Internal bremsstrahlung: the missing process in beta decay Monte Carlo simulation for Dose-Point-Kernel estimation

E. Amato[1,2], L. Auditore[1,2], D. Pistone[1,2], A. Italiano[2,3]

[1]BIOMORF Department, University of Messina, Messina, Italy

[2]INFN Section of Catania, Catania, Italy

[3]MIFT Department, University of Messina, Messina, Italy

Background: Internal Bremsstrahlung (IB) is a process accompanying the beta decay: photons with a continuous spectral distribution up to the end-point energy of the beta particles are emitted in association to the beta particles. Although IB emission has been widely studied, it is totally neglected in Monte Carlo simulations estimating the absorbed dose due to the exposure to a beta emitting radionuclide. Recent works [1-3] demonstrated that for some radionuclides, such as ^{32}P and ^{90}Y, IB should be included in MC simulations to avoid underestimations up to 15-20% of the results. Also Dose-Point-Kernel for these radionuclides are usually estimated ignoring IB photons [4,5]. The aim of this work is to revise DPK values that are currently used in the light of the relevance of IB emission in such calculations and provide the corrected DPK including IB photon contribution.

Material and Methods: DPK for ^{32}P and ^{90}Y have been estimated with GEANT4 (GAMOS) simulations, both neglecting and including IB photons as a further source term. *RadioactiveDecay* module of GEANT4 was used to sample the source beta spectrum while IB photon spectral distribution was modeled according to our previous works [1-3] and introduced in MC simulations as a histogram. 10^8 primary particles were simulated obtaining results with statistical uncertainties lower than 1%. Energy deposition was scored in concentric, spherical shells whose thickness was set to 0.02 cm thus covering the radial distance from the source from 0 to 5 cm.

Preliminary results: Results indicate that DPK values currently used and that are obtained by MC simulations ignoring IB photons, are underestimated by 20-40% for ^{32}P and by 20-30% for ^{90}Y. The inclusion of IB emission as an additive source term is advisable when high energy, pure beta emitters are simulated.

[1] Italiano A. et al. *Phys Med* 2021;76:159-165.
[2] Auditore L. et al., *Phys Med* 2022;90:158-163.
[3] Auditore L. et al., Rad Meas 2022;155: art. no. 106799.
[4] Botta et al. *Med Phys.* 2011;38(7):3944-3954.
[5] Graves et al., *Med Phys.* 2019;46(11):5284-93.