Chapter 6: The Monitor Proportional Counter

15 March 1984

6.0 Introduction

6.1 Instrument

Monitor Proportional Counter (MPC)
Time Interval Processor (TIP)
Pulse Height Analysis (PHA)

6.2 On line system - production system

6.3 Overview of OFF-LINE user-oriented system

6.3.1 Introduction to PHA analysis

6.3.2 Specific PHA analysis programs

MBASE
UNPACK
MMERG
SPECTBL1
MSPEC
MSPECPLT
HVARY
MPLT
PSDPLT

6.3.3 Introduction to TIP analysis

6.3.4 Specific TIP analysis programs

MPCPROC
TCORR
TIPCOR
TIPANAL - photon arrival times
TIPANAL2 - photon interval times
TIPANAL3 - folding for fixed period
TIPANAL4 - folding for a range of periods
TIPANAL5 - moments of arrival times

6.4 FILE FORMATS

MPC[.hut].PSD
MPC[.hut].DAT
MPC[.hut].BAC
MPC[.hut].BLK (MPC.DATA.BASE)
MPCOR.BIN.
SPECTBL1.DAT

6.5 EVALUATION
6.0 Introduction

The Monitor Proportional Counter (MPC) detector on the EINSTEIN Observatory extends the energy range of the focal plane detectors up to about 20 keV. The MPC is a proportional counter similar in sensitivity and overall characteristics to UHURU. The sensitivity is such that sources with an equivalent flux of greater than about 0.3 UFU (UHURU cts s$^{-1}$) can be detected in a single orbit of data. A complete description of the instrument is given in Gaillardet al. (1978), IEEE Trans. on Nucl. Sci., NS-25,437; further descriptions are in Giacconi et al 1979 Ap.J., V230, pp.540–, Grindlay et al 1980 Ap.J. 240, L121, and Halpern 1982 (thesis).

Data recorded by the MPC are of 2 types: PHA data (Pulse Height Analysis data) and TIP data (Time Interval Processor data). The PHA data are the total counts recorded in each of the 8 spectral channels in each 2.56 sec. integration. These are the data used for spectral analysis and an absolute measure of source flux. The primary PHA data analysis programs are the MPCSPEC(REVO) and MPCVARY(REVO) programs, which analyze the data for spectral fits (after first calculating the background) and for variability on 2.56 sec (and longer) timescales. The TIP data are analyzed with a series of TIPANAL programs (TIPANAL, TIPANAL2, etc.) and provide the capability to search for and quantify source variability on timescales down to 10 microsec. However background subtraction and PHA analysis are not possible for the TIP data (arrival times are indistinguishable between source counts and background events) so that variability on timescales below 2.56 sec is limited to the entire energy range of the MPC.

The data from the MPC are being reprocessed so that final analysis may be done. The reprocessing software was written (from modifications to the original(revo) MPC processing system) by J. Halpern, and reprocessing started in JULY 1983. The reprocessing should be complete by December 1984.

The reprocessing is necessary to make full use of the MPC data for several reasons:

1) The background count rate in the detector decreased monotonically throughout the Einstein mission (from $\sim$18.5 cts s$^{-1}$ to $\sim$15 cts s$^{-1}$ in the 1.1-20 keV band) probably due to the decay of the Cd S0109 calibration source (with 453 day half-life) which "leaked" into
the detector. The REVO data processing, which was not in strict time order, average over much of this effect (especially for the first ~6 months of data).

2) The variance in the predicted background rate (see section 6.3) was not calculated so that uncertainties in source fluxes — particularly in the two highest energy channels (PHA channels 7 and 8) — were underestimated for weak sources.

3) The REVO on-line processing of the MPC data did not make use of the final instrument calibration.

4) The REVO processing system was designed to analyse only single "RUTS" (orbits) and merging of data from many RUTS (for a given source) could only be done with cumbersome processing of many tapes.

In addition, the reprocessing will allow the entire MPC data base (spectral data only, but with the limiting 2.56 sec time resolution) to be resident on a single 200 Mbyte disk. This disk will be available once reprocessing is complete.

6.1 INSTRUMENT

The Einstein MPC is a sealed, Argon-filled detector which is sensitive to x-rays in the range 1.2 to 20 keV. The aluminum counter body contains two separate gas volumes, each having two anodes. The entrance windows are 38 micron (1.5 mill) beryllium foil having an unobstructed area of 720 cm². The collimator tubes have a square cross section, thus providing a triangular response in two perpendicular directions on the sky. Optical testing showed that the collimator response is adequately described by a triangle of 43 arc minutes FWHM with a flattened top approximately 5 arc minutes wide. The collimator transmission is approximately 93 on axis, yielding a net open area of 667 cm². The MPC is mounted on the outside of the Einstein Observatory and is aligned to within one arc minute of the optical (yz) axis. In addition, the square collimator tubes are parallel to the y and z-axes defined by the imaging detectors in the telescope focal plane.

The TIP (Time Interval Processor) records the time interval between photon arrivals, or, if the time interval is greater than 1 millisecond, it records the photon arrival time. There is no energy resolution in the TIP data; photon arrival times are recorded for any valid event in the entire range of the 8 channel PHA. Because of memory and telemetry constraints on the spacecraft, the TIP can only record arrival times for (nearly) all valid events for count rates up to about 30 counts s⁻¹. At higher count rates the instrument becomes increasingly dead-time limited since the TIP memory outputs data at a fixed rate of 100 counts s⁻¹. The net effect is that for a very bright source such as the Crab (1400 c s⁻¹) only about 0.2 sec of data is recorded for every 2.56 sec read-out cycle.
Pulse Height Analysis (PHA) covers the range 1.2 to 20 keV in eight approximately logarithmic energy intervals. The PHA electronics are preceded by coincidence and PSD (Pulse Shape Discriminator) electronics. Coincidence events are due mainly to cosmic rays and other charged particles in the earth's magnetosphere which traverse the gas volume. This is by far the major source of background in the MPC. The PSD circuit serves to further reduce the background counts due to charged particles. In flight background observations show that the background rejection efficiency is 95 i.e., the ratio of residual PHA counts to processed events is about 0.05. By determining the correlation between the coincidence rate and this residual PHA rate the background can be predicted and subtracted from source observations.

An in-flight calibration on the Crab nebula has been performed. The summed count rate from channels 3-5 was approximately 904 cts/sec. Since these channels correspond closely to the 2-6 keV Uhuru band, and since the Crab Uhuru flux is $9.47 \times 10^{-2}$ UFU (Forman et al 1978), we derive the approximate conversion that 1 MPC s$^{-1}$ in channels 3-5 equals 1.05 UFU.

6.2 Normal MPC Production (ON-LINE) Processing

The REV1 reprocessing is being conducted on the M/600 "development" computer during the midnight to 8 AM shift on the weekdays and as much of the time on weekends as possible. About 4 to 5 production tapes are processed per night. There are 3-4 tapes per day of the mission, so at the current rate we should complete the processing by December 1984.

Because of the time-dependent background in the MPC, the data are being reprocessed in strict time order. For each HUT of data on the original production data tapes, the MPC data are loaded onto disk, pre-processed into a cleaned data file (i.e., errors, earth block, SAA, etc. removed) and analyzed for source detection with the MPC spectral analysis program MPCSPEC.

The macro "MPC,LOAD.CLI" is responsible for loading on the MPC data. This macro also checks the MPC,DATA,BASE to be sure the huts are processed in strict time order, and reads part of the aspect solution (generating the .ORA file) off the tape. A partial aspect solution is needed in order to confirm the satellite pointing direction. When the data is loaded, the macro "DO.ANS.CLI" takes over and runs the analysis programs. The majority of the analysis is done by the macro "DO.MPC.CLI". For a detailed explanation of how the processing system is run, see Bruce Walton for a copy of the MPC processing writeup (BIG.WU). Structure charts of these macros are also available from Bruce.

The background is predicted for each 2.56 sec block of spectral data from the value of the anti-coincidence rate in that block and a correlation table (of PHA rate vs. anti-coincidence rate) derived from pure background observations within (typically) the preceding 2 weeks of the mission. If a source is not detected (at 3 sigma) within the HUT, and the sequence number is not one flagged as having a source probably detectable by the MPC (i.e., brighter than 0.1-0.3 UFU), then the data for that HUT are added into the current background correlation table being accumulated (called MAPCOR.BIN,#). This table (of binned coincidence rate vs. PHA rates) is accumulated until it contains 10
blocks (2.56 sec each) of data, whereupon it is smoothed and written as the next table to be used for continued processing. For each HUT processed, a compressed data file (MPC[HUT#].DAT) is written out to disk which contains the total counts detected in each 2.56 sec block in each of the 8 PHA channels. In addition a 32 word summary block for the HUT (--.BLK file) which contains standard header information (sequence number, HUT number, pointing direction, start time, and duration, etc.) as well as derived information (source detection, net count rates in 5 selected energy bands) is appended to a disk-resident file called MPC.DATA.BASE. If the HUT contained night-time earth-blocked data, these data alone are also written out (in nearly the same form as the primary, total, data file ---.DAT) in a file called MPC[HUT#].BAC. Finally, if the HUT contained a calibration (5 min duration, typically every 2 days), these data alone are also written out in a MPC[HUT#].CAL file. The ---.BAC and ---.CAL files are short and relatively infrequent but will be useful for analysis of the diffuse x-ray background and overall instrument stability, respectively (the detector gain has already been determined to have been extremely stable throughout the mission).

The raw data files (.DAT and .BAC) are stored in a directory whose name consists of the first three digits of the HUT. Thus there will be ~188 directories with names 000 through 188. The macro MPC.DATA is responsible for copying the data files to these directories, and requesting a tape dump whenever the truncated HUT (first three digits) changes. The MPC processed data therefore will consist of ~188 files on the MPC tapes, each containing on the order of 200 knts. It is planned that these tapes will eventually be copied to a single 200 Mbyte disk pack.

Two hard copy outputs (a printout and a microfiche copy) are produced in the reprocessing for each HUT. A printout of the processing log and MPCSPEC output is filed (in HUT order) in the data room. There is also a copy for permanent (and compact) storage on microfiche. The printout copies are for the daily checking of the processing for errors and are discarded when the microfiche copy is received. Also, a printout and plot of each MAPCOR.BIN file is made when a new background map is started.

If there is a source detected at greater than 3 sigma, then the MPCSPEC output shows the results of spectral fits to a fixed grid of template spectra as well as the summed counts (and predicted background) in each of the 8 PHA channels. The MPCSPEC program forms the heart of the ON-LINE data analysis system. It predicts the total background from the most current correlation (the MAPCOR.BIN.# file) between the coincidence rates and count rate values in each of the 8 pulse height channels. Note that the correlation table used here is not contemporaneous, and that the default table used by UNPACK (see 6.3.2) is contemporaneous. The background is thus predicted independently for each 2.56 sec block of PHA data. The total sum of predicted background in each block for the total major frame (16 blocks) is then compared with background limits (from MPCSPEC.PF) to decide whether data is acceptable for spectral (and subsequent temporal) analysis.

Power law (type 1), bremsstrahlung (type 3), and black body (type 4) spectra are fitted to the data. The observed distribution of counts in the 8 PHA channels are compared with tables of pre-calculated model spectra of the 3 types. These model spectra have been folded through the known instrumental
response of the MPC and are properly normalized so that relative flux calibration is preserved. The best-fit parameters for each spectral model are chosen by first finding the model yielding the minimum chi-square difference form the data and then interpolating between adjacent points in the grid of models to find the best-fit values of the spectral parameters. The chi-squares include statistical uncertainties and systematic errors in the instrument calibration. The errors in predicting the background rate from the MAPCOR.BIN. table is NOT included here — but is included in the OFF-LINE program MSPEC. This error is typically small enough to ignore except in the two highest PHA channels for weak sources.

6.3 OFF line system — user oriented

6.3.1 Overview of PHA OFF-LINE system

6.3.2 Running Specific PHA programs

6.3.3 Overview of TIP OFF-LINE system

6.3.4 Running Specific TIP programs

6.3.5 Examples of PHA and TIP analysis output

6.3.1 Overview of OFF-LINE system

The OFF-LINE data analysis system is meant to be a flexible, interactive system for general use. These are the programs most users will use to determine source spectra and variability.

The software for the OFF-LINE analysis of the REV1 MPC data is currently being developed. Most of these programs will be modifications of the REVO programs, and will appear very similar. The main difference from the REVO programs will be in the background calculations. In addition, there will be a set of programs to access the MPC.DAT, DATA.BASE and test for source existence, measure variability, and perhaps estimate crude spectra.

The -.DAT files, together with the summary MPC.DAT.BASE file, constitute the reprocessed MPC database and should fit on a single 200 Mbyte disk pack. Since this disk will not be made until after December 1984, users must currently load -.DAT files from tape. Each tape file contains HUTs in a 10,000 HUT interval. It is the -.DAT files which will be accessed and unpacked for data from a given source (or region) and for specified time intervals. Background and its statistical uncertainty for each PHA channel is derived from the correlation table closest in time to the observation (approximately 40 of these tables will be derived for the entire mission). The program which unpacks the data and predicts the background is UNPACK. The selected data and predicted background is then read by MSPEC which does the spectral fitting. Routines which will be developed by June 1984 include PSDPLOT, which will plot the selected background subtracted data in various energy channels and MVARY which will search for source variability. The program MFLOT is also being developed.
and it will allow the raw count rates to be plotted in 2.56 sec intervals. Detailed explanations of these programs follow. The numbers in brackets [#] must be typed at the console; numbers in curly brackets {[#]} are optional.

6.3.2 Running specific FGA analysis programs

***** MBASE *****

This program allows one to extract the MPC.DATABASE record for a given hut from the data base. If a hut has not been reprocessed there will be no record of it in the data base. Since the total counts and predicted background are included in the data base, this program can be used as a fast check for source existence. An example of the output follows.

Input files needed: MPC.DATABASE
Output files: MPC[hut#].LIS
Parameter files needed: MBASE.PF

**********To run MBASE type

MBASE [hut#]

where

[hut#] is the 7 digit hut number.

and then type or print the listing file generated, see the example below

(MPC268125.LIS): Hut #268125. of Seq #1518
RA, Dec, Roll = 262.24 -24.71 -93.22
Start Year, Day, Sec = 1979 78 80874.469
Stop Day, Sec = 78 83454.949
Start major, minor frames = 268125. 0.
Number of major frames = 64

Source expected in FOV, Production run with BKGND/N
For contemporaneous background data, use MAPCORE.BIN. 6 kill flag was -1

Time (sec) = 2170.38 Bkgnd/sec = 16.6

<table>
<thead>
<tr>
<th>Chans</th>
<th>1-2</th>
<th>3-5</th>
<th>6-8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total counts</td>
<td>9190</td>
<td>80105</td>
<td>63173</td>
</tr>
<tr>
<td>Bkgnd counts</td>
<td>3321</td>
<td>11549</td>
<td>21231</td>
</tr>
<tr>
<td>Counts/sec</td>
<td>2.703</td>
<td>31.580</td>
<td>19.320</td>
</tr>
</tbody>
</table>
The UNPACK program reads the -----DAT files and the most current MAPCOR.BIN.# in order to determine the total number of source and background counts for a given hut. It writes these numbers (as well as the variance in the predicted background) into the MPC[HUT#].PF file which is used by NSPEC to do the spectral fits. The -----PSD file which UNPACK creates contains the time ordered counts and background and is analogous to the REVO -----SPD file. UNPACK also makes the MPC[HUT#].HDR file which contains only those numbers which are needed by EDBH to create the MPC[HUT#].ASP file (similar to the REVO ASP[HUT#].MAG).

Input files: MPC[HUT#].DAT, MPC.DATA.BASE, MAPCOR.BIN.#
Output files: MPC[HUT#].PF, MPC[HUT#].PSD, MPC[HUT#].HDR, UNPACK.LIS
Parameter file: UNPACK.PF

* * * * * To Run UNPACK type:

TY UNPACK.HELP to get a short summary. and then type

UNPACK [hut#] [climit] [BMUF*EMUF] [ILIST]

were

[hut#]: is the 7 digit hut#
[climit]: is the upper coincidence rate acceptance limit in cts/2.56 sec

{BMUF*EMUF} are optional beginning and ending major frame limits.

{ILIST} controls the length of the listing produced when the global /L switch is used,
0 = suppress major frame summations
1 = suppress listing of each readout
2 = suppress nothing

By default UNPACK uses the MAPCOR.BIN.# which is contemporaneous with the hut being processed. This can be overridden by setting the parameter NVERS (see UNPACK.PF). Frames with the background coincidence limit below the range of the MAPCOR.BIN.# are by default excluded, this too can be overridden by the user (see UNPACK.PF)

* * * Global switches:

/L will cause UNPACK to produce a very verbose listing file (UNPACK.LIS) which
contains the PHA, predicted BKGD, and ERRORS for each 2.56 sec block of the
data, in each of the 8 PHA channels. Listing 6.3.2/1 is a very short example of
this listing file.

**MMERG**

This program will sum together the counts, background and variances from
several huts observations. You must first run UNPACK to generate the
MPC[hut#].PF files, then MMERG will add them together and write out another
MPC---.PF file which you will use as input to MSPEC.

To use MMERG in order to fit spectra over several huts worth
of data:

Input files: MPC[hut#].PF for all huts you wish to merge
Output file: MPC[seq#].PF - Merged data
Parameter file: MMERG.PF

**** To run MMERG type

TY MMERG.HELP for a short summary, then type

MMERG [seq#] [nhuts] [hut1*hut2*hut3]....

where

[seq#]: is the number of the output .PF file

[nhuts]: is the number of input .PF files

[hut1*hut2*...]: are the hut numbers to merge

**SPECTBL1**

This is the program to produce revised spectrum tables for MSPEC from the
detector response tables (RESTBLS). There are three differences between the
output spectrum tables of SPECTBL1 and the old program SPECTBL.
1. Four separate files are created for the four spectral types
   (See the file formats section for the SPECTBL#.DAT format)
2. Each file has a header containing parameter limits of the
   grid
3. Steps in Nh and Et are logarithmic, steps in alpha are linear,
   (cutoff energy has been eliminated)

Tables are calculated for Power Law(1), exponential(2), Thermal
Bremsstrahlung(3), and Blackbody(4).

==================================

Input files: RESTBL5.DAT
Output files: SPECTBL(1,2,3,4).DAT and .LIS if desired
Parameter files: SPECTBL1.PF

**************To run SPECTBL1, first type

TY SPECTBL1.HELP

for brief instructions and then type

SPECTBL1 [IHI*ILO] [HINH*LOWNH*NUMNH] [LOWT*HIGH*NUMT]

where:

[IHI*ILO]: is the range of tables to produce
[HINH*LOWNH*NUMNH]: are the high, low, and number of Nh values to
use, Nh must be less than or equal to 16
[LOWT*HIGH*NUMT]: are the low, high and number of temperatures or
(or alphas) to use, NUMT must be less than or equal to 50.

note that this program can take from 5 minutes to 1 hour to run.

***** MSPEC *****

This is a new version of the MPC spectrum program which is to be
used OFF-LINE only. The major differences from MPCSPEC (REV0)
are as follows:

1. Counts, background, and errors are entered through a
   parameter file.
2. Separate precalculated spectrum tables for each model are
   used. Each table contains internal values which control the
parameters of the Chi square grid. See also new program SPECTBL1 for compatibility changes.

3. Cutoff energy has been eliminated in favor of actual column density.

4. More complete and accurate ISM cross sections have been implemented.

5. Logarithmic intervals in Na and KT, linear intervals in Alpha are used.

6. An option exists to run an iterative grid search for the parameters of the absolute minimum Chi square fit. It should be noted that this option is very slow and can be responsible for ~98% of the CPU time if executed.

7. Cosmetic changes to printout.

8. The variance in the predicted background rate is now included.

Power law, exponential, thermal bremsstrahlung or black body spectra are fitted to data. The range of data to be fit (major frame limits) and/or spectral parameters (range of spectral index and/or low energy cutoff) are not controlled by MSPEC. To change these UNPACK and SPECTBL1 must be used. Fluxes in absolute units (from crab calib.) are given.

Spectral analysis of merged MPC data may also be conducted by first running the MMERG (not yet available) program (see separate description) and then MSPEC with the appropriate switches (see below).

To use the MSPEC program to analyze spectral data for a given HUT:

Input files: MSPECTBL1, MSPECTBL2, MSPECTBL3, MSPECTBL4, RESTBLS, MPC[HUT#].PF

Output files: MSPEC[HUT#].LS MSPEC[HUT#].RAD

The listing file (.LS) gives results of MSPEC processing. See listing 6.3.2/2 for an example of this listing.

Parameter files used: MPCSPEC.PF

** ** To execute the MSPEC macro, type command line:

TY MSPEC HELP

which types out (on the screen) abbreviated instructions and then types:

MSPEC [HUT#] [N0*NHI] [MODE]

where:
[HUT#] is the 7-digit major frame or sequence identification of the data set

[N0*NHI] are the first through last PHA channels to be fit
\[
F(E) = \text{CNORM} \cdot (E^\alpha) \cdot \exp(-\tau (\text{NH}, E)) \quad \text{KEV}/(\text{CM}^2 \cdot \text{SEC} \cdot \text{KEV})
\]

**MINIMUM CHISQUARE = 31.19 FOR NH = 1.44E+23, ALPHA = 2.7E, AND CNORM = 5.82E-01 KEV/(CM2-SEC-KEV)**

<table>
<thead>
<tr>
<th>LOG COLUMN DENSITY (CM-2)</th>
<th>22.68</th>
<th>22.88</th>
<th>23.08</th>
<th>23.28</th>
<th>23.48</th>
<th>23.68</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALPHA / 0.500 / 409.9</td>
<td>8.6</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>0.400 / 471.0</td>
<td>409.3</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>0.300 / 494.4</td>
<td>309.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>0.200 / 252.6</td>
<td>434.5</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>0.100 / 236.3</td>
<td>366.2</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>0.000 / 242.1</td>
<td>266.7</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>0.200 / 252.9</td>
<td>135.6</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>0.100 / 349.3</td>
<td>91.6</td>
<td>484.5</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>0.300 / 434.1</td>
<td>73.1</td>
<td>296.5</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>0.400 / 67.8</td>
<td>298.3</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>0.500 / 89.2</td>
<td>139.2</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>0.600 / 146.7</td>
<td>88.5</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>0.700 / 205.7</td>
<td>55.1</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>0.800 / 277.6</td>
<td>37.0</td>
<td>437.8</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>0.900 / 368.1</td>
<td>35.5</td>
<td>367.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>1.000 / 456.0</td>
<td>46.7</td>
<td>308.8</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>1.100 / 58.8</td>
<td>70.1</td>
<td>260.3</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>1.200 / 84.4</td>
<td>223.2</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>1.300 / 148.3</td>
<td>195.8</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>1.400 / 260.6</td>
<td>177.7</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>1.500 / 258.1</td>
<td>168.6</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>1.600 / 325.8</td>
<td>165.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>1.700 / 396.6</td>
<td>171.2</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>1.800 / 471.6</td>
<td>182.8</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>1.900 / 290.3</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>2.000 / 223.2</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>2.100 / 254.9</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>2.200 / 282.9</td>
<td>495.6</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>2.300 / 318.9</td>
<td>499.1</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>2.400 / 356.1</td>
<td>456.7</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>2.500 / 400.6</td>
<td>486.1</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>2.600 / 445.8</td>
<td>492.9</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>2.700 / 493.4</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>CHANNEL #</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>-----------</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>USED IN FIT (*)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OBSERVED COUNTS</td>
<td>8268</td>
<td>16827</td>
<td>53281</td>
<td>128538</td>
<td>291838</td>
<td>154925</td>
</tr>
<tr>
<td>DERIVED BACKGROUND</td>
<td>5822</td>
<td>9187</td>
<td>12685</td>
<td>17095</td>
<td>22539</td>
<td>28721</td>
</tr>
<tr>
<td>SIGMA DEVIATION</td>
<td>0.241</td>
<td>0.607</td>
<td>4.445</td>
<td>12.519</td>
<td>19.690</td>
<td>12.805</td>
</tr>
<tr>
<td>FIT PHOTONS/(CM2-SEC-KEV)</td>
<td>8.115E-08</td>
<td>2.739E-04</td>
<td>8.457E-03</td>
<td>2.912E-02</td>
<td>1.919E-02</td>
<td>1.125E-02</td>
</tr>
<tr>
<td>PHA CENTERS (KEV)</td>
<td>1.39</td>
<td>1.97</td>
<td>2.89</td>
<td>4.16</td>
<td>5.98</td>
<td>8.46</td>
</tr>
<tr>
<td>PHA BOUNDS (KEV)</td>
<td>1.19</td>
<td>1.63</td>
<td>2.38</td>
<td>3.53</td>
<td>4.94</td>
<td>7.95</td>
</tr>
</tbody>
</table>
if equal to 1, a grid search (item #6 above) is run

***** MSPEC PLOT *****

This program will be analogous to the REVO program SPEC PLOT but is not yet available. It will produce spectral plots of MPC data as analyzed by the MSPEC program. The best fit spectrum for each of the 4 spectral models fit (see MSPEC writeup) can be plotted as either an energy spectrum (keV/cm$^2$ s$^{-1}$ keV$^{-1}$), photon spectrum (photons/cm$^2$ s keV$^{-1}$), or CGS energy spectrum (ergs/cm$^2$ s Hz$^{-1}$). The best-fit model points are plotted as well as the observed flux, and 1 sigma errors (statistical only), at each of the 8 PHA channel energies. See figure 6.3.2/1 for an example of SPEC PLOT output.

To use MSPEC PLOT to plot MPC data for given [HUT]:

Input files needed: MPC[HUT].FAD produced by MSPEC program
Output files produced: SPEC[HUT].PLT
Parameter file used: SPEC PLOT.PF

* * * * To execute the SPEC PLOT macro, type command line:

TY SPEC PLOT, HELP

which types out (on the screen) abbreviated instructions and then type:

SPEC PLOT [HUT] [SRCNAM] [SPECTYPE] [MODEL] [OFFSET]

where:

[HUT] is the 7-digit major frame identification number of the data set

[SRCNAM] is the desired name of the source to appear on plot

[SPECTYPE] = 0 for energy spectrum vs. = 1 for photon spectrum plot
     = 2 for CGS energy spectrum

[MODEL] is the spectral model number (1-4) to plot (see MSPEC writeup)

[OFFSET] is the offset in degrees between the source position and the center of the MPC field of view; used to correct flux

Default arguments are such that if you type simply
POWER LAW FIT:

\[ \text{ALPHA} = 0.75 \]
\[ \text{NH} = 1.44E+23 \text{ CM}^{-2} \]
\[ \text{CNORM} = 5.82E-01 \]
**SPECLOT** [HUT] [SRCNAN]

You will get an energy spectrum plot for model 1 (power law fit) and the source is assumed to be on-axis (OFFSET = 0, 0).

***** MVARY *****

The MVARY program (not yet available) will be analogous to the MPCVARY(REVO) program. It will analyze the spectral data (PHA data) from the MPC, (which is binned in 2.56 sec integration time bins for each of the 8 spectral channels), for the presence of time variability. Analysis for both overall variability in the form of a departure from the fluctuations expected for Poisson variations of an otherwise constant source and for individual bursts is conducted. A search for periodic variations is performed by folding (into 10 bins) the total data segment into all statistically independent periods and doing a Chi-square test of the resulting light curves against a straight line. A significant period will stand out as a large Chi-square value; the largest such value is printed out at the end of the Chi-square vs. Period list, and the light curve of this most significant period is given in the form of a printer plot.

To use the MVARY program to conduct time variability analysis of a given HUT of MPC spectral data:

**Input files needed:**

MPC(HUT).PSD  
This is produced by the UNPACK program

MPC(HUT).FAD  
This is also produced (in part) by MSPEC  
The first record (called "SPECRES" for spectral program results) of this second block of this file is used by MPCVARY.

**Output files produced:**

MPC(HUT).FAD  
An additional record (called "VARYRES" for MPCVARY program results) is written into the second block of this file (immediately following the SPECRES record)  
MVARY.LIS - see listing 6.3.2/3

**Parameter file used:**

MSPEC.PF

* * * * To execute MVARY, type the command line:

TY MVARY HELP which will type out (on screen) abbreviated
MPCVARY OUTPUT

MPV VARIABILITY ANALYSIS OF 2.56 SEC PHA DATA RUN AT 15:37:28 06/26/80
ANALYSIS USES MPC0132377.FAD FILE -.5PD AND SPECTRES FILES; DATA FROM OBS. SEQUENCE NO. 3398 AND INTERVAL NO. 1

DATA ACCEPTED BY MPCSPEC BEGINS ON DAY 379 AT SECOND 50236.320 IN MAJOR FRAME 132378.
INTEGRATION TIME IS 578.6 SEC WITH (TOTAL) AVG. CTS/2.56 SEC = 714.79/- 25.74 IN PHA CHANNELS 1 TO 8

SEARCH FOR BURSTS GT. 5.0 SIGMA

Many "bursts" appear since this is the pulsar Cen X-3 and the 4.8 sec period is nearly twice the 2.56 sample time

DATA ACCEPTED FOR VARIABILITY ANALYSIS BEGINS ON DAY 379 AT SECOND 50236.320 IN MAJOR FRAME 132378.

POSSIBLE BURST ( 626.0 655.0 ) 5.2 SIGMA AT SECOND 50241.44 IN MAJ. FM. 132378, WITH COUNTS PER 2.56 SEC 860.0 687.0 1119.0 615.0 1056.0 498.0 974.0 482.0 743.0 693.0 687.8

POSSIBLE BURST ( 701.8 687.0 ) 6.8 SIGMA AT SECOND 50298.08 IN MAJ. FM. 132379, WITH COUNTS PER 2.56 SEC 600.0 757.0 400.0 629.0 505.0 1200.0 528.0 817.0 574.0 1048.0 748.0

POSSIBLE BURST ( 809.0 806.0 ) 5.2 SIGMA AT SECOND 50333.60 IN MAJ. FM. 132380, WITH COUNTS PER 2.56 SEC 563.0 568.0 969.0 526.0 1180.0 618.0 834.0 379.0 765.0 557.0 781.0

POSSIBLE BURST ( 799.0 746.0 ) 6.6 SIGMA AT SECOND 50366.88 IN MAJ. FM. 132381, WITH COUNTS PER 2.56 SEC 603.0 733.0 427.0 671.0 522.0 918.0 503.0 1209.0 631.0 1052.0 633.0

POSSIBLE BURST ( 878.0 736.0 ) 5.8 SIGMA AT SECOND 50402.72 IN MAJ. FM. 132382, WITH COUNTS PER 2.56 SEC 689.0 756.0 919.0 601.0 930.0 415.0 1080.0 422.0 1228.0 568.0 1124.0

POSSIBLE BURST ( 576.0 693.0 ) 6.7 SIGMA AT SECOND 50482.24 IN MAJ. FM. 132383, WITH COUNTS PER 2.56 SEC 663.0 706.0 514.0 355.0 976.0 890.0 969.0 556.0 1087.0 428.0 798.0 479.0

POSSIBLE BURST ( 685.0 539.0 ) 5.4 SIGMA AT SECOND 50489.76 IN MAJ. FM. 132384, WITH COUNTS PER 2.56 SEC 593.0 526.0 952.0 597.0 806.0 542.0 860.0 533.0 812.0 488.0 978.0

POSSIBLE BURST ( 129.0 129.0 ) 12.9 SIGMA AT SECOND 50528.16 IN MAJ. FM. 132385, WITH COUNTS PER 2.56 SEC 607.0 840.0 981.0 929.0 613.0 968.0 513.0 1129.0 438.0 1044.0 564.0

POSSIBLE BURST ( 1028.0 715.0 ) 11.4 SIGMA AT SECOND 50566.56 IN MAJ. FM. 132386, WITH COUNTS PER 2.56 SEC 985.0 735.0 634.0 631.0 809.0 610.0 854.0 606.0 780.0 482.0 872.0 401.0 1167.0

POSSIBLE BURST ( 503.0 1175.0 ) 17.2 SIGMA AT SECOND 50610.00 IN MAJ. FM. 132387, WITH COUNTS PER 2.56 SEC 494.0 712.0 897.0 914.0 670.0 958.0 636.0 1271.0 604.0 930.0 321.0

POSSIBLE BURST ( 723.0 407.0 ) 7.0 SIGMA AT SECOND 50648.48 IN MAJ. FM. 132388, WITH COUNTS PER 2.56 SEC 649.0 403.0 855.0 653.0 947.0 795.0 619.0 756.0 515.0 988.0 443.0 923.0 400.0 1181.0

POSSIBLE BURST ( 110.0 1610.0 ) 11.0 SIGMA AT SECOND 50692.00 IN MAJ. FM. 132389, WITH COUNTS PER 2.56 SEC 406.0 794.0 320.0 922.0 500.0 785.0 620.0 771.0 862.0 580.0 708.0 454.0 695.0 412.0
<table>
<thead>
<tr>
<th>PERIOD</th>
<th>5.120</th>
<th>5.140</th>
<th>5.160</th>
<th>5.180</th>
<th>5.200</th>
<th>5.222</th>
<th>5.242</th>
<th>5.263</th>
<th>5.284</th>
<th>5.305</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHISQR</td>
<td>17.18</td>
<td>123.40</td>
<td>28.29</td>
<td>663.30</td>
<td>38.31</td>
<td>25.27</td>
<td>38.28</td>
<td>38.27</td>
<td>29.26</td>
<td>5.305</td>
</tr>
<tr>
<td>PERIOD</td>
<td>5.327</td>
<td>5.349</td>
<td>5.371</td>
<td>5.393</td>
<td>5.415</td>
<td>5.437</td>
<td>5.460</td>
<td>5.483</td>
<td>5.506</td>
<td>5.530</td>
</tr>
<tr>
<td>CHISQR</td>
<td>25.02</td>
<td>51.13</td>
<td>58.43</td>
<td>7.15</td>
<td>328.71</td>
<td>1186.40</td>
<td>798.80</td>
<td>100.34</td>
<td>38.34</td>
<td>41.93</td>
</tr>
<tr>
<td>PERIOD</td>
<td>5.522</td>
<td>5.576</td>
<td>5.623</td>
<td>5.672</td>
<td>5.721</td>
<td>5.771</td>
<td>5.827</td>
<td>5.954</td>
<td>6.006</td>
<td>6.036</td>
</tr>
<tr>
<td>CHISQR</td>
<td>44.36</td>
<td>28.19</td>
<td>16.75</td>
<td>19.42</td>
<td>28.48</td>
<td>33.82</td>
<td>24.38</td>
<td>18.89</td>
<td>31.54</td>
<td>18.06</td>
</tr>
<tr>
<td>CHISQR</td>
<td>20.36</td>
<td>7.95</td>
<td>31.16</td>
<td>22.10</td>
<td>38.01</td>
<td>17.81</td>
<td>10.65</td>
<td>26.50</td>
<td>22.64</td>
<td>6.75</td>
</tr>
<tr>
<td>CHISQR</td>
<td>36.81</td>
<td>21.00</td>
<td>28.39</td>
<td>15.05</td>
<td>27.92</td>
<td>19.90</td>
<td>14.88</td>
<td>6.53</td>
<td>10.66</td>
<td>10.68</td>
</tr>
<tr>
<td>CHISQR</td>
<td>36.81</td>
<td>14.27</td>
<td>23.06</td>
<td>16.79</td>
<td>19.17</td>
<td>13.34</td>
<td>34.88</td>
<td>19.83</td>
<td>503.66</td>
<td>58.42</td>
</tr>
<tr>
<td>PERIOD</td>
<td>7.035</td>
<td>7.073</td>
<td>7.111</td>
<td>7.149</td>
<td>7.188</td>
<td>7.228</td>
<td>7.268</td>
<td>7.398</td>
<td>7.439</td>
<td>7.398</td>
</tr>
<tr>
<td>CHISQR</td>
<td>13.75</td>
<td>12.48</td>
<td>14.28</td>
<td>18.70</td>
<td>13.85</td>
<td>19.25</td>
<td>32.11</td>
<td>26.04</td>
<td>58.77</td>
<td>23.43</td>
</tr>
<tr>
<td>CHISQR</td>
<td>7.02</td>
<td>3.39</td>
<td>10.89</td>
<td>12.75</td>
<td>9.48</td>
<td>47.07</td>
<td>26.88</td>
<td>26.54</td>
<td>8.91</td>
<td>19.18</td>
</tr>
<tr>
<td>CHISQR</td>
<td>7.32</td>
<td>5.03</td>
<td>8.34</td>
<td>52.68</td>
<td>27.69</td>
<td>11.94</td>
<td>11.86</td>
<td>26.08</td>
<td>40.32</td>
<td></td>
</tr>
<tr>
<td>CHISQR</td>
<td>82.14</td>
<td>15.88</td>
<td>41.14</td>
<td>19.92</td>
<td>5.67</td>
<td>28.36</td>
<td>696.77</td>
<td>28.88</td>
<td>6.56</td>
<td>21.86</td>
</tr>
<tr>
<td>CHISQR</td>
<td>41.71</td>
<td>15.74</td>
<td>12.07</td>
<td>10.78</td>
<td>29.39</td>
<td>19.76</td>
<td>27.75</td>
<td>9.76</td>
<td>30.03</td>
<td>35.97</td>
</tr>
</tbody>
</table>

Approximately twice the known 4.83 sec period of Cen X-3
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CHISQR</td>
<td>11.71</td>
<td>40.31</td>
<td>31.39</td>
<td>8.99</td>
<td>21.33</td>
<td>30.39</td>
<td>66.86</td>
<td>313.36</td>
<td>43.87</td>
<td>19.86</td>
</tr>
<tr>
<td>CHISQR</td>
<td>5.23</td>
<td>41.71</td>
<td>22.48</td>
<td>12.93</td>
<td>43.64</td>
<td>66.45</td>
<td>26.51</td>
<td>16.22</td>
<td>26.05</td>
<td>18.28</td>
</tr>
<tr>
<td>CHISQR</td>
<td>25.77</td>
<td>7.39</td>
<td>22.75</td>
<td>4.55</td>
<td>42.07</td>
<td>63.09</td>
<td>26.83</td>
<td>14.30</td>
<td>18.72</td>
<td>08.75</td>
</tr>
<tr>
<td>CHISQR</td>
<td>35.86</td>
<td>19.31</td>
<td>37.76</td>
<td>10.48</td>
<td>27.76</td>
<td>22.87</td>
<td>17.74</td>
<td>792.46</td>
<td>29.11</td>
<td>14.93</td>
</tr>
<tr>
<td>CHISQR</td>
<td>16.99</td>
<td>34.21</td>
<td>22.85</td>
<td>7.50</td>
<td>12.92</td>
<td>10.21</td>
<td>21.39</td>
<td>15.90</td>
<td>15.62</td>
<td>39.26</td>
</tr>
<tr>
<td>CHISQR</td>
<td>33.29</td>
<td>14.65</td>
<td>25.10</td>
<td>60.54</td>
<td>19.46</td>
<td>34.54</td>
<td>23.21</td>
<td>7.84</td>
<td>40.85</td>
<td>72.99</td>
</tr>
<tr>
<td>CHISQR</td>
<td>20.69</td>
<td>4.48</td>
<td>24.62</td>
<td>33.99</td>
<td>30.27</td>
<td>22.54</td>
<td>24.42</td>
<td>43.93</td>
<td>128.76</td>
<td>44.948</td>
</tr>
<tr>
<td>PERIOD</td>
<td>34.582</td>
<td>35.494</td>
<td>36.455</td>
<td>37.469</td>
<td>39.548</td>
<td>39.673</td>
<td>40.974</td>
<td>42.149</td>
<td>43.584</td>
<td>44.948</td>
</tr>
<tr>
<td>CHISQR</td>
<td>30.82</td>
<td>14.92</td>
<td>23.44</td>
<td>22.56</td>
<td>46.41</td>
<td>21.21</td>
<td>16.36</td>
<td>7.49</td>
<td>167.95</td>
<td>21.50</td>
</tr>
<tr>
<td>PERIOD</td>
<td>46.430</td>
<td>48.139</td>
<td>49.987</td>
<td>51.687</td>
<td>53.054</td>
<td>55.067</td>
<td>59.466</td>
<td>61.073</td>
<td>63.919</td>
<td>67.836</td>
</tr>
<tr>
<td>CHISQR</td>
<td>12.74</td>
<td>28.07</td>
<td>39.51</td>
<td>9.87</td>
<td>38.65</td>
<td>25.55</td>
<td>32.66</td>
<td>22.85</td>
<td>46.72</td>
<td>46.72</td>
</tr>
<tr>
<td>PERIOD</td>
<td>70.465</td>
<td>74.253</td>
<td>79.459</td>
<td>83.156</td>
<td>88.432</td>
<td>94.399</td>
<td>101.197</td>
<td>109.010</td>
<td>118.876</td>
<td>128.713</td>
</tr>
<tr>
<td>CHISQR</td>
<td>65.33</td>
<td>23.91</td>
<td>22.57</td>
<td>12.84</td>
<td>27.28</td>
<td>21.75</td>
<td>33.19</td>
<td>28.00</td>
<td>30.55</td>
<td>19.92</td>
</tr>
<tr>
<td>PERIOD</td>
<td>141.352</td>
<td>156.596</td>
<td>175.395</td>
<td>198.751</td>
<td>228.089</td>
<td>269.860</td>
<td>324.089</td>
<td>404.184</td>
<td>528.692</td>
<td>899.80</td>
</tr>
<tr>
<td>CHISQR</td>
<td>37.51</td>
<td>0.27</td>
<td>11.43</td>
<td>29.96</td>
<td>13.68</td>
<td>15.93</td>
<td>19.18</td>
<td>27.84</td>
<td>53.16</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Longest period < data duration

Avoid sample period (2.56 sec) beats and periods < one-quarter data duration time & search for period with max. Chisq.

Significance of 2298.4 sigma obtained for CHISQR = 1084.49 by folding at period = 5.43 sec

Approximately at 4.8 sec

Light curve at this period follows with avg. CTS/BIN = 71.44

Sample period

Linear CTS/BIN --- scale is no. sigma about avg.
**instructions and then type:**

```
MVARY [HUT] [MODE] [START*STOP MAJ. FM.] [THRESH]
[IBACK] [PLO*PHI] [NBINS] [PSEL]
```

where:

[HUT] is the 7-digit major frame identification number of the data set

and the following arguments are * * OPTIONAL * *

[MODE] = 0 for analysis of all low-bkgd. data passed by UNPACK
   = 1 for analysis of data between major frame limits

[START*STOP MAJ. FM.] are the major frame limits to analyze if
   MODE = 1

[THRESH] is the no. of sigma threshold for identifying a burst

[IBACK] = 0 for no background subtraction (normal case)
   = 1 for background subtraction in each of the PHA channels used

[PLO*PHI] are the low, high PHA channel nos. to consider

   (default values are 1,8). Enter as integers, e.g. 2*6

[NBINS] are the number (<100) of bins used in the folding
   analysis for pulsations (default value is 10).

[PSEL] = 0 for a period search only
   = 1 for a period search _then_ option to fold
   at as many selected periods as desired. Periods
   are asked for while running; exit with -1.

Default arguments are such that if you type simply

```
MVARY [HUT]
```

you will get the time variability analysis of all the 8 PHA channels (summed)
without background subtraction. Bursts will be identified if the count rate in
any single 2.56 sec block exceeds 5 sigma above the mean for the entire HUT.
Folding will be done in 10-bin light curves.

***** MPLOT *****

This program is analogous to the REVO program MPCPLT. It produces the
count rate plots of MPC data which are usually found at the back of the REVO
printout for a given data set. This plot shows the total count rate (cts/2.56
sec) for the sum of the 8 PHA channels (top plot), followed by 4 plots of
different measures of the MPC background (fig 6.3.2/2). The "Coincidence" plot
MPG TOTAE COUNTS & PHA SUMS FOR FILE MPC013237

Total Events (PHA Chans. 1-8)

PHA data plot (run with Plot Mode = 2)

PHA Chans. 1 & 2 (1.10 - 2.24 KeV)

PHA Chans. 3 & 4 (2.24 - 4.63 KeV)

PHA Chans. 5 & 6 (4.63 - 9.65 KeV)

PHA Chans. 7 & 8 (9.65 - 21.0 KeV)

Number 3 Min. FM. Blocks after Major Frame 1.32378
shows the background rate which is normally used by the UNPACK program to
predict the background in each of the 8 spectral channels, which is then
subtracted from the total rate actually observed before fits to the spectral
shape are done.

The MPLOT program may also be used to give plots of the X-ray data alone
in either groups of 2 PHA channels (channels 1+2, 3+4, 5+6, and 7+8) or in the 8
channels individually (fig 6.3.2/3). These options thus enable spectral "light
curves" to be plotted for a given HUT. Note that these plots are still only
total counts (actually detected) and are not background subtracted. The time
base (2.56 sec/bin) is also fixed for these plots. A separate plot program
(PSDPLT---see writeup) must be used for generalized "light curve"
(background-subtracted) plots.

To use MPLOT to plot MPC data for given [HUT]:

Input files needed:  MPC[HUT].PPR
                     MPC[HUT].HDR
Output files produced: MPC[HUT].ELT
Parameter file used:   MPLOT.PP

* * * To execute the MPLOT macro, type command line:

TY MPLOT,HELP which types out (on the screen) abbreviated
instructions and then type:

MPLOT [HUT] [PLOT.MODE] [CONTROL.MODE] [START*STOP MAJ. FM.]

where:

[HUT]    is the 7-digit major frame identification number
          of the data set

[PLOT.MODE] = 1 for total PHA and 4 bkgrd. plots (normal plot)
              = 2 for PHA sums by pairs
              = 3 for PHA channels 1-5 (only)
              = 4 for PHA channels 6-8 and bkgrd. rates PSDI,
                  PSDT

[CONTROL.MODE] = 0 for all data in HUT
                  = 1 for data between specific major frame limits

[START*STOP MAJ. FM.] are the start and stop major frames to plot.
Note that this 4th argument is only needed if
Control.Mode=1. Enter this argument as 2 double
precision numbers separated by a *---e.g.1234567.D0*1234569.D0

Default arguments are such that if you type simply

MPLOT [HUT]
MPC PHA AND BKGN. DATA FOR FILE MPC0132377

TOTAL EVENTS (PHA CHANS. 1-8)

PSDI EVENTS (PHA CHANS. 4-6 REJECTS)

PSDT EVENTS (PHA CHANS. 1-3 REJECTS)

COINCIDENCE EVENTS

OVER SCALE EVENTS (PHA GT. 8)

COUNTS PER 8 MN. FM. (2.56 S) BLOCK

NO. 8 MN. FM. BLOCKS AFTER MAJOR FRAME 1323780
you will get the normal production plot (PHA sum and 4 hkgnd. rates) for the entire HUT.


****** PSDPLOT ******

This program is analogous to the REVO SPDPLT program. It produces count rate plots of MPC data which are background-subtracted (fig 6.3.2/4). That is, these plots represent the 'light curve' of the X-ray flux detected by the MPC. Background is derived in the UNPACK program (see writeup) by analysis of the correlation between the anticoincidence rate and rates detected in each of the 8 PHA channels. Thus the PSDPLOT program can only be run after the UNPACK program has been run. The UNPACK program also produces the MPC[HUT].PSD (for Pha Save Data) file which is the file actually plotted by PSDPLOT.

The PSDPLOT program may also be used to give plots of the X-ray flux in all 8 spectral channels summed, or in any contiguous grouping of the spectral channels (e.g. PHA channels 3–5, which are approximately 2–6 KeV and count at nearly the same rate as Uhuru). Other options include: choice of major frame limits, plots of up to 5 HUTS on the same sequential plot, choice of no. of bins (of 2.56 sec integrations) to sum for each bin plotted, and choice of both horizontal (length) scale and vertical count rate (max.) scale. A plot of the difference between the background and the average background for all the data accepted is also given. This is useful for comparison with variations in apparent flux, particularly for weak sources.

=================================================================

To use PSDPLOT to plot MPC data for given [HUT]:

Input files needed: MPC[HUT].PSD—both these files are needed for MPC[HUT].HDR each HUT to be plotted

Output files produced: PSD[HUT].PLT

Parameter file used: PSDPLOT.PF

* * * To execute the PSDPLOT macro, type command line:

TY PSDPLOT.HELP which types out (on the screen) abbreviated instructions and then type:

PSDPLOT [HUT] [NHUTS] [NBINS] [[HUT2] ... [HUT5]]

where:

[HUT] is the 7-digit major frame identification number of the (first) data set to be plotted.

[NHUTS] is the number of HUTS to plot (sequentially)

- 16 -
MPC0132377.SPD - MPC0132377

SEQ NO: 3590  PHA CHANNELS 1 - 8

START-MJF  1.32378000D-05
STOP-MJF  1.32392000D-05

Variation (about average) in predicted background

Source count rate (background subtracted) in 5.12 sec bins

START-TIME:  5.023632012700D-04  SEC.  ON DAY
P6.3.3

[NBINS] is the no. of 1.56 sec PHA integrations to sum per plotted bin

[[HUT2]. . .[HUT5]] are the 7-digit major frame numbers for the 2nd through 5th data sets, if these are to be plotted. NOTE the arguments HUT2—HUT5 may simply be omitted if they are not to be plotted.

To run the PSDPLOT program and be able to vary all the options, type

PSDPLOT/M [HUT] [NHUTS] [NBINS] [PLOHI] [XLEN] [YMAX] [MODE] and
[START*STOP MAJ. FM.] [[HUT2]. . .[HUT5]]

where the additional arguments are:

[MODE] = 0 for all data and auto-scaling on cts/sec axis
       = 1 for data (IN SINGLE HUT) between maj. fm. limits

[PLOHI] is the range of PHA channels used (e.g. 1*8)

[XLEN] is the plot length (X-axis) in inches

[YMAX] is the max. count rate plotted (used for MODE = 1 only)

[START*STOP MAJ. FM.] are the start and stop major frames to plot.

Note that this 4th argument is only needed if Control.Mode=1. Enter this argument as 2 double precision numbers separated by a *,—e.g.1234567.0 12345690.0.

Default arguments are such that if you type simply

PSDPLOT [HUT] [NHUTS] [NBINS] ([HUT2]. . .[HUT5])

you will get the light curve plotted for all data accepted in the HUT (or {list of up to 5 HUTS}) given with 4 PHA integrations/plot bin (e.g. 10.24 sec/plot bin) and a vertical count rate scale chosen to have a maximum of approximately 4 times the value of the maximum rate encountered in the data accepted. The length of the plot will be 20 inches.

6.3.3 Overview of the TIP analysis programs

The original (REVO) TIP processing system remains unchanged and there are currently no plans to revise it. Because the REVI and REVO systems generate different files with different formats it is necessary to run the REVO system to do the TIP analysis. This requires getting the raw data (---.FRD files) off
the production tapes. Scientists should fill out a data request form specifying MPC ONLY and one of the data aides will load the required files. Then run the macro MPCPROC (described below) with the global /TIP switch to process the data with the REVO system and run the TIP pre-processors and barycenter correction programs. The TIP analysis programs (TIPANAL, 1, 2, 3, 4 and 5) can then be run as described below.

6.3.4 Running specific TIP programs

The MPCPROC macro

MPCPROC.CLI is the macro used for all MPC special processing requests. It should be requested with a special processing form by circling "MPC Only". The following includes the help file MPCPROC.HELP, as well as a flowchart (fig. 6.3.4/1) showing the various programs and files generated. The default pathways are indicated by solid lines. Dotted lines are options which are called with global switches. Some hints which are not apparent from the flowchart are:

1) The MPCSPEC program also requires ASP[HUT#].MAG as input. Therefore, the /NA switch is rarely useful. An exception would be if MPCPPR were run twice for some reason. Then, /NA could be used to save time the second time.

2) MPCPLT takes a long time to generate the quicklock plot. These are generally available in the old printouts in the data room. Therefore, the /NPLT switch can be used to save a considerable fraction of the processing time.

All special processing requests will be run in the default mode

MPCPROC Instrument hut

unless global switches are specified. For the TIP processing, it is necessary to specify

MPCPROC/TIP Instrument hut

Output files will be placed on tape, with one hut per tape file. If you also want printouts, you should request

MPRINT hut

to be run on each hut. These macros are accessed via:

USEA HEAOB:MPC

***** MPCPROC.HELP *****

Purpose: This is the main MPC special processing macro in :UDD:HEAOB:MPC

Execution:
MPCPROC instrument hut

instrument: IPC, HRI, SSS, or FPCS
hut: 7 digit hut number

Required input:

MPA[hut].PRD or MPB[hut].PRD

global switches:
/NA - does not generate PGC and ASP files
/NPLT - does not run MPCPLT (quicklook plot) program
/NS - does not rerun MPCSPEC (spectrum) program
/PFR - in equivalent to /NPLT/NS
/TIP - runs TIP pre-processor and Barycentric correction programs

Output files:

MPRINT hut

****** TCORR program ******

This is the TIP analysis program for generating the barycentric correction to photon arrival times. The barycentric corrections are generated for the time corresponding to the start of each major frame of the data set. The output file, TIM[HUT].COR, contains a short identifying header and then the list of major frame no., barycentric correction (sec.). Both are double precision numbers, and the correction times are in the sense that they should be ADDED to the raw photon times for the true photon times as they would be measured at the solar system barycenter. The calculation for the position of the solar system barycenter includes the effects of Jupiter and Saturn as well as the sun. The TCORR program is designed to be run for each data set before beginning TIP analysis for that data set. However it is generally NOT necessary to apply barycentric corrections before doing TIP analysis unless one is searching for very fast periodicities (<0.5 sec, say) or is comparing photon arrival times over a long time interval.

To use the TCORR program for a given HUT:

Input files: MPC[HUT].HDR — 'header' for MPC data
            MPC[HUT].PFR — primary MPC data file

Output files: TIM[HUT].COR — barycentric corrections for each maj. fm.
Parameter files:
- HEAOB.PF
- MPCSPEC.PF

* * * * To execute the TCOHR program, type the command line

TCORR [HUT]

where:
\[ \text{[HUT]} \]

is the 7-digit major frame identification number of the data set

The output file, TIM[HUT].COR, containing the barycentric corrections for each major frame can be examined with the program TIMCORRD. To do this, type

TIMCORRD [HUT]

and the output file TCOR[HUT].LS will be printed out containing the observation title, pointing direction and list of major frame number, barycentric correction times for each frame in the HUT.

****** TIPCOR Program ******

This is the TIP analysis program for applying the barycentric correction to photon arrival times. The barycentric corrections must have first been calculated by running the TCOHR program (see writeup). It is generally not necessary to apply barycentric corrections before doing TIP analysis unless one is searching for very fast periodicities (<0.5 sec, say) or is comparing photon arrival times over a long time interval.

To use the TIPCOR program for a given HUT:

Input files:
- MPC[HUT].TIPSUB --- 'header' for TIP data
- MPC[HUT].TIMES --- photon arrival times
- TIM[HUT].COR --- barycentric corrections from TCOHR

Output files:
- MPC[HUT].TIPSUB.COR --- corrected header file
- MPC[HUT].TIMES.COR --- corrected photon times
- TIPCOR[HUT].LS --- optional output listing file

Parameter file: TIPCOR.PF
To execute the TIPCOR program, type the command line

TY TIPCOR.HELP which types out (on the screen) abbreviated instructions and then type

TIPCOR [HUT] [TIMES] [TIPSUB] [CTIMES] [CTIPSUB]

where:

[HUT] is the 7-digit major frame identification number of the data set

[TIMES] is the name of the 'TIMES' file used

[TIPSUB] is the name of the 'TIPSUB' file

[CTIMES] is the name of the corrected 'TIMES' file

[CTIPSUB] is the name of the corrected 'TIPSUB' file

Default arguments are such that if you type simply

TIPCOR [HUT]

the input files are assumed to be named MPC[HUT].TIPSUB and MPC[HUT].TIMES and the corrected output files will be named MPC[HUT].TIPSUB.COR and MPC[HUT].TIMES.COR.

***** TIPANAL Program *****

This is the primary analysis program for the TIP (Time Interval Processor) data from the MPC. It calculates the general variability characteristics of the X-ray source observed over all time-scales possible for the given data set. The variance of the source count rate is calculated for individual segments of the data, where the segment length is calculated as successive powers of two times a minimum segment length which is chosen to contain a minimum number of counts. A table of the number of sigma difference between these observed variances (of the source rate) and those expected for purely Poisson fluctuations of an otherwise constant source is printed out (listing 6.3.4/1).

The TIPANAL program is the most general way to examine the overall variability of a given segment of TIP data. Other TIP analysis programs are generally run afterwards and include:

TIPANAL2, which calculates the time-interval distribution of the data and can further compare this with an interval distribution created for simulated data
TIPANAL OUTPUT

NFC TIP ANALYSIS OF DATA USING HEADER FILE MFC013277.HDR AND CORRESPONDING MFC-013277.TIP FILE

DATA FROM OBSERVATION SEQUENCE NO. 3590 AND INTERVAL NO. 1 IN DATA IS 32 WORD MODE
ANALYSIS BEGINS IN MAJOR FRAME 132378. AND STOPS IN FRAME 132393.

WARNING - 2 CODE ONES IN A ROW

NUMBER OF EVENTS = 33279
INTEGRATION TIME = 144.410
COUNT RATE = 258.448

Less than data duration of 578 sec because of dead time of TIP at high count rate of 230.4 cts/sec

YOU HAVE INVOKED TIPFRT.
ENTER (THRU PARAM. FILE) THE MINIMUM NUMBER OF COUNTS PER BIN.
YOU ANSWERED 1000

RESULTS FROM THE VARIANCE ANALYSIS.
THE TIME RESOLUTION OF THE FINEST BINNING = 0.00028

CHosen so that minimum of 0.1 counts/bin is satisfied
THE AVERAGE NUMBER OF COUNTS PER BIN ON THIS SCALE WAS = 6.35E-02

TIME SCALE FOR EACH SECTION = 9.025631E-05


Integration time per bin:

<table>
<thead>
<tr>
<th>COUNTS EACH SECTION</th>
<th>2125</th>
<th>1997</th>
<th>2286</th>
<th>2110</th>
<th>2263</th>
<th>2209</th>
<th>2308</th>
<th>2389</th>
<th>2163</th>
<th>2414</th>
<th>2264</th>
<th>2186</th>
<th>1948</th>
<th>1650</th>
<th>1950</th>
<th>1621</th>
<th>1939</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count Rate</td>
<td>4.1</td>
<td>3.0</td>
<td>2.0</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
</tr>
</tbody>
</table>

TIME SCALE FOR EACH SECTION = 9.025631E-05

COUNTS EACH SECTION 4126. 4318. 4350. 4472. 4678. 4134. 3640. 3551.

<table>
<thead>
<tr>
<th>COUNTS EACH SECTION</th>
<th>4126</th>
<th>4318</th>
<th>4350</th>
<th>4472</th>
<th>4678</th>
<th>4134</th>
<th>3640</th>
<th>3551</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count Rate</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
</tbody>
</table>

TIME SCALE FOR EACH SECTION = 9.025631E-05

COUNTS EACH SECTION 8444. 8831. 8612. 7911.

<table>
<thead>
<tr>
<th>COUNTS EACH SECTION</th>
<th>8444</th>
<th>8831</th>
<th>8612</th>
<th>7911</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count Rate</td>
<td>7.1</td>
<td>7.0</td>
<td>7.0</td>
<td>6.2</td>
</tr>
</tbody>
</table>

Number of sigma departure (from Poisson statistics) of variance of total count rate on time scale (horizontal row) and in section of data (vertical column) shown

This source (Cen X-3, a 4.8 sec pulser) is highly variable on all time scales, especially ~0.5 sec. This is the time scale for rapid changes in the pulse profile.

16.3/4.1a
with the same average rate but only Poisson fluctuations.

TIPANAL3, which allows the data to be folded in a periodicity analysis at a given period in up to 100 phase bins and referenced to any absolute phase.

TIPANAL4, which allows a search for periodicity by folding the data over N independent periods starting at a given period (and progressing towards shorter periods). N can be arbitrarily large (within limits of machine time !), and the number of phase bins used in folding can be up to 16.

TIPANAL5, which calculates moments of the photon arrival time rate and gives the autocorrelation of the arrival times.

To use the TIPANAL program to initiate variability studies for a given HUT:

Input files: MPC[HUT].TIP -- primary TIP file from TIPPR
MPC[HUT].HDR -- header file from MPCPR, MPCSPEC, etc.

Output files: MPC[HUT].TIMES -- contains individual photon times
MPC[HUT].TIPSUB -- contains header info. to read the 'TIMES' file, which is broken up into continuous segments.

MPC[HUT].STD -- which is a concatenation of the 'TIMES' and 'TIPSUB' files.

MTREE[HUT].LS -- is the output listing file containing the 'tree' of variance result.

Parameter files: TIPANAL.PF -- controls primary options
TIPIN.PF -- controls "fixed" options

* * * To execute the TIPANAL program, type the command line

TY TIPANAL.HELP which types out (on the screen) abbreviated instructions and then type

TIPANAL [HUT] [ISUB] [MODE] [START STOP MAJ. FMS.]

where:

[HUT] is the 7-digit major frame identification number of the data set

[ISUB] = 0 to generate the 'TIMES' and 'TIPSUB' files from the current MPC[HUT].TIP and MPC[HUT].HDR files

= 1, to use already existing 'TIMES' and 'TIPSUB' files
[MODE]  = 0 for analysis of all data in file
       = 1 for analysis of all data, which is in fact between
       START and STOP major frames

[START*STOP MAJ WMS] are the major frame limits. Enter as 2 double
       precision numbers, e.g. 1234567.000 1234678.000

Default arguments are such that if you type simply

TIPANAL [HUT]

new 'TIMES' and 'TIPSUB' files will be created (as well as the 'STD' file) and
you will get the variance analysis on the entire data set.

*****TIPANAL2 Program *****

This is the TIP analysis program for calculating the interval distribution
of photon arrival times detected by the MPC. A comparison with simulated data
(with only Poisson fluctuations) can also be made. See the description of the
program TIPANAL for a general discussion of TIP analysis as well as file
structure.

To use the TIPANAL2 program for a given HUT, the same input, output, and
parameter files are used as for the main TIPANAL program (see writeup). Output
listing file is called MINTVL[HUT].LS, however.

* * * * To execute the TIPANAL2 program, type the command line

TY TIPANAL2.HELP which types out (on the screen) abbreviated
instructions and then type

TIPANAL2 [HUT] [ISUB] [ISIM] [MODE] [START*STOP MAJ. WMS.]

where:

[HUT] is the 7-digit major frame identification number of the data set

[ISUB] = 0 to generate the 'TIMES' and 'TIPSUB' files from the current
        MPC[HUT].TIP and MPC[HUT].HDR files
        = 1 to use already existing 'TIMES' and 'TIPSUB' files

[ISIM] = 0 to analyze actual data only for interval distribution
        = 1 for comparison with simulated data also

[MODE] = 0 for analysis of all data in file
        = 1 for analysis of all data, which is in fact between

- 23 -
START and STOP major frames

[START*STOP MAJ FM] are the major frame limits. Enter as 2 double precision numbers, e.g. 1234567.d00*1234678.d00

Default arguments are such that if you type simply

TIPANAL2 [HUT]

new 'TIMES' and 'TIPSUB' files will be created (as well as the 'STD' file) and you will get the interval distribution analysis on the entire data set; comparison with simulated data will NOT be done.

***** TIPANAL3 Program *****

This is the TIP analysis program for folding the MPC photon times at a given period to construct a phase histogram. Folding can be done in up to 512 phase bins; an arbitrary phase for the start of the first bin can be given. The output is given in a file MFOLD[HUT].LS. See the description of the program TIPANAL for a general discussion of TIP analysis as well as file structure.

To use the TIPANAL3 program for a given HUT, the same input, output, and parameter files are used as for the main TIPANAL program (see writeup). Output listing file is called MFOLD[HUT].LS, however.

* * * To execute the TIPANAL3 program, type the command line

TY TIPANAL3 .HELP which types out (on the screen) abbreviated instructions and then type

TIPANAL3 [HUT] [PERIOD] [NBINS] [ISUB] [TIPSUB] [TIMES]

where:
[HUT] is the 7-digit major frame identification number of the data set
[PERIOD] is the period (sec.) to fold at. Enter as double precision.
[NBINS] is the number of phase bins (LE. 512), Enter as integer.

[ISUB] = 0 to generate the 'TIMES' and 'TIPSUB' files from the current
MPC[HUT].TIP and MPC[HUT].HDR files
= 1 to use already existing 'TIMES' and 'TIPSUB' files

[TIPSUB] is the name of the 'TIPSUB' file to be used (if ISUB = 1)

[TIMES] is the name of the 'TIMES' file to be used (if ISUB = 1).

Default arguments are such that if you type simply

TIPANAL3 [HUT] [PERIOD] [NBINS]

new 'TIMES' and 'TIPSUB' files will be created (as well as the
'STD' file) and you will get the folding analysis on the entire
data set at the given PERIOD; NBINS are used and the absolute
phase is such that the left edge of the first phase bin is the
absolute time given as the start time of the data accepted.

***** TIPANAL4 Program *****

This is the TIP analysis program for folding the MPC photon
times at a range of periods to search for significant
periodicities. Folding can be done in up to 16 phase bins; an
arbitrary number of periods can be searched although computer
time required increases directly as the number of periods
searched. The periods are chosen to be statistically independent
but 'half-overlapping'. That is, approximately 2 (adjacent)
periods should show a significant effect for a true periodicity
in the data. Significance is tested by computing the Chisquare of
the phase histogram bins against a fixed value (= average no.
ccts./bin).

The output is given in a file MPSER[HUT].LS. See the
description of the program TIPANAL for a general discussion of
TIP analysis as well as file structure.

To use the TIPANAL4 program for a given HUT, the same input,
output, and parameter files are used as for the main TIPANAL
program (see writexp). Output listing file is called
MPSER[HUT].LS, however.
To execute the TIPANAL4 program, type the command line

```plaintext
TY TIPANAL4.HELP which types out (on the screen) abbreviated instructions and then type

TIPANAL4 [HUT] [PERIOD] [NSTEP] [NBINS] [SLEVEL] [ISUB] [TIPSUB] [TIMES]

where:
[HUT] is the 7-digit major frame identification number of the data set

[PERIOD] is the START period (sec.) to fold at. Enter as double precision. This period is the longest period to fold at; search is towards decreasing periods.

[NSTEP] is the number of periods to fold at (integer)

[NBINS] is the number of phase bins (LE. 16). Enter as integer.

[SLEVEL] is the minimum significance level (no. sigma, pos. or neg.) at which to print out the period, chisq. and no. sigma found.

[ISUB] = 0 to generate the 'TIMES' and 'TIPSUB' files from the current MPC[HUT].TIP and MPC[HUT].HDR files
= 1 to use already existing 'TIMES' and 'TIPSUB' files

[TIPSUB] is the name of the 'TIPSUB' file to be used (if ISUB = 1)

[TIMES] is the name of the 'TIMES' file to be used (if ISUB = 1).
```

Default arguments are such that if you type simply

```plaintext
TIPANAL4 [HUT] [PERIOD] [NSTEP] [NBINS]
```

new 'TIMES' and 'TIPSUB' files will be created (as well as the 'STD' file) and you will get the folding analysis (in NBINS) on the entire data set starting at the given PERIOD and progressing in NSTEP discrete periods towards shorter periods. The period, chisquare and max. number of sigma deviation (from the average) in the phase histogram are given for ALL periods (regardless of significance of the chisquare).

***** TIPANAL5 Program *****
This is the TIP analysis program for calculating the first, second, and third moments of the MPC photon arrival times within a specified time interval (e.g., 1 sec.) and for all possible intervals of this length within a given data set. The program also calculates the autocorrelation distribution of the data if the uncertainty in the variance of the entire data differs from the mean by a factor which can be specified (default value is 2.5). Each data interval of the length chosen is called an 'experiment'; the program is designed to be used in an interactive mode so that the interval length can be chosen to best match the data. Note that the TIP data are not continuous but have gaps with increasing relative dead time for sources with total count rates above about 30 cts/sec. See the description of the program TIPANAL for a general discussion of TIP analysis as well as file structure.

To use the TIPANAL5 program for a given HUT, the same input, output, and parameter files are used as for the main TIPANAL program (see writeup). Output listing file is called MTRIN[HUT].LS, however.

* * * * To execute the TIPANAL5 program, type the command line:

TY TIPANAL5.HELP which types out (on the screen) abbreviated instructions and then type

TIPANAL5 [HUT] [ISUB] [VLIM] [TIPSUB] [TIMES]

where:

[HUT] is the 7-digit major frame identification number of the data set

[ISUB] = 0 to generate the 'TIMES' and 'TIPSUB' files from the current MPC[HUT].TIP and MPC[HUT].HDR files
= 1 to use already existing 'TIMES' and 'TIPSUB' files

[VLIM] is the factor by which the UNCERTAINTY in the variance must differ from the mean for all the data in order for the autocorrelation to be calculated (default value is 2.5)

[TIPSUB] is the name of the 'TIPSUB' file to be used (if ISUB = 1)

[TIMES] is the name of the 'TIMES' file to be used (if ISUB = 1).

You must still supply 'experiment' length and no. bins interactively (see below).

- 27 -
TIPANAL5 [HUT]

new 'TIMES' and 'TIPSUB' files will be created (as well as the 'STD' file) and you will get the moments and autocorrelation analysis on the entire data set; you must still supply the 'experiment' length (no. secs. of unbroken data) and no. of bins for the autocorrelation interactively.

6.4 File Formats

MPC[HUT#].PSD

This is a binary file produced for each HUT containing the SavePhaData. This consists of the original total counts in each PHA channel for each 2.56 sec integration time block, the corresponding predicted background counts, and totals for these quantities for each major frame.

MPC[hut#].DAT

The MPC[Hut#].DAT file contains the accepted 'on source' data in its packed configuration. The file consists of a 4 byte header, followed by data blocks consisting of 266 bytes per major frame. The 4 byte header contains the starting major frame (words 48-49 of the Data Set Label) as a 32 bit integer. Note that this starting major frame is one greater than the hut name of the .PRD file.

The first word of the major frame block contains the major frame increment (integer) above the starting major frame, which is added to the hut to derive the present major frame number. The next 192 bytes contain the lowest order byte (bits 8-15) of the 8 PHA channels and 4 background indicators for each of the 16 2.56 second blocks. The remaining 72 bytes contain the second "nibble" (bits 4-7) of PHA channels 2-6 and the 4 background indicators. Figure 6.4/1 shows the format of a major frame block.

MPC[hut#].BAC

The MPC[hut#].BAC file (fig 6.4/2) contains the accepted earth-occluded background data in major frame sums. The file consists of a 4 byte header, followed by data blocks consisting
Bytes

F6.4/1

Δ Hut from Start

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

PH 1

2

3

4

5

(12,16) byte Array containing

lowest order byte

3-194

6

7

8

PSDI

PSDT

COINC

OVSCAL

PH 2

3

4

5

(9,16) nibble Array containing

second nibble

2.85

6

PSDI

PSDT

COINC

OVSCAL

F6.4/2

<table>
<thead>
<tr>
<th>Byte 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ Hut</td>
</tr>
</tbody>
</table>
of 16 bytes per major frame. The 4 byte header contains the starting major frame (words 48-49 of the Data Set Label) as a 32 bit integer. Note that this starting major frame is one greater than the nut name of the .PRO file.

The first word of the major frame block contains the major frame increment (integer) above the starting major frame, which is added to the nut to derive the present major frame number. The next 8 words contain the major frame sums for the 8 PHA channels. The remaining 4 words contain the major frame sums of the background indicators (integers).

MPC[nut#].BLK

The MPC[nut#].BLK file is a 32 word block which forms the basic element of the MPC.DAT.SBASE. Its format is as follows:

<table>
<thead>
<tr>
<th>WORD</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Nut# from DataSetLabel</td>
</tr>
<tr>
<td>3</td>
<td>Year from DSL</td>
</tr>
<tr>
<td>4</td>
<td>Start day from DSL</td>
</tr>
<tr>
<td>5-6</td>
<td>Start milliseconds from DSL</td>
</tr>
<tr>
<td>7</td>
<td>Stop day from DSL</td>
</tr>
<tr>
<td>8-9</td>
<td>Stop milliseconds from DSL</td>
</tr>
<tr>
<td>10</td>
<td>Number of major frames from DSL</td>
</tr>
<tr>
<td>11-12</td>
<td>Start SCID from DSL</td>
</tr>
<tr>
<td>13-14</td>
<td>Stop SCID from DSL</td>
</tr>
<tr>
<td>15</td>
<td>Seq # from DSL</td>
</tr>
<tr>
<td>16-17</td>
<td>R.A.</td>
</tr>
<tr>
<td>18-19</td>
<td>DEC.</td>
</tr>
<tr>
<td>20-21</td>
<td>Roll Angle</td>
</tr>
<tr>
<td>22</td>
<td>Kill flag from MPCSPEC</td>
</tr>
<tr>
<td></td>
<td>-1 = nut flagged by MPCSPEC as possible source</td>
</tr>
<tr>
<td></td>
<td>0 = source detected by MPCSPEC</td>
</tr>
<tr>
<td></td>
<td>1 = no source detected in 1 - 6</td>
</tr>
<tr>
<td></td>
<td>2 = no data accepted</td>
</tr>
<tr>
<td></td>
<td>3 = source in 7 + 8 only, possible detector breakdown</td>
</tr>
<tr>
<td>23</td>
<td>contemporaneous MAPCOR.BIN number</td>
</tr>
<tr>
<td>24</td>
<td>bitI = 1 if Cal source in during hut</td>
</tr>
<tr>
<td></td>
<td>bitII = 1 if nominal and actual point direction differ</td>
</tr>
<tr>
<td></td>
<td>bitIII = 1 if there is an error in the .QRA file</td>
</tr>
<tr>
<td>25</td>
<td>PHA 1,2, and 3 summed total counts</td>
</tr>
<tr>
<td>26</td>
<td>PHA 4,5, and 6</td>
</tr>
<tr>
<td>27</td>
<td>PHA 7 and 8</td>
</tr>
<tr>
<td>28</td>
<td>PHA 1,2 and 3 summed predicted background</td>
</tr>
<tr>
<td>29</td>
<td>PHA 4,5 and 6</td>
</tr>
<tr>
<td>30</td>
<td>PHA 7 and 8</td>
</tr>
<tr>
<td>31</td>
<td>space</td>
</tr>
</tbody>
</table>

- 29 -
32

Note that the predicted background count are not from the MAPCOR.BIN number in this .BLK, but from the previous MAPCOR.BIN file.

MAPCOR.BIN

The MAPCOR.BIN file contains lookup tables of binned PHA data as a function of coincidence rate. Any program which makes use of this file must read the first three words (integers) in order to derive the size of the remaining arrays. Figure 6.4/3 shows the default configuration containing 62 bins ranging from 195 to 55 in coincidence rate (counts per 2.56 seconds).

Figure 6.4/4 shows a sample plot of the seed MAPCOR.BIN.0 file. The figure plots the quantity SMOOTH(I,J)/BLOCKS(J) as a function of COINC(J). Before a MAPCOR.BIN file is completed in production processing, the array SMOOTH is filled with zeros, and the array SIGPH is not yet written. Upon accumulation of the specified number of blocks of data, the SMOOTH and SIGPH arrays are written, and the internal version number (NMAP) is appended to the file name.

SPECTBL#.DAT

The SPECTBL#.DAT files are the template spectra which MSPEC compares to the data and does chi-squared fits against. The spectrum types are (1) Power Spec, (2) Exponential, (3) Thermal Brems (with gain factor), and (4) Blackbody. The format is:

<table>
<thead>
<tr>
<th>BLOCK</th>
<th>NAME</th>
<th>CONTENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>HEADER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>lower Nh column density (f.p.)</td>
</tr>
<tr>
<td></td>
<td>(2)</td>
<td>upper Nh column density (f.p.)</td>
</tr>
<tr>
<td></td>
<td>(3)</td>
<td>number Nh steps (f.p.)</td>
</tr>
<tr>
<td></td>
<td>(4)</td>
<td>upper power law index (f.p.)</td>
</tr>
<tr>
<td></td>
<td>(5)</td>
<td>lower power law index (f.p.)</td>
</tr>
<tr>
<td></td>
<td>(6)</td>
<td>number power law indices (f.p.)</td>
</tr>
<tr>
<td></td>
<td>(7)</td>
<td>(128) : blank</td>
</tr>
<tr>
<td>1</td>
<td>XCTS(I,J)</td>
<td>predicted counts - one block for each power law index</td>
</tr>
<tr>
<td></td>
<td>(lowest alpha)</td>
<td>I = 1 to 8 for the Eight channels</td>
</tr>
<tr>
<td></td>
<td></td>
<td>J = 1 to 16 for each of the 16 allowed Nh values - first Nh is the highest density, they decrease as J increases.</td>
</tr>
<tr>
<td>2</td>
<td>(next higher alpha)</td>
<td></td>
</tr>
</tbody>
</table>
MINCO: default = 200 (integer)

MAXCO: default = 500 (integer)

ISTEP: default = 5 (integer)

SMOOTH(8,62) — Array of smoothed PHA counts per 2.56 seconds (real) for use by MPCSPEC as predicted background rates.

PHMEAN(8,62) — Array of summed raw PHA counts. These are truly sums, not average count rates.

Therefore the numbers can be quite large (D.P. real).

PHSQ(8,62) — Array of sums of squares of raw PHA counts. Also (D.P. real).

BLOCKS(62) — Number of 2.56 second blocks in each coincidence rate bin (real).

NMAP — version number of this file (integer).

SIGPH(8,62) — Array of standard errors in the quantity PHMEAN for use by MPCSPEC in deriving background errors. Units are counts/2.56 seconds (real).
NA blocks = number of power law indices

Words

1
MINCO: default = 200 (integer)

2
MAXCO: default = 5 (integer)

3
ISTEP: default = 5 (integer)

4-995
SMOOTH(8.62) - Array of smoothedPHA counts per 2.56 seconds (real) for use by MPCSPEC as predicted background rates.

995
PHMEAN(8.62) - Array of summed raw PHA counts. These are truly sums, not average count rates. Therefore the numbers can be quite large (D.P. real).

-2979

2980
PHSQ(8.62) - Array of sums of squares of raw PHA counts. Also (D.P. real).

-4963

4964
BLOCKS(62) - Number of 2.56 second blocks in each coincidence rate bin (real).

-5087

5088
NMAP - version number of this file (integer).

5089
SIGPH(8.62) - Array of standard errors in the quantity PHMEAN for use by MPCSPEC in deriving background errors. Units are counts/2.56 seconds (real).

-6080

6.5 Evaluation: (To be added at a later date)