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The Status and Future of the Third Interplanetary Network

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Abstract. The 3rd interplanetary network (IPN), which has been in operation since 1990, presently consists of 9 spacecraft: AGILE, RHESSI, Suzaku, and Swift, in low Earth orbit; INTEGRAL, in eccentric Earth orbit with apogee 0.5 light-seconds; Wind, up to ~7 light-seconds from Earth; MESSENGER, en route to Mercury; and Mars Odyssey, in orbit around Mars. Ulysses and HETE have ceased operations, and the Fermi GBM is being incorporated into the network. The IPN operates as a full-time, all-sky monitor for transients down to a threshold of about 6×10^{-7} erg cm^{-2} or 1 photon cm^{-2} s^{-1}. It detects about 275 cosmic gamma-ray bursts per year. These events are generally not the same ones detected by narrower field of view imaging instruments such as Swift, INTEGRAL IBIS, and SuperAGILE; the localization accuracy is in the several arcminute and above range.

Keywords: gamma-rays: bursts, instrumentation: detectors
PACS: 95.55.Ka

INTRODUCTION

The 3rd Interplanetary Network (IPN) came into existence in 1990, with the launch of the Ulysses spacecraft. Its purpose is to derive the positions of fast gamma-ray transients of all kinds by triangulation. Numerous spacecraft

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and instruments have participated in the network since its inception: BATSE, PVO, Ginga, WATCH, SIGMA, PHEBUS, EURECA, Mars Observer, BeppoSAX, HETE, NEAR, and SROSS, to name a few. Today, the network consists of AGILE (SuperAGILE and MCAL), RHESSI, Suzaku (HXD WAM), and Swift (BAT), in low Earth orbit; INTEGRAL (SPI ACS), in eccentric Earth orbit with an apogee of 0.5 light seconds; Wind (Konus), up to 7 light seconds from Earth; MESSENGER (GRNS), meandering through the inner solar system en route to Mercury, at distances up to about 600 light seconds from Earth; and Mars Odyssey (HEND and GRS), in orbit around Mars, at distances up to about 1000 light-seconds from Earth. The Fermi GBM is presently being added. Due to the large number of spacecraft, the roughly isotropic responses of the instruments aboard them, and the fact that three of them (INTEGRAL, Wind, and MESSENGER) view the entire sky without occultation by a planet, the IPN is in effect an all-sky, full-time monitor of fast gamma-ray transient activity. Its limiting accuracy for localization is about 1', although only a few events can be localized this well, and its event detection rate is ~275/year, considering only those bursts detected by two or more detectors (i.e. confirmed events). This makes it possible to study a wide variety of events which imaging GRB instruments like the Swift BAT, INTEGRAL-IBIS, and SuperAGILE will seldom detect in their fields of view. These include very intense bursts, very long bursts, repeating sources (gravitationally lensed GRBs and bursting pulsars like GRO1744-28 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 narrow-field instruments.

SENSITIVITY

The IPN sensitivity can be defined in various ways, since the experiments comprising it vary widely in their properties. A convenient measure is to consider the fluences and peak fluxes of the GRBs detected by two or more IPN detectors. The efficiencies as a function of fluence and peak flux are shown in figure 1. The thresholds for 50% efficiency are ~6×10^{-7} erg cm^{-2} and 1 photon cm^{-2} s^{-1}.

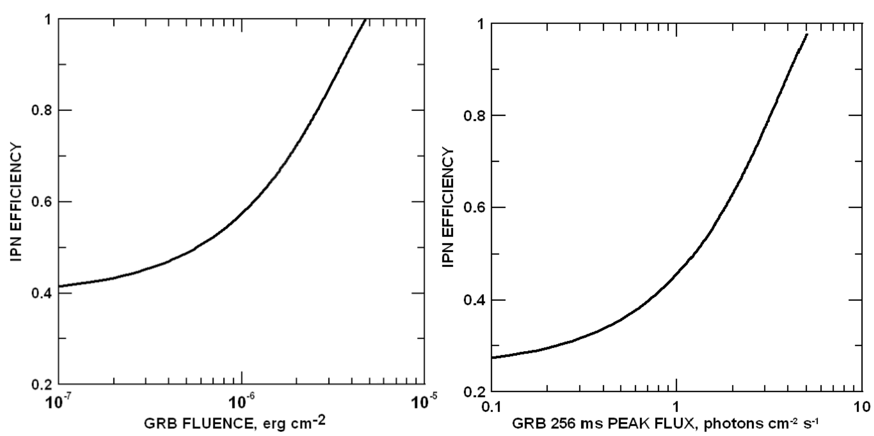

FIGURE 1. The IPN efficiency (probability of detecting a burst with two or more spacecraft) as a function of burst fluence (left) and peak flux (right), measured in the ~25-150 keV range.

BURST DETECTION RATES

The 3rd IPN has detected over 4500 cosmic gamma-ray bursts to date. However, as experiments come into and leave the network, the burst detection rate changes. This is illustrated in figure 2, where the impact of the arrival and departure of missions like Konus-Wind (1995-present) and GRO (1991-2000) can be seen in the rates. The present detection rate is about 275 events per year.

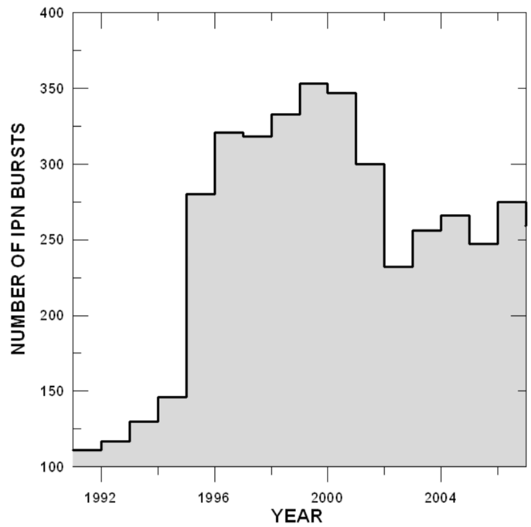

FIGURE 2. The IPN detection rate (bursts detected by two or more spacecraft) as a function of time.

IPN DATA AND ITS USES

The IPN data are public, and have been used for a wide variety of purposes, including searches for non-electromagnetic emissions from GRBs, such as gravitational radiation and neutrinos, in addition to the more mundane radio, optical, and X-ray counterpart searches. Burst lists can be retrieved at the IPN website (ssl.berkeley.edu/ipn3) and are also archived at the HEASARC, where they are available through the "browse" interface (go to Gamma Ray Bursts from the Interplanetary Network). Burst localizations are presently only available at the IPN website. Localization data is being added on a roughly daily basis, but at present the emphasis is on completing the data for the earlier events. For information on bursts which are not yet on the website, contact khurley@ssl.berkeley.edu.

THE FUTURE OF THE IPN

The IPN requires at least two interplanetary spacecraft to obtain precise localizations. MESSENGER is the interplanetary mission with the longest "guaranteed" lifetime (through March 2012). Mars Odyssey, the second interplanetary spacecraft, is subject to yearly reviews, and is currently approved through March 2009. RHESSI, Wind, and Swift undergo NASA Senior Reviews every two years.

In the early days of the IPN, it was possible to propose dedicated GRB experiments for interplanetary missions such as PVO and Ulysses. Today, this is no longer feasible, and GRB experiments must have other primary scientific objectives, such as planetary surface spectroscopy (e.g., Mars Odyssey and MESSENGER). Future interplanetary spacecraft with this capability include the Russian Sample Return mission to Phobos in 2009 or 2011, and ESA's BepiColumbo mission in 2014. Near-Earth spacecraft pose less of a problem. Missions and experiments like NeXT, SVOM, MAXI, Spectrum XG, JANUS, and EXIST, among others, will probably provide near-Earth vertices for the foreseeable future.

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