STEREO

SEP Solar Electron Proton Telescope (SEPT)

Level 1 Data Format

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1. Introduction

This document defines the format of the Level 1 data for the SEP Solar Electron Proton Telescope (SEPT) units, to be delivered by Caltech to University of Kiel/ESA-ESTEC 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 SEPT 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.

SEPT calibration data and software for generating SEPT Level 1 data are not described.

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. SEPT Science Data Frame Format Specification
3. IMPACT Performance Requirements
4. IMPACT Requirements Verification / Validation Plan
5. SEPT Operation Control And Data Processing Requirements 1.1

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. SEPT Level 1 Data Description

2.1. *General Description*

Level 1 data for the four SEPT units (two units in each of the ahead and behind spacecraft) consist of counting rates for two species of solar energetic particles, the ions (mainly protons) and the electrons. For each species, the counting rates for 32 energy intervals from 20 keV to > 2.2 MeV are provided. These energy ranges and intervals are the same for the ions and the electrons. The counting rate (i.e. the number of counts per accumulation interval) is provided as time-series, with one-minute resolution.

The counting rate has been preferred to intensities to enable statistical uncertainty calculations. To limit the size of the file, only the numbers of counts will be present in the data file and not the intensities. However, the header of the data file will contain all needed information for the user to calculate intensities (in units of particles/(cm^2 s sr MeV))

2.2. *Physical Units and Coordinate Systems*

Particle intensities are provided in counts. Look-directions (North, South, Toward the Sun, Away from the Sun) 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.

Note: definition of RTN

- R = Sun to Spacecraft unit vector
- T = (omega x R) / |(omega x R)| where omega is Sun's spin axis
- N completes the right-handed triad

2.3. *Direction of observations*

On each spacecraft (Ahead and Behind), one set of SEPT units (SEPT-E and SEPT-NS) enables to measure toward North (N), South (S), toward the Sun (T) or Away from the Sun (A) (in the ecliptic plane).

2.4. *Energy range and Intervals*

The energy range for each species is shown in the following table:

Species	Energy range
Electrons	20 keV- 400 keV
Ions	20 keV- 7 MeV

Table 1 Energy range for each species (TBC)

The data provided by one set of SEPT unit (SEPT-E and SEPT-NS) consist of 8 sets of 32 values of 12 bits each (logarithm representation with mantissa in 8 bits, "Hidden Leading One Notation" and exponent in 4 bits). They must be decompressed to integer values.
The 32 values represent accumulated counts for a given energy interval. The energy interval is the same for the ions and electrons. The different intervals are defined at the hardware levels and are shown in the following table for maximum energy of 2.2 MeV.

Index	Energy (keV)	Index	Energy (keV)	Index	Energy (keV)	Index	Energy (keV)
-1	0	9	129.4118	19	517.6471	29	1708.235
0	17.2549	10	155.2941	20	586.6667	30	1915.294
1	25.88235	11	181.1765	21	664.3137	31	> 2200
2	34.5098	12	207.0588	22	741.9608		
3	43.13726	13	241.5686	23	836.8627		
4	51.76471	14	276.0784	24	949.0196		
5	60.39216	15	310.5882	25	1069.804		
6	77.64706	16	353.7255	26	1199.216		
7	94.90196	17	405.4902	27	1354.51		
8	112.1569	18	457.2549	28	1518.431		

Table 2 Exponential binning table

The counter 0 gathers all the counts with energy between 0 and 17.25 keV, counter 1 gathers all the counts with energy between 17.25 and 25.88 and so on…. Particles, which stop in the detector stack and deposit higher energy than 2.2 MeV, will be counted in channel 31.

2.5. *Data Files and Formats*

2.5.1. File specifications

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

- The file name should have the following format:
  - SEPT_w_xxxx_yyy
  - w: A for Ahead spacecraft, B for Behind spacecraft
  - xxxx: year
  - yyy: day of the year (of the acquired data)
  - .dat extension
  - example: SEPT_A_0006_123.dat would correspond to the data acquired on the 123rd day of 2006 in nominal mode for the Ahead spacecraft.
- Data files will be in ASCII format.
- The two-character <CR><LF> sequence will define the record delimiter (TBR IMPACT Team).
- 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, a format has been proposed and is still TBC Impact team.
- 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 -1.

2.5.2. File Format

Within each sectored data file, the header section at the beginning of the file is defined as follows:
Line 1: SEPT Level 1
Line 2: Either "Ahead" or "Behind", indicating which STEREO spacecraft the data comes from.
Line 3: Institution label (University of Kiel, ESA/ESTEC)
Line 4: File creation date
Line 5: Software version
Line 6 to end of header section: description of data:

- Settings of the measurements (as defined in applicable document 5)

Accumulation time:	ACC_TIME
Conversion gain adjustment PDFE0-SEPT-E:	G_PDFE0-SEPT-E
Conversion gain adjustment PDFE1-SEPT-E:	G_PDFE1-SEPT-E
Conversion gain adjustment PDFE2-SEPT-E:	G_PDFE2-SEPT-E
Conversion gain adjustment PDFE3-SEPT-E:	G_PDFE3-SEPT-E
Conversion gain adjustment PDFE0-SEPT-NS:	G_PDFE0-SEPT-NS
Conversion gain adjustment PDFE1-SEPT-NS:	G_PDFE1-SEPT-NS
Conversion gain adjustment PDFE2-SEPT-NS:	G_PDFE2-SEPT-NS
Conversion gain adjustment PDFE3-SEPT-NS:	G_PDFE3-SEPT-NS
Main event detection level PDFE0-SEPT-E:	ML_PDFE0-SEPT-E
Main event detection level PDFE1-SEPT-E:	ML_PDFE1-SEPT-E
Main event detection level PDFE2-SEPT-E:	ML_PDFE2-SEPT-E
Main event detection level PDFE3-SEPT-E:	ML_PDFE3-SEPT-E

Main event detection level PDFE0-SEPT-NS: ML_ PDFE0-SEPT-NS
Main event detection level PDFE1-SEPT-NS: ML_ PDFE1-SEPT-NS
Main event detection level PDFE2-SEPT-NS: ML_ PDFE2-SEPT-NS
Main event detection level PDFE3-SEPT-NS: ML_PDFE3-SEPT-NS
Coincidence event detection level PDFE0-SEPT-E: CL_PDFE0-SEPT-E
Coincidence event detection level PDFE1-SEPT-E: CL_ PDFE1-SEPT-E
Coincidence event detection level PDFE2-SEPT-E: CL_ PDFE2-SEPT-E
Coincidence event detection level PDFE3-SEPT-E: CL_ PDFE3-SEPT-E
Coincidence event detection level PDFE0-SEPT-NS: CL_ PDFE0-SEPT-NS
Coincidence event detection level PDFE1-SEPT-NS: CL_ PDFE1-SEPT-NS
Coincidence event detection level PDFE2-SEPT-NS: CL_ PDFE2-SEPT-NS
Coincidence event detection level PDFE3-SEPT-NS: CL_ PDFE3-SEPT-NS

- Geometrical factor

SEPT-Away-electrons (20-400 keV, cm2 sr): Value TBD Univ.of Kiel
SEPT-Toward-electrons (20-400 keV, cm2 sr): Value TBD Univ.of Kiel
SEPT-North-electrons (20-400 keV, cm2 sr): Value TBD Univ.of Kiel
SEPT-South-electrons (20-400 keV, cm2 sr): Value TBD Univ.of Kiel
SEPT-Away-ions (20-2200 keV, cm2 sr): Value TBD Univ.of Kiel
SEPT-Toward-ions (20-2200 keV, cm2 sr): Value TBD Univ.of Kiel
SEPT-North-ions (20-2200 keV, cm2 sr): Value TBD Univ.of Kiel
SEPT-South-ions (20-2200 keV, cm2 sr): Value TBD Univ.of Kiel

- Energy intervals (keV): on one line the 32 values of the binning as defined in applicable document 5).
- Description of the format of the records:
  - Field 1: Timestamp- Decimal day of the year, floating point, with 5 digits to the right of the decimal point.
  - Field 2: day of the year "%2i"
  - Field 3: hour "%2i"
  - Field 4: minute "%2i"
  - Field 5: seconds "%2i"
  - Field 6: N (North), S (South), A (Away from the Sun) and T (Toward the Sun)
  - Field 7: E (Electrons), I (Ions)
  - Field 8: operational mode (0 for Nominal mode, 1 for Calibration, 2 for Test generator. The operational mode is obtained via the status word described in applicable document 5.
  - Field 9: Single Counter address: 0 to 7
    - 0: PDFE 0 main channel
    - 1: PDFE 0 coincidence channel
    - 2: PDFE1 main channel …
  - Field 10: Single counter value: count rate (integers, "%8i", 2^{24} max value)
  - Field 11 to field 42: count rate (integers, "%8i", 2^{24} max value) by increasing energy range.
- Count values of –1 indicate bad or missing data.

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

The following, in italics, is an example (with non consistent dating) of the beginning of a SEPT Level 1 data file:

SEPT Level 1
Ahead
University of Kiel, ESA/ESTEC
File created: Tue Aug 27 16:24:57 PDT 2002
Software version: 1.0
Accumulation Time: 59.897 ms
Main event detection level PDFE0-SEPT-E: 30
Main event detection level PDFE1-SEPT-E:29
…
Coincidence event detection level PDFE3-SEPT-NS: 18
SEPT-Away-electrons (20-400 keV, cm2 sr): 0.2
…
SEPT-South-ions (20-2200 keV, cm2 sr): 0.24
Energy intervals (keV): 0 17.255 25.882 34.510 43.137 …
Description of the format of the records:
Field 1: Timestamp- Day of the year, floating point, with 5 digits to the right of the decimal point.
Field 2: day of the year (%2i)
Field 3: hour (%2i) 0 to 24
Field 4: minute (%2i)
Field 5: seconds (%2i)
Field 6: N (North), S (South), A (Away from the sun) and T (Toward the sun)
Field 7: E (Electrons), I (Ions)
Field 8: 0 (nominal mode), 1 (Calibration mode), 2 (test generator mode)
Field 9: Single counter address (0:PDFE0 main channel, 1: PDFE0 coincidence channel…)
Field 10: Single counter value (%8i)
Field 11 to field 42: count rate (integers, %8i, 2^{24} max. value) by increasing energy range. Count values of -1 indicate bad or missing data.
END OF HEADER

```
2005.27397260  100  00  00  00  N  E  0 0  11111111   10345678   10345678   10345678   10345678   10345678  ……
2005.27397260  100  00  00  00  S  E  0 0  11111111    2345678    2345678    2345678    2345678    2345678  ……
2005.27397260  100  00  00  00  A  E  0 0  12121212    2345678    2345678    2345678    2345678    2345678  ……
2005.27397260  100  00  00  00  T  E  0 0  12121212    2345678    2345678    2345678    2345678    2345678  ……
2005.27397260  100  00  00  00  N  I  0 0  11111111    8765432    8765432    8765432    8765432    8765432  ……
2005.27397260  100  00  00  00  S  I  0 0  11111111         20         30         40         50         60  ..
2005.27397260  100  00  00  00  A  I  0 0  12121212    2345678    2345678    2345678    2345678    2345678  ……
2005.27397260  100  00  00  00  T  I  0 0  12121212   12345678   12345678   12345678   12345678   12345678  ……
2005.27466704  100  00  01  00  N  E  0 1  13131313   12345678   12345678   12345678   12345678   12345678  …
2005.27466704  100  00  00  00  S  E  0 1  13131313   12345678   12345678   12345678   12345678   12345678  …
2005.27397260  100  00  00  00  A  E  0 1  14141414   12345678   12345678   12345678   12345678   12345678  …
2005.27466704  100  00  00  00  T  E  0 1  14141414   12345678   12345678   12345678   12345678   12345678  …
2005.27466704  100  00  00  00  N  I  0 1  13131313   12345678   12345678   12345678   12345678   12345678  …
2005.27466704  100  00  00  00  S  I  0 1  13131313         28         28         28         28         28  …
2005.27466704  100  00  00  00  A  I  0 1  14141414   12345678   12345678   12345678   12345678   12345678  …
2005.27466704  100  00  00  00  T  I  0 1  14141414   12345678   12345678   12345678   12345678   12345678  …
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2.5.3. **File Sizes**

The file size is ~ 3.56 Mbytes/day.