Adaptation of GEANT4 for Single Event Simulations

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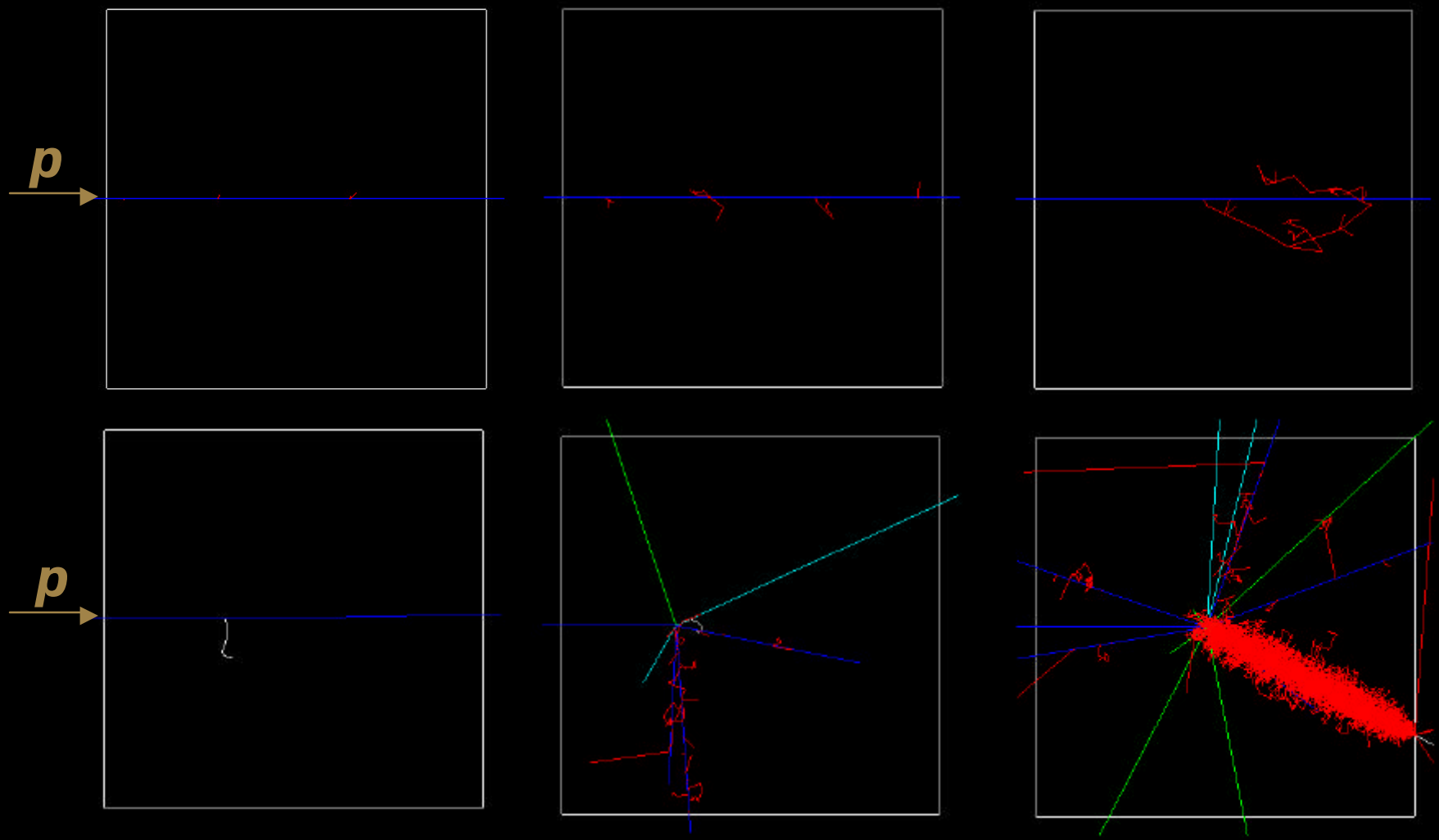
Overview

- What is GEANT4?
- Why use it?
- What is our strategy?
- How is the strategy implemented?
- What is the result?
- Summary (Current)
- What is next?

GEANT4? A Simulation Toolkit…

S. Agostinelli et al. “Geant4 - a simulation toolkit, ” Nucl. Instr. Meth. A506 (2003) 250.



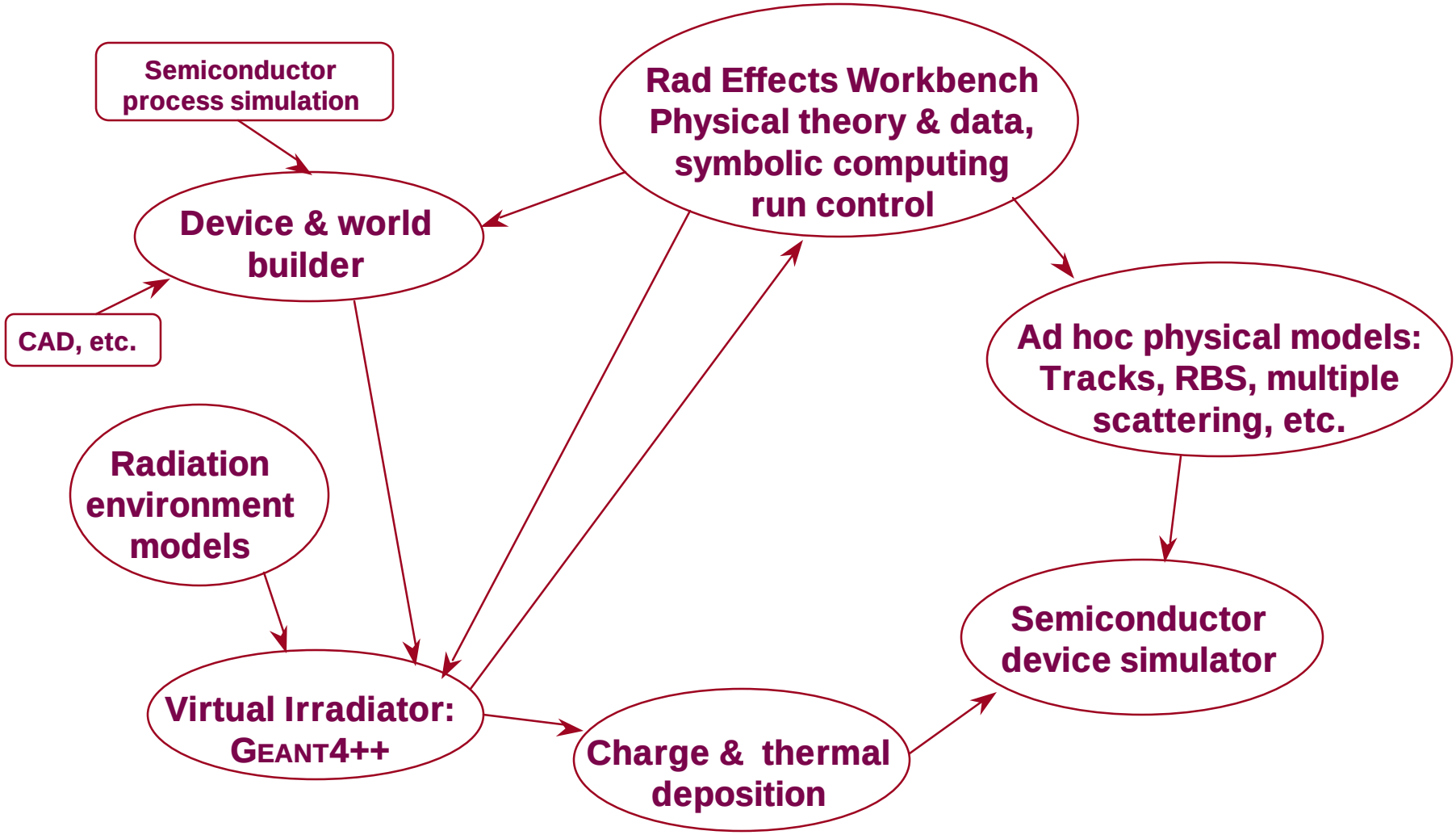
100 MeV protons ? 5 µm Si

Why use GEANT4 for radiation effects in electronics?

For an excited system, the average response, is not, in general, the response to the average excitation.

Translation: For very small devices, all events are *single* events.

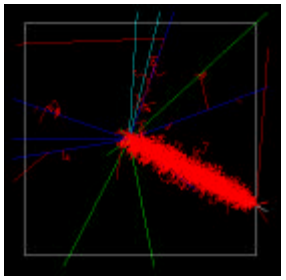
Strategy? The Virtual Rad Lab



Implementation? How it works…

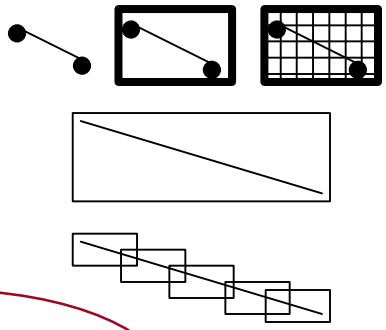
VUmps (GEANT4)

Events



C++ Tools, Scripting

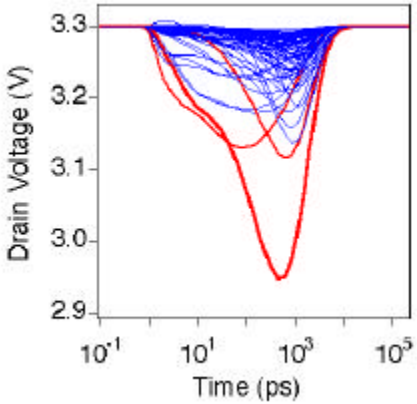
Automatic Meshing

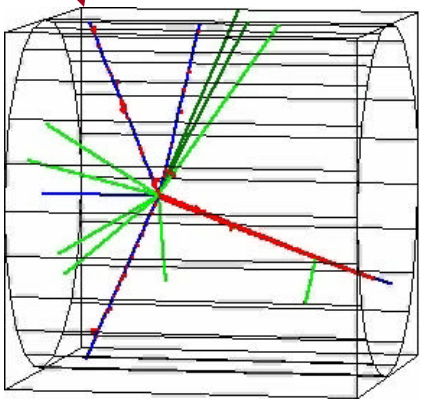


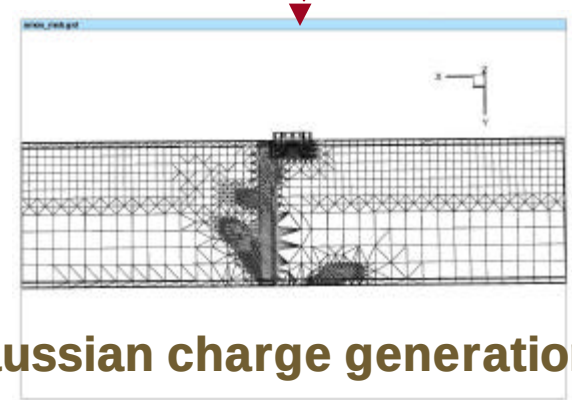
Geometry

Mathematica

ISE TCAD (DESSIS)

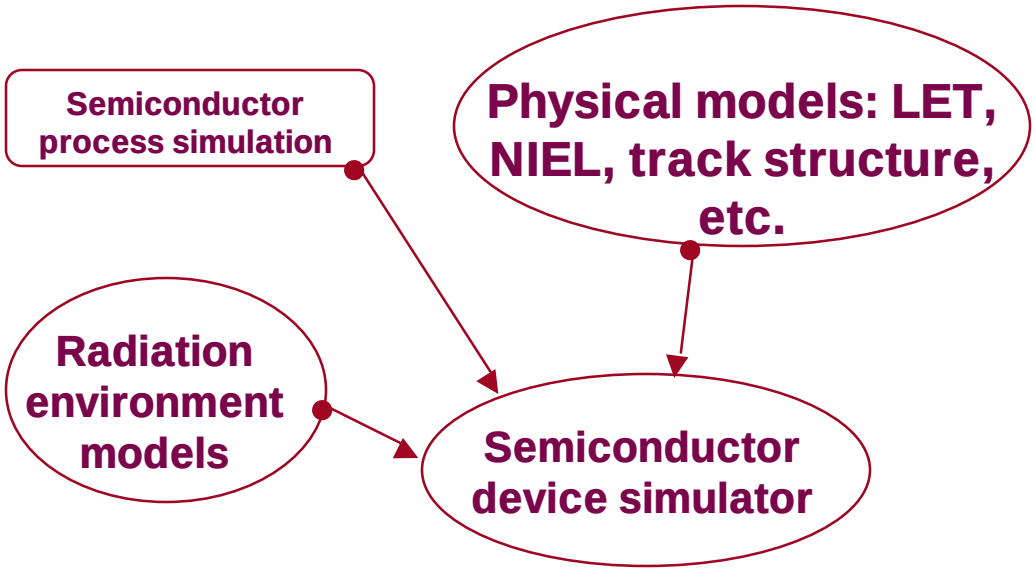


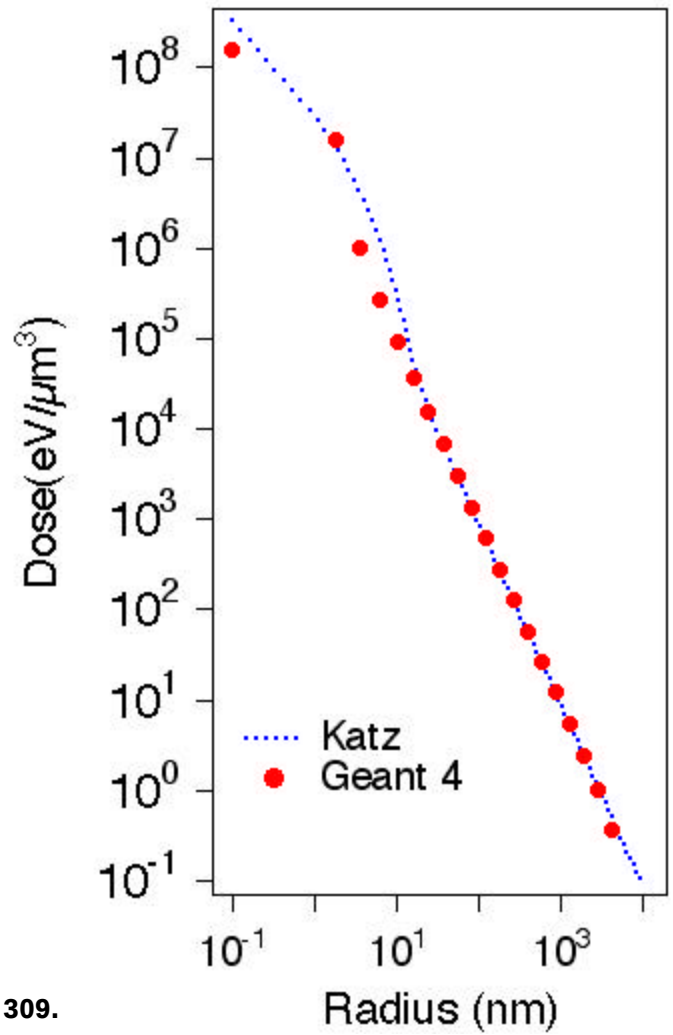




Gaussian charge generation

Result: Radial Track Structure

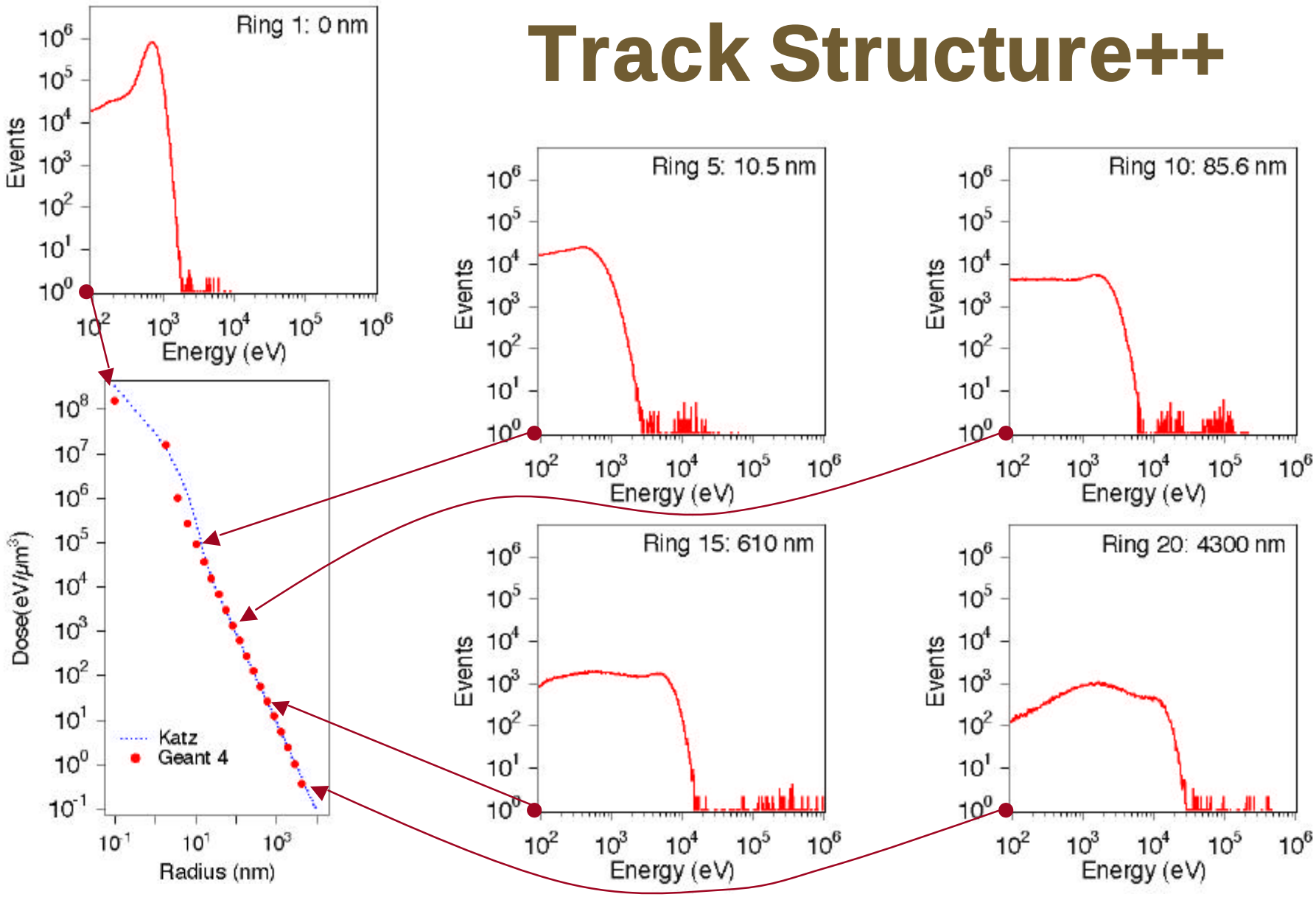




100 MeV protons in Si

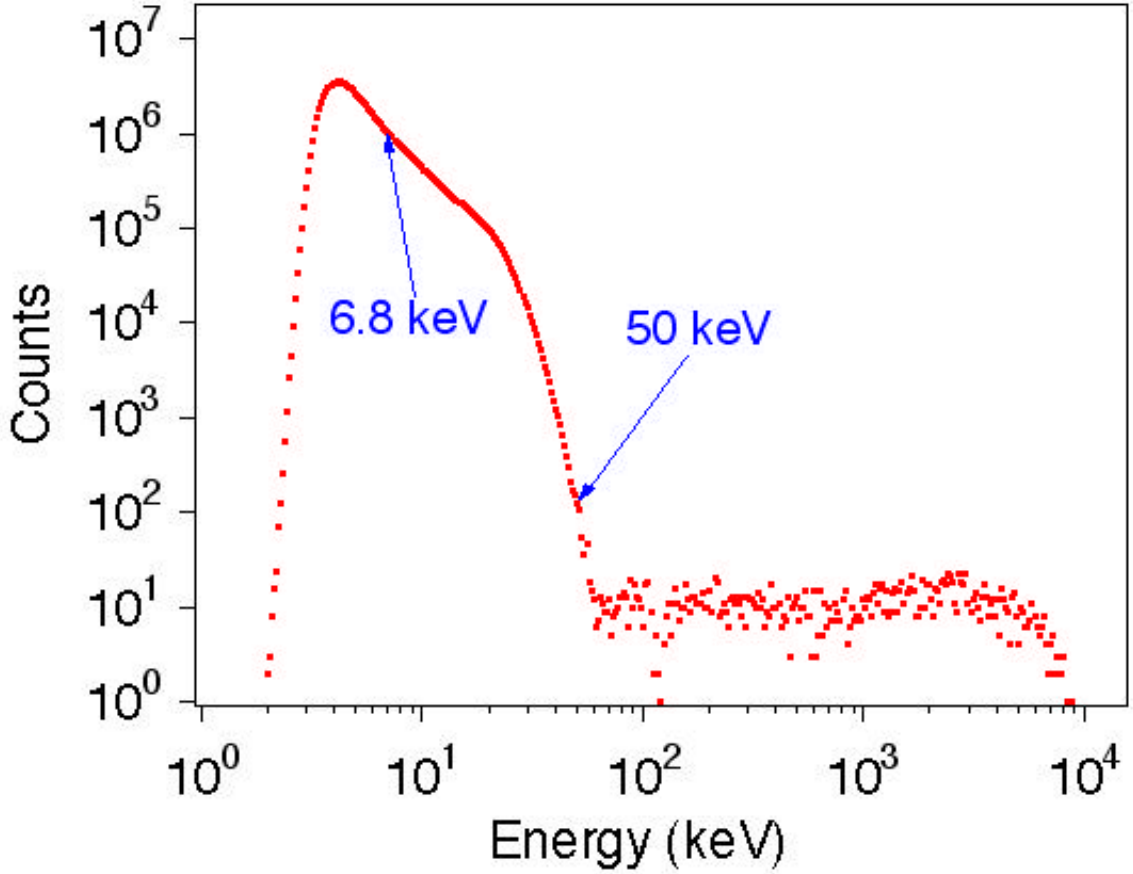
M. P. R. Waligórski, R. N. Hamm & R. Katz, Nucl. Tracks Radiat. Meas. 11 (1986) 309.

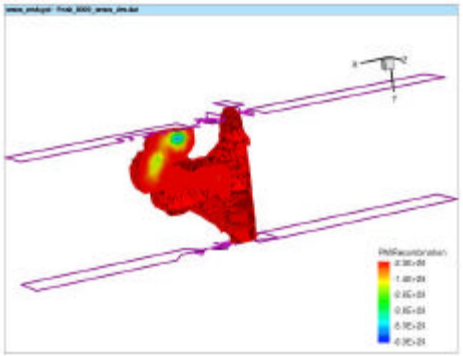
Track Structure++

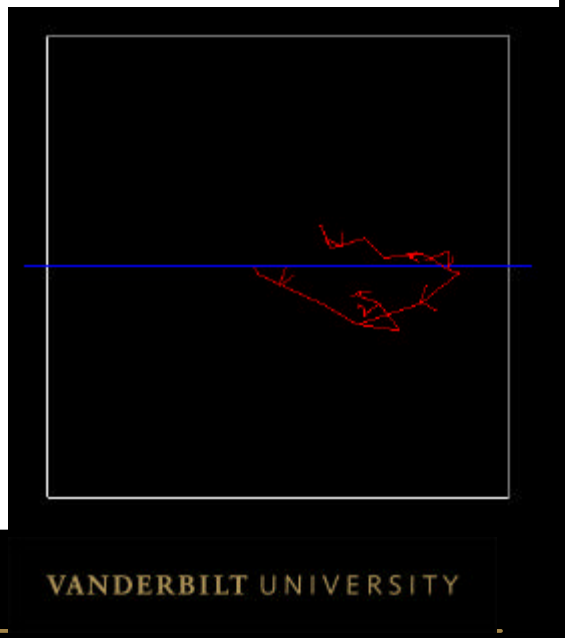


Result: MOS transistor response to energetic ?-ray events

Supply = 3.3 V R_L = 200 k? Biased off

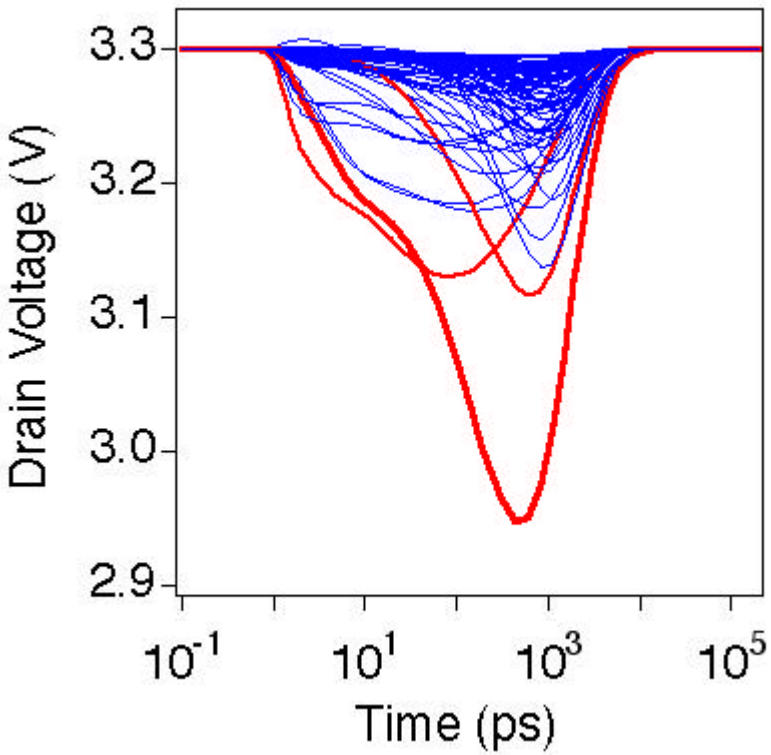




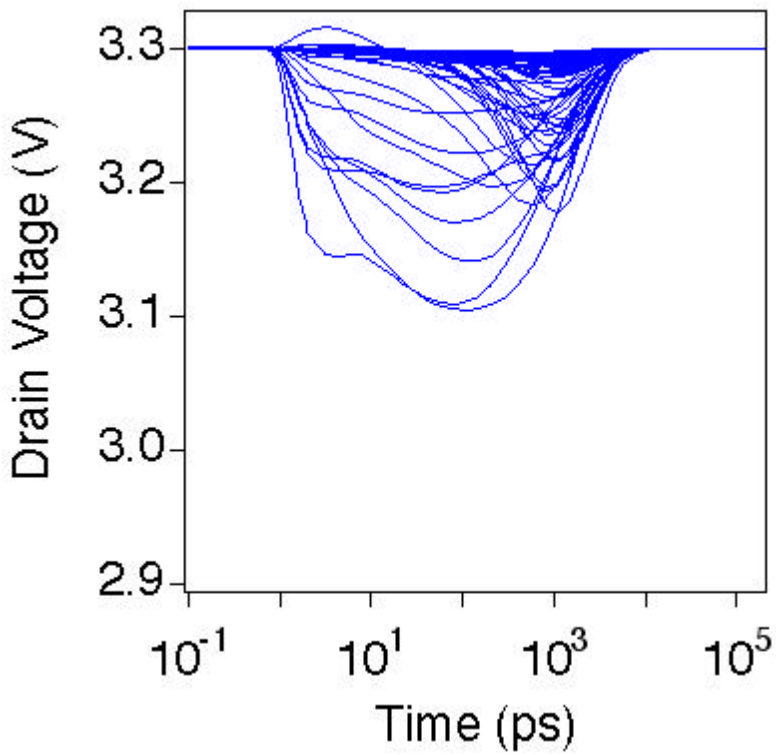


Drain Voltage Pulses

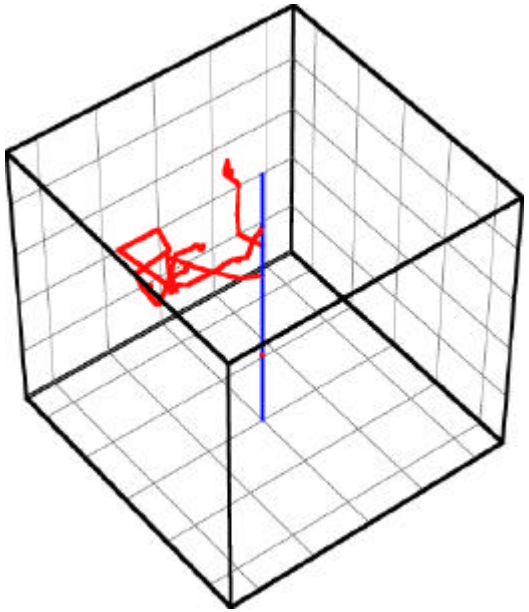
100 MeV protons



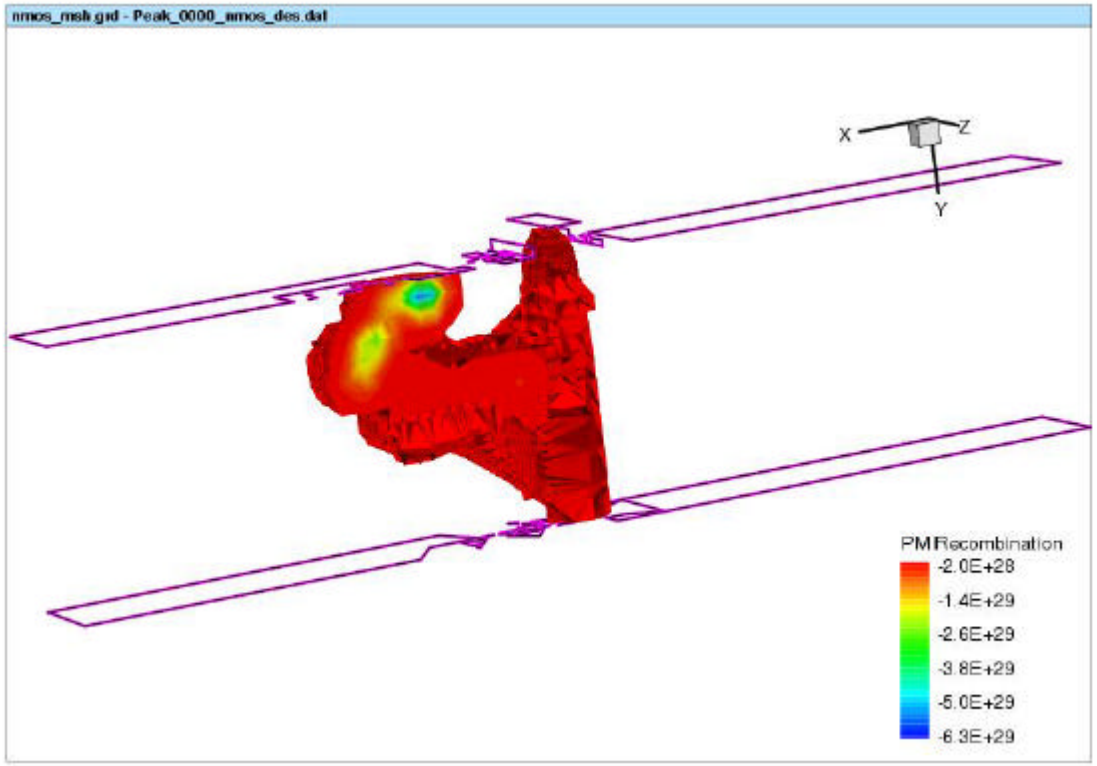
200 MeV protons



The largest event : ~10% V_{DS}



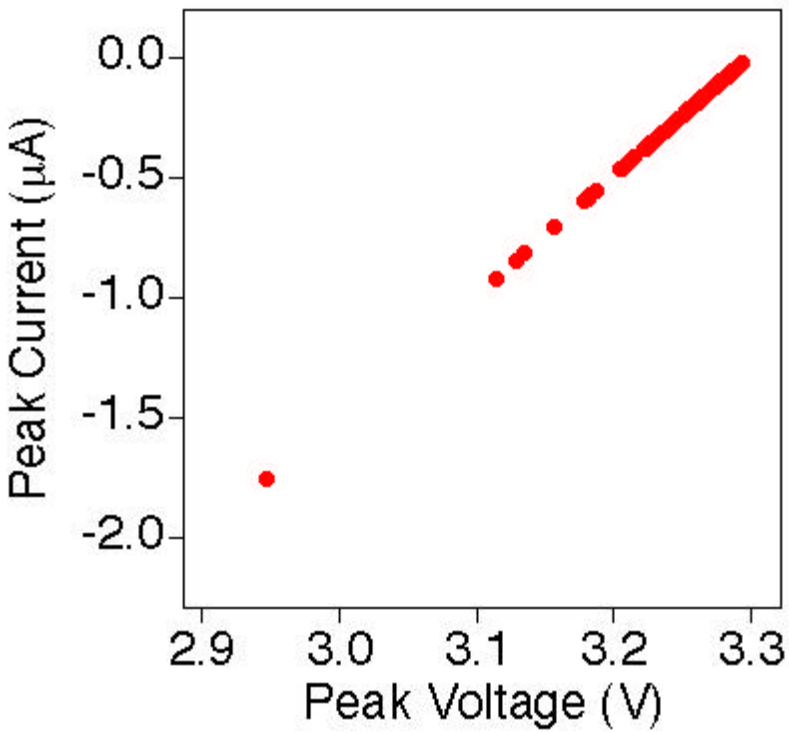
Particle Trajectories
Incident proton: blue
Electrons: red



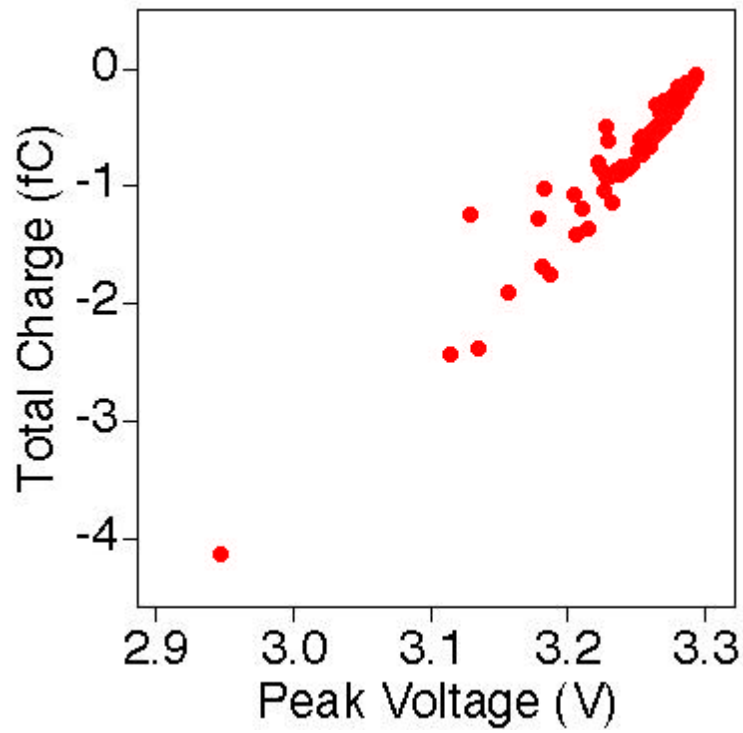
Energy in the transistor: 44.7 keV

Consistency Checks

Derivative = R_L = 200 k?

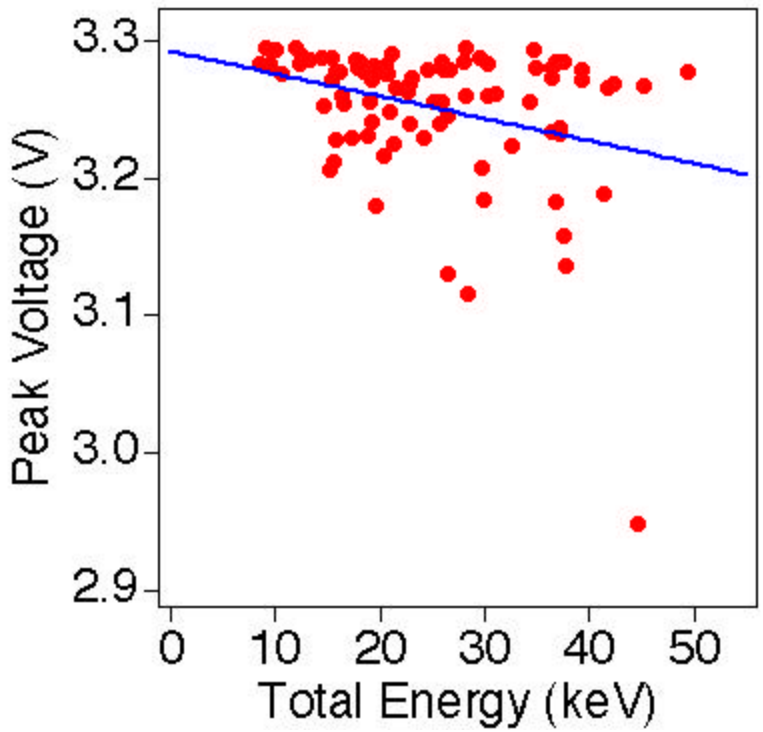


Pulse shape variability!

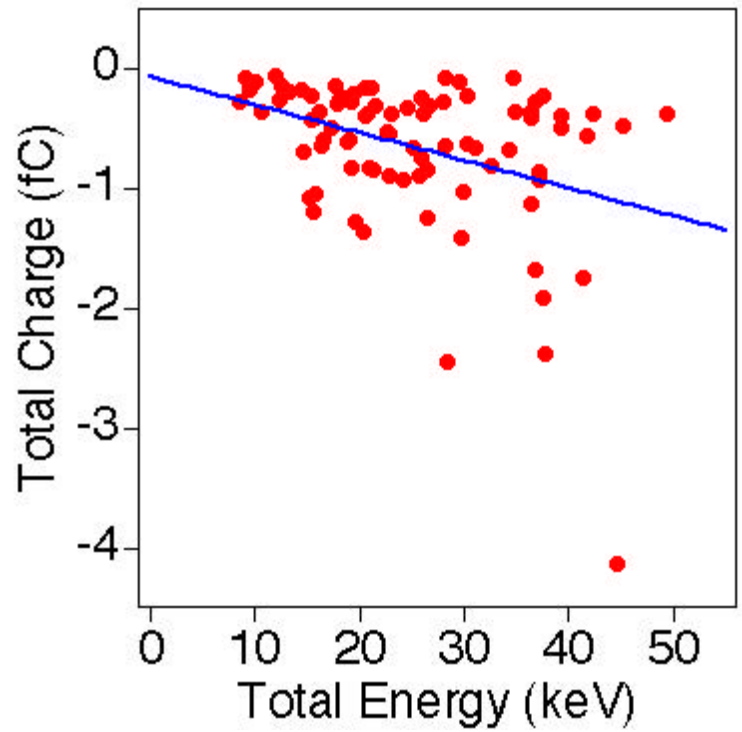


Pulse amplitude vs. event energy

Minimum V_{DS} & fit



Integrated I_D & fit



Note the dispersion!

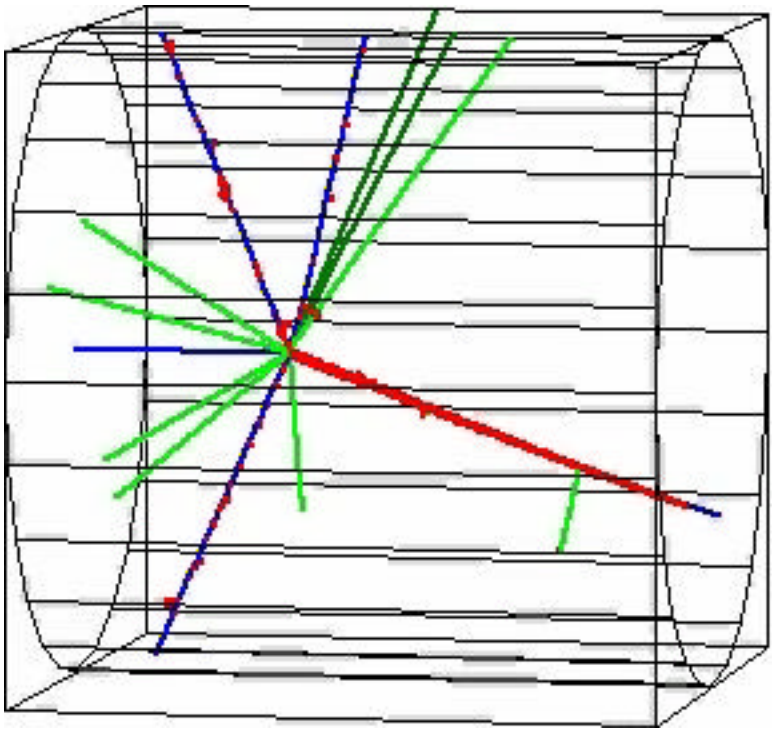
Summary

- The basic framework for ensemble simulation of single events is in place and tested.
- The methodology has been demonstrated by application to low-probability, high-energy, discrete ?-ray events.
- Development of both the overall SEE strategy and the GEANT4 libraries is ongoing.

What's next?

300 MeV p ? 5 µm Si

? E ? 18 MeV



Code: Red = e^-; Blue = + ion; Green = n, ?, etc.

- **Realistic geometry**
- **Proton nuclear reactions**
- **Screened Coulomb scattering**
- **Heavy-ion nuclear reactions**
- **Validation**
- **Statistical studies**
- **Practical circuits**
- **Cross section**