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Proposed FITS Keywords and Column Headers for ALEXIS Mission Data Files

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Abstract. We propose a set of standard character strings to be used in FITS files generated by data from the *ALEXIS* (Array of Low Energy X-ray Imaging Sensors) satellite mission.

1. Introduction

The Array of Low Energy X-ray Imaging Sensors (*ALEXIS*) satellite contains two experiments: a VHF radio-frequency ionospheric experiment called "BLACKBEARD," and the *ALEXIS* experiment itself, which consists of six low-energy X-ray telescopes in three pairs: named 1A, 1B, 2A, 2B, 3A, and 3B. These are multilayer mirror telescopes with micro-channel plate detectors, and each is tuned to a relatively narrow ($\Delta E/E \approx 5\%$) energy bandpass (see Table 1).

Telescope:	1A	1B	2A	2B	3A	3B
Energy	93 eV	71 eV	93 eV	66 eV	71 eV	66 eV
Wavelength	130 Å	172 Å	130 Å	186 Å	172 Å	186 Å

Table 1. The bandpass energy and wavelength for each of the six narrow-band telescopes on the *ALEXIS* satellite.

The scientific objective of the *ALEXIS* experiment is to map out the sky in these narrow energy bands and search for transient EUV sources as well as map out the diffuse EUV background (Priedhorsky et al. 1990; Bloch et al. 1994). The project is a collaborative effort between Los Alamos National Laboratory, Sandia National Laboratory, and the University of California–Berkeley Space Sciences Laboratory. The satellite is controlled entirely from a small ground station located at Los Alamos.

The six telescopes are arranged in three pairs. The satellite is always in scanning mode, and during each (≈ 50 s) rotation period they scan most of the anti-solar hemisphere of the sky. No pointed observations are possible. Each f/1 telescope consists of a spherical, multilayer-coated mirror and a photon counting detector containing a curved microchannel plate located at the prime focus. In front of each detector is a thin metal or plastic UV rejection filter. The spacing in the periodic layers of the multilayer coatings determine the bandpasses of the telescopes. The field of view of each telescope is 30° with a spatial resolution of $0\overset{\circ}{.}25$, limited by spherical aberration. Peak effective on-axis collecting areas range from 0.05 to $0.25\,\mathrm{cm}^2$, while the peak area-solid angle products of each telescope range from 0.01 to $0.05\,\mathrm{cm}^2\,\mathrm{sr}$.

Each X-ray photon or background event from each telescope is tagged with its time of arrival and location in the field of view. Ground processing must combine these event lists with the satellite aspect solution to place each photon back onto the proper place on the sky.

The mission was launched on 1993 April 25 by a Pegasus booster dropped from a B-52 into a 400×450 nautical mile, 70° inclination orbit. Unfortunately the satellite suffered damage to one of its solar arrays on launch, and the single spacecraft magnetometer, which was located on the damaged panel is dead. The missing magnetometer and the modified (and time varying) spacecraft mass properties have forced the project team to invent new methods for both controlling the orientation of the satellite and to determine spacecraft attitude. As of 1994 September, *ALEXIS* has generated over 55 CD-ROMs (650 MB each) of telemetry data. About 50% of that data are from the six telescopes. In the year since launch, the team has developed an attitude algorithm which is providing attitude solutions close to the originally desired 0.25° precision.

The current data processing system for *ALEXIS* relies on two internally generated data formats that date back to the beginning of the project in 1988, Generalized Data Format (GDF) files and IDL Data Format (IDF) files (Bloch et al. 1992, 1993). In order to use *ALEXIS* data with various software packages that are available in the high energy astrophysics communities, we need to define the correspondence between *ALEXIS* data in GDF or IDF files, and FITS files.

2. Proposed Keywords

The following is our current proposal for keywords to use for storing raw and processed *ALEXIS* mission data in FITS format.

`TELESCOP= 'ALEXIS '` is the name of the mission.

`INSTRUME= 'TP`*i*` '` corresponds to the three telescope pairs (i=1,2,3) which are the instruments in the *ALEXIS* mission. Data from a given region of the sky can be detected in either one or both elements of the binocular pair that is scanning that part of the sky. (The coverage of the different telescope pairs is non-overlapping.) We will use:

`DETNAM = 'A '` to identify data from telescope A only,

`DETNAM = 'B '` for data from telescope B only, or

`DETNAM = 'AB '` for combined data from both A and B.

We will use the filter keyword to specify the fixed mirror, filter, and detector complement of each telescope, since they all determine the telescope's bandpass response. These will be specified by concatenating strings identifying the mirror

ID, the filter material, the filter ID, the photocathode material, and the detector ID. The mirror/filter/detector combinations that are on the telescopes now (and therefore are fixed) are:

1A: `FILTER = 'XR04770_Lex/Ti/B-03639-2_MgF2-AF01'`

1B: `FILTER = 'XR05371_Al(Si)/C-03479-1_NaBr-AF06'`

2A: `FILTER = 'XR04763_Lex/Ti/B-03606-1_MgF2-AF03'`

2B: `FILTER = 'XR05339_Al(Si)/C-03483-1_NaBr-AF08'`

3A: `FILTER = 'XR05369_Al(Si)/C-03479-2_NaBr-AF05'`

3B: `FILTER = 'XR05306_Al(Si)/C-03483-2_NaBr-AF07'`

Three observation modes have been identified as relevant to the *ALEXIS* project. We will use:

`OBS_MODE= 'SCAN '` to indicate the normal spinning, drifting satellite condition,

`OBS_MODE= 'SPIN_UP '` to indicate that Torque Coil activity is in progress to change satellite spin period, and

`OBS_MODE= 'MANEUVER'` to indicate that a Torque Coil maneuver is in progress to change satellite spin vector orientation. We note that the `SLEW` keyword is usually reserved for satellites that are capable of a stable pointing.

The raw data can be output in three different formats (Klarkowski 1992):

`DATAMODE= 'RAWTEL '` is the raw data mode which puts detector Wedge Strip ZigZag anode values for each event into the data stream. (It turns out that almost all flight data is in this mode).

`DATAMODE= 'REDTEL '` is a reduced data mode which puts X,Y and timestamp values for each event into the data stream.

`DATAMODE= 'COMPTEL '` is a compressed data mode which puts X,Y, and the delta times between events into the data stream.

3. Proposed Column Headers for Photon Event Lists

Currently, photon lists are stored in an in-house format (either GDF or IDF). In migrating these existing files to FITS formats, we propose the following non-inclusive list of generic column headers (these will be of the form `TTYPE`*n* `=` `'`header`'`).

`TIME` is the double precision time in seconds since 1993 January 1.

`DETX` and `DETY` are the integer X and Y detector locations, each ranging from 0 to 127.

`PHA` is the long integer (32 bit) pulse height value for each event. For our telescope, pulse height contains little or no photon energy information, but instead tells about microchannel plate gain and background performance.

`PI` will be used for *ALEXIS* to denote spatial gain corrected pulse height values.

`RA` and `DEC` are currently stored in terms of XYZ direction cosines in event GDF records, and will be converted to right ascension and declination as part of the file transfer.

`ENERGY` and `WAVELENGTH` are essentially fixed by the narrow bandpass in *ALEXIS*; we will occasionally use this column when combining photons from several telescopes into one data file. The units would be in eV or Å.

`STATUS` of the data is currently kept in a set of instrument flags and a set of event tagging flags; these bits will be combined into a single word for this column.

The following are *ALEXIS*-specific column header names:

- `TELID` identifies with which telescope a given photon was observed. This knowledge will be important since many of our data sets combine data from several different telescopes.
- `RAWW`, `RAWS`, and `RAWZ` are integer values for the raw Wedge, Strip, and Zigzag anode values.
- `HIVOLT` is the single precision high voltage on the detector at the time the photon was observed.

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