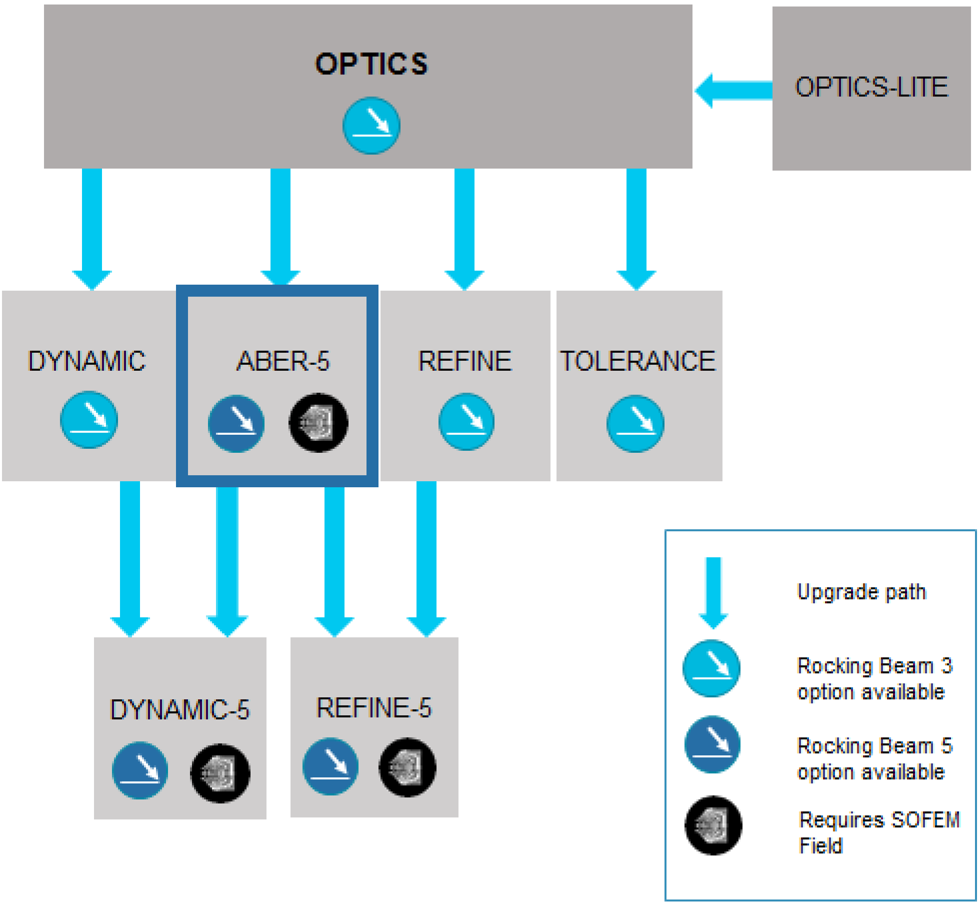
ABER-5

5th—order aberrations



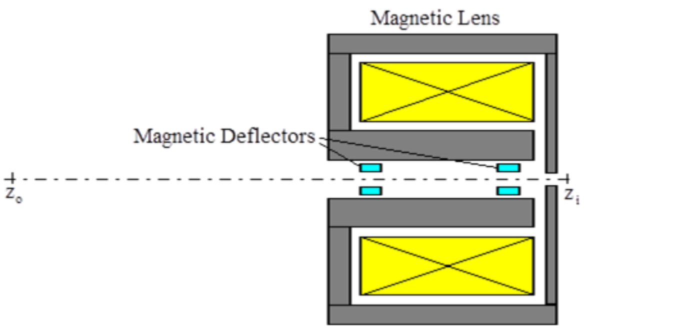
Overview

In addition to the 3rd - order geometrical and 1st - order chromatic aberrations computed by OPTICS, ABER-5 computes 5th - order geometrical and 3rd - order chromatic aberrations. The accurate prediction of these higher order aberrations is important in designing electron and ion beam systems which use large area projection or large field scanning. Such systems are required for high throughput lithography applications.

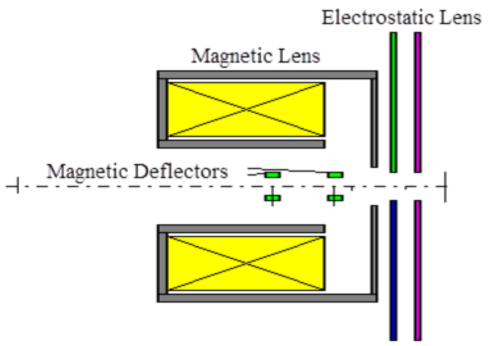
The software handles the same types of systems as the OPTICS package. This includes columns with any combination of electrostatic and magnetic lenses and deflectors. The axial field functions of the lenses and deflectors are first obtained with the SOFEM package. The radial expansions of these field functions, up to 5th - order terms in the off-axis distance, are then obtained by taking several axial derivatives of each axial field function. The high accuracy inherent in the fields computed with the SOFEM software is essential for obtaining accurate values of the high-order derivatives of the axial field functions.

The ABER-5 software first computes the principal paraxial rays by retaining only the 1st-order terms in the field expansions. In the next approximation, the 3rd -order terms in the field expansions are retained in order to compute the third-order geometrical aberrations, using aberration integrals in the standard way. These primary aberration integrals are evaluated using the principal paraxial rays. In the final approximation, the 5th -order terms in the field expansions are retained in order to compute the 5th - order geometrical aberrations, using specially derived aberration integrals.

Gaussian round beams or extended shaped beams can be handled. The deflection can be dual-channel (main and sub field), using multipole and planar deflectors, and the *x* and *y* deflectors can be located either at the same axial location or at sequential positions along the *z*-axis. All the rotationally symmetric and multipole aberrations are computed, including the fourfold aberrations of fifth-order, created by both the third and fifth harmonics of the deflection fields.



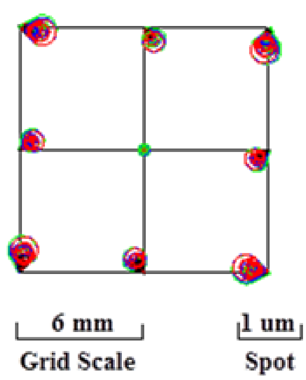
Pure magnetic focusing and deflection system

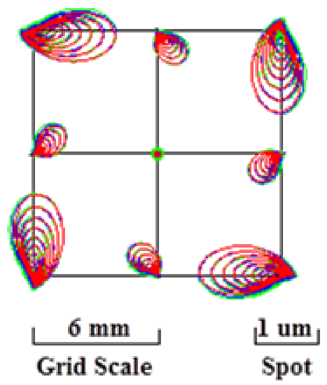


Mixed focusing and deflection system

Some of the terms of the complex fifth-order aberration integrals must be evaluated using the third-order trajectories. Integration by parts is used to minimize the required order of the derivatives of the axial field functions. A simplification in the complexity of the formulae has been obtained, by expressing the aberration integrals in terms of general aberration functions with dummy arguments. These functions are then evaluated with different combinations of the paraxial and third-order rays as their specific arguments, in order to extract all the individual aberration coefficients.

For a dual-channel deflection system (with main-field and sub-field deflection), there are 124 complex fifth-order geometrical aberration coefficients in the case of a point source, and 380 for a shaped beam system. All chromatic coefficients up to third order are also computed.





Aberration spot diagrams for the mixed (electrostatic and magnetic) focusing and deflection system. Left:3rd order, Right:3rd and 5th order