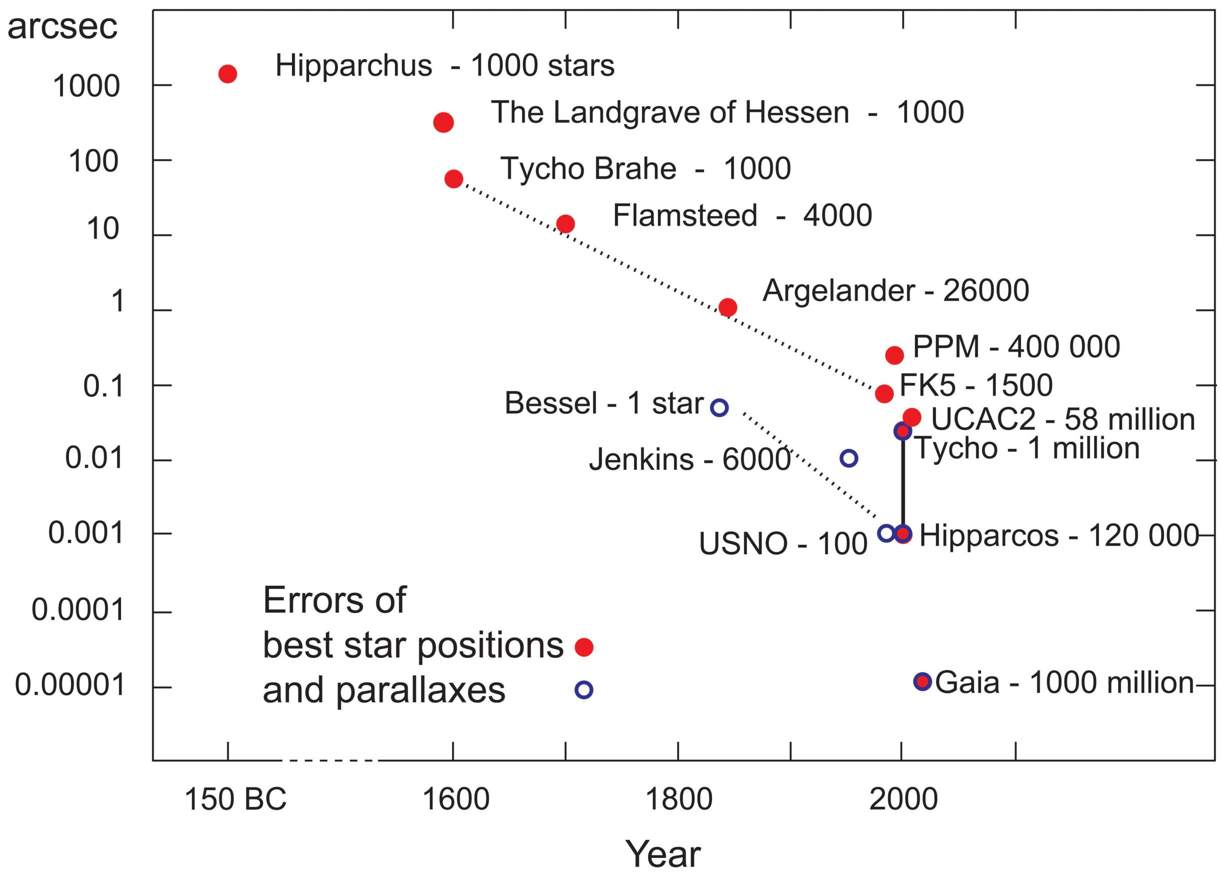

Progress in astrometric accuracy from Hipparchus to Tycho Brahe, Hipparcos, and Gaia. ESA's space astrometry mission Gaia pushes astrometric measurements to the limits.

Gaia's main goal is to collect high-precision astrometric data (i.e. positions, parallaxes, and proper motions) for the brightest 1 billion objects in the sky. These data, complemented with multi-band, multi-epoch photometric and spectroscopic data collected from the same observing platform, will allow astronomers to reconstruct the formation history, structure, and evolution of the Galaxy. In the Gaia Concept and Technology Study Report (published by ESA in 2000), it was shown that meeting these main mission objectives will require the observation of a complete sample of stars down to 20-th magnitude combined with end-of-life astrometric accuracies of $\sim$20–25 μas (or better) at V = 15 mag.

Order-of-magnitude estimates of Gaia's expected end-of-life astrometric accuracy can easily be obtained by using back-of-the-envelope calculations involving overall, system-level parameters such as primary mirror size, detector efficiency, and mission lifetime. In the current phase of the project, however, a fully-fledged astrometric accuracy tool is indispensable for carefully assessing the impact of various design alternatives on the scientific value of the mission product, for optimizing instrument parameters such as the mirror coating reflectivity, and for safeguarding the mission objectives in general. It has been the responsibility of the Gaia Project Scientist Support Team to set up, maintain, and expand such a general astrometric accuracy model.

The astrometric accuracy model currently in place provides a simplified yet realistic end-to-end simulation of the Gaia observation process, ranging from photon emission at the astronomical source at the one end, through the effects introduced by, e.g. the revolving scanning law and CCD TDI operation, to single-transit centroiding measurements of the line spread function, and the averaging of these results over the operational mission lifetime, at the other end. The model also includes, among other things, wave-front errors due to aberrations and image smearing due to transverse motion of sources in the focal plane and charge diffusion in the CCD detectors. The longer-term goal of this modelling effort is to include all effects affecting the final mission accuracies and to expand the model to include photometric and radial-velocity accuracy assessments.