

# Validation of Space Charge Laminar Flow in Diodes

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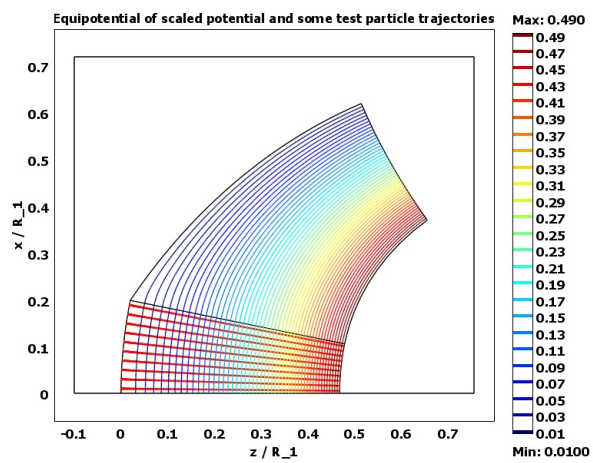
## Abstract

The well known Pierce design of electron and ion diodes is the base of particle source extraction systems [1,2]. It was heavily studied up to 1960 with analog computing and it now offers us a known case against which to compare the precision of fluid and particle tracing codes. The ideal model assumes zero particle kinetic energy at cathode emission, which is well matched in many sources: the extraction voltage is typically 20 kV, the emitter or plasma temperature below 0.5 eV, to which (in the case of plasma) we can add a small speed perpendicular to plasma surface equivalent to a kinetic energy of about 2 eV. Anyway, in the discretization of ideal model, we have to introduce a thin strip between the ideal cathode position where the ruling nonlinear Partial Differential Equation (nPDE) is singular and the simulated cathode position. In the construction of the COMSOL Multiphysics representation of the fluid model we can input not only the precise geometrical information on electrode size, but also the correctly defined mesh size and starting kinetic energy (all this information must be consistent). The expected and calculated exit radius of test particles agrees better than 4 digit precision (5 digits for most particles). The effect of small perturbations due to non uniform cathode emission current, of practical interest in many ion sources, can be so compared with a validated tool, which is important, since we know that this effect is small. The effect of the small emitter temperature is discussed with particle tracing models. Finally, the effect of anode lens aperture is computed (and compared to calculation), trying to determine aberrations due to finite aperture radius.

## Reference

1. R. J. Pierce, Theory and design of electron beams, Van Nostrand, Princeton, 1954 (2nd edition).
2. J. R. Coupland, T. S. Green, D. P. Hammond, and A. C. Riviere, Rev. Sci. Instrum., 44, 1258, (1973).

## Figures used in the abstract



**Figure 1:** Contour lines of scaled potentials, and ray tracing (only 10 trajectories shown for graph readability).