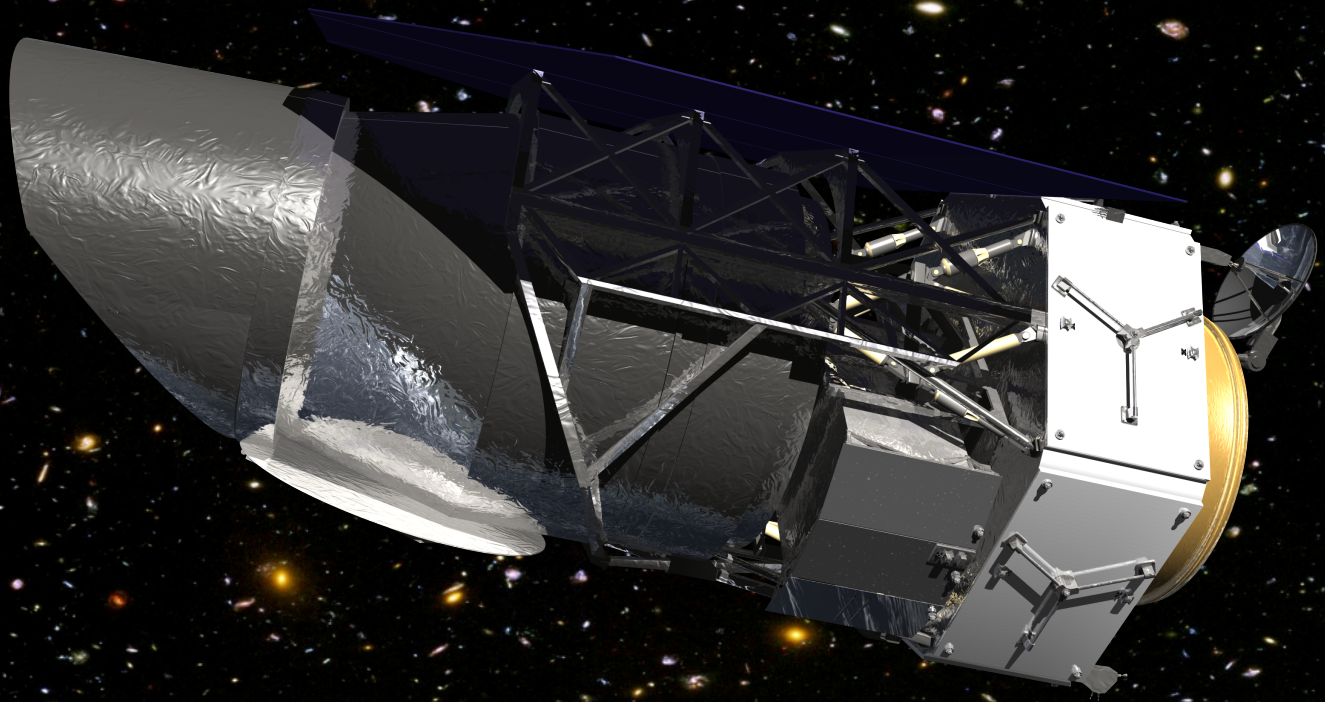
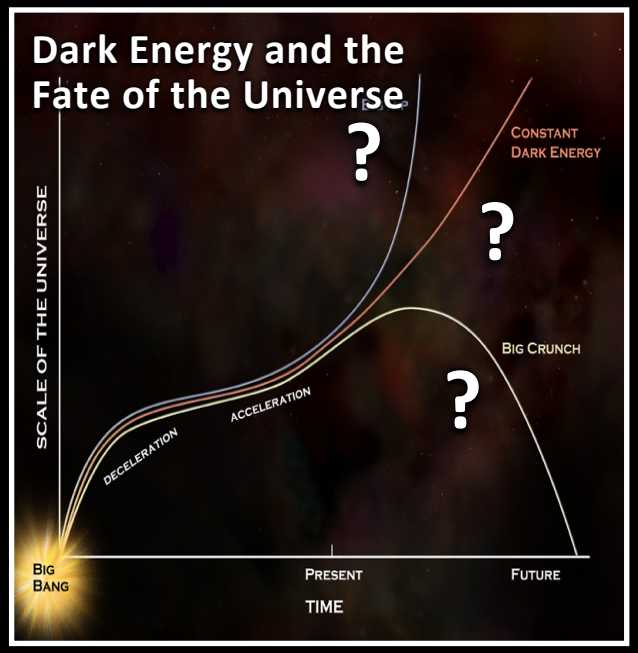
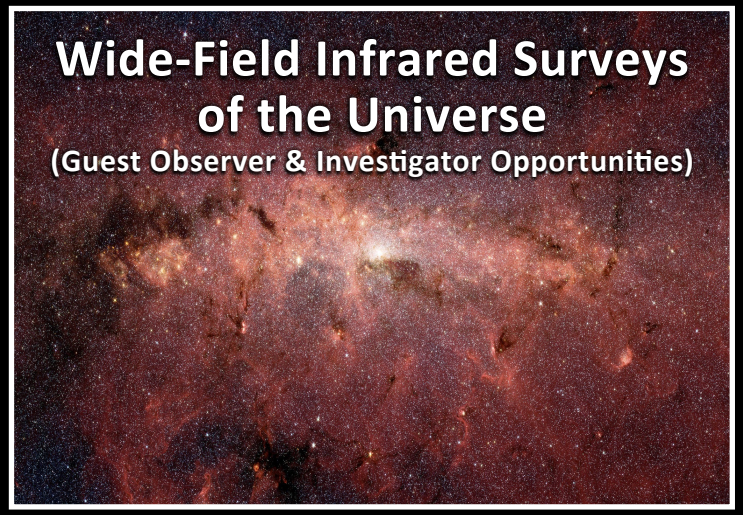
Wide-Field InfraRed Survey Telescope – Mission Status

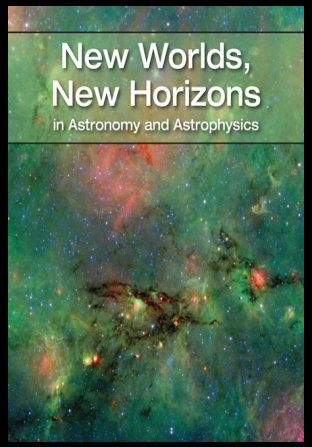


Jeffrey Kruk (NASA-GSFC)

WFIRST Scientific Objectives

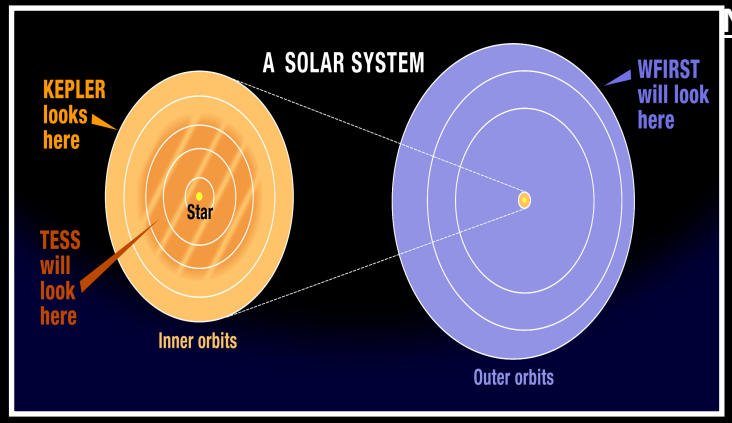






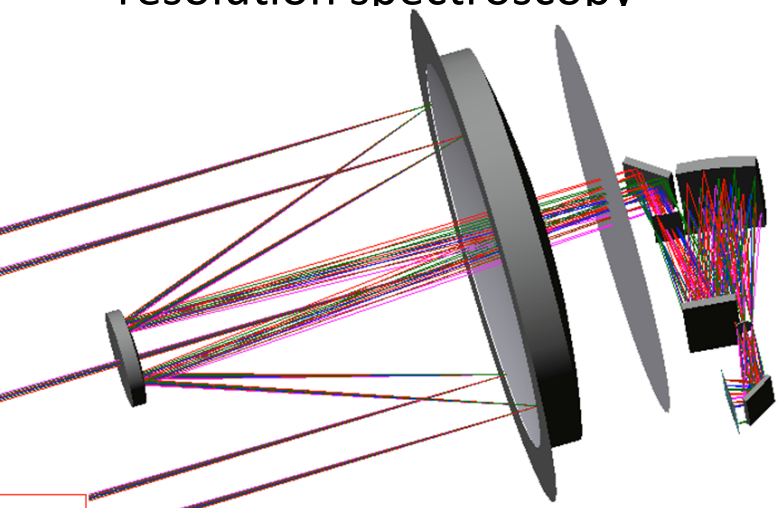
National Academy of Sciences
Astronomy & Astrophysics
Decadal Survey (2010)

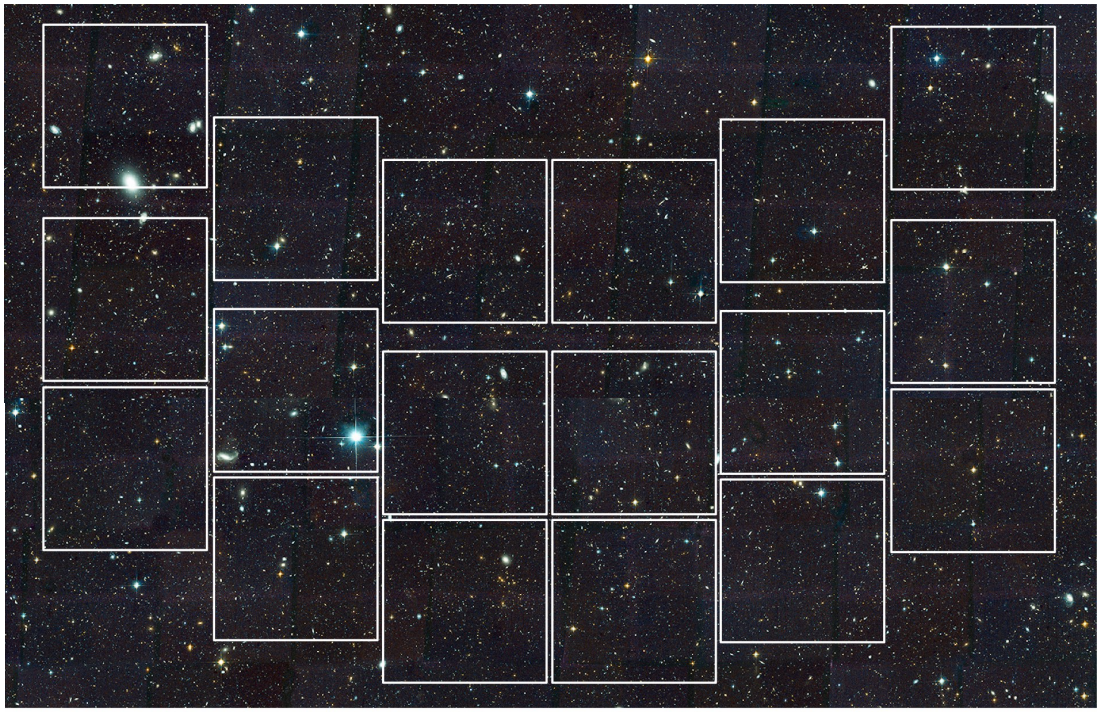
The full distribution of planets around stars



Wide Field Channel

- Very large imaging field of view (FOV) (0.8° x 0.4°)
- High spatial resolution (0.11 arcsec/pixel)
- Stable image quality (1.0 nm RMS wave front error variation in 180 sec)
- 7 imaging filters spanning visible & NIR: 0.48 to 2.0µm
- grism for multi-object, low-resolution spectroscopy

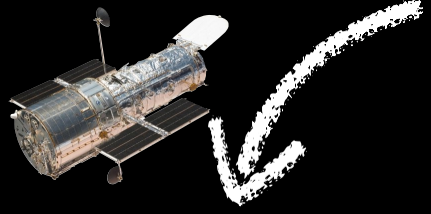




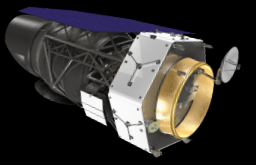
Andromeda - PHAT Survey

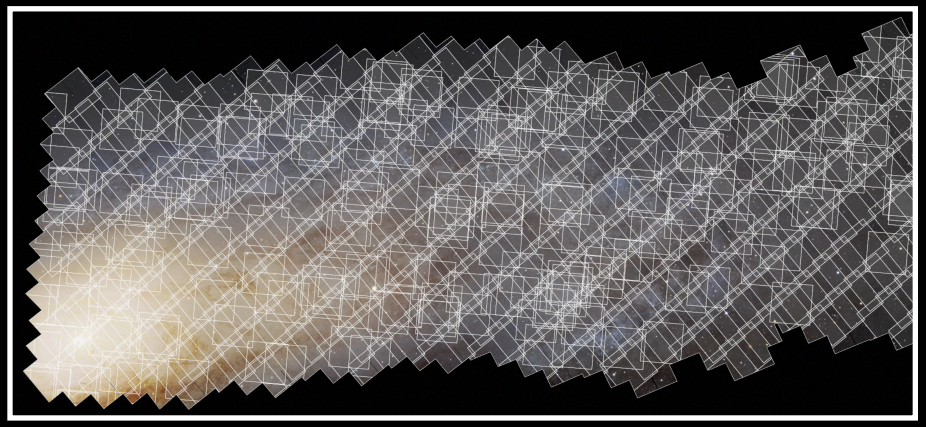
GO Program

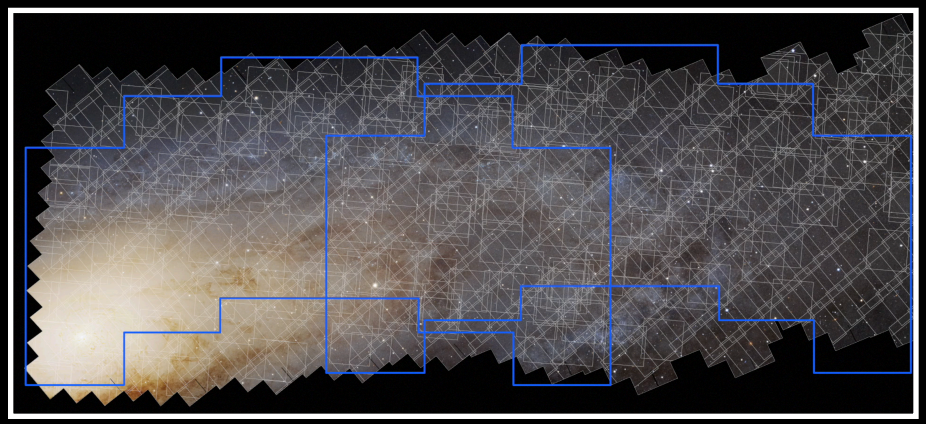
The Hubble Way
(400+ individual pointings)



The WFIRST Way
(2 pointings)



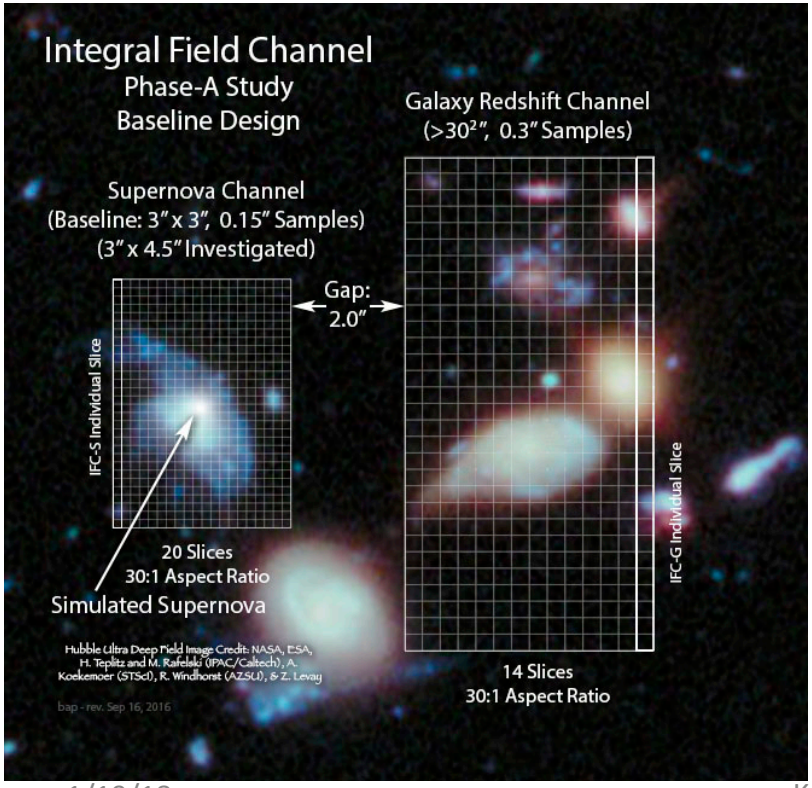


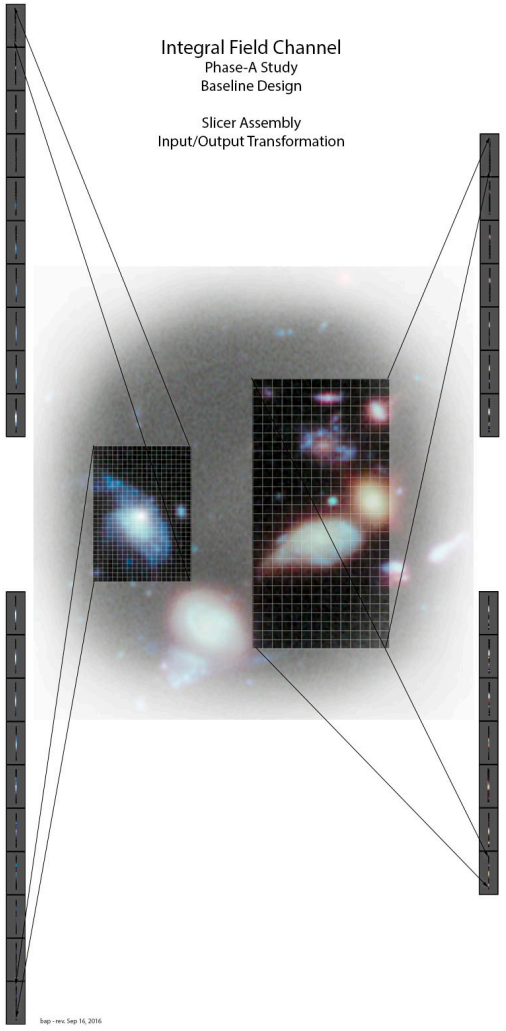


WFIRST will survey nearby galaxies 100x faster than Hubble

Integral Field Spectrograph

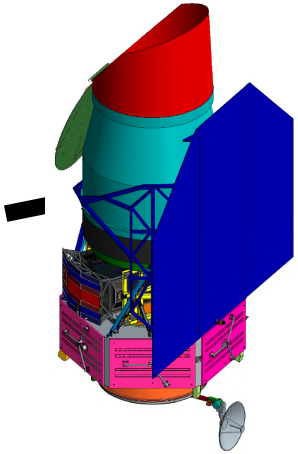
- Supernova FOV: 3 x 3 arcsec, 0.075 arcsec/pixel resolution
- Photo-z Calibration FOV 6 x 6 arcsec, 0.15”/pixel resolution
- Very high sensitivity, NIR pass band (0.45-2.0μm)
- Low spectral resolving power (70-140 λ/Δλ)



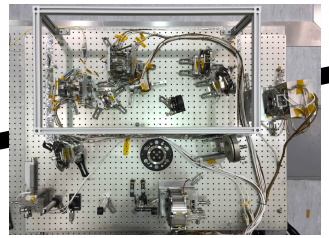


Coronagraph technology development

Large Ultra-stable Space Telescope & Observatory

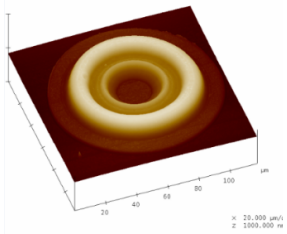


Autonomous Ultra-Precise Wavefront Sensing & Control System



First Use of Deformable Mirrors in Space

High Contrast Coronagraph Masks



Ultra-low Noise Photon Counting Visible Detectors

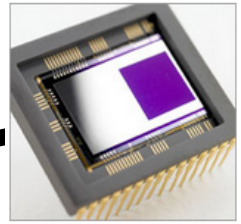
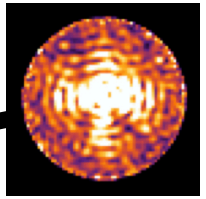
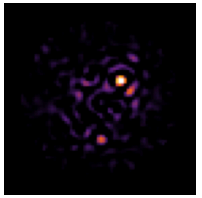


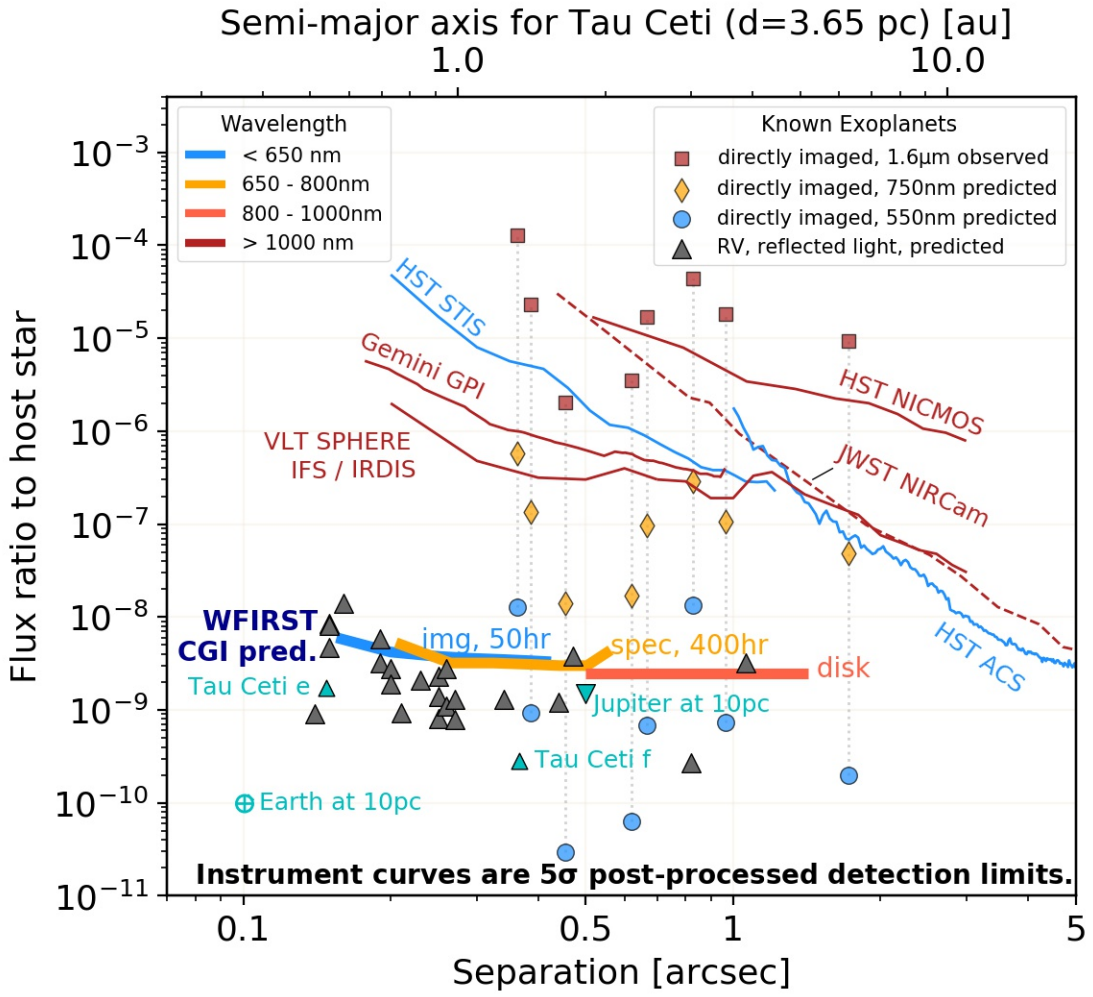
Image Processing at Unprecedented Contrast Levels



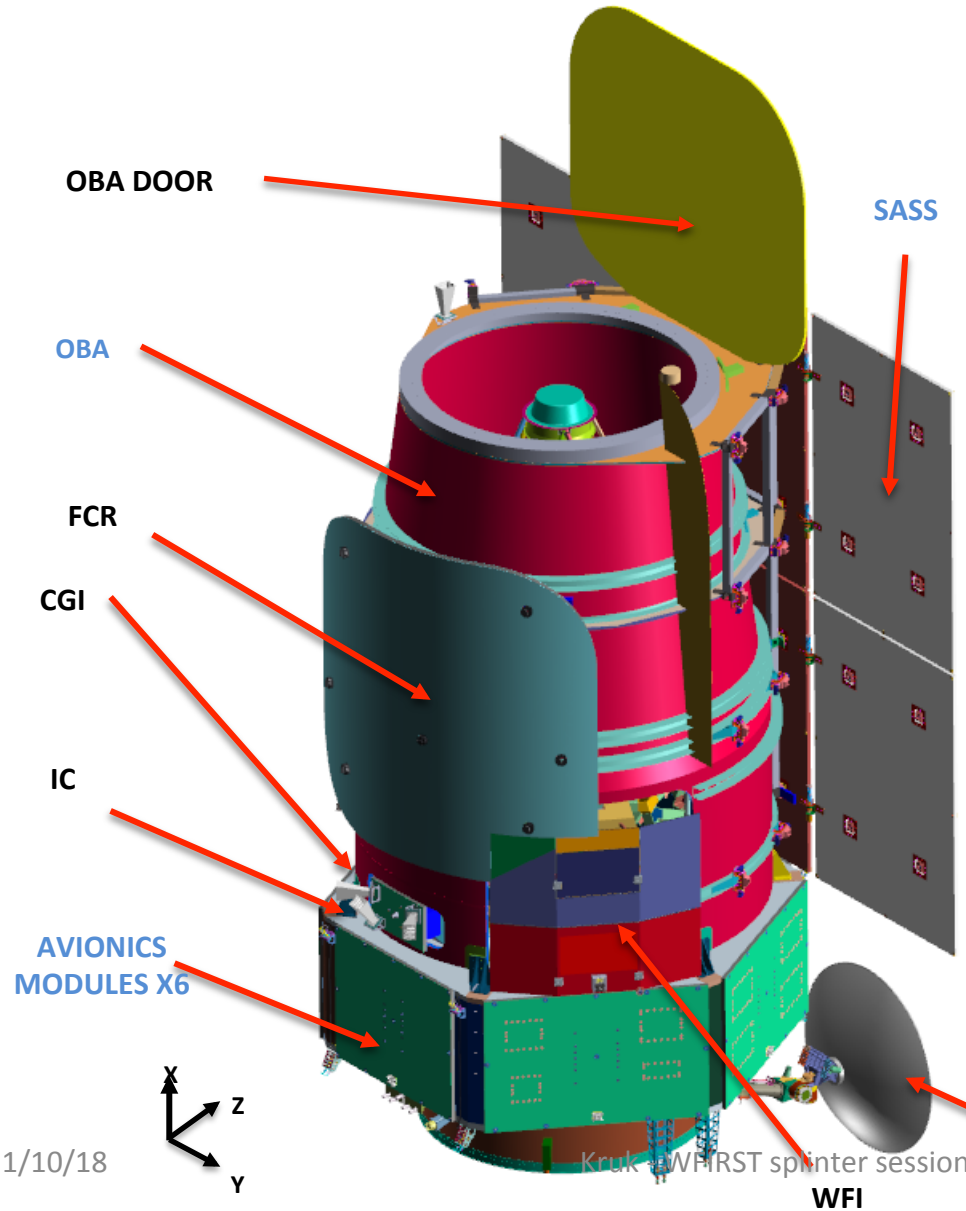


CGI is a direct predecessor to potential future flagship direct imaging missions aimed at *Earth-like* exoplanets (HabEx and LUVOIR)

Coronagraph Performance



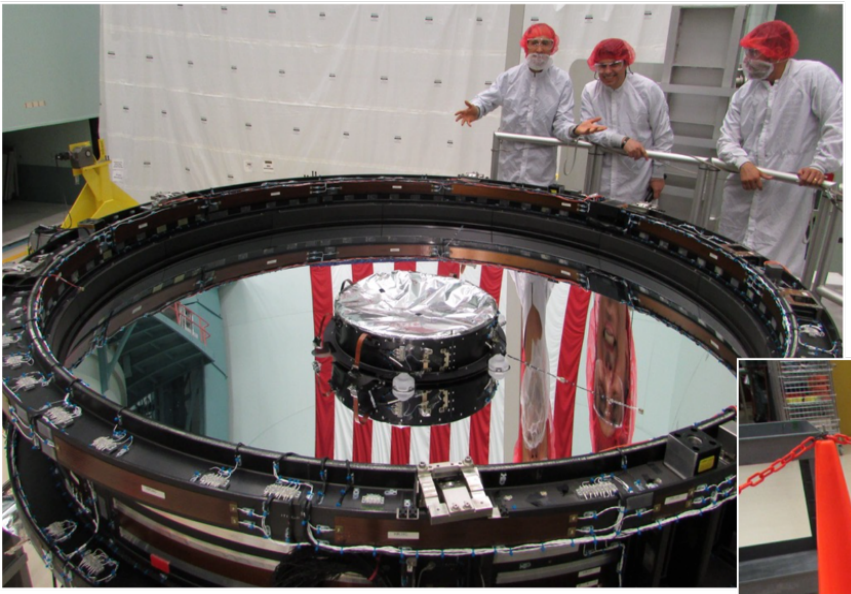
WFIRST Observatory Concept

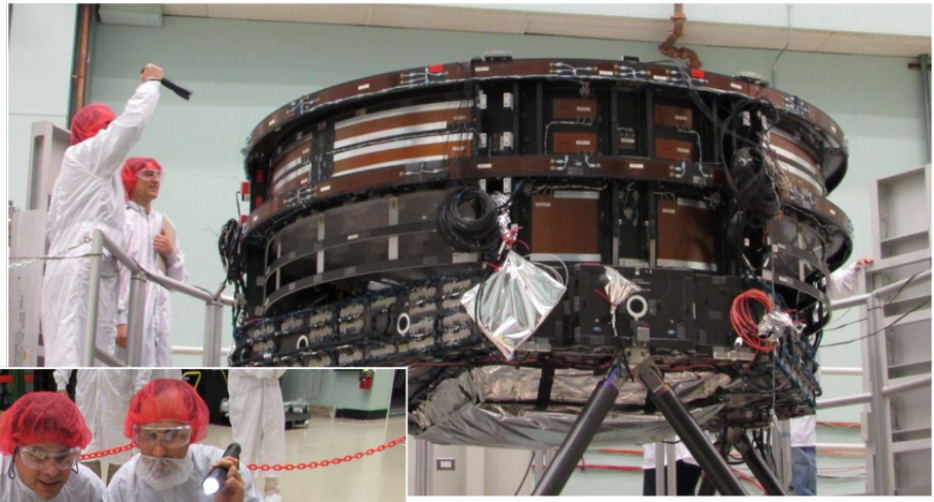


Key Features

- **Telescope**: 2.4m aperture
- **Instruments**
  - Wide Field Imager/ Spectrometer & Integral Field Unit
  - Internal Coronagraph with Integral Field Spectrometer
- **Data Downlink**: 275 Mbps
- **Data Volume**: 11 Tb/day
- **Orbit**: Sun-Earth L2
- **Launch Vehicle**: Falcon Heavy
- **Mission Duration**: 5 yr, 10yr goal
- **Serviceability**: Observatory designed to be robotically serviceable
- **Starshade compatible**

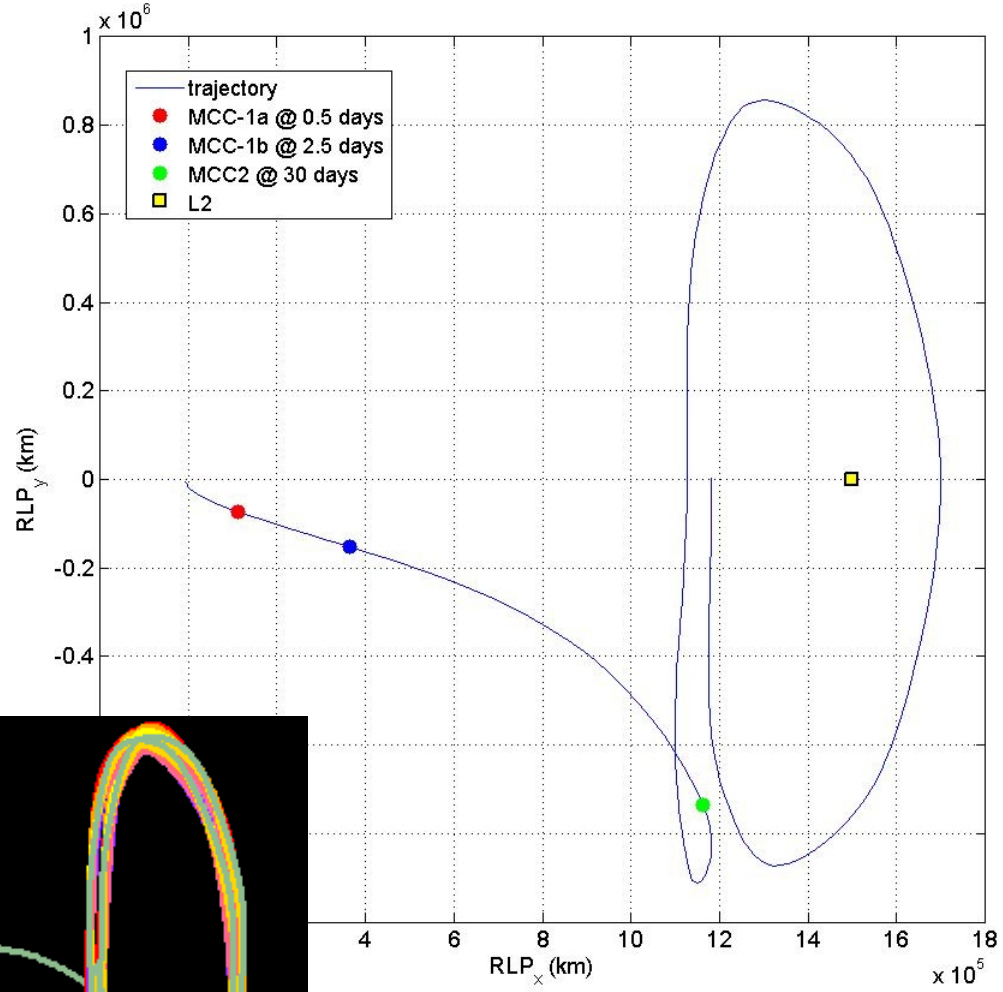
Telescope

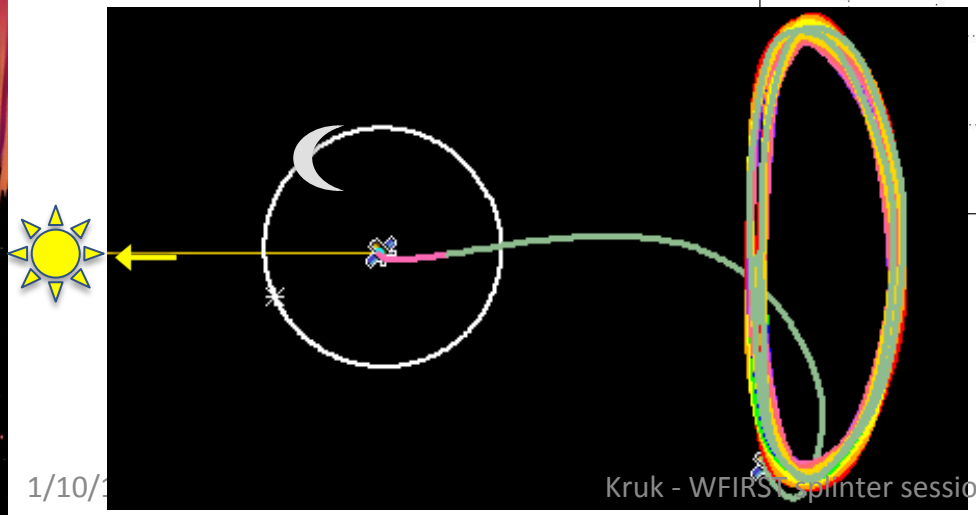




Planned Sun-Earth L2 halo orbit

Diameter of planned halo orbit is comparable to Earth-L2 distance





Project Schedule

Formulation Science teams selected

Implementation science teams selected
(First allocation of observing time)

GO Calls for proposals
3 calls – dates notional

FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	FY 29	FY 30

Development		Design, Fabrication, I&T			Science Operations
Pre-Phase A	Phase A	PhaseB	Phase C	Phase D	Phase E

SRR/ MDR

MPDR

MCDR

SIR

Launch

End of Prime Mission

We are here

Extended mission expected to continue 5 more years

Schedule continued

- Systems Requirements Review / Mission Definition Review - Feb 27 – March 2, 2018
  - Do requirements flow properly to mission?
  - If mission is built as described, will objectives be met?
- KDP-B – late April, 2018
  - Was SRR/MDR successful?
  - Are project plans, budgets, schedules adequate?

Cost savings - 1

- Project baseline has been revised to fit in $3.2B
- Savings that don't affect science return
  - Count foreign contributions in budget
    - Negotiations farther along than last Summer
  - Improved budget profile saves 6 months schedule
  - STMD contributes towards CGI costs
  - Continued optimization of design & I&T flow
    - Eliminate one processor by combining functions
    - Simplifications to payload I&T saves schedule and reduces some test equipment & facility costs

Cost Savings - 2

- Coronagraph
  - Reduction in masks & filters shortens I&T flow
  - Change to participating scientist program eliminates most associated science operation center costs
    - Model similar to PI-class instrument
  - *Otherwise maintained CGI architecture & functions*
- Wide-Field Instrument
  - Modest relaxation in detector requirements
    - Reduce number of detectors procured & characterized
  - Reduce dynamic range of relative calibration system
  - *Otherwise maintained full WFI H/W capabilities*

Cost Savings - 3

- Wide-Field Instrument SOC savings:
  - Grism & IFC pipelines contributed
  - Provide static PSF model, rather than deriving for each observation
  - Eliminate SOC tools for source injection & processing of simulated data
- GO program
  - 3 calls during prime mission; limit to ~30 programs
  - No GO-unique observing modes

WFIRST Observing Plan (nominal)

- High Latitude Survey - ~2000 sq deg
  - Imaging: Y, J, H, F184 to AB ~26.5 (5σ point src)
  - Slitless spectroscopy: 1.e-16 ergs/cm^2/s
- Supernovae
  - Imaging & IFC spectroscopy (6 months)
- Microlensing
  - Six Galactic Bulge seasons
- Coronagraphy
  - Technology demonstration, plus ???
- GO
  - 1.25 years – the sky is the limit!


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

QUESTIONS?

Science Investigation Teams

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 *
Benjamin Williams	GO science, nearby galaxies *
Alexander Szalay	GI science, archival research

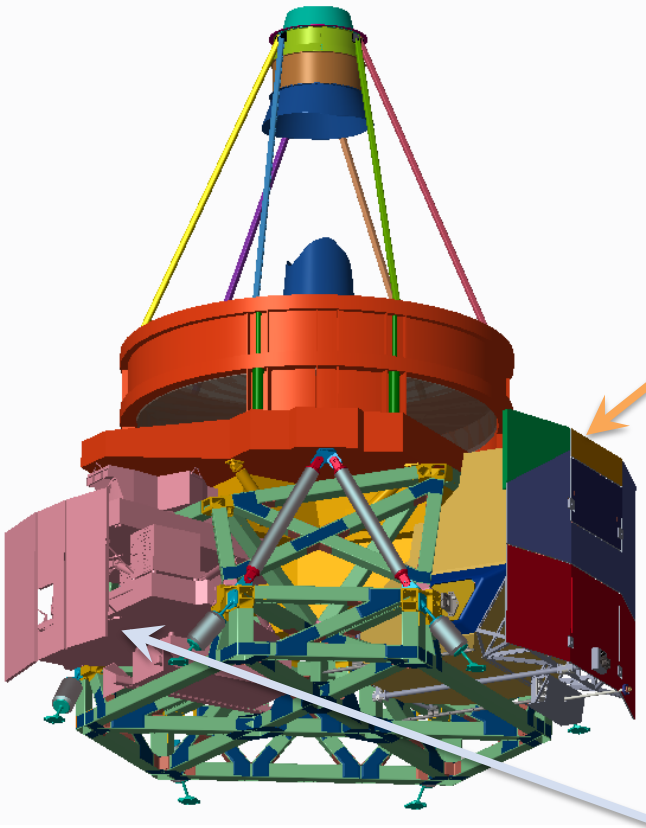
* Representative attending

WFC filters

Band	Element name	Min (μm)	Max (μm)	Center (μm)	Width (μm)	R
R	R062	0.48	0.76	0.620	0.280	2.2
Z	Z087	0.76	0.977	0.869	0.217	4
Y	Y106	0.927	1.192	1.060	0.265	4
J	J129	1.131	1.454	1.293	0.323	4
H	H158	1.380	1.774	1.577	0.394	4
	F184	1.683	2.000	1.842	0.317	5.81
Wide	W146	0.927	2.000	1.464	1.030	1.42
GRS	G150	0.95*	1.90*	1.445	0.890	461λ(2pix)

* Grism bandpass is adjustable, up to $\lambda max \leq 2 \times \lambda min$

WFIRST Instruments



Wide-Field Instrument

- *Imaging & spectroscopy over 1000s of sq. deg.*
- *Monitoring of SN and microlensing fields*
- 0.5 – 2.0 μm (imaging) & 1.0-1.9 μm (grism)
- 0.28 deg^2 FoV (100x JWST FoV)
- 18 H4RG detectors (288 Mpixels)
- 7 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.)
  - *Under revision: tech demo configuration TBD*
- Final contrast of 10^{-9} or better
- Exoplanet images from 0.1 to 1.0 arcsec

WFIRST Dark Energy Roadmap

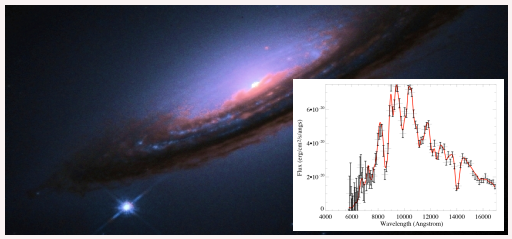
WIDE-FIELD INFRARED SURVEY TELESCOPE
DARK ENERGY • EXOPLANETS • ASTROPHYSICS

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

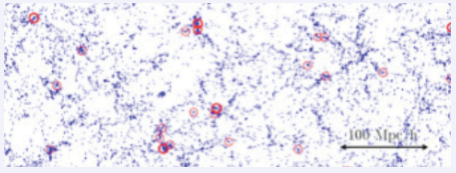
20 million Hα galaxies, z = 1–2
2 million [OIII] galaxies, z = 2–3

imaging: weak lensing shapes

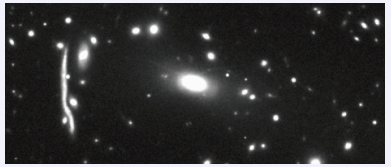
400 million lensed galaxies
40,000 massive clusters

standard ruler

distances	expansion rate
z = 1–2 to 0.4%	z = 1–2 to 0.72%
z = 2–3 to 1.3%	z = 2–3 to 1.8%

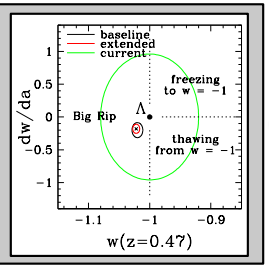


dark matter clustering
z < 1 to 0.16% (WL); 0.14% (CL)
z > 1 to 0.54% (WL); 0.28% (CL)
1.2% (RSD)



history of dark energy + deviations from GR

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



WFIRST Complements Kepler