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# Design of the fast radiation detector with 10-picosecond time resolution based on crossluminescence scintillator

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For obtaining spatial resolution ˜1.5 mm in TOF-PET devices, the coincidence time resolution ˜10 ps is needed, which is beyond the current state of the art. Crossluminescence (CL) crystals having fast (nanosecond) decay and very short (subpicosecond) rise time of emission can be considered as very promising scintillators for ultrafast radiation detectors. Despite of relatively low light yield of CL (˜$10^3$ photons/511 keV $\gamma$–quantum), estimations show that the limit time resolution of CL scintillators, determined as arrival time of the first scintillation photon, can be < 1 ps.
CsF crystals are well-known scintillators which are produced by several manufacturers. Scintillation detectors based on CsF scintillators (with thickness ˜4 cm) and standard PMT were tested in [1, 2] where time resolution of ˜400 ps was obtained for the detection of 511 keV $\gamma$–quanta. However, the prospects of using such kind of scintillation detectors are underestimated. CsF is an exceptional example of CL crystals which emits under standard conditions only fast CL without the presence of any slow emissions [3]. Decay time of CL in CsF is 2.8 ns and the CL rise time is expected to be ˜1 ps. The CL emission band of CsF is peaked at 390 nm which suits well the spectral sensitivity of standard SiPM detectors. The problem is its high hygroscopicity but there are well-known methods for the implementation of hygroscopic scintillators in radiation detectors. Besides that, some lower-hygroscopic multicomponent CL crystals based on CsF can be also considered.
One more factor limiting time resolution when using such kind of CL scintillators is their relatively large absorption length. For the efficient absorption of 511 keV $\gamma$–quanta the thickness of CsF scintillator should be at least ˜1 cm. Accordingly, in the standard scheme of scintillation detector with a single SiPM attached to the end face of the scintillation crystal there will be remarkable time difference for the detection of scintillation photons born near the front and end parts of the scintillator. In order to overcome this problem the SiPM array with the size of elements ˜0.1 cm can be attached to the scintillator along the direction of $\gamma$–quanta propagation. The time resolution of such scintillation detector will be limited by time resolution of SiPM.

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