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Technical Report

April 1, 1997 thru September 30, 1997

UNIVERSITIES SPACE RESEARCH ASSOCIATION

(USRA)

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Project Manager



TABLE OF CONTENTS

Task 93-01-00 – HEASARC

Angelini, Lorella.....	01
Corcoran, Michael.....	07
Drake, Stephen.....	10
McGlynn, Thomas A.	13
Whitlock, Laura A.	16

Task 93-02-00 – ROSAT-GOF

Snowden, Stephen.....	18
Turner, T. Jane	20

Task 93-03-00 – ASCA-GOF

Gotthelf, Eric.....	21
Mukai, Koji.....	24
Yaqoob, Tahir	27

Task 93-04-00 – XTE-GOF

Boyd, Padi.....	33
Lochner, James	36
Rots, Arnold.....	41
Smale, Alan.....	44

TASK 93-05-00 – XTE/PCA

Strohmayer, Tod	51
-----------------------	----

TASK 93-07-00 – ACE

Christian, Eric	54
-----------------------	----

TASK 93-09-00 – RMT/BATSE

Barthelmy, Scott	56
------------------------	----

TASK 93-10-00 – TGRS/WIND

Palmer, David	57
Seifert, Helmut.....	60

Task 93-11-00 – HE Cosmic Rays

Mitchell, John	63
----------------------	----



Task 93-12-00 – EGRET	
Esposito, Joseph.....	73
Sreekumar, P.....	76
Task 93-13-00 – Theory	
Hua, Xin-Min.....	79
Mandzhavidze, Natalie.....	81
Task 93-14-00 – Mirror Development	
Chan, Kai-wing.....	83
Soong, Yang.....	87
Task 93-17-00 – X-Ray Analysis	
George, Ian.....	89
Task 93-20-00 – CGROSSC	
Barrett, Paul.....	93
Bonnell, Jerry.....	96
Bridgman, W. Tom.....	97
Macomb, Daryl.....	99
Shrader, Chris.....	101
Watanabe, Ken.....	104
Task 94-07-00 – XTE-SOF	
Cannizzo, John.....	107
Corbet, Robin.....	108
Takeshima, Toshiaki.....	112
Task 97-01-00 – GRO Fellowship	
Baring, Matthew.....	114
Task 97-02-00 – ASTRO-E	
Ebisawa, Ken.....	115
Task 97-03-00 – Detector Technology	
Krizmanic, John.....	118
Task 97-05-00 – INTEGRAL Software	
Naya, Juan.....	121



**University Space Research Association High Energy Astrophysics
Program**

Technical Report April 1, 1997 to September 30, 1997

TASK: 5030/93-01-00 - HEASARC:

Lorella Angelini:

Programmatic work: My programmatic work includes the following main areas: 1.) Restoration efforts, 2.) software development, maintenance and support for XRONOS and XIMAGE, 3.) SAX US coordination facility. I am currently supervising the work of 5 persons divided as 1 for the software, 4 for the restoration/sax project.

Restoration: The restoration effort is focussed on 3 main areas: translate the data in fits (raw and higher products), create a suite of programs to access and analyze the fits data, generate calibration files when appropriate and make the data available in the HEASARC on-line service. In late December the restoration effort became one of the main tasks and at that time the group was understaffed (1 vs. 4). I have been screening applicants for the 3 vacancies (plus 1 for the software position). One started in January and two in June (one SAX and one restoration). In the past year the restoration effort was devoted mainly to data for the following experiments: 1- The low energy telescopes on EXOSAT, 2- The Goddard Cosmic X-ray Spectrometer on OSO-8, 3- The A2 experiment on HEA01. In all cases I have designed FITS file layout, design or modify software to translate data in FITS and to analyze the FITS data, test the scientific validity of the output, and design or optimize the pipeline for the processing. The following has been accomplished in the past year:

EXOSAT: The data restoration in FITS of the EXOSAT raw data for the low energy telescopes started in January 1997. The reading software for the FOT data (original format) have been modified to produce event files and relevant housekeeping data from the low energy experiment (CMA1 and CMA2). A number of tests were made to ensure the correct scientific outcome and the 'xselect' software modified to recognize FITS file from this new data set. All the data have been processed and are now in queue to obtain a final location on the juke-box. Software modified or created to analyze the CMA1 and CMA2 data in FITS will be distributed as package with the FTOOLS. The data volume in FITS is about 12 Gyg. Leonard Garcia (started January 1997) is the software/technical support on EXOSAT.

OSO-8 high temporal resolution data: The GCXS OSO-8 160 ms raw data have been processed and now all available in FITS format. Within this effort we had to recover about 100 days of the mission from the original tapes because the restored tapes were missing or corrupted. A second processing started to generate the lightcurves for individual sources from a catalog that I have put together combining old X-ray catalogs with a threshold on source flux suitable for OSO-8. The software that generates FITS lightcurves from the raw FITS data will be available to the user as part of FTOOL in the future distribution. The lightcurves will be available on line by the end of September via a database. The OSO-8 raw data (as well as the HEAO1 A2 raw data) are in the FTP area but not accessible via a database. Raw data from scanning satellite (HEAO1 and/or OS08) require a special dedicated browser currently non-available at HEASARC. Dave Dawson is the software/technical support on this project.

HEAO1 A2 spectra and lightcurves: The HEAO1 A2 raw data are currently all in FITS in the FTP area but not accessible via a database (see OSO-8 raw data). The source spectra and background for the pointed phase have been translated in FITS and available online. A processing to generate lightcurves for the pointed and scanning phase is half way and probably will be on-line by the middle of October. Jesse Allen is the software/technical support on this project.

GIF lightcurves, spectra and images: GIF products of FITS lightcurves, spectra and images were generated for the following missions: Einstein SSS and MPC (lightcurve and spectra), Einstein IPC and HRI (images), BBXRT (lightcurve and spectra), Vela 5B and Ariel 5 (lightcurves) HEAO1 A2 and A4 (spectra). I have written and tested scripts to generate the GIF products. The scripts make use of 'xronos' and 'fplot' (lightcurves), 'xspec' (spectra) and 'ximage' (images) analysis software. The on-line databases have also been updated to access these new data products. The actual production of the GIF files was done by Dave Dawson and Leonard Garcia.

TGS matrices and the X-ray background spectra: A bug in the reformatting software that translates the matrices from the old XSPEC format to the FITS format caused a deficiency in the total effective area in the response matrices of the Transmission Grating Spectrometer on EXOSAT. All the matrices have been re-made and put on-line. The production processing for the TGS matrices was done by Dave Dawson. The problem found in the TGS matrices suggested a revision of the current response matrix format, to better deal with grating experiments. This will be important for AXAF and XMM missions.

The high energy X-ray background measurement was one of the main HEAO1 A2 results. I have recovered the original spectra and response matrices which are now in FITS. The idea is to create a dedicated WWW page for X-ray background measurements from different missions.

WWW mission pages: I have designed the access and the content of the WWW Mission pages. This is currently under development and will be on-line by the last week of September.

Databases and products on-line: One of the bottle-necks in having the data on-line accessible via the database systems (W3browse and Browse) was the lack of a standard procedure to import database tables which point to data located in our FTP area. I have designed and done the first implementation of a procedure to automatize the ingest of databases and populate the different data product layer requested from the two database systems. We have now a general procedure that can input table into our database system very easily. The on-line databases obtained using this software are: SAXNFILOG, SAXWFCLOG, A4SPECTRA, A2SPECTRA, A2BACK. In queue are SSSRAW, EXOFOT, EXOMASTER. Shawn Slavin (June started) is the HEASARC/SAX staff working as software/technical support on this project.

SAX US Coordination Facility The NASA's 1996 Senior Review of Astrophysics Mission Operations and Data Analysis Programs founded an US facility for the SAX project at HEASARC, with the primary objective to provide an archive of the SAX data. I am the HEASARC staff responsible for the BeppoSAX US coordination facility (BSCF). In the past year I have accomplished the following: 1) Set up a mirror side of the WWW SAX-SDC here at Goddard and provide the WWW access from the HEASARC home page; 2) set up procedure and software to import the SAX log databases into the HEASARC system. Currently the SAXNFILOG and SAXWFCLOG are on-line and will be updated every time the SAX-SDC provides new log-files; 3) Ingest the SAX calibration data in the HEASARC calibration database, 4) Create and populate an FTP area which mirror the SAX-SDC side, 5) Import the SAX specific software modification in ximage and xselect.

When the Senior Review recommended the US-SAX archive at HEASARC, there was no written agreement between the NASA HQ and Italian Space Agency (ASI). In January 1997 the HEASARC director (N. White) and I have been to Italy to establish contacts for such exchange reaching a basic agreement with ASI (R. Ibba responsible for the SAX project within ASI) and with the Chair of the SSSC (Sax Scientific Steering Committee) Livio Scarsi. Currently the relevant parties, NASA HQ and ASI, have an official agreement, although the paperwork is not yet completed. In view of this archive exchange I have been working with the SDC on a 'protocol and media' exchange optimized to minimize resources. The data exchange will use non rewritable CD which storage is limited to 600 MG but less affected by degradation as the conventional media (tape). SAX data are expected to start flowing at the beginning of the year.

Software Development, Maintenance and support:

XRONOS: The Xronos version 5.1 has been distributed with FTOOLS 4 in May 1997. This version included a new way of building and distributing the package to

eliminate dependence from the XANADU or FTOOLS environment, reorganize the variable declaration with the usage of include files, using a standard read and write routines, a number of fixes requested from user and/or due to platform dependent differences. The bulk of the xronos software is under revision. The following has been/will be implemented: 1- redesigning the core xronos routines to be more modular (80% done), 2- inserting the ascii input (done), 3- provide more flexibility in the plotting (50% done). The programmer (Micah Jonston, June 1997) is working under my supervision.

XIMA GE changes: 1- change in the psf calculation to allow integration of counts selected from a box and/or circle; 2- User defined counts level can be now input in the commands which allow image display and contouring; 3- Upgrade the software to include the SAX mission: add the SAX instruments in the missions information, update the calibration information; 4- Add a new command to allow changes in the information of the internal header. The release will be probably in late fall.

General Tools: a) I made available in the FTOOLS a program 'nh' which calculates N_H values by reading a map from the Dickey and Lockman survey. I distributed this program prior the official FTOOLS release (May 1997) to the following data centers: SAX-SDC (Rome Italy), University of Cambridge (UK); b) I have modified programs in the FTOOL package to allow easier plotting for the restoration projects and imported the relevant change in 'xselect' to allow SAX analysis of the LECS and MECS instruments (in collaboration with the SAX-SDC in Rome).

X-ray account: The current changes in the XANADU software packages (XSPEC, XRONOS and XIMAGE) are incompatible with the 'Browse' program available from the X-ray account. Browse allows to retrieve data from a database and make use of the xanadu packages for quick analysis. To maintain such capability I had transferred, compiled and made visible from the x-ray account version 4.02 for xronos, 9.0 for xspec and 2.53 for ximage.

Scientific Research

(a) Low energy Line Emission from *LMXRB* This project is based on ASCA data and it is aimed to create an homogenous survey of line emissions from *LMXRB*. Line emissions provides diagnostic for element abundances, and hence the evolutionary status of the system, ionization state of the emission region and their variability constrain the location of that region. Line emissions from X-ray spectra and their emission mechanisms will be one of the main science with data from the future X-ray mission AXAF and XMM. Currently I have analyzed data from 10 *LMXRB* and modeled their spectra using photoionized and collision plasma models. Low energy lines thought to result from the X-ray continuum illuminating the accretion flow. Therefore the gas ionization condition is controlled primarily by photoionization. First results on the survey are quite surprising in particular they show that the simple photoionization emission models does not work and

the effect of the recombination continuum needs to be attenuated introducing scattering. Unfortunately photoionization code are not as developed as the collisional code. As part of this project I closely work with Tim Kallman to investigate the different regimes and line emission patterns for photoionization, photoionization plus scattering and 3 body recombination models. Collaborators Tim Kallman and Nick White.

(b) *WGA CAT projects:* The two main projects using WGA catalog are on variability studies

- *Flares, Transients and long term variability.* The sample of variable objects was obtained with the 'timing' imaging technique. It includes 213 sources from different class of objects as their spectral and timing characteristics suggest. The derived Log N-Log S distribution for the entire sample shows a turn over at about 1×10^{-13} ergs/s consistent with the sensitivity limit of the survey. This value can be used to predict the number of transient events that an all Sky monitor mission would see. We obtain the following estimates 9×10^5 and 1.8×10^5 for at flux levels 1×10^{-12} ergs/s/cm², 5×10^{-12} ergs/s/cm² respectively. This study was presented at the workshop (October 17-18 Goddard), on LOBSTER (an X-ray all-sky monitor concept), by Nick White and me; and at "All-Sky X-ray Observations in the Next Decades" March 3-5, 1997 (Tokyo, Japan) by Nick White.
- *Systematic Periodicity search in the WGA sources* About 80% the bright source lightcurves have been searched for coherent periodicity and we have now several good candidates. This project is in collaboration with G. Israel and L. Stella.

(c) *XTE Crab observation:* In collaboration with S. Pravdo, we obtained high spectral resolution data on the Crab Pulsar with XTE. The aim of the observation was to study the spectral evolution across the pulse, experiments that were not possible at such high spectral/time resolution from previous mission because of telemetry limitations. We have analyzed both PCA and HEXTE instruments and the analysis of both data sets was quite challenging. The PCA data set consisted in 1 Gygabyte of good data and the standard analysis provided by XTE-GOF was not suitable for the science we want to obtain, because time consuming. For this reason I wrote a special program capable to generate 100 (or more) phase resolved spectra simultaneously in a reasonable amount of time. This handles both PCA, HEXTE and any other data sets provided in FITS format as an event list. The Crab nebula+pulsar is the source mostly used to calibrate instruments. For this reason we have to confront with a series of non-solved calibration problems between PCA+HEXTE. The paper consists in the large fraction in discussion of many inter-calibration issues. As scientific outcome, we found that many of the X-ray characteristics support the Polar-Cap model rather than the outer gap model, others instead are not explained in neither of the two theories. The paper has been accepted in Ap. J. main Journal.

(d) *RXJ0146+612* is a newly discovered Be/neutron star which shows the longest period for a Be/neutron star system. I am collaborating with Frank Haberl (MPE) on this

project by using as many X-ray data available. A paper on the ASCA and ROSAT results has been submitted. Further observations have been already obtained and other proposed in the recent ASCA and ROSAT AO.

TASK: 5030/93-01-00 – HEASARC:

Michael F. Corcoran:

Position Requirements:

1. Oversight of the ROSAT archive at GSFC and associated HEASARC public access databases; Generation of data products (screened source lists and images) for the ROSAT Results Archive; Scientific Research - primarily X-ray observations to test our understanding of hot star atmospheres and colliding wind X-ray binaries, and oversight of K. Ishibashi, a U Minn. grad student;
2. Development/support of the ROSAT Rationalized Data File Format and its extensions;
3. ROSAT Guest Observer support/HEASARC user support; software testing;
4. Design of ROSAT CD-ROMS; and
5. Oversight of the HEASARC Calibration Database.

Evaluation Factors:

1. A. Accuracy of the archive and the databases; b. availability of data; and c. responsiveness to user problems.
2. a. number of data products screened; b. usefulness of screened source list; c. usefulness of data products;
3. a. importance of science results as measured by requests for invited talks, number of citations of previous work; b. successful defense of thesis by K. Ishibashi;
4. a. Ease of use by user in terms of clarity of style and logic of data presentation; b. Ease of use
5. a. customer satisfaction; b. responsiveness
6. a. Popularity of CD-ROMs
7. a. Ease of use by casual users; ability to find information quickly; b. Number of new installations at remote sites

Primary Accomplishments:

1. The software I wrote to ingest data into the GSFC archive has been in use for more than 1 year without any major problems. Generally, if data's available from the processing center, it doesn't take longer than 2-3 hours to copy the data from the data center, verify it, ingest into the HEASARC jukebox (typical volume about 2 Gbytes/transfer), generate gif images for each transferred sequence, and generate the update to the HEASARC ROSAT public data table (ROSPUBLIC). The main problem has been getting data from the data center. Due to cutbacks in manpower and (primarily) a

change in processing hardware, the release of data by the data center is behind (about 2 months in the release of US data and about 12 months in the release of MPE data - but the MPE data is also available via the MPE archive). As a result we've gotten some questions from users concerning data availability. In general if a dataset is backlogged and a user requests it, I'll arrange a special release from the data center directly to the user. There can also be some delays in incorporating the updates into the HEASARC databases, which has the unfortunate result that data may be in the archives but users of BROWSE might not know it's available. Overall this is not a big problem and is being largely automated at the HEASARC end.

2. The data screening is going along at a pretty good pace - we've screened 1670 datasets at GSFC alone. The software I wrote to do the HRI screening is in use at 5 sites (MPE, AIP, Leicester and SAO) and has been used without complaint for more than a year. We can basically screen the data as quickly as the datacenter releases it, which was a main goal. Two test versions of the RRA catalogue (i.e. the screened source lists) have been created and have been tested and are ready for release. We're waiting for documentation in the form of Journal articles being written at MPE and SAO before we release the databases as official ROSAT products. We may revisit this in the near future and release the source lists prior to publishing these articles for expediency. I believe that these source lists will be of enormous use to the user community, mainly because preliminary comparison with the 2 ROSAT source catalogues currently available (WGACAT & ROSATSRC) show significant discrepancies and include a number of false or unreliable sources.
3. This year has been very exciting for me in terms of research and results. The main cause of this excitement has been our RXTE and ASCA observations of Eta Car. The ASCA data we received and analyzed provide the best determination of the X-ray spectrum ever obtained. We confirmed an overabundance of nitrogen, confirmed the continued variability of the central source, produced a "recalibrated" lightcurve for the 1992-96 period, and discovered a fluorescent Fe K line. We've written a paper, which has been submitted to ApJ. Most of the excitement this year has been generated by RXTE. Our RXTE X-ray lightcurve has the highest time sampling ever obtained and shows intricacies of behavior not even dreamed of before. We discovered significant variability in the X-ray flux on timescales of days-weeks, significantly constraining the X-ray source to a very small volume around the star. We further discovered an apparently regular X-ray flaring which seems to repeat every 85 days, cause unknown. In addition we've measured the longterm change in the X-ray lightcurve and found a significant acceleration in the rate of brightening since Jan 1997. This long-term variability supports (pretty strongly) the recent idea that Eta Car may in fact be a binary. If so it's the Galaxy's most massive binary. Bish Ishibashi, a UMinn grad student, has been working with me for about 1 year on the analysis of the XTE lightcurve and spectrum. This May he successfully defended a master's thesis based on the preliminary

reduction of the lightcurve, and is currently working with me and Kris Davidson (UMinn) on understanding the RXTE/X-ray and HST/UV spectrum of the star. Bish is on his way to developing this work into a Ph. D. thesis.

4. The RDF format has been widely accepted by the user community despite the fact that it presented a significant change from the previous format used at GSFC, and a significant change from the MPE data format as well. There are far fewer complaints/questions about the data and how files are structured than there were with the REVO format (either the US or MPE format). The RDF format has been adopted for use with the All-Sky Survey data as well. Even though this was not the original intention, adapting the RDF form to the allsky survey data has been a fairly straightforward process (made more difficult by the fact that the RDF programmer, Maia Good, did not have access to the survey data in its raw form!).
5. We haven't had many visitors to the GOF. Most of our support these days is via e-mail (or documentation on the web). I helped Carol Grady, Robin Shelton and Randy Smith this year. I also handled hundreds of e-mail requests (generally problems with software, or requests for documentation, or archival data access). I've generally tried to respond to each e-mail the same day I receive it. Jane Turner and I have developed scripts to aid in testing new releases of the FTOOLS software; these scripts were used to test the ROSAT software package during the last FTOOLS release this spring.
6. We published volume 7 of the ROSAT CD-ROM this summer. I've taken over responsibility for actually burning the CD's (previously done by B. Perry who's now working on XMM at Leicester). I believe all copies taken for distribution at the summer's AAS meeting were distributed; issues of other volumes have entirely been exhausted as well.
7. I took this job over from Ian George this spring. I'm basically coming up to speed on it. I've helped Lorraine Breedon (the main caldb programmer) develop a script to perform caldb installations, and have answered a small number of questions via e-mail.

TASK: 5030/93-01-00 – HEASARC:

Stephen A. Drake:

Position Requirements:

1. To help oversee the HEASARC's on-line services (OLSS) and data archives so as to make them as useful (and user-friendly) as possible for the general user community.
2. To participate in the HEASARC's data restoration activities and to ensure that they are carried out in a timely, efficient and accurate manner.
3. To carry out 'cutting edge' research in the field of high-energy astrophysics, making use, inter alia, of the capabilities of X-ray satellites such as the *XTE*, *ASCA*, and *ROSAT* Observatories.
4. To carry out 'cutting edge' research in the areas of general astrophysics in which I have developed expertise, e.g., stellar coronae, cool stars, magnetic Bp stars, etc., making use of the appropriate observational and analytical techniques.

2) Evaluation Factors:

1. The success or failure of the HEASARC's online services and archives, and of my individual contribution to these activities, should ultimately be determined (i) by how useful our 'employer', NASA, and our 'customers', the astrophysics community, think it is, (ii) by how they regard its organization and contents, and (iii) by what their opinion is of our overall responsiveness to their complaints and comments. This performance is also periodically evaluated by the HEASARC Users' Group specifically formed for that purpose by NASA and, of course, by the head of the HEASARC, Nicholas White.
2. The criteria by which our data restoration activities should be judged are essentially whether we are maintaining our objective of making all high-quality cosmic high-energy astrophysics datasets available to the general user community within a reasonable time of the creation of the HEASARC.
3. Recognition by my peers in the form of my papers and guest investigator proposals being accepted, my services as a referee or proposal reviewer being requested, and by being invited to give review papers at specialty or general meetings.

3) Primary Accomplishments:

1. & 2. Our On-Line Service (OLS) comprises the HEASARC's World-Wide Web service, including the W3BROWSE/Ingres utility for browsing our databases and catalogs on the WWW, as well as our traditional XOBSEVER/BROWSE service, and our Anonymous ftp server (our Gopher server was removed due to low usage in May 1997). My major OLS roles have been ensuring the integrity of the data and software that is accessible to the user community, and ensuring that all messages sent to our unified OLS 'Hotline' (requestLalegacy.gsfc.nasa.gov) are answered in a timely and systematic manner.

In the last year or so (Oct 01 1996 to Aug 15 1997) we have added or modified about 40 catalogs or datasets to our BROWSE and W3BROWSE/Ingres databases. In an attachment I list the 25 databases that were worked on in the 6-month period from January 1 to June 30 1997. My part in this activity involves (i) working closely with the programmers who write the software to ingest these catalogs and convert them into a BROWSEable database, and, perhaps most importantly, (ii) ensuring that these new databases are accurate representations of the original catalogs. This activity can be a very time-consuming one, in some cases involving my checking the correctness of as many as 100 parameters for any given database entry, but I think that this process has been successful in resolving some data quality issues that arose previously when newly created catalogs were not consistently checked for errors before being placed on line. With the addition of a new programmer, George Hilton (Hughes STX), as a database creator, we have increased the rate of creation of databases compared to last year and started to reduce the backlog of databases waiting to be ingested.

I have been acting as the general overseer for the files placed in the anonymous ftp area of our main Legacy computer for the past couple of years. In this role I have tried to ensure that the various directories (i) are somewhat uniform in structure, (ii) contain sufficient built-in documentation in the form of README files, pop-up .message files, and other text files that users can easily figure out where to get the data that they want and what the format of the data files is, and (iii) the data files themselves are not corrupted or incomplete. The archive on Legacy has continued its rapid growth and has almost again doubled in size over the last year, to in excess of 700 Gigabytes (Gb). Not only has the archive volume increased but the amount of data, software, and other types of information shipped to users electronically has similarly increased: at present, we are supplying every month about 15 - 20 Gb of data and software files from the /FTP area via anonymous ftp, a similar amount of data and software from /FTP and /WWW areas via our http (WWW) server. If one extrapolates assuming a linear trend this means that by the middle of next year our archive will contain in excess of 1 Terabyte of data, and we will be transferring 50-60 Gb of data per month.

In other miscellaneous programmatic activities that I have performed in the last year, I have:

- a) continued the collaboration with Anil Pradhan (Ohio State U.), Claudio Mendoza (IBM Venezuela Scientific Center), and Tim Kallman (CSFC) on the installation and operation of the TOPBase database. This database contains atomic data generated by the Opacity Project. We now have a dedicated computer that runs the captive account that accesses the TOPBase data, and this service has been functional for about the last year. In addition, I have written Web pages that describe TOPBase that can be accessed from the HEASARC home page by clicking on Software and then the TOPBase link.
- b) run regular database meetings where our progress (or lack of it) in creating/updating HEASARC databases has been discussed.

3. & 4. Research Activity

My X-ray astronomy research has essentially continued the analysis of X-ray data on a wide variety of stars and has been fairly extensively presented in a number of

publications. I think that it is correct to summarize my research activity as being quite productive, and I again have more than enough present and planned projects, together with a backlog of previous research programs, to occupy 100% of my available time, let alone the nominal 33% of it that is supposed to be devoted to this activity!

I am a Co-Investigator on a multi-institution proposal to build a high sensitivity and high spatial resolution, soft X-ray telescope, christened 'Lobster' because of the similarity of its optics to the eyes of the crustaceans of the same name. This project is PI'ed by Bill Priedhorsky (Los Alamos). As a *Lobster* Co-I, I attended a number of meetings of the GSFC participants in this project, as well as a full team meeting held at GSFC in October 1996 at which I gave a presentation on the expected number of steady and transient stellar coronal sources that a telescope with Lobster's projected capabilities could detect. I also assisted in the writing of the proposal for this telescope as a Small Explorer (SMEX) mission that was submitted in June 1997. As of the time of writing, the status of this proposal was not known.

My work as a Co-Investigator for the joint GSFC/SAO High-Throughput X-Ray Spectroscopy (HTXS) Mission also continued in 1996-1997, albeit at a lower level than previously. HTXS is the merging of two concepts, the GSFC Next Generation X-Ray Observatory (NGXO) concept (PI, Nick White) and the SAO Large Area X-Ray Spectroscopy Mission (LAXSM) concept (PI, Harvey Tananbaum), and also involves collaborations with at least a dozen other institutions, Caltech, Columbia U., MSFC, MIT, NRL, Osservatorio Astronomico di Brera (Italy), Penn State U., U. Arizona, U. Colorado, U. Maryland, U. Michigan, U. Washington, and U. Wisconsin. HTXS seems to have become the *de facto* choice of a new X-ray mission for the 2005-2010 timeframe for the high-energy astrophysics community, and has a high visibility at *NASA* up to and including the Administrator, Mr. Daniel Goldin. As an HTXS Co-I, my primary expertise is in stellar coronae and flares. I attended the High-Throughput X-Ray Spectroscopy Workshop held in Cambridge, Mass. from September 29-October 1, 1996, and gave an oral presentation discussing simulated HTXS spectra of various types of stars (this presentation was also published in the proceedings of this workshop).

My radio astronomy research continued, albeit at a lower pace than in previous years. Three papers devoted to radio astronomy of which I was a co-author were published in the last year.

TASK: 5030/93-01-00 – HEASARC:

Thomas A. McGlynn:

Position Requirements:

Lead the scientific and technical effort to develop and maintain the archives catalogs and data retrieval systems of the HEASARC as the HEASARC Chief Archive Scientist. Continue development of *SkyView*, Astrobrowse and other innovative approaches in providing new windows to scientific data for astronomers and the general public. Continue research programs in high energy astrophysics and N-body interactions. Coordinate activities on the HEASARC archives amongst government, USRA and STX staff.

Evaluation Factors:

HEASARC Archive

- Ability and desire of astronomers and the public to use the HEASARC resources.
- Use of innovative technologies to access the HEASARC.
- Growth and integration of HEASARC archive resources and software.

SkyView, Astrobrowse

- Use and recognition of *SkyView* and other services within the scientific community.
- Creation of innovative services.
- Support for comparable efforts outside HEASARC.

Other Research - Programs underway.

- Creation of innovative technologies for astronomical research
- Papers written and published.

Coordination

- Effective use of government and contractor personnel within the archive systems.
- Maintenance and enhancement of structures to facilitate project management.

Primary Accomplishments:

HEASARC archive

Usage of major HEASARC archive resources continued to grow with typical increases in usage of such services as W3Browse and Argus in the range 30-100 %.

A formal Memorandum of Understanding with the NSSDC has been signed which officially designates the HEASARC as NASA's archive for high-energy astrophysics data. Previously the NSSDC had been NASA's 'official' archive site for all high-energy data while the HEASARC holdings were nominally transient. The NSSDC relinquishment of this role recognizes the success of the HEASARC and affirms our approach to providing rapid and flexible access to mission data.

Many enhancements to the Web interfaces have been made. The most recent allows a fully distributed system so that the HEASARC archive can be seamlessly integrated with that of other astronomical institutions. This integration has begun with some data from University of Leicester already available. Discussions with Leicester and the University of Geneva (for the Integral mission) are underway to ensure that the archive/catalogs systems of at least these systems are developed in concert.

The XTE archive is now entering the phase where initial mission data becomes non-proprietary. The XTE weather-map page is frequently accessed and has been used by the XTE team to help develop outreach programs to non-astronomers.

A batch interface to our catalog services was made available. This allows users at remote sites to use HEASARC catalogs as if they were local to their site. In some months the Batch interface has accounted for 80% of the HEASARC usage (though it is more typically 30%).

Comprehensive statistics on the usage of all HEASARC Web services are now being collected for the first time.

SkyView , Astrobrowse,

- * *SkyView* usage continues to increase by about 40% over the previous year. *SkyView* responds to an average of nearly 1,000 requests per day for images. (A very complimentary capsule review of *SkyView* was published in the September 1 issue of *Science*). Typically only 2-4 web sites drawn from all sciences are reviewed in any given issue. *SkyView* gets a steady stream of fan mail and is now recognized as a 'standard' Web service by astronomers and the interested public.

- * The Astrobrowse service has been launched. This new service already provides links to more than a thousand catalogs, name resolvers and image generators using a common, simple interface. This effort is being made in concert with groups at University of Strasbourg and the ST ScI who are developing complementary systems.

- * Several new catalogs were created for *SkyView* notably an updated ROSAT PSPC all-sky mosaic of pointed observations. Absent publication of the German all-sky data this represents most detailed public survey of X-ray imaging data in the world. Other surveys include the ROSAT 2 degree resolution survey, the Comptel survey and an updated COBE DIRBE data. *SkyView* software continued to evolve. More sophisticated Web abilities were implemented and the substantial capabilities were added to the Java interfaces. The Java FITS interfaces that I developed were sent to several interested parties (at GSFC and the NCSA) during this period.

- * Initial interfaces to *SkvMorph* were developed in collaboration with colleagues at JPL.

- * Other Research

Two papers were published in ApJ.

Research programs into the diffuse gamma-ray emission continue.

- * N-body simulations of dynamical collapse were begun after discussions with Peter Quinn (of ESO). * Participated in winning *SkyMorph* ADP proposal to analyze and provide public access to optical data from the Near Earth Asteroid Tracking project.
- * Coordination
- * Continued frequent consultations with government and STX representatives on management of HEASARC resources.
- * Organized and led OGIP meetings discussing all network activities including archives, catalogs, software, and user services.
- * Reorganized Web services group to more effectively respond to government needs.

TASK: 5030/93-01-00 – HEASARC:

Laura A. Whitlock:

Position Requirements:

1. Develop an active Education/Public Outreach program for the HEASARC, first focusing on the development of World Wide Web sites which teach astronomy (especially X-ray and gamma-ray astronomy) to all ages and education levels.
2. Be an active part of the X-ray astronomy community. Conduct analyses of X-ray data from various cosmic sources, in an effort to understand the physical processes which are occurring in these systems.

Primary Accomplishments:

I won two proposals for RXTE targets of opportunity...but none of my targets had an outburst this year. These proposals are being resubmitted for the next observing period, and the collaborations they represent maintained.

1. Considering the commendations received from both the Education Community and the Web community, I believe I have met the requirements and then some. In addition, I have been able to reach educators from all over the world and establish sustainable relationships -- as evidenced by the volunteer collaborations begun this year with teachers writing lesson plans for the Learning Center, translating StarChild into Portuguese and Greek, and developing kindergarten activities.

Usage of the sites is growing in an exciting way. StarChild is now accessed about 150,000 times per month and the Learning Center is accessed 70,000 times per month. At the current growth rates, the total accesses per month to the two sites will reach a half million before the end of the year.

The success of the HEA Learning Center has afforded us the opportunity to become the lead web site for the new Structure and Evolution of the Universe (SEU) Education Forum. As a result, the site is changing and expanding its focus to encompass the whole SEU theme. It will be renamed Imagine the Universe! Making this transition has been a major part of my efforts for the past 3 months.

2. It was not a good year for science. I was all prepared to dedicate myself to analyzing my RXT data on Cir X-1 only to find out that a processing error had occurred and there was no science data on my tape. Now, 6 months later, I have still not received the reprocessed data. So I am still waiting.

I continue to work to digitize and save the P78-1 X-ray monitor data.

StarChild and the HEA Learning Center have won many awards/commendations over the past year as outstanding sites for education and/or children. Some of these are listed below.

StarChild was featured by Ms. Jean Armour Polly in the 2nd edition of her book "The Internet Kids and Family Yellow Pages" and included in her list of "Don't Miss Sites for Kids Who Love Science". Ms. Polly also nominated the site for the Global Information Infrastructure Award for Children. Results will be known in February '98.

- Yahoo Top 5% Award
- WebPilot Wings Award
- Scout Report Websites of the Month
- WebCrawler Editorial Team Select Award
- Eisenhower National Clearinghouse Digital Dozen Award
- Astronomy Magazine Webweaver Selection
- Internet Life Magazine Site of the Month
- KidSafe Award
- Major Web Select "Seal of Excellence Award"

TASK 5030/93-02-00 – ROSAT-GOF:

Dr. Steven L. Snowden:

Position Requirements:

1. Lead scientist for the GSFC ROSAT Guest Observer Facility. General guidance of the GOF scientific support, run biweekly meetings, etc. USRA Group Leader for the ROSAT GOF.
2. Preparation of data-reduction software for both ROSAT PSPC and HRI observations of extended sources and the diffuse X-ray background: Extended Source Analysis Software (ESAS).
3. Spectral and non-cosmic background calibration of the ROSAT PSPC. Particle background calibration of the ROSAT HRI.
4. Documentation for the ROSAT project.
5. Operation of the ROSAT Trend data analysis.
6. Scientific analysis of ROSAT and other astrophysical data.

Evaluation Factors:

- 1) a. The smooth operation of the science support aspect of the ROSAT GOF.
- 2) a. The release to the ROSAT community of the prepared ESAS software.
b. The satisfaction of the community with this software.
c. The ease of installation and use of this package.
d. The support and documentation of this package.
- 3) a. Quality and progress of the PSPC non-cosmic background calibration.
b. Quality and progress of the PSPC spectral calibration.
c. Quality and progress of the HRI non-cosmic background calibration.
- 4) a. The status (completeness and release status) of the ROSAT Users' Handbook, Data Products Guide, and other documentation.
- 5) a. The operation of the Trend-analysis software and processing. Utility and availability of the data.
- 6) a. Submission and publication of papers, presentation of papers at scientific meetings, invitations to give seminars. Proposals submitted and accepted.

Primary Accomplishments:

1. The ROSAT GOF continues to operate exceptionally well even in this era of diminishing funding. It remains very responsive to GO questions and requests, and has made progress on documentation, calibration, user software, and provided data products. Again as last

year, this is due to support staff, both scientific and technical, who are of the highest quality.

2. The ESAS software package continues to be extensively used in the ROSAT community, and it is still the only means of undertaking the analysis of certain aspects of ROSAT observations (the soft X-ray diffuse background and large-scale extended sources). I am solely responsible for the maintenance, user support, and documentation for this package. Unfortunately, the conversion of this software to Ftools hit a snag because of reduced funding. However, the stand-alone software is being improved with additional pipelining features. This work is being done by myself and by the UMd graduate student K. Kuntz who is funded through an ADP grant that I received last year.
3. The non-cosmic background calibration of the PSPC is complete, at least if no discrepancies appear with further data analysis (this has not occurred in the last two years). I continue to refine the HRI particle background calibration as the appropriate data become available with the reprocessing of the data. In this, the TREND data are vital and even with no other reason validates our decision to pursue the TREND processing. I've completed the draft of a paper on the HRI particle background which is now being circulated among both ROSAT and AXAF project personnel. While inherently less accurate than the PSPC calibration due to no useful on-board monitor, it is sufficient to radically improve the quality of data analysis. The spectral-calibration analysis of the PSPC continues and some progress has been made. There remains, however, a great deal to be done. One area of progress is the nearly complete mapping of the temporal and spatial gain variations. This will be complete in a couple of months with the completion of the data reprocessing.
4. The production of documentation for the ROSAT project is an area of major interaction with MPE. The ROSAT Users' Handbook and Data Products Guide have both undergone some revision in the last year on the US side (I've participated in both) but contributions from the Germans are still lacking. The entire ROSAT WWW area has been reworked over the last year and again considerably improved.
5. The trend-analysis software is operating well and the processing is in step with the ROSAT Science Data Processing Center output. This version runs about five times faster as well. As of 31 July, 2133 days have been processed.
6. In the last year I've had one lead-author and eight co-authored papers either published or accepted in refereed publications, one lead-author and one co-authored additional papers submitted for publication, three lead-author papers (two invited talks) and eight co-authored papers presented at conferences, and given two seminars. The co-authored papers include several (three refereed) papers where the lead author were graduate students who I'm closely working with.

TASK 5030/93-02-00 – ROSAT-GOF:

Tracey Jane Turner:

Position Requirements:

1. Participate scientifically in all available X-ray missions by leading successful proposals and publishing relevant papers in refereed journals
2. Serve the community as a member of the ROSAT Guest Observer facility, provide the community with relevant information and analysis guidance as required.
3. Support ROSAT Proposal Reviews as technical advisor

Evaluation Factors:

1. Success in obtaining grants and X-ray satellite observing time
2. Publication rate, particularly of first-author papers in refereed journals
3. Support of remote and visiting guest observers
4. Support of ROSAT proposal reviews

Primary Accomplishments:

1) Success with proposals. Proposals Recently Approved:

- a) LTSA: "X-ray Spectroscopy of Active Galactic Nuclei: Probing the Central Engines"
Turner & Nandra (\$584,000)
- b) ASCA: "X-ray Observation of the Water Vapor Giga-Maser Source, TXFS2226-184"
Turner, Nandra & George (\$11,000)

2) I am continually available to help visiting and 'remote' Guest Observers and handle typically ~ 8 email/phone queries per week on ROSAT issues, especially problems with data analysis. Majority of queries handled via email.

3) Will support the AO-8 proposal review in Sept 1997.

TASK 5030/93-03-00 – ASCA-GOF

Eric Gotthelf:

Scientific Research Activity:

This year I have concentrated on continued scientific collaboration with my colleagues at Goddard and at several universities. This has been a most scientifically productive year with a total of 6 papers either in press or submitted to the *Astrophysical Journal Letters*, and 3 more papers in the main *Journal*. I have also forged new collaborations with researchers at the California Institute of Technology and at Northwestern University.

The year is highlighted by the discovery, by myself and Prof. Gautam Vasisht of the California Institute of Technology, of an anomalous 12 sec pulsar in the supernova remnant (SNR) "Kes 73". This discovery has important implication for neutron star formation theory and opens up the possibility that neutron stars are born rotating slowly, or spun down quickly at birth by perhaps a strong magnetic field. This result undermines the widely held view that pulsars are born spinning fast - like the young "Crab" and "Vela" pulsars. Our discovery and analysis papers are to appear back-to-back in the September issue of the *Astrophysical Journal Letters*. A NASA press release announcing our result is to be issued at this time. We intend to pursue this line of study and collaborate on several more exciting remnants in order to understand the nature of these extraordinary objects.

My collaboration with the pulsar group at the California Institute of Technology has been particularly fruitful. I was invited by Prof. Shrivinas Kulkarni to visit and give a talk in November. I was subsequently asked to join Prof. Kulkarni on his observing run at the Keck Observatory on top of Mauna Kea in Hawaii, to search for optical companions of neutron stars. This is part of a long-term collaboration to identify possible neutron star counterparts or the lack thereof; it was a fantastic and rare opportunity to use the world's most powerful optical telescope. I was also invited to collaborate on Prof. Kulkarni's Long-Term Space Astrophysical (LTSA) Research Program grant. This proposal was successful and includes funds for further collaboration visits to California and for travel to the Keck Observatory for future observing runs.

In the process of searching for X-ray pulsars in the Globular Cluster "M 28" as part of my collaboration with Prof. Kulkarni, I discovered an unusual X-ray burst in the ASCA data from this source. This burst is very similar to Type-I bursts associated with Low Mass X-ray Binaries (LMXB) in Globular Cluster but is unusual in two ways: it is intrinsically sub-luminous and seems to originate from a system which is fainter by three orders of magnitude than expected. In our paper, submitted to the *Astrophysical Journal Letters*, we propose a connection between this burst source and the mysterious low luminosity sources seen in clusters. These may be magnetized neutron stars accreting matter at a very low rate with the accreted material likely confined to the polar cap. We hope to find more such objects by searching through the ASCA archives.

The-supernova remnant "RCW 103" may well be a virtual twin of Kes 73 - it also harbors a radio-quiet, X-ray bright compact source near the center of the remnant. So far no pulsations have been detected from RCW 103's central source, but our new ASCA observation and perhaps our proposed ROSAT observation might well detect such pulsations. Our paper on this intriguing object, co-authored by Drs. Robert Petre and Una Hwang of GSFC, will soon appear in the Astrophysical Journal Letters. In it, we show that a hot Neutron Star origin, as previously claimed, is not confirmed by our analysis of the ASCA data - the temperature and luminosity are much too high to allow a simple cooling neutron star model. Along with Kes 73, this object is shedding new light on the origins of neutron stars. These radio-quiet neutron stars may well account for the "missing" neutron stars expected to be associated with SNRS, now revealed by the ASCA observatory's spectroimaging capabilities.

Other recent work on pulsars include collaboration with Prof. Victoria Kaspi of the Massachusetts Institute of Technology. We have discovered X-ray emission from the 63 millisecond radio pulsar "J1105-6107". This pulsar has the eight largest spindown period and X-ray emission was expected on theoretical ground, as is observed from the well studied Crab and Vela pulsars, both of which share striking similarities with J1105-6107. Analysis of our recent deep ASCA observation of J1105-6107 produced a fantastic result - a 9 sigma detection of the pulsar. We have submitted our findings to the Astrophysical Journal Letters.

I continue my work on synchrotron emission from shell-type supernovas, starting with the brightest observed in its class, "Cas-A". This work is a collaboration with Prof Larry Rudnick of the University of Minnesota and his graduate student Jonathan Keohane. This research will form the basis of Keohane's PhD thesis. Along with Dr. Glenn Allen of GSFC and members of the X-ray group at the University of California San Diego, we have recently published a paper in the Astrophysics Journal which provides evidence of X-ray synchrotron emission from electrons accelerated to 40 TeV in Cas-A. This is the second object after SN1006 to show strong evidence for cosmic-ray acceleration in SNR.

We have acquired the deepest (230 ksecs) high resolution X-ray image of Cas-A so far, using the ROSAT HRI observatory. Our goal is to compare the X-ray emission directly with the radio emission. We expect that if the same mechanism is responsible for the strong emission in both wave-bands, then the bright X-ray regions around the SNR will correspond to the bright radio regions. This would be strong evidence that much of the X-ray continuum is due to the same synchrotron emission mechanism observed in the radio band. This provides an independent test of the result discussed above. We are also using this high quality data set to measure the X-ray expansion rate of Cas-A, as predicted by radio measurements. University of Minnesota graduate student Barron Koralesky is using this research project as part of his dissertation.

The supernova remnant "IC 443" seems to hold many puzzles. It is located next to an unresolved EGRET gamma-ray source, has a curious radio and X-ray morphology and is

exploding into a molecular cloud, all of which may be related. We have discovered a bright hard unresolved ASCA X-ray source within the EGRET error circle. Our paper, which presents IC 443 as another possible site of cosmic-ray emission, has just appeared in a recent issue of the *Astrophysical Journal Letters*. I am working with Drs. Petre and Hwang of GSFC, and graduate student Keohane to uncover the mysteries of IC 443. This research will also be part of Keohane's PhD thesis. We expect that our upcoming Very Large Array (VLA) radio observation will help shed some light on the subject.

Other current projects include a new collaboration with Prof. Farhad Yusef-Zadeh of Northwest University. We are re-examining the ASCA data on the Galactic Center region by comparing radio maps with the X-ray images to better understand the energetics of this unique region. With my other collaborator from Northwest University, Prof. Daniel Wang, we have completed the first paper of a series on the X-ray bright "30 Doradus" region of the Large Magellanic Cloud. Our result has been accepted for publication this year in the *Astrophysical Journal*.

Much progress has been made on the project to search for serendipitous point sources in the ASCA archives. This research is being done in collaboration with Dr. Nick White. We have produced high quality exposure corrected mosaic images from the entire ASCA public archive, which we are searching for bright and faint sources. The catalog was formally presented at the ASCA Cherry Blossom meeting and is now available in the HEASARC browse database.

Project Activity:

As a member of the ASCA Guest Observer Facility, I am engaged in the following activities:

- Managing the ASCA X-ray data archive.
- Writing software to check and maintain the ASCA archive.
- * Maintaining and updating ASCA calibration software.
- * Maintaining several software packages for the ASCA project.
- * Providing expert advice on the ASCA project to the community.
- Writing and maintaining the NASA Research Announcement for the SCA project.
- Participating in the ASCA review as a Technical Expert.

Other duties which I have performed this year include:

- * Started recalibrating the satellite pointing attitude solution to decrease the ASCA point source error circle.
- Participated in the ASCA Cheery Blossom Meeting in Washington, D. C.; presented the ASCA SIS point source catalog.

TASK 5030/93-03-00 – ASCA-GOF and

TASK 5030/97-02-00 – ASTRO-E

Koji Mukai:

Position Requirements:

- 1) ASCA Guest Observer support, from proposal preparation, submission and review, observation planning, through to data analysis. These duties are shared among the ASCA GOF scientists. My particular responsibilities are SIS calibration and software issues and proposal planning tools.
- 2) Development and testing of ASCA analysis software: again a group effort, involving programmers as well as scientists; however, on SIS matters, I am acting as a point of contact between GSFC and the instrument team.
- 3) ASCA proposal review: from the AO-5 cycle, I am organizing the proposal review under Dr. Petre's supervision. My responsibilities include selection of reviewers and matching of proposals to reviewers while avoiding conflicts.
- 4) Planning for ASTRO-E software: currently we are in the process of defining the data formats, the division of responsibilities, and software requirements, in consultations with the Japanese colleagues.
- 5) Public education and outreach: as a member of the outreach group, to communicate the excitement of science to the general public, K-12 students and their teachers. I am an active, though not a leading, member of the group, with special interest in publicizing the latest ASCA results and results on cataclysmic variables.
- 6) Continuation of multi-wavelength study of cataclysmic variables and related objects: this is a broad description of my on-going research activities, involving IR to X-ray data and many different collaborators.

Evaluation Factors:

- 1) "Customer satisfaction": i.e., how well the community (particularly those who had direct interaction with myself) accomplish their respective goals for which our (my) help was sought.
- 2) The quality of the software released to the community; the quality the data products that are distributed to GOs or kept in the archives
- 3) The success of the process: that the ASCA proposals are judged by a competent and fair group of people, including preferably 2 or more experts on the subject. The success of the result: that the US share of the ASCA observing time is given to worthy projects.

- 4) Setting up a framework that allows rapid development of software that can be used for the preflight calibration, yet allows integration into the FTOOLS scheme for multi-mission analysis.
- 5) Success of the HEASARC learning center/StarChild websites/CD, as measured by the number of hits, and feedback from the members of the public.
- 6) The number of publications; their impact, as measured by citation and other means of recognition by the peers.

Primary Accomplishments

- 1) a. I was able to answer questions in a timely manner, mostly to the satisfaction of the guest observers. I estimate that I have answered of the order of 2 substantive Questions per week. Judging by the lack of controversy at the ASCA Users' Group meeting in 1997 April, the community appears to be happy with the level of support we provide.
- 2) a. I was able to debug new and improved tools that were included in FTOOLS 3.6 and 4.0, mostly in a timely manner. There were a few bugs which we failed to catch before the release, but I believe we have managed to minimize the impact to users.
- 3) a. The AC-5 review and merging process that I helped organize went smoothly. I am now planning for the AO-6 review; we have already (well before the proposal deadline) secured 14 quality reviewers.
- 4) a. It is hard to judge how the ASTRO-E software development is going at the moment (my responsibility is mostly towards the in-flight data analysis system, whereas current work is mostly on hardware).
- 5) a. I have contributed useful materials to the HEASARC learning center, and have answered my share of questions from the public.
- 6) a. I have analyzed the ASCA data on the probable magnetic cataclysmic variable, WZ Sge. Prof. Patterson is writing up a paper including the ASCA data as well as optical and ROSAT data.
 - b. I have started the analysis of XTE data on the eclipsing magnetic cataclysmic variable, EX Hya. I have worked with Dr. Rosen and Mr. Stavroyiannopoulos at Leicester who have complimentary data on the same system. We expect to submit several papers over the nest year or SO.
 - c. I have submitted a short paper on the magnetic cataclysmic variable V1432 Aql. This paper presents analysis of archival ROSAT data, accompanied by a new model for this puzzling system.

d. I hope to circulate a draft paper on FO Aqr by the end of this period. This paper is based on a full analysis of early ASCA data, from which a short paper has already been published.

TASK 5030/93-03-00 – ASCA-GOF

Tahir Yaqoob:

Position Requirements

- 1) Analysis and interpretation of data from the Japanese/US X-ray astronomy mission, *ASCA* (*Advanced Satellite for Cosmology and Astrophysics*). Research in the general area of observational and theoretical High Energy Astrophysics.
- 2) Write proposals to obtain data from *ASCA* and other missions for the purpose of research in High Energy Astrophysics.
- 3) Development of any necessary tools to aid in data analysis. Documentation of such software.
- 4) Co-supervision of graduate student, Andy Ptak.
- 5) Helping U.S. Guest Observers (GOs) to plan their *ASCA* observations, and submitting the plans to the *ASCA* operations team at the Institute of Space and Astronautical Science (ISAS), Japan. Also helping U.S. GOs by answering technical questions relating to *ASCA* and *ASCA* data analysis, on the e-mail exploder, 'ascahelp'. Both these activities are performed on a rota basis along with the other three scientists of the *ASCA* Guest Observer Facility (GOF). These duties are performed approximately two weeks out of four, every month.
- 6) Helping U.S. GOs analyse their *ASCA* data when they visit the *ASCA* GOF at Goddard.
- 7) Preparing the NRA (NASA Research Announcement) for the *ASCA* satellite. After the first year this mainly involves revisions of the first version, including the sizable technical appendix. It is done with the help of the other *ASCA* GOF scientists.
- 8) Keeping the *ASCA* GOF Web pages and Data Analysis Manual up-to-date.
- 9) Testing of *ASCA* FTOOLS data analysis software for development and for release to the general community.
- 10) Analysis and documentation of data from multi-mission observations for the purposes of inflight instrument cross-calibration. Data from *ASCA*, *ROSAT*, *BeppoSax*, and *XTE* are used.

Evaluation Factors

- 1) Publication of the results and interpretation of the data from the observations.
- 2) Obtaining data from successful proposals.
- 3) Successful development and documentation of tools to aid in data analysis.

- 4) This is not so easy to evaluate but would probably involve a number of things such as the progress and development of the graduate student's research and acquired skills, possibly resulting in publication of research results.
- 5) Successful and timely execution of required duties.
- 6) Helping the GO set realistic goals from his/her visit to the GOF and then helping them to meet those goals, following up after their visit if necessary.
- 7) Successful and timely preparation of the *ASCA* NRA document, making it available to the community so that they may submit *ASCA* proposals for the next AO armed with the most up-to-date knowledge.
- 8) Updating the *ASCA* GOF Web documentation and Data Analysis Manual in a timely fashion, keeping up with all the latest changes in calibration and software.
- 9) Timely testing of *ASCA* FTOOLS for developers and for public release.
- 10) The task of inflight cross-instrument calibration is part of an ongoing team-effort. My responsibility is essentially to analyse the inflight data (working substantially with Keith Gendreau (GSFC) who is also involved with this effort) and communicate the results to the various instrument teams quickly so that they may adjust the spectral responses of the instruments. Many iterations of this process are required in order for all instruments to reach self-consistency to a desired level of accuracy.

Primary Accomplishments

1) Significant Scientific Accomplishments

During the period under question, a total of twelve papers were published, two were accepted for publication but not yet published and two papers were submitted which are currently being reviewed by a referee. Of the total of sixteen papers, three were first author papers. Below are details of the most significant accomplishments from work done during the actual period pertaining to this review.

"A method to model heavy X-ray absorption in X-ray sources"

Normally, physical parameters are inferred from X-ray spectra by fitting a physical model whose parameters are adjustable and then finding the set of parameters which give the statistically bestfitting description of the data. This is done by an iterative procedure with spectral-fitting programs like XSPEC. One problem with this is that the model is sometimes so complicated that each iteration would take a prohibitively large amount of time to be practical. If the number of parameters is large, interpolating models on a pre-computed grid is also impractical. This has been a problem with modeling X-ray transmission in large column densities of matter when energy-dependent Compton scattering makes the output spectrum depend on the shape of the input spectrum. However, a method was developed to model the process in a manner which allows direct

fitting in XSPEC, by means of developing some analytical approximations. Although this is the result of work done over a period of four years, a major push was made in August-October of 1996 to complete the project and get the paper accepted. The paper (X-Ray Transmission in *Cold Matter: Nonrelativistic Corrections for Compton Scattering*) was accepted in November 1996 and published in April 1997. The new model has been coded into XSPEC, so it is now available to the entire astronomical community to use and finds application to both galactic and extragalactic X-ray sources.

“Parameter Estimation In X-ray Astronomy Revisited”

In the early days of X-ray astronomy, a number of workers lay down the prescriptions for estimating the statistical errors on physical parameters derived from X-ray observations of astrophysical sources. In those days the energy resolution of the instruments was over an order of magnitude worse than is possible today with missions such as *ASCA*. Since the improvement in the energy resolution, one can apply more complex physical models than was possible ~20 years ago. I set out to test whether the prescriptions for parameter-error estimation which were based on simple models and poor energy-resolution data are still applicable to the data and models which are in use today. Performing many thousands of simulations of *ASCA* data, it turns out that if one is trying to measure narrow spectral features such as emission lines and/or absorption edges, the traditional parameter estimation techniques can seriously under-estimate the true errors. Emission lines and absorption features have been found by *ASCA* in a wide variety of X-ray sources so these results are important for many people wishing to do X-ray spectroscopy with *ASCA* and future, upcoming X-ray astronomy missions. The paper (Parameter Estimation In X-ray Astronomy *Revisited*) has been refereed once and is now being reviewed again after some modifications.

“A new method of analyzing time-series with gaps”

Deconvolving the amount of power emitted by an X-ray source as a function of frequency of the variations (i.e. the power spectrum) is an invaluable tool for probing the physics of the X-ray source. Unfortunately, the gaps in satellite data due to Earth occultation make the method impractical for active galactic nuclei (AGN). (Note that Galactic X-ray sources such as X-ray binaries vary on much faster timescales than a typical satellite orbit). Almost all of the work done on the power spectra of AGN has used data from the *EXOSAT* satellite (which flew in the early to mid-eighties) because it had a highly eccentric orbit. Even then, less than a dozen AGN were suitable for study because of the limited sensitivity of *EXOSAT* to weak sources. Starting from around May of this year I began to think about how to extract information on - 1 to - 1000 second timescales from *ASCA* observations of AGN. The current understanding, from the limited information in

existence, is that the X-ray luminosity in AGN varies on all timescales without an observable cut-off. One of the motivations behind trying to probe the *ASCA* power spectrum is to search for such a cut-off at higher frequencies than were accessible to *EXOSAT*, due to the greater sensitivity of *ASCA*. The measurement of the cut-off would then place constraints on the mass of the central black hole. By thinking about how to probe the shortest time-scales in the *ASCA* data and vet not be affected by the data gaps, I discovered a method that I was looking for. Myself and collaborators (mostly at GSFC) then applied the method to one of the best AGN data-sets that *ASCA* has thus far produced (a long observation of the Seyfert galaxy MCG -6-30-15). We measured no cut-off down to the *ASCA* sensitivity limit (a factor 50 improvement in frequency coverage compared to *EXOSAT*) and were able to place strong limits on the percentage variability at the highest accessible frequency. We were also able to eliminate orbital modulation around a black hole as the origin of the X-ray variability. A paper was written and submitted (*A Simple New Method For Analyzing Gapped Time-Series: Search For A High-Frequency Cut-Off In The X-ray Power Spectrum Of The Seyfert Galaxy MCG -6-30-15*) and is currently being refereed. We intend to apply the method to many other sources in the *ASCA* archive and also develop the method to a higher level of sophistication.

Other Projects

Over a dozen other projects/papers were co-authored. These involved a number of new results on AGN, including (i) intense multi-waveband monitoring campaigns of the Seyfert galaxy NGC 415 (ii) first results of a sample of AGN observed by *ASCA*, revealing some new and interesting trends, particularly with respect to iron-line emission as a probe of the central black-hole region; (iii) first X-ray spectroscopy of the starburst galaxies M82 and NGC 253, the former source revealing a line-rich X-ray spectrum. There are further projects in progress which have not yet reached the final drafting stage, including an optical/EUVE/*ASCA* campaign of the highly variable "Narrow-Line Seyfert 1" (NLS1) galaxy, TON S 180. NLS1s are a very recently identified new class of active galaxies which appear to be accreting much more matter than "regular" active galaxies. It is hoped that study of NLS1s may elucidate the energy-generation mechanism in active galaxies as a whole.

2. The following is a list of (five) successful proposals for data in this period.

- *ASCA* PI: T. Yaqoob (GSFC)
Title: "Spectroscopic Observations of Steep Spectrum Narrow Line Seyfert 1 Galaxies"
- *ASCA* PI: T. Yaqoob (GSFC)
Title: "The Complete Sample of Piccinotti Broad Emission-Line AGN"
- *ASCA* PI: P. Serlemitsos (GSFC)
Title: "Iron K Line Diagnostics in the High Luminosity Quasar PG 0804+671"
- *ASCA* PI: I. George (GSFC)
Title: "X-Ray Observations of Optically Selected Quasars"

- ASCA PI: A. Ptak (GSFC)
Title: "X-Ray Observation of NGC 2655"
This is a fair number of accepted proposals.
3. Development and extension of the suite of IDL routines for *ASCA* analysis has continued in collaboration with P. Serlemitsos and Andy Ptak. A particular advancement has been the incorporation of a high level of automation so that analysis of many sources in very short amounts of time can be achieved. The *ASCA* data archive now contains over two thousand observations accumulated over four years so this work will be extremely useful for investigating the X-ray properties of large samples of objects.
 4. The graduate student, Andy Ptak, has now virtually finished writing up his thesis (entitled "*Accretion and Starburst Processes in Galactic Nuclei*"). P. Serlemitsos and I have been guiding and advising him in his work. He will defend in late September 1997.
 - 5.-7. The *ASCA* GOF duties (observation planning, answering e-mail ascahelp questions, helping visiting GOs, and preparing the *ASCA* NRA) have all been performed as required in a timely fashion.
 8. The *ASCA Data Analysis Guide* underwent a major overhaul this year in order to keep up with significant improvements and changes in the software and also incorporating user's comments to make it easier to understand and use. This took up a major amount of time in the months of February and March. The Guide was distributed to attendees of the *ASCA Cherry Blossom Workshop* as part of their registration package. The *ASCA* GOF pages also underwent a major update, mostly in the month of July, in particular incorporating the latest results of inflight cross-mission calibration (see [10] below).
 9. FTOOLS were tested before public release (every ~6 months); in addition programs under development were also tested on regular basis, in order to provide feedback to the programmers. Two such programs consumed a fair amount of time; (i) an FTOOL to model the background for XTE/PCA data, and (ii) the new general X-ray astronomy analysis program, XSELECT2.
 10. Simultaneous observations of the quasar 3C 273 with the three X-ray astronomy missions *ASCA*, *XTE* and *SAX* were performed in July 1996. This is very much a team effort (comprised of people from GSFC, MIT, ISAS, Nagoya), and Keith Gendreau (GSFC) has been setting the pace with his work on the refinement of the response of the X-ray Telescopes (XRT) aboard *ASCA*. Simultaneous observations represent an unprecedented opportunity for cross-calibration of the different missions because twelve different X-ray detectors observed the same source at the same time. The data also yield valuable scientific information about the X-ray spectrum and its origin (in particular, the *SAX/ASCA* combination lead us to the discovery of a huge and unexpected Oxygen edge feature - such features are normally only observed in less luminous quasars). The analysis is challenging, because one requires an understanding of data from all the different instruments and, since some of them are new, techniques for analyzing some of

the data are still being figured out so much of the analysis has to be repeated over and over again as the analysis systems are improved. The analysis results were written up in the form of two reports, made available to the various instrument teams so that they could then modify the instrument responses. The process is an iterative one and still requires further calibration observations because the discovery of the Oxygen edge makes 3C 273 rather unsuitable. A study was done with the other team members and the Seyfert galaxy Fairall-9 was selected after I had done some analysis of existing ASCA data.

TASK 5030/93-04-00 – XTE-GOF

TASK 5030/93-18-00 MOXE

Patricia Boyd:

Position Requirements:

(During the month of June I transitioned from the MOXE team to the XTE GOF. I have indicated which requirements go with which position below.)

1. Collaborate with MOXE team members at Los Alamos National Laboratory and the Russian Space Research Institute (IKI) to accomplish the completion of MOXE flight software.
2. Analyze calibration data of flight model detectors to map out gain variations in the detectors, and the energy response of the MOXE instrument.
3. Coordinate meetings of software team, and travel plans for short term Russian visitors with the MOXE project.
4. Manage the online documentation and information about the XTE satellite and the Guest Observer Facility (GOF), and prepare hard copies of documentation for the use of XTE Guest Observers.
5. Coordinate efforts of the active outreach group OXPOG (OGIP/X-ray Public Outreach Group) which involves online learning center resources, teacher workshops, science fair judging, student tours of the laboratory, etc.

Evaluation Factors:

1. a. Routines that were developed in last two years used to test operating modes of the flight model a electronics. Bugs pinpointed by this analysis, and in some cases, codes improved.
b. The state of MOXE flight software: is it well understood, and has it been "frozen" into its final format?
2. a. Calibration maps for each of the detectors generated, showing regions of high and low gain, with the design threshold for the MOXE detector gain variations.
b. Problems in the detectors and electronics identified by features in the calibration data, and corrected.
c. Response matrices calculated from calibration measurements with flood sources.
3. a. Visit of Valeri Efremov in early 1997 coinciding with software team meeting in Los Alamos and Flight Software Testing/Debugging session at GSFC.
b. Visit of Vadim Arefiev being planned to begin in October 1997, to coincide with the taking of new and improved calibration data at GSFC with the MOXE flight model detectors and electronics.
4. a. Updating web pages with information about XTE AO-3, x-ray counterparts of gamma ray bursts, new IAU Circulars, ApJ articles, etc.

- b. Developing postscript versions of some documentation so that visitors to web page may obtain paper copy- (This project is ongoing.)
- 5. a. Development of OXPOG group into educational resource entity recognized by GSFC and NASA HQ.
- b. Involvement of OXPOG as a whole and individual OXPOG members in outreach projects both large and small.
- c. Participation in state and national teachers' association meetings.

Primary Accomplishments:

1. MOXE Flight Software: During the past year, the MOXE team and the Spectrum X-Gamma team were very active with tests and trouble-shooting sessions to locate and correct problems with the flight software, and the data path from the detectors, through the spacecraft electronics, to the ground support electronics and quick-look analysis. Specifically there was an international flight acceptance test here at GSFC where detectors and spacecraft simulators were integrated and put through the various motions of the observing environment. The MOXE analysis software, which I developed in collaboration with Los Alamos and IKI co-workers, performed extremely well, allowing us to identify problems with the spacecraft clock and some inconsistencies in the MOXE Flight Software. These bugs have been located and corrected, and the MOXE flight software is currently in its final form awaiting delivery to Moscow. There is no doubt that the well-functioning Quick Look Analysis software was instrumental to our success in this effort. In addition, other instruments (BIUS) used the results of our analysis to locate their own bugs. Our QLA collaboration was a success.
2. MOXE Flight Model calibration: An enormous amount of calibration data of the MOXE flight detectors was analyzed over the past year. With some guidance from Kevin Black of the MOXE team I wrote and debugged codes for reading in the uniquely formatted calibration data, and analyzing it to obtain numerous characteristics of the detectors. Until I left the MOXE team, I was the lead person on the analysis of calibration data to obtain information on detector gain variations, and response matrices. Early analysis of this data pointed to a problems with the detector electronics, which will make determination of position resolution quite difficult without new calibration data. The electronics problems have been corrected in the detectors. Plans are underway to repeat the collection of calibration data at GSFC, with the corrected flight detectors and the flight electronics. The results of the analysis of the preliminary data are: maps of each detector for gain variation as a function of location on detector and from detector to detector; preliminary response matrices for a single detector; maps of detected photons for each of six flood sources on all detectors; and a clear idea of how to proceed with taking new calibration data. Based on the problems with the initial data, due to the electronics problem, my analysis gleaned everything from the data that could be obtained.
3. MOXE collaborator visits: Part of my duties as a MOXE team member has been to oversee the travel plans and GSFC visits of Russian co-workers from the Russian Space Institute (IKI). This involves handling the details of their appointments with USRA, and making sure that group software team meetings occur in coordination with their visits. Over the past year, I coordinated the visit of Valeri

Efremov, who worked on the short term MOXE data base development. During his visit, we had a software team meeting at Los Alamos, and a flight software test at GSFC. His visit lasted 10 weeks. I am also currently still in the process of planning the visit of Vadim Arefiev, whose stay at GSFC will coincide with the taking of new MOXE calibration data. During his visit, I will also have the chance to discuss my calibration analysis with him. Vadim is scheduled to arrive October 10, 1997 for a 10 week visit. I have agreed to continue to follow through on Vadim's travel plans and visit.

4. XTE WWW Information: I have just begun my tenure with the XTE GOF, and I feel I am coming up to speed with the responsibilities of the position. In my first month, I have become familiar with many aspects of the analysis of XTE data (though I am still learning!) and have taken over the task of updating the online information about the project and the analysis of data. Since this is the only source of information for our remote Guest Observers, I realize this is an important task, and I have been adding it regularly. In addition, I have already entered the rotation of the "hot seat", meaning that one week or so a month I field the data analysis questions emailed in by remote GOs. I find this is a great way to learn the ropes. I believe I am successfully integrating myself into the XTE GOF team, with lots of support from other team members.

5. OXPOG Outreach: The OXPOG has grown and changed tremendously over the past year. In March, I was approached by Jim Lochner and Nick White to take over as the Head of this group, as Jim was stepping down. Jim certainly got the ball rolling, and we continue to gain momentum at every turn it seems. At the National Science Teachers' Association meeting in New Orleans, I was introduced to Dr. Woods, of the Education office at NASA HQ. I have built a relationship with him over the months that has resulted in some very high profile opportunities for our group: I wrote a proposal that was accepted to represent the Structure and Evolution of the Universe Theme at the 1998 NSTA meeting in Las Vegas. This was in collaboration with Laura Whitlock. This proposal was also accepted for presentation at the Virginia and California state teachers' association meetings.

In addition, Laura was approached to head up the SEU section of a NASA Theme booth being prepared for future meetings. The fact that OXPOG projects and members are being asked to represent SEU at this time is quite significant, and was the result of lots of bridge-building and hard work. This year the OXPOG has gained the addition of three full time outreach employees in our lab. I am responsible in part for overseeing the efforts of one of these employees, Allie Cliffe. Allie is taking the lead in the development of High Energy Astronomy NASA Education Briefs and a Teacher's Guide to accompany the online learning centers. The OXPOG is clearly a success, measured both by its output of educational resources and by the recognition it is receiving in the NASA and Education communities.

TASK 5030/93-04-00 – XTE-GOF

James C. Lochner:

Position Requirements:

1. Direct the receipt and distribution of XTE Calibration Products. Aid Instrument Teams as needed in the development of calibration software and data files.
2. Direct deliveries of XTE ASM products to the GOF and make appropriate products available to astronomical community.
3. Provide support to XTE Guest Observers and to XTE proposers.
4. Participate in furthering the public outreach activities of USRA, the HEASARC, and the RXTE GOF.

Evaluation Factors:

- 1)
 - (a) Conformance to OGIP standards for both software and data files.
 - (b) Demonstrate progress with regard to the development of deliverable software and calibration files.
 - (c) Availability of calibration data, software, and documents to the astronomical community.
 - (d) Prompt and accurate responses to user problems and bug reports.
- 2)
 - (a) Nature of ASM Products clearly defined.
 - (b) Maintain a working processing pipeline for delivery of the products.
 - (c) Accessibility of ASM Products by astronomical community.
- 3)
 - (a) Prompt and accurate responses provided to GO/proposer queries.
 - (b) Spend fair share of time as duty scientist for visiting GOs.
 - (c) Provide accurate technical assessments of proposals.
- 4)
 - (a) Development of educational materials.
 - (b) Promotion of existing materials.
 - (c) Promotion of USRA/HEASARC/XTE GOF resources for education and public outreach.

Primary Accomplishments:

1. During the past year, I have continued to act as the interface between the RXTE instrument teams and the community for the delivery of calibration software and data files. For the PCA team, this has meant primarily upgrades to existing software; for the HEXTE team it continues to mean checkout of new software.

With the calibration files and software for the PCA now a well established part of the analysis of XTE data, I have now focused primarily on interfacing with the PCA team for their maintenance and upgrade. As the PCA team continues to better understand the response of their instrument, they continue to provide improved calibration files and software. I have continued to work with Keith Jahoda (GSFC) in providing these to the community via FTTOOLS releases and updates to the HEASARC's Calibration Database. In response to these updates, I have also revised the GOF developed software which wraps together the PCA calibration tools. In addition, I have also provide release notes to the FTTOOLS team describing the changes to the software. Finally, I have also worked with the HEASARC and the PCA team when needed to track down and fix software bugs in the various software. The most significant of these was coordinating with PCA, HEXTE, and the HEASARC to fix an ambiguity in the definition of the first channel in the energy spectra files.

I have also continued to work with the HEXTE team for the continued delivery of HEXTE calibration and analysis software. This year we met with some success with their delivery of software tools for separating on-source from off-source pointings of the HEXTE instrument and for computing the deadtime in energy spectra and light curves. I performed necessary tests on these when they were delivered, and continue to guide them for upgrades and future deliveries. I also assisted in developing a recipe for users to follow when analyzing their HEXTE data.

2. I have continued to develop and maintain the archive of public ASM data products and the community access to the products.

On a regular basis, I retrieve the weekly updates to the products from MIT, merge these updates into the database and post the updated products to the XTE public archives. Since Sept 96, MIT has produced 2 revisions of the products, and I've successfully incorporated these revisions into the archives. I have also provided appropriate ASM information for the GOF web pages.

During the past year, I also coordinated the implementation of making the results from real time data public. I oversaw the efforts of the SOF and the HEASARC, and verified the process and results. I also finalized the text and made public Tom McGlynn's (USRA- HEASARC) XTE ASM Weather Map web page for the real time data.

I have also worked to develop an "Educator's Interface" to the ASM products - see section 4.

3. I have actively participated in providing support to guest observers and proposers. I participated in the RXTE AO-2 review as a technical reviewer and assisted Dr. Alan Smale in organizing the peer review panels. I have answered questions as they come into our xtehelp email, and I have spent 95 hours of contact time helping visiting guest observers. Through these means, I've worked with GOs to help solve their problems, and occasionally review their results.

4. I have worked to further the public outreach efforts of USRA, the HEASARC, and the XTE GOF. For the HEASARC, I have provided a wide range of services in support of the High Energy Astrophysics Learning Center, and have represented the HEASARC to the Sun-Earth Connection Education Forum. For the RXTE GOF, I have begun the development of an "Education Interface" to the ASM data products. For USRA, I headed up the writing of a proposal in response to a NASA Announcement of Opportunity for regional education Broker/ Facilitators. I describe below these various activities. (I gave up leadership of the OXPOG in January so I could better devote myself to these efforts. However, I continue to work closely with the OXPOG's new leader, Padi Boyd, to guide and advise on OXPOG activities.)

SEC Forum - I guaranteed HEASARC's participation in the Sun-Earth Connection Education Forum by regularly participating in SEC Forum meetings. I promoted the HEASARC's ability to develop and maintain databases, and its ability to develop interfaces to the databases. This is relevant to the SEC Forum's plan to develop a catalogue of education materials covering SEC science, and to make selected science data available to teachers and students. HEASARC's participation includes a archive scientist at 1/4 time, and a programmer at 3/4 time. In addition, the HEASARC is also positioning itself to provide the same service for the Structure and Evolution of the Universe Education Forum, although arrangements are still being worked out.

BrokerIFacilitator Proposal - I volunteered to head up the USRA proposal to become a regional Broker/Facilitator in NASA's Office of Space Science's new Education Ecosystem. When the Announcement was issued by NASA HQ, I participated in discussions with David Holdridge, Laura Whitlock, and Padi Boyd about developing a B/F program. When our other candidates for the Principal Investigator turned us down, I stepped in as PI. I wrote the proposal and coordinated contributions from the others on our team. We successfully submitted our proposal, and are awaiting the results of the NASA review panel. Although it came late, Dr. George "Pinky" Nelson (deputy director of the AAAS' Project 2061) agreed, after reading the proposal, to be chair of the Steering Committee, a central feature of our program.

ASM Education Interface - I initiated the development of an "Education Interface" to the RXTE ASM products. To carry this out, I have supervised and coordinated the

efforts of Carveth "Bud" Worth (GSFC Summer Teacher Intern) and Maggie Masetti (Hughes/STX). This interface will allow teachers and students direct access to the RXTE light curves, and will provide them information on the x-ray sources and suggestions for using the data. Bud and I discussed lesson plans and project ideas to accompany these data, and Bud implemented one of the ideas. Bud hopes to continue to work with me through the school year to implement other lesson plan ideas. Ms. Masetti is developing the Web interface.

Ask a High-Energy Astronomer - I have continued to head up the "Ask a High-Energy Astronomer" feature of the HEA LC. We presently have a team of 10 PhD astronomers who take charge of being sure incoming questions get answered. They are supported by a group of about 10 other scientists and programmers who contribute answers. I make the schedules for the "hotseat", step in when needed on particularly difficult questions of policy, and create the archive of selected questions and answers to post on the HEA LC. We answered nearly 80 questions a month during the spring and early summer of 1997. Early in the summer, I worked with Allie Cliffe (Hughes/STX) to develop form letter responses for questions which already exist on the web site or in our archive of past questions, or which are outside our area of expertise.

Evaluation of the HEA LC - I headed up the contracting with SLI, an evaluation company based in Annapolis MD, to develop an evaluation instrument for the HEA LC. During the summer, this evaluation form has been given to teachers at workshops at Goddard and at Project ASTRO workshops in San Francisco, Seattle and Middletown, CT. Teachers have been given a CD of the HEA LC and asked to evaluate its content and features, with special attention to how it is used in the classroom. Results for this evaluation will be available in late September.

Brochure, Business card, and CD booklet - I supported the outreach efforts of the High Energy Astrophysics Learning Center by preparing a brochure describing its features, and business cards giving the web and mailing addresses. I also wrote the booklet giving the instructions and features for the Learning Center CD.

NYTI workshops - I have attended NTTI workshops to demonstrate and promote the HEA LC in Northern Va. and in Norfolk, Va. For the latter, I headed up the effort and was assisted by Mike Arida and Allie Cliffe (Hughes/STX). I also attended the NSTA's "Global Summit" in San Francisco in late December to support the exhibit promoting the web site.

Space and Earth Sciences Education Workshop - I participated in the planning, of this USRA-sponsored workshop for teachers and scientists in August. I also participated in the workshop as a scientist aid to a group of teachers.

Mentoring of Adam Severt - I mentored Mr. Adam Severt, a high school senior from Alton High School (Columbia, MD). Together, we studied the evolution of the

16.6 day orbital light curve of Circinus X-1 using data from the RXTE ASM and from the Vela 5B ASM. He attempted to fit the RXTE folded light curve using the model of Muirden (1980), which assumed the evolution of the light curve is due to the orbital precession of a binary system consisting of a neutron star and a massive blue Giant. This model failed to consistently fit the ASM data and the Vela 5B data. Through further examination of the color information in the ASM data, and through searching the literature, we developed a set of criteria that a new model for the system must satisfy. Chief among them is that the companion star be a low mass, not a high mass, star, which apparently changes the precession period from tens of years to thousands of years. My subsequent work will involve attempting to develop new models based on these criteria which also fit the data. Adam's experience provided him valuable training and insight into how science is done.

TASK 5030/93-04-00 – XTE-GOF

Arnold H. Rots:

Position Requirements:

1. Design and implement a system that can turn all XTE telemetry into FITS files:
 - 1.1. Design of the FITS table formats.
 - 1.2. Design of the XTE FITS DataBase (XFDB).
 - 1.3. Design, implementation, and testing of the XTE FITS Formatter (XFF).
 - 1.4. Design and supervision of the implementation of the XTE Data Finder (XDF).
2. Ensure the -quality of the XTE production pipeline' s products and the health and accessibility of the mission archives
3. Address any appropriate science/technical issue that presents itself in connection with the XTE mission, in particular time-related issues.
4. Contribute to the development of the XTE-GOF and participate in its operational tasks.
5. Scientific research relevant in the context of the XTE mission.
6. Serve on the OGIP and WGAS FITS Working Groups.

Evaluation Factors:

- 1)
 - a. Deliver robust and working software.
 - b. Deliver software on time.
 - c. Provide data access capabilities to all mission participants.
- 2)
 - a. Ease with which users can access data.
 - b. Timeliness with which products are available.
- 3)
 - a. Thorough understanding of all major aspects of the mission.
 - b. Promptly provide an essential service when the need arises.
- 4)
 - a. Providing support in any GOF-related area; happy users.
 - b. Participation in discussions, planning, and development.
- 5)
 - a. Papers and conference contributions.
 - b. Seminal effect on the other four areas.
- 6)
 - a. Attend, and participate in, meetings.
 - b. Provide communication between XTE project and OFWG.

Primary Accomplishments:

1. XFF has been turning out production data for a year and a half now, and clearly works well. I take care of updates in the EDS Configuration Data Base, in the SOF and XSDC, and the subsequent template file generation. XDF is now more than just

a data base navigator and allows users to browse the entire public mission archive at home without having to make any FTP transfers themselves or having a need for large amounts of disk space.

2. Last fall, I led the effort in diagnosing the problems that XSDC was having with the quality control of their product, and suggesting ways to fix the problems and dramatically improve their quality monitoring. I assisted in implementing the fixes which were almost all in the SOF's DataManagement subsystem software - though, in all fairness, a number of them were caused by misleading information about certain instrument telemetry formats -, implemented more monitoring code in XFF, and specified the quality monitoring methods for XSDC. The result is that processing at XSDC, at least from a technical point of view, proceeds very smoothly.

On the issue of the public archives the MDSS solution was pretty much a failure. It was decided that HEASARC would take care of the physical archives using an MO jukebox for physical media. Late delivery, faulty hardware, and faulty commercial software plagued this project. Originally, delivery was planned for spring 1996. The net result is that we expect to be putting it into public service in the second half of August 1997. Due to these developments, and extra complications brought on by the slow pace at which reprocessing is progressing at XSDC, I had to design and implement a scheme that would allow seamless merging of the archive-proper and the MDSS holdings, as a stop-gap measure. This appears to be successful and includes a scheme to manage the transition from proprietary to public data. I should mention that I also designed the architecture of the archive which required satisfying conflicting requirements: distribution of data over a fairly large number of partitions for security, while allowing fast access to metadata and common data.

3. The tall milestone was that I succeeded in finalizing the implementation of the fine correction application to the XTE clock. Photon arrival times can now be tagged with an absolute time stamp that is correct within 5 microseconds. This is a major achievement for science space missions and very appropriate for a timing mission.

I continue to supervise the creation of the as-flown time lines (ObsCat) and of the real-time archives

4. As the work on clock corrections progressed, it appeared that the accuracy of GOF software to calculate barycenter corrections was unknown; the original requirement had been 0.1 ms which is clearly not good enough for XTE. I wrote a completely new set of routines to calculate the solar system ephemeris and barycenter corrections to make this check. The result was that the existing software is actually good to 1 microsecond. But in the process we gained a second set of software routines to do these calculations that works from the original JPL DE solar system ephemeris, that can easily switch to the new ephemeris DE-405/406, due to come

out in August 1997, and that includes software to FITSify the JPL DE ephemeris files.

As an extension of this work, I provided new user-friendly tools that allow analysis of pulsar observations by simultaneous phase and spectral binning of the photon events, thus allowing light curve analysis as well as phase-resolved spectroscopy. These tools have become very popular among our users.

I have helped a number of guest observers, served on the xtehelp desk, and helped users devise ways to improve their data reduction procedures and write scripts to do large-scale processing.

I turned both the xtime tool and the Recommd tool into interactive web tools and provided web access to all time correction data, software, and documentation.

5. I have applied the phase binner tools to observations of three X-ray pulsars: B1509-58 (150 ms) B1821-24 (3 ms), and the Crab (33 ms). The results are very exciting, now that we can do absolute timing between radio and X-ray pulses to an accuracy never seen before. A paper on the first two pulsars has been submitted to ApJ. Work on the Crab is progressing, but it seems certain that radio and X-ray are not coincident; the X-ray peak is leading the radio by about 0.25 ms.

6. The OGIP (or HEASARC) FITS Working Group has not met, in the past year. However, I have become a member of the WGAS FITS Committee which is the regional North American committee on FITS standards and FITS conventions of the IAU FITS Working Group. The hot issue is the change in the date formats, in preparation for the year 2000. The European committee had adopted a resolution that mandated the use of UTC which I considered short-sighted, dangerous, and plain wrong. I became the editor of the North American version which now acknowledges the need for specifying the time scale used, and moved on to become the editor of the IAU FWG version.

TASK 5030/93-04-00 – XTE-GOF

Dr. Alan P. Smale:

Position Requirements

1. Manager of the RXTE Guest Observer Facility, a position with overall responsibility for:
 - (i) the receipt of RXTE production data and the conversion of telemetry into FITS formats;
 - (ii) data archiving and distribution to the user community;
 - (iii) software development for data analysis;
 - (iv) support of the astronomy community in their RXTE data analysis and interpretation.

The GOF Manager is also responsible for the administration of the GOF, assigning duties to personnel, and interfacing with other groups such as the Instrument Teams, the Astrophysics Data Facility, NSSDC, HEASARC etc.

- 2) Coordinator of the RXTE Guest Observer Program, including
 - (i) the preparation of technical information and proposal submission tools for community use;
 - (ii) helping potential Guest Observers during proposal preparation and submission;
 - (iii) the planning, organization and conduct of the RXTE proposal scientific and technical Peer Reviews;
 - (iv) the dissemination of the results to the community.
3. Lead developer of RXTE software for data selection, cleaning, and analysis (e.g. the accumulation of RXTE spectra, light curves and other data products, allowing for filtering by time, channel (energy), housekeeping and orbital parameters, source intensity, and binary Phase.)
4. Scientific research. Effective and timely analysis of data from X-ray and ground-based observatories; addressing scientific questions at the forefront of the field; keeping up-to-date on developments in X-ray astronomy and related science; applying successfully for observing time with RXTE and other instruments; insight into the physics of X-ray binaries and other galactic X-ray sources.

EVALUATION FACTORS

- la. Is the GOF effectively carrying out its support of the X-ray community with software tools and data analysis expertise?

1b. Is the community analyzing RXTE data successfully and publishing interesting results?

1c. Is the GOF functioning well within the organizational structure that includes the SOF, the Instrument Teams, HEASARC, and other NASA departments? Are the limited resources in the GOF being used wisely?

2a. At the times when RXTE proposals are solicited by NASA HQ and submitted by scientists in the community, does the GOF support the community well?

2b. Are a large number of competent proposals being submitted? (This is an index on some level of how well the GOF is publicizing RXTE and important information about it, and how successful it is in disseminating information to the community in an easy-to-use form.)

2c. Is the community satisfied with the performance of the GOF during the proposal preparation and peer review activities carried out this year?

3a. Is the software I develop flexible and easy to use? Are we meeting deadlines?

3b. Am I developing my skills and keeping them current? Am I learning new techniques and technologies? Is my work on RXTE data analysis software flexible to the demands and opportunities presented by improved software and hardware capabilities etc?

4a. Am I doing good science? Am I making the best use of the data available to me, and exploring the physics with sufficient depth? Am I involved in a range of different projects and wavelengths?

4b. Am I effectively supervising and assisting with the science of others, where appropriate?

4c. Am I successful in my proposals for new data? Am I thinking ahead to future scientific opportunities?

4d. Is my scientific expertise recognized by the community, and if so, how?

PRIMARY ACCOMPLISHMENTS

1. RXTE GOF Manager:

This year I have:

- * Directly supervised the efforts of 4 scientists and 4 programming staff the RXTE GOF, and ensured that the balance of responsibilities was shared fairly and that no part of the GOF effort fell behind;

- * Worked with many other personnel who are shared with other OGIP projects, and negotiated their efforts with the other supervisors in the building to ensure that the GOF's needs were represented;

- * Continued to be personally involved with the implementation of almost all the RXTE subsystems, and to lead the design for the FTOOLS data analysis systems (see below);
- * Worked actively with the instrument teams, the SOF and the Astrophysics Data Facility to ensure all the interfaces continue to function smoothly);
- * Represented the RXTE GOF at the RXTE Users' Group meetings in March and September 1997;
- * Helped reach an agreement with EUVE whereby EUVE time will automatically be granted to accompany a successful X-ray/UV RXTE AO-3 proposal;
- * Consulted with Arnold Rots about the design of the public archive and many issues surrounding its creation (a responsibility that seems to have devolved to the RXTE GOF);
- * Chaired the selection process to find a GOF Duty Scientist to replace Charles Day, who left to work for Physics Today. Padi Boyd was hired to fill this vacancy in May.
- * Taken my turn in assisting visiting Guest Observers with their data analysis -- I believe I'm currently in first place in terms of the number of GO contact hours performed in the GOF;
- * Regularly participated on an equal footing with the other GOF scientists in taking my turn in manning the Email hotseat for data analysis (and other) questions;
- * Performed public outreach and publicity functions, most notably participating in press conferences and briefings at the AAAS, and developing the AstroCappella project (see below);

One measure of the success of the GOF and its data analysis software and community support is the number of scientific results that have been generated by the community. So far there have been 70 IAU Circulars containing new RXTE results, 49 papers published in the literature, with another 9 accepted for publication.

APPRAISAL AND SUMMARY:

Under my management and with direct involvement from me in almost every aspect, the GOF is functioning well. In addition to my management/administrative role, I also play a major part in this effort as a team member at ground level.

2. RXTE GO Program Coordinator:

Activities this year have included:

- * The Budget Review for RXTE AO-2 (in Sept/Oct 1996);

- * The preparation of NPA materials for AO-3, involving writing new text, continuous interactions with HQ to resolve problems and issues, and the release of this NRA in May 1997;
- * Supporting the community prior to the proposal submission deadline on Sept 5 1997, and the classification of proposals and reviewers into panels for the review;
- * Other logistical preparations for the AO-3 Peer Review, to be held in November 1997 after the HEAD meeting.

I have played (or am playing) the lead role in all of these activities, and have met every deadline placed on me by NASA HQ. In addition, I have also:

- * Worked with the Users Group and NASA HQ to come to an agreement about the extension of proprietary time for RXTE AO-1 observers;
- * Dealt with AO-2 (and residual AO-1) budgetary issues, talking directly with NASA HQ, NASA Procurement and individual GOs to ensure that grant money was disbursed efficiently and with minimal confusion;
- * Helped with the Email hotseat to assist proposers with the technical and scientific aspects of writing their proposals and estimating proposal feasibility.

APPRAISAL AND SUMMARY:

I have ensured that the RXTE observing program has gone smoothly over the past year, from AO-2 budget review through the preparations for AO-

3. Software Designer

This year I have continued my work in designing and implementing the range of RXTE-specific software, and my supervision of full-time STX programmers Elza and Tripicco. Two particular highlights of this are the release of two powerful analysis programs, XSELECT2 and FLAUNCH, both of which are 'smart GUIs' that make the underlying FTOOLS easier to use.

I have performed extensive testing and analysis using GOF software and funneled my experience back into tool upgrades (in particular for the release of FTOOLS Version 4.0 in May). I have also tested and assessed PCA team background subtraction software, and proposal preparation software tools such as RPS and WebSpec.

To enable that users can use the tools effectively, I have written recipes for light curve analysis, QPO analysis, PGP use, and a number of other data analysis tasks.

APPRAISAL AND SUMMARY:

My software involvement continues, although perhaps not at quite such a high level as in previous years (which is partly to be expected, now that the analysis

software is maturing). Although programming interests me, I have chosen to spend more time on science this year to make up for previous years when my science output was not particularly high.

4. Scientist

Over the past year I have been involved in several scientific investigations:

(1) At the end of the last assessment period I was awaiting the results of my 4 RXTE AO-2 proposals. In fact all four proposals were successful, giving me a total of 560 ksec of time on 15 separate objects in this round and making me the most successful single AO-2 proposer.

(2) I discovered kilohertz oscillations in the 685-sec binary X1820-303, an important result both for this individual system and for the study of extremely fast time variability in LMXBs in general. I published an IAU Circular on the discovery in October, presented a poster about it at the January AAS in Toronto, completed and submitted the paper in March, and the paper appeared in APJL in July. I enclose a copy of the title and abstract page.

(3) My major new science initiative this year has been a multiwavelength campaign of observations of X-ray binaries, using RXTE X-ray data and optical and infrared observations obtained at CTIO (Cerro Tololo Interamerican Observatory, Chile). (These observations mark my return to optical observing, a long-standing goal of mine.) The optical observations were performed as a (long!) 11-night run at CTIO in April/May; thanks to some outstanding weather we obtained three nights of data on X1323-619, a 2.9-hr source displaying bursts and dips; four nights on X1254-690, a 3.9-hr dipper, and four nights on X1556-605, a little-studied system with a possible 9-hr period. Different energy regimes correspond to different physical locations within the binary, so multiwavelength observations provide a much more complete picture of the emission regions in these systems. Such observations have never before been made for these sources. In addition we were able to obtain quasi-simultaneous optical/X-ray observations of two other sources (X1624-490, X0918-549) which have been poorly studied in the past. As the nights were long at that time of year, we took an added bonus and studied the optical counterparts of the X-ray-quiet sources X1755-338 and X1659-298, in an attempt to clarify the nature of the mass-donating component while the system is uncomplicated by the large X-ray emission that exists while the sources are 'on.'

Since returning I have reduced the X-ray data from all of these sources, constructed light curves, and searched for kHz QPOs (extremely fast time variability) seen in other objects (see x1820-303, below). The optical work was done in collaboration with Stefanie Wachter (UWash). At the time of writing we have made

the following discoveries, all of which we plan to write up and publish by the end of 1997:

* X1254-690 is no longer showing dipping behavior in the X-ray, though the optical minima persist! This tells us that the structure on the disk edge has vanished almost completely and that the optical emission is coming from the heated face of the companion star.

* The 9.1-hr modulation previously observed in X1556-605 is not evident in our observations -- both the X-ray and optical data suggest the period is nearer 27 hrs, implying that the system is much larger (and the companion much more evolved) than we previously supposed.

* Despite the disappearance of X-ray emission, X1755-338 is still relatively bright in the optical (brighter than it "should" be for the type of companion star it probably contains). This may mean that mass accretion is continuing but that we do not see the neutron star directly, only the reprocessed optical emission.

I will present first results of this program at the HEAD meeting in Colorado in November 1997.

(4) This year we completed the analysis and publication of the RXTE ASM data showing a ~78-day period in Cygnus X-2, resulting in an IAU Circular, followed by an ApJ paper. The 78-day period is probably due to a precessing accretion disk.

(5) I've been continuing to work on my data from the burst in Cygnus X-2 (referred to in last year's summary: this is the source with such a high persistent accretion rate that no bursts should be observed). I completely reanalyzed the data twice this year, in October and April, and am still not quite happy with the X-ray fitting results (largely because of uncertainties in the PCA response matrix). I haven't yet decided whether to publish the result 'as is' or wait for the next iteration of the response matrix.

(6) In addition, I have been involved in several other science projects at a fairly low level. I did some spectral fitting and general mentoring for a project on X1916-053 ASCA work, with Yuan-Kuen Ko (UMd) and Koji Mukai (USRA). I am involved in a second study on the same source, based on ASCA, Exosat and ROSAT data, with Morley, Church and Balucinska-Church (U.Birmingham, UK). I am a co-author on a paper about the Cyg OB2 association with Steve Drake (USRA) and Wayne Waldron.

(7) I have given two invited review talks over the past year, one at the AAAS Annual Meeting in Seattle, and one at the Royal Astronomical Society National Astronomy Meeting in Southampton, England. Both were well received.

APPRAISAL AND SUMMARY:

My scientific research continues to be a strong component of my work, both as lead author and collaborator, and I expect this to continue as I write up the results described above from the RXTE/CTIO work and other RXTE-based projects.

TASK 5030/93-05-00 – XTE/PCA

Tod E. Strohmayer:

Position Requirements:

1. Support calibration and measurement of RXTE-PCA collimator responses and detector pointing directions.
2. Support calibration of PCA spectral response, response matrix generation and detector deadtime.
3. Assist RXTE Guest Observer Facility (GOF) concerning PCA field of view (collimator responses) and detector pointing issues as GOF needs dictate.
4. Support PCA team calibration and RXTE science needs and requirements as circumstances dictate.
5. Carry on an active astrophysics research program, primarily utilizing RXTE data.

Evaluation Factors:

1.
 - a) Significant progress in quantifying the accuracy of the PCA collimator model, including corrections for background and deadtime. Collimator model good to ~1% over the "core" half-power region. More detailed analysis required to characterize the wings of the response to this accuracy, and as a function of photon energy.
 - c) Characterized the effective solid angle viewed by the PCA collimators, important for understanding the contributions from diffuse sources (see copy of WWW document;
<http://lheawww.gsfc.nasa.gov/users/keith/fieldofview/collimator.html>).
2.
 - a) Collimator model characterization now being used as a benchmark for extending the current deadtime calibration to higher countrates with the use of scanning data over very bright sources (for example, Sco X-1). Important for understanding spectra of very bright sources.
3.
 - a) Redeliver collimator response files with modifications as GOF needs dictate.
 - b) Assistance to GOF staff; Jim Lochner, Gail Rohrbach and Padi Boyd regarding PCA pointing and collimator issues.

4.

- a) I supported the preparations for the Visiting Committee peer review of the Laboratory for High Energy Astrophysics in Dec. 1996. I was asked to present one of the science talks to the committee. The talk was about the discoveries of very high frequency variability in neutron stars by RXTE. I also led the development of a display board concerning the new science results obtained with RXTE during, its first year of operations. The display can be seen on the 2nd floor of building 2 at GSFC and is entitled, "RXTE: Exploring the Physics of Compact Objects and Their Environs."

5.

- a) 2 RXTE AO-2 PI observing proposals approved.
- b) Co-investigator on 8 additional RXTE AO-2 proposals.
- c) Submitted as PI I ASCA A06 proposal and co-I on one NASA ADP proposal
- c) Author or co-author on 4 International Astronomical Union (IAU) Circulars describing results from RXTE observations.
- d) Author or co-author on 5 Astrophysical Journal papers concerning results from RXTE observations.
- e) Conference abstracts, invited talks and contributed talks.

Primary Accomplishments:

- 1) Background and deadtime corrected scans of the Crab nebula and pulsar are used to quantify the accuracy of the PCA collimator models. Agreement to ~1 % demonstrated for the "core" half-power region of the response. .
- 2) Interpretation of scanning, data from Sco X- 1 and the collimator characterization confirms that additional deadtime corrections needed at very high countrates. Calibration currently in progress.
- 3) Further study of AO-1 PI observations of the X-ray burster 4U1728-34 on the timing and spectral properties of the rising portion of X-ray bursts strongly supports the rotational modulation scenario for the oscillations detected during X-ray bursts. Provides strongest confirmation to date that millisecond rotating, neutron stars exist in low mass X-ray binaries, and that these are the progenitors of at least some of the ms radio pulsars. (see, Strohmayer, Zhang, & Swank, 1997, ApJ, 487, Sep. 20 Letters)
- 4) Study of AO-1 PI observations of the pulsar 4U1907+09 reveal new X-ray intensity dips never before seen in this source (in' t Zand, Strohmayer & Baykal,

1997, ApJ, 479, L47). A second paper on the pulse timing, and detection of 18 s oscillations from this source has recently been submitted to ApJ.

5) Detection of 589 Hz oscillations in RXTE burst data from pointings near the galactic center region. The source position was constrained using the collimator calibrations and the observed rates in the five independent PCA detectors (see Strohmayer, Jahoda, Giles & Lee, 1997, ApJ, 486, 355)

6) Invited talks:

a) "Ultra-fast QPOS: RXTE and the Study of Neutron Stars," at the American Association for the Advancement of Science (AAAS) annual meeting, Feb. 1997, in Seattle, Washington.

b) "Observations of Millisecond Variability from Accreting, Neutron Stars," at the American Physical Society (APS) meeting in Washington, DC, Apr. 1997.

c) Invited to give talk at 1997 Meeting of the High Energy Astrophysics Division (HEAD) of the AAS, 11/97 in Estes Park, Colorado.

7) Contributed Talks:

a) "High Frequency Oscillations During Type I X-ray Bursts: Evidence for Millisecond Rotators in LMXB," at the AAS meeting in Toronto, Canada, Jan. 1997.

b) "Constraints on Neutron Star Properties from X-ray Burst Spectroscopy with RXTE," at the AAS meeting, in Winston-Salem, NC, June, 1997

Task 5030/93-07-00 - ACE

Eric R. Christian:

Position Requirements

1. ACE Deputy Project Scientist.
General support of the ACE Project Scientist including smoothing the interface between the science team, project office, and spacecraft contractor. Also represent science team at various meetings and on various working groups.
2. Instrument Investigator for CRIS and SIS instruments on ACE.
Assist with the design, test, and integration of the instruments, and the preparations for launch (August 25) and subsequent data analysis.
3. Co-I on High Energy Cosmic Ray groups SR&T program.
Support of ongoing balloon projects, specifically TIGER, IMAX, and ISOMAX.
4. Independent Research on Heliospheric Physics.
Anomalous cosmic rays with Voyager Cosmic Ray System. Theory of modulation. Darkening of cometary bodies in the Kuiper belt by cosmic rays.

Evaluation Factors

1. The best evaluation factor for this section is the opinion of the ACE team as to whether I'm useful and doing a good job. This year I was officially made Deputy Project Scientist because of my work on the project.
2. I have been assisting the SIS and CRIS teams for years now, and this year they have made me an Instrument Investigator to recognize my usefulness to the project.
3. The evaluation factors for the SR&T program are successful proposals, construction of instruments, successful flights, and publications.
4. The most quantitative evaluation factors for this section are the number of papers written and the number of times these papers have been cited in the literature.

Primary Accomplishments

1. I think I've done well in my task as *ACE* Deputy Project Scientist. I'm an active member of the Spacecraft Operations Working Group, and the Mission Operations Working Group. I represent the ACE Science Center (which is based in California) at many of the local Mission Operations meetings. I am chairman of the ACE Public Outreach committee, and was one of the editors of the Public Outreach Brochure for ACE, and I'm responsible (author and curator) for the Goddard ACE World Wide Web pages. Just before and after the launch, the ACE web pages were receiving thousands of hits per day. I continue to support the Cooperative Satellite Learning Program and the high school that has "adopted" ACE, and traveled to Old Bridge, NJ

three times last year. Although I was only a part of a very large team, the successful launch of ACE this August is my primary accomplishment this year.

2. I feel that I was an important part of getting the *CRIS* and *SIS* instruments delivered, integrated, and tested this last year. Although I was not the expert on any particular subsystem, my general knowledge of the whole system and ground support equipment allowed me to cover several different roles at one time during integration and test. My knowledge of the spacecraft and its ground support equipment also proved very useful. A substantial fraction of my time this last year was spent on ACE integration and test (just ask my wife).
3. *TIGER*: As I write this, the *TIGER* instrument is nearly flightready and waiting in Ft. Sumner, NM for a launch opportunity. I am Instrument Manager for the Goddard part of the instrument (Wash. U. is the principal institution). Since this is a reflight of the instrument from last two summers (when the balloons failed) I haven't had to spend much time on the hardware this year. However, the *TIGER* concept has become part of a possible space station experiment called *ACCESS*, and I am active in the definition phase of this project. I will be participating in the proposals we need to write in the next month.

IMAX: Data analysis is essentially complete. We have identified very good antiproton candidates and have near final isotope ratios. Several papers are either submitted or nearly completed.

ISOMAX: I am responsible for the *ISOMAX* command and data handling system, both onboard and ground support, and the design, construction and testing of the magnetic shields for the photomultiplier tubes. Due to a delay in the delivery of the magnet, *ISOMAX* work has been slow for the last year, but my work is continuing at a fairly low level. *ISOMAX* is due to fly in the summer of 1998.

4. I have not spent as much time on independent research as I would have liked to during the last year, but still have done useful work. I had a poster talk at the 1997 AGU meeting that developed from my work with John Cooper of GSFC/HSTX and Robert Johnson of U. of Virginia studying the darkening of comets in the Kuiper Belt by cosmic rays (anomalous cosmic rays are an important component). We are currently working towards a refereed paper on this topic.

TASK 5030/93-09-00 – RMT/BATSE

Scott Barthelmy:

There are six basic projects/areas that I work on. Let me review them with one-sentence explanations and acronym expansions in case they are not all that familiar to you from previous reports:

- 1) GCN (GRB Coordinates Network; formerly known as BACODINE: BATSE COordinates DIstribution NEtwork) monitors the real-time transmitted data from the BATSE instrument on GRO, calculates positions of GRBs (Gamma Ray Bursts), and distributes those locations to many sites around the world to make simultaneous, multi-band, follow-up observations. The expansion to the GCN system includes the distribution of GRB locations from the RXTE & Ulysses and extreme-UV transient locations from the ALEXIS spacecraft. GCN is a combination of a GRO GI proposal and NASA SR&T.
- 2) Our group continues work on the next generation of gamma-ray detectors: CdZnTe (CZT). This is a new technology which promises, and is delivering, medium-energy resolution with large collecting areas at room temperature at a cheap price (all positive aspects). The goal for this effort was our SMEX proposal for the BASIS mission to determine arcsecond locations of GRB and distribute them for follow-up observations within 10sec. We will know in September of the results of the SMEX competition.
- 3) The InFOCuS (International Focusing Optics Collaboration with microCrab Sensitivity) is our group's new SR&T balloon program. It is collaboration with Dr. Pete Serlemitsos with his grazing-incidence foil mirrors, the Nagoya (Japan) group to apply the multi-layers to increase the maximum grazing energy to 100keV, and our group to make the CZT detectors and the gondola. It will have imaging and spectroscopy.
- 4) The GRB Polarimeter is a DDF program (T. L. Cline is PI) to design and build an instrument to measure the last unmeasured parameter on GRBS.
- 5) GTOTE (GRB to Optical Transient Experiment) is a wide-FOV version of the RMT instrument. It uses BACODINE locations to make completely automated, rapid response, follow-up observation on GRBS. Additionally, there is the GCN (GRB Coordinates Network). This is an SR&T program which I combine BACODINE, IPN, XTE, and HETE GRB coordinate information into a single-source distribution network.
- 6) GRIS (Gamma Ray Imaging Spectrometer) is a balloon-borne, high energy-resolution, Germanium spectrometer to investigate gamma-ray sources in the universe.

TASK 5030/93-10-00 – TGRS/WIND

David Palmer:

Position Requirements

Most of my work this year has been concerned with BASIS (Burst and All-Sky Imaging Survey), a proposed small-explorer (SMEX) mission. The instrument is a coded aperture telescope using an innovative cadmium zinc telluride (CZT) room temperature semiconductor detector with 100 μm spatial resolution in combination with a 100 μm feature-size gold mask.

The goal of this work was to demonstrate that BASIS is a conceptually sound instrument, which can be built and flown in the required time frame (~3 years) and will be able to produce the desired observations.

1. BASIS control and data analysis software development. I designed and wrote the data capture and analysis software required to interface with several prototype CZT detector arrays. This software accepts data from the hardware interface, formats it, and then produces data analysis products including high resolution coded aperture images. It also allows us to characterize the performance of the detectors.
2. BASIS mask development. I have designed a mask pattern which allows imaging with two-scale detectors and also greatly reduces the computational requirements for locating point sources. I am working with people at the Advanced Photon Source (APS) to develop the mask fabrication techniques, which use X-ray lithography to produce a 100 μm thick gold layer on a beryllium substrate.
3. BASIS on-board processor architecture design. The imaging algorithms which must be performed on the BASIS spacecraft require massive, high-speed, but simple computations. I worked with the spacecraft electronics systems designers to define an architecture which could implement these calculations in the required time with the available power budget.
4. BASIS proposal writing. I wrote sections of the BASIS SMEX proposal dealing with the mask, imaging system, and image processing hardware. In addition to my BASIS work, I also made some scientific investigations using data from existing spacecraft instruments.
5. Developing new techniques for analysis of variations in high-resolution background spectra, such as those produced by TORS. I am working on a technique called Principal Component Analysis (PCA) which can separate a time-variable 8192-channel spectrum into the sum of a small number of spectra with constant shape and time-variable amplitude. This allows physically separate sources of background to be distinguished and isolated, at which point parts of the nuisance 'background' become interesting 'signal'.

6. Small investigations. These short-term projects are often event driven. e.g. Last October there was what appeared to be four GRBs from the same point in the sky within 48 hours. There have now been several GRBs which have produced afterglow at lower energies (X-ray, optical, and radio.)

Evaluation Factors

1. a. Analysis results.
b. Quality of software.
c. Publications of results.
2. a. Progress in development of shadow mask.
b. Utility of produced masks.
3. a. Ability of the architecture to carry out the required calculations.
b. Efficiency and economy of the architecture.
4. a. Quality of proposal.
5. a. Results or promise of technique.
6. a. Publication or presentation of results.

Primary Accomplishments:

1. The analysis software has produced excellent results. The following is the first γ -ray image ever made with a 100 μm feature size detector and coded-aperture mask. It was presented at the SPEE conference in San Diego in early August, and will be included in the proceedings. The design of the instrument control software is also very successful. By changing just a small code module, I am able to implement controllers for additional detector systems, which has proven useful as more diverse systems are being developed in our CZT program. The code was also easily modifiable to implement testing procedures and diagnostic outputs that were vital to getting the detector system working properly.
2. The shadow mask development is proceeding. 70 micron thick gold patterns have been produced, and we expect to push this to 100 μm thicknesses later this year. This requires further development in the techniques of the gold plating process, rather than the X-ray lithography *per se*. The APS group is also evaluating different substrates, including carbon composite material, to get away from the difficulties (metallurgical and toxicological) of beryllium. The masks that have been made have proven to be effective, as seen by the figure above. The two-scale pattern does not prevent the fine imaging from working properly.
3. The imaging processors on BASIS will use programmable logic arrays (PLAS) to implement the imaging algorithms. These are more effective than microprocessors

because a) greater parallelism is possible; b) computations are not restricted to 8, 16, etc. bits at a time, but *e.g.*, a 3 bit by 5 bit multiplier leading to an 18 bit accumulator can be implemented if that is the optimum; and c) operations not required by the algorithm need not be implemented. Thus, although fewer gates are available on a PLA than on a microprocessor, they can be used much more efficiently. The PLA architecture therefore produces more computing power (for this specialized application) for a lower cost and power consumption than a microprocessor implementation would.

4. I believe that our proposal was extremely strong, and therefore has a very good chance of being accepted. (In this field, a 30-50% chance is considered very good.)

5. Although my implementation of the principal component analysis technique is not fully debugged, it appears to separate the variations in the background spectrum into about five components for most time periods. This is sufficiently small that I expect to be able to ascribe physical meaning to most of these components, and to the residual in the periods when these components are insufficient.

6. The quadruple GRB was the subject of an IAU circular and a talk and paper in the Texas astrophysics symposium. I am first author on an IAU circular about the gamma-ray spectrum of one of the GRBs with an optical counterpart, and will be presenting results at the Huntsville GRB workshop in September.

Task: 5030/93-10-00 – TGRS/WIND

Helmut Seifert:

Position Requirements:

- 1) Lead the algorithm design, simulations & software development team (two scientists, one programmer) at NASA/GSFC in support of SPI, one of the two main instruments of the ESA INTEGRAL mission. Take charge of the SPI instrument mass-model.
- 2) Lead the design, development, implementation, and testing of TGRS data analysis and archiving software. Generate software requirements and specifications, and develop algorithms. Lead, guide, and assist the programmers' team (two programmers). Conduct progress review meetings with the TGRS and programmers' teams. Evaluation of programmers' performance and progress. Responsible for the Monte-Carlo modeling of TGRS, and development and update of the instrument response. This task is crucial for the correct scientific evaluation and interpretation of the data.
- 3) Responsible for TGRS mission operations issues, e.g. updates to the TGRS command, macro, procedures, telemetry, and constraints database when needed. Responsible for TGRS flight operations and instrument commanding. Attend meetings as the TGRS instrument representative as needed.
- 4) Analysis of TGRS data. Present scientific results at meetings and in scientific journals.

Evaluation Factors:

- 1)
 - a . Understanding of the SPI instrument, data flow, and intended science goals.
 - b. Definition and design of data formats, analysis algorithms and analysis software based on the given instrument characteristics and intended SPI science goals.
 - c. Status of the INTEGRAL/SPI software development, simulations, and method explorations.
 - d. Efficiency as the central point of contact for the SPI mass-model.
- 2)
 - a . Understanding of the TGRS instrument, data flow, and intended science goals.
 - b. Definition and design of the data analysis and archiving software requirements and specifications based on the given instrument characteristics and instrument science.

- c. Status of the data analysis/archiving software development, and response generation.
- 3) Status of the WIND/TGRS mission, and efficiency in representing the TGRS team, e.g. with the Flight Operations Team.
- 4) Status of TGRS data analysis and presented results.

Primary Accomplishments:

- 1) The LEGR group at NASA/GSFC is actively involved in Monte-Carlo simulations and data analysis algorithm and software development in support of the SPI, a coded aperture mask gamma-ray spectrometer aboard the ESA INTEGRAL observatory to be launched in 2001. Our group is playing an important role within the SPI team, and our contributions in the areas of spectral deconvolution, imaging, and background simulations have been crucial in identifying software needs and in making progress towards software prototypes. In the review period, I have attended, two meetings of the SPI instrument group, and the software development group (ISDAG): one in Milano, Italy, and the other in Williamsburg, VA. I have lead a team of two other scientists and one programmer to develop a powerful simulation framework, MGEANT, which can be used not only for SPI, but can be adapted for simulating any gamma-ray experiment (e.g. TGRS, GRIS). This software has been made available from our Web Site to the international gamma-ray community. I have designed the data structures which will be used for the SPI event data, and have adapted existing formats for spectra and instrument responses for SPI. Two "Ftools" software packages also have been released from the same site: *spihist* is used to histogram events for one or more detectors, and allows cuts on multiple events, and on events which are either transmitted through the Shield or scattered from the mask; *spimrsp* is used to generate spectral responses from the raw event files. These two latter packages are working prototypes of the SPI data analysis software which will eventually be used for flight data. Several other exploration studies involve to identify algorithms, and strategies for the deconvolution of spectra and extraction of images. The difficulty in this is to try separating spatial and spectral contributions to the measured data. We are currently developing a new method of decomposing the total response by using both simulations and analytic methods. Together with the University of Birmingham, UK, and the Max Planck Institute in Garching, Germany, in the review period the LEGR team has a clear lead in these studies, and significant progress has been made.

- 2) The TGRS data analysis package is now in a phase where most of the major analysis modules have been completed. However, still new features are added to the existing programs, and some new-more specialized-software is being added. One major activity during the review period was to develop the archiving requirement for TGRS. I have analyzed and identified the data structures and software needed, and one software module, mkrsp which translates TGRS response matrices to FITS format, has been completed. Another module, spc2pha which translates TGRS spectra, is currently under development. Apart from this, I took an active role in the testing, debugging, and improvement of all the software modules. Work on the response generation is continuing on a need basis, i.e. new responses are generated for new bursts which are to be analyzed. Modeling support is also given to the group members who study the 511 keV radiation from the Center of our Galaxy.
To ensure software quality and continuous project progress, I have been meeting with the programmers' team (two programmers) whenever needed, both to be available for questions and to resolve problems. Also I have been conducting status meetings of the TGRS scientists, the programmers' team, and their management, and have been actively involved in decisions about computing hardware and software acquisitions, and configuration issues.
- 3) I am responsible for these functions on a need basis; there were no major activities in the review period.
- 4) I have been mostly involved in the analysis of the TGRS burst data and their comparison to BATSE and KONUS. In the review period, I authored a paper on a bright gamma-ray burst which was observed on August 22, 1995. This GRB has been the brightest burst observed by TGRS to-date and, indeed is among the brightest bursts ever observed by any instrument. With the high resolution of TGRS, this GRB is ideal for the search of fine structure in the spectrum, and to study the sensitivity to potential line features. The paper will appear in The Astrophysical Journal 491, on December 20, 1997.

TASK 5030/93-11-00 – HE Cosmic Rays

John W. Mitchell:

Position Requirements and Primary Accomplishments:

My current research addresses a broad range of topics in high-energy astrophysics including: studies of high-energy Galactic cosmic rays as a probe of the origin and history of Galactic antimatter, of stellar nucleosynthesis, and of particle transport processes in the Galaxy; viewing high-energy gamma radiation as a probe of the physics of extreme conditions such as those found in Active Galactic Nuclei; obtaining a new perspective on the Universe through neutrino astronomy at TeV energies; and detection of the highest energy ($>10^{20}$ eV) particles to open a new astronomical window and to probe what may be the most energetic astrophysical processes in the universe. In addition, I am involved in an active program of high-energy nuclear and particle physics research.

General Description of GSFC Position Requirements and Responsibilities

I am a senior scientific member of the High Energy Cosmic Ray Group (HECR) in the Laboratory for High Energy Astrophysics (LHEA). My position involves participation in existing HECR projects as well as development of new research efforts. I feel that I have excelled in both of these areas. I am involved in all of the numerous HECR research programs and play a central role in the majority of these projects. After the group head, Dr. Robert Streitmatter, I am the most senior scientific member of the group and often function as "second-in-command" in group activities. In addition to my HECR work, I have acted as a consultant on particle detection to a number of research groups both within the LHEA and elsewhere in the academic, commercial, and government research communities.

I am an expert in experiment design, particle detectors, detector/trigger electronics, numerical modeling, and physical interpretation. I believe that I provide the HECR group and the LHEA the combination of expertise in instrumentation and in the underlying physics which is necessary to achieve some of their most exciting and important goals. My breadth of expertise has allowed the HECR group to undertake a number of projects which would not otherwise have been practical.

I am currently responsible for the BECR instrumental contributions to the balloon-borne ISOMAX and CAPRICE97 cosmic ray experiments and the satellite-based PAMELA cosmic ray instrument. I am responsible for the study/development of major components of the OWL orbital ultra-high-energy cosmic ray instrument. I am also a member of the instrument development teams for the balloon-borne TIGER, space station based ENTICE/ACCESS, and satellite-borne POEMS cosmic ray experiments.

I have often played a central role in identifying new areas of research and in developing the approaches to be used. My efforts have been crucial to the considerable success of the HECR group in obtaining funding for its work. For example, I conducted

some of the preliminary science studies and most of the instrumentation studies for the Isotope Magnet Experiment (ISOMAX), currently the main research program in the HECR group. I also played a critical part in formulating and writing the highly successful ISOMAX proposals (1992 and 1995) to NASA. In particular, I wrote virtually all of the instrumentation and management components of both proposals and was responsible for developing the budgets for the project. I was also responsible for the GSFC portions of the recent proposals to NASA for the WiZard Related Balloon Program (currently supporting CAPRICE97) and to the Italian Space Agency for the PAMELA satellite program. I played a part in the development of successful proposals to NASA for the Orbiting Wide-Field Light-Collector (OWL) satellite study, the ENTICE/ACCESS study, gas microstructure detector (GMSD) development for future gamma ray instruments, and the TIGER cosmic-ray experiment.

My professional reputation, particularly as an instrumentalist, has resulted directly in scientific opportunities for the HECR group. The GSFC involvement in the TIGER experiment came about as a result of the collaboration first approaching me as a consultant on the time-of-flight system. Similarly, I was first approached by the Italians to design the TOF for the experiment which later became PAMELA. Although the HECR group has had a long-standing collaboration with members of the PAMELA collaboration, GSFC involvement in PAMELA was originally based on my ability to design the TOF and associated electronics.

I was responsible for the HECR instrumental efforts on the balloon-borne MASS2, IMAX, TS93, and CAPRICE94 cosmic-ray experiments and am active in the interpretation of data from these experiments. I have also contributed to the development of the BESS instrument and to the subsequent scientific interpretation of the results. In the past year, eight refereed papers (published, accepted, or submitted) have been based on the results of these experiments.

Details of Selected GSFC-Related Research Efforts

ISOMAX: I am currently Instrument Manager for the GSFC-led Isotope Magnet Experiment (ISOMAX), a new balloon-borne experiment (to fly in 1998) which will make definitive measurements of the abundance of light isotopes in the cosmic radiation. The ISOMAX measurements of the ratio of radioactive ^{10}Be to stable ^9Be will provide an essential test of models of cosmic ray transport and storage in the Galaxy. I have the overall task of ISOMAX systems engineering as well as numerous specific responsibilities. I have had the lead role in designing and managing the construction of the instrument/payload, electronics, and superconducting magnet. I designed and built the state-of-the-art ISOMAX time-of-flight (TOF) detector system.

During the past year, excellent progress has been made on the development of ISOMAX. The detector systems, trigger, power system, and data

acquisition systems have been tested both independently and in partial integration using cosmic ray muons. It is expected that the instrument will be fully integrated for testing without the magnet by the end of 9/97. During the past year, I have worked extensively on all aspects of the experiment including detectors, magnet, trigger electronics, data acquisition electronics, DC and high voltage power systems, and mechanical systems. This work has involved coordinating and/or directing the work of a large GSFC team of scientists (L. Barbier, E. Christian, J. Krizmanic, S. Geier, S. Gupta), engineers (P. Beltran, S. Derdeyn, R. Smith, L. Ryan), and technicians (H. Costlow, S. Holder, R. Nace, D. Righter, S. Seufert) as well as researchers from the collaborating institutions.

I have developed most of the operational and testing procedures for ISOMAX. In the past year, this work has involved upkeep and re-evaluation of the engineering sensor suite, command list, and both the science and engineering data lists. I developed the dead time algorithm to be used and supervised its implementation. I worked extensively with Thomas Hams of University of Siegen and with Harry Costlow, Sunil Gupta, and Bob Smith of GSFC on detection and elimination of electronic noise in the drift chamber tracking system.

During the past year, I have also completed studies of the required dynamic range of the ISOMAX detector systems and of the gas dynamics of the magnet dewar system under both quench (collapse of field) and loss of guard vacuum conditions. On the basis of this I have designed the venting and fill systems for the magnet in the instrument gondola. I have also worked with S. Gupta (NAS/NRC) on measuring the performance of selected CAMAC electronics modules in the ISOMAX magnetic field (a paper on this work has been accepted for publication by NIM) and am in the process of designing shielding for the critical components. I have begun development of the safety documentation (cryogenic and magnetic) for ISOMAX.

One of the high points of the last year has been the completion of the time-of-flight detector system, consisting of 13 independent plastic-scintillator based detectors viewed by high-speed photomultipliers. This will be one of the highest performance TOF systems ever flown, with an expected timing resolution of about 60 picoseconds for beryllium nuclei over a 2.6 meter particle flight path. The TOF will provide the main velocity measurements for ISOMAX up to particle energies of about 1.5 GeV/nucleon and will be the only detector measuring the charge of incident nuclei. I designed the entire TOF system and built it with the help of Sven Geier, a graduate student from the University of Maryland College Park who will be basing, his PhD on ISOMAX. As discussed below, I am acting as Sven's main mentor at GSFC.

Major progress has also been made on the superconducting magnet. The magnet, for which I am responsible, was designed (based on my strawman) and is

being constructed by Oxford Instruments (OI) in the United Kingdom. Unfortunately, the development of the magnet has taken much longer than expected, with the most recent setback coming during the early spring when it was determined that OI had been unable to make the cryostat (liquid helium vessel) vacuum tight as required. I traveled to Oxford in April, 1997 with Sid McClure, a welding expert, to assess the situation. Sid found that poor welding technique had been employed and I found a number of engineering errors in the cryostat construction. We subsequently traveled to OI in July and August, 1997 to supervise the rework of the cryostat. During these trips, I was able to suggest a number of improvements to both the engineering and the fabrication techniques used and during the August trip was able to detect a number of electrical errors than had escaped detection by OI. Two more trips will be required (in September and October, 1997) to complete fabrication and testing of the magnet but at this point we anticipate delivery of the completed magnet to GSFC in early November, 1997.

CAPRICE97: The Cosmic Antiparticle Ring Imaging Cherenkov Experiment 1997 (CAPRICE97) is the current (to fly September, 1997) effort of the WiZard Collaboration and is directed toward the measurement of high-energy (4-20 GeV) cosmic ray antiprotons. I have leading roles in the scientific and instrumental direction of this collaboration (I am a member of the advisory board). I attended a scientific meeting of the collaboration at New Mexico State University in November, 1996.

During the past year, I built the TOF detector system and the event trigger electronics for CAPRICE 97. The TOF system was based on the earlier TOF which I had built for TS93 and CAPRICE94. However, the photomultipliers used in the past had developed problems and direct replacements are unavailable. As a result, I developed a refined installation using a newly developed type of photomultiplier (Hamamatsu R5924). This has resulted in a considerable improvement in TOF system performance. The demonstrated 230 picosecond timing resolution for relativistic $Z=1$ particles is more than adequate for the CAPRICE97 requirements and is one of the best achieved using magnetic field tolerant photomultipliers. In the course of this work, I carried out an extensive study of the aging and failure characteristics of the previously used Hamamatsu R2490 photomultipliers. The results of this study are of considerable interest in both the cosmic ray and nuclear physics communities.

Through my contacts at DOE laboratories, I obtained the time digitizer electronics for the drift chamber tracking system. This was a major contribution to the payload since the electronics required were not available within the collaboration and no funding was available to obtain them. Since the digitizers were slightly different from those used in the past WiZard experiments, I

supervised the modification of these electronics to meet the CAPRICE97 requirements. I also handled fault diagnosis and repair of a number of other CAPRICE97 electronic systems.

OWL:

I am leading focal plane detector definition studies for the Orbiting Wide-Field Light-Collector (OWL) satellite for detecting ultra-high-energy cosmic particles and have a major involvement in the trigger/electronics definition. OWL, which is under study by a GSFC-led collaboration, will study the energy, arrival direction, and interaction characteristics of the highest energy ($>10^{20}$ eV) individual particles yet observed. The origin of particles at these energies is poorly understood and their measurement will yield important insights into the fundamental physics of ultra-high-energy astrophysical processes.

The flux of cosmic rays at these energies is on the order of one per square kilometer per millennium. Thus, a huge detector is required to measure with any statistical significance in a limited amount of time. The OWL concept makes use of the Earth's atmosphere as a huge calorimeter by observing particle showers produced by energetic particles in the atmosphere. These showers are detected and measured by looking at the UV light from the ionization fluorescence of atmospheric nitrogen resulting from the passage of shower particles. This is accomplished by a space based optical system with a collecting aperture of several square meters looking down into the atmosphere. Depending on the detector configuration, OWL may observe as much as a million square kilometers at one time. OWL must detect and measure the shower tracks over a large area of atmosphere and in the presence of significant light contamination. Particular challenges are the spacecraft, the optical system, the trigger/electronics, and the focal plane detector.

During the past year, I concentrated on defining the detailed requirements that the focal plane detector must meet and identified candidate technologies for meeting these requirements. I presented this work at OWL meetings and will complete a write-up on this work before the end of the current reporting period. I will present the focal plane definition study at an international meeting on the highest-energy cosmic rays to be held at GSFC in October 1997.

PAMELA:

This is a compact magnet spectrometer experiment under development by an Italian-led international collaboration which includes researchers from Germany, Sweden, Russia, and the United States. The instrument is approved for flight on board a Russian satellite "Resurs-Arktika" which will fly toward the end of 1999. I am a member of the governing science and technical boards for PAMELA and am the head of the trigger subgroup. I am leading the development of the time-of-flight system by a team composed of scientists and engineers from

GSFC and the University of Siegen, Germany. I am also a consultant on photon detectors for the anti-coincidence system.

During the past year, the TOF team completed initial design of the detector and the mechanical interfaces. I attended an engineering meeting for PAMELA at New Mexico State University in November 1996 and an engineering/science meeting in Rome during December 1996. At the December meeting, I presented the current TOF design.

I have been working with a GSFC engineer, Larry Ryan, on the low power time and amplitude digitizers to be used on PAMELA. This work is sufficiently similar to that underway for the long-duration future flights of ISOMAX that both experiments will benefit.

TIGER, ENTICE/ACCESS: These are respectively a balloon-borne and a proposed space station based experiment to study the elemental composition of the cosmic radiation for charges greater than 26. The TransIron Galactic Element Recorder (TIGER) is essentially a proof-of-technique vehicle in preparation for a space borne investigation. Two previous flight attempts have met with balloon failure, and TIGER is currently in Ft. Sumner, NM awaiting a Fall, 1997 flight.

My principal role in the TIGER experiment is as an expert in time-of-flight measurements and in general experiment design. In order to meet the scientific goals of TIGER, the TOF system must have a resolution of about 30 to 50 ps. Partly as a result of my efforts this has been realized in accelerator tests and is expected in flight. Also, for 1997, the Cherenkov detectors for TIGER were refurbished using a new high-reflectivity coating which I identified.

ENTICE - was given provisional funding in 1996 and identified as part of the space station ACCESS project. The ENTICE collaboration (Washington University, Caltech, JPL, GSFC, NRL, and University of Minnesota) are currently in the process of proposing to carry out several development projects in support of ACCESS. I am responsible for the accelerator test plan and for the TOF photon detectors in this proposal. If ENTICE is successful, I expect to be responsible for the TOF detectors and electronics.

GLAST: I am a participant in development projects being carried out for a next-generation high-energy gamma ray telescope, known as the Gamma Ray Large Area Space Telescope (GLAST). During the past year, my main role has been in developing the highly segmented anticoincidence system. The baseline design was partly inspired and based on a detector (MLT - see below) which I built for the E896 experiment at the Brookhaven National Laboratory (BNL) Alternating Gradient Synchrotron (AGS). A prototype of this system is currently being built for a beam test at the Stanford Linear Accelerator (SLAC). For this prototype, I specified all of the active components including scintillator, waveshifting optical

fibers, and photomultiplier tubes. I have collaborated in the design and fabrication of all aspects of the detector.

I have also worked on the development of gas-based tracking detectors for a future gamma ray telescope. The current focus of this effort is on gas microstructure detectors (GMSD) as alternatives to the silicon microstrip detectors baselined for GLAST.

IMAX:

I was Instrument Manager for the GSFC-led Isotope Matter-Antimatter Experiment (IMAX), which flew in 1992, and helped direct the instrumental analysis and scientific interpretation of the IMAX data. IMAX was the first experiment to verify the existence of antiprotons in the cosmic radiation by fully resolving both their charge and mass. By simultaneously measuring the energy spectra of the antiprotons and of protons, IMAX demonstrated that the majority of the antiprotons in the critical 0.2 - 3 GeV energy range are the result of interactions of primary cosmic rays with the interstellar medium. This work, published in Physical Review Letters (J.W. Mitchell, et al., 1996, Phys. Rev. Lett. 76, 3057) and confirmed by other experiments (BESS, MASS 2, CAPRICE94) in which I participated, showed that no exotic processes are required to explain the measured antiproton flux and thus resolved an important and long standing question in cosmic ray astrophysics.

In addition to my role in the overall development of the instrument, I built the IMAX time-of-flight system, which provided the primary particle velocity measurements and charge identification. The high quality of the IMAX results were due in large part to the performance of this system, which delivered the best timing resolution (120 picoseconds for relativistic $Z=1$ particles, 98 picoseconds for $Z=2$) of any TOF system used in a flight instrument to date.

Following the IMAX flight, I helped lead (with Dr. Streitmatter) the instrumental analysis and the (ongoing) scientific interpretation. The most significant result of this to date was the antiproton paper cited above. For my work on IMAX, I won the 1996 USRA Award for Excellence in Technology. During the past year, I also helped write a paper on the ratio of ${}^3\text{He}$ to ${}^4\text{He}$ in the cosmic radiation as measured by IMAX. This paper has been accepted for publication in the Astrophysical Journal. A definitive paper on the antiproton flux, a paper on the H and He energy spectra, and a NIM paper on the instrument performance are in preparation and will be submitted during the next year.

General Description of Independent Research

Independent of GSFC, I am engaged both in astrophysical research and in a very active and wide ranging program of accelerator-based experimental high-energy nuclear and elementary particle physics. In the course of my research, I have designed and managed large parts of the Superconducting Magnet

Instrument for Light Isotopes (SMILI) cosmic ray experiment and the Lawrence Berkeley National Laboratory (LBNL) E683H, E849H, and E938H (Transport), and BNL E878 and E896 nuclear physics experiments. I designed and built detector systems and experiment electronics for these experiments as well as for the BNL E866 and LBNL E859H nuclear/particle physics programs. I have also developed and tested a number of advanced detectors and contributed to many successful experiment proposals.

My astrophysics research has involved experimental cosmic ray investigations (e.g. SMILI), the development of new detector techniques (e.g. LArC - Liquid Argon Calorimetry), and the measurement of astrophysically important nuclear interaction parameters. The latter effort, mainly using the LBNL Bevatron heavy-ion accelerator, has been directed toward measuring interaction rates and production probabilities (cross-sections) of nuclei and particles in nucleus-nucleus collisions at astrophysical energies. We are in the process of finalizing publication of the astrophysics-related results of the E683H, E849H, E859H, and E938H (Transport) experiments. In the past year I helped write 5 Transport papers, all of which have been published or accepted for publication. In the future, we will shift some of the focus of this effort toward understanding the fundamental nuclear physics involved in these interactions. The experiments listed above will provide a rich dataset for the investigation of peripheral nuclear collisions.

Recently my main research effort in nuclear/particle physics, using the BNL AGS, has been aimed at the measurement of antiparticle and antinucleus production cross-sections and searches for exotic particles produced under the extreme conditions of nuclear density and temperature present in the interaction of a high-energy heavy-ion beam with a massive nuclear target. This work probes energy regimes which have not existed since shortly after the Big-Bang. We are finalizing the interpretation of BNL experiment E878 which measured antinucleus production and searched for "strange quark matter", i.e. charged particles with mass/charge ratios $\gg 2$. Following initial publications in NIM, Nuclear Physics, and Phys. Rev Letters, a full paper on the antiproton results from E878 is in press in Phys. Rev. C and several additional papers are in preparation.

Currently, my focus is on BNL experiment E896 (described below). After 1998, my effort will shift to work on the Solenoidal Tracker at RHIC (STAR) instrument at the BNL Relativistic Heavy-Ion Collider (RHIC). My work on E896 and STAR is supported by the Department of Energy through a Visiting Research Scientist position in nuclear physics at Johns Hopkins University. This work is of great benefit to GSFC since by working at the cutting edge of nuclear and particle physics research I maintain and enlarge my expertise in state-of-the-art instruments and detector systems.

Summary of the E896 Experiment

E896 is primarily designed to search for the H^0 dibaryon, a short-lived ($c\tau \sim 4$ cm) neutral six quark particle (uuddss MIT bag) that is predicted to be produced in great numbers in heavy-ion central collisions. The H^0 is the focus of several major experiments but has not yet been detected. E896 is conducting the most sensitive test of the H^0 predictions to date by searching for a unique decay topology using two tracking systems, a finely segmented gas drift chamber and a solid state (silicon) drift array. In addition, E896 will make unique measurements of the production of other short-lived neutral (e.g. lambda) and charged particles in central collisions. The first run of E896, using an 1.6 GeV/nucleon Au beam, took place from December, 1996 through January, 1997. An engineering run, using a 21 GeV proton beam, was carried out in June, 1997.

My individual effort in E896 is quite significant. I am responsible for the fast event trigger electronics and for the high-rate trigger detectors. I am also partly responsible for the superconducting sweeper magnet and for the beamline layout. I contributed to the drift chamber, the TOF system, and numerous other experiment components. I played a major part in the design and execution of both experimental runs. In both runs, the trigger systems that I designed and implemented consistently performed at the high level required.

In addition to fast Cherenkov-based beam counters, the trigger detector system includes two other highly specialized detectors for which I am responsible. These are used by the trigger logic to determine, in less than 100 nanoseconds, the impact geometry (centrality) of a particular nuclear collision. Since central collisions yield the highest nuclear temperatures and densities, this allows the experiment to record a dataset which is enriched by a factor of about 100 over a beam trigger.

The primary centrality detector, the Multiplicity Telescope (MLT), determines the number of particles created in the beam/target interaction to provide a measure of the "violence" of the collision. The detector is located "downstream" of the interaction target in the bore of the 7 Tesla sweeper magnet and makes innovative use of waveshifting optical fibers to read out an array of thin lead/scintillator detectors. These detect high-energy photons (gamma rays) arising from the decay of primary neutral pions from the collision. I designed and built this detector making use of sensitivity models which I developed with a post-doctoral researcher, Zoran Milosovitch, at Carnegie Mellon University. In addition to its use in E896, the MLT has served as the prototype for the baseline anticoincidence system developed at GSFC for the GLAST gamma ray telescope.

The MLT is supplemented by an "External Charge Detector" (ECD) which measures the charge of outgoing "beam like" fragments produced by the breakup

of the incident beam nucleus. The absence of large ($Z > 2$) fragments indicates a central collision. The ECD is a high precision quartz Cherenkov detector. I designed the ECD and supplied some of its components. The ECD was primarily built and operated as a Masters project by Kris Kainz at Rice University. I helped direct this effort in collaboration with Dr. W. Liope of Rice.

The E896 collaboration is preparing for a full run of the experiment in a 1.6 GeV/nucleon Au beam in April, 1998. I will again be responsible for the trigger detectors and electronics.

TASK 5030/93-12-00 - EGRET

Joseph A. Esposito:

Position Requirements:

1. SR&T Research: Development of Gas MicroStrip Detectors (GMSD) for use in an Enhanced Resolution Gamma-ray Observatory (ERGO). Expectations: Work as a member of the multi-institution collaboration in the design, fabrication, testing, integration and testing of a GMSD track imaging system.
Over the past year I have been deeply involved in the development of GMSDs for use as a track imaging hodoscope in an Enhanced Resolution Gamma-ray Observatory (ERGO). The ERGO collaboration involves several institutions (NASA/GSFC, University of Louisville, LB CEBAF and Berkeley) and is composed of many scientists, graduate students and undergradua students. This research, which is led by Dr. S. D. Hunter as PI, is the cornerstone of the NASA/GSFC high-energy gamma-ray branch SR&T program. A full list of collaborating scientists at each institution is available at site: <http://lheawww.gsfc.nasa.gov/~jae/GMSD/> un the link for GMSD Collaboration.
2. Maintenance of the EGRET Likelihood Analysis Software (LAS). Expectations: Resolve user problems, upgrade the LAS as needed by the EGRET team and distribute the LAS among the EGRET team collaboration. Perform analysis of the EGRET viewing period data for dissemination among guest investigators. Analysis of EGRET data pertaining to in-flight calibration of the instrument.
3. Analysis of gamma-ray data as PI of EGRET team proposal "Galactic Supernova Target of Opportunity and Data Rights to EGRET observations of Supernova Remnants in the Galactic Plane," and as Co-I of proposal "EGRET Observations of Starburst Galaxies" with Dr. G. G. Fazio as PI.
4. Development and maintenance of GMSD public and restricted site at URL: <http://lheawww.gsfc.nasa.gov/~jae/GMSD/>. The primary goal of the site is dissemination of t progress achieved in the SR&T program.
5. Development and maintenance of EGRET LAS Users Guide at URL: <http://lheawww.gsfc.nasa.gov/~jae/LIKE/>. The primary goal of this site is support of the EGR instrument team and guest investigators using the instrument team LAS.

Evaluation Factors:

1. a) My primary tasks have been: conceptual mechanical design; conceptual design of the triggering and readout system; design and fabrication of low voltage Power Distribution Module (PDM); high voltage, low voltage and digital cabling buses; Monte Carlo instrument simulations and kinematic limit calculations using the EGS4 software package; component testing and quality assurance. A secondary

function has been development of a public site (URL given above) where the research being conducted in our SR&T program is described.

2.
 - a) Continued upgrading of the software to meet new requirements of users (e.g. upgrades enable output of formatted source information for the next [third] EGRET catalog.
 - b) Evaluating user reported runtime "bugs" and repairing the software when necessary. Presently two confirmed bugs are being investigated for repair upgrades.
 - c) Dissemination of the LAS package to MPI, Stanford and Heidelberg is presently up to date at version 5.50. The debugged LAS version 5.56 will be available for dissemination on 1 Aug-97.
 - d) Analysis of viewing period 6010 completed. Analysis of data for in-flight calibration is underway. This latter analysis includes, in part, calibrating the time dependence of the point spread function and determination of the source position resolution from in-flight data (presently only pre-flight calibration information is used). A manuscript entitled In-flight Calibration and Analysis Refinements for the Energetic Gamma-Ray Experiment Telescope (EGRET) on the Compton Gamma-Ray Observatory" has been submitted to ApJ and the referee comments are presently being addressed.
3.
 - a) Unfortunately no new supernova have occurred in our galaxy. Work continues on the gamma-ray emissions from supernova remnants. A second paper on this topic will be completed and submitted for publication by 01-Nov-97.
 - b) The current state of research into the emission of gamma-rays from nearby starburst galaxies was presented at the 4th Compton Symposium. A paper on this topic will be submitted for publication later this year.
4.
 - a) The initial HTML pages and graphics for the GMSD public WWW site have been completed. Links are provided to all collaborators and to the collaboration institutions. This work is best evaluated by inspecting the site at the URL given in I.4 above. A web browser which allows frames (Netscape or MS internet explorer versions 2.0 or greater).
5.
 - a) This site is slowly being developed. Users tend to ask questions directly even when the information is in the LAS documentation. An upgrade which uses frames and will be more user friendly is in the planning stage.

Primary Accomplishments

1. The SR&T research is an on-going project. Therefore, many of my primary tasks are also on-going. Completed tasks are: overseeing the design and fabrication of the low voltage PDM and design of a second generation PDM; low voltage, analog signal and digital signal harness schematics within and outside of the pressure vessel; testing and quality assurance of detector carrier frames and components;

computer control of applied high voltage. Kinematic limit calculations have been completed and software has been developed to simulate various instrument configurations. The SR&T VAW site has been installed and is under continuous development. Monte Carlo simulations of instrument configuration is in the initial testing phase but will commence by 15-Aug- 1997.

2. The on-going LAS work is up to date with a new version release on 04-Aug-97. The analysis of EGRET data for in-flight calibration is in progress. I feel that I am accomplishing all the goals of this work.
3. This work is progressing well and will produce publications.
4. The first stage of this work has been completed satisfactorily. Upgrading and addition of new HTML pages, graphics and CGI scripts are on-going. This work is best evaluated by visiting the WWW site.
5. A newer framework for this site has been developed based upon the GMSD site. The present format has provided helpful information to users and the soon to implemented upgrades will include indexing and cross-links.

I feel that my work to date has benefited this project and will continue to do so.

TASK 5030/93-12-00 - EGRET

Parameswaran Sreekumar:

Position Requirements:

1. EGRET data analysis
2. Maintain a model of the all-sky diffuse gamma ray emission
3. Create and maintain the final summary data base event lists for each EGRET observation
4. Provide QUICKLOOK results on the current EGRET observation.
5. Periodic evaluation of spark chamber performance degradation with time and the generation of appropriate correction factors.
6. Limited involvement in the instrument development work.

Evaluation Factors:

1.
 - a. Papers published
 - b. Thorough knowledge of the analysis system/software and assist short term visitors with the analysis tools.
 - c. Creating useful macros (shellscripts) of common interest to the team that facilitates carrying out many aspects of EGRET data analysis including source catalog generation.
2.
 - a. Production of the all sky diffuse emission model, particularly the high latitude emission.
 - b. Production of all the 64 allsky maps with each revision.
3.
 - a. Regularly maintain the summary photon data and the corresponding exposure history files.
 - b. Examine and correct the exposure history files for unexpected instrument performance/unacceptable operational modes, etc.
4.
 - a. Prompt results on the rapid analysis (QUICKLOOK) of the current EGRET observation.
 - b. Trouble-shooting any possible problems with the data production system during the QUICKLOOK.
5.
 - a. Evaluation of the EGRET scale factors as a function of energy and time as soon as the full data set is available.
 - b. Trouble-shooting or determining observation periods with unusual responses.

Primary Accomplishments:

1. During the time frame Sept '96 to Sept '97, I spent a large fraction of my time in the study of the extragalactic diffuse gamma-ray background. This was an extremely time consuming process since unlike any other EGRET investigations, I had to address and determine all background parameters (instrument, contaminating Galactic emission, etc). This included the need to impose more stringent selection criterion to remove additional data contamination from Earth-albedo gamma-rays (this selection has so far been used only for this analysis). Consequently, all data products for phases 1,2and3 had to remade and verified. Even though I had some help from one of our technical staff, I had to shoulder almost all of that reprocessing task. The results of the analysis is currently submitted as a paper to ApJ. The revised manuscript after including the referee's comments have already been mailed out.

I have also worked with Dr. Vestrand at LTNH on the first discovery of GeV emission from an X-ray binary (Centaurus X-3). An ApJ Letters paper on this is already in print.

I carried out the bulk of the analysis on a recently submitted paper (Bloom et al 1997) which discusses the EGRET result on the recent flare of BL Lacertae. This was carried out in record time since the data was made public as soon as it was fully processed.

I had initiated the master's thesis of Mr. G. Nandikotkur of Iowa State University using the method of structure functions to study blazar time-variability. Significant amount of progress was accomplished during his two 2-week visits to GSFC.

I also wrote the first version of the automatic source analysis script that was used to carry out the large scale analysis of the EGRET sources that were used to generate the next EGRET catalog (Hartman et al 1997 (in preparation) and the AGN paper (Mukherjee, et al 1997, ApJ in press)

2. No major revision of the diffuse model occurred in this time frame. Some additional changes to incorporate the new CO map was carried out as part of the analysis of the extragalactic emission.
3. This routine work of maintaining and troubleshooting problems associated with the standard EGRET data products continued. A complete duplicate set of maps were generated (cleaner data) as part of the extragalactic study.
4. A significant number of times, I had to respond to multiple QUICKLOOK analysis for a viewing period. These included special targets such as Mrk501 (was flaring at TeV energies), 3C279, etc. The most successful one was the discovery of intense

emission from the BL Lacertae. I did receive partial help from Dr. Steve Bloom in carrying out regular QUICKLOOKS.

5. This is also routine work. The determination of the final set of scale factors for phase5 is still not complete. Preliminary values were derived, however due to the nature of the current EGRET operations, the analysis is no longer as straightforward. I have devised a new approach to evaluate these values and this is now being tested to build confidence in the process. Completion of this work is expected only the end of October '97

TASK 5030/93-13-00 - Theory

Xinmin Hua:

Position Requirements

1. Research on high-energy solar physics and others.

Evaluation Factors:

1. Research results in the form of publications in journals and presentations in conferences.

Primary Accomplishments:

1. a. Determination of solar photospheric Helium-3 abundance: Based on the system of computer programs for calculation of neutron and gamma-ray line emissions from solar flares which I developed over the past few years, I am performing calculation of the time dependence of the 2.2 MeV line emission for various particle energy spectra, angular distribution, solar atmosphere model and helium-3 abundance in solar photosphere. By comparing the calculation results with recently reported data from OSSE/CGRO, we will be able to determine the helium-3 abundance and its uncertainty. The main computer codes, including the IDL procedures used in data fitting and graphic plotting, have been developed and tested.
- b. Analysis and interpretation of time variability data from X-ray and gamma-ray sources: I and colleagues have developed a model of thermal comptonization in a non-uniform atmosphere. The model can not only account for the observed energy spectra, but, more importantly, explain the observed timing properties in several X-ray binaries, especially the long standing puzzle of the frequency-7dependent hard X-ray lags. Using the model, we are able to successfully explain the spectral and temporal behavior of the blackhole candidate Cyg X-1 observed by Ginga and RXTE.

We are currently fitting the similar data from the source GRO J0422+32 obtained by OSSE. The model critically depends on the Monte Carlo computer code for the Comptonization in non-uniform media, which was developed by myself after overcoming several mathematical difficulties.

TASK 5030/93-13-00 - Theory

Natalie Mandzhavidze:

Position Requirements:

1. Theoretical modeling of nuclear interactions and gamma ray production in solar flares
2. Using gamma ray spectroscopy for the study of solar flare particle acceleration and solar atmospheric dynamics
3. Expanding of our solar flare research to the broader astrophysical problems.

Evaluation Factors:

1.
 - a. Publication of papers
 - b. Presentation at meetings
 - c. The use of our developed gamma ray codes by other people and groups.
2.
 - a. Publication of papers
 - b. Presentation at meetings
 - c. Obtaining new exciting results and insights on these processes
3.
 - a. Publication of papers
 - b. Presentation at meetings
 - c. Finding of very interesting applications of our solar flare research to solar and stellar formation, galactic chemical evolution and cosmology.

Primary Accomplishments:

1. We keep constantly updating our gamma ray line code by including the best available nuclear cross sections. In addition to these updates, we found new reactions leading to the lines that can provide unique information on the accelerated He³ abundance enhancements in impulsive flares.
2. We carry out detailed abundance studies of the solar flare accelerated particles that interact at the Sun and produce the observed gamma rays. These abundances provide, unique diagnostic tools for the understanding of the acceleration mechanism. Unlike the solar flare particle observations in space, which can only provide particle abundances integrated over entire events that last for many hours, the time dependent gamma ray fluxes yield temporal developments of the abundance enhancements during the acceleration process and thus allow us to trace the acceleration process on the real time scale.

3. We analyzed the fluxes of alpha-alpha lines that result from nuclear fusion of accelerated alpha particles with ambient helium.

We find that the high observed fluences of these lines require either high accelerated alpha/p or high ambient He abundance. The present gamma ray data do not allow us to distinguish between these two possibilities. However, we identified the series of pure alpha particle lines that will be observable with the future high resolution gamma ray detectors. These lines will allow unambiguous determination of the accelerated alpha/p ratio and ultimately of the ambient helium abundance. These issues are of fundamental importance for the understanding of the mechanisms of solar flare particle acceleration, solar atmospheric dynamics and solar evolutionary models.

4. We determine the photospheric He^3/He^4 ratio by combining the He^3/H obtained from the 2.223 MeV neutron capture line and He^4/H obtained from helioseismology. Our determined value is lower than He^3/He^4 measured in the solar wind. This apparent isotopic fractionation of helium has a very important implication on the theory of solar wind acceleration.
6. We obtain the protosolar deuterium abundance $(\text{D}/\text{H})_p$ from the present day photospheric He^3 abundance that follows from the 2.223 MeV line and protosolar (meteoritic) He^3 abundance by applying a solar evolutionary model. We find that it is comparable with the present day deuterium abundance in the interstellar medium measured with HST, implying that either there was not significant destruction of deuterium during 4.55 Gyrs (age of galaxy), or that the destruction was compensated by the extragalactic mass infall.

TASK 5030/93-14-00 – Mirror Development

Kai-wing Chan:

Position Requirements:

1. Production and Quality control of mirrors for the ASTRO-E telescopes.
2. Development of techniques and procedures in optical and x-ray examination of finished mirrors and telescopes.
3. Development of next generation techniques in making thin foil mirrors.

Evaluation Factors:

1.
 - a. State of production of ASTRO-E mirrors, in terms of schedules and maintenance of facility.
 - b. Quality and acceptance rate of mirrors.
2.
 - a. Introduction of new methods and improvement of current techniques in foil examination.
 - b. Usefulness of the examination processes employed, in terms of quality of result, feasibility and simplicity.
3.
 - a. Development of thin foil mirror with better angular resolution than is currently achieved with ASTRO-E.
 - b. Development of mirror with higher response in the hard X-ray.

Primary Accomplishments:

(I would like to note that any progress or setback of the project should be considered as the result of the whole ASTRO-E X-Ray Mirror team in general. I will try to delineate my own contributions to them. In any case, the general set up of the ASTRO-E XRT team is as follows. Peter J. Serlemitsos of Goddard heads the XRT effort and oversees the whole mirror development. Yang Soong, also of USRA and I manage the daily production of mirrors in addition to the continual development of better telescopic response, both in terms of obtaining a better angular resolution as well as a better response in higher x-ray energy. Y. Soong also performs most of the X-ray tests on the foils in telescope housing while I carry out the analysis from various studies. Y. Ogasaka, from Japan Society for Promotion of Science, carries out much of the work in x-ray monochrometer scanning and development of multilayer technique.

The general state of the project ASTRO-E XRT and that of the Mirror Laboratory are also outlined in our web sites:

<http://lheawww.gsfc.nasa.gov/docs/xray/astroe/MirrorLab/xrt.html>
<http://lheawww.gsfc.nasa.gov/docs/xray/astroe/MirrorLab/mirlab.html>

1. The state of ASTRO-E mirror production is still on schedule. Currently, we are producing 18 mirrors of various dimensions in each working day. There are about 7000 usable mirrors to fabricate for the 5 telescopes and we expect to finish the production by early 1999. (Launch of ASTRO-E is scheduled to be February 2000, and we are expected to deliver all the telescopes by mid 1999.) Currently, we have fabricated nearly 3000 foils. The daily rate of acceptance is generally maintained at over 80%, which is close to the level we have set out to perform. At this rate and with some spare quadrants of telescopes to make, there may still be some 6000 mirrors to make. Yang Soong and I are both responsible in maintaining the production schedule and quality. The actual work is done by a staff including 2 full-time engineers, 5 full-time technicians, and other supporting personnel at Goddard's Laboratory of High Energy Astrophysics.
7. One of the major shift in emphasis of my responsibility is from production to quality control, both in terms of instrumentation and analysis. Part of quality control of foil is done by examination of finished foils by optical means which is usually more efficient (the final definitive test is done in the x-ray). The items to be examined include the following.
8.
 - (a) General condition of replicated foils by visual examination.
 - (b) Focussing capability of individual mirrors with a wide parallel beam.
 - (c) Condition of surface in the sub-millimeter scale with a microscope.
 - (d) Curvature and roughness of foil with a laser scan micrometer.
 - (e) Surface profiling with an optical interferometer.
 - (f) High lateral resolution surface roughness analysis with an atomic force microscope.

Yang Soong and I set up the procedures and grading systems for items (a)-(c). In addition to the existing hardware, we have introduced some newer instruments like high sensitivity solid state detectors. A supporting engineering is carrying out the examination. For item (d), which is more quantitative, a laser with a position detector is used to detect one-dimensional surface profile to the depth of 0.1 micrometer over a scale of centimeters. I have been responsible for many of its installations and upgrades, both in terms of software and hardware. It is now a piece of largely automated equipment which is capable of scanning the mirror linearly (to 0.1 micrometer) as well as circularly (to 1 second-of-arc). The machine is a hybrid of two motorized stages on a granite platform. The controller is commanded by a separate computer which also run the analysis. The routine is

now done by a technician. This set up is now used extensively also in checking of pre-replicated foils. Item (e) is currently only done by myself but the work will eventually be transferred to a technician. The interferometer is basically a commercial product besides the modification of an extended stage which is needed to accommodate large samples. I have installed the sample stage on the machine in order to reduce the acoustic noise and vibration which prevent a clean measurement. I have used this machine to study the surface roughness of replicated foils and glass surfaces. These results are complementary to those deduced from x-ray measurements. Item (f) is the latest and is still under installation. The hardware is in but the machine is not ready yet for quality control work. (It is also my responsibility to have this up and tested by early September.)

Optical facilities are also used in study of telescopic responses. Y. Soong and I have carried out studies of telescope angular response in white light as well as in monochromatic frequency. We have used these optical beams to characterize deviations of the telescopes and reflectors from the-design. In particular, such study has showed that the original design of the width of the alignment groove is not adequate to constrain the foil properly. New design was sent in and new hardware has already started coming in.

In term of x-ray test, which is the ultimate test of quality of the telescopes, we have carried out tests on limited sets of foils (typically 5 pairs of reflectors with similar radii), as well as on a whole quadrant of a telescope. The tests were done at the long beam x-ray facility atop building 2 of Goddard. Yang Soong, with the assistance of an engineer, was the main person responsible for the tests. In these tests, it was demonstrated that we have achieved good energy and angular responses in general. The angular resolution of a localized region ("a sector") of a 5-pair set typically shows arc-minute or subarc-minute resolution, indicating that the surface is good and that the "curvature" along the optical axis direction is not dominant. In a number of tests involving whole reflectors, we also achieve approximately 1 arc-min resolution. However, we have also confirmed that there are misalignments of foils due to the small freedom of foils in the telescope housing. In one test with a full quadrant (a non-flight quadrant sent to Japan for various other tests), the angular resolution is 1.7 arc-minute. This worst case happened as the telescope was mounted sideways in the test. The lack of full constraint of the reflectors allows small displacements of various magnitudes for different foils. The result is anticipated from earlier studies with optical means. Tighter dimensions of the telescope housing have been put in and the first new housing is made and is scheduled to arrive mid-August.

In addition to experimental work, I am still pursuing supplementary studies on foil response by analytical means. This includes ray-tracing using

geometrical optics, which is best used to determine the effect of imperfection of foil and housing geometry.

3. Continual research for the next generation x-ray telescopes using thin foil reflectors are being carried out in two fronts. One is to produce a thin foil telescope with better response at higher x-ray energy. This is being pursued using multilayer technique. This work is being done preliminarily by Y. Ogasaka. The other line is to further improve the angular resolution, the primary goal of the imaging instrument. Yang Soong and I are currently pursuing this in terms of reduction of reflector curvature and more importantly, reduction in alignment errors. A factor of 3 or so in angular resolution is needed (similar to the improvement from that of ASCA to that of ASTRO-E) in order to meet the goal for the next generation X-ray telescope, the HTXS (High Throughput X-ray Spectroscopy mission).

Task 5030/93-14-00 – Mirror Development

Yang Soong:

Position Requirements:

1. To the advancement of X-ray imaging devices, e.g. grazing incidence X-ray reflecting mirrors as an astrophysical instrument. There are two major aspects of an aimed improvement: to better the spatial resolution of the image, to a level of sub-arcminute beyond the current 1 minute of arc, and to extend the response to higher energy band, say, up to 60 keV.
2. To fabricate Astro-E X-ray telescopes, which is part of an international collaboration between US and Japan. It is scheduled to be launched in February, 2000. It shall provide a one minute of arc spatial resolution and an unprecedented low energy resolution in the range of few hundred eV to 10keV.
3. To facilitate the high altitude balloon program which will be a predecessor of more ambitious programs, such as HTXS (High Throughput X-ray Spectroscopy) and SUMO (SUperMirror Observatory).
4. To manage the work force of the Astro-E fabrication, etc.

Evaluation Factors:

1. a. The actual breakthrough and followed by improvement from BBXRT in 1990 to the present Astro-E program.
2. a. Building a bridge from a small scale lab test to a large scale mass production in mirror fabrication processes.
3. a. Facilitate the multi-layer mirror program which can be an important pilot program for the future X-ray missions.
4. a. Keep the consistence of the quality of the product for Astro-E, which can provide a very significant token for acquiring future programs.

Primary Accomplishments:

1. We have carried the group tradition to the frontier of the technique of making thin-foil X-ray mirrors so that the future of this kind of imaging device is greatly enhanced.
2. Stabilized the processes of the in-house foil mirror making so that we can keep the set schedule of the Astro-E mission.
3. Create the backbone of the multi-layering process which needs a super smooth surface as the substrate to deposit layering on.

4. Processes are like laws, which will not be effective unless there are well established enforcement of quality control. In other words, managing the work force and streamline the work flow are keys to success of the program.

TASK 5030/93-17-00 – X-Ray Analysis and

TASK 5030/93-01-00 – HEASARC

Ian M George:

Position Requirements:

On 1997 Feb 01 I transferred from Task 93-01-00 (HEASARC) to Task 93-17-00 (XMM) with the following position requirements:

1. (HEASARC only) Maintenance & development of the 'HEASARC Calibration Database'
2. (HEASARC only) Serve as Archive Scientist for the HEASARC
3. (HEASARC only) Development of FITS file standards both within the HEASARC and in collaboration with the general community.
4. (HEASARC & XMM) Active participation in scientific research
5. (XMM) Preparation for the launch of XMM, with particular emphasis in aiding Richard Mushotzky (who is a member of the XMM Science Working Team).

Evaluation Factors:

1. HEASARC Calibration Database (caldb)
 - (a) Progress in automating the maintenance of the database infrastructure & contents, and related progress in developing the software suite used at NASA/GSFC and elsewhere (in collaboration with HEASARC programmers).
 - (b) Ability to ingest new calibration files into the database in a timely fashion and make them available to the international community (in collaboration with Instrument Teams, Guest Observer Facilities and HEASARC programmers)
 - (c) Quality of support provided to users - ability to solve calibration-related questions from users in a timely fashion.
 - (d) Availability and accessibility of information/documentation provided to facilitate use of the database by the general community.
2. Archive Scientist
 - (a) Participation in the archiving of data collected during past-missions
 - (b) Availability and willingness to handle queries from HEASARC users (both professional astronomers and the general public) in a timely fashion.
 - (c) Identification, design, writing & maintenance of software tools required by the community for the analysis of scientific datasets archived by the HEASARC

3. FITS file standards
 - (a) Ability to identify suggest solutions for the problems & inconsistencies within FITS files created within the HEASARC (and other institutions), along with ability to identify future potential FITS-related issues, and propose solutions.
 - (b) Ability and willingness to discuss the experiences and opinions of the HEASARC FITS Working Group both within the HEASARC, and to the general community.
4. Scientific research
 - (a) Ability to write successful proposals for observing time
 - (b) Ability to lead or collaborate in data analysis reduction projects
 - (c) Success as first/co-author of papers presented at meetings and/or submitted/accepted for publication in international scientific journals.
5. XMM Research Scientist
As for 4. (above) plus
 - (a) Ability to perform the necessary support work (simulations etc) to maximize the initial scientific returns from Richard's "Guaranteed Time" observations to be carried out immediately after launch in 1999.

Primary Accomplishments:

1. HEASARC Calibration Database (caldb)
 - (a) The caldb remains on-line and operational. Whilst on Task 93-01-00, I worked closely with Lorraine Breedon (HSTX) initiating her into the existing infrastructure, software etc. We also reviewed the new functionality etc that I considered necessary or desirable in the medium-long-term. On 1991- Feb 01, Lorraine formally took over primary responsibility for the caldb (with some scientific oversight provided by Mike Corcoran, USRA).
 - (b) While I was on the HEASARC Task, the data holding was steadily increasing and the response time (file delivery → file on-line) was \leq few days. (I have no reason to expect anything has changed since I left the task)
 - (c) User access to files within the caldb was highly variable, reflecting the variable rate of delivery of new files to the caldb, GO deadlines etc. Significant effort has been extended on the part of Lorraine to make the installation procedures as painless as possible to users.
 - (d) Frankly, the keeping of on-line documentation up-to-date continually got a low priority whilst I was the sole person responsible (there always being a more-pressing problem). I have not monitored the situation since leaving the task.

2. Archive Scientist

Whilst on the HEASARC task, I

- (a) participated in the on-going review of the HEASARC's data restoration plans, helped set priorities and helped solve related software and FITS formats issues.
- (b) estimate I personally handled .5-10 detailed telephone/e-mail queries per week (the vast bulk of the more 'trivial' queries are intercepted by other HEASARC staff first). Happily this has almost completely ceased now I am no longer on the HEASARC Task.
- (c) I worked closely with Banashree Seifert (HSTX) to ensure she would be able to maintain/develop the software tasks within the FTOOLS package for which I was responsible. Again, happily this appears to have been successful as it is very rare that my input is required now I am no longer on the HEASARC Task.

3. FITS file standards

- (a) The HEASARC FITS Working Group had a very quiet time over the period 1996 Oct - 1997 Feb, with no meetings held and just a couple of issues discussed and resolved via e-mail. I formally resigned from the panel on that date.
- (b) Prior to 1997 Feb, I served as secretary to the HFWG, and to maintain the panel's anonymous ftp and WWW areas. This responsibility has been passed to Bill Pence.

4. Scientific research

- (a) During the period 1996 Aug - 1997 Sept., I was PI on the following successful proposals:

ASC.4 AO-.5

- *ASC.4 Observations of Optically-Selected Quasars* (\$ 15600 awarded)

- *A Detailed Study of the UV and X-ray Absorbers in PG1309+3.5.5* (\$ 15,650 awarded)

and was co-I on a number of other successful proposals. I am PI on the following proposals still pending:

ASCA AO-6

- *ASCA Observations of Optically-Selected Quasars*

and co-I on several other proposals.

- (b) While on the HEASARC Task, I estimate the fraction of my time available to research averaged ~15-20%. On the XXM Task it's effectively running at 95%.

The completed data analysis projects are represented in the list of paper submitted/published below.

(c) For contributions at conferences and accepted/published papers, see below.

5. XMM Research Scientist

The real XMM-related work on this project does not start until 1997 'Sept. However, I have

become familiar with the mass of XMM documentation produced to date performed initial simulations in preparation for the selection of ACN to be observed as part Mushotzky's Guaranteed time.

TASK 5030/93-20-00 - CGROSSC

Paul Barrett:

Position Requirements:

1. COMPTEL instrument liaison. My major responsibilities include processing, archiving, and distributing COMPTEL data, preparing and distributing COMPTEL documentation and products, administering the COMPtel Analysis Software System (COMPASS), and providing COMPTEL user support at COSSC.
2. COSSC Remote Proposal Software (RPS) manager. My responsibilities include implementing and managing the COSSC electronic proposal software, and assisting guest observers during the proposal submission period.
3. COMPTEL Ftools support. My responsibility is to assist with the design, development, and testing of any Ftools using COMPTEL data.
4. GRO Help Desk. My responsibility is to be the primary contact for grohelp, an E-mail service to assist guest investigators and laymen working with or interested in the Compton Observatory. (Chris Shrader is the secondary contact)
5. CGRO Bibliography. Maintenance of the Compton Gamma Ray Observatory bibliographic database.

Evaluation Factors:

1.
 - a. The administration of the COMPTEL data and software.
 - b. The progress of COMPTEL data products processing and its distribution to the public, eg. via the World Wide Web.
 - c. Negotiation with members of COMPTEL team for delivery of raw data, data products, and software for public distribution.
 - d. The satisfaction of Guest Investigators for help in using and analyzing their data.
2.
 - a. Installation and successful operation of the Remote Proposal Software by the release date of the CGRO NASA Research Announcement.
 - b. The successful modification of the RPS software to enhance COSSC team productivity.
 - c. Reasonable satisfaction by users of the RPS software, especially during the last crucial week before the proposal deadline.
3.
 - a. Programmer satisfaction of my assistance during the development of the software.
4.
 - a. Prompt and accurate responses to grohelp requests by either myself or another member of the COSSC staff.

5.
 - a. Appreciation of the foresight to continue to maintain a list of CGRO publications when others saw little continued use for it.
 - b. Appreciation of the extra time spent on this mundane project.

Primary Accomplishments:

1.
 - a. During the last year, my highest priority COMPTEL project was the migration of COMPASS from SunOS to Solaris. Late last year a decision was made to migrate COMPASS from SunOS to Solaris. COMPASS would continue to operate on the old SunOS until we were satisfied that the new system was operating properly. This required an upgrade of the operating system from SunOS to Solaris, a new installation of the oracle database on Solaris, the migration of the database tables to the new database, and finally the migration of the COMPASS software to the Solaris OS. This migration is still in progress and has taken much longer than scheduled, though this is partly due to a recommendation of the COMPTEL team at UNH to wait until they have completed their COMPASS migration to Solaris. Due to a decrease in manpower at UNH, this project must be completed by 1997 October 1. My feeling is that the new system will be more stable and easier to maintain than the current system, so that the decision to proceed will be worth the effort.

Good effort has been made in maintaining the old COMPASS system by checking that all data files are available to the user and the system performs satisfactorily.
 - b. In response to a comment that I made last year about more effort being made toward distribution of data via the Web, an 'unofficial' COMPTEL source list was created and published on the COSSC home page. Efforts are underway to publish new COMPTEL results on a monthly basis.
 - c. There was some negotiation with the COMPTEL team at UNH to provide the COSSC with better database support and data products. An initial agreement was made between the two groups, though the final decision is not yet known at this time. I feel satisfied with my efforts here.
 - d. The current support of guest investigators appears to be satisfactory at present, though improvement can be made in this area as I continue to improve my knowledge of the COMPASS system. My attention to the needs of guest investigators has been very good and they appear to be satisfied with the help that I have given.
2.
 - a. Successful Installation and Management of RPS. RPS was successfully modified and updated for CGRO NRA 7. After two years of testing and use the system has improved significantly, resulting in a very smooth proposal process for all involved, i.e. support personnel and guest investigators.

- b. Though several suggestions for improvements to the RPS were made, no significant improvements were implemented.
 - c. Reliable Assistance to RPS Users. The final aspect of this task was to provide assistance to RPS users. The COSSC RPS team provided fast and efficient response to all questions. I feel very satisfied with our service.
3. a. Some effort was made to develop Ftools for COMPTEL data. Under the recommendation of Jay Norris, this has been place on hold for the next year.
4. a. My attention to the 'grohelp, service appears satisfactory. My replies are usually prompt and well received.
5. a. Creation of a Compton Observatory bibliography was motivated by the NASA White Paper in mid-1994. The data was mostly used to show how successful is the CGRO mission in terms of refereed papers, reviews, etc. Continuing to maintain the bibliography was believed to be of low priority by members of the COSSC, but with the 1996 NASA White Paper has been appreciated much more. A complete update of the bibliography beginning with 1991 is now complete. Efforts to keep up with current publications have been less successful.
- b. There does appear to be some appreciation by the civil servant in charge that this is worthwhile task.

TASK 5030/93-20-00 - GROSSC and
TASK 5030/96-02-00 – GLAST/GTOTE

Jerry T. Bonnell:

Position Requirements:

1. Provide general scientific support for Compton Observatory Science Support Center (COSSC/CGRO) activities.
2. Support Gamma-ray Large Area Space Telescope (GLAST) collaboration at LHEA.
3. Perform research related to high-energy astrophysics.

Evaluation Factors:

1.
 - a. Participation in COSSC data archive and guest investigator support efforts.
 - b. Participation in public outreach and education activities.
2.
 - a. Participation in GLAST calorimeter design and simulation projects.
3.
 - a. Publications and presentations.
 - b. Research proposals.

Primary Accomplishments:

1.
 - a. I have responded to all guest investigator queries referred to me about general CGRO and BATSE related issues. I have supported the ongoing data archiving process and consulted on the development of new BATSE CDROMS.
 - b. I have continued to co-author a popular WWW educational/outreach site "Astronomy Picture of the Day", and to co-organize an astronomical debate series at the Smithsonian Museum of Natural History.
2.
 - a. I have played a major role in setting up software and computers to simulate and test the GLAST instrument design. This is part of a major new SR&T proposal within LHEA for designing the next generation "GRO". The effort is ongoing and is just beginning to produce results. I have - contributed to detailed simulations of calorimeter designs; contributed to detailed simulations of gamma-ray burst observations using a baseline GLAST instrument; produced-a movie of simulated allsky GLAST observations.

TASK 5030/93-20-00 - GROSSC

William T. (Tom) Bridgman:

Position Requirements:

1. Facilitate guest investigator access to OSSE data and build an infrastructure enabling the long-term use of the OSSE database by future researchers.
2. Develop collaborations between university researchers and the CGRO Science Support Center.
3. Get some science done.
4. Serve on necessary support committees.

Evaluation Factors:

1.
 - a. Development of tools and documentation for GI use.
 - b. Implementation of standard procedures for GI access to data.
 - c. Handle GI inquiries.
 - d. Development of tools and documentation for maintaining the OSSE data archives
 - e. Making high-level data available online.
2.
 - a. Establishing scientific collaborations at universities resulting in publications.
 - b. Establishing educational collaborations at universities facilitating use of the OSSE database.
3.
 - a. Complete the Cygnus X-1 timing analysis paper.
 - b. Complete the reflection model paper.
 - c. Develop proposals.
4.
 - a. Served on CGRO Phase 7 Peer Review as Instrument Specialist.
 - b. Served on CGRO Phase 7 Timeline Committee.

Primary Accomplishments:

VSTAT (CGRO observation planning program) now compiles & runs under Ultrix. (However, the Ultrix machines are about to be removed from the network.)

Filled in for Neil Gehrels at a number of CGRO reboost meetings. Attended test firings of attitude and orbital adjustment thrusters on CGRO.

Wrote an enhanced IGORE2XSPEC converter in IGORE/IDL as prototype for a new FTOOL. Enhanced converter allows multiple PHA spectra to be stored in a single PHA

file. This is useful for storing daily OSSE observations in a format which can be directly used by XSPEC. However, NRL has since made revisions in their IGORE-TO-XSPEC converter to include certain instrument systematics. This will require some upgrade to my IGORE2XSPEC converter. The eventual plan is to modify this routine so it can directly use FITSified OSSE high-level data files to generate XSPEC compatible files. The new FTOOL will be written in either FORTRAN or C (most likely C). This project requires the completion of the SDB2FITS converters (see below).

As part of the above project, I wrote a VERIFY_XSPEC tool which checks FITS files to determine if they have the keywords necessary for utilization by XSPEC. This IDL prototype was turned over to the FTOOL group at HEASARC and converted into a standard verification utility.

Upgraded VMS version of the TOFU (To FITS Utilities) library to work with latest release of FITSIO. This is a necessary step for upgrading the SDB2FITS converters and ensuring their portability. Took a great deal of time resolving system configuration issues (which is still a problem) and learning about FITSIO (necessary) and VAX FORTRAN. Also had to track down old documentation of these utilities. Plan to implement better control over this when C. Meete resolves configuration management problems at COSSC.

SDB2FITS converter now work with OSSE high-level data products. There are a few more bugs to resolve but this is still a major accomplishment. NRL still wishes to propose an optimized FITS format for OSSE data, but this helps ensure that we will have OSSE data in FITS format. This opens the door for building true OSSE FTOOLS.- Ideally, the FTOOLS will work with both FITS formats.

Assembled extensive OSSE documentation for COSSC local documentation site. This site will act as a 'central clearing house' for OSSE documentation. Similar sites are available for the other CGRO instruments. The site also includes planning notes for OSSE FTOOLS and documentation for CGRO support tools such as VSTAT.

Modified Darryl Macomb's SRCTRACK program to generate a pipe-delimited file to incorporate the CGRO timeline into the HEASARC database. I am also responsible for updating this file with the HEASARC as the current timeline is subject to changes due to targets of opportunity, etc.

TASK 5030/93-20-00 – GROSSC and

TASK 5030/96-02-00 – GLAST/GTOTE

Daryl Macomb:

Position Requirements:

1. General support of CGRO guest investigators concentrating on EGRET instrument technical support: My main responsibility is to handle queries and request from guest investigators, especially concentrating on those with EGRET specific questions and tasks. This includes being aware of CGRO resources and capabilities, installing and testing data analysis software, and interfacing with the EGRET instrument team.
2. I continue to take part in activities designed to reach out to the general public. This includes web page development, publications, and educational activities.
3. Research: In order to better serve the guest investigator community, it is important that I be actively involved in the field of gamma-ray astronomy. I have maintained an active research schedule which includes research into pulsars, active galaxies, supernova remnants, and the creation of a general gamma-ray source catalog.

Evaluation Factors:

1.
 - a. Successful GI interactions
 - b. working software system
 - c. creation of new EGRET specific knowledge bases
2.
 - a. The creation of new products intended for public consumption.
3.
 - a. publications and contributed papers
 - b. is research relevant to the CGRO mission?

Primary Accomplishments:

- 1 Continued to install and test EGRET team software when necessary. Helped many GI's use and understand EGRET software here at the SSC.

Close to completion on an HTML EGRET User's Guide which will be available on the web and on the new EGRET CD. Planned and in the process of preparing a new EGRET CD. This will be a general resource which contains all of the SSC archival EGRET data as well as all available software and documentation. My efforts have gone into planning the CD, HTML'ing existing EGRET documentation, preparing some data quality checking scripts, and working on

JAVA programs to provide platform independent methods for utilizing the data on the CD.

2. Worked on, edited, and oversaw the publication of two major brochures. The first, the report of the Gamma-ray Astronomy Programs Working Group (GRAPWG) was largely authored by a NASA panel with some small additions of my own. I worked with GSFC graphics arts to create a brochure which was published this spring. The second, still in press, is a brochure put together by a group of GSFC scientists articulating the scientific themes for NASA's SEUS program. Worked on editing and layout of this pamphlet which was written by committee. Provided the HEASARC's Learning Center with written text and images on many different gamma-ray astronomy subjects for their Web site. Have also helped collaborate with teachers on a CGRO based lesson plan. Learned JAVA which will help in future Web efforts.
3. Continued to make progress on several projects as evidenced by my publication list. General gamma-ray source catalog with Gehrels is nearing completion. Future work will emphasize further studies of GeV gamma-ray sources, and work on CGRO detected x-ray binaries and pulsars. Submitted a cycle 7 CGRO proposal.

TASK 5030/93-20-00 - GROSSC

Chris Shrader:

Position Requirements:

1. Provide support to the Compton Gamma-Ray Observatory (CGRO) Guest Investigator (GI) Program in the areas of proposal preparation, submission and evaluation, and data analysis. In recent years, I have been responsible for editing and distributing the CGRO NASA Research Announcements (NRAs); served as the overall chair of the annual peer-review meetings where all Guest Investigator proposals are evaluated and ranked; and have in large part managed the Guest Investigator Program for the Project and Program Scientists. Presentations summarizing these activities are made periodically to the CGRO Users Committee. Additional responsibilities involve support to GIs in all aspects of acquisition and analysis of CGRO data, and dissemination to NASA Headquarters and the general public of pertinent CGRO science results.
2. Provide support to the CGRO project in a broad range of areas, including long-term mission planning, organization of scientific and technical meetings, preparation and presentation of technical and scientific documentation of mission related activities and public relations activities. I regularly participate in the organization of CGRO related meetings and workshops, such as the recent 4th Compton Symposium, for which I was the co-Chair of the local organizing committee. Project support also includes various public relations and outreach activities.
3. Participation in the installation and testing of Instrument Principle Investigator Team (PI Team) software and data products delivered to the CGRO Science Support Center (SSC) for GI use. Towards this end, personal scientific research utilizing CGRO data is carried out.
4. Serving as Group Leader for the CGRO SSC scientific staff. Responsibilities include input on staffing decisions, distribution of task responsibilities, monitoring of progress, and interaction with the Program Manager to report on the various aspects of the day-to-day CGRO SSC activities.

Evaluation Factors:

1.
 - a) The success of the CGRO GI program, and satisfaction within NASA management of the CGRO SSC's role in its implementation. My contribution to these issues as perceived by the CGRO Guest Investigator community and the project management.
 - b) Measures of the use of the CGRO SSC facilities, including remote access, and Guest Investigator feedback.

2.
 - a) The satisfaction (or dissatisfaction) with the level of support provided from the SSC expressed by the project and program scientists, deputy project scientist and Instrument Team PIs.
 - b) Assessment of CGRO project activities which are supported by the SSC by the CGRO Users Committee.
3.
 - a) Progress, documented by the scientific productivity of the CGRO GI community, in making a complete set of data and analysis tools available and as documented in publicly distributed CGRO SSC technical materials such -as the Users Guide and monthly status reports and on-line bulletin boards.
 - b) Data archive and computer usage at the SSC by GIs via remote access or direct visitation.
4.
 - a) The evaluation of the SSC scientific staff, the Project Scientist and Deputy Project scientist as well as that of the program manager.
 - b) The overall success of the CGRO SSC during the present time frame as compared to under its previous implementation.
5. The perception of the value of these services by the laboratory management and staff.
6. Documentation of results through publications and presentations.

Primary Accomplishments:

1. The CGRO Cycle-7 Proposal cycle has been successfully initiated. Proposals were received and given appropriate treatment by the SSC staff under my supervision. Critical input was provided to the CGRO Users Committee regarding the Guest Investigator Program as pertaining to strategic planning for the mission. The Cycle-7 Peer Review was organized and will be held during August. An extensive target database was developed for the CGRO time-line committee (of which I serve as the SSC representative). The time-line will be developed during August 1997. A large amount of strategic planning database preparation precedes this activity. The schedule is particularly tight this year.
2. In addition, several scientific papers on the status and achievements of CGRO were prepared and edited in collaboration with the project scientist. I chaired a joint HEASARC/CGRO-SSC committee to address the development of CGRO specific "FTOOLS" software with the goal of more fully integrating CGRO into the overall HEASARC methodology. Significant progress has resulted, with 3 EGRET utilities being delivered to the HEASARC, one long-existing but nonfunctional BATSE utility being debugged and redelivered, and several prototypes for additional utilities being assigned to SSC programmers for development.

3. Four journal publications, and two conference proceedings articles were published on CGRO related research during the evaluation period. Topics include both galactic high-energy transient phenomena and Active Galactic Nuclei. I was selected to give an invited review paper on active galactic nuclei "multiwavelength campaigns" for the 4th Compton Symposium.
4. I have been involved with various CGRO related public outreach activities, notably with the organization and implementation of a public workshop which preceded the 4th Compton Symposium. I am also responsible for the review of numerous public outreach materials produced by the CGRO-SSC staff.
5. I co-chair the Monday High-Energy Astrophysics Lunch Seminar series since November of 1994. The interest, as gauged by the attendance and audience participation in the event, is an indication of its success. Additionally, I serve on the Laboratory for High-Energy Astrophysics Seminar Committee.

TASK 5030/93-20-00 - GROSSC

Ken Watanabe:

Position Requirements:

1. To develop a database of CGRO/BATSE data products and a set of software tools that will make the BATSE data more easily accessible to the general research community at NASA/GSFC CGRO Science Support Center (COSSC).
2. To conduct scientific research related to the reduction, analysis, and interpretation of gamma-ray and x-ray astrophysics data with emphasis on CGRO at COSSC.
3. To support CGRO/BATSE public users in their scientific research.
4. To be a good mediator between COSSC and BATSE team at MSFC.

Evaluation Factors-

1. a. WWW
b. Pipeline
c. Software tools
2. a. Scientific importance of the research results
b. Contributions to scientific/public community
c. Collaborations
3. a. Promptness
b. Accuracy
4. a. Obtaining new BATSE data from MSFC
b. Joint Project such as making new BATSE 4B Catalog CD-ROMs

Primary Accomplishments:

1. a. I created new BATSE High Level products on the Earth occultation data and pulsar data with some tools on the web by January 1997. I have been maintaining the web site since then. As information., we have at least following access to the web site since January:

BATSE Home Page: 1823

BATSE High-Level Products Cover Page: 591 (32% wrt BATSE Home Page)

BATSE High-Level Products: Occultation: 338 (19% wrt BATSE Home Page)

BATSE High-Level Products: Occultation Tools: 159 (9% wrt BATSE Home Page)

BATSE High-Level Products: Pulsar: 130 (7% wrt BATSE Home Page)

- b. BATSE pipeline has been so complicated and no one knew how exactly it works. Because we have been making new BATSE 4B Catalog CD-ROM, it was necessary for me to know the details of the BATSE pipeline. Now, I know how it works. I also replaced a several software by new ones which were available from the BATSE team at MSFC. We will simplify the pipeline after the CD-ROM project is over. We will use more alpha machine than before in process which allows us to make archival products faster and better.
- c. I have been making a lot of IDL programs to do my job.
2. a. The cosmic gamma-ray background (CGB) is a more than thirty years old & problem. I have been studying the CGB in MeV region for six years using SMM
- b. data. Particularly, there have been a debate on the existence of a bump in spectrum in a few MeV region. Although CGRO/COMPTEL team announced the evidence of no MeV bump at the third CGRO Symposium, we also presented our results which show that the bump is due to some instrumental effects. We are still analyzing the data very carefully to show clean results. We are also interested in the SNIa contribution to the CGB in a few MeV region. The theoretical calculation on the SNIa contribution and accurate SMM measurements on the CGB give us information on the cosmic chemical evolution. These are hot issues and we will continue to study to reveal new facts.
- c. As you see in below, I have been working with several very fine researchers in the field.
3. a. I always try to answer the questions from CGRO public users around the world as soon as possible. (at least within 24 hours)
- b. I work with BATSE team at MSFC to give accurate answers to the users.
4. a. It is extremely important for me to be a good partner of the BATSE PI team in order to work at the COSSC primarily on the BATSE. There are a lot political issues in addition to the scientific issues between the COSSC and the BATSE team. I have been trying to be a good person whenever some people at the BATSE team give us hard time.
- b. Making new BATSE 4B catalog CD-ROMs has been my major task for a few months. It is unfortunate that the deadline for this summary is almost the same time for the CD-ROMS. We have been working very closely

with the BATSE team to make this product. The CD will be distributed at the Huntsville Symposium in September.

TASK 5030/94-07-00 – XTE-SOF

John Cannizzo:

Research:

Work continued investigating the flow of matter onto compact stars in interacting binaries. Several different aspects of this work have been carried out.

The first involves a continuation of what has historically been the most fruitful line of research - the comparison of observation and theory as regards the application of the accretion disk limit cycle mechanism to the observed light curves of dwarf novae and X-ray novae. A major numerical study involving a large exploration of parameter space has just been completed and was submitted to the *Astrophysical Journal* July 21.

The second involves investigations of instabilities in the flow patterns near the inner edge of accretion disks. This work has been largely stimulated by the recent results from the XTE satellite on the time variabilities seen in neutron star and black hole systems. The initial direction of this new work was to account for giant bursts seen in the "bursting pulsar", GRO J1744-28. As this work has matured and begun to affect the thinking of various other researchers in the field, we have come to address the even more bizarre behavior observed recently by XTE in the two galactic microquasars 1915+10 and 1655-40. The time variable nature of these new sources is - as with 1744-28 - unprecedented in astronomy, and sure to reveal new insights into the behavior of matter accreting onto very compact objects.

Most of my work is centered around two computer codes I have written and developed extensively, one that solves the steady state vertical structure of accretion disks, and one that solves the time dependent evolution. So many researchers have asked to collaborate with me and use my codes, that I have long since declined to take on any new collaborators. Recently I decided to make my codes available to interested workers, just because I feel bad that so much work is going undone, in particular, running models for specific objects that observers are keenly interested in. I made a formal announcement of the availability of my codes at the 13th North American Workshop on Cataclysmic Variables and Related Objects in June. Since that time, I have been answering between about 5 and 15 e-mails per day concerning questions relating to my codes, from people that I have given them out to.

An entirely new line of research, extragalactic observations, began with the activation of RXTE proposal 20326, Coordinated Observations of NGC 4258, a collaboration effort with myself as P.I., and as collaborators R. Mushotzky (Goddard), and J. Moran, L. Greenhill, and J. Herrnstein (Harvard). This is an accepted proposal for AO-2 which began observations 3 Dec. 1996, and ran approximately through the end of May 1997. The X-ray observations were being carried out at Goddard, and radio observations are being conducted at the VLA and Effelsberg, Germany. Herrnstein and Greenhill will travel to Goddard for visit in mid-September.

TASK 5030/94-07-00 – XTE SOF

Robin H. D. Corbet:

Position Requirements:

1. RXTE SOF - Chief Duty Scientist: Direct the RXTE SOF in undertaking real-time science operations.
2. Prepare the RXTE SOF for automated operations and reduced staffing in 1998
3. Undertake high quality astrophysical research

Evaluation Factors:

1. Is the SOF conducting operations satisfactorily?
 - Is instrument health and safety being ensured?
 - Are observations scheduled appropriately?
 - Are TOOs carried out effectively and quickly?
 - Is good support provided to visiting GOs?
2. Is a plan in place, and is progress being made at a satisfactory rate, to enable big savings in operations costs in 1998?
3. Astrophysical Research:
 - Publication of papers
 - Submission of winning proposals
 - Citation and other recognition

Primary Accomplishments:

1. SOF Operations:

RXTE was launched on December 30th 1995 and, after only one month we started regular guest investigator observations. In fact, some time-critical observations were carried out during the 30-day checkout period. No limits were placed on coordinated observations with RXTE and 58% of observations have some kind of time-constraint. Since we respond quickly to Targets of Opportunity (TOOS) our schedule can change rapidly.

In addition to supporting physical visitors to the SOF we have now developed the capability of supporting remote observers. We can provide remote observers with monitoring of their observation anywhere in the world that they have access to a computer or terminal running the X Windows system.

A large number of TOOs are immediately public. In order to make these data available as soon as possible, the SOF worked with the GOF on very quickly making FITS data available on the Internet and so bypassing the delays involved in the standard data pipeline. TOOs are being performed rapidly and we have achieved better than a 7 hour turnaround on occasions.

Because of the success of the automatic FITS Generation for TOOs we then decided to make basic FITS files available for all observations. The FITS files are available automatically within less than one day by anonymous ftp. In order to protect the proprietary nature of the data, all files are encrypted with PGP. The key is emailed to GOs when their observations is scheduled (we also provide the schedule by email to ensure this is correct) and this key is used both for decrypting the data files and remote observing.

With the provision of "remote observing" and rapid production of FITS data an electronic visitor to the SOF can achieve essentially everything that could be done by a physical visitor. Hence very few Guest Observers need to physically visit the SOF, while the number of electronic visitors is rather high. The provision of these services is probably unique to RXTE and both saves GOs travel costs and enhances scientific return through the rapid availability of data.

There have been some problems with the RXTE instruments and the SOF staff have worked with Instrument Team members on these. The problems with the ASM are, we hope, now behind us and various operational schemes have been implemented to deal with the PCA breakdowns.

During 1997 two spacecraft problems also occurred. On the first occasion a failure in a solar array drive occurred which stopped spacecraft slews. The SOF safed the instruments until spacecraft engineers were able to fix the solar array problem. On the second occasion, due to the effects of a storm, the RXTE Flight Operations Team were unable to uplink the next command load to the spacecraft. Again the SOF safed instruments until the problems were resolved. In response to these situations (and because of future reduced human monitoring) I had the RXTE FOT prepare new automatic safing procedures. This will automatically place the ASM and PCA instruments into a safe condition if (i) the spacecraft can no longer slew or (ii) the spacecraft encounters an end of a command buffer with no new buffer available.

In summary, the SOF has been highly successful in carrying out its mission. This has been recognized at GSFC by the presentation of a GSFC Honor Group Award.

2. Automation of the SOF

As the nominal "prime mission" of RXTE ends in early 1997, the funding available for operating the satellite will start to decrease. The SOF will suffer a

disproportionately large fraction of the cuts expected (which I view as a sign of our success!) compared to other elements of the SOC. In preparation for this, I have developed a plan for how we will operate within this drastically reduced (30-50% of the current level) environment. Key elements include:

- Additional software monitoring to replace current human monitoring.
- Software to tie monitoring into an automatic paging, system.
- Remote monitoring, software to facilitate off-site monitoring (e.g. at home).
- Increasing reliability of software in simple/cheap ways (e.g. software to monitor software)
- Low-cost additional hardware (alphanumeric pagers, LINUX workstations for off-site use)

While staff turnover in both the operations and software development teams is having some impact on the plans, it appears that cost-saving automation will be possible.

3. Astrophysical Research

This year my research have centered on the use of the use of the RXTE All Sky Monitor, this has resulted in a large number of scientific discoveries. The use of this data set has been challenging, however, as all data from this instrument is immediately public. I am thus competing with the entire astronomical community in searching for new results. Nevertheless, I believe that I have become recognized as a leader in discovering periods in these data. Results that I have obtained from this data set include:

- Discovery of a 25-day super-orbital period in the low-mass X-ray binary GX13+1.
- First detection of the 11.6 day optical period in X-rays for the unusual supergiant system 2SO114+650.
- Detection of a previously claimed 2.7 hr period in 2SO 1 14+650. This lends great weight to the interpretation of this period as a neutron star rotation period and rules out other models.
- Detection of a 55-day period in the Be star system GRO J2058+42. This is half the period claimed from BATSE observations which may have important implications.
- Discovery of a 37-day super-orbital period in the low-mass X-ray binary X2127+119, located in the globular cluster M1 5.

- Discovery of a 35 day period (probably the orbital period) in the Be star system X0726-260.
- The 35-day period in X0726-260 enabled me to schedule PCA observations at the correct time to obtain maximum flux and the PCA observations showed 103 second pulsations.
- A number of other periods are possibly detected in several other sources. These are both super-orbital periods (e.g. low-mass X-ray binaries) and orbital periods (e.g. Be star systems). As the number of super-orbital periods grows this will allow investigation of a possible dependence of super-orbital period on orbital period.

Proposals - All 5 of my proposals submitted for RXTE A02 were accepted. I am US Co-PI on an ASCA proposal (RXJ 1838.4-0301).

TASK 5030/94-07-00 – XTE SOF

Toshiaki Takeshima:

Position Requirements:

1. Monitoring the science output at RXTE operation room.
2. On-call duty
3. Operation/Analysis Software
4. RXTE WWW-Pages
5. RXTE Gamma-Ray Burst Observation
6. RXTE observations by my own approved proposal
7. Collaborating work using other satellites than RXTE

Evaluation Factors:

1. Taking care of real-time monitoring of scientific output from RXTE at -the operation room RXTE from 09:30 to 18:30 every Monday and Tuesday as a duty scientist of RXTE, who is responsible not only for current going observations but also responsible for the evaluation of TOO request and TOO alert from RXTE All Sky Monitor
2. Being "on-call duty scientist" for a week out of every three weeks. On-call duty scientist is responsible to making decision for some change in RXTE observations. on-call duty scientist is paged by beeper even at midnight.
3. Being responsible for many of software running at RXTE SOC (Science Operation Center) which treat ASM (All Sky Monitor) data. I wrote some programs/scripts to maintain the database of ASM data, to extract required data with some criteria, to help TOO (Time of opportunity) observation, etc.
4. Maintaining some of WWW pages of RXTE, which contribute to publicity of public RXTE data, to planning and decision for, TOO observation, and to science monitoring at RXTE SOC. The total number of access to these pages exceeds 100 per day in average.
5. Now we know that afterglow of Gamma-ray burst (GRE) is observable in X-ray energy band. But it decays quicker than the fastest response time of RXTE TOO with normal replan method (~7 hrs). In collaboration with BATSE team, we started to find the quicker way for GRB TOO observation and establish the method without threatening the safety of the RXTE satellite. We have already performed three observations to chase afterglow of GRBs and detected a possible afterglow from GRB 970616 event (IAUC #6683). The averaged response time is about 3 hrs and 10 minutes.

6. Two RXTE observation with my own proposal were performed March and June 1997. Data analysis is on the way. Quick results are reported to IAUC (#6595 & #6605).
7. Our nature paper on "dark cluster" using ASCA and ROSAT was published on July 10th issue (Vol.338, p.164). NASA press release was issued on this work (#97-91). This work was done by continuous collaboration with RIKEN (Japan) and Max Planck (Germany) team. Another paper on the ASCA observations of the Galactic center was also published (1996, PASJ, vol.48, p.249) in the ASCA special issue.

Primary Accomplishments:

1. Science monitoring is time consuming and occasionally boring, while it's very important to prevent satellite and/or payloads troubles. As I think fundamentally I'm paid for this duty, I believe I'm doing what I'm expected to do.
2. I'm always carrying my pager, but seldom beeped except for GRB chase (see 5).
3. Until the end of 1996, most of ASM software are almost established. So recently I don't use so much time as before. But when a problem comes up, it still easily takes my time away.
4. I'm still trying to make most of daily task for WWW maintenance automatic. This effort gave me more time for science to me than last year. But some of tasks are difficult to automate and require time.
5. RXTE project of GRB chase started March 1997. Since then most of my time was used for this task. At present time, only I can make quick observation of GRB within about 3 hrs, which procedure is established many tests and trials by me with helps of XTE MOC (mission operation center) staffs and SOF staffs. Whenever GRB that satisfies certain criteria is reported from BATSE team, I'm paged even if midnight. On call duty is one week out of three, but this job has no holiday. Now I'm trying to educate SOF staffs so that they can make quick TOO plan instead of me.
6. I don't think I analyze my own data very well, while I'm eager to do. After ASM software and WWW automating was established some extent, I could find time to analyze my data, whose results will be presented IAU symposium at Kyoto soon. Between March and July 1997, I hardly had time for the data analysis for my own data because of the GRB projects.
7. I believe that our Nature paper is a very good job. The paper on ASCA observation of the Galactic center is also a very good job, but I don't contribute this paper very much.

TASK 5030/97-01-00 – GRO Fellowship

Matthew G. Baring:

Position Requirements:

1. To perform research in the field of theoretical astrophysics
2. To publish results of this research in refereed journals
3. To disseminate scientific discoveries at U.S. and international meetings
4. To collaborate and interact with scientific colleagues both within and outside Goddard

Evaluation Factors:

1.
 - a. Level of productivity as measured by publication record.
 - b. Making conference presentations and being invited to give seminars'
2.
 - a. Significant publication list
3.
 - a. Active attendance at international scientific meetings
 - b. Presentations at such meetings.
4.
 - a. Evidence of substantial collaborative activity.

Primary Accomplishments:

1. My productivity in the study of shock acceleration theory, pulsars, gamma-ray bursts and supernova remnants has been substantial, as can be seen in the publication lists below. This work has led to a seminal paper on the comparison of shock acceleration models with observational data from the Ulysses spacecraft, two papers explaining how physical processes in the high field of the pulsar PSR1509-58 can truncate its spectrum at around 1 MeV, comprehensive analysis of pair production opacities in gamma-ray bursts, and a new and detailed shock acceleration model for gamma-ray production in supernova remnants.
2. Covered in 1.
3. Several meetings were attended, and I made oral presentations at all of them, including two invited reviews, and a written review paper in association with the 4th Compton Symposium.
4. Collaborations with three institutions outside Goddard as well as with several individuals at Goddard.

I feel that I did very well in all of these categories.

TASK 503-/97-02-00 – ASTRO-E

TASK 5030/93-03-00 – ASCA GOF

Ken Ebisawa:

Position Requirements:

Please note that I was formally transferred from ASCA GOF to Astro-E GOF as of 16 December 1996. Although I still have responsibilities on the ASCA project, my main task has shifted to the preparation of the Astro-E mission which is to be launched in early 2000. Thus, for the past one year, I worked both on ASCA and Astro-E projects.

1. As a member of the ASCA Guest Observer Facility, (GOF), provide reliable and user-friendly ASCA data analysis environment to the astronomical community.
2. In particular, I am responsible for releasing calibration information of the GIS instrument, in collaboration of the GIS team.
3. On Astro-E, my main responsibilities are the following:
 - a. Provide documentations which describe the mission overview and agreements between US Astro-E GOF and ISAS.
 - b. Prepare Astro-E data analysis software.
 - c. Release Astro-E information to the community through the World Wide Web
(<http://heasarc.gsfc-nasa.gov/docs/astroe/astroegof.html>).
4. Carry out independent research and present scientific results in meetings and publish papers in scientific journals.

Evaluation Factors:

1.
 - a. Quality of the user support of the ASCA Guest Observer program.
 - b. Satisfaction by the Guest Observers.
 - c. Scientific output by US ASCA Guest Observers using ASCA.
2. Quality and reliability of the GIS calibration information released to Guest Observers.
3.
 - a. Quality of the document I am preparing (Astro-E Program and Data Management Plan).
 - b. Accomplishment of the preliminary Astro-E data processing software (Astro-E FRFread).

- c. Quality of the Astro-E information released through the ASTRO-E GOP World Wide Web page.
- 4. a. Research proposals accepted.
- b. Presentation in scientific meetings and invited talks.
- c. Publications in refereed journals.

Primary Accomplishments:

1. a. Approximately 2000 targets have been observed with ASCA since its launch, and Guest Observers have been analyzing their data and publishing results with GOP supports. So far, at least 216 papers are published in the refereed journals mainly using the ASCA data (<http://heasarc.gsfc.nasa.gov/docs/asca/papers.html>). With the other members of the ASCA GOF, I helped guest observers analyze ASCA data through the ascahelp@athena.gsfc.nasa.gov help desk. I also prepared technical material for ASCA A06 proposals and wrote a part of the ASCA ABC guide (data analysis manual).
- b. I wrote and released a perl script named addasca-spec which allows users to conveniently combine ASCA spectra taken with different instruments or at different occasions.
- c. Based on the GIS background study of the GIS team, I derived an efficient and convenient GIS data screening criteria for Guest Observers to screen their GIS data. This has been implemented and released in the program ascascreen which has been a standard data analysis tool for Guest Observers.
2. a. The GIS energy gain has been slowly varying, and this has to be corrected before delivering the data products to Guest Observers. In cooperation with the GIS team and ASCA data processing team at GSFC, I have been deliberately working to make sure that reliable GIS datasets are delivered to Guest Observers.
- b. I have made several announcements on the status of the GIS calibration/performance through the World Wide Web. This includes, for example, the "GIS Back-ground and Data Selection" page at <http://heasarc.gsfc.nasa.gov/docs/asca/gisbgd.html>, and the release note of the new XRT/GIS responses at http://heasarc.gsfc.nasa.gov/docs/asca/xrt_new_response_announce/announcement.html.
3. a. I have been working on the Astro-E Program and Data Management, Plan, which describes the mission overview, and also coordinating agreements between GSFC and ISAS on the Astro-E data processing/analysis software system.

- b. I made three trips to Japan (November 1996, February 1997, and March 1997) to study Astro-E ground test system. I learned how this system works, and proposed a way to incorporate their ground test software to our Astro-E data processing system. Development of the Astro-E FRFread, whose task is to convert the Astro-E raw telemetry the standard FITS files, has been going on this line.
 - c. I am in charge of the WWW Astro-E GOF page, on which researchers interested in the Astro-E mission can obtain information.
- 4.
- a. I have one refereed publication last year as the leading author, and other three papers are published or accepted in refereed journals having me as a co-author.
 - b. I have participated in four scientific meetings. I presented a review talk in one of them, and gave oral presentations at other three.
 - c. I was invited to give a talk at Rice University.
 - d. I have one research proposal accepted for ASCA A05 and one for XTE A02 as a principle investigator:

TASK 5030/97-03-00 – Detector Technology

John F. Krizmanic:

Position Requirements:

1. Novel Semiconductor Detector Development: Perform research and development of semiconductor detectors for space based applications. Devices under development include silicon microstrip detectors for the measurement of charged particles and cadmium zinc telluride microstrip detectors for hard x-ray, soft gamma ray detection.
2. VLSI Electronics Development: Perform research and development of ultra-low power, low noise Application Specific Integrated Circuits (ASIC's) for space based use.
3. Orbiting Wide-angle Light collectors (OWL) Experiment: Investigating the feasibility of observing ultra-high energy cosmic ray interactions ($E > 10^{20}$ eV) within the Earth's atmosphere from orbit.
4. The Gamma-ray Large Area Space Telescope (GLAST): Develop a next generation high energy gamma ray astronomy experiment using silicon microstrip detector and ultra-low power VLSI technologies.
5. Isotope Matter Antimatter experiment (IMAX): Perform astroparticle physics analyses using the IMAX data to study the properties of the cosmic radiation.
6. The gamma-ray Burst ArcSecond Imaging and Spectroscopy (BASIS) experiment: Develop an experiment to perform hard x-ray, soft gamma ray astronomy using cadmium zinc telluride microstrip detector and low power ASIC technologies.

Evaluation Factors and Primary Accomplishments:

1. Novel Semiconductor Detector Development
Semiconductor detectors offer unique advantages over rival particle detection technologies which include the use of no 'consumables', operation at modest voltages, extremely fast response and low dead time. Furthermore, position sensing detectors, such as silicon microstrip detectors, yield precise particle position measurements ($\sigma \leq 10 \mu\text{m}$). At GSFC, I have continued the effort to develop this technology for astrophysical experimentation. Since joining USRA, a significant amount of my effort was devoted to constructing a semiconductor characterization laboratory at LHEA. This involved determining the characterization requirements, procuring equipment, and configuring the previously acquired testing equipment (including a probe station). Once this was accomplished, detailed studies were performed on the coupling capacitors that are integrated on the silicon microstrip detectors fabricated at GSFC. These capacitor structures are needed to properly integrate the

detectors to VLSI electronics that will read out the charge deposited by traversing charged particles. Furthermore, we are planning to use this process to fabricate separate capacitor structures that are needed to properly integrate cadmium zinc telluride microstrip detectors to ASIC electronics. The results of the capacitor characterization measurements demonstrated that the fabrication process has created structures with the anticipated properties. However, channel-to-channel variations were observed which are fairly well correlated to photolithographic errors on the sample under test. I have also been involved in developing a new prototype design for double sided silicon microstrip detectors for the POsition and Electron Magnetic Spectrometer (POEMS) experiment which has submitted a Small Explorer Experiment (SMEX) proposal this past June.

2. Electronics Development

NASA GSFC has recently begun to design and have fabricated VLSI, ASIC electronics to be integrated to a variety of detector technologies under development at GSFC. We currently have prototype ASICs which are to be used with gas microstrip detectors which are being developed at GSFC. These detectors could provide superior performance in a high energy gamma ray pair conversion telescope as compared to silicon microstrip detectors. As the scientist responsible for the testing and characterization of these devices, I continued the development of the needed hardware. The methodology I have employed is to interface directly to the data acquisition system which will be used with the actual detectors and electronics to create a computer controllable ASIC characterization environment. Electrical contacts to the bare ASIC die will be performed via a probe station and a probe card I have developed with a commercial company.

3. OWL

In order to properly determine the feasibility of observing the interactions of ultrahigh energy cosmic rays in the atmosphere from orbit, I had previously developed a physics simulation (Monte Carlo) to model an idealized instrument's response. This simulation will be essential to developing the OWL instrument and will eventually model the physical processes that will be observed. As with any physics simulation, a parameterization of the underlying physics was needed to be developed in order to determine the simulation's scientific performance. I developed a semi-empirical parameterization which included the initial generation of fluorescent light, propagation through the atmosphere, attenuation by optical elements, signal generation at an idealized photo-detector, and background estimates. A comparison of the results of the Monte Carlo and parameterization demonstrated the accuracy of the simulation. Moreover, the initial results have yielded an incident cosmic ray energy threshold for the OWL instrument below 10^{20} eV, thus proving that the concept is feasible.

4. GLAST

The GLAST instrument is to have an upper tracker section formed by silicon microstrip detectors interspersed with thin radiators to form a gamma ray pair conversion telescope. Driven by the desired scientific goals, we have started to evaluate and optimize the design of the instrument. I have been involved in translating these goals into the requirements of the

silicon detectors and electronics in order to optimize the design. Working with Code 718 at GSFC which has previously fabricated silicon microstrip detectors, I have begun to develop a research and development program to address these optimization issues. This has led to a serious investigation of upgrading the fabrication facilities at GSFC to 6 inch (from 4 inch) wafer technology. This leads a significant reduction in the percentage of dead, scattering material in the GLAST tracker. While at the VERTEX '97 workshop, I initiated a significant amount of discussions with other silicon microstrip detector researchers in regards to GLAST detector optimization and performance issues. I have also began a testing program of GLAST prototype detectors (fabricated by Hamamatsu Photonics) using the semiconductor characterization resources I have developed at GSFC.

5. IMAX

The IMAX experiment had acquired a wealth of scientific data during its flight in 1992. Using the analysis tools and techniques I have previously developed, I have begun the analyses to measure the flux and isotopic composition of the element lithium in the cosmic radiation. Initial results indicate that although IMAX was configured to measure antiprotons, (i.e. $Z = 1$ particles), the experiment also has measured a statistically significant amount of lithium during its flight.

6. BASIS

The BASIS collaboration has been developing cadmium zinc telluride (CZT) microstrip detectors for use in an imaging hard x-ray, soft gamma ray experiment. My research pioneered the integration of a CZT detector to ASIC electronics and demonstrate that both positional and spectroscopic information can adequately be obtained with this combination. The results of this experimentation was used as a demonstration of this technology for a BASIS mission we proposed as a SMEX this past June.

TASK 5030/97-05-00 – INTEGRAL Software

Juan E. Naya:

My work in this period has been mainly dedicated to two different projects of gamma-ray spectroscopy: the Gamma Ray Imaging Spectrometer (GRIS) and the INTErnational Gamma RAy Laboratory (INTEGRAL).

1.1 GRIS

During this period I continued the analysis and interpretation of the data from the last GRIS balloon campaign (October 1995). Three different areas of study can be distinguished.

1.1.1 The Detection of the Galactic 1809 keV Aluminum Line Emission

The study of the 1809 keV emission from the decay of Galactic ^{26}Al is crucial for the understanding of the nucleosynthetic activity in our Galaxy. The recent detection of the 1809 keV line emission performed by the Gamma-Ray Imaging Spectrometer (GRIS) has provided new and valuable information improving significantly the understanding of the ^{26}Al emission. The most remarkable result is the line was detected to be broad (5.4 keV FWHM) meaning that the ^{26}Al is moving at velocities of 540 km s^{-1} . The reason why the ^{26}Al has not stopped after 1 years is difficult to understand. (This result was published in Nature in November 1997 and presented at the 2nd INTEGRAL Workshop).

On the other hand, we have started to study the implications of this measurement on the distribution and intensity of the 1809 keV emission. The sky maps of the 1809 keV line emission obtained by COMPTEL have revolutionized our understanding of the origin of Galactic ^{26}Al . However, the GRIS measurement requires the existence of a significant fraction of the 1809 keV line emission that does not appear in the COMPTEL map. We are currently collaborating with the COMPTEL team (R. Diehl and P. von Ballmoos) in order to understand the origin of this extra emission. We have recently submitted a GRO proposal that would fund me a trip to Munich to work on a combined analysis of the GRIS and COMPTEL data (see attached document).

1.1.2 Analysis and Interpretation of the Galactic 511 keV Line Emission

The GRIS observation of the Galactic 511 keV emission has provided valuable information about its flux intensity in the central region. Moreover, the detection of significant emission from the Galactic plane region around $l=140$ deg opens the exciting possibility of discovery of a new 511 keV source. My participation in this work has been to study the GRIS instrument response at 511 keV energy and the analysis of the different sources of 511 keV background. I've also contributed to the elaboration of a model of the 511 keV emission, work led by Lingxiang Cheng at the University of Maryland. The results of this work have been recently submitted to the Astrophysical Journal.

1.1.3 Analysis of the GRIS Observation of the ^{60}Fe Galactic Emission

Models predict that ^{60}Fe ($t_{1/2}=1.5 \cdot 10^6$ y) is released into the interstellar medium through supernova explosions (Hoffmann et al. 1994). The calculated average ^{60}Fe mass yield from SN Type II explosions is about 37% of that for ^{26}Al . This implies that the 1173 and 1332 keV ^{60}Fe line emissions should be as intense as 16% of the observed 1809 keV ^{26}Al line emission, if the main contributor to the Galactic ^{26}Al are supernovae (Timmes et al. 1995). The detection of this emission would allow us to exclude Wolf-Rayet stars as major ^{26}Al sources, since they are not expected to produce detectable ^{60}Fe amounts (Prantzos & Diehl 1996). The combined ^{26}Al and ^{60}Fe emission measurements will therefore provide valuable information for the current models of nucleosynthesis, which is essential for the understanding of the chemical evolution of our Galaxy.

I've searched for the ^{60}Fe diffuse gamma-ray line emissions on the GRIS data and I do not find any evidence for such radiations. The derived 2-sigma upper limit for the Galactic emission is $6.4 \cdot 10^{-5}$ ph $\text{s}^{-1}\text{cm}^{-2}\text{rad}^{-1}$. This number is lower than those reported by previous observations performed at high energy resolution and has important implications on the yield of ^{60}Fe in Galactic chemical evolution models. We are currently working on the theoretical interpretation of this results with Frank Timmes, one of the best experts on the field.

Part of this work has been presented at the following meetings:

American Astronomic Society, Toronto
American Physical Society, Washington
IV COMPTON Symposium, Williamsburg

This work is going to be submitted to the ApJ very shortly.

1.1.4 The Next Step on Gamma-Ray telescopes: the Long Duration Balloon GRIS

The GRIS instrument has been a very successful experiment. It produced breakthrough scientific results on many of its 9 flights, contributing significantly to the study of nucleosynthetic ^{56}CO lines from SN1987A, the galactic 511 keV annihilation line, and the galactic ^{26}Al line (1.809 MeV) among other things. We have proposed to refurbish GRIS for the exciting new Long Duration Balloon (LDB) program. By configuring GRIS to do wide Field-Of-View (FOV, $120^\circ \times 70^\circ$) studies of diffuse emission, the program will be aimed at science that INTEGRAL cannot effectively address. For such lines GRIS will achieve a narrow line sensitivity of about a factor of 5 better than the CGRO sensitivity achieved with low resolution instruments. Narrow lines tend to come from diffuse sources, so a Ge spectrometer should have a wide FOV to be most effective. This is the specialty of this new incarnation of GRIS.

1.2 INTEGRAL

My work on this project has been based on the continuation of the studies of the instrumental background in satellite Ge spectrometers, the development of a software package for Monte-Carlo simulation of gamma-ray instruments and, the elaboration of a method for the calculation of the matrix response of gamma-ray telescopes.

1.2.1 Background Line Predictions for SPI

This issue is crucial for the design of the INTEGRAL Spectrometer and the understanding of its scientific capabilities. Such studies are being performed by me, at the Goddard Space Flight Center, in close collaboration with the CESR/INTEGRAL team at Toulouse.

One of the main contributions to the line background from gamma ray nuclear emission comes from the passive material inside the shield. While most of these lines are not at astrophysically important energies, there are some very important exceptions such as the 476 keV Be line, the 847 keV line, the 1809 keV Al line, the 4.4 MeV carbon line, and the 6.1 MeV oxygen line. My work has consisted in evaluating the background lines induced by the materials inside the shield. For this I have developed detailed calculations about the material activation and geometrical distribution in the instrument.

This work has been published in the SPIE's proceedings of 1996 and it has also been presented at the SPI working team meetings celebrated in Valencia (27-28 Nov. 96) and Milan (4-6 Feb. 97). These studies have been important to perform the material selection for the components inside the shield and to optimize the geometrical distribution in order to minimize the induced background.

1.2.2 Development of the Gamma-Ray Instrument Simulator MGEANT

For a complete understanding of the performance of the INTEGRAL Spectrometer we are developing the Instrument Software Simulator (MGEANT). This simulator should be able to reproduce the response of the Spectrometer to a variety of different inputs, including a representative sample of astrophysical sources as well as radioactive sources (and possibly accelerator beams) during ground calibrations. Extensive comparisons will be made between the ground calibration data and the simulator predictions. For flight data analysis the simulator must reproduce both the response to point and diffuse sources as well as generate a faithful reproduction of the instrumental background under a variety of conditions. The reproduction of source spectra will make use of the response matrix described in the next Section.

My main contribution has been the creation of the current version of the SPI numeric model and the definition of a significant fraction of the code. This effort

is being made in close collaboration with my colleagues Helmut Seifert and Steve Sturner.

1.2.3 A Method for the Generation of the Matrix Response of Gamma-Ray Instruments

The instrument response matrix is the operator that transforms the input photon spectrum into the measured counts spectrum. An accurate knowledge of the Spectrometer response will be vital to the full realization of this capability. Since SPI has imaging capabilities, its efficiency in function of the energy and direction has to be known in detail. The characterization of the instrument is not trivial due to the complexity of the instrument and the diverse ways of gamma rays interacting with matter.

Initial estimates of the time necessary to characterize this function by following standard methods were of the order of years. It was clear that a new approach was required in order to get this information within a reasonable period of time. At the SPI meeting celebrated in Williamsburg (April 24-45 and May 1) I presented a method for calculating the instrument response that will reduce the calculation time by two orders of magnitude. This new idea was very appreciated in the SPI team and I was assigned to further investigate this new concept (see attached copy for a description). The technical feasibility of the method and first results were presented at the SPI meeting celebrated in Toulouse (21-23 Jul. 97).

This idea is very innovative and it may be adopted by other similar instruments such as the INTEGRAL Imager. We are considering submitting a paper to a refereed journal.

1.3 CZT DETECTORS

The understanding of the instrumental background on CZT detectors is very important for the design of balloon and satellite experiments. The LHEA group is specially interested on this issue, a CZT prototype has flown in the last GRIS flight providing valuable data about the internal background on this kind of detectors. The understanding of the sources of background is of special interest for the design of an instrument that minimizes the background and thus, optimizes the sensitivity. During this year I've been working on CZT background models and comparison with the data. This study is being very helpful for the design of the anticoincidence shield in the CZT telescope Infocus, developed at Goddard under the PIship of Jack Tueller.

4 FUTURE GOALS

My future goals are:

I- GRIS related work

To finish the work related to the 1809 keV flux emission combining the GRIS and COMPTEL data. This will be done in collaboration with the CESR (Toulouse) and MPE (Munich).

To finish the analysis of the ^{60}Fe emission observed by GRIS.

To continue the study on the Cosmic Diffuse emission detected by GRIS.

To continue with the development of the LDB GRIS instrument.

2- INTEGRAL related work.

To enhance the capabilities of the software package MGEANT.

To continue the work on the generation of the instrument matrix response.

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