Letter to the Editor

Radial dose function of a $^{90}Sr-^{90}Y$ seed in water and A150: Comment on "Calibration and characterization of beta-particle sources for intravascular brachytherapy" [Med. Phys. 25, 339–346 (1998)]

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To the Editor,

Intravascular brachytherapy with beta sources has become a useful technique to prevent restenosis after cardiovascular intervention.[1–3] In particular, the Beta-Cath™ high-dose-rate system, manufactured by Novoste Corporation, is a commercially available $^{90}Sr-^{90}Y$ source for intravascular brachytherapy that is achieving widespread use. Its dosimetric characterization has attracted considerable attention in recent years. Unfortunately, the short ranges of the emitted beta particles and the associated large dose gradients make experimental measurements particularly difficult. This circumstance has motivated the appearance of a number of papers addressing the characterization of this source by means of Monte Carlo simulation techniques.[4–8]

To our knowledge, the only available experimental values of the radial dose function $g(r)$ and anisotropy function $F(r,\theta)$ of a single $^{90}Sr-^{90}Y$ seed from Novoste's Beta-Cath™ system are those published by Soares *et al.*[8] These data thus constitute a unique benchmark against which Monte Carlo results can be compared. For instance, Wang and Li[5] found, unexpectedly, large discrepancies when comparing their EGS4 radial dose function in an A150 plastic phantom to the measurements of Ref. 8. The observed differences were attributed to the electron transport models (multiple scattering algorithms and/or cross section databases) adopted by the various Monte Carlo codes.[6]

Recently[7] we have realized that, due to an inadvertent error, the ITS3 Monte Carlo data of Ref. 8 (Tables II and V, Fig. 6) actually correspond to water, not to A150 plastic. However, we erroneously assumed that the experimental data of Soares *et al.* also corresponded to water (see Fig. 1 in Ref. 7). Thus, the purpose of clarifying the situation prompted us to write the present Letter, in an attempt to avoid further misunderstandings and also to make this information generally available to the readers of Medical Physics. In addition, we present new simulated radial dose functions for a $^{90}Sr-^{90}Y$ seed in water and A150. Simulations using the PENELOPE[9] code were performed by following the procedure described by Asenjo *et al.*,[7] but with lower simulation parameters ($C_1=C_2=0.01$, $W_{cc}=0.1$ keV, $W_{cr}=1$ keV) in order to minimize the impact of the multiple scattering approaches employed to describe soft elastic and inelastic interactions; the number of simulated histories was 2×10^7. The MCNP4C[10] simulations were, in turn, carried out for the same setup with 0.1 mm radial bins and 1 keV energy cutoff for both electrons and photons; each run involved 2×10^8 histories.

Figure 1 shows the radial dose function for a single $^{90}Sr-^{90}Y$ seed in water as obtained with four different Monte Carlo codes. The ITS3 values from Soares *et al.*,[8] and the EGS4 data from Wang and Li[5] are displayed along with the present PENELOPE and MCNP4C simulation results. The overall agreement between the four $g(r)$ curves is seen to be reasonable, although some differences show up at intermediate distances that are relevant to intravascular brachytherapy. In particular, the MCNP4C radial dose function is slightly higher than that obtained using ITS3, and both curves are somewhat higher than the $g(r)$ from PENELOPE. On the other hand, EGS4 yields the lowest $g(r)$ function. The differences between the simulated radial dose functions should be ascribed to the physical modelling implemented in the various Monte Carlo codes, once it has been made clear that the plotted data correspond to water.

The radial dose function for one $^{90}Sr-^{90}Y$ seed in A150 plastic is depicted in Fig. 2. The agreement between the $g(r)$ curves obtained with PENELOPE and MCNP4C is similar to that found in Fig. 1. On the other hand, the experimental values for 3 mm$\leq r \leq$7 mm are considerably larger than the Monte Carlo data. Although there was a 15% uncertainty assigned to the measurements, the fact that all the measured values for

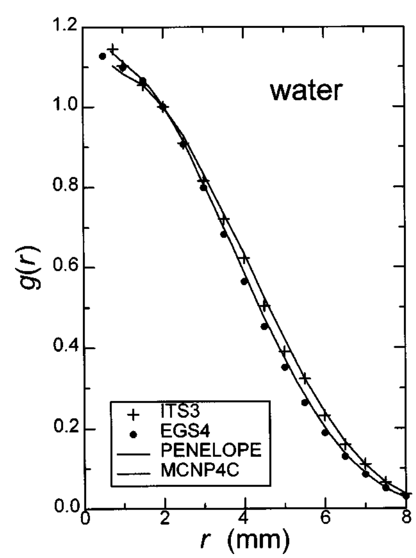

FIG. 1. Radial dose functions $g(r)$ for one $^{90}Sr-^{90}Y$ seed in water, normalized to 1 at $r_0=2$ mm as recommended by the AAPM TG-60 (Ref. 1). Crosses indicate calculations with ITS3 by Soares *et al.* (Ref. 8). Closed circles are calculations with EGS4 by Wang and Li (Ref. 5). The continuous and dashed curves correspond to the present simulations with PENELOPE and MCNP4C, respectively.

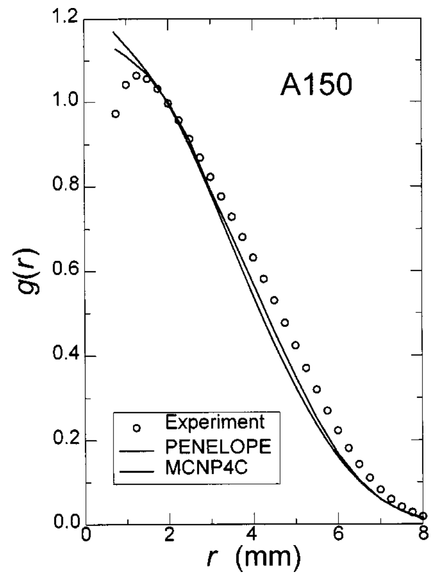

FIG. 2. Radial dose functions $g(r)$ for one $^{90}Sr-^{90}Y$ seed in A150, normalized to 1 at $r_0=2$ mm as recommended by the AAPM TG-60 (Ref. 1). Open circles are measurements by Soares *et al.* (Ref. 8). The continuous and dashed curves correspond to the present simulations with PENELOPE and MCNP4C, respectively.

$3\ \mathrm{mm} \leqslant r \leqslant 7\ \mathrm{mm}$ are consistently higher than the calculated radial dose functions constitutes a disagreement. We recall that this result is in accordance with similar discrepancies previously reported by Wang and Li[5] using EGS4.

In conclusion, the only experimental radial dose function available for the Beta-Cath™ system, which was measured in A150 plastic, is higher than simulation results using various Monte Carlo codes. Since the simulated $g(r)$ curves in water are in reasonable agreement in spite of the different models and algorithms adopted by the respective codes, the origin of the discrepancy between simulation and experiment in A150 is very likely due to the difficulties inherent to such measurements. However, we think that a definite conclusion cannot be drawn until further experiments are undertaken.

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