Multichannel Silicon Drift Detectors for High Speed, High Resolution X-ray Spectroscopy Applications

A.Niculae, R. Eckhardt, A.Liebel, H. Soltau

PNDetector GmbH, Munich, Germany

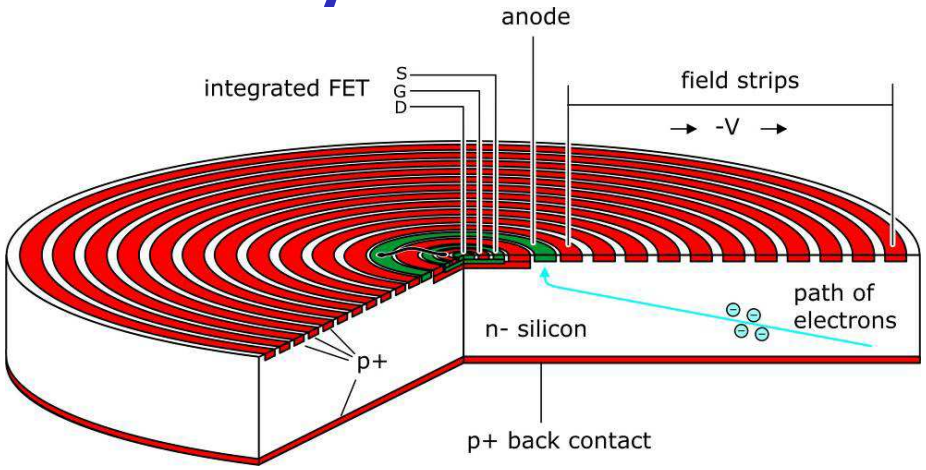
D. Schlösser, G. Lutz, L. .Strüder

PNSensor GmbH, Munich, Germany

Silicon Drift Detector – a success story

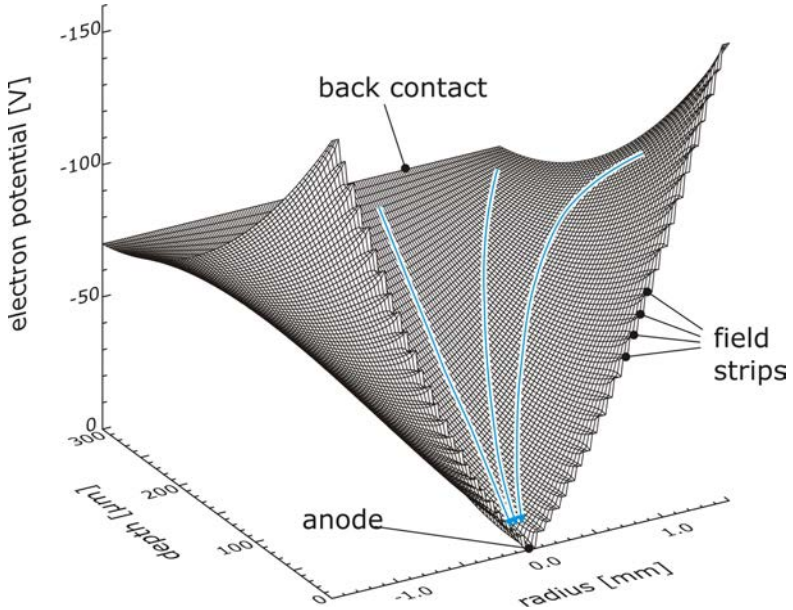
Silicon drift detector

- introduced by Gatti and Rehak in 1984
- revolutionized the spectroscopy world in the last ten years (the "*smart phone*" among the spectroscopic detectors)

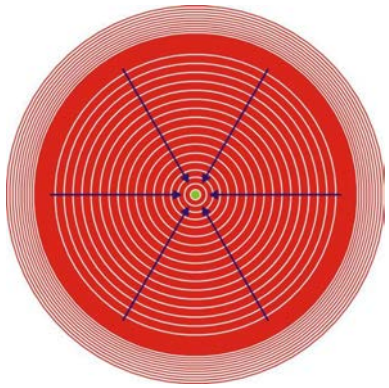


SDDs manufactured by PNDetector / PNSensor

- first SDDs to serve the industry and the research
- monolithic integration of 1st amplifying FET
  - minimization of the input capacitance (down to 50 fF)
  - excellent energy resolution at high count rate
  - robust against pickup, microphony
- ultra-clean fabrication technology leading to low leakage current values I_{leak} < 100 pA /cm^2 @ RT
- in 2013/2014 a new manufacturing line has been built and is being qualified

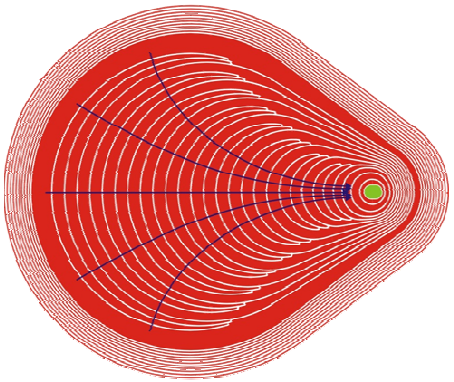


Single channel SDDs



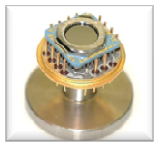
Standard round geometry (SDD):

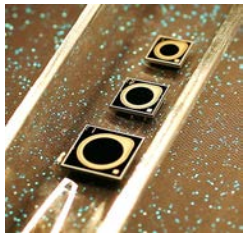
- **Anode and FET in the center of the device**
- **Radial drift fields**
- **Sizes: 5, 10, 20, 30, 60, 100 mm^2**



Droplet type geometry (SD3):

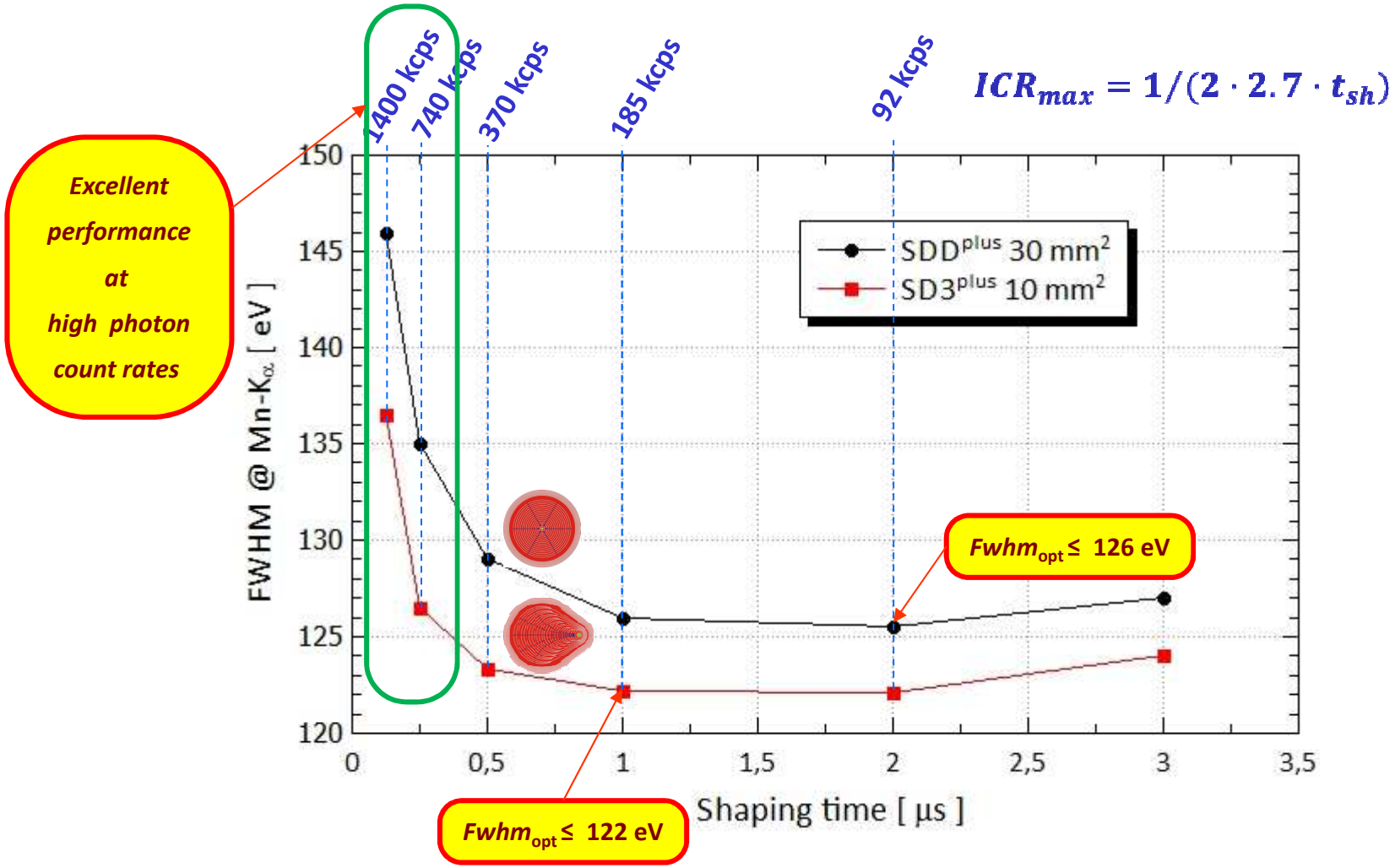
- **Displaced anode and FET**
- **Reduced input capacitance**
- **Improved peak to background**
- **Sizes: 5, 10, 20, 30 mm^2**





Single channel SDDs

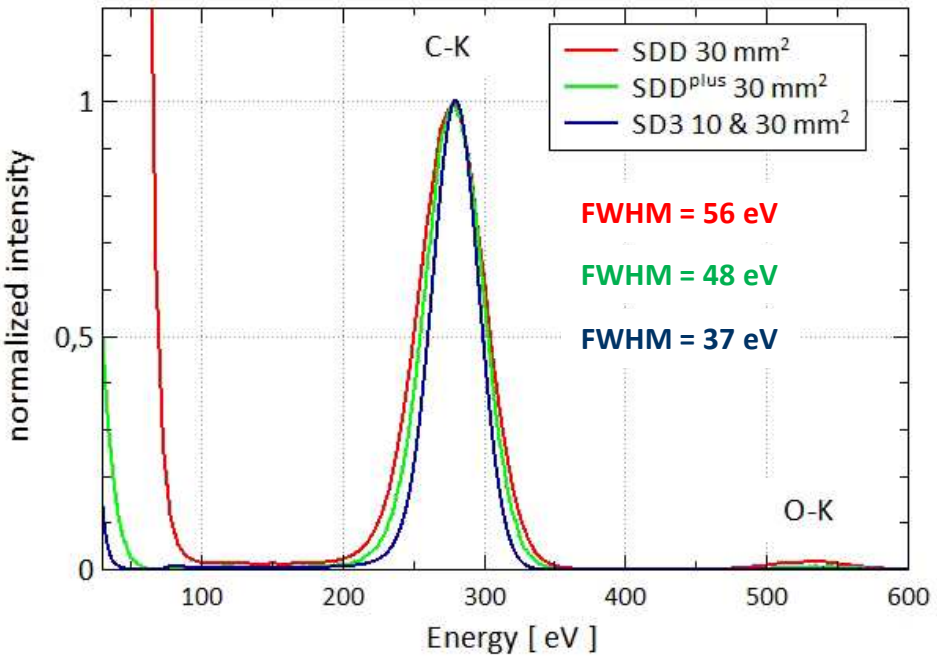
Spectroscopic performance at the theoretical limit

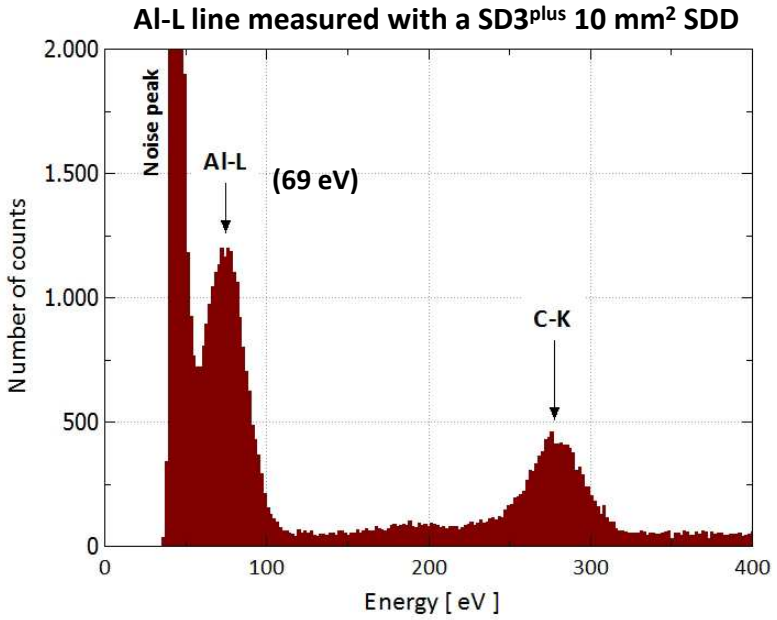


Single channel SDDs

Excellent light element performance due to low noise and optimum EW

- **energy resolution at C-K down to 37 eV**
- **energy threshold < 50 eV**





Multi-channel SDD detectors

Focus on customized detector solutions – multi-channel SDDs are part of it.

Why multi-channel SDDs?

Applications requiring multi-channel SDD detectors:

1. **Good spectroscopic performance at ultra-high count rates (e.g. > 1 Mcps)**

   „ a sorrow shared is a sorrow halved“

2. **Special geometry for optimum collection of the incoming photons**

3. **Spatial resolution for the incoming x-rays and γ-rays**

Advantages of monolithically integrated SDD arrays

- **Minimum dead area between the cells**
- **Flexible design of the cells**
- **Compact packaging of the whole detector**

Multi-channel SDD detectors

Applications requiring multi-channel SDD detectors:

1. **Good spectroscopic performance at ultra-high count rates (e.g. > 1 Mcps)**

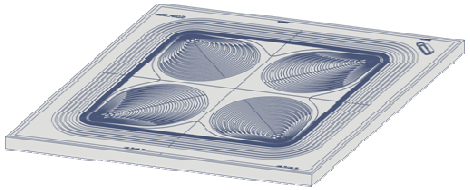
   „ a sorrow shared is a sorrow halved“

2. Optimum geometry for high collection efficiency of the incoming photons

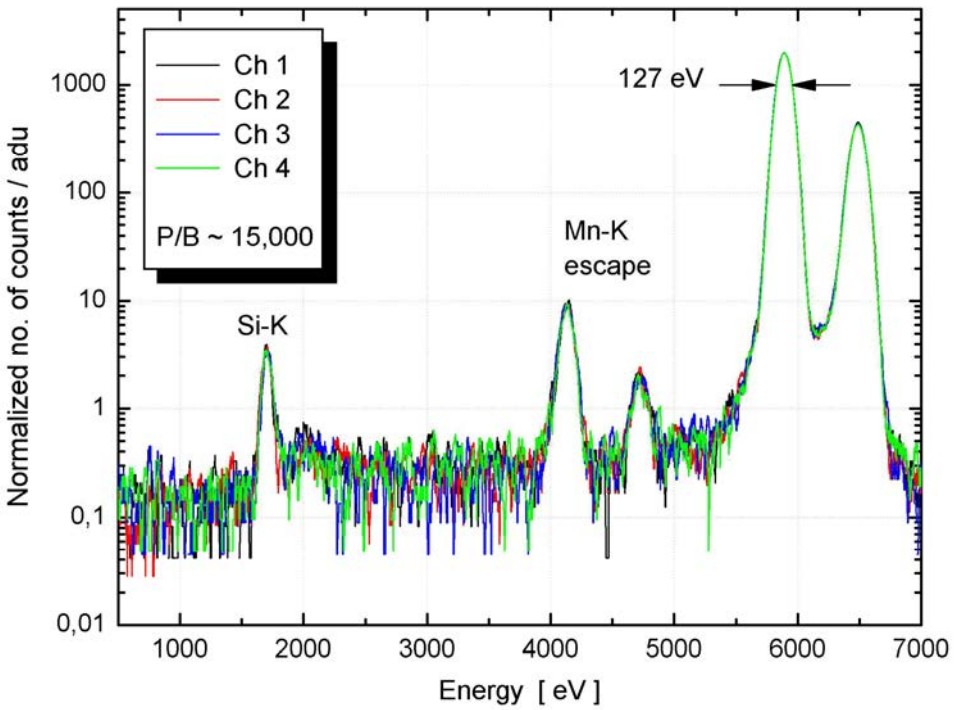
3. Spatial resolution for the incoming x-rays and γ-rays

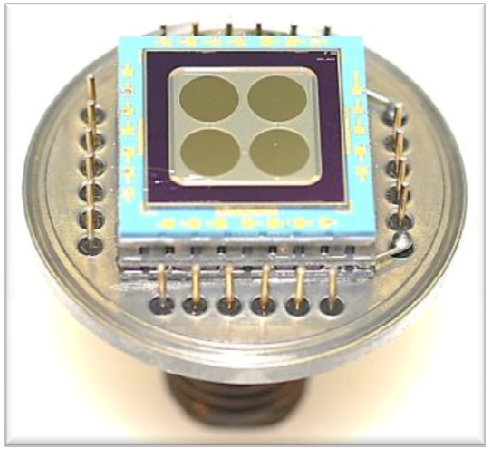
Multi-channel SDDs for ultra-high count rates

Rococo1 - 4-channel SD3 detector



- **active area 4 x 10 mm²**
- **SD3 topology - excellent energy resolution**
- **light element detection down to Be or lower**

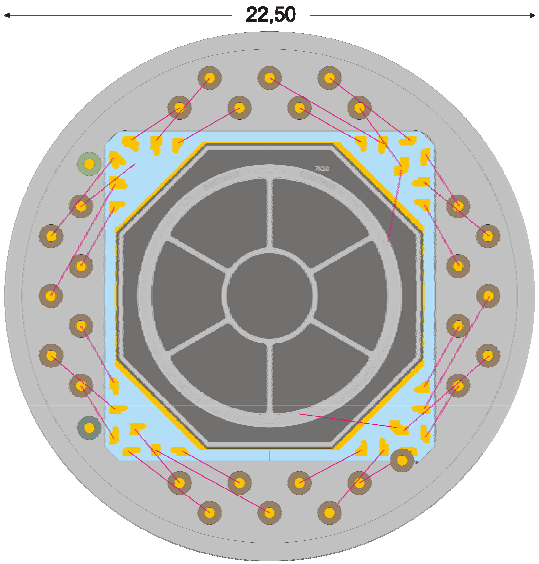


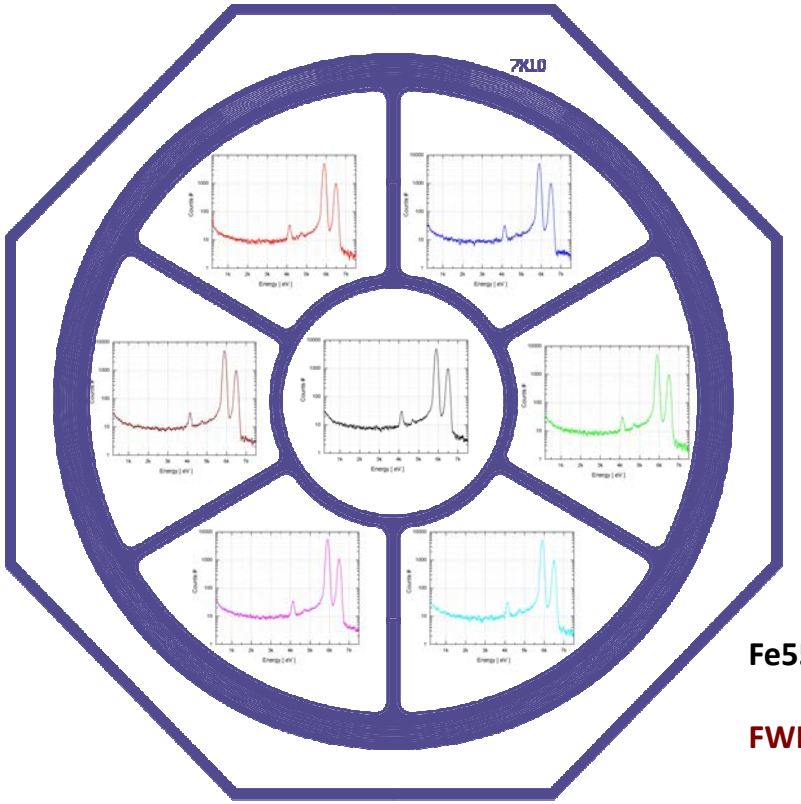


Multi-channel SDDs for ultra-high count rates

Compact 7-channel SDD detector

- active area of 7 x 10 mm^2
- maximal count rate capability of 7· 10^6 cps
- allow compact packaging on socket with Peltier cooler





Fe55 spectra of all 7 channels (no collimator)

FWHM @ Mn-Ka: 135 - 137 eV

Multi-channel SDD detectors

Applications requiring multi-channel SDD detectors:

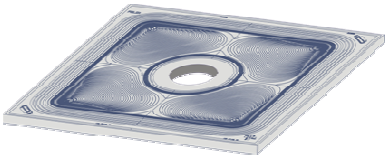
1. Good spectroscopic performance at ultra-high count rates (e.g. > 1 Mcps)

   „ a sorrow shared is a sorrow halved“

2. **Optimum geometry for high collection efficiency of the incoming photons**

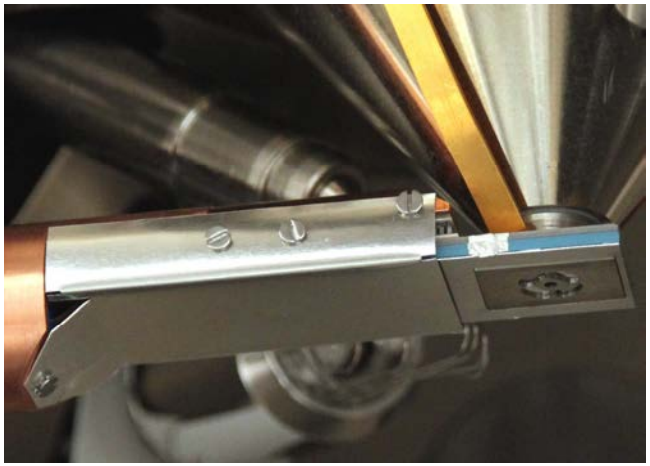
3. Spatial resolution for the incoming x-rays and γ-rays

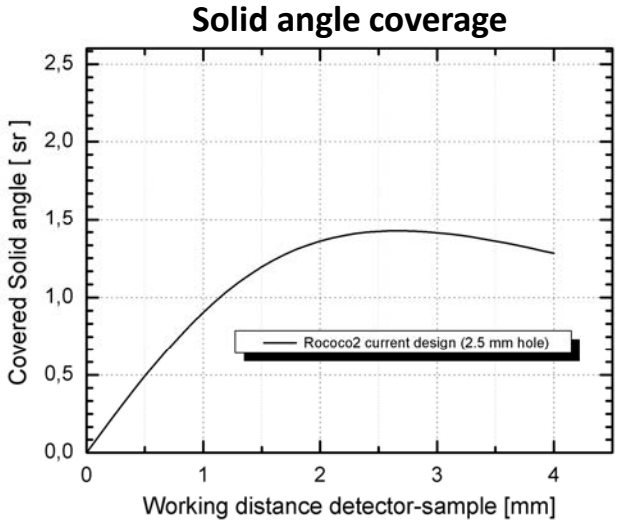
Multi-channel SDDs for high collection angle



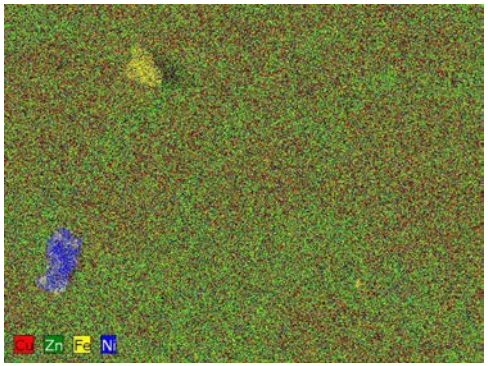
Rococo2 – 4-channel SD3 detector with central hole

- **ideal as pole-shoe EDX detector in SEM / TEM**

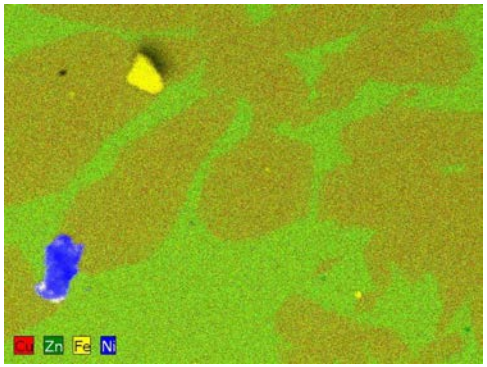




Comparative SEM elemental maps



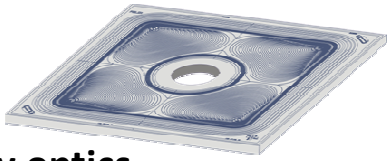
standard 10 mm² detector



Rococo2 detector

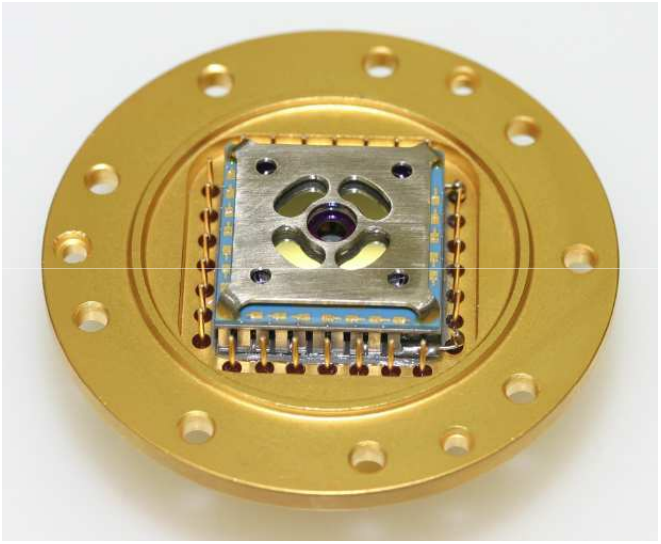
- same acquisition time
- up to 100x more photons collected with the Rococo2 detector

Multi-channel SDDs for high collection angle

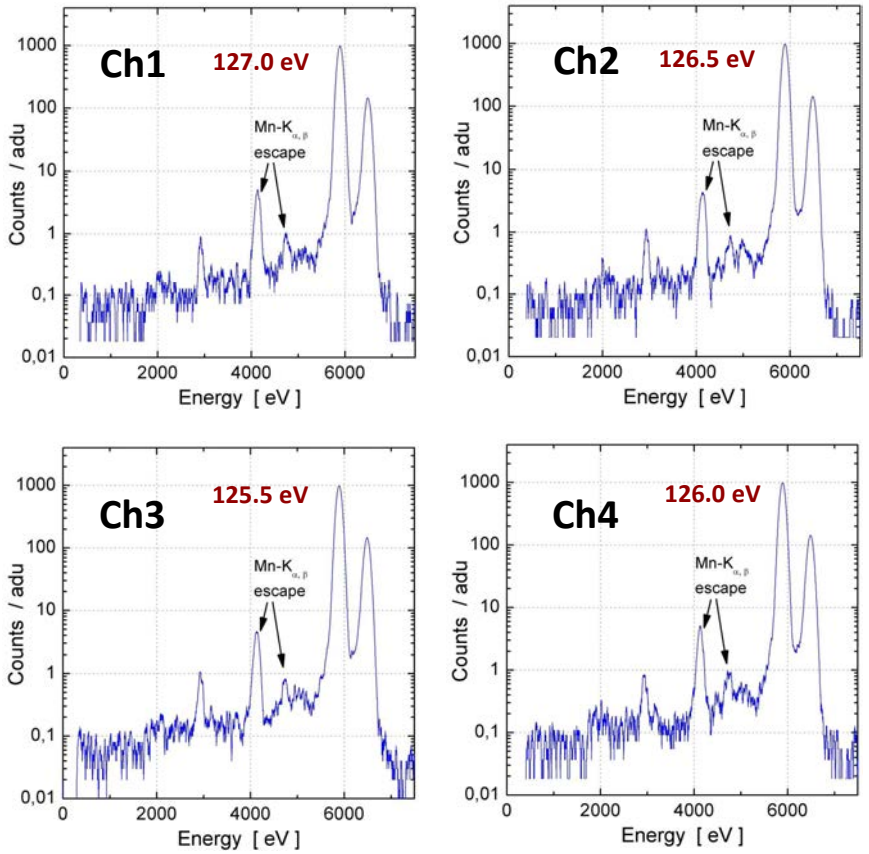


Rococo2 – 4-channel SD3 detector with central hole

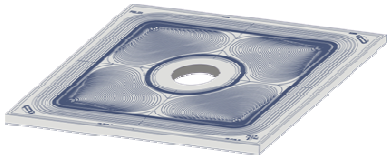
- **ultra-fast XRF analysis (“in-line” QC) in combination with poly-capilary optics**
- **high throughput measurements**



- **active area 60 mm^2**
- **input count rate > 2·10^6 cps**

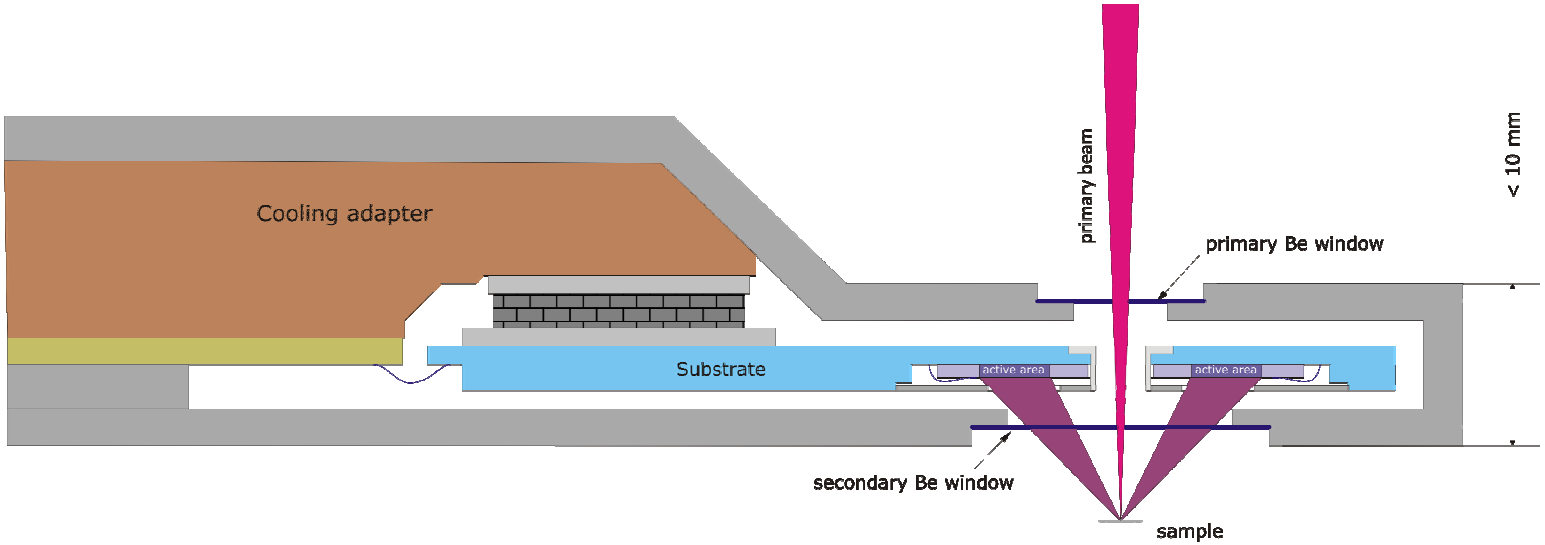


Multi-channel SDDs for high collection angle



Rococo2 – 4-channel SD3 detector with central hole

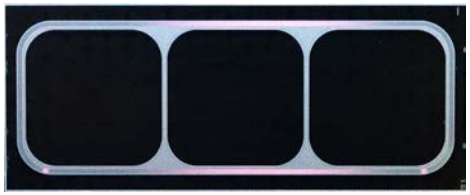
- **concept for a flat configuration for Nano-Beam XRF**
- **detector package can be less than 1 cm thin**

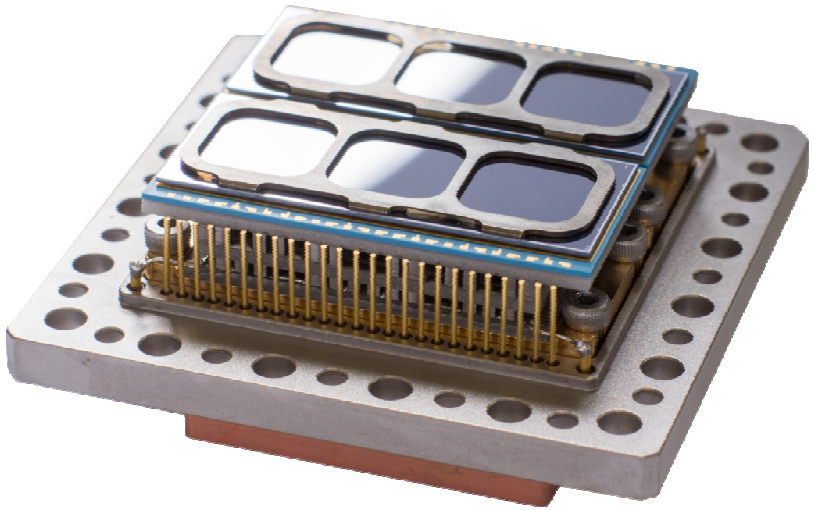


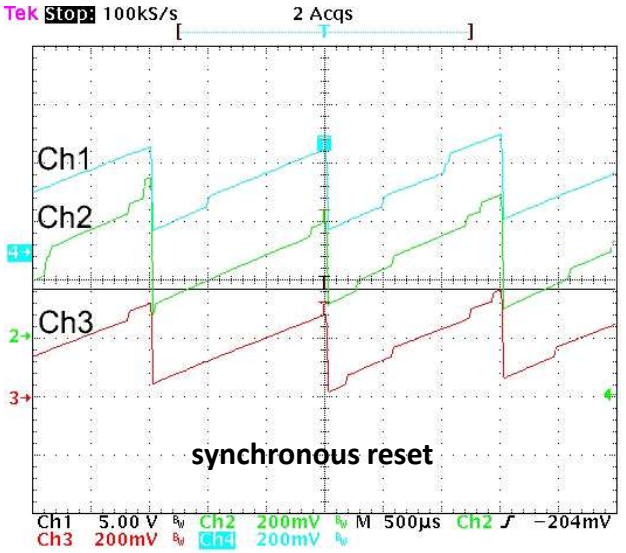
Multi-channel SDDs with large collection area

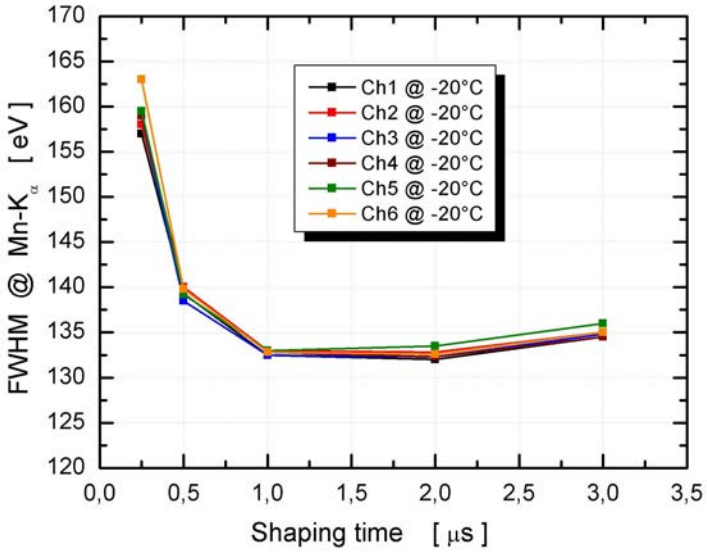
Large area SDDs for synchrotron experiments:

- **3x100 mm² SDDs (1 sensor packaged)**
- **6x100 mm² SDDs (2 sensor in a package)**





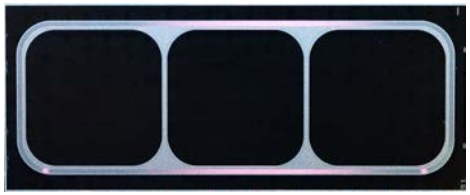


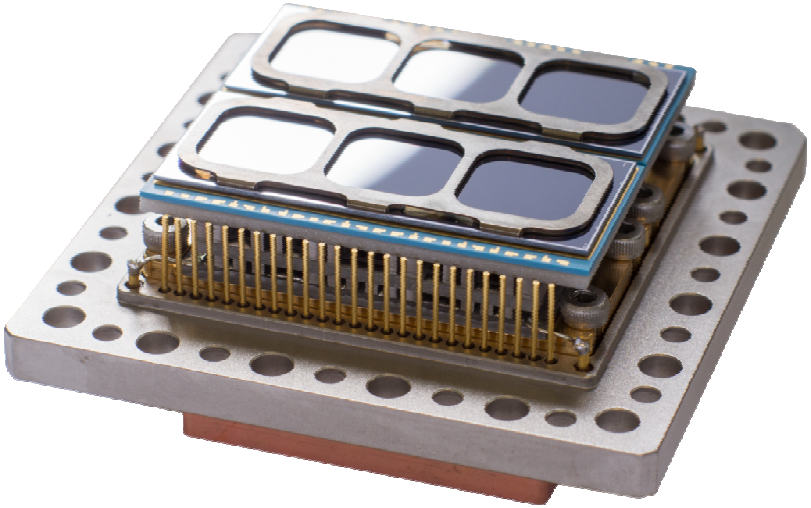


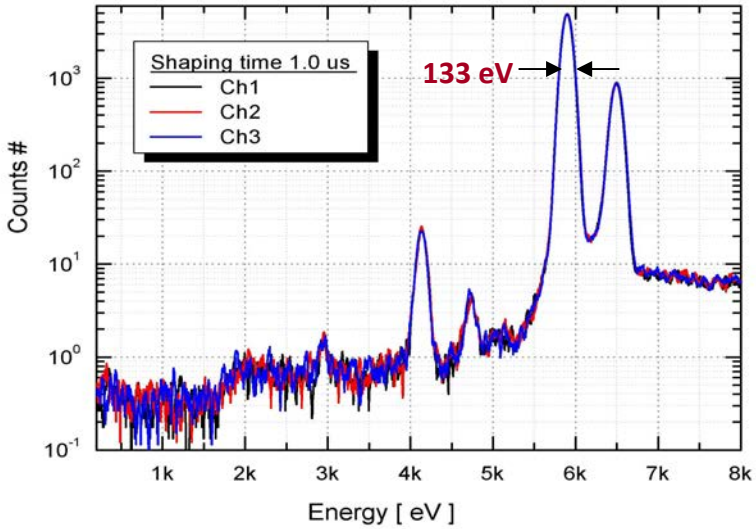
Multi-channel SDDs with large collection area

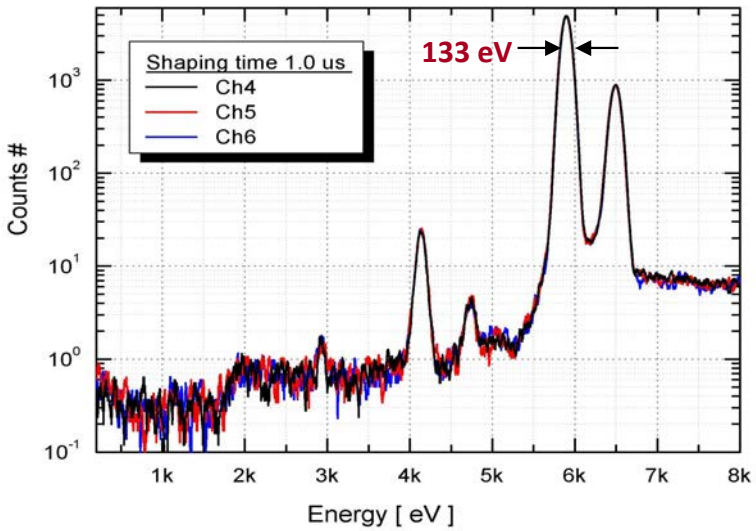
Large area SDDs for synchrotron experiments:

- **3x100 mm² SDDs (1 sensor packaged)**
- **6x100 mm² SDDs (2 sensor in a package)**









Several systems installed at various beam lines (ANKA, DLS, ESRF)

Multi-channel SDD detectors

Applications requiring multi-channel SDD detectors:

1. Good spectroscopic performance at ultra-high count rates (e.g. > 1 Mcps)

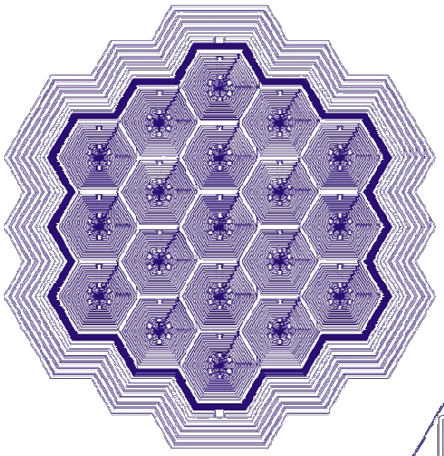
   „ a sorrow shared is a sorrow halved“

2. Optimum geometry for high collection efficiency of the incoming photons

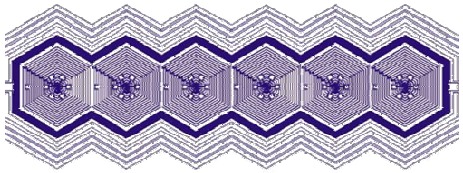
3. **Spatial resolution for the incoming x-rays and γ-rays**

SDD arrays for x-ray / γ-ray imaging and spectroscopy

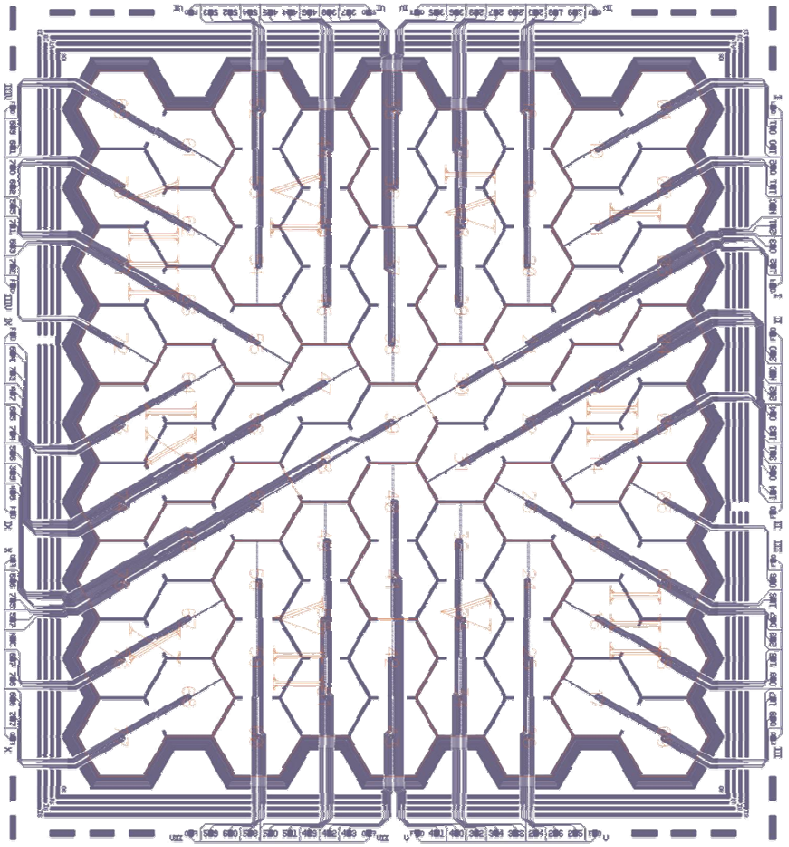
19-cell array



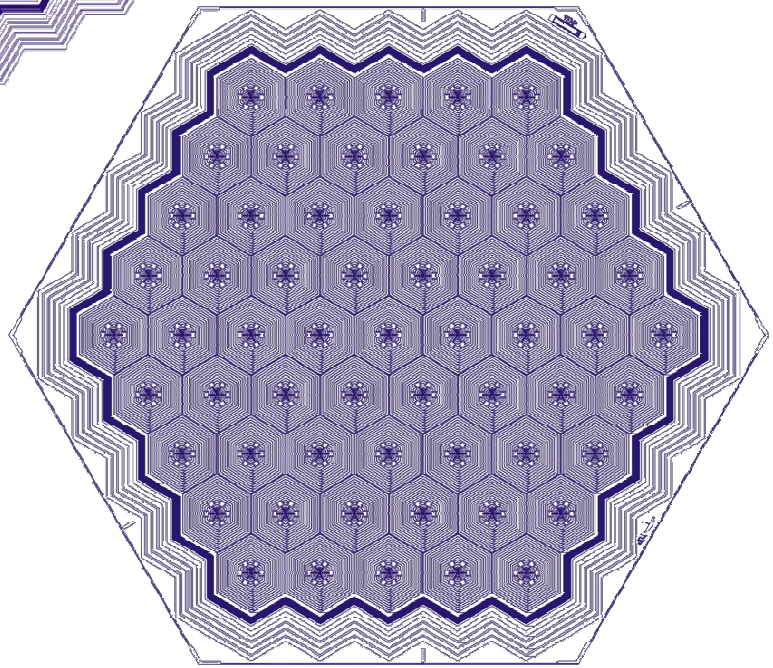
6-cell linear array



77-cell array



61-cell array



the SDD arrays can be combined with scintillators for γ-ray imaging

Thank you for your attention!