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APPLICATION OF EGS4 FOR THE HARD X-RAY DETECTOR II (HXD-II) ONBOARD ASTRO-E2

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Abstract

We have developed the Hard X-ray Detector onboard Astro-E. Shield parts of this detector work as an all sky monitoring instrument. So, we measured the energy response and the angular response of this parts. Then, we simulate the response between a detector and X-ray photons by EGS4. This result is suited in an experiment result well. From now on, construction of a precise response function of HXD is aimed at using mass model of the whole satellite.

1 The Hard X-ray Detector

We have developed the Hard X-ray Detector (HXD) onboard Astro-E [1, 2]. Astro-E was the fifth Japanese cosmic X-ray satellite. It launched in February 2000. But, the launch was unsuccessful. Its recovery mission, Astro-E2, to be launched in 2005, has been approved. We have started rebuilding the HXD as HXD-II.

The HXD consists of an array of 4×4 well-type GSO(main: gadolinium silicate)/BGO(shield: bismuth germanate) phoswitch counters, called Well-counters. The BGO well is separated into 4 parts, and one GSO and one silicon PIN diode are placed in each parts at the bottom. For X-ray below 60 keV, the energy resolution of GSO is insufficient. So silicon PIN diodes are installed above the GSO to expand the lower energy threshold to 10 keV. This array enlarges the effective area, decreases dead time of observation, and increase the anti-coincidence efficiency. Furthermore, the array is surrounded by 20 BGO active-shield counters, called Anti-counters (Fig 1). So, Compton scattered events and charged particle events are rejected by anti-coincidence between Well-counters and Anti-counters.

The Well-counters covers the range from 10 to 600 keV, with the very low background of typically 1×10^{-5} c s^{-1} cm^{-2} keV^{-1} at 200 keV on ground, with a typical effective area of 330cm^2 at 50 keV. The Anti-counters work also as an all sky monitoring instrument, watching transient objects by the earth occultation technique, as well as gamma-ray bursts [3].

2 Construction of the response function of Anti-counters

In this section, we explain construction of the response function of the Anti-counters. Photoelectric absorption and Compton scattering is main physical process from 10 to 600 keV which is the observation range of HXD. Then, we use EGS4 code which can treat an electromagnetic interaction.

We simulate the response between a detector and X-ray photons. In addition, we are taken in the energy resolution and the anguler response obtained from measurement of an detector. A final goal is building the response function about the entire HXD.

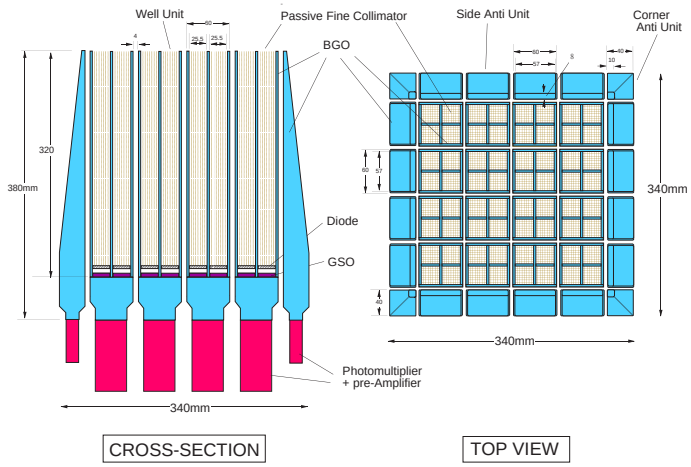

Figure 1: HXD sensor:vertical cross-section (left) and top view (right).

2.1 Energy response

Anti-counters are carrying out thin complicated form for the tip part, and are adhere two BGO crystal. Therefore, it is difficult to condense the visible photon made by a crystal carrying out an interaction to an X-ray photon to photomultiplier tube.

In fact,when measuring the energy response of an single Anti-counter using a gamma-ray source, the position of a photoelectric absorption peak changes with the positions where a gamma ray irradiates as shown in a Fig 2. In the energy response of Anti-counters, we also have to take in this position dependent effect.

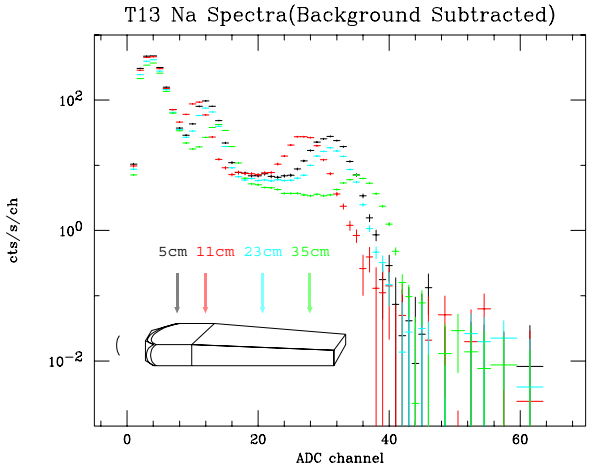

Figure 2: position dependece of energy response of anti-counter (^{22}Na) : Analog-to-Digital conversion channel vs counts/s.

The result of the simulation by EGS4 of the loss energy of the irradiated gamma ray becomes as it is shown in Fig 3. When a simulation is carried out only about a BGO crystal, it doesn't suit an experiment value by the low energy range. But, measurement environment, such as affection of Compton scattering from the wall of a laboratory, is also taken into consideration, and a simulation is suited in an experiment result well with inclusion in these.

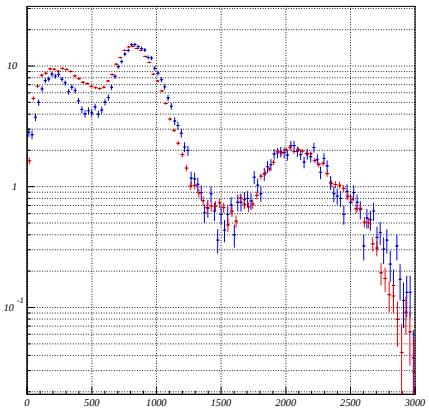

Figure 3: anti-counter energy spectra: red is experimental measurement, blue is simulation by EGS4. Analog-to-Digital conversion channel vs counts/s.

2.2 Anguler response

Since Well-counters are surrounded by Anti-counters, the number of counts of each detector changes with the arrival directions of the gamma rays to Anti-counters. For two surface with Anti-counters, Fig 4 shows the relation of the arrival direction of gamma rays and the energy spectrum.

If the arrival direction of gamma rays and the response of a detectors can be estimated correctly, when the gamma-ray burst phenomenon occurs, it will become possible to determine the direction where the phenomenon occurred.

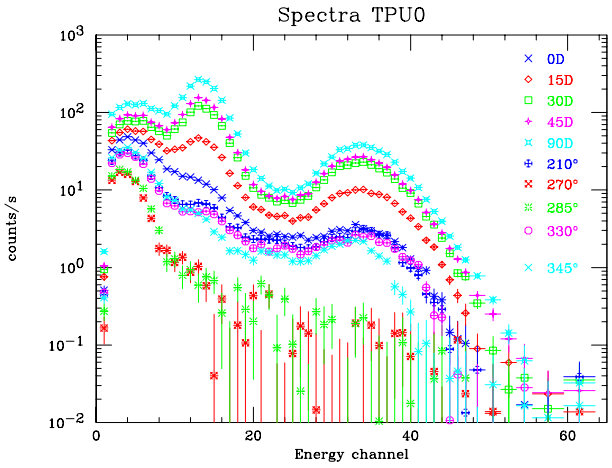

Figure 4: anti-counters anguler spectra (^{22}Na) : Analog-to-Digital conversion channel vs counts/s vs angle ϕ.

2.3 Total response onboard satellite

As section of a more than described, an energy response and angular response of detectors are calculated, and even if it builds the response function of HXD, it does not finish. As shown in Fig 5, on Astro-E2 satellite, the response of a detector changes with the structures in the surroundings of it compared with a HXD simple substance. Therefore, we do the simulation using mass model of the whole Astro-E2 satellite, and think that the more exact response function of HXD will be

built.

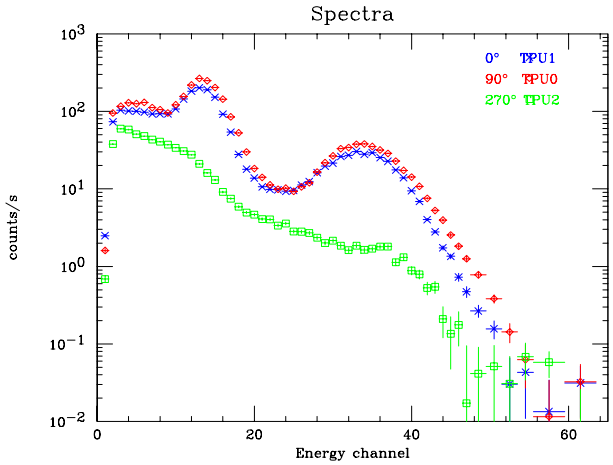

Figure 5: response of satellite: one side (TPU3) of Anti-counters is influenced the structure of a satellite (green).

3 Conclusion

We used EGS4 code in order to build the response function of HXD. Especially this paper described construction of the response function of the shield part of HXD. We investigated in detail about the energy response and the angular response of Anti-counters. The simulation result by EGS4 also often reproduced this experiment result. From now on, construction of a precise response function of HXD is aimed at using mass model of the whole satellite.

References

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