CR–206868

Raytheon
Raytheon STX Corporation
4400 Forbes Boulevard
Lanham, MD 20706-4392
(301) 794-5000
FAX: (301) 794-7106

16 March 1998

NASA/GSFC
Space Sciences Procurement Office
Code 216
Greenbelt, Maryland 20771

Attn: Kim Wiggins
Contract Administrator

Subject: Final Report

Reference: Purchase Order No. S-67246-Z

In Reply Refer to: 98-REP-0187

In accordance with above referenced contract, Raytheon STX Corporation ("RSTX"), formerly known as Hughes STX Corporation, encloses herewith one (1) copy of the subject report. Should additional information be required, please contact the undersigned at (301) 794-5496.

Sincerely,

RAYTHEON STX CORPORATION

Ralph E. Powe III
Jr. Contract Administrator

Enclosure

cc: NASA Center for Aerospace Information (CASI)
800 Elkridge Landing Road
Linthicum Heights, MD 21090-2934
Attn: Document Processing Section

Publication and Graphic Services Section
Code 253.1

Contracting Officer's Technical Representative
Attn: J.P. Norris, Code 661

CGRO CYCLE5 FINAL REPORT

This document provides the fourth quarter and final reports for the Cycle 5 Guest Investigation: BATSE SOLAR FLARE SPECTROSCOPY

- Dr. Richard A. Schwartz
- RaytheonSTX
- Code 682.3
- NASA/GSFC

- 2 March1998

Introduction

As a continuation of our Phase 2, 3, and 4 CGRO/GI efforts, we proposed four mutually supporting efforts to support the analysis of BATSE solar flare data with particular emphasis on hard X-ray spectroscopy. The four efforts included: (1) The continued improvement of a software and database environment capable of supporting all users of BATSE solar data as well as providing scientific expertise and effort to the BATSE solar GI community. (2) The continued participation with the PI team and other Guest Investigators in the detailed analysis of the BATSE detectors' response at low energies. (3) Using spectroscopic techniques to fully exploit the potential of electron time-of-flight studies. (4) A full search for flare gamma-ray line emission at 2.2 MeV from all GOES X-class flares observed with BATSE.

First Quarter

The main effort in this quarter was to support effort (2). The quantitative analysis of solar flares as well as gamma-ray bursts requires accurate knowledge of the detector response below 40 keV where the BATSE SPEC detectors have been plagued by problems. In an effort to sort out and to resolve these problems we have observed the standard candle of X-ray astronomy, the Crab. Having initiated this effort under PhaseIV, a great deal of new effort was expended greatly expanding the database to over 50,000 source/detector occultations using the DISCSP data covering almost 25% of the mission and 13,000 source/detector occultations using the DISCLA data. We owe great thanks to Mark Finger of the BATSE team who provided superior software to more accurately model the times of the occultation. Additionally, many thanks are given to Tom Skelton of UCSD and Rob Preece at MSFC for work toward resolving the energy calibration of the SPEC discriminator edges.

We rewrote most of the software used to create the data files, organize the data file directories, find the database files based on simple time and temporal , organize and read the extracted occultation information, expedite the computation of the discriminator edges and resultant expected count rates, and compute the location of the occultation edges. Additionally, we discovered an unknown discrete change in the offset of one SPEC detector's discriminator after a spacecraft reboost.

Software written in support of this effort:

VERAGE_STEPS.PRO
HECK_GAIN_ANGLE.PRO
LEAREM.PRO
IND_GOOD_OCCS.PRO
RAB_DISCSP_HKG.PRO
ERGE_DISCSP_HKG_OCC.PRO
CC_AVG.PRO
CC_FILETYPE.PRO
CC_FROM_FITS.PRO
LOT_CRAB.PRO
LOT_OCCS.PRO
LOT_OCC_ONDAY.PRO
LOT_RESPONSE.PRO
LOT_THRESH.PRO
EAD_DISCSP_M.PRO
EAD_RESULTS.PRO
EDO_EDGES.PRO
ESOLVE_NEW_OBS.PRO
UNIT.PRO
UN_OCC.PRO
BATSE_CRAB_RESP.PRO
CHECK_OCCS.PRO
CRAB_OCC_STR.PRO
GET_OCC_ONDAY.PRO
MAKE_OCC_RESULTS_SAV.PRO
MORE_OCCULTS.PRO
OCC_DBASE.PRO
OCC_FIND.PRO
PICK_POINTING.PRO
PLOT_DISCSP_CRAB.PRO
PLOT_OCCS_RES.PRO
PLOT_RATIOS.PRO
PLOT_RESULTS.PRO
PROCESS_CRAB_RESP.PRO
READ_OCC_DISCSP.PRO
READ_RESULTS2.PRO
REFORMAT_RESULTS.PRO
RESOLVE_RESULTS.PRO
RUN_MERGE_DISCSP_HKG_OCC.PRO
RUN_PLOT_OCCS.PRO

Second Quarter

The main effort in this quarter was to support effort (1). The BATSE flare database contains all the available IDBD files either in native VMS or CGROSSC FITS format including SHERB, SHER, HER, HERB, MER, DISCLA, CONT, DISCSP, DISCSC and now TTS format. A TTS data reader was also developed. These tools remotely supported 3 PhD investigations by Brian Park at Stanford, Paul Feffer at U. Ca. Berkeley, and Kristin Blais at the U. Hawaii. In particular, the Feffer work made particular use of extensive calibration work to investigate the nature of small sub 20 keV solar bursts, to attempt to classify them as thermal or non-thermal. Figure 2a highlights this taxonomy. We developed procedures for jointly displaying archived DISCLA data which had been digitally compressed together with a large database of DISCSP data to find examples of low intensity solar bursts with impulsive temporal characteristics but not observable at energies above 25 keV. We also developed tools to rapidly compute expected count rates as a function of energy band width, aspect angle, spectral shape and intensity.

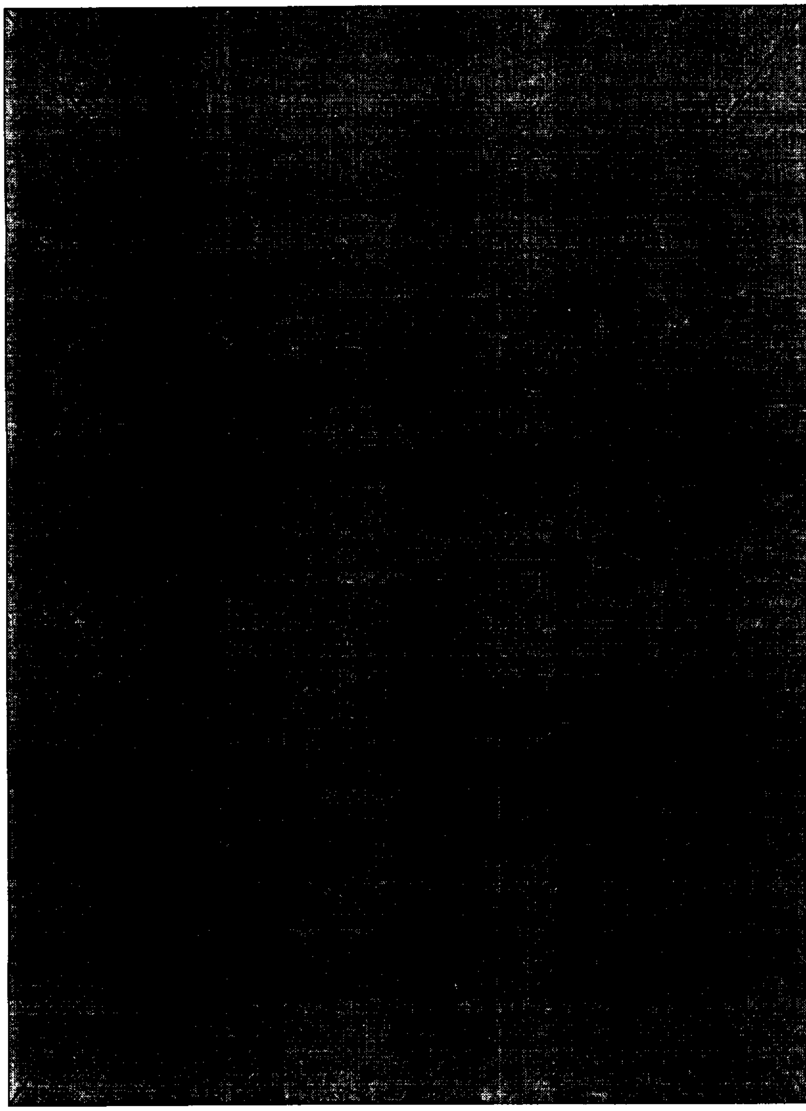
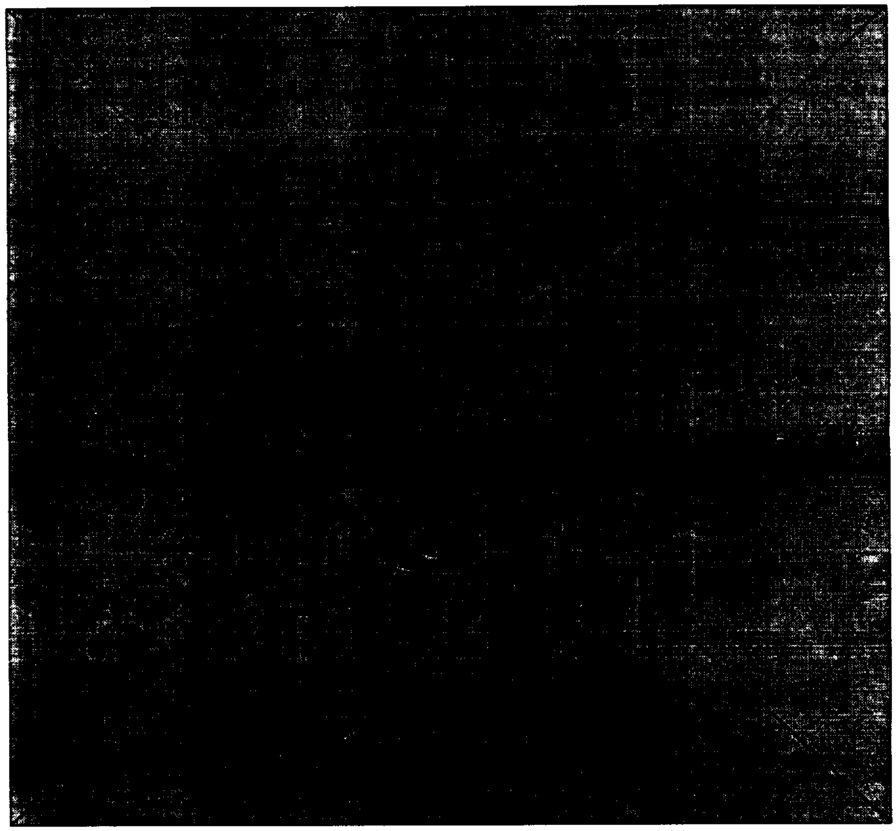


Fig 2a. Plot of BATSE count rates with GOES fluxes for small solar bursts. BATSE data are obtained from DISCSP and DISCLA.

Third Quarter

(1) The BATSE flare database contains all the available IDBD files either in native VMS or CGROSSC FITS format including SHERB, SHER, HER, HERB, MER, DISCLA, CONT, DISCSP, DISCSC and now TTS format. A TTS data reader was also developed. These tools remotely supported 3 PhD investigations by Brian Park at Stanford, Paul Feffer at U. Ca. Berkeley, and Kristin Blais at the U. Hawaii. In particular, the Feffer work made particular use of extensive calibration work to investigate the nature of small sub 20 keV solar bursts, to attempt to classify them as thermal or non-thermal. Figure 3a (ps) highlights

this taxonomy. 

(2) The quantitative analysis of solar flares as well as gamma-ray bursts requires accurate knowledge of the detector response below 40 keV where the BATSE SPEC detectors have been plagued by problems. In an effort to sort out and to resolve these problems we have observed the standard candle of X-ray astronomy, the Crab. Having initiated this effort under PhaseIV, a great deal of new effort was expended greatly expanding the database to over 50,000 source/detector occultations using the DISCSP data covering almost 25% of the mission and 13,000 source/detector occultations using the DISCLA data. We extend great thanks to Mark Finger of the BATSE team who provided superior software to more accurately model the times of the occultation. Additionally, many thanks were extended to Tom Skelton of UCSD and Rob Preece at MSFC for work in resolving the energy calibration of the SPEC discriminator edges. While some work remains, Figure 2 shows a good match between predicted (diamonds) and observed (crosses) count rates in the Summed and DISCSP2 panels. The discrepancy for DISCSP1, while still there, has been greatly reduced thanks to these systematic improvements. Additionally, we discovered an unknown discrete change in the offset of one SPEC detector's discriminator after a

spacecraft reboost.

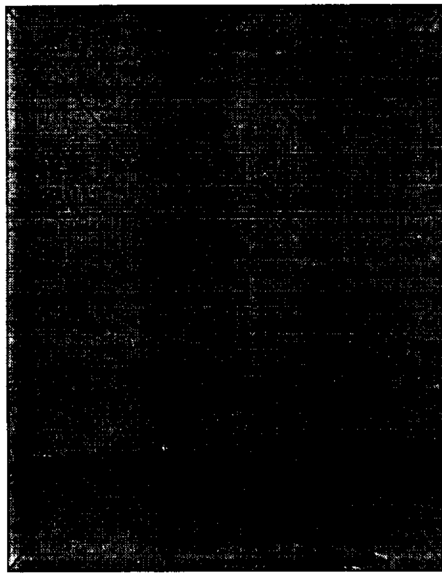


Fig 3b. Plot of Crab count rates observed using BATSE DISCSP versus observing angle.

3) High energy delays during solar flares have been frequently observed in solar flares with the delay thought to originate in either the longer lifetime of high energy electrons in magnetic traps or through the preferential re-acceleration of these electrons by some Fermi process in the turbulent flare atmosphere. Our work has shown using the BATSE MER data that the trapping times can be simply related to the electron energy through a single density and loop geometry over 100-200 keV. Markus Aschwanden again took the lead with this effort, but used many of the quantitative tools provided by this investigation.

Fourth Quarter

The major activity of the last quarter was the definition of the DISCLA channels in terms of the PHA channels used to bin the LAD energy loss events. Both systems measure all the events above the lower-level discriminator threshold and both are in anti-coincidence with the Charged-Particle Detector. There is more deadtime per event in the PHA system, hence the DISCLA rates, uncorrected for deadtime, will be slightly higher than the uncorrected HER or CONT rates. The DISCLA energy loss bins had been defined in terms of pre-flight calibrations, but there had never been a correspondance made between the two event binning modes to date to the knowledge of this user. To more fully utilize the DISCLA data in spectral analysis, including joint measurements made with CONT data, we have identified the DISCLA energy-loss thresholds in the PHA system.

We have used DISCLA and HER_COR spectra on days tjd 8377 and tjd 8799. About 100 HER accumultion intervals are used which have the best agreement with the DISCLA accumulations after correcting both for deadtime. The DISCLA rates were integrated in time to match the HER intervals. The next step was to sum each spectrum channel by channel, to create integral distributions and both distributions are normalized to unity at their peaks. Each of the integrated DISCLA channels has a value between 0 and 1 which is found by spline interpolation on the HER spectra, with the value of the HER channel taken as the PHA boundary of the DISCLA threshold. For edges DISCLA1, DISCLA2, DISCL3, and DISCLA4 no assumptions were needed, but the position of DISCLA0 was assumed to be found at 0.5% of the total intensity, its approximate position in LAD0 determined by inspection on TJD 8799. Figure 4a illustrates the technique used. The horizontal lines are placed at the level of the DISCLA(0-4) boundaries. The values obtained are given in Table 4a.

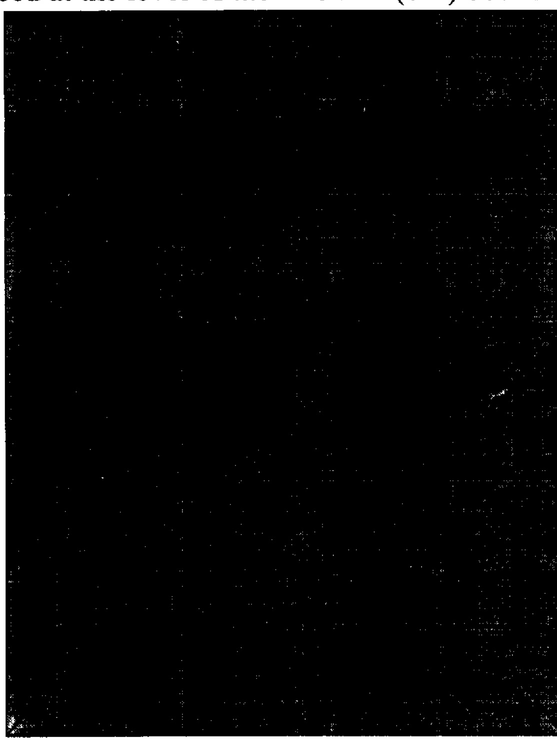


Fig 4a. Plot of PHA channel versus fractional total count rate showing the DISCLA(0-4) intercepts (red lines).

Table 4a. DISCLA Thresholds Measured in PHA Units

	DISCLA0	DISCLA1	DISCLA2	DISCLA3	DISCLA4
LAD0	5.7	8.3	14.5	25.7	67.3

LAD1	6.7	9.0	14.7	25.4	65.9
LAD2	5.0	7.0	14.4	25.4	67.5
LAD3	5.7	7.2	14.5	25.7	66.4
LAD4	6.4	8.3	15.3	26.5	67.3
LAD5	5.9	8.4	14.4	25.4	66.0
LAD6	5.3	6.5	13.6	25.0	64.3
LAD7	6.8	8.9	16.0	27.5	68.1