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Specification of Detector Operating & Observing Modes and Observation ID in OGIP FITS files

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SUMMARY

We list the strings used for the specification of the Detector Operating & Observing modes of the various instruments within the OGIP data holding. The definition of the 'observation ID' is also given.

[1]http://legacy.gsfc.nasa.gov/docs/bios/angelini.html
[2]http://legacy.gsfc.nasa.gov/docs/bios/imgeorge.html

LOG OF SIGNIFICANT CHANGES

Release Date	Sections Changed	Brief Notes
1994 May 11		First (internal) Draft
1994 Nov 30	All	Made compatible with `LaTeX2HTML` software
1995 Mar 10	All	Revised & Updated

Contents

1 INTRODUCTION

In order to facilitate the use of FITS datasets by downstream s/w and users, the OGIP is adopting a set of standard keywords containing mission dependent character strings to specify the detector operating, the detector observing mode and observation identification, used during the collection of a given dataset. This memo lists those currently approved for use and should be **strictly** adhered to within the OGIP.

Any comments or suggestions (especially if you have requirements not covered by this memo) should be e-mailed to the authors (`LHEAVX::ANGELINI` and/or `LHEAVX::GEORGE`).

2 OBSERVATION ID

Sequence numbers are commonly used by missions to identify 'uniquely' a particular dataset. The definition of the sequence number is not unique across mission and typically depend upon the different way a dataset is identified within that mission. Although sequence number suggests a numerical value only, past mission had given the sequence number as a mixture of numerical and character values. To avoid a proliferation of keywords to store the sequence number value, the OGIP recommend to use `OBS_ID`. The keywords value is a string, to allow back compatability with the already archived mission. The `OBS_ID` keyword value can be used by database software.

3 OBSERVING MODE

For many instruments, observations could/can be carried out under a number of different observing modes. Within a FITS file, data from different observing modes are usually stored in different extensions. The OGIP has therefore adopted the FITS keyword `OBS_MODE` to denote the observing mode of the data within a given extension. The standard (multi-mission) values of this keyword are described in Section 3.1, whilst instruments which have adopted a different standard are individually described in Section 3.2.

3.1 Standard Values of the OBS_MODE keyword

The standard, multi-mission character string values of the `OBS_MODE` keyword are as follows:

- `OBS_MODE='POINTING'`
  for data when a three-axes stabilized satellite is pointing in a particular direction of the sky, and a 'mean' pointing position can be given.

- `OBS_MODE='RASTER'`
  for data collected by a three-axes stabilized satellite which is making a 'raster scan' over a region of the sky.
- `OBS_MODE='SLEW'`
  for data obtained whilst a (typically three-axes stabilized) is moving between one observation and another.
- `OBS_MODE='SCAN'`
  for data collected by a scanning (spinning) satellite.

It should be noted that in the case of OBS_MODE='SLEW' and 'SCAN' observations, a mean pointing position can not be given. In this respect these two types of observing mode are very similar. However a SLEW mode is usually reserved for satellites which are capable of a stable pointing (i.e. capable of OBS_MODE='POINTING') whilst the satellite is moving between two different pointing positions.

3.2 Instrument-specific specification of Observing Modes

For various reasons, the observing mode under which a given dataset were collected for the following instruments are either not described using the `OBS_MODE` keyword, or the allowed values of `OBS_MODE` do not conform to the list given in Section 3.1.

3.2.1 ASCA

ASCA mission was planning to use the keyword `OBS_MODE` to store value related to the on-board computer set-up or to identify manoeuvre used mainly in the PV phase. The possible values of the `OBS_MODE` keyword are:

- `OBS_MODE='OBSERVATION'`
  Observation mode
- `OBS_MODE='LAUNCH'`
  Launch Mode
- `OBS_MODE='ASC'`
  Attitude Control System mode
- `OBS_MODE='STM'`
  Star Tracker Memory mode
- `OBS_MODE='TCU'`
  Telemetry Command Unit mode

- `OBS_MODE='BFM'`
  Bubble File Memory mode
- `OBS_MODE='GISM'`
  GIS Memory mode
- `OBS_MODE='DPM'`
  DP Memory mode
- `OBS_MODE='INITIALIZE'`
  Initialize mode
- `OBS_MODE='ELD'`
  Error Log Dump mode
- `OBS_MODE='UTILITY'`
  Utility mode
- `OBS_MODE='UNKNOWN'`
  any value of obsmode in telemetry that isn't one of the above

Early on in the mission files were produced with the `OBS_MODE` keyword set to `OBSERVATION`. The string value was changed to the value proposed in this memo, namely `POINTING`, starting with the processing software `frfread version 3.01`. Note that file created with `frfread` software older than that contain instead the string `OBSERVATION`.

4 DETECTOR OPERATING MODES

Many missions use/used an on-board computer to pre-process the data, before transmitting it to the ground. A typical pre-processor can/could select or accumulate different data-streams using one or all of the following basic criteria:

- detector identifier (for composite instruments, e.g. *EXOSAT* ME, *ASCA* SISs)
- time resolution
- energy resolution
- detector specific parameters

Generally other criteria or parameters can be used in the mode set-up, which are usually intimately related to the specific of the instrument. Within a FITS file, the data-streams arising from particular pre-processor datamodes are usually stored in different extensions, but with similar layouts or FITS structures. Within the OGIP, the FITS keyword `DATAMODE` is used to store a character string which specifies the type of data-stream information contained within a given FITS extension. The content of the keyword is by necessity mission specific and the string value are given below for each mission/instrument where such specification is required.

4.1 ARIEL-V

4.1.1 ASM

The `DATAMODE` keyword is used in the *Ariel-V* light curves obtained using the ASM instrument in order to distinguish the part of the sky viewed by the 512 individual elements of the ASM detector.

- `DATAMODE='ALL SKY'`
  - 512 detector elements observed the whole sky
- `DATAMODE='OCTANT'`
  - 512 detector elements observed only 1/16 of the whole sky

4.2 ASCA

The ASCA Observatory payload consists of four instruments two Gas Imaging Spectrometer (GIS) and two Solid-state Imaging Spectrometer (SIS). Depending on the type of instrument, SIS or GIS, the pre-processing on board is handle by different modes, which imply that different criteria are used across the two instruments. The string used in the `DATAMODE` keyword in the ASCA file contain only part of the mode definition used by the pre-processing on board computer. An attempt to construct a more complete string for the `DATAMODE` keywords which includes all the relevant parameters associated with a particular mode has been abandoned to avoid the risk of breaking pre-existing software which expects a particular value for that keyword.

Listed below are the strings for the `DATAMODE` keyword as used in the file with a description. It is also given a list of the other relevant keywords which all together define a mode.

4.2.1 GIS

Four different modes can be used with the GIS : pulse Height (PH), multi- channel pulse count (MPC), position calibration (PCAL), and memory-check mode. Here are the documented the string for only two of them PH and MPC.

- `PH mode` The on-board computer calculates event position and discards background events using rise-time and position information. Pulse high spectra of up 1024 channels for each detector can be obtained. 31 bits are used to describe the PHA value, X and Y position, rise time, spread and timing. The `DATAMODE` string value is
  `DATAMODE='PH  '`

To uniquely define the mode the FITS file also contains the following keywords. The value range for the different quantity stored below are given as number bits. The value stored in the keywords is the power of 2 of the number of bits.

- `PHA_BINS` number of channels in the energy spectra. The bits value allow are 10, 8
- `RAWXBIN` and `RAWYBIN` number of pixels for image. The bits value allow for positional information are 2, 4, 6, 8
- `RISEBINS` gives the rise time setting. The bits value allow for the rise time are 0, 5, 6, 8.
- `SP_BINS` gives the spread.The bits value allow for the spread are 0, 8.
- `TIMEBIN` gives the time resolution of the data. This value depends also on the `BIT_RATE`.The bits value allow are from 0 to 10. If 0 the time resolution is 62.5ms for `HIGH` bit rate, 500 for `MEDIUM` bit rate, 2 s for `LOW` bit rate. If 10 the time resolution is 61 μs for `HIGH` bit rate, 288 μs for `MEDIUM` bit rate, and 1.95 ms for `LOW` bit rate.
- `BIT_RATE` gives the string value of the the telemetry rate. The possible string values are `HIGH`, `MEDIUM` or `LOW`.

- MPC The `MPC` mode allows only to record pulse-height and temporal information+ The `DATAMODE` string value is
  `DATAMODE='MPC     '`

  To uniquely define the mode the FITS file also contains the following keywords. The value range for the different quantity stored below are given as number bits. The value stored in the keywords is the power of 2 of the number of bits.

  - `PHA_BINS` number of channels in the energy spectra. The number of channel is fixed at 256.
  - `TIMEBINS` is the time resolution – values allow (0-8). If 0 the time resolution is 0.5s for `HIGH` bit rate, 4s for `MEDIUM` bit rate, 16 s for `LOW` bit rate. If 8 the time resolution is 1.95 ms for `HIGH` bit rate, 15.6 ms for `MEDIUM` bit rate, and 62.5 ms for `LOW` bit rate.
  - `BIT_RATE` gives the string value of the the telemetry rate. The possible string values are `HIGH`, `MEDIUM` or `LOW`.

4.2.2 SIS

For the SIS, two (concurrent) modes are used to describe how the data are accumulated: the *clocking mode* and *data mode*. These, together with the telemetry rate parameter (LOW, MEDIUM, HIGH), defines the time resolution of the data, the number of detector channels per spectrum and the spatial resolution/distribution.

Each SIS camera has four CCDs, and the time resolution or *clocking mode*, is determined by the ordering of the imaging/read-out cycles of the CCDs. The allow values are *4-CCD*, *2-CCD*, *1-CCD*, *Parallel mode*. In *4-CCD* all 4-CCD are exposed at the same time. and the time resolution in high bit rate is 16 seconds. In *2-CCD* only 2 CCDs are exposed at the same time, but the field of view is half that obtained in 4-CCD mode, and the time resolution is 8 seconds. In *1-CCD* only 1 CCD is exposed, the field of view is a quarter of that obtained in 4-CCD mode, and the time resolution is 4 seconds. In *Parallel mode* only 1 CCD is exposed, but all spatial information is lost. The time resolution is 15,625 ms and is used in the FAST mode *data mode*.

The charge cloud produced by an X-ray photon is not localized to one pixel but spread out over several pixels. The *data mode* describes the different way of transmitting the 'spread' to the ground. The allow values are `FAINT`, `BRIGHT`, and `FAST`.

The keyword `DATAMODE` only contains the *data mode*.

- `FAINT` The SIS spectra have 4096 channels. The pixel position at the center of the event is given together with the pulse height recorded in the nine pixels around it.
- `BRIGHT` The SIS spectra have 2048 channels.The channel compression is obtained. compared with the faint mode, binning by a factor of two channels 1024-2047 and by a factor of four channels 2048-4095.
- `FAST` The SIS spectra have 2048 binned as in the bright mode.This mode, which makes used the parallel sum mode (see below), sacrifices the positional information for time resolution. timing information is available with a precision of 16ms

4.3 The Einstein Observatory

4.3.1 SSS & MPC

The original datamode 'name' for the *Einstein* SSS instrument were `PH mode`, `DELTA-T` (DT) mode, and `MS` mode. Within each mode different data-streams could have been accumulated setting either different time resolution parameter and/or different number of energy channels. A typical *Einstein* SSS FITS raw data file contains ten extensions (eight dedicated to SSS data and two to the simultaneous MPC data set), all of them having the same FITS layout/structure (`HDUCLAS1='TEMPORALDATA'`, `HDUCLAS2='COMBINED'`). Within each SSS extension, stream of data, obtained within an observation, from the three different modes with 'similar' characteristics are combined together. Therefore the original datamode is not unique within an extension, and the original value is kept within a column (MODE). Combining data from all three different modes, the SSS extension can contain either high time resolution data, or spectral data or event data or time histogram data. The string for the `DATAMODE` keyword contains a short description of the extension content.

Below are listed the string value for the `DATAMODE` keyword both for SSS and MPC.

- SSS data

  - `DATAMODE='SPEC_2.56s_128chan'`
    - The extension contains 128 channel spectrum every 2.56 seconds. The FITS extension layout is such that each row has one spectrum integrated 2.56 seconds.
  - `DATAMODE='TIME_2ms'`
    - The extension contains intensity value every 2 ms over the full energy range. The FITS extension layout is such that each row contains 1024 bin integrated 2.5 ms.
  - `DATAMODE='TIME_5ms'`
    - The extension contains intensity value every 5 ms over the full energy range.The FITS extension layout is such that each row contains 512 bin integrated 5 ms.
  - `DATAMODE='TIME_10ms'`
    - The extension contains intensity value every 10 ms over the full energy range. The FITS extension layout is such that each row contains 256 bin integrated 10 ms.
  - `DATAMODE='SPEC_1.28s_128chan'`
    - The extension contains 128 channel spectrum every 1.28 seconds. The FITS extension layout is such that each row has one spectrum integrated 1.28 seconds.
  - `DATAMODE='EVNT_1.28s_512pha'`
    - The extension contain PHA channel value for 'first' 512 events detected every 1.28 seconds. The FITS extension layout is such that each row has an array of 512 PHA channel value.
  - `DATAMODE='HISTO_1.28s_DT'`
    - This extension contains an histogram of 128 bins obtained with the DELTA-T mode in each row. Each bin contains the number of events arrived at the detector which were equi-spaced in time (1.28/128) * n.
  - `DATAMODE='SPEC_0.64s_128chan'`
    - The extension contains 128 channel spectrum every 0.64 seconds. The FITS extension layout is such that each row has one spectrum integrated 0.64 seconds.

- MPC data
  - `DATAMODE='SPEC_2.56s_8chan'`
    - The extension contains a 8 channel spectrum every 2.56 seconds. The FITS extension layout is such that each row has one spectrum integrated 2.56 seconds.
  - `DATAMODE='EVNT_1.28s_512time'`
    - This extension contains time values for the 'first' 512 events detected every 1.28 seconds. The FITS extension layout is such that each row has an array of 512 time value.

As said above, the SSS FITS file can be a combination of one or all of three modes available: `PH`, `DT` (`DELTA-T`),or `MS`. To have a short description of which mode was used to create the FITS file, the primary array only will contain the keyword SSSMODE with specified which mode has been used to create the file. The string for this keyword are :

- `PH_DT_MS` if data coming from the all three modes are used to create the FITS file
- `PH_DT` if data coming from the PHA or DELTA-T mode are used to create the FITS file

- `PH_MS` if data coming from the PHA and MS modes are used to create the FITS file
- `DT_MS` if data coming from the DELTA-T and MS modes are used to create the FITS file
- `PH` if data coming from the PHA mode only is used to create the FITS file
- `DT` if data coming from the DELTA-T mode only is used to create the FITS file
- `MS` if data coming from the MS mode is used to create the FITS file

4.4 XTE - Section INCOMPLETE

The XTE payload comprises the Proportional Counter Array (PCA), the High Energy X-ray Timing Experiment (HEXTE) and the All Sky Monitor (ASM). Data from each experiment are 'pre-organized' by on board computers. Data from the PCA are packaged and delivery to the telemetry by the Experiment Data System (EDS) which contains six programmable Event Analyzers (EAs) assigned to the PCA. The EAs are fully programmable with a variety of modes, which can be divided into several categories:

- Binned mode; Counts as function of time, energy, PCU,layer.
- Events mode; Single events in up to 30 bits per event.
- Single-bit mode; Timing events with a resolution of 0.1 ms
-

Two of the EAs will be dedicated to generate PCA data in two different 'standards' modes to have a continuous and consistent set of PCA data.

Within a FITS file for the XTE data, the keyword DATAMODE contains a string which is a short description of the mode used by the on board computer to sample the data. The string, for each of the categories itemized above, contains always a prefix (to identify the categories), the time resolution, the energy/channel boundaries (the last two can be missing for specific mode), plus a number of identifier specific to certain categories.

- `Events mode`: The string value is coded in the following way
  `DATAMODE='E_ttt_xxxA_lll_rrr'` where
  - `E` : mode prefix
  - `ttt`: time resolution [ms value (1,2) ; μ s value (1,2,4,8,16,32,64,128,512)]
  - `xxx`: number of energy channel [value (4,8,16,32,64)]
  - `A`: selects the set of energy boundaries (table to be inserted) [value (A,B,C,M)]

  - `lll`: lower PH limit for the lowest energy channel. For this category, the upper PH limit for the highest channel is always 255. [value (0,14,18,24,36,50)]
  - `rrr`: readout time [value s (1,8)]

  Note that not all the combination of the listed values for each item are allow.

- Binned mode: The string value is coded in the following way
  `DATAMODE='B_ttt_xxxA_lll_hhh_b_propane'` where

  - `B` : mode prefix
  - `ttt`: time resolution [ms value (1,2,4,8,16,64,250,500); μ s value (32,64,128,256,512)]
  - `xxx`: number of energy channel [value (2,4,8,10,14,16,19, 32,45,64,128)]
  - `A`: selects the set of energy boundaries (need a table) [value (A,B,C,M)]
  - `lll`: lower PH limit for the lowest energy channel [value (0)]
  - `hhh`: the upper PH limit for the highest channel [value (14,18,24,36,50,255)]
  - `b`: how many bits are used for each bin [value (H,Q,F) where H= 8 bits (Half words), Q=4 bits (Quarter words), F=16 bits (Full words)]
  - `propane`: used in the string only if the propane layer is added in with the xenon layer.

  Note that not all the combination of the listed values for each item are allow. Note also that the `b` and/or `propane` components can be absent.

- Single-bit mode: The string value is coded in the following way
  `DATAMODE='SB_ttt_lll_hhh_rrr'` where

  - `SB` : mode prefix
  - `ttt`: time resolution [μ s value (30,61,122,244,488)]
  - `lll`: lower PH limit for the lowest energy channel [value (0, 12,18,24,36)]
  - `hhh`: the upper PH limit for the highest channel [value (12,18,24,36,50,255)]
  - `rrr`: readout time [value s (1) value ms (250,500)]

  Note that not all the combination of the listed values for each item are allow. Note also that the `b` and/or `propane` components can be absent.

The standard modes used in two of the EAs are set up such to give either high time resolution with low energy resolution (Standard Mode 1) or low time resolution with high energy resolution (Standard Mode 2).

- Standards Mode 1: The string value is coded in the following way
  `DATAMODE='Standard1_ttt'` where
  From this mode nine time series histograms are generated, each spanning a time period

of `ttt` divided into 1024 bin,therefore the time resolution for each bin is 1024/`ttt` [`ttt` values (8,32,128)]. Six histogram represent broad energy range from the xenon layers; one is for propane layer; two give counts from anticoincidence information. All histograms are integrated over all PCUs. Note that if `ttt` is 128 the string can be simply `Standard1`.

- Standards Mode 2 The string value is coded in the following way
  `DATAMODE=' Standard2_ttt'` where
  Section Incomplete

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