UNIVERSITY OF COPENHAGEN

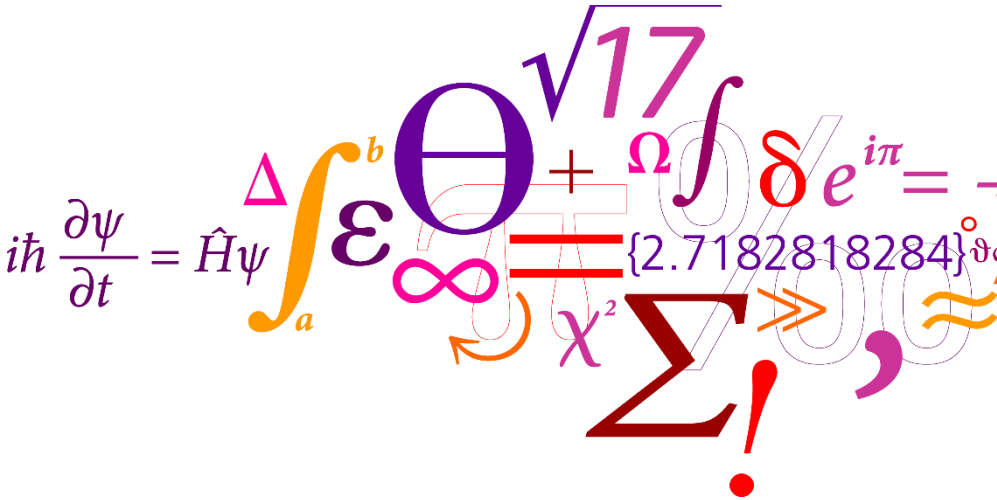
ADVACAM
Imaging the Unseen

Technical University of Denmark DTU

Intrinsic XRF correction in CdTe Timepix3 spectral detectors

M. khalil, D. Turecek, J. Jakubek, J. Kehres, E. Schou Dreier, U.L. Olsen

26 June 2018



DTU Physics
Department of Physics

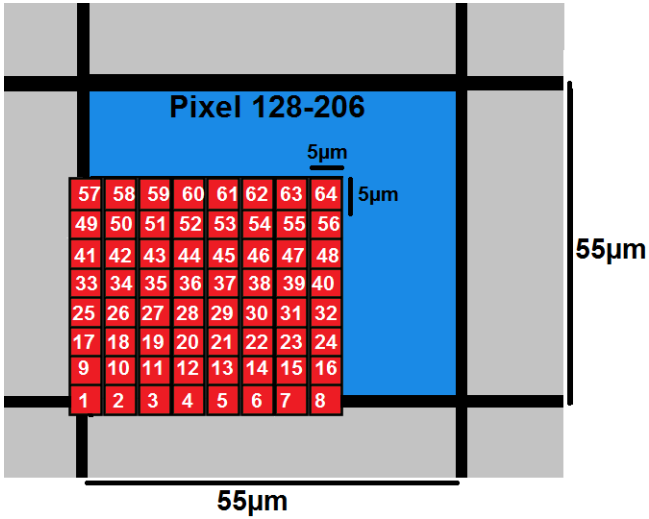
Outline

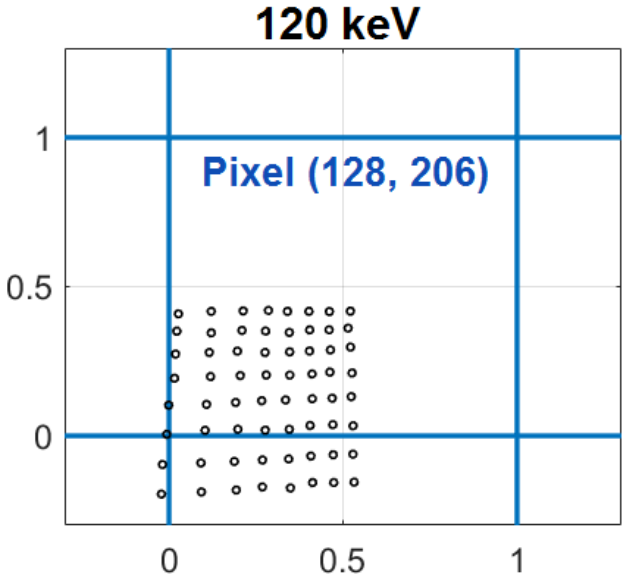
- **Timepix/Timepix3 detectors at DTU**
- **Hybrid Pixel detectors**
  - Limitations: due to intrinsic XRF
- **Timepix3**
  - Timepix3 vs Timepix
  - XRF correcton in Timepix3
- **Results of XRF corrections**
  - 57 Co spectrum: original vs XRF corrected
- **Summary**

Timepix/Timepix3 detectors at DTU

- Custom built setups for spectral imaging and diffraction
- Timepix and Timepix3 Si and CdTe detectors:
  - In-house TOT calibration at 25 ^{o}C

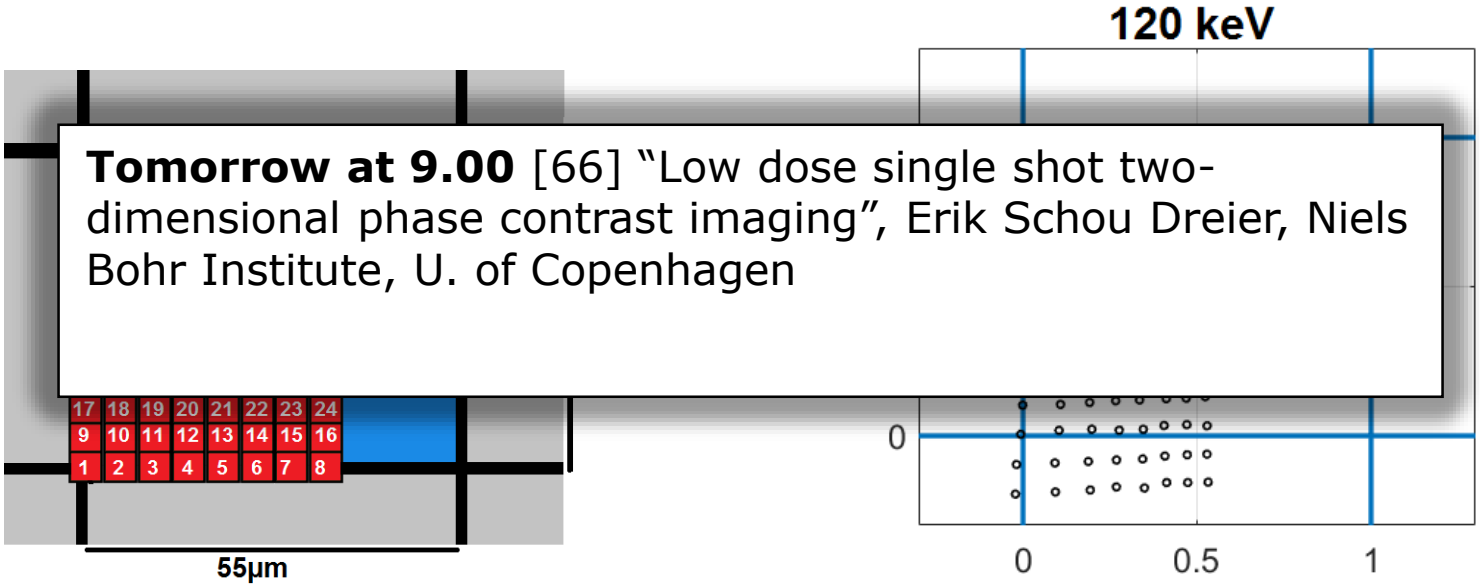
Timepix/Timepix3 detectors at DTU





- Custom built setups for spectral imaging and diffraction
- Timepix and Timepix3 Si and CdTe detectors:
  - In-house TOT calibration
  - Subpixel Resolution with Timepix3
  - Intrinsic XRF supression
  - Phase contrast imaging with Timepix3

Timepix/Timepix3 detectors at DTU



Tomorrow at 9.00 [66] "Low dose single shot two-dimensional phase contrast imaging", Erik Schou Dreier, Niels Bohr Institute, U. of Copenhagen

- Custom built setups for spectral imaging and diffraction
- Timepix and Timepix3 Si and CdTe detectors:
  - In-house TOT calibration
  - Subpixel Resolution with Timepix3
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Hybrid Pixel detectors

Limitations in **HPDs:**

- Intrinsic fluorescence => partial charge deposition
- Charge diffusion => charge sharing

- Absorption efficiency
- Fluctuations in the number of generated e-/h+ pairs
- Charge trapping, Leakage current, electronic noise, pileup

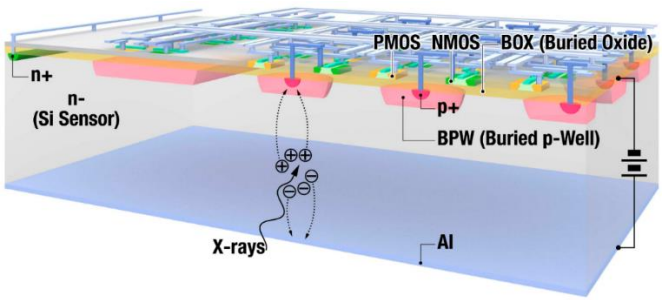
Hybrid Pixel detectors

Limitations of **HPDs:**

- Intrinsic fluorescence => partial charge deposition
- Charge diffusion => charge sharing

- Energy transfer to an orbital e
- e is ejected with h $E_{incident} - E_{binding}$
- The vacancy is promptly filled with e from other shells
- Fluorescence yield in CdTe is 80%

- Energy range: 3-100 keV
- Pixel size: 55 µm



Substance	Z	kα1 [keV]	kα2 [keV]	Mean free path kα1[µm]	Mean free path kα2[µm]
Cd	48	23.17	22.984	113.2	110.7
Te	52	27.44	27.202	59.32	57.85

Hybrid Pixel detectors

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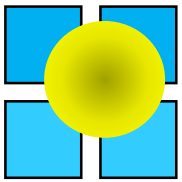
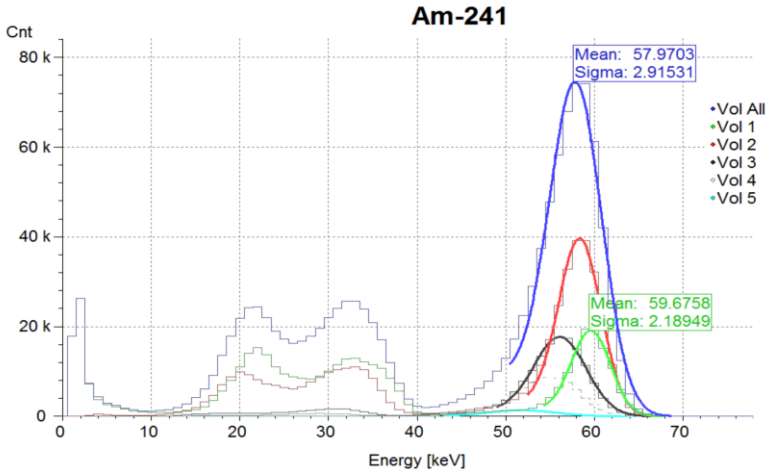
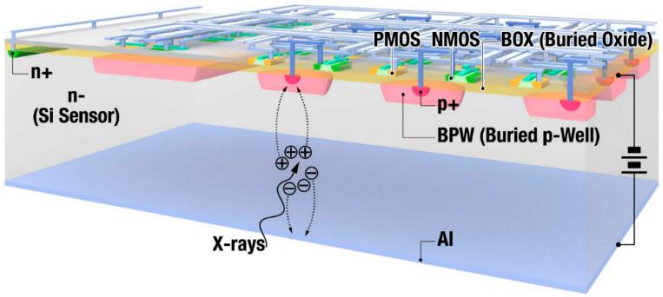


Charge diffusion leading to pixel clusters

1 mm CdTe

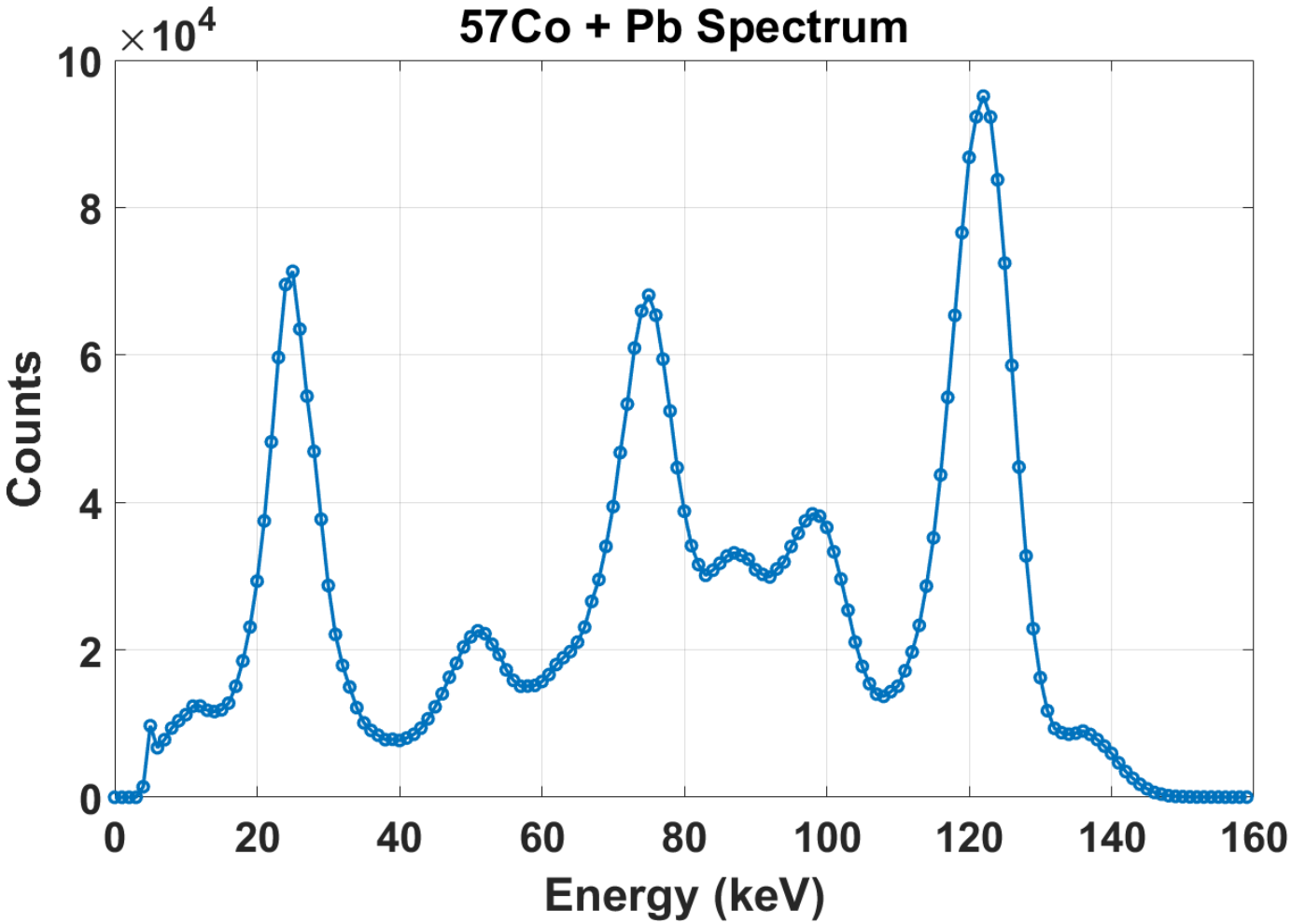




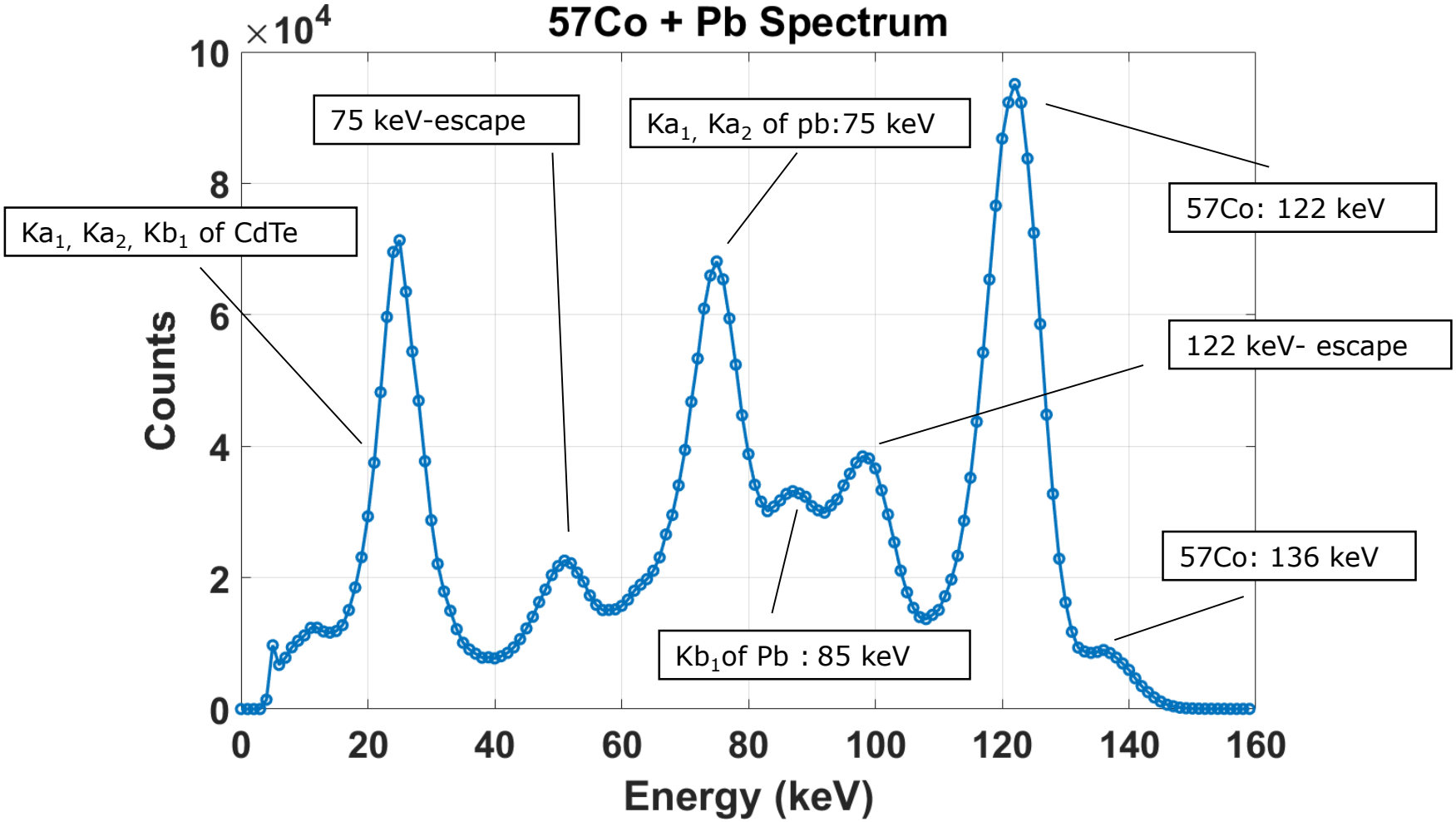
Timepix3 vs Timepix

Parameter	Timepix ASIC	Timepix3 ASIC
Pixel pitch	55 μm	55 μm (can achieve sub-pixel resolution of 14 μm)
Pixel matrix	256 × 256	256 × 256
Sensitive area	14 mm × 14 mm	14 mm × 14 mm
Detection modes	• Energy • Arrival Time • Counts	• Arrival Time and Energy • Arrival Time • Counts +integrated Energy
Readout mode	Frame based (1700 fps)	• Frame based (1700 fps) • Data driven (40 Mcts/s)
Time Resolution	Up to 10 ns	1.56 ns

Results


57Co + Pb Spectrum
×10^4
10
8
6
4
2
0
Counts
0
20
40
60
80
100
120
140
160
Energy (keV)

Results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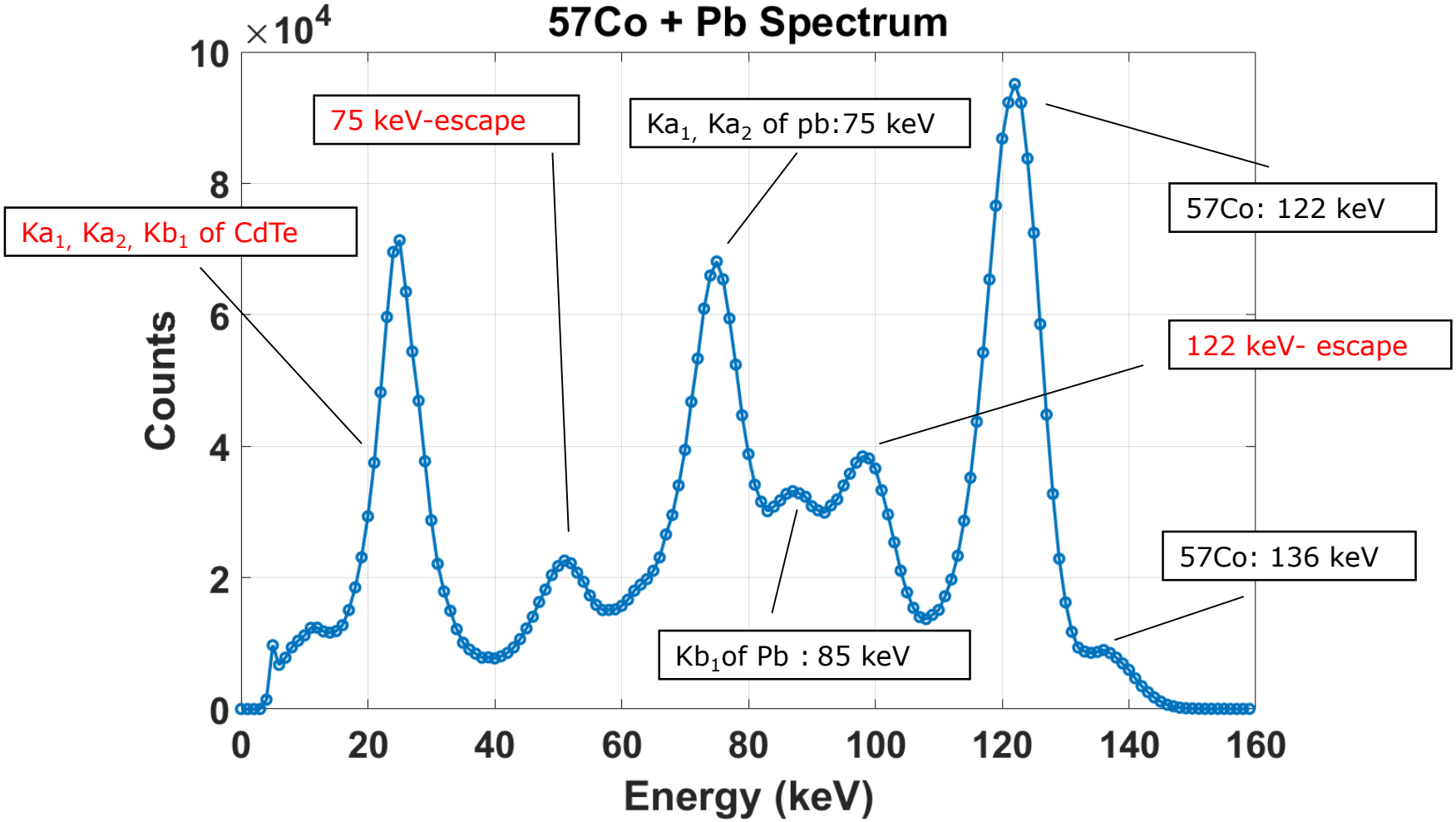
Energy (keV)
75 keV-escape
Ka1, Ka2 of pb:75 keV
Ka1, Ka2, Kb1 of CdTe
57Co: 122 keV
122 keV- escape
57Co: 136 keV
Kb1of Pb : 85 keV

Results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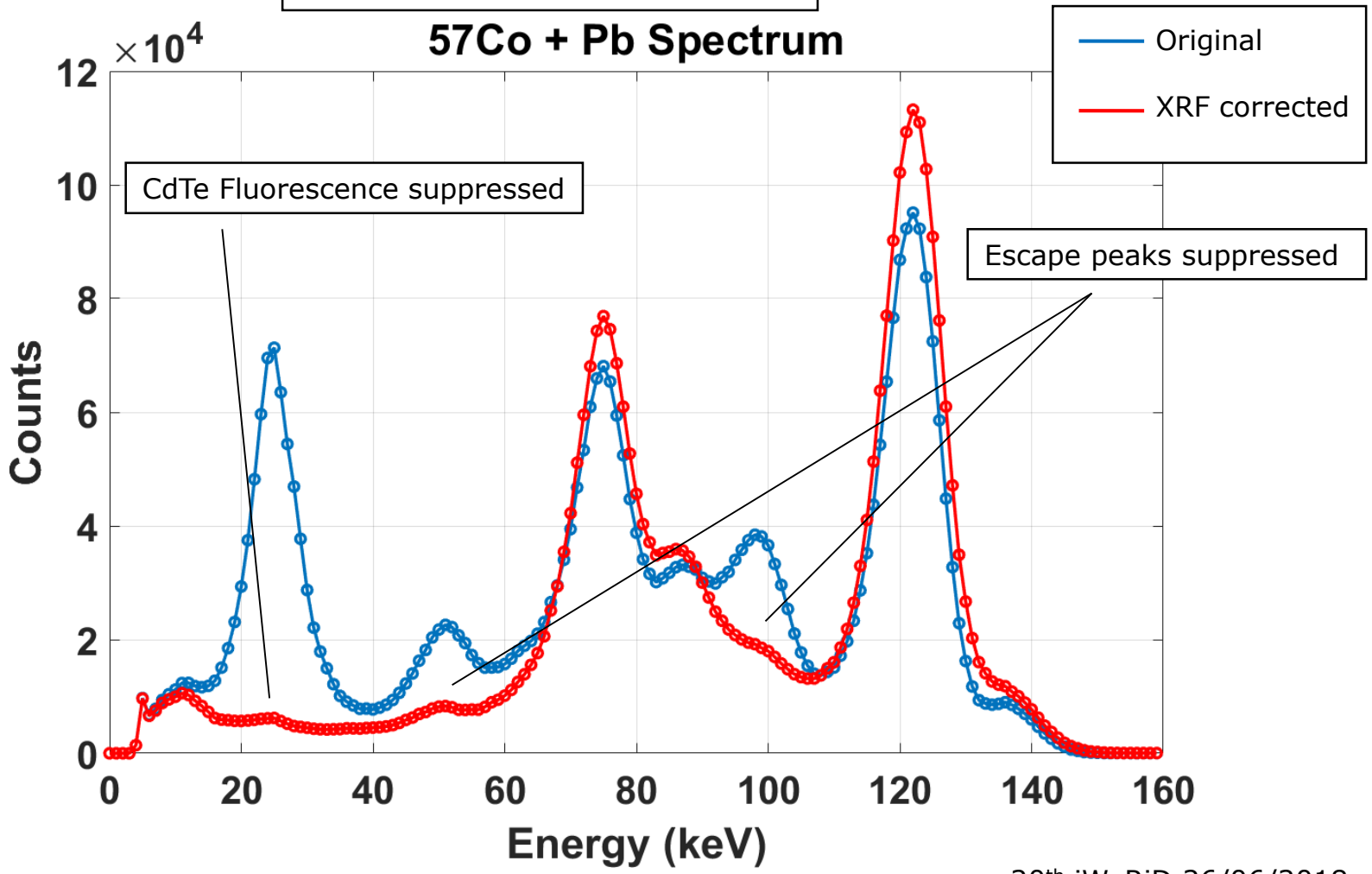
Results

E=15-40 keV
Time= 15 ns
Space= 100 pixels



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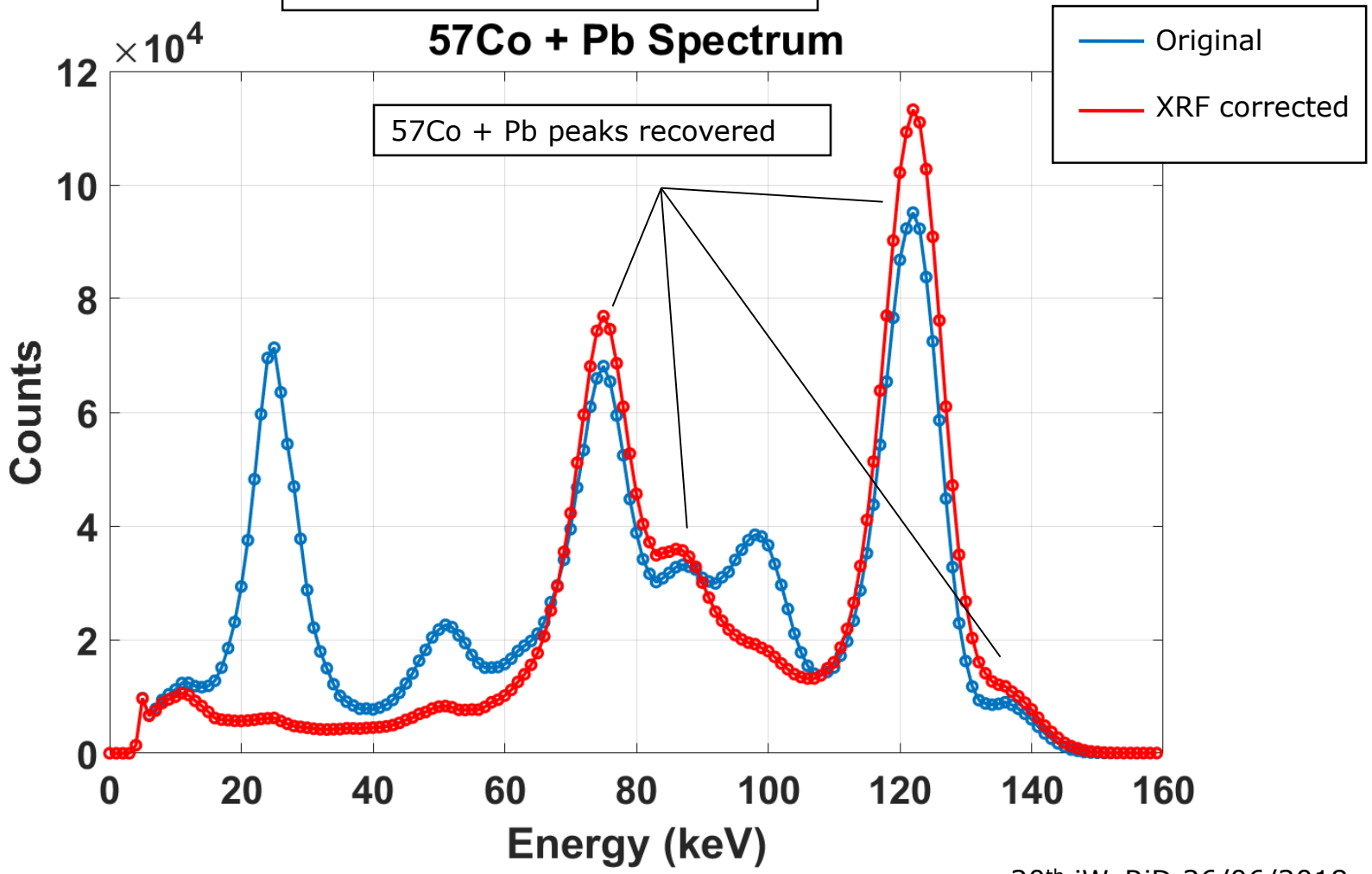
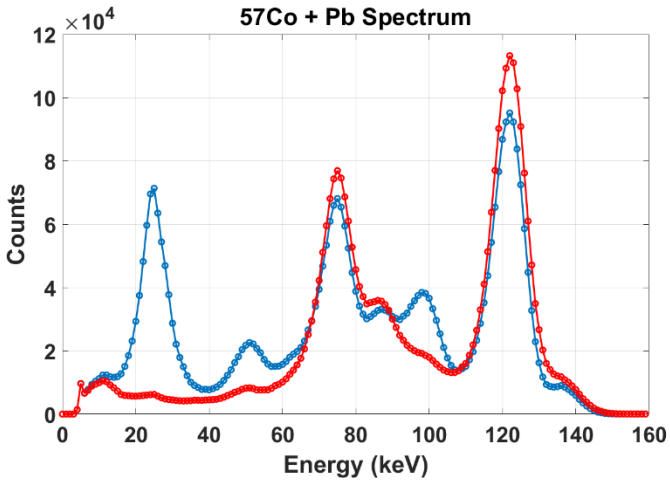


Summary



- Advapix-Timepix3 is a new hybrid pixel detector produced by ADVACAM:
  - Simultaneous Energy and arrival time measurements up 40
  - Unambiguous one-by-one photon detection
  - Advapix-Timepix3 XRF correction algorithm can significantly reduce spectrum distortions due to intrinsic XRF

Thank you

Questions ?

EXTRA

Timepix3 vs Timepix

Timepix:

- Either **TOT** (Time-Over-Threshold mode: Energy) or **TOA** (Time-of-Arrival) measurements.
- **TOT measurement mode:** a second particle strike on the same pixel while the shutter is open results in integrated TOT.
- **Frame-based readout mode (up to 1700 fps)**: Pixel matrix is insensitive during readout.

Timepix3:

- Simultaneous **TOT** and **TOA** measurements to identify pixel clusters and fluorescence events.
- Data driven readout **(up to 40 Mcts/s)**: when a pixel is hit, it immediately initiates the sending of its data off-chip. => no dead-time. 475 ns to clear digital information from a pixel.