SWA-PAS L2 Data User Guide

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Contents

Document scope

This document contains a short description the Solar Orbiter SWA-PAS sensor and the measurement implementation, a short descriptions of the L2 data and data frames, a description how to interpert the velocity distribution fuction (VDF), and the known data caviats.

Abbreviations

SWA	Solar Wind Analyzer	the package
PAS	Proton Alapha Sensor	Part of SWA
SRF	Spacecraft Reference Frame	
RTN	Radial Tangential Normalal Frame	Heliocentric
VDF	Velocity Distribution Function	
K	Number of ca[illegible]ngs per second	
NE	Number of energy bins	
SE	Start Energy bin	
NEL	Number of elevation bins	
SEL	Start Elevation bin	

1 PAS measurements

The Proton-Alfa Sensor (PAS) is designed to continuously determine the 3D distribution functions of the dominant ions of the solar wind, from 200 eV to 20 KeV, without mass and charge selection. In practice, this concerns mostly the proton and alfa populations. These measurements are used to calculate the density, speed, pressure and temperature tensors of the main component of the solar wind.

At full resolution, PAS measures the 3D ion distribution function, in the form of arrays of 96 energies, 11 azimuth angles and 9 elevation angles, in about ~1 second. The energy and the angle of elevation are selected by imposing different high voltages to the electrodes of the deflection system and the electrostatic analyzer. The 11 azimuthal angles correspond to the 11 detectors of the instrument (channeltron').

In "burst" mode, the measurement rate can reach up to 20 Hz. The phase space sampling is then reduced, for example by 24 energies and 5 deflections, which allows to increase the time cadence of distribution functions measurements. An algorithm (peak tracking procedure) is used to select the peak of the distribution and to center sampling around this peak.

The different types of sampling are programmed in the form of cyclograms. They define the operation of the instrument over periods of several days. In normal mode, the functions are measured every 4 s with, every 300 s, a short burst mode of 9 s (SnapShot). 'Long' burst mode is also acquired every day, consisting in 300 s of continuous sampling at high cadence. The sampling frequency during burst or snapshots is generally of 4 distributions / s (4 Hz analysis).

2 PAS frames and samplings

2.1 Frames and bins location

Figure 1 shows the Elevation and Azimuth angles relatively to PAS. Figure 2 shows the same in the SRF. Note that the solar orbiter frame corresponds to the RTN Heliocentric frame most of the time with $X_{RTN} \approxeq -X_{SC}$, $Y_{RTN} \approxeq -Y_{SC}$.

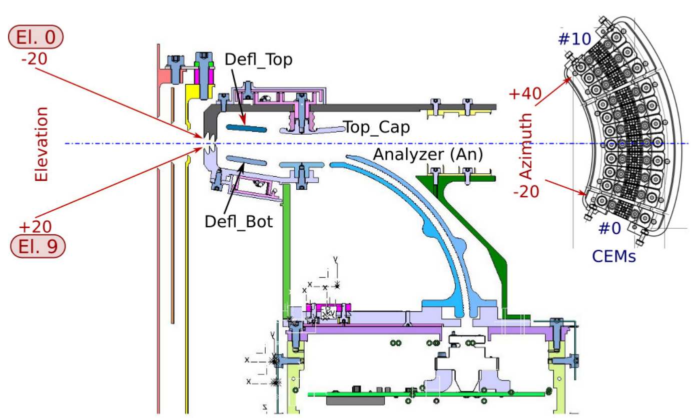

Figure 1: Elevation and azimuth bins and angles in the PAS analyzer frame. The CEMs plane is shown from the Analyzer.

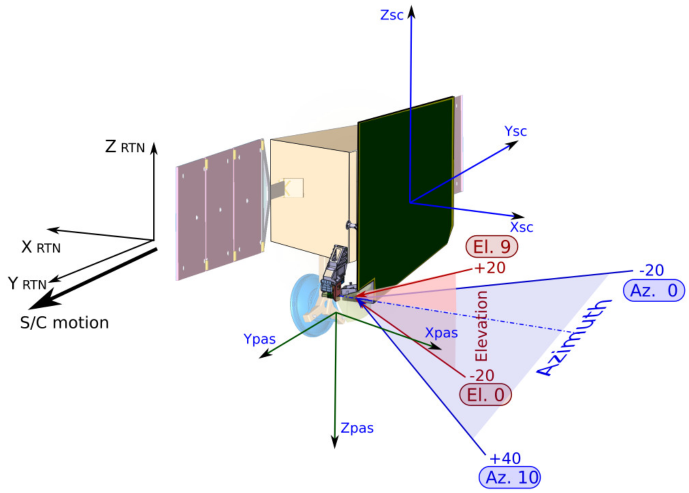

Figure 2: Elevation and azimuth bins in the Solar Orbiter frame.

Thus the **ion velocity** unit vector corresponding to the given bin is calculated as follows:
For the PAS frame:

$$V_X^{PAS} = -cos(El) \cdot cos(Az)$$

$$V_Y^{PAS} = -cos(El) \cdot sin(Az)$$

$$V_Z^{PAS} = sin(El)$$

For the Solar Orbiter (SRF) frame:

$$V_X^{SRF} = -cos(El) \cdot cos(Az)$$

$$V_Y^{SRF} = cos(El) \cdot sin(Az)$$

$$V_Z^{SRF} = -sin(El)$$

2.2 PAS sampling organization

PAS performs the energy-elevation sweep as shown in Figure 3. PAS keeps the constant energy while sweeping elevations. During the sweeping along one elevation bin, PAS accumulates counts in all 11 azimuth bins simultaneously. As soon as the energy-elevation sweep is completed the resulting data set (so called "sampling") is a matrix of [11 azimuth, 9 elevations, 96 energies]. Because in the most of cases the real sweep does not cover the full energy-elevation range (it may be like [11 azimuth, 3:7 elevations, 10:73 energies]), we provide also the supporting information about start/number of the energy and the elevation bins. Since a "peak tracking" runs permanently, the position of the energy x elevation window inside the 9 x 96 frame can change at any time.

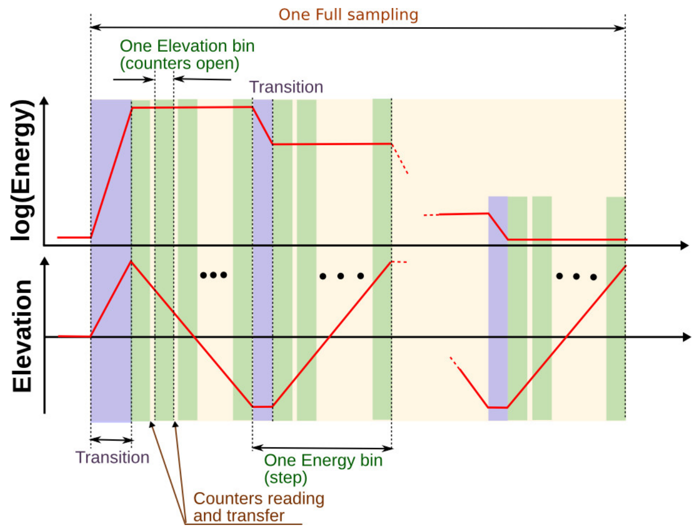

Figure 3: PAS measurements scheme

Normally the PAS cyclogram is looking as shown in Figure 4. PAS produce one sampling per 4 s. Every 100 s PAS tries to adapt the energy/elevation window to the solar wind velocity vector. Each 300s PAS performs fast measurements called "SnapShot". Here PAS provides "K" number of samplings per second without any gaps. This short cadence takes 9 s. The long fast measurements, called "Burst Mode" is performed by the ground TC. Duration of the "Burst Mode" is 300s.

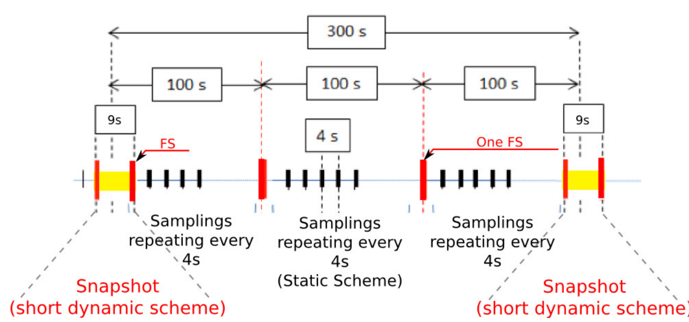

Figure 4: PAS Normal mode implementation

3 Caveats

For the moment (16th Oct 2020) the PAS L2 data caveats are as follows:

1. 3D velocity distribution function and 1D differential energy flux could be a little bit unstable inside the energy range [300 - 400] eV. The geometrical factor of the instrument is decreasing for these energies and a statistical count noise can cause perturbed VDF values.

2. 3D velocity distribution function and 1D differential energy flux could be irrelevant for the energies below 300 eV. The geometrical factor of the instrument is very small here and it cannot be determined with ~~a~~ sufficient accuracy.

3. A sporadic very low "ghost values" can appear in the extreme Elevation and Azimuthal angles in VDF (see Figure 6).

4. Ground calculated density and pressure tensor could by a little bit perturbed inside the solar wind velocity range [260 - 380] km/s.

5. Ground calculated density and pressure tensor are irrelevant for the solar wind velocity below 260 km/s.

4 Special notes about PAS VDF interpretation

PAS VDF data product is described in Section 5.1. Each corresponding CDF file (see Table 1) contains four supporting variables:

1. **Full Elevation** [11, 9, 3] = [Azimuthal bins, Elevation bins, [elArrMin,Center,elArrMax]]
2. **Full Azimuth** [11, 9, 3] = [Azimuthal bins, Elevation bins, [azArrMin,Center,azArrMax]]
3. **Elevation_correction** [96] = [Energy bins]
4. **Energy** [96] = [Energy bins]
   delta_p_Energy[96] = [Energy bins]
   delta_m_Energy[96] = [Energy bins]

These four tables define position of ~~of~~ each bin as follows:
ie : bin energy index [0 - 95]
iel : bin elevation index [0 - 8]
iaz : bin azimuth index [0 - 10]
all angles are in rads
se = **start_energy index**
sel = **start_elevation index**
E2V = 13.85

```
vMin[ie] = E2V * sqrt(Energy[ie]-delta_m_Energy)        #[km/s]
vMax[ie] = E2V * sqrt(Energy[ie]+delta_p_Energy)        #[km/s]
x0 = -cos(elArrMin[iaz,iel]*)*cos(azArrMin[iaz,iel])
x1 = -cos(elArrMin[iaz,iel]*)*cos(azArrMax[iaz,iel])
x2 = -cos(elArrMax[iaz,iel]*)*cos(azArrMin[iaz,iel])
x3 = -cos(elArrMax[iaz,iel]*)*cos(azArrMax[iaz,iel])
y0 =  cos(elArrMin[iaz,iel])*sin(azArrMin[iaz,iel])
y1 =  cos(elArrMin[iaz,iel])*sin(azArrMax[iaz,iel])
y2 =  cos(elArrMax[iaz,iel])*sin(azArrMin[iaz,iel])
y3 =  cos(elArrMax[iaz,iel])*sin(azArrMax[iaz,iel])
z0 = -sin(elArrMin[iaz,iel])
z1 = -sin(elArrMin[iaz,iel])
z2 = -sin(elArrMax[iaz,iel])
z3 = -sin(elArrMax[iaz,iel])
if(((ie - se) % 2) == 0) z0,1,2,3 += Elevation_correction[ie]
else z0,1,2,3 -= Elevation_correction[ie]

Pi = [Xi,Yi,Zi]
```

Now the cell points coordinates are defined according to Figure 5.

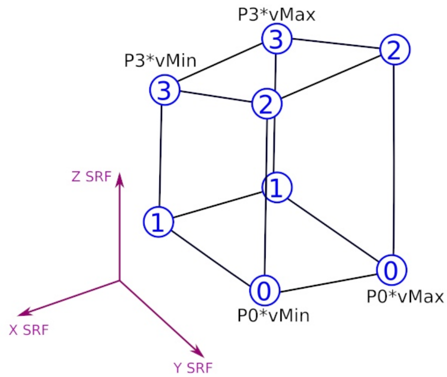

Figure 5: Definition of one bin in the velocity space in SRF frame

Figure 6 show the results of the integration of one hour averaged VDF along Vy and Vz. The "Elevation correction" gives the "saw-like" boundaries between bins in Vx-Vz plane. Also, in the plane Vx-Vy you can see that the VDFs value are perturbed for the velocities below 280 km/s.

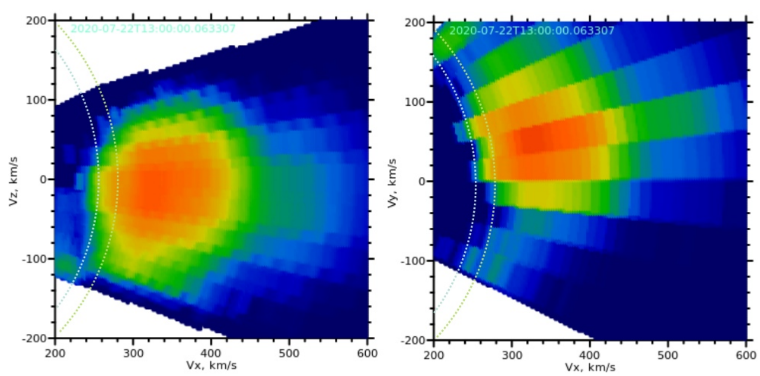

Figure 6: One hour averaged VDF projected into Vx-Vy[SRF] and Vx-Vz[SRF] panes. For convenience the sun is on the left and the Vx is positive.

5 L2 data products

We produce 3 PAS L2 products:

1. 3D velocity distribution function
2. 1D energy differential flux
3. Ground moments

5.1 3D velocity distribution function data

In this section the CDF variables are shown in bold.

The 3D velocity distribution function CDF file consists of 3D arrays (variable "**vdf**") of [11 azimuth, 9 elevations, 96 energies] of the ion number density in the phase space expressed in $s^3 \cdot m^{-6}$. Since the instant sampling may cover just a part of the full angular-energy range, the data record contains also the start and number of the elevation bins ("**start_elevation**", "**nb_elevation**"), the start and number of the azimuth bins ("**start_CEM**","**nb_CEM**"), and the start and number of the energy bins ("**start_energy**","**nb_energy**"). User shall use only records of the categories (variable "**Info**") as follows:

1: Normal sampling, one **"vdf"** each 4 sec

2: Snaphot sampling, "**nb_K**" VDFs per second

3: Burst sampling, "**nb_K**" VDFs per second

The full description is in the Table 1 below.

Table 1: 3D VDF file content

Item	Value	Dim.	Type	Date
VARIABLE	**Epoch**		**CDF_TIME_TT2000**	True
CATDESC	Epoch encoded as Terrestrial Time on rotating Earth geoid, ns since J2000			
DISPLAY_TYPE	time_series			
FIELDNAM	Epoch			
FILLVAL	-9.22337203685478E+018			
FORMAT	I			
LABLAXIS	Epoch			
SCALEMAX	9.22337203685478E+018			
SCALEMIN	-9.22337203685478E+018			
SCALETYP	linear			
SI_CONVERSION	1.0E-9>s			
UNITS	ns			
VALIDMAX	9.22337203685478E+018			
VALIDMIN	-9.22337203685478E+018			
VAR_TYPE	Data			
VARIABLE	**Half_interval**		**CDF_REAL4**	True
CATDESC	Acquisition half interval			
DEPEND_0	Epoch			
DISPLAY_TYPE	time_series			
FIELDNAM	Half_interval			
FILLVAL	-1			
FORMAT	F4.2			
LABLAXIS	Half-interval			
SCALEMAX	10			
SCALEMIN	-10			
SCALETYP	linear			
SI_CONVERSION	1.0s			
UNITS	s			
VALIDMAX	60			
VALIDMIN	-60			
VAR_TYPE	metadata			

Table 1: 3D VDF file content

Item	Value	Dim.	Type	Date
VARIABLE	**SCET**		**CDF_REAL8**	True
CATDESC	Elapsed time on the onboard clock			
DEPEND_0	Epoch			
DISPLAY_TYPE	time_series			
FIELDNAM	SCET			
FILLVAL	-1E+031			
FORMAT	f14.3			
LABLAXIS	SCET			
SCALEMAX	4294970000.0			
SCALEMIN	0.0			
UNITS	Ticks			
VALIDMAX	4294970000.0			
VALIDMIN	0.0			
VAR_TYPE	support_data			
VARIABLE	**Info**		**CDF_UINT1**	True
CATDESC	Info 0:Ground 1:Normal 2:Snapshot 3:Burst 4:Engineering 5:Calibration			
DEPEND_0	Epoch			
FIELDNAM	Info			
FILLVAL	255			
FORMAT	I3			
LABLAXIS	Info			
SCALETYP	linear			
UNITS	unitless			
VALIDMAX	11			
VALIDMIN	7			
VAR_TYPE	support_data			
VARIABLE	**start_energy**		**CDF_INT2**	True
CATDESC	Start energy bin			
DEPEND_0	Epoch			
FIELDNAM	start_energy			
FILLVAL	-32768			
FORMAT	I5			
LABLAXIS	Start energy			
SCALETYP	linear			
UNITS	unitless			
VALIDMAX	96			
VALIDMIN	0			
VAR_TYPE	support_data			
VARIABLE	**nb_energy**		**CDF_INT2**	True
CATDESC	Number energy bins			

Table 1: 3D VDF file content

Item	Value	Dim.	Type	Date
DEPEND_0	Epoch			
FIELDNAM	nb_energy			
FILLVAL	-32768			
FORMAT	I5			
LABLAXIS	Number energy			
SCALETYP	linear			
UNITS	unitless			
VALIDMAX	96			
VALIDMIN	0			
VAR_TYPE	support_data			
VARIABLE	**start_elevation**		**CDF_INT2**	True
CATDESC	Start elevation bin			
DEPEND_0	Epoch			
FIELDNAM	start_elevation			
FILLVAL	-32768			
FORMAT	I5			
LABLAXIS	Start elevation			
SCALETYP	linear			
UNITS	unitless			
VALIDMAX	9			
VALIDMIN	0			
VAR_TYPE	support_data			
VARIABLE	**nb_elevation**		**CDF_INT2**	**True**
CATDESC	Number elevation bins			
DEPEND_0	Epoch			
FIELDNAM	nb_elevation			
FILLVAL	-32768			
FORMAT	I5			
LABLAXIS	Number elevation			
SCALETYP	linear			
UNITS	unitless			
VALIDMAX	9			
VALIDMIN	0			
VAR_TYPE	support_data			
VARIABLE	**start_CEM**		**CDF_INT2**	**True**
CATDESC	Start CEM			
DEPEND_0	Epoch			
FIELDNAM	start_CEM			
FILLVAL	-32768			
FORMAT	I5			
LABLAXIS	Start CEM			
SCALETYP	linear			
UNITS	unitless			
VALIDMAX	1			
VALIDMIN	0			
VAR_TYPE	support_data			

Table 1: 3D VDF file content

Item	Value	Dim.	Type	Date
VARIABLE	**nb_CEM**		**CDF_INT2**	**True**
CATDESC	Number CEM			
DEPEND_0	Epoch			
FIELDNAM	nb_CEM			
FILLVAL	-32768			
FORMAT	I5			
LABLAXIS	Number CEM			
SCALETYP	linear			
UNITS	unitless			
VALIDMAX	11			
VALIDMIN	0			
VAR_TYPE	support_data			
VARIABLE	**nb_K**		**CDF_INT2**	True
CATDESC	Number of sub-sampings per second			
DEPEND_0	Epoch			
FIELDNAM	nb_K			
FILLVAL	-32768			
FORMAT	I5			
LABLAXIS	Number K			
SCALETYP	linear			
UNITS	unitless			
VALIDMAX	8			
VALIDMIN	0			
VAR_TYPE	support_data			
VARIABLE	**K**		**CDF_INT2**	True
CATDESC	Current sub-sampling			
DEPEND_0	Epoch			
FIELDNAM	K			
FILLVAL	-32768			
FORMAT	I5			
LABLAXIS	K			
SCALETYP	linear			
UNITS	unitless			
VALIDMAX	8			
VALIDMIN	0			
VAR_TYPE	support_data			
VARIABLE	**PAS_to_RTN**	**3x3**	**CDF_REAL8**	True
CATDESC	PAS to RTN transformation matrix			
COORDINATE_SYSTEM	SOLO_SWA_PAS			
TARGET_SYSTEM	SOLO_SUN_RTN			
DEPEND_0	Epoch			
FIELDNAM	PAS_to_RTN			
FILLVAL	-1E+031			
FORMAT	E10			
LABLAXIS	PAS to RTN			
SCALETYP	linear			

Table 1: 3D VDF file content

Item	Value	Dim.	Type	Date
UNITS	None			
VAR_TYPE	support_data			
VARIABLE	**vdf**	**11x9x96**	**CDF_REAL4**	True
CATDESC	Distribution function			
DEPEND_0	Epoch			
DEPEND_1	Azimuth			
DEPEND_2	Elevation			
DEPEND_3	Energy			
FIELDNAM	vdf			
FILLVAL	-1E+031			
FORMAT	E10			
LABLAXIS	VDF			
SCALETYP	linear			
UNITS	s^3 m^-6			
VALIDMAX	1			
VALIDMIN	0			
VAR_TYPE	data			
VARIABLE	**Energy**	**96**	**CDF_REAL4**	False
CATDESC	Center of energy bins			
DELTA_PLUS_VAR	delta_p_Energy			
DELTA_MINUS_VAR	delta_m_Energy			
FIELDNAM	Energy			
FILLVAL	-1E+031			
FORMAT	E12.2			
LABLAXIS	Energy			
SCALETYP	linear			
UNITS	eV			
VALIDMAX	40000.0			
VALIDMIN	0.0			
VAR_TYPE	support_data			
VARIABLE	**delta_p_Energy**	**96**	**CDF_REAL4**	False
CATDESC	Delta plus energy bins			
FIELDNAM	delta_p_Energy			
FILLVAL	-1E+031			
FORMAT	E12.2			
LABLAXIS	Delta plus energy			
SCALETYP	linear			
UNITS	eV			
VALIDMAX	40000.0			
VALIDMIN	0.0			
VAR_TYPE	support_data			
VARIABLE	**delta_m_Energy**	**96**	**CDF_REAL4**	False
CATDESC	Delta minus energy bins			
FIELDNAM	delta_m_Energy			
FILLVAL	-1E+031			
FORMAT	E12.2			

Table 1: 3D VDF file content

Item	Value	Dim.	Type	Date
LABLAXIS	Delta minus energy			
SCALETYP	linear			
UNITS	eV			
VALIDMAX	40000.0			
VALIDMIN	0.0			
VAR_TYPE	support_data			
VARIABLE	**Azimuth**	**11**	**CDF_REAL4**	False
CATDESC	Center of CEM bins (azimuth)			
DELTA_PLUS_VAR	delta_Azimuth			
DELTA_MINUS_VAR	delta_Azimuth			
FIELDNAM	Azimuth			
FILLVAL	-1E+031			
FORMAT	E12.2			
LABLAXIS	Azimuth (CEM)			
SCALETYP	linear			
UNITS	deg			
VALIDMAX	90.0			
VALIDMIN	-90.0			
VAR_TYPE	support_data			
VARIABLE	**Elevation**	**9**	**CDF_REAL4**	False
CATDESC	Center of elevation bins			
DELTA_PLUS_VAR	delta_Elevation			
DELTA_MINUS_VAR	delta_Elevation			
FIELDNAM	Elevation			
FILLVAL	-1E+031			
FORMAT	E12.2			
LABLAXIS	Elevation			
SCALETYP	linear			
UNITS	deg			
VALIDMAX	45.0			
VALIDMIN	-45.0			
VAR_TYPE	support_data			
VARIABLE	**delta_Azimuth**	**11**	**CDF_REAL4**	False
CATDESC	Delta Azimuth (CEM)			
FIELDNAM	delta_Azimuth			
FILLVAL	-1E+031			
FORMAT	E12.2			
LABLAXIS	Delta Azimuth			
SCALETYP	linear			
UNITS	deg			
VALIDMAX	45.0			
VALIDMIN	0.0			
VAR_TYPE	support_data			
VARIABLE	**delta_Elevation**	**9**	**CDF_REAL4**	False
CATDESC	Delta elevation table			
FIELDNAM	delta_Elevation			

Table 1: 3D VDF file content

Item	Value	Dim.	Type	Date
FILLVAL	-1E+031			
FORMAT	E12.2			
LABLAXIS	Delta elevation			
SCALETYP	linear			
UNITS	deg			
VALIDMAX	45.0			
VALIDMIN	-45.0			
VAR_TYPE	support_data			
VARIABLE	**Full_azimuth**	**11x9**	**CDF_REAL4**	False
CATDESC	Full definition azimuth table			
FIELDNAM	Full_azimuth			
FILLVAL	-1E+031			
FORMAT	E10			
LABLAXIS	Full Azimuth			
SCALETYP	linear			
UNITS	None			
VALIDMAX	-180.0			
VALIDMIN	180.0			
VAR_TYPE	support_data			
VARIABLE	**Full_elevation**	**11x9**	**CDF_REAL4**	**False**
CATDESC	Full definition elevation table			
FIELDNAM	Full_elevation			
FILLVAL	-1E+031			
FORMAT	E10			
LABLAXIS	FULL_EL_TABLE			
SCALETYP	linear			
UNITS	deg			
VALIDMAX	-90.0			
VALIDMIN	90.0			
VAR_TYPE	support_data			
VARIABLE	Elevation_correction	**96**	**CDF_REAL4**	**False**
CATDESC	Elevation correction for each energy			
FIELDNAM	Elevation_correction			
FILLVAL	-1E+031			
FORMAT	E10			
UNITS	deg			
VALIDMAX	10.0			
VALIDMIN	-10.0			
VAR_TYPE	support_data			

5.2 1D Differential Energy Flux

1D Differential Energy flux CDF file contain original velocity distribution function integrated over elevation and azimuth and converted to the differential energy flux. The value is expressed in $cm^{-2} \cdot s^{-1} \cdot eV/eV$. Since the instant sampling may cover just a part of the full energy range, the data record contains also the start and number of the energy bins (“**start_energy**”,”**nb_energy**”). User shall use only records of the categories (variable “**Info**”) as follows:

1: Normal sampling, one **"eflux"** each 4 sec

2: Snaphot sampling, "**nb_K**" **eflux**s per second

3: Burst sampling, "**nb_K**" **eflux**s per second

The full description is in the Table 2 below.

Table 2: 1D energy differential flux file content

Item	Value	Dim.	Type	Date
VARIABLE	**Epoch**		**CDF_TIME_TT2000**	True
CATDESC	Epoch encoded as Terrestrial Time on rotating Earth geoid, ns since J2000			
DISPLAY_TYPE	time_series			
FIELDNAM	Epoch			
FILLVAL	-9.22337203685478E+018			
FORMAT	I			
LABLAXIS	Epoch			
SCALEMAX	9.22337203685478E+018			
SCALEMIN	-9.22337203685478E+018			
SCALETYP	linear			
SI_CONVERSION	1.0E-9>s			
UNITS	ns			
VALIDMAX	9.22337203685478E+018			
VALIDMIN	-9.22337203685478E+018			
VAR_TYPE	Data			
VARIABLE	**Half_interval**		**CDF_REAL4**	True
CATDESC	Acquisition half interval			
DEPEND_0	Epoch			
DISPLAY_TYPE	time_series			
FIELDNAM	Half_interval			
FILLVAL	-1			
FORMAT	F4.2			
LABLAXIS	Half-interval			
SCALEMAX	10			
SCALEMIN	-10			
SCALETYP	linear			
SI_CONVERSION	1.0s			
UNITS	s			
VALIDMAX	60			
VALIDMIN	-60			
VAR_TYPE	metadata			
VARIABLE	**SCET**		**CDF_REAL8**	True
CATDESC	Elapsed time on the onboard clock			
DEPEND_0	Epoch			
DISPLAY_TYPE	time_series			
FIELDNAM	SCET			
FILLVAL	-1E+031			

Table 2: 1D energy differential flux file content

FORMAT	f14.3			
LABLAXIS	SCET			
SCALEMAX	4294970000.0			
SCALEMIN	0.0			
UNITS	Ticks			
VALIDMAX	4294970000.0			
VALIDMIN	0.0			
VAR_TYPE	support_data			
VARIABLE	**Info**		**CDF_UINT1**	True
CATDESC	Info 0:Ground 1:Normal 2:Snapshot 3:Burst 4:Engineering 5:Calib			
DEPEND_0	Epoch			
FIELDNAM	Info			
FILLVAL	255			
FORMAT	I3			
LABLAXIS	Info			
SCALETYP	linear			
UNITS	unitless			
VALIDMAX	11			
VALIDMIN	7			
VAR_TYPE	support_data			
VARIABLE	**start_energy**		**CDF_INT2**	True
CATDESC	Start energy bin			
DEPEND_0	Epoch			
FIELDNAM	start_energy			
FILLVAL	-32768			
FORMAT	I5			
LABLAXIS	Start energy			
SCALETYP	linear			
UNITS	unitless			
VALIDMAX	96			
VALIDMIN	0			
VAR_TYPE	support_data			
VARIABLE	**eflux**	**96**	**CDF_REAL4**	True
CATDESC	Energy Flux (Omni-directional)			
DEPEND_0	Epoch			
DEPEND_1	Energy			
FIELDNAM	eflux			
FILLVAL	-1E+031			
FORMAT	E10			
LABLAXIS	eflux			
SCALETYP	log			

Table 2: 1D energy differential flux file content

UNITS	cm-2 s-1 eV/eV			
VALIDMAX	1			
VALIDMIN	0			
VAR_TYPE	support_data			
VARIABLE	**Energy**	**96**	**CDF_REAL4**	False
CATDESC	Center of energy bins			
DELTA_PLUS_VAR	delta_p_Energy			
DELTA_MINUS_VAR	delta_m_Energy			
FIELDNAM	Energy			
FILLVAL	-1E+031			
FORMAT	E12.2			
LABLAXIS	Energy			
SCALETYP	linear			
UNITS	eV			
VALIDMAX	40000.0			
VALIDMIN	0.0			
VAR_TYPE	support_data			
VARIABLE	**delta_p_Energy**	**96**	**CDF_REAL4**	False
CATDESC	Delta plus energy bins			
FIELDNAM	delta_p_Energy			
FILLVAL	-1E+031			
FORMAT	E12.2			
LABLAXIS	Delta plus energy			
SCALETYP	linear			
UNITS	eV			
VALIDMAX	40000.0			
VALIDMIN	0.0			
VAR_TYPE	support_data			
VARIABLE	**delta_m_Energy**	**96**	**CDF_REAL4**	False
CATDESC	Delta minus energy bins			
FIELDNAM	delta_m_Energy			
FILLVAL	-1E+031			
FORMAT	E12.2			
LABLAXIS	Delta minus energy			
SCALETYP	linear			
UNITS	eV			
VALIDMAX	40000.0			
VALIDMIN	0.0			
VAR_TYPE	support_data			

5.3 PAS Ground Moments

Ground moments contain the number density, the velocity vector, the pressure tensor and the temperature of the proton peak, extracted from the 3D VDF. User shall use only records of the categories (variable "**Info**") as follows:

1: Normal sampling, one measurement each 4 sec

2: Snaphot sampling, "**nb_K**" measurements per second

3: Burst sampling, "**nb_K**" measurements per second

The "**validity**" flag shows the data quality. Do not use the data labeled as "1" since the number density and the pressure could be too low. Use the data labeled "2" with attention because the data could be noisy.

The full description is in the Table 3 below.

Table 3: Ground Moments CDF file content

Item	Value	Dim.	Type	Date
VARIABLE	**Epoch**		**CDF_TIME_TT2000**	True
CATDESC	Epoch encoded as Terrestrial Time on rotating Earth geoid, ns since J2000			
DISPLAY_TYPE	time_series			
FIELDNAM	Epoch			
FILLVAL	-9.22337203685478E+018			
FORMAT	I			
LABLAXIS	Epoch			
SCALEMAX	9.22337203685478E+018			
SCALEMIN	-9.22337203685478E+018			
SCALETYP	linear			
SI_CONVERSION	1.0E-9>s			
UNITS	ns			
VALIDMAX	9.22337203685478E+018			
VALIDMIN	-9.22337203685478E+018			
VAR_TYPE	Data			
VARIABLE	**Half_interval**		**CDF_REAL4**	True
CATDESC	Acquisition half interval			
DEPEND_0	Epoch			
DISPLAY_TYPE	time_series			
FIELDNAM	Half_interval			
FILLVAL	-1			
FORMAT	F4.2			
LABLAXIS	Half-interval			
SCALEMAX	10			
SCALEMIN	-10			
SCALETYP	linear			
SI_CONVERSION	1.0s			
UNITS	s			
VALIDMAX	60			
VALIDMIN	-60			
VAR_TYPE	metadata			
VARIABLE	**SCET**		**CDF_REAL8**	**True**
CATDESC	Elapsed time on the onboard clock			
DEPEND_0	Epoch			
DISPLAY_TYPE	time_series			
FIELDNAM	SCET			
FILLVAL	-1E+031			
FORMAT	f14.3			
LABLAXIS	SCET			

Table 3: Ground Moments CDF file content

SCALEMAX	4294970000.0			
SCALEMIN	0.0			
UNITS	Ticks			
VALIDMAX	4294970000.0			
VALIDMIN	0.0			
VAR_TYPE	support_data			
VARIABLE	**Info**		**CDF_UINT1**	True
CATDESC	Info 0:Ground 1:Normal 2:Snapshot 3:Burst 4:Engineering 5:Calib			
DEPEND_0	Epoch			
FIELDNAM	Info			
FILLVAL	255			
FORMAT	I3			
LABLAXIS	Info			
SCALETYP	linear			
UNITS	unitless			
VALIDMAX	11			
VALIDMIN	7			
VAR_TYPE	support_data			
VARIABLE	**validity**		**CDF_UINT1**	True
CATDESC	Validity flag : 1,2,3 (the bigger, the better)			
DEPEND_0	Epoch			
FIELDNAM	Validity			
FILLVAL	254			
FORMAT	I3			
LABLAXIS	Validity			
UNITS	unitless			
VALIDMIN	0			
VALIDMAX	255			
VAR_TYPE	support_data			
SCALETYP	linear			
VARIABLE	**N**		**CDF_REAL4**	True
CATDESC	Density			
DEPEND_0	Epoch			
FIELDNAM	Density			
FILLVAL	-1E+031			
FORMAT	E12.2			
LABLAXIS	Density			
UNITS	particles cm^-3			
VALIDMIN	0.0			
VALIDMAX	10000.0			

Table 3: Ground Moments CDF file content

VAR_TYPE	data			
SCALETYP	linear			
VARIABLE	**V_SRF**	**3**	**CDF_REAL4**	True
CATDESC	Velocity in SRF frame			
DEPEND_0	Epoch			
FIELDNAM	V_SRF			
FILLVAL	-1E+031			
FORMAT	E12.2			
LABLAXIS	V (SRF)			
UNITS	km/s			
VALIDMIN	-100000.0			
VALIDMAX	100000.0			
VAR_TYPE	data			
SCALETYP	linear			
VARIABLE	**V_RTN**	**3**	**CDF_REAL4**	True
CATDESC	Velocity in RTN frame			
DEPEND_0	Epoch			
FIELDNAM	V_RTN			
FILLVAL	-1E+031			
FORMAT	E12.2			
LABLAXIS	Velocity (RTN)			
UNITS	km/s			
VALIDMIN	-100000.0			
VALIDMAX	100000.0			
VAR_TYPE	data			
SCALETYP	linear			
VARIABLE	**P_SRF**	**6**	**CDF_REAL4**	True
CATDESC	Pressure tensor in SRF frame			
DEPEND_0	Epoch			
FIELDNAM	P_SRF			
FILLVAL	-1E+031			
FORMAT	E12.2			
LABLAXIS	Pressure (SRF)			
UNITS	J.cm^-3			
VALIDMIN	0.0			
VALIDMAX	1E+030			
VAR_TYPE	data			
SCALETYP	linear			
VARIABLE	**P_RTN**	**6**	**CDF_REAL4**	**True**
CATDESC	Pressure tensor in RTN frame			
DEPEND_0	Epoch			
FIELDNAM	P_RTN			
FILLVAL	-1E+031			
FORMAT	E12.2			
LABLAXIS	Pressure (RTN)			
UNITS	J.cm^-3			
VALIDMIN	0.0			

Table 3: Ground Moments CDF file content

VALIDMAX	1E+030			
VAR_TYPE	data			
SCALETYP	linear			
VARIABLE	**TxTyTz_SRF**	**3**	**CDF_REAL4**	True
CATDESC	Temperature components (Tx, Ty, Tz) in SRF frame			
DEPEND_0	Epoch			
FIELDNAM	TxTyTz_SRF			
FILLVAL	-1E+031			
FORMAT	E12.2			
LABLAXIS	TxTyTz (SRF)			
UNITS	eV			
VALIDMIN	-100000.0			
VALIDMAX	100000.0			
VAR_TYPE	data			
SCALETYP	linear			
VARIABLE	**TxTyTz_RTN**	**3**	**CDF_REAL4**	True
CATDESC	Temperature components (Tx, Ty, Tz) in RTN frame			
DEPEND_0	Epoch			
FIELDNAM	TxTyTz_RTN			
FILLVAL	-1E+031			
FORMAT	E12.2			
LABLAXIS	TxTyTz (RTN)			
UNITS	eV			
VALIDMIN	-100000.0			
VALIDMAX	100000.0			
VAR_TYPE	data			
SCALETYP	linear			
VARIABLE	**T**		**CDF_REAL4**	True
CATDESC	Temperature			
DEPEND_0	Epoch			
FIELDNAM	T			
FILLVAL	-1E+031			
FORMAT	E12.2			
LABLAXIS	Temperature			
UNITS	eV			
VALIDMIN	0.0			
VALIDMAX	1E+030			
VAR_TYPE	data			
SCALETYP	linear			