Prompt Gamma-ray Burst Alert System of the HETE-2 Spacecraft

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Abstract

The Hight Energy Transient Explorer 2 is a small spacecraft to study Gamma-ray Bursts (GRBs). Since an afterglow associated with a GRB fades steeply, a fast position alert is necessary to detect its afterglow in early (thereby bright) phase. We report in this paper the detail of the HETE−2 prompt position alert system. HETE−2 has sent out six near real-time alerts until the end of April, 2003. We have revealed previously unknown behavior of afterglows in early stage, and have contributed to study of origin of the GRBs.

1. The HETE−2 Burst Alert System

The High Energy Transient Explorer 2 (HETE−2), launched on October 9, 2000, is a small spacecraft designed to study the Gamma-ray Bursts (GRBs)

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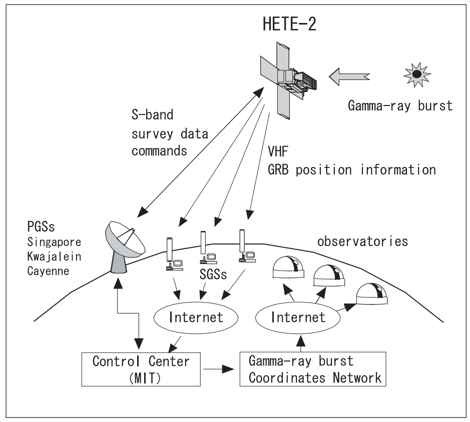

Fig. 1. The HETE−2 burst position alert system. When a GRB detected by HETE−2, a summary of the collected burst data is sent to a series of ground stations via VHF. These data are forwarded to MIT, where they are distributed to ground observers via the GCN. The distribution from the burst trigger takes a few 10 seconds.

which is one of the unrevealed objects in Astronomy [1]. Since an afterglow associated with a GRB fades steeply, a fast position alert is necessary to detect its afterglow in early (thereby bright) phase. The past Italian-Dutch X-ray mission, BeppoSAX, was able to send out precise GRB position alert with error diameter of about 10 arcminutes [2]. However, it takes 3-8 hours from the burst to distribute the information to the world, because the position was determined on the ground. On the other hand, HETE−2 determines position of GRB onboard. Figure 1. shows an GRB position alert system of HETE−2. The spacecraft monitors 1/10 of the sky. Once HETE−2 detects GRB, the position of the GRB is calculated automatically onboard with error diameter of around 10 arcminutes. The primary device for the onboard localization is wide-field X-ray monitor (WXM). The WXM constructs of four Xenon-filled position sensitive proportional counters and coded masks, and is sensitive to the X-ray with energies of 2-25keV [3]. After the onboard GRB localization, HETE−2 sends the position information to a ground station via VHF. The information is sent to MIT mission control center via internet, and then it is distributed to many observatories via the Gamma-ray Burst Coordinates Network (GCN, http://gcn.gsfc.nasa.gov/gcn/).

The spacecraft is in an equatorial orbit at altitudes between 580 to 630 km, with an inclination angle of 2 degrees. We constructed a chain of 14 ground stations along the equator to receive the position information from HETE−2 (see Fig.2.), and the stations cover nearly all of the HETE-2 orbit. The spacecraft is controlled so that the center of the instruments' field of view is pointed at the anti-solar direction. The spacecraft makes fifteen revolutions around the Earth per day, and the science instruments are operated in a night half of each orbit.

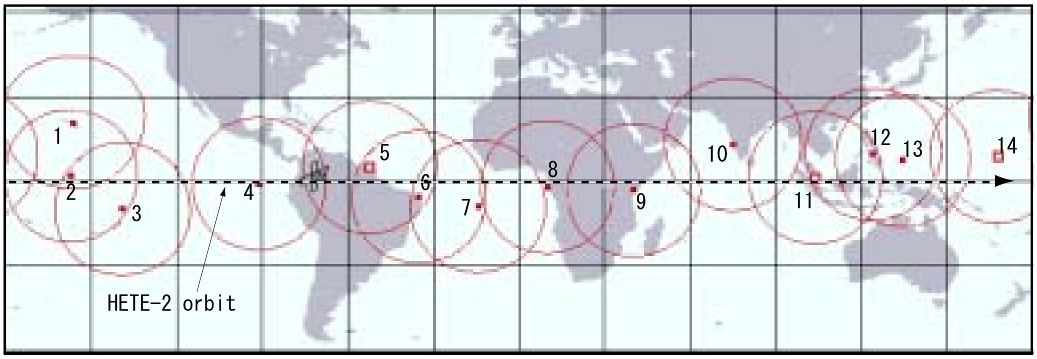

Fig. 2. A series of listen-only secondary ground stations (boxes). An open box denotes the ground station with the primary ground station which is used for uplink to and downlink from the spacecraft. Large circles mean the cover area of each secondary ground station.

2. A record of HETE−2 Position Alerts

The unique alert system has allowed us to detect GRBs at very early phase of the bursts. Figure 3. shows operation livetime of each month (line) and the number of localized GRBs per month (histogram). The open histogram in the figure denotes the number of GRBs associated with an afterglow. HETE−2 localizes about two GRBs per month at present phase. Figure 4. shows position alert time from a burst trigger. Open circles in the figure denotes the bursts in which an afterglow was found. We have sent out six near real-time position alerts until the end of April, 2003. The others were sent out manually by duty scientists.

The fastest position alert, GRB021211, was 22 seconds after the burst trigger. In this GRB, a bright (R$\sim$14.5) transient was detected by a robotic telescope KAIT [4] 108 seconds after the trigger. However, the optical transient faded quite steeply. Two hours after the burst, it became R$\sim$22.5. In a half of GRBs ever localized, optical afterglow has not detected. Such burst is called "dark GRB", and nobody had known if an afterglow was associate with the burst. A discovery of the steeply decaying afterglow with GRB021211 unveiled the "dark GRB". Without our prompt position alert, we never found this type of steeply decaying optical transient, because it is difficult to find fainter object than that of R<18-20 with small telescope which is mainly dedicated for hunting GRB transients.

1. HETE2 homepage, http://space.mit.edu/HETE/
2. Feroci, M. et al. Proc. SPIE, 3114 (1998) 186
3. Shirasaki, Y. et al. 2003, appears in this proceeding
4. Li, W. et al. 2002, GCN 1737

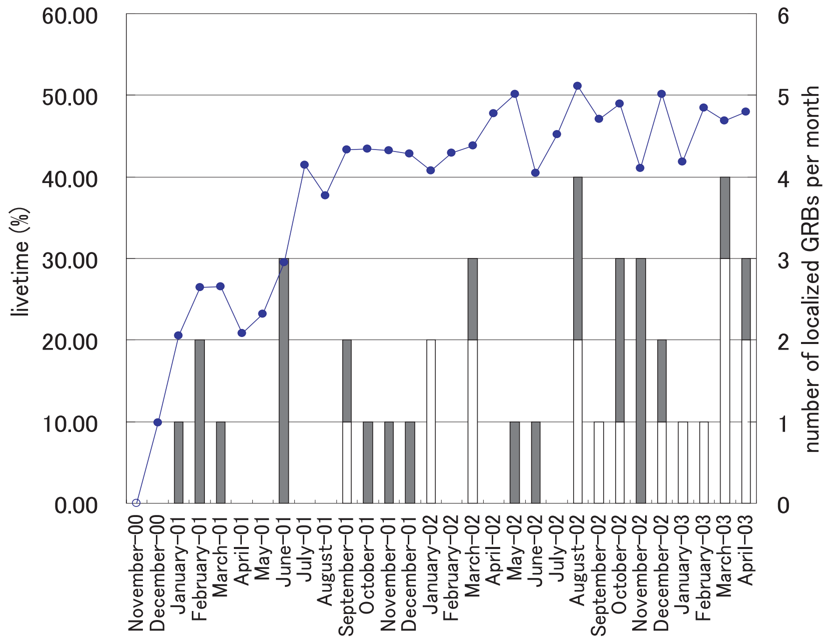

Fig. 3. Livetime of the WXM (line), and the localized GRBs per month (histogram). Open histogram denotes the localized GRB associated with an afterglow.

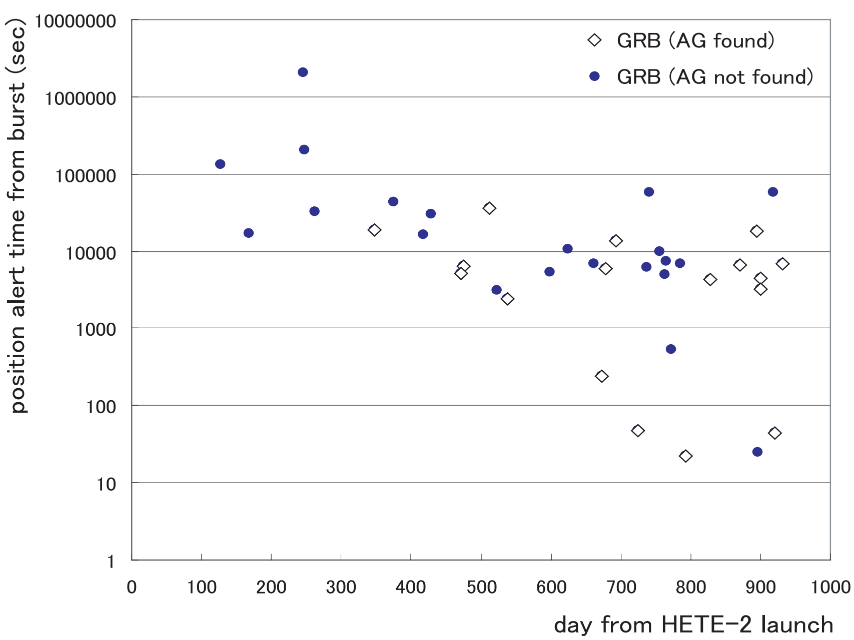

Fig. 4. Position alert time from burst trigger. The six circles below 1000 sec were onboard position alerts. Open circles mean the GRB in which an afterglow was found.