

First DQE measurement of 500
 μm thick Si hybrid pixel sensor
with Photon counting readout
for X-ray medical imaging

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Introduction

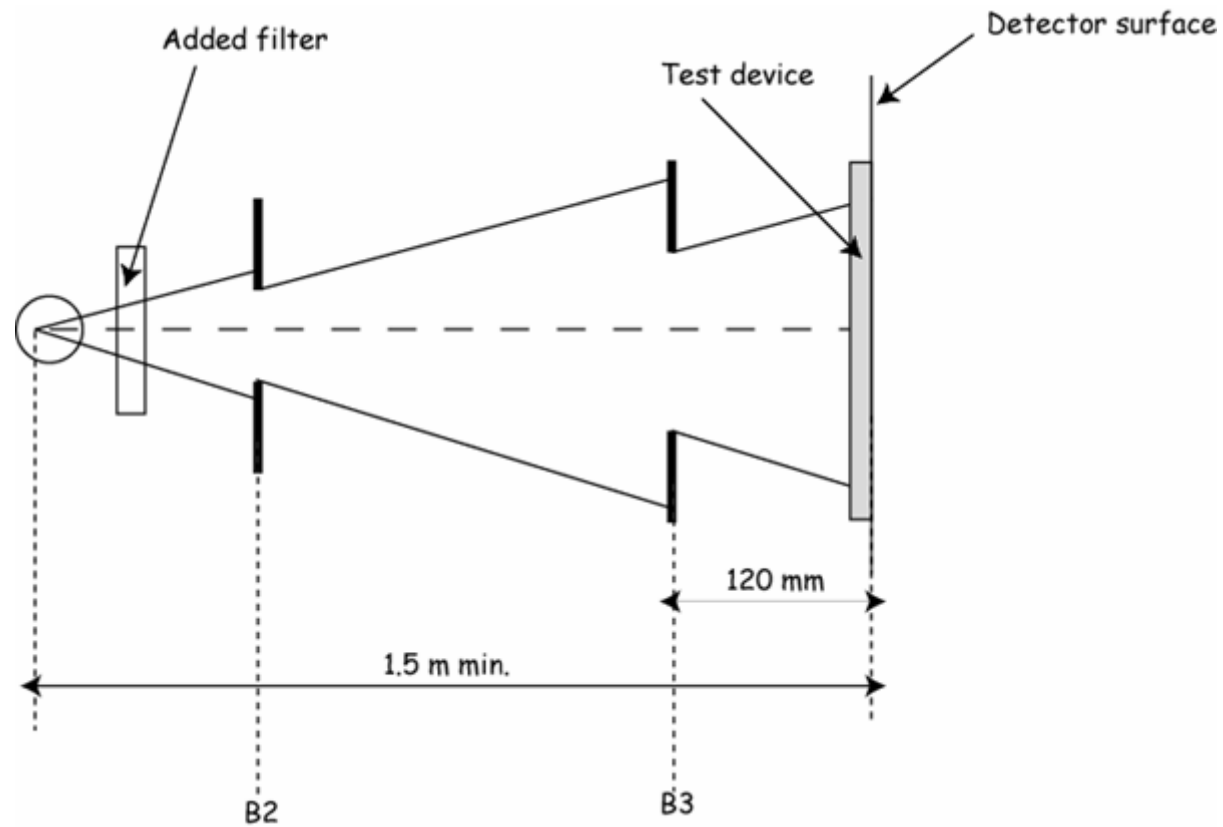
- Aim: to measure system DQE following a standard protocol
- Requirements:
 - IEC 62220-1
 - RQA 5 (~ 70 kVp)
 - Flat field corrected data

Establishment of Standard X-ray spectrum

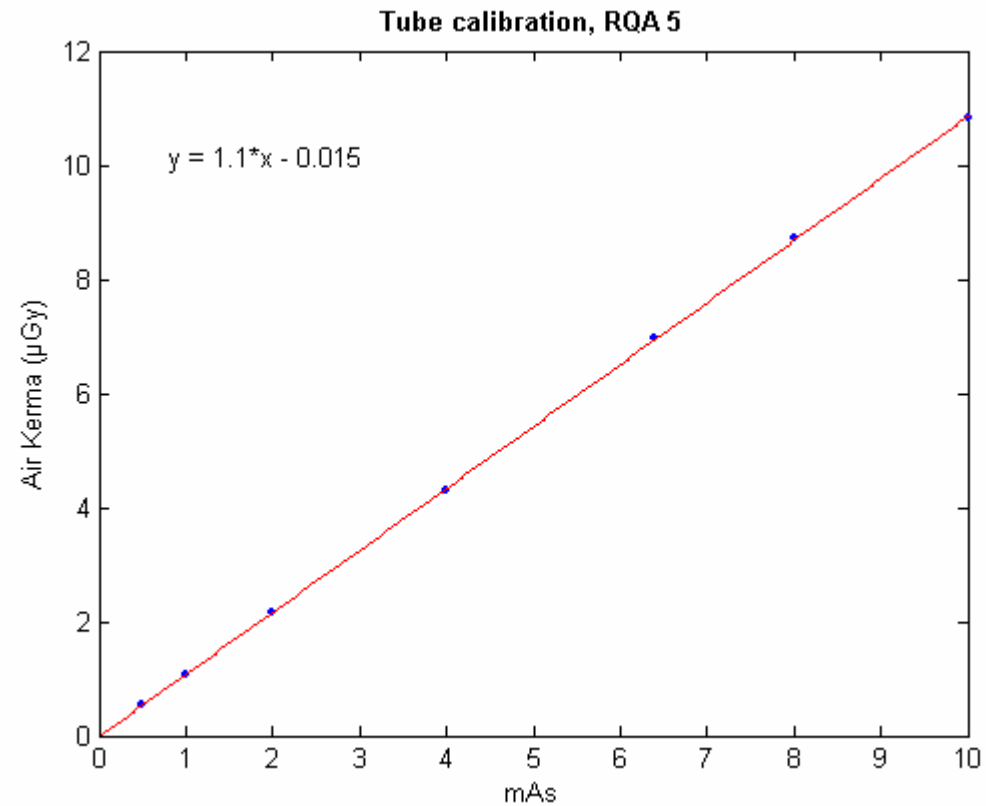
- Adjust kVp of generator to get RQA 5 spectrum such as:

Spectrum	Added filtration (mm Al)	HVL (mm Al)
RQA 3	10	7
RQA 5	21	7.1
RQA 7	30	9.1
RQA 9	40	11.5

Measurement geometry



Tube calibration @ RQA 5

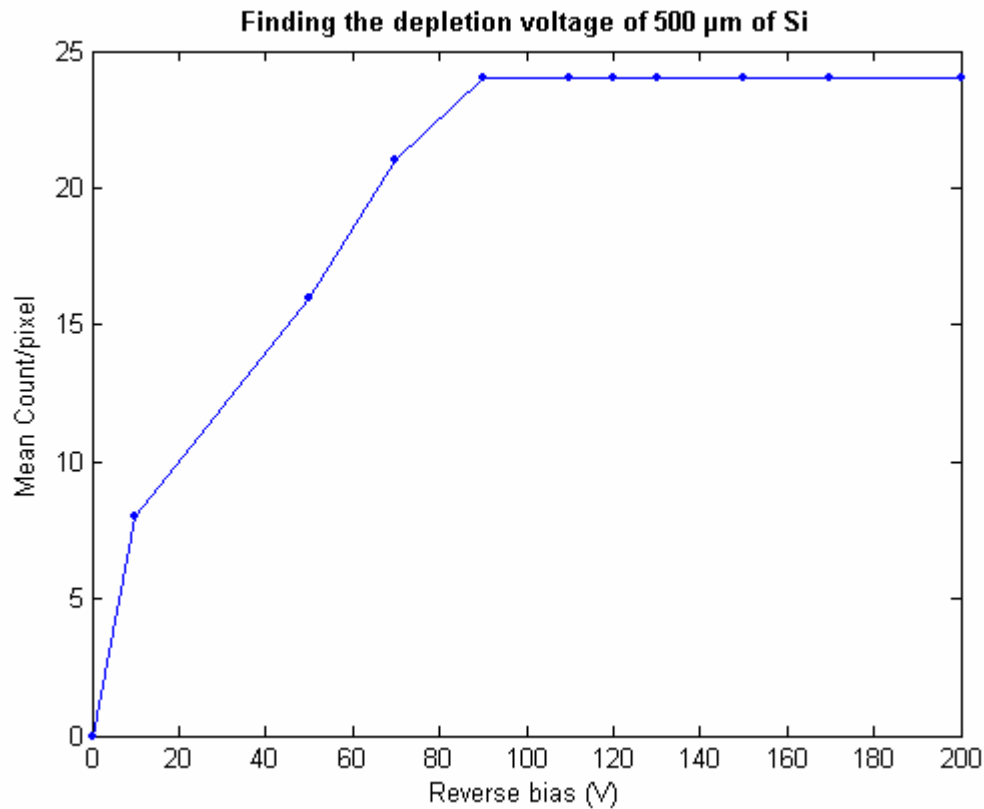


Set up ?

- Well known Photon counting chip = MEDIPIX 2 (chip set just above the noise)
- Bump bonded with 500 μm thick Si detector
- MUROS 2 interface
- Medisoft

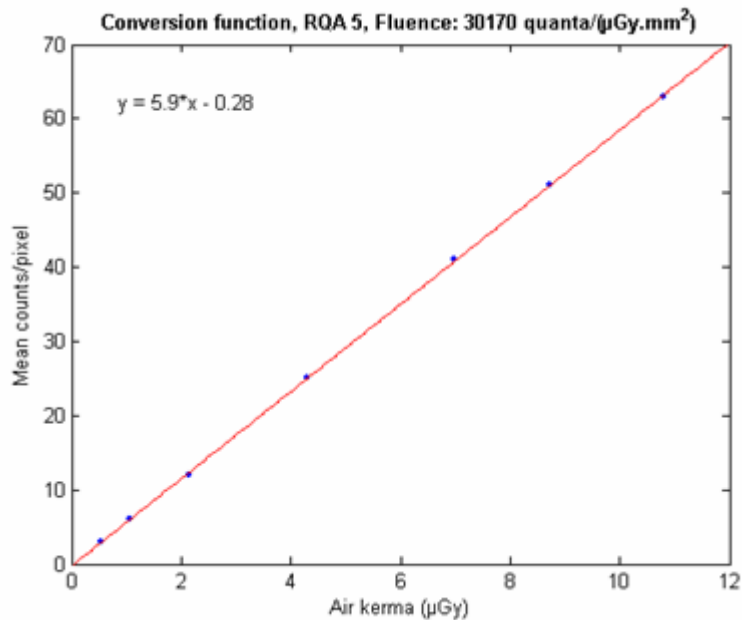
Thanks to the
MEDIPIX
collaboration

Depletion voltage



20 % overdepletion
→ 120 V

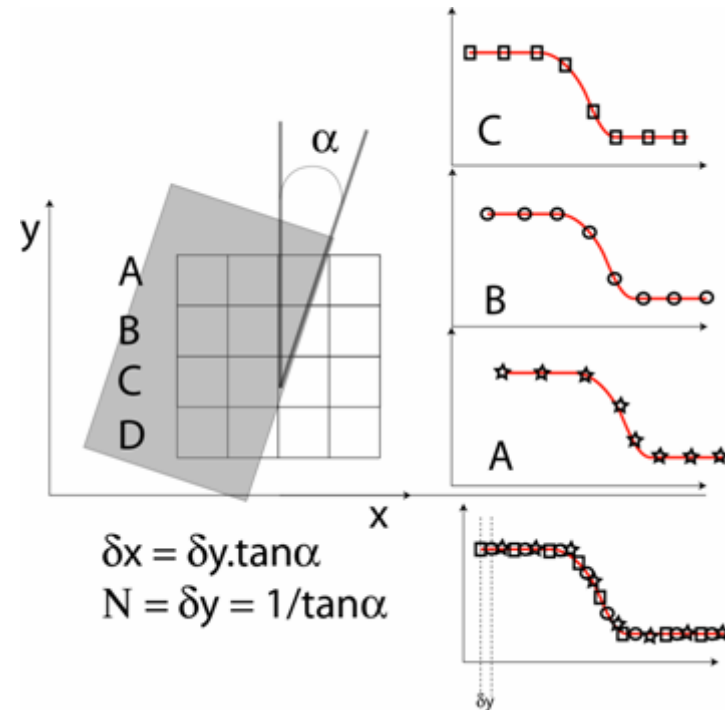
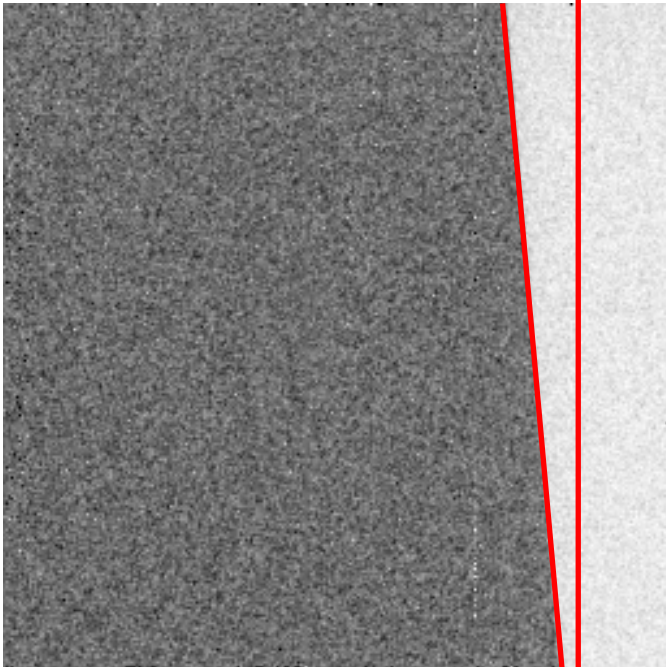
Conversion function



- Pixel size $55 \times 55 \mu\text{m}^2$
- Fluence: $91 \# / (\text{pixel} \cdot \mu\text{Gy})$
- Slope: $5.9 \text{ count} / (\text{pixel} \cdot \mu\text{Gy})$
- $G = 6.5\%$

MTF (ESF)

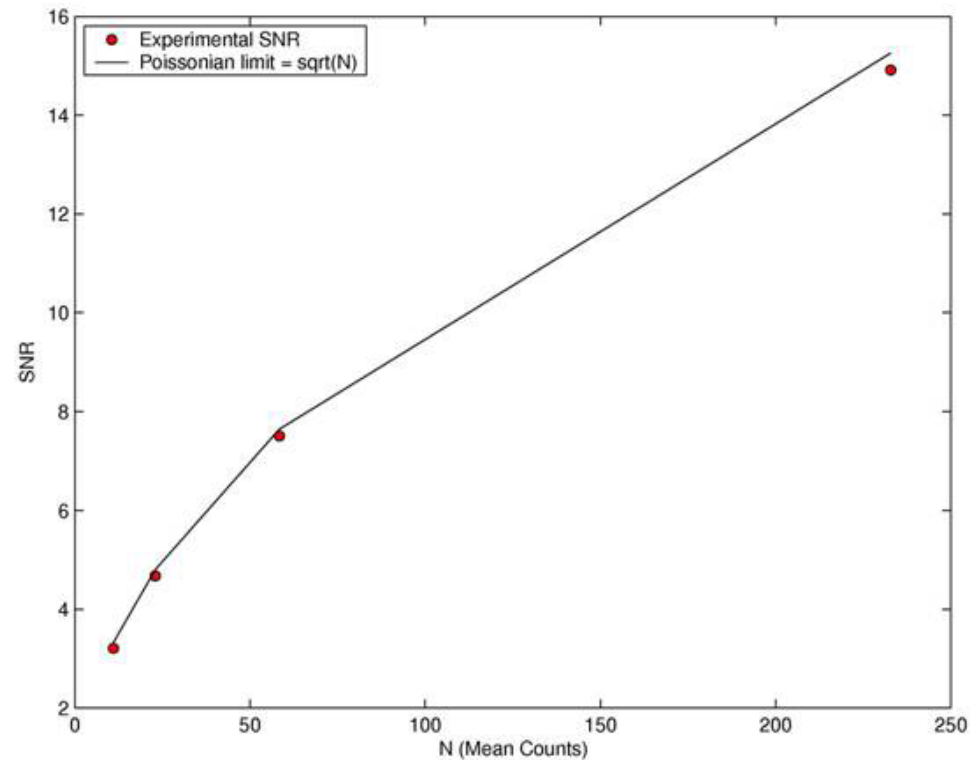
Angle α



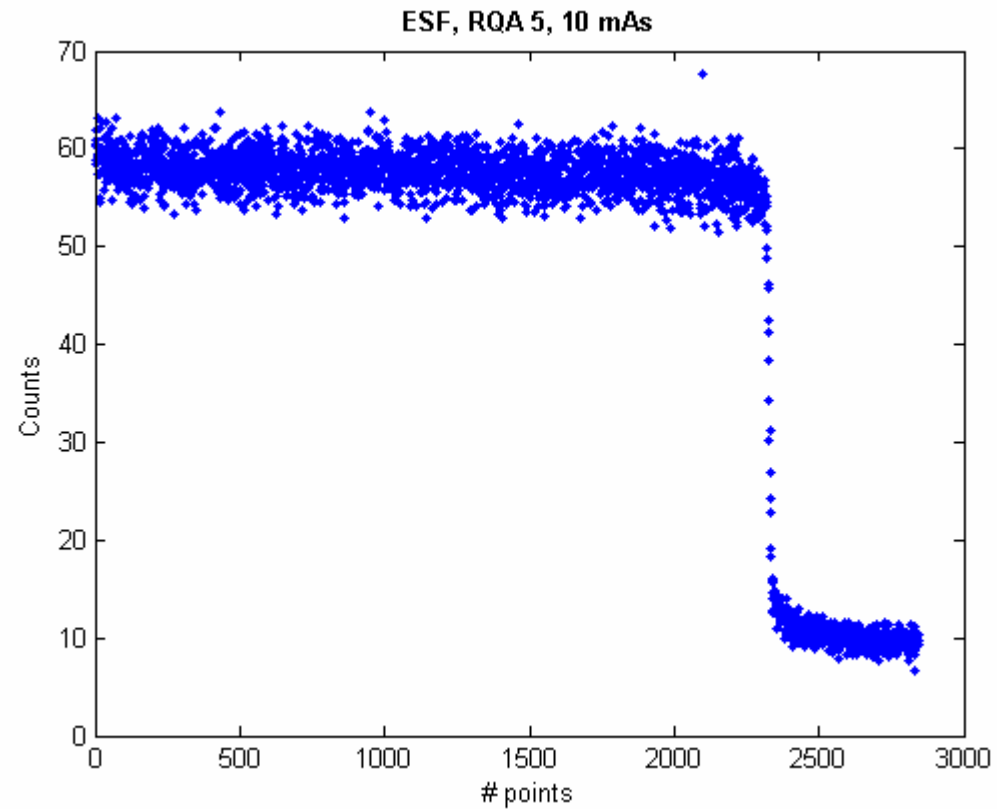
- $N = 1/\tan(\alpha) = 12$
- Oversampling = $0.055 \text{ mm}/12$

SNR ?

- 20 flood images to compute the flat field coefficients

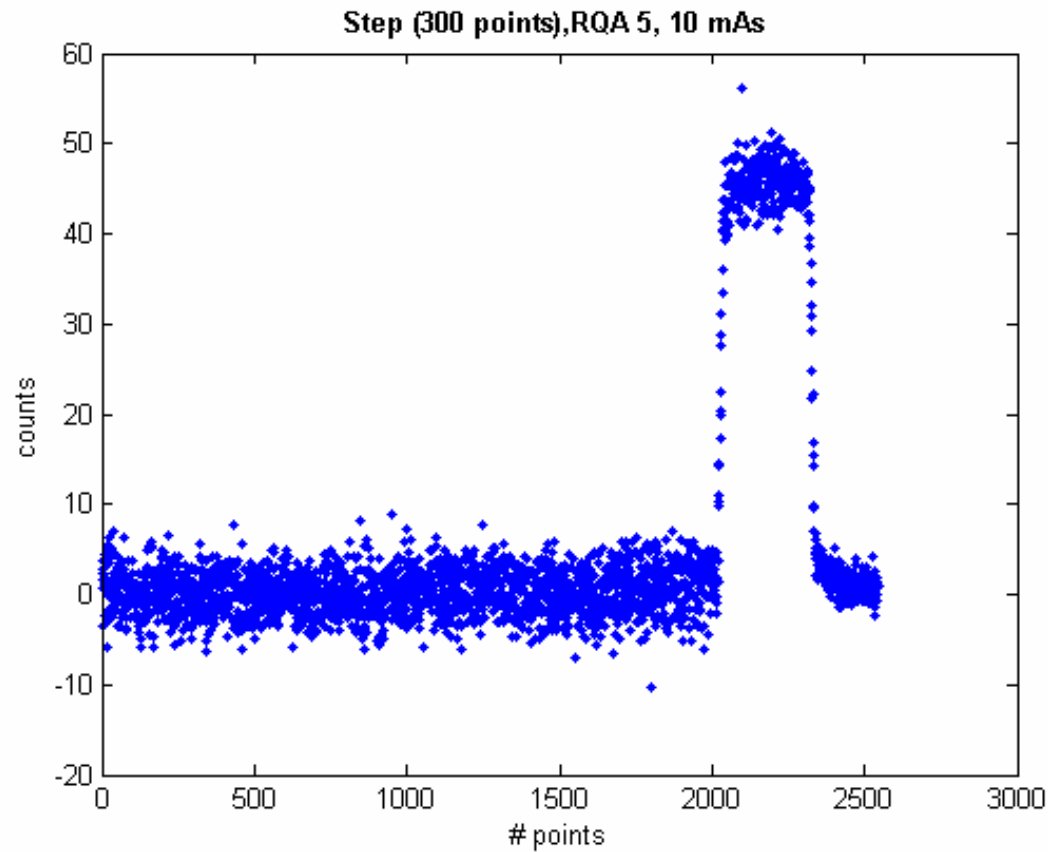


ESF, RQA 5, 10 mAs

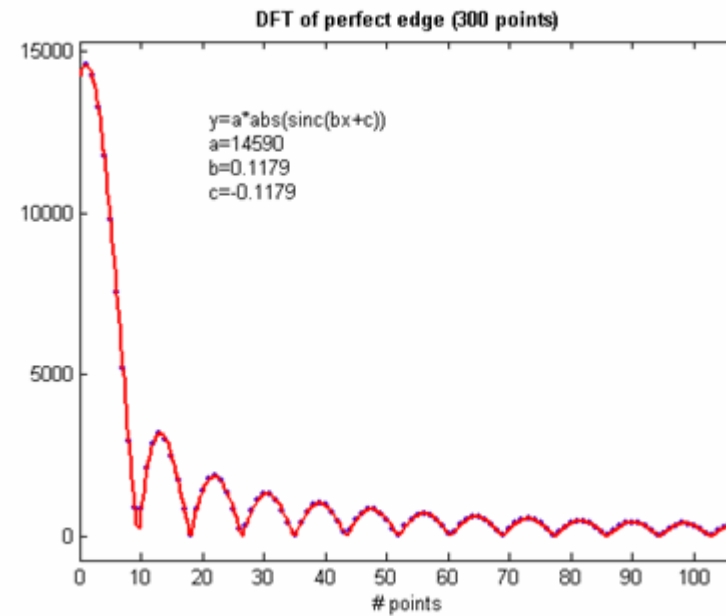
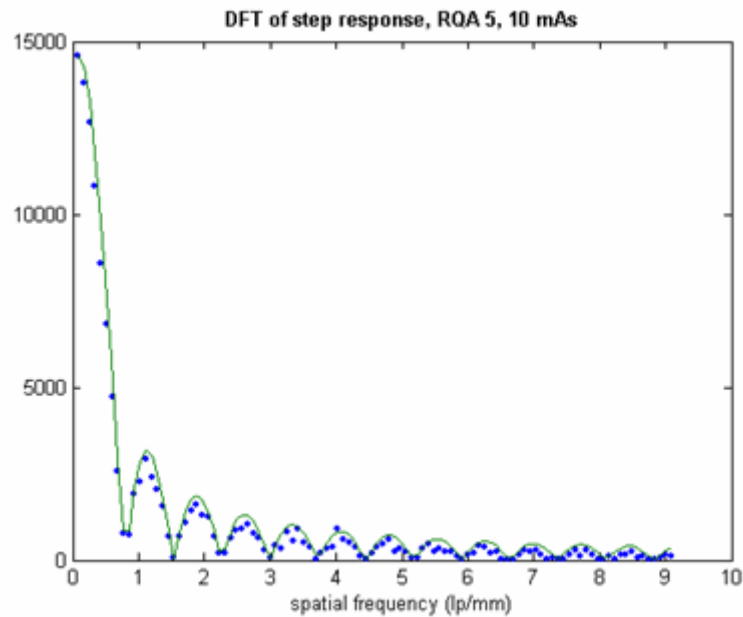


7. Step (300 pts), RQA 5, 10 mAs

$$\text{Step}(x) = \text{ESF}(x - x_{\text{shift}}) - \text{ESF}(x)$$

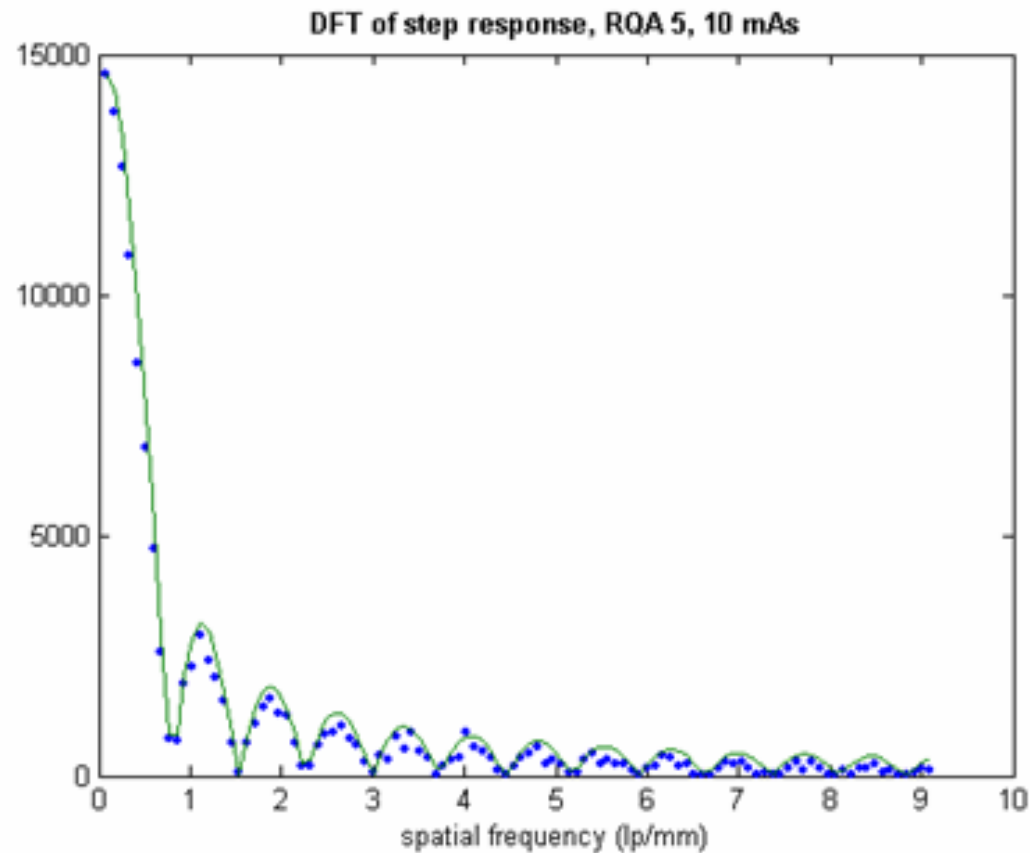


DFT(Step) (300 pts), RQA 5, 10 mAs



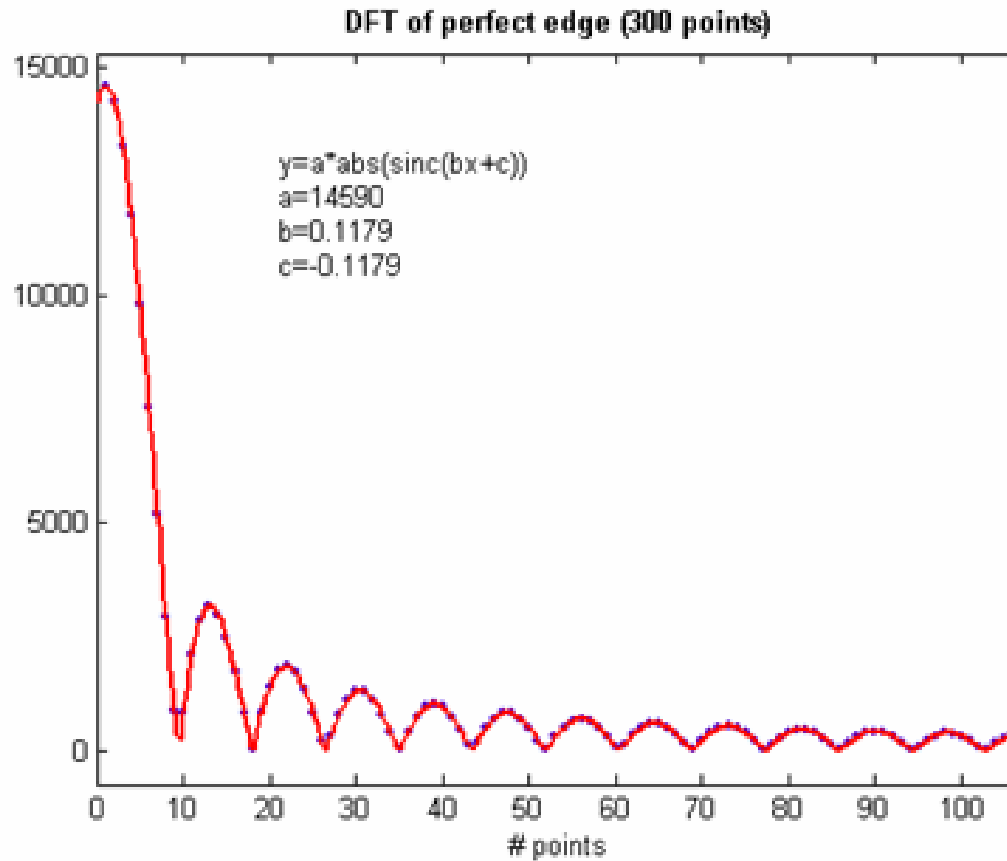
$$\text{MTF}(f) = \frac{|\text{DFT}(\text{real step}, f)|}{|\text{DFT}(\text{perfect step}, f)|}$$

DFT(Step) (300 pts), RQA 5, 10 mAs



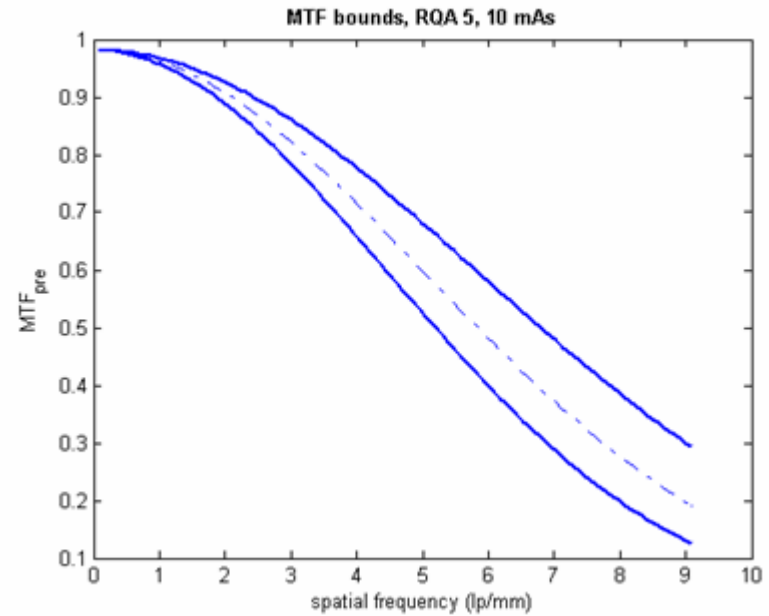
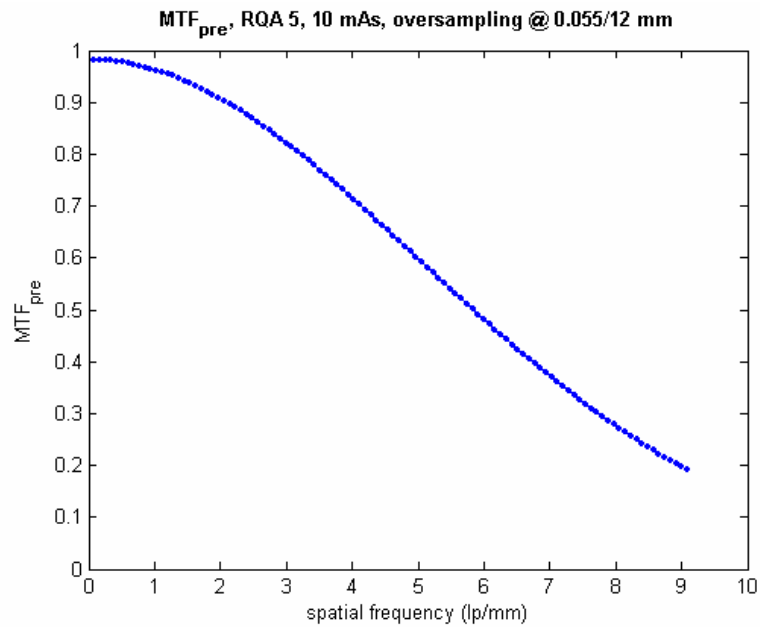
$$MTF(f) = |DFT(\text{real step}, f)| / |DFT(\text{perfect step}, f)|$$

DFT(Step) (300 pts), RQA 5, 10 mAs

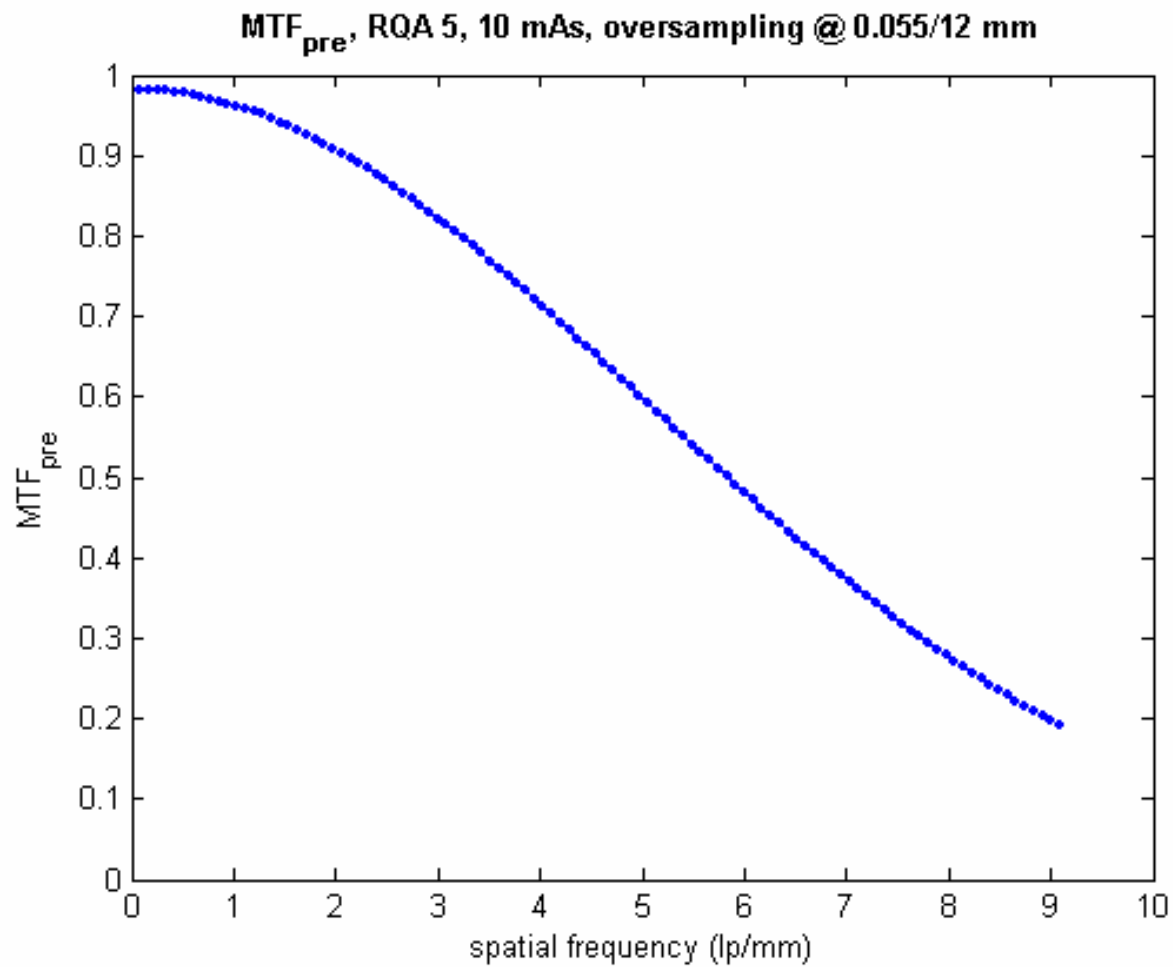


$$\text{MTF}(f)=|\text{DFT}(\text{real step},f)|/|\text{DFT}(\text{perfect step},f)|$$

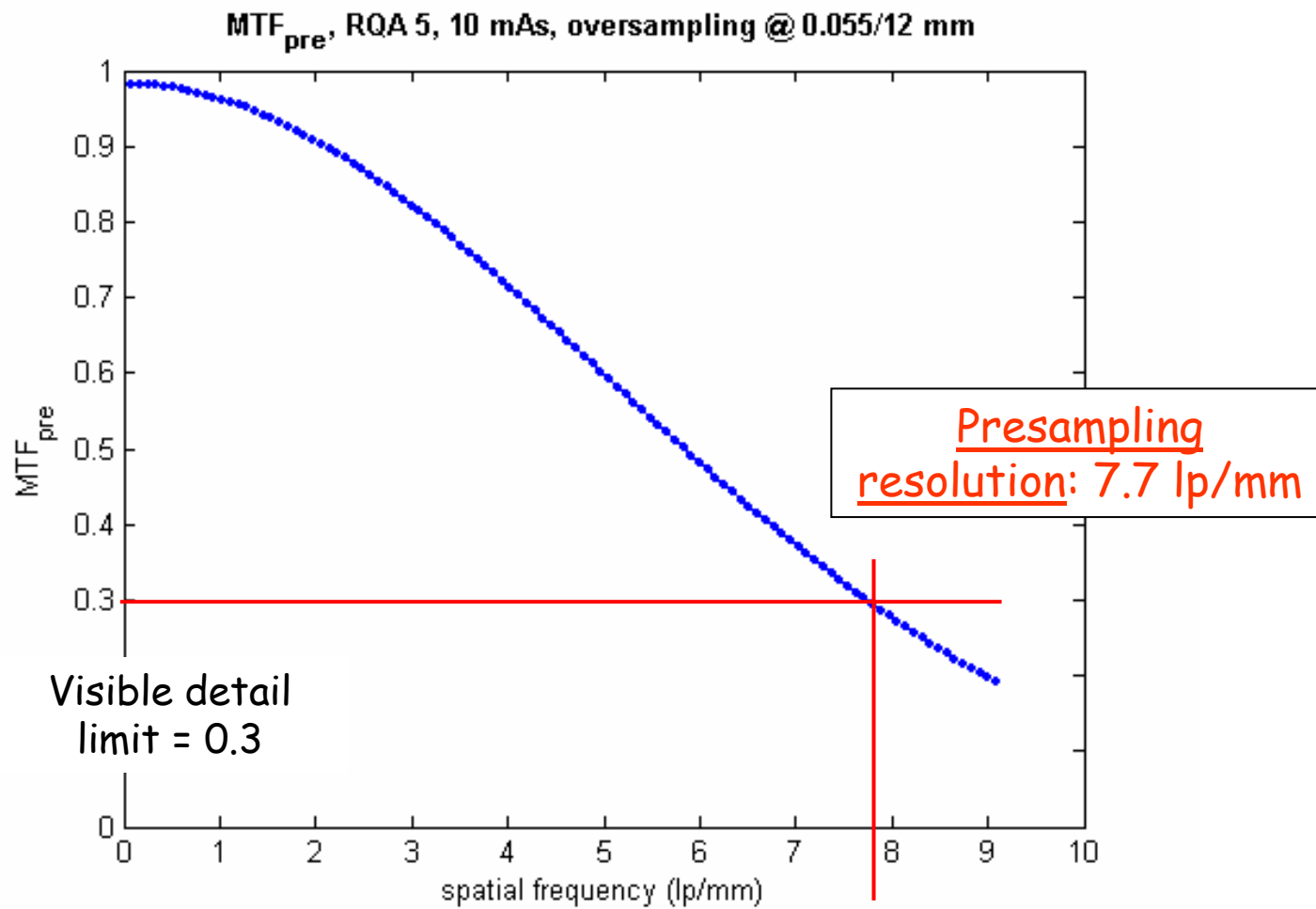
MTF, RQA 5, 10 mAs



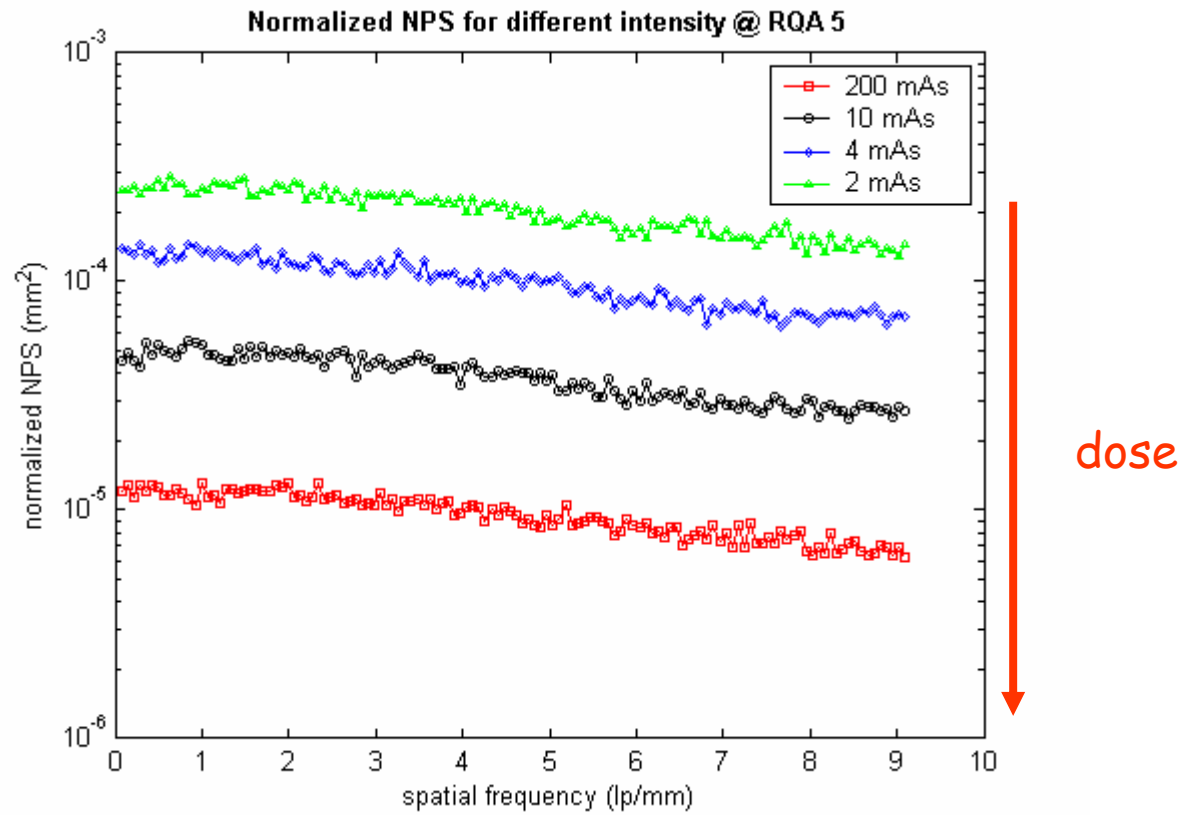
MTF, RQA 5, 10 mAs



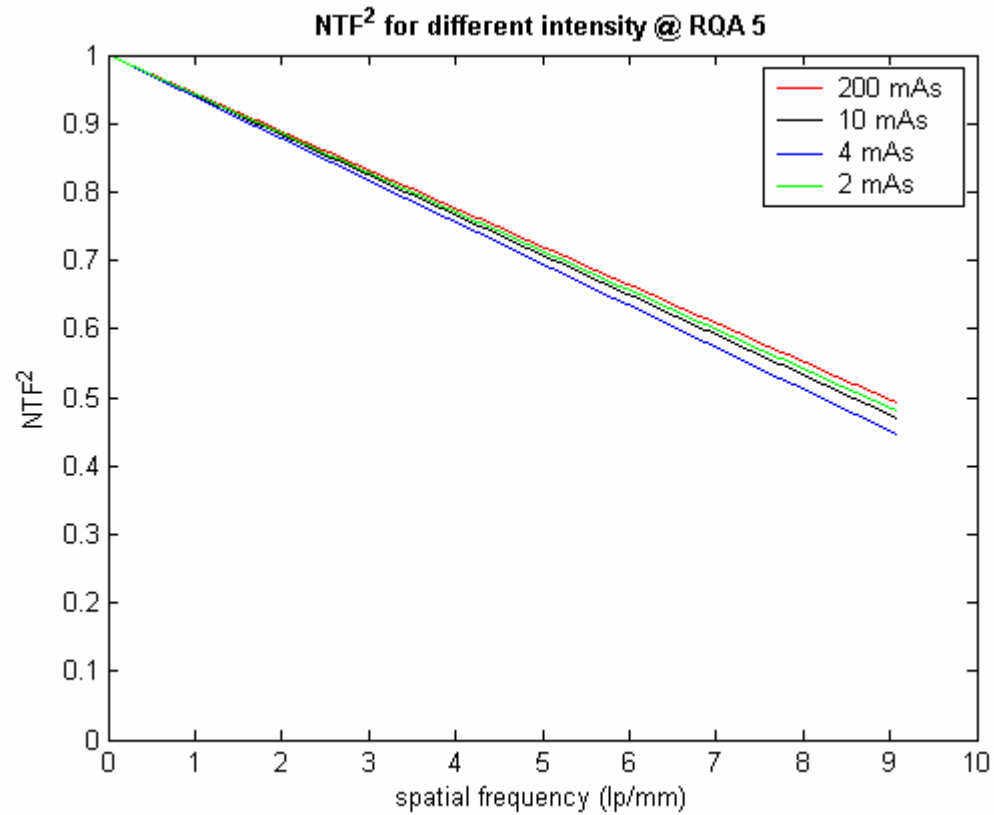
MTF, RQA 5, 10 mAs



NPS @ RQA 5

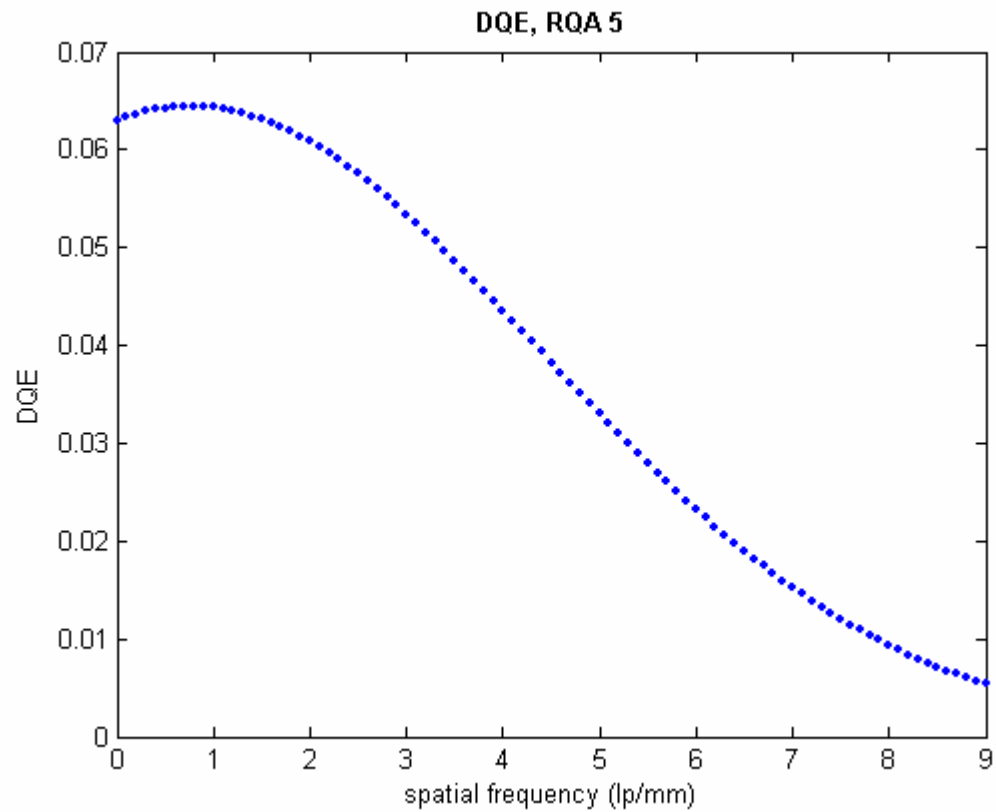


NTF² @ RQA 5



DQE @ RQA 5

$$DQE(f) = G \times MTF^2 / NTF^2$$

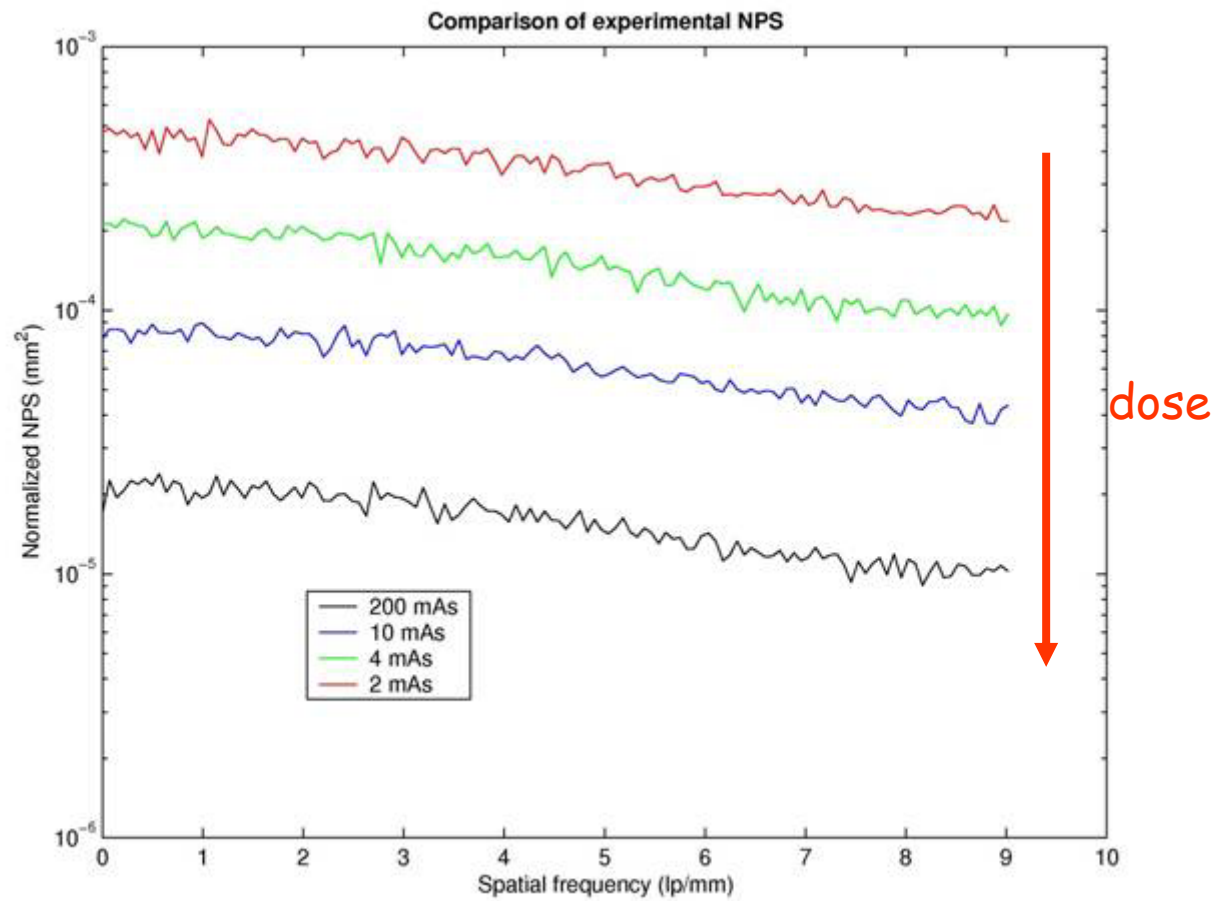


NPS considerations & calculation

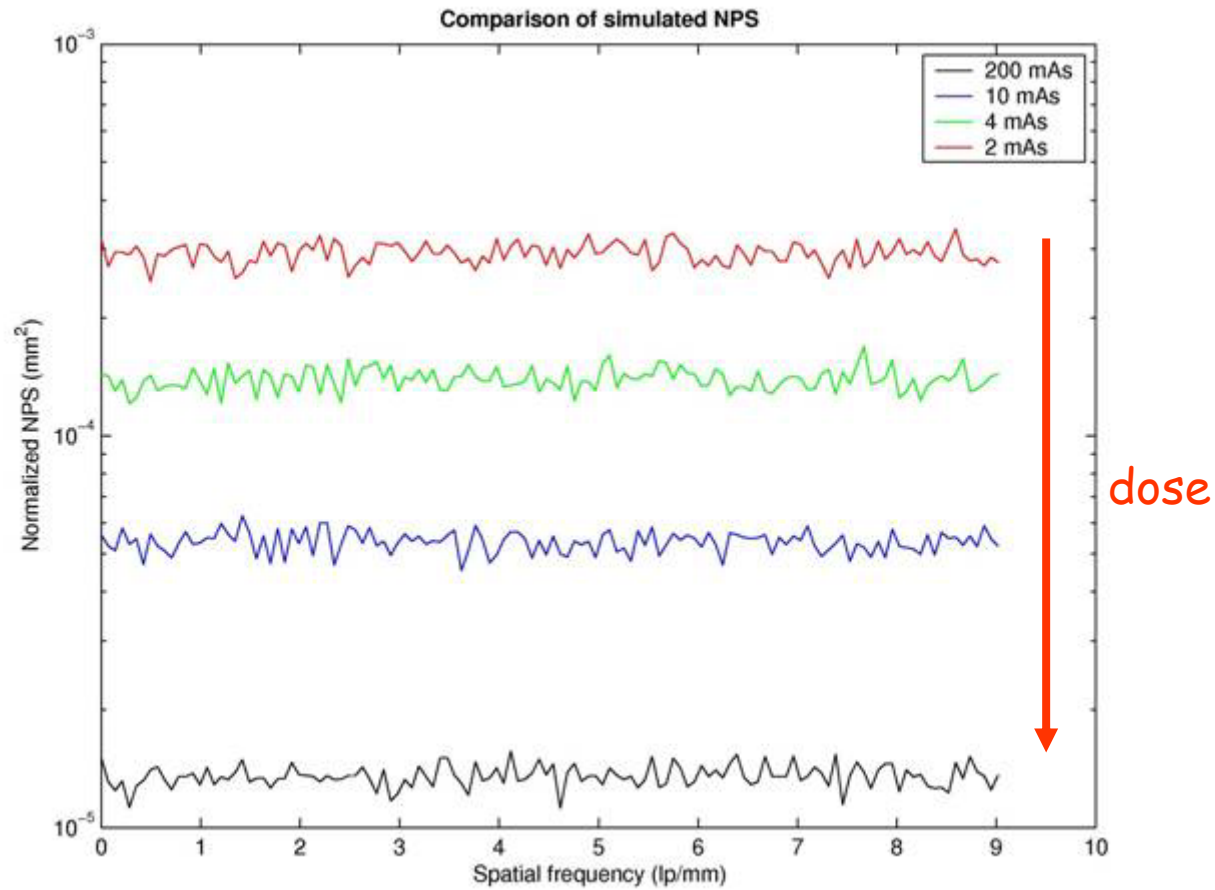
- Can we consider our results correct?

>>> Calculations and simulations...

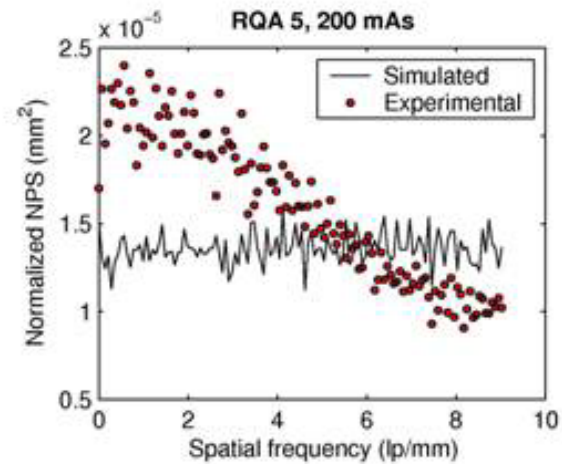
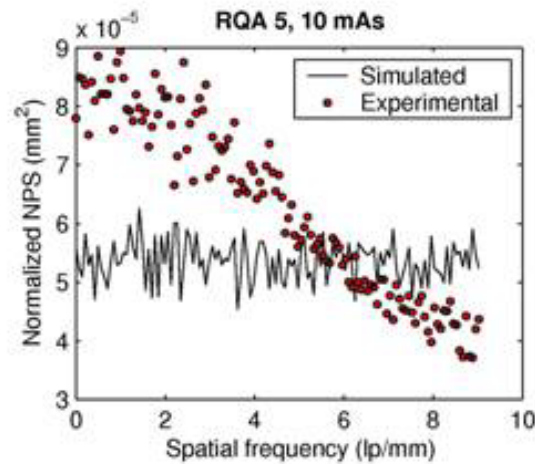
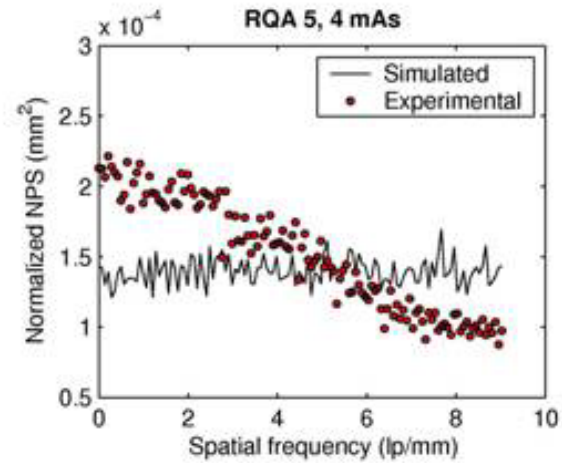
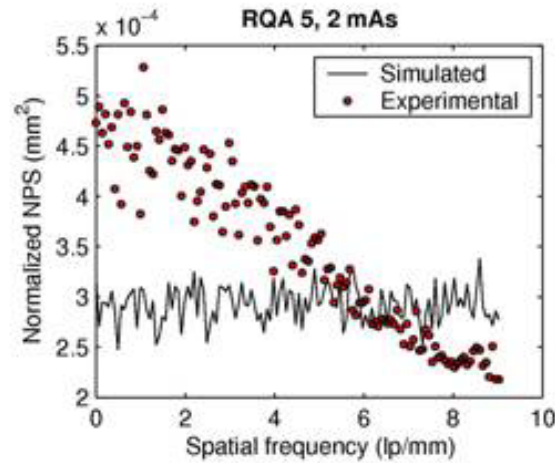
Experimental NPS



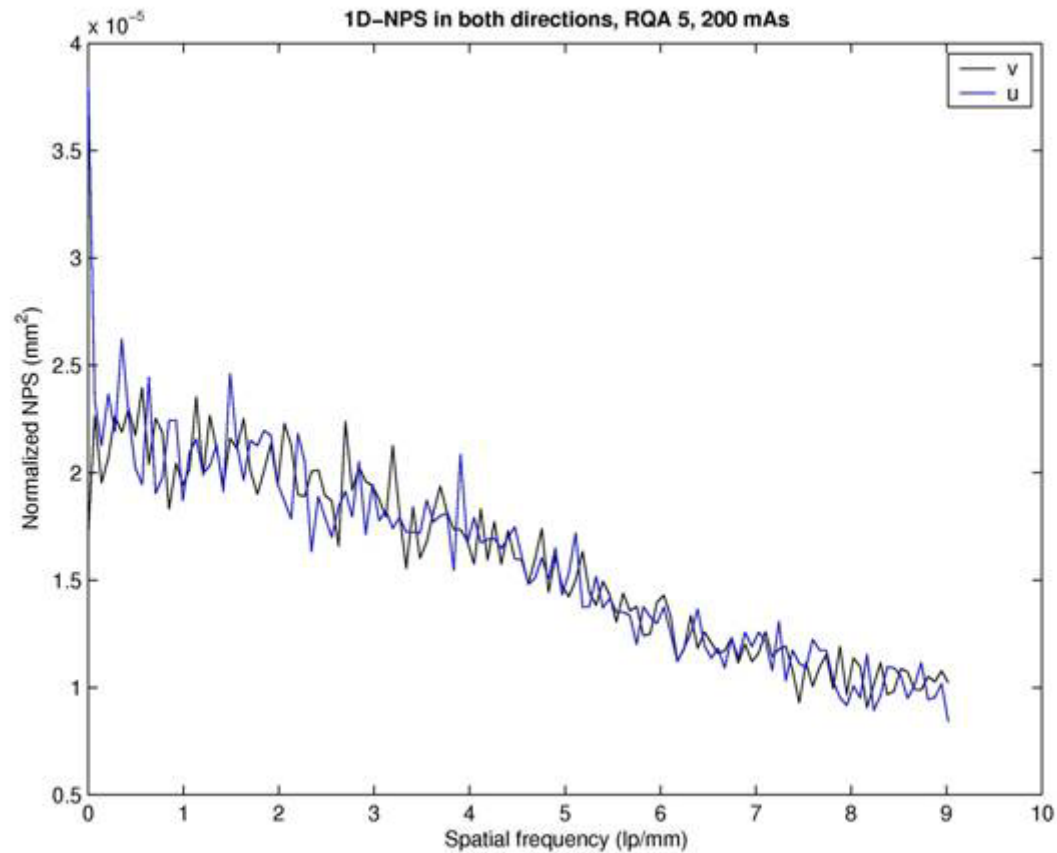
Simulated NPS



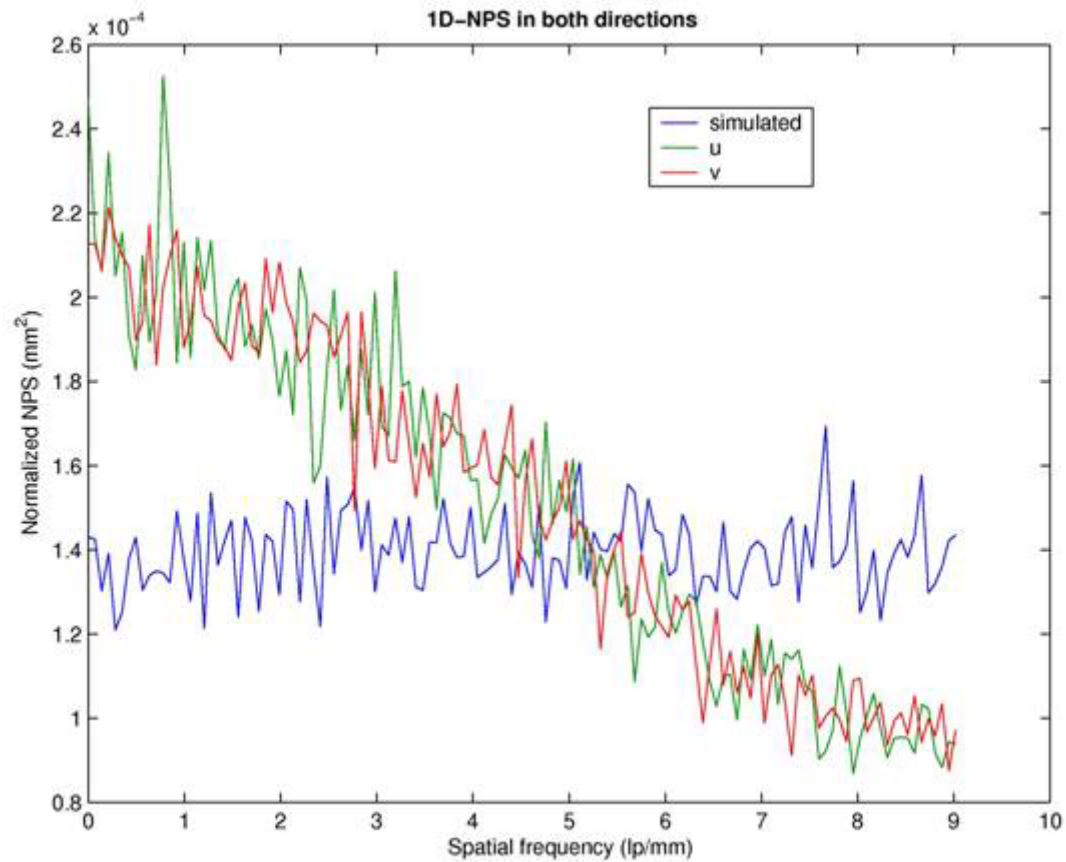
NPS comparison: sim & exp



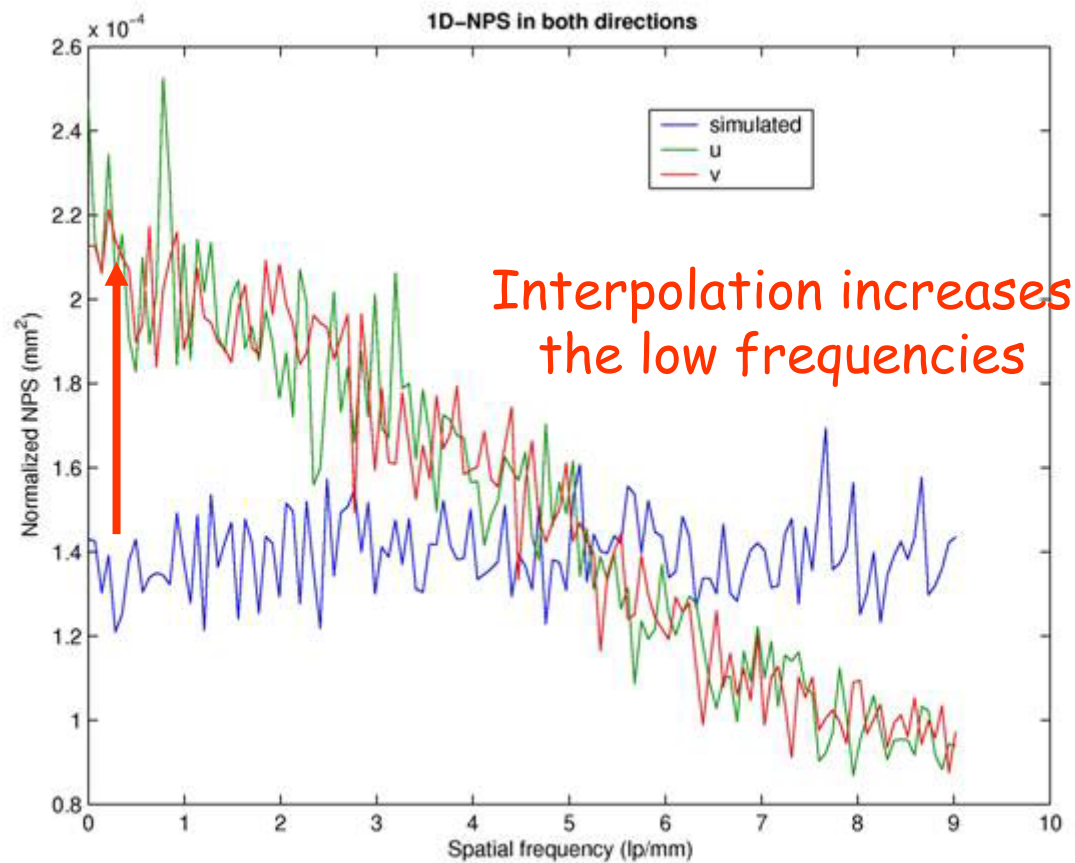
1-D NPS comparison, 2 directions



1-D NPS comparison



1-D NPS comparison

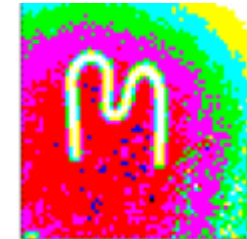


Conclusions

- DQE has been calculated on 500 μm thick Si, bonded to a MEDIPIX2 chip
- A standard measure protocol have been used
- DQE is not so evident to find...
- How to improve this DQE ? (*remember medicine*)
- Next step: comparison with detectors of different thickness, study in parallel with detectors from the market, further calculations...

Acknowledgements

- The MEDIPIX collaboration



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- L.SARRY



- You, for your attention