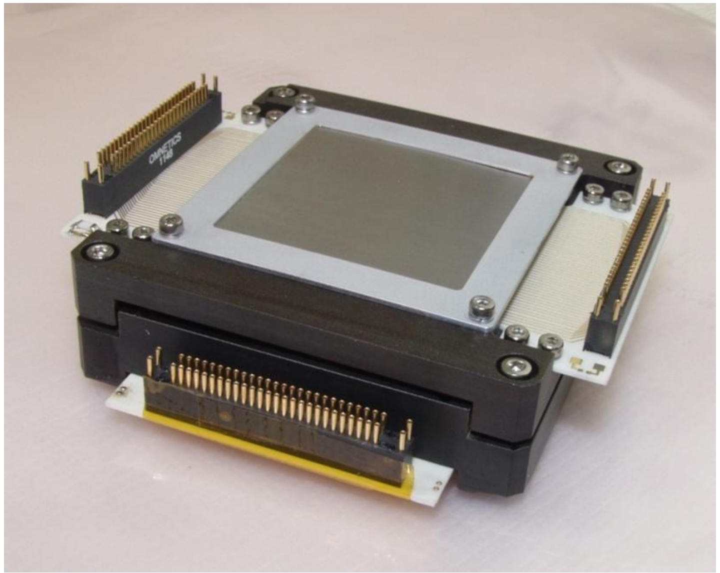
PheniX-Volga:
3D positioning in a Germanium DSSD

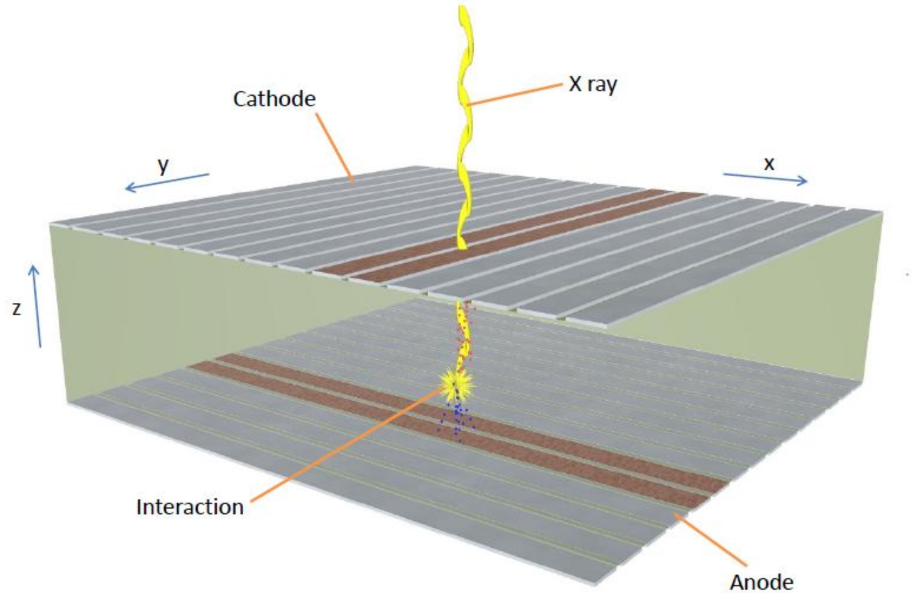


Isidre Mateu

(On behalf of Phenix-Volga's team)

How does a DSSD work?

DSSD: Double Sided Strip Detector



➢100 strips per side

➢350 um width + 50 um gap

➢Diode 1 cm thick

2N parallel signals

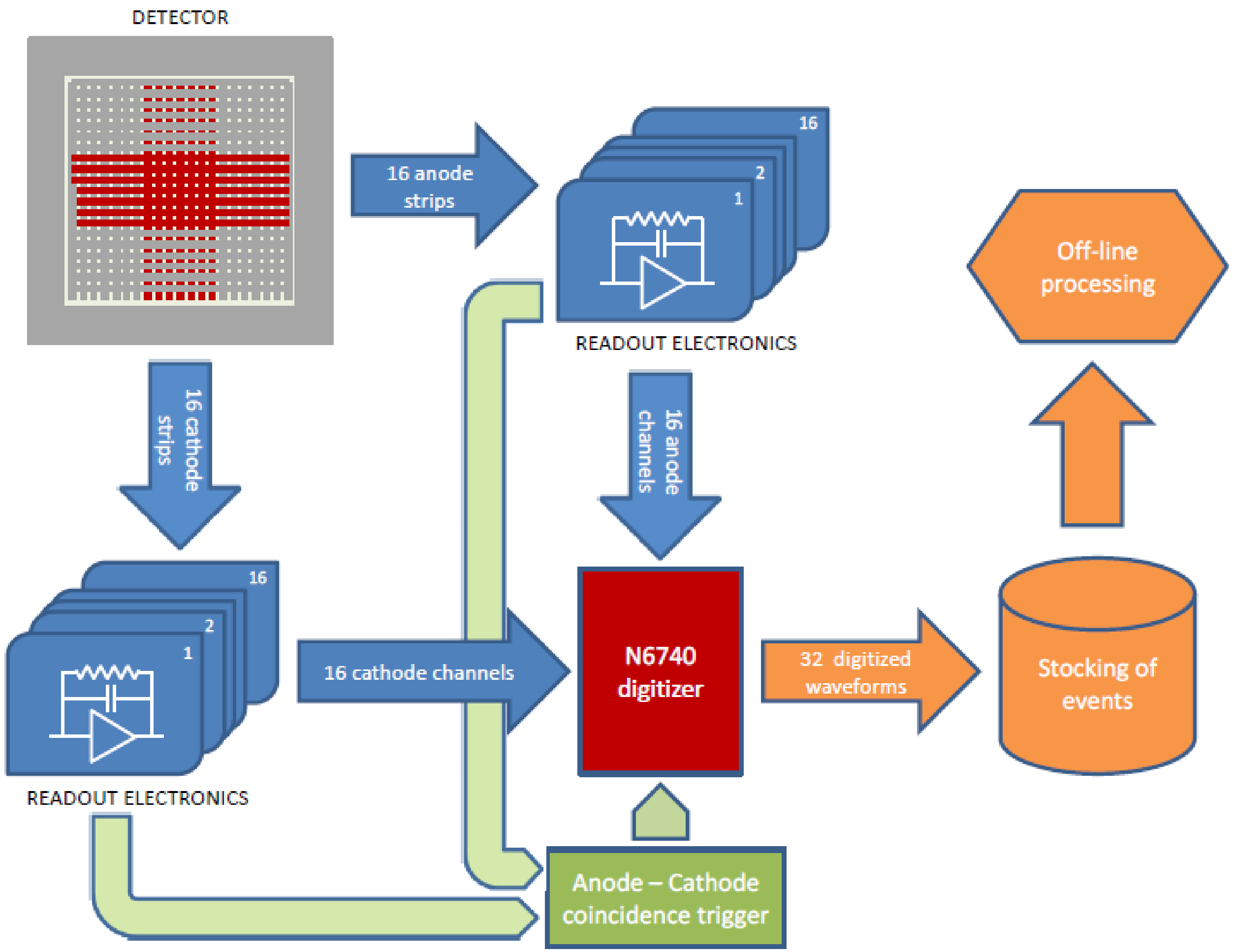
➢Deposited energy

➢Interaction position

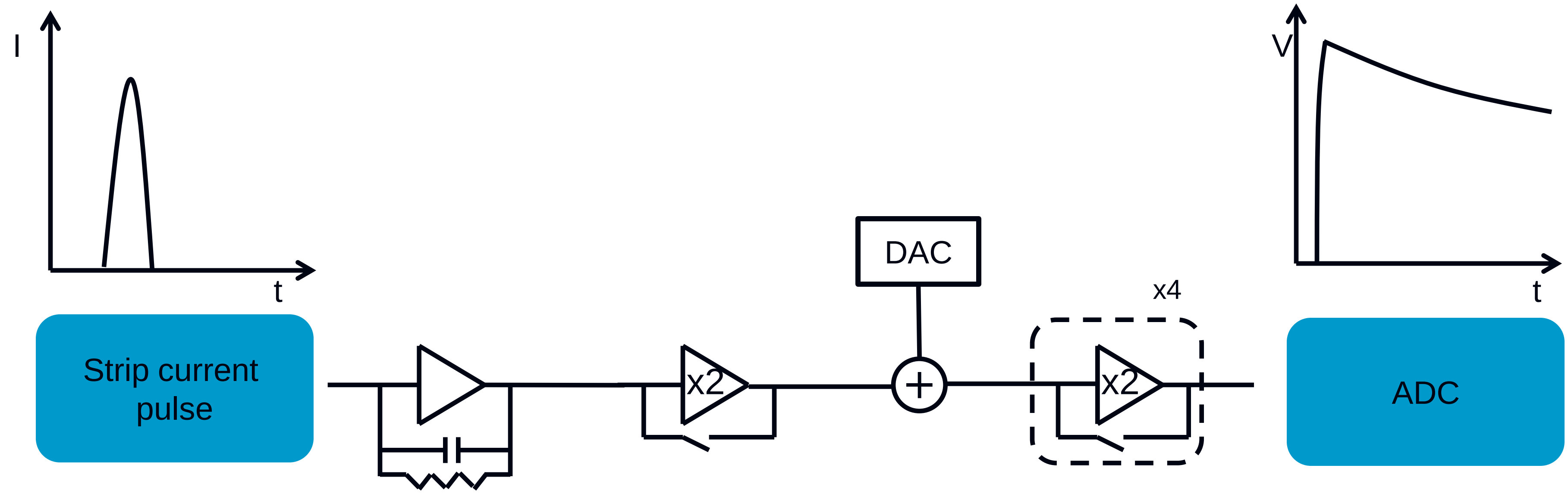
OUTLINE

1. **System description**
2. Energy Measurement
3. 3D positioning.
4. Conclusions.

Acquisition system



Analog signal processing



Amptek A250F
Charge
sensitive amp

Offset removal & gain adjustment

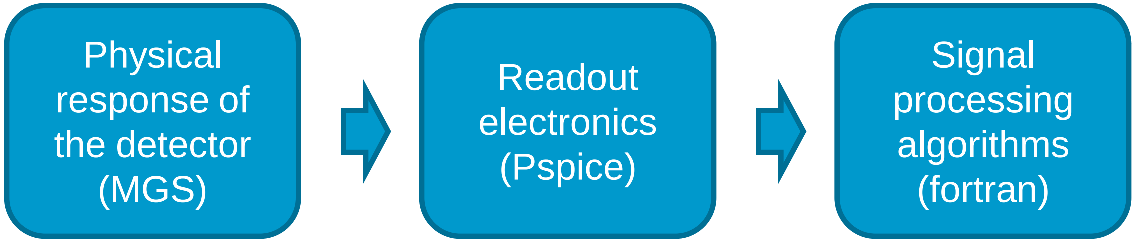
- Weak
- Short

- Amplitude adapted to the ADC dynamic range
- Amplitude carries energy information
- Long exponential decay

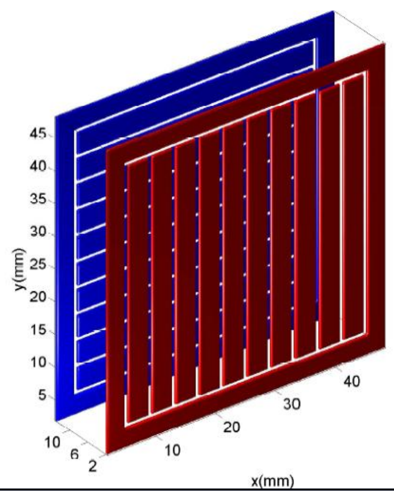
Impulsion analysis is carried out in the digital domain

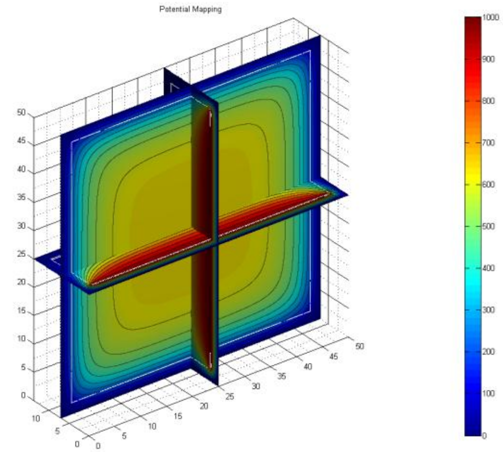
System simulation

- Development of a complete system simulation, from the detector response to the signal processing tools.



- MGS: Software tool developed and validated by the IPHC laboratory in the frame of the project AGATA.
- It focuses on the electron-hole pair collection process and the synthesis of the current pulses induced at the electrodes by the motion of the charges.





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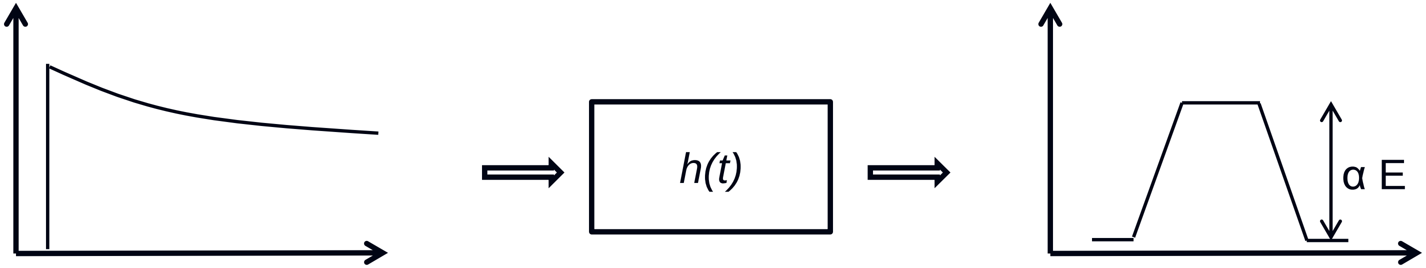
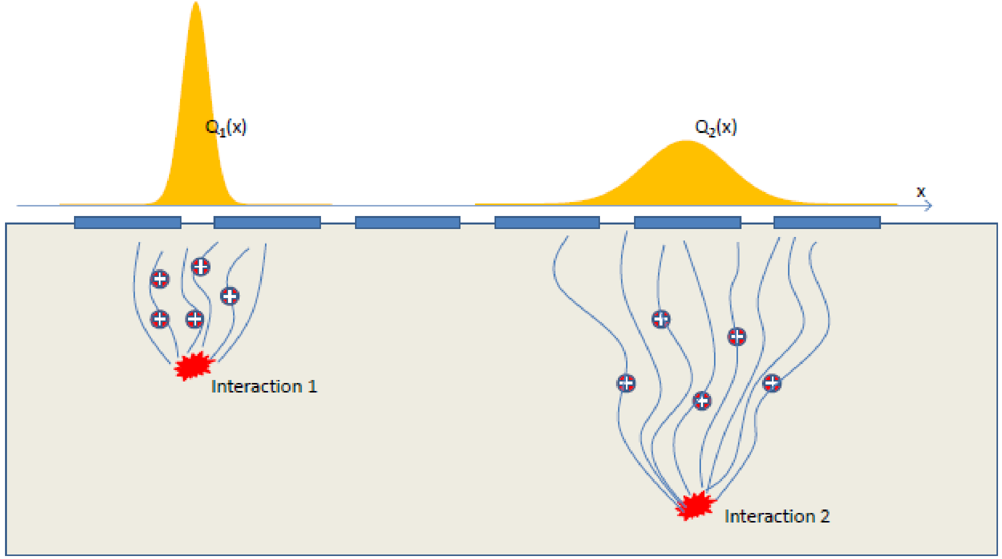
Energy measurement

➢ The amplitude of the pulse is measured through trapezoidal shaping to filter noise



➢ The energy measured on one electronic channel does not correspond to the energy deposited by the photon → Charge may be collected on several consecutive strips

Charge spread depends on:
-Energy
-Distance interaction-strips

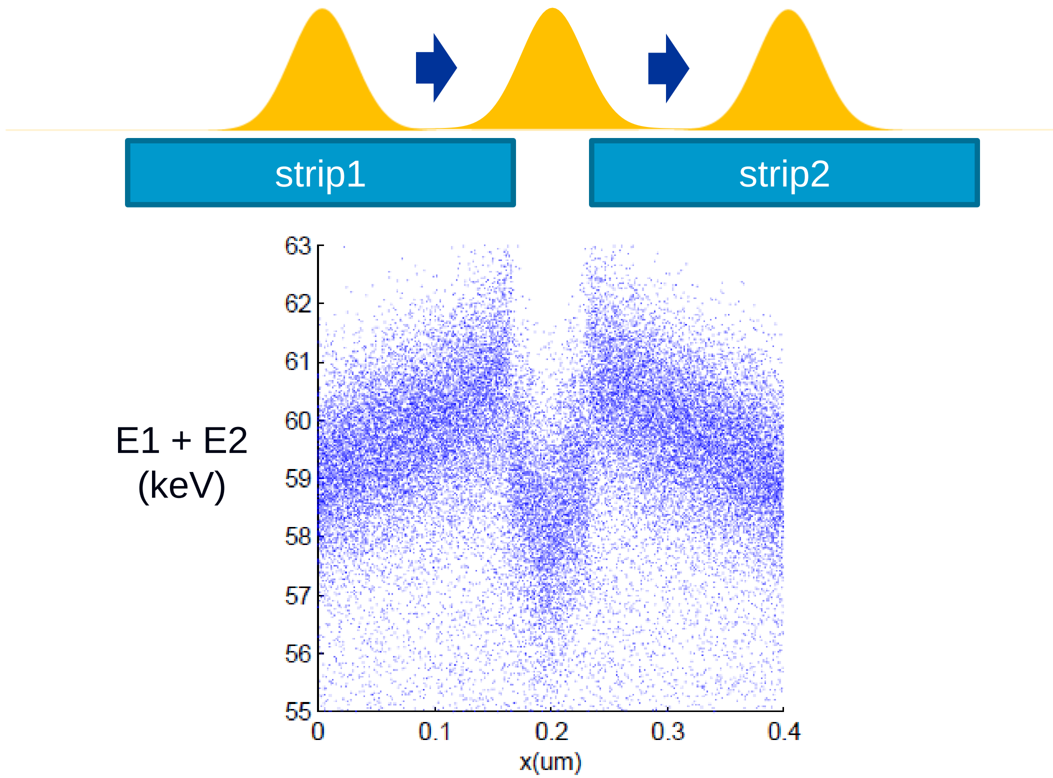


Charge sharing

- Charge sharing phenomena degrades energy resolution:
  - Charge losses.
  - Increase of electronic noise.

- Strips can not be calibrated separately.

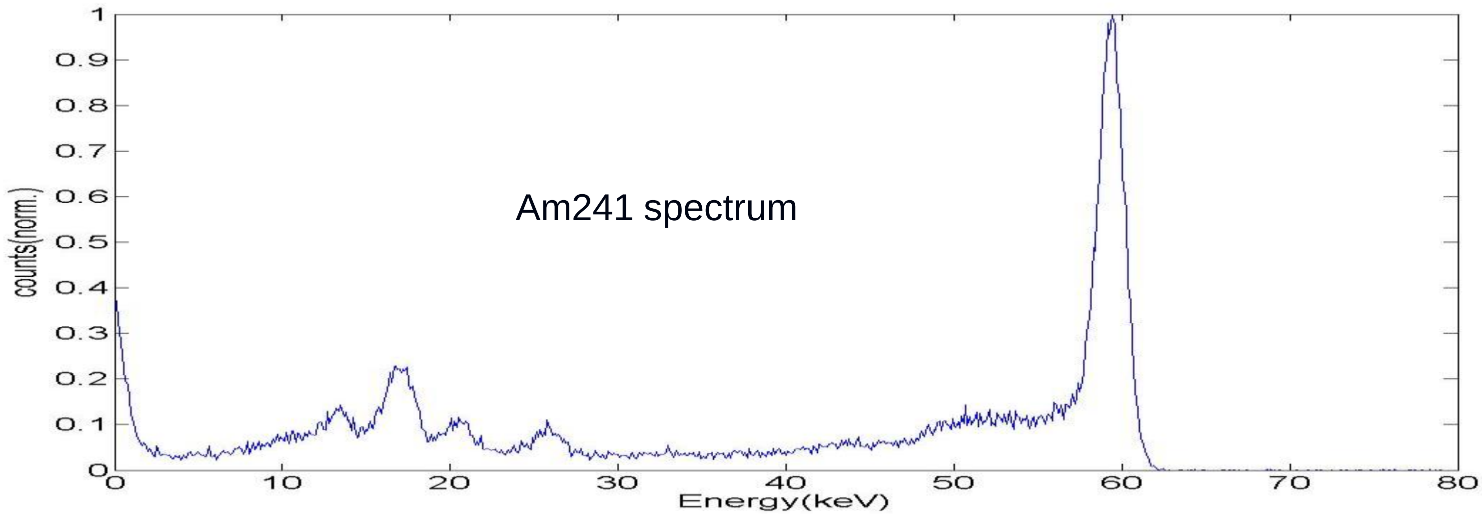
- Charge losses in the gap may be corrected.



Spectroscopy performances

- Measured resolutions:
  - 1.7 keV @ 60 keV
  - 2.0 keV @ 122 keV

- Margin for improvement.
  - Presence of LF noise (microphonics).
  - Temperature (detector + amplifiers) not optimal.
  - No charge loss correction.



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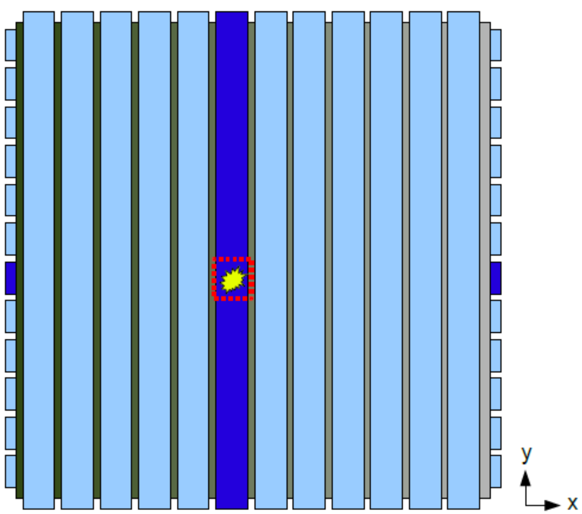
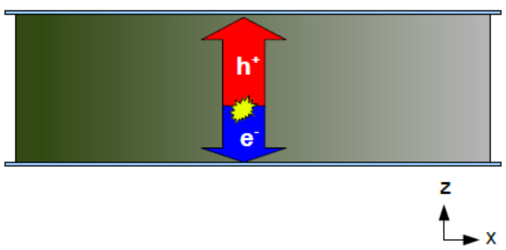
3D principle

- Positioning principle:
  - XY plane: intersection between the anode and the cathode strips define pixels.
  - Along z, position is obtained from timing measurements.

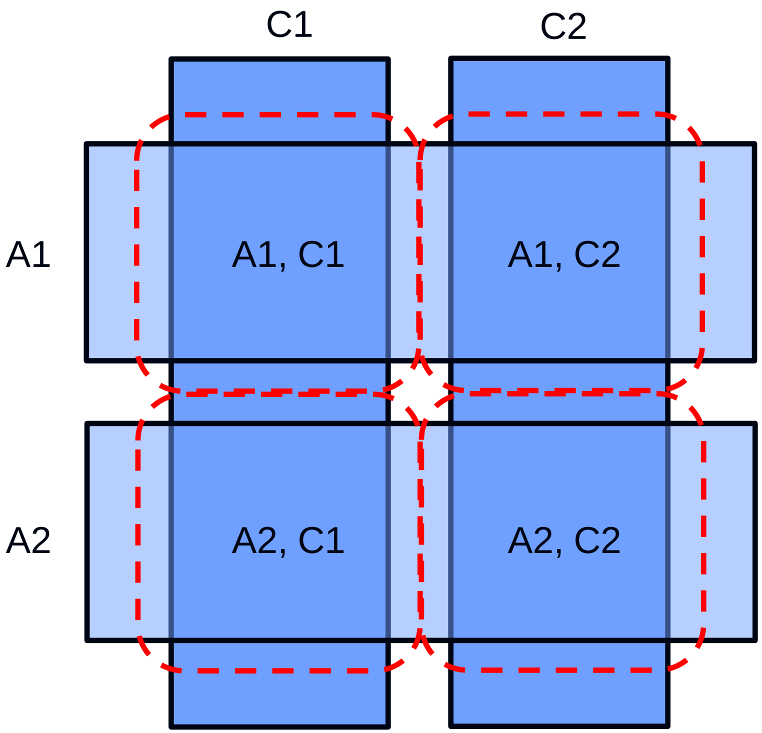
- 3D positioning allows:
  - Background reduction.
  - Measurement of Compton scattering angle.



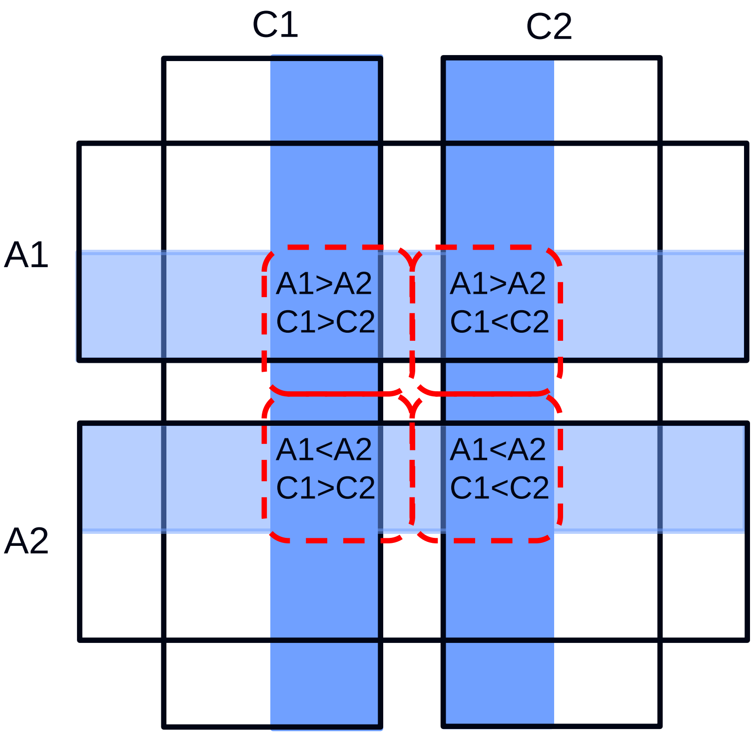


CAN WE IMPROVE SPATIAL RESOLUTION?

- If the charge is collected on one strip.
  - Pixel size equal to strip width



- Charge always shared between 2 strips.
  - 4x number of pixels.
  - Even better accuracy from exact sharing ratio.

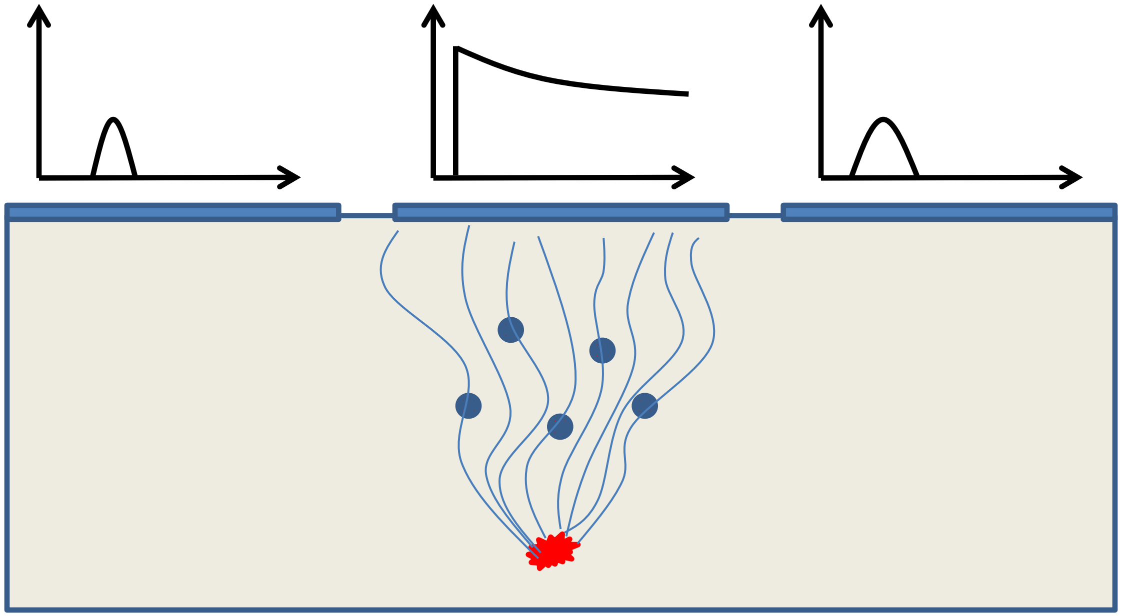


CHARGE SHARING BENEFITS SPATIAL RESOLUTION!

Spatial resolution

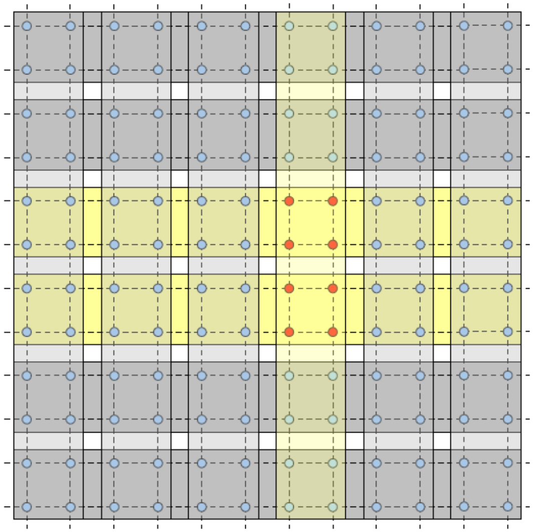
CHARGE SHARING DOES NOT OCCUR FOR ALL EVENTS.

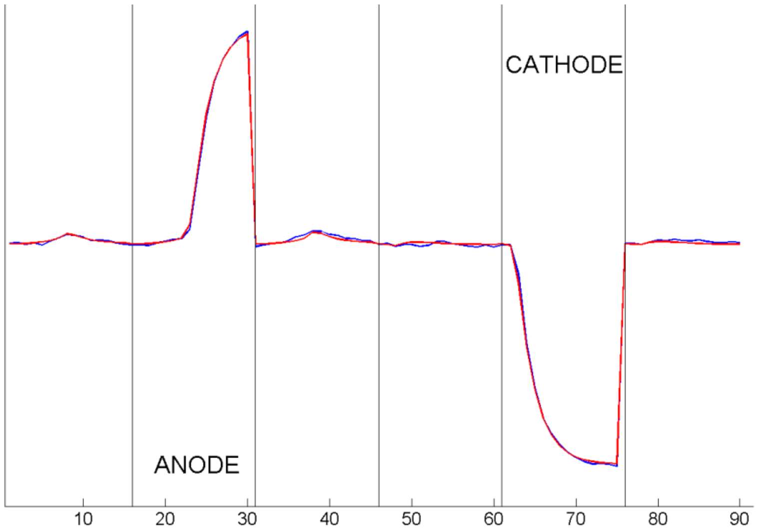
- Alternative: mirror charges.
  - Fast transitory signals that appear on the strips adjacent to those collecting the charge.
- Their analysis tells us about the interaction position.
- Simulations show that they can not be used with our current noise levels.
  - Need to improve SNR.
  - Wider strips?



Positioning algorithm

- Implemented 3D location algorithm: *matrix algorithm*. (Khaplanov, A. 2010, Phd thesis).
- Based on the knowledge of the detector response to a grid of basis points in the detector volume. The measured pulses are compared to the basis response in order to find the best fit in the least square error sense.
- Benefits:
  - Direct solution of the interaction: number of depositions, energy, 3D position.
  - Spatial resolution better than basis grid granularity.
  - Allows study of charge sharing/mirror charges.

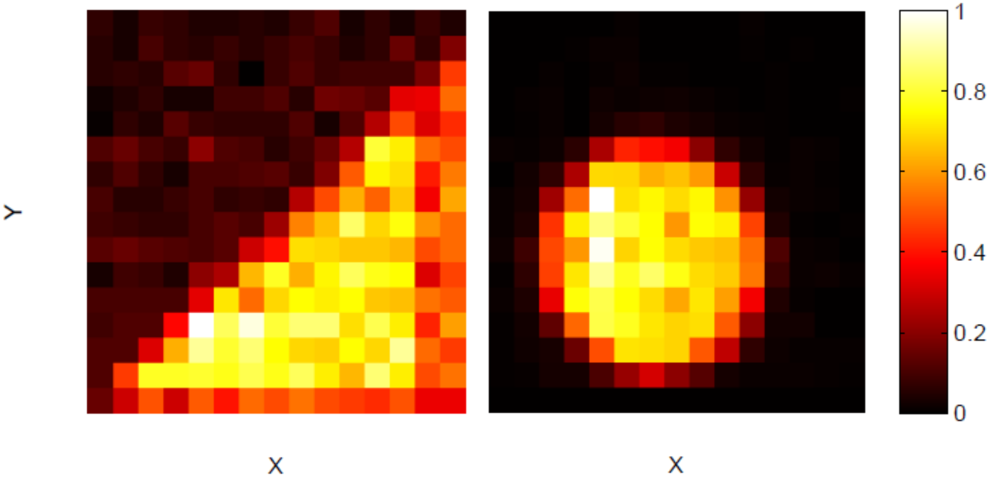




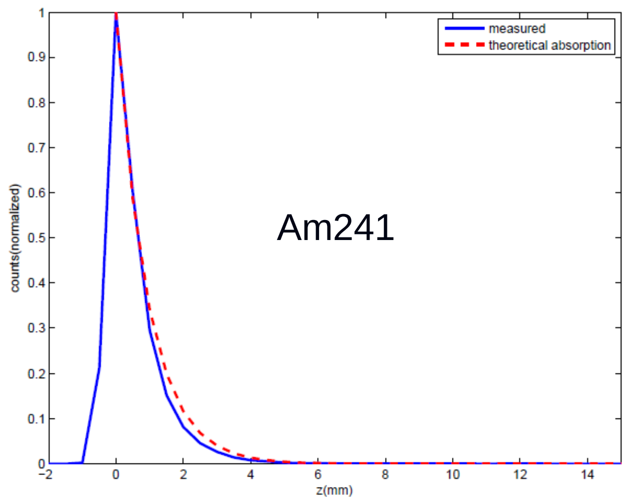
Algorithm validation

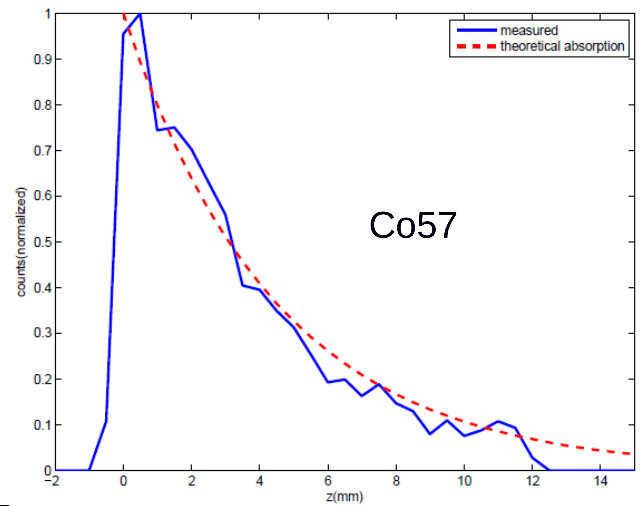
Validation of the algorithm

- Detection plane: irradiation of the detector using different masks.



- Interaction depth: comparison with theoretical absorption curves at different energies





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Conclusions

- DSSD technology allows 3D reconstruction of the interaction position.
- Charge sharing phenomena affects spectroscopy and positioning performances.
- Full characterization of the detector response will allow:
  - Assess the impact of charge losses on the energy resolution.
  - Correction of charge losses in the gap.
- Choice of strip width represents a trade-off.

Wider strips	Narrower strips
✓ Energy resolution ✓ Less electronic channels ✘ Spatial resolution ✓? Mirror charges	✘ Energy resolution ✘ More electronic channels ✓ Spatial resolution