# A SEARCH FOR PROMPT RADIO EMISSION FROM GRBS

D.A. GREEN, C.A.-C. DESSENNE, P.J. WARNER, D.J. TITTERINGTON and E.M. WALDRAM
*Mullard Radio Astronomy Observatory, Cavendish Laboratory, Madingley Road, Cambridge CB3 0HE, United Kingdom*

S.D. BARTHELMY, T.L. CLINE, N. GEHRELS and D. PALMER
*Goddard Space Flight Center*

and

G.J. FISHMAN, C. KOUVELIOTOU and C.A. MEEGAN
*Marshall Space Flight Center*

**Abstract.** The Cambridge Low Frequency Synthesis Telescope (CLFST) is being used to search for prompt radio emission from GRBs at 151 MHz. For this search a special observing mode has recently been developed; the antennas of the CLFST are split into seven groups which are spaced about 30° apart. When triggered by the real-time signals from the BACODINE system the antennas are slewed to the GRB position, with data being sampled at 1.5 or 3-s intervals. The antennas slew at about 10° per minute, so that an appreciable fraction of the sky can be accessed on timescales of a few minutes – any prompt radio emission from a GRB might be delayed by this timescale due to propagation effects.

**Key words:** GRB radio counterparts – BACODINE

## 1. Introduction

Although there are many models of gamma-ray bursts (GRBs) available (e.g. Nemiroff 1994), there are no convincing observations of counterparts to help constrain viable models. We are exploring one possible type of counterpart, by trying to identify prompt radio emission – "spikes" – from GRBs. Even if only a very small fraction of the total energy emitted in a GRB is radiated at radio wavelengths this will produce a relatively bright signal by radio astronomical standards. Baird et al. (1975) report an unsuccessful search for coincident radio pulses made in 1970–73 with a limit of the order of $10^5$ Jy (1 Jy = 1 jansky = $10^{-26}$W m$^{-2}$Hz$^{-1}$). We report here the progress of a search for coincident radio pulses from GRBs which promises a sensitivity of several orders of magnitude better than this limit.

## 2. Observations

The Cambridge Low Frequency Synthesis Telescope (CLFST) is an east–west aperture synthesis telescope (e.g. McGilchrist et al. 1990) operating at 151 MHz. It consists of 60 sets of yagi antennas spread along a 4.6-km baseline. Conventional observations made with the telescope over the last ten years consist of 12-h syntheses, which result in images with a resolution

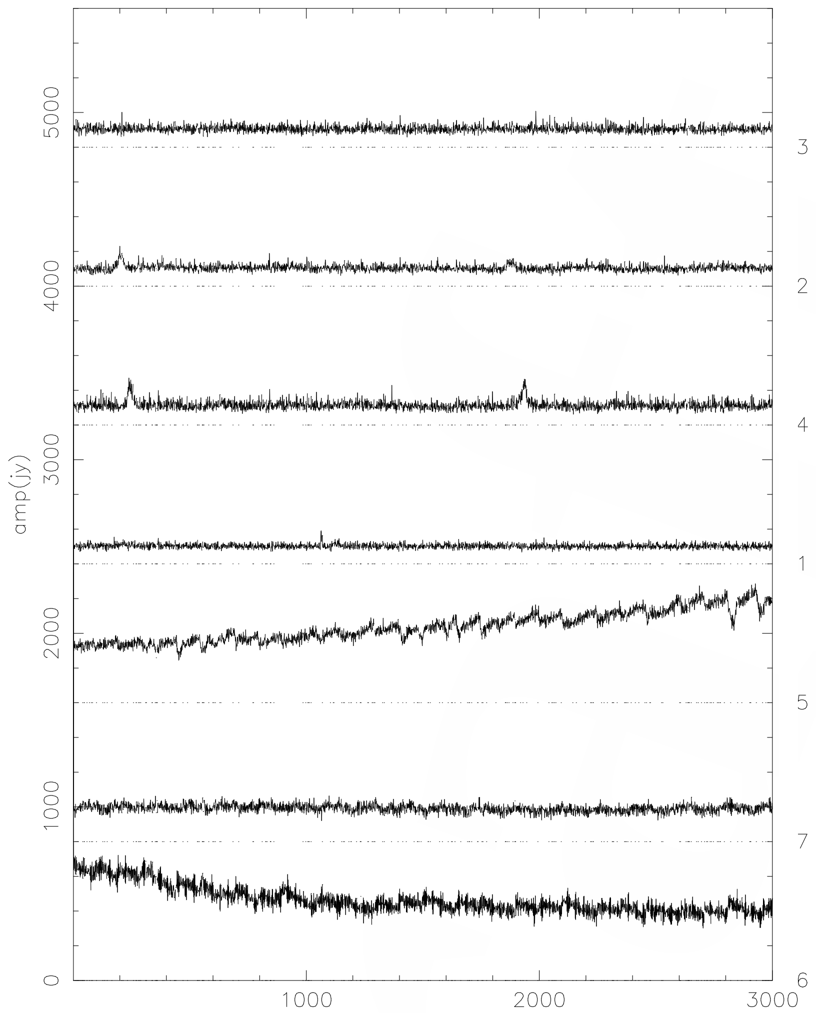


Fig. 1. The average amplitude versus sample number in each of the seven "beams" for 75 min of data, sampled at 1.5 s. The correlator produced spikes have been removed (at the positions indicated by the dots below each plot), and the plots have been offset by multiples of 800 Jy for clarity. The increased variations seen in beams 5 and 6 are due to the proximity of the bright radio source Cyg A. The arrangement of beams on the sky is: ${}_6{}^7{}_5{}^1{}_4{}^2{}_3$, with beams 7, 1, and 2 centred at $\delta = 65°$, and beams 6, 5, 4 and 3 at $\delta = 35°$.

of $1.2 \times 1.2\,\mathrm{cosec}(\delta)$ arcmin$^2$, with a wide field-of-view ($\sim 10°$). The sensitivity of such observations is typically 30 mJy beam$^{-1}$, although near bright sources such as Cas A, Cyg A and the Crab Nebula, or the Galactic plane, it can be considerably worse. For conventional observations an effective sampling of 30 s is used, each sample being the average of twenty 1.5-s samples which are automatically clipped for obvious interference spikes.

The CLFST has been used to make conventional images of the fields of several GRBs on timescales of days to about a year after the burst, to search for variability of any radio sources found in the field. So far no variations have been found (see Koranyi et al. 1994, 1995 for observations of GRB 920711 and 940301).

To search for any prompt radio emission we have developed a new mode of operation for the CLFST. The antennas of the telescope are split into seven groups or "beams", each of which is pointed in a different direction, to increase the effective field-of-view of the telescope, albeit at the expense of sensitivity. The pointings, each with a field-of-view of $\sim 10°$, are separated by about 30° in declination and $2^{\rm h}$ in right ascension. Each group of antennas consists of 14 or 16 independent baselines. In this new mode of operation the observed data are sampled at either 1.5 s (the intrinsic sampling built into the telescope hardware) or 3 s (to save diskspace), rather than the usual 30 s. The clipping of large signals, which would normally be done to eliminate interference, is not done in this mode.

Using the BACODINE system (Barthelmy et al. 1993), the approximate position of a GRB is available over the Internet only a few seconds after a burst is detected by BATSE on board the Compton Gamma Ray Observatory (Gehrels et al. 1993). This position is relayed to the CLFST realtime control computer, which – if the telescope is in the GRB waiting mode – can then slew the telescope to the GRB position. Since we are observing at a low frequency, any radio emission coincident with the GRB will be delayed due to propagation through the interstellar and/or intergalactic media. At our observing frequency (151 MHz) a time delay of the order of a few minutes is expected (Palmer 1993). The antennas of the CLFST can slew at a rate of about 10° per minute, so that a considerable fraction of the sky is accessible by one or more of the waiting groups of antennas.

This GRB waiting mode has been developed since the beginning of 1995, for use in the daytime when the CLFST is not being used for conventional 12-h observations. Although all the components of the system needed to trigger the telescope are in place, and have been tested, we have not yet been observing in this mode when BACODINE trigger signals have been received.

## 3. Preliminary Results

Observations made in this new mode reveal many short timescale spikes and other short features in the amplitudes averaged over the different groups of antennas (see Fig. 1). Many of the spikes are very similar in character, being a single sample, with an amplitude of the order of a thousand janskys. These are due to correlator errors, and are identified and removed automatically. (These glitches are not not evident in conventional observations, as they are automatically clipped as interference before the data are averaged to give 30-s samples). Our sensitivity in a given single group of antennas is of order of hundreds of janskys (see Fig. 1).

We are currently investigation the nature of the spikes and features seen, in order to understand what is "normal" interference, and how to decide what is terrestrial or aircraft or satellite interference. This is a complicated task, since in the conventional operation of the telescope almost all of these features are eliminated automatically, or in the subsequent analysis, so that we have not been previously studied. Local interference shows up in multiple beams, whereas aircraft or satellite interference occurs in adjacent beams at slightly different times (see Fig. 1, beams 2 and 4, near samples 200 and 1900).

An important property of the data is that each group of antennas has a range of baselines, small and large up to about 4.6-km. The range of baselines allows us to use the variation of amplitude and/or phase with baseline to distinguish between different types of interference. Data from a single sample, or a few samples, from a particular sub-beam can be used to synthesize a 1-D image with a resolution of about 1 arcmin. In addition, the phase information from a given group of antennas can, in principle, be used to see if there is evidence for curvature in the wavefront from terrestrial signals, or not.

## 4. Conclusions

The wide field-of-view of the CLFST, together with the prompt reporting of approximate GRB positions with the BACODINE system means that we are in a good position to make sensitive, directed searches for prompt radio emission from GRBs. It is planned to continue to run the CLFST in this mode in during daytimes, when it is not been used for conventional observations.

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