

Advanced software sharpens scintillation images of low-energy gamma rays

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By combining a monolithic scintillation detector with analytical and machine learning methods, researchers have pushed its resolution beyond the limits of its hardware when measuring low-energy gamma rays.

Scintillation detectors are vital tools in fields ranging from medical imaging to fundamental physics. When excited by ionizing radiation, they emit pulses of light which can be converted into electrical signals, allowing researchers to precisely determine the energy and intensity of incoming radiation. So far, however, most detector designs have been limited to segmented crystals, which are both complex to manufacture and leave dead spaces between segments that limit their efficiency. While the problem is now being addressed in measurements of higher-energy radiation, low-energy detectors have fallen behind.

In a new study published in *EPJ Techniques and Instrumentation*, researchers have demonstrated how low-energy gamma rays can be precisely measured using scintillation detectors made from continuous, monolithic crystals. Carried out by Gabriel Turturica, Bogdan Temelie, and Violeta Iancu at the Extreme Light Infrastructure – Nuclear Physics (ELI-NP), Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering, the approach could unlock new capabilities for radiation detection across a diverse array of fields.

The ELI-NP is part of the Extreme Light Infrastructure (ELI): a network of high-power laser facilities in Romania, Hungary, and the Czech Republic, which use powerful lasers to generate ultra-short pulses of high-energy photons, electrons, protons, and neutrons. To date, it is the largest and most advanced high-power laser infrastructure anywhere in the world.

Using the ELI-NP's resources, Turturica, Temelie, and Iancu coupled a thin, monolithic scintillating crystal to a silicon photomultiplier array, which vastly amplifies the electrical signal produced by incident light. Alongside this, the team developed two computational methods to analyse the detector's pixellated readout.

By analysing how light intensity is distributed across clusters of neighbouring pixels, each method aimed to identify the precise position within the crystal where an incoming gamma ray deposited its energy – achieving resolutions finer than a single pixel. While this has already been achieved in previous studies, it has always involved higher-energy gamma ray photons, which created far more distinctive intensity distributions. To capture the more subtle distributions created by lower-energy photons, a more purposeful approach would be needed.

The team tested two different methods: using an analytical model, they applied a mathematical formula describing how light spreads across the pixel array, then fitted the observed intensity pattern to estimate the interaction position. Alternatively, using a neural network, they trained a model to learn the relationship between intensity patterns and interaction positions from data, then applied it to new measurements.

Both approaches proved highly effective, allowing the detector to localise photon-crystal interactions at resolutions far exceeding those of the raw pixel array. The results clearly demonstrate how software can overcome inherent hardware limitations, enabling low-energy gamma ray imaging at resolutions beyond those offered by the detector hardware alone.

This could ultimately enhance radiation imaging capabilities across areas as wide-ranging as nuclear spectroscopy, industrial inspection, and medical imaging techniques, including CT and PET scans. ■

Reference

- [1] G.V. Turturica, B. Temelie, & V. Iancu, *EPJ Techn Instrum* **13**, 1 (2026) <https://doi.org/10.1140/epjti/s40485-026-00120-2>

