Modeling Electron Beam Dynamics for Nanoscale Sources

Roxanne Ridley

Introduction - Cold Field Emission Guns

-Smallest Possible Electron Spot Size of 0.5 Å

-Energy Spread of 1 eV

Introduction - Photoemission Sources

-Energy Spread of 10 meV

-Spot Size on the Order of Micrometers

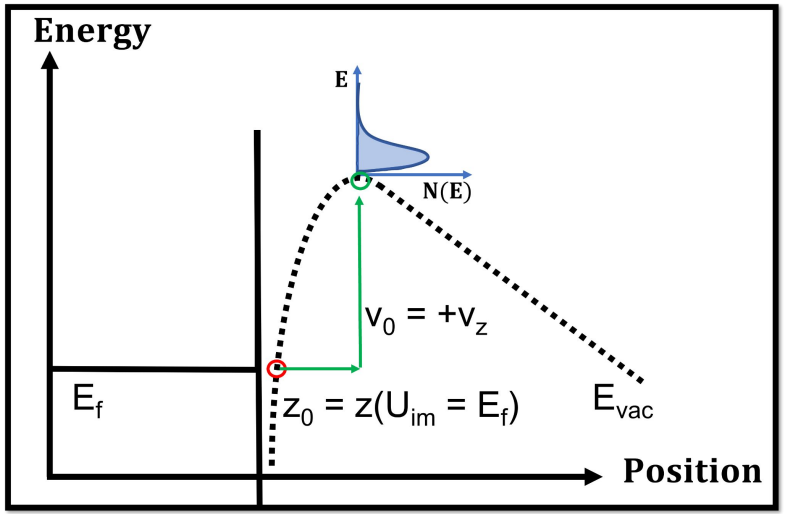
-Techniques could reduce spot size down to the nanometer range theoretically

Electron-Electron Interaction Model

-Initial Positions Generated According to a Gaussian

$$z_0 = \frac{-\phi + \sqrt{\phi^2 + \frac{E|e^-|}{4\pi}}}{2E}.$$

-Times Generated According to a Poisson Distribution



Electron-Electron Interaction Model

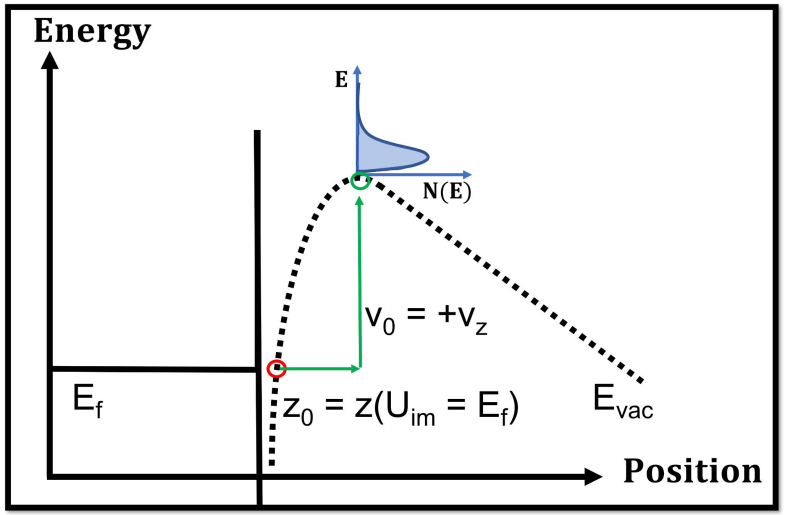
-Initial Energy Assigned Based on the Following Functions

$$N(E)dE = Ef(E)dE,$$

$$f(E) = 1/\left(1 - e^{\frac{E-E_{ex}}{k_B T}}\right),$$

-Initial Transverse Momentum Assigned Between 0 and

$$p_{\perp max} = \sqrt{2m_e E}.$$



Electron-Electron Interaction Model

-Velocity Verlet Algorithm

-Image Charge

-At 1e-20 second timesteps, less than 2% of electrons fall back due to error

Computational Results - Hypotheses

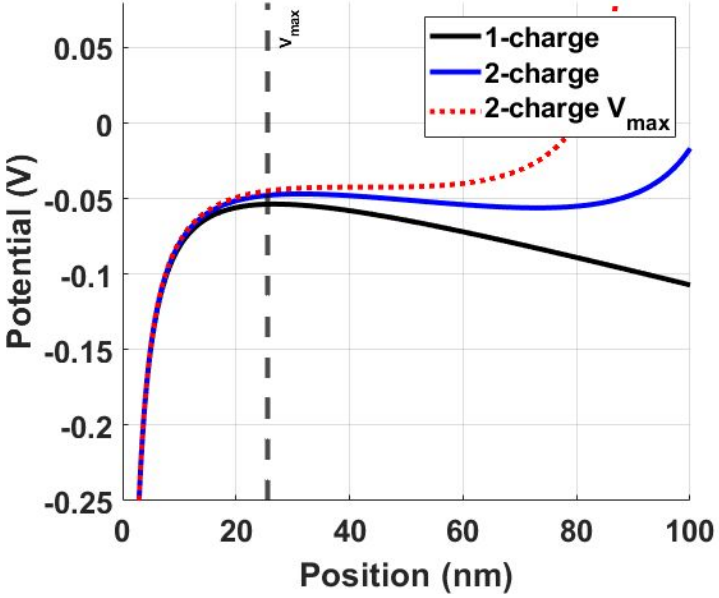
-MTE Energy Spread would increase over time

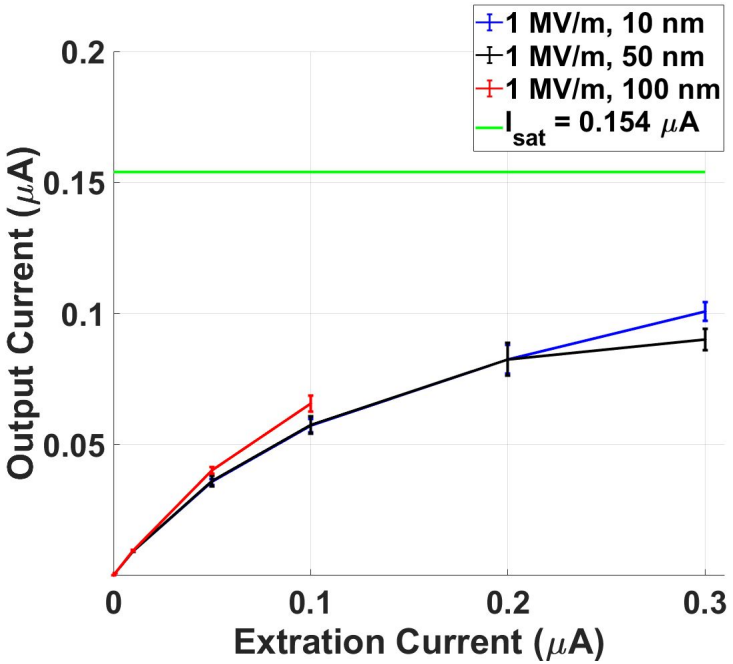
-RMS Energy Spread would increase as a result

-Losses due to electron fallback might occur but would be rare

We found that the exact opposite occurred!

Computational Results - Extraction Current



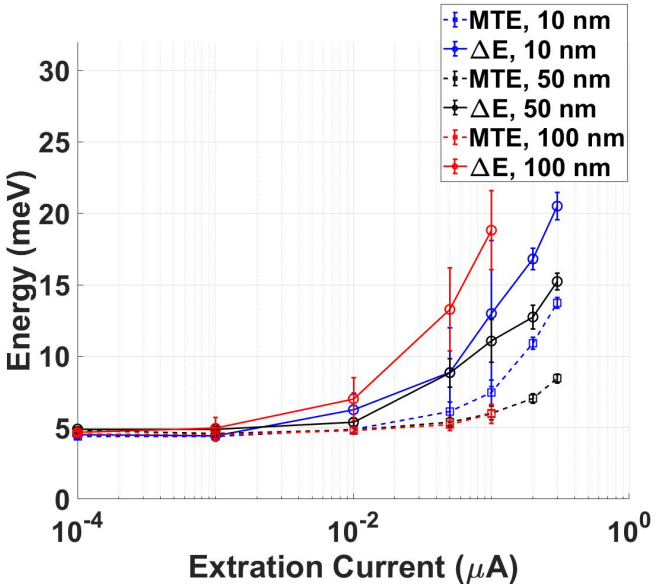


Computational Results - MTE and RMS

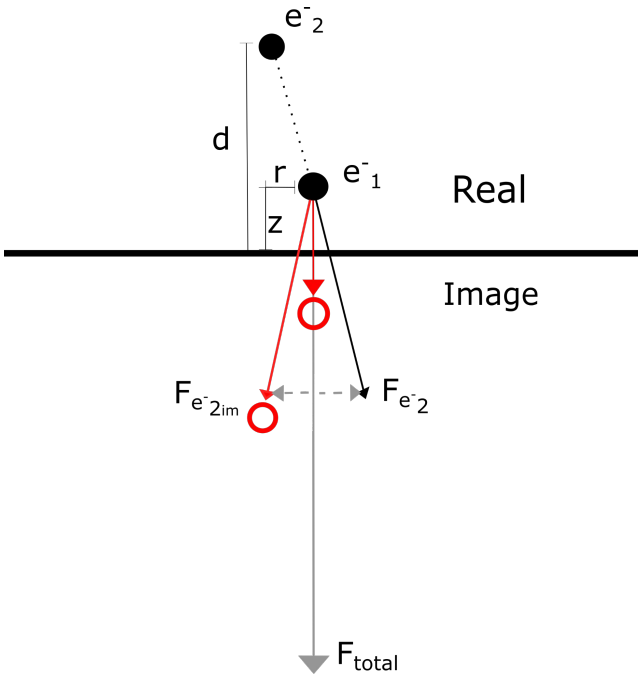
-MTE ranges between 4 and 14 meV

-RMS total energy spread ranges between 5 and 25 meV

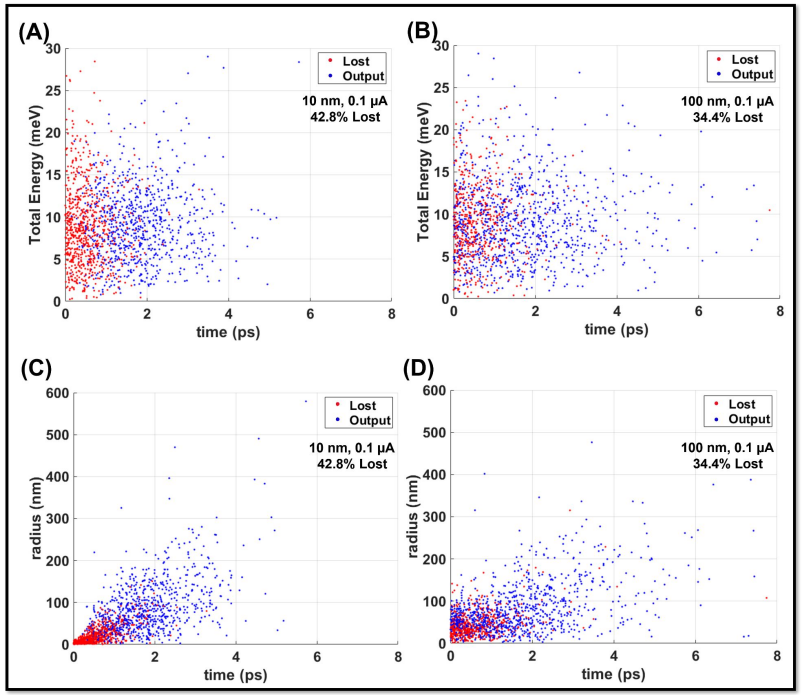
-Recall that the initial energy spread simulated was 10 meV



Computational Results - Model



Computational Results - Energies



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