

Energy calibration measurements of Medipix2

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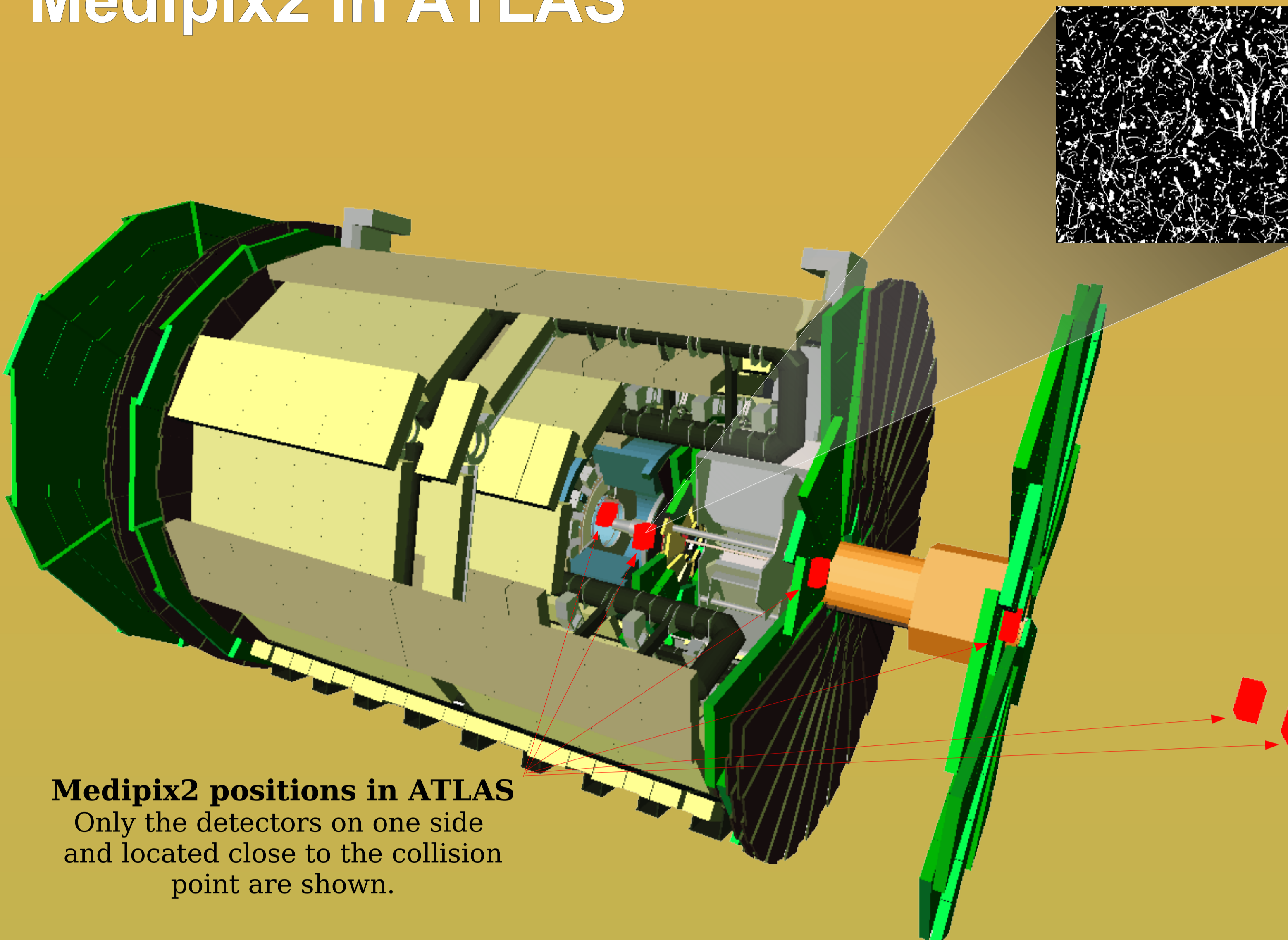
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This work was carried out within the CERN Medipix Collaboration

Medipix2 in ATLAS



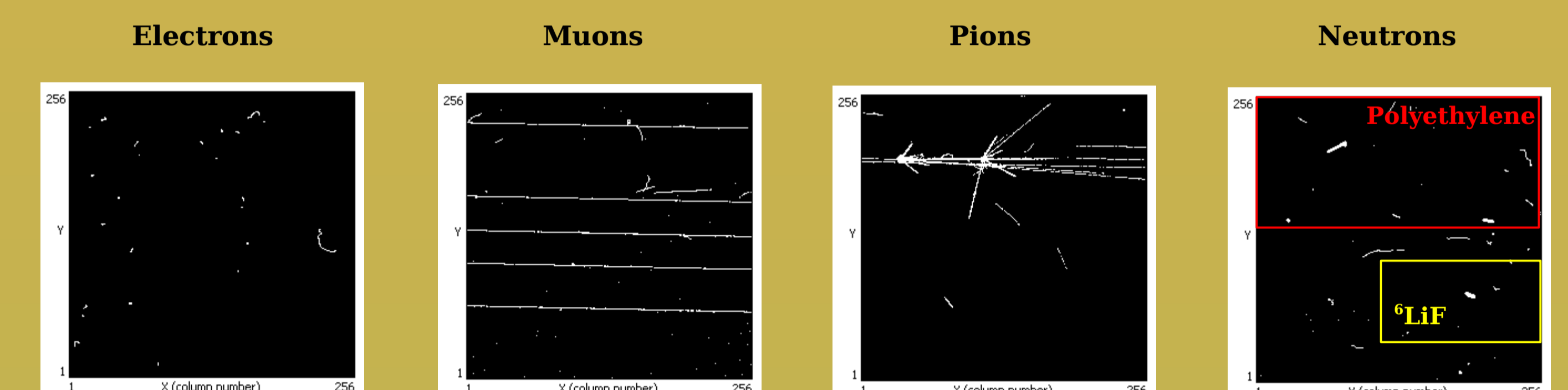
Medipix2 positions in ATLAS

Only the detectors on one side and located close to the collision point are shown.

A Medipix 2 detector module consists of a semiconductor detector bonded to the photon counting readout electronics Medipix2. These modules were successfully used in spectroscopic radiation measurements. This position-sensitive device, bump-bonded to a readout chip, is composed of a pixelated 300 μm thick semiconductor detector with 256x256 pixels, each of size 55 μm x 55 μm . The detector is fully controlled by the Universal Serial Bus (USB), which is presently the most widespread PC interface. The Medipix2 offers the possibility to adjust the energy thresholds, thus creating an energy window, which allows a selection of the energy of the detected radiation.

A network of Medipix devices will be installed within the ATLAS detector and cavern. Four devices will be located between the moderator (JM) shielding and Liquid Argon (LAR) calorimeter (two on each of the two sides of the ATLAS detector). Similarly, two devices on each side, will be installed along the TileCal (scintillator/iron hadronic calorimeter). A total of four devices will be placed near the ATLAS muon chambers and two devices will be located near the very forward (JF) shielding. These devices will allow real-time measurement of the composition and the spectroscopic characteristics of the radiation field inside the detector and the cavern.

Examples of particle detection with Medipix2



Calibration of Medipix with photons

In view of this application to ATLAS, calibration of the energy thresholds has been performed. The calibration has been done with photons of low energies, using ²⁴¹Am sources and X-rays. The X-ray measurements were performed at the Czech Metrology Institute in Prague.

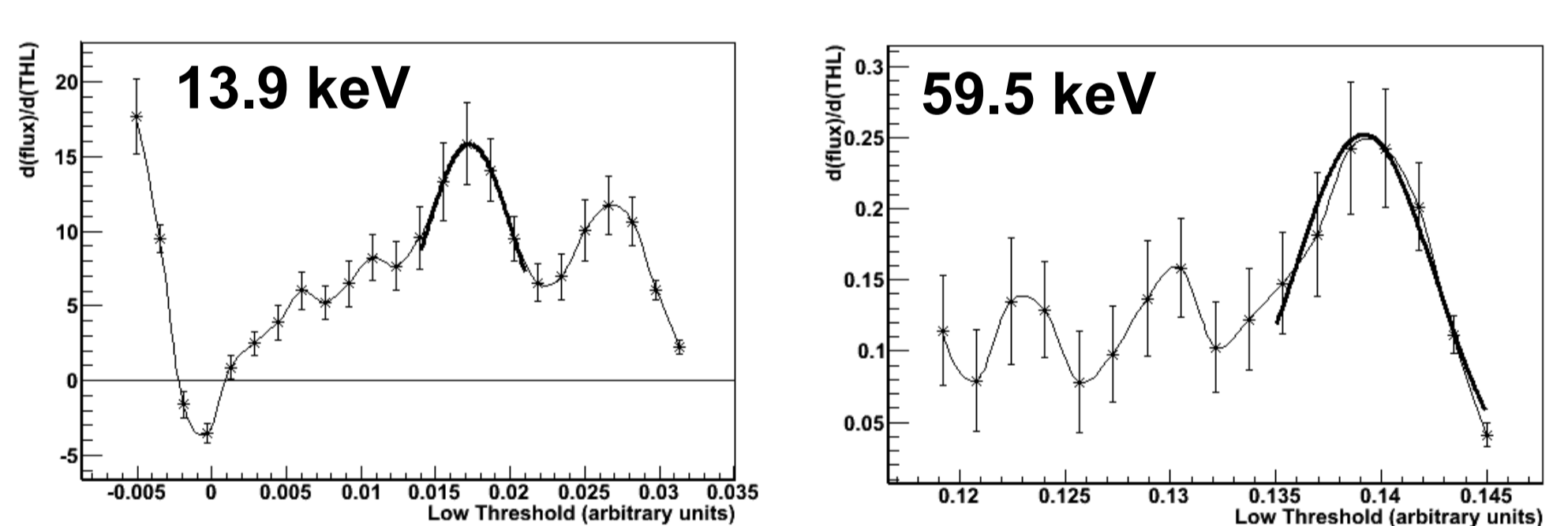
Photons of low energies

- Photon energy is transferred to the electron by photoelectric effect.
- Single pixel energy deposition.
- Energy threshold can be determined for each pixel.

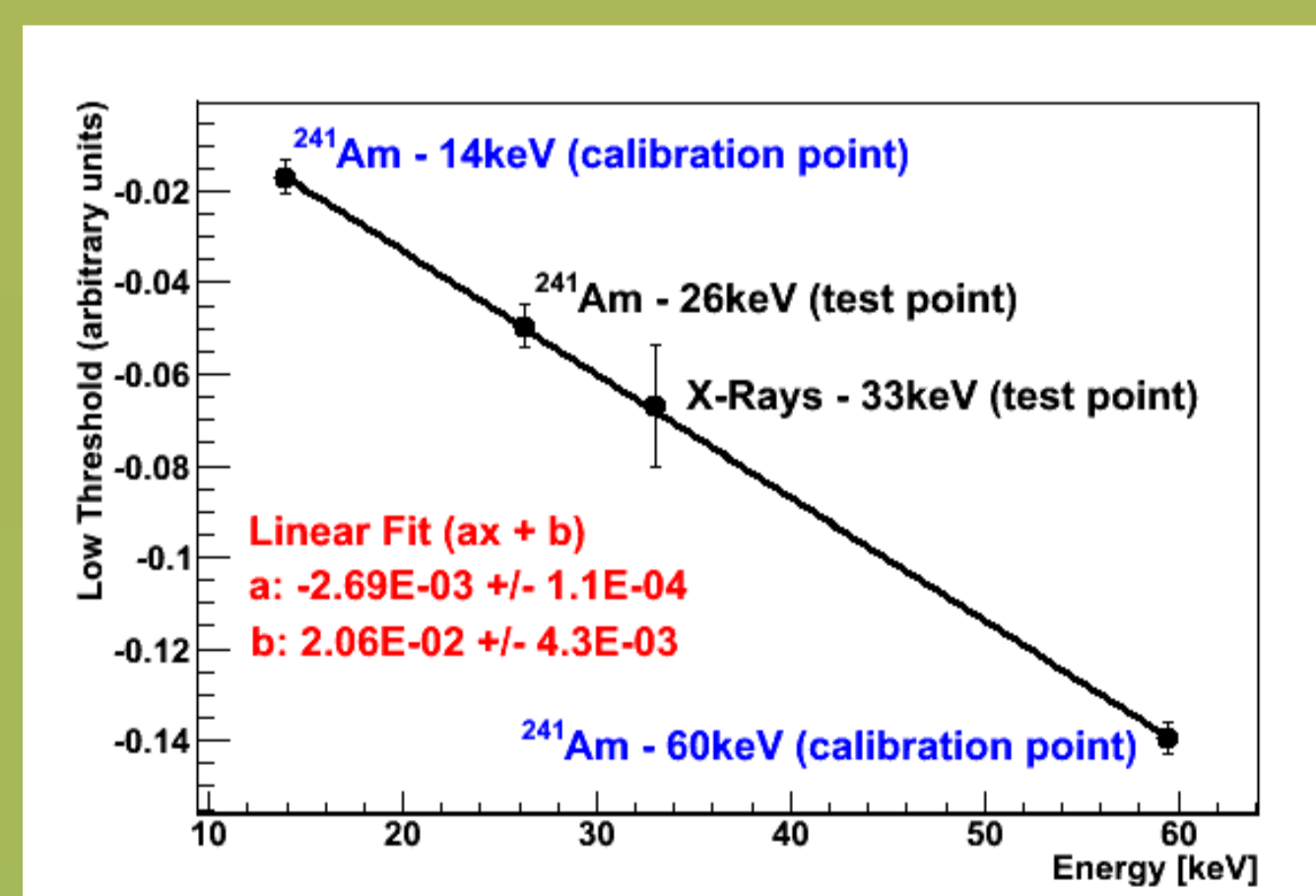
Radioactive source: ²⁴¹Am

- X-ray at 13.9 keV (37.0 %)
- γ -ray at 59.5 keV (35.9 %)

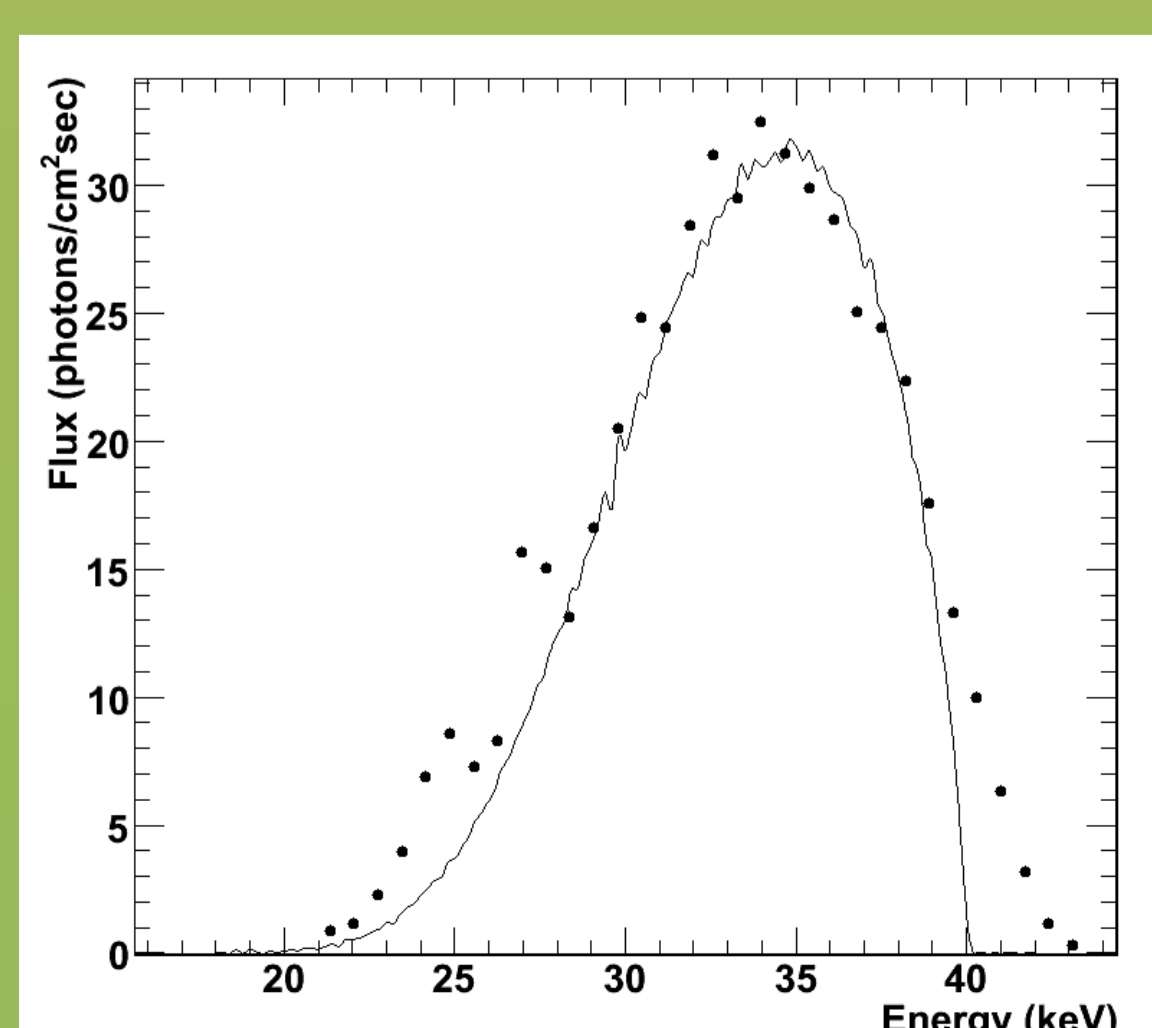
Examples of spectra obtained with the ²⁴¹Am source



Energy calibration of the low threshold of Medipix-USB



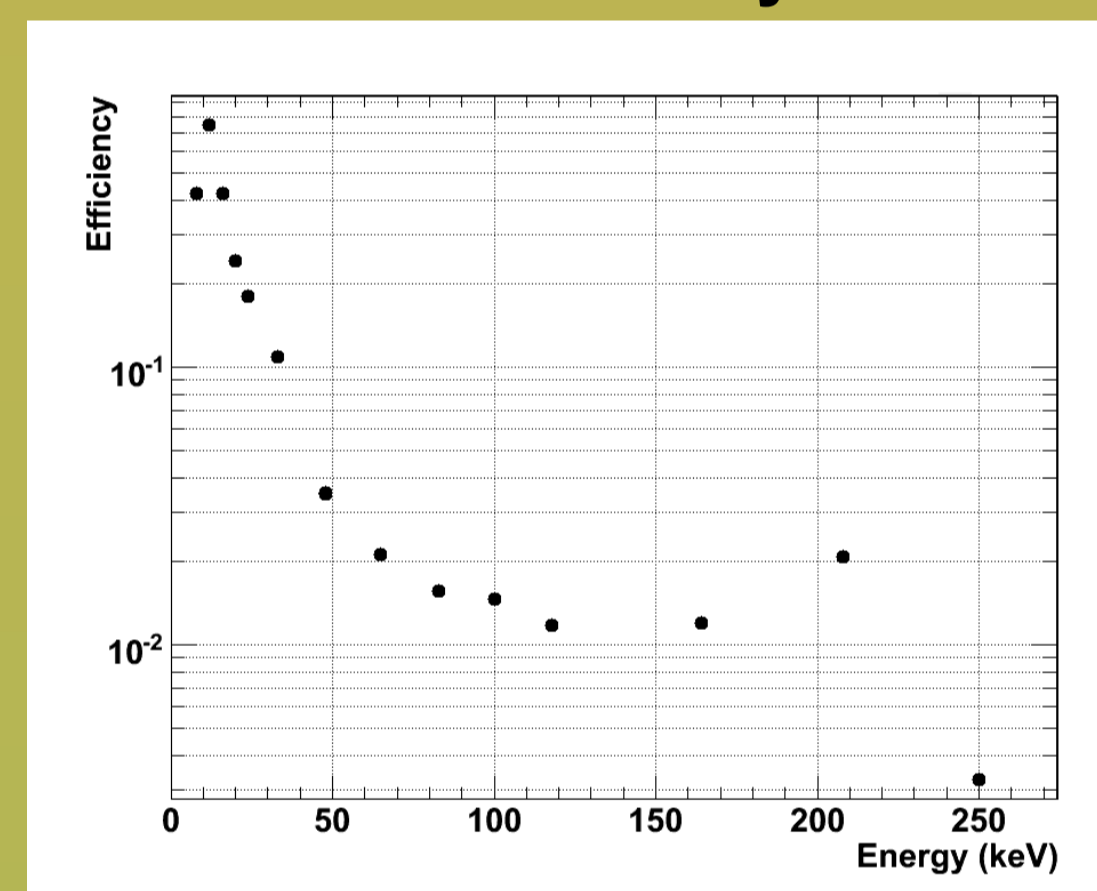
33 keV X-Ray spectrum from Medipix



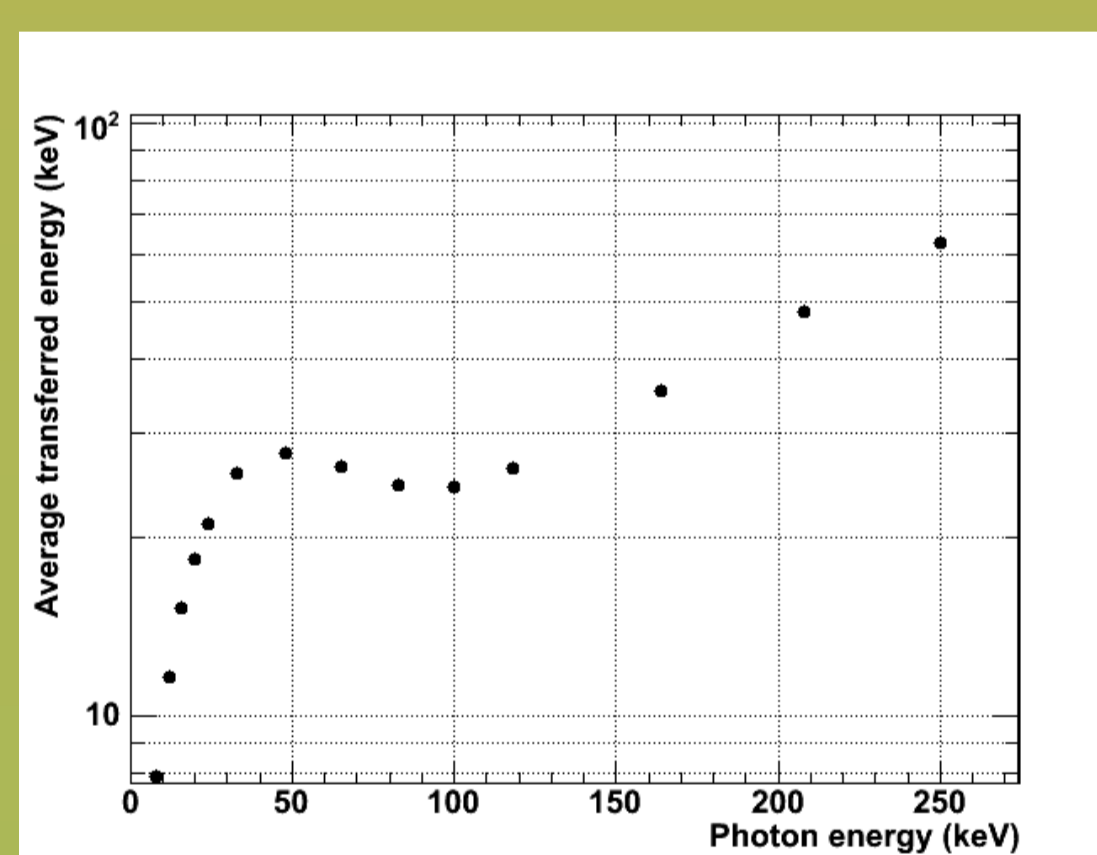
Efficiency of photon detection

Using X-ray tubes with filters, photons of energies between 8 keV and 250 keV were produced and the efficiency of the Medipix device at detecting these radiations was determined. The photons stroke the Medipix perpendicularly to the surface.

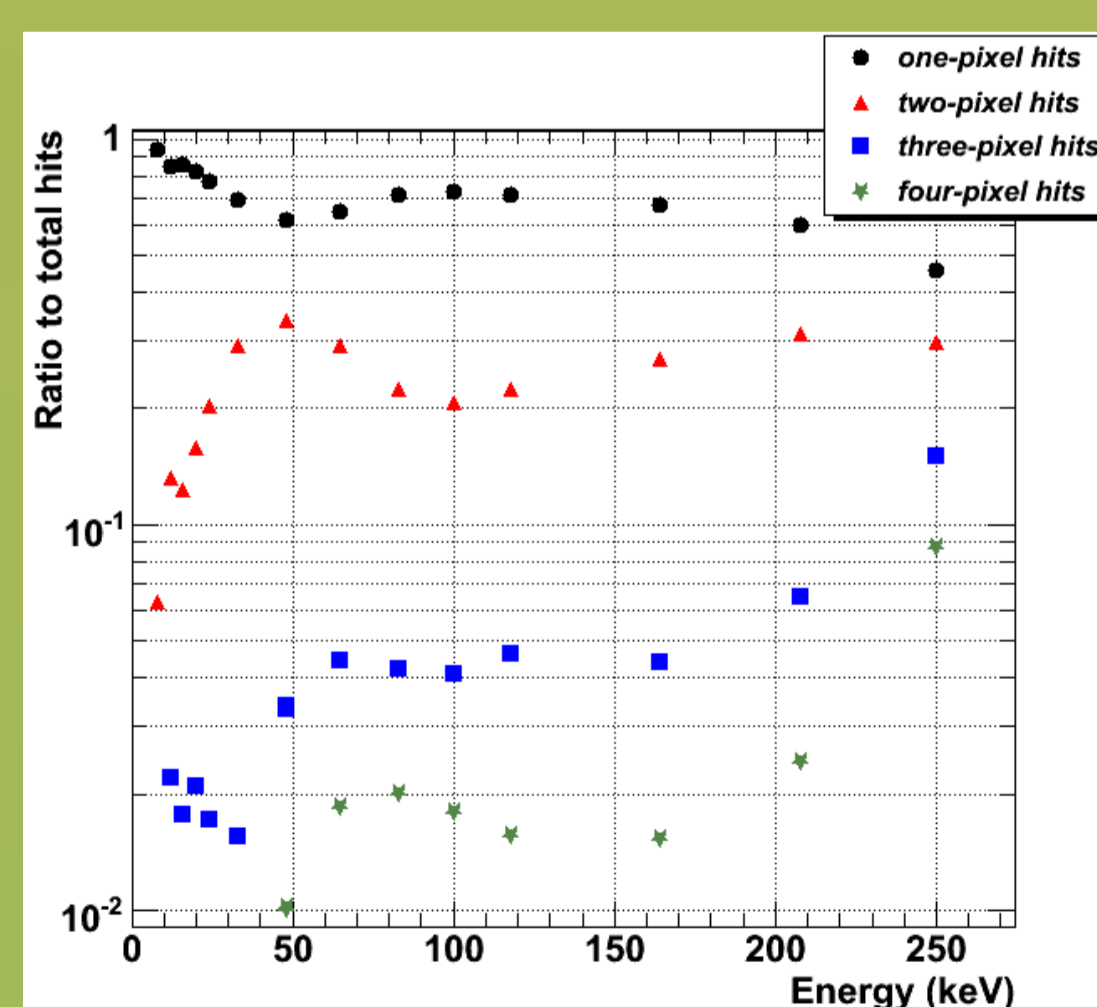
Photon detection efficiency of the Medipix



Average energy transferred to the electrons



Electron track length as a function of photon energy



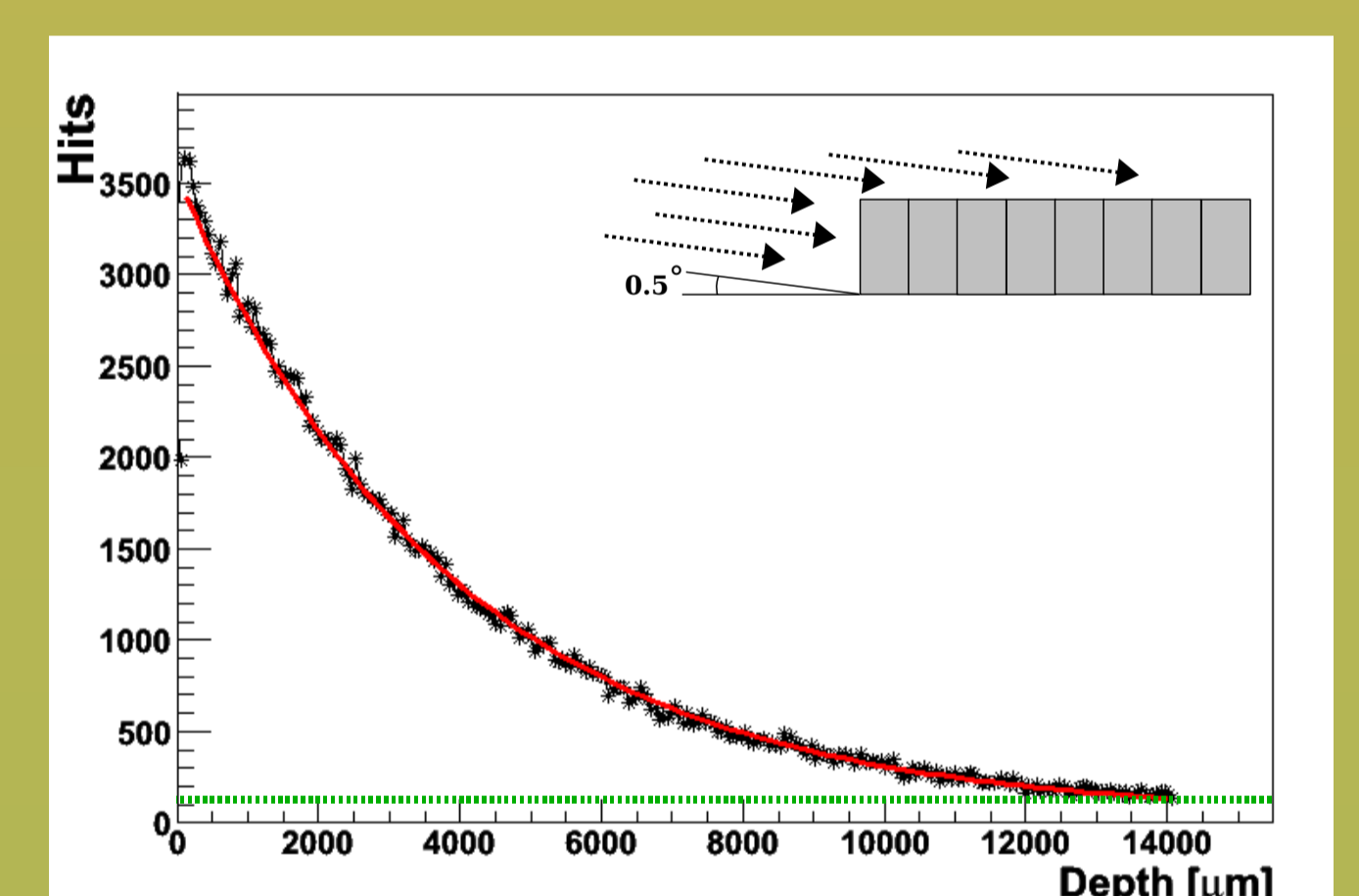
The average energy transfer can be correlated to the electron track length. For photon energies lower than 50 keV in silicon, the photoelectric effect dominates. Then, in the region between 50 and 100 keV the cross-sections of the photoelectric and the Compton effects are of the same order of magnitudes. Beyond 100 keV, the photoelectric effect is negligible compared to the incoherent scattering and the average relative energy transferred by that process (Compton) increases. The variation of energy transferred can be seen in the length of the electron tracks:

- Single-pixel hits decrease with increasing energy
- Double-pixel hits follow the average energy transferred curve until 250 keV is reached
- Triple- and quadruple-pixel hits rapidly increase for photon energies greater than 50 keV

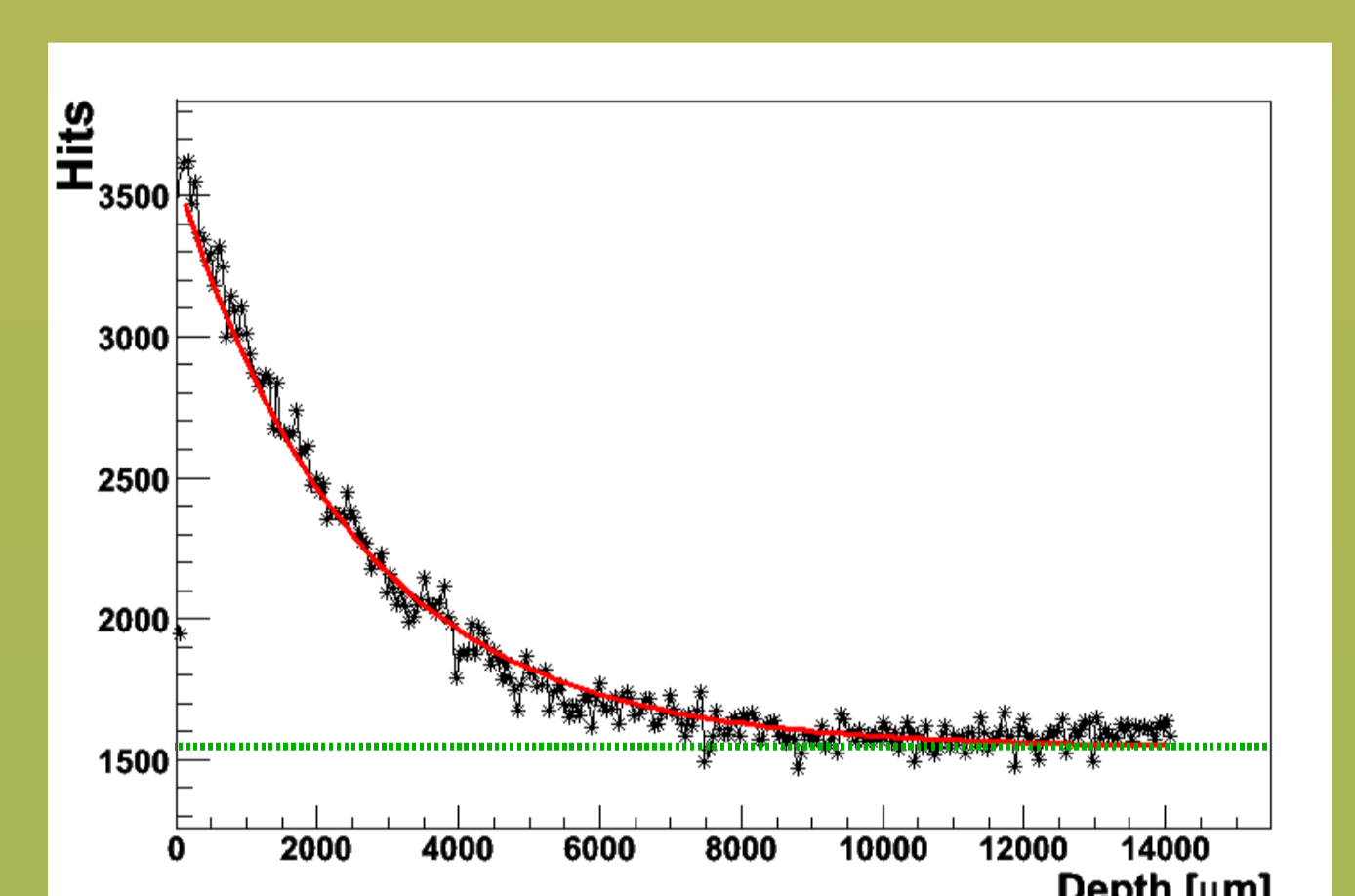
Beam direction determination

It was also possible to see the exponential decrease of the photon intensity as a function of depth, illuminating the Medipix detector with the beam almost parallel to the surface. Counts per pixel in a row as a function of the row position with respect to the X-ray beam are shown below. This latter measurement allows the determination of the beam direction with respect to the device.

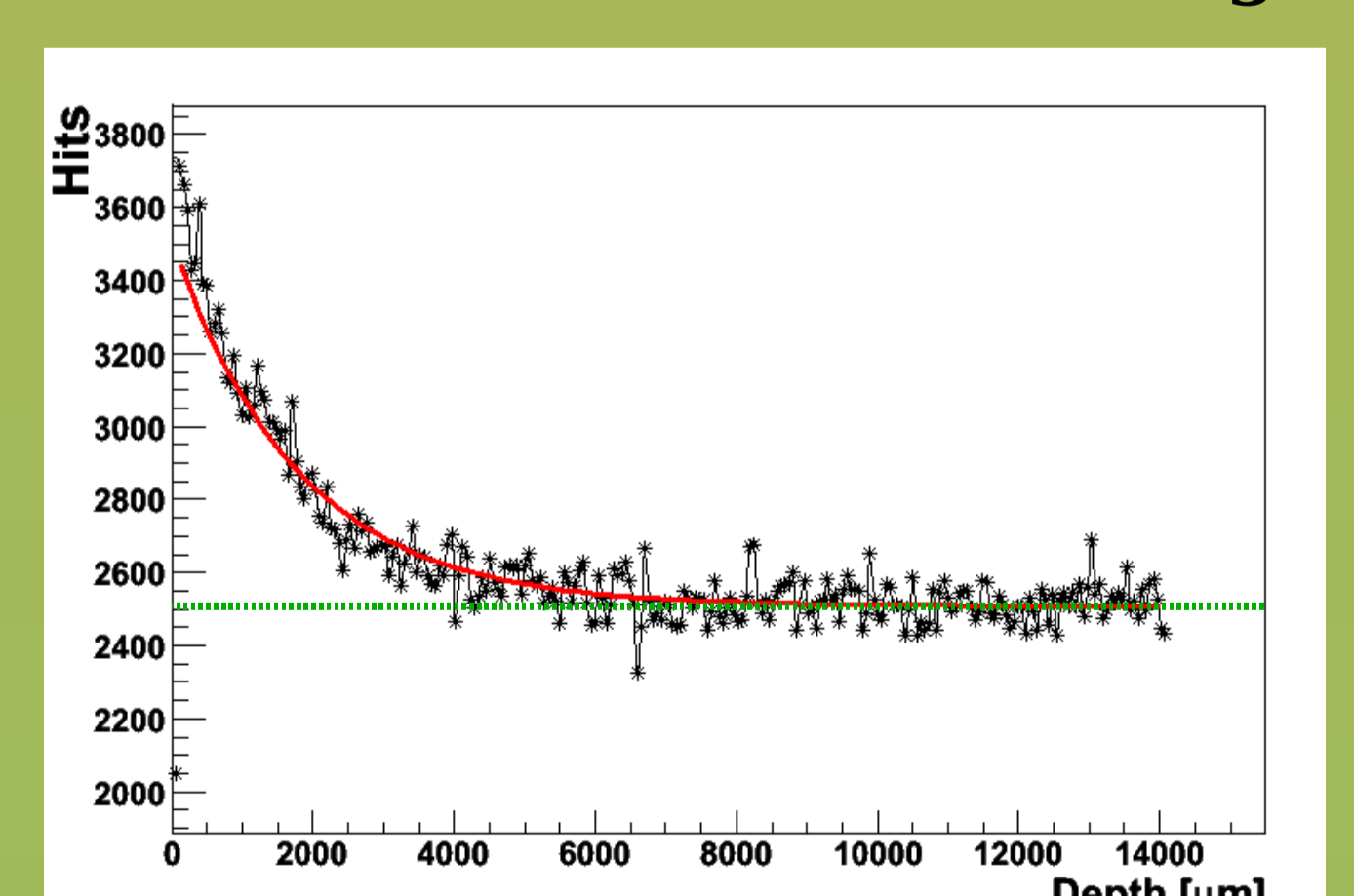
Attenuation in silicon - Beam angle 0.5°



Attenuation in silicon - Beam angle 2.5°



Attenuation in silicon - Beam angle 4.5°



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