Astrometry with the WFIRST Wide-Field Imager

The WFIRST Astrometry Working Group

R. E. Sanderson, A. Bellini, S. Casertano, J. R. Lu, P. Melchior, D. Bennett, M. Shao, J. Rhodes,
S. Malhotra, S. Gaudi, M. Fall, E. Nelan, R. Guhathakurta, J. Anderson, S. Ho, M. Libralato

Abstract

The Wide-Field InfraRed Space Telescope (WFIRST) will be capable of delivering precise astrometry for faint sources over the enormous field of view of its main camera, the Wide-Field Imager (WFI). This unprecedented combination will be transformative for the many scientific questions that require precise positions, distances, and velocities of stars. In our white paper we describe the expectations for the astrometric precision of the WFIRST WFI in different scenarios, illustrate how a broad range of science cases will see significant advances with such data, and identify aspects of WFIRST's design where small adjustments could greatly improve its power as an astrometric instrument.

Astrometric Performance of the WFIRST WFI

Context	Estimated performance
Single-exposure precision	0.01 px; 1.1 mas
Typical guest-observer program (100 exposures of one field)	0.1 mas
Absolute astrometry accuracy	0.1 mas
Relative proper motions derived from High-Latitude Survey	25 μas yr^{-1}
Relative astrometry, Exoplanet MicroLensing Survey (per image)	1 mas
Relative astrometry, Exoplanet MicroLensing Survey (full survey)	3–10 μas
Spatial scanning, single scan	10 μas
Spatial scanning, multiple exposures	1 μas
Centering on diffraction spikes	10 μas

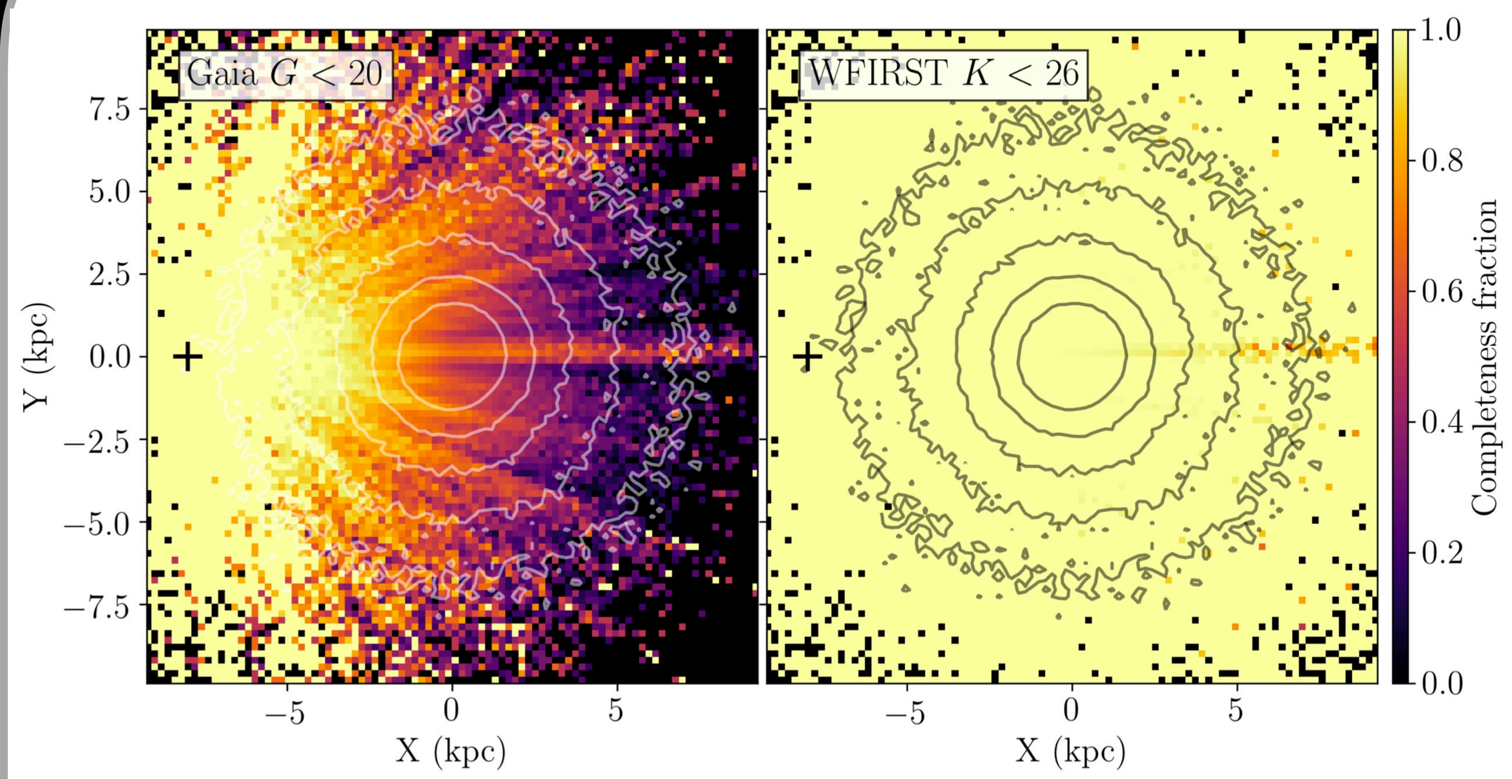
Approximate expected astrometric performance of the WFIRST WFI for different types of observations. All estimates are for well-exposed point sources, and provide order-of-magnitude only.

For a more comprehensive look, see our white paper online!

arXiv:1709.02763

We highlight areas where astrometry-specific considerations are especially important and can add significant extra science capability with little to no extra cost, including geometric distortion, pixel-level effects, chromaticity, scheduling, jitter, data management, high-level data products, and the archive.

Example Science Cases

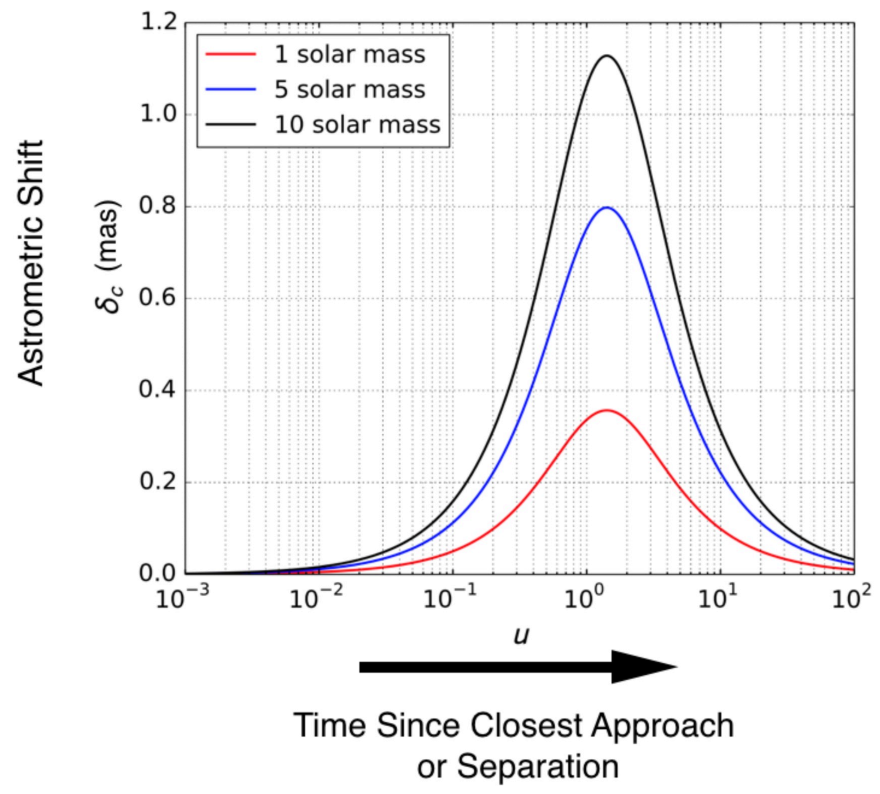


WFIRST astrometry reveals the structure of the Galactic bulge

Left: Simulated completeness of the distribution of red clump stars with distances |z| < 500 pc from the Galactic plane. On the left, stars that *Gaia* would detect in the optical (G < 20); on the right those seen by WFIRST in the infrared (K < 26). Grey contours show the Galactic stellar density on a log scale; the black cross marks the location of the Sun.

WFIRST astrometry constrains the Galactic population of compact objects

Right: Astrometric shift of a background bulge star (source, d = 8 kpc) lensed by a foreground compact object such as a black hole, neutron star, or white dwarf (lens, d = 4 kpc). The astrometric shift changes as a function of the projected source-lens separation on the sky, *u*, in units of the Einstein radius. For the 10 M⊙ case, the Einstein radius is ~4 mas and the time for the source to cross the Einstein ring is typically >100 days.



WFIRST astrometry maps 3D velocities in the Local Group