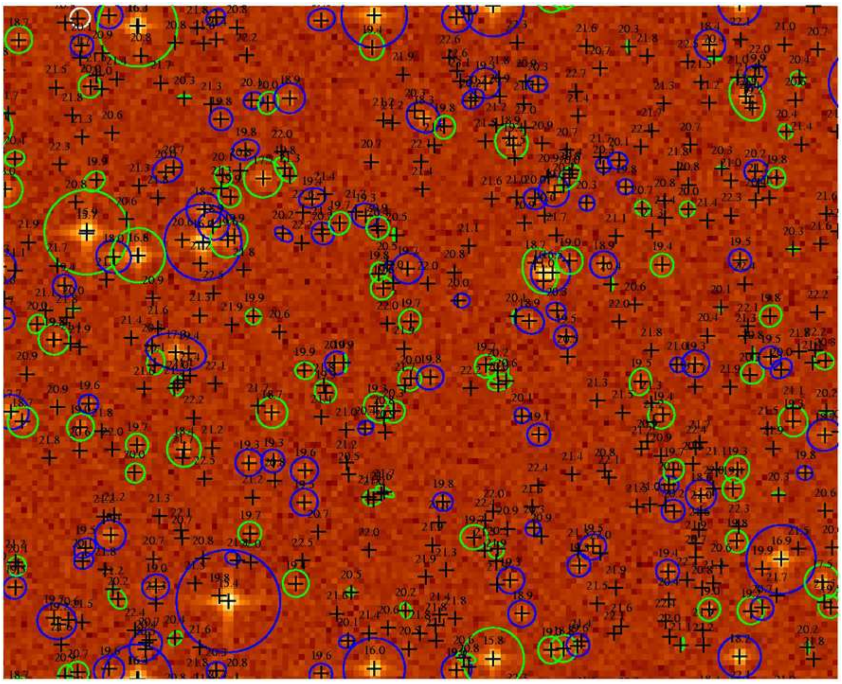

Simulation, based on HST data, of Baade's Window observed by Gaia's Sky Mapper (SM). A sky-mapper sample is composed of 2 × 2 binned pixels. Black crosses indicate all stars up to magnitude 23. Detections are shown with blue and green ellipses, corresponding to objects classified as single and multiple stars, respectively.

Gaia's main goal is to provide an astrometric catalogue of objects complete down to magnitude 20. Since similar catalogues in the Gaia photometric passband and with the Gaia spatial resolution do not exist, Gaia, unlike Hipparcos, cannot operate based on the principle of a pre-compiled input catalogue. Autonomous on-board object detection is thus compulsory, with two associated advantages: (i) on-board detection also allows 'special objects' such as supernovae and near-Earth objects to be naturally detected and observed; (ii) on-board detection allows object selection and object windowing, thus significantly limiting both the number of CCD pixels that have to be read, hence improving CCD noise performances, and the amount of data that have to be transmitted to ground.

The detection algorithm has an impact on the Gaia scientific return: the number and nature of the sources observed and the completeness of the Gaia Catalogue – and any selection biases – will depend on the detailed characteristics of the detection algorithm. Developing a suitable detection algorithm is subject to many trade-offs between scientific requirements (reliable discrimination between stars, double stars, extended non-stellar objects, blended stars, saturated stars, and prompt-particle events such as cosmic rays or solar protons; functional over the magnitude range 6–20; stable under the peculiarities of the real sky, etc.) and operational constraints (operation compliant with real-time constraints; on-board processing architecture; and on-board processing power; robust coupling with AOCS, etc.).

In early studies, several demonstration algorithms have been developed, initially detecting point sources only but subsequently elaborated to cope with extended sources. The latter prototype algorithm, which is based on a thresholding philosophy, features accurate centroiding, accounts for saturated stars, does not generate false detections on stellar diffraction spikes, and is capable of detecting close double stars, thus allowing window patches to be correctly assigned to cover both components. In a field of average stellar density, a 99% detection completeness for single stars is obtained at magnitude 20, with less than one false detection per million samples. Baade's Window is the challenging archetype of a large-scale high-density field which has to be managed in real time. The figure shows a 13 × 32 arcsec$^2$ image simulated with the GIBIS Gaia Simulator (developed by Carine Babusiaux and colleagues) based on a list of stars extracted from a high-resolution HST image. A detection rate of 86% at magnitude 20 without false detections is achieved; the incompleteness is mainly due to faint companions close to bright(er) primaries.

Current developments for the actual flight implementation are focused on providing a mixed hardware/software solution. This has already led to the design of original methods devoted to connected-component searches, deblending schemes for overlapping components, and real-time estimation of sky background.