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FINAL REPORT**

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Prepared by

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## INTRODUCTION

The four primary tasks of the delivery order have been completed. The Detector Response Matrices have been maintained and some improvements implemented. The spectral analysis tasks based on the 4 channel lad data have been accomplished. The BLOT team effort was completed and the SN1987A balloon flight data analysis paper was submitted.

## SOFTWARE SUPPORT & CALIBRATION

The Burst Location Optimization Team effort succeeded in reducing the RMS systematic error in the Gamma Ray Burst location errors from 7 degrees to 4 degrees. This particular calibration and software optimization effort was finished in November 1992. As of October 1993 I have been assigned control of the burst location code and I am overseeing the production of burst locations for the 2B catalog using the code that produced the 1B catalog data. I am also installing a few final improvements in the code that slipped past the programmer previously in charge of the code and may be able to improve the locations a bit more.

The fluxes and fluences were generated for the 1B catalog for 260 events. I then trained programmer Chris Chaganti to build an automated flux-fluence generator for use by the ops-team and the burst fluxes and fluences are now being generated in production mode. This code is also producing photon time histories in the four discla channels so we can make a burst movie for display to the general public using the lab's silicon graphics hardware.

New drms have been generated for the LAD's and SPEC detectors. Statistical fluctuations in the Monte Carlo data used to generate the matrices have been smoothed out to make the spectral reconstruction more accurate. More input energies have been added to the low energy end of the spec detectors to make them more accurate.

A set of subroutines were constructed that combine detector response matrices and atmospheric scattering to produce detector response matrices for any condition for the batse detectors. This code is in the BDAS area under configuration control and is used by the UCSD co-Is, the MSFC occultation team, and the MSFC pulsar team. Richard Shwartz is using it to facilitate solar flare spectral analysis of BATSE data from GSFC for guest investigators.

The Calibration of the 16 channel edges has been successful. The results were presented in a poster at the Second Compton Symposium and submitted in paper form for publication in the proceedings of the symposium (see attached abstract).

## SCIENTIFIC RESULTS

I am on the author list of 19 refereed journal articles and 37 non refereed publications produced during this period. I list below my lead author work and work with graduate students in Huntsville during this interval. The supernova paper has been submitted to ApJ. The Gamma-Ray Burst Continuum Properties paper has been accepted by ApJ. for publication in the August 10, 1994 issue. The spectral analysis of bursts indicate that there are dips in the spectra that may represent the superposition of two spectral components simultaneously in Gamma-Ray bursts. I presented results on this at the Compton symposium in St. Louis (1992) and at the second Huntsville Burst Workshop (1993). The results are presented in the published proceedings of these conferences.

I have worked with Bob Mallozzi to see what constraints the BATSE data can put on the low energy emission of the BLASAR's discovered by EGRET. These results are presented in the Compton symposium proceedings (1993). Bob and I have also looked at the temporal evolution of the energy output of bursts and solar flare in order to compare and contrast their spectral properties. These results are presented in the second Huntsville gamma-ray burst workshop (1993). I have been working with Tom Koshut comparing the spectral parameters of short emission spikes in longer bursts with those of the short duration events. These results are presented in the second Huntsville gamma-ray burst workshop (1993). The abstracts of articles on which I am lead author produced during this contract interval are appended to this report.

## The Continuum Spectral Characteristics of Gamma-Ray Bursts Observed by BATSE

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### ABSTRACT

Distributions of the continuum spectral characteristics of 260 bursts in the first BATSE catalog are presented. The data are derived from flux ratios calculated from the BATSE Large Area Detector (LAD) four channel discriminator data. The data are converted from counts to photons using a direct spectral inversion technique to remove the effects of atmospheric scattering and the energy dependence of the detector angular response. Although there are intriguing clusterings of bursts in the spectral hardness ratio distributions, no evidence for the presence of distinct burst classes based on spectral hardness ratios alone is found. All subsets of bursts selected for their spectral characteristics in this analysis exhibit spatial distributions consistent with isotropy. The spectral diversity of the burst population appears to be caused largely by the highly variable nature of the burst production mechanisms themselves.

**Continuum Spectral Characteristics of Bursts  
Measured with the BATSE Large Area Detectors**

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The continuum spectra of bursts are studied with particular emphasis placed on the search for spectral subcomponents. The spectra observed in individual bursts show significant evolution throughout their durations. This study addresses the degree to which hard and soft spectra are combined in bursts and the effect this has on the complexity of the observed spectra. In particular the presence of broad cusps in spectra in the 50-100 keV range are studied to determine both the degree to which these features are present in the LAD data and whether superposition of hard and soft spectra simultaneously can account for them. Also the time histories of the power output (ergs/sec) from bursts are studied to investigate the dynamic coupling between hard and soft spectra in bursts as a probe of the autonomy of the hard and soft emission mechanisms.

A STUDY OF GAMMA-RAY BURST CONTINUUM PROPERTIES  
PRESENTING EVIDENCE FOR TWO SPECTRAL STATES IN BURSTS

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ABSTRACT

Evidence is presented for the existence of two spectral states contributing simultaneously to the total spectrum observed in many gamma-ray bursts (GRB's). An ensemble of 120 GRB's measured by BATSE have been studied, using 4 channel spectral data, to determine in which bursts the spectral states can be most effectively resolved. The technique of summing the low intensity spectra together to get an average spectrum allows for precise characterization of the average low intensity spectral behavior. The 4 and 16 channel spectra obtained by the BATSE Large Area Detectors (LAD's) are analyzed using a model-independent spectral inversion technique. The results of these analyses applied to an individual burst are discussed in detail.

## Balloon-Borne Measurements of the SN1987A Hard X-ray Continuum

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### ABSTRACT

SN1987A hard X-ray continuum spectra obtained on 1987 October 29, 1988 April 9-10, and 1988 November 11, from balloon flight measurements are presented. The spectra, spanning the energy range from 25 keV to 300 keV, have been analyzed using a detector response matrix inversion technique that converts the spectra from counts/sec-cm<sup>2</sup>-keV to photons/sec-cm<sup>2</sup>-keV allowing direct comparison with theoretical models. The results indicate that the bulk of the <sup>56</sup>Co is mixed moderately through the inner regions of the SN envelope but they do not preclude the mixing of a small amount of the <sup>56</sup>Co further out into the envelope necessary to account for the observed <sup>56</sup>Co line fluxes. The effect of the ratio of <sup>57</sup>Co to <sup>56</sup>Co on the 1988 November 11, continuum spectrum is discussed.

**CHANNEL TO ENERGY CALIBRATION RESULTS  
FOR THE BATSE LARGE AREA DETECTORS**

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**ABSTRACT**

Continuum 16 channel spectra obtained from in flight data are used to identify and correct for nonlinearities in the channel-to-energy conversion algorithm for the BATSE<sup>1</sup> large area detectors. The Crab Nebula spectra obtained by the BATSE earth occultation technique<sup>2</sup> are used to characterize any nonlinearities inherent in the low energy channel bin widths on a detector by detector basis. The bin widths are optimized to remove distortions from observed gamma ray spectra. The recalibrated bin edges are used in an analysis of Crab Pulsar data<sup>3</sup> to verify the improvements in the calibration.





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