# Comparison between Rotating Slat and Parallel Hole collimation: Influence of Projector Models

Lin Zhou, Kathleen Vunckx and Johan Nuyts
Department of Nuclear Medicine, K.U.Leuven, B-3000, Leuven, Belgium

## I. Introduction

In our previous study [1], the parallel hole (PH) and the rotating slat (RS) collimators were compared based on the contrast-to-noise ratio (CNR) of a uniform phantom. The RS projector that we used in [1] is a "pixellated projector", which considers the detector array as detector pixels, and performs projection and back-projection for each detector pixel individually. This RS projector takes a lot of computation time due to the large number of detector pixels. For practical reasons, a simplified RS projector, which we call "non-pixellated projector", is more preferable. The non-pixellated projector treats all the detectors between the neighbouring collimator septa as one detector element, therefore it works much faster than the pixellated projector. However, the use of the non-pixellated RS projector might lead to a decrease in the CNR due to the loss of information. In this study, we focused on the influence of the RS projector model on the system comparison, investigating to what extent it is reasonable to replace the pixellated projector with the non-pixellated projector for RS.

## II. Methods

In this study, only planar imaging was investigated. An efficient analytical method, i.e., the Fisher information-based method [2]–[4], was used to calculate the CNR of the central point of a 2D flat disk phantom, using PH and RS collimator, respectively. The gain in the CNR (RS over PH) was calculated with the two RS projectors described above. The gains are defined as:

$$\text{Gain}^{\text{pix}} = \text{CNR}_{\text{RS}}^{\text{pix}}/\text{CNR}_{\text{PH}} \quad (1)$$

$$\text{Gain}^{\text{non-pix}} = \text{CNR}_{\text{RS}}^{\text{non-pix}}/\text{CNR}_{\text{PH}} \quad (2)$$

where $\text{CNR}_{\text{RS}}$ and $\text{CNR}_{\text{PH}}$ are the CNR yielded with RS and PH collimator, respectively. The superscripts $^{\text{pix}}$ and $^{\text{non-pix}}$ refer to the pixellated and the non-pixellated RS projector model, respectively.

We used the same system parameters as in [1]. Both PH and RS were equipped with a square detector array of $230.4mm \times 230.4mm$. $\text{Gain}^{\text{pix}}$ and $\text{Gain}^{\text{non-pix}}$ were calculated for different phantom sizes, as well as different phantom-to-detector distances.

## III. Results

As shown in Fig. 1, for small phantoms or a large detector distance, two RS projectors yield very similar results, and $\text{CNR}_{\text{RS}}$ is always higher than $\text{CNR}_{\text{PH}}$ ($\text{Gain}^{\text{non-pix}} \approx \text{Gain}^{\text{pix}} > 1$). For large phantoms or a small detector distance, we have $\text{Gain}^{\text{non-pix}} < \text{Gain}^{\text{pix}} < 1$, which means that PH outperforms RS anyway, no matter which RS projector is in use.

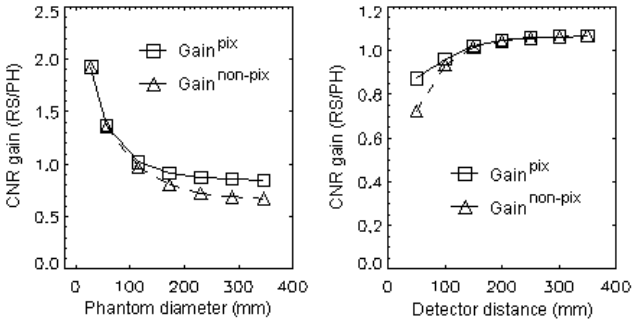


Fig. 1. CNR gains (RS over PH) of the central point of a 2D flat disk phantom. (a) CNR gains as a function of phantom diameter at a small detector distance ($distance = 50mm$). (b) CNR gains as a function of the detector distance, for a large phantom ($diameter = 230.4mm$)

## IV. Discussion and Conclusion

Suppose the number of detector pixels lying between the neighbouring RS collimator septa is $N_d$. With a non-pixellated projector, the computation time is $N_d$ times less than with a pixellated projector. However, the information carried in the measurement of a non-pixellated projector is less than that of a pixellated projector. Therefore, every point is reconstructed with lower certainty which results in a higher variance.

With a non-pixellated projector, the noise from the eccentric points is directly propagated to the central point of the phantom during the back-projection. This influence is much stronger when the phantom becomes larger or the phantom is positioned closer to the detector surface.

Based on the comparison result, we suggest that, for large phantom or a small phantom-to-detector distance, PH collimator is recommended. For the opposite cases, RS with a non-pixellated projector is more preferable, since it facilitates the system implementation, saves a lot of computation time and yields very similar results as the pixellated projector.

## References

[1] L. Zhou, M. Defrise, K. Vunckx, and J. Nuyts, "Comparison between parallel hole and rotating slat collimation." *IEEE Nuclear Science Symposium Conference Record*, pp. 5530-5539, 2008.

[2] J. A. Fessler, "Mean and variance of implicitly defined biased estimators (such as penalized maximum likelihood): applications to tomography." *IEEE Trans. Image Processing.*, 5(3), pp. 493-506, 1996.

[3] J. Qi and R. M. Leahy, "A theoretical study of the contrast recovery and variance of MAP reconstructions from PET data." *IEEE Trans. Med. Imag.*, 18(4), pp. 293-305, 1999.

[4] K. Vunckx, D. Bequé, M. Defrise and J. Nuyts, "Single and multipinhole collimator design evaluation method for small animal SPECT." *IEEE Trans. Med. Imag.*, 27(1), pp. 36-46, 2008.