Energy response function of CALET Gamma ray Burst Monitor

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Abstract

CALorimetric Electron Telescope (CALET) was successfully launched and attached to the exposed facility of the Japanese Experimental Module (JEM) called Kibo at the International Space Station (ISS) on August, 2015. CALET started its regular operation on Octorber 2015. CALET has two scientific instruments: CALorimetor (CAL) and CALET Gamma-ray Burst Monitor (CGBM). CGBM is specifically designed to observe gamma-ray bursts (GRBs).

We calibrated the energy response function of the CGBM using the ground and the flight data. The well calibrated energy response function is crucial for the spectral analysis of GRBs. We constructed the mass model of CALET using the GEANT4 simulation package. This mass model is used to construct the energy response function of CGBM. In this paper, we present the current status of the energy response function of the CGBM.

Key words: CALET

1. CALET Gamma-Ray Burst Monitor

CALorimetric Electron Telescope (CALET) was successfully launched and attached to the exposed facility of the JEM called Kibo at the International Space Station (ISS) on August, 2015. (Torii et al. 2015) CALET started its regular operation on Octorber 2015. CALET has two scientific instruments: CALorimetor (CAL) and CALET Gamma-ray Burst Monitor (CGBM). CGBM is specifically designed to observe gamma-ray bursts (GRBs). CGBM covers a wide range of energy by using two different types of scintillation detectors: The Hard X-ray Monitor (HXM), based on $LaBr_3$(Ce), covers the energy range 7 keV $\sim$ 1 MeV. The Soft Gamma-ray Monitor (SGM), based on BGO, covers the range 50 keV $\sim$ 20 MeV. (Yamaoka et al. 2013)

2. CGBM simulator and Full CGBM simulator

We use the GEANT4 (GEometry ANd Tracking 4) simulation package to construct the mass model of CGBM. The physical processes included in this simulator are the photoelectric effect, Compton scattering, electron-pair production and Rayleigh scattering.

2.1. CGBM simulator

Individual HXM and SGM simulators are built at first. We compared the simulator to the flight model. We checked the mass, the size, the material of the simulator to the actual design of the flight model and they agreed well with the flight model.

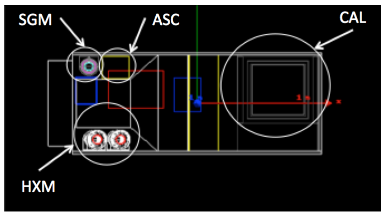

Fig. 1. CALET simulator as viewed from the top.

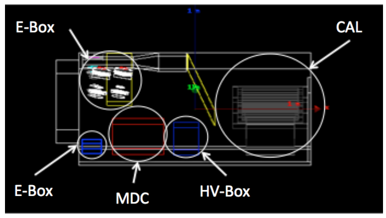

Fig. 2. CALET simulator as viewed from the side.

2.2. Full CGBM simulator

Next, we built the full CGBM simulator which includes the basic structures of CALET. In order to construct the energy response function, the effect of scattering by the surrounding materials is needed to be simulated accurately. Therefore, it is necessary to build the entire structure of CALET into the simulation, which we label the full CGBM simulator.

We incorporated the entire structure of CALET into

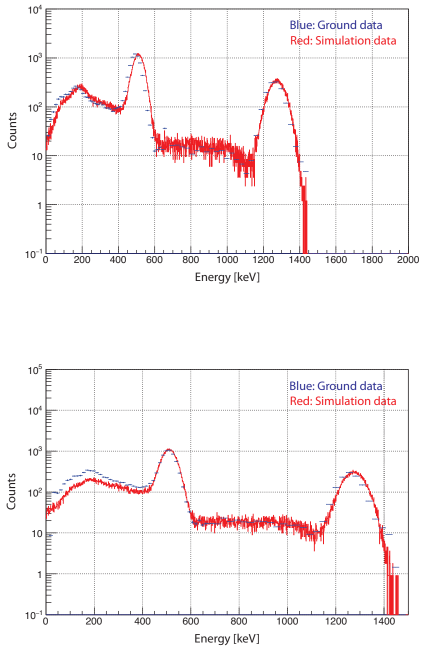

Fig. 3. The simulation spectrum (^{22}Na) above: The CGBM simulation bottom: The full CGBM simulation

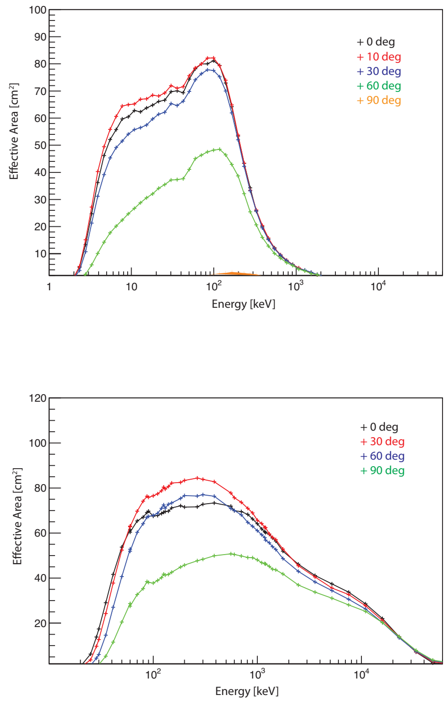

Fig. 4. Effective area of HXM (above) and SGM (bottom) of the full CGBM simulator

the full CGBM simulator, including CGBM, CAL, ASC, MDC, E-Box, and HV-Box. We checked the mass, the size, the material of the simulator and their positions of incorporated substances. They agreed well to the flight model. The figure 1, 2 are the full CGBM simulator.

3. Comparison between ground calibration data and simulation data

We performed ground calibration tests to obtain the data for constructing the energy response function. We used the following radiation sources: ^{22}Na, ^{57}Co, ^{88}Y, ^{109}Cd, ^{133}Ba and ^{137}Cs. We measured the energy linearity, the angle response and the uniformity of the crystal surface.

3.1. Verification of the CGBM simulator

The radiation source, ^{22}Na, was located in front of the CGBM for the simulation. The position of the radiation source is the same as the setup of the ground test. We replicate the setup of the ground calibration set up in the simulation. We simulated and made a comparison between the ground data and the simulation data. The simulation data and the ground calibration data agree quite well (fig 3).

3.2. Verification of the full CGBM simulator

The radiation source (^{22}Na and ^{109}Cd) were located on top of the CALET. The heights of radiation source are 0.3 m, 0.5 m and 0.86 m from the top part of the CGBM. We replicate the setup of the ground calibration test in the simulation. We compared the measured data and simulated data. The low energy part shows a mismatch between the simulation and the calibration data (fig 3). We are currently investigating the reason for this discrepancy. One possible reason is a lack of Compton scattering effect by surrounding materials in the simulator.

4. Effective area

We measured the effective area at several incident angles for the SGM and HXM using the full CGBM simulator. The effective area was calculated by changing the incident angles (0, 30, 60 and 90 deg). Both the CGBM simulation and the full CGBM simulation have the maximum effective area at 30 degrees, and when the angle is 90 degrees, effective area is the smallest. The effective area matches when the angle is 0 degrees, but when we changed the incident angle, the effective area of the full CGBM simulator becomes smaller than the CGBM simulator (fig 4).

References

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