WFIRST Project Interim Report: Presentation to the AAAC

James Green	SDT Co-Chair
Paul Schechter	SDT Co-Chair
Neil Gehrels	Study Scientist
Kevin Grady	Study Manager
Lia LaPiana	Program Executive
Rita Sambruna	Program Scientist

* These viewgraphs should not be read as a substitute for the full report.

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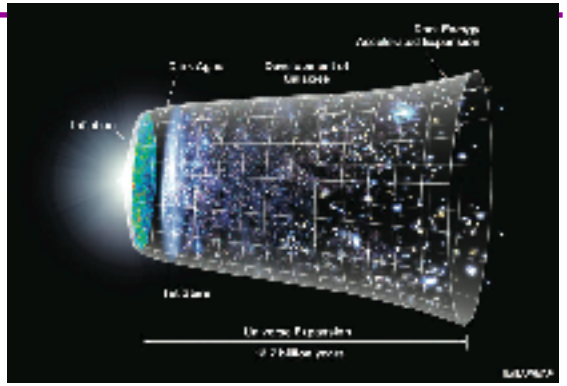
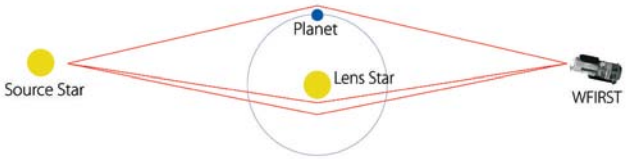
WFIRST Summary



❖ WFIRST is the highest ranked large space mission in NWNH, and plans to:

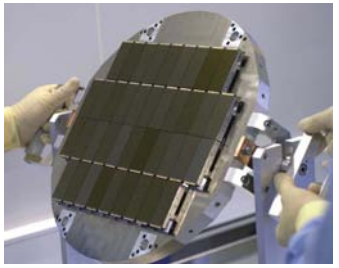
- complete the statistical census of Galactic planetary systems using microlensing
- determine the nature of the dark energy that is driving the current accelerating expansion of the universe
- survey the NIR sky for the community

❖ Earth-Sun L2 orbit, 5 year lifetime, 10 year goal



❖ The current Interim Design Reference Mission has

- 1.3 m unobstructed telescope
- NIR instrument with ~36 HgCdTe detectors
- >10,000 deg^2 5-sigma NIR survey at mag AB=25



❖ The time is ripe for WFIRST:

- Space-qualified large format HgCdTe detectors are US developed technology and flight ready

WFIRST – Science Objectives

1) Complete the statistical census of planetary systems in the Galaxy, from habitable Earth-mass planets to free floating planets, including analogs to all of the planets in our Solar System except Mercury.

2) Determine the expansion history of the Universe and its growth of structure in order to test explanations of its apparent accelerating expansion including Dark Energy and possible modifications to Einstein's gravity.

3) Produce a deep map of the sky at NIR wavelengths, enabling new and fundamental discoveries ranging from mapping the Galactic plane to probing the reionization epoch by finding bright quasars at z>10.

SDT Findings #1

WFIRST should include all of the science objectives and utilize all of the techniques outlined in the NWNH recommendations:

A: Baryon Acoustic Oscillation (BAO) Galaxy Redshift Survey
B: Exoplanet (ExP) Microlensing Survey
C: Supernova SNe-Ia Survey
D: Weak Lensing (WL) Galaxy Shape Survey
E: Near Infrared Sky Survey – w/Survey of the Galactic plane
F: Guest Investigator Program
G: *Redshift Space Distortions, or RSD, acquired in parallel with BAO for free*

The WFIRST IDRM is compliant with the NWNH recommendation for groundbreaking observations in Dark Energy, Exoplanet and NIR sky surveys

Exoplanet Survey Capability

- Planet detection to 0.1 Earth mass (M_{Earth})
- Detects ≥ 30 free floating planets of 1 M_{Earth} in a 500 day survey*
- Detects ≥ 125 planets of M_{Earth} (in 2 year orbits) in a 500 day survey*
- Detects ≥ 25 habitable zone† planets (0.5 to 10 M_{Earth}) in a 500 day survey *****

* Assuming one such planet per star; "500 day surveys" are concurrent

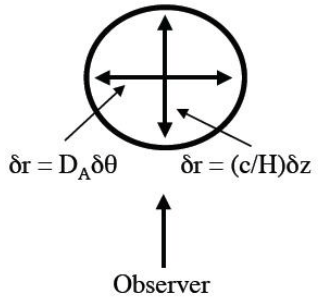
† 0.72-2.0 AU, scaling with the square root of host star luminosity

Data Set Rqts include:

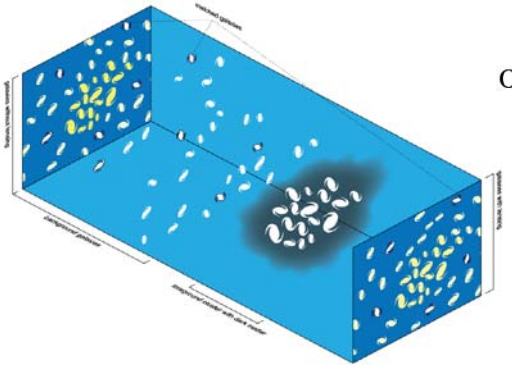
✓Observe ≥ 2 square degrees in the Galactic Bulge at ≤ 15 minute sampling cadence;
✓Minimum continuous monitoring time span: ~60 days;
✓Separation of ≥4 years between first and last observing seasons.

Dark Energy Techniques

- Three most promising techniques each provide different physical observables and unique information:

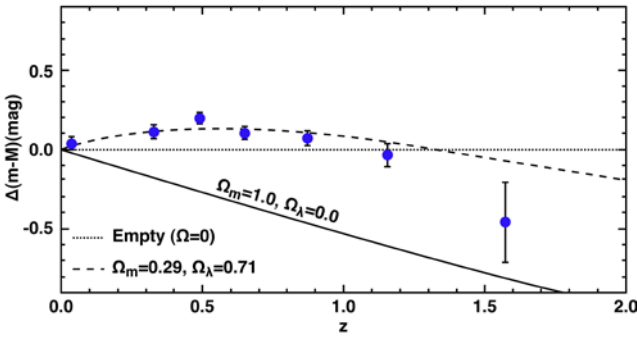


Baryon Acoustic Oscillation (BAO)
- Emission line galaxies positioned in 3D using strong Hα line
- Spectroscopic redshift survey in NIR



Weak Lensing (WL)
- Precision shape measurement of galaxy shap
- Photo-z redshifts

Type Ia Supernovae (SNe)
- Type Ia supernovae detected into NIR



- Redshift Space Distortions (RSD)
  - Distortions in Hubble flow
  - Galaxy redshifts from BAO survey can give growth of structure info

Dark Energy Survey Capabilities

- BAO/RSD: ... “WIDE” survey mode
  - 11,000 deg^2/dedicated year
  - Redshift errors $\sigma_z \leq 0.001(1+z)$, over redshift range $0.7 \leq z \leq 2$
- Weak Lensing: ... “DEEP” survey mode
  - 2700 deg^2/dedicated year
  - Effective galaxy density $\geq$30/amin^2, shapes resolved plus photo-zs
- SNe-Ia Survey:
  - >100 SN per $\Delta z = 0.1$ bin for most bins $0.4 < z < 1.2$, per dedicated 6 months
  - Redshift error $\sigma_z \leq 0.005$ per supernova

NIR Survey Capabilities

- Identify ≥100 quasars at redshift *z*>7
- Obtain broad-band NIR spectral energy distributions of ≥1e9 galaxies at z>1 to extend studies of galaxy formation and evolution
- Map the structure of the Galaxy using red giant clump stars as tracers

Data Set Rqts include:

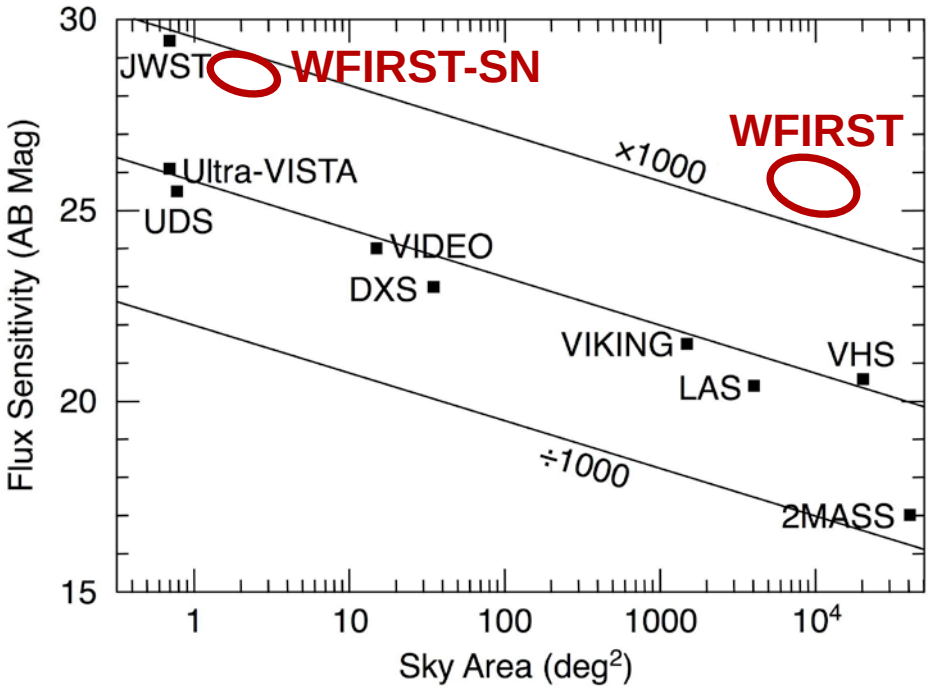
✓High Latitude data from Imager and Spectrometer channels during BAO/RSD and WL Surveys;
- Image 2500 deg^2 in 3 NIR filters to mag AB=25 at S/N=5

✓Galactic Plane Survey (~0.5 yr, per EOS Panel);
- Image 1500 deg^2 of the Galactic Plane in 3 NIR filters

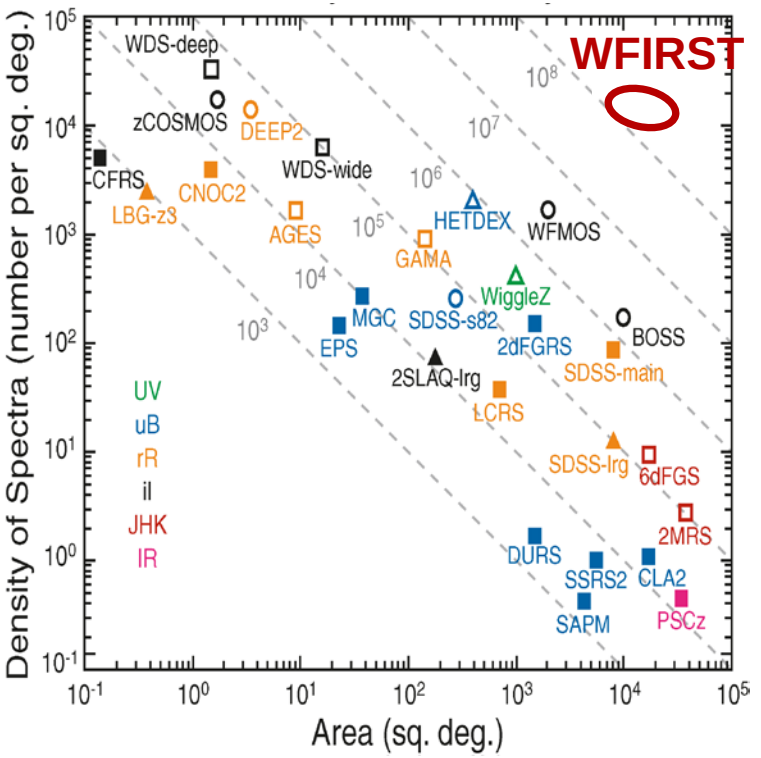
✓Guest Investigator observations (~1 yr, per EOS Panel) will supplement

WFIRST NIR Surveys

NIR Imaging Surveys



NIR Redshift Surveys



WFIRST provides a factor of 100 improvement in IR surveys

Science Return

Mission Performance: EOS Panel vs WFIRST IDRM

Science Investigation	EOS Panel Report	WFIRST IDRM
WL Survey	4000 deg^2	2700 deg^2/yr
BAO Survey	8000 deg^2	11,000 deg^2/yr
SNe	Not Mentioned	1200 SNe per 6 months
Exoplanet Microlensing	500 total days	500 total days
Galactic Plane Survey	0.5 yr GP Survey	0.5 yr GP Survey
Guest Investigators	1 year GI observations	1 year GI observations

Dark Energy Performance: NWNH Main Report vs WFIRST IDRM

DE Technique	NWNH Main Report	WFIRST IDRM 5 yr mission	WFIRST IDRM 5 yr Dark Energy*
WL Galaxy Shapes	2 billion	300 million (1 yr)	600 million (2 yr)
BAO Galaxy Redshifts	200 million	60 million (1 yr)	120 million (2 yr)
Supernova SNe-Ia	2000	1200 (1/2 yr)	2400 (1 yr)

***Including 5 year extended mission**

Science Return Summary

- WFIRST meets or comes close to meeting the time allocations and sky coverages given in the EOS Panel Report.

- For Dark Energy, WFIRST has fewer galaxies surveyed and SNe monitored than called for in the NWNH Main Report. The NWNH numbers were taken from the JDEM-IDECS RFI with 5 years of Dark Energy observations and were never feasible for WFIRST or JDEM-Omega (even with 5 years of DE).

- Still, the WFIRST IDRM has excellent performance compared to overall NWNH objectives as reviewed by the SDT. The FoM numbers are good for all science areas.

SDT Findings #2

How would WFIRST change if Euclid is selected?

- *Due to the importance of the scientific questions and need for verification of the results, WFIRST should proceed with all of its observational capabilities intact regardless of the ESA decision on Euclid.*
- *WFIRST has superior design for BAO (fixed prism) and WL (unobscured telescope) and has unique coverage of SNe and Exoplanet microlensing.*
- *The actual observation program would likely be altered in light of Euclid's selection or in response to any Euclid results prior to WFIRST's launch.*
- Now that EUCLID has been selected, we will be revisiting this issue in November.

SDT Findings #3

Should NASA and ESA decide to pursue a joint mission or program, all of the scientific approaches and broad objectives currently included in WFIRST must be included in the joint mission or program.

Future Study Areas

- IDRM design/analysis cycle underway and continuing into FY12.
- Assessment of collaboration opportunities with ESA once the status of Euclid is clarified in October 2011.
- Study of technical feasibility and scientific trades of increasing maximum wavelength beyond 2 microns.
- Study of technical feasibility and scientific trades of substituting a slit spectrometer or IFU for SN spectroscopy.
- Study of utilizing detectors with more, smaller pixels to achieve the same FOV with finer sampling.

Summary

- WFIRST has broad science capabilities
  - The most pressing fields in astrophysics all require a near infrared survey capability. WFIRST can satisfy all of the observational requirements . Our biggest problem is dividing up the observing time: proof of its scientific viability
- WFIRST is technologically mature
  - We could start development as soon as funding is available
- WFIRST is cost effective
  - $1.6B is a lot of money, but this cost estimate has been independently verified with the latest methodology and is credible
  - Given that WFIRST is the decadal #1 priority, and the broad science return in multiple areas, we believe that WFIRST is a bargain

- *WFIRST can move astrophysics forward into new frontiers of knowledge, and do it in less than a decade*