WHOLE SKY MAPS USING 5 YEARS OF COMPTEL DATA

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ABSTRACT

During 5 years of operation COMPTEL has collected data covering the entire sky, with exposures ranging from weeks to months. Full sky maps have already been published using data from the first 3 years of the mission; the additional information now available represent a significant addition to the COMPTEL data base and allows us to consolidate previous results. We present the most recent whole-sky maps and discuss their implications and limitations.

Keywords: gamma-rays; Galaxy; surveys; interstellar medium.

1. INTRODUCTION

Generation of intensity maps in low-energy γ-rays covering the whole sky in one of the main goals of the COMPTEL instrument on the Compton Gamma Ray Observatory CGRO. The first published maps (Schönfelder et al. 1995, 1996) were based on the initial three years of data, for which whole sky mapping first became feasible. The original sky coverage was extremely non-uniform; for this reason each CGRO observation cycle has seen a major proposal from the COMPTEL collaboration for observing time to render the exposure coverage more uniform and fill in regions of severe under-exposure. This procedure has been very successful; the minimum effective exposure anywhere on the sky is now about 7 days and for large areas more than 14 days. Cycle 6 observations will improve the uniformity further.

2. DATA

We use the data from Observation Periods 1 through 522.5, containing about 170 separate pointings from over 5 years of the mission. For each pointing the event and response data are generated in Galactic coordinates and then these datasets are added into full-sky datasets which are input to the imaging software. The binsize used is 1^o , and the standard COMPTEL energy ranges 1-3, 3-10 and 10-30 MeV are used.

3. METHOD

The method is maximum entropy reconstruction as described in Strong et al. (1995). The full COMPTEL response is used; because of the spherical coordinate system used the convolutions are slow and the CPU requirements large. The method requires an estimate of the instrumental background in the COMPTEL dataspace; unlike the case of lines (e.g. ^{26}Al: Oberlack et al. 1996) where adjacent energy bands allow a relatively straightforward background estimate, for the continuum this is not possible and we use instead a filter technique applied to the data themselves (see Bloemen et al. 1994a). This method is found to work well for this application but has the disadvantage that some signal is removed and so the intensity of features in the maps is underestimated. While the processing is performed on a uniform (l, b) grid, the maps can be subsequently displayed as Aitoff plots, or, since the latter are extremely distorted at high latitudes, as a set of orthographic projections centred on different regions of interest. The choice of maximum entropy iteration, which determines the relative effect of entropy (smoothness) and data (via the likelihood) on the image, is still somewhat subjective, but in practice it is evident from the appearance of the image when overfitting to the data begins and the iterations just prior to this are usually chosen. In fact the choice is not critical for the astrophysical interpretation.

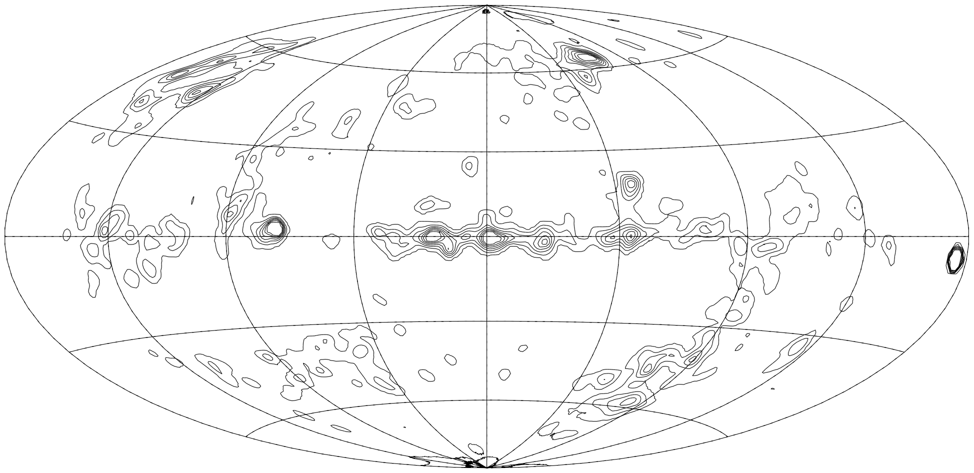

Figure 1: Full-sky intensity map for 1-3 MeV. Coordinate system: Galactic; projection: Aitoff centred on l=0, b=0

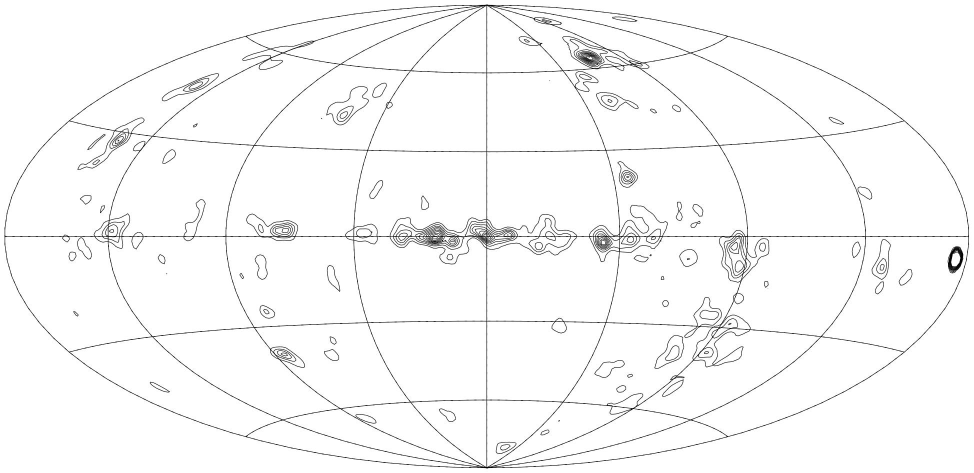

Figure 2: Full-sky intensity map for 3-10 MeV

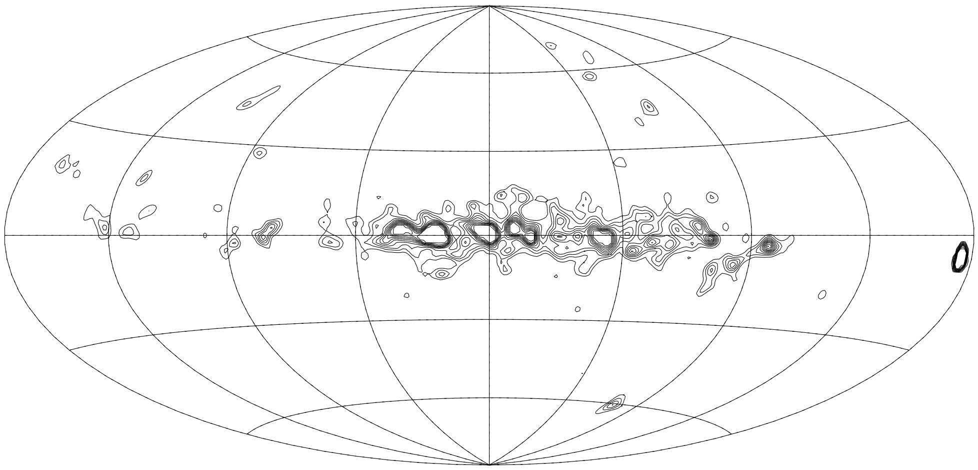

Figure 3: Full-sky intensity map for 10-30 MeV

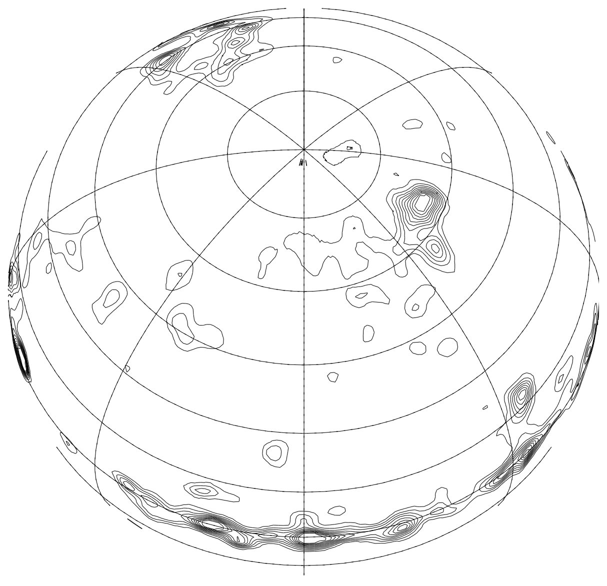

Figure 4: Skymaps for 1-3 MeV, orthographic projection centred on l=0° , b=60°

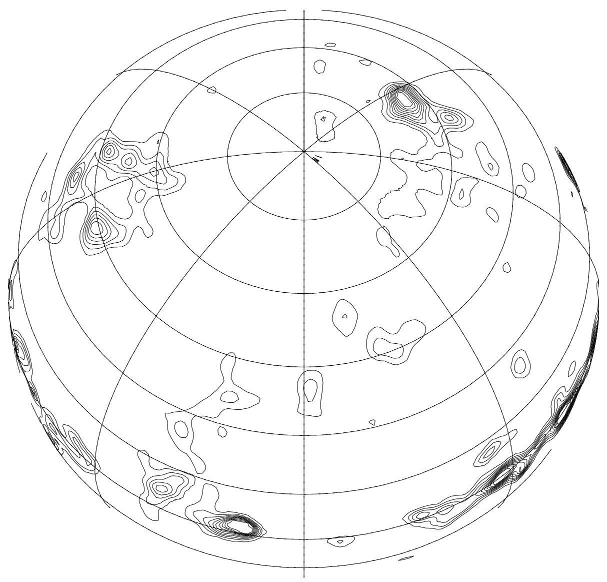

Figure 5: ..... centred on l=60° , b=60°

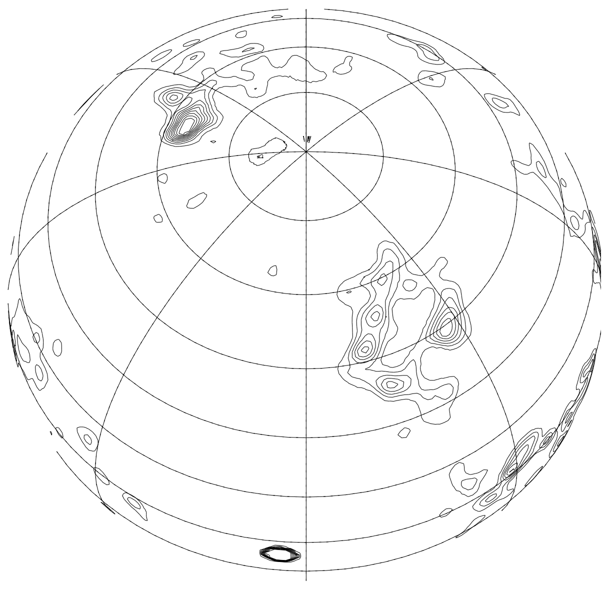

Figure 6: ..... centred on l=180° , b=60°

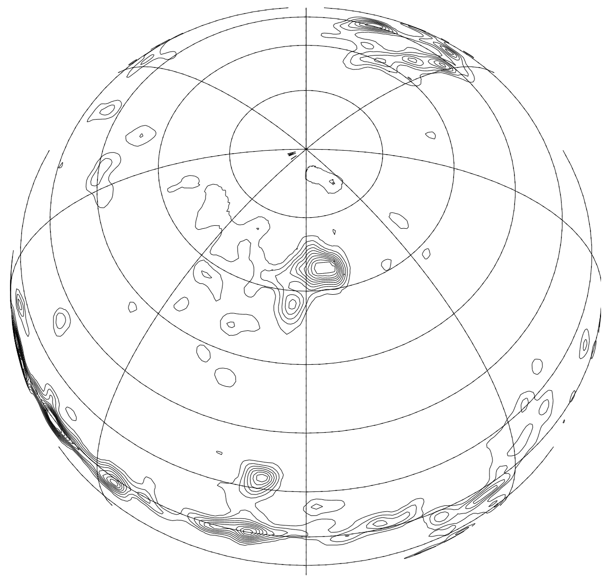

Figure 7: ..... centred on l=300° , b=60°

4. WHOLE SKY MAPS

The maps (Figs 1-3) show the intense emission associated with the Galactic plane which dominates the low-energy γ-ray sky. The astrophysical interpretation of this continuum emission is reviewed in Strong et al. (1996). (Note that in the 1-3 MeV band about 10% of the total emission is from the 1.8 MeV ^{26}Al line). Well-known sources in the plane appear: the Crab (l=184.5^o ,b=-5.9^o), Vela (263.6,-2.5) above 3 MeV, Cyg X-1 (71.1,+3.3) as well as striking excesses at (18,0) and near the Galactic centre. At higher latitudes the sky is dominated by extragalactic sources: Cen A (310,+20) below 10 MeV, (Steinle et al. 1995), 3C273 (290,+64) and 3C279 (305,+57) (Williams et al. 1995). Various 'MeV blazars': 3C454 (86,-38), PKS0208-512 (276,-62), GRO J0516-609 (270,-35) appear in one or more of the energy ranges. Details on these sources can be found in Blom et al. (1996) and references therein. Note that since these sources are variable their appearance in these time-averaged maps may not reflect their published fluxes or spectra precisely. Another interesting feature is the apparent presence of significant areas of diffuse emission out of the plane; in particular the $\sim$10^o radius region around (170,+50) has been presented as a candidate for assocation with a high-velocity cloud complex (Blom et al., this conference). Details in the structure of this emission should however be viewed with caution (see Sec. 5).

Figs 4-7 show orthographic projections centred on b=60^o for l=0,180^o , 60^o and 300^o . These give a better visualization of the high-latitude regions, while the galactic plane appears as a great circle near the borders. The Virgo region with 3C273 and 3C279 is especially clear on these maps; a detailed account of this region is given by Collmar et al. (1996). The diffuse emission around l=170^o is also very evident.

One drawback of the background estimation method used here is the tendency to suppress signals near to a very intense source. Proximity to the Crab can thus explain the fact that the QSO PKS0528+134 at (191,-11) (Collmar et al. 1994) does not appear although it has significant emission above 3 MeV. For the same reason the Orion extended source around (208,-18) (Bloemen et al. 1994b and these proceedings) is not evident in the 3-10 MeV map. These sources do however appear at higher iterations than shown here. Some suppression of the intensity above and below the strong Galactic plane emission in the inner Galaxy is also probable.

The maps confirm those published earlier based on the first 3 years data only; now however more significant structure is visible due to the improved coverage and statistics, but still subject to the cautionary note below. They give a global picture of the γ-ray sky, and serve to discover new sources and features which merit more detailed investigation.

5. NOTE ON INTERPRETATION OF ALL-SKY CONTINUUM MAPS

Because of the high background of COMPTEL, generating skymaps is difficult, especially in the continuum, for the reasons given in Section 3. No fully satisfactory method of background estimation has yet been developed, and for this reason we must still interpret these maps with caution. The method is the same as used previously for Phases 1-3, only the data have been supplemented with the additional sky coverage from Cycles 4 and 5. Therefore the limitations of the earlier maps due to the method are equally present in the new maps. The fact that the Galactic plane and bright sources appear as expected adds confidence but there may well be some features which are simply artefacts of the background estimation method. This applies particularly to extended structures. Any source or feature which is a candidate for astrophysical interpretation has to be independently checked by detailed analysis and alternative methods such as the likelihood-ratio. The reader is therefore warned against drawing conclusions or making detailed correlations with other objects on the basis of these maps alone. The potential of COMPTEL for such large scale survey work in the future has however been clearly demonstrated. More precise background estimation methods are expected to lead to significant improvement in the quality of such all-sky maps.

6. MORE INFORMATION

Additional information relating to this project, including colour versions of COMPTEL all-sky maps can be found on the WWW under http://

wwwgro.unh.edu:8080/comptel/comptel_main.html

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