Energy Calibration of The Gamma-ray Transients Monitor

Hao-Min Chang[1*], Hsiang-Kuang Chang[1,2], Chih-Hsun Lin[3], Che-Chih Tsao[4], Chin-Ping Hu[5], CHIU, Ching-Wen[4], CHU, Hsiang[4], CHEN, Hong-Yi[6], An-Hsuan Feng[4], LO, Cheng-En[4], Tzu-Hsuan Lin[1], LEE, Yi-Sian[5], Chih-En Wu[2], WANG, Yu-Hua[4]

[1]*Department of Physics, National Tsing Hua University, Hsinchu, Taiwan*
[2]*Institute of Astronomy, National Tsing Hua University, Hsinchu, Taiwan*
[3]*Institute of Physics, Academia Sinica, Taipei, Taiwan*
[4]*Department of Power Engineering, National Tsing Hua University, Hsinchu, Taiwan*
[5]*Department of Physics, National Changhua University of Education, Changhua, Taiwan*
[6]*Department of Electronics and Electrical Engineering, National Yang Ming Chiao Tung University, Hsinchu, Taiwan*

* Presenter : Hao-Min Chang, email : hankchang01@gmail.com

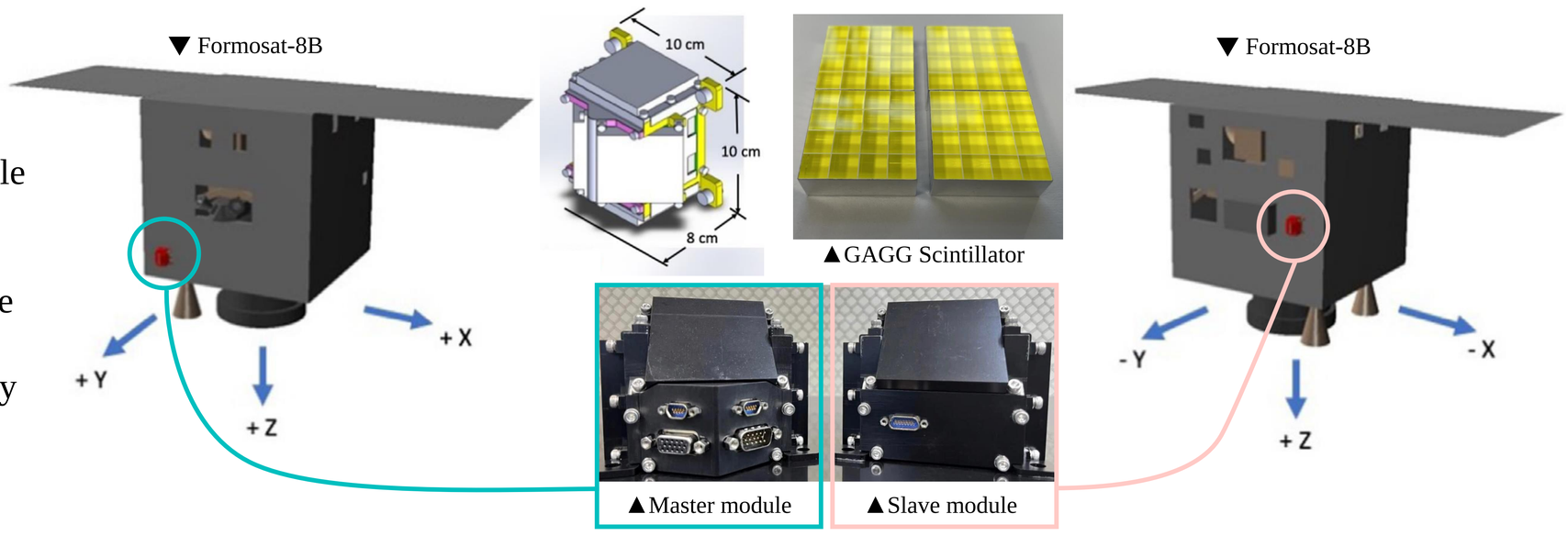
Abstract

The Gamma-ray Transients Monitor (GTM) is a science payload on the Taiwanese satellite Formosat-8B, designed to detect GRBs and other gamma-ray transients in the 50 keV to 2 MeV range. It consists of two detector units, each with four sensor modules using GAGG(Ce) scintillators and Silicon Photomultipliers (SiPMs), providing all-sky coverage.

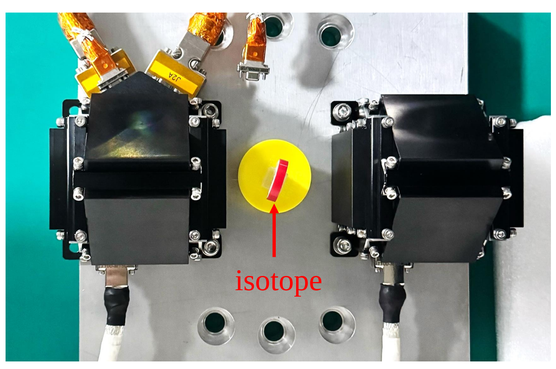
In this report, we present the energy calibration of GTM, which is essential for accurately interpreting the detector readout signals. We performed radiation measurements using multiple isotopes to establish the ADC to-energy relationship for all channels. Finally, we obtained the energy resolution as a function of energy for all detectors.

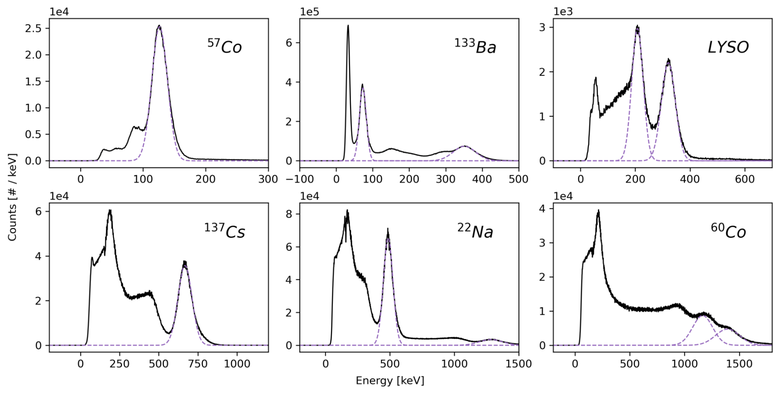
Instrument Design

The GTM consists of two parts: a Master module and a Slave module. Each part includes four detectors made with GAGG scintillators. These two modules are mounted on opposite sides of the Formosat-8B satellite, as illustrated in the figure on the right. This configuration allows for full-sky coverage and facilitates the localization of GRB events.



Energy Calibration



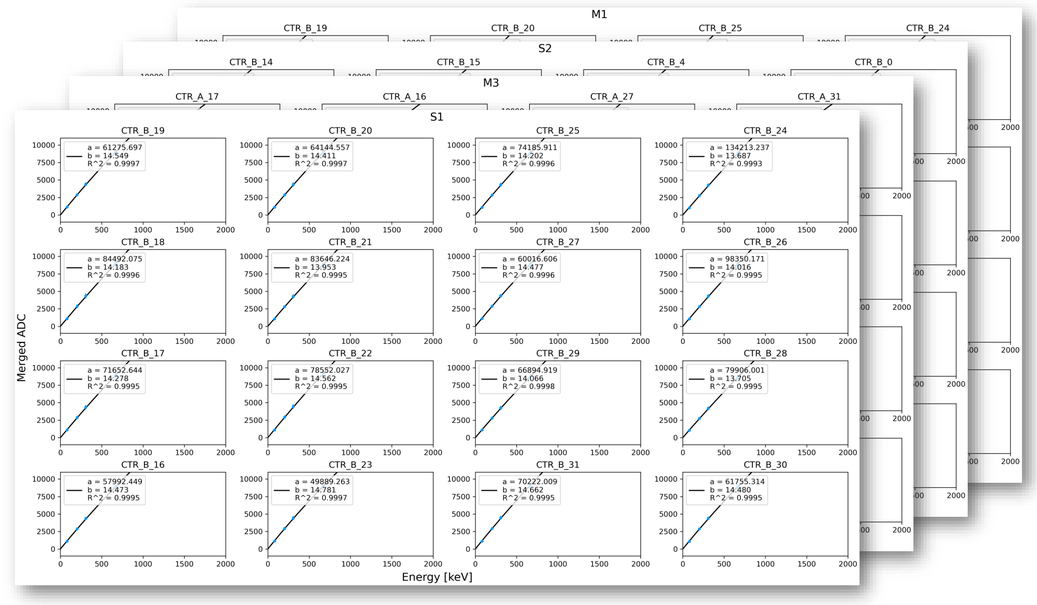


To accurately convert readout ADC values to energy, we can only rely on isotopes with well-known peaks to establish the mapping. In real measurements, these peaks appear as Gaussian distributions due to uncertainties. By analyzing the widths of these peaks from various radioactive sources, we can evaluate the energy resolution of the GTM detectors.

Test setting & ADC to energy relation

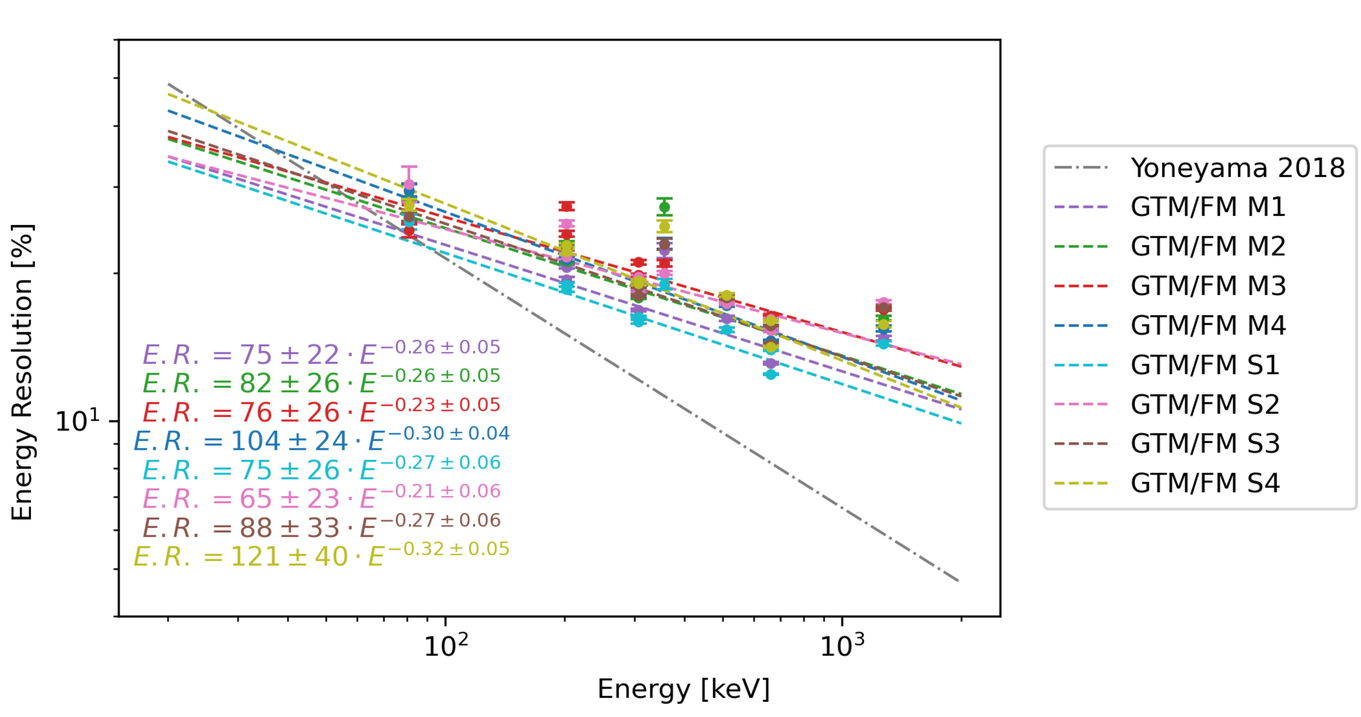
Source	Peak [keV]	LG/HG	HV [V]	DAC
LYSO(Ce)	202 & 307	both	55	certain
^{133}Ba	81 & 356	2/20	55	certain
^{137}Cs	662	both	55	certain
^{22}Na	511 & 1274	1/10	55	certain
^{60}Co	1173 & 1332	1/10	55	certain

The table lists the isotope peaks used in our measurements, as well as the applied voltage and DAC settings for each test. The "certain" DAC setting ensures that all channels operate with nearly identical gain values.



The ADC-to-energy relationships for all channels were determined and documented.

Energy Resolution



The energy resolution as a function of energy shows a consistent trend among the GTM's GAGG detectors, yielding approximately 15% resolution at 662 keV. This value is notably higher than the 7.6% reported in the literature. The difference may be explained by the detector setup, in which combined 4 SiPM pixels into a single readout channel.

Reference

The Gamma-ray Transients Monitor (GTM) on board Formosat-8B and its GRB detection efficiency , Advances in Space Research, 2022

Energy calibration of GTM on ground , Nuclear Instruments and Methods in Physics Research - section A, 2024

M. Yoneyama et al 2018 JINST

GTM website!