AbstractID: 9037 Title: Fast, accurate photon beam accelerator modeling using BEAMnrc and VMC++: A systematic investigation of variance reduction and efficiency enhancing methods and cross-section data

Purpose: To report on the accuracy of cross-section data in BEAMnrc and on the performance of variance reduction and efficiency enhancing techniques for fast, accurate linac simulations using the BEAMnrc and VMC++ code systems.

Method and Materials: BEAMnrc and VMC++ were used to simulate a 6 MV photon beam from a Siemens Primus linac. Phase space (PHSP) files were generated for a range of field sizes, from 10×10 to 40×40 cm^2. BEAMnrc parameters under investigation were grouped by: i) photon and bremsstrahlung cross-sections; ii) approximate efficiency improving techniques (AEIT); iii) variance reduction techniques (VRT); iv) VRT (bremsstrahlung splitting) with AEIT (range rejection). Efficiencies were obtained for the mean energy, fluence, angular and spectral distributions and PHSP files were subsequently used as input for DOSXYZnrc-based phantom dose calculations; these calculations were verified against measurements.

Results: Efficiencies were calculated for the various VRT/AEIT combinations in BEAMnrc, relative to simulations without VRT/AEIT, namely: (a) 935 (~111 min. on a single 2.6 GHz CPU) and 200 for 10×10 and 40×40 resp. using directional bremsstrahlung splitting (DBS) and no electron splitting, (b) 420 and 175 for 10×10 and 40×40 resp. using DBS and electron splitting combined with augmented range rejection, a technique recently introduced in BEAMnrc. Calculations with VMC++ produced efficiencies of 1400 (~6 min. on a single CPU) for 10x10 versus BEAMnrc (no VRT/AEIT). Noteworthy differences (±1-3%) were observed with the NIST bremsstrahlung cross-sections compared with those of Bethe-Heitler (default). However, MC calculated dose distributions (using all combinations of VRT/AEIT and cross-section data) agreed within 2%/2 mm of measurements.

Conclusions: VRT/AEIT related to DBS significantly improves the efficiency of BEAMnrc PHSP simulations. VMC++ can be used to perform simulations of the entire linac and phantom within minutes on a single processor. Further investigation of bremsstrahlung cross-section data is warranted.

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