Scalable Nanophotonic Scintillators

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Scintillator performance is fundamentally constrained by optical losses arising from refractive index mismatch, total internal reflection, and imperfect photon transport to the photosensor. Improving light extraction efficiency remains a key challenge for the next generation of radiation detectors targeting higher energy resolution, improved timing capabilities, and reduced operation cost.

Traditionally, scintillator research has focussed on developing new materials to improve performance and tailor components for specific applications. This work investigates the use of nanophotonic design principles to engineer the optical environment at the scintillator interface, with the goal of enhancing photon outcoupling without compromising bulk scintillation properties. So far, nanophotonic scintillator research has largely utilised expensive, time-consuming lithographic techniques[1,2]. By introducing a nanostructured, self-assembled, photonic layer compatible with standard scintillator materials, a substantial enhancement in detected light output has been demonstrated relative to an unmodified reference configuration, at a fraction of the cost.

Initial experimental results show a 105% increase in extracted light intensity for the modified scintillator, measured under identical excitation and lens coupled readout conditions. This improvement is attributed to modified optical boundary conditions that increase the probability of photon escape into the collection optics. The approach is passive, scalable, cheap and does not rely on changes to the scintillator composition itself.

Ongoing work focuses on systematic optimization of the nanophotonic parameters, wavelength-dependent characterization, and further evaluation of the impact on resolution and detector stability. These early results suggest that cheaper nanophotonic scintillator architectures can offer a promising pathway toward significantly improved detector efficiency for a broad range of radiation detection applications.

References:

1. Charles Roques-Carmes et al. A framework for scintillation in nanophotonics. Science, Vol. 375, Issue 6583, February 2022.

2. Louis Martin-Monier et al. Large-scale self-assembled nanophotonic scintillators for X-ray imaging, Nature Communications 16, Article 5750, July 2025.