MONTE CARLO SIMULATION CODE FOR PHOTON COLLECTION IN S(T)EM SCINTILLATION DETECTORS

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The inefficient collection of photons emitted from luminescent centres in a scintillation detector of electrons is a frequent cause of poor S(T)EM images, particularly in the BSE image mode. In such cases, edge guided signal (EGS) scintillation systems utilising a signal from the side of a scintillator, and having a complicated geometry, are often used. The best way of avoiding the light-guiding problems of these systems is Monte Carlo (MC) simulation optimisation for signal photon collection. Unfortunately, the previous code SCINTIL [1] developed in our laboratory was built using an algorithm for rotationally symmetric systems where a function of one variable coordinate was used. Therefore, the extended code SCIUNI, intended for practically any geometry, has been written and its features are presented in this paper.

PHOTON TRAJECTORY AND TRANSPORT EFFICIENCY

The MC model makes use of the random generation of photons emitted from a luminescent centre and describes the trajectory and efficiency of photon transport up to the photocathode of the PMT. The initial direction, as well as any subsequent direction, is described by the directional cosines C_x, C_y and C_z of each trajectory. Each part of the trajectory is given by two subsequent interactions of the photon with the scintillator or light-guide surfaces. The new trajectory direction and the new probability that the photon will reach the photocathode are determined by the interaction surface normal line and the absorption coefficient of each material used, respectively. The algorithmization of photon absorption, reflection and transmission is the same as for the SCINTIL code [1].

INTERACTION SURFACES

The main extension of the SCIUNI code is the description of detector surfaces and subsequently the determination of the position of photon interaction with the surfaces mentioned. Now, any surface can be described by the equation:

$$k_x \frac{(x-x_0)^2}{A^2} + k_y \frac{(y-y_0)^2}{B^2} + k_z \frac{(z-z_0)^2}{C^2} = P \qquad \textbf{(1)}$$

where x, y and z are the coordinates of the intersection point, x_0, y_0 and z_0 are the coordinates of the surface body origin, and k_x, k_y, k_z, A, B, C and P are geometrical coefficients of the surface as described for different bodies in Table 1.

OUTPUT FROM SCIUNI SIMULATIONS

Some results of the MC simulations of very simple EGS scintillation detector configurations are shown in Fig. 1. Photon collection is expressed by the photon transport efficiency in dependence on the coordinate of the scintillator excitation point. This gives the probability that the photon will reach the photocathode of the PMT.

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

body \ coefficient	A	B	C	k_x	k_y	k_z	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)

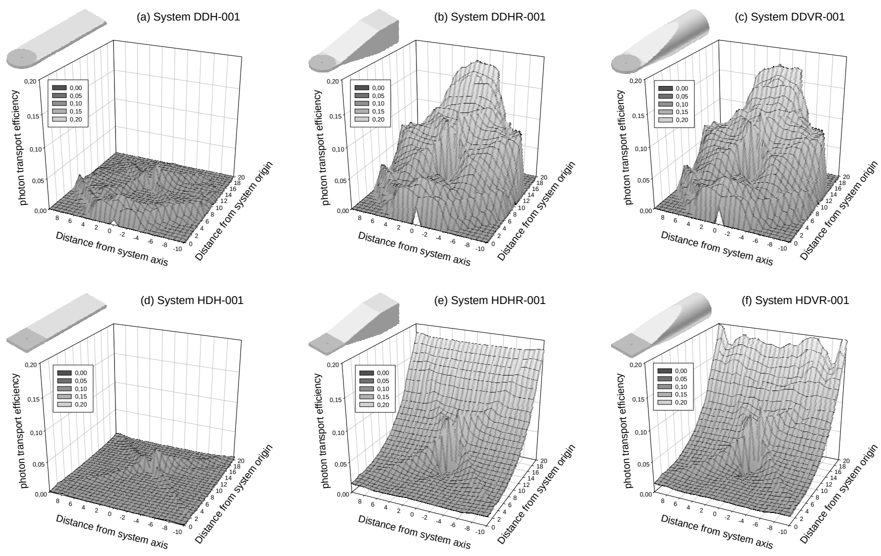

Figure 1. Photon transport efficiency in dependence on the point of excitation on the scintillator surface for different shapes of scintillators and light-guides.

YAG:Ce single crystals and PMMA were the materials used for the scintillators and light-guides, respectively. The scintillators were connected to the light-guides by an optical cement. Two shapes of scintillators (20 mm in diameter alternatively in side length) with a middle hole and with Al deposited on the electron impact surface, in combination with three shapes of light-guides (60 mm long), were calculated.

REFERENCE

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

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