Outlook for development of a scintielecton detector with improved energy resolution

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The development prospects have been considered of a scintillatior-photodiode type detector with improved energy resolution attaining several per cent (R = 1÷2 %). The main contributions to the scintielectron detector energy resolution have been analyzed theoretically and their theoretical and physical limits determined. Experimental data have been presented on properties of scintillators of promise confirming the possibilities to minimize each of the resolution components. New ways are proposed to optimize the detector statistical contribution and the scintillator intrinsic resolution. A special role of the latter is outlined as the critical factor for the spectrometric possibilities (threshold) of scintillation-photodiode type detector with improved energy resolution at energy values E_γ from 662 keV to 10 MeV.

Рассмотрены перспективы создания детектора типа сцинтиллятор-фотодиод с улучшенным энергетическим разрешением, достигающим единиц процентов (R = 1÷2 %). Проведен теоретический анализ основных компонент энергетического разрешения сцинтиэлектронного детектора, установлены их теоретический и физический пределы. Приведены экспериментальные данные о свойствах перспективных сцинтилляторов, подтверждающие возможность минимизации каждой из компонент разрешения. Предложены способы оптимизации статистического вклада детектора и собственного разрешения сцинтиллятора. Выделена особая роль внутреннего разрешения сцинтиллятора как определяющего спектрометрические возможности (порог) детектора сцинтиллятор-фотодиод с улучшенным энергетическим разрешением при энергиях E_γ = 662 keV÷10 MeV.

Solid state detectors of scintillator-PMT (S-PMT) and scintillator-photodiode (S-PD) types are used widely along with semiconductor ones (SCD). In the latter type, the ionizing radiation is converted immediately into charge carriers while in scintielectron S-PMT and S-PD ones, a two-stage conversion takes place: first into optical photons (in the scintillator) and then into charge carriers (in the photoreceiver). The two-stage conversion causes energy losses and redistribution (dissipation), thus, in the case of small-volume detectors, the SCD sensitivity and energy resolution are one decimal order higher. An S-PD detector comprising a traditional CsI(Tl) scintillator of about 1 cm^3 volume and a silicon or HgI_2 photodiode has the energy resolution 5 to 6 % at room temperature for 662 keV line [1, 2].

While the energy conversion in scintillators has been considered comprehensively enough and several models have been proposed to date describing that process satisfactorily [3–6], there are no works considering possible correlation between integral characteristics of that process (quantum efficiency, conversion one, self-absorption, etc.) and energy resolution of the scintillator itself and of the scintillator-containing detection system as a whole; the same is true for theoretical consideration of the at-