Investigating β-Ga_2O_3 as a Potential Scintillator for Photon Counting CT

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Photon-counting computed tomography (PCCT) is a highly significant innovation currently taking place in medical imaging. PCCT promises to deliver higher-quality images at lower dose. Moreover, spectral X-ray photon-counting detectors (PCDs) make it possible to acquire quantitative information that can be used to e.g. determine tissue composition. A main requirement in the development of X-ray PCDs is that they must be fast enough to process up to several hundreds of Mcps/mm^2 without suffering from pulse pile-up, as this gives rise to non-linear distortion of both the X-ray photon count and the spectral information. Current clinical PCCT devices utilize PCDs based on CdTe, CZT, or Si that directly convert X-ray photons into electrical pulses. The high cost of such detectors tends to make PCCT scanners expensive. In addition, spectral fidelity is affected by charge sharing. We recently showed that detectors based on ultrafast scintillators and silicon photomultipliers (SiPM) can meet the count rate requirements of PCCT [1,2]. Moreover, the absence of charge sharing in scintillation detectors can potentially be used to enhance spectral fidelity [3].

We are investigating beta-gallium oxide (β-Ga_2O_3) as a potential scintillator for photon-counting CT. β-Ga_2O_3 has a mass density of about 5.9 g cm^{-3}, comparable to CdTe. Previous studies have shown that β-Ga_2O_3 exhibits a primary decay time constant of about 2 ns, a light yield of about 8 photons per keV, and an energy resolution of about 7% FWHM at 662 keV [4]. Here, we present a detailed characterization of β-Ga_2O_3, including its radioluminescence spectrum, light yield, decay time, non-proportionality, and afterglow. To evaluate the performance of β-Ga_2O_3 under realistic operating conditions, we furthermore couple β-Ga_2O_3 crystals to SiPMs and assess the resulting pulse shape. Preliminary results indicate that β-Ga_2O_3 has good proportionality and low afterglow. We measured a primary decay time of 3.4 ns (72% of the total intensity) but also observe a decay component of 45 ns (28%), see Fig. 1. In conclusion, β-Ga_2O_3 may be a promising material for use in X-ray PCDs, although the influence of the slow decay component on detector performance needs to be studied in more detail.

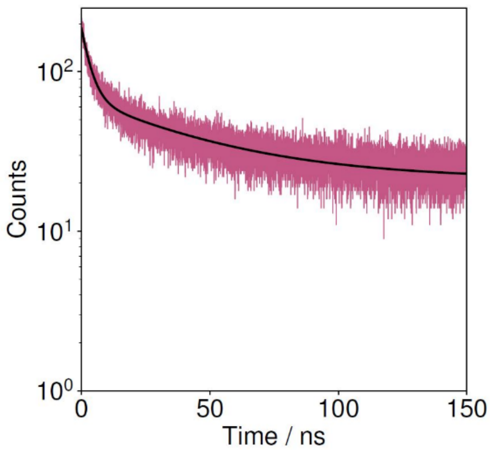

Fig. 1. Time-correlated single-photon decay time measurement under X-ray excitation, fitted with a two-component exponential fit.

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