# Chapter 6: The Monitor Proportional Counter

15 March 1984

**Figures:**

## 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 grater 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 Gaillardetz et.al. (1978),IEEE Trans. on Nuc. 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(REV0) and MPCVARY(REV0) 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(rev0) 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 ~18.5 cts s$^{-1}$ to ~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 "HUTS" (orbits) and merging of data from many HUTS (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 mil) beryllium foil having an unobstructed area of 720 $cm^2$. 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 6 arc minutes wide. The collimator transmission is approximately 93 on axis, yielding a net open area of 667 $cm^2$. The MPC is mounted on the outside of the Einstein Observatory and is aligned to within one arc minute of the optical (+x) 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 millisec., 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 947 UFU (Forman etal 1978) , we derive the approximate conversion that 1 MPC c $s^{-1}$ 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 .QRA 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.AMS.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 $10^5$

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 3 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 huts. 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. The same output is also copied 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 error 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 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.DATA.BASE and test for source existence, measure variability, and perhaps estimate crude spectra.

The ---.DAT files, together with the summary MPC.DATA.BASE file, constitute the reprocessed MPC data base 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 MPLOT 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 PHA analysis programs

****** MBASE *******

This program allows one to extract the MPC.DATA.BASE 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 existance. An example of the output follows.

---

Input files needed: MPC.DATA.BASE
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 = 268126.  0.
Number of major frames = 64

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

Time (sec)  =  2170.88         Bkgnd/sec  = 16.6

          Chans.        1-2          3-5          6-8

Total counts            9190.        80105.       63173.
Bkgnd counts            3321.        11549.       21231.
Counts/sec                 2.703        31.580       19.320
```

## ***** UNPACK *****

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 MSPEC 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]   {BMJF*EMJF}     {ILIST}
```

were

[hut#]: is the 7 digit hut#

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

{BMJF*EMJF} 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 which 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.

```
Hut #  476456. of Seq #  1478
RA, Dec,    1 =   20.46 -59.07 -64.87
Start Year, Day, Sec = 1979 177   60921.941
Stop Day, Sec =             177   61331.541
Start major, minor frames =  476467.        0.
Stop major, minor frames =   476477.        0.
Number of major frames =          11
MPCSPEC detect flag = -1
Concurrent background table is MAPCOR.BIN.13

Major frame #  476477. starts at  61331.541 secs. of day 177 1979
 PH1    PH2    PH3    PH4    PH5    PH6    PH7    PH8     PSDI  PSDT COINC OSCAL TOTEV IFLAG
Data with coincidence rates lower than  200 has been allowed
   2      3      1      9      9      8     11      7       68   302   195   195    50     3
   1.4    2.3    3.1    4.2    5.4    6.8    8.1    8.2
    .02    .03    .04    .04    .05    .05    .06    .06
   3      4      5      5      7     12     12      5       68   314   228   197    53     0
   1.4    2.3    3.1    4.2    5.5    7.0    8.4    8.5
    .01    .01    .02    .02    .02    .02    .03    .03
   0      6      3      5      8      7      6      6       47   310   215   182    41     0
   1.5    2.3    3.1    4.2    5.4    6.9    8.3    8.4
    .01    .01    .02    .02    .02    .02    .03    .03
   0      1      3      9      4     10      9      9       45   281   219   221    45     0
   1.5    2.3    3.1    4.2    5.4    6.9    8.3    8.4
    .01    .01    .02    .02    .02    .02    .03    .03
   1      3      3      2      3     12      8      3       60   315   235   180    35     0
   1.5    2.3    3.1    4.2    5.6    7.1    8.5    8.6
    .01    .01    .02    .02    .02    .02    .03    .03
   1      2      5      7      4      7      4     10       52   284   231   204    40     0
   1.4    2.3    3.1    4.2    5.5    7.0    8.4    8.6
    .01    .01    .02    .02    .02    .02    .03    .03
   0      4      1      6      3      7     11      9       41   286   235   234    41     0
   1.5    2.3    3.1    4.2    5.6    7.1    8.5    8.6
    .01    .01    .02    .02    .02    .02    .03    .03
   0      7      4      3      3     12     10      7       53   320   230   213    46     0
   1.4    2.3    3.1    4.2    5.5    7.0    8.4    8.6
    .01    .01    .02    .02    .02    .02    .03    .03
   4      2      3      3      5      4     10     10       56   300   195   206    41     3
   1.4    2.3    3.1    4.2    5.4    6.8    8.1    8.2
    .02    .03    .04    .04    .05    .05    .06    .06
   2      5      3      7      6      4      8      8       63   318   234   176    43     0
   1.4    2.3    3.1    4.2    5.5    7.0    8.4    8.6
    .01    .01    .02    .02    .02    .02    .03    .03
   2      4      2      7      7     10     13      5       47   277   195   214    50     3
   1.4    2.3    3.1    4.2    5.4    6.8    8.1    8.2
    .02    .03    .04    .04    .05    .05    .06    .06
   2      3      4      3      8      5     10      6       54   293   236   208    41     0
   1.5    2.3    3.1    4.2    5.6    7.1    8.5    8.6
    .01    .01    .02    .02    .02    .02    .03    .03
   1      2      2      5     10      8      4      8       57   291   204   196    40     0
   1.4    2.3    3.1    4.2    5.5    6.9    8.1    8.3
    .01    .02    .02    .02    .03    .03    .03    .03
   1      3      5      5      8      8      4     10       62   290   239   192    44     0
   1.5    2.3    3.1    4.2    5.6    7.1    8.5    8.6
    .01    .01    .02    .02    .02    .02    .03    .03
   1      5      8      2      5     10      3     10       51   287   215   192    44     0
   1.5    2.3    3.1    4.2    5.4    6.9    8.3    8.4
    .01    .01    .02    .02    .02    .02    .03    .03
   2      3      6      4     14      9      7      5       45   285   252   217    50     0
   1.5    2.3    3.1    4.2    5.6    7.2    8.7    8.8
    .01    .01    .02    .02    .02    .03    .03    .03
```

1. four separate files are created for the four spectral types (See the file formats section for the SPECTBL#.DAT format)
2. each files has a header containing parameter limits of the grid
3. steps in Nh and Kt 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: RESTBLS.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*NUMHN] [LOWT*HIGHT*NUMT]
```

where:

[IHI*ILO]: is the range of tables to produce

[HIHN*LOWNH*NUMNH]: are the high, low, and number of Nh values to use, Nh must be less than or equal to 16

[LOWT*HIGHT*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 Nh 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 brems. 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#].FAD
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 type:

```
        MSPEC [HUT#] {NLO*NHI} {MODE}
```

where:

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

{NLO*NHI} are the first through last PHA channels to be fit

```
1) POWER LAW FIT:  F(E) = CNORM*(E**-ALPHA)*EXP(-TAU(NH,E))  KEV/(CM2-SEC-KEV)

        MINIMUM CHISQUARE =  31.19 FOR NH = 1.44E+23, ALPHA =  0.75, AND CNORM = 5.82E-01 KEV/(CM2-SEC-KEV)

        -------------------------------------------------
             LOG COLUMN DENSITY (CM-2)
          22.60  22.80  23.00  23.20  23.40  23.60
 ALPHA / -------------------------------------------------
-0.500 /  489.9    0.0    0.0    0.0    0.0    0.0
-0.400 /  471.0  405.9    0.0    0.0    0.0    0.0
-0.300 /  494.4  309.8    0.0    0.0    0.0    0.0
-0.200 /    0.0  252.0  434.5    0.0    0.0    0.0
-0.100 /    0.0  230.5  306.2    0.0    0.0    0.0
 0.000 /    0.0  242.1  206.7    0.0    0.0    0.0
 0.100 /    0.0  282.8  135.6    0.0    0.0    0.0
 0.200 /    0.0  348.3   91.6  404.5    0.0    0.0
 0.300 /    0.0  434.1   73.1  296.6    0.0    0.0
 0.400 /    0.0    0.0   77.8  208.3    0.0    0.0
 0.500 /    0.0    0.0  103.2  139.2    0.0    0.0
 0.600 /    0.0    0.0  146.7   88.5    0.0    0.0
 0.700 /    0.0    0.0  205.7   55.1    0.0    0.0
 0.800 /    0.0    0.0  277.6   37.8  437.8    0.0
 0.900 /    0.0    0.0  360.1   35.5  367.0    0.0
 1.000 /    0.0    0.0  450.8   46.7  308.0    0.0
 1.100 /    0.0    0.0    0.0   70.1  260.3    0.0
 1.200 /    0.0    0.0    0.0  104.4  223.2    0.0
 1.300 /    0.0    0.0    0.0  148.3  195.8    0.0
 1.400 /    0.0    0.0    0.0  200.6  177.7    0.0
 1.500 /    0.0    0.0    0.0  260.1  168.6    0.0
 1.600 /    0.0    0.0    0.0  325.8  166.0    0.0
 1.700 /    0.0    0.0    0.0  396.6  171.2    0.0
 1.800 /    0.0    0.0    0.0  471.6  182.8    0.0
 1.900 /    0.0    0.0    0.0    0.0  200.3    0.0
 2.000 /    0.0    0.0    0.0    0.0  223.2    0.0
 2.100 /    0.0    0.0    0.0    0.0  250.9    0.0
 2.200 /    0.0    0.0    0.0    0.0  282.9  495.6
 2.300 /    0.0    0.0    0.0    0.0  318.8  489.1
 2.400 /    0.0    0.0    0.0    0.0  358.1  486.7
 2.500 /    0.0    0.0    0.0    0.0  400.6  488.1
 2.600 /    0.0    0.0    0.0    0.0  445.8  492.9
 2.700 /    0.0    0.0    0.0    0.0  493.4    0.0
        -------------------------------------------------
```

L6.3.2/2b

```
MODEL (1) FIT:      TIME (SEC) =      9502.72      CTS/SEC IN FIT =    56.55 +/-  0.99
 1
------------------------------------------------------------------------------------------------------------
CHANNEL #
USED IN FIT (*)              1            2            3            4            5            6            7            8
                             *            *            *            *            *            *            *            *
------------------------------------------------------------------------------------------------------------
OBSERVED COUNTS            8280.       16827.       53281.      128538.      201030.      154925.       89843.       51490.
DERIVED BACKGROUND         5822.        9187.       12685.       17095.       22539.       28720.       35057.       35749.
    NET CTS/SEC            0.259        0.804        4.272       11.727       18.783       13.281        5.765        1.656
        (+/-)           ( 0.016)     ( 0.028)     ( 0.130)     ( 0.354)     ( 0.565)     ( 0.401)     ( 0.577)     ( 0.167)
    BEST FIT COUNTS        0.241        0.687        4.445       12.519       19.000       12.805        5.701        1.984
    SIGMA DEVIATION        1.126        4.213       -1.325       -2.236       -0.383        1.189        0.111       -1.960
FIT KEV/(CM2-SEC-KEV)   1.130E-07    5.395E-04    2.441E-02    8.367E-02    1.133E-01    9.522E-02    8.361E-02    6.820E-02
FIT PHOTONS/(CM2-SEC-KEV) 8.115E-08  2.739E-04    8.457E-03    2.012E-02    1.919E-02    1.125E-02    6.920E-03    4.023E-03
OBS PHOTONS/(CM2-SEC-KEV) 8.726E-08  3.204E-04    8.128E-03    1.885E-02    1.897E-02    1.167E-02    6.997E-03    3.358E-03
                (+/-)  (5.429E-09) (1.105E-05) (2.482E-04) (5.687E-04) (5.712E-04) (3.520E-04) (7.008E-04) (3.393E-04)
PHA CENTERS (KEV)           1.39         1.97         2.89         4.16         5.90         8.46        12.08        16.95
PHA BOUNDS  (KEV)      1.19         1.63         2.38         3.50         4.94         7.05        10.16        14.37        20.00
------------------------------------------------------------------------------------------------------------
```

{MODE} if equal to 1, a grid search (item #6 above) is run

## ****** MSPECPLOT *******

This program will be analogous to the REVO program SPECPLOT 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$^{-1}$ keV$^{-1}$), or CGS energy spectrum (ergs/cm$^{-2}$ s$^{-1}$ 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 SPECPLOT output.

To use MSPECPLOT 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: SPECPLOT.PF

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

```
TY SPECPLOT.HELP
```

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

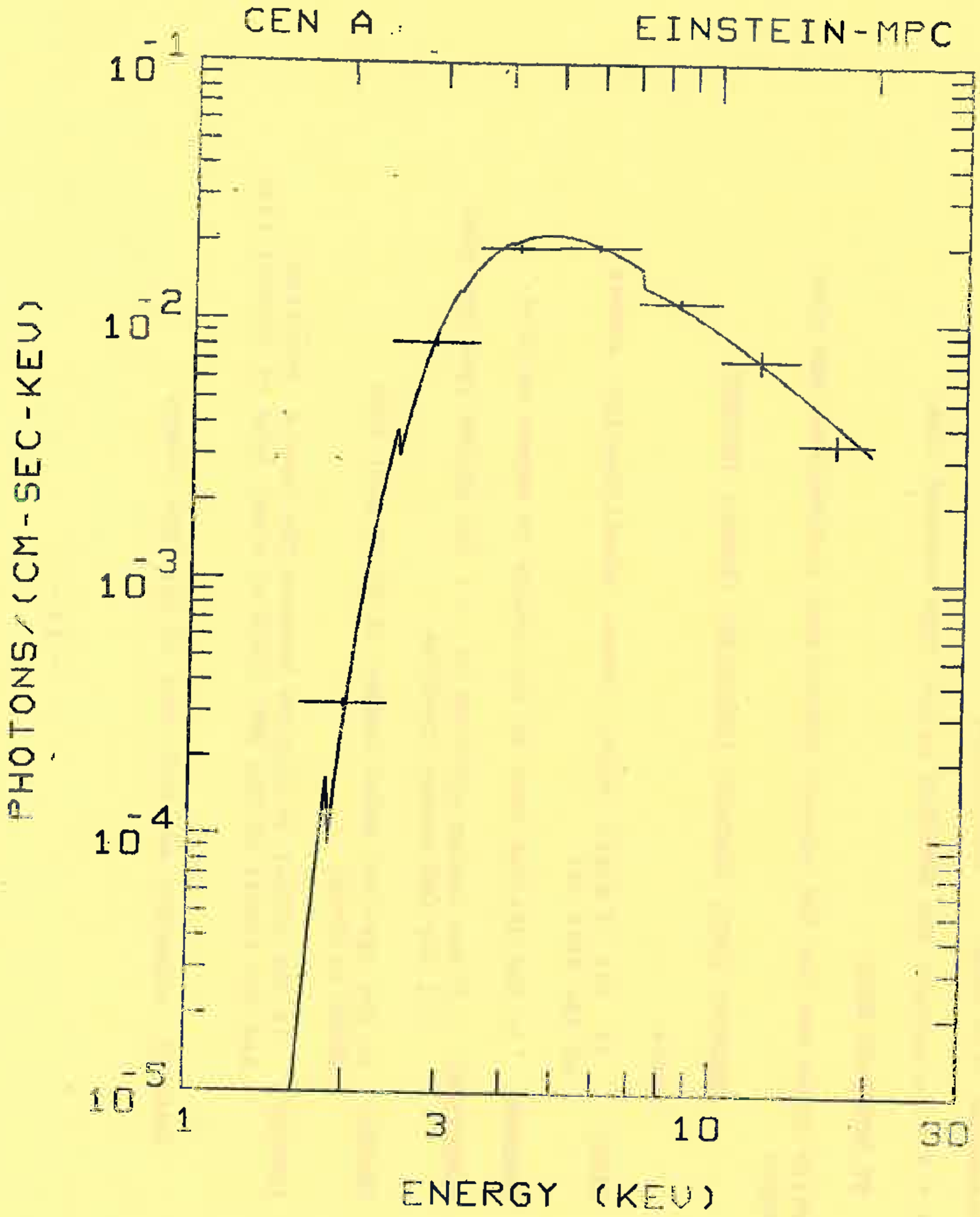
```
SPECPLOT [HUT] [SRCNAM] [SPECTYPE] [MODEL] [OFFSET]
```

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<br>= 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

F6.3.2/1



POWER LAW FIT:

ALPHA = 0.75

NH = 1.44E+23 CM(-2)

CNORM = 5.82E-01

```
        SPECPLOT [HUT] [SRCNAM]
```

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 the 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 typeout (on screen) abbreviated

L6.3.2/3a

# MPCVARY OUTPUT

```
MPC VARIABILITY ANALYSIS OF 2.56 SEC PHA DATA RUN AT 15:37:28  08/26/80
ANALYSIS USES MPC0132377.FAD  FILE, -.SPD AND SPECRES FILES; DATA FROM OBS. SEQUENCE NO.    3590 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+/-   26.74 IN PHA CHANNELS   1 TO   8

  SEARCH FOR BURSTS GT.   5.0 SIGMA

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

 POSSIBLE BURST (    5.2 SIGMA) AT SECOND  50241.44IN MAJ. FM.   132378. WITH COUNTS PER 2.56 SEC
    626.0    855.0   631.0    574.0    461.0   860.0    607.0   1119.0   615.0  1056.0   498.0   974.0    482.0    743.0    693.0    687.0

 POSSIBLE BURST (    6.8 SIGMA) AT SECOND  50290.08IN MAJ. FM.   132379. WITH COUNTS PER 2.56 SEC
    701.8    687.8   827.0    701.0    896.0   508.0    757.0    408.0   829.0   505.0  1200.0   528.0    817.0    574.0   1048.0    748.0

 POSSIBLE BURST (    5.2 SIGMA) AT SECOND  50333.60IN MAJ. FM.   132380. WITH COUNTS PER 2.56 SEC
    809.0    806.0   622.0    792.0    516.0   853.0    568.0    969.0   526.0  1180.0   618.0   834.0    379.0    765.0    557.0    781.0

 POSSIBLE BURST (    6.6 SIGMA) AT SECOND  50366.88IN MAJ. FM.   132381. WITH COUNTS PER 2.56 SEC
    709.0    746.0   890.0    567.0    915.0   603.0    733.0    427.0   871.0   522.0   918.0   503.0   1209.0    631.0   1052.0    633.0

 POSSIBLE BURST (    5.8 SIGMA) AT SECOND  50402.72IN MAJ. FM.   132382. WITH COUNTS PER 2.56 SEC
    870.0    736.0   768.0    688.0    611.0   696.0    526.0    910.0   615.0   930.0   477.0  1080.0    422.0   1228.0    568.0   1124.0

 POSSIBLE BURST (    6.7 SIGMA) AT SECOND  50446.24IN MAJ. FM.   132383. WITH COUNTS PER 2.56 SEC
    570.0    893.0   666.0    768.0    564.0   468.0    784.0    595.0   976.0   589.0   969.0   556.0   1007.0    428.0    780.0    479.0

 POSSIBLE BURST (    5.4 SIGMA) AT SECOND  50489.76IN MAJ. FM.   132384. WITH COUNTS PER 2.56 SEC
    685.0    539.0   860.0    807.0    970.0   959.0    773.0    952.0   597.0   886.0   542.0   860.0    533.0    812.0    408.0    970.0

 POSSIBLE BURST (   12.9 SIGMA) AT SECOND  50528.16IN MAJ. FM.   132385. WITH COUNTS PER 2.56 SEC
    563.0   1059.0   607.0   1019.0    847.0   707.0    840.0    581.0   929.0   613.0   968.0   513.0   1129.0    430.0   1044.0    564.0

 POSSIBLE BURST (   11.4 SIGMA) AT SECOND  50566.56IN MAJ. FM.   132386. WITH COUNTS PER 2.56 SEC
   1020.0    715.0   985.0    662.0    753.0   634.0    631.0    809.0   618.0   860.0   606.0   780.0    482.0    872.0    401.0   1167.0

 POSSIBLE BURST (   17.2 SIGMA) AT SECOND  50610.08IN MAJ. FM.   132387. WITH COUNTS PER 2.56 SEC
    503.0   1175.0   552.0    893.0    621.0   847.0    712.0    636.0   914.0   682.0   958.0   639.0   1071.0    604.0    930.0    321.0

 POSSIBLE BURST (    7.8 SIGMA) AT SECOND  50648.48IN MAJ. FM.   132388. WITH COUNTS PER 2.56 SEC
    923.0    407.0   649.0    400.0    685.0   653.0    947.0    795.0   619.0   756.0   515.0   800.0    443.0    923.0    400.0   1101.0

 POSSIBLE BURST (   11.0 SIGMA) AT SECOND  50692.00IN MAJ. FM.   132389. WITH COUNTS PER 2.56 SEC
    489.0   1010.0   406.0    754.0    320.0   802.0    500.0    785.0   620.0   771.0   862.0   580.0    708.0    494.0    686.0    412.0
```

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

5.3

```
POSSIBLE BURST (   9.3 SIGMA) AT SECOND  50730.40IN MAJ. FM.    132390. WITH COUNTS PER 2.56 SEC
    964.0   350.0  1062.0    526.0    893.0    416.0    759.0    507.0    621.0    614.0    614.0    829.0    671.0    726.0    346.0    675.0

POSSIBLE BURST (   7.9 SIGMA) AT SECOND  50773.92IN MAJ. FM.    132391. WITH COUNTS PER 2.56 SEC
    428.0   927.0   447.0    820.0    396.0    711.0    379.0    644.0    643.0    669.0    853.0    616.0    851.0    477.0    728.0    462.0

POSSIBLE BURST (   8.5 SIGMA) AT SECOND  50860.96IN MAJ. FM.    132393. WITH COUNTS PER 2.56 SEC
    403.0   825.0   515.0    942.0    414.0    733.5    723.6    691.5    733.3    684.8    691.2    725.8    761.9    729.5    678.3    685.0

REDUCED CHISQUARE =   57.40 FOR 240 BINS (2.56 SEC)
NO. OF (BAD OR HIGH BKGD.) BINS FILLED WITH AVG. CTS. WAS    14
NO. OF SKIPPED MAJOR FRAMES WAS     1
DEPARTURE FROM POISSON VALUE IS 616.5 SIGMA
```

Number of sigma significance of departure of $\chi^2$ on rate from that expected for purely Poisson variations

```
RESULT OF FOLDING DATA INTO    10 BINS AT ALL INDEPENDENT PERIODS GT. 5.12 SEC

DATA DURATION IS  655.36 SEC AND AVG. CTS/(2.56 SEC*PHASE BIN)IS    71.441 +/-    .546

PERIOD =     5.120     5.140     5.160     5.180     5.201     5.222     5.242     5.263     5.284     5.306
CHISQR =     17.18    123.40     28.29    663.92     38.01    877.76     25.27     38.29     38.27     29.28

PERIOD =     5.327     5.349     5.371     5.393     5.415     5.437     5.460     5.483     5.506     5.529
CHISQR =     25.24     51.13     58.43      7.15    329.71   1084.49    798.58    108.34     38.34     41.93

PERIOD =     5.552     5.576     5.599     5.623     5.647     5.672     5.696     5.721     5.746     5.771
CHISQR =     44.36     28.18     16.75     19.42     28.40     33.82     24.38     38.89     31.54     18.06

PERIOD =     5.796     5.822     5.848     5.874     5.900     5.927     5.954     5.981     6.008     6.036
CHISQR =     20.36     17.55     31.16     22.10     38.01     17.01     10.65     28.50     22.64      6.25

PERIOD =     6.063     6.091     6.120     6.148     6.177     6.206     6.236     6.265     6.295     6.326
CHISQR =     36.81     21.00     28.39     15.05     27.92     19.98     27.23     14.88      6.53     10.60

PERIOD =     6.356     6.387     6.418     6.449     6.481     6.513     6.546     6.578     6.611     6.645
CHISQR =     30.35     26.45     21.29     22.14     48.18     21.69     12.72     25.04      8.89     20.47

PERIOD =     6.678     6.712     6.747     6.781     6.816     6.852     6.888     6.924     6.961     6.997
CHISQR =     36.01     14.27     23.86     16.70     19.17     13.34     34.60     19.83    583.66     58.42

PERIOD =     7.035     7.073     7.111     7.149     7.188     7.228     7.268     7.308     7.349     7.390
CHISQR =     13.75     12.40     14.28     18.70     13.85     19.25     32.11     26.04     58.77     23.43

PERIOD =     7.432     7.474     7.516     7.559     7.603     7.647     7.692     7.737     7.782     7.829
CHISQR =      7.02      3.39     10.89     12.75      9.48     47.07     26.88     20.34      8.91     19.18

PERIOD =     7.875     7.923     7.971     8.019     8.068     8.118     8.168     8.219     8.271     8.323
CHISQR =      7.32      5.03      8.34     52.68     27.69     16.60     11.94     11.06     26.00     48.92

PERIOD =     8.376     8.429     8.483     8.538     8.594     8.650     8.707     8.765     8.824     8.883
CHISQR =     82.14     15.08     41.14     19.92      5.67     20.30    896.77     28.88      6.56     21.86

PERIOD =     8.943     9.004     9.066     9.129     9.193     9.257     9.322     9.389     9.456     9.524
CHISQR =     41.71     15.74     12.07     10.78     29.39     19.76     27.75      9.76     30.89     35.97

PERIOD =     9.593     9.664     9.735     9.807     9.880     9.955    10.031    10.107    10.185    10.264
CHISQR =     75.08   1037.52     65.40     19.89      8.17      4.41    214.93      5.64     43.51     32.88
```

Approximately twice the known 4.83 sec period of Cen X-3

L6.3.2/3c

5.3

```
PERIOD =   10.345    10.426    10.509    10.594    10.679    10.766    10.855    10.945    11.036    11.129
CHISQR =    11.71     48.31     31.89      8.99     21.33     30.39    683.86    313.56     43.07     19.06

PERIOD =   11.223    11.320    11.417    11.517    11.618    11.721    11.826    11.932    12.041    12.152
CHISQR =     5.25     41.71     22.48     12.93     43.64     96.45     26.51     16.22     20.05     18.20

PERIOD =   12.264    12.379    12.496    12.615    12.737    12.860    12.986    13.115    13.246    13.380
CHISQR =    25.77      7.38     22.75      4.56     42.07     53.08     20.33     14.30     18.72     88.75

PERIOD =   13.517    13.656    13.798    13.944    14.092    14.244    14.398    14.557    14.718    14.883
CHISQR =     8.59     13.50     21.43     36.72     13.27     21.88     35.32    311.13     19.04     22.60

PERIOD =   15.052    15.225    15.402    15.583    15.768    15.958    16.152    16.351    16.555    16.765
CHISQR =    33.86     10.31     37.76     10.48     39.76     22.87     17.74    792.46     29.11     14.59

PERIOD =   16.979    17.199    17.425    17.656    17.894    18.138    18.389    18.647    18.913    19.186
CHISQR =    16.80     34.21     22.85      7.50     12.92     10.21     21.39     19.90     15.62     39.25

PERIOD =   19.466    19.755    20.053    20.360    20.676    21.002    21.339    21.686    22.045    22.416
CHISQR =     8.68     12.22     13.18     21.83     19.98     31.54     11.39    324.79     23.13     18.61

PERIOD =   22.799    23.196    23.606    24.031    24.472    24.929    25.403    25.895    26.407    26.939
CHISQR =    38.29     14.69     25.10     60.54     19.40     34.54     23.81     27.84     40.85     72.99

PERIOD =   27.493    28.069    28.670    29.298    29.952    30.637    31.353    32.103    32.889    33.714
CHISQR =    20.68      4.48     24.62     33.38     30.27     20.54     24.42     23.29     43.98    120.76

PERIOD =   34.582    35.494    36.455    37.469    38.540    39.673    40.874    42.149    43.504    44.948
CHISQR =    30.02     14.92     23.44     22.58     48.41     21.21     16.96      7.49    167.95     21.58

PERIOD =   46.490    48.139    49.907    51.807    53.854    56.067    58.466    61.073    63.919    67.036
CHISQR =    12.74     20.87     30.51      9.87     38.65     26.55     19.66     32.08     22.85     46.72

PERIOD =   70.465    74.253    78.460    83.156    88.432    94.398   101.197   109.010   118.076   128.713
CHISQR =    60.33     23.91     22.57     12.04     27.28     21.73     39.19     28.00     30.55     19.92

PERIOD =  141.352   156.596   175.305   198.751   228.889   268.860   324.009   404.104   528.692      .000
CHISQR =    37.51      8.27     11.43     29.96     13.60     15.83     19.18     27.84     53.16       .00
```

Longest period ≲ data duration

```
AVOID SAMPLE PERIOD (2.56 SEC) BEATS AND PERIODS GT. ONE-QUARTER DATA DURATION TIME & SEARCH FOR PERIOD WITH MAX. CHISQ.


SIGNIFICANCE OF 2298.4 SIGMA OBTAINED FOR CHISQ =    1084.49 BY FOLDING AT PERIOD =     5.437 SEC
         LIGHT CURVE AT THIS PERIOD FOLLOWS WITH AVG. CTS/BIN =      71.44
BIN     CTS.     BIN SIGMA  NO. SIG. DEV.                 LINEAR CTS/BIN ---SCALE IS NO. SIGMA ABOUT AVG.

                                                -8        -6        -4        -2         0         2         4         6
 1    49.62           .45      -47.98   I*
 2    54.32           .48      -35.99   I*
 3    66.93           .52       -8.71   I******
 4    85.84           .60       24.07   I********************************************************************************
 5    92.11           .63       32.67   I********************************************************************************
 6    92.64           .62       34.12   I********************************************************************************
 7    85.03           .58       23.30   I********************************************************************************
 8    77.10           .59        9.55   I********************************************************************************
 9    62.93           .51      -16.63   I*
10    49.75           .45      -40.64   I*
```

Approximately at 4.8 sec known period plus 0.64 sec sample period 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]
```

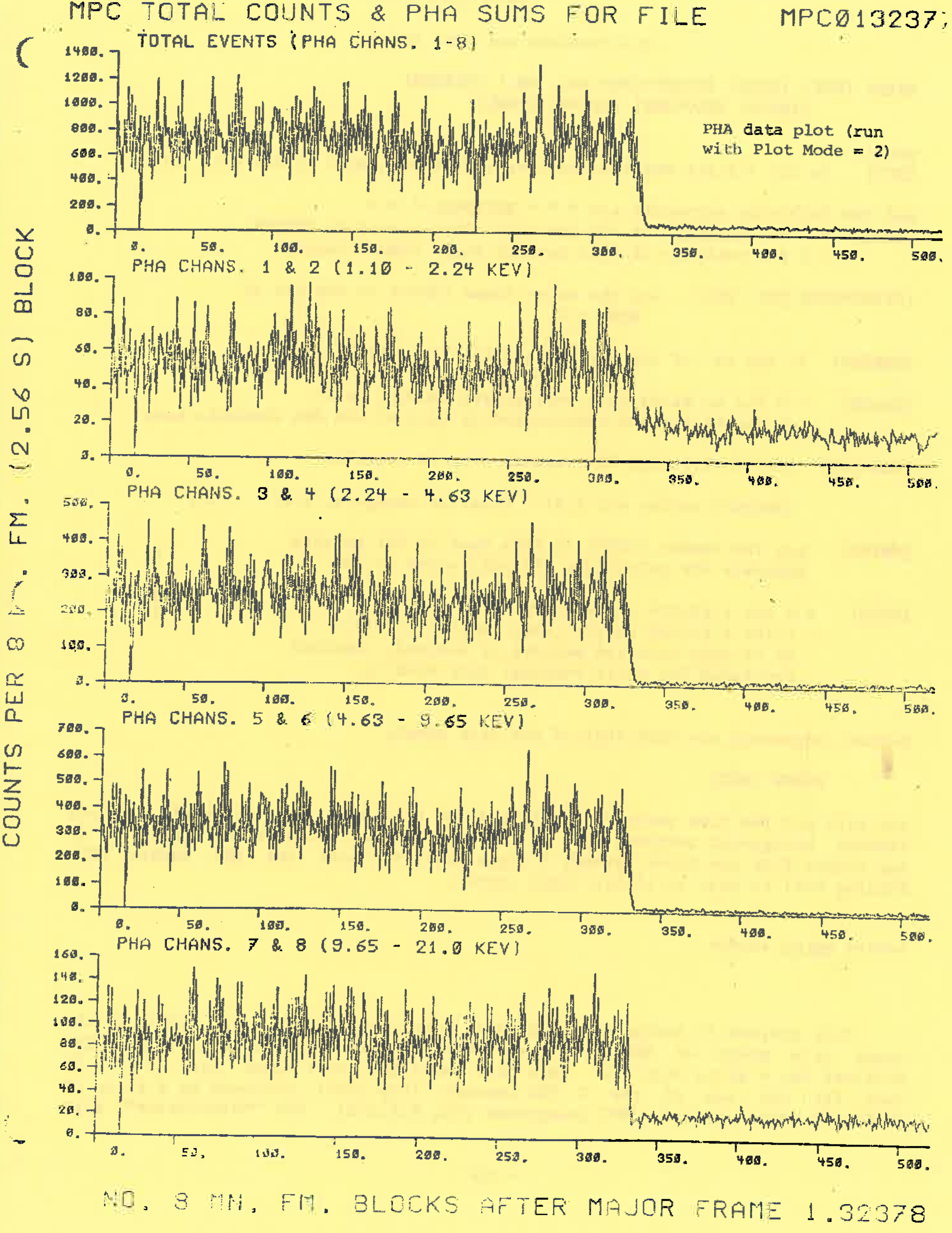
you will get the time variability analysis of all the 8 PHA channels (summed) without background subtraction. Bursts will be identified if the count rate in any single 2.56 sec block exceeds 5 sigma above the mean for the entire HUT. Folding will be done in 10-bin light curves.

## ****** 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

F6.3.2/2

MPCPLT OUTPUT



PHA data plot (run with Plot Mode = 2)

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<br>MPC[HUT].HDR |
| Output files produced: | MPC[HUT].PLT |
| Parameter file used: | MPLOT.PF |

* * * * 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 bkgnd. plots (normal plot)
= 2 for PHA sums by pairs
= 3 for PHA channels 1-5 (only)
= 4 for PHA channels 6-8 and bkgnd. 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

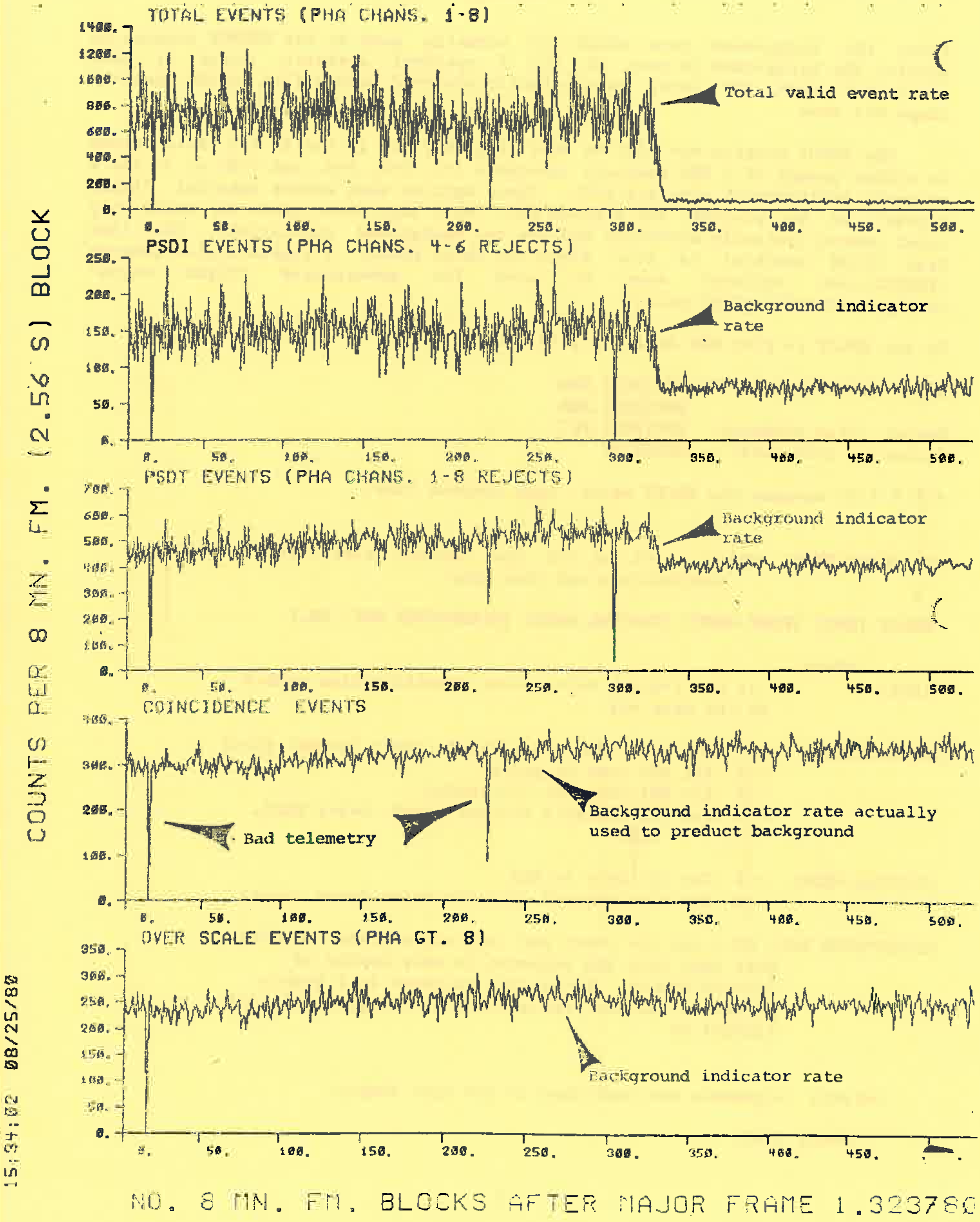
```
MPLOT [HUT]
```

F6.3.2/3

MPCPLT OUTPUT

5.3

MPC PHA AND BKGN. DATA FOR FILE MPC0132377



Total valid event rate

Background indicator rate

Background indicator rate

Bad telemetry

Background indicator rate actually used to preduct background

Background indicator rate

you will get the normal production plot (PHA sum and 4 bkgnd. 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: PSDPLT.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]}
```

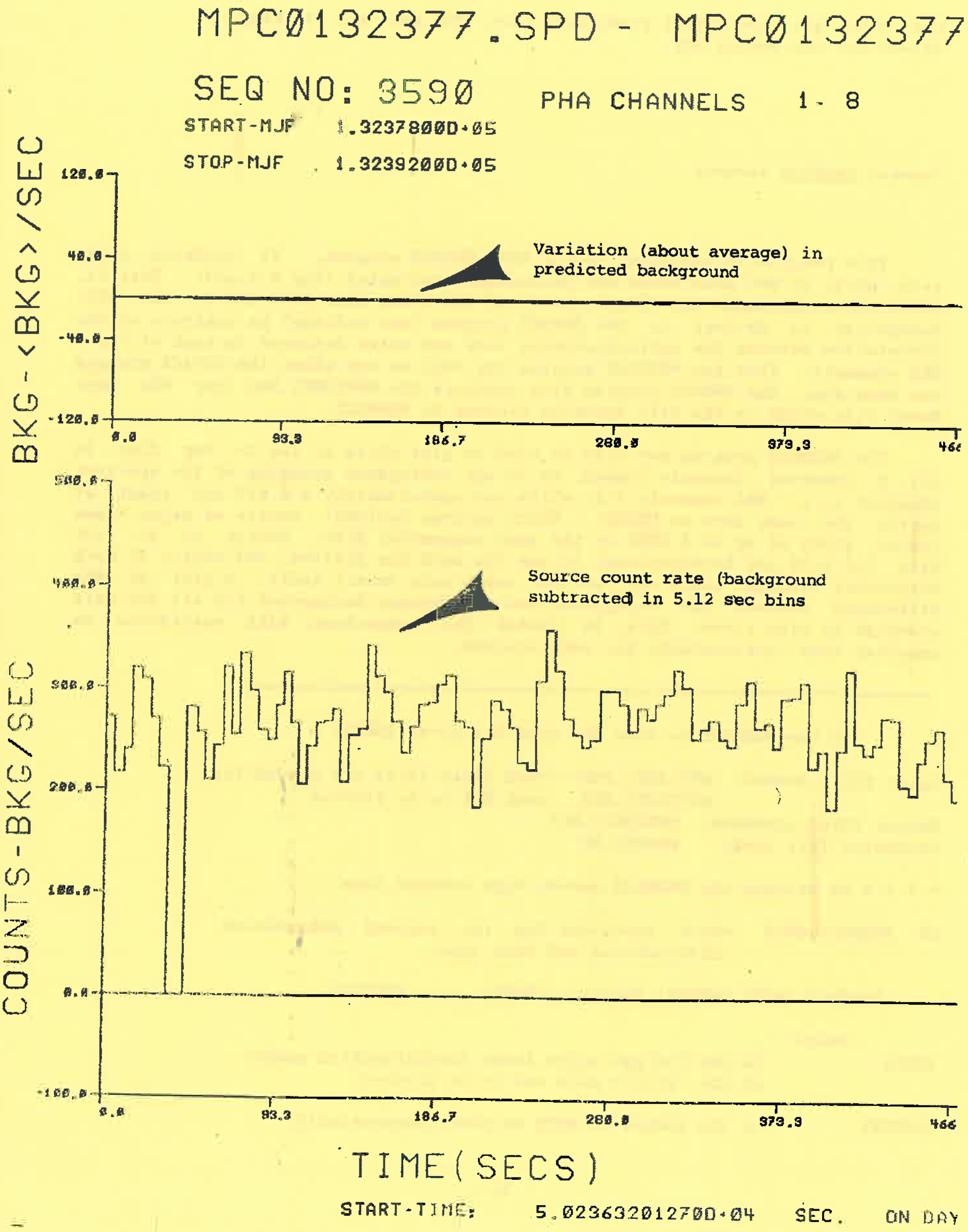
where:

[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) ε

F6.3.2/4

## SPDPLT OUTPUT



Variation (about average) in predicted background

Source count rate (background subtracted) in 5.12 sec bins

**[NBINS]** is the no. of 2.56 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.D0* 1234569D0.

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 (REV0) TIP processing system remains unchanged and there are currently no plans to revise it. Because the REV1 and REV0 systems generate different files with different formats it is necessary to run the REV0 system to do the TIP analysis. This requires getting the raw data (---.PRD 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 quicklook 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
```

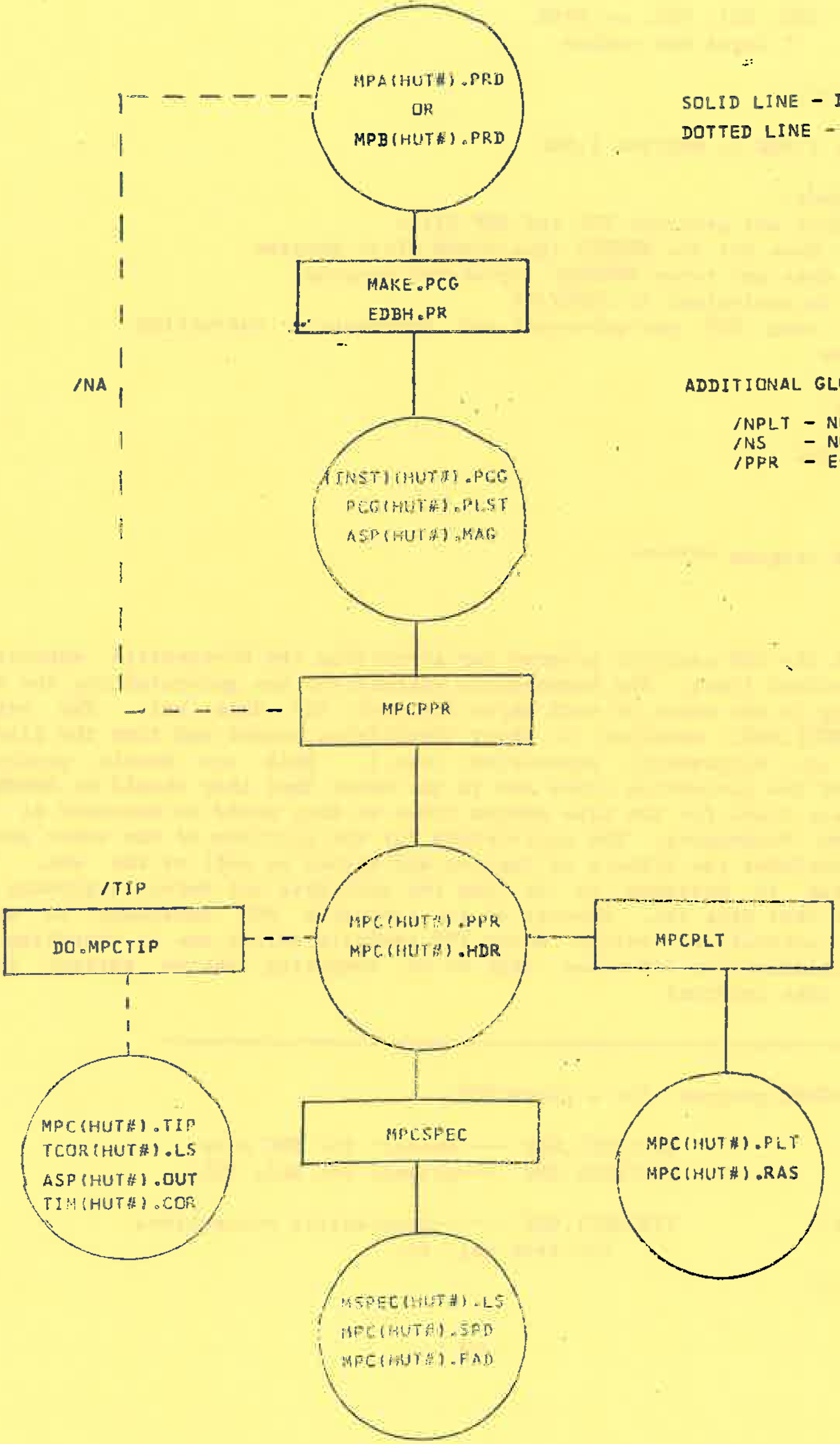
**** MPCPROC.HELP ******

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

Execution :

F6.3.4/1

MPCPROC.CLI



SOLID LINE - DEFAULT PATHWAY
DOTTED LINE - OPTION VIA GLOBAL SWITCH

ADDITIONAL GLOBAL SWITCHES:

/NPLT - NO MPCPLT
/NS - NO MPCSPEC
/PPR - EQUALS /NPLT/NS

```
     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
     /PPR - 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].PPR  ---primary MPC data file

Output files:            TIM[HUT].COR ------barycentric corrections
                                for each maj. fm.
```

**Parameter files:** HEAOB.PF
MPCSPEC.PF

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

```
TCORR [HUT]
```

where:

[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 TCORR 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 TCORR

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:

| | |
|---|---|
| [BUT] | 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

```
MPC TIP ANALYSIS OF DATA USING HEADER FILE MPC0132377.HDR  AND CORRESPONDING MPC-------.TIP FILE

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

Start, stop major frames accepted for low background by MPCSPEC

```
WARNING - 2 CODE ONES IN A ROW


    NUMBER OF EVENTS=    33279.
     INTEGRATION TIME=   144.410
           COUNT RATE=   230.448
```

**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 TIPTRE.
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 WAS =      .00028
THE AVERAGE NUMBER OF COUNTS PER BIN ON THIS SCALE WAS =   6.35E-02
TIME SCALE FOR EACH SECTION =     9.02563(S)
 COUNTS EACH SECTION 2129. 1997. 2208. 2110. 2269. 2090. 2309. 2163. 2414. 2264. 2186. 1948. 1650. 1990. 1621. 1930.
              .00028   4.1   3.0   5.1   2.0    .7    .7   1.7   1.7   3.0   -.0   4.3   3.6   3.3   3.0   2.4   3.3
              .00055   5.3   2.8   3.5   2.2    .7   1.5   3.6   1.9   3.6    .7   5.7   4.9   3.1   4.1   3.9   4.8
              .00110   5.7   6.2   5.9   2.8   2.4   2.0   4.4   4.1   3.3   1.3   7.9   6.3   3.8   6.3   4.1   6.2
              .00220   8.2   9.0   7.9   4.7   6.2   4.4   5.1   6.2   4.3   3.3  10.2   8.9   4.5   9.2   7.5   9.8
              .00441  10.9  12.7  11.3   8.5   8.8   6.0   9.1   7.9   6.8   4.6  13.6  12.8   7.3  12.1   8.2  14.2
              .00881  15.8  16.8  16.4  13.1  13.5   7.1  13.2  11.8  10.7   6.6  18.8  19.1  10.8  16.4  13.2  20.1
              .01763  22.2  24.5  21.8  18.4  19.5  11.1  18.8  17.4  15.2  10.4  28.0  24.2  17.3  22.4  21.1  29.0
              .03526  30.0  32.3  29.5  24.9  23.8  17.1  26.0  24.6  21.5  15.2  37.1  34.8  23.5  31.6  30.6  39.0
              .07051  41.5  43.8  39.0  33.7  32.3  23.7  35.8  33.7  28.6  21.9  51.7  47.8  31.0  44.4  43.1  53.7
              .14103  54.8  59.8  52.4  42.4  44.3  30.2  45.3  46.1  35.6  26.7  70.2  61.8  41.5  61.9  55.9  76.5
              .28205  64.4  65.1  63.9  45.8  50.9  39.5  53.4  45.4  37.2  31.5  91.9  79.2  54.4  73.4  69.8  78.7
              .56410  80.4  82.4  64.3  57.0  45.7  40.7  45.1  30.4  23.8  31.1  54.9  73.1  63.0  66.2  52.8  52.5
             1.12820  86.3  68.2  62.9  33.8  48.2  45.6  44.9  29.5   2.9  15.3  46.3  36.1  43.8  40.1  58.7  43.5
             2.25641  47.5  26.7  46.4  11.9  13.0  47.7   4.2  15.4   5.0  10.3  49.5  12.8  15.1   7.2  31.3   5.5
```

Chosen so that minimum of 0.1 counts/bin is satisfied

Integration time per bin

```
TIME SCALE FOR EACH SECTION =    18.05125(S)
 COUNTS EACH SECTION 4126. 4318. 4359. 4472. 4678. 4134. 3640. 3551.
              .00028   5.0   5.0   1.0   2.5   2.2   5.7   4.6   4.2
              .00055   5.9   4.1   1.6   3.9   3.1   7.6   5.3   6.3
              .00110   8.4   6.2   3.1   6.0   3.3  10.2   7.5   7.6
              .00220  12.1   9.0   7.6   8.0   5.4  13.7  10.3  12.6
              .00441  16.7  14.0  10.6  12.2   8.1  18.8  14.4  16.5
              .00881  23.0  20.9  14.8  17.7  12.4  26.9  20.1  24.4
              .01763  33.1  28.5  22.0  25.7  18.3  37.3  29.0  36.4
              .03526  44.1  38.5  29.2  35.9  26.2  51.3  40.4  50.5
              .07051  60.3  51.5  40.1  49.3  35.9  71.0  55.5  70.1
              .14103  80.8  67.0  53.3  64.6  44.4  94.1  76.1  96.1
              .28205  91.1  77.3  64.3  69.8  48.7 121.7  93.6 107.0
              .56410 113.6  84.7  61.0  53.3  38.5  89.9  94.0  76.5
             1.12820 106.5  66.7  65.3  51.9  12.9  59.0  62.6  73.6
             2.25641  49.9  39.0  40.5  13.6  10.9  45.5  22.3  29.5
             4.51281  10.1  12.4  21.9  11.2  11.8  16.2  20.9  10.6
TIME SCALE FOR EACH SECTION =    36.10251(S)
 COUNTS EACH SECTION 8444. 8831. 8812. 7191.
              .00028   7.1   2.5   5.5   6.2
              .00055   7.0   3.9   7.5   8.2
              .00110  10.3   6.5   9.4  10.6
              .00220  14.9  11.0  13.3  16.2
              .00441  21.7  16.1  18.8  21.8
              .00881  31.1  23.1  27.5  31.4
              .01763  43.5  33.8  39.0  46.2
              .03526  58.3  46.1  54.4  64.2
```

**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 pulsar) is highly variable on all time scales, especially ~0.5 sec. This is the time scale for rapid changes in the pulse profile

```
          .07051  78.9   63.2   75.0   88.6
          .14103 104.2   83.3   97.0  121.4
          .28205 118.6   94.5  118.9  141.2
          .56410 138.9   80.2   90.7  119.8
         1.12820 120.3   81.5   52.1   94.7
         2.25641  61.2   36.8   43.1   35.4
         4.51281  15.6   21.7   26.9   20.8
         9.02563   3.2    4.3   19.8   23.2
TIME SCALE FOR EACH SECTION =   72.20502(S)
 COUNTS EACH SECTION17275.16003.
          .00028   6.7    8.4
          .00055   7.7   11.3
          .00110  11.8   14.5
          .00220  18.3   21.3
          .00441  26.7   29.4
          .00881  38.2   42.7
          .01763  54.5   61.5
          .03526  73.8   85.7
          .07051 100.4  118.3
          .14103 132.4  157.6
          .28205 150.4  189.1
          .56410 153.9  156.4
         1.12820 141.6  114.5
         2.25641  68.8   75.8
         4.51281  27.0   62.7
         9.02563   6.9   71.5
        18.05125   4.7   81.3
TIME SCALE FOR EACH SECTION =  144.41000(S)
 COUNTS EACH SECTION33278.
          .00028  10.7
          .00055  13.4
          .00110  18.6
          .00220  28.0
          .00441  39.8
          .00881  57.3
          .01763  82.3
          .03526 112.9
          .07051 154.8
          .14103 205.3
          .28205 240.3
          .56410 221.0
         1.12820 184.1
         2.25641 105.5
         4.51281  67.5
         9.02563  60.6
        18.05125  67.1
        36.10251  86.8
```

Longest section is total integration time; shorter sections of "tree" are powers of 2 shorter than this 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 MPCPPR, 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 results


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 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

```
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. 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

[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

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. cts./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 writeup). Output listing file is called MPSER[HUT].LS, however.

* * * * To execute the TIPANAL4 program, type the command line

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

```
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 MTBIN[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).

Default arguments are such that if you type simply

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

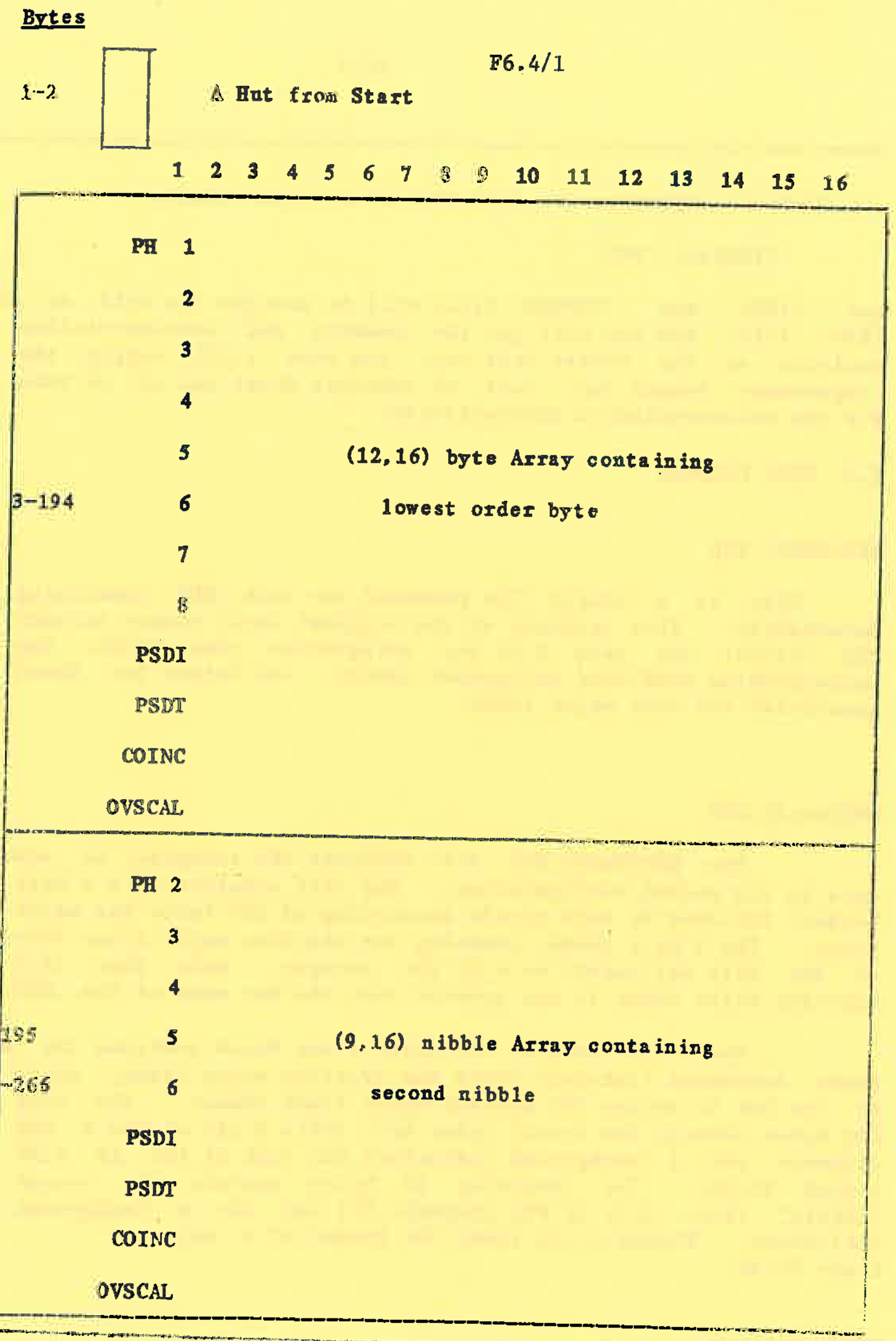
The MPC[Hut#].DAT file contains the accepted 'on source' data in its packed configuration. The file consists of a 4 byte header, followed by data blocks consisting of 266 bytes per major frame. The 4 byte header contains the starting major frame (words 48-49 of the Data Set Label) as a 32 bit integer.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

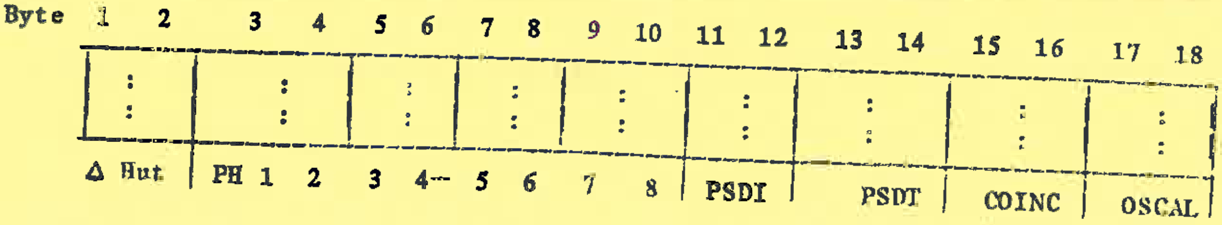
### MPC[hut#].BAC

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

F6.4/1


Bytes
1-2
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
6
7
8
PSDI
PSDT
COINC
OVSCAL
3-194
(12,16) byte Array containing
lowest order byte
PH 2
3
4
5
6
PSDI
PSDT
COINC
OVSCAL
195
-266
(9,16) nibble Array containing
second nibble

F6.4/2


Byte 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Δ Hut
PH 1 2 3 4-- 5 6 7 8
PSDI
PSDT
COINC
OSCAL

of 18 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 .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 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[hut#].BLK**

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

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

| | |
|---|---|
| 32 | spare |

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.

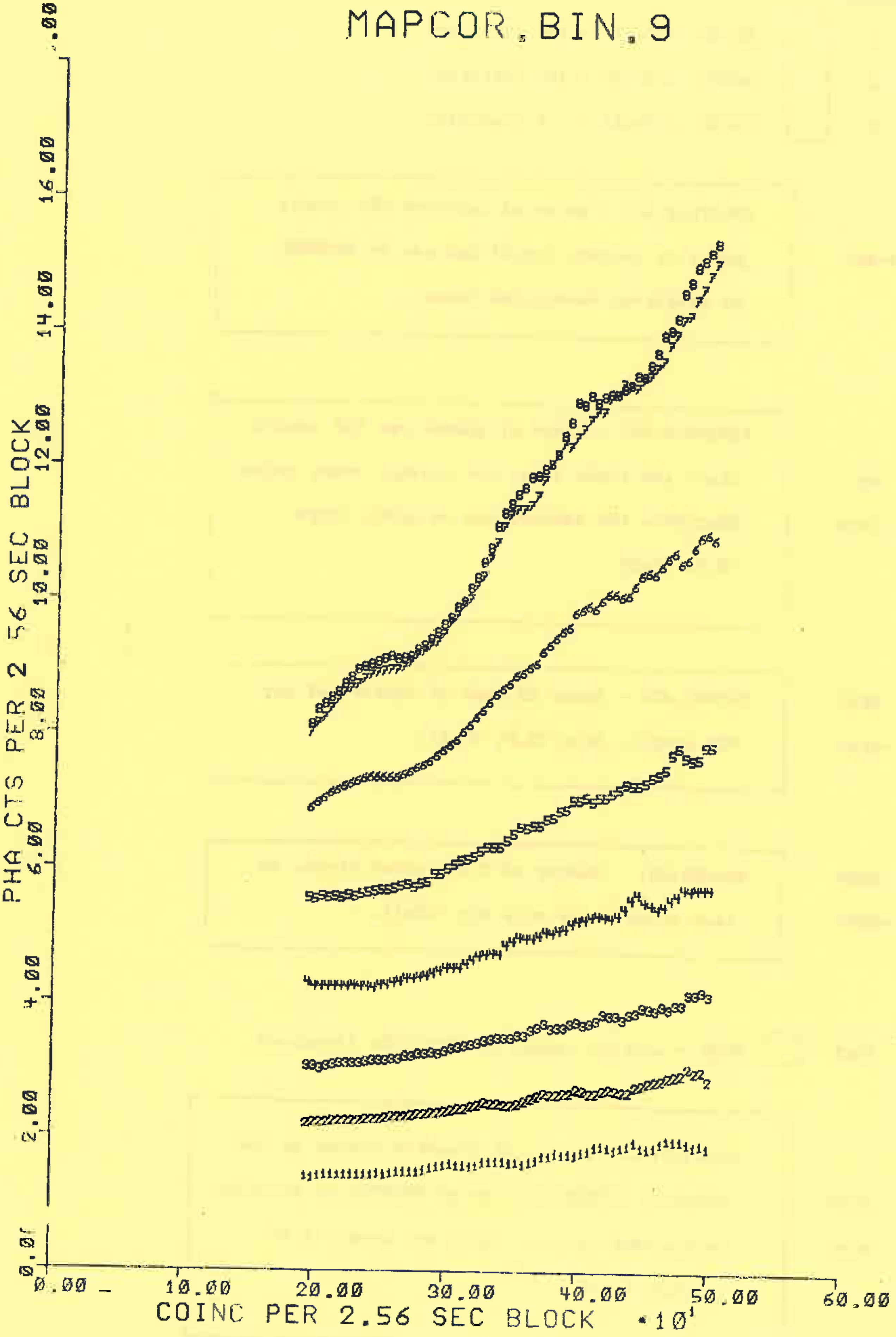
### SPECTBL#.DAT

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 gaunt factor), and (4) Blackbody. The format is:

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

| Words | |
|---|---|
| 1 | MINCO: default = 200 (integer) |
| 2 | MAXCO: default = 500 (integer) |
| 3 | ISTEP: default = 5 (integer) |
| 4-995 | SMOOTH(8,62) - Array of smoothed PHA counts per 2.56 seconds (real) for use by MPCSPEC as predicted background rates. |
| 995 -2979 | 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). |
| 2980 -4963 | PHSQ(8,62) - Array of sums of squares of raw PHA counts. Also (D.P. real). |
| 4964 -5087 | BLOCKS(62) - Number of 2.56 second blocks in each coincidence rate bin (real). |
| 5088 | NMAP - version number of this file (integer). |
| 5089 -6080 | 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). |

F6.4/4


MAPCOR, BIN, 9
PHA CTS PER 2.56 SEC BLOCK
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
.00
COINC PER 2.56 SEC BLOCK *10¹
0.00
10.00
20.00
30.00
40.00
50.00
60.00
1
2
3
4
5
6
7
8

.

.

NA blocks = number of power law indicies

| Words | |
|---|---|
| 1 | MINCO: default = 200 (integer) |
| 2 | MAXCO: default = 5 (integer) |
| 3 | ISTEP: default = 5 (integer) |
| 4-995 | SMOOTH(8,62) - Array of smoothed PHA counts per 2.56 seconds (real) for use by MPCSPEC as predicted background rates. |
| 995 -2979 | 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). |
| 2980 -4963 | PHSQ(8.62) - Array of sums of squares of raw PHA counts. Also (D.P. real). |
| 4964 -5087 | BLOCKS(62) - Number of 2.56 second blocks in each coincidence rate bin (real). |
| 5088 | NMAP - version number of this file (integer). |
| 5089 -6080 | 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). |

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