Examining the Noise Power Spectra of a dental detector for high kVp irradiation conditions

Eva Goumenou[1], Nektarios Kalyvas[1*], Christos Michail[1], Ioannis Valais[1], Evangelia Karali[1], Αναστασία Φούντου[2], George Fountos[1], Ioannis Kandarakis[1]

[1]Radiation Physics, Materials Technology and Biomedical Imaging Laboratory, Department of Biomedical Engineering, University of West Attica, Egaleo, Greece

[2]Dentist postgraduate student , Dentistry School National and Kapodistrian University of Athens. Athens, Greece

*nkalyvas@uniwa.gr

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Introduction

X-ray dental imaging is based on digital detectors which convert the absorbed X-rays into voltage and subsequently into imaging bits. Detection technology uses either direct detectors, where the absorbed X-ray energy is transformed into electron-hole pairs, or indirect detectors where the absorbed radiation is transformed into optical photons which in turn are detected by electronic optical sensors. The electric signals from the sensor are channeled to digitizers through gate drivers and multiplexers for the formation of the final digital image. A fundamental criterion of a good image is high spatial resolution and reduced noise. The latter is of importance since it provides the limit of low contrast tissues detectability [1]. Dental imaging employs X-ray tube voltages of 60 kVp and 70 kVp. In this work, the noise properties of a dental detector were examined in terms of the Normalized Noise Power Spectrum (NNPS) [2] for tube voltages of 100 kVp and 120 kVp.

Materials and Methods 1

In this study a SCHICK CDR indirect digital dental detector (Figure 1) with a pixel size of 40 µm was utilized [2].

Figure 1: Schick CDR dental detector

Materials and Methods 2

The detector was irradiated with a CPI, series CMP 200DR 50kW, at X-ray tube voltages of 100 kVp and 120 kVp at a distance of 72.5 cm (Figure 2). The tube current ranged from 25 mA to 50 mA. The irradiation time was 400 ms.

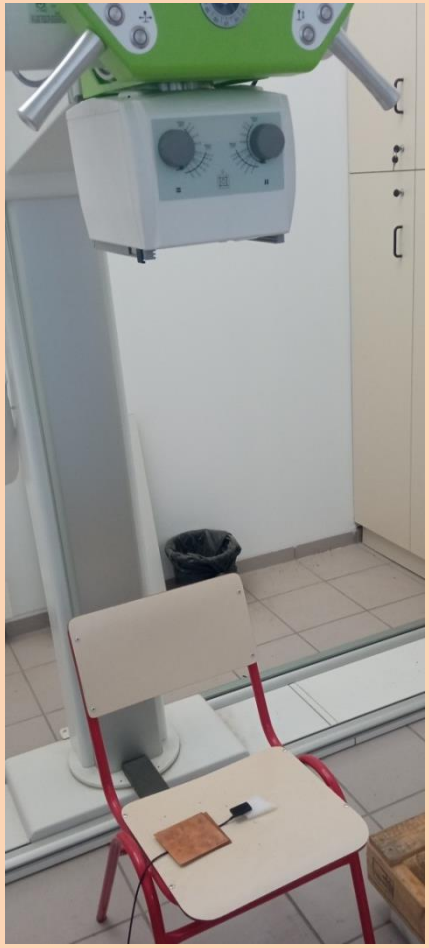

Figure 2: Irradiation setup

Materials and Methods 3

The final image was obtained processed by the vendor software in 8 bit and 16 bit format. NNPS was evaluated by COQ, an ImageJ plug-in software [3]. A noise transfer function (NTF) was calculated as the square root of NNPS normalized to its maximum value Entrance surface air KERMA (ESAK) was measured with a Piranha multimeter. COQ software is shown in Figure 3.

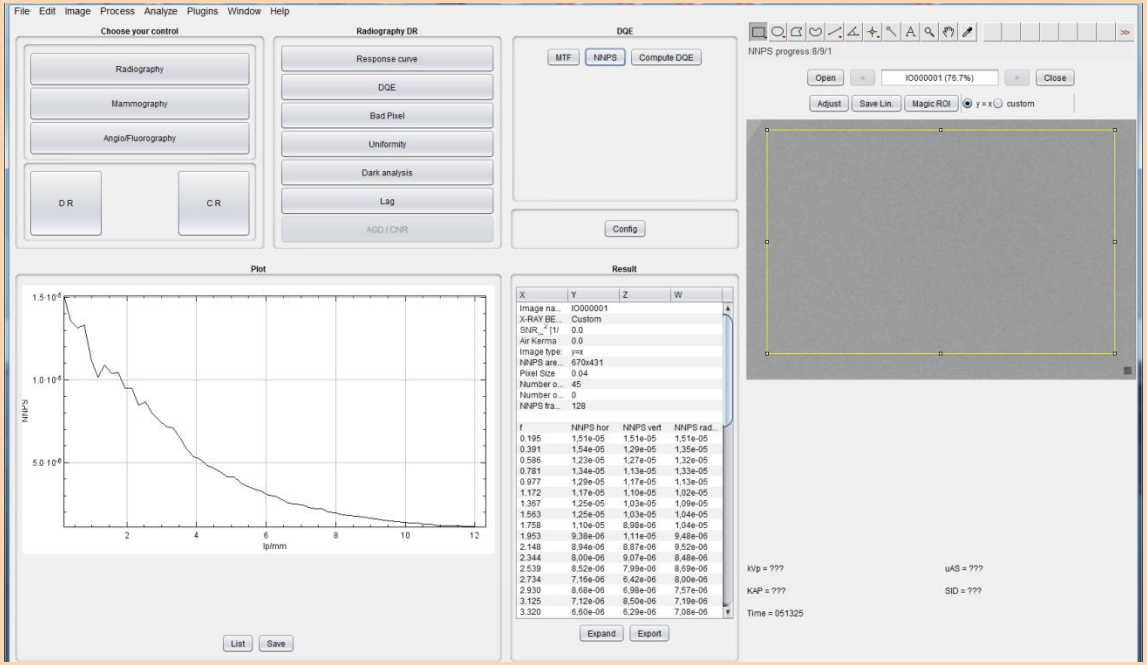

Figure 3: The COQ software environment [3]

Results and Discussion 1

ESAK ranged from 97.4 µGy to 256.1 µGy.

NNPS was calculated higher for the 16 bit image presentation.

At 100 kVp and 25 mA and at the spatial frequency of 2.34 lp/mm, the NNPS at 8 bit was $5x10^{-6}$ mm^2 while the corresponding NNPS at 16 bit was $6.7x10^{-6}$ mm^2.

The differences were significantly reduced at higher spatial frequencies close to the resolution limit of the system. In Figure 3 the NNPS curves for the 100 kVp exposure conditions are shown.

Compared with literature results for 60 kVp and 70 kVp irradiation and ESAK equals to 109 µGy and 92 µGy and 8 bit [2], the presented NNPS curves were calculated higher at 25 and 32 mA at 100 kVp. For the 120 kVp the 36 mA and 32 mA 8 bit NNPS were lower than the 60 kVp and 70 kVp ones.

Results and Discussion 2

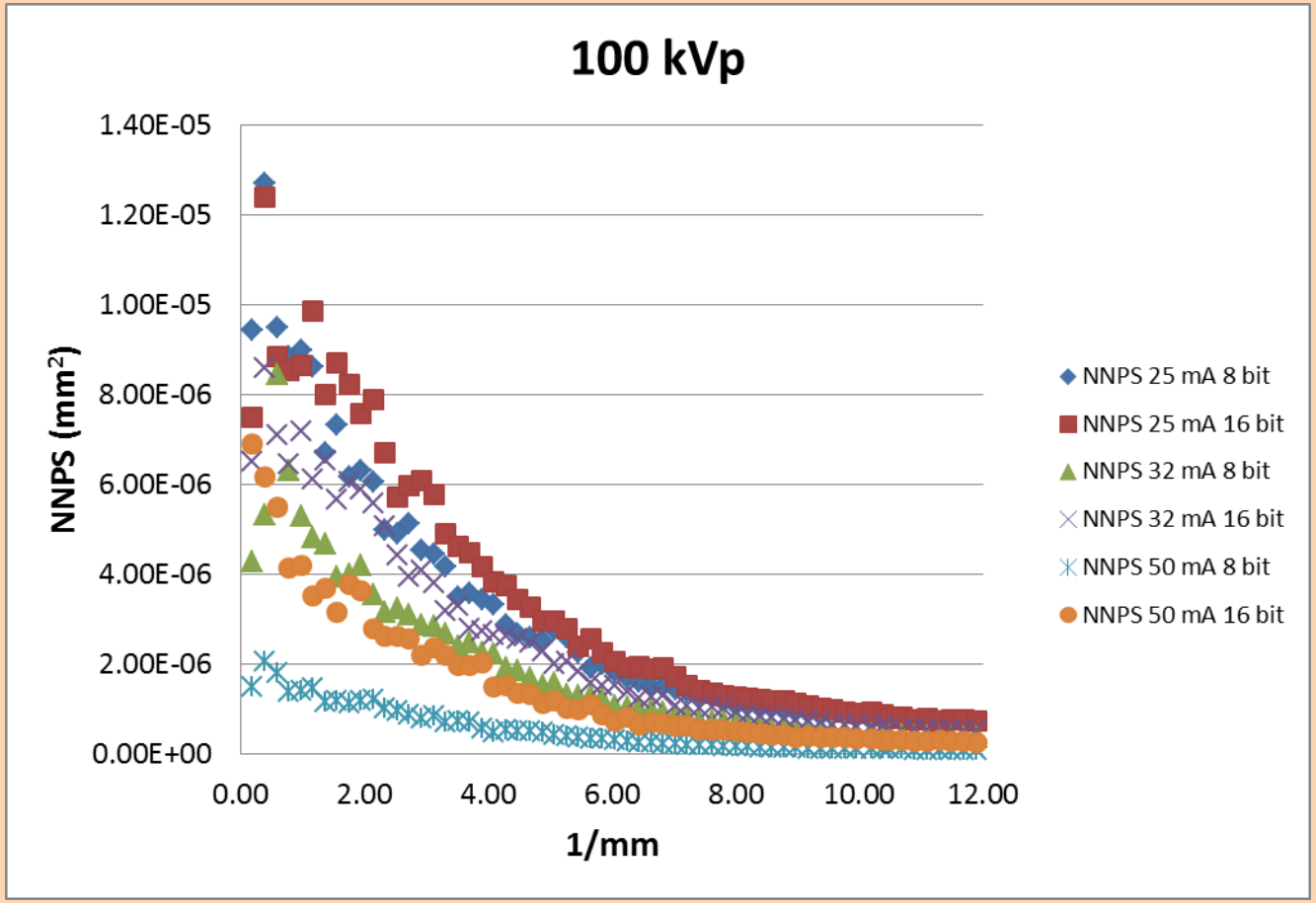

Figure 4: NNPS curves at 100 kVp

Results and Discussion 3

Similar results were obtained at 120 kVp irradiation conditions as shown in Figure 5.

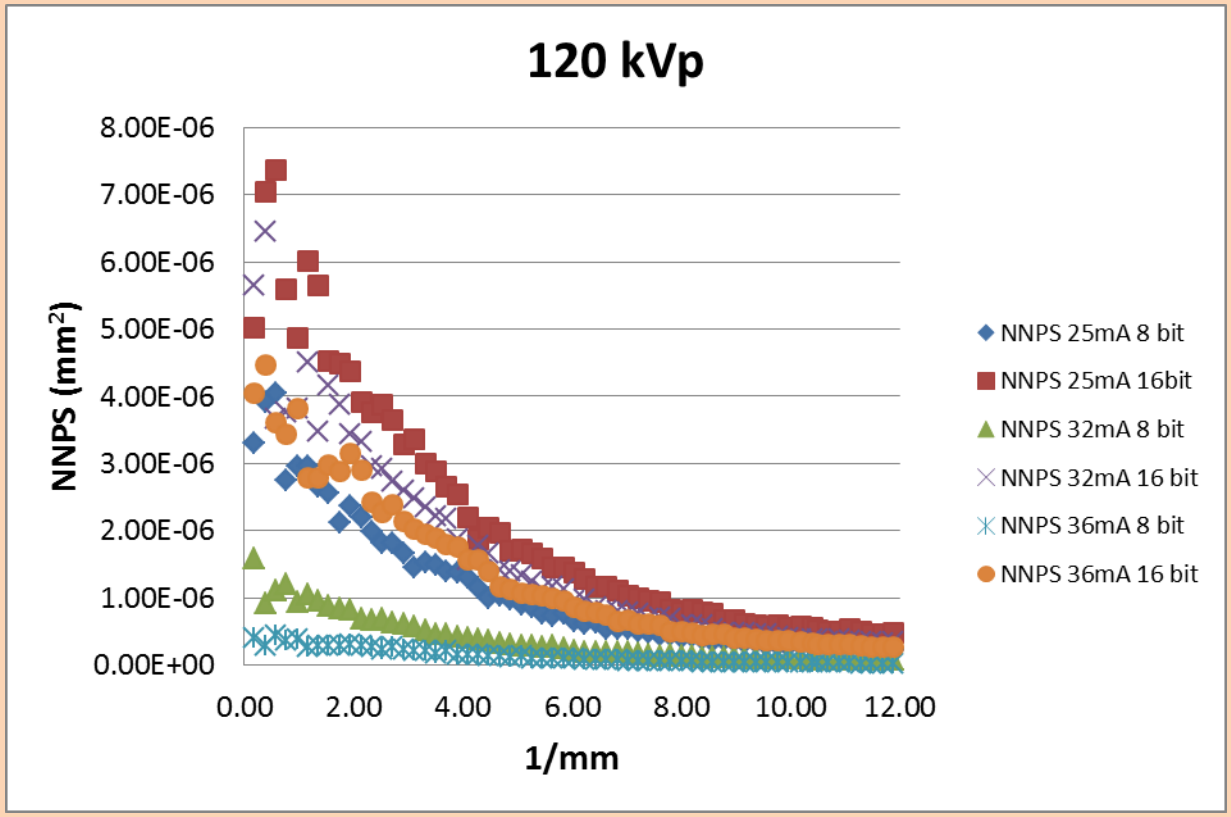

Figure 5: NNPS curves at 120 kVp

Results and Discussion 4

The corresponding NTF values for 100 kVp and 120 kVp are shown in Figures 6 and 7 respectively. For each kVp, the NTF values were comparable.

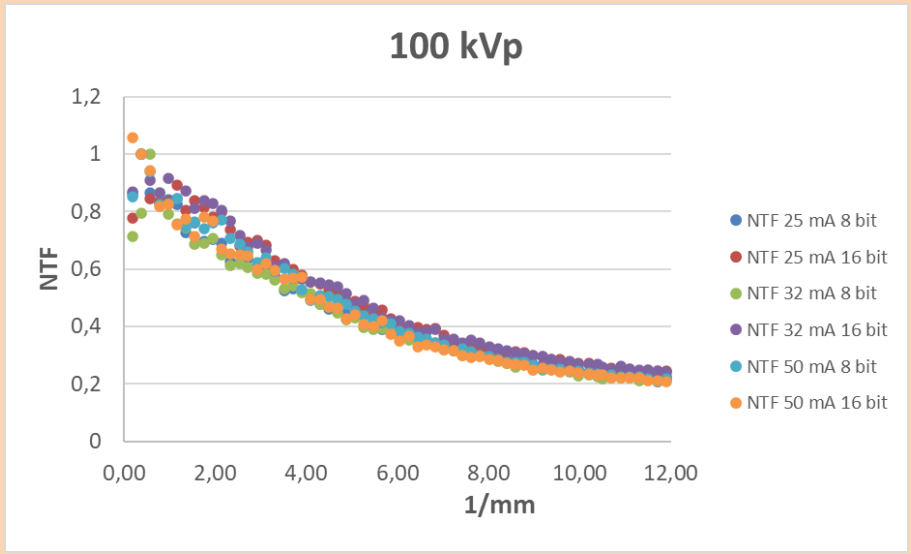

Figure 6: NTF curves at 100 kVp

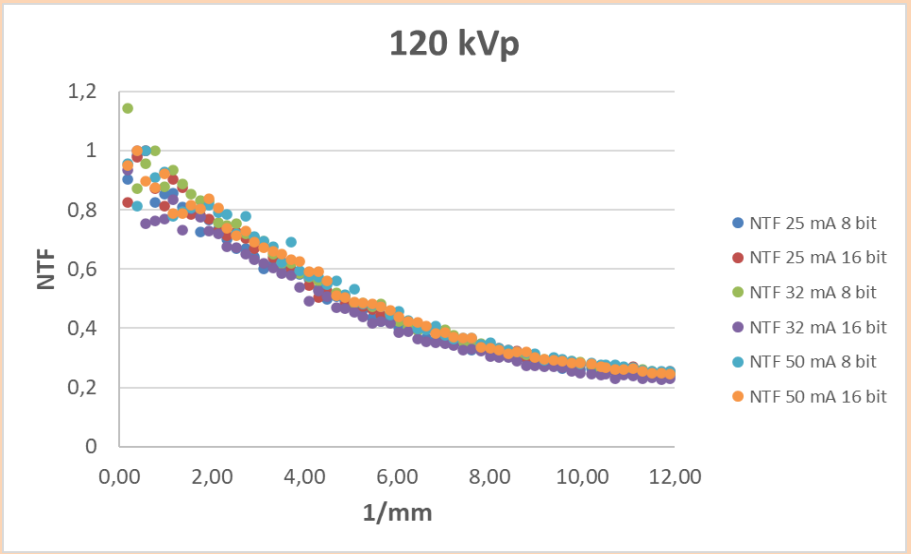

Figure 7: NTF curves at 120 kVp

Conclusion

The noise properties of a commercially dental digital detector were evaluated. It was found that increasing the ESAK decreases the NNPS values. The 16-bit quantification was found to increase NNPS due to the larger available grey levels.

References

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3. B. Donini, S. Rivetti, N. Lanconelli, M. Bertolini, "Free software for performing physical analysis of systems for digital radiography and mammography", Med.Phys. 41 (5) (2014), 051903-1 up to 51903-10.