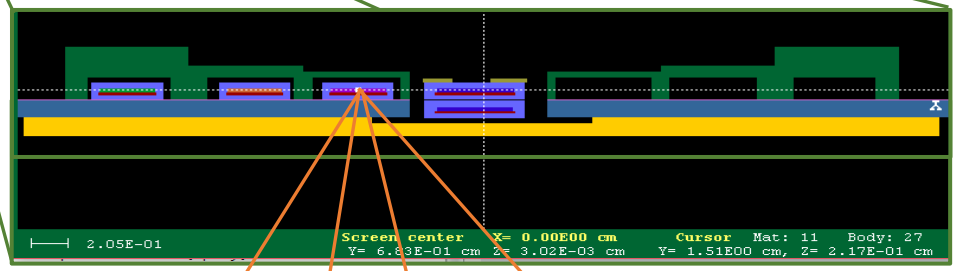
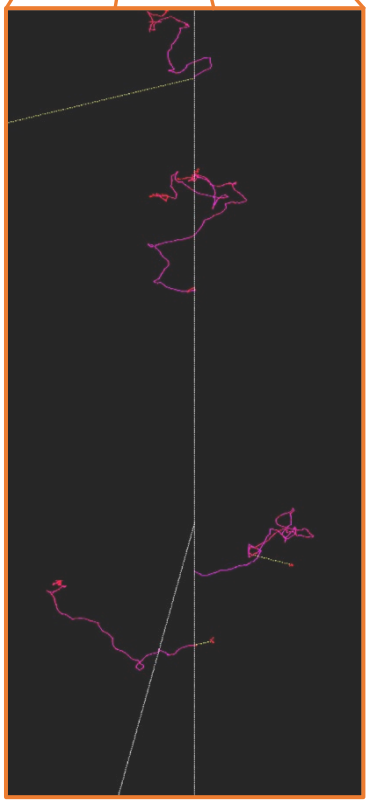
Monte Carlo Simulations for X-ray sensor development at RTI

Any detector-layout and measurement setup may be expressed in terms of geometrical structures or voxels as obtained from 3D-CAD.

In a Monte Carlo simulation, interaction probabilities are used to predict the response of a detector upon irradiation with x-rays. All interactions depend on particle energy and medium.

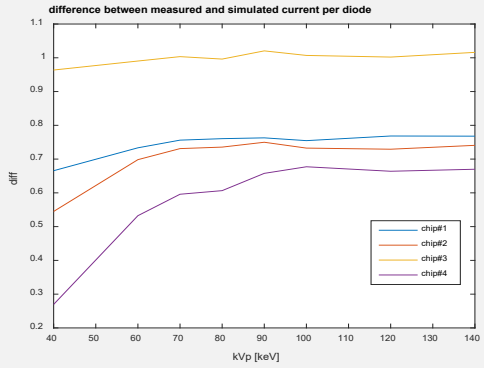


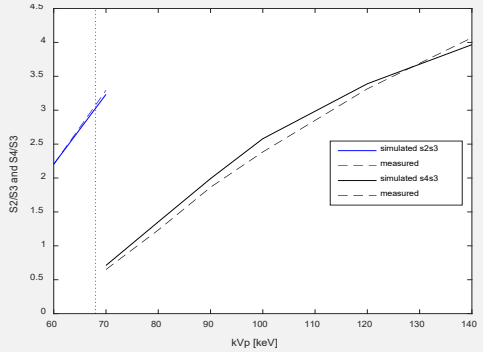
Any unknown x-ray spectrum can simply be obtained when simulating a beam of electrons with kV_p hitting an anode. Each material is specified by its physical properties and probability distributions for interaction mechanisms.



Relevant γ-interactions are photo-electric effect, Compton and Rayleigh scattering. Every interaction deposits energy and all paths are recorded until fully absorbed.

The ionization of a semiconductor creates electron/hole-pairs that migrate through the substrate until collected at the electrodes. The generated current is proportional to the total deposited energy and thus a measure for imparted dose of the incoming radiation.





Comparisons of measured and simulated currents are made for the Cobia geometry and W-spectra with 3mmAl total filtration and energies ranging from 40 to 140 kV_p.

The simulation assumes an ideal lattice structure and geometric efficiency. Diodes as used for the Cobia, have a decreased efficiency due to edge effects and defects within the crystal. These account for a 30% decrease in comparison to simulation. However, a collimator removes this factor as shown by the central diode (chip#3).

Conclusively, simulated signal ratios are a powerful and reliable tool for the development of future x-ray sensors and measurement methods.