Methods for the characterization of the long-term behaviour of X-ray detectors

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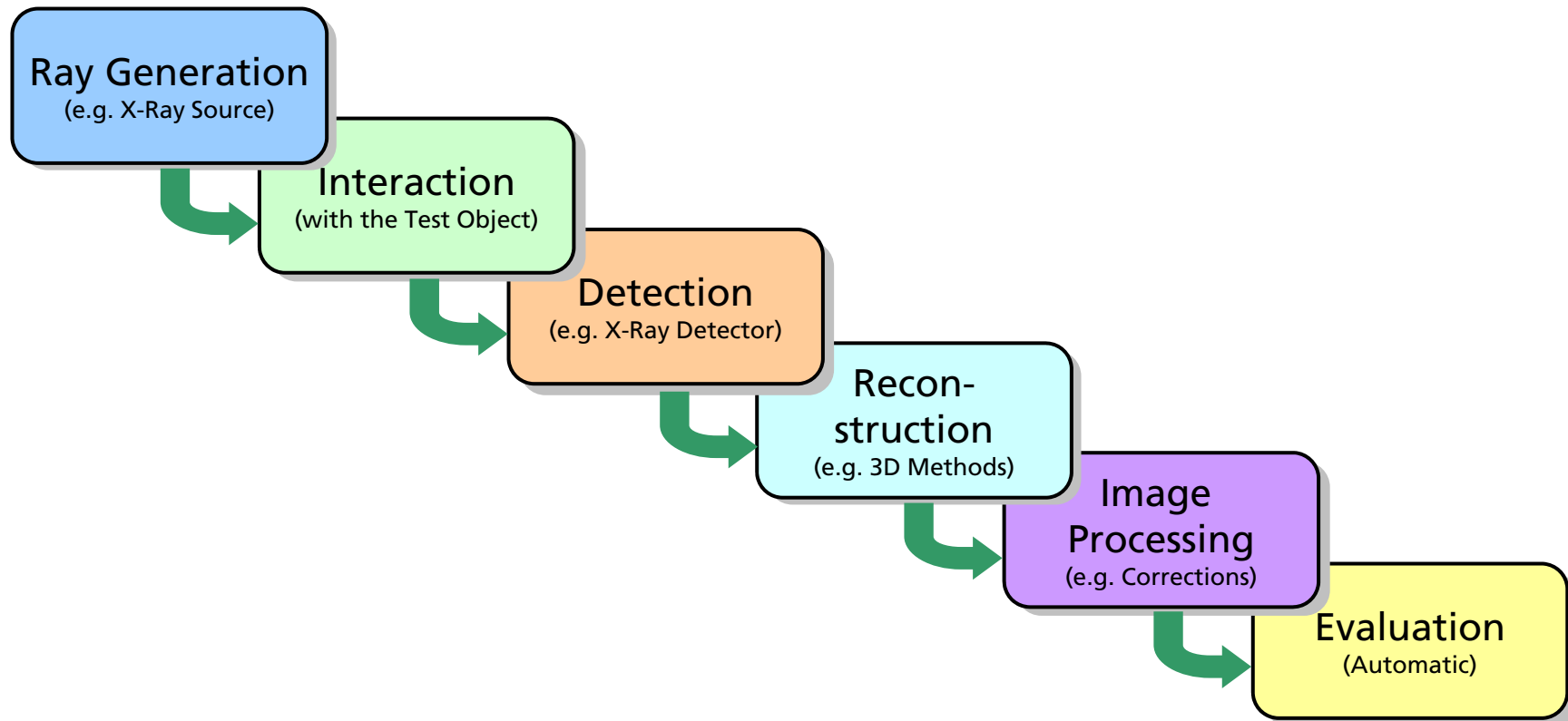[2] Cluster "Engineering of advanced Materials", University Erlangen

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X-ray imaging
Process Chain

```
Ray Generation
(e.g. X-Ray Source)
    →
        Interaction
        (with the Test Object)
            →
                Detection
                (e.g. X-Ray Detector)
                    →
                        Recon-
                        struction
                        (e.g. 3D Methods)
                            →
                                Image
                                Processing
                                (e.g. Corrections)
                                    →
                                        Evaluation
                                        (Automatic)
```

X-ray imaging
Process Chain

Ray Generation	Interaction	Detection	Reconstruction	Image Processing	Evaluation
■Simulation ■Excitation ■Optics ■Light Sources ■Light Transp. ■Projection Techniques ■Polarization	■Simulation ■New Methods ■Scattering ■Absorption ■Fluorescence	■Simulation ■**Characterization** ■Electronics ■Indirect Conversion ■Direct Conversion ■Szintillators ■Detector Scattering	■Simulation ■Algorithms ■2D Methods ■3D Methods ■Tomosynthesis	■Artifact Reduction ■Conversion ■Surface Extraction ■Registration	■In 3D ■Pores ■Blowholes ■Extraneous Elements ■Metrology ■Simulation ■Measurement Uncertainty ■Automatic Evaluation ■Electronics Testing

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Characterization of Digital Detector Arrays
Motivation

ASTM E 2597-07:

Standard Practice for Manufacturing Characterization of Digital Detector Arrays

Additional Tests:

- BSR
- Achievable Contrast Sensitivity
- Specific Material Thickness Range
- Image Lag
- Efficiency
- Burn-In
- Bad Pixels
- Internal Scatter Radiation

- MTF
- Dark Current
- DQE
- Pixel Noise

(Fraunhofer EZRT Quality Control)

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Adaption of characterizations
Differentiation between photon counting and charge integrating detectors

Charge integrating detectors

- BSR
- MTF
- Dark Current + Pixel Noise
- Achievable Contrast Sensitivity
- Specific Material Thickness Range
- Image Lag
- DQE
- Bad Pixels
- Efficiency
- Internal Scatter Radiation
- Burn-In

Photon counting detectors

- BSR
- MTF
- Threshold Scan
- Achievable Contrast Sensitivity
- Specific Material Thickness Range
- -
- QE + Multiplicity
- Bad Pixels
- Efficiency
- Multiplicity
- -

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Example: Comparison of characterization
Setup

Charge integrating detectors	Photon counting detectors
RadEye™ Sensor (RadIcon)	Medipix2 (2 x 2 "Quad", Medipix2 Collaboration)
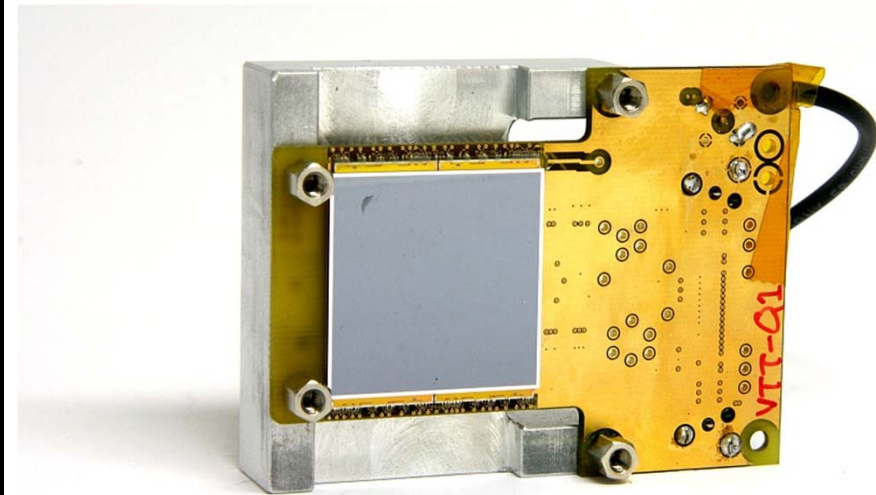
Example: Comparison of characterization
Setup

Charge integrating detectors

- RadIcon RadEye™ Sensor

- Charge integrating

-

- 1024 x 1024 pixels, 48 μm pitch

Photon counting detectors

- Medipix2 (Medipix2 Collaboration)

- Photon counting chip

- Upper and lower energy threshold

- 512 x 512 pixels, 55 μm pitch

Example: Comparison of characterization
Basic spatial resolution

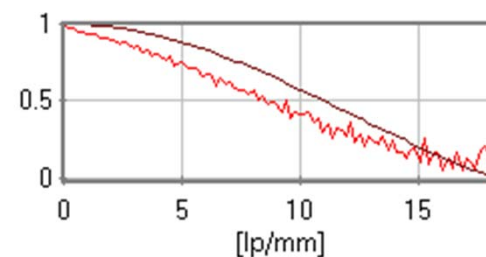Charge integrating detectors
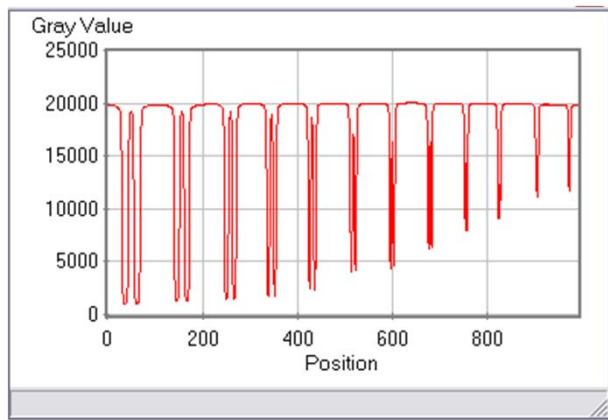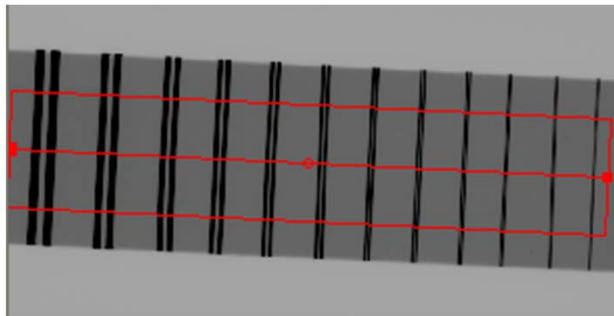
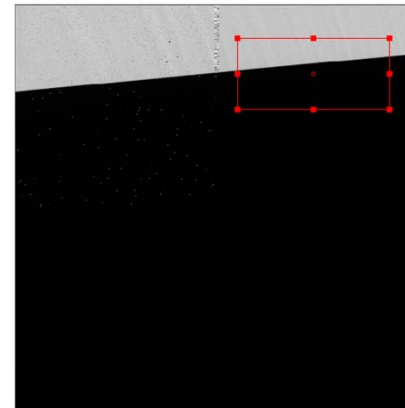Photon counting detectors
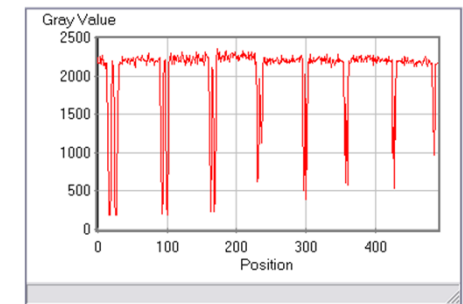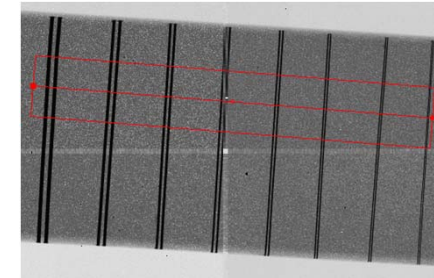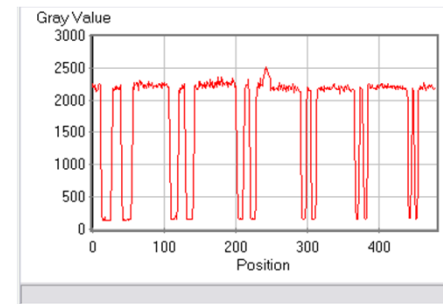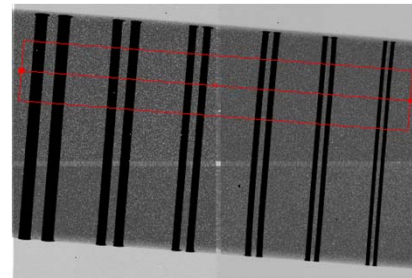
Example: Comparison of characterization
Modul transfer function

Charge integrating detectors
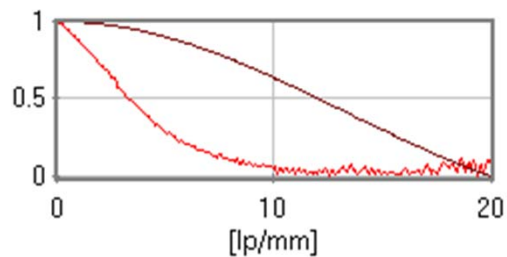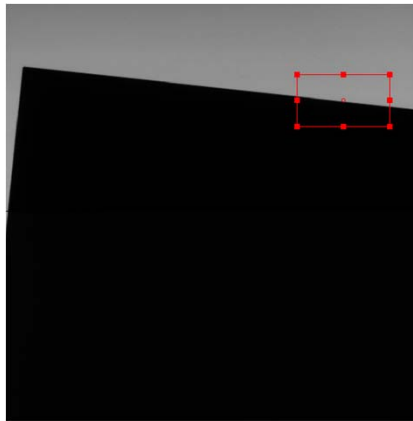
	[lp/mm]
bei 80% :	1,582
bei 50% :	3,340
bei 20% :	6,152

Photon counting detectors

	[lp/mm]
at 80% :	3,711
at 50% :	8,594
at 20% :	13,672

Example: Comparison of characterization

DarkCurrent – Pixel Noise/ Threshold

Charge integrating detectors
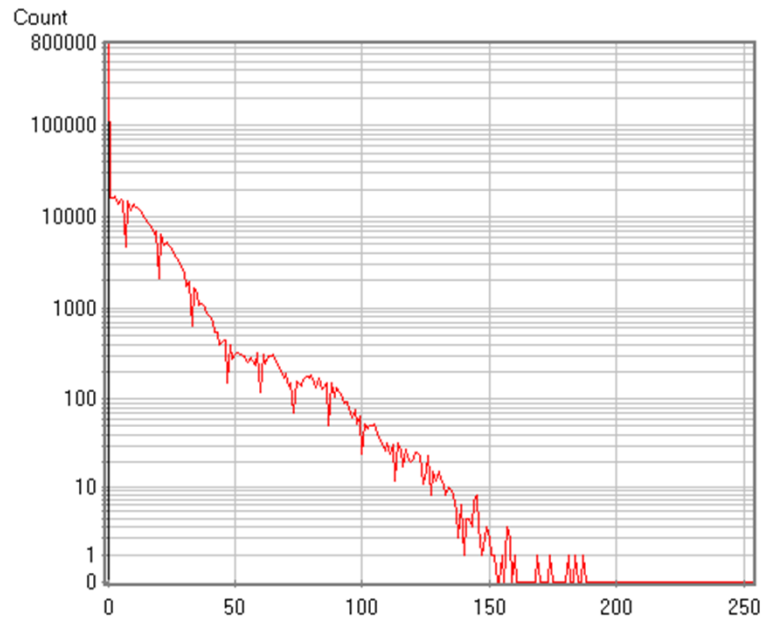
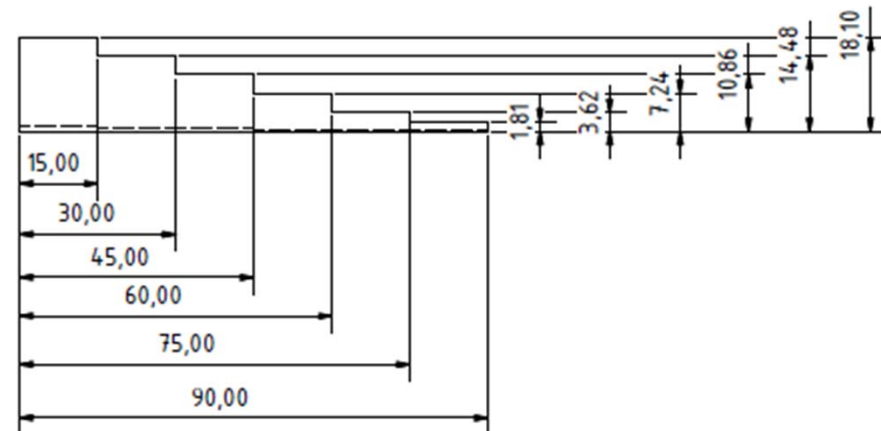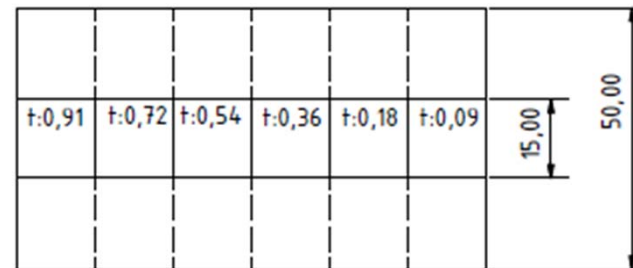Std.Dev: 60.52

Photon counting detectors
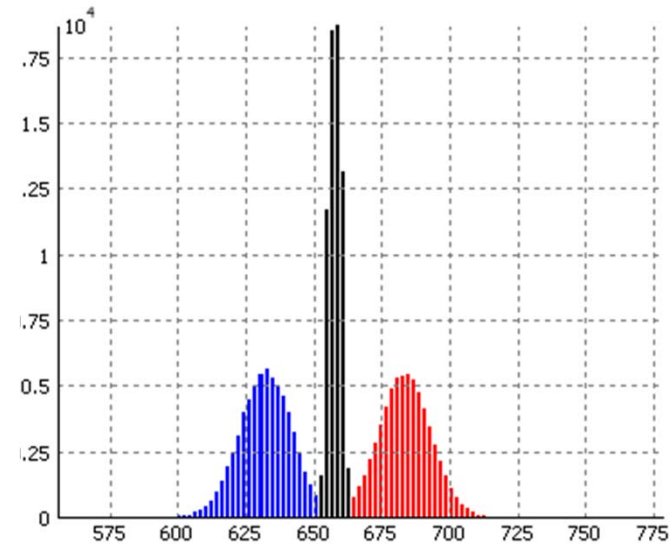
Threshold Scan (MediPix)

Example: Comparison of characterization
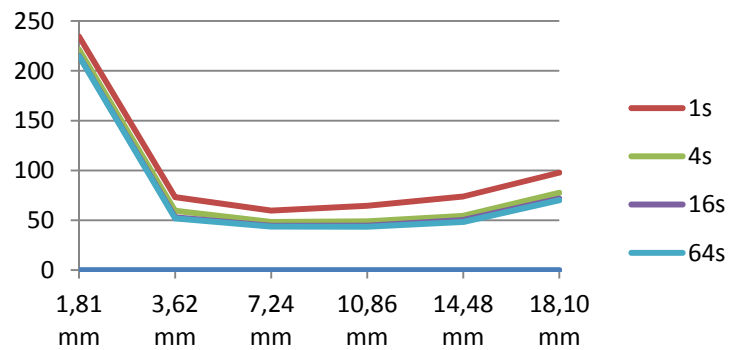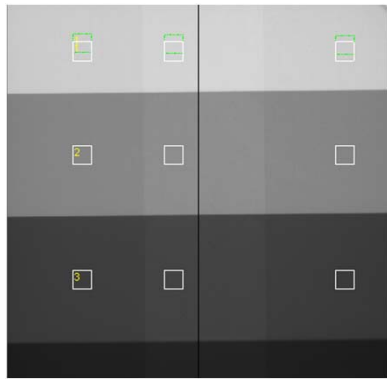## Achievable Contrast Sensitivity / Specific Material Thickness Range

- Adaption of step wedge to detector dimension

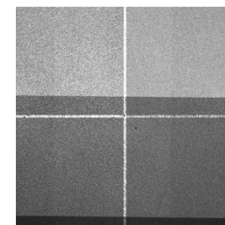- Contrast behind step wedge corresponding to 160 kV and 0.5 mm Cu

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Example: Comparison of characterization
Achievable Contrast Sensitivity / Specific Material Thickness Range
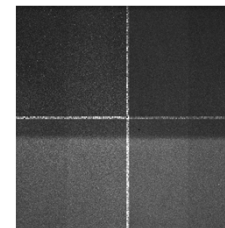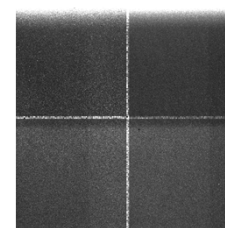
Charge integrating detectors

Photon counting detectors

Step 1, 2

Step 3, 4

Step 5, 6

Example: Comparison of characterization
Efficiency

ASTM

- 50 kV, no filter
- 90 kV, 30 mm Al
- 120 kV, 40 mm Al
- 120 kV, 3 mm Cu
- 160 kV, 10 mm Fe
- 220 kV, 8 mm Cu
- 420 kV, 16 mm Cu

50 kV spectrum

- 25 kV, no filter
- 25 kV, 1 mm Al
- 50 kV, no filter
- 50 kV, 3 mm Al
- 50 kV, 0.3 mm Cu

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Conclusion and Outlook

- Differentiation between photon counting and charge integrating detectors

- Adoptions of current characterizations

- Alternatives of characterizations for integrating detectors

→ Influence of characterizations on image quality

→ Forecast of lifetime

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Thank you for your attention!

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