MEASUREMENT OF THE
COSMIC DIFFUSE GAMMA-RAY SPECTRUM
FROM 800 KEV TO 30 MEV

BY

SRINIVAS CHEENU KAPPADATH

B.A., Illinois Wesleyan University, 1991

M.S., University of New Hampshire, 1994

DISSERTATION

Submitted to the University of New Hampshire
in Partial Fulfillment of
the Requirements for the Degree of

Doctor of Philosophy
in
Physics

May 1998

This dissertation has been examined and approved.

Dissertation Director, Dr. James M. Ryan
Professor of Physics

Dr. Edward L. Chupp
Professor of Physics

Dr. Mark L. McConnell
Research Associate Professor of Physics

Dr. Volker Schönfelder
Professor

Dr. Harvey K. Shepard
Professor of Physics

Date

dedicated to Beth and Nicholas

ACKNOWLEDGMENTS

The synthesis of this work would not have been possible without the dedication of my advisor Jim Ryan. To him I express my sincere gratitude. I am grateful for his overall vision and valuable advise. His sense of humor has been a welcome relief when dealing with the nerve-wracking COMPTEL background. I wish to acknowledge all members of the COMPTEL collaboration led by Volker Schönfelder. I am indebted to team members Alanna Connors, John Macri and Mark McConnell for their help in understanding instrument operation, statistics and data analysis. I wish to especially thank team members Dan Morris, Rob van Dijk, Martin Varendorff and Georg Weidenspointner whose background studies have contributed to a better understanding of the instrument. Special thanks to Rita Freuder, John Labonte, Tom Milliman and Neil Schonwald for their computer expertise. I thank my fellow graduate students and friends at the University of New Hampshire, particularly Doug Biesecker, Marc Kippen, Vance Pomeroy, Gerhard Rank and Alex Young, for sharing in this experience and encouraging me along the way. Last but not the least, I wish to express my deepest gratitude to my wife Beth, for her support, optimism and sacrifice, and my son Nicholas, for sharing his wonder and enthusiasm, throughout my graduate studies. This work has been supported by the National Aeronautics and Space Administration grant NAS5-26645.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

MEASUREMENT OF THE
COSMIC DIFFUSE GAMMA-RAY SPECTRUM
FROM 800 KEV TO 30 MEV

by

SRINIVAS CHEENU KAPPADATH
University of New Hampshire, May, 1998

The Cosmic Diffuse Gamma-Ray (CDG) spectrum between 800 keV and 30 MeV has been 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 the CDG flux mainly because of its large detection area, wide field-of-view (~1.5 sr), low background and long exposure times. The major difficulty in measuring the CDG radiation at MeV energies is the intense instrumental background. The instrumental background in COMPTEL is created mainly in the surrounding material. The striking feature of the pre-COMPTEL CDG spectrum 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, referred to as the *MeV bump*, in the 1 to 10 MeV range.

These CDG flux measurements in the 1 to 10 MeV range are about 5 to 10 times lower than the pre-COMPTEL estimates. They show no evidence of a 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. This work represents the first significant detection of the CDG emission in the 9 to 30 MeV range. No statistically significant deviations from isotropy is observed in the 4.2 to 30 MeV CDG emission when comparing the spectrum from the Virgo and the South Galactic Pole directions.

The CDG spectrum was measured using COMPTEL data by first 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. 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.

In the light of this work, possible contributions from all processes that explain the MeV bump, such as primordial matter-antimatter annihilations, are significantly lower than previously believed. Our measurements below 3 MeV within errors are consistent with the level predicted by the model where the CDG emission arise from the decay of elements produced in supernovae. A blazar origin for the CDG emission seems likely above ~100 MeV. However, the situation is less certain in the 1 to 30 MeV range because the blazar emission at these energies is not well known. A simple continuation of the blazar contribution from higher energies is allowed by the COMPTEL measurements.

The method developed in this work to measure the CDG spectrum 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 and consequently will improve the COMPTEL imaging capabilities.