Extended Algorithm for Optimization of Photon Transport in Scintillation Detector

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To avoid inefficiency and inhomogeneity of BSE scintillation detection systems, efficient transport of photons from luminescent centres in a scintillator to a photocathode of a photomultiplier tube must be provided. Optimization of the photon transport of a rotationally symmetric Everhart-Thornley detector is quite a feasible task, because a code for the Monte Carlo (MC) simulation is based on the system geometry which is a function of one variable coordinate. For such a rotationally symmetric detection system the previous MC code Scintil [1] was developed in our laboratory. The Scintil code includes photon generation in a point source, mirror reflection by a metal coated surface, Fresnel reflection by a metal uncoated surface, Fresnel passage through the boundary of different materials, diffusion reflection and passage through a matted surface and optical absorption in material.

Unfortunately, BSE scintillation detectors have no rotational symmetry. Therefore, it was necessary to rebuild the algorithm of Scintil for the optimization of BSE detection systems. Such an extended algorithm has been used in our SciUni code for practically any geometry. The main difference between the algorithms of SciUni and Scintil is in the description of detector surfaces and subsequently in the determination of the position of the photon interaction with the surfaces mentioned. Using SciUni, any surface can be described as:

$$\sum_{i=1}^{3} k_i \frac{\left(x_i - x_{0i}\right)^2}{A_i^{\,2}} = P \qquad \textbf{(1)}$$

where x_1, x_2 and x_3 are the x, y and z intersection point coordinates, respectively, x_{01}, x_{02} and x_{03} are the x, y and z surface body origin coordinates, respectively, and k_1, k_2, k_3, A_1, A_2, A_3 and P are geometrical coefficients of the surface as described for different bodies in Table 1. Using the extended SciUni code and the Fortran 77 compiler a SciUni program for different computer platforms (including PC) has been developed, and the MC light-guiding simulation as the basic method for the computer optimized design (COD) of new BSE scintillation detectors is available at our laboratory,

Table 1. Some examples of coefficients for different lateral areas for equation (1)

body \ coefficient	A_1	A_2	A_3	k_1	k_2	k_3	P
Sphere (any axis)	r	r	r	1	1	1	1
Cone (y axis)	r	v	r	1	-1	1	0
Cylinder (x axis)	1	r	r	0	1	1	1
Plane ($\perp z$ axis)	1	1	1	0	0	1	0
Plane (defl. from z axis)	k	1	1	1	0	-1	0
Ellipsoid (y axis)	a	c	a	1	1	1	1
Hyperboloid (x axis)	c	a	a	-1	1	1	1

r - radius, v - body high, k - slope of deflection, a - half-axis (plane of symmetry), c - half-axis (along body axis)

References:

[1] Schauer, P.; Autrata, R.: *Scanning* **14** (1992), 325-333.