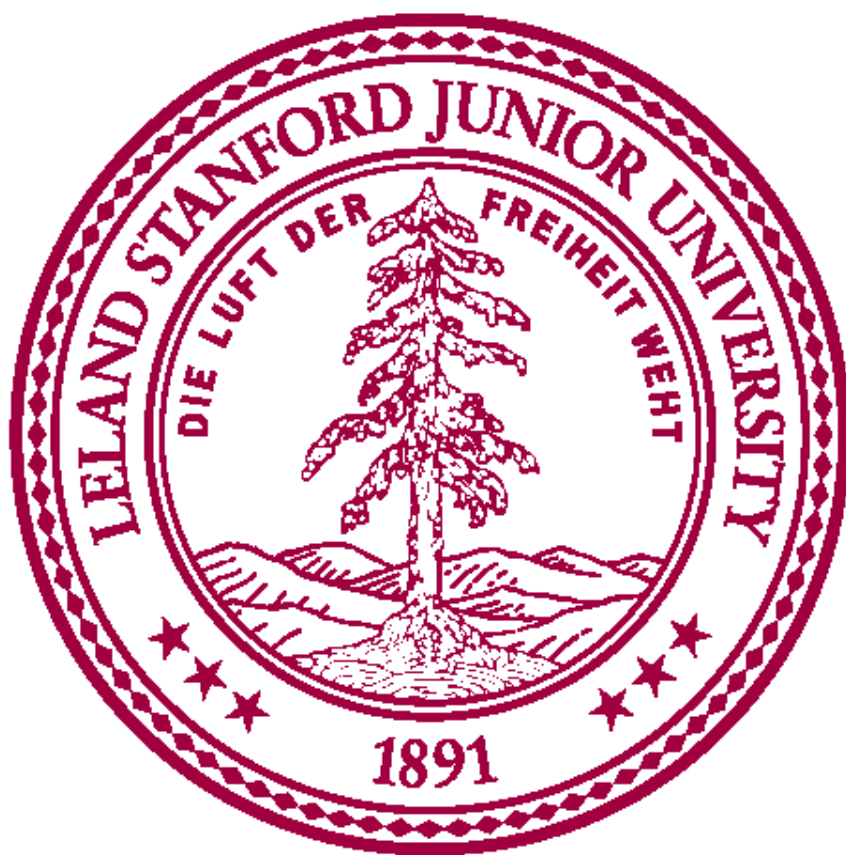


Electrothermal Modeling with Geant4 + COMSOL Integration



Ricardo Peterson

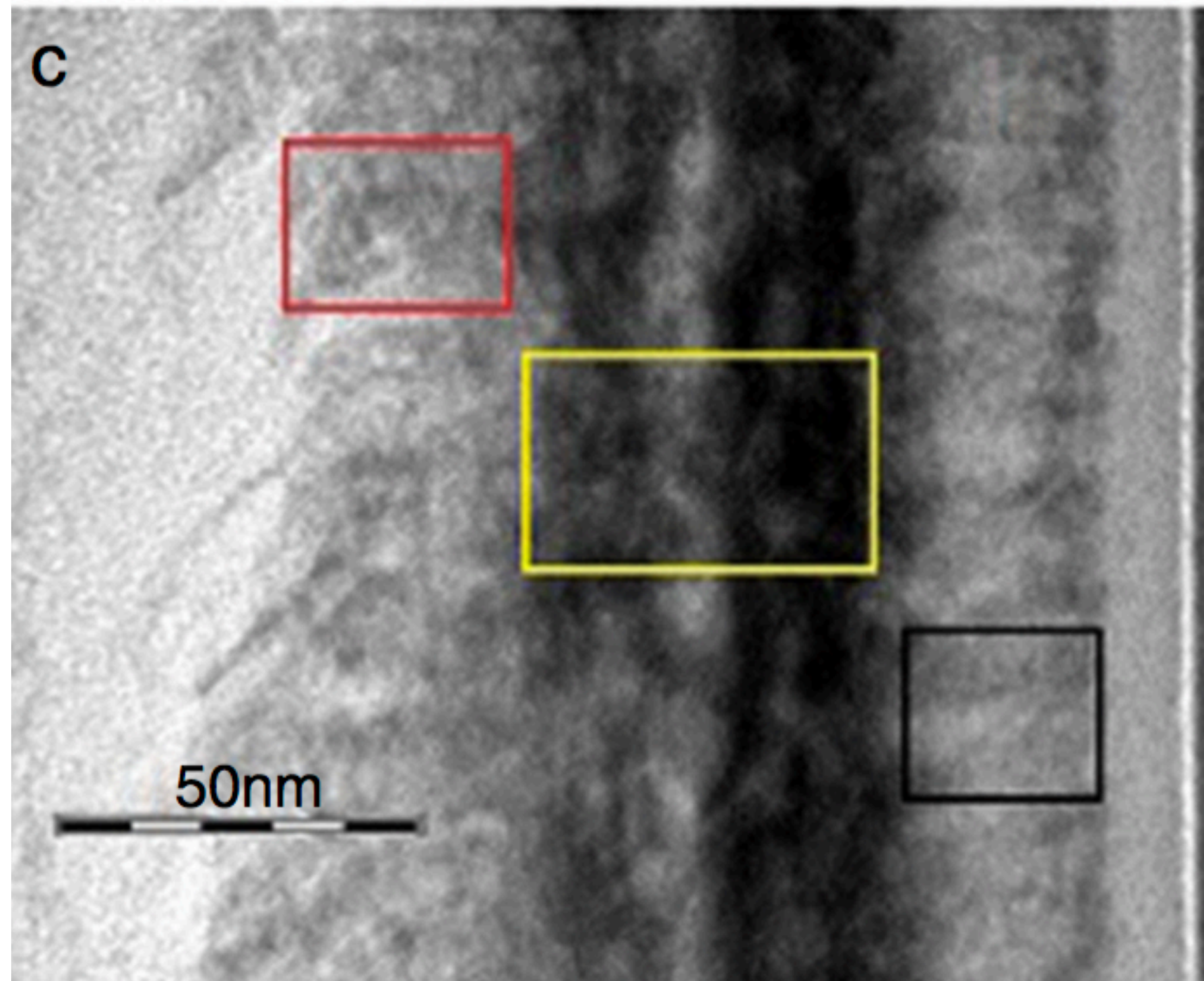
Department of Electrical Engineering
Extreme Environment Microsystems Lab (XLab)
Stanford University



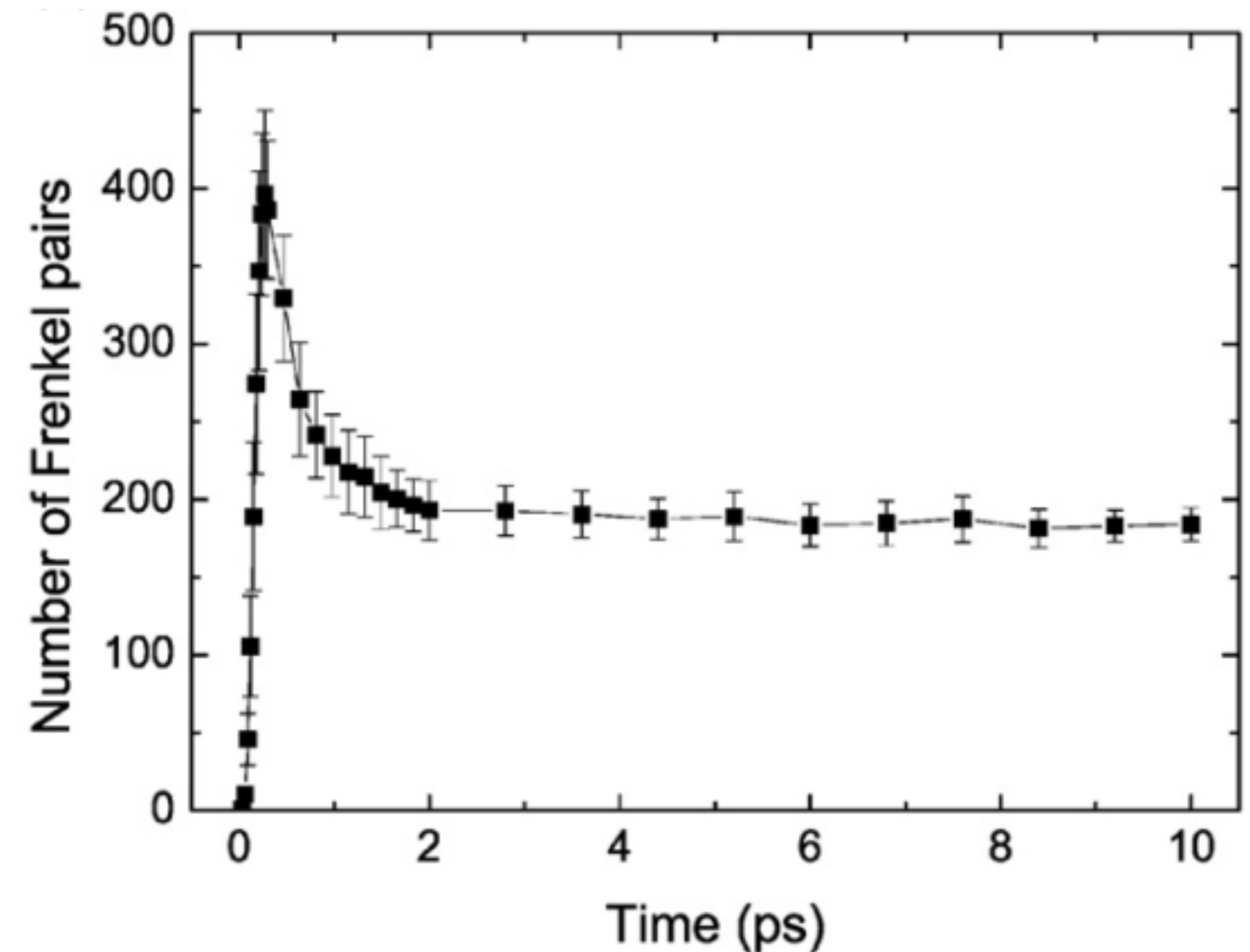
PI: Prof. Debbie Senesky

Department of Aeronautics and Astronautics
Department of Electrical Engineering (by Courtesy)

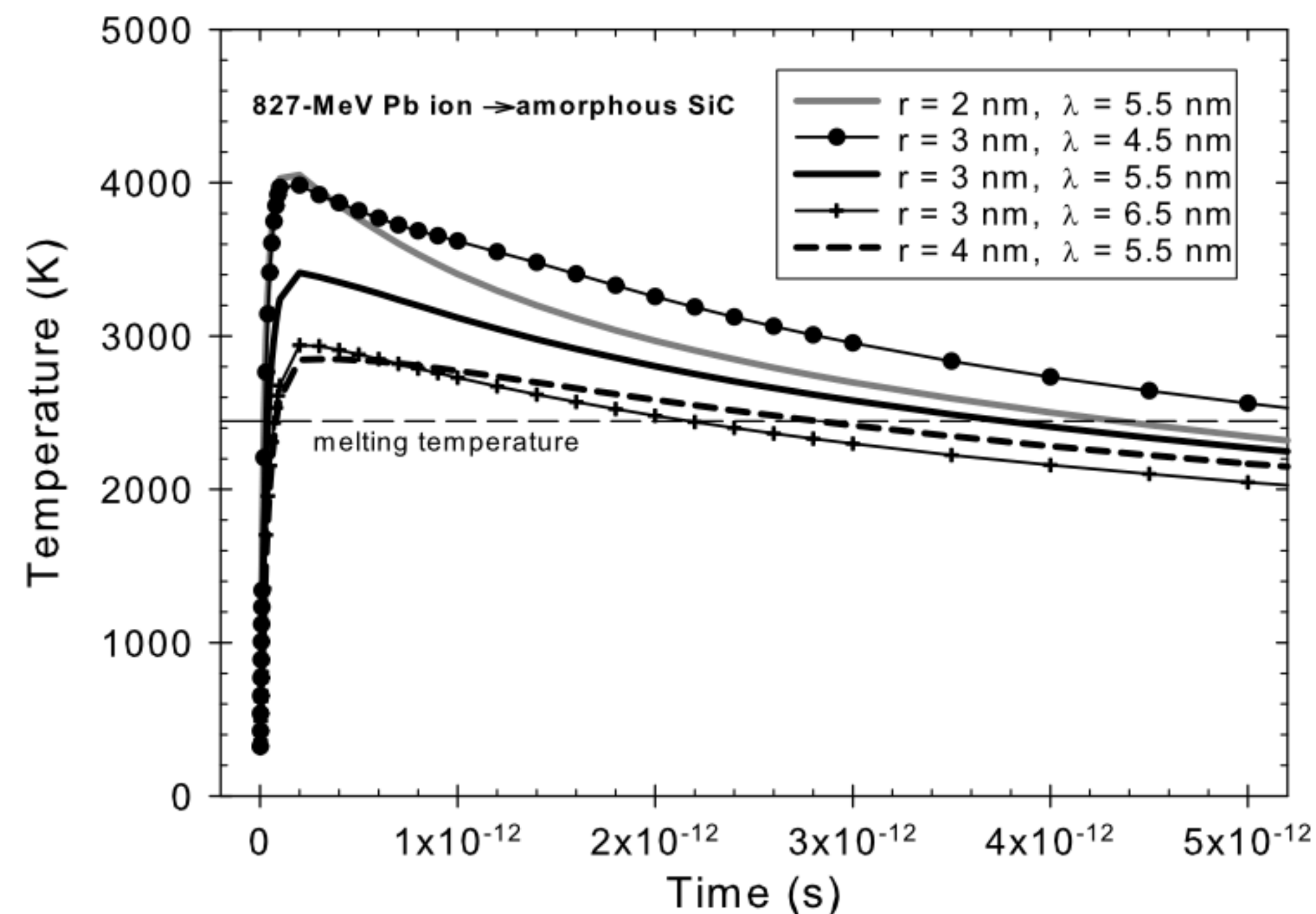
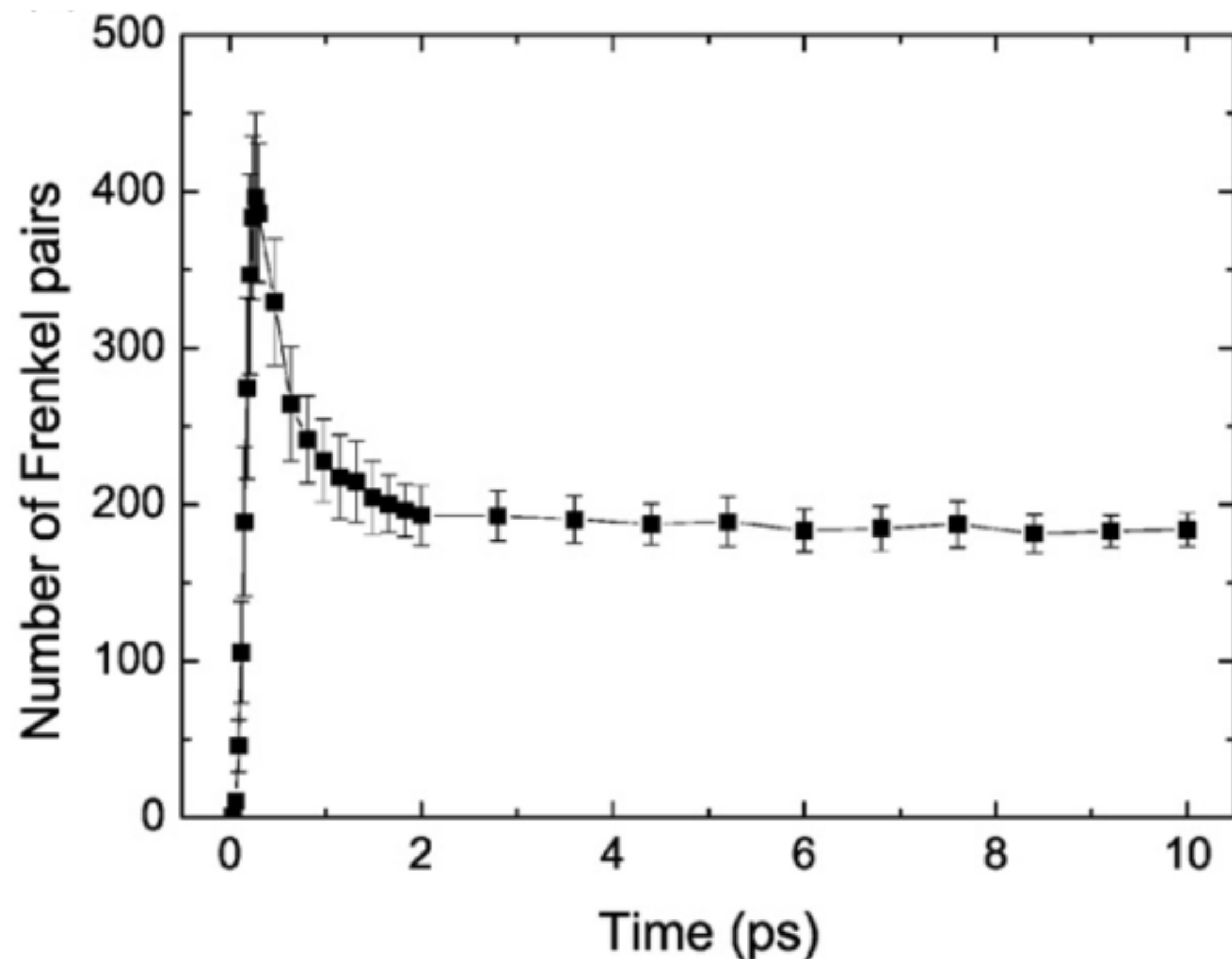
Irradiation-induced M-S Interface Degradation



After 120MeV Au irradiation

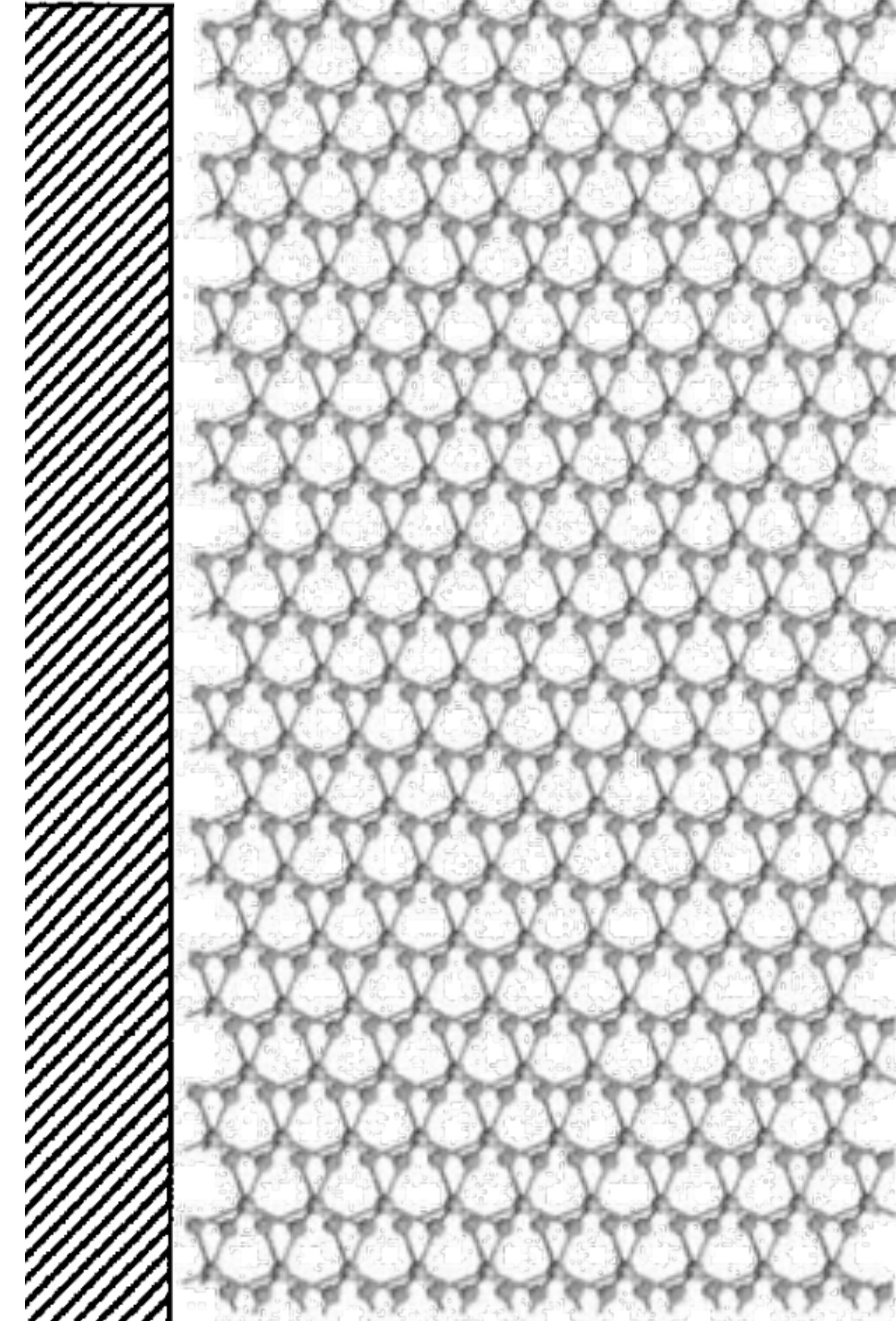
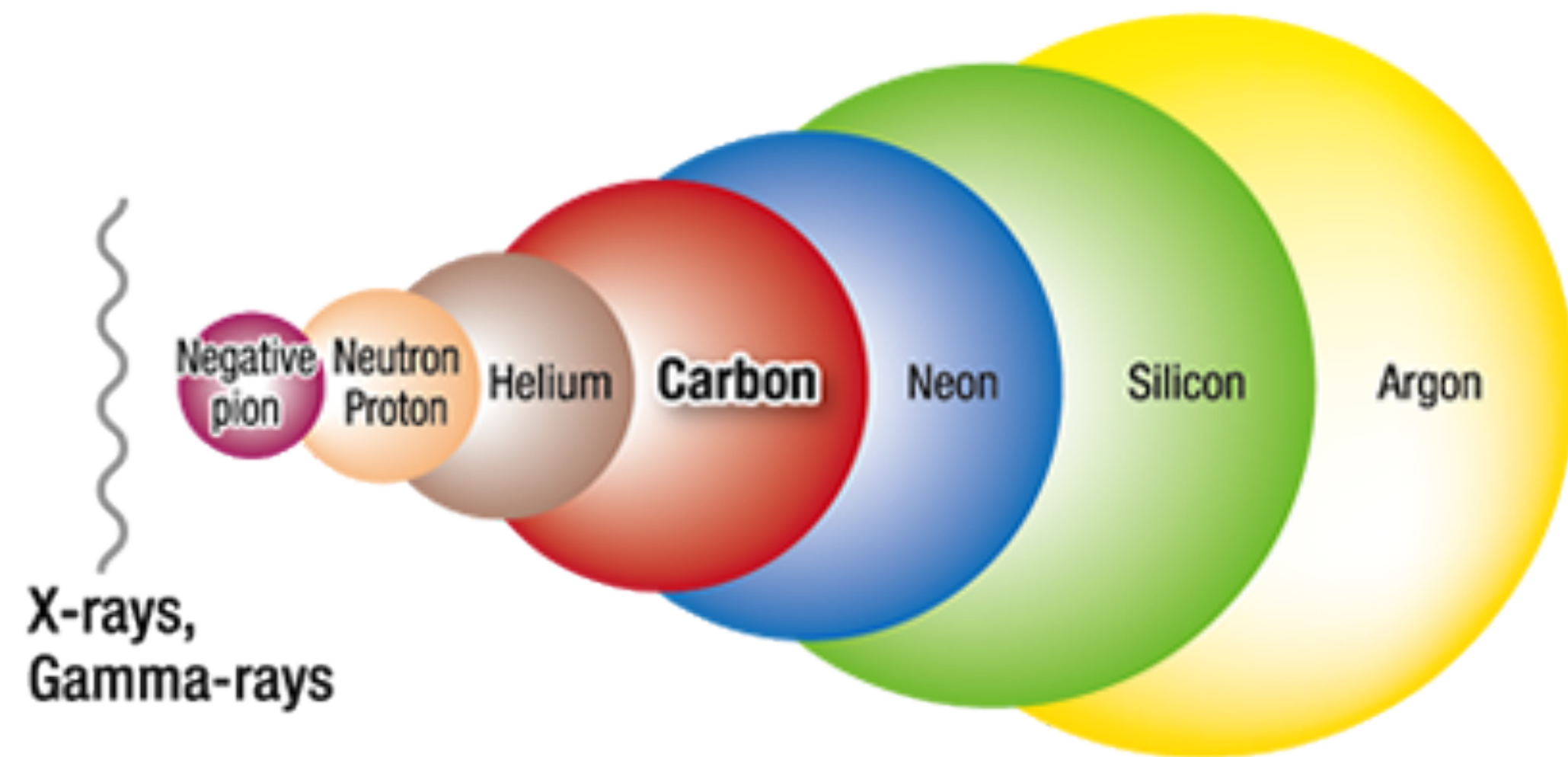


Time Evolution of Defects Comparable Duration of Thermal Spikes

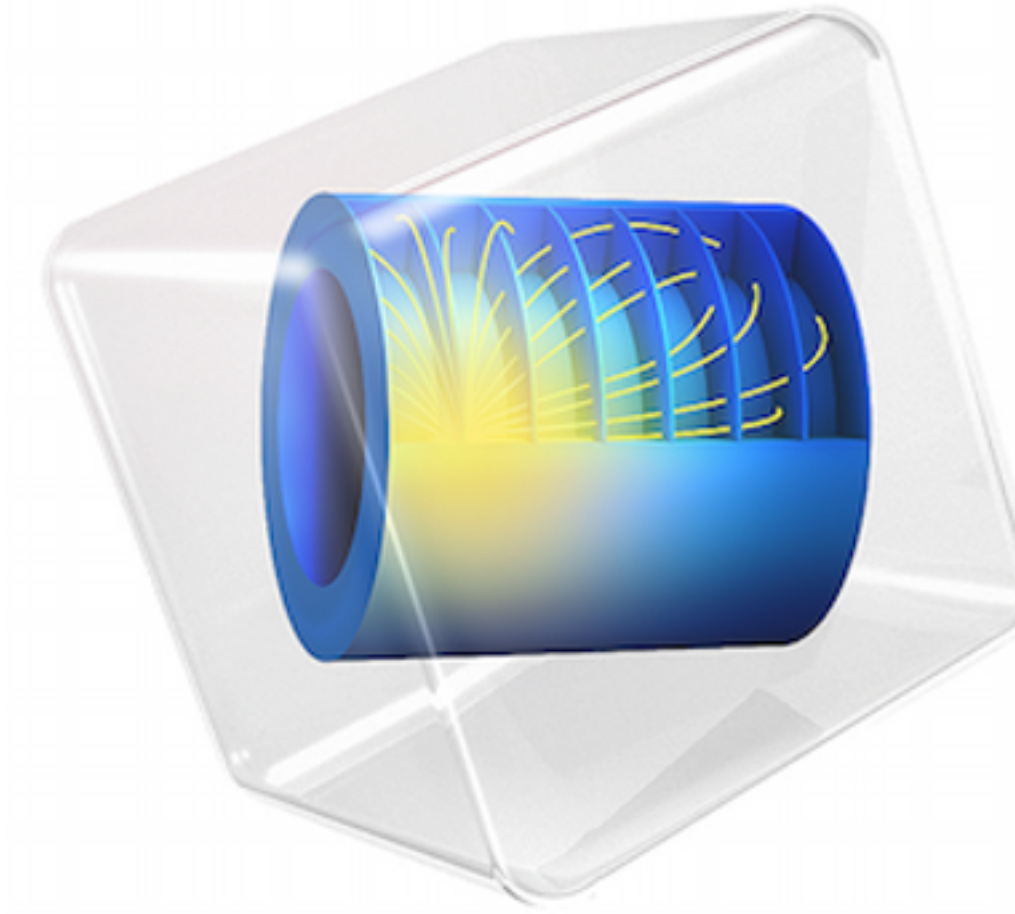
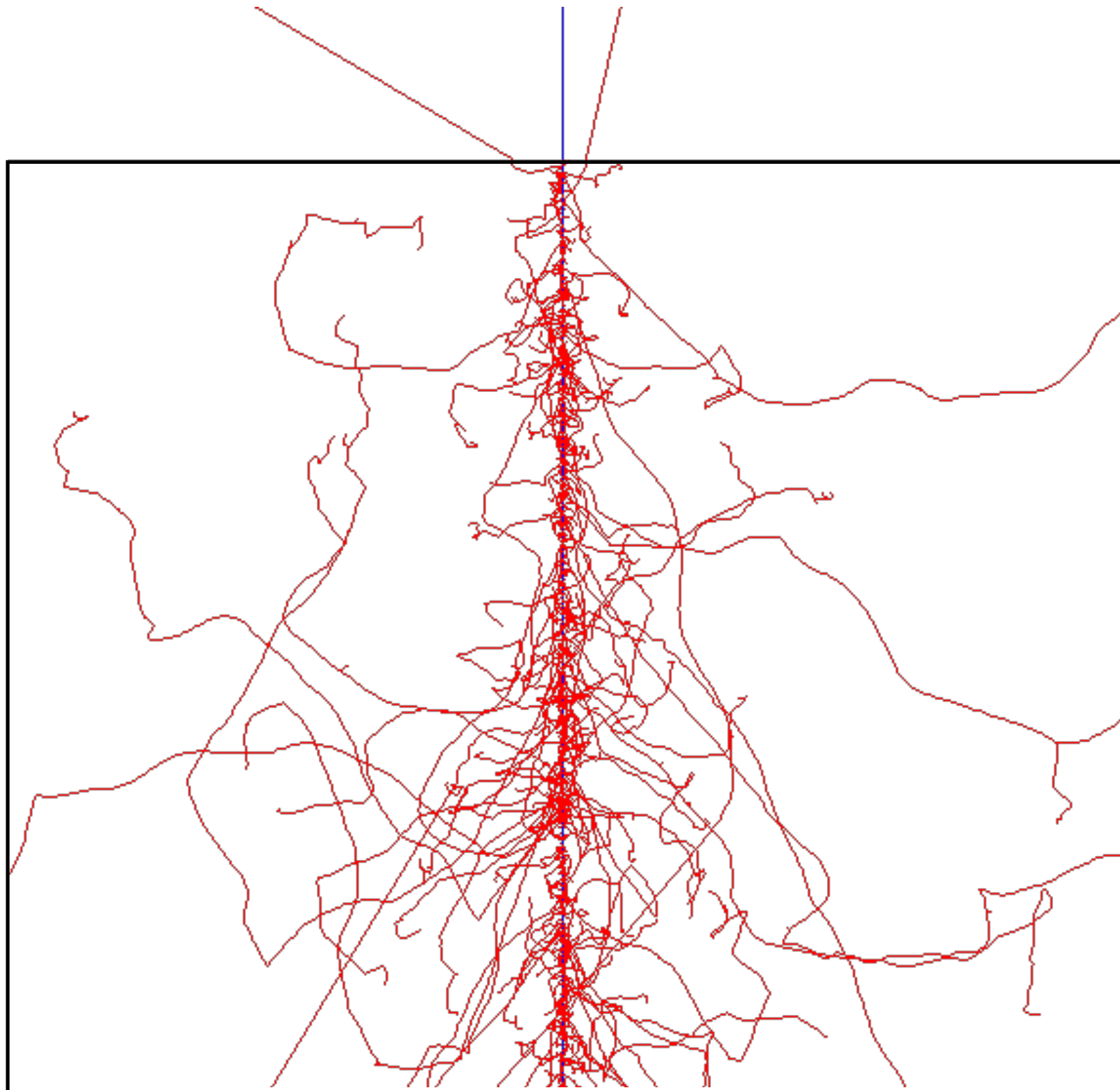


- Tang, D., Martin-Bragado, I., He, C., Zang, H., Xiong, C., Li, Y., ... Zhang, J. (2016). Time dependent modeling of single particle displacement damage in silicon devices. *Microelectronics Reliability*, 60, 25–32. <http://doi.org/10.1016/j.microrel.2016.03.004>
- A. Benyagoub, "Irradiation effects induced in silicon carbide by low and high energy ions," Nucl. Instruments Methods Phys. Res. Sect. B Beam Interact. with Mater. Atoms, vol. 266, no. 12–13, pp. 2766–2771, 2008.

GOAL: To Simulate SETs and Thermal Spikes



GEANT4 OUTPUT —> COMSOL

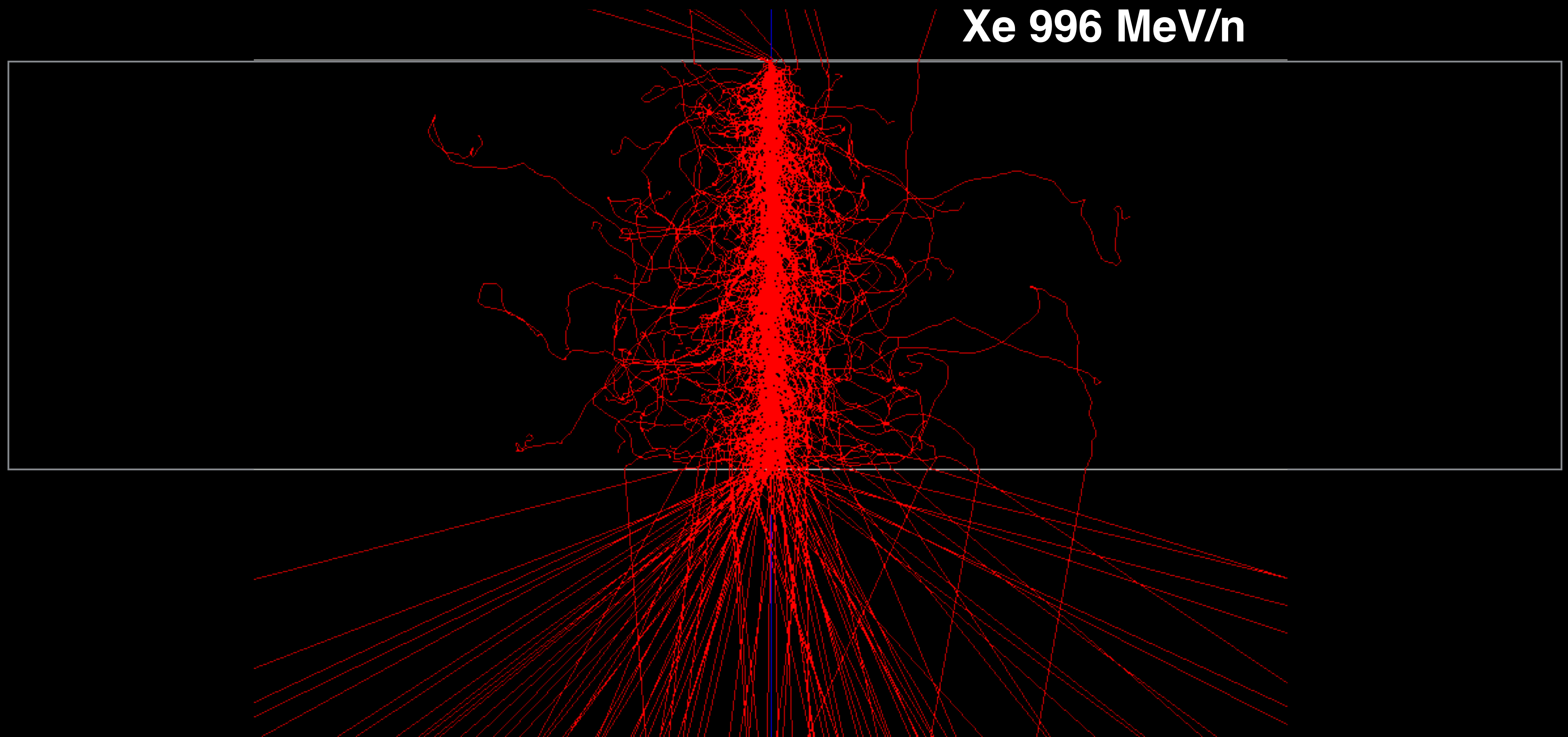


Semiconductor
Module

Heat Transfer
Module

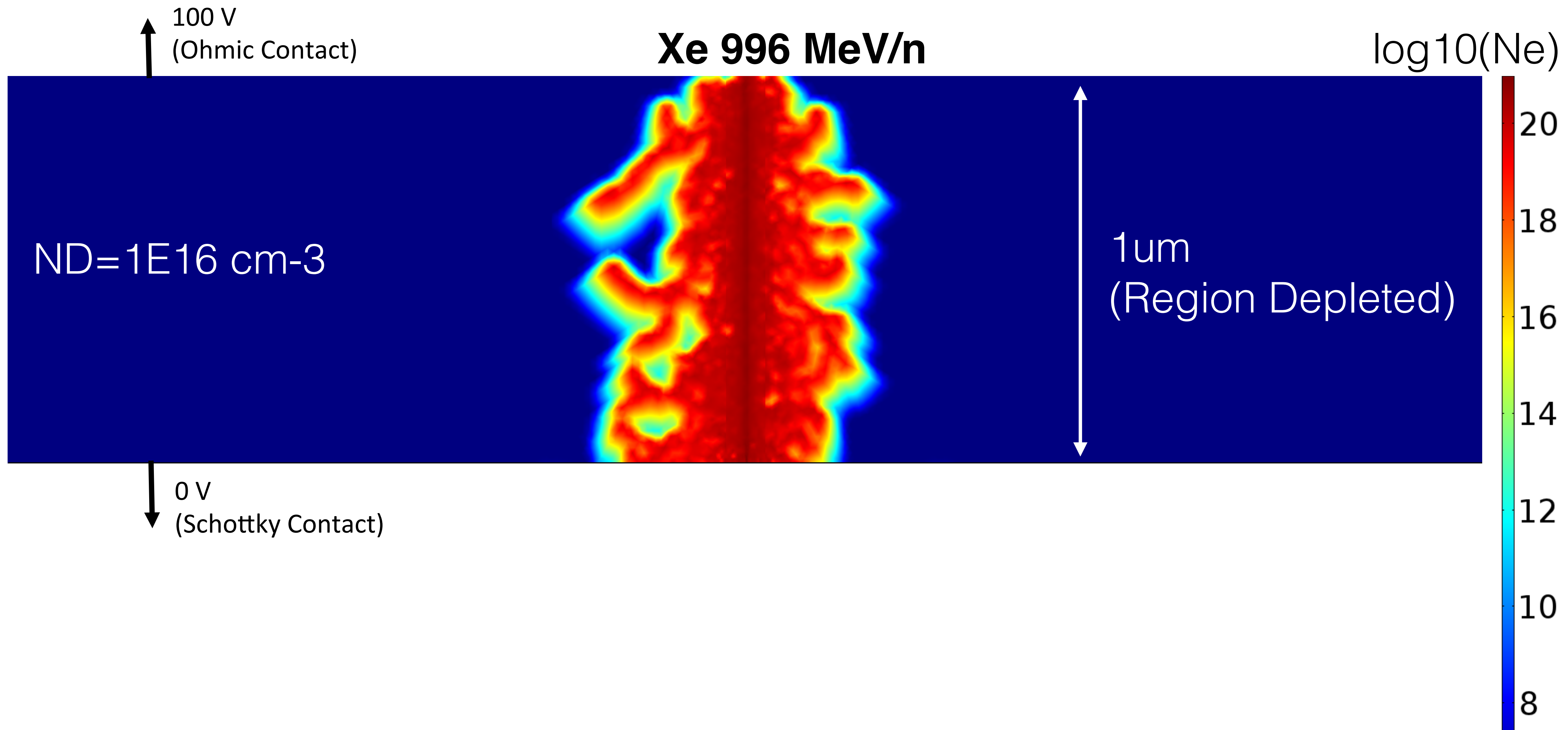
LiveLink™
for MATLAB®

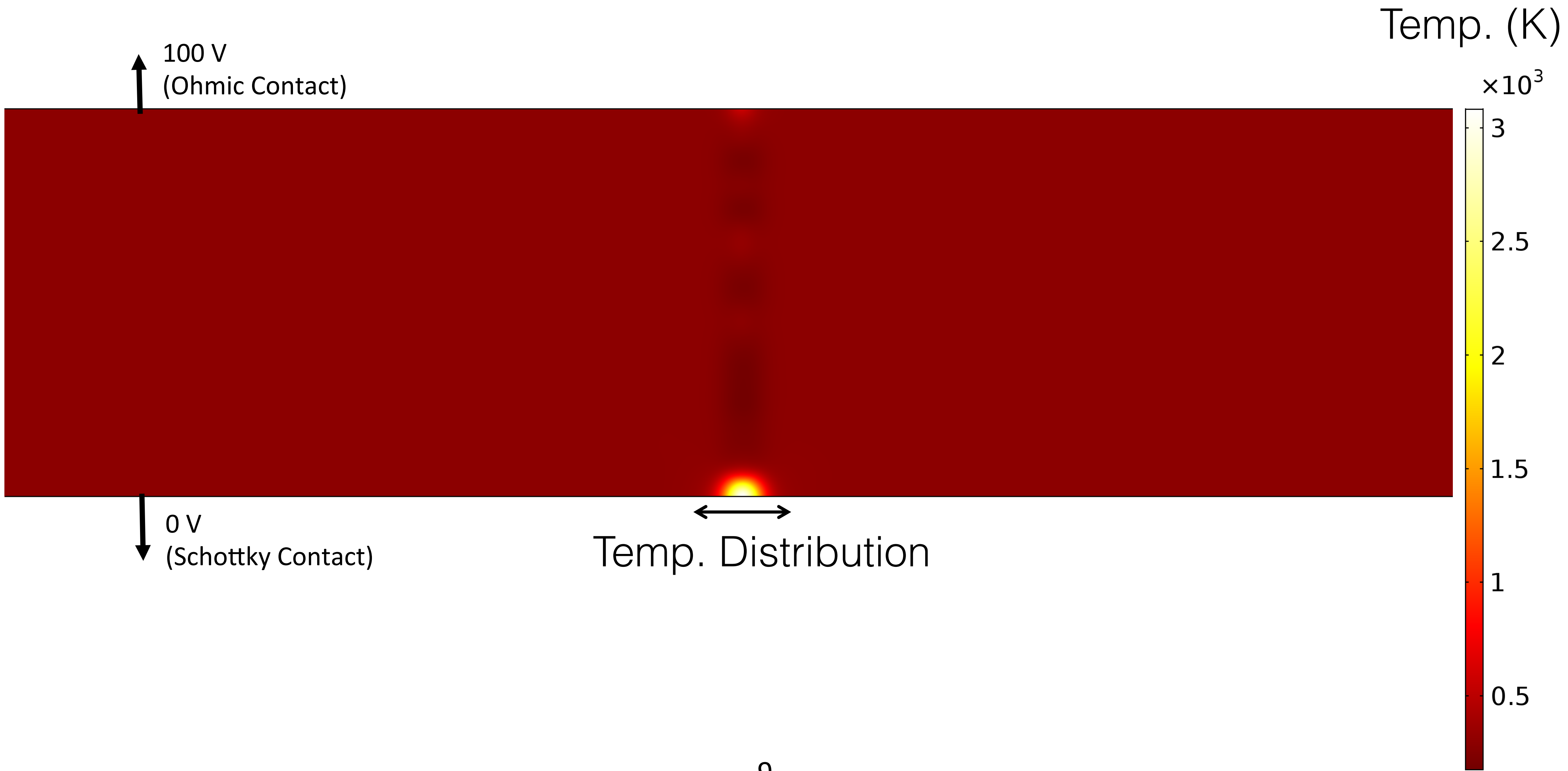
Example: 4H-SiC Schottky Diode

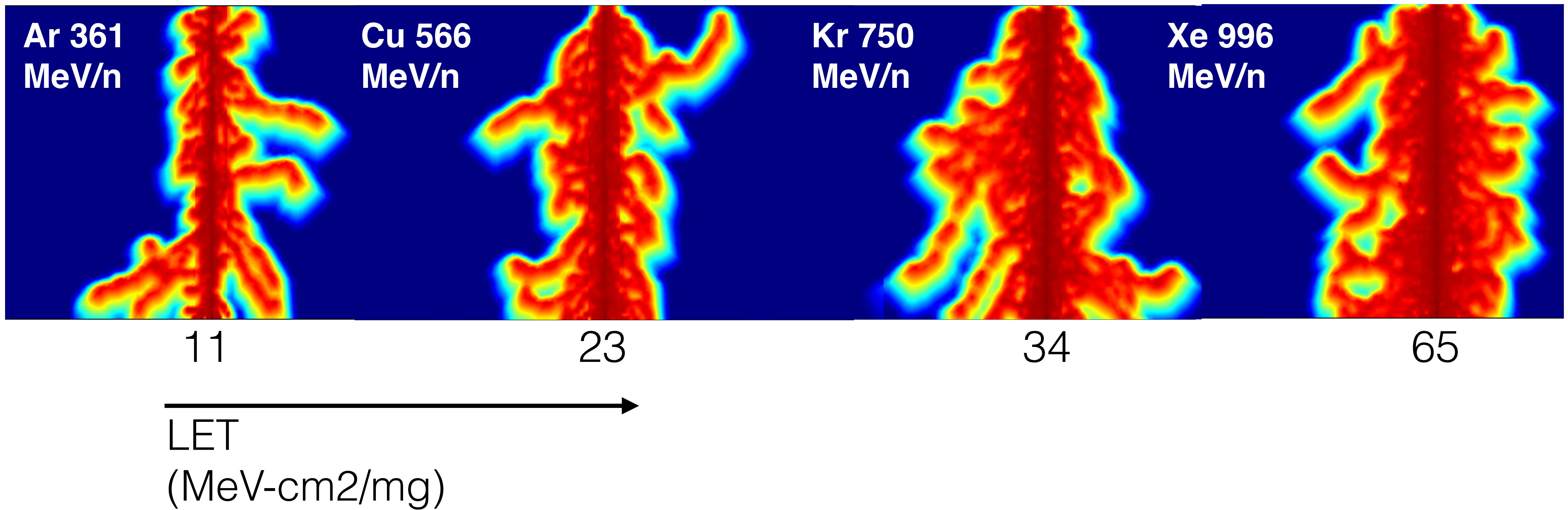


Example: 4H-SiC Schottky Diode

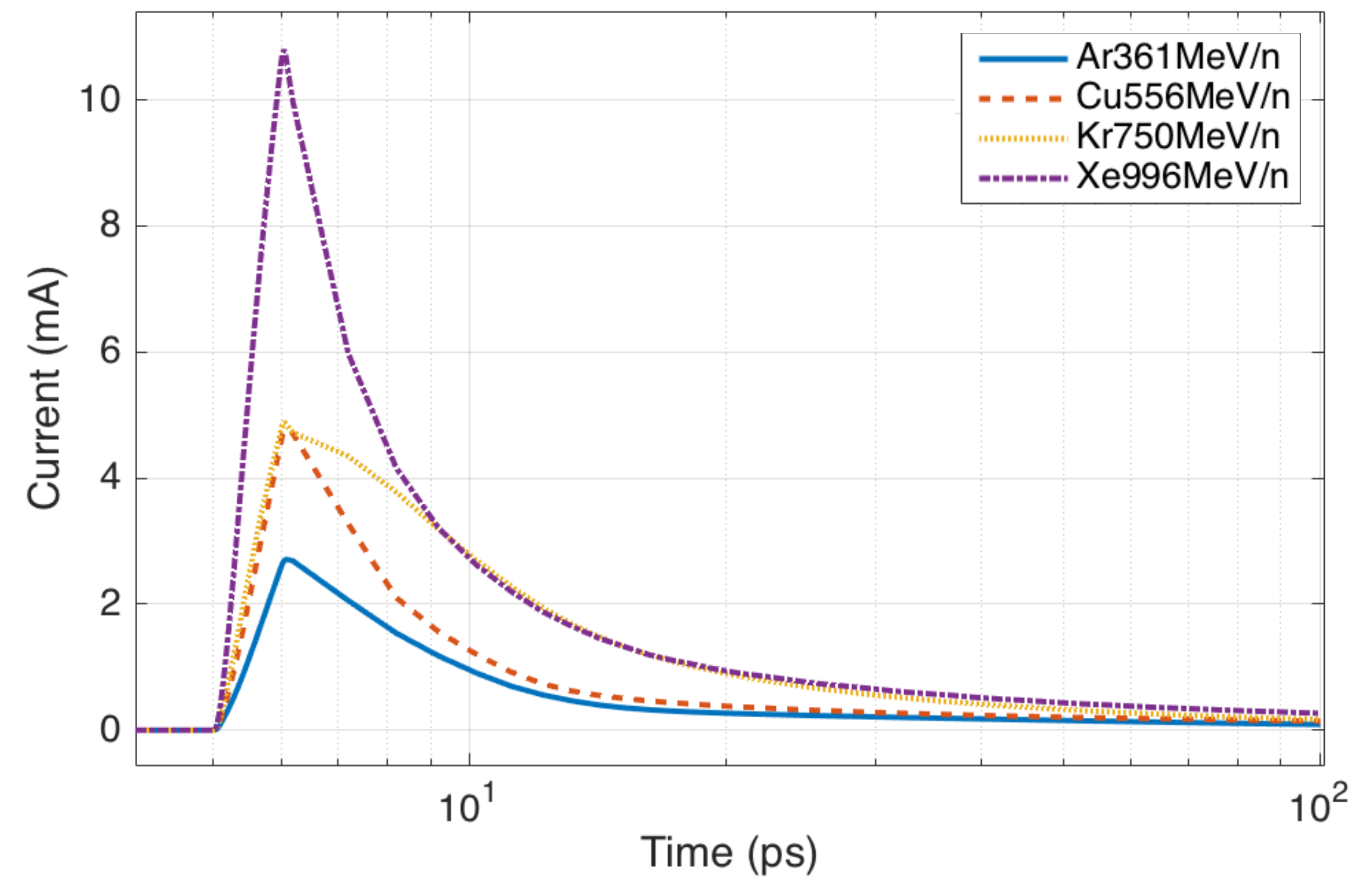
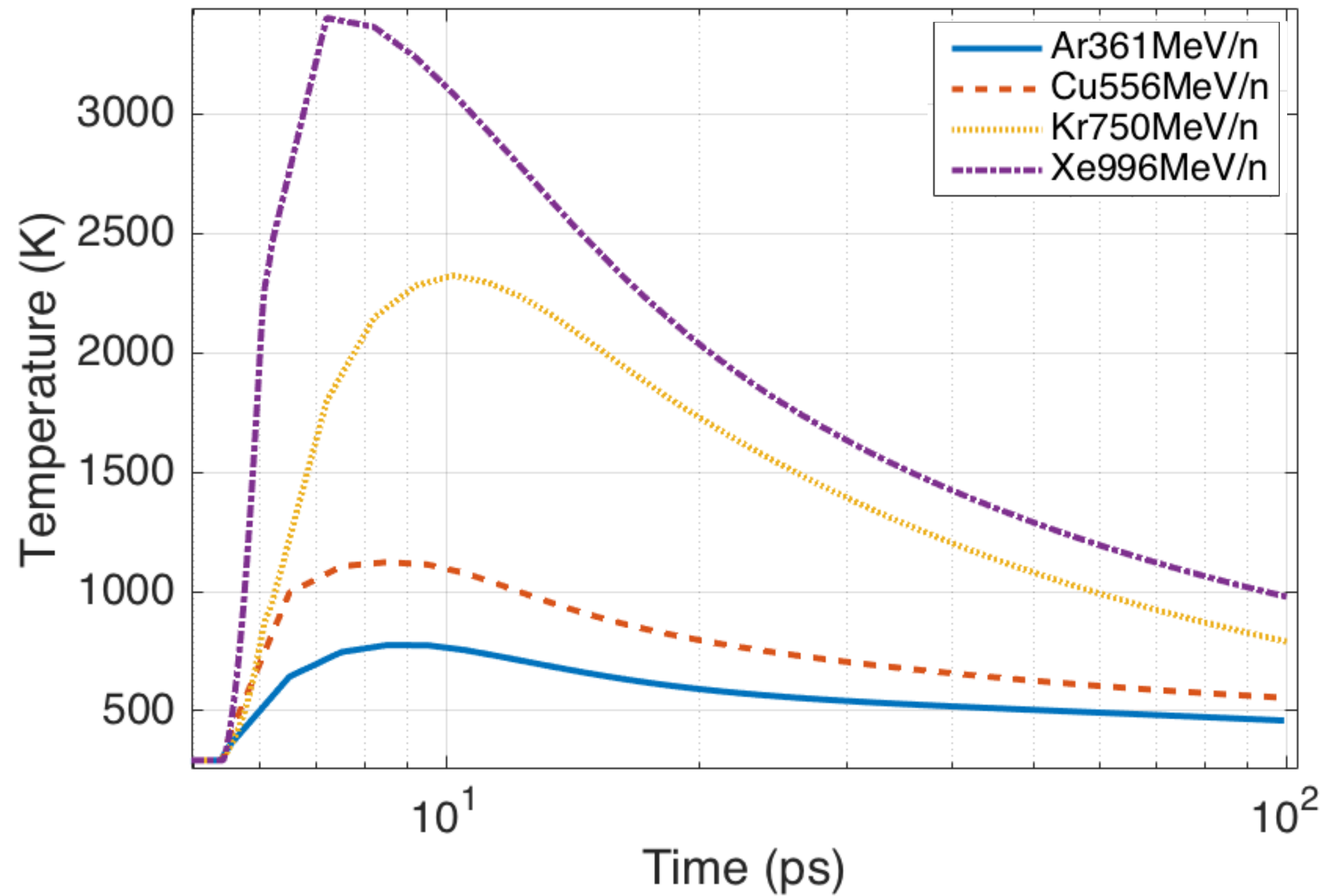




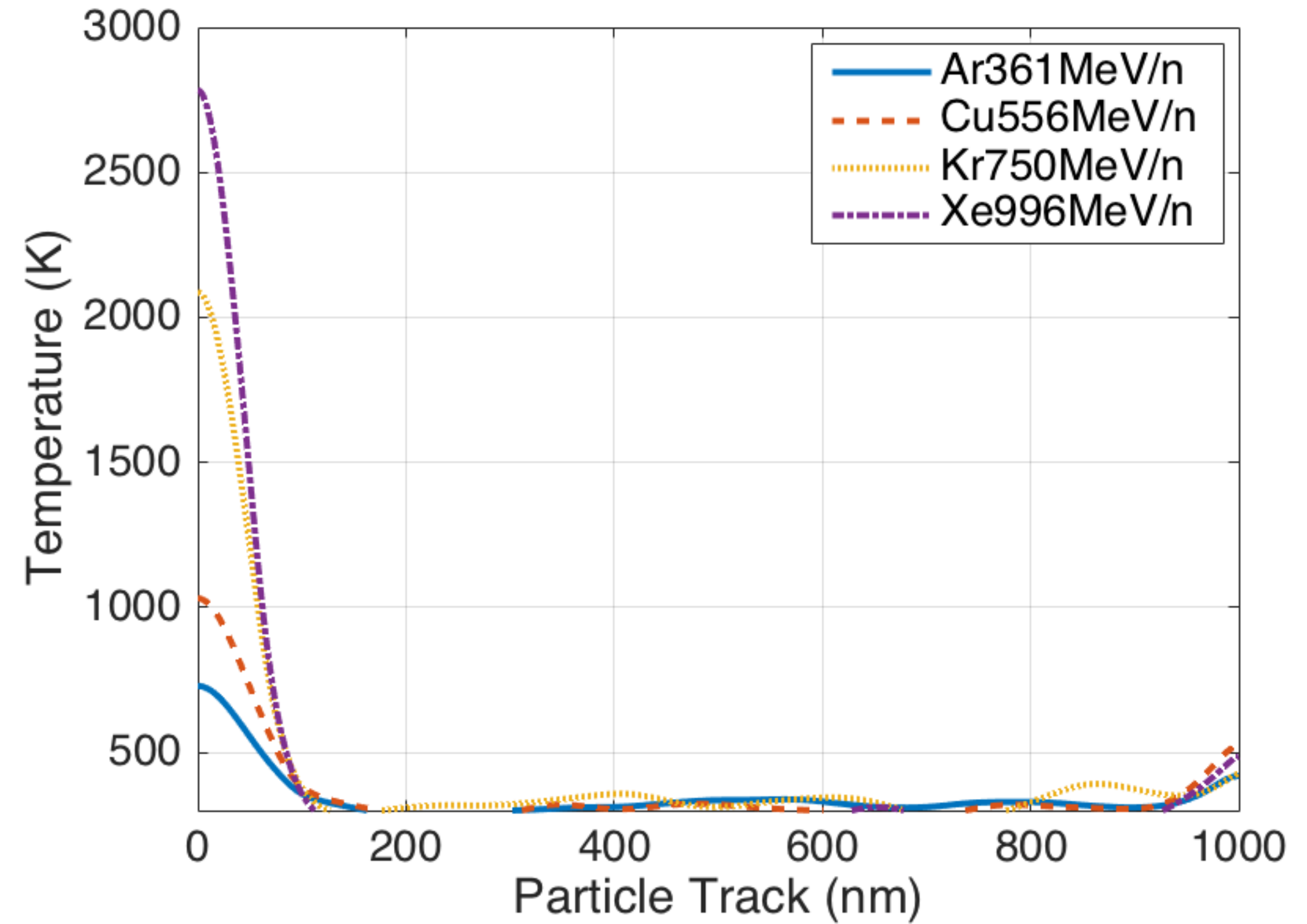
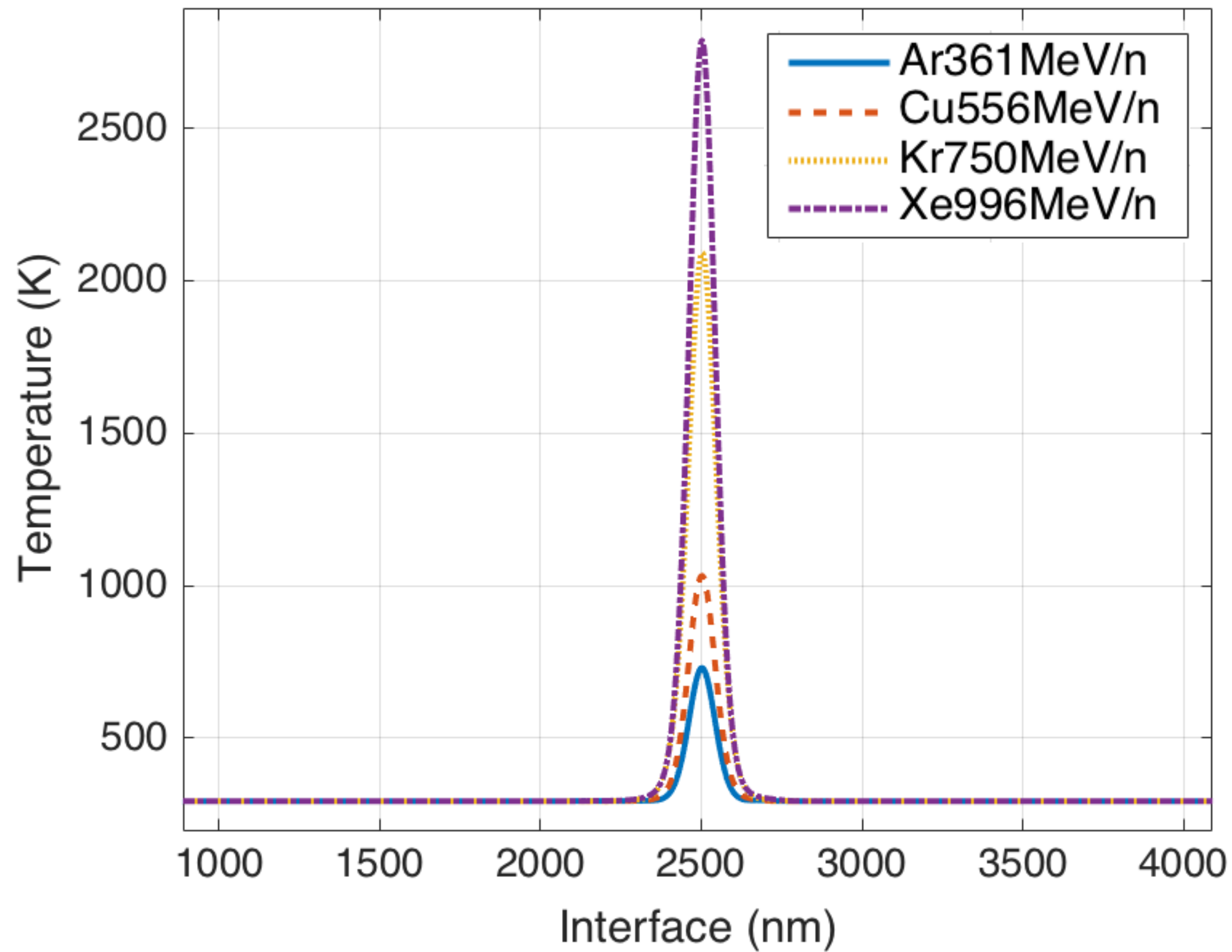




Current & Temperature vs. Time



Temperature along Particle Track & Interface

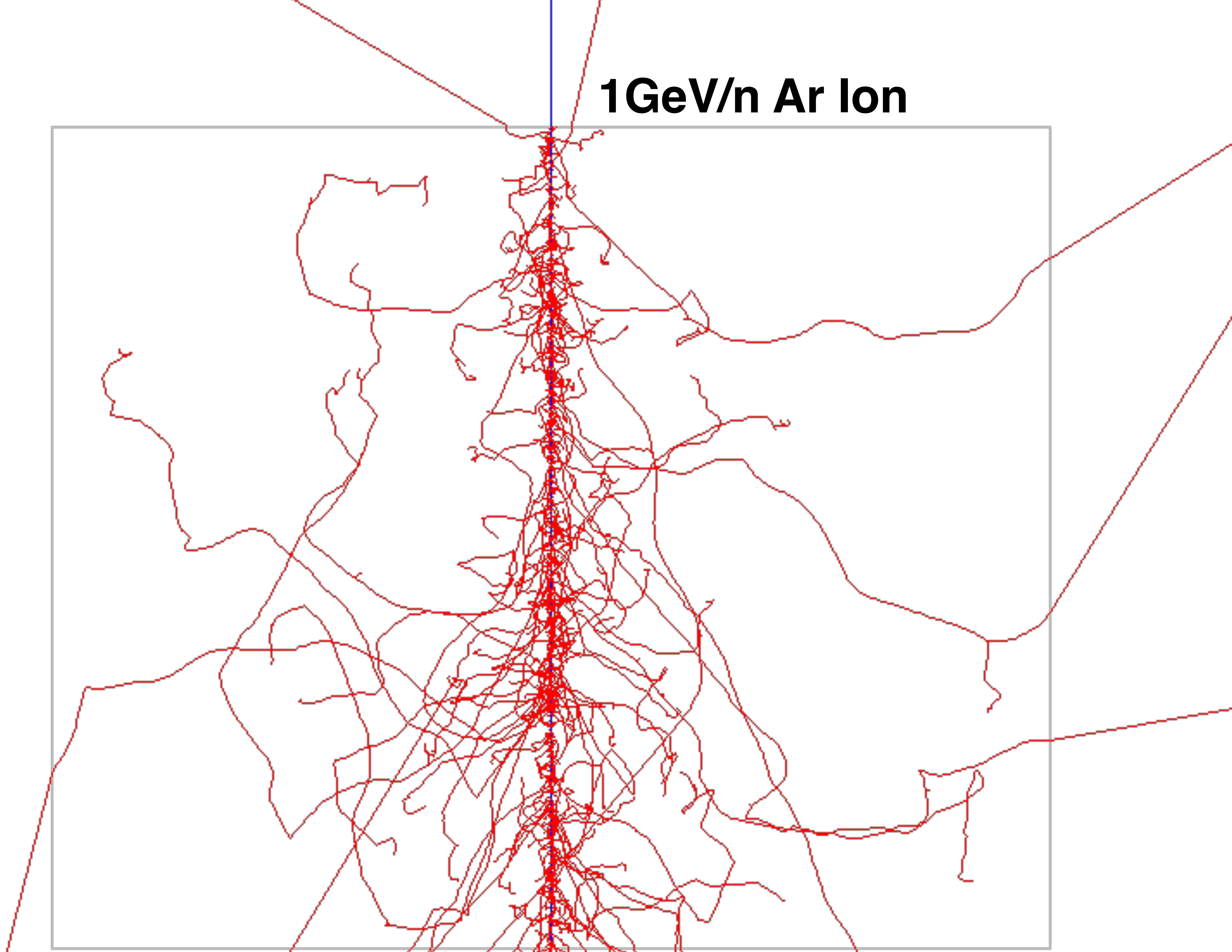


t ~ 10 ps

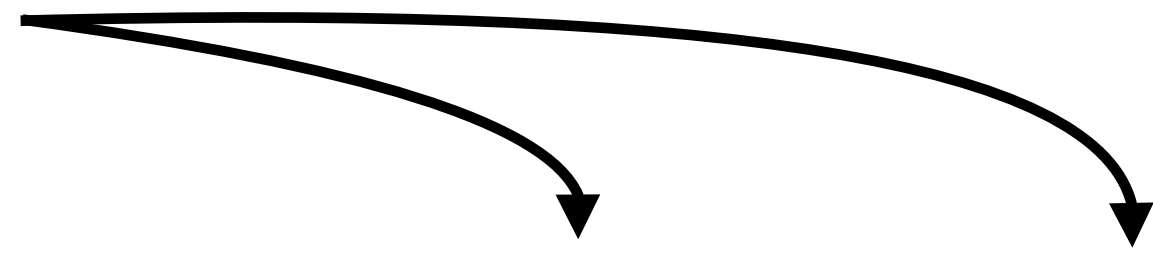
Extending Framework to Other Applications

1 GeV/n Ar Ion

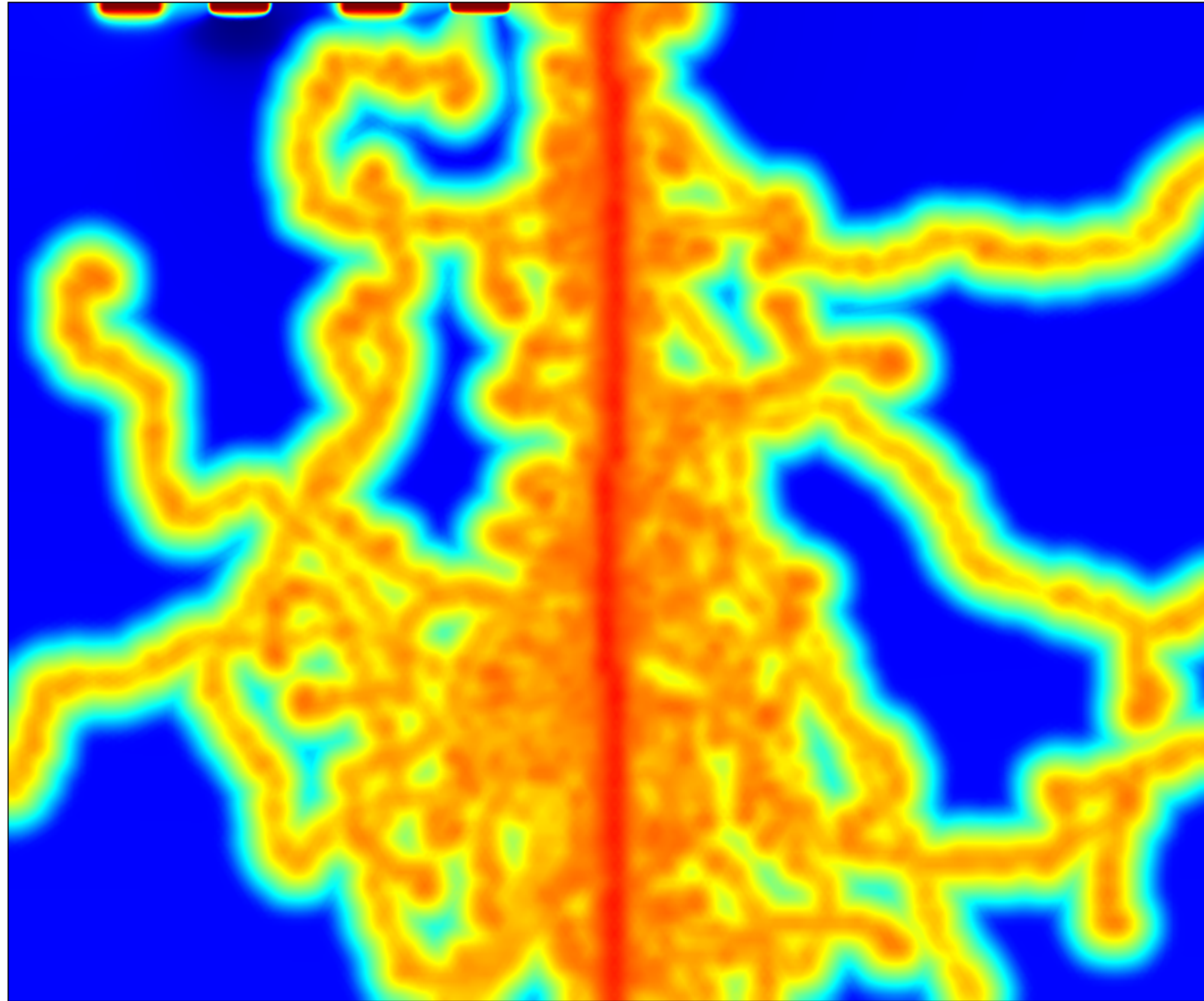
12um



MOSFETs



12um

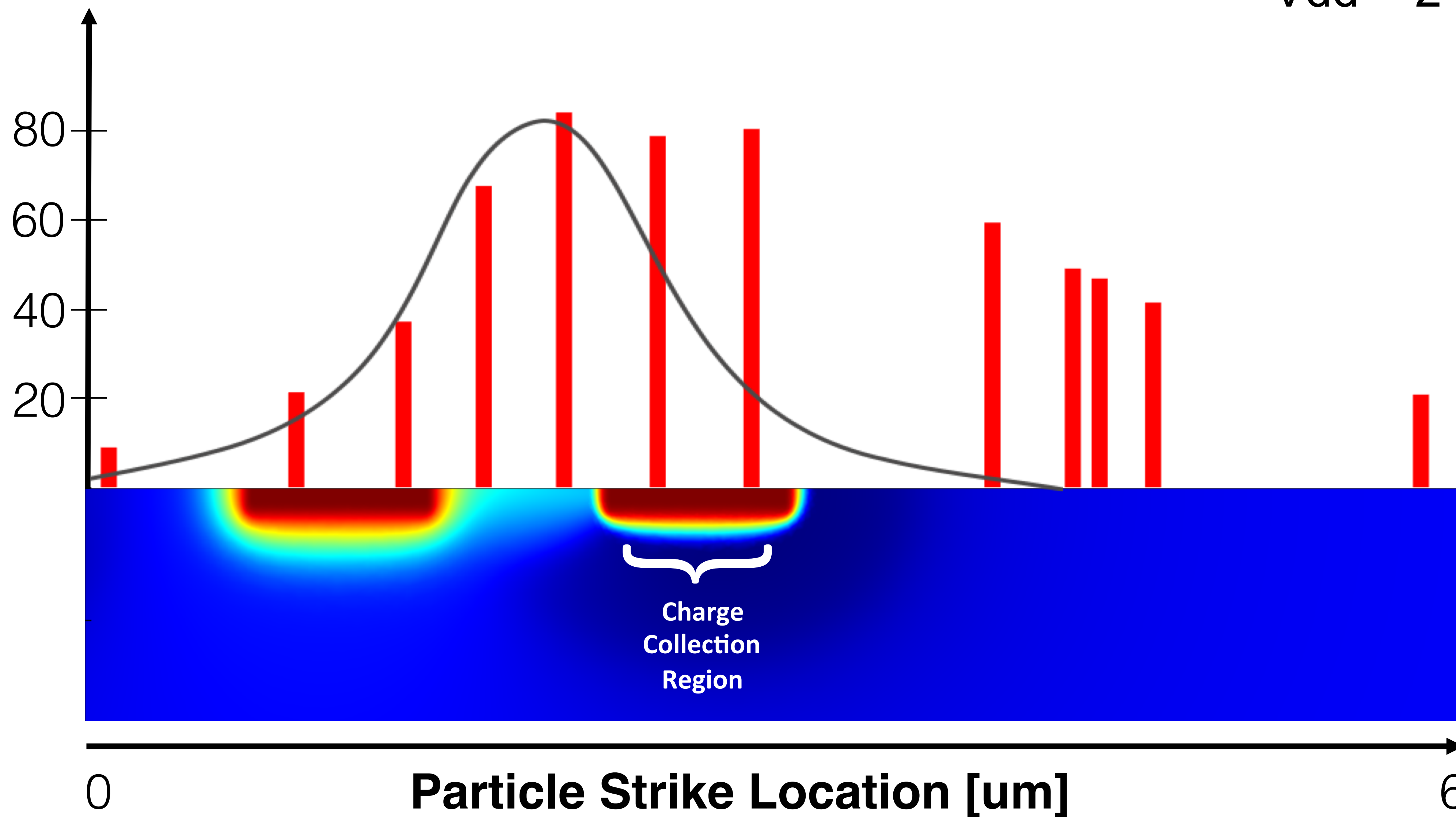


**Charge Collected [fC]
@ Drain**

1 GeV/n Ar Strike

$V_{gs} = 0 \text{ V}$

$V_{dd} = 2 \text{ V}$



INTEGRATION WITH COMSOL'S APPLICATION BUILDER


GEANT4 CSV File

STRIKE PARAMETERS

X-Shift um
Y-Shift um
Rotate Deg

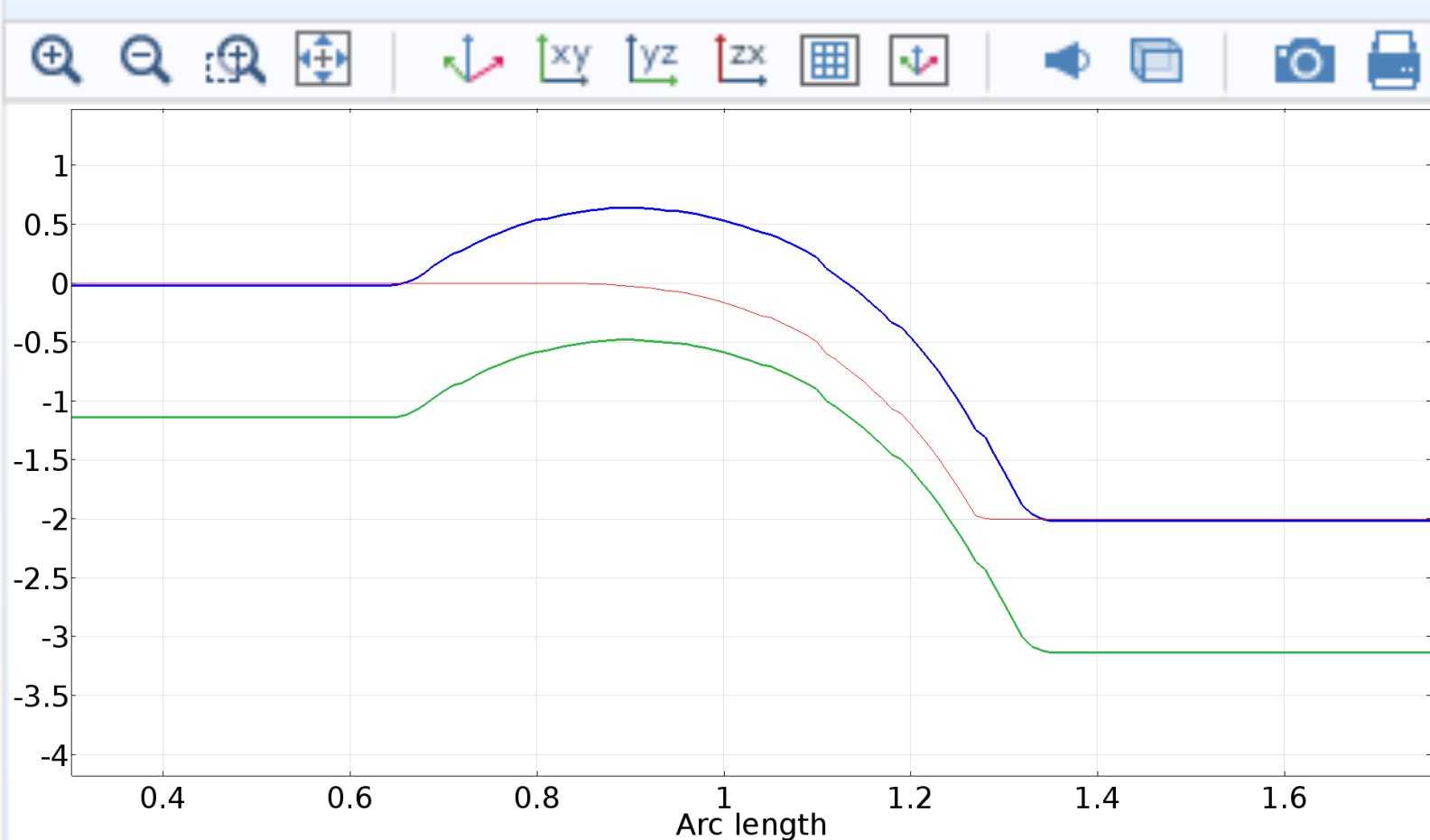
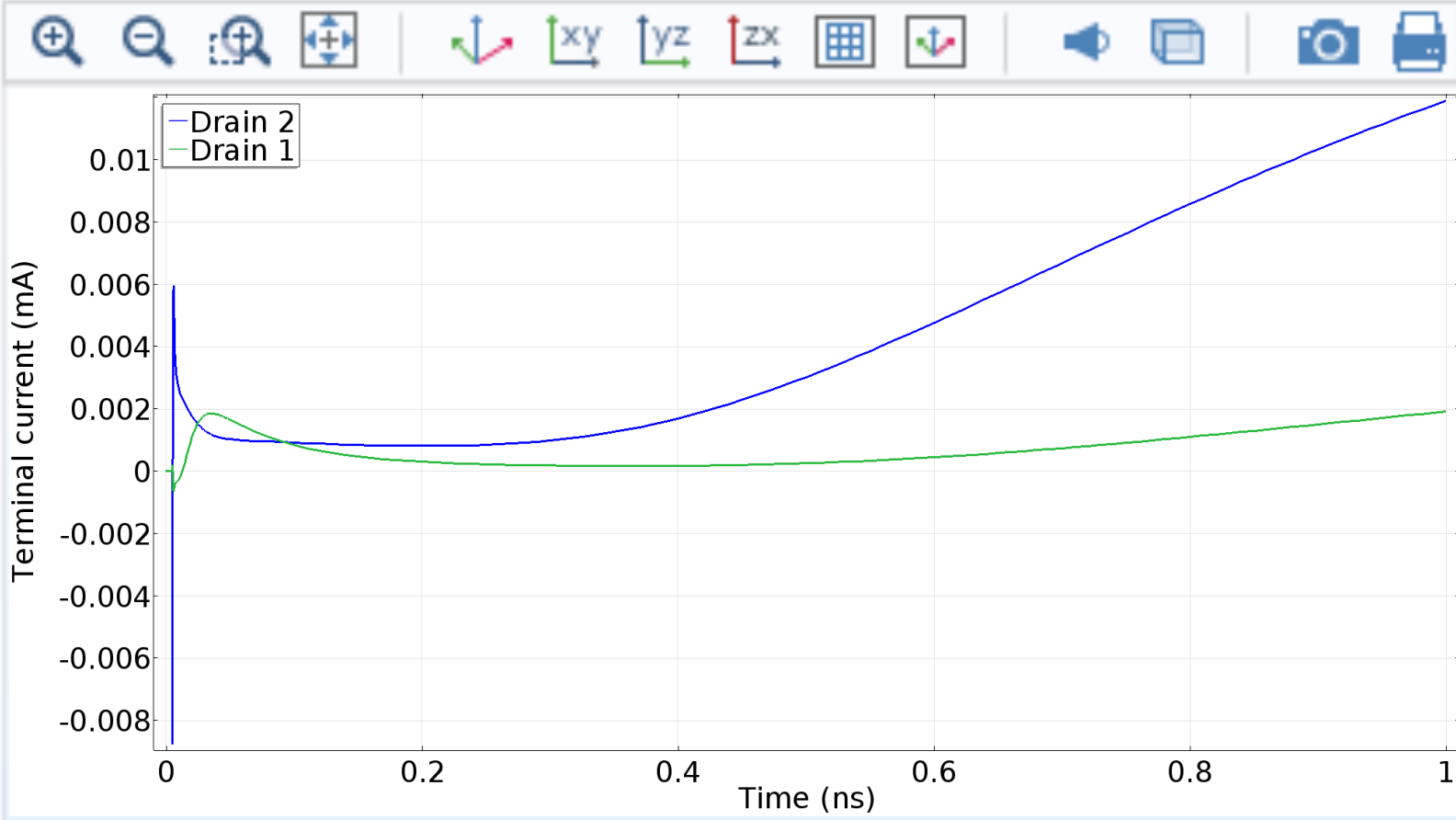
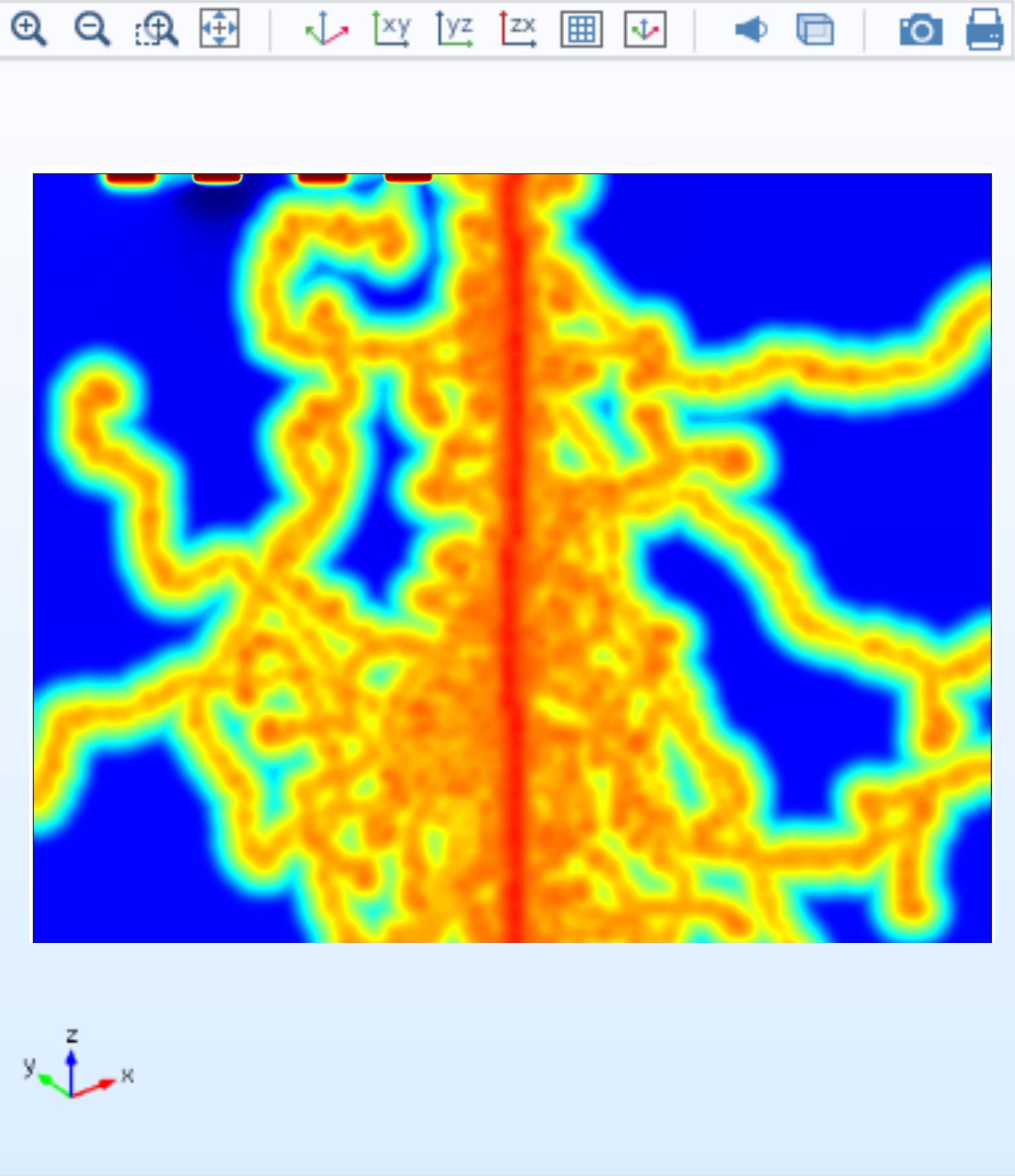

Import G4
Data

Duration: ps
VGS: V
VDD: V
VSS: V


Compute







IMPORT 1D PLOT


ADD PLOT TO
FIGURE









1D PLOT

Line
x1 um
y1 um
x2 um
y2 um

 Electric Field	 Temperature	 Max Temp vs. Time
 eCharge	 Electric Potential	 Band Diagram

2D SURFACE PLOT

 Electron Concentration	 Temperature	 Power Density
 Hole Concentration	 Electric Field	 Electric Potential

Thank You