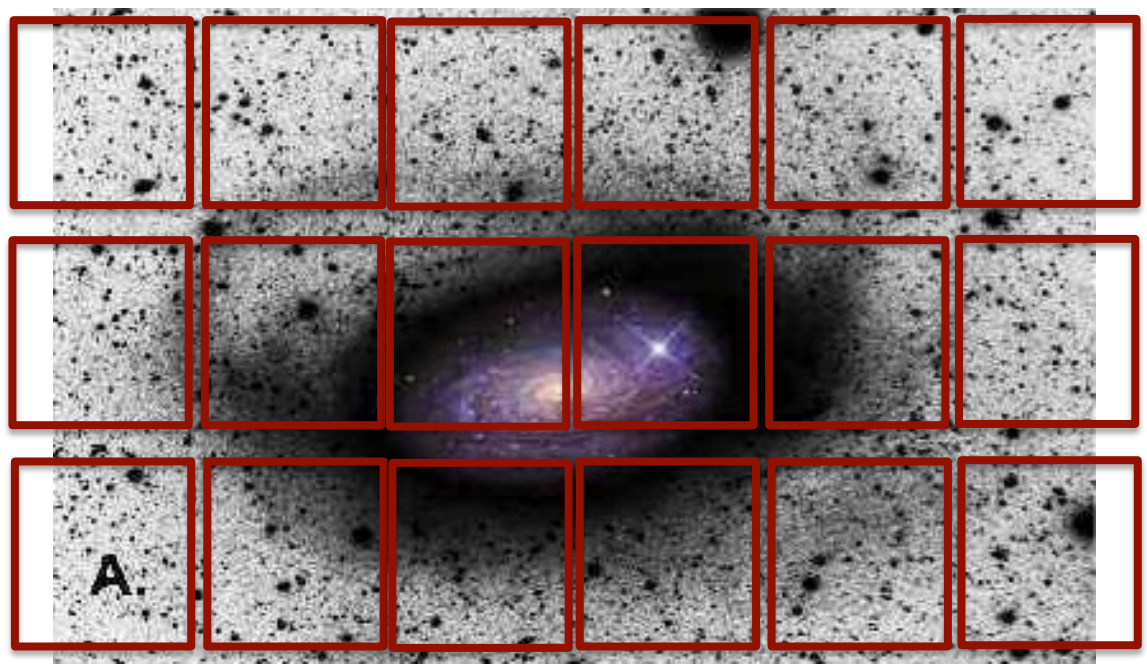
- WFIRST provides the first wide-field high resolution map of the Milky Way
- Mapping star forming regions and interplay with environment
- The initial mass function and dependencies on environment
- Star cluster formation and dissolution processes
- Dust extinction mapping

Unique Probe of Stellar Populations & Nearby Galaxies



Resolve and characterize stellar pops out to large distances (47 Tuc and SMC - Kalirai et al. 2012)

Ultra-deep imaging of galaxy halos (M63 - Martinez-Delgado et al. 2010)



Unique Probe of Cosmic Structure Formation History

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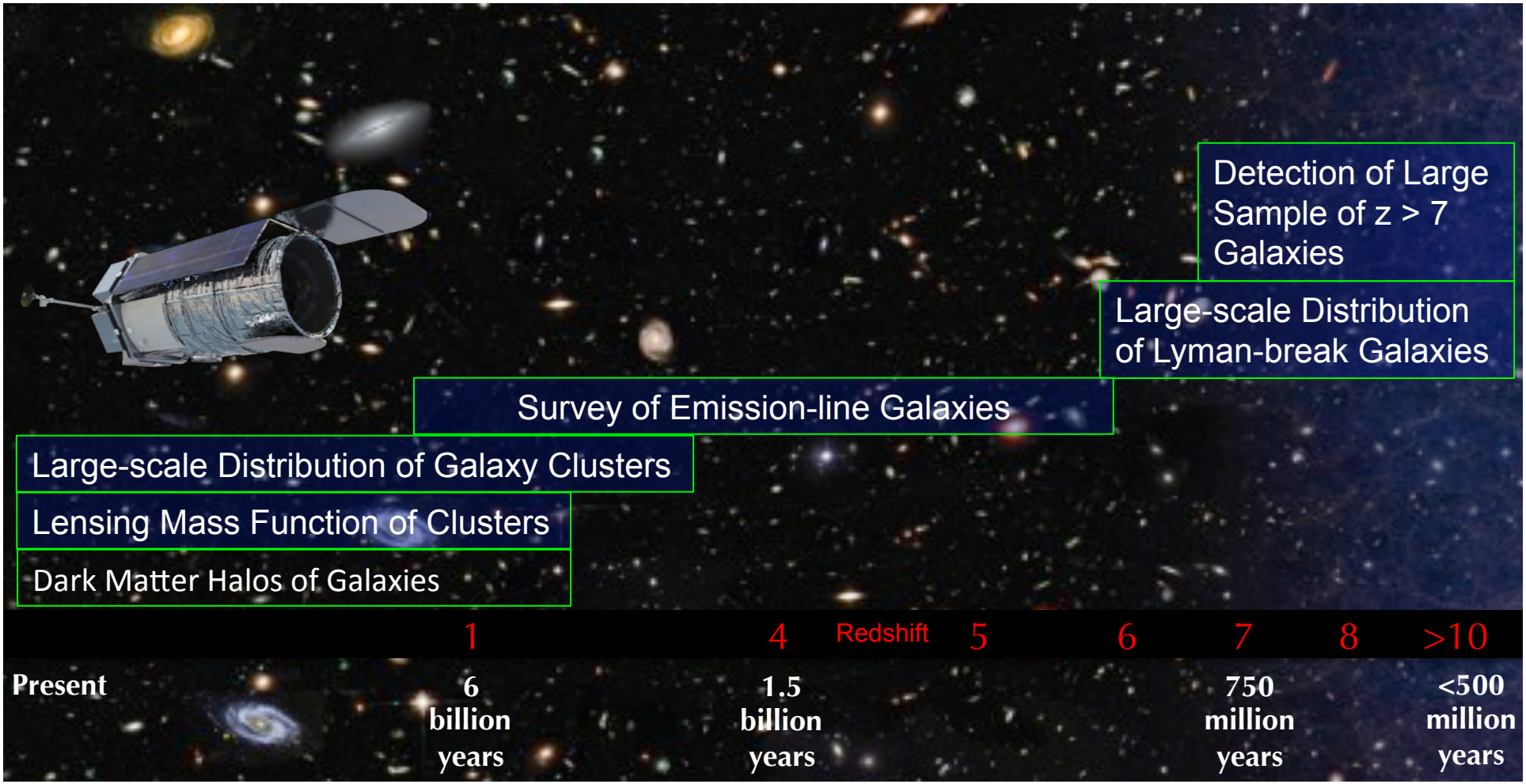
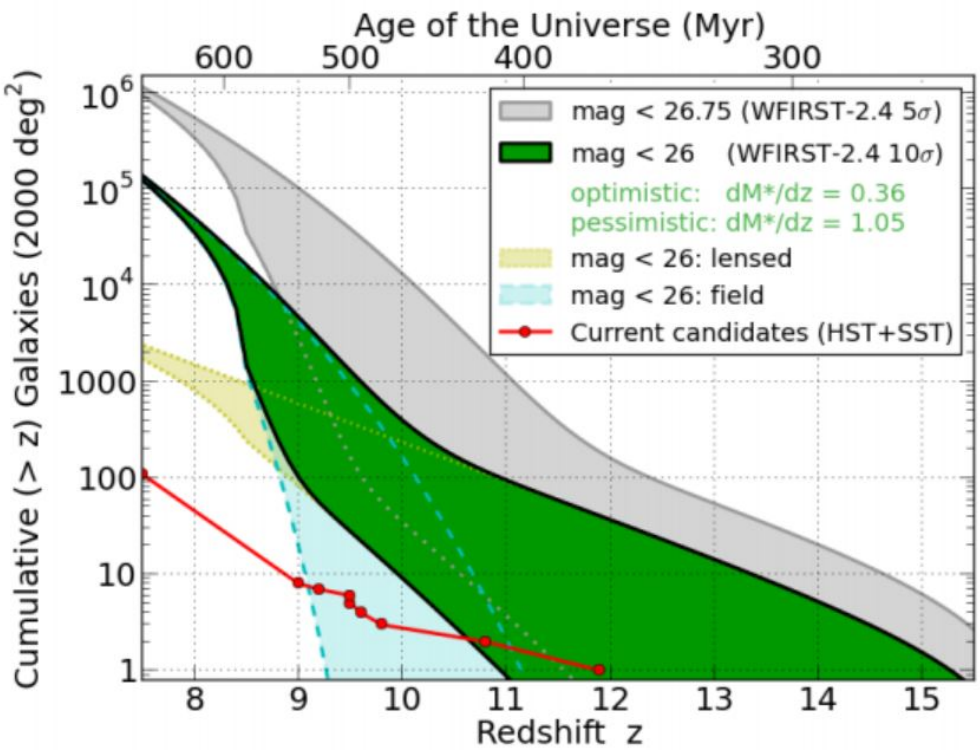
Using Observations from the High Latitude Survey and GO Programs



High Redshift Galaxies

- WFIRST High Latitude Survey will yield up to 2 orders of magnitude more high redshift galaxies than currently known



Postman & Coe
SDT Report 2015

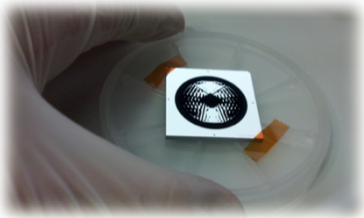
WFIRST FSWG

Name	Affiliation	Role
Neil Gehrels, **Chair**	NASA/GSFC	Project Scientist
David Spergel, **Deputy Chair**	Princeton University	WFI Adjutant Scientist
Jeremy Kasdin, **Deputy Chair**	Princeton University	CGI Adjutant Scientist
Dominic Benford, *ex officio*	NASA/HQ	Program Scientist
Dave Bennett	UMBC & GSFC	Microlensing
Ken Carpenter, *ex officio*	NASA/GSFC	Project science
Roc Cutri, *ex officio*	IPAC	Science center
Olivier Doré	NASA/JPL	Cosmology: GRS+WL
Ryan Foley	UIUC	Supernova Cosmology
Scott Gaudi	Ohio State U.	Microlensing
Chris Hirata	Ohio State U.	Cosmology: WL
Jason Kalirai	JHU & STScI	GI/GO – Galactic science
Jeff Kruk, *ex officio*	NASA/GSFC	Project science
Nikole Lewis	STScI	Coronagraph
Bruce MacIntosh	Stanford	Coronagraph
Roeland van der Marel, *ex officio*	STScI	Science center
S. Perlmutter	UC Berkeley	Supernova Cosmology
James Rhoads	Arizona State	GI/GO – Cosmic Dawn
Jason Rhodes, *ex officio*	NASA/JPL	Project science
Aki Roberge	NASA/GSFC	Coronagraph
Brant Robertson	UC Santa Cruz	GI/GO – Galaxy evolution
Alexander Szalay	Johns Hopkins	GI/GO – Archival science
Wes Traub, *ex officio*	NASA/JPL	Project science
Maggie Turnbull	GSI & SETI	Coronagraph
Yun Wang	Caltech/IPAC	Cosmology: GRS
David Weinberg	Ohio State Univ.	Cosmology: Clusters
Benjamin Williams	U. Washington, Seattle	GI/GO – Nearby Galaxies

What's Happening with WFIRST

- Key Decision Point A (KDP-A) completed – February 17, 2016.
- Mission Concept Review (MCR) successfully completed in December.
- WFIRST technology (Coronagraph and IR detectors) continue to make excellent progress. All milestones successfully completed.
  - Technology Assessment Committee (TAC) provides for external review
- Budget for FY17 has $90M from SMD and $10M from STMD. Recent augmented funding (FY14-16, $203M) has enabled significant mission progress.
  - Technology maturation.
  - Increased fidelity in the design reference..
- Wide Field concept study RFP to industry released January 4th.
  - Awarded concept studies to Ball and Lockheed.
- WFIRST Formulation Science Working Group (FSWG) and Science Investigation Teams selection made December 17, 2015.
- FSWG kick-off with Project held February 2-4, 2016.

H4RG-10 mounted in EDU structure



coronagraph shaped pupil mask

Observatory Configuration

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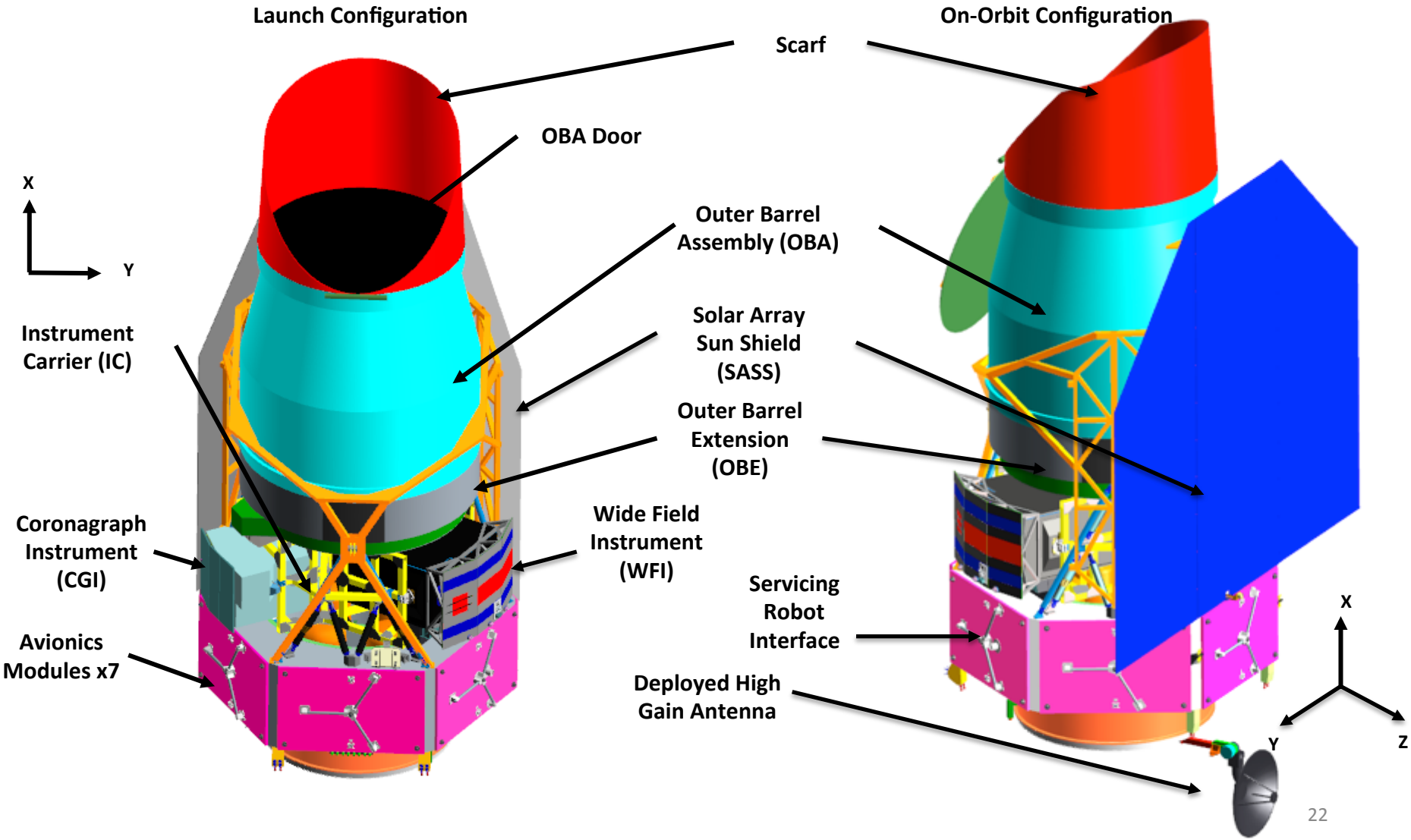
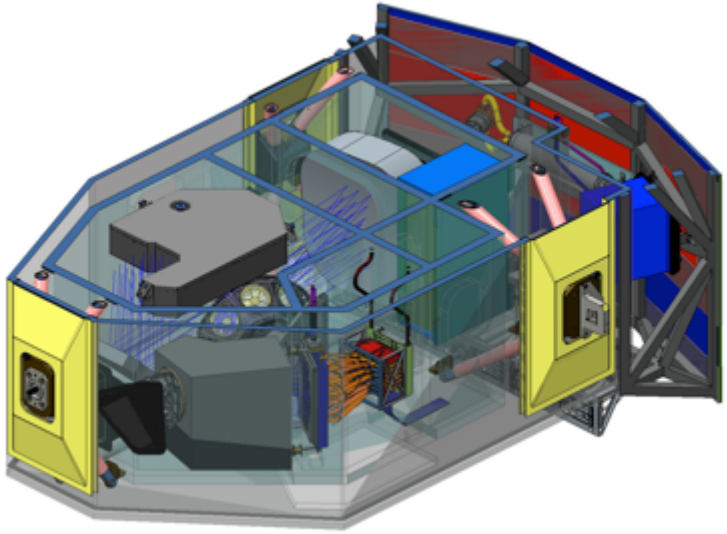
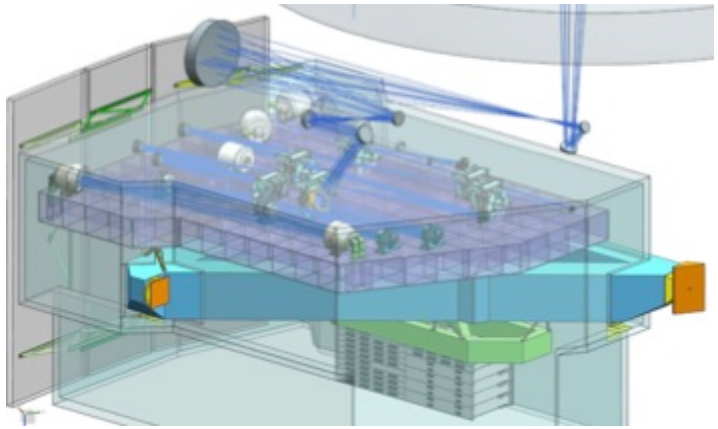


WFIRST Instruments

- Wide Field Instrument (WFI) - GSFC
  - Provides wide field imaging and spectroscopy in support of the dark energy surveys and the microlensing survey.
  - Provides integral field spectroscopy in support of the supernova survey and weak lensing photometric redshift calibrations.
  - Provides guide star data for observatory fine pointing.
- Coronagraph Instrument (CGI) - JPL
  - Provides high contrast imaging and integral field spectroscopy in support of exoplanet and debris disk science.





WFIRST Schedule

WFIRST
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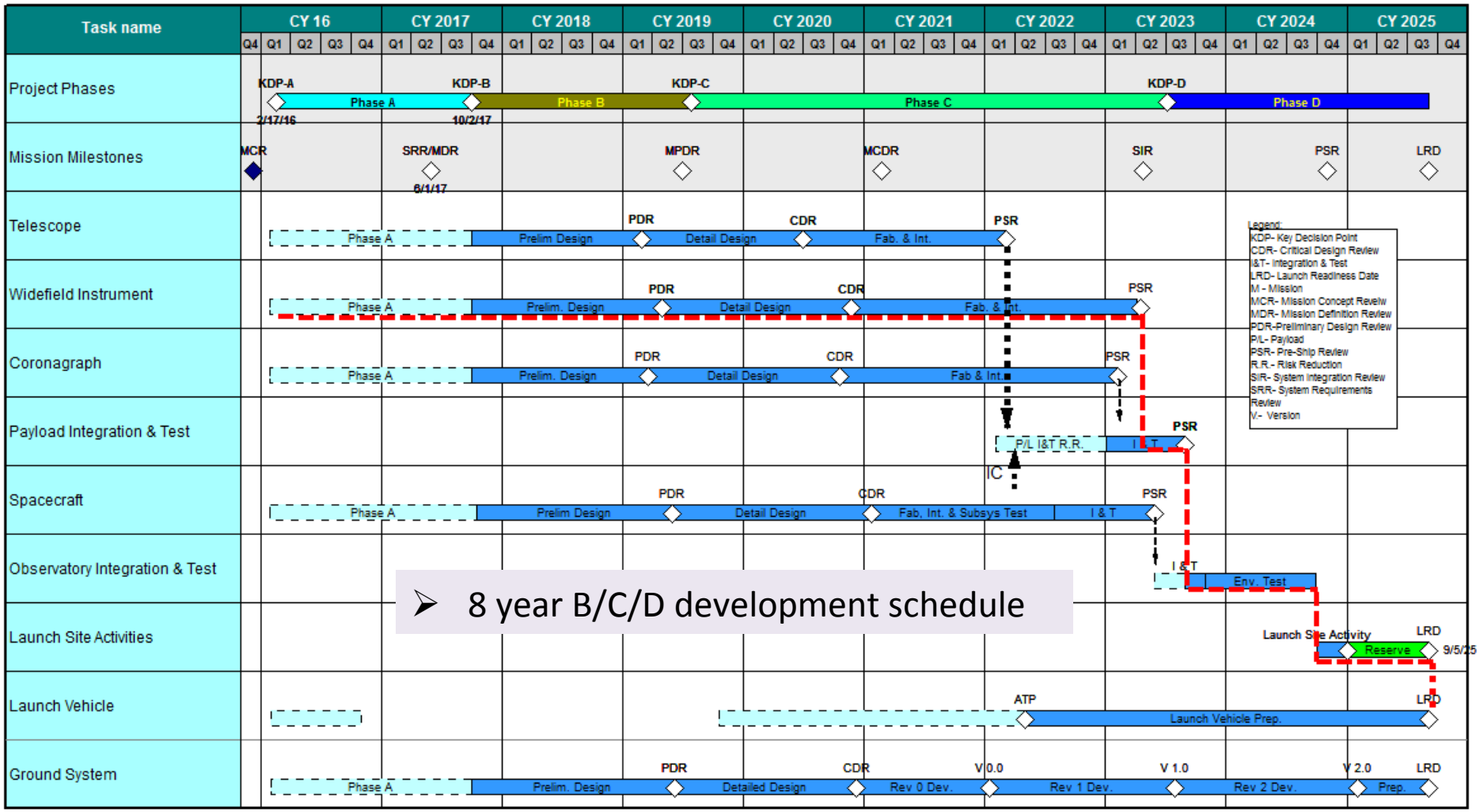


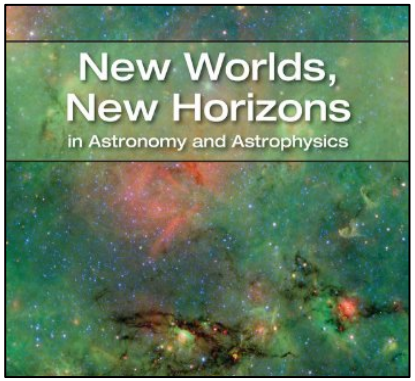
- 8 year B/C/D development schedule

WFIRST Summary

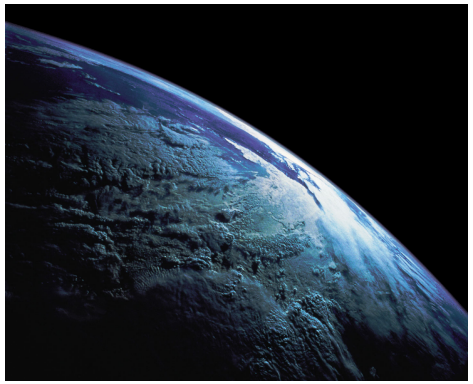
Hits 5/6 NASA Strategic Goals

Addresses all 3 APS performance goals

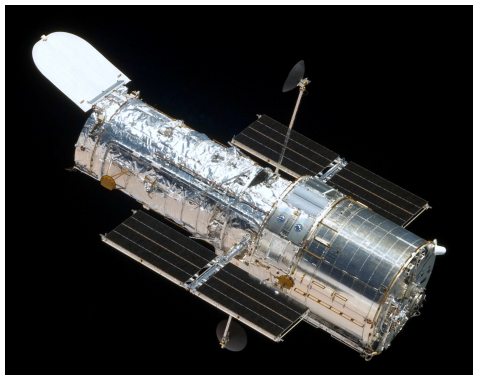
#1 Priority of Astro Decadal Survey



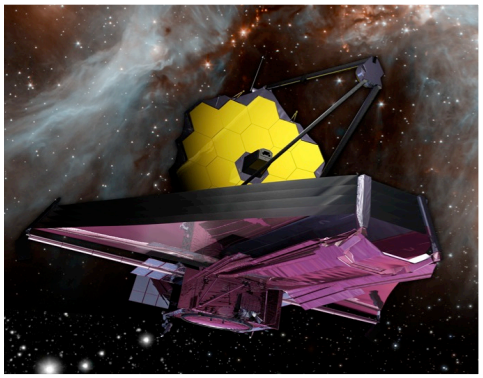
Brings the Universe to STEM education



Foundation for discovering Earth-like planets



Hubble's clarity over 10% of the sky



Complements and enhances JWST science