# Description of the Fast Auroral Snapshot (FAST) Small Explorer Fluxgate Magnetometer High Resolution Data Files – Version 1 CDF Files

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| 1.0 | 11/30/13 | Initial Release, Version 1 CDF Files |

**Table of Contents**

## 1. Introduction - FAST Mission Overview

The Fast Auroral Snapshot (FAST) Small Explorer was launched on August 21, 1996 from the Western Test Range at the Vandenberg Air Force Base, by a Pegasus-XL vehicle. The elliptical orbit initial inclination was 83˚, with apogee at 4175 km and perigee at 350 km. The FAST instrumentation includes an electric field measurements, 3-axis search coil and fluxgate magnetometers, ion and electron electrostatic analyzers (ESAs), and a Time-of-flight Energy Angle Mass Spectrometer (TEAMS). The spacecraft was launched into a reverse cartwheel orbit, with the spacecraft spin-axis nominally opposite to the orbit angular momentum vector.

The primary FAST mission objective was to explore the auroral acceleration region with high resolution and high cadence particles and fields instrumentation. The FAST mission and instrumentation are described in a series of papers published in *Space Science Reviews*, Volume 98, Nos. 1–2, 2001. Initial results were published in *Geophys. Res. Lett.*, Volume 25, Issue 12, 1998.

After orbit 51315, April 30, 2009, spacecraft science data acquisition was terminated. The end time for the magnetometer data was 10:22:31.46 UT.

## 2. Acquisition of Magnetometer Data

The FAST fluxgate magnetometer was designed to operate in full Earth magnetic field at low altitude. The magnetometer consequently has a dynamic range of ~ ± 65,000 nT. The magnetometer data were initially digitized to 16 bits, corresponding to ~ 2 nT resolution, with a lower resolution ADC being used after a power system anomaly (see the discussion of the P12S7V anomaly below). The data were acquired at different data rates, depending on the spacecraft mode. These rates were as low as 4 samples per second, usually used for “back orbit,” when only the fluxgate magnetometer acquired data, to as high as 512 samples per second. In the CDFs 512 samples per second data are averaged down to 128 samples per second.

With the reverse cartwheel high-inclination orbit the spin-plane magnetic field measurements are roughly along the spacecraft track and near vertical, close to the background magnetic field direction at high latitudes. The spin-axis component is nominally an east-west component. Deviations in the east-west component are the primary signature of auroral-zone field-aligned currents.

The FAST fluxgate magnetometer is described in more detail by Elphic et al., “Magnetic Field Instruments for the FAST Auroral Snapshot Explorer,” *Space Sci. Rev., 98*, 151–168, 2001. First results for the magnetometer are given by Elphic et al., “The auroral current circuit and field-aligned currents observed by FAST,” *Geophys. Res. Lett., 25*, 2033–2036, doi: 10.1029/98GL01158, 1998.

Table 2.1 lists the major events related to the FAST fluxgate magnetometer.

Prior to orbit 407 (Sept. 28, 1996, 00:45:00 UT) various spin-up and spin-down maneuvers were performed. Data acquired before this orbit should not be used for science analysis, and CDFs have not been generated for orbits before orbit 407.

The P12S7V (Positive 12 System 7 Voltage) anomaly was related to a positive 12 Volt rail failing to hold voltage. Once the voltage dropped below ~ 5 Volts the magnetometer Analog to Digital Converter (ADC) failed to provide the correct values. This required a modification of the gain and offset values in the calibration file.

| **Event** | **Orbit**<br>**Date** | **Comments** |
|---|---|---|
| Magnetometer first power on | Orbit 6,<br>Aug. 21, 1996, 22:51:53.5 UT | Magnetometer still stowed |
| Magnetometer boom deployment | Orbit 26,<br>Aug. 23, 1996, 18:48:10 UT | |
| Spin-plane booms deployment | Orbit 315<br>Sept. 19, 1996, ~13:30 UT | Variable spin rate |
| End of deployment maneuvers | Orbit 407<br>Sept. 28, 1996, 00:45:00 UT | Final spin rate - first science |
| Spin-axis boom deployment | Orbit 1795<br>Feb. 3, 1997, 10:07 UT | Only one boom deployed |
| P12S7V anomaly detected | Orbit 8430<br>Oct. 9, 1998, 05:05 UT | Degraded magnetometer data |
| P12S7V data outage begins | Orbit 8437<br>Oct. 9, 1998, 19:54 UT | Magnetometer data acquisition halted |
| Partial orbits begin | Orbit 8478<br>Oct. 13, 1998, 14:18:36 UT | Restart of magnetometer data acquisition, partial orbits |
| ADC gain changes because of P12S7V under-voltage | Orbit 9146<br>Dec. 14, 1998, 03:18:11 UT | Under-voltage began to seriously affect magnetometer gain |
| ADC switched | Orbit 9937<br>Feb. 24, 1999, 22:29:47 UT | Switched to new ADC |
| Full orbit acquisition resumed | Orbit 20202<br>Sept. 20, 2001, 01:00:42 UT | Allowed for better calibration |
| End of magnetometer data transmission | Orbit 51315<br>Apr. 30, 2009, 10:22:31.46 UT | Effective end of mission |

Table 2.1. Major magnetometer-related events.

A secondary effect of the lower voltage is that sometimes the magnetic field is large enough that the output from the magnetometer would be greater than the P12S7V voltage rail, causing the data to be clipped. At this time no work-around has been found for this problem.

After the P12S7V anomaly was detected acquisition of magnetometer data was suspended on orbit 8348 while the effect of the anomaly was assessed. After analysis it was decided to restart magnetometer data acquisition on orbit 8478, but only partial orbits were acquired as the impact of full orbit operations on the System 7 positive 12 Volt rail was not well known. There was concern that full orbit operations would result in further rapid degradation of the voltage,

resulting in termination of magnetometer data acquisition. But partial orbit acquisition reduced the ability to determine absolute gains and spin-axis offsets, as these relied on full orbits of data for model field comparison. Because the P12S7V voltage did not display any further major degradation, full orbits of data were again acquired beginning on orbit 20202 (Sept. 20, 2001, 01:00:42 UT)

On or about orbit 9146 (orbit start date Dec. 14, 1998, 03:18:11 UT) the under-voltage began to seriously affect the ADC gain, and it was decided that another ADC would have to be used. Flight software was able to redirect the data flow, and on orbit 9937 (Feb. 24, 1999, 22:29:47 UT) the ADC used by the magnetometer was changed. This ADC had lower resolution than the original ADC, resulting in greater digitization noise in the data. Changing the ADC removed the ADC gain problem, but did not remove the clipping in high fields, as this was related to the low P12S7V voltage.

As a result of the P12S7V voltage anomaly and the corrective actions taken, data acquired on or after orbit 8478 (Oct. 13, 1998, 14:18:36 UT) and before orbit 20202 (Sept. 20, 2001, 01:00:42 UT), covering the interval were partial orbits were acquired, should be treated with caution as the absolute calibration is less reliable, especially for the spin-axis. Data acquired on or after orbit 9146 (Dec 14, 1998, 03:18:11 UT) and before orbit 9937 (Feb. 24, 1999, 22:29:47 UT) should considered suspect as the ADC gain change was sufficient to affect the magnetometer calibration. The calibration file does attempt to capture these changes in gain, but there are large uncertainties.

The current release of FAST magnetometer CDFs is from orbit 407 (starting September 28, 1996, 00:45:00 UT) to orbit 8430 (ending October 9, 1998, 06:21:20 UT), as this is the orbit were the P12S7V anomaly first occurred. The range of data available will be extended in subsequent releases.

## 3. Description of the Common Data Format (CDF) High Resolution Data Files

Because the FAST magnetometer data are better ordered by orbit, rather than daily files, say, the naming convention for the CDF files includes the time of the first magnetic field data record for the orbit. When data are acquired over the entire orbit this will be the start of the orbit. But for partial orbits this need not be the case. An example of the file name is as follows: fast_hr_dcb_19980919172656_v01.cdf . The “fast_hr_dcb” string identifies the mission (FAST), the time resolution (hr = High Resolution), and the basic data quantity (dcb = “DC” or low frequency magnetic field). The string “19980919172656” gives the time of the first magnetometer data record in the file, in year (4 digits), month (2 digits), day (2 digits), hour (2 digits), minute (2 digits), and seconds (2 digits). The last string “v01” identifies the version number.

Appendix A gives a complete listing of the metadata included in the FAST high resolution magnetometer CDF file. Here we will summarize the data quantities included in the CDF.

*3.1. High resolution data*

The primary data products are provided at the intrinsic resolution of the data, with the exception of 512 sample per second data. These have been filtered to 128 samples per second, as the fluxgate magnetometer response is not optimized for signals with an intrinsic frequency greater than this.

In order to make the data scientifically meaningful a variety of additional processing is performed. This processing includes the following: (1) Re-registering the data to a common time reference point, since the original components of the magnetic field are not sampled simultaneously. (2) Backing out the effects of a recursive filter that attenuates and phase-shifts the spin-tone for low data rates. (3) Orthogonalizing the spinning magnetic field data so that the spin-axis component has no spin-tone, and the spin-plane components are in quadrature, and have no DC offset. For completeness the "tweakers" that are used to orthogonalize the data are included in the CDF file, as are the orbit-average coupling matrix and offsets.

Time Specification:

| | |
|---|---|
| Epoch | Time stamp for the high-resolution data, stored as a TT2000 variable. |
| range_epoch | First and last time of the high-resolution data. Useful for routines that require time range information. |

Magnetic Field Deviations:

Magnetic field deviations are given in several coordinate systems. The deviations (DeltaB) are the difference between the measured field and the International Geomagnetic Reference Field version 11 (IGRF 11), specified at the mean time of the Epoch. Bad data have been removed and replaced with a flag value of -1.e31. Unless otherwise stated the magnetic fields are given in nT.

| | |
|---|---|
| DeltaB_DSC | DeltaB in Despun Spacecraft Coordinates (DSC). DSC is defined as: z-axis along the spin-axis; y-axis in the spin-plane, perpendicular to the Sun-direction; and x completing the triad x-y-z. |
| DeltaB_GEI | DeltaB in Geocentric Equatorial Inertial coordinates. |
| DeltaB_SM | DeltaB in Solar Magnetic coordinates. Dipole axis direction from IGRF version 11. |
| DeltaB_FAC | DeltaB in Field-Aligned Coordinates (FAC). FAC defined as: 'b' along the model magnetic field; 'e' as East, in the direction of B-cross-R; and 'o' outwards, completing the triad o-e-b. Near the poles 'outwards' points towards the respective north or south pole. |
| DeltaB_FAC_V | DeltaB in Field-Aligned spacecraft coordinates. Field-aligned spacecraft coordinates use the spacecraft velocity vector (hence DeltaB_FAC_V) in specifying the coordinate system, which is defined as: 'b' along the model magnetic field; 'p' perpendicular, in the direction of B-cross-vel_spacecraft, that is, across track; and 'v' nominally along the spacecraft velocity vector, along track, completing the triad v-p-b. |

| | |
|---|---|
| DeltaB_FAC_SP | DeltaB in Field-Aligned/Spin Plane Coordinates. Field-aligned/spin plane coordinates use the spin plane (hence DeltaB_FAC_SP) in specifying the coordinate system, which is defined as: 'b' along the model magnetic field; 's' in the spin-axis cross model B direction, that is, in the spin-plane and perpendicular to the model field; and 'p' perpendicular (B x (spin-axis x B)), nominally along the spin-axis, completing the triad s-p-b. The spin-plane coordinate 's' is in the same direction as the despun electric field "E along V" component. Note that "E along V" is nominally along the spacecraft velocity only in the northern hemisphere, and is nominally anti-parallel to the spacecraft velocity vector in the southern hemisphere. The "E along V" electric field crossed with the p-component of "deltaB_FAC_SP" contributes to the field-aligned Poynting flux. In this s-p-b coordinate system, positive field-aligned Poynting flux is into the northern ionosphere, but away from the southern ionosphere. The other contribution to the field-aligned Poynting flux would be from the p-component of the electric field crossed with the s-component of the DeltaB magnetic field, but the p-component of the electric field is mainly given by the spin-axis electric field measurement. Because one of the axial booms did not deploy on FAST the spin-axis electric field is generally not used. |

Total Magnetic Field and Support Parameters:

These date are included to provide both a record of the magnetometer data used to generate the “Delta_B” quantities, and quality flags and other ancillary data that document the data reduction process, such as the time-varying tweakers, or torquer coil offsets. This allows for independent verification of the data, or the use of different model magnetic fields. Again, unless otherwise stated, the magnetic field data are in nT.

| | |
|---|---|
| B_GEI | Full (not detrended with respect to IGRF 11) magnetometer data in Geocentric Equatorial Inertial coordinates, with bad data deleted. |
| DEL_MAG_FLAG | Flags data that have been deleted in B_GEI and DeltaB data, or should be deleted from the non-detrended B_DSC and B_SSC data (see below). |
| Torquer | Estimated torquer coil magnetic field, in spinning spacecraft coordinates. Units are pseudo-nT since the field is estimated with intermediate (partially calibrated) data. |
| Tweaker | Time-varying tweaker matrix that gives final orthogonalization and removes spin-plane offsets. Tweaker takes into account on-orbit variations caused by eclipse entry, etc.<br>TW_ZX is used to remove from the z-sensor any spin-tone signals in phase with the x-sensor.<br>TW_ZY is used to remove from the z-sensor any spin-tone signals in phase with the y-sensor.<br>TW_YY is used to make the y-sensor have the same gain as the x-sensor.<br>TW_YX is used to remove from the y-sensor any spin-tone signals in phase with the x-sensor. |

O_X is used to remove any DC offsets from the x-sensor.
O_Y is used to remove any DC offsets from the y-sensor.

MAG_QUAL_FLAG The Magnetometer Data Quality Flags are additive. Flag values 1 - 16 are Torquer and other data processing flags. Flag values 32 - 2048 are Spin phase related flags. Any data with a flag value 2048 or greater should be used with care.

Flag values:

0 good;
1 Torquers on;
2 Torquer ramp;
4 Nutation [not yet implemented];
8 RESERVED;
16 RESERVED;
32 spin phase object set to zero;
64 in eclipse (using nadir table);
128 RESERVED;
256 RESERVED;
512 spin phase data not smoothed;
1024 spin phase data patched with nadir or Mission Unique Electronics (MUE) phase data;
2048 Missing spin phase data.

B_DSC Full magnetometer data in Despun Spacecraft Coordinates (DSC), with bad data included, indicated by DEL_MAG_FLAG = 1. Despun Spacecraft Coordinates have the z-axis along the nominal spin axis, and the Sun in the x-z plane.

B_SSC Full magnetometer data in Spinning Spacecraft Coordinates (SSC), with bad data included, indicated by DEL_MAG_FLAG = 1.

Bharmonic_DSC Magnetic field spin-tone harmonic in Despun Spacecraft Coordinates (DSC). Bad data removed, DEL_MAG_FLAG = 1.

*3.2. Spin Phase Information:*

Time Specification:

Spin_Epoch Time stamp for the spin phase data, stored as a TT2000 variable. Spin phase data are nominally at 3 (~ 15 second) or 4 (~ 20 second) spin period cadence.

Spin Phase Data:

Spin_Freq Spacecraft spin frequency at the time specified by Spin_Epoch, in degrees/s.

Spin_Phase Phase angle of the magnetometer x-axis with respect to the Sun at the time specified by Spin_Epoch, in degrees.

*3.3. Orbit and Ephemeris*

Orbit and Ephemeris data are provided by the FAST data system using an IDL routine called get_fa_orbit. This routine uses the IGRF version 7 magnetic field coefficients to specify the local model magnetic field, and to trace the magnetic field from the FAST spacecraft to 100 km altitude, with respect to the Earth geoid, according to the documentation within the IDL routine. For the purposes of detrending the magnetometer data the model magnetic field at the spacecraft location as returned by the get_fa_orbit routine has been replaced with the IGRF version 11 model magnetic field. The field line tracing algorithm may also be updated to use the IGRF version 11 magnetic field in a later version of the CDF files.

Time Specification:

| | |
|---|---|
| Ephemeris_Epoch | Time stamp for the ephemeris data, stored as a TT2000 variable, with a 1-second cadence. |

Orbit Data:

| | |
|---|---|
| Orbit | Orbit number as specified by the FAST ephemeris software. |
| pos_gei | FAST spacecraft position in Geocentric Equatorial Inertial coordinates, in km. |
| vel_gei | FAST spacecraft velocity in Geocentric Equatorial Inertial coordinates, in km/s. |
| B_model_gei | Model magnetic field in nT (IGRF version 11 at the date of acquisition) in Geocentric Equatorial Inertial coordinates. |
| alt | FAST altitude in km with respect to Earth equatorial radius (6378.14 km), not mean radius or geodetic altitude. |
| lat | FAST geographic latitude in degrees with respect to sphere with Earth equatorial radius (6378.14 km), not geodetic. |
| lng | FAST geographic longitude in degrees with respect to sphere with Earth equatorial radius (6378.14 km), not geodetic. |
| ilat | FAST invariant latitude in degrees, calculated with respect to offset tilted dipole. Dipole geographic position: [-402.199, 287.504, 195.908] km; Dipole orientation: latitude 79.3637 degrees, longitude 288.454 degrees. Invariant latitude defined using 6371.2 km radius with respect to dipole origin. |
| ilng | FAST invariant longitude in degrees, calculated with respect to offset tilted dipole. Dipole geographic position: [-402.199, 287.504, 195.908] km; Dipole orientation: latitude 79.3637 degrees, longitude 288.454 degrees. |
| mlt | FAST magnetic local time in hours, calculated from ILNG. |

Magnetic Footprint:

As noted above, according to the documentation for the IDL get_fa_orbit routine, the following quantities correspond to the magnetic footprint of the spacecraft at 100 km altitude, with the

altitude, latitude and longitude in geodetic coordinates. The field-line tracing routine and the footprint magnetic field are specified using the IGRF version 7 coefficients. These data maybe superceded in a future release of the CDF files.

| | |
|---|---|
| flat | Latitude of FAST magnetic footprint at 100 km altitude (degrees, geodetic coordinates). |
| flng | Longitude of magnetic footprint at 100 km altitude (degrees, geodetic coordinates). |
| B_foot_gei | IGRF Version 7 model magnetic field at the position specified by FLAT, FLNG, and 100 km altitude geodetic. |

Ancillary Coordinate System Information:

The following two quantities give the direction of the sun and the dipole orientation in GEI coordinates, as these are used to construct transformations to other coordinate systems such as solar magnetic (SM) coordinates.

| | |
|---|---|
| sun_dir_gei | Unit vector giving the Sun direction in Geocentric Equatorial Inertial coordinates. Used to construct the despun spacecraft to Geocentric Equatorial Inertial coordinate transformation. This unit vector is also used to generate the GEI to Solar Magnetic coordinate transformation.. |
| dip_orient_gei | Unit vector giving dipole orientation in Geocentric Equatorial Inertial coordinates. Dipole specified by the g10, g11, and h11 values of the IGRF 11 model, using the center time of the orbit as the reference epoch. Used to generate GEI to Solar Magnetic coordinate transformation. |

*3.4. Fixed Values Per Orbit*

The following parameters are fixed for each orbit, but are included with a timestamp so that long-term variations can be investigated.

| | |
|---|---|
| Orbit_Fixed_Epoch | Orbit_Fixed_Epoch specified as the median time of the Ephemeris_Epoch timespan. Time is specified as a TT2000 variable. |
| Orbit_Value | Fixed value of the orbit number. |
| Coupling_Matrix | Magnetometer coupling matrix components, fixed values for the orbit. Coupling matrix components can change from orbit to orbit. |
| Offsets | Magnetometer offsets, fixed values for the orbit. Offsets can change from orbit to orbit. |
| Spin_Axis | Spin axis right ascension (RA) and declination (DEC), obtained by comparing IGRF model field with data. The parameters RA_FDF and DEC_FDF are also included, and are the starting values for the initial comparison (FDF = Flight Dynamics Facility). |
| Spin_Phase_Delta | Angle by which the measured field leads the model field in the spin-plane, before correction. The applied correction is to rotate the measured field back by this angle. |

*3.5. CDF Support Variables*

The following quantities are required as part of the CDF file format. The "DEPEND" variables are used for multi-dimensional quantities, for example, 3-component vectors, or 9-component matrices. The "LABL" variables contain label strings for use when plotting data, etc.

Since the names are self-explanatory, we will simply provide a listing here.

Depend Variables:

Vector_DEPEND_1
Tweaker_DEPEND_1
Spin_Axis_DEPEND_1
Matrix_DEPEND_1

Label Variables:

DeltaB_DSC_LABL_1
DeltaB_GEI_LABL_1
DeltaB_SM_LABL_1
DeltaB_FAC_LABL_1
DeltaB_FAC_V_LABL_1
DeltaB_FAC_SP_LABL_1
B_GEI_LABL_1
B_DSC_LABL_1
B_SSC_LABL_1
Bharmonic_DSC_LABL_1
Torquer_LABL_1
Tweaker_LABL_1
pos_gei_LABL_1
vel_gei_LABL_1
B_model_gei_LABL_1
B_foot_gei_LABL_1
sun_dir_gei_LABL_1
dip_orient_gei_LABL_1
Coupling_Matrix_LABL_1
Offsets_LABL_1
Spin_Axis_LABL_1

## 4. Known Data Artifacts

There are several data artifacts that still remain in the magnetometer data as given in the Version 1 CDF data files. Future versions of the CDF files may use additional processing tools to remove these artifacts, but at this stage we are releasing the data with the artifacts still present. We will give examples of the artifacts here, which are summarized in Table 4.1.

| Artifact | Section |
|---|---|
| Torquer Coil Operations | 4.1 |
| Spacecraft Nutation | 4.2 |
| Data “Glitches” | 4.3 |
| UT Offset Change | 4.4 |
| Spin-Phase Errors | 4.5 |
| System 7 Under Voltage - Initial anomaly | 4.6 |
| System 7 Under Voltage - ADC Effects | 4.7 - Example in future doc. |
| System 7 Under Voltage - Saturation | 4.8 - Example in future doc. |

Table 4.1. List of known data artifacts.

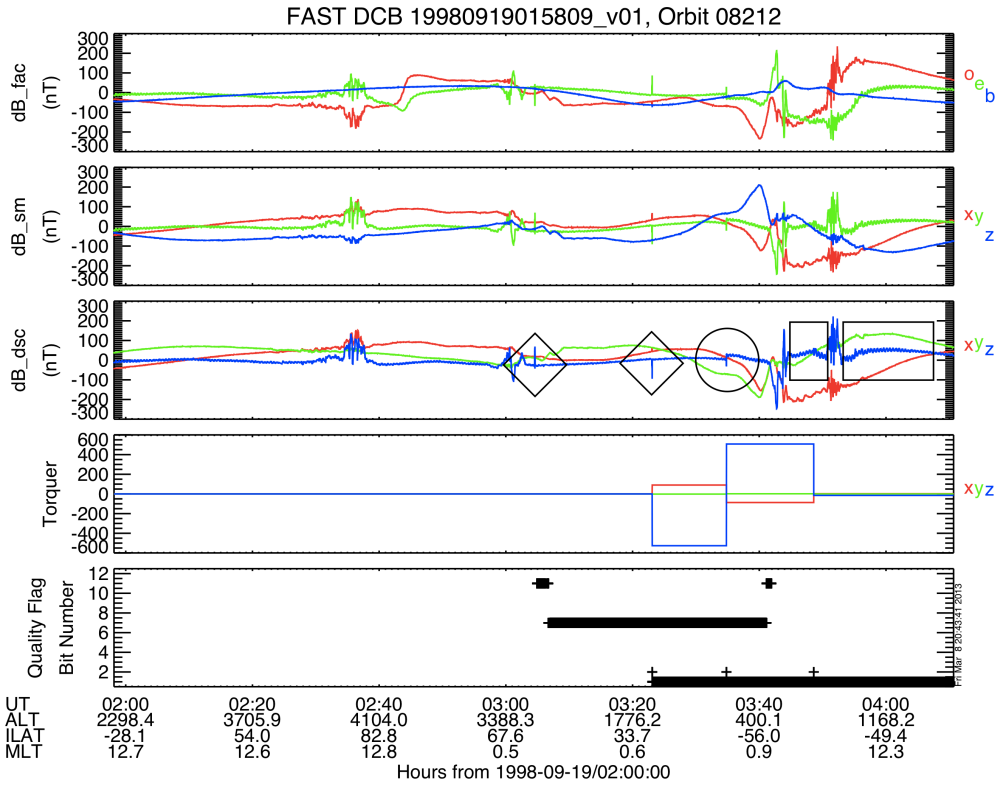


Figure 4.1. Example of torquer coil and nutation artifacts. This figure has the same content as the diagnostic plots generated as part of the magnetometer CDF file generation. The data quantities are defined in Section 3. In the middle panel the circle shows a torquer coil artifact, the diamonds show small data glitches, and the rectangles mark nutation artifacts. The same artifacts can be seen in the data plotted in field-aligned coordinates (dB_fac, top panel) and Solar Magnetic coordinates (dB_sm, second panel), but the artifacts are usually most clear in the despun spacecraft (dB_dsc) coordinates.

*4.1. Torquer Coil Operations*

The FAST spacecraft attitude was maintained through routine operations of magnetic torquer coils. Not surprisingly, these resulted in changes in the magnetometer offsets while the torquer coils were operating. As part of the magnetometer data reduction these steps are identified automatically and removed. The removal process is not perfect, however, and a residual step often remains. An example is shown in Figure 4.1.

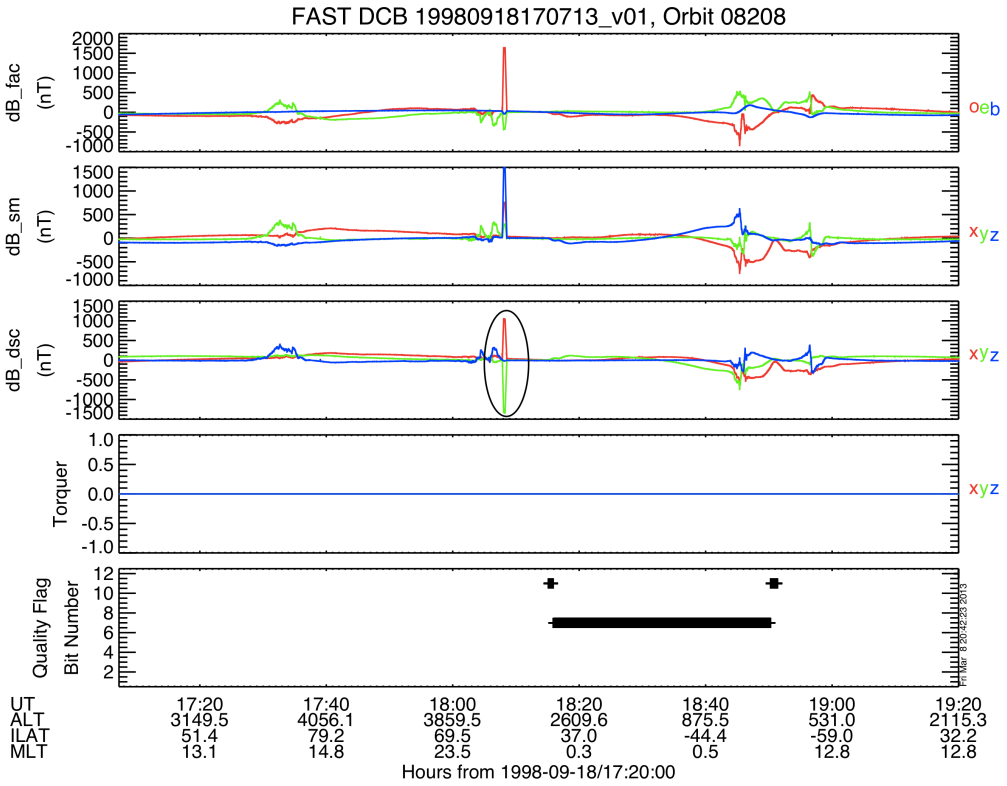


Figure 4.2. Example of a large data glitch, marked by the oval in the middle panel. As with the previous examples, the glitch can also be seen in the other coordinate systems (dB_fac and dB_sm).

In Figure 4.1 the second panel from the bottom shows the derived torquer coil magnetic signal that was subtracted from the measured field. The bottom panel shows the Quality Flag Bit Number. This bit number 2 is set when the torquer coil is being ramped, and bit number 1 is set when the software determines there is a torquer-coil related offset. For completeness, bit number 7 is set when the spacecraft is in eclipse and using the horizon crossing data and nadir tables to compute spin phase, rather than the sun pulse. Bit 11 is usually set at eclipse entry and exit, as the data are "patched" to align the sun-pulse-derived phase and the nadir-derived phase. The despun magnetic field data in the top three panels of Figure 4.1 show pulses when torquer coil is ramping, and occasional jumps (i.e., change in offset) across the ramp. The jump is most clear in

the z-component in the middle panel at around 10:35 UT. This panel shows the despun spacecraft coordinate system, and the z-axis is the spin-axis. Closely related to the torquer coil operations and partially obscuring the jump is the change in the nutation-induced signal, which we will discuss in the next section.

*4.2. Spacecraft Nutation*

As already noted in discussing Figure 4.1, the spacecraft "nutates" after torquer coil operations. This manifests itself as an approximately 30-second period oscillation that is observed mainly in the spin-axis component (z-axis in the third panel in Figure 4.1). Because the magnetic field is mainly in the spin-plane at high (auroral) latitudes, any change in the spin-plane orientation is a small effect. The signal is very clear to the eye, but because it changes in both amplitude and frequency as the nutation damps out, it is difficult to design a filter that would not also remove the desired science data. The nutation signal typically damps out after one orbit.

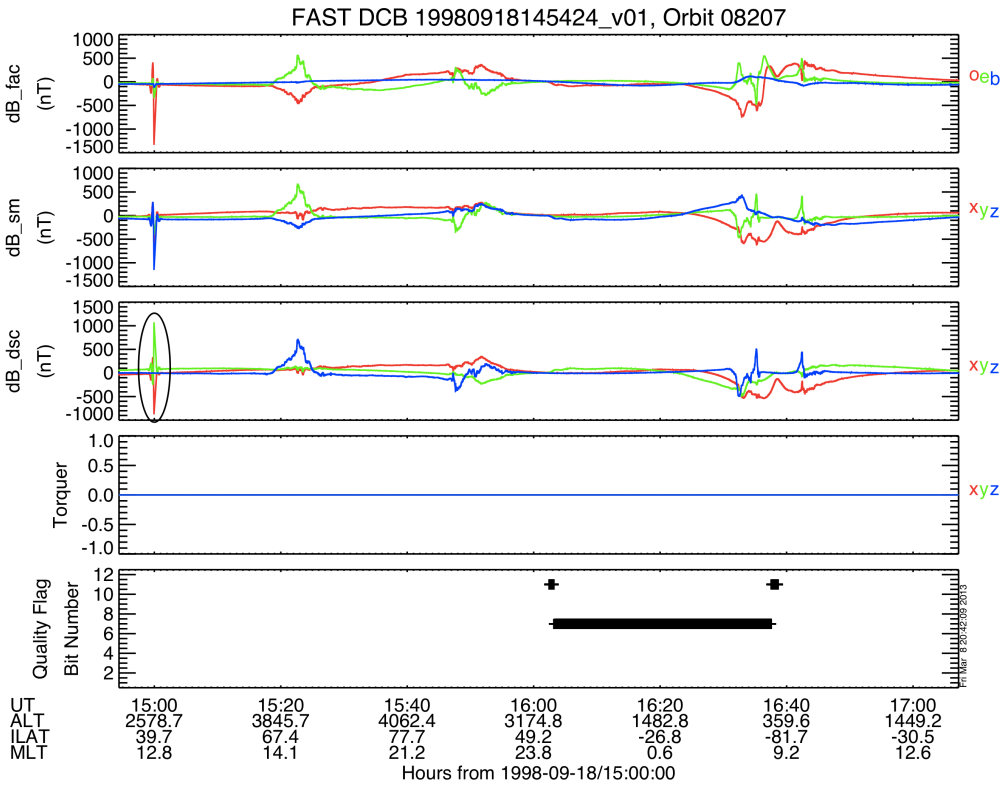


Figure 4.3. Example of a UT offset change. The signature of the UT offset change is marked by the oval in the third panel.

*4.3. Data "Glitches"*

The software that generates the magnetometer data from the raw telemetry includes code that attempts to identify large steps in the data ("glitches") and removes them from the data. The times of the deleted data are flagged in the DEL_MAG_FLAG data quantity. The code does not remove all of the data glitches. Figure 4.1 shows some small glitches around 03:05 and 03:20 UT. Figure 4.2 shows a large data glitch around 18:10 UT. This is often associated with a change in the data rate. The changes in data rate are not synchronized with the packet boundaries.

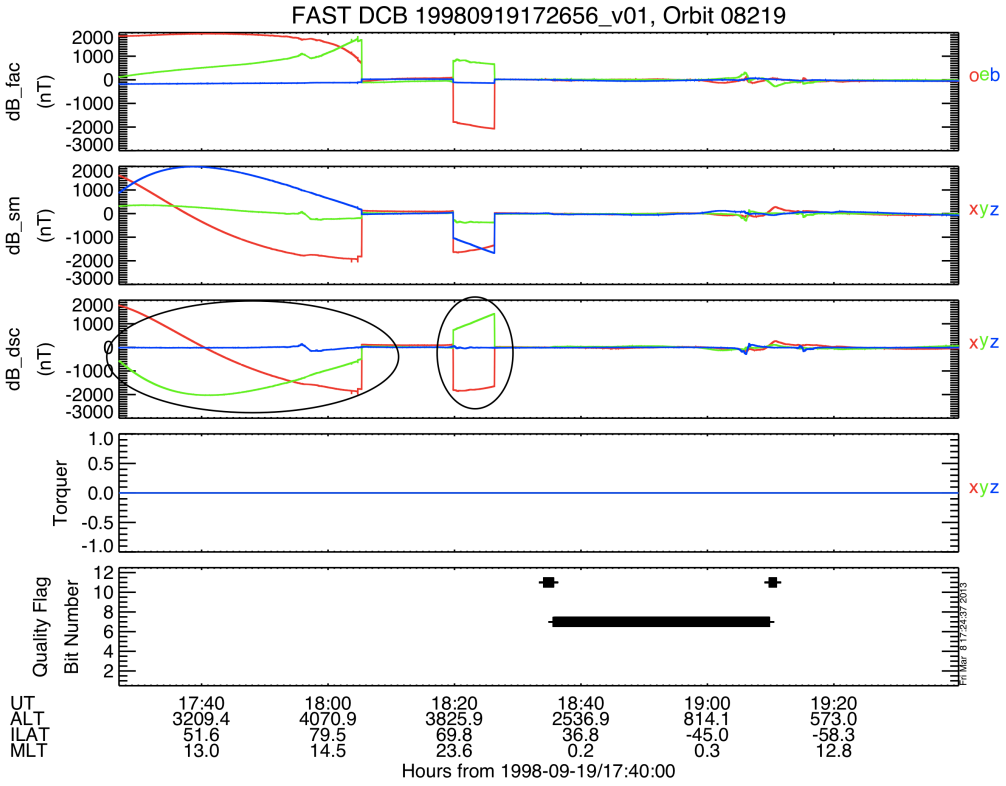


Figure 4.4. Example of missing spin phase data. The ovals mark intervals of bad spin phase data in the despun spacecraft coordinate data.

*4.4. UT Offset Change*

About once a day (i.e., every 11 orbits) the spacecraft clock is corrected for drift with respect to Universal Time. This causes a jump in the time-stamp of the data. This in turn causes spin-phase errors. The deglitching algorithm does remove some of the bad data, but there is usually a residual signal, such as that shown at 15:00 UT in Figure 4.3.

*4.5. Spin-Phase Errors*

At times the spin-phase data are incorrect. An example is shown in Figure 4.4. The large residuals in the spin-plane components indicate the phase error. It is not clear what causes this error, but it seems to be related to missing spin-phase data in the telemetry stream.

When the spacecraft is in eclipse the spin phase is determined from horizon crossing indicators. The resultant spin-phase data are noisier than the data using the sun sensor. Furthermore, the spin frequency changes as the spacecraft and booms cool down. The data reduction software tries to match the eclipse phase data with the non-eclipse data, but the patch is not perfect. An example is shown in Figure 4.5. The Quality Flag Bit Number is set to 11 on eclipse entry and exit. At that time the "dB_dsc" (delta-B in despun spacecraft coordinates) shows a smooth several-minute oscillation in the x- and y-components. This is a residual of the phase-patching algorithm. The primary indicators are, first, the colocation with eclipse entry and exit, and, second, the smoothness of the variation.

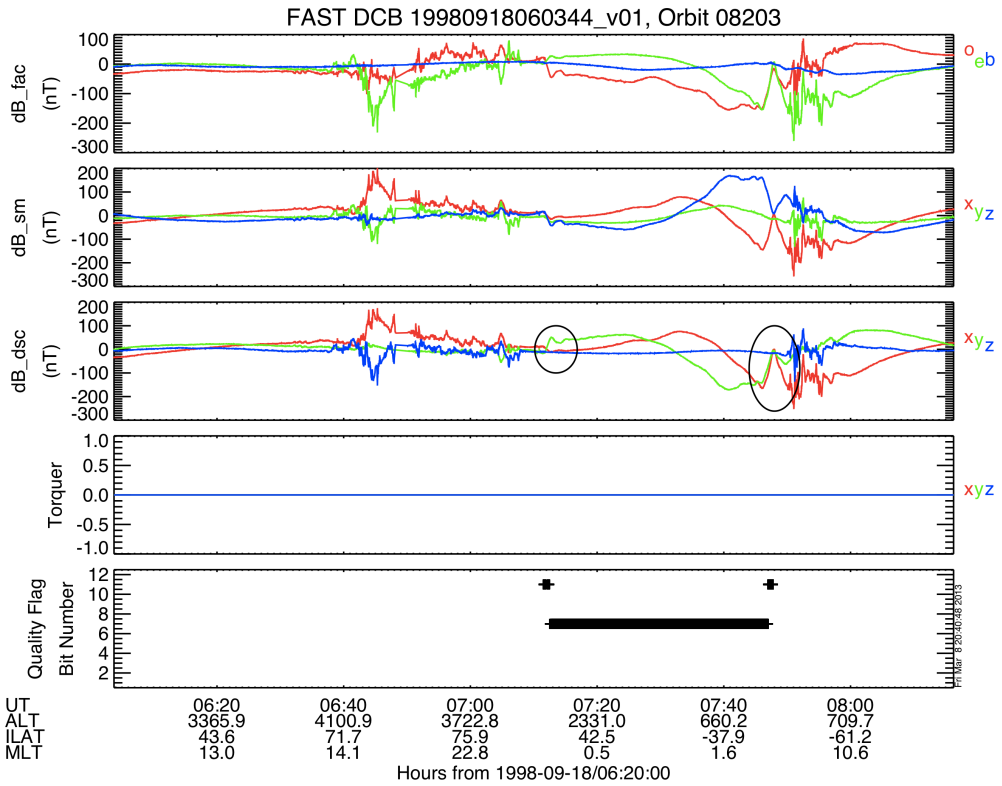


Figure 4.5. Example of phase errors associated with eclipse entry and exit. The ovals mark the phase-error intervals in the despun data.

*4.6. System 7 Under Voltage - Initial Anomaly*

The Positive 12 System 7 Voltage (P12S7V) under-voltage first occurred on orbit 8430. Data from that orbit are shown in Figure 4.6. The anomaly is marked by the oval centered at ~ 05:10 UT. At this time the P12S7V voltage briefly dropped below ~ 5 Volts, which resulted in spurious noise in the data. The System 7 positive 12 voltage partially recovered after the initial anomaly, but the voltage continued to decay, as discussed in Section 2.

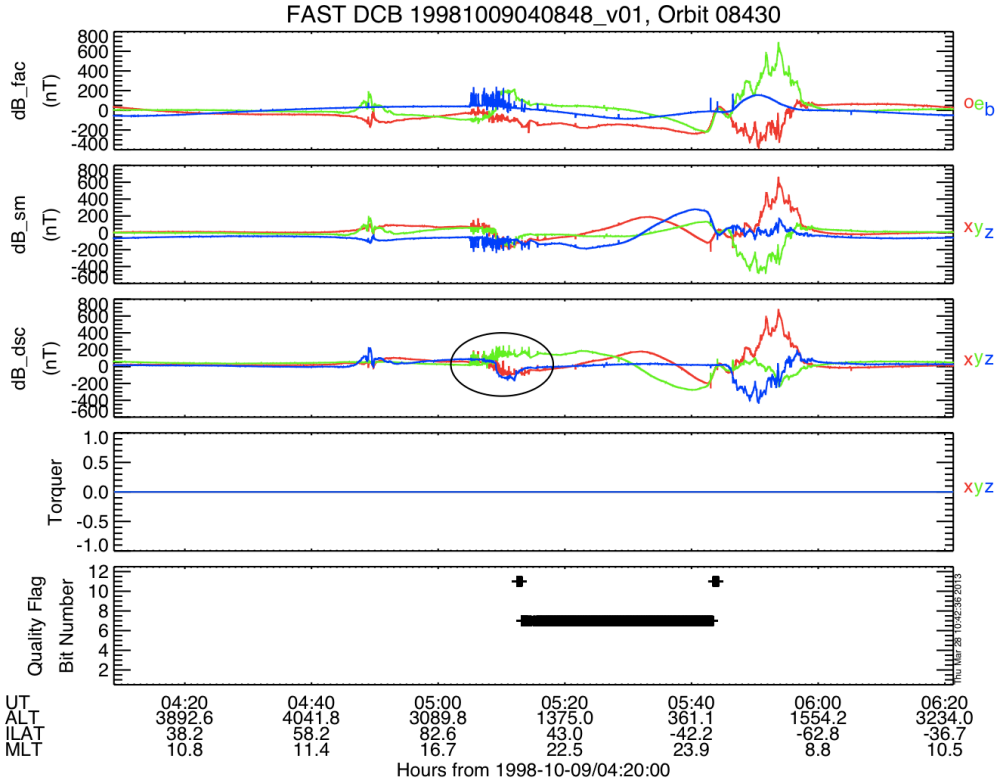


Figure 4.6. Data acquired when the initial P12S7V anomaly occurred. The time of the anomaly is indicated by the oval in the third panel, where the data are noisy.

*4.7. System 7 Under Voltage - ADC Effects*

This section will be populated in a subsequent version of this document, to be released with the CDF files after orbit 8430 (ending October 9, 1998, 06:21:20 UT), when the Positive 12 System 7 Voltage (P12S7V) under-voltage first occurred.

*4.8. System 7 Under Voltage - Saturation*

This section will be populated in a subsequent version of this document, to be released with the CDF files after orbit 8430 (ending October 9, 1998, 06:21:20 UT), when the Positive 12 System 7 Voltage (P12S7V) under-voltage first occurred.

## Appendix A. FAST Magnetometer CDF File Metadata

The following is a listing of the metadata in the FAST magnetometer high resolution CDF files.

```
File Info
========================================
CDF File:     fast_hr_dcb_19980919172656_v01
Version:      3.5.0
Copyright:
Common Data Format (CDF)
(C) Copyright 1990-2013 NASA/GSFC
Space Physics Data Facility
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771 USA
(Internet -- GSFC-CDF-SUPPORT@LISTS.NASA.GOV)


Global Attributes (26 attributes)
========================================
Project (1 entry):
      0 (CDF_CHAR/21):  "FAST Data Enhancement"
Source_name (1 entry):
      0 (CDF_CHAR/26):  "FAST>Fast Auroral SnapshoT"
Discipline (2 entries):
      0 (CDF_CHAR/36):  "Space Physics>Magnetospheric Science"
      1 (CDF_CHAR/33):  "Space Physics>Ionospheric Science"
Data_type (1 entry):
      0 (CDF_CHAR/23):  "HR>High Time Resolution"
Descriptor (1 entry):
      0 (CDF_CHAR/25):  "DCB>Fluxgate Magnetometer"
File_naming_convention (1 entry):
      0 (CDF_CHAR/26):  "source_datatype_descriptor_yyyyMMddHHmmss"
Data_version (1 entry):
      0 (CDF_CHAR/2):   "01"
PI_name (1 entry):
      0 (CDF_CHAR/17):  "Robert Strangeway"
PI_affiliation (1 entry):
      0 (CDF_CHAR/4):   "UCLA"
TEXT (1 entry):
      0 (CDF_CHAR/439):       "Calibrated fluxgate magnetometer data acquired
by the Fast Auroral SnapshoT Small Explorer (FAST). Data have been
calibrated, despun, and detrended against the International Geomagnetic
Reference Field (IGRF), using IGRF coefficients for the date of acquisition.
Data are provided in several coordinate systems. Non detrended data in
spacecraft and Geocentric Equatorial Inertial coordinates are also provided.
Ephemeris data are provided."
Instrument_type (1 entry):
      0 (CDF_CHAR/23):  "Magnetic Fields (space)"
Mission_group (1 entry):
      0 (CDF_CHAR/4):   "FAST"
Logical_source (1 entry):
      0 (CDF_CHAR/11):  "fast_hr_dcb"
Logical_file_id (1 entry):
      0 (CDF_CHAR/30):  "fast_hr_dcb_19980919172656_v01"
Logical_source_description (1 entry):
      0 (CDF_CHAR/55):  "High-resolution Fluxgate Magnetometer data for the
FAST Mission"
```

```
Time_resolution (1 entry):
      0 (CDF_CHAR/8):   "Variable"
Rules_of_use (1 entry):
      0 (CDF_CHAR/42):  "Include acknowledgement in any publication"
Generated_by (1 entry):
      0 (CDF_CHAR/20):  "Robert J. Strangeway"
Generation_date (1 entry):
      0 (CDF_CHAR/24):  " Thu Nov 28 03:18:40 2013"
Acknowledgement (1 entry):
      0 (CDF_CHAR/53):  "Charles W. Carlson, FAST PI, and Robert J.
Strangeway"
MODS (1 entry):
      0 (CDF_CHAR/58):  "Initial CDF development 8/14/12
Version 1 release 03/07/13
Updated to CDF version 3.5.0 12/26/13"
ADID_ref (1 entry):
      0 (CDF_CHAR/11):  "FAST_HR_DCB"
LINK_TEXT (1 entry):
      0 (CDF_CHAR/40):  "FAST Magnetometer Instrument Description"
LINK_TITLE (1 entry):
      0 (CDF_CHAR/188):       "Elphic, R. C., J. D. Means, R. C. Snare, R. J.
Strangeway, L. Kepko, and R. E. Ergun, Magnetic field instruments for the
Fast Auroral Snapshot Explorer, Space Sci. Rev., 98, 151-168, 2001."
HTTP_LINK (1 entry):
      0 (CDF_CHAR/53):
      "http://www.springerlink.com/content/kq063646631ugg42/"
SPASE_Resource_ID (1 entry):
      0 (CDF_CHAR/48):  "VMO/NumericalData/FAST/Magnetometer/PT0.0078125S"

Variable Attributes (32 attributes)
=======================================
CATDESC
DEPEND_0
DEPEND_1
DEPEND_2
DEPEND_3
DICT_KEY
DISPLAY_TYPE
FIELDNAM
FILLVAL
FORMAT
LABLAXIS
LABL_PTR_1
LABL_PTR_2
LABL_PTR_3
UNITS
UNIT_PTR
VALIDMIN
VALIDMAX
VAR_TYPE
SCALETYP
SCAL_PTR
VAR_NOTES
MONOTON
LEAP_SECONDS_INCLUDED
RESOLUTION
Bin_location
TIME_BASE
```

```
TIME_SCALE
REFERENCE_POSITION
ABSOLUTE_ERROR
RELATIVE_ERROR
FORM_PTR

Variable Information (0 rVariable, 66 zVariables)
=========================================================
Epoch                   CDF_TT2000/1  0:[]  T/
range_epoch             CDF_TT2000/1  0:[]  T/
Vector_DEPEND_1         CDF_INT4/1    1:[3] F/T
DeltaB_DSC              CDF_REAL4/1   1:[3] T/T
DeltaB_GEI              CDF_REAL4/1   1:[3] T/T
DeltaB_SM               CDF_REAL4/1   1:[3] T/T
DeltaB_FAC              CDF_REAL4/1   1:[3] T/T
DeltaB_FAC_V            CDF_REAL4/1   1:[3] T/T
DeltaB_FAC_SP           CDF_REAL4/1   1:[3] T/T
B_GEI                   CDF_REAL4/1   1:[3] T/T
DEL_MAG_FLAG            CDF_INT4/1    0:[]  T/
Torquer                 CDF_REAL4/1   1:[3] T/T
Tweaker                 CDF_REAL4/1   1:[6] T/T
MAG_QUAL_FLAG           CDF_INT4/1    0:[]  T/
B_DSC                   CDF_REAL4/1   1:[3] T/T
B_SSC                   CDF_REAL4/1   1:[3] T/T
Bharmonic_DSC           CDF_REAL4/1   1:[3] T/T
Spin_Epoch              CDF_TT2000/1  0:[]  T/
Spin_Freq               CDF_REAL4/1   0:[]  T/
Spin_Phase              CDF_REAL4/1   0:[]  T/
Ephemeris_Epoch         CDF_TT2000/1  0:[]  T/
Orbit                   CDF_REAL4/1   0:[]  T/
pos_gei                 CDF_REAL4/1   1:[3] T/T
vel_gei                 CDF_REAL4/1   1:[3] T/T
B_model_gei             CDF_REAL4/1   1:[3] T/T
alt                     CDF_REAL4/1   0:[]  T/
lat                     CDF_REAL4/1   0:[]  T/
lng                     CDF_REAL4/1   0:[]  T/
ilat                    CDF_REAL4/1   0:[]  T/
ilng                    CDF_REAL4/1   0:[]  T/
mlt                     CDF_REAL4/1   0:[]  T/
flat                    CDF_REAL4/1   0:[]  T/
flng                    CDF_REAL4/1   0:[]  T/
B_foot_gei              CDF_REAL4/1   1:[3] T/T
sun_dir_gei             CDF_REAL4/1   1:[3] T/T
dip_orient_gei          CDF_REAL4/1   1:[3] T/T
DeltaB_DSC_LABL_1       CDF_CHAR/8    1:[3] F/T
DeltaB_GEI_LABL_1       CDF_CHAR/8    1:[3] F/T
DeltaB_SM_LABL_1        CDF_CHAR/7    1:[3] F/T
DeltaB_FAC_LABL_1       CDF_CHAR/8    1:[3] F/T
DeltaB_FAC_V_LABL_1     CDF_CHAR/10   1:[3] F/T
DeltaB_FAC_SP_LABL_1    CDF_CHAR/11   1:[3] F/T
B_GEI_LABL_1            CDF_CHAR/7    1:[3] F/T
B_DSC_LABL_1            CDF_CHAR/7    1:[3] F/T
B_SSC_LABL_1            CDF_CHAR/7    1:[3] F/T
Bharmonic_DSC_LABL_1    CDF_CHAR/15   1:[3] F/T
Torquer_LABL_1          CDF_CHAR/6    1:[3] F/T
Tweaker_LABL_1          CDF_CHAR/5    1:[6] F/T
pos_gei_LABL_1          CDF_CHAR/9    1:[3] F/T
vel_gei_LABL_1          CDF_CHAR/9    1:[3] F/T
```

```
B_model_gei_LABL_1    CDF_CHAR/13   1:[3] F/T
B_foot_gei_LABL_1     CDF_CHAR/12   1:[3] F/T
sun_dir_gei_LABL_1    CDF_CHAR/13   1:[3] F/T
dip_orient_gei_LABL_1 CDF_CHAR/16   1:[3] F/T
Orbit_Fixed_Epoch     CDF_TT2000/1  0:[]  T/
Orbit_Value           CDF_REAL4/1   0:[]  T/
Coupling_Matrix       CDF_REAL4/1   1:[9] T/T
Offsets               CDF_REAL4/1   1:[3] T/T
Spin_Axis             CDF_REAL4/1   1:[4] T/T
Spin_Phase_Delta      CDF_REAL4/1   0:[]  T/
Coupling_Matrix_LABL_1 CDF_CHAR/8   1:[9] F/T
Offsets_LABL_1        CDF_CHAR/3    1:[3] F/T
Spin_Axis_LABL_1      CDF_CHAR/7    1:[4] F/T
Tweaker_DEPEND_1      CDF_INT4/1    1:[6] F/T
Spin_Axis_DEPEND_1    CDF_INT4/1    1:[4] F/T
Matrix_DEPEND_1       CDF_INT4/1    1:[9] F/T


Variable (66 variables)
=======================================

Epoch
-----
Attribute Entries:
     CATDESC         (CDF_CHAR/31): "Default Time for Processed Data"
     FIELDNAM        (CDF_CHAR/5): "Epoch"
     FILLVAL         (CDF_TT2000/1): 9999-12-31T23:59:59.999999999
     LABLAXIS        (CDF_CHAR/5): "Epoch"
     UNITS           (CDF_CHAR/2): "ns"
     VALIDMIN        (CDF_TT2000/1): 1990-01-01T00:00:00.000000000
     VALIDMAX        (CDF_TT2000/1): 2029-12-31T23:59:59.999999999
     VAR_TYPE        (CDF_CHAR/12): "support_data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/127): "Time is specified as a TT2000 variable.
Conversion to TT2000 assumes the UTC as given by the FAST data decommutator
is correct."
     MONOTON         (CDF_CHAR/8): "INCREASE"
     TIME_BASE       (CDF_CHAR/5): "J2000"
     TIME_SCALE      (CDF_CHAR/16): "Terrestrial Time"
     REFERENCE_POSITION (CDF_CHAR/20): "Rotating Earth Geoid"

range_epoch
-----------
Attribute Entries:
     CATDESC         (CDF_CHAR/15): "Start-Stop Time"
     FIELDNAM        (CDF_CHAR/11): "range_epoch"
     FILLVAL         (CDF_TT2000/1): 9999-12-31T23:59:59.999999999
     LABLAXIS        (CDF_CHAR/11): "range_epoch"
     UNITS           (CDF_CHAR/2): "ns"
     VALIDMIN        (CDF_TT2000/1): 1990-01-01T00:00:00.000000000
     VALIDMAX        (CDF_TT2000/1): 2029-12-31T23:59:59.999999999
     VAR_TYPE        (CDF_CHAR/12): "support_data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/46): "Start and stop times for the current CDF
file."
     MONOTON         (CDF_CHAR/8): "INCREASE"
     TIME_BASE       (CDF_CHAR/5): "J2000"
     TIME_SCALE      (CDF_CHAR/16): "Terrestrial Time"
```

```
     REFERENCE_POSITION (CDF_CHAR/20): "Rotating Earth Geoid"

Vector_DEPEND_1
---------------
Attribute Entries:
     CATDESC         (CDF_CHAR/38): "Component Number for a Depend 1 Vector"
     FIELDNAM        (CDF_CHAR/11): "Comp Number"
     FILLVAL         (CDF_INT4/1): -2147483648
     FORMAT          (CDF_CHAR/2): "I8"
     LABLAXIS        (CDF_CHAR/11): "Comp Number"
     VALIDMIN        (CDF_INT4/3): 1, 1, 1
     VALIDMAX        (CDF_INT4/3): 3, 3, 3
     VAR_TYPE        (CDF_CHAR/12): "support_data"
     SCALETYP        (CDF_CHAR/6): "linear"

DeltaB_DSC
----------
Attribute Entries:
     CATDESC         (CDF_CHAR/39): "DeltaB in Despun Spacecraft Coordinates"
     DEPEND_0        (CDF_CHAR/5): "Epoch"
     DEPEND_1        (CDF_CHAR/15): "Vector_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/10): "DeltaB_DSC"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/10): "DeltaB_DSC"
     LABL_PTR_1      (CDF_CHAR/17): "DeltaB_DSC_LABL_1"
     UNITS           (CDF_CHAR/2): "nT"
     VALIDMIN        (CDF_REAL4/3): -100000.0, -100000.0, -100000.0
     VALIDMAX        (CDF_REAL4/3): 100000.0, 100000.0, 100000.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/322): "DeltaB in Despun Spacecraft
Coordinates. Model Magnetic Field is IGRF version 11. Despun Spacecraft
Coordinates (DSC) are defined as: z-axis along the spin-axis; y-axis in the
spin-plane, perpendicular to the Sun-direction; and x completing the triad x-
y-z. Detrended (DeltaB) data have bad data deleted, DEL_MAG_FLAG = 1."

DeltaB_GEI
----------
Attribute Entries:
     CATDESC         (CDF_CHAR/52): "DeltaB in Geocentric Equatorial Inertial
Coordinates"
     DEPEND_0        (CDF_CHAR/5): "Epoch"
     DEPEND_1        (CDF_CHAR/15): "Vector_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/10): "DeltaB_GEI"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/10): "DeltaB_GEI"
     LABL_PTR_1      (CDF_CHAR/17): "DeltaB_GEI_LABL_1"
     UNITS           (CDF_CHAR/2): "nT"
     VALIDMIN        (CDF_REAL4/3): -100000.0, -100000.0, -100000.0
     VALIDMAX        (CDF_REAL4/3): 100000.0, 100000.0, 100000.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
```

```
     VAR_NOTES       (CDF_CHAR/159): "DeltaB in Geocentric Equatorial
Inertial coordinates. Model Magnetic Field is IGRF version 11. Detrended
(DeltaB) data have bad data deleted, DEL_MAG_FLAG = 1."

DeltaB_SM
---------
Attribute Entries:
     CATDESC         (CDF_CHAR/36): "DeltaB in Solar Magnetic Coordinates"
     DEPEND_0        (CDF_CHAR/5): "Epoch"
     DEPEND_1        (CDF_CHAR/15): "Vector_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/9): "DeltaB_SM"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/9): "DeltaB_SM"
     LABL_PTR_1      (CDF_CHAR/16): "DeltaB_SM_LABL_1"
     UNITS           (CDF_CHAR/2): "nT"
     VALIDMIN        (CDF_REAL4/3): -100000.0, -100000.0, -100000.0
     VALIDMAX        (CDF_REAL4/3): 100000.0, 100000.0, 100000.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/171): "DeltaB in Solar Magnetic coordinates.
Model magnetic field and dipole axis direction from IGRF version 11.
Detrended (DeltaB) data have bad data deleted, DEL_MAG_FLAG = 1."

DeltaB_FAC
----------
Attribute Entries:
     CATDESC         (CDF_CHAR/35): "DeltaB in Field-Aligned Coordinates"
     DEPEND_0        (CDF_CHAR/5): "Epoch"
     DEPEND_1        (CDF_CHAR/15): "Vector_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/10): "DeltaB_FAC"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/10): "DeltaB_FAC"
     LABL_PTR_1      (CDF_CHAR/17): "DeltaB_FAC_LABL_1"
     UNITS           (CDF_CHAR/2): "nT"
     VALIDMIN        (CDF_REAL4/3): -100000.0, -100000.0, -100000.0
     VALIDMAX        (CDF_REAL4/3): 100000.0, 100000.0, 100000.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/389): "DeltaB in Field-Aligned Coordinates.
Model Magnetic Field is IGRF version 11. Field-Aligned Coordinates (FAC)
defined as: 'b' along the model magnetic field; 'e' as East, in the direction
of B-cross-R; and 'o' outwards, completing the triad o-e-b. Near the poles
'outwards' points towards the respective north or south pole. Detrended
(DeltaB) data have bad data deleted, DEL_MAG_FLAG = 1."

DeltaB_FAC_V
------------
Attribute Entries:
     CATDESC         (CDF_CHAR/46): "DeltaB in Field-Aligned Spacecraft
Coordinates"
     DEPEND_0        (CDF_CHAR/5): "Epoch"
     DEPEND_1        (CDF_CHAR/15): "Vector_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/12): "DeltaB_FAC_V"
```

```
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/12): "DeltaB_FAC_V"
     LABL_PTR_1      (CDF_CHAR/19): "DeltaB_FAC_V_LABL_1"
     UNITS           (CDF_CHAR/2): "nT"
     VALIDMIN        (CDF_REAL4/3): -100000.0, -100000.0, -100000.0
     VALIDMAX        (CDF_REAL4/3): 100000.0, 100000.0, 100000.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/523): "DeltaB in Field-Aligned spacecraft
coordinates. Model Magnetic Field is IGRF version 11. Field-aligned
spacecraft coordinates use the spacecraft velocity vector (hence
DeltaB_FAC_V) in specifying the coordinate system, which is defined as: 'b'
along the model magnetic field; 'p' perpendicular, in the direction of B-
cross-vel_spacecraft, that is, across track; and 'v' nominally along the
spacecraft velocity vector, along track, completing the triad v-p-b.
Detrended (DeltaB) data have bad data deleted, DEL_MAG_FLAG = 1."

DeltaB_FAC_SP
-------------
Attribute Entries:
     CATDESC         (CDF_CHAR/46): "DeltaB in Field-Aligned/Spin Plane
Coordinates"
     DEPEND_0        (CDF_CHAR/5): "Epoch"
     DEPEND_1        (CDF_CHAR/15): "Vector_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/13): "DeltaB_FAC_SP"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/13): "DeltaB_FAC_SP"
     LABL_PTR_1      (CDF_CHAR/20): "DeltaB_FAC_SP_LABL_1"
     UNITS           (CDF_CHAR/2): "nT"
     VALIDMIN        (CDF_REAL4/3): -100000.0, -100000.0, -100000.0
     VALIDMAX        (CDF_REAL4/3): 100000.0, 100000.0, 100000.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/1485): "DeltaB in Field-Aligned/Spin Plane
Coordinates. Model Magnetic Field is IGRF version 11. Field-aligned/spin
plane coordinates use the spin plane (hence DeltaB_FAC_SP) in specifying the
coordinate system, which is defined as: 'b' along the model magnetic field;
's' in the spin-axis cross model B direction, that is, in the spin-plane and
perpendicular to the model field; and 'p' perpendicular (B x (spin-axis x
B)), nominally along the spin-axis, completing the triad s-p-b. The spin-
plane coordinate 's' is in the same direction as the despun electric field "E
along V" component. Note that "E along V" is nominally along the spacecraft
velocity only in the northern hemisphere, and is nominally anti-parallel to
the spacecraft velocity vector in the southern hemisphere. The "E along V"
electric field crossed with the p-component of "deltaB_FAC_SP" contributes to
the field-aligned Poynting flux. In this s-p-b coordinate system, positive
field-aligned Poynting flux is into the northern ionosphere, but away from
the southern ionosphere. The other contribution to the field-aligned Poynting
flux would be from the p-component of the electric field crossed with the s-
component of the DeltaB magnetic field, but the p-component of the electric
field is mainly given by the spin-axis electric field measurement. Because
one of the axial booms did not deploy on FAST the spin-axis electric field is
generally not used. Detrended (DeltaB) data have bad data deleted,
DEL_MAG_FLAG = 1."
```

```
B_GEI
-----
Attribute Entries:
     CATDESC         (CDF_CHAR/65): "Full Magnetic Field in Geocentric
Equatorial Inertial Coordinates"
     DEPEND_0        (CDF_CHAR/5): "Epoch"
     DEPEND_1        (CDF_CHAR/15): "Vector_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/5): "B_GEI"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/5): "B_GEI"
     LABL_PTR_1      (CDF_CHAR/12): "B_GEI_LABL_1"
     UNITS           (CDF_CHAR/2): "nT"
     VALIDMIN        (CDF_REAL4/3): -1.0e+08, -1.0e+08, -1.0e+08
     VALIDMAX        (CDF_REAL4/3): 1.0e+08, 1.0e+08, 1.0e+08
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/139): "Full (non-detrended) magnetometer data
in Geocentric Equatorial Inertial coordinates, with bad data deleted,
indicated by DEL_MAG_FLAG = 1."

DEL_MAG_FLAG
------------
Attribute Entries:
     CATDESC         (CDF_CHAR/30): "Magnetometer Deleted Data Flag"
     DEPEND_0        (CDF_CHAR/5): "Epoch"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/12): "DEL_MAG_FLAG"
     FILLVAL         (CDF_INT4/1): -2147483648
     FORMAT          (CDF_CHAR/2): "I8"
     LABLAXIS        (CDF_CHAR/12): "DEL_MAG_FLAG"
     VALIDMIN        (CDF_INT4/1): 0
     VALIDMAX        (CDF_INT4/1): 1
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/137): "Flags data that have been deleted in
B_GEI and detrended (DeltaB) data, or should be deleted from the non-
detrended B_DSC and B_SSC data."

Torquer
-------
Attribute Entries:
     CATDESC         (CDF_CHAR/18): "Torquer Coil Field"
     DEPEND_0        (CDF_CHAR/5): "Epoch"
     DEPEND_1        (CDF_CHAR/15): "Vector_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/7): "Torquer"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/7): "Torquer"
     LABL_PTR_1      (CDF_CHAR/14): "Torquer_LABL_1"
     UNITS           (CDF_CHAR/9): "pseudo-nT"
     VALIDMIN        (CDF_REAL4/3): -1.0e+08, -1.0e+08, -1.0e+08
     VALIDMAX        (CDF_REAL4/3): 1.0e+08, 1.0e+08, 1.0e+08
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
```

```
     VAR_NOTES       (CDF_CHAR/143): "Estimated torquer coil magnetic field,
in spinning spacecraft coordinates. Units are pseudo nT since field is
estimated with intermediate data."

Tweaker
-------
Attribute Entries:
     CATDESC         (CDF_CHAR/27): "Time-Varying Tweaker Matrix"
     DEPEND_0        (CDF_CHAR/5): "Epoch"
     DEPEND_1        (CDF_CHAR/16): "Tweaker_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/7): "Tweaker"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/7): "Tweaker"
     LABL_PTR_1      (CDF_CHAR/14): "Tweaker_LABL_1"
     VALIDMIN        (CDF_REAL4/1): -1000.0
     VALIDMAX        (CDF_REAL4/1): 1000.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/630): "Time-varying tweaker matrix that gives
final orthogonalization and removes spin-plane offsets. Tweaker takes into
account on-orbit variations caused by eclipse entry, etc.
TW_ZX is used to remove from the z-sensor any spin-tone signals in phase with
the x-sensor.
TW_ZY is used to remove from the z-sensor any spin-tone signals in phase with
the y-sensor.
TW_YY is used to make the y-sensor have the same gain as the x-sensor.
TW_YX is used to remove from the y-sensor any spin-tone signals in phase with
the x-sensor.
O_X is used to remove any DC offsets from the x-sensor.
O_Y is used to remove any DC offsets from the y-sensor."

MAG_QUAL_FLAG
-------------
Attribute Entries:
     CATDESC         (CDF_CHAR/30): "Magnetometer Data Quality Flag"
     DEPEND_0        (CDF_CHAR/5): "Epoch"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/13): "MAG_QUAL_FLAG"
     FILLVAL         (CDF_INT4/1): -2147483648
     FORMAT          (CDF_CHAR/2): "I8"
     LABLAXIS        (CDF_CHAR/13): "MAG_QUAL_FLAG"
     UNITS           (CDF_CHAR/7): "OK<2048"
     VALIDMIN        (CDF_INT4/1): 0
     VALIDMAX        (CDF_INT4/1): 4096
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/604): "The Magnetometer Data Quality Flags are
additive. Flag values 1 - 16 are Torquer and other data processing flags.
Flag values 32 - 2048 are Spin phase related flags. Any data with a flag
value 2048 or greater should be used with care.

Flag values:

0    good;
1    Torquers on;
2    Torquer ramp;
```

```
4    Nutation [TBD];
8    RESERVED;
16   RESERVED;
32   spin phase object set to zero;
64   in eclipse (using nadir table);
128  RESERVED;
256  RESERVED;
512  spin phase data not smoothed;
1024 spin phase data patched with nadir or Mission Unique Electronics (MUE)
phase data;
2048 Missing spin phase data."

B_DSC
-----
Attribute Entries:
     CATDESC         (CDF_CHAR/52): "Full Magnetic Field in Despun Spacecraft
Coordinates"
     DEPEND_0        (CDF_CHAR/5): "Epoch"
     DEPEND_1        (CDF_CHAR/15): "Vector_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/5): "B_DSC"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/5): "B_DSC"
     LABL_PTR_1      (CDF_CHAR/12): "B_DSC_LABL_1"
     UNITS           (CDF_CHAR/2): "nT"
     VALIDMIN        (CDF_REAL4/3): -1.0e+08, -1.0e+08, -1.0e+08
     VALIDMAX        (CDF_REAL4/3): 1.0e+08, 1.0e+08, 1.0e+08
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/238): "Full (non-detrended) magnetometer data
in Despun Spacecraft Coordinates (DSC), with bad data included, indicated by
DEL_MAG_FLAG = 1. Despun Spacecraft Coordinates have the z-axis along the
nominal spin axis, and the Sun in the x-z plane."

B_SSC
-----
Attribute Entries:
     CATDESC         (CDF_CHAR/54): "Full Magnetic Field in Spinning
Spacecraft Coordinates"
     DEPEND_0        (CDF_CHAR/5): "Epoch"
     DEPEND_1        (CDF_CHAR/15): "Vector_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/5): "B_SSC"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/5): "B_SSC"
     LABL_PTR_1      (CDF_CHAR/12): "B_SSC_LABL_1"
     UNITS           (CDF_CHAR/2): "nT"
     VALIDMIN        (CDF_REAL4/3): -1.0e+08, -1.0e+08, -1.0e+08
     VALIDMAX        (CDF_REAL4/3): 1.0e+08, 1.0e+08, 1.0e+08
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/135): "Full (non-detrended) magnetometer data
in Spinning Spacecraft Coordinates (SSC), with bad data included, indicated
by DEL_MAG_FLAG = 1."

Bharmonic_DSC
```

```
-------------
Attribute Entries:
     CATDESC         (CDF_CHAR/74): "Removed Magnetic Field Spin-Tone
Harmonic in Despun Spacecraft Coordinates"
     DEPEND_0        (CDF_CHAR/5): "Epoch"
     DEPEND_1        (CDF_CHAR/15): "Vector_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/13): "Bharmonic_DSC"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/13): "Bharmonic_DSC"
     LABL_PTR_1      (CDF_CHAR/20): "Bharmonic_DSC_LABL_1"
     UNITS           (CDF_CHAR/2): "nT"
     VALIDMIN        (CDF_REAL4/3): -1.0e+08, -1.0e+08, -1.0e+08
     VALIDMAX        (CDF_REAL4/3): 1.0e+08, 1.0e+08, 1.0e+08
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/109): "Magnetic field spin-tone harmonic in
Despun Spacecraft Coordinates (DSC). Bad data removed, DEL_MAG_FLAG = 1."

Spin_Epoch
----------
Attribute Entries:
     CATDESC         (CDF_CHAR/51): "Default Time for Spin Phase and Spin
Frequency Data"
     FIELDNAM        (CDF_CHAR/10): "Spin_Epoch"
     FILLVAL         (CDF_TT2000/1): 9999-12-31T23:59:59.999999999
     LABLAXIS        (CDF_CHAR/10): "Spin_Epoch"
     UNITS           (CDF_CHAR/2): "ns"
     VALIDMIN        (CDF_TT2000/1): 1990-01-01T00:00:00.000000000
     VALIDMAX        (CDF_TT2000/1): 2029-12-31T23:59:59.999999999
     VAR_TYPE        (CDF_CHAR/12): "support_data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/127): "Time is specified as a TT2000 variable.
Conversion to TT2000 assumes the UTC as given by the FAST data decommutator
is correct."
     MONOTON         (CDF_CHAR/8): "INCREASE"
     TIME_BASE       (CDF_CHAR/5): "J2000"
     TIME_SCALE      (CDF_CHAR/16): "Terrestrial Time"
     REFERENCE_POSITION (CDF_CHAR/20): "Rotating Earth Geoid"

Spin_Freq
---------
Attribute Entries:
     CATDESC         (CDF_CHAR/14): "Spin Frequency"
     DEPEND_0        (CDF_CHAR/10): "Spin_Epoch"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/14): "Spin Frequency"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/9): "Spin_Freq"
     UNITS           (CDF_CHAR/5): "deg/s"
     VALIDMIN        (CDF_REAL4/1): -1000.0
     VALIDMAX        (CDF_REAL4/1): 1000.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/62): "Spacecraft spin frequency at the time
specified by Spin_Epoch."
```

```
Spin_Phase
----------
Attribute Entries:
     CATDESC         (CDF_CHAR/10): "Spin Phase"
     DEPEND_0        (CDF_CHAR/10): "Spin_Epoch"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/10): "Spin Phase"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/10): "Spin_Phase"
     UNITS           (CDF_CHAR/3): "deg"
     VALIDMIN        (CDF_REAL4/1): -1080.0
     VALIDMAX        (CDF_REAL4/1): 1080.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/99): "Phase angle of the magnetometer x-axis
with respect to the Sun at the time specified by Spin_Epoch."

Ephemeris_Epoch
---------------
Attribute Entries:
     CATDESC         (CDF_CHAR/26): "Default Time for Ephemeris"
     FIELDNAM        (CDF_CHAR/15): "Ephemeris_Epoch"
     FILLVAL         (CDF_TT2000/1): 9999-12-31T23:59:59.999999999
     LABLAXIS        (CDF_CHAR/15): "Ephemeris_Epoch"
     UNITS           (CDF_CHAR/2): "ns"
     VALIDMIN        (CDF_TT2000/1): 1990-01-01T00:00:00.000000000
     VALIDMAX        (CDF_TT2000/1): 2029-12-31T23:59:59.999999999
     VAR_TYPE        (CDF_CHAR/12): "support_data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/188): "Time is specified as a TT2000 variable.
Conversion to TT2000 assumes the UTC as given by the FAST data decommutator
is correct. Ephemeris data are usually provided with a 1-second cadence."
     MONOTON         (CDF_CHAR/8): "INCREASE"
     TIME_BASE       (CDF_CHAR/5): "J2000"
     TIME_SCALE      (CDF_CHAR/16): "Terrestrial Time"
     REFERENCE_POSITION (CDF_CHAR/20): "Rotating Earth Geoid"

Orbit
-----
Attribute Entries:
     CATDESC         (CDF_CHAR/17): "FAST Orbit Number"
     DEPEND_0        (CDF_CHAR/15): "Ephemeris_Epoch"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/5): "Orbit"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/5): "Orbit"
     VALIDMIN        (CDF_REAL4/1): 0.0
     VALIDMAX        (CDF_REAL4/1): 99999.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/104): "Orbit number as specified by the FAST
ephemeris software, together with the other ephemeris information."

pos_gei
-------
```

```
Attribute Entries:
     CATDESC         (CDF_CHAR/65): "Spacecraft Position in Geocentric
Equatorial Inertial Coordinates"
     DEPEND_0        (CDF_CHAR/15): "Ephemeris_Epoch"
     DEPEND_1        (CDF_CHAR/15): "Vector_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/7): "pos_gei"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/7): "pos_gei"
     LABL_PTR_1      (CDF_CHAR/14): "pos_gei_LABL_1"
     UNITS           (CDF_CHAR/2): "km"
     VALIDMIN        (CDF_REAL4/3): -1.0e+08, -1.0e+08, -1.0e+08
     VALIDMAX        (CDF_REAL4/3): 1.0e+08, 1.0e+08, 1.0e+08
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/71): "FAST spacecraft position in Geocentric
Equatorial Inertial coordinates."

vel_gei
-------
Attribute Entries:
     CATDESC         (CDF_CHAR/65): "Spacecraft Velocity in Geocentric
Equatorial Inertial Coordinates"
     DEPEND_0        (CDF_CHAR/15): "Ephemeris_Epoch"
     DEPEND_1        (CDF_CHAR/15): "Vector_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/7): "vel_gei"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/7): "vel_gei"
     LABL_PTR_1      (CDF_CHAR/14): "vel_gei_LABL_1"
     UNITS           (CDF_CHAR/4): "km/s"
     VALIDMIN        (CDF_REAL4/3): -1.0e+08, -1.0e+08, -1.0e+08
     VALIDMAX        (CDF_REAL4/3): 1.0e+08, 1.0e+08, 1.0e+08
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/71): "FAST spacecraft velocity in Geocentric
Equatorial Inertial coordinates."

B_model_gei
-----------
Attribute Entries:
     CATDESC         (CDF_CHAR/66): "Model Magnetic Field in Geocentric
Equatorial Inertial Coordinates"
     DEPEND_0        (CDF_CHAR/15): "Ephemeris_Epoch"
     DEPEND_1        (CDF_CHAR/15): "Vector_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/11): "B_model_gei"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/11): "B_model_gei"
     LABL_PTR_1      (CDF_CHAR/18): "B_model_gei_LABL_1"
     UNITS           (CDF_CHAR/2): "nT"
     VALIDMIN        (CDF_REAL4/3): -1.0e+08, -1.0e+08, -1.0e+08
     VALIDMAX        (CDF_REAL4/3): 1.0e+08, 1.0e+08, 1.0e+08
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
```

```
     VAR_NOTES       (CDF_CHAR/112): "Model magnetic field (IGRF version 11
at the date of acquisition) in Geocentric Equatorial Inertial coordinates."

alt
---
Attribute Entries:
     CATDESC         (CDF_CHAR/36): "FAST Altitude Relative to 6378.14 km"
     DEPEND_0        (CDF_CHAR/15): "Ephemeris_Epoch"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/8): "Altitude"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/8): "Altitude"
     UNITS           (CDF_CHAR/2): "km"
     VALIDMIN        (CDF_REAL4/1): 0.0
     VALIDMAX        (CDF_REAL4/1): 99999.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/105): "FAST altitude with respect to Earth
equatorial radius (6378.14 km), not mean radius or geodetic altitude."

lat
---
Attribute Entries:
     CATDESC         (CDF_CHAR/24): "FAST Geographic Latitude"
     DEPEND_0        (CDF_CHAR/15): "Ephemeris_Epoch"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/8): "Latitude"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/8): "Latitude"
     UNITS           (CDF_CHAR/3): "deg"
     VALIDMIN        (CDF_REAL4/1): -90.0
     VALIDMAX        (CDF_REAL4/1): 90.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/104): "FAST geographic latitude with respect
to sphere with Earth equatorial radius (6378.14 km), not geodetic."

lng
---
Attribute Entries:
     CATDESC         (CDF_CHAR/25): "FAST Geographic Longitude"
     DEPEND_0        (CDF_CHAR/15): "Ephemeris_Epoch"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/9): "Longitude"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/9): "Longitude"
     UNITS           (CDF_CHAR/3): "deg"
     VALIDMIN        (CDF_REAL4/1): -180.0
     VALIDMAX        (CDF_REAL4/1): 180.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/105): "FAST geographic longitude with respect
to sphere with Earth equatorial radius (6378.14 km), not geodetic."

ilat
```

```
----
Attribute Entries:
     CATDESC         (CDF_CHAR/23): "FAST Invariant Latitude"
     DEPEND_0        (CDF_CHAR/15): "Ephemeris_Epoch"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/4): "ILAT"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/4): "ILAT"
     UNITS           (CDF_CHAR/3): "deg"
     VALIDMIN        (CDF_REAL4/1): -90.0
     VALIDMAX        (CDF_REAL4/1): 90.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/294): "FAST invariant latitude (ILAT)
calculated with respect to offset tilted dipole. Dipole geographic position:
[-402.199, 287.504, 195.908] km; Dipole orientation: latitude 79.3637
degrees, longitude 288.454 degrees. Invariant latitude defined using 6371.2
km radius with respect to dipole origin."

ilng
----
Attribute Entries:
     CATDESC         (CDF_CHAR/24): "FAST Invariant Longitude"
     DEPEND_0        (CDF_CHAR/15): "Ephemeris_Epoch"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/4): "ILNG"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/4): "ILNG"
     UNITS           (CDF_CHAR/3): "deg"
     VALIDMIN        (CDF_REAL4/1): -180.0
     VALIDMAX        (CDF_REAL4/1): 180.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/214): "FAST invariant longitude (ILNG)
calculated with respect to offset tilted dipole. Dipole geographic position:
[-402.199, 287.504, 195.908] km; Dipole orientation: latitude 79.3637
degrees, longitude 288.454 degrees."

mlt
---
Attribute Entries:
     CATDESC         (CDF_CHAR/24): "FAST Magnetic Local Time"
     DEPEND_0        (CDF_CHAR/15): "Ephemeris_Epoch"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/3): "MLT"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/3): "MLT"
     UNITS           (CDF_CHAR/4): "hour"
     VALIDMIN        (CDF_REAL4/1): 0.0
     VALIDMAX        (CDF_REAL4/1): 24.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/230): "FAST magnetic local time (MLT)
calculated from ILNG, which in turn uses an offset tilted dipole. Dipole
```

```
geographic position: [-402.199, 287.504, 195.908] km; Dipole orientation:
latitude 79.3637 degrees, longitude 288.454 degrees."

flat
----
Attribute Entries:
     CATDESC         (CDF_CHAR/32): "FAST Magnetic Footprint Latitude"
     DEPEND_0        (CDF_CHAR/15): "Ephemeris_Epoch"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/4): "FLAT"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/4): "FLAT"
     UNITS           (CDF_CHAR/3): "deg"
     VALIDMIN        (CDF_REAL4/1): -90.0
     VALIDMAX        (CDF_REAL4/1): 90.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/224): "Latitude of FAST magnetic footprint at
100 km altitude (geodetic coordinates). IGRF Version 7 used for magnetic
field model (IGRF Version 7 is the default in the field-line tracing code).
Latitude is in geodetic coordinates."

flng
----
Attribute Entries:
     CATDESC         (CDF_CHAR/33): "FAST Magnetic Footprint Longitude"
     DEPEND_0        (CDF_CHAR/15): "Ephemeris_Epoch"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/4): "FLNG"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/4): "FLNG"
     UNITS           (CDF_CHAR/3): "deg"
     VALIDMIN        (CDF_REAL4/1): -180.0
     VALIDMAX        (CDF_REAL4/1): 180.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/221): "Longitude of magnetic footprint at 100
km altitude (geodetic coordinates). IGRF Version 7 used for magnetic field
model (IGRF Version 7 is the default in the field-line tracing code).
Longitude is in geodetic coordinates."

B_foot_gei
----------
Attribute Entries:
     CATDESC         (CDF_CHAR/70): "Footprint Magnetic Field in Geocentric
Equatorial Inertial Coordinates"
     DEPEND_0        (CDF_CHAR/15): "Ephemeris_Epoch"
     DEPEND_1        (CDF_CHAR/15): "Vector_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/10): "B_foot_gei"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/10): "B_foot_gei"
     LABL_PTR_1      (CDF_CHAR/17): "B_foot_gei_LABL_1"
     UNITS           (CDF_CHAR/2): "nT"
     VALIDMIN        (CDF_REAL4/3): -1.0e+08, -1.0e+08, -1.0e+08
```

```
     VALIDMAX        (CDF_REAL4/3): 1.0e+08, 1.0e+08, 1.0e+08
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/169): "IGRF Version 7 model magnetic field at
the position specified by FLAT, FLNG, and 100 km altitude geodetic (IGRF
Version 7 is the default in the field-line tracing code)."

sun_dir_gei
-----------
Attribute Entries:
     CATDESC         (CDF_CHAR/59): "Sun Direction in Geocentric Equatorial
Inertial Coordinates"
     DEPEND_0        (CDF_CHAR/15): "Ephemeris_Epoch"
     DEPEND_1        (CDF_CHAR/15): "Vector_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/11): "sun_dir_gei"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/11): "sun_dir_gei"
     LABL_PTR_1      (CDF_CHAR/18): "sun_dir_gei_LABL_1"
     VALIDMIN        (CDF_REAL4/3): -1.0, -1.0, -1.0
     VALIDMAX        (CDF_REAL4/3): 1.0, 1.0, 1.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/215): "This unit vector is used to construct
the despun spacecraft to Geocentric Equatorial Inertial coordinate
transformation. This unit vector is also used to generate the GEI to Solar
Magnetic coordinate transformation."

dip_orient_gei
--------------
Attribute Entries:
     CATDESC         (CDF_CHAR/64): "Dipole Orientation in Geocentric
Equatorial Inertial Coordinates"
     DEPEND_0        (CDF_CHAR/15): "Ephemeris_Epoch"
     DEPEND_1        (CDF_CHAR/15): "Vector_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/14): "dip_orient_gei"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/14): "dip_orient_gei"
     LABL_PTR_1      (CDF_CHAR/21): "dip_orient_gei_LABL_1"
     VALIDMIN        (CDF_REAL4/3): -1.0, -1.0, -1.0
     VALIDMAX        (CDF_REAL4/3): 1.0, 1.0, 1.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/279): "Unit vector giving dipole orientation
in Geocentric Equatorial Inertial coordinates. Dipole specified by the g10,
g11, and h11 values of the IGRF 11 model, using the center time of the orbit
as the reference epoch. Used to generate GEI to Solar Magnetic coodinate
transformation."

DeltaB_DSC_LABL_1
-----------------
Attribute Entries:
     CATDESC         (CDF_CHAR/16): "DeltaB_DSC label"
     FIELDNAM        (CDF_CHAR/17): "DeltaB_DSC_LABL_1"
     FORMAT          (CDF_CHAR/3): "A25"
```

```
     LABLAXIS        (CDF_CHAR/17): "DeltaB_DSC_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

DeltaB_GEI_LABL_1
-----------------
Attribute Entries:
     CATDESC         (CDF_CHAR/16): "DeltaB_GEI label"
     FIELDNAM        (CDF_CHAR/17): "DeltaB_GEI_LABL_1"
     FORMAT          (CDF_CHAR/3): "A25"
     LABLAXIS        (CDF_CHAR/17): "DeltaB_GEI_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

DeltaB_SM_LABL_1
----------------
Attribute Entries:
     CATDESC         (CDF_CHAR/15): "DeltaB_SM label"
     FIELDNAM        (CDF_CHAR/16): "DeltaB_SM_LABL_1"
     FORMAT          (CDF_CHAR/3): "A25"
     LABLAXIS        (CDF_CHAR/16): "DeltaB_SM_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

DeltaB_FAC_LABL_1
-----------------
Attribute Entries:
     CATDESC         (CDF_CHAR/16): "DeltaB_FAC label"
     FIELDNAM        (CDF_CHAR/17): "DeltaB_FAC_LABL_1"
     FORMAT          (CDF_CHAR/3): "A25"
     LABLAXIS        (CDF_CHAR/17): "DeltaB_FAC_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

DeltaB_FAC_V_LABL_1
-------------------
Attribute Entries:
     CATDESC         (CDF_CHAR/18): "DeltaB_FAC_V label"
     FIELDNAM        (CDF_CHAR/19): "DeltaB_FAC_V_LABL_1"
     FORMAT          (CDF_CHAR/3): "A25"
     LABLAXIS        (CDF_CHAR/19): "DeltaB_FAC_V_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

DeltaB_FAC_SP_LABL_1
--------------------
Attribute Entries:
     CATDESC         (CDF_CHAR/19): "DeltaB_FAC_SP label"
     FIELDNAM        (CDF_CHAR/20): "DeltaB_FAC_SP_LABL_1"
     FORMAT          (CDF_CHAR/3): "A25"
     LABLAXIS        (CDF_CHAR/20): "DeltaB_FAC_SP_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

B_GEI_LABL_1
------------
Attribute Entries:
     CATDESC         (CDF_CHAR/11): "B_GEI label"
     FIELDNAM        (CDF_CHAR/12): "B_GEI_LABL_1"
     FORMAT          (CDF_CHAR/3): "A25"
     LABLAXIS        (CDF_CHAR/12): "B_GEI_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

B_DSC_LABL_1
```

```
------------
Attribute Entries:
     CATDESC         (CDF_CHAR/11): "B_DSC label"
     FIELDNAM        (CDF_CHAR/12): "B_DSC_LABL_1"
     FORMAT          (CDF_CHAR/3): "A25"
     LABLAXIS        (CDF_CHAR/12): "B_DSC_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

B_SSC_LABL_1
------------
Attribute Entries:
     CATDESC         (CDF_CHAR/11): "B_SSC label"
     FIELDNAM        (CDF_CHAR/12): "B_SSC_LABL_1"
     FORMAT          (CDF_CHAR/3): "A25"
     LABLAXIS        (CDF_CHAR/12): "B_SSC_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

Bharmonic_DSC_LABL_1
--------------------
Attribute Entries:
     CATDESC         (CDF_CHAR/19): "Bharmonic_DSC label"
     FIELDNAM        (CDF_CHAR/20): "Bharmonic_DSC_LABL_1"
     FORMAT          (CDF_CHAR/3): "A25"
     LABLAXIS        (CDF_CHAR/20): "Bharmonic_DSC_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

Torquer_LABL_1
--------------
Attribute Entries:
     CATDESC         (CDF_CHAR/13): "Torquer label"
     FIELDNAM        (CDF_CHAR/14): "Torquer_LABL_1"
     FORMAT          (CDF_CHAR/3): "A25"
     LABLAXIS        (CDF_CHAR/14): "Torquer_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

Tweaker_LABL_1
--------------
Attribute Entries:
     CATDESC         (CDF_CHAR/13): "Tweaker label"
     FIELDNAM        (CDF_CHAR/14): "Tweaker_LABL_1"
     FORMAT          (CDF_CHAR/3): "A23"
     LABLAXIS        (CDF_CHAR/14): "Tweaker_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

pos_gei_LABL_1
--------------
Attribute Entries:
     CATDESC         (CDF_CHAR/13): "pos_gei label"
     FIELDNAM        (CDF_CHAR/14): "pos_gei_LABL_1"
     FORMAT          (CDF_CHAR/3): "A23"
     LABLAXIS        (CDF_CHAR/14): "pos_gei_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

vel_gei_LABL_1
--------------
Attribute Entries:
     CATDESC         (CDF_CHAR/13): "vel_gei label"
     FIELDNAM        (CDF_CHAR/14): "vel_gei_LABL_1"
```

```
     FORMAT          (CDF_CHAR/3): "A23"
     LABLAXIS        (CDF_CHAR/14): "vel_gei_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

B_model_gei_LABL_1
------------------
Attribute Entries:
     CATDESC         (CDF_CHAR/17): "B_model_gei label"
     FIELDNAM        (CDF_CHAR/18): "B_model_gei_LABL_1"
     FORMAT          (CDF_CHAR/3): "A23"
     LABLAXIS        (CDF_CHAR/18): "B_model_gei_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

B_foot_gei_LABL_1
-----------------
Attribute Entries:
     CATDESC         (CDF_CHAR/16): "B_foot_gei label"
     FIELDNAM        (CDF_CHAR/17): "B_foot_gei_LABL_1"
     FORMAT          (CDF_CHAR/3): "A23"
     LABLAXIS        (CDF_CHAR/17): "B_foot_gei_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

sun_dir_gei_LABL_1
------------------
Attribute Entries:
     CATDESC         (CDF_CHAR/17): "sun_dir_gei label"
     FIELDNAM        (CDF_CHAR/18): "sun_dir_gei_LABL_1"
     FORMAT          (CDF_CHAR/3): "A27"
     LABLAXIS        (CDF_CHAR/18): "sun_dir_gei_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

dip_orient_gei_LABL_1
---------------------
Attribute Entries:
     CATDESC         (CDF_CHAR/20): "dip_orient_gei label"
     FIELDNAM        (CDF_CHAR/21): "dip_orient_gei_LABL_1"
     FORMAT          (CDF_CHAR/3): "A27"
     LABLAXIS        (CDF_CHAR/21): "dip_orient_gei_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

Orbit_Fixed_Epoch
-----------------
Attribute Entries:
     CATDESC         (CDF_CHAR/61): "Reference Time for Variables that are
Constant over the Orbit"
     FIELDNAM        (CDF_CHAR/17): "Orbit_Fixed_Epoch"
     FILLVAL         (CDF_TT2000/1): 9999-12-31T23:59:59.999999999
     LABLAXIS        (CDF_CHAR/17): "Orbit_Fixed_Epoch"
     UNITS           (CDF_CHAR/2): "ns"
     VALIDMIN        (CDF_TT2000/1): 1990-01-01T00:00:00.000000000
     VALIDMAX        (CDF_TT2000/1): 2029-12-31T23:59:59.999999999
     VAR_TYPE        (CDF_CHAR/12): "support_data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/207): "Time is specified as a TT2000 variable.
Conversion to TT2000 assumes the UTC as given by the FAST data decommutator
is correct. Orbit_Fixed_Epoch specified as the median time of the
Ephemeris_Epoch timespan."
     MONOTON         (CDF_CHAR/8): "INCREASE"
```

```
     TIME_BASE       (CDF_CHAR/5): "J2000"
     TIME_SCALE      (CDF_CHAR/16): "Terrestrial Time"
     REFERENCE_POSITION (CDF_CHAR/20): "Rotating Earth Geoid"

Orbit_Value
-----------
Attribute Entries:
     CATDESC         (CDF_CHAR/12): "Orbit Number"
     DEPEND_0        (CDF_CHAR/17): "Orbit_Fixed_Epoch"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/5): "Orbit"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/5): "Orbit"
     VALIDMIN        (CDF_REAL4/1): 0.0
     VALIDMAX        (CDF_REAL4/1): 99999.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/73): "Fixed value of the orbit number,
specified at the Orbit_Fixed_Epoch time."

Coupling_Matrix
---------------
Attribute Entries:
     CATDESC         (CDF_CHAR/15): "Coupling Matrix"
     DEPEND_0        (CDF_CHAR/17): "Orbit_Fixed_Epoch"
     DEPEND_1        (CDF_CHAR/15): "Matrix_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/15): "Coupling Matrix"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/15): "Coupling_Matrix"
     LABL_PTR_1      (CDF_CHAR/22): "Coupling_Matrix_LABL_1"
     VALIDMIN        (CDF_REAL4/1): -2.0
     VALIDMAX        (CDF_REAL4/1): 2.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/127): "Magnetometer coupling matrix
components, fixed values for the orbit. Coupling matrix components can change
from orbit to orbit."

Offsets
-------
Attribute Entries:
     CATDESC         (CDF_CHAR/20): "Magnetometer Offsets"
     DEPEND_0        (CDF_CHAR/17): "Orbit_Fixed_Epoch"
     DEPEND_1        (CDF_CHAR/15): "Vector_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/7): "Offsets"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/7): "Offsets"
     LABL_PTR_1      (CDF_CHAR/14): "Offsets_LABL_1"
     UNITS           (CDF_CHAR/2): "nT"
     VALIDMIN        (CDF_REAL4/3): -1000.0, -1000.0, -1000.0
     VALIDMAX        (CDF_REAL4/3): 1000.0, 1000.0, 1000.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
```

```
     VAR_NOTES       (CDF_CHAR/89): "Magnetometer offsets, fixed values for
the orbit. Offsets can change from orbit to orbit."

Spin_Axis
---------
Attribute Entries:
     CATDESC         (CDF_CHAR/41): "Spin Axis Right Ascension and
Declination"
     DEPEND_0        (CDF_CHAR/17): "Orbit_Fixed_Epoch"
     DEPEND_1        (CDF_CHAR/18): "Spin_Axis_DEPEND_1"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/9): "Spin Axis"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/9): "Spin_Axis"
     LABL_PTR_1      (CDF_CHAR/16): "Spin_Axis_LABL_1"
     UNITS           (CDF_CHAR/3): "deg"
     VALIDMIN        (CDF_REAL4/1): -720.0
     VALIDMAX        (CDF_REAL4/1): 720.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/222): "Spin axis right ascension (RA) and
declination (DEC), obtained by comparing IGRF model field with data. The
parameters RA_FDF and DEC_FDF are the starting values for the initial
comparison (FDF = Flight Dynamics Facility)."

Spin_Phase_Delta
----------------
Attribute Entries:
     CATDESC         (CDF_CHAR/16): "Spin Phase Delta"
     DEPEND_0        (CDF_CHAR/17): "Orbit_Fixed_Epoch"
     DISPLAY_TYPE    (CDF_CHAR/11): "time_series"
     FIELDNAM        (CDF_CHAR/16): "Spin_Phase_Delta"
     FILLVAL         (CDF_REAL4/1): -1.0e+31
     FORMAT          (CDF_CHAR/5): "E12.2"
     LABLAXIS        (CDF_CHAR/16): "Spin_Phase_Delta"
     UNITS           (CDF_CHAR/3): "deg"
     VALIDMIN        (CDF_REAL4/1): -720.0
     VALIDMAX        (CDF_REAL4/1): 720.0
     VAR_TYPE        (CDF_CHAR/4): "data"
     SCALETYP        (CDF_CHAR/6): "linear"
     VAR_NOTES       (CDF_CHAR/156): "Angle by which the measured field leads
the model field in the spin-plane, before correction. Correction is to rotate
the measured field back by this angle."

Coupling_Matrix_LABL_1
----------------------
Attribute Entries:
     CATDESC         (CDF_CHAR/21): "Coupling Matrix label"
     FIELDNAM        (CDF_CHAR/22): "Coupling_Matrix_LABL_1"
     FORMAT          (CDF_CHAR/3): "A31"
     LABLAXIS        (CDF_CHAR/22): "Coupling_Matrix_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

Offsets_LABL_1
--------------
Attribute Entries:
     CATDESC         (CDF_CHAR/13): "Offsets label"
```

```
     FIELDNAM        (CDF_CHAR/14): "Offsets_LABL_1"
     FORMAT          (CDF_CHAR/3): "A23"
     LABLAXIS        (CDF_CHAR/14): "Offsets_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

Spin_Axis_LABL_1
----------------
Attribute Entries:
     CATDESC         (CDF_CHAR/15): "Spin_Axis label"
     FIELDNAM        (CDF_CHAR/16): "Spin_Axis_LABL_1"
     FORMAT          (CDF_CHAR/3): "A25"
     LABLAXIS        (CDF_CHAR/16): "Spin_Axis_LABL_1"
     VAR_TYPE        (CDF_CHAR/8): "metadata"

Tweaker_DEPEND_1
----------------
Attribute Entries:
     CATDESC         (CDF_CHAR/46): "Time-Varying Tweaker Matrix, Depend 1
Variable"
     FIELDNAM        (CDF_CHAR/15): "Tweaker Element"
     FILLVAL         (CDF_INT4/1): -2147483648
     FORMAT          (CDF_CHAR/2): "I8"
     LABLAXIS        (CDF_CHAR/15): "Tweaker Element"
     VALIDMIN        (CDF_INT4/1): 1
     VALIDMAX        (CDF_INT4/1): 6
     VAR_TYPE        (CDF_CHAR/12): "support_data"
     SCALETYP        (CDF_CHAR/6): "linear"

Spin_Axis_DEPEND_1
------------------
Attribute Entries:
     CATDESC         (CDF_CHAR/53): "Component Number for the Spin Axis,
Depend 1 Variable"
     FIELDNAM        (CDF_CHAR/21): "Spin Axis Comp Number"
     FILLVAL         (CDF_INT4/1): -2147483648
     FORMAT          (CDF_CHAR/2): "I8"
     LABLAXIS        (CDF_CHAR/21): "Spin Axis Comp Number"
     VALIDMIN        (CDF_INT4/1): 1
     VALIDMAX        (CDF_INT4/1): 4
     VAR_TYPE        (CDF_CHAR/12): "support_data"
     SCALETYP        (CDF_CHAR/6): "linear"

Matrix_DEPEND_1
---------------
Attribute Entries:
     CATDESC         (CDF_CHAR/31): "Element Number, Depend 1 Matrix"
     FIELDNAM        (CDF_CHAR/21): "Matrix Element Number"
     FILLVAL         (CDF_INT4/1): -2147483648
     FORMAT          (CDF_CHAR/2): "I8"
     LABLAXIS        (CDF_CHAR/21): "Matrix Element Number"
     VALIDMIN        (CDF_INT4/1): 1
     VALIDMAX        (CDF_INT4/1): 9
     VAR_TYPE        (CDF_CHAR/12): "support_data"
     SCALETYP        (CDF_CHAR/6): "linear"
```