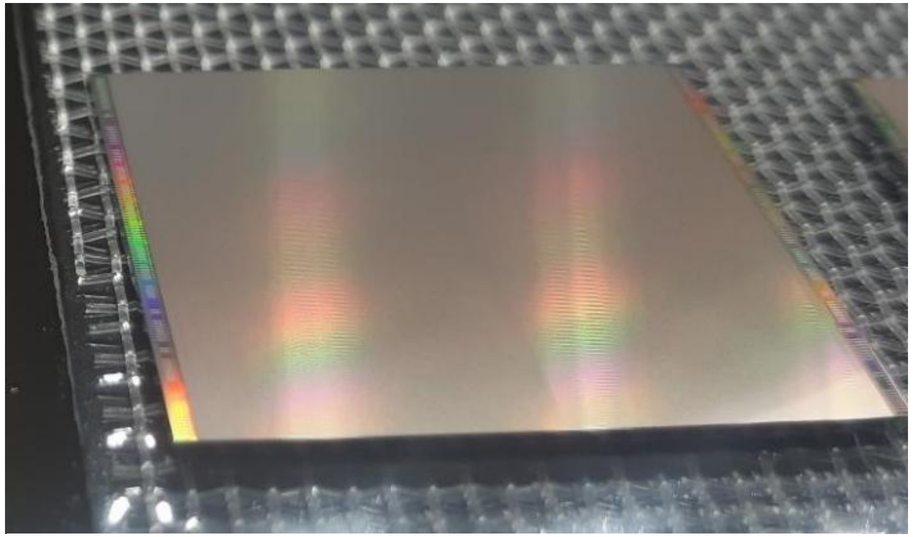
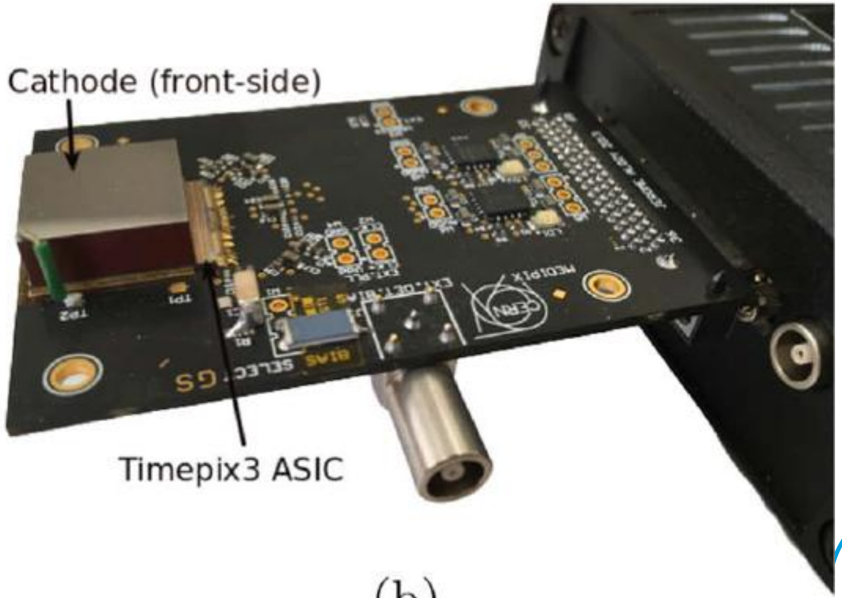
Timepix and high-Z sensors

HIZPAD meeting, 15-16 Jan 2026, Zurich

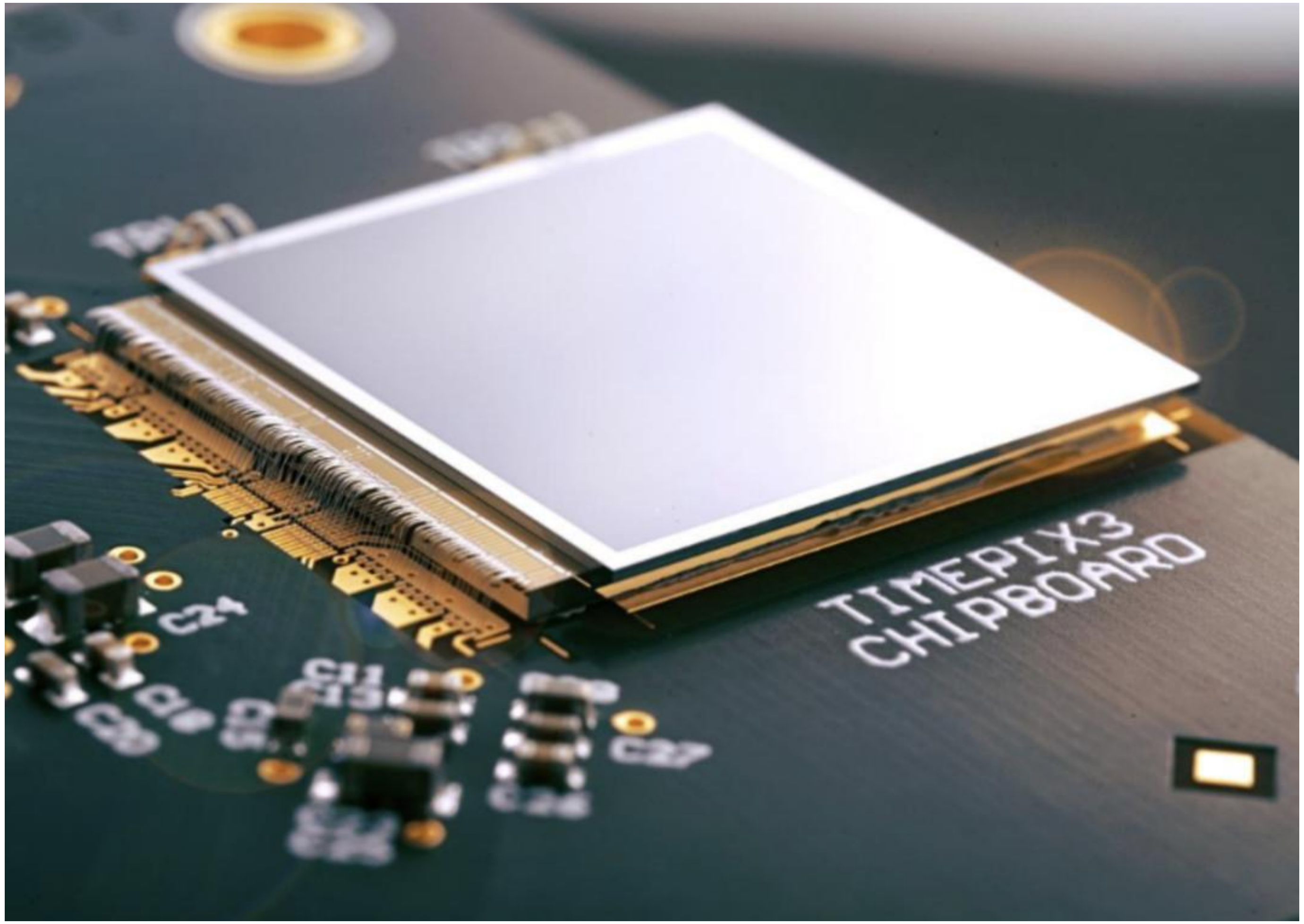
David Pennicard, Jonathan Correa, Adriana Simancas,
Sergei Fridman, Sabine Lange, Heinz Graafsma – DESY





(b)

~ns timing



55 µm pixels

~a few keV energy resolution

Overview

- The Timepix ASIC series
- Use in high-Z sensor characterization
- General applications in X-ray detection
- Timepix and high-Z at light sources – systems and applications

Medipix collaborations and chip development

- Four collaborations over more than 25 years
- Led by CERN, with majority of ASIC design by CERN (+ NIKHEF and IFAE)
- Member institutes provide funding, and work on tests and applications
- Anniversary symposium 2025: https://indico.cern.ch/event/1539

CERN Medipix team

Medipix collaborations and chip development

- Medipix chips – spectroscopic photon counting
- Timepix chips – timestamping

Medipix2 collaboration	Medipix3 collaboration	Medipix4 collaboration
Medipix2 (2001)	Medipix3 (2011)	Timepix4 (2022)
Timepix (2007)	Timepix3 (2014)	Medipix4 (2024)
Timepix2 (2020)		

https://medipix.web.cern.ch/

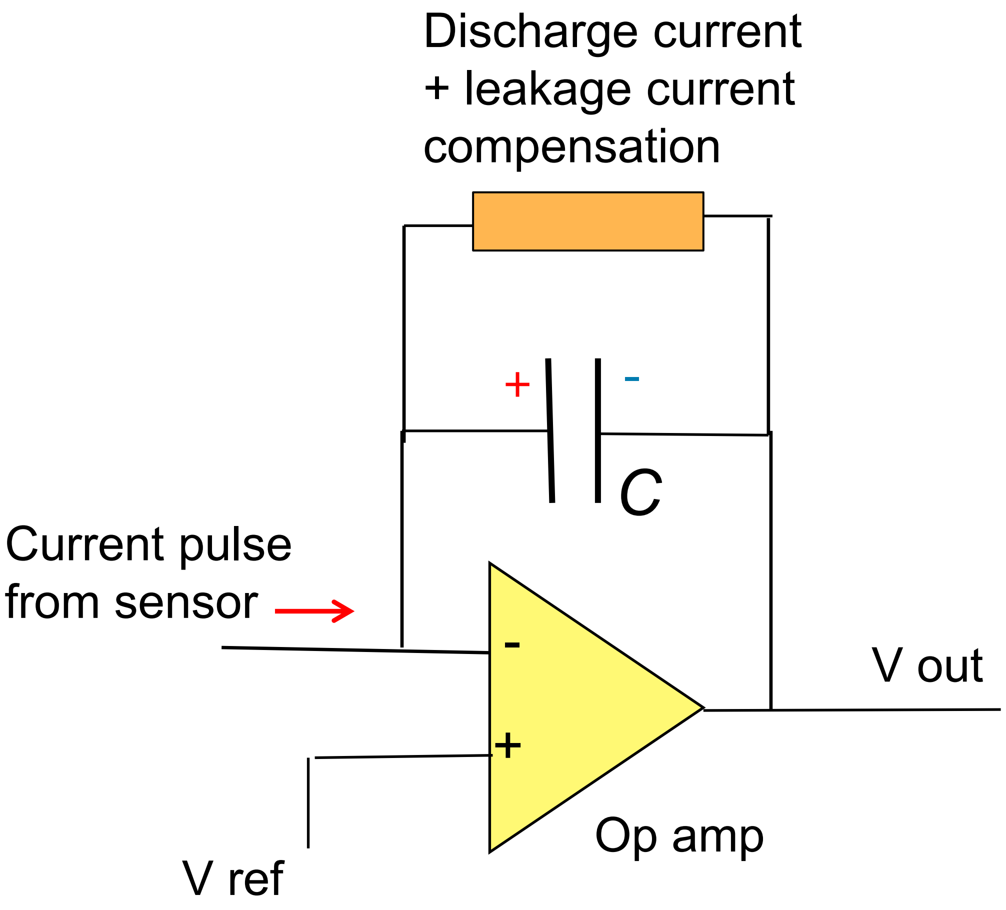
Timepix - X. Llopart et al., NIMA 581 (2007) 485–494. https://doi.org/10.1016/j.nima.2007.08.079

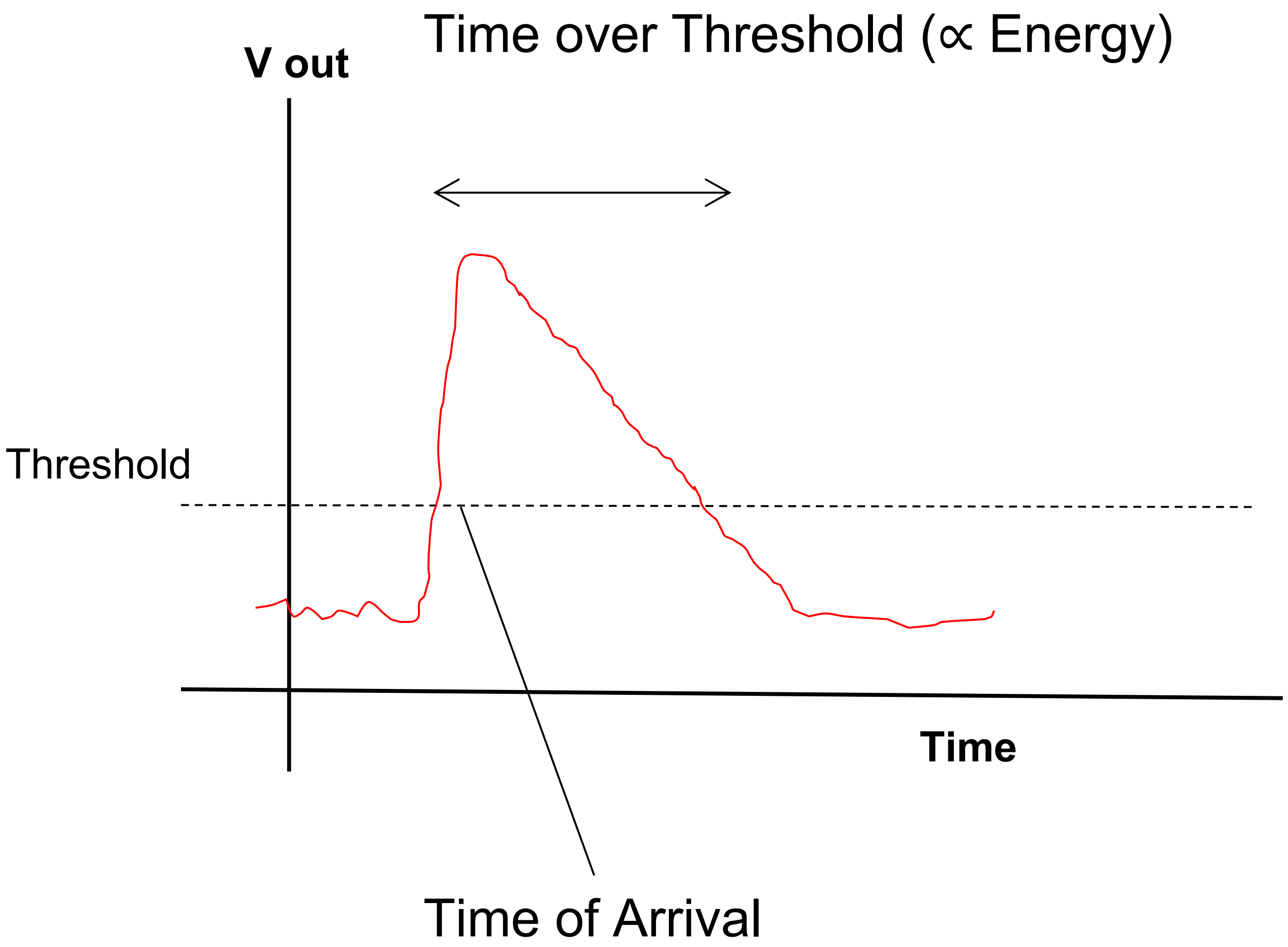
Timepix3 - T Poikela et al 2014 JINST 9 C05013. https://doi.org/10.1088/1748-0221/9/05/C05013

Timepix4 - X. Llopart et al 2022 JINST 17 C01044. https://doi.org/10.1088/1748-0221/17/01/C01044

Timepix signal processing

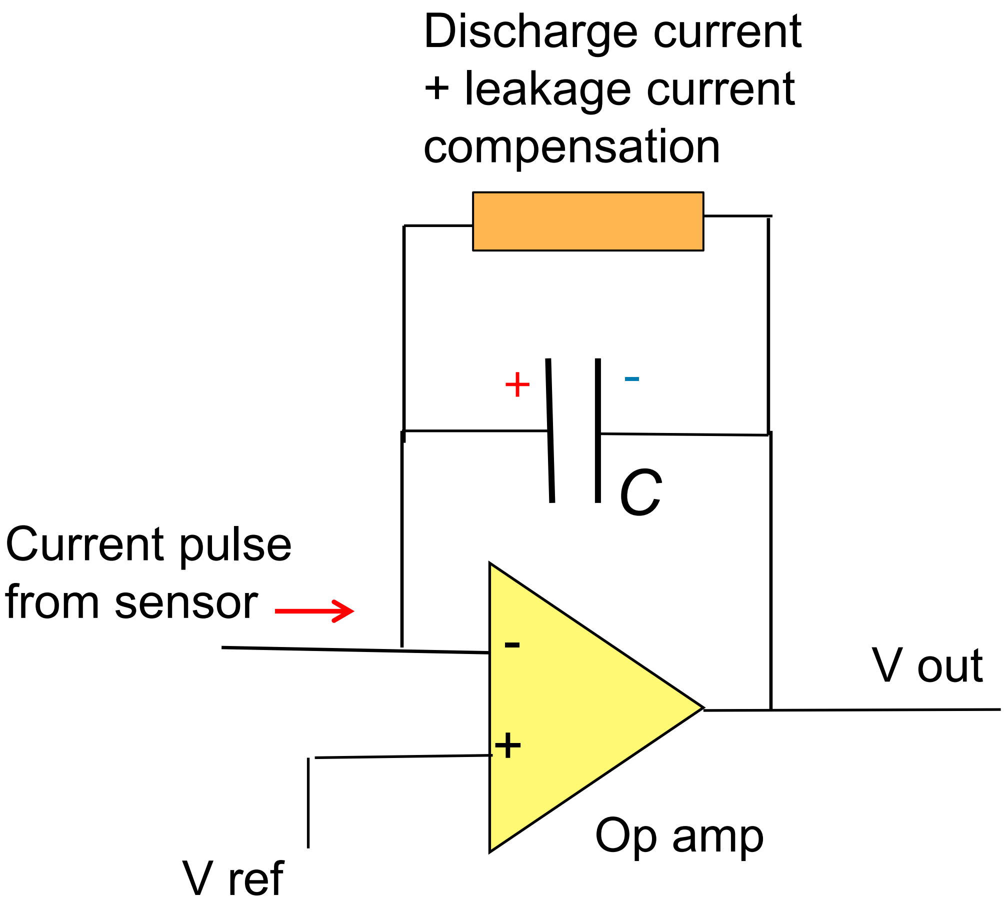
- Charge integrating preamplifier plus linear discharge mechanism

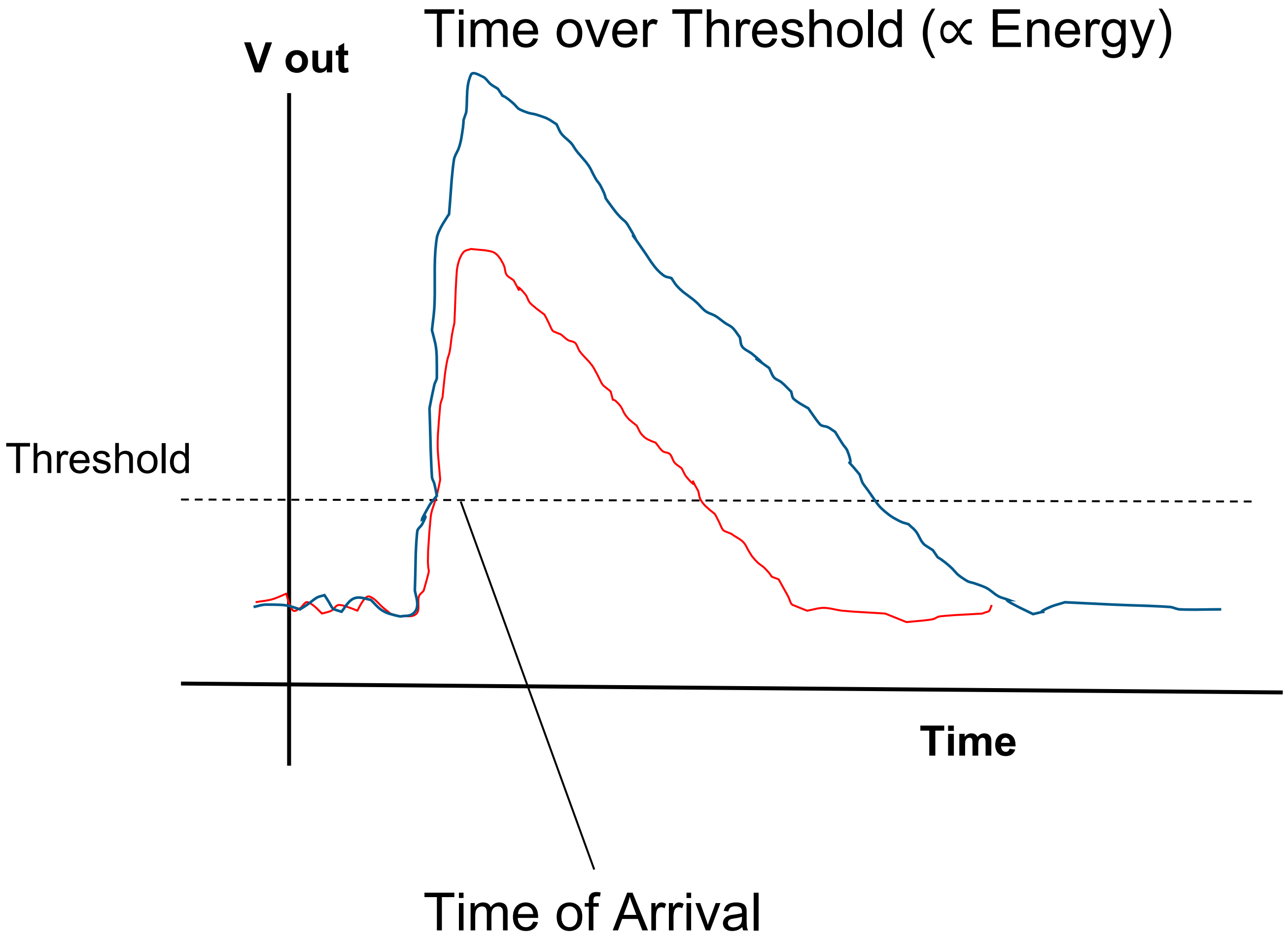




Timepix signal processing

> Charge integrating preamplifier plus linear discharge mechanism

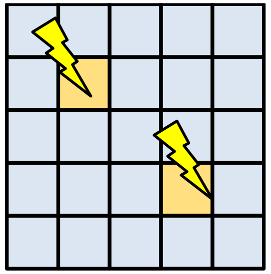




Operating modes and readout (Timepix3 + 4)

1) Time-stamping and event-driven readout

Detector

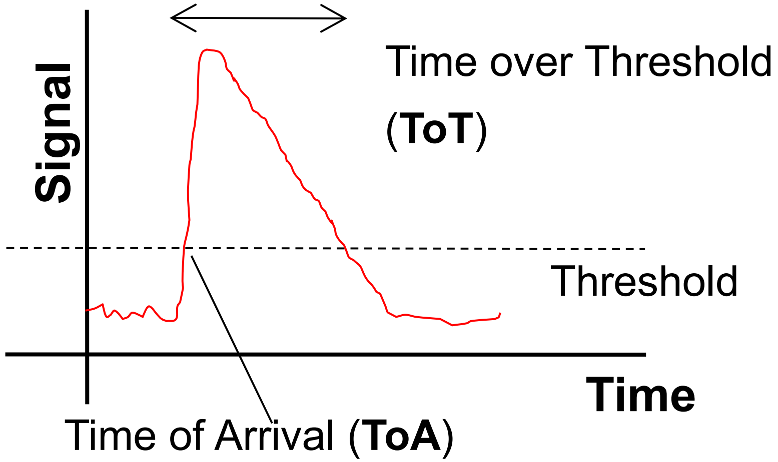


55 µm pixels

Data packets

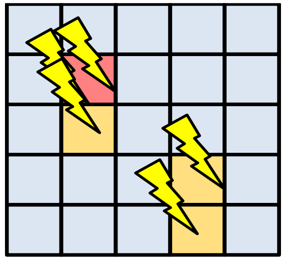
Pixel (1,1)
Time 525.3 ns
Energy ~14 keV

Pixel (3,3)
Time 762.9 ns
Energy ~10 keV



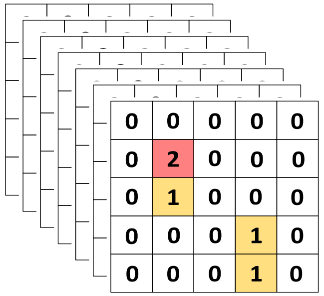
2) Photon counting and frame readout

Detector

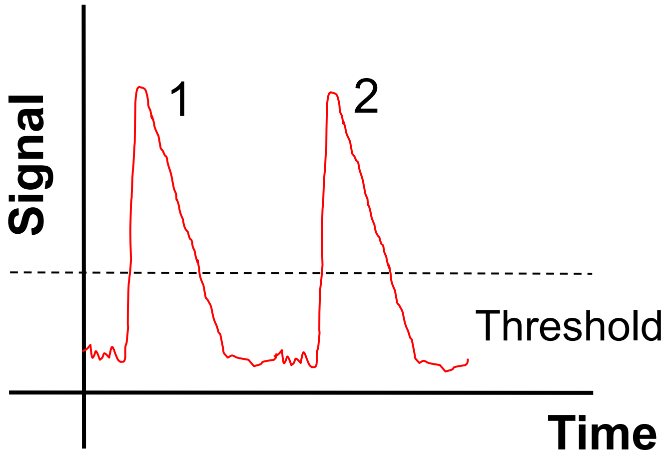


55 µm pixels

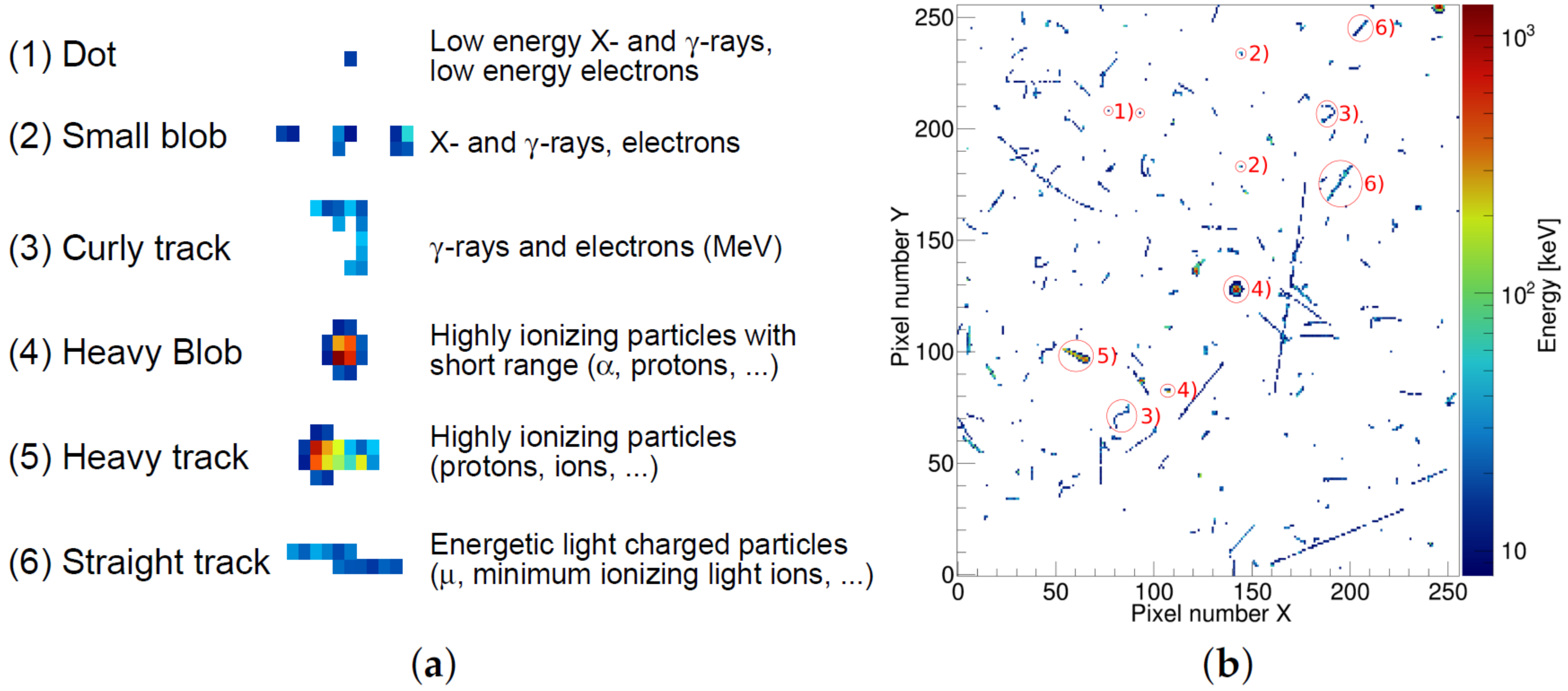
Frame readout



0	0	0	0	0
0	2	0	0	0
0	1	0	0	0
0	0	0	1	0
0	0	0	1	0

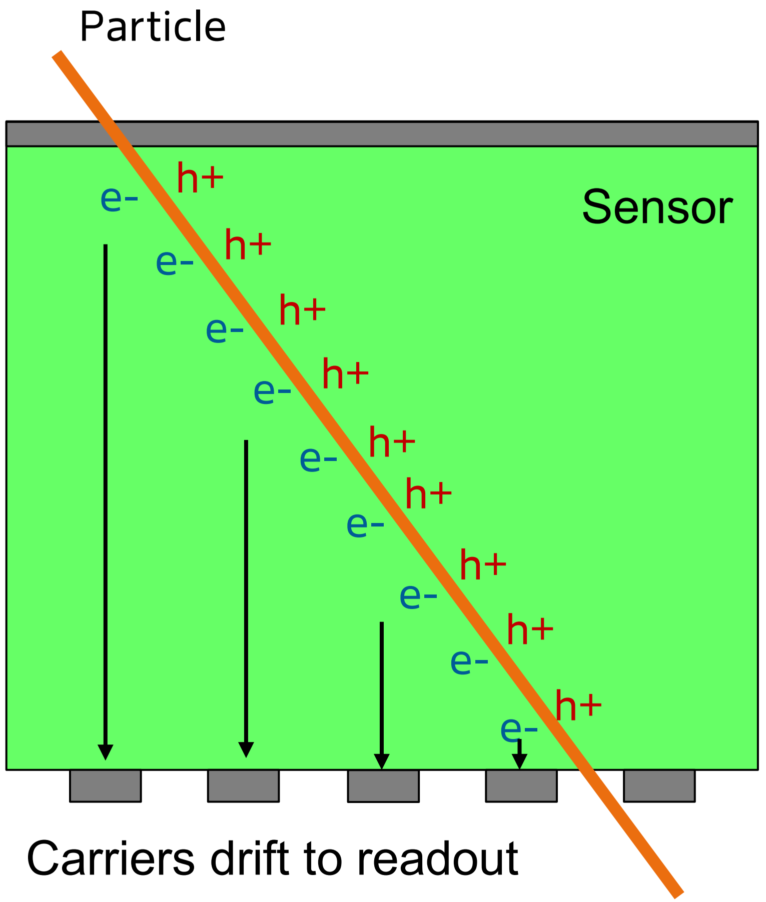


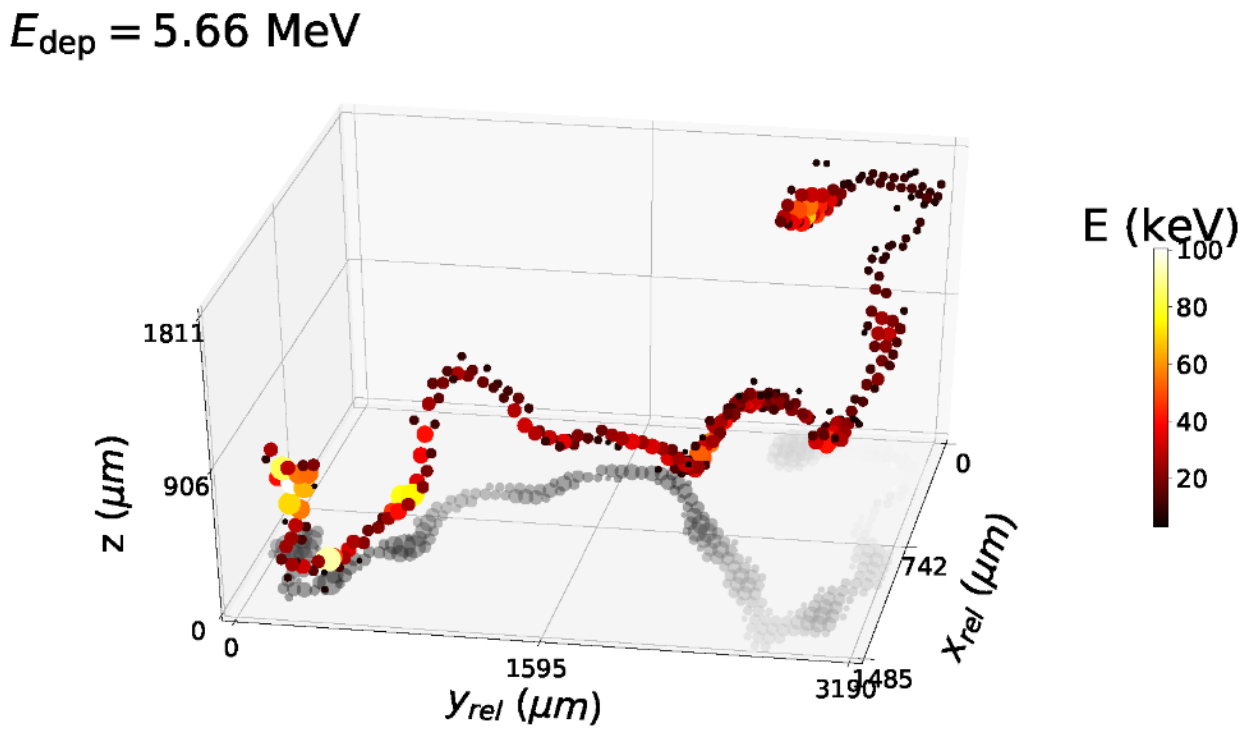
Advantages of spatial, time and energy resolution



Bergmann et al., Instruments **2024**, 8, 17. https://doi.org/10.3390/instruments8010017

Advantages of spatial, time and energy resolution

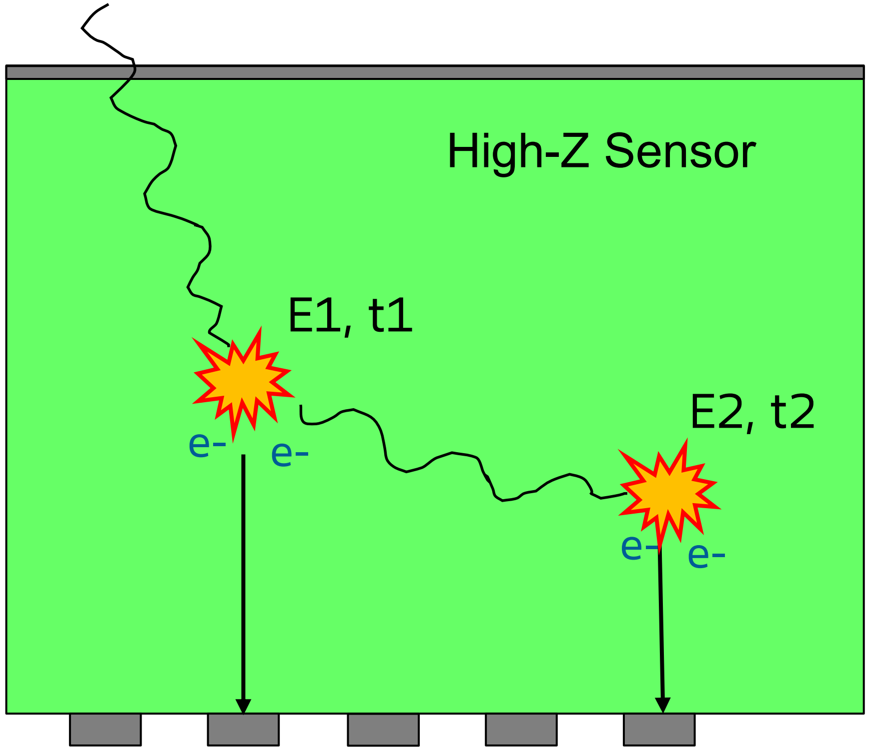




Bergmann et al., Instruments **2024**, 8, 17. https://doi.org/10.3390/instruments8010017

Advantages of spatial, time and energy resolution

Fluorescence correction in high-Z sensor using time coincidence and energy



Element	k-edge (keV)	Fluorescence yield	Kα energy (keV)	Mean Kα absorption distance (μm)
Si	1.85	0.05	1.74	12
Ge	11.10	0.55	9.89	51
Ga	10.38	0.51	9.25	42
As	11.88	0.57	10.54	16
Cd	26.72	0.84	23.17	128
Te	31.82	0.87	27.47	64

M. Khalil et al 2019. JINST 14 C01018 https://doi.org/ 10.1088/1748-0221/14/01/C01018

Advantages of spatial, time and energy resolution

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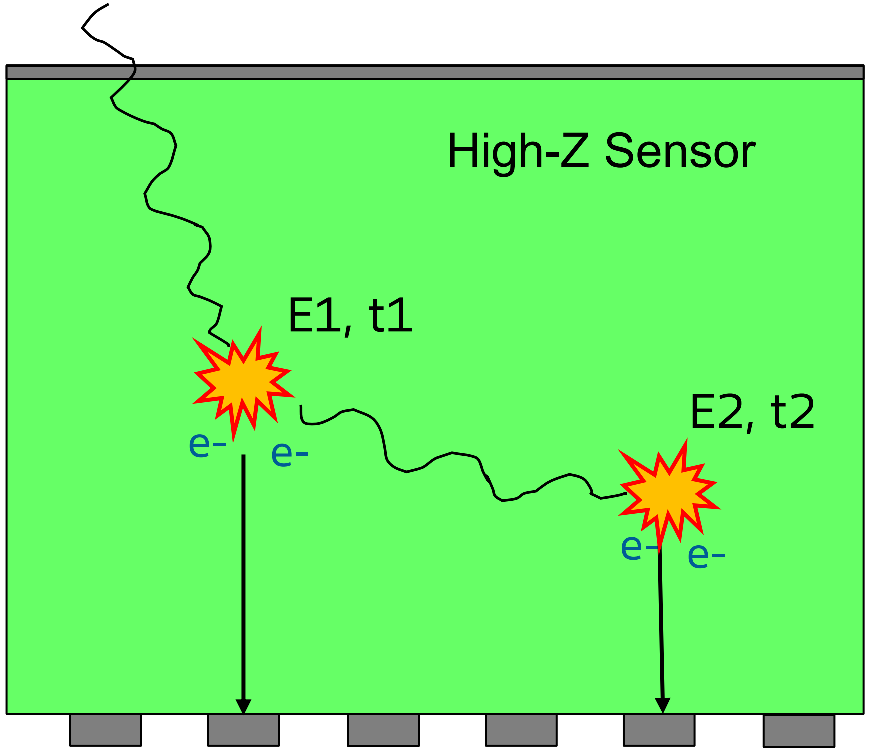
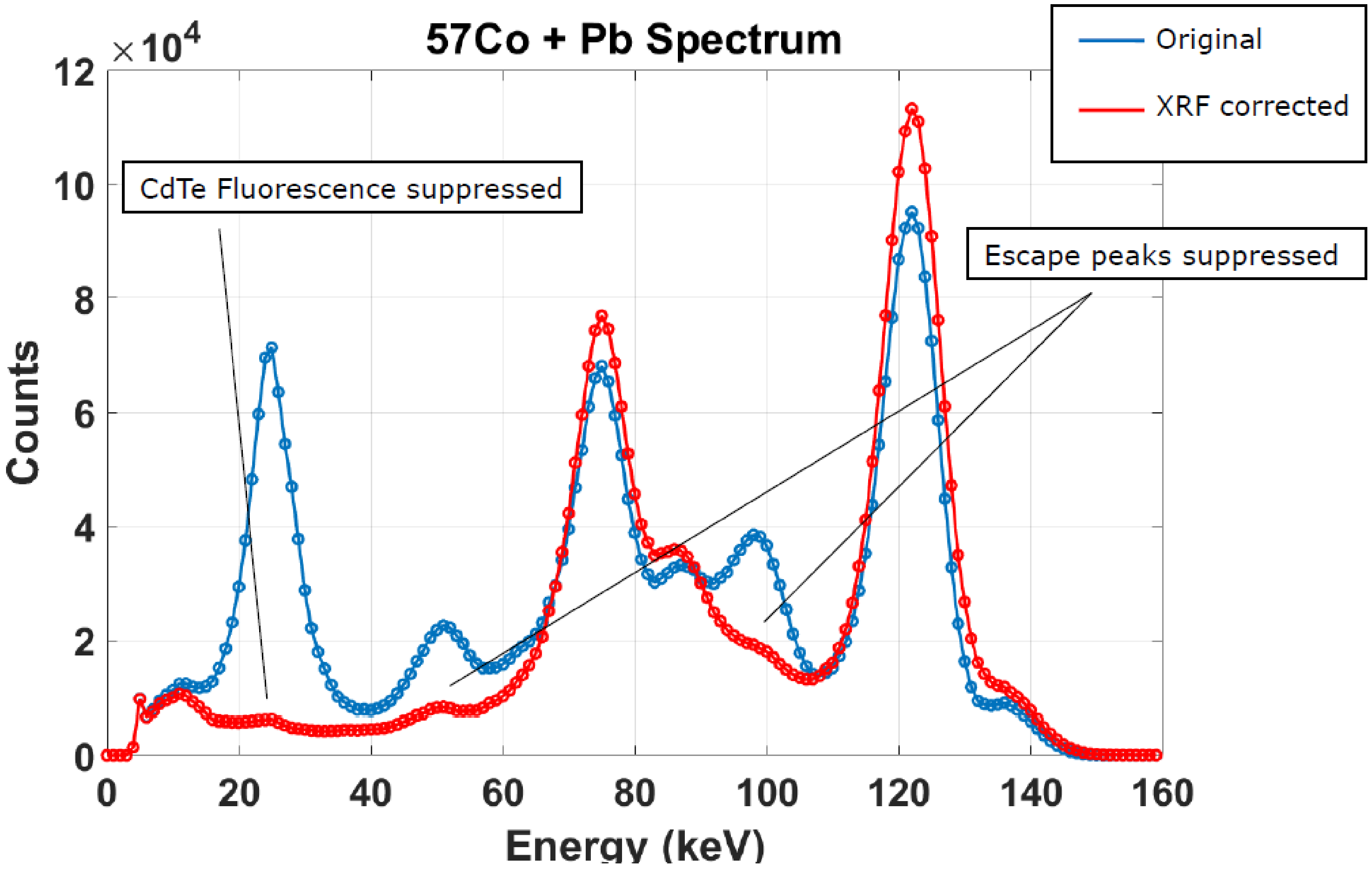
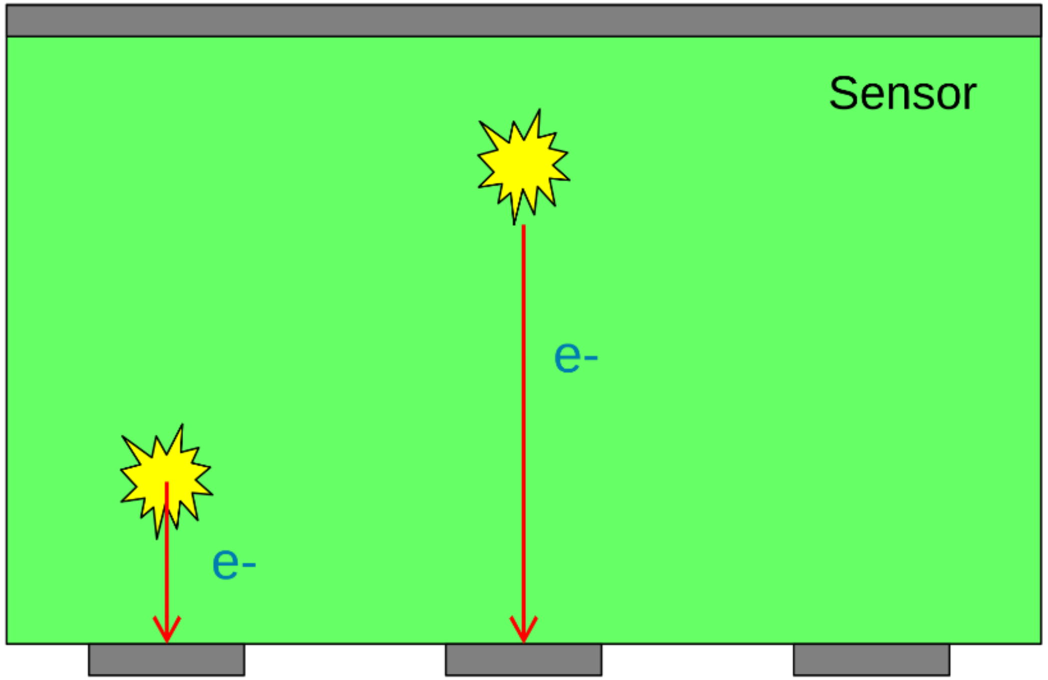




M. Khalil et al 2019. JINST 14 C01018 https://doi.org/ 10.1088/1748-0221/14/01/C01018

Time resolution when detecting X-rays in semiconductors

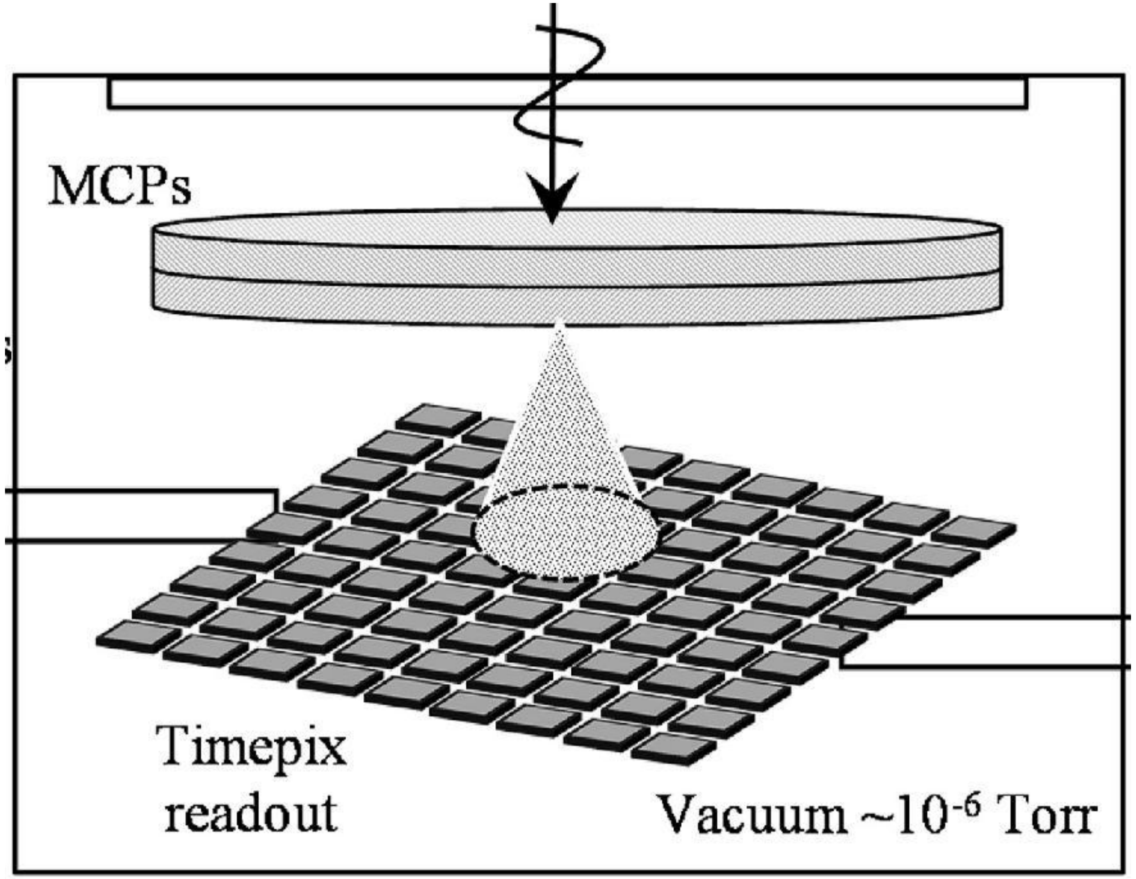
- Varying absorption depth leads to time variation of signal pulse
- Resulting time variation depends on both **absorption profile** and **carrier velocity**



Carriers drift to readout

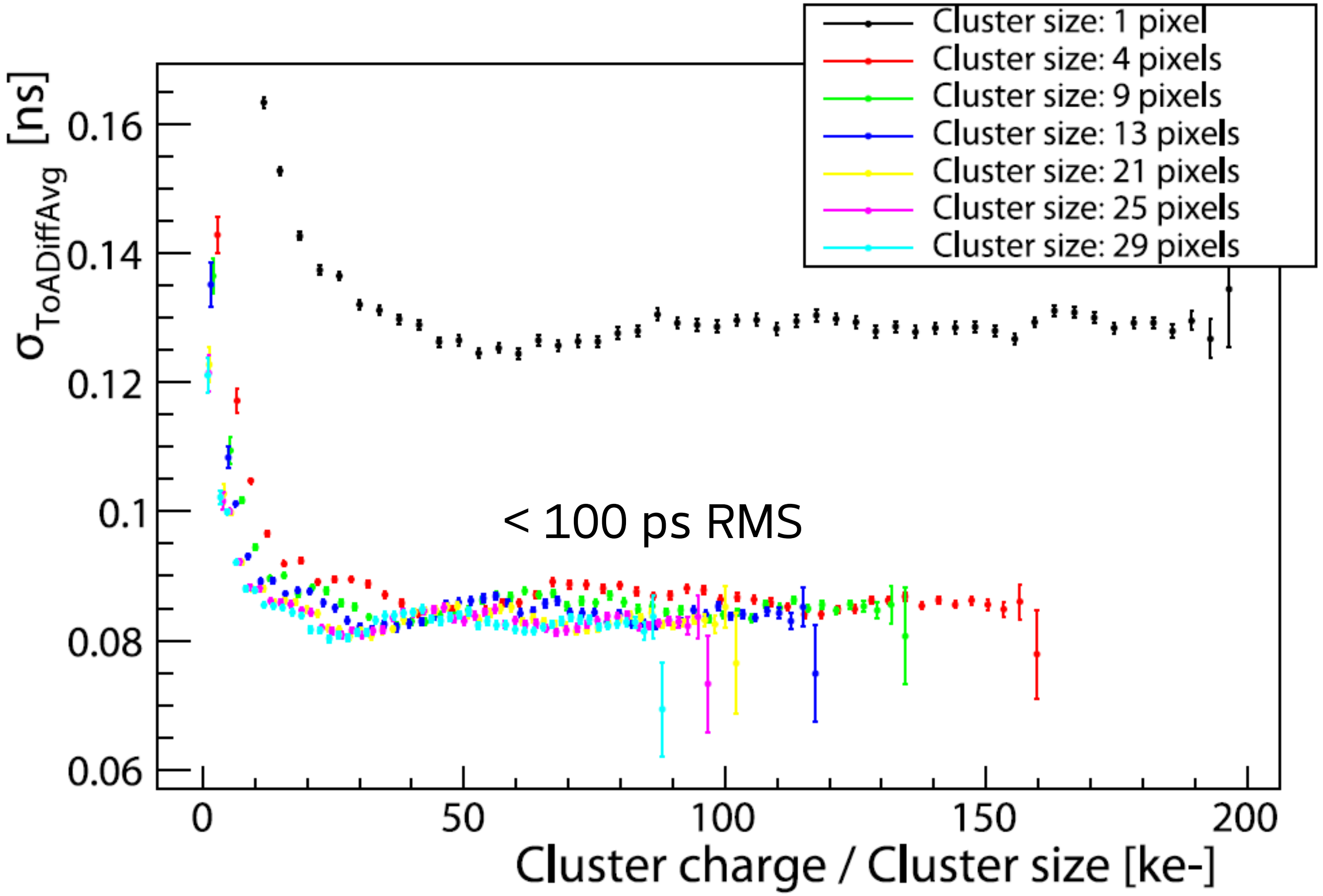
E.g. 300um Si, hole collection, 200V bias:
~ **10 ns** maximum drift time

Detecting soft X-rays, electrons and ions with MCPs



A. Tremsin et al., J. Synchrotron Rad. (2021). 28, 1069–1080
https://doi.org/10.1107/S1600577521003908

IR laser test at INFN Ferrara
Photocathode + MCP + Timepix4



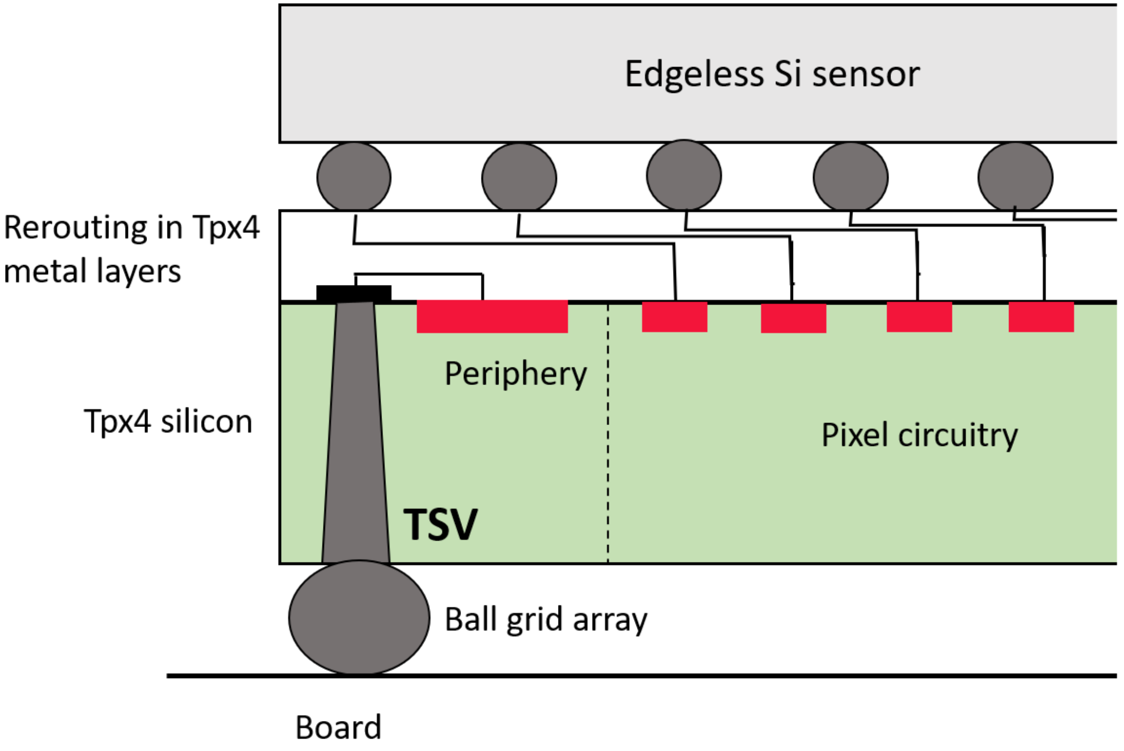
R. Bolzonella et al., NIMA A 1082 (2026) 170965
https://doi.org/10.1016/j.nima.2025.170965

Key differences between chips

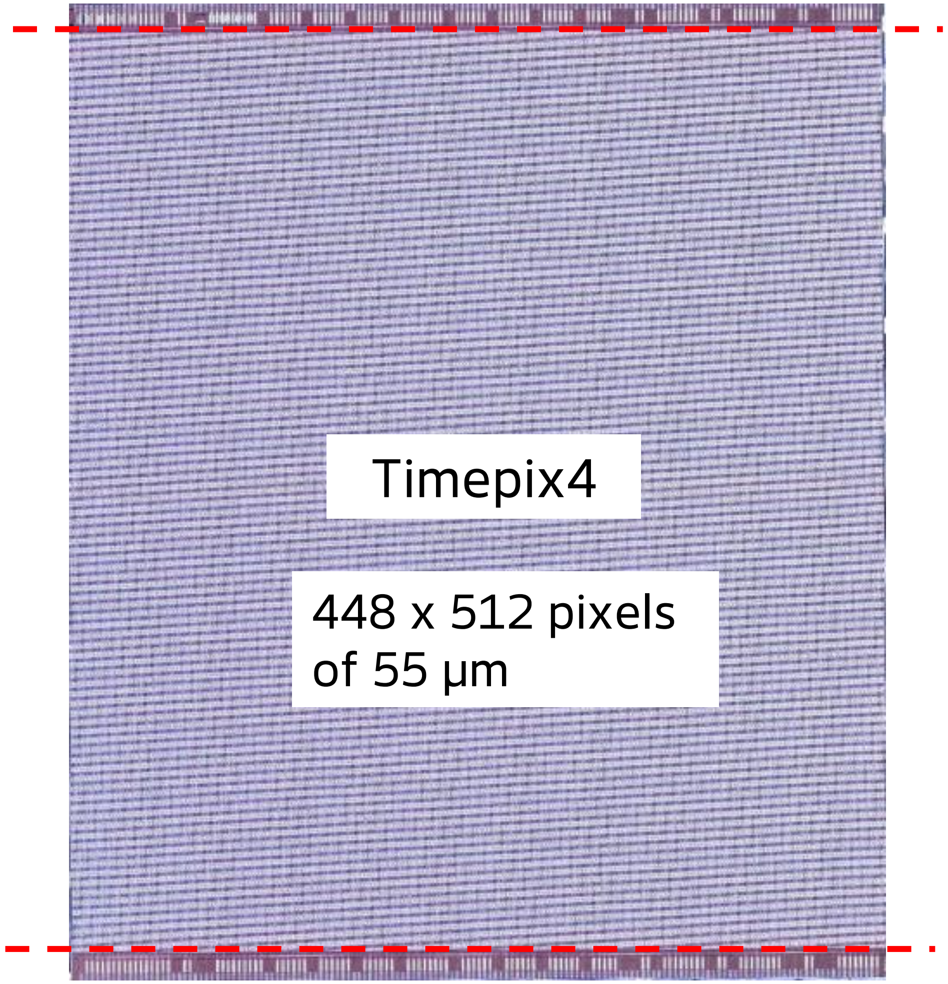
	Timepix (IBM 250nm)	Timepix3 (IBM 130nm)	Timepix4 (TSMC 65nm)
Time of Arrival binning	10 ns	1.56 ns	0.2 ns
Event rate	Frames, one hit per image, ToT or ToA only	43 x 10^6 hits/cm^2/s	358 x 10^6 hits/cm^2/s
Energy resolution (FWHM, Si)*	< 3 keV	~ 2 keV	~ 1.5 keV
		NB – Minimum threshold 500 e- (~2 keV)	
Photon counting performance	3.2 kfps 1 x 10^5 counts/pix/s	1.62 kfps (zero suppressed, worst case) 2.5 x 10^5 counts/pix/s	45 kfps 24 x 10^5 counts/pix/s
Chip layout	256 x 256 pixels 55 µm	256 x 256 pixels 55 µm	448 x 512 pixels 55 µm 4-side buttable with TSVs

Timepix4 – 4-side buttable with Through Silicon Vias

- With TSVs, full chip surface is covered with pixels
  - Rerouting in metal layers creates space for periphery
- Improved TSV landing pads, redundant inputs, extra power TSV connections in centre of chip



Wire bond pads can be diced off

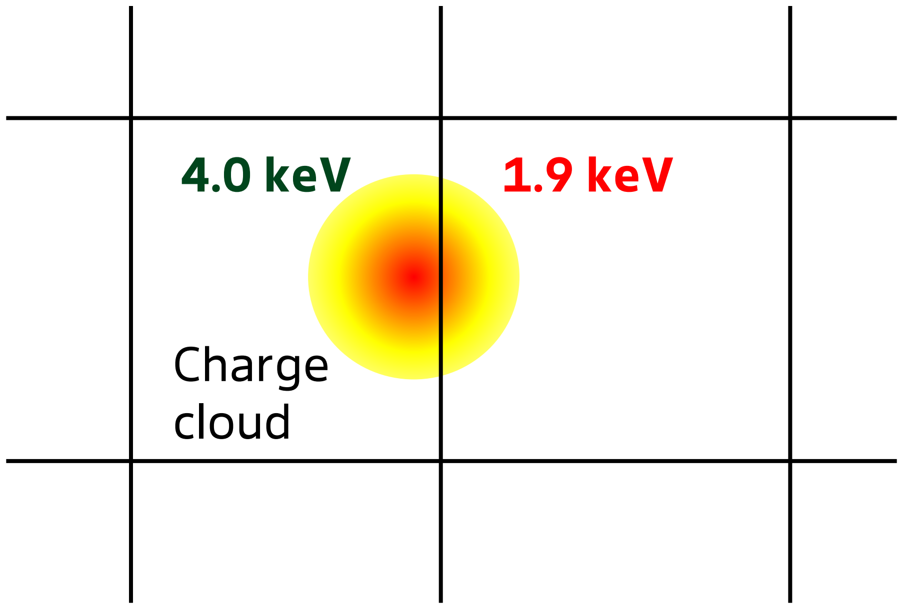


Xavier Llopart https://indico.cern.ch/event/1539538/timetable/#20250923

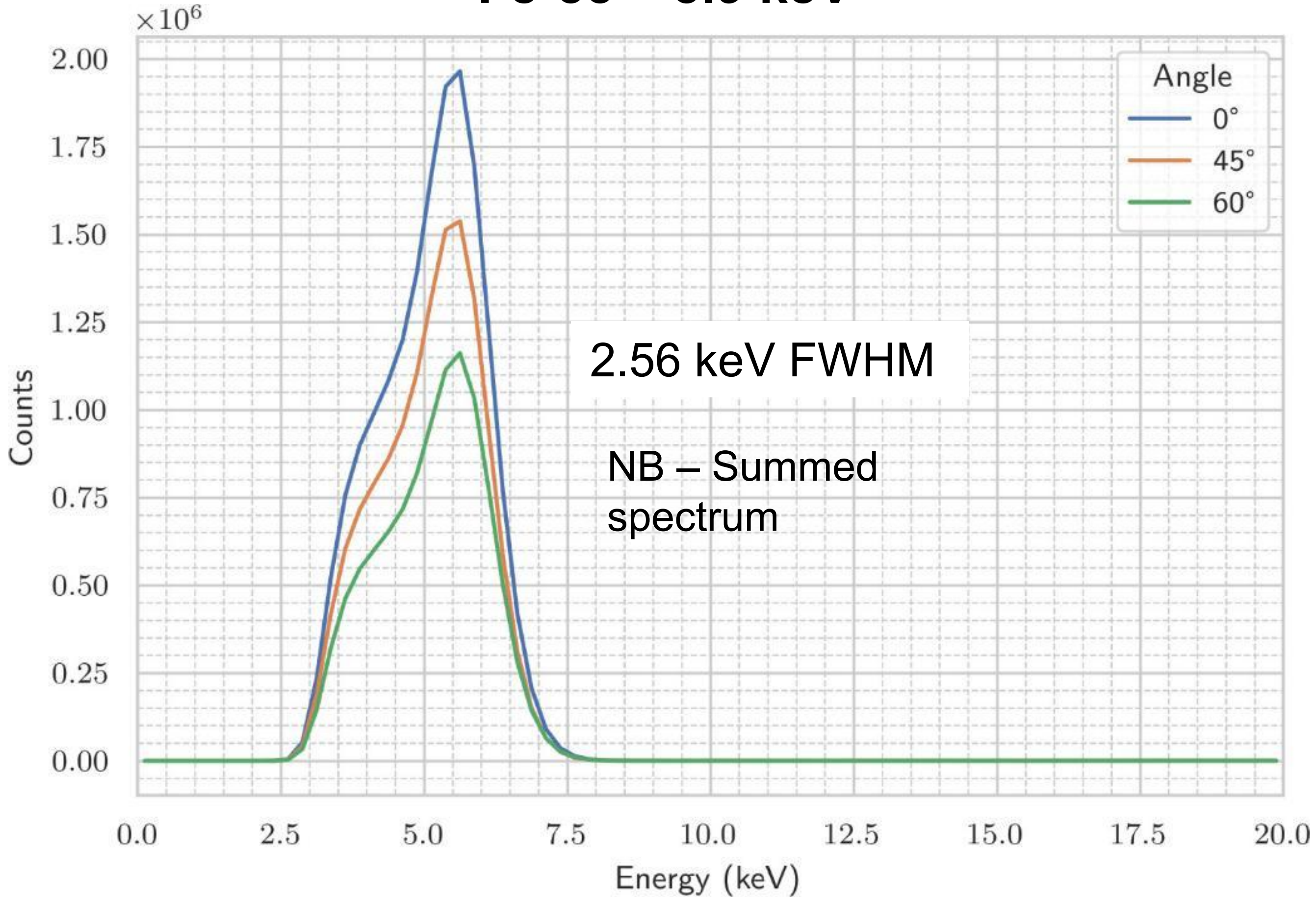
			Timepix	Timepix2	Timepix3	Timepix4	Picopix
Tech. node (nm)			IBM 250	TSMC 130	IBM 130	TSMC 65	TSMC 28
Year			**2006**	**2018**	**2013**	**2019**	2026
Pixel sixe (μm)			55	55	55	55	50
# pixels (x x y)			256 x 256	256 x 256	256 x 256	448 x 512	384 x 256
Sensitive area			1.98 cm^2	1.98 cm^2	1.98 cm^2	6.94 cm^2	2.45 cm^2
Number of sides for tiling using WB			3 (87.1% active area)	3 (85.6% active area)	3 (86.7% active area)	2 (93.7% active area)	2 (78.5% active area)
Number of sides for tiling using TSV			No TSV ready	3 (85.6% active area)	3 (91.6% active area)	4 (99.3% active area)	2 (78.5% active area)
Front-end		positive (h+)	Gain (16mV/kh^+) (Volcano >0.8MeV/pixel)	High Gain (25mV/kh^+) Logarithmic Gain (19mV/kh^+)	High Gain (45mV/kh^+) (Volcano >0.3MeV/pixel)	High Gain (35mV/kh^+) Low Gain (20mV/kh^+) Logarithmic Gain	
		negative (e-)	Gain (16mV/ke^-)	High Gain (25mV/ke^-)	High Gain (45mV/ke^-)	High Gain (35mV/ke^-) Low Gain (20mV/ke^-)	High Gain (35mV/ke^-) Low Gain (20mV/ke^-)
Minimum detectable charge			~750 e^-	~600 e^-	~500 e^-	~500 e^-	~500 e^-
Operation Modes	Tracking (Event arrival time and/or energy)	Readout	Full Frame-based (Sequential R/W)	Full Frame-based (Sequential or Continuous R/W)	Data-driven (48-bit packet per pixel hit)	Data-driven (64-bit packet per pixel hit)	Data-driven (72-bit packet per pixel hit)
		Event Data	TOT or TOA	TOT and TOA; TOT or TOA	TOT & TOA	TOT & TOA	TOT & TOA & hitmap
		TOT energy resolution	<3keV (FWHM Si)	~0.75keV (FWHM Si)	~2KeV (FWHM Si)	~1KeV (FWHM Si)	~1KeV (FWHM Si)
		TOA bin size	10ns (@100MHz)	10ns (@100MHz)	1.56ns (On-pixel TDC @40MHz)	195ps (On-pixel TDC @40MHz)	~35ps (On-pixel TDC @40MHz)
		TOA dynamic range	118.1μs (@100MHz)	2.62ms (@100MHz)	409.6μs (14b@40MHz)	1.63ms (16b@40MHz)	107s (32b@40MHz)
		Max Rate	<1x10^6 hits/cm^2/s (with 300μs readout dead time)	<1x10^6 hits/cm^2/s	43x10^6 hits/cm^2/s	358x10^6 hits/cm^2/s	1.56x10^9 hits/cm^2/s (@ 24-bit mode)
		Max Pix Rate	33 Hz/pixel	33 Hz/pixel	1.3 KHz/pixel	10.8 KHz/pixel	39 KHz/pixel (24-bit Mode)
	Imaging (Event counting)	Readout	Full Frame-based (Sequential R/W)	Full Frame-based (Sequential or Continuous R/W)	Zero-suppressed (with pixel addr) (Sequential R/W)	Full Frame-based (Continuous R/W)	Zero-suppressed (with pixel addr) (Sequential R/W)
		Counter depth	14-bits	10-bit or 14-bit	Counting (10-bit) or iTOT (14-bit)	8-bits or 16-bits	12-bits
		Frame rate	100 fps @1x100Mbps 3.2 kfps @32x100Mbps	4.9 kfps @10-bit 32x100Mbps 3.5 kfps @14-bit 32x100Mbps	1.62 kfps @48-bit 8x640Mbps	89.2 kfps @8-bit 16x163Gbps 44.8 kfps @16-bit 16x163Gbps	52 kfps @102.8Gbps
		Max Count Rate	~35 x 10^9 hits/cm^2/s	~35 x 10^9 hits/cm^2/s	~82 x 10^9 hits/cm^2/s	~800 x 10^9 hits/cm^2 /s	~800 x 10^9 hits/cm^2 /s
Maximum Readout bandwidth			3.2Gbps (32 x 100MHz)	3.2Gbps (32 x 100MHz)	≤5.12Gbps (8x SLVS@640 Mbps)	≤163.84Gbps (16x @10.24 Gbps)	≤102.8Gbps (4x @25.6 Gbps)
Power consumption			330mW/cm^2 (nominal)	450mW/cm^2 (nominal) 165mW/cm^2 (low power mode)	625mW/cm^2 (nominal) 108mW/cm^2 (low power)	700mW/cm^2 (nominal) 200mW/cm^2 (low power)	1W/cm^2 (nominal)
Other			Out of production				On-pixel clustering On-chip time calibration On-chip packet sorting
Paper			https://www.sciencedirect.com/science/article/pii/S0168900207017020	https://www.sciencedirect.com/science/article/pii/S1350448719305165	https://iopscience.iop.org/article/10.1088/1748-0221/9/05/C05013	https://www.sciencedirect.com/science/article/pii/S0168900222007811	

Energy resolution in practice (Timepix4)

Si sensor, 300µm thick, hole collection, 100V *3.6 keV threshold*



Fe-55 – 5.9 keV

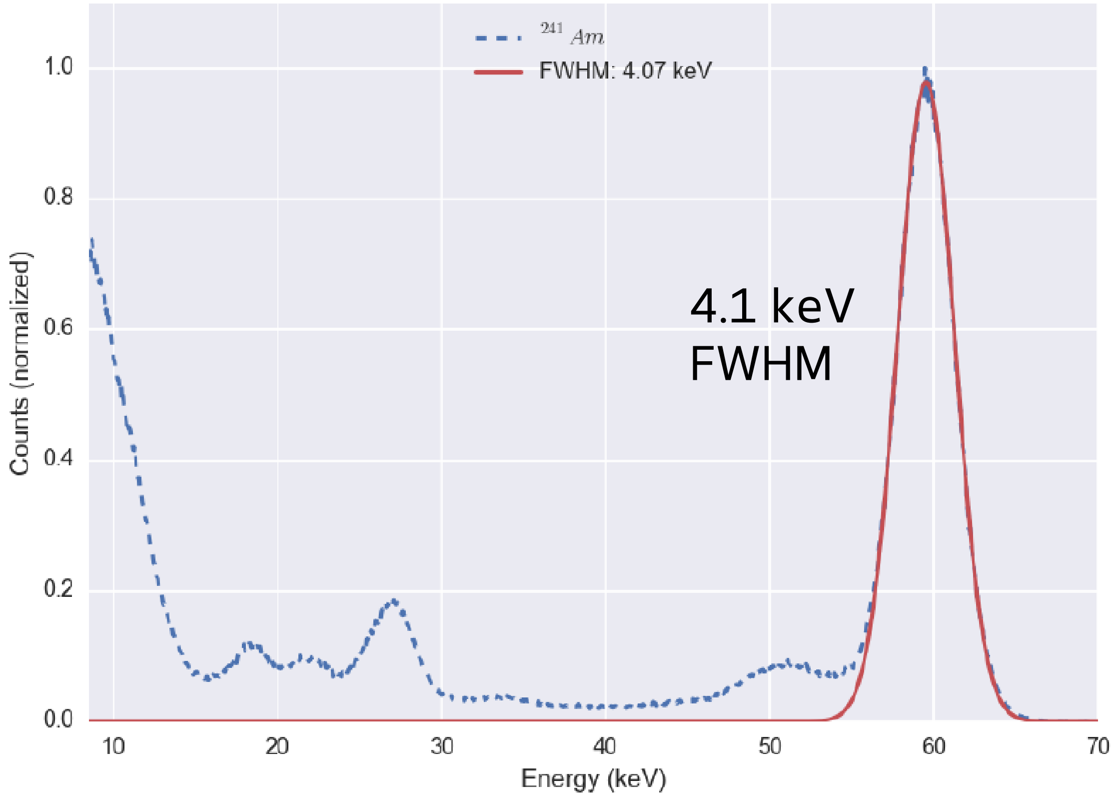


T. Genetay et al., NIMA 1083 (2026) 171163, https://doi.org/10.1016/j.nima.2025.171163

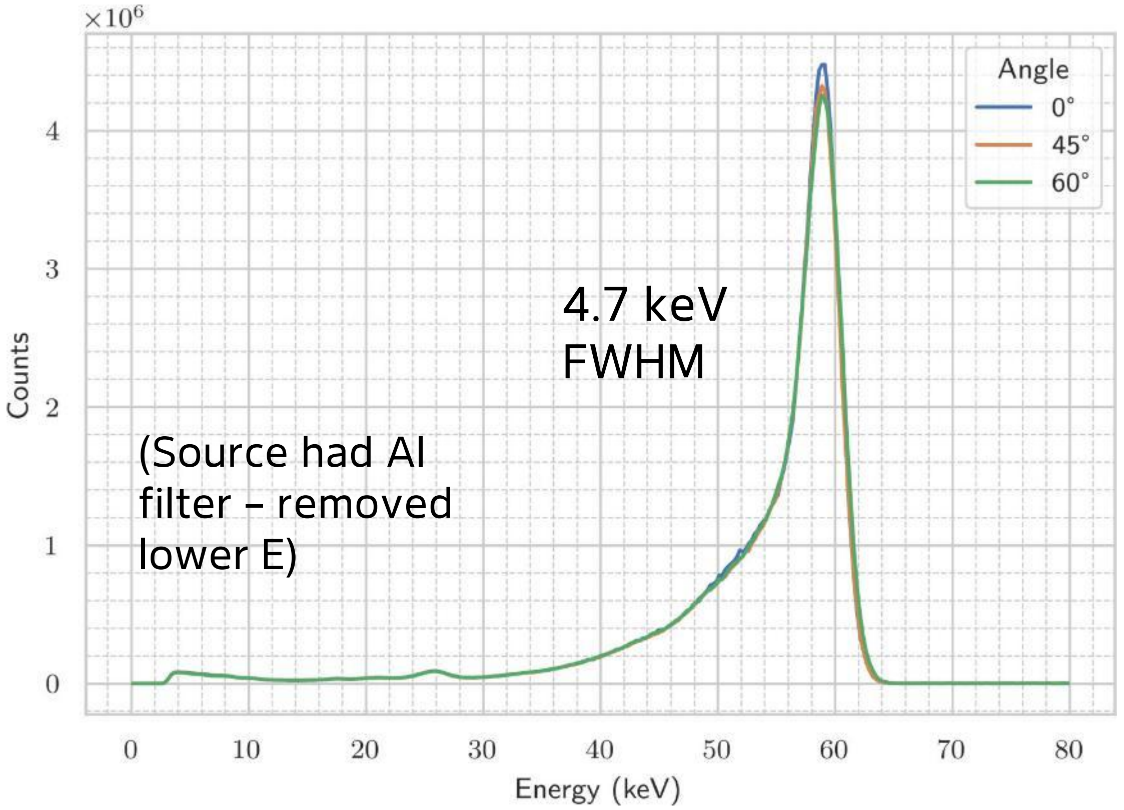
High-energy photons – Timepix3 and 4

Both papers use Si sensor, 300μm thick, hole collection, 100V, ~4 keV threshold. **Am-241 source**.

Timepix3



Timepix4



E Frojdh et al., JINST 10 C01039 (2015), doi:10.1088/1748-0221/10/01/C01039
T. Genetay et al., NIMA 1083 (2026) 171163, https://doi.org/10.1016/j.nima.2025.171163

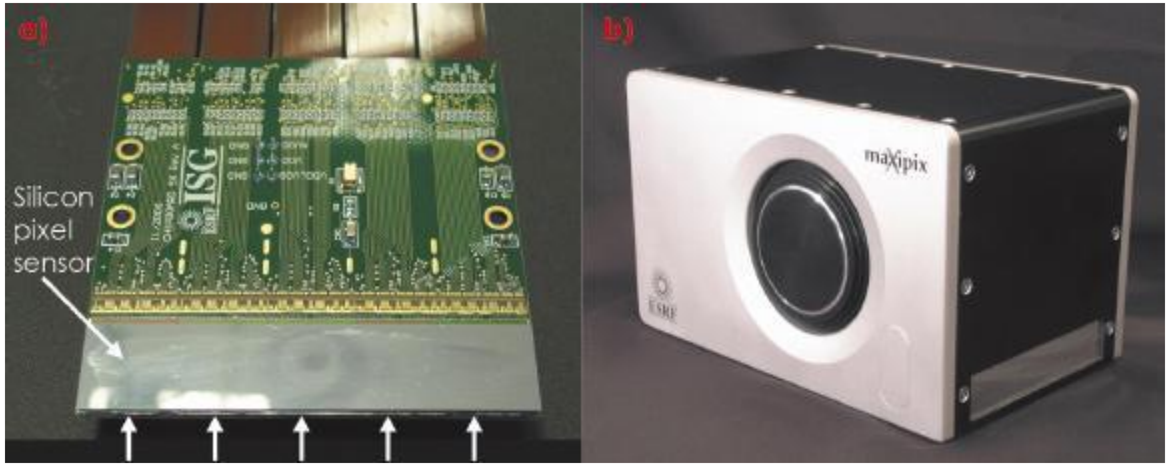
Some Timepix systems

Minipix (Czech Technical University, Advafab) – Timepix1-3

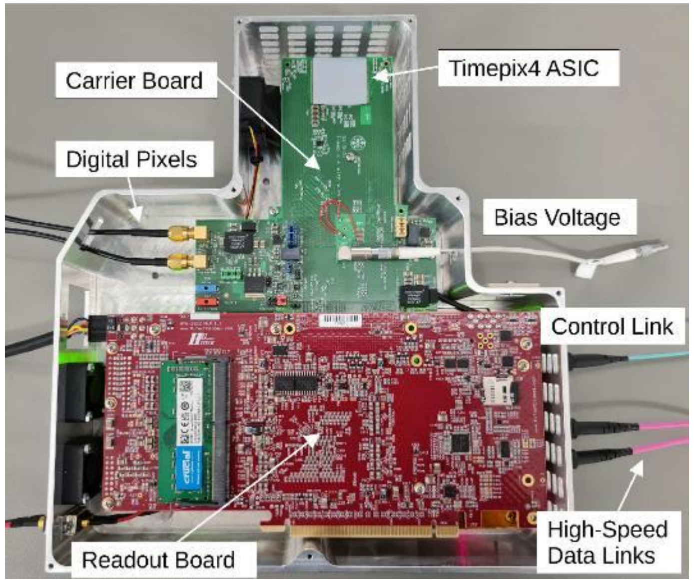
SPIDR/SPIDR4 (NIKHEF) – Timepix3/4

Tristan 10M, (Diamond Light Source) – Timepix3

Maxipix (ESRF), Timepix



TEMPUS (DESY) Timepix4



Overview

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- General applications in X-ray detection
- Timepix and high-Z at light sources – systems and applications

Timepix and high-Z sensor characterisation

- High spatial resolution
- High time resolution
- Reasonable energy resolution

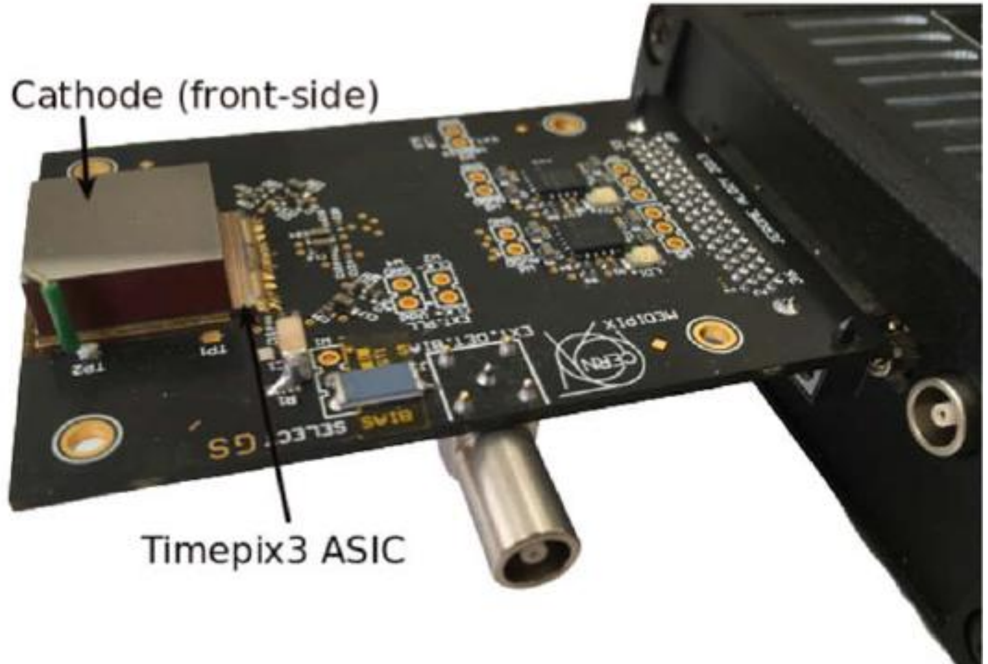
- Good rejection of dark and afterglow currents

- Limited count rate (unable to test extreme flux conditions)

Kromek CZT – 5 mm thickness, Timepix3 readout

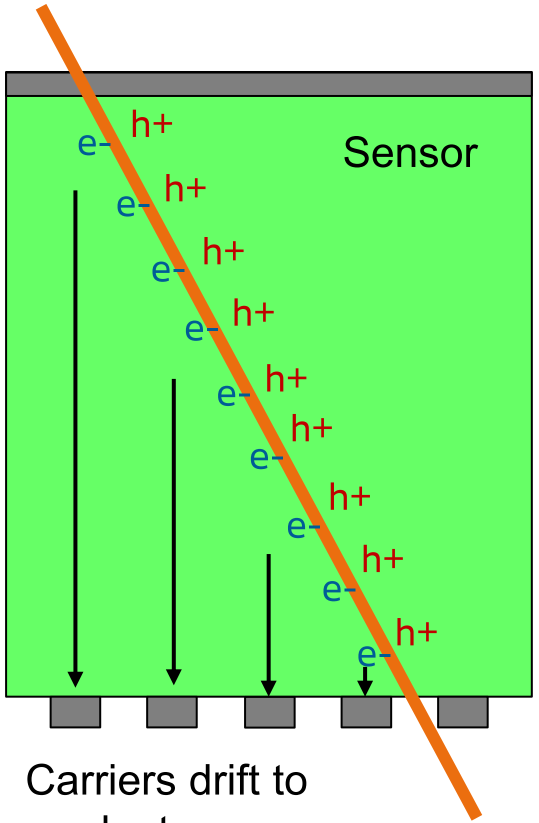
P Smolyanskiy et al., Phys. Scr. 99 (2024) 015301, https://doi.org/10.1088/1402-4896/ad10dd

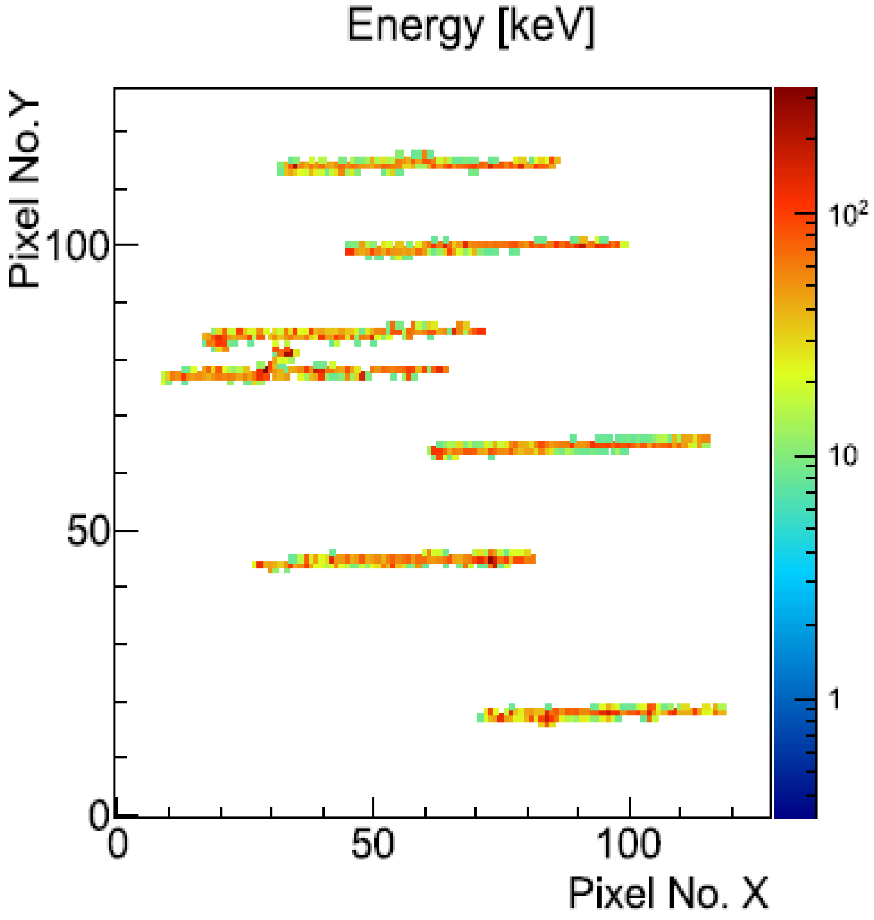
- Collaboration between Czech Technical University, Uni Glasgow and Kromek
- Pt Schottky contact, Travelling Heater Method growth
- 110 µm pixel pitch

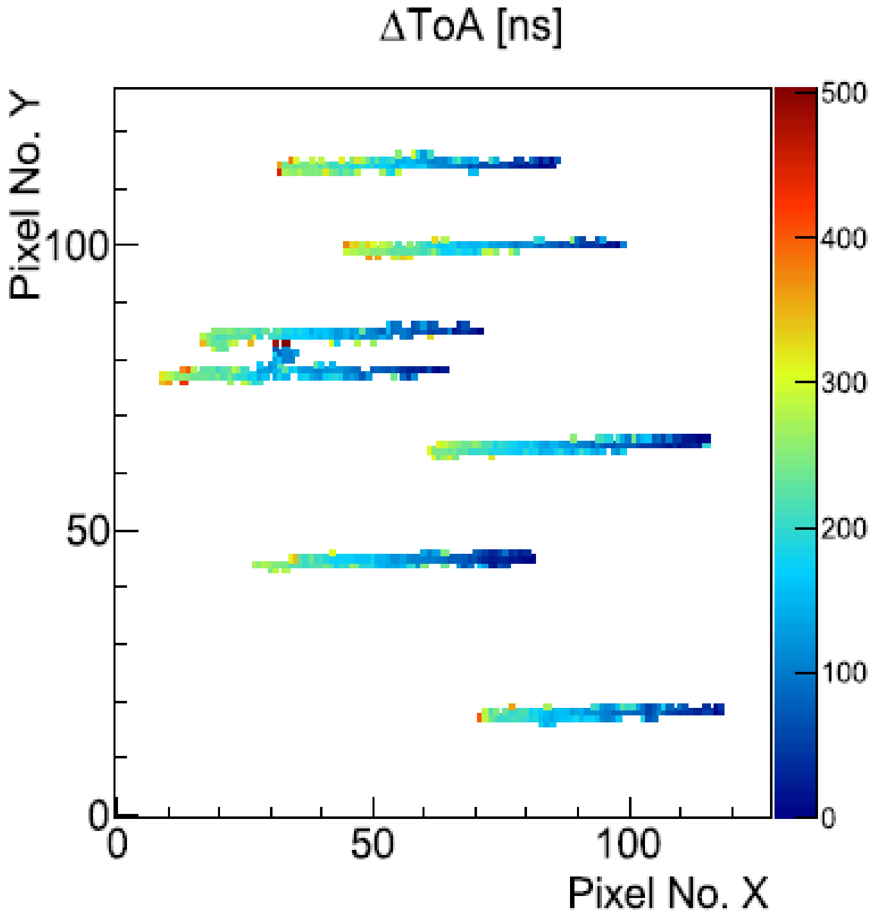


(b)

Kromek CZT – pion beam characterization at CERN



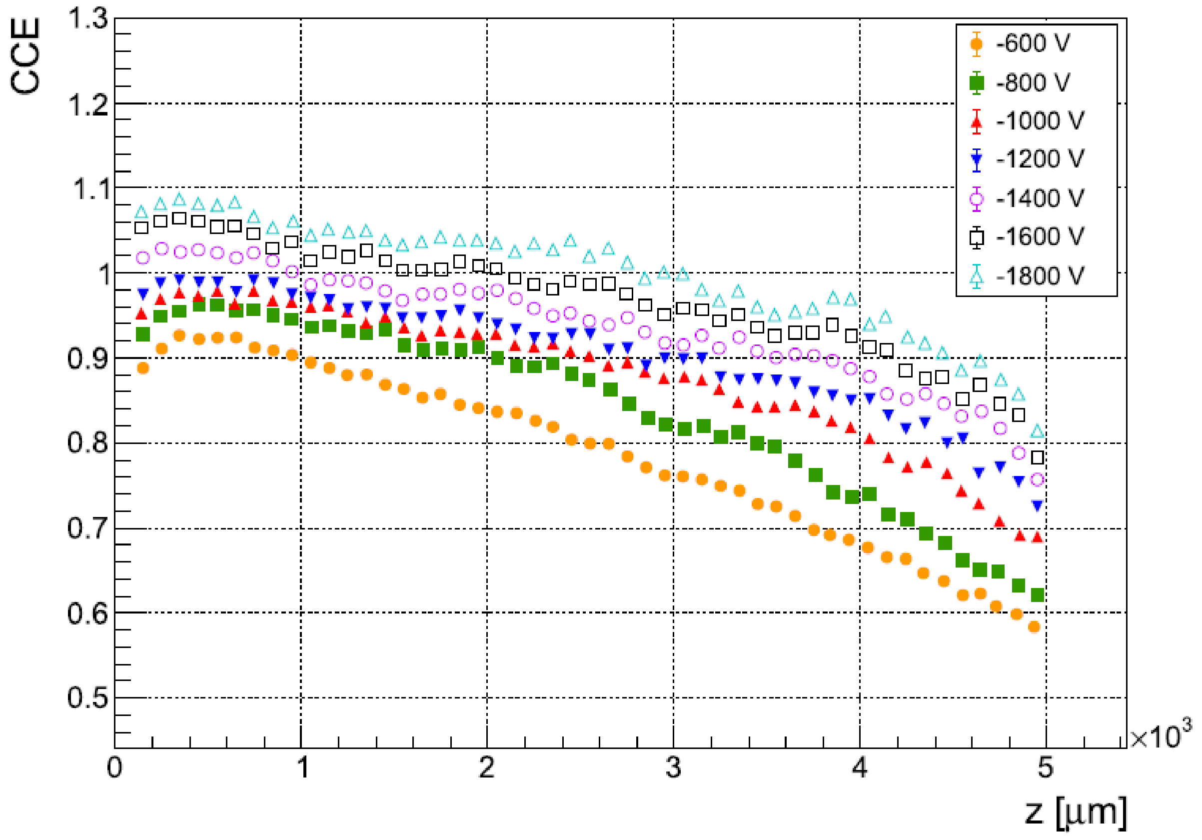




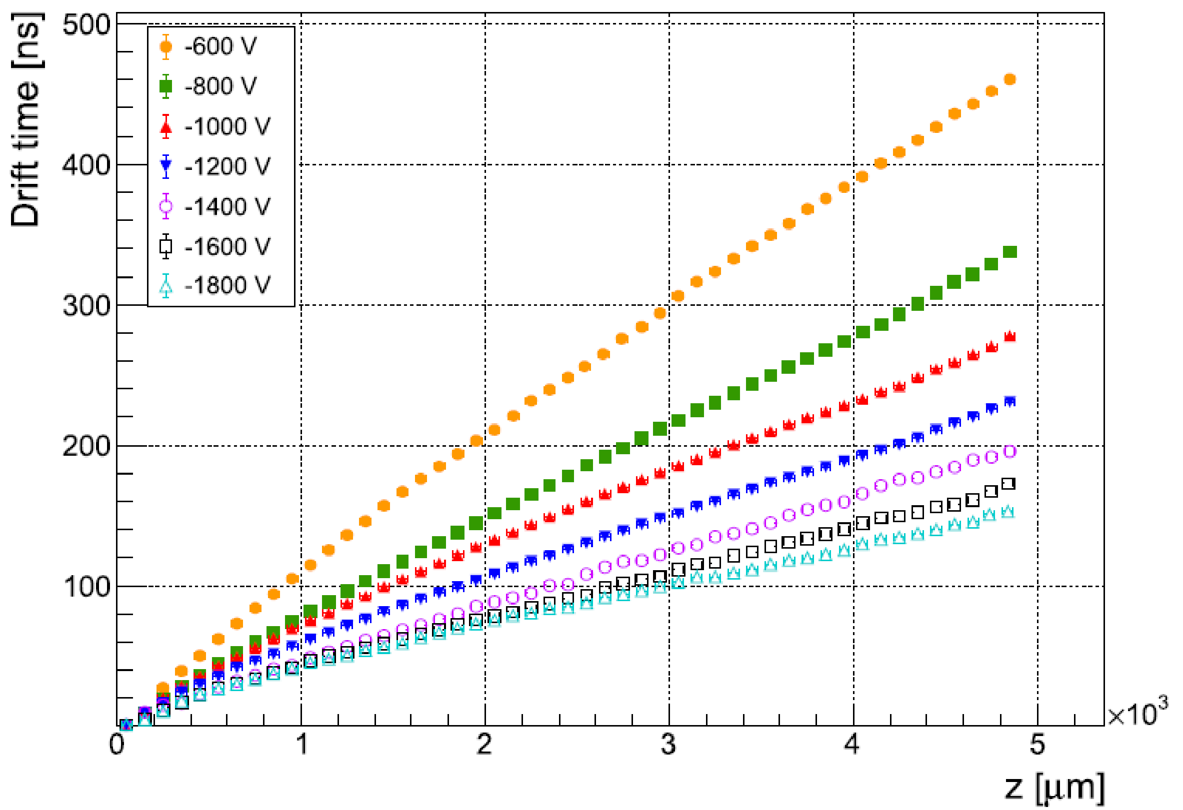
P Smolyanskiy et al., Phys. Scr. 99 (2024) 015301, https://doi.org/10.1088/1402-4896/ad10dd

Kromek CZT – pion beam characterization at CERN

CCE vs depth



Drift time vs depth

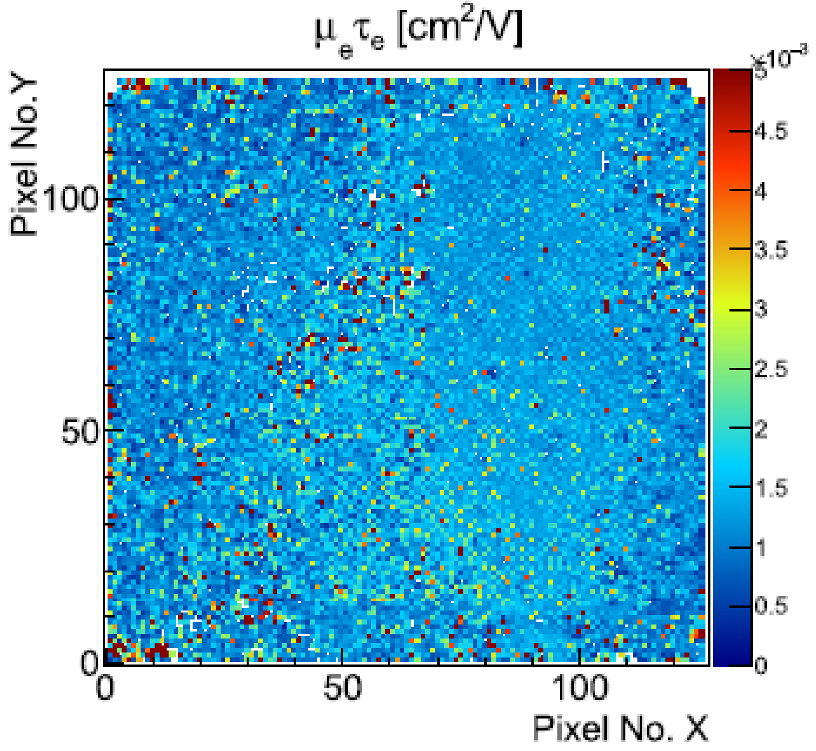


DESY.

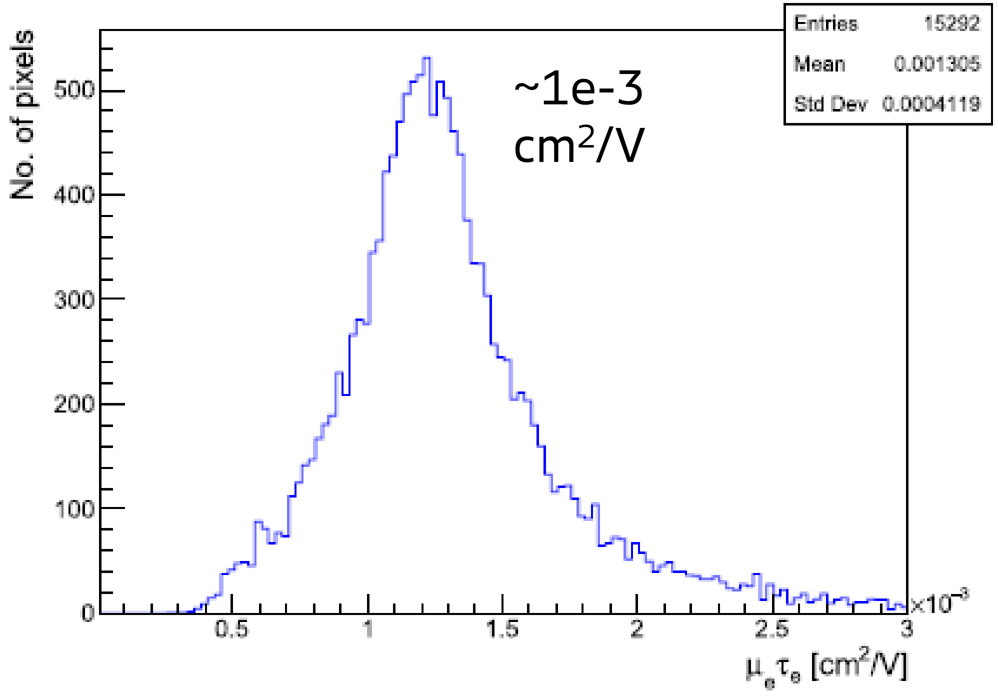
P Smolyanskiy et al., Phys. Scr. 99 (2024) 015301, https://doi.org/10.1088/1402-4896/ad10dd

Kromek CZT – pion beam characterization at CERN

$\mu_e\tau_e$ product



(a)



(b)

Mobility:
μ_e = 945 cm^2/V/s

Figure 4. (a) Mobility-lifetime $\mu_e\tau_e$ product mapped across the pixel matrix; (b) Distribution of the mobility $\mu_e\tau_e$ product for all pixels.

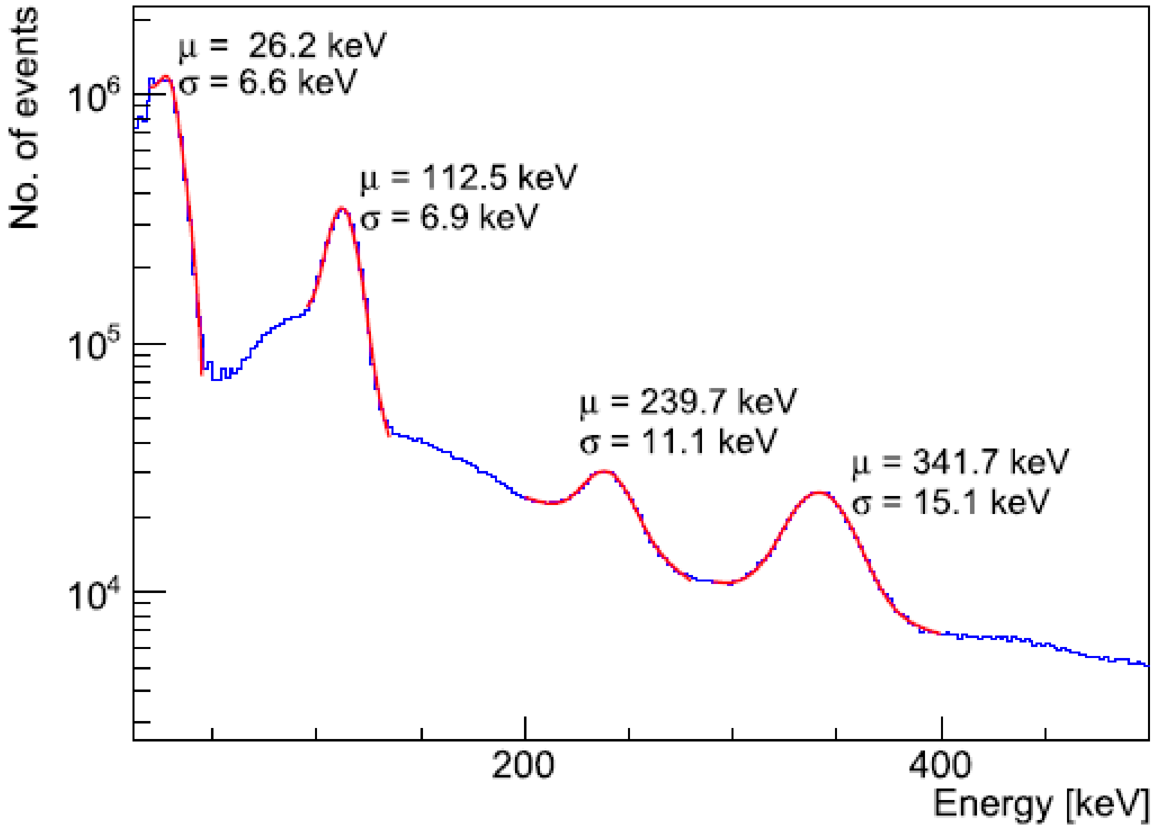
NB – Redlen has $\mu_e\tau_e$ about 4e-3 for HF material, 12e-3 for LF – See M. Bishop et al 2025, 10.1088/1748-0221/20/09/P09009

DESY.

P Smolyanskiy et al., Phys. Scr. 99 (2024) 015301, https://doi.org/10.1088/1402-4896/ad10dd

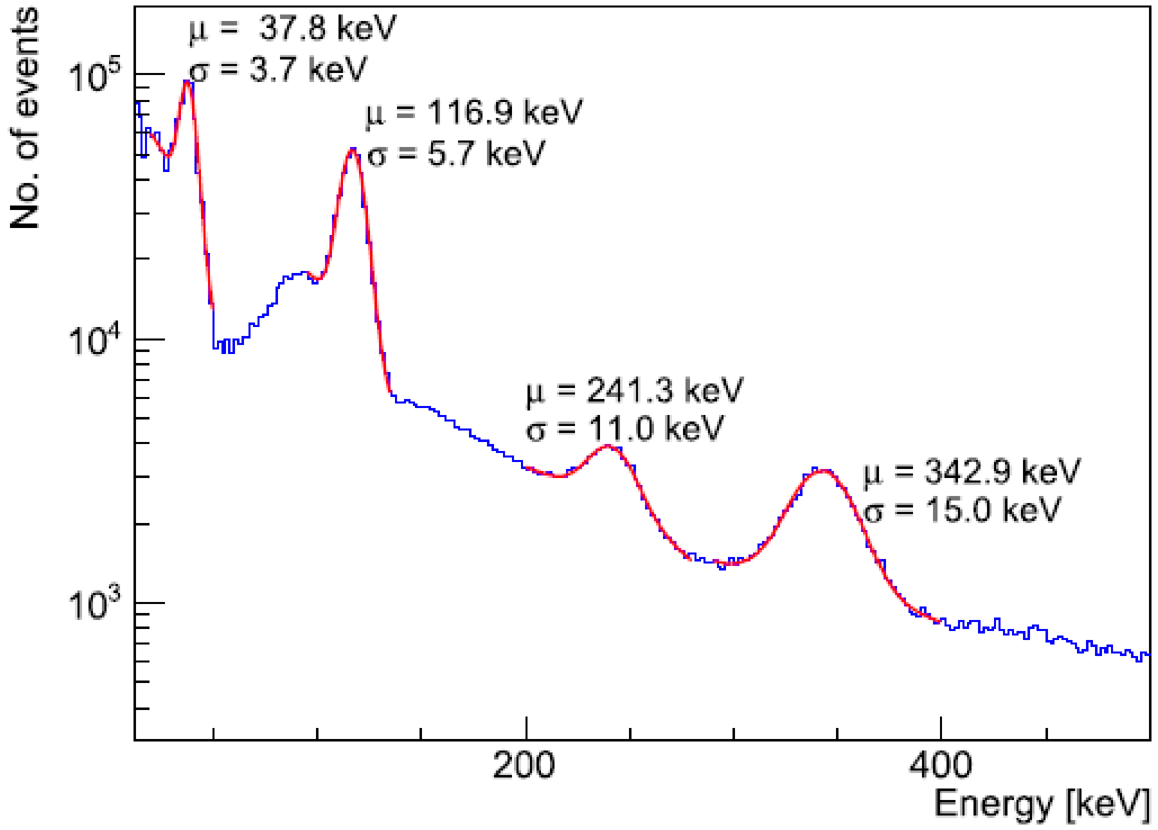
Kromek CZT – ^{152}Eu gamma-ray spectrum

Back-surface illumination



(a)

Pixel-side illumination

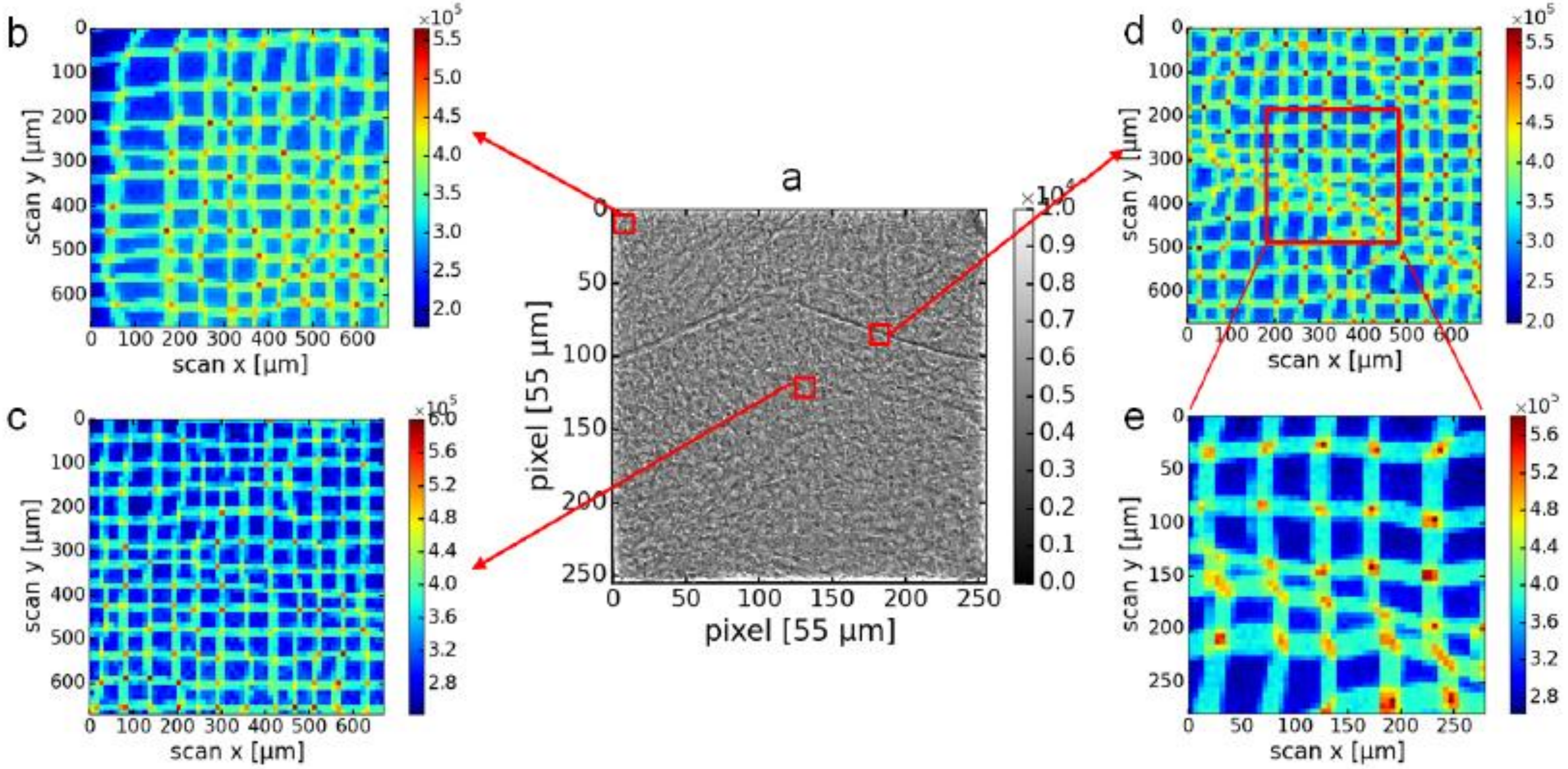


(b)

P Smolyanskiy et al., Phys. Scr. 99 (2024) 015301, https://doi.org/10.1088/1402-4896/ad10dd

Tomsk Cr-compensated GaAs (Timepix)

> Study by ESRF with microfocused beam

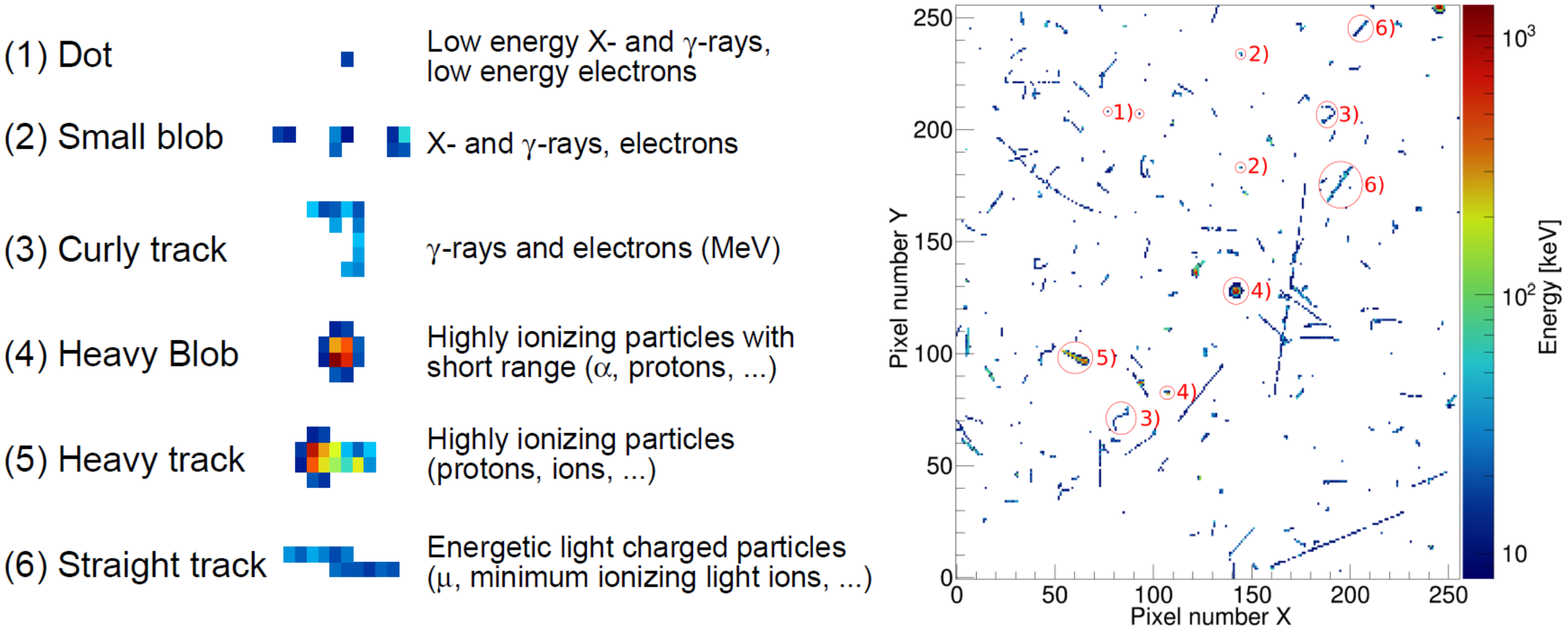


C. Ponchut et al 2017 JINST 12 C12023, https://doi.org/10.1088/1748-0221/12/12/C12023

Overview

- The Timepix ASIC series
- Use in high-Z sensor characterization
- General applications in X-ray detection
- Timepix and high-Z at light sources – systems and applications

Mixed field radiation monitoring



(a) (b)

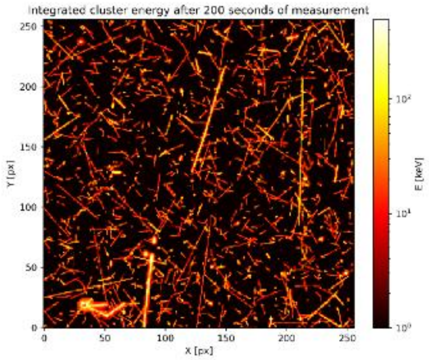
Bergmann et al., Instruments **2024**, 8, 17. https://doi.org/10.3390/instruments8010017

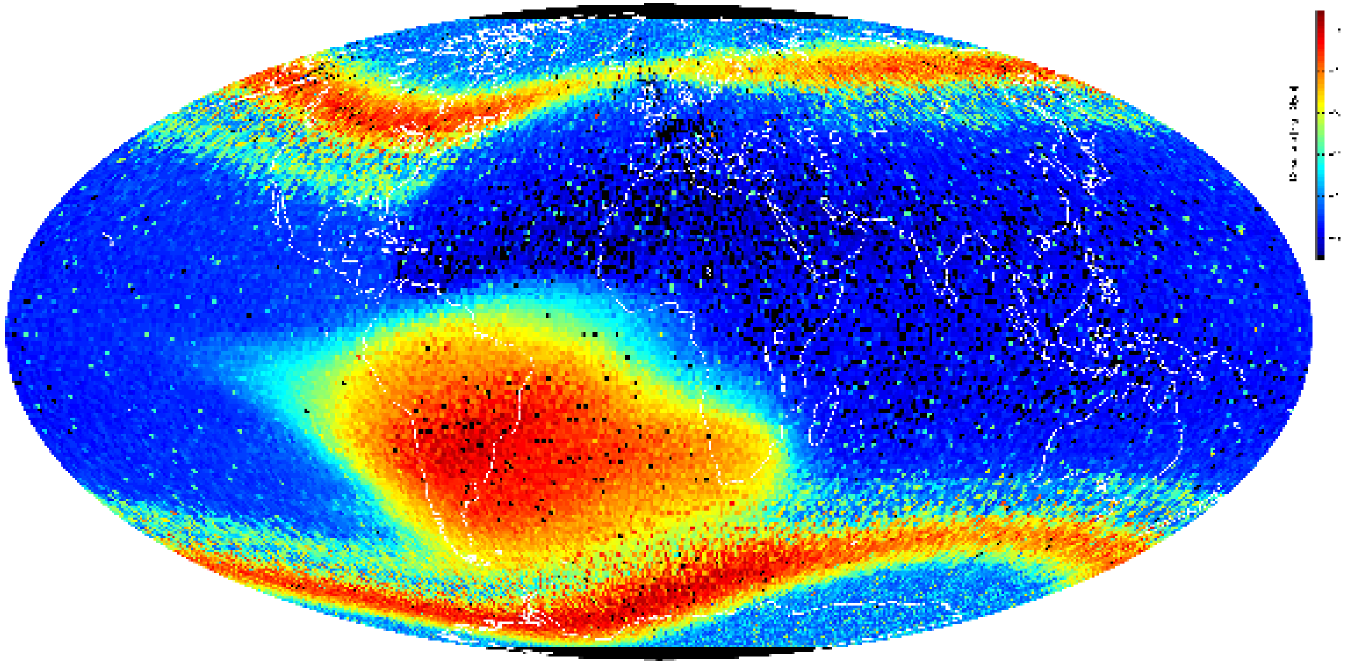
Radiation monitoring in space – “space weather”

Jan Jakubek, Medipix symposium 2025, https://indico.cern.ch/event/1539538/timetable/#20250923
Czech Technical University, University of Houston, NASA, Advacam

Timepix USB aboard International Space Station

Radiation measurement from
Proba-V satellite in Low Earth Orbit

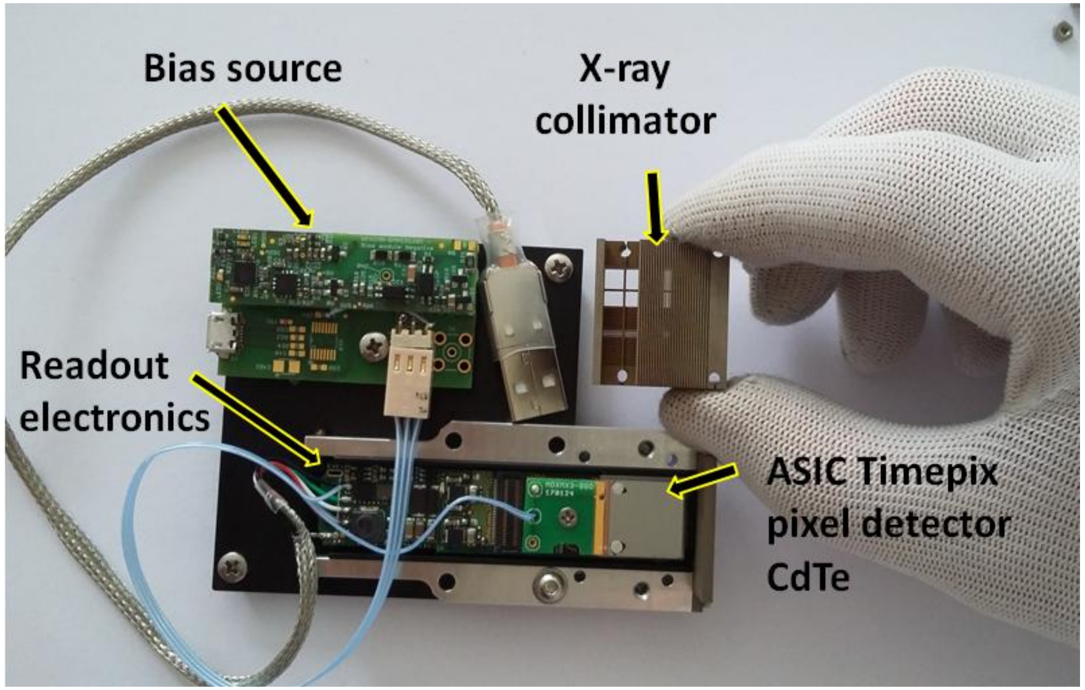


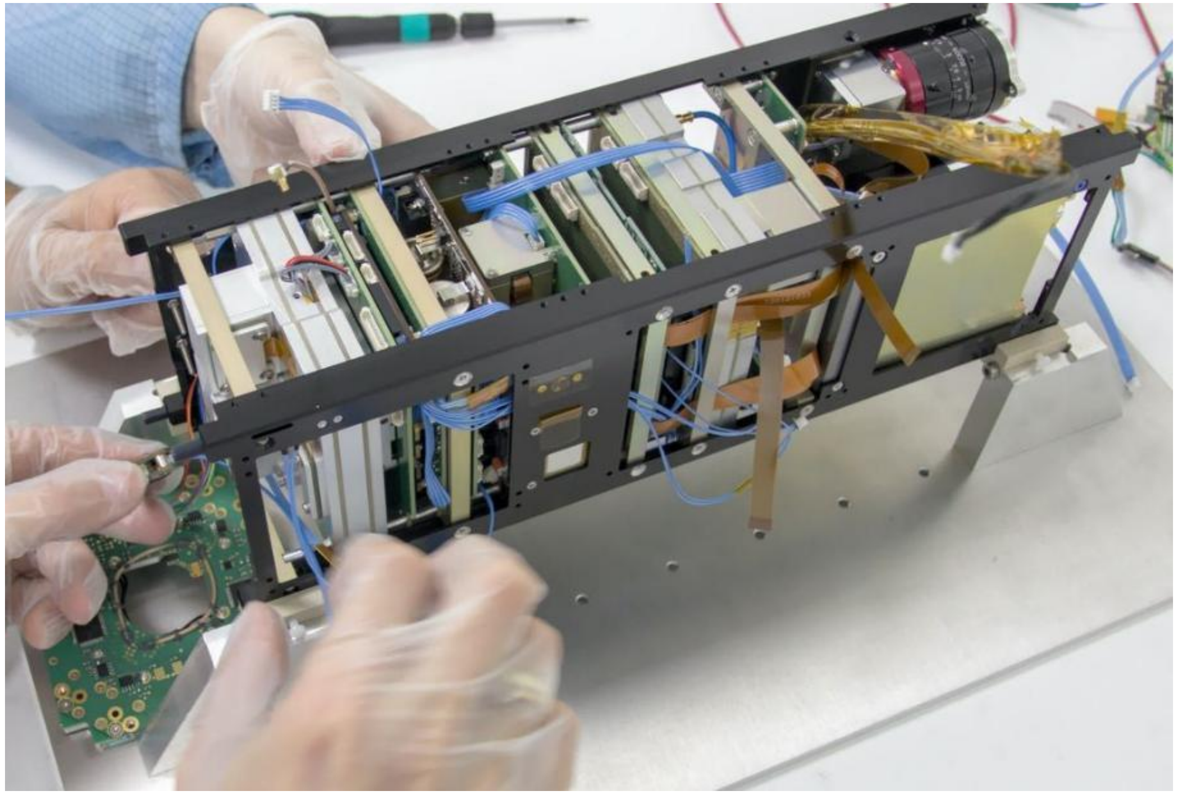


X-ray / Gamma imager developed for VZLUSAT-2 CubeSat

Czech CubeSat, launched 2022 – Earth observation and radiation detection (e.g. gamma-ray bursts)

2mm-thick CdTe, Acrorad

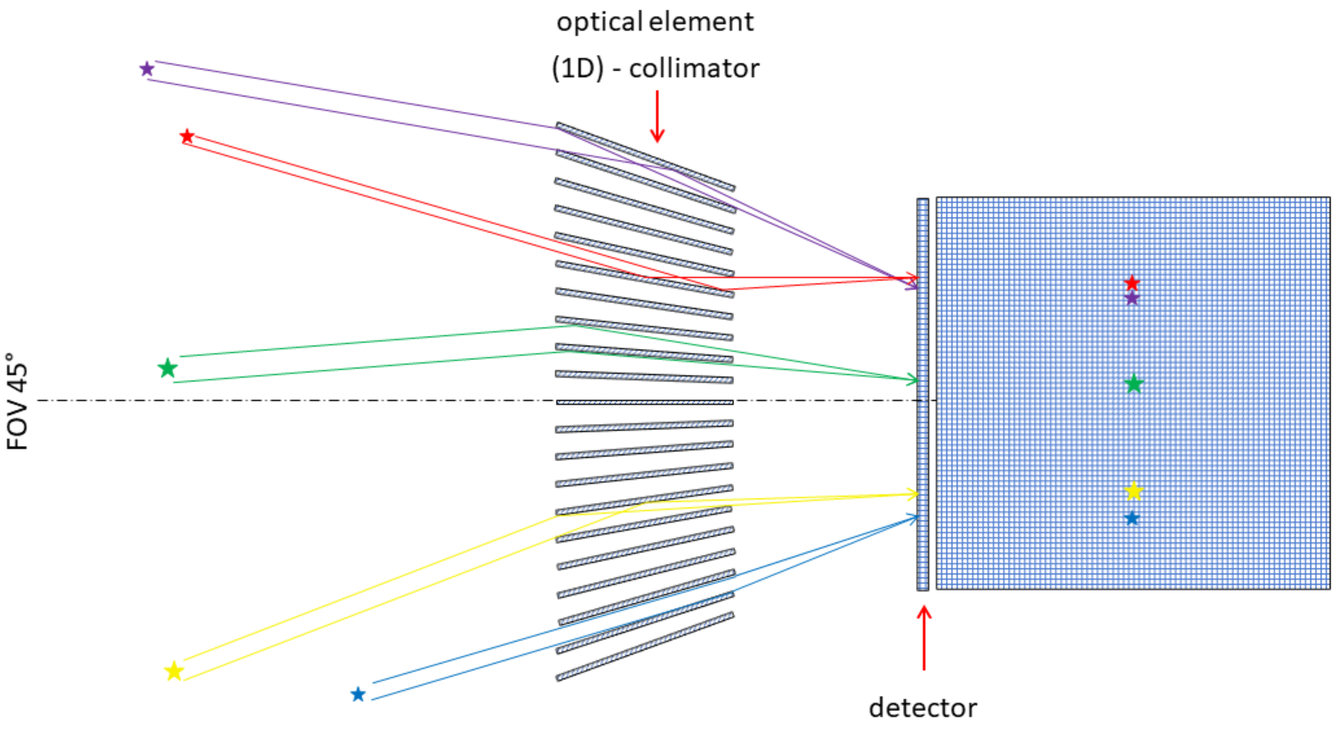


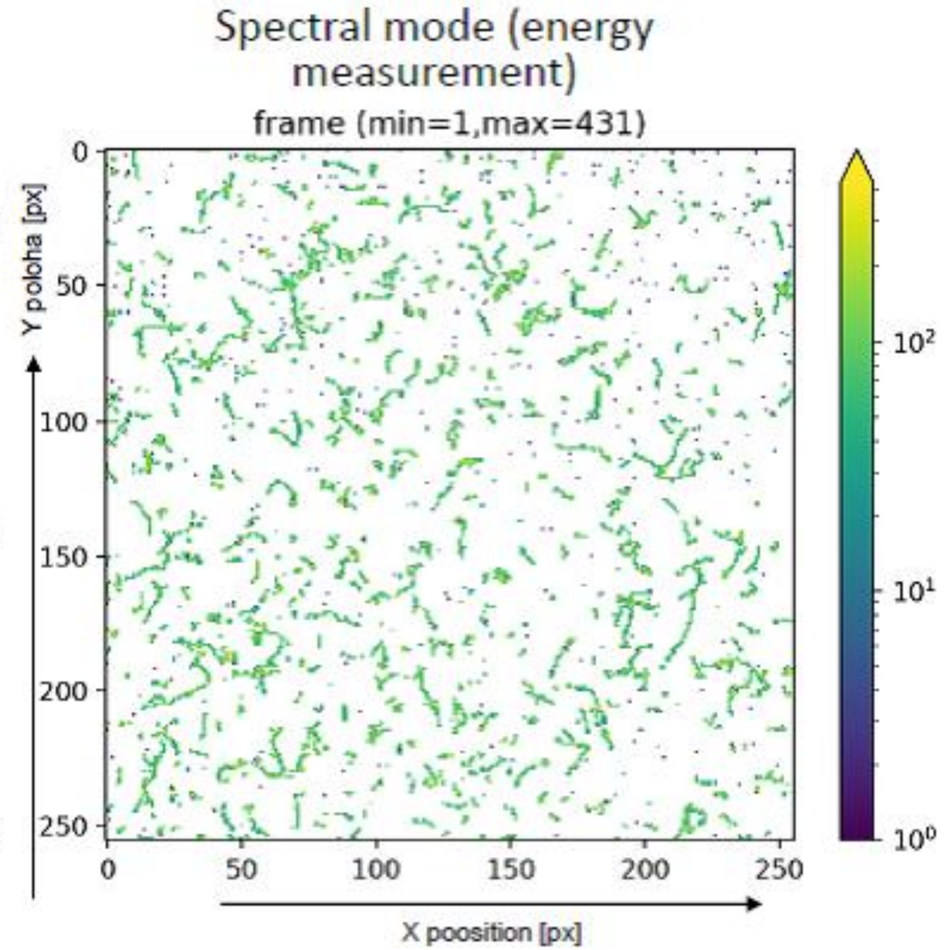


Granja et al., Universe 2022, 8, 241. https://doi.org/10.3390/universe8040241

X-ray / Gamma imager developed for VZLUSAT-2 CubeSat

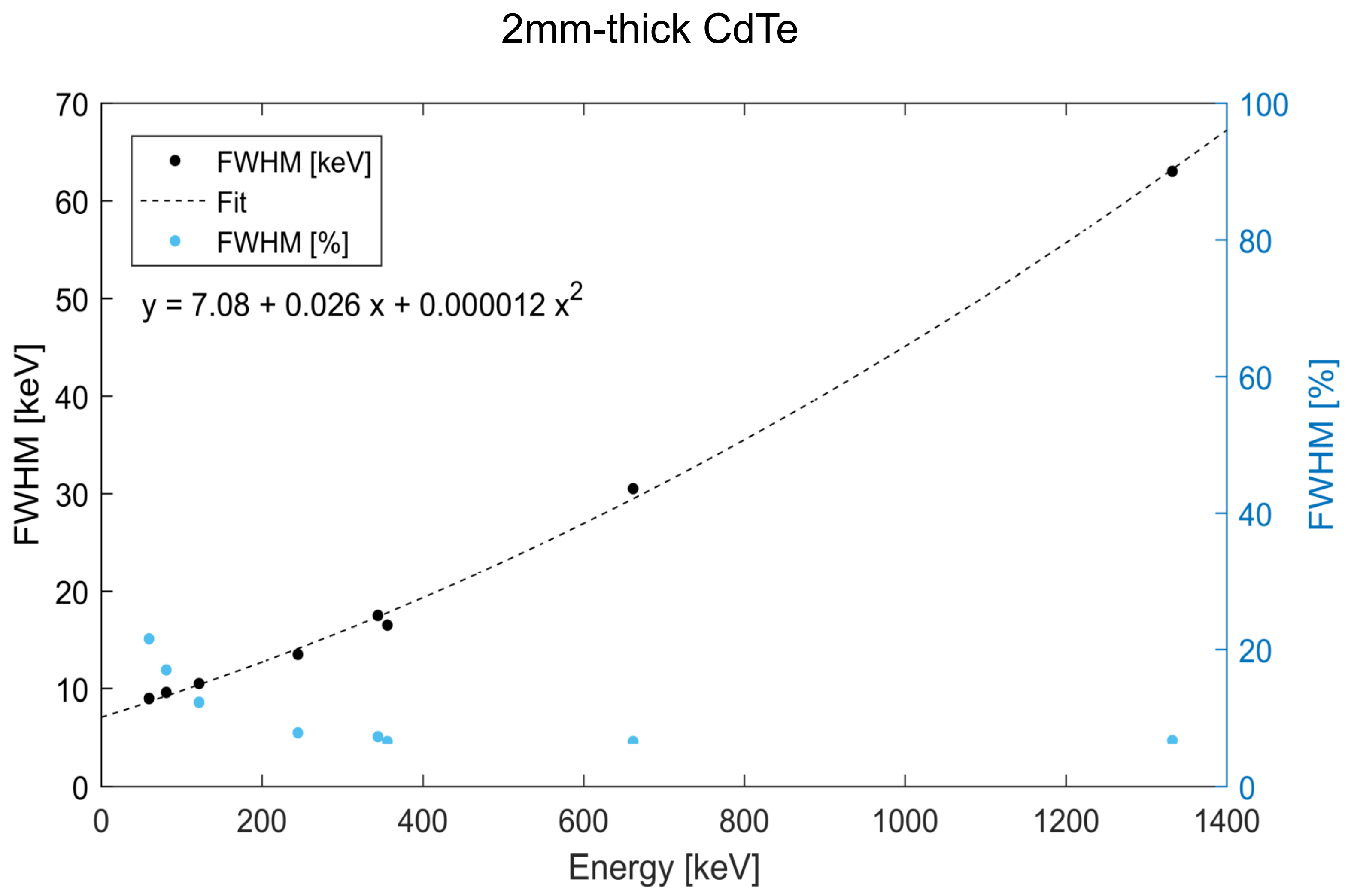
X-ray collimator





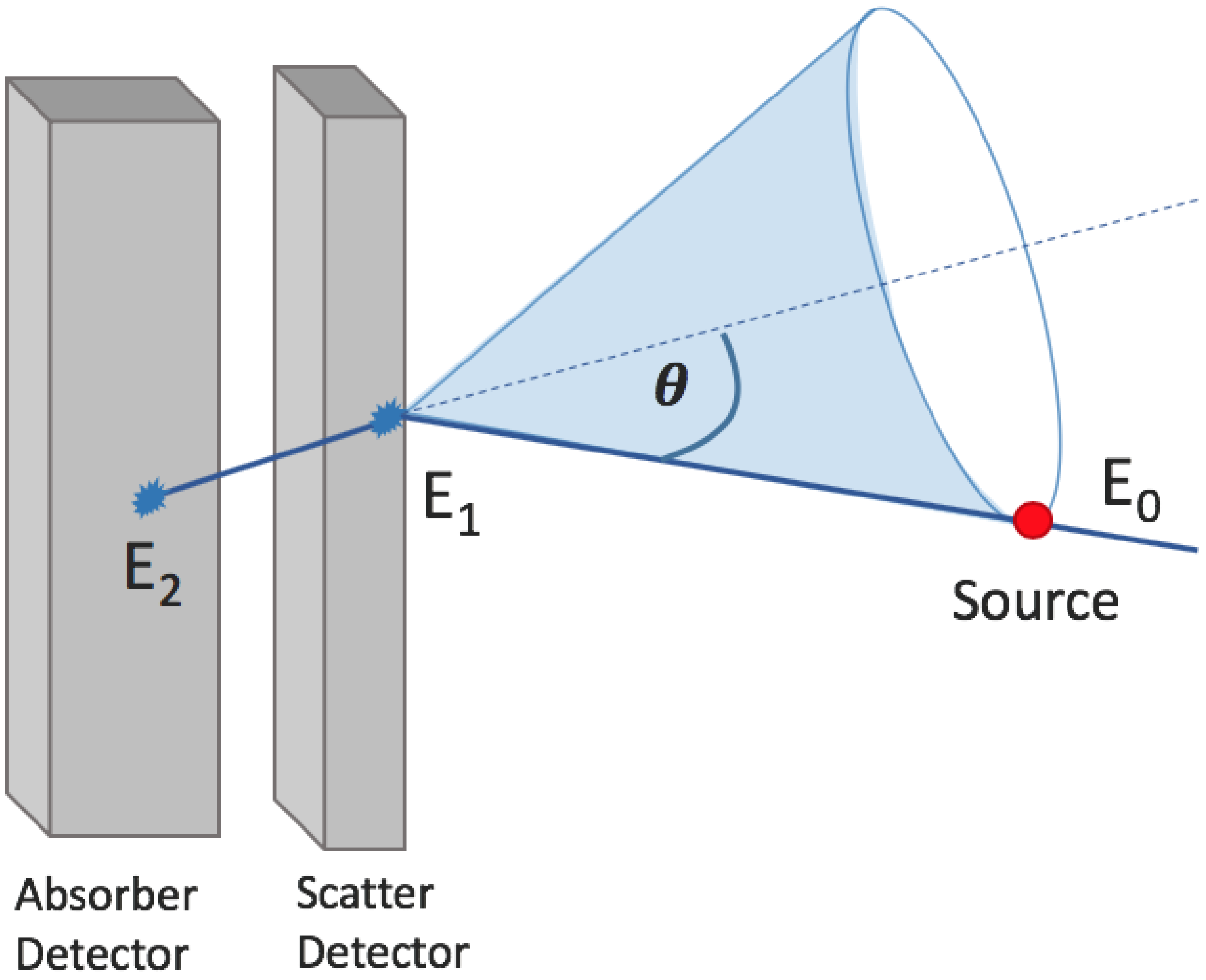
Granja et al., Universe 2022, 8, 241. https://doi.org/10.3390/universe8040241

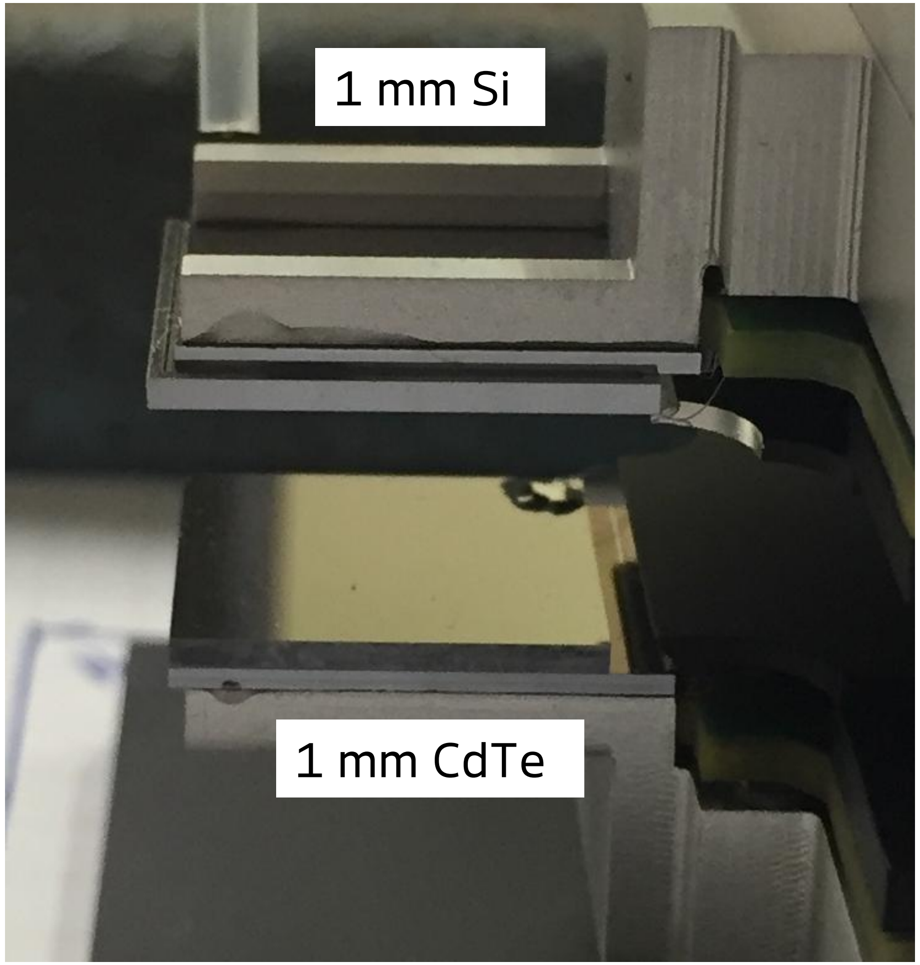
X-ray / Gamma imager developed for VZLUSAT-2 CubeSat



Granja et al., Universe 2022, 8, 241. https://doi.org/10.3390/universe8040241

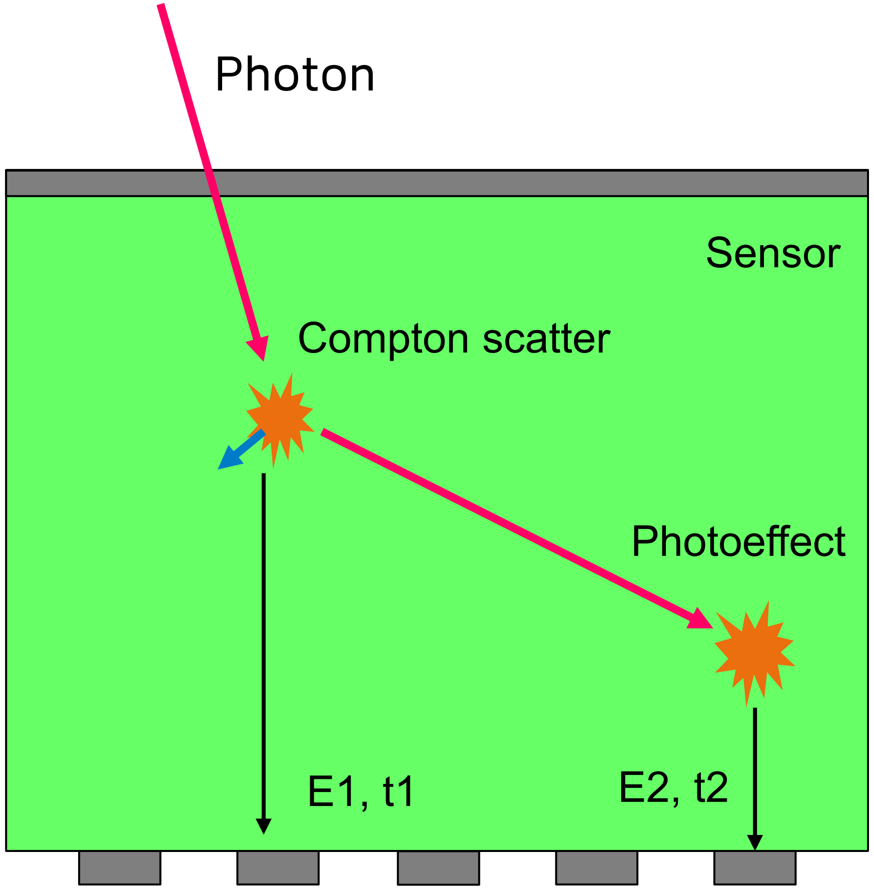
Timepix3 and high-Z for Compton cameras



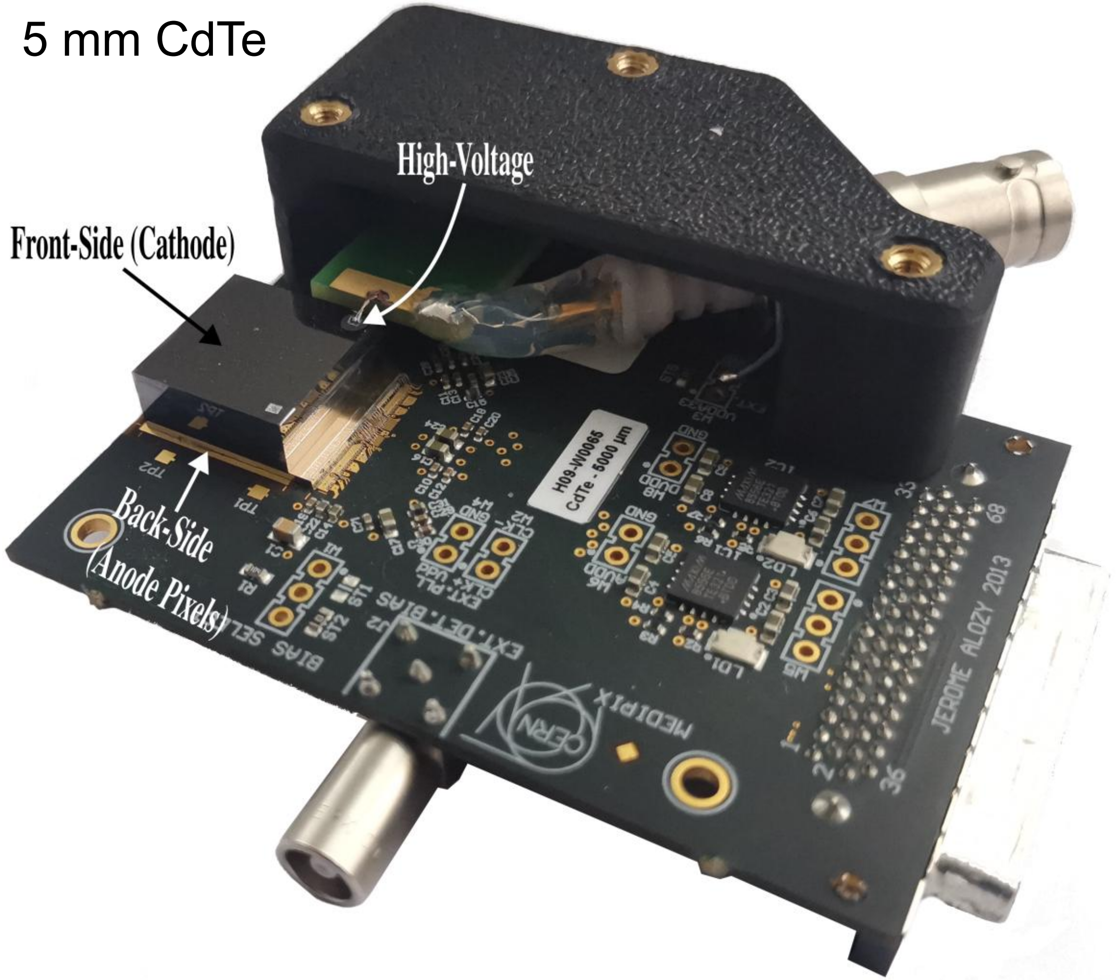


D. Turecek et al 2018 JINST 13 C11022, https://doi.org/10.1088/1748-0221/13/11/C11022

Single-layer Compton camera – 5 mm CdTe

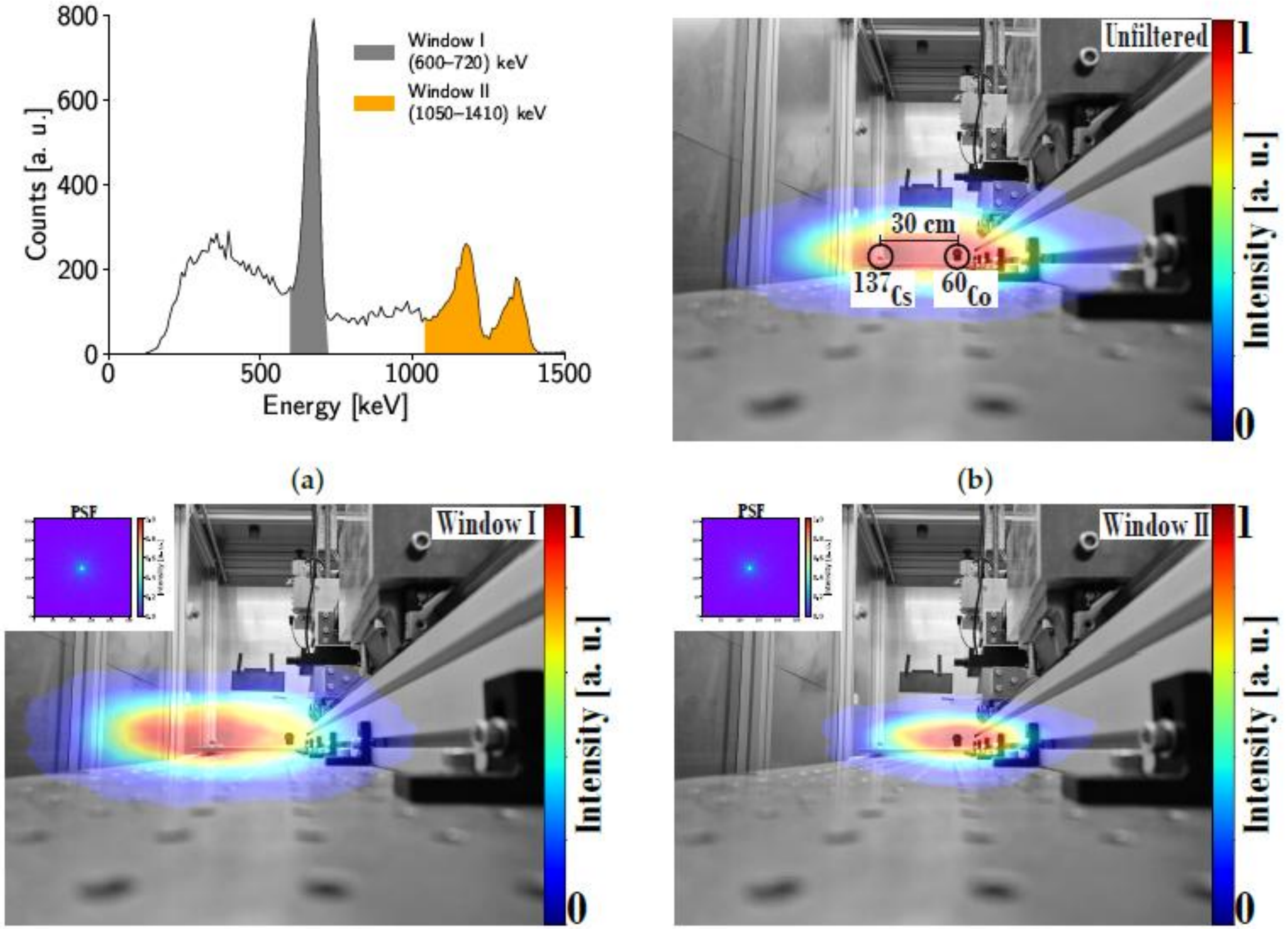


5 mm CdTe



U. Parra et al., Sensors **2024**, 24, 7974. https://doi.org/10.3390/s24247974

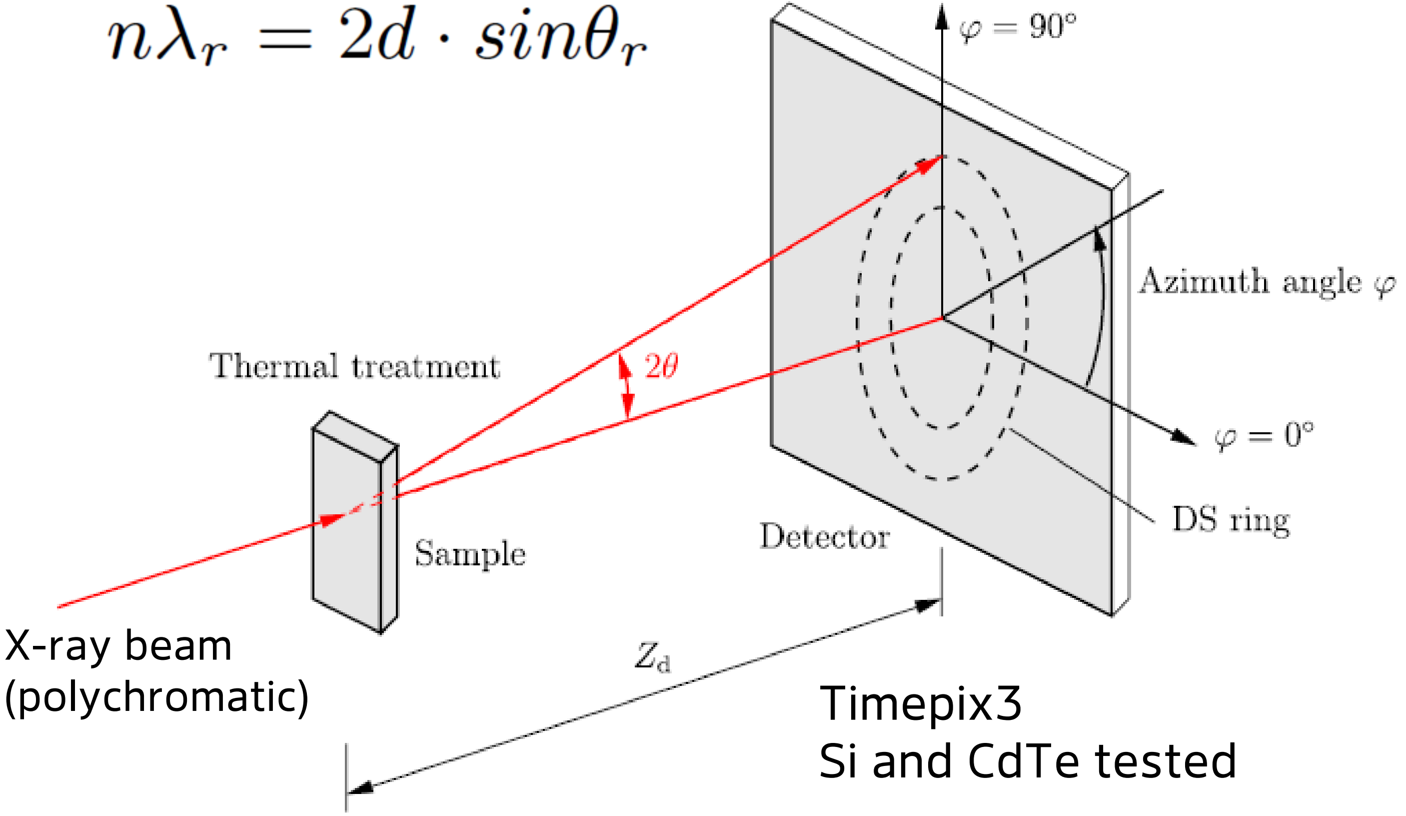
Single-layer Compton camera – 5 mm CdTe



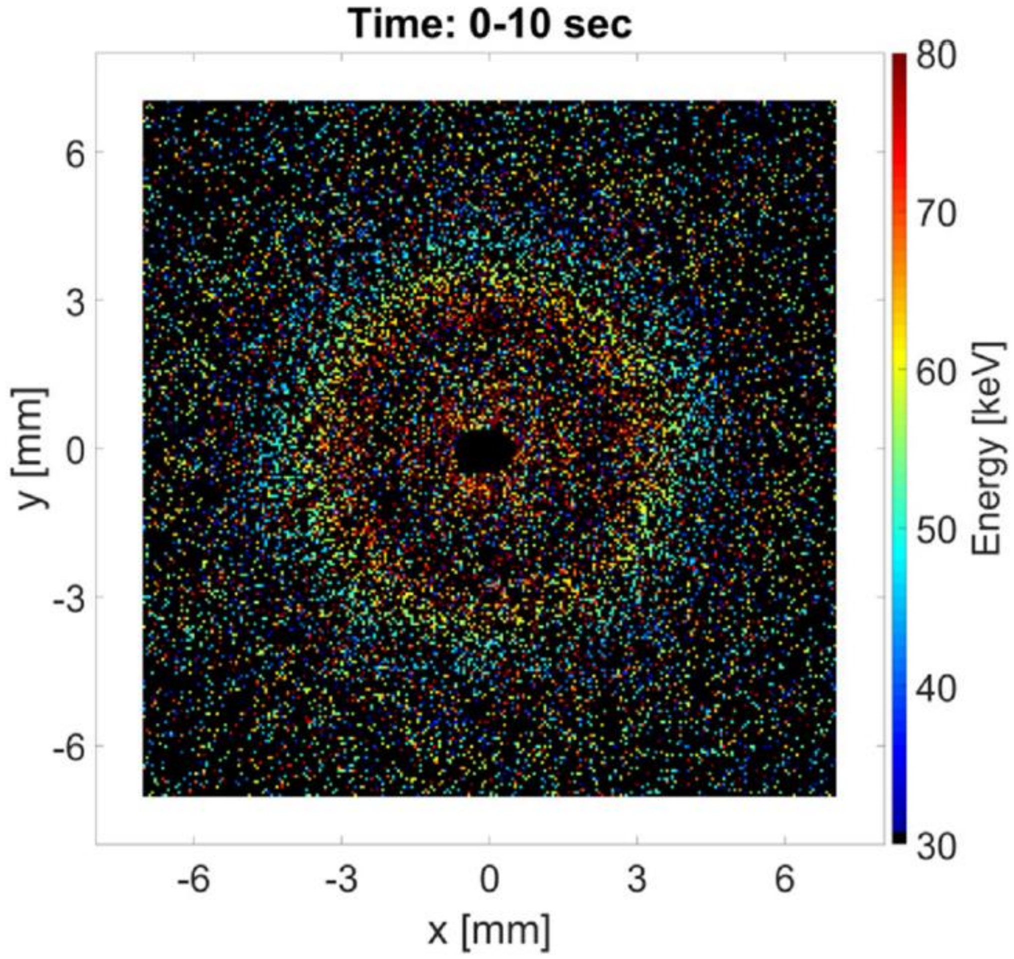
U. Parra et al., Sensors **2024**, 24, 7974. https://doi.org/10.3390/s24247974

Energy-resolved X-ray diffraction with X-ray tube

$$n\lambda_r = 2d \cdot sin\theta_r$$

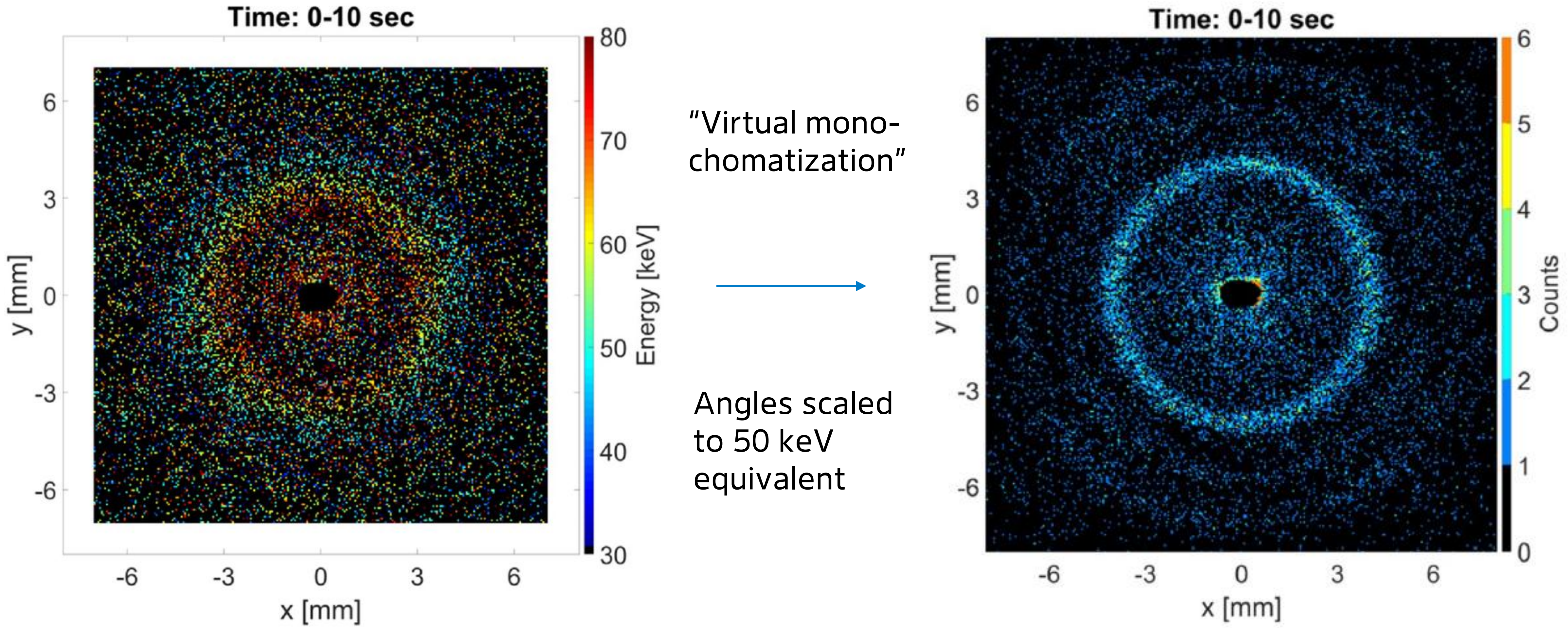


Timepix3
Si and CdTe tested



D. Vavrik et al., Scientific Reports (2025) 15:31752 https://doi.org/10.1038/s41598-025-16314-9

Energy-resolved X-ray diffraction with X-ray tube



"Virtual mono-chomatization"

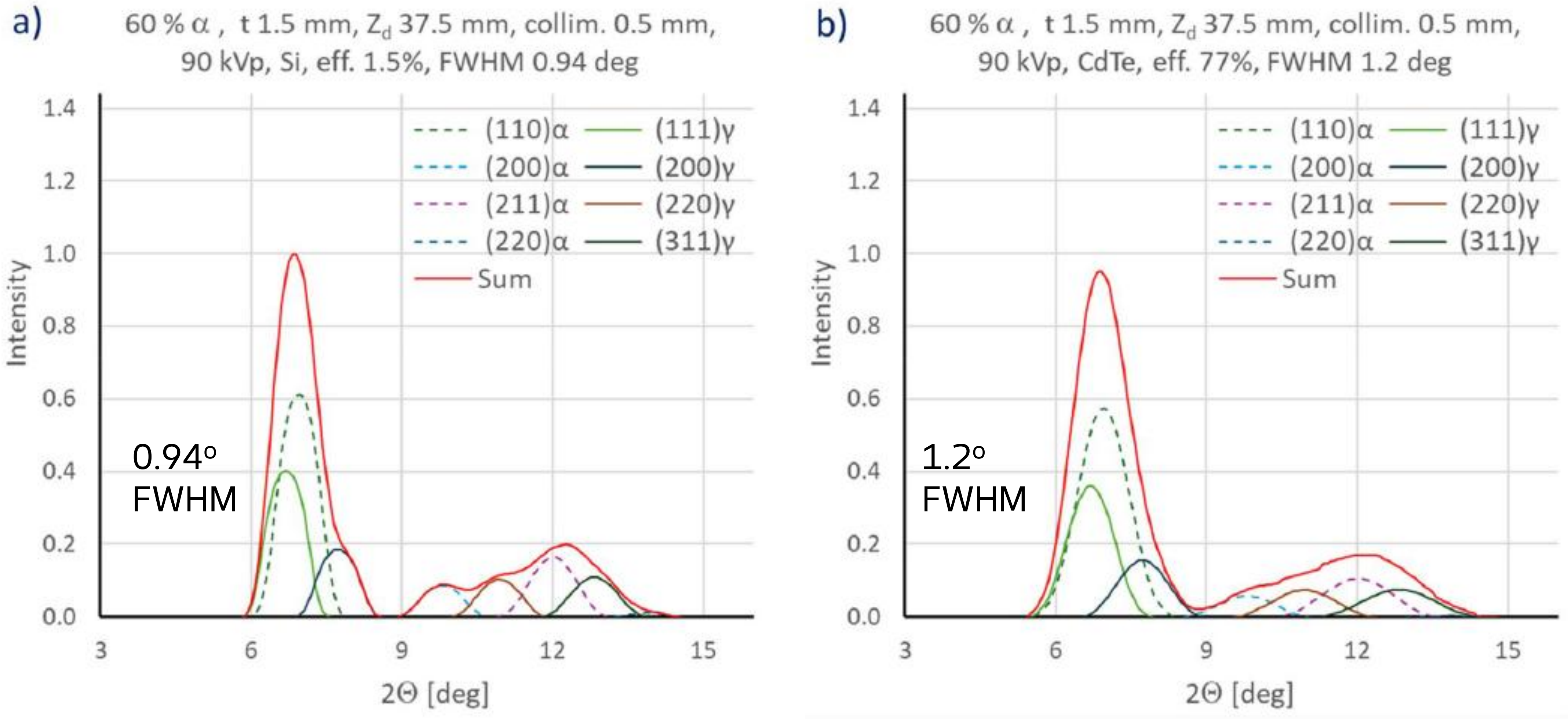
Angles scaled to 50 keV equivalent

D. Vavrik et al., Scientific Reports (2025) 15:31752 https://doi.org/10.1038/s41598-025-16314-9

Energy-resolved X-ray diffraction with X-ray tube

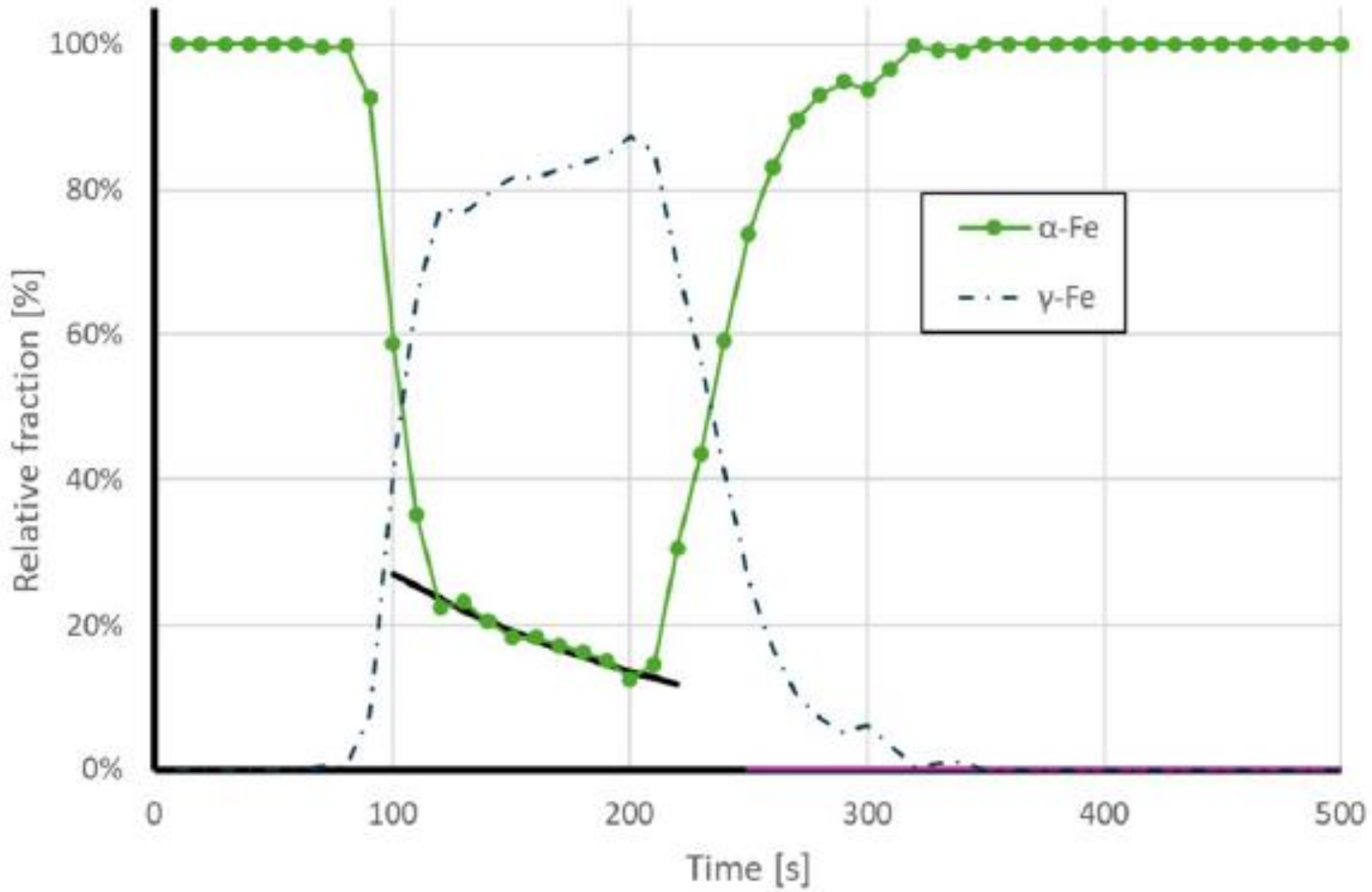
Si – 500 µm, ~4 keV FWHM at 60 keV

CdTe – 500 µm, ~8.5 keV FWHM at 60 keV



D. Vavrik et al., Scientific Reports (2025) 15:31752 https://doi.org/10.1038/s41598-025-16314-9

Energy-resolved X-ray diffraction with X-ray tube



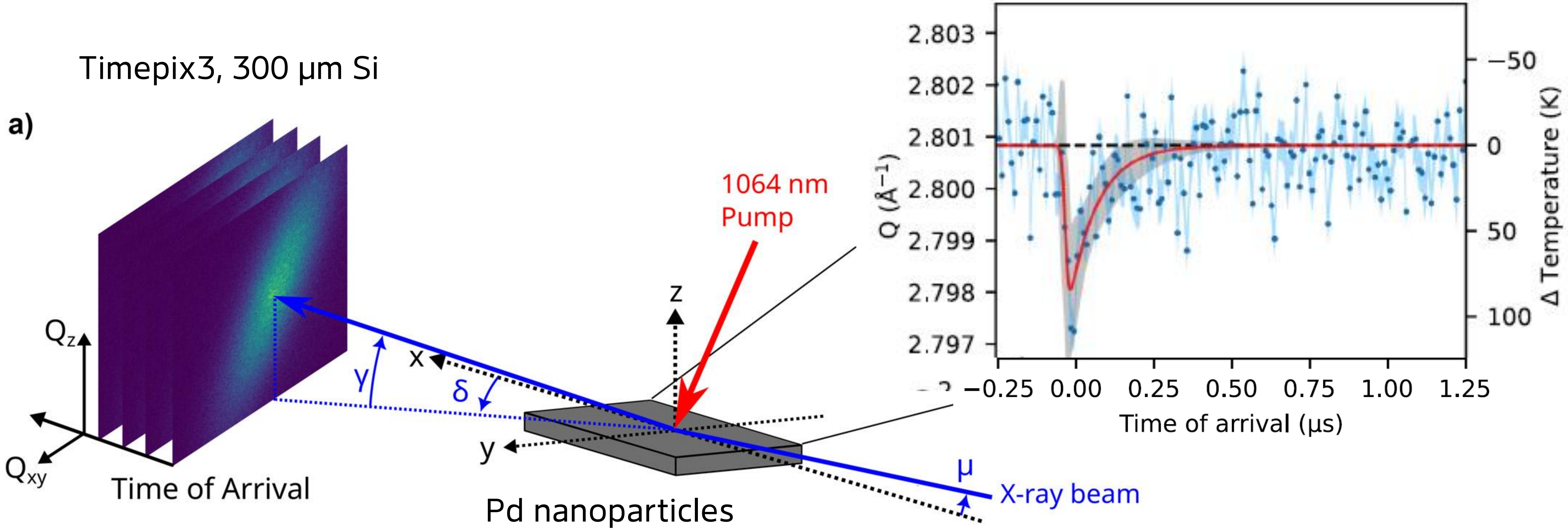
Phase transitions in heating and cooling steel

D. Vavrik et al., Scientific Reports (2025) 15:31752 https://doi.org/10.1038/s41598-025-16314-9

Time-resolved pump-probe X-ray diffraction

NB – Measured with single Timepix3 and X-ray tube

Shift in Pd-111 Bragg peak following laser heating



Cu kα X-ray beam

S. Chung et al., Struct. Dyn. 11, 044301 (2024); doi: 10.1063/5.0189052

Overview

- The Timepix ASIC series
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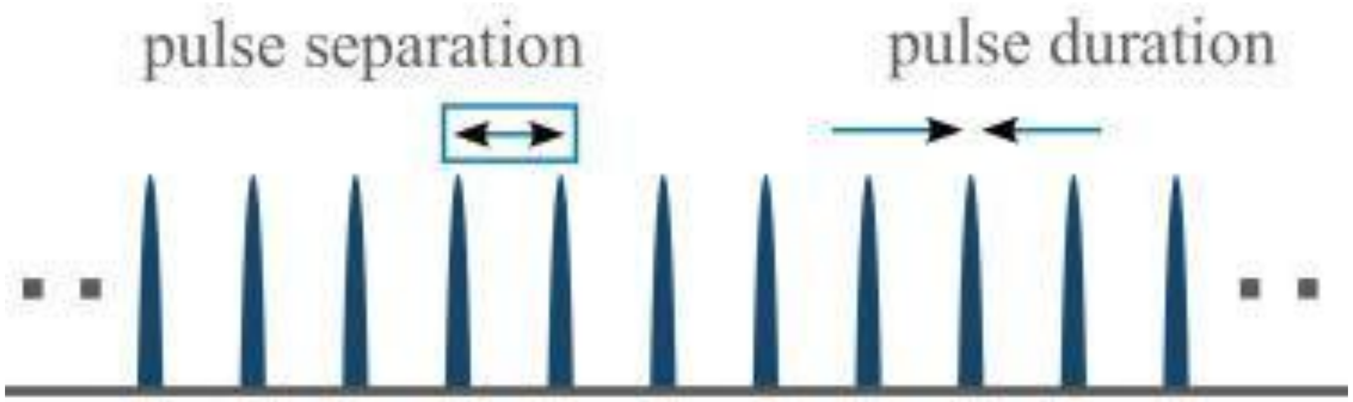
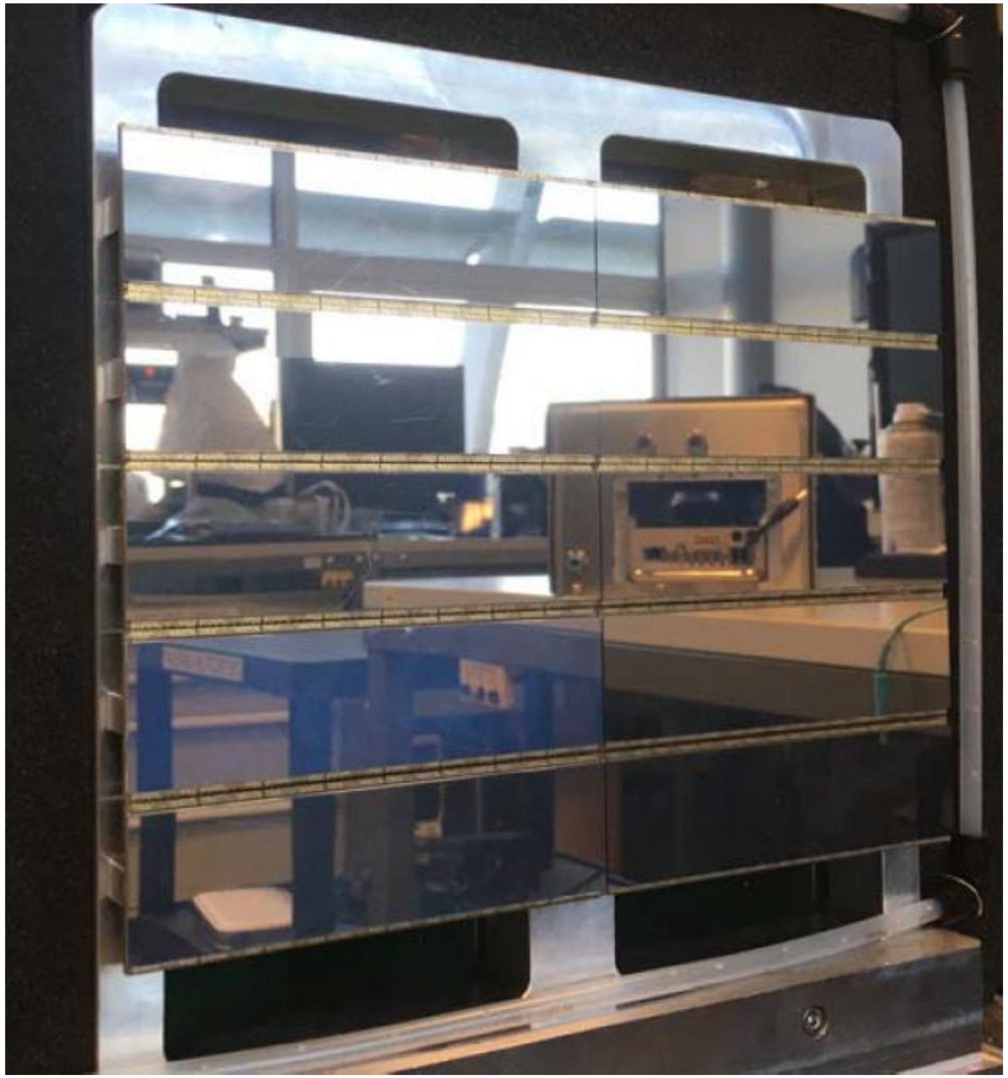
- General applications
- Timepix and high-Z at light sources – systems and applications

Timestamping X-rays at synchrotrons

- Time resolution down to single bunches (e.g. 5 – 200ns)
  - Pump-probe X-ray diffraction, etc.
  - Correlation techniques – XPCS, XCCA
- Sub-bunch time resolution in timing modes
  - Nuclear Resonant scattering
  - Time-of-flight measurement of electrons and ions – Photoelectron spectroscopy

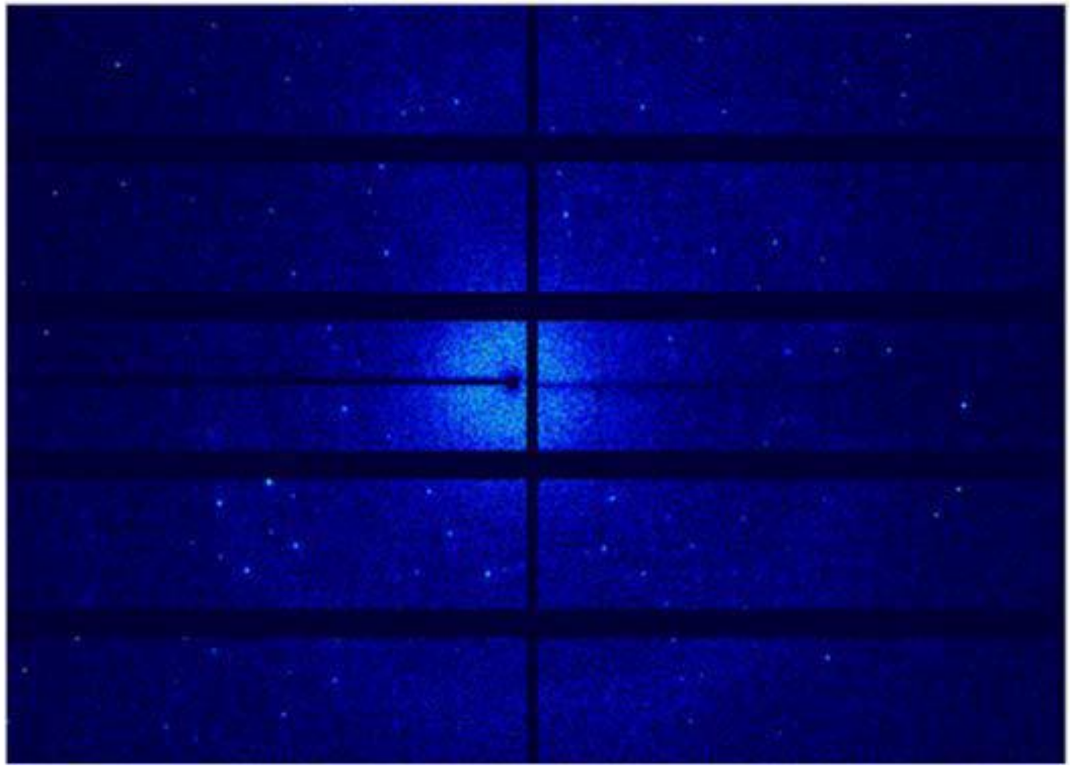


Tristan10M with Timepix3 – Diamond Light source



Construction: 10 modules of 8 x 2 Timepix3 ASICs (160 total)

Small-Molecule Single-Crystal Diffraction beamline (I19)



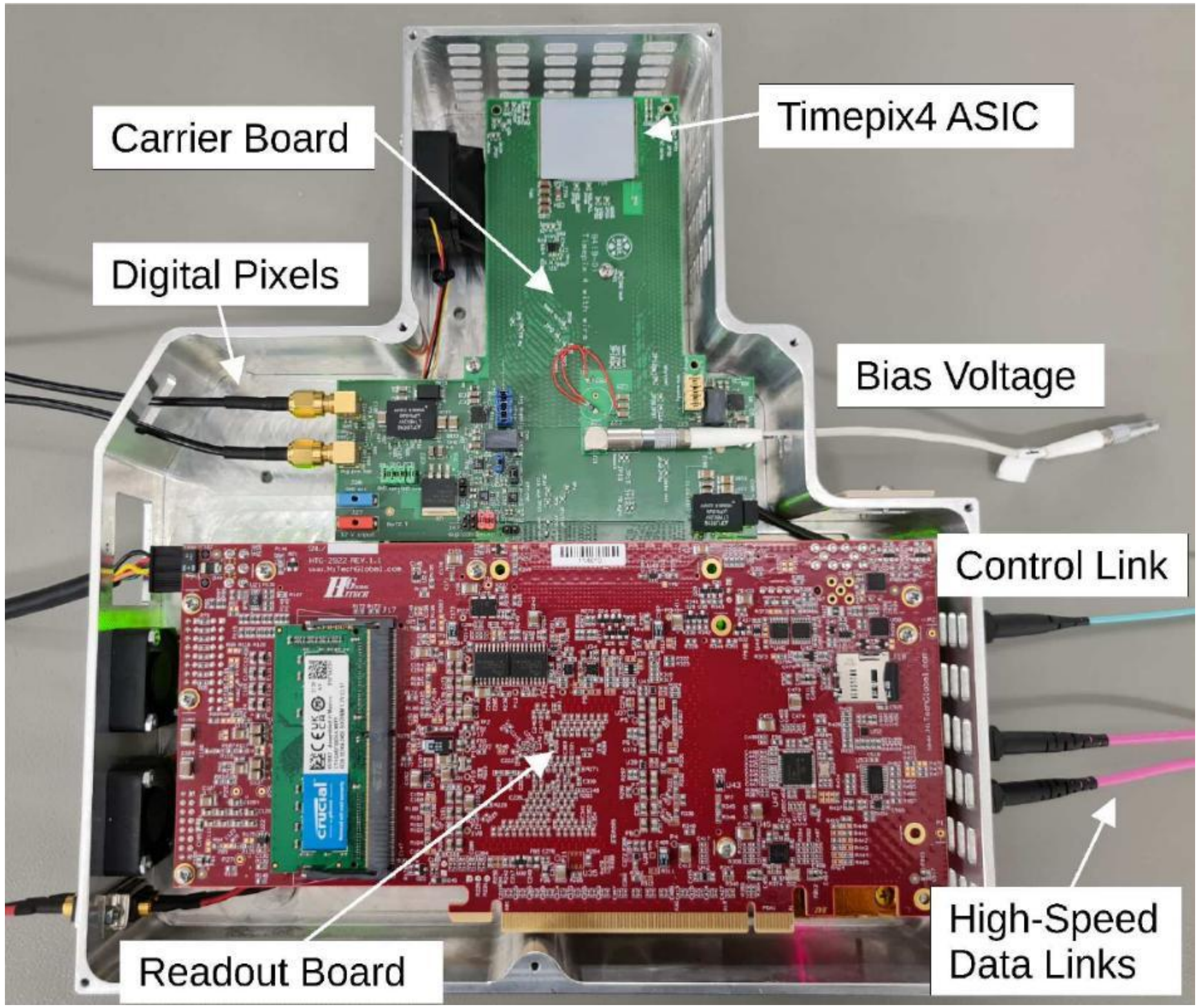
D. Omar et al., IEEE Trans. Nucl. Sci 69, 2188 (2022). https://doi.org/10.1109/TNS.2022.3204064

Key differences between chips

	Timepix (IBM 250nm)	Timepix3 (IBM 130nm)	Timepix4 (TSMC 65nm)
Time of Arrival binning	10 ns	1.56 ns	0.2 ns
Event rate	Frames, one hit per image, ToT or ToA only	43 x 10^6 hits/cm^2/s	**358 x 10^6 hits/cm^2/s**
Energy resolution (FWHM, Si)*	< 3 keV	~ 2 keV	~ 1 keV
		NB – per pixel, minimum threshold ~2 keV	
Photon counting performance	3.2 kfps 1 x 10^5 counts/pix/s	1.62 kfps (zero suppressed, worst case) 2.5 x 10^5 counts/pix/s	**45 kfps** **24 x 10^5 counts/pix/s**
Chip layout	256 x 256 pixels 55 µm	256 x 256 pixels 55 µm	448 x 512 pixels 55 µm

TEMPUS system – Timepix4 - DESY

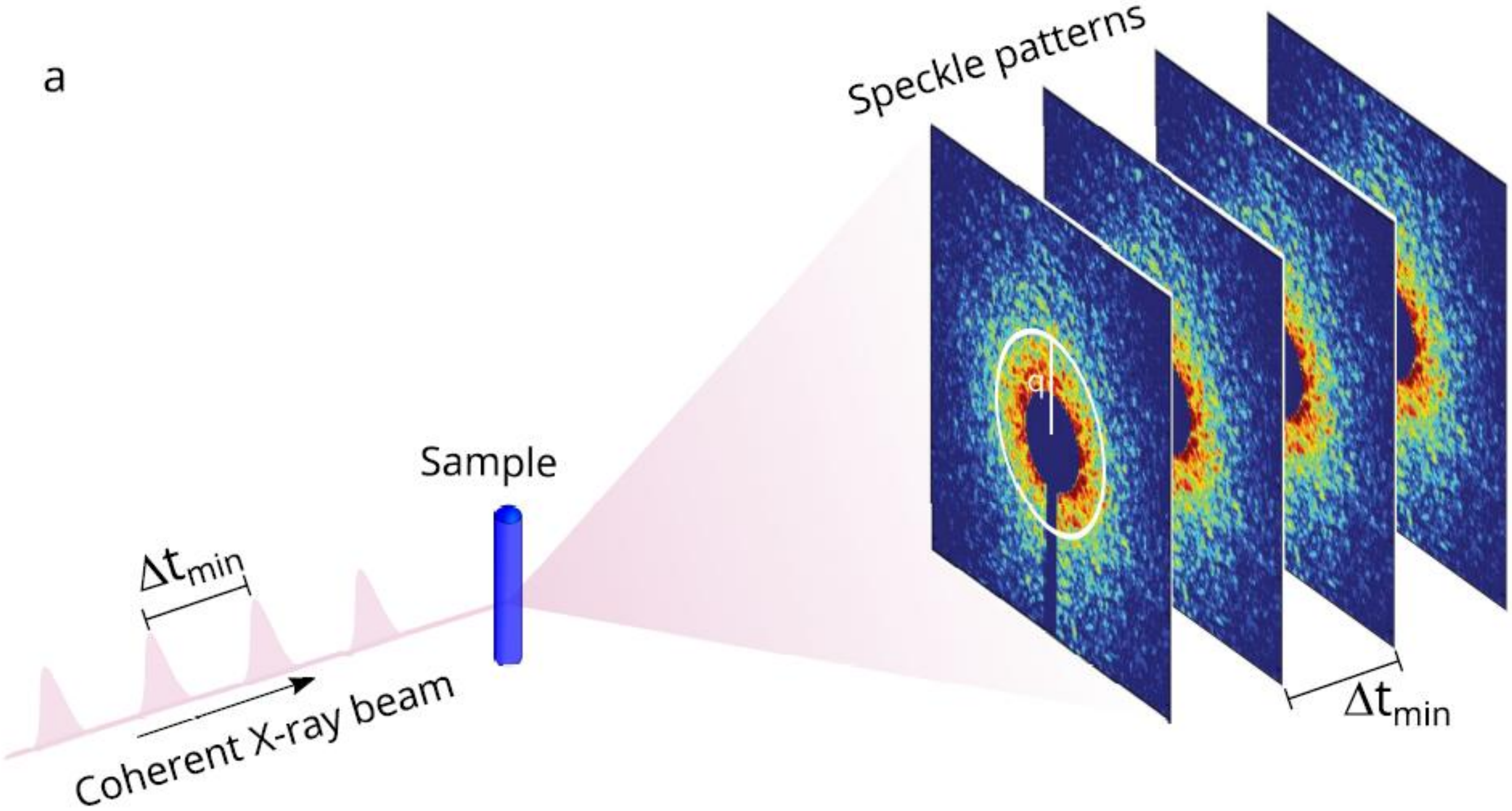
- > Project lead **Jonathan Correa**, postdoc **Adriana Simancas**
- > Single-chip system with off-the-shelf FPGA board
- > Used in a variety of beamtimes
  - >PETRA-III, ESRF, Eu.XFEL, APS, BNL
- > Work in progress:
  - –Number and stability of serialisers
  - –Time resolution
  - –Energy calibration



J. Correa et al. (2024). J. Synchrotron Rad. 31. https://doi.org/10.1107/S1600577524005319

X-ray Photon Correlation Spectroscopy

- Measures of dynamics in fluids, e.g. colloids or biomolecules in solution
- Motion of particles in fluid causes fluctuation in coherent speckle pattern

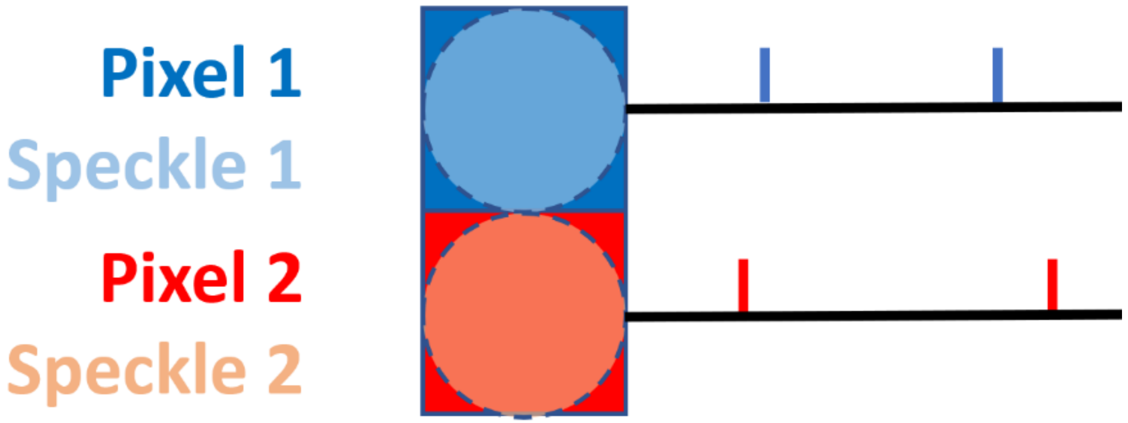


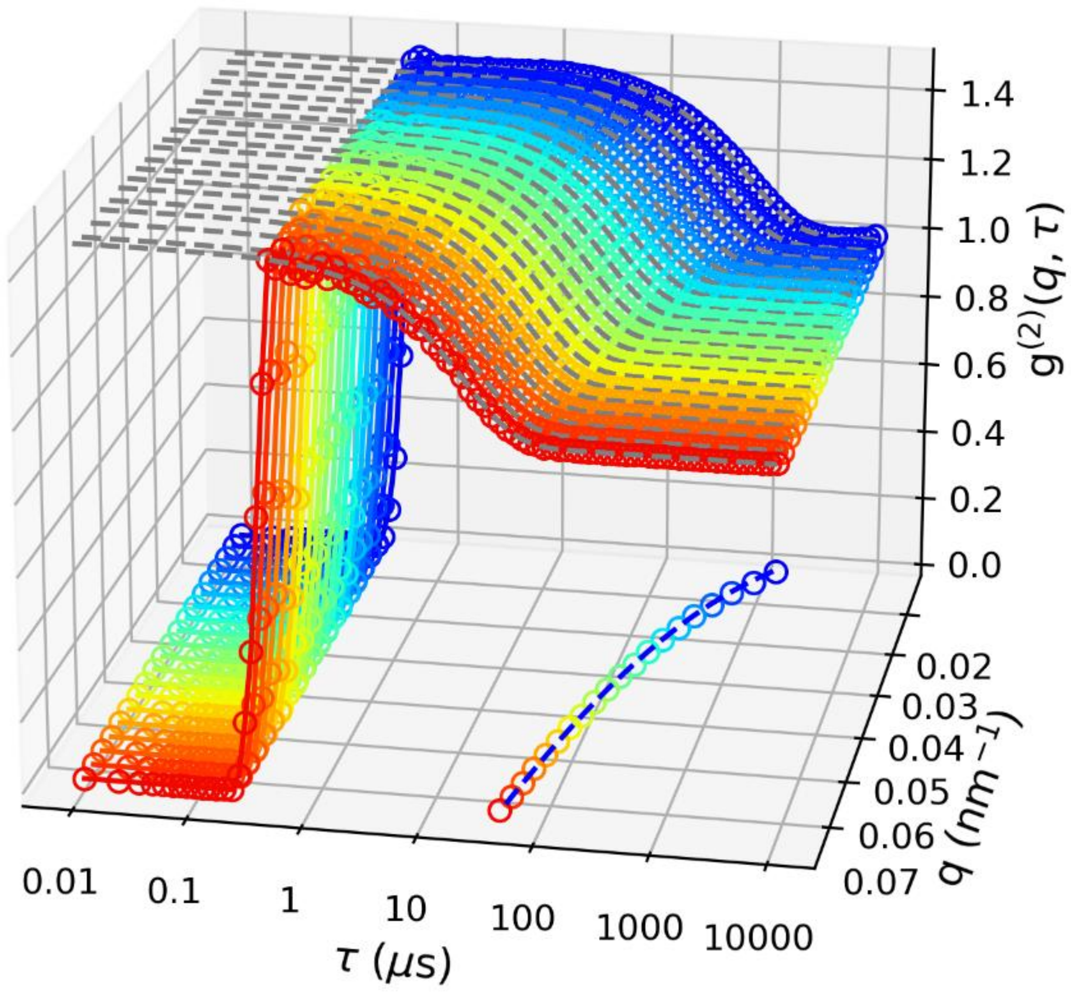
F. Lehmkuhler et al., Appl. Sci. 2021, 11, 6179. https://doi.org/10.3390/app11136179

X-ray Photon Correlation Spectroscopy

- Measurement at ESRF-EBS ID10
- Gold colloidal nanoparticle test sample

Autocorrelation
Limited by pixel recovery time ~400 ns



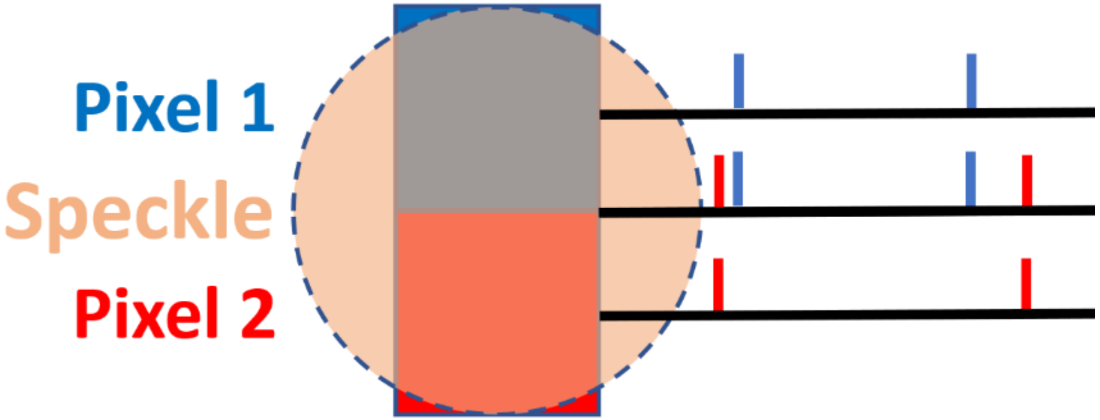


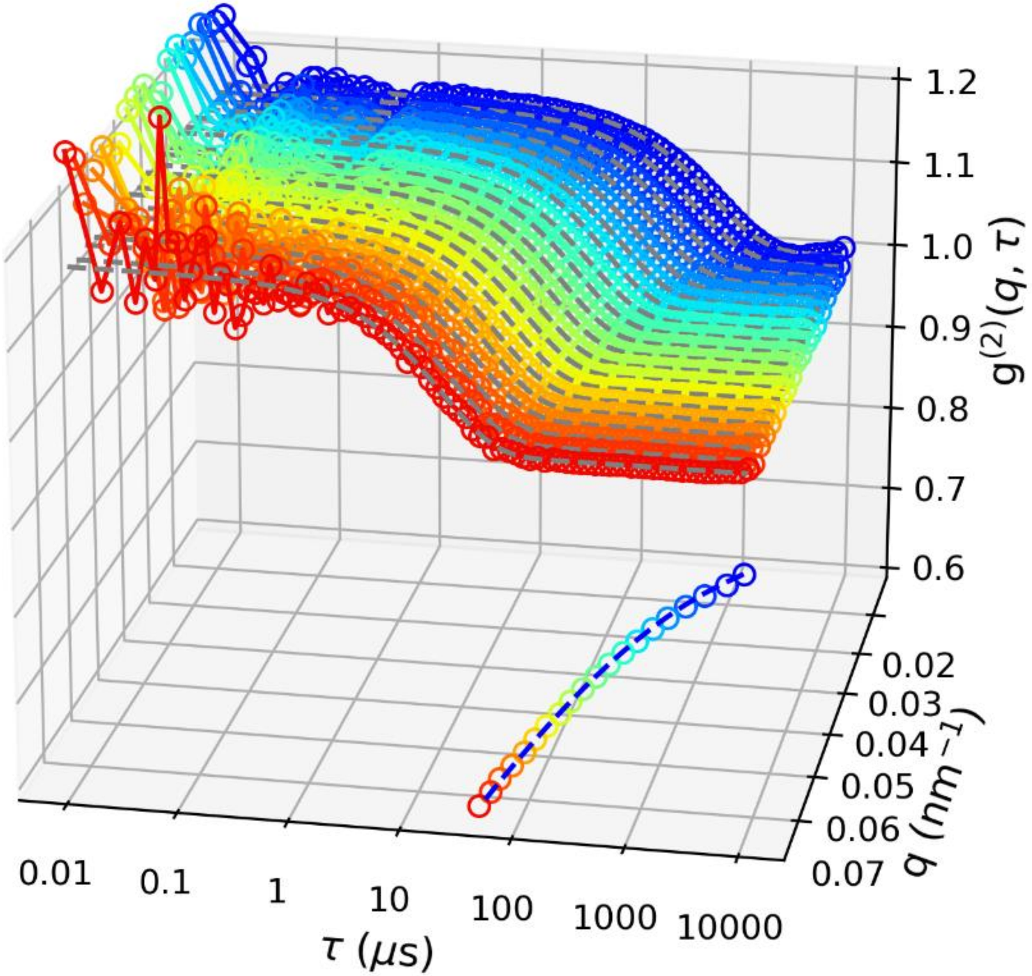
Y. Chushkin et al., J. Synchrotron Rad. (2025). 32, 1220–1227. https://doi.org/10.1107/S1600577525006599

X-ray Photon Correlation Spectroscopy

- Measurement at ESRF-EBS ID10
- Gold colloidal nanoparticle test sample

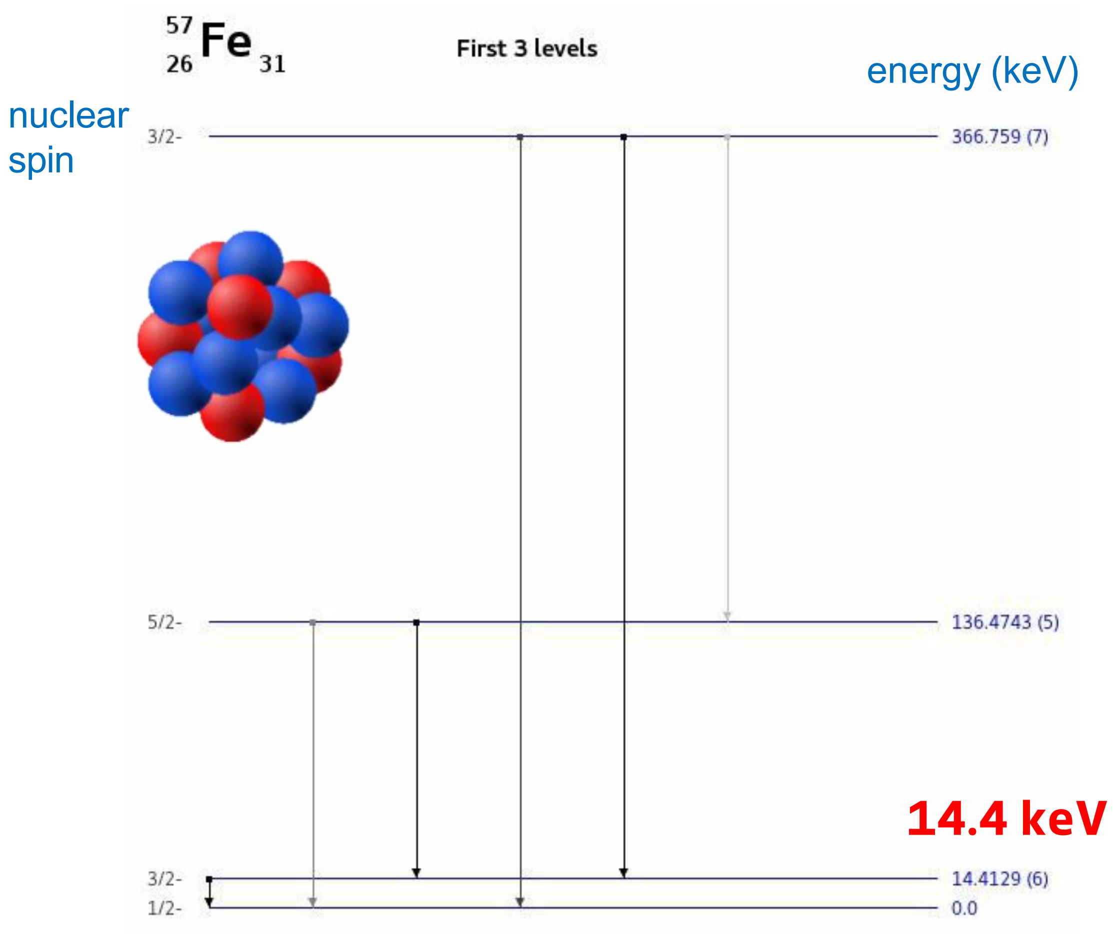
Cross-correlation between pixels
10 ns time resolution achieved





Y. Chushkin et al., J. Synchrotron Rad. (2025). 32, 1220–1227. https://doi.org/10.1107/S1600577525006599

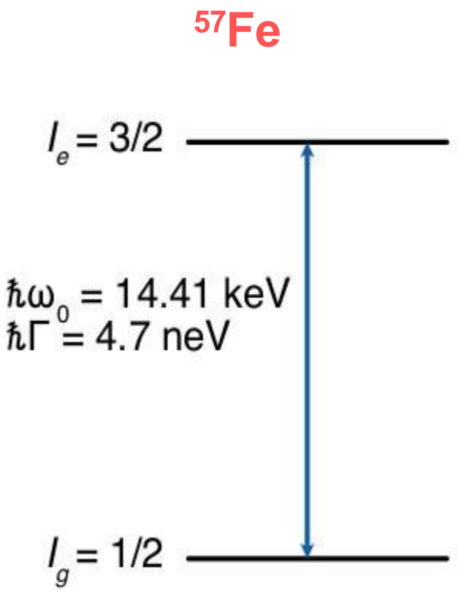
Nuclear Resonant Scattering

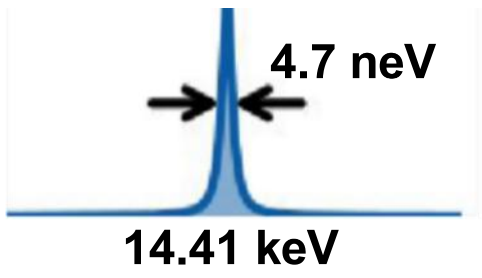


- Atomic nuclei have internal excitation states
- **Mössbauer nuclei**: low-lying long-living states in the hard x-ray regime (< 100 keV)

Nuclear resonant excitations have interesting properties

- Extremely narrow linewidth (neV)
- Long lifetimes (~10-100 ns)

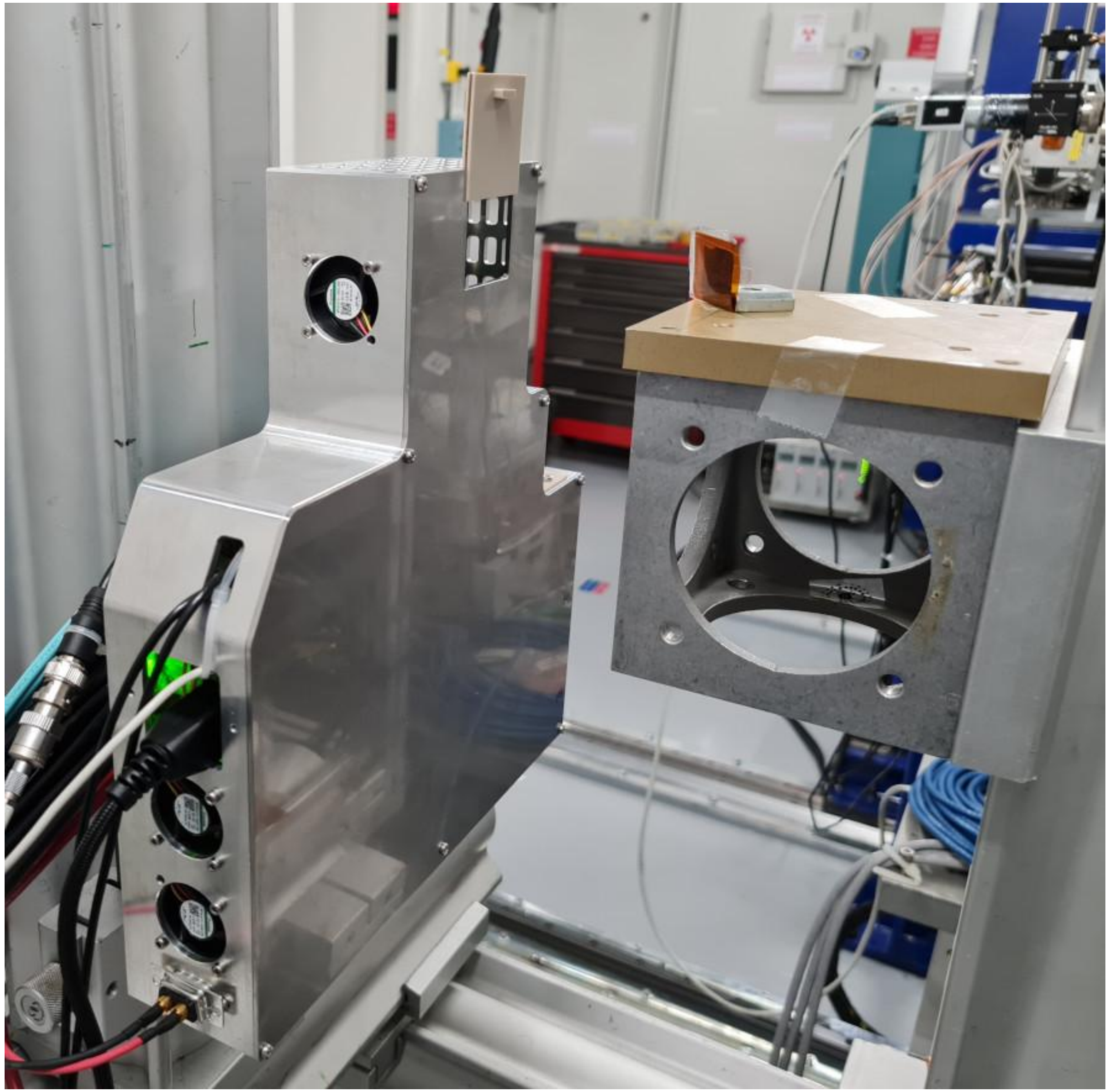




Thanks to Leon Lohse for material

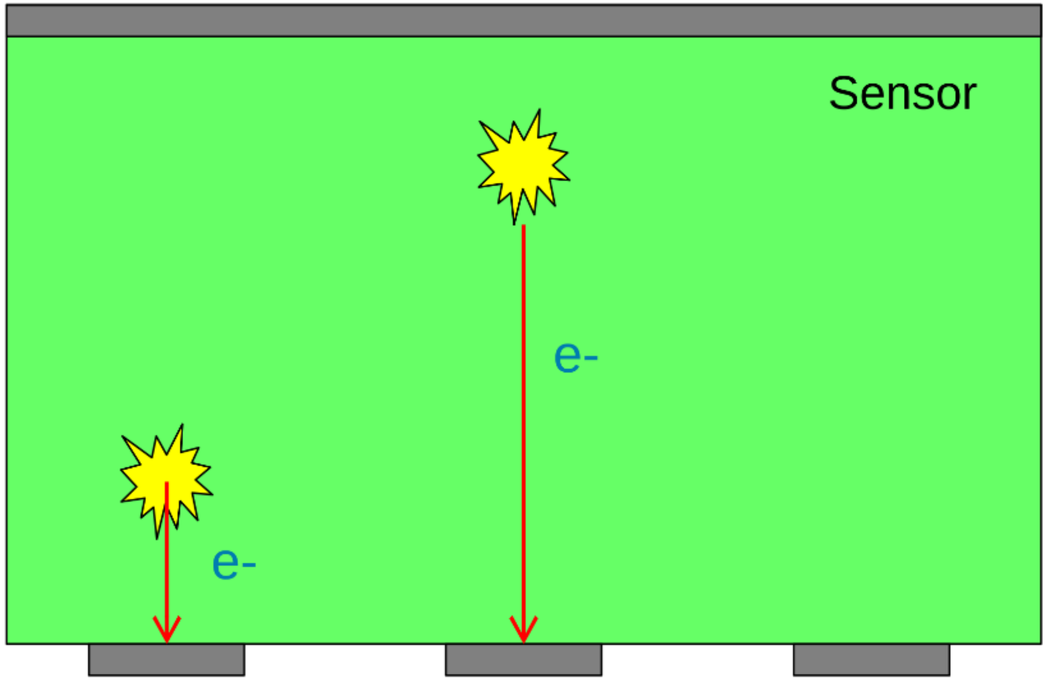
NRS experiments at PETRA-III P01

- NRS works with a small number of isotopes:
  - ^{57}Fe ~ 14.4 keV
- Measurements can be sensitive to E and B-fields or atomic motion
  - E.g. splitting of energy levels in B-field produces "beating" in time response
- Currently using APD:
  - Very high time resolution ~ 200 ps
  - Lacking hit rate and statistics



Achieving high time resolution with X-ray photons

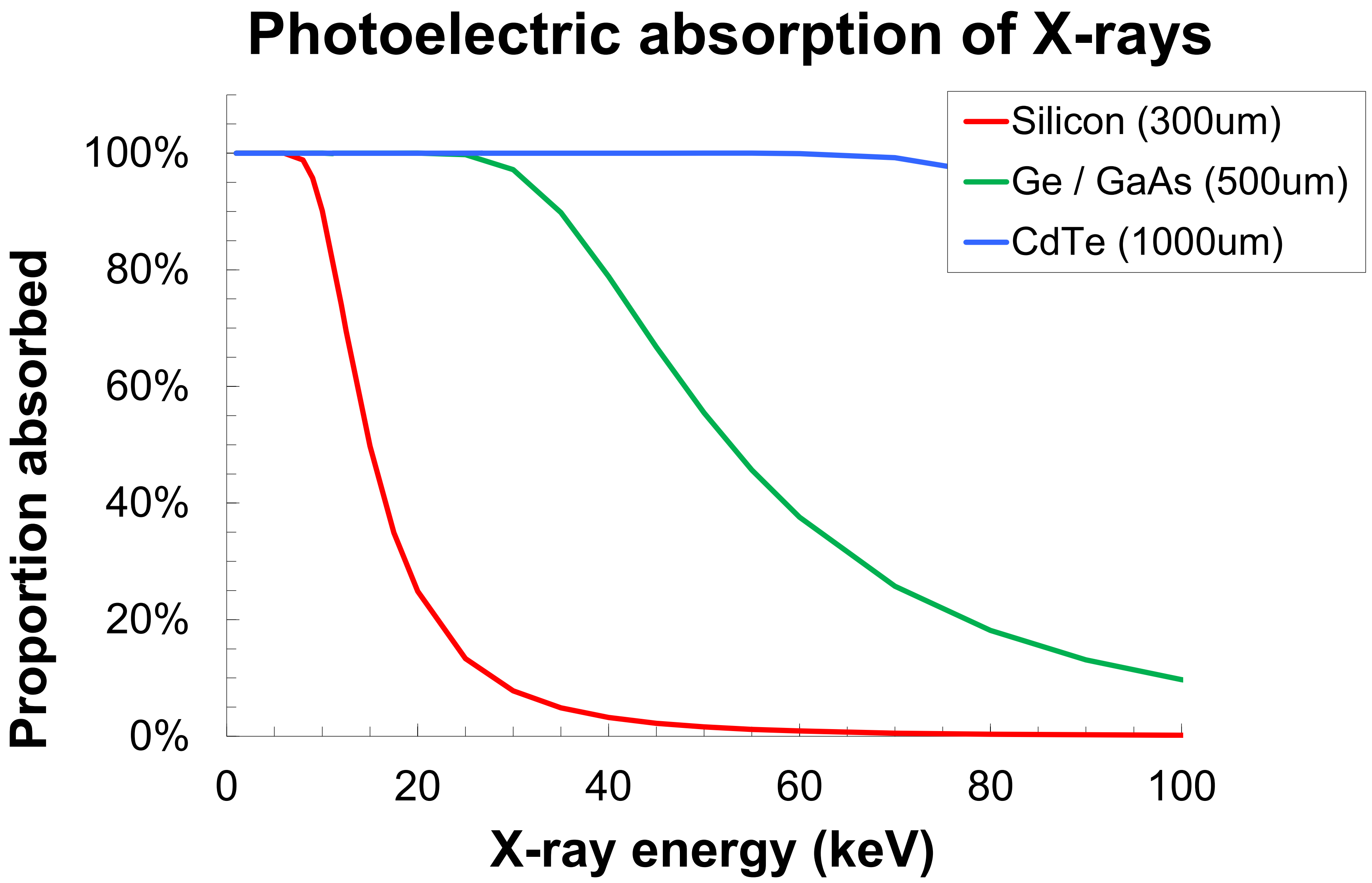
- Absorption depth leads to time variation of signal pulse
- Resulting time variation depends on both **absorption profile** and **carrier velocity**



Carriers drift to readout

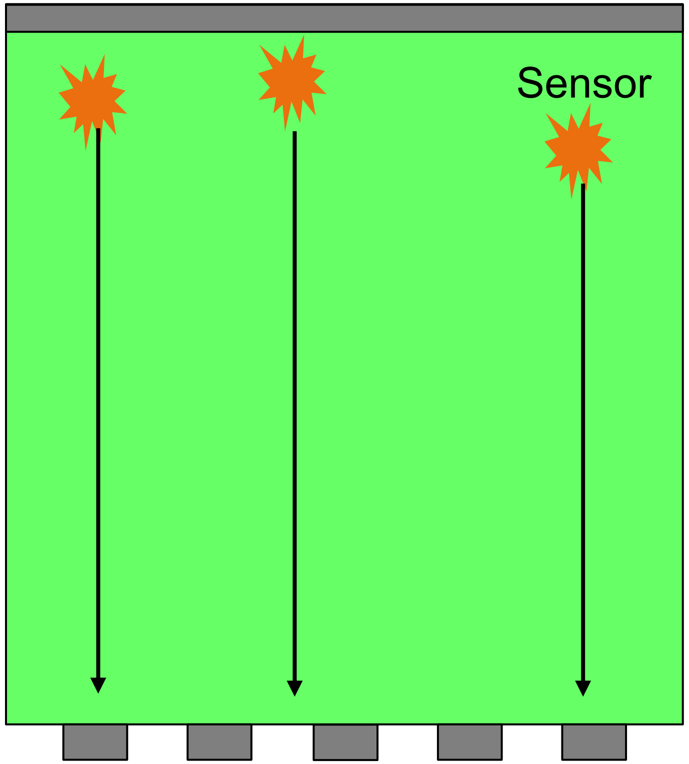
300um Si, hole collection, 200V bias:
~ **10 ns** maximum drift time

High-Z sensors

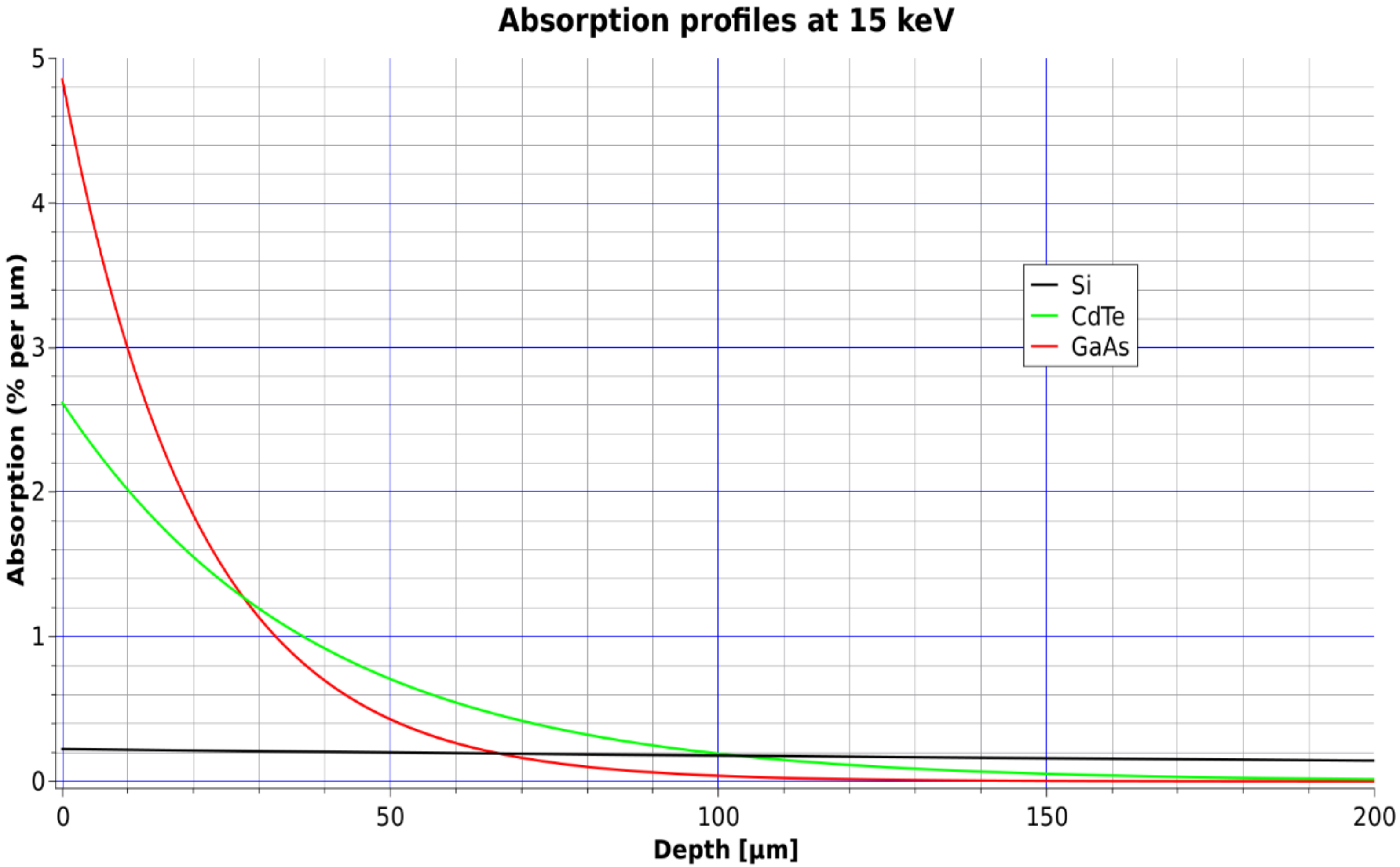


High-Z materials for improved time resolution

> High-Z materials can offer more localized X-ray absorption, improving consistency of drift time



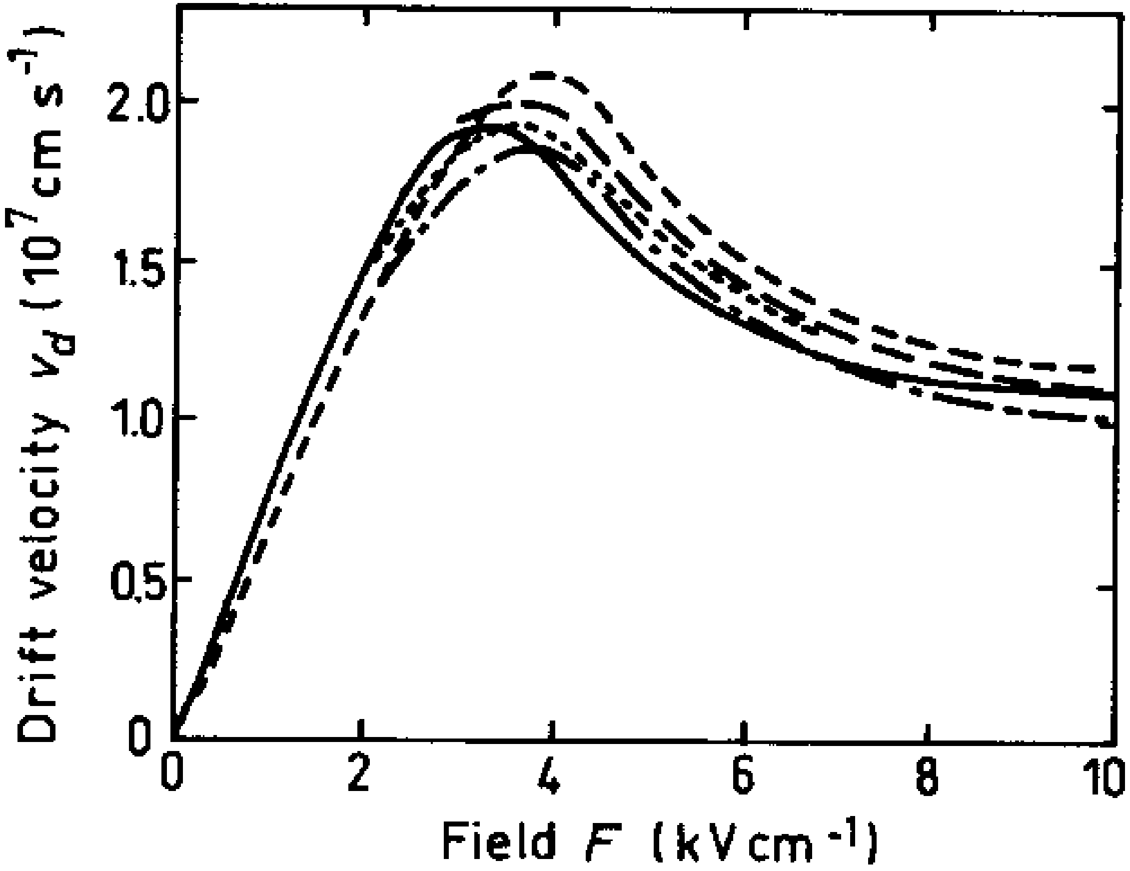
Carriers drift to readout



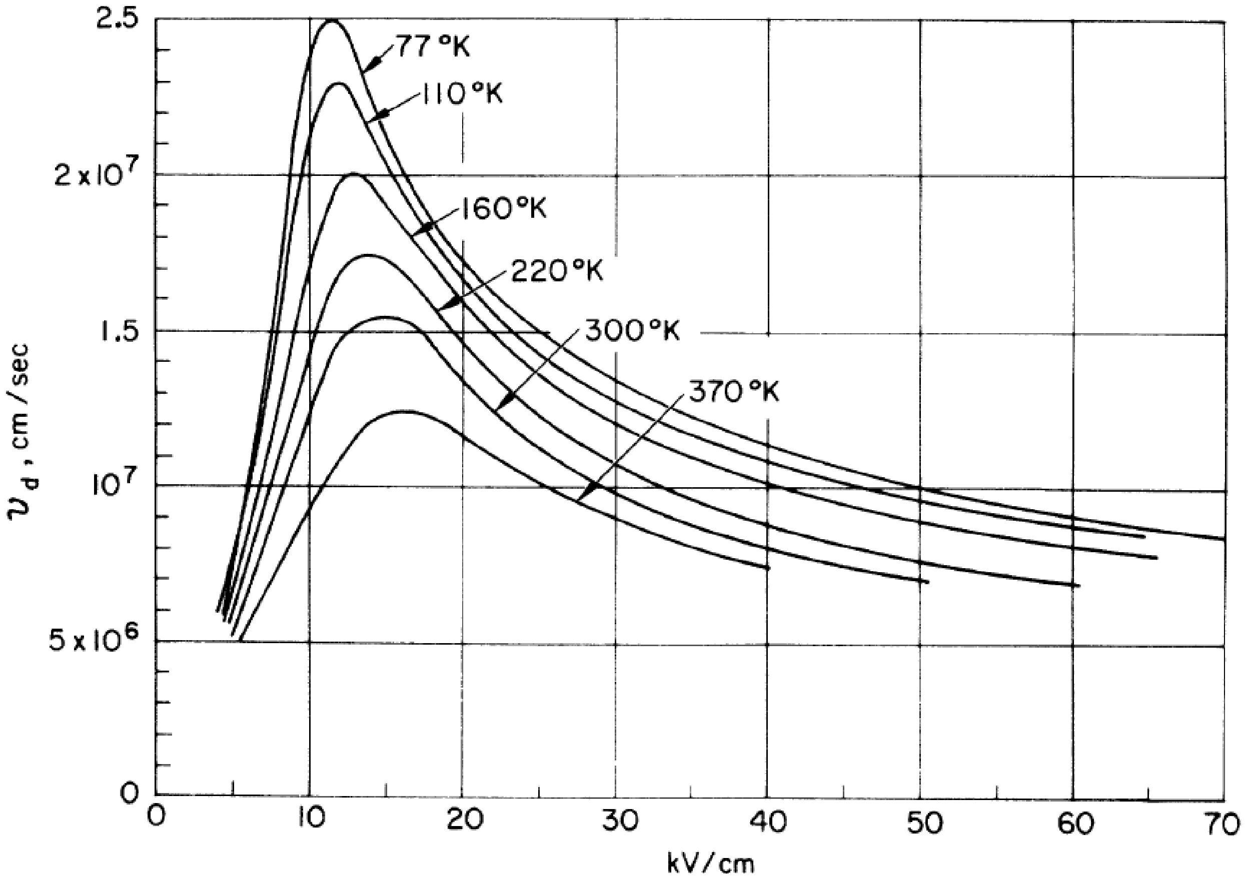
High-Z materials for improved time resolution

- GaAs offers high saturation velocity without requiring excessive operating voltage

GaAs



CdTe



High-Z materials for improved time resolution

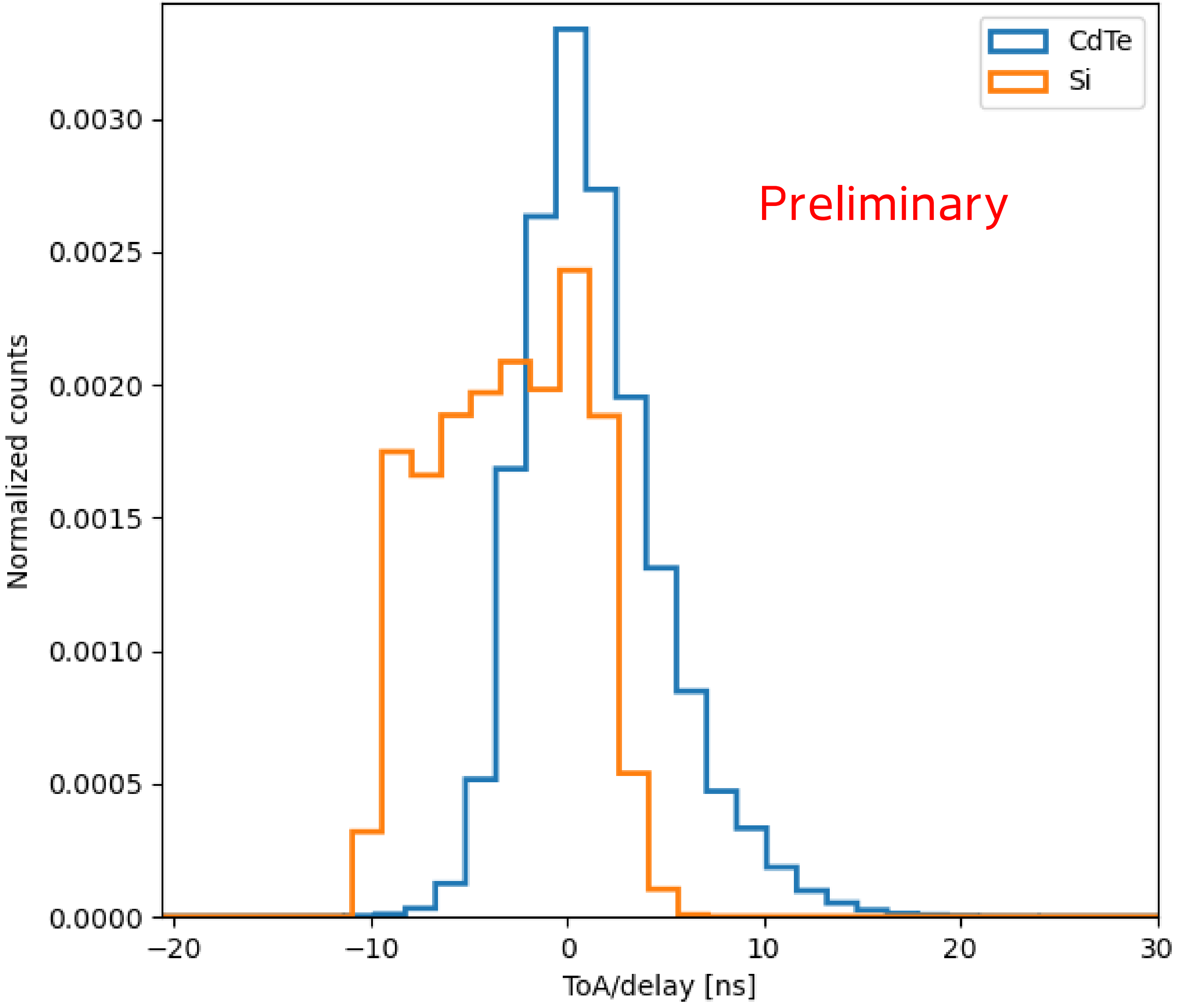
- Estimated drift time variation for different sensors

15 keV photons

	Si (h+), 300 µm, 100V	Si (e-), 300 µm, 300V	CdTe, 1000 µm, 500V	GaAs, 500 µm, 200V
RMS variation	2.86 ns	1,43 ns	0,76 ns	0,12 ns
Mean diff variation	2.46 ns	1,23 ns	0,56 ns	0,09 ns

Comparison between Si and CdTe

Si
300 µm
-200V
11.5 ns FWHM

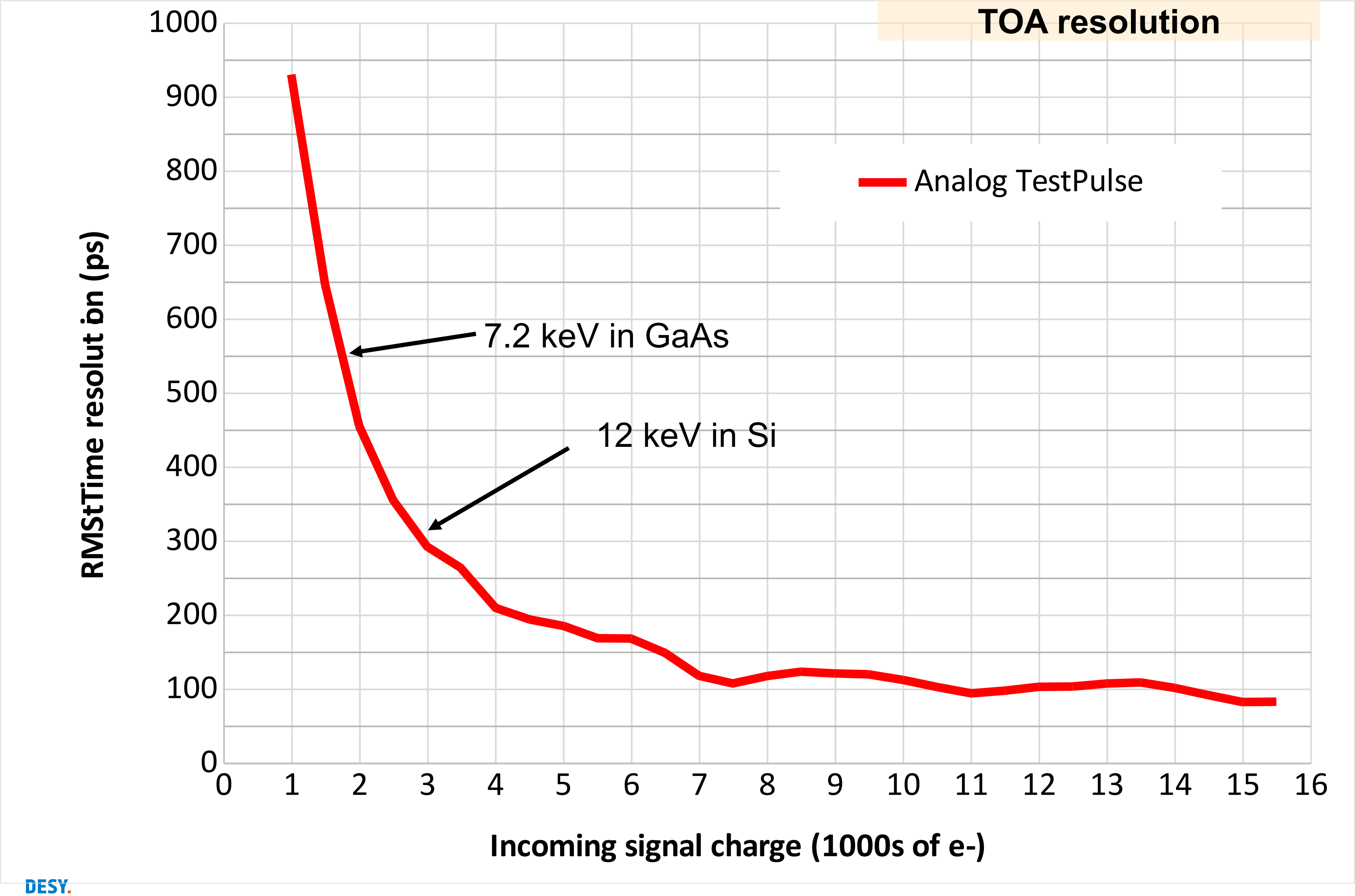


CdTe
1000 µm
-250V
6.2 ns FWHM

NB – Not yet timewalk corrected

Signal magnitude and time jitter

Time jitter



- **Variation in timing due to noise or variability in instant signal**, this depends on peaking time of amplifier response

Timepix4 ASIC time resolution; measured by CERN with internal test pulses

Conclusions

- Timepix's combination of time, spatial and energy resolution enables diverse experiments
- In material characterisation, Timepix offers complementary information to integrating detectors
- Timepix4 and high-Z show strong potential for time-resolved synchrotron experiments
- Please get in touch if you're interested!
  - Jonathan Correa – jonathan.correa@desy.de
  - David Pennicard – david.pennicard@desy.de

Thanks for listening!