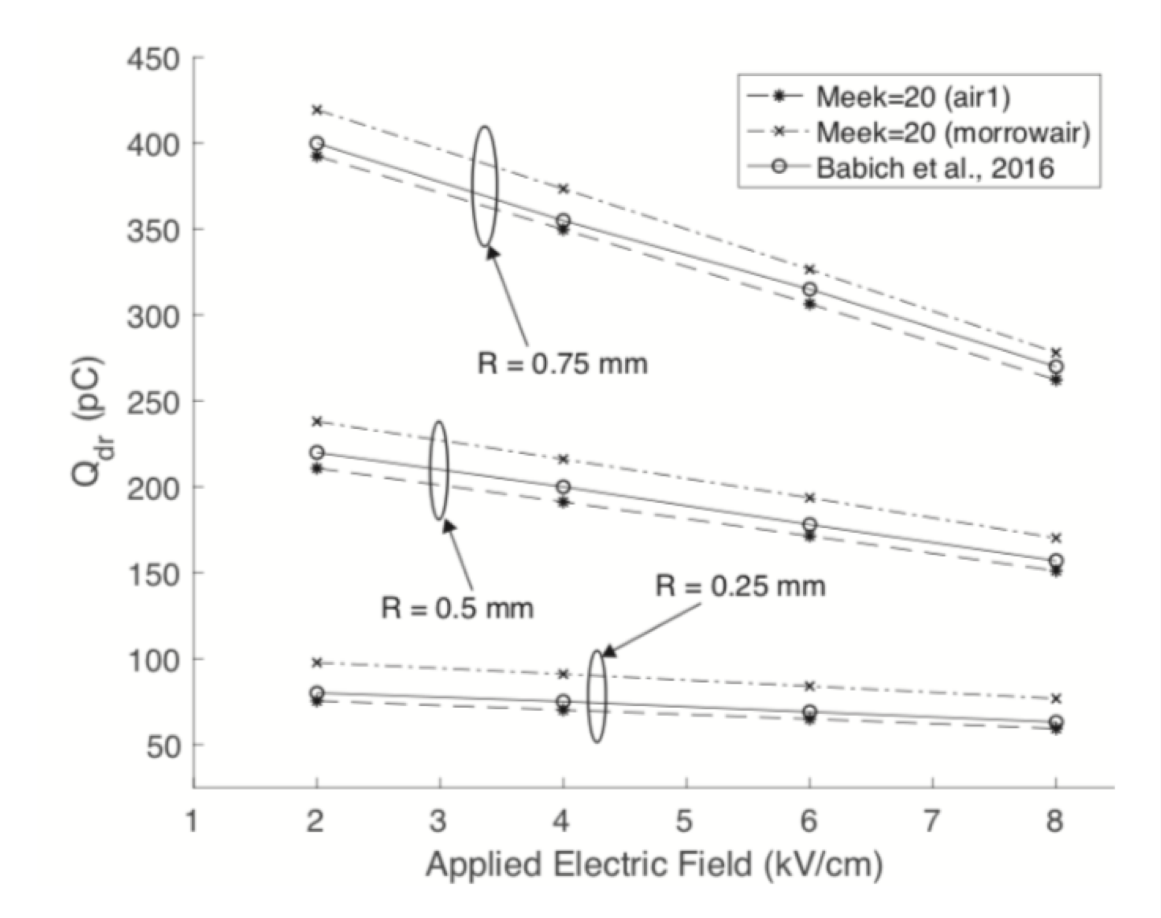
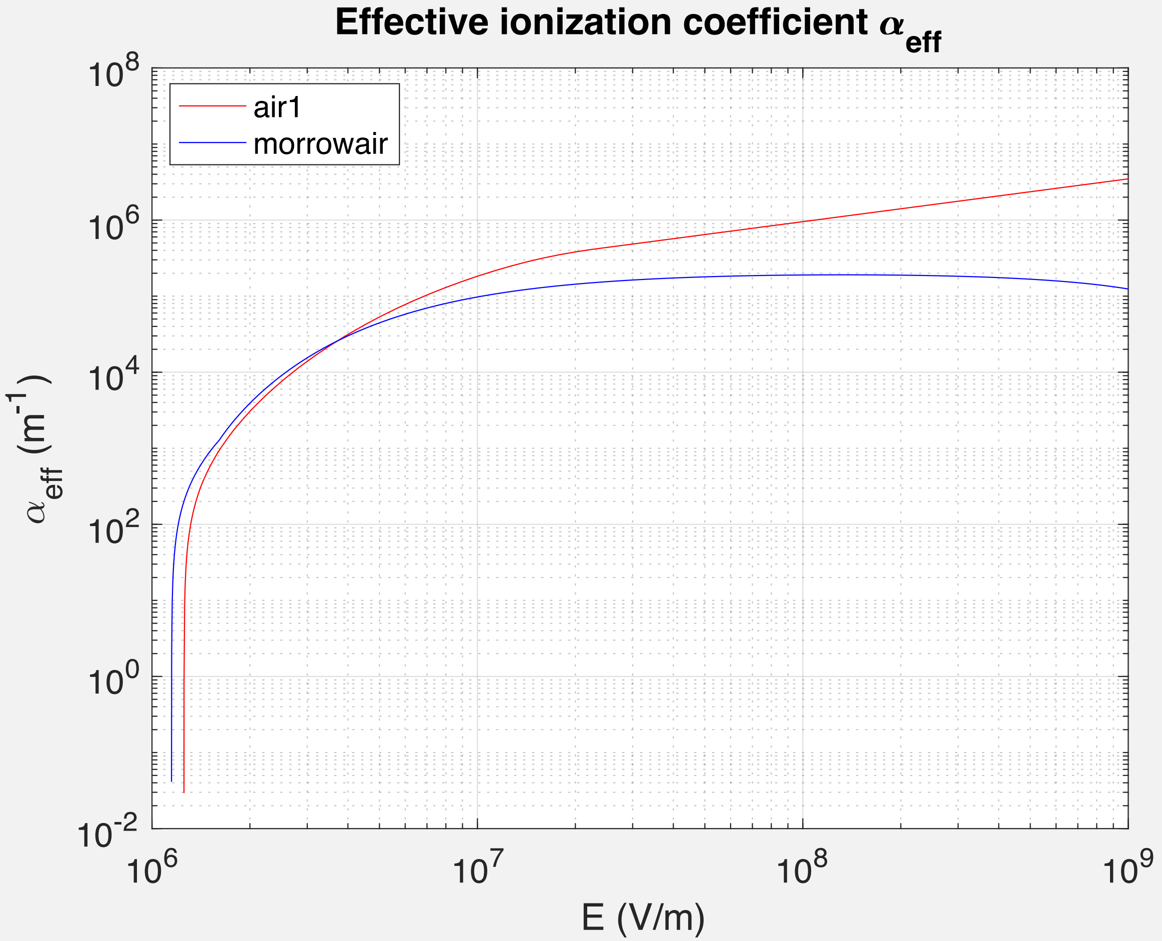
PRESENTATION SEPTEMBER 11, 2019

Wenjie Yu

RESULTS FOR THE ONE-SPHERE CASE





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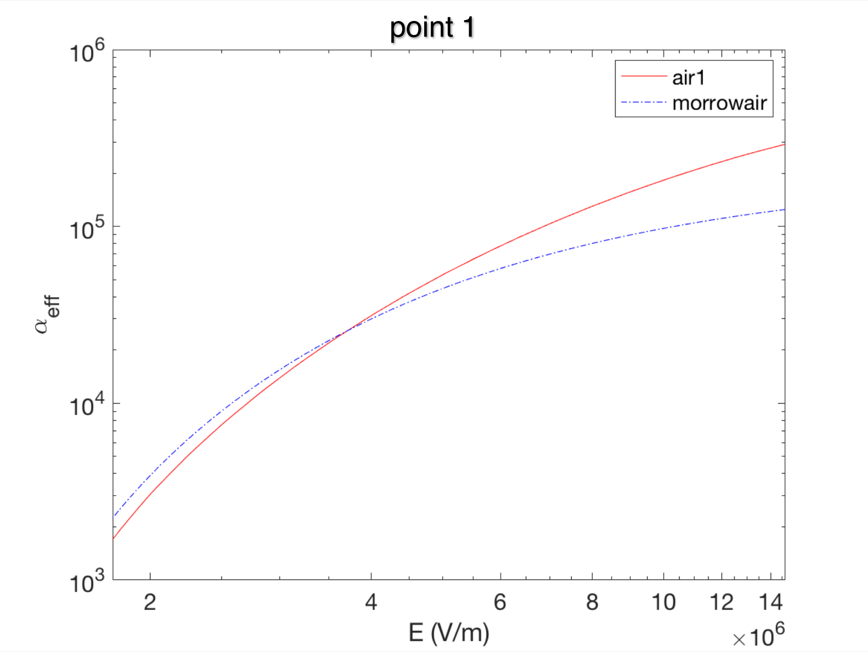

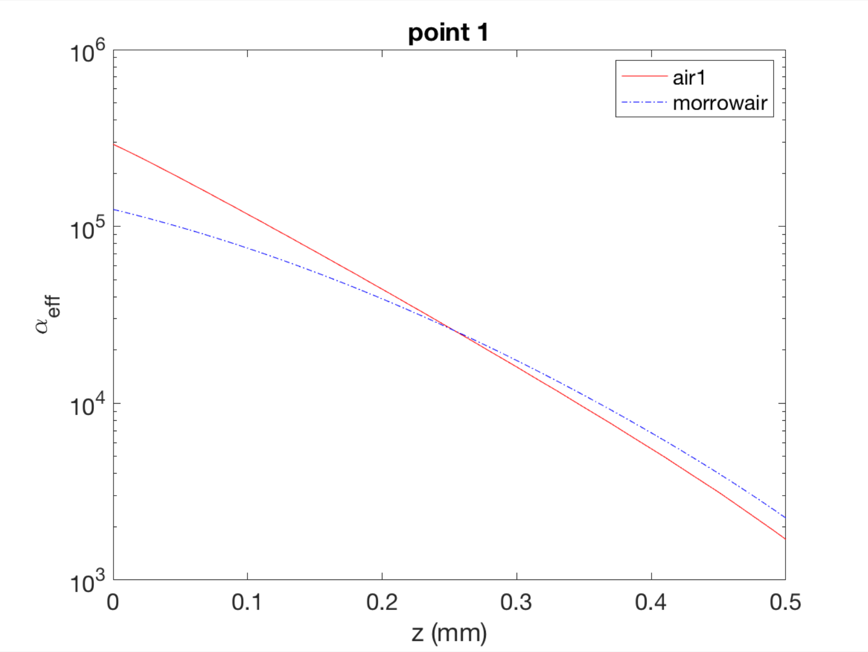

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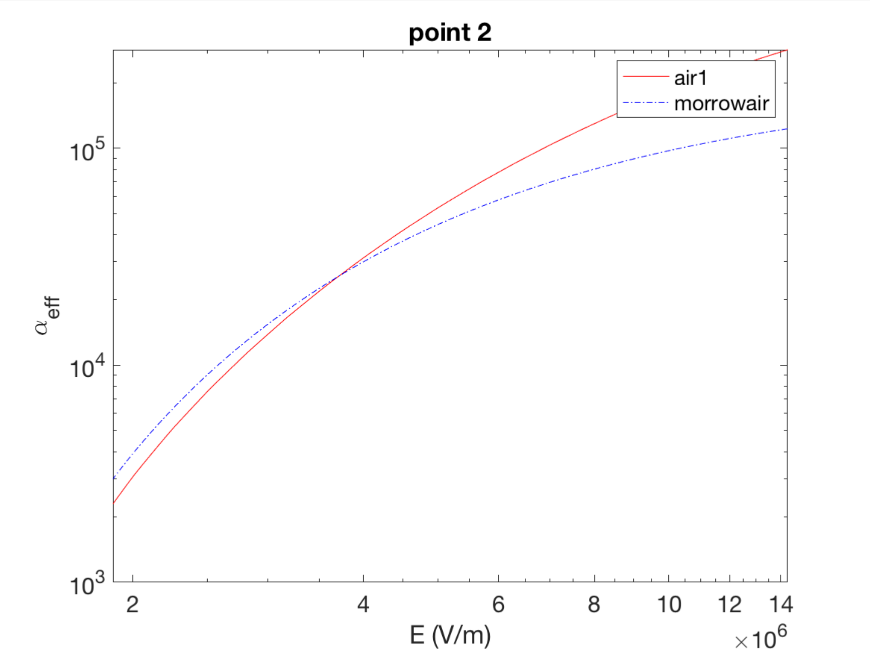

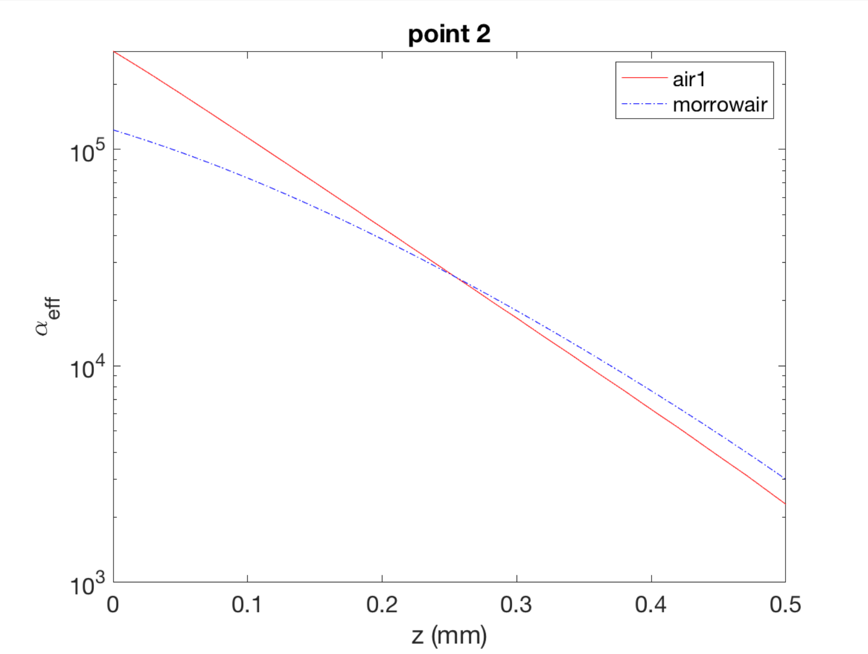

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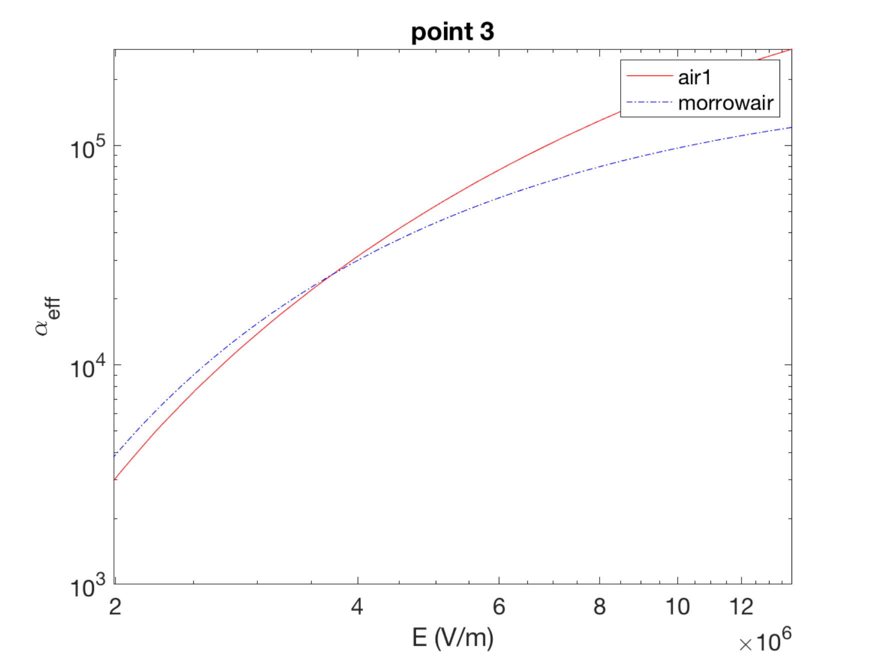

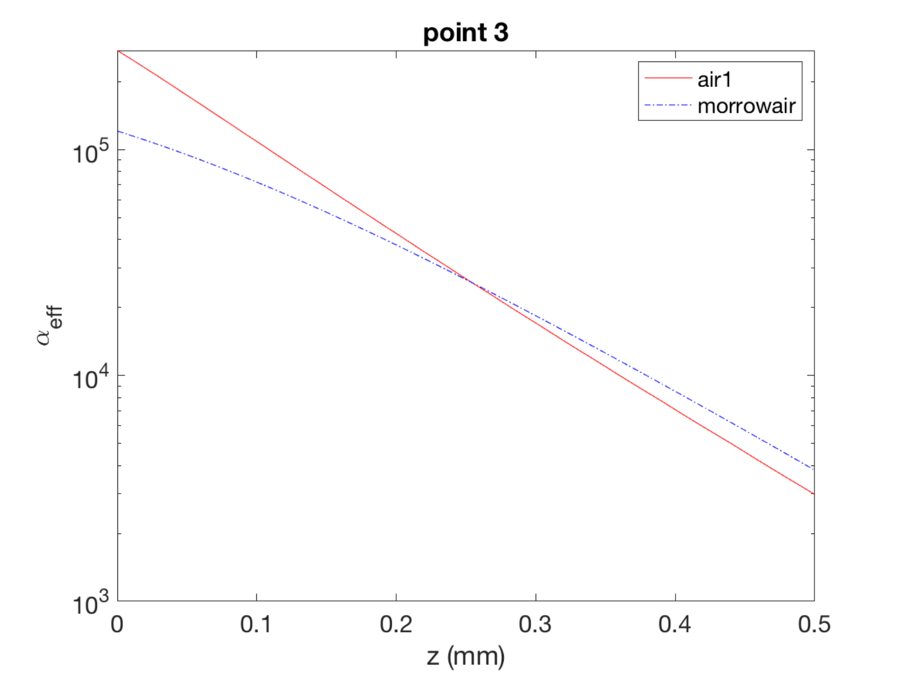

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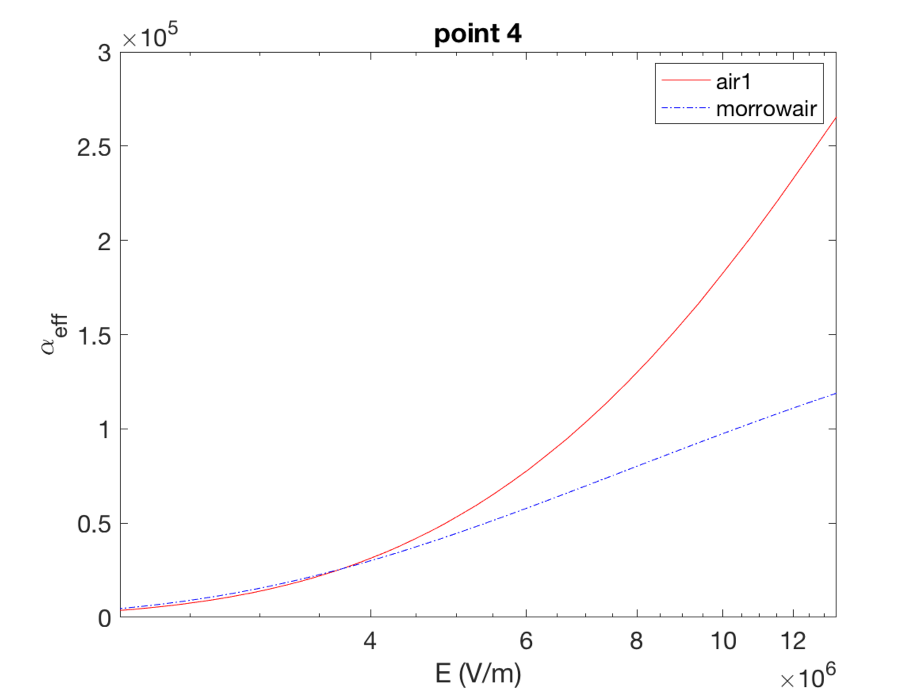

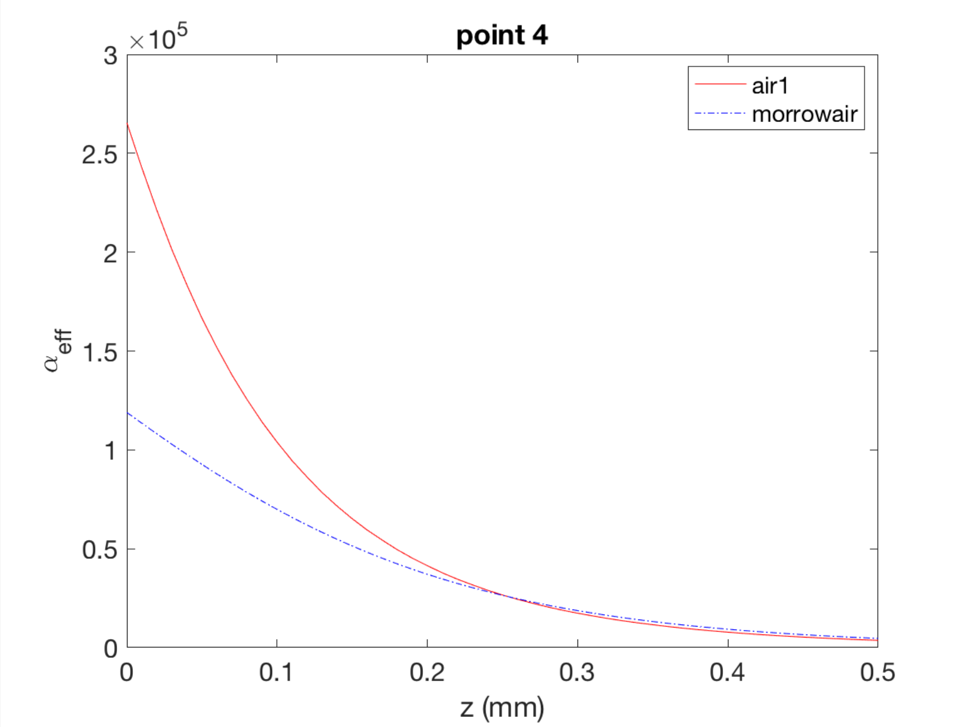

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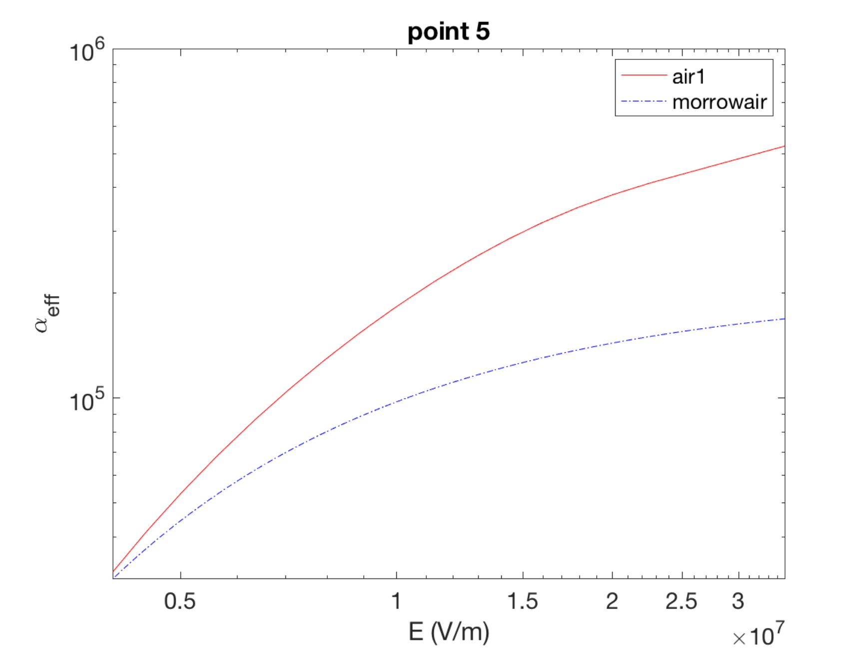

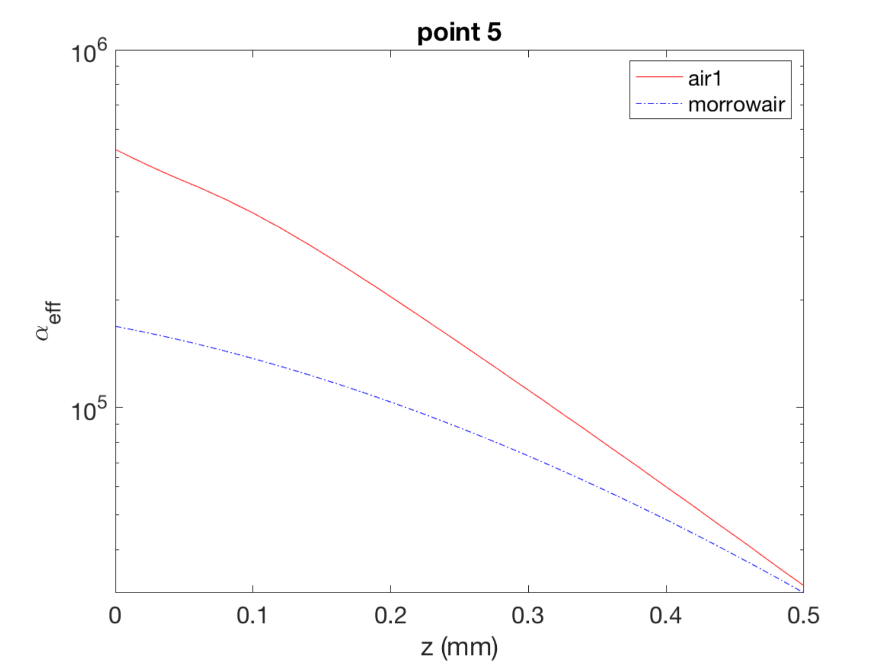

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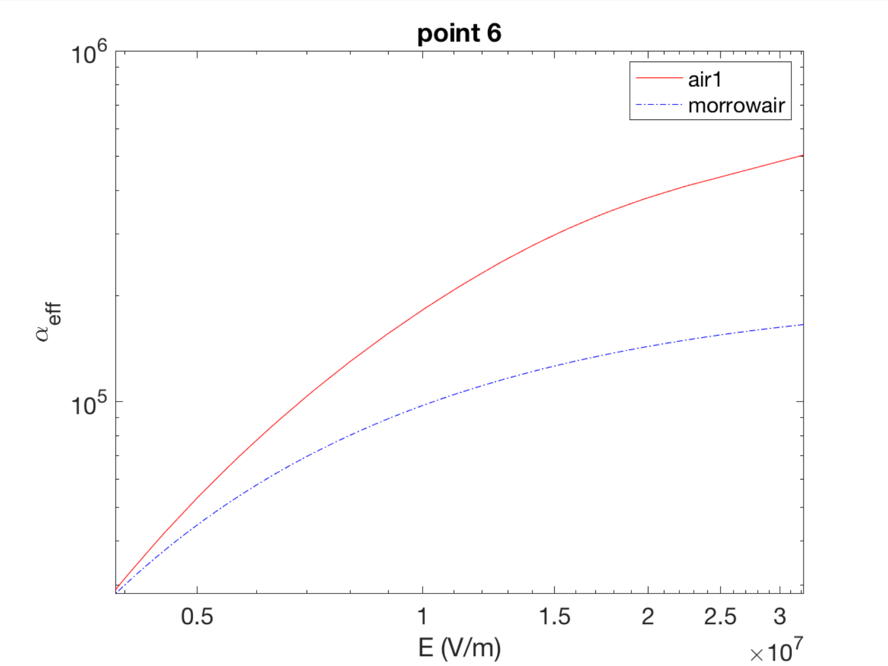

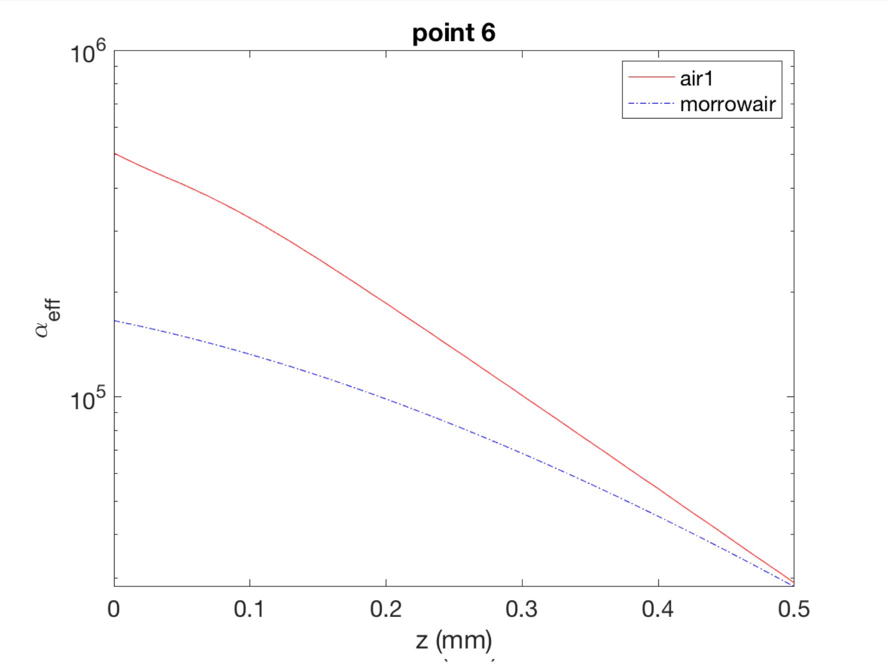

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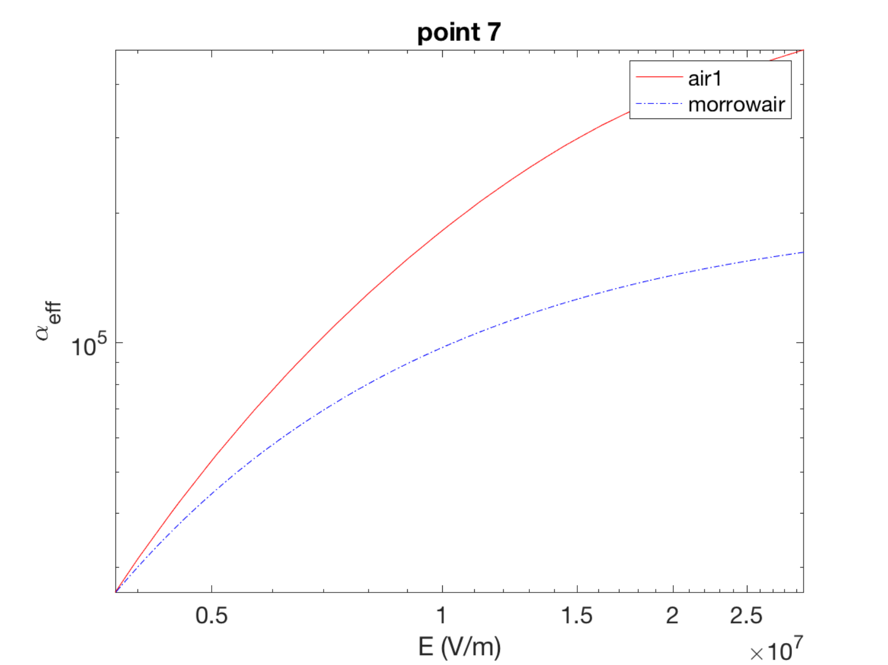

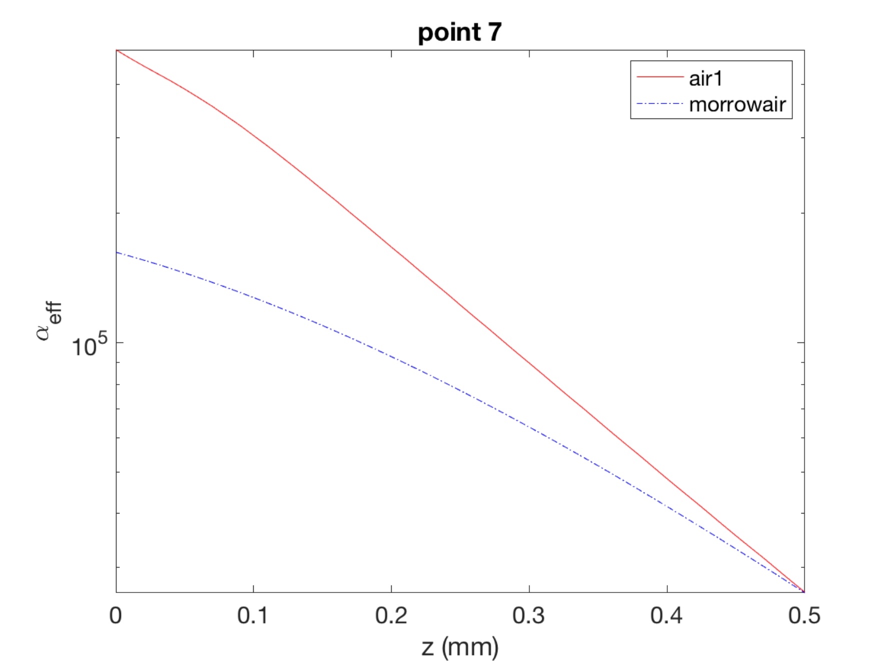

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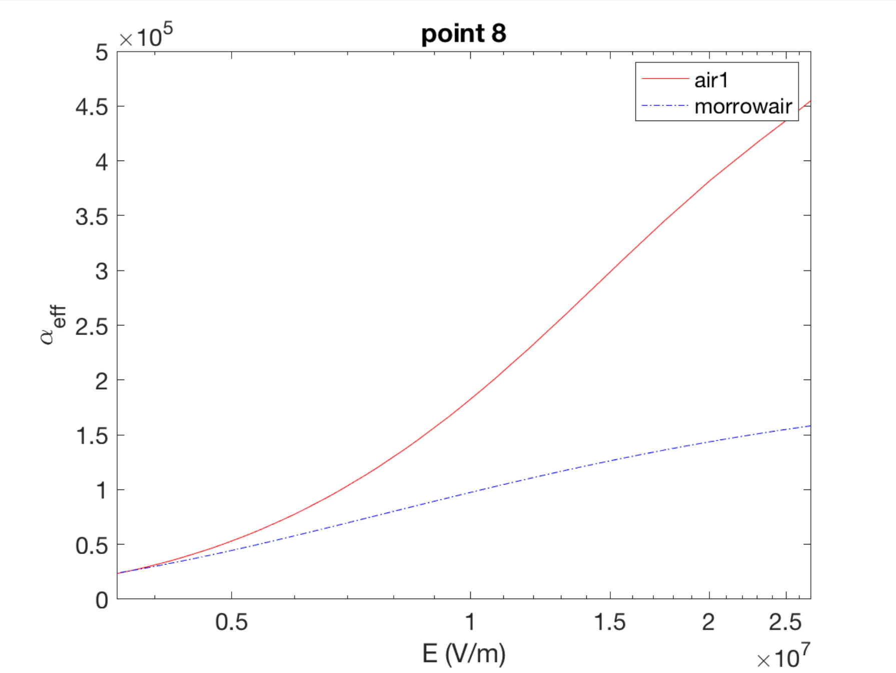
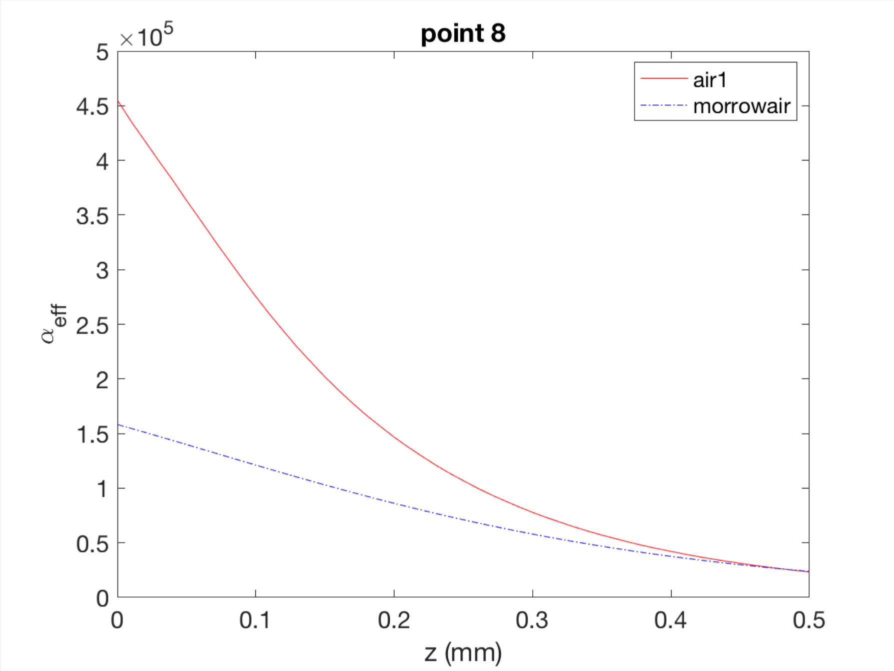
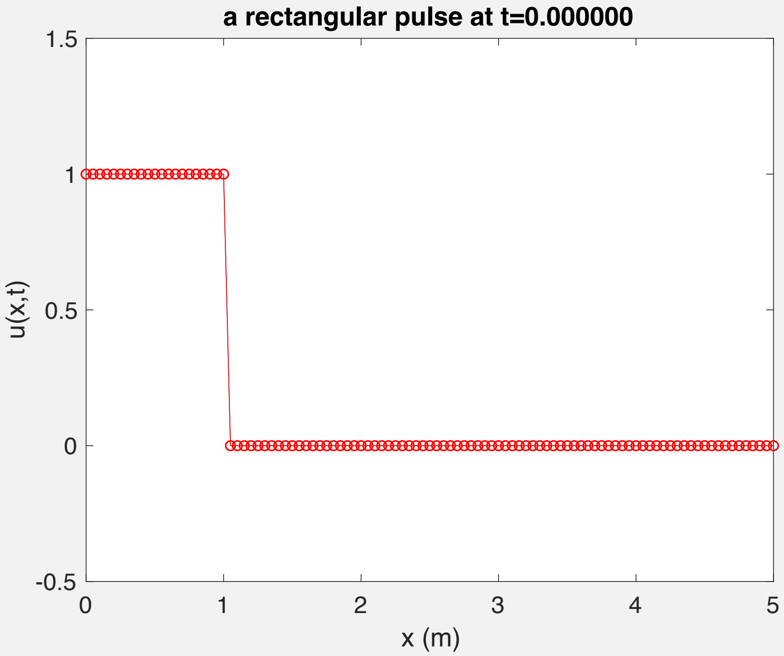
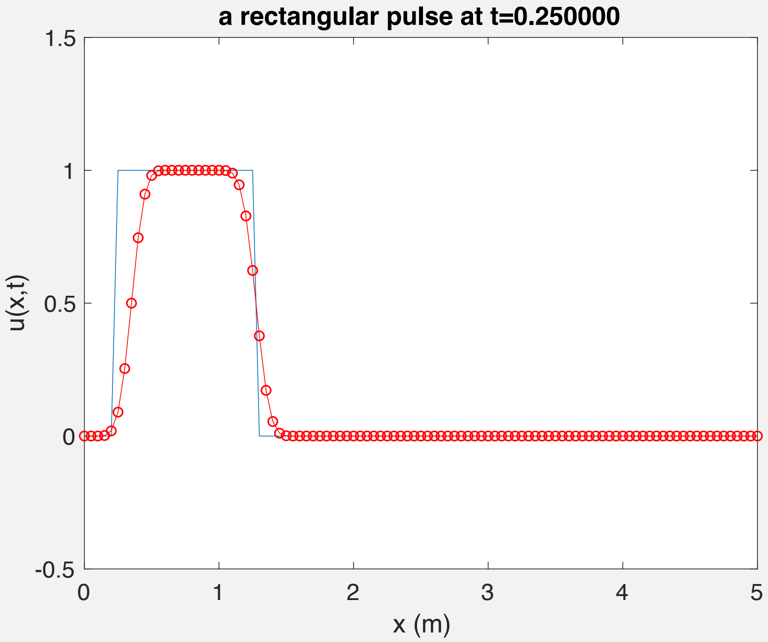
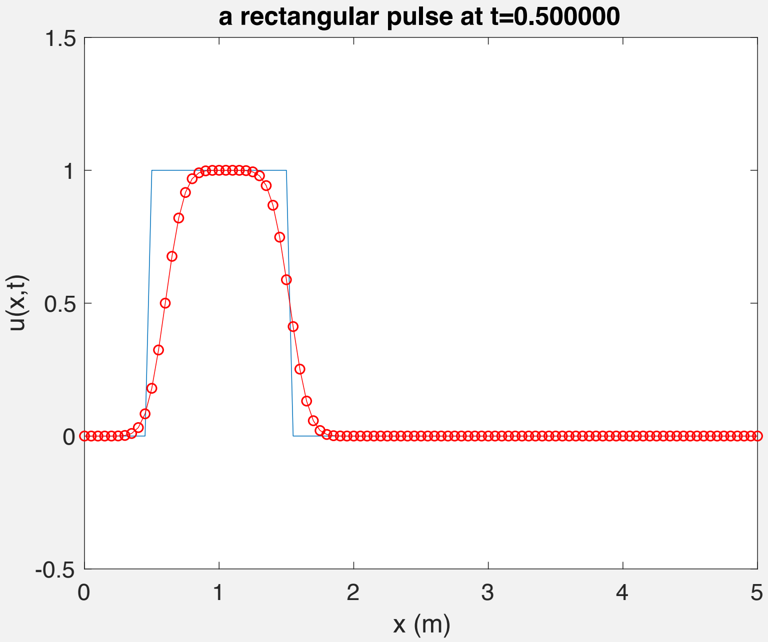




DEBUG OF THE 1D FCT (LOW ORDER)







$$F^L_{i+1/2} = \left[(f^n_{i+1} + f^n_i)/2 - |v|(q^n_{i+1} + q^n_i)/2 \right] \Delta t$$

DEBUG OF THE 1D FCT (LOW ORDER)

Our low order flux for advection is given by the first order upwind scheme:

$$F^L_{i+(1/2)} = \left[\frac{1}{2}\left(f^n_{i+1} + f^n_i\right) - \frac{1}{2}|u|\left(q^n_{i+1} - q^n_i\right)\right]\Delta t^{n+1/2}. \qquad (14)$$

The high order fluxes are given by the formulae in the Appendix of [13]. As an example, the fourth order flux is given by:

$$F^{H4}_{i+(1/2)} = \left[\frac{7}{12}\left(f^a_{i+1} + f^a_i\right) - \frac{1}{12}\left(f^a_{i+2} + f^a_{i-1}\right)\right]\Delta t^{n+1/2} \qquad (15)$$

where the time level t^a is meant to denote whatever time level or average of time levels is required by the particular substep of the particular time discretization chosen.

The high order dissipative fluxes of order N_D, which are added to the above high order fluxes, are simply the flux form representation of $\partial^{N_D} q/\partial x^{N_D}$, normalized to damp the Nyquist mode completely in one timestep at a Courant number of unity. As an example, the order 4 dissipative flux is given by:

$$F^{D4}_{i+(1/2)} = -|u|\left[\frac{3}{16}\left(q^n_{i+1} - q^n_i\right) - \frac{1}{16}\left(q^n_{i+2} - q^n_{i-1}\right)\right]\Delta t^{n+1/2}. \qquad (16)$$

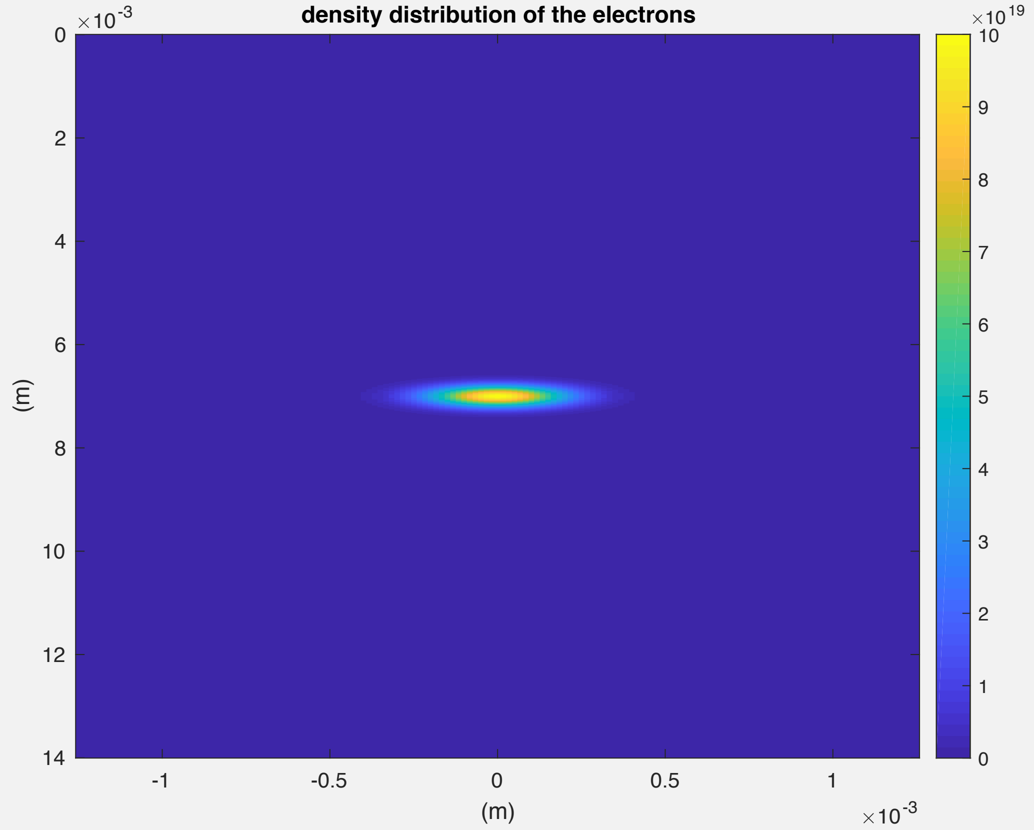
INITIAL CONDITION

$$n_e(r,z)|_{t=0} = n_p(r,z)|_{t=0}$$
$$= n_0 \exp\left[-\left(\frac{r}{\sigma_r}\right)^2 - \left(\frac{z-z_0}{\sigma_z}\right)^2\right]. \quad (32)$$

The center of the Gaussian distribution is located in the middle of the simulation domain, at $z_0 = 0.7$ cm, and it is assumed that $\sigma_r = \sigma_z = 0.02$ cm and $n_0 = 10^{20}$ m^{-3}. The size of the computational domain is 1.4×0.125 cm^2. The computational grid is uniform in both radial and axial directions. The total number of cells is $n_z \times n_r = 1681 \times 151$, where n_z and n_r represent number of cells in the axial and radial directions, respectively. As part of preparatory work for the model

Bourdon et al. 2007

INITIAL CONDITION



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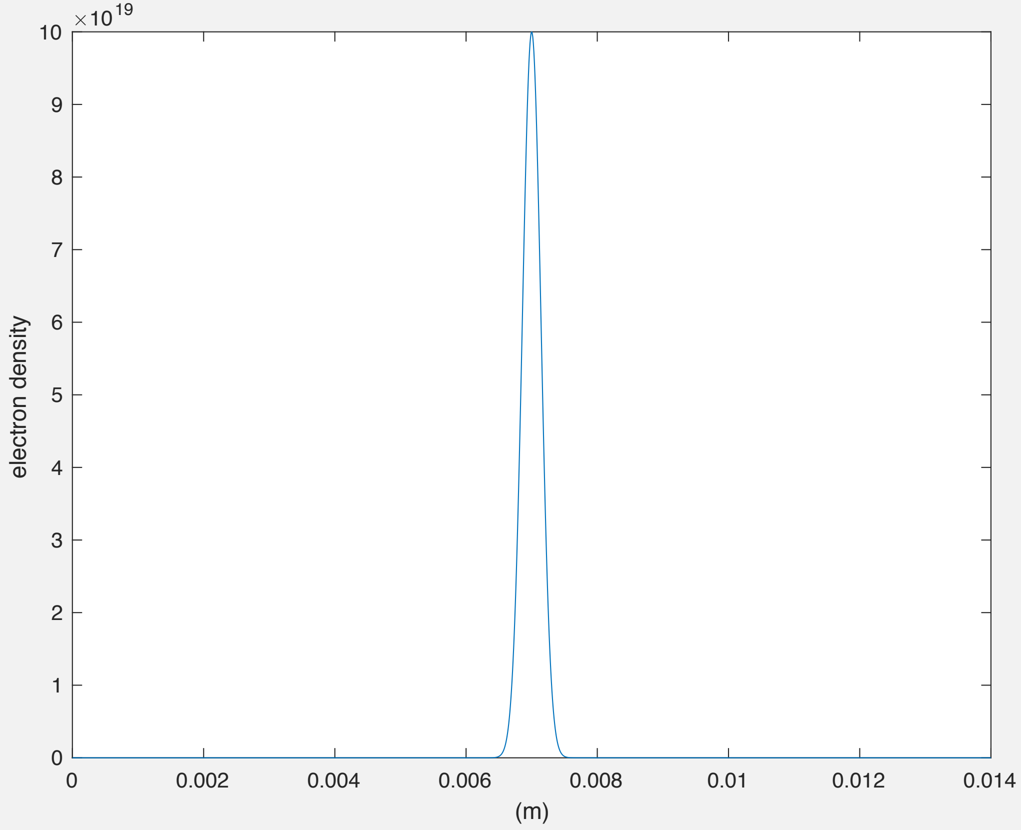

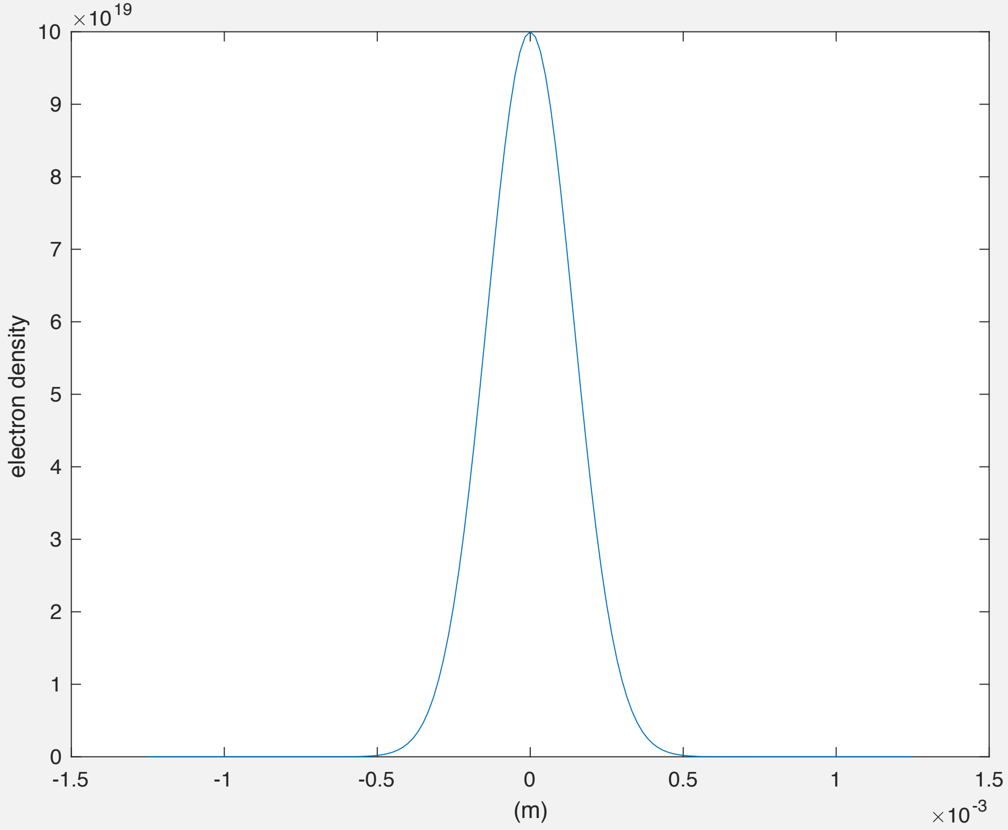

$$\frac{\partial n_e}{dt} + \nabla\cdot(\mathbf{v}_e n_e) - D_e \nabla^2 n_e = \alpha n_e v_e + S, \qquad (1a)$$

$$\frac{\partial n_+}{dt} + \nabla\cdot(\mathbf{v}_+ n_+) - D_+ \nabla^2 n_+ = \alpha n_e v_e + S, \qquad (1b)$$

$$\nabla^2 \Phi = -q_e (n_+ - n_e)/\epsilon_0, \qquad (2)$$

$$N_{i,j}^{t+\Delta T/2} = N_{i,j}^{t} - \frac{\Delta T}{2 r_{i,j} V_{i,j}} (F_{i+\frac{1}{2},j}^{t} - F_{i-\frac{1}{2},j}^{t} + G_{i,j+\frac{1}{2}}^{t} - G_{i,j-\frac{1}{2}}^{t}), \qquad (7a)$$

$$N_{i,j}^{t+\Delta T} = N_{i,j}^{t} - \frac{\Delta T}{r_{i,j} V_{i,j}} (F_{i+\frac{1}{2},j}^{t+\Delta T/2} - F_{i-\frac{1}{2},j}^{t+\Delta T/2} + G_{i,j+\frac{1}{2}}^{t+\Delta T/2} - G_{i,j-\frac{1}{2}}^{t+\Delta T/2}), \qquad (7b)$$

where $V_{i,j}$ and $r_{i,j}$ are the volume and radius of the i, jth cell, and F^t and G^t are the fluxes corresponding to $f = rNv_r$ and $g = rNv_z$, respectively, at time t.

The donor cell fluxes are

$$F_{i+\frac{1}{2},j} = \pi \Delta z (r_{i,j} + r_{i+1,j})(\tilde{v}_r)_{i+\frac{1}{2},j} \times \begin{bmatrix} N_{i,j} & \text{if } (\tilde{v}_r)_{i+\frac{1}{2},j} \geqslant 0 \\ N_{i+1,j} & \text{if } (\tilde{v}_r)_{i+\frac{1}{2},j} < 0 \end{bmatrix}, \qquad (10a)$$

$$G_{i,j+\frac{1}{2}} = \frac{\pi (r_{i-1,j} + 2 r_{i,j} + r_{i+1,j})(r_{i+1,j} - r_{i-1,j})}{4} \times (\tilde{v}_z)_{i,j+\frac{1}{2}} \begin{bmatrix} N_{i,j} & \text{if } (\tilde{v}_z)_{i,j+\frac{1}{2},j} \geqslant 0 \\ N_{i,j+1} & \text{if } (\tilde{v}_z)_{i,j+\frac{1}{2},j} < 0 \end{bmatrix}, \qquad (10b)$$

where

$$(\tilde{v}_r)_{i+\frac{1}{2},j} = [(v_r)_{i,j} + (v_r)_{i+1,j}]/2$$

and

$$(\tilde{v}_z)_{i,j+\frac{1}{2}} = [(v_z)_{i,j} + (v_z)_{i,j+1}]/2.$$