# Adding an Aluminum Sheet to Copper Shield for Reducing the Absorbed Dose in Computed Tomography: a Pilot Study

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## 1. Introduction

- ✓ Copper shield is an example of the radioprotective shields used for reducing absorbed X-ray dose to the radiosensitive organs in computed tomography (CT).
- ✓ However, copper generates incoherent scattering of X-rays incident to diagnostic X-rays in comparison with bismuth, another material used in commercially available radioprotective shields.

## 2. Objectives

- ✓ To evaluate the effectiveness of adding an aluminum sheet to the copper shield in order to attenuate secondary X-rays generated from the copper shield.

## 3. Materials

A) Measurement of photon energy spectra

- ✓ Photon energy spectra of primary X-ray beams (120-kVp tube voltage and approximately 50-keV effective energy) were obtained using a high-purity germanium detector (GLP-06165/05P; EG&G ORTEC, Oak Ridge, TN) (Fig.1) when a commercially available bismuth sheet (ARB42; F&L Medical Products, Vandergrift, PA), copper plate (0.1–0.3-mm thick and 99.9% pure), or copper plate in combination with an aluminum sheet (0.2–0.4-mm thick and 99.9% pure) was placed between the X-ray tube and the detector.

Fig.1: A high-purity germanium detector system

- ✓ The detector was collimated using lead pinhole collimators to avoid detecting secondary X-ray beams.

B) Measurement of absorbed dose (Fig.2)

- ✓ The absorbed doses in the Mix-Dp phantom were measured at depths of 0, 3, 6, 9, and 12 cm from the surface of the phantom by inserting radiophotoluminescent glass dosimeters (GD-302M; Chiyoda Technol, Tokyo, Japan) into the phantom when the bismuth sheet, copper plate, or copper with aluminum sheet was placed at the surface of the phantom.

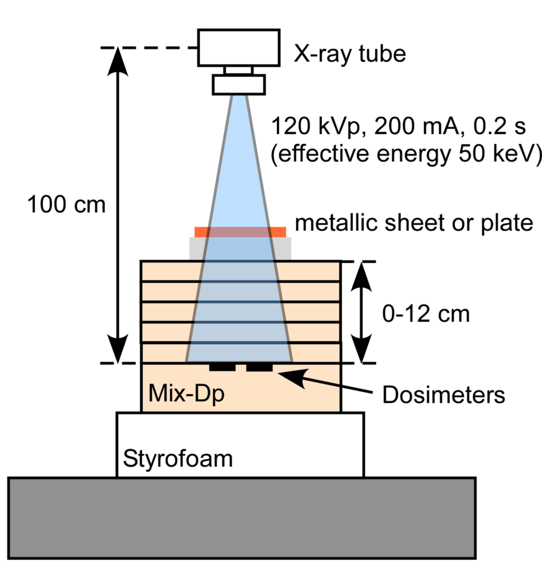


Fig.2: Geometrical setup for measurement of absorbed dose

## 4. Results

A) Photon energy spectra (Fig.3)

- ✓ There was a tendency for more photons of primary X-ray beams to attenuate as the thicknesses of the copper and aluminum increased.
- ✓ The photon energy spectrum in the case of the bismuth sheet was a little bit similar to that of the 0.2-mm-thick copper plate.
- ✓ More photons of primary X-ray beams were attenuated in the case of the copper plate with the aluminum sheet compared with only the copper plate; however, this difference was negligible in case of the 0.3-mm-thick copper plate.

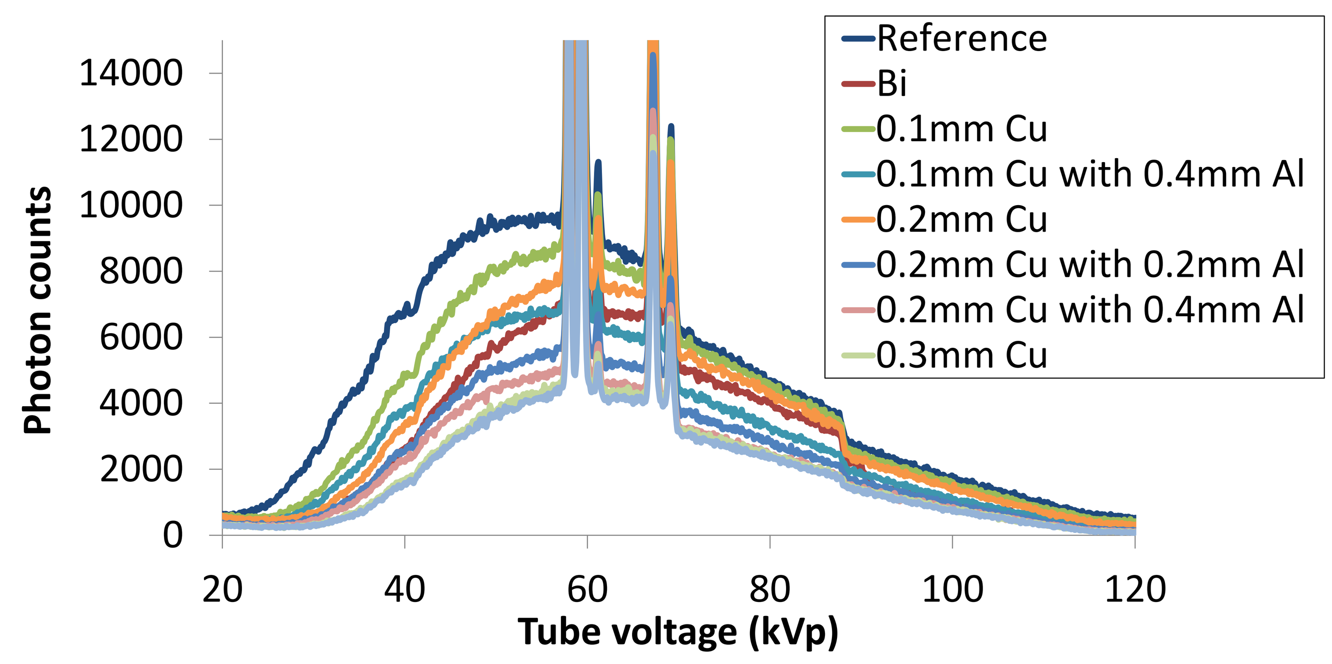


Fig.3: The photon energy spectra of primary X-ray beams

B) Absorbed dose (Fig.4)

- ✓ The absorbed doses were increased in the case of the 0.1-mm-thick copper plate with the aluminum sheet compared with only the 0.1-mm-thick copper plate.
- ✓ The absorbed doses were decreased in the case of the 0.2-mm-thick copper plate with the aluminum sheet compared with only the 0.2-mm-thick copper plate, and were decreased as the thickness of the aluminum sheet increased.
- ✓ The differences of absorbed doses were negligible between the 0.3-mm-thick copper plate and the 0.3-mm-thick copper plate with the aluminum sheet.

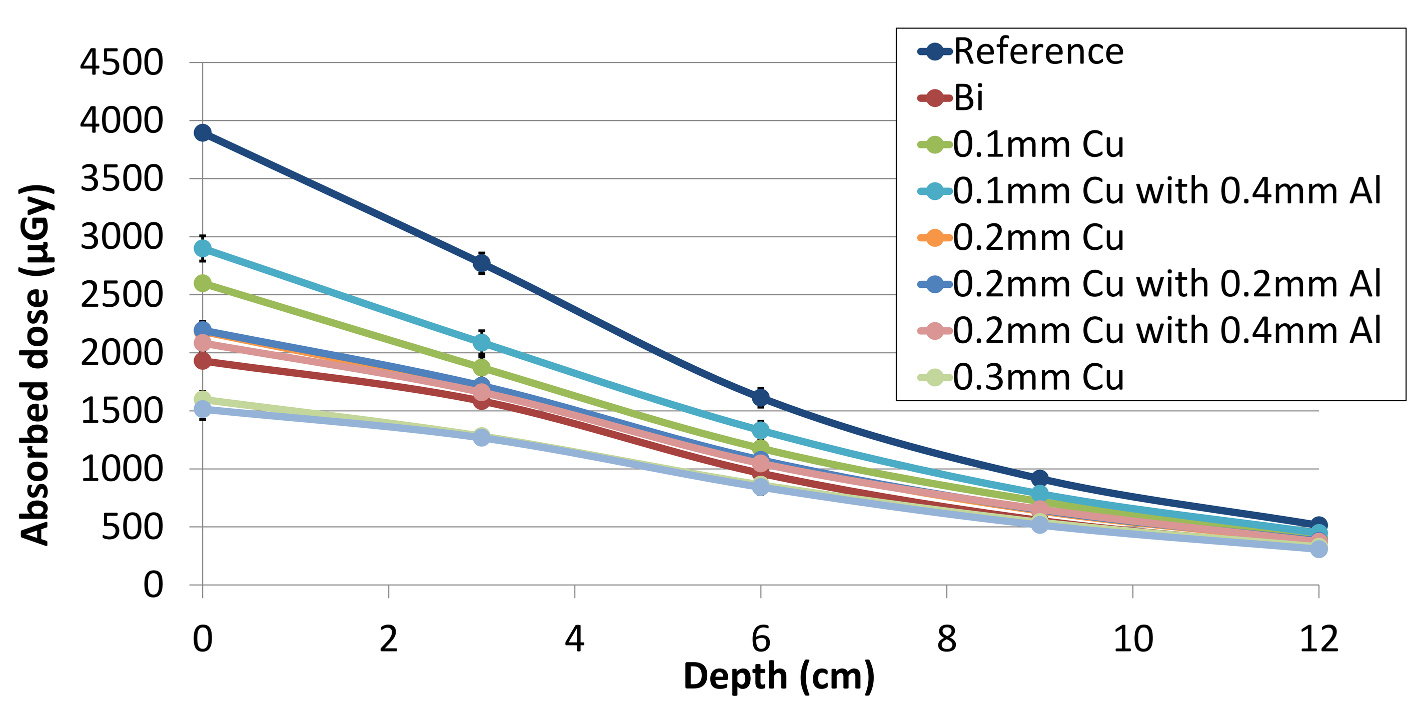


Fig.4: The absorbed doses in the Mix-Dp phantom

## 5. Discussion

- ✓ More secondary X-rays were generated when the 0.1-mm-thick copper plate with the aluminum sheet was placed, because the photons of low-energy X-ray beams were not attenuated sufficiently by the 0.1-mm-thick copper plate and they generated secondary X-rays by interaction with the aluminum sheet.
- ✓ The photons of low-energy X-ray beams were sufficiently attenuated by the 0.3-mm-thick copper plate and there was no further advantage of adding the aluminum sheet. However, the aluminum sheet efficiently attenuated secondary X-rays generated from the 0.2-mm-thick copper plate.

## 6. Conclusions

- ✓ The photon energy spectrum of a primary X-ray beam in the case of placing a commercially available bismuth sheet is a little bit similar to that of a 0.2-mm-thick copper plate.
- ✓ The addition of an aluminum sheet is effective in attenuating secondary X-rays generated from a 0.2-mm-thick copper plate.

## Acknowledgment

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