Munro's Electron Beam Software

Software Brochure

MEBS
ELECTRON BEAM SOFTWARE

Welcome to MEBS

MEBS (Munro's Electron Beam Software Ltd.) was founded by Eric Munro, John Rouse and Xieqing Zhu in 1991. Our founding members have devoted their working lives to developing electron optical design software, and all our employees have specialised scientific training in physics and electron optics. Our company's mission is to develop and provide software for the simulation, design and optimisation of charged particle optical systems, especially electron microscopes, and equipment for semiconductor manufacturing industry, such as electron and ion beam lithography and inspection systems.

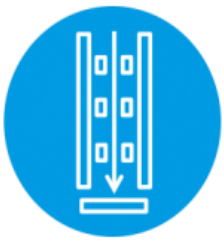
We provide state of the art charged particle optical system design tools to maximise the designer's productivity and creativity

As well as developing electron optical design software, we offer consultancy services for the design of electron beam equipment. With a rapidly growing demand for this specialised consultancy work, we set up our sister company MCS (Munro's Consultancy Services Ltd.), specifically to handle design work for clients. Through MCS, we also offer lecture courses on charged particle optics, and training courses in the use of our software, either at our own premises in London or at customers' sites.

We remain an agile company of enthusiasts, dedicated to our fundamental goal of providing our clients with world-leading charged particle optical design software, software support and consultancy services.

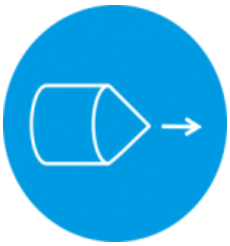
Eric Munro

Our Software Families



OPTICS
Charged particle optical column design

IMAGE
Direct coulomb interactions



SOURCE
Electron and ion source design

MULTIPOLE
Multipole system design

CURVE
Curved axis simulation

MIRROR
Electron mirrors

Not sure which package is most suitable for your needs?

SOFEM
2D Field computation & direct ray tracing

3D
3D Field computation & direct ray tracing

WIEN
Electron optical column design

PROJECTION
Projection optics

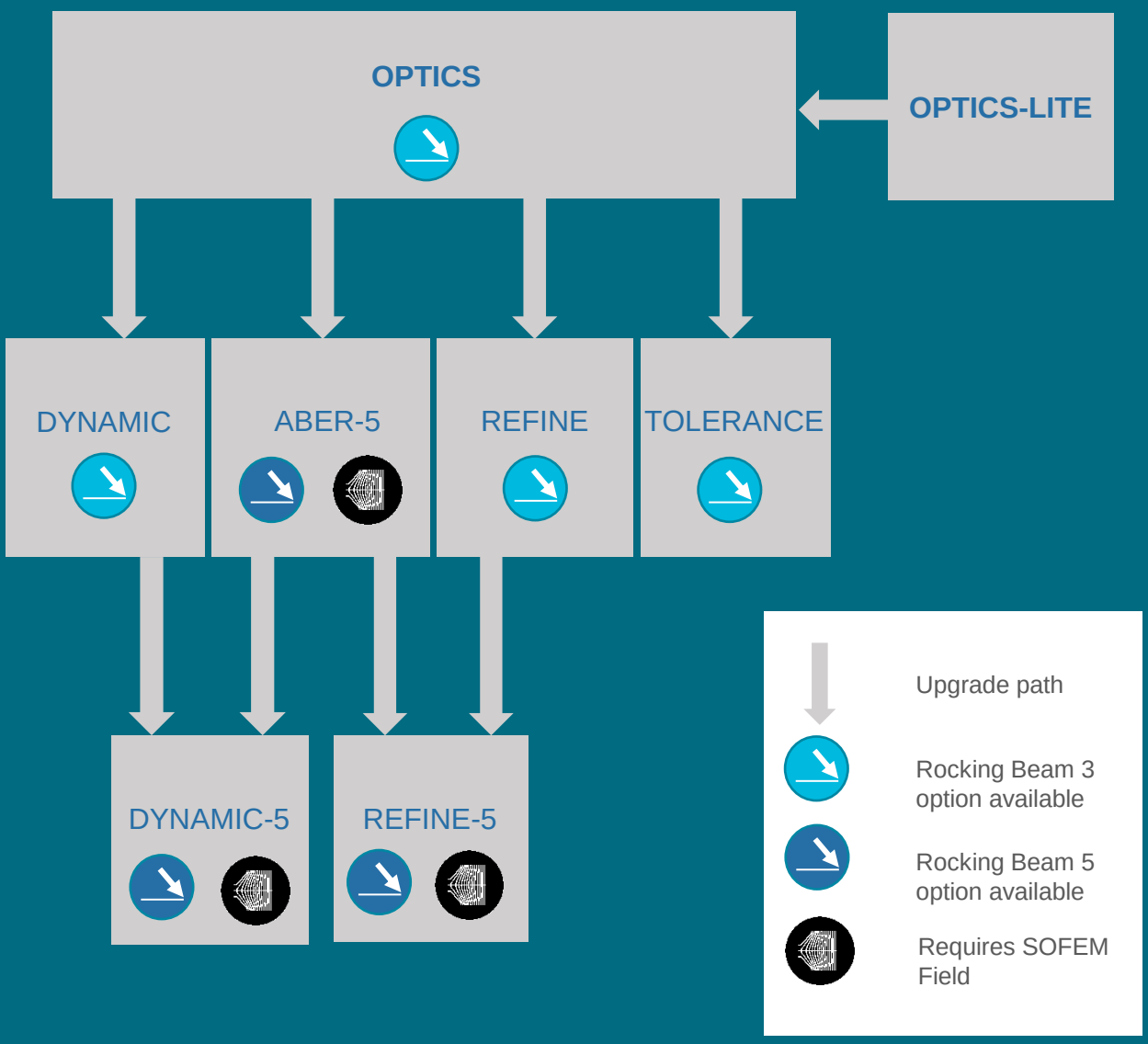
WAVE
Wave optical simulations

Contact us at info@mebs.co.uk

The OPTICS Family

Charged Particle Optical Column Design

OPTICS is our core family of packages. It is used for the simulation and design of electron and ion optical columns consisting of any combination of round electron lenses and deflectors



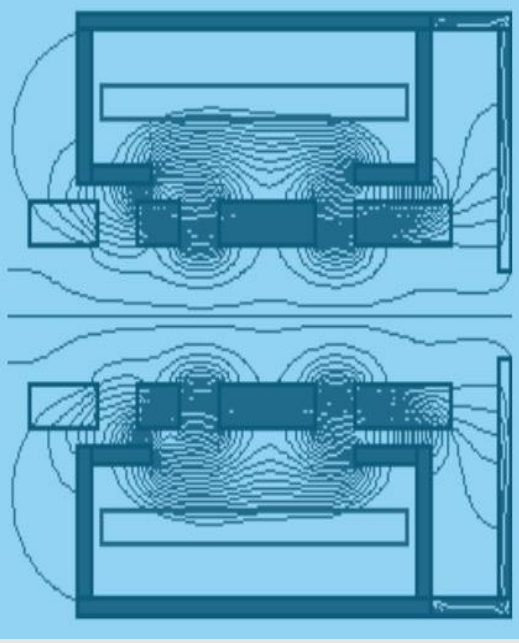
The OPTICS Family Base Packages

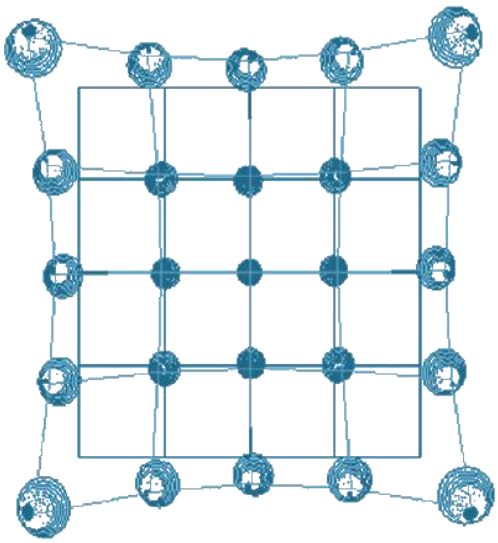
OPTICS-LITE

Column simulation - limited functionality

The OPTICS-LITE software is an entry level version of the core OPTICS package, but with reduced functionality. The package also includes simple tolerancing capabilities.

The simulation is limited to a single round electrostatic lens and single round magnetic lens, and there is no option for deflector simulation within this package.





OPTICS

Column simulation - full functionality

The OPTICS software is a package for the simulation and design of charged particle columns consisting of any combination of round lenses and deflectors. Its purpose is to assist with the field computation in individual lenses and deflectors, the computation of the optical properties and aberrations of any combination of such elements and the graphical display of the effects of the aberrations.

The OPTICS Family Upgrade Packages

REFINE

Column optimisation

The REFINE module takes the initial design of the column, and interactively refines it to optimise the performance. A particle beam column contains many design parameters that can be varied and there are numerous aberrations which each depend on the variable parameters. REFINE allows the user to choose which design parameter to vary and which aberration to target. The program then runs several optimisation cycles and generally yields designs with better properties than those obtained through trial and error.

DYNAMIC

Dynamic correction elements design

The DYNAMIC module allows the user to compensate for certain deflection aberrations by the application of correction signals at each point in the deflection field. These dynamic correction signals are applied using stigmators for the correction of deflection astigmatism, and dynamic focus lenses for the correction of deflection field curvature.

DYNAMIC may be used to design such stigmators and dynamic focus lenses. The field functions of the stigmators and dynamic focus lenses are used to compute the required strengths to correct the deflection astigmatism and field curvature.

REFINE - 5

Column optimisation of aberrations up to 5^{th} -order.

The REFINE-5 module extends the functionality of REFINE to allow the optimisation of the aberrations up to 5^{th}-order terms.

DYNAMIC - 5

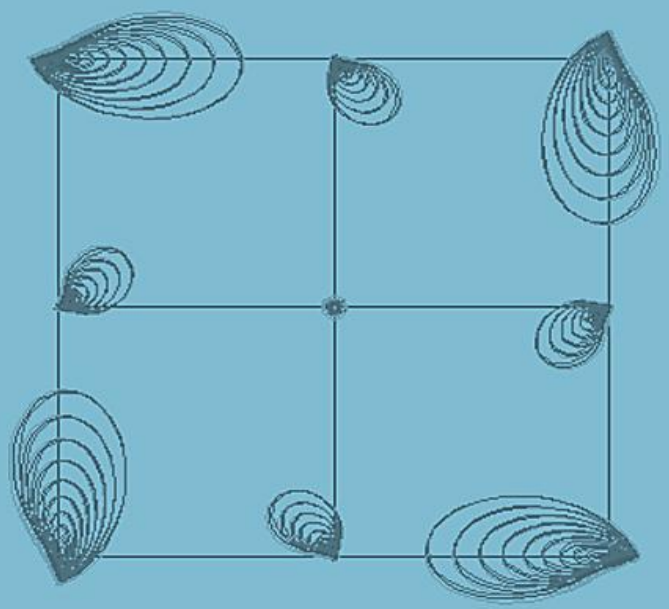
Dynamic correction elements design with aberrations up to 5^{th}-order

The DYNAMIC-5 module provides the functionality of DYNAMIC, but computes the aberrations up to 5^{th}-order terms.

TOLERANCE

Column tolerancing

Real columns suffer from asymmetry errors caused by small mechanical imperfections during construction and alignment. Using the TOLERANCE software the user can compute the perturbation fields and aberrations due to tilts, misalignments and ellipticities in the electrodes, to ensure that the system will perform in accordance with its design specifications.



ABER - 5

5th-order aberrations

ABER-5 extends the capabilities of the OPTICS package to compute the higher-order aberrations of complete columns – specifically the 5th-order geometric and 3rd-order chromatic aberrations.

RB3/RB5

Rocking beam option

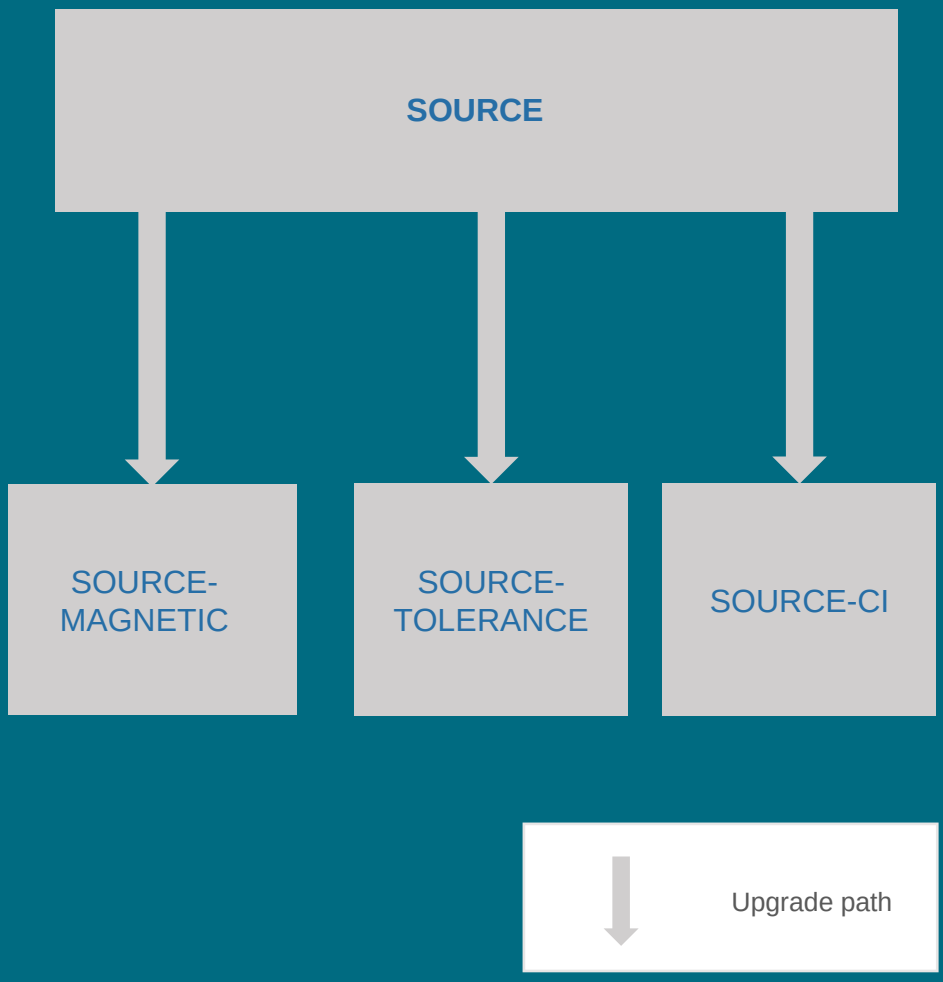
Recently, it has become important to be able to rock or tilt the beam about a specified position in the image plane.

RB3 allows the aberrations of rocking beam systems to be computed up to 3rd-order terms. RB5 allows the aberrations of rocking beam systems to be computed up to 5th-order terms.

The SOURCE Family

Electron and ion beam source design

The SOURCE family of software is used for the simulation and design of electron and ion sources. Upgrades allow magnetic focusing, tolerancing and the computation of coulomb interaction effects



The SOURCE Family Packages

SOURCE

Electron source design, electrostatic focusing only

The SOURCE package is used for analysing and designing electron sources taking into account volumetric space charge effects. The software uses the second-order finite element method, which provides greater accuracy than the first order method and which allows very accurate modelling of curved cathodes and electrodes. SOURCE can only handle rotationally symmetric or planar symmetric structures.

SOURCE-TOLERANCE

Electron source tolerancing

Real columns suffer from asymmetry errors caused by small mechanical imperfections during construction and alignment. Using the SOURCE-TOLERANCE software the user can compute the perturbation fields and aberrations due to tilts, misalignments and ellipticities in the electrodes or cathodes, to ensure that the system will perform in accordance with its design specifications.

SOURCE-MAGNETIC

Electron source design including magnetic focusing

The SOURCE-MAGNETIC software extends the capabilities of the SOURCE software to include magnetic focusing generated by magnetic lenses.

SOURCE-CI

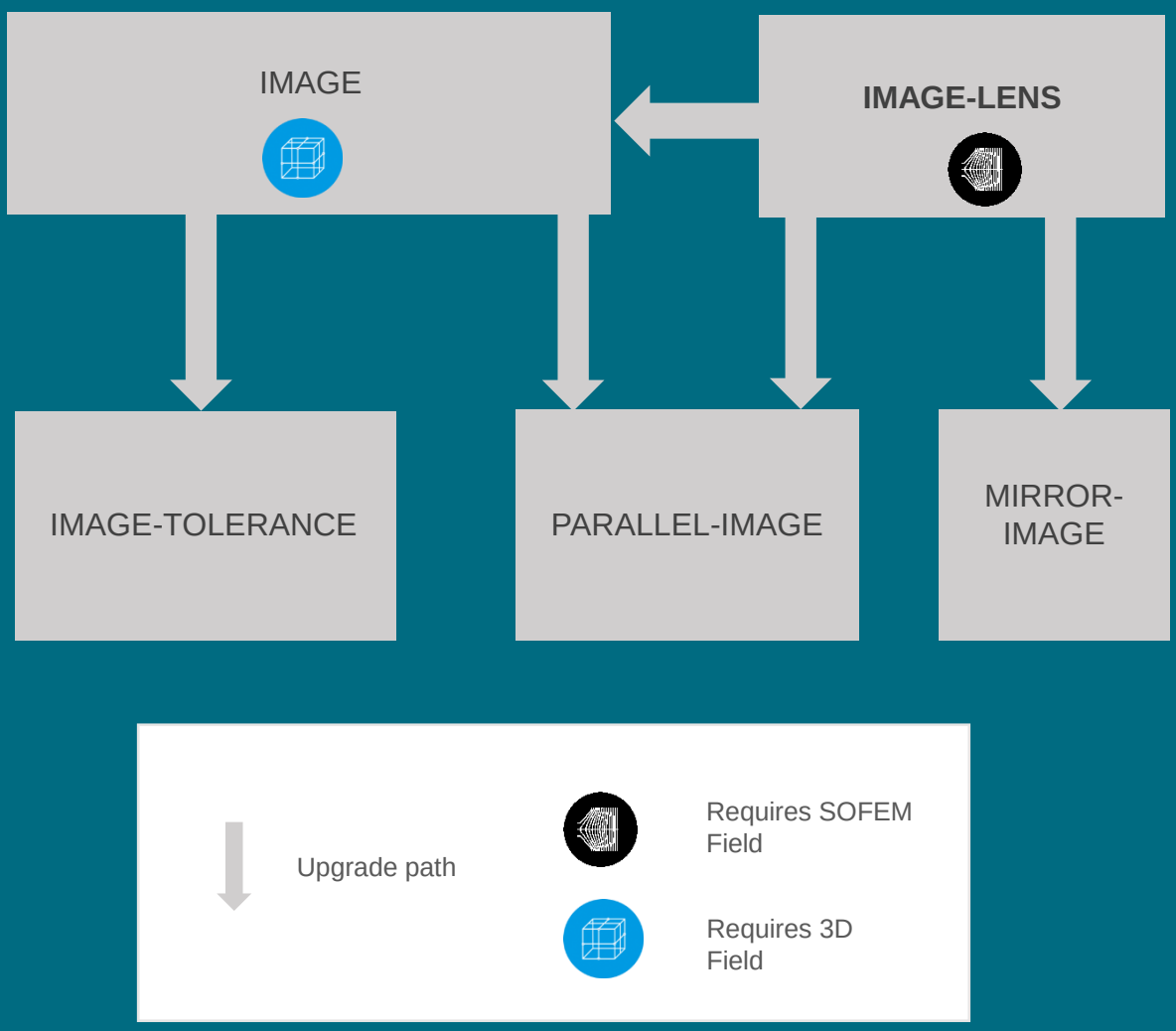
Coulomb interactions in electron sources

All of the SOURCE modules take into account volumetric space charge effects. SOURCE-CI extends SOURCE to include the effects of inter-particle coulomb interactions. Such interactions are always computationally intensive, but our fast tree code coulomb algorithm helps to reduce computation time.

The IMAGE Family

Discrete coulomb interaction

The IMAGE family of packages computes the combined effects of aberrations and discrete Coulomb interactions in electron and ion beams by direct ray-tracing. Upgrades allow application to a large range of systems including combinations of round lenses, deflectors and stigmators, multipole systems, electron mirrors and Wien filters.

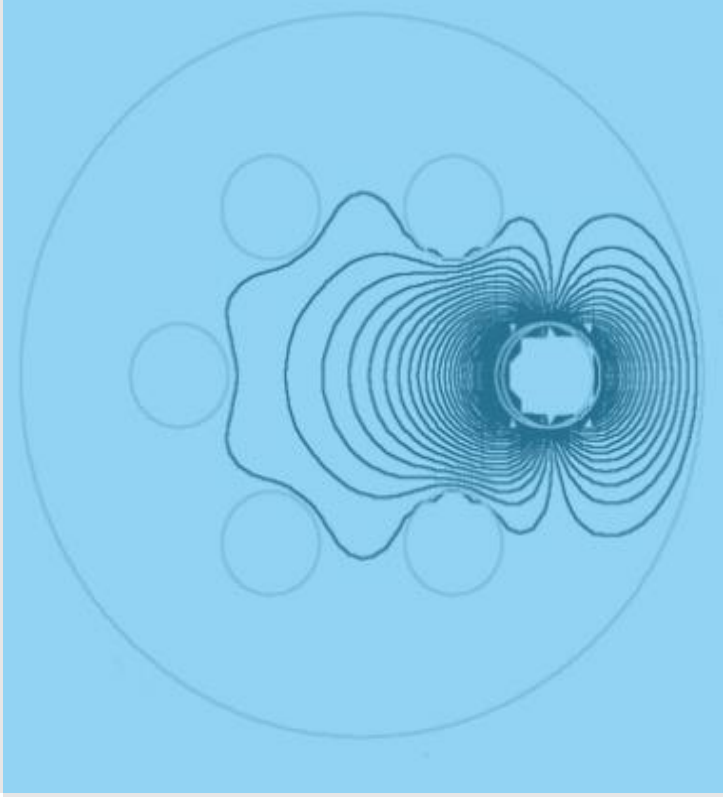


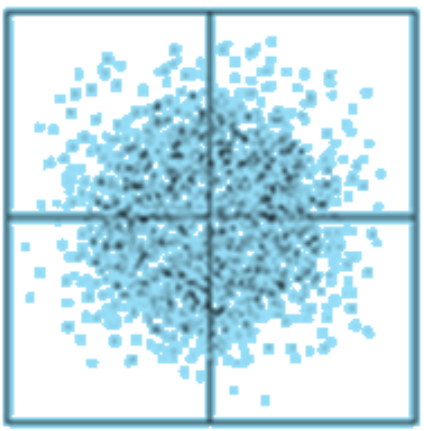
The IMAGE Family Base Packages

IMAGE-LENS

Simulation of aberrations and discrete Coulomb interactions for round lens systems.

IMAGE-LENS allows the analysis of systems containing round lenses only. Accurate direct ray tracing eliminates the need to use conventional aberration theory, and the method is therefore applicable to systems with aberrations of any order. The software computes and plots the total blur including both aberrations and coulomb interaction effects. Post-processing facilities are included, for plotting point spread functions and through-focal series of edge blur diagrams.





IMAGE

Upgrade to handle deflectors, multipole lenses and Wien filters

The IMAGE software extends the capabilities of IMAGE-LENS to allow the analysis of a wide range of systems which, in addition to round lenses, can include combinations of multipole lenses, deflectors, stigmators and Wien filters.

The IMAGE Family Upgrade Packages

IMAGE-TOLERANCE

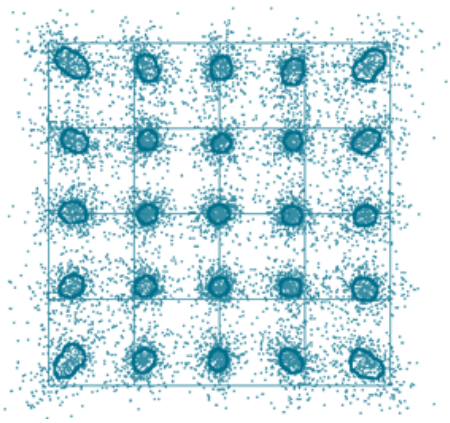
Upgrade for tolerancing capabilities

Real columns suffer from asymmetry errors caused by small imperfections during construction. Using the IMAGE-TOLERANCE software the user can compute the perturbation fields and aberrations due to tilts, misalignments and ellipticities in the electrodes or cathodes, to ensure that the system will perform in accordance with its design specifications. The IMAGE-TOLERANCE software allows the combination of aberrations and coulomb interactions to be computed and plotted for a system with asymmetry errors.

PARALLEL-IMAGE

Parallel execution on multi-core processors

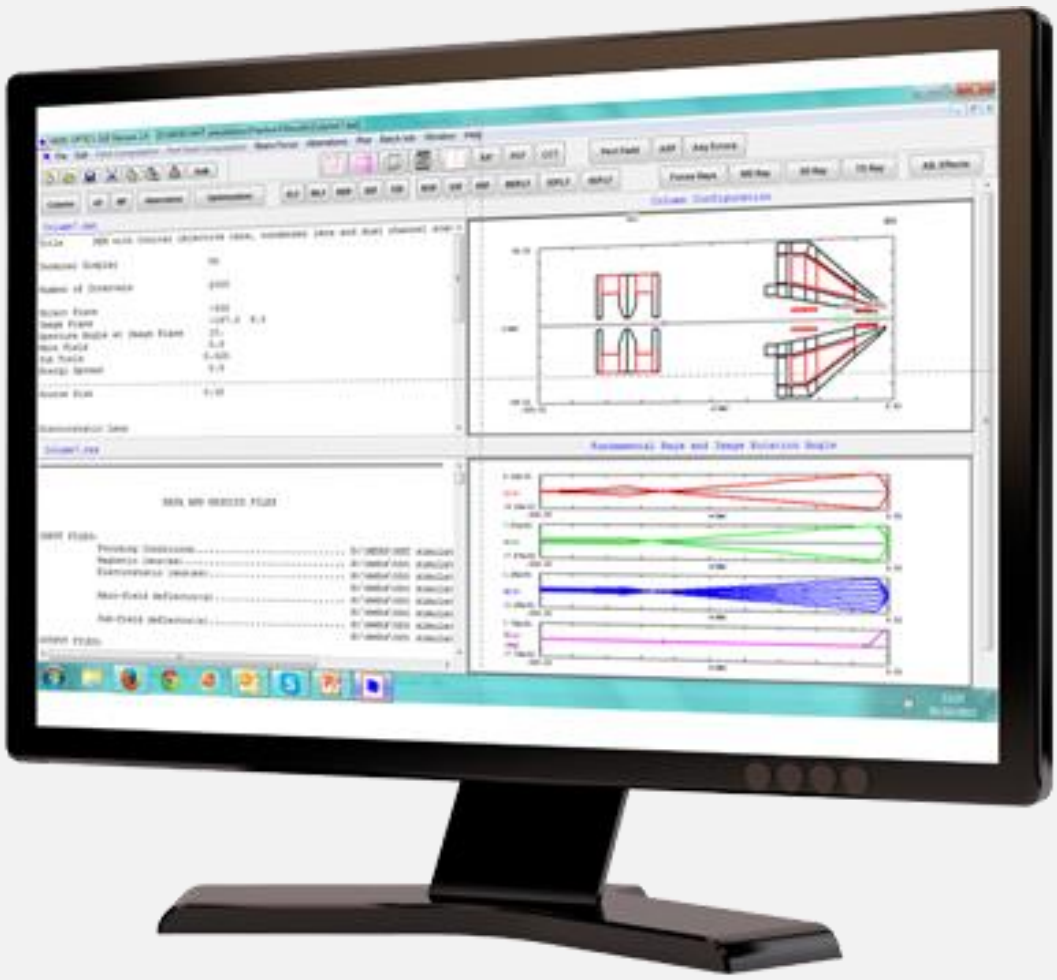
In PARALLEL-IMAGE we have introduced new algorithms that take advantage of the multi-core CPUs available in most modern PCs. The time-intensive parts of the programs involve the computation of the discrete Coulomb forces between particles in the system. This force computation has been significantly speeded up by using a hierarchical tree algorithm that operates in parallel, so that the Coulomb forces on each time-step of the ray-trace can be computed on all the available cores in the PC.



MIRROR-IMAGE

Simulation of electron and ion mirrors

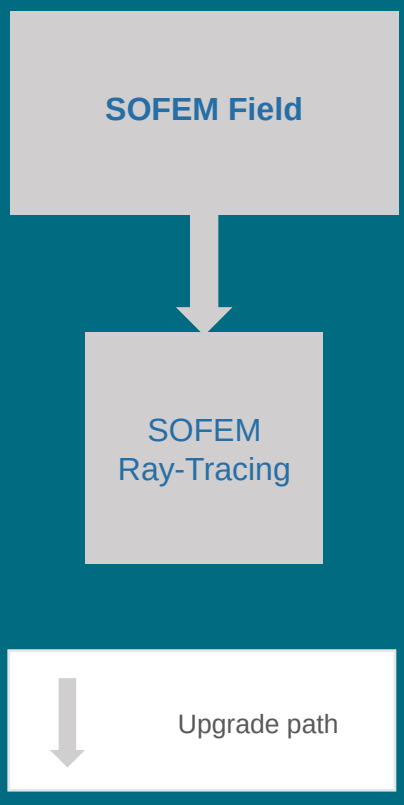
The MIRROR-IMAGE package uses a direct ray trace to calculate the combined effects of aberrations and discrete coulomb interactions in systems containing an electron mirror.



The SOFEM Family

2D second-order field computation and direct ray tracing

The SOFEM package uses the second order Finite Element Method to give increased accuracy to two dimensional field computations



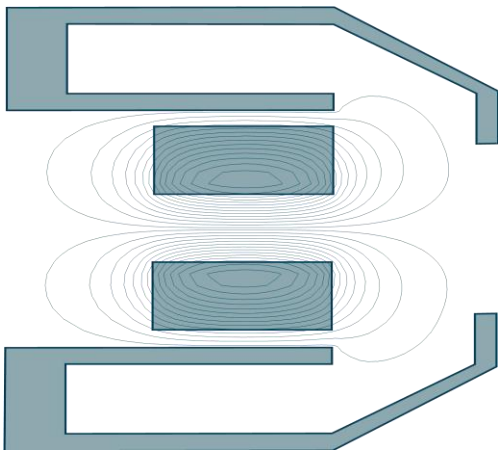
The SOFEM Family of Packages

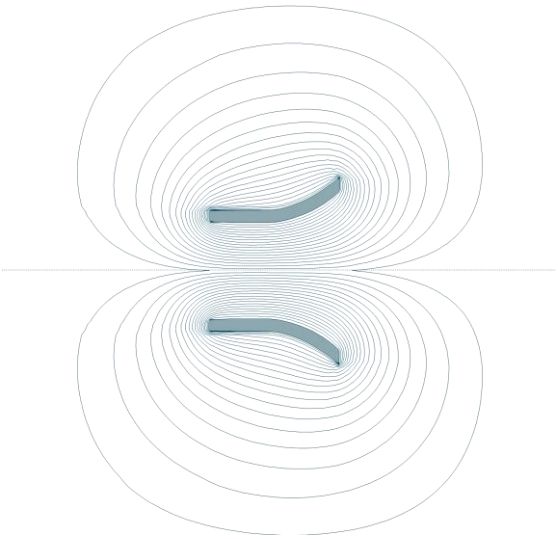
SOFEM Field

2D second order electrostatic and magnetic field simulation

The SOFEM Field software computes the potential distributions of magnetic and electrostatic lenses using the Second-order Finite Element Method (SOFEM).

SOFEM Field is used to calculate the fields for several MEBS packages.





SOFEM Ray-Tracing

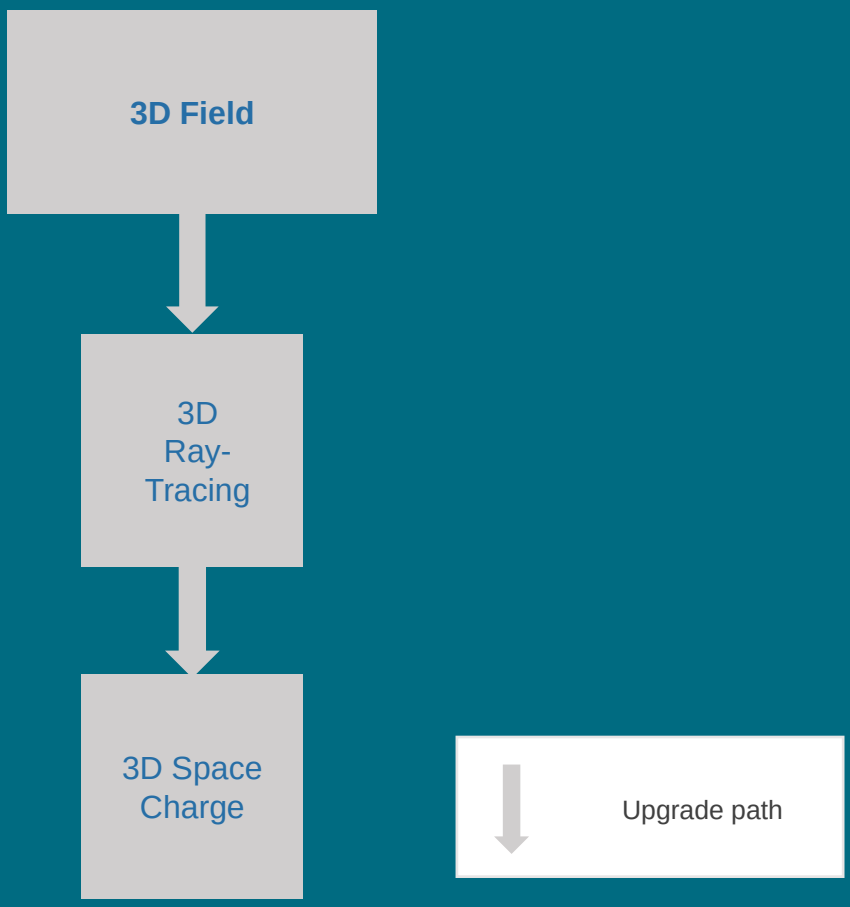
2D direct ray-tracing using second-order finite element method

The SOFEM Ray-Tracing software provides the facility for the computation and plotting of electron trajectories using direct ray-tracing through the computed electrostatic and magnetic lens fields. Since the field components are obtained to a high accuracy (typically better than 1 part in 10^4), the trajectories obtained with this software are very accurate, and can be used to estimate the lens aberrations directly from the raytrace.

The 3D Family

3D field computation, direct ray tracing and space charge

3D offers a fully three dimensional potential computation, direct ray tracing solution and space charge computation



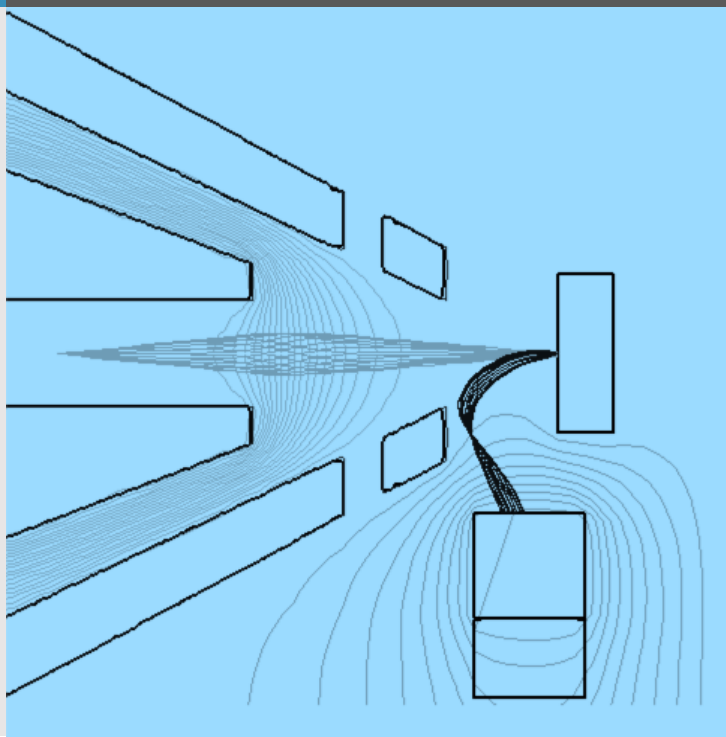
The 3D Family of Packages

3D Field

3D electrostatic and magnetic field simulation

3D Field uses the finite difference method (FDM) to compute the potential distribution of the elements. The surfaces of the electrodes do not have to conform to the grid lines and thus, 3D objects of varied shape can be analysed without the need for the user to define a complicated mesh to fit around the objects.

3D Field is used by several MEBS packages for field computation.



3D Ray-Tracing

Direct ray-tracing using 3D finite difference method

3D Ray-Tracing, which is available as an upgrade to 3D Field, calculates trajectories using the initial positions, energies and emission angles of each charged particle.

3D Space Charge

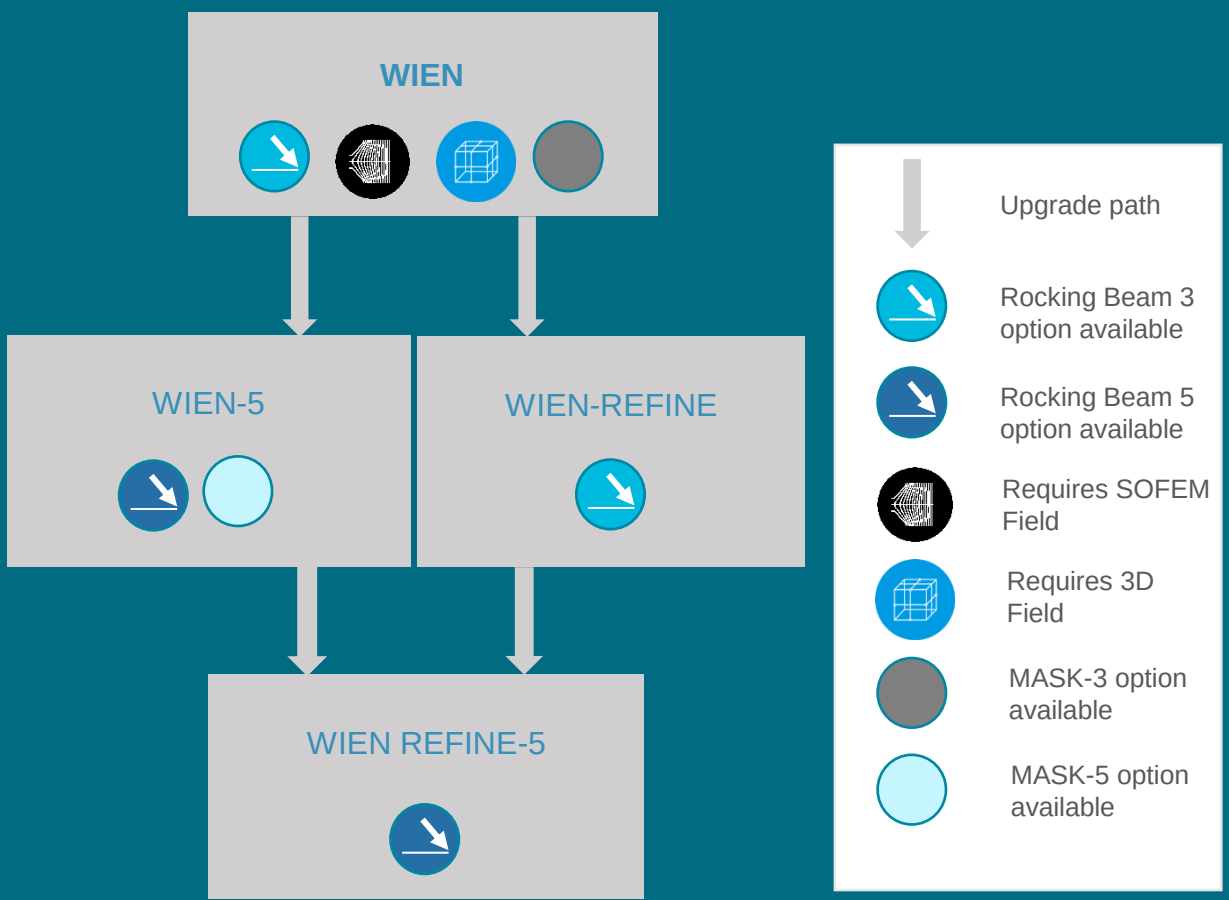
Simulation of effects of space charge

The 3D Space Charge software extends the functionality of 3D Field and 3D Ray-Tracing to take into account space charge effects.

The WIEN Family

Column design including Wien filters

The WIEN family of software packages handles complete columns of round lenses, multipole lenses and Wien filters.



The WIEN Family of Packages

WIEN

Multipole and Wien filter systems

The WIEN program handles complete columns containing round lenses, multipole lenses and Wien filters and calculates aberrations up to 3rd-order.

WIEN-REFINE

Optimisation of aberrations up to 3rd

The WIEN-REFINE module takes the initial design of the column, and interactively refines it to optimise the performance. A electron beam column contains many design parameters that can be varied and there are numerous aberrations which each depend on the variable parameters. WIEN-REFINE allows the user to choose which design parameter to vary and which aberration to target. The program then runs several optimisation cycles and generally yields designs with better properties than those obtained through trial and error.

WIEN-5

Multipole and Wien filter systems with aberrations up to 5th-order

WIEN-5 extends the capabilities of WIEN to include aberrations up to 5th-order.

WIEN REFINE-5

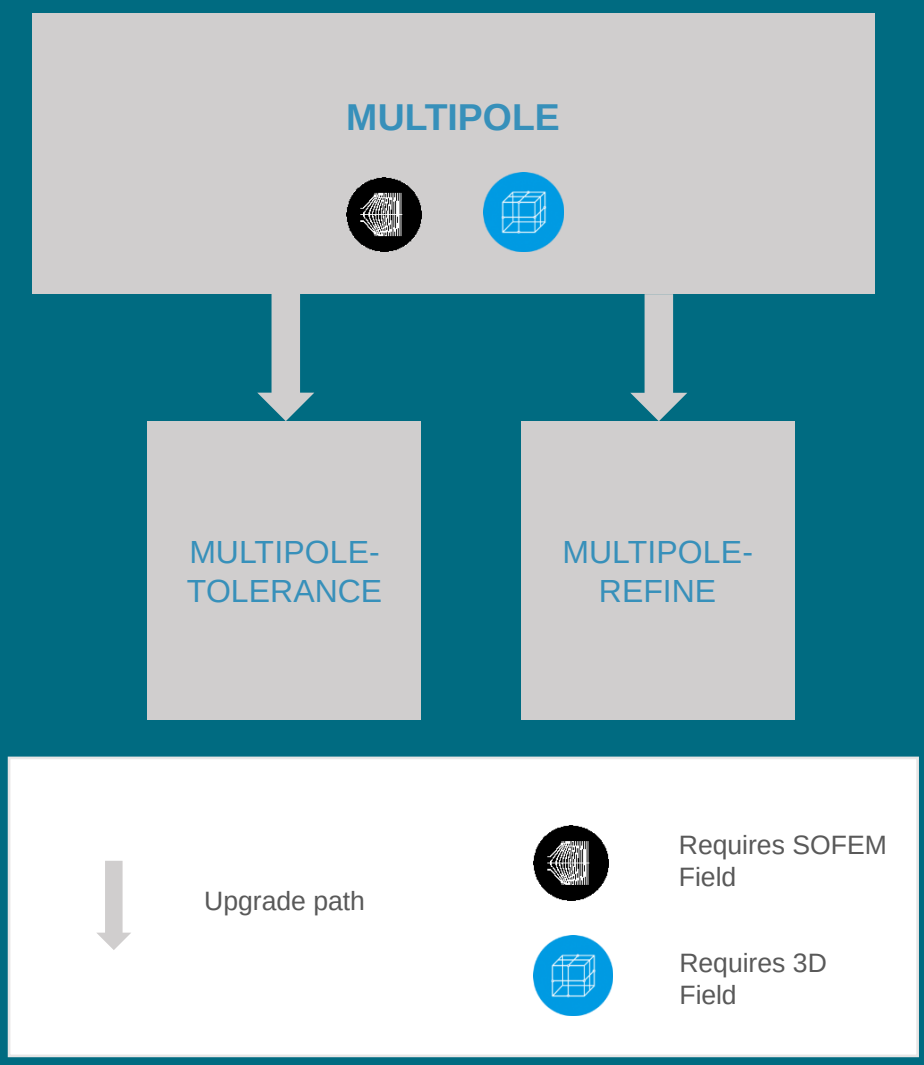
Optimisation of aberrations up to 5th - order

The WIEN-REFINE-5 module extends the functionality of WIEN-REFINE to allow optimisation of the aberrations up to 5th-order terms.

The MULTIPOLE Family

Multipole system design

The MULTIPOLE family of software is used for the simulation and design of whole columns containing multipole lenses and deflectors. Upgrade modules provide optimisation and tolerancing functionality.



The MULTIPOLE Family of Packages

MULTIPOLE

Multipole column design

MULTIPOLE simulates the optical properties and aberrations of systems containing combinations of round lenses, multipole lenses and deflectors for aberrations up to 3rd-order.
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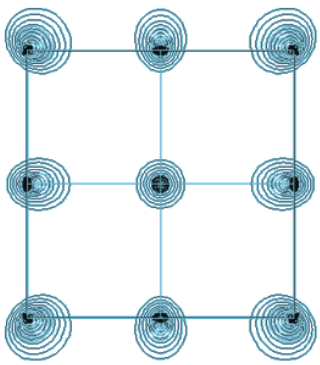


MULTIPOLE-REFINE

Multipole column design-order

The MULTIPOLE-REFINE module takes the initial design of the column, and interactively refines it to optimise the performance. An electron beam column contains many design parameters that can be varied and there are numerous aberrations which each depend on the variable parameters.

MULTIPOLE-REFINE allows the user to choose which design parameter to vary and which aberration to target. The program then runs several optimisation cycles and generally yields designs with better properties than those obtained through trial and error.

MULTIPOLE-TOLERANCE

Multipole column tolerancing

Real columns suffer from asymmetry errors caused by small mechanical imperfections during construction and alignment. Using the MULTIPOLE-TOLERANCE software the user can compute the perturbation fields and aberrations due to tilts, misalignments and ellipticities in the electrodes, to ensure that the system will perform in accordance with its design specifications.

The CURVE Family

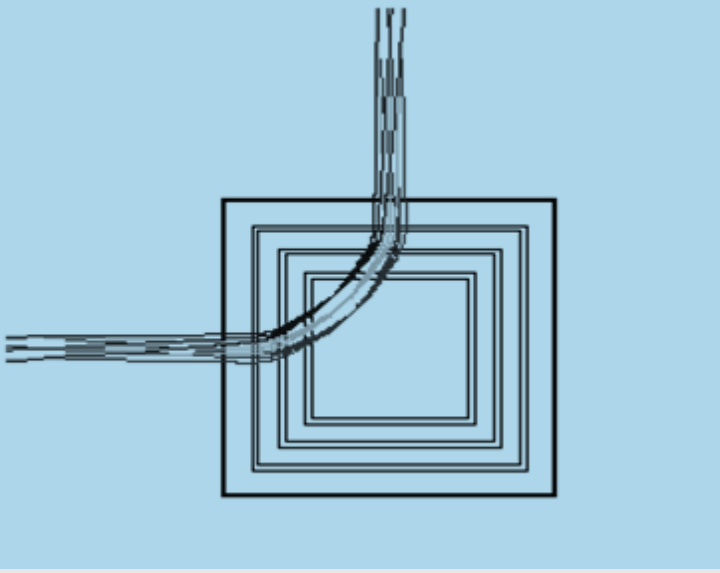
Curved axis systems

Simulation of optical systems which have a curved axis. All of the packages in this family can be purchased independently as stand alone packages.

FILTER

Simulation of imaging energy filters

The FILTER software is used for the design of magnetic imaging energy filters.



PRISM

Simulation of magnetic prisms

The PRISM software simulates magnetic PRISMS. PRISM computes the 3rd-order aberrations of the system, but is limited to axes with a 90° bend.

CURVED IMAGE

Simulation of aberrations and Coulomb interactions in curved axis systems

CURVED-IMAGE is an extension of our IMAGE software that computes the aberrations and Coulomb interactions in systems that can have a curved axis. The software will handle any combination of round lens and multipole lenses, as well as Wien filters and prisms.

CURVED IMAGE requires the SOFEM Field and 3D Field packages.

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MIRROR

Electron Mirrors

The MIRROR software package is used for simulating the optical properties of electron mirrors, including the generation of aberration coefficients up to 5^{th}-order, using the differential algebra method. The software handles electron mirrors containing any combination of rotationally symmetric fields. The software can handle combinations of electron mirrors and electron lenses. MIRROR is a stand alone package

MIRROR requires he SOFEM field package..

PROJECTION

Projection Optics

The PROJECTION software package is used for the simulation of electron beam projection systems including dynamic corrections and optimisation up to 5th-order aberrations. PROJECTION is a stand alone package.

WAVE

Wave optical simulations

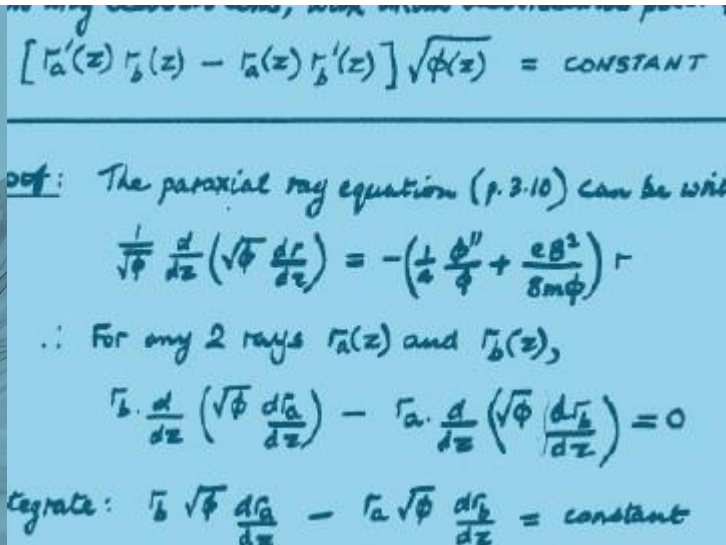
The WAVE software is used for calculating the current density distributions in electron beams. WAVE computes the current density in a probe, taking into account the effects of diffraction, spherical aberration, axial chromatic aberration and de-magnified source size. WAVE is a stand alone package.

Consultancy and Bespoke Design

As well as developing electron optical design software, we also offer consultancy services for design of electron beam equipment. With a rapidly growing demand for this specialized consultancy work, we set up our sister company MCS (Munro's Consultancy Services Ltd) in June 1998, specifically to handle design work for clients.

Through MCS, we have applied our software and simulation techniques to designing a wide range of electron optical systems and components, including electron and ion microscopes, electron beam lithography and inspection equipment, photomultiplier tubes, electron beam welding equipment, microwave tubes, Auger spectrometers, Wien filters, topographic and voltage contrast detectors, magnetic prisms, bending magnets, X-ray sources and imaging energy filters.

Please contact us for details of our daily consulting rates.



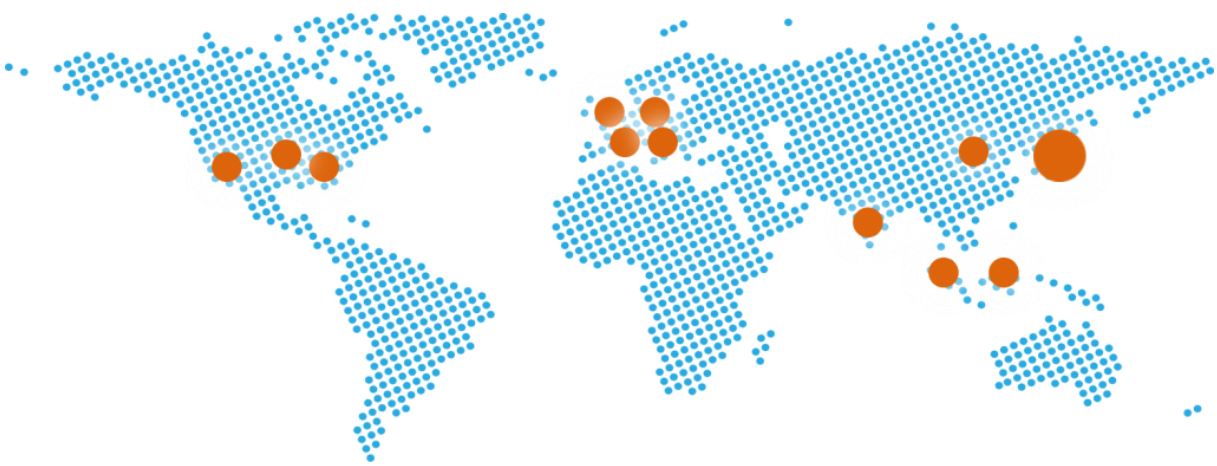
Support

Our software packages are powerful and feature-rich. The User Manuals and other reference materials are great resources, but it is natural that users sometimes require further assistance. Indeed in our meetings with customers we often encounter users who are not fully taking advantage of the features and capabilities of the software.

For these reasons we encourage all our customers to invest in Software Support to help them get the most out of our software.

Software Support provides unlimited telephone and email support throughout the one year term. It also includes upgrades to the latest versions of the software – where available. Generally we provide Software Support free-of-charge for the first year after purchase. Customers can then buy further support on an annual basis.

Please contact us for details and prices.



global customer base with local agents

Training

All of our software is accompanied by a comprehensive manual which often contains examples as well as detailed instructions on file preparation and analysis. However, many of our customers find that in order to access the full potential of the software and to use it in the most efficient way, some software training is required. We provide training in a number of different forms.

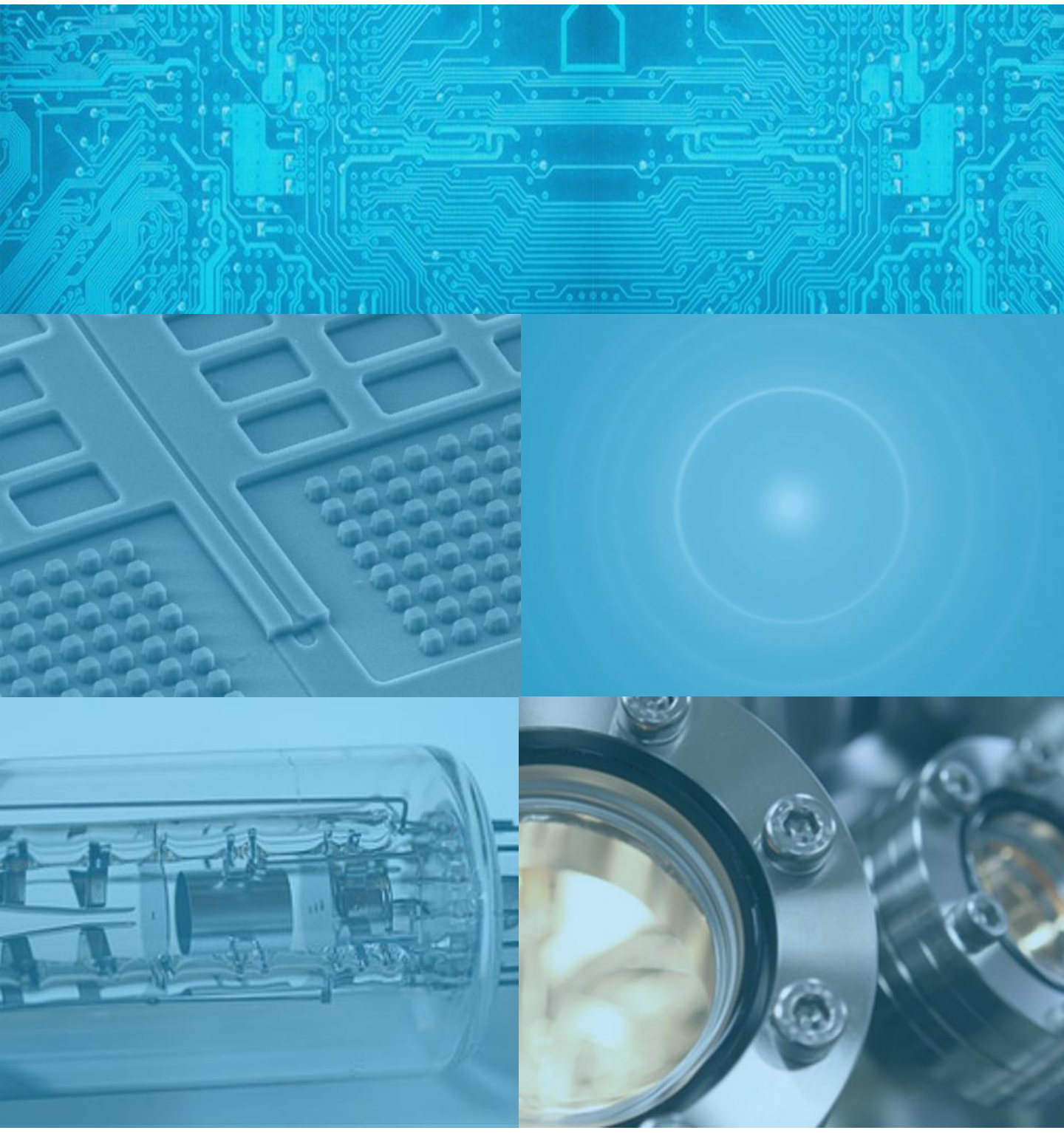
We can provide on-site training, where you and your team will be led through the operation of the software in a tailor made course which is designed to meet your specific requirements. Training can take place over several days, depending on the complexity of your requirements and we will provide you with all the necessary materials.

We can provide videos and power point presentations for some of our packages which provide a quick and easy introduction to the basic operation of the software.

Education

Electron optics is often not taught as a standard course at universities now. MEBS has developed its own lecture courses which are based on a series of lectures given by Dr. Eric Munro.

The lectures can be adapted to the technical level of the audience and if you have a particular field of interest, we are happy to tailor the course to these specific areas. Full lecture notes and any additional material will be provided with any lecture course booked.



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