Probing Defects

in a Small Pixellated CdTe Sensor Using an Inclined Mono Energetic X-Ray Micro Beam

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[1]Mid Sweden University [2]CERN [3]Glasgow University [4]Diamond Light Source
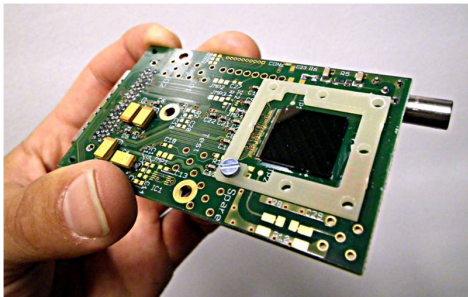Oct 31 2012, R-10, RTSD

Outline

- Timepix and sensor
- Measurement Setup
- X-ray response maps
- Defects
    - Big defect
    - Point defect
    - Line defect
    - Large ring defect
- Conclusions

Timepix

- Developed by the Medipix2 collaboration
- Single photon processing
  - Time of arrival
  - Time over threshold
  - Photon counting
- 256x256 pixels
- 55μm pixel pitch
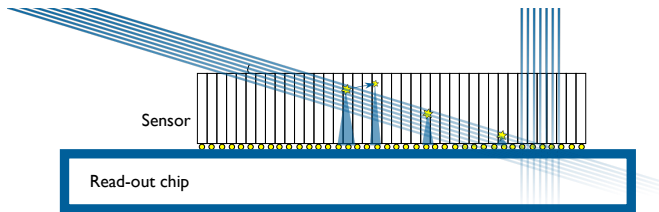- Electron or hole collection mode.

The Sensors

- CdTe, with Ohmic contacts (Pt)
- 55μm and $110\mu m$ pixel pitch
- 1mm thick
- Bump bonded to Timepix by FMF Freiburg
- CdTe from ACRORAD

Energy resolution in counting mode at 79keV

- 55μm FWHM: 5.6%
- 110μm FWHM: 3.5%

Measurement Setup

- Mono energetic 79keV micro beam (I15)
- Timepix with CdTe Sensor
- Fitpix 2.3 Read out system, Pixelman software (IEAP, Czech Technical University, Prague)
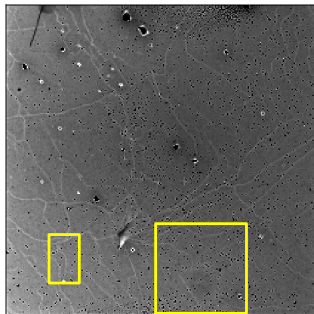- Python, PyRoot for data analysis

X-ray response map

110μm, -300V
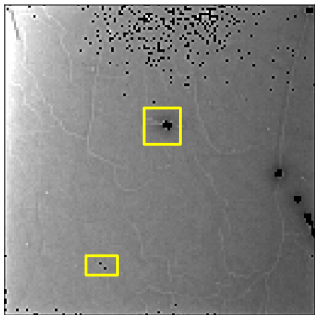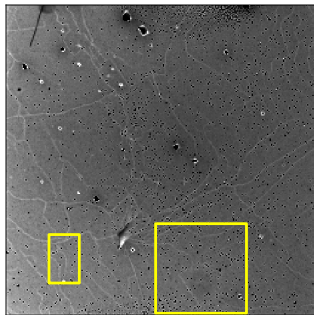
55μm, -300V

X-ray response map
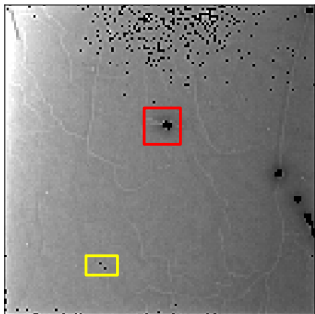
110μm, -300V   55μm, -300V

Large Defect

- Raster scan over the defect
- 110μm step
- Counting mode
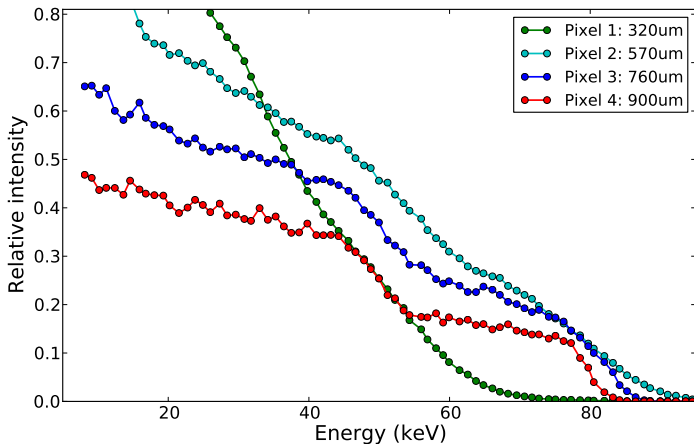- Compare the beam position with the counts in the sensor
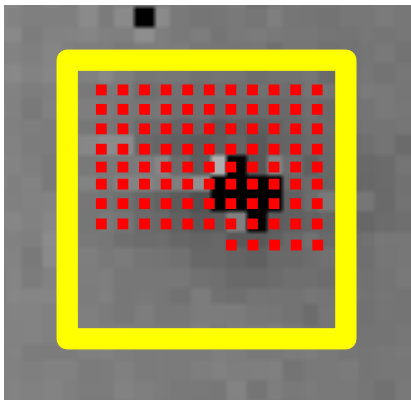
Large Defect

- Charge drifts towards the center of the defect
- Indication of high leakage in the center

Large Defect

Pixel 4: 900um
good field

Pixel 3: 760um
distorted field
but close to pixel

Pixel 2: 570um
charge drifts in

Pixel 1: 320um
distorted field

ttuniversitetet
a sweden university
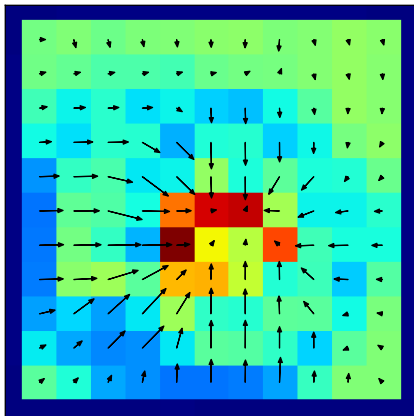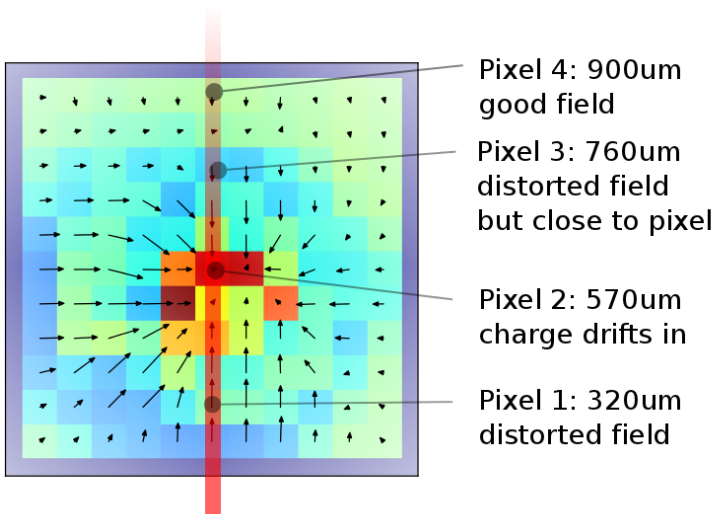
Integrated spectra

Large Defect

- Scan with an inclined beam
- Time over threshold mode
- Investigating depth of interaction response
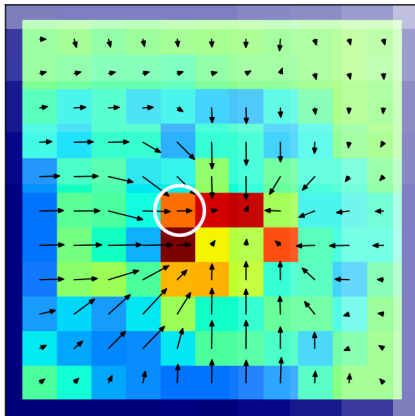
Depth of Interaction Response

Depth:64.0 um
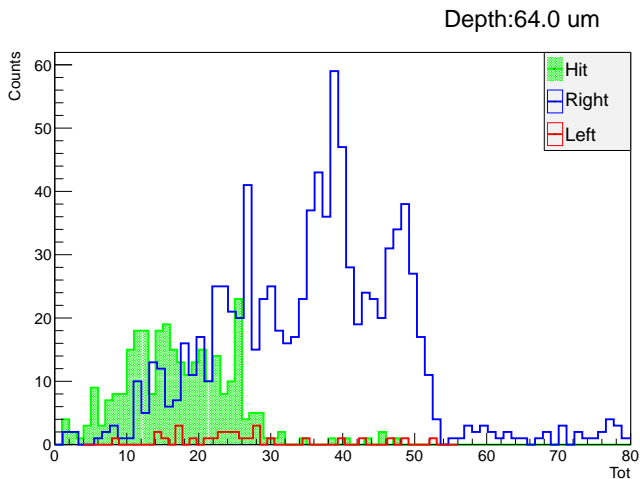
Depth of Interaction Response

Depth:191.0 um
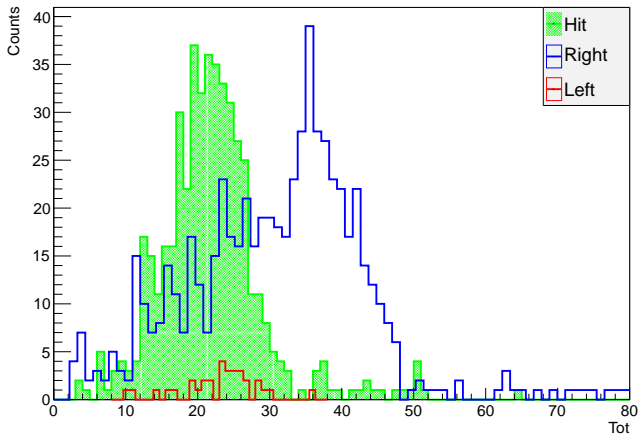
Depth of Interaction Response

Depth:318.0 um
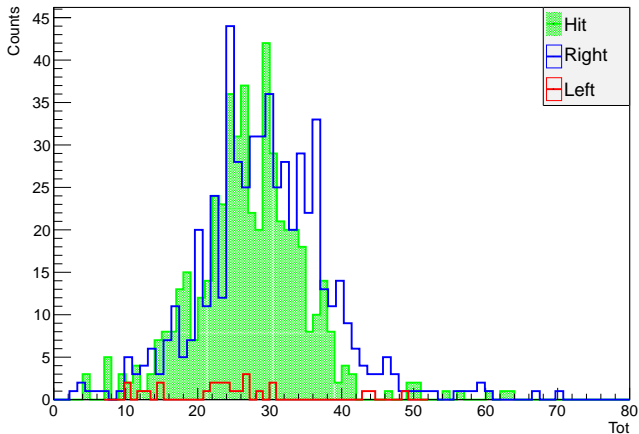
Depth of Interaction Response

Depth:445.0 um
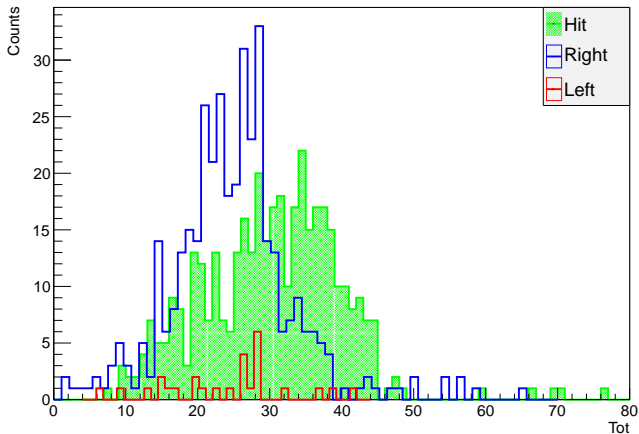
Depth of Interaction Response

Depth:572.0 um

Depth of Interaction Response

Depth:699.0 um

Depth of Interaction Response

Depth:889.0 um

X-ray response map

110μm, -300V
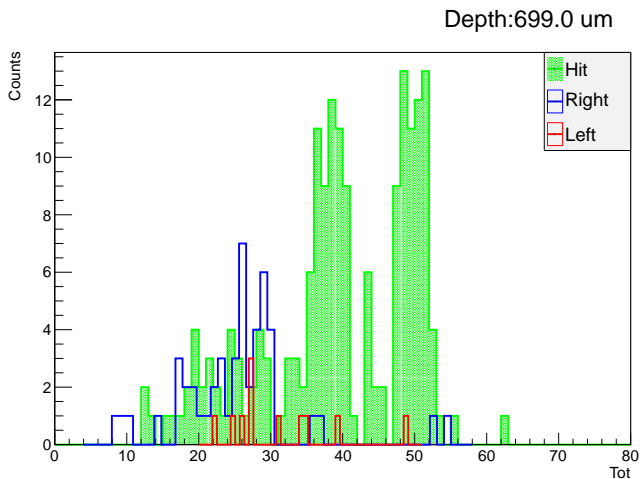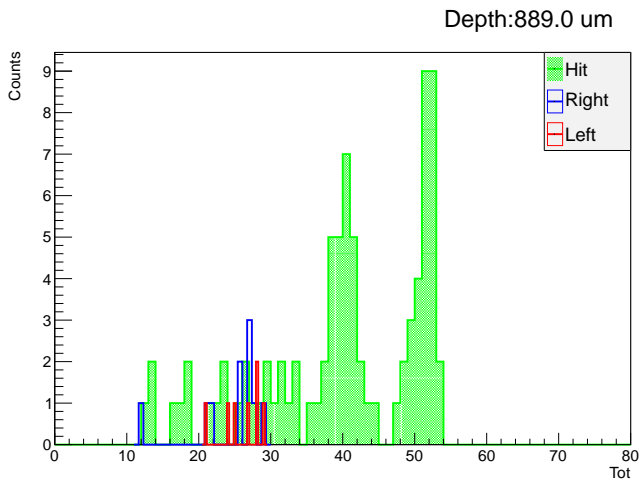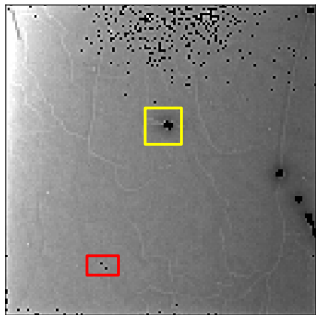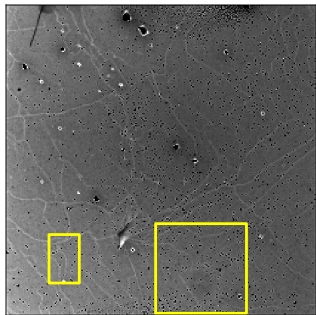
55μm, -300V
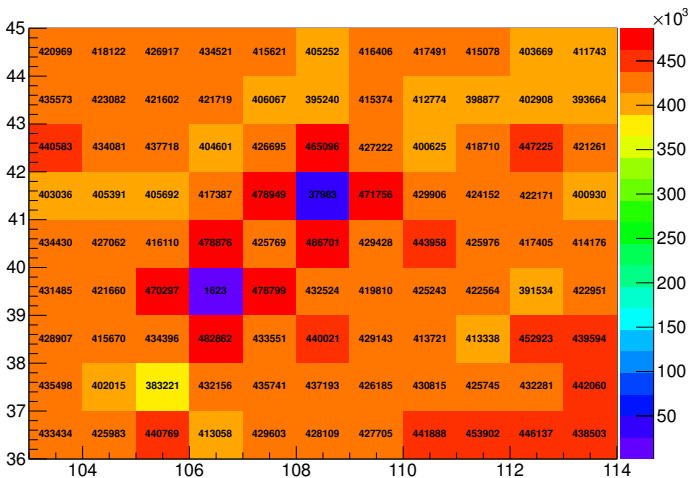
Point Defect
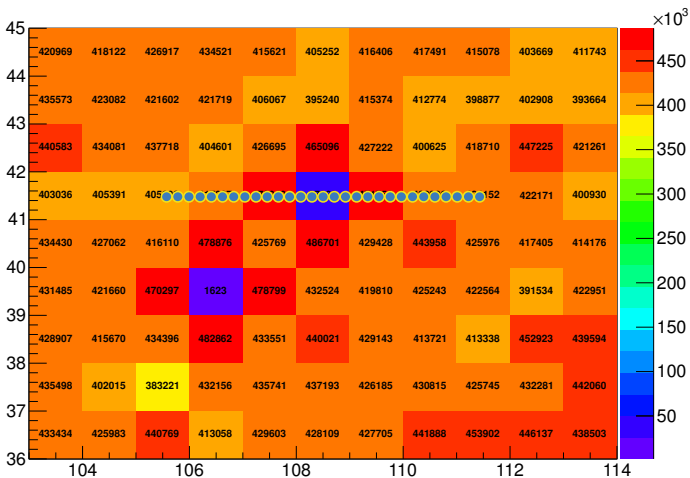
Point Defect
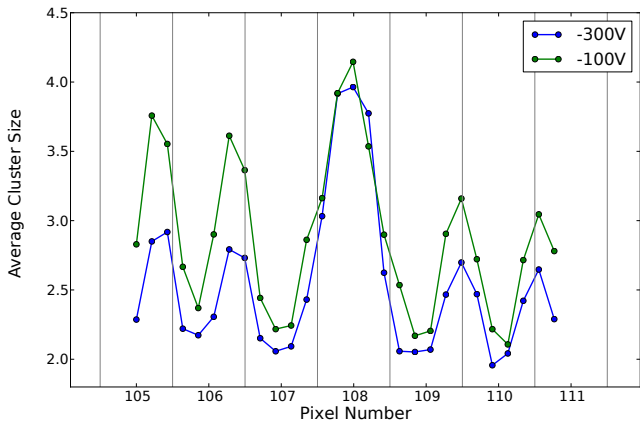
Point Defect

Point Defect

X-ray response map

110μm, -300V

55μm, -300V

Lines

150 μm   400 μm   750 μm   150 μm   400 μm   750 μm

TH: 6keV   TH: 60keV
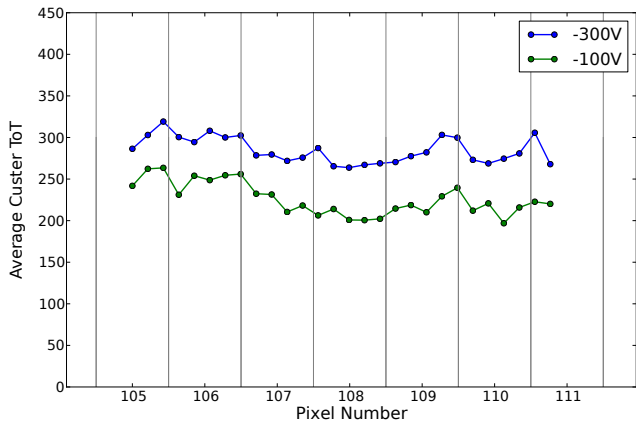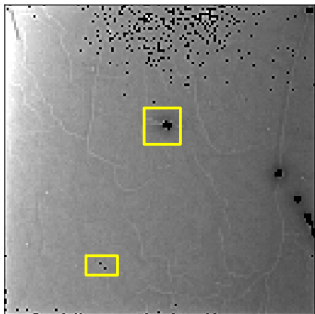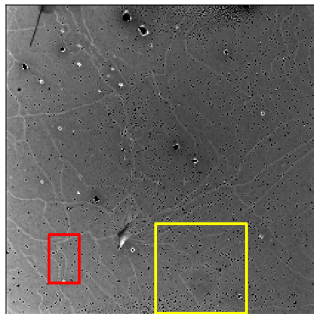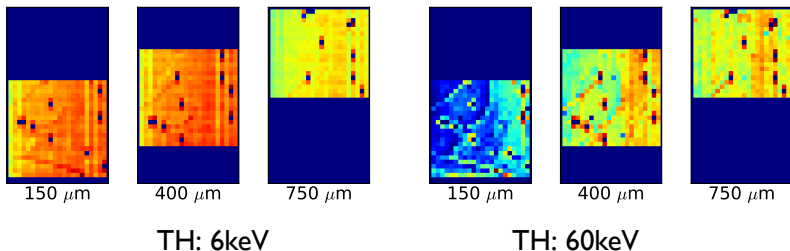
- Lines stay at the same place troughout the detector
- Indications of better charge transport.
    - More visible in the top layer
    - More visible with higher threshold

Positive bias

55μm -300V
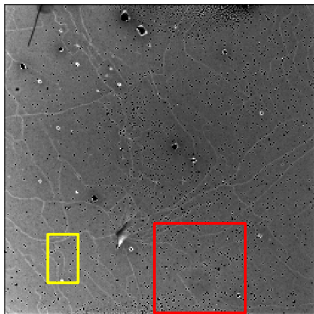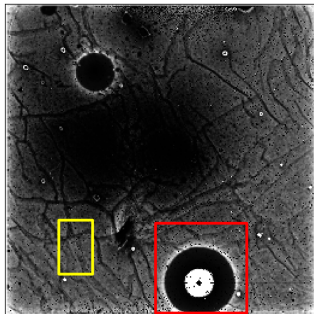
55μm +150V

Circular Defects

- Different behavior from negative bias
- Defect travel and pulse over time
- After image remains for some time. *(Bias cycle does not help)*
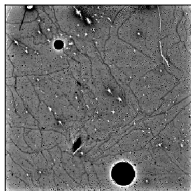
+500V
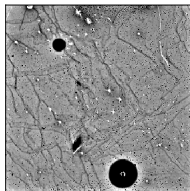
+300V

+150V

+50V

Circular Defect

-300V

Bias: +150V single step

Circular Defect

-300V

Bias: +150V single step

Circular Defect

-300V

Bias: +150V single step
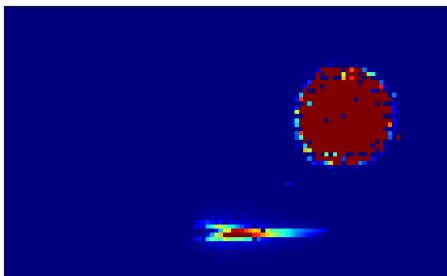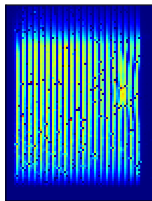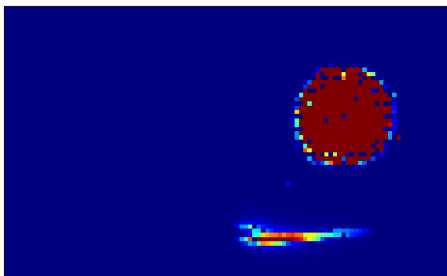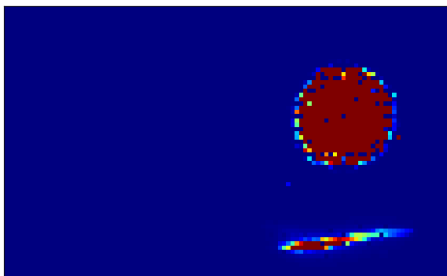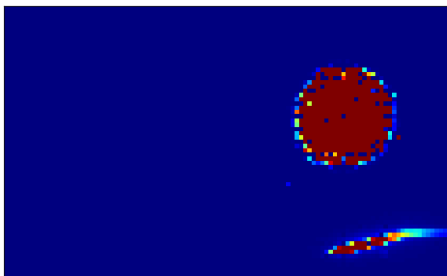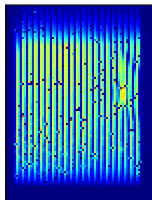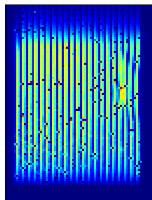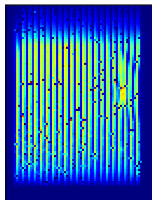
Circular Defect

-300V

Bias: +150V single step
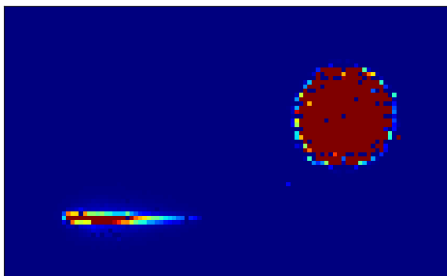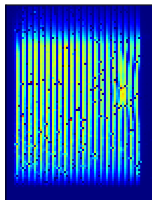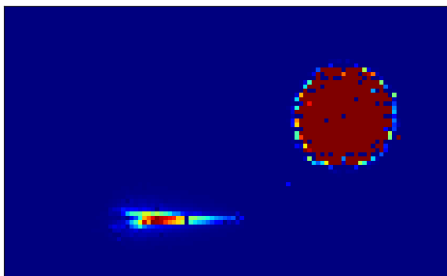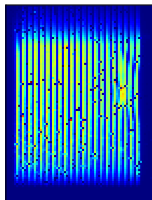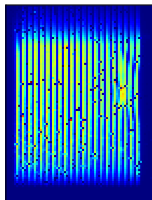
Circular Defect

-300V

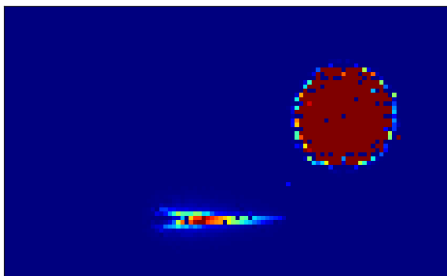

Bias: +150V single step

Circular Defect

-300V

Bias: +150V single step

Circular Defect

-300V

Bias: +150V single step

Circular Defect

-300V

Bias: +150V single step

Circular Defect

-300V

Bias: +150V single step

Circular Defect

-300V

Bias: +150V single step

Circular Defect

-300V

Bias: +150V single step
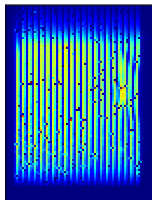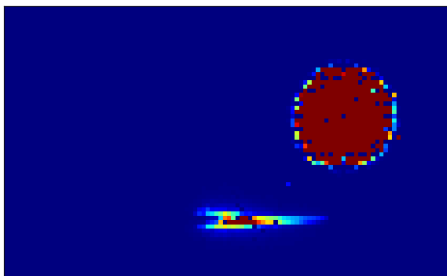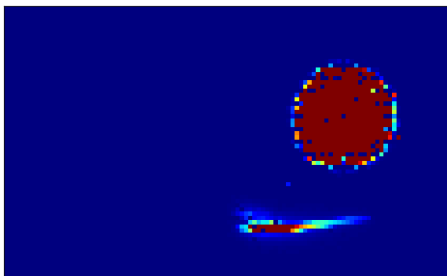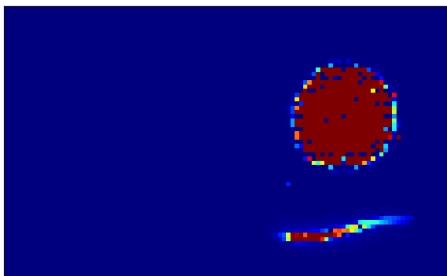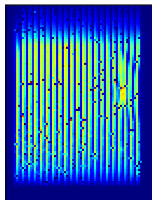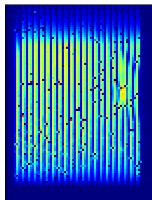
Circular Defect

-300V

Bias: +150V single step
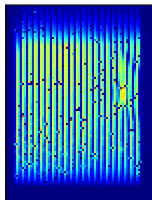
Circular Defect

-300V

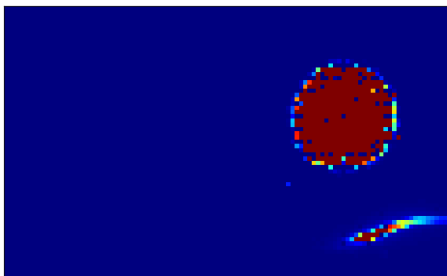Bias: +150V single step

Circular Defect

-300V

Bias: +150V single step
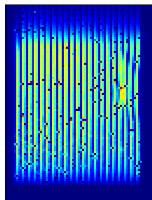
Circular Defect

-300V
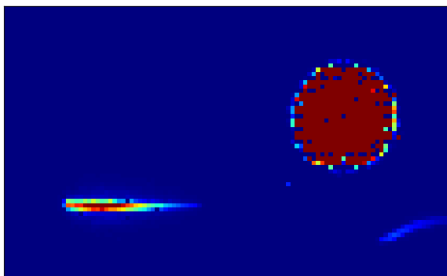
Bias: +150V single step

Circular Defect

-300V

Bias: +150V single step
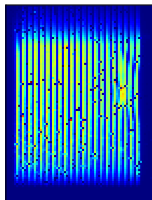
Circular Defect

-300V
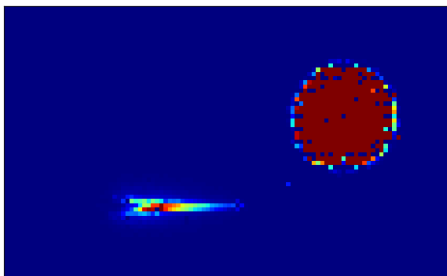
Bias: +150V single step

Circular Defect

-300V

Bias: +150V single step

Circular Defect

-300V

Bias: +150V single step
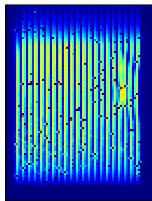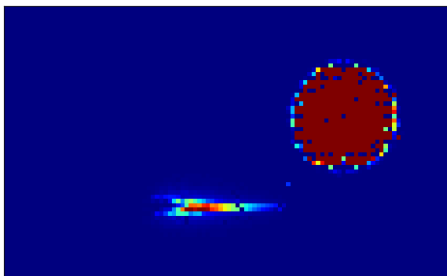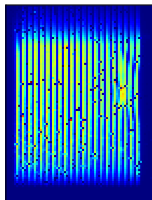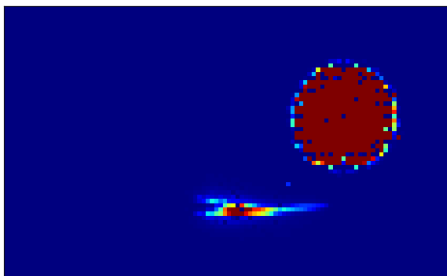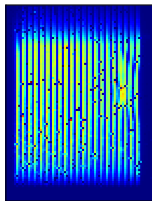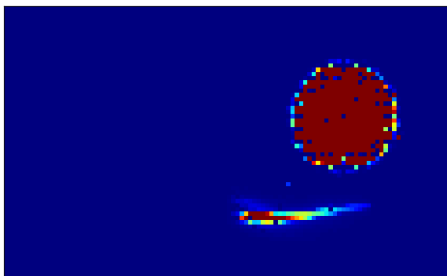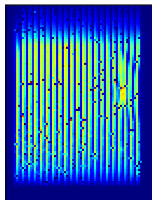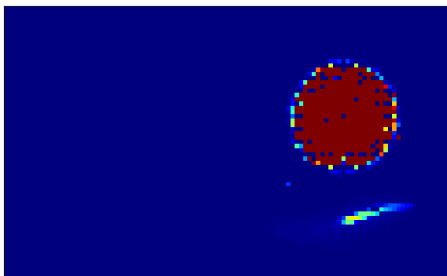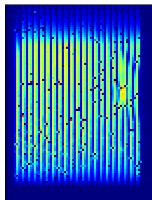
Circular Defect

-300V

Bias: +150V single step

Conclusions

- We can map the response of defects in CdTe sensors with an monoenergetic microbeam.

- Using an inclined beam can provide information about the depth of interaction dependence

- Defects shows a large difference in behavior when swithing bias polarity

- This information can be used to understand the nature of the defect and to create correction algorithms

- Combination with other characterization methods would be useful