THE FIRST TWO YEARS OF THE BATSE/COMPTEL/NMSU GRB RAPID RESPONSE NETWORK

B. J. MCNAMARA, T. E. HARRISON
Box 30001/ Dept. 4500, New Mexico State University, Las Cruces, NM 88003, USA
J. RYAN, R. M. KIPPEN
Space Science Center, University of New Hampshire, Durham, NH 03824, USA
K. BENNETT, L. HANLON
Astrophysics Division, ESTEC, NL-2200 AG Noordwijk, The Netherlands
J. GREINER
Max-Planck-Institute für Extraterrestrische Physik, 85740 Garching, Germany
and
G. J. FISHMAN, C. KOUVELIOTOU, C. A. MEEGAN
Space Science Laboratory, ES 66, NASA/Marshall Space Flight Center, Huntsville, AL 35899, USA

July 14, 1995

Abstract. The BATSE/COMPTEL/NMSU Rapid Response Network (RRN) was formed to provide rapid follow-up of γ-ray bursts imaged by the COMPTEL instrument on the Compton Gamma-Ray Observatory. The RRN consists of ≈ 22 professional observatories located around the world spanning both northern and southern hemispheres. Also included in the RRN is the Airforce GEODSS network. The goal of the RRN is to perform optical and radio observations of COMPTEL error boxes as soon after the burst as possible. We present results from the first two years of operation of this network.

Key Words: – Gamma-ray bursts – Optical and radio observations

1. Introduction

The BATSE/COMPTEL/NMSU Rapid Response Network was established in 1993. Its aim is to obtain timely, deep, images (at a variety of wavelengths), of newly detected strong BATSE gamma-ray burst (GRB) fields, and GRBs that have been localized by the University of New Hampshire COMPTEL team. Here we report on the composition of the network and results obtained during its first two years of operation.

2. Network Sites

The BATSE/COMPTEL/NMSU Rapid Response Network (RRN) consists of 18 optical and 4 radio observatories located around the world. The network has redundant longitudinal coverage. This insures that our coverage is not compromised by isolated site problems. An important contributor to the

RRN is the Air Force GEODSS system. The GEODSS system consists of 3 sites that employ large aperture (1 m), wide field-of-view ($> 2^{\circ}$), Schmidt-like telescopes. They can reach $m_V \approx 17.0$ with a 0.6 second integration.

Once a GRB has been localized by the UNH COMPTEL team, network sites are notified by email, FAX, and/or telephone. We have found that a significant amount of time may pass before e-mail messages sent to the various sites are read. In order to improve our response time, a number of U.S. sites are notified by alpha-numeric pagers. Direct telephone links to the GEODSS sites have been established, while approvals to allow us to call observers in the dome at our international sites are also being obtained.

3. A Brief History of Time

The response times for follow-up observations of GRBs have been declining over time. For GRB781119, one of the best observed bursts of the 70's, the typical response times were in **100s of days**. The earliest, deep, wide field of view observations for GRB930131 were obtained **1.46 days** after burst detection (Schaefer *et al.* 1994). RRN radio observations of GRB940301, reported in Harrison *et al.* (1995), began only **0.04 days** after burst detection. We believe that the RRN has the capability of obtaining deep images **within minutes** after notification of a COMPTEL GRB localization.

4. BATSE/COMPTEL/NMSU Rapid Response Network Results

The observations being collected by the RRN are among the most extensive, timely, and deepest ever obtained for GRB localizations. The network's response is summarized in Table 1. As a result of our campaign on GRB940301 (c.f. Hanlon *et al.* in these proceedings), a number of candidate sources were identified near the burst position, but, unfortunately, none could be conclusively associated with the GRB. Nevertheless, new constraints on the fluxes that a GRB counterpart can emit at low energies were obtained. Seven hours after the burst, the optical flux of this GRB counterpart must have been less than 2.5×10^{-6} F_{γ}. This limit is a significant improvement over the previous value of 1/200 obtained by Greiner *et al.* (1994), and indicates that if optical emission is ever present, it rapidly decays. No new radio sources appeared within this error box up to 32 days after the GRB. This observation can be used to constrain models which predict such emission (e.g., Paczynski and Rhoads 1993). GRB940301 is of special interest because it may be the *first classical GRB observed to repeat* (Kippen *et al.* 1995). Details about the RRN's responses to other bursts will be presented elsewhere.

TABLE I
The BATSE/COMPTEL/NMSU Rapid Response Network Burst Alerts

Name	Burst Origin	Δt (Days)	Depth of Earliest Response
GRB930131	COMPTEL	0.28/1.46	m=6.5/20.5
GRB930309	COMPTEL	–	–
GRB930805	BATSE	1.5	3° of IPN to V = 15.0
GRB931014	BATSE	1.45	2.5° of IPN to V = 15.0
GRB931031	BATSE	2.87	3° of IPN to V = 15.0
GRB931204	BATSE	–	–
GRB931221	COMPTEL	–	–
GRB931226	BATSE	3.66	3° of IPN to V = 12.0
GRB940128	COMPTEL	1.69	14° of IPN to V = 12.0
GRB940210	BATSE	3.0	$10^\circ \times 10^\circ$ to V = 13.0
GRB940217	COMPTEL	0.71	$\leq$500 mJy at 151 MHz
GRB940301	COMPTEL	0.31	4.5° of IPN to V = 16.0
GRB940520	COMPTEL	0.37	4.5° of IPN to V = 16.0
GRB940728	COMPTEL	–	–
GRB940921	COMPTEL	–	–

5. Observational Parameter Space

Since the early 1970's, numerous GRB error boxes have been examined at different wavelengths, and over a variety of post-detection time frames. These investigations attempted to identify GRB counterparts by searching small error boxes for objects that posessed erratic variability, an unusual energy spectrum, or a gradually fading signal. The RRN has played a major role in these activities. In Figure 1 is shown the range of parameter space explored by ground-based optical follow-up efforts. The RRN's responses are indicated by filled circles. The RRN response largely defines the current boundaries of parameter space explored for optical counterparts (the same is true at radio wavelengths). The hatched area of Figure 1 delineates the region of parameter space that remains to be explored. Clearly, very rapid, deep follow-up efforts are still needed. The area we expect to explore with the capabilites of the RRN are labeled (either with the "GEODSS" system, or with network Schmidt telescopes). Radio coverage provided by the RRN has been extensive when compared to previous efforts. Future radio observations should attempt to image as deeply as possible.

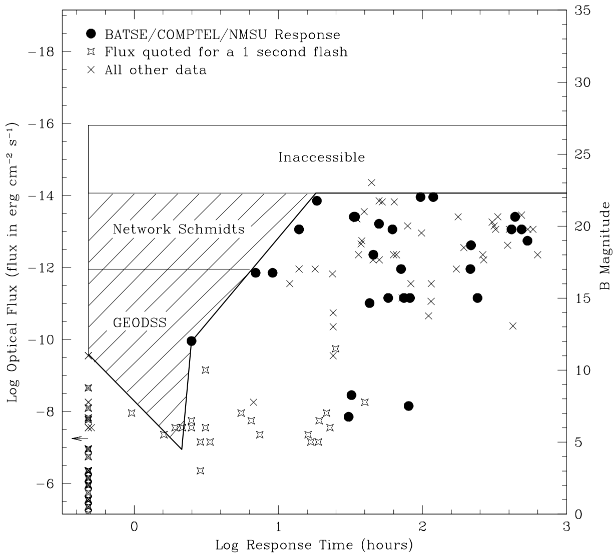

Fig. 1. Optical follow-up to GRBs. RRN responses are plotted as filled circles.

6. Summary

The BATSE/COMPTEL/NMSU Rapid Response Network has made significant contributions to limiting the time and flux domain within which a GRB counterpart may exist. The network has provided the most extensive, deepest, and timely GRB coverage ever obtained. Our results largely define the optical boundary of GRB follow-up efforts, and dominate at radio wavelengths. *The time and flux domain that has yet to be explored for GRB counterparts has been clearly identified.* To be effective, investigations of this region will require a global network of observatories with a very rapid, deep imaging capability. The RRN is well suited to meet this need. The success of our network GRB activites is largely due to the unique ability of COMPTEL to produce error boxes that are amenable to deep imaging. Software improvements at COMPTEL should soon produce GRB error boxes within 10 minutes.

References

Greiner, J., *et al.*: 1994, AIP Conference Proceedings **307**, 408.
Harrison, T. E., *et al.*: 1995, *Astron. Astrophys.*, **297**, 465.
Kippen, R. M., *et al.*: 1995, *Astron. Astrophys.*, **293**, L5.
Paczynski, B., and Rhoads, J. E.: 1993, *Astrophys. J.*, **418**, L5.
Schaefer, B. E., *et al.*: 1994, *Astrophys. J.*, **422**, L71.