



# **WFIRST Project Status**

### Neil Gehrels WFIRST Project Scientist

WFIRST Pasadena Conference February 29, 2016





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**Neil Gehrels WFIRST** Project Scientist

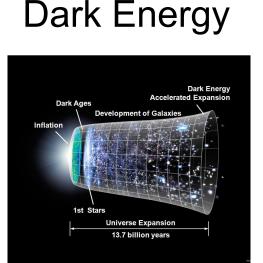
L'unce connot aler **WFIRST** Pasadena Conference February 29, 2016



## **Discovery Science**

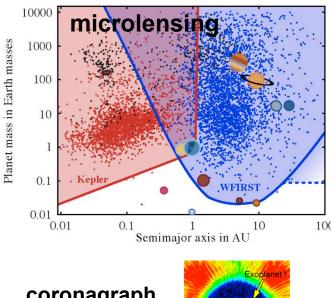


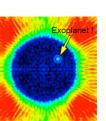
- WFIRST was highest ranked large space mission in 2010 Decadal Survey
- Use of 2.4m telescope enables
  - Hubble quality imaging over 100x more sky
  - Imaging of exoplanets with 10<sup>-9</sup> contrast with a coronagraph

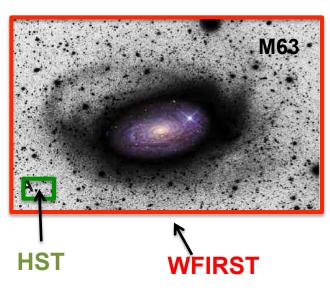




### Astrophysics







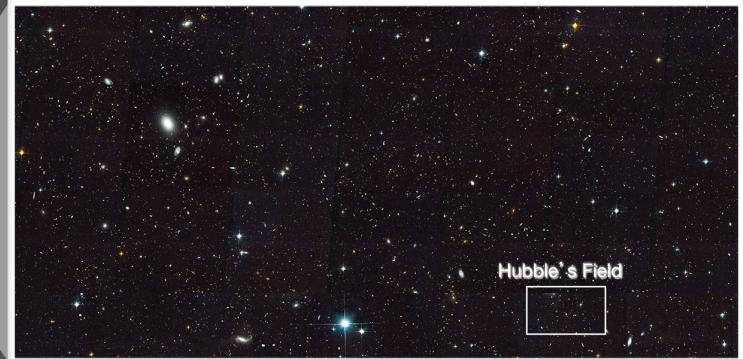
### Hubble - A Spectacular Start





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

### WFIRST-AFTA - Hubble X 100



An AFTA/WFIRST Deep Field A New Window on the Universe - **1,000,000** galaxies at a time



# **Scientific Objectives**

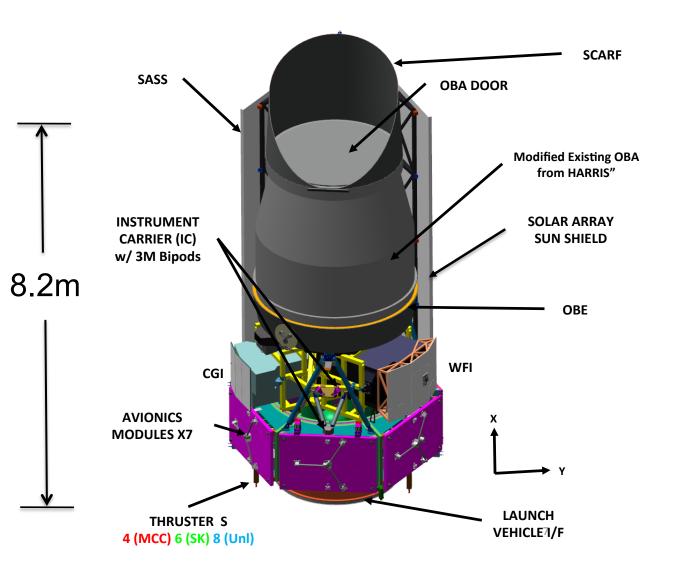


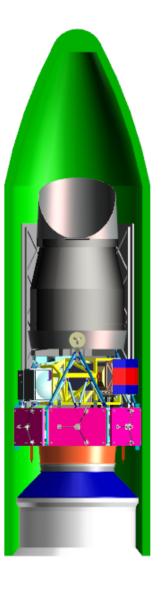
- Produce Hubble-quality NIR sky images and spectra over 1000's of sq deg (J = 27AB imaging, F\_line = 10<sup>-16</sup> erg cm<sup>-2</sup> sec<sup>-1</sup>)
- Determine the expansion history of the Universe and the growth history of its largest structures in order to test possible explanations of its 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 observing time



# **Observatory Configuration**



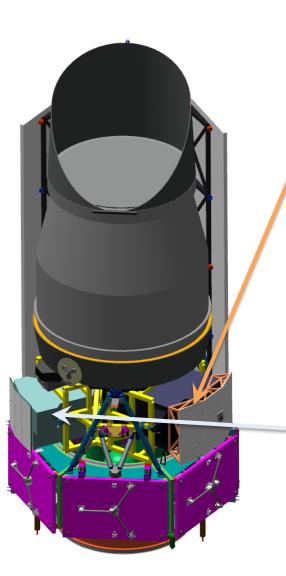






# **WFIRST Instruments**





#### **Wide-Field Instrument**

- Imaging & spectroscopy over 1000s of sq. deg.
- Monitoring of SN and microlensing fields
- 0.7-2.0 μm (imaging), 1.1?-1.89 μm (spec.), 0.45-2.0 μm (IFU)
- 0.28 deg<sup>2</sup> FoV (100x JWST FoV), 9 asec<sup>2</sup> & 36 asec<sup>2</sup> (IFU)
- 18 H4RG detectors (288 Mpixels), 2 H1RG detectors (IFU)
- 6 filter imaging, grism + IFU spectroscopy

### Coronagraph

- Image and spectra of exoplanets from super-Earths to giants
- Images of debris disks
- 430 970 nm (imaging) & 600 970 nm (spec.)
- Final contrast of 10<sup>-9</sup> or better
- Exoplanet images from 0.1 to 1.0 arcsec



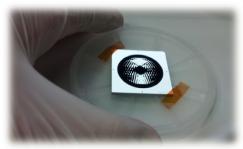
### What's Happening with WFIRST



- WFIRST in Phase A with highly successful KDP-A reviews culminating with NASA agency council review Feb. 17, 2016
- Science teams selected! 5 year term
- \$196M in FY14-16 has enabled major steps forward
  - Detector & coronagraph development
  - Design cycles, Project work
- 3 day Mission Concept Review, Dec. 2015
- SDT 2014 & 2015 studies completed
- Preparatory science studies funded, \$5M
- Conferences in 2014 & 2016
- Next one planned at STScI in 2017
- Special sessions at AAS's & IAU
- Canada, ESA, Japan interest
- ExoPAG, COPAG, PhysPA white papers
- Exciting times for WFIRST



H4RG-10 mounted in EDU structure



coronagraph shaped pupil mask

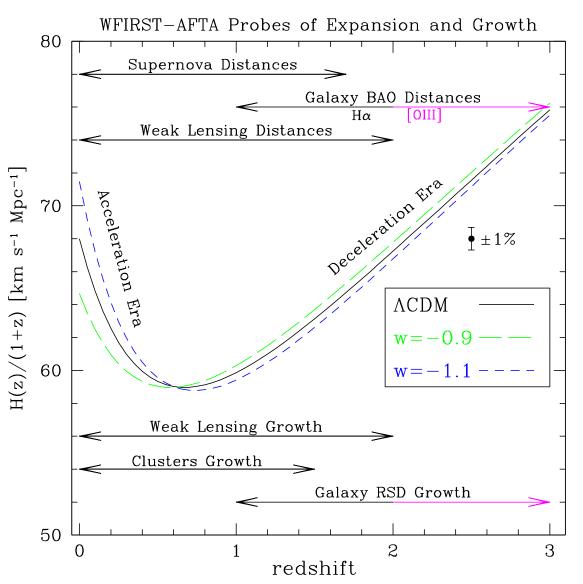


# **Dark Energy Program**



- 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

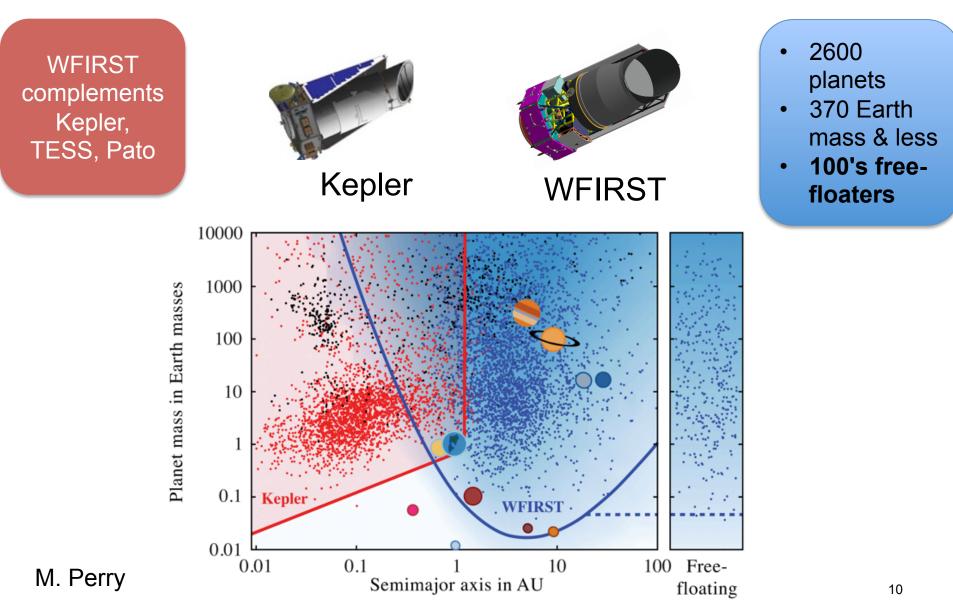
Weinberg & SDT 2014





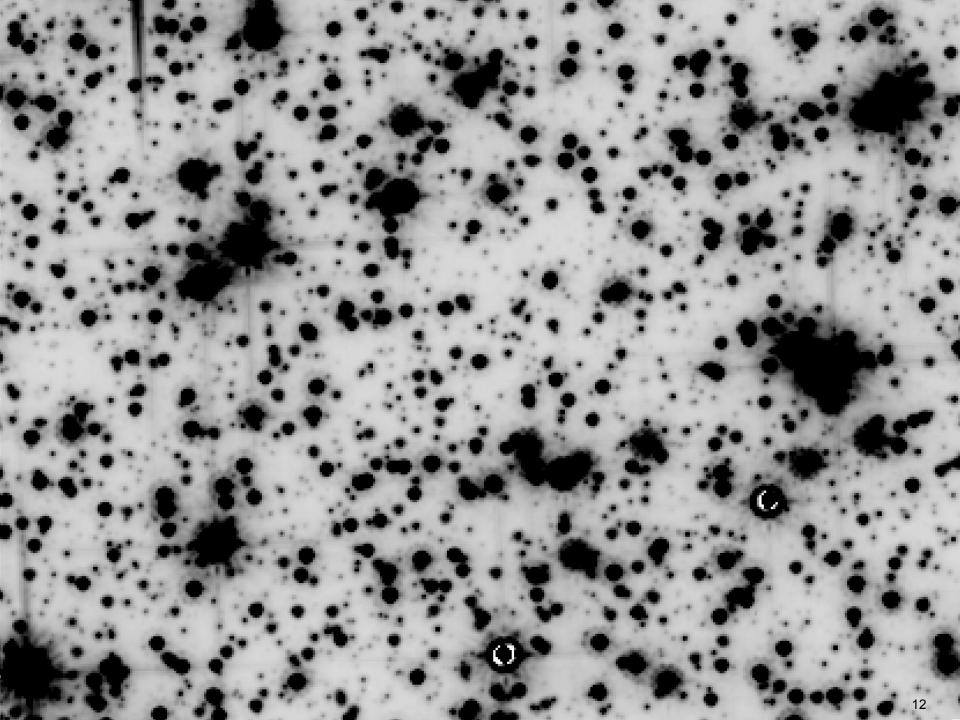
### **Microlensing Survey Yields**





# **SWEEPS 2012/4 F814W STACK**

# Jay Anderson



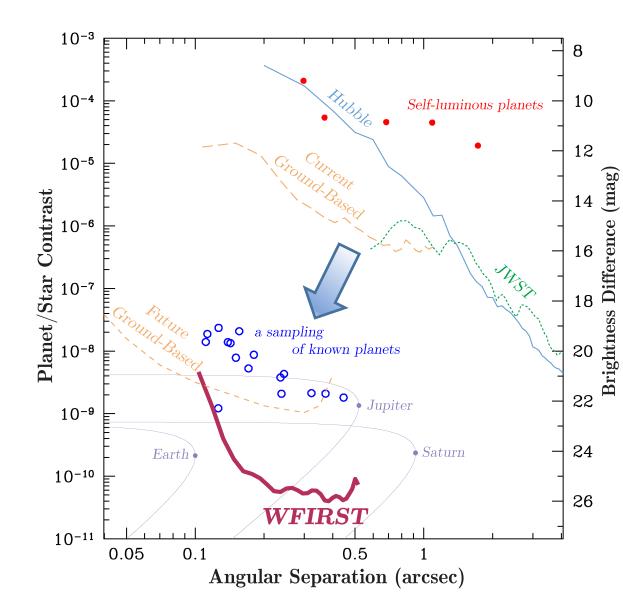


# **Coronagraph Performance**



- 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

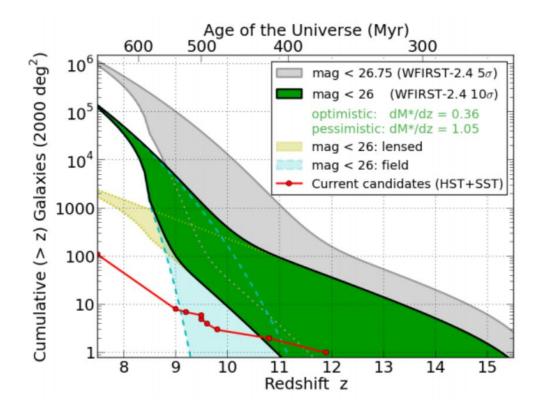




### **Guest Observer Science**



- GO Science: 25% of WFIRST observing time in first 6 years and 100% in years 6+
- Example: WFIRST's HLS will yield up to 2 orders of magnitude more high redshift galaxies than currently known



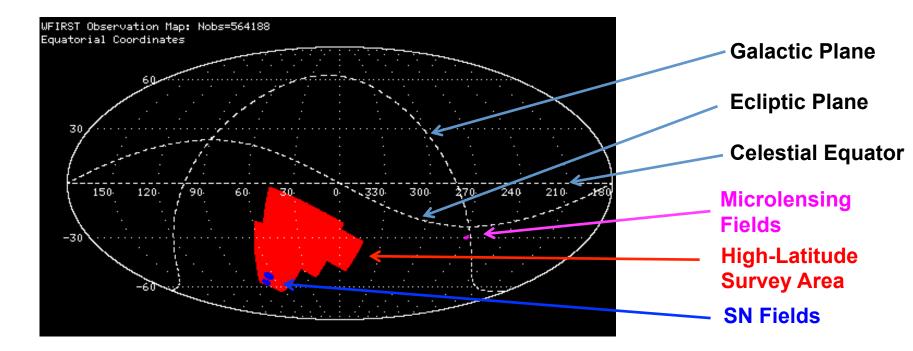
Postman & Coe SDT Report 2015



# **Example Observing Program**



- High-latitude survey (HLS: imaging + spectroscopy): 2 years
- Microlensing: 1 year, 6 seasons, after lunar cutouts
- SN survey: 0.5 years, monitoring, field embedded in HLS footprint
- Coronagraphy: 1 year, interspersed throughout the mission
- GO program: 1.5 years



Hirata & SDT 2015



### Attributes

Imaging survey

Slitless spectroscopy

Number of SN Ia SNe Number galaxies with spectra Number galaxies with shapes Number of galaxies detected Number of massive clusters Number of microlens exoplanets

# Yields



### **WFIRST** Yields

 $J \sim 26.7 \text{ AB over } 2200 \text{ sq deg}$  $J \sim 29 \text{ AB over } 3 \text{ sq deg deep fields}$  $R \sim 461\lambda \text{ over } 2200 \text{ sq deg}$ 

2700 to  $z \sim 1.7$   $2x10^7$   $4x10^8$ few x  $10^9$   $4x10^4$ 2600 10s





# **Preparatory Science Teams**



#### WFI Imaging

- Peter Capak: weak lensing, redshift calibration
- Douglas Clowe: cluster weak lensing
- Robert Lupton: WFIRST-LSST, WL galaxy blending
- Michael Shao: astrometry, sub-pixel calibration
- Michael Schneider: WFIRST-LSST, WL galaxy blending

#### WFI & IFU Spectroscopy

- Chuck Bennett: constraining dark energy parameters,
- Bob Kirshner: HST RAISINS SN Ia implications for WFIRST
- Ryan Foley: SN Ia, color corrections
- Saul Perlmutter: refine SN Ia program for WFIRST
- James Rhoads: HLS spectroscopy, studies with HST and ground
- Uros Seljak: HLS spectroscopic survey, open-source toolbox

#### **Exoplanets**

- David Bennett: microlensing (mass parallax, distance)
- Geoffrey Bryden: coronagraph RV planets
- Christine Chen: exoplanets imbedded in disks
- Nikole Lewis: coronagraph spectroscopy and polarimetry
- Dmitry Savransky: coronagraph performance modeling
- Margaret Turnbull: coronagraph filter spectroscopy



### FSWG



- Formulation Science Working Group (FSWG) is the science executive committee of WFIRST
- Membership (25 members)
- Project Scientist Chair, Adjutant Scientists Co-Chairs
- PIs and some Deputy PIs from Science Investigation Teams
- Program Scientist (ex-officio) Benford
- GSFC and JPL Deputy Project Scientists (ex-officio) Kruk, Rhodes, Traub
- Science Center Leads (ex-officio) Cutri, van der Marel

#### **Science Investigation Team PIs**

- David Spergel WFI Adjutant Scientist
- Jeremy Kasdin
  CGI Adjutant Scientist
- Olivier Doré Weak lensing and galaxy redshift survey
- Saul Perlmutter
  Supernovae
- Ryan Foley
  Supernovae
- Scott Gaudi Microlensing
- Bruce Macintosh Coronagraphy
- Margaret Turnbull Coronagraphy

- Jason Kalirai GO science, Milky Way
- James Rhoads
  GO science, cosmic dawn
  - Brant Robertson GO science, galaxy formation & evolution
  - Alexander Szalay GI science, archival research
- Benjamin Williams GO science, nearby galaxies



# **Data Rights Considerations**



- The 2014-15 SDT committee found that the standard one year data proprietary time does not make sense for WFIRST
- WFIRST WFI has wide FoV that makes proprietary data difficult
- Different science areas for WFIRST have different data needs and processing requirements.
- An open data policy such as that of LSST appears to be the natural fit for most or all of the WFIRST data
- Rapid public access to broad-use survey data has been demonstrated to maximize scientific output.
- To be considered by the FSWG



# **WFIRST Summary**



#### Hits 5/6 NASA Strategic Goals



# Addresses all 3 APS performance goals



#### #1 Priority of Astro Decadal Survey



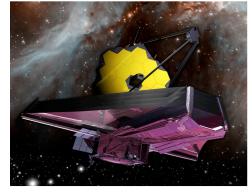
# Brings the Universe to STEM education





Foundation for discovering Earth-like planets





overing Hubble's clarity over Com ets 10% of the sky enhance

Complements and enhances JWST science