
# Science Operations and Support for the Wide-Field Instrument (WFI) for WFIRST

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## Introduction:

The Wide-Field Infrared Survey Telescope (WFIRST) was identified by the Astro2010 Decadal Survey as the highest priority for a large space-based mission. Expected to launch in mid-2020s, WFIRST will have a 2.4 m primary mirror and provide HST-quality imaging over 0.27 deg$^2$, which is roughly a factor of 100 improvement over HST. WFIRST will have two instruments: the Coronagraphic Instrument (CGI) and Wide-Field Instrument (WFI); here we focus on the latter. The WFI will have 18 4k×4k detectors with seven broadband filters (for 0.5–2 $\mu$m) and two spectroscopic elements: a high-resolution grism (R∼700 for 1–2 $\mu$m) and a low-resolution prism (R∼100 for 0.8–1.8 $\mu$m). We will discuss the role of STScI as the Science Operations Center of observation planning/scheduling, science support, and data archiving. Finally, we will describe the key surveys designed to study dark energy or exoplanets (High-Latitude Survey, Supernova Survey, Exoplanet Microlensing Survey, and Coronagraphic Program) and the opportunities for targeted General Observer (GO) programs and/or archival Guest Investigator (GI) analyses.

## Documentation and Technical Reports:

**Bellini et al. (2018)** tested the feasibility of using the Gaia final release to calibrate the geometric distortion of WFI to within mission requirements. They simulated a set of dithered images of the Sagittarius window in the Galactic bulge and applied a 1% distortion level to the raw data. The simulated images take into account spatial variations of the PSF, intra-pixel capacitance variations, and jitter effects. They find that, when Gaia's end-of-mission astrometric errors are taken into account, the precision of the recovered distortion solution is about 0.04 pixels (1$\sigma$ RMS), with most of the error due to the reference Gaia catalog, which far exceeds mission requirements. The geometric-distortion solution will substantially improve when the distortion itself is solved for using an autocalibration approach.

**Ryan et al. (2019)** considered a notional calibration strategy to use an open stellar cluster (M67) to determine the "wavelength zeropoint" (the lowest order term in the dispersion solution). Using known positions, velocities, and colors of cluster members, they showed that a typical WFI detector will have ∼100 confirmed cluster members of knowable spectral type. For a modest exposure time of 8×350s, they concluded that position of the Pa$\beta$ absorption line can unambiguously determine the wavelength zeropoint (to a typical percent error of ∼0.01%).

**http://www.stsci.edu/wfirst/documentation**

## Calibration Plans:

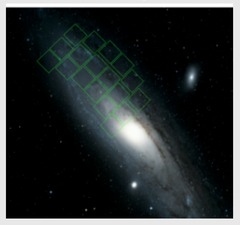
Table to the right is taken from the *WFIRST WFI Calibration Plan: Science Operations Calibrations* (October 2019 version; Casertano et al.), which describes a notional, on-orbit calibration strategy. These calibrations are designed to satisfy several data quality requirements for the WFIRST Mission, which is to support several large surveys, the Guest Observer programs, and archival research. Some of these calibrations require dedicated observations, while others can be derived from science observations or other calibration data (indicated with 0 hours). Finally, this calibration plan supplement calibrations from ground-based and commissioning data.

| Program | Time (hr) | Cadence | Ave. (hr/yr) | Total (d) |
|---|---|---|---|---|
| **Detector Calibrations** | | | | |
| Pix-pix Flatfield | 2.2[1] | Monthly | 26.4 | 5.5 |
| Subpix response | 121/40[2] | Yearly | 56.2 | 11.7 |
| Readnoise | 0 | Monthly[3] | 0 | 0 |
| Classic non-linearity | 0 | Monthly[3] | 0 | 0 |
| CRNL: lamp on/off test | 5 | 5/yr[4] | 25 | 5.2 |
| CRNL: direct | 62 | Yearly | 62 | 12.9 |
| Unstable pix | 0 | Weekly | 0 | 0 |
| Persistence | 0 | Exposure | 0 | 0 |
| Burn-in | 0 | Monthly | 0 | 0 |
| Gain | 0 | Monthly | 0 | 0 |
| Inter-pix capacitance | 0 | Weekly | 0 | 0 |
| Inter-pix non-linearity | 0 | Monthly | 0 | 0 |
| **Imaging Calibrations** | | | | |
| Darks | 1.4 | Weekly | 72.8 | 15.2 |
| Large scale uniformity | 0 | N/A | 0 | 0 |
| Small scale uniformity | 7 | Yearly | 7 | 1.5 |
| Bandpass uniformity | 7 | Twice | 3 | 0.6 |
| Temporal stability | 1 | Quarterly | 4 | 0.8 |
| Spectrophotometric response | 14 | Yearly | 14 | 2.9 |
| Cross-survey calib | 4.5 | Yearly | 14 | 2.9 |
| Geometric distortion | 24 | Yearly | 24 | 5 |
| Absolute astrometry | 0 | Exposure | 0 | 0 |
| PSF Calibration | 0 | Exposure | 0 | 0 |
| **Spectroscopic Calibrations** | | | | |
| Darks | 2.7 | Weekly[1] | 140.4 | 29.2 |
| Pointing reconstruction | 0 | Exposure | 0 | 0 |
| Wavelength zeropoint | 2 | Yearly | 2.9 | 0.4 |
| Dispersion solution | 3 | Yearly | 3 | 0.6 |
| Trace calibration | 0 | N/A | 0 | 0 |
| Flux calibration (Spatial) | 1 | Monthly | 12 | 2.5 |
| Flux calibration (wavelength) | 2.5 | Yearly | 2.5 | 0.5 |
| Spectrophotometric stability | 0 | N/A | 0 | 0 |
| PSF | 0 | N/A | 0 | 0 |

**Footnotes:**
1. Includes 0.5 hours wait.
2. 121 hours the first year (3 filters); 40 hours (one filter) each subsequent year, unless changes are seen
3. Shares data with pixel-level flat field
4. Four times per year with F184; once per year with W146 (if possible)
5. May be skipped during imaging-only campaigns

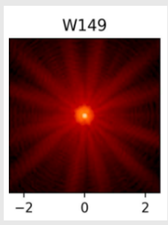
## WFI Simulation Tools:

### FoV Overlay Tool



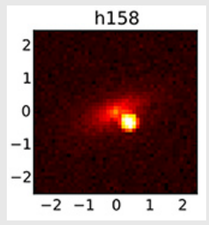
MAST contains the infrastructure to overlay locations and instrument apertures on images, which facilitates spatial footprint queries on catalog databases.

### WebbPSF




WebbPSF-WFIRST provides a customizable interface to simulate the PSF for the WFI. These PSFs are then used by Pandeia and STIPS.

### Source Simulation and ETC (Pandeia)




Pandeia is the ETC system developed for JWST and adapted for WFIRST. It takes 3d data cubes that describe the spatial and spectral properties, which are projected on to a detector plane to estimate S/N.

### Complex Scene Simulation (STIPS)

The Space Telescope Image Product Simulator (STIPS) produces simulated images based on user inputs, instrument models, and catalogs of stellar populations. The WFIRST implementation is capable of simulating a single detector for the WFI.

**http://www.stsci.edu/wfirst/science-planning-toolbox**

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