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Au-coated X-ray Anti-scattering Grid Performance Test by MCNP

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1. Introduction

It is required to protect individual against the dangers of ionizing radiation from medical exposure [1]. And increasing of resolution for x-ray radiography tools can give radiation protectoral benefits. Because the image device has higher resolution in same energy source, it requires low energy level source and it can reduce individual dose.

The anti-scattering grid is sub-device that is attached in front of detector (direction of source). It is square lattice shape generally. It is composed of penetration parts and shielding parts. Penetration part is generally air (the void) and in some studies it uses wood or aluminum. Shielding part is composed of various materials such as lead or copper [2].

In this study, it is focused on the gold as one of X-ray grid materials, where gold is generally known as excellent shielding material and the performance test on the gold coated anti-scattering grid is carried out by MCNP simulation

2. Methods and Results

2.1. MCNP

All simulations are performed using MCNP6 [3].

MCNP is particle transport tool that is widely used in nuclear core design and radiation protection. It is based on Monte-Carlo method. It can be used from 1keV to 100GeV in the case of photon. MCNP can transport various particles under user customized geometry and material.

2.2. Simulation design

Three types of material are used in this study; body, structure glass and gold.

Body is scatter target. For making scattered photon, low density target is needed. In order to match with real condition, it is used that the real body's elemental composition.

As a shielding material, gold is used. Gold is well-known material which can shield photon excellently. Glass is simply composed by Si:O = 1:2 and its gram density is 2.365 g/cm^3. Gold is composed in pure gold with density of 19.3 g/cm^3 and its isotope composition is natural.

Geometry is simple; body, grid and detector. It is shown in figure 1.

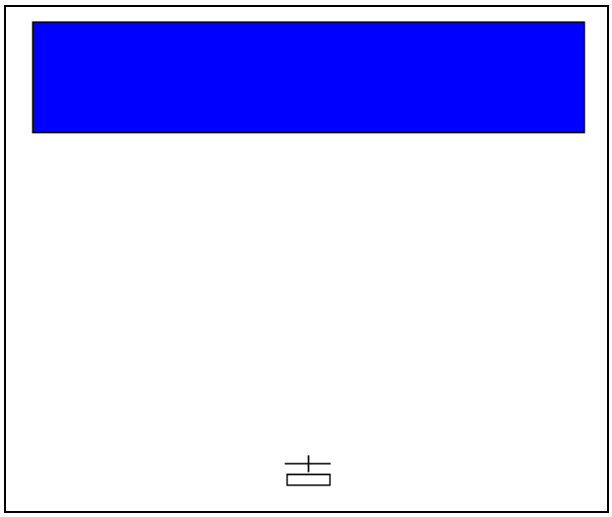
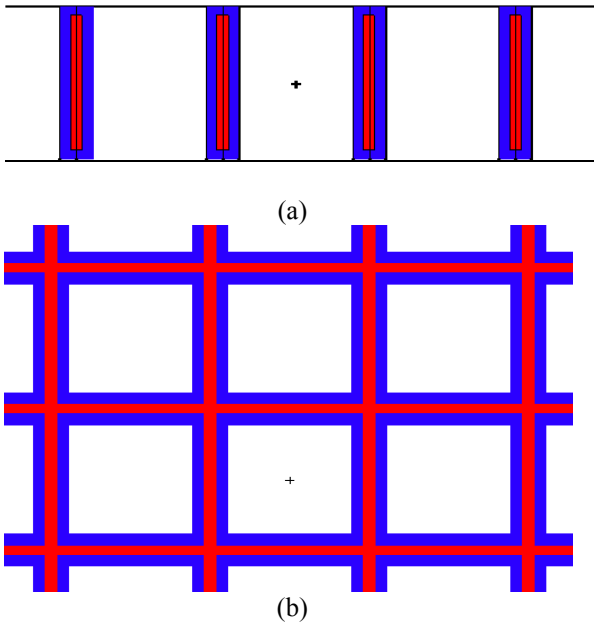


Fig. 1. Overall view of simulation geometry

The blue box is body which has thickness of 10 cm. Center cross is grid which has thickness of 1mm.



(a)

(b)

Fig. 2. Geometry of grid. (a) is view of XZ plane. (b) is view of XY plane.

The design of grid is shown at figure 2. Grid size is 4cm X 4cm and resolution is 200 X 200 (40000 pixel). One latice squre has side length of 200 μm. Thickness of glass is 30 μm and coated gold is 30 μm. The left side of vertical line is "with grid" which means it has grid. And the right side of vertical line is "without grid" which means there is no grid in that side.

The white box is detector. Detector is void because of efficiency of detection.

Source is 50 keV single-energy photon source and it has distance of 20cm above the body.

2.4. Results

In this section, it contains the result of tallies; mesh tally result and energy tally result

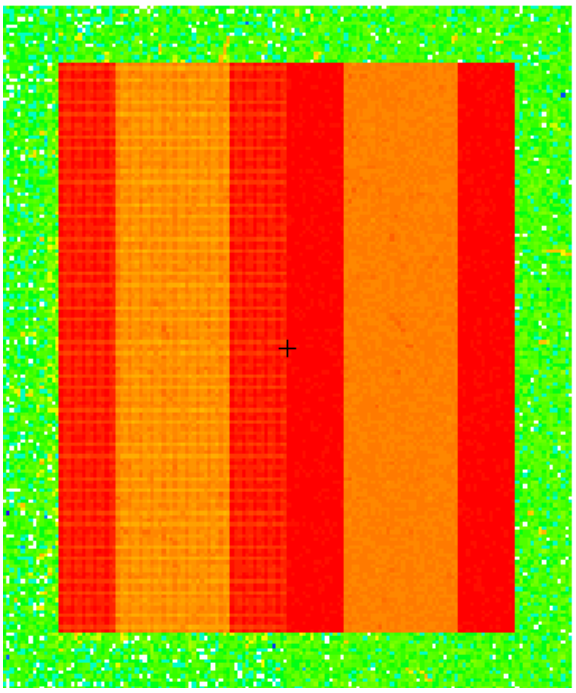


Fig. 3. Result of mesh tally. The left side is "with grid", the right side is "without grid".

Figure 3 shows the mesh tally result. Left side from the center cross is with grid zone, and right side from the center cross is without grid zone.

It can be checked that boundary of right side is greener than left side. Repeating again, left side has more white dots. The green part is scattered photon tallied zone. The more white dots means less photon is tallied in the zone. So, it can be visually resulted that grid can reduce the scattered photon.

This figure shows qualitative result.

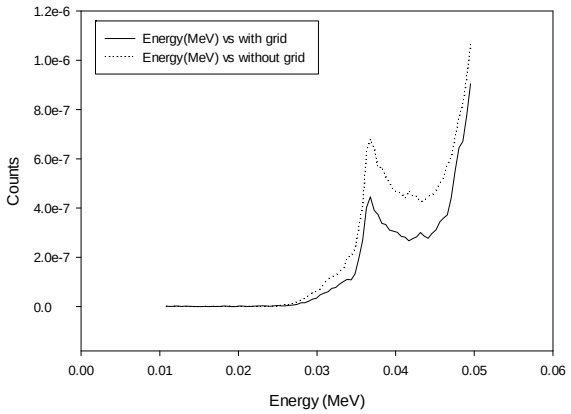


Fig. 4. Result of tally. Dotted line is "without grid". Normal line is "with grid".

Figure 4 shows the result of the simulation. X-axis is energy, and y-axis is counts.

The height of peak of "without grid" is reduced by 65.49 % comparison to "with grid".

In energy range between 0.02 keV and 0.461 keV, graph's area under the graph "without grid" is reduced by 62.01 % comparison to the graph "with grid". It is calculated by Matlab® "polyarea" function.

The total dose ratio is 94.16 %. The grid only shields 5 % of whole photon but it shields one third of scattered photon. Therefore, this grid can reduce the scattered photon efficiently.

This figure shows quantitative result.

3. Conclusion

X-ray grid was simulated by using MCNP code and its performance was investigated. It was understood that glass based and Au-coated grid could lessen the scattered photons more where the reduction was about two third.

In further study, geometry optimization or material selection will be conducted by MCNP simulation for giving benefits to design proper grid for various instruments.

REFERENCES

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[3] Los Alamos National Laboratory, "MCNP – a general monte Carlo N-Particle Transport Code version 5" (2008)