An hierarchical Boundary Element Method (BEM) solver for the General Particle Tracer (GPT) code

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The General Particle Tracer (GPT) code is a well-established simulation package for the design of electron and ion optics. Key features of the code are 3D positioning of all beamline components, its ability to handle relativistic effects, and various particle-particle interaction models. Here we present a new extension to the code that allows for the calculation of electrostatic fields in complex 3D geometries using a hierarchical Boundary Element Method (BEM) solver. This dense matrix method does not require a volume mesh, is insensitive to scale differences, and it can produce analytical multipole expansions of the resulting fields.

The new GPT extension consists of five individual components:

- A parametric 3D surface modeller.
- A re-mesher that iteratively converts a visualisation mesh into a mesh that is tailor-made for the BEM method (figure 2).
- A hierarchical BEM solver that allows for hundreds of thousands of surface-triangles to be solved with ppm precision.
- Analytical on-axis multipole components.
- On-axis, off-axis and chromatic aberration coefficients from tracking results.

Combined with the built-in capabilities of the GPT code, the above five components can work together to track particles through the most demanding electrostatic fields such as nanotip structures (figure 3) and aperture lens arrays (figure 1). In the latter case, aberration coefficients for individual apertures can be obtained to 7th order precision. The built-in multi-objective genetic optimiser paves the way to full 3D geometrical optimisation of electron and ion beam optics.

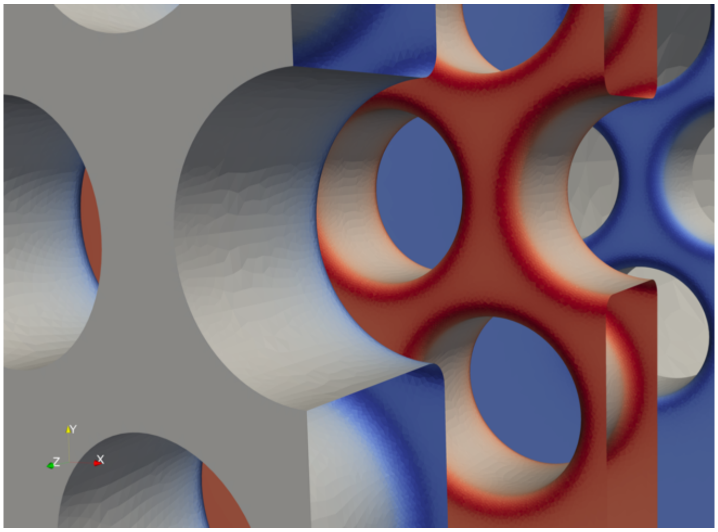

Figure 1: Surface charge density in a hexagonal Einzel lens array.

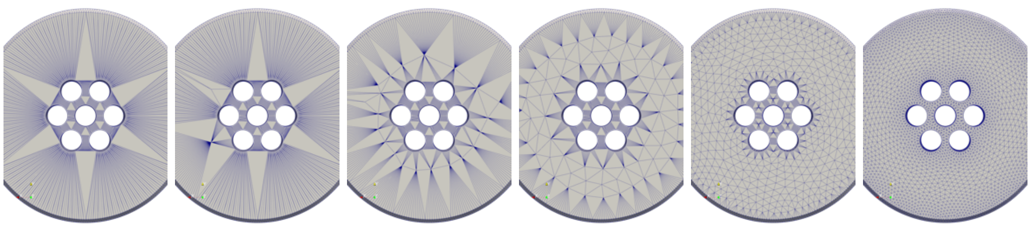

Figure 2: Illustration of the iterative re-meshing component converting a visualisation mesh into a computational mesh.

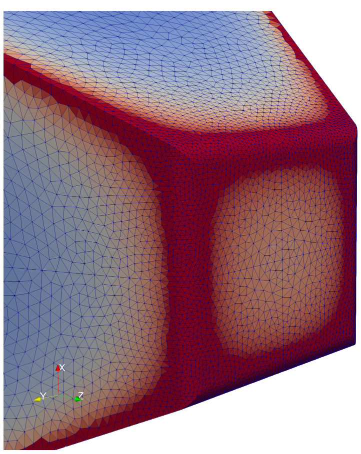

Figure 3: Re-meshed tip-geometry colour-coded on surface charge density.