The SAX WFC Data Analysis System

"How to make your SAX life even better"

— Software User Manual —

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This manaul is a hardcopy of several files which can be accessed online on the NeSDaC WWW-server, `http://purple.sron.ruu.nl`. Also PostScript copies of this and other manuals can be found here.

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Chapter 1

Introduction

The data acquired during one Observing Period by the Wide Field Cameras (WFC1 and WFC2) of the SAX satellite will be received on so-called Final Observation Tapes (FOT) from the Science Data Centre (SDC). The specifications of the FOT is laid down in the "Mission Support Component FOT layout Document" (TPZ/GO.SDC-100/FOT-TN/SAX)

This document describes the first two stages of the FOT data-processing for the WFCs. The first stage includes the extraction of all science data and housekeeping data plus some general satellite information data into a set of FITS files. Using WFC instrument and satellite HK parameters filtering and cleaning of the event data is performed. The second stage involves the Scientific Analysis.

Presently the WFC software package is only available for UNIX based operating systems. The descripions are based on this assumption.

All processing is done by invoking programs or scripts that allow the user to automatically invoke a sequenc of programs or apply programs to a set of data files. Of each program and script a detailed description will available.

For getting a completer background of the technical issues the following reference material are recommended:

- "Mission Support Component FOT layout Document" (TPZ/GO.SDC-100/FOT-TN/SAX)
- "SAX Users's manual" (Alenia SX-MA-AI-019) Chapter 11 (Wide Field Cameras)
- "Definition of the Flexible Image Transport System (FITS)" NOST 100-1.0
- "Users' Guide to FTOOLS" (HEASARC issue of Ftools)

1.1 Relase notes

Presently the discrepance between the pointing of each WFC centre-axis and the pointing of the satellite Y-axis has not been sufficiently verified and is currently assumed to be zero. The values specifying this misalignment residing in the detector calibration files will be updated with a next distribution.

Presently the algorithm to detect x-ray bursts has not been very succesful. The instances stored in the dedicated peakfiles are not reliable enough to warrant inspection. In a next version the peaks detection facility will be added.

1.2 Abbreviations

Below is a list of frequently used abbreviations throughout the WFC documentation.

```
 FITS - Flexible Image Transport System (standard for file structure)
  FOT - Final Observation Tape (delivered by the SDC)
  GTI - Good Time Interval (used for selecting time periods)
  HEA - High Energy Astrophysics
 HEAD - HEA Data-handling
   HK - Housekeeping
  IFC - In-Flight Calibration (uses Radiation Sources)
  NFI - Narrow Field Instrument (any of LECS, MECS, HP-GSPS and PDS)
   NP - Nominal Pointing
  NPI - Nominal Pointing Interval
  OBT - On-Board Time
  OCC - Operations Control Centre (utilizes satellite links)
   OP - Observing Period (consisting of one or more observations)
  SAX - Astronomical X-ray Satellite
  SDC - Science Data Centre
  SPV - Sensor Performance Verification
  WFC - Wide Field Camera (any of WFC1 and WFC2)
```

1.3 FOT production

The flightdata from the WFC instruments are telemetered to the ground and stored in the Science Data Centre (SDC). The telemetry consists of a stream of packets containing the data as produced by the instrument.

The layout and contents of the packets for the WFCs are fully described in the SAX Wide Field Camera User Manual (SRON document SRU/SAX/PR-15 or ALENIA document SX-MA-AI-019 SAX USER'S MANUAL Volume 11)

At the SDC this data is processed and results in the production of Final Observation Tapes (FOT) which are shipped to the requesters of the data either for the WFCs or for the Narrow Field Cameras (NFI)

Not only the data received when the satellite is locked on the target

(Normal Observation) but also during the time it is slewing from the previous target (Initial Slew) and the time it is slewing to the next target (Final Slew) is stored on the FOT.

Here we only discuss the FOT of the WFCs which contains all information of the Wide Field Camera (WFCs) recorded during one Observing Period (OP). Although during such a period a fixed part of the sky will be observed it is very likely to be split up in several Observations mostly resulting from instrument mode changes by commanding. This may occur as a reaction on earth eclipses and passes through radiation belts or otherwise.
Each such Observation results in a specific set of data files. Such a set consists always of the following files:
a. Experiment Configuration datafile (EXCONF)
b. Instrument Housekeeping datafile (HKD000)
c. Science Housekeeping datafile (ENG000)
d. Science Event datafile from one of the following modes:
Normal Mode (DIR001)
High Time Resolution Mode (DIR002)
Background Analysis Mode (DIR003)
Diagnostic Reduced Mode (DIR004)
Diagnostic Extended Mode (DIR005)
Test Mode (TST000)

In the SDC the telemetry packets of DIR001 and DIR002 and ENG000 are reformatted while the other modes are passed on as the were transmitted by the satellite.

FOTs can be identified in several ways:

- By Observation Period number
  It is a number uniquely assigned to a certain time that the instrument was observing a pre-assigned target.
  It must be realised that it is possible that several FOTs can be produced over the same OP. This may happen when improved auxiliary data has come available or when FOTs are requested anew.
- By FOT number
  This number is uniquely assigned to each FOT and is stored in the first record of a FOT
- By the startdate and time of an Observation Period Starttime
  Also these times are to found in the first record of a FOT.

N.B.
Throughout this document the OP-number is used to specify a FOT.

1.4 FOT structure for WFC's

The following FOT scheme is only for WFCs. The structure of a FOT for NFI the layout is similar but WFC and NFI will not be placed together on the same FOT.

```
* Structure of tape:
     General part
     Science part

     * Contents of General part:
          Tape Directory
          Ephemeris data file
          Attitude data file
          OBT-UTC conversion data file
  IT-diagnostic data file
  TCU-HK data file
          (optionally Other Satellite HK data files)

     * Structure of Science part:
          Instrument file set 1 (WFC-1)
          Instrument file set 2 (WFC-2)

          * Structure of Instrument file set:
               Instrument Directory
               Initial Slew Observation set (1)
           ......
               Initial Slew Observation set (n)
               Normal Observation set (1)
           ......
               Normal Observation set (n)
               Final Slew Observation set (1)
                  .....
               Final Slew Observation set (n)

               * Contents of Observation set:
                    Observation Directory
                    Experiment Configuration file
                    Instrument HK data file
                    Science HK data file
                    Science Event data file

Directories are ASCII files that contain one line for each file or set
of files that is described.
- The Tape Directory describes each file on the FOT
- The Instrument Directory describes each observation set of an instrument
- The Observation Directory describes each file in an observation set

It is possible that a FOT may comprise of more than one tape.  As the
distribution tapes may store 2 Megabytes splitting of FOTs is higly
unlikely to occur.

For a complete specification of the FOT refer to the "Mission Support
Component FOT layout Document" (TPZ/GO.SDC-100/FOT-TN/SAX)
```

1.5 FOT fetching

```
The WFC-FOT data can be retrieved both from magnetic tape and by 'ftp'
from a provider on the internet.  The FOT processing is done by using
datafiles on disk.  This means that the data from the tape has to be
copied onto disk before it can be used.

Datafiles retrieved from the internet have names ending in '.dat',
while those copied from tape have names that end in '.fot'.  There is no
essential difference between files named according to these two schemes.

It is also possible to get the disk data in 'tar'-format.  In that case
after 'untar'ing the data will be in either one of the two naming schemes.
Example of untarring data from a tape device into current directory:
  >  tar -xvf /dev/rmt/0mn
Example of untarring from a 'gzip'ped tarfile:
  >  gzip -cd /disk/fotfile.tar.gz | tar xvf -

In case of '.dat' nametypes it is necessary to make symbolic linkfiles of
the '.fot' nametypes prior to processing.  See description of 'w_vaxlink'
script how to do this.
Example for Observation Period 999:
  >  w_vaxlink -obsper 999 -prefix OP999 -datdir /fotdisk/wop_999
which may result in the following filenames (parly shown):
  OP999__0001.fot -> /fotdisk/wop_999/tapedirtape_000000_00_0.dat
  OP999__0002.fot -> /fotdisk/wop_999/ephemeris_000000_00_0.dat
  OP999__0003.fot -> /fotdisk/wop_999/attitude_000000_00_0.dat
  OP999__0004.fot -> /fotdisk/wop_999/obt_utc_000000_00_0.dat
  OP999__0005.fot -> /fotdisk/wop_999/w1instdirtape_000000_00_0.dat
  OP999__0006.fot -> /fotdisk/wop_999/w1obsdirtape_000000_01_n.dat
  OP999__0007.fot -> /fotdisk/wop_999/w1exconf_00999_01_n.dat
  OP999__0008.fot -> /fotdisk/wop_999/w1hkd000_00999_01_n.dat
  OP999__0009.fot -> /fotdisk/wop_999/w1eng000_00999_01_n.dat
  OP999__0010.fot -> /fotdisk/wop_999/w1dir001_00999_01_n.dat

Some highlevel scripts like 'w_run' automatically detect the need for making
these links and will create them automatically.

If the data is delivered on magnetic tape in FOT format it is necessary to
load the tapefiles onto disk by using script 'w_proc'.
For example:
  >  w_proc -fot -f OP999 -d /fotdisk/wop_999

Although the FOT_ID (OP999) and the name of the directory (wop_999) can
be freely chosen, it is advised to use the shown naming as some high level
simple-to-use scripts assume this convention so they can be driven by only
entering the OP-number (999 here).
```

1.6 Resulting filename conventions

```
 layout:  ffffff_%%%%w$@zz$.xxxx (= one letter per field)

 where:   ffffff = Any alpha-numeric string, but normally the OP-number
   preceded by 'OP' or else the FOTnumber of the tape
   consisting of 6 letters.
  %%%%   = observation sequence number as unique within one FOT.
   '0000' for general FOT (auxiliriary) data
  w#  = wfc camera id (either w1 or w2)
      '__' for general FOT data
  @  = observation mode (either s = slew or p = pointing)
      No distinction for 'initial' or 'final' slew and not
   relevant for general FOT data.
  zz$  = instrument/derived contents
      where $ is a number indicating the level of processing
   hs$ = housekeeping science
hi$ = housekeeping instrument
rn$ = rate normal
rh$ = rate high
ba$ = background analysis
dr$ = diagnostic reduced
de$ = diagnostic extended
rp$ = pseudo-events
ib$ = packet block info
rc$ = calibration source events
pk$ = peak rates
dt$ = dead times
gn$ = gain values
 for general files '%%%%w#@zz$' will be any of the following
  0000__eph0 = ephemeris data
0000__att0 = attitude data
0000w#att0 = attitude data
0000__utc0 = OBT tp UTC converison date
0000__obs0 = observation survey file
0000w#hit0 = IT housekeeping data
additional files
0000w#     = for all files pertaining to the
     whole OP for a particular camera

.xxxx  = extension part.  For data files of FITS format it
will be '.fits', for GTI files it will be '.gti.',
for asci text files it will be '.txt', and for
PostScript files it will be '.ps'

It is not advisable to run Stage-II processes on raw data file ($ = 0)
However it is possible to pass cleaned and filtered files to it ($ = 1)
as well as position corrected files ($ = 2)

A full description of all files, their naming and contents can be fiound
in document (TBD) "Description of SAX/WFC files produced by Stage-I"
```

1.7 Structure of run levels

```
There are several levels to run the WFC software.

Below is a schematic drawing to show the hierarchy of the scripts (w_xxx)
and invoked programs.  Each of the mentioned items will be described
seperately.

w_run --> w_stageI --> w_dearchive
      -            -
      -   --> w_vaxlink
      -            -
      -   --> w_proc --> w_fits ---> wfotfits
      -                       -
      -         --> w_clean --> wattproc
      -      -          --> wmakgti
      -      -    --> wmrggti
      -      -    --> wgtiflt
      -      -    --> wgain
      -      -    --> wattana (?)
      -                       -
      -      --> w_plot ---> wqplot
      -                       -
      -      --> w_shift (?)
      -                       -
      -      --> w_spv ----> run_spv --> evaccum
      -      --> format
      -
      --> w_stageII --> cdi
      --> iros
    --> wopi
    --> wspiros
    --> correlate
    --> lcv


The lowest (rightmost) level consists of the pool of machine programs.
To run these requires quite some expertise in order to use all the
possible parameters correctly.

As most of these programs act on one observation only, scripts of the
are available to enable the pre-processing (stage-I) of a complete
Observation Period.

To give a reasonable flexibility for moderately knowledgeable users
two scripts 'w_vaxlink' and 'w_proc' are distributed to enable a relatively
simple calling of the programs of stage-I as a number of default tuning
variables are built in.

On the next higher level two scripts 'w_stageI' and 'w_stageII' are
available.  They are intended to be used by 'w_run' but can be inviked
seperately from user specific scripts.
```

The currently highest level is presented by script 'w_run' which can be used only a standerd way of processing and analysing. It may well serve as a template for scripts built be the indivual user.

N.B.

Script 'w_dearchive' is only relevant for the archiving system of SRON-Utrecht. Presently for external proecessing locations it is assumed that the FOT data is on-line available.

Chapter 2

General use of scripts and programs

```
In the following it is assumed that there exists a disk structure where
the distributed scripts and programs are located in the directories
/WFC_DIST_DIR/etc and /WFC_DIST_DIR/bin respectively.  Before any use
can be made of them these directories should be added the search path
of the user.
For example:
  >  set path = ( /WFC_DIST_DIR/bin /WFC_DIST_DIR/etc $path )

It is advisable to place all the commands for preparing the correct shell
environment into a text file that can be 'sourced' by the shell interpreter
either each time before processing or as part of the standard shell startup
file (e.g. .cshrc).
For example:
  >  source winit

setenv WFC_TOP /wfc/distribution
setenv WFC_ETC /wfc/distribution/etc
setenv WFC_BIN /wfc/distribution/bin
setemv WFC_CAL /wfc/distribution/cal
setenv WFC_CAT /wfc/distribution/lib/catalogs
```

2.1 Parameter passing by the FTOOLS convention

```
As the WFC software utilizes the parameter passing system of the
'ftools' package also the following shell environment variables
are required:

  > setenv FTOOLDIR /ftools/distribution

that holds all relevant subdirectories.  Some of the subdirectories may
also a subdirectory of the FTOOLS structure (e.g. saxwfc).
```

```
A program is invoked in the following form

=> program-name par-value1 ... par-value# [option1] [option2] ... [option#]

where option can either be [option-name] or [option-name=value]
where values may be either a string (with or without quotes), an integer,
a real, a boolean (only yes or no are accepted)

Parameters are position dependent, but can be placed anywhere in the runline
by the [parname=par-value] construct.

In order to enable the tracing back of the data flow the parameters that
control the processing options will be stored in all resulting files.
These parameters will be stored as keywords into the Primary Header
of an FITS output file.

The following general parameters are the same for all of these programs.

a. verbsty=integer   The number controls the volume of the output to STDOUT
    The higher number the more information about the
    processing is given.  If 0 there will be minimal output;
    only signalling the starting end the stopping of the
    program and warnings will be output plus additional
    information on fatel errors that may occur.
b. title=string     Option to insert user defined text as a parameter
    keyword into the fileheader
c. blockio=boolean  If 'no' use is made of block reads or writes to or from
    the file.  The advantage is much faster I/O times
    than when using the standard ftools/fitsio routines.
    The drawback is that files created in that way may
    not be compatible with those on different com[puter
    systems and that adding columns in a file needs
    modifying all the programs that read or write such
    a file.
```

2.2 w_run

```
PURPOSE:

This script is intended as a general tool for users
of the SAX-WFC analysis software package.
It can also serve as a template for user dedicated
processing.

USE:
w_run  OPnum  [FOT data topdir] [FITS data topdir] [camers]

parameter 1:  OP number
parameter 2:  FOT data topdir.  (def: /saxdat1/tmp)
               (data-dir will be /saxdat1/tmp/wop_xxx)
parameter 3:  fits data topdir  (def: /saxdat1/tmp/)
```

```
              (fits-dir will be /saxdat1/tmp/username/wop_xxx)
any parameter: 'w1' or 'w2' only processes specified camera

This script can be used if certain assumptions about the
directory naming is valid.
It is required that the FOT data has been stored in a
subdirectory of a general top directory, say /fottop.
Further it is assumed that the the name of the subdirectory
is of the form 'op_####' or 'wop_####' where '####' represents
the Observation Period number (OP_num).
Additionally the resulting files after stageI are stored in
subdirectory of a username dedicated top directory.

For barolo this would mean that for
username = user
OP = 777
fottop  = /fot3/wfc
fitstop = /arch2/wfc
after
w_run 777 /fot3/wfc /home
the FOT data is taken to resid in
/fot3/wfc/op_777
the fitsfiles of stage-1 are stores in directory
/home/user/wop_777
the result files from stage-2 in directory where you
currently invoked w_run
```

2.3 w_vaxlink

```
FUNCTION
Script to link names according the 'wfotfits' convention
to the SDC-SAC convention.

USAGE

w_vaxlink -obsper number -prefix string [-datdir directory-name]

DESCRIPTION
When data is read from tape by invoking the 'dd' utility the
resulting files are of the form 'PREFIX__####.POSTFIX' where
standard POSTFIX is '.fot' and #### denotes the sequence number
on the FOT as they also appear in the TAPE DIRECTORY (first file
FOT.
  In order to enable the use of data retrieved by internet from
SDC-SAC a conversion of the names is needed.  By this convention
file names are of the form 'FILETYPE_#####_##_@.DAT' where #####
are sequentially incremented numbers and @ is either mode
'I', 'N' or 'F'

  Below a sample (WFC1 only) of the FOT of OP 1234 in the order
```

```
as they would have appeared on a FOT on tape medium

tapedirtape_000000_00_0.dat
ephemeris_000000_00_0.dat
attitude_000000_00_0.dat
obt_utc_000000_00_0.dat
ithkd000_000000_00_0.dat
tchkd000_000000_00_0.dat
w1instdirtape_000000_00_0.dat
w1obsdirtape_000000_01_i.dat
w1exconf_01233_01_i.dat <--- 1233 = number of previous OP
w1hkd000_01233_01_i.dat
w1eng000_01233_01_i.dat
w1dir001_01233_01_i.dat
w1obsdirtape_000000_01_n.dat
w1exconf_01234_01_n.dat <--- 1234 = number of this OP
w1hkd000_01234_01_n.dat
w1eng000_01234_01_n.dat
w1dir001_01234_01_n.dat
w1obsdirtape_000000_02_n.dat
w1exconf_01234_02_n.dat
w1hkd000_01234_02_n.dat
w1eng000_01234_02_n.dat
w1dir001_01234_02_n.dat
w1obsdirtape_000000_01_f.dat
w1exconf_01235_01_f.dat <--- 1235 = number of following OP
w1hkd000_01235_01_f.dat
w1eng000_01235_01_f.dat
w1dir001_01235_01_f.dat


OPTION SPECIFIERS

-obsper  [integer]
Specifies the Observation Period of the Fot data
If omitted the user is prompted to enter it

-prefix  [string]
Specifies the string prefixed to the resulting linknames
If omitted the user is prompted to enter it.  If entered
a '^' it will become the OP number prefeixed by 'OP'

-datdir  [string]
Specifies the directory weher the  Fot datais located.
If omitted the current directory is taken as default.

-ext  [string]
Specifies the extension of the linknames.
Default '.fot' [NOT NORMALLY CHANGED]
-test
Only echo the link commands but do not perform


EXAMPLE:
```

Make linkfiles in current directory pointing to files in the data directory /FOTDIR of Obspervation Period 999

```
  >  w_vaxlink -obsper 999 -prefix OP999 -datdir /FOTDIR
```

NOTES

- By default the links are made in the current directory
- the tape filenames must be either upper- or lowercase, but not mixed.
- names of the DAT files are renamed with removed revision extensions ';*'
- The Observation Period ID must be numeric and pertain to the Normal observing period (so NOT of Initial/Final Obs. Per.)
- For reference see Document TPZ/GO.SDC-100/FOT-TN/SAX chapt 2.3 + 2.4

SEE ALSO
w_proc, w_stageI

2.4 w_viewps

FUNCTION
Script to allow viewing of Postscript plot files resulting fron standard survey plots of Stage-I processing

USE
w_viewps [w1/w2]

DESCRIPTION
Of the current directory all PostScript files having names starting with 'W' and ending with '.ps' are siaplayed by program 'ghostview'. This program allows printing of the plot by entering character 'p' and quiting the plot in order to display the next one by entering charcter 'q'.

OPTIONS

-w1 Only display files pertaining to WFC camera 1
all files matching 'W*w1*.ps'

-w2 Only display files pertaining to WFC camera 2
all files matching 'W*w2*.ps'

```
NOTES
    -For 'ghostview' it is required that the environment
     variable DISPLAY is properly set.


KNOWN BUGS
    -The script uses option '-path' with the 'find' command, but
     this seems not to be available with each UNIX implementation.


EXAMPLE:

DISPLAY all PostScript file in current directory of camarea w2 only

   >  w_viewps  -w2


SEE ALSO
w_plot  wqplot  ghostview
```

Chapter 3

Stage-I scripts

```
The WFC software is divided in three parts of which this
chapter deals with the first  one:

  I - Read data from FOTs and store in FITS formatted files
    - extract data from all possible instrument modes and
      all relevant satellite information
    - Cleaning eventfiles from spurious and unwanted data
    - monitoring instrument behaviour by comprehensive
      logging and plotting
    - produce dead time data from housekeeping ratemeters
    - produce detector gain data from inflight calibration sources
    - create GTI files from selectable criteria
    - analyse pointing stability

The other stages are mentioned briefly here:

 II - reconstruction of the sky image as viewed by the cameras
    - detection of Xray sources within the the field of view

III - analysis of spectra and
    - analysis of lightcurves of sources
```

3.1 General use of scripts

```
general use of scripts
----------------------

The general format of the runline for a script is like:

   script_name [-specifier [argument]] ..... [-specifier [argument]]



Arguments always have to include a specification of the FOT.
```

For this the switch '-f FOTID' is used where the FOTID is the identifying string. Only in case the files are retrieved from the tape in the same call to w_proc will by default the identifying string extracted from the first line of the Tape Directory.

Arguments not recognized by w_proc will be passed on to subsequentky invoked scripts.

Some general used switches used by all scripts are:

-h Display a concise help on the available switches of the script. It will not show the switches of possible subsequently invoked scripts.

-vv # Regulates the output verbosity volume. If 0 a minimal output will occur. If 1 it shows the programs that were active and some info on files produced. Larger value will pruduce more debugging info.

-t @ Defines the directory where the input disk files are located In case of files first copied from ......

-d @ defines the destination directory where all subsequent result files will be stored.

Examples:

Copy a FOT onto disk in directory 'FOTDIR' from default tape-unit

```
  >  setenv FOT_TOP /disk2/fotdir
  >  w_proc -fot
```

Process a FOT from tape completely with standard options and save the output in a logfile

```
::: w_proc -fot -all -t FOTDIR > logfile
```

To re-process a selected range (obs 3 thru 5) of observations and store results in different destination directory

```
::: w_proc -f FOT_ID -clean -t FOTDIR -d DESTDIR -n1 3 -n2 5
```

To process all relevant files for SPV test.
So all observations with modes DIR001, DIR004 and DIR005

```
::: w_spv -f FOT_ID -t FOTDIR
```

3.2 w_proc

```
FUNCTION
Main script to invoke a suite of other scripts that
call into action programs (stage-1) for extracting,
monitoring and processing SAX-WFC FOTs in order to
prepare the data for detecter correlation and X-ray
sources detection (stage-2).

USAGE

w_proc -f prefix [-specifier [argument]] ..... [-specifier [argument]]

  or

w_proc -fot  [-specifier [argument]] ..... [-specifier [argument]]

        Where a specifier can be a switch or option followed by an argument.
At least one of the following specifiers must be present:
'-fot'   to copy files from tape to disk,
'-fits'  to process FOT data into FITS files,
'-clean' to select Good Time Intervals and produce filtered files;
'-shift' to do event positioning processing,
'-plot'  to produce survey plots (PostScript format).
All these actions (except '-fot') require the use of '-f'.
If given with option '-fot' it will overrule the automatic
setting of FOTID.  Common practice is taking for the FOTID the
Observation Period number preceded by 'OP'

Before being able to use the w_proc at least the
following shell environment variables must be set:

WFC_TOP e.g. /home/xrayman/wfc
WFC_ETC e.g. $WFC_TOP/etc
WFC_BIN e.g. $WFC_TOP/bin
path  e.g. ( $WFC_ETC $WFC_BIN $path )

As in some instances use is made of ftools utilities
also the following environment variable must be set

FTOOLDIR e.g. /home/library/ftools

To store the parameter files In addition a directory in
your home directory must exist with the following name:

$HOME/pfiles/release

The names of these directories may be site dependent,
so when in doubt ask your local ftools manager.

It is advisable to create a single shell source file
for setting these variables plus others to be used
```

```
with stage-2 processing.


DESCRIPTION
When the '-fot' option is used it reads data from tape by
invoking the 'dd' utility to copy the data from the FOT onto disk.
If will create the specified FOT directory if not present.
   All other actions will invoke a call to one or more of the
following relevant scripts: w_fits, w_clean, w_plot, w_shift, etc
and will be described at the relevant document parts.
   Throughout a FOT-prefix is used to specify which
particular WFC-FOT has to be processed.  Presently
only one FOT can be processed at a time.


ACTION SPECIFIERS

    The order of actions or options is not fixed.  An option can
    be either a switch or a keyword followed by one or more arguments.
    At least one of the following actions must be selected:

-fot
Copy FOT data directly from tape onto diskfiles.
Resulting names are of the form 'prefix__nnnn.fot'
where nnnn is a numeric field.  If no prefix
is specified by the '-f' switch, the FOT number
as found in the TAPEDIRECTORY (first file) will
be taken.

-fits
Process FOT files previously copied from tape or
retrieved by internet and renamed by w_vaxlink.
  Swap bytes if the data is written according the VAX
byte ordering.
  Extract the relevant data into files structured
according the FITS standard.
  Issue warnings about the instrument status and
out-of-limit situations.
  Print an overview of types and times of extracted data.
The resulting files are level 0 processed fits files
and will be of the form Wprefix_*0.fits'.

-clean
Clean and select from level 0 processed FOT files according
selection criteria (script 'w_clean' will be invoked).
The resulting files are level 1 processed fits files
and will be of the form Wprefix_*1.fits'.
Additionally the attitude data is processed and
analyzed to produce information on camera pointings
and earth occultations.  Stage-2 processing can
take place on level 1 procesing or higher.

-shift
Process level 1 processed FOT files to produce drift corrected
```

```
detector positions (script 'w_shift' will be invoked).
The resulting files are level 2 processed fits files and will
be of the form Wprefix_*2.fits'

-plot
Produce a standard set of plots in PostScript format (script 'w_plot'
will be invoked).  They contain ratemeter plots, instrument
houskeeping values, pointing information, observation modes, etc.
One sheet is produced per each observation.

-spv
Run a Sensor Performance Verification on level 0 data.
(script 'w_spv' will be invoked but is presently only available
at SRON-Utrecht)


GENERAL OPTION SPECIFIERS

-h
Display a concise help on the available switches and recognized
environment settings.  It will not show the switches of possible
subsequently invoked scripts however.

-f [string]
The argument specifies the FOT identifier.  TFor resulting files
this will become the prefix of all names.  Only when processing
directly from tape with the '-fot' action can this switch be omitted,
in which case the FOTID is taken from the FOT directory.  But also
in this case it will be overruled by giving the -f FOT_ID switch.

-t [string]
Specify (top-)directory where input (link)files are located.
By default the current directory is taken.  This default
can be overruled by setting environment variable $WFC_OBS
    Only in case of '-fot' action this will be the destination
directory where the FOT files from tape will be placed to be
used as input for level 0 (-fits) processing.
It will overrle the value of enveironment variable FOT_TOP.

-d [string]
Force result files under destination top-dir.
By default this will be the input directory.
Already existing result files will be overwritten.

-vv [integer]
Argument value regulates the output verbosity volume.  When 0 a
minimal (silent) output will occur.  The default is 1 where it
will show the programs that were active and some info on files
produced.  A larger value will produce more diagnostic info.
This switch will be passed on to subsequently invoked scripts.

-w1
-w2
Only process the data of one (-w1 or -w2) camera.
```

```
(not relevant for '-fot' and -fits' actions)

-save
Force intermediate files to be saved.  By default the
lower level files will be discarded.

-n  [integer]
-n1 [integer]
-n2 [integer]
Indicates the number (-n) or number range (-n1 and -n2)
of observations to be processed.  By default n1 = 1 and
n2 = 999.

-c1 [string]
-c2 [string]
        The name of the input FITS file that contains the
coefficients to calculate the physical values of
temperatures and voltages from digitally coded
analog value.   By default they are $WFC_CAL/wfc1.det
and $WFC_CAL/wfc1.det respectively.  The defaults can
be fixed by setting environment variables W_INSCAL1
and W_INSCAL2 respectively.

-blockio
Allow writing and reading data files in fast block I/O.
This may introduce a non-standerd FITS format that cannot
be used across different computer systems and will not work
with systems using VAX byte order.  Presently by default
the blockio option is disabled for OSF1 unix systems and
enabled for all other systems like HPUX.


LEVEL 0 RELATED OPTIONS

-swap
-noswap
Specify whether the data is organized according to VAX
definition and bytes of words and double-words must be
swapped.  This will be normally the case if FOT's were
produced by the Science Data Centre.
Presently by default the swap option is disabled for OSF1
unix systems and enabled for all other systems like HPUX.

-tape [string]
Specify the device name of the tape-unit.  Only relevant
in case of '-fot; action.  default: /dev/rmt/0mn.
The default can be preset with environment variable TAPE.

-nvol [integer]
Specify number of tape volumes.  default: 1

-att [string]
-eph [string]
-obt [string]
```

```
Specify the name of an alternative file containing attitude,
ephemeris or OBT_UTC data.  It will replace the one that is in
the FOT.  If not present in the FOT it will be inserted at the
porper place in the original FOT.
  It is possible to specify the alternative file by setting
the respective environment variables W_ATTFILE, W_EPHFILE,
or W_OBTFILE.

-frt [string]
Argument specifies root-name of disk created fotfiles
By default takes the specified FOTID plus '_'
NOT RECOMMENDED TO CHANGE THE DEFAULT

-fxt [string]
Argument specifies extension of disk located fotfiles (default .fot)
NOT RECOMMENDED TO CHANGE THE DEFAULT

HIGHER LEVEL RELATED OPTIONS

-fi [string]
Name of the file containing expression for making the
Good Times Intervals from each Instrument Housekeeping file
By default file $WFC_ETC/etc/wfc_sel_ins is used.  This
default can be fixed by setting environment variable W_SELINS

-fs [string]
Name of the file containing expression for making the
Good Times Intervals from each Science Housekeeping file
By default file $WFC_ETC/etc/wfc_sel_sci is used.  This
default can be fixed by setting environment variable W_SELSCI

-fe [string]
Name of the file containing expression for making the
Good Times Intervals from the Ephemeris file.
By default file $WFC_ETC/etc/wfc_sel_eph is used.  This
default can be fixed by setting environment variable W_SELEPH

-plotall
Plots all observations.  By default only the observations
having instrument housekeeping plus instrument and science
data will result in a plotting sheet.

-plotslew
Plots also obsrvations in slew mode.
By default these observations will not be plotted

-spvslew
Also perform SPV on slew observations.
By default this will not be done.


RECOGNIZED ENVIRONMENT VARIABLES

    In addition default values for switches and installed settings
```

```
    can be overruled by the following  shell environment variables.

TAPE used when reading from tape with the '-fot' option
(default: /dev/rmt/0mn)

WFC_TOP The top directory of the WFC software distribution
No default as it is site dependent

WFC_ETC Place where scripts and general selection files are located
if not present default to $WFC_TOP/etc

WFC_BIN Place where the program executable binaries are located
if not present default to $WFC_TOP/bin

WFC_CAL Place where calibration and instrument definition files.
if not present default to $WFC_TOP/cal
(see also switches '-c1' and '-c2')

WFC_FITSORIG  String to be used for the ORIGIN keyword in produced
Fitsfiles (default: `hostname` )

FOT_TOP The directory where the FOT files are resided.
This is the input directory for all actions except for
the '-fot' option where it will be the directory in
which the FOT files are loaded. (default: `pwd` )

W_INSCAL1
if not present default to $WFC_CAL/wfc1.det
(see also switch '-c1')

W_INSCAL2
if not present default to $WFC_CAL/wfc2.det
(see also switch '-c2')

W_EPHFILE
if not present default to "-"
(see also switch '-eph')

W_ATTFILE
if not present default to "-"
(see also switch '-att')

W_OBTFILE
if not present default to "-"
(see also switch '-obt')

W_SELEPH
if not present default to $WFC_ETC/wfc_sel_eph
(see also switch '-fe')

W_SELINS
if not present default to $WFC_ETC/wfc_sel_ins
(see also switch '-fi')
```

```
W_SELSCI
if not present default to $WFC_ETC/wfc_sel_sci
(see also switch '-fs')

PLT_MET1  Meter name of upper graph to be plotted
if not present default to RATE_EVENT

PLT_MET2  Meter name of middle graph to be plotted
if not present default to RATE_PROC

PLT_MET3  Meter name of lower graph to be plotted
if not present default to RATE_GUARD


EXAMPLES:

Copy a FOT onto disk in directory /FOTDIR from default tape-unit
and force FOTID to 'OP999'

  >  w_proc -fot -t /FOTDIR -f OP999


Process a FOT from tape completely with standard options, put resulting
files in the current directory and save the output in a logfile

  >  w_proc -fot -fits -clean -plot -t FOTDIR > logfile

To re-process all observation of camera 2 only and store the results
in a different destination directory

  >  w_proc -f OP1234 -w2 -clean -t FOTDIR -d /DESTDIR


To process all relevant files for SPV test on a selected range (obs 3 thru 5)
of observations on the FOT.  So all observations with modes DIR001, DIR004
and DIR005 if present

  >  w_proc -f OP678 -spv -n1 3 -n2 5 -t /FOTDIR



NOTES

    - The destination directory will be created if not present.

    - Specifiers specific for subsequently invoked scripts are
passed on without prior checking.

    - By default the resulting files of the '-fot' action will be of
the form 'FOTID__####.fot' where '####' is a file sequence number.
The names files resulting from any other action will be of the
form 'WFOTID_####w@xxxx' where '####' is the observation number,
'@' is the camera number and 'zzzz' is filetype specific string.
```

```
    - Although not used by w_proc itself the following environment
variables are relevant to other scripts invoked:
W_INSCAL1, W_INSCAL2, W_EPHFILE, W_ATTFILE, W_OBTFILE, W_FOTREPDIR

    - In case a FOT resides on disk its filenaming is not of the
form 'prefix__nnnn.fot' a renaming or namelink is needed
by script w_vaxlink available in $WFC_ETC.

    - Presently '-shift' option is not operational as insufficient
analysis has been performed due to unreliable attitudes.

    - The detector calibration files are created during
the installment of Stage-2 software package.

    - Unspecified options exist fot handling cases of incomplete
or corrupt FOTs.  They are not advised for use in general
operations.


SEE ALSO
w_vaxlink, w_stageI, w_fits, w_clean, w_plot
```

3.3 w_fits

```
FUNCTION
Main script to invoke the FOT reading program wfotfits
call into action programs (stage-1) for extracting,
monitoring and processing SAX-WFC FOTs in order to
prepare the data for detecter correlation and X-ray
sources detection (stage-2).


USAGE

w_fits -f prefix [-specifier [argument]] ..... [-specifier [argument]]

        Where a specifier can be a switch or option followed by an argument.
Common practice is taking for the FOTID the
Observation Period number preceded by 'OP'

Before being able to use the w_proc at least the
following shell environment variables must be set:

WFC_TOP e.g. /home/xrayman/wfc
WFC_ETC e.g. $WFC_TOP/etc
WFC_BIN e.g. $WFC_TOP/bin
path  e.g. ( $WFC_ETC $WFC_BIN $path )

As in some instances use is made of ftools utilities
also the following environment variable must be set
```

```
FTOOLDIR e.g. /home/library/ftools

To store the parameter files In addition a directory in
your home directory must exist with the following name:

$HOME/pfiles/release

The names of these directories may be site dependent,
so when in doubt ask your local ftools manager.

It is advisable to create a single shell source file
for setting these variables plus others to be used
with stage-2 processing.


DESCRIPTION
From the recieved FOT data is extracted checked on
anomalies and copied into FITS formatted files.
The producing of the files is done by invoking
program 'wfotfits' with the proper parameters.
Checking of required directory structures is performed
and the user is warned if missing.

The following filetypes are/can be produced of all but
the last are in FITS format:

       FOT
|
V
    --------
    wfotfits
    --------
|
|--> *__att0.fits [attitude data]
|--> *__eph0.fits [ephemerides data]
|--> *__utc0.fits [OBT-UTC table]
|--> *__obs0.fits [observations table]
|--> *w#hit0.fits [IT diagnostic ITHKD000]
|--> *w#@hi0.fits [instrument housekeeping HKD000]
|--> *w#@hs0.fits [science housekeeping ENG000]
|--> *w#@rn0.fits [normal rate data DIR001]
|--> *w#@rh0.fits [high rate data DIR002]
|--> *w#@ba0.fits [background analysis data DIR003]
|--> *w#@dr0.fits [reduced diagnostic data DIR004]
|--> *w#@de0.fits [extended diagnostic data DIR005]
|--> *w#@ib0.fits [packetblocks info]
|--> *w#@rn0.gti  [GTI file]
|--> *w#@rh0.gti  [GTI file]
|--> *w#obs0.txt  (observation times survey text]
-

where 'w#' denotes the camarea ('w1' or 'w2'), '@' denotes
the type of observation ('p' for pointing, 's' for slewing)
```

```
and '0.' the level of processing.  This will be reflected
in keyword 'VERSION' of the

The "EXCONF'(experiment configuration) data is stored in the
extension header of the instrument housekeeping (*hi0.fits) file

The script allows the insertion or replacement of auxiliary
files according to te following conventions.  A file can be
explicitly assigned by using swith '-att' or by pre-setting
the corresponding environment variable.
It is also possible to have a directory searched automatically
for a file.  This is done by pre-setting environment variable
'WFC_FOTREPDIR'.
Then for '-f prefix' a files are searched with the name
  $WFC_FOTREPDIR/Wprefix_ATT/attitude*.dat or
  $WFC_FOTREPDIR/Wprefix_EPH/ephemeris*.dat or
  $WFC_FOTREPDIR/Wprefix_OBT/obt_utc*.dat
If found that file will be the replacement file.



OPTION SPECIFIERS

    The order of actions or options is not fixed.  An option can be
    either a switch or a keyword followed by one or more arguments.
    At least one of the following actions must be selected:

-h
Display a concise help on the available switches and recognized
environment settings.  It will not show the switches of possible
subsequently invoked programs however.

-f [string]
The argument specifies the FOT identifier.  TFor resulting files
this will become the prefix of all names.  Only when processing
directly from tape with the '-fot' action can this switch be omitted,
in which case the FOTID is taken from the FOT directory.  But also
in this case it will be overruled by giving the -f FOT_ID switch.

-t [string]
Specify (top-)directory where input (link)files are located.
By default the current directory is taken.  This default
can be overruled by setting environment variable $WFC_OBS
    Only in case of '-fot' action this will be the destination
directory where the FOT files from tape will be placed to be
used as input for level 0 (-fits) processing.
It will overrle the value of enveironment variable FOT_TOP.

-d [string]
Force result files under destination top-dir.
By default this will be the input directory.
Already existing result files will be overwritten.

-vv [integer]
```

```
Argument value regulates the output verbosity volume.  When 0 a
minimal (silent) output will occur.  The default is 1 where it
will show the programs that were active and some info on files
produced.  A larger value will produce more diagnostic info.
This switch will be passed on to subsequently invoked scripts.

-w1
-w2
Only process the data of one (-w1 or -w2) camera.
(not relevant for '-fot' and -fits' actions)

-save
Force intermediate files to be saved.  By default the
lower level files will be discarded.

-n  [integer]
-n1 [integer]
-n2 [integer]
Indicates the number (-n) or number range (-n1 and -n2)
of observations to be processed.  By default n1 = 1 and
n2 = 999.

-c1 [string]
-c2 [string]
        The name of the input FITS file that contains the
coefficients to calculate the physical values of
temperatures and voltages from digitally coded
analog value.   By default they are $WFC_CAL/wfc1.det
and $WFC_CAL/wfc1.det respectively.  The defaults can
be fixed by setting environment variables W_INSCAL1
and W_INSCAL2 respectively.

-blockio
Allow writing and reading data files in fast block I/O.
This may introduce a non-standerd FITS format that cannot
be used across different computer systems and will not work
with systems using VAX byte order.  Presently by default
the blockio option is disabled for OSF1 unix systems and
enabled for all other systems like HPUX.

-swap
-noswap
Specify whether the data is organized according to VAX
definition and bytes of words and double-words must be
swapped.  This will be normally the case if FOT's were
produced by the Science Data Centre.
Presently by default the swap option is disabled for OSF1
unix systems and enabled for all other systems like HPUX.

-att [string]
-eph [string]
-obt [string]
Specify the name of an alternative file containing attitude,
ephemeris or OBT_UTC data.  It will replace the one that is in
```

```
the FOT.  If not present in the FOT it will be inserted at the
porper place in the original FOT.
  It is possible to specify the alternative file by setting
the respective environment variables W_ATTFILE, W_EPHFILE,
or W_OBTFILE.

-frt [string]
Argument specifies root-name of disk created fotfiles
By default takes the specified FOTID plus '_'
NOT RECOMMENDED TO CHANGE THE DEFAULT

-fxt [string]
Argument specifies extension of disk located fotfiles (default .fot)
NOT RECOMMENDED TO CHANGE THE DEFAULT


RECOGNIZED ENVIRONMENT VARIABLES

    In addition default values for switches and installed settings
    can be overruled by the following  shell environment variables.

WFC_TOP The top directory of the WFC software distribution
No default as it is site dependent

WFC_ETC Place where scripts and general selection files are located
if not present default to $WFC_TOP/etc

WFC_BIN Place where the program executable binaries are located
if not present default to $WFC_TOP/bin

WFC_CAL Place where calibration and instrument definition files.
if not present default to $WFC_TOP/cal
(see also switches '-c1' and '-c2')

WFC_FITSORIG  String to be used for the ORIGIN keyword in produced
Fitsfiles (default: `hostname` )

FOT_TOP The directory where the FOT files are resided.
This is the input directory for all actions except for
the '-fot' option where it will be the directory in
which the FOT files are loaded. (default: `pwd` )

W_INSCAL1
if not present default to $WFC_CAL/wfc1.det
(see also switch '-c1')

W_INSCAL2
if not present default to $WFC_CAL/wfc2.det
(see also switch '-c2')

W_EPHFILE
if not present default to "-"
(see also switch '-eph')
```

```
W_ATTFILE
if not present default to "-"
(see also switch '-att')

W_OBTFILE
if not present default to "-"
(see also switch '-obt')


EXAMPLES:

Process a FOT from tape completely with standard options, put resulting
files in the current directory and save the output in a logfile

  >  w_fits -fot -f OP1234 -t FOTDIR > logfile

To re-process all observation of camera 2 only and store the results
in a different destination directory

  >  w_proc -f OP1234 -w2 -clean -t FOTDIR -d /DESTDIR



NOTES

    - For narmal use it is recommended to invoke this script
by use of script w_proc

    - The destination directory will be created if not present.

    - In case a FOT resides on disk its filenaming is not of the
form 'prefix__nnnn.fot' a renaming or namelink is needed
by script w_vaxlink available in $WFC_ETC.

    - The detector calibration files are created during
the installment of Stage-2 software package.

    - Unspecified options exist fot handling cases of incomplete
or corrupt FOTs.  They are not advised for use in general
operations.


SEE ALSO
w_vaxlink, w_stageI, w_proc, wfotfits
```

3.4 w_plot

```
FUNCTION
Main script to invoke a quick survey plotting program
wqplot for a complete FOT
```

```
USAGE
w_plot -f prefix [-specifier [argument]] ..... [-specifier [argument]]

Before being able to use the w_proc at least the
following shell environment variables must be set:

WFC_TOP e.g. /home/xrayman/wfc
WFC_ETC e.g. $WFC_TOP/etc
WFC_BIN e.g. $WFC_TOP/bin
path  e.g. ( $WFC_ETC $WFC_BIN $path )

As in some instances use is made of ftools utilities
also the following environment variable must be set

FTOOLDIR e.g. /home/library/ftools

To store the parameter files In addition a directory in
your home directory must exist with the following name:

$HOME/pfiles/release

The names of these directories may be site dependent,
so when in doubt ask your local ftools manager.

It is advisable to create a single shell source file
for setting these variables plus others to be used
with stage-2 processing.


DESCRIPTION
Produce a standard set of plots in PostScript format.  They contain
ratemeter plots, instrument housekeeping values, pointing information,
observation modes, etc.  One sheet is produced per each observation.
   Per observation one sheet is produced.  Only in case of a very
long observation will two sheets be made.
   One sheet plotting contains on top some general info of the
 observation like FOTnumber OP-ID date of observation, camera
 pointing info etc.  The bottom lines contain values extracted
 of the instrument housekeeping like temperatures of the camera
 structure and voltages of the dtector electronics.
   In the middle space is available for plots of threee selctable
 rate-meters from the science housekeeping.


GENERAL OPTION SPECIFIERS

-h
Display a concise help on the available switches and recognized
environment settings.  It will not show the switches of possible
subsequently invoked scripts however.

-f [string]
```

```
The argument specifies the FOT identifier.  TFor resulting files
this will become the prefix of all names.  Only when processing
directly from tape with the '-fot' action can this switch be omitted,
in which case the FOTID is taken from the FOT directory.  But also
in this case it will be overruled by giving the -f FOT_ID switch.

-t [string]
Specify (top-)directory where input (link)files are located.
By default the current directory is taken.  This default
can be overruled by setting environment variable $WFC_OBS
    Only in case of '-fot' action this will be the destination
directory where the FOT files from tape will be placed to be
used as input for level 0 (-fits) processing.
It will overrle the value of enveironment variable FOT_TOP.

-d [string]
Force result files under destination top-dir.
By default this will be the input directory.
Already existing result files will be overwritten.

-vv [integer]
Argument value regulates the output verbosity volume.  When 0 a
minimal (silent) output will occur.  The default is 1 where it
will show the programs that were active and some info on files
produced.  A larger value will produce more diagnostic info.
This switch will be passed on to subsequently invoked scripts.

-w1
-w2
Only process the data of one (-w1 or -w2) camera.
(not relevant for '-fot' and -fits' actions)

-n  [integer]
-n1 [integer]
-n2 [integer]
Indicates the number (-n) or number range (-n1 and -n2)
of observations to be processed.  By default n1 = 1 and
n2 = 999.

-c1 [string]
-c2 [string]
        The name of the input FITS file that contains the
coefficients to calculate the physical values of
temperatures and voltages from digitally coded
analog value.   By default they are $WFC_CAL/wfc1.det
and $WFC_CAL/wfc1.det respectively.  The defaults can
be fixed by setting environment variables W_INSCAL1

-plotall
Plots all observations.  By default only the observations
having instrument housekeeping plus instrument and science
data will result in a plotting sheet.

-plotslew
```

```
Plots also obsrvations in slew mode.
By default these observations will not be plotted

-spvslew
Also perform SPV on slew observations.
By default this will not be done.


RECOGNIZED ENVIRONMENT VARIABLES

    In addition default values for switches and installed settings
    can be overruled by the following  shell environment variables.

WFC_TOP The top directory of the WFC software distribution
No default as it is site dependent

WFC_ETC Place where scripts and general selection files are located
if not present default to $WFC_TOP/etc

WFC_BIN Place where the program executable binaries are located
if not present default to $WFC_TOP/bin

WFC_CAL Place where calibration and instrument definition files.
if not present default to $WFC_TOP/cal
(see also switches '-c1' and '-c2')

W_INSCAL1
if not present default to $WFC_CAL/wfc1.det
(see also switch '-c1')

W_INSCAL2
if not present default to $WFC_CAL/wfc2.det
(see also switch '-c2')

PLT_MET1  Meter name of upper graph to be plotted
if not present default to RATE_EVENT

PLT_MET2  Meter name of middle graph to be plotted
if not present default to RATE_PROC

PLT_MET3  Meter name of lower graph to be plotted
if not present default to RATE_GUARD


EXAMPLES:

Make standard plots of cleaned files of FOTID OP999 located in directory
/FITSDIR  and save

  >  w_plot -f OP999 -w2 -t /FITSDIR -d /PLOTSDIR

   or alternatively

  >  w_proc -f OP999 -w2 -t /FITSDIR -d /PLOTSDIR
```

```
NOTES

    - The destination directory will be created if not present.

    - Throughout a FOT-prefix is used to specify which
      particular WFC-FOT has to be processed.  Presently
      only one FOT can be processed at a time.

    - The detector calibration files are created during
the installment of Stage-2 software package.


SEE ALSO
w_proc, wqplot
```

3.5 w_clean

```
FUNCTION
Clean and select from level 0 processed FOT files according
selection criteria.  The resulting files are level 1 processed
fits files and will be of the form Wprefix_*1.fits'.
Additionally the attitude data is processed and analyzed to
produce information on camera pointings and earth occultations.
Stage-2 processing can take place on level 1 procesing or higher.
   Convert to physical values the housekeeping information and
make selections for Good Time Intervals (GTIs) based on these
values indicating correct instrument behaviour. (program whkproc)
  Calculate deadtime correction factors from the science rate
meters (program whkproc)
  Make list of detected rate-peaks [under construction still]
(program whkproc)
  Make selections for Good Time Intervals (GTIs) based on values
that indicating correct instrument behaviour. (program wmakgti)
    Clean the event data by filtering out unwanted data like pseudo-
events, events from IFCs. (program wgtiflt)
  Analyze the Ephemeris and Attitude date to calculate earth
occultation data (program wattproc)
  Process the attitude data to provide the actual instrument
pointing information and analyze possible attitude anomalies
by establishing Nominal Pointings (program wattana)
     Calculate the gain correction factors per time
(program wgain)


USAGE

w_clean -f prefix [-specifier [argument]] ..... [-specifier [argument]]
```

```
        Where a specifier can be a switch or option followed by an argument.
Common practice is taking for the FOTID the Observation Period
number preceded by 'OP'

Before being able to use the w_proc at least the
following shell environment variables must be set:

WFC_TOP e.g. /home/xrayman/wfc
WFC_ETC e.g. $WFC_TOP/etc
WFC_BIN e.g. $WFC_TOP/bin
path  e.g. ( $WFC_ETC $WFC_BIN $path )

As in some instances use is made of ftools utilities
also the following environment variable must be set

FTOOLDIR e.g. /home/library/ftools

To store the parameter files In addition a directory in
your home directory must exist with the following name:

$HOME/pfiles/release

The names of these directories may be site dependent,
so when in doubt ask your local ftools manager.

It is advisable to create a single shell source file
for setting these variables plus others to be used
with stage-2 processing.


DESCRIPTION
    Of each program a short description plus the dataflow and
    filenaming is shown

whkproc:
     - reads housekeeping files and discards invalid records
  - converts temperature monitors to physical values
    - converts voltage monitors to physical values
    - Does a burstpeak hunt on science ratemeters
    - Produces deadtime values per second from science ratemeters

    *w#@hi0* --->|
    *w#@hs0* --->|
 V
      -------
      whkproc
      -------
 |
 |---> *w#@hi1* [cleaned + converted Ins-HK data]
 |---> *w#@hs1* [cleaned Sci-HK data]
 |---> *w#@dt1* [deadtime data]
 |---> *w#@pk1* [ratepeak data]
 -
```

```
wgtiflt:
  - removes pseudo-events
  - extracts events belonging to the In-Flight Calibration
    sources (IFC) from Normal Mode events.
  - optionally filters events files according the GTI file

    *w#@rn0* ------>|
    *w#@rh0* ------>|
    V
         -------
         wgtiflt
         -------
    |
    |---> *w#@rn1*  [filtered Normal Rate events]
    |---> *w#@rc1*  [IFC events]
    |---> *w#@rh1*  [filtered High Rate events]
    -

watproc:
  - Make separate attitude file for each camera
  - Add Earth Centre in WFC coordinates (x,y,z) and rim_angle
  - Add observation mode information to attitude data

    *__att0* --->|
    *__eph0* --->|
    *__obs0* --->|
 V
      -------
      watproc
      -------
 |
 |---> *w1att1*  [augmented attitude data]
 |---> *w2att1*  [augmented attitude data]
 -

wattana:
  - Analyzes one or more attitude files
  - Produce one list of nominal-pointing sets (NP) from actual
    pointings

    *w#att1* --->|
 V
      -------
      wattana
      --------
 |
 |---> *__pnt1*  [pointings table]
 -

wgain:
  - Compute

    *w#@rc1* --->|
```

```
    *w#@rn1.gti->|
 V
      -------
      watproc
      -------
 |
 |---> *w#@gn2*  [augmented attitude data]
 -
```

```
OPTION SPECIFIERS

    The order of actions or options is not fixed.  An option can
    be either a switch or a keyword followed by one or more arguments.
    At least one of the following actions must be selected:


-h
Display a concise help on the available switches and recognized
environment settings.  It will not show the switches of possible
subsequently invoked scripts however.

-f [string]
The argument specifies the FOT identifier.  TFor resulting files
this will become the prefix of all names.  Only when processing
directly from tape with the '-fot' action can this switch be omitted,
in which case the FOTID is taken from the FOT directory.  But also
in this case it will be overruled by giving the -f FOT_ID switch.

-or [string]
Set the root prefix of the output files.  By default it is
the same is that of the input: FOTIF ade preceeded by the
character 'W" and followed by an underscoore '_'
NOT ISED WITH STANDRD PRACTICES

-t [string]
Specify (top-)directory where input (link)files are located.
By default the current directory is taken.  This default
can be overruled by setting environment variable $WFC_OBS
    Only in case of '-fot' action this will be the destination
directory where the FOT files from tape will be placed to be
used as input for level 0 (-fits) processing.
It will overrle the value of enveironment variable FOT_TOP.

-d [string]
Force result files under destination top-dir.
By default this will be the input directory.
Already existing result files will be overwritten.

-vv [integer]
Argument value regulates the output verbosity volume.  When 0 a
minimal (silent) output will occur.  The default is 1 where it
```

```
will show the programs that were active and some info on files
produced.  A larger value will produce more diagnostic info.
This switch will be passed on to subsequently invoked scripts.

-w1
-w2
Only process the data of one (-w1 or -w2) camera.

-save
Option to save all inetermadeiate resultfiles.  By default
thses files like most zere level (*0.fits) files will be
discarded.

-n  [integer]
-n1 [integer]
-n2 [integer]
Indicates the number (-n) or number range (-n1 and -n2)
of observations to be processed.  By default n1 = 1 and
n2 = 999.

-c1 [string]
-c2 [string]
        The name of the input FITS file that contains the
coefficients to calculate the physical values of
temperatures and voltages from digitally coded
analog value.   By default they are $WFC_CAL/wfc1.det
and $WFC_CAL/wfc1.det respectively.  The defaults can
be fixed by setting environment variables W_INSCAL1
and W_INSCAL2 respectively.

-blockio
Allow writing and reading data files in fast block I/O.
This may introduce a non-standerd FITS format that cannot
be used across different computer systems and will not work
with systems using VAX byte order.  Presently by default
the blockio option is disabled for OSF1 unix systems and
enabled for all other systems like HPUX.

-swap
-noswap
Specify whether the data is organized according to VAX
definition and bytes of words and double-words must be
swapped.  This will be normally the case if FOT's were
produced by the Science Data Centre.
Presently by default the swap option is disabled for OSF1
unix systems and enabled for all other systems like HPUX.

-fi [string]
Name of the file containing expression for making the
Good Times Intervals from each Instrument Housekeeping file
It overrules the default file $WFC_ETC/etc/wfc_sel_ins or an
alternative file prescribed in setting environment variable
W_SELINS.
```

```
-fs [string]
Name of the file containing expression for making the
Good Times Intervals from each Science Housekeeping file
It overrules the default file $WFC_ETC/etc/wfc_sel_sci or an
alternative file prescribed in setting environment variable
W_SELSCI.

-fe [string]
Name of the file containing expression for making the
Good Times Intervals from the Ephemeris file.
It overrules the default file $WFC_ETC/etc/wfc_sel_eph or an
alternative file prescribed in setting environment variable
W_SELEPH.

-gainbin [real]
Specifies the timebin in seconds for which each gain value
has to be computed.

-slew
Option to process also slew data

-filtonly
Option to filter only and skip attitude analysing and gain
calculations


RECOGNIZED ENVIRONMENT VARIABLES

    In addition default values for switches and installed settings
    can be overruled by the following  shell environment variables.

WFC_TOP The top directory of the WFC software distribution
No default as it is site dependent

WFC_ETC Place where scripts and general selection files are located
if not present default to $WFC_TOP/etc

WFC_BIN Place where the program executable binaries are located
if not present default to $WFC_TOP/bin

WFC_CAL Place where calibration and instrument definition files.
if not present default to $WFC_TOP/cal
(see also switches '-c1' and '-c2')

WFC_FITSORIG  String to be used for the ORIGIN keyword in produced
Fitsfiles (default: `hostname` )

FOT_TOP The directory where the FOT files are resided.
This is the input directory for all actions except for
the '-fot' option where it will be the directory in
which the FOT files are loaded. (default: `pwd` )

W_INSCAL1
if not present default to $WFC_CAL/wfc1.det
```

```
(see also switch '-c1')

W_INSCAL2
if not present default to $WFC_CAL/wfc2.det
(see also switch '-c2')

W_EPHFILE
if not present default to "-"
(see also switch '-eph')

W_ATTFILE
if not present default to "-"
(see also switch '-att')

W_OBTFILE
if not present default to "-"
(see also switch '-obt')

W_SELEPH
if not present default to $WFC_ETC/wfc_sel_eph
(see also switch '-fe')

W_SELINS
if not present default to $WFC_ETC/wfc_sel_ins
(see also switch '-fi')

W_SELSCI
if not present default to $WFC_ETC/wfc_sel_sci
(see also switch '-fs')

PLT_MET1  Meter name of upper graph to be plotted
if not present default to RATE_EVENT

PLT_MET2  Meter name of middle graph to be plotted
if not present default to RATE_PROC

PLT_MET3  Meter name of lower graph to be plotted
if not present default to RATE_GUARD


EXAMPLES:

Process a complete FIT with standard options, put resulting  files in
the current directory and save the commentary output in a logfile:

  >  w_clean -f OP1234 -t /FITSDIR > logfile

To re-process all observation of camera 2 only and store the results
in a different destination directory and save original data for
a future rerun:

  >  setenv W_SELSCI user_sel_sci
  >  w_clean  -f OP1234 -w2 -filtonly -save -t FITSDIR -d /DESTDIR
```

or alternatively

```
  >  w_clean  -f OP1234 -w2 -fs user_sel_sci -filtonly -save -t FITSDIR -d /DESTDIR
```

NOTES

- The destination directory will be created if not present.

- The detector calibration files are created during the installment of Stage-2 software package.

- For each observation a separate GTI file is produced. All these GTI files are per camera accumulatively merged into one GTI file for a complete observation

SEE ALSO

w_proc, whkproc, watproc, wattana, wmakgti, wmrggti, wgtiflt, wgain

Chapter 4

Stage-I programs

4.1 watproc

```
FUNCTION
    Program to make WFC camera specific attitude data added with
    observation-mode and Earth-Position info.


USAGE
    watproc atifile ato1file ato2file ephfile obsfile [options]


DESCRIPTION
    From the raw attitude FITS file as extracted from the FOT for
    each WFC a separate attitude file is made.  The program will
    fill the column with observatio mode (Pointing / Slew) from
    observation tables in the observation file.
Derived from data of the ephemeris file columns will be
    filled containing the angle between instrument pointing and
    direction angle to center of earth.


PARAMETERS

    atifile [string]
Name of the raw attitude FITS file as extracted from the FOT.

    ato1file [string]
Name of the attitude output file dedicated for WFC-1 with
additional information like obervation mode (Normal Pointing or
Slewing) plus derived infirmation from the Ephemeris files like
Earth Occultation information.

    ato2file [string]
Same as for ato2file but specific for WFC-2.

    ephfile [string]
```

```
Name of input ephemerides FITS file as extracted from the FOT.

    obsfile [string]
Name of input observation file containing the observation table
of one FOT.

    (calfile1="-") [string]
        The name of the input FITS file from which are fetched the
misalignment angles to calculate the instrument pointing.

    (calfile2="-") [string]
        Same as for calfile1, only used for SAX WFC-2

    (verbsty=0)  [integer]
The verbosity level will control the output volume.

    (pforce=yes) [boolean]
If true all attitude data of unknown observation mode is
forced to Normal Pointing mode.

    (tforce=no) [boolean]
If true the start of the ephemeris data will be aligned with
that of the attitude data.  (Used for TEST only)

    (title=" ") [string]
User caption to be tagged to each output FITS file header


EXAMPLES:

     >  watproc  OBS__att0.fits OBSw1att1.fits OBSw2att1.fits OBS__eph0.fits \
    OBS__obs0.fits

REMARKS:
   -The program uses the parameter passing of the FTOOLS convention.
   -The Earth-Position is relative to the pointing of the camera
and will be used to correct for the earth occultation fraction
of detected X-ray sources.


SEE ALSO
    wfotfits, wattana
```

4.2 wattana

```
FUNCTION
    Program to Analyze attitude data, in order to produce nominal
    pointing records reflecting the stability of the pointing or
    to concatenate attitudes of different observations.

USAGE
```

```
    wattana atifile(s) pntfile [options]
```

DESCRIPTION

```
Analyzes the given attitude and by using some criteria (maximum
    arc-angle tolerance and maximum north-angle tolerance) to order to
    determine clusters of pointings of one or a grouipt of observations.
    Of each cluster record is produced containing its nominal (weighted
    average) pointing, its identification number (unique within all
    input files) and the number of members allocated to it.
The pointing file will contain a record for each Nominal
    Pointing.
The analysis can be done over several attitude files of
    different cameras.
        Attitude during a slew period is normally not to be taken
    into account as many pointings can be expected.  It is an option
    to force analyzing also that part.
```

PARAMETERS

```
    atifile  [string]
        The (comma separated) name(s) of the input attitude FITS
file(s)  If more than one input file these files need not be
in chronological (time sorted) order.  However, the order of
the input files must be equal and in the same order as the
outputfiles.
Of these attitude files must have filled their observation
mode columns.

    ptofile  [string]
        The name of the resulting FITS file containing the Nominal
Pointing of each grouped actual pointings.

    (outfile=STDOUT)  [string]
Device or file to listing output.

    (slewmode=no)  [boolean]
Force slewmode te be analyzed

    (calfile1="-")  [file name]
        The name of the input FITS file that contains among others
the misalignment angles to calculate the instrument pointing.

    (calfile2="-")  [file name]
        Same as for calfile1, only used for SAX WFC-2.

    (append=no)  [boolean]
It yes, use is made of an previous pointing file.
All found pointings will be attempted to be placed in the
existing pointing clusters and if unsuccesful a new
nominal cluster pointing will be appended.

    (ptifile="-")  [string]
        The name of the input FITS file containing the Nominal
```

```
Pointing of each grouped actual pointings. This option
is only useful if pointings must be appended.

    (parctol=0.25)  [real]
Maximum distance in degrees between the nominal pointing and
that of the cluster members in pointing mode.

    (prottol=0.05)  [real]
Maximum rotation in degrees difference between the nominal
north-angle and those of its cluster members in pointing mode.

    (sarctol=0.25)  [real]
Maximum distance in degrees between the nominal slewing and
that of the cluster members in pointing mode.

    (srottol=0.05)  [real]
Maximum rotation in degrees difference between the nominal
north-angle and those of its cluseter members in slewing mode.

    (calfile1="-")  [file name]
        The name of the input FITS file from which are fetched the
misalignment angles to calculate the instrument pointing.

    (calfile2="-")  [file name]
        Same as for calfile1, only used for SAX WFC-2.

    (outfile=STDOUT) [string]
Name of file for output listing. The volume of which is controlled
by the verbosity level.

    (verbsty=0)  [integer]
The verbosity level will control the output volume

    (title=" ") [string]
User caption to be tagged to each output FITS file header

    (cluster=0)  [integer]
The Camera number (1 or 2) for which the clustering of the pointing
must be analyzed in case raw the attitude data is used that has not
been split per camera. (only for TEST purposes)

    (pforce=no)  [boolean]
Force pointing mode for unknown modes (only for TEST purposes)

EXAMPLES

    1.  Analyze one attitude file and produce one pointing file

--> wattana  FOTw1att1 FOTw1pnt1

    2.  Analyze two attitude files and produce new pointing file from existing one

--> wattana  aFOTw1att1,bFOTw2att1 NEW_pnt append=yes ptifile=OLD_pnt
```

```
METHOD

-  A simplified version of the method used with COMIS (by G.K.Skinner, B'ham)
   The full algorithm is not very stable and causes problems in some cases.
   Each attitude is assigned to the nearest Nominal Pointing.  If an attitude
   falls outside the tolerated circle (arctol) around that Nominal Pointing
   or North Angle (a new NP will be initiated.
-  The actual assignment to a NP of events (photons) to a Nominal Pointing and
   a possible consequent position shift will be performed by program wshift.


REMARKS

-  The program uses the parameter passing of the FTOOLS convention.

-  Slew can be handled but will probably yield too many clusters to be
   of practical use.  So in standard processing data in slew mode is
   skipped. (slewmode = no)  In case it is enabled different tolerences
   can be specified for pointing and slew mode.

-  There are two modes of operation
   a. In case of standard processing the attitude file is
      processed for the complete Observing Period per camera.
      This will result in two pointing files.
   b. In case of pointing clustering across several Observations of
      different Observing Periods (=FOTS) all related attitude files
      will be analyzed to produce one single nominal pointing file.
      That may involve the use of different cameras.  In case the
      analysis is not done in one run by using the mulitple input
      file construct, the 'append=yes' mode for analyzing subsequent
      attitude files is required.

SEE ALSO
    watproc, wgtiflt, wshift
```

4.3 wfotfits

```
FUNCTION
    Program to extract and process SAX-WFC FOT data

USAGE
wfotfits  rootname inpdir outdir [options]


DESCRIPTION

Read FOT data either directly from tape or from DISK files
previously copied from tape or retrieved by internet.
Read and checks the FOT contents.
Extract the relevant data into files structured
```

```
according the FITS standard.
Issue warnings about the instrument status and out-of-
limit situations.
Print an overview of types and times of extracted data.
Swap bytes if the data is written according the VAX byte
ordering.

PARAMETERS

    rootname  [string]
        The name part that prefixes the part that preceedes the
4-digit number of the FOTfile.  It is good practice to
choose the FOT-ID and some delimiter (e.g. 123456__)

    inpdir  [string]
     The name of the directory where the FOT files are located.
In case of reading directly from tape this argument is
irrelevant (but must be given).

    outdir  [string]
The name of the directory where the resulting data files
will be placed.  Note that the name has to end with a '/'
in case of a unix host.

    (minpacks=9)  [integer]
Required minimal number of science packets that one observation
must contain in order to be precessed

    (extname=".fot")  [string]
The extansion part of the input filenames that come after the 4-digit
number of the FOTfile.

    (outpref="fop_")  [string]
The part of the all output files that prefixes the
program generated name part which starts with a 4-digit
observation number. (Cf document on files ....)

    (procsite="S.R.O.N.")  [string]
The processing site will be put in the Primary Header of all
resulting FITS-file under the ORIGIN-keyword

    (fotscope"="SAX")  [string]
The placce or institute wher the data is originated will be
put in the Primary Header of all resulting FITS-file under
the TELESCOP-keyword (in development scope it will be "SAX-LBT")

    (swap=no)  [string]
Specified whether the data is organized according to VAX
definition and bytes of words and double-words must be
swapped.  This will normally the cxase if FOT's were
produced produced by the Science Data Centre.

    (blockio=yes)  [boolean]
Option to write output event data files in fast block transfer mode.
```

```
This may introduce a non-standerd FITS format that cannot be used
across different computer systems.

    (pseudout=no)  [boolean]
Enable extraction of Pseudo Events in normal Mode data and
write them into a separate FITS file

    (minio=1)  [integer]
Indicates the units in bytes that are written by direct access
data transfer to files.  For DEC systems this number must be 4.

    (calfile1"="..../wfc1.det")  [string]
        The name of the input FITS file that contains the coefficients
to calculate the physical values of temperatures and voltages
from digitally coded analog value.  For a description of the
relevant table in this file, see TBD.

    (calfile2="..../wfc2.det")  [string]
        Same as for calfile1, only used for SAX WFC-2

    (ephfile="-")  [string]
Pathname of alternative EPHEMERIS auxiliary file

    (attfile="-")  [string]
Pathname of alternative ATTITUDE auxiliary file

    (obtfile="-")  [string]
Pathname of alternative OBT_UTC auxiliary file

    (attfile="-")  [string]
Pathname of alternative ATTITUDE auxiliary file

    (fromtape=no)  [boolean]
If yes the FOT data is read from a tape device.

    (tapename="/dev/rmt/0mn")  [string]
The tape device name is site dependent.

    (verbsty=1)  [integer]
Verbosity volume.  The higher the number the more printing
     0: is minimal output volume

    (testopt=0)  [integer]
Possible test options (only for testing purposes)
0: is the normal situation
1: extra Reduction Factor breaks will be forced in
   Normal mode and High Time Resolution mode.

    (procmode=1)  [integer]
Processing mode
     0: Only read files do not produce output files.
1: Output all data files

    (namemode=1)  [integer]
```

```
name composition option
Different ways of composing filenames are obsolete now
but may be needed in future again.

    (slewopt=yes)  [boolean]
If this option slew procesing option
If 'no' processing of data during slewing periods will
be skipped.  (only used for test purposes)

    (convopt=no)  [boolean]
If yes the temperatures and voltages in the housekeeping
files will be converted to physical values. (only used
for testing purposes)

    (title=" ") [string]
User caption to be tagged to each output FITS file header

    (fileseq="1/ON")  [string]
This string contains the file selection from FOT and is
used for including or excluding FOT files
The format is "token,token,..." where a token consists
of a filenumber and operator separated by a '/'.
The operators are:
  ON : from specified number all files will be processed
  OF : from specified number all files will be skipped
  Y  : the specified file will be processed in all cases
  N  : the specified file will be skipped in all cases
(only used for test purposes)

    (fotrev="F2")  [string]
Denotes the FOT definition level to be used (F1 is out of
date now and only used for processing of old simulated FOTs.

    (imageopt=no) [boolean]
  If 'yes' normal mode event data will be accumulated in
detector image file. (only for TEST purposes)

NOTES
   -The program uses the parameter passing of the FTOOLS convention.
   -Of all data modes the block sequence is checked.  Interuptions
of such a sequence is reported in the log.
Only of the Normal Mode and the High Time Resolution mode the
blocksequences and their times are stored separately in a file


EXAMPLES
    1.  Process complete FOT from tape

    --> wfotfits tape=yes swap=yes outdir=/SAXPOOL/ \
outpref=W123456_ calfile1=/SAX_TOP/CAL/wfc1.det calfile2=/SAX_TOP/CAL/wfc2.det


    2. Process FOT from disk only the first 7 files
```

```
    --> wfotfits inpdir=/SAX_POOL/ rootname=SOTLBT__ fileseq=1/ON,8/OF outdir=/SAXPOOL/
outpref=WSOTLBT_ calfile1=/SAX_TOP/CAL/wfc1.det calfile2=/SAX_TOP/CAL/wfc2.det

OPEN ISSUES
- Documentation of Calibration File input
- description of file formats

REMARKS
- All produced filenames follow the followoing convention
      fffff_%%%%w#@zz$.xxxx (= one letter per field)
    ||||||||||||||||||||
    FOTID_0005w2phs0.fits (= example filename)

  fffff = Any alpha-numeric string, but normally the 6-digit
     FOTnumber of the tape.
  %%%%  = observation number as unique within one FOT
     assigned sequentially by wfotfits.  Will be '0000'
  for files pertaining to the general FOT information.
  w# = wfc camera id (either w1 or w2)
     '__' for general FOT data
  @ = observation mode (either s = slew or p = pointing)
     No distinction for 'initial' or 'final' slew and not
  relevant for generakl FOT data.
  zz$ = instrument/derived contents (The number digits expresses
     the level of processing that has been done on the data)
  wfotfits only produces raw data resulting in a 0 number
   hs0 = housekeeping science
hi0 = housekeeping instrument
rn0 = rate normal
rh0 = rate high
ba0 = background analysis
dr0 = diagnostic reduced
de0 = diagnostic extended
rp0 = pseudo-events [optional with rate normal]
ib0 = packet block info
ib0 = packet block info
ec0 = experiment configureation info
 for general files '%%%%w#@zz$' will be any of the following
  0000__eph0 = ephemeris data
0000__att0 = attitude data
0000__utc0 = OBT to UTC conversion date
0000__obs0 = observation survey file
0000w#hit0 = IT housekeeping data
 additional files
rn0_gti = GTIs for valid NM event data
rh0_gti = GTIs for valid HTR event data

KNOWN BUGS
None


SEE ALSO
whkproc, wmakgti, wmrggti, wgtiflt, watproc, wattana,
wshift, wslew, wqplot
```

4.4 wgain

```
FUNCTION
    Program to calculate the detector gain from IFC photons

USAGE
    wgain  ifcfile gainfile [gtifile] [options]

DESCRIPTION
       Accumulate per given timebin the energy spectrum of all events
    (photons) from the input file.  Analyze this spectrum to find the
    channel position of the peaks for the  Fe_55 and Cd-109 radiation
    sources respectively.  Convert the channel values to kEV and from
    the nominal peak energies calculate the gain factor for each of them.

CALCULATION
-----------

    For establishing the detector gain or spectral response use is made of
    the events that are produced by the In-Flight Calibration radiation
    sources as detected during the Normal Mode operation of the WFCs.
    Extracting the IFC events is done by program 'wgtiflt'.  There are nine
    Fe-55 radiation sources of which eight are emitting about 0.2 photons per
    second and 1 producing 10 photons per second plus one Cd-109 soiurce
    emitting about 1 photon per second.
       The detector positions and boxes from where the photon events are
    taken are stored and updated in the detector calibration file (wfc#.det)
    as part of the data extension named 'califc'.
       Calculating the detector gain is done by program 'wgain'.  Per specified
    number of seconds the spectrum of the energy bands are accumulated and
    analyzed for finding peaks in two different regions covering respectively
    the Fe-55 (channels 7 thru 19) and Cd-109 (channels 24-31).  The channel
    peaks are converted to KeV to compare with the nominal energy peaks at
    5.98 and 22.6 KeV respectively.
      The chennel to energy conversion values are stored and updated in the
    detector calibration file (wfc#.det) as part of the data extension
    named 'phakev'.


PARAMETERS

    ifcfile [string]
The name of the event input FITS file.  The file is assumed
to be time ordered and free of Pseudo-events and contains only
events originating from In-Flight calibration sources.

    gainfile [string]
        The name of the output gain file that contains one record
(row) for each timebin.  A row contains colomns (fields)
```

```
for the Fe-55/Cd-109 gain, Fe-55/Cd-109 mean channel, and
Fe-55/Cd-109 channel FWHM.

    (gtifile = "-") [string]
        The name of the Good Time Interval FITS file to be used to
        filter the input table by rejecteing events not covered by
any of the intervals.  If omitted the entire input file is
processed and no events are rejected.

    (calfile1 = "-" ) [string]
        The name of the input FITS file that contains the channel
to energy conversion tables.  The data only pertains to
events of SAX/WFC-1.

    (calfile2="-" ) [string]
        Same as for calfile1, only used for SAX/WFC-2

    (bintime=200000.) [double]
The time in seconds per energy accumulation.
Providing a sufficiently large number will result in
a single gain value for the whole input file.

    (blockio=yes)  [boolean]
Option to write output data files in fast block transfer mode.
This may introduce a non-standerd FITS format that cannot be used
across different computer systems.

    (title=" ") [string]
User caption to be tagged to each output FITS file header

    (verbsty=0)  [integer]
The verbosity level will control the output volume.


EXAMPLE
     Calculate the gain per hour

ft>  wgain  ifc_events gain_table gtifile=gti_events bintime=3600

REMARKS
   -The program uses the parameter passing of the FTOOLS convention.
   -Calculating the efficiency may be done in future.

SEE ALSO
    wfotfits, wgtiflt
```

4.5 wgtiflt

```
FUNCTION
    Program to filter a FITS table by selecting only the rows that have
    a time stamp within a specified set of time intervals.
```

```
       Additionally removes and stores events located in any of a number
    of given areas into a separate new FITS file.
       Further all Pseudo-Events are discarded.


USAGE
    wgtiflt infile gtifile outfile [options]


DESCRIPTION
       Selects rows from in input FITS table and writes them to an
    output table if the time stamp for that row falls within one of an
    input set of "Good Time Intervals" (GTIs).
       Optionally removes and stores events located in any of a number
    of given areas into a separate new FITS file.  These clip areas are
    defined in an instrument calibration file.
       Automatically the parameters that are read in will be copied
    in the Primary Header of each FITS file.
       Records with bad (=negative time) are always removed.

PARAMETERS

    infile [string]
        The name the input FITS table containing the list of events
to be filtered.

    gtifile [string]
        The name of the Good Time Interval FITS file to be used to
        filter the input table.  This is a FITS table or bintable
        extension which contains 2 columns defining the start and stop
        times of a set of Good Time Intervals.   The column values in
        this table are given in units of seconds relative to a start
        time specified in the extension header  (see the description
of the gtidate and gtitime parameters).

    outfile [string]
        The name of the output "filtered" FITS table containing  the
        selected events from the input file.  This table will contain
        the same number and order of columns contained in the input

    (clipout=yes) [boolean]
        If YES, then the task will clip and store events located in a
a number of given areas into a separate new FITS file.

    (clipfile=" ")  [string]
        The name of the output "clipped" FITS table containing the
        selected events from the input file which are located in a
a number of given rectangular areas.  This table will contain
the same number and order of columns contained in the input
        table.  It is useful to get the counts of the In-Flight
Calibration sources in a file for separate processing.

    (calfile1="-") [string]
        The name of the input FITS file that contains the coordinates
```

```
of the area boxes used for clipping and storing all events being
located in any of these rectangulars.  The data only pertains to
events of SAX WFC-1.  The purpose is to store separately all the
events that come from the In-Flight Calibration sources for
further gain calculations.  For a description of the relevant
table in this file, see TBD.

    (calfile2="-") [string]
        Same as for calfile1, only used for SAX WFC-2

    (tcolumn="WFC_TIME") [string]
        The name of the column in INFILE that contains  the  time  stamp
        value  that is used to determine if that row falls within one of
        the input Good  Time  Intervals.   The  values  in  this  column
        should  be  in  units  of  seconds  relative  to  the start time  ??
        specified by the obsdate and obstime keywords in the  header  of
        the extension.

    (xcolumn="RAWX") [string]
        Name for the column in the in/output file containing the X
        coordinate of the pixel.

    (ycolumn="RAWY") [string]
        Name for  the  column in the output file containing the Y
        coordinate of the pixel.

    (obsdate="-") [string]
        The name of the keyword containing the reference date in the
        input events table.  The value can either be blank (or  "-")  to
        defeat the reference checking, in julian days or in 'dd/mm/yy'
        format.

    (obstime="MJDREF") [string]
        The name of the keyword containing the reference time in the
        input events table in 'hh:mm:ss.ddd' format.  This parameter is
        only used if obsdate is in dd/mm/yy format.

    (obsunit="T_UNIT") [string]
        The name of the keyword containing the units of the time column.
If omitted unites of 1 second are assumed.

    (gticols="START,STOP") [string]
        The name of the columns in GTIFILE containing start and stop
        times.

    (gtidate="-") [string]
        The name of the keyword containing the reference date in the
        input GTI table.  The value can either be blank (or  "-") to
        defeat the reference checking, in julian days or in 'dd/mm/yy'
        format.  It must have the same format as the obsdate parameter.

    (gtitime="MJDREF") [string]
        The name of the keyword containing the reference time in the
        input GTI table in 'hh:mm:ss.ddd' format.  This parameter is
```

```
        only used if obsdate is in dd/mm/yy format.

    (exposure="ONTIME") [string]
        The name of the keyword containing the exposure time in the
        input and output FITS file.  If the keyword doesn't exist it
        will be created.

    (clipout=yes) [boolean]
        If YES, then the task will clip and store events located in a
a number of given areas into a separate new FITS file.

    (blockio=yes)  [boolean]
Option to write output data files in fast block I/O.
This may introduce a non-standerd FITS format that cannot be used
across different computer systems.

    (verbsty=0)  [integer]
The verbosity level will control the output volume.

    (title=" ") [string]
User caption to be tagged to each output FITS file header


EXAMPLES
    1.  Filter the FITS file contianing Hight time resolution event data
    using a GTI file.  As no detector positions are available in this mode
    no IFC clipfile can be produced

  => wgtiflt  OBSw1prh0 OBSw1gti OBSw1prh1 clipfile=no obsdate='-' obstime='MJDREF'

    2.  Filter a FITS file named contianing normal mode data using
    a GTI file extract IFC data events

  => wgtiflt  OBSw2prn0 OBSw2gti OBSw2prn1 clipout=yes clipfile=OBSw2prc1


NOTES
   -The program uses the parameter passing of the FTOOLS convention.


KNOWN BUGS

    'obsdate' and 'obstime' does not work like documented.  For WFC
    only 'obsdate = -' and 'obstime = MJDREF' will work properly.


SEE ALSO
    fltime, mgtime, maketime, wmakgti, wmrggti
```

4.6 whkproc

```
FUNCTION
    Program to proces both instrument and science housekeeping files
    of SAX-WFC and converts all housekeeping values to physical units.
    Discards records with bad times.  Produces deadtime values
    and detects peaks in countrates from science housekeeping data.

USAGE
    whkproc infile outfile [options]


DESCRIPTION
The resulting housekeeping data files can be used as input for
the determination of the Good Times Intervals for selecting
the event lists.


PARAMETERS

    infile  [string]
        Name of the input housekeeping FITS file to be precessed.

    outfile  [string]
Name of the cleaned and processed output housekeeping FITS file

    (peakfind=yes)  [boolean]
        If positive a peakfile will be generated, the name of which is
the argument of the 'peakfile' parameter

    (peakfile=" ")  [string]
        The name of the output FITS file containing the rise and
fall times that specify detected countrate peaks.

    (deadcalc=yes)  [boolean]
        If positive a deadtime file will be generated, the name of which is
the argument of the 'deadfile' parameter

    (deadfile=" ")  [string]
        The name of the output FITS file containing the calculated
deadtimes per second.

    (calfile1=" ")  [string]
        The name of the input FITS file that contains the coefficients
to calculate the physical values of temperatures and voltages
from digitally coded analog value.  For a description of the
relevant table in this file, see TBD.

    (calfile2=" ")  [string]
        Same as for calfile1, only used for SAX WFC-2.

    (convsec=no)  [boolean]
     Option to convert the value in the time column to seconds.
This normally is not needed, but is handy when making
plots with 'fplot' the standard ftools plot facility.
```

```
    (verbsty=0)  [integer]
The verbosity level will control the output volume.

    (title=" ") [string]
User caption to be tagged to each output FITS file header

    (tforce=no)  [boolean]
This will introduce artificial rate bursts to test the
peakhunt routines.  (only for TEST puroposes)


EXAMPLES
    1.  Clean and convert a science housekeeping file and produce
a file with calculated deadtime factors.

=> whkproc  OBS_phs0 OBS_phs1 deadcalc=yes deadfile=OBS_pdt1

    2.  Clean and convert an instrument housekeeping file durinf slew mode
and produce and convert the time to seconds and produce peakrate table

=> whkproc OBS_shi0 OBS_shi1 convsec=yes peaqkfind=yes peakfile=OBS_spk1

METHOD
    - Rejected are negative time tahs (flagged by wfordits in case of bad records
      or negative time jumps)
    - Peaks are found by analyzing the counts within a sliding window.
      Within a window only one peak can be recognized.
      Expressed in seconds are the size of the window, the minmum and the
      maximum length of an aceptable peak.  Further the minimum height above
      the window average to be accepted as a peak is given in counts/sec.
      Finally a time period is used to restart the peakhunt after a data gap.

NOTES
   -The program uses the parameter passing of the FTOOLS convention.

SEE ALSO
    wfotfits, wmakgti, wqplot, fplot
```

4.7 wmakgti

```
FUNCTION
    Program to create Good Time Interval (GTI) FITS file based on
    parameters in a Housekeeping data FITS file.


USAGE
    wmakgti infile outfile expr


DESCRIPTION
    This task creates a GTI table from a subset of times in an input
```

HK table. The rows are selected on the basis of a boolean expression whose variables are parameters in the column names. If, after substituting the values associated with a particular parameter into the variables, the expression evaluates to true, then the time is included in the GTI table.

Boolean operators can be used in the expression in either their Fortran or C forms. The following boolean operators can be used in the expression:

```
"equal"          .eq. .EQ. ==  "not equal"            .ne.  .NE.  !=
"less than"      .lt. .LT. <   "less than/equal"      .le.  .LE.  <= =<
"greater than"   .gt. .GT. >   "greater than/equal"   .ge.  .GE.  >= =>
"or"             .or. .OR. ||  "and"                  .and. .AND. &&
"negation"      .not. .NOT. !  "approx. equal(1e-7)"  ~
```

The expression may also include arithmetic operators and functions. Trigonometric functions use degrees, not radians. The following arithmetic operators and functions can be used in the expression:

```
"addition"            +          "subtraction"         -
"multiplication"      *          "division"            /
"negation"            -          "exponentiation"      **   ^
"absolute value"      abs(x)     "cosine"              cos(x)
"sine"                sin(x)     "tangent"             tan(x)
"arc cosine"          arccos(x)  "arc sine"            arcsin(x)
"arc tangent"         arctan(x)  "arc tangent"         arctan2(x,y)
"exponential"         exp(x)     "square root"         sqrt(x)
"natural log"         log(x)     "common log"          log10(x)
"modulus"             i % j
```

There is also a function for testing if two values are close to each other, i.e., if they are "near" each other to within a user specified tolerance. The arguments, value_1 and value_2 can be integer or real and represent the two values who's proximity is being tested to be within the specified tolerance, also an integer or real:

```
near(value_1, value_2, tolerance)
NEAR(value_1, value_2, tolerance)
```

The following type casting operators are available, where the inclosing parentheses are required and taken from the C language usage. Also, the integer to real casts values to double precision:

```
"real to integer"    (int) x     (INT) x
"integer to real"    (float) i   (FLOAT) i
```

In addition, several constants are built in for use in expressions:

```
#pi                   3.1415... #e                   2.7182...
#deg                  #pi/180   #row                 current row number
```

A string constant must be enclosed in quotes as in 'Crab'. Due to

```
    the generalities of FITS column names, a column name
    which resembles an arithmetic or boolean expression must be enclosed
    in "$" characters as in $column-name$ to force its interpretation as
    a column and not as column minus name.

    Numerical keyword values found in the current TABLE extension's
    header my be used as part of the expression.  Keywords should be
    preceded by a single "#" as in #MAXPHA.  If the keyword contains a
    space or character might appear as an arithmetic term then inclose
    it in "$" characters as in #$MAX PHA$ or #$MAX-PHA$.

    It is also possible to use a text file containing the expression by
    placing at the expression argument the name of that file preceeded
    by an AT sign line "@expr_file"


PARAMETERS

    infile  [string]
Name and extension number in square brackets of the input FITS
file containing the columns that are used for selection.

    outfile  [string]
        The name of the created GTI FITS file

    expr [string]
        The boolean expression string giving the criteria to select from
the the HK file Good Time Intervals.
If the input is '-', the expression is taken from the file indicated
by the parameter 'filexpr'.
If the input is '@' the remainder is the name of the file from
which the expression is taken.

    (filexpr=" ")  [string]
        The name name of file containing the boolean expression giving
the criteria to select from the the HK file Good time intervals.

    (time="TIME_WFC")  [string]
        The column name containing the housekeeping parameter time
        stamp.

    (value="VALUE")  [string]  --> see comment
        The column name containing the housekeeping parameter values.
        This parameter is ignored for expanded (compact=no) files.

    (compact=no)  [boolean]  --> see comment
        The flag for compact ASCA Housekeeping  FITS files.  Compact
        files have three columns:  time, housekeeping parameter name,
        and parameter value.  Each row in the file indicates that the
        specified parameter changed value at that time.  Expanded
        housekeeping files have a column for time, and a column for
        each housekeeping parameter, containing the value of that
        parameter at each time.
```

```
    (timunit="T_SCALE")  [string]
Name of keyword that contains the unit of time values in seconds

    (timeref="MJDREF")  [string]
Name of keyword containing the Mofified Julian Day that
corresponds to the value 0 of the TIME

    (start="START")  [string]
        The output GTI column name containing the start times.

    (stop="STOP")  [string]
        The output GTI column name containing the stop times.

    (prefr=0.5)  [double]
        This is the amount of the previous time interval to be included
        in the GTI.  A value of 1.0 means to include the whole
        interval.  The default is to take half of the time interval as
        if the state change occurred between measurements.

    (postfr=0.5)  [double]
        This is the amount of the following time interval to be
        included in the GTI.  A value of 1.0 means to include the whole
        interval.  The default is to take half of the time interval as
        if the state change occurred between measurements.

    (verbsty=0)  [integer]
The verbosity level will control the output volume.

    (title=" ") [string]
User caption to be tagged to each output FITS file header


EXAMPLES
    1. Generate the GTI FITS file gti.fit using the expanded HK FITS
file hk.fit which has the parameter HV_MON greater than
and the parameter HV_SET equals 8:

        ft> wmakgti fotid_hihk.fit gti.fit "(HV_MON.gt.3300).and.(HV_MON<3400)" \
    anything anything TIME no

    2. Generate the GTI FITS file gti.fit using a file containing the
expression FITS Science HK file

        ft> wmakgti fotid_hs.fit gti.fit "@hkexpr.file" \ NAME VALUE TIME yes


NOTES
   -The program uses the parameter passing of the FTOOLS convention.


COMMENTS
    -The source is copied largely from the FTOOLS utility 'maketime'
It contains an option to use ASCA compacted HK files.
Although SAX-WFC presently does not create such file the options
```

```
to do so are left as a possible future extension.
    -Parameters 'prefr' and 'postfr' have not been evaluated


SEE ALSO
    whkproc, wmrggti, wgtiflt
```

4.8 wmrggti

```
FUNCTION
    Program to merge two or more GTI FITS files.


USAGE
    wmrggti ingti outgti merge [options]


DESCRIPTION
    This  task  merges  two or more (up to 50) Good Time Interval files,
    using either of two modes:
       AND - output GTI file contains time intervals common to both files,
       OR  - output GTI file combines time intervals from both files.


PARAMETERS

    ingti [filenames]
        The file names and extensions for input GTI  FITS  files  to  be
        merged.

    outgti [filename]
        The file name for merged output GTI FITS file.

    merge [string]
        The merge mode, either logical "AND" or logical "OR".

    (instarts = "START") [string]
        Names  of  columns for start times in input files, up to 50.  If
        the values are different in  the  different  files,  supply  one
        column name for each file.  Times are assumed to be in seconds.

    (instops = "STOP") [string]
        Names  of  columns  for stop times in input files, up to 50.  If
        the values are different in  the  different  files,  supply  one
        column name for each file.  Times are assumed to be in seconds.

    (indates = "MJDREF") [string]
        Names  of  keywords for reference date of the times in the input
        files, up to 50.  If the values are different in  the  different
        files,  supply  one  column  name  for each file.  Two reference
```

```
        time formats are supported: the reference zero time  may  be  in
        julian  days,  or  in  dd/mm/yy  format.   If  no reference time
        checking is desired, a blank or "-" may be entered.

    (intimes = " ") [string]
        Names of keywords for the reference start time of  the  time  in
        input  files,  up  to  50.   If  the values are different in the
        different files, supply one column name  for  each  file.   This
        value  is  only used for indates in dd/mm/yy format.  The format
        of this keyword is hh:mm:ss.sss.

    (outstart = "START") [string]
        Names of columns for start times  in  output  file.   Times  are
        output in seconds.

    (outstop = "STOP") [string]
        Names of columns for stop times.  Times are output in seconds.

    (title=" ") [string]
User caption to be tagged to each output FITS file header


EXAMPLES
    1.  Merge by logical ANDing contents of the two GTI FITS files,
        gti1.fits and gti2.fits into the output GTI FITS file gtiout.fits
        using defaults for all other hidden parameters.

            ft> wmrggti "gti1.fits,gti2.fits" gtiout.fits AND

    2.  Merge by logical ORing contents of the two GTI FITS files,
        gti1.fits[3] and gti2.fits[2] into the output GTI FITS file gtiout.fits

            ft> wmrggti "gti1.fits[3],gti2.fits[2]" gtiout.fits OR


NOTES
   -The program uses the parameter passing of the FTOOLS convention.
   -This utility is almost identical to wmgtime.  In addition
it updates CREATOR/DATE keywords and adds keywords for
archiving the program parameter arguments
   -It also prints the total number of resulting GTIs


SEE ALSO
    maketime
```

4.9 wqplot

```
FUNCTION
    Program to make plots from SAX WFC housekeeping data
    and additional data like gain
```

```
USAGE
    wqplot  shfile ihfile [options]


DESCRIPTION
Read selected values (colomns) from both the Instrument-
and Science Housekeeping.
Shows
At least the Instrument is required.  All other files are
optional a less complete plot may result if omitted.

PARAMETERS

    shfile=" "  [string]
Name of the science housekeeping file.

    ihfile=" "  [string]
Name of the instrument housekeeping file.

    (gtifile=" ")  [string]
Name of a GTI file.  If present wil result in a bar for
each GTI on top of the upper plot.

    (pkfile=" ")  [string]
Name of the peakrates file.  If present will result in an
arrow at the bottom of the upper plot.

    (meter1="RATE_EVENT")  [string]
Name of a meter in upper plot

    (meter2="RATE_PROC")  [string]
Name of a meter in middle plot

    (meter3="RATE_GUARD")  [string]
Name of a meter in lower plot

    (calfile1="..../wfc1.det")  [string]
        The name of the input FITS file that contains the coefficients
to calculate the physical values of temperatures and voltages
from digitally coded analog value.  For a description of the
relevant table in this file, see TBD.

    (calfile2="..../wfc2.det")  [string]
        Same as for calfile1, only used for SAX WFC-2

    (device="pgplot/VCPS")  [string]
Plotdevice as recognized by the PGPLOT libraries.
Device VCPS invokes Vertical Color PostScript format,
while /XW produces the plot on the window screen.

    (verbsty=0)  [integer]
The verbosity level will control the output volume.
```

```
NOTES
   -The program uses the parameter passing of the FTOOLS convention

   -  The following value names are selectable for the
instrument housekeeping:

RATE_LOGIC RATE_GUARD RATE_MAIN INV_SCIBL
STAT_RBI STAT_FRONT STAT_EVENT STAT_COMM
HV_STAT HV_SET HV_MON MCDM_COUNT
MCDM_NAME MCDM_STA TMP_STR TMP_STR2
TMP_STR3 TMP_STR4 TMP_STR5 TMP_STR6
TMP_STR7 TMP_STR8 TMP_EL1 TMP_EL2
VLT_P15 VLT_P8  VLT_M8  VLT_5_28

The selectable values of the Science Housekeeping are:

RATE_EVENT RATE_PROC  RATE_NOPILE  RATE_ANODE
RATE_UPPER RATE_INVALID  RATE_LOGIC* RATE_GUARD*
RATE_MAIN* STAT_FRONT*  STAT_EVENT*  STAT_COMM*
HV_SET* HV_STAT*

- Names marked with a '*' are only selectable if no instrument
  data is available.
- Names must be given in uppercase.

EXAMPLES
Make a plot with High Voltage Setting in lower plot

     >wqplot OBSw1phs1 OBSw1phi1 meter3=HV_SET


SEE ALSO
whkproc, wmakgti, wmrggti, wgtiflt, watproc, wattana, fitsview
```

4.10 wshift

```
FUNCTION
    Program to reshift event detector positions

USAGE
    wshift  infile attfile pntfile outfile npifile [options]


DESCRIPTION
Reshift the detector position of each event in order to
    cancel out the effects pruduced by relatively small drifts of
    the camera pointing.  A prescribed set of Nominal Pointings
    is given in a separate file (pntfile) calculated by the
    attitude analysis program 'wattana'.
```

```
PARAMETERS

    infile [string]
The name of the event input FITS file.  The file is assumed
to be time ordered and free of Pseudo-events and of events
originating from In-Flight calibration sources.

    attfile [string]
        The name of the attitude file that contains the attitudes
for the given period.

    pntfile [string]
        The name of the Nominal Pointing FITS file to be  contian as
the choice pointings to which event postions mustsbe shifted.
This file is the oputput of wattame.

    outfile [string]
        The name of the output event FITS file.  It is a copy of the
input file having changed its position values in the X and Y
columns.  In case of the camera pointing shifts the Z column
will be incremented by twice the identification
number of the Nominal Pointing

    npifile [string]
Name of output Nominal pointing Interval FITS file.  This file
will contain the start and stop times of each time interval
during which all events al reshifted towards the same Nominal
Pointing.

    (calfile1 = "-" ) [string]
        The name of the input FITS file from which are fetched the
misalignment angles to calculate the instrument pointing.

    (calfile2="-" ) [string]
        Same as for calfile1, only used for SAX WFC-2

    (poscor=no) [boolean]
Correct positions for detector grid distortion

    (pntcor=yes) [boolean]
Correct[postions for pointing deviations (NOT YET IMPLEMENTED)

    (interpol=no) [boolean]
Interpolate event positions witninn one attitude attitudes
resolution period (.05 seconds)

    (xrange = ??) [real]
max allowed range in x-axis in pixel units

    (yrange = ??) [real]
max range in y-axis in pixel units

    (arange = ??) [real]
```

```
max range in rotation angle in arcminutes

    (blockio=yes)  [boolean]
Option to write output data files in fast block transfer mode.
This may introduce a non-standerd FITS format that cannot be used
across different computer systems.

    (dateref="MJDREF") [string]
Name of reference start date keyword

    (timeunit="T_SCALE") [string]
Name time unit of keyword

    (tcolumn="TIME_WFC") [string]
        The name of the column in INFILE that contains the time

    (verbsty=0)  [integer]
The verbosity level will control the output volume.

    (title=" ") [string]
User caption to be tagged to each output FITS file header


EXAMPLES
    Shift each event to the closest nominal pointing available

=> wshift  OBSw1prn1 FOTw1att1 FOTw1pnt1 OBSw1prn2 npifile=OBSw1npi2 pntcor=yes

NOTES
    - The program uses the parameter passing of the FTOOLS convention.
    - Presently the realignment of detector positions is not supported.
    - Presently the interpolation of positins not yet supported.
    - The default allowed ranges are only provisional

SEE ALSO
    wfotfits, wgtiflt, watproc, wattana
```

4.11 wslew

```
FUNCTION
    Program to process eventdata during recorded during slewing
    to produce instrument pointing and countrates per timebin.

USAGE
    wslew infile attfile outfile [optional parameters]


DESCRIPTION
Eventfiles are processed so that the actual countrates over
    the detector can be calculated.  To exclude the counts of the
    In-Flight Calibration sources filtered files should be used.
```

```
PARAMETERS

    infile [string]
        The name and extension number in square brackets of the input
        FITS table extension containing the list of events to be
        filtered.  If no extension is given the complete file with all
its extension will be processed.

    attfile  [string]
        Name of the input attitude FITS file needed for calculating
the actual instrument pointing

    outfile  [string]
        Name of the resulting FITS file containing per timebin
the event flux and instrument pointing.

    (bintime=2.0)  [real]
The time in seconds per accumulation of eventrates.

    (calfile1=" ")  [string]
        The name of the input FITS file that contains among others
the misalignment angles to calculate the instrument pointing.

    (calfile2=" ")  [string]
        Same as for calfile1, only used for SAX WFC-2.

    (tcolumn="WFC_TIME") [string]
        The name of the column in INFILE that contains  the  time  stamp
        value  that is used to determine if that row falls within one of
        the input Good  Time  Intervals.  The  values  in  this  column
        should  be  in  units  of  seconds  relative  to  the start time  ??
        specified by the obsdate and obstime keywords in the  header  of
        the extension.

    (obsdate="-") [string]
        The name of the keyword containing the reference date in the
        input events table.  The value can either be blank (or  "-")  to
        defeat the reference checking, in julian days or in 'dd/mm/yy'
        format.

    (obstime="MJDREF") [string]
        The name of the keyword containing the reference time in the
        input events table in 'hh:mm:ss.ddd' format.  This parameter is
        only used if obsdate is in dd/mm/yy format.

    (obsunit="T_SCALE") [string]
        The name of the keyword containing the units of the time column.
If omitted unites of 1 second are assumed.

    (blockio=yes)  [boolean]
Option to write output data files in fast block transfer mode.
This may introduce a non-standerd FITS format that cannot be used
```

```
across different computer systems.

    (verbsty=0)  [integer]
The verbosity level will control the output volume.

    (tforce=no)  [boolean]
Option to force the start time of attitude data to be aligned
with that of the event data.  (only use for TEST purposes)

    (title=" ") [string]
User caption to be tagged to each output FITS file header


EXAMPLES

    1.  Make file with detector fluxes per 5 seconds

--> wslew  OBSw1srn1 FOTw1att1 OBSw1ssl2 bintime=5.


NOTES
   -The program uses the parameter passing of the FTOOLS convention.
   -Presently countrates not corrected for deadtime.


SEE ALSO
    wfotfits, wgtiflt
```

Chapter 5

Stage-II programs

5.1 Stage-II overview

```
Stage II processing units:

   * environment, environment variables, file names, paths and types.

   * mask, define the mask pattern.
   * detector, physical detector parameters, calibration data.
   * instrument create the instrument data file.

   * cdi, assemble a detector image from an eventfile.
   * correlate, reconstruct celestial image.
   * iros, reconstruct celestial image, identify sources.
   * simulate, compute a mean detector image, given a sourcelist.
   * lcv, compute lightcurve and spectrum for selected sky positions.

   * eci, restore X-ray data in reduced sky .res image.
   * wop, arithmatic operations on FITS images.
```

5.2 Environment settings

```
File format, types

All stageII datafiles have the same FITS (Flexible Image Transport System)
dataformat.

The different stageII filetypes in use are identified by the value of the
"CONTENT" keyword. A default suffix, appended to a file’s name, may provide
a clue to its type.

File paths

By default, any file referenced by its simple name, ie. not containing any
path information, must be located in the current working directory,
otherwise it cannot be found. To use a file in an arbitrary location in the
```

file system, specify an absolute or relative path. The default location for specific groups of files can be altered by defining an environment variable for this filegroup, however a filename containing an explicit path is never changed.

WFC_TOP=
    unused.

WFC_CAL= directory
    The default location of the instrument, mask and det definition files will be directory.

WFC_SOURCEDIR = indir
WFC_DESTDIR= outdir
    The default location of any input file is indir, output files are created in outdir. When chaining some programs where the output from the one provides the input file for the next, this really does not make much sense. However, it can be handy when processing a lot of different datafiles with one proces.

WFC_CONFIG = path
    path is the full pathname of the wfc configuration file used in the StageII processes to contruct the proper instrument data filename from the FITS keys INSTRUME and TELESCOP.

    In the WFC software distribution, this file has the name wfc_config and is located in the $WFC_CAL directory.

WFC_CAT= catalogname
    A SAX-WFC format specific catalog file with X-ray source position and spectral parameters.

WFC_CATALOG= catalog-dir
    A WFC specific catalog is to be searched in directory catalog-dir. do not use, use WFC_CAT.

Other references

WFC_FITSORIG
    Gives the default value for the "ORIGIN" keyword in every FITSfile created.

5.3 WFC configuration

NAME

wfc_config, locate the default instrument data file, IDF.

SYNOPSIS

Each Wide Field Camera has its own instrument data file, IDF. A configuration file is used to match the FITS keys INSTRUME, TELESCOP and a user defined string U to listed values, and to assign the name of the instrument data file.

The configuration file is build out of commentlines (starting with #) and lines consisting of 4 words, eg

```
# this is a sample WFC configuration file.
  SAX           WFC1      *lr           wfc1.ins
  SAX           WFC2      *lr           wfc2.ins
```

If the first column matches the value of the key TELESCOP, the second matches INSTRUME and the third matches a user defined string U (default value is "*lr"), the name of the instrument data file is in the fourth column.

The crucial difference is of course in the fitskey INSTRUME, selecting the proper WFC. By default, the generated instrument data file specifies a celestial image resolution (pixelsize) derived from the maskelement size.

The configuration file's full pathname can be given in the environment variable WFC_CONFIG. If this variable is undefined, the configurationfile used is $WFC_CAL/wfc_config.

5.4 mask

NAME

mask - Create a two dimensional maskpattern.

SYNOPSIS

* mask
* mask -p [options] config esizex esizey eosizex eosizey mskfile

The program can be started with no arguments at all, in which case the parameter values are taken from the parameterfile.
Alternatively, values can be passed via the commandline, the required items as command arguments, the optional ones as valued switches.

The table lists all the parameters used by mask, the second column lists the paramater key names used in the parameterfile, the first column gives the corresponding switch letter.

iros parameters

switch	key	value	IO	description
	config	string	i	mask pattern configuration string, syntax
	esizex	real	i	mask element length, x axis.
	esizey	real	i	mask element length, y axis.
	eosizex	real	i	length of transparent part of open mask element, x axis.

```
       eosizey  real   i  length of transparent part of open mask element,
                          y axis.
       mskfile  string o  mask pattern file .msk

   p   debug    int    i  only as first commandline argument: ignore
                          parameterfile, set debuglevel. general
   i   title    string i  file title, description cq. comments. general

   L   logfile  string i  redirect diagnostic and informational messages.
                          see general

       mode     "ql"   i  has meaning for (some) parameterfile
                          parsers/readers only.
```

DESCRIPTION

mask creates a 2-dimensional pattern of transparent (1) and opaque (0) elements.

class
- prN pseudorandom pattern, overall transparancy is N %. N can be either 25, 33 or 50 (integral N).
- rN random pattern, overall transparancy is N % (real N).
- tN test pattern (integral N)
  - N= 1 -> all elements opaque (0).
  - N= 2 -> all elements transparent (1).
  - N= 3 -> elements alternating, checker board pattern.
  - N= 4 -> horizontal, centered line of transparent elements.
  - N= 5 -> vertical, centered line of transparent elements.
  - N= 6 -> centered cross of transparent elements.
  - N= 7 -> one transparent element in center.

size
: gives the number of elements along the x (nx) and y (ny) axis and optional repeat factors (rx, ry) for the mask pattern. if ny is not given, it defaults to the nx value (note. cf class pr50). the repeat factors default to 1, otherwise they give a repetition of the basic nx*ny patterns into an array of (rx.nx) by (ry.ny) elements.

fold
: folding method to 2 dimensions, either linear or diagonal.

code
: either simple or repeated.

shift
: shift array before folding to 2D.

mirror
: mirror 2D pattern.

rotate
: rotate 2D pattern.

EXAMPLE

```
  mask -p "pr33,[256,256],my" 1.0 1.0 wfc.msk
```

produces a file 'wfc.msk', with the mask pattern as used in the SAX-WFC camera's.

```
  mask -p "pr50,[255,257],shift 18456,diag" 1.0 1.0 comis.msk
```

produces a file 'comis.msk', with the mask pattern as used in the TTM/COMIS-WFC camera.

```
  mask -p "r23.4,[200,200],mi x,ro 90" 1.0 1.0 ran.msk
```

produces a file 'ran.msk', a random pattern, overall tranparancy aproximately. 23.4 %, pattern is mirrored in the X-axis, then rotated through 90 deg.

```
-----------------------------------------------------------------------------
                  mask pattern configuration string syntax
 term                                   expansion

config  ::= class "," size [","fold] [","code] [","shift] [","mirror]
            [","rotate]

class   ::= "pr25" | "pr33" | "pr50"["("int")"] | "r"real["("int")"] |
            "t"int
size    ::= "[" int[,int[,int[,int]]] "]"
fold    ::= ("diagonal" | "linear")
code    ::= ("simple" | "repeated")
shift   ::= "shift" int
mirror  ::= "mirror" ("x"|"y"|"xy")
rotate  ::= "rotate" 0|1|2|3
```

NOTE

SEE ALSO

5.5 detector

NAME

detector calibration data

DESCRIPTION

The detector calibration data are gathered in an ASCII file. This information is maintained and updated by hand as calibration data become available and are refined. The files det_wfc1.asc and det_wfc2.asc, one for each WFC, are located in $WFC_TOP/cal

There is no specific program to generate the FITS-format .det file (as exists for the .msk and .ins files), used by both the StageI and StageII. The FITS-format version of this file is generated by genFits from the ASCII detector calibration datafile.

NOTE

SEE ALSO

5.6 instrument

NAME

instrument, create an instrument data-file

SYNOPSIS

* instrument
* instrument -p [options] mask det focal-length IDF

The program can be started with no arguments at all, in which case the parameter values are taken from the parameterfile.
Alternatively, values can be passed via the commandline, the required items as command arguments, the optional ones as valued switches.

The table lists all the parameters used by instrument, the second column lists the paramater key names used in the parameterfile, the first column gives the corresponding switch letter,

instrument parameters

switch	key	value	IO	description
	mskfile	string	i	input mask, maskpattern file (FITS).
	detfile	string	i	input det, detector datafile (FITS).
	focallen	real	i	input, "focallength', the mask-detector distance (mm).
	insfile	string	o	output, the instrument data filename IDF
u	rotangle	int	i	compute shadow corrected Tk factors.
r	rotangle	real	i	mask-detector rotation.
x	rotcntrx	real	i	mask-detector rotation center, x.
y	rotcntry	real	i	mask-detector rotation center, y.
c	resci	real	i	sky image resolution.
d	resdi	real	i	detector image resolution.
n	dnlfile	string	i	DO NOT USE!!!. differential detector non-linearity data, replaced by the integral non-linearity data in detectorfile.
p	debug	int	i	only as first commandline argument: ignore parameterfile, set debuglevel. general
i	title	string	i	file title, description cq. comments. general
L	logfile	string	i	redirect diagnostic and informational messages. see general
	mode	"ql"	i	has meaning for (some) parameterfile parsers/readers only.

DESCRIPTION

NOTE

5.7 cdi

NAME

cdi – create a detector-image from one or several eventfile(s)

SYNOPSIS

* cdi
* cdi -p [options] evl di

The program can be started with no arguments at all, in which case the parameter values are taken from the parameterfile.
Alternatively, values can be passed via the commandline, the required items as command arguments, the optional ones as valued switches.

The table lists all the parameters used by cdi, the second column lists the paramater key names used in the parameterfile, the first column gives the corresponding switch letter,

cdi parameters

switch	key	value IO	description
	expfile	stringo	di, detector image file (FITS).
	evtfile	list i	evl, simple eventfile or list of eventfiles.
I	insfile	stringi	overrides the IDF name as inferred from the (first) input eventfile.
g	gtifile	stringi	the event selection time intervals are read from the g(ood)t(ime)i(nterval) file gti. Default action is to apply the HK data based gti-file created during WFC-StageI. Explicit selection of a time interval (-t,-T) cancels the automatic use of the gtifile, an explicit -g filename will be used.
t	t_filtr	range i	select events within one of the time intervals, events from the intervals are gathered into one image. The time interval must be specified in modified julian days (MJD). By default, all events are used. The time unit is not particularly easy to use, the numbers are large and do not readily relate to a date, however it allows you to select any event detected over the WFC's life time. Several interval can be specified in the form of a comma separated list.
T	t_ftrsec	range i	as -t, however the interval time(s) is in seconds from the start time of the first input(event) file. (if both -t and -T are present, the -T switch is

				ignored.
e	e_filtr	range	i	for a value e0–e1 assemble a detector image, selecting events with an energy in the WFC–channel range from e0 to e1 (incl). You can specify more ranges (up to 32), each range defines a detector image. The images are stored as a 3 dimensional FITS image. The default value of this parameter is 1–31, ie. generate 1 image with no energy resolution, all events are accumulated in one detector image.
z	z_filtr	range	i	Select events detected in the lower (–z0 (equiv. –z0–0)) or the upper ((–z1) detector compartment. default value is (–z0–1), do not discriminate.
p	p_filtr	area	i	area= x0–x1:y0–y1. Select events with a detector coordinate in a rectangle with lower left corner (x0,y0) and upper right corner (x1,y1). Several area's can be specified in the form of a comma separated list.
w	wsbar	int	i	select events detected under a support structure bar (i= 1) or only those events NOT under such a bar (i= –1). (i= –1 is not equivalent to a run with no –w parameter at all. .... explain)
b	tbin	real	i	append to the outputfile a count vs. time histogram (lightcurve) of the events in the form of a FITS Binary table. The parameter value specifies the resolution (time–bin length) in seconds. The table will contain a column for every detector plane created, only the events selected for the image are used in the lightcurve
f	b_filtr	int	i	In cases of non–nominal satellite stability, the StageI processing software has the option to partition the observation period in a number of intervals. For each interval a nominal instrument pointing is computed, event detector(!) coordinates are corrected for drift within this interval and the event is labeled with the interval's index. The –b switch selects the events with a particular range of pointing indeces. (b0 is equivalent to b0–b0). Currently, the StageI software deos not provide this functionality. (Alternative – we may delete this procedure, as the pointing clusters define a event partition in time also, providing the user with the time intervals for a selected pointing makes this event labeling superfluous.)
p	debug	int	i	only as first commandline argument: ignore parameterfile, set debuglevel. general
i	title	string	i	file title, description cq. comments. general
L	logfile	string	i	redirect diagnostic and informational messages. see general

```
       mode      "ql"  i  has meaning for (some) parameterfile
                          parsers/readers only.
```

DESCRIPTION

Read one or more eventfiles, creating a 2 (or 3) dimensional image.

-binning- detector pixel size as defined in the instrument data file used.

-linearisation-

EXAMPLE

We have 2 eventfiles

* WOP816_0034w2prn1.fits
* WOP816_0036w2prn1.fits

the command (assuming valid environment variables are set)

```
cdi -p2 -e2-12,13-25 -b2.0 WOP816_0034w2prn1.fits,WOP816_0036w2prn1.fits WOP816
```

produces the follwing output

```
===============================================================================
  cdi                                       Tue Jan  7 17:24:06 1997  page    1
   ------------------------------------------------------------
[E]cdi_defaultgtiname: cannot extract gti filename from "WOP816_0034w2prn1.fits"
 +                     use "-g gtifile" (parameter gtifile) to override default.
```

(StageI standard software produces a gti file with a default name, cf.
StageI naming conventions)

```
[1]evt_assemble: tstart=50317.32992, tend=50317.45865,  5562 bins
[1]evt_open: "WOP816_0034w2prn1.fits"[SCI_NM], 1 of 2.
 +          time  50317.32992 - 50317.38663 (MJD)  [  4899.73 sec.]
[1]evt_open: "WOP816_0036w2prn1.fits"[SCI_NM], 2 of 2.
 +          time  50317.39621 - 50317.45865 (MJD)  [  5394.96 sec.]
   evt_assemble: scanned 2 files, accepted 6266656 events in detector image
                 9830.385 sec. exposure time, starting (UT) Thu Aug 22 07:55:04 1996
```

and produces a file WOP816.exp. The ftool fstruct run on WOP816.exp produces

```
No. Type     EXTNAME      BITPIX Dimensions(columns)      PCOUNT  GCOUNT

0  PRIMARY                -32     680 680 2                   0    1
1  BINTABLE WFC_Eventspec   8     16(4) 32                    0    1
2  BINTABLE WFC_DetLcv      8     8(1) 5562                   0    1
```

The created file contains a

* PRIMARY FITS IMAGE (NAXIS=3), containing two 2-dimensional detector
  images, the first with events with an energy in the range 2-12

(channels), the second in the range 13–25.
* BINARY TABLE extension WFC_Eventspec list the number of events found in each channel. though there are 32 columns, only channels 2–25 (2–12+13–25) as selected, are filled.
* BINARY TABLE extension WFC_DetLcv list the number of events found in 2 second wide timebins, the table has 1 entry, an array with 2 elements (real (4byte) data–type, hence the 8byte width reported by fstruct), the lightcurve for the first and second energy range respectively.

NOTE

SEE ALSO

5.8 correlate

NAME

correlate – reconstruct a celestial–image from a detector–image by balanced correlation only.

SYNOPSIS

* correlate
* correlate –p [options] di ci

The program can be started with no arguments at all, in which case the parameter values are taken from the parameterfile.
Alternatively, values can be passed via the commandline, the required items as command arguments, the optional ones as valued switches.

The table lists all the parameters used by cdi, the second column lists the paramater key names used in the parameterfile, the first column gives the corresponding switch letter.

correlate parameters

switch	key	value	IO	description
	expfile	string	i	di, detector image file.
	rsyfile	string	o	oreconstruction of sky image, .sky
I	insfile	string	i	overrides the IDF reference in detector image file.
b	binphase	real	i	detector bin phase.
p	p_filtr	area	i	in(ex)clude section form detector image input. area::= x0–x1:y0–y1 Select the rectangular detector area, lower left corner (x0,y0) and upper right corner (x1,y1). The idea here is to exclude the events from one (or more) strong source(s) in the correlation, thereby nullifying its effects (mask and poissonian noise) on weak(er) sources in the field of view. Alternatively, one should be allowed to enter a

```
                           source position, this better matches the intended
                           use, but is NOT YET IMPLEMENTED !!!

                            1 do not apply normalisation with respect to
                            exposure time, skypixel unit is cts/cm2.

                            2 do not apply normalisation with respect to
                            triangular response (vignetting), no correction
                            for local mask transparency variations.
   c   cmode      int   i  skypixel unit is cts/sec.
                            4 NOT IMPLEMENTED !!! correct for rectangular
                            response only, no correction for local mask
                            transparencies. skypixel unit is cts/cm2/sec.

                            8 do not compute the error data plane in the
                            output celestial image.

   s   smdist    real   i the X-raysource to mask distance in mm., LBT
                           (Long Beam Test) event data only.
                           when detector image input is TSPZ(TeleSPaZio
   -   ofits     int    i format, applicable for QLA only), force FITS
                           output.

   p   debug     int    i only as first commandline argument: ignore
                           parameterfile, set debuglevel. general
   i   title     string i file title, description cq. comments. general

   L   logfile   string i redirect diagnostic and informational messages.
                           see general

       mode      "ql"   i has meaning for (some) parameterfile
                           parsers/readers only.
```

DESCRIPTION

Correlate reads a detector-image, reconstructing the celestial image for each detector plane in the detector-image file. The output image data are normalised with respect to the exposure time (FITS key EXPOSE in di) and the effective detector area, pixel data unit is cts/sec.cm2.

* binning, celestial pixel size - as defined in the instrument-file(FITS)
* linearisation, correcting the non-linearities in position and area of detector pixels.

EXAMPLE

NOTE

SEE ALSO

5.9 iros

NAME

iros (Iterative Removal Of Sources) reconstruct celestial image for a detector-image.

SYNOPSIS

* iros
* iros -p [options] di irs

The program can be started with no arguments at all, in which case the parameter values are taken from the parameterfile.
Alternatively, values can be passed via the commandline, the required items as command arguments, the optional ones as valued switches.

The table lists all the parameters used by iros, the second column lists the paramater key names used in the parameterfile, the first column gives the corresponding switch letter.

iros parameters

switch	key	value	IO	description
	expfile	string	i	input di, detector image file.
	resfile	string	o	output, reduced sky and det image, sourcelist .res
I	insfile	string	i	overrides the IDF name in expfile.
k	catfile	string	i	overrides default X-ray source catalog (environment).
a	anafile	string	i	-NOT YET IMPLEMENTED- use analyse outputfile 'name' as initial sourcelist.
b	attfile	string	i	attitude data file, overrides default path/name
d	trshld	real	i	stop criterium, threshold, sources detected may account for at most a fraction 'r' of the total counts in the detector
r	radius	real	i	maximum radial distance between detected and catalog X-ray source for identification.
c	cmode	int	i	correlation mode, correlate
n	niros	int	i	absolute limit on number of iros iterations, default is 15, but if niros is not assigned iros will also stop at an increase in Chi2.
				1 suppress use of X-ray source catalogs. 2 interactive operation, subtract detected sources one by one, prompting the user for position, flux and pointspread function modification. 4 use all detected sources in second and next

```
                             iterations, whether this source could be
                             identified or not.
   m   iros     int    i
                             8 accept any pixelconfiguartion as valid source.
                             16 suppres use of source list found as
                             (FITS)extension in input detector image (usually
                             simulated data).
                             32 treat detector as having no pointspread
                             function, all pixels from a reconstructed x-ray
                             source in the celestial image are treated
                             separately.

   s   srclim   int    i  limit number of sources considered to subtract.
   p   p_filtr  area   i  in(ex)clude section form detector image input.
   -   xchisq   int    i  NOT used in this releasedet. fit control,

   y   inlcrcn  int    i  set to 1 to use integral detector non-linearity
                          data.
   h   atmhght  real   i  earth atmosphere thickness (km).
                          when detector image input is TSPZ(TeleSPaZio
   -   ofits    int    i  format, applicable for QLA only), force FITS
                          output.

   p   debug    int    i  only as first commandline argument: ignore
                          parameterfile, set debuglevel. general
   i   title    string i  file title, description cq. comments. general

   L   logfile  string i  redirect diagnostic and informational messages.
                          see general

       mode     "ql"   i  has meaning for (some) parameterfile
                          parsers/readers only.
```

DESCRIPTION

the output file contains a primary image and 2 extensions: (PRIMARY) residual celestial-image, resulting from cleaned detector. WFC_Sourcelist(BINTABLE) row for each identified source (position, name, flux etc.) rdi (IMAGE) residual detector-image

* correlate reconstruct the celestial image from the detector image.
* analyse locate the sources in the celestial image.
* simulate compute the (average) detector image produced with

this sourcelist. -linearisation- iv. subtract subtract the simulated detector image from the measured one, and iterate the procedure with this 'corrected' detector image. -binning- as defined in the instrument-file(FITS)

EXAMPLE

NOTE

SEE ALSO

5.10 simulate

NAME

simulate - create a detector image file from a source configuration description.

SYNOPSIS

* simulate
* simulate -p [options] sim di

The program can be started with no arguments at all, in which case the parameter values are taken from the parameterfile.
Alternatively, values can be passed via the commandline, the required items as command arguments, the optional ones as valued switches.

The table lists all the parameters used by simulate, the second column lists the paramater key names used in the parameterfile, the first column gives the corresponding switch letter.

simulate parameters

switch	key	value	IO	description
	simfile	string	i	sim, Field Of View description.
	expfile	string	o	di, detector image file.
m	smode	int	i	simulation algoritm, 0-flat, 1-inl.
I	insfile	string	i	overrides the IDF name in expfile.
p	debug	int	i	only as first commandline argument: ignore parameterfile, set debuglevel. general
i	title	string	i	file title, description cq. comments. general
L	logfile	string	i	redirect diagnostic and informational messages. see general
	mode	"ql"	i	has meaning for (some) parameterfile parsers/readers only.

DESCRIPTION

* linearisation, correcting the non-linearities in position and area of detector pixels.

EXAMPLE

NOTE

SEE ALSO

5.11 lcv

NAME

lcv, create lightcurve and spectrum for each source found in irs resultfile.

SYNOPSIS

```
* lcv
* lcv -p [options] irs lcv
* lcv -q
```

The program can be started with no arguments at all, in which case the parameter values are taken from the parameterfile.
Alternatively, values can be passed via the commandline, the required items as command arguments, the optional ones as valued switches.

The last form (-q) creates the parameterfile in $PFILES.

The table lists all the parameters used by lcv, the second column lists the paramater key names used in the parameterfile, the first column gives the corresponding switch letter.

lcv parameters

switch	key	value	IO	description
	resfile	string	i	irs file, iros data file.
	lcvfile	string	o	lcv, spectrally resolved lightcurve, one file, base.k.lcv (k= {0,1,2 ...}, generated for each source k in res
I	insfile	string	i	overrides the IDF name in expfile.
a	skysize	int	i	directly reconstructed sky is size*size pixels (default 5).
b	tbin	real	i	time bin size in seconds (default is 100.0).
s	srclim	int	i	the first ‘srclim‘ sources from sourcelist in res.
-	e_filtr	range	i	DO NOT USE. channel selection, ignored, spectral resolution is 31 channels always.
p	p_filtr	area	i	UNTESTED, EXPERIMENTAL!! select the rectangular detector area, lower left corner (x0,y0) and upper right corner (x1,y1). The idea here is to exclude the events from one (or more) strong source(s) in the correlation, thereby nullifying its effects (mask and poisson noise) on weak(er) sources.
t	t_filtr	range	i	UNTESTED, EXPERIMENTAL!! select events within one of the time intervals, the time interval must be specified in modified julian days (MJD).
z	z_filtr	range	i	UNTESTED, EXPERIMENTAL!! event selection on the

```
                          Z-bit.
 ---------------------------------------------------------------------------
 p, L, i                  StageII global switches
```

DESCRIPTION

output is a FITS binary table, existing of 1+32+32 columns for every timebin:

```
    column   name              unit
       1     time               sec.
    2-33     lc0 ,lc1... lc31    cts/sec.cm^2
   34-65     err0,err1... err31  cts/sec.cm^2

    lc0(err0)              lightcurve of all events summed,
    lc1..lc31(err1..err31) lightcurve in each channel.
```

EXAMPLE

NOTE

SEE ALSO

5.12 eci

NAME

eci - restore X-ray sources in reduced sky image from iros.

SYNOPSIS

* eci
* eci -p [options] irs ci

The program can be started with no arguments at all, in which case the parameter values are taken from the parameterfile.
Alternatively, values can be passed via the commandline, the required items as command arguments, the optional ones as valued switches.

The table lists all the parameters used by eci, the second column lists the paramater key names used in the parameterfile, the first column gives the corresponding switch letter.

eci parameters

switch	key	value	IO	description
	expfile	string	i	.res, reduced skyimage
	rsyfile	string	o	restored sky image, .sky
m	mode	int	i	decorate the restored sources with a cross, value gives length (pixels) of cross

```
 ---------------------------------------------------------------------------
 p, L, i                  StageII global switches
```

DESCRIPTION

Correlate reads a detector-image, reconstructing the celestial image for each detector plane in the detector-image file. The output image data are normalised with respect to the exposure time (FITS key EXPOSE in di) and the effective detector area, pixel data unit is cts/sec.cm2.

* binning, celestial pixel size - as defined in the instrument-file(FITS)
* linearisation, correcting the non-linearities in position and area of detector pixels.

EXAMPLE

NOTE

SEE ALSO

5.13 wop

NAME

wop - arithmatic operations on FITS image files.

SYNOPSIS

```
   * wop
   * wop statement [,statement]
```

The program can be started with no arguments at all, in which case it will run in an interactive mode. Wop display's a promptstring and executes commands, there is NO quit/exit command, stop by typing ^D (control D).

If legal statements are passed as arguments, wop executes them one by one and exits.

DESCRIPTION

wop is a first attempt to develop a program performing a number of operations on FITS datafiles, both images and tables. Say we have a FITS file A, containing an image in the PRIMARY extension plus 3 image extensions, a0,a1 and a2

The statement

```
B=A[a1,5:10,0:5]
```

creates a FITS image file B, with NAXIS= 2, NAXIS1= 10, NAXIS2= 5. The image in B is a section (x from 5 to 14 (inclusive), y from 0 to 4) from the extension a1 in A. Generally, a FITS imagefile can be referenced as:

Filename[extname,x0:nx,y0:ny....] (syntax)

..

..

..

Currently, no operations are defined on FITS ’BINARY TABLE’ extensions.

OPERATIONS

FUNCTIONS

bin ([fx,] [fy,] fitsimage)
: parameters: fx binfactor for first dimension of image (default value is 1). fy binfactor for second dimension of image (default value is 1). fitsimage fits-image input.

crash ([axis,] [mode,] fitsimage)
: crash, ie. reduce the number of dimensions of an image by 1. this reduction is accomplished by replacing all data along an axis, a row (column, vector or whatever) by just a scalar value, this can be the mean, minimum or maximum from the axis being crushed. parameters: axis "x", "y" etc. (alternativly 0 (== "x") 1 ..) mode "s" compute mean "t" select maximum "v" select minimum fitsimage fits-image input.

clip ([low,] fitsimage)
: clip the image, all pixels with value .lt. low are replaced by this value. parameters: low clip all image data with a value under low. fitsimage fits-image input.

his ([np,] [low,] [upr,] fitsimage)
: produce a histogram, a 1D vector with np elements. parameters: np number of bins in histogram (default value is 100). low lower bound on pixelvalues (default value is minimum of fitsimage). upr upper bound on pixelvalues (default value is maximum of fitsimage). fitsimage fits-image input.

int (fitsimage)
: integrate the fitsimage, ie. starting at the first axis, replace p[x, y, z...] with the sum p[0, y, z...]+p[1, y, z...]+ .. + p[x, y, z...], x= 1-nx, y= 0-ny, z= 0-nz ... then repeat for the next axis until all done.

  parameters: fitsimage fits-image input.

mirror ([r,] fitsimage)
: mirror the fitsimage in one of its axis, given by r. parameters: r 0: mirror in x-axis (y := -y), 1: mirror in y-axis (x := -x) fitsimage fits-image input.

plot ([device,] [label,] [slabel,] fitsimage { [,slabel,] fitsimage })
: plot fitsimage, this image is always interpreted as a 1D vector, if the image has more dimensions only the first row of numbers is plotted. if you give several fitsimage input data, all these will be tiled onto one output page in (smaller and smaller, as the number increases) subplots.

```
     parameters: device pgplot style outputdevice (eg. "pic.ps/ps" create
     postscript file pic.ps). label label for the complete plot output.
     slabel sub-label, tagged on the individual plots. fitsimage fits-image
     to be plotted, if this image has more then 1 dimension, only the values
     along the first axis are used.
sum (fitsimage)
     print the sum of all pixelvalues in fitsimage.
stats ([dim,] [mode,] fitsfile)
     print some characteristics of the pixelvalues in fitsimage, printed are
     : name n sum mean sd min max
tile ([dim,] [mode,] fitsfile)
```

EXAMPLE

The instrument database file contains an extension named WFCcf, an 3D image, containing the Tk correction factors. For every pixel in the camera's, digitized, field of view, the first plane of WFCcf gives 1.0/Ao, Ao represents the detector area (in geometrical sense) seen from this skypixel, the second imageplane gives 1.0/Ac, Ac is the from this skypixel not visible, area of the detector.
The WFC mask has an overal transparancy of 1/3, so, looking from any skypixel, (and ignoring the detector support structure) Ao/Ac is aprox. one halve.

wfc.ins is the name of the instrument database file, the command:

```
wopi "A= wfc.ins[WFCcf,,,1:1] / wfc.ins[WFCcf,,,0:1]"
```

results in a FITS image A, giving (1.0/Ac)/(1.0/Ao)= Ao/Ac, for every pixel in the field of view.
The image may be displayed (eg. saoimage), or you can examine the distribution of the pixel values (expected value 0.5) with the command:

```
wopi "plot(his(500, .4, .6, A))"
```

plotting a histogram of all pixels in 500 points, ranging from 0.4 to 0.6. a command like:

```
wopi "plot(1/wfc.ins[WFCcf,0:,255:1,0:1])"
```

illustrates the WFC's triangular response, the plot shows the active detector area in cm2, along the x-axis (0:, start offset 0, full length) in the center of the field of view (y=255:1, start offset 255, length 1 pixel) and from the first image plane (z=0:1, start offset 0, length 1 pixel).

```
-----------------------------------------------------------------------------
                       wopi expression syntax
  term                                 expansion
list      ::= [; statement]
statement ::= NAME = expr | expr
expr      ::= term [(+ | -) term]
term      ::= factor [(* | /) factor]
factor    ::= ffile | const | NAME ( explist ) | ( expr ) | - expr
ffile     ::= NAME [qualifier]
```

```
qualifier ::= [ NAME ] | [ section ] | [ NAME , section ]
section   ::= axis [, axis]
axis      ::= | [initial] : length | initial : [length]
explist   ::= [expr [, expr]]
NAME      ::= string of characters
const     ::= number | string
string    ::= "string of characters exept quote "
initial   ::= integer
length    ::= integer
number    ::= real | integer

SEE ALSO
```

5.14 wspiros

```
FUNCTION
    Program to produce for further analysing SPEX compatible files on
    energy spectrums of both sky sources and accumulated detector

USAGE
    wspiros infile rootfile [optional parameters]


DESCRIPTION
   If the input file contains an extension having
EXTNAME = "WFC_Sourcelist" one FITS file '[rootname].src'
will be produced plus for each source a SPEX compatible
textfile having the name '[rootname]nn.spa', where 'nn'
equals 1 thru 99 corresponding to the order in the input file.
   If the input file contains an extension having
EXTNAME = "WFC_Eventspectrum" a SPEX compatible textfile
having the name [rootname]00.spa is produced.

PARAMETERS

    infile [string]
        The name of the input FITS file containing a sourcelist
or a (partial) detector energy spectrum

    rootname  [string]
        The rootname of which the complete names the resulting output
files will be composed.

    (source=0)  [integer <= 99]
The single source number to be extracted.
If 0 all available sources will be extracted.

    (verbsty=0)  [integer >= 0]
The verbosity level will control the output volume.

    (title=" ")  [string]
```

```
User caption to be tagged to each output FITS file header


EXAMPLE

    1.  Extract the sources and write result into files OBSw1prn##.spa
and OBSw1prn.src

--> wspiros  OBSw1prn1  OBSw1prn


NOTES
    -The program uses the parameter passing of the FTOOLS convention.
    -A maximum of 99 sources can be processed
    -   The number of energy bands may not exceed 32
    -   Of the extension holding a sourcelist only the columns
with the following names are extracted:
'ra', 'dec', 'flux', 'sigma', 'signif', 'cname', and 'tname'
    -The layout in the '.src' FITS file is such as to enable the
use of standard plotting utilities for FITS compatible files


SEE ALSO
    iros
```

5.15 File types

```
NAME

File types

DESCRIPTION

All stageII datafiles have the FITS (Flexible Image Transport System)
dataformat.

The filetypes used are identified by the value of the CONTENT keyword in the
primary FITS header.
A "type" dependant suffix, by default appended to the name of every file
created, provides merely a clue to the type. A program, requiring a certain
type of a file, will append the default suffix to the name supplied

                              StageII filetypes

  content suffix                        description

   ???          generic fits file, no special meaning for StageII
                software.
   Msk     .msk  mask pattern file, msk
   Det     .det  detector properties file, det

   Ins     .ins  generic fits file, no special meaning for StageII
```

		software.
Di	.exp	mask pattern file, msk
Ci	.sky	reconstructed a celestial image, by balanced correlation
SCI_NM	.enm	event file, Normal Mode events.
Lcv	.lcv	time-event histogram, resolved for a position in the field of view and for each energy channel (lightcurve file).
Iros	.res	reconstructed a celestial image, by the iros (Iterative Removal Of Sources) method.
SCI_NM	.enm	event file, Normal Mode events.
SCI_DMR	.edr	event file, Diagnostic Mode 1 (reduced).
SCI_DME	.ede	event file, Diagnostic Mode 2 (extended).
INS_HK	.hki	instrument housekeeping.
SCI_HK	.hks	science housekeeping.
ATTITUDE	.att	attitude data file.
TST	.tst	generic format, test (debug) images, usually not recognised on input.

5.15.1 mask file

NAME

mask data file, default name suffix .msk.

DESCRIPTION

The maskfile contains an image of the camera's mask, produced by mask

EXAMPLE

NOTE

SEE ALSO

5.15.2 detector file

NAME

detector data file, default name suffix .det.

DESCRIPTION

The detector data file provides a complete description of the detector, this file is produced by genFits from ASCII input data.

detector data structure

ext.name	type	dim	description
primary	--	0	keyword data only.
ss	BT	-	window support structure description.

```
wfrm         BT   -  detector wireframe description.
cs           BT   -  detector calibration sources, location and strength.
energy_calib BT   -  detector energy channels, channel boundaries in keV.
inl          BT   -  integral nonlinearity
align        BT   -
detbord      BT   -
tempcoef     BT   -
voltcoef     BT   -
hvmonfac     BT   -
califc       BT   -
```

EXAMPLE

NOTE

SEE ALSO

5.15.3 instrument file

NAME

instrument data file (IDF), default name suffix .ins.

DESCRIPTION

The instrument data file (IDF) is the resultfile of instrument. It stores a description of some Wide Field Camera properties and contains references to other calibration datafiles. Amongst these is the name of the mask file and the appropriate detector file.

IDF FITS structure

ext.name	type	dim	description
PRIMARY	---	0	keyword data only.
WFCbinmask	-32	nx ny 2	mask pattern, binned to match detector pixelsize, first plane computed with open maskelement set to 1, closed element to 0, second plane vice versa.
WFCdftmask	-32	nx ny 2	discrete Fourier transform of the original mask pattern, planes differing as above.
WFCcf	-32	nx ny 2	first plane : for each pixel in the sky, the reciprocal of the total detector area (cm2) seen through open maskelements. second plane: for each pixel in the sky, the reciprocal of the area (not) seen through closed maskelements.

5.15.4 detector image file

NAME

detector-image file, default name suffix .exp..

DESCRIPTION

A WFC detector-image file contains a reconstruction of the detector plane, ie. a 2 dimensional histogram of the X and Y fields of events gathered.

The file may contain one or several image planes, where each plane harbours events within a certain energy band. The number of planes is given by the keyword NBAND, the energy range (a lower an upper limit, in WFC-channel numbers) is listed in BANDn (1 <= n <= NBAND).

The total time over which the image was taken, is given by the keywords TSTART and TEND. If this interval contains one or more gaps, the detector-image file has an extension named 'GTI', listing the start and end times of all 'good' intervals.

Pointing.

Binning. Depending on used instrument data file. X and Y event coordinates, format depends on Stage I processing

Simulation keywords.

EXAMPLE

NOTE

SEE ALSO

5.15.5 sky file

NAME

reconstructed sky image (field of view), default name suffix .sky.

DESCRIPTION

This is a simple three dimensional FITS image. For each selected energy band, the file contains a pair of images, the reconstructed sky and the error.

5.15.6 res file

NAME

IROS result file, reduced sky and det image, sourcelist, default name suffix .res.

DESCRIPTION

```
                         IROS result file structure

    ext.name    type    dim                    description

 PRIMARY         -32 nx ny ne ne reduced celestial images, for each energy
                              band.
 rdi             -32 nx ny ne ne reduced detecor images.
 WFC_Sourcelist  BT  width ns list of ns identified sources.
```

5.15.7 source list

NAME   sl - source list file

DESCRIPTION

```
  A FITS file with a BINARY TABLE extension, build of 11 columns :

   1. ra  (right ascension), degrees, double (1D).
   2. dec (declination), degrees, double (1D).
   3. flux (estimated brightness), cts/cm2/sec, float, fixed size, array (4E).
   4. error (estimated, poissonian error), cts/cm2/sec, float, fixed size, array (4E).
   5. signif (flux/error), dimen.less, float, fixed size, array (4E).
   6. cname (canonical name), char, fixed size, array (32A).
   7. tname (trivial name), char, fixed size, array (32A).
   8. type (spectral type), int, (1J).
   9. nh (column dens.), real, (1E).
  10. index (spectral index), real, (1E).
  11. spare (), int, (1E).
```

EXAMPLE

NOTE

SEE ALSO

5.15.8 lcv file

NAME

create lightcurve and spectrum file, default name suffix .lcv.

DESCRIPTION

The lightcurve file contains a FITS binary table, with the following columns
for every timebin

```
                  lightcurve bintable structure

 columntype                      description
  time  D   center bin time, MJD.
```

```
 bnltf  E   bin lifetime fraction, TBD.
 vsbyf  E   bin visibility (earth obscuration) fraction, TBD.
  lc0   E   flux (cts/sec/cm2), summed over all energy channels.
  lci   E   flux in energy channel i, i= 1..31.
  err0  E   error for flux lc0.
  erri  E   error for flux lci, i= 1..31.
```

EXAMPLE

NOTE

SEE ALSO

5.16 Parameter interface

NAME

parameter interface

SYNOPSIS

Following parameters are present in all StageII parameterfiles and the equivalent switches are honoured by all StageII programs.

A program is directed to obtain its run time parameters from the command line,

entirely ignoring the parameterfile contents,

if the very first command line argument is:

```
-p[debug-level]
```

debug-level is an optional (integer) number, the higher the number, the more informational messages the program will produce, unfortunatly little effort has been invested in the differentiation of these debuglevels.

Messages are logged onto the standard error file (stderr). This output can be redirected to a file logfile-name by the option

```
-L logfile-name[,lpp]
```

The optional ",lpp" gives the maximum number of lines per page. A formfeed character and a new header is written to the logfile creating a new page after this many lines. The default value is 0, meaning an infinite pagelength.
(If logfile-name is an empty string, output is written not to stderr but to stdout.)

```
-i title
```

assign title to the FITS keyword TITLE in any output file created. (if title contains space characters, include the entire string in quotes)

The parameterfile key mode is not accessable from the commandline, its value directs the pcl routines how to handle the parameterfile data.

Except for the the initial switch -p (which value is optional), all switches on the commandline are expected to have a value, optionally separated from the switchname by a space-character. If a switch value's first character is '-', ie. the next switchname, it is assumed the switch value is an empty string.
A consequense is that the last switch on the commandline may take its value from what you meant to be the first(non-switch) argument. A special string -- halts any switch processing beyond this string. Preceeding the first argument by -- prevents it from being interpreted as a switchvalue. Command line entries following a -- can never be switches, even if their first character is a -

```
                      StageII global parameters summary

 switch   key    value IO                   description
                           first argumen only, entirely ignore
   p   debug    int    i  parameterfile, get run time parameters from
                           command line.
                           value controls diagnostic messages volume.
   i   title    string i  file title, description cq. comments.
   L   logfile  string i  redirect diagnostic and informational messages.

       mode     "ql"   i  is interpreted by (some) parameterfile
                           parsers/readers only.
```

5.17 File lists

NAME

filename-list - list

SYNOPSIS

Several StageII programs can accept a namelist-parameter. A namelist-parameter is a list of strings, delimited by one or more ',' (commas) or white-space (as defined by the isspace function, unix:ctype (man(3C))), characters.

Each of these strings must be either the name of a FITS file (that can be used by the program), or the name of a file containing another namelist-parameter.

The current implementation is not at all flawless, we are bound to run into trouble sometime. Any file that

* does not begin with the string : "SIMPLE = ", ie. is NOT a FITS file
* and is shorter than 8 Kbyte

is assumed to be a valid namelist-parameter file. If this assumption is wrong, unpredictable things will happen. The file is openend, the content interpreted as a list of filenames and the program eventually will try to access these files. If one is lucky, this will fail on errors in the category "cannot open" immediately, occasionally a valid filename is used and errors occur further along the line of processing. (see the source file .../src/evt/evt_open.c:idrctnlist).

This potentially dangerous implementation must be resolved soon, maybe by defining a special FITS file type, ie. a namelist-parameter FITS file.

5.18 Ranges

NAME

range and area syntax.

DESCRIPTION

StageII programs have parameter types specifying a range of values, eg. select events in a time interval or within a range of energy-channels. Given a range value, with a lower bound p and an upper bound q, and a length L= p-q for real and L=p-q+1 for integral data. The data-type of boundary values depends on the internal interpretation of the data, not on the format, eg. presence or absence of a decimal point, wherein you cast the numbers.
A range can be specified in one of the formats

```
        * p-q
        * p : L
        * p
```

Several ranges can be specified in a comma separated list

```
     p0-q0,p1-q1, ...
```

The data-type of boundary values depends on the internal interpretation of the data, not on the format, eg. presence or absence of a decimal point, wherein you cast the numbers. The format listed last (p)is an abbrevation for p-p, this does not make sense for a real valued interval, as it will have zero length. This abbrevation was introduced to facilitate the selection of integral values, eg. a combination a energy-channel numbers.

The value for an area parameter consists of two ranges, glued together by a : (colon). The ranges apply respectively to the first axis (x) and second axis (y) lengths of the (rectangular) area. The area value may be preceeded by a letter (i or x), to emphasize the intended meaning, include or exclude items in the area.
Parameters with this type usually are used to select or reject certain sections in the formation or destruction of an image.
Again several values may be chained in a comma separated list.

```
Example.

   * the timerange variable 200:300,700-800 covers a timeinterval from 200
     up to 500 (say) seconds, then skips time till 700, again covering the
     interval up to 800 sec.
   * 2,5,9,12 (short for 2-2,5-5,9-9,12-12, or equivalently
     2:1,5:1,9:1,12:1) selects a number of points from an integer variable,
     eg. the energy-channel.
   * x0-x1:y0-y1,x2-x3:y2-y3 select the union of the area's [x0,y0]-[x1,y1]
     and [x2,y2]-[x3,y3] (points are 'lower-left' and 'upper-right' corner
     respectively).
   * x660:20:660-680 from some process, exclude the area
     [660,660]-[680,680].
```

Chapter 6

Miscellaneous topics

This chapter addresses a number of issues and methods used.

6.1 Time assignment

When the instrument sends a packet to the telemetry it will always contain a time stamp. This timestamp is derived from the spacecraft clock pulse. The resolution of the spacecraft clock is 2^-16 seconds. (= 15 microsec.) In the WFC's, however, the highest used resolution is 2^-12 (1/4096) seconds. The time resolutions are:

```
DIR001 Normal mode   2^-11 = 488 microsec.
DIR002 High Time Resolution mode 2^-12 = 244 microsec.
DIR003 Background Analysis mode  2^-10 = 977 microsec.
DIR004 Diagnostic Reduced mode   2^-12 = 244 microsec.
DIR005 Diagnostic Extended mode  2^-12 = 244 microsec.
```

All other modes have a time resolution of 1 second only.

In the FITS files produced by Stage-I times can occur as keyworods in headers and as columns in the rows of the data part.

As a general rule in Stage-I all times of the eventfiles are the clock times in 2^-12 ticks. This does not reflect the actual time resolution. All times in the headers are in MJD

6.1.1 Dates and times in files

Times in FITS files may be represented in several ways:

a. Directly as a Modified Julian Day number and fraction (MJD)

```
    It will always be represented in Double Precision (REAL*8) format.
    allowing a precision of 15.95 significant decimal digits.
    With an MJD daynumber being around 50000.0 this allows a maximam
    resolution of about 10^-6 seconds (1 microsecond).
    The time column will have the name 'TIME' in this case

b.  Indirectly as an integral number of time-units relative to a
    certain reference date.  In Stage-I processing all of these timea
    will be scaled to units of 2^-12 (= 2.44140625E-04) seconds and be
    stored in Integer (Integer*4) format.  The reference time is given
    as in Modified Julian Days as with (a.).
    FITS files that have such a time-columns will contain the
    following keywords:
MJDREF   / MJD of S/C clock = zero
T_SCALE  / scale factor of times (seconds)
    The time column will be nemaed
        WFC_TIME / Space Craft clock time of the WFC
    So if the given relative time is TIME_WFC then the actual times in
    MJDs will be:  MJDREF + (TIME_WFC * T_SCALE / 86400)

c.  A combination of a. and b.  If only MJDREF is specified in
    the priamary header time in MJD will be
        MJDREF + TIME
    IF T_SCALE  is also specified time on MJD will be:
        MJDREF + TIME * T_SCALE / 86400.

d.  Instrument On-Board time ticks.  One tick is defined as 2^-16
    second.  These ticks will be stored only for the start or end of
    observations.  Relevant keywords are
SCSEQBEG=    spacecraft clock begin (ticks)
SCSEQEND=    spacecraft clock end (ticks)

e.  As time periods they will be stored in seconds
    Used in headers with keywords:
    TELAPSE   (elapse time from start to end in seconds)
    ONTIME    (Total uncorrected integrated time ion seconds)

f.  In Calendar days and times are stored in character string keywords
    and have the form 'dd/mm/yy' (all numerics) and 'hh:mm:ss' or
    'hh:mm:ss.sss'  Used keywords are DATE-OBS, TIME-OBS, DATE-END and
    TIME-END.
```

6.1.2 External time referencing

```
Neither the science data nor the housekeeping data coming from the
instrument contains actual date and time stamps.  Only the On-Board Time
in units of 2^-16 ticks are available and stored in the telemetry packets.
In order to enable the matching of these tick-times to actual dates
a special reference file will be present on each FOT containing an
OBT to UTC conversion table.  This file is used to calculate a
reference time (MJDREF) for each new observation.
```

To obtain the reference date the instrument time is matched with the latest OBT that is preceeding the instrument time (ticks) so that the reference can be calculated as follows:

```
   if SCSEQBEG contains the ticks of the first event and
   OBT is the closest time in the OBT_UTC files, then

   MJDREF = UTC -  OBT / ( 2^-16 * 86400)

   where UTC is the time corresponding to the OBT value
```

The following problems are provided for:

a. In case the time is falling outside the provided conversion OBTs a warning is issued. Then depending which is closest to the instrumemnt time either the first or the last OBT is taken to calculate the reference data (MJDREF).

b. The OBT counter may scroll though zero during the observation. This will happen every 2^16 (65535) seconds or 18.2 hours. This can be easily solved as during one Observing Period the starttimes within one observation must not occur before the endtimes of previous observations. Only the first one will take the earliest OBT match.

6.2 Attitude processing

Reconstruction of the sky from the detector image can only be done if during the recording of the photons the pointing of the instrument is within narrow bounds. The satellite is guaranteed to maintain its pointing stability within an error of 1 arcminute and the absolute pointing error is guaranteed to be exact within 3 arcminutes.
For the WFC having a field of view of about 40 degrees the error in absolute pointing is not very critical. In order to prepare for larger instability than expected or allowed the following three programs have been implemented:

a. Program 'watproc' copies the raw attitude file for each instrument separately and adds information about Observing Mode (Normal/Slew) plus the position of the Earth w.r.t. the camera. From the Ephemeris data that gives the location of the satellite is calculated the centre of the Earth in the camara coordinates km in X, Y and Z).

b. Program 'wattana' analyzes the attitude data and establishes a number of clusters so that actual pointings belonging to one cluster are within the permitted maximum limits from the center or nominal pointing of that group. Such a nominal pointing is characterized by Right Ascension, Declination and North Angle. For each of these a maximum range can be specified, both for Normal Pointing or Slewing Operational Mode.
The result will be a file that contaions the list of all calculated Nominal Pointings. In the case of ideal stability it shall of course

have only one. It is envisaged to run this analysis standardly over the complete Observing Period (one FOT).

c. Program 'wshift' will shift the position of each individual photon event over the detector to the position that is would have had if the detector had positioned to a reference pointing. The reference pointing will be the closest from a set of Nominal Pointings as calculated by 'wattana'. As the shift is done of a part of the Observation Period only a subset of the Nominal Pointings will be used.

A file containing the Time Intervals per Nominal Pointing is produced in order to enable the separate processing the of photon events of one Nominal Pointing at a time as is required by the correlation programs of Stage-II proceswsing which can operate only on one accumulated detector image.
The layout of such a Nominal Pointing Interval (NPI) file is identical to those of the Good Time Interval (GTI) files, but with an extra column containing the number of the Nominal Pointing.

If only one NP is calculated and the range of the photon detector positions is very small it is possible to skip the shifting of the events altogether and pass the event datafile directly to Stage-II processing.

Here is flow of the attitude processing of several FOTs (having same target):

```
   FOT
    |
    V
==========
 wfotfits
==========
    |
    | |   |
    |-->FOTID1_0000__att0 ------|   |
    | | |   |
    |-->FOTID1_0000__obs0 ----  | |   |
    |       | | |   V
    |-->FOTID1_0000__eph0 --  | | |   FOTID3_0000w#att1
    |     | | | V   |
    |     V V V FOTID2_0000w#att1   |
    |   ========= |   |
    |    watproc |   |
    |   ========= |   |
    |       |  --------------   |
    |       |        |  |
    |       |-->FOTID1_0000w1att1 --->>>     |  |
    |       |        |  |
    |       |-->FOTID1_0000w2att1 --------   |  |
    |       |   |         |  |  |
    |       -  |     V  V  V
    |   |    =========
    |   |     wattana
    |   |    =========
    |   |        |
    |   |        V
    |   |         MERGED_0000__pnt1
```

```
    |-->FOTID1_####w2prn0 --  |        |
    |     |   |        |
    |     |   |     -----------
    |     V    -----   |
    |        ============ |  |
    V           filter  |  |
    V         processing  |  |
    V        ============ |  |
    | V  V
    V       ========
     FOTID1_%%%%w2prn1 ------> wshift
          |       ========
    | |  |
    | |   ---------------
    | |                 |
    | V    V
    | FOTID1_%%%%w2prn2  FOTID1_%%%%w2npi2
    | |    |
    | |    |
    | V    |
    |    ============    |
     ----------->    Stage-II   <----------
    processing
   ============
```

6.3 Data cleaning and selection

```
Cleaning of data files is used here in the very broad meaning of
preparing data for further processing.
During this cleaning stage the following functions are performed:

- conversion of instrument housekeeping values to physical units
  for all temeratures, voltages.
- testing and rejecting all data that have obvious defects like
  a-sequential times, monitoring meters out of limits or unstable
  High Voltage after instrument state switching.
- extracting calibration (IFC events) data from science data
  to be used for detector gain calculations.
- filtering instrument monitoring data (Pseudo-events) from science data.

The Housekeeping files are cleaned by program 'whkproc' which does the
value conversions and the bad time rejections.  The resulting data files
are used for making Good Time Interval files by program 'wmakgti', which
uses a selection criteria file containing the conditions for accepting
good data.

Presently on four different data streams GTI files are selected.

a. Selection criteria on Instrument Housekeeping which are laid down
   in an expression file (default $WFC_ETC/wfc_sel_ins) containing
   one single line
```

```
b. Selection criteria on Science Housekeeping which are laid down
   in an expression file (default $WFC_ETC/wfc_sel_sci) containing
   one single line
c. Selection criteria on Attitude which are laid down in an expression
   file (default $WFC_ETC/wfc_sel_att) containing one single line.
d. Selection criteria on Ephemeris which are laid down in an expression
   file (default $WFC_ETC/wfc_sel_eph) containing one single line.

a. and b. result in one GTI file per Observation while c. in one GTI file
for each camera and d, in one for the whole FOT.

Program 'wmakgti' can read the selection criteria either as a parameter
argument or as an expression contained in a textfile.  However in the
standard producion selection is done by an expression file.

Merging of all or a set of GTI files is done by program 'wmrggti'.

Per FOT the following general GTI file are produced:
  WOPid_0000__eph0.gti
  WOPid_0000w#att1.gti

Per Observation the following GTI files are produced:
  WOPid_nnnnw#prn0.gti  (produced by wfotfits and not selectable)
  WOPid_nnnnw#phi1.gti
  WOPif_nnnnw#phs1.gti

Above 5 files are merged into one GTI for the observation:
  WOPid_nnnnw#.gti

Per camera all these files are merged into one GTI file:
  WOPid_0000w1.gti
  WOPid_0000w2.gti
These files are passed to stage II for actually selecting the
required data intervals.


EXPRESSION EXAMPLES:

By wfc_sel_hkd select only data with High Voltage Monitoring value at least
3000 Volts:

  (HV_MON .gt. 3000) && (HV_STAT .ne. 0)


By wfc_sel_att select data only out of the earth occultation ie. with the
angle between earth-rim and WFC pointing at least 15 degrees:

  (G_RIMANG .gt. 15.)


By wfc_sel_eph select data only out of the South Atlantic Anomaly

  (SAA_FLAG .eq. 0)
```

By wfc_sel_sci select only data with High Voltage Setting value at least 2500 Volts and accept a count rate of at least

```
  (HV_SET .gt. 2500) && (RATE_EVENT .gt. 100)
```

6.4 Satellite and instrument axes

The orientation of the satellite determines the orientation of each individual camera with respect to the sky. The sky coordinate of the sighting axis (Z-axis) of an instrument is called its pointing.

Use is made of the following right-handed coordinate system:

```
+Y     +X
 |      |
 |      |
 -X______|_____+X   ===      |_____+Y
/    /|
       /           / |
      +Z   <= towards eye of reader =>   -Z |
    -X
```

```
In this system the North-Angle is defined as the the angle to turn
anti-clockwise the -X (== +X of sky-image) onto the plane through the
North Pole and the Z while having the -Z axis (== detector) in your back.
The North-Angle is always related to the sky-image (mirrored around
Y-axis from detector image).
Note, that in this definition the NA will be undefined if +Z points
exactly at any of the two poles.

For the instruments the following definitions are in force:

for each camera:
  Z = the heart axis through the instrument with the detector at -Z
and +Z at the mask side pointing to the observed sky
  Y = the side of the detector perpendicular to the groundplate with
the groundplate at -Y and the other side of the instrument at +Y
  X = the side of the detector parallel at and closest to the
instrument groundplate with +X going right when looking from
outside through the instrument into the detector.
      **NOTE:  The instrument +X_axis == the sky image -X_axis !!!

 WFC-1: X = + SAT-Z = sky image -X axis
Y = - SAT-X
Z = - SAT-Y = instrument pointing

 WFC-2: X = - SAT-Z = sky image -X axis
Y = - SAT-X
```

```
Z = + SAT-Y = instrument pointing

As each axis is given by its Right Ascension and its Declination
the following pointing relations exist:

WFC1: SAX:
----------
ra_x  =    RA_Z
dec_x =        DEC_Z
ra_y  =   180 + RA_X
dec_y =       - DEC_X
ra_z  =   180 + RA_Y    =  RA_PNT
dec_z =       - RAS_Y = DEC_PNT

and
WFC2: SAX:
----------
ra_x  =   180 + RA_Z
dec_x =       -DEC_Z
ra_y  =   180 + RA_X
dec_y =       - DEC_X
ra_z  = RA_Y =  RA_PNT
dec_z = DEC_Y = DEC_PNT

It is envisaged that the instrument alignment on the satellite is not
exact.  So the difference between the nominal and the actual pointing
of each instrument is defined by the following three (delta) parameters:

  DELTA_THETA the angle between the nominal Y-axis and the actual Z-axis
minus 90.  (nomally 0 degrees)
  DELTA_PHI the angle going from the plane through the nominal Y-axis
and the nominal Z-axis to the one going through the nominal
Y-axis and the actual Z-axis (nomally 0 degrees)
  DELTA_ROLL    the angle going from the plane through the nominal Z-axis
and the nominal Y-axis to the one going through the nominal
Z-axis and the actual Y-axis (nomally 0 degrees)

These values will be stored and updated in the detector calibration file
(wfc#.det) as part of the data extension named 'align'.


GENERAL DEFINITION NORTH-ANGLE (NA)
Valid for an imaging instrument with its own X and Y axes
---------------------------------------------------------

The angle to turn the +X axis of the SKY-IMAGE anti-clockwise
towards the North Pole, with the observer looking to the sky and
having the detector behind his back.

so:

if Zsat = -Xwfc1 = North  then  NAwfc1 = 180
if Xsat = -Ywfc1 = North  then  NAwfc1 = 270
if Ysat = -Zwfc1 = North  then  NAwfc1 = undefined
```

```
if Zsat =  Xwfc2 = North  then  NAwfc2 =   0
if Xsat = -Ywfc2 = North  then  NAwfc2 = 270
if Ysat =  Zwfc2 = North  then  NAwfc2 = undefined

Always valid:  NA_WFC1 + NA_WFC2 = 180 modulo 360



SAX/WFC ORIENTATION from INSTRUMENT DIRECTORY on FOT
----------------------------------------------------

- From FOT number 773 the ROLL as given in the INSTRUMENT directories
  (w1instdir_000000_00_0.dat and w2instdir_000000_00_0.dat) of both
  cameras are identical to the North Angle as defined for the instruments.

- Prior to FOT number 694 the following anomalous situation exists:

  R.A. and Dec. of WFC1 and WFC2 both equal the R.A. and Dec.
  of the satellite +Y-axis which is correct for WFC-2 but

  The ROLLwfc1 equals 180 - ROLLwfc2
  The ROLLwfc2 equals the North Angle of WFC2 + 90 degrees

  so:  NAwfc1 = ROLLwfc1 + 90 = 270 - ROLLwfc2
NAwfc2 = ROLLwfc2 - 90 =  90 - ROLLwfc1

- From FOT number 694 up to 773 the following improvement is made:

  The ROLL situation same as before/
  R.A. and Dec. of WFC1 now equals R.A. and Dec. of satellite -Y axis
  The ROLL situation is same as before, however.

NOTE:
 In a previous definition the X-axis of the instrument was taken to
 be the X-axis of the DETECTOR.  For orientation of the sky-image,
 however, the X-axis of the IMAGE is pointing in the opposite direction.
 So, Xwfc(sky) = -Xwfc(det)
```

6.5 Rate peak detection

Finding peaks in the detector countrate is performed by program 'whkproc'. Per detected peak a row is stored in a FITS file. The information stored is risetime and falltime of the peak, the countrate at the peak maximum, and the total counts of the peak above the running average.

The algorithm for finding a peak is based on the count rate of the input event processor. This countrate is available every second in the Science Housekeeping data. The FITS keyword for the column containing these values is 'RATE_EVENT'. At any point the counts of a fixed number of seconds (currently 50) are buffered and used to find a peak. A peak is accepted if the distance to the falltime of a previous peak is at least a predetermined number of seconds (presently 3) and if for at most a fixed number of succesive counts (presently 24) counts are above the buffer average by at least a fixed number (presently 100)

6.6 Dead time calculation

In order to enable the correction of photon fluxes a file is produced containing the deadtimes per specified period (minimum 1 second).
The calculation is performed by program 'whkproc' from the Science Housekeeping data.

The MAIN trigger ratemeter counts the number of events which triggers the low level discriminator of the Main A nnode section of detector.
The LOGIC trigger ratemeter counts the number of events which pass the first validation check in the Digital Frontend and triggers the Event Processor to transfer the event data into the Event Processor.
During the transfer process the ratemeter is stopped and also if for any reason buffers temporarily cannot be sent to the telemetry.
This allows the calculation of the dead-time of the instrumant.
Both meters are reset to zero every second.

Therefore the deadtime = (RATE_MAIN - RATE_LOGIC) / RATE_MAIN

and the actual_flux = measured_flux / (1 - deadtime)

The deadtime is stored in a FITS file together with the time in Modified Julian Day plus the accumulation or binning time in seconds