GRB Detection Efficiency and Localization Capability of the Gamma-ray Transients Monitor (GTM) on board Formosat-8B

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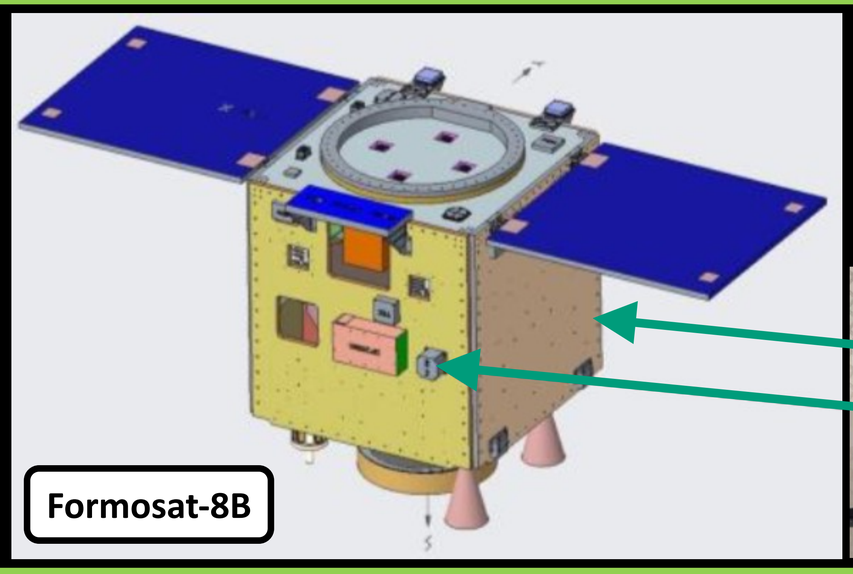
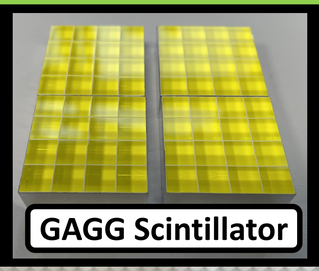
Abstract

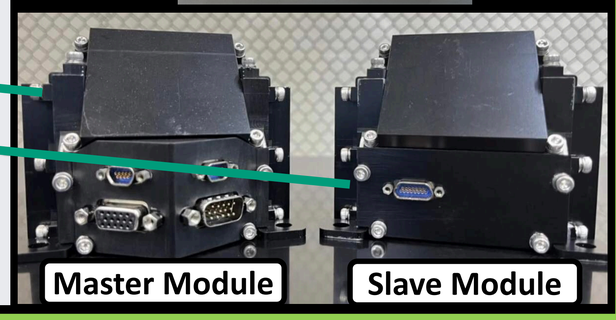
The scientific purposes of GTM are to monitor Gamma-Ray Bursts (GRBs) and other bright gamma-ray transients in the energy range from 50 keV to 2 MeV. Base on detailed simulations, the 50% detection efficiency happens at the fluences (in the energy range from 10 keV to 1 MeV) of 2×10^(−6) erg/cm^2 and 6×10^(−7) erg/cm^2 for long and short GRBs, respectively. GTM is therefore expected to detect about 50 GRBs per year, according to the Fermi/GBM 10-year GRB-fluence distribution. For localization capability, the localization uncertainty at 3 sigma confidence level of long GRBs with the fluences of 4×10^(−5) erg/cm^2 and 4×10^(−6) erg/cm^2 are about 3 and 30 degrees, respectively.

Instrument Design

GTM is a secondary payload on board Formosat-8B (FS-8B), a Taiwanese remote-sensing satellite scheduled to launch in 2026. GTM consists of two identical modules located on two opposite sides of FS-8B. Each module has four sensor units facing different directions to cover half of the sky. The two modules will then cover the whole sky, including the direction occulted by the Earth. Each sensor unit is composed of a GAGG scintillator array (50 mm x 50 mm x 8 mm) to be readout by SiPM with 16 pixel-channels.

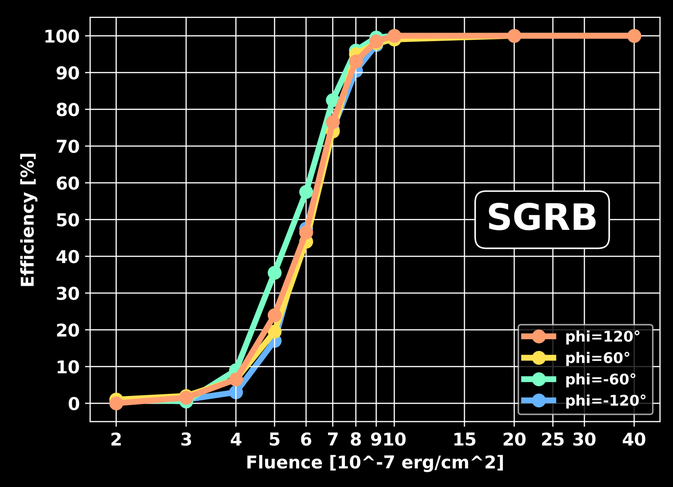


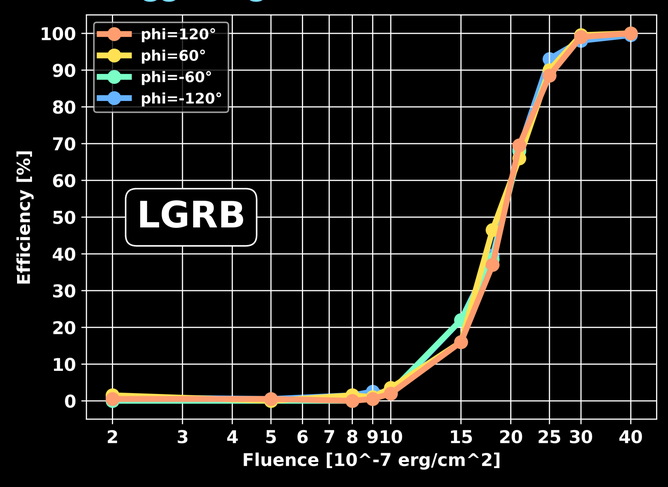




Simulation Results

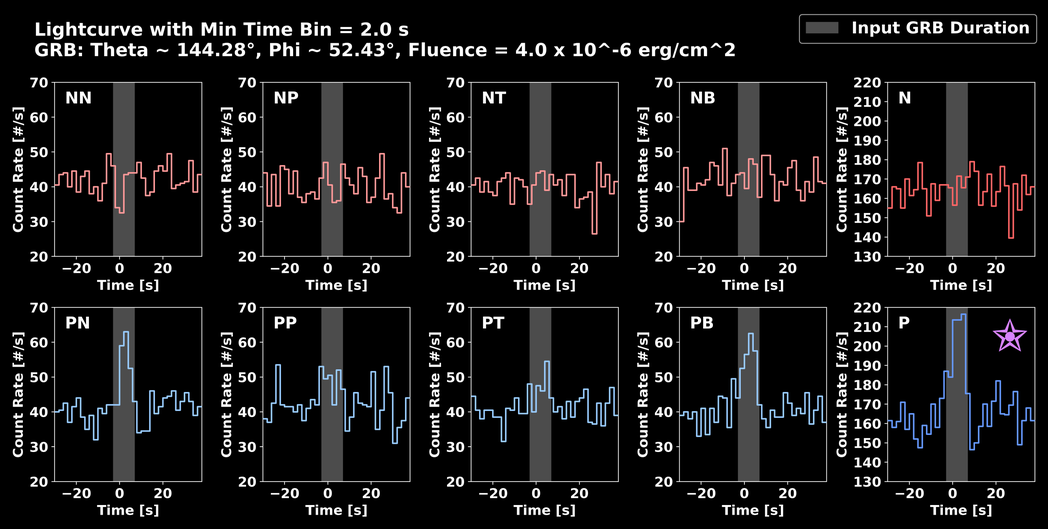
To derive the detection efficiency, 10,000 # artificial light curves with a certain fluence from a certain direction are fed into the trigger algorithm.

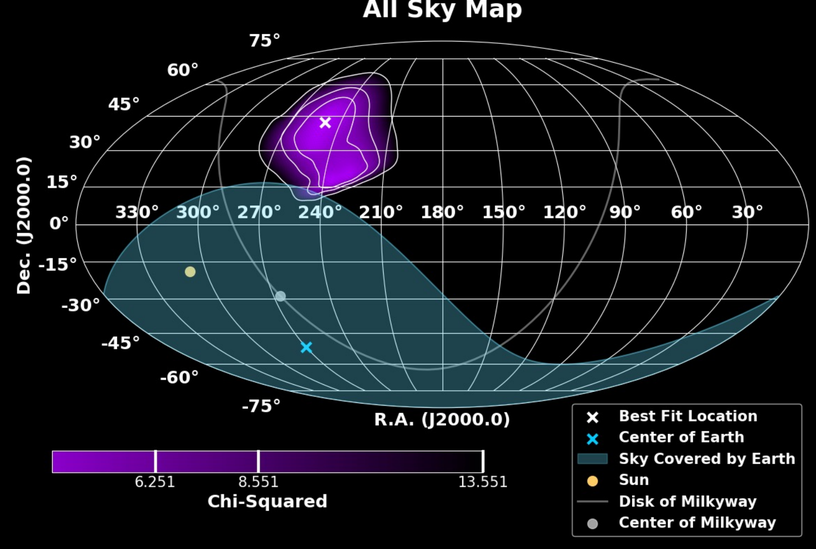


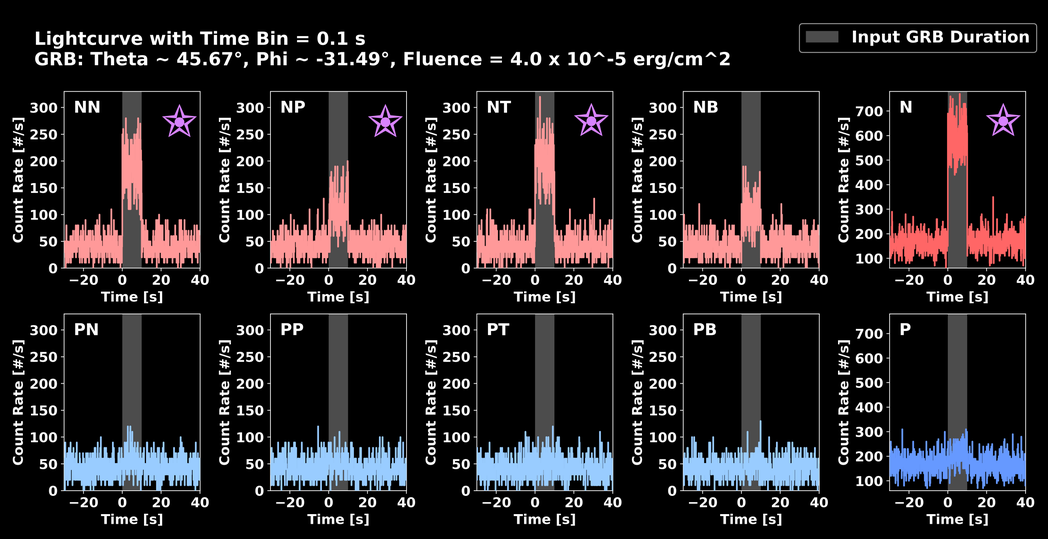


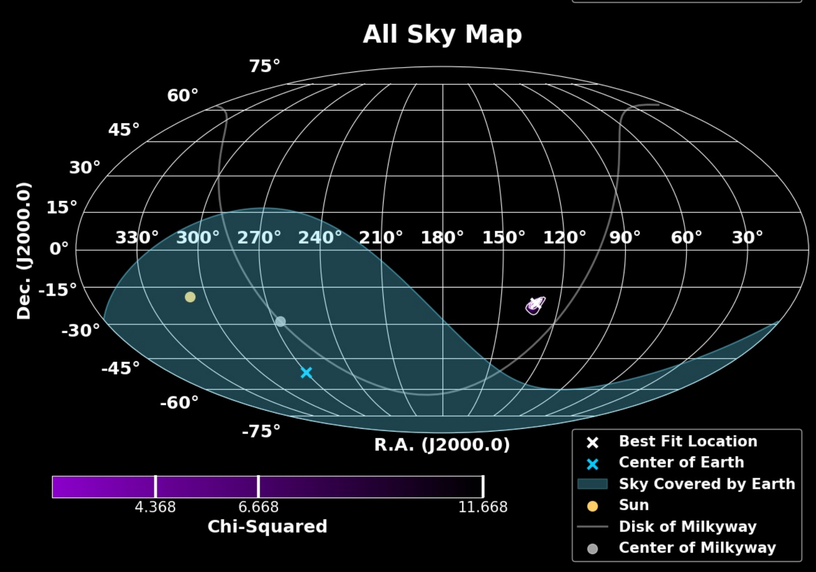
- Artificial light curve
  - Interval: 1,000 s
  - LGRB: 10 s, soft (alpha=-1, Ep=300 keV) CPL spectra
  - SGRB: 0.5 s, hard (alpha=-0.5, Ep=500 keV) CPL spectra
  - Count rate bases on **Chang et al., 2022, ASR, 69, 1249**
- Trigger algorithm
  - Time bin: 1, 2, 5 [ms, 10ms, 100ms & s] & 10 s and also their half-bin shift
  - If 8 individual sensors can't find GRB trigger, 4 sensors on one module would be collected together to search
  - Threshold is defined as an average level making the false alarm probability of Poisson distribution of background level < 1e-3

For the localization, a simulated table was built up by separating all sky to become 1,600 directions and enlarging them to 41,168 directions with Fibonacci sphere. Therefore, the real observed data can be compared with the simulated table by the Chi-squared fitting. Finally, the most possible direction and the confidence level will be reported.









Reference