

Characterization of an Al-STJ based X-ray Detector with Synchrotron Radiation

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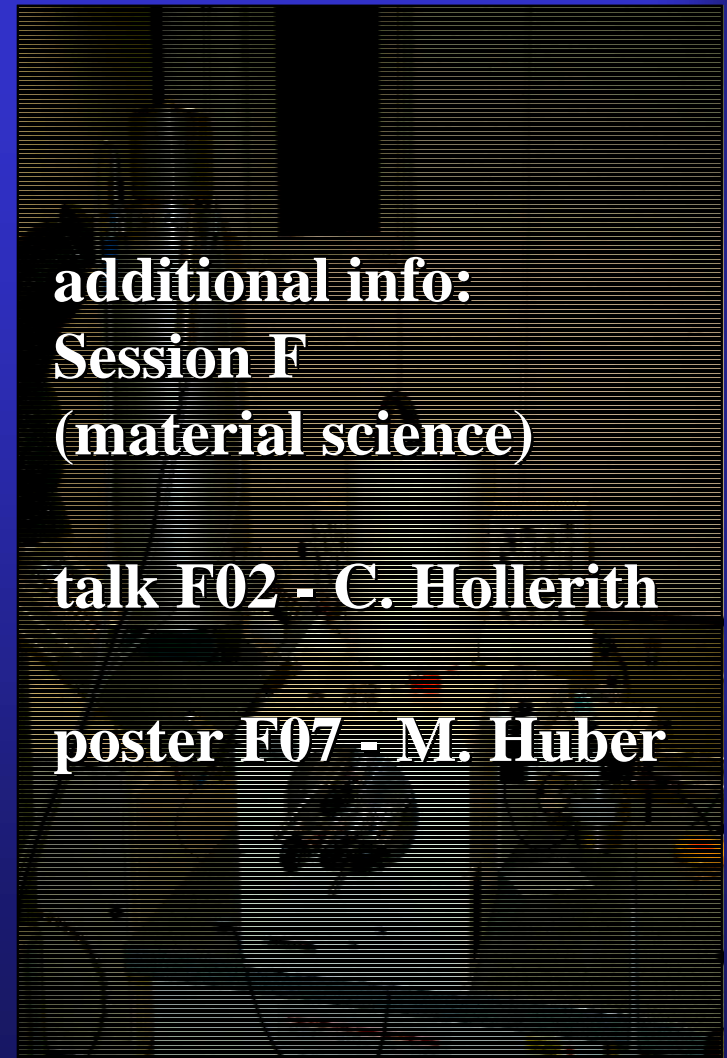
*Application of STJ based detectors
in X-ray fluorescence analysis
(e.g. semiconductor industry)*

STJ's advantages over TES:

- higher count rate capability
- insensitivity to temperature changes

Picture:

Cryogenic spectrometer *Polaris* (TES based)
attached to SEM at laboratory of semiconductor
company *Infineon Technologies*



additional info:

Session F

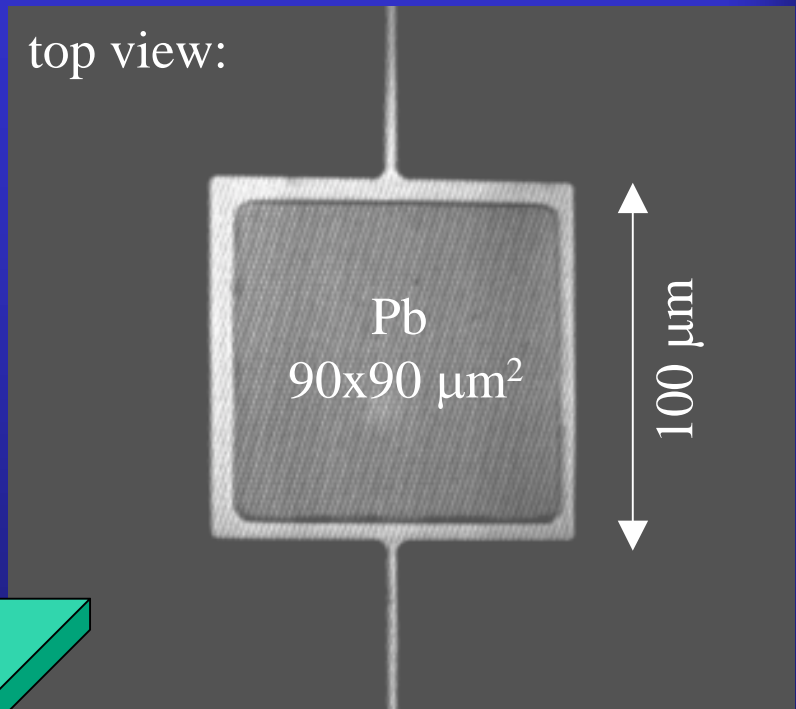
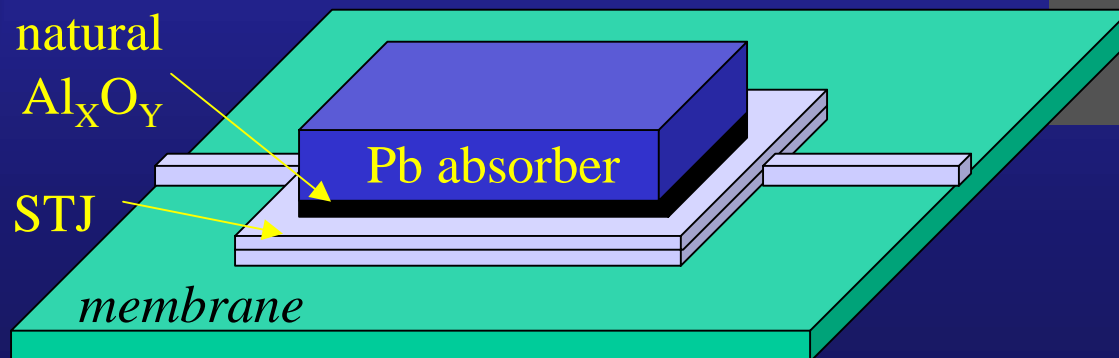
(material science)

talk F02 - C. Hollerith

poster F07 - M. Huber

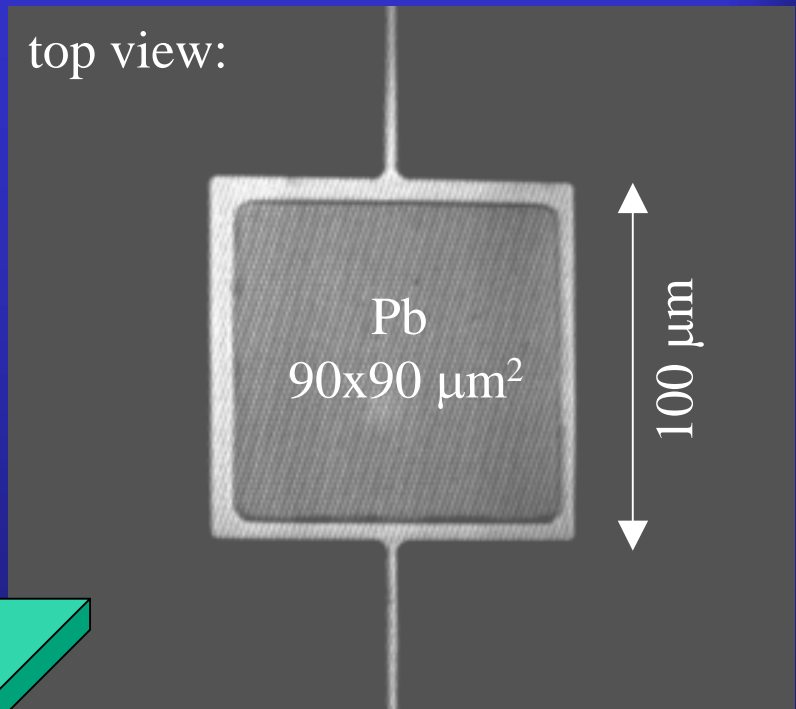
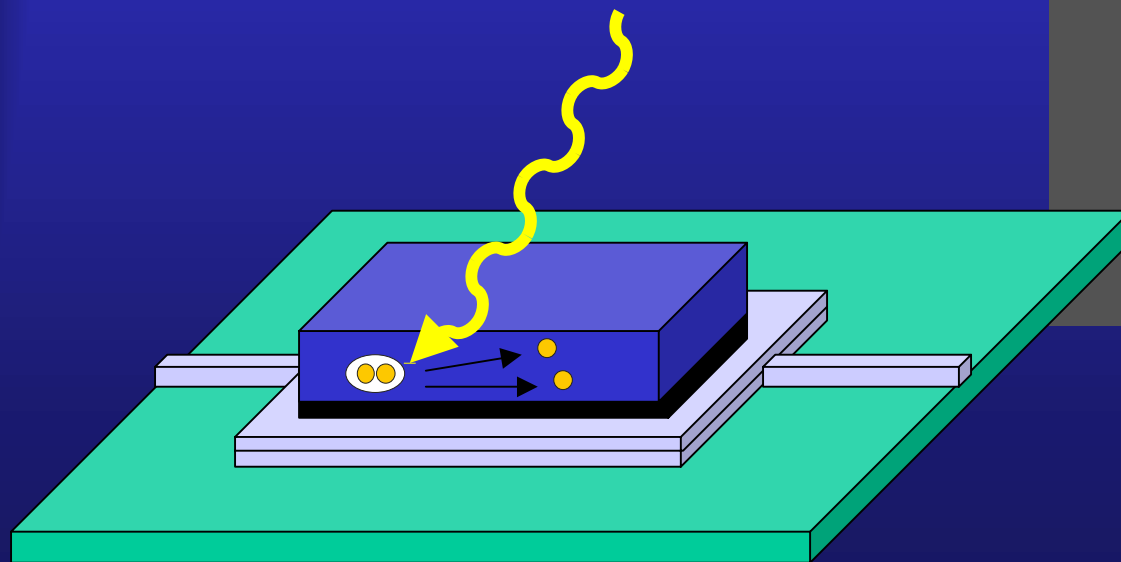
Al-STJ with Pb absorber on membrane:

- Si_3N_4 membrane (300 nm)
- Pb absorber ($1.3 \mu\text{m}$)
- *phononic read-out* by STJ over natural Al_xO_y



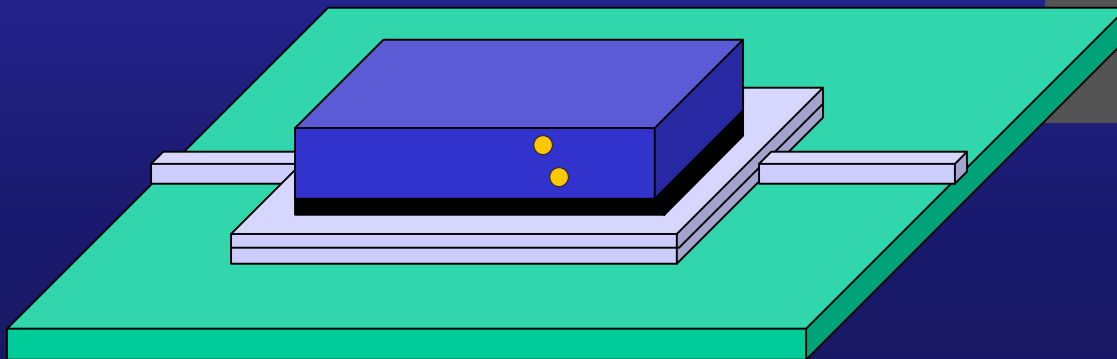
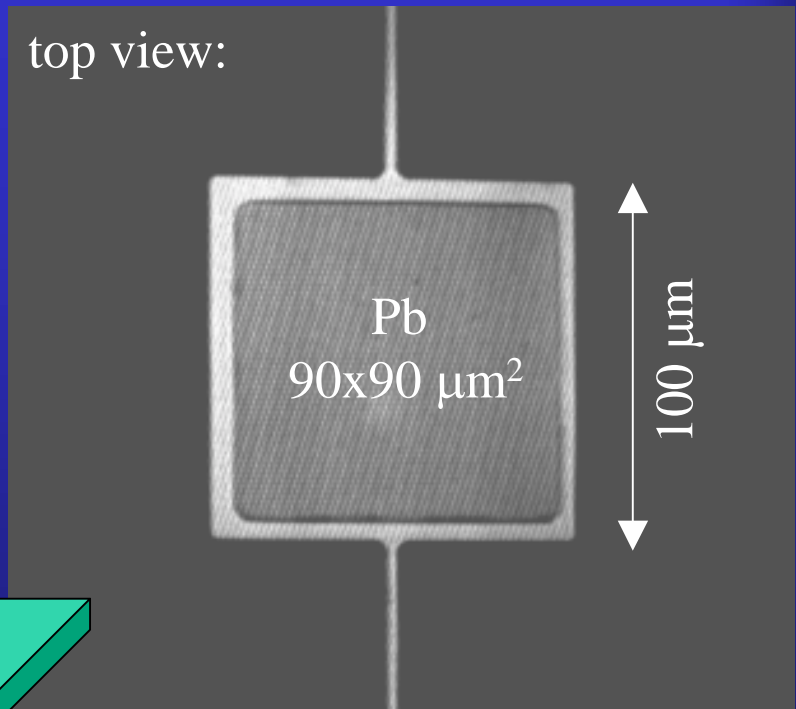
Working principle:

- breaking of Cooper pairs



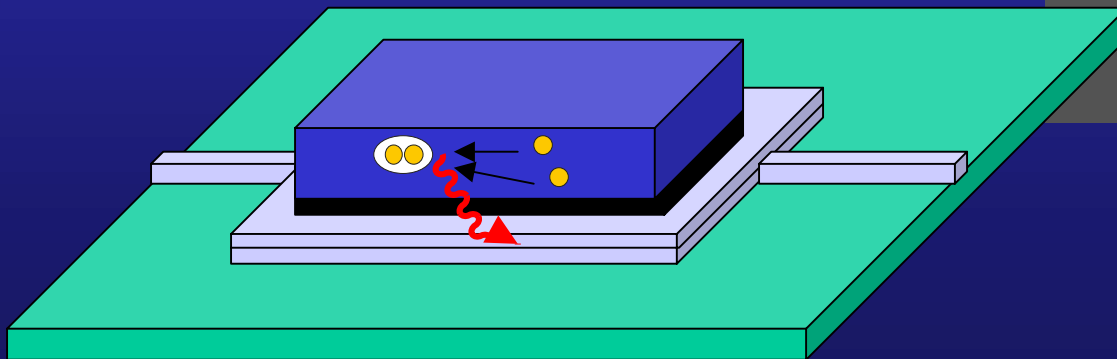
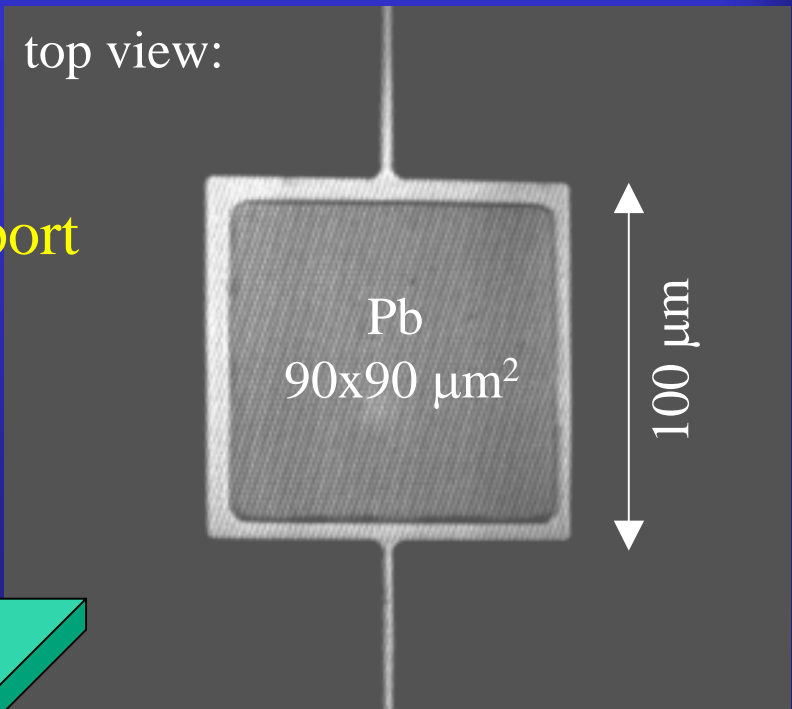
Working principle:

- breaking of Cooper pairs
- quasiparticle lifetime



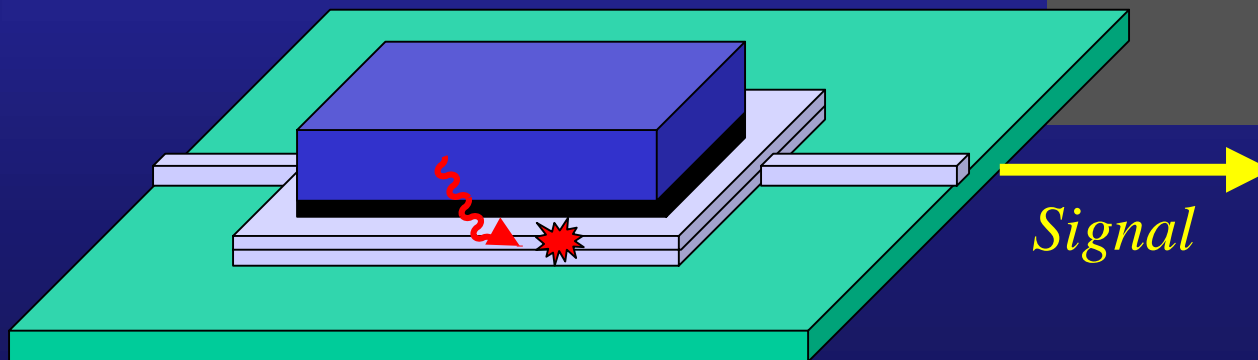
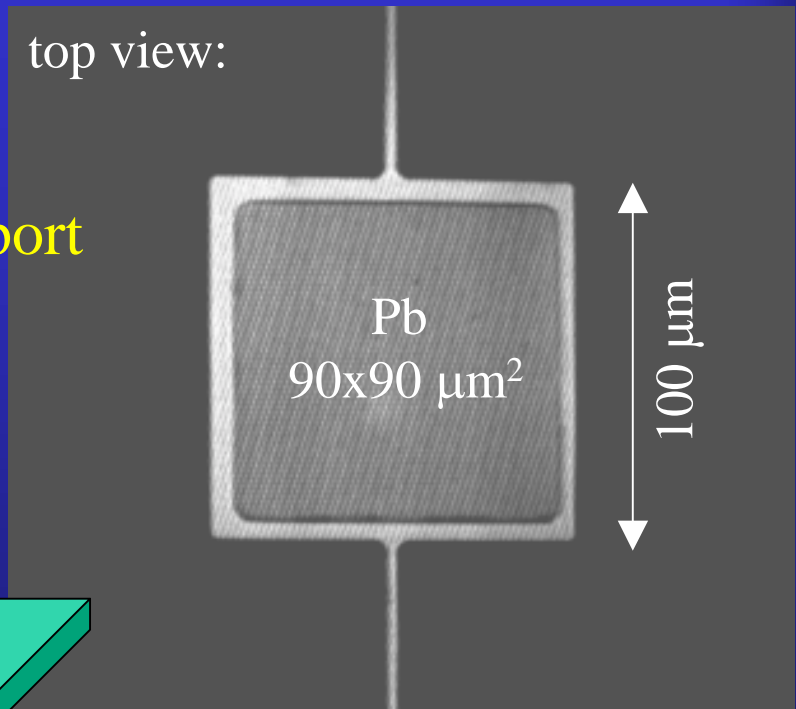
Working principle:

- breaking of Cooper pairs
- quasiparticle lifetime
- recombination, phononic energy transport

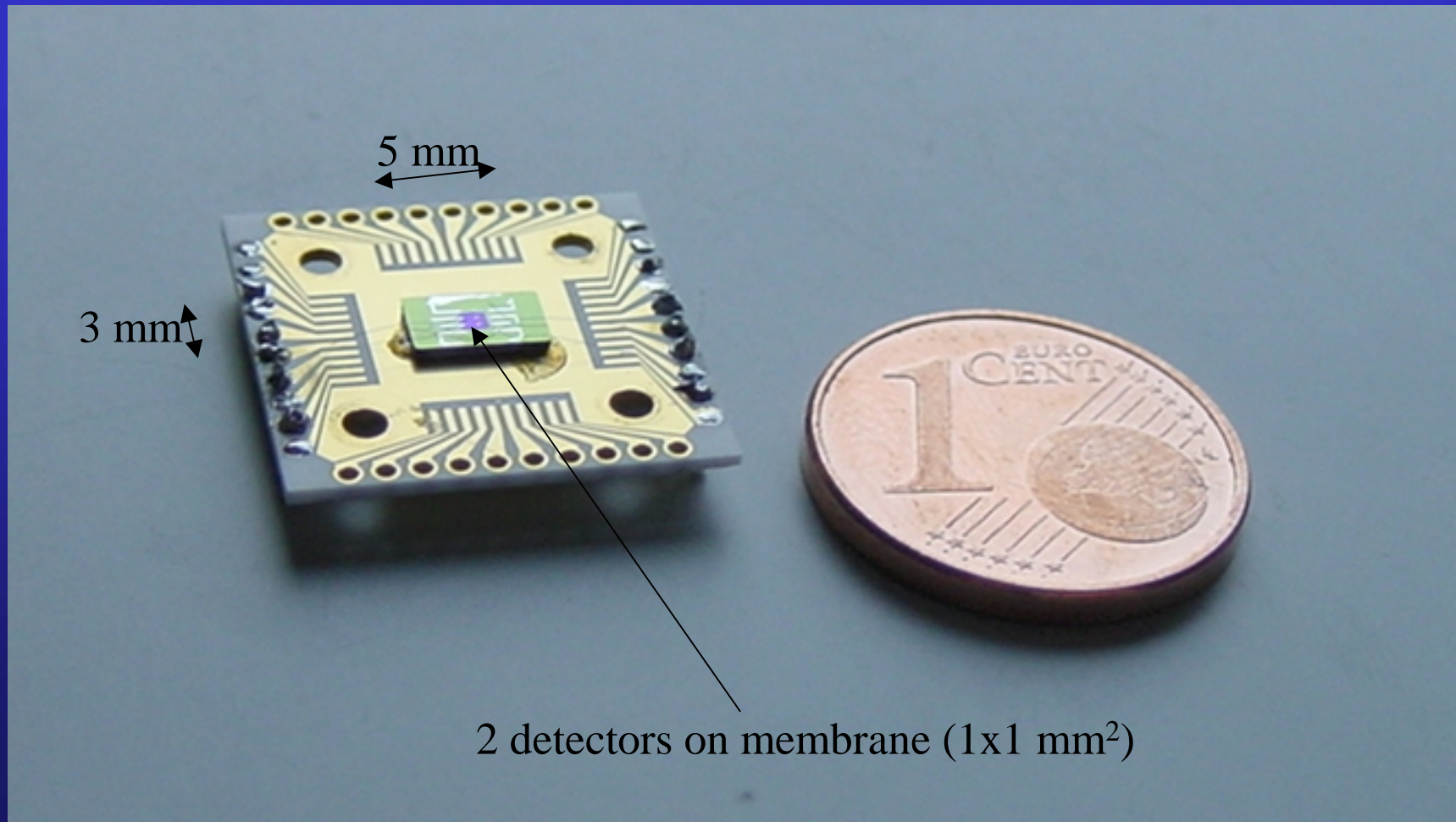


Working principle:

- breaking of Cooper pairs
- quasiparticle lifetime
- recombination, phononic energy transport
- phonon absorption, STJ signal



Picture of STJ detector chip ($3 \times 5 \text{ mm}^2$), glued on chip holder





Electron Storage Ring *BESSY II* (Berlin, Germany)
PTB operates several beamlines at *BESSY II*

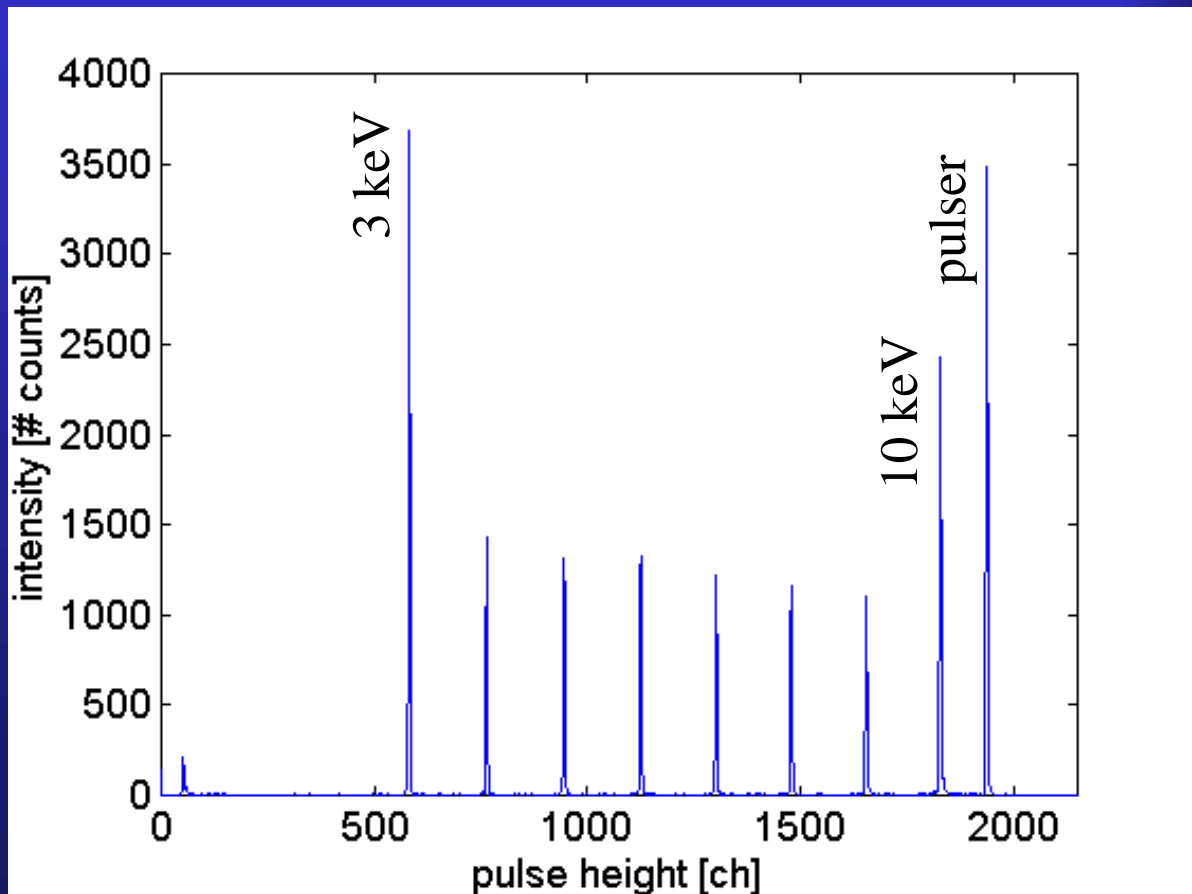
ADR cryostat and STJ preamplifier
(designed and supplied by LLNL)
available at PTB beamline

Energy scan:

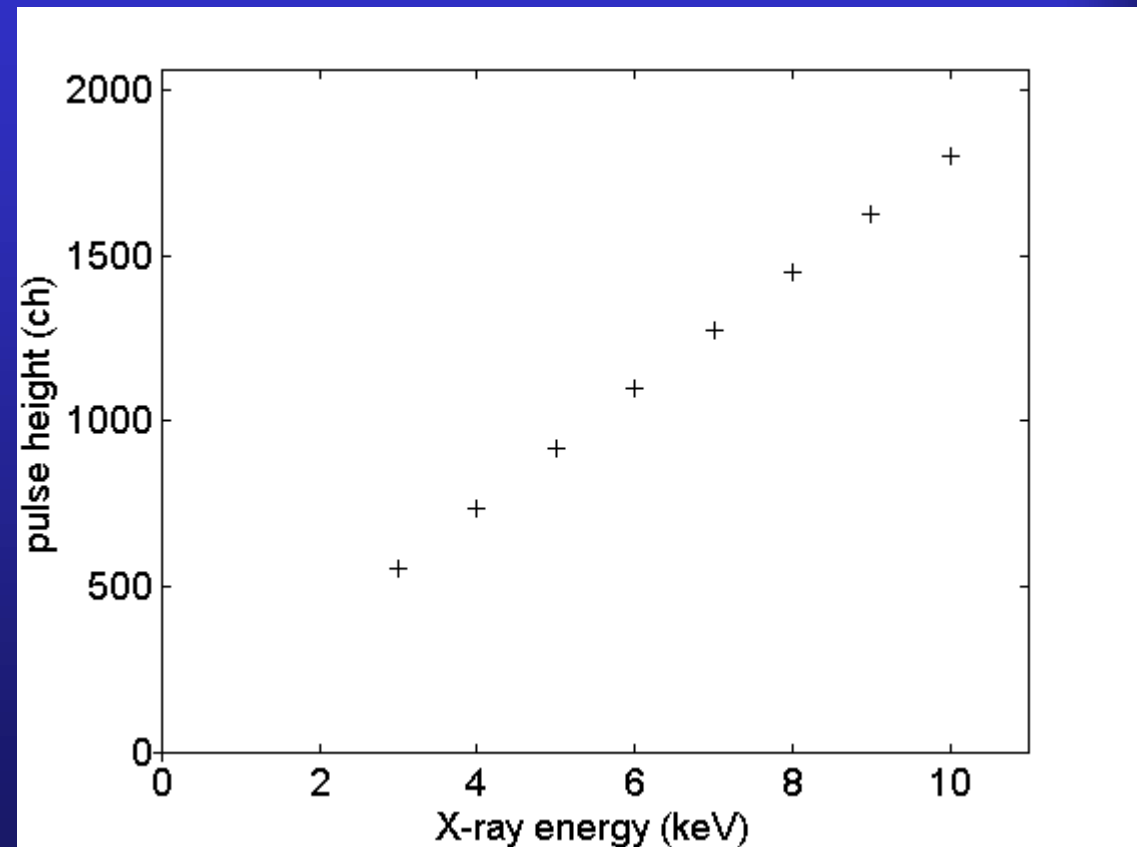
X-ray energy:
3 keV to 10 keV
in steps of 1 keV

electronical pulser
for stability control

pulse height only;
no pulse shape
discrimination

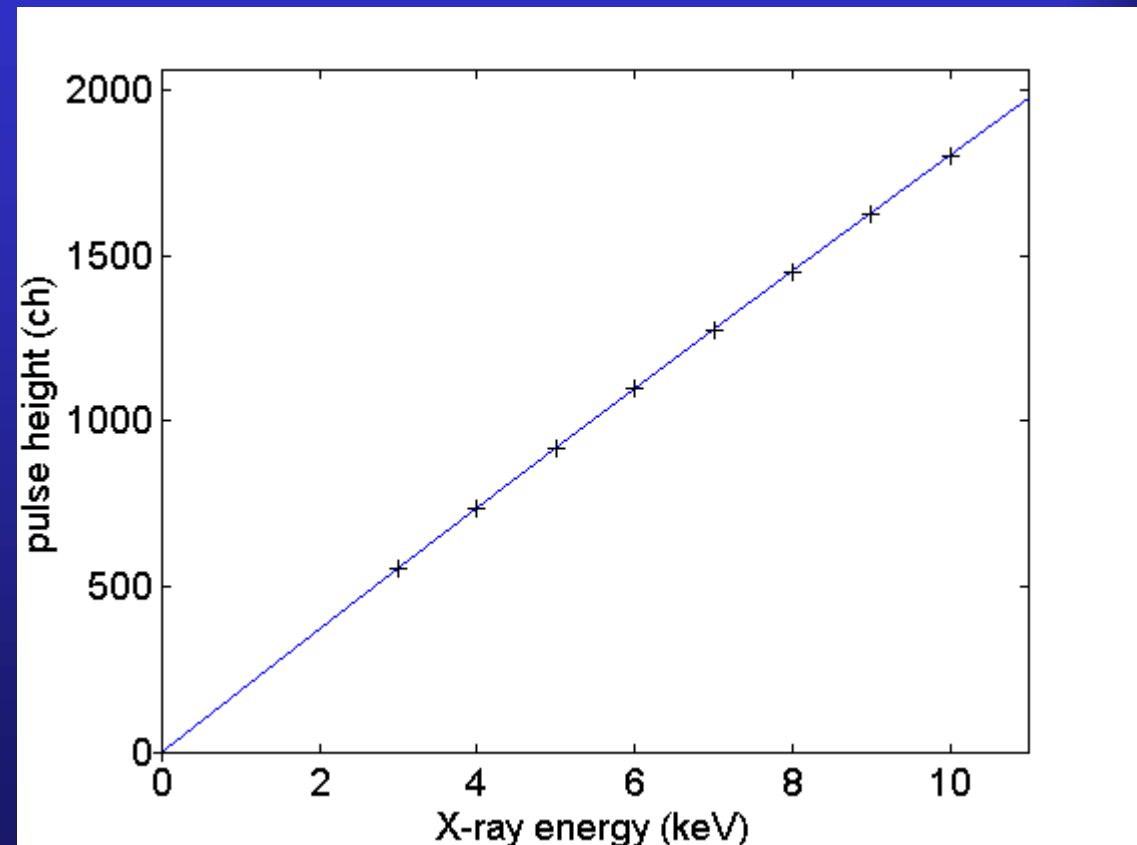


Relation of detector pulse height - X-ray energy:



Relation of detector pulse height - X-ray energy:

Best fit:
polynomic function
with small
quadratic term
(blue line)



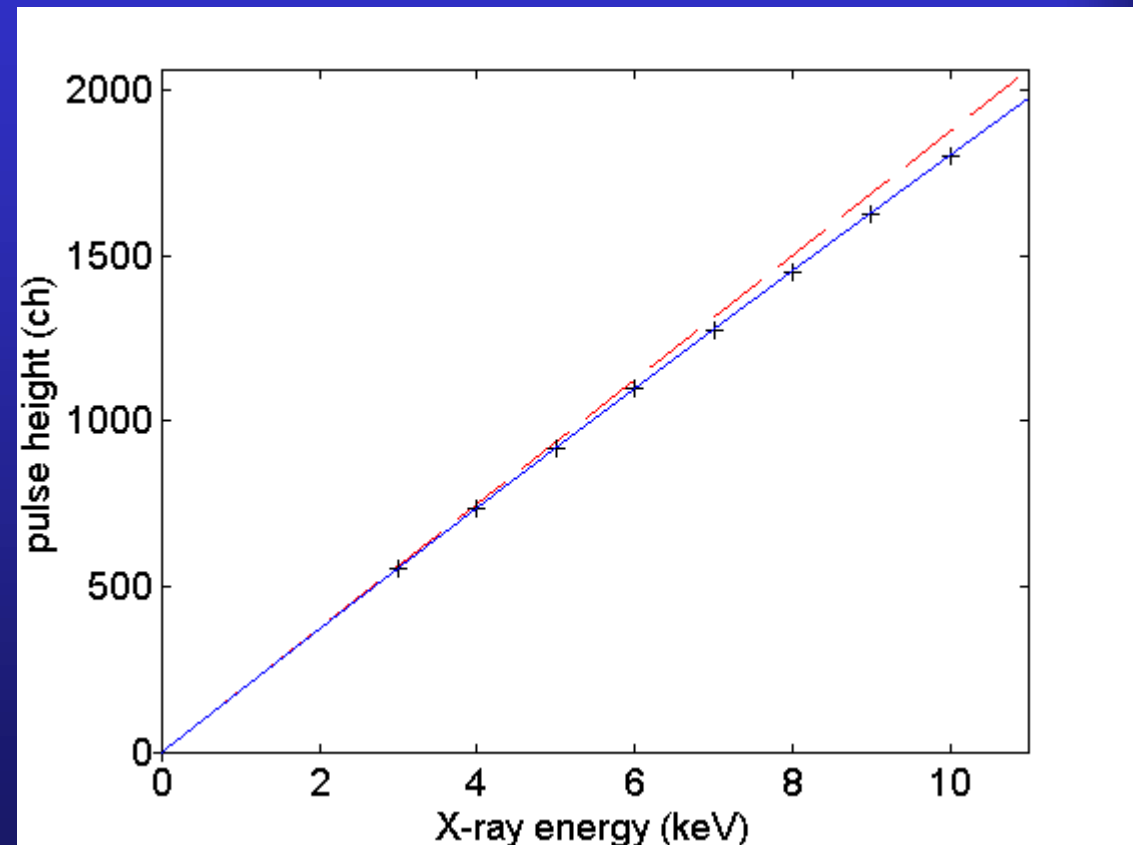
Relation of detector pulse height - X-ray energy:

Best fit:

polynomic function
with small
quadratic term
(blue line)

for comparison:
same function
w/o quadratic term
(red dashed line)

**quadratic deviation due to
escape of recombination phonons**

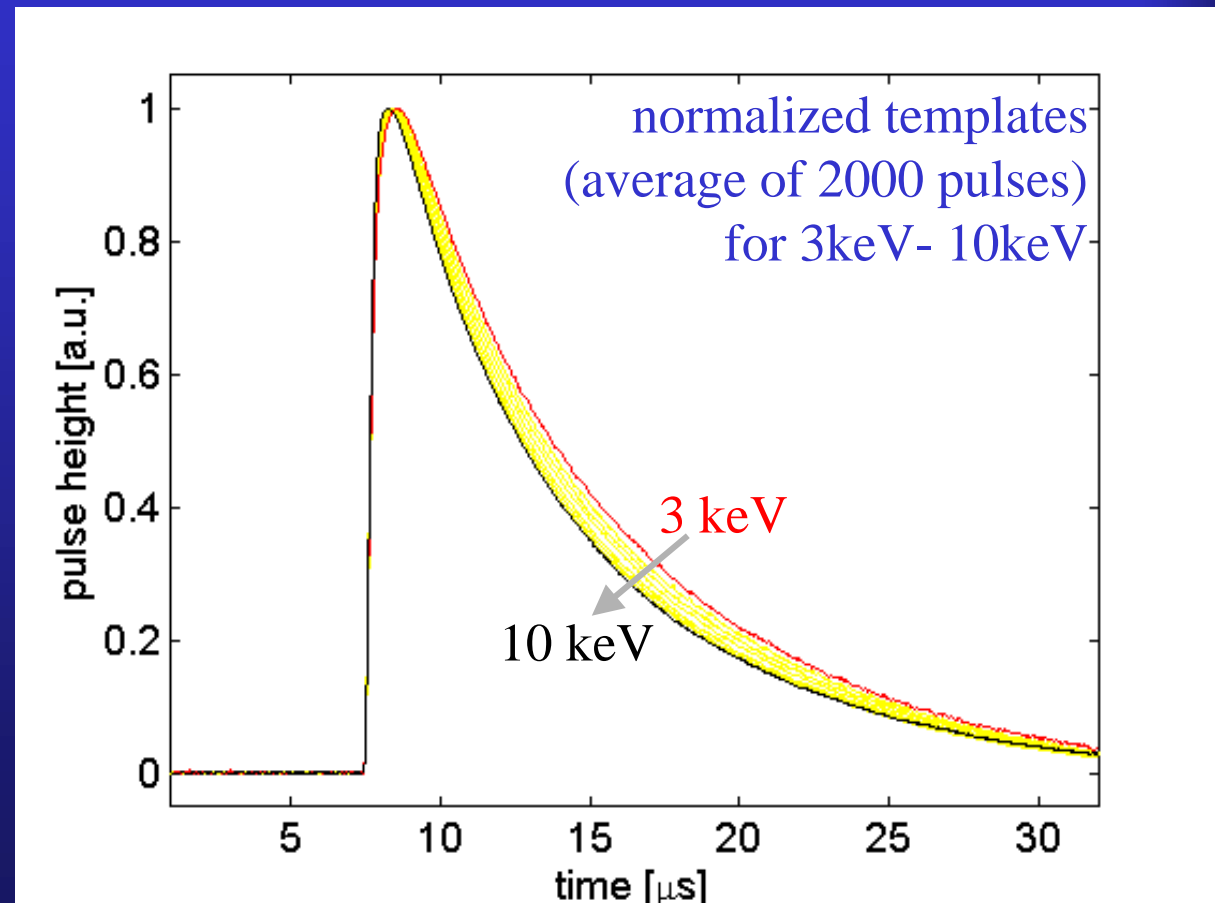


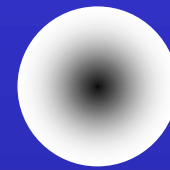
qualitative confirmation from pulse shape data:

slight energy
dependence
of signal rise
and signal decay

due to

energy dependence
of QP lifetime
in Pb & Al

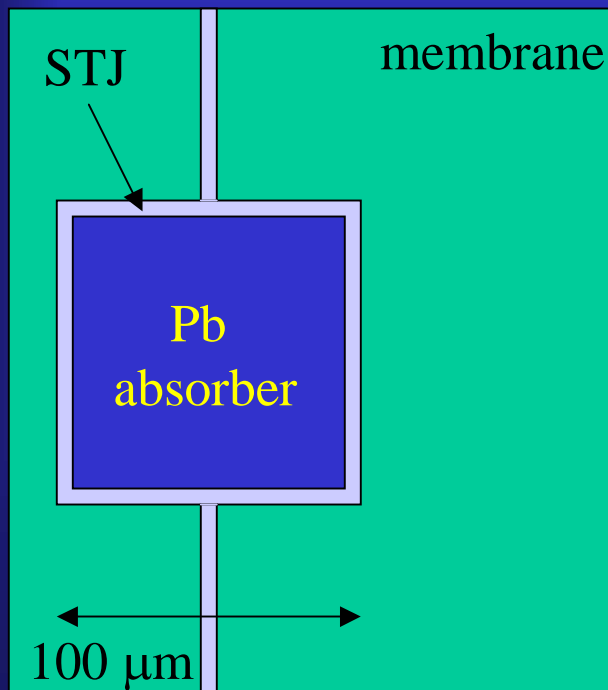




X-ray beam

50 μm

Detector top view:

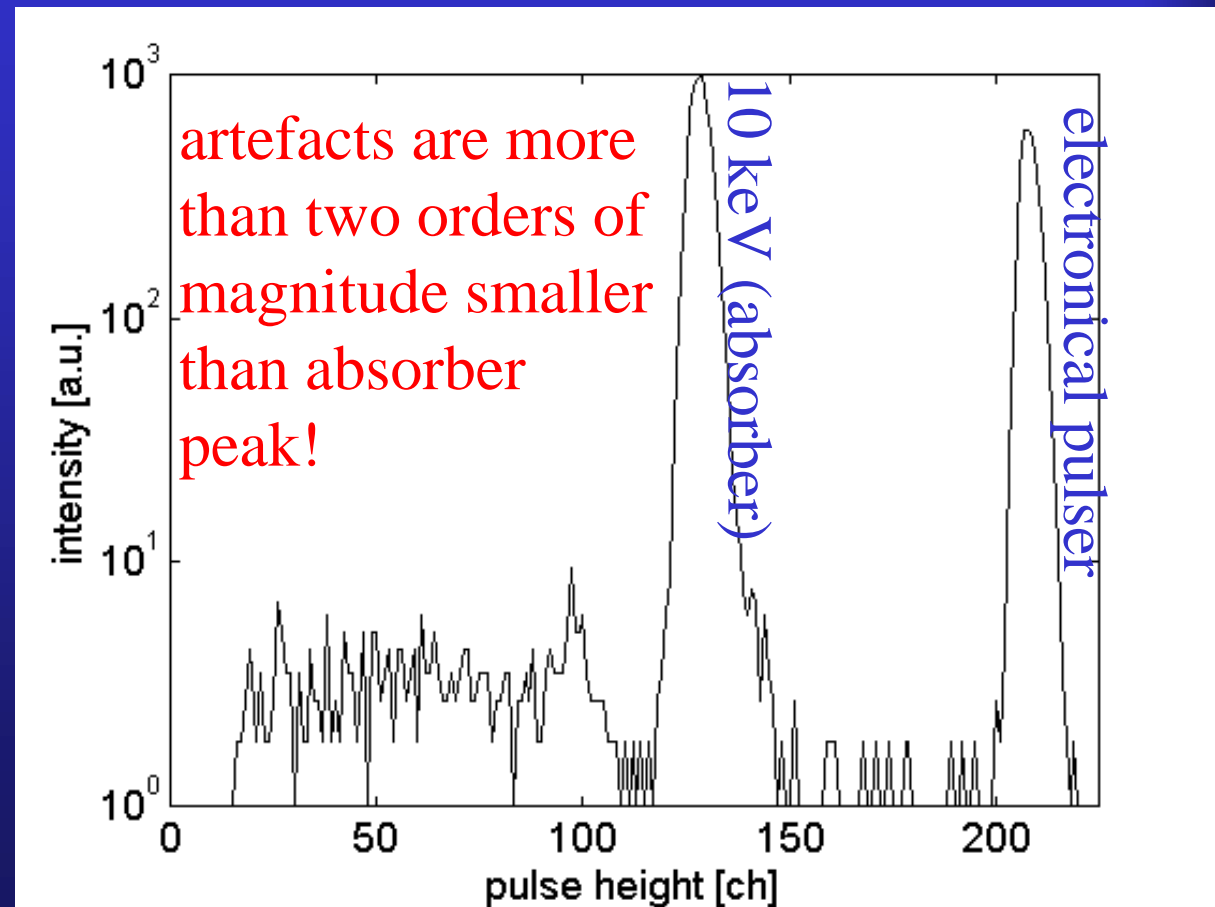
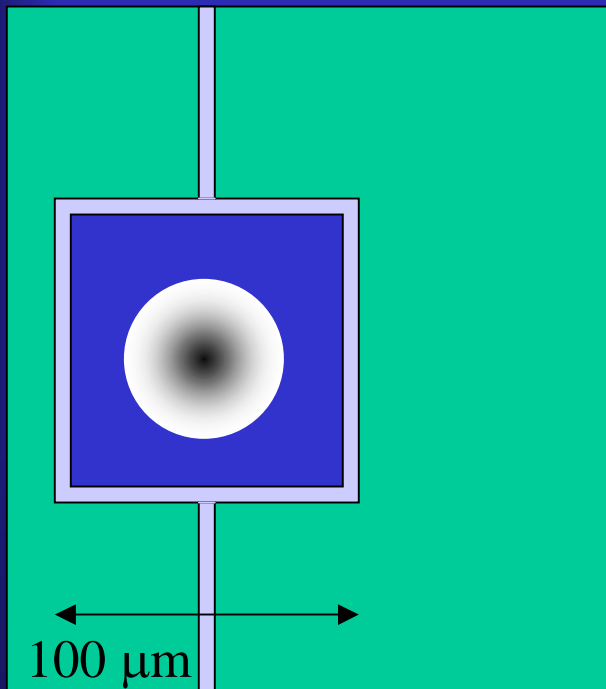


Idea:

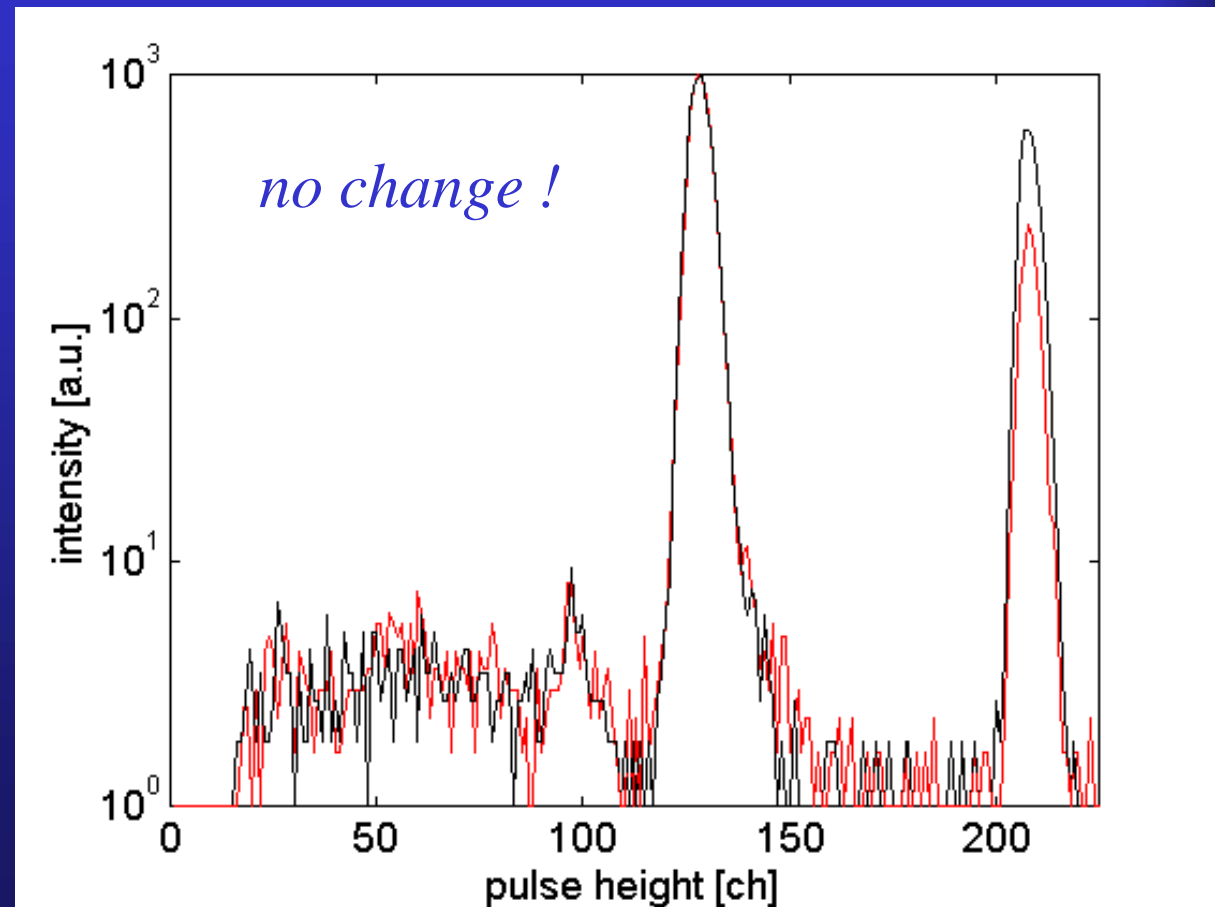
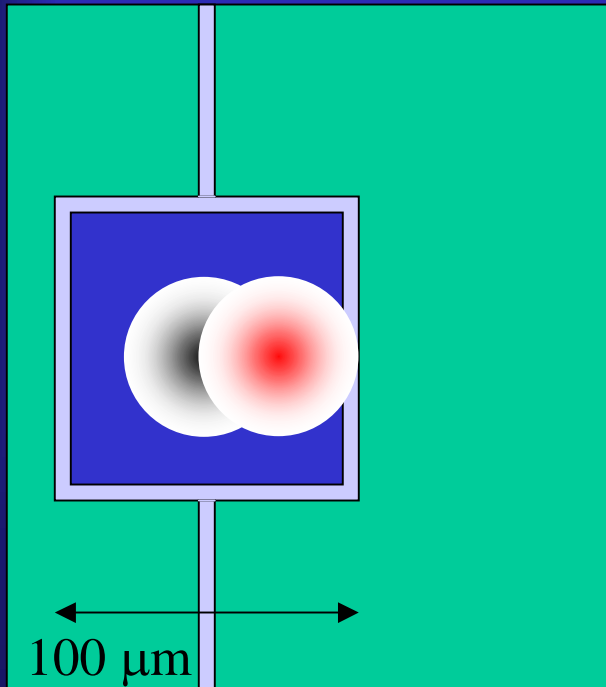
- constant X-ray energy of 10 keV
- spatial scan in steps of 25 μm
- measurement of detector response

- pulse height spectrum (semilog. scale)
- absorber peak normalized

black: center position



red: + 25 μm
black: center position

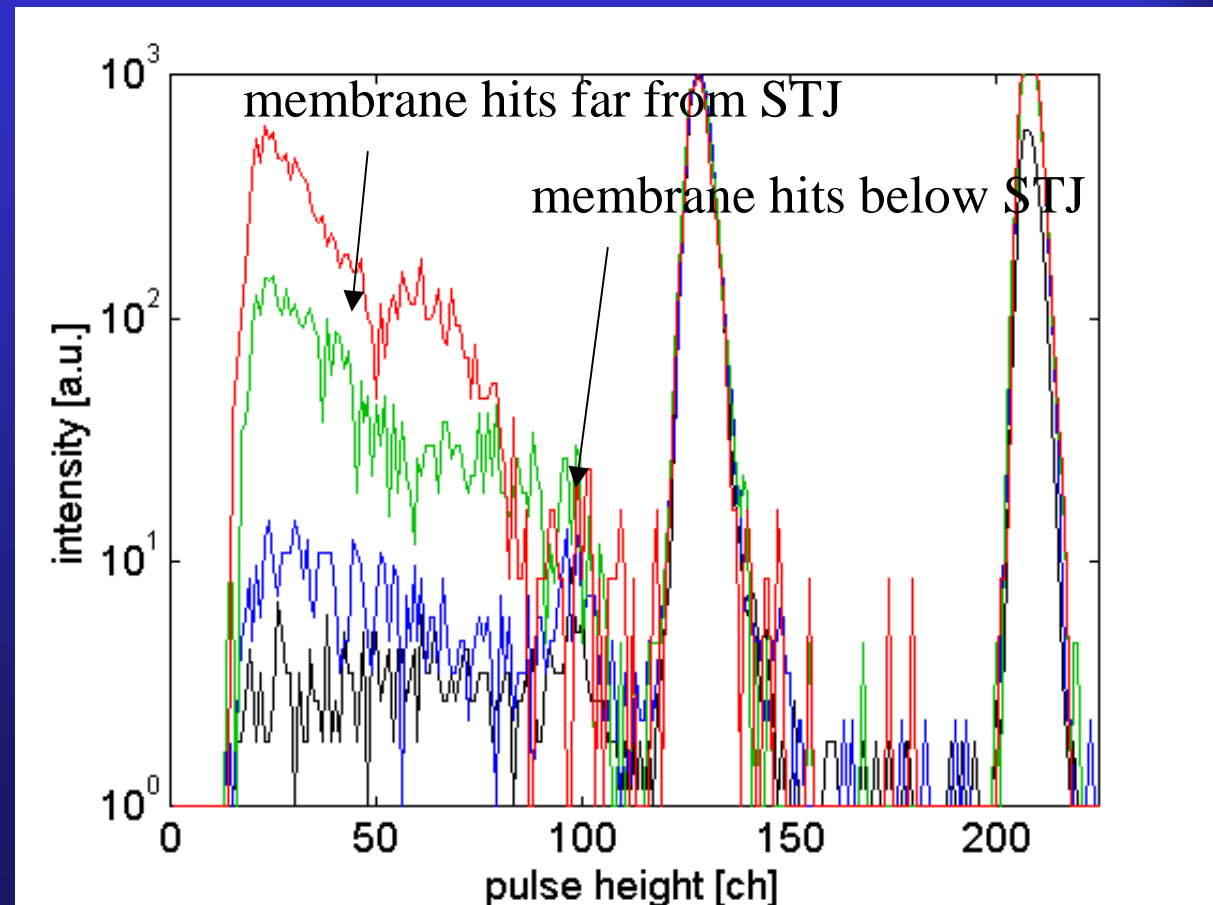
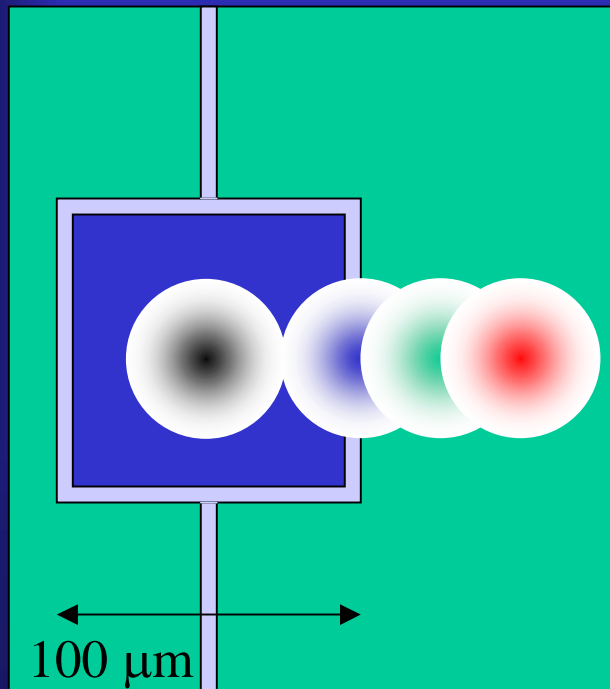


yellow: + 100 μm

green: + 75 μm

blue: + 50 μm

black: center position



- detector was successfully operated at BESSY synchrotron
- low deviation from linearity detected, can be corrected easily
- detector artefacts more than two orders of magnitude smaller than X-ray line, origin understood (further suppression via PSD)

Thank you for your attention !