ASC FITS File Designers' Guide
ASC-FITS-1.0

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1 Introduction

This document contains recommendations for the contents of ASC data product FITS headers. It is assumed that the reader is familiar with the basics of FITS use.

For general FITS issues, see the information provided by the FITS Support Office at GSFC[1] and the FITS archive at NRAO[2].

The conventions outlined in this document comply with the FITS standards, of course, but also with the HEASARC FITS Working Group's[3] recommendations. There is no good document describing their recommended conventions; the best available are a summary[4] and a more detailed list[5]. We shall refer to those collectively as **HFWG/95**.

1.1 General style considerations

- FITS files allow the possibility of arbitrarily large numbers of extensions (sections, 'HDUs') containing unrelated data. However, we recommend including only one main 'object' of information in each file, with extra extensions only when those extensions contain auxiliary information relevant specifically to the main object. For instance, a file might contain an events list, together with its associated good time intervals, which apply specifically to that events list.
- Most of our data are best stored in tabular form, and so most data products will contain a null FITS primary image, followed by a main binary table (BINTABLE) extension containing

[1]http://fits.gsfc.nasa.gov/fits_home.html
[2]http://www.cv.nrao.edu/fits/
[3]http://heasarc.gsfc.nasa.gov/docs/heasarc/ofwg/ofwg_intro.html
[4]http://legacy.gsfc.nasa.gov/docs/heasarc/ofwg/ofwg_recomm.html
[5]ftp://legacy.gsfc.nasa.gov/fits_info/ofwg_recomm/recomm.txt

the main data (we will call this the **Principal HDU**), and possibly some auxiliary extensions (which we will call **Auxiliary HDUs**). The ASCII table extension type is to be avoided.

- Some of our data are in the form of binned images (of 1, 2 or 3 dimensions). These should be stored in the primary (first) HDU of a FITS file which then becomes its principal HDU. Do not make a null primary image followed by an IMAGE extension, since many FITS image viewers can only see the data if it is in the primary HDU.

- Each HDU must be as far as possible self contained. Some software extracts a single HDU without checking the rest of the file, and so we must repeat some of the basic information in each HDU. We define below the ASC header styles of a **major header** and a **minor header**: the minor header contains only the most basic information, while the major header contains all the relevant information about the observation. The principal HDU and (if different) the primary HDU should both have major headers; the remaining HDUs may have minor headers.

- All HDUs are to contain the DATASUM and CHECKSUM keywords, so that they are properly checksummed, in conformance with the FITS Checksum Convention proposed by Seaman and Pence. HDUs following this convention have a 32-bit one's complement checksum that is -0 (all ones). This is an important tool in our quest to ensure the integrity of the archive and to achieve fault-free file transfers.

- Avoid the use of the '-' (hyphen,minus) character in keyword and column (TTYPE*n*) names. Use the underscore ('_') instead. Exception: the hyphen may be used specifically to indicate negation. Exception: The preexisting DATE-OBS, DATE-END, MJD-OBS, MJD-END keywords are retained. (HEASARC rule HFWG/95 R1).

- Every column in a TABLE or BINTABLE extension shall be given a unique name using the TTYPE*n* keyword. This name shall include only upper or lower case letters, digits, and the underscore character; it shall not include embedded blanks (trailing blanks are not significant) and it shall begin with a letter (*ASC may wish to use leading digits in some cases, violating this rule*). Case shall not be considered significant in searching for names, (so COL_NAME and col_Name are not considered to be unique) *but names shall be returned by software as they are, so low level software must write and read them in a case sensitive way.* Names shall be unique within the first 16 characters. (HEASARC rule HFWG/95 R15).

- TLMIN*n* and TLMAX*n* are used to record the minimum and maximum legal (*i.e.*, meaningful) values for a column. For instance, they are used to define the image size for a positional column in an event list. (HFWG/95 R6) These keywords should be used for all table columns for which they are meaningful, since they are a key piece of information used by the XSELECT program.

- Units given in FITS files, for example those given as values of TUNIT*n* or CUNIT*n*, should follow the convention of OGIP/93-001, (HFWG/95 R5) basically SI with some astronomical additions. Case is important in units -the classic example is the use of 'S', which is a unit of electrical conductance, and different from 's' which is a unit of time. Some units are allowed to have SI prefixes ('k' for kilo, *etc.*) and others are not. See table of allowed units at end of document.

  Compound units are formed using spaces to imply multiplication and / to imply division of the immediately following token, with tokens grouped by round parentheses (). The operator

** implies raising to the power. For example, 'erg /(cm**2 s)' is erg per sq cm per s, while 'erg /cm**2 s' is erg s per sq cm. Numerical prefixes of the form 10**n may be given, *e.g.* '10**(-12) erg /(cm**2 s)'.

A restricted list of functional operators is also permitted in unit strings. These are:

- log, ln, exp, sqrt
- sin, cos, tan, asin, acos, atan, sinh, cosh, tanh

although I would strongly discourage the use of the second group (sin, *etc.*). - better to make the quantity dimensionless before you take its sin.

- String valued keywords in standard FITS are limited to 68 characters. To store a longer string in a header keyword, we use multiple keywords as follows: the string is split into segments of no more than 67 characters; each segment is terminated with the ampersand character & and written as an ordinary string keyword. The first keyword shall be the actual keyword name, subsequent keywords shall all be named CONTINUE and will be FITS no-value keywords, recognized by the absence of the equals sign. In addition, files using this convention will include the keyword LONGSTRN = 'OGIP 1.0'. (HFWG/95 R13). Example:

```
LONGSTRN= 'OGIP 1.0'
AUTHOR  = 'J.C. McDowell, &'  / Author keyword
CONTINUE  'G. d''Aurillac, V.I. Ulyan&' / Continuation
CONTINUE  'ov, and L.D. Ahenobarbus' /
REFERENC= 'Journal of Improbable CoAuthors, &' /
CONTINUE  'Vol 1., No. 1, p. 42.'/
```

- Quality flags (integer values used to encode the fact that data may have particular kinds of problem) should use the value zero to mean 'good data' and non-zero values to indicate varying degrees of bad or masked out data. (HFWG/95 R9).

2 ASC conventions

2.1 Time information

The observation start and stop times are the most important pieces of data, and are carried in redundant ways. The TSTART and TSTOP keywords are the primary carriers of this information; the DATE-OBS and DATE-END keywords and the MJD-OBS keywords repeat the information in a format which is easier for the human reader. For specifying good time intervals one should use the HEASARC-style GTI tables (binary tables containing two columns: START and STOP).

2.1.1 GTI Tables

For integration with the Data Model, we require the addition of the following keywords in the header of GTI tables:

```
MTYPE1 = 'TIME'
MFORM1 = 'START,STOP'
METYP1 = 'R'
```

When we have implemented vector columns and range elements, this will tell the Data Model that the start and stop columns on the GTI are a range on the quantity time.

2.1.2 TIME, TSTART and TSTOP

All time tags in the table data, and all TSTART and TSTOP values, should be mission time measured in seconds from an AXAF specified mission reference epoch.

- The AXAF reference epoch for calibration data was 1993 Dec 31, 00:00:00 UTC.
- The AXAF reference epoch for flight data shall be 1998 Jan 1, 00:00:00 TT, or MJD 50814.0 TT.
- The reference epoch used shall be stored as an MJD (modified Julian Date) value in the header keyword MJDREF, or alternatively MJDREFI and MJDREFF (integer and fractional parts) if greater precision is needed.
- The time tags shall be the total number of seconds in a continuous count since the reference epoch.
- To convert a time tag TIME to an absolute MJD(TT), use the formula

  ```
  MJD(TT) = MJDREF(TT) + ( TIMEZERO  + TIME ) / 86400
  ```

where the TIMEZERO header keyword contains a time adjustment in seconds (usually zero).

- When converting to UTC calendar dates, remember that you may need to account for leap seconds. As long as you stick with the time tags, or TT calendar dates, leap seconds are not a problem.

- In Level 0 data, the time tags may not be corrected for clock drift. In this case, the best estimate clock correction will be stored in the TIMEZERO keyword. In higher level products, the clock correction should be applied and (TBR) the clock correction polynomial coefficients used shall be stored in the keywords CLOCK0, CLOCK1, ... CLOCKn. The TIMEZERO keyword will be set to zero, but the total correction used will be stored as a comment. The CLOCKAPP = T (CLOCKAPP = F) keyword is used to record whether or not the clock correction has been applied to the time tags.

2.1.3 DATE keywords

There is a family of DATE keywords, of which we use DATE (date of FITS file creation); DATE-OBS (date of observation start), and DATE-END (date of observation end). The format of these keywords is currently undergoing a change in the FITS standard to handle the year 2000 problem. Dates prior to 1999 Jan 1 are required to be written the old way, but for the purposes of AXAF we will deem 1999 to start early so we don't have to have IF statements everywhere. The old style required two keywords, *e.g.* , DATE-OBS and TIME-OBS:

```
DATE-OBS= '23/02/98'          / Day, month, year as per FITS standard
TIME-OBS= '11:22:33'          / Hour minute second UTC as per FITS standard
```

The new format uses the ISO standard date representation ccyy-mm-ddThh:mm:ss, and combines the date and time info into one keyword:

```
DATE-OBS= '1999-02-23T11:22:33'  / ISO standard date and time
```

2.1.4 Other time keywords

- MJDREF records the Modified Julian Day of the mission time zero point. It implies a coordinate system on the TIME column, with the TCRVLn value of MJDREF, an implied TCRPXn of 0.0 and TCUNIn of 'd'. (See the section below on column coordinate systems for the meanings of TCRVL, TCRPX and TCUNI). For greater precision, it can be split into integer and fractional parts MJDREFI and MJDREFF.

- TSTART and TSTOP record the start time and stop time of the observation, in units of TIMEUNIT since MJDREF (unless TIMESYS='MJD' or 'JD'). They can be split into integer and fractional parts TSTARTI, TSTARTF, TSTOPI, TSTOPF. If a TIME column is present in the data, its TUNITn value must be the same as TIMEUNIT.

- TIMEDEL records the time resolution of the data: the bin size between rows for a binned dataset, the resolution of the time stamp for event lists.
- TIMEPIXR indicates where in each bin the time stamp falls. It has a value between 0.0 and 1.0. The default is 0.5 (center of the bin). If the time stamp refers to the beginning of the bin (as is the case for event data if the event was received between TIME and TIME+TIMEDEL), one should set TIMEPIXR=0.0.
- TIMEZERO and TIMEDEL record the time of the bins in a binned dataset. The nominal time of the time bin center of row n is TIMEZERO $+(n-1)*$ TIMEDEL. The keywords have the unit of TIMEUNIT. TIMEZERO can be split into TIMEZERI and TIMEZERF.
- TIMESYS records the time system used for MJDREF. We will use TIMESYS = 'TT '. When the time is corrected to the barycenter of the solar system TIMESYS = 'TDB' (but see also TIMEREF and PLEPHEM below).

This system supports three different time systems at once: the absolute MJD time system (given in MJDREF); the system used to record header times (given in TIMESYS); and the system used to record times in the table itself (given in TIMESYS and the TUNITn keyword). For example, suppose we have:

```
MJDREF  =      44238.0 / Reference time
TIMESYS = 'TT      '   / Time system
TIMEUNIT= 'd       '   / Time unit
TIMEZERO=         14.0 / Time zero point
TTYPE1  = 'TIME    '   / Time column
TUNIT1  = 'd       '   / Time unit
TSTART  =          0.1 /
TSTOP   =          0.2 /
  TIME
     0.01
     0.02
```

Then the first row encodes a time which is 0.01d from TIMEZERO, which is 14.0 days from MJDREF=44238.0, in other words 1980 Jan 14.01. If instead we have

```
MJDREF  =      44238.0 / Reference time
TIMESYS = 'MJD     '   / Time system
TIMEUNIT= 'd       '   / Time unit
TIMEZERO=      44252.0 / Time zero point
TTYPE1  = 'TIME    '   / Time column
TUNIT1  = 'd       '   / Time unit
TSTART  =         0.01 /
TSTOP   =         0.02 /
```

```
  TIME
    0.01
    0.02
```

This is unneccessarily baroque for most purposes, and the following is essentially equivalent and much more generic (requiring fewer new keyword inventions):

```
TSTART  =          0.0 /
TSTOP   =       8640.0 /
TTYPE1  = 'TIME    '   / Time column
TUNIT1  = 's       '   / Time unit
TCTYP1  = 'DATE    '   / Absolute date
TCUNI1  = 'd       '   / Date unit
TCRVL1  =      44252.0 / Reference value
TCRPX1  =          0.0 / Reference pixel
  TIME
  1800.0
  3600.0
```

We recommend the following style and convention. TIMEUNIT ='s', always. A very simple transformation from VCDU number to *basic time* will be defined for the duration of the mission. All clock corrections will be relative to *basic time*. In files at Level 0 and below, all times (TIME column, TSTART, TSTOP) will be in *basic time* and TIMEZERO will contain the best clock correction available at the time the file was created. Files above Level 0 will have TIMEZERO = 0.0, with all clock corrections applied, so that TSTART, TSTOP *etc.* and the values in the TIME column are true time, but write the clock correction (relative to *basic time*) in the comment field of TIMEZERO. Include a WCS on the TIME column so that generic software can convert the times to absolute dates, assuming that CLOCKAPP = T. Simple software can then ignore TIMESYS, TIMEUNIT, TIMEZERO and just use MJDREF or TCRVL1, while the other keywords are retained for HEASARC compatibility and all information about clock corrections is retained. This gives us:

```
MJDREF  =      50814.0 / Reference time
TIMESYS = 'TT      '   / Time system
TIMEUNIT= 's       '   / Time unit
TIMEZERO=          0.0 / 0.896745 is the cumulative clock correction
TSTART  =    1209600.0 / Seconds since MJDREF
TSTOP   =    1218240.0 / Seconds since MJDREF
CLOCKAPP=            T /
COMMENT Column related keywords
TTYPE1  = 'TIME    '   / Time column
TUNIT1  = 's       '   / Time unit
TCTYP1  = 'DATE    '   / Absolute date
```

```
TCUNI1  = 'd        '   / Date unit
TCRVL1  =       50814.0 / Reference value
TCRPX1  =           0.0 / Reference pixel
TCDLT1  = 1.15740740741e-05 /
  TIME
1211400.0
1213200.0
```

- TIMEREF records what corrections have been made to event times. It applies only to tables which contain a single time which represents a photon arrival time. The default value is TIMEREF='LOCAL' which means that the actual arrival time is stored. Other values give a location and indicate that TIME has been corrected to the time that other photons in the same wavefront would have arrived at the given location. Note that this is NOT a change of time frame, since it depends on the direction the photon is coming from. For a wide field of view instrument, two photons with the same arrival time but coming from different directions would have different corrected times. Note that this makes the definition of TSTART and TSTOP, *etc.*, problematic unless a specific direction (RA_OBJ or RA_PNT, for instance) is intended.

  The possible locations (values of TIMEREF) are: 'GEOCENTRIC' (Earth center), 'HELIOCENTRIC' (Sun center), and 'SOLARSYSTEM' (Solar system barycenter). This last value is implied when TIMESYS = 'TDB'. See also PLEPHEM, below.

  When photon times with different location corrections are stored in different columns of the same file, HEASARC recommends that the column name itself be given special values, DIFFERENT from the corresponding values of TIMEREF. GEOCENTRIC maps to REFEARTH, HELIOCENTRIC maps to REFSUN, and SOLARSYSTEM maps to REFBSOLS. In addition, special keywords for each of these cases replace TSTART, TSTOP and TIMEZERO, namely ESTART, ESTOP, ETIMEZER, SSTART, SSTOP, STIMEZER, and BSTART, BSTOP, BTIMEZER. Note that these special keywords for each case would not have been needed if some kind of WCS-type indexed keyword had been used to store time coordinate information. This is not one of HEASARC's most well-considered recommendations and such practices are not to be encouraged. Note also, that TIMESYS may become ambiguous.

- Another keyword which has a slightly different meaning to TIMEREF is TASSIGN. TASSIGN "specifies where the time assignment of the data is done. for example, for EXOSAT time assignment was made at the Madrid tracking station, so TASSIGN ='Madrid'. Since the document goes on to state that this information is relevant for barycentric corrections, one assumes that this means what is of interest is not the location of the computer where time tags where inserted into the telemetry stream, but whether those time tags refer to the actual photon arrival time or to the time at which the telemetry reached the ground station, *etc.* For example, for Einstein the time assignment was performed at the ground station but corrected to allow for the transmission time between satellite and ground, so I presume in this case TASSIGN='SATELLITE'. I believe that for AXAF, TASSIGN = 'SATELLITE'. OGIP/93-003 also specifies the location for the case of a ground station should be recorded the keywords GEOLAT, GEOLONG, and ALTITUDE. This is rather unfortunate since it would be nice to reserve these keywords for the satellite ephemeris position. However, since no ground station is defined for AXAF, we feel that we can use GEOLONG, GEOLAT, and ALTITUDE for these purposes, especially since such usage is consistent with their usage for ground-based observations. TASSIGN has obviously no meaning when TIMESYS = 'TDB'.

- TIERRELA and TIERABSO give the dimensionless clock rate error and the absolute timing precision in seconds. They may be included for informational purposes.
- PLEPHEM indicates, when times are corrected to the barycenter of the solar system, which planetary ephemeris was used. There are two legal values, at present: 'JPL-DE405' and 'JPL-DE200'. The former will be the normal value. However, one should be aware that it can only be used in conjunction with RADECSYS = 'ICRS', whereas the latter value can only be used with RADECSYS = 'FK5'. In certain cases it may be necessary to use DE200, *e.g.*, when one needs to compare the data with a timing ephemeris that is derived on the basis of DE200. To summarize, the following keyword value combinations are legal:

```
TIMESYS = 'TDB     '     / Time scale: Barycentric Dynamical Time
TIMEREF = 'SOLARSYSTEM'  / Reference location of photon arrival times
EQUINOX =         2000.0 / J2000
RADECSYS= 'ICRS    '     / International Celestial Reference System
PLEPHEM = 'JPL-DE405'    / Planetary ephemeris used
```

and:

```
TIMESYS = 'TDB     '     / Time scale: Barycentric Dynamical Time
TIMEREF = 'SOLARSYSTEM'  / Reference location of photon arrival times
EQUINOX =         2000.0 / J2000
RADECSYS= 'FK5     '     / International Celestial Reference System
PLEPHEM = 'JPL-DE200'    / Planetary ephemeris used
```

2.2 Coordinate information

2.2.1 Observation Details

Observation details derived from the observation catalog will be included in Level 1 products and beyond.

- OBJECT is the name of the target.
- OBSERVER is the principal investigator of the observation.
- OBS_ID is a string denoting the observation.
- TITLE is the proposal title.

- RA_NOM and DEC_NOM, in degrees, are the nominal ICRS/J2000 RA and Dec of the observation, used as the center of the sky plane. At Level 1 processing these may be overridden with values actually derived from the aspect solution, if those conflict with the planned ones.
- EQUINOX = 2000.0 denotes that all equatorial coordinate positions use equinox 2000.0. (HFWG/95 R3)
- RADECSYS = 'ICRS' denotes that our positions derive from the ICRS (Hipparcos) reference frame, rather than the earlier FK4 or FK5 systems. (Actually our star catalog is technically an ICRS/FK5 hybrid, but is consistent with ICRS within our errors). (HFWG/95 R3)
- ROLL_NOM, in degrees, is the nominal roll angle of the observation. At Level 1 processing this may be overridden with a value actually derived from the aspect solution, if this conflict with the planned one.

2.2.2 Other RA and Dec keywords

The following keywords may also be used, but we won't normally have them.

- RA_OBJ and DEC_OBJ record the position of the source, if the data file contains data on a single extracted source (or if there is a defined target source). Values are decimal degrees. (HFWG/95 R3)
- RA_PNT, DEC_PNT, and ROLL_PNT record the mean pointing direction of the telescope optical axis during the observation. (HFWG/95 R3)
- RA_SCX, DEC_SCX, RA_SCY, DEC_SCY, RA_SCZ, DEC_SCZ record the orientation of the spacecraft X, Y and Z axes in the equatorial coordinate frame. (HFWG/95 R3)

2.2.3 Column coordinate systems

The HEASARC conventions for storing coordinate systems in columns will be followed.

We can distinguish three types of coordinate system transformations in FITS files: linear transformations on a single axis or column, two-dimensional projections on a pair of axes or columns, and linear matrix transformations on all the axes and columns. I believe that the last type is needed only in rare cases.

For single-axis rescalings, we use the following algorithm: the data quantity p with name P is related to a world coordinate x with name X by

$$x = x_0 + \Delta(p - p_0)$$

P can be an IMAGE axis or a TABLE/BINTABLE column.

Table 1: Simple coordinate keywords

Quantity	Meaning	IMAGE keyword	TABLE keyword
P	data quantity name	-	TTYPEn
X	coordinate name and transform type	CTYPEn	TCTYPn
p_0	Reference pixel	CRPIXn	TCRPXn
x_0	Reference value	CRVALn	TCRVLn
Δ	Pixel increment	CDELTn	TCDLTn

For two-dimensional coordinates, the standard FITS WCS does not explicitly tie the two columns together. You use a special pair of CTYPE/TCTYP value strings, *e.g.*

```
TTYPE4 = 'X'
TTYPE5 = 'Y'
TCTYP4 = 'RA---TAN'
TCTYP5 = 'DEC--TAN'
```

which combine both the coordinate names and the transform projection type. For the ASC data model, we introduce extra keywords to group columns together under a common name:

```
MTYPE1 = 'POS'
MFORM1 = 'X,Y'
MTYPE2 = 'EQPOS'
MFORM2 = 'RA,DEC'
```

Finally, the keyword TDBINi may be used to specify a binning size for a binary table column, to let data model software know how to bin by default; the units are TUNITi:

```
TDBIN1   =     4.2  /  Default bin size
```

2.3 What kind of data am I? - the HDUCLAS keywords

Each HDU should contain information allowing generic software to identify what kind of data it contains.

- The FITS standard keyword EXTNAME is used to give the name of an HDU; it may be overridden by the ASC keyword HDUNAME (if EXTNAME has to have some other value for compatibility reasons). In a primary HDU, there is some argument that EXTNAME is illegal, and so there we always use HDUNAME.

- The ASC keyword CONTENT is used to store basic information about the content of a file.
- The HDUCLAS hierarchy is used by FTOOLS and other software to determine the type of a file. HDUCLAS gives the origin of the hierarchy, either 'OGIP' or 'ASC'. HDUCLAS1 gives the highest level filetype, *e.g.* 'LIGHTCURVE', HDUCLAS2 is more specific, *e.g.* 'NET', HDUCLAS3 more specific still, *e.g.* 'RATE'.
- The ASC keyword HDUSPEC contains, if applicable, a (human readable) reference to the Interface Control Document (ICD) or other design document, including its version, that specifies the detailed format of the HDU.

The dictionary of EXTNAME, content and HDUCLAS keywords is given at the end of this document; hence, this document is referenced in HDUDOC.

2.4 Keywords describing the instrumental setup

- MISSION is used to define the overall project, *e.g.* AXAF, HTXS, *etc.*, even when different telescopes (*e.g.* ground based cal optics) are being used. This keyword is an ASC internal invention and is not yet adopted by HEASARC. The ASC keyword MISSION = 'AXAF' labels data as being part of the AXAF project, even if not taken with the AXAF telescope; it is used to group together ground cal data with flight data.
- TELESCOP is a FITS standard reserved keyword; HEASARC (OGIP/93-013 R12) specifies the strings used in particular missions. We will use the following values:

Table 2: TELESCOP keyword values

Value	Use
AXAF	Flight
XRCF/HRMA	XRCF

- INSTRUME is a FITS standard reserved keyword. HEASARC (OGIP/93-013 R12) specifies that INSTRUME should refer to the focal plane instrument even when a grating is in place, *i.e.*, INSTRUME='HRC-S', not INSTRUME='LETGS'. We consider ACIS to be a single instrument, since any six of its chips can be read out. We consider HRC-I and HRC-S to be separate instruments.

  We use the following values:

Table 3: INSTRUME keyword values

Value	Use
ACIS	Flight, XRCF
HRC-I	Flight, XRCF
HRC-S	Flight, XRCF
EPHIN	Flight

PCAD	Flight
SPACECRAFT	Flight
GENERAL	Flight
EPHIN	Flight
FPC	XRCF
SSD	XRCF
HSI	XRCF
ACIS-2C	XRCF

PCAD includes ACA, Gyro, Earth and Sun Sensors, Attitude, Earth Angle. SPACECRAFT includes Power, Thermal, Status, Alignment, Grating, SIM, HRMA, Telemetry. GENERAL includes Orbit Ephemeris, Orbit Events, Mission Timeline.

- GRATING is introduced to record the gratings. We will use the values LETG and HETG (and TOGA at XRCF), and (optionally) NONE.
- DETNAM is used in HEASARC OGIP/93-013 R12 to record the sub-detector or combination of sub-detectors used. We recommend for the AXAF science instrument the following: in general, use ACIS- followed by the chip numbers in use (any 6 for ACIS, *e.g.* ACIS-012789). However, we prefer certain mnemonics for the commonly used cases:

Table 4: DETNAM keyword values

DETNAM	Equivalent	INSTRUME
HRC-I		HRC-I
HRC-S		HRC-S
HRC-SI		HRC-S
ACIS-I	ACIS-012367	ACIS
ACIS-S	ACIS-456789	ACIS
ACA		PCAD
GYRO		PCAD
SSENSOR		PCAD
ESENSOR		PCAD
POWER		SPACECRAFT
THERMAL		SPACECRAFT
GRATING		SPACECRAFT
SIM		SPACECRAFT
HRMA		SPACECRAFT

In fact we hope always to use the mnemonics. Note that DETNAM is not required.

- FILTER is used to denote optional filters. We don't have any instruments in flight which use removable filters, so we won't use this keyword for flight data.
- OBS_MODE (OGIP/94-001) is used to record the observing mode. The valid values are 'POINTING', 'SLEW', 'RASTER', and 'SCAN', of which POINTING and SLEW are used by AXAF. ASC also uses the value 'GROUND' to denote ground calibration data.

- DATAMODE (OGIP/94-001) is used for detector operating modes. Values for the ASCA SIS CCD were BRIGHT, FAINT, FAST. In the ASCA project, the DATAMODE keyword was changed when extra information was added to the data in later processing, thus it reflected not the way the data was taken but the current state of processing. We believe that it is better to retain information on the original experiment configuration, and determine the current state of processing from the presence or absence of the appropriate table columns. We note this is an incompatibility with ASCA.

  For AXAF HRC, we will use: OBSERVING, NEXT_IN_LINE (note these refer to the telemetry mode in use, not the actual purpose of the observation). For AXAF ACIS, we earlier used: GRADED, RAW, HISTO, FAINT, FAINT-BIAS, SPECIAL. These values have now been revised. The new values are:

Table 5: DATAMODE keyword values for ACIS

ACIS mode	DATAMODE
TE Raw	RAW
TE Histogram	HISTO
TE Faint	FAINT
TE Faint with Bias	FAINT_BIAS
TE Very Faint	VFAINT
TE Graded	GRADED
TE Graded Histogram	GRADED_HISTO
CC Raw	CC_RAW
CC Faint	CC_FAINT
CC Graded	CC_GRADED
Other	SPECIAL

- READMODE is an ASC ACIS-specific keyword used to denote the ACIS read mode. It has values TIMED or CONTINUOUS to denote whether the data is in timed exposure (TE) or continuous clocking (CC) mode.

An example of a standard observation identification segment of the FITS header would then be:

```
MISSION = 'AXAF    '      / Project
TELESCOP= 'AXAF-I  '      / Telescope
INSTRUME= 'HRC-S   '      / Instrument
GRATING = 'LETG    '      / Grating
DETNAM  = 'HRC-S   '      / Detector
OBS_MODE= 'POINTING'      / Observation mode
DATAMODE= 'SPECTROSCOPIC' / Data mode
```

2.5 Exposure Keywords

- ONTIME records the sum of all good time intervals. TELAPSE records the difference between the start and stop times of an observation. LIVETIME records the ONTIME corrected for dead time corrections. EXPOSURE is the time corrected for all effects, including spatial ones such as vignetting, that are specified. Beware that Xspec wants a value for EXPOSURE; hence, it is prudent to include an EXPOSURE keyword in spectral and light curve headers, even if the contents is identical to LIVETIME. This should not lead to confusion since the corrections applied to EXPOSURE are all explicitly named in the various "correction applied" logical keywords. All of these should have units of seconds. (HFWG/95 R11). TELAPSE is not particularly profound and its use is optional.
- DEADC is equal to LIVETIME/ONTIME and is used to record the dead time correction, in the range 0 to 1. (O HFWG/95 R11). It may be used as a table column if the correction varies from row to row. (OGIP/93-003). If several energy bands are present with different corrections, the DEADC column is a vector with one value per band; as a header keyword it is replaced by the indexed keyword DEADCn. SAO has historically used DTCOR instead of DEADC. For reasons of PROS compatibility we shall use DTCOR.
- DEADAPP = T indicates that dead time corrections have been applied to count rates in the file. (OGIP/93-003).

2.6 Count and Count Rate

Count and count rate data are described in OGIP/92-007 and OGIP/93-003. There are two paradigms for storing count and count rate data. In type I tables, the table can store one detector channel or energy band per table row, with one corresponding count or count rate value each. In type II tables, each table row contains the entire set of count values for all channels or bands, the corresponding channel or band values are inferred from header keywords, and the different rows represent the changing of some other parameter such as time. In this case, the keyword NUMBANDS gives the number of different count values per row.

- NUMBANDS gives the number of different bands for type II files. (OGIP/93-003)
- COUNTS, of type integer, is a table column giving the uncorrected counts. In type II files, it is an array of NUMBANDS values. (OGIP/92-007, OGIP/93-003)
- RATE, of type real, is a table column giving the count rate. In type II files, it is an array of NUMBANDS values. RATE and COUNTS should not both be present. (OGIP/92-007, OGIP/93-003)
- ERROR, of type real, is a table column giving the error on the COUNTS or the RATE. (OGIP/93-003)
- BACKV, of type real, is a table column giving the background value. (OGIP/93-003). Although OGIP/93-003 does not say this explicitly, we assume that if the table contains the

COUNTS column, BACKV is interpreted as being the background counts, while if the table contains RATE, BACKV is interpreted as being the background rate. It is recommended to include a TUNITn keyword to this effect, in order to avoid unnecessary confusion. If BACKV is constant with row number, it is used as a header keyword; if NUMBANDS is more than 1, an indexed keyword BACKVn is used.

- BACKE, of type real, is a table column giving the error on BACKV. (OGIP/93-003). The keyword BACKEn allows storage of these values as an indexed header keyword, similar to BACKVn.

2.7 Source and Background related keywords

These keywords presume the existence of a 'source' and a 'background', usually defined as spatial subsets of a set of observational data. The keywords are mostly meaningful for histogram tables such as PHA files and light curves. The specification of spatial filtering that is applied to the data may be presented in the format of a REGION table (see ASC-FITS-REGION-1.0).

- ERRCOR is used to apply a correction to the errors. The definition is unclear, but I am guessing what is meant is that in a PHA dataset or light curve dataset with counts and errors on counts, software which applies a conversion to counts/s and errors on count/s using correction factors such as VIGNET should multiply the error by this extra value. (HFWG/95 R11)
- GEOAREA records the geometric area of the detector, usually in sq. cm. (OGIP/93-003).
- AREASCAL is an 'area scaling factor' which is used to renormalize the histogram. It is an alternative to the use of an ARF calibration file; usually we use the ARF and set AREASCAL equal to 1.
- VIGNET is used to record the vignetting factor needed to convert the data to the equivalent on-axis values. The keyword is used for datasets which contain uncorrected values, not to record a correction which has already been made. The definition is value(on-axis) = value(datafile) / VIGNET. It usually lies between zero and one.
- VIGNAPP = T indicates that vignetting corrections have been applied. It is defined in OGIP/93-003 where it refers specifically to the values of RATE.
- BACKFILE is the filename of a background data file associated with the current one.
- BACKSCAL is a 'background scaling factor' which will be applied to the data in BACKFILE when it is used with the given dataset.
- BACKAPP = T indicates that background subtraction has been performed. As currently defined it applies specifically to the values of the RATE column (OGIP/93-003).
- NPIXSOU and NPIXBACK are used to record the area in pixels of the source and background regions. (OGIP/93-003).

- CORRFILE is a 'correction file', containing a spectrum that is to be subtracted from the source spectrum.
- CORRSCAL is used to scale the data in the correction file.
- RESPFILE is the spectral response matrix RMF file to be used with the data.
- ANCRFILE is the ancillary response file (effective area versus energy) to be used with the data.
- POISSERR is a logical keyword set to T if Poission rather than Gaussian errors should be used with the data. In a table with a column COUNTS, the STAT_ERR statistical errors may be omitted and inferred from the COUNTS if POISSERR is T.
- SYS_ERR is the fractional systematic error on the data in a column called COUNTS or RATE.
- QUALITY is a quality flag describing the data. As a header keyword, it usually is used with value zero to indicate that all the data is good.
- BPIXFILE is the name of the file containing the bad pixel map.

3 AXAF data product header components

We define the following header components:

- CC: Configuration control component
- T: Timing component
- O: Observation info component
- M: Mandatory FITS keywords for HDU type
- IC: Image coordinate system keywords (CTYPEn, *etc.*)
- TC: Table coordinate system (TCRPIX) and ranges (TLMIN/TLMAX)

Each of the first three has full and short versions which are defined below. The components should be present as follows:

Table 6: Required FITS header components

Type	FITS Primary or extension	ASC Principal or auxiliary	Header components
Image	Primary	Principal	M, IC, CC, T, O
Null	Primary	Aux	M, Null CC, Short T, Short O
Table	Extn	Principal	M, TC, CC, T, O
Table	Extn	Aux	M, TC, Short CC, Short T, Short O
Image	Extn	Aux	M, IC, Short CC, Short T, Short O

However, one should apply common sense to the design of FITS headers; keywords that are meaningless in a specific context should be left out.

3.1 Full configuration control component (CC)

```
COMMENT                                                   +------------------+
COMMENT                                                   | AXAF FITS   File |
COMMENT                                                   +------------------+
COMMENT              **************************************************************
COMMENT              >    This file is written following certain AXAF-ASC    <
COMMENT              >    conventions which are documented in ASC-FITS-1.0   <
COMMENT              **************************************************************
COMMENT                        / Configuration control-------------------------
ORIGIN  = 'ASC     '
CREATOR = 'xxx - Version 0.0'
REVISION=                    0 / Processing system revision number
COMMENT $Id: ascfits.tex,v 1.1 1998/03/04 21:50:12 arots Exp arots $
CHECKSUM= '0000000000000000'   / ASCII encoded HDU checksum
DATASUM = '         0'         / Data unit checksum written in ASCII
CONTENT = '        '           / What data product
HDUNAME = '        '           / If no EXTNAME
HDUSPEC = 'HRC Level 1 Data Products ICD, Version 1.1' / ICD reference
HDUDOC  = 'ASC-FITS-1.0: McDowell, Rots: ASC FITS File Designers Guide'
HDUVERS = '1.0.0   '
HDUCLASS= 'ASC     '
HDUCLAS1= '        '
HDUCLAS2= '        '
HDUCLAS3= '        '           / As needed ...
LONGSTRN= 'OGIP 1.0'           / The OGIP long string convention may be used.
COMMENT   This FITS file may contain long string keyword values that are
COMMENT   continued over multiple keywords.  This convention uses the  '&'
COMMENT   character at the end of a string which is then continued
COMMENT   on subsequent keywords whose name = 'CONTINUE'.
```

3.2 Short configuration control component (Short CC)

```
COMMENT                        / Configuration control--------------------------
ORIGIN  = 'ASC     '
CREATOR = 'xxx - Version 0.0'
CHECKSUM= '0000000000000000'   / ASCII encoded HDU checksum
DATASUM = '         0'         / Data unit checksum written in ASCII
CONTENT = '        '           / What data product
HDUNAME = '        '           / If no EXTNAME
HDUDOC  = 'ASC-FITS-1.0: McDowell, Rots: ASC FITS File Designers Guide'
HDUVERS = '1.0.0   '
HDUCLASS= 'ASC     '
HDUCLAS1= '        '
HDUCLAS2= '        '
HDUCLAS3= '        '           / As needed ...
```

3.3 Configuration control component for null primary HDU (Null CC)

```
COMMENT                        / Configuration control--------------------------
ORIGIN  = 'ASC     '
CREATOR = 'xxx - Version 0.0'
CHECKSUM= '0000000000000000'   / ASCII encoded HDU checksum
DATASUM = '         0'         / Data unit checksum written in ASCII
```

3.4 Full timing component (T)

```
                              / Time information block-------------------------
DATE    = '1998-01-01T00:00:00'  / Date and time of file creation (UTC)
DATE-OBS= '1998-01-01T00:00:00'  / TT, with clock correction if CLOCKAPP
DATE-END= '1998-01-01T00:00:00'  / TT, with clock correction if CLOCKAPP
TIMESYS = 'TT      '          / AXAF time will be TT (Terrestrial Time)
MJDREF  =                50814 / 1998-01-01T00:00:00 (TT) expressed in MJD (TT)
                              / MJD = JD - 2400000.5
TIMEZERO=                  0.0 / 0.0 is the cumulative clock correction
TIMEUNIT= 's       '
TIMEREF = 'LOCAL   '          / No pathlength corrections
TASSIGN = 'SATELLITE'         / Spacecraft clock
CLOCKAPP=                    T / Clock correction applied
TIERRELA=              1.0E-9 / Short-term clock stability
TIERABSO=              1.0E-4 / Absolute precision of clock correction
TIMVERSN= 'ASC-FITS-1.0'      / AXAF FITS design document
TSTART  =                  0.0 / As in the "TIME" column: raw space craft clock;
TSTOP   =                  0.0 /   add TIMEZERO and MJDREF for absolute TT
STARTMJF=                    0 / Major frame count at start
STARTMNF=                    0 / Minor frame count at start
STOPMJF =                    0 / Major frame count at stop
STOPMNF =                    0 / Minor frame count at stop
TIMEPIXR=                  0.0 / Time stamp refers to start of bin
TIMEDEL =                  0.0 / Time resolution of data (in seconds)
```

3.5 Short timing component (short T)

```
                              / Time information block-------------------------
DATE    = '1998-01-01T00:00:00'  / Date and time of file creation (UTC)
DATE-OBS= '1998-01-01T00:00:00'  / TT, with clock correction if CLOCKAPP
DATE-END= '1998-01-01T00:00:00'  / TT, with clock correction if CLOCKAPP
TIMESYS = 'TT      '          / AXAF time will be TT (Terrestrial Time)
CLOCKAPP=                    T / Clock correction applied (if false)
TIMEZERO=                  0.0 / Clock correction (if not zero)
TIMEUNIT= 's       '
MJDREF  =                50814 / 1998-01-01T00:00:00 (TT) expressed in MJD (TT)
                              / MJD = JD - 2400000.5
TSTART  =                  0.0 / As in the "TIME" column: raw space craft clock;
TSTOP   =                  0.0 /   add TIMEZERO and MJDREF for absolute TT
```

3.6 Full observation info component (O)

Only include those keywords which are determined by that stage of processing.

```
                              / Observation information block------------------
OBSERVER= '        '          / Name of Principal Investigator/Guest Observer
OBS_ID  = 'xxxxxxxxxxxxxxx'   / Whatever the convention is ...
MISSION = 'AXAF    '          / Mission is AXAF
TELESCOP= 'AXAF    '          / Telescope is AXAF
INSTRUME= '        '          / HRC, ACIS, EPHIN, S/C subsystems
DETNAM  = '        '          / Detector name
GRATING = 'NONE    '          / Grating
OBS_MODE= 'POINTING'          / Pointing, slew, or scan
DATAMODE= '        '          / Datamode (varies only for science instr. data)
SIM_X   =           0.0       / Position of SIM in mm
SIM_Y   =           0.0       /
SIM_Z   =        -237.4       /
FOC_LEN =       10065.0       / Assumed focal length, mm
ONTIME  =         100.0       / Sum of GTIs
LIVETIME=          98.0       / Ontime multiplied by DTCOR
DTCOR   =           0.98      / Dead time correction
                              / Source information block-----------------------
OBJECT  = '        '          / Source name
RA_NOM  =              -100.0 / Nominal pointing
DEC_NOM =              -100.0 / Nominal pointing
ROLL_NOM=               -40.0 / Nominal roll angle, deg
EQUINOX =              2000.0 / J2000.0
RADECSYS= 'ICRS    '          / Julian coordinate reference frame
DATACLAS= 'SIMULATED'         / If fake data,
                              / include this (default is DATACLAS='OBSERVED')
```

3.7 Short observation info component (short O)

```
                              / Observation information block------------------
OBS_ID  = 'xxxxxxxxxxxxxxx'   / Whatever the convention is ...
MISSION = 'AXAF    '          / Mission is AXAF
TELESCOP= 'AXAF    '          / Telescope is AXAF
INSTRUME= '        '          / HRC, ACIS, EPHIN, S/C subsystems
```

Appendix 1: EXTNAME/HDUCLAS/CONTENT dictionary

Null primary images are not included. Note that this appendix represents the state of this table at the time the document was frozen. The table itself is a living document; the current version can be found at http://hea-www.harvard.edu/~arots/asc/fits/content.txt.

Data product	HDU name	CONTENT	HDUCLASS	HDUCLAS1	HDUCLAS2	HDUCLASS3
L0 Events	EVENTS	EVT0	OGIP	EVENTS	ALL	
L1 Events	EVENTS	EVT1	OGIP	EVENTS	ALL	
	GTI	GTI	OGIP	GTI	ALL	
L2 Events	EVENTS	EVT2	OGIP	EVENTS	ACCEPTED	
	GTI	GTI	OGIP	GTI	STANDARD	
	REGION	REGION	ASC	REGION	STANDARD	
L2 Spectrum	SPECTRUM	SPECTRUM	OGIP	SPECTRUM	TOTAL	COUNTS
	GTI	GTI	OGIP	GTI	STANDARD	
L2 Spectrum	SPECTRUM	SPEC_BKG	OGIP	SPECTRUM	BKG	COUNTS
	GTI	GTI	OGIP	GTI	STANDARD	
L2 Lightcurve	LIGHTCURVE	LIGHTCURVE	OGIP	LIGHTCURVE	TOTAL	RATE
	GTI	GTI	OGIP	GTI	STANDARD	
L2 Lightcurve	LIGHTCURVE	LTCRV_BKG	OGIP	LIGHTCURVE	BKG	RATE
	GTI	GTI	OGIP	GTI	STANDARD	
L0 HRC VCDU	VCDU	HRC_VCDU	ASC	TEMPORALDATA	VCDU	
L0 ACA VCDU	VCDU	ACA_VCDU	ASC	TEMPORALDATA	VCDU	
L0 EPHIN VCDU	VCDU	EPH_VCDU	ASC	TEMPORALDATA	VCDU	
L0 HRC gaps	TLM_GAP	TLM_GAP	ASC	TEMPORALDATA	TLM_GAP	
L0 EPHIN gaps	TLM_GAP	TLM_GAP	ASC	TEMPORALDATA	TLM_GAP	
L0 HRC HK	HSKPNG	HRCHK	ASC	TEMPORALDATA	HKP	
L0 HRC Sec. Sci	SSCIENCE	HRCSS	OGIP	TEMPORALDATA	EVRATE	
L0 ACIS Exposure	EXR	EXR	ASC	TEMPORALDATA	EXPOSURES	
L0 ACIS Bias	BIAS	BIAS	OGIP	IMAGE	BKG	
L1 ACIS Exp. Stats	EXPSTATS	EXPSTATS	ASC	TEMPORALDATA	EXPOSURES	
L1 ACIS Mask	WINDOW	MSK	ASC	CONFIG	WINDOW	
L1 ACIS Bad Pix	BADPIX	BADPIX	ASC	TEMPORALDATA	BADPIX	
L1 ACIS Summary	SUMMARY	ACIS_SUMMARY	ASC	CONFIG	ACIS	
L1 HRC Summary	SUMMARY	HRC_SUMMARY	ASC	CONFIG	HRC	
L1 HRC Livetime	DTF	DTF	ASC	TEMPORALDATA	DTCOR	
L0 EPHIN histo	EPHHIST1	EPHHIST	ASC	TEMPORALDATA	SPECTRUM	
L0 EPHIN HK	EPHHKDTC	EPHHK	OGIP	TEMPORALDATA	HKP	
L0 EPHIN EIO	EPHEIO	EPHEIO	ASC	TEMPORALDATA	?	
L0 EPHIN PHA	EPHPHA	EPHPHA	ASC	TEMPORALDATA	RAWPHA	
L0 EPHIN TLM	EPHTLMBK	EPHTLM	ASC	TEMPORALDATA	TLM	
ACA Image	ACA_IMG_0	ACAIMG	ASC	TEMPORALDATA	ACAIMG	
Orbit ephemeris	EPHEM	EPHEM	OGIP	TEMPORALDATA	EPHEM	
HRC gap map	?	HRCGAP	ASC	CORRECTION	GAPS	
HRC gain map	GAIN	HRCGAIN	ASC	IMAGE	GAIN	
Sky image	IMAGE	IMG	OGIP	IMAGE	TOTAL	
Exposure map	EXPMAP	EXP	OGIP	IMAGE	EXPOSURE	
Source list	SRCLIST	SRC	OGIP	SRCLIST		
Aspect sol.	ASPECT	ACASOL	OGIP	TEMPORALDATA	ASPECT	
Aspect offsets	ASPOFF	ASPOFF	ASC	TEMPORALDATA	ASPOFF	
Aspect cal	ACACAL	ACACAL	ASC	CORRECTION	ACACAL	
Mission Timeline	MTL	MTL	OGIP	TEMPORALDATA	TSI	
L0 Gyro	AXAF_GY	GYRO	OGIP	TEMPORALDATA	HKP	
L0 Earth sensor	AXAF_ES	ESENSOR	OGIP	TEMPORALDATA	HKP	
L0 Sun sensor	AXAF_SS	SSENSOR	OGIP	TEMPORALDATA	HKP	

L0 Attitude	AXAF_AT	ATTITUDE	OGIP	TEMPORALDATA	HKP
L0 Earth angle	AXAF_EA	EANGLE	OGIP	TEMPORALDATA	HKP
L0 Power	AXAF_PW	POWER	OGIP	TEMPORALDATA	HKP
L0 Thermal	AXAF_TH	THERMAL	OGIP	TEMPORALDATA	HKP
L0 Status	AXAF_ST	STATUS	OGIP	TEMPORALDATA	HKP
L0 Alignment	AXAF_AL	ALIGNM	OGIP	TEMPORALDATA	HKP
L0 Grating	AXAF_GR	GRATING	OGIP	TEMPORALDATA	HKP
L0 SIM	AXAF_SIM	SIM	OGIP	TEMPORALDATA	HKP
L0 HRMA	AXAF_HRMA	HRMA	OGIP	TEMPORALDATA	HKP
L0 Orbit events	AXAF_OEVT	ORBEVTS	OGIP	TEMPORALDATA	HKP
L0 Telemetry temp	AXAF_TT	TLMTEMP	OGIP	TEMPORALDATA	HKP
Raw telemetry	AXAF_TLM	TLM	ASC	TEMPORALDATA	TLM

Appendix 2: Allowed units from OGIP/93-001

Table 8: OGIP/93-001 SI prefixes

HEASARC Prefix	SI prefix	Value
y	yocto (y)	10^{-24}
z	zepto (z)	10^{-21}
a	atto (a)	10^{-18}
f	femto (f)	10^{-15}
p	pico (p)	10^{-12}
n	nano (n)	10^{-9}
u	micro (μ)	10^{-6}
m	milli (m)	10^{-3}
c	centi (c)	10^{-2}
d	deci (d)	10^{-1} (deprecated)
da	deca (D)	10 (deprecated)
h	hecto (h)	10^{2} (deprecated)
k	kilo (k)	10^{3}
M	mega (M)	10^{6}
G	giga (G)	10^{9}
T	tera (T)	10^{12}
P	peta (P)	10^{15}
E	exa (E)	10^{18}
Z	zetta (Z)	10^{21}
Y	yotta (Y)	10^{24}

Note in particular the use of the ASCII letter u in the HEASARC system to represent the symbol μ in the SI system.

Table 9: OGIP/93-001 allowed units

Unit	Name	Type	Prefix?
m	metre	SI	Y
kg	kilogram	SI	Y (on g)
s	second	SI	Y
rad	radian	SI	Y
sr	steradian	SI	Y
K	kelvin	SI	Y
A	ampere	SI	Y
mol	mole	SI	Y
cd	candela	SI	Y
Hz	hertz	SI	Y
J	joule	SI	Y
W	watt	SI	Y
V	volt	SI	Y

N	newton	SI	Y
Pa	pascal	SI	Y
C	coulomb	SI	Y
ohm	ohm	SI	Y
S	siemens	SI	Y
F	farad	SI	Y
Wb	weber	SI	Y
T	tesla	SI	Y
H	henry	SI	Y
lm	lumen	SI	Y
lx	lux	SI	Y
deg	arc degree		N
arcsec	arc second		N
arcmin	arc minute		N
min	minute		N
h	hour		N
yr	Julian year 365.25d		N
d	day		N
eV	electron volt		Y
erg	erg		N
angstrom	angstrom		N
AU	astronomical unit		N
lyr	light year		N
pc	parsec		Y
Jy	Jansky		Y
mag	stellar magnitude		N
Crab	Crab flux		Y
G	gauss		N
count	counts		N
photon	photons		N
pixel	pixel		N
barn	barn		N
chan	detector channel		N
bin	bin		N
voxel	3-D pixel		N
byte	byte		N