# Dose distribution in water for monoenergetic photon point sources of energies between 10 and 2000 keV: Monte Carlo simulations with PENELOPE and GEANT4 codes

Julio F. Almansa
Servicio de Radiofísica y Protección Radiológica, Hospital Universitario "Puerta del Mar", E-11009 Cádiz, Spain.

Rafael Guerrero
Servicio de Radiofísica, Hospital Universitario "San Cecilio", Avda. Dr. Olóriz, 16, E-18012 Granada, Spain.

Feras M.O. Al-Dweri, Marta Anguiano and Antonio M. Lallena
Departamento de Física Moderna, Universidad de Granada, E-18071 Granada, Spain.

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These tables correspond to simulations of monoenergetic photon point sources of energies between 10 and 2000 keV in water. Simulations have been performed with PENELOPE (v. 2003) and with GEANT4 (v. 4.5.2).

The tables are organized by energies. In the preamble of each one, the information quoted is the following:

1. The photon point source in keV.
2. The number of trajectories followed, which in the present calculation is $3{\cdot}10^7$.
3. The mass energy-absorption coefficient in cm$^2$ g$^{-1}$, which has been obtained from the data of Hubbell and Seltzer[1], interpolating when necessary.
4. The air kerma strenght per unit activity in nGy cm$^2$ Bq$^{-1}$ h$^{-1}$. The air kerma strength has been calculated as

$$S = cAE(\mu_{\rm en}/\rho)/(4\pi)\,,$$

where $c = 0.5768$ $\mu$Gy kg h$^{-1}$ keV$^{-1}$ MBq$^{-1}$.

[1] http://physics.nist.gov/PhysRefData/XrayMassCoef/cover.html

5. The dose rate constant in $\mathrm{cm}^{-2}$, calculated as

$$\Lambda \,=\, \dot{D}(r_0)/S\,,$$

where $\dot{D}(r_0)$ is the dose rate at the reference point $r_0 = 1$ cm in water. In the tables the values obtained for both PENELOPE and GEANT4 are given.

The results quoted in the tables have been obtained using two different phantoms: an infinite water phantom and a spherical finite phantom with a radius of 15 cm, filled with water and with the point source situated at its center. In both cases the scoring voxels have been chosen to be concentric spherical shells with thickness 0.5 mm and centered in the point source. The first voxel has a thickness of 0.25 mm.

In our simulations, the energy deposited in each voxel $j$, $E^j$, was scored to obtain the histograms corresponding to the dose rate $\dot{D}(r)$. We labeled $\dot{D}^j$ the value corresponding to the $j$-th voxel.

To avoid the effect of the geometric factor ($r^{-2}$ in this case) which dominates $\dot{D}(r)$, we have calculated also the quantity

$$R(r) \,=\, r^2\,\dot{D}(r) \tag{1}$$

in two different ways. First, we have simulated this quantity by scoring directly ($r^2E$), thus obtaining $R^j$ for each scoring shell $j$. The columns 2 and 5 give the results obtained for this quantity calculated with PENELOPE and for the infinite and finite phantoms, respectively, in nGy $\mathrm{cm}^2$ $\mathrm{Bq}^{-1}$ $\mathrm{h}^{-1}$.

Second we have calculated this quantity as

$$R^j_{\mathrm{M}} \,=\, (r^j_{\mathrm{M}})^2\,\dot{D}^j\,, \tag{2}$$

for each bin $j$ of the histogram corresponding to $\dot{D}(r)$. The results for this quantity are given in columns 3 (PENELOPE) and 4 (GEANT4) for the infinite phantom, and 6 (PENELOPE) and 7 (GEANT4) for the finite one, in nGy $\mathrm{cm}^2$ $\mathrm{Bq}^{-1}$ $\mathrm{h}^{-1}$.

In the preceeding equation

$$r^j_{\mathrm{M}} \,=\, (r^j_{>} + r^j_{<})/2\,, \tag{3}$$

with $r^j_{<}$ and $r^j_{>}$ the minimum and maximum $r$ values corresponding to the $j$-th voxel. The values of this quantity in cm are given in column 1.