

# Compact SiPM-Coupled Scintillation Detector for Hard X-Ray Spectroscopy in Fusion Plasmas

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Hard X-ray spectroscopy is an important diagnostic tool for studying runaway electrons and plasma behavior in plasma fusion. In many fusion experiments, hard X-ray measurements have traditionally been performed using various scintillation detectors coupled with conventional photomultiplier tubes (PMTs), such as LaBr<sub>3</sub>(Ce), NaI(Tl), and plastic scintillators. During plasma operation under strong magnetic fields, PMT-based scintillation detector systems generally require large iron shielding enclosures and high-voltage biasing to ensure stable operation.

To overcome the limitations associated with the size, high-voltage operation, and magnetic-field sensitivity of PMT-based systems, we have carried out a performance evaluation of a compact silicon photomultiplier (SiPM)-coupled scintillation detector for hard X-ray spectroscopy in fusion plasmas. In this work, the performance of a LaBr<sub>3</sub>(Ce) scintillation detector with a crystal size of 25 mm in diameter and 20 mm in thickness, coupled to a 25 mm diameter SiPM array board, is evaluated. The detector assembly is enclosed in an aluminum housing with an outer diameter of 60 mm and a total length of 71.5 mm. The detector is operated with a +5 V bias voltage, and signals from the SiPM readout are digitized using a DT5790N data acquisition system (250 MHz sampling rate, 12-bit resolution).

The detector performance is characterized using standard gamma-ray sources (<sup>137</sup>Cs, <sup>60</sup>Co, and <sup>22</sup>Na) as well as an X-ray generator with photon energies ranging from 40 keV to 300 keV. The LaBr<sub>3</sub>(Ce) scintillator coupled with a SiPM readout will be installed on the Thailand Tokamak-1 for hard X-ray measurements during the 2026 experimental campaign and will be compared with conventional PMT-based detector systems utilizing LaBr<sub>3</sub>(Ce) [1], pure LaCl<sub>3</sub> [2], and plastic scintillators for runaway electron study. Compared with conventional PMT-based systems, the SiPM-based detector offers improved compactness, reduced high-voltage requirements, and enhanced operational stability in high magnetic-field environments, making it well suited for deployment in plasma fusion experiments.

1. K. Rongpuit, et al., “Initial results of hard X-ray spectroscopy by LaBr<sub>3</sub>(Ce) detector for runaway electron study in Thailand Tokamak-1”, *Radiation Physics and Chemistry* **227**, 112346, 2025.
2. K. Ploykrachang, et al., “Feasibility and characterization of a pure LaCl<sub>3</sub> scintillation detector for hard X-ray measurements in Thailand Tokamak-1”, *Radiation Physics and Chemistry* **240**, 113471, 2026.

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