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# Photometric light collection shapes

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"Photometry-friendly" scintillator shapes have been proposed, their optical features have been considered and dynamic reasons for efficient light collection therein have been established.

Предложены "фотометрические" формы сцинтилляторов, рассмотрены их оптические особенности и установлены динамические причины эффективного светособирания.

Spectrometric parameters and efficiency of scintillation detectors and light guides depend heavily on the light collection character therein [1–3]. The light collection is influenced substantially by the following physical conditions:

*Optical factors*. The scattering character at the detector boundary $\partial Q$ and within its volume $Q$. Mirror, diffuse or combined scattering; at different indicatrix $f|_{\partial Q}$; with Fresnel reflection $r_F(\theta)$ (where $\theta$ is the reflection angle) and total internal one, as well as with the surface absorption $r_\alpha \infty \exp(-\alpha)$ included in the total reflection coefficient $r|_{\partial Q}$, etc. A critical part in the light collection is played by reabsorption in the crystal having a transmittance $t \equiv \exp(-\beta) = \exp(-\mu\Delta)$ (where $\beta$ is the optical density; $\mu$, the linear attenuation coefficient; $\Delta$, mean free path length between reflections from $\partial Q$).

*Geometric factors*. The $\partial Q$ shape, dimensions, dimensionality, curvature $K|_{\partial Q}$ and multiconnections (presence of internal boundaries). The $\partial Q$ geometry defines the chaotic, regular or mixed dynamics type of light rays being propagated within $Q$ with or without mixing. This dynamic character effects directly all the light collection features.

*Technological factors*. In real detectors, the light collection process is always a multifactor one. That is why the optimum detector design is difficult to chose. Therefore, it is expedient to select the most substantial of the above-mentioned factors for the previous (qualitative) theoretical consideration. Then, the limiting attainable quantitative values of spectrometric characteristics corresponding to selected factors are to be established and the physical reasons defining the ideal light collection are to be found. In the radiometry and spectrometry, a high light yield is required at its high uniformity. In general, both these stringent requirements are not easy to satisfy simultaneously. Experiments and numerical calculations are intended most often for their optimization. Therefore, the search for detector types providing both maximum light yield and minimum fluctuation level becomes especially actual. To solve this problem, it is just the "photometry-friendly" detector and/or light guide shapes that will be of great importance. Those include the light measuring sphere as well as some other less traditional shapes corresponding to the geometry of special type chaotic billiard (Fig. 1). In such shapes, the light collection fluctuations (non-uniformity) turn out to be minimum at the light energy use coefficient ($\kappa$) values close to unity.