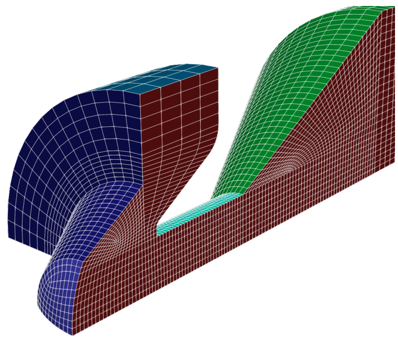
boltzplatz
numerical plasma dynamics

Kinetic Simulation of a High-Power Electron Beam Generator

Electron and ion beams play a crucial role in technologies such as vacuum surface coating and semiconductor manufacturing. One of these techniques is electron beam physical vapour deposition (EBPVD), where a high-powered electron beam is used to evaporate a target material for the subsequent coating process.

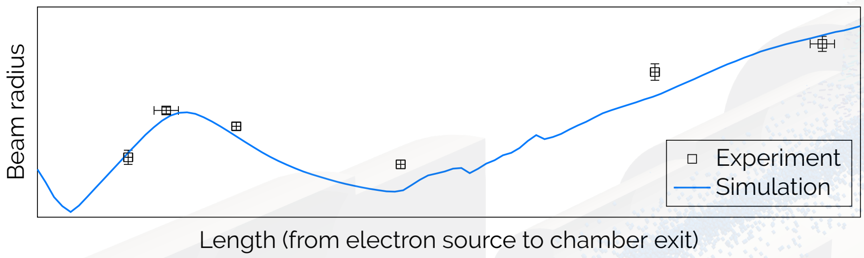
Numerical setup



The open-source plasma simulation software PICLas was used to investigate the transport of the electron beam through various stages of the generator, including acceleration to relativistic speeds and the deflection by two magnetic fields. For this purpose, the Particle in Cell (PIC) method was coupled with the Monte Carlo Collisions (MCC) method to account for the self-fields of the charged species as well as the ionization processes due to the presence of a neutral background gas. Simulations were performed for a 3D model as well as an axisymmetric setup.

Experimental validation

To validate the simulation results, experimental measurements of the beam diameter were performed by placing a metal mesh at different positions inside the beam generator. The simulated beam diameter, corresponding to 95% of the total beam energy, agrees well with the measured values.



Benefits of simulation results

With such investigations, application-related questions can be numerically studied without the need for costly experiments. Examples of such questions include:

- **Effect of assembly tolerances:** What impact does a tilted cathode have on the beam geometry?
- **Investigation of background pressure:** What happens when the beam passes through regions with varying pressure levels?
- **Influence of applied potentials:** How does the potential difference affect the energy distribution of electrons?

Plasma Kinetic Code
PICLas
STUTTGART

boltzplatz offers services around the simulation software PICLas, originally developed by the University of Stuttgart.

Particle-in-Cell (PIC)

The Particle-in-Cell method self-consistently models a collisionless flow of charged particles under the influence of electromagnetic forces:

- 2D axisymmetric and 3D simulation domains
- Relativistic treatment of electrons and ions
- Optimized for high-performance computing
- Choice between electromagnetic or electrostatic solution

The PIC method can be coupled with the Direct Simulation Monte Carlo or Monte Carlo Collisions to include ionization and relaxation processes.

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