Semiplanar p-type Point Contact HPGe Detector

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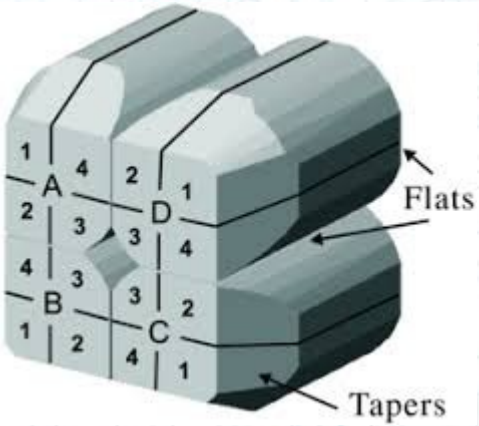
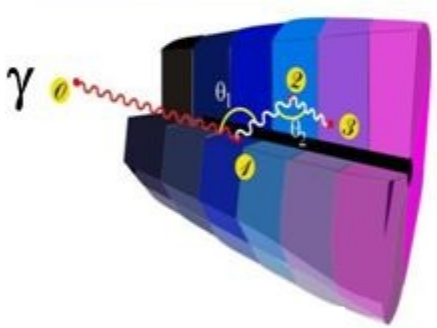
R&D on Novel Ge-Detector Geometries for Ultimate Position Resolution and Efficiency

Position Sensitive Ge Detector

- Segmentation of the HPGe detectors has enabled the position sensitive arrays with high energy resolution

EXOGAM MINIBAL AGATA





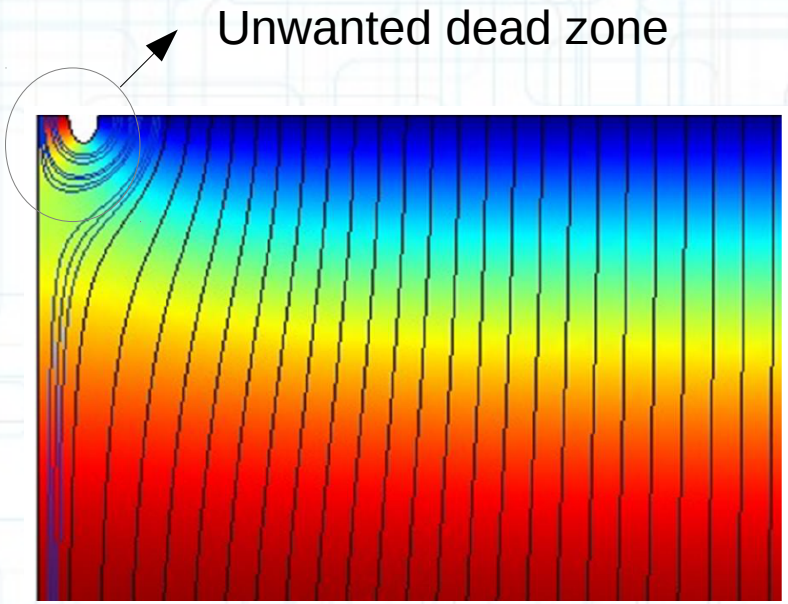
- Planar HPGe detectors are to be utilized within DESPEC project
  - Position determination
  - Uniformity of the electric field

Field Defect

The necessary guard ring around the active volume leads to drastic losses in usable solid angle and thus the achievable efficiency falls.

Surface channel effect limits
the efficiency of
the enclosed planar detectors

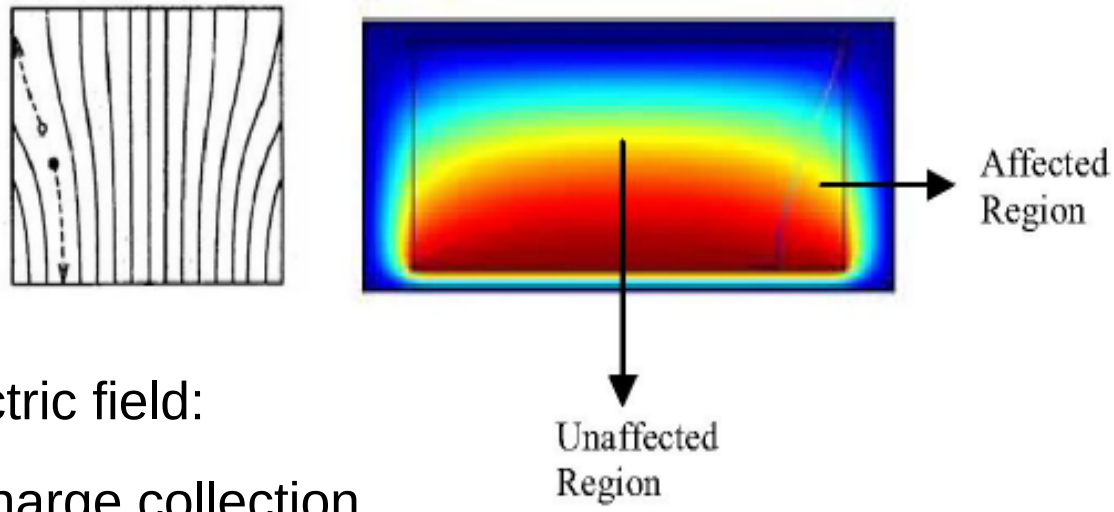
-incomplate charge collection
-loss of efficiency



The leak current flowing through the detector channel and the defects created by fast neutrons or other particles (ions) contribute to increase this effect.

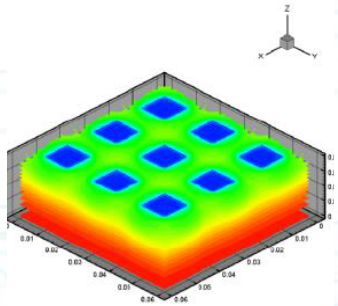
Field Defect

- Optimal geometry is defined by simulating the shape of the useful area.
- A field defect radial region in the peripheral part of the detector is created



A non-uniform electric field:

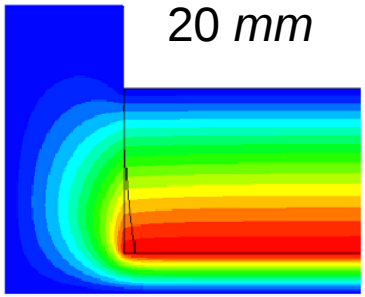
- Complicates the charge collection
- Wrong interpretation of the point of interaction
- Diverts part of the charge carriers toward the surface
- Excludes them from being collected
- Determine the electric field distribution by simulations and compare with the pulse shape response.

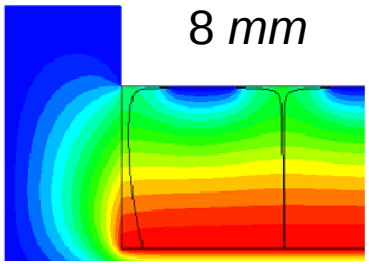


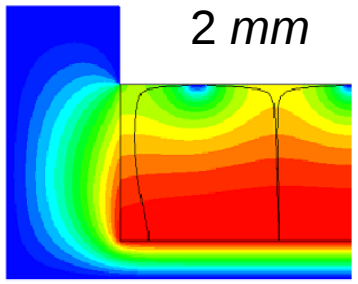
Position Sensitive Planar Detector

The idea is to make several points on a planar, responsible from certain area

Based on:
-Net charge collection on the electrodes
→ Depth of interaction
-The charge induced between neighbors
→ Lateral position







A certain geometry of the contacts may enable a good position resolution combining the net charge and the induced charge signals.

Simulations showed that the decrease of the pixel size tends to result in a distortion of the electric potential and better position resolution resulting in better imaging capability

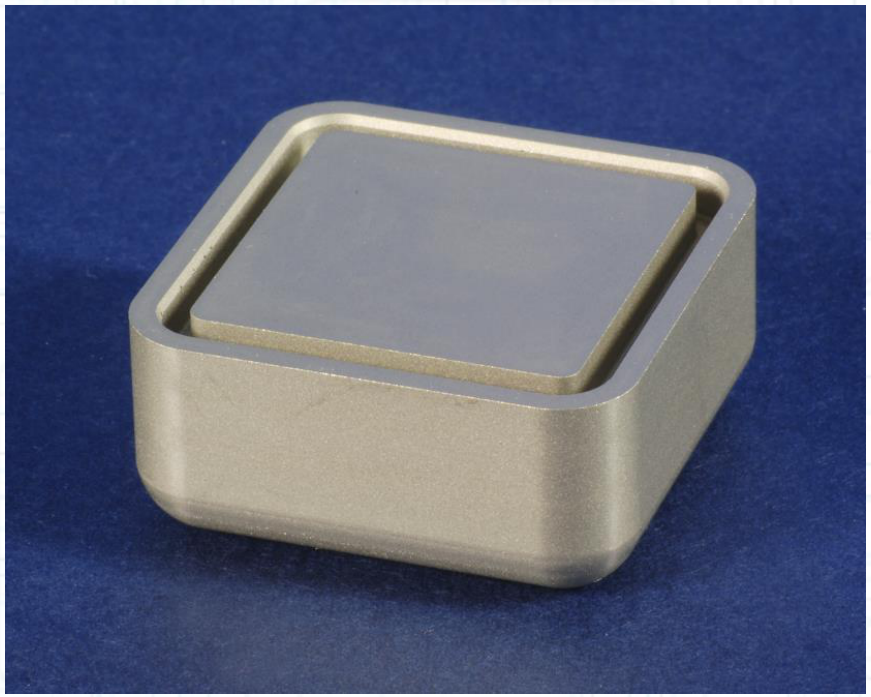
Position Sensitive Ge Detector

Position resolution of a Ge detector using a semiplanar configuration with point contact read out :

- Dedicated high resolution imaging detectors in gamma spectroscopy
- It can be used as an implantation detector with a good energy resolution
- Identification of the different positions of decaying nuclei in the implanter
- Tracing-back the origin of the gamma ray, enabling suppression of background

Prototype Crystal

- Non-segmented p-type HPGe detectors in point contact configuration
- HPGe crystal with the size of 33.2 *x* 33.2 *x* 15.5 *mm*
- Carrier concentration of 3.3 *x* 10^9 *atom/cm*^{3}

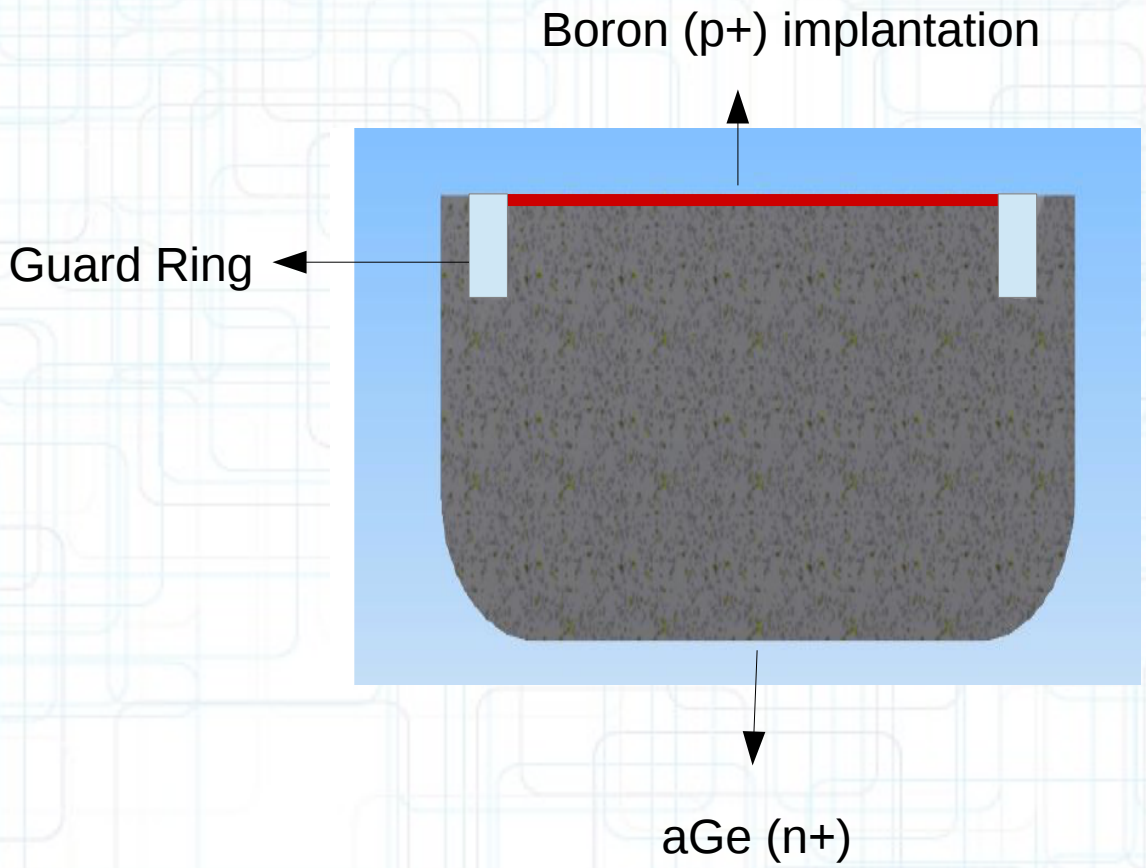


Quasi-planar prototype Ge:

- Amorphous Ge blocking contact
- Efficient use of Ge material
- Sensitive surface to low energy radiation
- More complicated segmentation pattern

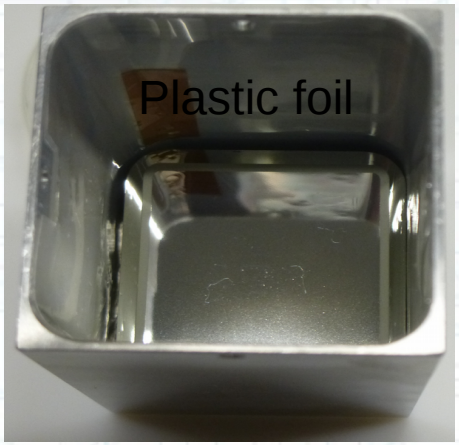
Prototype Crystal

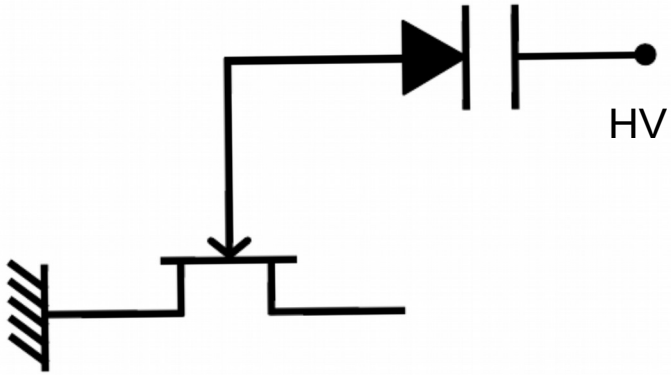
- Fully depleted at 450 V
- The charge signal from the p+ electrode.
- Wrapping the bottom electrode prevents trapping at the sides



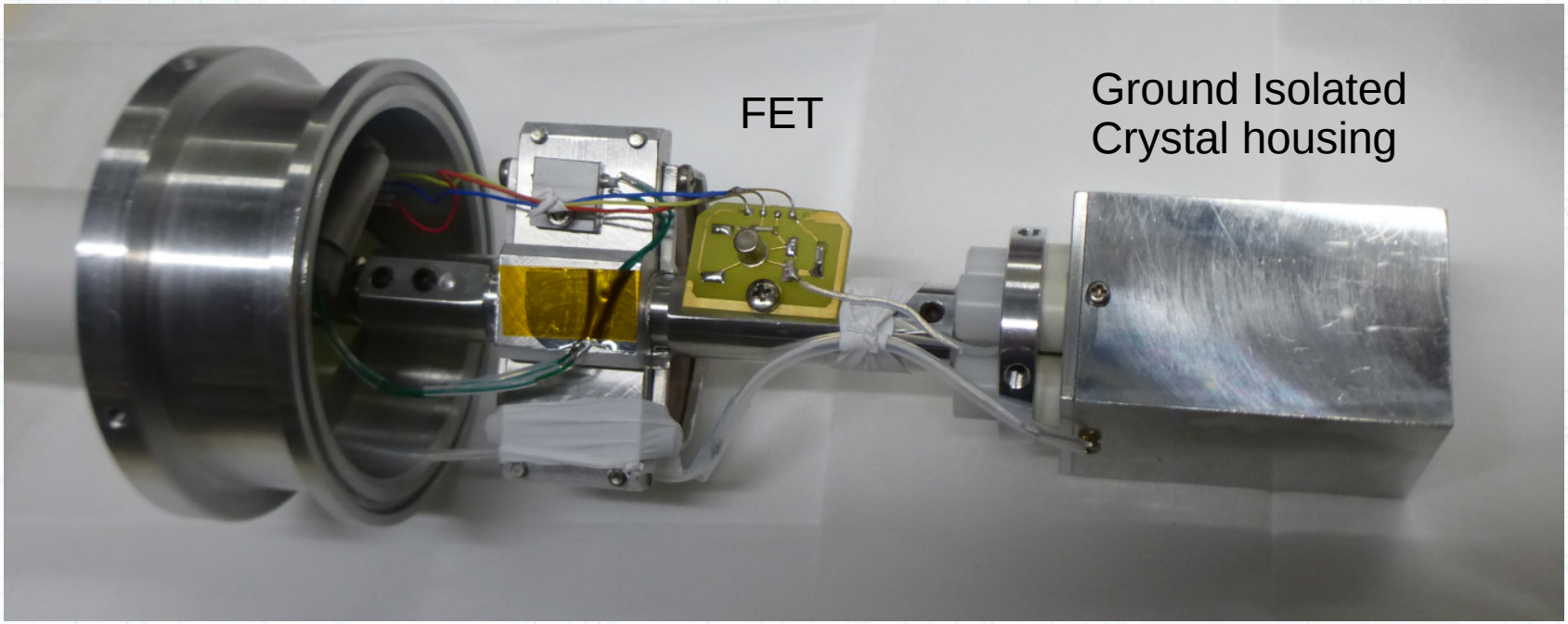
Assembly

- Assembly of the prototype crystal is done using a POPTOP capsule





DC coupling
was used

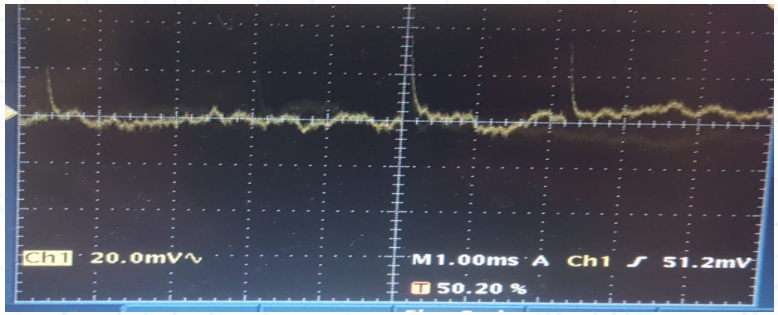


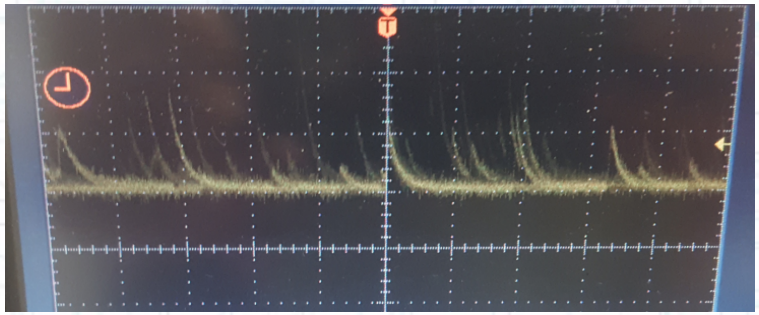
Detector Test

1.2 *pA* leakage current at operation voltage of 100 *V* was observed

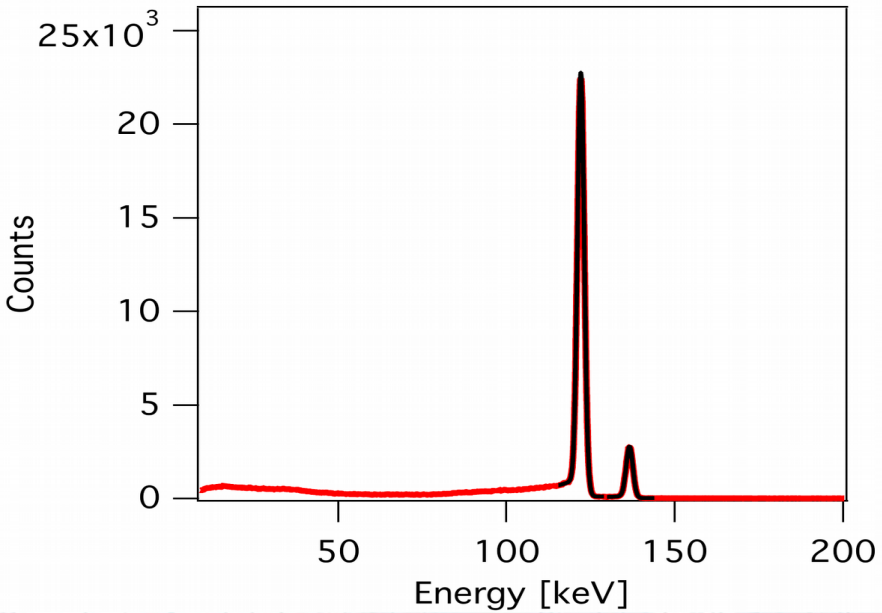
Sudden increase of the leakage current when increasing the bias voltage was observed, indicating the break-down of the junction.
Encapsulation?

- V_{dep} is needed to extend the depletion depth to the back surface
- No electric field is created in undepleted region
- Charge carriers are not collected in this thick dead layer
- Partially depleted detector is sensitive only in the front side

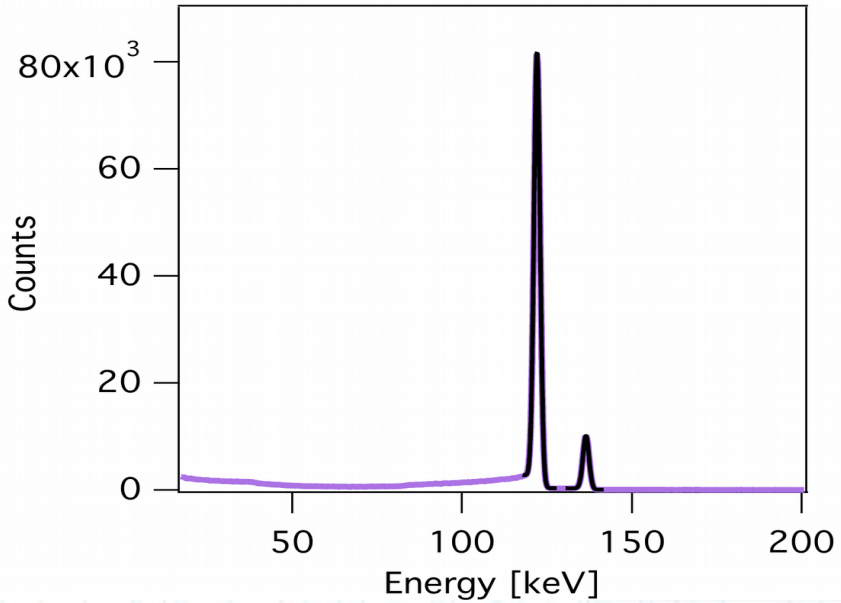




Detector Test



Shaping time 6 μs



Shaping time 3 μs

^{57}Co source

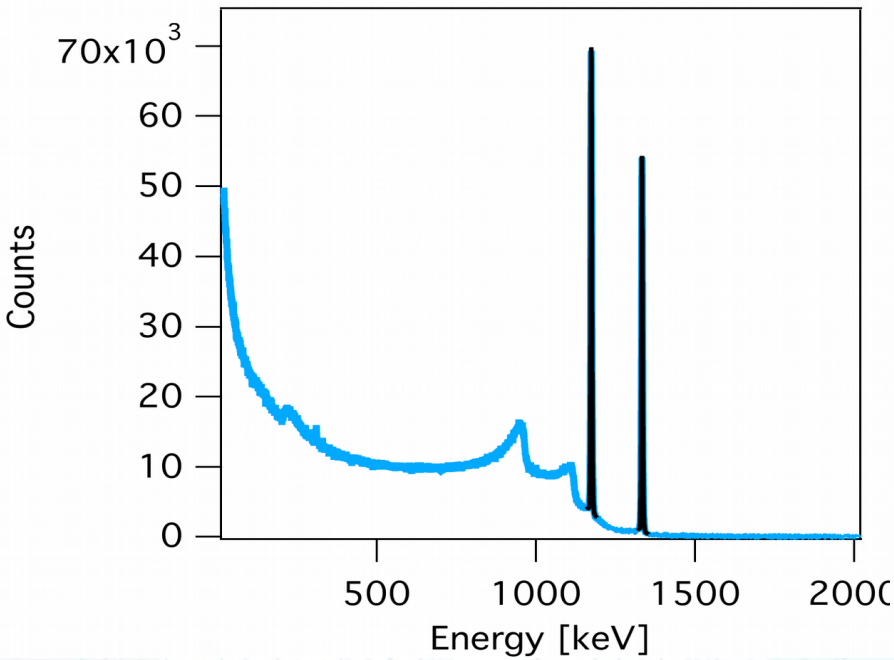
V_{dep} = 450 V

V_{op} = 100 V

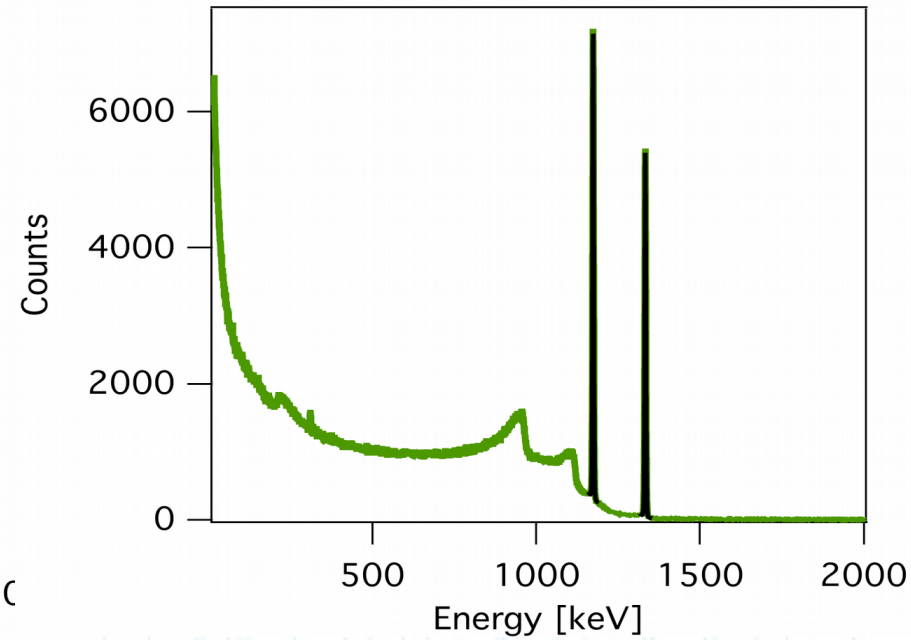
Shaping time (μs)	3	6
Energy *(keV)*	122	122
FWHM (keV)	2.13(1)	2.35(1)

Fitted with exponentially modified Gaussian function

Detector Test



Shaping time 6 µs



Shaping time 3 µs

Shaping time (µs)	3	6
Energy *(keV)*	1332	1332
FWHM (keV)	4.53(1)	4.32(1)

^{60}Co *source*

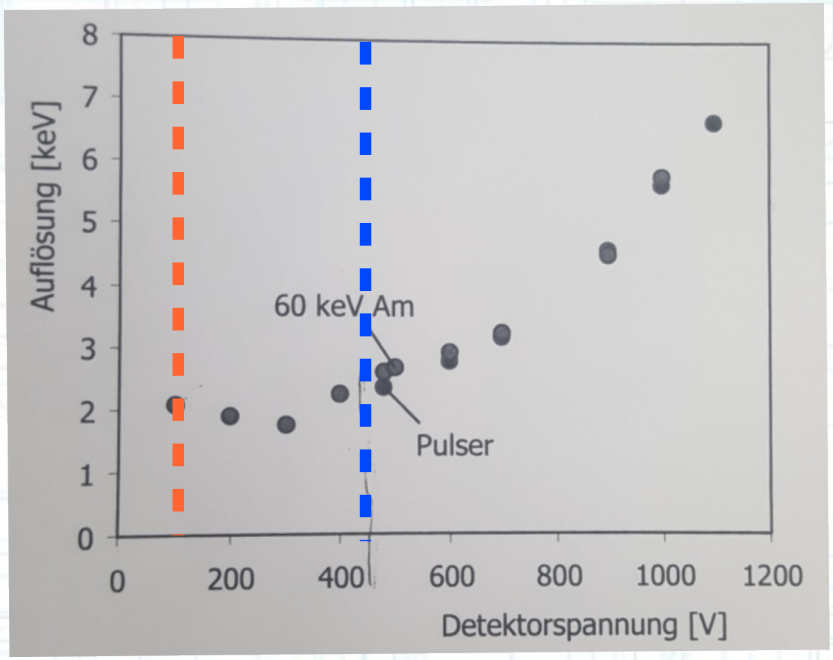
$V_{dep} = 450\ V$

$V_{op} = 100\ V$

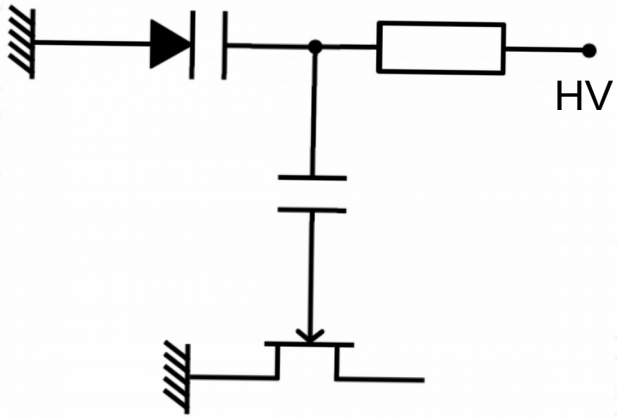
Fitted with exponentially modified Gaussian function

Detector Test

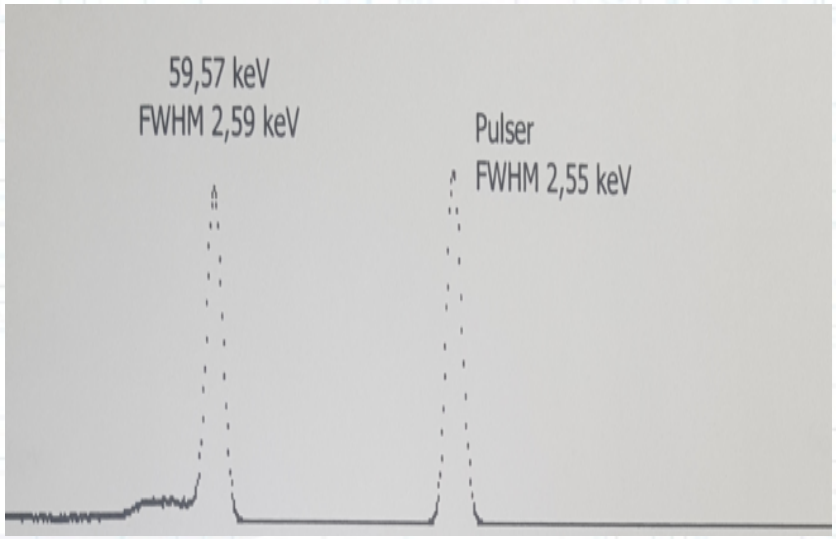
SEMIKON Detector GmbH
Semiconductor Detectors for Science and Industry

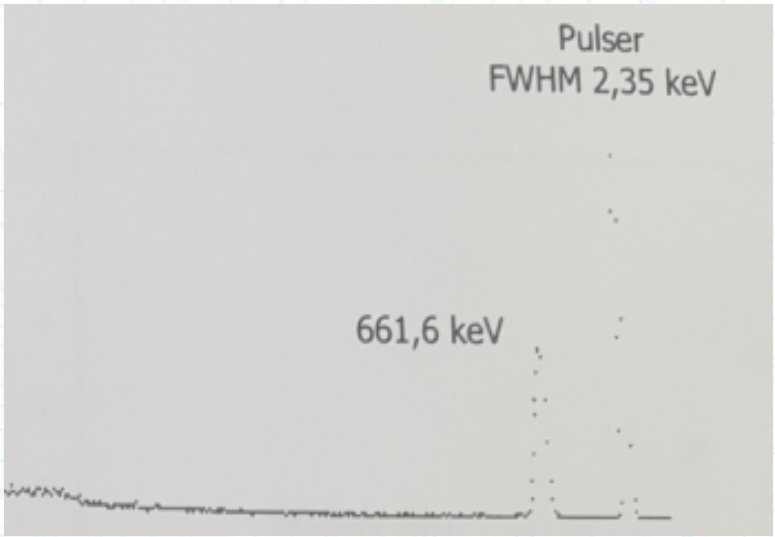


Operated at 480 V, 3 nA noise
AC coupling



With low capacity, V_d is achievable





Conclusion

- As an optimal geometry of the detector, semi-planar is chosen over the planar

  Easy encapsulation
  Minimized Field defect
  Pixel, strip, point contact

  - Field defect leads to

    Incomplete charge collection
    Loss of efficiency

- The size of the active volume has to be determined using the scanning technique

  Depleted region
  Shape of the field