Overview and first year observation of CALET Gamma ray Burst Monitor

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Abstract

Calorimetric electron telescope (CALET) was launched by the 5th H-IIB/HTV on August 19, 2015. CALET includes CALET Gamma ray Burst Monitor (CGBM) to observe GRB prompt emissions. CGBM consists of two Hard X-ray Monitors (HXM) and Soft Gamma ray Monitor (SGM). CGBM is able to observe prompt emissions of GRBs in the 7 keV - 20 MeV band (HXM; 7 keV - 1 MeV, SGM; 40 keV - 20 MeV). CALET started its nominal observation on October 8, 2015. So far, CGBM detected 49 GRBs which include 9 short GRBs and 40 long GRBs. The detection rate is about 4 GRBs per month. Four GRBs are also detected by MAXI. The distribution of T_{90} is similar to GRBs detected by BATSE. The mean of T_{90} measured by CGBM is 8.9 s.

Key words: GRB — CALET

1. Introduction

A gamma ray burst (GRB) is a mysterious explosion in the universe. A prompt emission, an explosive main emission of GRBs, is very bright and variable. Although the mechanism of a prompt emission is not well understood, a cogent scenario is the internal shock model. That is collisions between each ejecta which have a different velocity in a relativistic jet cause the internal shock (Rees and Meszaros, 1994). The shock accelerated electrons radiate X-rays or gamma-rays due to the synchrotron radiation. The spectra of the prompt emissions show a broad energy distribution from keV to MeV range. These spectra are well represented by a smoothly jointed broken power-law, namely Band function (Band et al. 1993). To study its wide band nature, spectral observations of prompt emissions need a broad energy coverage. Fermi/LAT detected very high energy photons above 100 MeV from GRBs and found out that they came later than typical hard X-ray photons of prompt emission (Abdo et al. 2009). The high energy photons are thought to be caused by an external shock which arises when the ejecta from the GRB collides with interstellar medium.

2. CALorimetric Electron Telescope (CALET)

A main purpose of CALorimetric Electron Telescope (CALET) mission is observations of cosmic electrons and gamma-rays in the GeV - TeV energy band (Torii et al. 2011). CALET also aims to observe high energy transients such as GRBs in X-ray and gamma-ray range. CALET carries two scientific instruments CALorimetor (CAL) and CALET Gamma ray Burst Monitor (CGBM). CAL has a sensitivity for gamma-rays in the 1 GeV - 10 TeV band. CGBM utilizes two type of scintillation detectors : Hard X-ray Monitor (HXM; 7 keV - 1 MeV) and Soft Gamma ray Monitor (SGM; 40 keV - 20 MeV). All sensors of CGBM have two amplifiers with different gain (high / low) to observe GRB radiations in the broad energy range.

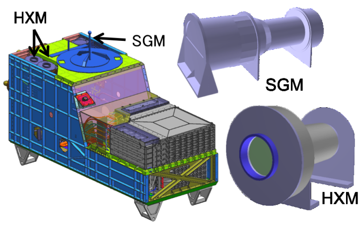

Fig. 1. The image of CALET. CALET is equipped with one SGM and two HXMs.

Table 1. Specification of HXM and SGM

	HXM	SGM
Number of detector	2	1
Detector	$LaBr_3$(Ce)	BGO
Diameter [mm]	61	102
Thickness [mm]	12.7	76
Energy range [keV]	7-1000	100-20000
Field of view	∼3 sr	∼8 sr

3. Data collection and In-orbit operation

CGBM regularly collects two kinds of monitor data. One is Pulse Height (PH) data. The other is Time History (TH) data. CGBM has the on-board trigger system which calculates a signal-to-noise ratio every 0.25 s. If the signal-to-noise ratio exceeds a trigger threshold, CGBM captures event data with a time resolution of 62.5 μs. We setup a pipeline to send an alert to Gamma-ray Coordinates Network automatically. When the CGBM on-board trigger happens, CAL decreases the lower energy thresholds for gamma ray from 10 GeV to 1 GeV. Advanced Stellar Compass (ASC) which is a optical star camera takes two images.

Table 2. Data of CGBM

Data	Channels (High)	Channels (Low)	Time resolution
Time History (TH)	4	4	0.125s
Pulse Height (PH)	102	410	4s
Event data (EVT)	4096	4096	62.5μs

CALET was launched by the 5th H-IIB/HTV on August 19, 2015 and attached on the JEM module of the international space station (ISS) on August 25. The initial checkout was performed on September 22. The 72 hour running test was carried out from October 5 to 8. During this test, CGBM detected GRB 151006A which was the first GRB detection by CGBM. CGBM started the nominal observation on October 8. Since CGBM high voltages are turned off at the SAA region and high latitude regions to protect PMT and to reduce false trigger alerts, the observation efficiency is about 60%.

4. Observation

CGBM detected 49 GRBs, 40 long bursts and 9 short bursts, during October 2015 to November 2016. The detection rate of GRBs is ~4 GRBs per month. The most of the CGBM GRBs were also detected by other instruments (e.g. Fermi/GBM, INTEGRAL/ACS, KONUS/Wind, Swift/BAT, MAXI/GSC). Especially, 4 GRBs were also detected by MAXI/GSC. The T_{90} durations of GRBs detected by CGBM were measured by SGM in the 40 - 1000 keV band. We classified GRBs based on the T_{90} smaller than 2 s as short bursts. Fig. 2 shows the T_{90} distributions of GRBs detected by CGBM. The mean of T_{90} of the CGBM GRBs is 8.9 s a bit smaller than that of 9.3 s by BATSE (see Fig. 2). Since the T_{90} is measured at different energy bands by different instruments, the measured T_{90} could be affected by the energy dependence of GRB pulses (Fenimore et al. 1995) and the sensitivity of instruments.

CALET joins to the LIGO/Virgo electro-magnetic follow up program. When GW 150914 occurred, CGBM

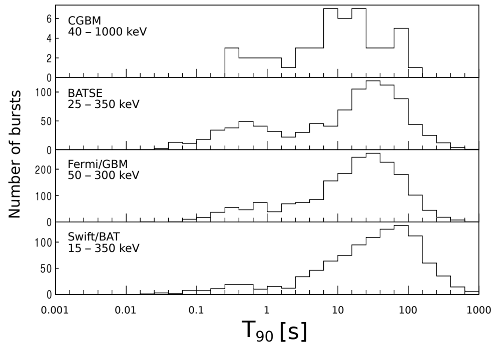

Fig. 2. The distribution of T_{90}. The top panel shows distribution of CGBM GRBs (mean is 8.9s). The middle high panel shows that of BATSE GRBs (mean is 9.3s). The middle low panel shows that of Fermi/GBM GRBs (mean is 13.4s). The bottom panel shows that of Swift/BAT GRBs (mean is 24.4s).

was not in the normal operation. However, when GW 151226 occurred, CGBM was working. We checked TH light curve data within a period of ± 60 s from the GW trigger time. As the result, no significant signal was seen in the CGBM data. We also estimated 7σ upper limit for GW 151226 assuming a spectrum of a typical short GRB ($\alpha = -0.58$, $E_{peak} =$ 355 keV; Ghirlanda et al. 2009). The 7σ upper limit of HXM is 1.0 $\times 10^{-6}$ cm^{-2} s^{-1} (7 - 500 keV) assuming 1 s integration time. The 7 σ upper limit of SGM is 1.8 $\times 10^{-6}$ cm^{-2} s^{-1} (50 - 1000 keV) assuming 1 s integration time (Adriani et al. 2016).

5. Summary

CGBM is performing a nominal observation since October 8, 2015. The current observation efficiency is ~60 %. CGBM detected 49 GRBs which consist of 40 long GRBs and 9 short. The rate of short GRBs is ~18 %. The detection rate of GRB is 4 GRBs a month. 4 GRBs were also detected by MAXI/GSC. The distribution of the T_{90} obtained by CGBM is similar to that by BATSE. CALET did not find a significant electro magnetic counterpart of GW151226 (Adriani et al. 2016).

References

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