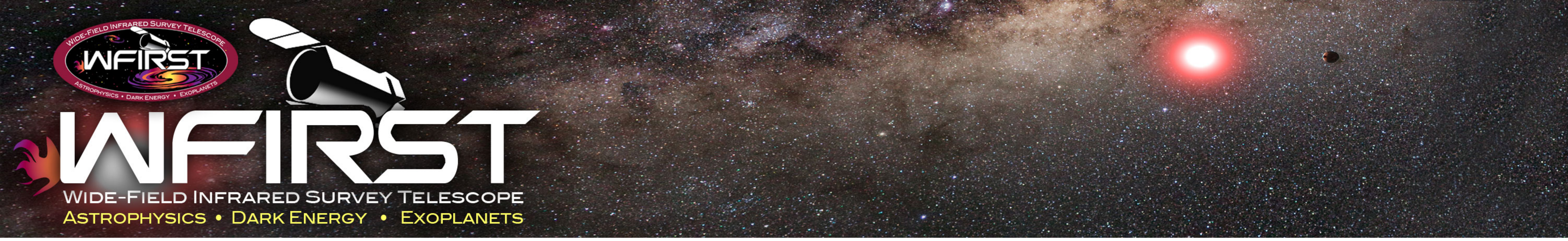
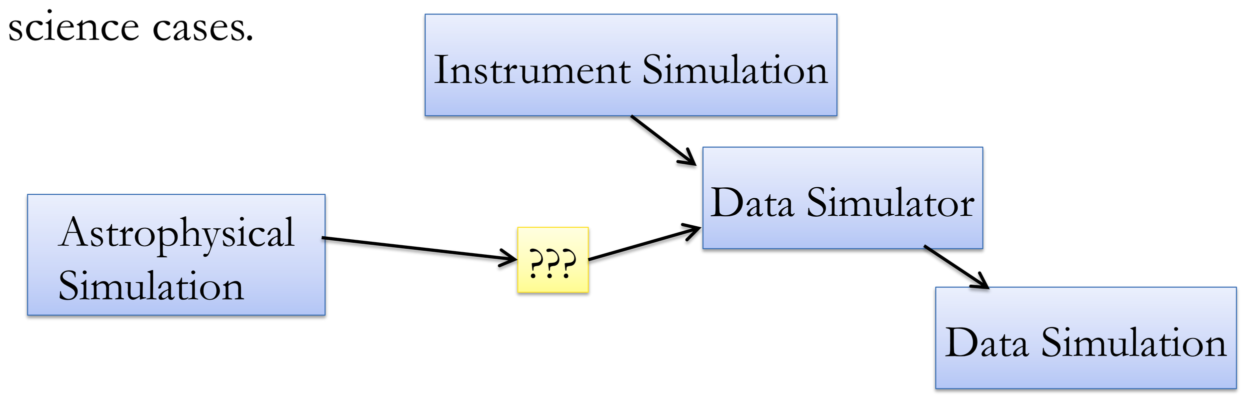


Simulating the WFIRST Sky

Molly S. Peeples (STScI), Matthew Penny, Gregory F. Snyder, Christopher Hirata, Ami Choi, Michael Jarvis, Rachel Mandelbaum, Michael Troxel
on behalf of the WFIRST Wide Field Instrument Simulations Working Group

The Problem: From Astrophysical Simulations to Synthetic Data

The WFIRST Wide Field Imager (WFI) Simulations Working Group has been focused on interfacing instrument simulation tools, primarily developed by the WFIRST Science & Operation Centers (Goddard, IPAC, and STScI), with the astrophysical simulations being developed by the Science Investigation Teams for specific science cases.



In early 2017, the working group put together a white paper on the need for a robust WFIRST WFI Data Simulator (see abstract and link to the right). Below, we highlight three examples of simulated WFIRST WFI data and methods from working group members and different Science Investigation Teams.

White Paper on The Need for a Robust WFIRST Wide Field Imager Data Simulator

Molly S. Peeples, James Bullock, Scott Gaudi, Michael Jarvis, Rebekah Hounsell, Alina Kiessling, Rubab Khan, Sangeeta Malhotra, Rachel Mandelbaum, Joshua E. G. Peek, Matthew Penny, Laura V. Sales, Gregory F. Snyder, Rachel Street, Harry Teplitz, V. Tilvi, Ben Williams, Jennifer Yee
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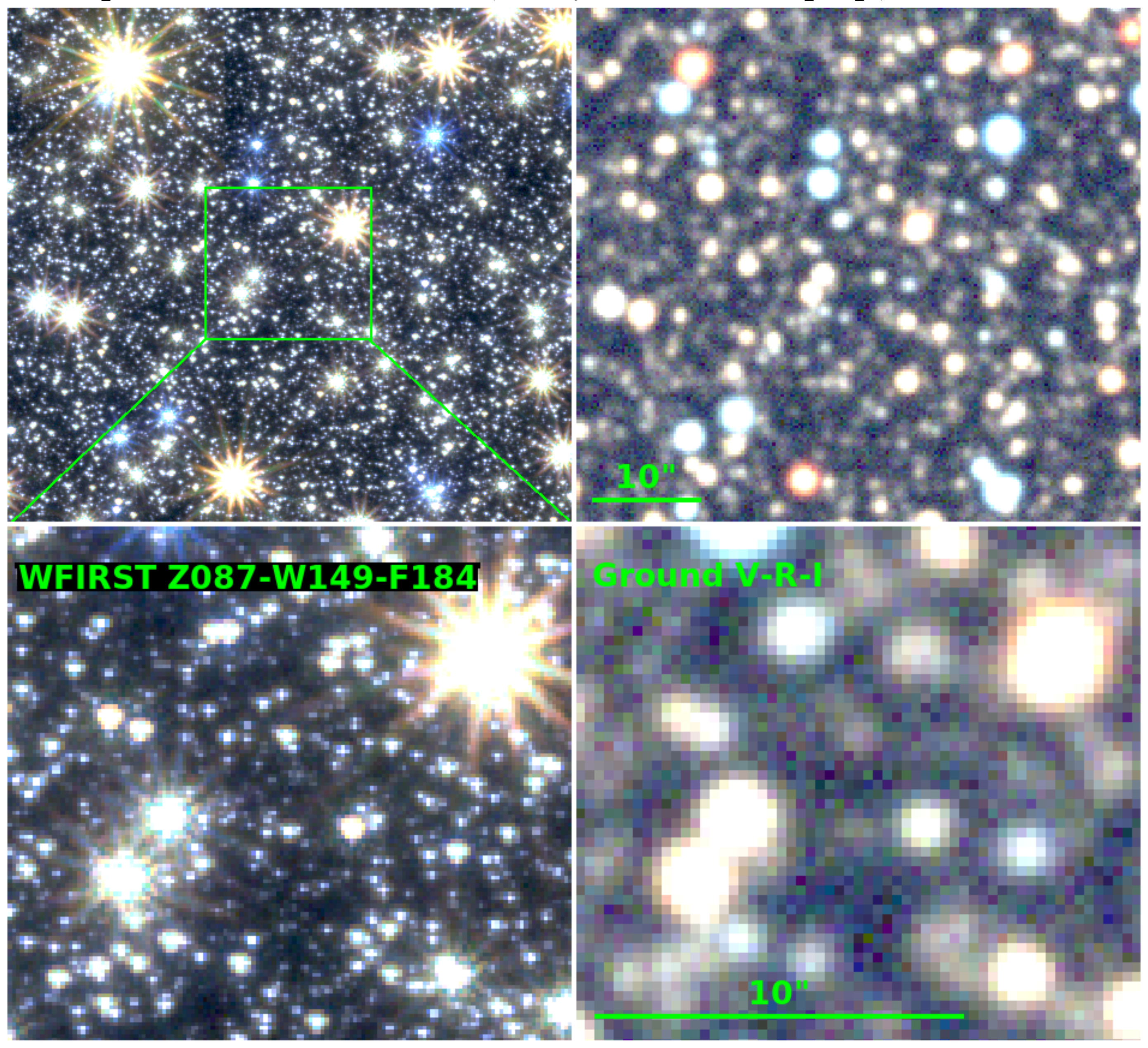
As astronomy's first high-resolution wide-field multi-mode instrument, simulated data will play a vital role in the planning for and analysis of the data from WFIRST's WFI (Wide Field Imager) instrument. Part of the key to WFIRST's scientific success lies in our ability to push the systematics limit, but in order to do so, the WFI pipeline will need to be able to measure and take out said systematics. The efficacy of this pipeline can *only* be verified with large suites of synthetic data; these data must include both the range of astrophysical sky scenes (from crowded starfields to high-latitude grism data observations) and the systematics from the detector and telescope optics the WFI pipeline aims to mitigate. In the near future, a definitive WFI Data Simulator (WFIDS) will save redundant efforts across the SITs: these teams have limited resources, and it makes sense for the development of the WFIDS to be closely-coupled with instrumentation updates, rather than distributed amongst the SITs. In the longer term, these tools will maximize the science return of the mission. In particular, we stress the integrated nature of the WFIRST surveys: if the Microlensing Survey (MLS) is to be used to calibrate the other WFI observations, then it is likewise critical that the data simulator used to prepare for the MLS is the same as that used to prepare for the High Latitude Survey (HLS) and GO observations. In short, the least risky and most efficient course is to have all effects carefully vetted for one simulator, instead of separately by many teams with disparate goals. We outline here the need for a robust WFIDS, a survey simulator, and suites of synthetic WFI data.

The full white paper can be found at https://tinyurl.com/wfids.

Microlensing Survey

Comparison of WFIRST and ground-based imaging of a simulated star field in the WFIRST microlensing survey. WFIRST's ~0.15" resolution and infrared detectors allow it to resolve and monitor main sequence stars in the Galactic bulge. This enables the detection of large numbers of cold, low mass planets such as the simulated detection of a Mercury-mass planet 2AU from its star (Penny et al. 2018 in prep.).

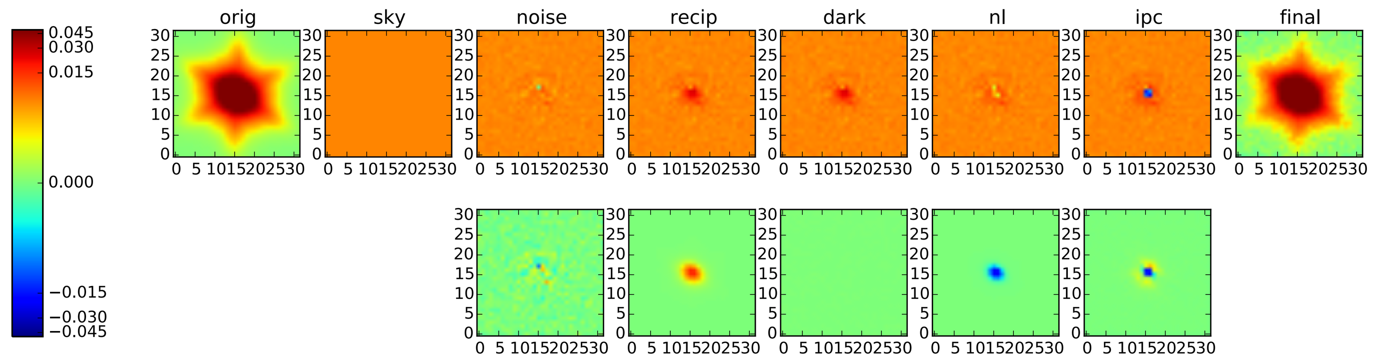


Deep Fields

Mock WFIRST deep fields (in addition to HST and JWST) from the Illustris simulation (Snyder et al. 2017, MNRAS, 468, 207) are posted to MAST at https://archive.stsci.edu/prepds/illustris/. The simulation catalog from which each image is generated is also provided, enabling users to locate sources, link them to intrinsic simulation quantities, and conduct analyses across observation and theory space. The Illustris Project consists of hydrodynamic simulations of galaxy formation in a volume 106.5 Mpc across, with detail resolved on kiloparsec scales. As simulations grow to encompass ever-larger slices of the universe, we will be able to predict how WFIRST might observe the details of galaxy assembly throughout the cosmic web.

High-Latitude Survey

The success of the WIFRST weak lensing survey, a key component of the High-Latitude Survey, relies on the ability to accurately measure the shapes of galaxies and therefore also the ability to understand how instrumental effects change the observed galaxy shape. Here we show an example of a simulated bright, elliptical galaxy produced by the GalSim/WFIRST image simulation pipeline. The top row of subpanels begins with the original simulated bright elliptical galaxy (far left). Each subpanel to the right of the original galaxy is a "difference" image that has the original galaxy subtracted off after the given effect (top label) has been applied. These effects are: sky background, noise, reciprocity, dark current, nonlinearity, and inter-pixel capacitance, respectively. The bottom row of subpanels corresponds to the individual, isolated effects (top label). The top, far right subpanel shows the final galaxy image after all effects have been applied. The sub panels have been normalized by the maximum flux value of the original galaxy image, and the colors have been mapped to $\log_{10}$ values with a small range right around zero mapped to linear values as shown on a single colorbar corresponding to all of the subpanels. Courtesy Chris Hirata, Ami Choi, Michael Jarvis, Rachel Mandelbaum, Michael Troxel.



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JPL Jet Propulsion Laboratory
STScI Space Telescope Science Institute
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