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A proof-of-concept of cross-luminescent metascintillators

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—In order to achieve superior timing for time-of-flight positron emission tomography, combined with high detection efficiency and cost-effectiveness, we probe the applicability of BaF2 in metascintillators driven by timing of cross-luminescence photon production. Building on simulation study of energy sharing and analytic multi-exponential scintillation pulse and sensitivity characteristics, we build a 300 μm BGO:300 μm BaF2 pixel of 3x3x15 mm3 and test it in the laboratory. In order to harness the deep ultraviolet cross-luminescent light component which provides the timing, we use the FBK VUV SiPM and cold glycerin for coupling. Metascintillator energy sharing is addressed through a simple double integration approach, algorithmically developed in Python. We reach an energy resolution of 22%, comparable to an 18% resolution of simple BGO pixels for the same system, through the optimized use of both integrals of the metascintillator pulse. We demonstrate our ability to measure the energy sharing extent of each individual pulse in a pipelined manner and match the measured distribution with the features of the simulated one. With the knowledge of energy sharing, a timewalk correction is applied which brings significant improvements in both coincidence time resolution (CTR) and fitting quality of the Δt histogram. We reach a 242 ps CTR for the entire photopeak, while for a subset of 13% of the most shared events isolated, the CTR value reached is at 108 ps, better than the 3x3x5 mm3 LYSO:Ce:Ca reference crystal, thus limited by the measurement setup. While we are considering different ways to further improve these results, this proof-of-concept system and measurements demonstrate the applicability of cross-luminescence for metascintillator development through the application of UV friendly optical devices and simple and easily implementable digital algorithms.

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