

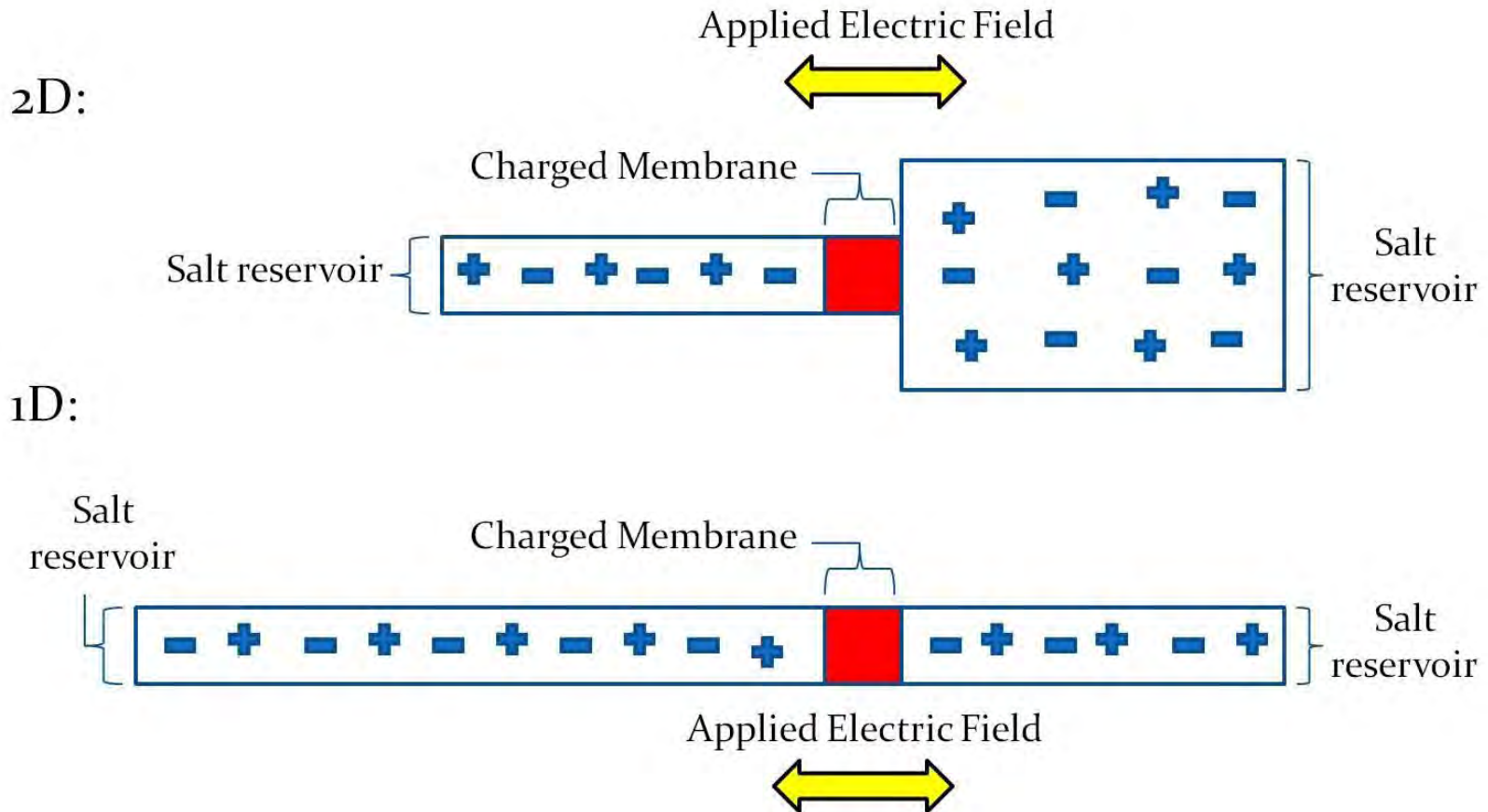
Presented at the 2011 COMSOL Conference

The Role of 1D & 2D Asymmetric Diffusion Layers In Rectification Through Ion- Selective Membranes

W. Booth, J. Schiffbauer
West Virginia University

B. Edwards
Utah State University

Micro-Nano-Fluid Electrolyte System

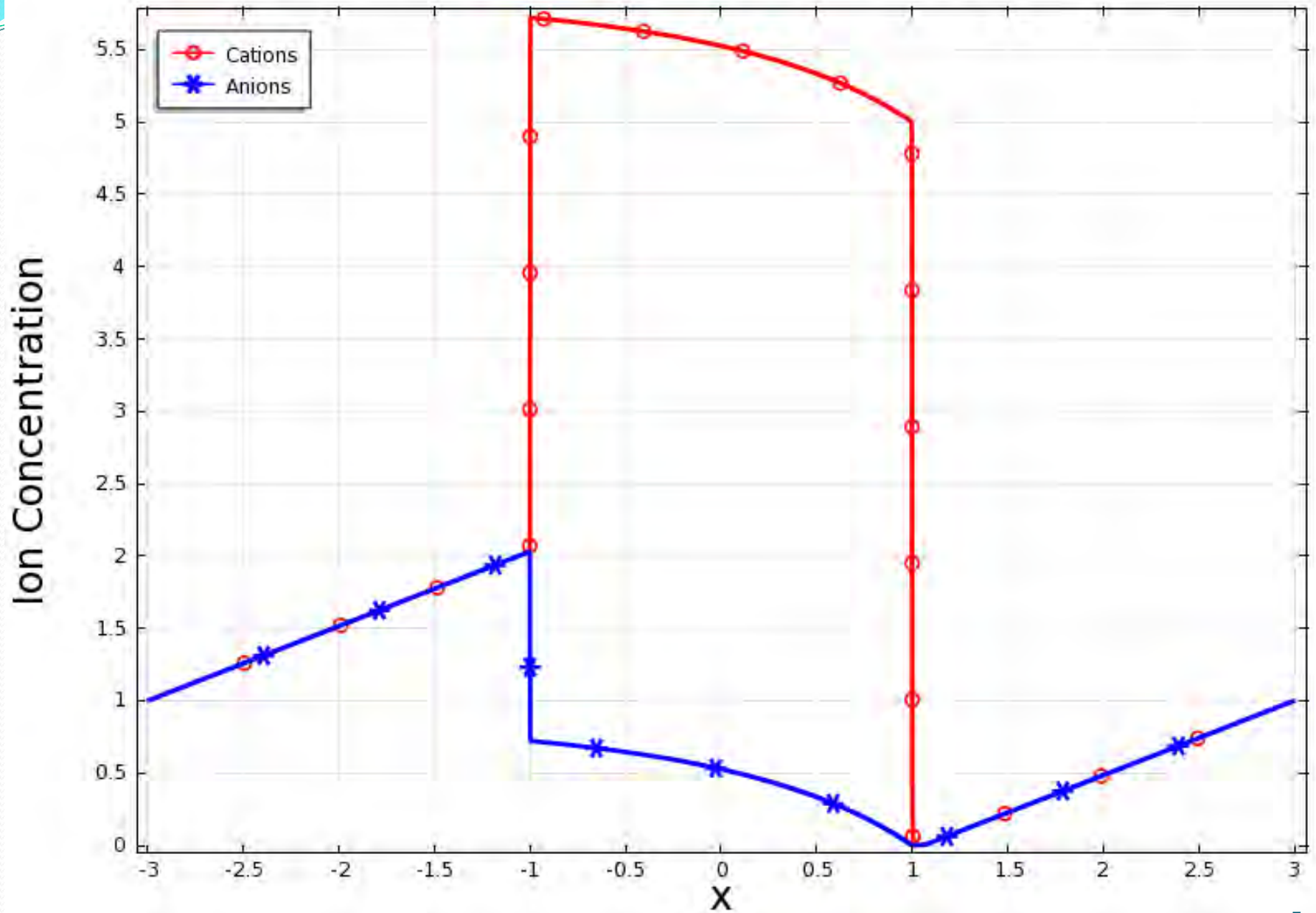


Steady-State Scaled Equations

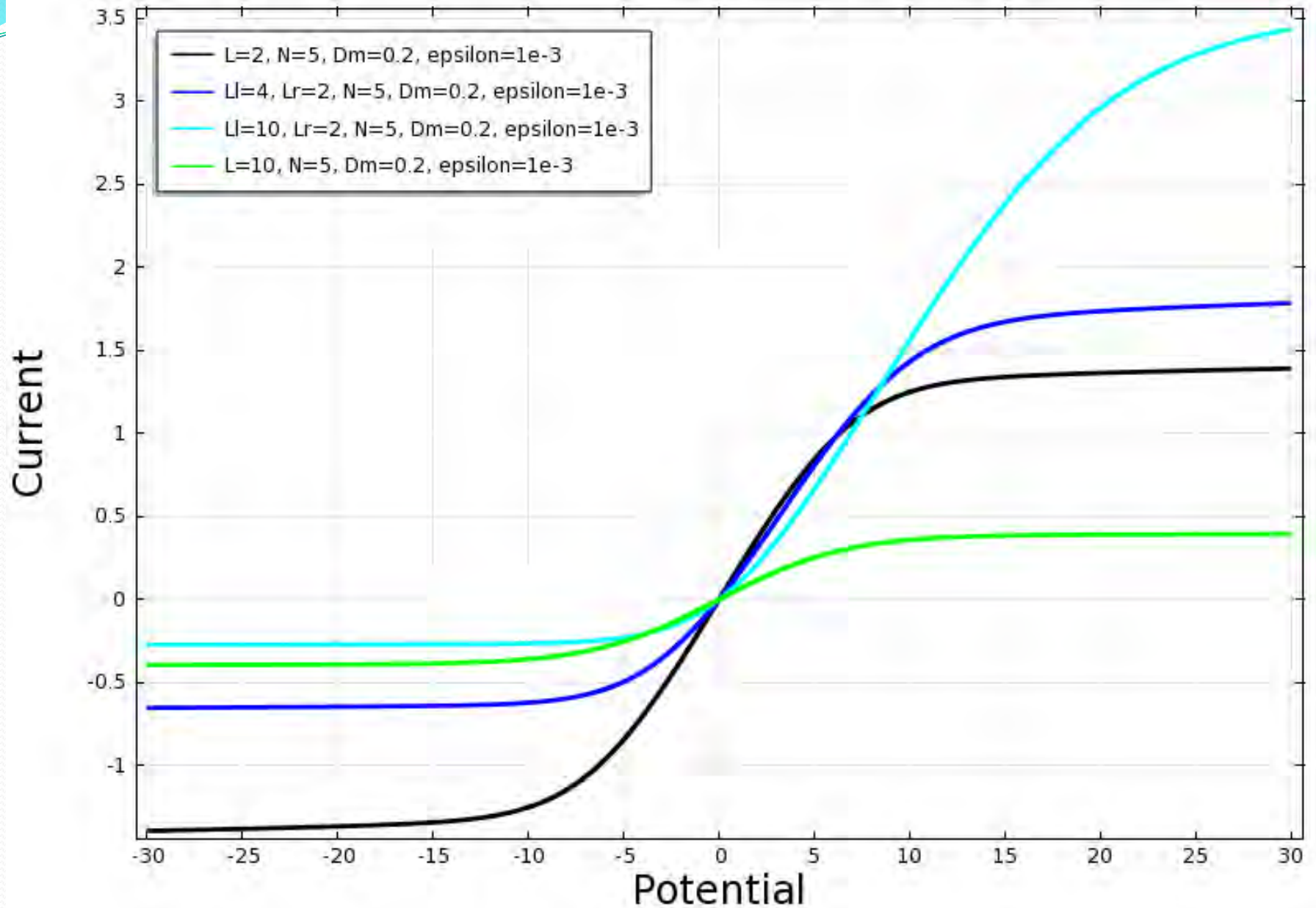
- Poisson's Eqn.: $-\varepsilon^2 \nabla^2 \phi = p - n - N(\vec{x})$
- Continuity Eqns.: $\vec{\nabla} \cdot D(\vec{x}) \left[-\vec{\nabla} c_i - z_i c_i \vec{\nabla} \phi \right] = 0, c_{p,n} = p, n$
 - p is the counter-ion concentration
 - n is the co-ion concentration
 - $N(\vec{x})$ is the membrane fixed charge
 - $D(\vec{x})$ is the system diffusivity
 - ϕ is the electrostatic potential
 - ε is the scaled electric double layer (EDL) length
 - z_i is the ion valence. (+/- 1)

Parameter	Expression
Electric Potential	$\phi = e\tilde{\phi}/k_B T$
Ion Concentration: positive, negative	$c_{p,n} = \tilde{c}_{p,n}/c_0$
Charge Number	$z_{p,n} = \pm 1$
Debye length	$\varepsilon^2 = dk_B T / (c_0 e^2 \delta^2)$
Fixed Membrane Charge	$N = \tilde{N}/c_0$
Membrane Half-Length	$\delta = 1$
Channel Lengths: left, right	$L_{l,r}$
Channel Heights	$H_{l,r}$
Relative Membrane Diffusivity	$D_m = 0.2$
Applied Potential	V

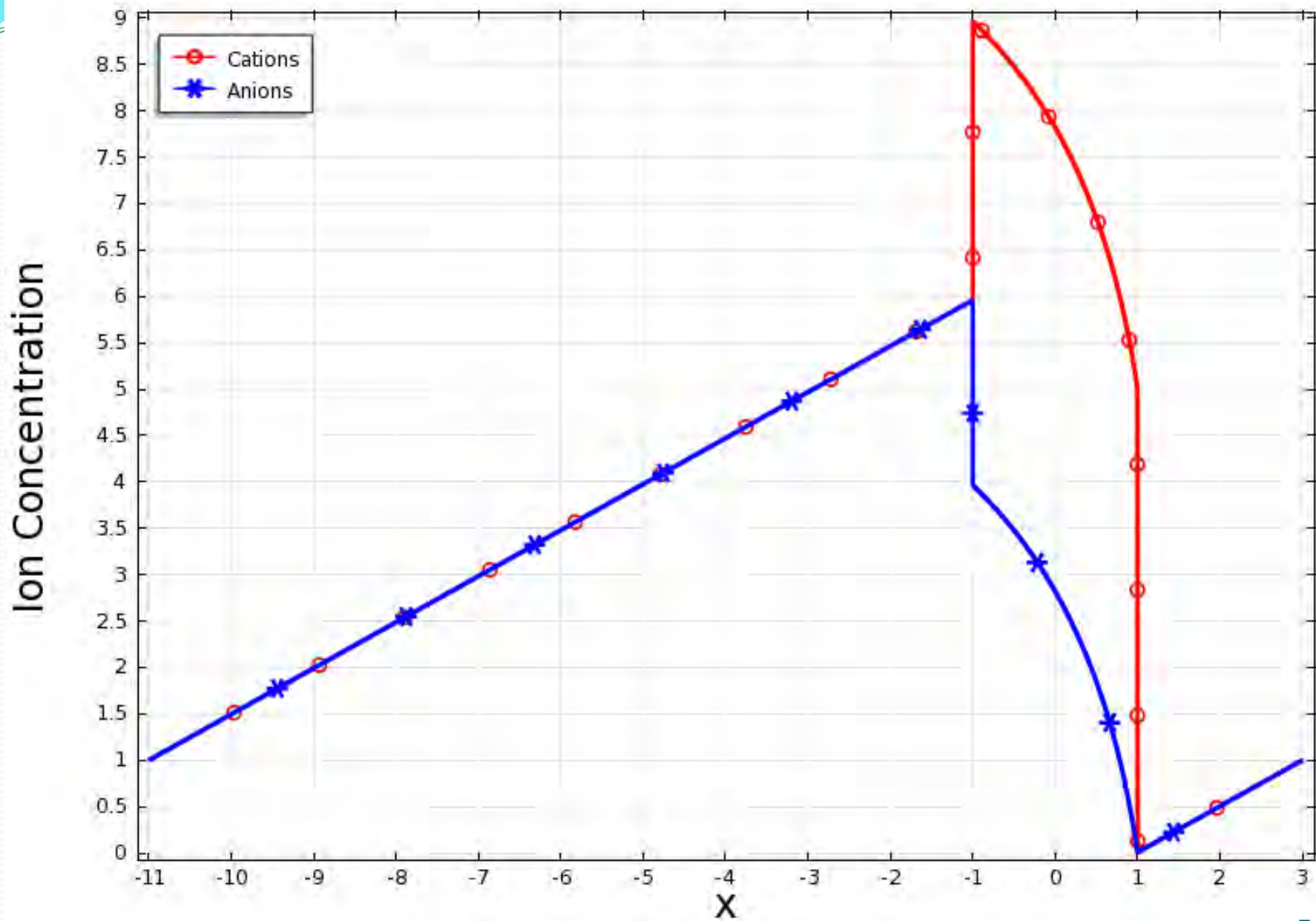
$V=30, L=2, N=5, Dm=0.2, \text{eps}=1e-3$



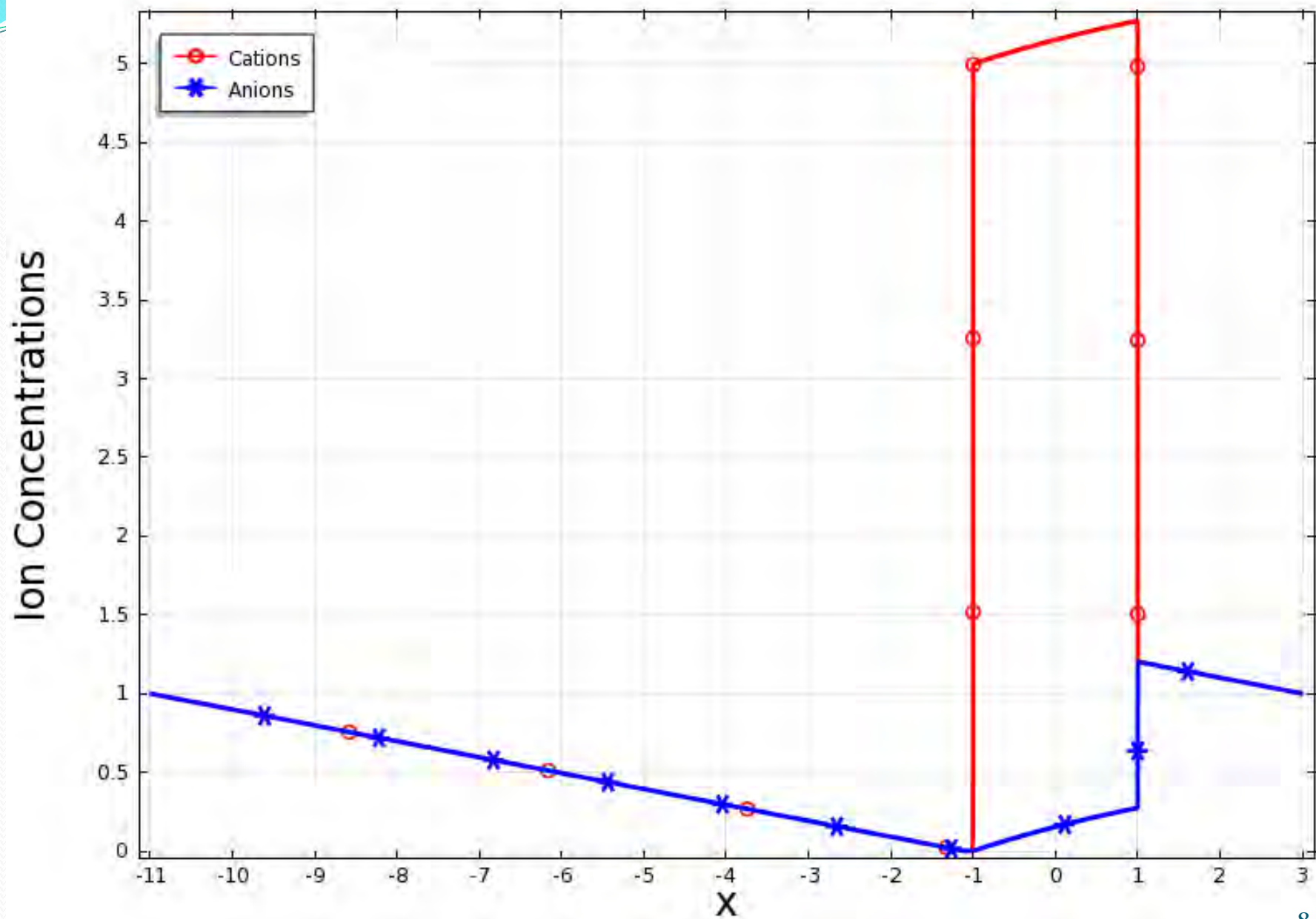
IV: DL Length



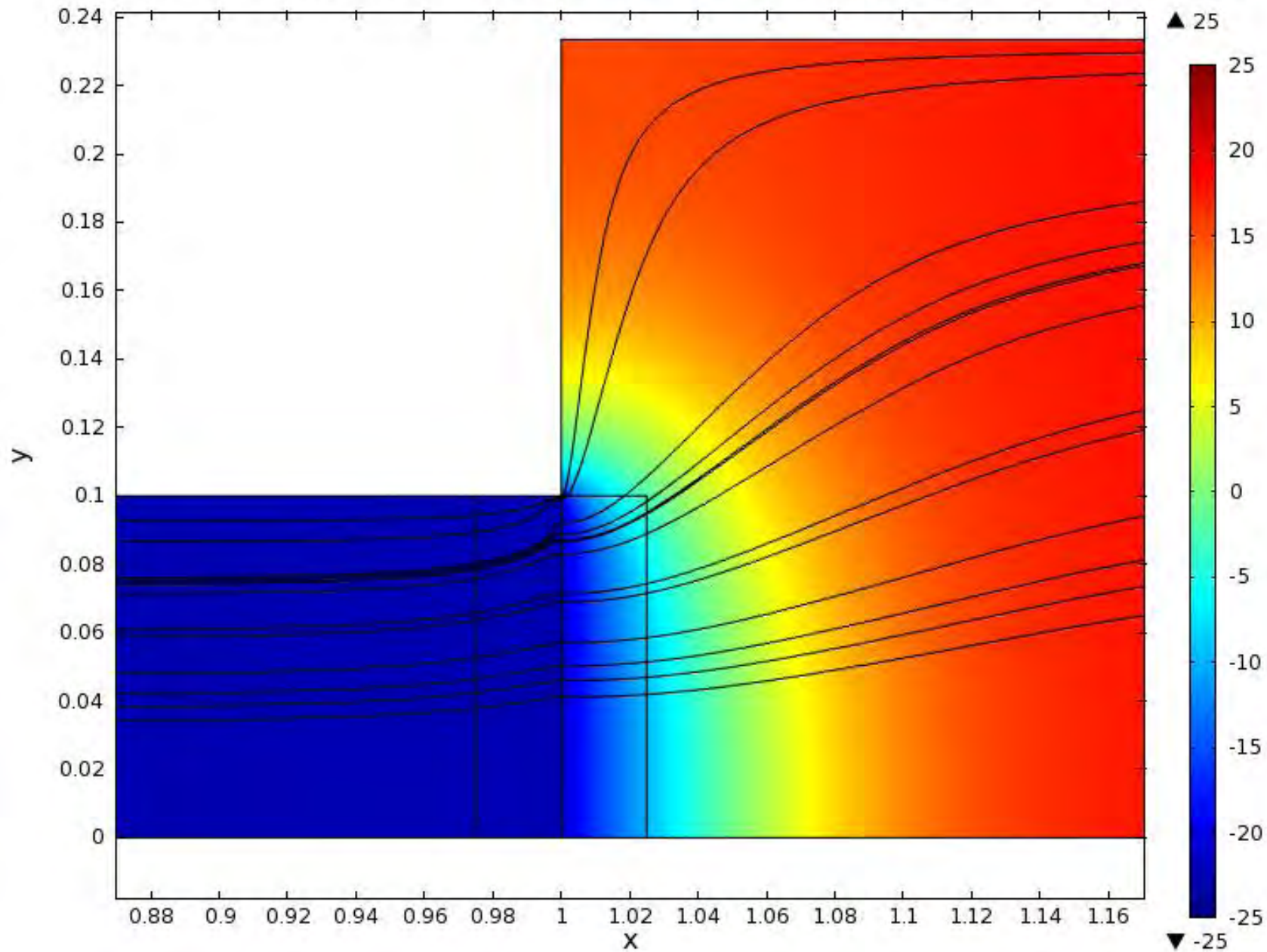
$V=30, L_l=10, L_r=2, N=5, D_m=0.2, \text{eps}=1e-3$

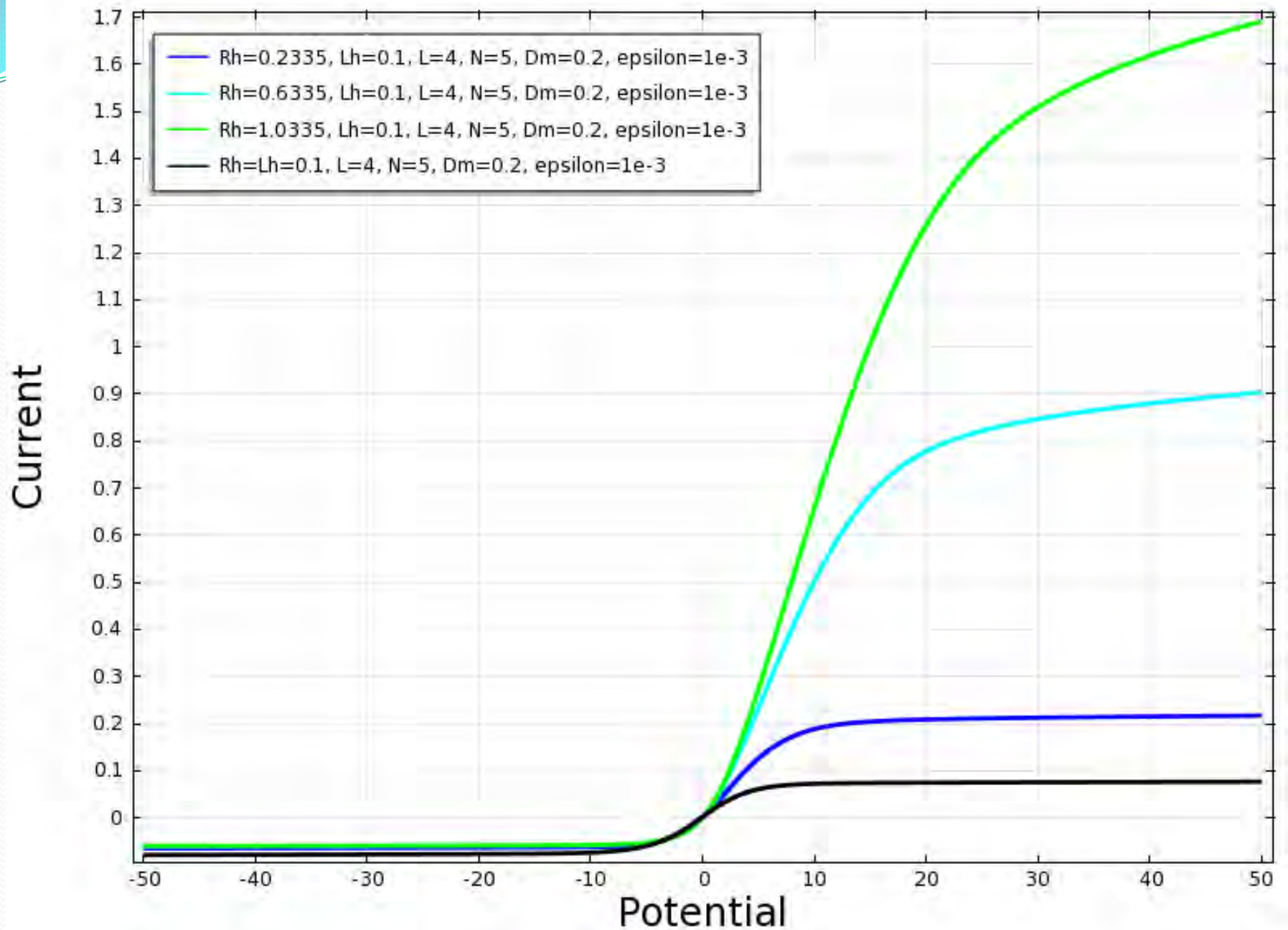


$V=-30$, $LI=10$, $Lr=2$, $N=5$, $Dm=0.2$, $\text{eps}=1e-3$



Potential Surface, Electric Field Streamlines: $Hr=0.2335$, $N=5$, $Dm=0.2$, $\epsilon=1e-3$

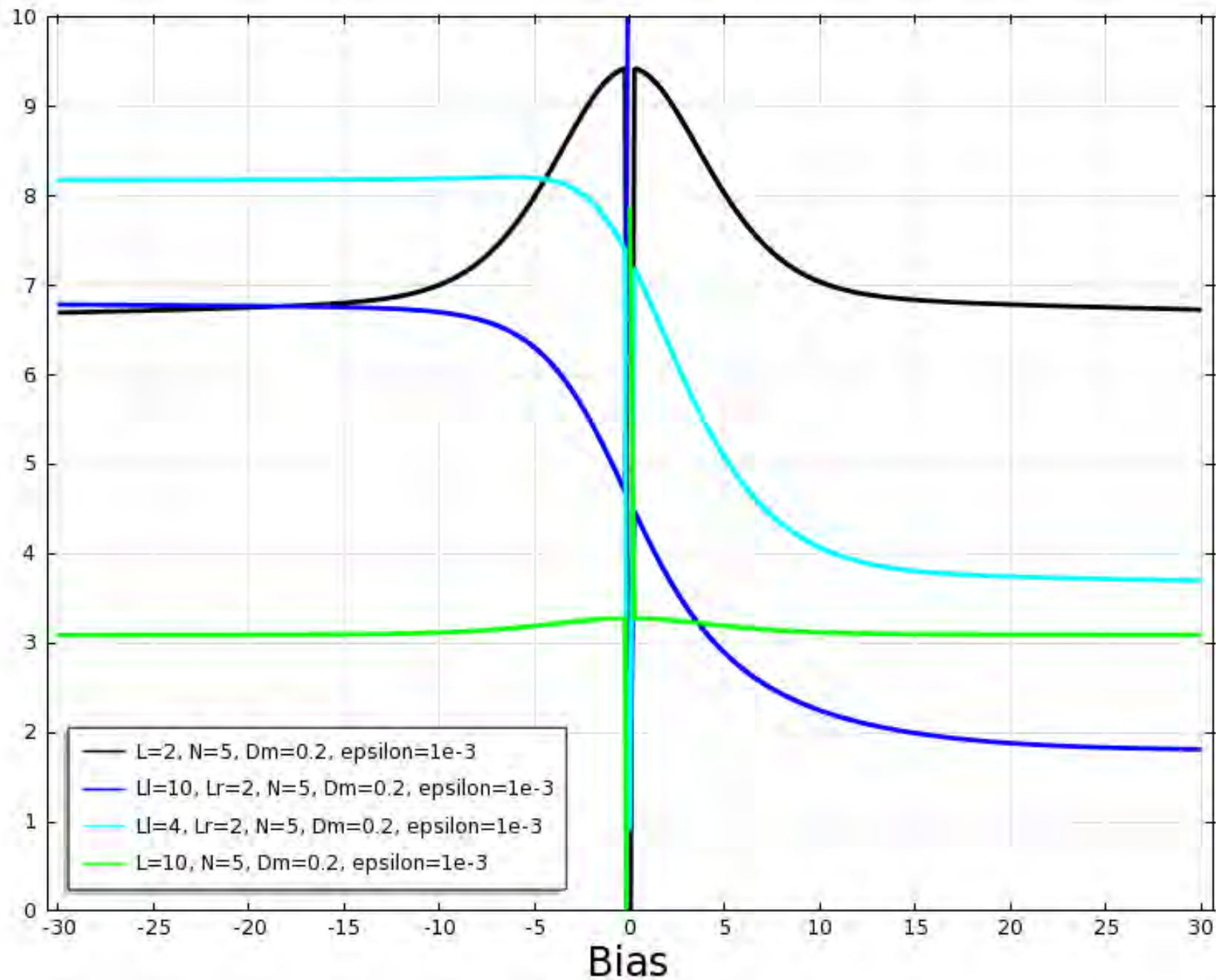




Thanks. Questions?

- Gilad Yossifon, Peter Mushenheim, Yu-Chen Chang, and Hsueh-Chia Chang, Physical Review E 81, 1-13 (2010). **Field-focusing.**
- Gilad Yossifon, Peter Mushenheim, Yu-Chen Chang, and Hsueh-Chia Chang, Physical Review E 79, 1-9 (2009). **Non-linear IV characteristics of nanochannels.**
- Jarrod Schiffbauer, Will Booth, Kathleen Kelly, Boyd Edwards, and Aaron Timperman. Submitted to PRL. (2011). **1D analytical theory of these rectifying systems.**

Selectivity (j_p/j_n)



Depletion Layer Space Charge: $N=5$, $D_m=0.2$, $\epsilon=1e-3$

