STATUS OF THE BATSE ENHANCED EARTH OCCULTATION ANALYSIS PACKAGE FOR STUDYING POINT SOURCES

R. T. Skelton,* J. C. Ling, R. Radocinski, and Wm. A. Wheaton
Jet Propulsion Laboratory
California Institute of Technology, Pasadena, CA 91109

ABSTRACT

The Compton Gamma-Ray Observatory's Burst and Transient Source Experiment (BATSE) has a powerful capability to provide nearly uninterrupted monitoring in the 25 keV—2 MeV range of cosmic point sources using occultation by the Earth. The physical model for the background variations, central to this package, will allow use of more data, enhancing the sensitivity by a factor of several compared to the BATSE Mission Operations package, which has proven valuable. This physically-based model fits for the diffuse background (including Earth blockage), prompt cosmic-ray effects, South Atlantic Anomaly activation, atmospheric cosmic-ray secondaries, and cosmic sources in 14 Medium Energy Resolution energy bands of the Large Area Detectors. Features include the ability to correlate set and rise of a given source and to handle multiple sources within the fit window. The count spectrum is deconvolved using the detector energy response matrix to yield a source photon spectrum. We describe the current status and performance of the system.

INTRODUCTION

BATSE'S capability to provide almost uninterrupted monitoring of gamma-ray sources by Earth occultation permits unprecedented long-term observation of galactic black hole candidates and AGN. Further discussion of the scientific motivation for this can be found in Skelton et al. (1993). Approaches include a simple fit of data near occult ation edges (Harmon et al. 1992), a global mathematical model (Rubin et al. 1993a, 1993b), and the JPL physically based global model (Skelton et al. 1993; Wheaton et al. 1992). Since this paper updates an earlier one of the same title (Skelton et al. 1993), only recent progress and future directions will be discussed. A full description of the JPL model is given in Skelton et al. (1993).

RECENT PROGRESS

Progress in the last year has accomplished the following:

- transferred the primary analysis package to a VAX system from a Sun SparcStation.
- implemented XSPEC as the program to convert count rates in the BATSE LAD Medium Energy Resolution for each source to source photon spectra.
- repaired various minor bugs.
- streamlined user interface.
- established an end-to-end analysis system.
- performed significant testing and cross-calibration with the Mission Operations system results.

These last two items have been the key step in producing recent scientific results (Ling et al. 1993).

Figure 1 shows the data flowpath for the end-to-end system, which is designated the Enhanced BATSE Occultation Package (EBOP) Version 1.0. It is to be noted that the flowpath involves not only the JPL model fitting program, but also the so-called

* National Academy of Sciences/National Research Council Senior Resident Research Associate

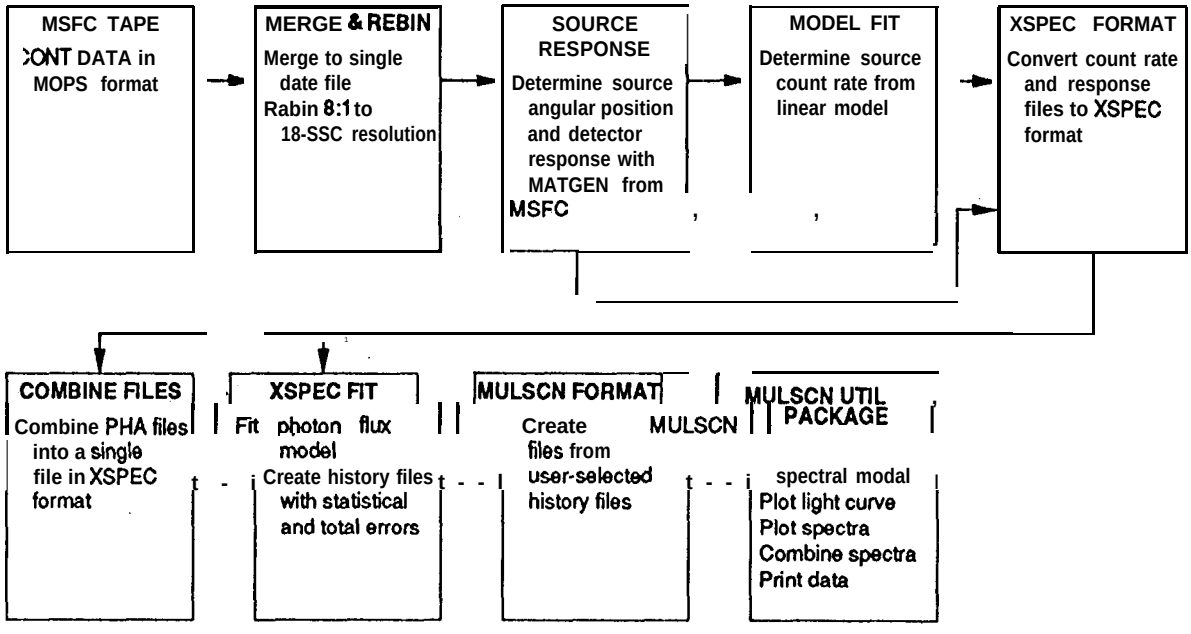

Figure 1. Data anaysis flowpath for the Enhanced BATSE Occultation Package (EBOP) version 1.0.

MULSCN utilities, a series of routines developed at JPL in conduction with the prime *HEAO C-1* data analysis procedures (Wheaton et al. 1993), the Goddard Space Flight Center XSPEC program (GSFC 1990), and the MSFC Response Matrix Generation soft ware.

Current one-day sensitivity for measuring a strong source, such as the the Crab pulsar and nebula, is summarized in Table 1. The total uncertainty includes statistical and systematic contributions. The latter is obtained from the degree of consistency between two different detectors for the same day, averaged over 65 days,

Energy Range (keV)	Crab Flux Ph/cm^2 keV s	One-Day Statistical Uncertainty	One-Day Total Uncertainty
45-140	1.18 X 10^{-3}	1.2 x 10^{-5} 11	5.3 x 10^{-5} 45
33-42	6.31 x10-3	1.3 X1 O-4 20	1.1 X1 O-3 168
42-56	3.42x10^{-3}	6.7x10^{-5} 20	3.2 x 1 0^{-4} 9 4
56-75	1.72x10^{-3}	3.4 X1 O-5 20	1.5 X1 O-4 86
75-95	1.02 X10-3	2.3x10^{-5} 22	9.1 X1 O-5 90
95-115	6.40 x10-4	1.7x10^{-5} 27	5.0 X10-5 79
115-136	4. O7X1O-4	1.3 X1 O-5 33	3.2 x 1 0^{-5} 7 9
136-177	2.60 x10-4	8.2x10^{-6} 31	2.5 x 1 0^{-5} 9 5
177-235	1.5 OX1O-4	6.4×10^{-6} 42	2.3x10^{-5} 152
235-325	6.65 x10-5	4.6x 10^{-6} 70	1.4 X1 O-5 217
325-433	3.55 X10-5	4.5 X1 O-6 127	1. OX1O-5 282
433-596	1.89 x10-5	4.2x10^{-6} 222	8.5x10^{-6} 449
596-745	1. O5X1O-5	4.1 X10-6 387	5.4 X1 O-6 513
745-1100	6.62x10^{-6}	2.5×10^{-6} 383	3.5 X1 O-6 534
1100-1818	2.48 x10–G	1.8x10^{-6} 726	1.8x10^{-6} 740

Table 1. Current sensitivity of the EBOP package for a strong source. One-day statistical and total uncertainties are specified in both flux units (Photons/cm^2 s keV) and mCrab.

FUTURE DIRECTIONS

Anumber ofimprovements totheanalysis package are under consideration. The principal ones are:

- Install upgraded instrument response matrix and energy edges.
- Incorporate direct multi-detector fitting.
- Fit model at 2.048-s time resolution.
- Improve the modeling of cosmic-ray activation.
- Incorporate Compton scattering from cosmic sources by the Earth's atmosphere.
- Constrain appropriate terms to be positive.
- Perform separate Singular Value Decomposition (SVD) on cosmic sources.
- Streamline further the user interface.
- Improve computer memory management.

A few of these warrant further comment. Currently, cosmic ray activation includes only a term for ^{128}I. A term for ^{24}Na would be clearly indicated, as well as a term for longer-lived species. Currently, these contributions are included in the term for constant background, which leads to inaccuracies in the Earth blockage term: the Earth does not block long-lived activation. The separate SVD on cosmic source would address the issue of source confusion by at least identifying sources which are not cleanly separated. Computer memory management is a major practical issue since it currently affects the capability to add other cosmic ray activation terms and impels the use of 16-second binned data.

ACKNOWLEDGEMENTS

The assistance of G. J. Fishman, B. A. Harmon, W. S. Paciesas, B. C. Rubin, and the rest of the BATSE team is gratefully acknowledged, We also appreciate the contributions made by N-F Ling, K. Polito, and R. Esquivel to the package and its testing. The research described in this paper was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under contract to the National Aeronautics and Space Administration.

REFERENCES

GSFC 1990. XSPEC: An X-ray "Spectral Fitting Package User's Guide v7.0, NASA Goddard Space Flight Center, Greenbelt, MD

Harmon, B. A., Finger, M. H., Rubin B. C., et al., 1992. In: Shrader C., Gehrels N., and Dennis B. (eds.)Proc. Compton Observatory Workshop (NASA Conf. Pub. #3137). NASA, Greenbelt, MD, 69

Ling J. C., Wheaton Wm. A., Skelton R. T., et al. 1993. BATSE Observations of Cygnus X-1, these Proc.

Rubin B. C., Harmon B. A., Brock, M. N., et al., 1993a. In: Friedlander M., Gehrels N., and Macomb D. (eds.) Proc. CGRO Symp. (AIP Conf. Proc. #280). AIP, New York, 1127

Rubin B. C., Harmon B. A., Finger M. H, et al. 1993b, Modeling the γ-Ray Background with BATSE, these Proc.

Skelton R. T., Ling J. C., and Wheaton Wm. A., 1993. In: Friedlander M., Gehrels N., and Macomb D. (eds.) Proc. CGRO Symp. (AIP Conf. Proc. #280). AIP, New York, 1189

Wheaton Wm. A., Ling J. C., Skelton R. T., et al. 1992. In: Holt S. S., Neff S. G., and Urry C. M. (eds.) Proc. Testing the AGN Paradigm (AIP Conf. Proc. #254). AIP, New York, 356

Wheaton Wm. A., Dunklee A. L., Jacobson A. S., et al. 1993. Multi-Parameter Linear Least-Square Fitting to Poisson Data One Count at a Time, submitted to AP.J.