



Standard file format guidelines for particle count rates

S. Bourdarie (ONERA - France)
T.P. O'Brien (Aerospace Corporation – USA)

Panel on Radiation Belt Environment Modeling (PRBEM)



V1.0

Standard count rate file format guidelines

I. Introduction	3
II. File format	3
II.1 File naming convention	4
II.2 Global attributes	4
II.3 Variables.....	9
II.3.1 Data	9
II.3.2 Support_Data.....	11
II.3.3 Metadata	14
III. Reading the cdf files	15
IV. Example	15

I. Introduction

The purpose of this document is to provide guidelines to produce standard radiation belt files to facilitate data exchange between different groups involved in the field and tools development that will use these data sets. Data acquired in different countries/institutes/agencies are usually stored in various format (cdf, hdf, ascii, binary, idl saveset, ...) more or less exotic with no standard header, information, description ... This current status makes it difficult to cross-compare different data sets (it is always necessary to develop dedicated routines usually done several times throughout the world, ...). Guidelines are needed from the worldwide community of developers of space radiation data bases to permit standardization of data file format and therefore minimize efforts for data users.

This document provides guidelines for the format and organization of “count rate files” (Level 1) that will store “raw” counts that can be converted into flux files. The objective is to create a file that contains everything one would need, aside from the instrument response itself, for any further analysis, including data assimilation and angle/spectral inversion. Because many measurements are taken on spinning spacecraft, angular inversions require fairly detailed information about the orientation of the instrument relative to the spin vector. In the count rate files only time varying quantities are stored. It was decided that quasi-static information about the instrument should remain in a distinct “response” CDF (separate standard). Such information includes the energy, angle, and energy-angle response functions, nominal geometric and energy factors, as well as dead time and saturation information, etc..

II. File format

An easy to use and flexible file format must be selected. To include data as well as relevant information attached to the data, self described file format are the most convenient. One widely used by now is cdf (Common Data File). We then strongly suggest following ISTP/IACG guidelines (<http://cdf.gsfc.nasa.gov/>). In this section we recall what those guidelines are and we add one more layer to ensure that any cdf file produced will be done according to the same philosophy. We concentrate here only on particle measurements in space. Note that all text in italic originates from the NASA ISTP web site:



where authors and curators are

Mona Kessel, mona.kessel@gsfc.nasa.gov, (301)286-6595
Code 632, NASA Goddard Space Flight Center
Greenbelt, MD 20771, USA

A CDF data set using ISTP/IACG guidelines, by definition forms a logically complete and self-sufficient whole (data and descriptions). The goal is to make the resulting CDF data set



Standard count rate file format guidelines

correctly and independently usable by the science community. These guidelines have been adopted by a wide SEC community (<http://pwg.gsfc.nasa.gov/istp/collaborating/>).

A CDF file is composed of global attributes which provide descriptions of the whole data set, variables, and variable attributes.

II.1 File naming convention

The ISTP file naming convention is the following:

- One file per day is generated
- The file name has to be like:
 SPACECRAFT **_INSTRUMENT_DETECTIONHEAD_yyyyymmdd_V++.cdf where:
 - o SPACECRAFT is the name of the spacecraft in capital letters
 - o ** can either be "Hn>High Resolution data" for certified data of higher resolution than Key Parameters. n can run from 0 to 9 to allow for more than one kind of data product. For Cluster/CSDS this can either be "SP>Summary Parameter" or "PP>Prime Parameter". Other possible data types may be defined in future. If any of these data sets are modified or used to produce derived products, the data type should be, e.g., "Mn>Modified Data n", where n is from 0 to 9.
 - o INSTRUMENT is the name of the instrument in capital letters
 - o DETECTIONHEAD is the name and/or logic of the detection head (i.e. Asingle, or telescope)
 - o yyyy being the year
 - o mm being two digit month (integer)
 - o dd being two digit day of month
 - o ++ indicates the file version number (two digits) and can run from 00 to 99!

II.2 Global attributes

Global attributes are used to provide information about the data set as an entity. Together with variables and variable attributes, the global attributes make the data correctly and independently usable by someone not connected with the instrument team, and hence, a good archive product. The global attributes can also be used by any software, one popular example being the CDAWeb Display and Retrieval system (<http://cdaweb.gsfc.nasa.gov/cdaweb/>).

A list of global attributes is provided below, note that it is not limited, one can decide to add more global attributes if needed for his own applications.

"Data_type"	required
"Data_version"	required
"Descriptor"	required
"Discipline"	required
"Instrument_type"	required
"Logical_file_id"	required
"Logical_source"	required
"Logical_source_description"	required
"Mission_group"	required
"PI_affiliation"	required
"PI_name"	required
"Project"	required
"Source_name"	required



Standard count rate file format guidelines

"TEXT"	required
"Time_resolution"	required
"Acknowledgement"	recommended
"ADID_ref"	recommended
"Generated_by"	recommended
"Generated_with_software"	recommended
"Generation_date"	recommended
"LINK_TEXT"	recommended
"LINK_TITLE"	recommended
"HTTP_LINK"	recommended
"MODS"	recommended
"Planet"	recommended
"Rules_of_use"	recommended
"Parents"	optional
"Skeleton_version"	optional
"Software_version"	optional
"TITLE"	optional
"Validate"	optional

Some required Global Attributes are listed here with example values. Note that CDF attributes are case-sensitive and must *exactly* follow what is shown here.

ATTRIBUTE	EXAMPLE VALUE
"Project"	{ "ISTP>International " - "Solar-Terrestrial Physics" }.
"Source_name"	{ "GEOTAIL>Geomagnetic Tail" }.
"Discipline"	{ "Space Physics>Magnetospheric Science" }.
"Data_type"	{ "H0>High time resolution" }.
"Descriptor"	{ "EPI>Energetic Particles" - " and Ion Composition" }.
"Data_version"	{ "1" }.
"Logical_file_id"	{ "GE_H0_EPI_19920908_V01" }.
"PI_name"	{ "D. Williams" }.
"PI_affiliation"	{ "JHU/APL" }.
"TEXT"	{ "reference to journal article, URL address" }.
"Instrument_type"	{ "Magnetic Fields (space)" }.
"Mission_group"	{ "Geotail" }.
"Logical_source"	{ "GE_H0_EPI" }.
"Logical_source_description"	{ "Geotail Magnetic Field Key Parameters" }.

The Global Attribute Definitions are provided below in alphabetical order

Acknowledgement--- recommended

Text string at PI disposal allowing for information on expected acknowledgment if data is citable.

Standard count rate file format guidelines

ADID_ref --- recommended

This attribute stores the control authority identifier associated with the detached SFDU label. If no control authority identifier has been assigned, then the identifier associated with the ISTP/IACG Guidelines (NSSD0241) or with CDF (NSSD0110) can be used.

Data_type --- required

This attribute identifies the data type of the CDF data set. Both a long name and a short name are given. For ISTP exchangeable data products the values are "Kn>Key Parameter" for approximately minute averaged survey data, and "Hn>High Resolution data" for certified data of higher resolution than Key Parameters. \$n\$ can run from 0 to 9 to allow for more than one kind of data product. For Cluster/CSDS this can either be "SP>Summary Parameter" or "PP>Prime Parameter". Other possible data types may be defined in future. If any of these data sets are modified or used to produce derived products, the data type should be, e.g., "Mn>Modified Data n", where n is from 0 to 9.

Data_version --- required

This attribute identifies the version of a particular CDF data file for a given date, e.g., the file POLAR_H0_CEPPAD_19960923_V01 is the first version of data for 1996 September 23. **Each time** this particular data file is reproduced - for recalibration or other reasons - the Data_version is incremented by 1. Data_version always starts at '1'.

Descriptor --- required

This attribute identifies the name of the instrument or sensor that collected the data. Both a long name and a short name are given. An example for ISTP is "EPI>Energetic Particles and Ion Composition". The short name should be limited to from 2 to 4 characters for consistency with ISTP. This attribute should be single valued.

Discipline --- required

This attribute describes both the science discipline and subdiscipline. More than one entry is allowed. The list for space physics is:

- "Space Physics>Magnetospheric Science"
- "Space Physics>Interplanetary Studies"

Generated_by --- recommended

This attribute allows for the generating data center/group to be identified.

Generated_with_software – recommended

This attribute describes the software and its version being used for processing the data as well as the library and its version for computing magnetic coordinates (e.g. IRBEM-SVN 231)

Generation_date --- recommended

Date stamps the creation of the file using the syntax yyyyymmdd, e.g., "19920923". This is distinct from the date in "validate" below which records the times of later validation processes.

HTTP_LINK, LINK_TEXT and LINK_TITLE --- recommended



Standard count rate file format guidelines

V1.0

This attribute stores the URL for the PI or CoI web site holding on-line data. This attribute is used in conjunction with "LINK_TEXT" and "LINK_TITLE". There can be up to 5 entries for each - there MUST be a corresponding entry of "LINK_TEXT" and "LINK_TITLE" for each "HTTP_LINK" entry. As an example CDAWeb will then link to the URL given by "HTTP_LINK" using the "LINK_TITLE" and the description in "LINK_TEXT", on the CDAWeb Data Explorer page. For example

- *"LINK_TEXT" = 3-sec MGF magnetic field 1 Sep 1993 through 30 Sep 1997 available at*
- *"LINK_TITLE" = ISAS DARTS*
- *"HTTP_LINK" = <http://www.darts.isas.ac.jp/spdb/index.html>*

will give the following link:

3-sec MGF magnetic field 1 Sep 1993 through 30 Sep 1997 available at ISAS DARTS

Instrument_type --- required

This attribute is used to facilitate making choices of instrument type. More than one entry is allowed. The following list contains the valid values.

- *Particles (space)*
- *Plasma and Solar Wind*

Logical_file_id --- required

This attribute stores the name of the CDF file using the ISTP naming convention (source_name / data_type / descriptor / date / data_version), e.g., POLAR_H0_CEPPAD_19960923_V01. This attribute is required (1) to allow storage of the full name on IBM PCs, and (2) to avoid loss of the original source in the case of accidental (or intentional) renaming. For CDFs created on the ISTP CDHF, the correct Logical_file_id will be filled in by an ICSS support routine.

Logical_source --- required

This attribute carries source_name, data_type, and descriptor information.

Logical_source_description --- required

This attribute writes out the full words associated with the encrypted Logical_source above, e.g., "POLAR CEPPAD High resolution particle data".

Mission_group --- required

This attribute has a single value and is used to facilitate making choices of source. Valid values include (but are not restricted to) :

- *Geotail*
- *IMP8*
- *Wind*
- *Geosynchronous Investigations*

MODS --- recommended

This attribute is an NSSDC standard global attribute which is used to denote the history of modifications made to the CDF data set. The MODS attribute should contain a description of all significant changes to the data set. This attribute is not directly tied to Data_version, but



Standard count rate file format guidelines

each version produced will contain the relevant modifications. This attribute can have as many entries as necessary to contain the desired information.

Parents --- optional

This attribute lists the parent CDF(S) for files of derived and merged data sets. Subsequent entry values are used for multiple parents. The syntax for a CDF parent would be e.g. "CDF>logical_file_id".

PI affiliation --- required

This attribute value should include a recognizable abbreviation.

PI name --- required

This attribute value should include first initial and last name.

Planet --- recommended

This attribute value indicate from which planet the data are (e.g. "Earth" or "Jupiter").

Project --- required

This attribute identifies the name of the project and indicates ownership. For ISTP missions and investigations, the value used is "ISTP>International Solar-Terrestrial Physics". For the Cluster mission, the value is "STSP Cluster>Solar Terrestrial Science Programmes, Cluster".

Rules of use --- recommended

Text containing information on, e.g. citability and PI access restrictions. This may point to a World Wide Web page specifying the rules of use.

Skeleton version --- optional

This is a text attribute containing the skeleton file version number. This is a required attribute for Cluster, but for IACG purposes it exists if experimenters want to track it.

Software version --- optional

This is a required attribute for Cluster, but for IACG purposes it exists if experimenters want to track it.

Source name --- required

This attribute identifies the mission or investigation that contains the sensors. For ISTP, this is the mission name for spacecraft missions or the investigation name for ground-based or theory investigations. Both a long name and a short name are provided. This attribute should be single valued. Examples:

- "GEOTAIL>Geomagnetic Tail"
- "WIND>Wind Interplanetary Plasma Laboratory"
- "GOES_7>Geostationary Operational Environmental Satellite 7"
- "IMP-8>Interplanetary Monitoring Platform"
- "LANL1989_046>Los Alamos National Laboratory 1989"
- "C1>Cluster Satellite No 1".

TEXT --- required

Standard count rate file format guidelines

This attribute is an NSSDC standard global attribute which is a text description of the experiment whose data is included in the CDF. A reference to a journal article(s) or to a World Wide Web page describing the experiment is essential, and constitutes the minimum requirement. A written description of the data set is also desirable. This attribute can have as many entries as necessary to contain the desired information.

Time resolution --- required

specifies time resolution of the file in seconds, e.g., "3 seconds".

TITLE --- optional

This attribute is an NSSDC standard global attribute which is a title for the data set, e.g., "POLAR CEPPAD High Resolution Data".

Validate --- optional

Details to be specified. This attribute is written by software for automatic validation of features such as the structure of the CDF file on a simple pass/fail criterion. The software will test that all expected attributes are present and, where possible, have reasonable values. The syntax is likely to be of the form "test>result>where-done>date". It is not the same as data validation.

II.3 Variables

In this section we *define data variables, support_data variables, and metadata variables including their dimensionality and what is needed for their correct display.* The list of variables is provided below, note that one can decide to add more variables if needed for particular data sets or applications (e.g., housekeeping).

*We have identified three types of variables to be included in ISTP/IACG CDF files: **data** variables of primary importance (e.g., `particle_flux`), **support_data** variables of secondary importance (e.g., `time`, `energy_bands` associated with `particle_flux`) and **metadata** variables (e.g., a variable holding "xGEO,yGEO,xGEO" to label spacecraft position). Variables are defined with CDF specifications and required attributes. Data variables also have attached variables for time and dependencies (`support_data`) and labels (`metadata`). The `support_data` variables can be attached to data variables via `DEPEND_i` variable attributes. Metadata variables can be attached to data variables via `LABL_PTR_i` variable attributes (see below).*

NOTE: *ISTP/IACG now encourages the use of `z` variables which carry their own dimensionality.*

The complete variable description is provided next.

II.3.1 Data

These are variables of primary importance (e.g., `particle_count_rates`). Data variables are completely defined with the combination of CDF specifications, variable attributes, and attached variables such as time and dependencies (`support_data`) and labels (`metadata`).



Standard count rate file format guidelines

One of the goals of these guidelines is to use the same variable names across spacecraft/instruments to ease data exchange and software development. Note that having the same data type throughout all spacecraft/instrument is highly recommended, i.e. all real variables are CDF_REAL4 and all integer variables are CDF_INT2. This variable types guarantee enough precision for the quantities stored in the cdf files.

The following CDF variable specifications are required.

Data is always either Real or Integer type. Data is always time (record) varying, but can be of any dimensionality. Real or Integer data are always defined as having one element. In order to not make huge files, requiring large data space or large memory we suggest using only REAL4 and INT2 data type. This provides enough precision for particle measurements and associated geographic and magnetic parameters.

The following variable attributes are required. See section II.3 for more details.

- *AVG_TYPE*
- *CATDESC* (see http://spdf.gsfc.nasa.gov/istp_guide/vattributes.html#CATDESC)
- *DEPEND_0 = Epoch*
- *DEPEND_i*
- *DICT_KEY*
- *DISPLAY_TYPE* (*time_series, spectrogram, stack_plot, image*)
- *FIELDNAM*
- *FILLVAL*
- *FORMAT/FORM_PTR*
- *LABLAXIS/LABL_PTR_i*
- *UNITS/UNIT_PTR*
- *VALIDMIN*
- *VALIDMAX*
- *VAR_TYPE = data*
- *RESPONSE_FUNCTION* (provides the cdf file where the response function for each count rates can be found at, assuming it is in the same directory as the count rates cdf files are)

The need for DEPEND_i (other than DEPEND_0) and either LABLAXIS or LABL_PTR_i depends on the data itself and how it will be displayed.

The following variable attributes are recommended:

- *SCALETYP* (*linear or log*)
- *VAR_NOTES*

The list of variables that must be present in cdf files is the following:

- Position: Position is a three-dimensional variable which provides spacecraft position in geographic Cartesian coordinates – Units: km. Var type = CDF_REAL4
- B_Calc: Calculated magnetic field strength where the internal field is DGRF/IGRF and the external field is Olson-Pfitzer quiet magnetic field models – Units: nT. Var type = CDF_REAL4



Standard count rate file format guidelines

- B_Eq: Calculated magnetic field strength at magnetic equator where the internal field is DGRF/IGRF and the external field is Olson-Pfitzer quiet magnetic field models – Units: nT. Var type = CDF_REAL4
- L: Calculated McIlwain's L parameter where the internal field is DGRF/IGRF and the external field is Olson-Pfitzer quiet magnetic field models. Var type = CDF_REAL4
- L_star: Calculated Roederer's L* parameter where the internal field is DGRF/IGRF and the external field is Olson-Pfitzer quiet magnetic field models. Var type = CDF_REAL4
- I: Calculated adiabatic invariant (second invariant) where the internal field is DGRF/IGRF and the external field is Olson-Pfitzer quiet magnetic field models. Full definition of I can be found in Roederer, J. G., Dynamics of the geomagnetically trapped radiation, Springer New York, pp. 48, 1970. Units: RE (Earth Radius, 1 RE = 6378.13 km). Var type = CDF_REAL4
- MLT: Calculated Magnetic Local Time – Units: hours. Var type = CDF_REAL4
- Alpha: Local pitch angle of particles entering the instrument at nominal incidence (often assume to be 90° for large viewing angle – omni-directional instrument) – Units: degrees. Var type = CDF_REAL4
- Alpha_Eq: Computed equatorial pitch angle, derived from Alpha, B_Calc and B_Eq – Units: degrees. Var type = CDF_REAL4
- CountRate: Count Rate – units: #/s. Var type = CDF_REAL4 (note: it is best to fill in the variable attribute “VAR_NOTES” and specify whether and how dead time corrections have been accounted for)

The list of variables strongly recommended to be present in cdf files is the following:

- Counts: counts as they come from the instrument, i.e. with no dead time correction. units: #, Var type = CDF_INT4. Note that to enable users to apply an alternate dead time correction the support data “lifetime” and “integration_time” are required.

II.3.2 Support_Data

These are variables of secondary importance (e.g., time, pitch-angle, pitch-angle band associated with particle_count rate).

The following CDF variable specifications are required. Support_data is always either Real or Integer type. Support_data is usually time invariant, but can be time varying.



Standard count rate file format guidelines

If a support_data variable is attached to a data variable via `DEPEND_i`, then it must be of the same size as the dimension `i`. Real or Integer support data are always defined as having one element.

The following variable attributes are required:

- `CATDESC`
- `DICT_KEY`
- `DEPEND_0` = Epoch (if time varying)
- `FIELDNAM`
- `FILLVAL` (if time varying)
- `FORMAT/FORM_PTR`
- `LABLAXIS/LABL_PTR_i`
- `UNITS/UNIT_PTR`
- `VALIDMIN` (if time varying)
- `VALIDMAX` (if time varying)
- `VAR_TYPE` = support_data

The following variable attributes are recommended:

- `VAR_NOTES`

The list of support data that must be present in cdf files is the following (other support data may be added is needed):

- Epoch: "Epoch" should be the first variable in each CDF data set. All time varying variables in the CDF data set will depend on the "Epoch" variable (or on a `CDF_EPOCH` type variable) - more than one `CDF_EPOCH` type variable is allowed in a data set to allow for more than one time resolution. For ISTP the time value of a record refers to the center of the accumulation period for the record if the measurement is not an instantaneous one. Epoch allows for a scalar representation of time which provides for seamless crossings of day and year boundaries. Epoch time is simply the time in milliseconds A.D. CDF toolkit programs will display and expect `CDF_EPOCH` values in the format `dd-mmm-yyyy hh:mm:ss.ccc` where `dd` is the day of the month, `mmm` is the month, `yyyy` is the year, `hh` is the hour, `mm` is the minute, `ss` is the second and `ccc` is the millisecond (e.g., 01-Aug-1992 10:30:05.025). "Epoch" will be monotonically increasing so that the attribute `MONOTON` should be defined as "INCREASE". (Note: All CDF data sets using the Epoch variable should use the subroutines provided in the CDF toolkit for making the conversion between this value and year, month, day, etc. These routines are available as black boxes from NSSDC. To determine Epoch time it is only necessary to call the subroutine `compute_Epoch` (year, month, day, hour, minute, second, msec, Epoch) with arguments as shown for making the conversion between this value and year, month, day, etc. This ensures that all users use the same conversion when generating their CDF data sets and will therefore have the same view of the effects of the various calendar changes that have occurred over the last two thousand years.) . Var type = `CDF_EPOCH`
- Position Quality: Position Quality Flag – time dependent (0 means highest quality, 1 means bad quality). Var type = `CDF_INT2`



Standard count rate file format guidelines

- CountRateIndex: Channel index for count rate. Var type = CDF_INT2 (note: this variable is necessary to have an ISTP-CDF file compliant.)
- CountRateSpecies: Indicates most probable species being measured. The species must be designed by the element symbol (e.g. C, N, O ...), except for electron where “E” and for proton where ‘P’ must be used instead – Var type = CDF_CHAR
- CountRateBackground: Indicates estimated Galactic Cosmic Rays (GCR) count rate background – Var type = CDF_REAL4
- CountRate_Quality: Quality Flag for Countrate – time dependent (0 denotes highest quality, 1 denotes problem with time resolution, 2 is unused, 3 denotes saturation, 4 denotes any other problem, 5 denotes background and 10 is the default values while data have not been yet filtered). Var type = CDF_INT2
- integration_time: nominal integration time which can be time dependent. Var type = CDF_REAL4
- livetime: livetime is either the nominal integration time for the sensor or an actually measured integration time. Note that $dead_time = integration_time - livetime$. This variable can be time dependent. Var_type=CDF_REAL4.
- Support data for directional count rate
 - CountRate_Alpha: Local pitch-angles for count rate – Units: Degree. Var type = CDF_REAL4. Must be a 1D array, time independent because interpretation of CountRate depends on CountRate_Alpha. So the central pitch-angle is given here. If pitch-angle band is known then it is recommended to add another support data described next, in order to not lose details of measurement.
 - CountRate_AlphaRange: Local pitch-angles range for count rate – Units: Degree. Var type = CDF_REAL4. Must be a 2D array [2, number of pitch-angle channels]. Use VAR_NOTES attribute to specify interpretation of this range (e.g., FWHM).
 - CountRate_Alpha_Eq: Equatorial pitch-angles for count rate – Units: Degree. Var type = CDF_REAL4. Must be a 1D array + time dependent. So it corresponds to the central local pitch-angle described above.

Next, support data to retrieve instrument orientation relative to the local magnetic field is required. These data are designed for use with a Response Function Library that provides utilities that, among other things, compute the instrument response in magnetic coordinates. In case these support data listed below are not available, then they must be filled with baddata.

The instrument coordinate axes are a right-handed system, s_0, s_1, s_2 , with s_0 parallel to particles travelling into the instrument boresight. A polar angle, THETA (θ) measures declination from s_0 . An azimuth or longitude angle PHI (ϕ) measures the angle in the s_1 - s_2

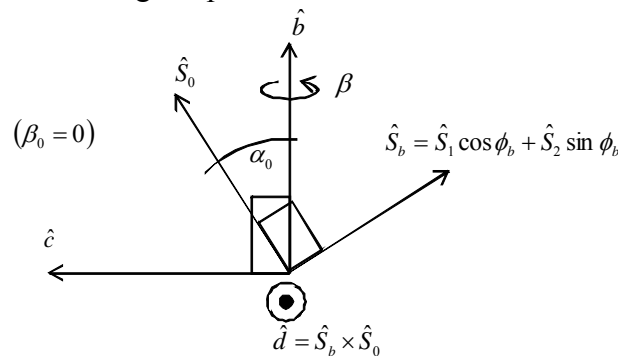
Standard count rate file format guidelines

V1.0

plane from s_1 to s_2 . Rotations between instrument coordinates and magnetic field coordinates (pitch angle α and gyrophase β) can be further performed with attitude information provided in these files. Polar angles α , θ range from 0 to 180°, while β and ϕ range from 0 to 360°. The instrument coordinates are given in the following required support data:

- S0_LAT: latitude in GEI of instrument bore sight (S_0 , $\theta=0$ axis) – Unit=degree – Var type = CDF_REAL4
- S0_LON: longitude in GEI of instrument bore sight – Unit=degree – Var type = CDF_REAL4
- S1_LAT: latitude in GEI of S_1 axis ($\theta=90^\circ$, $\phi=0^\circ$) – Unit=degree – Var type = CDF_REAL4
- S1_LON: longitude in GEI of S_1 axis ($\theta=90^\circ$, $\phi=0^\circ$) – Unit=degree – Var type = CDF_REAL4
- S2_LAT: latitude in GEI of S_2 axis ($\theta=90^\circ$, $\phi=90^\circ$) – Unit=degree – Var type = CDF_REAL4
- S2_LON: longitude in GEI of S_2 axis ($\theta=90^\circ$, $\phi=90^\circ$) – Unit=degree – Var type = CDF_REAL4

The figure below illustrates the case for $\beta_0=0$ (i.e., for the gyrophase angle of s_0 being 0). The magnetic field points along the b axis, and vectors in the b - c plane have gyrophase (β) equal to 0. Note that for $\alpha_0=0$, $\beta_0=0$, $\phi_b=0$, the s_0 axis is parallel to the b axis, the s_1 axis is anti-parallel to the c axis, and the s_2 axis is anti-parallel to the d axis. This anti-parallel topology arises from the choice of having s_0 in the first octant of the c - d - b coordinates, and b in the first octant of the s_1 - s_2 - s_0 coordinates. Also note that b - c - d coordinates are equivalent to c - d - b coordinates, and s_0 - s_1 - s_2 coordinates are equivalent to s_1 - s_2 - s_0 coordinates, but we have followed the convention of having the polar axis as the third coordinate.



II.3.3 Metadata

These are variables of secondary importance e.g., a variable holding "xGEO,yGEO,zGEO" to label spacecraft position.

The following CDF variable specifications are required.

Standard count rate file format guidelines

Metadata is always character type. Metadata is always time invariant if it is used to label a data variable. Metadata can be time varying if it is NOT used as a label.

If a metadata variable is attached to a data variable via `LABL_PTR_i`, then it must be of the same size as the dimension `i`.

Character metadata must define the number of elements to be the same as the number of characters used in its value.

The following variable attributes are required.

- `CATDESC`
- `DICTIONARY_KEY`
- `FIELDNAM`
- `FORMAT/FORM_PTR`
- `VAR_TYPE = metadata`

The list of metadata that must be present in cdf files is the following:

- `Position_LABL_1`: Position variable labels. Var type = `CDF_CHAR`
- `CountRate_LABL_1`: Channel labels count rates. Var type = `CDF_CHAR`

If “Counts” variable is provided then `Count_LABL_1` is required: Channel labels counts. Var type = `CDF_CHAR`

III. Reading the cdf files

In this section, the logic to read the cdf files and to take advantage of all information in there is provided.

- 1- Retrieve `CountRate` variables. This variable should contain original data provided by the PI and should not have been modified at all. This guarantees that anyone can re-plot the data as he has provided them without any extra modification. Retrieve the `UNITS`, `LABL_PTR_1` and `RESPONSE_FUNCTION` attributes.
- 2- Retrieve the variable provided by `LABL_PTR_1` attribute (should be `CountRate_LABL_1`).
- 3- Read response function cdf file if necessary.

IV. Example