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W Collmar
Max-Planck-Institut für extraterrestriche Physik

K Bennett
ESTEC

H Bloemen
Space Research Organization of the Netherlands

H deBoer
SRON

M Busetta
ESTEC

See next page for additional authors

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Authors
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COMPTEL observations of gamma-ray bursts: time profiles and spectra

W. Collmar[1], K. Bennett[4], H. Bloemen[2], H. de Boer[2], M. Busetta[4], A. Connors[3], R. Diehl[1], J. Greiner[1], L. Hanlon[4], J.W. den Herder[2], W. Hermsen[2], L. Kuiper[2], G.G. Lichti[1], J. Lockwood[3], J. Macri[3], M. McConnell[3], D. Morris[3], R. Much[1], J. Ryan[3], V. Schönfelder[1], J.G. Stacy[3], H. Steinle[1], A.W. Strong[1], B.N. Swanenburg[2], B.G. Taylor[4], M. Varendorff[1], C. de Vries[2], W. Webber[3], O.R. Williams[4] and C. Winkler[4]

[1] Max-Planck Institut für extraterrestrische Physik, D-8046 Garching, Germany
[2] Laboratory for Space Research, Leiden, P.B. 9504, NL-2300 RA Leiden, The Netherlands
[3] University of New Hampshire, Institute for the Study of Earth, Oceans and Space, Durham NH 03824, U.S.A.
[4] Astrophysics Division, Space Science Department of ESA/ESTEC, NL-2200 AG Noordwijk, The Netherlands

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Abstract. — The COMPTEL experiment aboard CGRO is designed to image celestial γ-radiation in the energy range from 0.7 - 30 MeV, and also to accumulate time-resolved NaI detector spectra (0.1 - 10 MeV) upon receipt of a BATSE burst trigger signal. During the early phases of the GRO mission several bursts have been observed. In this paper we present time profiles and first results from spectral analysis for GRB 910425, GRB 910601, and GRB 910814.

Key words: gamma rays — gamma ray bursts.

1. Introduction.

The imaging Compton telescope COMPTEL is one of four instruments on board the Compton Gamma Ray Observatory satellite (CGRO), launched on April 5, 1991. COMPTEL can observe γ-ray bursts by two different modes: the 'telescope mode' and the 'single-detector mode'.

In the 'telescope mode' a γ photon is first Compton scattered in one of the upper detector modules followed by an interaction in a module of the lower detector. This is the normal operating mode of COMPTEL where imaging in the 1 steradian field of view with a location accuracy of $\sim 0.5°$ is possible. This mode is described in detail by Schönfelder *et al.* (1984).

In the 'single-detector mode' described in detail by Winkler *et al.* (1986) two NaI modules of the lower detector are used as burst detection modules covering two different energy ranges: a low range of $\sim$ 0.1 MeV to 1.1 MeV and a high range of $\sim$ 1 MeV to 10 MeV. These burst modules can accumulate energy spectra in three different modes according to different telecommandable integration times. For all the bursts discussed in this paper, the integration times were set to 0.5, 6, and 100 seconds for high, medium and low time resolution, respectively. In the absence of a BATSE trigger, spectra with low time resolution are accumulated for background estimates. If BATSE detects a γ-ray burst, a trigger signal is sent to the two COMPTEL burst modules causing them to enter their burst mode with the accumulation of six high time resolution spectra. Then 133 tail spectra of intermediate time resolution are accumulated before the low time resolution background mode is entered again.

From the γ-ray bursts observed by COMPTEL, the brighter ones occurring within its field of view could be imaged and localized (Varendorff *et al.* 1992 and Connors *et al.* 1992). For GRB 910503 preliminary spectral results have already been published (Winkler *et al.* 1992). In this paper we present time profiles and first spectral results for GRB 910425, GRB 910601, and GRB 910814. Unfortunately, for the latter two bursts only high-range data are available as the low-range burst module had to be switched off on May 25, 1991.

2. Data and analysis.

2.1. Time profiles.

In Figure 1 the time profiles of the three bursts as observed by the high-range burst module are shown. These profiles are generated by energy integration of the accumulated spectra. The lightcurves are deadtime corrected but not background subtracted. In the plots the transitions from the background mode into the high time resolution burst mode at the BATSE trigger and later on into the tail mode is visible. While for GRB 910814 the countrate rose right at the BATSE burst trigger, for GRB 910425 and GRB 910601 the main burst emission was delayed by several seconds. The observed time profiles of these three bursts already illustrate the great variety in temporal structure seen for γ-ray bursts in general. The corresponding telescope mode light curves are published in Varendorff *et al.* (1992).

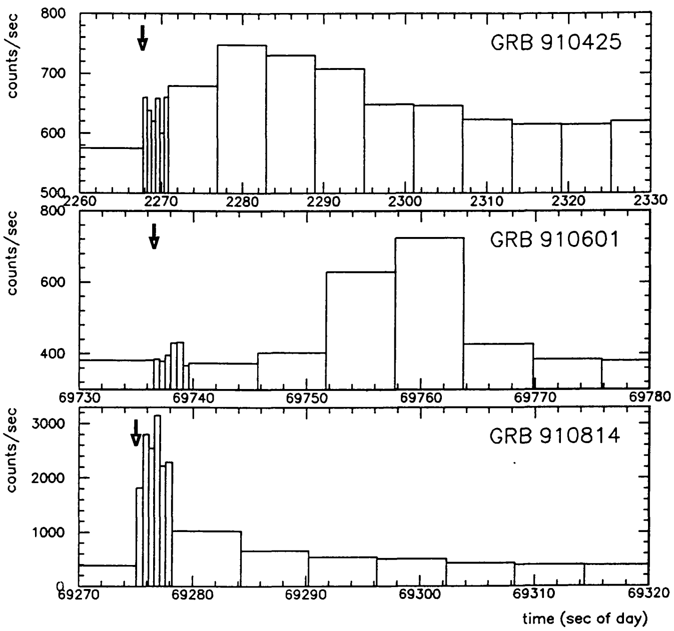

FIGURE 1. High-range time profiles for GRB 910425, GRB 910601, and GRB 910814. The BATSE triggers are indicated by arrows.

2.2. SPECTRAL EVOLUTION.

In order to search for spectral evolution during the bursts, hardness ratios have been calculated using energy-integrated, background-subtracted, and deadtime-corrected countrates. For GRB 910425 the hardness ratio was derived by dividing the countrate of the high-range burst module by the one of the low range. For the two latter bursts the spectra of the high range module had to be subdivided into two energy intervals. To obtain reasonable countrate statistics in each interval, the subdivision was made at 2 MeV. In none of the three bursts could any significant spectral evolution with time be observed. This is unlike GRB 910503 for which clearly a hard-to-soft evolution could be seen in the COMPTEL data (Winkler *et al.* 1992).

2.3. ENERGY SPECTRA AND FLUENCES.

For each burst time-integrated and background-subtracted energy spectra have been derived. The last complete background spectrum prior to the burst was used for background subtraction. In Figure 2 the count spectra observed from the high-range burst module, including the best fitting power-law model, are given. The fitting was done for energy ranges which are limited by avoiding threshold effects on the lower side and by signal-to-

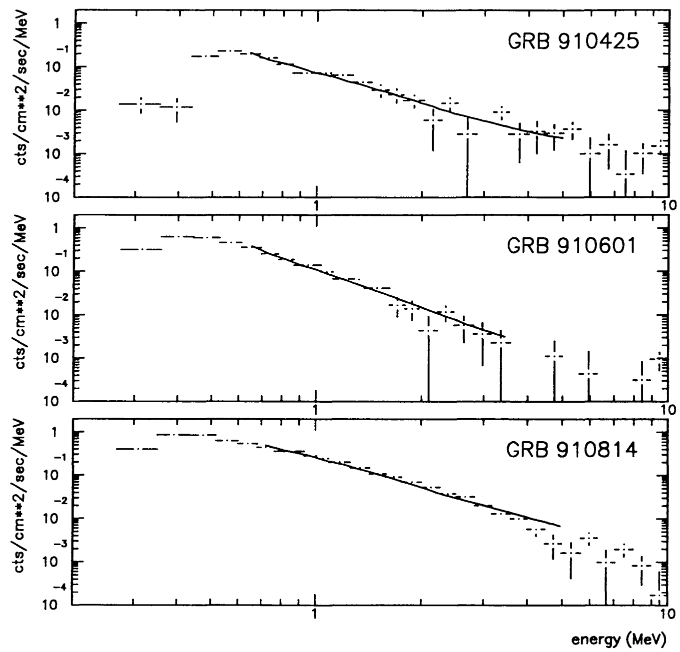

FIGURE 2. Time integrated counts vs. energy spectra including best-fit power-law model for GRB 910425, GRB 910601, and GRB 910814.

TABLE 1. *Summary table.*

GRB	910425	910601	910814
detectors	low/high	high	high
BATSE trig.	2268 sec	69736 sec	69275 sec
duration	75 sec	33 sec	40 sec
emission (MeV)	to $\sim$ 5	to $\sim$ 3.5	to $\sim$ 5
spec. evolution	none obs.	none obs.	none obs.
spectral fitting			
low range (MeV)	0.4 - 1	——	——
PL-index (90%)	-2.2±0.2	——	——
high range (MeV)	0.7 - 5	0.7 - 3.5	0.7 - 5
PL-index (90%)	-2.2±0.1	-2.75±0.15	-2.1±0.1
fluence (erg/cm^2)			
S(>0.1 MeV)	$8 \cdot 10^{-5}$	——	——
S(>1.0 MeV)	$4 \cdot 10^{-5}$	$2.3 \cdot 10^{-5}$	$1.1 \cdot 10^{-4}$

background ratio the upper side. A fit to the low-range burst spectrum for GRB 910425 is in good agreement with the fit derived in the high range. The results of the power-law fits are given in Table 1.

Using the derived spectral parameters along with the known integration time of the burst spectrum, burst fluences can be obtained. The fluences calculated for two energy ranges are given in Table 1.

3. Summary.

First results of three γ-ray bursts occurring in the COMPTEL field of view for some ten seconds have been derived. All three bursts were seen in the 'telescope mode' as well as in the 'single detector mode' with significant emission up to at least 4 MeV. This confirms that emission above 1 MeV is a common and characteristic feature of γ-burst spectra (Matz *et al.* 1985). Up to 4 MeV there are no indications of a sharp spectral cutoff as might be expected from e^+e^--pair production by high energy γ-rays moving in a strong magnetic field of a neutron star. According to Harding *et al.* (1986) and Higdon & Lingenfelter (1990) the transverse component of the magnetic field, $B \sin\theta$, must be less than $\sim 2E(\mathrm{MeV})^{-0.9} \times 10^{12}$ G (assuming a path length through the magnetic field of $\sim$1 km) to enable photons to escape without significant attenuation from pair production. Emission up to at least 4 MeV as seen for all three bursts would therefore constrain $B \sin\theta$ to less than 0.6×10^{12} G at the production site of the high energy γ-rays.

First spectral fitting, based on simple power-law models only, showed that the $\geq$ 1 MeV emission differs from burst to burst. For example, the spectra of GRB 910425 and GRB 910814 (with power-law indices of about -2.2) were flatter than the one of the June 1 burst with an index of -2.75. A more detailed spectral analysis applying also other spectral models (e.g. thermal bremsstrahlung, broken power-laws) is in progress. This is in particular necessary for the spectrum of GRB 910814 which is not well described by a simple power-law up to the highest energies.

Significant spectral time evolution was not observed in any of the three bursts.

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