**Project: Solar Orbiter SWA**

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**CHANGE RECORD**

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|  |  | Section 3.1 | Large section of science objectives removed for clarity |
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|  |  | Table 3.1 | HIS Burst mode LL details added |
|  |  | Table 3.2 | Table changes |
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|  |  | Table 3.1 | Low Latency data added to HIS Low Cadence |
|  |  | Section 4.1 | Details included about de-compression of EAS and HIS and conversion of HIS data to physical units |
|  | 17/03/2016 | Section 5.2 | Explanation of the start and end times in the filenames |
|  |  |  | SCET attributes changed |
|  |  |  | Counts data attributes changed |
|  |  |  | Elevation data attribute added |
|  |  |  | Azimuth data attribute added |
|  |  | Section 5.3 | Explanation of the start and end times in the filenames |
|  |  |  | SCET attributes changed |
|  |  |  | Density data attributes changed |
|  |  |  | Velocity data attribute changed |
|  |  |  | Pressure data attribute changed |
|  |  | Section 5.4 | Explanation of the start and end times in the filenames |
|  |  |  | SCET attributes changed |
|  |  |  | Ratio1 data attributes changed |
|  |  |  | Ratio2 data attribute changed |
|  |  |  | Spectra1 data attribute changed |
|  |  |  | Spectra2 data attribute changed |
| D | 22/03/2016 | Section 5.2 | XYZ changed to RTP for the EAS rotation matrix |
|  |  |  | SC changed to SO |
|  |  |  | D-Vary changed from F to T in Azimuth, Elevation and Rotation matrix |
|  |  |  | ‘Bin centres’ added to CATDESC for Elevation and Azimuth |
|  |  | Section 5.3 | 6 element array changed to 9-element array |
|  |  |  | SCALETYP changed to Linear for Velocity and Pressure |
|  |  |  | REPRESENTATION\_3 removed |
|  |  |  | REPRESENTATION\_1/2 changed to Rows and Columns |
|  |  |  | SC changed to SO in Rotation matrix |
|  |  | Section 5.4 | Energy Variable: R-vary changed from F to T |
| E |  | All | C. J. Owen changed C. J. Owen |
| F |  | Section 5.2 | EASn Rot Matrices changed from XYZ to RTP |
|  |  | Section 5.2 | Coordinate system added to EAS 1&2 SS data |
| G | 13/01/2017 | Section 5.4 | Ratio species denominator and numerator added to the HIS variable list |
| H | Decmber 2017 | Section 4.2 | Updated pipelines description |
|  |  | Section 5 | Updated file names and bits of metadata values |
| I | February 2019 | Section 4 | Updated pipeline description |
|  |  | Section 5 | Updated Metadata values and details of data product in liaison with Andrew Walsh |

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# Introduction

## Purpose and Scope

This Low Latency Data Product Definition Document (LLDPDD) describes the format and content of the Solar Wind Analyser (SWA) Low Latency (LL) data. It includes descriptions of the data products and associated metadata, including the data format, content, and generation pipeline system, in accordance with the Low Latency CDF ICD [NR2]. These products will be stored and distributed from the Solar Orbiter Science Archive [ID4] of the SOC.

The specifications described in this LLDPDD apply to all SWA Low Latency products generated by the instrument-provided pipeline system running at the Solar Orbiter SOC, specified as LL01 data. A similar document will be provided by the SOC, describing the SWA LL02 data that are generated at SOC after processing the LL01 data.

This document only includes descriptions of Low Latency products generated at SOC. It does not address the Science data delivered by the Science pipelines run at the Solar Wind Analyser Team premises, as these data products shall be described in [ID2].

# Normative and Informative documents

## Normative References

The documents listed below form a part of this document, to the extent specified and described herein.

|  |  |  |
| --- | --- | --- |
| **Ref.** | **No** | **Title** |
| NR1 | SO-SWA-MSSL-RQ-010 | Solar Orbiter SWA Scientific Operations, Algorithms and Processes Requirements Document |
| NR2 | SOL-SGS-ICD-0004 | Solar Orbiter Interface Control Document for Low Latency Data CDF Files |
|  |  |  |

## Informative Documents

The following documents are called up in this document and are used for guidance and information only.

|  |  |  |
| --- | --- | --- |
| **Ref.** | **No** | **Title** |
| ID1 |  | CDF User’s Guide v3.5, available from <http://cdf.gsfc.nasa.gov> |
| ID2 | SOL-SGS-OTH-004-TPL\_DPDD | Solar Orbiter SWA Data Product Description Document template |
| ID3 | SOL-SGS-TN-0006 | SOC Engineering Guidelines for External Users |
| ID4 | SOL-SGS-PL-0009 | Solar Orbiter Archive Plan |
| ID5 | ESA/SRE(2011)14 | Solar Orbiter definition study report (Red Book) |

## Acronyms, Abbreviations and Terms

| **Abbreviation** | **Meaning** |
| --- | --- |
| CCSDS | Consultative committee for space data systems |
| cdf | Common data format |
| CME | Coronal Mass Ejection |
| DPU | Data Processing Unit |
| EAS | Electron Analyser System |
| ESAC | European Space Astronomy Centre |
| FIP | First Ionisation Potential |
| FOV | Field of view |
| HIS | Heavy Ion System |
| LL | Low Latency |
| LLDPDD | Low Latency Data Product Definition Document |
| MHD | Magneto-Hydro-Dynamics |
| MOC | Mission Operations Centre |
| NM | Normal Mode |
| OBT | On board time |
| PAS | Proton Analyser System |
| PHA | Pulse Height Analysis |
| RPW | Radio Plasma Wave |
| S/C | Spacecraft |
| SCET | Space craft elapsed time |
| SEGU | Solar Orbiter engineering guidelines for external users |
| SOAR | Solar Orbiter Archive |
| SOC | Spacecraft Operations Centre |
| SSMM | Solid State Mass Memory |
| SWA | Solar Wind Analyser |
| TBC | To Be Confirmed |
| TBD | To Be Determined |
| TOF | Time of Flight |
| UTC | Universal coordinated time |
| VA | Virtual Appliance |
| VDF | Velocity Distribution Function |

# SWA Instrument Description

## Science Objectives

The overarching objective of SWA is to provide the comprehensive in situ measurements of the solar wind, which are critical if we are to establish the fundamental physical links between the Sun’s highly dynamic and inhomogeneous magnetised atmosphere and the solar wind in all its quiet and disturbed states.

This critical step requires comprehensive in-situ measurements of the various constituents of the solar wind plasma including high time resolution velocity distributions of solar wind ions and electrons and composition up to suprathermal energies – for example, the measurement of heavy ion charge states reflect coronal temperatures at their source. These measurements are vital if we are to discover the fundamental links between e.g. solar eruptions, shocks and the suprathermal ions that are the seed populations of hazardous solar particle events.

The SWA sensors will sample comparatively pristine solar wind plasma at the closest ever distances to the Sun, but also assess their radial evolution. This will provide key information on the evolution of the solar wind with distance from the Sun, providing a separation of those processes which are inherent in the solar wind itself from those which play a role in the formation of the wind near to the Sun. Furthermore, the SWA will for the first time measure the near-Sun solar wind at higher latitudes revealing the latitudinal dependence of these near-Sun phenomena as the spacecraft climbs out of the ecliptic. Solar Orbiter will thus extend our direct measurements of space plasmas into a new realm that will transform our view of the connections from the solar atmosphere into the solar wind, and help us project this understanding to other stellar environments. For further details see [ID5].

## SWA Sensors

SWA consists of four separate sensors, 2 Electron Analysers (EAS), a Proton/Alpha sensor (PAS) and a Heavy Ion Sensor (HIS). The data products delivered by each sensor are tabulated below in Table 3.1. A full description of all the available data products and modes is beyond the scope of this document but can be found in [NR1]. Highlighted in Table 3.1 are the SWA science data products that will be delivered via the low latency route.

As illustrated in Table 3.1, the low latency data products (LL01) will only be generated during the ‘normal modes’ of SWA. However in the event that a lower cadence of data is required, a LL01 product will still be produced at a reduced rate.

|  |  |  |  |
| --- | --- | --- | --- |
| **Sensor** | **Science Mode** | **Destination Packet Store** | **Data Product** |
|  |  |  |  |
| EAS | Normal Mode | **Low-latency** | **Single Energy 2D VDF (≥100s TBC)** |
| Regular (all downloaded) | Electron Moments (4s) |
| Full 3D VDF (≥100s TBC) |
| Optional  (BKA managed) | Trigger buffer freeze (on event) |
| Burst Mode | Regular (all downloaded) | Scheduled Burst (5 mins core) |
| Optional  (BKA managed) | Scheduled Burst (selectable) |
| Low Cadence Mode | **Low-latency** | **Single Energy 2D VDF (much reduced cadence, ≥400s TBC)** |
| Regular (all downloaded) | Moments (4s) |
| Full 3D VDF (much reduced cadence, ≥400s) |
| Optional  (BKA managed) | Trigger buffer freeze (v limited use) |
|  |  |  |  |
| HIS | Normal Mode | **Low-latency** | **2x Charge State Ratios** |
| **2x Rate spectra** |
| Regular (all downloaded) | NM Rates |
| NM PHA's |
| Burst Mode | BM Rates |
| BM PHA's |
| **Low-latency** | **2x Charge State Ratios** |
| **2x Rate spectra** |
| Low Cadence Mode | Regular (all downloaded) | NM Rates |
| NM PHA's |
| **Low-latency** | **2x Charge State Ratios** |
| **2x Rate spectra** |
|  |  |  |  |
| PAS | Normal Mode | **Low-latency** | **Ion Moments (4s)** |
| Regular (all downloaded) | 3D VDFs (4 sec cadence) |
| Options for PAS reduced 3D VDF’s at higher time resolution during the 8 secs of RPW snapshot every 300 secs |
| Optional  (BKA managed) | Trigger buffer freeze (per event) |
| Burst Mode | Regular (all downloaded) | Options for 2D/3D VDFs at high cadence during scheduled burst (core) |
| Optional  (BKA managed) | Options for 2D/3D VDFs at high cadence during scheduled burst (selectable) |
| Low Cadence Mode | **Low-latency** | **Ion Moments (4s)** |
| Regular (all downloaded) | 3D VDFs (> 16 sec cadence) |
| Options for PAS reduced 3D VDF’s at higher time resolution during the 8 secs of RPW snapshot every >1200 secs |

Table . SWA sensor data products and destination packet store

## SWA Measurements for Low Latency Download

### EAS

The 2 EAS sensors measure electrons distributed over a spectrum of energies and over a range of azimuths and elevations to provide a full, 3d phase space distribution covering the 4π space. In normal mode, EAS will produce a full 3d distribution every second with every 100th second distribution being sent to the SSMM as the 3d data product. From the 50th second distribution, a reduced angular distribution, containing measurements from a single energy bin will be extracted by the DPU. This product is termed the ‘single-strahl’ and will be compressed and packeted with the appropriate header and sent to the LL01 packet store.

There are also various engineering modes that allow instrument health monitoring and fault diagnosis to be performed on a semi-regular basis (~1 per week, for a limited duration). In order to ensure that the sensor is maintained in optimum configuration, some data generated from two of these modes (which are also a form of reduced distributions) will also be compressed, packeted with header and sent to the LL01 packet store.

The engineering mode data in the Low Latency packets will be used by the EAS team only. There will be no requirement of the SOC team to process this data.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Data Name** | **Cadence (sec)** | **Dimensions** | **Duration** | **Frequency** | **Average telemetry rate \*\*** |
| Single Strahl \* | 100 | 2 (1, 32,16) | continuous | continuous | 43.52 bps |
| Eng 3 | 1 | 2 (1, 32, 1) | 5 mins | weekly | 1.04 bps |
| Eng 4 | 1 | 2 (1, 32, 1) | 5 mins | weekly | 1.04 bps |
| Low cadence single strahl \* | 400 | 2 (1, 32, 16) | continuous | continuous | 10.88 bps |

Table . EAS data products sent to the LL01 packet store. (\* only one of these single strahl products is returned at any one time. \*\* assumes compression ratio of 4.0)

### PAS

The PAS sensor measures protons and alpha particles distributed over a spectrum of energies and over a range of azimuths and elevations to provide a partial phase space distribution covering the ram direction plasma. In normal mode, PAS will produce a distribution at varying cadences dependant on the sensor settings. From these distributions, SWA will calculate a set of proton/alpha moments every four seconds. The PAS moment product will consist of a single density value, a 3-element velocity vector, and 6 terms from a 9-element pressure tensor. Twenty-five PAS moment products will be packeted into one ccsds packet with the appropriate headers and sent to the LL01 packet store.

There is also engineering mode data that allow instrument health monitoring and fault diagnosis to be performed on a semi-regular basis (~1 per week, for a limited duration). In order to ensure that the sensor is maintained in optimum configuration, some data generated from this mode will also be compressed, packeted with header and sent to the LL01 packet store.

The engineering mode data in the Low Latency packets will be used by the PAS team only. There will be no requirement of the SOC team to process this data.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Data Name** | **Cadence (sec)** | **Dimensions** | **Duration** | **Frequency** | **Average telemetry rate** |
| PAS moments | 4 | 1 (10 values) | continuous | continuous | 41.6 bps |
| Low cadence PAS moments | 4 | 1 (10 values) | continuous | continuous | 41.6 bps |
| PAS eng mode |  |  |  |  |  |

Table . PAS data products sent to the LL01 packet store. Only one of these moments products is returned at any one time. There is no compression of this data product.

### HIS

The HIS sensor measures heavier ions distributed over a spectrum of energies and over a range of azimuths and elevations to provide a partial phase space distribution covering the ram direction plasma. HIS also measures time of flight (TOF) of these particles in order to determine species. Each heavy ion entering HIS is deemed and event. The rates of events over different ranges (energy, elevation, TOF) are recorded. In normal mode, HIS can provide the full pulse height analysis (PHA) and the rates of PHA. From these distributions, SWA-HIS will send two rate spectra plus two rate ratios packaged into a single packet to the LL01 packet store. These will be used for payload-wide science planning and end-to-end instrument health monitoring.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Data Name** | **Cadence**  **(sec)** | **Dimensions** | **Duration** | **Frequency** | **Average telemetry rate** |
| NM 2x (ratio & spectra) | 300 | 1 (131 values) | continuous | continuous | 45.3 bps |
| BM 2x (ratio & spectra) | 300 | 1 (67 values) | TBD | 1 per day | TBD |
| NM 2x (ratio & spectra) Low Cadence | 300 (TBC) | 1 (131 values) | continuous | continuous | 4.5 bps |
| BM 2x (ratio & spectra) Low Cadence | 300 (TBC) | 1 (67 values) | TBD | 1 per day | TBD |

Table . HIS data products sent to the LL01 packet store. Only one of these four groups is returned at any one time. This data has been compressed to 8-bit numbers.

# LL01 DATA GENERATION PROCESS

The SWA LL01 products are produced by an LL data pipeline system, illustrated below in 

Figure 4.1. This pipeline system will be delivered by the SWA Instrument Team and run at SOC. The procedure for delivery of the LL data pipelines from the SWA Instrument Team to the SOC will be fully compliant with the SOC Engineering Guidelines for External Users [ID3].

SOC will host the SWA pipeline system and retrieve the low latency data from MOC after downlink, passing it as input to the pipeline. SOC will also post process the output of the pipeline, applying operations that will include, but not necessarily be limited to, time conversion from on-board time (OBT) to UTC and transformation of FOV parameters from instrument coordinates to an appropriate scientific coordinate system. SOC will not apply calibrations to the output of the pipeline. SOC will also provide a simple web-based visualisation tool for the low latency data and distribute the LL01 data files via the Solar Orbiter Archive, hosted at ESAC, following the policies described in the Archive Plan [ID4].



Figure . Illustration of the SWA LL01 data pipeline system hosted at SOC

## Data Flow Overview

The Low Latency data processing flows from the SOC through the SWA Virtual Appliance (VA) which houses all the SWA pipelines, back into the SOC as illustrated in Figure 4.1.

Inside the SWA VA there are four distinct pipelines:

1. SWA Pipeline A: Brings in the data from the SOC and performs a first unpack and it performs decompression of EAS data if needed. The .ccsds formatted data is unpacked into packets for HIS, PAS and EAS. These .ccsds packets will be stored locally on the SWA VA.
2. EAS Pipeline: Reads in the EAS .ccsds packets and performs initial tests and reforms the data into useful arrays. The final data arrays are saved into .cdf formatted files and saved locally on the SWA VA.
3. PAS Pipeline: Reads in the PAS .ccsds packets and performs a further unpack into the quick look moments data products. The pipeline performs initial tests and reforms the data into useful arrays. The final data arrays are saved into .cdf formatted files and saved locally on the SWA VA.
4. HIS Pipeline: Reads in the HIS .ccsds packets and performs a further unpack into the ratios and spectra data products. The pipeline performs initial tests on the data. It then un-compresses and converts the data into physical units using a table of conversion constants. The pipeline then reforms the data into useful arrays. The final data arrays are saved into .cdf formatted files and saved locally on the SWA VA.

# Data Product Descriptions

SWA LL01 data products are formatted in accordance with the rules outlined in [NR1]. This section provides details on the filenames, formats and metadata for each of the products included in the SWA LL01 data.

## General Data Format

The SO-SWA LL01 data are formatted in cdf files as described in [ID1]. The filename will follow this format:

solo\_LL01\_swa-[SENSOR]-[DATA TYPE]\_[StartTime-EndTime]\_V[Gen\_Time]C.cdf

Where StartTime and EndTime are the course seconds from the first and last SCET. It is expected that these files will cover 86400 second periods. Gen\_Time is the generation time in the format ‘YYYYMMDDhhmm’

The following sections provide a detailed description of the content and format of each type of file produced by the LL pipeline.

## EAS Single Strahl

This file contains the Single Strahl data product from the EAS. The file format is cdf. Its intended use is to enable the assessment of the magnetic connectivity between the Sun and the spacecraft.

**Filename**: solo\_LL01\_swa-eas-ss\_[StartTime-EndTime]\_V[Gen\_Time]C.cdf

**Expected data volume and time resolution**: This file contains the data between the start time and end time in the file name. The start and end times are spacecraft elapsed time (SCET) at 1 second coarse resolution, from the reference point (1 Jan 2000 TBC). The time resolution of the file is nominally 100 seconds. It contains 2 x 32 x 16 variable arrays of electron counts for each time-stamp. It is expected that the file will cover 1 single 24 hour period approximately. In this case there will be 864 records and the file size will be of the order of 1.7 Mbytes per day.

**Global Attributes**

|  |  |  |
| --- | --- | --- |
| **Name** | **Entry** | **Value** |
| Project | 1 | SOLO>Solar Orbiter |
| Project | 2 | Cosmic Visions |
| Source Name | 1 | SOLO>Solar Orbiter |
| Discipline | 1 | Space Physics>Interplanetary Studies |
| Data Type | 1 | LL01>Level 1 Low Latency Data |
| Descriptor | 1 | SWA-EAS-SS |
| Data Version | 1 | 01 |
| Software Version | 1 | 01.00.00 |
| PI Name | 1 | C. J. Owen |
| PI Affiliation | 1 | MSSL-UCL, University College London, UK |
| Instrument Type | 1 | Plasma and Solar Wind |
| Mission Group | 1 | Solar Orbiter |
| Logical Source | 1 | Solo\_LL01\_swa-eas-ss |
| Logical File id | 1 | solo\_LL01\_swa-eas-ss\_0000000000-0000000000\_VYYYYMMDDhhmm[CI] |
| Logical Source Description | 1 | SWA-EAS Low Latency data |
| Rules of Use | 1 | Consult with MSSL-UCL before using |
| Generated by | 1 | Solar Orbiter SOC, ESAC |
| Generation date | 1 | YYYY-MM-DDTHH:MN:SSZ |
| Mods | 1 | V01 First Version |
| Data product | 1 | SS>Single Strahl |
| Level | 1 | LL01>Level 1 Low Latency Data |
| Instrument | 1 | SWA-EAS>Solar Wind Analyser-Electron Analyser System |

**Variables** #Note that SCET must always be the first variable in a LL01 file.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SCET | CDF\_REAL8 | 1 | 1 | T | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | SCET | | | |
| CATDESC | CDF\_CHAR | Elapsed time of onboard clock at the time of EAS1 observation | | | |
| DISPLAY\_TYPE | CDF\_CHAR | time\_series | | | |
| FILLVAL | CDF\_REAL8 | -1E31 | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| LABLAXIS | CDF\_CHAR | Spacecraft Elapsed Time (Ticks) | | | |
| UNITS | CDF\_CHAR | Ticks | | | |
| VALIDMIN | CDF\_REAL8 | 0 | | | |
| VALIDMAX | CDF\_REAL8 | 4294967295.000 | | | |
| SCALETYP | CDF\_CHAR | linear | | | |
| SCALEMIN | CDF\_REAL8 | 0 | | | |
| SCALEMAX | CDF\_REAL8 | 4294967295.000 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |
| VAR\_NOTES | CDF\_CHAR | The EAS1 time tag is from the center of the acquisition interval which is 1 sec. | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SCET\_1 | CDF\_REAL8 | 1 | 1 | T | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | SCET | | | |
| CATDESC | CDF\_CHAR | Elapsed time of onboard clock at the time of EAS2 observation | | | |
| DISPLAY\_TYPE | CDF\_CHAR | time\_series | | | |
| FILLVAL | CDF\_REAL8 | -1E31 | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| LABLAXIS | CDF\_CHAR | Spacecraft Elapsed Time (Ticks) | | | |
| UNITS | CDF\_CHAR | Ticks | | | |
| VALIDMIN | CDF\_REAL8 | 0 | | | |
| VALIDMAX | CDF\_REAL8 | 4294967295.000 | | | |
| SCALETYP | CDF\_CHAR | linear | | | |
| SCALEMIN | CDF\_REAL8 | 0 | | | |
| SCALEMAX | CDF\_REAL8 | 4294967295.000 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |
| VAR\_NOTES | CDF\_CHAR | The EAS2 time tag is from the centre of the acquisition interval which is 1 sec. | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_EAS1\_SS\_DATA | CDF\_REAL8 | 2 | 32,16 | T | T,T |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | EAS1 Single Strahl Data | | | |
| CATDESC | CDF\_CHAR | The single strahl data from EAS1 | | | |
| DEPEND\_0 | CDF\_CHAR | SCET | | | |
| DEPEND\_1 | CDF\_CHAR | SWA\_EAS\_AZIMUTH | | | |
| DEPEND\_2 | CDF\_CHAR | SWA\_EAS\_ELEVATION | | | |
| DISPLAY\_TYPE | CDF\_CHAR | spectrogram | | | |
| FILLVAL | CDF\_REAL8 | -1E31 | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| LABLAXIS | CDF\_CHAR | Electron Counts | | | |
| UNITS | CDF\_CHAR | Counts/Acc | | | |
| VALIDMIN | CDF\_REAL8 | 0.1 | | | |
| VALIDMAX | CDF\_REAL8 | 65535 | | | |
| SCALETYP | CDF\_CHAR | log | | | |
| SCALEMIN | CDF\_REAL8 | 0.1 | | | |
| SCALEMAX | CDF\_REAL8 | 65535 | | | |
| ACC\_TIME | CDF\_CHAR | 1 ms | | | |
| COORDINATE\_SYSTEM | CDF\_CHAR | EAS1 | | | |
| VAR\_TYPE | CDF\_CHAR | data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_EAS2\_SS\_DATA | CDF\_REAL8 | 2 | 32,16 | T | T,T |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | EAS2 Single Strahl Data | | | |
| CATDESC | CDF\_CHAR | The single strahl data from EAS2 | | | |
| DEPEND\_0 | CDF\_CHAR | SCET\_1 | | | |
| DEPEND\_1 | CDF\_CHAR | SWA\_EAS\_AZIMUTH | | | |
| DEPEND\_2 | CDF\_FLOAT | SWA\_EAS\_ELEVATION | | | |
| DISPLAY\_TYPE | CDF\_CHAR | spectrogram | | | |
| FILLVAL | CDF\_REAL8 | -1E31 | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| LABLAXIS | CDF\_CHAR | Electron Counts | | | |
| UNITS | CDF\_CHAR | Counts/Acc | | | |
| VALIDMIN | CDF\_REAL8 | 0.1 | | | |
| VALIDMAX | CDF\_REAL8 | 65535 | | | |
| SCALETYP | CDF\_CHAR | log | | | |
| SCALEMIN | CDF\_REAL8 | 0.1 | | | |
| SCALEMAX | CDF\_UINT4 | 65535 | | | |
| ACC\_TIME | CDF\_CHAR | 1 ms | | | |
| COORDINATE\_SYSTEM | CDF\_CHAR | EAS2 | | | |
| VAR\_TYPE | CDF\_CHAR | data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_EAS\_ELEVATION | CDF\_REAL8 | 1 | 16 | F | T |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | EAS Elevation | | | |
| CATDESC | CDF\_CHAR | The elevation angles of the EAS sensor bin centres | | | |
| FILLVAL | CDF\_REAL8 | -1E31 | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| LABLAXIS | CDF\_CHAR | Elevation Angle | | | |
| UNITS | CDF\_CHAR | Degrees | | | |
| VALIDMIN | CDF\_REAL8 | -45.0 | | | |
| VALIDMAX | CDF\_REAL8 | 45.0 | | | |
| SCALETYP | CDF\_CHAR | linear | | | |
| SCALEMIN | CDF\_REAL8 | -45.0 | | | |
| SCALEMAX | CDF\_REAL8 | 45.0 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_EAS\_AZIMUTH | CDF\_REAL8 | 1 | 32 | F | T |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | EAS Azimuth | | | |
| CATDESC | CDF\_CHAR | The azimuth angles of the EAS sensor bin centres | | | |
| FILLVAL | CDF\_REAL8 | -1E31 | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| LABLAXIS | CDF\_CHAR | Azimuth Angle | | | |
| UNITS | CDF\_CHAR | Degrees | | | |
| VALIDMIN | CDF\_REAL8 | 0 | | | |
| VALIDMAX | CDF\_REAL8 | 360 | | | |
| SCALETYP | CDF\_CHAR | linear | | | |
| SCALEMIN | CDF\_REAL8 | 0 | | | |
| SCALEMAX | CDF\_REAL8 | 360 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_EAS1\_ENERGY | CDF\_REAL8 | 1 | 1 | T | T |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | EAS1 Energy | | | |
| CATDESC | CDF\_CHAR | The Energy bin used to obtain the Single Strahl value for EAS1 | | | |
| FILLVAL | CDF\_REAL8 | -1E31 | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| LABLAXIS | CDF\_CHAR | Energy | | | |
| UNITS | CDF\_CHAR | eV | | | |
| VALIDMIN | CDF\_REAL8 | 0.1 | | | |
| VALIDMAX | CDF\_REAL8 | 6000.0 | | | |
| SCALETYP | CDF\_CHAR | log | | | |
| SCALEMIN | CDF\_REAL8 | 0.1 | | | |
| SCALEMAX | CDF\_REAL8 | 6000.0 | | | |
| SI\_CONVERSION | CDF\_CHAR | 1.60217646e-19>J | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_EAS2\_ENERGY | CDF\_REAL8 | 1 | 1 | T | T |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | EAS2 Energy | | | |
| CATDESC | CDF\_CHAR | The Energy bin used to obtain the Single Strahl value for EAS2 | | | |
| FILLVAL | CDF\_REAL8 | -1E31 | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| LABLAXIS | CDF\_CHAR | Energy | | | |
| UNITS | CDF\_CHAR | eV | | | |
| VALIDMIN | CDF\_REAL8 | 0.1 | | | |
| VALIDMAX | CDF\_REAL8 | 6000.0 | | | |
| SCALETYP | CDF\_CHAR | log | | | |
| SCALEMIN | CDF\_REAL8 | 0.1 | | | |
| SCALEMAX | CDF\_REAL8 | 6000.0 | | | |
| SI\_CONVERSION | CDF\_CHAR | 1.60217646e-19>J | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| EAS1\_ROT\_MATRIX | CDF\_REAL8 | 2 | 3,3 | F | T,T |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | EAS1 Rotation Matrix | | | |
| CATDESC | CDF\_CHAR | The rotation matrix that will transform EAS1 to Spacecraft frame | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| EAS2\_ROT\_MATRIX | CDF\_REAL8 | 2 | 3,3 | F | F,F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | EAS2 Rotation Matrix | | | |
| CATDESC | CDF\_CHAR | The rotation matrix that will transform EAS2 to Spacecraft frame | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| QUALITY\_FLAG | CDF\_UINT1 | 1 | 1 | T | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | EAS1 Data Quality | | | |
| CATDESC | CDF\_CHAR | EAS1 Data Quality flag | | | |
| FILLVAL | CDF\_UINT1 | 255 | | | |
| LABLAXIS | CDF\_CHAR | EAS1 data quality | | | |
| VALIDMIN | CDF\_UINT1 | 0 | | | |
| VALIDMAX | CDF\_UINT1 | 4 | | | |
| SCALETYP | CDF\_CHAR | linear | | | |
| SCALEMIN | CDF\_UINT1 | 0 | | | |
| SCALEMAX | CDF\_UINT1 | 4 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| QUALITY\_FLAG\_1 | CDF\_UINT1 | 1 | 1 | T | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | EAS2 Data Quality | | | |
| CATDESC | CDF\_CHAR | EAS2 Data Quality flag | | | |
| FILLVAL | CDF\_UINT1 | 255 | | | |
| LABLAXIS | CDF\_CHAR | EAS2 data quality | | | |
| VALIDMIN | CDF\_UINT1 | 0 | | | |
| VALIDMAX | CDF\_UINT1 | 4 | | | |
| SCALETYP | CDF\_CHAR | linear | | | |
| SCALEMIN | CDF\_UINT1 | 0 | | | |
| SCALEMAX | CDF\_UINT1 | 4 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

## PAS Quick Look Moments

This file contains the quick look moments data product from PAS. The file format is cdf. Its intended use is to provide valuable space weather beacon products.

**Filename**: solo\_LL01\_swa-pas-mom\_[StartTime-EndTime]\_V[Gen\_Time]C.cdf

**Expected data volume and time resolution**: This file contains the data between the start time and end time in the file name. The start and end times are spacecraft elapsed time (SCET) at 1 second coarse resolution, from the reference point (1 Jan 2000 TBC). The time resolution is 4 seconds. Each time stamp contains an ion density value, a 3 element array of ion velocity, a 9 element array of ion pressure. It is expected that the file will cover approximately 1 single 24 hour period. In this case there will be 21600 records and the file size will be of the order of 970 kbytes per day.

**Global Attributes**

|  |  |  |
| --- | --- | --- |
| **Name** | **Entry** | **Value** |
| Project | 1 | SOLO>Solar Orbiter |
| Project | 2 | Cosmic Visions |
| Source Name | 1 | SOLO>Solar Orbiter |
| Discipline | 1 | Space Physics>Interplanetary Studies |
| Data Type | 1 | LL01>Level 1 Low Latency Data |
| Descriptor | 1 | SWA-PAS-MOM |
| Data Version | 1 | 01 |
| Software Version | 1 | 01.00.00 |
| PI Name | 1 | C. J. Owen |
| PI Affiliation | 1 | MSSL-UCL, University College London |
| Instrument Type | 1 | Plasma and Solar Wind |
| Mission Group | 1 | Solar Orbiter |
| Logical Source | 1 | solo\_LL01\_swa-pas-mom |
| Logical File id | 1 | solo\_LL01\_swa-pas-mom\_0000000000-0000000000\_VYYYYMMDDhhmm[CI] |
| Logical Source Description | 1 | SWA-PAS Quick Look Moments |
| Rules of Use | 1 | Consult with MSSL-UCL before using |
| Generated by | 1 | Solar Orbiter SOC, ESAC |
| Generation date | 1 | YYYY-MM-DDTHH:MN:SSZ |
| Mods | 1 | V01 First Version |
| Data product | 1 | MOM>Quick Look Moments |
| Level | 1 | LL01>Level 1 Low Latency Data |
| Instrument | 1 | SWA-PAS>Solar Wind Analyser-Proton Alpha System |

**Variables** #Note that SCET must always be the first variable in a LL01 file.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SCET | CDF\_REAL8 | 1 | 1 | T | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | SCET | | | |
| CATDESC | CDF\_CHAR | Elapsed time of onboard clock at the time of PAS observation | | | |
| DISPLAY\_TYPE | CDF\_CHAR | time\_series | | | |
| FILLVAL | CDF\_REAL8 | -1E31 | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| LABLAXIS | CDF\_CHAR | Spacecraft Elapsed Time | | | |
| UNITS | CDF\_CHAR | Ticks | | | |
| VALIDMIN | CDF\_REAL8 | 0 | | | |
| VALIDMAX | CDF\_REAL8 | 4294967295.000 | | | |
| SCALETYP | CDF\_CHAR | linear | | | |
| SCALEMIN | CDF\_REAL8 | 0 | | | |
| SCALEMAX | CDF\_REAL8 | 4294967295.000 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_PAS\_DENSITY | CDF\_REAL8 | 1 | 1 | T | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | Proton Density | | | |
| CATDESC | CDF\_CHAR | The quick look proton density data from PAS | | | |
| DISPLAY\_TYPE | CDF\_CHAR | time series | | | |
| FILLVAL | CDF\_REAL8 | -1E31 | | | |
| DEPEND\_0 | CDF\_CHAR | SCET | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| LABLAXIS | CDF\_CHAR | Proton Density | | | |
| UNITS | CDF\_CHAR | cm^-3 | | | |
| SI\_CONVERSION | CDF\_CHAR | 1.0E6 > m^-3 | | | |
| VALIDMIN | CDF\_REAL8 | 0.0001 | | | |
| VALIDMAX | CDF\_REAL8 | 1000.0 | | | |
| SCALETYP | CDF\_CHAR | log | | | |
| SCALEMIN | CDF\_REAL8 | 0.0001 | | | |
| SCALEMAX | CDF\_REAL8 | 1000.0 | | | |
| VAR\_TYPE | CDF\_CHAR | data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_PAS\_VELOCITY | CDF\_REAL8 | 1 | 3 | T | T |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | Proton Velocity | | | |
| CATDESC | CDF\_CHAR | The quick look proton velocity from PAS | | | |
| DISPLAY\_TYPE | CDF\_CHAR | time\_series | | | |
| FILLVAL | CDF\_REAL8 | -1E31 | | | |
| DEPEND\_0 | CDF\_CHAR | SCET | | | |
| COORDINATE\_SYSTEM | CDF\_CHAR | PAS | | | |
| REPRESENTATION\_1 | CDF\_CHAR | REP\_PAS\_VEL | | | |
| TENSOR\_ORDER | CDF\_CHAR | 1 | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| LABL\_PTR\_1 | CDF\_CHAR | PAS\_VEL\_LABEL | | | |
| UNITS | CDF\_CHAR | km s^-1 | | | |
| SI\_CONVERSION | CDF\_CHAR | 1000.0 > m s^-1 | | | |
| VALIDMIN | CDF\_REAL8 | -10000.0 | | | |
| VALIDMAX | CDF\_REAL8 | 10000.0 | | | |
| SCALETYP | CDF\_CHAR | linear | | | |
| SCALEMIN | CDF\_REAL8 | -10000.0 | | | |
| SCALEMAX | CDF\_REAL8 | 10000.0 | | | |
| VAR\_TYPE | CDF\_CHAR | data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_PAS\_PRESSURE | CDF\_REAL8 | 2 | 3,3 | T | T,T |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | Proton pressure | | | |
| CATDESC | CDF\_CHAR | The quick look proton pressure data from PAS | | | |
| DISPLAY\_TYPE | CDF\_CHAR | time\_series | | | |
| FILLVAL | CDF\_REAL8 | -1E31 | | | |
| DEPEND\_0 | CDF\_CHAR | SCET | | | |
| COORDINATE\_SYSTEM | CDF\_CHAR | PAS | | | |
| REPRESENTATION\_1 | CDF\_CHAR | REP\_PAS\_PRES\_1 | | | |
| REPRESENTATION\_2 | CDF\_CHAR | REP\_PAS\_PRES\_2 | | | |
| TENSOR\_ORDER | CDF\_CHAR | 2 | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| LABLAXIS | CDF\_CHAR | Proton pressure tensor | | | |
| UNITS | CDF\_CHAR | eV cm^-3 | | | |
| SI\_CONVERSION | CDF\_CHAR | 1.602E-25 > J m^-3 | | | |
| VALIDMIN | CDF\_REAL8 | 1.0E-08 | | | |
| VALIDMAX | CDF\_REAL8 | 20 | | | |
| SCALETYP | CDF\_CHAR | linear | | | |
| SCALEMIN | CDF\_REAL8 | 1.0E-08 | | | |
| SCALEMAX | CDF\_REAL8 | 20 | | | |
| VAR\_TYPE | CDF\_CHAR | data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| PAS\_ROT\_MATRIX | CDF\_REAL8 | 2 | 3,3 | F | F,F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | Rotation Matrix to transform PAS to SO | | | |
| CATDESC | CDF\_CHAR | The rotation matrix that will transform PAS to SO | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| PAS\_VEL\_LABEL | CDF\_CHAR | 1 | 3 | F | F,F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | Label Cartesian velocity components | | | |
| CATDESC | CDF\_CHAR | Label for Cartesian velocity components | | | |
| Data | CDF\_CHAR | [“Vx”, “Vy”, “Vz”] | | | |
| FORMAT | CDF\_CHAR | A2 | | | |
| VAR\_TYPE | CDF\_CHAR | meta\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| REP\_PAS\_VEL | CDF\_CHAR | 1 | 3 | F | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | Vector Representation for Velocity | | | |
| CATDESC | CDF\_CHAR | The vector representation for the velocity vector [‘x’,’y’,’z’] | | | |
| FORMAT | CDF\_CHAR | A1 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| REP\_PAS\_PRES\_1 | CDF\_CHAR | 1 | 3 | F | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | Vector Representation for Rows of Pressure Tensor | | | |
| CATDESC | CDF\_CHAR | The vector representation for the rows of the pressure tensor [‘x’,’y’,’z’] | | | |
| FORMAT | CDF\_CHAR | A1 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| REP\_PAS\_PRES\_2 | CDF\_CHAR | 1 | 3 | F | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | Vector Representation for Columns of the Pressure Tensor | | | |
| CATDESC | CDF\_CHAR | The vector representation for the columns of the pressure tensor [‘x’,’y’,’z’] | | | |
| FORMAT | CDF\_CHAR | A1 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| QUALITY\_FLAG | CDF\_UINT1 | 1 | 1 | T | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | PAS Quick look moments Quality | | | |
| CATDESC | CDF\_CHAR | PAS Quick look moments Quality flag | | | |
| FILLVAL | CDF\_UINT1 | 255 | | | |
| LABLAXIS | CDF\_CHAR | Quality flag | | | |
| VALIDMIN | CDF\_UINT1 | 0 | | | |
| VALIDMAX | CDF\_UINT1 | 4 | | | |
| SCALETYP | CDF\_CHAR | linear | | | |
| SCALEMIN | CDF\_UINT1 | 0 | | | |
| SCALEMAX | CDF\_UINT1 | 4 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

## HIS

This file contains the charge state data and the rate spectra products from HIS. The file format is cdf. Its intended use is to enable monitoring of solar wind type (slow, fast, shock) and baseline tracking of structure. It is also the best measure of the plasma environment and a correct end-to-end operation of the HIS sensor.

**Filename**: solo\_LL01\_swa-his-rat\_[StartTime-EndTime]\_V[Gen\_Time]C .cdf

**Expected data volume and time resolution**: This file contains the data between the start time and end time in the file name. The start and end times are spacecraft elapsed time (SCET) at 1 second coarse resolution, from the reference point (1 Jan 2000 TBC). The time resolution is nominally 300 seconds. Each time stamp contains 2 ratio values, and 2, 64 element spectra arrays. It is expected that the file will cover approximately 1 single 24 hour period. In this case there will be 2880 records and the file size will be of the order of 1.5 Mbytes per day.

**Global Attributes**

|  |  |  |
| --- | --- | --- |
| **Name** | **Entry** | **Value** |
| Project | 1 | SOLO>Solar Orbiter |
| Project | 2 | Cosmic Visions |
| Source Name | 1 | SOLO>Solar Orbiter |
| Discipline | 1 | Space Physics>Interplanetary Studies |
| Data Type | 1 | LL01>Level 1 Low Latency Data |
| Descriptor | 1 | SWA-HIS-RAT |
| Data Version | 1 | 01 |
| Software Version | 1 | 01.00.00 |
| PI Name | 1 | C. J. Owen |
| PI Affiliation | 1 | MSSL-UCL, University College London |
| Instrument Type | 1 | Plasma and Solar Wind |
| Mission Group | 1 | Solar Orbiter |
| Logical Source | 1 | solo\_LL01\_swa-his-rat |
| Logical File id | 1 | solo\_LL01\_swa-his-rat\_0000000000-0000000000\_VYYYYMMDDhhmm[CI] |
| Logical Source Description | 1 | SWA-HIS Ratios and Spectra |
| Rules of Use | 1 | Consult with MSSL-UCL before using |
| Generated by | 1 | Solar Orbiter SOC, ESAC |
| Generation date | 1 | YYYY-MM-DDTHH:MN:SS |
| Mods | 1 | V01 First Version |
| Data product | 1 | RAT>HIS Ratios and Spectra |
| Level | 1 | LL01>Level 1 Low Latency Data |
| Instrument | 1 | SWA-HIS>Solar Wind Analyser-Heavy Ion Sensor |

**Variables** #Note that SCET must always be the first variable in a LL01 file.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SCET | CDF\_REAL8 | 1 | 1 | T | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | SCET | | | |
| CATDESC | CDF\_CHAR | Elapsed time of onboard clock | | | |
| DISPLAY\_TYPE | CDF\_CHAR | time\_series | | | |
| FILLVAL | CDF\_REAL8 | -1E31 | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| LABLAXIS | CDF\_CHAR | Spacecraft Elapsed Time | | | |
| UNITS | CDF\_CHAR | Ticks | | | |
| VALIDMIN | CDF\_REAL8 | 0 | | | |
| VALIDMAX | CDF\_REAL8 | 4294967295.000 | | | |
| SCALETYP | CDF\_CHAR | linear | | | |
| SCALEMIN | CDF\_REAL8 | 0 | | | |
| SCALEMAX | CDF\_REAL8 | 4294967295.000 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_HIS\_Ratio1 | CDF\_REAL8 | 1 | 1 | T | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | Ratio 1 | | | |
| CATDESC | CDF\_CHAR | The Ratio between 2 species from HIS | | | |
| DISPLAY\_TYPE | CDF\_CHAR | time\_series | | | |
| FILLVAL | CDF\_REAL8 | -1E31 | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| LABLAXIS | CDF\_CHAR | Ratio between two species | | | |
| DEPEND\_0 | CDF\_CHAR | SCET | | | |
| VALIDMIN | CDF\_REAL8 | 0.0001 | | | |
| VALIDMAX | CDF\_REAL8 | 32000 | | | |
| SCALETYP | CDF\_CHAR | log | | | |
| SCALEMIN | CDF\_REAL8 | 0.0001 | | | |
| SCALEMAX | CDF\_REAL8 | 32000 | | | |
| VAR\_TYPE | CDF\_CHAR | data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_HIS\_Ratio2 | CDF\_REAL8 | 1 | 1 | T | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | Ratio 2 | | | |
| CATDESC | CDF\_CHAR | The ratio between 2 species from HIS | | | |
| DISPLAY\_TYPE | CDF\_CHAR | time\_series | | | |
| FILLVAL | CDF\_REAL8 | -1E31 | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| LABLAXIS | CDF\_CHAR | Ratio between two species | | | |
| DEPEND\_0 | CDF\_CHAR | SCET | | | |
| VALIDMIN | CDF\_REAL8 | 0.0001 | | | |
| VALIDMAX | CDF\_REAL8 | 32000 | | | |
| SCALETYP | CDF\_CHAR | log | | | |
| SCALEMIN | CDF\_REAL8 | 0.0001 | | | |
| SCALEMAX | CDF\_REAL8 | 32000 | | | |
| VAR\_TYPE | CDF\_CHAR | data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_HIS\_Spectrum1 | CDF\_REAL8 | 1 | 64 | T | T |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | Spectrum 1 | | | |
| CATDESC | CDF\_CHAR | Spectrum 1 data from HIS | | | |
| DISPLAY\_TYPE | CDF\_CHAR | spectrogram | | | |
| FILLVAL | CDF\_REAL8 | -1E31 | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| LABLAXIS | CDF\_CHAR | Differential number flux | | | |
| DEPEND\_0 | CDF\_CHAR | SCET | | | |
| DEPEND\_1 | CDF\_CHAR | SWA\_HIS\_ENERGY | | | |
| UNITS | CDF\_CHAR | (cm^2 s sr keV)^-1 | | | |
| VALIDMIN | CDF\_REAL8 | 0 | | | |
| VALIDMAX | CDF\_REAL8 | 255 | | | |
| SCALETYP | CDF\_CHAR | log | | | |
| SCALEMIN | CDF\_REAL8 | 0.1 | | | |
| SCALEMAX | CDF\_REAL8 | 255 | | | |
| SI\_CONVERSION | CDF\_CHAR | 1.0E+4>(m^2 s sr keV)^-1 | | | |
| VAR\_TYPE | CDF\_CHAR | data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_HIS\_Spectrum2 | CDF\_REAL8 | 1 | 64 | T | T |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | Spectrum 2 | | | |
| CATDESC | CDF\_CHAR | Spectrum 2 data from HIS | | | |
| DISPLAY\_TYPE | CDF\_CHAR | spectrogram | | | |
| FILLVAL | CDF\_REAL8 | -1E31 | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| LABLAXIS | CDF\_CHAR | Differential number flux | | | |
| DEPEND\_0 | CDF\_CHAR | SCET | | | |
| DEPEND\_1 | CDF\_CHAR | SWA\_HIS\_ENERGY | | | |
| UNITS | CDF\_CHAR | (cm^2 s sr keV)^-1 | | | |
| VALIDMIN | CDF\_REAL8 | 0 | | | |
| VALIDMAX | CDF\_REAL8 | 255 | | | |
| SCALETYP | CDF\_CHAR | log | | | |
| SCALEMIN | CDF\_REAL8 | 0.1 | | | |
| SCALEMAX | CDF\_REAL8 | 255 | | | |
| SI\_CONVERSION | CDF\_CHAR | 1.0E+4>(m^2 s sr keV)^-1 | | | |
| VAR\_TYPE | CDF\_CHAR | data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_HIS\_ENERGY | CDF\_REAL8 | 1 | 64 | T | T |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | HIS Energy Table | | | |
| CATDESC | CDF\_CHAR | The energy table of the HIS sensor | | | |
| FILLVAL | CDF\_REAL8 | -1E31 | | | |
| FORMAT | CDF\_CHAR | f14.4 | | | |
| LABLAXIS | CDF\_CHAR | Energy | | | |
| UNITS | CDF\_CHAR | eV | | | |
| VALIDMIN | CDF\_REAL8 | 0.1 | | | |
| VALIDMAX | CDF\_REAL8 | 80000 | | | |
| SCALETYP | CDF\_CHAR | log | | | |
| SCALEMIN | CDF\_REAL8 | 0.1 | | | |
| SCALEMAX | CDF\_REAL8 | 80000 | | | |
| SI\_CONVERSION | CDF\_CHAR | 1.60217646e-19>J | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_HIS\_SPECIES1 | CDF\_CHAR | 1 | 1 | T | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | HIS Species associated with SWA\_HIS\_SPECTRUM1 | | | |
| CATDESC | CDF\_CHAR | The species used to get the spectrum1 spectra | | | |
| FORMAT | CDF\_CHAR | A3 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_HIS\_SPECIES2 | CDF\_CHAR | 1 | 1 | T | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | HIS Species associated with SWA\_HIS\_SPECTRUM2 | | | |
| CATDESC | CDF\_CHAR | The species used to get the spectrum2 spectra | | | |
| FORMAT | CDF\_CHAR | A3 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_HIS\_RATIOSPECIES1\_NUM | CDF\_CHAR | 1 | 1 | T | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | The species associated with the Ratio1 numerator | | | |
| CATDESC | CDF\_CHAR | The species used to get the Ratio1 numerator | | | |
| FORMAT | CDF\_CHAR | A3 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_HIS\_RATIOSPECIES1\_DEN | CDF\_CHAR | 1 | 1 | T | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | The species associated with the Ratio1 denominator | | | |
| CATDESC | CDF\_CHAR | The species used to get the Ratio1 denominator | | | |
| FORMAT | CDF\_CHAR | A3 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_HIS\_RATIOSPECIES2\_NUM | CDF\_CHAR | 1 | 1 | T | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | The species associated with the Ratio2 numerator | | | |
| CATDESC | CDF\_CHAR | The species used to get the Ratio2 numerator | | | |
| FORMAT | CDF\_CHAR | A3 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| SWA\_HIS\_RATIOSPECIES2\_DEN | CDF\_CHAR | 1 | 1 | T | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | The species associated with the Ratio2 denominator | | | |
| CATDESC | CDF\_CHAR | The species used to get the Ratio2 denominator | | | |
| FORMAT | CDF\_CHAR | A3 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable\_Name** | **Data\_type** | **DIMS** | **SIZES** | **R\_VARY** | **D\_VARY** |
| QUALITY\_FLAG | CDF\_UINT1 | 1 | 1 | T | F |
|  |  |  | | | |
| **Attribute Name** | **Data Type** | **Value** | | | |
| FIELDNAM | CDF\_CHAR | HIS Ratios and Spectra Quality | | | |
| CATDESC | CDF\_CHAR | HIS Ratios and Spectra Quality flag | | | |
| FILLVAL | CDF\_UINT1 | 255 | | | |
| LABLAXIS | CDF\_CHAR | Quality flag | | | |
| VALIDMIN | CDF\_UINT1 | 0 | | | |
| VALIDMAX | CDF\_UINT1 | 4 | | | |
| SCALETYP | CDF\_CHAR | linear | | | |
| SCALEMIN | CDF\_UINT1 | 0 | | | |
| SCALEMAX | CDF\_UINT1 | 4 | | | |
| VAR\_TYPE | CDF\_CHAR | support\_data | | | |

# APPENDIX – SWA LL01 Data products matrix

A table with a summary of the data products names and description.

|  |  |  |  |
| --- | --- | --- | --- |
| Data Product | Nominal telemetry time resolution (seconds) | Expected daily telemetry volume (kBytes) | Expected daily .cdf volume (kBytes) |
| SWA\_EAS\_LL01 | 100 | 450 | 1748 |
|  |  |  |  |
| SWA\_PAS\_LL01\_Moments | 4 | 430 | 970 |
|  |  |  |  |
| SWA\_HIS\_LL01\_data | 30 | 50 | 1529 |
|  |  |  |  |
| **Total** |  | **930** | **4247** |

Table . LL data product sizes.