From Galileo Galilei to Computer Tomography

Georgy Shelkov (JINR,DLNP)

JINR AYSS Conference 30 October 2024

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My personal point of view on some facts in the history of Science

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Outline:

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My personal point of view on some facts in the history of Science

Outline:

- Introduction.
- History of the discovery of X-rays and the idea of X-ray tomography.
- Implementation of the idea of computed tomography.
- Trends in the development of computed tomography.
- Conclusion.

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Which invention of Humanity or Mankind most significantly distinguishes us now from all other animals on Earth?

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Ability to record the results of their activities!

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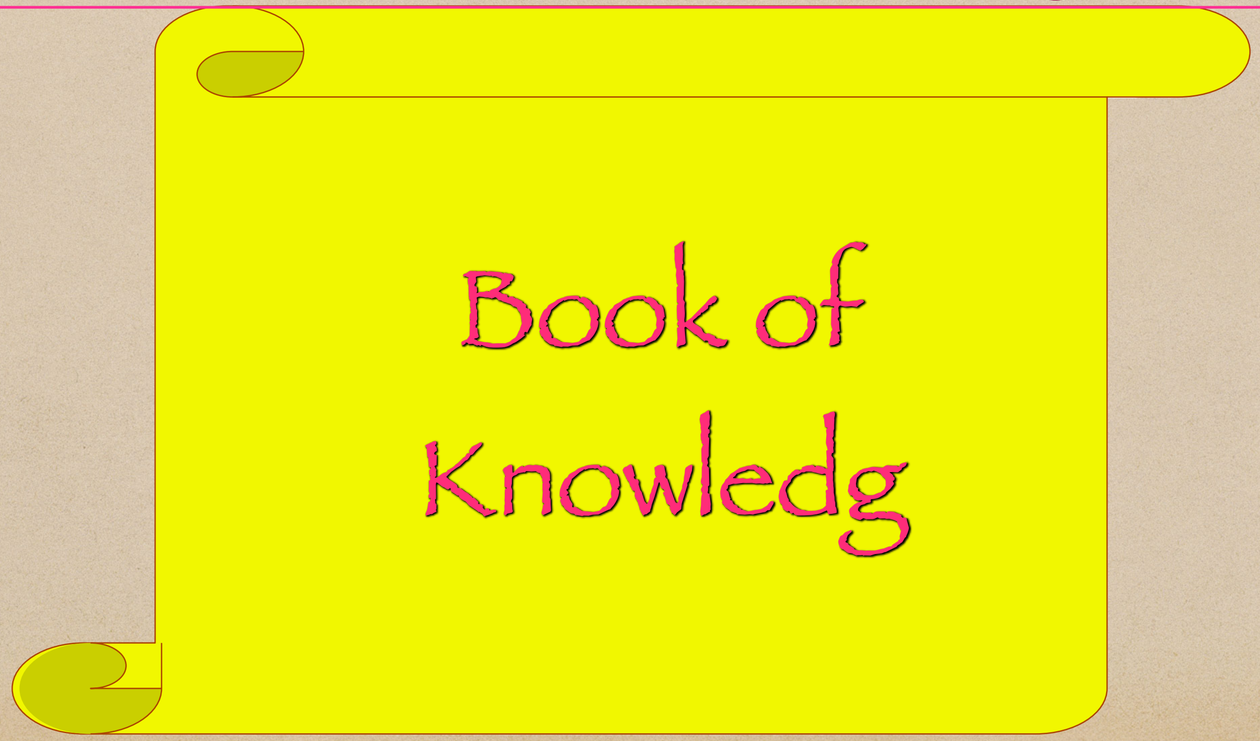

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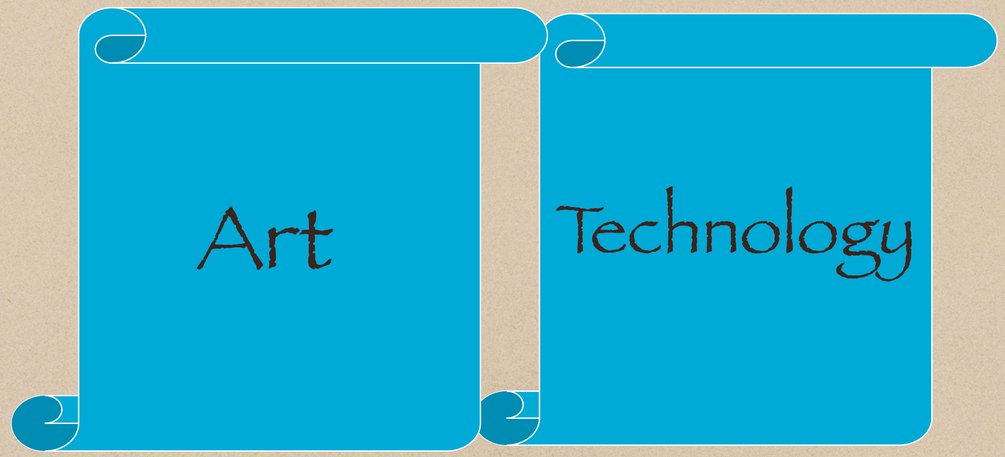

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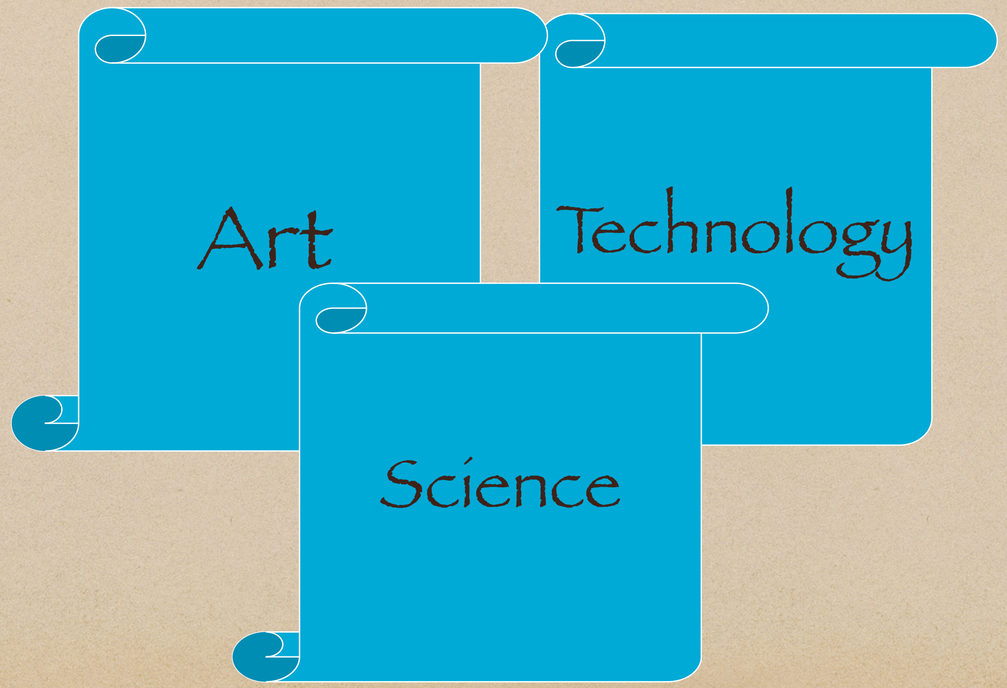

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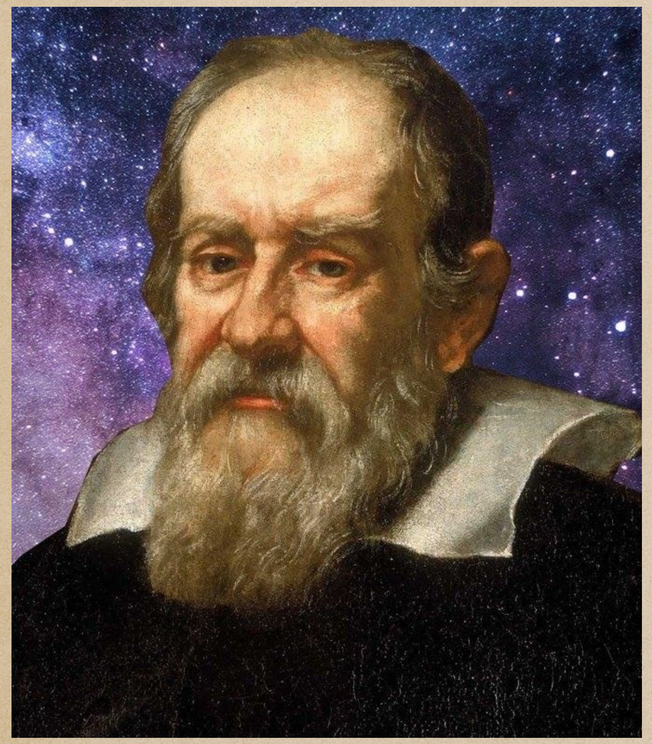

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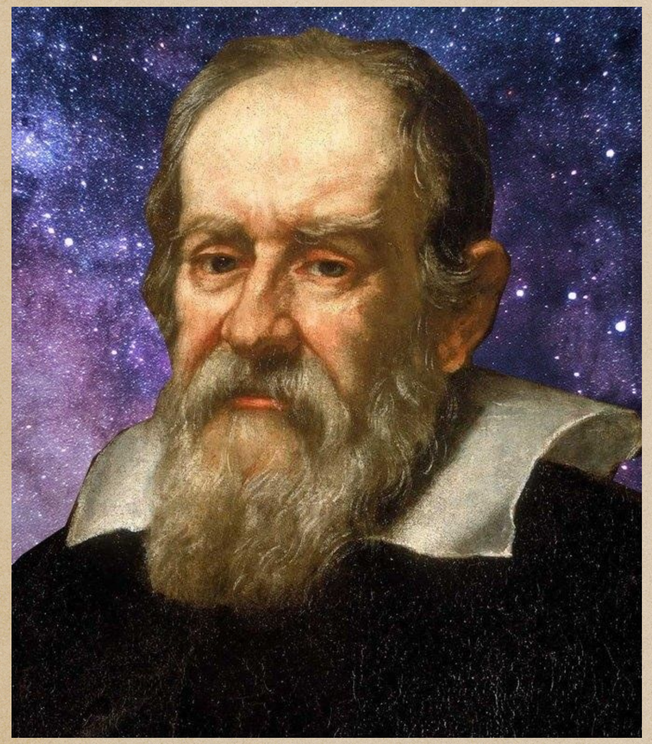

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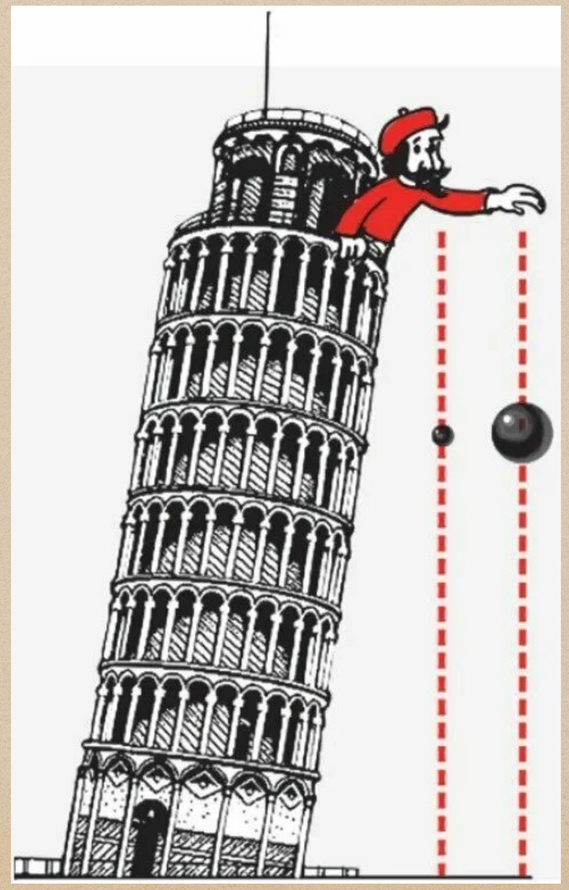

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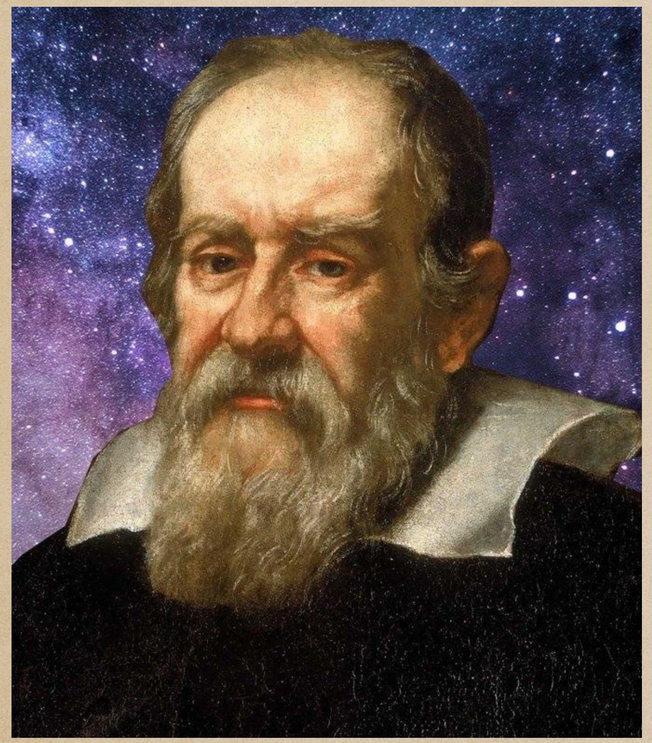

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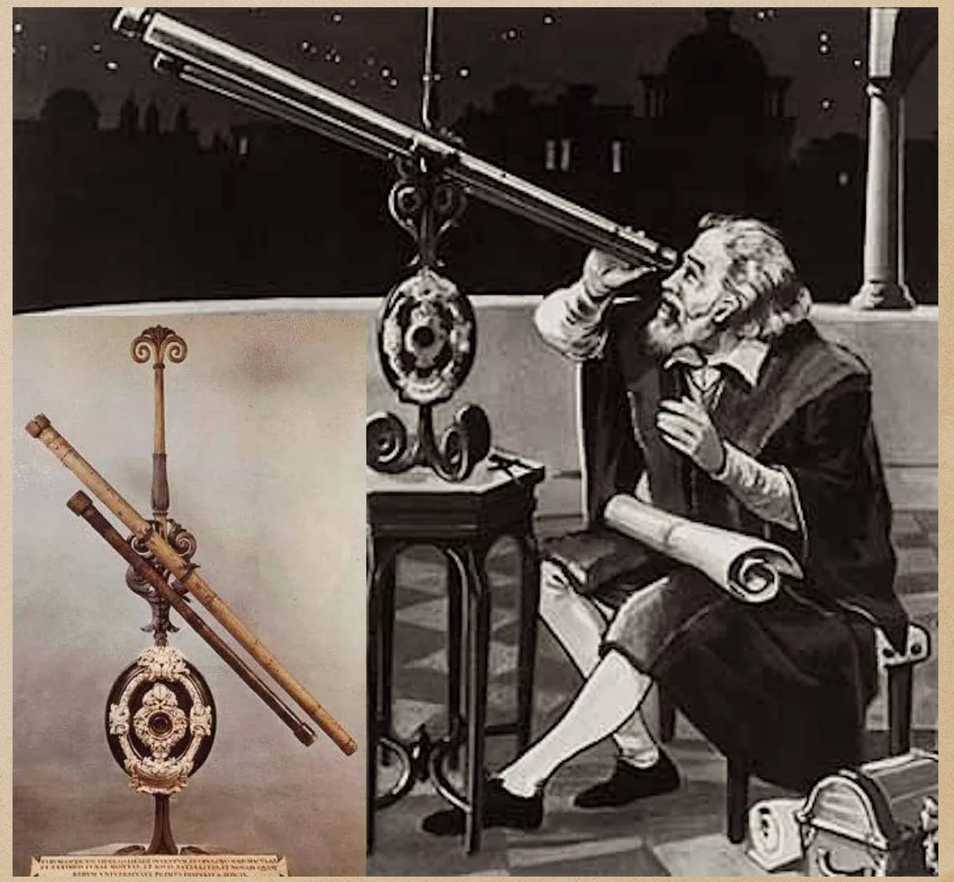

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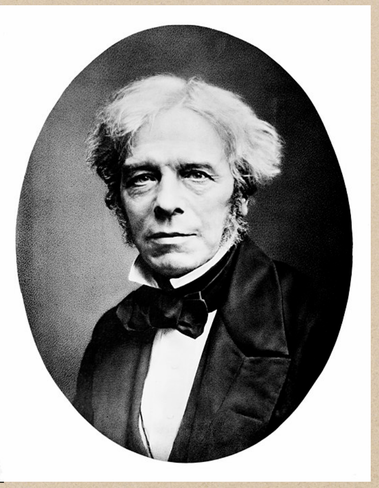

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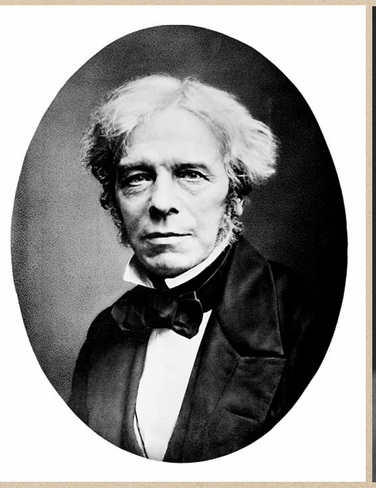

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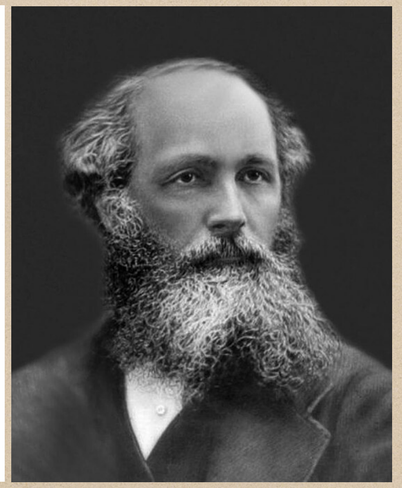

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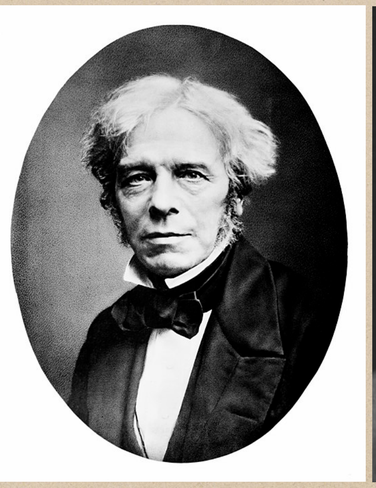

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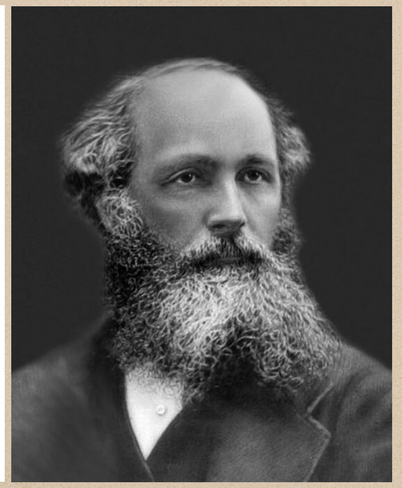

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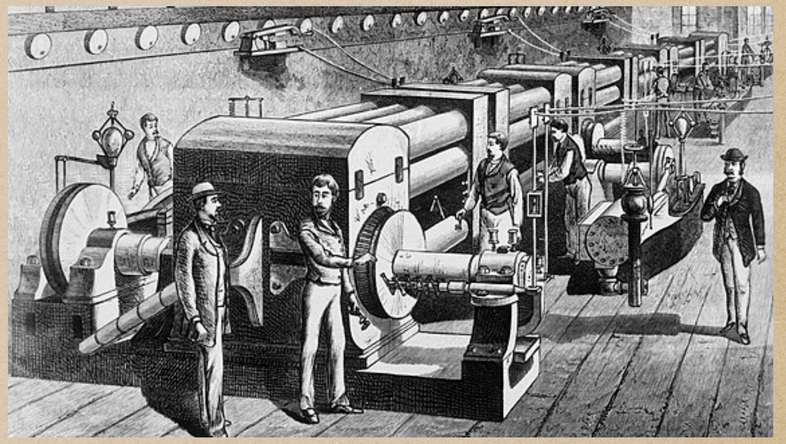

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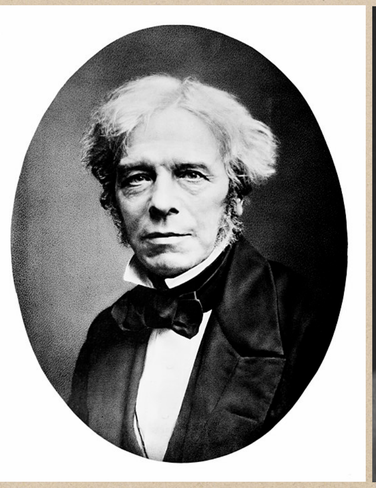

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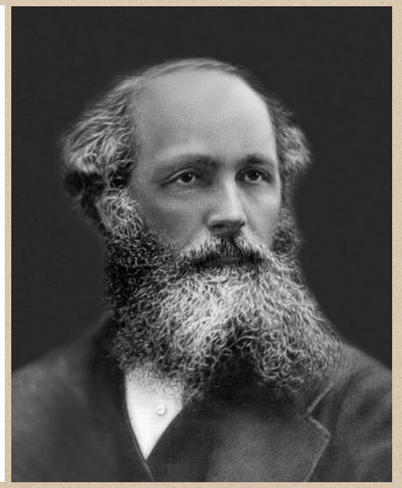

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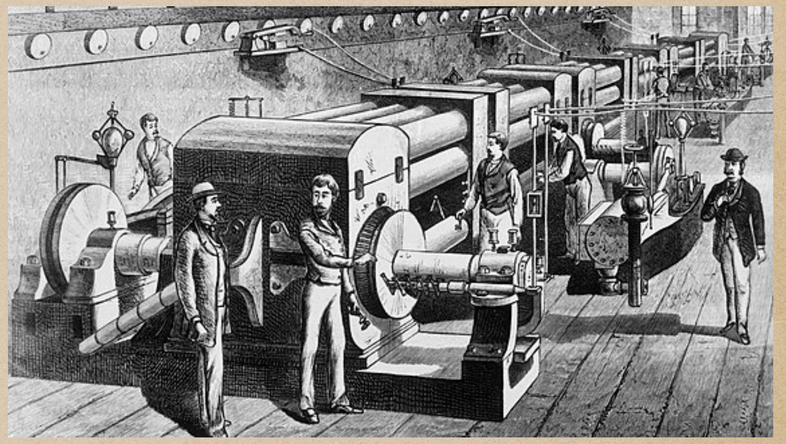

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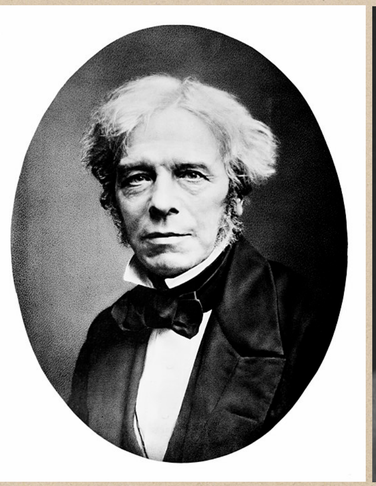

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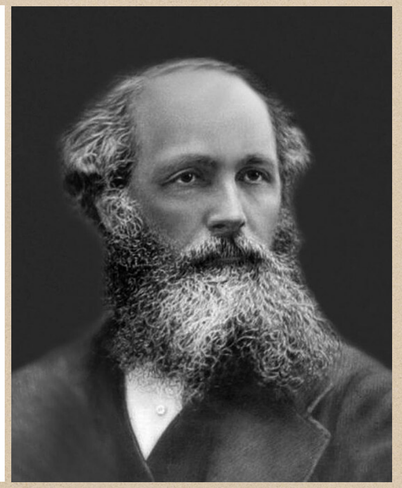

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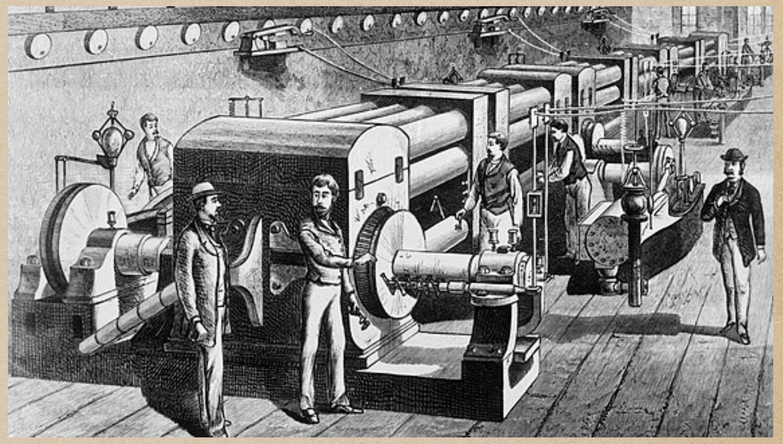

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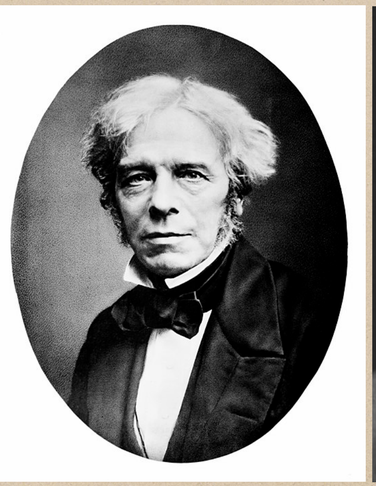

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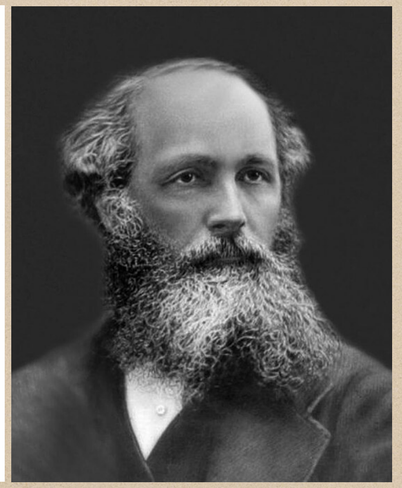

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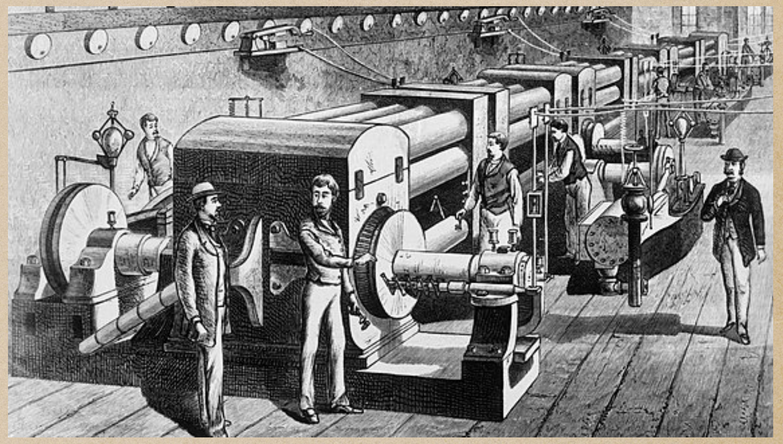

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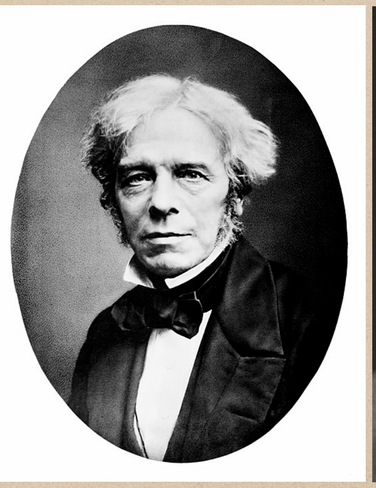

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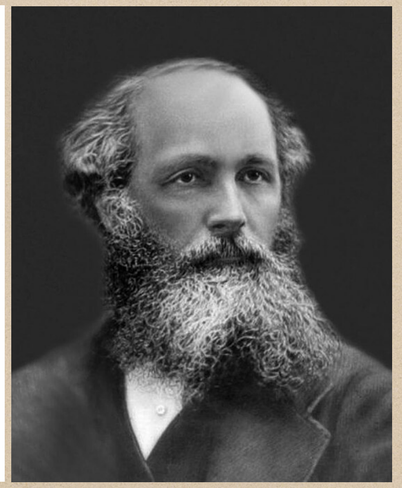

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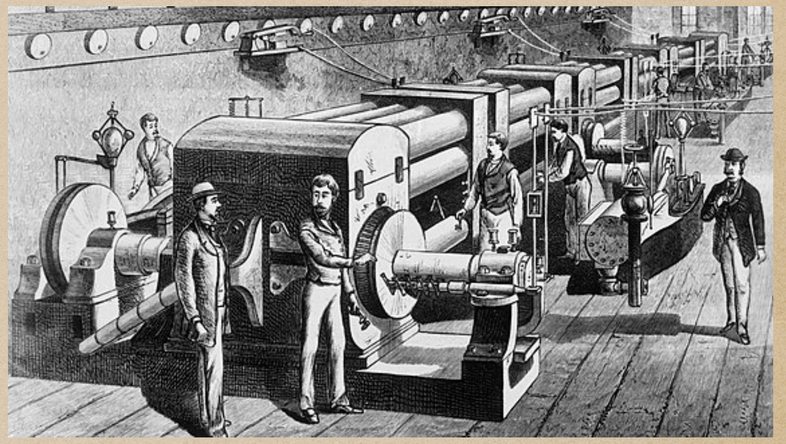

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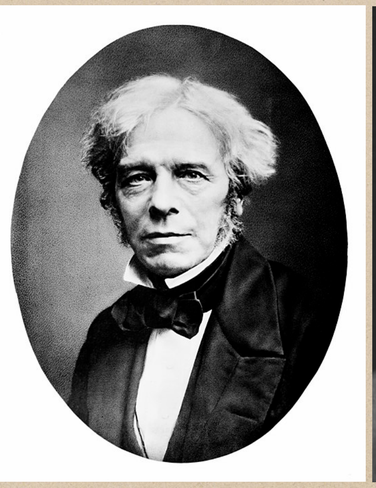

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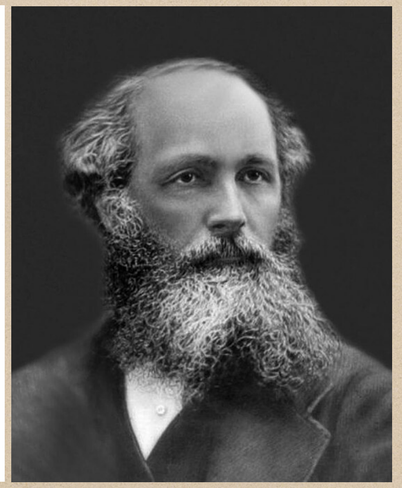

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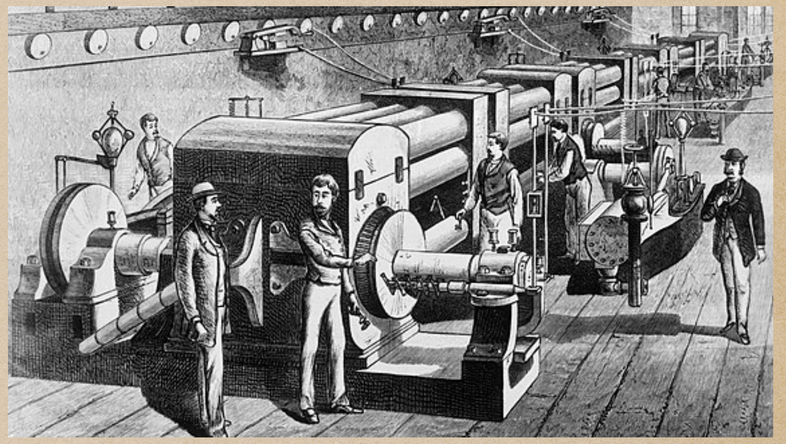

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Semiconductors and so on…

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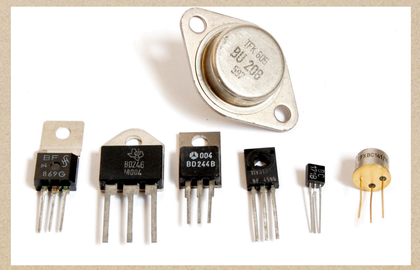
~10 y only !!

First transistor plant ~1960



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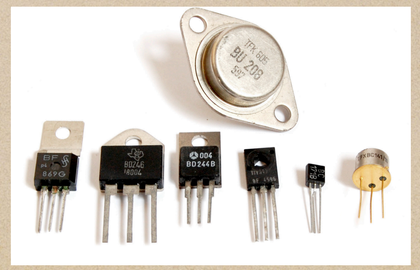

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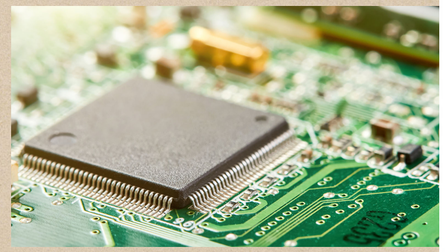

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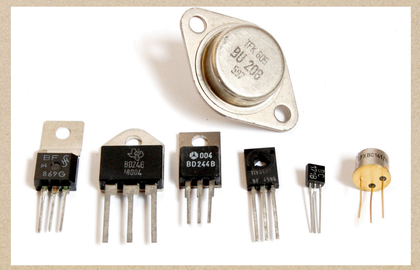

2024

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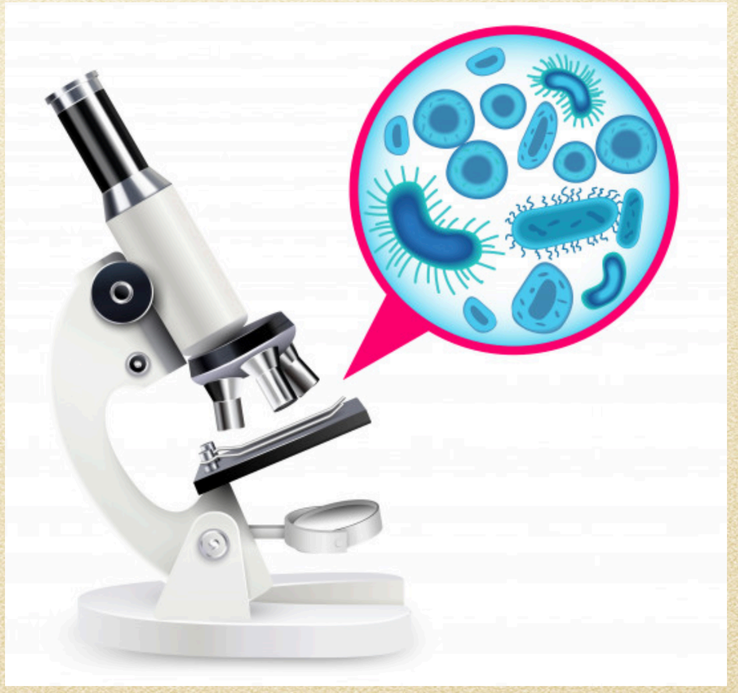

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1971. Clinical trials of the first CT scanner

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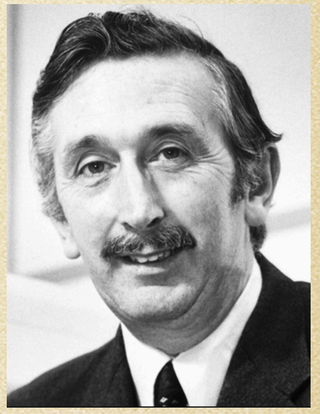

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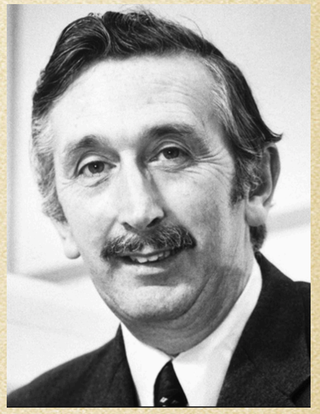

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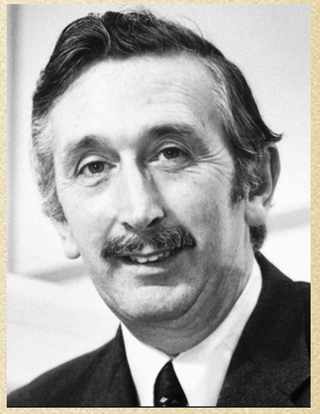

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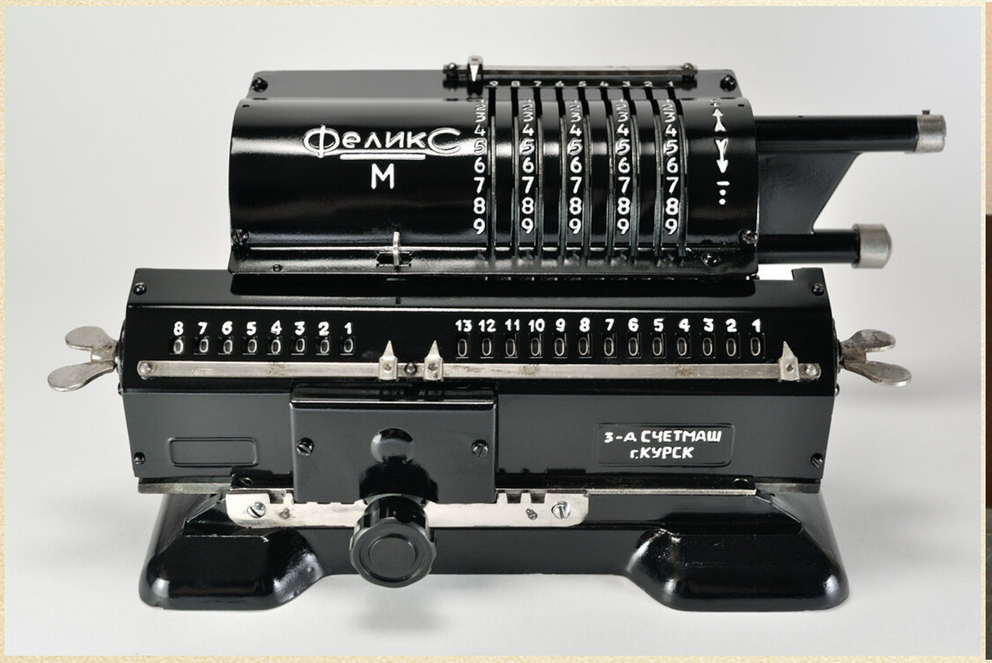
“Computers” in the first half of the 20th century



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The latest achievements of science and technology were and are still being used in the creation of CT scanners !!

How a 2D X-ray image differs from a 3D CT scan ?

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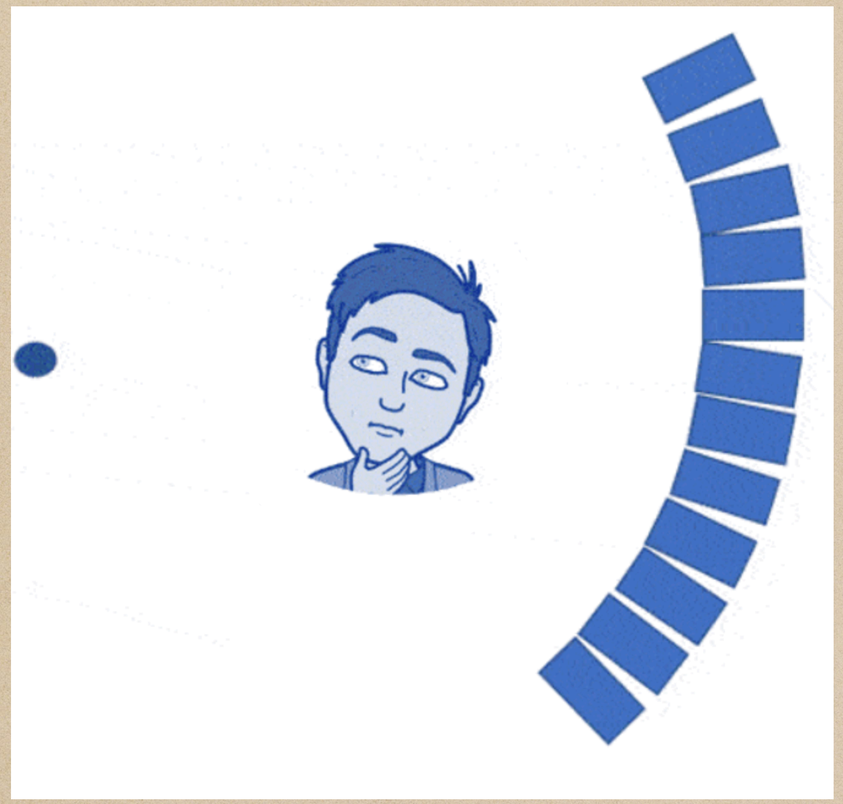

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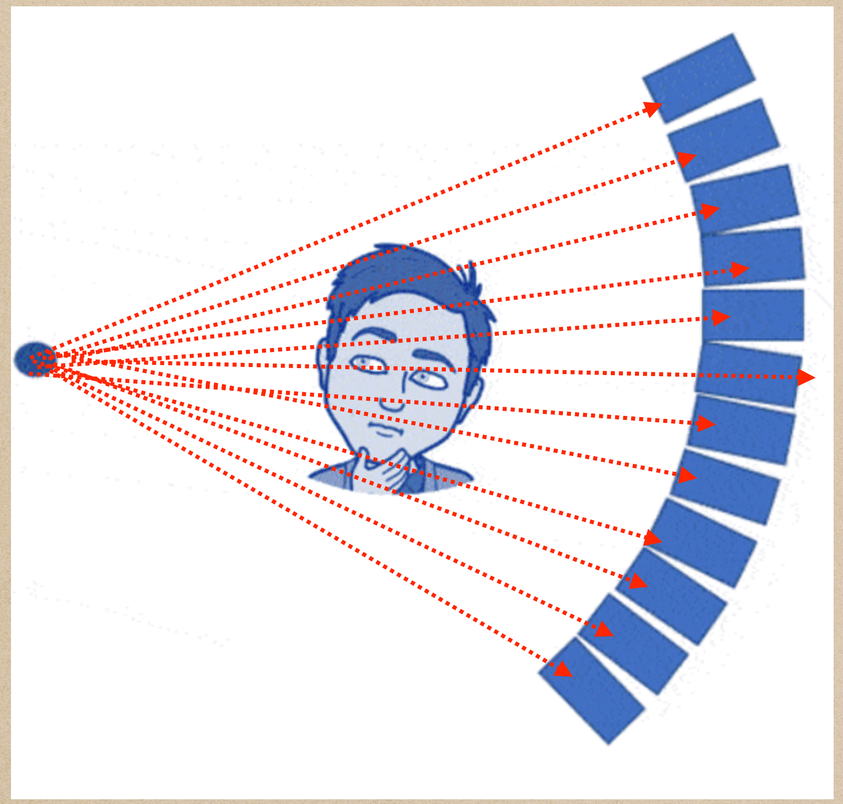

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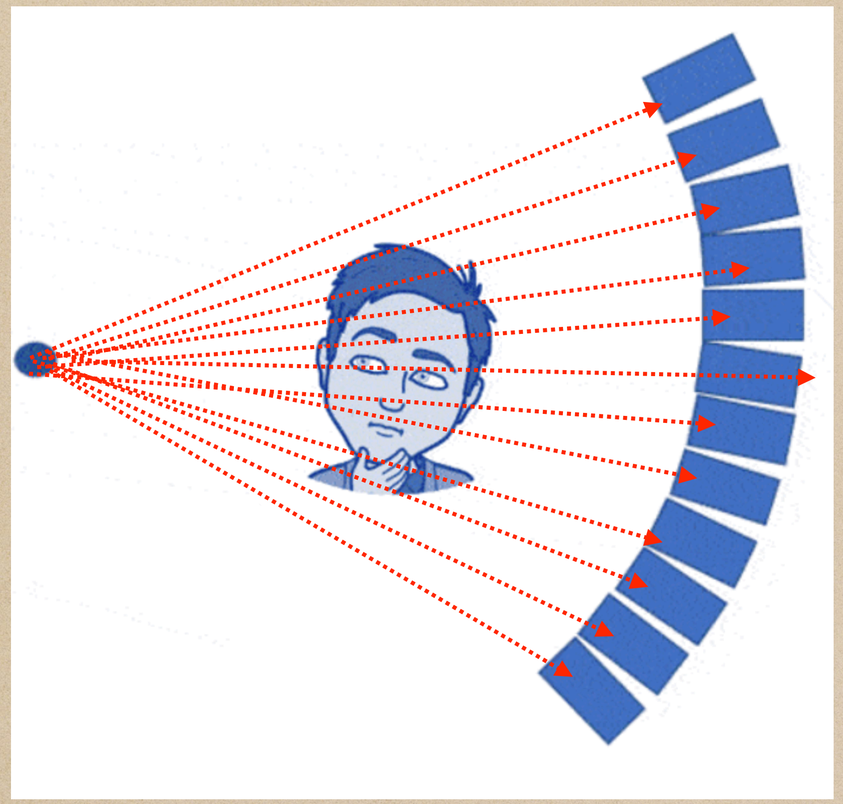

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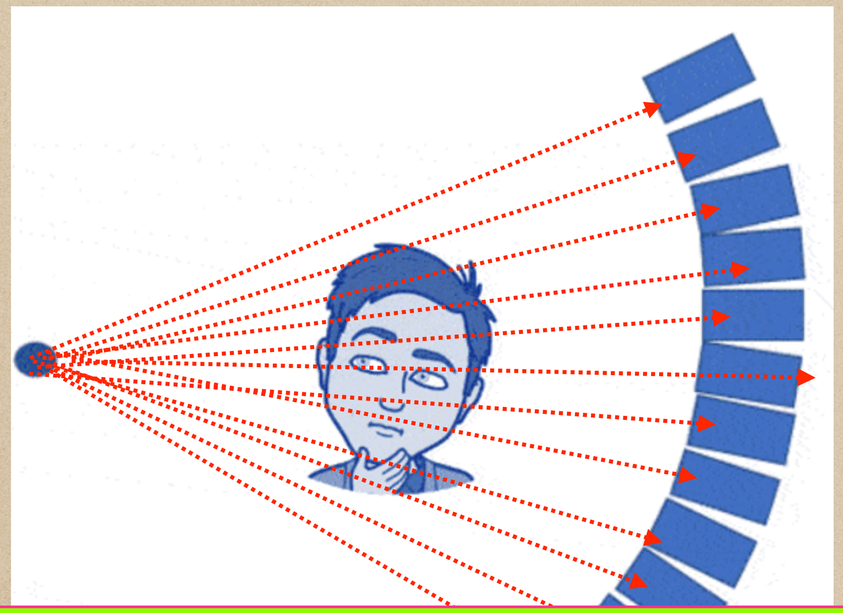

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- **X-ray tube;**
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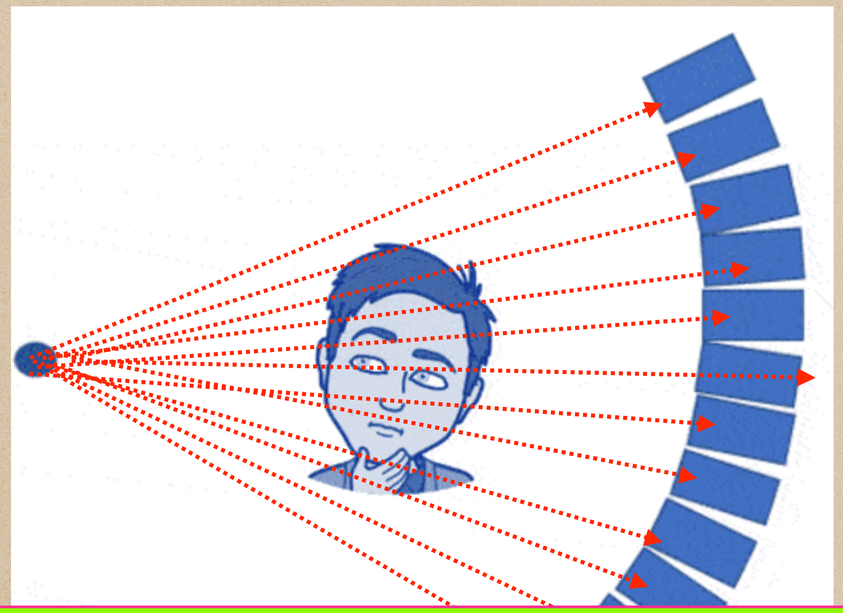

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In the following we will consider the situation with X-ray image detectors - the most high-tech elements of modern CT scanners.

What are the features/difficulties of x-ray image registration?

An ideal image detector should be not transparent to the type of radiation it detects and absorb it completely.

Examples for visible light: the retina of the eye, photographic films, CCD matrices (made from silicon) in modern gadgets.

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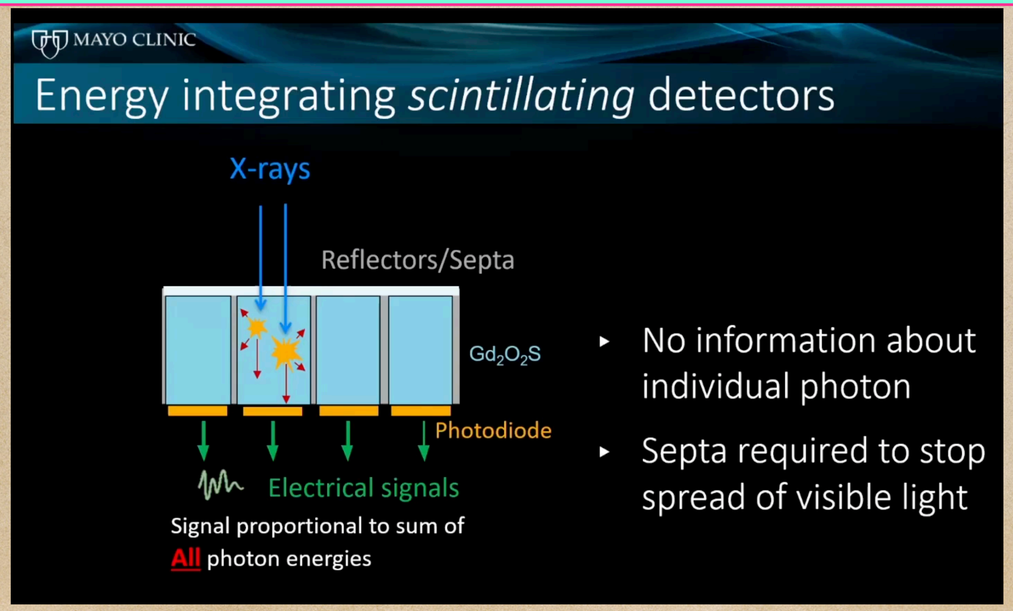

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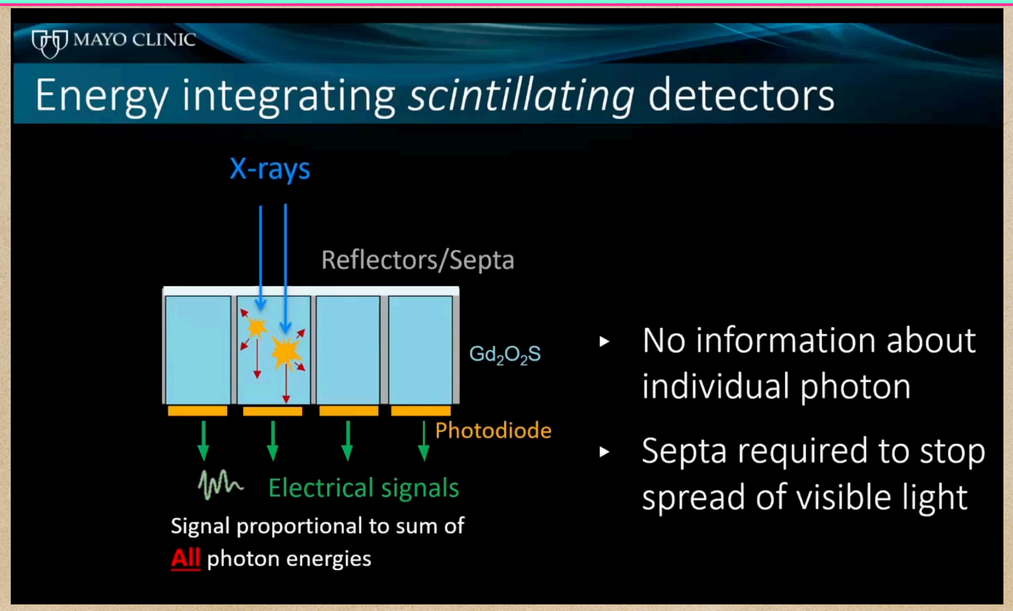

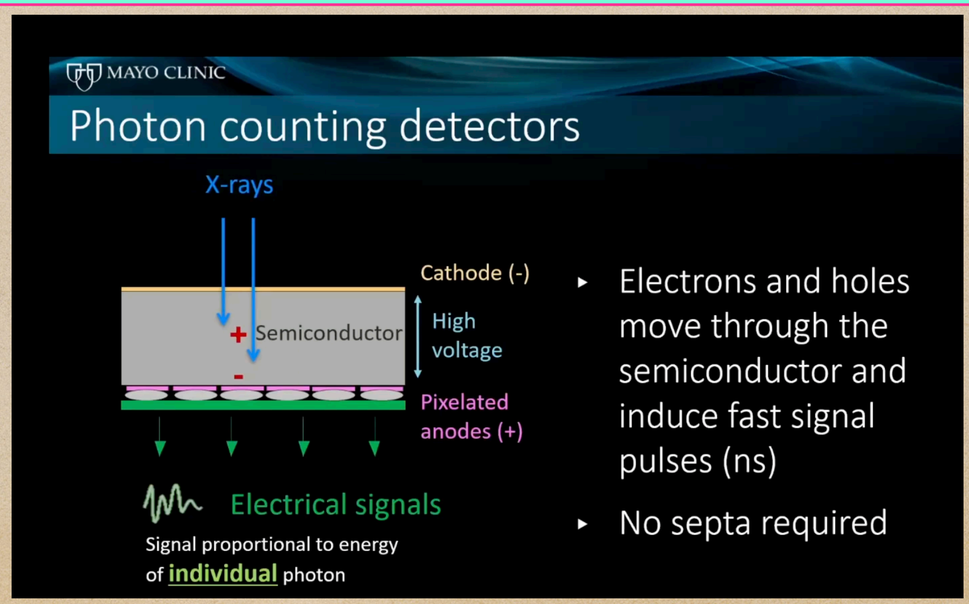

What is a modern detector for registration of X-ray images?

What X-ray sources are used in CT scanners?

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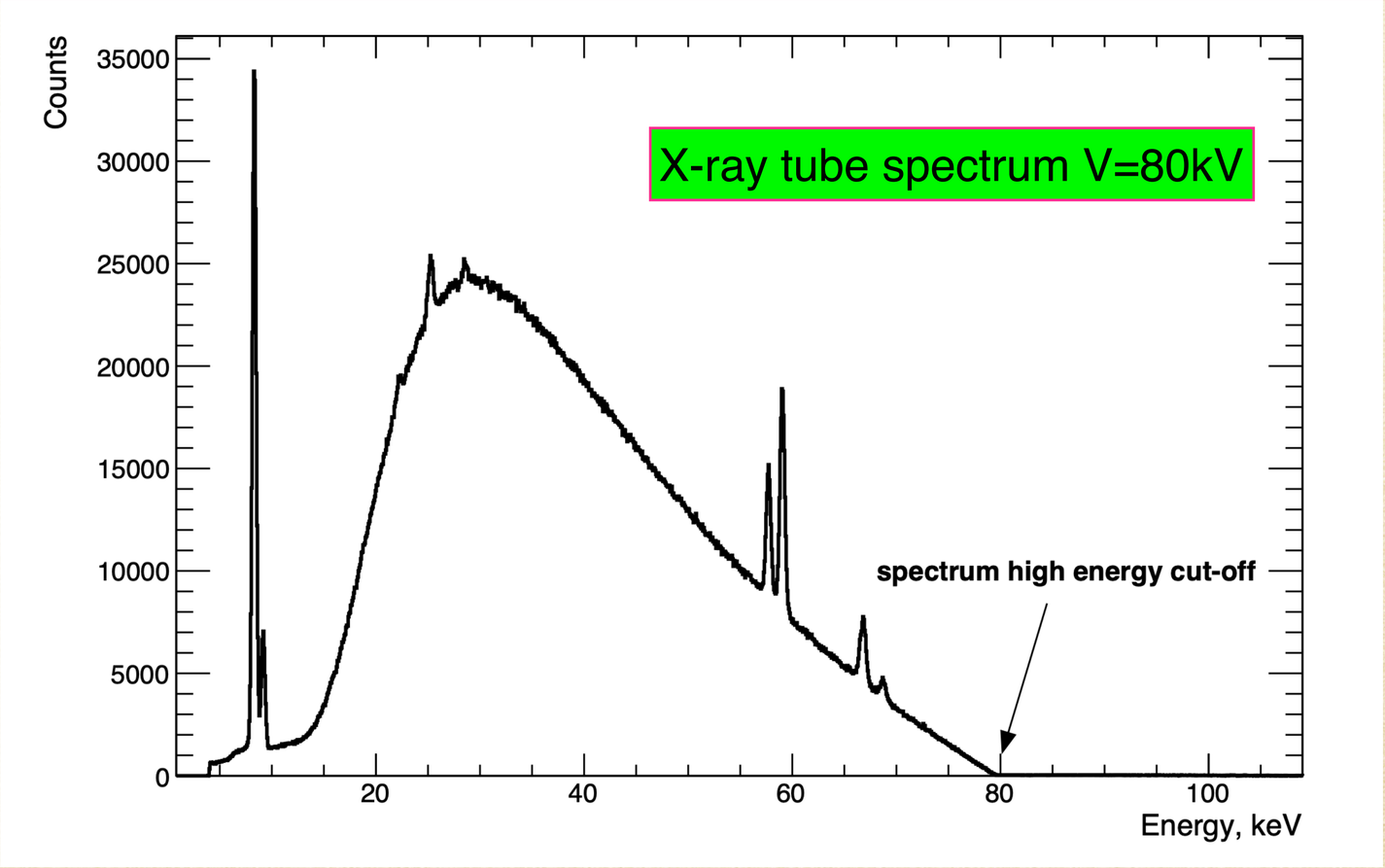
Almost all CT scanners use X-ray tubes as a source of X-rays. This is a cheap and mass-produced device. X-ray tubes produce X-rays in a wide energy spectrum.



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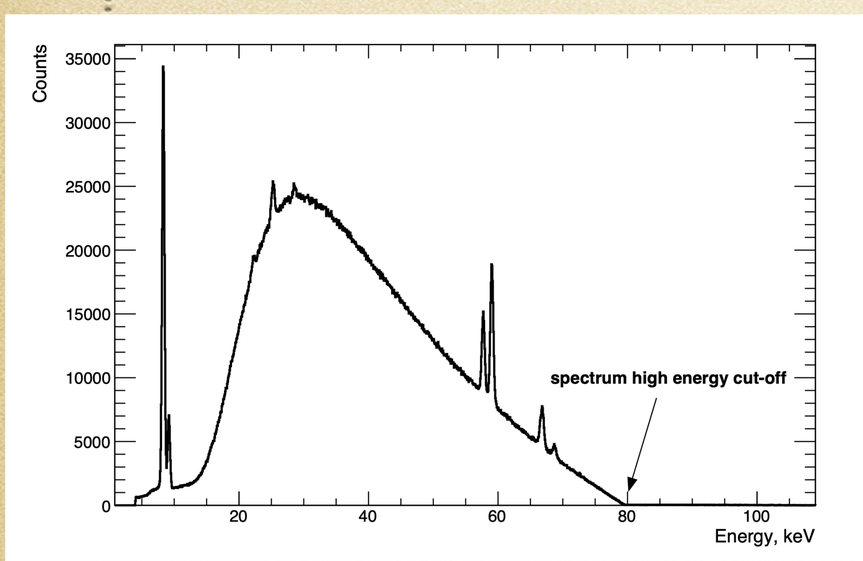

X-ray tube spectrum V=80kV

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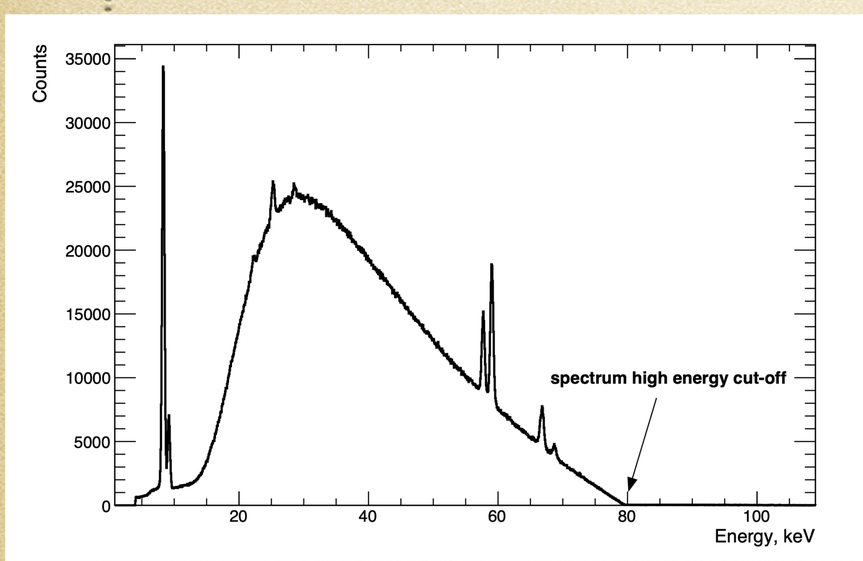

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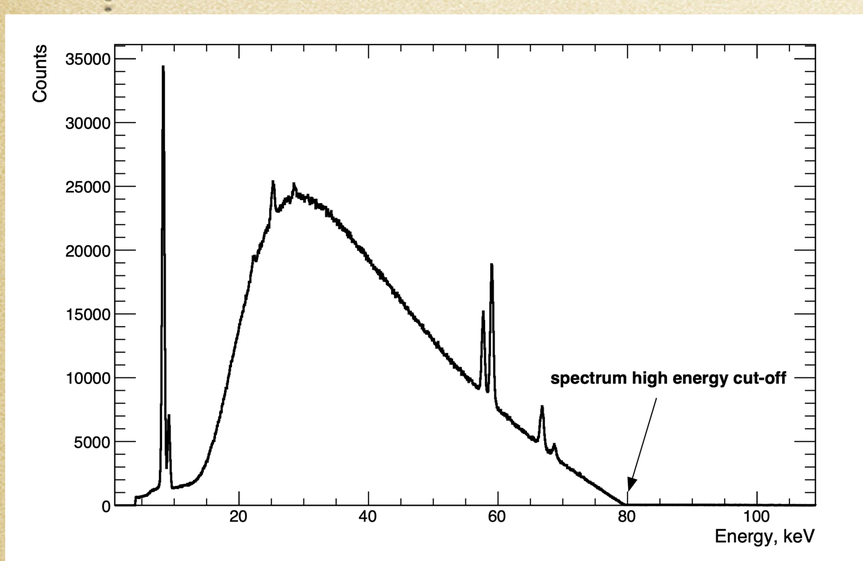

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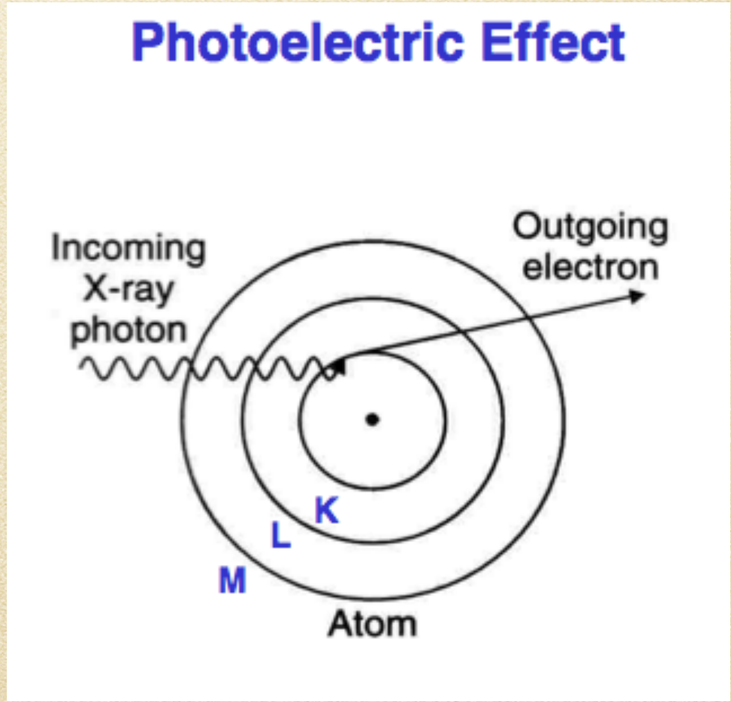

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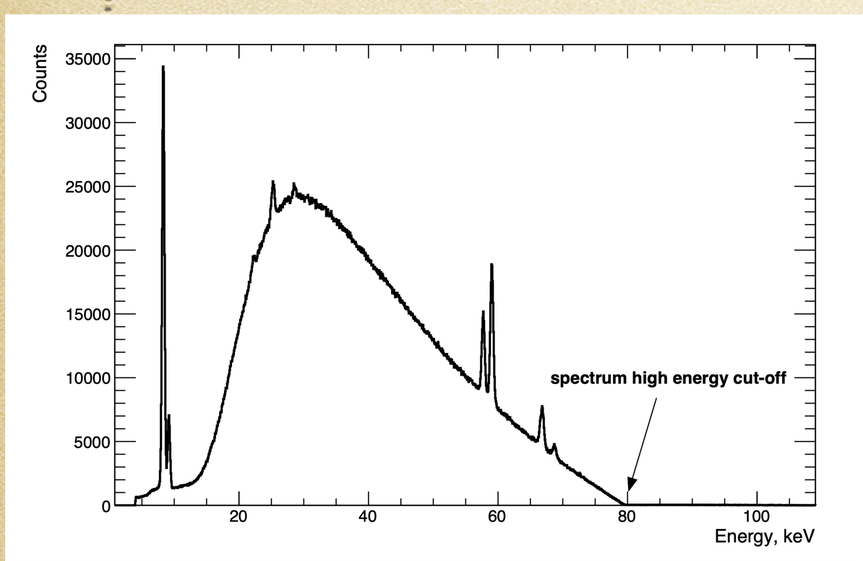

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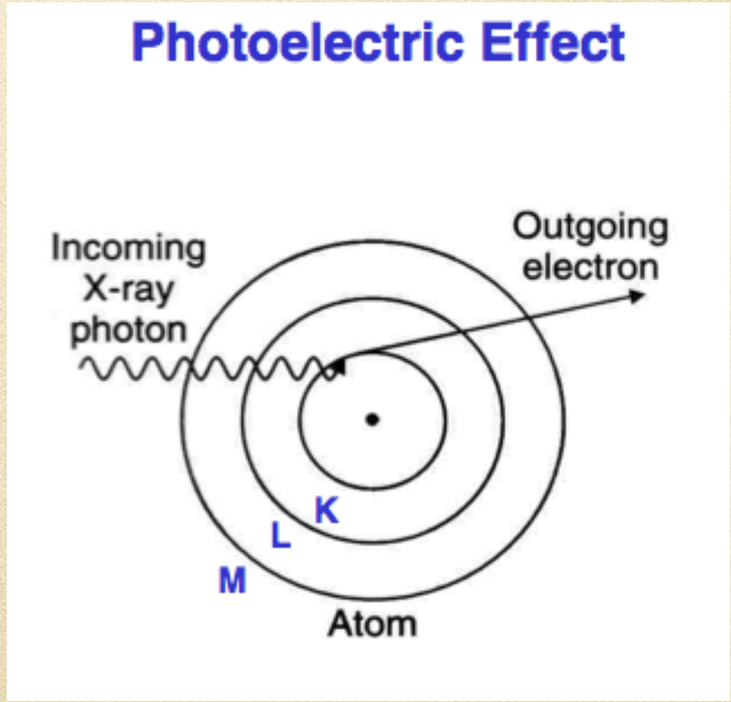

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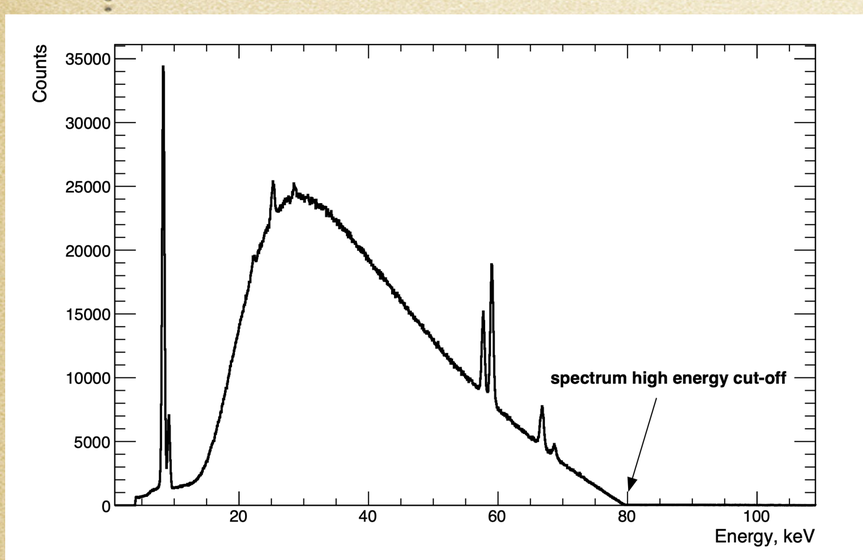

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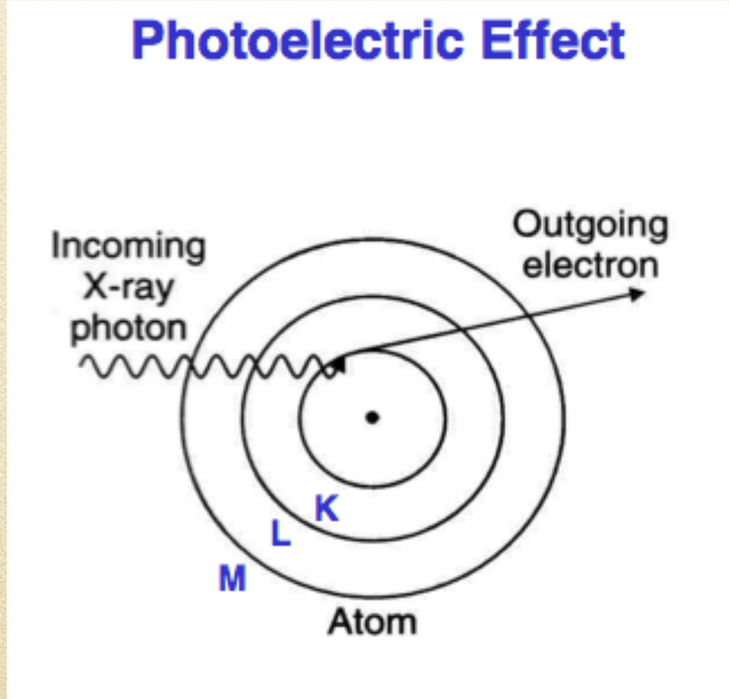

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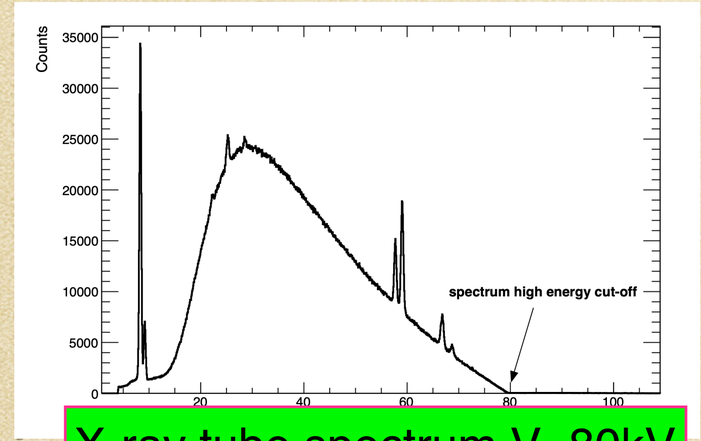
How can an X-ray be converted into a charged particle?

The problem is that silicon (Si) absorbs visible light very well, but is practically transparent to X-rays.

That is why the currently widespread X-ray image detectors use a two-stage registration principle:

X-rays are converted to light in heavy scintillator crystals (CsJ, …); and this light is detected in Si-based photodetectors.

The **main disadvantage** of this scheme is that the possibility of **measuring the energy of the absorbed X-ray quantum is lost.**



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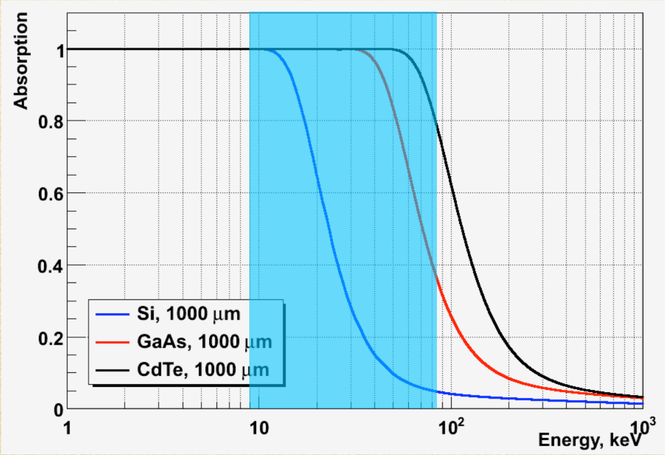

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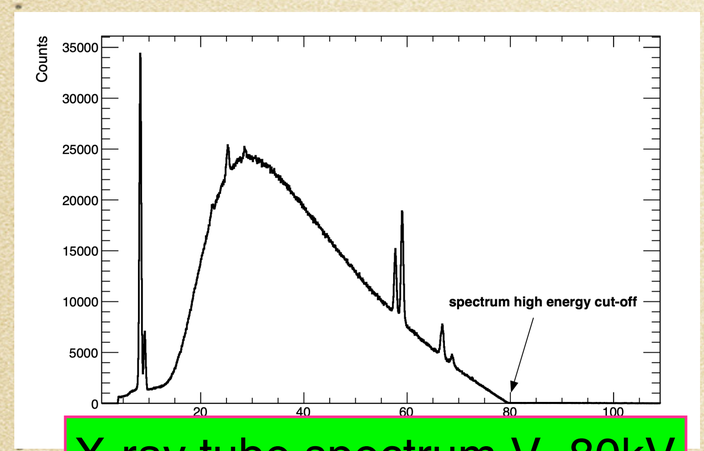

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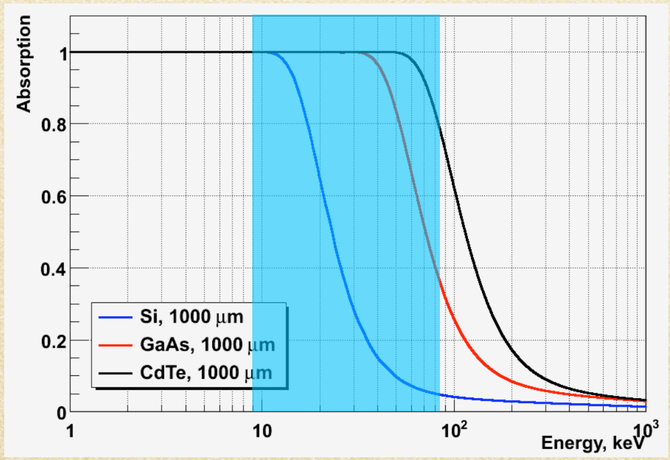

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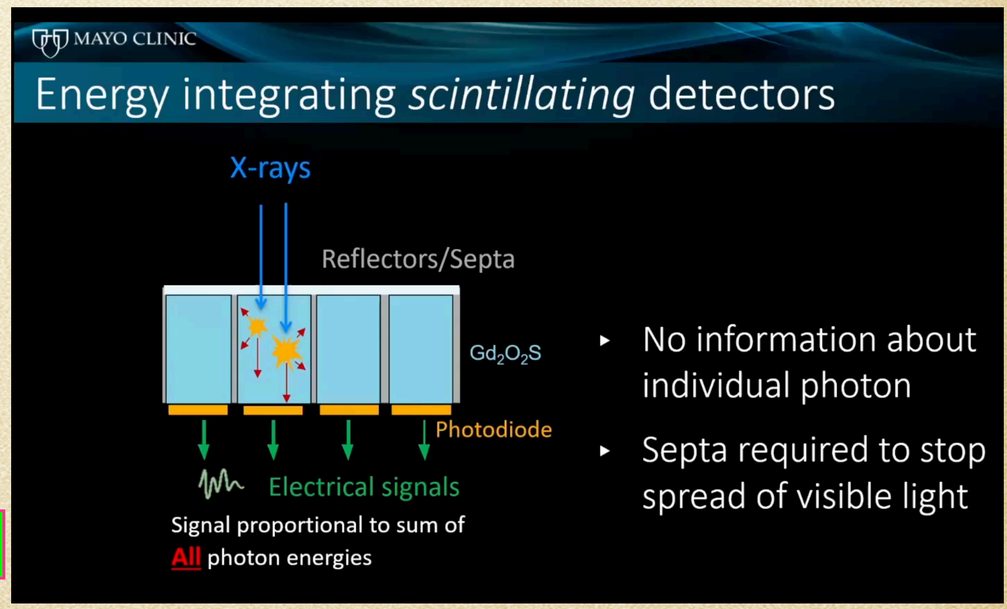
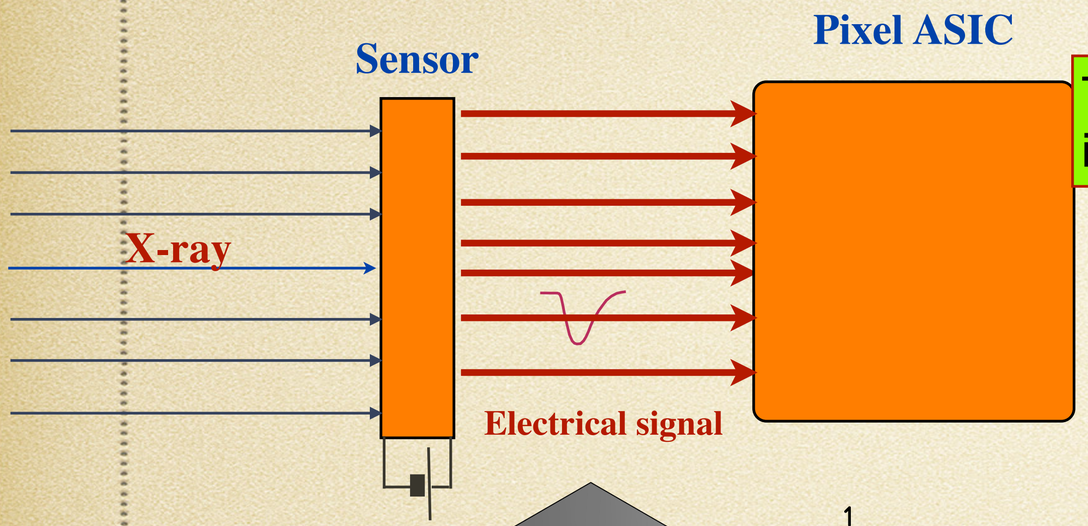
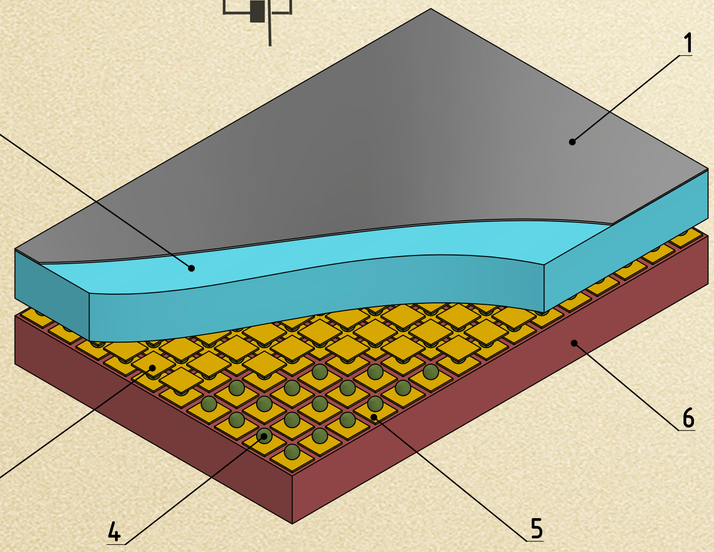


Block diagram of a hybrid pixel semiconductor detector



The dimension of the pixel Medipix chip (ASIC) is (14x14) mm2 and it contains (256x256=65536) independent registration channels

to computer



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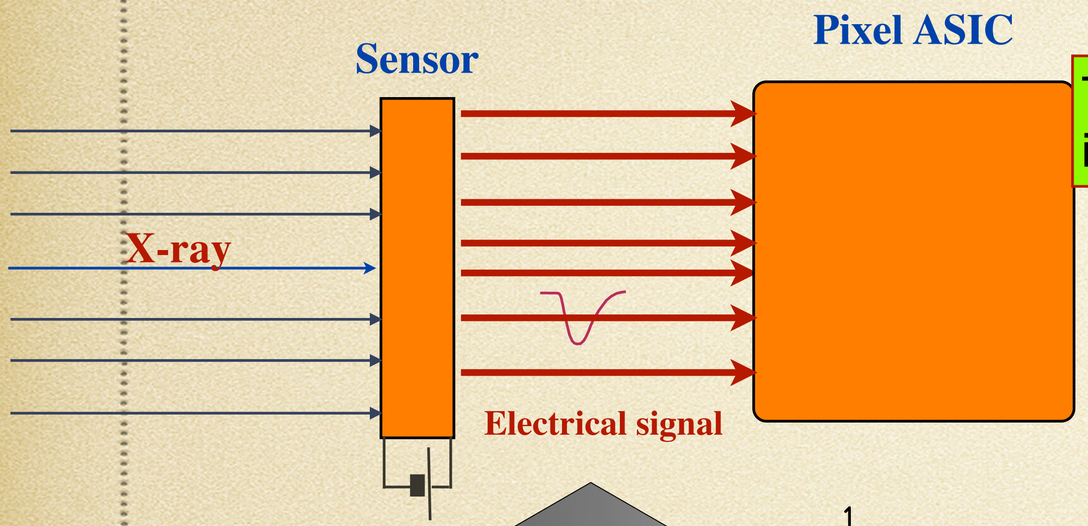

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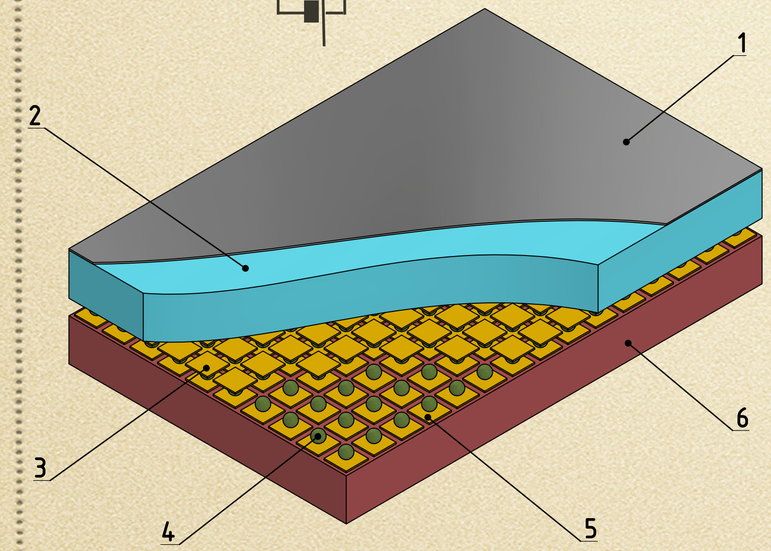

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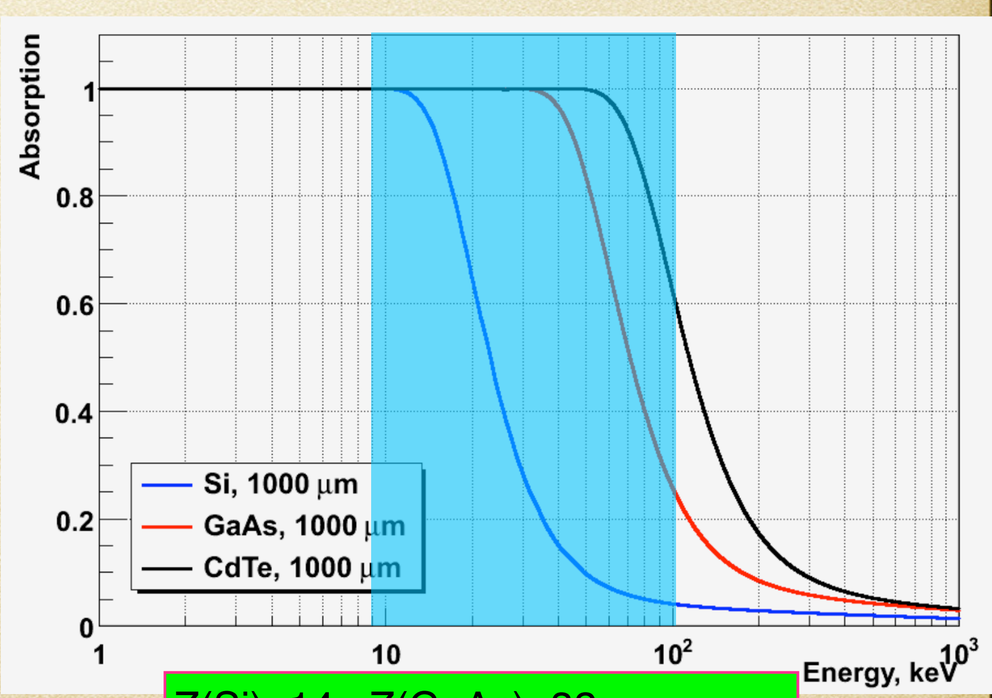

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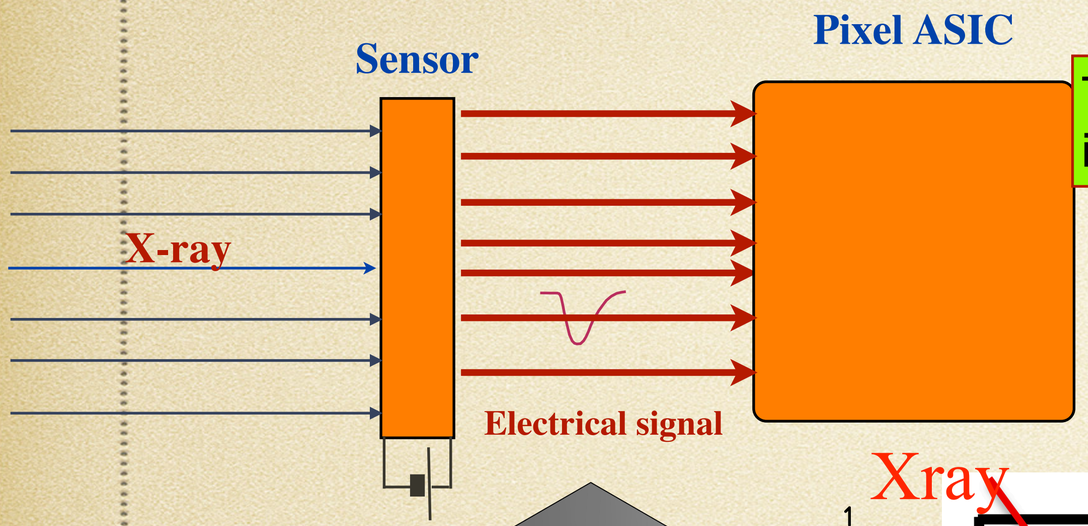

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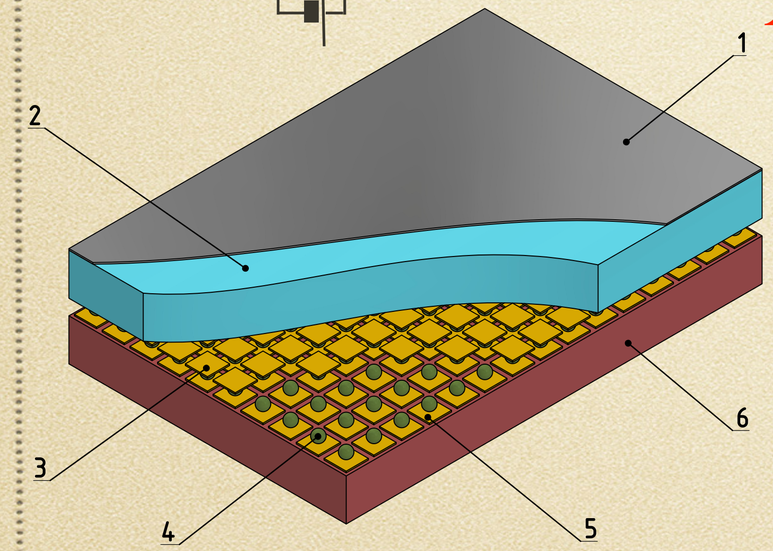

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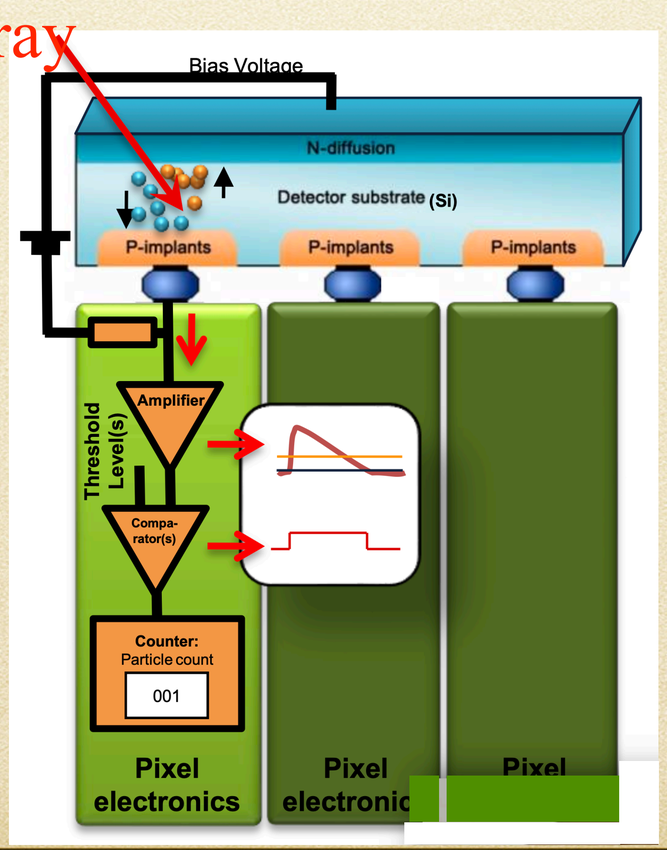

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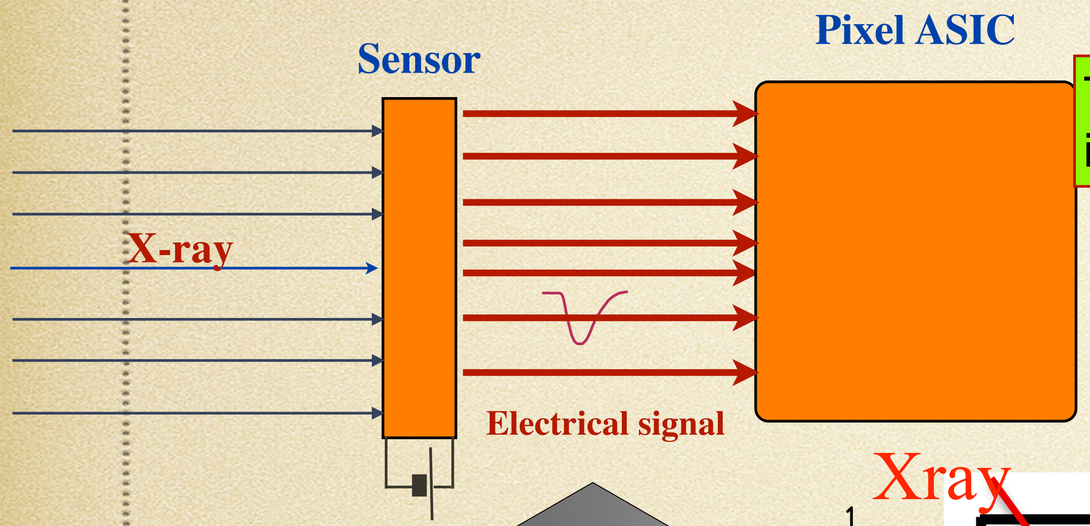

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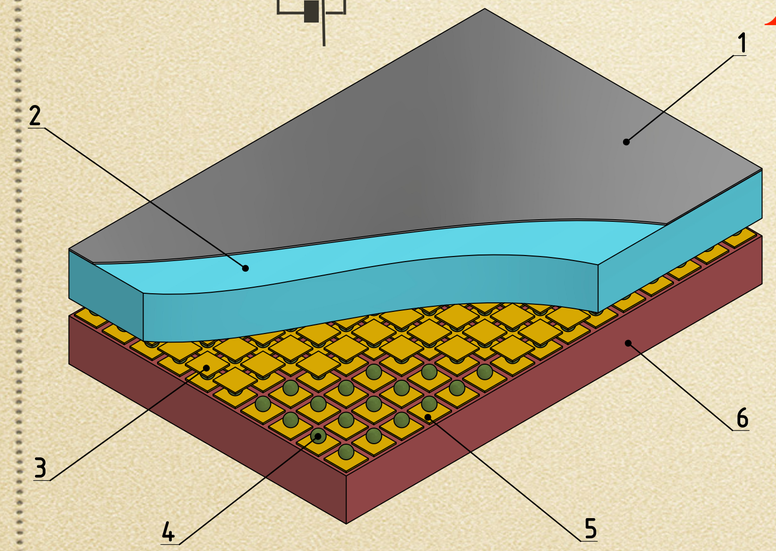

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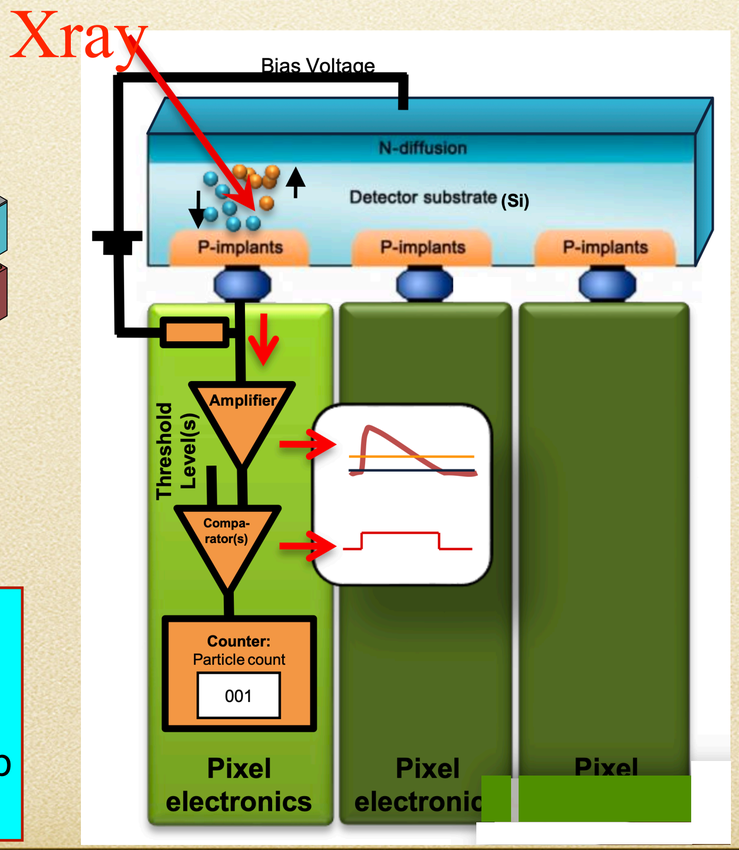
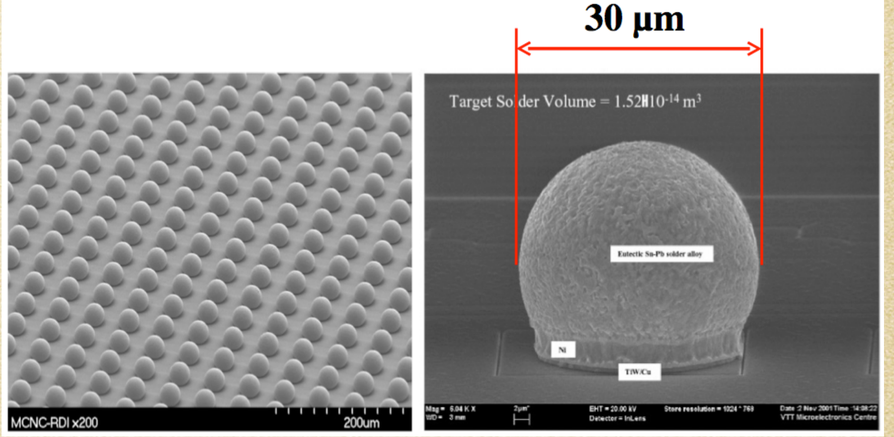


Connecting Sensor Pixels to Readout Chip
(Flip chip bonding)



Measurement of the γ-quantum energy provides a unique opportunity to identify a material by the K-line in the X-ray absorption spectrum.

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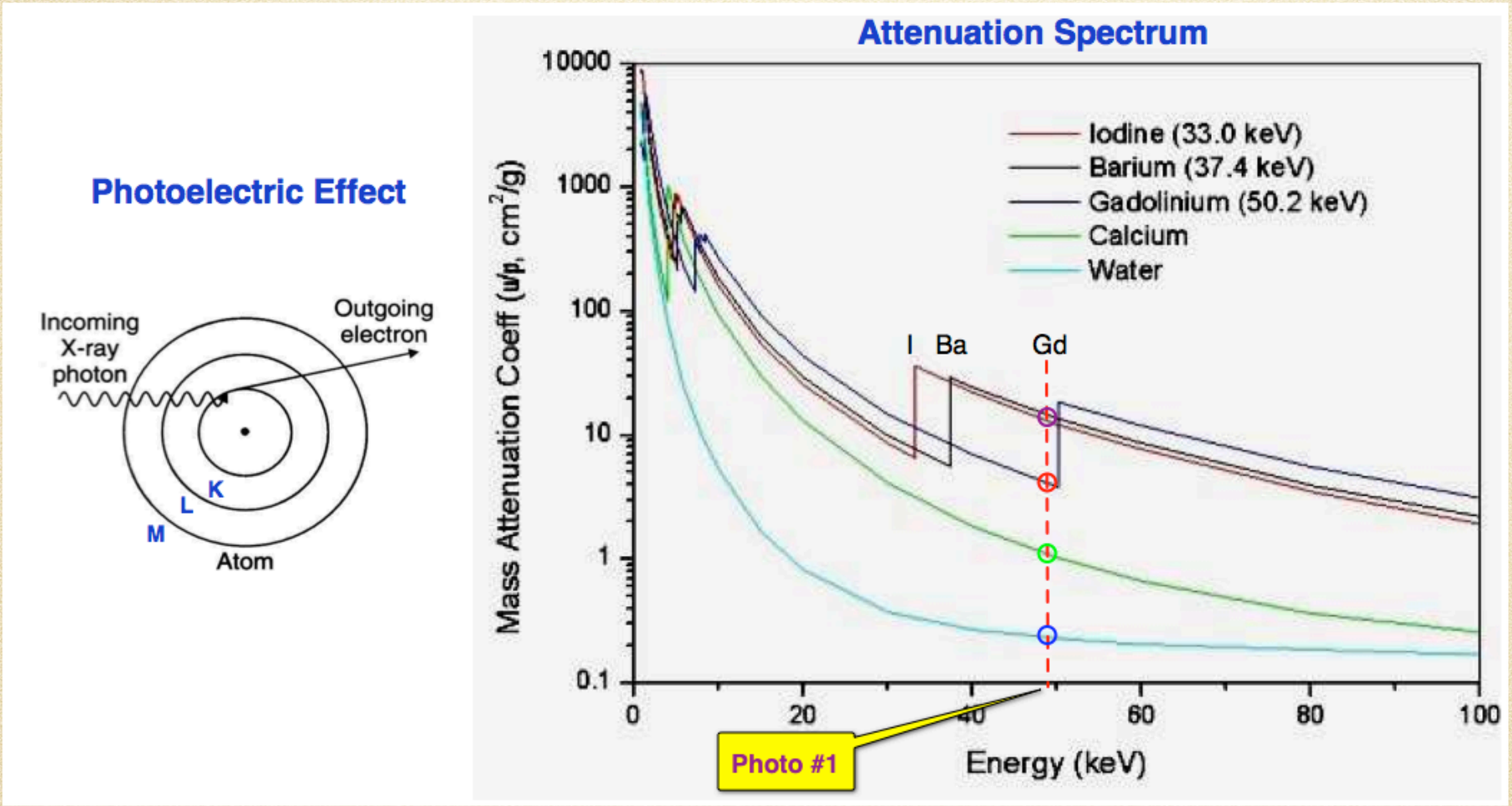

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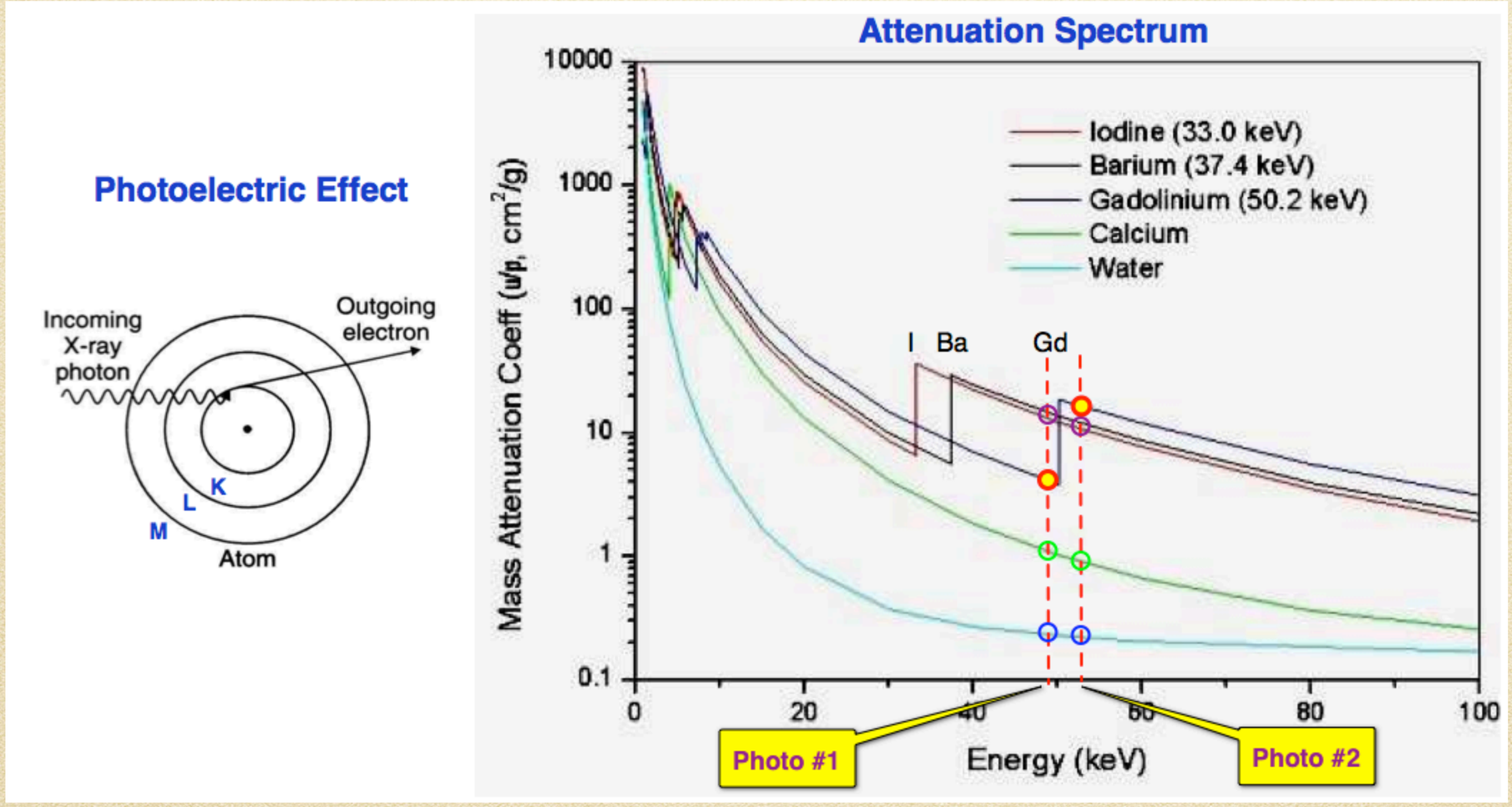
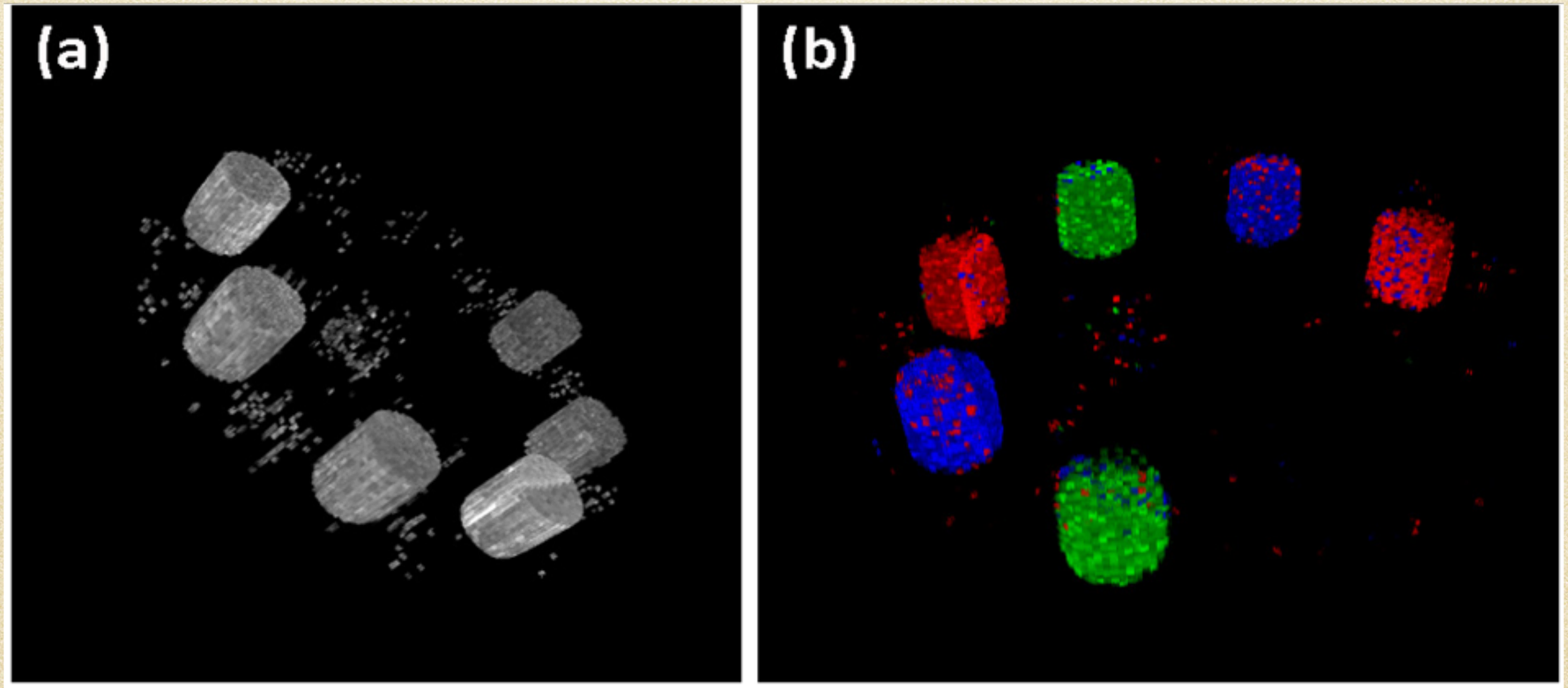


Studies have been carried out in the past:

Algorithms for selection in radiography/tomographic images of various materials using information about the energy of registered photons.

Together with chemists from Moscow State University, work is underway to create new types of contrast agents based on lanthanides. (RNF grant 22-15-00072)



Classic grey 3D phantom reconstruction with La, Nd and Gd samples

The same data reconstructed taking into account energy information:
La - red; Nd - blue and Gd - green.

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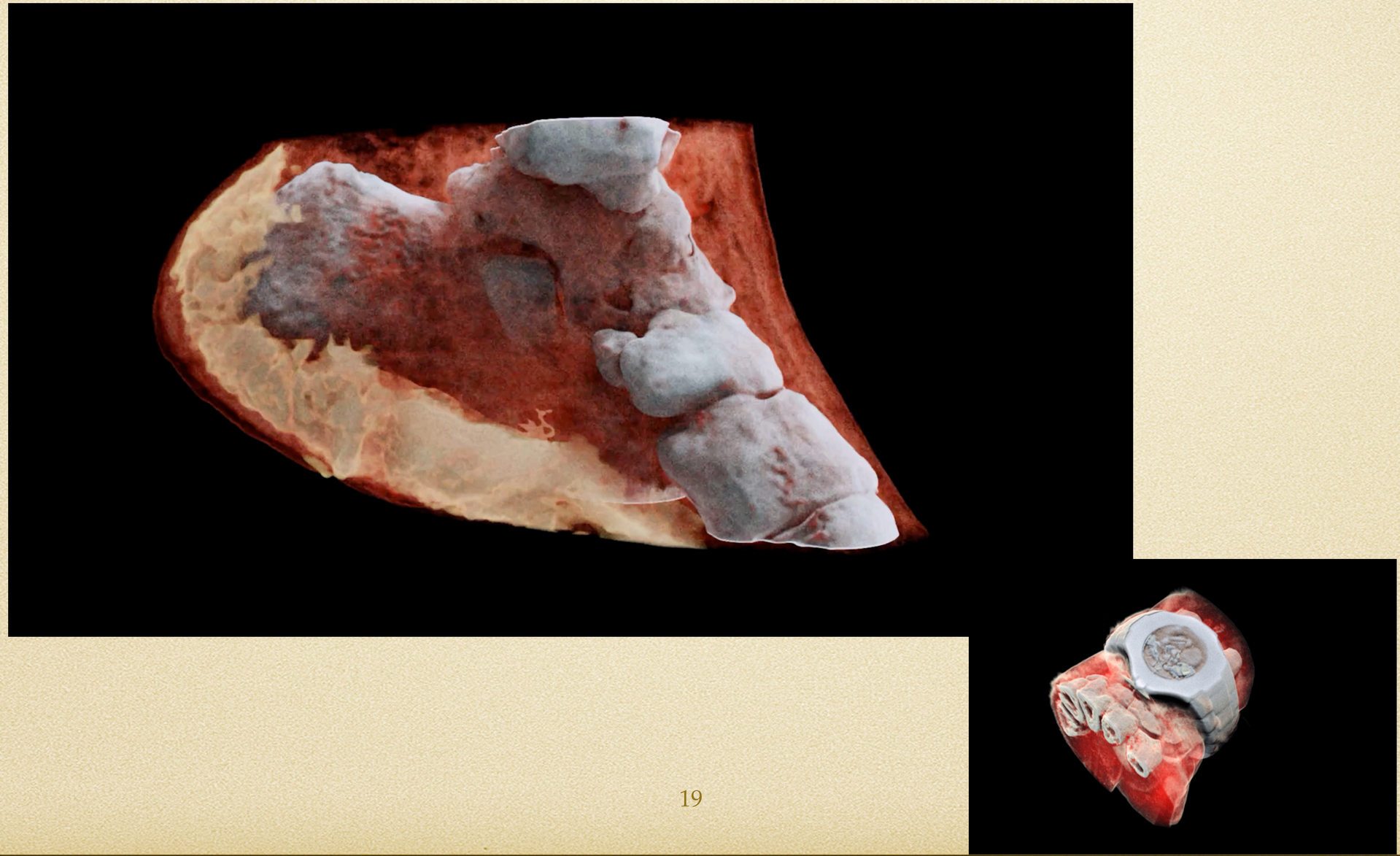
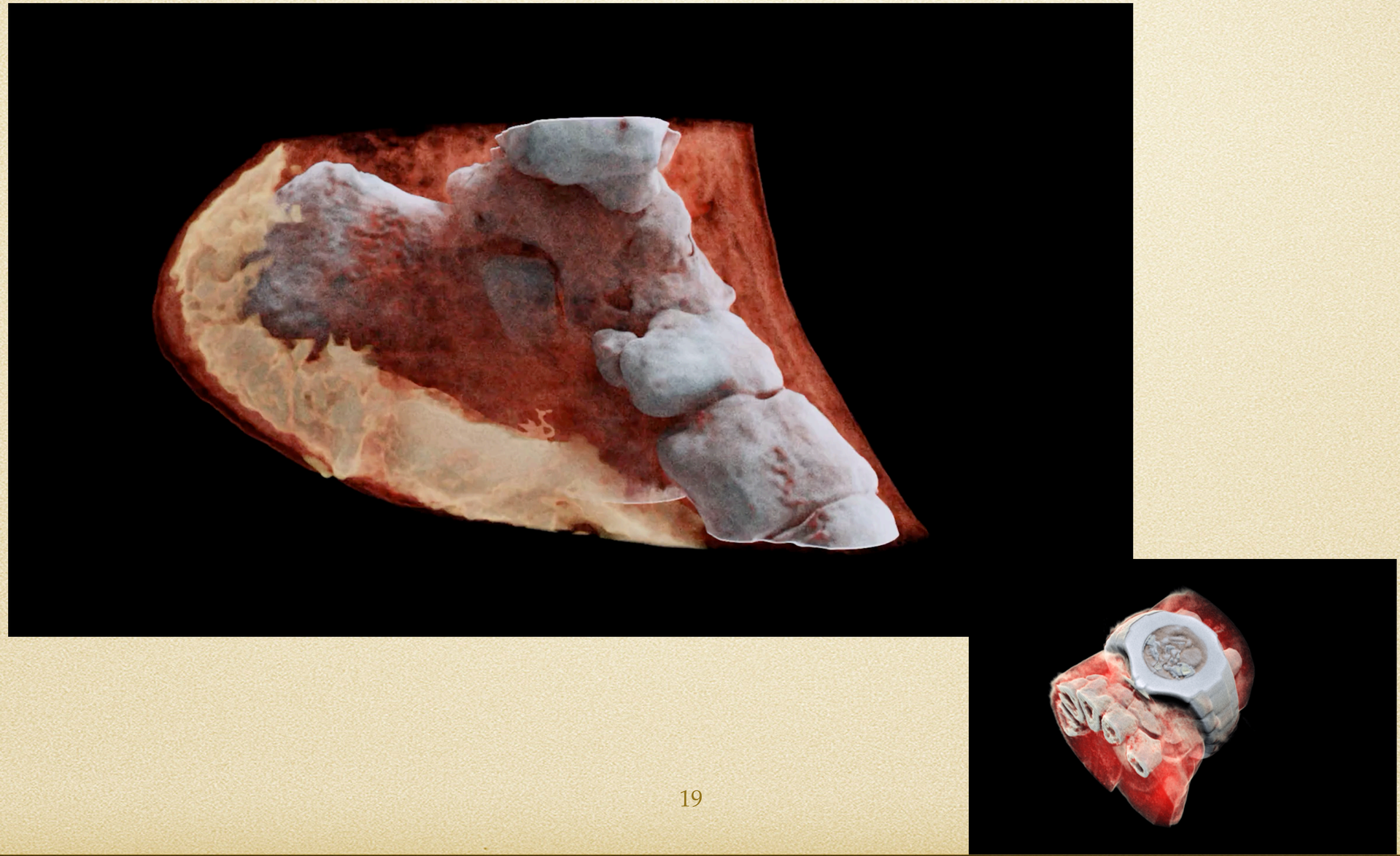
A key element in the design of such detectors is a pixel chip.

Human foot CT obtained from the first full-scale tomograph with Medipix3-RX ASIC at Crischurch University in New Zealand.



Human foot CT obtained from the first full-scale tomograph with Medipix3-RX ASIC at Crischurch University in New Zealand.



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If you have questions that I can answer - ask me now.

Thank you for your attention!