

STEREO

SEP Low Energy Telescope (LET)

Level 1 Data Format

LET-Level1DataFormatB.doc
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Document Revision Record

Rev.	Date	Description of Change	Approved By
A	2002-Aug-28	First Draft	-
B	2002-Sep-20	Changed coordinate system for look-direction data to RTN. Added possibility of comma-delimited fields within records – another TBR item... Improved definition of timestamp – it now refers to the beginning of the time interval during which the data were collected in the sensor. Added year, day-of-year, hour&minute to timestamp (in addition to fractional year). Changed fill-data value from –9999.9 to -9999 (to allow for integer fields).	

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Table of Contents

Document Revision Record.....	ii
Distribution List.....	ii
1. Introduction.....	1
1.1. <i>Document Conventions.....</i>	<i>1</i>
1.2. <i>Applicable Documents.....</i>	<i>1</i>
1.3. <i>Acronyms.....</i>	<i>1</i>
2. LET Level 1 Data Description	2
2.1. <i>General Description.....</i>	<i>2</i>
2.2. <i>Physical Units and Coordinate Systems.....</i>	<i>2</i>
2.3. <i>Data for the full LET Geometry Factor (Unsectored Data).....</i>	<i>2</i>
2.4. <i>Sectored Data.....</i>	<i>3</i>
2.5. <i>Data Files and Formats.....</i>	<i>3</i>
2.5.1. File Format for Unsectored Data	4
2.5.2. File Format for Sectored Data.....	5
2.5.3. File Sizes	7

1. Introduction

This document defines the format of the Level 1 data for the SEP Low Energy Telescope (LET) sensors, to be delivered by Caltech to UCB on a regular schedule during the STEREO mission. Per the STEREO Phase A Report, “Level 1 data are also referred to as high (time) resolution data, and contain all of the measurements made by the IMPACT instruments in physical units.”

The document describes the data that will be included in LET Level 1 data files, the physical units of the data, the coordinate systems used, the format of the data files, and the predicted size of the files. Example fragments of data files are included.

LET calibration data and software for generating LET Level 1 data are not described, since these data and software will not be delivered by Caltech to UCB (at least until after the early shakedown phase of the mission).

1.1. *Document Conventions*

In this document, **TBD** (To Be Determined) means that no information currently exists. **TBR** (To Be Resolved) means that a statement is preliminary. In either case, the acronym is typically followed by the initials of those responsible for providing the information, or the responsible institution.

1.2. *Applicable Documents*

Some of these documents can be found on the Berkeley STEREO/IMPACT website: <http://sprg.ssl.berkeley.edu/impact/dwc/>. Others are currently available from Caltech SRL.

1. Phase A Report/PAIP (Performance Assurance Implementation Plan)
2. LET Science Data Frame Format Specification
3. IMPACT Performance Requirements
4. IMPACT Requirements Verification / Validation Plan

1.3. *Acronyms*

ACE	Advanced Composition Explorer
IMPACT	In situ Measurements of Particles and CME Transients
LET	Low Energy Telescope
SEP	Solar Energetic Particles
SIT	Suprathermal Ion Telescope
SEPT	Solar Electron Proton Telescope
SRL	Space Radiation Laboratory

2. LET Level 1 Data Description

2.1. General Description

Level 1 data for the two LET sensors (one sensor in each of the ahead and behind spacecraft) consist of intensities of solar energetic particles for various species. For each species, intensities for a number of energy intervals within an energy range are provided. These energy ranges and intervals are not necessarily the same for each species; however there are a large number of energy intervals that are common to most of the species provided. The intensities are provided as time-series, with one-minute averages.

The intensities referred to above are calculated using the full geometry factor of the LET instrument. For a subset of the species referred to above, intensities for a number of more narrowly defined look-directions (sectors) are also provided. The energy intervals over which sectorized data are provided are similar to the energy intervals provided for data calculated using the full geometry factor, but some energy intervals are combined in order to increase statistics and to conserve telemetry bandwidth.

2.2. Physical Units and Coordinate Systems

Particle intensities are provided in units of Particles/(cm² s sr MeV) for protons, and Particles/(cm² s sr MeV/nucleon) for species with $Z \geq 2$. Look-directions for sectorized data will be provided in the Radial Tangential Normal (RTN) coordinate system (**TBR, Caltech, in consultation with IMPACT team**). In this coordinate system the origin is centered at the spacecraft, R is from the sun to the spacecraft, T is parallel to the solar equator in the direction of the Sun's rotation, and N completes the right-handed coordinate system.

2.3. Data for the full LET Geometry Factor (Unsectorized Data)

Intensities for the following species will be provided: H, ³He, ⁴He, C, N, O, Ne, Mg, Si, Fe. Intensities for the following species will be provided if the instrument performance is adequate: Na, Al, S, Ar, Ca.

Exact energy ranges and exact boundaries for energy intervals for each species are **TBD Caltech**. The following table is derived from the performance requirements, and shows some examples only:

Species	Number of Energy Intervals		Energy Range	
	Requirement	Goal	Requirement (MeV/nuc.)	Goal (MeV/nuc.)
H	3	4	1.5 - 3	1.4 – 6
He	6	8	1.5 - 13	1.4 – 13
O	6	8	3 - 25	2.5 – 25
Fe	6	8	3 - 25	2.5 – 50

2.4. *Sectored Data*

Each LET sensor has a field-of-view consisting of two oppositely directed 130x30° fans. Particles entering a fan are binned into eight sectors during onboard processing. Thus a particle entering a LET sensor can be binned into one of 16 sectors.

The look-direction of each sector will change as the spacecraft attitude changes. Therefore the look-direction of each sector will be included in each record of the LET Level 1 sectored data. It will be provided as three components of a unit vector, in the GSE coordinate system (**TBR Caltech**).

To conserve bandwidth, sectored data for only a subset of species will be telemetered. In addition, some species will be grouped, and some energy intervals will be combined in the sectored data.

Exact species, energy ranges and exact boundaries for energy intervals for each species in the sectored data are **TBD Caltech**.

2.5. *Data Files and Formats*

The following specifications apply to all LET Level 1 data files:

- Data files will be in ASCII format.
- The two-character <CR><LF> sequence will define the record delimiter (**TBR IMPACT Team**). This choice will be embraced by Windows PC users, but might be a mild nuisance to UNIX/Linux users, who might prefer just <LF>. Anyway, tools exist to resolve this issue.
- Fields within records will be space-delimited. Tab-delimited or comma-delimited are also options, so this spec is **TBR IMPACT Team**).
- Each file will begin with a header section that describes the data and provides version and creation-date information, etc. in readable English. Linefeeds in the header section will be the same character sequence as used for data record delimiters.
- The header section will be separated from the data records by a standard character sequence that is **TBD IMPACT Team**). A possible candidate for this separator sequence is shown in the examples below.
- Each data file will cover a period of 1 day.
- Each data record will cover a one-minute interval.
- Each data record will contain a timestamp, in a format that should be uniform across all IMPACT level 1 data. This format is **TBD IMPACT Team**. The timestamp will refer to the beginning of the one-minute interval during which the data were accumulated by the sensor (**TBR IMPACT Team**). A proposed format for the timestamp is given in the examples below.
- The first data record in each data file will have a timestamp corresponding to the first minute of the day. Timestamps will increase monotonically with record number in the file. The last data record in each data file will have a timestamp corresponding to the last minute of the day. **Note:** this definition allows for several records to have the same timestamp, which is desirable if several species are to be included in the same data file.

- There will be no data gaps in data files. One-minute records for which no data are available will be present in the data files. They will have correct timestamps, but will contain fill-data in the fields for which no data are available. Fill-data will be denoted by $-9.999e+03$

2.5.1. File Format for Unsectored Data

Within each unsectored data file, the header section at the beginning of the file is defined as follows:

Line 1: Short descriptive label

Line 2: Either “Ahead” or “Behind”, indicating which STEREO spacecraft the data comes from

Line 3: Institution label

Line 4: File creation date

Line 5: Software version

Line 6 to end of header section: description of data. For each species, define the energy intervals. Define the format of the data records.

Last line of the header will contain the following: ##### END OF HEADER

The following, in italics, is an example of the beginning of a LET Level 1 unsectored data file:

LET Level 1 Unsectored Data

Ahead

Caltech Space Radiation Laboratory

File created: Tue Aug 27 16:24:57 PDT 2002

Software version: 1.0

This file contains solar energetic particle intensities in one-minute averages for the following species: H, 3He, 4He, C, N, O, Ne, Mg, Si, Fe.

Energy intervals for each species are as follows:

H...TBD

3He...TBD

3He...TBD

C...TBD

N...TBD

O...TBD

Ne...TBD

Mg...TBD

Si...TBD

Fe...TBD

For each intensity, an associated event count is also provided. The event count allows for calculation of statistical uncertainties in the intensities.

Within each data record below, the following fields are defined:

Field 1: Timestamp – Year, a 4-digit integer, e.g. 2005.

Field 2: Timestamp – UT Day-of-year, integer.

Field 3: Timestamp – UT Hour-of-day and minute-of-day combined into a four-digit integer, e.g. 0215 for 2:15am.

Field 4: Timestamp - Year, floating point, with 8 digits to the right of the decimal point.

Field 5: A character string that defines the species. Characters A-Z, a-z, 0-9, _ and - are allowed. No spaces, tabs, non-printing characters, etc. are allowed. Example: Fe

Field 6: A positive integer N defining the number of intensity fields following in the record. N = the number of energy intervals defined above for the species, in format “%2d”.

Fields 7, 9, ...2N+5: N intensities, in format “% 11.4e”. Example: 1.2345e-04

Fields 8,10, ... 2N+6: N event counts, in integer format.

Intensity or count values of –9999 (-9.999e+03) indicate bad or missing data.

END OF HEADER

```
2005 100 0000 2005.000000000 H 4 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45
2005 100 0000 2005.000000000 3He 6 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 4He 6 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 C 6 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 N 6 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 O 6 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 Ne 6 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 Mg 6 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 Si 6 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 Fe 6 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45 1.2345e-04 59 5.4321e-04 60
2005 100 0001 2005.00000190 H 4 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45
2005 100 0001 2005.00000190 3He 6 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45 1.2345e-04 59 5.4321e-04 60
2005 100 0001 2005.00000190 4He 6 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45 1.2345e-04 59 5.4321e-04 60
2005 100 0001 2005.00000190 C 6 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45 1.2345e-04 59 5.4321e-04 60
2005 100 0001 2005.00000190 N 6 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45 1.2345e-04 59 5.4321e-04 60
2005 100 0001 2005.00000190 O 6 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45 1.2345e-04 59 5.4321e-04 60
2005 100 0001 2005.00000190 Ne 6 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45 1.2345e-04 59 5.4321e-04 60
2005 100 0001 2005.00000190 Mg 6 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45 1.2345e-04 59 5.4321e-04 60
2005 100 0001 2005.00000190 Si 6 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45 1.2345e-04 59 5.4321e-04 60
2005 100 0001 2005.00000190 Fe 6 1.2345e-04 59 5.4321e-04 60 2.3456e-04 50 3.4567e-04 45 1.2345e-04 59 5.4321e-04 60
.
.
.
```

2.5.2. File Format for Sectorized Data

Within each sectorized data file, the header section at the beginning of the file is defined as follows:

Line 1: Short descriptive label

Line 2: Either “Ahead” or “Behind”, indicating which STEREO spacecraft the data comes from

Line 3: Institution label

Line 4: File creation date

Line 5: Software version

Line 6 to end of header section: description of data. For each species, define the energy intervals. Define how the sectors are designated and look-directions defined. Define the format of the data records.

Last line of the header will contain the following: ##### END OF HEADER

The following, in italics, is an example of the beginning of a LET Level 1 sectorized data file:

LET Level 1 Sectored Data

Ahead

Caltech Space Radiation Laboratory

File created: Tue Aug 27 16:24:57 PDT 2002

Software version: 1.0

This file contains solar energetic particle intensities in one-minute averages, for 16 sectors (look directions), for the following species: H, He, CNO, Fe.

Energy intervals for each species are as follows:

H ... TBD

He ... TBD

CNO ... TBD

Fe ... TBD

For each intensity, an associated event count is also provided. The event count allows for calculation of statistical uncertainties in the intensities.

Within each data record below, the following fields are defined:

Field 1: Timestamp – Year, a 4-digit integer, e.g. 2005.

Field 2: Timestamp – UT Day-of-year, integer.

Field 3: Timestamp – UT Hour-of-day and minute-of-day combined into a four-digit integer, e.g. 0215 for 2:15am.

Field 4: Timestamp - Year, floating point, with 8 digits to the right of the decimal point.

Field 5: A character string that defines the species. Characters A-Z, a-z, 0-9, _ and - are allowed. No spaces, tabs, non-printing characters, etc. are allowed. Example: Fe

Field 6: Sector index – a positive integer from 0 – 15 inclusive, in format “%2d”.

Fields 7,8,9: X,Y,Z components of sector look-direction unit vector in GSE coordinate system, in format “% 11.4e”.

Field 10: A positive integer N defining the number of intensity fields following in the record. N = the number of energy intervals defined above for the species, in format “%2d”.

Fields 9, 11, ...2N+7: N intensities, in format “% 11.4e”. Example: 1.2345e-04

Fields 10,12, ... 2N+8: N event counts, in integer format.

Intensity or count values of –9999 (–9.999e+03) indicate bad or missing data.

END OF HEADER

```
2005 100 0000 2005.000000000 H 0 5.0201e-01 8.3839e-01 2.1234e-01 2 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 H 1 5.0201e-01 8.3839e-01 2.1234e-01 2 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 H 2 5.0201e-01 8.3839e-01 2.1234e-01 2 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 H 3 5.0201e-01 8.3839e-01 2.1234e-01 2 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 H 4 5.0201e-01 8.3839e-01 2.1234e-01 2 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 H 5 5.0201e-01 8.3839e-01 2.1234e-01 2 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 H 6 5.0201e-01 8.3839e-01 2.1234e-01 2 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 H 7 5.0201e-01 8.3839e-01 2.1234e-01 2 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 H 8 5.0201e-01 8.3839e-01 2.1234e-01 2 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 H 9 5.0201e-01 8.3839e-01 2.1234e-01 2 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 H 10 5.0201e-01 8.3839e-01 2.1234e-01 2 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 H 11 5.0201e-01 8.3839e-01 2.1234e-01 2 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 H 12 5.0201e-01 8.3839e-01 2.1234e-01 2 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 H 13 5.0201e-01 8.3839e-01 2.1234e-01 2 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 H 14 5.0201e-01 8.3839e-01 2.1234e-01 2 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 H 15 5.0201e-01 8.3839e-01 2.1234e-01 2 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 He 0 5.0201e-01 8.3839e-01 2.1234e-01 2 1.2345e-04 59 5.4321e-04 60
```

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2005 100 0000 2005.000000000 He 1 5.0201e-01 8.3839e-01 2.1234e-01 2 1.2345e-04 59 5.4321e-04 60
2005 100 0000 2005.000000000 He 2 5.0201e-01 8.3839e-01 2.1234e-01 2 1.2345e-04 59 5.4321e-04 60
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```

2.5.3. File Sizes

Daily file sizes for unsectored data will be ~ 2megabytes/day. Daily file sizes for sectored data will be ~5 megabytes/day. These estimates are very rough, and depend on the number of species included, etc.