Observations of the 1991 June 11 solar flare with COMPTEL

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ABSTRACT

The COMPTEL instrument onboard the Compton Gamma Ray Observatory is well suited for the observation of solar flares. It is sensitive to γ-rays in the energy range from 0.75 to 30 MeV. In addition COMPTEL has the novel capability to detect individual neutrons from solar flares.

During the period of unexpectedly high solar activity in June 1991 several flares from active region 6659 were observed by COMPTEL. For one of these - that of June 11th - we present the latest results from the analysis of COMPTEL data. This includes the time history of the γ-ray emission extending for at least two hours after the impulsive phase.

INTRODUCTION

On June 11th the active solar region 6659 produced a huge flare, being accompanied by a loop prominence. It was classified as a 3B event optically and as a X-12 GOES event. The X-ray emission has started at 1:56 UT, had a maximum at 2:09 UT and faded away at about 2:20 UT. Orbital sunrise of Compton GRO has taken place at 1:48 UT, a few minutes before the flare onset. So the evolution of the flare can be studied for a whole orbital observation period. In its telescope mode COMPTEL uses a double scattering of the γ-rays and provides energy and incoming direction of the radiation. To avoid background of charged particles, the whole instrument is shielded by anti-coincidence domes. The remaining γ-ray background originating in the earth's atmosphere and the instrument itself can be supressed using the imaging capability of COMPTEL. Fig. 1 demonstrates these imaging qualities for a time interval during the flare.

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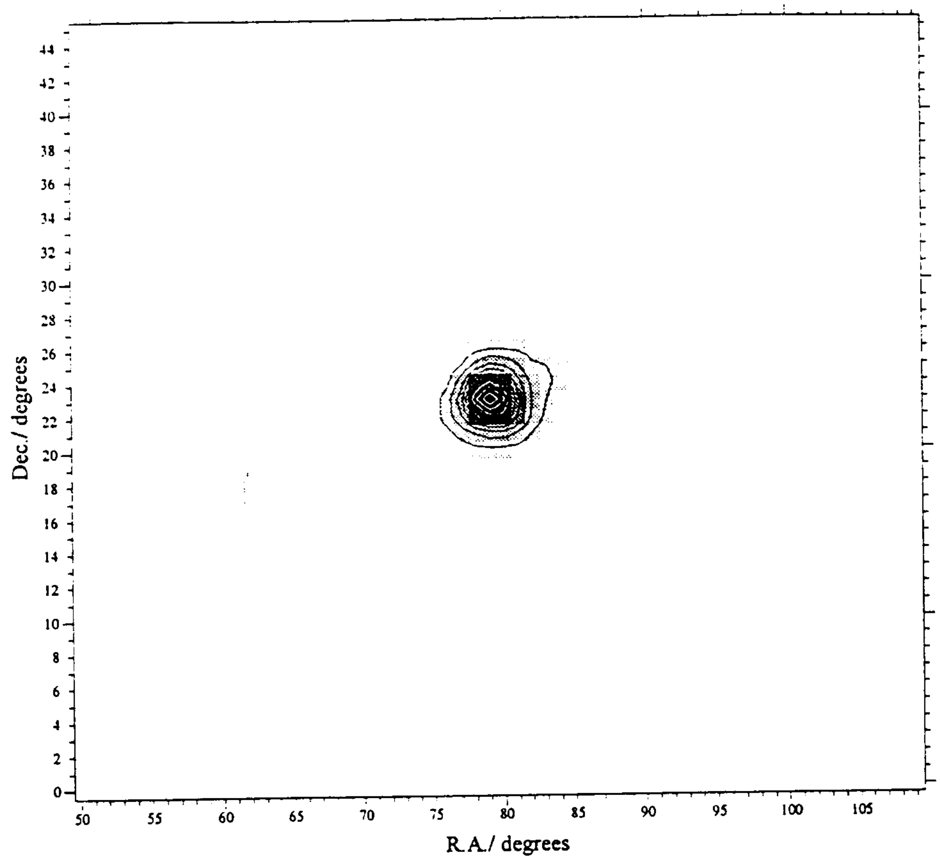

Fig 1 Image of the solar flare during the same time period as the spectrum in fig.3a. To perform this Maximum Entropy picture γ-ray data in the spectral range from 0.8 to 8 MeV were used.

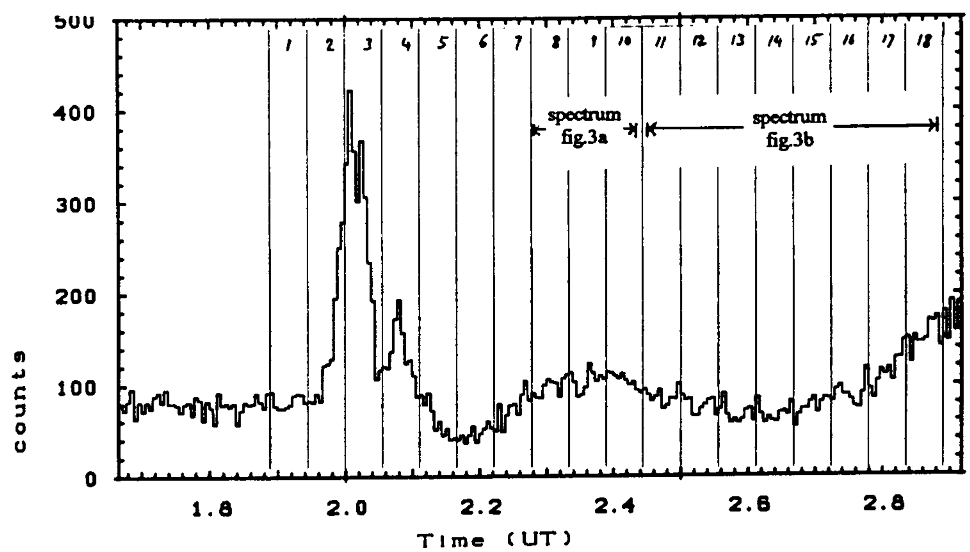

Fig 2 Time profile of raw telescope events in the energy range from 0.75 to 30 MeV. The indicated intervals are explained in the text.

So only events really coming from the sun can be selected. The remaining γ-ray background of the telescope shows orbital variations due to changes in rigidity and spacecraft orientation relative to the earth. After every 15 or 16 orbits the orbital parameters are reproduced quite precisely. Therefore, data from 15 and 16 orbits apart from the flare can be used to get a model background.

Because of the enormous γ- and X-ray flux during the flare the data interpretation is very difficult due to lifetime effects, the occurence of multi-hit processes in the telescope and restrictions by the event buffers and the telemetry rate. For the impulsive phase these effects are not yet completely understood. Therefore, the data from to the impulsive phase cannot be analyzed in a reliable manner and will not be shown here.

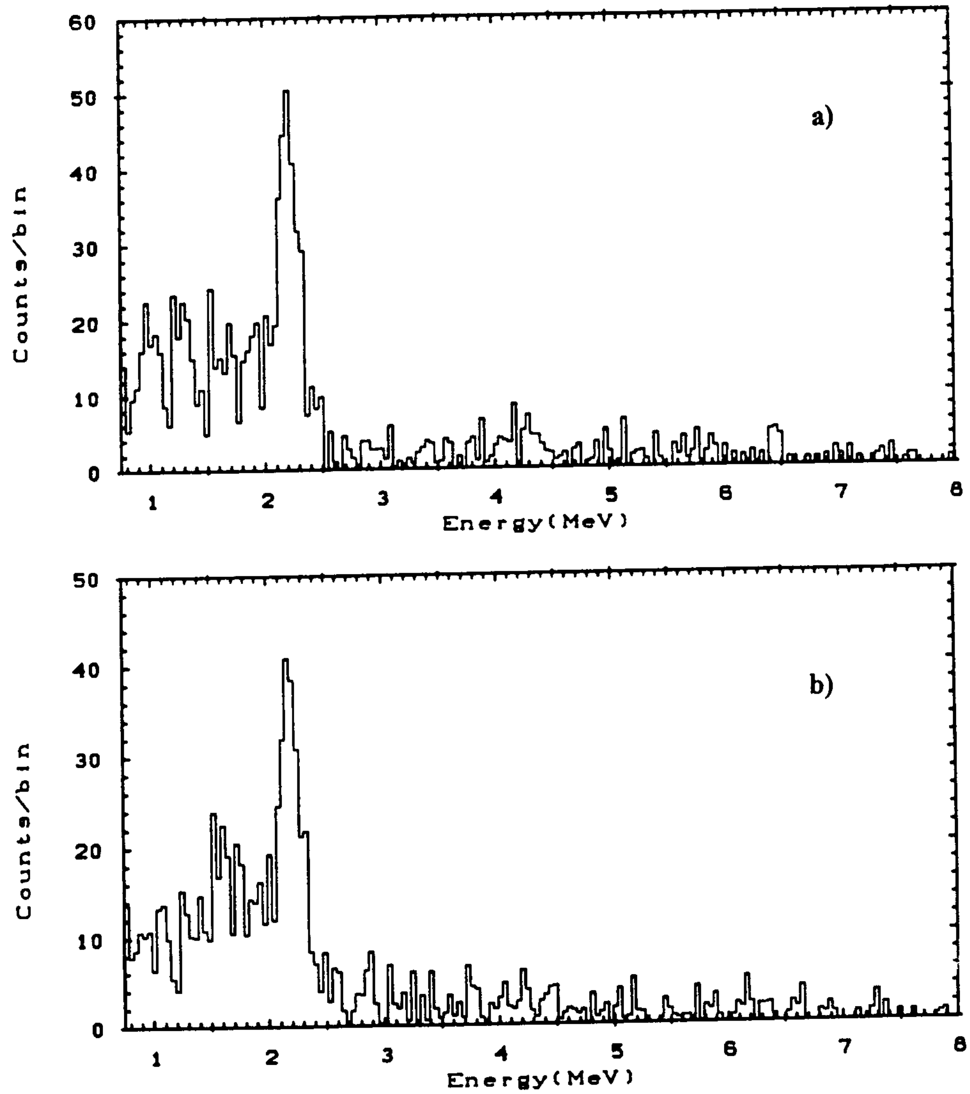

Fig 3 a, b Spectra corrected for background and lifetime effects. The different time intervals are illustrated in fig. 2. The used energy binning is 40 keV, the integration time is 800s for the first and 1200s for the second spectrum.

RESULTS

Our analysis concentrates on the flare spectrum and its evolution throughout the satellite orbit in which the flare occured. To study the time history of the event, eighteen time intervals of 200s each were defined, beginning at the onset of the flare. Fig. 2 shows the raw uncorrected count rate of γ-rays and illustrates the position of the intervals. As established above the first 7 intervals are excluded from the studies. For the remaining intervals raw spectra in the energy range from 0.75 MeV to 15 MeV were obtained and corrected for background and lifetime effects.
Emission from the solar event can also be measured in the next two satellite orbits following the flare (see McConnell et al., 1992).
The spectra in fig.3 show the energy loss in the telescope for two different time intervals as indicated in the raw event plot (fig.2). The spectrum after the impulsive phase is dominated by a strong 2.2 MeV emission line of the neutron capture. This line feature declines exponentially with a time constant of 11.8 minutes (see fig.5). At energies below 2.2 MeV there is a continuum which rises slowly in time relatively to the line. The continuum measured at higher energies above 4 MeV is low and also the line fluxes at 4.4 and 6.3 MeV are not remarkable. The time history for the γ-ray emission from 0.75 to 15 MeV is displayed in fig.4.

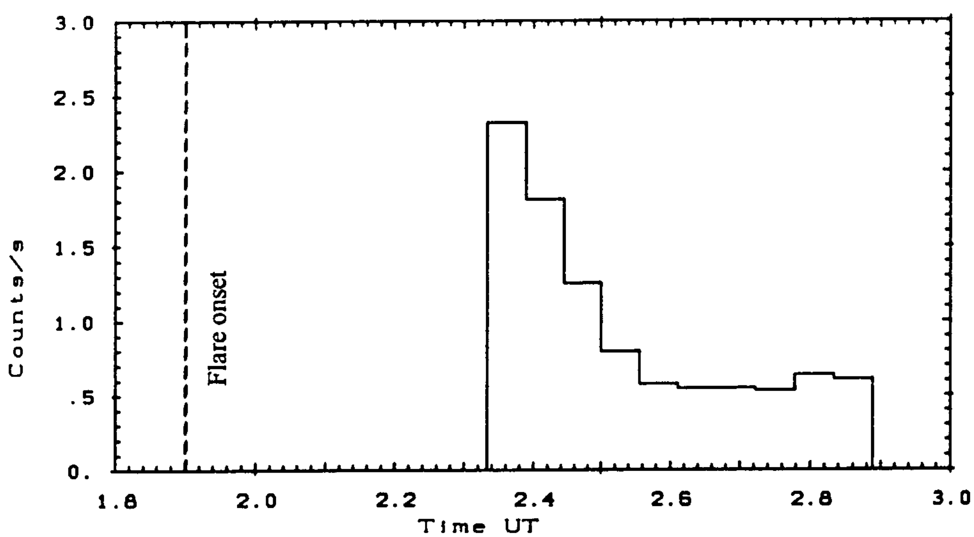

Fig 4 Time history of background and lifetime corrected count rate for 0.75 to 15 MeV.

CONCLUSIONS

We could obtain a history of spectra of the 1991 June 11th flare from COMPTEL data. A clear evolution of the spectrum as demonstrated in fig. 2 was found. Interesting values for theoretical models are expected from flux ratios as (2.2MeV line)/(4-7MeV) and (1-2MeV)/(2.2MeV line) but there are still uncertainties remaining in the present analysis that makes more precise studies necessary.
In addition we found evidence for the detection of flare neutrons in the raw data, but the analysis may be difficult and remains to be done.

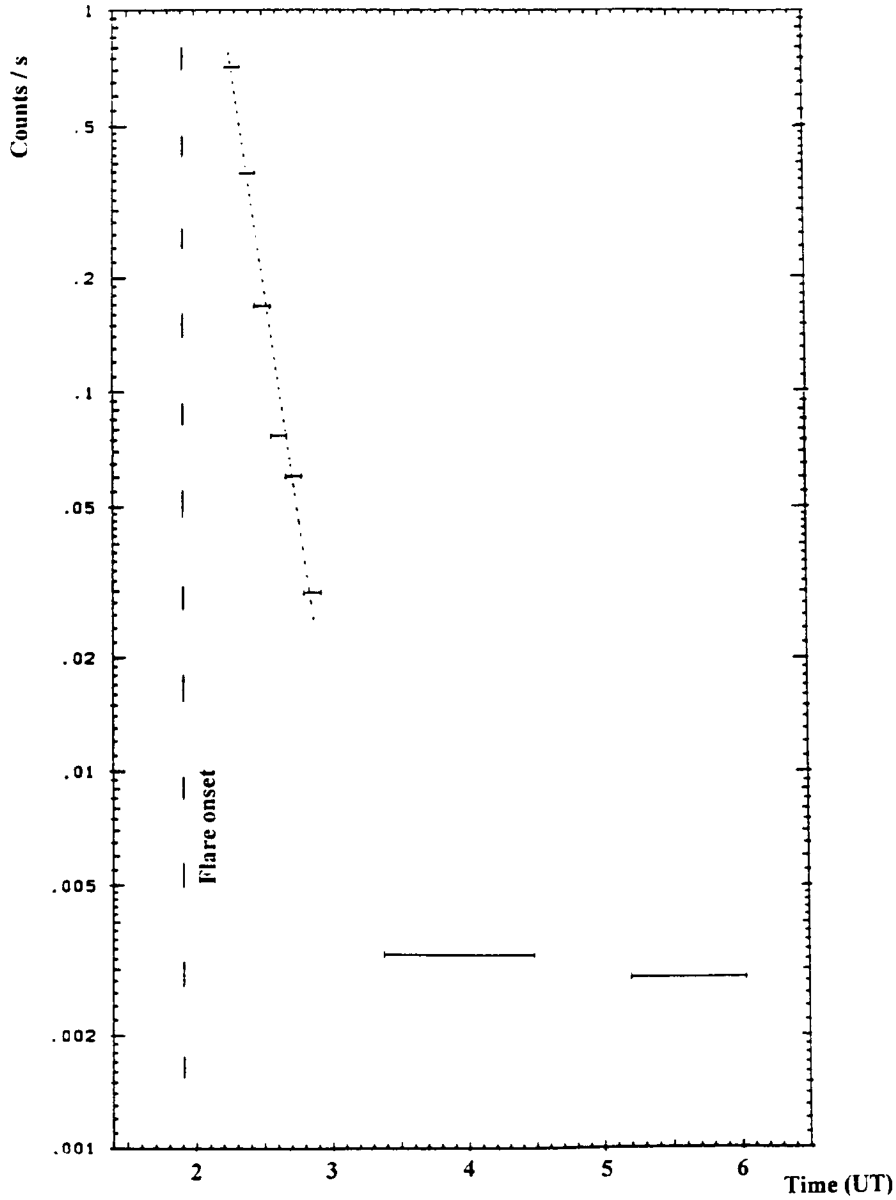

Fig 5 Time history of the γ-ray count rate 2.2 MeV line for the flare orbit and the next two orbits. The data are obtained from the background and lifetime corrected count rates. No line fitting has been done.

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