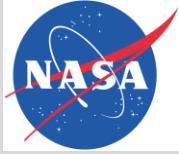


NASA's Wide Field Infrared Survey Telescope (WFIRST)

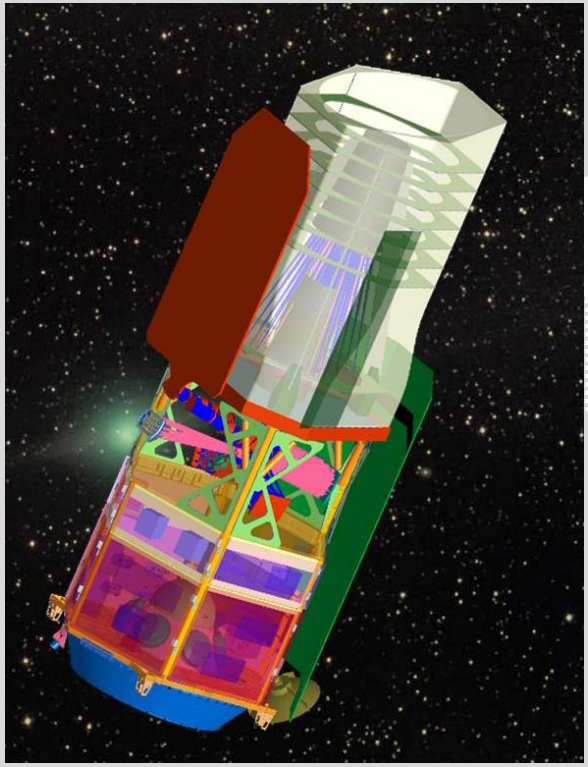
Jason Rhodes (JPL/Caltech)

Multi-Object Spectroscopy in the Next Decade

March 5, 2015

© 2015, government sponsorship acknowledged

WFIRST =



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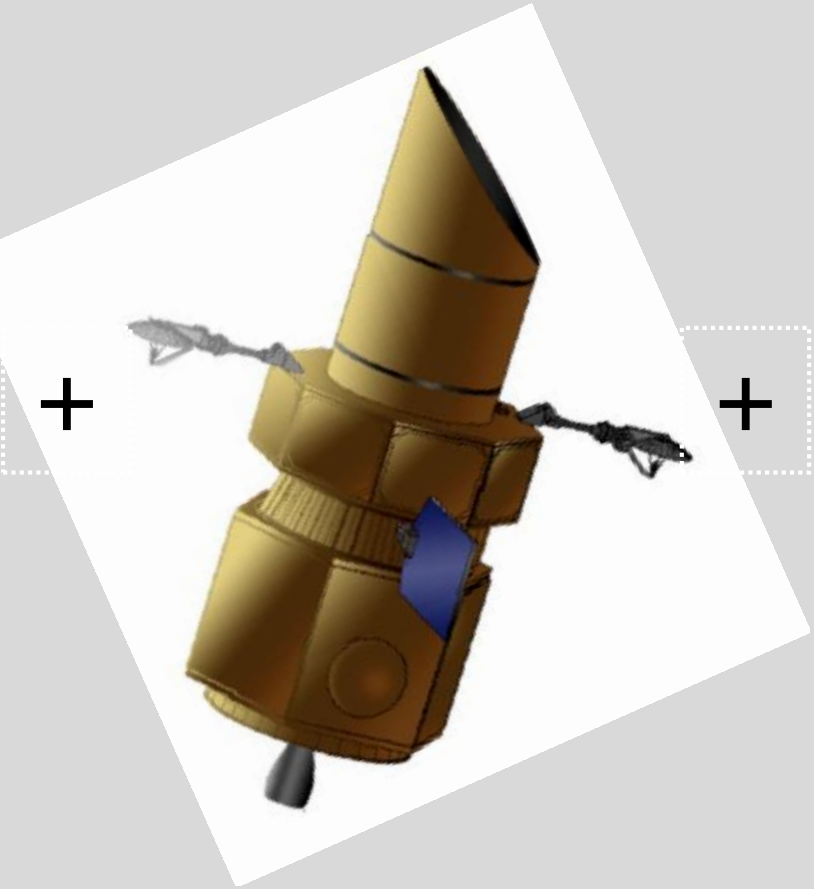

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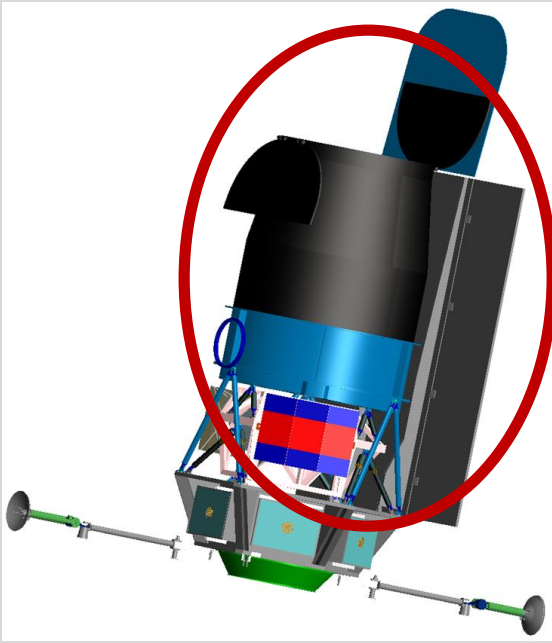
JDEM-Ω

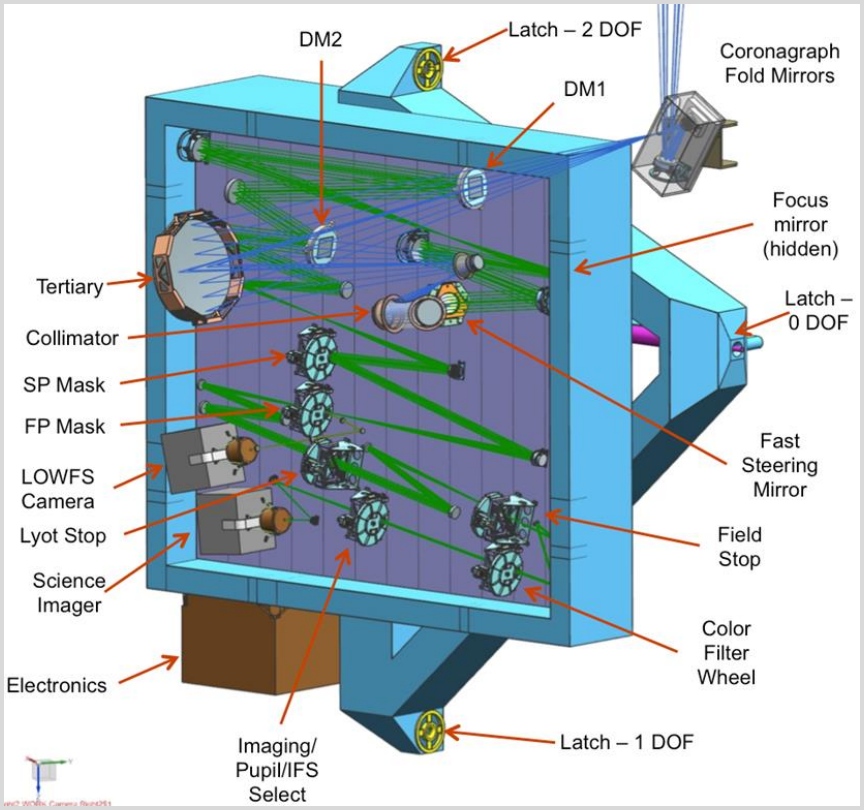
MPF

NIRSS

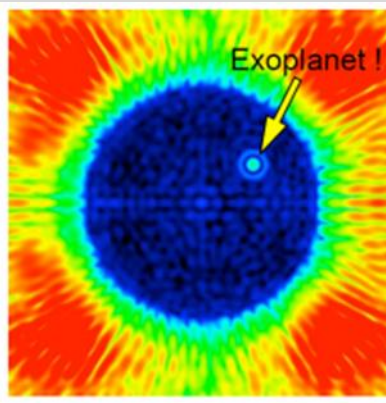
WFIRST-AFTA

- Latest Design Reference Mission is WFIRST– **AFTA** (Astrophysics Focused Telescope Asset)
- AFTA is a repurposed 2.4 m telescope from the US National Reconnaissance office (NRO)
- The AFTA telescope is already built, and sitting in a storage facility





- WFIRST-AFTA includes a coronagraph to image exoplanets
- This was not envisaged by the decadal survey
- Enabled by the 2.4 meter mirror



WFIRST-AFTA Checks Many Boxes

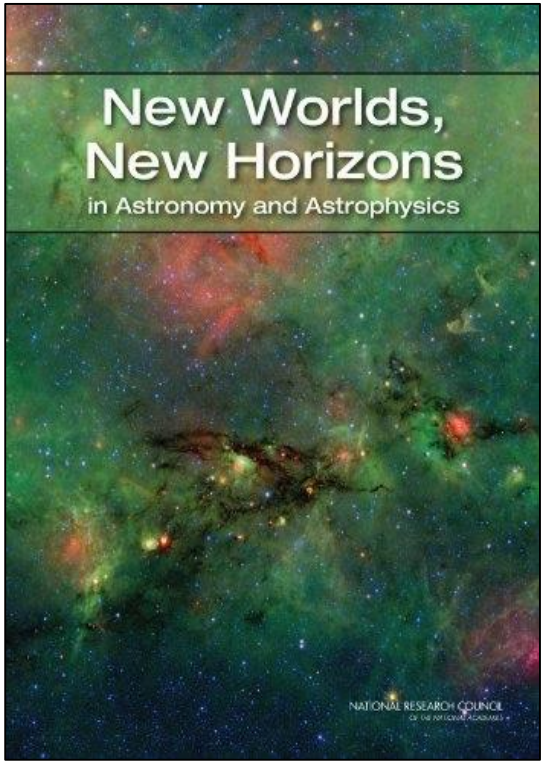
Highest Priority

#1 Large-Scale Priority - Dark Energy, Exoplanets

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

(prepare for 2020s planet imaging mission)

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

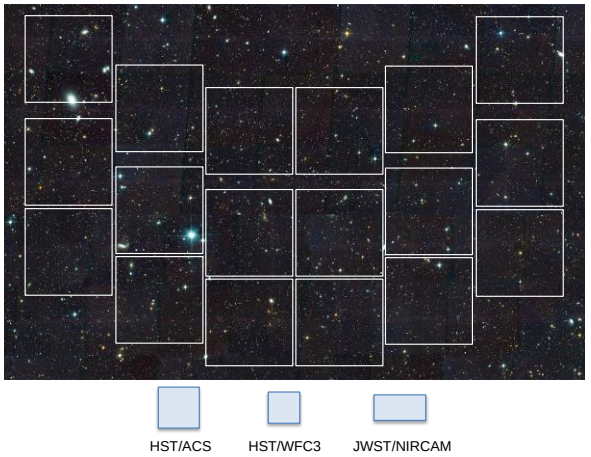
Origins **(7/7 key areas)**

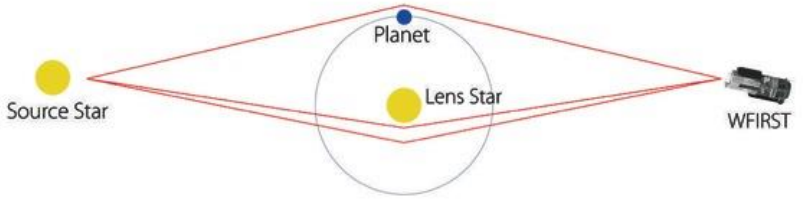
Understanding the Cosmic Order **(6/10 key areas)**

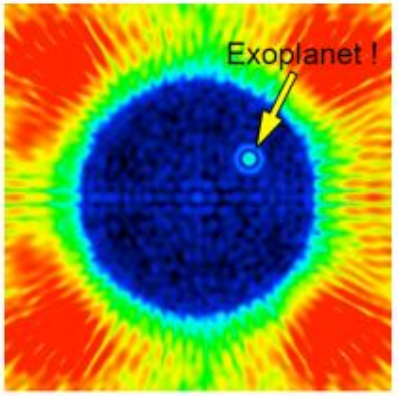
Frontiers of Knowledge **(3/4 key areas)**

WFIRST-AFTA Summary

- WFIRST is the highest ranked NWNH large space mission.
  - Determine the nature of the dark energy that is driving the current accelerating expansion of the universe
  - Perform statistical census of planetary systems through microlensing survey
  - Survey the NIR sky
  - Provide the community with a wide field telescope for pointed wide observations
- Coronagraph characterizes planets and disks, broadens science program and brings humanity closer to imaging Earths.
- WFIRST gives Hubble-quality and depth imaging over thousands of square degrees
- The WFIRST-AFTA Design Reference Mission has
  - 2.4 m telescope (already exists)
  - NIR instrument with 18 H4RG detectors
  - Baseline exoplanet coronagraph
  - 6 year lifetime





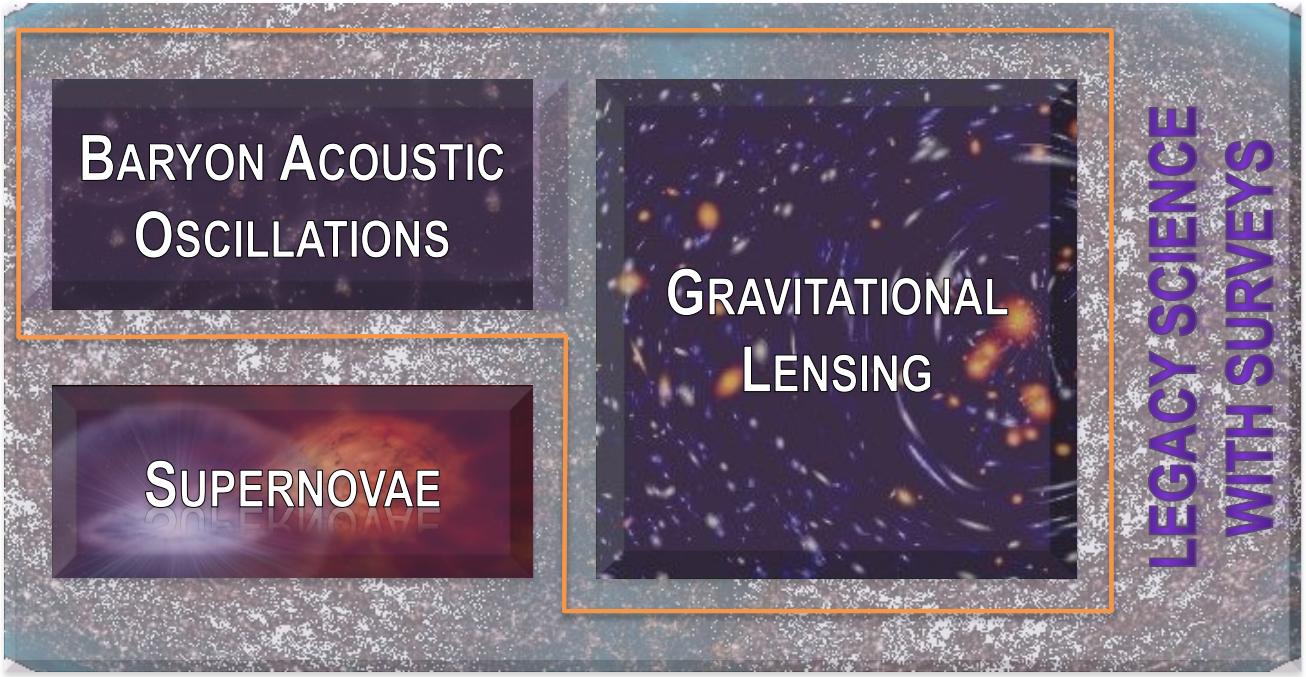


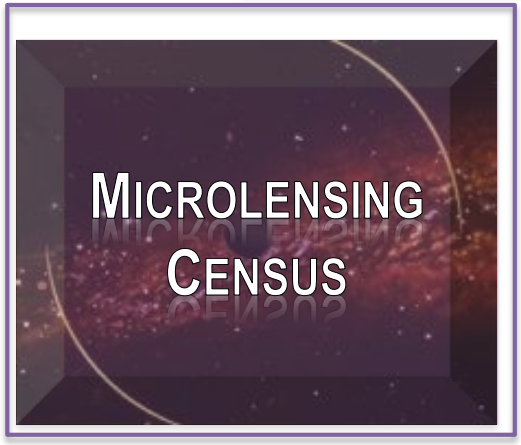
WFIRST-AFTA Science

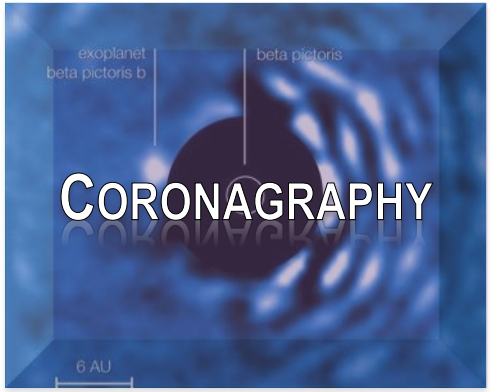
complements Euclid

complements LSST

complements Kepler

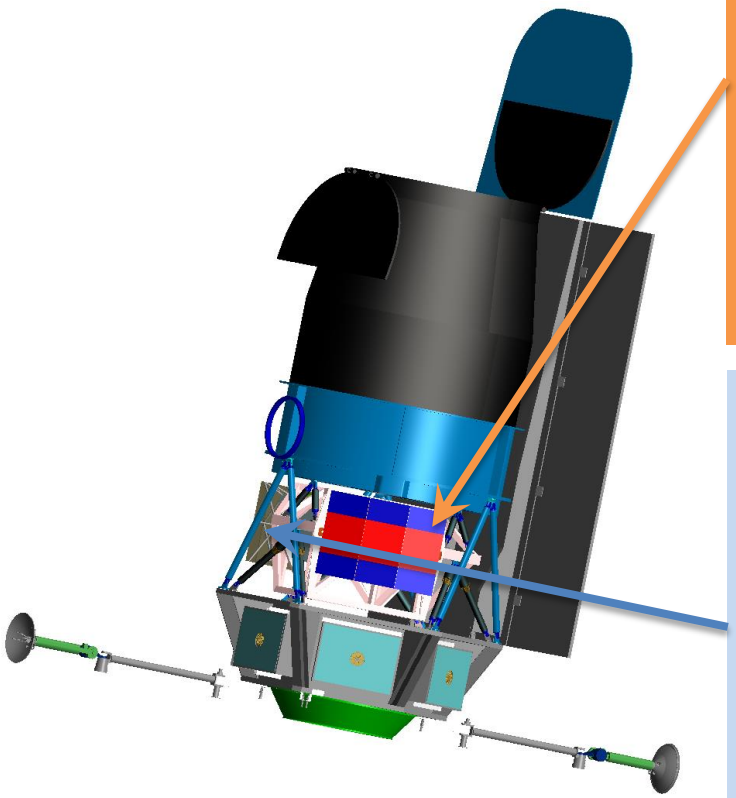






continues Great Observatory legacy

WFIRST-AFTA Instruments



Wide-Field Instrument

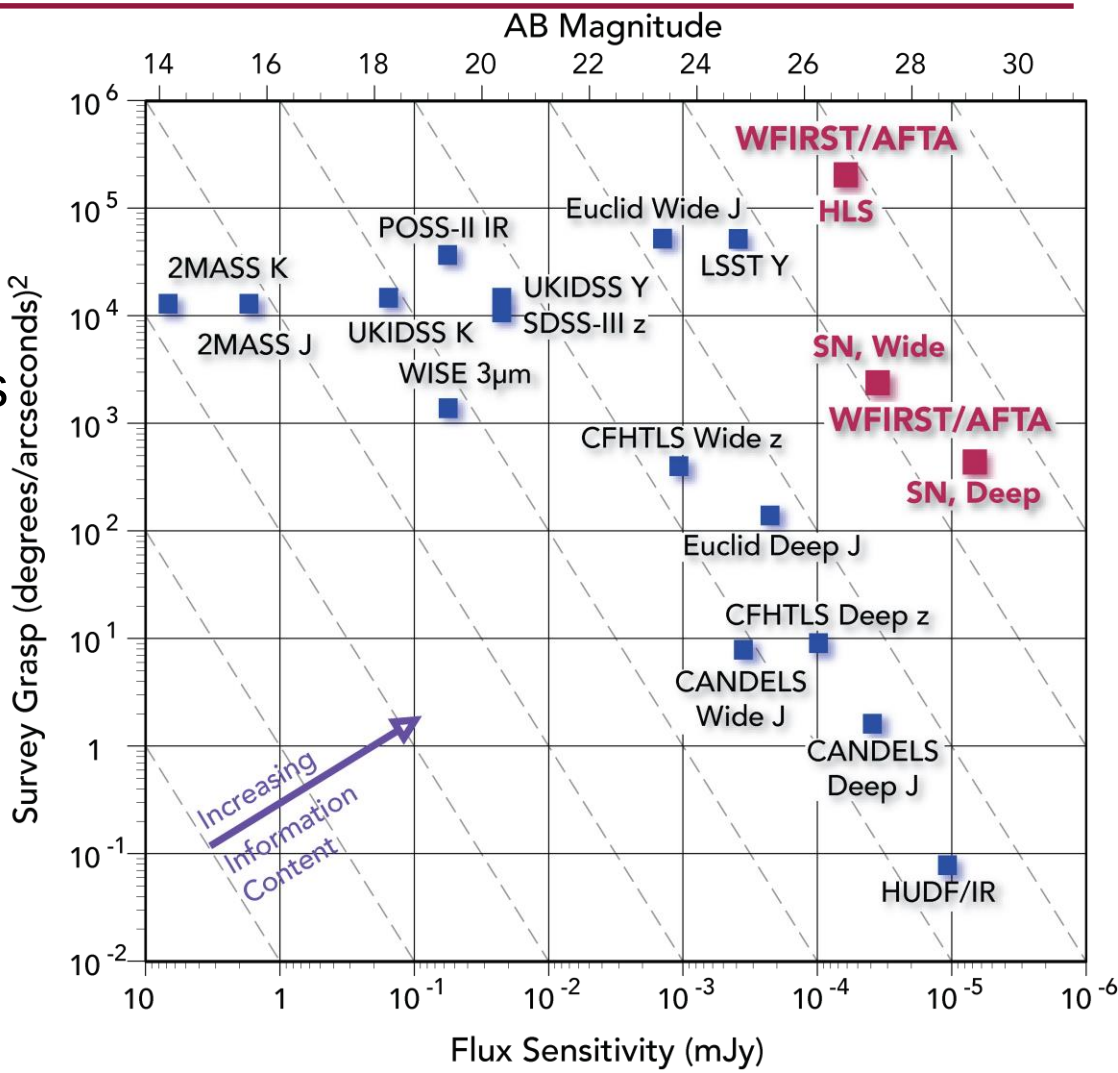
- *Imaging & spectroscopy over 1000s of sq. deg.*
- *Monitoring of SN and microlensing fields*
- 0.7 – 2.0 μm (imaging) & 1.35-1.89 μm (spec.)
- 0.28 deg^2 FoV (100x JWST FoV)
- 18 H4RG detectors (288 Mpixels)
- 6 filter imaging, grism + IFU spectroscopy

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^{-9} or better
- Exoplanet images from 0.1 to 1.0 arcsec

WFIRST-AFTA Surveys

- Multiple surveys:
  - High-Latitude Survey
    - Imaging, spectroscopy, supernova monitoring
  - Repeated Observations of Bulge Fields for microlensing
  - 25% Guest Observer Program
  - Coronagraph Observations
- Flexibility to choose optimal approach



Near Infrared Surveys

Capabilities

WFI:

Imager	**0.76-2.0 microns** 0.28˚ FoV, 0.11" pixel scale
Filters:	z (0.76 - 0.98), Y (0.93-1.19), J (1.13-1.45), H(1.38-1.77),
	F184 (1.68-2.0), W149 (0.93-2.00)
Grism:	**1.35-1.89 microns** 0.28˚ FoV, R=461λ, 0.11" pixel scale
IFU:	**0.6-2.0 microns** 3" & 6" FoV, R~100, 0.075" pixel scale

Coronagraph:

Imager:	**0.43-0.97 microns** 1.63" FoV (radius), 0.01" pixel scale, 1k x 1k EMCCD, 10^{-9} final contrast, 100-200 mas inner working angle
IFS:	**0.60-0.97 microns** 0.82" FoV (radius), R~70

Field of Regard: 54˚ - 126˚ 60% of sky

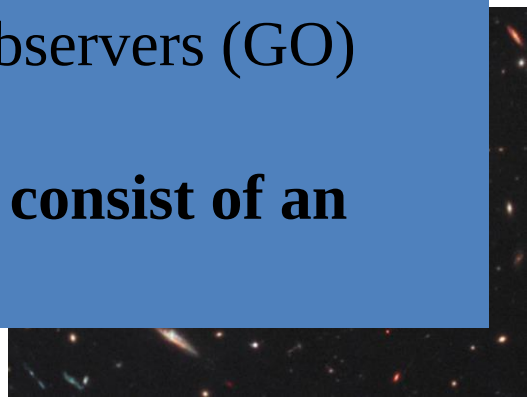
Design Reference Mission Yields

Attributes	WFIRST-AFTA Yields
Imaging survey	J ~ 27 AB over 2200 sq deg
Slitless	s
Numbe	
Numbe	
Numbe	
Numbe	
Numbe	
Number of microlens exoplanets	2600
Number of imaged exoplanets	10s

This is in a 6 year mission with:

- 2 years High Latitude Survey (HLS) imaging an spectroscopy
- ~6 months SN search and follow-up with IFU
- ~1 year for coronagraph
- ~1 year for microlensing planet search
- ~1.5 years (25%) dedicated to Guest Observers (GO)

An extended mission (10+ years) would consist of an expanded GO program



WFIRST-AFTA Status

- Significant WFIRST-AFTA funding added to the NASA budget by Congress for FY14 and FY15 for a total of $106.5M.
- Funding is being used for pre-Phase A work to prepare for a rapid start and allow a shortened develo
  - Detector array developme
  - Coronagraph technology
  - Science simulations and
  - Observatory design work
- ROSES "Preparatory Sci nteen proposals funded at ~$15
- NASA HQ charge for tele for coronagraph is "not drive ward the fastest, cheapest imp
- Community engagement: PAGs, conferences and outreach
  - Special sessions held at January & June 2014 and January 2015 AAS conferences
  - Wide-Field Infrared Surveys conference held in November 17-22, 2014 in Pasadena
- **Foreign contributions being actively pursued (Europe, Canada, Japan, Korea)**

Jason's best guess: 2017 full start for 2024 launch with a 10 year mission

Additional Material

WFIRST-AFTA SDT

Co-Chairs

- David Spergel, Princeton University
- Neil Gehrels, NASA GSFC

Members

- Charles Baltay, Yale University
- Dave Bennett, University of Notre Dame
- James Breckinridge, California Institute of Technology
- Megan Donahue, Michigan State University
- Alan Dressler, Carnegie Institution for Science
- Scott Gaudi, Ohio State University
- Tom Greene, NASA ARC
- Olivier Guyon, Steward Observatory
- Chris Hirata, Ohio State University
- Jason Kalirai, Space Telescope Science Institute
- Jeremy Kasdin, Princeton University
- Bruce Macintosh, Stanford University
- Warren Moos, Johns Hopkins University
- Saul Perlmutter, University of California Berkeley
- Marc Postman, Space Telescope Science Institute
- Bernie Rauscher, NASA GSFC
- Jason Rhodes, NASA JPL
- Yun Wang, IPAC/Cal Tech
- David Weinberg, Ohio State University

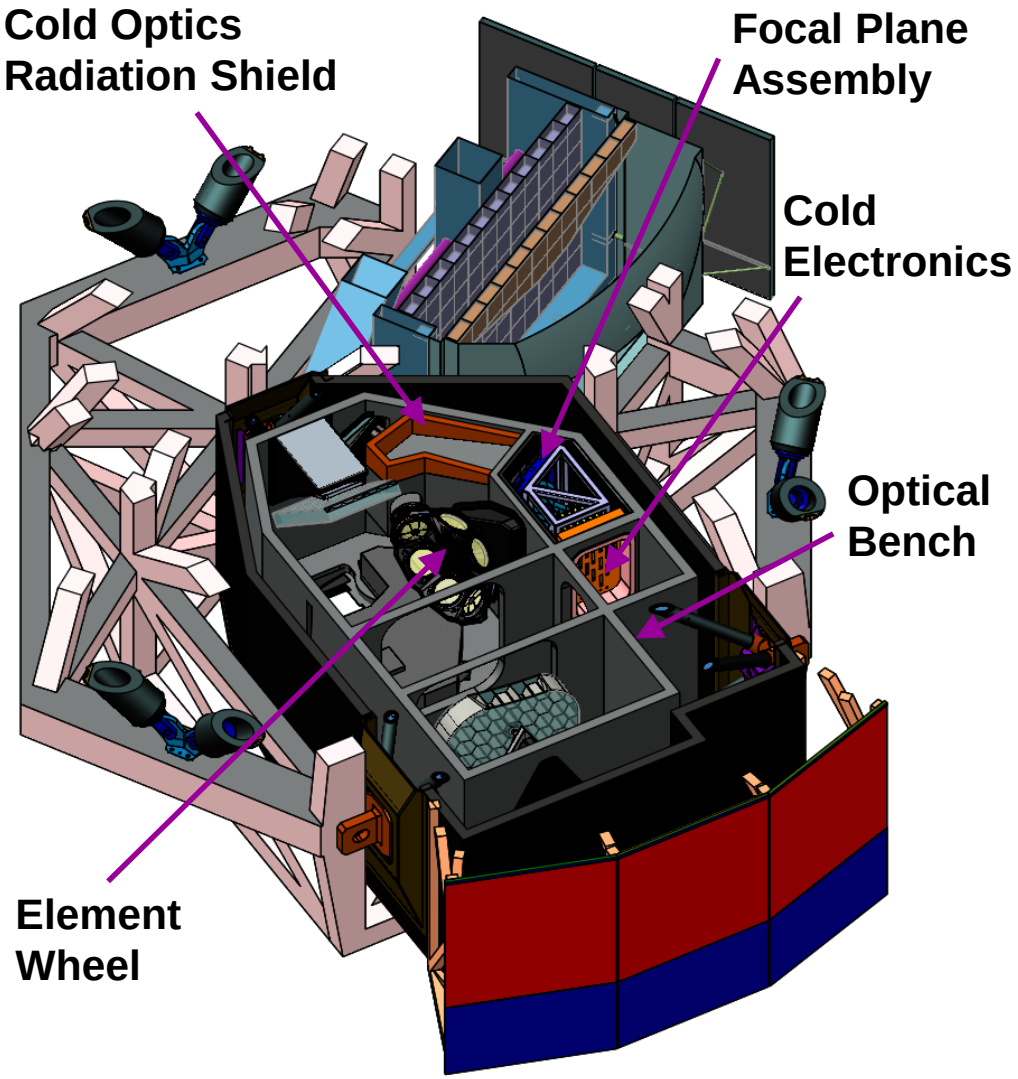
Ex Officio

- Dominic Benford, NASA HQ
- Mike Hudson, Canadian Space Agency
- Woong-Seob Jeong, Korea Astronomy and Space Science Institute
- Yannick Mellier, European Space Agency
- Wes Traub, NASA JPL
- Toru Yamada, Japan Aerospace Exploration Agency

Wide Field Instrument Overview

Key Features

- Wide field channel instrument for both imaging and spectroscopy
  - 3 mirrors, 1 powered
  - 18 4k x 4k HgCdTe detectors cover 0.76 - 2.0 μm
  - 0.11 arc-sec plate scale
  - Single element wheel for filters and grism
  - Grism used for GRS survey covers 1.35 – 1.89 μm with R = 461λ (~620 – 870)
- IFU channel for SNe spectra, single HgCdTe detector covers 0.6 – 2.0 μm with R between 80-120

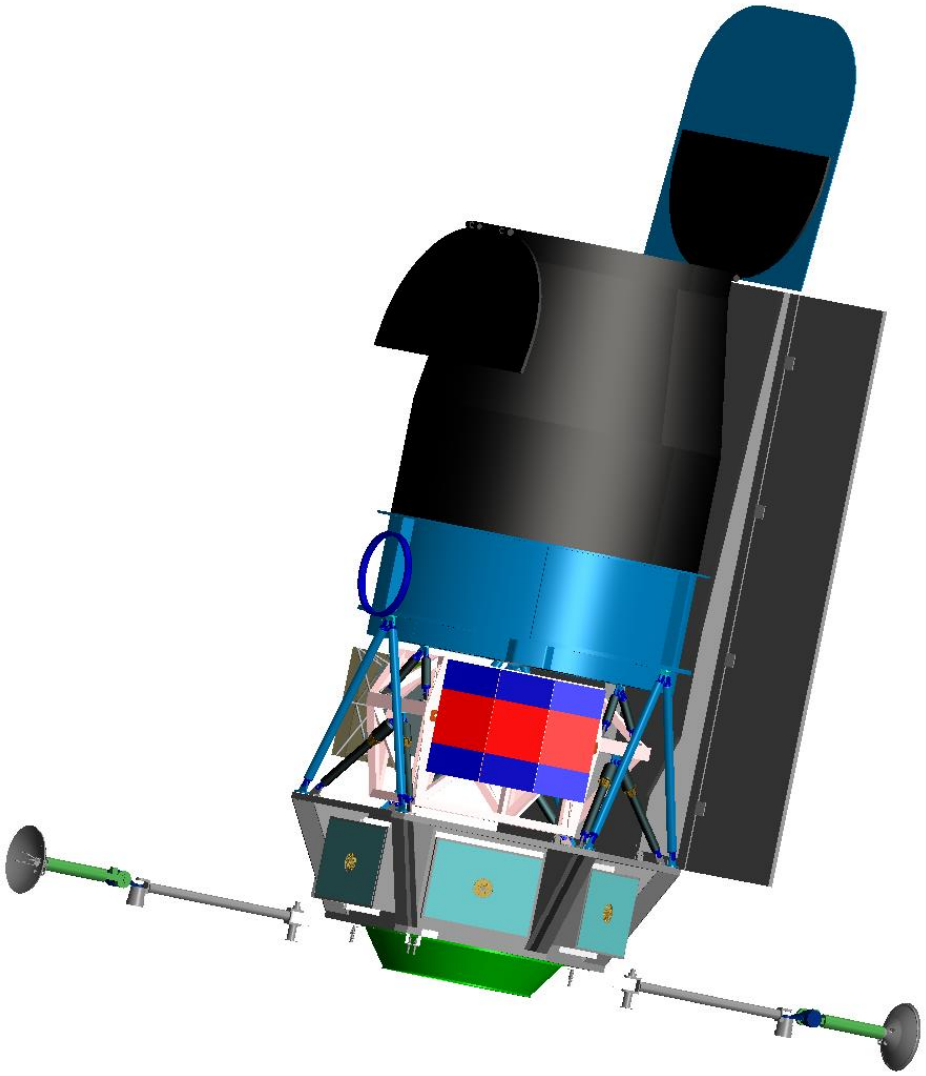


Wide Field Channel Description & Modes

- The wide field channel's only routinely moving part is the element wheel (EW)
- 8 positions: 6 filters, blank, grism (galaxy redshift survey)
- Table shows how measurement modes and observations align

				SN Detect		SN Spec	HLS		Microlensing		Avail for GO
#	Min (mm)	Max (mm)	R	Shallow	Med/Deep		Image	Spec	Monitor	Color	
Z087	0.760	0.977	4.0							2X daily	All
Y106	0.927	1.192	4.0	X			Photo-z				
J129	1.131	1.454	4.0	X	X						
H158	1.380	1.774	4.0		X		Photo-z & Shapes				
F184	1.683	2.000	5.81								
W149	0.927	2.000	1.442						15 min cadence		
GRS	1.35	1.95	461*l					X			
IFU	0.600	2.000	75			X					

WFIRST-AFTA Observatory Concept



Key Features

- **Telescope:** 2.4 m aperture primary mirror
- **Instruments**
  - Wide Field Imager/Spectrometer & Integral Field Unit
  - Internal Coronagraph with Integral Field Spectrometer
- **Overall Dry Mass:** 4059 kg (CBE)
- **Structure:** high stiffness composites; modular packaging for avionics
- **GN&C/Propulsion:** inertial pointing, 3-axis stabilized, mono-prop system for stationkeeping & momentum unloading
- **Data Downlink Rate:** Continuous 600 Mbps Ka-band to dedicated ground station
- **C&DH:** low rate bus for housekeeping and spacecraft control, high speed bus for science data
- **Power:** ~2400 W average power (CBE)
- **GEO orbit**
- **Launch Vehicle:** Delta IV Heavy
- **GSFC:** leads mission, wide field instrument, spacecraft
- **JPL:** leads telescope, coronagraph