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Simulation of an Electron Thermionic-gun

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Abstract

Electron beams are widely used in scientific and technological applications, including particle accelerators, where high-quality beam production requires precise control of trajectory, transverse size, and focusing. In this work, a three-dimensional model of a thermionic electron-gun system was developed using COMSOL Multiphysics to study electron-beam dynamics under electrostatic and magnetostatic fields. Simulations were compared with measurements obtained at Jefferson Lab. The simulated magnetic field reaches 0.0347 T at a solenoid current of 0.500 A, in close agreement with the experimental value of 0.034 T. Particle-tracking simulations also reproduce the expected focusing of the electron beam. However, the simulated effective beam diameter differs by approximately 25% from the experimental measurement, motivating further investigation of the simulation assumptions and experimental conditions affecting the beam-size comparison. These results demonstrate the usefulness of the model for studying electron-beam dynamics and provide a basis for further refinement that can be used for investigating the operating conditions of the electron-gun system at Jefferson Lab.

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