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# Scintillator response time probed at femtosecond photoexcitation

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Time-of-flight positron emission tomography (TOFPET) is currently one of the key directions in medical imaging enabling substantially higher spatial resolution and lower radiation dose for patients. This trend requires new scintillators with faster response and currently results in the substitution of BGO by LYSO:Ce as the scintillator of choice in TOFPETs. The scintillator material represents the major part of the total TOFPET production costs, thus the tradeoff between the less expensive technologies for growing LYSO:Ce single crystals and the response time of these crystals to annihilation gamma-quanta become an important issue for future TOFPETs.
We report on a method for express testing the response time of scintillators, particularly LYSO:Ce, which is based on measuring the transient optical absorption induced by a resonant photoexcitation of activator ions Ce3+ [1]. We show that the electrons optically excited to Ce3+ higher energy levels laying in the conduction band of the host matrix have two relaxation routs to the lowest excited level 5d1 serving as a radiative level: the intracenter relaxation, which is found to have a characteristic time of ˜500 fs, and the relaxation via the extended states in the conduction band with subsequent trapping at shallow traps. As at the excitation by ionizing radiation, the latter process governs the rise time in the population of the lowest excited state 5d1, which is of the order of a few picoseconds at resonant Ce3+ excitation and can be reliably measured using femtosecond laser pulses without any problems of optical coupling and readout electronics.
We demonstrate that the technique based on the transient optical absorption measurements in subpicosecond domain is a powerful tool for both searching for novel fast scintillators and express routine testing of scintillator crystals selected for TOFPET devices.

[1] M. Korzhik, G. Tamulaitis, A.N. Vasil'ev, Physics of Fast Processes in Scintillators, Springer, 2020.

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