Study of the scattered X-ray distributions around a mammography unit

**Poster No.:** C-0466  
**Congress:** ECR 2013  
**Type:** Scientific Exhibit  
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**Keywords:** Radiation safety, Physics, Mammography, Radioprotection / Radiation dose, Radiation physics, Professional issues, Occupational / Environmental hazards  
**DOI:** 10.1594/ecr2013/C-0466

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Purpose

The main goals of this research were:

1. To study the distribution of scattered radiation in a mammography unit during the execution of a breast radiological examination, for the protection of the workers and public.
2. To estimate the scattered radiation absorbed by the patient undergoing a mammographic exam, for shielding design purposes.

Methods and Materials

Sample

One hundred (n=100) exposures were made in both the axial plane and the coronal plane with a tube voltage of 30 kVp, anode-filter combination molybdenum/molybdenum and large focus.

Measurements of the scattered radiation were carried out with an anthropomorphic phantom couple to a breast phantom to simulate the body of an adult patient.

Instruments

The dose rate for scattered radiation was measured by placing a solid state sensor every 10 degrees around the mammographic unit at 1 meter distance from the center’s field of view (FOV), in the axial and coronal planes of the breast. The scattered radiation distribution was treated as isodose curves, specifying the amount of radiation that will be delivered to a specific point in the room around the equipment. The setup included the following equipments (Fig 1).

- Mammography unit GE Senographe DMR;
- Unfors Xi Survey Detector;
- PMMA Breast phantom;
- Whole-body anthropomorphic phantom.
Fig. 1: Equipment, phantom and detection system.

References: Department of Radiology, Health School - University of Algarve

Procedures

This study was divided into three experiments which consisted of:

- 1st Experiment: exposures in the CC incidence of the breast (axial) with only the breast phantom;
- 2nd Experiment: exposures in the CC incidence of the breast (axial) with the breast phantom and whole-body anthropomorphic phantom;
- 3rd Experiment: exposures in the incidence of the profile breast (coronal plane) with only the breast phantom.

Results

Experiment 1 and 2

The scattered radiation in the 1st experiment has a regular behavior. At 0° position, the scattered radiation level reaches the highest value due to the non-uniform geometry of the breast phantom, offering the photons a shorter attenuated passage through the phantom. At the 180° position, the scattered radiation is totally absorbed by the equipment (Fig. 2).

The 2nd experiment shows a reduction of the scattered radiation, in the in the range angle of 30° to 30°, that is, behind the anthropomorphic phantom. This is due to the skeleton
and tissue equivalent constitution of the anthropomorphic phantom, but mainly due to the spinal column (Fig 2).

In the range angle of 80° to 160°, and comparing both 1st and 2nd experiments, results suggest that the anthropomorphic phantom contributes to an increase of the scattered radiation level due to backscattering effect (Fig. 2).

![Stray radiation isodose curves (XY plane) GE Senographe DMR+ (30kVp, Mo/Mo, focus 0.3 mm)](image)

**Fig. 2**: 1st and 2nd Experiments: Stray radiation isodose curves (XY plane) GE Senographe DMR+ (30kVp, Mo/Mo, focus 0.3 mm)

**References**: Department of Radiology, Health School - University of Algarve

**Experiment 3**

In the 3rd experiment, the behavior of the scattered radiation in the YZ plane - coronal is evaluated. Results show that the primary radiation is partially absorbed by the potter and the scattered radiation presents lower levels of intensity in the range angle of 30° to 90°. Between 90° and 160° the backscattering effect predominates at 180° the dispersed radiation is completely absorbed by the mammography unit (Fig. 3).
In the axial plane, results show that the scattered radiation on the back of the anthropomorphic phantom is absorbed up to 73%, at the potter bucky plane height (Fig. 3).

In the coronal plane, the scattered radiation significantly increases with the angle due to backscattering effect. Assuming the direction of the incidence beam is 0° results show that the scattered radiation is 86% higher at 160° than at 90° (Fig. 3).

**Fig. 3:** 3rd Experiment: Stray radiation isodose curves (YZ plane) GE Senographe DMR+ (30kVp, Mo/Mo, focus 0.3 mm)

**References:** Department of Radiology, Health School - University of Algarve

**Conclusion**

This study concludes that the type of mammographic view, more properly the mediolateral oblique (MLO) view in the coronal plane (YZ plane), must be considered in the worst case scenario for shielding calculation design with special care at backscattering angles toward opposite lateral barriers. This result is in accordance with (Simpkin, 1996) and (Kunzel, 2006), and was first introduced in the structural shielding design specified in the (NCRP, 2004).
However, this study is the first to investigate the absorption of the scattered radiation due to the mammography unit and the patient. For barriers facing the back of the mammography unit, the scattered radiation is totally intercepted by the column and the U-arm. No scattered radiation is present at the back in a solid angle of approximately 20 degrees and this result depends on the material and design geometry of the mammography unit structure. For barriers facing the back of the patient, results showed that the scattered radiation is partially absorbed up to 73%, and the body of the patient intercepts the scattered radiation in a solid angle of about 30 degrees. The scattered radiation absorption due to the patient in mammographic installations is not yet introduced in the shielding calculation, leading to an over estimate of shielding effectiveness. The result suggests that additional shielding is not required at the barrier behind the patient.

References


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Images for this section:

Fig. 4