Chapter VIII

CONCLUSIONS

The striking feature of the pre-COMPTEL CDG spectrum in the MeV range was an apparent flattening between 1 and 10 MeV. A simple power law extrapolation from the X-ray regime showed the presence of an excess, the MeV bump, in the 1 to 10 MeV range. The measurement of this excess was tentative with different amounts of excess reported in measurements by different groups. Although widely accepted, the shape and the intensity of the CDG spectrum in the 1-10 MeV range was considered controversial. The major difficulty in measuring the CDG radiation at MeV energies was the intense instrumental background.

The cosmic diffuse gamma-ray (CDG) spectrum between 800 keV and 30 MeV was measured with the Imaging Compton telescope COMPTEL, aboard the *Compton* Gamma Ray Observatory. Although COMPTEL is primarily an imaging detector, it is well suited to measure with greater precision and accuracy the CDG flux mainly because of its large detection area, low-background, wide field-of-view (~1.5 sr) and long exposure times.

Some of the new key elements developed in this analysis include the use of the time-of-flight measurement to improve the signal-to-background ratio, devising a unique method to eliminate atmospheric photons from the COMPTEL data, using the charged-particle detector rates as measures of the prompt background, and employing Monte Carlo simulations to determine the absolute COMPTEL response to the diffuse isotropic radiation and to determine the dataspace characteristics of background events from the decay of long-lived radioactive isotopes.

The CDG spectrum was computed by measuring the count rate of gamma rays from high galactic latitudes, during those periods when the Earth was outside the COMPTEL field-of-view. Special data selections were applied to suppress the prompt and delayed background components. Above 4.2 MeV, in the absence of long-lived background, the count rates were extrapolated to zero cosmic-ray intensity to eliminate the prompt background and arrive at the CDG count rates. The delayed emission from long-lived radioactivity, present only below 4.2 MeV, was determined by fitting the energy spectrum. Below 4.2 MeV, their contributions were subtracted prior to the extrapolation to zero cosmic-ray flux to determine the CDG count spectrum. Finally, the CDG flux was determined by deconvolving the resultant count spectrum with the computed instrument response for an isotropic diffuse source having a power-law distribution in energy. The systematic uncertainties surrounding the analysis were rigorously calculated to ensure no oversubtraction of the background. The systematic errors added to the statistical uncertainties in the final CDG spectrum.

The CDG flux measurements in the 1 to 10 MeV range are about 5–10 times lower than the pre-COMPTEL estimates (figure VII.1). Our measurements show no evidence of the MeV bump in the 1 to 10 MeV range. The measured CDG emission between 0.8 and 30 MeV is well described by a power-law photon spectrum with an index of -2.4 ± 0.2 and a flux normalization of $(1.05 \pm 0.2) \times 10^{-4}$ photons/cm^2-s-sr-MeV at 5 MeV. The integrated flux from 0.8 to 9 MeV is $(4.7 \pm 1.7) \times 10^{-3}$ photons/cm^2-s-sr and that from 9 to 30 MeV is $(1.5 \pm 0.3) \times 10^{-4}$ photons/cm^2-s-sr. This work represents the first significant detection of the CDG emission in the 9 to 30 MeV range. The CDG flux in the 4.2–9 and 9–30 MeV range measured for five independent datasets are consistent with a constant emission. Over large scales (Virgo and the South Galactic Pole), the 4.2–30 MeV CDG measurements are compatible with an isotropic emission.

This work has led to a simpler appearance of the high energy diffuse radiation. The 1–30 MeV flux is consistent with power-law extrapolations from lower (e.g., HEAO-1: Kinzer et al. 1997, SMM: Watanabe 1996) and higher energies (EGRET: Sreekumar et al. 1998). With no evidence for a MeV bump, possible contributions from all processes that explain the MeV bump, such as primordial matter-antimatter annihilations (Stecker 1971), are significantly reduced. The measurements below 3 MeV within errors are consistent with the level predicted by the supernovae model (The, Leising, and Clayton 1993). The blazar origin for the extragalactic diffuse seems likely above ~100 MeV. However, the situation is less certain in the 1–30 MeV range because the blazar emission at these energies is not well known. To date only eight of the EGRET blazars have been detected by COMPTEL. A simple continuation of the blazar contribution from higher energies is allowed by the COMPTEL measurements. The CDG spectrum above ~4 MeV will provide important constraints on the gamma-ray properties of blazars (e.g., the ratio of quiescent to flare-state blazar emission). If the CDG spectrum represents the average blazar spectrum then the COMPTEL data suggest that the average blazar spectrum changes smoothly with a break between ~30 and 100 MeV.

The general method developed in this work to measure the CDG emission is a new method for analyzing COMPTEL data. Such a procedure could be used to study other sources of diffuse emission, for example, the diffuse Galactic emission. This work has led to a better understanding of the physical nature of the COMPTEL background. Improved data selections based on the physical background will improve the COMPTEL imaging capabilities (see, for example, Collmar et al. 1997).