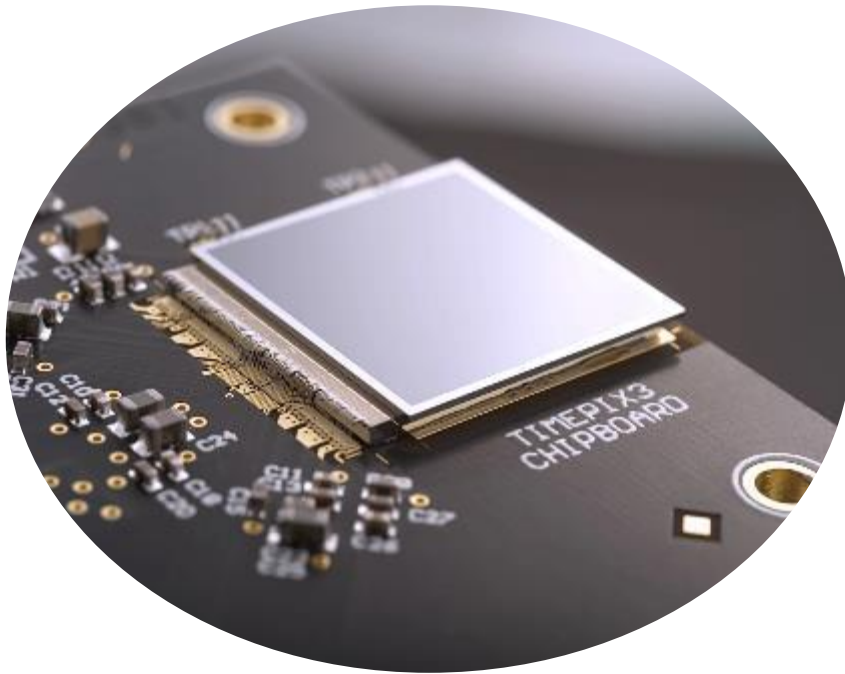


Characterisation of scattered radiation field in interventional radiology theatres



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Supported by KT Medical Application



Introduction

The evaluation of the exposition of the workers is a major issue for radiation protection

⇒ Dose = energy absorbed by unit of mass

$$D = \int_0^{E_{max}} \Psi_E(E) \cdot \left(\frac{\mu_{ab}(E)}{\rho} \right) dE$$


$$\Psi_E(E) = \frac{d\Phi}{dE}(E)dE$$

Fluence function of the energy

Energy absorption coefficient

➡ energy spectrum

Introduction

Nowadays: Lower the dose to the patient's skin

=> Stronger filtration of the X-Ray tube = increase beam hardening

Impact on the exposition of the staff ?



Impact on dosimetry ?

Impact on the radiation protection gear / shielding ?

Characterisation of the radiation fields by energy spectrum

Introduction

Energy spectrum with Hybrid Pixel Detector

=> Raw data

= retrospective approach

New tool to help to manage the occupational radiation risks

In this study:

- Characterisation of the detector
 - Measurements in controlled conditions
 - Measurements in clinical conditions
 - What still has to be done before having a useful tool?
- } Proof of concept

Hybrid Pixel Detector - HPD

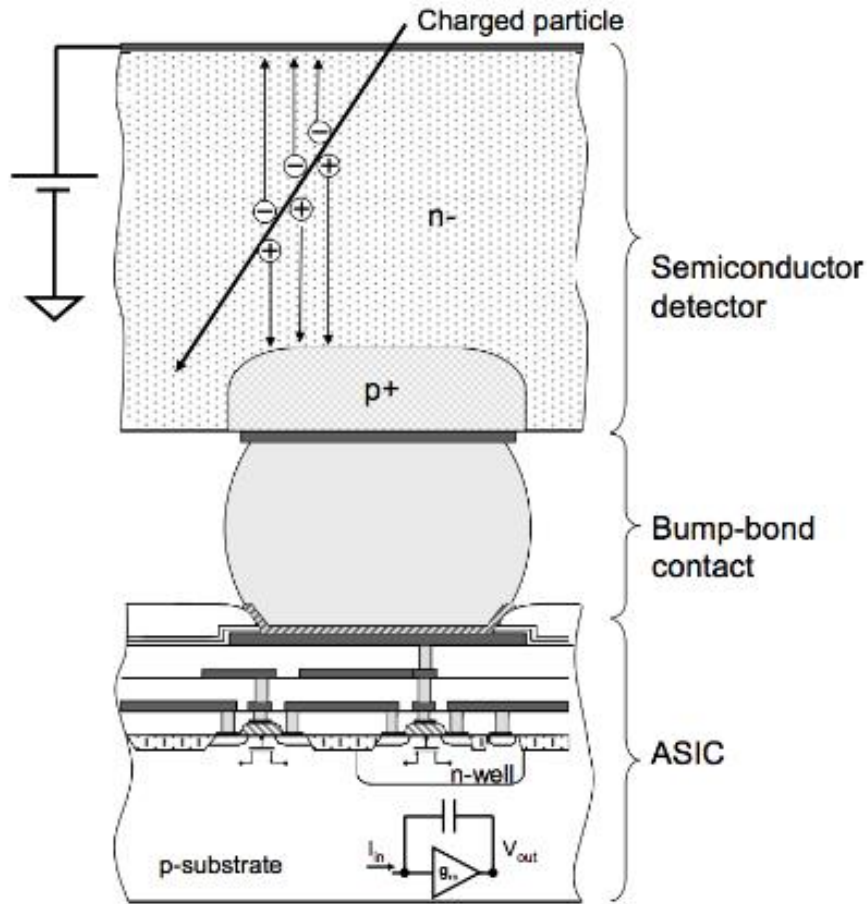
Timepix3



Timepix3 specification

Pixel size	55 μm x 55 μm
Pixel matrix	256 x 256
Minimum time resolution	1.56 ns
Data driven readout	Dead time free for a maximum hits rate of 40 Mhits.cm ⁻² .s ⁻¹

Hybrid Pixel Detector - HPD



- HPD = Readout chip and sensor
- processed in different substrates
 - Connected to form the detection and imaging system

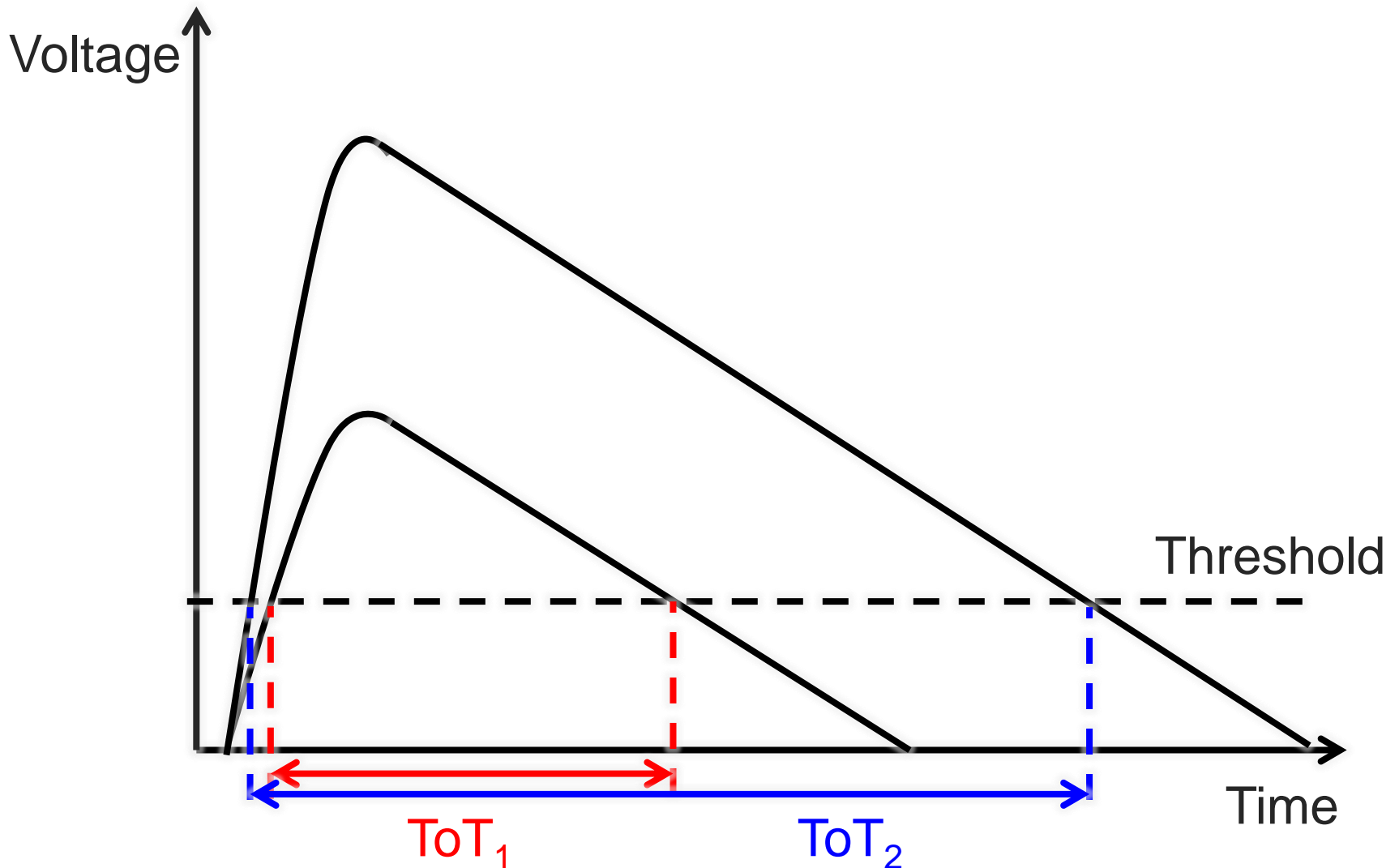
Ballabriga, R. The Design and Implementation in 0.13 μ m CMOS of an Algorithm Permitting Spectroscopic Imaging with High Spatial Resolution for Hybrid Pixel Detectors. (Universitat Ramon Llull, 2009).

Timepix3



- Spatial information
- Temporal information
- Time over threshold

Time over Threshold - ToT



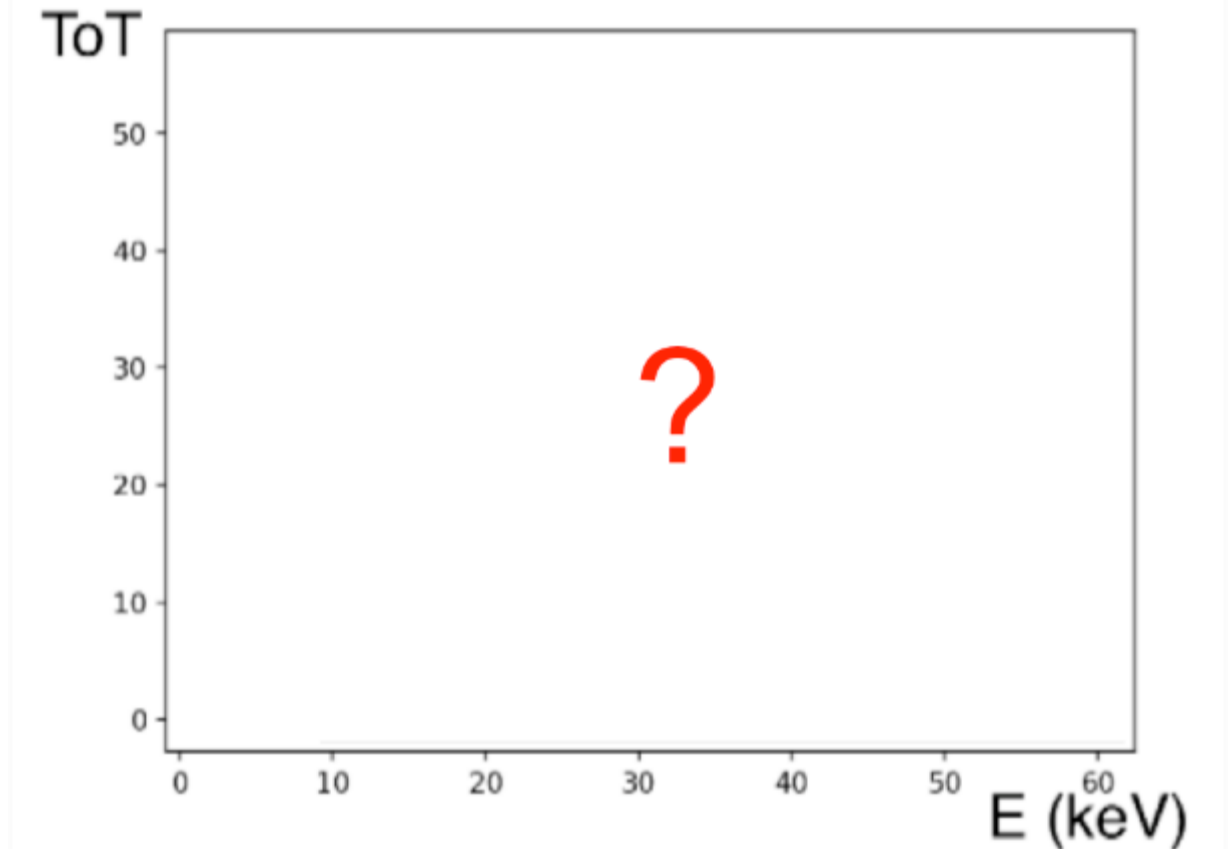
Calibration curve

Sources:

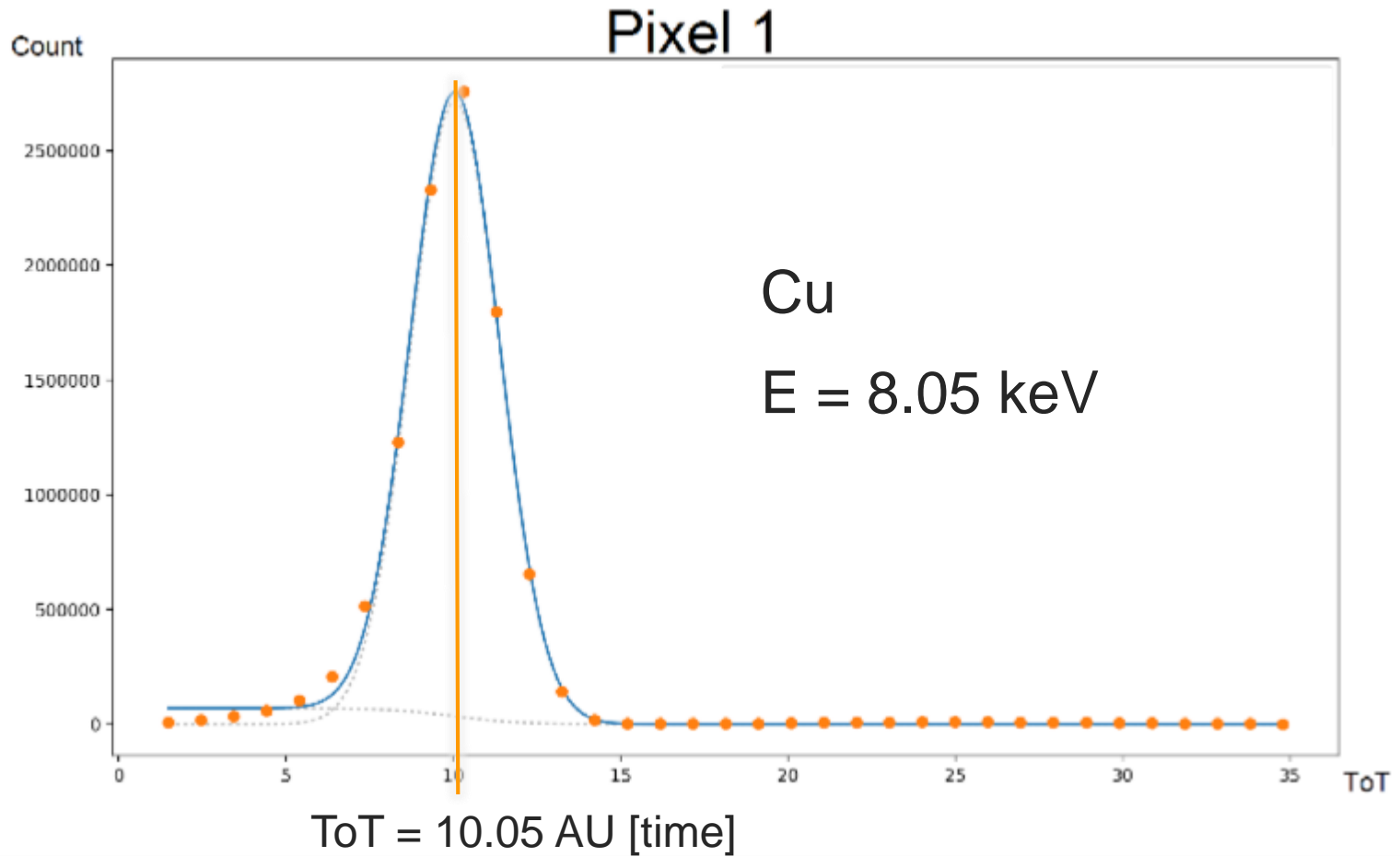
- Am-241
- Fe-55

X-ray fluorescence
from metallic foils:

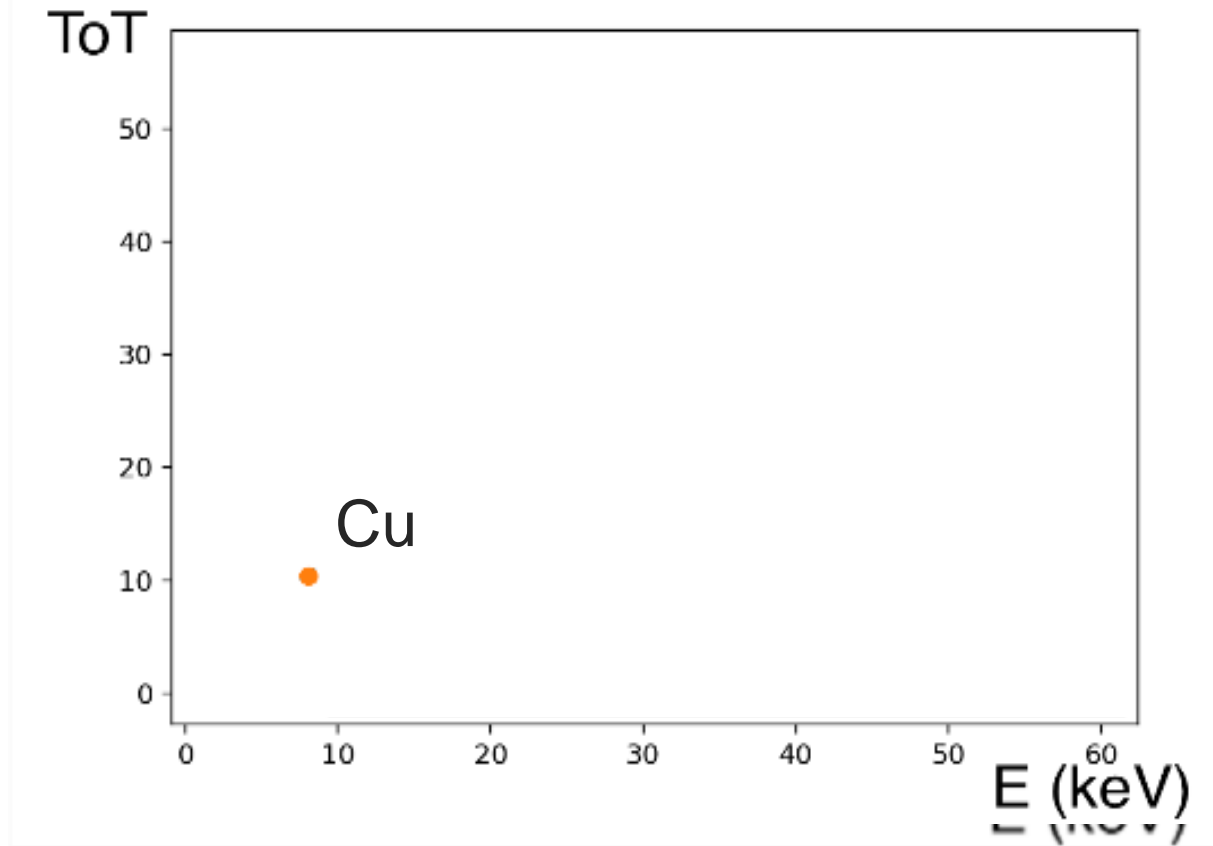
- Ag
- Ca
- Cu
- Mn
- Mo
- Sn
- Ti
- Zr



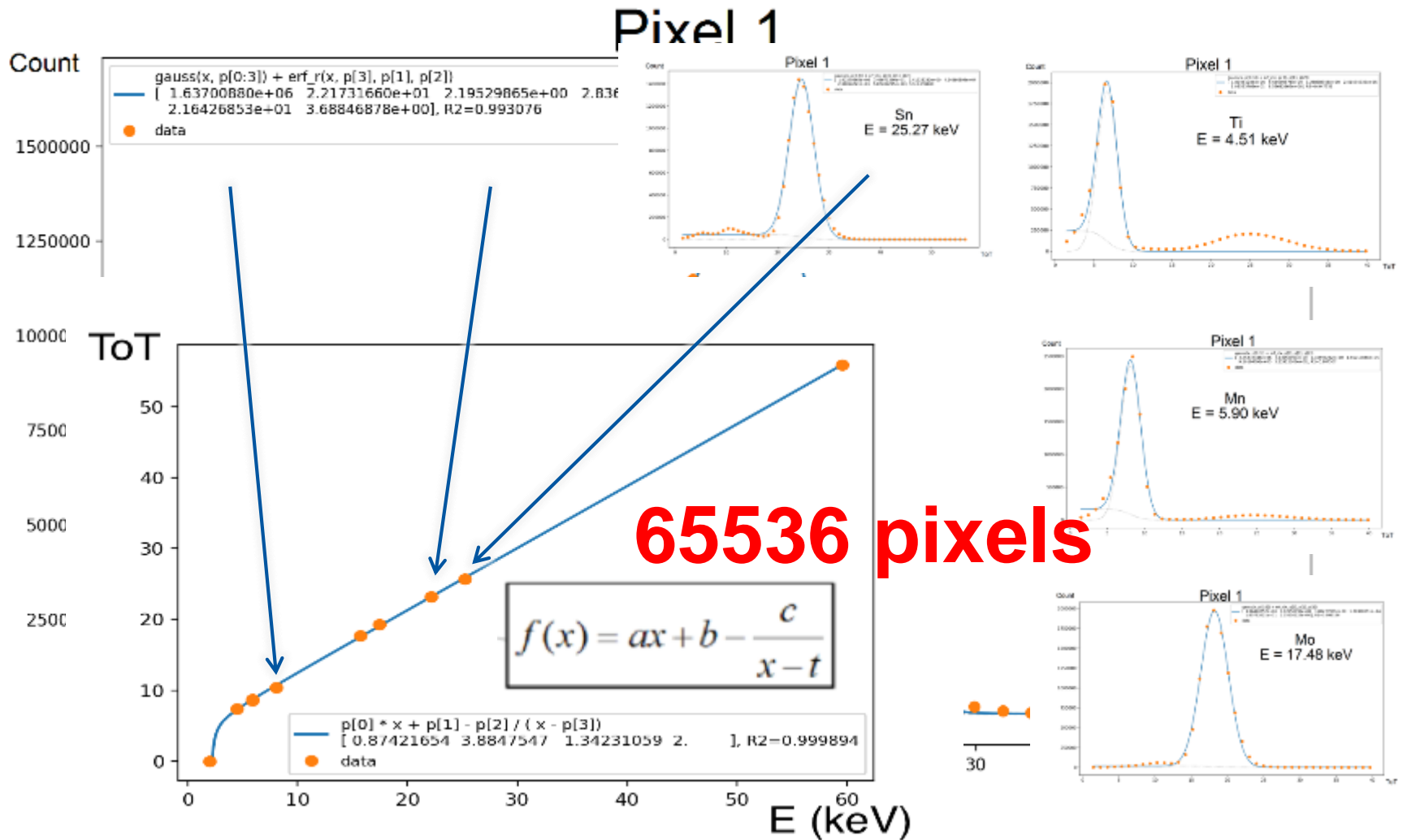
Calibration curve



Calibration curve



Calibration curve



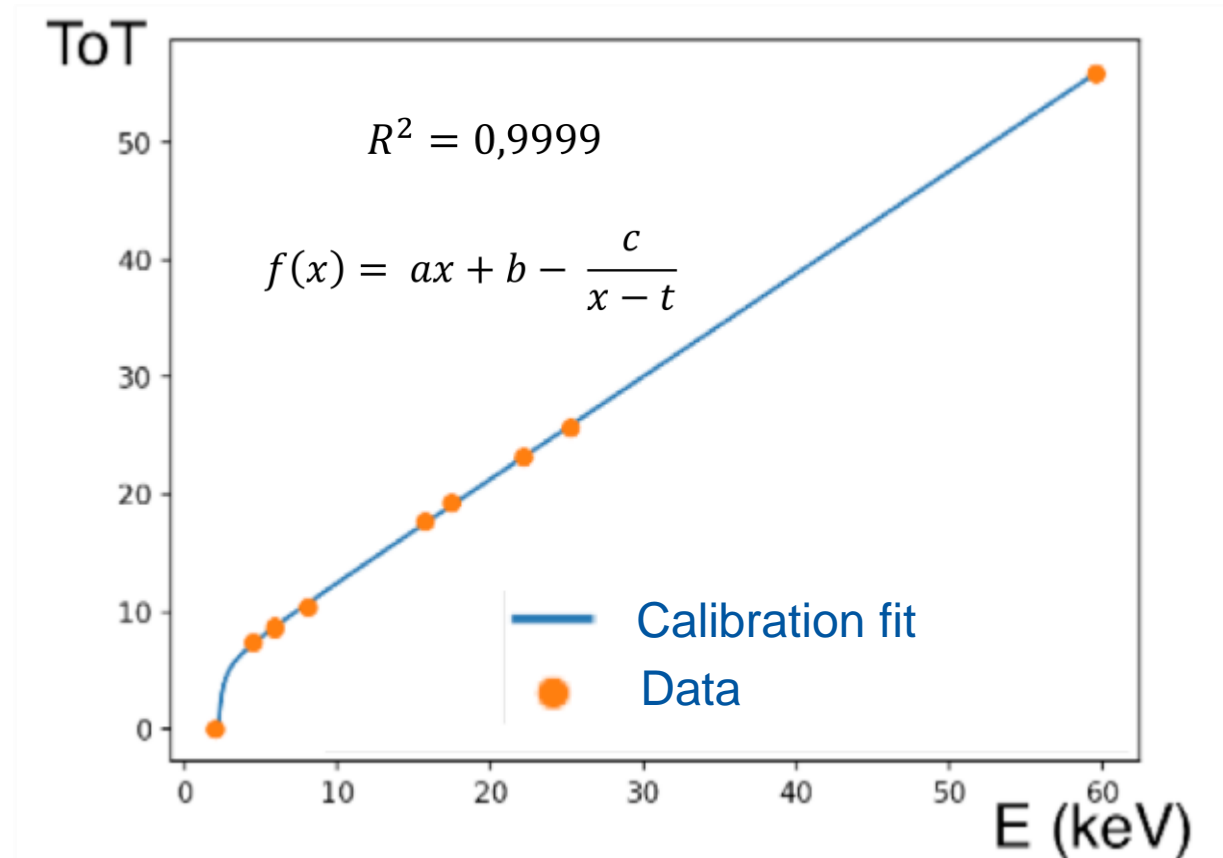
Calibration curve

Sources:

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- Fe-55

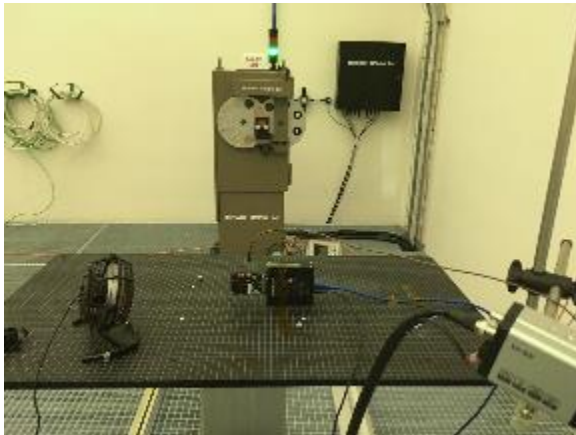
X-ray fluorescence
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- Ag
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Jakubek, Jan. "Precise energy calibration of pixel detector working in time-over-threshold mode." Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 633 (2011): S262-S266.

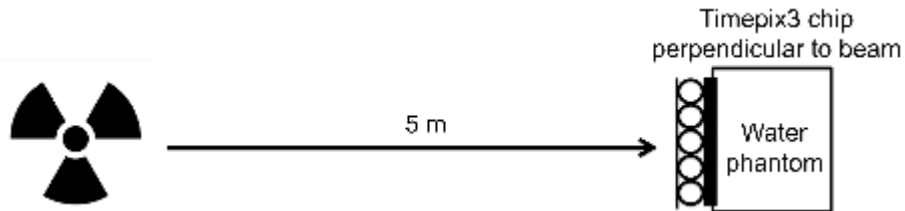
Measurement under controlled conditions



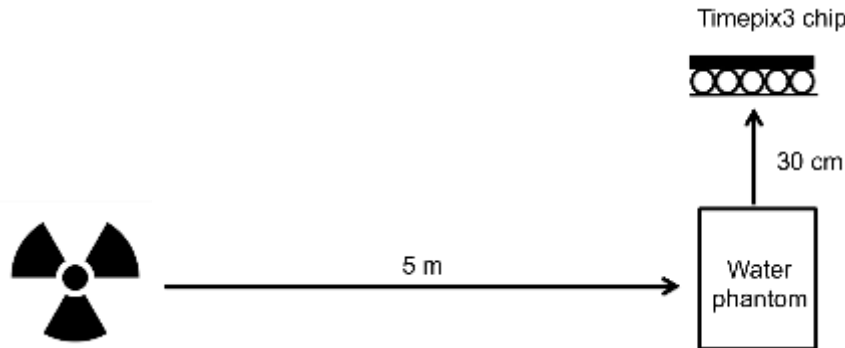
CERN – Irradiator facilities – bat 72

Measurement under controlled conditions

Measurement in the primary beam:

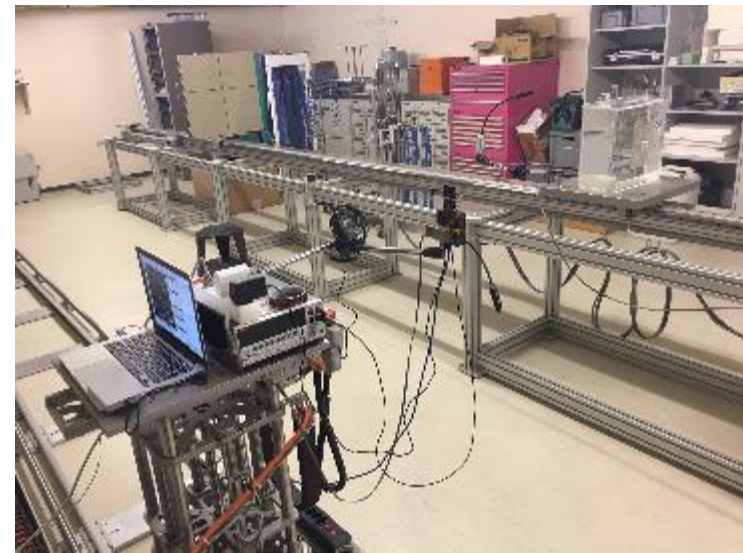


Measurement in the scattered radiation field:



Toshiba installation; Tungsten anode (Institute of Radiation Physics – Lausanne – CH)

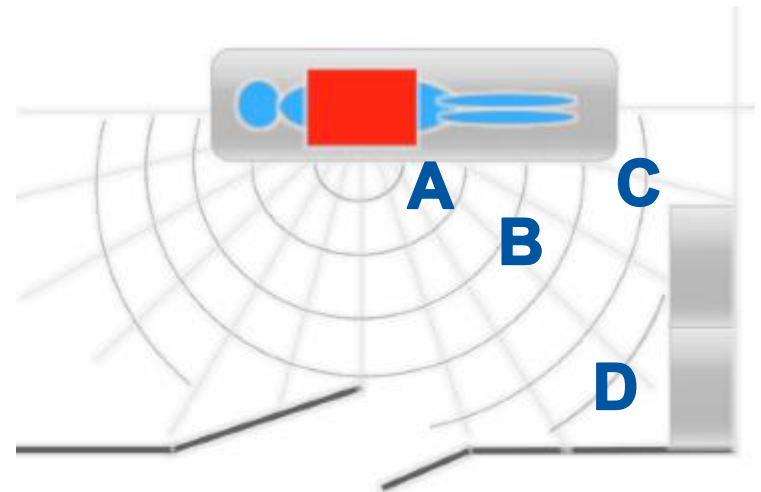
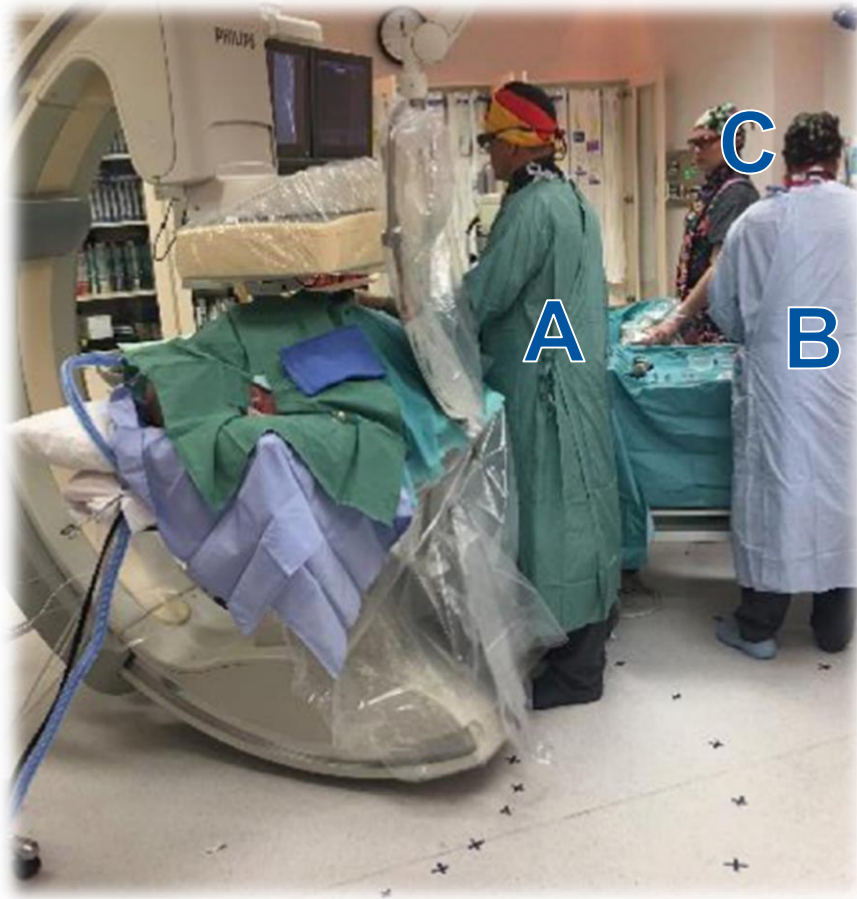
- 60 and 120 kVp
- From 10 mA to 160 mA



Measurement in interventional radiology theatre



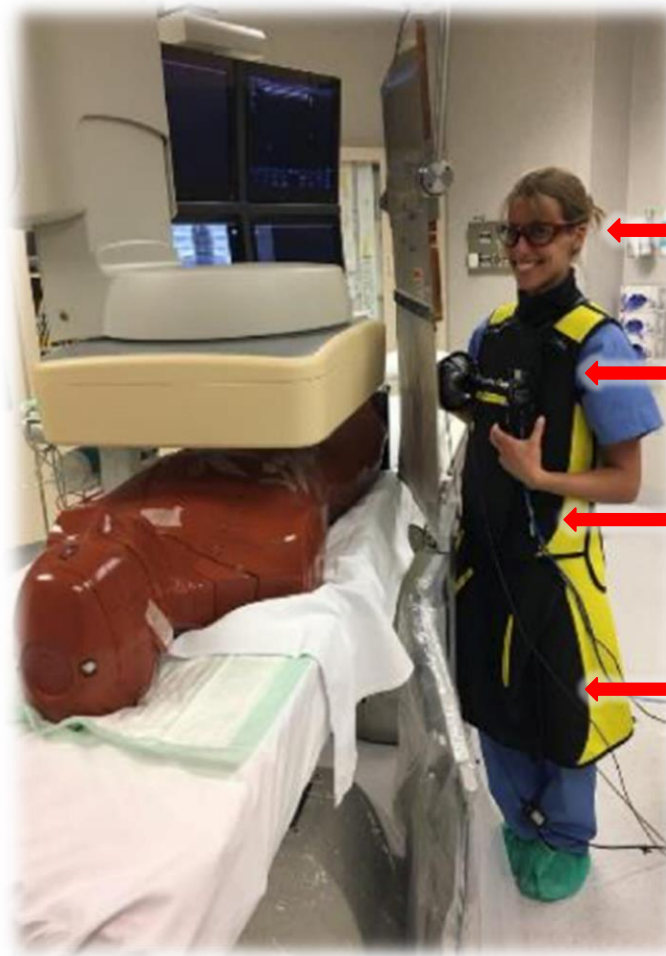
Measurement setup



Measurement setup

Protocol:

- Pelvis/Iliac
 - 3 fps
 - 74 kVp
 - 12.0 mA
- Normal dose protocol
 - 0.4 mm Cu + 1 mm Al
- Standard patient (70 kg)



Reference man: 1.76 m

← Eye lens - 170 cm

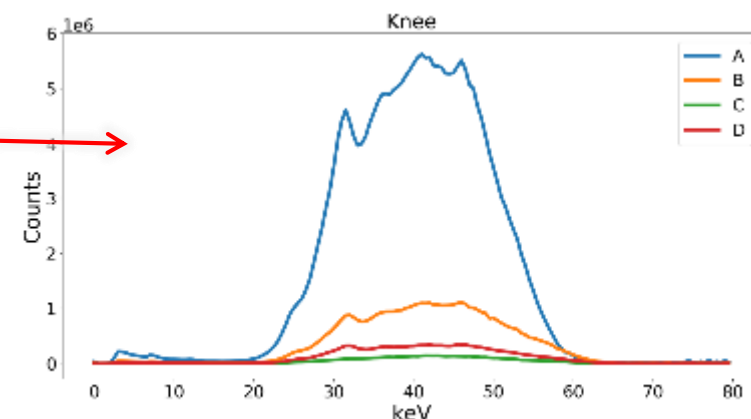
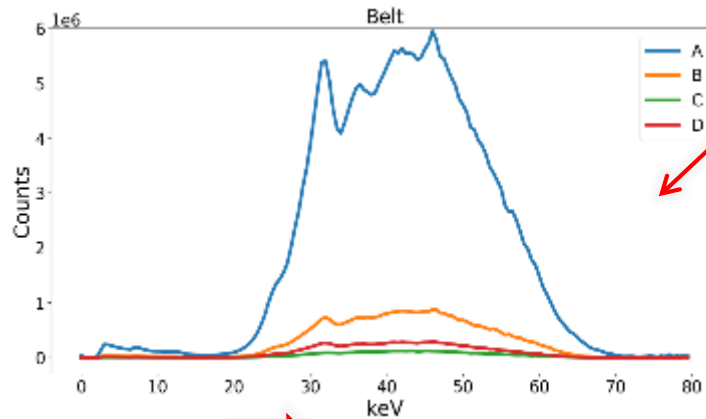
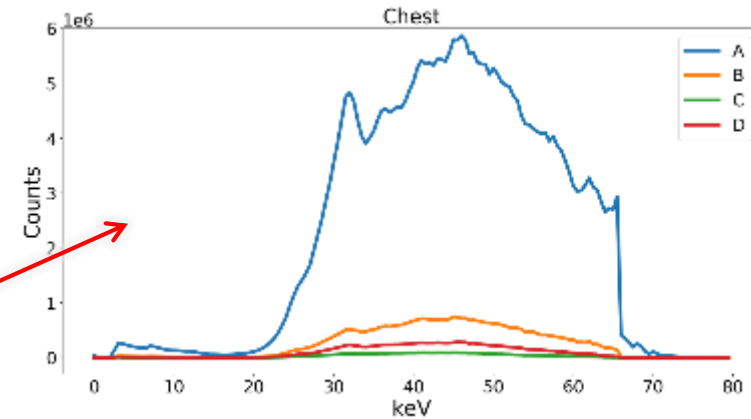
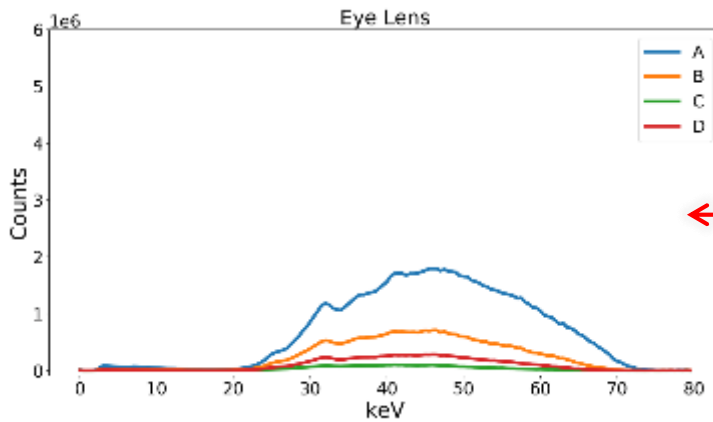
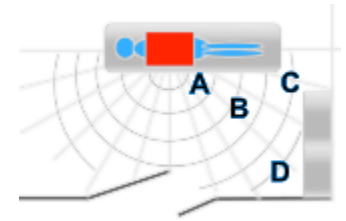
← Chest - 135 cm

← Belt - 96 cm

← Knee - 53 cm

Results

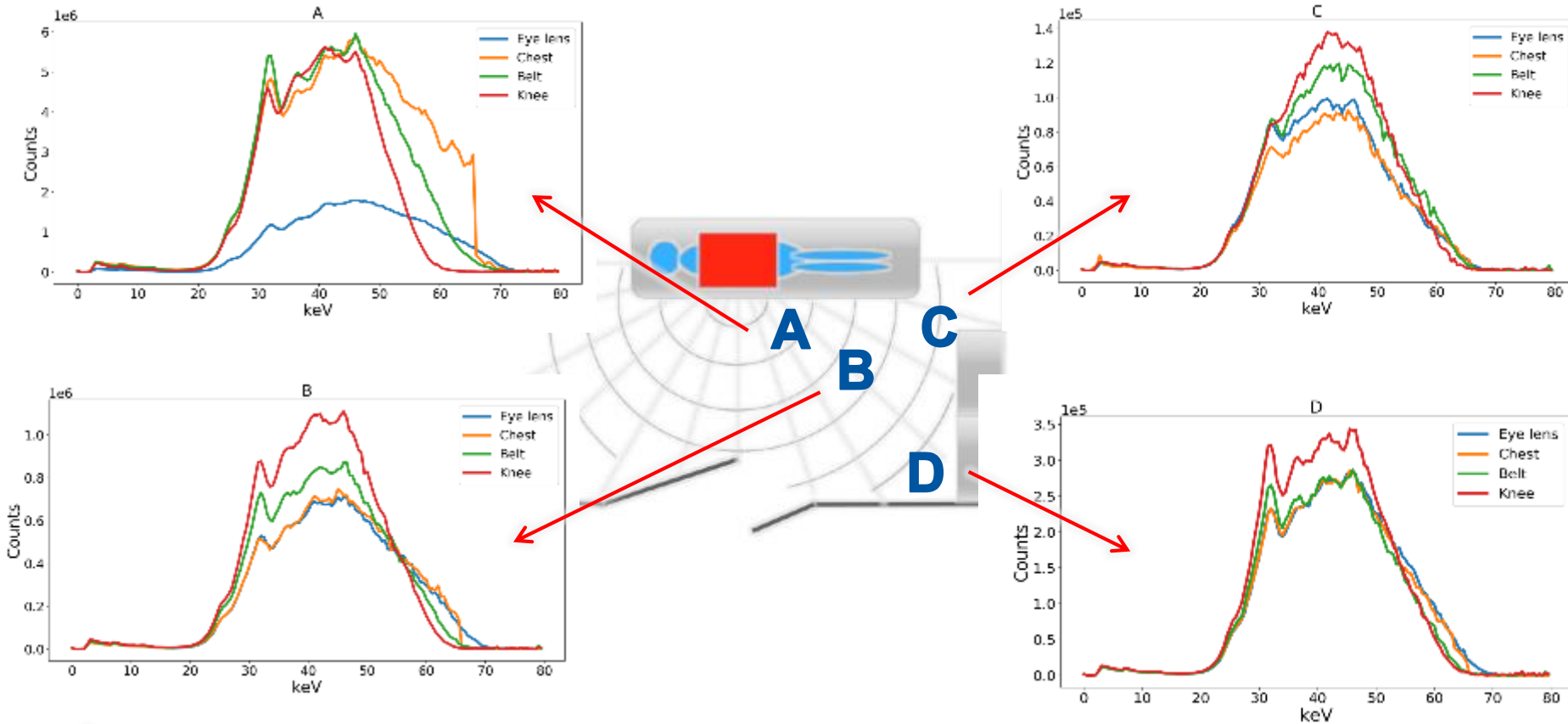
Energy spectra for each medical staff at a given height



 A difference in fluence is observed for each staff member

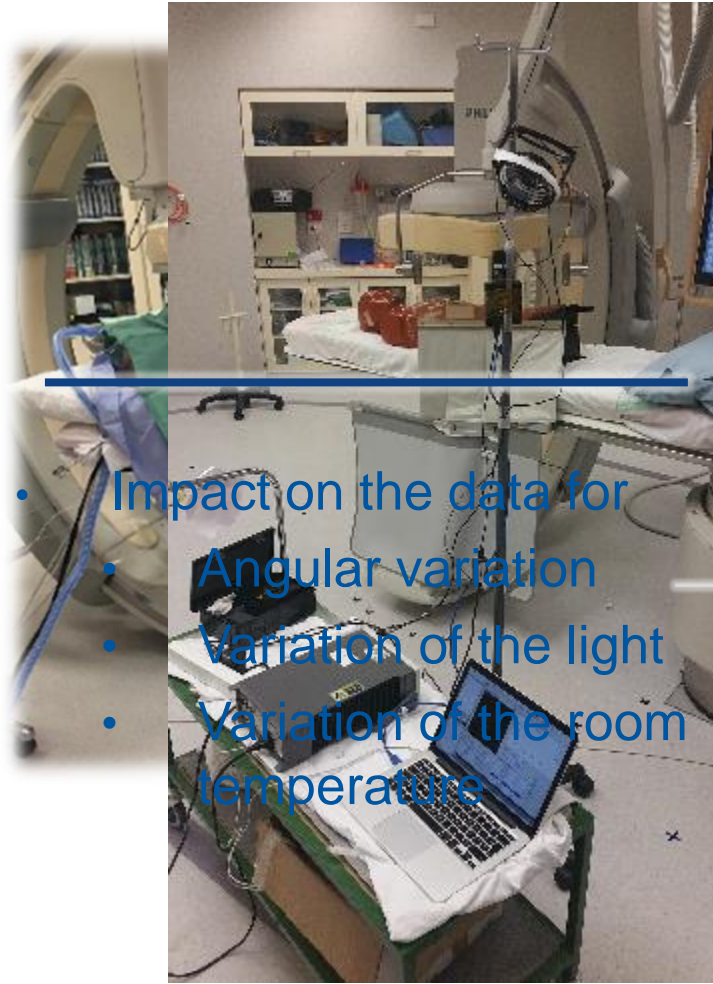
Results

Energy spectra for each height for a given person



➔ Shift in energy from head to toes on position A = non homogenous exposure

Perspectives



- Impact on the data for
 - Angular variation
 - Variation of the light
 - Variation of the room temperature

ation



Conclusion

- We validated the proof of concept:
 - The **scattered radiation** field has been **characterised** in an hospital theatre
 - This new approach allows to **characterise and to compare** the different **energy spectra** to which staff members are exposed
 - guide practitioners in choosing the appropriate radiation protection gear
 - This tool provides on the fly information on the homogeneity of the radiation field
- Next steps:
 - Compare result with gold standards
 - Metrological traceability
 - Convert the measured energy spectrum to a dose, then compare the dose obtained with the Timepix3 to a dose obtain with TLDs



**Institut
de radiophysique**