A Summary of Observations Made by the GRB Coordinates Network (GCN) Sites

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Abstract. We present a status report on the broad range of follow-up observations made by the various GRB Coordinates Network (GCN) operations. Because of the wide variety and complexity of the observations, only summaries for each site and each waveband will be reported: numbers of observations and range for the time delays to be on-target, error box coverage percentages, and flux measurements or upper limits. Emphasis will be given to follow-up observations within the last year. A few of the more significant sites and observations will be high-lighted and a listing of the new instruments soon to come on-line will be given.

INTRODUCTION

The GRB Coordinates Network (GCN) has become very active since the afterglow detections in the x-ray, optical, and radio bandpasses [2] [3] and because GCN is now delivering GRB locations with error boxes compatible with medium and small FOV instruments [1] [5].

SITE STATISTICS

As of Sept 1997, GCN distributes GRB locations to 63 operations with ~200 researchers with a total of 73 separate instruments at 68 sites around the world (see Table 1). There have been 21 new sites added since June.

There are 25 optical operations, 13 radio, 21 x- and gamma-ray instruments, 2 neutrino detectors, and 2 gravity wave detectors.

Only the LOTIS, Bradford, ETC, APT, CLFST and FLIRT instruments are fully automated systems with, therefore, very short acquisition times. However, the non-automated instruments have been shown to respond as rapidly as within minutes to an hour (see Table 4).

Eight of the 21 gamma-ray instruments are special cases in that they are various spacecraft (e.g. CGRO, WIND, Ulysses, RXTE, ALEXIS). GCN provides a heads-up notification to the instrument teams so they can make quick-look analyses of their data and, therefore, potentially provide more timely, correlative information about the GRB.

TABLE 1. Active GCN Sites.

BAND PASS	INSTRUMENT, LOCATION	RESPONSE TIME	
Optical:	LOTIS; LLNL, CA	1-5 sec	Auto
	ETC; MIT, AZ	1-60 sec	Auto
	Bradford, England	0-2 min	Auto
	APT, Australia	0-1 min	Auto
	GEODSS, (Hawaii to India)	30-60 min	
	EON (Ger, Czech, Bulgaria)	0-60 min	
	Schmidt, CTIO, Chile	1-2 hr	
	ESO Obs., Chile	1-10 min	
	SBAG Obs., 6xUSA	7-15 min	
	NEAT, JPL/USAF, Hawaii	mins	
	USNO, AZ	30 min	
	U.Texas, TX	mins	
	Beijing Obs, 2xChina	mins	
	GMAN-MACHO, Mt.Stromlo,Aus	mins	
	MLOWFC 1and2, Mt.Laguna, CA	$\sim$2 min	
	H.Bond on KPNO and CTIO	hrs	
	A.Chernenko SAO_Rus 6m, Russia	hrs	
	GAMA, Cz amateurs	hrs	
	LONEOS, AZ	hrs	
	M.Garcia, Whipple 1.2m, AZ	$<$24 hrs	
	H.Pedersen, NOT, Canary Islands	hrs	
	B.Schaefer, CTIO Schmidt	hrs	
	A.Castro-Tirado, Spain	hrs	
	T.Galama, Netherlands	hrs	
	S.Howell, AZ	hrs	
	Super-LOTIS; LLNL, CA (3)	5 min	Auto
	TAROT, France (3)	secs	Auto
	Ondrejov Robotic Tele, Czech (3)	0-1 min	Auto
	ROTSE-Wide, NM (3)	1-5 sec	Auto
	ROTSE-Narrow, NM (3)	$\sim$20 sec	Auto
	ROYDS, Tenerife (3)	secs	Auto

Tables 1, 2 and 3 list the sites that are currently operating using the GCN system. They are divided into the optical, radio, gamma-ray band passes, and other. The first column is the name of the instrument and its location(s). The second column lists the range of typical target acquisition times (not including

TABLE 2. Active GCN Sites.

Radio:	FLIRT; Cal Tech, CA	5 sec	Auto
	CLFST, MRAO, England	0-2 min	Auto
	STARE, NH (1)	0 sec	Auto
	Haystack, Mass	1-60 min	
	Effelsberg, Germany	1-24 hr	
	Westerbork, NL	2-6 hr	
	Parkes, Australia	1-6 hr	
	VLBA (Hawaii to St.Croix)	5-15 min	
	VLA, NM, D.Frail	1-2 day	
	Tenerife-II, Bartol	10-300 sec	
	NRAO, Virginia	3-12 hrs	
	BIMA, CA	12-30 hrs	
	S.Kulkarni	hrs	

TABLE 3. Active GCN Sites.

Gamma Ray:	WHIPPLE Obs., Mt.Hopkins, AZ	15 min
	CASA-MIA, Utah	0-5 min
	HEGRA, La Palma	5-7 min
	HEGRA, Dugway	several min
	CANGAROO, Australia	0-5/20 min
	AKENO, Japan	several min
	INCA, Bolivia	few hrs
	EASTOP	few hrs
	MILAGRO, NM (3)	15 min
	GRO-COMPTEL (1) (2)	15 min
	GRO-EGRET (1)	1 hr
	GRO-OSSE (1)	3 hr
	IPN-Ulysses (2)	2-6 hr
	RXTE-PCA	2-4 hr
	RXTE-ASM (1)	0 hr
	BeppoSAX-GRBM/WFC/MECS/LECS	1-4 hr
	WIND-TGRS (1)	1-2 day
	WIND-KONUS (1)	week
	ALEXIS (1)	1-4 hr
	DMSP (1)	2 day
	ASCA	$\sim$1 day
Other:	J. Weber, MD	0 min
	ROG, G.Pizzella, Italy	0 min
	Super-Kamiokande, Japan (1)	0 min
	MACRO, Italy (1)	0 min

the 5 sec of delay in the BATSE-to-GCN system). Sites with a zero response time are "stare mode" instruments, i.e. they are taking data continously with a large FOV and are therefore on-target when the burst occurs. Some systems are suffixed with an "auto" marker, which means they are totally automated, hence the small response time. Sites marked with a "(1)" use the Notices as a "heads-up" function to allow them to more quickly analyze their data and look for the GRB. Those sites marked with a "(2)" receive BATSE or COMPTEL data in real-time from the GCN system, allowing them to analyze their data in minutes instead of a day's delay, to derive improved GRB positions. The sites marked with a "(3)" are in the building phase and will be operating within the next 6-12 months.

RESULTS OF FOLLOW-UP OPERATIONS

A summary: As of May 25 1997, 409 (237 in the last 13 months) follow-up observations on ~350 different GRBs have been made by various GCN operations. See Table 4 for a summary. For each operation the total number of observations plus the number within the last 13 months (in parentheses) along with the range of delay times is listed (column 3); the range of percent coverage of the final error box (column 4); the instrumental upper limits (column 5) are listed as ranges because the conditions for each observation vary. Several of the entries are "TBD" indicating that the information is not known at this time. This table attempts to list only the range of observations made and the upper limits – only a "flavor" of the body of efforts encompassed.

Highlights of a few entries: LOTIS (the first of the 2nd generation instruments) now has 9 observations with quick response, excellent coverage, and improving sensitivity. The large set of 28 lower-sensitivity GROCSE follow-ups is still impressive. The EON (European Observation Network) "narrow" FOV observations are a large set; but as fate would have it, the shortest delay times have the poorest error box coverage and/or the poorest upper limits. The EON "wide" FOV observations have a fair number which are truly simultaneous, but the extreme wide FOV of the instruments (meteor patrol systems) means that the upper limits are not very constraining. The automated radio system, FLIRT, has made 71 observations at 74 MHz to 100 Jy. Their response times are encouraging for radio dispersion delay measurements. These instruments cover the initial portion of the light curve that can not be accessed with the BeppoSAX procedure. RXTE has joined the list with an impressive first-time observation at T+3.3 hours. The GEODSS system covers a large area quickly and to a reasonable sensitivity. They are improving their response times and are now attaining <1 hour.

THE FUTURE

GCN has reduced the delay in making follow-up observations on GRBs from weeks and days to hours and minutes, and even to seconds for the fully automated LOTIS, APT, ETC, CLFST and FLIRT systems. This will improve further, because 7 of the new optical instruments slated to come on-line in

TABLE 4. FOLLOW-UP OBSERVATIONS SUMMARY.

Site Name	Total Number GRBs (Cy 6)	Delay Times	Coverage [%]	Instrumental Upper Limit
LOTIS	9 (9)	9-20 sec	80-100	11-14 mag
GROCSE	29 (1)	0-128 sec	85-100	7.5-8.5 mag
EON Narrow	18 (5)	5-20 hr	30-100	12-16 mag
EON Wide	51 (20)	0-6 hr	80-100	4-11 mag
USNO	1 (1)	30 hr	$\sim$100	$\sim$19 mag
ETC	1 (0)	90 sec	> 50	10 mag
GEODSS	6 (?)	$\sim$1 hr	> 90	> 15 mag
SBAG	8 (0)	0.2-5 hr	35-100	8-10 mag
KPNO	1 (0)	28 hr	> 99	> 18 mag
Lick	2 (0)	1-2 day	TBD	18 mag
CLFST	7 (0)	0-3 min	50-90	75-300 Jy
FLIRT	71 (15)	8-11 sec	TBD-100	100 Jy
Effelsberg	1 (1)	TBD	$\sim$100	30 mJy
VLBA	1 (0)	5 day	> 70	40 Jy
VLA	3 (0)	1-9 day	75-100	1-5 mJy
Tenerife	1 (0)	17 hr	20	6-20 Jy
Langston	3 (0)	12-24 hr	$\sim$10-70	2 Jy
RXTE-PCA	1 (1)	3.3 hr	$\sim$100	< 2 mCrab
OSSE	1 (0)	3 hr	< 50	TBD
ALEXIS	4 (4)	0 sec	100	1000 ph/cm^{2}sec
Whipple	15 (5)	2-60 min	$\sim$0-75	$>10^{-9}$ erg/cm^2
HEGRA Cher	2 (2)	10 min	0	1-5x10^{-9} ph/cm^{2}sec
HEGRA Scint	30 (30)	10 sec	100	5x10^{-8} ph/cm^{2}sec
Chacaltaya	104 (104)	0 sec	100	.08-2x10^{-3} ph/cm^{2}sec
RON	39 (39)	0 sec	100	TBD

the near future (see Table 1 entries marked with a “(3)”) are fully automated, fast-slewing systems.

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