Detector development at the Detector Laboratory of HIP

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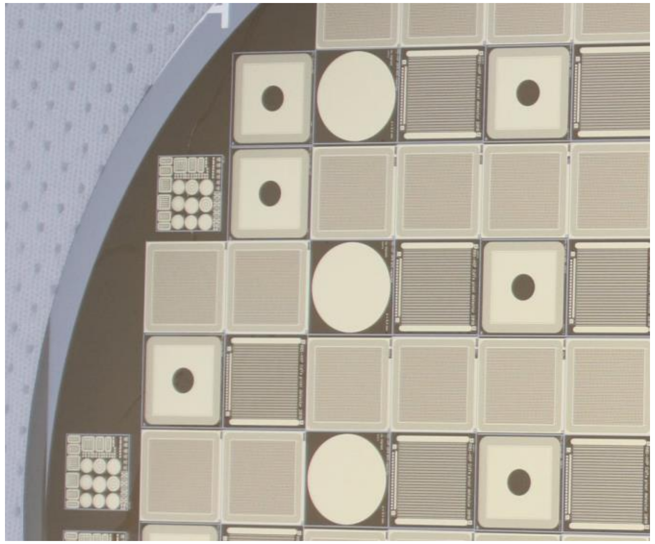
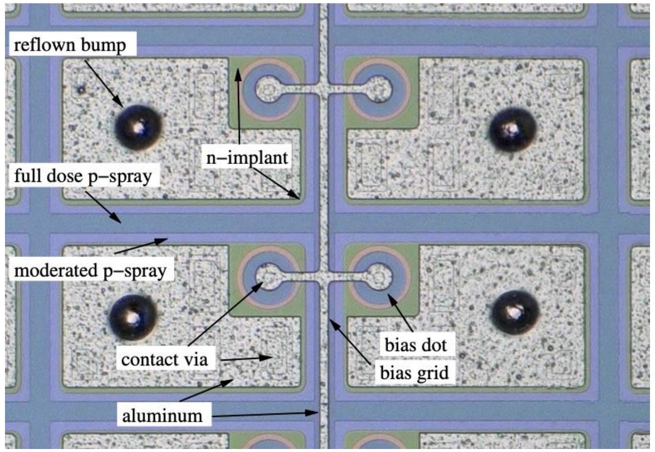
Semiconductor detector development at HIP

- Motivation
  - Keeping up the capability of manufacturing sensors.
  - Offering academic value to students
- Facilities
  - Local laboratory
    - Clean room premises
    - Interconnection tools: semiautomatic wirebonders, flip-chip bonder, reflow oven
    - Characterization tools: probestations, TCT, X-ray set-up, climate chamber, …
    - Simulation tools: Sentaurus TCAD, …
  - Access to Micronova
  - Other university groups (Accelerator lab, ALD lab, …)
  - Collaborators (Okmetic, VTT, DT, STUK)

Radiation hard pixel detector

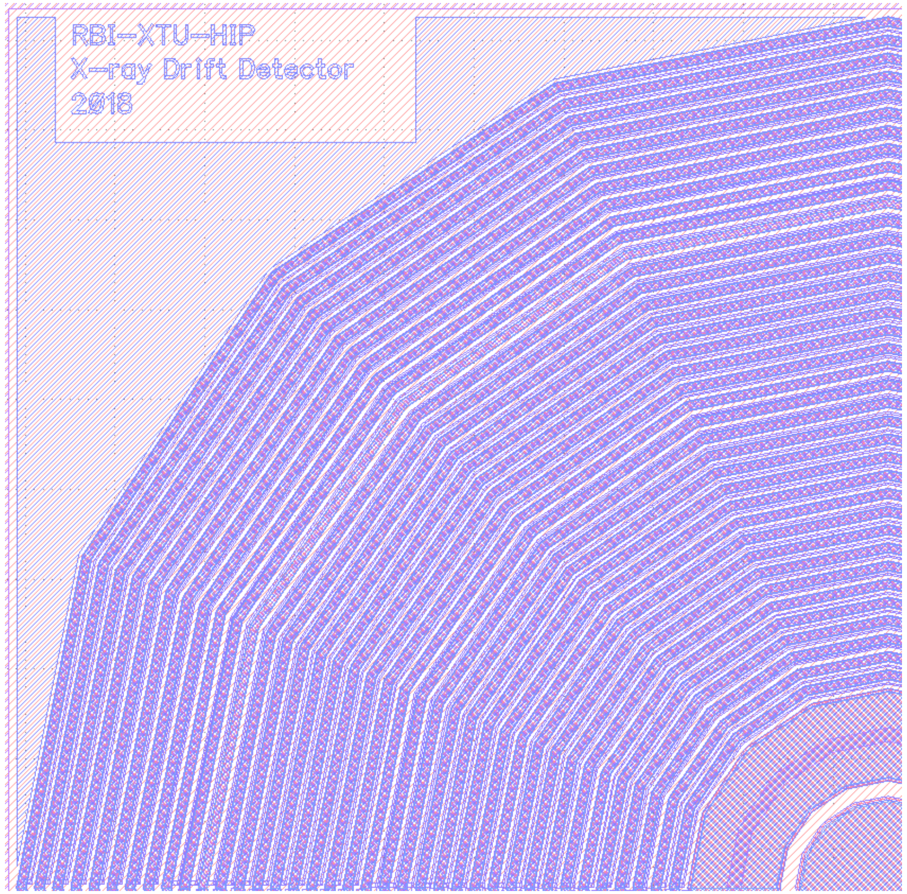
- Designs optimized for particle physics experiments.
- Using low-oxygen Magnetic Czochralski silicon from Okmetic.
- A comparison of radiation hardness between MCz and standard Float-zone silicon diodes.
- Studying ALD-grown insulation and resistor materials for capacitively coupled pixels.

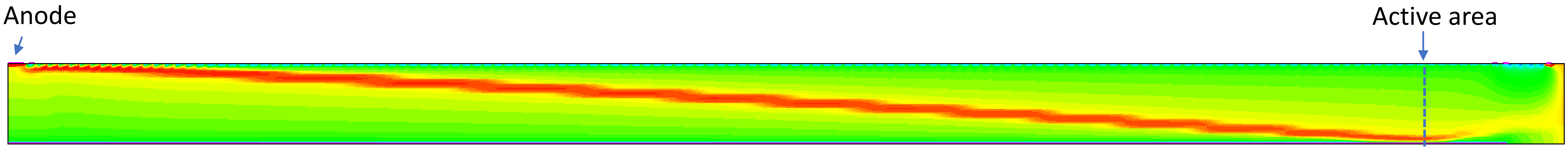




Silicon Drift Detector SDD

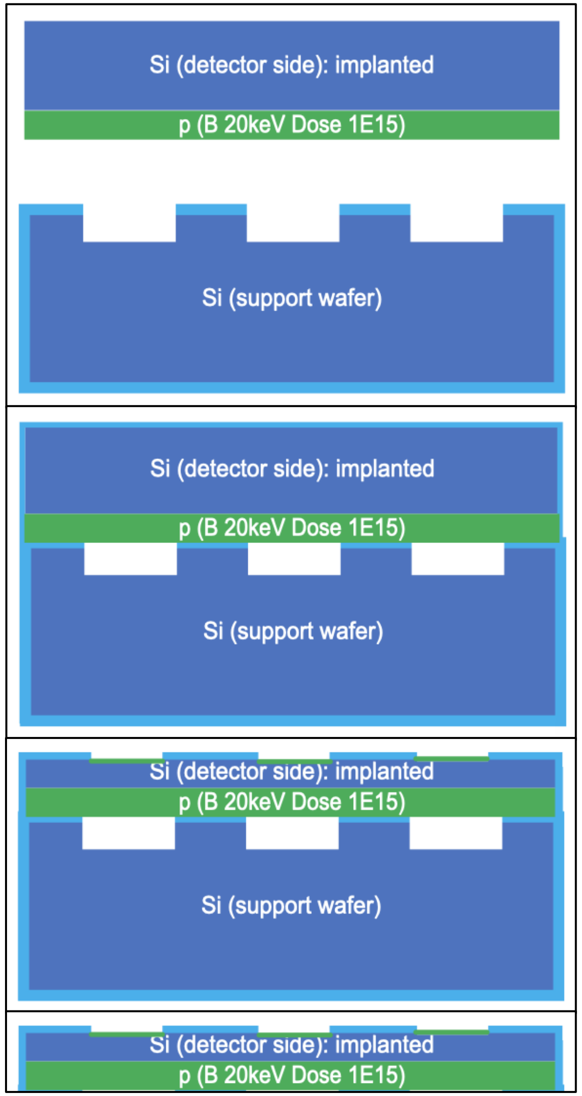
- SDD detector utilizes Concentric electrode structure to provide horizontal field.
- Electrons drift to the relatively small anode.
- Excellent energy resolution due to small capacitance





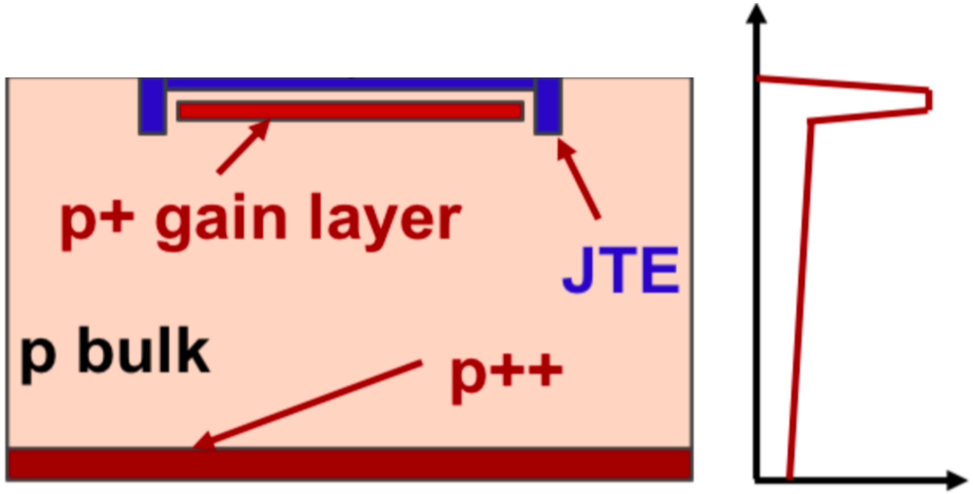
Thin SDD

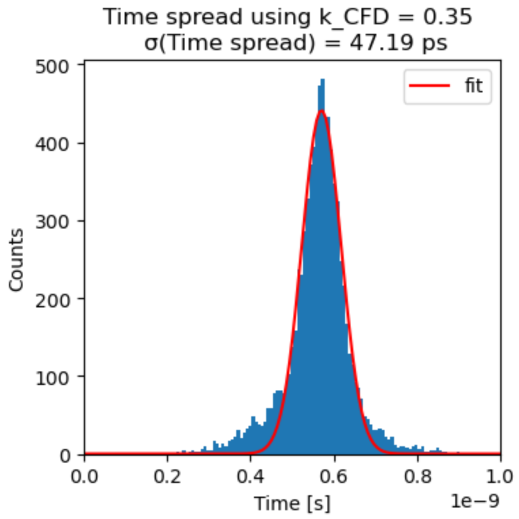
- Thin SDD detector (less than 100 microns)
- Large surface area (from several mm^2 up to cm^2)
- Transparent detector for low energy X-rays (10 keV +)
- Collaboration with Okmetic Oy using SOI technology.
- Silicon detector is attached on a support wafer and thinned and patterned.
- Simulations undergoing, studying processing methods.

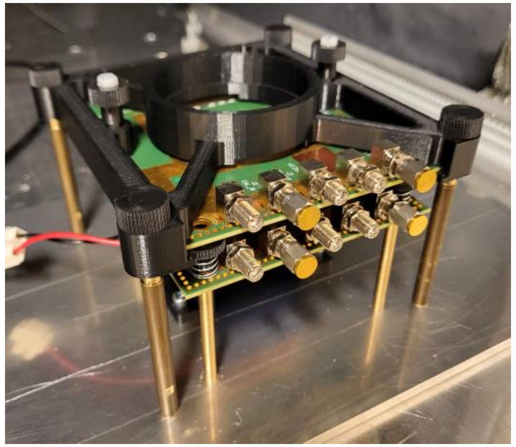


Low Gain Avalanche Detector (LGAD)

- Halfway between conventional silicon diode and an avalanche diode
- Signal amplified in a highly-doped avalanche region close to the anode.
- High signal-to-noise ratio.
- Suitable for high-rate environments.
- Excellent time resolution: 30 ps.

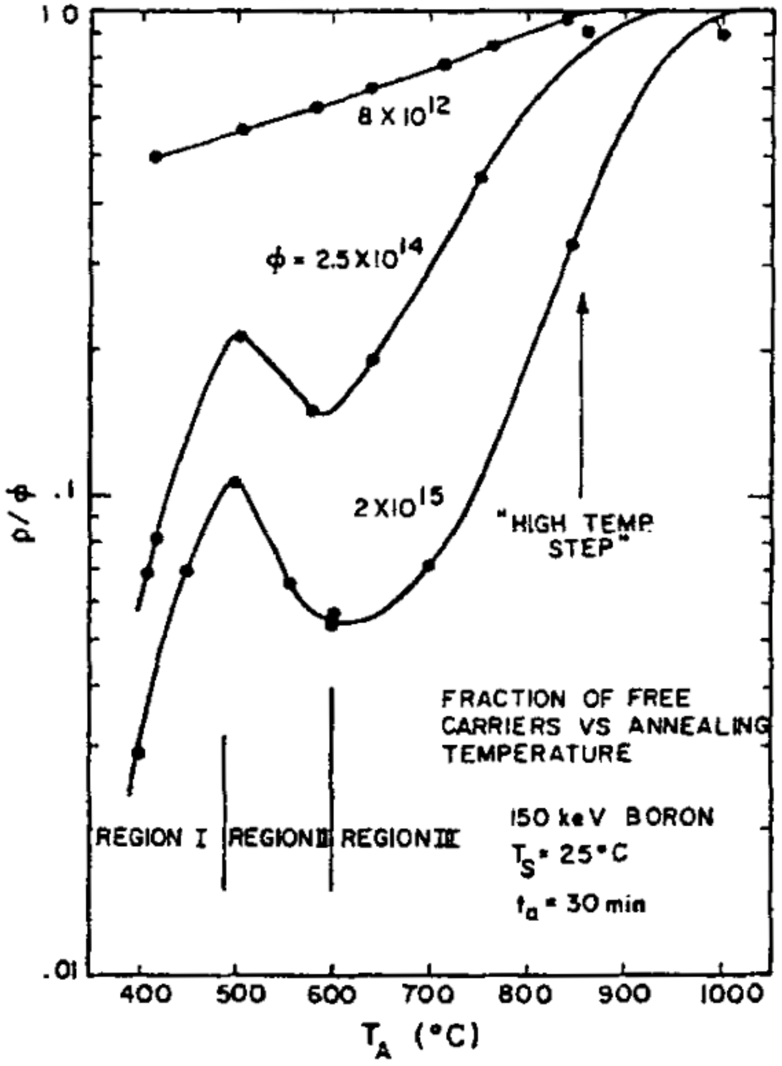






LGAD - Fast timing detector

- Study of partial activation of boron
  - Proposal for RD 50 project
  - LGADs suffer acceptor removal at high fluences:
    - $B_s + Si_i \rightarrow B_i$
    - $B_i + O_i \rightarrow B_iO_i$
  - Start with higher doping of boron
  - Only partially activate the boron (annealing process)
  - Out-of-lattice boron atoms may reduce acceptor removal
  - -> Improved radiation hardness of LGADs.



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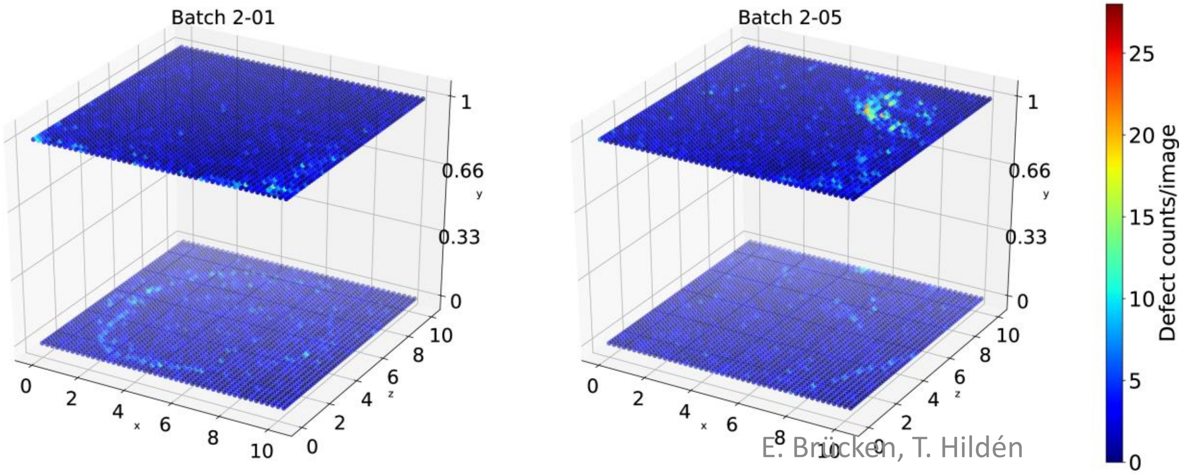
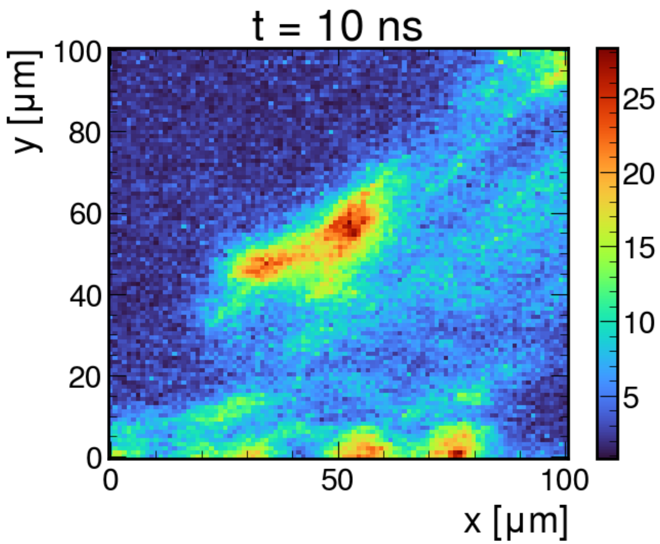
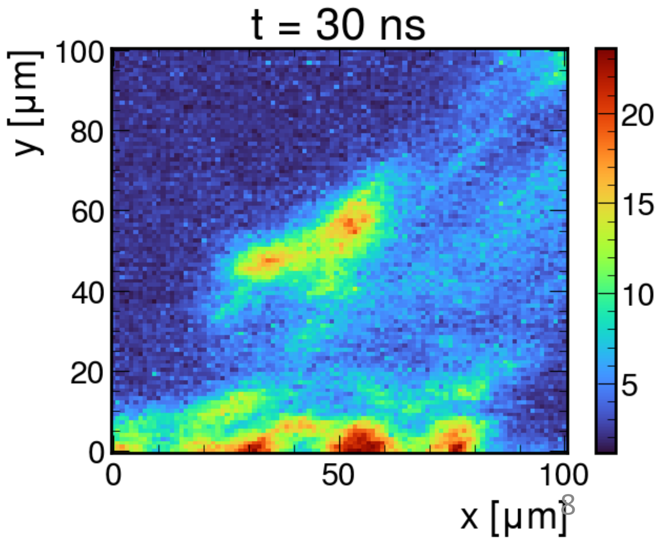
CdTe detector development

- Production of prototype pixel sensors
- 3d scanning CdTe crystals with IR camera scanner and ML based analysis to find defects.
- Development of Transient Current Technique (TCT) -based methods for electrical characterization of defects.
- Current setup utilizing red, NIR, and IR lasers for probing different depth ranges of the crystal





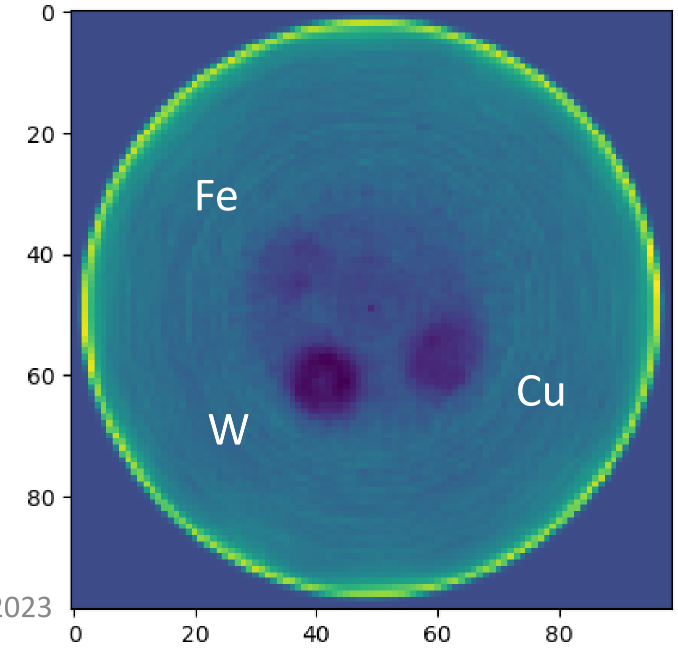


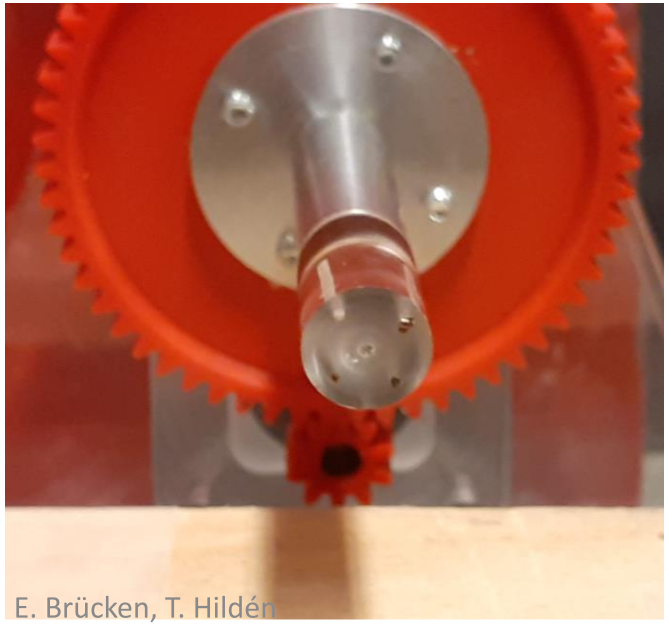
Passive tomography for Boron Neutron Capture Therapy (BNCT)

- BNCT activities a follow-up to the earlier Academy of Finland RADDESS call project, Multispectral Photon-counting for Medical Imaging and Beam characterization
- Received 4-year Academy of Finland funding via HUS for testing detectors at their BNCT facility. Collaboration with Detector Technology Plc.
- Goals
  - Evaluating current technological performance
  - Mapping out strengths and limitations of tested detectors
  - First 3d image of the boron concentration inside a phantom by passive tomography
- Short-term objectives
  - Background radiation measurement
  - Beam profile measurements with CMOS X-ray flat panel detector
  - Measurement of prompt gammas from the BNC reaction using CdTe-based photon-counting line detectors

BNCT

- Acquired two CdTe based line detectors and a CMOS panel detector with neutron converter from Detection Technology Plc.
- Preparation for beam tests at HUS
- Now testing the detectors, running simulations and building tools for tomography.





Thank You!