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Design and evaluation of a MeV gamma-ray camera aboard a 50-kg class small satellite

Waseda University and Tokyo Tech are developing a 50-kg class small satellite, tentatively named INSPIRE, scheduled for launch in FY2026. The satellite's primary detector is a BOX-type Compton Camera (CC-BOX). This camera covers a dynamic range spanning two orders of magnitude: it observes low energy (30 keV – 200 keV) in Pinhole mode and high energy (200 keV –3 MeV) in Compton mode. The CC-BOX comprises a pixelized Ce:GAGG scintillator array and an MPPC array operating at ˜40V to cover total geometrical area of 10×10 cm^2. The Ce:GAGG scatter layer is 5mm thick, and the absorber features a four-layer, 20mm thick depth-of-interaction (DOI) structure. Additionally, Ce:GAGG elements are positioned on the sides of the detector to enhance its sensitivity than traditional Compton Cameras. For the observation of low-energy gamma rays, the scatter has 5mm square holes in each 5×5 cm^2 module to facilitate pinhole imaging. Furthermore, BGO shields are positioned on the side and bottom of the detector for efficient event rejection.
In this presentation, we begin by detailing the design of the CC-BOX, its data processing flow—including the DAQ board, USB board, and Raspberry Pi—as well as weight and power specifications. We then assess the detector's anticipated performance through both hands-on device testing and simulations, focusing on detection sensitivity to point sources, imaging resolution, energy resolution, the BGO shield's background removal capability, anticipated spectra when observing the Crab Nebula, and polarization observations. Finally, we share the findings from a series of environmental tests in preparation for the FY2026 launch, which cover the activation characteristics of the Ce:GAGG scintillator, high-rate data acquisition using Raspberry Pi, radiation damage assessment of the DAQ board, and engagement tests, including communication trials.

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