Characterization of Dosepix detector as QA prototype in Diagnostics

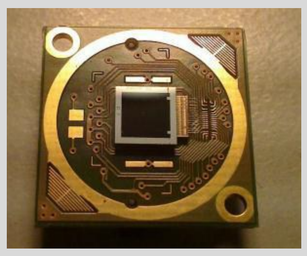
F.Bisello[1,3*], I. Ritter[1], A.Zang[1], W.Wong[2], E.Frojdh[2], M.Campbell[2], J-C.Celi[3], G.Anton[1], T.Michel[1]

Dosepix Detector: General overview

The dosepix detector is characterized as quality assurance tool in diagnostics, in particular for mammography examinations (X-Ray tube voltage: 22-35 kV).

The dosepix detector belongs to the family of the hybrid pixel detector and it was developed within the framework of a research partnership between CERN, Friedrich-Alexander-University Erlangen Nürnberg and IBA Dosimetry.

The technology allows the analysis of single photon and the reconstruction of deposited energy spectrum.

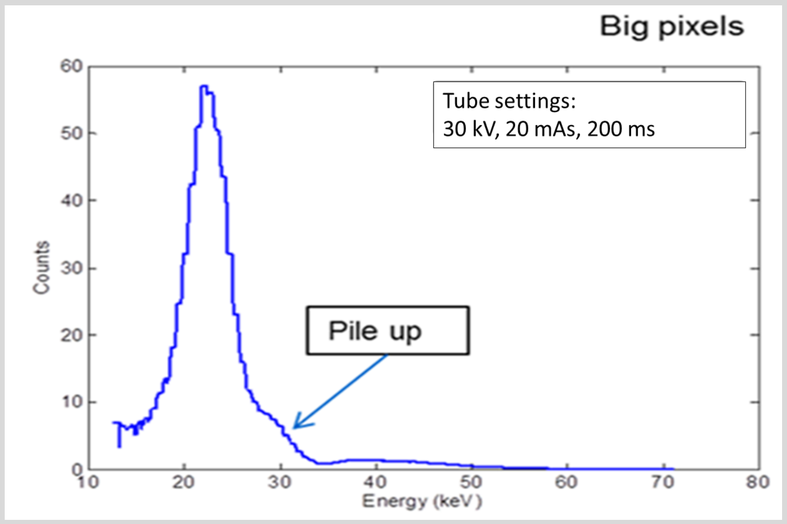


PARAMETER	SPECIFICATION
Pixel Pitch	220 µm x 220 µm
Big pixel side size Small pixel side size	220 µm 55 µm
No. of Rows	16
No of Columns	16
Sensitive Area	3.52 mm x 3.52 mm
Sensor Thickness	300 µm
Sensor Material	Silicon

Detector Characterization (I): Pile-up correction

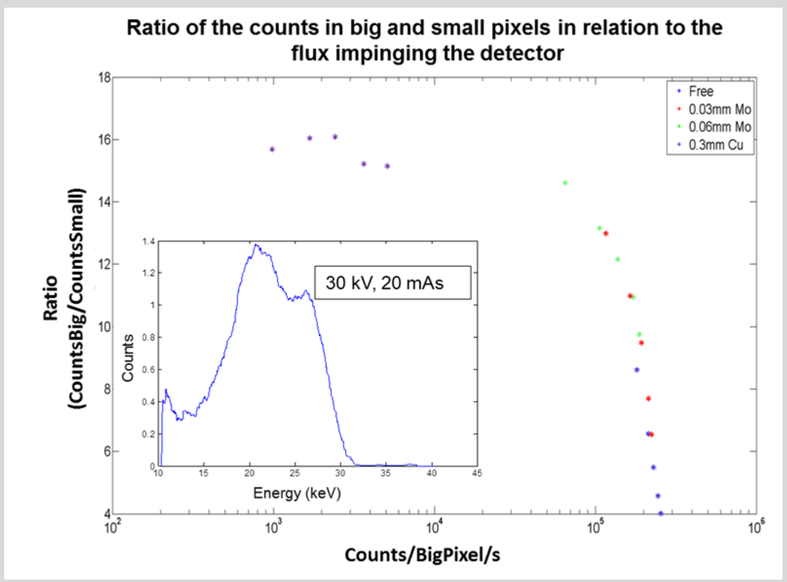
Typical flux in mammography : 10^6-10^7 photons/mm^2/s.

In this condition, energy deposition spectra of the big pixels are affected by front-end pile up.



Reduction of the distortion of the energy deposition spectra due to pile up:

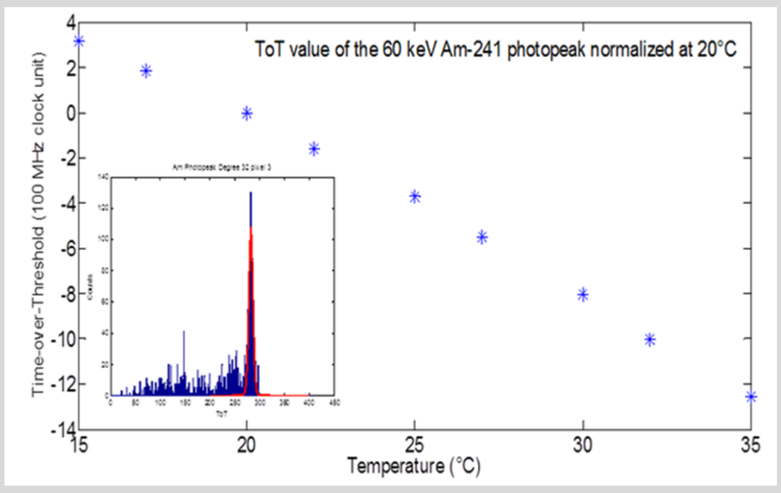
- Pile-up contribution can be monitored by the ratio between the counts in small and big pixels. Nominally the ratio should be equal to 16.
- Additional filtration of 0.3mm Cu provides a stability in the counts ratio in the whole flux range.
- The detector ASIC is able to process the impinging radiation up to $3 \cdot 10^5$ photons/mm^2/s without the data being affected by front end pile-up.
- This allows the use of the end point of the spectrum for the determination of the tube operation voltage of the mammographic unit.



Detector Characterization (II): Temperature dependency

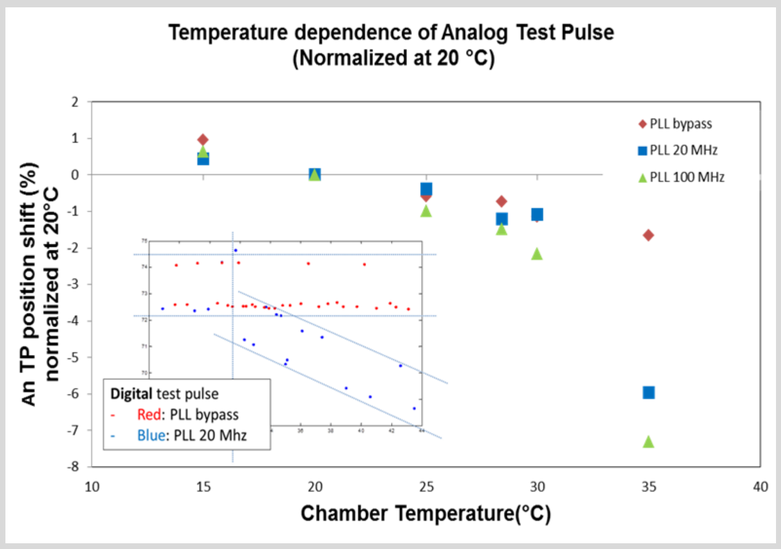
The IEC 61676 "*Medical electrical equipment – Dosimetric instruments used for non-invasive measurement of X-ray tube voltage in diagnostic radiology*" requires a stability of the detector response of 1% in the temperature range 15°- 35°C.

Time-over-Threshold value of the 60 keV Am-241 photopeak, (100 MHz clock unit) in relation to the external temperature shows a slope in the temperature range of 15°- 35°C of -0.8%\°C.



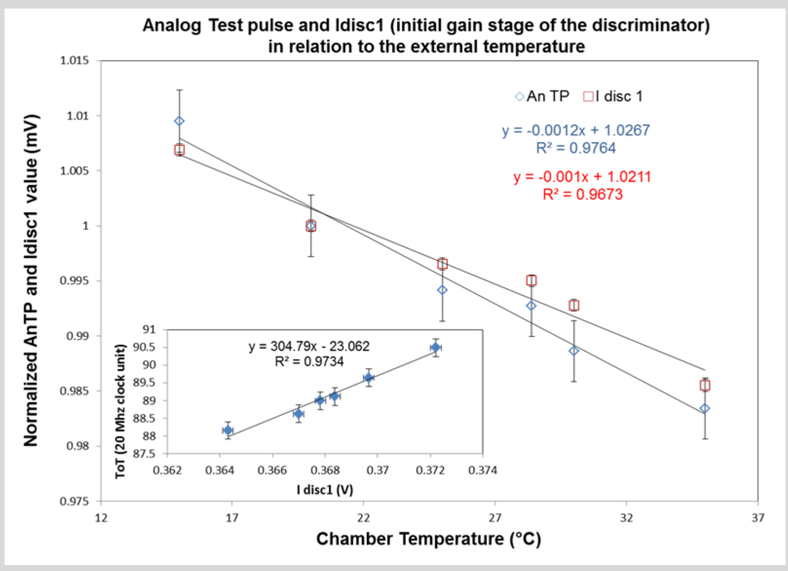
Source of Instability (I) : PLL circuit

- Digital test pulses are not affected by instability due to external temperature
- Programming the chip bypassing the PLL circuit gives a stability of the ToT readout within 1.6%.



Source of Instability (II): Initial gain stage of the discriminator

- Monitor of the voltage of the initial gain stage of the discriminator (Idisc1) through a dedicated DAC.
- Both the voltage of Idisc1 and the ToT value of internal test pulse (20 MHz clock unit, bypassing the PLL circuit) present a slope of about 0.1%\°C.



In normal temperature conditions (20-30 °C) the stability is within 1.5%, allowing to continue the evaluation of the detector performance as quality assurance tool.

Detector Characterization (III): Radiation Tolerance

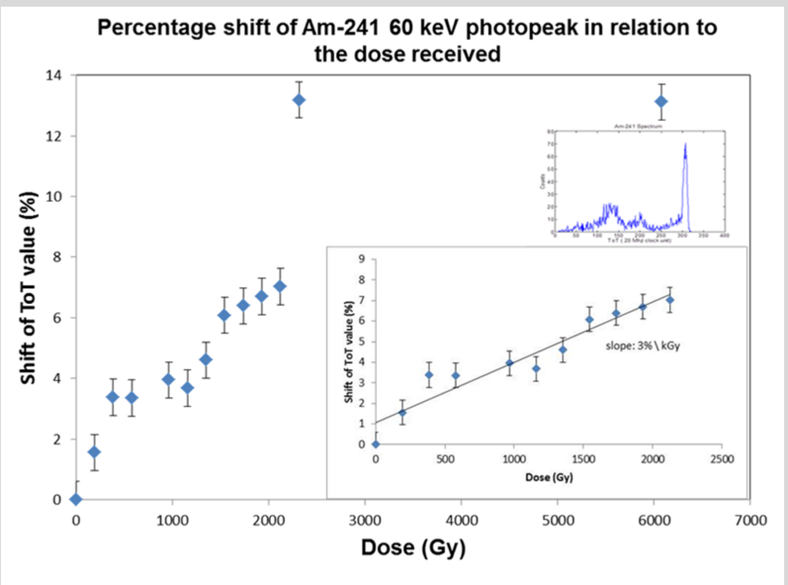
Dose estimation of 30 years of working life as quality assurance device in mammography: 500 Gy.

Accumulated dose for the test: 5 kGy in step of 200 Gy

Tube settings: 40 kV, 2 mA dose rate 4.83 Gy/min

Evaluation of the position of the 60 keV Am-241 photopeak in term of Time-over-Threshold value (100 MHz clock unit):

- Shift of 3% up to 1.2 kGy
- High stability in the range between 400 and 1200 Gy.
- Up to 2 kGy, the experimental data can be fitted with a linear fit with a slope of 3%\kGy.



Conclusions

The dosepix detector shows good potentiality as quality assurance tool:

- the additional filtartion of 0.3mm Cu allow the use of the detector in the mammography conditions.
- The chip design provides good results in radiation tolerance studies.
- A future redisign of the detector is under evaluation in order to compensate the sensetivity to temperature.
- Future steps will be the analysis of the impinging spectra in order to obtain information about the tube filtration and the anode material.

References

Acknowledgements & Affiliations

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Affiliations:

(1) Friedrich-Alexander-Universität, Erlangen-Nürnberg

(2) Medipix Team, Microelectronics Group, CERN

(3) IBA Dosimetry, Schwarzenbruck, Germany

*contact: francesca.bisello@iba-group.com