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Photon Counting X-ray Detector Systems

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ABSTRACT

This licentiate thesis concerns the development and characterisation of X-ray imaging detector systems. “Colour” X-ray imaging opens up new perspectives within the fields of medical X-ray diagnosis and also in industrial X-ray quality control. The difference in absorption for different “colours” can be used to discern materials in the object. For instance, this information might be used to identify diseases such as brittle-bone disease. The “colour” of the X-rays can be identified if the detector system can process each X-ray photon individually. Such a detector system is called a “single photon processing” system or, less precise, a “photon counting system”.

With modern technology it is possible to construct photon counting detector systems that can resolve details to a level of approximately 50 µm. However with such small pixels a problem will occur. In a semiconductor detector each absorbed X-ray photon creates a cloud of charge which contributes to the picture achieved. For high photon energies the size of the charge cloud is comparable to 50 µm and might be distributed between several pixels in the picture. Charge sharing is a key problem since, not only is the resolution degenerated, but it also destroys the “colour” information in the picture.

The problem involving charge sharing which limits “colour” X-ray imaging is discussed in this thesis. Image quality, detector effectiveness and “colour correctness” are studied on pixellated detectors from the MEDIPIX collaboration. Characterisation measurements and simulations are compared to be able to understand the physical processes that take place in the detector. Simulations can show pointers for the future development of photon counting X-ray systems. Charge sharing can be suppressed by introducing 3D-detector structures or by developing readout systems which can correct the crosstalk between pixels.