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First step towards the design of metamaterials combining dense scintillator host with nanocrystals

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In the search for prompt photon emission, colloidal semiconductor nanocrystals with supressed Auger recombination have proven to be a promising source of ultrafast light under ionizing radiation. Previous studies \[1\] have concluded in a sub-100ps effective decay time for CdSe 2D nanoplatelets and sub-1ns for CdSe/CdS giant shell quantum dots with an estimation of around 500 and 1000 photons per 511 keV emitted within the first 100 ps, respectively. However, the implementation of nanocrystal-based scintillators as a new generation of fast radiation detectors with sub-20ps time resolution requires that this amount of prompt photons is efficiently transported to the photodetector with improved SPTR and a minimum transfer time spread. In this work, we estimate the light coupling efficiency of drop-casted colloidal nanocrystal films deposited on the outer surface of optical fibers. Calculations are performed using the Wave Optics Module of COMSOL multiphysics software by implementing the high frequency homogenization method to reduce calculation time. Measurements of this quantity in terms of number of photons transported to the end of the waveguide are carried out under pulsed X-ray excitation up to 40 keV and SiPM readout. This study aims to maximize the amount of fast photons reaching the photodetector by correlating measurements and calculations in order to evaluate and conclude in an optimal nanocrystal-coupled-to-waveguide readout. It also constitutes the first step in the research path towards a design of an efficient radiation detector heterostructure combining fast nanocrystal photon-emission with dense materials suitable for electromagnetic calorimetry.

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