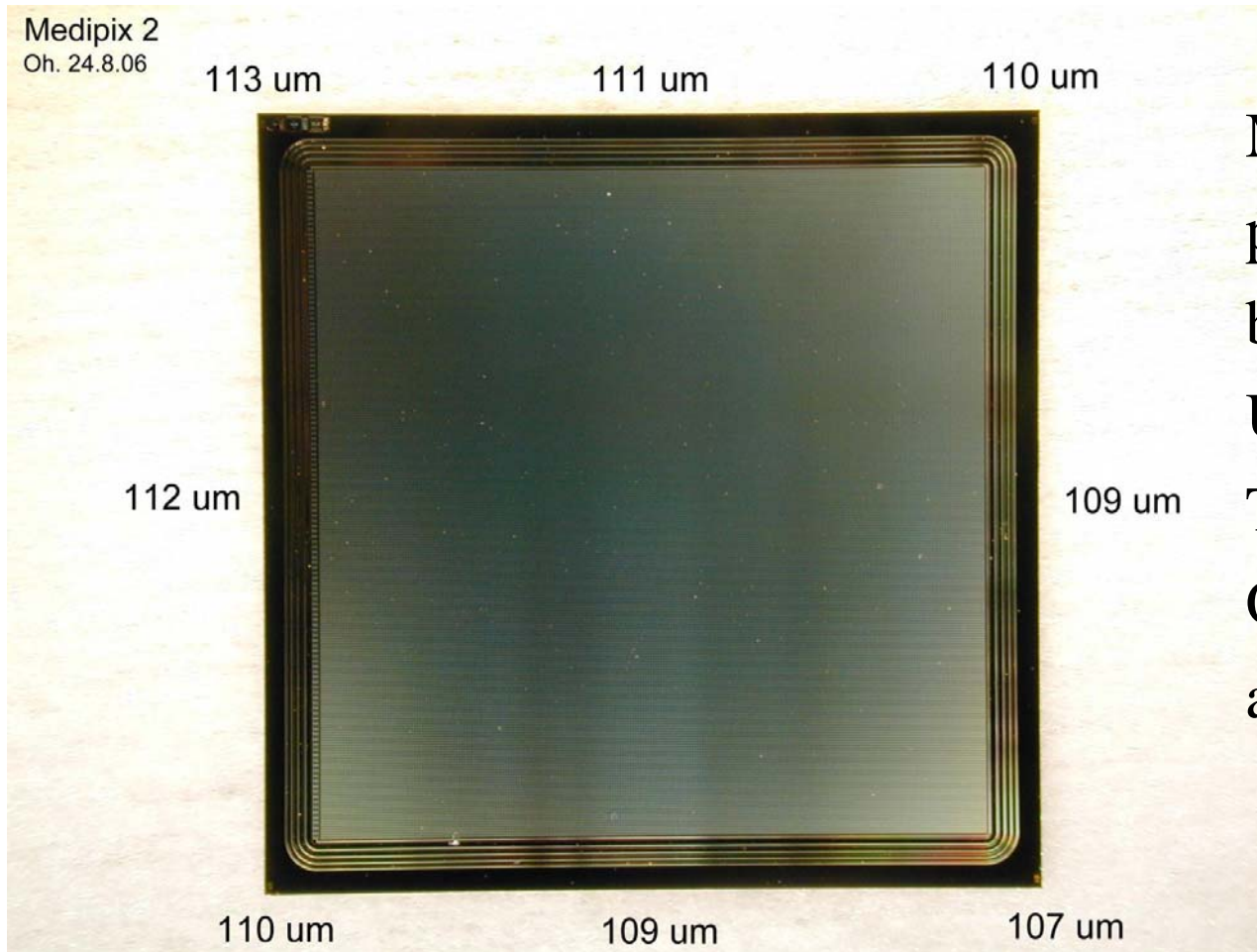




Characterization of an epitaxial GaAs/Medipix2 detector using fluorescence photons



GaAs sensor

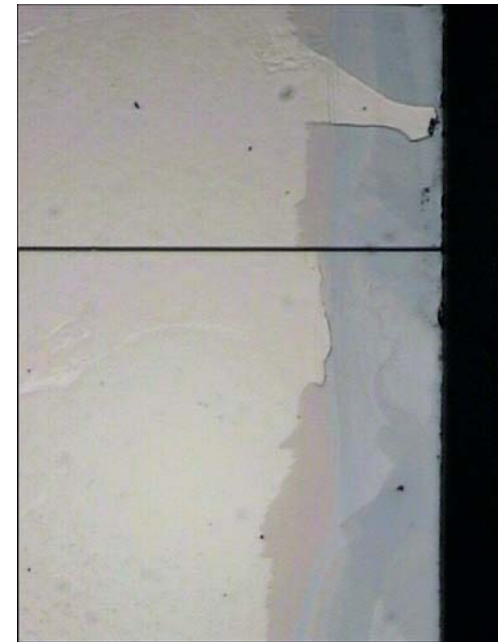
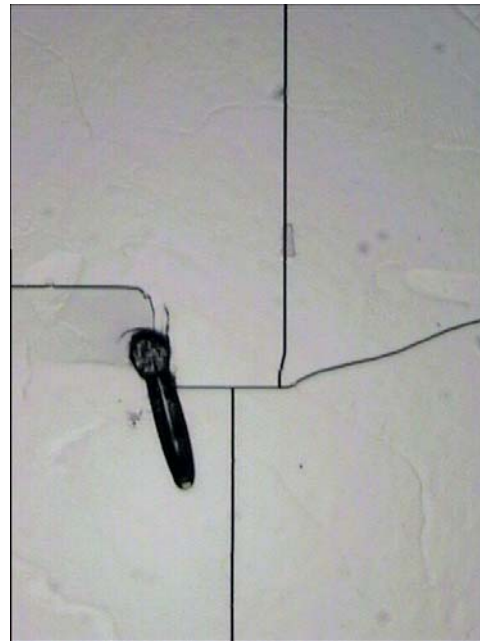
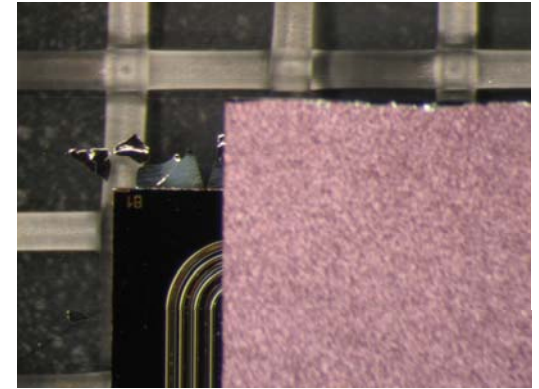


MPX2/GaAs
pin assembly
by Helsinki
Univ. of
Technology,
Oxford Instruments
and VTT



Bad news first ...

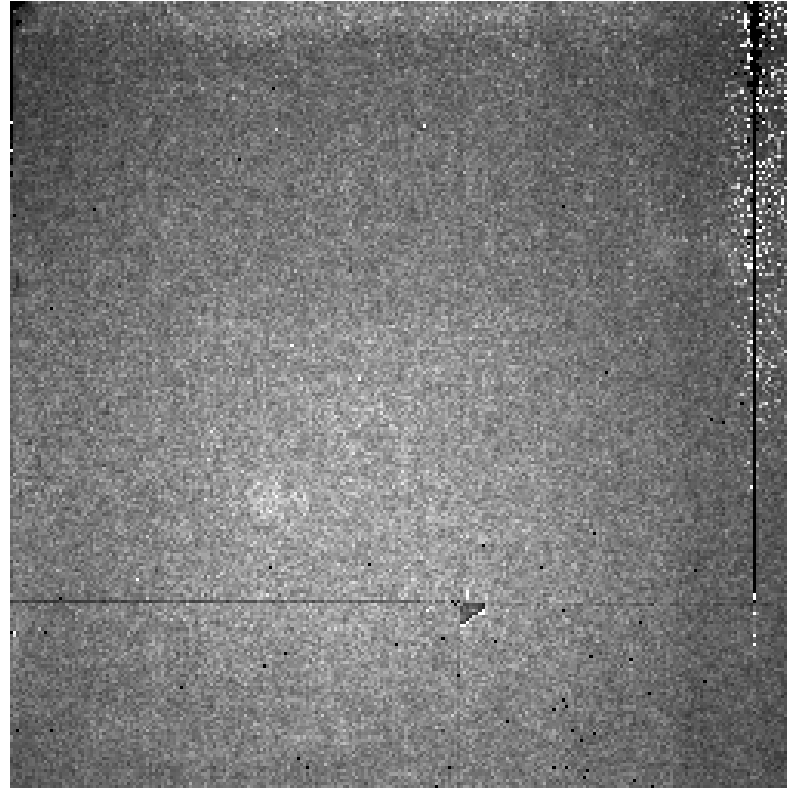
X4 gel-pack with sensor face down
+ $10\mu\text{m}$ curvature + vacuum ...



→ 4 sensors



Good news – still working

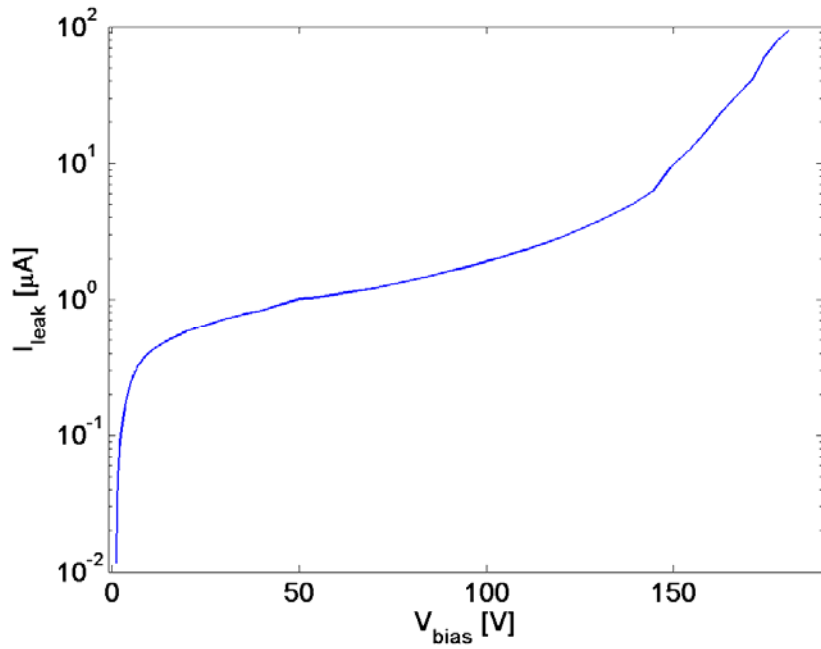


^{90}Sr , 1 min

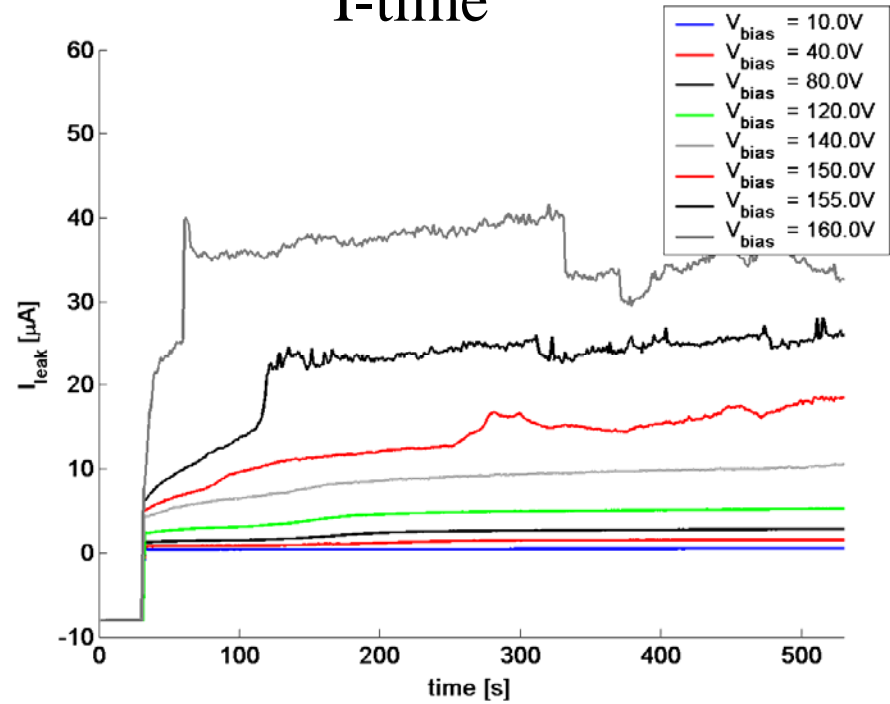


But

I-V



I-time





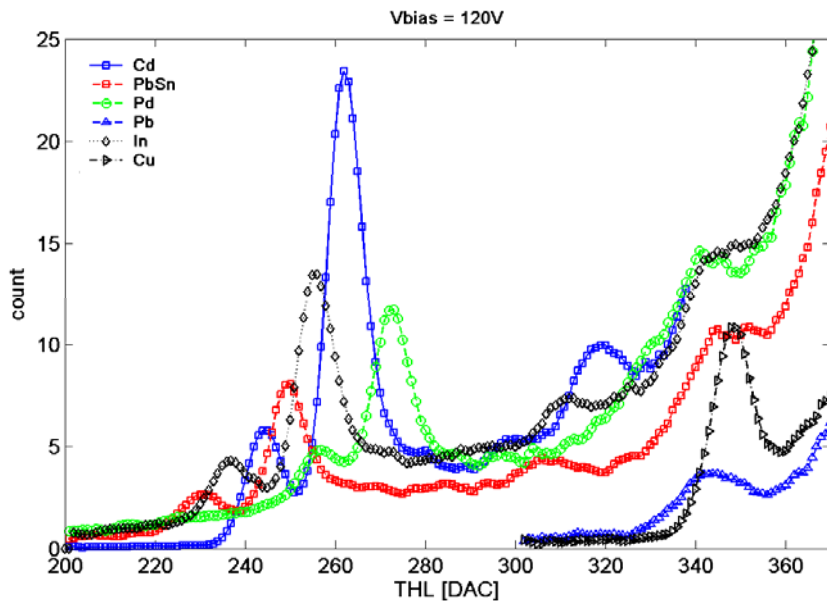
Xray Florescence

- PANalytical X-pert system, Cu target X-ray tube 50 keV, 10 mA.
- Sheets of different materials were placed approx. 10 cm in front of the tube and the backward emitted fluorescence photons were measured
 - **GaAs**: $K\alpha/K\beta$ of Cd (23.1 / 26.1 keV), Sn (25.7 / 28.4 keV), Pd (21.2 / 23.8 keV), In (24.2 / 27.3 keV) and Cu (8.05 / 8.9 keV).
L-lines of Pb at 10.5 and 12.6 keV overlap with Ga fluorescence at 9.2 and 10.2 keV and As fluorescence at 10.5 and 11.7 keV and could not be fitted properly.
 - **Si**: Cd (23.1 / 26.1 keV), Pd (21.2 / 23.8 keV), In (24.2 / 27.3 keV) and Cu (8.05 / 8.9 keV)

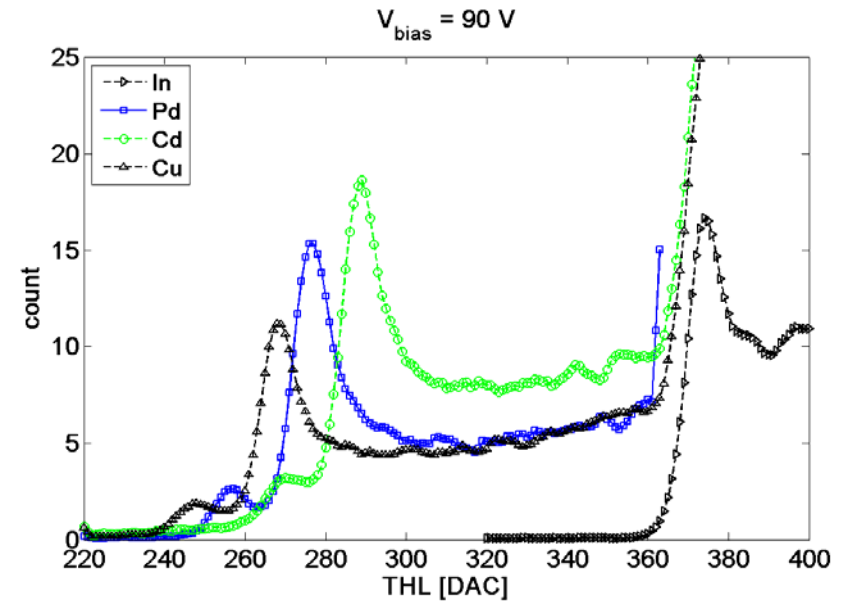


Energy calibration

- MPX2 low threshold scanned over energy range, derivative
- **Single pixel spectra realigned – threshold spread removed**



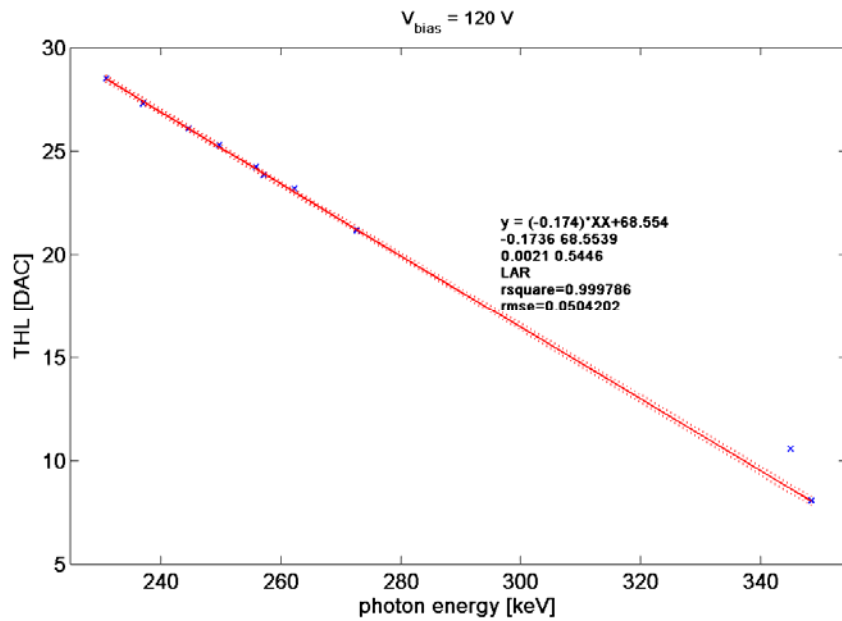
GaAs



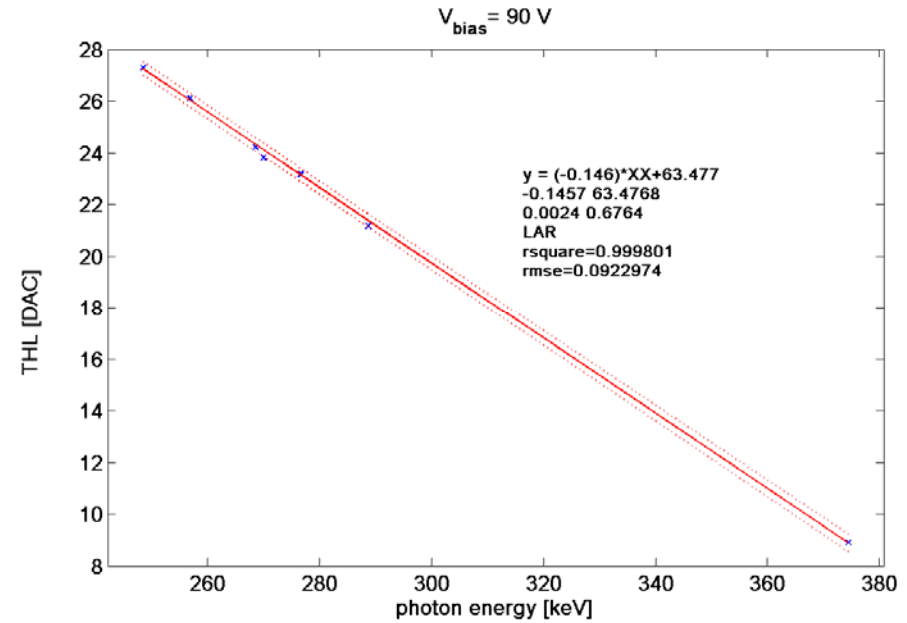
Si



Energy calibration



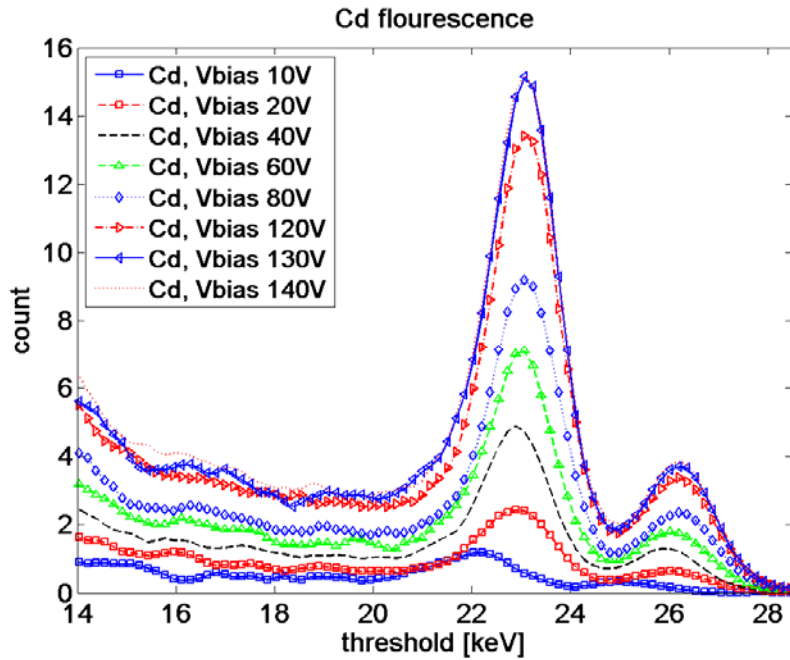
GaAs
41.3 e⁻ / THL LSB



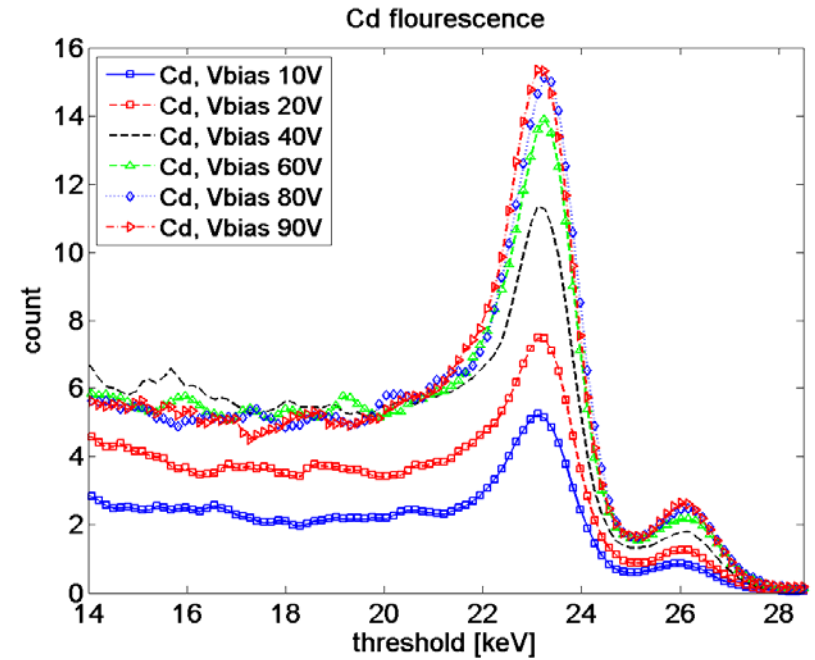
Si
40.5 e⁻ / THL LSB



Cd fluorescence vs sensor bias voltage



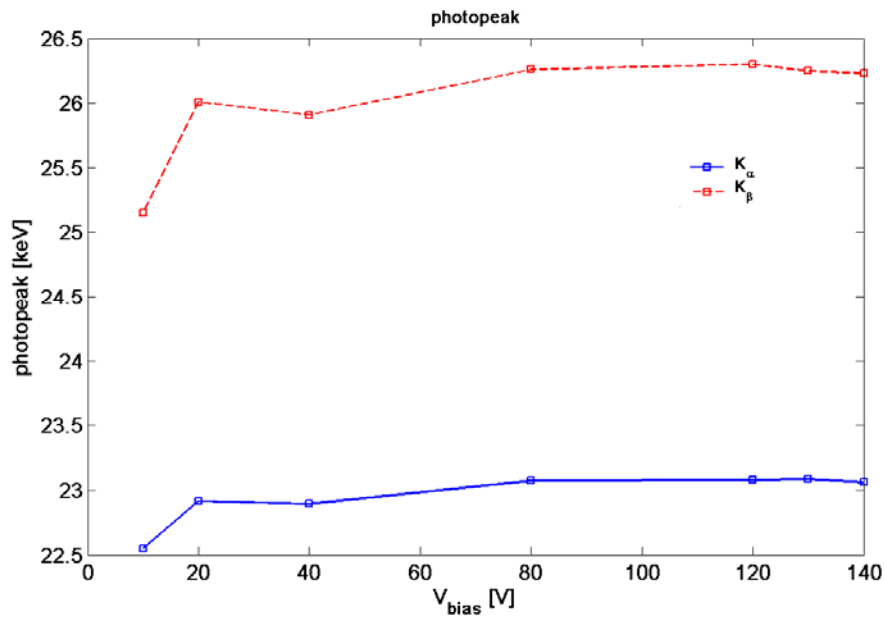
GaAs



Si

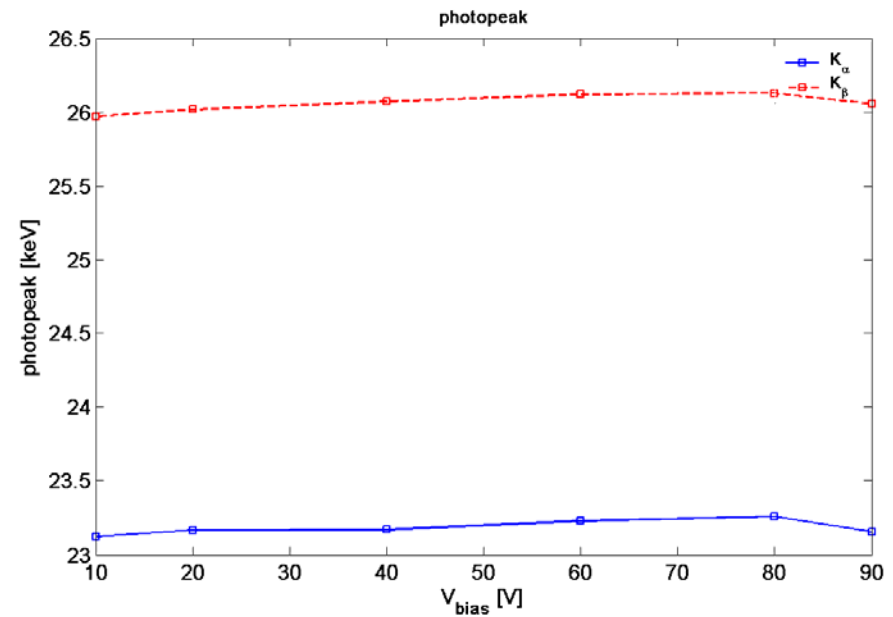


Photopeak position vs depletion voltage



GaAs

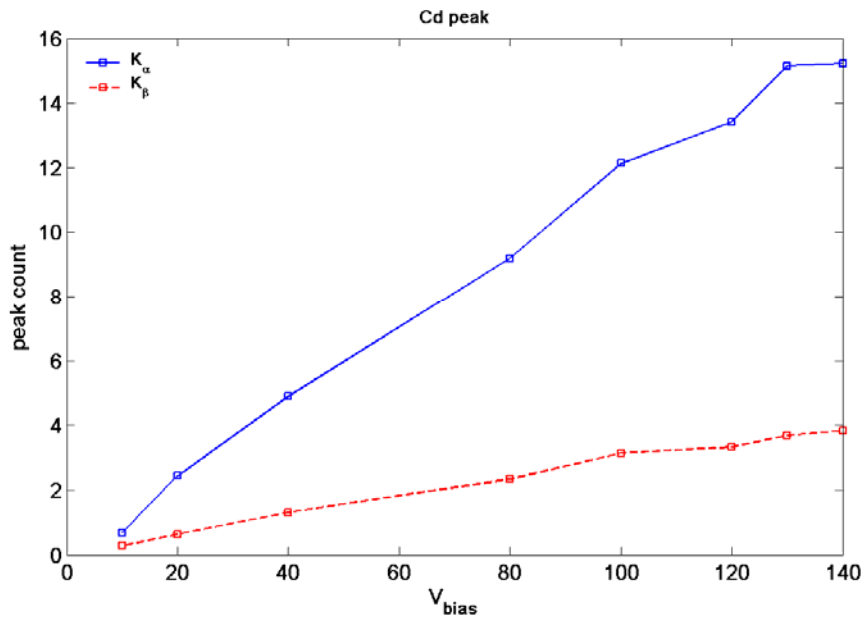
Photopeak position moves at low bias voltages due to charge sharing



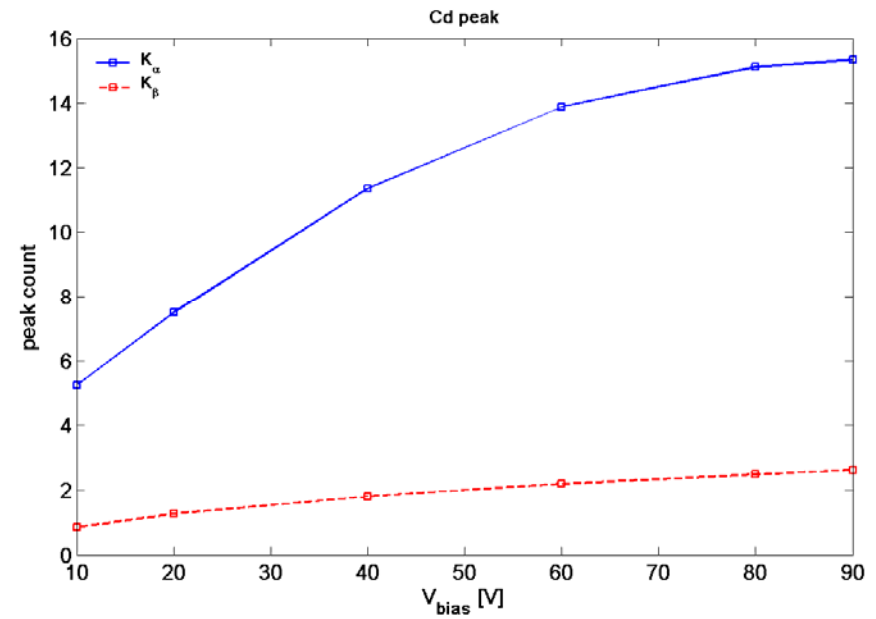
Si



Photopeak count vs depletion voltage



GaAs

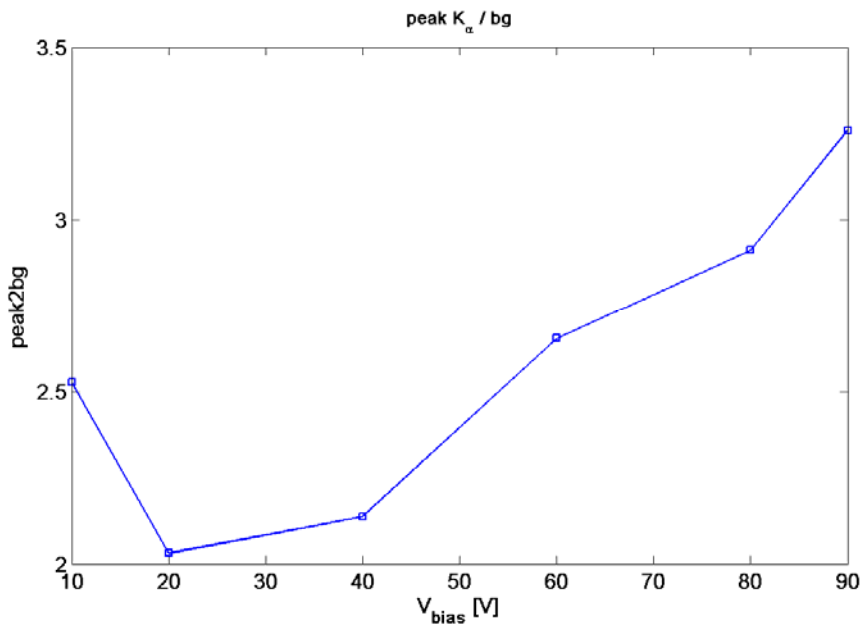


Si

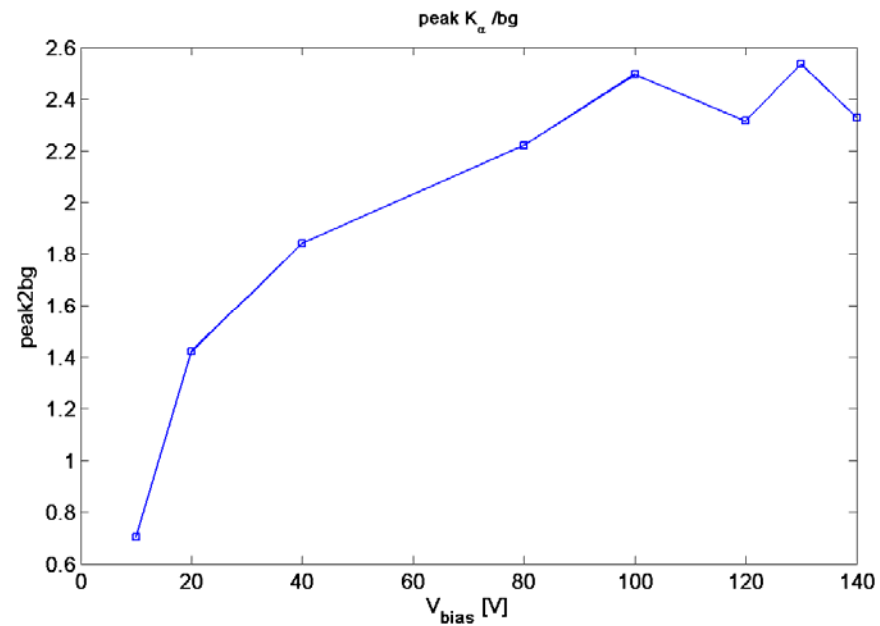
GaAs not fully depleted



Photopeak/background vs depletion voltage



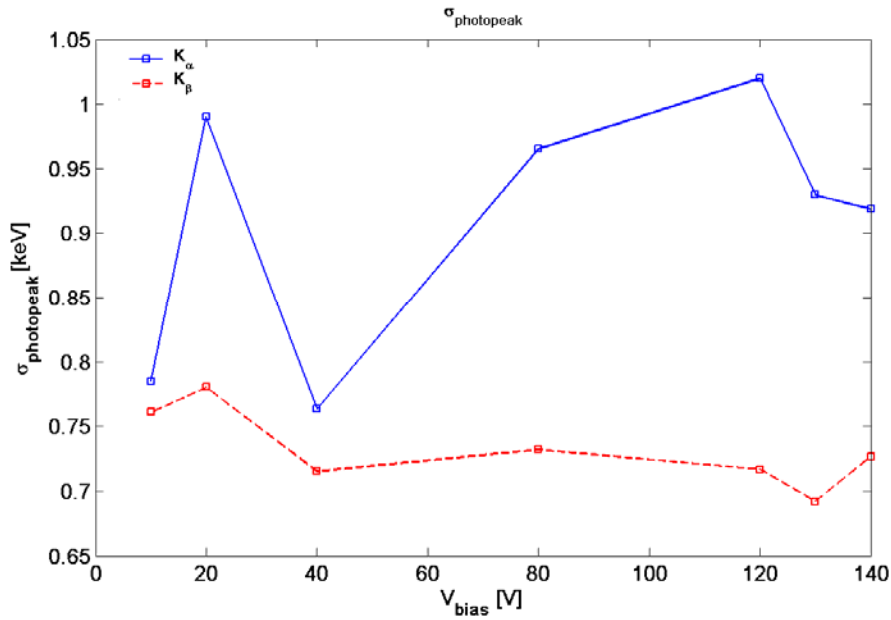
GaAs



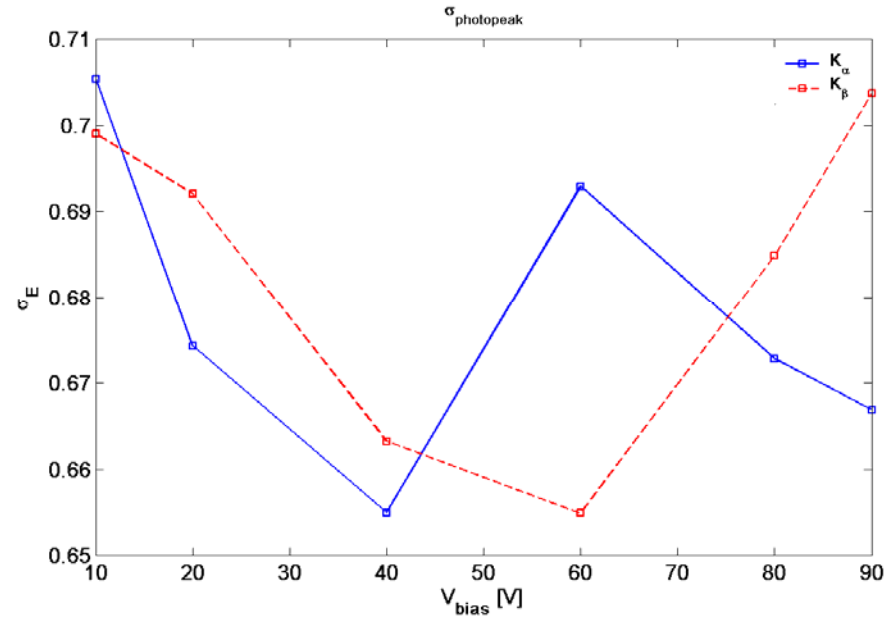
Si



Photopeak sigma vs depletion voltage



GaAs



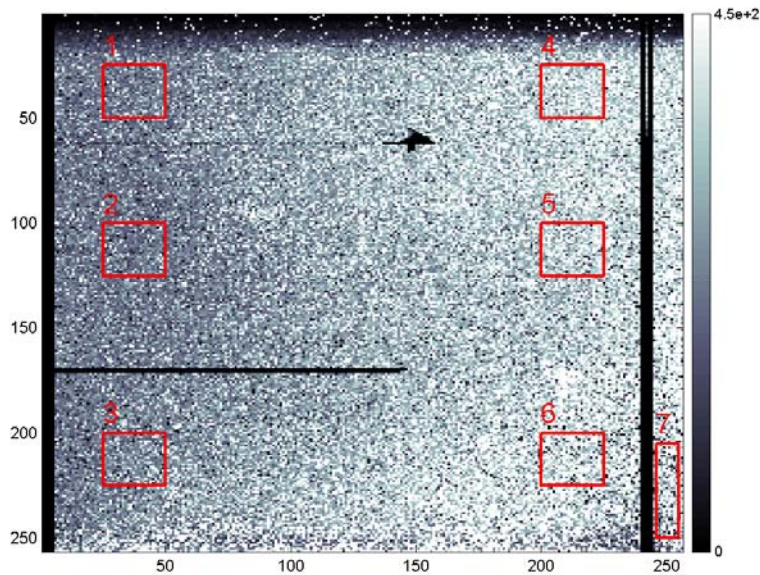
Si

CCE \pm comparable

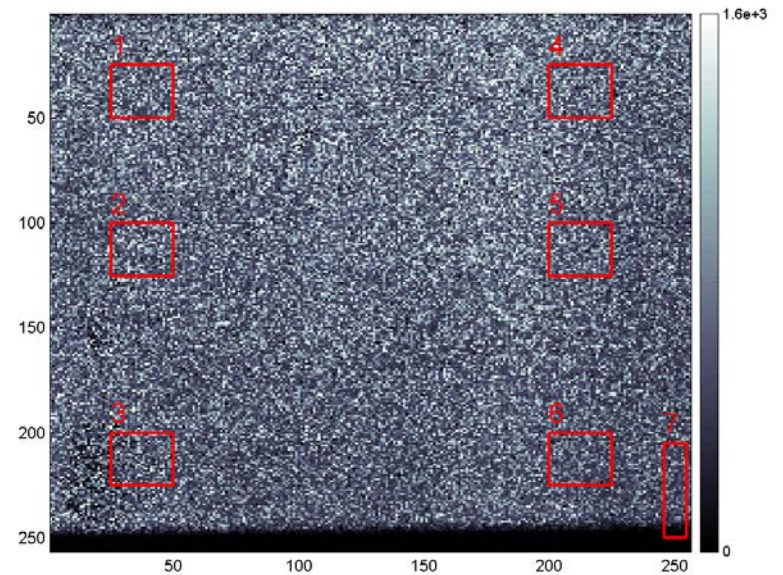


Depletion depth estimate using Cu K_α

7 regions of interest on the sensor used to calculate the relative detection efficiency



GaAs

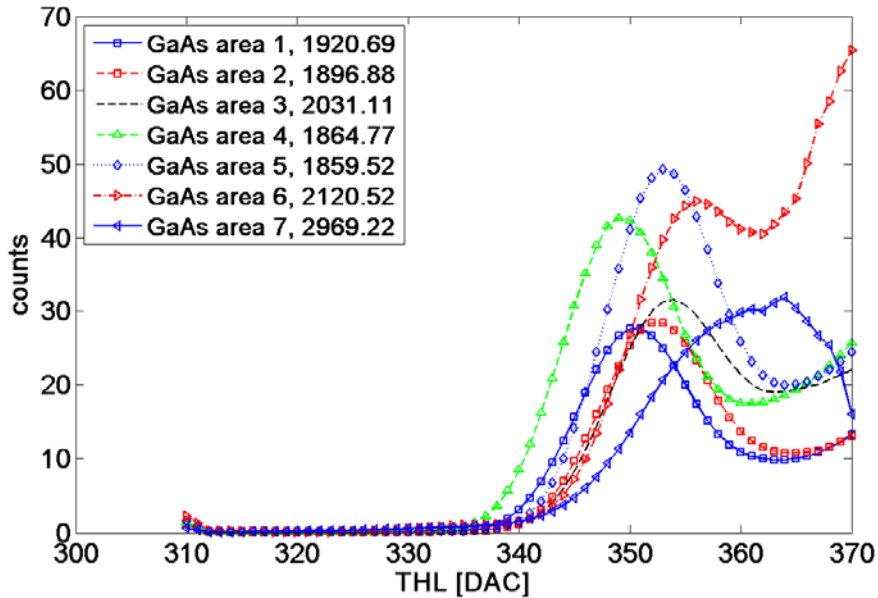


Si



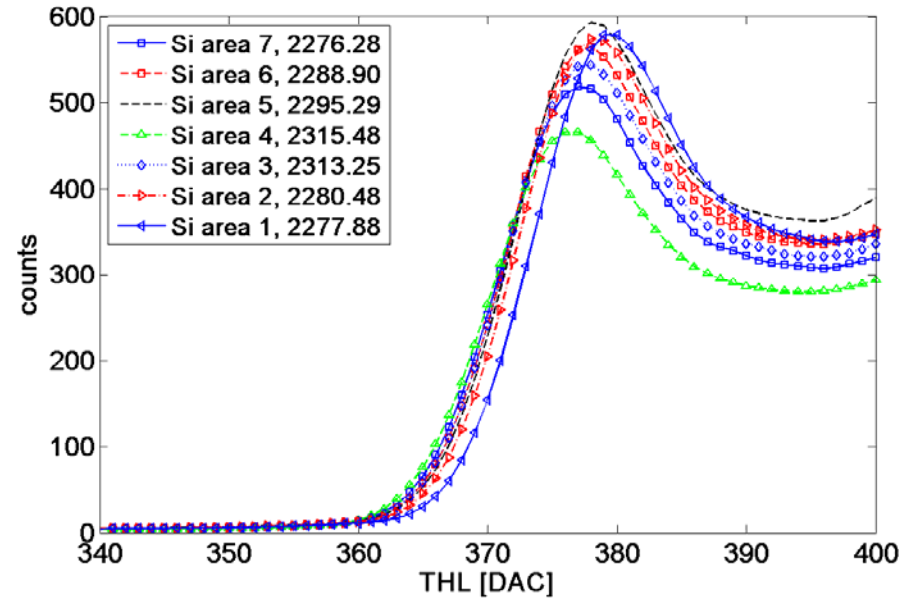
Cu fluorescence

$V_{\text{bias}} = 120 \text{ V}$



GaAs

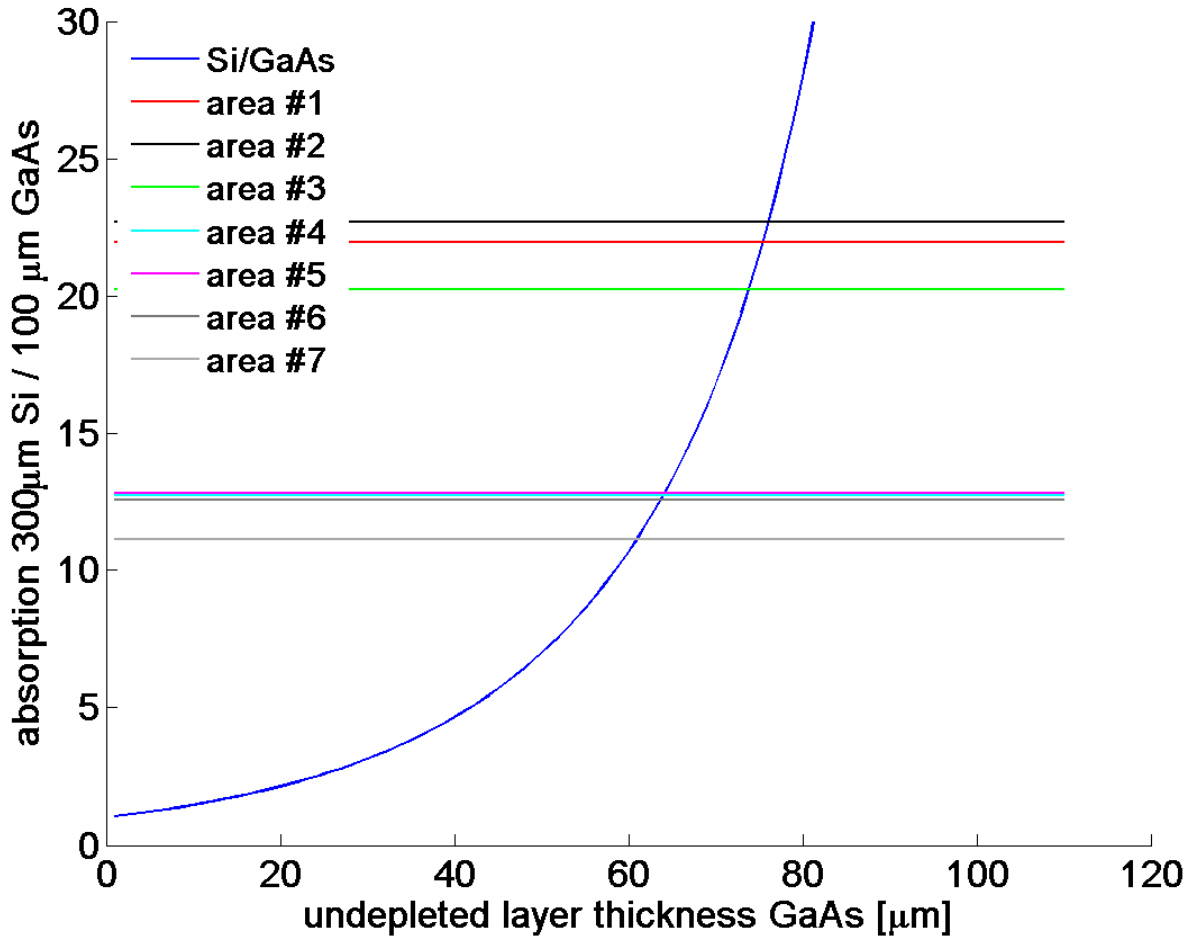
$V_{\text{bias}} = 90 \text{ V}$



Si



Estimation of undepleted layer thickness



- Si sensor depleted assuming 100% absorption
- GaAs sensor depleted from the readout side → pre-absorption undepleted layer in GaAs



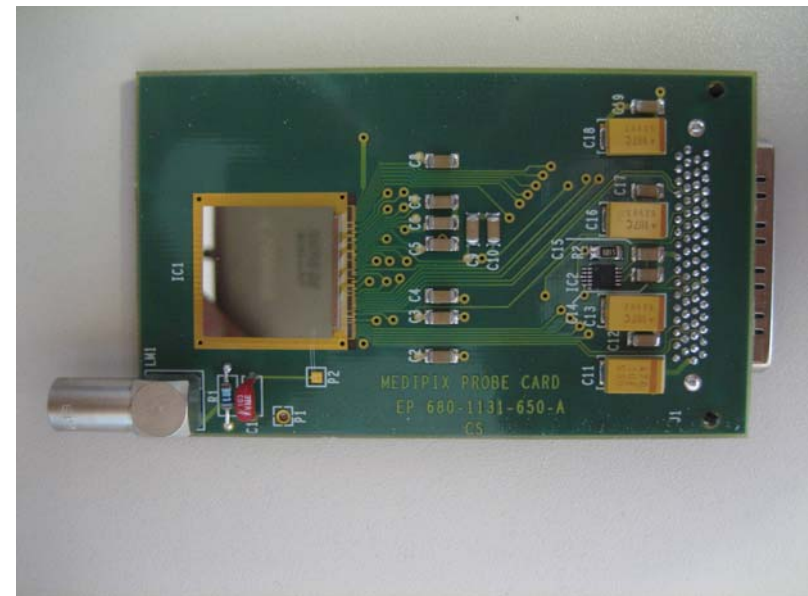
Summary

- Successfully bonded to MPX2, good bonding quality in spite of sample bow
- Almost imaging quality
- GaAs very brittle → requires careful handling
- Low leakage (cracked/broken sensor)
<math> < 200 \mu\text{A} @ 100\text{V}</math>
- Good spectroscopic response
- not fully depleted at room temperature, $\leq 50\%$



Future work

- New samples available bump bonded to Timepix
- Initial characterization indicates comparable behaviour
- Measurements to be repeated with cooled devices





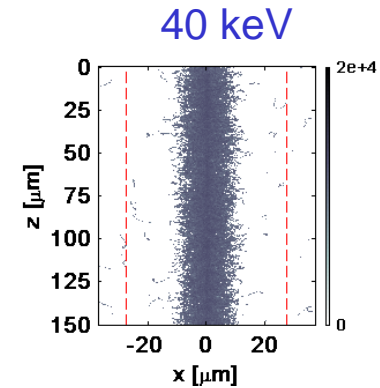
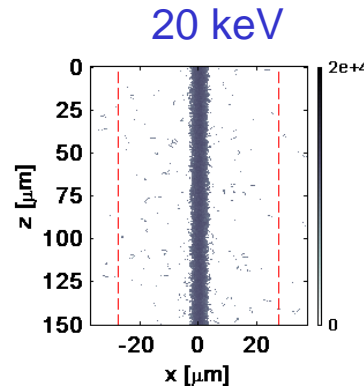
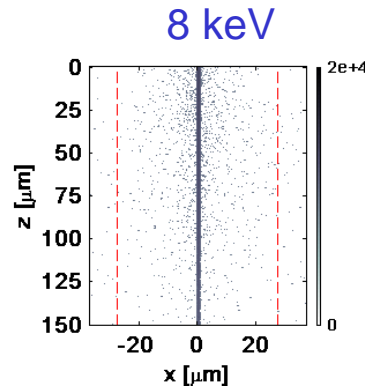




Simulation of charge deposition

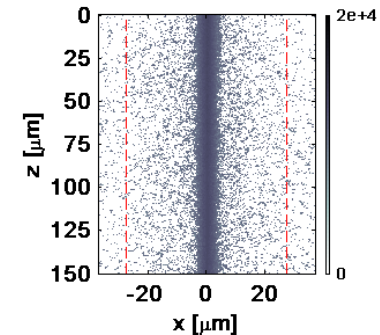
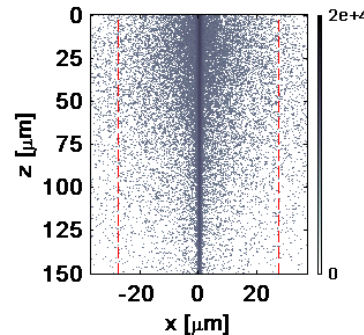
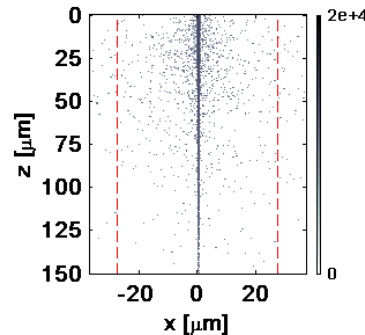
Si

~4%, 1.7 keV, ~12 μm



GaAs

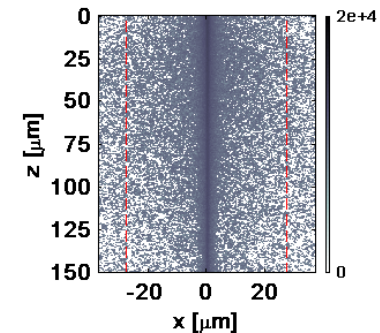
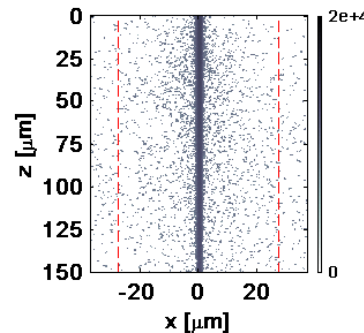
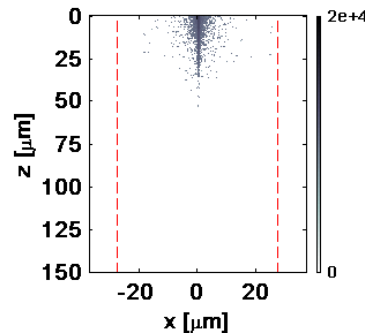
~50%, 9 keV, 40 μm
10 keV, 16 μm



x and y
axes do
not scale

CdTe

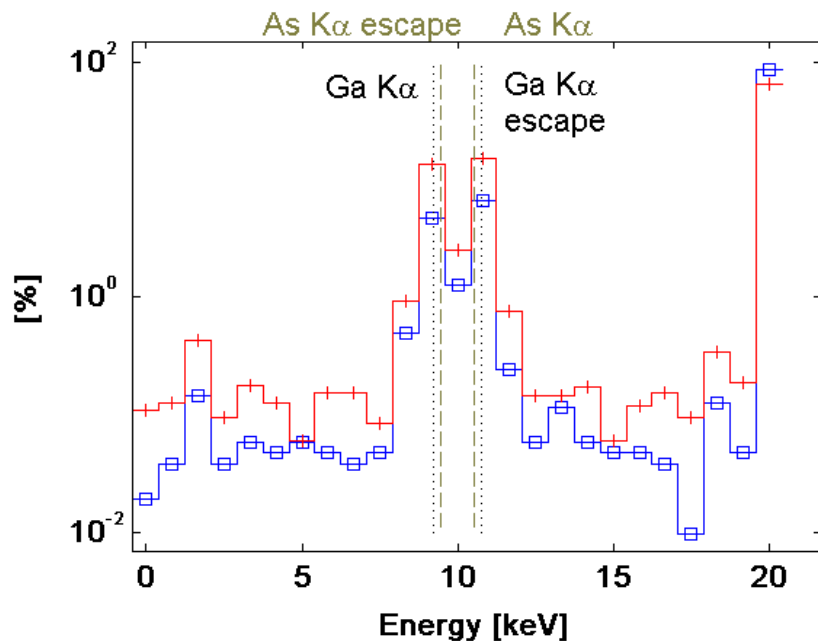
~80%, 23 keV, 110 μm
27 keV, 57 μm



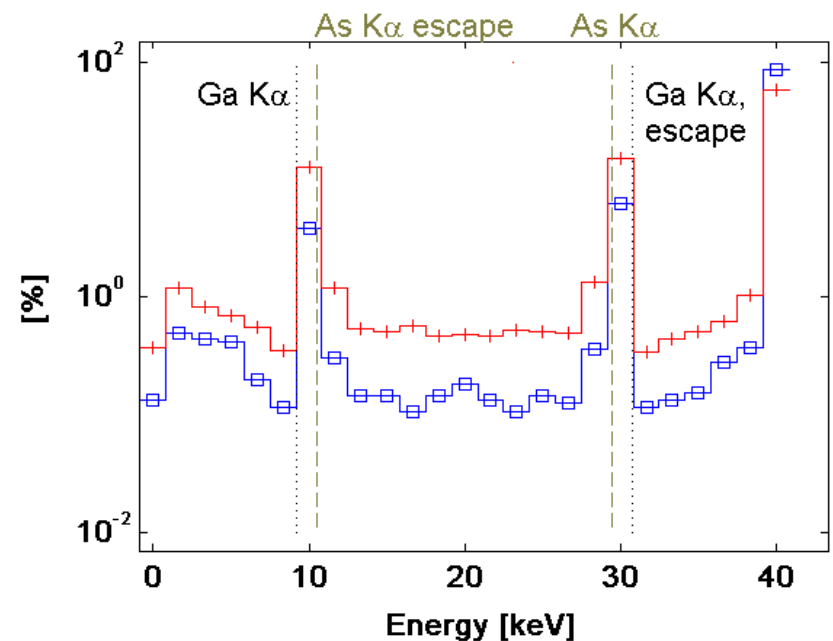


Deposited energy spectrum

GaAs - 20 keV



GaAs - 40 keV

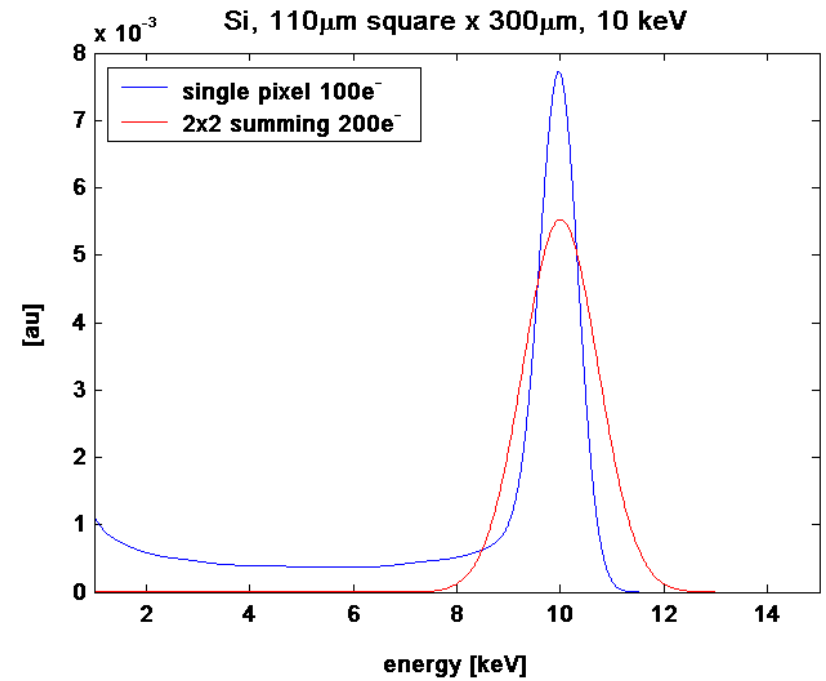
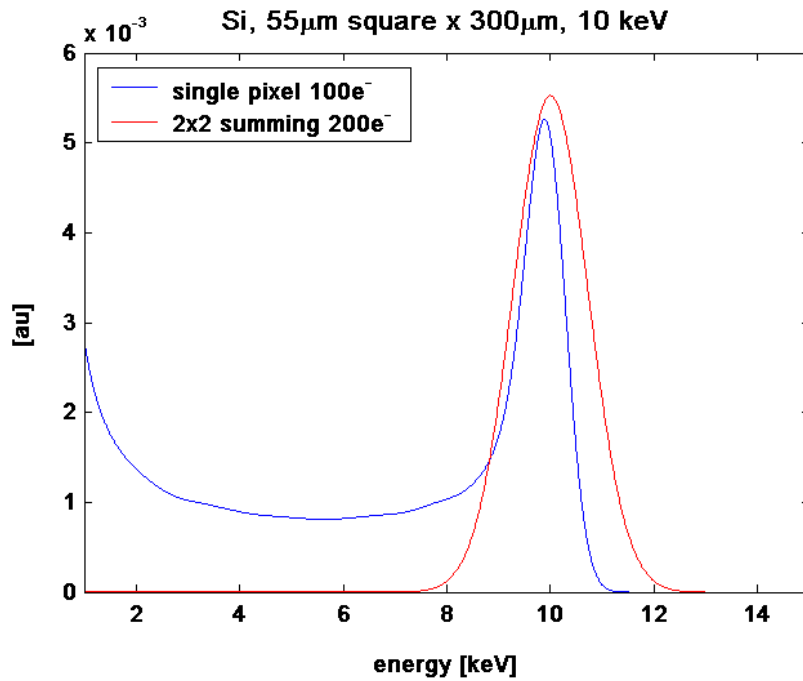


Simulation monochromatic 20 and 40 keV photons in 300 μm thick GaAs sensor

Pixel size	% in photopeak @ E_γ	
	20 keV	40 keV
55 μm	64.1 %	58.0 %
300 μm	85.6 %	85.0 %



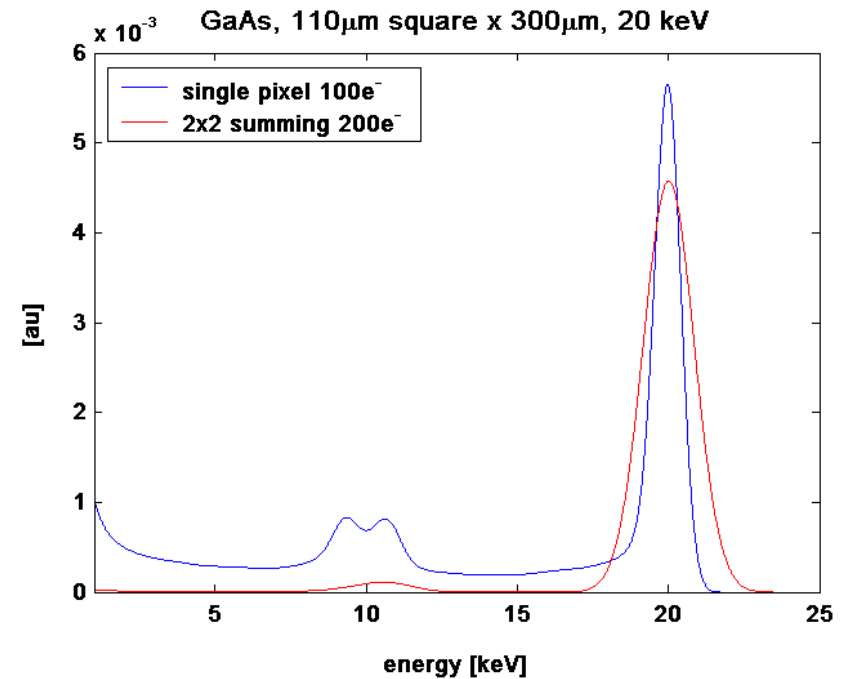
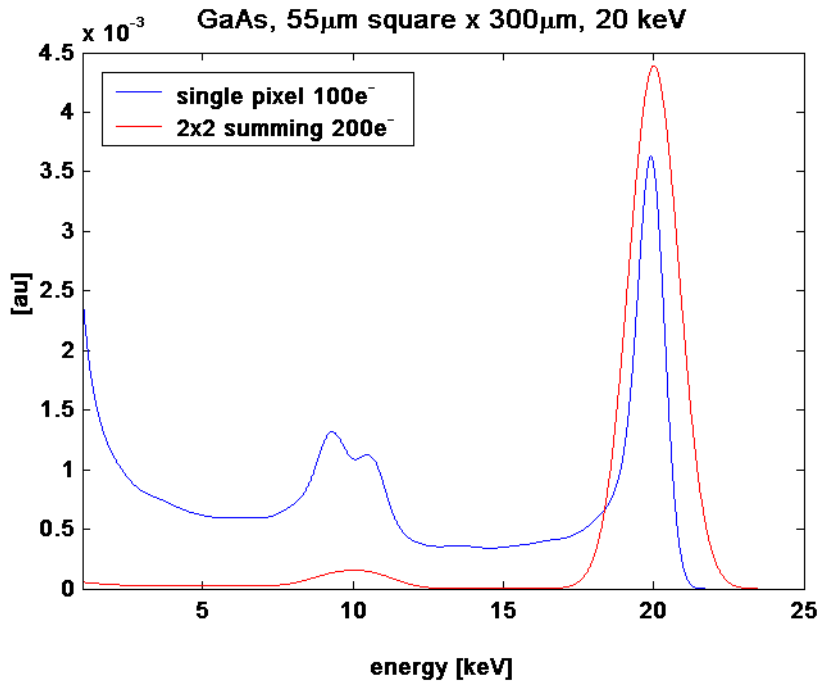
300 μm Si, 120 V



$$\mu\tau \text{ 120V/300}\mu\text{m} \geq 5.8\text{e}3 \text{ cm}$$



300 μm GaAs, 650 V



$$\mu_e \tau_e \text{ 650V/300}\mu\text{m} \sim 1.7 \text{ cm}$$

$$\mu_h \tau_h \text{ 650V/300}\mu\text{m} \sim 0.086 \text{ cm}$$