CALCULATION OF BACKSCATTER FACTORS FOR LOW ENERGY X-RAYS USING THE TOPAS MONTE CARLO CODE

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Introduction: Kilovoltage x-ray beams are widely used for the treatment of skin cancers in radiotherapy[1]. The dosimetry of kilovoltage x-ray beams poses many challenges due to high dose gradients and detectors having significant energy response at these low photon energies.

The backscatter factor (BSF) is an important factor for dose determination in these x-ray beams in both reference and relative dosimetry[2]. The BSF is usually taken from published dosimetry codes of practice. However BSFs can be calculated using Monte Carlo calculations or measurments with radiochromic film due to its good spatial resolution[3]. The purpose of this work is to use the TOPAS Monte Carlo code to determine BSFs for a range of x-ray beams and compare with reference data as well as measured BSFs.

Materials and Methods: All calculations and measurements were performed for x-ray beams in the energy range from 50 to 280 kVp x-ray beams and field sizes ranging from 2 cm diameter to 12×12 cm^2. Incident x-ray spectra for a Pantak therapeutic x-ray unit were calculated using the SpekCalc code and adjusted so that the HVLs of the beams were in good agreement to measured HVLs.

All dose calculations were performed using the TOPAS Monte Carlo code version 3.0.1. Benchmarking of the TOPAS code was performed by comparing with dose calculations in water phantoms.

Doses were calculated using TOPAS in small voxels of water and of air in order to determined the BSF. The effect of varying the voxel thickness on the BSF was studied and final thickness of 100 µm which is similar to ICRU skin thickness.

The BSFs were also measured using both the radiochromic film (Gafchromic EBT3) and and OSLDs. BSFs were also determined from published data as listed within the AAPM TG-61 kV dosimetry protocol.

Results: The relative dose calculations in water using TOPAS showed good agreement with those dose calculations using the EGSnrc code. The measured depth doses agreed to within 2% for all the x-ray beam energies compared.

For the BSF calculations, the largest differences were within 2% relative to the maximum dose. TOPAS was also within 2% of the published BSFs. The results for the 100 kVp x-ray beam are shown in figure 1. The TOPAS calculations were found to be consistent with film measurements, typically less than 2%, but larger differences of up to 5% were found for some field sizes and energies.

The OSLs overestimated BSFs for the larger field sizes particularly when used at the higher x-ray beam energies. This was more than 10% for the 280 kV x-ray beam and the 12×12 cm field size. As such they are not recommended for BSF determination in all kilovoltage x-ray beam geometries and energies.

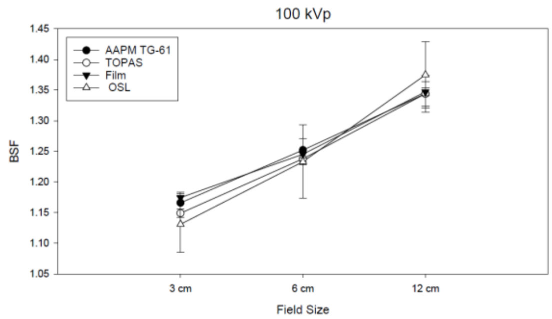

Figure 1: BSFs determined for the 100 kVp beam from TOPAS MC calculations, AAPM TG-61 published data and measured with Gafchromic EBT3 film and OSLDs.

Conclusions: The TOPAS Monte Carlo code has been shown to be sufficiently accurtate for the determination of BSFs of clinical kilovoltage x-ray beams. The calculated BSFs were in good agreement to those measured BSFs using Gafchromic EBT3 film. Therefore, TOPAS can be used to independently determine BSFs for clinical kilovoltage x-ray beams.

References:

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