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GEOTAIL Spacecraft Mission
EPIC/ICS Pulse Height Analysis (PHA) Data Product

File content, format and naming convention

Version 1.0

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Abstract

This document lists and describes the file content, format and naming convention for the GEOTAIL/EPIC/ICS Pulse Height Analysis (PHA) data product.

References

For additional information on ICS PHA measurements, consult the following references (Please note: nomenclature for some aspects of the instrument may differ in these various references):

Schlemm et al., 1990, EPIC Software Requirements and Data Definition Document for the ISTP Geotail Spacecraft, JHU/APL;

Schlemm et al., 1993, EPIC Instrument User's Guide, JHU/APL;

Nylund et al., 2016, Geotail Spacecraft Mission EPIC Ground-Based Data Conversions and Corrections, JHU/APL.

Williams et al., GEOTAIL energetic particles and ion composition instrument, ***J. Geomag. Geoelect., 46***, 39-57, 1994, doi:10.5636/jgg.46.39.

EPIC/ICS Pules Height Analysis Data Product

PHA Events Data Description

The ICS subsystem of the EPIC instrument produces Pulse Height Analysis (PHA) event information based upon analysis of individual detected particles. Up to 48 ICS PHA events are accumulates over two sequential spins (nominally 6 seconds) of the Geotail spacecraft.

The EPIC Data Processing Unit (DPU) can collect ICS PHA data in two different modes: a (rotating) priority mode and a FIFO mode. Each of these modes will be explained in detail.

Priority mode:

In priority mode, the mass bins of received particles are subdivided into four different energy levels and four different mass levels (the P, HE, M and H ranges). There are 16 possible combinations of energy and mass levels, which are the ICS PHA ranges.

For each two-spin period, the DPU tries to collect up to 3 event words from each PHA range and each sector, so a maximum of 3*16*16 = 768 PHA words are collected. To get an equal distribution over heads, the DPU will not accept more than two event words from either head for each sector and PHA range. The collected PHA words are stored in internal buffers.

Since only 48 PHA words can be transmitted every two spins, the four different energy levels and the four mass levels are assigned different priorities in every second spin and the DPU will always try to transmit high priority PHA words before others. The mass level priority rotates every second spin and wraps around after 2 spins * 4 priorities = 8 spins. Therefore, the energy level rotates every 8th spin such that all possible combinations are looped through within 8 spins * 4 priorities = 32 spins, which is called an EPIC Science Record.

In every second spin, the DPU tries to transmit 48 PHA words, three of each sector, from the presently highest priority PHA range. If there were not enough events collected in that range, events are taken from the range with the next-to-the-highest priority and so on.

Using an EPIC command, it is possible to stop priority rotation for mass and/or energy levels, so that high visibility can be given to any of the defined mass and/or energy levels.

FIFO mode:

During FIFO mode, there is no differentiation between PHA ranges. The DPU will store the first 48 event words it receives each sector, so a maximum of 48*16 = 768 PHA words are received during two spins.

Every second EDB, the DPU chooses the events to place in the telemetry stream by looping through the 16 sector buffers as often as it needs to fill the available telemetry space of 48 PHA words. The first loop would choose the first event received in every sector (if one was received), the second loop the second event and so on. So, if during every sector at least three events were received, the events would be equally distributed over sectors.

Schlemm et al. [1990; 1993] give additional information on this topic and shows which mass bins are assigned to the different PHA ranges.

PHA Data Product

The ICS PHA data are stored in ASCII (plain text), space-delimited, fixed-column format files. The day-long data files are named in the following form:

epic_ics_pha_*yyyyddd*.txt,

where *yyyy* is the year and *ddd* is the day of year of observation. Files do not exist for days without any data.

Each PHA data file starts with this line of titles for the 12 parameters on each line:

```
YYYY DOY HH MM SS.SS EDB SEC  TCh  ECh HD   TOF      Energy
```

These parameters are described in Table 1. Table 2 lists the first twenty lines from a PHA data file.

Through ground processing, this information is converted into one PHA data line per ICS PHA event. Each line contains the time, time of flight, energy, and flight direction of the particle. Specifically, PHA data lines provide the time of the particle event, and the particle's time of flight, in nsec, and energy, in keV. The data lines also contain the ICS look-direction sector in the equatorial spin plane (i.e., its azimuth) and in the polar detector plane (i.e., its elevation). For completeness, several additional PHA raw engineering measurements are included and explained in *Schlemm et al*. [1990; 1993] although they should not be of interest to general users.

Some PHA and counting rate event data contain incorrect information resulting from uncorrectable transmission errors which occurred during the downlink of the original raw telemetry from the Geotail spacecraft. Various attempts were made in ground processing to remove some of these instances; nonetheless, the processed PHA and rate data contain some erroneous values.

Figure 1 – Geotail Spacecraft and EPIC Sensor Azimuthal Geometries

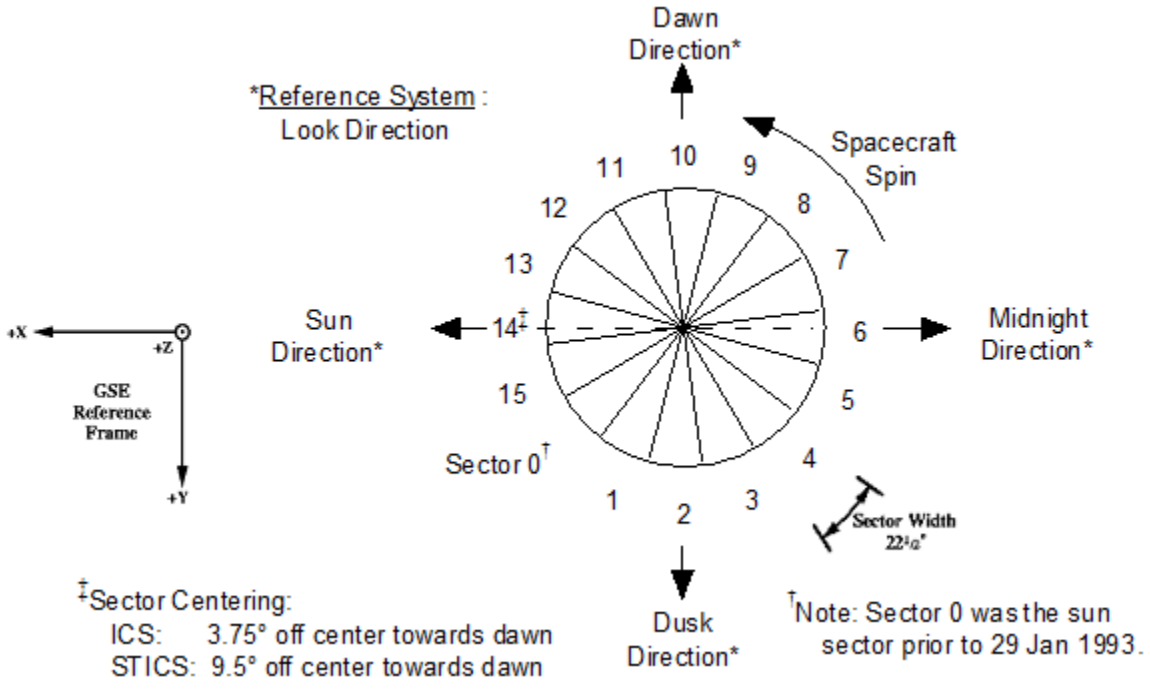

Figure 2 – EPIC ICS and STICS Sensor Polar Elevation Angles

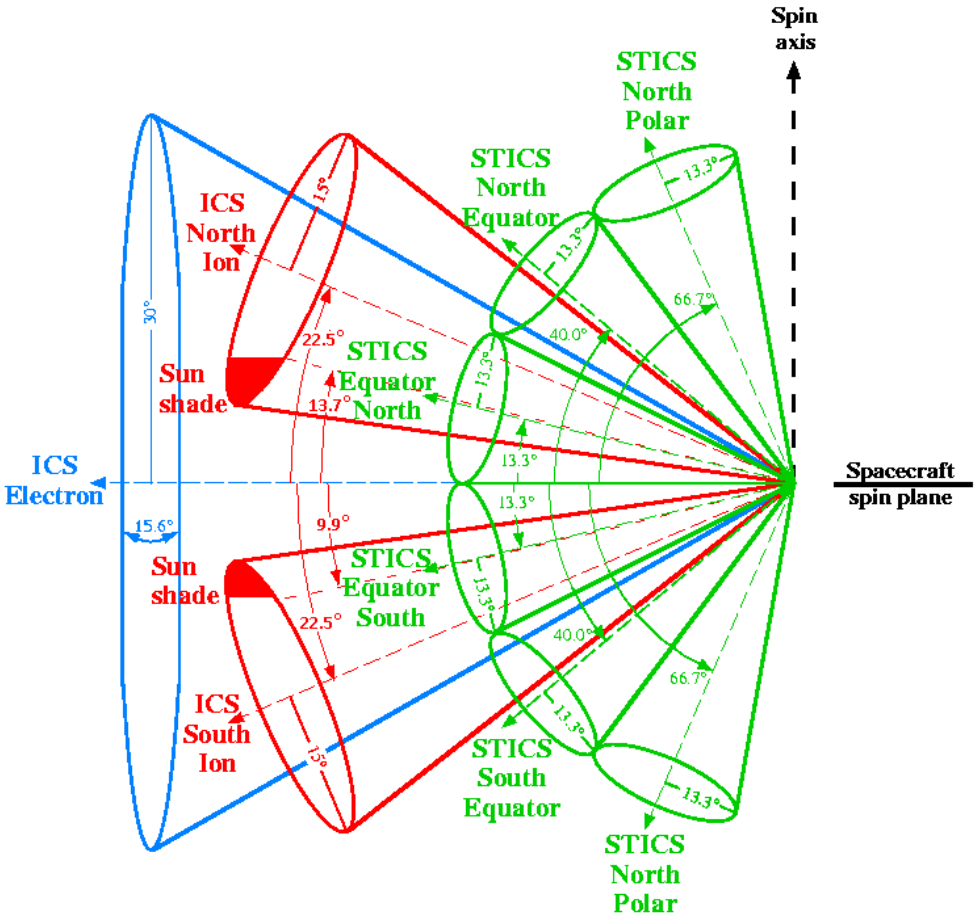

Figure 3 - ICS Energy vs. Time of Flight Diagram

Location of the 36 ICS species channels in the space of measured TOF vs. measured energy. In addition the location of the 16 single-parameter TOF (energy) channels is shown on the vertical (horizontal) axis.

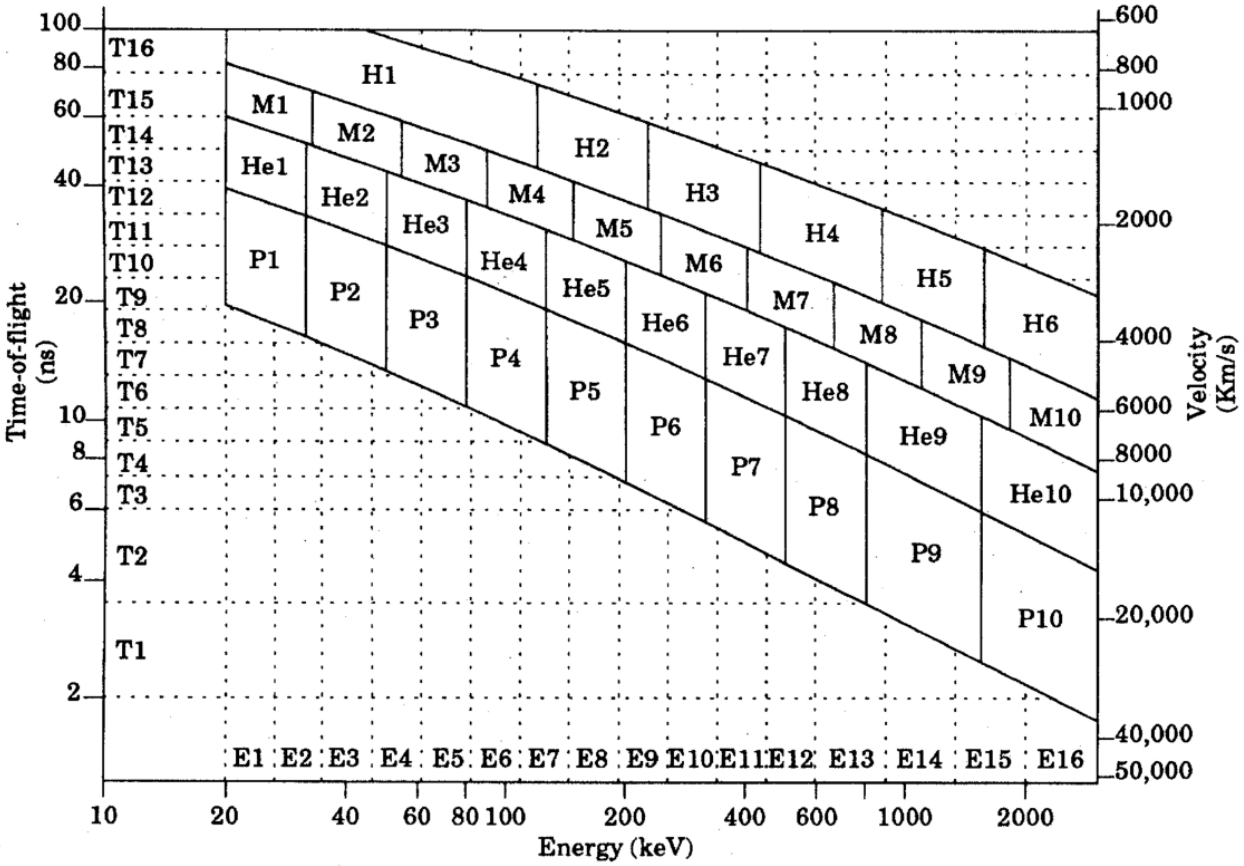

Table 1 – EPIC/ICS PHA File Content and Format

Column	Format	Parameter	Raw	Parameter description
1 - 4	I4	YYYY		Year
6 - 8	I3	DOY		Day of year
10 - 11	I2	HH		Hour
13 - 14	I2	MM		Minute
16 - 20	F5.2	SS.SS		Second
22 - 24	I3	EDB	Raw	Raw engineering data: Engineer Data Block number (range: 0-31).
27 - 28	I2	SEC		Sector of sensor's equatorial look-direction (range: 0-15, where, for most of the mission, 14 is sunward looking and 10 is dawn looking).
31 - 33	I3	TCh	Raw	Raw engineering data: Time-of-Flight channel number.
36 - 38	I3	ECh	Raw	Raw engineering data: Energy channel number.
40 - 41	I2	HD		Head (range: 0-1). This parameter indicates the sensor's polar head look-direction, where 0 is the North head, 1 is the South head.
45 - 50	F6.3	TOF		Particle time of flight [nsec]
53 - 69	F7.3	Energy		Particle energy [keV]

Table 2 – Sample EPIC/ICS PHA File Output

YYYY	DOY	HH	MM	SS.SS	EDB	SEC	TCh	ECh	HD	TOF	Energy
1993	365	00	02	2.37	10	15	530	9	1	46.158	33.750
1993	365	00	02	8.37	12	12	620	24	0	57.732	90.000
1993	365	00	02	8.37	12	9	311	48	0	17.995	180.000
1993	365	00	02	14.37	14	11	367	10	1	25.196	37.500
1993	365	00	02	20.37	16	14	674	11	0	64.676	41.250
1993	365	00	02	26.37	18	13	440	8	1	34.584	30.000
1993	365	00	02	56.37	28	14	359	45	0	24.167	168.750
1993	365	00	03	2.37	30	11	342	36	0	21.981	135.000
1993	365	00	03	2.37	30	11	342	9	0	21.981	33.750
1993	365	00	03	8.37	0	9	303	11	0	16.966	41.250
1993	365	00	03	26.37	6	14	762	14	0	75.993	52.500
1993	365	00	03	26.37	6	15	419	59	0	31.883	221.250
1993	365	00	03	32.37	8	0	931	13	0	97.727	48.750
1993	365	00	03	50.37	14	1	363	10	1	24.682	37.500
1993	365	00	04	2.37	18	9	284	302	0	14.522	1132.500
1993	365	00	04	14.37	22	14	593	10	1	54.260	37.500
1993	365	00	04	20.37	24	14	342	9	0	21.981	33.750
1993	365	00	04	32.37	28	0	406	17	0	30.212	63.750
1993	365	00	05	2.37	6	14	574	8	1	51.816	30.000

A sample graphical representation of one day of ICS PHA data is given in Figure 3.

Figure 3 - ICS Energy vs. Time of Flight Plot

Sample ICS PHA energy-vs.-time-of-flight plot for 1994/001/1159-2356.