MEV MEASUREMENTS OF GAMMA-RAY BURSTS BY CGRO-COMPTEL

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ABSTRACT

Since the launch of the Compton Gamma–Ray Observatory in April 1991, the imaging COMPTEL telescope has accumulated positions and 0.75–30 MeV spectra of more than thirty gamma-ray bursts within its $\sim \pi$ sr field of view. In an ongoing collaboration with BACODINE and New Mexico State University (BCN), COMPTEL positions are relayed to a global network of multiwavelength observers in near real time ($\sim$ 10 minutes). Here we present spatial, spectral, and temporal data for the latest of these events, GRBs 960808, 961001, and 961212. In concurrence with earlier SMM and current BATSE, OSSE, and EGRET measurements, COMPTEL data add to the accumulating evidence that GRB spectra do seem to have a characteristic shape: a peak (in $E^2F(E)$) around several hundred keV; and a power law above (spectral index 1.5-3.5) extending beyond the COMPTEL energy range.

INTRODUCTION

The detection of fading light from the explosive event known as GRB 970228 profoundly changed the decades-old controversy over the nature and origin of gamma-ray bursts. The arc-minute X-ray position, measured hours after the initial burst was detected by BeppoSAX, lit the way for the detection of the first optical counterpart of a gamma-ray burst, possibly a point source on the edge of a distant galaxy (Van Paradijs et al. 1997 and references therein). Since then, BeppoSAX X-ray detections of a much fainter event, GRB 780508, led to optical and radio counterparts that apparently brightened for several days (Bond 1997; Frail et al. 1997). However, no optical or radio counterparts were detected for the more intense event GRB 970111, or the fainter event GRB 970402 (Castro-Tirado et al. 1997; Groot et al. 1997). Do the different gamma-ray, x-ray, optical, and radio behaviors of these intrinsically gamma-ray events signal different classes of explosive events, or do all have a single physical origin? What would an optical counterpart look like, if measured within minutes rather than hours or days after the burst? The new discoveries have sharpened the ongoing debate.

In a novel use of its direct imaging of MeV photons, the Compton Telescope (COMPTEL) on board the Compton Gamma-Ray Observatory (CGRO), in partnership with BACODINE and New Mexico State, broadcasts $\sim 1-2^\circ$ GRB positions to a world-wide network of ground-based observers within 7-15 minutes of the onset of a bright MeV burst within its $\sim \pi$ steradian field of view (McNamara et al. 1995a,b; McNamara et al. 1996). This raises the exciting possibility of catching an afterglow with a decay time considerably shorter than that of GRB 970228. Also, COMPTEL measures spectra and light-curves of bursts in its field of view both in its imaging telescope mode (0.75-30 MeV) and its spectroscopic single detector mode (0.1-11 MeV) (Schönfelder et al. 1993). From launch in April 1991 through April 1995, the COMPTEL collaboration had accumulated measurements of positions, light-curves and spectra of 29 bursts that occured within 65° of telescope zenith (Kippen et al 1997a,b; Kippen at al 1996 and refs therein). In this paper, we describe the detection of three more bursts, bringing the total COMPTEL sample to 32.

In the next section we present the data, including preliminary positions, light-curves, and spectra of the new events. In section 3 we summarize some global properties of the COMPTEL burst catalog.

OBSERVATIONS: GRB 960808, GRB961001, and GRB 961212

The search for bursts in COMPTEL data followed the procedure described in Kippen et al. (1997b). Light-curves around the time of the BATSE trigger were examined both with an automatic routine and by hand, for all bursts with BATSE zenith $< 65°$. Maximum likelihood maps were created for the best burst time interval. Bursts with a maximum log-likelihood > 20 were considered positive detections. Below we display light-curves and position contours for the three bursts detected by COMPTEL since April 1995. We used standard data selections, plus for the light-curves we required events to fall within $\pm 10°$ of the best fit position.

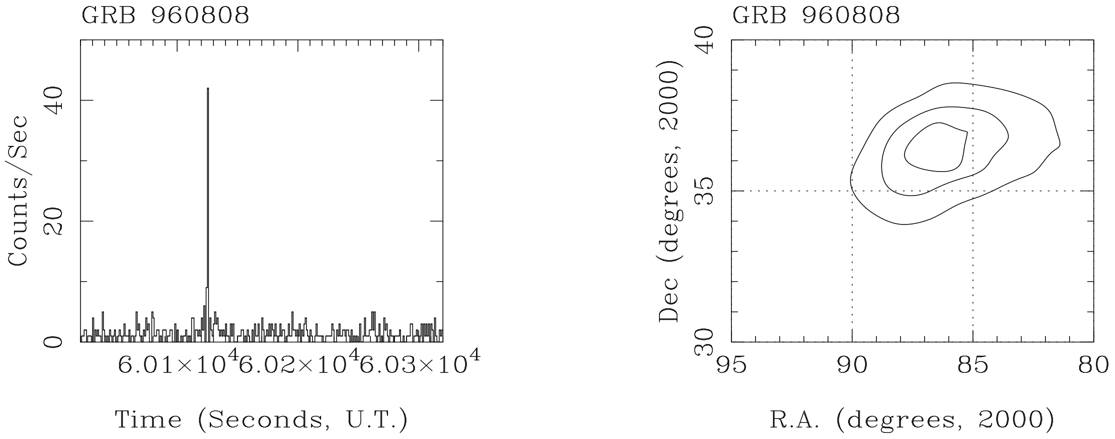

Fig. 1: COMPTEL telescope light-curve in counts per 1 second bin (left); and 1, 2, and 3σ *position contours (right) for GRB 960808.*

The bright gamma-ray burst which occurred on 08-August-1996 at 16:42:03 UT was detected by the COMPTEL telescope with a significance of about 6.3 sigma. The current most probable COMPTEL position of GRB 960808 is (R.A., Decl. 2000) of $(86.38°, 36.53°)$ with a mean 2σ error radius $\sim 0.9°$. Unfortunately, the BACODINE system did not respond to this burst so that rapid follow up observations could not be obtained.

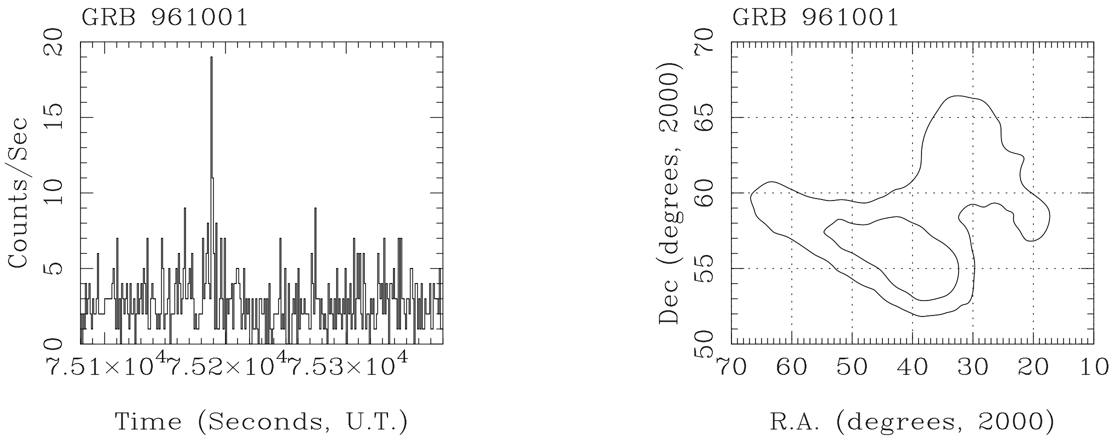

Fig. 2: COMPTEL telescope light-curve in counts per 1 second bin (left); and 1, 2, and 3σ *position contours (right) for GRB 961001.*

The gamma-ray burst which triggered BATSE/BACODINE on 01-Oct-1996 at 20:53:05 UT was detected by the COMPTEL telescope with a significance of about 4 sigma. An initial localization of this burst was distributed to the BCN observer network only 8.5 minutes after the trigger. Unfortunately, the localization is not very accurate due to few events and the proximity of the source to the earth's limb. The burst was also detected by Ulysses, providing an IPN timing annulus (Hurley et al 1996). The current most probable COMPTEL position of GRB 961001 is (R.A., Decl. 2000) of $(37.75°, 54.80°)$ with a mean 2σ error radius $\sim 1.9°$.

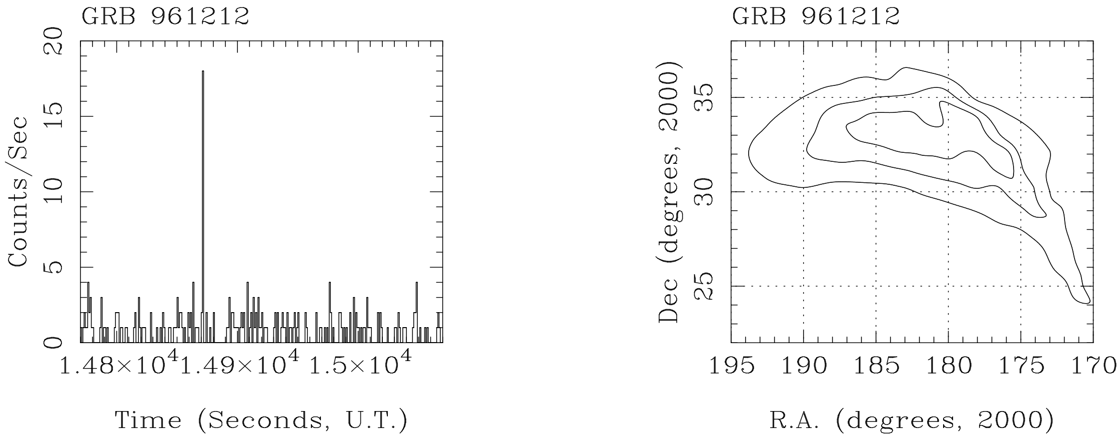

Fig. 3: COMPTEL telescope light-curve in counts per 1 second bin (left); and 1, 2, and 3σ *position contours (right) for GRB 960808.*

The latest COMPTEL telescope detection occurred on 12-December 1996 at 04:07:51 UT. The event was about 42 degrees from telescope zenith, but bright enough so that about thirty 0.75-30 MeV burst photons were detected in about 1.5 seconds. On rare occasions, the automatic estimate of the burst interval is not optimal, and the duty scientist must re-calculate the burst position with better time limits, delaying the procedure by about 7 minutes. The single-spike light-curve of GRB 961212 caused just this difficulty, so launch of the burst position to the world-wide BCN network of ground-based observers was delayed until about 15 minutes after burst onset. The preliminary most probable position is (R.A., Decl. 2000) of $(180.1°, 33.7°)$ with a mean 2σ error radius $\sim 1.8°$. No IPN detection was available for this burst (Hurley et al. 1996).

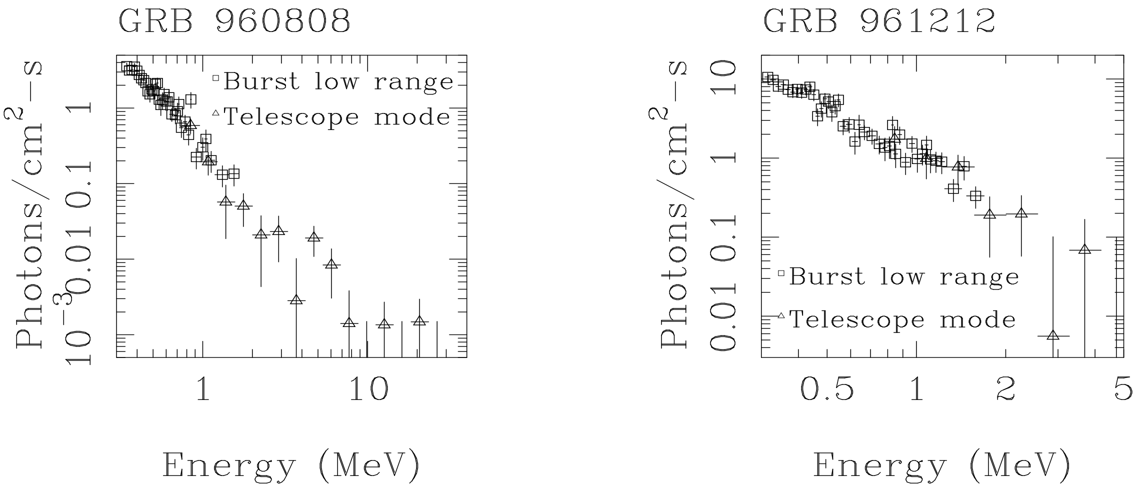

Fig. 4: COMPTEL low-range burst detector plus telescope spectra for GRB 960808 (left) and GRB 961212 (right).

Above we show preliminary spectra for GRB 960808 and GRB 961212. Since GRB 961001 occurred so close to the bright Earth's limb, we did not analyze its spectrum. Both appear consistent with power-laws in our energy range. The 0.3-1 MeV low-range burst mode data and 0.75-30 MeV telescope data were analyzed following the procedures in Hanlon et al. (1994) and Kippen et al. (1996), repectively. For GRB 960808, we used a 14 s integration time, while for GRB 961212, we used a 2 s integration time. The best fit for the former was $N_E(E) \sim (0.3 \pm 0.02)E^{-2.4\pm0.09}$; and for the latter, $N_E(E) \sim (0.9 \pm 0.3)E^{-2.1\pm0.5}$.

SUMMARY AND CONCLUSIONS

Spectral characteristics are often considered key to revealing underlying physical mechanisms. In a few bright bursts, COMPTEL has measured curvature consistent with a peak in nu-Fnu space at around 1 MeV, as shown in Winkler et al. (1995a,b); Hanlon et al. (1995); see also Hanlon et al. (1994). However, for the COMPTEL sample of bursts as a whole, Kippen et al (1996, and references therein) , summarizing results through April 1995, finds that above ~ 1 MeV, the distribution is consistent with power–law spectra, with an average photon index ~ 2.5 . The most recent bursts have spectra consistent with this. This, in addition to SMM, OSSE, BATSE, and EGRET results, (Winkler et al 1995a,b; Matz et al 1985; Share et al 1994; Schaefer et al. 1994; Band at al. 1993), show that gamma-ray bursts as a class do indeed seem to have a characteristic shape: a peak in nuFnu space somewhat less than an MeV, and typically around 200 keV, followed at higher energies by a power-law tail extending out as far as it as measureable, sometimes to 100 MeV or more; with some indication of more flattening when connected to yet lower energies (Aigner et al. 1995) No significant line features have been detected in any individual burst.

COMPTEL continues to detect MeV-bright bursts in its field of view, at the rate of several per year. We look forward to distributing rapid $\sim 1^\circ$ locations for more bursts in the near future.

ACKNOWLEDGEMENTS
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