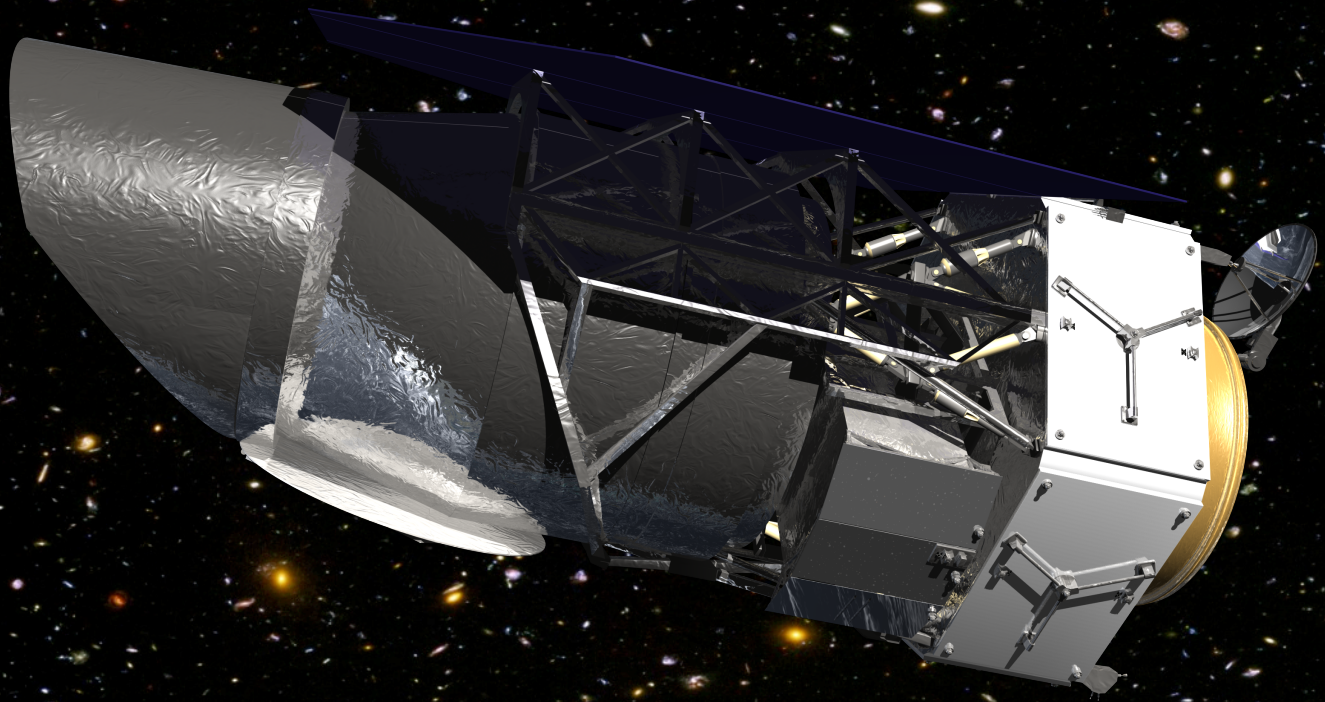
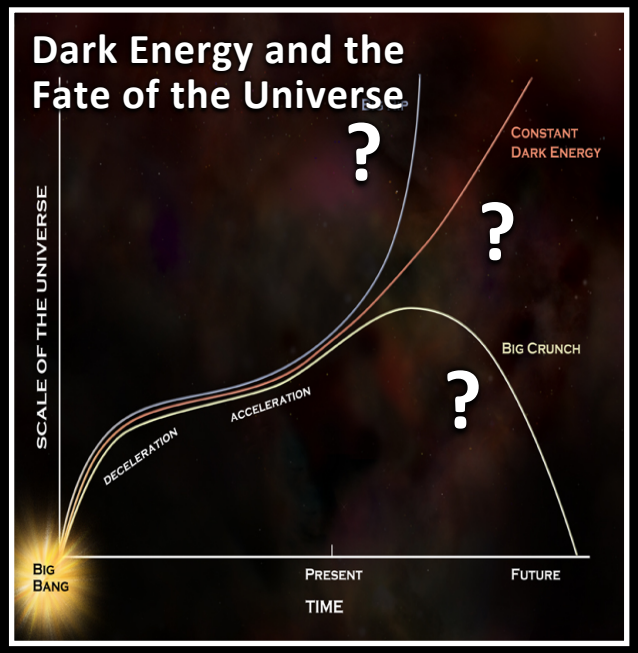
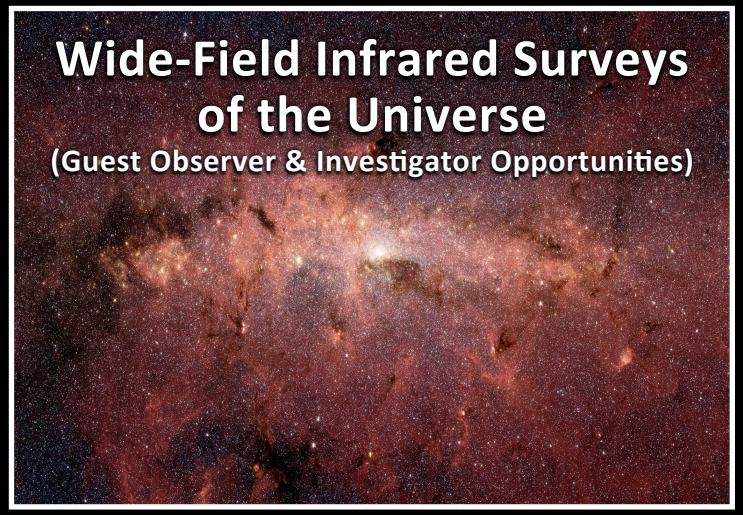
Wide-Field InfraRed Survey Telescope – Mission Status

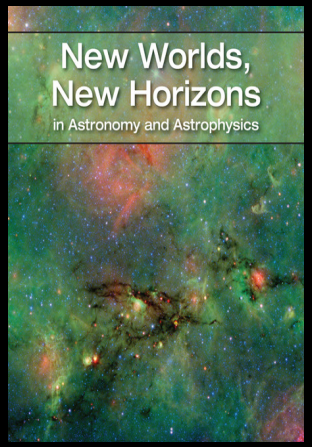


Jeffrey Kruk (NASA-GSFC)

WFIRST Scientific Objectives

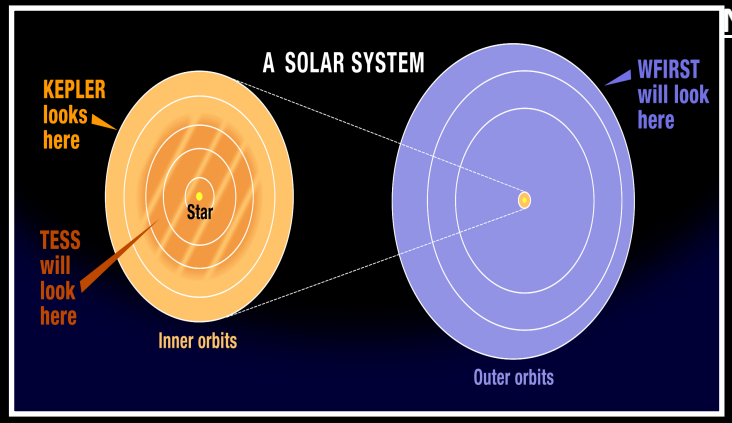






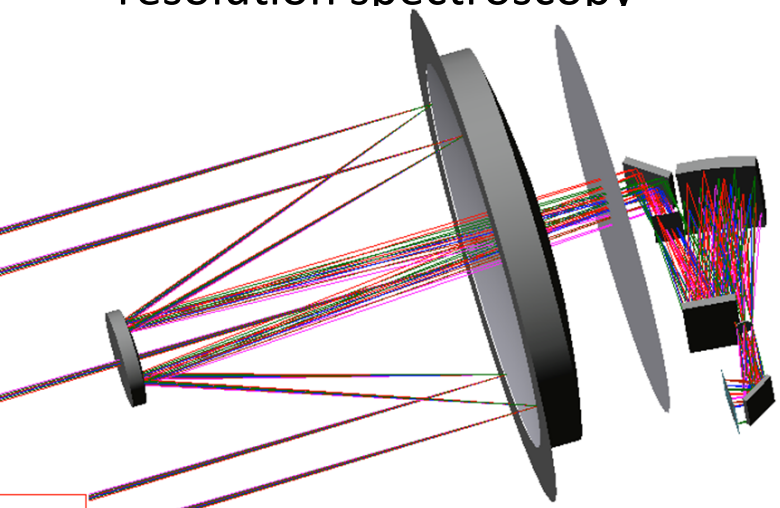
National Academy of Sciences
Astronomy & Astrophysics
Decadal Survey (2010)

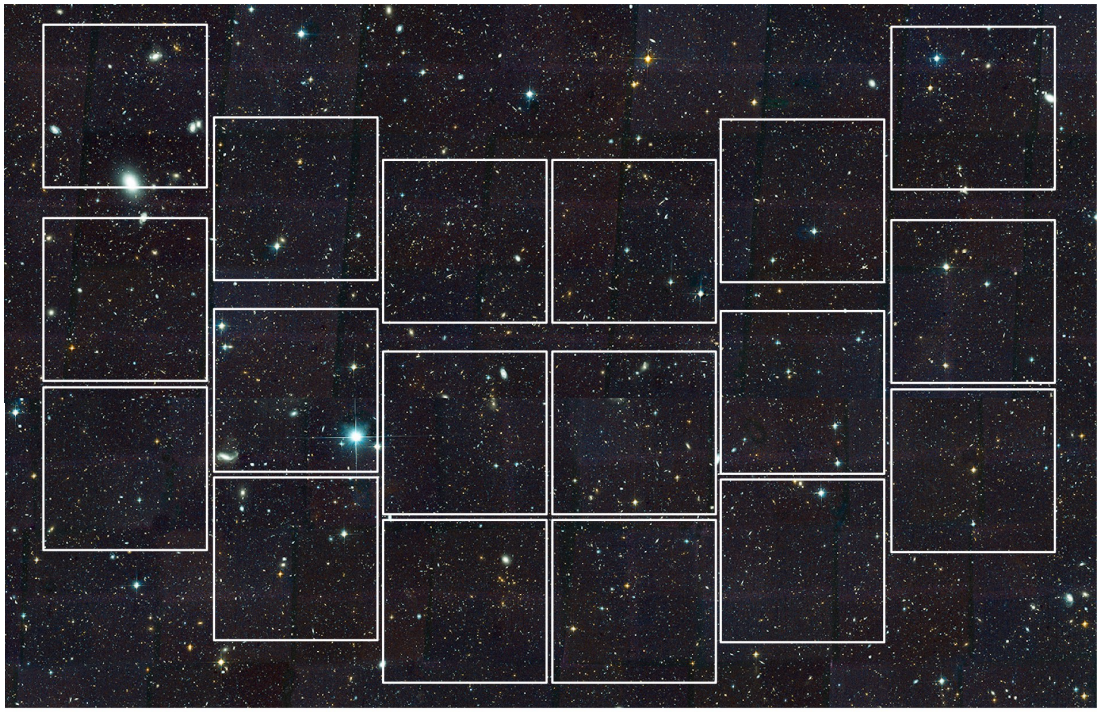
The full distribution of planets around stars



Wide Field Channel

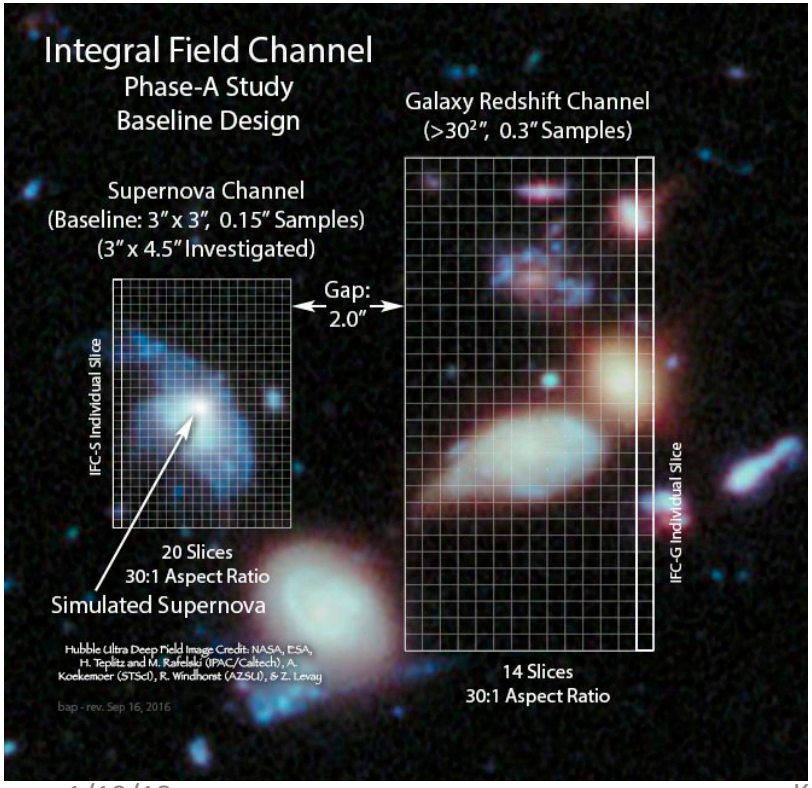
- Very large imaging field of view (FOV) (0.8° x 0.4°)
- High spatial resolution (0.11 arcsec/pixel)
- Stable image quality (1.0 nm RMS wave front error variation in 180 sec)
- 7 imaging filters spanning visible & NIR: 0.48 to 2.0µm
- grism for multi-object, low-resolution spectroscopy

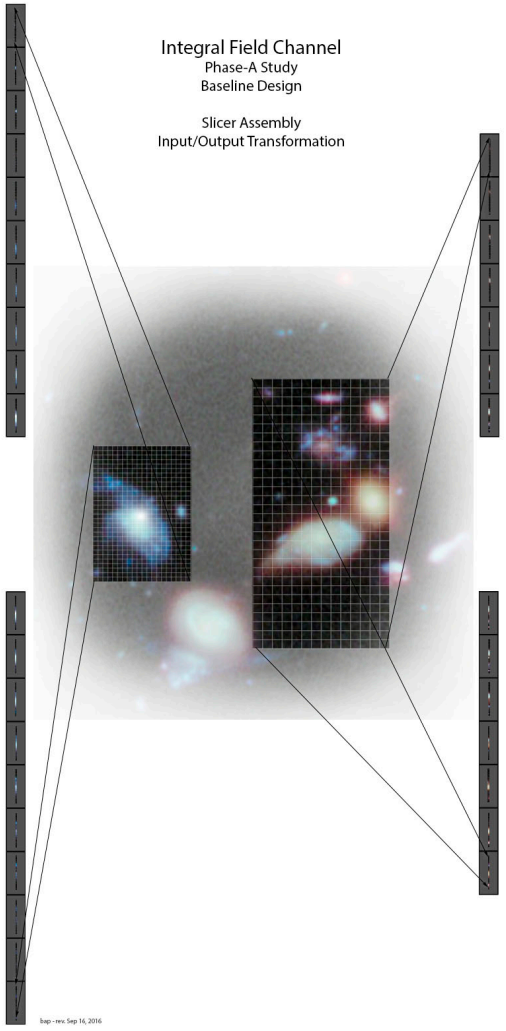




Integral Field Spectrograph

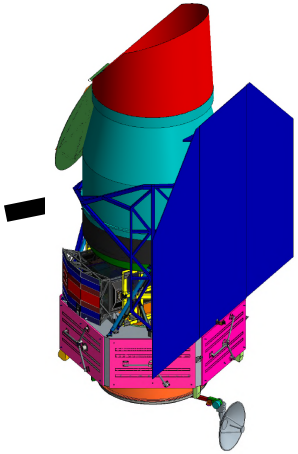
- Supernova FOV: 3 x 3 arcsec, 0.075 arcsec/pixel resolution
- Photo-z Calibration FOV 6 x 6 arcsec, 0.15”/pixel resolution
- Very high sensitivity, NIR pass band (0.45-2.0µm)
- Low spectral resolving power (70-140 λ/Δλ)



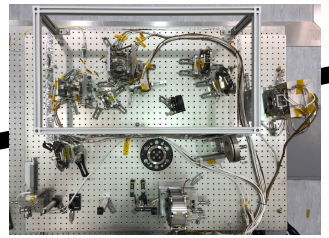


Coronagraph technology development

Large Ultra-stable Space Telescope & Observatory

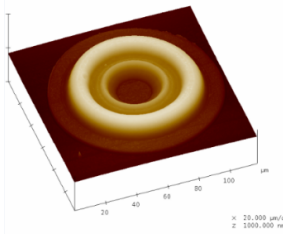


Autonomous Ultra-Precise Wavefront Sensing & Control System



First Use of Deformable Mirrors in Space

High Contrast Coronagraph Masks



Ultra-low Noise Photon Counting Visible Detectors

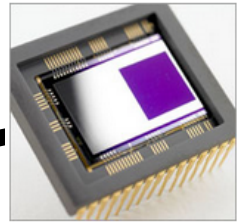
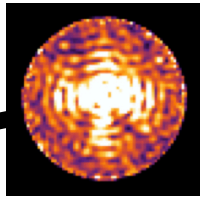
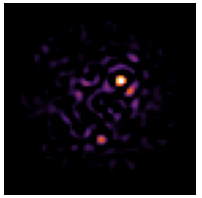


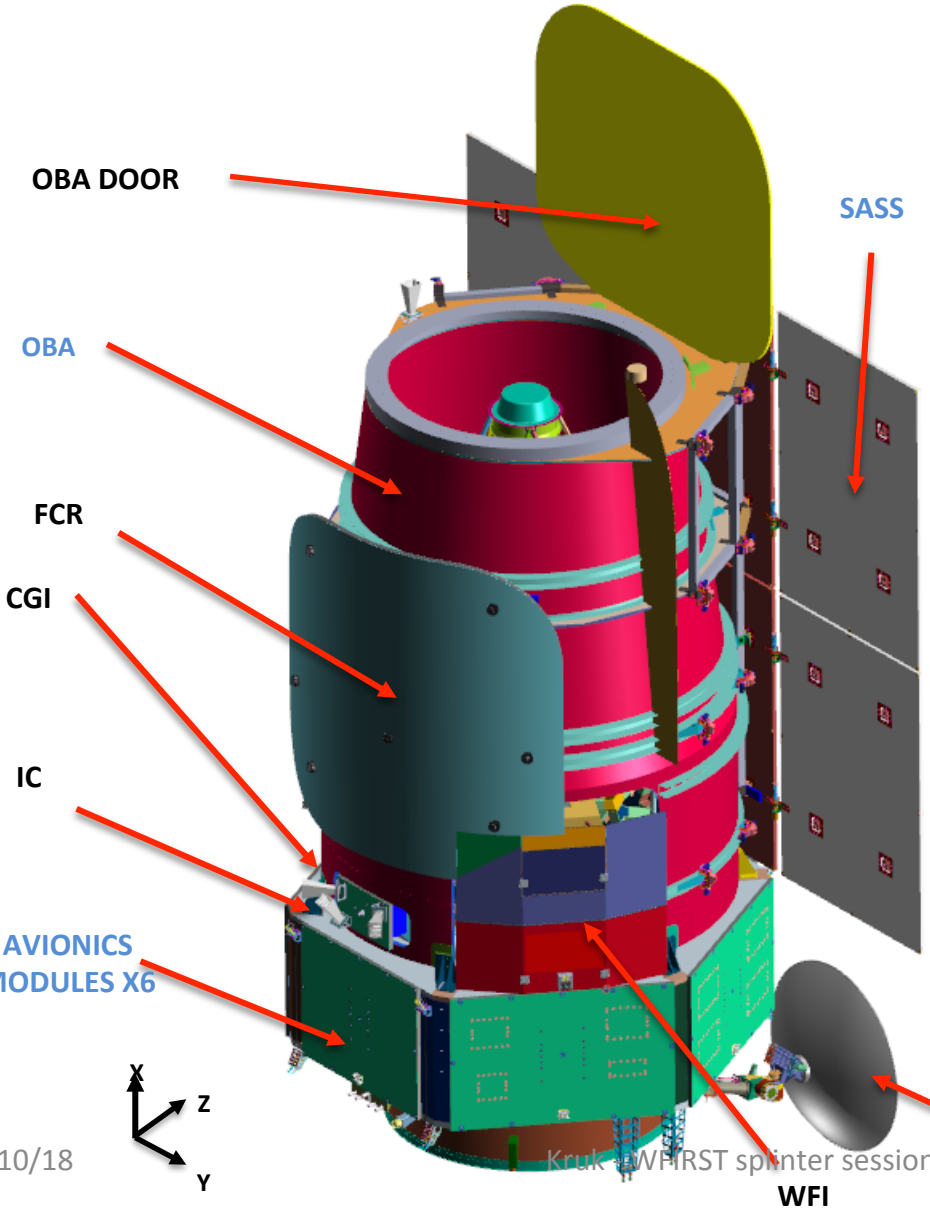
Image Processing at Unprecedented Contrast Levels





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

WFIRST Observatory Concept

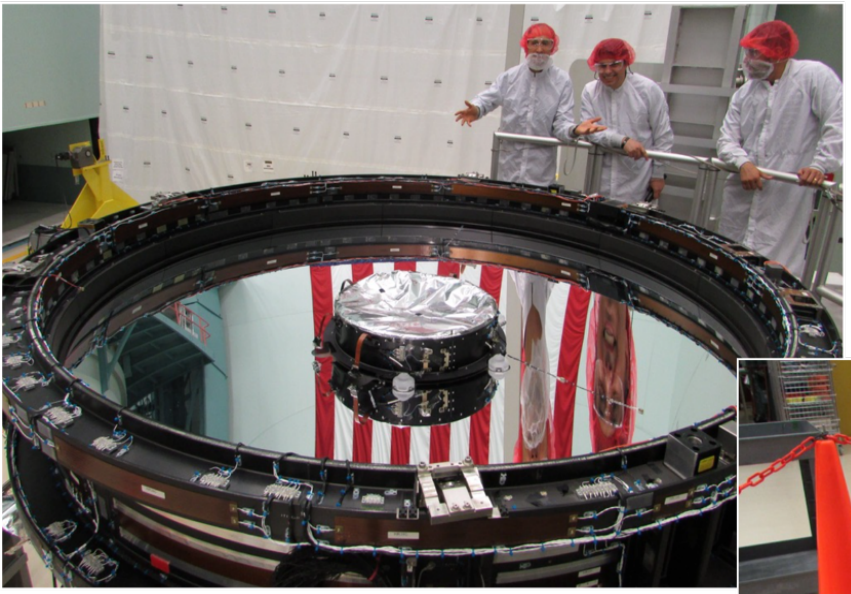


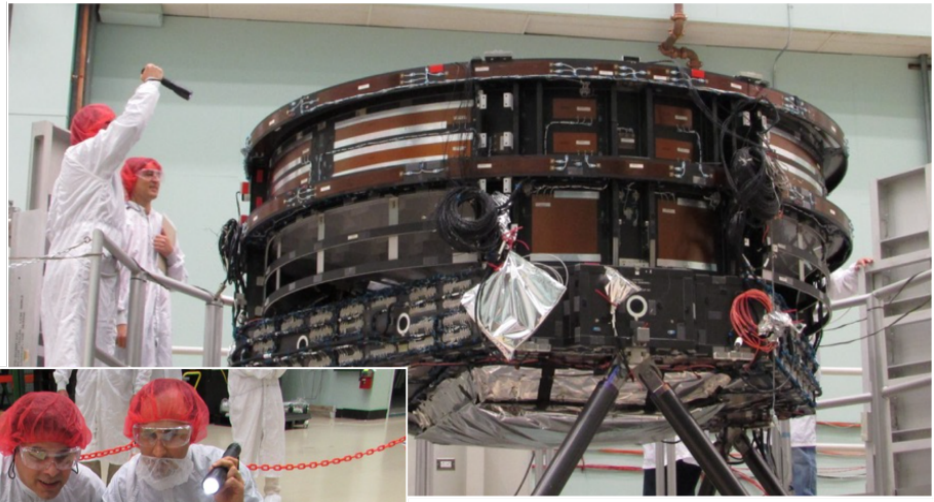
Key Features

- **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**

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

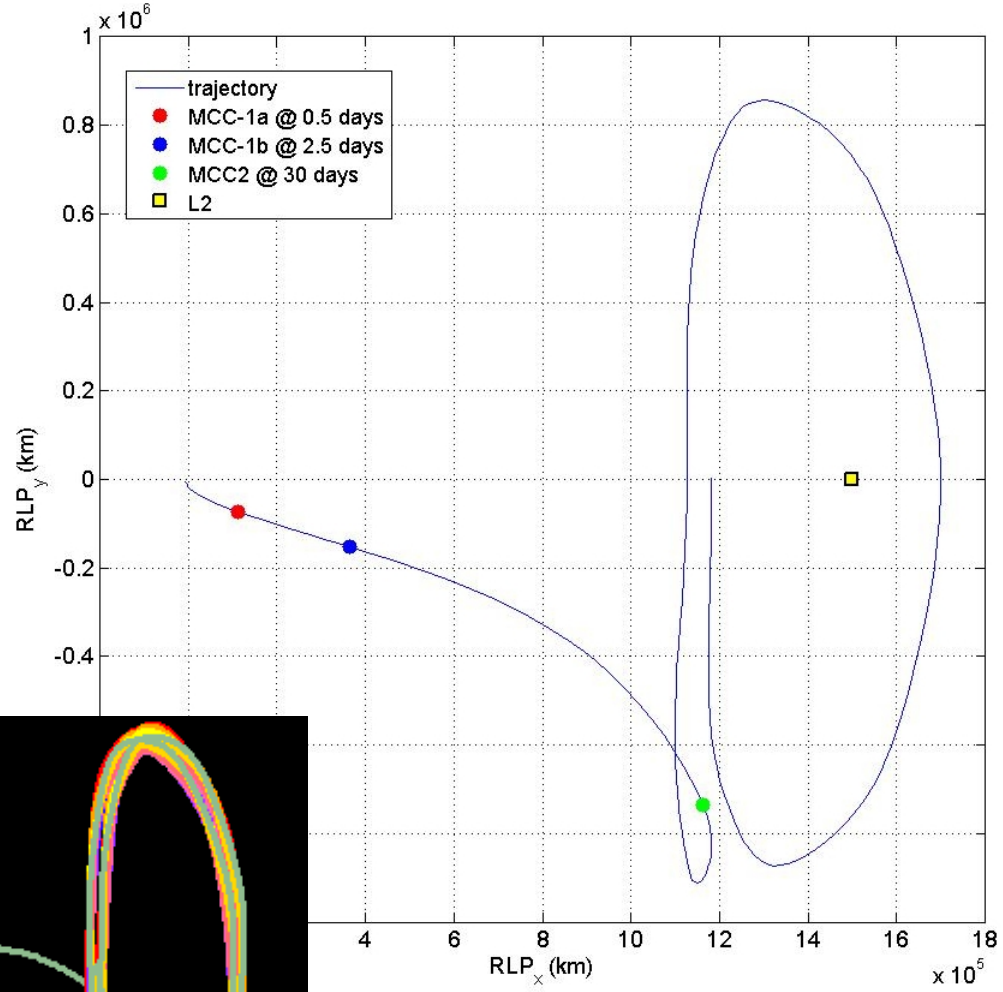
Telescope

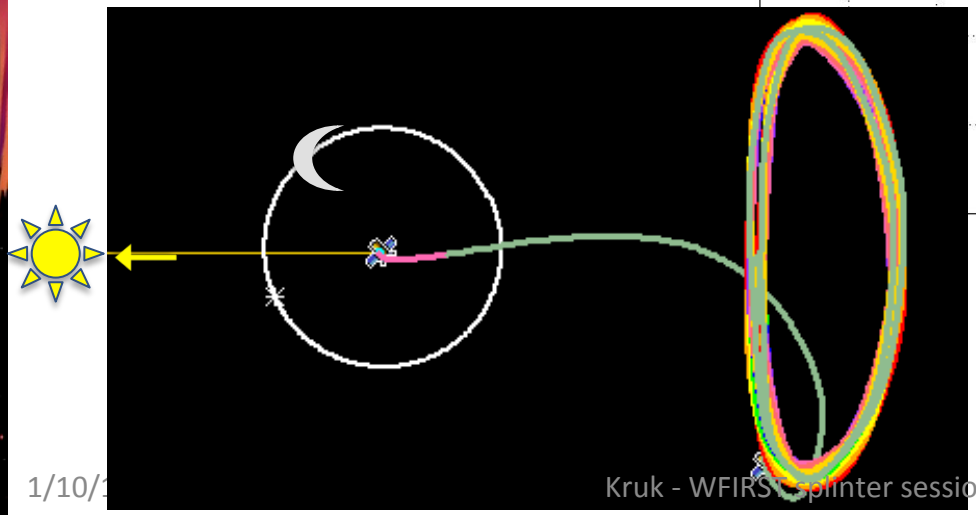




Planned Sun-Earth L2 halo orbit

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





Project Schedule

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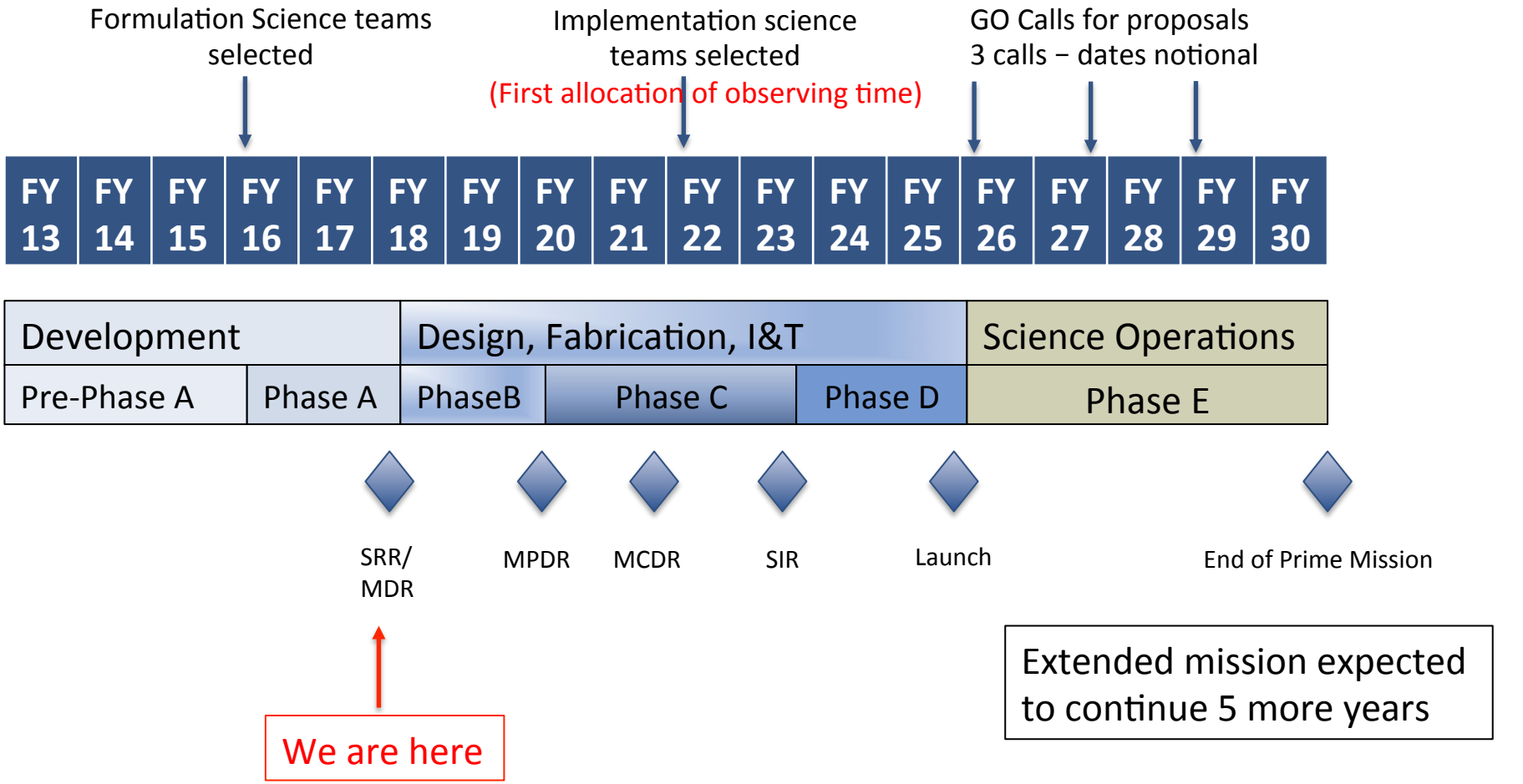


Schedule continued

- 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 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

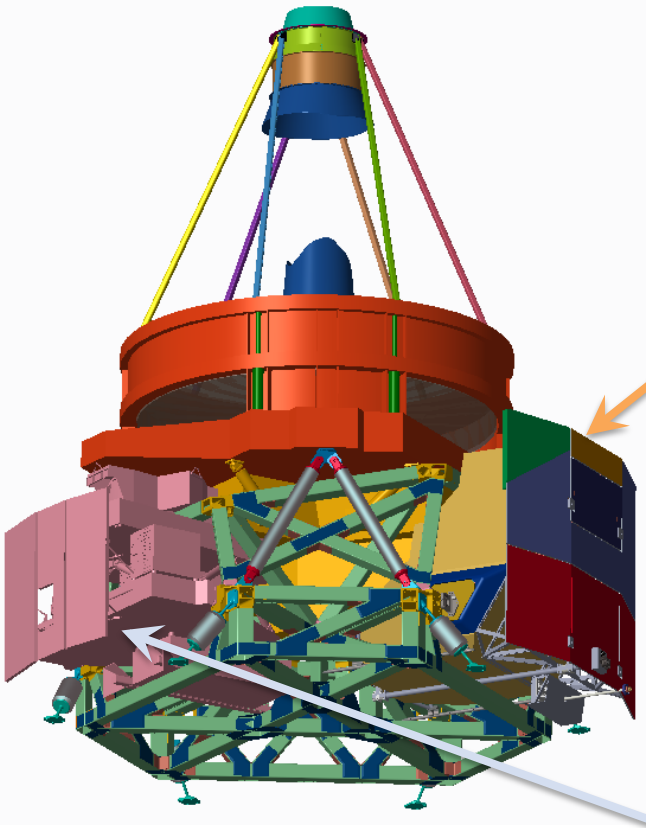
* Representative attending

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

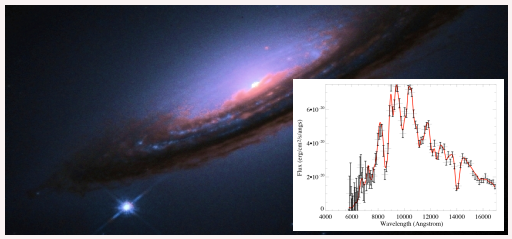
WIDE-FIELD INFRARED SURVEY TELESCOPE
DARK ENERGY • EXOPLANETS • ASTROPHYSICS

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

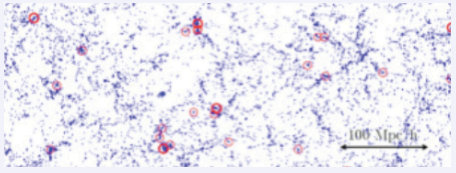
20 million Hα galaxies, z = 1–2
2 million [OIII] galaxies, z = 2–3

imaging: weak lensing shapes

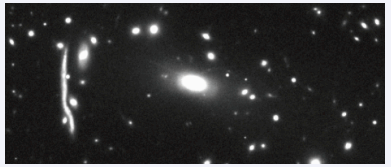
400 million lensed galaxies
40,000 massive clusters

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%

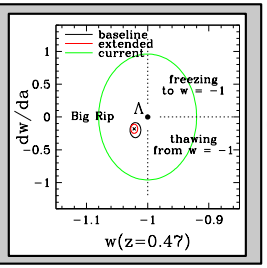


dark matter clustering
z < 1 to 0.16% (WL); 0.14% (CL)
z > 1 to 0.54% (WL); 0.28% (CL)
1.2% (RSD)



history of dark energy + deviations from GR

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



WFIRST Complements Kepler