The Suzaku HXD-WAM in the 3rd Interplanetary Network

– A Cycle 1 - 4 Guest Investigator Project

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Abstract

The BGO anticoincidence shield of the Suzaku Hard X-Ray Detector Wideband All-Sky Monitor (HXD WAM) has a geometrical area of 800 cm^2, and operates in the 50 - 5000 keV energy range. It has been designed to act as a gamma-ray burst detector, providing light curves with up to 15.625 millisecond time resolution and energy spectra with up to 55 channels. It was incorporated into the 3rd interplanetary network shortly after launch, and it is now detecting about one confirmed gamma-ray or soft gamma repeater burst every 2.5 days. It has detected over 500 events so far. We describe the HXD-WAM, and explain how the data are being utilized by the scientific community.

Key words: gamma rays: bursts; instrumentation: detectors

1. Introduction

We are using the data from the Suzaku Hard X-Ray Detector Wideband All-Sky Monitor (HXD WAM), in conjunction with the data from 8 other missions in the Interplanetary Network (IPN), to derive the positions of gamma-ray bursts by triangulation. The GRB data which we use are recorded automatically, regardless of Suzaku pointing direction. The IPN is an all-sky, full-time monitor of transient activity, when the integrated response of all the instruments in the network is considered, and has a limiting accuracy of < 1'. Its current event detection rate is > 300/year above a threshold of $\sim 10^{-6}$ erg cm^{-2}, considering only those bursts detected by two or more spacecraft. This makes it possible to study a wide variety of events which imaging GRB instruments like the Swift BAT and INTEGRAL-IBIS will seldom detect. These include very intense bursts, very long bursts, repeating sources (gravitationally lensed GRBs and bursting pulsars like GRO J1744-28 are two examples), soft gamma repeater activity, and possibly other as-yet undiscovered phenomena. The IPN detection rate of short-duration GRBs is much greater than those of imaging instruments (e.g. Ohno et al. 2008).

2. The Suzaku HXD WAM

The HXD WAM (Takahashi et al. 2007, Yamaoka et al. 2009) has 20 BGO anticoincidence shields. They present a geometrical area of 800 cm^2 at normal incidence to a side, and the wedge-shaped units which comprise the shield have an average thickness of 2.6 cm. The energy range is 50 – 5000 keV. The shield electronics comprises a GRB trigger, and triggered data include both 15.625 or 31.25 ms resolution time histories in 4 energy channels, and 55 channel energy spectra with 0.5 or 1 s resolution. The HXD also detects bursts in the untriggered data with 1 s time resolution. By comparing the responses of the units which comprise the shield, a coarse GRB localization may be obtained. Over 500 confirmed and 400 unconfirmed GRBs have been detected in both modes since launch (Table 1 – this does not include SGR bursts). "Confirmed" means that the event was observed by at least one other spacecraft in the IPN, and can therefore be localized to some extent. Thus the Suzaku/IPN rate is about 1 burst/2.5 days. The WAM limiting 50-5000 keV burst sensitivity is $\sim 5\text{x}10^{-7}$ erg cm^{-2}. Much of the data may be found on the Suzaku website: www.astro.isas.jaxa.jp/suzaku/HXD-WAM/WAM-GRB/.

The IPN currently includes 8 spacecraft, in addition

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to Suzaku. These are *Mars Odyssey* , in orbit around Mars, MESSENGER, on its way to Mercury, *Wind* , in a distant prograde orbit, INTEGRAL, in an eccentric orbit, and RHESSI, *Swift* , AGILE, and *Fermi* , all in low Earth orbit. For more details, refer to the IPN website: ssl.berkeley.edu/ipn3/index.html.

3. Some Results To Date

Over 100 GCN Circulars have now been issued for interesting Suzaku-IPN events. We have called Swift ToOs for GRB060928 (GCN 5686, 5721, and 5688), for SGR1806-20 (GCN 5416), for the very intense, long-duration GRB060213 (GCN 4762, 4763, 4770, 4773), for the short-duration hard spectrum GRB060429 (GCN 5039, 5067, Ohno et al. 2008) and for GRB070124 and 070125. The IPN localizations of 070125 and 081105 were used to refine the Swift-BAT positions (GCN Reports 28.1, 28.2, GCN Circ. 8484). The short duration, hard spectrum GRB051103, whose IPN localization suggested a possible origin in M81 or M82 (GCN 4197), was observed as a ToO by XMM. Other bursts, with only coarse and/or delayed localizations, have found a wide variety of uses. An intriguing ground-based muon detector increase was reported in conjunction with GRB 090315 (GCN 9009). IPN bursts are being or have been used by the AMANDA and IceCube groups, the ANITA group, and the RICE group to search for neutrino emission associated with GRBs. They have also been used by the Milagro group to search for 100 GeV – 100 TeV emission in conjunction with GRBs, (Atkins et al. 2004, 2005). Because the IPN GRB detection rate is over 300 bursts/year, and because these bursts are the more intense (and therefore probably, on average, closer) ones, IPN bursts constitute a particularly rich database for these searches (e.g. GCN 4249). The LIGO group has used them to search for coincident gravitational radiation (Abbott et al. 2008a,b), and they have been used to search for orphan afterglows. IPN data are being studied to determine whether any energetic Type Ic hypernovae had gamma-ray emission associated with them (Hurley et al. 2007). The advantages of the IPN in these searches are its isotropic response and $\sim 100\%$ duty cycle. Alexandre Pelangeon and Jean-Luc Atteia have used them to refine their pseudo-redshift algorithm. Observations of SGR bursts are also of great interest to many groups for triggering multi-wavelength ToO observations.

4. GRB Energy Spectra

The Suzaku HXD WAM has been very carefully calibrated, and has excellent high energy sensitivity. Thus it is often able to derive GRB energy spectra into the MeV range, if the arrival direction is well enough known. Figure 1 shows some examples. Over 30 energy spectra have been analyzed so far.

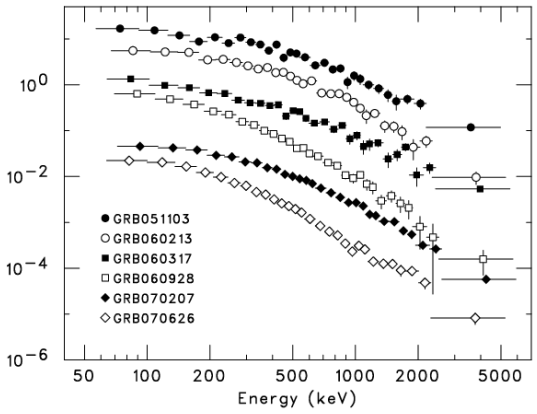

Fig. 1. Energy spectra in flux units of six Suzaku-IPN bursts. Note the excellent high energy response of the HXD-WAM (Yamaoka et al. 2009). The spectra have been renormalized to fit on a single plot and the y-axis normalization is arbitrary.

5. Conclusions

The HXD WAM has proven to be a very sensitive GRB detector, and it plays an important role in the IPN. Its spectral data have excellent statistics up to the several MeV range, and therefore can complement the Swift GRB data, whose spectra extend only to around 300 keV. The IPN and Suzaku WAM data are public, and can therefore be accessed by all interested groups. Burst lists are available at the HEASARC (http://heasarc.gsfc.nasa.gov/cgi-bin/W3Browse), and both burst lists and triangulation results are available at the IPN website (ssl.berkeley.edu/ipn3/index.html).

Table 1. Suzaku bursts, August 2005 - March 2009

Data	Triggered bursts	Untriggered bursts
Confirmed	324	202
Unconfirmed	170	273

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