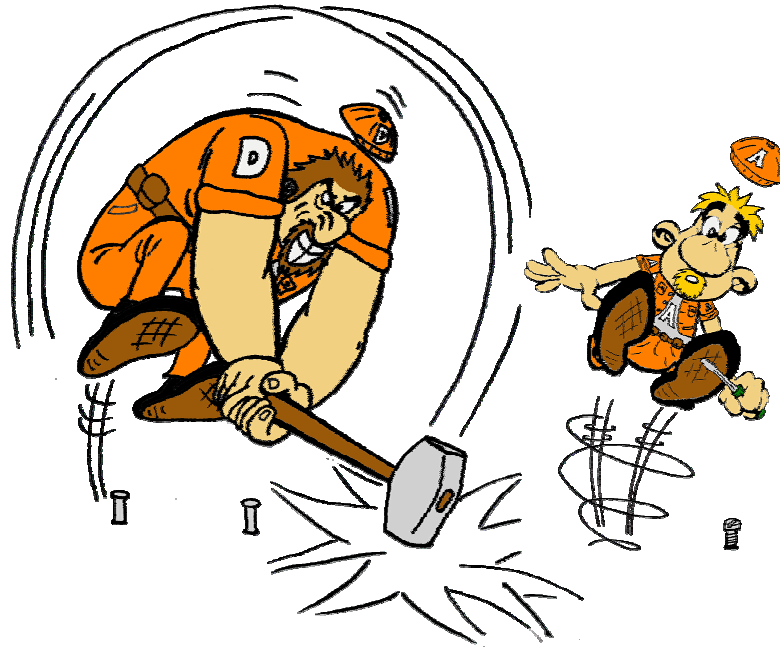# Evaluation of Mixed-Signal Noise Effects in Photon Counting X-Ray Image Sensor Readout Circuits

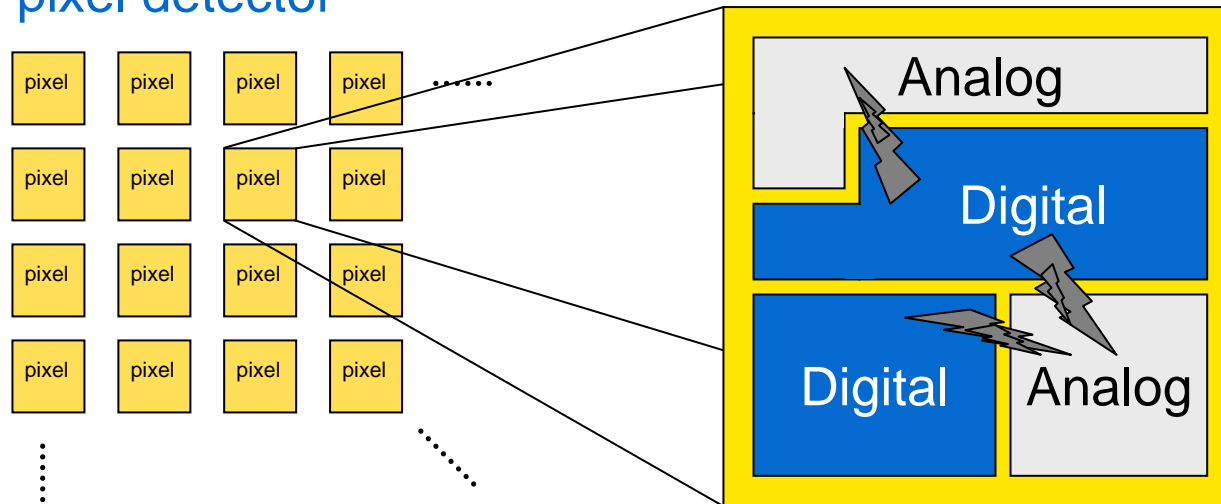## Jan Lundgren, Suliman Abdalla, Mattias O´Nils, Bengt Oelmann

The problem of digital and analog circuits working together.

# Outline

- Motivation
- The error scenario
- Simulation models
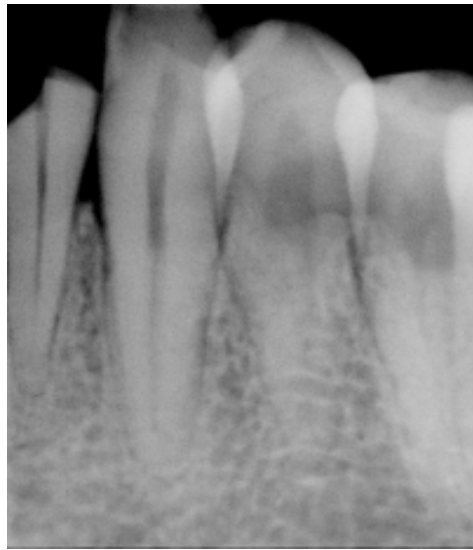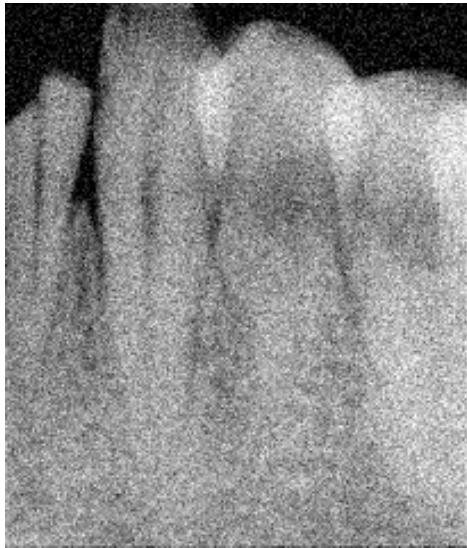- Simulation results
- Conclusions
- Future work
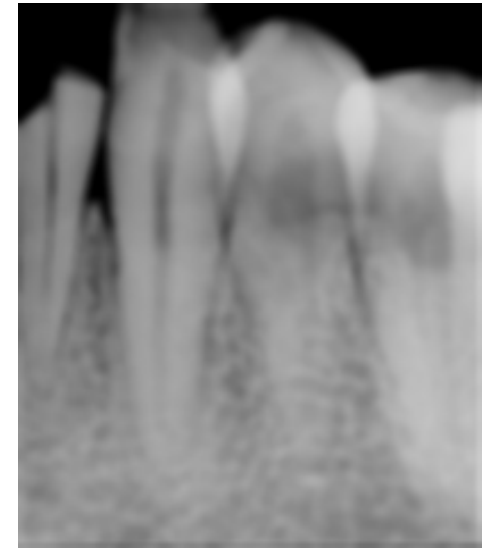
# Motivation

Photon counting
pixel detector

# The error scenario

Self-generated
noise within a pixel



Noise between
adjacent pixels



Example of a dental
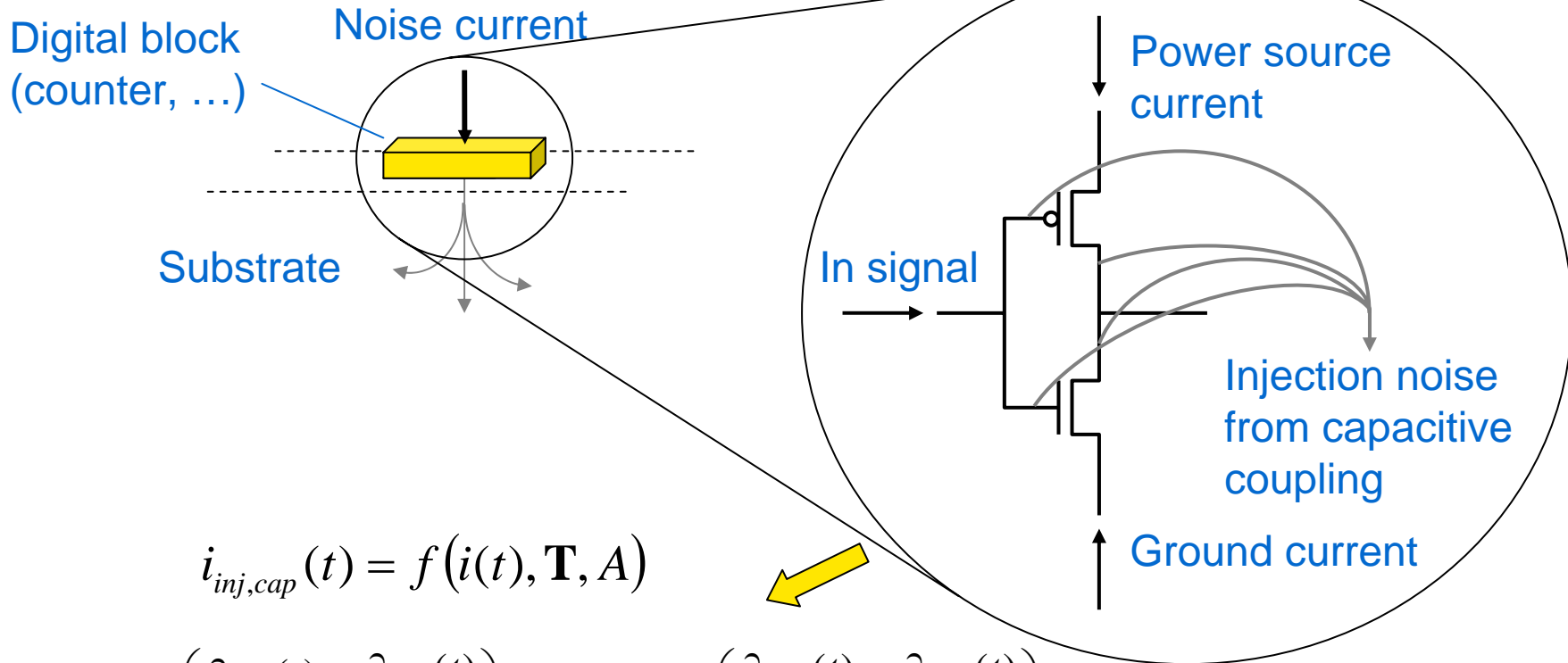X-ray image

ELECTRONICS
Design Division

Mittuniversitetet
MID SWEDEN UNIVERSITY

# Simulation models
## Photon counting pixel detector

ELECTRONI**C**S
Design Division

Mittuniversitetet
MID SWEDEN UNIVERSITY
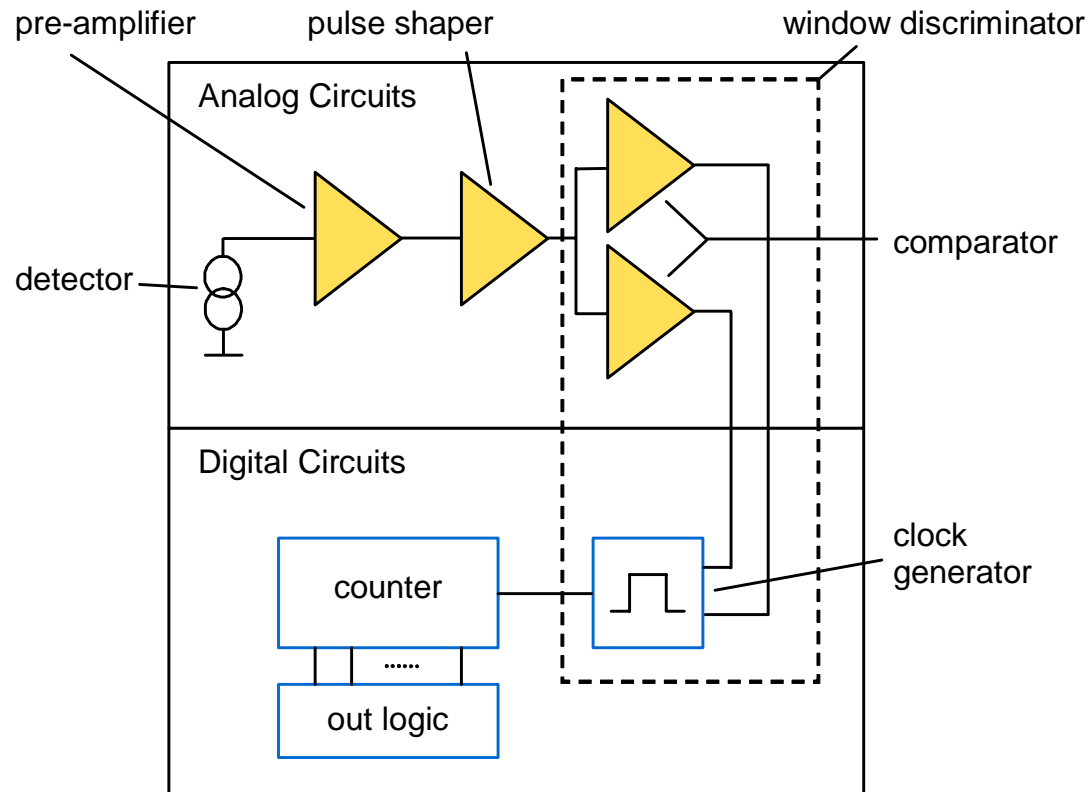
# Simulation models
## Noise injection modeling



Digital block (counter, …)

Noise current

Substrate

Power source current

In signal

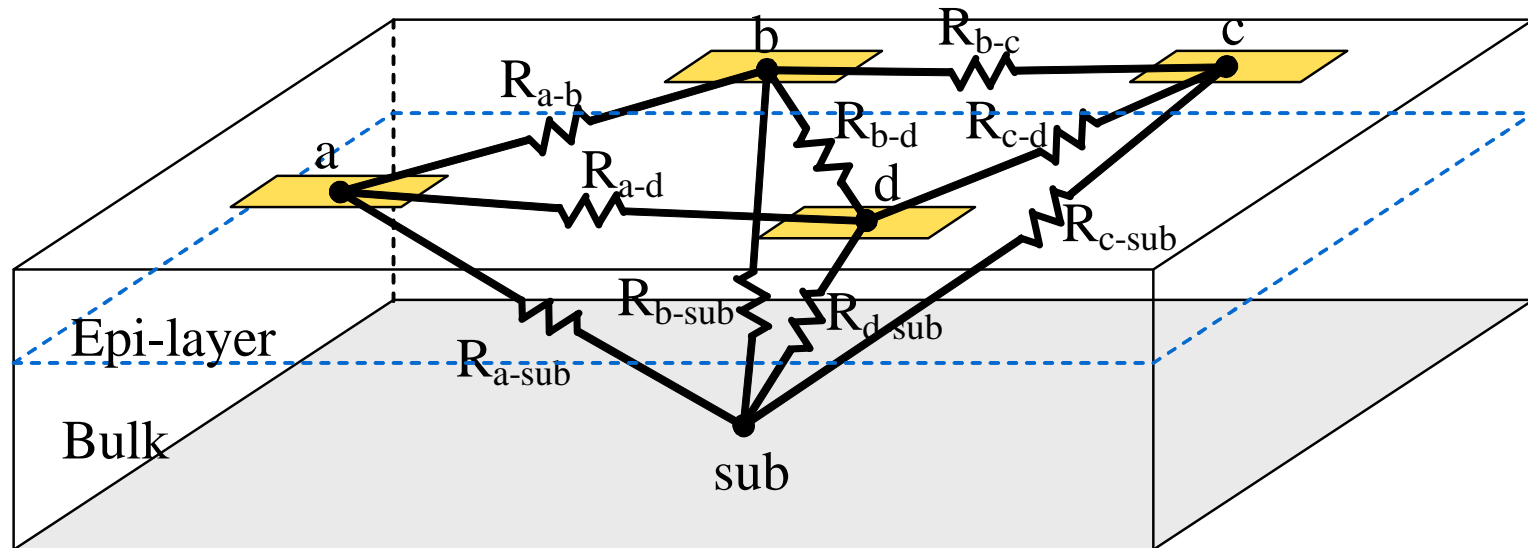Injection noise from capacitive coupling

Ground current

$$i_{inj,cap}(t) = f\left(i(t), \mathbf{T}, A\right)$$

$$i_{inj,cap}(t) = C_j\left(\frac{\partial u_{sn}(t)}{\partial t} + \frac{\partial u_{sp}(t)}{\partial t}\right) + \left(C_{ox} + C_{ch}\right)\left(\frac{\partial u_{gn}(t)}{\partial t} + \frac{\partial u_{gp}(t)}{\partial t}\right)$$

ELECTRONICS
Design Division

2005-07-06

Jan Lundgren

Mittuniversitetet
MID SWEDEN UNIVERSITY

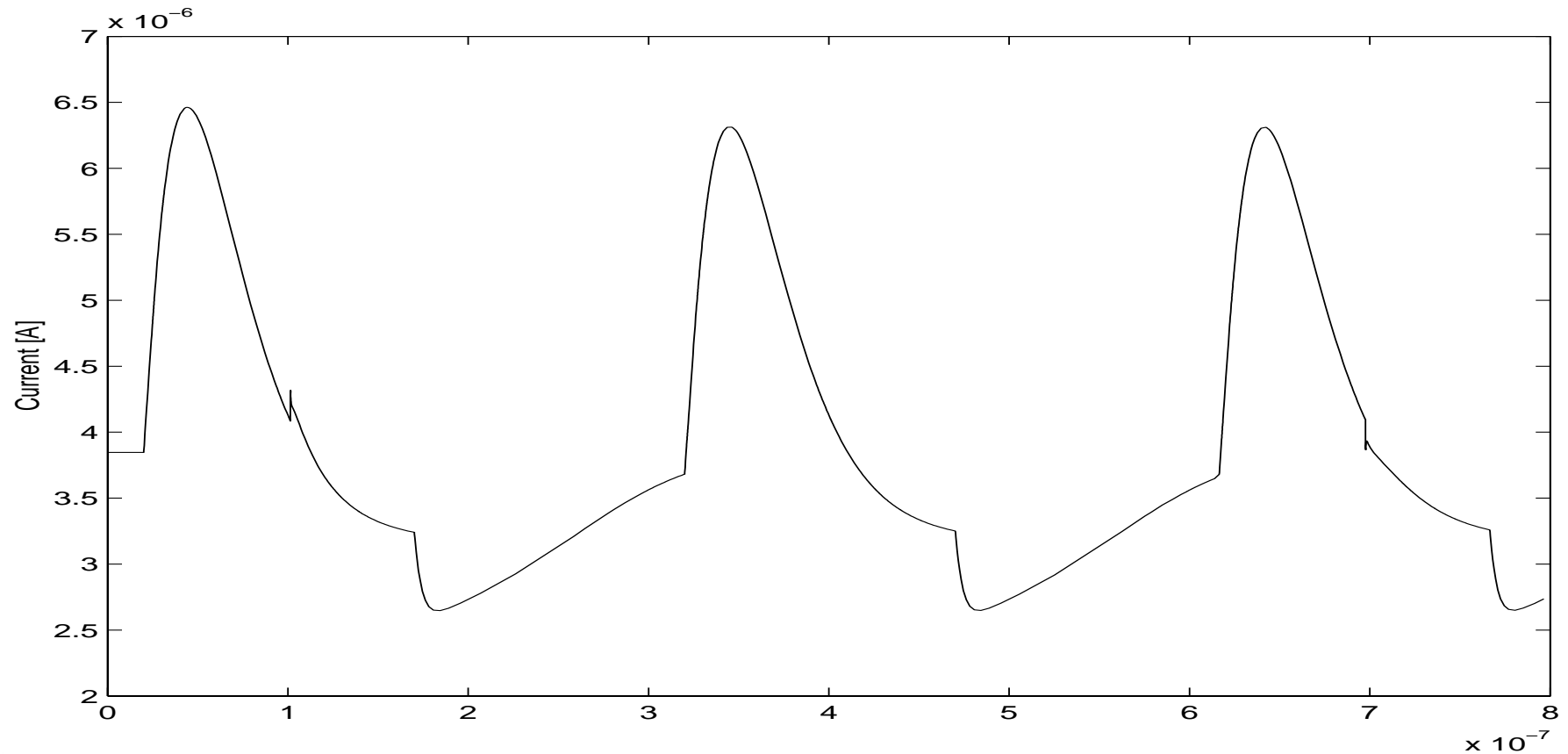# Simulation models
## Substrate modeling



The 3D single substrate node model with a resistive network ready for simulation.

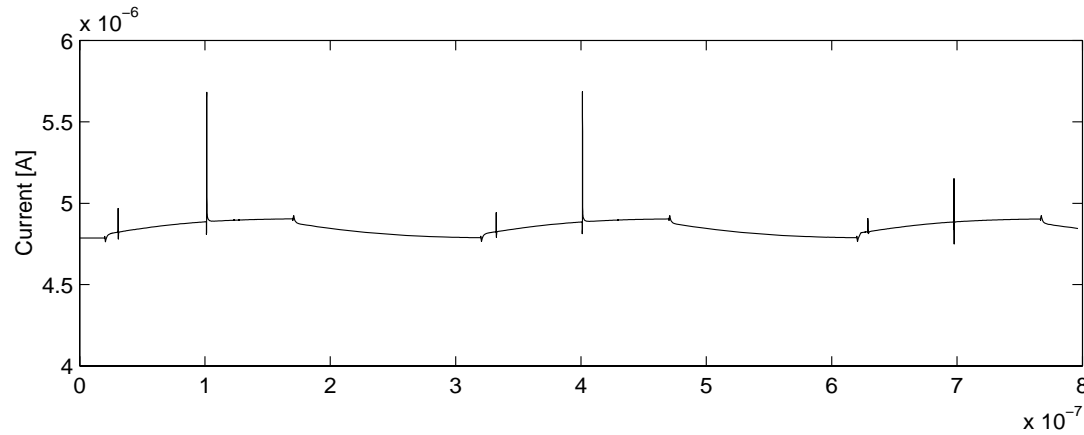In this case, with an epi-layer model.

# Simulation results
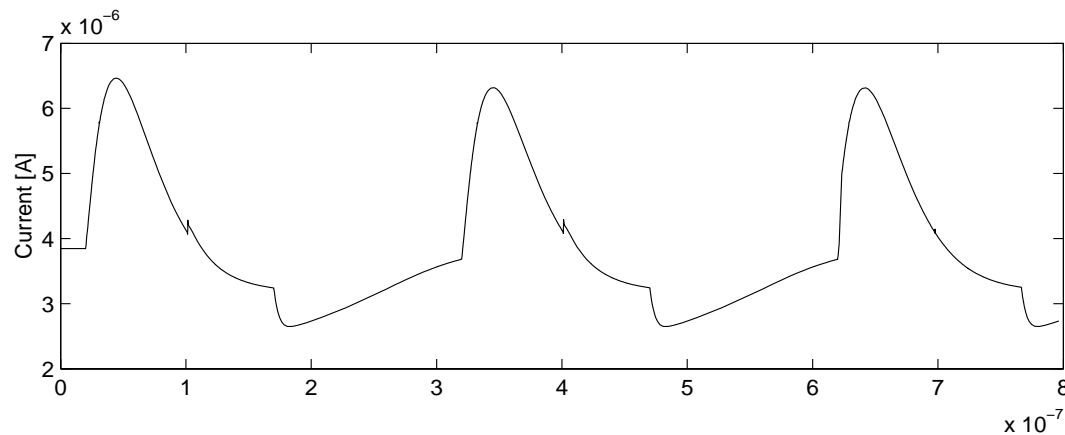## Effect from one bit (20um away)

# Simulation results
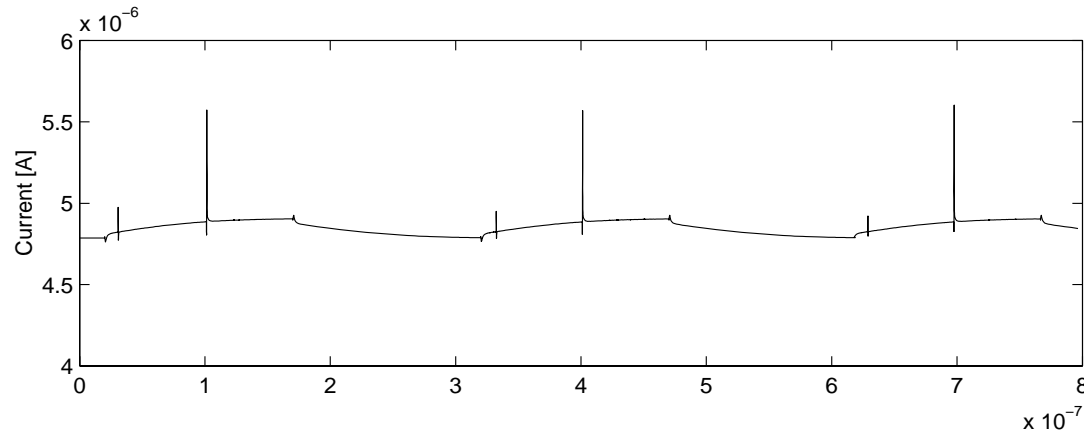## Effect from 12 bits in 12 bit counter (20um)
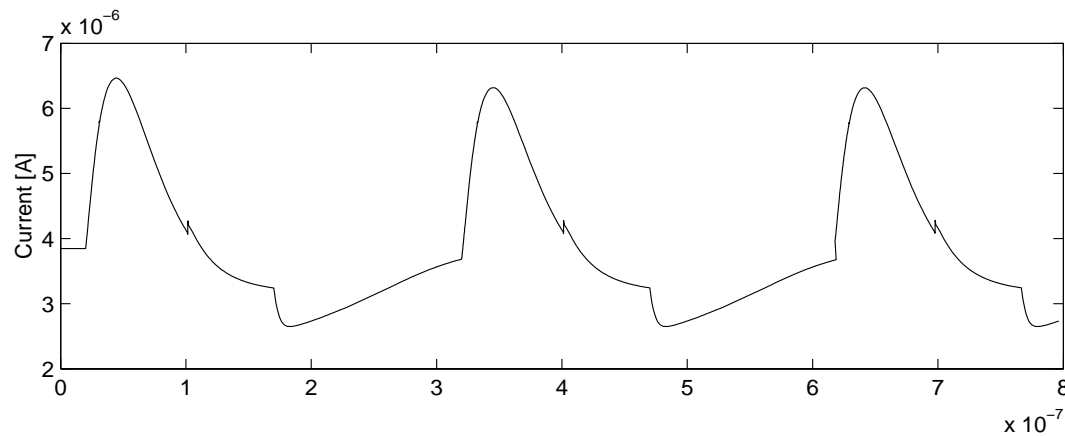


Output current from preamplifier

Output current from pulse shaper

# Simulation results
## Noise from 16 bits in 16 bit counter (20um)



Output current from preamplifier

Output current from pulse shaper

# Conclusions

- Substrate coupling needs to be considered in future readout electronics where components are more tightly integrated.

- The problems with substrate noise coupling can be avoided with smart floorplanning.

# Future work

- Implementation of remaining parts into Behavioral level Noise Coupling (BeNoC) simulation.

- Behavioral level Noise Coupling (BeNoC) evaluation of photon counting pixel detector.

- Survey and design of RFID sensor interface.