Physikalisches Institut Universität Erlangen-Nürnberg

Investigation of Charge Carrier Transport and Charge Sharing in X-Ray Semiconductor Pixel Detectors such as Medipix2

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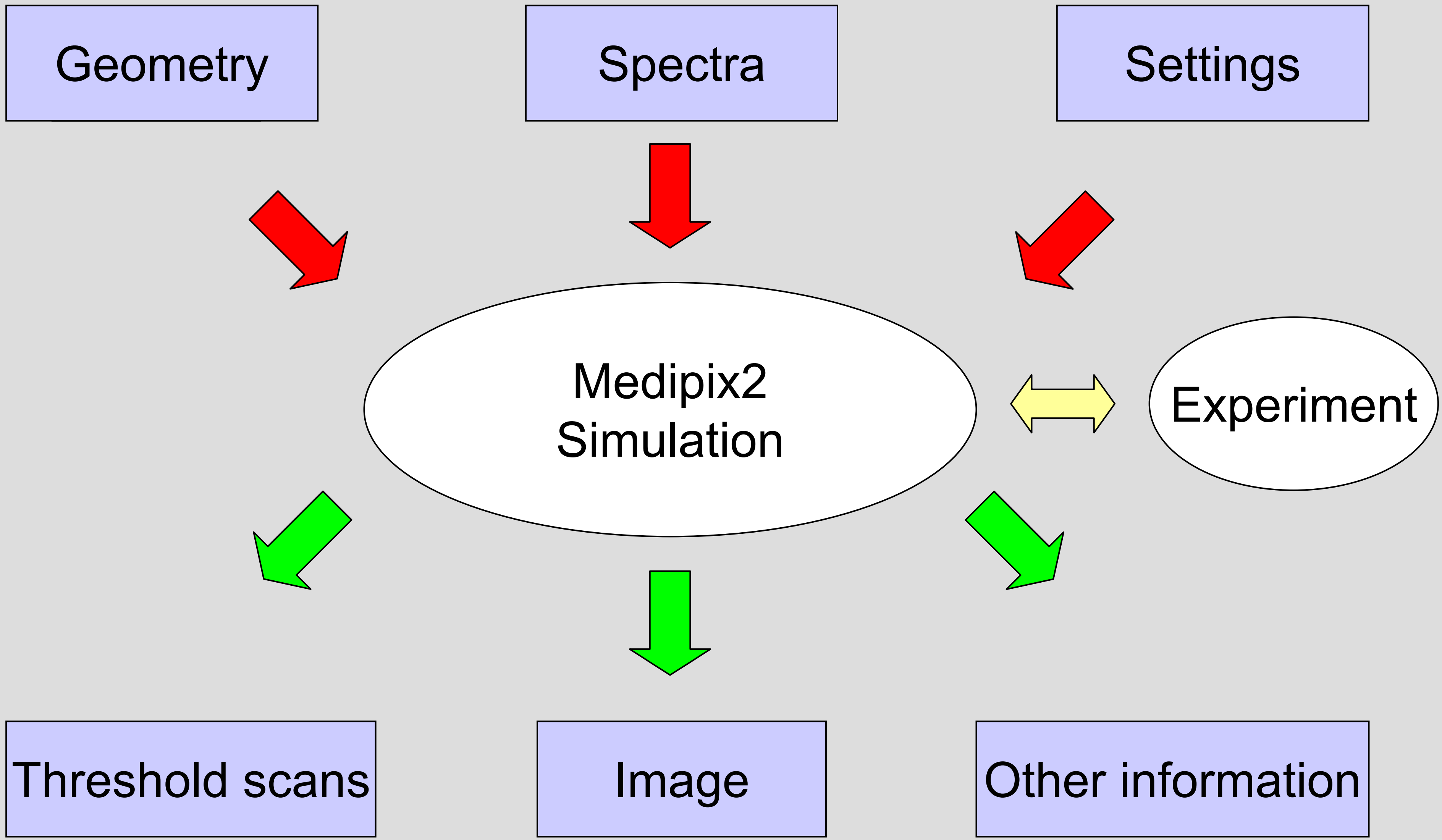
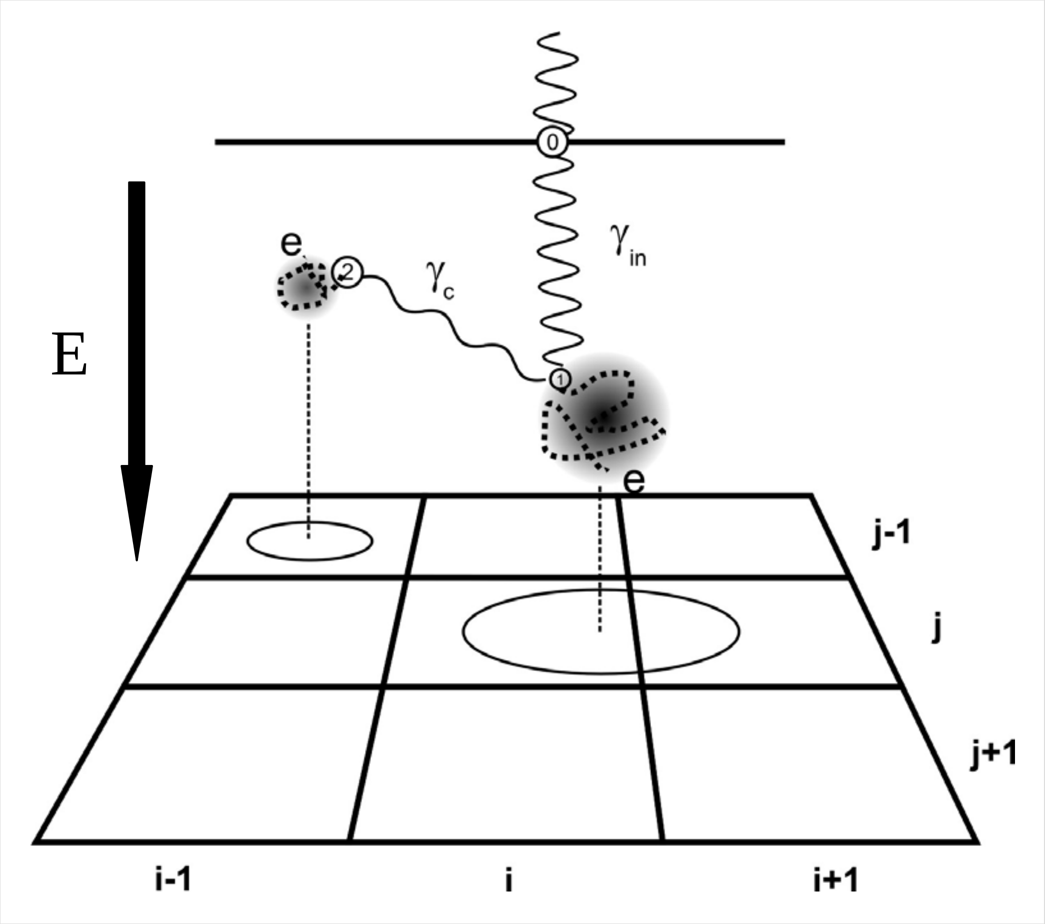
09.07.06

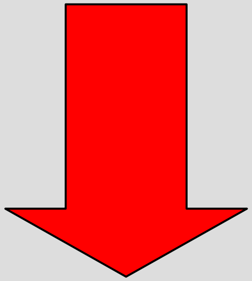
Motivation


Geometry
Spectra
Settings
Medipix2
Simulation
Experiment
Threshold scans
Image
Other information

Charge Sharing / Spreading



Diffusion

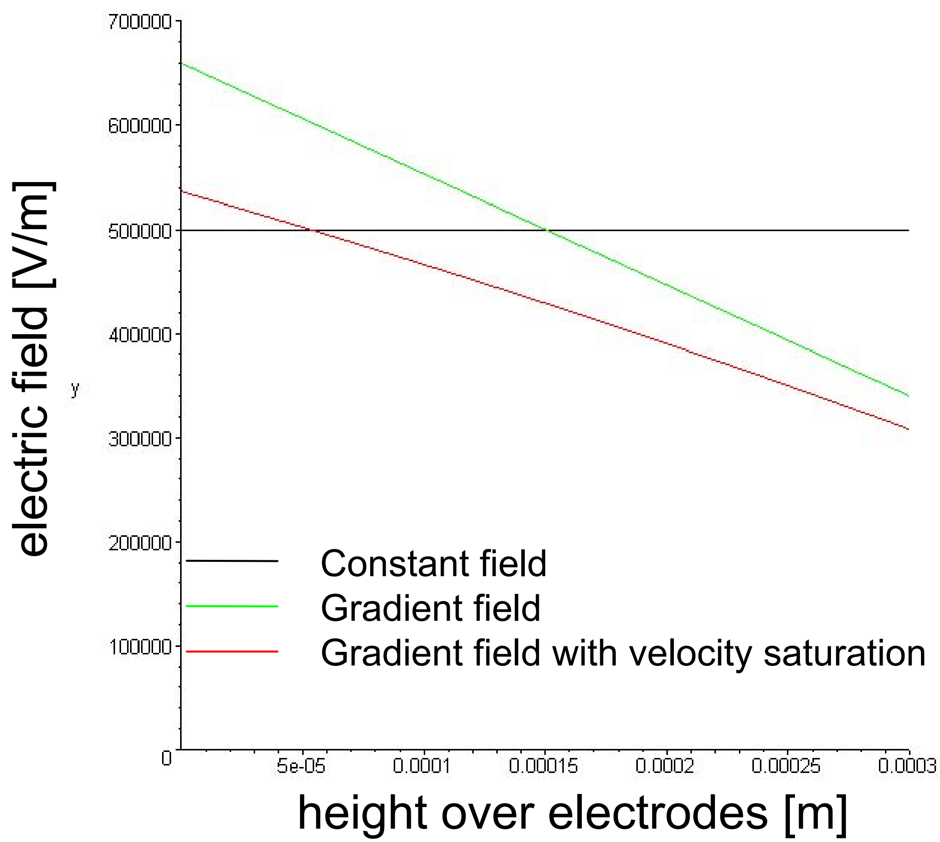


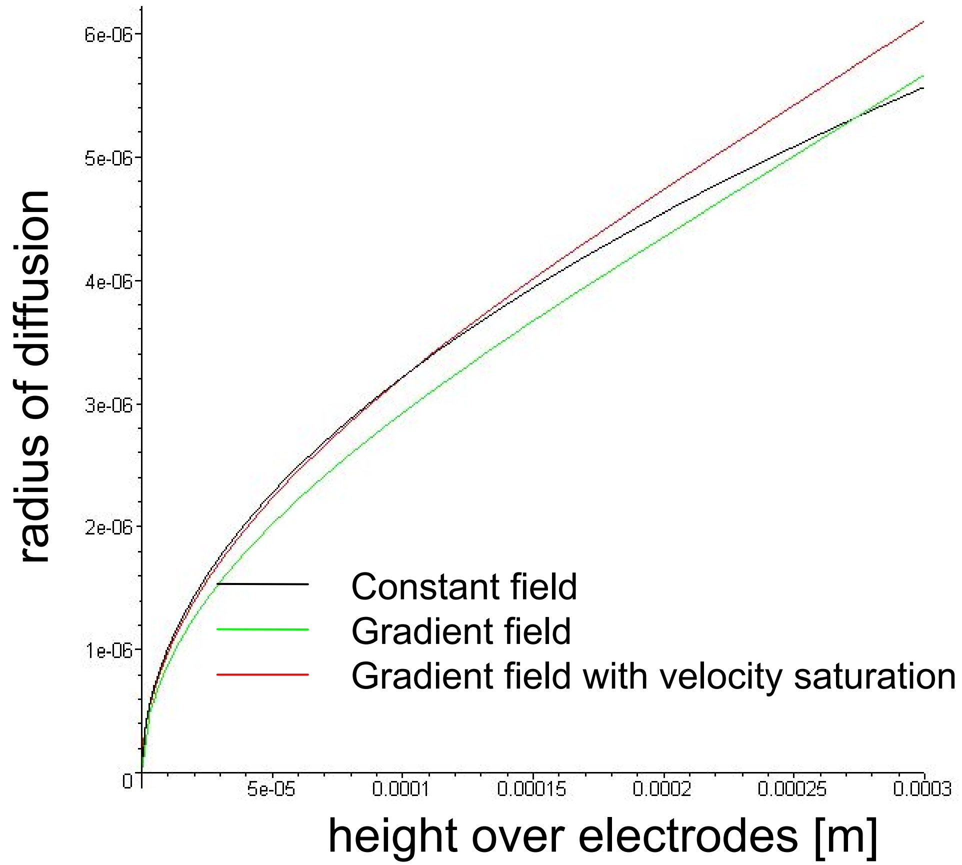
Spatial spreading

Energy distribution

Efficiency

Diffusion





$$\sigma^2 = 2Dt \text{ with } D = \frac{k_B T}{e}\mu \text{ and } t = \int_0^{z_0} \mathrm{d}z \, \frac{1}{\mu(E)E(z)}$$

ROSI - Roentgen Simulation

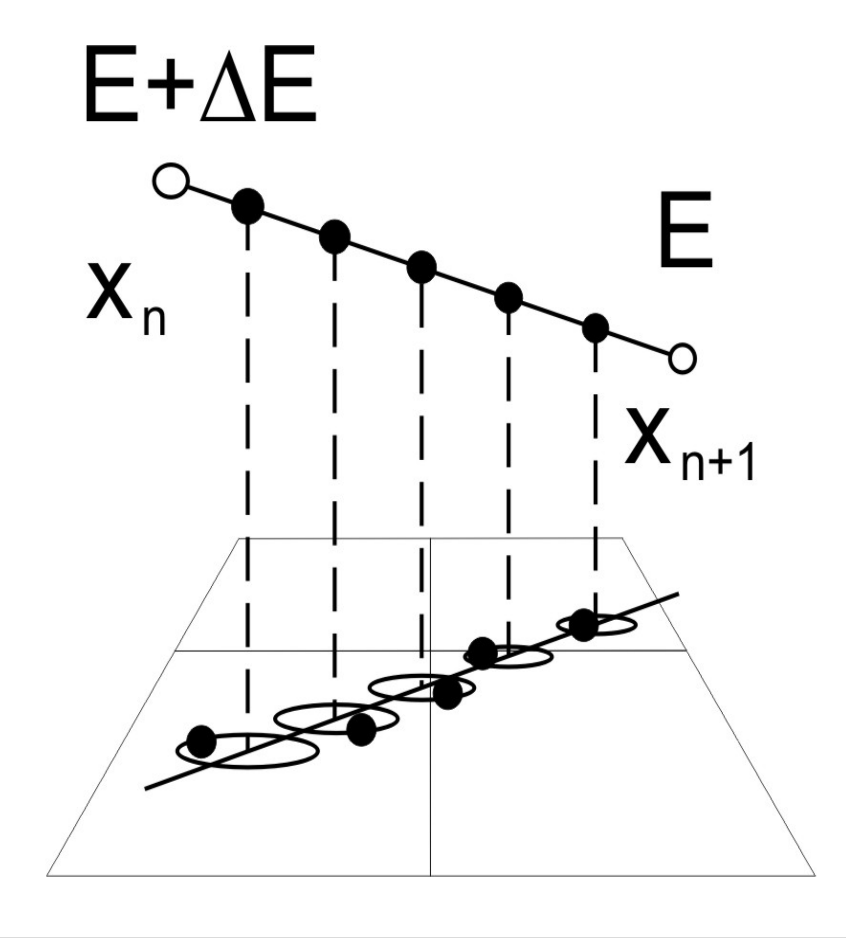
Simulation of interaction
Gives location and energy deposition of interactions inside the sensor layer.

(x,y,z,E) of interaction

Simulation of diffusion
Each e-h pair is Gaussian distributed with s = s(z) and projected in x,y plane.

(x,y) single charge 3.6 eV

Simulation of electronics
The energy in a spatial intervall (Pixel) is also blurred Gaussian (electronic noise). The resulting energy per pixel is discriminated by the threshold and counted.



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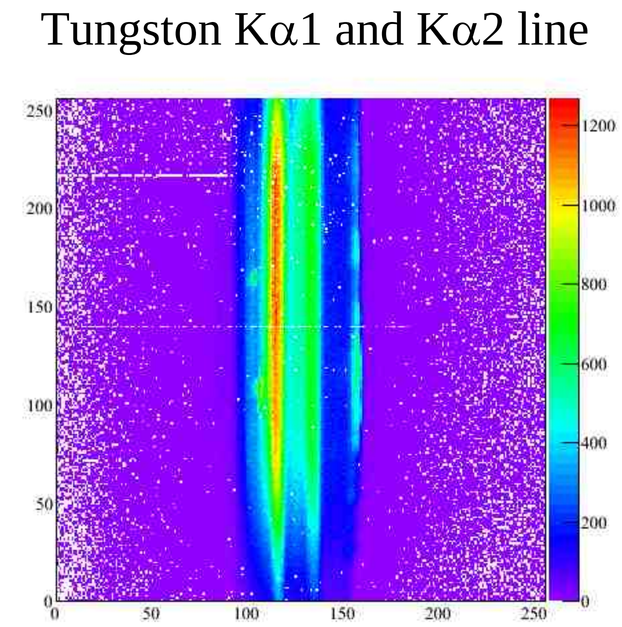
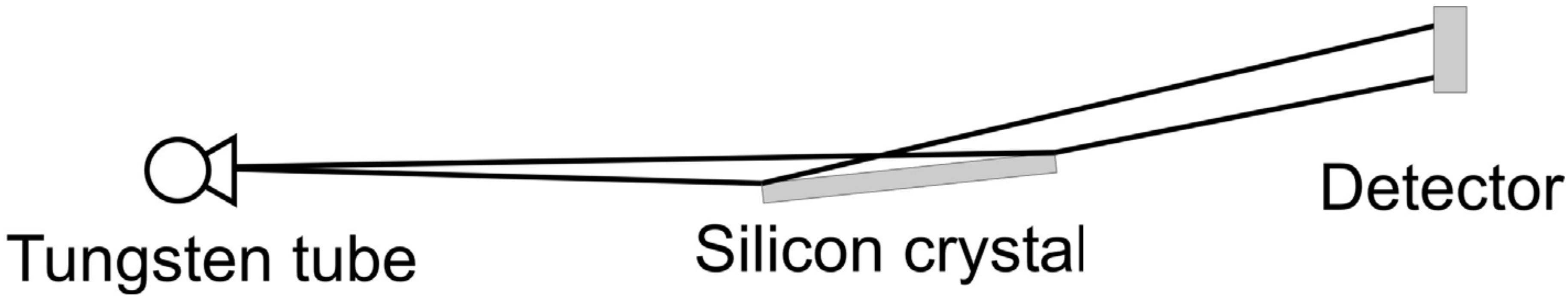
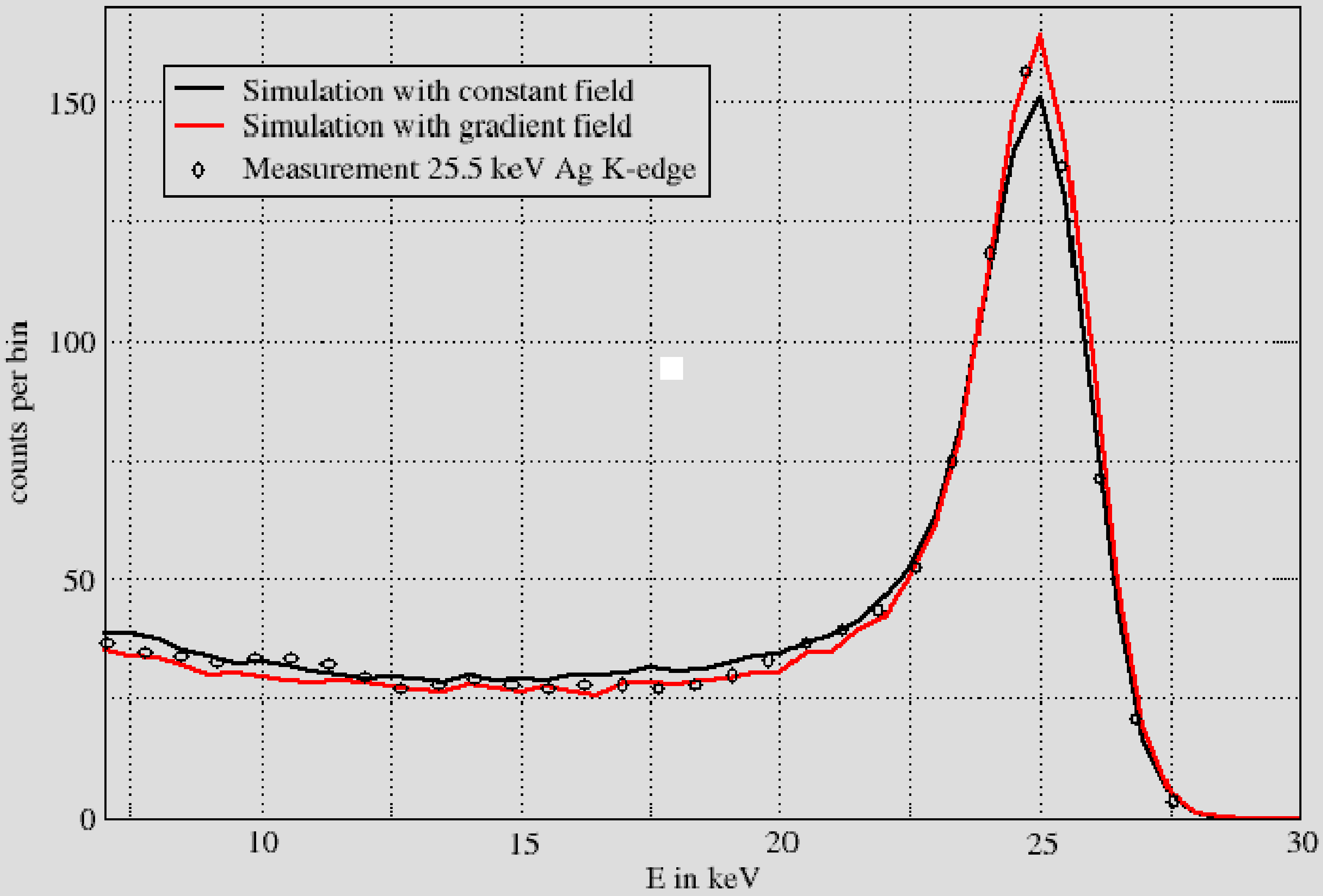
Experimental setup

- Bragg reflections as monoenergetic sources
- Threshold scans with Medipix2.

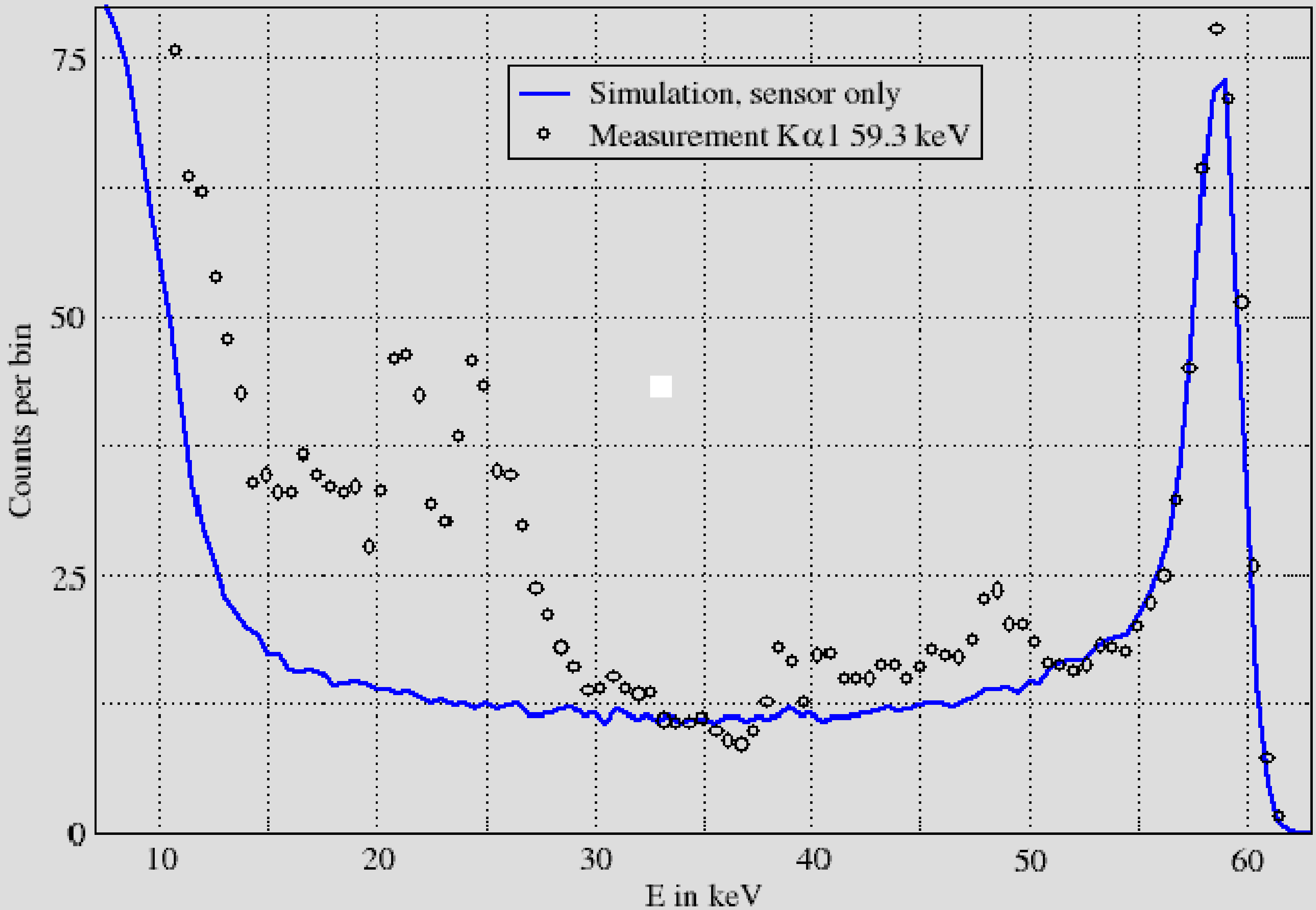




25.5 keV monoenergetic



59.3 keV monoenergetic



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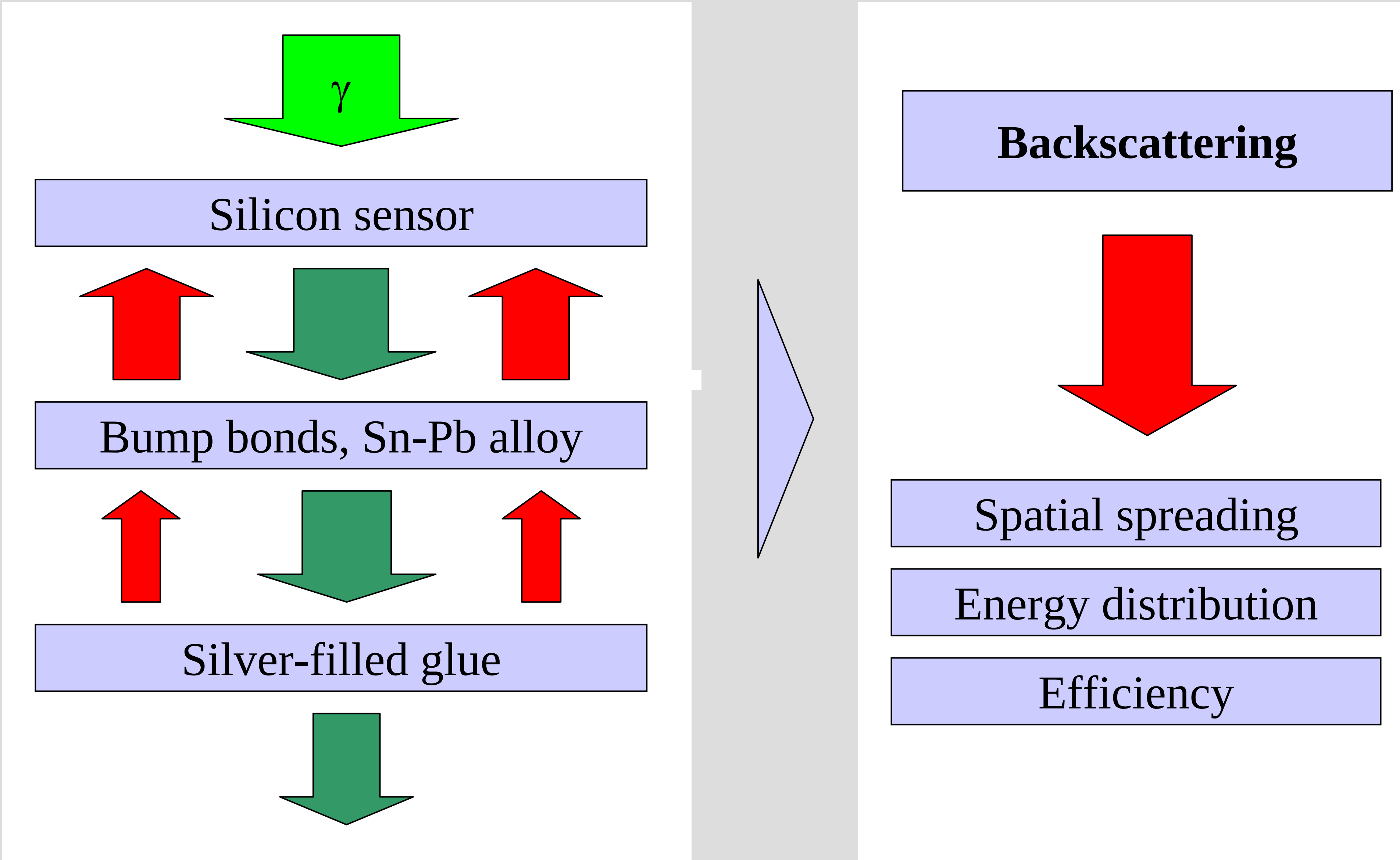
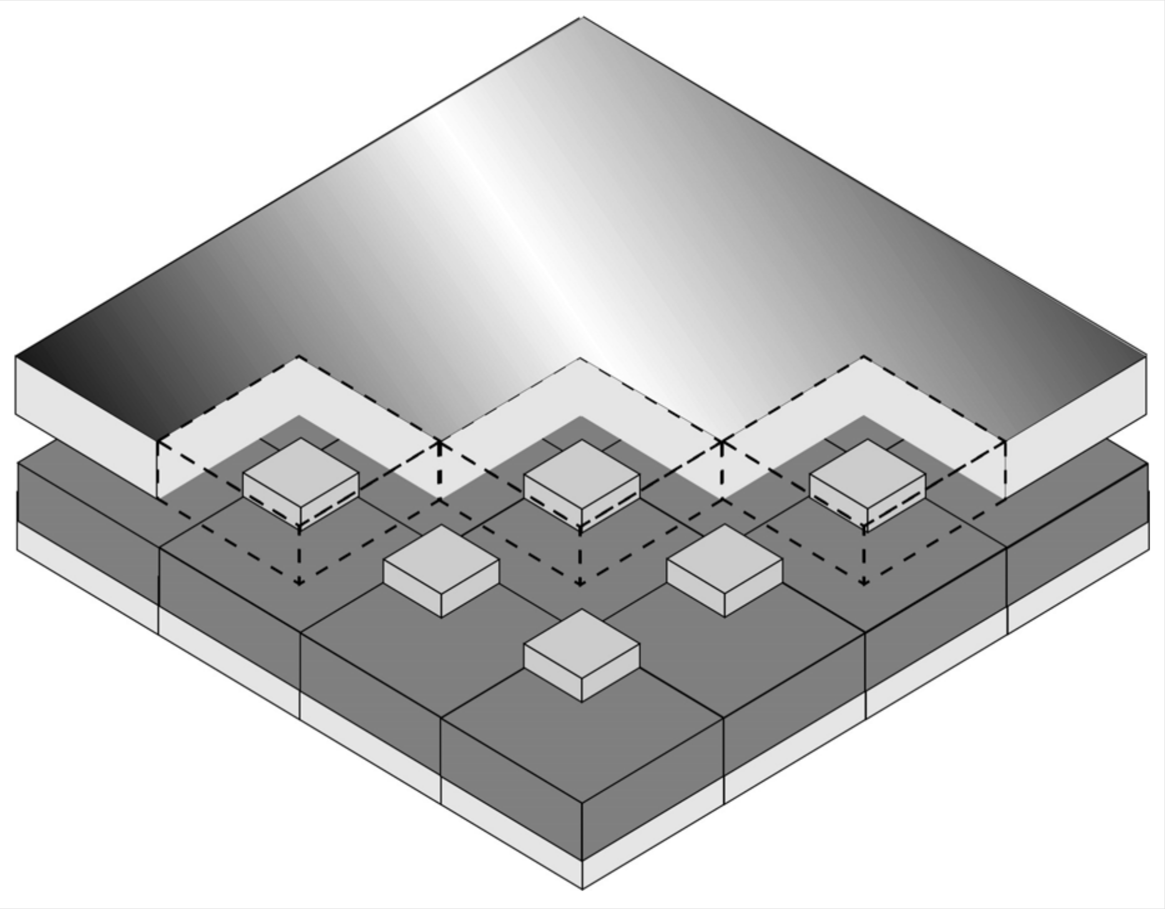
Backscattering



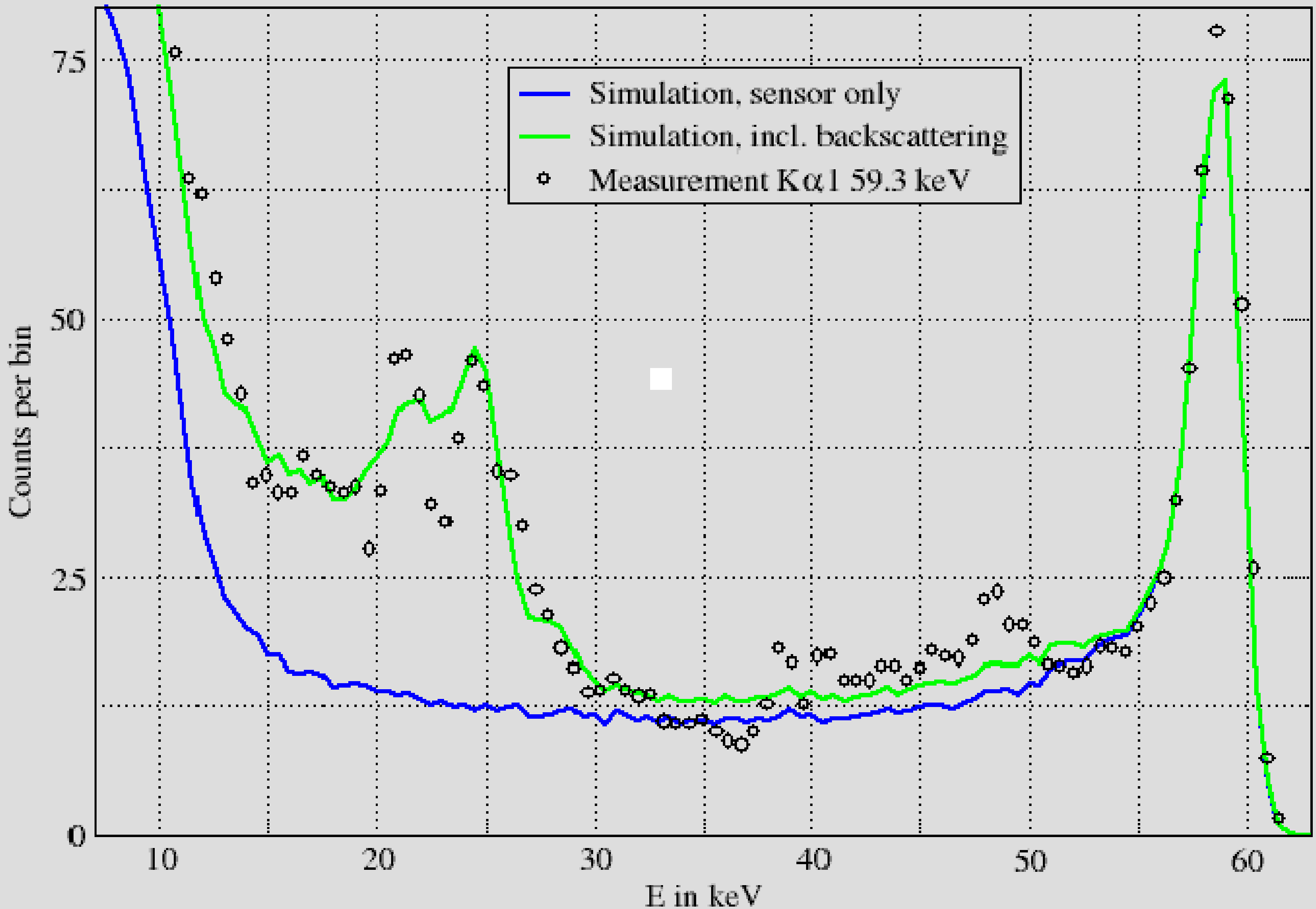
Implementation of the assembly

- Sensor, 700 µm silicon.
- Bump bonds, Sn/Pb alloy, cubics 25 µm.
- ASIC, 700 µm Si layer.
- Silver-filled glue 7 µm.



But: Simulation time up to a factor of 100.

59.3 keV


Simulation, sensor only
Simulation, incl. backscattering
Measurement Kα1 59.3 keV
Counts per bin
E in keV
0
25
50
75
10
20
30
40
50
60

Conclusion

- For energies below 30 keV the energy response can be discribed by a convolution of a Gaussian charge distribution and the pixel aperture.
- For energies higher than 30 keV fluorescense of the assembly becomes significant (Silicon sensors) and the assembly as a whole has to be considered.

Energy response of the Medipix2 detector can be described by our simulation.

Thank you, for your attention