



#### **WFIRST Project Office Update**

#### Neil Gehrels & Kevin Grady WFIRST Study Scientist and Manager NASA-GSFC

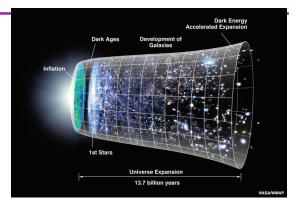
October 19, 2011



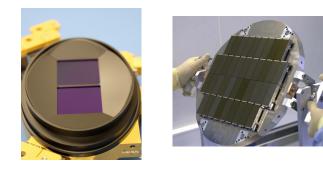
## **WFIRST Summary**



- 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<sup>2</sup> 5-sigma NIR survey at mag AB=25
- Space-qualified large format HgCdTe detectors are US developed technology and flight ready









# **WFIRST Project**



- WFIRST Project resides in Exoplanet Exploration Program (ExEP) at JPL
- WFIRST Project is joint effort between GSFC and JPL
- GSFC responsibilities
  - Project management
  - System engineering
  - Instrument & spacecraft management
- JPL responsibilities
  - Telescope design & implementation
  - Participate in system engineering
  - Data center (IPAC)
- HQ program oversight
  - Program Executive: Lia LaPiana
  - Program Scientist: Rita Sambruna



### WFIRST SDT



• The WFIRST project is working closely with the Science Definition Team (SDT) on refining the WFIRST requirements and developing a reference mission design

James Green, U. Colorado/CASA Co-Chair Paul Schechter, MIT Co-Chair

Rachel Bean, Cornell University Charles Baltay, Yale Charles Bennett, JHU David Bennett, Univ. of Notre Dame Robert Brown, STScl Christopher Conselice, Univ. of Nottingham Megan Donahue, Michigan State Univ. Scott Gaudi, Ohio State Univ. Tod Lauer, NOAO Bob Nichol, Univ. of Portsmouth Saul Perlmutter, UC Berkeley / LBNL Bernard Rauscher, GSFC Jason Rhodes, JPL Thomas Roellig, Ames Daniel Stern, JPL Takahashi Sumi, Nagoya Univ. Angelle Tanner, Georgia State Univ. Yun Wang, Univ. of Oklahoma Edward Wright, UCLA

Neil Gehrels, GSFC Ex-Officio Wes Traub, JPL Ex-Officiio Rita Sambruna, NASA HQ Ex-Officio



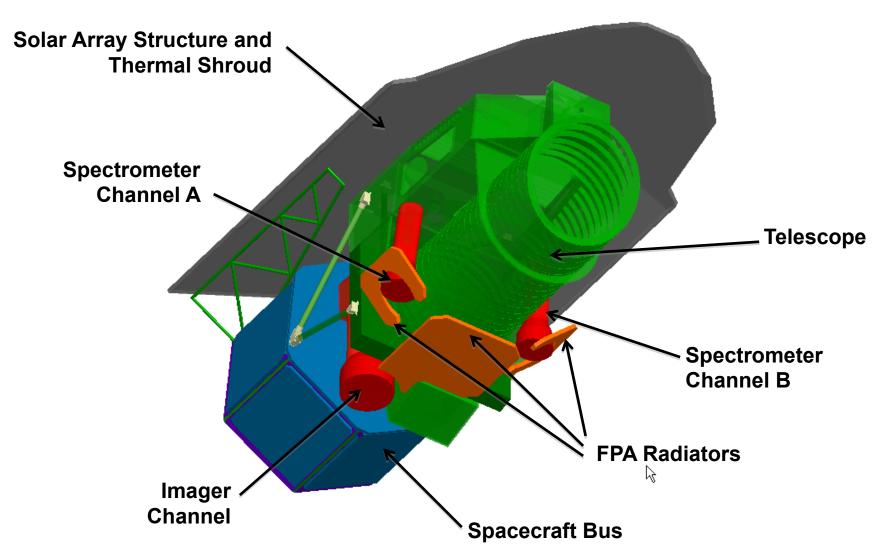


- Interim Design Reference Mission defined & studied
- Independent cost estimate performed
- Requirement flowdown defined
- Near IR detector array EDU under development
- Studies in progress of HgCdTe detector validation for weak lensing measurement
- Simulations underway, with more planned
- Science outreach events planned



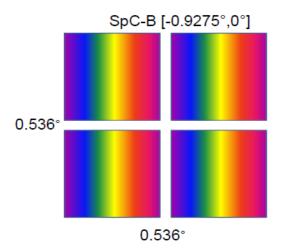
#### WFIRST IDRM Observatory Layout

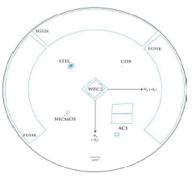






Moon (average size seen from Earth)

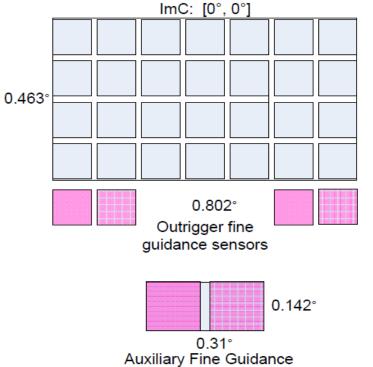




Channel field layout for WFIRST IDRM-1

The Fields of view of the imaging channel (ImC), spectroscopy channels (SpCs), and guiding modes (FGS) are shown to scale with the Moon, HST, and JWST. Each square is a 4Mpix vis-NIR sensor chip assembly (SCA)

ImC: 7x4 @ 0.18"/p; SpC 2(2x2)@0.45"/p [xfield center, yfield center, degrees]



0.31° Auxiliary Fine Guidance System: 2@0.25"/p [0°, -0.6°] JWST [all instruments]

SpC-A [0.9275°,0°]





- Performed by Aerospace Corp
- CATE = Cost And Technical Evaluation
- Input was Interim Design Reference Mission
- Aerospace cost estimate is within 7% of \$1.6B cost estimate from the Decadal Survey
- "Project has presented a feasible technical design consistent with stated science goals"



#### **Requirements Flowdown**



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- Early substantiation that IDRM can achieve the science objectives mandated by NWNH.
- Block diagram of the requirements has been developed with SDT
- Traces science requirements from top level objectives

| 1) Compl<br>to all c<br>2) Deterr<br>cluding<br>-3) Produc  | f the planets in our Sol<br>nine the expansion hist<br>plark Energy and mor<br>te a deep map of the  | us of planetary systems in the Galaxy, from hab<br>ar System except Mercury.<br>tory of the Universe and its growth of structure<br>iffications to Einstein's gravity.<br>sky at NIR wavelengths, enabling new and fu  | itable Earth-mass planets to free floating planets, including ana<br>so as to test explanations of its apparent accelerating expansio<br>udamental discoveries ranging from mapping the Galactic plan   |
|---|--|--|---|
| probin  | g the reionization epoc  | h by identifying quasars at z>10.  |   |
| WFIRST Surv   | ey Capability Rqts   | WFIRST Data Set Rqts   | WFIRST IDRM Design/Operations Concept Overvi  |
| <ul> <li>Planet detectic<br/>Earth mass (M</li> <li>Detects ≥ 125<br/>year orbits in a<br/>the masses of<br/>boing determin</li> <li>Detects ≥ 25 f<br/>(0.5 to 10 Mg);</li> <li>Detects ≥ 30 f<br/>Mg in a 500 c</li> <li>* Assuming or<br/>† 0.72-2.0 AU</li> </ul>   | Explanet (ExP) Microlensing Survey<br>Planet decision capability t= 0.1<br>Explanet and the set of the planet of the the planet of | Exoplanet Data Set Rats<br>= Observe - 2 aquara degree in the Galactic Bulgo<br>at 51 minute sampling caterics<br>= SiW-100 fbr J-band magnitude 5205 sources<br>= Simple Topologia en telebiotic<br>= Simple Topologia en telebiotic<br>= Simple Topologia en telebiotic<br>= Minimum continuous monitoring time span. ~60<br>days<br>= Separation of 2-4 years between first and last ob-<br>serving seasons   | Every WIRST IDEM Observatory Design Parameters           Offeas for all letterope, If and maintee treaters perturbe         = 2401 Materia           - Offeas for all letterope, If and maintee treaters         = 2604 Materia           - Portog fare and maintee         = 2604 Materia           - Portog fare and the galaxies         = 2604 Materia           - Portog fare and the galaxies         = 2604 Materia           - Born particeal fifter end on wheel, divers by M., Ske, VA.         = 1004 Fare Materia           - Into Effective Acces 0.31 m1 (in glare materia)         E Carl Materia           - Portog fare and service.         = 2021 dog Simps side - 20 and million solution           - POV code and so in the Sing fare Materia         = 2004 dog Simps side - 20 and millions side.           - POV code and so in the Sing fare Materia         = 2004 dog Simps side - 20 and millions - 20 and   |
| BAO/RSD Ga<br>= ≥11,000 dog <sup>2</sup><br>cated year (in<br>Source densi<br>shift range 0.<br>Redshift error<br>Fraction of m<br>per source by<br><u>Superno</u>  | tergy Surveys<br>laxy Redshift Survey<br>sky coverage per dedi-<br>a 'WDE' Survey mode)<br>yn(2PR(2) = 0 wer red-<br>'≤ z≤ 2 for k=0.2hMpc<br>s o;≤0.001(1+2)<br>sionfidiol lines STBD%<br>ke, ≤10% overall  | Dark Energy Data Sets           BAORSD Data Set Rgts           Sillera prim. +40) horeac           Sillera prim. +40) horeac           Hor prim. +40 horeac           Hor prim. +40 horeac           Hor prim. +40 horeac           Pola 2 for 2 horeac           Hore mission lines at 2 0 µm           Pola clade 2 40 mas           System PSF EEX0K nature 400 mas at 2 µm           Settem PSF EEX0K nature 400 mas at 2 µm   |   |
| <ul> <li>&gt;100 SNe-la<br/>bins for 0.4 &lt;<br/>months</li> </ul>   | per ∆z=0.1 bin for most<br>z < 1.2, per dedicated 6  | <ul> <li>Imager (for redshift zero reference)<br/>S/N≥10 for H<sub>AB</sub>≤23.5</li> </ul>  | <ul> <li>Roll ±10<sup>+</sup>; SNe observations inertially fixed for ~90 days for viewing inertially fixed for ~90 days fo</li></ul> |
| Peodott error<br>va<br>Redatte instru-<br>photogen ingene<br>Distance moe<br>lightcorve) or,<br>Vice State<br>Additice behave<br>Additice behave<br>Additive behav | ulus error (from<br>$\mathfrak{s0}, 02 \text{ per } \Delta z=0.1 \text{ bin}$<br><b>y Shape Survey</b><br>sky coverage per dedi-<br>a "DEEP" Survey mode)<br>xy denaity $\Rightarrow 30/\text{amin}^2$ ,<br>ed plus photo- as<br>error $\Rightarrow 310^4$<br>shear error $\Rightarrow 1\times 10^3$<br>distribution $\Rightarrow 0.04(1+2)$ .   | <ul> <li>Equal time in fitters FH4 and F178<br/>Supernova Data Set Bats<br/>Minimum menibring time-span for an individual         fittel - 2 years with a sampling cadence 55 days<br/>Conset fitter conditations 30.000<br/>SetBats patient specific (1000)<br/>SetBats patient specific (1000)</li></ul> | Ihe actipic policy) Ginabal array and the set of the se                |
| ImC Filters<br>F087   | 0.76 - 0.97  | to the community through peer-reviewed, open<br>competition  | <ul> <li>*WIDE* Galaxy Redshift Survey (-11,000 deg<sup>2</sup>/yr, -30 deg<sup>2</sup>/day)</li> <li>8 SpC maps are acquired during 4 separate passes (2 opposito)/-<br/>dispersed maps are acquired each pass, one from each of two SpCs</li> <li>The first two passes are offset from each ofter to rough fill both SpC</li> </ul>   |
| F111<br>F141<br>F178<br>W149<br>ImC<br>Prisms   | 0.97 - 1.24<br>1.24 - 1.57<br>1.57 - 2.00<br>0.97 - 2.00   |  | <ul> <li>In this first two passes are offset from each other to rough it both spc, and<br/>and mCS Cda pays, and the same is done for the next two passes at<br/>-5° different roll angle and with a different into: fitter<br/>SpC arguments time of 1200 Each the rough-filled nature of the outpo-<br/>sare results in only 6 coopsures being accumulated over -69K will<br/>observed aby, a only 6X SVB = 000 or 59C. The is constallable<br/>- 30 deg are completed each day, with pool KNS hemisphere finability<br/>&lt; integration times are not constant with next over full redenit tran<br/></li> </ul>   |
| P130  | 0.60-2.00<br>uirements Flowdown O  |  |   |



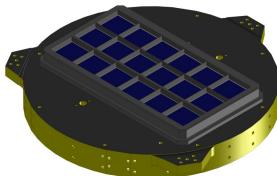
#### **Detector Array EDU**



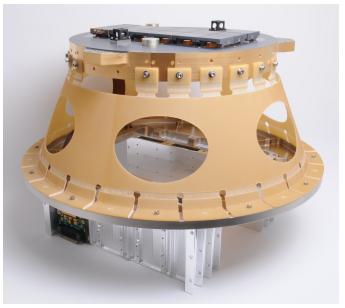
 Development of 3x6 HgCdTe Engineering Development Unit detector array at GSFC



Light shield (silicon carbide)



**EDU Focal Plane Array** 



EDU FPA with structural assembly

 Silicon carbide mounting of HgCdTe detectors is under development and will be space qualified with EDU



# **HgCdTe Detector Studies**



- Potential issues with HgCdTe capabilities for weak lensing galaxy shape measurement include:
  - Interpixel capacitance
  - Persistance
  - Linearity & reciprocity
- Laboratory test program in place to assess issues and find workarounds (GSFC, JPL, Caltech, Teledyne, STScI, U Hawaii)
- Initial results are encouraging that HgCdTe detectors can be used for galaxy shape measurements and photo-z's with needed precision



### Simulations



- Pixel scale study for WL at JPL / Caltech (Rhodes, Hirata, Rowe)
  - Shapelet simulations, image combination software, dithering study
  - Results show that 0.18 "/pixel of WFIRST Imager is adequate for weak lensing shape measurement
  - Working on making widely used WL image simulation software "simage" available to community via IPAC
- Sky tiling sims for BAO & SNe at GSFC (Weiland, Kruk, Hinshaw)
- Exoplanet microlensing sims at Notre Dame (Bennett, Rhie, Gaudi)





- Science calculators and estimators being deployed to the community through IPAC
- WFIRST booth developed and displayed at key conferences
- Science workshop planned for Feb 13-15, 2012 at IPAC
- WFIRST "Meeting-In-A-Meeting" proposed for June AAS in Anchorage



### Conclusions



- Strong team using unique expertise of GSFC & JPL
- Project Office is working closely with SDT
- Independent costs estimates are consistent with WFIRST cost assumed by NWNH.
- Project Office and SDT have produced capable Interim Design.
- Simulations and laboratory studies are underway.
- Outreach to science community is proceeding.
- Project is well prepared to continue development of the Design Reference Mission and consideration of partnership opportunities.





# BACKUPS



#### WFIRST – Euclid Comparison



| OF LEADRAILETS - MU | WFIRST  | Euclid  |
|---------------------|---|---|
| Aperture            | 1.3m unobstructed (equivalent to 1.5m obstructed)   | 1.2 m obstructed  |
| Wavelength          | 760nm - 2µm   | 500nm - 2µm   |
| Pixel size          | 018" NIR imaging<br>0.45" NIR spectro   | 0.1" optical imaging<br>0.3" NIR imaging and spectro  |
| Lifetime            | 5 years primary, 10 years goal  | 5.5-6 years primary   |
| Instruments         | <ol> <li>NIR imaging instrument with filter wheel</li> <li>2 NIR spectrographs</li> </ol> | <ol> <li>Optical imager with fixed filter(s)</li> <li>NIR instrument with filter wheel</li> </ol> |

#### WFIRST uniquely has

- exoplanet microlensing
- SNe
- WL shape measurements in NIR, complementary to LSST
- BAO survey with dedicated spectrometer (prism instead of grism on wheel)
- 5 times as many BAO galaxies
- deeper NIR sky survey with finer pixels