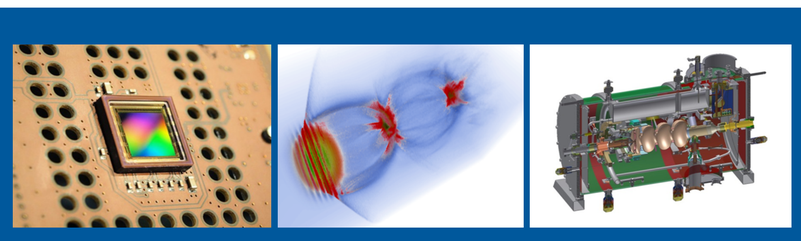
Programme Matter and Technologies

Development of Edgeless Silicon Pixel Sensors

DTS - Edgeless Detectors for Photon Science at Synchrotrons and XFELs



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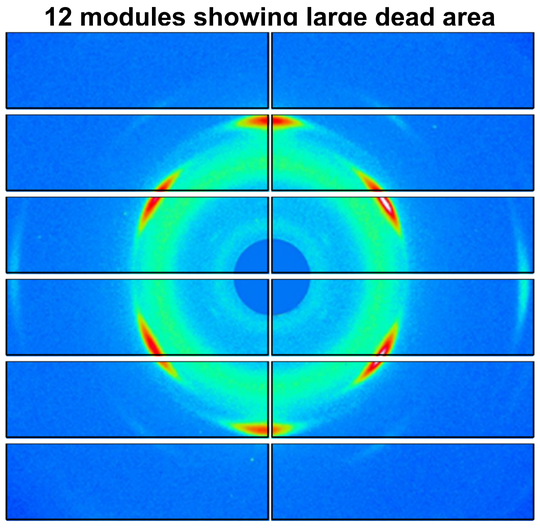
in collaboration with SINTEF, Advacam/VTT, CERN and IZM

1. Motivation

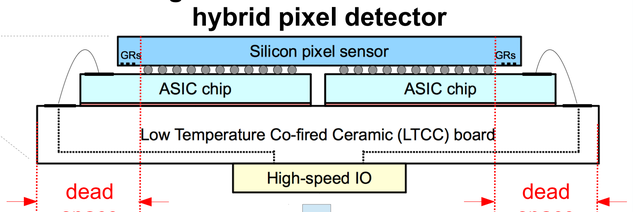
Drawback of conventional hybrid pixel detectors:

• information missing within dead space → problems in image reconstruction

A conventional detector with 12 modules showing large dead area

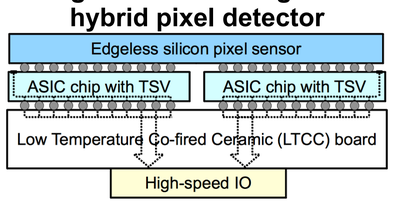


Single module of conventional hybrid pixel detector



replaced by

Single module of edgeless hybrid pixel detector

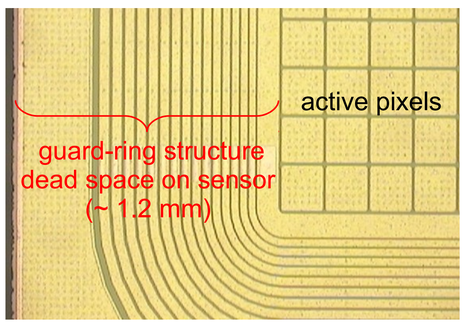


Goal: Development of edgeless hybrid pixel detectors using

• edgeless silicon sensors with active edges
• ASIC chips with through-silicon-vias (TSV)
• circuit board and ASIC chips integrated with ball grid array

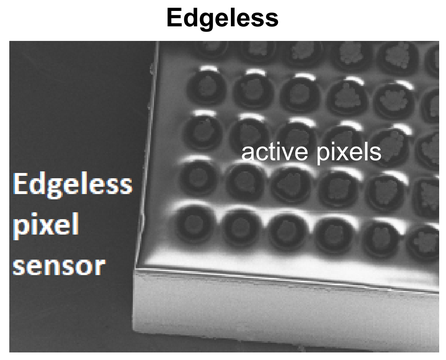
2. From conventional to edgeless sensor

Conventional

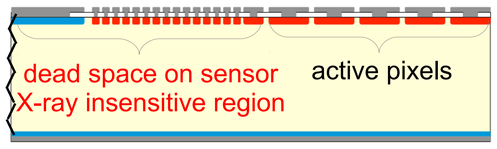


conventional to edgeless

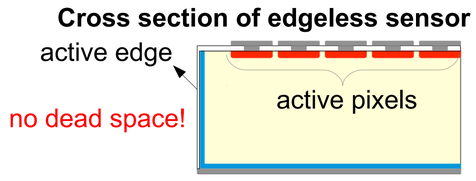
Edgeless



Cross section of conventional sensor



Cross section of edgeless sensor



Additional processes for edgeless sensor:

• silicon wafer bonding to support wafer
• deep trench by Deep Reactive Ion Etching
• edge implantation
• support wafer removal

Potential foundries

ADVACAM IMAGING THE UNSEEN · VTT · FBK FONDAZIONE BRUNO KESSLER · SINTEF

3. Model development for edgeless sensors

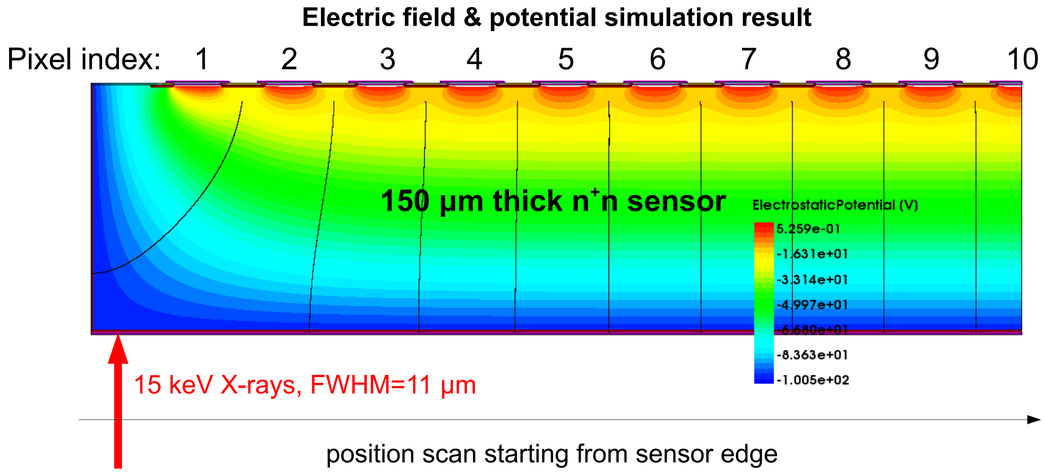
Model developed for charge collection of edgeless sensors:

• electric field & potential distribution (Synopsys TCAD)
• drift, diffusion and collection of e-h pairs produced by X-rays (Python)

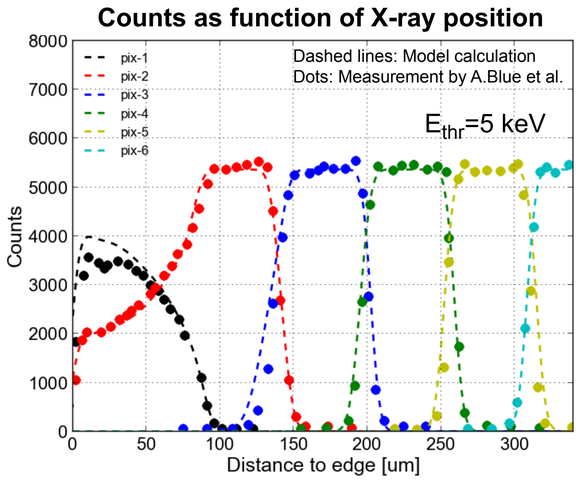
Results of model calculation and compared to measurement:

• backside scan of edgeless sensor (150 µm thick, 55 µm pitch & 50 µm last pixel-to-edge distance, produced by VTT/Advacam) with X-rays

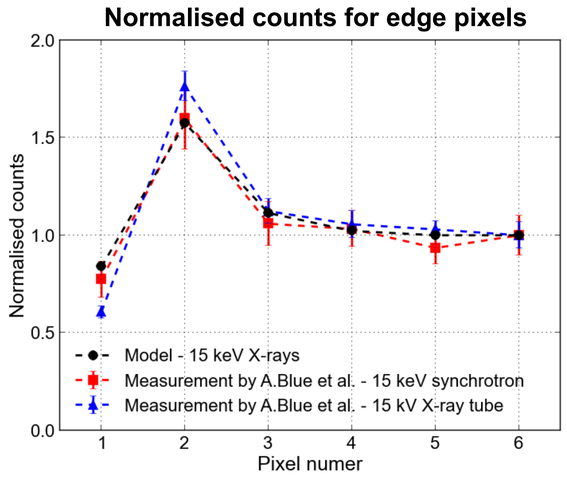
Electric field & potential simulation result



Counts as function of X-ray position



Normalised counts for edge pixels



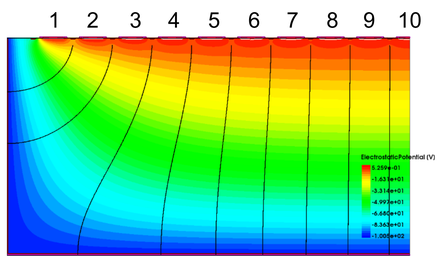
Measurements explained by developed model!

4. Modeling charge-collection behavior

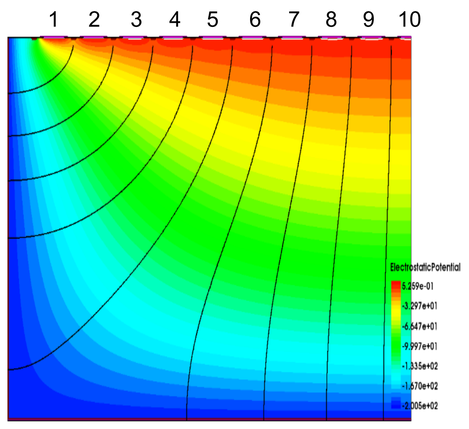
Results for thicker edgeless sensors predicted by developed model:

Electric field & potential simulation result

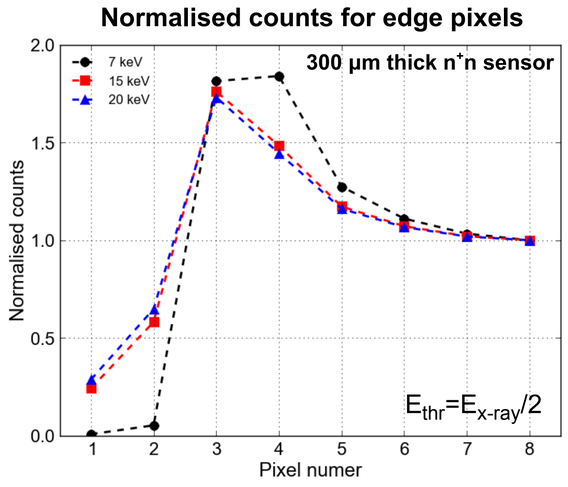
300 µm thick n+n sensor

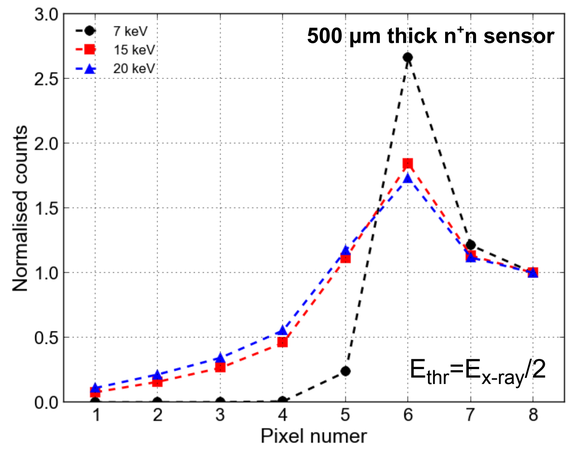


500 µm thick n+n sensor



Normalised counts for edge pixels





Main features/conclusions:

• bending of electric field close to sensor edge
• non-uniform charge collection for edge pixels
• sensor thickness, X-ray energy and last pixel-to-edge distance dependence
• charge collection in HEP applications compatible with results from >15 keV X-rays

Hint for sensor design: Last pixel-to-edge distance should be kept at least 50% of the sensor thickness to obtain the optimized charge collection for edge pixels!

5. Summary

• **Edgeless sensor development in progress:**
- model developed for understanding recent measurement results
- charge-collection behavior for photon science and HEP applications predicted by model calculation

6. Outlook

• **Optimization of sensor layout started and to be continued**
• **Photon-counting ASIC chips (Medipix) with TSV design ready**
• **Design of compatible circuit board will start soon**
• **First module of edgeless detector expected in 2015**

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