Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 17-19, 2017

Effect of geometrical misalignment on the MTF measurement

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1. Introduction

The modulation transfer function (MTF) has been widely used to characterize the spatial resolution of x-ray imaging systems [1]. The MTF is generally obtained from the modulus of the Fourier transform of line-spread function (LSF) normalized to unity at zero frequency [1]. Three methods can be used to measure the LSF such as the wire, edge-phantom [2, 3], and slit-camera [4, 5, 6, 7, 8] techniques. The wire method obtains the LSF by inverting the thin wire response. The edge-phantom method obtains the LSF by differentiating the edge response. Without any additional work the slit-camera method obtains directly the LSF.

When x-rays hit the slit-camera, scattered and K-fluorescence x-rays can be produced. These secondary radiations can affect the slit response function. Moreover misalignment of the slit with the beam geometry can distort the slit response function.

In this study, the effects of secondary radiations and geometrical misalignments on the slit response function both in the spatial and frequency domains.

2. Methods

Using the parameters, as described in Fig. 1 and Table 1, the slit response function is analytically modeled.

For the slit-camera method, two parallel jaws are used, as shown in Fig. 1(a). The distance between the parallel jaws is separated by 0.01 mm and the angle of the beveled jaw is defined as 0 ~ 4 °. In this geometry, the source is defined as a photon source at way by 1500 mm from the 1.5 mm thick Tungsten slit diaphragm. The photons are emitted in a cone-wide form. The photon energy ranges from 30 keV to 110 keV as monoenergetic x-ray spectra.

Misalignment is simulated with respect to the source positions and the tilting angle ϕ.

The slit MTF is calculated by computing the modulus of the Fourier transformation of the spatial slit response function obtained from the analytic model.

The thickness of the tungsten through which x-ray are transmitted is different because of the irradiation angle of con-beam. Therefore, the jaw angle θ is also included in the simulations as a parameters.

3. Preliminary Results

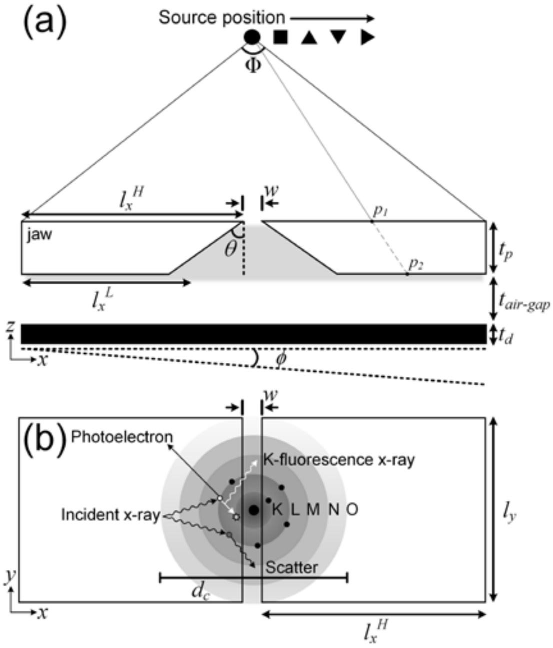

Fig. 1. Schematic illustration of a geometry used in the slit-camera simulation. (a) Simulation geometry, (b) X-ray interaction of the generated in the slit-camera

Figure 2(a) shows the numerical simulation LSF results or the spatial slit response function. As the energy and jaw angle increase, the LSF is broadened. However, the LSF at 70 keV is lower than those at 50 keV and 90 keV.

Figure 2(b) shows the corresponding MTF results. As the energy increases, the MTF decreases except the MTF at 70 keV. The MTF of jaw angle 4^o is the worst in each case.

4. Ongoing and Further Studies

The analysis of slit response function for various geometric parameters are under progress. The results will be presented with discussions on the behind physics. In parallel, the Monte Carlo simulations are being carried out to validate the analytic models. This study will provide the allowable tolerance of the slit method for the MTF determination under misalignments.

ACKNOWLEDGEMENT

This work was supported by the National Research Foundation of Korea (NRF) grants funded by the Korea governments (MSIP) (No. 2014R1A2A2A01004416).

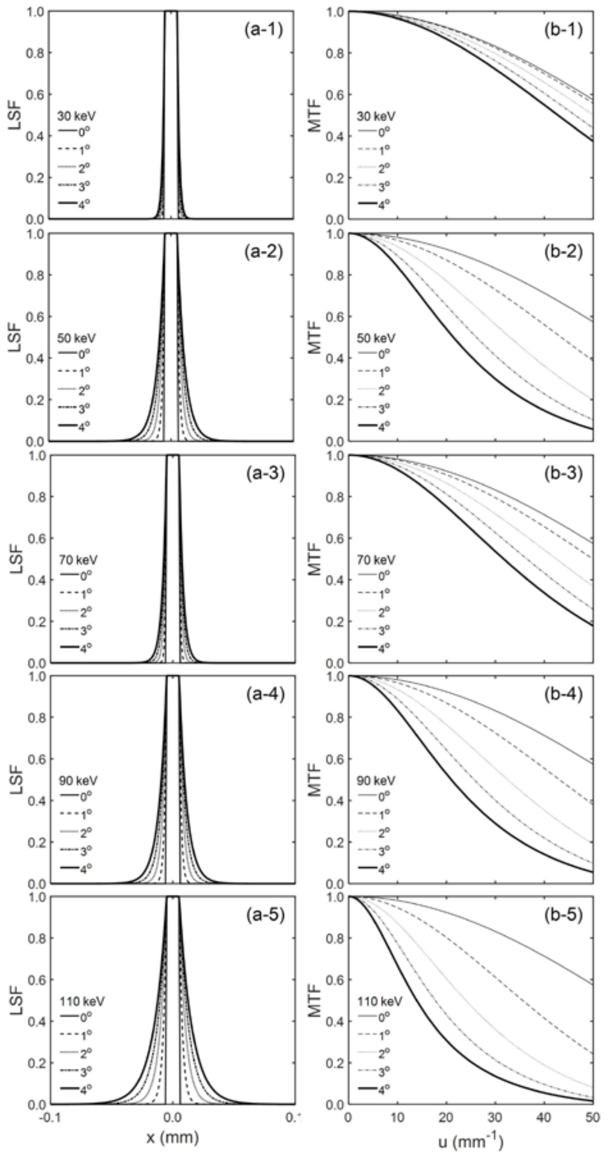

Fig. 2. Numerical simulation results using the slit-camera method. (a) LSF, (b) MTF.

Table I: Numerical simulation conditions

Source position	● ~ ▶
w (mm)	0.01
θ (°)	0 ~ 4
ϕ (°)	0 ~ 5
Φ (°)	0.99998
SDD (mm)	1500
t_p (mm)	1.50
l_H (mm)	29.995
l_L (mm)	28.946 ~ 29.995
d_c (mm)	20
Energy (keV)	30, 50, 70, 90, 110
Material	Tungsten (W)
W μ (cm^{-1})	22.73, 5.95, 11.04, 5.79, 3.48
W ρ (g/cm^3)	19.25

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