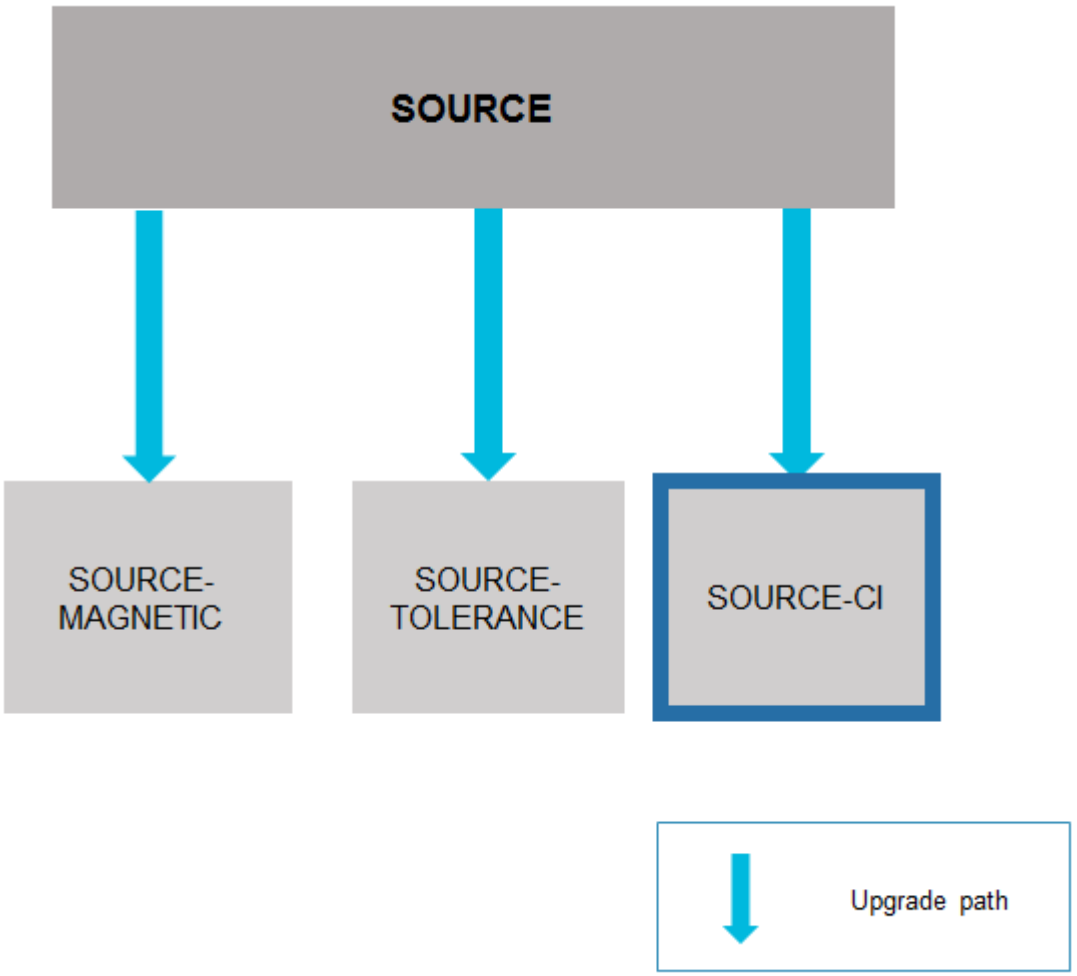
SOURCE-CI

Coulomb interactions in electron sources



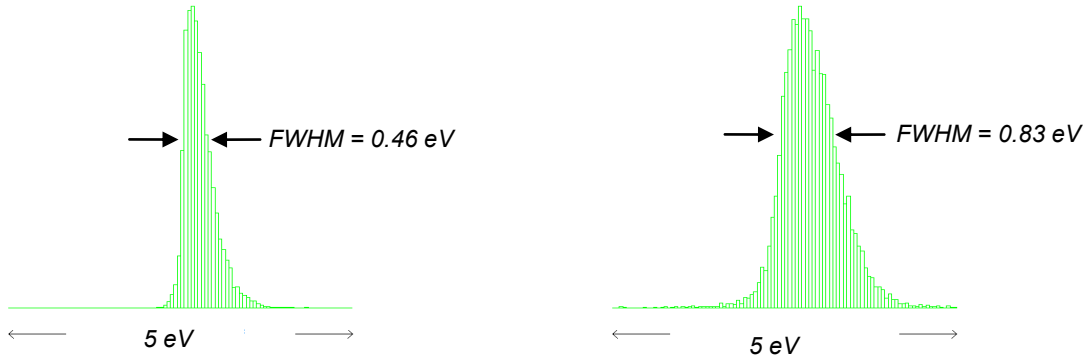
Overview

All of the SOURCE modules take into account volumetric space charge effects, however SOURCE-CI extends SOURCE to include the effects of inter-particle coulomb interactions. It achieves this by computing the trajectories of emitted electrons in bunches and then modelling the inter-particle Coulomb interactions. Such interactions are always computationally intensive, but our fast tree code coulomb algorithm helps to reduce computation time.

The SOURCE-CI post-processing tools enable the computation of the position and size of the virtual source and its emittance, including the energy broadening due to the Börsch effect and radial broadening due to the Löffler effect.

To compute the gun properties, including CI effects, we employ a two-stage process. Firstly we compute the Poisson potential distribution, assuming no inter-particle interactions. Secondly, we directly trace many thousands of electrons through this pre-computed Poisson field from cathode to gun exit, taking CI effects into account. By recording the electrons' data at the exit of the gun we can subsequently post-process the information to determine the properties of the gun, including the virtual source properties, energy spread and emittance.

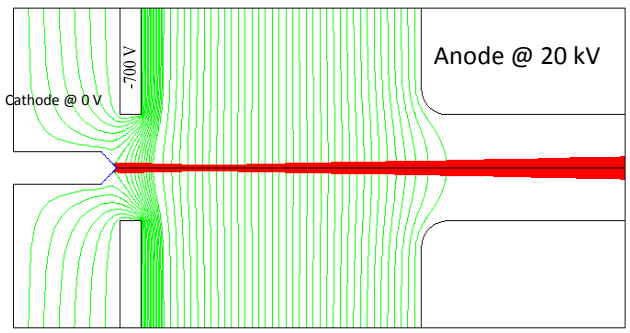
For the CI ray trace, we consider the continuous beam of particles to be composed of one or more discrete bunches of particles. Each bunch of particles is traced from cathode to gun exit plane and the CI effects from each particle in the present bunch are computed. More bunches of particles can be used to improve statistics. To achieve good modelling of the CI effects, we typically need to use bunches of electrons containing >5000 particles per bunch.



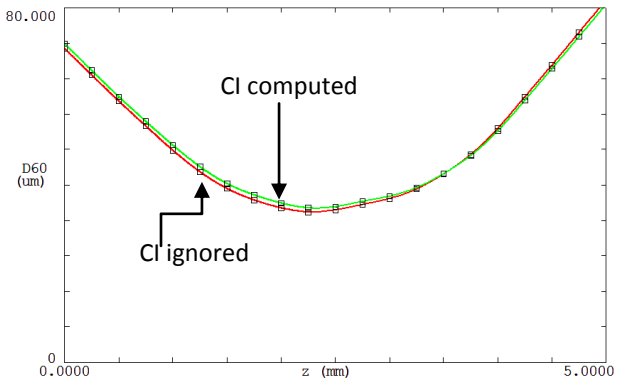
Final energy histograms for CI ignored (left) and CI computed (right).

The example above shows histograms of the energy of the particles at the gun exit for the two cases considered. As can be seen, the CI forces cause a significant increase in energy spread (Börsch effect).

By ignoring the CI effects in the model we obtain a good estimate of the position and size of the virtual source, but an underestimate of energy spread in the beam. The bigger energy spread in the gun computed by the SOURCE-CI software will impact the final spot size when the beam is subsequently focused using lenses with chromatic aberrations and so provides useful new information for the column designer.



LaB6 gun, showing electrode structure, equipotentials and electron rays.



Curves size of virtual source against of 60% beam current with defocus for CI ignored and CI computed.