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PART OF MID SWEDEN UNIVERSITY

Monte Carlo and Charge Transport Simulation of Pixel Detector Systems

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Abstract:
This thesis is about simulation of semiconductor X-ray and particledetectors. The simulation of a novel coating for solid state neutrondetectors is discussed as well as the implementation of a simulationframework for hybrid pixel detectors.

Today's most common thermal neutron detectors are proportionalcounters, that use 3He gas in large tubes or multi wire arrays. Globalnuclear disarmament and the increase in use for homeland securityapplications has created a shortage of the gas which poses a problemfor neutron spallation sources that require higher resolution and largersensors. In this thesis a novel material and clean room compatible pro-cess for neutron conversion are discussed. Simulations and fabricationhave been executed and analysed in measurements. It has been proventhat such a device can be fabricated and detect thermal neutrons.

Spectral imaging hybrid pixel detectors like the Medipix chipare the most advanced imaging systems currently available. Thesechips are highly sophisticated with several hundreds of transistors perpixel to enable features like multiple thresholds for noise free photoncounting measurements, spectral imaging as well as time of arrivalmeasurements. To analyse and understand the behaviour of differentsensor materials bonded to the chip and to improve development offuture generations of the chip simulations are necessary. Generally, allparts of the detector system are simulated independently. However, itis favourable to have a simulation framework that is able to combineMonte Carlo particle transport, charge transport in the sensor as wellas analogue and digital response of the pixel read-out electronics. Thisthesis aims to develop such a system that has been developed withGeant4 and analytical semiconductor and electronics models. Further-more, it has been verified with data from measurements with severalMedipix and Timepix sensors as well as TCAD simulations.

Results show that such a framework is feasible even for imagingsimulations. It shows great promise to be able to be extended withfuture pixel detector designs and semiconductor materials as well asneutron converters to aim for next generation imaging devices.