HIGH-ENERGY PER-PIXEL CALIBRATION OF TIMEPIX PIXEL DETECTOR WITH LABORATORY ALPHA SOURCE
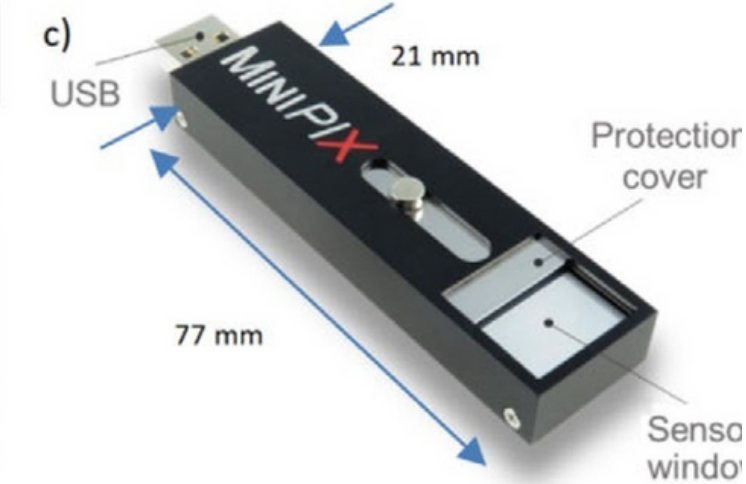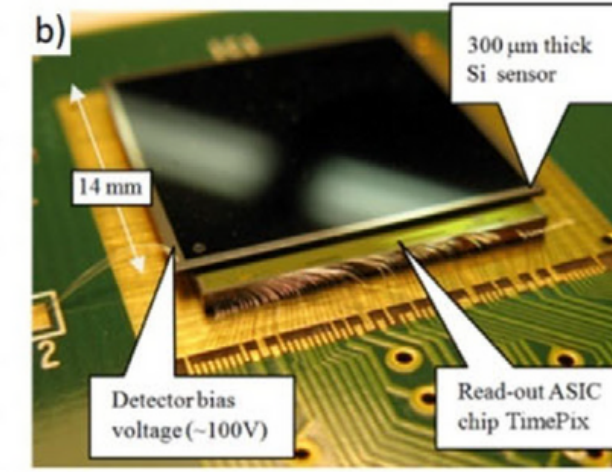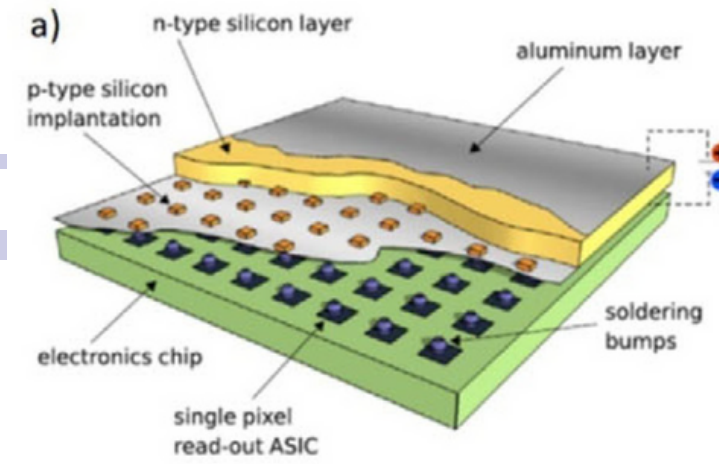
M. SOMMER, C. GRANJA, S. KODAIRA, O. PLOC

NUCLEAR PHYSICS INSTITUTE OF THE CZECH ACADEMY OF SCIENCES, CZECH REPUBLIC
ADVACAM, CZECH REPUBLIC
NATIONAL INSTITUTES FOR QUANTUM AND RADIOLOGICAL SCIENCE AND TECHNOLOGY, JAPAN

Timepix pixel detector

a)
- n-type silicon layer
- aluminum layer
- p-type silicon implantation
- soldering bumps
- electronics chip
- single pixel read-out ASIC

b)
- 300 μm thick Si sensor
- 14 mm
- Detector bias voltage (~100V)
- Read-out ASIC chip TimePix

c)
- USB
- 21 mm
- MINIPIX
- 77 mm
- Protection cover
- Sensor window

Used for dosimetry at ISS and several low Earth orbit satellites, spectral imaging and nondestructive testing

Clusters allow to characterize the type and incident angle of particles

Low detection threshold - appx. 5 keV

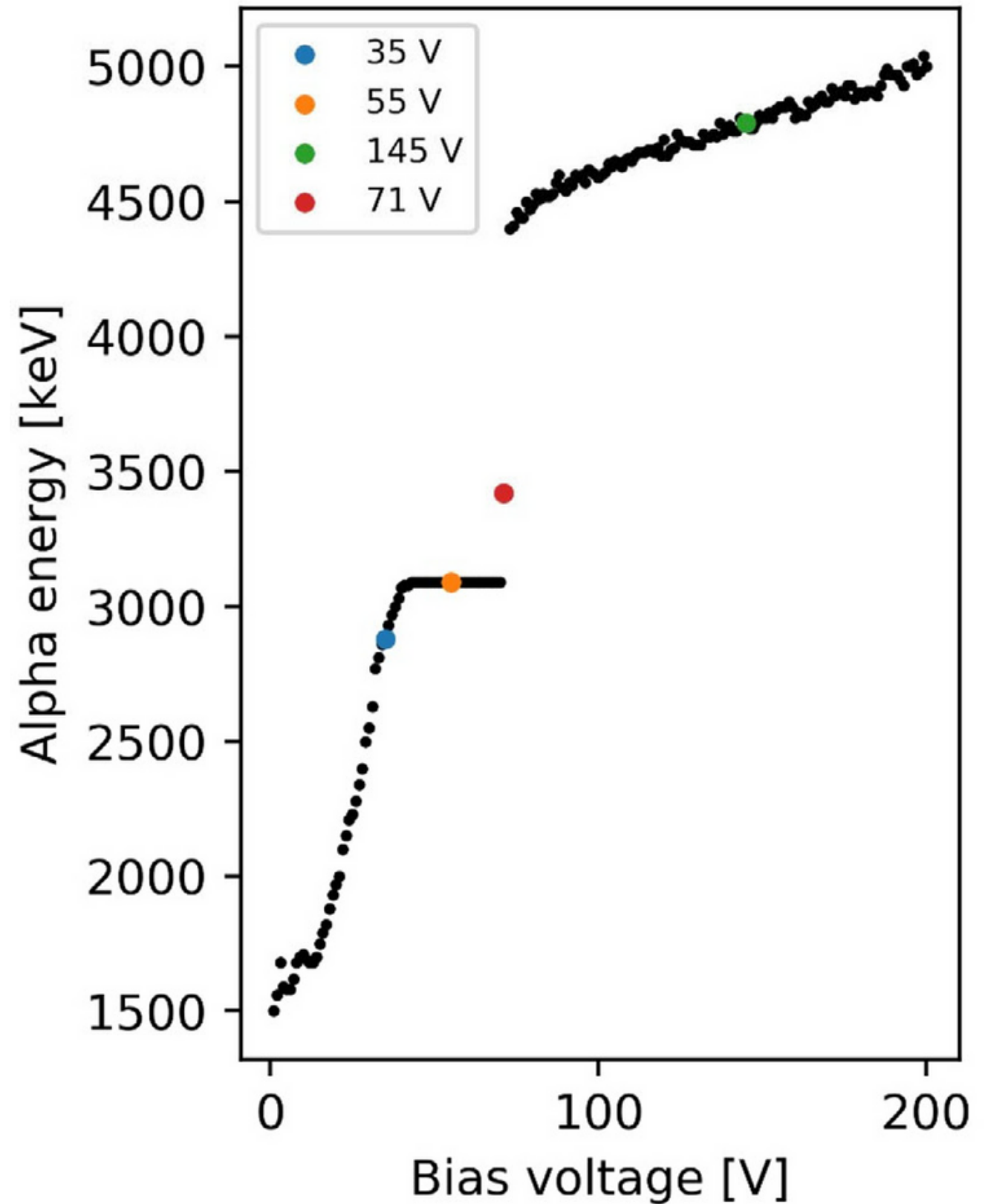High spatial resolution (size of a pixel 55 um), 256 x 256 pixels

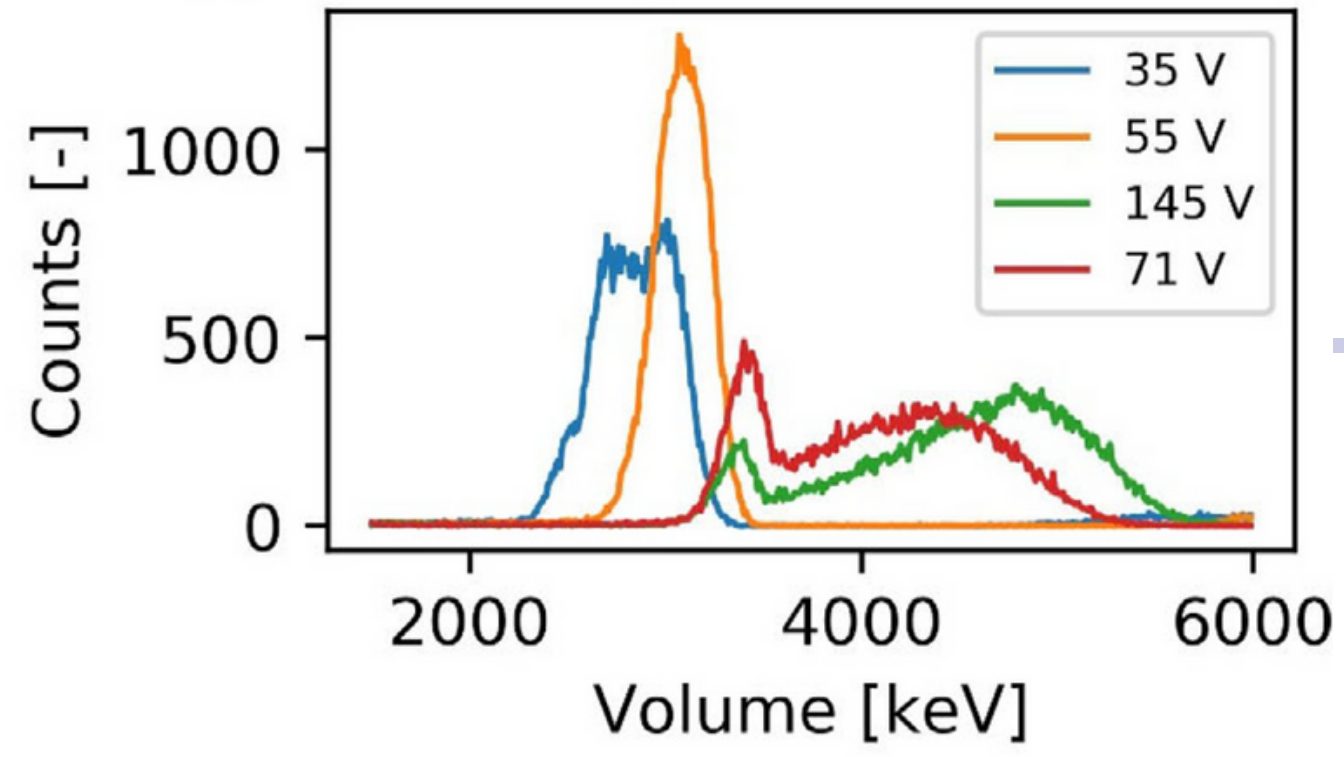Telescopic multi layer configuration of Timepix detectors
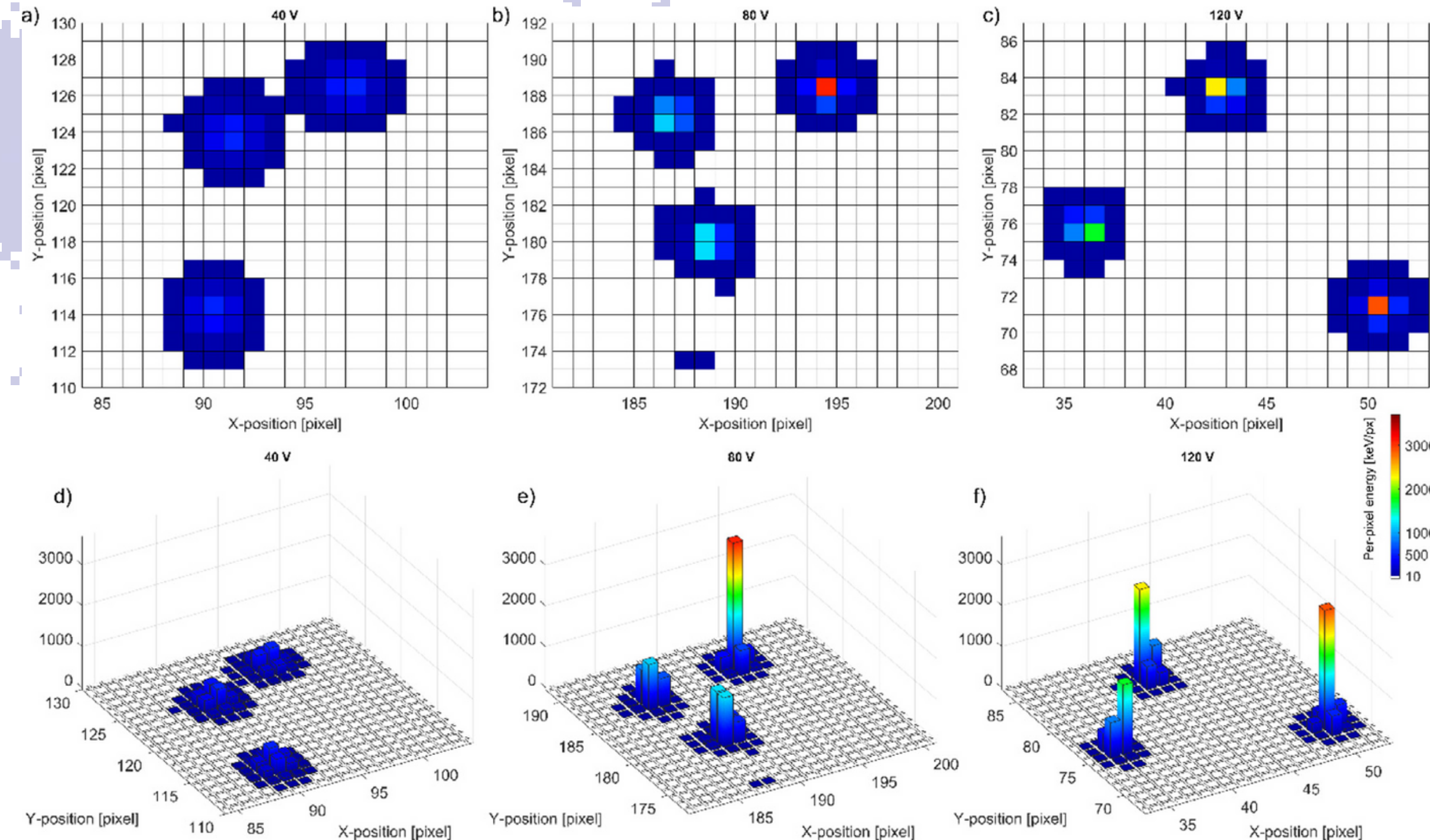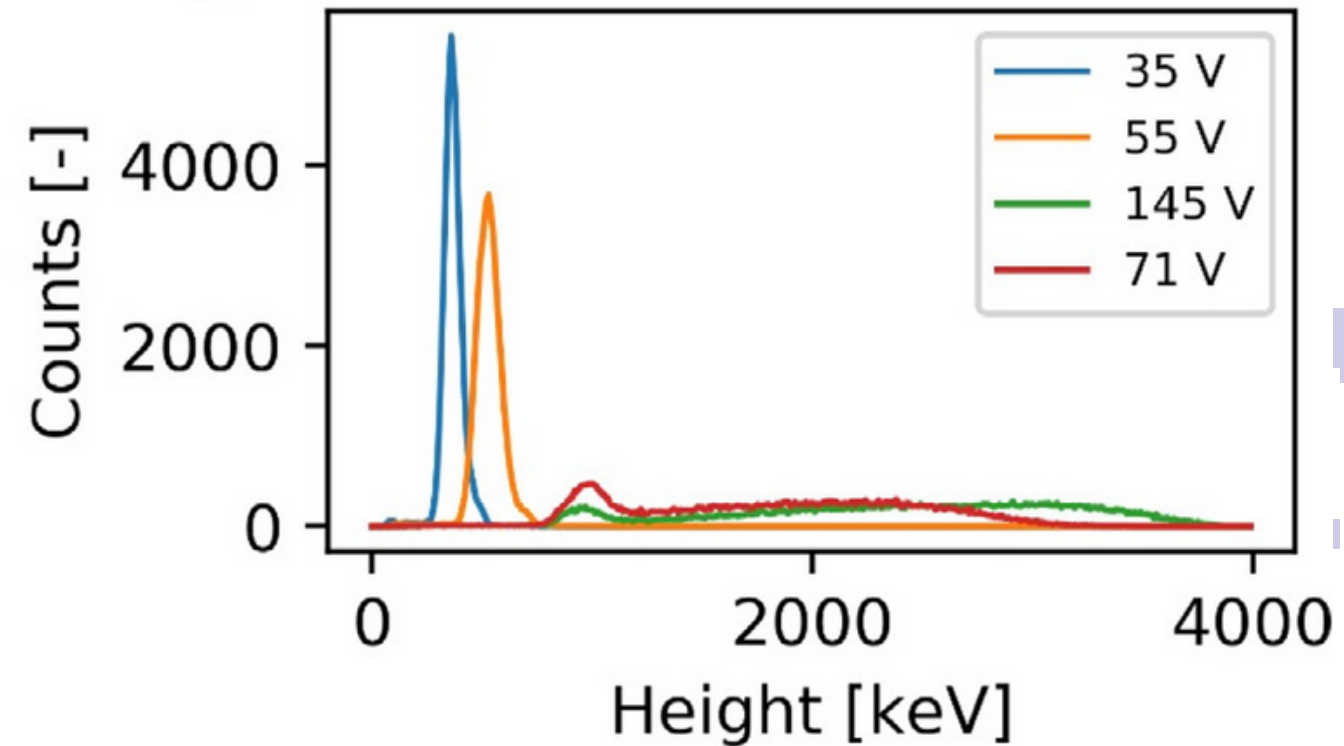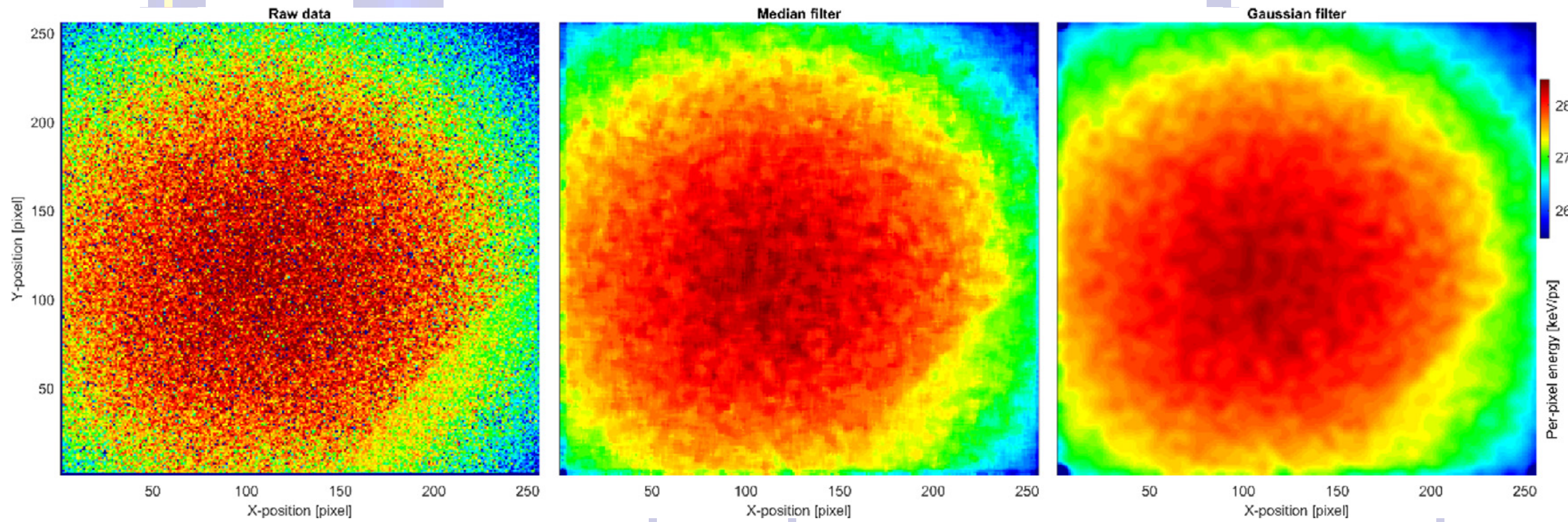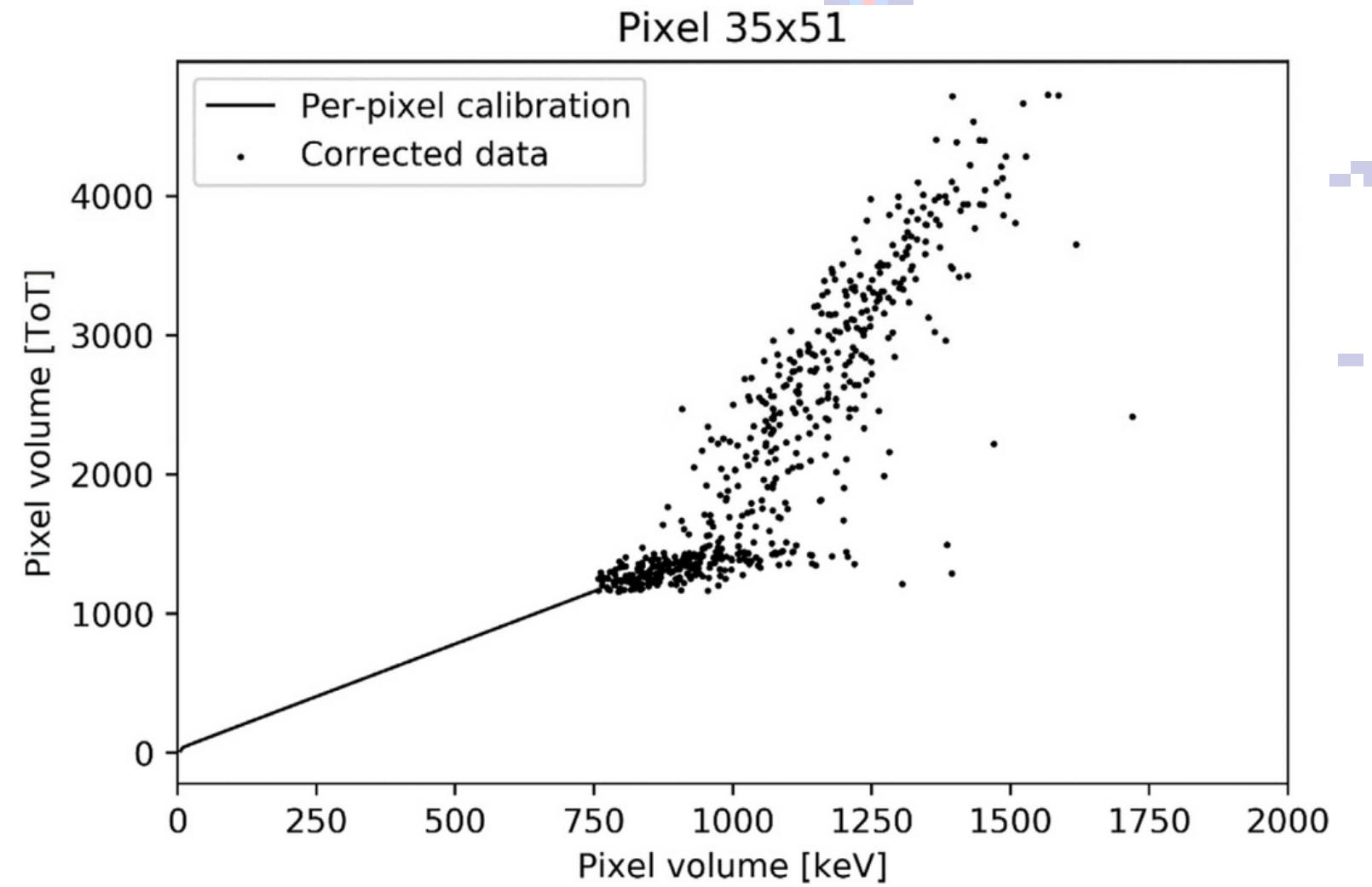
Saturation of pixel electronics
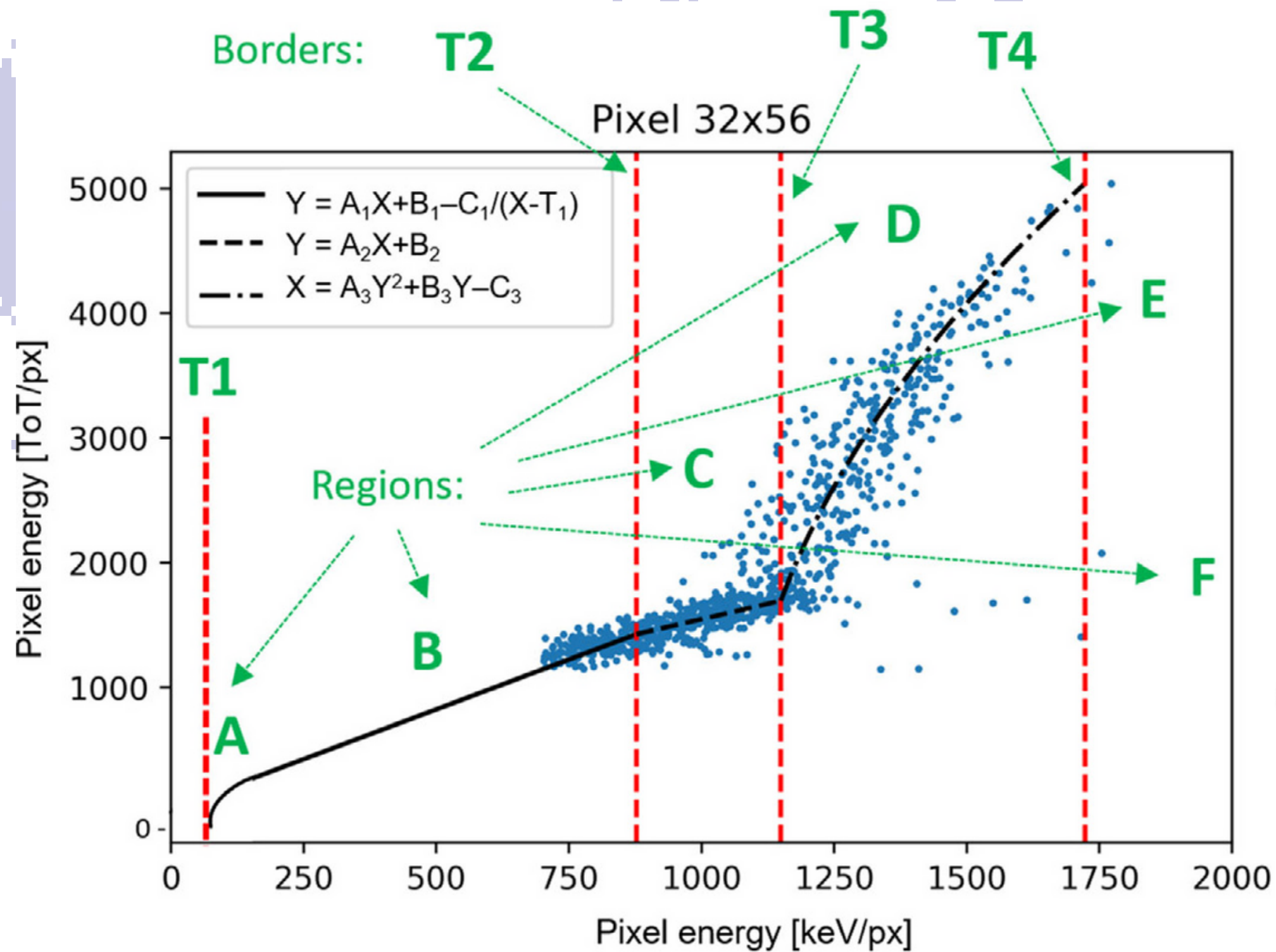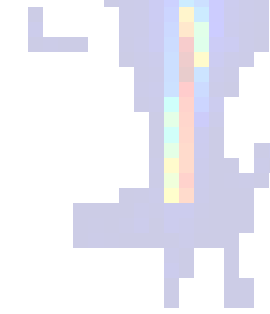
Reference energy

Reference matrix for each distance - only clusters with heights lower than threshold (800-850 keV)

Comparison of clusters with only one hot pixel gives us the real energy of the hot pixel

Pixel 35x51

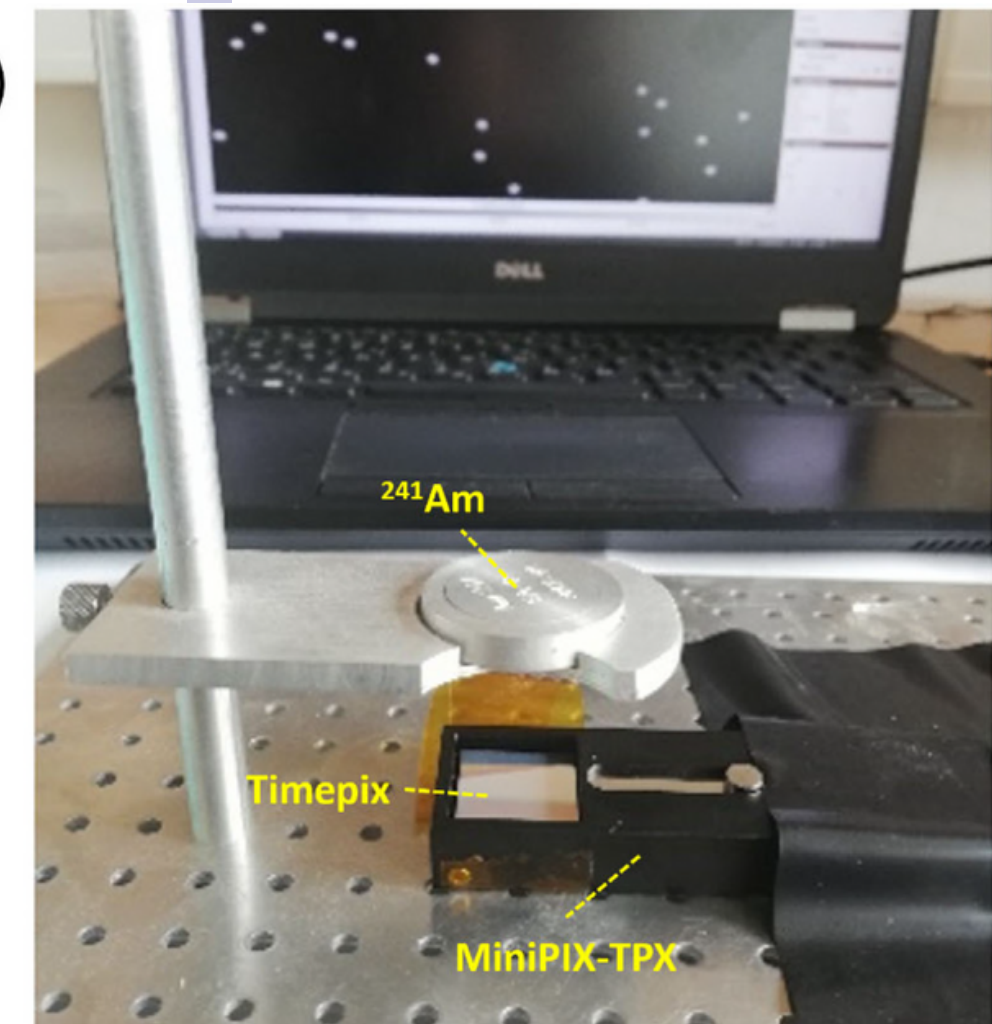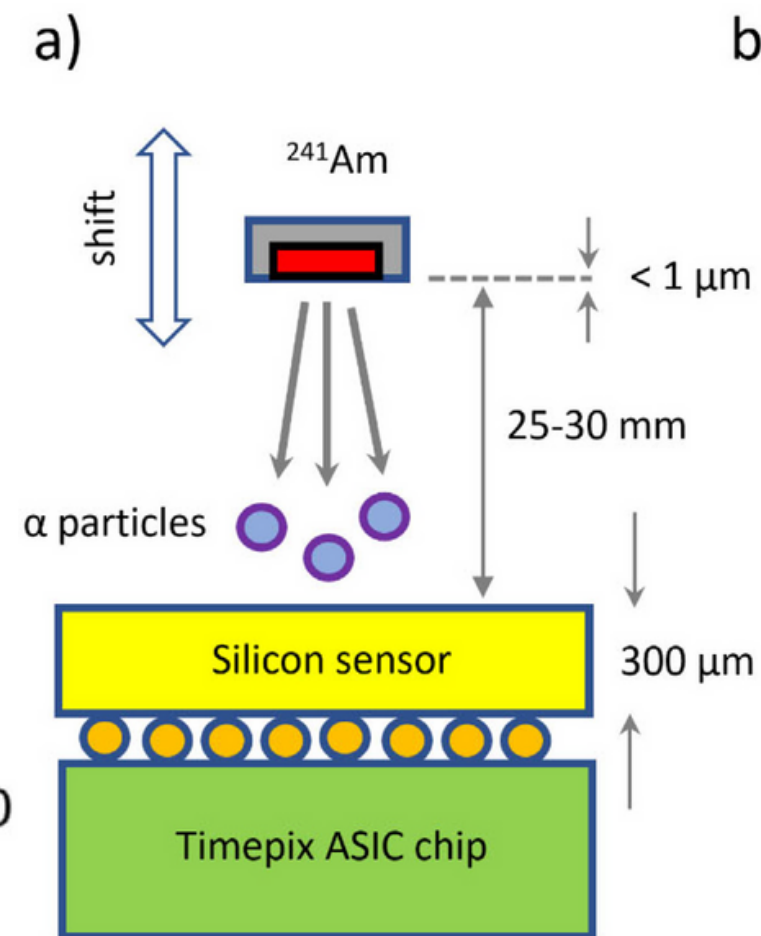Raw data

Median filter

Gaussian filter

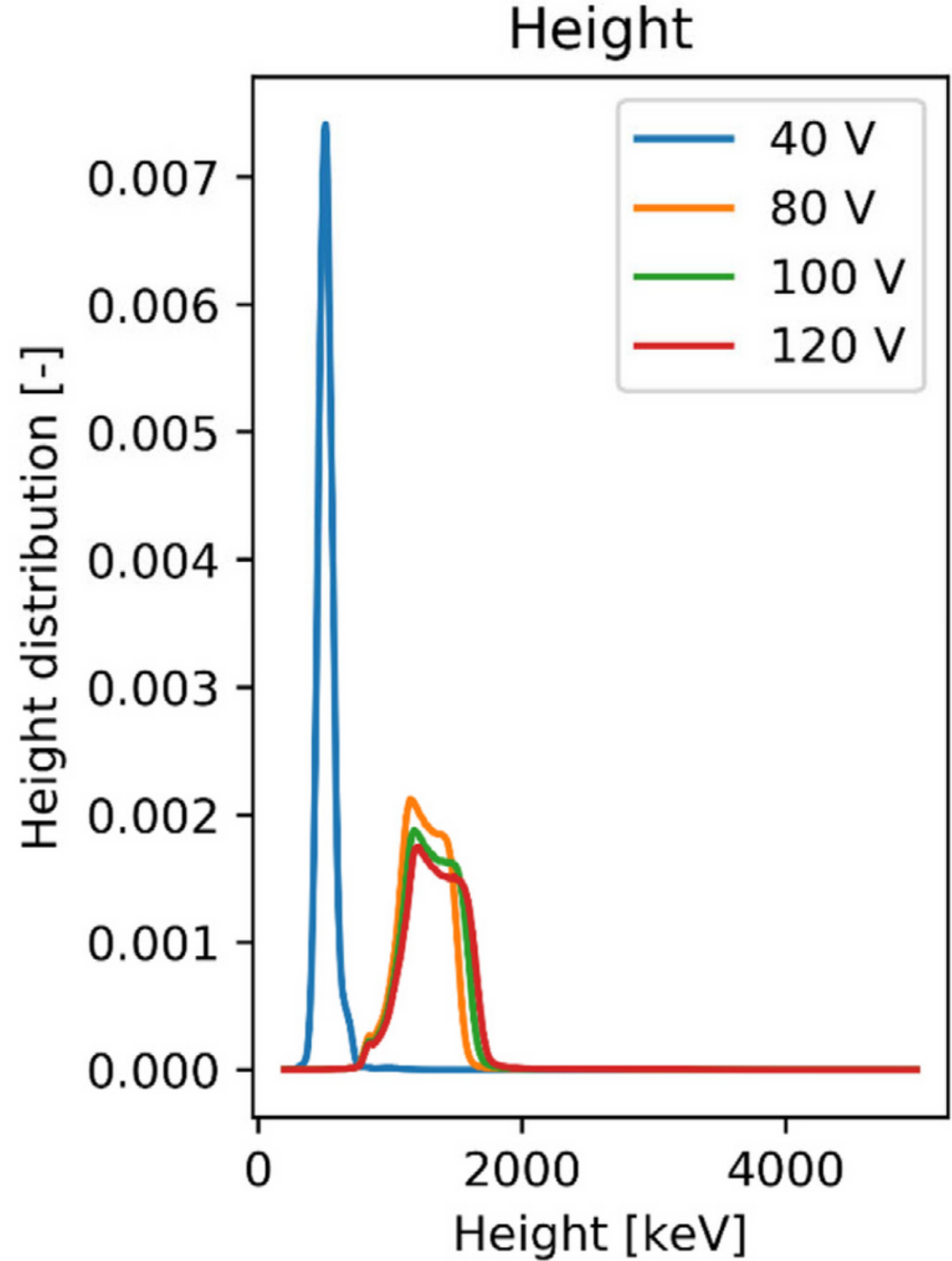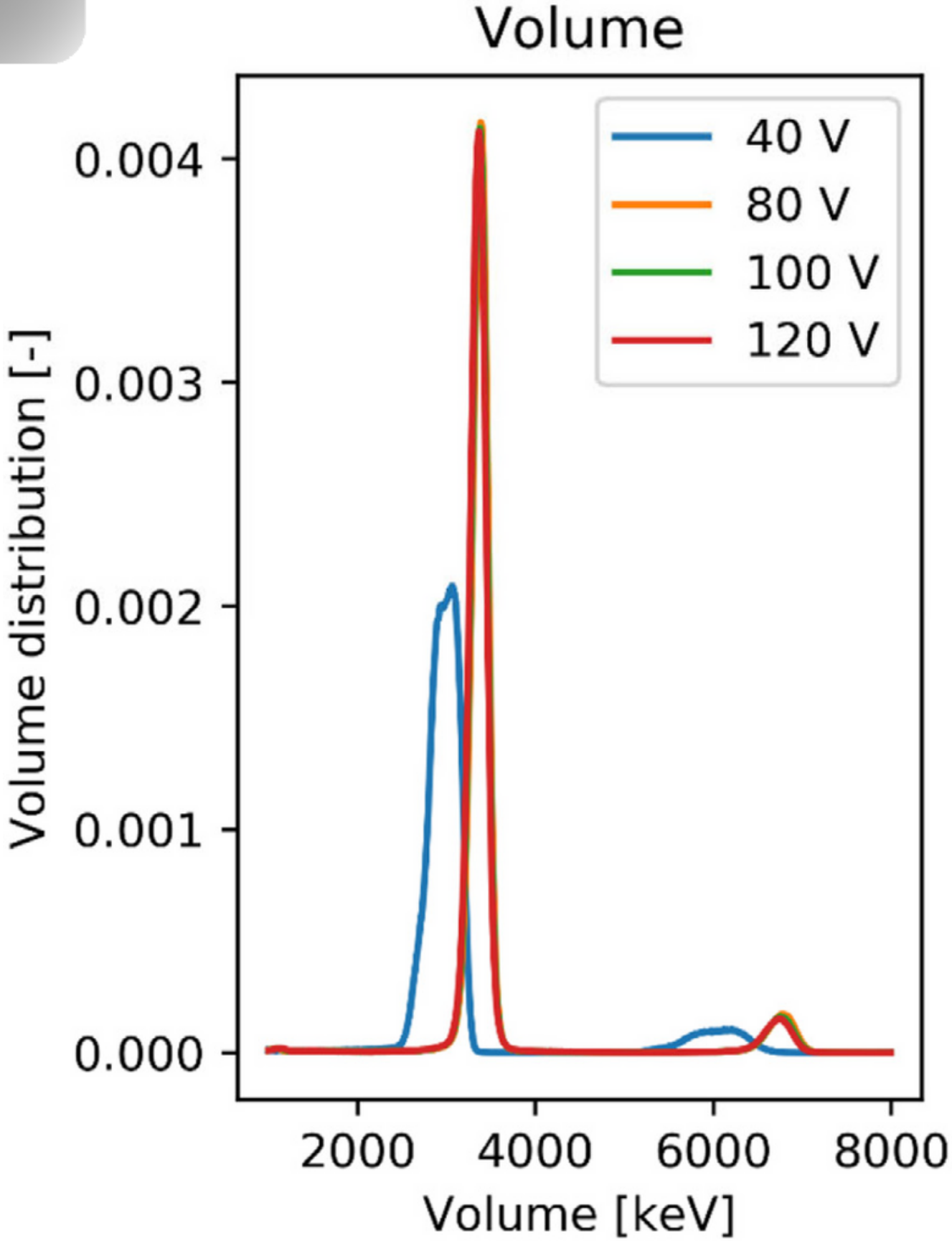# High-energy per-pixel calibration

SDD and bias voltage influence the charge sharing effect

Extends the calibration range from 850 keV/px up to 1700 keV/px

Allows measurement of high LET particles such as H and He

Legend:
- $Y = A_1X + B_1 - C_1/(X-T_1)$
- $Y = A_2X + B_2$
- $X = A_3Y^2 + B_3Y - C_3$

Borders: T1, T2, T3, T4

Pixel 32x56

Regions: A, B, C, D, E, F

Pixel energy [ToT/px] vs Pixel energy [keV/px]

a)
^{241}Am
shift
< 1 µm
25-30 mm
α particles
Silicon sensor
300 µm
Timepix ASIC chip

b)
^{241}Am
Timepix
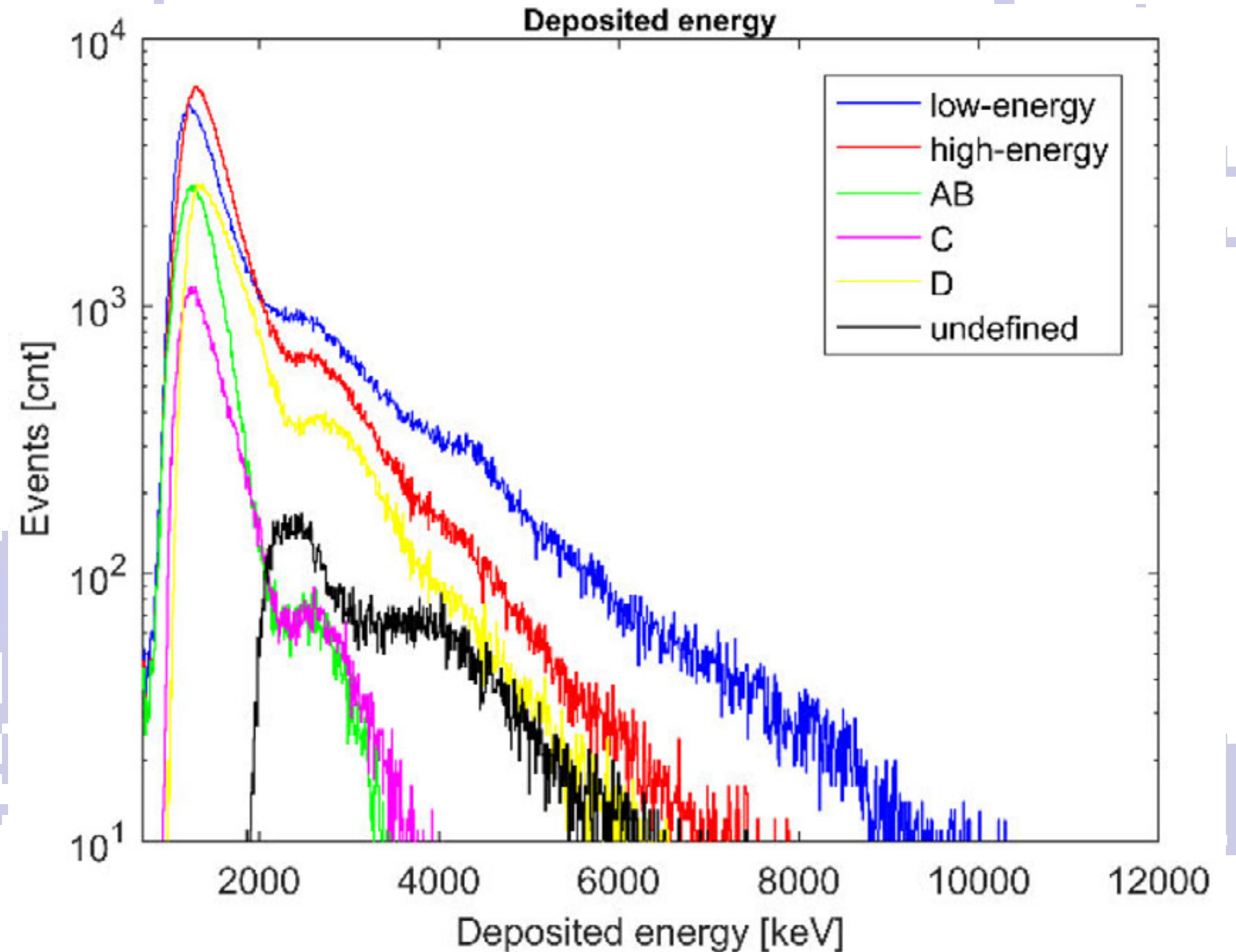MiniPIX-TPX

Validation of high–energy per–pixel calibration

Use of high-energy per-pixel calibration

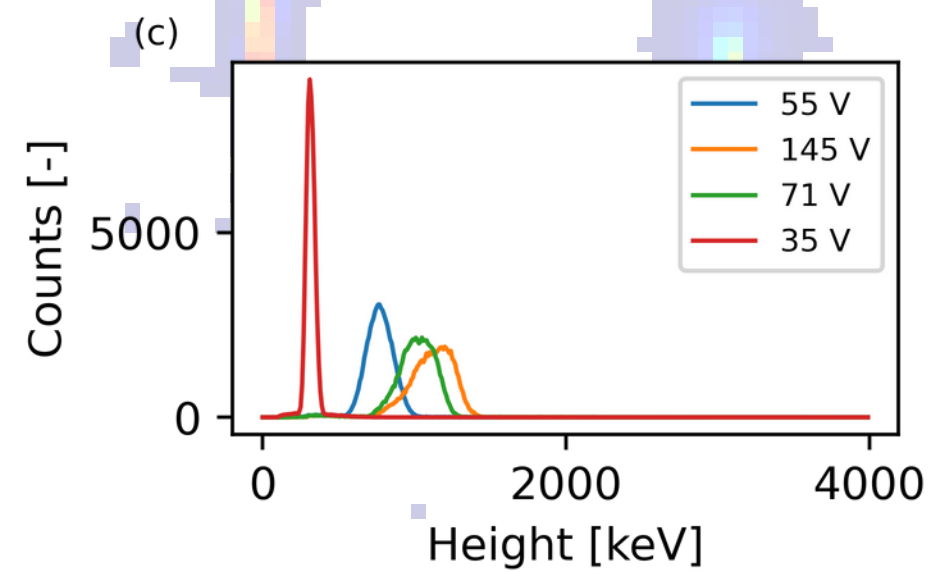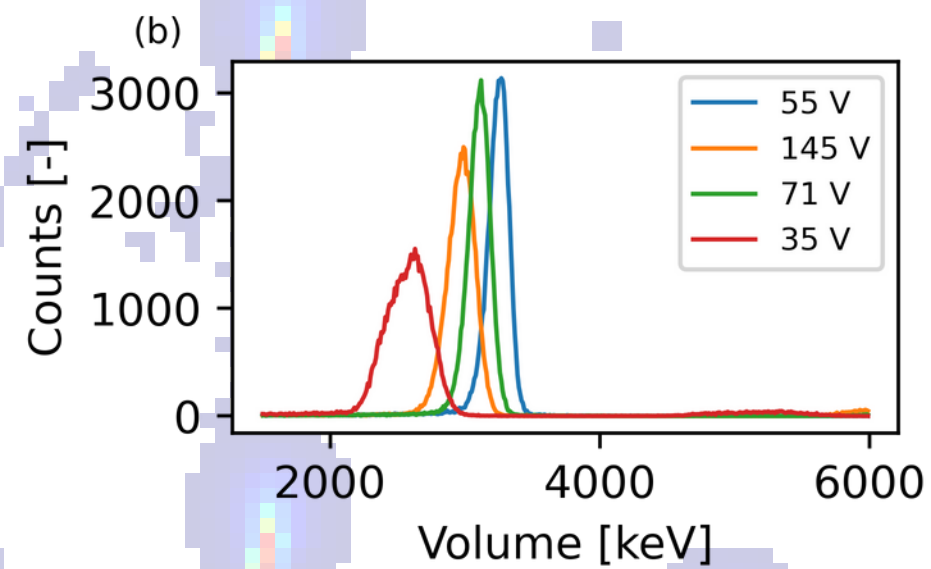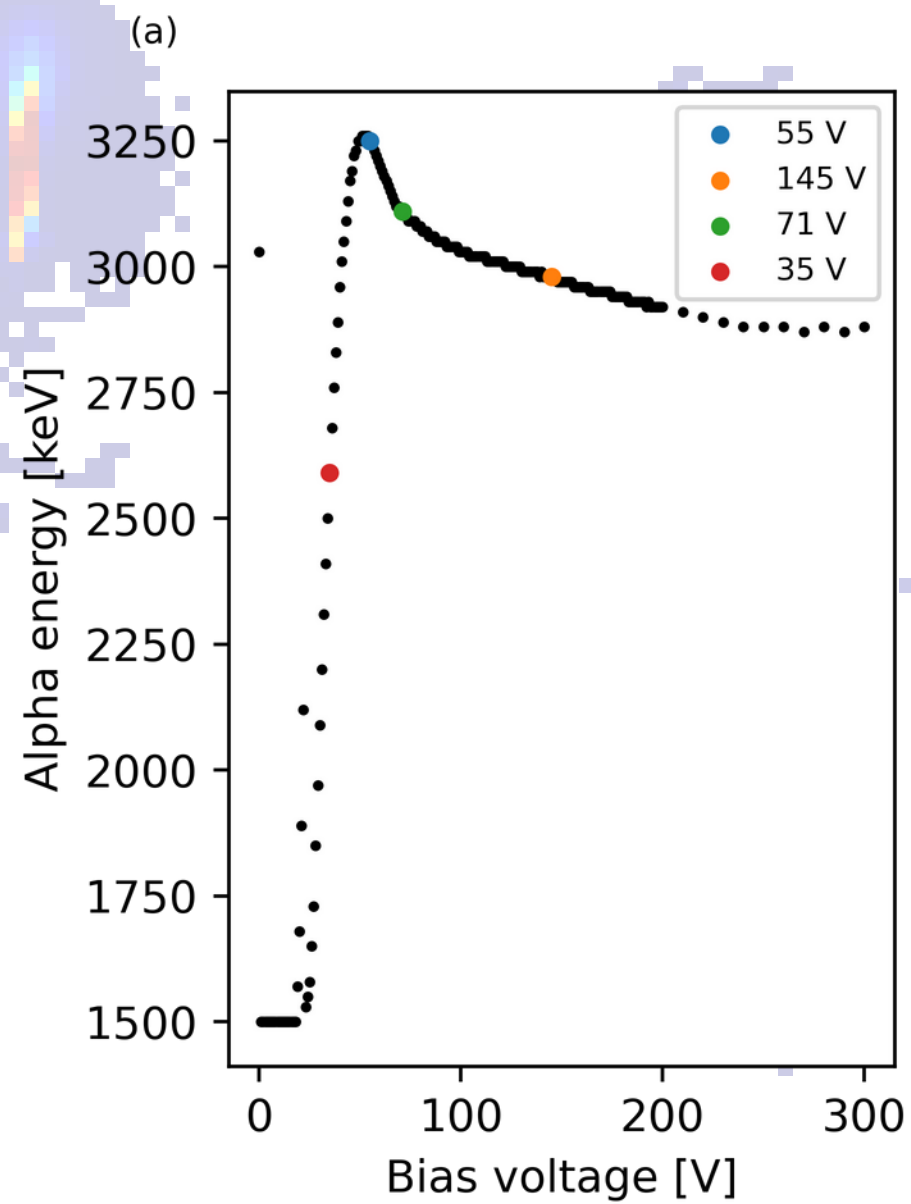Original use case was for Matroshka-III space experiment at ISS

Use of the calibrated devices for measurement of cosmic radiation onboard aircraft

Use of the high-energy per-pixel calibration for new Timepix3 and Timepix2 devices

Timepix3 and Timepix2

(a)

(b)

(c)

Timepix3 seems to have very low threshold in which the standard per-pixel calibration is valid - that does not allow the high-energy calibration

The analog amplifiers of Timepix2 were designed to avoid the odd behavior of the signal

Timepix2 linear up to appx. 1200-1400 keV/px

Pixel 76x175