OGIP Memo OGIP/92-007

The OGIP Spectral File Format

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SUMMARY

The approach and OGIP standard format for storing PHA data for spectral analysis is outlined and discussed. We describe the formats for both a file containing a single PHA dataset and the more general case of a file containing multiple datasets from the same instrument. The requirements imposed on the resultant PHA file such that response matrices *etc.* can be easily constructed are also outlined.
Intended audience: primarily OGIP programmers, hardware teams & authors of spectral analysis s/w.

LOG OF SIGNIFICANT CHANGES

Release Date	Sections Changed	Brief Notes
1992 Sep 21		Version published in Legacy 2
1994 Nov 30	All	Made compatible with `LaTeX2HTML` software
1995 Mar 5	All	Overhauled and proper description of multiple dataset files added
1997 Jun 25	All	Removed some ambiguities and changed DATA column from I*2 to I*4
1998 Dec 2	All	Replaced HDUVERSn with HDUVERS to comply with HFWG recommendation R8. Clarified which keywords are mandatory and which optional

1 INTRODUCTION

Any general X-ray spectral analysis package requires two type of input:

1. a file containing the data. This is usually the number of counts observed in each spectral channel/bin of the detector, and commonly known as the PHA (Pulse Height Analyser) file for historical reasons.
2. auxiliary information required during the spectral analysis process. This includes:
   - calibration data (detailing the transformation between an input X-ray spectrum and the number of counts in each detector channel, the spectral response of the detector *etc.*). The OGIP standard format for the calibration files associated with spectral analysis is given in OGIP Calibration memo CAL/GEN/92-002[1] (George *et al.* 1992a)
   - the background in the detector during the observation
   - any miscellaneous corrections applicable during the observation

   The precise requirements for this type of input are obviously highly detector- and observation-specific.

A generic mission-independent X-ray spectral analysis package (*e.g.* XSPEC) requires that both of the above types of information are provided prior to the spectral analysis process in the form of input files. The two types of information are separable, with this memo setting out the OGIP standard format for the PHA file. However it is important to note that the auxiliary information is invariably highly dependent upon the criteria used to construct a given PHA dataset (*e.g.* upon the observation date, the size and position of the extraction cell in detector co-ordinates *etc.*), along with the value of any number of housekeeping parameters during the observation. Thus the PHA data file must contain sufficient information to allow the auxiliary information to be generated either inside or outside the spectral analysis package. We use XSPEC to set the requirements since it is the most sophisticated package generally available to date, and in widespread use throughout the community.

The PHA data file formats specified here were developed with the following goals in mind:

1. The format must be FITS
2. The file must contain all information required by a spectral analysis package.
3. The file must contain a complete creation and modification history.

[1]All OGIP memos of general interest are available on the WWW at the URL http://heasarc.gsfc.nasa.gov/docs/heasarc/caldb/caldb_docs.html. A subset of these will eventually appear as articles in *Legacy*, but are also available on request from Pat Tyler, Code 662, NASA/GSFC, Greenbelt, MD 20771, USA

4. The file must contain enough information for the response matrix for the particular observation to be generated using this file and any associated the basic calibration files (BCFs –see George 1992).

5. For those instruments for which a background prediction algorithm is used, the file must also contain enough information to do this.

As will be discussed in Section 3 below, within the OGIP standard format for PHA files, the information is divided between several standard FITS extensions.

2 REQUIREMENTS

The input PHA files required by XSPEC Versions prior to 8.2 are in the so-called SF format[2]. This is a non-portable (sequential access) binary format which stores the required data as a number of "packages" within the file. The FITS format must contain all the information contained in the mandatory SF "packages". This information comprises:

1. **The data plus optional errors and systematics.** The data is either in counts in which case Poisson errors will be applied by XSPEC (and optional systematic errors can be given) or in count/s in which case the file must also include errors (and optional systematic errors). The systematic errors should be expressed as a fraction of the data.

2. **File information.** This comprises a detector identification string, the number of channels in the PHA spectrum, the integration time, the area scaling factor, the background scaling factor (for an imaging instrument this should be the area on the sky over which the spectrum is accumulated), the correction scaling factor.

3. **Associated file information.** Also required are pointers to the default background, correction, redistribution matrix (RMF), and ancillary response (ARF) files.

Additional optional information can also be used by XSPEC. This includes:

1. **Grouping information.** This specifies any "raw" detector channels that should be ignored by default and also includes any user-specified binning of the data to be performed. In the SF files the actual stored data is binned and the grouping card describes how this was done so that XSPEC can bin up any background and response in the same way. In the FITS format this is modified so that the data is always stored in unbinned mode and the grouping card indicates to XSPEC how data should be binned up when it is read in.

[2]Though XSPEC Versions 8.0 onwards also allow input of FITS PHA files which do not conform to the standard described here

2. **Filter information.** This consists of a set of character strings which are used to specify how the data was selected. This might include time ranges, spatial region specifiers, phase specifiers *etc.* This information is used in XSPEC to perform joint spectral/spatial and spectral/temporal analysis.

3 THE OGIP STANDARD PHA FILE FORMAT

The standard spectral file consists of a FITS file with a number of extensions. For imaging detectors the primary array can contain an image of the region from which the spectrum was extracted. Each PHA dataset is contained within a

- Data Extension

However, each file may also include a number of (optional) associated, additional extensions which contain the detector- and observation-specific information required for construction of the calibration data *etc.* (*i.e.* describing how that PHA dataset was selected, housekeeping parameters during the extraction *etc.*). These include:

- a Good Time Interval (GTI) extension
- a Detector extension
- a (Selector) History extension

The format of these extensions will also conform to OGIP standards. It should be noted that **none** of the latter optional extensions are strictly mandatory for specification of the PHA dataset, and hence as an input to XSPEC. Thus these extensions are not discussed in detail here, and if disk space becomes a problem may be deleted by the user prior to using XSPEC. However, it should be stressed that any analysis package *may* require information in the GTI and Detector extensions when joint spectral/temporal and/or spectral/spatial analysis is to be performed. Information from the Detector extension will also be required when background modelling is to be performed. Such complex, detector-specific tasks will be discussed individually elsewhere. However, in most cases the XFLTXXXX keyword (discussed below) provides an adequate description of the required information.

We first discuss the case where a single PHA dataset is stored. Then we describe a more general format whereby multiple PHA datasets can be stored in a single extension, as is required for some analysis tasks.

3.1 Type I: The PHA Data Extension for a single dataset

This is a BINTABLE extension containing the data. In this simplest of cases, the data is stored as a 1-dimensional list (as a function of detector channel). The number of rows in the BINTABLE is therefore the number of (raw) detector channels.

3.1.1 Extension Header

The header for the PHA file Data Extension includes all the information required by XSPEC (and by extension any other general spectral analysis package) to describe the stored PHA data. This consists of the following (mandatory) keywords/values:

- EXTNAME (= SPECTRUM) - the name (*i.e.* type) of the extension
- TELESCOP - the "telescope" (*i.e.* mission/satellite name).
- INSTRUME - the instrument/detector.
- FILTER - the instrument filter in use (if any)
- EXPOSURE - the integration time (in seconds) for the PHA data (assumed to be corrected for deadtime, data drop-outs *etc.*)
- AREASCAL - the area scaling factor (see below).
- BACKFILE - the name of the corresponding background file (if any)
- BACKSCAL - the background scaling factor (see below).
- CORRFILE - the name of the corresponding correction file (if any)
- CORRSCAL - the correction scaling factor.
- RESPFILE - the name of the corresponding (default) redistribution matrix file (RMF; see George *et al.* 1992a).
- ANCRFILE - the name of the corresponding (default) ancillary response file (ARF; see George *et al.* 1992a).
- HDUCLASS - should contain the string "OGIP" to indicate that this is an OGIP style file.
- HDUCLAS1 - should contain the string "SPECTRUM" to indicate this is a spectrum.
- HDUVERS - the version number of the format (this document describes version 1.1.0)
- POISSERR - whether Poissonian errors are appropriate to the data (see below).

- CHANTYPE - whether the channels used in the file have been corrected in anyway (see below).
- DETCHANS - the total number of detector channels available.

The AREASCAL keyword gives the scaling factor of the PHA data. In most cases AREASCAL = 1.0, since the instrumental effective area is provided within the spectral calibration files (specifically by the SPECRESP column of the ARF in the general case – see George *et al.* 1992a). Internally, XSPEC divides the observed spectrum by AREASCAL before comparing it to the model spectrum.

The BACKSCAL keyword is used to scale the background spectrum read from the BACKFILE before it is subtracted from the source spectrum. XSPEC multiplies the background spectrum by the ratio of the BACKSCAL keyword in the spectrum file and the BACKSCAL keyword in the background file. The usual application of BACKSCAL is when analyzing spectra from an imaging instrument. In this case BACKSCAL is a measure of the area of the image from which the spectrum was extracted.

The POISSERR keyword is not required if a STAT_ERR column is present however it is recommended in this case for clarity. If STAT_ERR is to be used for the errors then POISSERR is set to false.

The CHANTYPE keyword specifies whether the channels referred to in the file are as assigned by the detector electronics at the time of data collection (in which case CHANTYPE = PHA), or whether any corrections have been applied. An example of the latter case is when the data has been re-mapped onto a standard "pulse-Invariant" (PI) channel grid, in which case CHANTYPE = PI (see also CAL/GEN/92-002, George *et al.* 1992, Section 7).

The following keywords are mandatory if the channel numbering-scheme for an instrument does **NOT** start at unity:

- TLMIN*nnn* - giving the minimum legal value for the values in the column *nnn* named 'CHANNEL' (ie. the lowest PHA channel possible for the instrument under the current operational mode, irrespective of whether or not that channel is stored as part of the PHA dataset).
- TLMAX*nnn* - giving the maximum legal value for the values in the column *nnn* named 'CHANNEL' (ie. the highest PHA channel possible for the instrument under the current operational mode, irrespective of whether or not that channel is stored as part of the PHA dataset).

These keywords are optional for datasets for which the channel numbering scheme starts at channel one (and hence the value of the TLMAX*nnn* keyword should equal the value of the DETCHANS keyword), but are recommended for clarity.

The following optional keywords supply further information:

- XFLTXXXX - the XSPEC selection filter descriptor, where XXXX is a number (see below).
- OBJECT - the observed object.
- RA-OBJ - the nominal Right Ascension of the object (in decimal degrees)
- DEC-OBJ - the nominal declination of the object (in decimal degrees)
- EQUINOX - the equinox of the above celestial co-ordinate (RA & DEC) specifications
- RADECSYS - the coordinate frame used for EQUINOX
- DATE-OBS - nominal U.T. date when integration of this PHA data started (yyyy-mm-dd). Old files may have dd/mm/yy format which will be interpreted as 19yy-mm-dd.
- TIME-OBS - nominal U.T. time when integration of this PHA data started (hh:mm:ss).
- DATE-END - nominal U.T. date when integration of this PHA data ended (yyyy-mm-dd). Old files may have dd/mm/yy format which will be interpreted as 19yy-mm-dd.
- TIME-END - nominal U.T. time when integration of this PHA data ended (hh:mm:ss).
- CREATOR - to indicate the name & version number of the s/w task which created the PHA dataset. The suggested format is:
  CREATOR = `'{progname} v{i.j.k}'`
  where `{progname}` is the task name, and `i.j.k` its version number (i, j & k integers; k changing most rapidly).
- HDUCLAS2 - indicating the type of data stored.
  Allowed values are:
  - 'TOTAL' for a gross PHA Spectrum (source + bkgd)
  - 'NET' for a bkgd-subtracted PHA Spectrum
  - 'BKG' for a bkgd PHA Spectrum
- HDUCLAS3 - indicating further details of the type of data stored.
  Allowed values are:
  - 'COUNT' for PHA data stored as counts (rather than count/s)
  - 'RATE' for PHA data stored in count/s

The XFLTXXXX keyword is used by XSPEC to aide joint spectral/temporal or spectral/spatial fitting when the input consists of several individual PHA files. The keyword will contain the values of the appropriate time (or phase *etc.*), or spatial parameters describing the PHA dataset. Thus, in the case of joint spectral/temporal analysis for example, the XFLT0001 keyword will consist of a string containing the start & stop time of the PHA dataset. These times will be in the units required by the spectral/temporal model to be used within XSPEC (and thus could be in units of orbital phase of a binary system). It is the responsibility of the User to consult the relevant GTI and/or Detector extensions (below), and place the required information into the relevant XFLTXXXX keyword. Further examples of such complex spectral analysis tasks will be given elsewhere.

Finally, a number of optional keywords are provided to supply the user with information on the precise start & stop times of the integration of the PHA dataset. These will be listed elsewhere and adhere to the standard OGIP method for defining times (see Angelini *et al.* 1992). Such keywords are necessary since times calculated using the standard (DATE-OBS + TIME-OBS) & (DATE-END + TIME-END) keywords are not guaranteed exact (since they involve a conversion from spacecraft clock to UT *etc.*), and in any case do not allow sub-second temporal resolution. Times specified by these keywords are in the original temporal units supplied by the spacecraft/pre-processing system. Thus, in the case of (say) sub-second, phase-resolved spectroscopy users are able to cross-check that their selected PHA dataset does indeed correspond to that required from the ephemeris, taking into account any glitches in the spacecraft clock, leap seconds, baryocentric corrections *etc.* It is strongly recommended that the information supplied by these keywords is included in all PHA datasets, even if not strictly necessary from the scientific viewpoint. Of course, the exception to this recommendation is when the times have no meaning — *e.g.* when a phase-folded or source-intensity-selected PHA dataset has been constructed.

3.1.2 Data Format

The BINTABLE columns are:

1. *Chan*, a 2-byte INTEGER scalar giving the channel number for each row.
   The FITS column name is **CHANNEL**.
   (unitless).
2. *Data*, either
   - a 4-byte INTEGER scalar giving the number of counts observed in that channel.
     The FITS column name is **COUNTS**, and the recommended units are counts.
   - a 4-byte REAL scalar giving the number of counts per second observed in that channel.
     The FITS column name is **RATE**, and the recommended units are counts/s.
3. *Stat_err*, a 4-byte REAL scalar giving the statistical error on the value within *Data*.
   The FITS column name is **STAT_ERR**.
   The recommended units are as for *Data* above.
4. *Sys_err*, a 4-byte REAL scalar giving the fractional systematic error to be applied to the data in this row (channel).
   The FITS column name is **SYS_ERR**.
   (unitless).
5. *Qual*, a 2-byte INTEGER scalar giving the data quality flag for this row (channel):

Table 1: OGIP format for a single PHA dataset

Extension
to *(filename)***.PHA**
Name: SPECTRUM
Description: PHA data, one row per detector channel
Format: BINTABLE

column 1	2	3	4	5	6
contents					
Detector channel number	**Observed counts or count rate**	**Observed statistical error**	**Fractional systematic error**	**Quality flag**	**Grouping flag**
Chan	*Data*	*Stat_err*	*Sys_err*	*Qual*	*Grpg*
format of each column					
2-byte integer	4-byte integer or 4-byte real	4-byte real	4-byte real	2-byte integer	2-byte integer
total number of elements per row					
1	1	1	1	1	1
column name					
CHANNEL	COUNTS or RATE	STAT_ERR	SYS_ERR	QUALITY	GROUPING

(a) $Qual = 0$ if the data quality is "good"

(b) $Qual \neq 0$ if the data quality is "bad", with the option of the integer value specifying the origin of the flag:

- $Qual = 1$; channel defined "bad" by s/w
- $Qual = 2$; channel defined "dubious" by s/w
- $Qual = 3, 4$; *spare (i.e. flag value not used)*
- $Qual = 5$; channel set "bad" by user

The FITS column name is **QUALITY**.
(unitless).

6. *Grpg*, a 2-byte INTEGER scalar giving the data grouping flag for this row (channel):

   (a) $Grpg = +1$ if the channel is the start of a new bin.

   (b) $Grpg = -1$ if the channel is part of a continuing bin.

   (c) $Grpg = 0$ if the data grouping is undefined for all channels (see below)

   The FITS column name is **GROUPING**.
   (unitless).

These are summarized in Table 1.

It should be noted that an alternative scheme whereby the $Qual$ and $Grpg$ columns are combined into a single quantity, dqf (with the column name **DQF**) is also allowed, though no longer recommended. Under this scheme (which is used on the 1992 June 01 CD-ROM distributed by the HEASARC containing *Einstein* SSS and MPC data), $dqf = 0$ corresponds to "bad" data, and $dfq = +1$ & $dfq = -1$ flag whether the channel is (respectively) the start of a new bin, or part of a continuing bin.

<u>Points to Note & Conventions</u>

- The ordering of the columns is of course arbitrary, however that used here is strongly recommended.
- The order of *Chan* should be sequential, starting from the lowest. If not all the valid channels in a detector are included then TLMIN and TLMAX keywords must be included to define the first and last detector channel number.
- Alternate internal formats (*e.g.* DOUBLE PRECISION) for the specification of the values within *Data* & *Stat_err* are of course allowed but the full precision may not be used by the analysis program.
- In the case of *Data* in units of Counts per channel (only), if appropriate the *Stat_err* column can be deleted from the data table, and **POISSERR=T** specified as a keyword within the extension header. XSPEC will then assume Poissonian errors are appropriate to the data stored in *Data*.

- *Sys_err* is the fractional systematic error (relative to the value of *Data* in each row) which XSPEC will add in quadrature to the error given by *Stat_err* (or the calculated Poissonian error). If no such systematic error is to be applied, then **SYS_ERR = 0** should be specified as a keyword within the extension header, and the *Sys_err* column deleted from the data table.
- If all rows contain the value $Qual = 0$ ("good"), then **QUALITY = 0** should be specified as a keyword within the extension header, and the *Qual* column deleted from the data table. Within XSPEC, *Qual=1* and *Qual=5* rows will never be accessible and *Qual=2* may be ignored using the "ignore bad" command.
- If the data has not been "grouped" (*i.e.* the rebinning of the channels has not been defined), then **GROUPING = 0** should be specified as a keyword within the extension header, and the *Grpg* column deleted from the data table.

3.2 Type II: The PHA Data Extension for multiple datasets

For a number of analysis tasks in which multiple PHA datasets are to be stored and/or analysed simultaneously, it is generally considered cumbersome if each resides in a separate file. This is particularly the case for (say) sub-second, time-resolved spectroscopy when a single observation may give rise to a very large number of datasets. It should be stressed however that this is for datasets from the same instrument. Users wishing to simultaneously analyse PHA data from different instruments should **always** use multiple input files. Finally, it is worth noting that users who prefer to use the multiple file approach for such analysis (especially if only a small number of datasets are to be considered) can still do so by using the XFLTXXXX keyword described above.

As in the single dataset case, the data will be stored as a BINTABLE extension. However here, vector arrays are used in place of scalars for several columns. Thus the PHA data, errors *etc.* are vectors and each row contains a single PHA dataset. The other columns list all other parameters which vary between the datasets.

3.2.1 Extension Header

The mandatory and optional keywords are as defined above; the exceptions are those keywords which are now column names.

3.2.2 Data Format

1. *Num*, a 2-byte INTEGER scalar giving the reference number of the spectrum stored in this row.

The FITS column name is **SPEC_NUM**.
(unitless).

2. *Channel*, a 2-byte INTEGER array containing the channel numbers for the spectra in the *Data* column.

3. *Data*, either:

   - a 4-byte INTEGER array containing the number of counts observed in all channels during this time interval;
   - or a 4-byte REAL array containing the number of counts per second observed in all channels during this time interval.

   In both cases the notation is as described in Section 3.1.2.

4. *Stat_err*, a 4-byte REAL array giving the statistical error on the values within *Data*. The notation is as described in Section 3.1.2.

5. *Sys_err*, a 4-byte REAL array giving the fractional systematic error to be applied to each value within *Data*. The notation is as described in Section 3.1.2.

6. *Qual*, a 2-byte INTEGER array giving the data quality flag for each value within *Data*. The notation is as described in Section 3.1.2.

7. *Grpg*, a 2-byte INTEGER array giving the data data grouping flag for each channel. The notation is as described in Section 3.1.2.

8. *Rowid*, an (optional) CHARACTER string giving a unique identifier for each spectrum. The FITS column name is **ROWID**.

9. *Bkgdfile*, a CHARACTER string giving the name of the background file (if any) associated with the dataset contained in *Data*.
   The FITS column name is **BACKFILE**

10. *Backscal*, a 4-byte REAL giving the scaling factor to be applied to *Bkgdfile*.
    The FITS column name is **BACKSCAL**

11. *Corrfile*, a CHARACTER string giving the name of the correction file (if any) associated with the dataset contained in *Data*.
    The FITS column name is **CORRFILE**

12. *Corrscal*, a 4-byte REAL giving the scaling factor to be applied to *Corrfile*.
    The FITS column name is **CORRSCAL**

13. *Respfile*, a CHARACTER string giving the name of the redistribution matrix file (RMF) associated with the dataset contained in *Data*.
    The FITS column name is **RESPFILE**

14. *Ancrfile*, a CHARACTER string giving the name of the ancillary response file (ARF; if any) associated with the dataset contained in *Data*.
    The FITS column name is **ANCRFILE**

Points to Note & Conventions (in addition to those given in Section 3.1.2)

- As with all OGIP files, any of the above variables which have the same value in every row can be removed from the table, and specified as a keyword within the header. Here this is most likely in the case of **BACKFILE**, **BACKSCAL**, **CORRFILE**, **CORRSCAL**, **RESPFILE**, and **ANCRFILE**.

4 EXAMPLE FITS HEADERS

Here we give an example of keywords used for the Primary and Data extensions (only) appropriate for the ASCA GIS. In Section 4.2 we give an example from XTE of the format with multiple datasets in one file.

4.1 ASCA GIS

This example demonstrates a PHA dataset which is stored in counts, and requires Poissonian errors (with no systematic errors) to be included during spectral analysis. The file contains grouping information instructing XSPEC to bin up the data by a factor of four. We do not show the entire headers because they include a large amount of history information.

4.1.1 Primary Header

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                   32 / number of bits per data pixel
NAXIS   =                    2 / number of data axes
NAXIS1  =                   50 / length of data axis   1
NAXIS2  =                   49 / length of data axis   2
EXTEND  =                    T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format defined in Astronomy and
COMMENT   Astrophysics Supplement Series v44/p363, v44/p371, v73/p359, v73/p365.
COMMENT   Contact the NASA Science Office of Standards and Technology for the
COMMENT   FITS Definition document #100 and other FITS information.
HDUCLASS= 'ogip    '           / Format conforms to OGIP/GSFC conventions
HDUCLAS1= 'IMAGE   '           / Extension contains an image
HDUCLAS2= 'WMAP    '           / Extension contains a weighted map
WMREBIN =                    1 / Weighted Map rebinning
CRPIX1  =  1.00000000000000000E+00 / X axis reference pixel
CRPIX2  =  1.00000000000000000E+00 / Y axis reference pixel
CRVAL1  =  1.03000000000000000E+02 / coord of X ref pixel
```

```
CRVAL2  =  1.02000000000000000000E+02 / coord of Y ref pixel
OPTIC1  =  1.33300003049999986615E+02 / X Optical axis
OPTIC2  =  1.31699996950000013385E+02 / Y Optical axis
CDELT1  =  2.50000000000000000000E-01 / X axis increment
CDELT2  =  2.50000000000000000000E-01 / Y axis increment
TOTCTS  =                1080 / Total pixel count
BLANK   =                  -1 / Null value
HDUVERS = '1.1.0   '          / Version of format (OGIP memo OGIP-92-001)
EXTNAME = 'WMAP    '          / Weighted Map Image
HISTORY   extractor v3.43
END
```

4.1.2 Data Extension

```
XTENSION= 'BINTABLE'          / binary table extension
BITPIX  =                   8 / 8-bit bytes
NAXIS   =                   2 / 2-dimensional binary table
NAXIS1  =                   8 / width of table in bytes
NAXIS2  =                1024 / number of rows in table
PCOUNT  =                   0 / size of special data area
GCOUNT  =                   1 / one data group (required keyword)
TFIELDS =                   3 / number of fields in each row
TTYPE1  = 'CHANNEL '          / label for field   1
TFORM1  = 'I       '          / data format of the field: 2-byte INTEGER
TTYPE2  = 'COUNTS  '          / label for field   2
TFORM2  = 'J       '          / data format of the field: 4-byte INTEGER
TUNIT2  = 'count   '          / physical unit of field
TTYPE3  = 'GROUPING'          / label for field   3
TFORM3  = 'I       '          / data format of the field: 2-byte INTEGER
EXTNAME = 'SPECTRUM'          / name of this binary table extension
TLMIN1  =                   0 / Lowest legal channel number
TLMAX1  =                1023 / Highest legal channel number
POISSERR=                   T / Poissonian errors to be assumed
STAT_ERR=                   0 / no statistical error specified
SYS_ERR =                   0 / no systematic error specified
QUALITY =                   0 / no data quality information specified
DETCHANS=                1024 / Total No. of Detector Channels available
```

Additional Mandatory keywords for XSPEC (in addition to those above)

```
EXPOSURE=  2.91189522666037082672E+04 / Exposure time
AREASCAL=  0.1000000000000E+01  /nominal effective area
CORRSCAL=  0.1000000000000E+01  /correlation scale factor
BACKSCAL=  0.2815246582031E-01  /background scale factor
BACKFILE= 'back.sp '          / background FITS file for
```

```
CORRFILE= 'none    '           / correlation FITS file for
RESPFILE= 'none    '           / redistribution
ANCRFILE= 'none    '           / ancillary response
CHANTYPE= 'PI      '           / Channels assigned by detector electronics
HDUCLASS= 'OGIP    '           / format conforms to OGIP standard
HDUCLAS1= 'SPECTRUM'           / PHA dataset (OGIP memo OGIP-92-007)
HDUVERS = '1.1.0   '           / Version of format (OGIP memo OGIP-92-007)
TELESCOP= 'ASCA    '           / Telescope (mission) name
INSTRUME= 'GIS2    '           / Instrument name
FILTER  = 'none    '           / Instrument filter in use
```

Additional Optional (but recommended) keywords

```
DATAMODE= 'PH      '           / Datamode
XFLT0001= 'none    '           / XSPEC selection filter description
OBJECT  = 'BD +30 3639'        / Name of observed object
USER    = 'kaa     '           / User name of creator
FILIN001= 'screen.evt'         / Input file name
ORIGIN  = 'NASA/GSFC'          / origin of fits file
DATE    = '1995-02-07'         / FITS file creation date (yyyy-mm-dd)
EQUINOX =               2000.0 / Equinox of celestial coord system
RADECSYS= 'FK4     '           / coord frame used for EQUINOX
DATE-OBS= '1994-10-29'         / Date observations were made (yyyy-mm-dd)
TIME-OBS= '23:34:56'           / Time observations were made (hh:mm:ss)
DATE-END= '1994-10-30'         / Date observations ended (yyyy-mm-dd)
TIME-END= '18:30:56'           / Time observations ended (hh:mm:ss)
HDUCLAS2= '        '           / WARNING This is NOT an OGIP-approved value
HDUCLAS3= 'COUNT   '           / PHA data stored as Counts (not count/s)
HDUVERS1= '1.1.0   '           / Obsolete - included for backwards compatibility
TOTCTS  =                 1080 / Total counts in spectrum
END
```

4.2 XTE PCA

This example PHA dataset is for some test XTE PCA data.

4.2.1 Primary Header

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                    8 / number of bits per data pixel
NAXIS   =                    0 / number of data axes
EXTEND  =                    T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format defined in Astronomy and
COMMENT   Astrophysics Supplement Series v44/p363, v44/p371, v73/p359, v73/p365.
```

```
COMMENT   Contact the NASA Science Office of Standards and Technology for the
COMMENT   FITS Definition document #100 and other FITS information.
CONTENT = 'SPECTRUM'           / light spectrum file
ORIGIN  = 'NASA/GSFC'          / origin of fits file
CREATOR = 'SAEXTRCT v3.3.0'    / Program name that produced this file
DATE    = '1995-02-06'         / FITS file creation date (yyyy-mm-dd)
TELESCOP= 'XTE     '           / Telescope (mission) name
INSTRUME= 'PCA     '           / Instrument used for observation
MJDREF  =  4.9352000696574076E+04 / 1993.0
TSTART  =  7.32588800000000E+06 / Observation start time
TSTOP   =  7.32601600000000E+06 / Observation stop time
OBJECT  = 'M81     '           / OBJECT from the FIRST input file
RA_OBJ  =       1.48000000E+02 / RA of First input object
DEC_OBJ =       6.93000031E+01 / DEC of First input object
EQUINOX =              2000.00 / Equinox of the FIRST object
RADECSYS= 'FK5     '           / Co-ordinate frame used for equinox
DATE-OBS= '1993-03-26'         / EARLIEST observation date of files
TIME-OBS= '18:58:08'           / EARLIEST time of all input files
DATE-END= '1993-03-26'         / LATEST observation date of files
TIME-END= '19:00:16'           / LATEST time of all input files
END
```

4.2.2 Data Extension

```
XTENSION= 'BINTABLE'           / binary table extension
BITPIX  =                    8 / 8-bit bytes
NAXIS   =                    2 / 2-dimensional binary table
NAXIS1  =                 1312 / width of table in bytes
NAXIS2  =                    3 / number of rows in table
PCOUNT  =                    0 / size of special data area
GCOUNT  =                    1 / one data group (required keyword)
TFIELDS =                    5 / number of fields in each row
TTYPE1  = 'SPEC_NUM'           / label for field   1
TFORM1  = 'I       '           / data format of the field: 2-byte INTEGER
TTYPE2  = 'CHANNEL '           / label for field   2
TFORM2  = '129I    '           / data format of the field: 2-byte INTEGER
TUNIT2  = 'channel '           / physical unit of field
TTYPE3  = 'COUNTS  '           / label for field   3
TFORM3  = '129E    '           / data format of the field: 4-byte REAL
TUNIT3  = 'count   '           / physical unit of field
TTYPE4  = 'STAT_ERR'           / label for field   4
TFORM4  = '129E    '           / data format of the field: 4-byte REAL
```

```
TUNIT4  = 'count   '           / physical unit of field
TTYPE5  = 'ROWID   '           / label for field   5
TFORM5  = '20A     '           / data format of the field: ASCII Character
EXTNAME = 'SPECTRUM'           / name of this binary table extension
HDUCLASS= 'OGIP    '           / format conforms to OGIP/GSFC Spectral standards
HDUDOC  = 'Arnaud et al. 1992a,                Legacy 2, p 65, Type: II' / forma
HDUCLAS1= 'SPECTRUM'           / Extension contains a Spectrum
HDUCLAS2= 'TOTAL   '           / Extension contains a Spectrum
HDUCLAS3= 'TYPE:II '           / Multiple PHA file contained
HDUCLAS4= 'COUNT   '           / Extension contains counts
HDUVERS1= '1.1.0   '           / Obsolete - included for backwards compatibility
HDUVERS = '1.1.0   '           / Version number of the format
POISSERR=                    F / Are Poisson Distribution errors assumed
SYS_ERR =                    0 / No systematic error was specified
GROUPING=                    0 / No grouping data has been specified
QUALITY =                    0 / No data quality information specified
TELESCOP= 'XTE     '           / Telescope (mission) name
INSTRUME= 'PCA     '           / Instrument name
FILTER  = 'none    '           / Instrument filter in use
EXPOSURE=  1.28000000000000E+02 / Exposure time
AREASCAL=       1.00000000E+00 / Nominal effective area
BACKSCAL=       1.00000000E+00 / Background scale factor
CORRSCAL=       0.00000000E+00 / Correlation scale factor
BACKFILE= 'none    '           / Background FITS file for this object
CORRFILE= 'none    '           / Correlation FITS file for this object
RESPFILE= 'none    '           / Redistribution matrix file (RMF)
ANCRFILE= 'none    '           / Ancillary response file (ARF)
XFLT0001= 'none    '           / XSPEC selection filter description
CHANTYPE= 'PHA     '           / Channels assigned by detector electronics
DETCHANS=                  129 / Total number of detector channels available
TLMIN2  =                    0 / Lowest Legal channel number
TLMAX2  =                  128 / Highest Legal channel number
CPIX2   = '(0~4),(5:51),(52~141;2),(142~237;3),(238~249;4),(250~255)' / Channel
OBJECT  = 'M81     '           / OBJECT from the FIRST input file
FILENAME= 'several '           / Spectrum was produced from more than one file
ORIGIN  = 'NASA/GSFC'          / origin of fits file
CREATOR = 'SAEXTRCT/XTE/GOF'   / Program name that produced this file
DATE    = '1995-02-06'         / FITS file creation date (yyyy-mm-dd)
RA-OBJ  =       1.48000000E+02 / RA of First input object
DEC-OBJ =       6.93000031E+01 / DEC of First input object
EQUINOX =              2000.00 / Equinox of the FIRST object
RADECSYS= 'FK5     '           / Co-ordinate frame used for equinox
DROLLANG=       0.00000000E+00 / Mean roll angle
PHAVERSN= '1992a   '           / OGIP memo number for file format
DATE-OBS= '1993-03-26'         / EARLIEST observation date of files
TIME-OBS= '18:58:08'           / EARLIEST time of all input files
```

```
DATE-END= '1993-03-26'         / LATEST observation date of files
TIME-END= '19:00:16'           / LATEST time of all input files
TIMESYS = 'MJD     '           / The time system is MJD
TIMEUNIT= 's       '           / unit for TSTARTI/F and TSTOPI/F, TIMEZERO
MJDREF  =  4.9352000696574076E+04 / 1993.0
TSTART  =  7.32588800000000E+06 / Observation start time
TSTOP   =  7.32601600000000E+06 / fractional observation stop time
TIMEDEL =  1.60000000000000E+01 / integration time
END
```

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