XRONOS

A Timing Analysis Software Package
User's Guide

Version 3.01

L. Stella [1,2,*], L. Angelini [3,2,*]

[1] Osservatorio Astronomico di Brera, Via Brera 28, 20121 Milano, Italy
[2] EXOSAT Observatory, Astrophysics Division, Space Science Department of ESA,
ESTEC, Keplerlaan 1, 2200 AG Noordwijk, The Netherlands
[3] University Space Research Association, NASA GSFC, Greenbelt, MD 20771, USA
[*] Affiliated to ICRA

June 1993

Contents

Chapter 1

Introduction

XRONOS is a general purpose timing analysis package. Although it was designed mostly for X-ray astronomy, XRONOS is basically detector and wavelength-independent. It has been used to analyse data from the Einstein Observatory, EXOSAT and Ginga, as well as optical photometry and helioseismology data. It includes programs for: light curve(s), hardness ratio and colour-colour plotting, epoch folding, power spectrum, autocorrelation, cross-correlation, time skewness and statistical analysis.

XRONOS consists of a collection of programs, each dedicated to one task, which can be run from the control environment provided by the `xronos` program. The program `xronos` is characterised by 3 different user interfaces: a QUESTION/ANSWER user interface, a PARTIAL QUESTION/ANSWER user interface and a COMMAND-DRIVEN user interface. Command files are supported by the question/answer and command-driven user interfaces of XRONOS. XRONOS applications can be run in their command-driven fashion within the EXOSAT Database System.

The new user is advised to read chapter 2 (`overview`), which gives an overview of XRONOS, and chapter 3 (`walk_through`), which is a walk-through of a XRONOS session. XRONOS uses the `QDP/PLT` plotting package which is described briefly in Appendix A and in more detail in the QDP/PLT User's Guide (Tennant 1990).

1.1 Timing analysis

This manual describes in detail the algorithms and features of XRONOS; obviously, it is not a treatise on the technique of timing analysis. Some references describing the relevant techniques are given. If the user is completely new to the field, he should first talk to an expert.

1.2 History

XRONOS is a descendant of a series of timing analysis programs written at the EXOSAT Observatory to analyse interactively the EXOSAT data on Hewlett Packard Series 1000 minicomputers. The development of XRONOS started in 1987 during the post operational phase of the EXOSAT project. XRONOS was designed to provide a timing analysis package as independent of the detectors as possible, so that it could be used for future missions with few if any changes. Some of the original design characteristics of XRONOS were deeply influenced by the experience with the analysis of large sets of high time resolution EXOSAT data. In order to limit the number of page folds, while retaining the array sizes needed, e.g., for the fast Fourier transform (FFT) of large data sets, it was decided that XRONOS should consist of a collection of programs, each dedicated to one task. Preference was initially given to a question/answer user interface.

A preliminary version of XRONOS was developed under UNIX on a Hewlett Packard 9000 computer. This was ported to VAX/VMS in 1988 to make XRONOS produce light curves within the EXOSAT database system. A test version of XRONOS, including only a small number of applications, was presented at the the first EXOSAT Database Workshop in December 1988. In response to suggestions by participants XRONOS was made more user-friendly and a command/driven user interface added which could speed up the work of experienced users. The number of XRONOS applications grew rapidly in 1989. Since early 1990 all XRONOS applications can be run from the control environment provided by the program `xronos`, which is characterised by 3 different user interfaces: a question/answer user interface, a simplified, partial question/answer user interface and a command-driven user interface. Moreover, all XRONOS applications are available in a command-driven fashion within the EXOSAT Database System. An intermediate version of XRONOS was presented at the Second EXOSAT Database Workshop in February 1990.

Version 3.00 (July 1992) was the first complete portable version of XRONOS and runs on VAX/VMS and SUN, DEC and NEXT UNIX machines. The current version (4.02) extends XRONOS to include FITS input and output file support.

1.3 Future

XRONOS is currently being interfaced to FITS tables and to the Xanadu Parameters Interface (XPI) library. The latter will make both command driven as well as standalone XANADU (and XRONOS) tasks easier to write, will complement them with a graphic user interface, and will allow standalone tasks to run under IRAF. Future applications will include:

- Searches for coherent periodicities both with power spectrum and epoch folding techniques
- Pulse phase and period determination for light curves with a coherent signal and orbital solutions
- Display and analysis of `time images`
- Cross spectrum analysis
- Alternative Power spectrum and correlation technique in the presence of sparse and/or non-equispaced data
- Fractal analysis

1.4 Acknowledgements

The XRONOS code and help files currently consist of about 25,000 lines, most of which were written by L. Stella. The development of XRONOS has been carried out by L. Stella at the following institutes:

- EXOSAT Observatory (ESTEC, NL) from mid 1987 to February 1989;

- Department of Physics of the University of Rome (I) from March 1989 to August 1989;
- EXOSAT Observatory (ESTEC, NL) from September 1989 to December 1989;
- Brera Astronomical Observatory (Milan, I) from January 1990 onwards;

L. Angelini has given major contributions to XRONOS, first developing the test routines to read `rate buffers` into XRONOS (in collaboration with R. Shafer), then carrying out a very high number of tests on the power spectrum and epoch folding analysis programs and, more recently, producing the portable version of XRONOS at NASA/GSFC. P. Giommi, A. Parmar, A. Pollock, G. Tagliaferri, M. van der Klis and N. White provided several fortran routines and a number of suggestions. Useful suggestions and bug reports were also provided by a number of other people. C. Day carefully read and corrected an earlier version of this guide.

1.5 Contact Person

Further information about XRONOS can be obtained from Luigi Stella at

- Brera Astronomical Observatory, Via Brera 28, 20121 Milano, Italy
- Telephone: +39-2-72023751/9
- Fax: +39-2-72001600
- SPAN: ASTMIB::STELLA (or, equivalently, 39216::STELLA)

or from Lorella Angelini at

- NASA GSFC, Code 668, Greenbelt, MD 20771, USA
- Telephone: +1-301-286-3607
- Fax: +1-301-286-9240
- SPAN: HEASRC::ANGELINI (or, equivalently, 15735::ANGELINI)
- Internet: angelini@maruko.gsfc.nasa.gov

XRONOS is currently available on magnetic tape kit (800/1600/6250 BPI, TK50, TK70 or EXABYTE) or for remote installation via computer network. For VAX/VMS installations please contact L. Stella; for UNIX installations please contact L. Angelini.

Chapter 2

Overview

XRONOS consists of a set of programs which are accessed by the control program `xronos`. This is invoked from the operating system by typing `xronos`. There are 3 different user interfaces which can be used within XRONOS:

- QUESTION/ANSWER user interface, in which the user specifies input files and analysis parameters by answering individual questions;
- PARTIAL QUESTION/ANSWER user interface, in which input filenames are specified only once and analysis parameters are entered by replying to questions;
- COMMAND-DRIVEN user interface, in which applications are run by entering a command string followed by qualifiers and arguments

Inexperienced users are advised to start with the question/answer user interfaces.

`Xronos` issues a `Xronos>` prompt from which commands are entered. In the question/answer user interfaces (the default), after entering a command corresponding to a XRONOS application, each question is written on the screen followed by a `=>` prompt. Defaults, where relevant, are indicated in square brackets. In the command-driven user interface the execution of a XRONOS application is controlled by specifying qualifiers in the command string. The XRONOS help file is accessed by entering `help` from any XRONOS prompt. Operating system commands can be given from within XRONOS by prefixing the command with `$`. A set of XRONOS commands in a file can be input using `@filename` from the `Xronos>` prompt. Note that all commands (not replies to questions !) can be abbreviated to unique strings. Comments can be included in any reply or command line if they are prefixed with an exclamation mark `!`.

2.1 Reading data

XRONOS is designed to read in time series from many (up to 50) consecutive input files (this is to avoid wasting disk space by chaining many input files in a single file). Time series from up to 3 different energy ranges can be handled simultaneously within XRONOS. Additional flexibility is provided by Input File Options, which are used, e.g. to perform algebraic operations on individual input files, shift times, apply barycentric time corrections etc.

In the question/answer user interface input data are specified by entering the input filenames, one by one, in response to the relevant questions. In the partial question/answer and command-driven user interfaces the input files are specified using the `data` command. Currently, two different kinds of input files are supported: Rate Buffers (with extension `.rbf`), which are binary files (4 different formats are available), and QDP files, which are ASCII files written according to the QDP/PLT standard. XRONOS input files can either contain binned data or unbinned data (i.e. input files containing the arrival times of individual photons).

2.2 Applications

XRONOS applications are the subset of XRONOS commands which are used to carry out different types of analysis. The following XRONOS applications are available:

- `lda` - List DAta in input (header and points)
- `asc` - convert binary file to ASCII
- `lc1` - plot Light Curve for 1 time series
- `lc2` - plot Light Curve and ratio for 2 time series
- `lc3` - plot Light Curve and ratios for 3 series (and colour-colour)
- `sta` - STatistical Analysis
- `win` - create/read/change a window file
- `ef1` - Epoch Folding for 1 time series
- `ef2` - Epoch Folding and ratio for 2 time series
- `ef3` - Epoch Folding and ratios for 3 series (and colour-colour)
- `efs` - Epoch Folding Search for periodicities
- `qdp` - plot a QDP file
- `psd` - Power Spectrum Density analysis with FFT
- `pss` - Power Spectrum density analysis with Slow direct FT
- `acf` - Auto Correlation Function with fast method
- `acs` - Auto Correlation function with Slow method
- `ccf` - Cross Correlation Function with fast method
- `ccs` - Cross Correlation function with Slow method
- `tss` - Time Skewness function with Slow method

Note that a number of applications include utilities to rebin the results of the analysis either by using a constant or a logarithmic step and to remove (or analyse) various types of trends from the input series.

2.3 Terminology

Within XRONOS the user has full control of the binning to be used in the analysis, the way of subdividing a time series and/or grouping the results of the analysis. To this aim four basic entities are used in most XRONOS applications:

- BINS : these are the time bins of the time series which is/are being analysed. Note that there can be more than one bin durations, (e.g. two consecutive time series, one with 0.5 s bins and the other with 2 s bins). In the examples in chapter 3 (`walk_through`) the input files contain 743 bins of 1 s.
- NEWBINS : these correspond to the time resolution with which the analysis is carried out. One of the examples in section 3.1.2 (`walk question psd`) shows how to calculate a power spectrum using a 3 s resolution, i.e. newbins of 3 s. Note that: (i) newbins cannot be shorter than the longest bin duration of the time series which is/are being analysed; (ii) in many XRONOS applications (e.g. `psd`, `pss`, `acf`, `ccf`) the newbin duration is forced to be an integer multiple of the longest bin duration.
- INTERVALS : an interval is defined by the number of newbins over which the analysis is carried out. One of the examples in section 3.1.2 (`walk question psd`) shows how to calculate power spectra for intervals of 64 newbins of 3 s, corresponding to 32 independent Fourier frequencies. Note that in applications using FFT algorithms (e.g. `psd`, `acf`, `ccf`) the number of newbins in an interval must be a power of 2.
- FRAMES : a frame consists of the average of the results of the analysis of one or more contiguous intervals. Each XRONOS QDP file and, therefore, each plot produced by XRONOS corresponds to a frame. The examples in section 3.1.2 (`walk question psd`) show how to average the power spectra from 1, 2 or 4 intervals (each of 64 newbins of 3 s) in a frame. Note that in certain applications (e.g. `lc1`, `lc2` and `lc3`), a frame consists always of one interval.

2.4 Windows

There are 4 different types of windows which can be specified within XRONOS: time, phase, intensity and exposure windows. In applications requiring more than one input series (e.g. a cross-correlation analysis) intensity and exposure windows are specified separately for each series. Intensity and exposure windows can be specified separately for bins, newbins and intervals. Command `win` is to create, read or change XRONOS window files (default extension `.wi`). Many XRONOS application use some default exposure windows, which are designed to avoid analysing data sets which are too inhomogeneous with respect to their statistical properties.

2.5 Plotting

Most XRONOS applications create a XRONOS QDP File containing the results of the analysis carried out with a XRONOS application. These files have a `.qXXX` extension, where `XXX` is the relevant XRONOS application (e.g. files created with application `psd` have extension `.qpsd`), and contain the results from ONE Frame only. Plotting within XRONOS is performed through QDP/PLT by using the interface provided by these files. By default XRONOS applications plot results from one frame automatically and return either to the execution of the rest of the analysis (if any) or to the XRONOS prompt. Alternatively, by replying `interactive` to the relevant question in the question/answer user interfaces or by using the `/plt` qualifier in the command-driven user interface, the user is left in the interactive plotting mode (`PLT>` prompt) to allow customisation of the plot. A number of other plot options can be specified by replying to the relevant questions in the question/answer user interfaces, or by using dedicated qualifiers in the command-driven user interface. In particular, a stack of QDP/PLT commands written in a file can be applied to each plot. The plot device to be used is set at the beginning of a XRONOS session or by using the command `cpd` (change plot device) from the XRONOS prompt.

2.6 Global Parameters

Additional flexibility is achieved by using a number of global parameters controlling the XRONOS session. These are specified by running command `cpf` (change parameter file). XRONOS global parameters are designed to:

- control the chattiness of XRONOS applications
- write to a application log file all the interactions with XRONOS applications and specify the application log file chattiness
- change the default output filename root and i/o status
- replace data gaps with a moving average of the light curve(s)
- force a given start time in the analysis
- calculate errors bars for the results of various types of analysis by propagating theoretical error bars or by direct evaluation of the scatter around the mean values in a frame
- analyse window functions
- normalise the results in various ways
- force strict simultaneity in time series from two or three energy bands, e.g. for cross-correlation analysis
- specify special windows for burst analysis
- specify a rescaling factor and an additive constant for the results

2.7 Getting help

XRONOS has an interactive help facility which is accessed by the `help` command from the XRONOS prompt, or by replying `help` to any question asked by a XRONOS application.

2.8 Miscellaneous

All output to the screen can be written to log files. Separate files are written for the output from the control program `xronos` (log files, extension `.log`, see command `log`) and from XRONOS applications (application log files, extension `.alog`, see global parameter number 3). The level of output to the screen and to the log file of XRONOS applications can be controlled (see global parameter number 1 and 2). XRONOS commands can be written into an ASCII file (script files, extension `.xco`, see command `script`) and then invoked from the `xronos` prompt by using an `@` symbol in front of the filename.

The commands `recall` and `reexecute` can be used, respectively, to recall a previous command and to reexecute several previous commands in any order. Commands from previous XRONOS session are also accessible through `recall`. The `buffer` command will invoke command line recall by using the line recall key on the terminal. The major advantage of this command is that it allows the recalled command to be edited.

In the question/answer user interfaces, each application can be terminated by entering an "end of file" (`cntl z` in VMS, `cntl d` in UNIX) in response to any question, or by entering an interruption (`cntl y` in VMS, `cntl c` in UNIX) during execution. XRONOS can be terminated by the `bye`, `exit` or `quit` commands.

Chapter 3

Walk through

In this section we run through a fictitious XRONOS session to illustrate some of the commands and their usage in the various user interfaces. The input files required for this session are distributed together with XRONOS and can be found in the xanadu:[xronos.tut] directory. Startup up XRONOS on your machine in the above directory by typing `xronos` from the operating system prompt. You will see a banner giving useful information, followed by the XRONOS prompt:

```
Welcome to Xronos                        5-JUL-1992 18:07:40     V. 3.00 Jul 92

                                                    Type "help" for information



[1]Xronos>
```

The number in square brackets identifies each of the XRONOS commands that you enter. (The command `recall` followed by `n` will execute again the n-th command.)

If a default plot device is not yet defined for your session, or if you need to change it, type `cpd` (change plot device):

```
[1]Xronos> cpd
Current plot device is /HQ2393
Device names are preceded by a slash
e.g. /te for tektronics
Enter plot device [? for a list]:
```

If you reply ? to the question above you will see the list of available PGPLOT devices and you will be asked again for one:

```
Enter plot device [? for a list]: ?
%PGPLOT, PGPLOT v4.9
%PGPLOT, Copyright 1989 California Institute of Technology
%PGPLOT, Legal PGPLOT device types are:
%PGPLOT, /GF (GraphOn)     /GRINNELL        /GTERM           /HIDMP
%PGPLOT, /HQ2393           /IKON            /NULL            /PAINTJET
```

```
%PGPLOT, /PS                /PRINTRONIX       /RETRO            /TEK4010
%PGPLOT, /TFILE             /VERSATEC         /VPS              /VT125
%PGPLOT, /VVERSATEC         /WS1              /X11 (Landscape)
Graphics device/type (? to see list): /vt125
```

3.1 Question/Answer walk through

On entering XRONOS the default user interface is Question/Answer; you can check that by typing `cui` (change user interface) and replying `q` to the question:

```
[2]Xronos> cui
Current user interface is :            question/answer
Enter user interface (? to see list)=> q
Current user interface is :            question/answer
```

3.1.1 lc1

Now plot the light curve of file `a2030.rbf` (from the 42 s pulsar EXO2030+375) with application `lc1` (this example is useful to learn how to use BINS, NEWBINS and INTERVALS). User's replies follow the `=>` prompt; defaults are indicated in square brackets and allowed replies (where relevant) in curly brackets:

```
[3]Xronos> lc1
>>>> Program lc1          5-JUL-1992 19:15:07        Xronos vers. 3.00 Jul 92

     Enter up to  50 input filenames and options for series 1 (or rtn)
lc1> Ser. 1 filename   1 +options[.rbf]=> a2030

Source ............EXO 2030+40    +   Start Time ........1985 302  15:59: 4
Bin Time (s) ......   1.000           Stop  Time ........1985 302  16:11:20
No. of Points .....         743       Experiment ........   EXOSAT ME
Instrum., OBC rec..     AR , E5       Detectors on Source       5-  8
PHA Bin range .....       2- 16       Detectors on Bkgd..       1-  4

lc1> Ser. 1 filename   2 +options[.rbf]=>
```

`lc1` displays a summary of the header information of the file, including the BIN duration, and prompts for another filename; a carriage return implies that no other file is specified. Carry on entering carriage returns in response to the other questions, in order to use default values:

```
lc1> Window Options ?          {y/n}[n]=>

   0 Time,     0 Phase,     0 Intensity,     2 Exposure Windows


Expected Start ...   302.66604129903  (days)      15:59: 5:968  (h:m:s:ms)
Expected Stop ....   302.67464446032  (days)      16:11:29:281  (h:m:s:ms)
```

```
Minimum Newbin Time    1.0000000      (s)
Maximum Newbin No..               744
Default Newbin Time    1.4534868      (s) (to have 1 Intv. of    512 Newbins)
```

lc1 displays the expected start and stop times of the series to be analysed and the minimum newbin time which can be used in the analysis. In the example above, since only one input file is used, this corresponds to the duration of the BINS in the input file (i.e. 1 s). (If there were more than one input files, the minimum newbin time would be the longest BIN duration of all input files). The maximum number of expected newbins corresponds to the minimum newbin time. The default NEWBIN time is chosen so as to produce a single light curve (i.e.the light curve from a single interval) of 512 points. Note that in the case of lc1 the NEWBIN time need not be a multiple of the minimum newbin time. lc1 then prompts the user for the duration of the NEWBINS to be used in the light curve:

```
lc1> Enter Newbin Time(s) or neg. rebinning
     of Min. Newbin Time [   1.453    ]=>

Newbin Time ......     1.4534868      (s)
Maximum Newbin No.                512    (or      1 Intvs. of       512 Newbins)
```

A single INTERVAL containing a maximum of 512 newbin is thus expected. lc1 then prompts for the number of NEWBINS which define an INTERVAL (the default is to have intervals of 512 newbins at most):

```
lc1> No. of Newbins/Intv.  (max: 65536)
     {value or neg.pow.of 2}[      512]=>

Maximum of      1 Intvs. with       512 Newbins of       1.45349     (s)

lc1> Order of polynomial trend removal
           {0=none,1=1st,....,4=4th}[0]=>
lc1> Time axis units
       {0=s from start,1=s,2=h,3=d} [1]=>
lc1> Enter output filename
     [xronos.qlc1                    ]=>
lc1> Plot options ?            {n/y}[n]=>

Intv    1   Start  302 15:59: 6
    Ser.1     Avg  42.83        Chisq  3685.       Var  329.1     Newbs.  511
              Min -7.916          Max  117.1    expVar  49.47      Bins   743
            Light curve ready !
Frme    1   Written to output file : xronos.qlc1
```

lc1 produces a summary of statistical quantities relevant to the interval, writes the light curve to file xronos.qlc1 and automatically plots it by using QDP/PLT:

```
            Plot done !

>>>> Program lc1           5-JUL-1992 19:16:29          Normal termination
[4]Xronos>
```

`lc1` terminates and the XRONOS prompt is issued again.

Repeat the procedure above, this time by using a NEWBIN time of 2 s and INTERVALS of 100 newbins (i.e. 200 s):

```
lc1> Enter Newbin Time(s) or neg. rebinning
     of Minimum Bin Time [   1.453    ]=> 2.

Newbin Time ......     2.0000000      (s)
Maximum Newbin No.               372    (or      1 Intvs. of       372 Newbins)

lc1> No. of Newbins/Intv.  (max: 65536)
     {value or neg.pow.of 2}[      372]=> 100

Maximum of      4 Intvs. with       100 Newbins of       2.00000     (s)
```

`lc1` now produces 4 subsequent intervals containing 100 newbins at maximum: for each of them a summary of the statistical quantities is output and a light curve file written and plotted automatically by QDP/PLT:

```
Intv    1   Start  302 15:59: 6
    Ser.1     Avg  43.54        Chisq  931.5       Var  310.3     Newbs.   100
              Min -2.285          Max  100.2    expVar  33.31      Bins    200
            Light curve ready !
Frme    1   Written to output file : xronos.qlc1
            Plot done !
Intv    2   Start  302 16: 2:26
    Ser.1     Avg  42.78        Chisq  1171.       Var  369.0     Newbs.   100
              Min  12.92          Max  116.0    expVar  31.51      Bins    200
            Light curve ready !
Frme    2   Written to output file : xronos.qlc1
            Plot done !
Intv    3   Start  302 16: 5:46
    Ser.1     Avg  48.18        Chisq  810.5       Var  280.2     Newbs.   100
              Min  19.68          Max  96.27    expVar  34.58      Bins    200
            Light curve ready !
Frme    3   Written to output file : xronos.qlc1
            Plot done !
Intv    4   Start  302 16: 9: 6
    Ser.1     Avg  34.69        Chisq  375.6       Var  142.1     Newbs.    72
              Min  9.541          Max  66.42    expVar  27.51      Bins    143
            Light curve ready !
Frme    4   Written to output file : xronos.qlc1
            Plot done !

>>>> Program lc1           6-JUL-1992 16:40:15          Normal termination
```

In order to leave QDP/PLT in the interactive plotting mode (`PLT>` prompt) after each plot and allow customisation, reply as follows to the relevant questions:

```
lc1> Plot options ?            {n/y}[n]=> y
lc1> Plot results ?            {y/n}[y]=>
lc1> Interactive or automatic? {i/a}[i]=> i
lc1> Pgplot device   [/vt125          ]=>
lc1> Specify QDP command file? {y/n}[n]=>
```

To get on line help about QDP/PLT, enter `help` from the `PLT>` prompt. QDP/PLT is terminated by `exit` or `quit`.

3.1.2 psd

Now calculate the power spectrum of file `c2030.rbf` with application `psd` (this example is useful to learn how to use also FRAMES). Defaults are used after the input filename:

```
[5]Xronos> psd
>>>> Program psd         6-JUL-1992 18:32:27        Xronos vers. 3.00 Jul 92

     Enter up to  50 input filenames and options for series 1 (or rtn)
psd> Ser. 1 filename   1 +options[.rbf]=> c2030

Source ............EXO 2030+40    +   Start Time ........1985 302  15:59: 4
Bin Time (s) ......   1.000           Stop  Time ........1985 302  16:11:20
No. of Points .....         743       Experiment ........   EXOSAT ME
Instrum., OBC rec..     AR , E5       Detectors on Source       5-  8
PHA Bin range .....       2- 36       Detectors on Bkgd..       1-  4

psd> Ser. 1 filename   2 +options[.rbf]=>
psd> Window Options ?          {y/n}[n]=>

   0 Time,     0 Phase,    0 Intensity,    3 Exposure Windows

Expected Start ...   302.66604129903  (days)      15:59: 5:968  (h:m:s:ms)
Expected Stop ....   302.67464446032  (days)      16:11:29:281  (h:m:s:ms)
Minimum Newbin Time    1.0000000      (s)
Maximum Newbin No..             744
Default Newbin Time    1.0000000      (s) (to have 1 Intv. of   1024 Newbins)

++++ Warning: Newbin Time must be an integer multiple of Minimum Newbin Time
```

Note the difference with respect to the case of `lc1`: the NEWBIN time must be an integer multiple of the minimum newbin time (this is in order to avoid beats between the bin and newbin times). Moreover the default NEWBIN time in `psd` is such as to produce a single interval of 4096 newbins at most. `psd` uses an FFT algorithm and the number of newbins in an interval must be a power of 2.

```
psd> Enter Newbin Time (s) or neg.rebinning
     of Min. Newbin Time [   1.000    ]=>

Newbin Time ......     1.0000000      (s)
```

```
Maximum Newbin No.               744    (or      1 Intvs. of      1024 Newbins)

psd> No. of Newbins/Intv.  (max: 65536)
     (it must be a power of 2)
     {value or neg.pow.of 2}[     1024]=>

Maximum of      1 Intvs. with      1024 Newbins of       1.00000     (s)
```

Only one INTERVAL of 1024 NEWBINS is expected, the power spectrum of which will be calculated. This will consist of 512 independent Fourier frequencies, i.e. 512 analysis results. Since there is only one INTERVAL, there will be only one FRAME containing the results from that interval:

```
psd> No. of Intvs per Frame     [    1]=>
psd> Rebin results ? {>1= const. rebin,
     <-1= geom. reb, 0= no reb}[  0.00]=>

Results from up to      1 Intvs. will be averaged in a Frame

psd> Order of polynomial trend removal
           {0=none,1=1st,....,4=4th}[0]=>
psd> Enter output filename
     [xronos.qpsd                     ]=>
psd> Plot options ?            {n/y}[n]=>

   512 analysis results per interval


Intv    1   Start  302 15:59: 5
    Ser.1     Avg  78.43        Chisq  7342.       Var  1243.     Newbs.   743
              Min -2.481          Max  298.2    expVar  125.7      Bins    743
            Power spectrum ready !
Frme    1   Written to output file : xronos.qpsd
            Plot done !
```

The power spectrum is calculated, written to file `xronos.qpsd` and plotted automatically with QDP/PLT. Then `psd` terminates

```
>>>> Program psd          6-JUL-1992 18:33:08          Normal termination

[6]Xronos>
```

Repeat the example above by using a NEWBIN time of 3 s and INTERVALS of 64 newbins (i.e. 192 s):

```
psd> Enter Newbin Time (s) or neg.rebinning
     of Min. Newbin Time [   1.000    ]=> 3.

Newbin Time ......     3.0000000      (s)
Maximum Newbin No.               248    (or      1 Intvs. of       256 Newbins)
```

```
psd> No. of Newbins/Intv.  (max: 65536)
     (it must be a power of 2)
     {value or neg.pow.of 2}[      256]=> 64

Maximum of      4 Intvs. with        64 Newbins of       3.00000     (s)
```

In this case up to 4 INTERVALS of 64 NEWBINS are expected. The default is to calculate the power spectrum for each interval (32 independent Fourier frequencies) and average the 4 power spectra to produce the power spectrum of a FRAME (i.e. the default is again to produce a single frame):

```
psd> No. of Intvs per Frame     [    4]=>
psd> Rebin results ? {>1= const. rebin,
     <-1= geom. reb, 0= no reb}[  0.00]=>

Results from up to      4 Intvs. will be averaged in a Frame
```

The average spectrum from the 4 intervals is written to file `xronos.qpsd` and plotted automatically with QDP/PLT.

Repeat the same example, but produce a power spectrum for each interval (i.e. each FRAME will consist of 1 INTERVAL only):

```
psd> No. of Intvs per Frame     [    4]=> 1
psd> Rebin results ? {>1= const. rebin,
     <-1= geom. reb, 0= no reb}[  0.00]=>

Results from up to      1 Intvs. will be averaged in a Frame
```

4 power spectra will be produced and plotted.

Repeat the same example, but produce this time an average power spectrum for each group of two INTERVALS (i.e. each FRAME will consist of two INTERVALS):

```
psd> No. of Intvs per Frame     [    4]=> 2
psd> Rebin results ? {>1= const. rebin,
     <-1= geom. reb, 0= no reb}[  0.00]=>

Results from up to      2 Intvs. will be averaged in a Frame
```

2 power spectra will be produced and plotted.

`psd` and many other XRONOS applications include a facility to rebin the results of the analysis. To see the way this is done consider again the first `psd` example above: a single spectrum of 512 independent Fourier frequencies is produced. In order to artificially decrease the Fourier resolution by a factor of four and obtain a power spectrum with 128 frequencies (i.e. rebin the results by four) reply:

```
psd> Rebin results ? {>1= const. rebin,
     <-1= geom. reb, 0= no reb}[  0.00]=> 4

Results from up to      1 Intvs. will be averaged in a Frame
```

```
Results will be rebinned by a factor of    4.01
```

There is also a way of rebinning a power spectrum in a "differential" way in which frequency bins are nearly equispaced in a log-frequency representation (useful for studying continuum power spectrum components): this is done by specifying a negative number (usually from -1.1 to -1.4) whose modulus represents the step of the geometric series used to work out the rebinning factor, step by step. To do this reply:

```
psd> Rebin results ? {>1= const. rebin,
     <-1= geom. reb, 0= no reb}[  0.00]=> -1.2

Results from up to      1 Intvs. will be averaged in a Frame

Results will be rebinned geometrically  with a series of step    1.20
```

In this case the power spectrum is rebinned to 25 frequency bins; note the spectrum is now plotted automatically in a log-log scale.

3.1.3 lc2

Now plot the soft and hard light curves of the 42 s pulsar EXO2030+375 and their ratio: the corresponding files are `a2030.rbf` and `b2030.rbf`. This is done with application `lc2` (this example is useful to learn how to use different SERIES): user's replies follow the `=>` prompt:

```
[7]Xronos> lc2
>>>> Program lc2          7-JUL-1992 11:19:27         Xronos vers. 3.00 Jul 92

     Enter up to  50 input filenames and options for series 1 (or rtn)
lc2> Ser. 1 filename   1 +options[.rbf]=> a2030

Source ............EXO 2030+40    +   Start Time ........1985 302  15:59: 4
Bin Time (s) ......   1.000           Stop  Time ........1985 302  16:11:20
No. of Points .....         743       Experiment ........   EXOSAT ME
Instrum., OBC rec..     AR , E5       Detectors on Source       5-  8
PHA Bin range .....       2- 16       Detectors on Bkgd..       1-  4
```

SERIES 1 is the `soft` series: after entering `a2030` press carriage return to indicate that there are no other input files for series 1:

```
lc2> Ser. 1 filename   2 +options[.rbf]=>
```

`lc2` then prompts for the 1st input file of SERIES 2 (the `hard` series)

```
     Enter up to  50 input filenames and options for series 2 (or rtn)
lc2> Ser. 2 filename   1 +options[.rbf]=> b2030

Source ............EXO 2030+40    +   Start Time ........1985 302  15:59: 4
Bin Time (s) ......   1.000           Stop  Time ........1985 302  16:11:20
```

```
No. of Points .....          743      Experiment ........   EXOSAT ME
Instrum., OBC rec..      AR , E5      Detectors on Source       5-  8
PHA Bin range .....       17- 36      Detectors on Bkgd..       1-  4

lc2> Ser. 2 filename   2 +options[.rbf]=>
```

After entering `b2030` press carriage return to indicate that there are no other input files for series 2. From this point onwards the example closely parallels the first example given for `lc1` except for the additional plot options (see below) and the summary of statistical information of each interval which, in the case of `lc2`, is given separately for the two series:

```
Intv    1   Start  302 15:59: 6
    Ser.1     Avg  42.83       Chisq  3685.       Var  329.1     Newbs.   511
              Min -7.916         Max  117.1    expVar  49.47      Bins    743

    Ser.2     Avg  35.58       Chisq  3182.       Var  283.1     Newbs.   511
              Min-0.1958         Max  106.8    expVar  48.55      Bins    743
            Light curves ready !
Frme    1   Written to output file : xronos.qlc2
            Plot done !

>>>> Program lc2           7-JUL-1992 11:22:11          Normal termination
```

The two light curves and their ratio are written to file `xronos.qlc2`, and plotted automatically vs. time with QDP/PLT. Then `lc2` terminates and the XRONOS prompt is issued again.

In order to leave QDP/PLT in the interactive plotting mode (`PLT>` prompt) and plot the hardness ratio of the two light curves vs. the sum of the two light curves reply as follows to the relevant questions:

```
lc2> Plot options ?            {n/y}[n]=> y
lc2> Plot results ?            {y/n}[y]=>
lc2> Interactive or automatic? {i/a}[i]=> i
lc2> Pgplot device   [/vt125          ]=>
lc2> Specify QDP command file? {y/n}[n]=>
lc2> Hardness vs. intensity ?  {n/y}[n]=> y
lc2> Series 1, 2 or sum on X-axis ?
                       {0,1,2} [sum=0]=>
```

In order to plot the sum of the light curves and their ratio vs. time in an automatic fashion, reply as follows:

```
lc2> Plot options ?            {n/y}[n]=> y
lc2> Plot results ?            {y/n}[y]=>
lc2> Interactive or automatic? {i/a}[i]=> a
lc2> Pgplot device   [/vt125          ]=>
lc2> Specify QDP command file? {y/n}[n]=>
lc2> Hardness vs. intensity ?  {n/y}[n]=>
lc2> Plot only light curves ?  {n/y}[n]=>
lc2> Plot hdns and summed l.c.?{n/y}[n]=> y
```

3.2 Partial Question/Answer walk through

Move to the partial question/answer user interface by typing:

```
[8]Xronos> cui p
Current user interface is :           partial question/answer
```

The partial question/answer user interface is designed to avoid specifying the input filename(s) every-time a XRONOS application is run. Rather input filenames are entered and stored using the `data` command. The same files used in the previous section are specified by typing:

```
[9]Xronos> data
     Enter up to  50 input filenames and options for series 1 (or rtn)
     Ser. A filename   1 +options[.rbf]=> c2030

Source ............EXO 2030+40    +   Start Time ........1985 302  15:59: 4
Bin Time (s) ......   1.000           Stop  Time ........1985 302  16:11:20
No. of Points .....         743       Experiment ........   EXOSAT ME
Instrum., OBC rec..     AR , E5       Detectors on Source       5-  8
PHA Bin range .....       2- 36       Detectors on Bkgd..       1-  4

     Ser. A filename   2 +options[.rbf]=>
     Enter up to  50 input filenames and options for series 2 (or rtn)
     Ser. B filename   1 +options[.rbf]=> a2030

Source ............EXO 2030+40    +   Start Time ........1985 302  15:59: 4
Bin Time (s) ......   1.000           Stop  Time ........1985 302  16:11:20
No. of Points .....         743       Experiment ........   EXOSAT ME
Instrum., OBC rec..     AR , E5       Detectors on Source       5-  8
PHA Bin range .....       2- 16       Detectors on Bkgd..       1-  4

     Ser. B filename   2 +options[.rbf]=>
     Enter up to  50 input filenames and options for series 3 (or rtn)
     Ser. C filename   1 +options[.rbf]=> b2030

Source ............EXO 2030+40    +   Start Time ........1985 302  15:59: 4
Bin Time (s) ......   1.000           Stop  Time ........1985 302  16:11:20
No. of Points .....         743       Experiment ........   EXOSAT ME
Instrum., OBC rec..     AR , E5       Detectors on Source       5-  8
PHA Bin range .....      17- 36       Detectors on Bkgd..       1-  4

     Ser. C filename   2 +options[.rbf]=>


[10]Xronos>
```

Note that in this way files `c2030.rbf`, `a2030.rbf` and `b2030.rbf` have been associated to SERIES A, B and C, respectively. Equivalently, all filenames could have been entered from the XRONOS prompt as follows:

```
[10]Xronos> data c2030,,a2030,,b2030
```

Note that a single comma separates input files from the same series, a double comma input files from different series. The current input filename setup is checked by typing:

```
[11]Xronos> data/show

Series A :  file  1 : C2030

Series B :  file  1 : A2030

Series C :  file  1 : B2030
```

In order to repeat the `lc1` examples in the previous section by using the partial question/answer user interface, you should type:

```
[12]Xronos> lc1 b
```

By doing this the input file(s) which is the `data` command associated with SERIES B (i.e. `a2030.rbf`) will be used as input files for `lc1` (i.e. SERIES 1)

```
>>>> Program lc1          7-JUL-1992 16:41:40         Xronos vers. 3.00 Jul 92

     Enter up to  50 input filenames and options for series 1 (or rtn)
lc1> Ser. 1 filename   1 +options[.rbf]=> A2030

Source ............EXO 2030+40    +   Start Time ........1985 302  15:59: 4
Bin Time (s) ......   1.000           Stop  Time ........1985 302  16:11:20
No. of Points .....         743       Experiment ........   EXOSAT ME
Instrum., OBC rec..     AR , E5       Detectors on Source       5-  8
PHA Bin range .....       2- 16       Detectors on Bkgd..       1-  4

lc1> Ser. 1 filename   2 +options[.rbf]=>
lc1> Window Options ?          {y/n}[n]=>

xrask> EOF in input string
lc1> Window Options ?          {y/n}[n]=>
```

From this point onwards the execution of `lc1` proceeds as in the previous section.

Similarly, in order to repeat the `psd` examples in the previous section type:

```
[13]Xronos> psd a
```

or, more simply:

```
[14]Xronos> psd
```

By doing this the input file(s) which the `data` command associated with SERIES A (i.e. `c2030.rbf`) will be used as input file(s) for `psd` (i.e. SERIES 1); after that you can reply to individual questions as in the question/answer user interface.

In order to repeat the `lc2` examples of the previous section:

```
[15]Xronos> lc2 b c
```

By doing this the input file(s) associated to SERIES B and SERIES C with the `data` command (i.e. `a2030.rbf` and `b2030.rbf`, respectively) will be used as the `soft` (i.e. SERIES 1) and `hard` (i.e. SERIES 2) input files for `lc2`, respectively.

3.3 Command-Driven walk through

Move to the partial command-driven user interface by typing:

```
[16]Xronos> cui c
Current user interface is :            command driven
```

Input filename(s) are entered by using the `data` command, as in the partial question/answer user interface. The same input files as in the previous section are used in the examples below. To check the specified input file type:

```
[17]Xronos> data/show

Series A :  file  1 : C2030

Series B :  file  1 : A2030

Series C :  file  1 : B2030
```

3.3.1 lc1

In order to use file `a2030.rbf` (SERIES B) and repeat the first `lc1` example you should type:

```
[18]Xronos> lc1 b
```

The difference in this case is that, after the input filenames, all default values are taken automatically and `lc1` is executed. The following summary is output:

```
Maximum of      1 Intvs. with       512 Newbins of       1.45349     (s)

Intv    1   Start  302 15:59: 6
    Ser.1     Avg  42.83        Chisq  3685.       Var  329.1     Newbs.   511
              Min -7.916          Max  117.1    expVar  49.47      Bins    743
            Light curve ready !
Frme    1   Written to output file : xronos.qlc1
```

before the light curve is plotted and the XRONOS prompt is issued again.

In the command-driven user interface the execution of a XRONOS application is controlled by QUALIFIERS. To display the list of allowed qualifiers for `lc1` type:

```
[19]Xronos> lc1/?

 Allowed qualifiers are:

/CMDQDPFILE    /FULLINFO      /HEADER        /IMAGE
/LPARM         /NBINS         /NINT          /NOECHO
/NOPLOT        /OUTFILE       /PLT           /TNEWBIN
/TREND         /TRENDMODE     /TUNIT         /WINDOW
```

The `/FULLINFO` qualifier will run `lc1` displaying the same information as in the question/answer user interfaces; type:

```
[20]Xronos> lc1/fullinfo b
```

The `/HEADER` qualifier will display the same information, but without executing the `lc1` command; this is especially useful for checking the `lc1` set up in the command-driven user interface:

```
[21]Xronos> lc1/header b
>>>> Program lc1         9-JUL-1992 13:25:55        Xronos vers. 3.00 Jul 92

     Enter up to  50 input filenames and options for series 1 (or rtn)
lc1> Ser. 1 filename   1 +options[.rbf]=> A2030

Source ............EXO 2030+40    +   Start Time ........1985 302  15:59: 4
Bin Time (s) ......   1.000           Stop  Time ........1985 302  16:11:20
No. of Points .....         743       Experiment ........   EXOSAT ME
Instrum., OBC rec..     AR , E5       Detectors on Source       5-  8
PHA Bin range .....       2- 16       Detectors on Bkgd..       1-  4

lc1> Ser. 1 filename   2 +options[.rbf]=>
lc1> Window Options ?         {y/n}[n]=>                              ! WINDOW

   0 Time,    0 Phase,    0 Intensity,    2 Exposure Windows

Expected Start ...   302.66604129903  (days)      15:59: 5:968  (h:m:s:ms)
Expected Stop ....   302.67464446032  (days)      16:11:29:281  (h:m:s:ms)
Minimum Newbin Time    1.0000000      (s)
Maximum Newbin No..              744
Default Newbin Time    1.4534868      (s) (to have 1 Intv. of    512 Newbins)

lc1> Enter Newbin Time (s) or neg.rebinning
     of Min. Newbin Time [   1.453    ]=>                       ! TNEWBIN,NINT

Newbin Time ......     1.4534868      (s)
Maximum Newbin No.               512    (or      1 Intvs. of       512 Newbins)
```

```
lc1> No. of Newbins/Intv.  (max: 65536)
     {value or neg.pow.of 2}[      512]=>                              ! NBINS

Maximum of      1 Intvs. with      512 Newbins of       1.45349     (s)

lc1> Order of polynomial trend removal
           {0=none,1=1st,....,4=4th}[0]=>                              ! TREND
lc1> Time axis units
       {0=s from start,1=s,2=h,3=d} [1]=>                              ! TUNIT
lc1> Enter output filename
     [xronos.qlc1                   ]=>                        ! OUTFILE,IMAGE

lc1> Plot options ?           {n/y}[n]=> y
lc1> Plot results ?           {y/n}[y]=> y                            ! NOPLOT
lc1> Interactive or automatic? {i/a}[i]=> a                              ! PLT
lc1> Pgplot device   [/vt125         ]=>
lc1> Specify QDP command file? {y/n}[n]=>                         ! CMDQDPFILE
```

The `/LPARM` (`list parameters`) qualifier does the same thing, except that the input file(s) information is not displayed. Note that the qualifiers controlling the replies to individual questions are indicated on the right hand side after the exclamation mark.

Now run `lc1` on the same file, this time by using a NEWBIN time of 2 s and INTERVALS of 100 newbins (i.e. 200 s); add the `/LPARM` to check that the set up is correct:

```
[22]Xronos> lc1/tnewbin=2./nbins=100/lparm b
```

If you are satisfied with the setup remove the `/lparm` qualifier and execute `lc1` (note that qualifiers can be abbreviated as long as the remain unambiguous):

```
[23]Xronos> lc1/tn=2./nb=100/lparm b
```

In order to leave QDP/PLT in the interactive plotting mode (`PLT>` prompt) after each plot and allow customisation, add the `/PLT` qualifier:

```
[24]Xronos> lc1/tn=2./nb=100/plt b
```

3.3.2 psd

Now calculate the power spectrum of file `c2030.rbf` (SERIES A) with application `psd`

```
[25]Xronos> psd/fullinfo a
```

Repeat by using a NEWBIN time of 3 s and INTERVALS of 64 : first check that the setup is correct:

```
[26]Xronos> psd/tn=3./nb=64/lparm a
```

then remove `/LPARM` and run `psd` (note that `a`, the default, can be omitted)

```
[27]Xronos> psd/tn=3./nb=64
```

The spectra corresponding to each of the 4 intervals are averaged to produce the power spectrum of a FRAME (i.e. 1 FRAME of 4 INTERVALS); this is written to file `xronos.qpsd` and plotted automatically with QDP.

Repeat by producing and plotting interactively a power spectrum for each interval (i.e. 4 FRAMES, each of 1 INTERVAL):

```
[28]Xronos> psd/tn=3./nb=64/plt/eachpsd
```

Repeat by producing an average power spectrum for each group of two intervals (i.e. 2 FRAMES each of 2 INTERVALS):

```
[29]Xronos> psd/tn=3./nb=64/plt/navpsd=2
```

Now obtain again a single power spectrum from the 1 s resolved light curve (i.e. NEWBINS of 1 s) in a single 1024 newbin INTERVAL (i.e. 512 Fourier frequencies) and decrease artificially the Fourier resolution by a factor of four by rebinning the power spectrum; first check the setup:

```
[30]Xronos> psd/rebinpsd=4/lparm
```

and then run `psd`:

```
[31]Xronos> psd/rebinpsd=4
```

Now rebin the power spectrum in a `differential` way such that the frequency bins are nearly equispaced in a log-frequency plot. To do this specify the (negative) step of the geometric series by typing:

```
[32]Xronos> psd/rebinpsd=-1.2
```

Alternatively you might specify the dedicated qualifier `/logrebinpsd`, which will use a geometric series step of about 1.19 (producing a spacing of about 1/4 of octave):

```
[33]Xronos> psd/logrebinpsd
```

3.3.3 lc2

Now plot the soft and hard light curves of the 42 s pulsar EXO2030+375 and their ratio with `lc2`: the corresponding files are `a2030.rbf` (SERIES B) and `b2030.rbf` (SERIES C).

```
[34]Xronos> lc2 b c

Maximum of      1 Intvs. with      512 Newbins of      1.45349    (s)


Intv    1   Start  302 15:59: 6
    Ser.1     Avg  42.83       Chisq  3685.       Var  329.1     Newbs.   511
              Min -7.916         Max  117.1    expVar  49.47      Bins    743

    Ser.2     Avg  35.58       Chisq  3182.       Var  283.1     Newbs.   511
```

```
              Min-0.1958          Max  106.8    expVar  48.55      Bins    743
            Light curves ready !
Frme    1   Written to output file : xronos.qlc2
```

In order to leave QDP/PLT in the interactive plotting mode (`PLT>` prompt) and plot the hardness ratio of the two light curves vs. the sum of the two light curves, type:

```
[35]Xronos> lc2/hdns/plt b c
```

In order to plot in an automatic fashion the sum of the light curves and their ratio vs. time type:

```
[36]Xronos> lc2/sumandhdns b c
```

Chapter 4

Commands

This chapter describes individual Xronos commands. Applications are the subset of XRONOS commands which are used to carry out different types of analysis. A summary of XRONOS commands follows (applications are marked with "A"):

- `?` - display command summary
- `acf` - Auto Correlation Function with fast method - A
- `acs` - Auto Correlation function with Slow method - A
- `alias` - rename a command string
- `asc` - convert binary file to ASCII - A
- `buffer` - recall a previous command with terminal recall key
- `ccf` - Cross Correlation Function with fast method - A
- `ccs` - Cross Correlation function with Slow method - A
- `cpd` - Change Plot Device
- `cpf` - Change Parameter File
- `cui` - Change User Interface
- `data` - specify input filenames and options
- `ef1` - Epoch Folding for 1 time series - A
- `ef2` - Epoch Folding and ratio for 2 time series - A
- `ef3` - Epoch Folding and ratios for 3 series (and colour-colour) - A
- `efs` - Epoch Folding Search for periodicities - A
- `lc1` - plot Light Curve for 1 time series - A
- `lc2` - plot Light Curve and ratio for 2 time series - A

- `lc3` - plot Light Curve and ratios for 3 series (and colour-colour)- A
- `lda` - List DAta in input (header and points) - A
- `log` - open/close a log file
- `psd` - Power Spectrum Density analysis with FFT - A
- `pss` - Power Spectrum density analysis with Slow direct FT - A
- `qdp` - plot a QDP file - A
- `recall` - recall a previous command
- `reexecute`- reexecute a previous command sequence
- `script` - echo commands to a file
- `sta` - STatistical Analysis - A
- `tss` - Time Skewness function with Slow method - A
- `win` - create/read/change a window file - A
- `@` - execute a command file
- `$` - execute an operating system command
- `exit` - terminate current XRONOS session
- `quit` - terminate current XRONOS session
- `bye` - terminate current XRONOS session

4.1 Command syntax

Most of the XRONOS commands corresponding to applications can be run by using three different user interfaces, characterised by different syntaxes.

In the Question/Answer user interface an application (e.g. `psd`) is executed by simply typing:

```
[n]Xronos> psd
```

In the Partial Question/Answer user interface the syntax of the same application is:

```
[n]Xronos> psd [series1]
```

where `series1` (= `a`, `b` or `c`) indicates which of the series entered with the `data` command should be used as input to `psd`. The default is `a`. If an application requires two input series (e.g. `lc2`) then:

```
[n]Xronos> lc2 [series1] [series2]
```

where `series1` (= `a`, `b` or `c`) and `series2` (= `a`, `b` or `c`) indicate which of the series entered with the `data` command should be used as the soft and hard input series of `lc2`. The default is `a b`. Similarly, for applications requiring three input series (e.g. `lc3`):

```
[n]Xronos> lc3 [series1] [series2] [series3]
```

with the default `a b c`.

In the Command-Driven user interface the syntax of Xronos application `psd` is

```
[n]Xronos> psd[/qualifier1/qual2/... etc] [series1]
```

where `/qualifier1/qual2/...` control the execution of application `psd`, and `series1` (= `a`, `b` or `c`) indicates which of the series entered with the `data` command should be used as input to `psd`. By analogy with the Partial Question/Answer user interface, if more than one input series is required then

```
[n]Xronos> lc2[/qualifier1/qual2/... etc] [series1] [series2]
```

and

```
[n]Xronos> lc3[/qualifier1/qual2/... etc] [series1] [series2] [series3]
```

4.2 About commands

All command and qualifier names can be abbreviated to the minimum number of characters required to make each unique. Commands are not case sensitive. There must be no spaces between the qualifiers, nor between the first qualifier and the command name. Command strings can be up to 255 characters long. They are continued beyond the current line by typing a minus sign followed by a carriage return `-<cr>`.

4.3 ?

Display command summary.

```
[n]Xronos> ? [string1] [string2] [......
```

displays a one-line summary of each XRONOS command. if no string is given, all of the commands are listed. Specifying also `string1`, `string2`, etc., will list those commands that match, or partially match, the string.

4.4 acf

Auto Correlation Function fast method (Application).

Application `acf` calculates the auto correlation function of a time series by using a FFT algorithm. It requires one input series. It is run in the Question/Answer user interface by typing:

```
[n]Xronos> acf
```

in the Partial Question/Answer user interface by typing:

```
[n]Xronos> acf [series1]
```

and in the Command-Driven user interface by typing:

```
[n]Xronos> acf[/qualifier1/qual2/... etc]  [series1]
```

4.4.1 More on acf

The newbin time must correspond to an integer multiple of the maximum bin time. The default newbin time is either the maximum bin time (if fewer than 512 newbins are expected) or the integer multiple of it which gives a single interval with 512 newbins at most. Due to the FFT algorithm in `acf`, the number of newbins per Interval must be a power of 2. The average count rate in each interval is subtracted from all newbins, and, before the auto correlation function is calculated, gaps and rejected newbins are replaced with zeroes.

The auto correlation error bars can only be calculated directly from the standard deviation of the average of the autocorrelations in each delay bin from different intervals, if the specified number of intervals per frame is larger than the value of global parameter number 9 (default =5); otherwise error bars are set =0. (To calculate the autocorrelation errors in each interval by propagating the newbins statistical errors use the slow algorithm autocorrelation application `acs`). Error bars are plotted by default.

The effects introduced by windows, data gaps etc. can be studied by analysing the exposure profile of the time series, by setting global parameter number 10 to 1.

4.4.2 Normalisations

The analysis normalisation flag, specified by global parameter number 11, has the following meaning for application `acf`:

- =0 autocorrelations are normalised by dividing by the number of good newbins in each interval, i.e. they are autocovariances.
- =1 (d/f); autocorrelations are normalised by dividing by the number of good newbins and the variance of newbins in each interval. Since the variance contains also the variance expected from (Poisson) noise etc. in newbins , the values of the autocorrelation for non zero time delays will be underestimated. The autocorrelation at zero time delay is =1 by definition.
- =2 non-zero (zero) delay autocorrelations are normalised by dividing by the number of good newbins and the excess variance (variance) of newbins in each interval. Since the effects due to the variance expected from Poisson noise in newbins are now removed, the autocorrelation is now normalised correctly (note that a correction of the data errors for instrument dead time effects might also be necessary; see e.g. EXOSAT ME light curves). Problems arise when, due to statistical fluctuations, the excess variance of an interval is negative. In this case in order to avoid a meaningless negative normalisation, `acf` adopts automatically normalisation number 1.

- =3 non-zero (zero) delay autocorrelations are normalised by dividing by the excess variance (variance) of newbins in each frame after averaging autocovariances. This is meant to avoid problems arising with normalisation number 2 when one or more intervals in a frame have negative excess variance. Problems arise again when, due to statistical fluctuations, the excess variance of a frame is negative. In that case, in order to avoid a meaningless negative normalisation, `acf` adopts automatically normalisation number 1. Note that a correction of the data error for instrument dead time effects might also be necessary; see e.g. EXOSAT ME light curves.

If other values than those listed above are used, they are treated as =0.

4.5 acs

Auto Correlation Function slow method (Application).

Application `acf` calculates the auto correlation function of a time series by using a slow algorithm. It requires one input series. It is run in the Question/Answer user interface by typing:

```
[n]Xronos> acs
```

in the Partial Question/Answer user interface by typing:

```
[n]Xronos> acs [series1]
```

and in the Command-Driven user interface by typing:

```
[n]Xronos> acs[/qualifier1/qual2/... etc]  [series1]
```

4.5.1 More on acs

The newbin time must correspond to an integer multiple of the maximum bin time. The default newbin time is either the maximum bin time (if fewer than 512 newbins are expected) or the integer multiple of it which gives a single interval with 512 newbins at most. The average count rate in each interval is subtracted from all newbins, and gaps and rejected newbins are replaced with zeroes, before the auto correlation function is calculated.

The auto correlation error bars are obtained either by propagating the theoretical errors bars of the autocorrelations from individual intervals (in turn obtained by propagating the newbin error bars through the autocorrelation formula) or by evaluating directly the standard deviation of the average of the autocorrelations in each delay bin from different intervals. This depends on whether the specified number of intervals per frame is, respectively, smaller or larger than the value of global parameter number 9. (default =5). Error bars are plotted by default.

The effects introduced by windows, data gaps etc. can be studied by analysing the exposure profile of the time series, by setting global parameter number 10 to 1.

4.5.2 Normalisations

The analysis normalisation flag, specified by global parameter number 11 has the same meaning as in application `acf`.

4.6 alias

Rename a command string to an alias name. Type:

```
[n]Xronos> alias[/qualifier] [name] [command_string]
```

Only one qualifier is allowed. `name` specifies the new name, `command_string` is that to be renamed. If the command string contains blanks, it must be enclosed in double quotes.

To execute an alias enter its `name`: any other character following will be appended after the command string. Moreover:

```
[n]Xronos> alias name cmd_string  !store command ‘cmd_string‘ as ‘name‘
[n]Xronos> alias/previous name    !store previously executed command as ‘name‘
[n]Xronos> alias/delete name      !delete ‘name‘ from the list of aliases
[n]Xronos> alias/show             !list available aliases
[n]Xronos> alias/show c*          !list available aliases beginning with ‘c‘
[n]Xronos> alias/show name        !show command_string corresponding to ‘name‘
[n]Xronos> alias/?                !list allowed qualifiers
```

There are system-defined and user-defined aliases. The former are useful aliases provided for all users. If the qualifier `/system` or `/user` is given in connection with `/show`, then only those aliases are listed. User-defined aliases are stored in the file `xronos.udc` kept in the user's root directory. System defined aliases are entered by adding the `/system` qualifier (system managers only). There is currently a limit of 100 system and 100 user aliases.

4.7 asc

To write input file(s) in ASCII (application)

Application `asc` converts one or more input files to an ASCII file. It requires one input series. It is run in the Question/Answer user interface by typing:

```
[n]Xronos> asc
```

in the Partial Question/Answer user interface by typing:

```
[n]Xronos> asc [series1]
```

and in the Command-Driven user interface by typing:

```
[n]Xronos> asc[/qualifier1/qual2/... etc]  [series1]
```

4.7.1 More on asc

The ASCII output file produced by application `asc` has a default extension `.txt` and cannot be used as input to any XRONOS application. If the specified file already exists the output is appended at the end of the file. Note that any lg file option specified through global parameters number 2 and 3 is ignored by `asc`.

4.7.2 ASCII Files

Besides the file header the ASCII files produced by `asc` contain 7 columns for each bin; these are (data gaps are not output):

- Bin Counter. This counter recycles after 262144 bins.
- Centre Time of each bin in units of days.
- Centre Time of each bin in hours, minutes, seconds and milliseconds.
- Binning Time in seconds.
- Value of count rate of each bin (counts/s or other units in input file(s)).
- Error on count rate of each bin (counts/s or other units in input file(s)).
- Fractional exposure (0->1) in each bin; besides dead time effects, it includes also instrument-dependent constants (i.e. the collimator efficiency in the case of the EXOSAT ME and GS experiments, or the normalisation for the EXOSAT LE) such that, when dealing with photon counting experiments, the relevant Poisson statistics can be reconstructed.

4.8 buffer

Recall a previous command with terminal recall key

The `buffer` command will invoke command line recall using the line recall key on the terminal. To turn on the terminal recall key, type:

```
[n]Xronos> buffer on
```

The major advantage of this command (compared to `recall` and `reexecute`) is that it allows the recalled command to be edited. A list of the previous commands is obtained by typing:

```
[n]Xronos> buffer list
```

The option is turned off by typing:

```
[n]Xronos> buffer off
```

Warning: This command is terminal dependent. For some terminal types it may cause strange effects, such as the input not being echoed to the screen. If this happens, use `buffer off` to reset the terminal.

4.9 ccf

Cross Correlation Function fast method (Application).

Application `ccf` calculates the cross correlation function of a time series by using a FFT algorithm. It requires two input series. It is run in the Question/Answer user interface by typing:

```
[n]Xronos> ccf
```

in the Partial Question/Answer user interface by typing:

```
[n]Xronos> ccf [series1] [series2]
```

and in the Command-Driven user interface by typing:

```
[n]Xronos> ccf[/qualifier1/qual2/... etc]  [series1] [series2]
```

4.9.1 More on ccf

The newbin time must correspond to an integer multiple of the maximum bin time. The default newbin time is either the maximum bin time (if fewer than 512 newbins are expected) or the integer multiple of it which gives a single interval with 512 newbins at most. Due to the FFT algorithm used in `ccf`, the number of newbins per interval must be a power of 2. The average count rate in each interval is subtracted from all newbins, and gaps and rejected newbins are replaced with zeroes, before the cross correlation function is calculated.

The time delays refer to the 1st series: therefore a cross correlation function peaking for positive time delays indicates that variations in the 2nd series lag those in the 1st series.

The cross correlation error bars can only be calculated directly from the standard deviation of the average of the cross correlations in each delay bin from different intervals, if the specified number of intervals per frame is larger than the value of global parameter number 9 (default =5); otherwise error bars are set =0. (To calculate the cross correlation errors in each interval by propagating the newbins statistical errors use application `ccs`). Error bars are plotted by default.

The effects introduced by windows, data gaps etc. can be studied by analysing the exposure profile of the time series. This is done by setting global parameter number 10 to 1. By setting global parameter number 12 to 1, a strict simultaneousness between the two series can be imposed: any rejected newbin or gap found in one series will cause the corresponding newbin of the other series to be rejected. This is useful to check whether artificial time delay between the two series are introduced by a non strict simultaneousness of the two series.

Note that no result rebinning is allowed by `ccf`.

4.9.2 Normalisations

The analysis normalisation flag, specified by global parameter number 11, has the following meaning for application `ccf`:

- =0 cross correlations are normalised by dividing by the sqrt of the product of the number of good newbins of the two series in each interval, i.e. they are cross covariances.
- =1 (d/f); cross correlations are normalised as in the case =0 and by dividing also by the sqrt of the product of the newbin variances of the two series in each interval. Since the variance contains also the variance expected from (Poisson) noise etc. in newbins, all values of the cross correlation are underestimated.

- =2 cross correlations are normalized as in the case =0 and by dividing also by the sqrt of the product of the newbin excess variances of the two series in each interval. Since the effects due to the variance expected from the Poisson noise in newbins are now removed, the cross correlation is now normalised correctly (note that a correction of the data errors for instrument dead time effects might also be necessary; see e.g. EXOSAT ME light curves). Problems arise when, due to statistical fluctuations, the excess variance of an interval is negative for any of the two series. In this case in order to avoid a meaningless negative normalisation, `ccf` adopts automatically normalisation number 1.

- =3 cross correlations are normalized by dividing by the sqrt of the product of the avg. newbin excess variances of the two series in each frame after averaging cross covariances. This is meant to avoid problems arising with normalisation number 2 when one or more intervals in a frame have a negative excess variance, for any of the two series. Problems arise again when, due to statistical fluctuations, the excess variance of a frame is negative for any of the two series. In this case, in order to avoid a meaningless negative normalisation, `ccf` adopts automatically normalisation number 1. Note that a correction of the data errors for instrument dead time effects might also be necessary; see e.g. EXOSAT ME light curves.

If other values than those listed above are used, they are treated as =0.

4.10 ccs

Cross Correlation Function slow method (Application).

Application `ccs` calculates the cross correlation function of a time series by using a slow algorithm. It requires two input series. It is run in the Question/Answer user interface by typing:

```
[n]Xronos> ccs
```

in the Partial Question/Answer user interface by typing:

```
[n]Xronos> ccs [series1] [series2]
```

and in the Command-Driven user interface by typing:

```
[n]Xronos> ccs[/qualifier1/qual2/... etc]  [series1] [series2]
```

4.10.1 More on ccs

The newbin time must correspond to an integer multiple of the maximum bin time. The default newbin time is either the maximum bin time (if fewer than 512 newbins are expected) or the integer multiple of it which gives a single interval with 512 newbins at most. The average count rate in each interval is subtracted from all newbins, and gaps and rejected newbins are replaced with zeroes, before the cross correlation function is calculated.

Time delays refer to the 1st series: therefore a cross correlation function peaking for positive time delays indicates that variations in the 2nd series lag those in the 1st series.

The cross correlation error bars are obtained either by propagating the theoretical error bars of the cross correlations from individual intervals (in turn obtained by propagating the newbin errors bars through the cross correlation formula) or by evaluating directly the standard deviation of the average of the cross correlation in each delay bin from different intervals. This depends on whether the specified number of intervals per frame is, respectively, smaller or larger than the value of global parameter number 9 (default =5). Error bars are plotted by default.

The effects introduced by windows, data gaps etc. can be studied by analysing the exposure profile of the time series, by setting global parameter number 10 to 1. By setting global parameter number 12 to 1, a strict simultaneousness between the two series can be imposed: any rejected newbin or gap found in one series will cause the corresponding newbin of the other series to be rejected. This is useful to check whether artificial time delay between the two series are introduced by a non-strict simultaneousness of the two series.

4.10.2 Normalisations

The analysis normalisation flag, specified by global parameter number 11, has the same meaning as in application `ccf`.

4.11 cpd

To change default plot device. Type:

```
[n]Xronos> cpd [device]
```

In particular:

```
[n]Xronos>  cpd          !display current plot device and prompt for the new
[n]Xronos>  cpd ?        !list available plot devices and prompt for new
[n]Xronos>  cpd /device  !set plot device to '/device'
```

4.12 cpf

To change global parameters interactively. Type:

```
[n]Xronos> cpf
```

4.13 cui

To change user interface (default is question/answer). Type:

```
[n]Xronos> cui [user_interface]
```

In particular:

```
[n]Xronos> cui          !display current user interface and prompt for the new
[n]Xronos> cui ?        !list available user intefaces and prompt for the new
[n]Xronos> cui question !change user interface to questions/answer
[n]Xronos> cui partial  !change user interface to partial questions/answer
[n]Xronos> cui command  !change user interface to command driven
```

4.14 data

To handle input filenames and options for Xronos applications when using the Partial Questions/Answer or the Command-Driven user interface. Files of each series must be chronologically ordered. Only one qualifier is allowed. Type:

```
[n]Xronos> data[/qualifier] [a1,a2,,b1,,c1]
```

The compatibility of the input files, if more than one file is specified, is checked (e.g. time order, overlapping, bin durations, etc). Input files must be in chronological order. Up to 10 input file options can be specified for each input file. In particular:

```
[n]Xronos> data           !ask for input filenames (and options) for all series
[n]Xronos> data a1,a2,,b1 !input filenames (and options) from command string:
                           one comma separates files (and options) from the
                           same series, two commas separate files(and options)
                           from different series (in the example `a1` and `a2`
                           are the filenames for series A, `b1` is the
                           filenames for series B)
[n]Xronos> data/show       !list current input filenames
[n]Xronos> data/read=file  !read input filenames and options from `file.cm`
[n]Xronos> data/write=file !write input filenames and options to `file.cm`
[n]Xronos> data/?          !list allowed qualifiers
```

4.15 ef1

Epoch Folding 1 Series (Application)

Application `ef1` produces a folded light curve of one series of data. It is run in the Question/Answer user interface by typing:

```
[n]Xronos> ef1
```

in the Partial Question/Answer user interface by typing:

```
[n]Xronos> ef1 [series1]
```

and in the Command-Driven user interface by typing:

```
[n]Xronos> ef1/period=X[/qualifier1/qual2/... etc]  [series1]
```

where the `/period=` qualifier specifies the period over which the data are folded (in seconds if X>0 or days if X<0).

4.15.1 More on ef1

There are two important input parameters for folding applications: the epoch and the period over which the data will be folded. In folding applications the newbin time corresponds to the time duration of a phase bin in the folded light curve. This is determined by the chosen number of phasebins per period. The default is such as to produce a folded light curve with 128 phasebins at maximum. The newbins per interval, together with the newbin time, determines the length of the time axis (an "interval") over which each folded light curves is accumulated. Folded light curves from different intervals can be averaged in one or more frames. The default is to produce one frame only. The reason for averaging folded light curves from different intervals in a frame is to work out the error bars in the folded light curves from the standard deviation of the mean values of each phase bins. To calculate the error bars in this way global parameter number 9 (default =5) must be smaller than the specified number of intervals per frame. Note that two cycles and error bars are plotted by default.

4.15.2 Normalisations

The analysis normalisation flag, specified by global parameter number 11, has the following meaning for application `ef1`:

- =0 folded light curve are normalised to counts/s
- =1 (d/f) folded light curves are normalised by the dividing by the avg. source intensity in the frame (normalised intensity)

If other values than those listed above are used, they are treated as =0. Note the hardness ratios are not affected by the normalisation flag.

4.16 ef2

Epoch Folding 2 Series and Hardness Ratio (Application)

Application `ef2` produces a folded light curve of two series of data, and calculates and plots in various ways their hardness ratio (Series 2/Series 1). It is run in the Question/Answer user interface by typing:

```
[n]Xronos> ef2
```

in the Partial Question/Answer user interface by typing:

```
[n]Xronos> ef2 [series1] [series2]
```

and in the Command-Driven user interface by typing:

```
[n]Xronos> ef2/period=X[/qualifier1/qual2/... etc]  [series1] [series2]
```

where the `/period=` qualifier specifies the period over which the data are folded (in seconds if X>0 or days if X<0).

4.16.1 More on ef2

There are two important input parameters for folding applications: the epoch and the period over which the data will be folded. In folding applications the newbin time corresponds to the time duration of a phase bin in the folded light curve. This is determinated by the chosen number of phasebins per period. The default is such as to produce a folded light curve with 128 phasebins at maximum. The newbins per interval, together with the newbin time, determines the length of the time axis (an "interval") over which each folded light curves is accumulated. Folded light curves from different intervals can be averaged in one or more frames. The default is to produce one frame only. The reason for averaging folded light curves from different intervals in a frame is to work out the error bars in the folded light curves from the standard deviation of the mean values of each phase bins. To calculate the error bars in this way global parameter number 9 (default =5) must be smaller than the specified number of intervals per frame.

If a phasebin is rejected in any of the series, after folding the corresponding phasebins of the other series are also rejected. The default is to plot the folded light curve of series 1, series 2 and their hardness ratio vs. phase (two cycles are plotted). By specifying the relevant plot options the hardness ratio can be plotted vs. series 1 , vs. series 2, vs. series 1+2, or removed altogether.

4.16.2 Normalisations

The analysis normalisation flag, specified by global parameter number 11 has the same meaning as in application ef1.

4.17 ef3

Epoch Folding 3 Series and Colour Colour Diagram (Application)

Application `ef3` produces a folded light curve of three series of data and to calculate and plot in various ways the colour colour diagram (Ser.2/Ser.1 and Ser.3/Ser.2). It is run in the Question/Answer user interface by typing:

```
[n]Xronos> ef3
```

in the Partial Question/Answer user interface by typing:

```
[n]Xronos> ef3 [series1] [series2] [series3]
```

and in the Command-Driven user interface by typing:

```
[n]Xronos> ef3/period=X[/qualifier1/qual2/...etc] [series1] [series2] [series3]
```

where the `/period=` qualifier specifies the period over which the data are folded (in seconds if X>0 or days if X<0).

4.17.1 More on ef3

There are two important input parameters for folding applications: the epoch and the period over which the data will be folded. In folding applications the newbin time corresponds to the time duration of a phase bin in the folded light curve. This is determinated by the chosen number of phasebins per period. The default is such as to produce a folded light curve with 128 phasebins at maximum. The newbins per interval, together with the newbin time, determines the length of the time axis (an "interval") over which each folded light curves is accumulated. Folded light curves from different intervals can be averaged in one or more frames. The default is to produce one frame only. The reason for averaging folded light curves from different intervals in a frame is to work out the error bars in the folded light curves from the standard deviation of the mean values of each phase bins. To calculate the error bars in this way global parameter number 9 (default =5) must be smaller than the specified number of intervals per frame.

If a phasebin is rejected in any of the series, after folding the corresponding phasebin of the other series is also rejected. The default is to plot the three folded light curves and the two hardness ratios (colours) vs. phase (two cycles are plotted). By specifying the relevant plot options, the hardness ratios can be plotted against each other (colour-colour) or removed altogether.

4.17.2 Normalisations

The analysis normalisation flag, specified by global parameter number 11 has the same meaning as in application `ef1`.

4.18 efs

Epoch Folding Search for Periodicities (Application)

Application `efs` searches for periodicities with epoch folding in an input series. This is done folding the data over a range of periods and by searching for the maximun chi-square as a function of period. It is requires one input series. It is run in the Question/Answer user interface by typing:

```
[n]Xronos> efs
```

in the Partial Question/Answer user interface by typing:

```
[n]Xronos> efs [series1]
```

and in the Command-Driven user interface by typing:

```
[n]Xronos> efs/period=X[/qualifier1/qual2/... etc]  [series1]
```

where the `/period=` qualifier specifies the period over which the data are folded (in seconds if X>0 or days if X<0).

4.18.1 More on efs

There are two important input parameters for folding applications: the epoch and the period over which the data will be folded. In folding applications the newbin time corresponds to the time duration of a phase bin in the folded light curve. This is determinated by the chosen number of phasebins per period. The default is such as to produce a folded light curve with 32 phasebins at maximum. The newbins per interval, together with the newbin time, determines the length of the time axis (an "interval") over which a group of folded light curves is accumulated and their chi-square vs. period calculated. Note that no averaging of folded light curves in a frame is allowed: therefore each frame contains only the results from 1 interval.

The period resolutions is the spacing between two contiguous periods in the search: the default is half Fourier resolution in the interval (i.e. P*P/T(i)/2, where P is the trial period and T(i) the interval duration). If this is used a coherent periodicity will appear as a 1-2 bin broad peak in the chi-square vs. period plot.

The number of the default trial periods in the search are 128, but the number should be kept as small as possible in order to limit the execution time.

Error bars for the chi-square represent the standard deviation of the relevant chi-square distribution, rescaled by the value of the chi-square for each period divided by N-1, where N is the number of bins in the folded light curves.

4.19 lc1

Light Curve for 1 Series (Application)

Application `lc1` produces a light curve of one series of data. It is run in the Question/Answer user interface by typing:

```
[n]Xronos> lc1
```

in the Partial Question/Answer user interface by typing:

```
[n]Xronos> lc1 [series1]
```

and in the Command-Driven user interface by typing:

```
[n]Xronos> lc1[/qualifier1/qual2/... etc]  [series1]
```

4.19.1 More on lc1

The default newbin time is either the maximum bin time (if fewer than 512 newbins are expected) or such as to give a single Interval with 512 newbins at most. The number of newbins per interval determines the length of the times axis of each interval and therefore the number of intervals that will be produced. Note that in light curve applications each frame can contain only results from one interval (i.e. intervals and frames coincide; see also chapter 2 `terminology`). Four different time axis units can be used for plotting:

- 0 for seconds from the start of the interval (which might be different from the time of the first accepted newbin)
- 1 for seconds from the start of the hour
- 2 for hours from the start of the day
- 3 for days

To plot the exposure profile, instead of the light curve, set global parameter number 10 to 1.

4.20 lc2

Light Curve for 2 Series and Hardness Ratio (Application)

Application `lc2` produces a light curve of two series of data and calculates and plots in different ways the hardness ratio (Series 2/ Series 1). It is run in the Question/Answer user interface by typing:

```
[n]Xronos> lc2
```

in the Partial Question/Answer user interface by typing:

```
[n]Xronos> lc2 [series1] [series2]
```

and in the Command-Driven user interface by typing:

```
[n]Xronos> lc2[/qualifier1/qual2/... etc]  [series1] [series2]
```

4.20.1 More on lc2

The default newbin time is either the maximum bin time (if fewer than 512 newbins are expected) or such as to give a single interval with 512 newbins at most. The number of newbins per interval determines the length of the time axis of each interval and therefore the number of intervals that will be produced. Note that in light curve applications each frame can contain only results from one interval (i.e. intervals and frames coincide; see also chapter 2 `terminology`). Four different time axis units can be used for plotting:

- 0 for seconds from the start of the interval (which might be different from the time of the first accepted newbin)
- 1 for seconds from the start of the hour
- 2 for hours from the start of the day
- 3 for days

The default is to plot series 1, series 2, and hardness ratio vs. time. By specifying the relevant plot options the hardness ratio can be plotted vs series 1, vs. series 2, vs. series 1+2, or removed altogether.

4.21 lc3

Light Curve for 3 Series and Colour Colour Diagram (Application)

Application `lc3` is to produce a light curve of three series of data and calculates and plots in different ways the soft (Series 2/ Series 1) and the hard (Series 3/Series 2) hardness ratio (colours). It is run in the Question/Answer user interface by typing:

```
[n]Xronos> lc3
```

in the Partial Question/Answer user interface by typing:

```
[n]Xronos> lc3 [series1] [series2] [series3]
```

and in the Command-Driven user interface by typing:

```
[n]Xronos> lc3[/qualifier1/qual2/... etc]  [series1] [series2] [series3]
```

4.21.1 More on lc3

The default newbin time is either the maximum bin time (if fewer than 512 newbins are expected) or such as to give a single interval with 512 newbins at most. The number of newbins per interval determines the length of the time axis of each interval and therefore the number of intervals that will be produced. Note that in light curve applications each frame can contain only results from one interval (i.e. intervals and frames coincide; see also chapter 2 `terminology`). Four different time axis units can be used for plotting:

- 0 for seconds from the start of the interval (which might be different from the time of the first accepted newbin)
- 1 for seconds from the start of the hour
- 2 for hours from the start of the day
- 3 for days

The default is to plot the three series and the two hardness ratios (colours) vs. time. By specifying the relevant plot options the hardness ratios can be plotted against each other (colour-colour diagram) or removed altogether.

4.22 lda

List Data (Application)

Application `lda` is to list the data from input files at the terminal. It requires one input series. It is run in the Question/Answer user interface by typing:

```
[n]Xronos> lda
```

in the Partial Question/Answer user interface by typing:

```
[n]Xronos> lda [series1]
```

and in the Command-Driven user interface by typing:

```
[n]Xronos> lda[/qualifier1/qual2/... etc]  [series1]
```

4.22.1 More on lda

By default the header content of each input file is displayed but not the data points. The exposure in each bin used by XRONOS applications, besides dead time, also includes instrument-dependent constants (i.e. the collimator effinciency in the case of the EXOSAT ME and GS experiments, or the normalisation for the EXOSAT LE) such that, when dealing with photon counting experiments, the relevant Poisson statistics can be reconstructed.

4.23 log

Open/close a log file

The output to the screen produced by the control program `xronos` can be written to a log file. The file is specified by typing:

```
[n]Xronos> log [filename]
```

The file is automatically given the extension `.log`. If no filename is specified the default of `xronos.log` is used. If the filename is prefixed with a `+`, then the output is appended to an existing file. A log file is closed if

- a new log filename is specified (this will open a new log file),
- the filename is given as `none`,
- or the control program `xronos` is exited

Warning: The output to the screen produced by XRONOS applications is not written to log files. This is written instead to "application log files" (`.alog`), according to global parameters number 2 and 3.

4.24 psd

Power Spectral Density Fast Method (Application).

Application `psd` calculates the power spectral density of a time series, by using a FFT algorithm. It requires one input series. It is run in the Question/Answer user interface by typing:

```
[n]Xronos> psd
```

in the Partial Question/Answer user interface by typing:

```
[n]Xronos> psd [series1]
```

and in the Command-Driven user interface by typing:

```
[n]Xronos> psd[/qualifier1/qual2/... etc]  [series1]
```

4.24.1 More on psd

The newbin time must correspond to an integer multiple of the maximum bin time. The default newbin time is either the maximum bin time (if fewer than 4096 newbins are expected) or the integer multiple of it which will produce a single interval with number of newbins <4096. The FFT algorithm requires that the number of newbins per interval be a power of 2. The average count rate in each interval is subtracted from all newbins, and gaps and rejected newbins are replaced with zeroes, before the power spectrum is calculated.

The power spectrum error bars are obtained either by propagating the theoretical error bars of the spectra from individual intervals (from the relevant chi-square distribution) or by evaluating directly the standard deviation of the average of the power in each frequency bin from different intervals. This depends on whether the specified number of intervals per frame is, respectively, smaller or larger than the value of global parameter number 9 (default =5).

Error bars are plotted by default only if two or more power spectra are averaged. Sidelobes and other effects introduced by windows, data gaps etc. can be studied by analysing the exposure profile of the time series. This is done by setting global parameter number 10 to 1.

4.24.2 Normalisations

The analysis normalisation flag, specified by global parameter number 11, has the following meaning for application `psd`:

- =0 power spectra are normalised by dividing by the number of good newbins in each interval.
- =1 (d/f); power spectra are normalised such that the (white) noise level expected from the data errors, corresponds to a power of 2 (note that a correction of the data errors for instrument dead time effect might be necessary to bring the expected noise level to 2; See e.g. the EXOSAT ME light curves)
- =2 power spectra are normalised such that their integral gives the squared rms fractional variability (therefore the power spectrum is in units of $(\text{rms})^2/\text{Hz}$). The expected (white) noise level must be subtracted to obtain the rms fractional variability of the series. This level is written out by `psd` (note that it might be necessary to correct the white noise level: see e.g. EXOSAT ME light curve. Other corrections for instrumental dead time effects, e.g. the energy dependent correction of the source rms in EXOSAT ME light curves, must be handled separately). The squared rms is normalised by $(\text{avg})^{-2}$; if the light curves are not background subtracted, to get the source squared rms fractional variability the power spectrum must be multiplied by $(\text{avg})^2/(\text{avg-bkgd})^2$. Alternatively the background can be subtracted from the light curves by using input file option `sd`.

- =-1 as =1, but the expected white noise level is subtracted
- =-2 as =2, but the expected white noise level is subtracted

Negative normalisation flags should be used only after having established that the observed (white) noise level is as expected. If other normalisation flag values than those listed above are used, they are treated as =0.

4.25 pss

Power Spectral Density Slow Method (Application).

Application `pss` is to calculate the power spectral density of a time series, by using a direct slow Fourier algorithm. It requires 1 input series. It is run in the Question/Answer user interface by typing:

```
[n]Xronos> pss
```

in the Partial Question/Answer user interface by typing:

```
[n]Xronos> pss [series1]
```

and in the Command-Driven user interface by typing:

```
[n]Xronos> pss[/qualifier1/qual2/... etc]  [series1]
```

4.25.1 More on pss

The newbin time must correspond to an integer multiple of the maximum bin time. The default newbin time is either the maximum bin time (if fewer than 4096 newbins are expected) or the integer multiple of it which will produce a single interval with number of newbins <4096. The average count rate in each interval is subtracted from all newbins, and gaps and rejected newbins are replaced with zeroes, before the power spectrum is calculated.

The power spectral error bars are obtained either by propagating the theoretical error bars of the spectra from individual intervals (from the relevant chi-square distribution) or by evaluating directly the standard deviation of the average of the power in each frequency bin from different intervals. This depends on whether the specified number of intervals per frame is, respectively, smaller or larger than the value of global parameter number 9 (default =5).

Error bars are plotted by default only if two or more power spectra are averaged. Sidelobes and other effects introduced by windows, data gaps etc. can be studied by analysing the exposure profile of the time series, by setting global parameter number 10 to 1.

4.25.2 Normalisations

The analysis normalisation flag, specified by global parameter number 11 has the same meaning as in application `psd`.

4.26 qdp

To plot a QDP file (Application). Type:

```
[n]Xronos> qdp/qualifier(s) [n]
```

In particular:

```
[n]Xronos> qdp/lc1              !plot last QDP file created with command ‘lc1‘
                                 for series A. The same syntax is used for QDP
                                 files created with other Xronos commands
[n]Xronos> qdp/lc1 n            !as above but for series n=A,B,C
[n]Xronos> qdp/file=qdpfile     !plot QDP file ‘qdpfile.qdp‘
[n]Xronos> qdp/file=qdpfile.qlc1 !plot QDP file ‘qdpfile.qlc1‘
[n]Xronos> qdp/file=qdpfile/lc1  !plot QDP file ‘qdpfile.qlc1‘
[n]Xronos> qdp/?                !list allowed qualifiers
```

4.27 recall

Recall a previous command.

```
[n]Xronos> recall[/max] [command_number]
```

`Recall` with no argument provides a list of the last up to 50 commands. The default number of previous commands displayed is 20, but this can be increased or decreased using the `/max=n` qualifier. A desired command can then be reexecuted by number.

Warning: this command DOES NOT recall previous commands to the command line for changing. For example:

```
[n]Xronos> recall            ! provide list of the last commands
[n]Xronos> recall 4          ! reexecutes command 4
```

4.28 reexecute

Reexecute a previous command sequence

```
[n]Xronos> reexecute [command_number_list]
```

`Reexecute` with no argument provides a list of the last up to 20 commands. A desired selection of these can then be reexecuted by number. This command DOES NOT recall previous commands to the command line for hanging. It is useful for repeating a sequence of command after input files have been changed.

`command_number_list` is a list of numbers and/or number ranges which denote previously called commands. If no `command_number_list` is given then a list of the last up to 20 commands is provided. For example:

```
[n]Xronos> reexecute            ! Provide list of the last commands (max.=20)
[n]Xronos> reexecute 4 15-18    ! Reexecute commands 4,15,16,17,18
```

4.29 script

Echo XRONOS commands to a file

```
[n]Xronos> script [filename]
```

Opens a script file where all commands entered from the `Xronos>` prompt are written. The file is automatically given the extension `.xco`. If no filename is specified the default of `xronos.xco` is used. A script file is closed if

- a new script filename is specified (this will open a new script file),
- the filename is given as `none`,
- or the control program `xronos` is exited

Script files can be used as command driven cmd files.

4.30 sta

Statistical Analysis (Application).

Application `sta` is to perform a statistical analysis of the light curve of 1 series of data. It is run in the Question/Answer user interface by typing:

```
[n]Xronos> sta
```

in the Partial Question/Answer user interface by typing:

```
[n]Xronos> sta [series1]
```

and in the Command-Driven user interface by typing:

```
[n]Xronos> sta[/qualifier1/qual2/... etc]  [series1]
```

4.30.1 More on sta

The default newbin time is either the maximum bin time (if fewer than 512 newbins are expected) or such as to give a single interval with 512 newbins at most. The number of newbins per interval determines the length of the time axis of each interval and therefore the number of intervals that will be produced. Note that in light curve applications each frame can contain only results from one interval (i.e. intervals and frames coincide; see also chapter 2 `terminology`). No output file is produced by `sta`. The results are output to the screen. A number of quantities are calculated:

- Newbin integration time (x2 gives the shortest timescale sampled in the analysis)
- Interval duration (gives the longest timescale sampled)
- Number of good (accepted) newbins in interval
- Average (and its error)
- Standard deviation
- Minimum and maximum count rates in interval
- Variance (and its Gaussian error), as evaluated from the data scatter
- Expected variance from a constant source (and its Gaussian error), as evaluated from the errors in the newbin count rates (corrected for dead time effects as appropriate)
- Third moment
- Average absolute deviation
- Skewness (and its Gaussian error)
- Kurtosis (and its Gaussian error)
- RMS fractional variation (and its Gaussian error) or a 3 sigma upper limit if the variance is not larger than the expected variance at a confidence level higher than 99.86%
- Chi-square and corresponding number of degrees of freedom
- Constant source probability associated to the Chi-square value
- Constant source probability from a Kolmogorov-Smirnov test (note however that, strictly speaking, this test should be applied only to unbinned data; moreover this test often fails if used with background subtracted light curves of faint sources)

4.31 tss

Time Skewness Function Slow Method (Application).

Application `tss` is to calculate the time skewness function of a time series by using a slow algorithm. It requires 1 time series. It is run in the Question/Answer user interface by typing:

```
[n]Xronos> tss
```

in the Partial Question/Answer user interface by typing:

```
[n]Xronos> tss [series1]
```

and in the Command-Driven user interface by typing:

```
[n]Xronos> tss[/qualifier1/qual2/... etc]  [series1]
```

4.31.1 More on tss

The newbin time must correspond to an integer multiple of the maximum bin time. The default newbin time is either the maximum bin time (if fewer than 512 newbins are expected) or the integer multiple of it which gives a single interval with 512 newbins at most.

The average count rate in each interval is subtracted from all newbins, and gaps and rejected newbins are replaced with zeroes, before the time skewness function is calculated.

The time skewness error bars are obtained either by propagating the theoretical error bars of the time skewness from individual intervals (in turn obtained by propagating the newbin errors bars through the time skewness formula) or by evaluating directly the standard deviation of the average of the time skewness in each time delay bin from different intervals. This depends on whether the specified number of intervals per frame is, respectively, smaller or larger than the value of global parameter number 9 (default =5).

Error bars are plotted by default. The effects introduced by windows, data gaps etc. can be studied by analysing the exposure profile of the time series. This is done by setting global parameter number 10 to 1.

4.31.2 Normalisations

The analysis normalisation flag, specified by global parameter number 11, has the following meaning for application `tss`:

- =0 time skewness is normalised by dividing by the number of good newbins in each interval.
- =1 (d/f) time skewness is normalised by dividing by the number of good newbins and the third moment of newbins in each interval. No correction for the third moment due to Poisson statistics in newbins is calculated.

If other values than those listed above are used, they will be treated as =0.

4.32 win

Window Handling (Application).

Application `win` writes , reads and copies Xronos window files used by XRONOS. It can only be run in a Question/Answer fashion by typing:

```
[n]Xronos> win
```

See chapter 8 (`windows`) for details.

4.33 @

To execute XRONOS commands from a command file or from a script file (default extension `.xco`). Command files can be nested to a depth of eight. Type:

```
[n]Xronos>  @filename
```

to execute XRONOS commands in file `filename.xco`.

4.34 $

Spawn to the operating system. Type:

```
[n]Xronos> $[oper_sys_cmd]
```

In particular:

```
[n]Xronos> $                !enter operating system; type 'lo' (VMS) or 'exit'
                             (UNIX) to return to Xronos
[n]Xronos> $ oper_sys_cmd  !execute operating system command 'oper_sys_cmd'
```

Chapter 5

Questions/Answers

In the Question/Answer user interface the execution of XRONOS applications is controlled by answering individual questions. Questions are asked after a XRONOS application is started, e.g. :

```
[n]Xronos> lc1
>>>> Program lc1          5-JUL-1992 19:15:07         Xronos vers. 3.00 Jul 92

     Enter up to  50 input filenames and options for series 1 (or rtn)
lc1> Ser. 1 filename   1 +options[.rbf]=> a2030
```

User's replies are given after the `=>` prompt. A default is indicated in square brackets and allowed replies (when relevant) in curly brackets.

5.1 General Questions

A number of questions are common to most XRONOS applications.

5.1.1 Input filename(s)

The following question is issued for input filename(s) :

```
lc1> Ser. 1 filename   1 +options[.rbf]=>
```

If no filename extension is specified, `.rbf` is appended by default, i.e. default input files are rate buffers. Up to 50 chronologically ordered input files can be specified for each input series. Up to 10 input file options can be specified for each input file. At least one input filename (for each series) must to be entered. Press `return` when you have specified all the input filenames for each series.

A summary of the header content of each input file is displayed on the screen. The amount of header information displayed on the screen is controlled by global parameter number 1.

5.1.2 Window Options

Windows can be specified in most XRONOS applications. Reply `y` to the following question in order to use the window options:

```
lc1> Window Options?          {y/n} [n]=> y
```

The first mode is to specify windows interactively (`i`, the default) or use a window file (`f`) created with application `win` (the user is prompted for the window filename in this case).

```
lc1> Interact. or window file {i/f} [i]=>
```

In the interactive window mode (`i`), windows can be entered as in application `win`. An option is included to write the windows specified interactively to a window file for future use. In order to enter windows from a window file `file.wi` reply as follows:

```
lc1> Interact. or window file? {i/f}[i]=> f
lc1> Window filename              [.wi]=> file.wi
```

Note that intensity and exposure windows originally specified, e.g., for series C in the window file `file.wi` can be reassigned to series 1 of application `lc1` by typing:

```
lc1> Window filename              [.wi]=> file.wi c
```

Similarly, if intensity and exposure windows for series B and C in the window file `file.wi` are to be used, respectively, in series 1 and 2 of application `ccf`, then type:

```
ccf> Window filename              [.wi]=> file.wi b c
```

5.1.3 Newbin Time

The newbin duration (in seconds) is entered by replying to the following question:

```
lc1> Enter Newbin time (s) or neg.rebinning
     of min. Newbin Time [  214.4     ]=>
```

The default newbin duration (in square brackets) is such as to produce a single interval with a fixed number of newbins (typically between 128 and 4096, depending on the application). For binned input files the newbin duration cannot be shorter than the longest bin duration in the input files (i.e. the minimum newbin time). In a number of applications (e.g. `psd`, `pss`, `acf`, `acs`, `ccf`, `ccs`) the newbin time must be an integer multiple of the minimum newbin time. The newbin duration is not relevant for applications using epoch folding techniques. Note that if a negative number is specified, this is interpreted as the number of times the minimum newbin duration is to be rebinned in order to give the newbin duration.

5.1.4 Newbins/Interval

The number of newbins which determines the duration of an interval is entered by replying to the following question:

```
lc1> No. of Newbins/Intv.  (max. 65536)
     {value or neg.pow.of 2}[      512]=>
```

This number, together with the newbin duration, determines the interval duration and, therefore, the total number of intervals over which the analysis will be carried out. The number can be specified either as a positive integer (e.g. 4000) or as a negative integer (e.g. -12), in which case the number of newbins per interval is the corresponding (positive) power of 2 (e.g. 2**12=4096). The default number of newbins per interval is indicated; this is usually between 128 and 4096 depending on the application. The maximum number of newbins per interval which can be used in each application is also displayed.

5.1.5 Intervals/Frame

The results of the analysis from individual intervals can be averaged in a frame. The following question is issued to specify the number of intervals the results of which should be averaged to produce a frame (and therefore in most cases also an output file and a plot):

```
psd> No. of Intvs per Frame    [      25]=>
```

In certain applications (e.g. `lc1`, `lc2`, `lc3`, `efs`) every frame must contain results from one interval only and therefore the question is not issued.

5.2 Rebin Results

The results of the analysis of individual frames can be rebinned either with a constant rebinning factor or with a geometrical series rebinning, which is useful to produce nearly equispaced bins in a log x representation. To specify the rebinning answer the following question:

```
psd> Rebin results ? { >1= const. rebin,
     <-1= geom. reb, 0= no reb}[   0.00]=>
```

The default (0) is not to rebin the results. Values greater than 1 indicate a constant rebinning factor. The geometrical series rebinning is specified by entering a value less than -1, whose modulus represents the step of the geometrical series used to calculate a varying rebinning factor. Values between -1.4 and -1.2 are adequate in most cases.

5.3 Trend Removal

A polynomial trend can be removed from the time series in most XRONOS applications (N.B. not in epoch folding applications). By replying to the following question it is possible to specify the degree of the polynomial fit which will be removed from each series:

```
lc1> Order of polynomial trend removal
           {0=none,1=1st,....,4=4th}[0]=>
```

The default (=0) is not to remove any trend from the input series. If the polynomial trend removal is selected (maximum is 4th order), it is possible to specify whether the trend should be subtracted from the time series, or the time series should be divided by the trend, or the time series should be replaced with the fitted trend:

```
lc1> Subtr.,Div.,Replace data with trend
     {1=Subtract,2=Divide,3=Replace}[1]=>
```

5.4 Output File Name

The following question is issued to specify the output filename :

```
lc1> Enter output filename
     [xronos.qlc1                    ]=>
```

The default filename is `xronos.qXXX` where `XXX` is the name of the XRONOS application that is being used (different default filenames can be specified by changing global parameter number 5; the output file status is controlled via global parameter number 6). If a filename without extension is entered the default extension `.qXXX` will be appended. For application `asc` the default output filename is the name of the first input filename with the extension modified to be `.txt`.

5.5 Plot Results

By default XRONOS applications plot automatically every XRONOS QDP file containing the results of the analysis in each frame. To get access to a number of plot options reply `y` to the following question:

```
lc1> Plot options?             {n/y}[n]=>
```

If results should not be plotted, reply `n` to the following question:

```
lc1> Plot results?             {n/y}[y]=>
```

By replying `i` to the following question:

```
lc1> Interactive or automatic?  {i/a}[a]=>
```

QDP/PLT is left in the interactive plotting mode at the end of each plot and commands can be entered from the `PLT>` prompt to allow plot customisation. If necessary, the plot device (and its default) can be changed by replying to the following question (enter `?` to list available plot devices):

```
lc1> Pgplot device  [/ws               ]=>
```

A file containing a set of QDP/PLT commands to be applied to each plot can be specified by replying `y` to the following question:

```
lc1> Specify QDP command file?  {y/n}[n]=>
```

and by specifying the QDP/PLT command file in response to the following question:

```
lc1> QDP cmd filename [xronos.pco] =>
```

When running applications `lc2` and `ef2` the following additional questions are asked:

```
lc2> Hardness vs. intensity ? {n/y} [n]=>
```

If the answer is `y` then the hardness ratio will be plotted against intensity. By replying to the next question is then possible to specify whether the intensity on the X-axis should be that of the first series, the second series or the sum of them (the default):

```
lc2> Series 1, 2 or sum on X-axis ?
                       {0, 1, 2}[sum=0]=>
```

Moreover it is possible to prevent the plotting of the hardness ratio vs. time, by replying `y` to the following question:

```
lc2> Plot only light curves ?  {n/y}[n]=>
```

or to plot the hardness ratio and the sum of the light curves from series 1 and 2 vs. time by replying `y` to the following question:

```
lc2> Plot hdns and summed l.c.?{n/y}[n]=>
```

When running applications `lc3` and `ef3` the following additional questions are asked:

```
lc3> Colour-Colour Diagram ?   {n/y}[n]=>
```

If the answer is `y` than the soft ratio (series 2/ series 1) and hard hardness ratio (series 3/series 2) will be plotted against each other. Moreover, it is possible to prevent the plotting of the hardness ratios vs. time, by replying `y` to the following question:

```
lc3> Plot only light curves  ? {n/y}[n]=>
```

5.6 Time Axis Units

By replying to the following question it is possible to choose the units of the time axis in applications `lc1`, `lc2` and `lc3`:

```
lc1> Time axis units
        {0=s from start,1=s,2=h,3=d}[2]=>
```

Four different time axis units can be specified: (0) seconds from the start time of the interval (which might be different from the time of the first accepted newbin) (1) seconds from the start of the hour, (2) hours from the start of the day, and (3) days. The default depends on the duration of the input series and is indicated in square brackets.

5.7 Epoch Folding

When running epoch folding applications (e.g `ef1`, `ef2`, `efs`) several additional questions are asked. The first is to specify the format in which the epoch of zero phase will be entered:

```
ef1> Format for epoch
       {1=d / 2=d s / 3=d h m s ms} [1]=>
```

The default (1) is to enter the epoch in days. The other possibilities are (2) to enter the epoch in (integer) days and seconds and (3) to enter the epoch in days, hours, minutes, seconds and milliseconds. After that, the epoch should be entered in the specified format:

```
ef1> Epoch          [      302.00000000]=>
```

By replying to the following question:

```
ef1> Format for period  {1=d / 2=s} [2]=>
```

it is possible to specify whether the period over which the input data are to be folded should be entered (1) in days (the default) or (2) in seconds. After that the period should be entered according to the specified format (note that in application **efs** the period entered represents the centre of the range of trial periods over which the data will be folded):

```
ef1> Period         [    0.00000000E+00]=>
```

The following question is issued in order to enter the number of phasebins in the folded light curve(s):

```
ef1> No. of Phasebins/Period  (max: 65536)
     {value or neg. power of 2} [    128]=>
```

The duration of a phase bin represents in the context of epoch folding applications the equivalent of the newbin duration. The default is such as to produce a folded light curve of 128 bins at most.

Application **efs** requires two additional inputs. The first is the period resolution to be used in the search; this is entered by replying to the following question (note that the same units used to enter the period should be used):

```
efs> Period Resolut. [   0.18018900E-05]=>
```

The default is half the Fourier resolution over the interval (i.e. P*P/T(i)/2, where P is the trial period and T(i) the interval duration). If the default resolution is used a coherent periodicity will appear as a 1-2 bin broad peak in the chi-square vs. trial period plot.

The second is the number of periods over which the search should be carried out:

```
efs> No. of Periods         (max:  7281)
     {value or neg. power of 2} [   128]=>
```

The number of periods should be kept as small as possible in order to limit the execution time.

Chapter 6

Qualifiers

In the Command-Driven user interface the execution of XRONOS applications is controlled by qualifiers. Qualifiers are entered after a XRONOS command (e.g. `psd`) with the following syntax (no blank spaces allowed!):

```
[n]Xronos> psd[/qualifier1/qual2/... etc]
```

Allowed qualifiers for each XRONOS command are listed by using `/?`, e.g.

```
[n]Xronos> psd/?
```

Unambiguous abbreviations of any qualifier are accepted by XRONOS.

6.1 General Qualifiers

The following qualifiers are used in most XRONOS applications.

6.1.1 /cmdqdpfile=file

Specify plot CoMmanDs in a QDP command FILE

Plot automatically by using additional QDP/PLT commands contained in file `file.pco`

6.1.2 /fullinfo

Display FULL INFOrmation

Run a XRONOS application while displaying the same information as in a XRONOS Question/Answer session.

6.1.3 /header

list also HEADER information

List a summary of the input file header(s) and all parameters of a XRONOS application without running the application itself. This is especially useful to check the defaults and/or the setup specified by the user through other qualifiers.

6.1.4 /image

Write to an IMAGE XRONOS binary file

Reset the output file to be a XRONOS binary file (with extension `.xXXX`, where `XXX` is the XRONOS command) containing results from all frames; this can be displayed as a `time image` (display application not yet available)

6.1.5 /lparm

List PARaMeters

List all parameters of a XRONOS application without running the application itself. This is especially useful to check the defaults and/or the setup specified by the user through other qualifiers.

6.1.6 /nbins=I

Number of newBINS in an interval (I=integer; I<0 for nbins=2**(-I))

Number of newbins in an interval; together with the newbin time duration determines the interval duration and, therefore, the number of intervals over which the analysis will be carried out.

6.1.7 /nint=I

Number of INTegrations in a newbin (I=integer)

Number of times the minimum newbin time (i.e. the longest bin integration time in input file(s)) is to be rebinned to give the newbin time duration. (Not available in `ef1`, `ef2`, `ef3` and `efs`).

6.1.8 /noecho

Run a XRONOS application, displaying only error messages.

6.1.9 /noplot

Prevent a XRONOS application from plotting results.

6.1.10 /outfile=file

Specify OUTput FILEname

Write results from a frame to QDP output file `file.qxxx`, where `xxx` is the XRONOS command used to create the file.

6.1.11 /plt

Interactive PLT plotting

Leave a XRONOS application in the interactive QDP/PLT plotting/fitting mode (`PLT>` prompt) after plotting results.

6.1.12 /tnewbin=X

Specify Time duration of NEWBINs (X=real)

Specify newbin time durations (in seconds) to be used in the analysis. The default is to produce a single interval with a number of newbins which changes from one application to another. (Not available in `ef1`, `ef2`, `ef3` and `efs`).

6.1.13 /trend=I

TREND removal (I=integer)

Remove a polynomial trend from the input series; I=1,2,3,4 to remove a 1st, 2nd, 3rd, 4th-order polynomial trend, respectively. The trend is determined separately for each interval of each series by using a least square technique. (Not available in `ef1`,`ef2`, `ef3` and `efs`).

6.1.14 /trendmode=I

TREND removal MODE (I=integer)

Specify I=1 (=default) to subtract trend from the time series, I=2 to divide the time series by trend or I=3 to replace the time series with trend.

6.1.15 /window=file

Use WINDOW file

Use windows from a XRONOS window file `file.wi` (see application `win`).

Note that intensity and exposure windows specified for series A, B and C in `file.wi` will be applied to the data from the input files of series A, B and C, respectively. For example, typing:

```
[n]Xronos> psd/windows=file c
```

will cause the power spectral density of series C to be calculated, after the application of the intensity and exposure windows specified in `file.wi` for series C.

6.1.16 /?

List allowed qualifiers for each XRONOS application or command.

6.2 Application Specific Qualifiers

A number of XRONOS qualifiers are specific to a single application or a group of applications. Below is a description of each of these qualifiers:

6.2.1 /points

List POINTS in input file(s) (application: `lda`)

List on the screen all points contained in input file(s). To interrupt the listing type `cntl Y` (VMS) or `cntl C` (UNIX)

6.2.2 /nopoints

NO POINTS written to the ASCII file (application: `asc`)

To write to the output ASCII file only the header information of input file(s) and no data points.

6.2.3 /tunit=I

To specify Time UNITs for time axis (applications: `lc1`,`lc2`,`lc3`)

Four time axis units are available for plotting light curves:

- I=0 seconds from the start of the interval (which might be different from the time of the first accepted newbin)
- I=1 seconds from the start of the hour
- I=2 hours from the start of the day
- I=3 days

6.2.4 /sumandhdns

To plot SUM of series 1 AND 2 and HarDNesS (series 2/series1) vs. time (applications `lc2`), or vs. phase (applications `ef2`)

6.2.5 /hdns

To plot HarDNesS vs. sum of series 1 and 2 (applications: `lc2`,`ef2`).

6.2.6 /hdnsvs1

To plot HarDNesS vs. series 1 (applications: `lc2`,`ef2`).

6.2.7 /hdnsvs2

To plot HarDNesS vs. series 2 (applications: `lc2`,`ef2`).

6.2.8 /lconly

To plot Light Curves vs. time ONLY when more than one series is used (applications: `lc2`,`ef2`,`lc3`,`ef3`)

6.2.9 /colours

To plot COLOUR-COLOUR diagram (applications: `lc3`,`ef3`).

The two hardness ratios (two colours: series 2/series 1 and series 3/series 2) are plotted one versus the other.

6.2.10 /period=X

PERIOD to be used in epoch folding (applications: `ef1`,`ef2`,`ef3`,`efs`).

The period can be input in two formats: a positive value (X>0) implies that the period is given in seconds, a negative value (X<0) means that the period is given in days.

6.2.11 /nphasebins=I

Number of PHASE BINS in epoch folding (applications: `ef1`,`ef2`,`ef3`,`efs`).

The number of phase bins in a folded period, together with the period, determines the duration of a phase bin which, for epoch folding, is the equivalent of the newbin duration.

6.2.12 /epoch=X

EPOCH of zero phase in days (X=real) (applications: `ef1`,`ef2`,`ef3`).

Epoch to be used as zero phase in folding. X must be given in days.

6.2.13 /navflc=I

Number of individual Folded Light Curves to be AVeraged (application: `ef1`, `ef2`, `ef3`, `efs`).

Folded light curves from I different intervals are averaged to produce the folded light curve of a frame.

6.2.14 /eachflc

To have EACH Folded Light Curve in one frame (applications: `ef1`,`ef2`,`ef3`, `efs`).

A frame will consist only of the folded light curve of one interval. This is equivalent to `/navflc=1`.

6.2.15 /resolution=X

RESOLUTION for period search (application: `efs`).

The period resolutions is the spacing between two contiguous periods in the search: the default is half Fourier resolution in the interval (i.e. P*P/T(i)/2, where P is the trial period and T(i) the interval duration). If this is used a coherent periodicity will appear as a 1-2 bin broad peak in the chi-square vs. period plot. The resolution X should be given in the same units (seconds or days) used to for the period.

6.2.16 /nperiods=I

Number of PERIODS in the search (application: `efs`)

The default number of trial periods in the search is 128, but the number should be kept as small as possible in order to limit the execution time.

6.2.17 /navpsd=I

Number of AVeraged Power Spectral Densities in a frame (applications: `psd`, `pss`)

`I` specifies the number of individual power spectra (each from one interval) which should be averaged to produce the power spectrum of a frame.

6.2.18 /eachpsd

To have EACH Power Spectral Density in one frame (applications: `psd,pss`)

A frame will consist only of the power spectrum of one interval. This is equivalent to `/navpsd=1`.

6.2.19 /rebinpsd=X

To REBIN in frequency the Power Spectral Density (applications: `psd,pss`)

The power spectrum from each frame can be rebinned either with a constant rebinning factor or with a geometrical series rebinning which is useful to produce nearly equispaced bins in a log(freq) representation.

- X> +1 Constant rebinning factor
- -2 <X< -1 Geometrical series rebinning, for log(freq) plots; the modulus of this value corresponds to the step of the geometrical series (X=-1.4 for 1 octave spacing).

The error bars are always propagated in the rebinning process, independently of the way in which they are calculated before rebinning.

6.2.20 /logrebinpsd

LOG REBINning of Power Spectral Density (applications: `psd`, `pss`).

To rebin logarithmically with a step that produces 1/4 octave spacing. This is equivalent to `/rebinpsd=-1.19`.

6.2.21 /navacf=I

Number of AVeraged Auto Correlation Functions in a frame (applications: `acf`, `acs`)

`I` specifies the number of individual auto correlation functions (each from one interval) which should be averaged to produce the auto correlation function of a frame.

6.2.22 /eachacf

To have EACH Auto Correlation Function in one frame (applications: `acf`,`acs`)

A frame will consist only of the auto correlation function of one interval. This is equivalent to `/navacf=1`.

6.2.23 /rebinacf=X

To REBIN in time delay the Auto Correlation Function (applications:`acf`,`acs`)

The auto correlation from each frame can be rebinned either with a constant rebinning factor or with a geometrical series rebinning which is useful to produce nearly equispaced bins in a log(tau) representation.

- X> +1 Constant rebinning factor
- -2 <X< -1 Geometrical series rebinning, for log(tau) plots; the modulus of this value corresponds to the step of the geometrical series.

The error bars are always propagated in the rebinning process, independently of the way in which they are calculated before rebinning.

6.2.24 /logrebinacf

LOG REBINning of Auto Correlation Function (applications: `acf`, `acs`).

To rebin logarithmically in time delay. This is equivalent to `/rebinacf=-1.19`

6.2.25 /navccf=I

Number of AVeraged Cross Correlation Functions in a frame (applications: `ccf`, `ccs`)

`I` specifies the number of individual cross correlation functions (each from one interval) which should be averaged to produce the cross correlation function of a frame.

6.2.26 /eachccf

To have EACH Cross Correlation Function in one frame (applications:`ccf`,`ccs`)

A frame will consist only of the cross correlation function of one interval. This is equivalent to `/navccf=1`.

6.2.27 /navtsf=I

Number of AVeraged Time Skewness Functions in a frame (application: `tsf`)

`I` specifies the number of individual time skewness functions (each from one interval) which should be averaged to produce the time skewness function of a frame.

6.2.28 /eachtsf

To have EACH Time Skewness Function in one frame (application: `tsf`)

A frame will consist only of the time skewness function of one interval. This is equivalent to `/navtsf=1`.

6.2.29 /rebintsf=X

To REBIN in time delay the Time Skewness Function (applications:`tsf`)

The time skewness function from each frame can be rebinned either with a constant rebinning factor or with a geometrical series rebinning which is useful to produce nearly equispaced bins in a log(tau) representation.

- X> +1 Constant rebinning factor
- -2 <X< -1 Geometrical series rebinning, for log(tau) plots; the modulus of this value corresponds to the step of the geometrical series.

The error bars are always propagated in the rebinning process, independently of the way in which they are calculated before rebinning.

6.2.30 /logrebintsf

LOG REBINning of Time Skewness Function (application: `tsf`).

To rebin logarithmically in time delay. This is equivalent to `/rebintsf=-1.19`

Chapter 7

Global Parameters

Additional flexibility in XRONOS applications is achieved by using a number of global parameters. These are written to file `xronos.pf` in the working directory. When the control program `xronos` is invoked, a version of file `xronos.pf` containing all default values is automatically copied to the working directory. However, if file `xronos.pf` already exists in your working directory, it will not be overwritten, unless you type:

```
[n]Xronos> $xronos_init newpf
```

To change the value of any global parameter type `cpf(change parameter file)` and reply to the questions interactively. Below is a description of global parameters.

7.1 1 Terminal Chattiness

(Integer parameter; d/f=5; range 0->10)

Set terminal chattiness: (0-4) only little information is output in running XRONOS applications; (5) default chattiness; (6-7) more details on input files, windows, intervals statistics, etc.; (>8) mostly for debugging purposes.

7.2 2 Appl Log File Chattiness

(Integer parameter; d/f=0; range 0->10)

Set application log file chattiness: the default (=0) is not to write any application log file; for all other values information is written to the application log file, with a chattiness which is specified by the value of this parameter (chattiness levels are the same as for global parameter number 1).

7.3 3 Appl Log Filename

(Character parameter; d/f= `xronos.alog`)

Specify the application log filename (note the `.alog` extension). The application log file contains all the interaction with XRONOS applications and results from the analysis which are normally output only to the terminal. Note that this is done in the style of the question/answer user interface, even if the XRONOS session is being run with its partial question/answer or command-driven user interface.

7.4 4 Macro Filename

(Character parameter; d/f= `xronos.ma`)

Specify macro filename (note the `.ma` extension) to which commands for XRONOS applications are automatically written, when a command file is created from the question/answer user interface.

7.5 5 Output Filename Root

(Character parameter; d/f= `xronos`)

Specify the filename root which is used by XRONOS applications to generate the default output filename. The default is `xronos`; e.g. running application `lc1` the default output filename will be `xronos.qlc1`. Note that if `default` is specified as filename root, then the filename root will be the filename root of the 1st input file (e.g. running application `lc1` with `a2030.rbf` as input file will cause the default output filename to be `a2030.qlc1`).

7.6 6 Output File Status

(Character parameter; d/f= `unknown`)

Specifies the status in the open call for output files (`unknown`, the default, or `new`).

7.7 7 Running Mean Gap Filling

(Integer parameter; d/f=0; range 0->)

Replace gaps in input series with running mean. If =0 (the default) data gaps are not filled. If =n newbin data gaps in input series are filled in with running mean values calculated over n newbins. Note that a gap newbin is filled in only if the corresponding running mean is calculated over n/4 points at least (this means that in order to bridge a gap of m newbins n must be >1.35m). This global parameter is ignored in epoch folding applications.

7.8 8 Force Start Time

(Flag parameter; d/f=0; range 0-1)

If =1 the first interval will be forced to start at the time of the first time window.

7.9 9 Error Bar Evaluation

(Integer parameter; d/f=5; range >1)

This is one of the most important global parameters of XRONOS: it is used to define the way in which the error bars of the results of XRONOS applications are calculated. If the specified number of the intervals per frame is higher than the value of the parameter (default=5), the error bars of the result points are evaluated by using the standard deviation of the average of the result points (based on the measured scatter). Otherwise the error bars are evaluated by propagating the theoretical error bars through the averaging process. Note that for several XRONOS applications (e.g. `acf`, `ccf`) only the former way of evaluating error bars is available.

For example, for the default value of 5 and application `psd`: (a) if a frame is specified to be the average of 5 or less power spectra, then the error bars in the average power spectrum will be calculated by propagating through the average the theoretical error bars associated to each power spectrum (in turn obtained from the relevant chi-square distribution); (b) on the other hand if a frame is specified to be the average of 6 or more power spectra, then the error bars in the average power spectrum will be calculated by evaluating the standard deviation of the average power for each frequency.

By adjusting the value of this global parameter it is possible, e.g. to evaluate error bars as in (a), also in the case in which a large number of intervals per frame has been specified. Values < 5 are not recommended (at least 5-6 measures are necessary to reliably evaluate the standard deviation of the average from the scatter around it).

7.10 10 Exposure Profile

(Flag parameter; d/f=0; range 0-1)

If =1 the exposure profile(s) (i.e. newbin values are set =1, gaps and rejected newbins are set =0) is/are analysed (instead of the input series).

7.11 11 Normalisation

(Flag parameter; d/f=1; range -2 -> 3)

Flag to specify the result normalisation to be used. The standard normalisation corresponds to a value of 1 (the default) in all XRONOS applications. Other normalisation flags are described for each application.

7.12 12 Simultaneousness

(Flag parameter; d/f=0; range 0-1)

If =1 a strict simultaneousness is forced between the input series in applications which use more then one series (i.e. if the n-th newbin of a series is a gap or is rejected, then the n-th newbin of all other series will be also rejected). This flag is ignored in epoch folding applications `ef2` and `ef3`.

7.13 13 Special Windows Before

(Real parameter; d/f=0.; range 0 ->)

Special newbin window : seconds before. If a value >0 is used , e.g. 10.0, then all the newbins within 10.0 seconds before a newbin rejected by an intensity window will also be rejected. The default (=0) is not to apply this type of special newbin window.

7.14 14 Special Windows After

(Real parameter; d/f=0.; range 0 ->)

Special newbin window : seconds after. If a value >0 is used , e.g. 10.0, then all the newbins within 10.0 seconds after a newbin rejected by an intensity window will also be rejected. The default (=0) is not to apply this type of special newbin window.

7.15 15 Rescaling Factor

(Real parameter; d/f=1.)

Rescaling factor applied to result variables and errors. The rescaling is applied just before writing the output file (this to avoid affecting the the statistical variables for the frame).

7.16 16 Additive Constant

(Real parameter; d/f=0.)

Additive constant summed to result variables. Result error bars are left unchanged. The additive constant is added just before writing the output file (this to avoid affecting the the statistical variables for the frame). Note that if also a rescaling factor is specified (different from 1), then the results are first multiplied by the rescaling factor.

Chapter 8

Windows

There are 4 different types of windows that can be used by XRONOS:

- Time Windows : consist of up to 100 time intervals
- Phase Windows : consist of an Epoch, a Period and up to 10 phase intervals
- Intensity Windows : consist of up to 10 intensity intervals
- Exposure Windows : consist of up to 1 exposure interval

Intensity and Exposure Windows can be specified independently for: (i) Bins , (ii) New Bins , (iii) Intervals. When dealing with applications involving more than one time series, Intensity and Exposure Windows must be specified separately for each series. Therefore there can be a maximum of 10*3*3=90 Intensity Windows and 1*3*3=9 Exposure Windows. In addition there are Special Newbin Windows which are controlled by global parameters number 13 and 14.

When running a XRONOS application in a Question/Answer user interface windows can be entered interactively (and written to a window file for future use if necessary). A window file containing the relevant windows must be created with application `win`, before running a XRONOS application in the Command Driven user interface. Window files are in any case recommended when the same windows will be used more than once.

Note that Time and Phase Windows are applied to Bins. Then Intensity and Exposure windows are applied first to Bins, then Newbins and finally to Intervals, as specified. Almost all Xronos applications use default Exposure Windows.

8.1 Time Windows

Time Windows consist of up to 100 start/stop times. Only those bins whose center time is within the start and stop times of a time window are accepted. Time Windows must be chronologically ordered Three formats are available to specify time windows:

- 1 = d = days .... e.g. 123.524268391

- 2 = d s = day and sec .... e.g. 123 45296.789
- 3 = d h m s ms = day hr min sec msec ... e.g. 123 12 34 56 789

Time windows covering a larger duration then the input series are reset to the start and stop of the input series. The first interval can be forced to start at the start time of the first time window by using global parameter number 8.

8.2 Phase Windows

Phase Windows consist of an Epoch, a Period, and up to 10 start and stop Phases. Only those bins whose center time is within the specified start and stop phases (for the specified epoch and period) are accepted. Phases' range is from 0 to 1. Phase Windows must be phase ordered (except for the case in which the last window straddles phase 0). Three formats are available to specify the Epoch:

- 1 = d = day .... e.g. 123.524268391
- 2 = d s = day and sec .... e.g. 123 45296.789
- 3 = d h m s ms = day hr min sec msec ... e.g. 123 12 34 56 789

Two formats are available to specify the Period:

- 1 = d = day .... e.g. 0.1234567
- 2 = s = sec .... e.g. 10666.659

8.3 Intensity Windows

Intensity Windows consist of a set of up to 10 minimum and maximum intensity levels. Units are the same as in input files (counts/s usually). Intensity windows must be ordered with increasing intensity and can be specified independently for the intensity of (i) Bins, (ii) Newbins, (iii) Intervals, for each of the series which is being analysed. Note that the "intensity" of an interval is its average intensity. Only those Bins, Newbins, and Intervals whose intensity is within the corresponding specified minimum and maximum intensities will be accepted. Intensity windows in newbins can be used in conjunction with "Special Newbin Windows".

8.4 Exposure Windows

Exposure Windows consist of a minimum and a maximum exposure level. Units are such that 1 means 100% exposure. Exposure windows can be specified independently for the exposure of (i) Bins, (ii) Newbins, (iii) Intervals, for each of the series which is being analysed.

Note that the Bin Exposure used by XRONOS applications, besides dead time includes also instrument-dependent constants (i.e. the collimator efficiency for the ME and GS, the normalisation for the LE) such that, when dealing with photon counting experiments, the relevant Poisson statistics can be reconstructed. For example if a 5 s bin in an input file has been effectively "exposed" only for 2 s (e.g. as a consequence of dead time effects, collimator efficiencies, data dropouts etc.), then its exposure is 40%.

The Newbin Exposure is obtained by propagating the bin exposures to each newbin; for example, if in a 30 s newbin the total exposure (due to the sum of the individual exposure of the bins contributing to the given newbin) is 18 s then its exposure is 60%.

The Interval Exposure is the ratio of accepted to expected newbins: for example, if a 128 newbin long interval contains only 32 accepted newbins, then its exposure is 25%.

Note that exposures can be higher than 100% (e.g. if the newbin time is not a multiple of the bin time, then "beats" are generated which might bring the exposure of a newbin to values >100%; or if two or more input files for the same time series overlap in part, some of the newbins will be more than 100% exposed).

Many XRONOS applications use default exposure windows (see `Default Windows`)

8.5 Special Newbin Windows

Special Newbin Windows operate on Newbins in conjunction with intensity windows in newbins and are specified by changing to positive values global parameters number 13 (par13)and/or 14 (par14). Their use is the following: if e.g. par13 is set =10, all newbins, whose center time is within 10 second before the center time of a newbin rejected by intensity windows, will also be rejected; if e.g. par14 is set =20, all newbins, whose center time is within 20 second after the center time of a newbin rejected by intensity windows, will also be rejected. Special Newbin Windows are particularly useful e.g. to exclude the parts of a light curve which immediately follow or precede a burst or a background event which has been rejected by intensity windows in newbins.

8.6 Default Windows

Default exposure windows are used in many XRONOS applications. This mostly in order to avoid dealing with data sets which are too inhomogeneous with respect to their statistical properties. The default exposure windows are:

- Minimum Exposure in Bins =0.2 (i.e. 20 % exposure)
- Minimum Exposure in Newbins =0.0 (i.e. 0 % exposure)
- Minimum Exposure in Intervals=0.5 (i.e. 50 % exposure)
- Maximum Exposure =50.0 in Bins , Newbins and Interval (i.e. 5000 % exposure, meaning that virtually everything which is more than 100 % exposed will be accepted).

Default exposure windows are applied as follows:

- In Bins and Newbins ....for applications lc1, lc2, lc3, sta, lda, asc, ef1, ef2, ef3 and efs.

- In Bins, Newbins and Intervals ......for all other applications

Note that this is done mainly for protection purposes, to maintain the statistical quality of the results from different intervals as homogeneous as possible. For example suppose that you have a 136 newbin series of which you want to calculate the average power spectrum in intervals of 64 newbins each. Three intervals will be accumulated, two with 64 newbins each and one with 8 newbins. If there were no exposure windows in intervals, the power spectrum the third interval (containing only 8 newbins, i.e. 12.5 % exposed) would be averaged with the power spectra of the first two intervals (both containing 64 newbins, i.e. 100 % exposed).

The side-effects of default exposure windows can be annoying sometimes. For example, when intensity windows in bins or newbins have been specified, and it is difficult to evaluate a priori which fraction of bins and newbins will be accepted, one might end up with many newbins and/or intervals rejected by default exposure windows. Also when specifying time or phase windows, the default windows might need to be reset depending on what fraction of bins and newbins will actually be accepted.

If you do not want any exposure windows you can either create (with application `win`) and use a window file containing no exposure windows, or specify from a question/answer session that no exposure windows should be used.

Example:

```
This example shows how to run application ‘win‘ (interactively) to produce a
window file. User’s input follow the ‘=>‘prompt, if the replay is a blank the
default will be used.
Comments to the example are in between double exclamation marks.
```

$ win >>>> Program win 2-JUL-1992 18:39:42.42 Xronos vers. 3.00 Jul 92

win> Read window file ? y/n[n]=> win> Enter windows ? y/n[y]=> y win> Time windows ? y/n[n]=> y win> Format for time windows 1=d / 2=d s / 3=d h m s ms [1]=> 3 win> Enter up to 100 time ordered windows(- to exit) win> Window 1 start[0 0 0 0 0]=> 359 19 win> Window 1 stop [0 0 0 0 0]=> 359 21 35 40 312 win> Window 2 start[0 0 0 0 0]=> 359 18 40 52 870 xrinerr> Error: windows are not ordered !! note wrong reply !! win> Window 2 start[0 0 0 0 0]=> 359 22 40 52 870 win> Window 2 stop [0 0 0 0 0]=> 361 win> Window 3 start[0 0 0 0 0]=> xrinerr> Error: windows are not ordered !! to exit a - must be entered !! win> Window 3 start[0 0 0 0 0]=> - win> Phase windows ? y/n[n]=> y win> Format for epoch 1=d / 2=d s / 3=d h m s ms [1]=> 1 win> Epoch [0.00000000]=> 359.02545 win> Format for period 1=d / 2=s[2]=> 1 win> Period [0.00000000E+00]=> .027789941 win> Enter up to 10 phase windows (- to exit) !! Note phase order !! win> Phase wind. 1 start 0->1[0.0000]=> .1 win> Phase wind. 1 stop 0->1[0.0000]=> .36 win> Phase wind. 2 start 0->1[0.0000]=> .46 win> Phase wind. 2 stop 0->1[0.0000]=> .94 win> Phase wind. 3 start 0->1[0.0000]=> -

win> Intensity windows ? y/n[n]=> y win> How many time series ? 1/2/3[1]=> 2 !! i.e. for series A and B !! win> Series A: intensity windows in Orig. Bins? y/n[n]=> y win> Enter up to 10 ints ordered windows for Orig. Bins in series A (- to exit) win> Ints. wind. 1 min(c/s)[0.000E+00]=> win> Ints. wind. 1 max(c/s)[0.000E+00]=> 300. win> Ints. wind. 2 min(c/s)[0.000E+00]=> - win> Series A: intensity windows in New Bins ? y/n[n]=> y win> Enter up to 10 ints ordered windows for New Bins in series A (- to exit) win> Ints. wind. 1 min(c/s)[0.000E+00]=> 5. win> Ints. wind. 1 max(c/s)[0.000E+00]=> 200. win> Ints. wind. 2 min(c/s)[0.000E+00]=> 400. win> Ints. wind. 2 max(c/s)[

0.000E+00]=> 500. win> Ints. wind. 3 min(c/s)[0.000E+00]=> - win> Series A: intensity windows in Intervals ? y/n[n]=> y win> Enter up to 10 ints ordered windows for Intervals in series A (- to exit) win> Ints. wind. 1 min(c/s)[0.000E+00]=> 200. win> Ints. wind. 1 max(c/s)[0.000E+00]=> 500. win> Ints. wind. 2 min(c/s)[0.000E+00]=> -

win> Series B: intensity windows in Orig. Bins? y/n[n]=> n win> Series B: intensity windows in New Bins ? y/n[n]=> win> Series B: intensity windows in Intervals ? y/n[n]=> y win> Enter up to 10 ints ordered windows for Intervals in series B (- to exit) win> Ints. wind. 1 min(c/s)[0.000E+00]=> 150. win> Ints. wind. 1 max(c/s)[0.000E+00]=> 300. win> Ints. wind. 2 min(c/s)[0.000E+00]=> - win> Exposure windows ? y/n[y]=> y win> Keep default expos. winds?y/n[y]=> y win> Write window file ? y/n[y]=> win> Window filename [.wi]=> example_a_win Written window file example_a_win.wi !! note filename extension appended by the program !! >>>> Program win 2-JUL-1992 18:45:22.67 Normal termination

Chapter 9

QDP/PLT

QDP/PLT is an all purpose plotting and function fitting program. It operates on ASCII files containing both the data and plotting command used to control the display. QDP was written and is currently maintained by Allyn Tennant, at the Marshall Space Flight Center (SSL::TENNANT). PGPLOT, provided and maintained by Tim Pearson, is the graphics package used by QDP/PLT.

9.1 Overview

QDP reads the ASCII file containing various plotting commands and the data, then calls the PLT subroutines which then executes the commands and plot the data. At this point the `PLT>` prompt appears and the user can then proceed to perform the following:

- Display informations on about the interactive commands via HElp.
- Override various PLT defaults.
- Override the PLT commands found in the QDP file.
- Add/remove labels.
- Plot data with various combinations of lines, markers, and error bars.
- Change the appearance/style of the of the plot, for example converting all text into Roman Font.
- Plot the data as a function of a different x variable.
- Change the number of panels in which the data is plotted.
- Define models and to calculate the 'best fit' parameter values.
- Generate hardcopy.

QDP/PLT can be run within each XRONOS application, either automatically or interactively, to plot and fit QDP output files. The default is the automatic plotting mode.

9.2 Useful QDP Commands

A few, commonly used QDP/PLT commands are given below; the full descriptions of the PLT commands is in the "QDP/PLT User's Guide" or can be listed on the terminal typing ? or help from the PLT prompt.

- Rescaling: to rescale X and Y axes use:

```
PLT> r x xlow xhigh
PLT> r y ylow yhigh
PLT> r xlow xhigh ylow yhigh
```

- Logaritmic_Axes: to make the x and/or y axes logarithmic (to the base 10) use:

```
PLT> log x
PLT> log y
```

- To turn off the logarithmic axes use

```
PLT> log off
```

- Device: to change the current plot device use:

```
PLT> dev /xxx
```

  where `/xxx` is the new plot device.

- Modelling and Fitting: to use the fitting capability of QDP/PLT two are the main commands `MOdel` and `FIT`. The `MOdel` command is used to define the model, any combination of model components can be added together. For example:

```
PLT> mo cons linr quad
```

  will add a constant, a linear and a quadratic term. The list of the available models is given typing:

```
PLT> mo ?
```

  The `Fit` command cause PLT to call the fitting routine to search for the best fitting parameters for the model specified with the `MOdel` command.

- Hardcopy: a hardcopy of the current plot is obtained using:

```
PLT> hardcopy filename
```

  The file is in postscript.

- EXit: to exit from the PLT subroutine type:

```
PLT> exit
```

Chapter 10

Input Files

XRONOS currently supports two different types of input files:

- RATE BUFFERS (extension `.rbf`): these are binary files (with 128 words/rec) created by the EXOSAT interactive analysis and database software. They contain a 4 record header whose content is (in part) displayed when running most XRONOS applications. In short there are 5 types of rate buffers:

  (0) Type 0 rate buffers contain binned data (16 bins/rec); for each bin the center time (1 ms accuracy), dead time, count rate and error on count rate are stored. The barycentric time correction can either be applied to the bin center times, or stored in records 3-4 and applied by XRONOS at run time.

  (1) Type 1 rate buffers contain binned data (256 bins/rec); only the number of counts in the bin is stored. The barycentric time correction can be stored in records 3-4 and applied by XRONOS at run time.

  (2) Type 2 rate buffers contain binned data (64 bins/rec); for each bin the count rate and error on count rate are stored. The barycentric time correction can be stored in records 3-4 and applied by XRONOS at run time.

  (3) Type 3 rate buffers are not implemented yet.

  (4) Type 4 rate buffers contain photon arrival times (16 photons/rec). The layout of the data records is the same as in type 0 rate buffers.

  (5) PAT Rate buffers (Photon Arrival Time) have a different layout in that they can contain the photon arrival times of more than one source in the field of view of an imaging detector. Each PAT- subfile contains the data from one source. The number of events in each data record is 64.

  Note that for cases (4) and (5) an exposure file is required to reconstruct exactly the exposure during the observation (e.g. telemetry dropouts, data gaps, etc.). It is assumed that: (a) the exposure file is a type 0 rate buffer covering the same interval of the arrival time file; (b) its filename coincides with the rate buffer filename except that the first letter of the filename is replaced by a `B`. A warning is issued if such file is not found. In this case XRONOS assumes a 100 per cent exposure in each newbin.

- QDP FILES (extension `.qXXX`, where `XXX` can be any 3 characters) these are ASCII files written according to the QDP/PLT specifications. They consist of a header and a number of "vectors", each written as a column. Xronos QDP files (see chapter 11 `output_files`) are an example of these files. To use QDP files as input to XRONOS applications it is essential that these have a two line header at least.

It is essential that bins (in input files containing binned data) or photon arrival times (for arrival time input files) are stored in chronological order.

10.1 Rate Buffers

A description of rate buffers files for all experiments currently supported by XRONOS follows. The descriptions of records 1 thru 4 are for the so-called "new" types of file-headers. The old types of file-headers have been phased out in 1986 and they are not supported by XRONOS. To find out whether a particular header is in the old or new format, see record 1 word 55.

Files are binary with records 128 words long. Default variable type for all fields is normal signed integer*2.

The layout of record 1 is common to all instruments

```
Record 1
--------

   Word                     Description
   ----                     -----------

   1-8                 source name (a16,ascii)
   9-10                s/c pointing ra, scaled such that
                       360 degrees = 10**9 (i*4)
   11-12               s/c pointing dec, scaled such that
                       90 degrees = 10**9  (i*4)
   13                  s/c roll in units of 0.1 degree
   14                  =1 if slew flag set, =0 otherwise
   15                  spare
   16                  type of rates file:
                        =0 for old low-resolution rates file
                        =1 for old msec (luigi-type)  "   "
                        =2 for new low-resolution rates file
                        =3 for new msec (luigi-type) "    " (not supported)
                        =4 for old low-res rates files obtained
                           from arriv. time files
                        this determines which layout of recs 5
                        onwards applies.
   17-18               Bin integration time. It can be specified in the
                       following units, depending on the value of word 29:
                       a) 2**-14 sec  (i*4)  (word 29 = 0)
                       b) microsec           (word 29 = 1)
                       c) sec                (word 29 = 2)
```

19-20	shf key of start of rates file (i*4)
21-22	shf key of end of rates file (i*4) do not use these shf keys for accurate correlation of s/c time with utc. they are ok to an accuracy of 1 second, but for precise correlation use the 'datation area'.
23	experiment number (1,2,3,4,5,6 = L1,L2,ME, GS,SSS,MPC) this determines which layout of record 2 applies below.
24	0 = no correction to bin times has been calculated 1 = barycentric correction has been applied to the data in records 5 and on 2 = barycentric correction has been computed, and the results for various times are stored in records 3 and 4 as described below, and may be interpolated to correct the time of any bin.
25-26	no. of data points/bins, not including special markers for gaps, e-o-f..(i*4)
27-28	shf key of file creation time (i*4)
29	Flag to control the units in which the bin integration time is specified (see words 17-18) the allowed values are: =0 for 2**-14 sec units =1 for microsec units =2 for sec units
30-31	spare
32	power of 2 by which to multiply all c/s in recs 5 onwards of a compressed low- res rates file - not used for other file -types. the program reading the file should multiply all bin values by 2 to this number, to obtain the 'true' values
33	power of 2 by which to multiply all err/sec in recs 5 onwards of a compressed low-res rates file - not used for other file types.
34	power of 2 by which to multiply all deadtimes in recs 5 onwards of compressed low-res file - this is for future use
35-36	average count rate for data in file in units of 0.001 cts/sec (i*4) for all instruments but L1 & L2 (for which units are 1.e-6 cts/sec)
37-38	standard deviation of previous quantity in units of 0.001 cts/sec (i*4) for all instruments but L1 & L2 (for which units are 1.e-6 cts/sec)

```
39                no. of data gaps in a msec file -
                  not used for low-res
40                set to 1 if real variables converted to
                  hp 9000 ieee standard
41-42             time of centre of first bin in file
                  relative to the datation reference point
                  given in words 43-44 (following immediately)
                  and expressed in s/c clock units. (signed i*4)
                  the ref time of the centre of the 1st bin is
                  therefore:
                       words 43-44  plus  words 41-42
                  (calculated with i*4 arithmetic).
43-48             accurate datation information, for relating
                  s/c clock to utc. no correction for
                  propagation etc is made. contains 3 i*4's:
       (1)    s/c clock of datation reference point, i.e.
              the ref time of the 1st hk record in units
              of 2**-14 secs         (unsigned i*4)
       (2)    the utc of the datation reference point,i.e.
              the ground station time of the 1st hk record
              this i*4 contains the whole number of secs
              i.e. the shf key
       (3)    the remaining microsecs to complete the utc
              of the datation reference (between 0 and 999999)
49-54             exactly the same information as given in
                  words 43 to 48, but for a datation reference
                  at the end of the file (the last hk record).
                  only of interest for cases when extreme time
                  accuracy is needed and when it is necessary
                  to measure the speed of the s/c clock.
55                this location defines whether recs 1 to 4
                  are in new or old format. this listing
                  only describes the new format actually,
                  for which word 55 = 1. old headers can be
                  identified as such by value 0 for word 55.
                  the value 2 means that header is in new
                  format but was derived from old format;
                  some fields may therefore be missing.
56                spare
57-58             source ra scaled such that 360 deg =1.e9 i*4
59-60             source dec scaled such that 90 deg =1.e9 i*4
61-62             no. of 128 word records in file
63                average barycentric correction in units of
                  0.1 sec applied to file if word(24)=1
64                spacecraft clock correction, the no.of pulses
                  /expected pulses = (0.999999+word(64)*1.d-10)
                  this will only be set if word(24)=1 OR 2.
65                =1 if file is concatenated using conlc
```

```
66                spare
67-68             if word(24)=2 contains the no. of msec
                  to be added to the 1st datation time (43-48)
                  in order to correct arrival times to the
                  barycenter (see also word 71).
69-70             as words 67-68 but for the time given by wrds
                  49-54.
71                residual no of microsec to be added as 67-68
72                residual no of microsec to be added as 69-70

73-74             shf key of observation start (implemented on 19/7/88)
75-76             shf key of observation end   (      "      "    "   )

77-128            spare
```

The layout of record 2 is different for different instruments.

For the EXOSAT ME:

```
Record  2  (for ME)
-----------

  This contains information that is specific to the me:

    Words                 Description
    -----                 -----------

     1               instrument  (ar=1,xe=2 , both = 3)
     2               record type (a2, ascii)    e.g.'e3'
     3               start detector number selected(1-8)
     4               stop detector number selected (1-8)
     5               start b/g det no. (1-8) 0 if no b/g sub
     6               stop         "         "
     7               start bin number (1-128)
     8               stop   "     "      "
    9-10             spare
     11              collimator efficiency (10**4 = 1.0)
     12              spare
     13              background correction method 0=none
                     1=auto, 2=by file, 3=yes
   14-16             bg correction file name [if meth=2] (a6)
     17              minimum wait time (htr3 only)
   18                deadtime correction factor [only if dt:ca]
                     scaled such that 10**3 = 1.0
   19-20             hk cts/sec such that 100 =1 cts/sec (i*4)
   21-22             spare
   23-24             lc correction additive constant (10**3=1.0)
    25               =1 if cts are deadtime corrected else 0
                     for no correction or 2 for time dep correct.
```

```
                       (note that in type 1 rate buffers the correction is
                       applied (due to the integer representation), even
                       if there are some old rate buffers for which
                       word (25)=1
      26               spare?
      27               start channel number (as opposed to bin
                        number) channels numbered 0..255
      28               end channel number as opposed to bin number
     29-33             spare
      34               no. of on-source dets
      35               no. of bg dets used
     36-128            spare
```

For the EXOSAT GSPC:

```
Record 2  (for GSPC)
--------------------

   Words                      Description
   ------                     ------------

     1                 instrument ( = 4 , meaning gs)
     2                 app. program no.
    3-4                spare
     5                 bl lower value
     6                 bl upper value
     7                 start channel
     8                 stop channel
    9-10               spare
     11                collimator efficiency scaled such that
                        10000 = 1.0
```

For the EXOSAT LE:

```
Record 2  (for LE)
------------------
(New layout implemented on 22-8-86 on hp2)

  Words                           Description
  -----                           -----------

    1                  instrument(=5 for both le1 and le2!!)
                        (le1 & le2 can be distinguished from
                        record 1 word 23)
    2                  obc ap number (from which it can also
                        be deduced whether le1 or le2 is used)
                        if>100 then this location contains
                        (ap no)*100+submode workspace param.
```

```
   3                filter wheel position number (as in
                     telecommand readout)
   4                minimum wait time (units of 2**-5 secs)
  5-10              spare
 11&12              normalisation that has been applied to
                     all data points in file; to remove the
                     effect of the normalisation, all points
                     may be divided by this value. it is
                     encoded as 2 i*2's which should be
                     interpreted as follows:
                     rec(12)/3000.0*10.0**rec(11)
                     i.e. like an exponent & mantissa.
                     typical value is in fact 1.0!!
  13                minimum fractional exposure that a bin
                     must have before it is filled * 10000
  14                lcurv version # (iver*100+imod)
  15                1000 * correction factor
                     corresponding to mean fractional deadtime
 16-29              spare
  30                =1 if dead time corrected for sample rate
  31                =1 if corrected for telemetry available
  32                =1 if bg subtracted
  33                =1 if source only =0 if bg only
  34                =0 generally (normal counts in file)
                     =1 for 'existence profile' (bins=0 or 1)
                     =2 for exposure time profile (bins =
                      between 0.0(empty)&1.0(fully exposed))

                      words 35 to 60 or words 61 to 65 may
                      specify pixels included in file

  35                number of source boxes (up to 3)
  36                number of background boxes (up to 3)
                     (only 2 allowed for in old format)
 37-40              low x, low y, high x, high y, srce box 1
                     (linearised raw x's and y's)
 41-44              same for bg box 1
 45-48              same for source box 2 (spare if no box 2)
 49-52              same for bg box 2 (spare if no box 2)
 53-56              same for source box 3 (spare if no box 3)
 57-60              same for bg box 3 (spare if no box 3)
 61                 source x coordinate
 62                 source y coordinate
 63                 radius of source box
 64                 radius of inner bkgnd box
 65                 radius of outer bkgnd box
 66                 srce box area/bkgnd box area * 10000
 67                 bkgnd non-uniformity correction factor
```

```
                          applied * 10000
     68-128              spare
```

For the Einstein SSS:

```
   Record 2  (for SSS)
   -------------------
   (implemented on 20/7/89)

       Words                      Description
       ------                     ------------

         1               instrument mode
         2               spare
         3-4             shf time of last defrost
         5               start channel
         6               stop channel
         7-8             opto rate scaled 10000=1.0
         9               rate
```

For the Einstein MPC:

```
    Record 2  (for MPC)
    --------------------
    (implemented on 23/8/89)

       Words                      Description
       ------                     ------------

         1               start channel
         2               stop channel
         3               l cut-off (scaled 10000=1)
         4               b cut-off (scaled 10000=1)
         5               anticoinc. cut-off (scaled 100=1)
         6               sequence no.
```

For the HEAO-1 A-1:

```
   Record 2  (for A-1)
   -------------------
   (implemented on 1/9/91)

       Words                      Description
       ------                     ------------
```

```
1               instrument (=10 A-1)
2               spare
3-10            catalog name (a16 ascii)
11-12           galactic latitude (10^9 units)
13-14           galactic longitude (10^9 units)
15-16           first major frame in file
17-18           second major frame in file
19-22           first instrument mode
23-26           second instrument mode
27-30           third instrument mode
31              total number of mjf's
32              lower energy range (keV x100)
33              upper energy range (keV x100)
```

The layout of records 3 and 4 is common to all instruments:

```
Records 3 and 4
----------------

   Contains 256 arrival time correction values if word(24) of
   record 1 is set to 2. In which case the differences wrt to a
   linear relation between arrival time correction and time are
   given. The following gives the formulae for reconstructing the
   arrival time corrections which should be added to the times in
   the file:
   correction values are val(j)
    let t1=time of 1st datation (rec 1, words 43,48)
        t2=time of 2nd datation (rec 1, words 49,54)
        i1=correcn to be added in msec at t1 (rec1, words 67,68)
        i2=correcn to be added in msec at t2 (rec1, words 69,70)
        m1=residual correction in microsec at t1 (rec1, word 71)
        m2=residual correction in microsec at t2 (rec1, word 72)
    then c1=i1+m1/1000.d0  (correction in msec at t1)
         c2=i2+m2/1000.d0  (correction in msec at t2)
         dt=(t2-t1)/255.d0 (interval between 256 correction vals)
         grad=(c2-c1)/(t2-t1).d0
         cval(j)=c1+grad*dt*(j-1) (linear value)
         tcor(j)=cval(j)+val(j)/1000.d0
    tcor(j) gives the time correcn in msec at times corresponding
    to t1+(j-1)*dt for j=1,256
```

For TYPE 0 RATE BUFFERS the layout of records 5 to n is:

```
Records 5-n   (if file type =0 i.e. old low-resolution files )
-----------
```

```
Each record contains 16 bins of data. each bin consists of:

Word                    Description
----                    -----------

n                  day no.
n+1,n+2            time of day (msec) (i*4)
n+3                scaled dead time (i*2) (0-10000)
n+4,n+5            counts/sec       (r*4)
n+6,n+7            error (cts/sec)  (r*4)

where n=1,9,17,..121  for bins 1,2,3,..16

n+8                -1 on last day no. to indicate end
```

For TYPE 1 RATE BUFFERS the layout of records 5 to n is:

```
Records 5-n   (if file type = 1, i.e. old msec file)
-----------

  256 8-bit intensity samples with 0-252 giving the cts/integration
  interval, 253 indicating end of file, 254 indicating >252 cts/
  integration interval and 255 a data gap.
```

For TYPE 2 RATE BUFFERS the layout of records 5 to n is:

```
Record 5-n   (if file type=2  i.e new low-resolution files)
-----------

   word  n    =    cts/sec as semi-log scaled i*2
   word  n+1  =    err/sec as semi-log scaled i*2

     if err = -1 this means bin is completely empty, i.e.
                 it lies completely within a data gap
     if err = -2 this means end of file
                 (and the accompanying counts/sec is not to be
                 interpreted as a bin)
     if err = -3 this means that the accompanying countrate
                 couldnt be converted to semilog without overflow.
 I.e. 64 bins per rec, and the time of a bin is implied by its
 offset in the file. Numbers are scaled by a common power of 2
 as given in rec 1 of the file. Direct access to any time in the
 file is thus possible. No deadtimes.
```

For TYPE 4 RATE BUFFERS the layout of records 5 to n is:

```
Records 5-n   (if file type =4 i.e. old low-resolution files obtained from
-----------    arrival time files)

   Note that in this case the data are unbinned and each time represents
   the arrival time of each photon.
   For each photon the following information is given (16 photons/rec):

   Word                      Description
   ----                      -----------

   n                   day no.
   n+1,n+2             time of day (msec) (i*4)
   n+3                 scaled dead time set to 10000=1 in this case
   n+4,n+5             counts/sec, set =1 in this case
   n+6,n+7             error (cts/sec), set =1 in this case

   where n=1,9,17,..121  for photons 1,2,3,..16

   n+8                 -1 on last day no. to indicate end
```

10.1.1 PAT Rate Buffers

The photon arrival time (PAT) rate buffers are binary files (with 128 words/rec) created by the EXOSAT LE automatic analysis and database software. A PAT file is divided in PAT-subfiles, each containing the data of one detected source in the field of view. The first header record, partially displayed when a XRONOS applications is executed, contains the following basic information:

```
   Word                        Description
   ----                        -----------
    1-2               'PAT ' (a4,ascii) identifies a PAT-rate buffer
     3                N, number of PAT-subfiles present (if N is
                      negative the photons in each subfile are time
                      ordered)
     4                total number of records in the PAT-rate buffer
   5+(N-1)*4          (=M) start record number of the N-th PAT-subfile
   M+1 to M+3         N-th PAT-subfile name (a6,ascii)
```

The maximum number of PAT-subfiles is 31. To select the N-th subfile use the `fsN` input file option (see sect. 10.3, `input file options`). The first 2 records of each subfile are the header records for each detected source and use the same layout of normal EXOSAT LE rate file header records. Note some header information in PAT-subfiles and, in general, photon arrival time rate buffers is irrelevant. This is:

- there is no binning time

- there is no background subtraction, i.e. photons for each source are both from the source and the background
- the barycentric time correction is not supported in PAT-rate buffers

The following records of a PAT-subfile contain the arrival time of each photon. This is stored in units of 2**-14 seconds from a start time corresponding to words 19 and 20 of the first header record of each PAT-subfiles. The end of the data (before the end of the last record) in a PAT-subfile is indicated by a photon arrival time of -1.

10.1.2 ME Rate Buffers

Note that XRONOS applications by default work out and apply EXOSAT ME dead time correction to count rates (if not applied yet) and to errors on count rates (to reconstruct exactly the expected variance from a constant source) of ME rate buffers; this will work only if all the relevant infos are contained in the ME rate buffer header. Otherwise a warning message is produced and input file option `ma` should be used to correct count rates and errors for a dead time correction constant and/or option `dv` to correct the error bars for the dead time effects on the variance (see Eq. 2.21 in Lewin et al. 1988 Sp. Sc. Rev., 46, 273, with tau=5.5e-6 s for HTR3 and HTR5, tau=4.88e-4 for PULS and PULS2, and tau=2.44e-4 for all other ME data types).

10.2 QDP Input Files

They must be files written according to the QDP/PLT specifications. They consist of a header and a number of "vectors", each written as a column. To use QDP files as input to XRONOS applications it is essential that these have 2 header lines at least:

- QDP HEADER LINE containing the `READ` command according to the QDP specifications. This is essential to let XRONOS know which vector have errors associated to them. Note that in case a QDP file contains asymmetric errors (`READ TERR ....`) only the first error column of a vector is used by Xronos.
- XRONOS HEADER LINE starting with `!!H` and followed by 5 numbers: (1) the first number represents the bin integration time of the file expressed in seconds: a negative number indicates an arrival time file in which times represent the arrival times of individual photons; (2-3) the second and third numbers give the center times of the first and last bin in the file expressed in days; (4) the fourth number is a file format flag and should be specified as follows: =0 if the Y-values are in counts/s (or any equivalent), =1 if Y-values are in counts; (5) the fifth number specifies the units of the time axis (X-axis): if =0 the units are seconds from the start time given by the 2nd number in the header; if =1 units are seconds from the beginning of the hour specified by the 2nd number; if =2 units are hours from the beginning of the day specified by the 2nd number; if =3 units are days. The fourth and fifth numbers might not be specified in the Xronos header line in which case they are taken =0 by default.

If the XRONOS header line is missing, XRONOS applications will assume a bin integration time of 1 s, a start time at day 1.000000 and a stop time 511 s later (i.e. 512 bins of 1 s). The information contained in the XRONOS header line can also be used to specify the times to be used in the X-axis: in this case Y-values in the QDP file will be assigned times obtained by stepping the bin integration time (1st number of the XRONOS header line) from the start time (2nd number of the Xronos header line) onwards. This is done by specifying a negative number after the input file option `vx` (see section on input file options).

XRONOS applications include the input file options `vx`, `vy` and `ve` to specify which vector should be assigned, respectively, to the X-axis (i.e. time axis), which to the Y-axis and which to the bin exposure. By default vector 1 is assigned to the X-axis (i.e. time axis) and vector 2 to the Y-axis (i.e. the input series). Then if the input file contains more than 2 vectors the last vector is assigned by default to the bin exposure (note that this is the convention used in Xronos QDP Output Files). If the input file contains only 2 vectors the bin exposure will be =1 by default. If a negative number is specified after the input file option `ve`, then the bin exposure is forced to be =1, even if more the input file contains more than 2 vectors. Note that bin exposure, if present in a file in which Y-axis values are in counts (i.e. 4th number of the XRONOS header line is =4), are used to rescale Y-axis values and errors to counts/s.

The error on the X-axis points (i.e. the semiwidth of time bins) is not used by XRONOS applications. Errors on the Y-axis points are instead necessary. If the QDP file does not contain Y-axis errors, XRONOS applications calculate the error by using Poisson statistics (i.e. sqrt(Yvalue*bintime)/bintime, if the 4th number of the Xronos header line is =0, or sqrt(Yvalue), if the 4th number of the Xronos header line is =1). Note that in this case Y-axis bins should not be background subtracted. If the QDP file contains 1 vector only this is assigned to the Y-axis by default and X-axis values are stepped according to the content of the XRONOS header line. If an arrival time QDP file is indicated the Y-axis values and errors are always set =1.

Gaps in the vector(s) are indicated by the (QDP/PLT) value =-1.2e-34.

Note that XRONOS QDP files produced by XRONOS applications can be used as QDP input files.

10.3 Input File Options

In all XRONOS applications up to 10 INPUT FILE OPTIONS can be specified for each input file. Options are specified in the same string in which each input filename is given and consist of 2 characters followed, in most cases, by a numerical constant containing up to 8 characters. Available options are (`X` indicates the numerical constant):

- `bt` = to apply Barycentric Time correction contained in the rate buffer header. (Relevant only to Type 0,1,2 Rate Buffers)
- `dn` = not to apply any additional dead time correction(s) to the EXOSAT ME rate buffer, besides that (those) which are already applied in the rate buffer. (Relevant only to ME rate buffers).
- `stX`= Shift all Times in input file by X days
- `ssX`= Shift all times in input file by X Seconds
- `frN`= start reading input file from record number N (First Record)
- `lrN`= stop reading input file at record number N (Last Record) (Options `fr` and `lr` are useful to speed up the reading of a very large input file, when only part of the input file has to be analysed.

They effectively work as fast time windows. The correspondence of record number and time can be worked out based on the input file type. These options apply to Rate Buffers only)

- `vxN`= use vector number N as x-axis (i.e. time axis) in a QDP input file (a negative value of N means that X-axis will be stepped according to the content of the XRONOS header line in the QDP input file)
- `vyN`= use vector number N as y-axis (i.e. series to be analysed) in a QDP input file
- `veN`= use vector number N as bin exposure in a QDP input file (a negative value of N means that no exposure vector is specified even if the input file contains more than 2 vectors)
- `fsN`= Find Subfile number N in a PAT-rate buffer. If the option is not specified than XRONOS will use the first subfile (N=1).

Options below are applied in the same order in which they are specified:

- `muX`= multiply data and errors by X (MUltiply)
- `mdX`= multiply data by X (Multiply Data)
- `meX`= multiply errors by X (Multiply Errors)
- `maX`= as muX but exposure is divided by X (used for dead time correction)
- `diX`= divide data and errors by X (DIvide)
- `ddX`= divide data by X (Divide Data)
- `deX`= divide errors by X (Divide Errors)
- `daX`= as diX but exposure is multiplied by X
- `aaX`= add data and errors with X (Add All)
- `adX`= add data with X (Add Data)
- `aeX`= add errors with X (Add Errors)
- `saX`= subtract data and errors with X (Subtract All)
- `sdX`= subtract data with X (Subtract Data)
- `seX`= subtract errors with X (Subtract Errors)
- `qaX`= add to data the square of data multiplied by X and add to errors the product of data and error multiplied by X. (This is used to multiply data (Y) and errors (SY) by a linear interpolation constant: Y'= Y(A+BY)= AY+BYAYA/AA= YA+CYAYA with C=B/AA , SY'= SY(A+BY)= SYA+BYASYA/AA= SYA+CYASYA. This can be done by using options: `muA qaC` (where A and C are those used above). To easily get C knowing A and B run command `$ lfo`)
- `qdX`= as above but for data only
- `qeX`= as above but for errors only

- `dvX=` work out and apply EXOSAT ME dead time correction for errors on count rates (to work out expected variance), by providing the source average count rate manually (this is for the case in which not all the relevant infos are contained in the rate buffer header). A positive (negative) value of `X` represents the source average count rate before (after) dead time correction. Note that in the absence of other instrumental effects the dead time correction is only a multiplicative constant which can be applied to both the data and errors with option `mu`. (This option is relevant only to ME rate buffers).

For example suppose that you want to shift the times of file **`file1.rbf`** by -3.256 days and correct file `file2.rbf` to barycentric times and subtract a constant of 13.2 from the data. If using the Question/Answer user interface instead of simply replying filenames you should enter:

```
lc1> Ser. 1 filename   1 +options[.rbf]=> file1.rbf st-3.256
lc1> Ser. 1 filename   2 +options[.rbf]=> file2.rbf bt sd13.2
```

Otherwise if using the `data` command you should enter:

```
[n]Xronos> data file1.rbf st-3.256,file2.rbf bt sd13.2
```

Chapter 11

Output Files

Output files created by XRONOS applications are:

- XRONOS QDP FILES (extension `.qXXX`): these are ASCII files containing the results of analysis carried out with XRONOS applications. They can also be used as inputs to XRONOS applications. The filename extension is `.qXXX` where `XXX` is the command which creates the file (e.g. XRONOS QDP files created with the `lc1` have extension `.qlc1`). XRONOS QDP files contain results from ONE Frame only. They are written according to the QDP/PLT specifications and consist of:

  (i) a header containing: QDP/PLT plotting command lines (which always start with a letter); comment lines (which always start with `!`) some of which contain useful information obtained from the analysis. Note that QDP/PLT commands might also be present at the end of the file.

  (ii) independent variable vector and error, result vectors and error and exposure vector, according to the QDP commands given in the header.

- XRONOS BINARY FILES (extension `.xXXX`) (Not yet fully supported) These are binary files containing the results of analysis carried out with XRONOS applications. The filename extension is `.xXXX` where `XXX` is the name of the application which creates the file (e.g. XRONOS binary files created with application `lc1` have extension `.xlc1`). Xronos binary files contain the results from ALL frames of a run.

11.1 Header of QDP Output Files

QDP Output files created by XRONOS applications always start with a series of QDP/PLT commands; these are (see the QDP/PLT specifications):

```
LA T ....... Contains some basic infos: source name, year of observ. + summary
             from 1st file of each series (e.g. instrument channel range etc.)
LA OX ...... Contains start/stop times of analysed data (times refer to the
             center of the 1st and last good newbins)
READ SERR .. Specifies which vectors in file have errors
CO 1 ON .... Specifies which vectors will be plotted by default
CO 0 ON .... Specifies which vectors will not be plotted by default
```

```
VPORT ...... Specifies the QDP/PLT viewport
CSIZE ...... Specifies the label character size
LA Y1 ...... Describes the X-axis variable (i.e. vector number 1)
LA Yn ...... Describes the Y-axis variable n-1 (i.e. vector number n)
             (n is not specified if only 1 Y-variable is plotted)
```

Then a number of lines starting with ! follow: these are regarded as comments by QDP/PLT but they contain useful infos obtained from XRONOS applications and some of them are read by XRONOS applications. Note that in the description below k is the number of input series used by the applications which creates the file.

```
! file ..... Specifies QDP output filename and XRONOS application used
! created .. Specifies file creation date and XRONOS version used
! iflags ... the 20 numbers in the following two lines starting with '!!0'
             are the INTEGER FLAGS used in analysis
! rflags ... the 10 numbers in the following two lines starting with '!!0'
             are the REAL FLAGS used in analysis
!H ......... Describes the content of the XRONOS HEADER LINE
!!H ........ XRONOS HEADER LINE
!! new/int.. Describes the content of the INTEGER VARIABLES in the following
             k lines (lines containing the relevant variables start with
             '!!1', '!!2' or '!!3', respectively, for the 1st, 2nd and 3rd
             series)
!! avg(c/s). Describes the content of some of the REAL VARIABLES in the
             following 2k lines (lines containing the relevant variables start
             with '!!1', '!!2' or '!!3' and lines containing the errors of the
             corresponding variables start with '!E1', '!E2' and '!E3',
             respectively, for the 1st, 2nd and 3rd series).
!! min(c/s). Describes the content of the other REAL VARIABLES in the
             following 2k lines (lines containing the relevant variables start
             with '!!1', '!!2' or '!!3' and lines containing the errors of the
             corresponding variables start with '!E1', '!E2' and '!E3',
             respectively, for the 1st, 2nd and 3rd series).
!! epoch ..  Describes the content of some of the DOUBLE PRECISION VARIABLES
             in the following k lines (lines containing the relevant variables
             start with '!!1', '!!2' or '!!3', respectively, for the 1st, 2nd
             and 3rd series)
!! newb ...  Describes the content of the other DOUBLE PRECISION VARIABLES
             in the following k lines (lines containing the relevant variables
             start with '!!1', '!!2' or '!!3', respectively, for the 1st, 2nd
             and 3rd series)
!! ........  Dummy line
```

Then all the lines containing vectors (in the QDP/PLT sense) follow. Gaps in the vector(s) are indicated by the (QDP/PLT) value =-1.2e-34. Note that in `.qefs` files two additional QDP/PLT label lines are written at the end of the file.

The `DEV ...` command (specifying the plot device), the `PLOT VERT ...` command (used only when more than one Y-variable is plotted by default), any additional plot options (specified from individual applications such as `lc2`, or through a `.pco` file) and the `EXIT` command (for automatic plotting) are written at the end of the file.

Note that errors on the Y-axis variables are evaluated from the standard deviation of the average (based on measured scatter), as opposed to (theoretical) error propagation, depending on the value of the 9th global parameter.

11.1.1 Integer Flags

Below is the meaning of each flag

- 1 - File type (currently =0) as in Xronos header line
- 2 - Units for time axis (0=secs from start, 1=secs from start of the hour 2=hour from start of the day, 3=days) as in Xronos Header Line
- 3 - Trend removal flag (0=none; 1,2,3,4= degree of polynomial removed)
- 4 - Mode for trend removal (1=Subtract; 2=Divide; 3=Replace)
- 5 - Total number of windows used in analysis
- 6 - Min. number of expected good intvs/frame to calculate scatter errors
- 7 - Analysis normalisation flag
- 8 - Number of result columns (Y-axis columns)
- 9 - Number of indep. variable columns (X-axis columns)
- 10 - Number of input series
- 11 - Max number of boxes/plot in QDP (exposure variable is not counted)
- 12 - Max number of frames expected
- 13 - Expected number of result bins after rebinning
- 14 - Requested number of analysis points before rebinning
- 15 - Max number of analysis points
- 16 - Simultaneousness flag
- 17 - Number of newbins used in running mean for filling in gaps
- 18-20 - Spare (=0)

11.1.2 Real Flags

Below is the meaning of each flag

- 1 - Rebinning constant (d/f=0, >0 linear reb., <0 geometr. reb.)
- 2 - Rescaling factor for results (d/f=1.)
- 3 - Additive constant for results (d/f=0.)
- 4 - Expected white noise level (only for power spectrum applications)
- 5-10 - Spare (=0)

11.1.3 Xronos Header Line

The Xronos header line starts with `!!H` and contains the following information

- 1 - Binning time (in secs) used in the analysis
- 2 - Start Time (in days) of the data analysed (this is the center time of the 1st newbin in frame independent of whether it was a good or a rejected newbin). For folding applications this is the epoch
- 3 - Stop Time (in days) of the data analysed (this is the center time of the last good newbin in frame
- 4 - Type of file: this is set =0 to indicate counts/s units (or any equivalent of that in input files)
- 5 - Unit of time axis: used only if the X-axis in the file is time (=0 in all other cases: =0 units are secs from the Start Time; =1 units are secs from the beginning of the hour specified in Start Time =2 units are hours from the beginning of the day specified in Start Time =3 units are days.

The XRONOS header line is used by XRONOS applications to reconstruct the timing information when QDP Output Files are used as input to XRONOS applications.

11.1.4 Integer Variables

```
newb/int .... requested number of newbins in interval
intv/frame .. requested number of intervals in frame (-1 means: frame=intv)
good bins ... number of good bins analysed in frame
good newb ... number of good newbins analysed in frame
good intv ... number of good intervals in frame
bin anal .... requested number of analysis bins before rebinning
bin result... expected number of result bins after rebinning
```

11.1.5 Real Variables

Note that errors on the variables below are evaluated from the standard deviation of the average (based on measured scatter), as opposed to (theoretical) error propagation, depending on the value of the 9th global parameter. For some variables only the former errors are available. Averages are unweighted.

```
avg(c/s) .... average count/s in frame (average of averages in intervals)
frac.expos... fractional exposure in frame (from average of fractional
              exposures in intervals)(fractional exposure in interval =
              = ratio of good newbins to number of newbins/interval)
variance .... variance in frame (average of variances in intervals)
expec.var.... expected variance in frame (average of expected variances in
              intervals) (expected variance in interval is calculated from
              the error bars of the newbins)
3rd moment... 3rd moment in frame (average of 3rd moments in intervals)
min(c/s)..... minimum count/s in frame (error=0)
max(c/s)..... maximum count/s in frame (error=0)
excess var... excess variance in frame (average of excess variances in
              intervals)(excess variance in interval = variance-exp.var.)
chi-square....chi-square in frame (average of chi-squares in intervals)
rms variation rms fractional variation in frame (average of rms fractional
              variation in intervals)(rms fractional variation in interval
              = sqrt(excess var)/avg(c/s) )
```

11.1.6 Double Precision Variables

```
epoch or 1st newb .... epoch used in folding or time center of first newbin
                       analysed (days)(=2nd number in Xronos header line)
frme baryc.time ...... barycenter time of frame (average of barycenter time
                       of intervals)(days). To be used as `center` time of a
                       frame weighted for gaps, rejected data etc.
period(s) ............ period (secs) in folding
newb duration ........ newbin duration (secs)(=1st number in Xronos header
                       line)
first good newb ...... center time of first good newbin in frame
last good newb ....... center time of last good newbin in frame (=3rd number
                       in Xronos header line)
```

11.2 Format of QDP Output Files

The meaning and format of independent variable vector and error, result vectors and errors and exposure vector written to XRONOS QDP files depend on the XRONOS application which is used.

11.2.1 acf acs Output Files

The output file produced by application `acf` and `acs` contains 3 vectors

- Vector 1: Time Delay (with errors representing half width of time delay bin)(X-axis)
- Vector 2: Autocorrelation (with errors) (Y-axis)
- Vector 3: Exposure (without errors): this is the number of times delay bins that were averaged in time delay (as a result of rebinning) and in time (as a result of averaging in a frame).

11.2.2 ccf ccs Output Files

The output file produced by application `ccf` and `ccs` contains 3 vectors

- Vector 1: Time Delay (with errors representing half width of time delay bin)(X-axis)
- Vector 2: Cross Correlation (with errors) (Y-axis)
- Vector 3: Exposure (without errors): this is the number of times delay bins that were averaged in time (as a result of averaging in a frame).

11.2.3 ef1 Output File

The output file produced by application `ef1` contains 3 vectors

- Vector 1: Phase (with errors representing half phasebin width) (X-axis)(2 cycles are written)
- Vector 2: Normalised Intensity or Counts/s (with errors) (Y-axis)
- Vector 3: Exposure of each newbin (without errors).

11.2.4 ef2 Output File

The output files produced by application `ef2` contains 6 vectors

- Vector 1: Phase (with errors representing half phasebin width) (X-axis)(2 cycles are written)
- Vector 2: Normalised Intensity or Counts/s Series 1 (with errors)
- Vector 3: Normalised Intensity or Counts/s Series 2 (with errors)
- Vector 4: Normalised Intensity or Counts/s Series 1+2 (with errors)
- Vector 5: Ratio Series 2/Series 1 (with errors)
- Vector 6: Exposure of each newbin (without errors) (flag only) (=1 if phasebins of series 1 and 2 are good, =-1.2e-34 otherwise)

11.2.5 ef3 Output File

The output file produced by application `ef3` contains 8 vectors

- Vector 1: Phase (with errors representing half phasebin width) (X-axis)(2 cycles are written)
- Vector 2: Normalised Intensity or Counts/s Series 1 (with errors)
- Vector 3: Normalised Intensity or Counts/s Series 2 (with errors)
- Vector 4: Normalised Intensity or Counts/s Series 3 (with errors)
- Vector 5: Ratio Series 2/Series 1 (with errors)
- Vector 6: Ratio Series 3/Series 2 (with errors)
- Vector 7: Normalised Intensity or Count/s Ser. 1+2+3 (with errors)
- Vector 8: Exposure of each newbin (without errors) (flag only) (=1 if phasebin of series 1, 2 and 3 are good, =-1.2e-34 otherwise).

11.2.6 efs Output File

The output file produced by application `efs` contains 3 vectors

- Vector 1: Period (with errors representing half period resolution) (X-axis)
- Vector 2: Chi squared (with errors)
- Vector 3: Exposure=1 (without errors) (flag only).

11.2.7 lc1 Output File

The output file produced by application `lc1` contains 3 vectors

- Vector 1: Time (with errors representing half newbin width)(X-axis)
- Vector 2: Counts/s (with errors)
- Vector 3: Exposure of each newbin (without errors)

11.2.8 lc2 Output File

The output file produced by application `lc2` contains 6 vectors

- Vector 1: Time (with errors representing half newbin width)(X-axis)
- Vector 2: Counts/s Series 1 (with errors)
- Vector 3: Counts/s Series 2 (with errors)

- Vector 4: Counts/s Series 1+2 (with errors)
- Vector 5: Ratio Series 2/ Series 1 (with errors)
- Vector 6: Exposure of each newbin (without errors) (flag only) (=1 if both newbins of series 1 and 2 are good, else =-1.2e-34)

11.2.9 lc3 Output Files

The output file produced by application `lc3` contains 8 vectors

- Vector 1: Time (with errors representing half newbin width)(X-axis)
- Vector 2: Counts/s Series 1 (with errors)
- Vector 3: Counts/s Series 2 (with errors)
- Vector 4: Counts/s Series 3 (with errors)
- Vector 5: Ratio Series 2/ Series 1 (with errors)
- Vector 6: Ratio Series 3/ Series 2 (with errors)
- Vector 7: Counts/s Series 1 + Series 2 + Series 3 (with errors)
- Vector 6: Exposure of each newbin (without errors) (flag only) (=1 if newbins of series 1, 2 and 3 are good, else =-1.2e-34)

11.2.10 psd pss Output Files

The output file produced by application `psd` and `pss` contains 3 vectors

- Vector 1: Frequency (with errors representing freq. bin half width)(X-axis)
- Vector 2: Power (with errors)
- Vector 3: Exposure (without errors): this is the number of power spectrum bins that were averaged in frequency (as result of rebinning) and in time (as a result of averaging in a frame). This value x2 gives the number of degree of freedom of the relevant chi-square distribution of the power in each frequency bin (x1 for the Nyquist frequency).

11.2.11 tss Output Files

The output file produce by the application `tss` contains 3 vectors :

- Vector 1: Time Delay (with errors representing half width of time delay bin) (X-axis)
- Vector 2: Time skewness (with errors)
- Vector 3: Exposure (without errors): this is the number of time delay bins that were averaged in time delay (as a result of rebinning) and in time (as a result of averaging in a frame).

Chapter 12

Cmd Files

The different user interfaces available in XRONOS require different (working) set up and definition for command files. Command files are supported in the questions/answer and command-driven user interfaces, but not for the partial questions/answer user interface.

12.1 Questions/Answer Cmd Files

Command files for the question/answer user interface contain the answers to the questions of a specific XRONOS application. In order to create such a command file in an automatic fashion, while answering to the questions asked by a XRONOS application, specify the command filename (note that the command file must not exist) from the run string, e.g.:

```
[n]Xronos> lc1 @lc1.cm
```

(the extension `.cm` if not specified is appendend automatically). Then answer to individual questions as if the application was being run interactively. In this way correct answers are written to file `lc1.cm`, whereas incorrect answers are ignored.

- (a) Creating a Complete Command File.

  If all the questions of a XRONOS application are answered, then a complete command file is created. This can be run by entering again the command string from the `Xronos>` prompt (`Xronos> lc1 @lc1.cm` in the example above). Note that every time a complete command file is created the corresponding command string from the `Xronos>` prompt is written to the macro file specified by global parameter number 4 (`xronos.ma` by default). This is especially useful when a number of command files have been created and need to be executed; in this case enter `Xronos> @xronos.ma`

- (b) Creating an Incomplete Command File.

  If only the first N questions are answered and an end of file (`cntl Z` in VMS, `cntl D` in UNIX) is entered in response to the (N+1)th question, then an incomplete command file is created. This can be run by entering again the command string from the `Xronos>` prompt (`Xronos> lc1 @lc1.cm` in the example above). In this case only the first N questions will be answered. From the (N+1)th question onwards, answers will have to be entered interactively.

- (c) Using an Incomplete Command File to create another Command File.

  An incomplete command file (e.g. `lc1.cm`) can be used as a template to quickly create another command file (e.g.`psd.cm`) by typing : `Xronos> psd @psd.cm @lc1.cm`. In this case the first N answers are read from file `lc1.cm` and written to file `psd.cm` (after checking that the replies are correct also for application `psd`). At the (N+1)th question the control is transferred to the terminal, from which answers can be entered as in cases (a) and (b).

12.2 Command Driven Cmd Files

In the command-driven user interface a sequence of XRONOS commands (and qualifiers) can be written to a command file `file.xco` with the editor, and then executed by typing:

```
[n]Xronos> @file.xco
```

Command files can be nested to a depth of 8. Xronos script files can be used as command driven command files.

Chapter 13

V4 changes

13.1 FITS files

XRONOS can now read light curves given in FITS file format. Binned data (EXTNAME = 'RATE' or HDUCLAS2= 'LIGHTCURVE') as well as event list data (EXTNAME = 'EVENT' or HDUCLAS2= 'EVENT') can be directly read in XRONOS. The different formats are given in the OGIP memo 93-003 (also see Legacy no. 3). Sample of the FITS header file can be found in the anonymous ftp account on legacy.gsfc.nasa.gov machine in the directory fits_info.

13.2 Input file Option

In all XRONOS applications up to 10 INPUT FILE OPTIONS can be specified for each input file. Options are specified in the same string in which each input filename is given and consist of 2 characters followed, in most cases, by a numerical constant containing up to 8 characters. Most of the avaliable options given in the chapter `Input File` can be used also for FITS input file. New options are available to account the versatility of the FITS format. Those (valid only for FITS input file) allow : energy selection, extension table selection, columns selection. Below are listed : a) the subset of all the pre-existing options which meaning is also valid to the FITS input file structure; b) the new options valid only for a FITS input file; c) the list of those which are not applicable to FITS input file.

Any other options described in the chapter `Input File` and not listed here are still valid for FITS input file.

Group a)

- `frN`= start reading input file from record number N (First Record). If the input file is in FITS format, the option `frN` indicates the first row to start reading.

- `lrN`= stop reading input file at record number N (Last Record) If the input file is in FITS format, the option `lrN` indicates the last row to stop reading. (Options `fr` and `lr` are useful to speed up the reading of a very large input file, when only part of the input file has to be analysed. They effectively work as fast time windows. The correspondence of record number and time can be worked out based on the input file type. These options apply to Rate Buffers only)

- `vxN`= use vector number N as x-axis (i.e. time axis) in a QDP input file (a negative value of N means that X-axis will be stepped according to the content of the XRONOS header line in the QDP input file) If the input file is in FITS format, N gives the column number used as x-axis. By default the reader searches for x-axis, a column named `TIME`.
- `vyN`= use vector number N as y-axis (i.e. series to be analysed) in a QDP input file. If the input file is in FITS format, N gives the column number used as y-axis. By default the reader searches for y-axis, a column named COUNT or RATE.
- `veN`= use vector number N as bin exposure in a QDP input file (a negative value of N means that no exposure vector is specified even if the input file contains more than 2 vectors). If the input file is in FITS format, N gives the column number used as fractional exposure. By default the reader searches for a column named FRAC_EXP. The fractional exposure column needs to be in the same extension of the x-axis and y-axis. If the FITS file format is an EVENT list, exposure is by default calculated using the GTI extension. In the case of EVENT list N=0 turns off the usage of the GTI extension for the exposure calculation.

Group b)

- `rtN`= use extension N of the FITS file to read the data, where N =1 is the first extension in the FITS file (the primary array is irrelevant).
- `ysN`= use column number N as error for y-axis. By default the reader searches for y-axis error , a column named ERROR.
- `feN`= select binned counts or events from channel number N (First Energy). By default for an event list the channel selection is made on the column named `PHA`.
- `leN`= select binned counts or events up to channel number N (Last Energy). If `feN` is not specified all the counts or events up to channel `leN` are used. By default for an event list the channel selection is made on the column named `PHA`.
- `vcN`= use column number N as channel selection column. By default the reader searches for a column named `PHA`

The option `bt`, `dn`, `dv`, and `fs`, listed in the chapter `Input File`, are not relevant for FITS file format, but applicable only for rate buffer format input file.

13.3 News

13.3.1 Folding

The efs and ef1, ef2, ef3 tasks are now accounting for a constant period derivative.

13.3.2 Default Exposure window

The default exposure window for the new bin has been changed. Any new bin which exposure is lower than 0.01 of the integration time is rejected. To change the default exposure values in the new bin, exposure window can be inserted using the task `win`.

13.3.3 Ouput file

Gaps are not longer written in the QDP output file.

Chapter 14

References

- Bloomfield, P. 1976, "Fourier Analysis of Time Series: an Introduction" (John Wiley & Sons - New York): introductory.
- EXOSAT Observatory Team 1991, "The EXOSAT Database System: BROWSE Version 3.0 User's Guide", ESA TM-11.
- EXOSAT Observatory Team 1991, "The EXOSAT Database System: On-line User's Guide" , ESA TM-12.
- Jenkins, G.M. and Watts, D.G. 1968, "Spectral Analysis and its Applications" (Holden Day-Oakland): general.
- Leahy, D.A. et al. 1983, Ap. J., 266, 160: searches for periodicities
- Press, W.H. et al. 1986, "Numerical Recipes", (Cambridge Univ. Press): general
- Sutherland, P.G. Weisskopf, M.C., Kahn, S.M. 1978, Ap. J., 219, 1029: counting statistics corrections
- Tennant, A. 1990, "The QDP/PLT User's Guide", NASA-MSFC preprint
- van der Klis, M. 1989, in "Timing Neutron Stars", NATO ASI, Series C, ed. H. Ogelmann (Dordrecht: Reidel), p.27: on Fourier techniques.