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Spatial distribution of scatter radiation for gridless X-ray irradiation examinations: A Monte Carlo study

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1. Background-Aim

In medical X-ray imaging, scatter radiation drastically reduces image quality specially in the absence of radiographic grids.

Monte Carlo simulation is a power tool for assessing the radiation interactions and energy absorption in various materials.

The scope of this study is the Monte Carlo evaluation of scatter radiation at the exit of a simulated tissue phantom for X-ray spectra of 60 kV.

This study may be of value for gridless X-ray irradiation examinations such as: arm, dental and mobile radiography were 60 kV are utilized. In these cases tube voltage choice is expected to yield adequate image quality properties, while the radiation dose remains low.

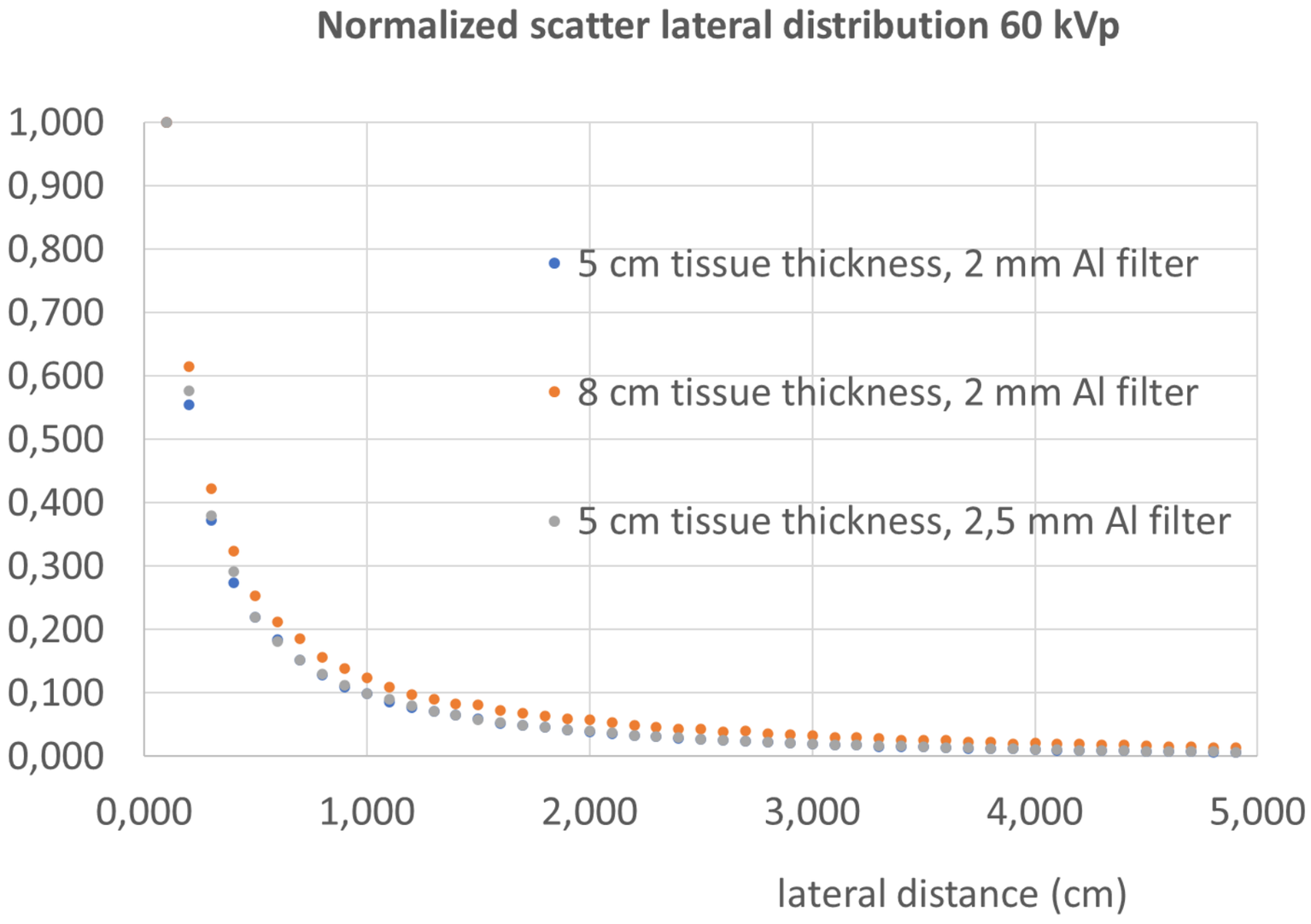
2. Materials & Methods

This study uses a Monte Carlo software tool PenEasy [1] to calculate the profile of the distribution of the scatter X-rays at the exit of a tissue phantom. PenEasy is based on Penelope Monte Carlo code. It has built-in functions which enable the calculation of absorbed energy distribution in various geometrical planes and vectors.
The geometry utilized assumed two parallel mathematical planes with distances ranging from 5 cm to 40 cm. The material inside the planes had the tissue radiation interaction characteristics as obtained by the Penelope database.

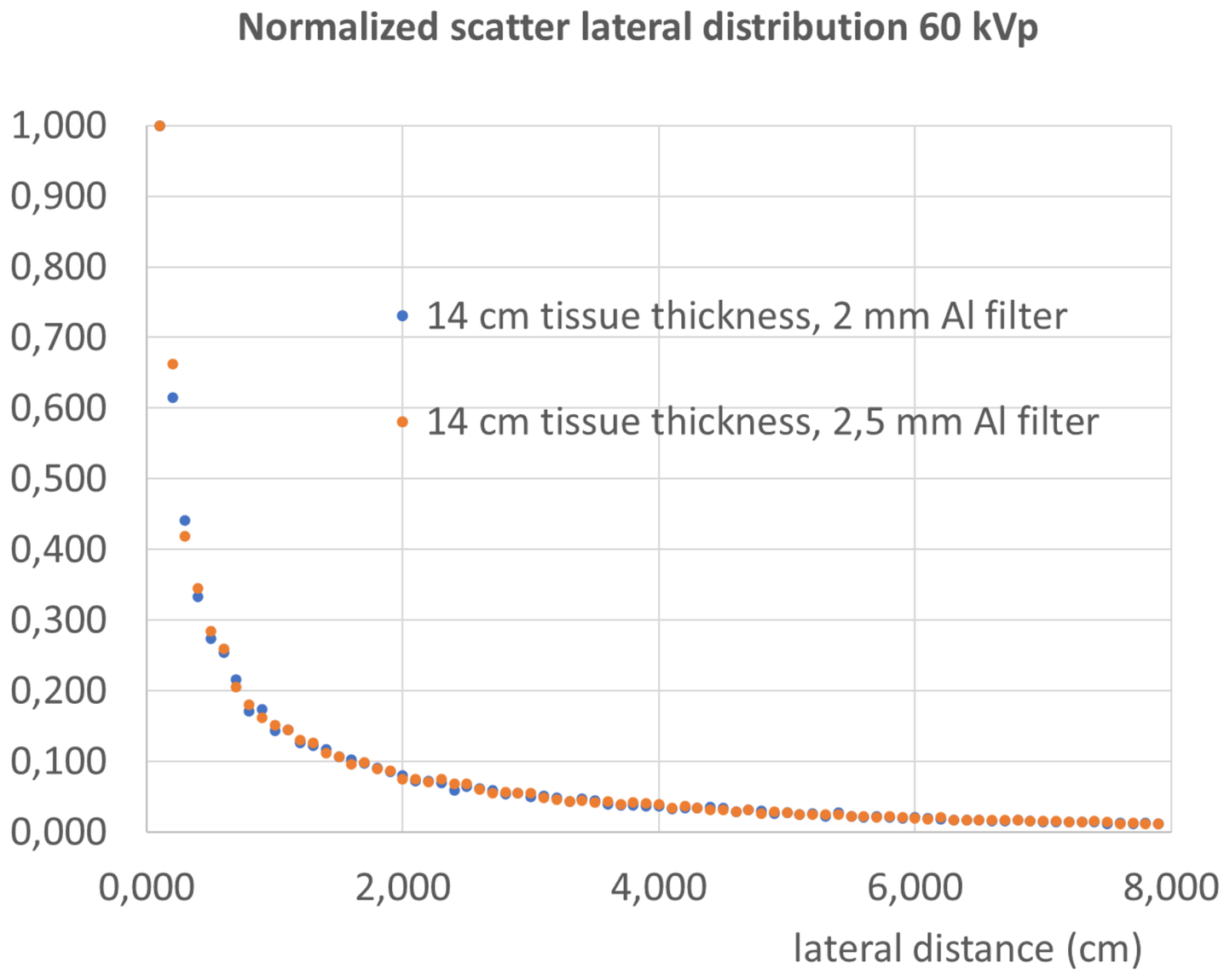
The required X-ray spectra were created by a free available software [2] and were inserted as a text file in PenEasy software.
The X-ray tube voltage was kept constant at 60 kV and the Al filtration thickness varied from 1,5 mm up to 3,5 mm [3].

The lateral spread of the scatter X-rays absorbed energy was calculate at a thin layer of the exit surface of the tissue phantom.

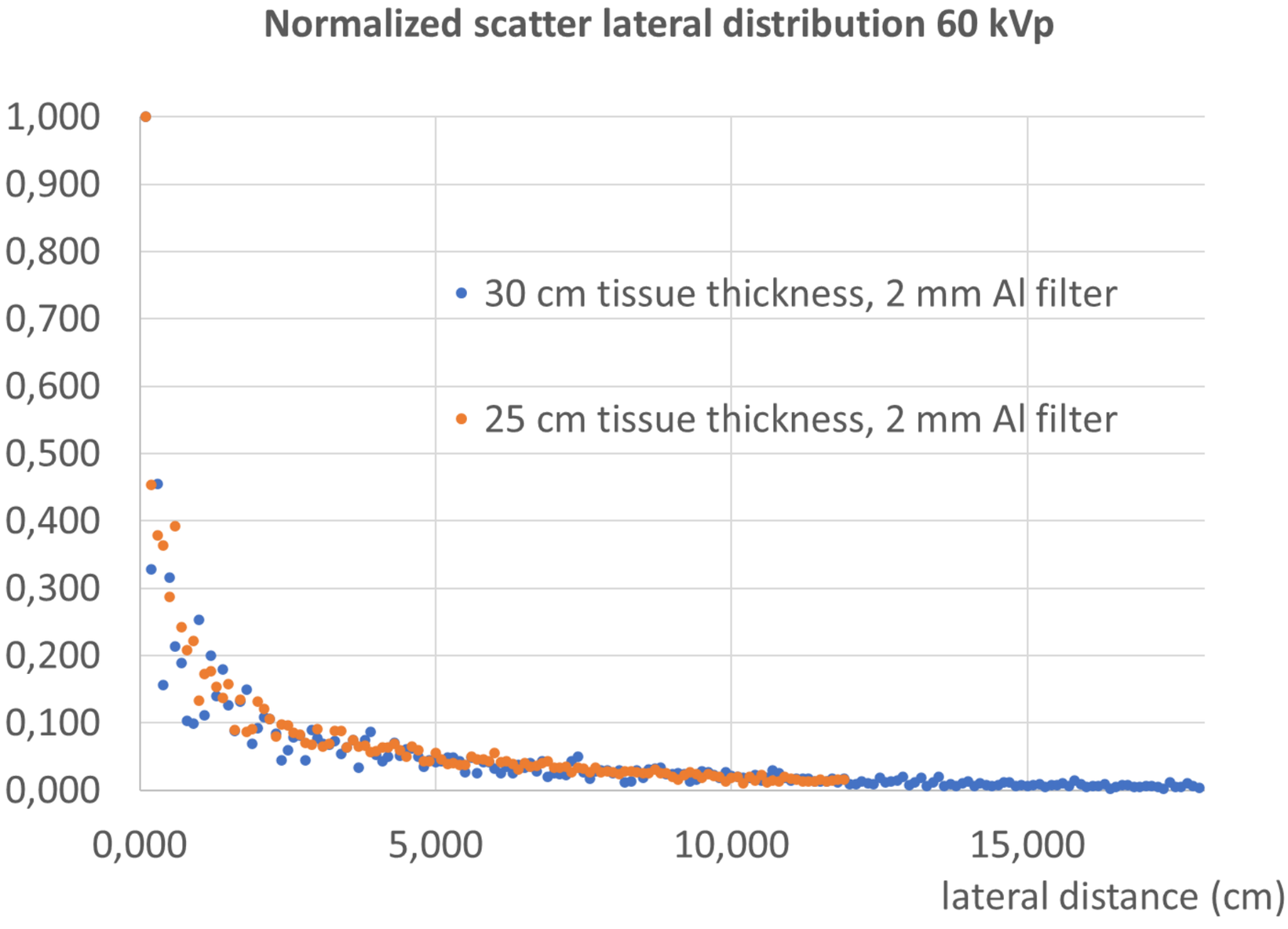
3. Results I


Normalized scatter lateral distribution 60 kVp
1,000
0,900
0,800
0,700
0,600
0,500
0,400
0,300
0,200
0,100
0,000
0,000
1,000
2,000
3,000
4,000
5,000
lateral distance (cm)
5 cm tissue thickness, 2 mm Al filter
8 cm tissue thickness, 2 mm Al filter
5 cm tissue thickness, 2,5 mm Al filter

3. Results II


Normalized scatter lateral distribution 60 kVp
1,000
0,900
0,800
0,700
0,600
0,500
0,400
0,300
0,200
0,100
0,000
14 cm tissue thickness, 2 mm Al filter
14 cm tissue thickness, 2,5 mm Al filter
0,000
2,000
4,000
6,000
8,000
lateral distance (cm)

3. Results III



4. Conclusions

For the 60 kV and 2 mm Al spectrum, the percentage of the scatter at 2 cm lateral distance from the central axis was found 39,3% for tissue thickness of 5 cm and 57,6% for tissue thickness of 8 cm.

For 5 cm and 14 cm tissue thickness values, the increase in filtration from 2,0 mm Al to 2,5 mm Al has no significant impact on the scatter lateral distribution.

For 5 cm tissue thickness the scatter in the exit surface extends laterally up to 5 cm, while for the 30 cm tissue thickness the corresponding extension is up to 18 cm.

Scatter distribution depends upon the tissue thickness and the X-ray tube filter thickness. The results of the study may be of importance for applications where the removal of the grid is required.

A drawback of this work is that the results of the MC software are based in calculating the energy absorbed laterally to the X-ray incidence vector. This calculation includes characteristic X-rays absorption [4], but does no incorporate Rayleigh scattering.

5. References

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