Distribution of scattered radiation in superfical X-ray therapy

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Introduction

It is known [1], that Pb shields are used in superficial radiotherapy of the periorbital region to reduce the dose delivered to critical structures beneath the area requiring treatment, which are close to or over the eye [2, 3]. The protection efficiency of lead eye shields must be evaluated before their appliance in superficial X-ray therapy treatment.

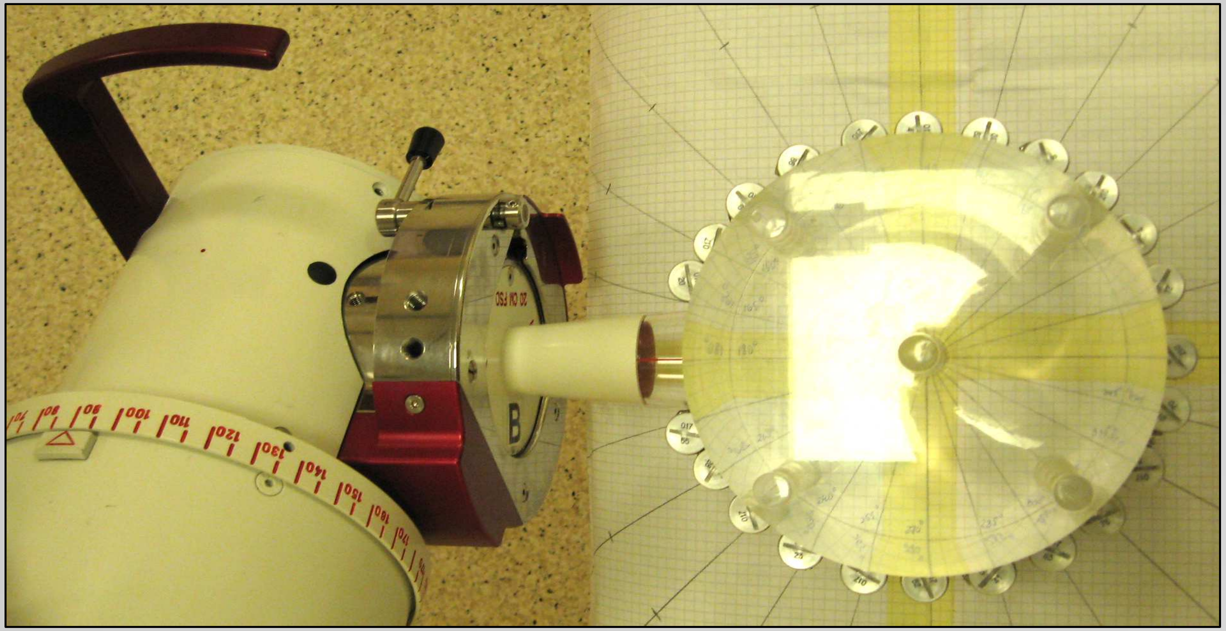
One of the most recent evaluations of eye protection efficiency from direct X-rays for the case when the applicator is set in a certain distance from the irradiated area has been performed by M. J. Butson et al. [3].

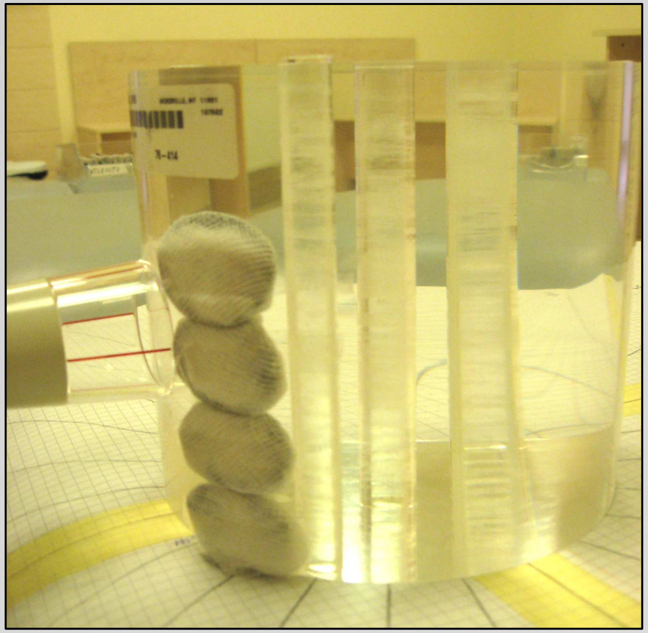
However the superficial X-ray therapy is also performed when the applicator contacts with patient surface. In this case, the eye protection and the evaluation of protection efficiency raise some questions, because of the scattered photons, originating from the applicator and lead shielding.

Purpose

The purpose of this work was to investigate experimentally the angular distribution of scattered radiation of X-ray photons that were responsible for the doses registered on the head phantom surface without shielding and with a lead shielding during superfical X-ray therapy treatment, and to evaluate the efficiency of this shielding when the applicator contacts the phantom surface.

Experimental set up





GULMAY D3225 X-ray therapy unit with a acrylic conical applicator (orbicular exposure field - Ø4 cm) was used for the irradiation of PMMA head phantom (Cardinal Health Model 76-414-4150, Ø16 cm, h =15.8 cm, ρ =1.190 g/cm^3 without shielding and shielded with a pieces of lead (4.12 x 3.15 x 0.183) cm^3.

A set of calibrated pencil dosimeters D-500 (dose range - 0.02÷5 Gy) were used for dose measurements. Dose values were estimated using analizator KID-6.

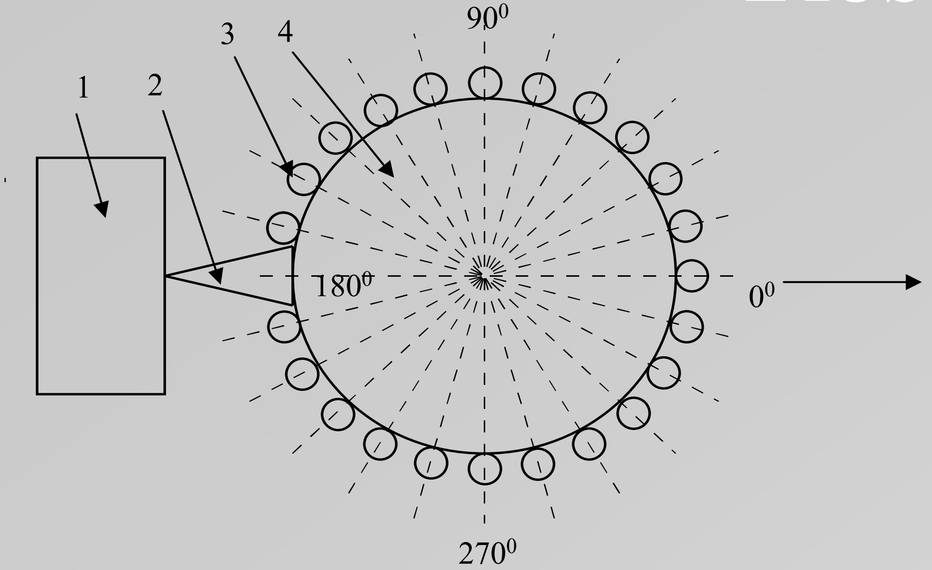
Methods

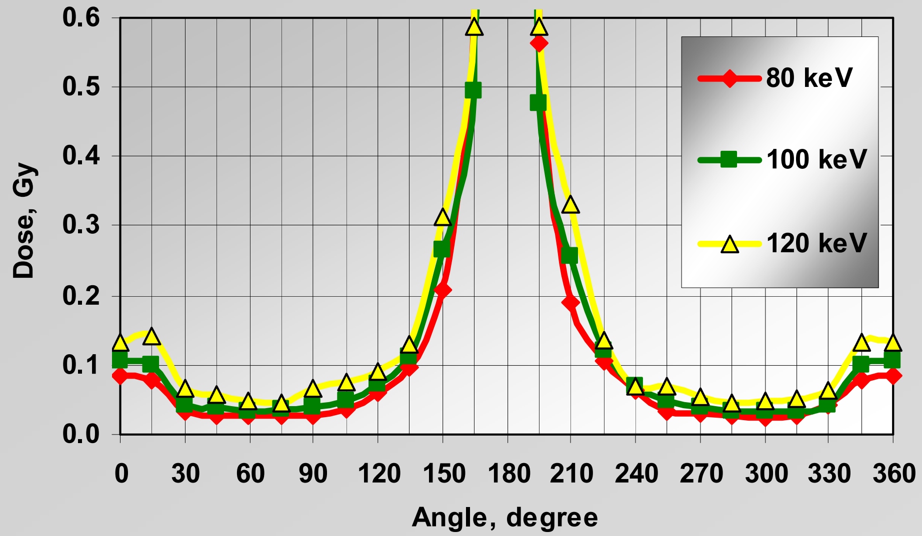
Central angle of 28.072 degree was estimated for the irradiation field diameter, when the applicator had a contact with the phantom. In order to include the contribution of side scattered photons from the applicator to the phantom surface dose, dosimeters were placed around a phantom with an angular step of 15 degree. This arrangement enabled us to measure edge doses when the pieces of shielding lead were placed on the phantom's surface just beneath the applicator.

Two types of measurements have been performed: angular surface dose distribution (without and with a Pb shielding) was evaluated changing a beam quality (80 keV, 100 keV, 120 keV) and photon penetration depth (0.5cm, 1.0 cm and 2.0 cm). Irradiation dose to the target, D_T = 4.0 Gy cm depth was kept during all measurements. Irradiation parameters are provided in the Table 1.

Tube voltage, kVp	$D_{0.5}$, Gy	D_0, Gy	Photon pennetration depth, cm	HVL	Tube current, mA	FSD, cm
80		4,56		2,44 mm Al		
100	4,0	4,50	0,5	2,97 mm Al	20,0	20
120		4,45		5,33 mm Al		

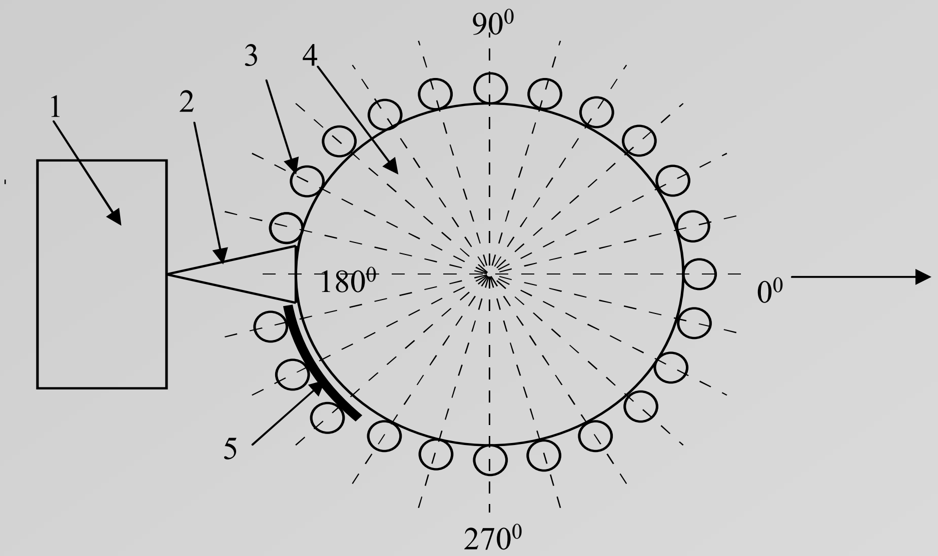
Results

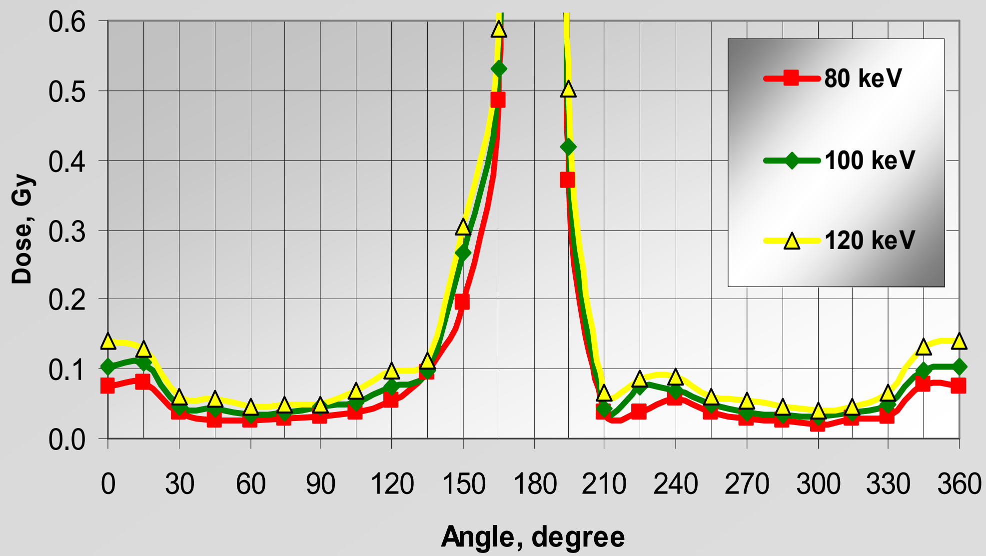




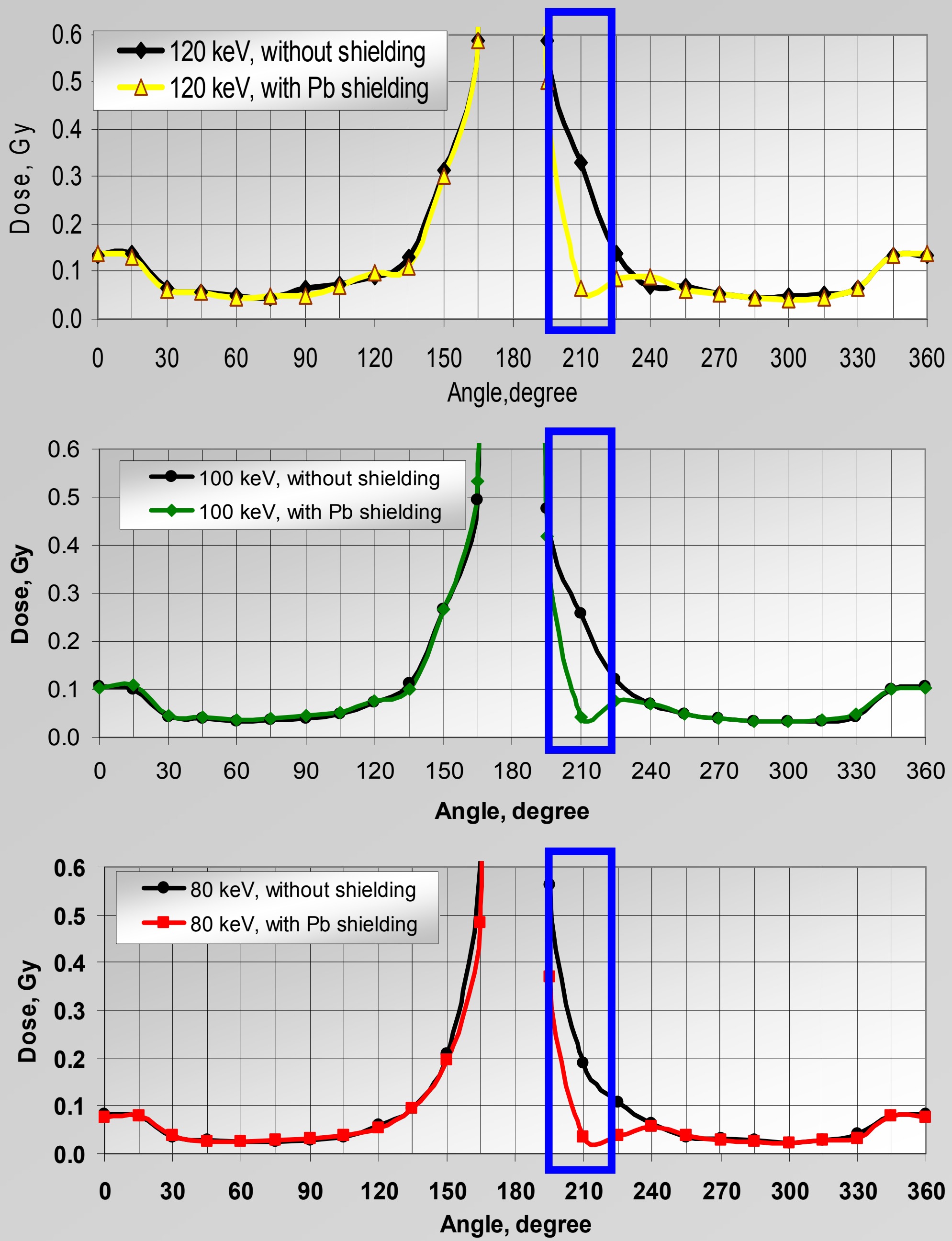
1 – GULMAY D3225 X-ray therapy unit; 2 – conical applicator; 3 – pencil dosimeter D-500; 4 – PMMA head phantom; 5 - lead eye shield

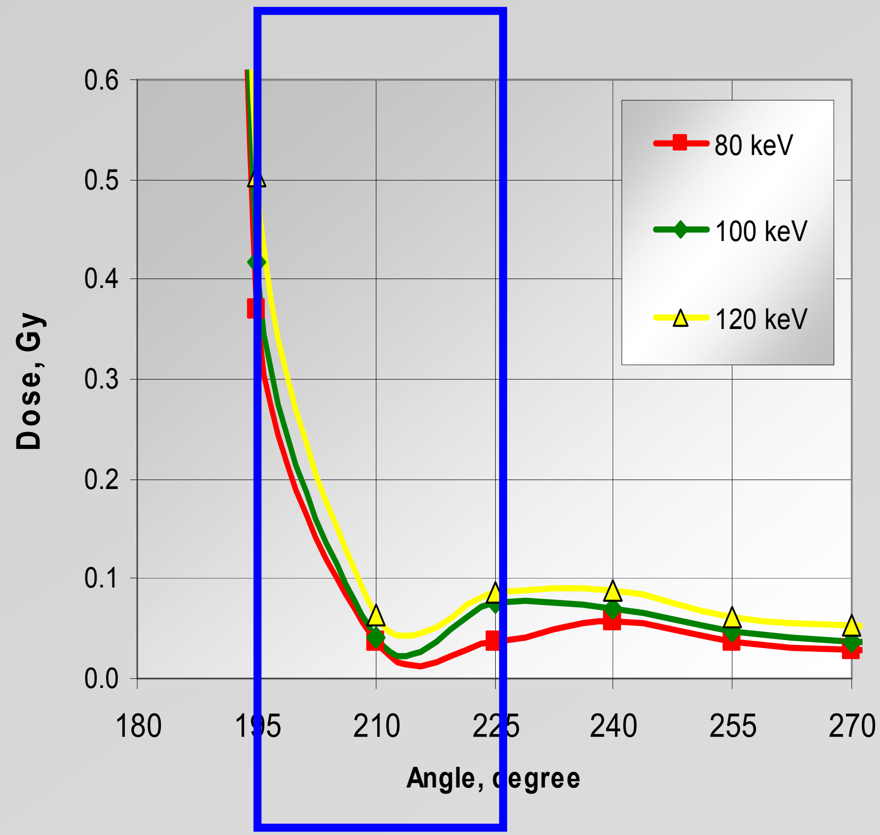
Angular surface dose distributions





Results





Shielded
area

Conclusions

Investigation has shown that the Pb shielding placed on the phantom surface near by the applicator of X-ray irradiation unit “narrows” side scattering range of X-ray photons and reduces the doses in the shielded area depending on the beam quality, photon penetration depth and angular position. The most effective dose reduction of > 70% was obtained at the angle of 210 degree, which corresponds to the distance of ~2 cm from the edge (applicator side) of Pb shielding plate. However due to the edge conditions (applicator - Pb plate) at 195 degree, the dose reduction of < 20% was not satisfying. Shielding effectiveness in this region has to be investigated in more details.

References

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