European Space Agency
Research and Science Support Department
Planetary Missions Division

Venus Express – ASPERA-4

To Planetary Science Archive Interface Control Document

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Change Log

Date	Sections Changed	Reasons for Change
15 December 2006	Creation of Issue 0 Revision 0 (V0.0)	First Issue
17 January 2007	Version 0.1 – All sections modified	Draft, internally circulated
24 January 2007	Version 0.2 - § 2.2	Input from E. Penou on data handling process
08 March 2007	Version 0.3 – HK data converted to physical units Data objects renamed to a reduced length of character string	After checking consistency with requirements specification
28 May 2007	Version 0.4 – All sections revised with minor corrections	Based on feedback from PSA
14 June 2007	Version 0.5 – Format corrected where applicable	Based on validation and conformance tests of the generating PDS data software
26 September 2007	Version 0.6 – Correct index page	Based on internal meeting with CNES
07 February 2008	Version 1.0 – All sections revised with major corrections	Data format disapproved by the PSA
25 February 2008	Version 1.1 – All sections revised with minor corrections	Based on feedback from PSA and internal lecture
25 April 2008	Version 1.2 – All sections revised with minor corrections	Based on feedback from the PI and after the PSA's analyse of dataset sample
07 December 2009	Version 1.3 – AI sections revised with minor corrections	Corrections resulting from RID review
05 February 2010	Version 1.4 – A major feature is added to the document: all sections are updated to reflect the latest changes	Data must be delivered in several datasets in accordance with the extended mission operations plan
18 March 2011	Version 1.5 – Dataset name of extended mission is modified where applicable	A generic naming is used for dataset names related to extended mission phases

TBD ITEMS

Section	Description

Table Of Contents

1   Introduction

1.1   Purpose and Scope

The purpose of this EAICD (Experimenter to (Science) Archive Interface Control Document) is two fold. First it provides users of the ASPERA-4 instrument with detailed description of the product and a description of how it was generated, including data sources and destinations. Secondly, it is the official interface between ASPERA-4 and Planetary Science Archive (PSA) of ESA.

1.2   Archiving Authorities

The *Planetary Data System* Standard is used as archiving standard by:

- NASA for U.S. planetary missions, implemented by PDS
- ESA for European planetary missions, implemented by the Research and Scientific Support Department (RSSD) of ESA

ESA's *Planetary Science Archive* (PSA)
ESA implements an online science archive, the PSA
- to support and ease data ingestion
- to offer additional services to the scientific user community and science operations teams as e.g.:
  - search queries that allow searches across instruments, missions and scientific disciplines
  - several data delivery options as:
    - direct download of data products, linked files and data sets
    - ftp download of data products, linked files and data sets
The PSA aims for online ingestion of logical archive volumes and will offer the creation of physical archive volumes on request.

1.3   Contents

This document describes the data flow of the ASPERA-4 instrument on Venus Express from the data acquisition until the insertion into the PSA for ESA. It includes information on how data were processed, formatted, labeled and uniquely identified. The document discusses general naming schemes for data volumes, data sets, data and label files. Standards used to generate the product are explained. Software that may be used to access the product is explained further on.

The design of the data set structure and the data product is given. Examples of these are given in the appendix.

1.4   Intended Readership

The staff of the archiving authority (Planetary Science Archive, ESA, RSSD, design team) and any potential user of the ASPERA-4 data.

1.5   Scientific Objectives

Main scientific goals of ASPERA-4 experiment are to study the solar wind – atmosphere interaction and characterize the plasma and neutral gas environment in the near-Venus space through energetic neutral atom (ENA) imaging and *in situ* charged particle measurements. The studies would be extremely important to determine the impact of plasma processes on the atmosphere evolution, and to quantify in particular the induced atmospheric escape processes which would explain the dehydration of the Venusian atmosphere.

The ASPERA-4 experiment comprises four sensors: two ENA sensors, an electron spectrometer, and an ion spectrometer. Each of which will contribute, both alone or in combination, to achieve the following science goals of ASPERA-4:

1. Remote sensing of energetic neutral atoms (ENA):
   a. For remote mapping of the global solar wind interaction with the Venusian atmosphere,
   b. To characterize quantitatively the effects of plasma interacting with the atmosphere,
   c. To determine the morphology of the global plasma and neutral gas outflow at Venus.

2. Provide *in situ* measurements of ions and electrons:
   a. To better understand the transfer of energy, mass and momentum of solar wind plasma to the Venusian ionosphere and upper atmosphere,
   b. To provide adequate measurements of the plasma acceleration/outflow from the Venusian ionosphere, part of the outflow charge-exchanging to ENAs,
   c. To provide undisturbed solar wind parameters required for interpretation of ENA images

1.6   Applicable Documents

AD 1.   Planetary Data System Standards Reference, August 1, 2003, Version 3.6, JPL, D-7669, Part 2, http://pds.jpl.nasa.gov/documents/sr/stdref2003/index.hml

AD 2.   Venus Express Archive Generation, Validation and Transfer Plan, June 7, 2004, Issue 1, Rev. 1, VEX-RSSD-PL-001

AD 3.   VEX / ASPERA-4 Instrument Manual, June 17, 2006, Issue 1, Rev. 1, VE-ASP-TN-060402

AD 4.   VEX Archive Conventions, May 30, 2008, Issue 2, Rev. 2, VEX_EST-TN-036

AD 5.   Description of L1 VEX data files, E. Penou, CESR, 16/10/2006, Edit. 4, Rev. 0, ASPPERA4-L1-061016

AD 6.   Rosetta/MEX/VEX Mission Control System - DDID - Appendix H ESA/ESOC, July 1, 2006, Issue 3, Rev. 2, RO-ESC-IF-5003/MEX-ESC-IF-5003/VEX-ESC-IF-5003

AD 7.   Planetary Science Archive. Experiment Data Release Concept. Technical proposal, May 12, 2005, Issue 1, Rev. 16, SOP-RSSD-TN-015

AD 8.   Rosetta Time Handling, February 28, 2006, RO-EST-TN-3165, Issue 1, Rev. 1

AD 9.   Planetary Science Data Archive Technical Note. Geometry and Position Information, April 2, 2007, Issue 4, Rev. 1, SOP-RSSD-TN-010

AD 10.   VEX science cases and operations, October 2004, Issue 1, Rev. A, VEX-RSSD-TN-001_1_A_VEX_Science_Cases_2004Oct06

AD 11.   VEX science operation theme summary, June 7, 2004, Issue 2, VEX-RSSD-LI-004, http://www.rssd.esa.int/open/?4c2BoNV6l5

AD 12.   VEX mission subphases index table, VEX-RSSD-LI-009.TAB

AD 13.   Venus Express ELS Data Analysis Summary, N. Shane, D. Kataria and A. Coates, February 9, 2009, Issue 2, Rev. 0.

AD 14.   Minutes of the 10th DAWG telecon, November 6, 2009, Issue 1, Rev. 0, VEX-SCIOPS-MN-433_1_0_DAWG_Telecon_10_2009Nov06.pdf

1.7   Relationships to Other Interfaces

No products, software and documents would be affected by a change in this EAICD.

1.8   Acronyms and Abbreviations

amu	atomic mass unit
ASPERA	Analyzer of Space Plasmas and Energetic Atoms
CESR	Centre d'Etude Spatiale des Rayonnements
CNES	Centre National d'Etudes Spatiales
CNRS	Centre National de Recherche Scientifique
CODMAC	Committee on Data Management, Archiving, and Computing
Co-I	Co-Investigator
Co-PI	Co-Principal Investigator
DDS	Data Delivery System (ESOC server)
DPU	Digital Processing Unit (of the ASPERA-4 instrument package)
EAICD	Experiment Archive Interface Control Document
EDR	Experiment Data Record
EEPROM	Electrically Erasable Programmable Read Only Memory
ELS	Electron Spectrometer (of the ASPERA-4 instrument package)
EME	Earth Mean Equator
ENA	Energetic Neutral Atom
ESA	European Space Agency
ESOC	European Space Operation Center
ESTEC	European Space Research and Technology Center
EXT	Mission phase: Extended mission
HK	Housekeeping
IRF	Swedish Institute of Space Physics (Institutet för Rymdfysik - Kiruna)
IMA	Ion Mass Analyzer (of the ASPERA-4 instrument package)
keV	kilo electron Volt
MCP	Microchannel plate
MU	Main Unit (of the ASPERA-4 instrument package)
NPD	Neutral Particle Detector (of the ASPERA-4 instrument package)
NPI	Neutral Particle Imager (of the ASPERA-4 instrument package)
PROM	Programmable Read Only Memory
OASW	Orbit and Attitude data access SoftWare
OBT	On Board Time
PDS	Planetary Data System (NASA/JPL)
PHD (or PH)	Pulse Height Distribution (which is the variation of the magnitude of the output pulses from a detector at a constant applied voltage)
PI	Principal Investigator
PSA	Planetary Science Archive (ESA)
PVO	Pioneer Venus Orbiter
PVV	PSA Validation and Verification tool
RSSD	Research and Scientific Support Department (ESA)
S/C	Spacecraft
SwRI	Southwest Research Institute
TBC	To Be Confirmed
TBD	To Be Defined
TC	Telecommand
TDC	Time to Digital Converter
TM	Telemetry
UTC	Coordinated Universal Time
VEX	VEnus eXpress

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Planetary Science Archive

PI   Co-PI, Archiving Manager   Contract Manager   Data processing software
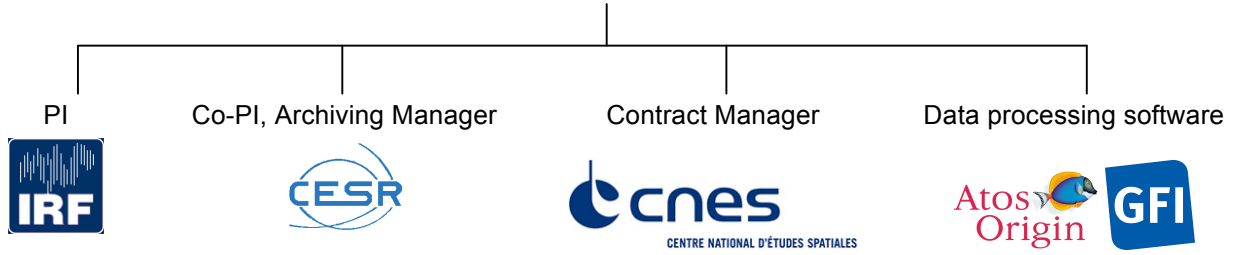
2   Overview of Instrument Design, Data Handling Process and Product Generation

The general scientific objectives of the Analyzer of Space Plasma and Energetic Atoms experiment, 4th version (ASPERA-4), on board the Venus Express spacecraft are to study the solar wind – atmosphere interaction and characterize the plasma and neutral gas environment in the near-Venus space through energetic neutral atom (ENA) imaging and *in situ* charged particle measurements. The ASPERA-4 experiment (shown in Figure 1) is an instrument comprised of four different sensors (or detectors): the Electron Spectrometer (ELS), the Ion Mass Analyzer (IMA), the Neutral Particle Detector (NPD), and the Neutral Particle Imager (NPI).

Overall configuration

The ASPERA-4 experiment is a comprehensive plasma diagnostic package to measure ENAs, electrons, and ions with a wide angular coverage from a three axis stabilised platform [AD 3]. Mechanically ASPERA-4 consists of two units, the Main Unit (MU) and the Ion Mass Analyzer (IMA), mounted separately (see Figure 1). The Main Unit comprises three sensors: the Neutral Particle Imager (NPI), the Neutral Particle Detector (NPD), the Electron Spectrometer (ELS), and a digital processing unit (DPU), which all are located on a rotating platform: the mechanical scanner. The combination of the 360° sensor field of view (180° for the NPD) and the scans from 0° to 180° give, ideally, the required 4π maximum coverage, but part of the field of view is blocked by the spacecraft body. The real coverage depends on the instrument location on the spacecraft.
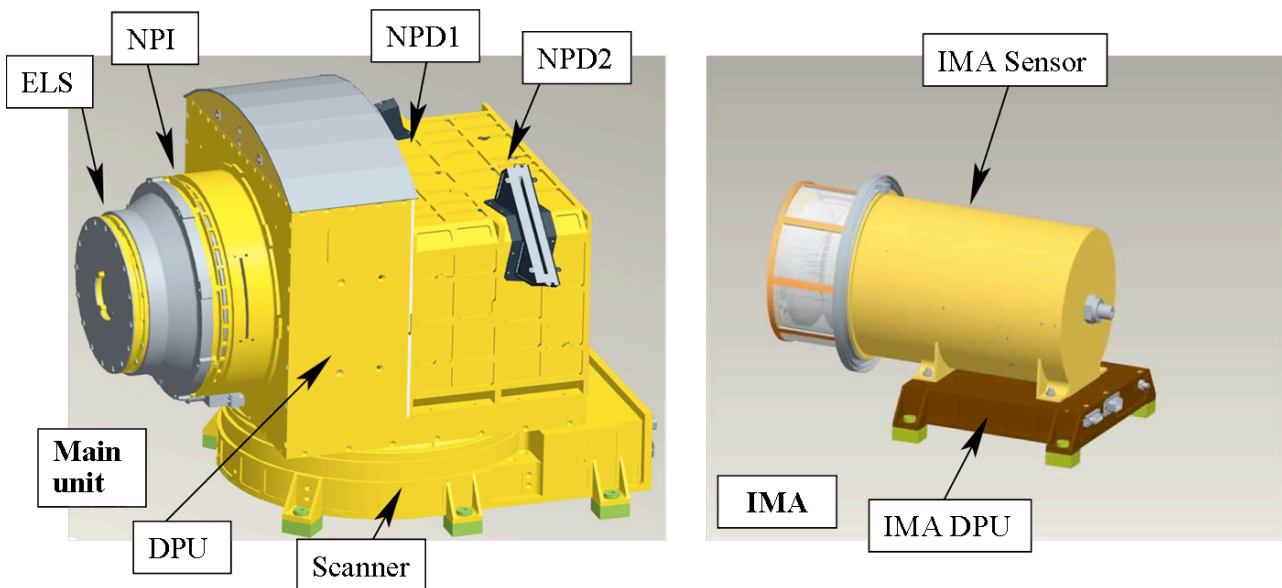
Figure 1. ASPERA-4 instrument contains two units: Main Unit (left panel) and IMA (right panel). Main Unit contains four sensors ELS, NPI, NPD1 and NPD2. The sensors and DPU are mounted on the scanner. IMA comprises IMA DPU and the IMA sensor.

All electrical interfaces of the instrument with the spacecraft are made through the scanner. Electrically IMA interfaces only MU. The total mass of the instrument is 9.00 kg; the main unit flight model mass without thermal hardware is 6.63 kg; and the mass of the IMA flight model is 2.37 kg without thermal hardware. The maximum power consumption is 18 W. The Main unit envelope is 350×263×288 mm3 and for the IMA 287×187×165 mm3.

The ASPERA-4 two ENA sensors complement each other. The Neutral Particle Imager (NPI) provides measurements of the integral ENA flux in the energy range 0.1 - 60 keV with no mass and energy resolution but comparatively high angular resolution 4.6 deg. x 11.5 deg. The Neutral Particle Detector (NPD) provides

measurements of the ENA flux in the energy range 0.1 - 10 keV, resolving velocity and mass (H and O) with a coarse angular resolution. The Electron Spectrometer (ELS) is a standard top-hat electrostatic analyzer in a very compact design with the high 8% energy resolution to perform photoelectron spectroscopy. These three sensors are located on a scanning platform covering ideally the full sphere. The instrument also contains an ion mass composition sensor, IMA (Ion Mass Analyzer). Mechanically, IMA is a separate unit connected by a cable to the ASPERA-4 main unit. IMA provides ion measurements in the energy range 0.01 – 36 keV/q for the main ion components H^+, H_2^+, He^{++}, He^+, O_2^+, O^+ and the group of molecular ions (20 - 80 amu/q). The instantaneous field of view is 4.6 deg x 360 deg. Electrostatic sweeping performs the elevation (90 deg.) coverage. The baseline performance of the ASPERA instrument is presented in the Table 1.

The Neutral Particle Detector (NPD)

The Neutral Particle detector (NPD) instrument provides measurements of the ENA flux, resolving velocity and mass (H and O) with a coarse angular resolution. It consists of two identical pinhole detector cameras, each with a 90° of Field of View (FoV) in the instrument azimuth plane and arranged to cover a FoV of 180° (see Figure 2). Within each detector near the entrance, charged particles with energies up to 70 keV (electrons and ions) are removed by the deflection system, while neutrals proceed into the camera. The deflection system consists of two 90° sectors separated by a 4.5 mm gap. Apart from being ON or OFF, the deflection system can be operated in an alternating mode.

Entering particles not swept away by the deflection plates are ENA particles. The ENA beam emerging from the 4.5 x 4.5-mm pin-hole hits the START surface under the grazing angle 15° and causes secondary electron emission. Using a system of collecting grids, the secondary electrons are transported to one of two microchannel plates (MCP) assemblies giving the START signal for NPD's time-of-flight (TOF) electronics.

Depending on the azimuth angle, the collection efficiency varies from 80% to 95%. The incident ENAs are reflected from the START surface near-specularly. Since the charge state equilibrium is established during the interaction with the surface, the emerging beam contains both the neutral and ionized (positive and negative) components. To increase the total efficiency, no further separation by the charge is made. As proven by the ion tracing, there is very little disturbance to the reflected atomic ions leaving the START surface with an energy above 80 eV, introduced by the START electron optics. Therefore particles of all charge states - negative, neutral, and positive - will impact the second surface, the STOP surface, and again produce secondary electrons which are detected by one of the three MCP assemblies giving the STOP signal for NPD's TOF electronics.
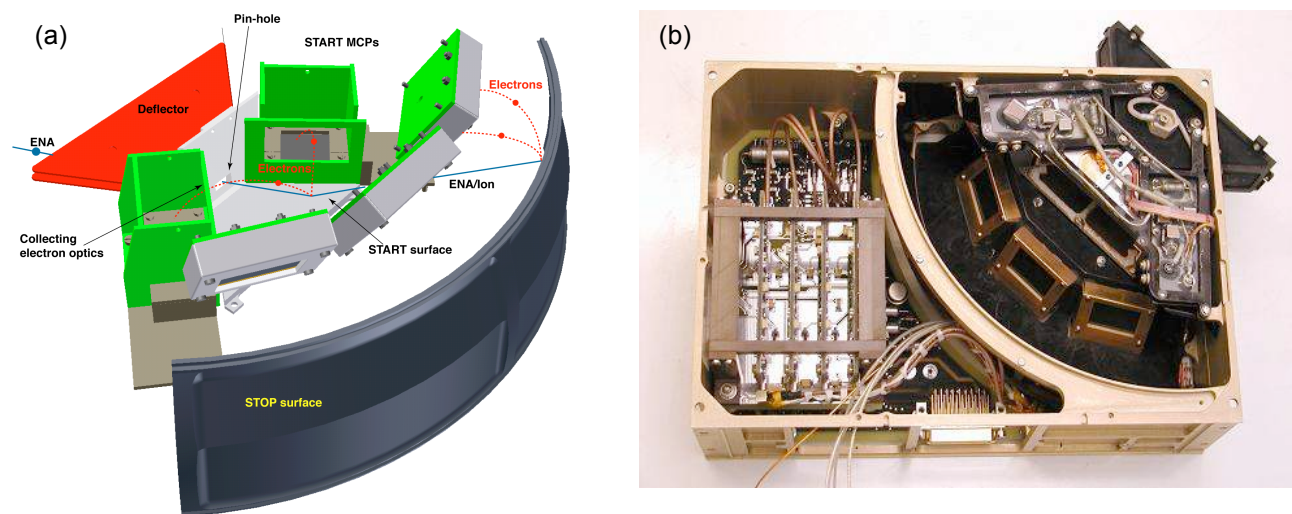
Figure 2. NPD in theory and practice. The theoretical design of the NPD is shown in (a). This design was implemented to produce a NPD flight unit shown in (b).

The TOF over the fixed NPD distance of 8 cm defines the particle velocity. The STOP MCPs also give the azimuthal direction. Since the secondary electron yield emitted from the START surface for the same velocity ENA depends on the ENA mass, the pulse height distribution analysis of the START signals and independent analysis of the STOP signals provide the estimation of ENA mass. Each event is stored in the array START MCP charge x STOP MCP charge x time-of-flight x direction.

The UV suppression in NPD is based on the coincidence of START/STOP signals. To increase the particle reflectivity, we will use very smooth (roughness is of the order of 5 - 10 A) metal surfaces. On the other hand the STOP surface is proposed to be made of graphite (roughness around 100 nm) covered by MgO. This combination has a very high secondary electron yield, low photoelectron yield and high UV absorption. Both proposed surfaces are stable and do not require special maintaining.

Two separate NPD units are required to produce a complete NPD instrument. One unit was available as the spare from Mars Express ASPERA-3. IRF produced a second NPD unit and a flight spare.

The Neutral Particle Imager (NPI)

The Neutral Particle Imager (NPI) head is a replica of the NPI-MCP sensor developed for the ASPERA-C experiment on the Mars-96 mission and successfully, flown on the Swedish micro-satellite Astrid-1 launched in 1995 (see Figure 3). NPI provides measurements of the integral ENA flux with no mass and energy resolution, but comparatively high angular resolution.
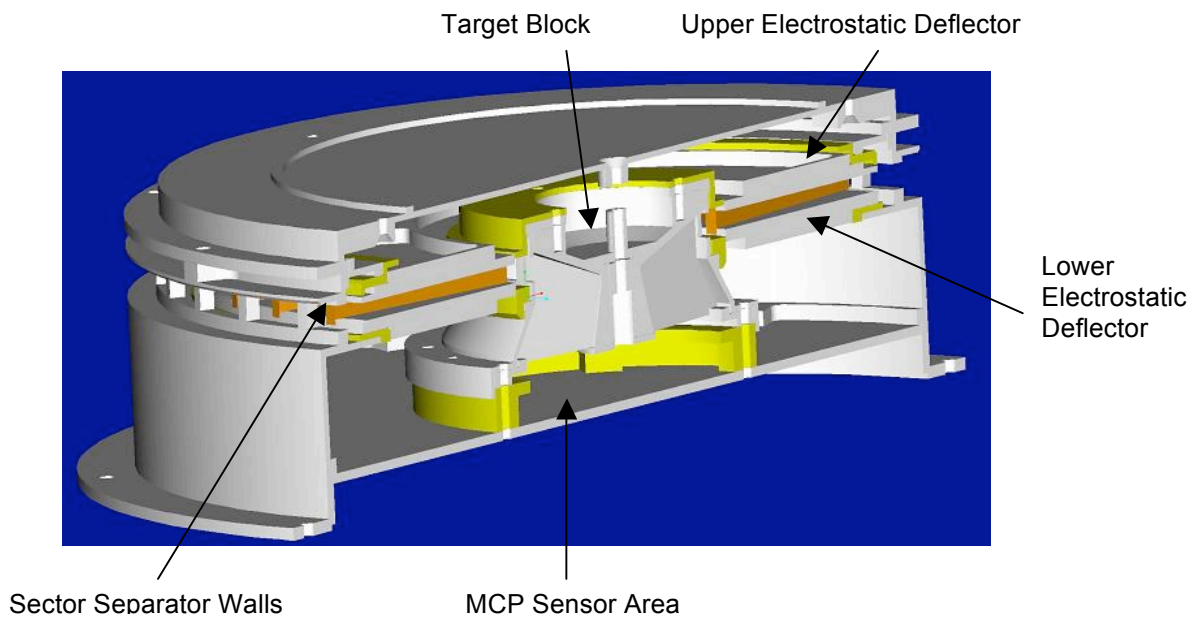
Figure 3. Internal View of the ASPERA-4 NPI. Shown is a cut through the NPI. Major components are identified. The Electrostatic Deflector sweeps away charged particles leaving an input beam of neutral particles.

In the NPI, incoming particles pass between two 150 mm diameter discs, which are separated by 3 mm gap and have a 5 kV potential between them. Charged particles with energies up to 60 keV are deflected by the electric field and captured, but neutral particles pass between the discs. The disks also collimate the incoming beam in the elevation angle. Apart from being ON or OFF the deflection system can be operated in an alternating mode. The deflection system also collimates the beam into 32 sectors.

Neutrals passing through the deflection system hit a 32 sided cone target with a grazing (20°) angle of incidence. A MCP stack in the chevron configuration detects the particles leaving the target block with 32 anodes. The signal from the MCP gives the direction of the primary incoming neutral. The MCP operates in ion mode with a negative bias of -2.4 kV and thus detects (a) sputtered ions of the target material, (b) ions resulting from stripping of the primary neutrals, and (c) neutrals reflected from the target surface. In order to improve the angular resolution and collimate the particles leaving the interaction surface, 32 separating walls are attached to the target forming a star-like structure. NPI covers 4π in one instrument scan and produces an image of the ENA distribution in the form of an azimuth x elevation matrix. To suppress the UV flux the NPI target uses the same coating as in the PIPPI and ASPERA-C experiments, namely, DAG 213, a resin-based graphite dispersion.

The VEX NPI flight unit was built from MEX NPI spare parts. Electronics was modified to cope with higher radiation requirements.

The Electron Spectrometer (ELS)

The Electron Spectrometer (ELS) instrument determines the energy spectrum of incoming electrons in each of sixteen 22.5 sectors. It represents a new generation of ultra-light (300 g), low-power (650 mW), electron sensors flight-proven on Astrid-2 and Munin (see Figure 4).

The ELS is formed by a 17° spherical electrostatic analyzer in a top hat configuration. The electrostatic analyser consists of two concentric hemispherical electrodes, the outer of which has a central hole, through which electrons are admitted, covered by the 'top hat' and a single collimator system. Particles arriving within the elevation field of view of the collimator enter the aperture at any angle in the plane of incidence. Electrons are then deflected into the top hat spectrometer by applying a positive potential on the inner hemisphere These energy band filtered electrons exit the annular gap between the hemispheres and hit a MCP detector. Electrons with energies outside the selected range will be captured.

The plates are stepped in voltage to achieve an energy spectrum. Electrons with energies up to 20 keV/q are measured, with a maximum time resolution of one energy sweep (128 values) per four seconds. There are 16 anodes behind the MCP, which provide simultaneous measurement, each anode defining a 22.5° sector and each connected to a preamplifier. As the ELS sensor is moved through 180 by the mechanical scanner, a complete 4π steradian (whole sphere) angular distribution of electrons is measured.
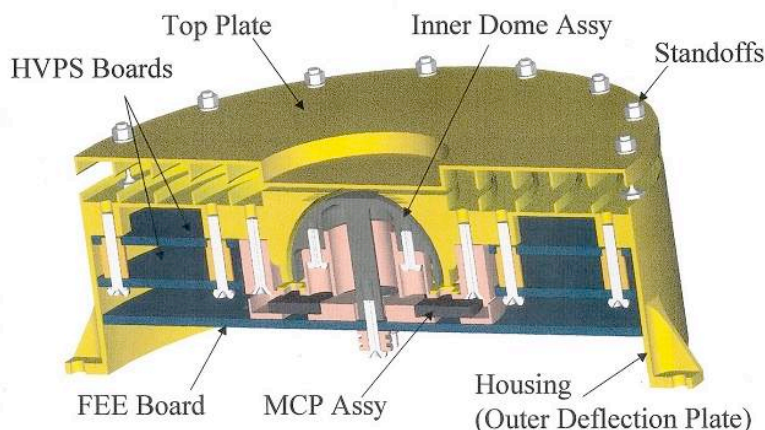
Figure 4. Internal View of the ASPERA-4 ELS. View of the ELS cut in half to reveal its major internal parts. ELS is a standard top hat sensor constructed with high precision.

The ELS energy resolution is 8% and its geometric factor is $7x10^{-5}$ cm^2 sr. ELS was designed to resolve the major photoelectron peaks from Venus measurements. Identification of these major peaks aids in identification of major atmospheric species which have been ionized. Its capabilities will be an important diagnostic tool used at Venus to identify atmospheric escape.

The ELS was designed to be solar blind so that it may operate in exposure to direct sunlight. This has been achieved using two UV reducing mechanisms and one secondary electron suppression technique. UV is minimized through the use of a series of light baffles in the ELS collimator and a series of UV light traps at the entrance to the spherical deflection plates. Secondary electrons are reduced by the addition of a special coating, based on a modified Ebanol-C process, which is included through out the deflection surface, light trap, and collimator system (*Johnstone et al.*, 1997).

By varying the electrostatic potential between the hemispheres of the electrostatic analyzer, the energy of the electrons selected by the filter can be changed. The voltage applied to the inner hemisphere is swept once every four seconds and the number of anode hits per sample interval is recorded to give an energy spectrum for the incoming electrons in each sector. The ELS unit has a self contained, dual range, linear high voltage power supply. The first power supply range is from 0 to about 20 volts (about 150 eV) and has 4096 possible settings. The second power supply range is from 0 to 2800 volts (about 20 keV) and also has 4096 possible settings. The ELS sweep is fully programmable within the constraint of the maximum decay rate of 32 steps/s. On any given step, the deflection plate voltage is held constant during a minimum of 28.125 ms used to accumulate electrons. There is a minimum of 3.125 ms of data latency between energy steps for transition.

SwRI provided the ELS unit. The ELS Flight Spare from the Mars Express program has been modified and calibrated by MSSL, to become the Flight Unit for Venus Express. SwRI upgraded, modified, and calibrated the Mars Express ELS engineering unit so that it became a space qualified Flight Spare for Venus Express.

The Ion Mass Analyzer (IMA)

The Ion Mass Analyzer (IMA) is an improved version of the ion mass spectrographs TICS (Freja, 1992), IMIS (part of ASPERA-C, Mars-96, 1996), and IMI (Planet-B, 1998). It is an exact copy of the ICA instrument on board the Rosetta spacecraft. IMA is a mass resolving instrument providing ion measurements in a selectable energy range 0.01 - 30 keV/q for the main ion components (1, 2, 4, 16 amu/q) and the group of molecular ions (20 - 80 amu/q) (See Figure 5).
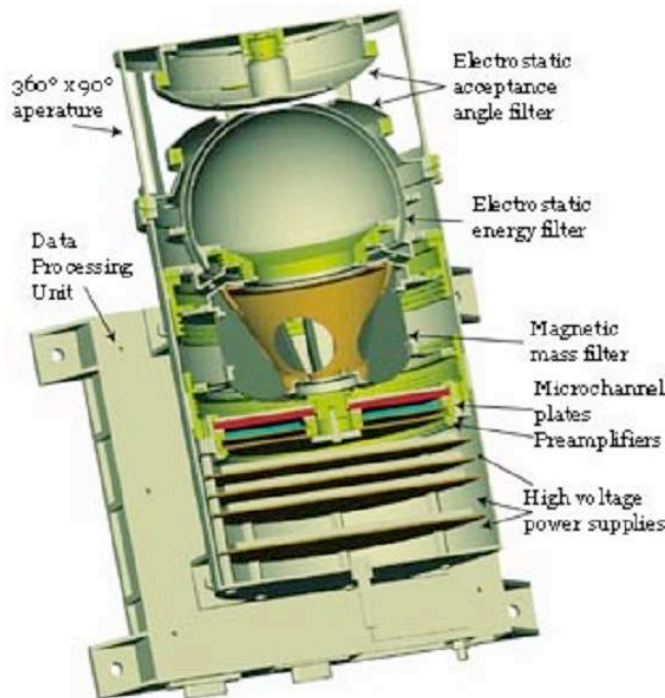
Figure 5. Internal view of the ASPERA-4 IMA. Shown is a slice through the IMA to reveal the internal IMA deflection. The electrical acceptance filter, electrostatic energy filter, and magnetic mass filter are arranged to analyze entering ions.

Ions arriving at the IMA pass through the external grounded grid and enter the deflection system. The deflection system comprises two curved, charged plates that deflect ions arriving in the instrument elevation range from 45 above to 45 below instrument azimuth plane (plane perpendicular to the symmetry axis) and from any azimuth angle into the entrance of the electrostatic analyzer. Then ions pass through the electrostatic analyzer.

The top hat electrostatic analyzer consists of two concentric hemispherical shaped electrodes with a variable electric field between them. Ions that lie within the energy pass band of the analyzer travel between the hemispheres without being stopped by hitting a wall, exit the annular space separating them and travel on towards the magnetic mass analyzer. The electrostatic potential between the hemispheres determines the energy range of the ions that pass through the analyzer.

The geometry of the designed top hat electrostatic analyzer allows incoming parallel ion beam to focus to a small spot size in the vicinity of the endings of the analyzer. Since the top hat analyzer has a full 360° cylindrical symmetry, the azimuthal range of the instrument is 360°. After passing the electrostatic analyzer the ions are deflected from its path in a static, cylindrical magnetic field set up by permanent magnets. Sixteen gaps between the magnets correspond to 16 azimuthal sectors of the instrument of 22.5° each. As the ions leave the magnetic mass analyzer they finally hit a 10 cm diameter MCP and are detected by an anode system with digital position determination electronics. The radial deviation of the ion trajectories at the bottom of the magnetic field region corresponds to particle velocity per charge, with lighter ions deflected towards the centre of the cylinder more than heavy ones. Since particles exiting the top hat electrostatic analyzer have the same energy per charge value, ion position codes their masses.

The anode system resolves 32 bins in the radial position and 16 azimuthal sectors: 32 concentric rings dedicated to measure the radial impact position (discriminating ion mass) and 16 sector anodes to measure the azimuthal impact position (representing ion entrance angle). The magnet assembly can be biased with respect to the electrostatic analyzer to post-accelerate ions and optimize the mass range and mass resolution.

Besides the ion analyser and position sensitive detector the IMA sensor includes a high voltage unit that provides the sweep voltage for all electrodes and MCP bias, and an IMA DPU. The IMA DPU, which is built around the 16-bit MA31750 processor from Dynex, controls analyser voltages, reads out and accumulates the position information for each detector event, and forms telemetry packets. The hardware operation mode is fixed. The fastest changing parameter is the particle energy. It sweeps from 30 keV down to 10 eV over 96 logarithmically equidistant steps. The exposure time on each energy step is 125 ms. During this time interval 16 radial position spectra (32 points) corresponding to 16 azimuthal sectors are accumulated. After each complete energy sweep the instrument changes the polar angle of the field of view. The polar angle is scanned from −45° up to +45° over 16 steps. The total time to complete a full 3D spectrum is 192 s. This spectrum consists of 32 radial (mass) points × 16 azimuthal sectors × 96 energy steps × 16 polar angles. The data processing includes 3 stages: 1) logarithmic compression of the count values; 2) integration (if necessary) over polar angles, and/or azimuthal angles; and 3) Rice compression of the final spectrum. The processing mode is set by TC or chosen automatically according to the TM rate limitations. The acceleration level is also commendable. Only 3 values of acceleration are available: 0 V, -2150 V, and -3650 V.

A specific Data Processing Unit (DPU) for IMA controls IMA data compression and IMA data formats. The IMA DPU works with the main DPU to control the ASPERA telemetry resources. All ASPERA commands are sent to the main DPU. The main DPU passes IMA related commands on to the IMA DPU.

The flight spare IMA sensor head from the Mars Express mission are provided by IRF. The IMA sensor head has been modified by CESR/CNRS and calibrated by CESR/CNRS. IRF rebuilt a new set of IMA DPU electronics for Venus Express.

Table 1. The performance of the ASPERA-4 sensors

parameter	NPI	NPD	ELS	IMA
particles to be measured	ENA	ENA	electrons	ions
energy, keV per charge	~0.1 – 60	0.1 - 10	0.01 – 20	0.01 - 36
energy resolution, ΔE/E	N/A	0,5	0.08	0.07
mass resolution	N/A	Distinguish H, O	N/A	m/q=1,2,4,8,16,32,>40
intrinsic field of view	9° x 344°	9° x 180°	4° x 360°	90° x 360°
angular resolution, FWHM	4.6° x 11.5°	5° x 30°	2° x 22.5°	4.5° x 22.5°
G-factor / pixel, cm²sr	2.7×10^{-3}	6.2×10^{-3}	7×10^{-5}	3.5×10^{-4}
efficiency, %	~1	0.5 - 15	included in G-factor	included in G-factor
Time resolution (full 3D), s	32	32	32	196 / energy – elevation sweep
mass, kg	0.7	0.65 each	0.3	2.2

The Digital Processing Unit (DPU)

The Digital Processing Unit's main task is to control the sensors and the mechanical scanner. The DPU processes, compresses and stores the sensor data and forwards it (together with housekeeping data) to the satellite telemetry system. It also receives and implements commands sent to the ASPERA-4 instrument.

The ASPERA-4 DPU mechanically includes two boards: the DPU board itself, and a Housekeeping (HK) board. These are connected together with the sensor control electronics and the power supply via a common bus system with 8 address and 16 data lines besides control, analog and power supply lines.

The DPU is built around the 16-bit processor MA31750 from Dynex with 12 MHz system clock frequency and an Actel Field Programmable Gate Array (FPGA) RT54SX32S, which implements memory management, watchdog functions and the serial spacecraft interface protocol. The software runs inside a 128 kByte RAM, organised in 2 banks of two 32kByte static memory chips each. On power-up, a two times 16 kByte bipolar PROM (HARRIS) is activated with a boot loader, which transfers the complete PROM contents into the RAM, changes then the program control to the RAM area and switches the power to the PROMs off via transistor switches to conserve power. It then starts monitoring the telecommand (TC) interface for possible boot instructions. This allows the configuration of the instrument in a flexible, but safe manner: If a start configuration is defined via TC, the software continues accordingly. Otherwise the default start configuration inside the EEPROM is used. If this is corrupted, the original default configuration from PROM will be used.

A 512 kByte radiation hardened EEPROM (Maxwell) contains additional program code and configuration information, which can be modified from ground. 2 MByte mass memory RAM is used to store measurement data and buffer telemetry packets.

An Actel FPGA RT1280 implements the serial data transfer protocol to the IMA detector with an interface identical to the corresponding hardware used on the Rosetta mission. All interface lines are buffered via special circuits to protect the instrument from external noise effects.

The DPU board is controlled by a 24 MHz crystal which is divided down to 12 MHz and 42 buffered inside an FPGA before it is used for FPGA and processor operations and also on the HK board. As the main FPGA needs 2.5 V operations voltage, this is generated by dedicated regulators directly on the DPU and on the HK board. The watchdog circuit inside the FPGA can be enabled by software. Then it has to be reset regularly by software access. Otherwise it issues a hardware reset to the whole DPU board after 16 seconds. Except for a special error message, the behaviour is identical to a boot sequence after power-up. The DPU board controls most detector voltages with direct access to the power supply board.

The HK board is controlled by a separate RT54SX32S FPGA, which maps all input and output functions into standard bus address space. It also implements the needed counters for detector pulses from the NPI and ELS.

Four eight-channel analog multiplexers select one out of 32 analog voltages to be monitored. They are digitalised by one 14-bit Analog-to-Digital-Converter (ADC, LTC1419). Another 14-bit ADC monitors the ELS deflection voltage. Two 8-bit Digital-to-Analog-Converters generate via 8 latching buffers the control voltages for NPD, NPI, ELS and the scanner. Also the sun-sensor electronics is implemented on the HK board.

The software is built around a real-time system with scheduler and interrupt handler. All executable routines are defined inside a routing table, which resides in EEPROM and can be modified during flight. In this way new or modified software routines can be stored inside a free area of the EEPROM, verified and added to the operating software by including their start address into this routing table. A macro feature of the TC handler offers the possibility to generate sequences of standard TCs automatically according to a pre-defined list, reducing the need for complex TC groups to be up-linked over and over again. Besides detector activation and parameter control, compression and averaging of measurement data allow the reduction of the amount of telemetry generated.

The primary design drivers for the Digital Processing Unit (DPU) are optimum use of the allocated telemetry rate and correct handling of TCs. The ASPERA-4 instrument makes extensive use of sophisticated lossless data compression to enhance the scientific data yield. The principal compression method used is based on the Rice algorithm, an adaptive compression technique that remains efficient over a wide range of input data entropy conditions. This is achieved by employing multiple encoders, each of which is optimized to compress data in a particular entropy range. The structure of the algorithm also permits a simple interface to data packetisation schemes, such as those used for space data communications, without the need to carry auxiliary information across packet boundaries.

The Scanner

The mechanical scanner sweeps the three sensors mounted on it (ELS, NPD, and NPI) through 180 degrees to give the ASPERA-4 instrument 4π steradian (unit sphere) coverage when the spacecraft is 3-axis stabilized. This occurs in 32, 64, or 128 seconds depending on the scanner operational mode. The scanner is equipped with one stepping motor, which turns a worm screw. The screw drives a worm wheel, which is attached to the moving part of the scanner. The scanner payload can be turned to any arbitrary angle within the range 0-180 degrees or perform continuous scanning. The operational rotation rates are 1.5, 3.0 and 6.0 degrees per second. The system offers an angular positioning accuracy of 0.2 degrees.

Table 2. Mechanical scanner platform technical data

technical data	value	unit
maximum angle of rotation	±100	[deg.]
angular movement per step, fs. Mode	0.0190	[deg.]
angular movement per step, hs. Mode	0.0095	[deg.]
angular position feedback resolution	0.05	[deg.]
angular positionning accuracy	0.2	[deg.]
operationnal rotation rate	1.5/3.0/6.0	[deg/s]
maximum rotation rate	~25.0	[deg/s]
power dissipation	0.5-2.0	[W]
platform load	3.7	[kg]
maximum platform load	~12	[kg]
dimensions	60 × 254 × 232	[mm]
mass	1.42	[kg]
operationnal lifetime in vacuum	~3	[years]
Gear ratio	1:188	-

ASPERA-4 sensors orientation

The following pictures show the ASPERA-4 sensors location and orientation in the spacecraft system [AD 3].
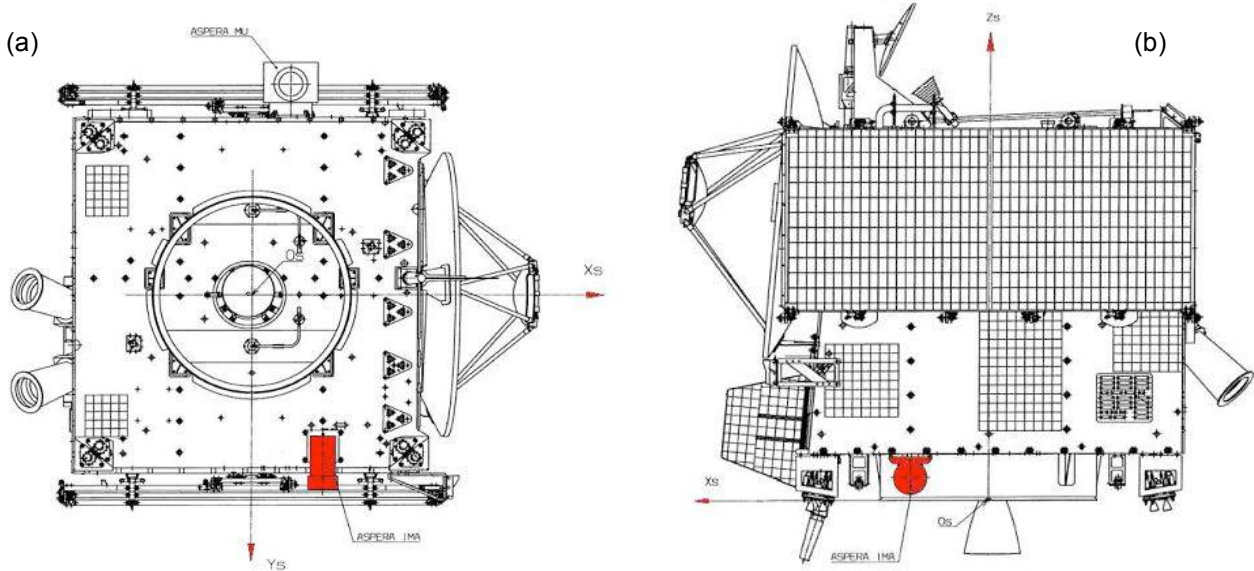
Figure 6. IMA location in (a) X_SY_S plane and (b) X_SZ_S plane, where $X_SY_SZ_S$ defined the satellite reference frame.
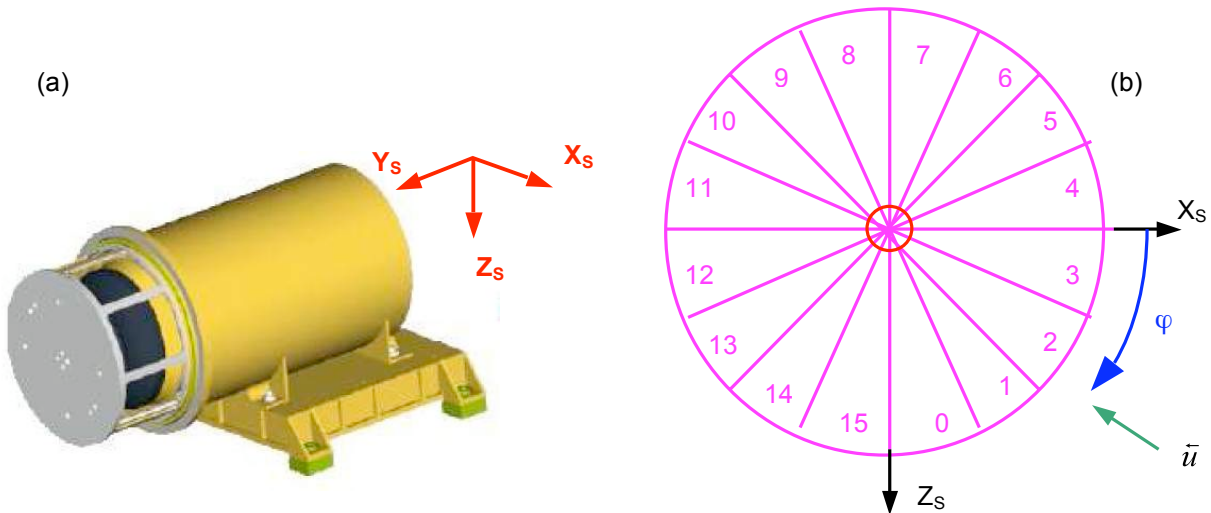
Figure 7. (a) IMA orientation in $X_SY_SZ_S$ plane. (b) Sketch showing the DPU sensor numbering and the corresponding sector looking direction in the X_SZ_S plane. $\bar{u}$ is the velocity vector of a particle entering in the middle of each sector and φ the associated azimuthal angle. The complementary angle θ is the elevation angle counted from X_SZ_S plane and directed towards $+Y_S$. It is noted that the view doesn't correspond to the physical sectors position. For example, an ion entering the sensor with an incident velocity vector $\bar{u}$ will be registered in the azimuthal sector 2.

Table 3. φ *and* $\bar{u}_{XsZs}$ *values of each IMA sector.*

sector	begin	middle	end	$\bar{u}_{XsZs}$ in the middle
0	90,00	78.75	67.50	(-0.195 , -0.981)
1	67.50	56.25	45.00	(-0.556 , -0.831)
2	45.00	33.75	22.50	(-0.831 , -0.556)
3	22.50	11.25	0.00	(-0.981 , -0.195)
4	0.00	348.75	337.50	(-0.981 , 0.195)
5	337.50	326.25	315.00	(-0.831 , 0.556)
6	315.00	303.75	292.50	(-0.556 , 0.831)
7	292.50	281.25	270.00	(-0.195 , 0.981)
8	270.00	258.75	247.50	(0.195 , 0.981)
9	247.50	236.25	225.00	(0.556 , 0.831)
10	225.00	213.75	202.50	(0.831 , 0.556)
11	202.50	191.25	180.00	(0.981 , 0.195)
12	180.00	168.75	157.50	(0.981 , -0.195)
13	157.50	146.25	135.00	(0.831 , -0.556)
14	135.00	123.75	112.50	(0.556 , -0.831)
15	112.50	101.25	90.00	(0.195 , -0.981)

(a) (b)
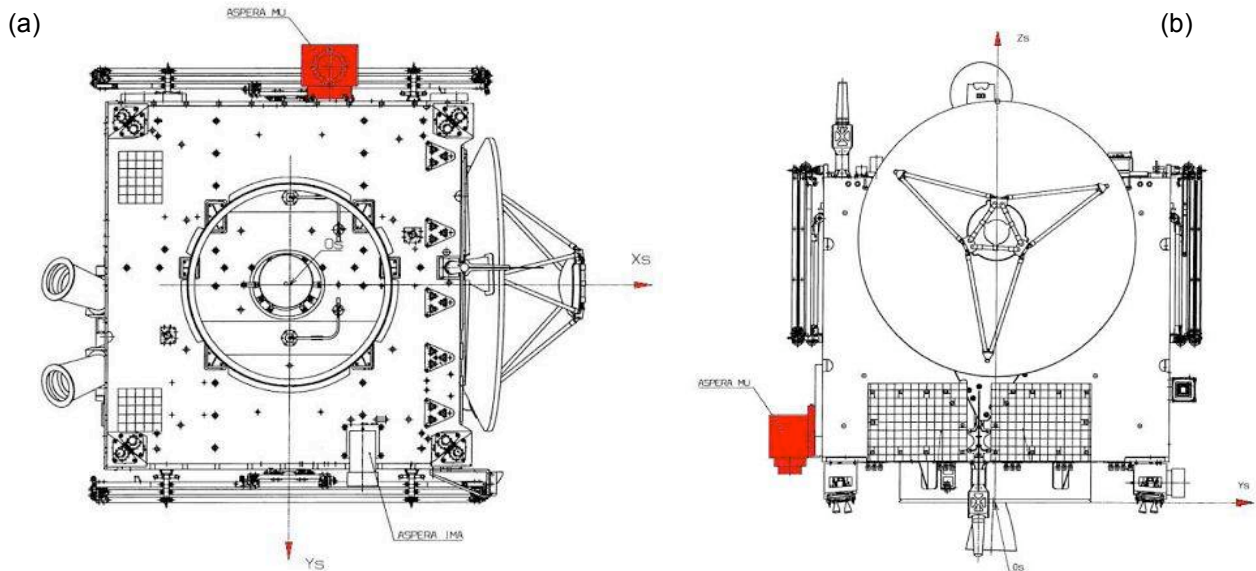
Figure 8. MU location in (a) X_SY_S plane and (b) Y_SZ_S plane onto the spacecraft.

Main Unit can turn around Y_S axis. To describe the instance attitudes of each sensor mounted on the rotating platform, we have to introduce a new reference frame $X_{mu}Y_{mu}Z_{mu}$ attached to MU. $X_{mu}Y_{mu}Z_{mu}$ is defined as a system equivalent to $X_S Y_S Z_S$ when MU is in a parking position as shown in Figure 9.
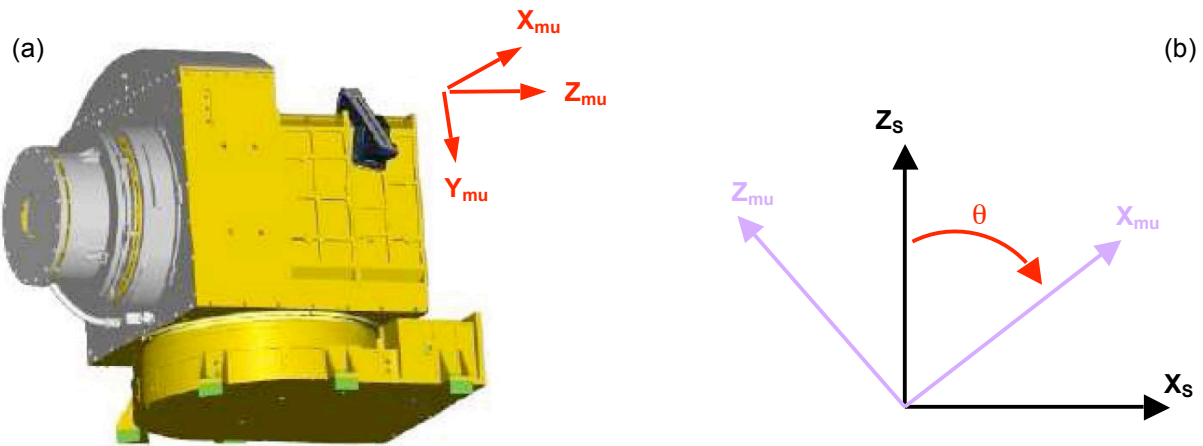
Figure 9. (a) Representation of the $X_{mu}Y_{mu}Z_{mu}$ reference frame attached to MU while MU is in a parking position. (b) Picture showing the X_{mu} and Z_{mu} vectors in the $X_S Z_S$ plane. The change of coordinates from the MU system to the satellite system is accomplished by a rotation of θ angle. θ is the scanner angle in the $X_S Z_S$ plane of the satellite system. The complementary angle φ is the azimuthal angle counted from the $+X_{mu}$ axe and contained in the 2D plane $X_{mu}Y_{mu}$.
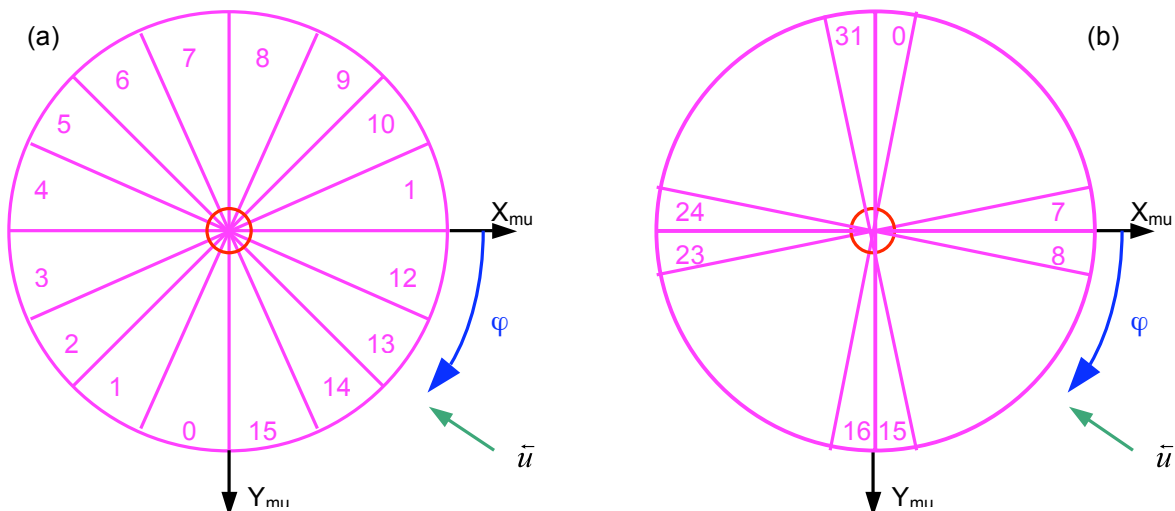
Figure 10. (a) ELS and (b) NPI sketches showing the DPU sensors numbering and the corresponding sector looking direction in the $X_{mu}Y_{mu}$ plane. $\bar{u}$ is the direction of the velocity vector of incidence particle entering in the middle of each sector. φ is the associated azimuthal angle as defined above. It is noted that the views don't correspond to the physical sectors position. For example, a particle entering ELS sensor with an incident velocity vector $\bar{u}$ will be registered by sector 13.

Table 4. φ and $\bar{u}_{X_{mu}Y_{mu}}$ *values of each ELS sector.*

sector	begin	Middle	end	$\bar{u}_{X_{mu}Y_{mu}}$ *in the middle*
0	90.00	101.25	112.50	(0.195 , -0.981)
1	112.50	123.75	135.00	(0.556 , -0.831)
2	135.00	146.25	157.50	(0.831 , -0.556)
3	157.50	168.75	180.00	(0.981 , -0.195)
4	180.00	191.25	202.50	(0.981 , 0.195)
5	202.50	213.75	225.00	(0.831 , 0.556)
6	225.00	236.25	247.50	(0.556 , 0.831)
7	247.50	258.75	270.00	(0.195 , 0.981)
8	270.00	281.25	292.50	(-0.195 , 0.981)
9	292.50	303.75	315.00	(-0.556 , 0.831)
10	315.00	326.25	337.50	(-0.831 , 0.556)
11	337.50	348.75	0.00	(-0.981 , 0.195)
12	0.00	11.25	22.50	(-0.981 , -0.195)
13	22.50	33.75	45.00	(-0.831 , -0.556)
14	45.00	56.25	67.50	(-0.556 , -0.831)
15	67.50	78.75	90	(-0.195 , -0.981)

Table 5. φ and $\bar{u}_{X_{mu}Y_{mu}}$ *values of each NPI sector.*

sector	begin	Middle	end	$\bar{u}_{X_{mu}Y_{mu}}$ *in the middle*
0	270.00	275.62	281.25	(-0.098 , 0.995)
1	281.25	286.88	292.50	(-0.290 , 0.957)
2	292.50	298.12	303.75	(-0.471 , 0.882)
3	303.75	309.38	315.00	(-0.634 , 0.773)
4	315.00	320.62	326.25	(-0.773 , 0.634)
5	326.25	331.88	337.50	(-0.882 , 0.471)
6	337.50	343.12	348.75	(-0.957 , 0.290)
7	348.75	354.38	0.00	(-0.995 , 0.098)
8	0.00	5.62	11.25	(-0.995 , -0.098)
9	11.25	16.88	22.50	(-0.957 , -0.290)
10	22.50	28.12	33.75	(-0.882 , -0.471)
11	33.75	39.38	45.00	(-0.773 , -0.634)
12	45.00	50.62	56.25	(-0.634 , -0.773)
13	56.25	61.88	67.50	(-0.471 , -0.882)
14	67.50	73.12	78.75	(-0.290 , -0.957)
15	78.75	84.38	90.00	(-0.098 , -0.995)
16	90.00	95.62	101.25	(0.098 , -0.995)
17	101.25	106.88	112.50	(0.290 , -0.957)
18	112.50	118.12	123.75	(0.471 , -0.882)
19	123.75	129.38	135.00	(0.634 , -0.773)
20	135.00	140.62	146.25	(0.773 , -0.634)
21	146.25	151.88	157.50	(0.882 , -0.471)
22	157.50	163.12	168.75	(0.957 , -0.290)
23	168.75	174.38	180.00	(0.995 , -0.098)
24	180.00	185.62	191.25	(0.995 , 0.098)
25	191.25	196.88	202.50	(0.957 , 0.290)
26	202.50	208.12	213.75	(0.882 , 0.471)
27	213.75	219.38	225.00	(0.773 , 0.634)
28	225.00	230.62	236.25	(0.634 , 0.773)
29	236.25	241.88	247.50	(0.471 , 0.882)
30	247.50	253.12	258.75	(0.290 , 0.957)
31	258.75	264.38	270.00	(0.098 , 0.995)
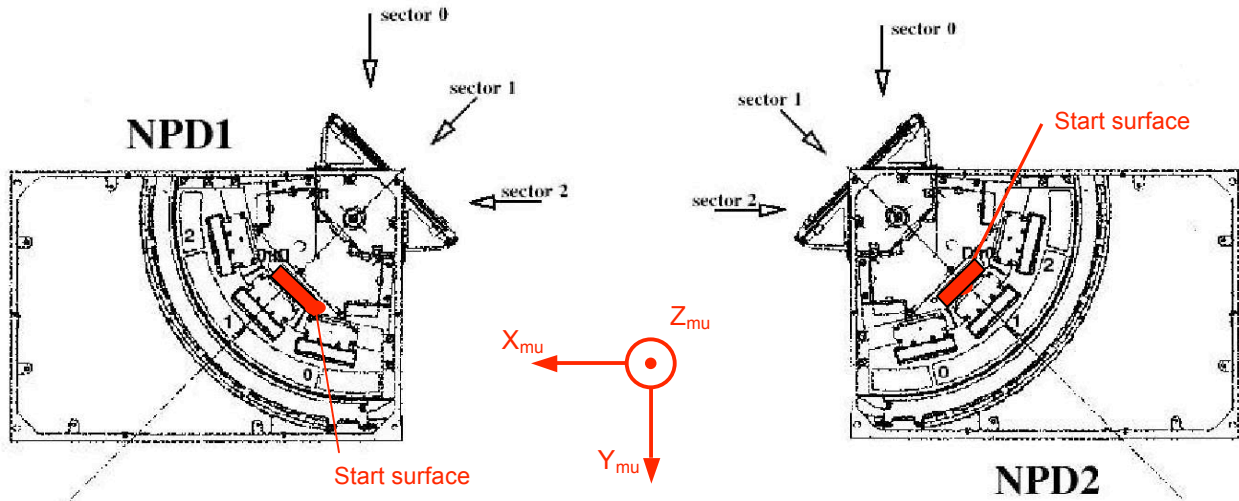
Figure 11. NPD sectors looking position in the $X_{mu}Y_{mu}$ plane. The NPD bore sight plane is inclined on the angle 15 degrees to -Zmu (NPD1) and to Zmu (NPD2) relative to the plane $X_{mu}Y_{mu}$.

Table 6. φ and $\vec{u}_{X_{mu}Y_{mu}}$ values of each NPD1 sector.

sector	begin	middle	end	$\vec{u}_{X_{mu}Y_{mu}}$ in the middle
0	270.00	255.00	240.00	(0.259 , 0.966)
1	240.00	225.00	210.00	(0.707 , 0.707)
2	210.00	195.00	180.00	(0.966 , 0.259)

Table 7. φ and $\vec{u}_{X_{mu}Y_{mu}}$ values of each NPD2 sector.

sector	begin	middle	end	$\vec{u}_{X_{mu}Y_{mu}}$ in the middle
0	270.00	285.00	300.00	(-0.259 , 0.966)
1	300.00	315.00	330.00	(-0.707 , 0.707)
2	330.00	345.00	0.00	(-0.966 , 0.259)

2.1 Scientific Objectives

The ASPERA-4 experiment comprises a comprehensive set of instruments devoted to study the solar wind – Venusian atmosphere interaction and characterize the plasma / atmospheric escape through energetic neutral atom (ENA) imaging and local charged particle measurements. Ultimately, the studies would lead to a better understanding of the origin and evolution of the planet, and particularly of induced escape mechanisms responsible, among others, to the Venusian atmosphere dehydration process.

The absence of a planetary magnetic field exhibits important differences between Venus' and Earth's atmospheric escape and energy deposition processes. The upper atmosphere of Venus is not protected by magnetic field from direct interaction with the solar wind. As a result, Venus is subject to comet-like atmosphere erosion processes and solar-wind induced current systems that have no terrestrial counterparts. Figure 12 shows an overview of the known plasma environment of Venus.

There are two main reasons why we need to understand the solar wind interaction with the Venusian atmosphere: First, it is needed to fulfill the objective of the entire VEX mission. Second, atmospheric escape into space is the ultimate atmospheric loss process, which plays an important role in the water escape, most likely escaping to space in the form of water-derived constituents such as neutral and ionized hydrogen and oxygen. It is known that losing light hydrogen is relatively easy, but the oxygen created by the implied loss of so much water-derived hydrogen presents a major unresolved problem. ASPERA-4 will clearly make progress in our understanding of atmospheric oxygen escape from Venus.
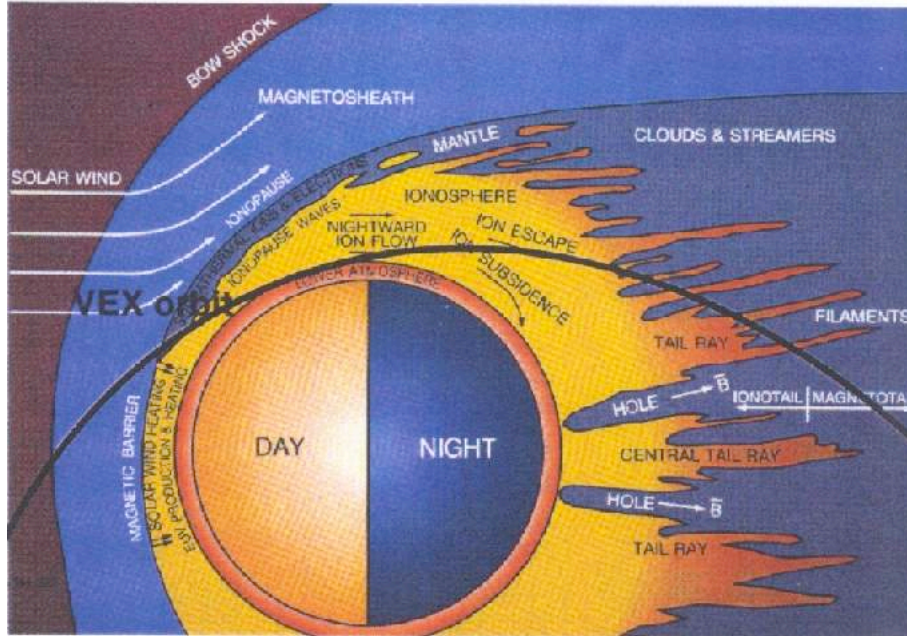
Figure 12. The Near Planet Structure Around Venus. Shown is an artist conception of the structure of the Venus ionosphere induced by the solar wind interactions. The black line shows the Venus Express orbit. ASPERA-4 operations occur through out the solar wind interaction region.

Contemporary escape processes at Venus include mechanisms affecting both neutral and ionized constituents. There are four basic escape mechanism known to date: (1) pick-up ion processes; (2) thermal "Jeans" escape; (3) sputtering from particle precipitation; and (4) polar wind outflow.

The first atmospheric escape process of a non-magnetized planet is the pick-up process. Solar radiation is the source for ionizing the atmospheric neutrals which forms an ionosphere. A thermal ion from the ionosphere is gradually accelerated by the convective electric field from the solar wind. The pick-up ion can reach energies greater than the escape energy and thus be lost from the ionospheric and atmospheric system and be carried away by the solar wind (mass loading). This process should be effective for H+ through O+ and even molecular ions.

A second escape process is the thermal escape due to heating of atmospheric species. The upper atmosphere can be heated by particle precipitation to energies above the gravitational escape energy (~10 km/s or an energy of ~ 9 eV for oxygen and a fraction of eV for hydrogen). In the case of Venus, the dominating heat source is solar EUV and penetration of solar wind ions. The second most important heat source is precipitating ENAs produced in the solar wind and by charge exchange of pick-up ions. The third source is precipitating pick-up O+ and protons. Although solar radiation and solar wind ion precipitation is the dominating heating process, the second and third source may be important for the long-term evolution of the atmosphere. Generally, the more massive a particle is, the lower its average speed at a given temperature is, meaning it is less likely to escape.

A third escape process is backscattering of atmospheric constituents of the continuous bombardment of precipitating particles. In addition to heating the neutral thermosphere, precipitating ions give up some of their energy to a backscattered component of atmospheric particles. Those backscattered particles with energies above that required for escape contribute to the loss of oxygen and other constituents from Venus.

In contrast to hydrogen, the proposed physics of the oxygen loss involves a chain of processes starting with the ionization of the upper atmospheric particles present above the Venus ionopause. Following pickup by the solar wind electric field, these atmospheric ions can escape directly, or they may charge exchange in the oxygen or hydrogen exosphere to become fast atmospheric neutrals (leaving behind a new slow exospheric ion to be picked up), or avoid escaping but reimpact the exobase where they effectively sputter oxygen atoms away.

Each escape process has specific observable signatures that can be used to sort out their contributions: sputtering and charge exchange produce distinctive ENA populations, pickup ion distributions can be identified using an ion spectrometer and a magnetometer to determine the particle pitch angles, and bulk ion removal can be diagnosed at the terminator and in the low altitude wake with an ion spectrometer and magnetometer data.

In order to study the escape of the present day Venus atmosphere one must measure the incident solar wind flux, and the escaping ions whose thermal and bulk velocities will range from about 10 to 1000 km s−1, depending on the mechanism at work. To investigate and estimate the global atmospheric escape rates one must also measure the neutral components which contribute to the escaping population. In particular, the ENA imager must be able to separate planetary ENAs from solar wind ENAs. Almost all oxygen ENAs are planetary in origin, but hydrogen ENAs could originate from the atmosphere (pick-up ions) or the direct charge exchange between the solar wind protons and the neutral exosphere. Solar wind hydrogen ENAs have a spectrum that peaks around 1 keV (around the incident solar wind energy), whereas the planetary hydrogen ENAs display an almost flat continuum down to about 10-100 eV.

To date, none of the previous missions was suitably instrumented to address these objectives. Only the Pioneer Venus Orbiter (PVO) contributed significally to develop a comprehensive ideas of the Venus solar wind interaction physics and the consequences for the planet, but crucial holes in knowledge are left due to the limitations of the instruments carried by PVO when it was launched in 1978. The plasma analyzer on PVO, designed primarily for solar wind monitoring, did not have the possibility for mass discrimination and covered only a small solid angle and insufficient energy range. In addition the electron instrument on PVO was restricted to the 0,5 keV energy and limited in coverage. Thus it made difficult to quantify the details of the escape scenario.

The IMA will put a definitive composition label on the atmospheric pickup ions produced at Venus and will detect them over a much greater (up to 36 keV as opposed to PVO's 8 keV) energy range. The ELS will measure both low energy escaping plasma and high energy electrons that contribute to the ion production through electron impact ionization. The NPD will provide a measure of the fluxes and composition of the ENAs, while imaging these particles with NPI will show the spots or regions of the most intense ENA precipitation, and give information on their variation with solar wind conditions. The ASPERA-4 IMA, with the added magnetometer MAG, on Venus Express should finally allow the evaluation of escape rates for oxygen ions as well as other species, their variation with interplanetary conditions, and their implications for related sputtering losses.

The ASPERA-4 experiment opens up the possibility to perform for the first time comprehensive plasma measurements at Venus in unprecedented detail and accuracy. In particular, the ASPERA-4 experiment will (1) investigate the interaction between the solar wind and Venus atmosphere, (2) characterize quantitatively the impact of plasma processes on the atmosphere, (3) determine the global plasma and neutral gas distribution, (4) identify the mass composition and quantitatively characterize the flux of the out flowing atmospheric materials, (5) investigate the plasma domains of the near-Venus environment, and (6) provide undisturbed solar wind parameters.

The specific science measurements to carry out these goals are:
1. Integral ENA fluxes in the energy range of 0.1 to 60 keV.
2. Mass/energy resolved neutral hydrogen and oxygen atom spectra in the energy range of 0.1 to 10 keV.
3. Ion energy/mass/angle resolved spectra in the energy range of 0.01 to 36 keV; from 1 to high atomic mass units per unit charge (amu/q); with 4π steradian coverage.
4. Electron spectra in energy range of 0.01 to 15 keV, with up to 4π steradian coverage. However, due to spacecraft blockage, 4π steradian coverage is never really achieved.

The ASPERA-4 data measurements will be conveniently archived into data sets conforming to the Planetary Data System (PDS) format-like standard that facilitates the ease of storage and long-term maintenance, and enables as well future scientists who are unfamiliar with the original experiments to analyze the data, using a variety of computer platforms, with no additional support (see [AD 1]). Basically, the ASPERA-4 archived data sets consists of primary data product files, together with information files defining the contents and format of the data, and accompanied by supportive documentation and ancillary files describing the mission, spacecraft, instrument, geometry, calibration, software and additional elements which assist in

understanding and using the data products. Both are necessary to satisfy comprehensible data analysis of the scientific return. Typically the ASPERA-4 data archive will be divided into four data sets, each one containing sensor data (ELS, IMA, NPI, NPD) annotated with instrument state and geometric data. The data sets are given an unique alphanumeric identifier (data set ID) constructed according to PDS naming conventions (described in section 3.1.2), and each one includes a generic tree-like hierarchical structure containing subdirectories such as the DATA subdirectory for the labeled data products storage, and the required and optional ancillary sub-directories (e.g. INDEX, LABEL, DOCUMENT, CATALOG, GAZETTER, SOFTWARE, CALIB, GEOMETRY and EXTRAS). Each data product (file) has a unique data product ID (file name without extension) and is associated to a product label, which describes, identifies and defines the structure of the data. The file naming convention for data products are given in section 3.1.4.

2.2 Data Handling Process

ASPERA-4 data handling process is the primary responsibility of the ASPERA-4 Co-PI institution, Centre d'Etude Spatiale des Rayonnements (CESR). The CESR is furthermore responsible for the production of the PDS-labeled data products and for their ingestion into the Planetary Science Archive (PSA) database for long-term ESA archival. The Centre National d'Etudes Spatiales (CNES) provides support to the CESR for developing a software tool that will generate the raw PDS-compliant data and label files, and for any possible reprocessing data that will impact the archive products. Besides the particular domain of the data production in which the CESR is actively involved, the PI and ASPERA-4 Co-I team are responsible for the scientific evaluation of the data being delivered to the long-term archive. Since Swedish Institute of Space Physics (IRF) is the ASPERA-4 leading PI institution, it is their responsibility, together with the Co-I team, to ensure that proper information is disseminated for the development and operation of the data system, and the ASPERA-4 PI has the final say on what data are included in the archive. The relevant contact information is provided in section 1.9. Figure 13 shows a simplified scheme for the handling and archiving of technical and scientific ASPERA-4 data. The mechanism of the data flow is the following:

The ASPERA-4 data collected on board the Venus Express spacecraft will be transferred to the European Space Operation Center (ESOC) and stored at ESOC on the Data Delivery System (DDS) in Darmstadt (Germany). It will be then transferred via FTP from the DDS to IRF.

(1) All ASPERA-4 telemetry data files are collected at IRF and distributed to the CoI team. Following the operations plan the CESR retrieves archived packets (science and HK) and the time correlation log file by direct request to the web IRF server via wget utility at http://aspera-4.irf.se/archive/raw and stores them into a suited CESR database. The CESR also handles ancillary data (attitude/orbit files) provided by ESOC via ftp://ssols01.esac.esa.int/pub/data/ESOC/VEX that might be appropriate to correctly interpret science data.

(2) As soon as they are received, the science and HK data raw packets are passed through data processing software for disassembling packets into a collection of data set records, sorted by object type (ELS, IMA, NPI, NPD1, NPD2 and HK) and written in a telemetry-like format that contains uncalibrated data (science and HK) tagged with timing information. This process preserves the raw high-resolution data in an organized way that requires no reprocessing. The CESR will archive the level-1 (uncalibrated data) instrument data file products in ASCII format, and make sure that they are immediately accessible to the PI and the authorized remainder ASPERA-4 Co-I team through W3-CESR server http://interball2.cesr.fr:8001/. The format of the data level 1 is described in [AD 5].

(3) Meanwhile the executed commands for stepping the in-flight IMA post-acceleration high voltage are extracted from the telecommand packets and stored in the CESR database as PAHLR.ASC ASCII files. These information are useful for interpreting the IMA scientific data.

(4) The final step of the product generation is the conversion from the CESR telemetry-like format to PDS format and the generation of the complete data sets. This step is also performed at CESR in Toulouse about two months before final delivery to PSA. A software tool which is currently under CNES construction will process as input the level-1 instrument data file sets prepared by the CESR to produce ASPERA-4 data products following the PSA standard (equivalent to the PDS standard from NASA). Each execution of the software tool will generate an individual data file and the associated detached PDS label for the time range specified and for the object type selected. The PDS-labeled data product files will be ASCII files containing

uncalibrated data of the science type, level-stamped as level CODMAC 2. It is also planed to generate PDS-labeled data product files of calibrated HK type, level-stamped as level CODMAC 3.

(5) PDS data files, labels and all ancillary information PDS-formatted and documented files (e.g. geometry information, indexes, etc.) are collected onto a sensor-type data set (e.g., ELS, IMA, NPI, NPD), and all of the PDS required files (AAREADME, INDEX, ERRATA, etc.) are generated. A single ASPERA-4 data set is organized as a single archive volume. Each archive volume (data set) contains all ASPERA-4 data available for the time interval covered by the archive volume, between the dates given for the Mission Phase, i.e. Nominal Mission or Extended Mission. Once the data and files are generated and organized for a data set, the CESR staff runs the PSA provided validation software tool (PVV) to ensure that all files are present and conform to PDS standards. Any errors are corrected. The final ASPERA-4 data archives will be submitted first to the PI who is in charge, together with the Co-I team, for the scientific evaluation of the data. Approved archives will then be delivered to PSA for ingestion to the official public archive after the proprietary period.

(6) For the archival of any subsequent ASPERA-4 in-flight data, the CESR will use the software tool in an automated fashion. CESR will submit each new PDS-labeled data product (release) to IRF. Upon receipt, the IRF team and the remainder ASPERA-4 Co-I team will confirm the structure of the files and labels checking as well the compliance with the PDS standards. Once the data is scientifically evaluated and approved, the release is delivered to PSA.

The delivery format is described in this document (see section 3.1.1).
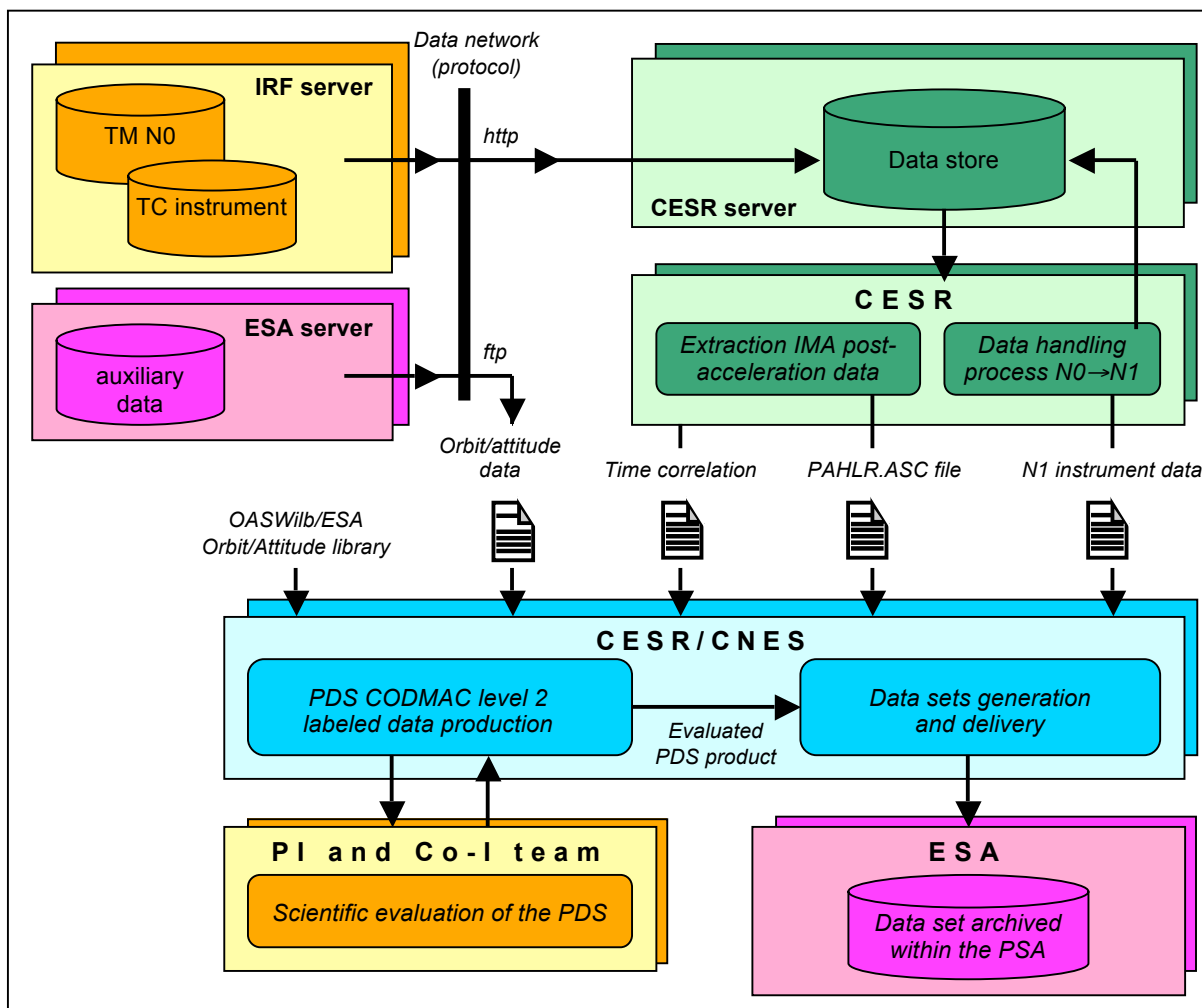
Figure 13. ASPERA-4 rough data flow and archiving process are illustrated in the figure above.

2.3 Overview of Data Products

2.3.1 Pre-Flight Data Products

No pre-flight data products will be provided.

2.3.2 Sub-System Tests

No sub-system test data will be provided.

2.3.3 Instrument Calibrations

The calibration from instrument counts to physical values is performed using the coefficients derived from the ground calibration tests. These raw ground calibration data are not archived, but the coefficients derived from these tests are included as a set of tables. The structure and content of the calibration tables are described in section 3.4.3.2. The calibration reports and any other calibration documentation are given in the DOCUMENT directory.

2.3.4 Other Files written during Calibration

No other calibration information is available for archive.

2.3.5 In-Flight Data Products

The ASPERA-4 in-flight data products correspond to all the on board data. They are produced during the following mission sub-phases:

Table 8. Standard values for MISSION_PHASE_NAME with starting date and orbit number. An updated version of this table may be found within the latest version of both [AD 4] and [AD 12] documents.

MISSION_PHASE_NAME	ORBIT_NUMBER	Start Date (dd-mm-yyyy)
"CRUISE"	-1	09-11-2005
"VOI"	0	11-04-2006
"PHASE 0"	23	14-05-2006
"PHASE 1"	44	04-06-2006
"PHASE 2"	82	11-07-2006
"PHASE 3"	146	14-09-2006
"PHASE 4"	209	16-11-2006
"PHASE 5"	286	01-02-2007
"PHASE 6"	330	16-03-2007
"PHASE 7"	370	25-04-2007
"PHASE 8"	436	30-06-2007
"PHASE 9"	488	21-08-2007
"PHASE 10"	531	04-10-2007
"PHASE 11"	554	27-10-2007
"PHASE 12"	623	04-01-2008
"PHASE 13"	711	01-04-2008
"PHASE 14"	776	05-06-2008
"PHASE 15"	833	01-08-2008
"PHASE 16"	886	23-09-2008
"PHASE 17"	985	31-12-2008
"PHASE 18"	1046	02-03-2009

"PHASE 19"	1110	05-05-2009
"PHASE 20"	1160	24-06-2009
"PHASE 21"	1248	20-09-2009
"PHASE 22"	1276	18-10-2009
"PHASE 23"	1336	17-12-2009
"PHASE 24"	1383	02-02-2010
"PHASE 25"	1447	07-04-2010
"PHASE 26"	1500	30-05-2010
"PHASE 27"	1543	12-07-2010

The CRUISE sub-phase corresponds to data collected before the VOI (VENUS Orbit Injection), including the Near Earth Verification (NEV) and Interplanetary Cruise (IC) sub-phases. After the VOI, the nominal mission is divided into different VENUS mission sub-phases defined by the VENUS EXPRESS mission planning (see Table 8). Along the S/C orbit, two targets of observation are identified, leading to two main divisions of the ASPERA-4 in flight data products. The TARGET_NAME element attempts to describe the item that was being observed at the time the data was acquired.

1. Near Earth Verification (NEV) and Interplanetary Cruise (IC) data
   a. TARGET_NAME = "SOLAR WIND"
   b. TARGET_TYPE = "N/A"
2. Venus orbit data
   a. TARGET_NAME = "VENUS"
   b. TARGET_TYPE = "PLANET"

There were originally 12 PSA Level 1b (CODMAC Level 2) data sets for storing data products through the entire mission duration: one per sensor and, per phase of the mission (NOMINAL, EXTENDED 1, EXTENDED 2) conforming to the schedule outlined in the minutes of the November DAWG telecon [AD 14]:

Table 9. Data sets duration with starting date and end date.

Data set	*Mission phase abbreviation*	*Start date* (dd-mm-yyyy)	*End date* (dd-mm-yyyy)
NOMINAL MISSION	*blank field*	Launch	02-10-2007
EXTENDED MISSION 1	EXT1	03-10-2007	31-05-2009
EXTENDED MISSION 2	EXT2	01-06-2009	?

Based on its overwhelming successes, the operations of ESA's Venus Express have been granted additional extended mission phases. A PSA Level 1b data set will be generated for each new phase of the mission and for each sensor.

For both nominal and extended mission phases, the Experiment Data Record (EDR) data sets contents are:

1. VEX-V/SW-ASPERA-2-<mission phase abbreviation>-ELS – Electron Spectrometer data (counts/accumulation) with up to 128 energy steps (center eV) ranging from 0.01 to 15 keV.
2. VEX-V/SW-ASPERA-2-<mission phase abbreviation>-IMA – Ion Mass Analyzer data (counts/accumulation) in the energy range 0.01 to 36 keV for all mass channels and azimuth anodes.
3. VEX-V/SW-ASPERA-2-<mission phase abbreviation>-NPI – Neutral Particle Imager data (counts/accumulation) of integral ENA fluxes in the energy range 0.1 to 60 keV.
4. VEX-V/SW-ASPERA-2-<mission phase abbreviation>-NPD – Neutral Particle Detector data (counts/accumulation) of atom spectra in the energy range 0.1 to 10 keV.

Each data set will be organized as a logical volume with ancillary data (geometry and calibration tables) included to the data set where applicable.

However, the data products included may differ depending on the sensor (ELS, IMA, NPI, and NPD) modes and operations during the interplanetary cruise and Venus orbit. The data, both scientific and housekeeping, are listed in documents [AD 3] and [AD 5]. See Table 10 for scientific measurements of the data sets.

Table 10. ASPERA-4 sensors Data Sets and the scientific measurements associated.

sensor	Data Set ID	Science Raw/Edited Data Description	Number of modes
ELS (electron spectrometer)	VEX-V/SW-ASPERA-2-ELS-V1.0 VEX-V/SW-ASPERA-2-EXTi-ELS-V1.0[1] PSA Level 1b CODMAC Level 2	Electron spectra containing a maximum of 128 steps × 16 sectors raw data	4
IMA (ion mass spectrometer)	VEX-V/SW-ASPERA-2-IMA-V1.0 VEX-V/SW-ASPERA-2-EXTi-IMA-V1.0[1] PSA Level 1b CODMAC Level 2	Full 3D ion spectrum consisting of a maximum of 16 polar angle steps × 96 energy steps × 16 azimuthal sectors × 32 mass channel data in raw counts 3 values of post-acceleration are available	32
NPI (neutral particle imager – flux)	VEX-V/SW-ASPERA-2-NPI-V1.0 VEX-V/SW-ASPERA-2-EXTi-NPI-V1.0[1] PSA Level 1b CODMAC Level 2	Integral ENA fluxes containing 32 azimuthal sectors raw data	2
NPD (mass/energy resolved neutral particle detector)	VEX-V/SW-ASPERA-2-NPD-V1.0 VEX-V/SW-ASPERA-2-EXTi-NPD-V1.0[1] PSA Level 1b CODMAC Level 2	Each event is stored in the array: time-of-flight (velocity measurement) × stop pulse height (for mass identification) × azimuthal direction (possible of 3)	4 / sensor identical structure files for both detectors

[1] where i is the occurrence number of the extended mission phase (starting from 1)

Note: HK are also archived in PDS-labeled data product files and must be contained within the sensor data set to which they belong. Mainly, there are 2 types of HK data. The MU provides status information and housekeeping data for ELS, NPI and NPDs sensors whereas the IMA engineering data are monitored and prepared by the IMA Data Processing Unit. Raw HK data incoming from both systems are converted into physical values when calibration is applied.

2.3.6   Software

No software is provided within the ASPERA-4 data sets.

2.3.7   Documentation

Most of the documentation provided in the archive volumes is either in the form of PDS catalog (.CAT) files in the CATALOG directory or are in the DOCUMENT directory. The documents provided in the DOCUMENT directory are:

1. VEX / ASPERA-4 Instrument Manual, June 17, 2006, Issue &, Rev. 1, VE-ASP-TN-060402
2. Description des fichiers N1 VEX, E. Penou, CESR, 16/10/2006, Edit. 4, Rev. 0
3. EAICD (this document)

This EAICD document is the only document that is considered critical documentation for the understanding of the contents and usage of the ASPERA-4 archived data sets.

2.3.8   Derived and other Data Products

We do not intend to provide any other derived data or data products that result from co-operation with other instrument teams.

2.3.9   Ancilary Data Usage

It is important for ASPERA-4 science studies to know where in space and time the Venus Express spacecraft and ASPERA-4 instruments are located and what objects (Sun, Venus, Earth) are in the fields of views.

ESOC will provide via the IRF server the Venus Express spacecraft general orbit data related to the Earth Mean Equator (EME) of J2000 coordinates for use in conjunction with the ASPERA-4 data (see [AD 6] 4.2). The attitude data files will be provided apart by ESOC via IRF. The following orbit and attitude files from ESOC are used for the generation of ASPERA-4 data products:

ORHV_FDLVMA_DA_____vvvvv.VEX
                            (covers the cruise phase from launch to Venus orbit insertion, orbital data are provided as Heliocentric states in the EMEJ2000 reference frame)

ORVV_FDLVMA_DA_YYMMDDhhmmss_vvvvv.VEX
                            (covers the operational orbit around Venus after orbit insertion, orbital data are provided as Venus centric states in the EMEJ2000 reference frame)
ORVV_MERGED_vvvvv.ORB

                            (Contains Venus Express orbit pericenter and apocenter times, orbital elements, and additional geometry parameters)

ATNV_FDLVMA_DAPYYMMDDhhmmss_vvvvv.VEX
                            (S/C attitude, EMEJ2000, several days / segment)

ATPV_FDLVMA_DAPnnnnn_YYMMDD_vvvvv.VEX
                            (S/C attitude, EMEJ2000, medium term planning predicted attitude information covering the time span starting at the date YYMMDD)

Deliveries require the software OASW to access and process orbit and attitude data, and the use of the SPICE kernel data file containing JPL's Planetary Ephemerides (DE) 405 together with the SPICE toolkit for computing coordinates change from the EMEJ2000 frame into the VSO (Venus-Sun-Orbit) coordinates system.

All SPICE files will be included in a VEX data set. SPICE files are also available at the ESAC FTP Server : ftp://ssols01.esac.esa.int/pub/data/SPICE/VEX, or can be downloaded from the ftp mirror NAIF website: ftp://naif.jpl.nasa.gov/pub/naif/VEX.
Additional ancillary data files are required for our processing data chain: at higher levels, the raw data are converted into more useful paramaters and formats, in physical units. For the understanding of IMA data scientific analysis, the IMA post-acceleration high voltage values recorded within TC packets are retrieved from IRF server and stored at CESR as PAHLR.ASC ASCII files together with telemetry data packets.

A useful 3D visualization tool which allows users to represent the predicted and re-constructed orbit and attitude of the VEX probe all along the mission is accessible at the GFI server: http://mm3dview.gfi-toulouse.fr.

3   Archive Format and Content

This chapter contains general rules and constraints for the ASPERA-4 data sets. The schemes or conventions used for naming the directories and files is specified below.
Specific and detailed information are provided in subchapters of chapter 4.3.

3.1   Format and Conventions

3.1.1   Deliveries and Archive Volume Format

Deliveries to the PSA will be made by the CESR archive team. First ASPERA-4 data will be delivered once the archive volume generation and submission process are successfully passed, as scheduled in Table 11. Subsequent data will be delivered in the long term every 3 months till the end of the VEX operational mission, and stored into the appropriate archive volume. Date for deliveries should be at least 2 months after the last data of the archive volume. An approximate ASPERA-4 data delivery schedule is shown below:

Table 11. List of the dataset release number with the associated data coverage period and deliveries.

Mission phase	Release number	Data collection period	Delivery to PSA	Public distribution
Nominal mission	0001	Launch-Cruise-Commissioning 09 Nov 2005 (launch date) to August 2006	Sep 2008	After the PSA approval, individual releases older than 6 months will be delivered to the public with respect to the proprietary period of 6 months.
	0002	Sep/Oct/Nov 2006	Sep 2008	
	0003	Dec 2006 / Jan/Feb 2007	Sep 2008	
	0004	Mar/Apr/May 2007	Sep 2008	
	0005	Jun/Jul/Aug 2007	Sep 2008	
	0006	Sep 2007 / 2Oct 2007	Sep 2008	
Extended mission 1	0001	3 Oct 2007 / Nov/Dec 2007	Sep 2008	
	0002	Jan/Feb/Mar 2008	Sep 2008	
	0003	Apr/May/Jun 2008	Oct 2008	
	0004	Jul/Aug/Sep 2008	Jan 2009	
	0005	Oct/Nov/Dec 2008	Apr 2009	
	0006	Jan/Feb/Mar 2009	Jul 2009	
	0007	Apr/May 2009	Sep 2009	
Extended mission 2	0001	Jun/Jul/Aug 2009	Dec 2009	
	0002	Sep/Oct/Nov 2009	Mar 2010	
	0003	Dec 2009 / Jan/Feb 2010	Jun 2010	
	0004	Mar/Apr/May 2010	Sep 2010	
	...	...	…	
Extended mission i[(1)]	...	...	…	

[(1)] where i is the occurrence number of the extended mission phase (starting from 1)

Tens of logical archive volumes will be delivered for the whole mission where each volume contains a single dataset. For the purposes of the PSA, a volume is equivalent to a dataset, so volume identifiers are typically not applicable. A dataset consists of science and HK data, together with documents (see chapter 3.4.3.10). Within a dataset, data are split up into several releases, that together form a complete PSA compatible dataset. A release will concern a well-defined period of time, and may cover several orbit numbers.

Deliveries are based on the concept of a release and a revision of a well-defined period of time [AD 7]. Data are delivered to PSA as units (releases), which can be updated (revision). The list of the ongoing dataset releases arranged by numbering is given in Table 11. Foreseen schedule for deliveries to PSA and public distribution are also displayed. The delivery will be performed only via file transfer, no storage media like CD or DVD will be used.

PSA implemented this concept to allow the delivery of experiment data without the delivery of all supplementary information, that has already been delivered at the first initial delivery of a fully PDS compatible archive volume, containing the VOLDESC.CAT file and all necessary CATALOG, DOCUMENT, INDEX, DATA, etc directories and their content. Two specific data elements (keywords) are included to handle the release concept:

```
RELEASE_ID
REVISION_ID
```

RELEASE_ID defines the release number and REVISION_ID defines the revision number. All labels within the first delivery must contain RELEASE_ID = 0001 and REVISION_ID = 0000.

Each PDS data set must have a unique name (DATA_SET_NAME) and a unique identifier (DATA_SET_ID), both formed from up to seven components. The components are listed here:

Instrument host	VENUS EXPRESS (VEX)
Target	VENUS (V) / SOLARWIND (SW)
Instrument	ASPERA
Data processing level number	see below
Mission phase	see below
Description (optional)	see below
Version number	V1.0

Data processing level number used in ASPERA-4 naming scheme conforms to the Committee on Data Management and Computation (CODMAC) norm:

Level	Type	Data Processing Level Description
1	Raw Data	Telemetry data with data embedded.
2	Edited Data	Corrected for telemetry errors and split or decommutated into a data set for a given instrument. Sometimes called Experimental Data Record (EDR). Data are also tagged with time and location of acquisition.
3	Calibrated Data	Edited data that are still in units produced by instrument, but that have been corrected so that values are expressed in or are proportional to some physical unit such as radiance. No resampling, so edited data can be reconstructed.
4	Resampled Data	Data that have been resampled in the time or space domains in such a way that the original edited data cannot be reconstructed. Could be calibrated in addition to being resampled.
5	Derived Data	Derived results, as maps, reports, graphics, etc.
6	Ancillary Data	Nonscience data needed to generate calibrated or resampled data sets. Consists of instrument gains, offsets, pointing information for scan platforms, etc.
7	Correlative Data	Other science data needed to interpret space-based data sets.
8	User Description	Description of why the data were required, any peculiarities associated with the data sets, and enough documentation to allow secondary user to extract information from the data.
N	N	Not Applicable

For our concern, the ASPERA-4 data sets are level-stamped as level 2 (CODMAC level 2).

Mission phase
This field is used to refer to the mission phase ID. The mission phase is displayed only for the extended mission phases data. It would be: EXTENSION i, where i assigns the occurrence number of the extended mission phase (starting from 1). A blank field is assigned for the nominal mission phase.

Description
The description field is used to distinguish the ASPERA-4 sensor datasets themselves. The description would be: ELS, IMA, NPD or NPI.

Thus, the archive volumes (data sets) have the following naming convention (see [AD 4] 3.1.1):

DATA_SET_NAME = <INSTRUMENT_HOST_NAME> <target name> <INSTRUMENT_ID> <data processing level number> <mission phase> <description> V<version>

Examples:

data set for the nominal mission phase data:
DATA_SET_NAME = "VENUS EXPRESS VENUS/SOLARWIND ASPERA 2 IMA V1.0"

data set containing data from the first extended mission phase:
DATA_SET_NAME = "VENUS EXPRESS VENUS/SOLARWIND ASPERA 2 EXTENSION 1 IMA V1.0"

Note: The DATA_SET_NAME must be changed whenever it will become necessary to deliver different versions. It is expected that the file version number will remain 1.0 during all the mission. If any extreme cases occur where changes are made to the products or the data set itself, the reprocessed files replace the older ones and have the version number incremented.

3.1.2   Data Set ID Formation

PDS data set identifiers (DATA_SET_ID) conform to the following format (see [AD 4] 3.1.2):

DATA_SET_ID =   <INSTRUMENT_HOST_ID>-<target id>-<INSTRUMENT_ID>-<data processing level number>-<mission phase abbreviation>-<description>-V<version>

Examples: DATA_SET_ID = "VEX-V/SW-ASPERA-2-IMA-V1.0

DATA_SET_ID = "VEX-V/SW-ASPERA-2-EXT1-IMA-V1.0"

3.1.3   Data Directory Naming Convention

Below the DATA directory, data are organized into several subdirectories, sorted by release. The Figure 14 shows the dataset directory structure used for each sensor of the ASPERA-4 experiment and for each mission phase defined in the operations plan.

```
                        |-CALIB-
                        |-CATALOG-
                        |               |- release 1
                        |- DATA ----|- release 2
|- root directory -----|               |- release 3
                        |               |- etc
                        |-DOCUMENT-
                        |-GEOMETRY-
                        |-INDEX-
                        |-LABEL-
```
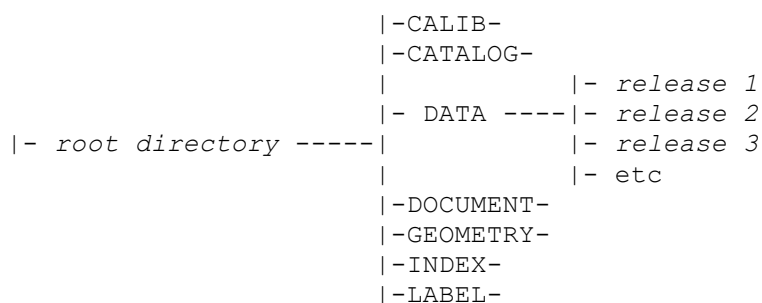
Figure 14. Data Set Directory Structure.

The *release X* subdirectory names will be replaced by the corresponding time period (see Table 11). The naming convention will be as following:

<begin of observation>_<end of observation>

Where   **<begin of observation>** = YYYYMMDD for Year, Month and Day
          <end of observation>   = YYYYMMDD for Year, Month and Day

For example, the NPD RELEASE1 raw data of the nominal mission phase will be in the DATA subdirectory 20051109_20070430.

If a revision is delivered for the same NPD raw data, it will be in the same DATA subdirectory, but the data labels will have updated REVISION_ID keyword values.

All data sets are delivered separately through the release ID values. For a mission phase, a given release ID corresponds to the same specific time period, and this time period is the same for all the data sets (ELS, IMA, NPI, and NPD).

3.1.4   Filenaming Convention

Within a "release" subdirectory, data are grouped and stored into individual and separate sequence files (namely data products) according to operational mode or sub-mode of equal number of sampling steps, keeping same data pattern in a file.

Data products provided by ASPERA-4 team will have names of the following form:

<exp>_<data type>_<begin of observation>_<index of occurrence><number of occurrences>.<ext>

where   **<exp>** (3 characters) = {ELS, IMA, NPI, NP1 or NP2} with last ones for NPD1 and NPD2 respectively

<data type > (7 characters) = There are several possible data type namings that depict data files regarding their content for science and housekeeping.
- 2 housekeeping data types may exist: {HK3MUXX} and {HK3IMAX} for discriminating calibrated data (processing level 3) coming from the Main Unit processor and the IMA digital processor unit respectively.
- Several science data type namings, each of which describing the flight sampling mode of operation that is used in the measurements (see §4).

<begin of observation> (12 characters) = time of test or working session in UTC yymmddhhmmss:
- yy = year
- mm = month
- dd = day
- hh = hour
- mm = minute
- ss = second

<index of occurrence> (1 character) = part of the fragmented file in the sequence.

<number of occurrences> (1 character) = total number of parts after splitting file bigger than 500Mb into any consecutive pieces of small size (<500Mb).

<ext> = extension of file depending on the type of the file. For ASPERA-4 the possible extension are:
- TAB for tabular raw data containing science or HK data (CODMAC level 2 or 3)
- LBL   for the associated label file

Character X is provided in names where significant characters are not applicable.

Examples :

NP1_RAWXXXX_070501144149_11.TAB
Data included in this non-fragmented file are ASPERA-4 NPD1 Science RAW data recorded on flight on 01 May 2007 beginning at 14:41:49 (UTC). They are edited data, in NPD coordinates.

NP1_HK3MUXX_060903121000_11.TAB
Data included in this non-fragmented file are calibrated HK flight data recorded on-board by the Main Unit processor on 03 Sep 2006 beginning at 12:10:00 (UTC). Extracted data are related to the NPD1 sensor or common housekeeping data information.

3.2 Standards Used in Data Product Generation

3.2.1 PDS Standards

The archive structure given in this document complies with PDS standard version 3.6. Each PDS archived product is described using label objects that provide information about the data types of stored values.

In order to identify and describe the organization, content, and format of each data product, PDS requires a distinct data product label for each individual data product file. This data product label can be attached or detached from the data. The ASPERA-4 PDS data product label is detached from the data and resides in a separate file which contains a pointer to the data product file. There is one detached label file for every data product file and for each sensor (ELS, IMA, NPI, NPD). The label file should have the same base name as its associated data file, but the extension is .LBL.

Each PDS label must begin with the PDS_VERSION_ID data element. This element identifies the published version of the standards to which the label adheres. For labels adhering to the standards version 3.6 the appropriate value is PDS3:

PDS_VERSION_ID = PDS3

3.2.2 Time Standards

On board the S/C all telemetry, i.e. experiment science and housekeeping data, are time-tagged with an On-Board Time (OBT) obtained from the VEX on board running high frequency clock, to which sensor clocks are synchronized. This time-stamp is contained in the header of each telemetry source packet for referring to the data acquisition start time of each observation. Although ideally the spacecraft clock is a very convenient quantity for a time scale and easy for software to manipulate, it may be subject to discontinuous jumps or resets, and therefore it cannot be used where it is necessary to label data with a unique time, or where a uniformly increasing time is required. Experience with other missions has shown the necessary use of the Coordinated Universal Time (UTC) for labelling instrument telemetry records with a continuously increasing time scale, and, in addition, facilitating comparison of data from a particular spacecraft or ground-based facility with data from other sources (see [AD 8]).

Both OBT and UTC time scales are related with each other. The OBT is converted to the UTC by using time correlation/correction coefficients provided within the time correlation packets, for the time range they are valid. Those packets are automatically retrieved by IRF from the DDS, and regularly distributed via its server, together with the reconstituted experiment telemetry packets.

Finally two time standards are used in the ASPERA-4 data products:
- OBT: seconds and fractions of seconds since last switch-on of the spacecraft, on March 1st 2005 00:00:00.
- UTC: year, month, day, hour, minute, second, millisecond when the data were measured by the sensor on board the S/C.

These time values are provided in the data product labels, which provide a start and stop time for the measurement, and a corresponding clock count from the spacecraft. Below, the standards used to define these values are described, and the method by which the OBT is converted to UTC.

3.2.2.1 Date and Time Formats

The dates and times used within ASPERA-4 data files are the times when the data are sampled in UTC. The START_TIME and STOP_TIME values in the data product labels and catalog templates are also in UTC and in the same format as the dates and times within the data files:

yyyy-mm-ddThh:mm:ss.sss

where yyyy is the 4-digit year, mm is a 2-digit month, dd is the 2-digit day of the month, hh is the 2-digit hour of the day (00-23), mm is the 2-digit minute of the hour (00-59), and ss.sss indicates the seconds (including fraction) of the minute.

The PRODUCT_CREATION_TIME is also in UTC and indicates the date/time that the data files and labels are generated as taken from the local computer. The dates/times of the PRODUCT_CREATION_TIME have format:

yyyy-mm-ddThh:mm:ss

where yyyy is the 4-digit year, mm is a 2-digit month, dd is the 2-digit day of the month, hh is the 2-digit hour of the day, mm is a 2-digit minute of the hour, and ss indicates the seconds of the minute.

3.2.2.2 Spacecraft Clock Formats

The spacecraft clock count provides the only time information available to the instrument for a space-based observation during operation. It allows direct comparison of measurements on the same spacecraft with high accuracy, before additional errors are introduced by the OBT-to-UTC conversion.

The PDS keywords SPACECRAFT_CLOCK_START_COUNT and SPACECRAFT_CLOCK_STOP_COUNT represent the OBT counters of the spacecraft and instrument computers. These elements are required in labels for describing space-based data. The associated values are formatted as a string to preserve precision, as it is explained below.

The OBT counter is given in the headers of the experiment telemetry source packets. It contains the data acquisition start time as 32 bits of unit seconds followed by 16 bits of fractional seconds. The time resolution of the fractional part is $2^{-16} = 1.53 \times 10^{-5}$ seconds.

The OBT is represented as a decimal real number in floating point notation with 10 digits before the decimal point and 5 digits after the decimal point as the following format:

SPACECRAFT_CLOCK_START_COUNT/STOP_COUNT =
            <reset number>/<unit seconds>.<fractional seconds>

The unit seconds and the fractional seconds are separated by a full stop character. The fractional seconds are expressed as multiples of $2^{-16} = 1.53 \times 10^{-5}$ seconds and count from 0 to $2^{16} - 1 = 65535$. Thus the OBT is indicated with a maximum of 10 digits after the slash and 5 digits after the full stop character. E.g. in SPACECRAFT_CLOCK_START_COUNT = "1/21983325.392" the 392 fractional seconds correspond to $392 \times 2^{-16} = 0.00598$ decimal seconds.

An integer number followed by a slash represents a reset of the spacecraft clock (e.g., "1/" or "2/"). If any change occurs, it would imply a change of the OBT zero point.

3.2.2.3 OBT to UTC Time Conversion

UTC time is a function of the time correlation packets and the on-board time. The file named *time-corr-LATEST* contains linear segments that map the OBT time to UTC time since the 1st March 2005, well before the beginning of the mission (03:33:00 UTC on 9th November 2005). The linear segments are represented by time correlation coefficients, mainly the time offset and the time gradient.

The time correlation packet as described in [AD 5] has the following structure:

Table 12. Time correlation packet structure.

DDS Packet Header	Time correlation Packet Data Field			
	Gradient	offset	standard deviation	generation time
	64 bits	64 bits	64 bits	48 bits
144 bits (18 bytes)	240 bits (30 bytes)			

Within the time correlation packets, the DDS header contains the time at which the contained time correlation became valid. The time correlation packet is expected to be valid while no update file occurs in the meantime.

3.2.2.3.1   Time processing for HKxxxx, ELS, NPI, NPDx files

The conversion function is:

```
Time in UTC = Offset + OBT(seconds) × gradient
```

where
- `OBT` is the on-board time in seconds,
- `Time in UTC` is the computed UTC time containing the number of seconds past since 00:00:00 on January 1st 1970.

3.2.2.3.2   Time processing for IMA file

Particularly, the IMA time information is composed of an internal timer which scales down the accuracy to 31.25 msec. The on-board timer of IMA returns to 0 when it exceeds the value 0x7FFFF. This happens approximately every six days (see [AD 3] appendix 9).

The conversion function is:
```
Time in UTC = Offset + (IT(seconds) + no×(0x80000)) × gradient
```

where
- `IT` is the on-board timer of IMA in seconds ,
- `no` the number of time the IMA on-board time is returned to 0 (timer swapping around about once per 6 days),
- `Time in UTC` is the computed UTC time containing the number of seconds past since 00:00:00 on January 1st 1970.

Note: To determine `no`, it is recommended to increment the variable `no` inside a loop (starting from 0) until `Time in UTC` corresponds to the day that we are processing.

The on-board time is then derived as follows:
```
OBT(seconds) = IT(seconds) + no×(0x80000)
```

where `no` is the computed number of time for which the IMA on-board time is returned to 0.

3.2.3   Reference Systems

The ASPERA-4 data are always in the instrument reference frame since data are sampled *in situ*. The other reference systems used for ASPERA-4 data products are:

- Venus Express spacecraft coordinates system (see "*ASPERA-4 sensors orientation"* in section 2)

- EMEJ2000 (Earth Mean Equator and equinox at epoch J2000) - The standard inertial reference frame is defined as follows: Earth centered, where the X axis points from the Earth towards the first point of

Aries (the position of the Sun at the vernal equinox). This direction is the intersection of the Earth's equatorial plane and the ecliptic plane --- thus the X axis lies in both planes. The Z axis is parallel to the rotation axis of the Earth and the Y axis completes a right-handed orthogonal coordinate system. As mentioned above, the X axis is the direction of the mean vernal equinox of J2000. The Z axis is also defined as being normal to the mean Earth equator of J2000.

- VSO frame (Venus Solar Orbital) - A cartesian coordinate system centered on Venus. The components of this coordinate system are as follows: The X axis direction points from the center of Venus to the Sun, taken positive towards the Sun, the Z axis is parallel to the northward pole of the Venus orbital plane, the Y axis completes the right-handed set and points towards dusk. Locations of bodies (spacecraft) given in VSO coordinates are usually represented in units of Venus radii where Rv = 6052 km.

The GEOMETRY directory will contain the S/C orbital position and attitude relative to the EMEJ2000 and VSO reference frames, with data sampled according to the time cadence of the instrument observations. To derive the ASPERA-4 looking directions for each sensor and in both reference frames, the change of frame matrix as defined in section 2 is applied.

3.2.4   Other Applicable Standards

No other standards are used .

3.3   Data Validation

In summary, once the ASPERA-4 science and HK data product archives are generated by CESR, the PDS files will be first scientifically evaluated by the ASPERA-4 PI and Co-I team (e.g., by visual inspection with the readPDS IDL tool) to be then delivered to the Planetary Science Archive for archival purposes.

Prior to the data being ingested into the online PSA (http://www.rssd.esa.int/PSA), the CESR team fully test the data sets for compliancy using the PVV tool (PSA Validation and Verification Tool developed by ESTEC). This software checks the syntax of all keywords and labels within the data sets, and crosschecks values for keywords that should be identical. If the PVV tool successfully verifies a data set, then the data set is PDS compliant and will be ingested into the online PSA.

In addition, before the ASPERA-4 data are archived and released to the scientific community, the data sets and documentation undergo a thorough peer review. This is completed in several stages by independent external reviewers who validate the usefulness of the archive and provide constructive input to improve the data sets in the same way as a professional paper may be reviewed.

3.4   Content

This section describes the contents of the ASPERA-4 standard product archive collection volumes (datasets), including the file names, file contents, file types, and organizations responsible for providing the files. The complete directory structures are shown in Appendix C, D, E and F. All directories and ancillary files described herein appear on each ASPERA-4 archive volume (dataset), except where noted.

3.4.1   Volume Set

For Venus Express ASPERA-4 data set deliveries to PSA, a volume set is equivalent to a data set.

Despite the fact that there is no physical volume, a value must have been assigned for every applicable keywords within the VOLUME object, as required for PDS compliance (see [AD 3] § 2.2).

```
DATA_SET_ID            = see section 3.1.2
DESCRIPTION            = "This volume contains…"
```

```
MEDIUM_TYPE            = "ONLINE"
PUBLICATION_DATE       = YYYY-MM-DD
VOLUME_FORMAT          = "ISO-9660"
VOLUME_ID              = see [AD 3] Table 14
VOLUME_NAME            = see [AD 3] Table 11
VOLUME_SERIES_NAME     = "MISSION TO VENUS"
VOLUME_SET_NAME        = see [AD 3] Table 11
VOLUME_SET_ID          = see [AD 3] Table 13
VOLUME_VERSION_ID      = "VERSION 1"
VOLUMES                = "1"
```

3.4.2   Data Set

The ASPERA-4 data will be archived in as many data sets as individual sensor contained within the ASPERA-4 experiment, level data processing in use and possible mission phases.

Each data set will contain the data products of one sensor (ELS, IMA, NPI, NPD) and of one data level (CODMAC Level 2) in the time interval of the given mission phase, accompanied by ancilliary data, software, and documentation, needed to understand and use the observations. Files in a data set share a unique data set name, a unique data set identifier, and are described by a single DATASET.CAT catalog object. The data set name and identifier, as previously defined in section 3.1.2., are built from the following parts:

Table 13. Elements for the DATA_SET_ID and DATA_SET_NAME formation.

Name element	Data Set ID	Data Set Name
INSTRUMENT_HOST_ID / INSTRUMENT_HOST_NAME	VEX	VENUS EXPRESS
target id / target name	V/SW	VENUS/SOLARWIND
INSTRUMENT_ID	ASPERA	
Data processing level number	Level 2 contains level 2 SC (and level 3 HK)	
mission phase	EXTi[1] (the nominal mission phase is displayed as a blank field)	EXTENSION i[1]
description	ELS, IMA, NPD or NPI	
version	The first version of a data set is V1.0	

[1] where i assigns the occurrence number of the extended mission phase (starting from 1)

Different types of dataset will be delivered:

    DATA_SET_ID = "VEX-V/SW-ASPERA-2-ELS-*Vx.x*"
    DATA_SET_ID = "VEX-V/SW-ASPERA-2-EXTi-ELS-*Vx.x*"
    DATA_SET_ID = "VEX-V/SW-ASPERA-2-IMA-*Vx.x*"
    DATA_SET_ID = "VEX-V/SW-ASPERA-2-EXTi-IMA-*Vx.x*"
    DATA_SET_ID = "VEX-V/SW-ASPERA-2-NPI-*Vx.x*"
    DATA_SET_ID = "VEX-V/SW-ASPERA-2-EXTi-NPI-*Vx.x*"
    DATA_SET_ID = "VEX-V/SW-ASPERA-2-NPD-*Vx.x*"
    DATA_SET_ID = "VEX-V/SW-ASPERA-2-EXTi-NPD-*Vx.x*"

[1] where i is the occurrence number of the extended mission phase (starting from 1)

3.4.3   Directories

Each ASPERA-4 archive volume/dataset (VEX-V/SW-ASPERA-2-ELS-V1.0, VEX-V/SW-ASPERA-2-EXTi-ELS-V1.0[(1)], VEX-V/SW-ASPERA-2-IMA-V1.0, VEX-V/SW-ASPERA-2-EXTi-IMA-V1.0[(1)], VEX-V/SW-ASPERA-2-NPI-V1.0, VEX-V/SW-ASPERA-2-EXTi-NPI-V1.0[(1)], VEX-V/SW-ASPERA-2-NPD-V1.0, VEX-V/SW-ASPERA-2-EXTi-NPD-V1.0[(1)]) is a PDS compatible archive volume, containing the VOLDESC.CAT and AAREADME.TXT files and all necessary CATALOG, DOCUMENT, INDEX, DATA, etc.. directories and their content.

The corresponding VEX-V_SW-ASPERA-2-ELS-V1.0, VEX-V_SW-ASPERA-2-EXTi-ELS-V1.0[(1)], VEX-V_SW-ASPERA-2-IMA-V1.0, VEX-V_SW-ASPERA-2-EXTi-IMA-V1.0[(1)], VEX-V_SW-ASPERA-2-NPI-V1.0, VEX-V_SW-ASPERA-2-EXTi-NPI-V1.0[(1)], VEX-V_SW-ASPERA-2-NPD-V1.0, VEX-V_SW-ASPERA-2-EXTi-NPD-V1.0[(1)], directories are root directories following the organization scheme outlined in Figure 14.

[(1)] where i is the occurrence number of the extended mission phase (starting from 1)

3.4.3.1   Root Directory

The root directory contains the following standard PDS files:

Table 14. Root directory contents.

File Name	File Contents
AAREADME.TXT	This file completely describes the volume contents and format information
ERRATA.TXT	A cumulative listing of all known errors, omissions, and areas of non-conformance with PDS standards in the current volume and in previous volumes of a set.
VOLDESC.CAT	A description of the contents of this volume in PDS format readable by both humans and computers

The name of the root directory is the DATA_SET_ID.

3.4.3.2   Calibration Directory

The CALIBration directory contains the calibration tables (.TAB files) and associated labels (.LBL files) necessary to convert or process the raw data in counts (PSA Level 1b) to calibrated physical units (PSA Level 2). The CALINFO.TXT file describes the contents of the directory and how to use the calibration tables in the directory.

Table 15. Calibration directory contents.

File Name	File Contents
CALINFO.TXT	A description of the contents of the CALIB directory
<exp>_<data type>_CAL<_Type>.TAB	A calibration data table for data products beginning with <exp>_<data type> as described in section 3.1.4. If more than one table is needed, then a table type <_Type> is appended to the name. For example, if ELS data products need only one table, then the name is ELSX_CAL.TAB, but if separate tables are needed, then the name for geometry factors could be something like ELSX_CAL_GF.TAB
<exp>_<data type>_CAL<_Type>.LBL	A PDS detached label that describes <exp>_<data type>_CAL<_Type>.TAB

3.4.3.3   Catalog Directory

The CATALOG directory provides a top level understanding of the mission, spacecraft, instruments and data sets. The catalog directory contains the following standard PDS files:

Table 16. Catalog directory contents.

File Name	Contents
CATINFO.TXT	A description of the contents of the catalog directory
DATASET.CAT	Data set information
INSTHOST.CAT	Instrument host (spacecraft) information
INST.CAT	Instrument information
MISSION.CAT	Mission information
PERSON.CAT	PDS personnel catalog information about the instrument team responsible for generating the data products. There will be one file for each instrument team providing data to this data set.
REF.CAT	Full citations for references mentioned in any and all of the catalog files, or in any associated label files.
RELEASE.CAT	For each data set, there is one release catalog file which defines, through release objects, a data products delivery to the PSA
TARGET.CAT	A listing of key physical properties of Venus, Solar Wind, some of which are the object of research based on data in this archival volume.

3.4.3.4   Index Directory

Files in the INDEX directory are dedicated to help the user to locate and identify data products of interest on an archive volume/dataset. As the typical index file is used to describe only the data contained within the data products, PSA requires to create an index file for providing geometry and position information about the data as well. Thereby, within the PSA, the geometry index files will enable the ingestion of additional searching parameters into the database. For a detailed description of this file and of its associated label file, please refer to [AD 9].

The index files are generated using the PSA PVV tool and the geometry files are generated using appropriate software linked with the PSA geolib library. Both files are included in the INDEX directory:

Table 17. Index directory contents.

File Name	Contents
INDXINFO.TXT	A description of the contents of the index directory
INDEX.LBL	PDS detached label for the volume index file, INDEX.TAB
INDEX.TAB	A table listing all data products on this volume
GEO_VENUS.LBL	PDS detached label describing corresponding *.TAB file
GEO_VENUS.TAB	Geometry index file providing geometry and position information about all data product listed in INDEX.TAB.

Each index table contains a number of columns describing a data product on a dataset release. The table is formatted so that it can be read directly into many data management systems. All fields are separated by commas and character fields are enclosed in double quotation marks ("). Character fields are left justified and numeric fields are right justified. Each record (row) ends with ASCII carriage return <CR><LF> (ASCII 13 and 10). All fields in the tables are fixed width. This allows the table to be treated as a fixed length record file.

3.4.3.4.1   Dataset Index File, index.lbl and index.tab

The INDEX directory contains the required PDS index files which are generated by PVV. In the data index table (INDEX.TAB) a set of parameters are referenced such as the file specification name, the product ID, the time at which the data file was created, an identifier unique for the dataset, the release ID, the revision ID, and others.

3.4.3.4.2   Geometric Index File, geoindex.lbl and geoindex.tab

The INDEX directory also contains the geometry index file as defined in [AD 9]. Within the geometry index table (GEOMETRY_INDEX.TAB) each data product is described by a set of parameters providing geometry and position information about the data. These information parameters are related to the sun in terms of longitude and latitude, to the state of the S/C with respect of the target body and the sun, in terms of position and velocity, and to the instruments viewing. Non-geometrical parameters are also required and included in the geometry index table.

3.4.3.4.3   Other Index Files

No additional index files are used.

3.4.3.5   Browse Directory and Browse Files

ASPERA-4 data sets do not have browse products.

3.4.3.6   Geometry Directory

Some basic cruise (orbit/attitude) information is tabulated for the user and included in ASCII files within the GEOMETRY directory. These files are needed to understand observation geometry. The parameters included in the orbit files are: the UTC time, the S/C position vector and the 9 attitude parameters expressed in both EMEJ2000 and VSO coordinates system. With respect to the EMEJ2000 reference frame, the orbital data are provided during cruise as heliocentric states, in the operational orbit as Venus centric states. In addition to the geometry data and associated label files there is an include file (ORB.FMT) referenced by a pointer within each geometry label file that describes the common columns of all PDS table objects.
The following files are contained in the GEOMETRY directory.

Table 18. Geometry directory contents.

File Name	Contents
GEOMINFO.TXT	A description of the contents of this directory
ORB_<begin of observation>_<length of observation>.TAB	ASCII table with orbit summary data recorded at high rate, defined as 192s and 60s sampling for ELS / IMA and NPI / NPD respectively. Each ASCII file covers a time period corresponding to the associated data product time interval. Field names are described in section 3.1.4.
ORB_<begin of observation>_<length of observation>.LBL	A PDS detached label that describes ORB_<begin of observation>_<length of observation>.TAB
ORB.FMT	Spacecraft orbit/attitude information

3.4.3.7   Software Directory

There will be no SOFTWARE directory.

3.4.3.8 Gazetter Directory

There is no GAZETTER directory for ASPERA-4 dataset deliveries.

3.4.3.9 Label Directory

The LABEL directory contains include files (.FMT files with label definitions) referenced by a pointer within each PDS label file in the corresponding dataset directory of the label file. This prevents the needless repetition of information that is not changing within the PDS label files.

The following files are included in the corresponding instrumental label directory where it is applicable :

Table 19. Label directory contents.

File Name	Contents
LABINFO.TXT	A description of the contents of this directory (.FMT files)
ELS_SPECTRUM_HEAD.FMT	Edited (raw) header science data for ELS
ELS_SPECTRUM_HEAD_ENG.FMT	Edited (raw) header engineering data for ELS
ELS_SPECTRUM_HKELS.FMT	Calibrated HK data for ELS
IMA_SPECTRUM_HEAD.FMT	Edited (raw) header data for IMA
IMA_SPECTRUM_HKMU.FMT	Calibrated HK data for IMA/MU
IMA_SPECTRUM_HKIMA.FMT	Calibrated HK data for IMA/IMA DPU
NPD_RAWHEAD.FMT	Edited (raw) header data for NPD1 and NPD2 in RAW mode
NPD_BINHEAD.FMT	Edited (raw) header data for NPD1 and NPD2 in BIN mode
NPD_TOFHEAD.FMT	Edited (raw) header data for NPD1 and NPD2 in TOF mode
NPD1_HKNPD1.FMT	Calibrated HK data for NPD1
NPD2_HKNPD2.FMT	Calibrated HK data for NPD2
NPI_NRMHEAD.FMT	Edited (raw) header data for NPI in NORMAL mode
NPI_STPHEAD.FMT	Edited (raw) header data for NPI in STEP mode
NPI_HKNPI.FMT	Calibrated HK data for NPI

3.4.3.10 Document Directory

This directory contains documentation to help the user to understand and use the archive data. The following files are contained in the document directory:

Table 20. Document directory contents.

File Name	Contents
DOCINFO.TXT	A description of the contents of this directory
ASPERA4_DESC.TXT	This file describes the ASPERA-4 instruments flying onboard the VEX S/C
ASPERA4_DESC.LBL	PDS label for file ASPERA4_DESC.TXT
VE-ASP-TN-060402.PDF	ASPERA-4 Instrument Manual [AD 3]
VE-ASP-TN-060402.LBL	PDS label for file VE-ASP-TN-060402.PDF
BARABASHP3.PDF	ASPERA-4 scientific objectives and instrument description
BARABASHP3.LBL	PDS label for file BARABASHP3.PDF
ASPERA4-L1-061016.PDF	ASPERA-4 N1 data file description [AD 5]
ASPERA4-L1-061016.LBL	PDS label for file ASPERA4-L1-061016.PDF
VEX_ASP_CESR_EAICD_V1_4.PDF	This document
VEX_ASP_CESR_EAICD_V1_4.LBL	PDS label for file VEX_ASP_CESR_EAICD_V1_4.PDF
VEX_SCIENCE_CASE_ID_DESC.TXT	VEX science case definition document [AD 10]
VEX_SCIENCE_CASE_ID_DESC.LBL	PDS label for file VEX_SCIENCE_CASE_ID_DESC.TXT
OBSERVATION_TYPE_DESC.TXT	The document defines the values of the OBSERVATION_TYPE keyword, as refered in [AD 11]
OBSERVATION_TYPE_DESC.LBL	PDS label for file OBSERVATION_TYPE_DESC.TXT
VEX_ORIENTATION_DESC.TXT	This file describes the convention used to describe the spacecraft orentation

VEX_ORIENTATION_DESC.LBL	PDS label for file VEX_ORIENTATION_DESC.TXT
VEX_POINTING_MODE_DESC.TXT	Spacecraft pointing mode definitions, as refered in [AD 4]
VEX_POINTING_MODE_DESC.LBL	PDS label for file VEX_POINTING_MODE_DESC.TXT
VEX_RSSD_LI_009.TAB	VEX mission subphases index table
VEX_RSSD_LI_009.LBL	PDS label for file VEX_RSSD_LI_009.TAB
VEX-SCIOPS-TN-050.LBL	The document provides information about the mission, its phases and some of the environmental conditions
VEX-SCIOPS-TN-050.PDF	PDS label for file VEX-SCIOPS-TN-050.PDF

The ASPERA-4 EAICD document will be provided in PDF (Adobe Portable Document Format).
All helpful technical ASPERA-4 documentation provided by the ASPERA-4 team will be provided in the DOCUMENT directory in PDF format.

Note: The latest NPD calibrations reports are archived in the DOCUMENT directory of the NPD dataset. The document is named GRIGORIEV_NPD_REPORT.PDF and is accompanied by its associated label file GRIGORIEV_NPD_REPORT.LBL. The calibration reports concerning the ELS sensor are archived in the DOCUMENT directory of the ELS dataset. The document is ELS_DATA_ANALYSIS_SUMMARY.PDF and its associated label file ELS_DATA_ANALYSIS_SUMMARY.LBL.

3.4.3.11 Extras Directory

There is no EXTRAS directory.

3.4.3.12 Data Directory

The DATA directory contains a separate subdirectory for each release in which the VEX ASPERA-4 data products are stored. Within each subdirectory, the data products are organized as ASCII tables, a description of which is given in the corresponding PDS detached label.

Table 21. Data directory contents.

File Name	Contents
<exp>_<data type>_<begin of observation>_<index of occurrence><number of occurrences>.TAB	Science or HK data file with <exp>, <data type>, <begin of observation>, <index of occurrence> and <number of occurrences> fields as described in section 3.1.4
<exp>_<data type>_<begin of observation>_<index of occurrence><number of occurrences>.LBL	PDS label for data files of same base name

The naming scheme of the data subdirectory is described in chapter 3.1.3. Details of the products to be provided in the DATA directory and their structure and labelling can be found in Section 4.3 and its sub-sections.

4 Detailed Interface Specifications

This section describes in detail the contents of the ASPERA-4 data sets, describing the structure of the data sets themselves and the design of the individual data products provided. Appendix A contains information about the PDS software to read and validate the data products. The following Appendices provide examples of PDS labels and the complete directory structure of an example data set.

4.1 Structure and Organization Overview

The ASPERA-4 data sets are structured as illustrated in Section 3.4.3. The ASPERA-4 ELS, IMA, NPI and NPD raw data will be archived in separate data sets and organized for each dataset into DATA subdirectories, separating observations into releases. Within a subdirectory, pattern matching is used to filter and group data of a certain structure into one data product. The filtering depends essentially on what mode flags are set in the description data fields and the in-flight sampling processes that are in use while measuring particles. Data are also filtered and grouped together for those that are contained in the same time interval. The time sequence that is used for grouping data coincides mostly with a daily-like time division. Besides the time and mode criterions, data product files may be additionally divided when their size is exceeding the upper limit of 500Mb beyond what most workstation resources need and, as a result, must incorporate relatively expensive technologies for processing such files. Those files are split into pieces of suitable size (below the restricted size) regardless of how or where they are fragmented.

All ASPERA-4 data products are stored in .TAB files and distributed along with their associated detached PDS label .LBL files, which have the same names. Each .TAB file contains uncalibrated science, CODMAC Level 2, that are acquired directly from the ASPERA-4 experiment with no modification or validation and archived in the DATA directory of the corresponding dataset. Calibrated HK data, CODMAC Level 3, are also stored into .TAB files and included within DATA directories. During the nominal mission, several products will be provided for every observational time sequence: several files will be present for each sensor, among which 2 files related to the HK (4 for IMA) and others related to the science raw data, as described below. Following data product files are named according to the scheme described in Section 3.1.4.

ELS_ENGXXXX_*yymmddhhmmss_wz*.TAB
ELS_ENGXXXX_*yymmddhhmmss_wz*.LBL
ELS_EeeeAaa_*yymmddhhmmss_wz*.TAB
ELS_EeeeAaa_*yymmddhhmmss_wz*.LBL
ELS_HK3MUXX_*yymmddhhmmss_wz*.TAB
ELS_HK3MUXX_*yymmddhhmmss_wz*.LBL

where eee is a 3-digits number of energy bins with 3 possible values, 032, 064 and 128, and aa the number of angular sectors which could take any value between 01 and 16.

IMA_MnnSssX_*yymmddhhmmss_*wz.TAB
IMA_MnnSssX_*yymmddhhmmss_wz*.LBL
IMA_MnnXXXX_*yymmddhhmmss_*wz.TAB
IMA_MnnXXXX_*yymmddhhmmss_wz*.LBL
IMA_HK3IMAX_*yymmddhhmmss_wz*.TAB
IMA_HK3IMAX_*yymmddhhmmss_wz*.LBL
IMA_HK3MUXX_*yymmddhhmmss_wz*.TAB
IMA_HK3MUXX_*yymmddhhmmss_wz*.LBL

where nn designates the mode index, and ss the number of sets in records from 01 to 15.

NPI_NORMALX_*yymmddhhmmss_wz*.TAB
NPI_NORMALX_*yymmddhhmmss_wz*.LBL
NPI_STEPXXX_*yymmddhhmmss_wz*.TAB
NPI_STEPXXX_*yymmddhhmmss_wz*.LBL
NPI_HK3MUXX_*yymmddhhmmss_wz*.TAB
NPI_HK3MUXX_*yymmddhhmmss_wz*.LBL

NP1_RAWXXXX_*yymmddhhmmss_wz*.TAB
NP1_RAWXXXX_*yymmddhhmmss_wz*.LBL
NP1_BINmmDd_*yymmddhhmmss_wz*.TAB
NP1_BINmmDd_*yymmddhhmmss_wz*.LBL
NP1_TOFXXXX_*yymmddhhmmss_wz*.TAB
NP1_TOFXXXX_*yymmddhhmmss_wz*.LBL
NP1_HK3MUXX_*yymmddhhmmss_wz*.TAB
NP1_HK3MUXX_*yymmddhhmmss_wz*.LBL

NP2_RAWXXXX_*yymmddhhmmss_wz*.TAB
NP2_RAWXXXX_*yymmddhhmmss_wz*.LBL
NP2_BINmmDd_*yymmddhhmmss_wz*.TAB
NP2_BINmmDd_*yymmddhhmmss_wz*.LBL
NP2_TOFXXXX_*yymmddhhmmss_wz*.TAB
NP2_TOFXXXX_*yymmddhhmmss_wz*.LBL
NP2_HK3MUXX_*yymmddhhmmss_wz*.TAB
NP2_HK3MUXX_*yymmddhhmmss_wz*.LBL

where mm could take any of these 3 possible values, 01, 02 or 16, for indicating the size of the selected PH*TOF matrix, 1×16, 2×16 and 16×16 respectively, and d represents the number of stop detector (0, 1 or 2) referring to the direction of arrival neutral particles.

The following sections give the structure and contents of the DATA directories for each ASPERA-4 instrument.

4.1.1   ELS Data Directory Structure

The following is the organization and content of the DATA directory for a ELS data set. The first three releases of the nominal mission phase are represented on this organization scheme.

```
                                        |-- ELS_ENG*.TAB
                    |                    |-- ELS_ENG*.LBL
                    |                    |-- ELS_E*A*.TAB     ELS Data
                    |-- 20051109_20060831 ----|-- ELS_E*A*.LBL     Release 1
                    |                    |-- ELS_HK3*.TAB
                    |                    |-- ELS_HK3*.LBL
                    |
                    |                    |-- ELS_ENG*.TAB
                    |                    |-- ELS_ENG*.LBL
     |              |                    |-- ELS_E*A*.TAB     ELS Data
   -|- DATA ----|-- 20060901_20061130 ----|-- ELS_E*A*.LBL     Release 2
     |              |                    |-- ELS_HK3*.TAB
     |              |                    |-- ELS_HK3*.LBL
                    |
                    |                    |-- ELS_ENG*.TAB
                    |                    |-- ELS_ENG*.LBL
                    |                    |-- ELS_E*A*.TAB     ELS Data
                    |-- 20061201_20070228 ----|-- ELS_E*A*.LBL     Release 3
                    |                    |-- ELS_HK3*.TAB
                    |                    |-- ELS_HK3*.LBL
```

4.1.2   IMA Data Directory Structure

The following is the organization and content of the DATA directory for a IMA data set. The first three releases of the nominal mission phase are represented on this organization scheme.

```
                                        |-- IMA_M*.TAB
                         |              |-- IMA_M*.LBL      IMA Data
                         |-- 20051109_20060831 ----|-- IMA_HK3*.TAB    Release 1
                         |              |-- IMA_HK3*.LBL
                         |
                         |              |-- IMA_M*.TAB
     |                   |              |-- IMA_M*.LBL      IMA Data
  -|- DATA ----|-- 20060901_20061130 ----|-- IMA_HK3*.TAB    Release 2
     |                   |              |-- IMA_HK3*.LBL
                         |
                         |              |-- IMA_M*.TAB
                         |              |-- IMA_M*.LBL      IMA Data
                         |-- 20061201_20070228 ----|-- IMA_HK3*.TAB    Release 3
                         |              |-- IMA_HK3*.LBL
```

4.1.3   NPI Data Directory Structure

The following is the organization and content of the DATA directory for a NPI data set. The first three releases of the nominal mission phase are represented on this organization scheme.

```
                                        |-- NPI_NOR*.TAB
                         |              |-- NPI_NOR*.LBL
                         |              |-- NPI_STE*.TAB    NPI Data
                         |-- 20051109_20060831 ----|-- NPI_STE*.LBL    Release 1
                         |              |-- NPI_HK3*.TAB
                         |              |-- NPI_HK3*.LBL
                         |
                         |              |-- NPI_NOR*.TAB
                         |              |-- NPI_NOR*.LBL
     |                   |              |-- NPI_STE*.TAB    NPI Data
  -|- DATA ----|-- 20060901_20061130 ----|-- NPI_STE*.LBL    Release 2
     |                   |              |-- NPI_HK3*.TAB
                         |              |-- NPI_HK3*.LBL
                         |
                         |              |-- NPI_NOR*.TAB
                         |              |-- NPI_NOR*.LBL
                         |              |-- NPI_STE*.TAB    NPI Data
                         |-- 20061201_20070228 ----|-- NPI_STE*.LBL    Release 3
                         |              |-- NPI_HK3*.TAB
                         |              |-- NPI_HK3*.LBL
```

4.1.4 NPD Data Directory Structure

The following is the organization and content of the DATA directory for a NPD data set. The first three releases of the nominal mission phase are represented on this organization scheme.

```
                                            |-- NP1_RAW*.TAB
                                            |-- NP1_RAW*.LBL
                                            |-- NP1_BIN*.TAB
                                            |-- NP1_BIN*.LBL
                                            |-- NP1_TOF*.TAB
                                            |-- NP1_TOF*.LBL
                           |                |-- NP1_HK3*.TAB
                           |                |-- NP1_HK3*.LBL    NPD Data
                           |-- 20051109_20060831 ----|-- NP2_RAW*.TAB    Release 1
                           |                |-- NP2_RAW*.LBL
                           |                |-- NP2_BIN*.TAB
                           |                |-- NP2_BIN*.LBL
                           |                |-- NP2_TOF*.TAB
                           |                |-- NP2_TOF*.LBL
                           |                |-- NP2_HK3*.TAB
                           |                |-- NP2_HK3*.LBL
                           |
                           |                |-- NP1_RAW*.TAB
                           |                |-- NP1_RAW*.LBL
                           |                |-- NP1_BIN*.TAB
                           |                |-- NP1_BIN*.LBL
                           |                |-- NP1_TOF*.TAB
                           |                |-- NP1_TOF*.LBL
                           |                |-- NP1_HK3*.TAB
    |            |                |-- NP1_HK3*.LBL    NPD Data
  -|- DATA ----|-- 20060901_20061130 ----|-- NP2_RAW*.TAB    Release 2
    |            |                |-- NP2_RAW*.LBL
                           |                |-- NP2_BIN*.TAB
                           |                |-- NP2_BIN*.LBL
                           |                |-- NP2_TOF*.TAB
                           |                |-- NP2_TOF*.LBL
                           |                |-- NP2_HK3*.TAB
                           |                |-- NP2_HK3*.LBL
                           |
                           |                |-- NP1_RAW*.TAB
                           |                |-- NP1_RAW*.LBL
                           |                |-- NP1_BIN*.TAB
                           |                |-- NP1_BIN*.LBL
                           |                |-- NP1_TOF*.TAB
                           |                |-- NP1_TOF*.LBL
                           |                |-- NP1_HK3*.TAB
                           |                |-- NP1_HK3*.LBL    NPD Data
                           |-- 20061201_20070228 ----|-- NP2_RAW*.TAB    Release 3
                           |                |-- NP2_RAW*.LBL
                           |                |-- NP2_BIN*.TAB
                                            |-- NP2_BIN*.LBL
                                            |-- NP2_TOF*.TAB
                                            |-- NP2_TOF*.LBL
                                            |-- NP2_HK3*.TAB
                                            |-- NP2_HK3*.LBL
```

4.2 Data Sets, Definition and Content

ASPERA-4 data sets will be generated and delivered to the PSA as scheduled in Table10. The data sets will follow the identifier conventions outlined in Section 3.1.2, whereby the elements for the DATA_SET_ID formation are given in Table 13.

This gives several datasets ID of the form: VEX-V/SW-ASPERA-2-ELS-V1.0, VEX-V/SW-ASPERA-2-EXTi-ELS-V1.0[1], VEX-V/SW-ASPERA-2-IMA-V1.0, VEX-V/SW-ASPERA-2-EXTi-IMA-V1.0[1], VEX-V/SW-ASPERA-2-NPI-V1.0, VEX-V/SW-ASPERA-2-EXTi-NPI-V1.0[1], VEX-V/SW-ASPERA-2-NPD-V1.0, VEX-V/SW-ASPERA-2-EXTi-NPD-V1.0[1].

[1] where i is the occurrence number of the extended mission phase (starting from 1)

The following delivery schedule is planned for the ASPERA-4 dataset releases to the PSA:

Table 22. Delivery of ASPERA-4 Datasets.

Data Set ID	Data Type	Data Release Delivery Schedule
VEX-V/SW-ASPERA-2-ELS-V1.0 VEX-V/SW-ASPERA-2-EXTi-ELS-V1.0[1]	PSA Level 1b - CODMAC Level 2 Raw counts (cnts/accum)	Several dataset releases are to be delivered every three months starting September 2008. The first delivery is a release containing data from launch through August 2006. Next deliveries contain three months of data each and the last one contains the remaining data till the end of the VEX operational mission. Dataset releases delivery has to observe a minimum time lag of two months after the last data recorded within the data archive for ensuring more consistency and stability in the data.
VEX-V/SW-ASPERA-2-IMA-V1.0 VEX-V/SW-ASPERA-2-EXTi-IMA-V1.0[1]	PSA Level 1b - CODMAC Level 2 Raw counts (cnts/accum)	
VEX-V/SW-ASPERA-2-NPI-V1.0 VEX-V/SW-ASPERA-2-EXTi-NPI-V1.0[1]	PSA Level 1b - CODMAC Level 2 Raw counts (cnts/accum)	
VEX-V/SW-ASPERA-2-NPD-V1.0 VEX-V/SW-ASPERA-2-EXTi-NPD-V1.0[1]	PSA Level 1b - CODMAC Level 2 Raw counts (cnts/accum)	

[1] where i is the occurrence number of the extended mission phase (starting from 1)

4.3 Data Product Design

The following types of data products are defined for ASPERA-4:

- Electron data products (ELS): edited data (CODMAC level 2).
- Ion data products (IMA): edited data (CODMAC level 2).
- Neutral particle data products (NPI): edited data (CODMAC level 2).
- Mass/energy resolved neutral particle data products (NPD): edited data (CODMAC level 2).
- Housekeeping data related to each individual sensor.

Each ASPERA-4 data product file are designed to contain one or several records with a same data pattern in order to maintain the use of fixed width-table structure which is the most effective way for manipulating and reading data using standard software. This is also more suitable for long term archiving. To meet this requirement, incoming data of a scientific observation sensor are split into separate data product files according to operational mode or sub-mode of equal number of sampling steps, keeping same data pattern in a file.

One record of an edited data product file consists of a one-row science data values preceded by the associated header set of information that are acquired during one sequence of measurement (also named full cycle or spectra). The header refers typically to observational parameters about operation mode, date of observation, accumulation time, etc. that are identified in the time interval of one spectra. Science data are a structured collection of particle count values resulting from an entire scan cycle of measurement. Within the same edited data product file, each of the subsequent records contains both header and science data referring to measurements accomplished in the time ahead. Each of these records spans same number of

columns with the same widths. As a whole, the file is therefore physically structured as a header table followed by a data table with single or multiple rows equal to the number of records. The length of a line is determined by the size of the column headings and the number of channels along axes of resolved parameters such as mass, energy, polar angle or azimuth angle, which are described in the selected sensor mode. The figure below depicts the components used in an edited data product file.

Since the ASPERA-4 data products have known fixed-length records, the PDS TABLE is the chosen format for archival of these data. It is a common format consisting of space separated values in which string fields are enclosed in double quotes. Both housekeeping and edited data product files are using embedded data TABLE objects with ASCII data values stored in columns. A single data TABLE object is in use for containing data housekeeping in a file. Whereas for dealing with parallel header and science data TABLE objects, edited data product files are including the use of the ROW_PREFIX_BYTES and ROW_SUFFIX_BYTES keywords, each of which indicating the header and data table sizes respectively The format and content of each data object are defined in the associated detached PDS label file, wherein pointers are required for all data objects referenced, as shown in the Figure 14.
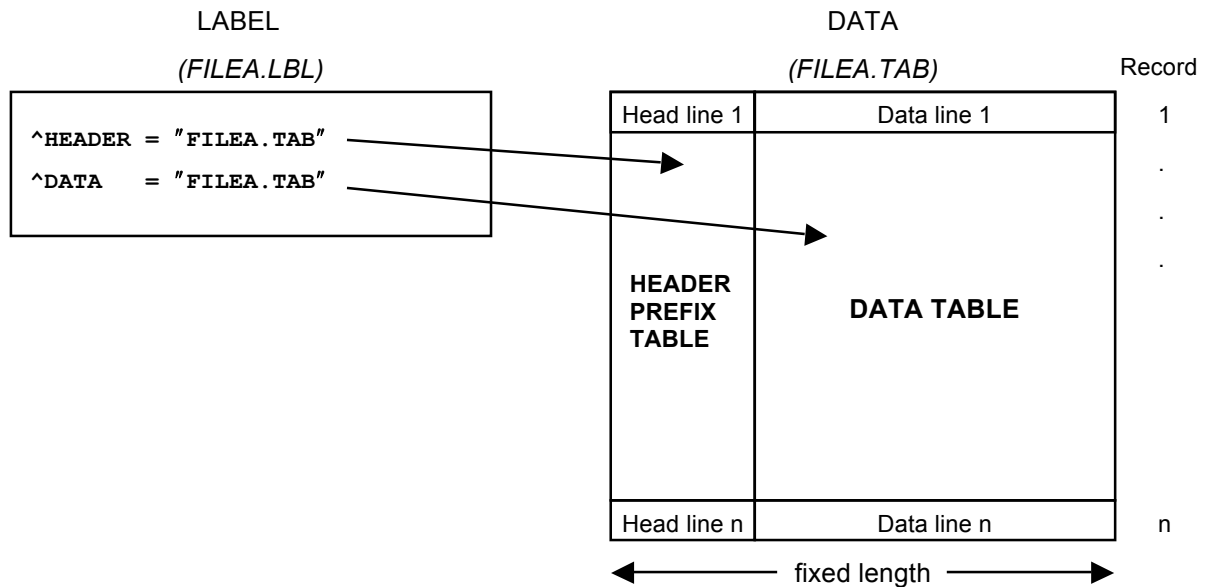
Figure 14. Example file of data object pointer usage for edited data product file with detached label.

4.3.1 Electron Spectrometer Science Edited Data Product Design (Level 2)

The ELS sensor can be operated in 4 modes as described in the document [AD 3], producing 4 different types of formatted block data in telemetry packets, one for each selected operation mode. One of those modes of operation is related to the acquisition of instrumental engineering information. The others deal with the storage of electron counts that are measured in different azimuth directions from the 16 possible sectors, and for any energy sweep pattern as stepped and specified by the instrument operation mode in use. Considering above, 2 types of ELS edited science file may essentially exist: 1) one data product is designed for containing engineering data, 2) while electron counts are split and stored into appropriate electron counting data files according to their number of energy bins and angular sectors. The Table 23 indicates the data contents for each science data file and their PDS representation object. Apart from the engineering mode, the ELS science data are always delivered as a fixed-size azimuth×energy array, stored in a linear row-major order where azimuth (the first) is the fastest varying parameter.

An ELS header, for both engineering and electron counting modes, is added before each data mode-dependent collection as represented in the Figure 14. It gives the mask of active azimuthal sectors, the software version, the OBT and UTC time at the start of the data matrix, the ELS compression scheme, the scanner direction, speed and position. Specific heading information are added to the ELS header in engineering data files. The ELS headers information and values are shown in the Table 24.

Table 23. ELS science data file contents and structure.

Data type	Mode	Data description	PDS data object
ENGXXXX	Engineering information	First ELS packet within one scan cycle. Contains engineering information needed for analysis of ELS data. No science data included.	Linear storage in a TABLE object of 256 blank-separated data values giving information about the deflection potential sweep pattern
EeeeAaa with eee=032, 064 or 128, and aa a 2-digits value from 01 to 16	Complete sweep	Data (in counts/accumulation) obtained from one complete energy sweep and for all unblocked (active) azimuthal sectors.	Linear storage in a TABLE object containing electron counts for a maximum of 128 energy levels and for each unblocked (active) azimuthal sector of detection.
	Steps number 0-63	Data (in counts/accumulation) obtained from first 64 energy steps in one sweep and for all unblocked (active) azimuthal sectors.	Linear storage in a reconstructed TABLE object containing electron counts for 128 energy level and for each unblocked (active) azimuthal sector of detection.
	Steps number 64-127	Data (in counts/accumulation) obtained from latter 64 energy steps in one sweep and for all unblocked (active) azimuthal sectors.	

Table 24. ELS headers content.

Rank	Field / Value		Rank	Field / Value	
ELS mode electron counting data header					
1	UTC correlated Time at the start of the data matrix		7	Log compression	
2	OBT Time at the start of the data matrix		8	Rice compression flag status	0 = non valid 1 = vadid
3	SW version		9	Rice compression assigned value	
4	ELS sector mask		10	Scanner direction	0 = 0 - 180 1 = 180 - 0
5	Time compression	1, 2, 4, 8, 16 sweeps or –1 for undefined	11	Scanner speed	0 (standing), 32s scan, 64s scan, or 128s scan
6	Energy compression	1, 2, 4, steps or –1 for undefined	12	Scanner Position	On start of scan (or step) period
ELS mode engineering data header					
1	UTC correlated Time at the start of the data matrix		10	Scanner direction	0 = 0 - 180 1 = 180 - 0
2	OBT Time at the start of the data matrix		11	Scanner speed	0 (standing), 32s scan, 64s scan, or 128s scan
3	SW version		12	Scanner Position	On start of scan (or step) period
4	ELS sector mask		13	ELS status	
5	Time compression	1, 2, 4, 8, 16 sweeps or –1 for undefined	14	ELS temperature	
6	Energy compression	1, 2, 4, steps or –1 for undefined	15	ELS MCP reference	
7	Log compression		16	ELS MCP monitor	
8	Rice compression flag status	0 = non valid 1 = vadid	17	ELS screen grid reference	
9	Rice compression assigned value		18	ELS screen grid monitor	

The table objects are detailed in the following paragraphs.

4.3.1.1   File Characteristics Data Elements

The following elements are present in the labels for every ELS science edited data product, and they describe the basic characteristics of the data product in terms of structure and naming:

```
/* FILE CHARACTERISTIC DATA ELEMENTS */
PRODUCT_ID                      = this element defines the current product file name,
                                  without extension
RECORD_TYPE                     = FIXED_LENGTH
RECORD_BYTES                    = this element indicates the number of bytes in a data
                                  record, including record terminators and separators
FILE_RECORDS                    = this element indicates the number of records within
                                  the data file
```

4.3.1.2   Data Object Pointers Identification Data Elements

Pointer statements with the following format are used to indicate the location of data objects in the data product file:

     ^object = location

where the carat character (^, also called a pointer) is followed by the name of the specific data object. The location is the 1-based starting byte location for the data object within the file. For ELS, 4 pointers are present, identifying the ASCII tables within which the ELS status and engineering and science (electron counting) data are stored. The data object pointers that reference TAB files are:

```
^HEAD_ENG_TABLE
^ENG_TABLE
^HEAD_TABLE
^DATA_SCIENCE_TABLE
```

4.3.1.3   Instrument and Detector Descriptive Data Elements

The following data identification elements provide additional information about the ELS data products for both engineering and electron counting data modes.

```
/* PRODUCER IDENTIFICATION */
PRODUCER_ID                     = "CESR_ASPERA4_GROUP"
PRODUCER_FULL_NAME              = "EMMANUEL PENOU"
PRODUCER_INSTITUTION_NAME       = "CENTRE D'ETUDE SPATIALE DES RAYONNEMENTS"
PRODUCT_CREATION_TIME           = YYYY-MM-DDThh:mm:ss[.fff]

/* DATA DESCRIPTION AND IDENTIFICATION */
DATA_SET_NAME                   = "
                    VENUS EXPRESS VENUS/SOLARWIND ASPERA 2 ELS V1.0"  or
        "VENUS EXPRESS VENUS/SOLARWIND ASPERA 2 EXTENSION 1 ELS V1.0"  or
        "VENUS EXPRESS VENUS/SOLARWIND ASPERA 2 EXTENSION 1 ELS V1.0"  or
        …
DATA_SET_ID                     = "VEX-V/SW-ASPERA-2-ELS-V1.0"        or
                                  "VEX-V/SW-ASPERA-2-EXT1-ELS-V1.0"   or
                                  "VEX-V/SW-ASPERA-2-EXT2-ELS-V1.0"   or
                                  …
RELEASE_ID                      = 0001
REVISION_ID                     = 0000
PRODUCT_TYPE                    = EDR
PROCESSING_LEVEL_ID             = 2
MISSION_NAME                    = "VENUS EXPRESS"
MISSION_ID                      = VEX
INSTRUMENT_HOST_NAME            = "VENUS EXPRESS"
INSTRUMENT_HOST_ID              = VEX
MISSION_PHASE_NAME              = As defined in [AD 4]
```

```
INSTRUMENT_NAME                 = "
      ANALYZER OF SPACE PLASMA AND ENERGETIC ATOMS (4TH VERSION)"
INSTRUMENT_ID                   = ASPERA4
INSTRUMENT_TYPE                 = {"ELECTROSTATIC ANALYZER",
                                   "MASS SPECTROMETER",
                                   "NEUTRAL PARTICLE IMAGER",
                                   "NEUTRAL PARTICLE DETECTOR"}
DETECTOR_ID                     = VEX_ASP4_ELS
^INSTRUMENT_DESC                = "ASPERA4_DESC.TXT"

/* TARGET IDENTIFICATION */
TARGET_TYPE                     = "PLANET" or "N/A"
TARGET_NAME                     = "VENUS"  or "SOLAR WIND"
RIGHT_ASCENSION                 = "N/A"
DECLINATION                     = "N/A"

/* SCIENCE OPERATIONS INFORMATION */
OBSERVATION_TYPE                = {"AC003B", "PE001A", "PE004A"} or "N/A"
^OBSERVATION_TYPE_DESC          = "OBSERVATION_TYPE_DESC.TXT"

/* TIME RELATED INFORMATION */
START_TIME                      = YYYY-MM-DDThh:mm:ss.fff
STOP_TIME                       = YYYY-MM-DDThh:mm:ss.fff
SPACECRAFT_CLOCK_START_COUNT    = "01/xxxxxxxxxx.xxxxx"
SPACECRAFT_CLOCK_STOP_COUNT     = "01/xxxxxxxxxx.xxxxx"

/* ORBITAL INFORMATION */
ORBIT_NUMBER                    = UNK
ORBITAL_ECCENTRICITY            = UNK
ORBITAL_INCLINATION             = UNK
ORBITAL_SEMIMAJOR_AXIS          = UNK
PERIAPSIS_ALTITUDE              = UNK
PERIAPSIS_ARGUMENT_ANGLE        = UNK
PERIAPSIS_TIME                  = "UNK"
SPACECRAFT_ORIENTATION          = UNK
^SPACECRAFT_ORIENTATION_DESC    = "VEX_ORIENTATION_DESC.TXT"
SPACECRAFT_POINTING_MODE        = "ALL"
^SPACECRAFT_POINTING_MODE_DESC = "VEX_POINTING_MODE_DESC.TXT"
```

4.3.1.4   Structure Definition of Instrument Parameter Objects

N/A

4.3.1.5   Data Object Definition

This section of the label defines the structure and content of the ELS science edited data products. As specified in §4.3, each data file (TAB) contains typically 2 objects: a header TABLE and a science data TABLE object stored in parallel. The number of rows within the tables is variable and depends roughly on the number of records contained in the processed level-1 data file. The data objects are ASCII tables for handling the engineering data and science data. There is also a specific ASCII table data object containing the header information for engineering and science data blocks. The columns within the TABLE object corresponding to the heading tags are first described in the section below. The science data objects are defined in the following separate sections.

4.3.1.5.1   The description of the ELS science data header table:

It is common to all ELS science (electron counting) edited data products.

```
OBJECT                  = HEAD_TABLE
    NAME                = "ELS_SPECTRUM_HEAD"
```

```
        ROW_SUFFIX_BYTES      = Number of bytes that are accounted in the subsequent
                                table, including record terminators and separators
        INTERCHANGE_FORMAT    = ASCII
        ROWS                  = Number of rows within the data file
        COLUMNS               = 12
        ROW_BYTES             = 94
       ^STRUCTURE             = "ELS_SPECTRUM_HEAD.FMT"
    END_OBJECT                = HEAD_TABLE
```

The structure of the TABLE object is described in the file ELS_SPECTRUM_HEAD.FMT as follows:

```
    /*  Contents of format file  "ELS_SPECTRUM_HEAD.FMT"  */
    OBJECT                  = COLUMN
       COLUMN_NUMBER        = 1
       NAME                 = "UTC"
       DATA_TYPE            = TIME
       START_BYTE           = 1
       BYTES                = 23
       UNIT                 = "N/A"
       DESCRIPTION          = "This column represents the UTC at the start
                                of the data matrix in PDS standard format
                                YYYY-MM-DDThh:mm:ss.sss"
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
       COLUMN_NUMBER        = 2
       NAME                 = "OBT"
       DATA_TYPE            = CHARACTER
       START_BYTE           = 26
       BYTES                = 19
       UNIT                 = "N/A"
       DESCRIPTION          = "On board Time (OBT) is represented as :
                                <Reset number>/<unit seconds>.<fractional seconds>
                                with
                                <Reset number>: integer starting at 1
                                   Reset number 1 starts at 2005-03-01T00:00:00 UTC
                                <unit seconds>: 10 digits number of unit seconds
                                <fractional seconds>: 5 digits number of fractional
                                   seconds expressed as multiples of 2^-16 seconds"
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
       COLUMN_NUMBER        = 3
       NAME                 = "SW_VERSION"
       DATA_TYPE            = ASCII_INTEGER
       START_BYTE           = 47
       BYTES                = 5
       UNIT                 = "N/A"
       FORMAT               = "I5"
       DESCRIPTION          = "Software version"
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
       COLUMN_NUMBER        = 4
       NAME                 = "SECTOR_MASK"
       DATA_TYPE            = CHARACTER
       START_BYTE           = 54
       BYTES                = 16
       UNIT                 = "N/A"
       DESCRIPTION          = "ELS Sector mask defines the active sectors that are
                                set for the measurement. The Binary format is used.
                                One bit (or character) represents the status of one
```

```
                               ELS sector and may take one of the following values
                               bit 0 (sector 0): 1 (enable), 0 (disable)
                               bit 1 (sector 1): 1 (enable), 0 (disable)
                               bit 2 (sector 2): 1 (enable), 0 (disable)
                               bit 3 (sector 3): 1 (enable), 0 (disable)
                               bit 4 (sector 4): 1 (enable), 0 (disable)
                               bit 5 (sector 5): 1 (enable), 0 (disable)
                               bit 6 (sector 6): 1 (enable), 0 (disable)
                               bit 7 (sector 7): 1 (enable), 0 (disable)
                               bit 8 (sector 8): 1 (enable), 0 (disable)
                               bit 9 (sector 9): 1 (enable), 0 (disable)
                               bit 10 (sector 10): 1 (enable), 0 (disable)
                               bit 11 (sector 11): 1 (enable), 0 (disable)
                               bit 12 (sector 12): 1 (enable), 0 (disable)
                               bit 13 (sector 13): 1 (enable), 0 (disable)
                               bit 14 (sector 14): 1 (enable), 0 (disable)
                               bit 15 (sector 15): 1 (enable), 0 (disable)"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 5
   NAME                  = "TIME_COMPRESSION"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 72
   BYTES                 = 2
   UNIT                  = "N/A"
   FORMAT                = "I2"
   DESCRIPTION           = "Time compression.
                            The field takes one of the following values:
                            1 (sweep)
                            2 (sweeps)
                            4 (sweeps)
                            8 (sweeps)
                            16 (sweeps)
                            -1 (for undefined)"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 6
   NAME                  = "ENERGY_COMPRESSION"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 75
   BYTES                 = 2
   UNIT                  = "N/A"
   FORMAT                = "I2"
   DESCRIPTION           = "Energy compression value indicates how many
                            energy steps have been summed over. 128 divided
                            by this value gives the number of energy steps.
                            The field takes one of the following values:
                            1 (step)
                            2 (steps)
                            4 (steps)
                            -1 (for undefined)"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 7
   NAME                  = "LOG_COMPRESSION"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 78
   BYTES                 = 1
   UNIT                  = "N/A"
```

```
   FORMAT              = "I1"
   DESCRIPTION         = "Log compression"
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
   COLUMN_NUMBER       = 8
   NAME                = "RICE_COMPRESSION_FLAG"
   DATA_TYPE           = ASCII_INTEGER
   START_BYTE          = 80
   BYTES               = 1
   UNIT                = "N/A"
   FORMAT              = "I1"
   DESCRIPTION         = "Rice compression flag status.
                          The field takes one of the following values:
                          0 = non valid
                          1 = valid"
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
   COLUMN_NUMBER       = 9
   NAME                = "RICE_COMPRESSION_VALUE"
   DATA_TYPE           = ASCII_INTEGER
   START_BYTE          = 82
   BYTES               = 1
   UNIT                = "N/A"
   FORMAT              = "I1"
   DESCRIPTION         = "Rice compression"
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
   COLUMN_NUMBER       = 10
   NAME                = "SCANNER_DIRECTION"
   DATA_TYPE           = ASCII_INTEGER
   START_BYTE          = 84
   BYTES               = 1
   UNIT                = "N/A"
   FORMAT              = "I1"
   DESCRIPTION         = "Scanner direction.
                          The field takes one of the following values:
                          0: 0 - 180
                          1: 180 - 0"
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
   COLUMN_NUMBER       = 11
   NAME                = "SCANNER_SPEED"
   DATA_TYPE           = ASCII_INTEGER
   START_BYTE          = 86
   BYTES               = 3
   UNIT                = SECOND
   FORMAT              = "I3"
   DESCRIPTION         = "Scanner speed.
                          This is not the actual moving speed at the
                          specified time, but a setting speed value that is
                          applied in operation to the scanner once a command
                          is sent to move it.
                          The field takes one of the following values:
                          0 (standing)
                          32 (seconds scan)
                          64 (seconds scan)
                          128 (seconds scan)"
END_OBJECT             = COLUMN
```

```
OBJECT                  = COLUMN
   COLUMN_NUMBER        = 12
   NAME                 = "SCANNER_POSITION"
   DATA_TYPE            = ASCII_REAL
   START_BYTE           = 90
   BYTES                = 5
   UNIT                 = "DEGREE"
   FORMAT               = "F5.1"
   DESCRIPTION          = "Scanner position in degrees"
END_OBJECT              = COLUMN
```

Detailed description of those parameters is provided in documents [AD 3].

4.3.1.5.2 The description of the ELS engineering header table:

The raw engineering values are converted into physical values when calibration is applied.

```
OBJECT                  = HEAD_ENG_TABLE
   NAME                 = "ELS_SPECTRUM_HEAD_ENG"
   ROW_SUFFIX_BYTES     = Number of bytes that are accounted in the subsequent
                          table, including record terminators and separators
   INTERCHANGE_FORMAT   = ASCII
   ROWS                 = Number of rows within the data file
   COLUMNS              = 18
   ROW_BYTES            = 129
  ^STRUCTURE            = "ELS_SPECTRUM_HEAD_ENG.FMT"
END_OBJECT              = HEAD_ENG_TABLE
```

The structure of the TABLE object is described in the file ELS_SPECTRUM_HEAD_ENG.FMT as follows:

```
/*  Contents of format file  "ELS_SPECTRUM_HEAD_ENG.FMT"  */
OBJECT                  = COLUMN
   COLUMN_NUMBER        = 1
   NAME                 = "UTC"
   DATA_TYPE            = TIME
   START_BYTE           = 1
   BYTES                = 23
   UNIT                 = "N/A"
   DESCRIPTION          = "This column represents the UTC at the start
                           of the data matrix in PDS standard format
                           YYYY-MM-DDThh:mm:ss.sss"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 2
   NAME                 = "OBT"
   DATA_TYPE            = CHARACTER
   START_BYTE           = 26
   BYTES                = 19
   UNIT                 = "N/A"
   DESCRIPTION          = "Spectrum On board Time :
                           OBT is represented as :
                           Reset number (integer starting at 1) / seconds.
                           Reset number 1 starts at 2005-11-09T03:33:00 UTC
                           The time resolution is 1/65536 s "
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 3
   NAME                 = "SW_VERSION"
   DATA_TYPE            = ASCII_INTEGER
```

```
        START_BYTE          = 47
        BYTES               = 5
        UNIT                = "N/A"
        FORMAT              = "I5"
        DESCRIPTION         = "Software version"
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        COLUMN_NUMBER       = 4
        NAME                = "SECTOR_MASK"
        DATA_TYPE           = CHARACTER
        START_BYTE          = 54
        BYTES               = 16
        UNIT                = "N/A"
        DESCRIPTION         = "ELS Sector mask defines the active sectors that are
                               set for the measurement. The Binary format is used.
                               One bit (or character) represents the status of one
                               ELS sector and may take one of the following values
                               bit 0 (sector 0): 1 (enable), 0 (disable)
                               bit 1 (sector 1): 1 (enable), 0 (disable)
                               bit 2 (sector 2): 1 (enable), 0 (disable)
                               bit 3 (sector 3): 1 (enable), 0 (disable)
                               bit 4 (sector 4): 1 (enable), 0 (disable)
                               bit 5 (sector 5): 1 (enable), 0 (disable)
                               bit 6 (sector 6): 1 (enable), 0 (disable)
                               bit 7 (sector 7): 1 (enable), 0 (disable)
                               bit 8 (sector 8): 1 (enable), 0 (disable)
                               bit 9 (sector 9): 1 (enable), 0 (disable)
                               bit 10 (sector 10): 1 (enable), 0 (disable)
                               bit 11 (sector 11): 1 (enable), 0 (disable)
                               bit 12 (sector 12): 1 (enable), 0 (disable)
                               bit 13 (sector 13): 1 (enable), 0 (disable)
                               bit 14 (sector 14): 1 (enable), 0 (disable)
                               bit 15 (sector 15): 1 (enable), 0 (disable)"
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        COLUMN_NUMBER       = 5
        NAME                = "TIME_COMPRESSION"
        DATA_TYPE           = ASCII_INTEGER
        START_BYTE          = 72
        BYTES               = 2
        UNIT                = "N/A"
        FORMAT              = "I2"
        DESCRIPTION         = "Time compression.
                               The field takes one of the following values:
                               1 (sweep)
                               2 (sweeps)
                               4 (sweeps)
                               8 (sweeps)
                               16 (sweeps)
                               -1 (for undefined)"
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        COLUMN_NUMBER       = 6
        NAME                = "ENERGY_COMPRESSION"
        DATA_TYPE           = ASCII_INTEGER
        START_BYTE          = 75
        BYTES               = 2
        UNIT                = "N/A"
        FORMAT              = "I2"
```

```
     DESCRIPTION              = "Energy compression value indicates how many
                                energy steps have been summed over. 128 divided
                                by this value gives the number of energy steps.
                                The field takes one of the following values:
                                1 (step)
                                2 (steps)
                                4 (steps)
                                -1 (for undefined)"
   END_OBJECT                 = COLUMN

   OBJECT                     = COLUMN
      COLUMN_NUMBER           = 7
      NAME                    = "LOG_COMPRESSION"
      DATA_TYPE               = ASCII_INTEGER
      START_BYTE              = 78
      BYTES                   = 1
      UNIT                    = "N/A"
      FORMAT                  = "I1"
      DESCRIPTION             = "Log compression"
   END_OBJECT                 = COLUMN

   OBJECT                     = COLUMN
      COLUMN_NUMBER           = 8
      NAME                    = "RICE_COMPRESSION_FLAG"
      DATA_TYPE               = ASCII_INTEGER
      START_BYTE              = 80
      BYTES                   = 1
      UNIT                    = "N/A"
      FORMAT                  = "I1"
      DESCRIPTION             = "Rice compression flag status.
                                 The field takes one of the following values:
                                 0 = non valid
                                 1 = valid"
   END_OBJECT                 = COLUMN

   OBJECT                     = COLUMN
      COLUMN_NUMBER           = 9
      NAME                    = "RICE_COMPRESSION_VALUE"
      DATA_TYPE               = ASCII_INTEGER
      START_BYTE              = 82
      BYTES                   = 1
      UNIT                    = "N/A"
      FORMAT                  = "I1"
      DESCRIPTION             = "Rice compression"
   END_OBJECT                 = COLUMN

   OBJECT                     = COLUMN
      COLUMN_NUMBER           = 10
      NAME                    = "SCANNER_DIRECTION"
      DATA_TYPE               = ASCII_INTEGER
      START_BYTE              = 84
      BYTES                   = 1
      UNIT                    = "N/A"
      FORMAT                  = "I1"
      DESCRIPTION             = "Scanner direction.
                                 The field takes one of the following values:
                                 0: 0 - 180
                                 1: 180 - 0"
   END_OBJECT                 = COLUMN

   OBJECT                     = COLUMN
      COLUMN_NUMBER           = 11
```

```
     NAME              = "SCANNER_SPEED"
     DATA_TYPE         = ASCII_INTEGER
     START_BYTE        = 86
     BYTES             = 3
     UNIT              = SECOND
     FORMAT            = "I3"
     DESCRIPTION       = "Scanner speed.
                         This is not the actual moving speed at the
                         specified time, but a setting speed value that is
                         applied in operation to the scanner once a command
                         is sent to move it.
                         The field takes one of the following values:
                         0 (standing)
                         32 (seconds scan)
                         64 (seconds scan)
                         128 (seconds scan)"
  END_OBJECT           = COLUMN

  OBJECT               = COLUMN
     COLUMN_NUMBER     = 12
     NAME              = "SCANNER_POSITION"
     DATA_TYPE         = ASCII_REAL
     START_BYTE        = 90
     BYTES             = 5
     UNIT              = "DEGREE"
     FORMAT            = "F5.1"
     DESCRIPTION       = "Scanner position in degrees"
  END_OBJECT           = COLUMN

  OBJECT               = COLUMN
     COLUMN_NUMBER     = 13
     NAME              = "ELS_STATUS"
     DATA_TYPE         = ASCII_INTEGER
     START_BYTE        = 96
     BYTES             = 3
     UNIT              = "N/A"
     FORMAT            = "I3"
     DESCRIPTION       = "ELS Status"
  END_OBJECT           = COLUMN

  OBJECT               = COLUMN
     COLUMN_NUMBER     = 14
     NAME              = "ELS_TEMPERATURE"
     DATA_TYPE         = ASCII_REAL
     START_BYTE        = 100
     BYTES             = 7
     UNIT              = "CELSIUS"
     FORMAT            = "F7.2"
     DESCRIPTION       = "ELS temperature in degree Celsius "
  END_OBJECT           = COLUMN

  OBJECT               = COLUMN
     COLUMN_NUMBER     = 15
     NAME              = "ELS_MCP_REFERENCE"
     DATA_TYPE         = ASCII_INTEGER
     START_BYTE        = 108
     BYTES             = 3
     UNIT              = "ADC_UNITS"
     FORMAT            = "I3"
     DESCRIPTION       = "Uncalibrated ELS MCP reference"
  END_OBJECT           = COLUMN
```

```
OBJECT                  = COLUMN
   COLUMN_NUMBER        = 16
   NAME                 = "ELS_MCP_MONITOR"
   DATA_TYPE            = ASCII_REAL
   START_BYTE           = 112
   BYTES                = 7
   UNIT                 = "VOLT"
   FORMAT               = "F7.2"
   DESCRIPTION          = "ELS MCP bias monitor in Volts"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 17
   NAME                 = "ELS_SCREEN_GRID_REFERENCE"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 120
   BYTES                = 3
   UNIT                 = "ADC_UNITS"
   FORMAT               = "I3"
   DESCRIPTION          = "Uncalibrated ELS screen grid reference"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 18
   NAME                 = "ELS_SCREEN_GRID_MONITOR"
   DATA_TYPE            = ASCII_REAL
   START_BYTE           = 124
   BYTES                = 6
   UNIT                 = "VOLT"
   FORMAT               = "F6.3"
   DESCRIPTION          = "ELS screen grid bias monitor in Volts"
END_OBJECT              = COLUMN
```

Detailed description of those parameters is provided in documents [AD 3].

4.3.1.5.3 The description of the ELS science table:

An ELS data packet can contain a maximum of 128 energy-steps × 16 azimuthal-sectors values. However, data for all sectors may not always be returned. The field sector mask indicates which of the sixteen possible anode sectors are being returned in the data matrix. Depending upon the number of sectors that operate and process for measuring electrons within a cycle time interval, the electron counting table may have to be dimensioned with an azimuthal number lower than the 16 possible sectors. This number may vary between records from a same processed level-1 data file, making necessary the use of separate data products for storing those data using fewer azimuthal sectors in a fixed width table structure. On the other hands, this makes useless the external files (FMT) referenced by include pointers since a number of different TABLE objects use different definitions.

The sector mask is meant to block unwanted instrument data from entering the telemetry stream. The blocked data is from that sector which has data determined to be obstructed or not scientifically useful. The aim here is not to use TM space by not bringing down data which is of questionable use or not as important; TM may be freed for other data or higher resolution data (fewer compression techniques applied). One of the ways to get down more of the useful data from sectors is to block data from those ELS sectors which do not yield the effect that the scientists wish to study. When a bit within the sector mask is turned on, then data from that sector is allowed to pass to the telemetry stream and accumulates in the science matrix. At the start of the mission, all sectors should pass their data to be accumulated within the science data matrix.

In addition to the variable number of active sectors, the number of energy steps could be variable as well, depending on the energy compression scheme that is applied within a ELS complete sweep. The Energy Compression field, as specified in the header content associated to science data, informs the way in which energy steps have been summed over for each value returned. The energy-steps total number is derived by the division of two quantities: the maximal 128 energy-steps (corresponding to a complete sweep with no

energy compression) and the energy compression parameter value that could take any of the following values: 1, 2 or 4. In order to maintain fixed width table structure within each data product, data of different energy compression parameter value will be split and stored in different data product files as well.

For the ELS science data storage, it exists a total of 48 possible data products for containing block of data of each combination of numbers of azimuthal sectors and energy steps. Only one science data TABLE object is defined per data product label file wherein a ROW_PREFIX_BYTES keyword value is indicating the size in bytes that are accounted in the preceding and parallel heading table, as shown in the following object description.

```
OBJECT                  = DATA_SCIENCE_TABLE
   NAME                 = "ELS_SPECTRUM_DATA"
   ROW_PREFIX_BYTES     = 94
   INTERCHANGE_FORMAT   = ASCII
   ROWS                 = Number of rows within the data file
   COLUMNS              = 1
   ROW_BYTES            = Number of bytes that are accounted in this table,
                          including record terminators and separators

   OBJECT               = COLUMN
      COLUMN_NUMBER     = 1
      NAME              = "ELS_COUNTS"
      DATA_TYPE         = ASCII_INTEGER
      START_BYTE        = 1
      BYTES             = Number of bytes that are accounted in this table,
                          including record terminators and separators
      UNIT              = "ADC_UNITS"
      FORMAT            = "I5"
      DESCRIPTION       = "Electrons (counts/accumulation) counted in the current
                           energy step number and azimuthal sector."
      ITEMS             = Number equal to the product of the number of energy bins
                          by the number of valid angular sectors
      ITEM_BYTES        = 6
   END_OBJECT           = COLUMN

END_OBJECT              = DATA_SCIENCE_TABLE
```

4.3.1.5.4 The description of the ELS engineering table:

The following TABLE object description is applicable to those label files that are associated to science data of engineering mode. The object storage format is well-known since only one data pattern exists for this mode.

```
OBJECT                  = ENG_TABLE
   NAME                 = "ELS_SPECTRUM_ENGINEER"
   ROW_PREFIX_BYTES     = 129
   INTERCHANGE_FORMAT   = ASCII
   ROWS                 = Number of rows within the data file
   COLUMNS              = 2
   ROW_BYTES            = 1538

   OBJECT               = COLUMN
      COLUMN_NUMBER     = 1
      NAME              = "ELS_DEFLECTION_REF_VALUE"
      DATA_TYPE         = ASCII_INTEGER
      START_BYTE        = 1
      BYTES             = 768
      UNIT              = "N/A"
      FORMAT            = "I5"
      DESCRIPTION       = "Uncalibrated ELS deflection reference
                           in the current potential sweep step"
      ITEMS             = 128
```

```
        ITEM_BYTES          = 6
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 2
      NAME                  = "ELS_DEFLECTION_MON_VALUE"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 769
      BYTES                 = 770
      UNIT                  = "N/A"
      FORMAT                = "I5"
      DESCRIPTION           = "Uncalibrated ELS deflection monitor
                               in the current potential sweep step"
      ITEMS                 = 128
      ITEM_BYTES            = 6
   END_OBJECT               = COLUMN

  END_OBJECT                = ENG_TABLE
```

Detailed description of those parameters is provided in documents [AD 3]. Energy tables are provided in [AD 13] in order to help users to convert raw values (uncalibrated deflection voltage) into physical units (energy in Volt).

4.3.1.6   Description of Instrument

The description of the instrument is done in above and as a brief overview in the INST.CAT catalog file.

4.3.1.7   Parameters Index File Definition

N/A

4.3.1.8   Mission Specific Keywords

Mission specific keywords should all have the MISSION_ID "VEX" prefix.

```
    VEX:SCIENCE_CASE_ID          = "ALL"
    VEX:SCIENCE_CASE_ID_DESC     = "Please refer to VEX_SCIENCE_CASE_ID_DESC.TXT
                                    in the DOCUMENT directory."
```

4.3.2   ELS Housekeeping Calibrated Data Product Design (Level 3)

ELS level 3 HK contains calibrated ELS housekeeping data with PDS detached labels. The incoming raw HK values are converted into physical values when calibration is applied. This type of data is identified by the following data descriptors within the current label file:

```
    PRODUCT_TYPE                 = RDR /* EDR for RAW, RDR for calibrated data */
    PROCESSING_LEVEL_ID          = 3
```

HK parameters are listed in the following fields table in the same order that they appear in the data product label file.

Table 25. ELS housekeeping content.

Rank	Field	Rank	Field
1	UTC correlated Time	23	Scanner vrefmc
2	OBT Time	24	Scanner init
3	ELS temperature	25	Lost step
4	Scanner temperature sensor	26	Scanner status state
5	SW version	27	Scanner status direction

6	ELS -5V screen grid reference	28	Scanner status position clock
7	ELS -5V screen grid monitor	29	Scanner status cw end position
8	ELS bias MCP reference	30	Scanner status ccw end position
9	ELS bias MCP monitor	31	Scanner speed
10	ELS range	32	Scanner setup direction
11	ELS table index	33	Scanner setup mode
12	ELS enable HV	34	Scanner +30V on/off
13	ELS +30V on/off	35	Scanner coast current reference
14	HK i +30V	36	Scanner ramp current reference
15	HK i +5V	37	Scanner threshold cw reference
16	HK V +12V	38	Scanner threshold ccw reference
17	HK V +30V	39	Scanner threshold wheel reference
18	HK V +5V	40	Scanner position
19	HK V -12V	41	SW mode
20	HK V -5V	42	Cpu load
21	Sun sensor 1	43	ELS sector mask
22	Sun sensor 2	44	ELS compression scheme

The table object is detailed in the following paragraph.

4.3.2.1   File Characteristics Data Elements

The following elements are present in the labels for every ELS housekeeping calibrated data product, and they describe the basic characteristics of the data product in terms of structure and naming:

```
/* FILE CHARACTERISTIC DATA ELEMENTS */
PRODUCT_ID                    = this element defines the current product file name,
                                without extension
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 222
FILE_RECORDS                  = this element indicates the number of records within
                                the data file
```

4.3.2.2   Data Object Pointers Identification Data Elements

The ELS housekeeping calibrated data are organized as ASCII table. The data object pointer that references TAB file is:

```
^HK_ELS_TABLE
```

4.3.2.3   Instrument and Detector Descriptive Data Elements

See the applicable section 4.3.1.3

4.3.2.4   Structure Definition of Instrument Parameter Objects

N/A

4.3.2.5   Data Object Definition

This section of the label defines the structure and content of the ELS housekeeping calibrated data product. Each data file (TAB) contains a 44 columns table with the calibrated HK data when calibration is applied.

```
OBJECT                    = HK_ELS_TABLE
    NAME                  = "HK_ELS"
    INTERCHANGE_FORMAT    = ASCII
    ROWS                  = this element indicates the number of rows within
                            the data file
```

```
   COLUMNS              = 44
   ROW_BYTES            = 222
   ^STRUCTURE           = "ELS_SPECTRUM_HKELS.FMT"
END_OBJECT              = HK_ELS_TABLE
```

The structure of the TABLE object is described in the file ELS_SPECTRUM_HKELS.FMT as follows:

```
/*  Contents of format file  "ELS_SPECTRUM_HKELS.FMT"  */
OBJECT                  = COLUMN
   COLUMN_NUMBER        = 1
   NAME                 = "UTC"
   DATA_TYPE            = TIME
   START_BYTE           = 1
   BYTES                = 23
   UNIT                 = "N/A"
   DESCRIPTION          = "This column represents the UTC of the
                           ELS HK data set in PDS standard format
                           YYYY-MM-DDThh:mm:ss.sss"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 2
   NAME                 = "OBT"
   DATA_TYPE            = CHARACTER
   START_BYTE           = 26
   BYTES                = 19
   UNIT                 = "N/A"
   DESCRIPTION          = "On board Time (OBT) is represented as :
                           <Reset number>/<unit seconds>.<fractional seconds>
                           with
                           <Reset number>: integer starting at 1
                              Reset number 1 starts at 2005-03-01T00:00:00 UTC
                           <unit seconds>: 10 digits number of unit seconds
                           <fractional seconds>: 5 digits number of fractional
                              seconds expressed as multiples of 2^-16 seconds"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 3
   NAME                 = "ELS_TEMP"
   DATA_TYPE            = ASCII_REAL
   START_BYTE           = 47
   BYTES                = 7
   UNIT                 = "CELSIUS"
   FORMAT               = "F7.2"
   DESCRIPTION          = "ELS temperature in degree Celsius"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 4
   NAME                 = "SCANNER_TEMP_SENSOR"
   DATA_TYPE            = ASCII_REAL
   START_BYTE           = 55
   BYTES                = 7
   UNIT                 = "CELSIUS"
   FORMAT               = "F7.2"
   DESCRIPTION          = "Scanner temperature sensor in degree Celsius"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 5
   NAME                 = "SW_VERSION"
```

```
      DATA_TYPE              = ASCII_INTEGER
      START_BYTE             = 63
      BYTES                  = 5
      UNIT                   = "N/A"
      FORMAT                 = "I5"
      DESCRIPTION            = "Software version
                                To decode into Binary format. Bit description:
                                patchVersion [3:0]
                                minorVersion [8:4]
                                majorVersion [13:9]
                                releaseClass [15:14]: 1 (D), 2 (T), 3 (R)"
   END_OBJECT                = COLUMN

   OBJECT                    = COLUMN
      COLUMN_NUMBER          = 6
      NAME                   = "ELS_MINUS_5V_SCREEN_GRID_REFERENCE"
      DATA_TYPE              = ASCII_INTEGER
      START_BYTE             = 69
      BYTES                  = 3
      UNIT                   = "ADC_UNITS"
      FORMAT                 = "I3"
      DESCRIPTION            = "ELS -5V screen grid reference"
   END_OBJECT                = COLUMN

   OBJECT                    = COLUMN
      COLUMN_NUMBER          = 7
      NAME                   = " ELS_MINUS_5V_SCREEN_GRID_MONITOR "
      DATA_TYPE              = ASCII_REAL
      START_BYTE             = 73
      BYTES                  = 6
      UNIT                   = "VOLT"
      FORMAT                 = "F6.3"
      DESCRIPTION            = "ELS -5V screen grid monitor in Volts"
   END_OBJECT                = COLUMN

   OBJECT                    = COLUMN
      COLUMN_NUMBER          = 8
      NAME                   = "ELS_BIA_MCP_REFERENCE"
      DATA_TYPE              = ASCII_INTEGER
      START_BYTE             = 80
      BYTES                  = 3
      UNIT                   = "ADC_UNITS"
      FORMAT                 = "I3"
      DESCRIPTION            = "ELS bias MCP reference"
   END_OBJECT                = COLUMN

   OBJECT                    = COLUMN
      COLUMN_NUMBER          = 9
      NAME                   = "ELS_BIA_MCP_MONITOR"
      DATA_TYPE              = ASCII_REAL
      START_BYTE             = 84
      BYTES                  = 7
      UNIT                   = "VOLT"
      FORMAT                 = "F7.2"
      DESCRIPTION            = "ELS bias MCP monitor in Volts"
   END_OBJECT                = COLUMN

   OBJECT                    = COLUMN
      COLUMN_NUMBER          = 10
      NAME                   = "ELS_RANGE"
      DATA_TYPE              = ASCII_INTEGER
      START_BYTE             = 92
```

```
      BYTES                 = 1
      UNIT                  = "N/A"
      FORMAT                = "I1"
      DESCRIPTION           = "ELS range.
                               The field takes one of the following values:
                               0 low
                               1 high"
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 11
      NAME                  = "ELS_TABLE_INDEX"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 94
      BYTES                 = 3
      UNIT                  = "N/A"
      FORMAT                = "I3"
      DESCRIPTION           = "ELS table index"
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 12
      NAME                  = "ELS_ENABLE_HV"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 98
      BYTES                 = 1
      UNIT                  = "N/A"
      FORMAT                = "I1"
      DESCRIPTION           = "ELS enable HV flag.
                               The field takes one of the following values:
                               0 off
                               1 on"
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 13
      NAME                  = "ELS_PLUS_30V_ON_OFF"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 100
      BYTES                 = 1
      UNIT                  = "N/A"
      FORMAT                = "I1"
      DESCRIPTION           = "ELS +30V on/off
                               The field takes one of the following values:
                               0 off
                               1 on"
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 14
      NAME                  = "HK_I_PLUS_30V"
      DATA_TYPE             = ASCII_REAL
      START_BYTE            = 102
      BYTES                 = 6
      UNIT                  = "MILLIAMPERE"
      FORMAT                = "F6.2"
      DESCRIPTION           = "HK i +30V in milli-amperes"
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 15
      NAME                  = "HK_I_PLUS_5V"
```

```
        DATA_TYPE           = ASCII_REAL
        START_BYTE          = 109
        BYTES               = 7
        UNIT                = "MILLIAMPERE"
        FORMAT              = "F7.2"
        DESCRIPTION         = "HK i +5V in milli-amperes"
     END_OBJECT             = COLUMN

     OBJECT                 = COLUMN
        COLUMN_NUMBER       = 16
        NAME                = "HK_V_PLUS_12V"
        DATA_TYPE           = ASCII_REAL
        START_BYTE          = 117
        BYTES               = 5
        UNIT                = "VOLT"
        FORMAT              = "F5.2"
        DESCRIPTION         = "HK V +12V in Volts"
     END_OBJECT             = COLUMN

     OBJECT                 = COLUMN
        COLUMN_NUMBER       = 17
        NAME                = "HK_V_PLUS_30V"
        DATA_TYPE           = ASCII_REAL
        START_BYTE          = 123
        BYTES               = 6
        UNIT                = "VOLTS"
        FORMAT              = "F6.2"
        DESCRIPTION         = "HK V +30V in Volts"
     END_OBJECT             = COLUMN

     OBJECT                 = COLUMN
        COLUMN_NUMBER       = 18
        NAME                = "HK_V_PLUS_5V"
        DATA_TYPE           = ASCII_REAL
        START_BYTE          = 130
        BYTES               = 4
        UNIT                = "VOLT"
        FORMAT              = "F4.2"
        DESCRIPTION         = "HK V +5V in Volts"
     END_OBJECT             = COLUMN

     OBJECT                 = COLUMN
        COLUMN_NUMBER       = 19
        NAME                = "HK_V_MINUS_12V"
        DATA_TYPE           = ASCII_REAL
        START_BYTE          = 135
        BYTES               = 6
        UNIT                = "VOLT"
        FORMAT              = "F6.2"
        DESCRIPTION         = "HK V -12V in Volts"
     END_OBJECT             = COLUMN

     OBJECT                 = COLUMN
        COLUMN_NUMBER       = 20
        NAME                = "HK_V_MINUS_5V"
        DATA_TYPE           = ASCII_REAL
        START_BYTE          = 142
        BYTES               = 5
        UNIT                = "VOLT"
        FORMAT              = "F5.2"
        DESCRIPTION         = "HK V -5V in Volts"
     END_OBJECT             = COLUMN
```

```
OBJECT                   = COLUMN
   COLUMN_NUMBER         = 21
   NAME                  = "SUN_SENSOR_1"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 148
   BYTES                 = 1
   UNIT                  = "N/A"
   FORMAT                = "I1"
   DESCRIPTION           = "Sun sensor 1 output"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 22
   NAME                  = "SUN_SENSOR_2"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 150
   BYTES                 = 1
   UNIT                  = "N/A"
   FORMAT                = "I1"
   DESCRIPTION           = "Sun sensor 2 output"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 23
   NAME                  = "SCANNER_VREFMC"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 152
   BYTES                 = 3
   UNIT                  = "ADC_UNITS"
   FORMAT                = "I3"
   DESCRIPTION           = "Scanner vrefmc"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 24
   NAME                  = "SCANNER_INIT"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 156
   BYTES                 = 1
   UNIT                  = "N/A"
   FORMAT                = "I1"
   DESCRIPTION           = "Scanner initialized"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 25
   NAME                  = "LOST_STEP"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 158
   BYTES                 = 1
   UNIT                  = "N/A"
   FORMAT                = "I1"
   DESCRIPTION           = "Lost step"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 26
   NAME                  = "SCANNER_STATUS_STATE"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 160
   BYTES                 = 1
```

```
                  UNIT            = "N/A"
                  FORMAT          = "I1"
                  DESCRIPTION     = "Scanner status state.
                                     The field takes one of the following values:
                                     0 not busy
                                     1 ramp up
                                     2 full speed move
                                     3 ramp down"
END_OBJECT        = COLUMN

OBJECT            = COLUMN
   COLUMN_NUMBER  = 27
   NAME           = "SCANNER_STATUS_DIRECTION"
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 162
   BYTES          = 1
   UNIT           = "N/A"
   FORMAT         = "I1"
   DESCRIPTION    = "Scanner status direction
                     The field takes one of the following values:
                     0 0-180
                     1 180-0"
END_OBJECT        = COLUMN

OBJECT            = COLUMN
   COLUMN_NUMBER  = 28
   NAME           = "SCANNER_STATUS_POS_CLOCK"
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 164
   BYTES          = 1
   UNIT           = "N/A"
   FORMAT         = "I1"
   DESCRIPTION    = "Scanner status position clock"
END_OBJECT        = COLUMN

OBJECT            = COLUMN
   COLUMN_NUMBER  = 29
   NAME           = "SCANNER_STATUS_CW_END_POS"
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 166
   BYTES          = 1
   UNIT           = "N/A"
   FORMAT         = "I1"
   DESCRIPTION    = "Scanner status cw end position
                     The field takes one of the following values:
                     0 scanner not in cw end position
                     1 scanner in cw end position"
END_OBJECT        = COLUMN

OBJECT            = COLUMN
   COLUMN_NUMBER  = 30
   NAME           = "SCANNER_STATUS_CCW_END_POS"
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 168
   BYTES          = 1
   UNIT           = "N/A"
   FORMAT         = "I1"
   DESCRIPTION    = "Scanner status ccw end position
                     The field takes one of the following values:
                     0 scanner not in ccw end position
                     1 scanner in ccw end position"
END_OBJECT        = COLUMN
```

```
OBJECT                    = COLUMN
   COLUMN_NUMBER          = 31
   NAME                   = "SCANNER_SPEED"
   DATA_TYPE              = ASCII_INTEGER
   START_BYTE             = 170
   BYTES                  = 1
   UNIT                   = "N/A"
   FORMAT                 = "I1"
   DESCRIPTION            = "Scanner speed
                            This is not the actual moving speed at the
                            specified time, but a setting speed value that is
                            applied in operation to the scanner once a command
                            is sent to move it.
                            The field takes one of the following values:
                            0 STOP
                            1 32s scan
                            2 64s scan
                            3 128s scan"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 32
   NAME                   = "SCANNER_SETUP_DIRECTION"
   DATA_TYPE              = ASCII_INTEGER
   START_BYTE             = 172
   BYTES                  = 1
   UNIT                   = "N/A"
   FORMAT                 = "I1"
   DESCRIPTION            = "Scanner setup direction
                            The field takes one of the following values:
                            0 0-180
                            1 180-0
                            for manual mode speed command only"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 33
   NAME                   = "SCANNER_SETUP_MODE"
   DATA_TYPE              = ASCII_INTEGER
   START_BYTE             = 174
   BYTES                  = 1
   UNIT                   = "N/A"
   FORMAT                 = "I1"
   DESCRIPTION            = "Scanner setup mode
                             The field takes one of the following values:
                             0 normal
                             1 manual"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 34
   NAME                   = "SCANNER_PLUS_30V_ON_OFF"
   DATA_TYPE              = ASCII_INTEGER
   START_BYTE             = 176
   BYTES                  = 1
   UNIT                   = "N/A"
   FORMAT                 = "I1"
   DESCRIPTION            = "Scanner +30V on/off
                             The field takes one of the following values:
                             0 off
                             1 on"
```

```
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 35
   NAME                 = "SCANNER_COAST_CURRENT_REF"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 178
   BYTES                = 3
   UNIT                 = "ADC_UNITS"
   FORMAT               = "I3"
   DESCRIPTION          = "Scanner coast current reference"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 36
   NAME                 = "SCANNER_RAMP_CURRENT_REF"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 182
   BYTES                = 3
   UNIT                 = "ADC_UNITS"
   FORMAT               = "I3"
   DESCRIPTION          = "Scanner ramp current reference"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 37
   NAME                 = "SCANNER_TRESHOLD_CW_REF"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 186
   BYTES                = 3
   UNIT                 = "ADC_UNITS"
   FORMAT               = "I3"
   DESCRIPTION          = "Scanner threshold cw reference"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 38
   NAME                 = "SCANNER_TRESHOLD_CCW_REF"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 190
   BYTES                = 3
   UNIT                 = "ADC_UNITS"
   FORMAT               = "I3"
   DESCRIPTION          = "Scanner threshold ccw reference"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 39
   NAME                 = "SCANNER_TRESHOLD_WHEEL_REF"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 194
   BYTES                = 3
   UNIT                 = "ADC_UNITS"
   FORMAT               = "I3"
   DESCRIPTION          = "Scanner threshold wheel reference"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 40
   NAME                 = "SCANNER_POSITION"
   DATA_TYPE            = ASCII_REAL
   START_BYTE           = 198
```

```
    BYTES                   = 5
    UNIT                    = "DEGREE"
    FORMAT                  = "F5.1"
    DESCRIPTION             = "Scanner position in degrees"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    COLUMN_NUMBER           = 41
    NAME                    = "SW_MODE"
    DATA_TYPE               = ASCII_INTEGER
    START_BYTE              = 204
    BYTES                   = 3
    UNIT                    = "N/A"
    FORMAT                  = "I3"
    DESCRIPTION             = "Software mode"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    COLUMN_NUMBER           = 42
    NAME                    = "CPU_LOAD"
    DATA_TYPE               = ASCII_INTEGER
    START_BYTE              = 208
    BYTES                   = 3
    UNIT                    = "N/A"
    FORMAT                  = "I3"
    DESCRIPTION             = "CPU load"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    COLUMN_NUMBER           = 43
    NAME                    = "ELS_SECTOR_MASK"
    DATA_TYPE               = ASCII_INTEGER
    START_BYTE              = 212
    BYTES                   = 5
    UNIT                    = "N/A"
    FORMAT                  = "I5"
    DESCRIPTION             = "ELS sector mask defines the active sectors that are
                               set for the measurement. This field value must be
                               decoded in Binary format.
                               Bit description :
                               bit 0 (sector 0): 1 (enable), 0 (disable)
                               bit 1 (sector 1): 1 (enable), 0 (disable)
                               bit 2 (sector 2): 1 (enable), 0 (disable)
                               bit 3 (sector 3): 1 (enable), 0 (disable)
                               bit 4 (sector 4): 1 (enable), 0 (disable)
                               bit 5 (sector 5): 1 (enable), 0 (disable)
                               bit 6 (sector 6): 1 (enable), 0 (disable)
                               bit 7 (sector 7): 1 (enable), 0 (disable)
                               bit 8 (sector 8): 1 (enable), 0 (disable)
                               bit 9 (sector 9): 1 (enable), 0 (disable)
                               bit 10 (sector 10): 1 (enable), 0 (disable)
                               bit 11 (sector 11): 1 (enable), 0 (disable)
                               bit 12 (sector 12): 1 (enable), 0 (disable)
                               bit 13 (sector 13): 1 (enable), 0 (disable)
                               bit 14 (sector 14): 1 (enable), 0 (disable)
                               bit 15 (sector 15): 1 (enable), 0 (disable)"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    COLUMN_NUMBER           = 44
    NAME                    = "ELS_COMPRESSION_SCHEME"
    DATA_TYPE               = ASCII_INTEGER
```

```
        START_BYTE          = 218
        BYTES               = 3
        UNIT                = "N/A"
        FORMAT              = "I3"
        DESCRIPTION         = "ELS compression scheme (i.e. defines mode)"
  END_OBJECT                = COLUMN
```

Detailed description of those parameters is provided in documents [AD 3].

4.3.2.6   Description of Instrument

See the applicable section 4.3.1.6

4.3.2.7   Parameters Index File Definition

N/A

4.3.2.8   Mission Specific Keywords

See the applicable section 4.3.1.8

4.3.3   Ion Mass Analyzer Science Edited Data Product Design (Level 2)

The IMA sensor can be operated in 32 modes as described in the document [AD 3] and be divided into 5 groups: Min, Nrm, Har, Exm and Special. But only 27 modes are physically producing formatted science data in telemetry packets during nominal mission. These packets contain data for a number of measurement cycles, wherein each data cycle usually contains one particle count value for each parameter sampled within the resolved parametric space azimuth×mass×energy×polar-angles. Thus there are 27 different types of IMA edited science file, one for each selected operation mode. Both of them are always delivered as fixed-size azimuth×mass×energy×polar arrays that are transposed to a row vector, where azimuth (the first) is the fastest varying parameter. For masses above or equal to 8, the integration is simply done by adding adjacent mass bins (e.g., 8 mass bins integrate them 4 by 4 from the 32 available). Note that the imager addressing is such that the heavier masses comes first and the lighter ones last. For masses below 8 (i.e. ≤6), the mass bins are integrated according to lookup tables and supposed to represent true M/q. Azimuth, energy and polar angles always come in the same order. The Table 26 indicates the data contents for each science data file and their representation in the parametric space mass×azimuth×energy×polar-angles. An additional IMA header, common to all IMA modes, is inserted before each data cycle-dependent collection as represented in the Figure 14. The general IMA header information and values are shown in the Table 27.

Table 26. IMA science data file contents and structure.

Data type	Mode		Data description					Array Layout
	index	name	Azimuth angles	Masses	Energies	Polar angles	Max sets	
Minimum - 16 minutes of duration								
	0	idle						No data are produced
M02SssX	2	Mspo	1	2	32	1	15	2×32×ss spectra
M04SssX	4	Msis	1	6	96	1	05	6×96×ss spectra
M05SssX	5	Mexm	1	32	96	1	05	32×96×ss spectra
Normal - 192 seconds of duration								
M08XXXX	8	Nrm-0	16	6	96	16		16×6×96×16 spectra
M09XXXX	9	Nrm-1	16	6	96	8		16×6×96×8 spectra
M10XXXX	10	Nrm-2	16	6	96	4		16×6×96×4 spectra

M11XXXX	11	Nrm-3	16	6	96	2		16×6×96×2	spectra
M12XXXX	12	Nrm-4	8	6	96	2		8×6×96×2	spectra
M13XXXX	13	Nrm-5	4	6	96	2		4×6×96×2	spectra
M14XXXX	14	Nrm-6	4	3	96	2		4×3×96×2	spectra
M15XXXX	15	Nrm-7	4	3	96	1		4×3×96×1	spectra
Burst - 192 seconds of duration									
M16XXXX	16	Har-0	16	16	96	16		16×16×96×16	spectra
M17XXXX	17	Har-1	16	16	96	8		16×16×96×8	spectra
M18XXXX	18	Har-2	16	16	96	4		16×16×96×4	spectra
M19XXXX	19	Har-3	16	8	96	4		16×8×96×4	spectra
M20XXXX	20	Har-4	16	4	96	4		16×4×96×4	spectra
M21XXXX	21	Har-5	16	2	96	4		16×2×96×4	spectra
M22XXXX	22	Har-6	8	2	96	4		8×2×96×4	spectra
M23XXXX	23	Har-7	8	2	96	2		8×2×96×2	spectra
M24XXXX	24	Exm-0	16	32	96	16		16×32×96×16	spectra
M25XXXX	25	Exm-1	16	32	96	8		16×32×96×8	spectra
M26XXXX	26	Exm-2	16	32	96	4		16×32×96×4	spectra
M27XXXX	27	Exm-3	16	32	96	2		16×32×96×2	spectra
M28XXXX	28	Exm-4	8	32	96	2		8×32×96×2	spectra
M29XXXX	29	Exm-5	4	32	96	2		4×32×96×2	spectra
M30XXXX	30	Exm-6	2	32	96	2		2×32×96×2	spectra
M31XXXX	31	Exm-7	2	32	96	1		2×32×96×1	spectra
Special									
	32	Test							
	33	Cal1	Special modes are mainly aimed for ground testing and calibration. No data archival are planned for these modes						
	34	Cal2							
	35	Fake							

Table 27. IMA header content.

Rank	Field / Value			Rank	Field / Value		
1	UTC correlated Time			16	Auto_reduc_change_switch		0 = Disabled 1 = Enabled
2	OBT Time			17	Compression_switch		0 = Disabled 1 = Enabled
3	Sync_Pattern	0xE3 0x31 0xCA		18	FIFO_filling		
4	Unit	1 = ICA (Rosetta) 2 = IMA (MEX) 3 = IMA (VEX)		19	PROM_EEPROM_section_1_16_loaded		0 = PROM 1-16 = EEPROM section 0-15
5	Mode_index	0, 2, 4, 5 or any value in the range 8 to 35		20	Sample_processing_overrun		
6	Experiment_data_format_counter			21	Sweep_processing_overrun		
7	Number_of_sets_in_minimum_mode			22	Post_processing_overrun		
8	Checksum_1_failure			23	Solar_wind_energy_start_index		
9	Checksum_0_failure			24	Reset_due_to_watchdog_or_machine_error		
10	TM_FIFO_emptied			25	Format_start_time_in_units_of_31.25ms		
11	HV_ramping_in_progress			26	Format_length_in_words		
12	Test_pattern			27	Shadow_masking_switch		0 = Disabled 1 = Enabled
13	Post_acc_level	0 = Low 1 = High		28	Bad_HV_masking_switch		0 = Disabled 1 = Enabled
14	Alternating_post_acc_switch		1 = alternating else it is fixed	29	Error	If Error is not equal to 0, the data decompression process is invalid	
15	Post_acc_high_level_reference						

The table objects are detailed in the following paragraphs.

4.3.3.1   File Characteristics Data Elements

The following elements are present in the labels for every IMA science edited data product, and they describe the basic characteristics of the data product in terms of structure and naming:

```
/* FILE CHARACTERISTIC DATA ELEMENTS */
PRODUCT_ID                      = this element defines the current product file name,
                                  without extension
RECORD_TYPE                     = FIXED_LENGTH
RECORD_BYTES                    = this element indicates the number of bytes in a data
                                  record, including record terminators and separators
FILE_RECORDS                    = this element indicates the number of records within
                                  the data file
```

4.3.3.2   Data Object Pointers Identification Data Elements

Typically 2 pointers are defined in a label file, identifying the ASCII PDS objects within which the IMA status and uncalibrated science data are stored. The data object pointers that reference TAB files are:

```
^HEAD_TABLE
^DATA_SCIENCE_TABLE
```

4.3.3.3   Instrument and Detector Descriptive Data Elements

The following data identification elements provide additional information about the IMA data products for both particle counting data modes.

```
/* PRODUCER IDENTIFICATION */
PRODUCER_ID                     = "CESR_ASPERA4_GROUP"
PRODUCER_FULL_NAME              = "EMMANUEL PENOU"
PRODUCER_INSTITUTION_NAME       = "CENTRE D'ETUDE SPATIALE DES RAYONNEMENTS"
PRODUCT_CREATION_TIME           = YYYY-MM-DDThh:mm:ss[.fff]

/* DATA DESCRIPTION AND IDENTIFICATION */
DATA_SET_NAME                   = "
                    VENUS EXPRESS VENUS/SOLARWIND ASPERA 2 IMA V1.0"  or
        "VENUS EXPRESS VENUS/SOLARWIND ASPERA 2 EXTENSION 1 IMA V1.0"  or
        "VENUS EXPRESS VENUS/SOLARWIND ASPERA 2 EXTENSION 1 IMA V1.0"  or
        …
DATA_SET_ID                     = "VEX-V/SW-ASPERA-2-IMA-V1.0"       or
                                  "VEX-V/SW-ASPERA-2-EXT1-IMA-V1.0"   or
                                  "VEX-V/SW-ASPERA-2-EXT2-IMA-V1.0"   or
                                  …
RELEASE_ID                      = 0001
REVISION_ID                     = 0000
PRODUCT_TYPE                    = EDR
PROCESSING_LEVEL_ID             = 2
MISSION_NAME                    = "VENUS EXPRESS"
MISSION_ID                      = VEX
INSTRUMENT_HOST_NAME            = "VENUS EXPRESS"
INSTRUMENT_HOST_ID              = VEX
MISSION_PHASE_NAME              = As defined in [AD 4]
INSTRUMENT_NAME                 = "
        ANALYZER OF SPACE PLASMA AND ENERGETIC ATOMS (4TH VERSION)"
INSTRUMENT_ID                   = ASPERA4
INSTRUMENT_TYPE                 = {"ELECTROSTATIC ANALYZER",
                                   "MASS SPECTROMETER",
                                   "NEUTRAL PARTICLE IMAGER",
                                   "NEUTRAL PARTICLE DETECTOR"}
DETECTOR_ID                     = VEX_ASP4_IMA
```

```
^INSTRUMENT_DESC            = "ASPERA4_DESC.TXT"

/* TARGET IDENTIFICATION */
TARGET_TYPE                 = "PLANET" or "N/A"
TARGET_NAME                 = "VENUS"  or "SOLAR WIND"
RIGHT_ASCENSION             = "N/A"
DECLINATION                 = "N/A"

/* SCIENCE OPERATIONS INFORMATION */
OBSERVATION_TYPE            = {"AC003B", "PE001A", "PE004A"} or "N/A"
^OBSERVATION_TYPE_DESC      = "OBSERVATION_TYPE_DESC.TXT"

/* TIME RELATED INFORMATION */
START_TIME                  = YYYY-MM-DDThh:mm:ss.fff
STOP_TIME                   = YYYY-MM-DDThh:mm:ss.fff
SPACECRAFT_CLOCK_START_COUNT   = "01/xxxxxxxxx.xxxxx"
SPACECRAFT_CLOCK_STOP_COUNT    = "01/xxxxxxxxx.xxxxx"

/* ORBITAL INFORMATION */
ORBIT_NUMBER                = UNK
ORBITAL_ECCENTRICITY        = UNK
ORBITAL_INCLINATION         = UNK
ORBITAL_SEMIMAJOR_AXIS      = UNK
PERIAPSIS_ALTITUDE          = UNK
PERIAPSIS_ARGUMENT_ANGLE    = UNK
PERIAPSIS_TIME              = "UNK"
SPACECRAFT_ORIENTATION      = UNK
^SPACECRAFT_ORIENTATION_DESC   = "VEX_ORIENTATION_DESC.TXT"
SPACECRAFT_POINTING_MODE       = "ALL"
^SPACECRAFT_POINTING_MODE_DESC = "VEX_POINTING_MODE_DESC.TXT"
```

4.3.3.4 Structure Definition of Instrument Parameter Objects

N/A

4.3.3.5 Data Object Definition

This section of the label defines the structure and content of the IMA science edited data products. As specified in §4.3, each data product file (TAB) contains typically 2 objects: a header TABLE and a science data TABLE object stored in parallel. The number of rows within these tables is variable and depends roughly on the number of records contained in the processed level-1 data file. The science data objects are ASCII tables handling particle counts as collected into the entire and discrete instrument mass, azimuth, energy and polar-angles sample space. There is also a common ASCII table data object to all IMA measurements containing the common header information about the sensor status. The columns within this TABLE object are first described in the section below. The science data objects are defined in the following separate sections for each mode occurring and archived in PDS format.

4.3.3.5.1 The description of the IMA header table:

The IMA header information is organized as an ASCII table of fixed width as shown below.

```
OBJECT              = HEAD_TABLE
   NAME             = "IMA_SPECTRUM_HEAD"
   ROW_SUFFIX_BYTES = Number of bytes that are accounted in the subsequent
                      table, including record terminators and separators
   INTERCHANGE_FORMAT = ASCII
   ROWS             = Number of rows within the data file
```

ASPERA 4 EAICD

Document No.   : VEX_ASP_CESR_EAICD_V1_5
Date   : 18 Mar 2011
Page   : 76

```
    COLUMNS              = 29
    ROW_BYTES            = 141
    ^STRUCTURE           = "IMA_SPECTRUM_HEAD.FMT"
END_OBJECT               = HEAD_TABLE
```

The structure of the TABLE object is described in the file IMA_SPECTRUM_HEAD.FMT as follows:

```
/*  Contents of format file  "IMA_SPECTRUM_HEAD.FMT"  */
OBJECT                   = COLUMN
    COLUMN_NUMBER        = 1
    NAME                 = "UTC"
    DATA_TYPE            = TIME
    START_BYTE           = 1
    BYTES                = 23
    UNIT                 = "N/A"
    DESCRIPTION          = "This column represents the UTC of the
                            spectrum in PDS standard format
                            YYYY-MM-DDThh:mm:ss.sss"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    COLUMN_NUMBER        = 2
    NAME                 = "OBT"
    DATA_TYPE            = CHARACTER
    START_BYTE           = 26
    BYTES                = 19
    UNIT                 = "N/A"
    DESCRIPTION          = "On board Time (OBT) is represented as :
                            <Reset number>/<unit seconds>.<fractional seconds>
                            with
                            <Reset number>: integer starting at 1
                               Reset number 1 starts at 2005-03-01T00:00:00 UTC
                            <unit seconds>: 10 digits number of unit seconds
                            <fractional seconds>: 5 digits number of fractional
                               seconds expressed as multiples of 2^-16 seconds"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    COLUMN_NUMBER        = 3
    NAME                 = "SYNC_PATTERN"
    DATA_TYPE            = CHARACTER
    START_BYTE           = 48
    BYTES                = 14
    UNIT                 = "N/A"
    DESCRIPTION          = "The 3 bytes 0xE3 0x31 0xCA mark the start of a
                            new Experiment Data Format. A search for this is
                            required as the EDF s floats in the TM data
                            stream."
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    COLUMN_NUMBER        = 4
    NAME                 = "UNIT"
    DATA_TYPE            = ASCII_INTEGER
    START_BYTE           = 64
    BYTES                = 1
    UNIT                 = "N/A"
    FORMAT               = "I1"
    DESCRIPTION          = "This parameter defines the experiment unit.
                            The field takes one of the following values:
                            0 (undefined)
                            1 (ICA)
```

```
                                    2 (IMA MEX)
                                    3 (IMA VEX)"
  END_OBJECT                 = COLUMN

  OBJECT                     = COLUMN
    COLUMN_NUMBER            = 5
    NAME                     = "MODE_INDEX"
    DATA_TYPE                = ASCII_INTEGER
    START_BYTE               = 66
    BYTES                    = 2
    UNIT                     = "N/A"
    FORMAT                   = "I2"
    DESCRIPTION              = "This is the data reduction mode index used for the
                                data in this EDF. The field takes one of the
                                following values: 0, 2, 4, 5, or any values
                                included in the range 8 to 35."
  END_OBJECT                 = COLUMN

  OBJECT                     = COLUMN
    COLUMN_NUMBER            = 6
    NAME                     = "EXPERIMENT_DATA_FORMAT_COUNTER"
    DATA_TYPE                = ASCII_INTEGER
    START_BYTE               = 69
    BYTES                    = 3
    UNIT                     = "N/A"
    FORMAT                   = "I3"
    DESCRIPTION              = "This is an running counter incremented by 1 for
                                each released EDF. It swaps over to 0 after 255."
  END_OBJECT                 = COLUMN

  OBJECT                     = COLUMN
    COLUMN_NUMBER            = 7
    NAME                     = "NUMBER_OF_SETS_IN_MINIMUM_MODE"
    DATA_TYPE                = ASCII_INTEGER
    START_BYTE               = 73
    BYTES                    = 2
    UNIT                     = "N/A"
    FORMAT                   = "I2"
    DESCRIPTION              = "This parameter gives the number of sets in
                                this EDF for the minimum modes."
  END_OBJECT                 = COLUMN

  OBJECT                     = COLUMN
    COLUMN_NUMBER            = 8
    NAME                     = "CHECKSUM_1_FAILURE"
    DATA_TYPE                = ASCII_INTEGER
    START_BYTE               = 76
    BYTES                    = 1
    UNIT                     = "N/A"
    FORMAT                   = "I1"
    DESCRIPTION              = "This bit will se if the checksum 1 fails during
                                RAM booting. Sets from both PROM and EEPROM
                                booting."
  END_OBJECT                 = COLUMN

  OBJECT                     = COLUMN
    COLUMN_NUMBER            = 9
    NAME                     = "CHECKSUM_0_FAILURE"
    DATA_TYPE                = ASCII_INTEGER
    START_BYTE               = 78
    BYTES                    = 1
    UNIT                     = "N/A"
```

```
      FORMAT                 = "I1"
      DESCRIPTION            = "This bit will se if the checksum 0 fails during
                                RAM booting. Sets from both PROM and EEPROM
                                booting."
  END_OBJECT                 = COLUMN

  OBJECT                     = COLUMN
      COLUMN_NUMBER          = 10
      NAME                   = "TM_FIFO_EMPTIED"
      DATA_TYPE              = ASCII_INTEGER
      START_BYTE             = 80
      BYTES                  = 1
      UNIT                   = "N/A"
      FORMAT                 = "I1"
      DESCRIPTION            = "This bit will set if the TM FIFO is emptied before
                                the start of this EDF. Always forced to and from
                                special EDF s."
  END_OBJECT                 = COLUMN

  OBJECT                     = COLUMN
      COLUMN_NUMBER          = 11
      NAME                   = "HV_RAMPING_IN_PROGRESS"
      DATA_TYPE              = ASCII_INTEGER
      START_BYTE             = 82
      BYTES                  = 1
      UNIT                   = "N/A"
      FORMAT                 = "I1"
      DESCRIPTION            = "This bit will set if HV ramping has been performed
                                during the data taking for this EDF."
  END_OBJECT                 = COLUMN

  OBJECT                     = COLUMN
      COLUMN_NUMBER          = 12
      NAME                   = "TEST_PATTERN"
      DATA_TYPE              = ASCII_INTEGER
      START_BYTE             = 84
      BYTES                  = 2
      UNIT                   = "N/A"
      FORMAT                 = "I2"
      DESCRIPTION            = "For testing purposes a number of imager test
                                patterns can be commanded. This parameter gives
                                the actual test pattern number used. Ensure it is 0
                                for real scientific data."
  END_OBJECT                 = COLUMN

  OBJECT                     = COLUMN
      COLUMN_NUMBER          = 13
      NAME                   = "POST_ACC_LEVEL"
      DATA_TYPE              = ASCII_INTEGER
      START_BYTE             = 87
      BYTES                  = 1
      UNIT                   = "N/A"
      FORMAT                 = "I1"
      DESCRIPTION            = "This bit gives the post acceleration level used
                                for this format.
                                The field takes one of the following values:
                                0 = Low
                                1 = High"
  END_OBJECT                 = COLUMN

  OBJECT                     = COLUMN
      COLUMN_NUMBER          = 14
```

```
        NAME                = "ALTERNING_POST_ACC_SWITCH"
        DATA_TYPE           = ASCII_INTEGER
        START_BYTE          = 89
        BYTES               = 1
        UNIT                = "N/A"
        FORMAT              = "I1"
        DESCRIPTION         = "This bit indicates the post acceleration mode.
                               If set (1) it is alternating else it is fixed."
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        COLUMN_NUMBER       = 15
        NAME                = "POST_ACC_HIGH_LEVEL_REFERENCE"
        DATA_TYPE           = ASCII_REAL
        START_BYTE          = 91
        BYTES               = 3
        UNIT                = "N/A"
        FORMAT              = "F3.1"
        DESCRIPTION         = "This parameter gives the post-acceleration high
                               level reference value. It is retrieved from the
                               accompanied PAHLR.asc file in the time range where
                               applicable, if not it is set by default to 6.0.
                               The post-acceleration index can be any value
                               between 0 to 7. But calibration information exists
                               only for post-acceleration index = 0, 3, 6.
                               The calibrated values are:
                                0 :    39 Volts
                                3 :  1902 Volts
                                6 :  3615 Volts"
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        COLUMN_NUMBER       = 16
        NAME                = "AUTO_REDUC_CHANGE_SWITCH"
        DATA_TYPE           = ASCII_INTEGER
        START_BYTE          = 95
        BYTES               = 1
        UNIT                = "N/A"
        FORMAT              = "I1"
        DESCRIPTION         = "This bit indicates whether automatic data
                               reduction change is enabled or not.
                                0 = Disabled
                                1 = Enabled"
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        COLUMN_NUMBER       = 17
        NAME                = "COMPRESSION_SWITCH"
        DATA_TYPE           = ASCII_INTEGER
        START_BYTE          = 97
        BYTES               = 1
        UNIT                = "N/A"
        FORMAT              = "I1"
        DESCRIPTION         = "This bit indicates whether data compression
                               is enabled or not.
                                0 = Disabled
                                1 = Enabled"
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        COLUMN_NUMBER       = 18
        NAME                = "FIFO_FILLING"
```

```
          DATA_TYPE            = ASCII_INTEGER
          START_BYTE          = 99
          BYTES               = 3
          UNIT                = "N/A"
          FORMAT              = "I3"
          DESCRIPTION         = "This gives the approximate number of 1355 link
                                 packets in the TM FIFO. To convert to words,
                                 unpack the F8 code and multiply by 3."
       END_OBJECT             = COLUMN

       OBJECT                 = COLUMN
          COLUMN_NUMBER       = 19
          NAME                = "PROM_EEPROM_SECTION_1_16_LOADED"
          DATA_TYPE           = ASCII_INTEGER
          START_BYTE          = 103
          BYTES               = 2
          UNIT                = "N/A"
          FORMAT              = "I2"
          DESCRIPTION         = "This parameter gives the program code currently
                                 loaded and running in RAM. It is coded as:
                                 0    = PROM
                                 1-16 = EEPROM section 0-15"
       END_OBJECT             = COLUMN

       OBJECT                 = COLUMN
          COLUMN_NUMBER       = 20
          NAME                = "SAMPLE_PROCESSING_OVERRUN"
          DATA_TYPE           = ASCII_INTEGER
          START_BYTE          = 106
          BYTES               = 1
          UNIT                = "N/A"
          FORMAT              = "I1"
          DESCRIPTION         = "This bit is set if a process overruns,
                                 i.e. the current data processing is not
                                 finished when a new is requested."
       END_OBJECT             = COLUMN

       OBJECT                 = COLUMN
          COLUMN_NUMBER       = 21
          NAME                = "SWEEP_PROCESSING_OVERRUN"
          DATA_TYPE           = ASCII_INTEGER
          START_BYTE          = 108
          BYTES               = 1
          UNIT                = "N/A"
          FORMAT              = "I1"
          DESCRIPTION         = "This bit is set if a process overruns,
                                 i.e. the current data processing is not
                                 finished when a new is requested."
       END_OBJECT             = COLUMN

       OBJECT                 = COLUMN
          COLUMN_NUMBER       = 22
          NAME                = "POST_PROCESSING_OVERRUN"
          DATA_TYPE           = ASCII_INTEGER
          START_BYTE          = 110
          BYTES               = 1
          UNIT                = "N/A"
          FORMAT              = "I1"
          DESCRIPTION         = "This bit is set if a process overruns,
                                 i.e. the current data processing is not
                                 finished when a new is requested."
       END_OBJECT             = COLUMN
```

```
OBJECT                   = COLUMN
   COLUMN_NUMBER         = 23
   NAME                  = "SOLAR_WIND_ENERGY_START_INDEX"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 112
   BYTES                 = 3
   UNIT                  = "N/A"
   FORMAT                = "I3"
   DESCRIPTION           = "This parameter gives the energy start index
                             when in the 32 level energy mode."
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 24
   NAME                  = "RESET_DUE_TO_WATCHDOG_OR_MACHINE_ERROR"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 116
   BYTES                 = 1
   UNIT                  = "N/A"
   FORMAT                = "I1"
   DESCRIPTION           = "This bit will set if the experiment has
                             rebooted due to watchdog or machine error reset."
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 25
   NAME                  = "FORMAT_START_TIME_IN_UNITS_OF_31.25MS"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 118
   BYTES                 = 8
   UNIT                  = "UNITS OF 31.25MS"
   FORMAT                = "I8"
   DESCRIPTION           = "This parameter is the starting time of the EDF.
                             Note that more significant bits must be taken from
                             the ESA packet time. Some attention should be paid
                             close in time when this 3 bytes counter swaps
                             around. That happens at about once per 6 days."
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 26
   NAME                  = "FORMAT_LENGTH_IN_WORDS"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 127
   BYTES                 = 7
   UNIT                  = "N/A"
   FORMAT                = "I7"
   DESCRIPTION           = "This parameter gives the total length of
                             the format (EDF) in words."
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 27
   NAME                  = "SHADOW_MASKING_SWITCH"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 135
   BYTES                 = 1
   UNIT                  = "N/A"
   FORMAT                = "I1"
   DESCRIPTION           = "This bit indicates if imager data is masked
                             (set to zero) or not for angles that are regarded
```

```
                                        as obscured by other S/C items.
                                         0 = Disabled
                                         1 = Enabled."
        END_OBJECT               = COLUMN

        OBJECT                   = COLUMN
           COLUMN_NUMBER         = 28
           NAME                  = "BAD_HV_MASKING_SWITCH"
           DATA_TYPE             = ASCII_INTEGER
           START_BYTE            = 137
           BYTES                 = 1
           UNIT                  = "N/A"
           FORMAT                = "I1"
           DESCRIPTION           = "This bit indicates if imager data is masked
                                      (set to zero) or not for angles/energies that can
                                      not be reached due to insufficient or too
                                      inaccurate HV.
                                      0 = Disabled
                                      1 = Enabled."
        END_OBJECT               = COLUMN

        OBJECT                   = COLUMN
           COLUMN_NUMBER         = 29
           NAME                  = "ERROR"
           DATA_TYPE             = ASCII_INTEGER
           START_BYTE            = 139
           BYTES                 = 3
           UNIT                  = "N/A"
           FORMAT                = "I3"
           DESCRIPTION           = "If this parameter is not equal to 0,
                                      the data decompression process is invalid."
        END_OBJECT               = COLUMN
```

Detailed description of those parameters is provided in documents [AD 3].

4.3.3.5.2   The description of the IMA science data

The IMA sensor observes charged particles (ions) within the near-Venus space, and discriminates them by energy, angle of arrival, and mass species. Depending upon the science mode selected, data information may be reduced aboard the spacecraft by integrations in the measured parametric space azimuth×mass×energy×polar-angles. The resulting size of the data set array may therefore vary with respect to the applicable mode. To maintain the fixed-width table structure, science data arrays of a same type of sampling are grouped into a same data product, and formatted and stored as row vectors within a data table object. Each row of the storage table consists of a series of particle counts that are collected and compressed while scanning the entire parametric space of one complete cycle of measurements. The size of the table width is strictly tied to the science mode selected.

The linear storage data model is the chosen format for accommodating multi-dimensional arrays of homogeneous elements in fixed length data files with no-repeating heading columns information. The following example, as illustrated in the Figure 15, shows a 3-dimensional array with arbitrary parameters X, Y, Z. The corresponding PDS TABLE object in use for storing the reformatted data is depicted in the bottom right of this panel and written below. The algorithm transposing the 3-dimensional array into a row vector structure keeps the rightmost axis of the array sequence varying the fastest in order to satisfy compliance with the ordering used in the IDL programming language (and Fortran) for visualization of scientific data.

X
n_x items

Y
n_y items

Z
n_z items

$X_0, X_1, X_2,$
$Y_0, Y_0, Y_0,$
$Z_0 \quad Z_0 \quad Z_0$

$X_0, X_1, X_2, X_3,$
$Y_1, Y_1, Y_1, Y_1,$
$Z_0 \quad Z_0 \quad Z_0 \quad Z_0$

$X_0, X_1,$
$Y_2, Y_2,$
$Z_0 \quad Z_0$

$X_0, X_1, X_2,$
$Y_0, Y_0, Y_0,$
$Z_1 \quad Z_1 \quad Z_1$
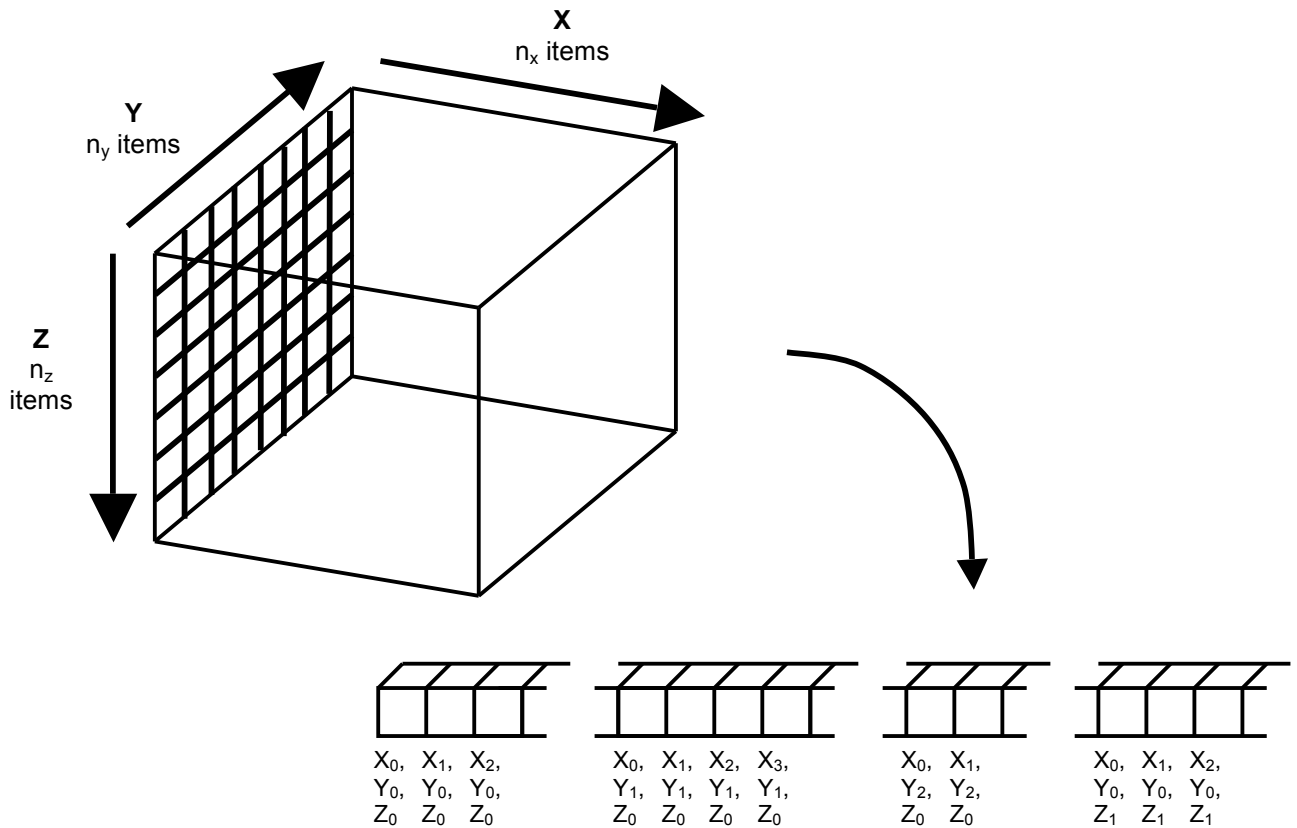
Figure 15. Conceptual view of the transpose operation between a3D geometry data storage and the PDS TABLE data object storing data in columns.

```
OBJECT                    = DATA_SCIENCE_TABLE
   NAME                   = "IMA_SPECTRUM_DATA"
   ROW_PREFIX_BYTES       = 141
   INTERCHANGE_FORMAT     = ASCII
   ROWS                   = Number of rows within the data file
   COLUMNS                = 1
   ROW_BYTES              = Number of bytes that are accounted in this table,
                             including record terminators and separators
                             nx*ny*nz*6+2

   OBJECT                 = COLUMN
      NAME                = "IMA_COUNTS"
      DATA_TYPE           = ASCII_INTEGER
      START_BYTE          = 1
      BYTES               = Number of bytes that are accounted in this table,
                             including record terminators and separators
                              nx*ny*nz*6+2
      UNIT                = "N/A"
      FORMAT              = "I5"
      DESCRIPTION         = "Particles (counts/accumulation) counted in the
                              current nX, nY, nZ sector index.
                              Within the X Y Z matrix, particle counts are
                               displayed as acquired in the corresponding mode
                               with the first index varying the fastest."
      ITEMS               = nx*ny*nz
      ITEM_BYTES          = 6
   END_OBJECT             = COLUMN
END_OBJECT                = DATA_SCIENCE_TABLE
```

4.3.3.5.2.1 The description of the IMA science data in mode MSPO:

The energy deflection is stepped through 32 levels starting at the solar wind start index. For each scan all data for the two masses protons and alpha (table look up) are integrated over the sunward facing sectors. This produces a maximum of 15 sets of 2 masses $\times$ 32 energy-levels spectra.

As many as can be fitted (on the average to stay within the TM capacity) in the current TM mode block size are transmitted. Therefore, data for all sets may not always be returned. The Number_of_sets_in_minimum_mode field value specifies the number of set in a record for the minimum modes. This number may vary between records of a same processed level-1 data file from 0 to 15, making necessary the use of separate data products for storing those data using fewer sets in a fixed width table structure. On the other hands, this makes useless the external files (FMT) referenced by include pointers since a number of different TABLE objects use different definitions.

For the IMA MSPO science data storage, it exists a total of 15 possible data products for containing block of data of each number of sets. Within each corresponding data product label file, only one science data TABLE object is defined, wherein a ROW_PREFIX_BYTES keyword value is indicating the size in bytes that are accounted in the preceding and parallel heading table, as shown in the following object description.

```
OBJECT                = DATA_SCIENCE_TABLE
   NAME               = "IMA_SPECTRUM_DATA_M02"
   ROW_PREFIX_BYTES   = 141
   INTERCHANGE_FORMAT = ASCII
   ROWS               = Number of rows within the data file
   COLUMNS            = 1
   ROW_BYTES          = 384*n_sets +2

   OBJECT             = COLUMN
      COLUMN_NUMBER   = 1
      NAME            = "IMA_COUNTS"
      DATA_TYPE       = ASCII_INTEGER
      START_BYTE      = 1
      BYTES           = 384*n_sets +2
      UNIT            = "N/A"
      FORMAT          = "I5"
      DESCRIPTION     = "Particles (counts/accumulation) counted in the
                         current mass, energy and set sector.
                         Within the mass energy set matrix,
                         particle counts are displayed as acquired
                         in the MSPO mode with the first index varying
                         the fastest."
      ITEMS           = 64*n_sets
      ITEM_BYTES      = 6
   END_OBJECT         = COLUMN

END_OBJECT            = DATA_SCIENCE_TABLE
```

4.3.3.5.2.2 The description of the IMA science data in mode MSIS:

The energy deflection is stepped through all 96 levels for each of the 16 entrance steps. For each scan all data for 6 selected ion species (table look up) are integrated over all angles (azimuth and polar). This produces a maximum of 5 sets of 6 masses $\times$ 96 energy-levels spectra.

As many as can be fitted (on the average to stay within the TM capacity) in the current TM mode block size are transmitted. Therefore, data for all sets may not always be returned. The Number_of_sets_in_minimum_mode field value specifies the number of set in a record for the minimum modes. This number may vary between records of a same processed level-1 data file from 0 to 5, making necessary the use of separate data products for storing those data using fewer sets in a fixed width table structure. On the other hands, this makes useless the external files (FMT) referenced by include pointers since a number of different TABLE objects use different definitions.

For the IMA MSIS science data storage, it exists a total of 5 possible data products for containing block of data of each number of sets. Within each corresponding data product label file, only one science data TABLE object is defined, wherein a ROW_PREFIX_BYTES keyword value is indicating the size in bytes that are accounted in the preceding and parallel heading table, as shown in the following object description.

```
OBJECT                 = DATA_SCIENCE_TABLE
   NAME                = "IMA_SPECTRUM_DATA_M04"
   ROW_PREFIX_BYTES    = 141
   INTERCHANGE_FORMAT  = ASCII
   ROWS                = Number of rows within the data file
   COLUMNS             = 1
   ROW_BYTES           = 3456*n_sets +2

   OBJECT              = COLUMN
      COLUMN_NUMBER    = 1
      NAME             = "IMA_COUNTS"
      DATA_TYPE        = ASCII_INTEGER
      START_BYTE       = 1
      BYTES            = 3456*n_sets +2
      UNIT             = "N/A"
      FORMAT           = "I5"
      DESCRIPTION      = "Particles (counts/accumulation) counted in the
                          current mass, energy and set sector.
                          Within the mass energy set matrix,
                          particle counts are displayed as acquired
                          in the MSIS mode with the first index varying
                          the fastest."
      ITEMS            = 576*n_sets
      ITEM_BYTES       = 6
   END_OBJECT          = COLUMN

END_OBJECT             = DATA_SCIENCE_TABLE
```

4.3.3.5.2.3 The description of the IMA science data in mode MEXM:

The energy deflection is stepped through all 96 levels for each of the 16 entrance steps. For each scan all data for 32 mass bins are integrated over all angles (azimuth and polar). This produces a maximum of 5 sets of 32 mass-bins × 96 energy-levels spectra.

As many as can be fitted (on the average to stay within the TM capacity) in the current TM mode block size are transmitted. Therefore, data for all sets may not always be returned. The Number_of_sets_in_minimum_mode field value specifies the number of set in a record for the minimum modes. This number may vary between records of a same processed level-1 data file from 0 to 5, making necessary the use of separate data products for storing those data using fewer sets in a fixed width table structure. On the other hands, this makes useless the external files (FMT) referenced by include pointers since a number of different TABLE objects use different definitions.

For the IMA MEXM science data storage, it exists a total of 5 possible data products for containing block of data of each number of sets. Within each corresponding data product label file, only one science data TABLE object is defined, wherein a ROW_PREFIX_BYTES keyword value is indicating the size in bytes that are accounted in the preceding and parallel heading table, as shown in the following object description.

```
OBJECT                 = DATA_SCIENCE_TABLE
   NAME                = "IMA_SPECTRUM_DATA_M05"
   ROW_PREFIX_BYTES    = 141
   INTERCHANGE_FORMAT  = ASCII
   ROWS                = Number of rows within the data file
   COLUMNS             = 1
   ROW_BYTES           = 18432*n_sets +2

   OBJECT              = COLUMN
```

```
        COLUMN_NUMBER       = 1
        NAME                = "IMA_COUNTS"
        DATA_TYPE           = ASCII_INTEGER
        START_BYTE          = 1
        BYTES               = 18432*n_sets +2
        UNIT                = "N/A"
        FORMAT              = "I5"
        DESCRIPTION         = "Particles (counts/accumulation) counted in the
                               current mass, energy and set sector.
                               Within the mass energy set matrix,
                               particle counts are displayed as acquired
                               in the MEXM mode with the first index varying
                               the fastest."
        ITEMS               = 3072*n_sets
        ITEM_BYTES          = 6
    END_OBJECT              = COLUMN

  END_OBJECT               = DATA_SCIENCE_TABLE
```

4.3.3.5.2.4 The description of the IMA science data in mode NRM0:

The energy deflection is stepped through all 96 steps for each of the 16 entrance steps. In normal mode (group), science data are always delivered as row vectors and stored in the azimuth×mass×energy×polar-angle columns of the data TABLE object, wherein azimuth being the fastest varying index.

```
    OBJECT                  = DATA_SCIENCE_TABLE
        NAME                = "IMA_SPECTRUM_DATA_M08"
        ROW_PREFIX_BYTES    = 141
        INTERCHANGE_FORMAT  = ASCII
        ROWS                = Number of rows within the data file
        COLUMNS             = 1
        ROW_BYTES           = 884738

        OBJECT              = COLUMN
            COLUMN_NUMBER   = 1
            NAME            = "IMA_COUNTS"
            DATA_TYPE       = ASCII_INTEGER
            START_BYTE      = 1
            BYTES           = 884738
            UNIT            = "N/A"
            FORMAT          = "I5"
            DESCRIPTION     = "Particles (counts/accumulation) counted in the
                               current azimuth, mass, energy and polar angle
                               sector.
                               Within the azimuth mass energy polar-angle matrix,
                               particle counts are displayed as acquired
                               in the NRM0 mode with the first index varying
                               the fastest."
            ITEMS           = 147456
            ITEM_BYTES      = 6
        END_OBJECT          = COLUMN
    END_OBJECT              = DATA_SCIENCE_TABLE
```

4.3.3.5.2.5 The description of the IMA science data in mode NRM1:

```
    OBJECT                  = DATA_SCIENCE_TABLE
        NAME                = "IMA_SPECTRUM_DATA_M09"
        ROW_PREFIX_BYTES    = 141
        INTERCHANGE_FORMAT  = ASCII
        ROWS                = Number of rows within the data file
        COLUMNS             = 1
```

```
     ROW_BYTES            = 442370

     OBJECT               = COLUMN
        COLUMN_NUMBER     = 1
        NAME              = "IMA_COUNTS"
        DATA_TYPE         = ASCII_INTEGER
        START_BYTE        = 1
        BYTES             = 442370
        UNIT              = "N/A"
        FORMAT            = "I5"
        DESCRIPTION       = "Particles (counts/accumulation) counted in the
                             current azimuth, mass, energy and polar angle
                             sector.
                             Within the azimuth mass energy polar-angle matrix,
                             particle counts are displayed as acquired
                             in the NRM1 mode with the first index varying
                             the fastest."
        ITEMS             = 73728
        ITEM_BYTES        = 6
     END_OBJECT           = COLUMN

 END_OBJECT               = DATA_SCIENCE_TABLE
```

4.3.3.5.2.6 The description of the IMA science data in mode NRM2:

```
     OBJECT               = DATA_SCIENCE_TABLE
        NAME              = "IMA_SPECTRUM_DATA_M10"
        ROW_PREFIX_BYTES  = 141
        INTERCHANGE_FORMAT = ASCII
        ROWS              = Number of rows within the data file
        COLUMNS           = 1
        ROW_BYTES         = 221186

        OBJECT            = COLUMN
           COLUMN_NUMBER  = 1
           NAME           = "IMA_COUNTS"
           DATA_TYPE      = ASCII_INTEGER
           START_BYTE     = 1
           BYTES          = 221186
           UNIT           = "N/A"
           FORMAT         = "I5"
           DESCRIPTION    = "Particles (counts/accumulation) counted in the
                             current azimuth, mass, energy and polar angle
                             sector.
                             Within the azimuth mass energy polar-angle matrix,
                             particle counts are displayed as acquired
                             in the NRM2 mode with the first index varying
                             the fastest."
           ITEMS          = 36864
           ITEM_BYTES     = 6
        END_OBJECT        = COLUMN

 END_OBJECT               = DATA_SCIENCE_TABLE
```

4.3.3.5.2.7 The description of the IMA science data in mode NRM3:

```
     OBJECT               = DATA_SCIENCE_TABLE
        NAME              = "IMA_SPECTRUM_DATA_M11"
        ROW_PREFIX_BYTES  = 141
        INTERCHANGE_FORMAT = ASCII
```

```
     ROWS                     = Number of rows within the data file
     COLUMNS                  = 1
     ROW_BYTES                = 110594

     OBJECT                   = COLUMN
        COLUMN_NUMBER         = 1
        NAME                  = "IMA_COUNTS"
        DATA_TYPE             = ASCII_INTEGER
        START_BYTE            = 1
        BYTES                 = 110594
        UNIT                  = "N/A"
        FORMAT                = "I5"
        DESCRIPTION           = "Particles (counts/accumulation) counted in the
                                 current azimuth, mass, energy and polar angle
                                 sector.
                                 Within the azimuth mass energy polar-angle matrix,
                                 particle counts are displayed as acquired
                                 in the NRM3 mode with the first index varying
                                 the fastest."
        ITEMS                 = 18432
        ITEM_BYTES            = 6
     END_OBJECT               = COLUMN

END_OBJECT               = DATA_SCIENCE_TABLE
```

4.3.3.5.2.8 The description of the IMA science data in mode NRM4:

```
     OBJECT                   = DATA_SCIENCE_TABLE
        NAME                  = "IMA_SPECTRUM_DATA_M12"
        ROW_PREFIX_BYTES      = 141
        INTERCHANGE_FORMAT    = ASCII
        ROWS                  = Number of rows within the data file
        COLUMNS               = 1
        ROW_BYTES             = 55298

        OBJECT                = COLUMN
           COLUMN_NUMBER      = 1
           NAME               = "IMA_COUNTS"
           DATA_TYPE          = ASCII_INTEGER
           START_BYTE         = 1
           BYTES              = 55298
           UNIT               = "N/A"
           FORMAT             = "I5"
           DESCRIPTION        = "Particles (counts/accumulation) counted in the
                                 current azimuth, mass, energy and polar angle
                                 sector.
                                 Within the azimuth mass energy polar-angle matrix,
                                 particle counts are displayed as acquired
                                 in the NRM4 mode with the first index varying
                                 the fastest."
           ITEMS              = 9216
           ITEM_BYTES         = 6
        END_OBJECT            = COLUMN

END_OBJECT               = DATA_SCIENCE_TABLE
```

4.3.3.5.2.9 The description of the IMA science data in mode NRM5:

```
     OBJECT                   = DATA_SCIENCE_TABLE
        NAME                  = "IMA_SPECTRUM_DATA_M13"
```

```
    ROW_PREFIX_BYTES     = 141
    INTERCHANGE_FORMAT   = ASCII
    ROWS                 = Number of rows within the data file
    COLUMNS              = 1
    ROW_BYTES            = 27650

    OBJECT               = COLUMN
        COLUMN_NUMBER    = 1
        NAME             = "IMA_COUNTS"
        DATA_TYPE        = ASCII_INTEGER
        START_BYTE       = 1
        BYTES            = 27650
        UNIT             = "N/A"
        FORMAT           = "I5"
        DESCRIPTION      = "Particles (counts/accumulation) counted in the
                            current azimuth, mass, energy and polar angle
                            sector.
                            Within the azimuth mass energy polar-angle matrix,
                            particle counts are displayed as acquired
                            in the NRM5 mode with the first index varying
                            the fastest."
        ITEMS            = 4608
        ITEM_BYTES       = 6
    END_OBJECT           = COLUMN

END_OBJECT               = DATA_SCIENCE_TABLE
```

4.3.3.5.2.10 The description of the IMA science data in mode NRM6:

```
    OBJECT               = DATA_SCIENCE_TABLE
        NAME             = "IMA_SPECTRUM_DATA_M14"
        ROW_PREFIX_BYTES = 141
        INTERCHANGE_FORMAT = ASCII
        ROWS             = Number of rows within the data file
        COLUMNS          = 1
        ROW_BYTES        = 13826

        OBJECT           = COLUMN
            COLUMN_NUMBER = 1
            NAME         = "IMA_COUNTS"
            DATA_TYPE    = ASCII_INTEGER
            START_BYTE   = 1
            BYTES        = 13826
            UNIT         = "N/A"
            FORMAT       = "I5"
            DESCRIPTION  = "Particles (counts/accumulation) counted in the
                            current azimuth, mass, energy and polar angle
                            sector.
                            Within the azimuth mass energy polar-angle matrix,
                            particle counts are displayed as acquired
                            in the NRM6 mode with the first index varying
                            the fastest."
            ITEMS        = 2304
            ITEM_BYTES   = 6
        END_OBJECT       = COLUMN

END_OBJECT               = DATA_SCIENCE_TABLE
```

4.3.3.5.2.11 The description of the IMA science data in mode NRM7:

```
OBJECT                  = DATA_SCIENCE_TABLE
   NAME                 = "IMA_SPECTRUM_DATA_M15"
   ROW_PREFIX_BYTES     = 141
   INTERCHANGE_FORMAT   = ASCII
   ROWS                 = Number of rows within the data file
   COLUMNS              = 1
   ROW_BYTES            = 6914

   OBJECT               = COLUMN
      COLUMN_NUMBER     = 1
      NAME              = "IMA_COUNTS"
      DATA_TYPE         = ASCII_INTEGER
      START_BYTE        = 1
      BYTES             = 6914
      UNIT              = "N/A"
      FORMAT            = "I5"
      DESCRIPTION       = "Particles (counts/accumulation) counted in the
                           current azimuth, mass and energy sector.
                           Within the azimuth mass energy matrix,
                           particle counts are displayed as acquired
                           in the NRM7 mode with the first index varying
                           the fastest."
      ITEMS             = 1152
      ITEM_BYTES        = 6
   END_OBJECT           = COLUMN

END_OBJECT              = DATA_SCIENCE_TABLE
```

4.3.3.5.2.12   *The description of the IMA science data in mode HAR0:*

The energy deflection is stepped through all 96 steps for each of the 16 entrance steps. In burst high angular resolution mode (group), science data are always delivered as row vectors and stored in the azimuth×mass×energy×polar-angle columns of the data TABLE object, wherein azimuth being the fastest varying index.

```
OBJECT                  = DATA_SCIENCE_TABLE
   NAME                 = "IMA_SPECTRUM_DATA_M16"
   ROW_PREFIX_BYTES     = 141
   INTERCHANGE_FORMAT   = ASCII
   ROWS                 = Number of rows within the data file
   COLUMNS              = 1
   ROW_BYTES            = 2359298

   OBJECT               = COLUMN
      COLUMN_NUMBER     = 1
      NAME              = "IMA_COUNTS"
      DATA_TYPE         = ASCII_INTEGER
      START_BYTE        = 1
      BYTES             = 2359298
      UNIT              = "N/A"
      FORMAT            = "I5"
      DESCRIPTION       = "Particles (counts/accumulation) counted in the
                           current azimuth, mass, energy and polar angle
                           sector.
                           Within the azimuth mass energy polar-angle matrix,
                           particle counts are displayed as acquired
                           in the HAR0 mode with the first index varying
                           the fastest."
      ITEMS             = 393216
      ITEM_BYTES        = 6
   END_OBJECT           = COLUMN
```

```
END_OBJECT              = DATA_SCIENCE_TABLE
```

4.3.3.5.2.13   The description of the IMA science data in mode HAR1:

```
OBJECT                 = DATA_SCIENCE_TABLE
    NAME               = "IMA_SPECTRUM_DATA_M17"
    ROW_PREFIX_BYTES   = 141
    INTERCHANGE_FORMAT = ASCII
    ROWS               = Number of rows within the data file
    COLUMNS            = 1
    ROW_BYTES          = 1179650

    OBJECT             = COLUMN
        COLUMN_NUMBER  = 1
        NAME           = "IMA_COUNTS"
        DATA_TYPE      = ASCII_INTEGER
        START_BYTE     = 1
        BYTES          = 1179650
        UNIT           = "N/A"
        FORMAT         = "I5"
        DESCRIPTION    = "Particles (counts/accumulation) counted in the
                          current azimuth, mass, energy and polar angle
                          sector.
                          Within the azimuth mass energy polar-angle matrix,
                          particle counts are displayed as acquired
                          in the HAR1 mode with the first index varying
                          the fastest."
        ITEMS          = 196608
        ITEM_BYTES     = 6
    END_OBJECT         = COLUMN

END_OBJECT             = DATA_SCIENCE_TABLE
```

4.3.3.5.2.14   The description of the IMA science data in mode HAR2:

```
OBJECT                 = DATA_SCIENCE_TABLE
    NAME               = "IMA_SPECTRUM_DATA_M18"
    ROW_PREFIX_BYTES   = 141
    INTERCHANGE_FORMAT = ASCII
    ROWS               = Number of rows within the data file
    COLUMNS            = 1
    ROW_BYTES          = 589826

    OBJECT             = COLUMN
        COLUMN_NUMBER  = 1
        NAME           = "IMA_COUNTS"
        DATA_TYPE      = ASCII_INTEGER
        START_BYTE     = 1
        BYTES          = 589826
        UNIT           = "N/A"
        FORMAT         = "I5"
        DESCRIPTION    = "Particles (counts/accumulation) counted in the
                          current azimuth, mass, energy and polar angle
                          sector.
                          Within the azimuth mass energy polar-angle matrix,
                          particle counts are displayed as acquired
                          in the HAR2 mode with the first index varying
                          the fastest."
        ITEMS          = 98304
        ITEM_BYTES     = 6
```

```
    END_OBJECT              = COLUMN

END_OBJECT                  = DATA_SCIENCE_TABLE
```

4.3.3.5.2.15 The description of the IMA science data in mode HAR3:

```
    OBJECT                  = DATA_SCIENCE_TABLE
       NAME                 = "IMA_SPECTRUM_DATA_M19"
       ROW_PREFIX_BYTES     = 141
       INTERCHANGE_FORMAT   = ASCII
       ROWS                 = Number of rows within the data file
       COLUMNS              = 1
       ROW_BYTES            = 294914

       OBJECT               = COLUMN
          COLUMN_NUMBER     = 1
          NAME              = "IMA_COUNTS"
          DATA_TYPE         = ASCII_INTEGER
          START_BYTE        = 1
          BYTES             = 294914
          UNIT              = "N/A"
          FORMAT            = "I5"
          DESCRIPTION       = "Particles (counts/accumulation) counted in the
                               current azimuth, mass, energy and polar angle
                               sector.
                               Within the azimuth mass energy polar-angle matrix,
                               particle counts are displayed as acquired
                               in the HAR3 mode with the first index varying
                               the fastest."
          ITEMS             = 49152
          ITEM_BYTES        = 6
       END_OBJECT           = COLUMN

END_OBJECT                  = DATA_SCIENCE_TABLE
```

4.3.3.5.2.16 The description of the IMA science data in mode HAR4:

```
    OBJECT                  = DATA_SCIENCE_TABLE
       NAME                 = "IMA_SPECTRUM_DATA_M20"
       ROW_PREFIX_BYTES     = 141
       INTERCHANGE_FORMAT   = ASCII
       ROWS                 = Number of rows within the data file
       COLUMNS              = 1
       ROW_BYTES            = 147458

       OBJECT               = COLUMN
          COLUMN_NUMBER     = 1
          NAME              = "IMA_COUNTS"
          DATA_TYPE         = ASCII_INTEGER
          START_BYTE        = 1
          BYTES             = 147458
          UNIT              = "N/A"
          FORMAT            = "I5"
          DESCRIPTION       = "Particles (counts/accumulation) counted in the
                               current azimuth, mass, energy and polar angle
                               sector.
                               Within the azimuth mass energy polar-angle matrix,
                               particle counts are displayed as acquired
                               in the HAR4 mode with the first index varying
                               the fastest."
          ITEMS             = 24576
```

```
        ITEM_BYTES        = 6
      END_OBJECT          = COLUMN

END_OBJECT                = DATA_SCIENCE_TABLE
```

4.3.3.5.2.17 The description of the IMA science data in mode HAR5:

```
    OBJECT                = DATA_SCIENCE_TABLE
      NAME                = "IMA_SPECTRUM_DATA_M21"
      ROW_PREFIX_BYTES    = 141
      INTERCHANGE_FORMAT  = ASCII
      ROWS                = Number of rows within the data file
      COLUMNS             = 1
      ROW_BYTES           = 73730

      OBJECT              = COLUMN
        COLUMN_NUMBER     = 1
        NAME              = "IMA_COUNTS"
        DATA_TYPE         = ASCII_INTEGER
        START_BYTE        = 1
        BYTES             = 73730
        UNIT              = "N/A"
        FORMAT            = "I5"
        DESCRIPTION       = "Particles (counts/accumulation) counted in the
                            current azimuth, mass, energy and polar angle
                            sector.
                            Within the azimuth mass energy polar-angle matrix,
                            particle counts are displayed as acquired
                            in the HAR5 mode with the first index varying
                            the fastest."
        ITEMS             = 12288
        ITEM_BYTES        = 6
      END_OBJECT          = COLUMN

END_OBJECT                = DATA_SCIENCE_TABLE
```

4.3.3.5.2.18 The description of the IMA science data in mode HAR6:

```
    OBJECT                = DATA_SCIENCE_TABLE
      NAME                = "IMA_SPECTRUM_DATA_M22"
      ROW_PREFIX_BYTES    = 141
      INTERCHANGE_FORMAT  = ASCII
      ROWS                = Number of rows within the data file
      COLUMNS             = 1
      ROW_BYTES           = 36866

      OBJECT              = COLUMN
        COLUMN_NUMBER     = 1
        NAME              = "IMA_COUNTS"
        DATA_TYPE         = ASCII_INTEGER
        START_BYTE        = 1
        BYTES             = 36866
        UNIT              = "N/A"
        FORMAT            = "I5"
        DESCRIPTION       = "Particles (counts/accumulation) counted in the
                            current azimuth, mass, energy and polar angle
                            sector.
                            Within the azimuth mass energy polar-angle matrix,
                            particle counts are displayed as acquired
                            in the HAR6 mode with the first index varying
                            the fastest."
```

```
        ITEMS              = 6144
        ITEM_BYTES         = 6
    END_OBJECT             = COLUMN

END_OBJECT                 = DATA_SCIENCE_TABLE
```

4.3.3.5.2.19   The description of the IMA science data in mode HAR7:

```
    OBJECT                 = DATA_SCIENCE_TABLE
        NAME               = "IMA_SPECTRUM_DATA_M23"
        ROW_PREFIX_BYTES   = 141
        INTERCHANGE_FORMAT = ASCII
        ROWS               = Number of rows within the data file
        COLUMNS            = 1
        ROW_BYTES          = 18434

        OBJECT             = COLUMN
            COLUMN_NUMBER  = 1
            NAME           = "IMA_COUNTS"
            DATA_TYPE      = ASCII_INTEGER
            START_BYTE     = 1
            BYTES          = 18434
            UNIT           = "N/A"
            FORMAT         = "I5"
            DESCRIPTION    = "Particles (counts/accumulation) counted in the
                               current azimuth, mass, energy and polar angle
                               sector.
                               Within the azimuth mass energy polar-angle matrix,
                               particle counts are displayed as acquired
                               in the HAR7 mode with the first index varying
                               the fastest."
            ITEMS          = 3072
            ITEM_BYTES     = 6
        END_OBJECT         = COLUMN
    END_OBJECT             = DATA_SCIENCE_TABLE
```

4.3.3.5.2.20   The description of the IMA science data in mode EXM0:

The energy deflection is stepped through all 96 steps for each of the 16 entrance steps. In normal mode (group), science data are always delivered as row vectors and stored in the azimuth×mass×energy×polar-angle columns of the data TABLE object, wherein azimuth being the fastest varying index.

The energy deflection is stepped through all 96 steps for each of the 16 entrance steps. In burst energy-mass matrix mode (group), science data are always delivered as row vectors and stored in the azimuth×mass×energy×polar-angle columns of the data TABLE object, wherein azimuth being the fastest varying index.

```
    OBJECT                 = DATA_SCIENCE_TABLE
        NAME               = "IMA_SPECTRUM_DATA_M24"
        ROW_PREFIX_BYTES   = 141
        INTERCHANGE_FORMAT = ASCII
        ROWS               = Number of rows within the data file
        COLUMNS            = 1
        ROW_BYTES          = 4718594

        OBJECT             = COLUMN
            COLUMN_NUMBER  = 1
            NAME           = "IMA_COUNTS"
            DATA_TYPE      = ASCII_INTEGER
```

```
        START_BYTE          = 1
        BYTES               = 4718594
        UNIT                = "N/A"
        FORMAT              = "I5"
        DESCRIPTION         = "Particles (counts/accumulation) counted in the
                               current azimuth, mass, energy and polar angle
                               sector.
                               Within the azimuth mass energy polar-angle matrix,
                               particle counts are displayed as acquired
                               in the EXM0 mode with the first index varying
                               the fastest."
        ITEMS               = 786432
        ITEM_BYTES          = 6
    END_OBJECT              = COLUMN

END_OBJECT                 = DATA_SCIENCE_TABLE
```

4.3.3.5.2.21   The description of the IMA science data in mode EXM1:

```
    OBJECT                 = DATA_SCIENCE_TABLE
        NAME                = "IMA_SPECTRUM_DATA_M25"
        ROW_PREFIX_BYTES    = 141
        INTERCHANGE_FORMAT  = ASCII
        ROWS                = Number of rows within the data file
        COLUMNS             = 1
        ROW_BYTES           = 2359298

        OBJECT             = COLUMN
            COLUMN_NUMBER   = 1
            NAME            = "IMA_COUNTS"
            DATA_TYPE       = ASCII_INTEGER
            START_BYTE      = 1
            BYTES           = 2359298
            UNIT            = "N/A"
            FORMAT          = "I5"
            DESCRIPTION     = "Particles (counts/accumulation) counted in the
                               current azimuth, mass, energy and polar angle
                               sector.
                               Within the azimuth mass energy polar-angle matrix,
                               particle counts are displayed as acquired
                               in the EXM1 mode with the first index varying
                               the fastest."
            ITEMS           = 393216
            ITEM_BYTES      = 6
        END_OBJECT         = COLUMN

END_OBJECT                 = DATA_SCIENCE_TABLE
```

4.3.3.5.2.22   The description of the IMA science data in mode EXM2:

```
    OBJECT                 = DATA_SCIENCE_TABLE
        NAME                = "IMA_SPECTRUM_DATA_M26"
        ROW_PREFIX_BYTES    = 141
        INTERCHANGE_FORMAT  = ASCII
        ROWS                = Number of rows within the data file
        COLUMNS             = 1
        ROW_BYTES           = 1179650

        OBJECT             = COLUMN
            COLUMN_NUMBER   = 1
```

```
            NAME                = "IMA_COUNTS"
            DATA_TYPE           = ASCII_INTEGER
            START_BYTE          = 1
            BYTES               = 1179650
            UNIT                = "N/A"
            FORMAT              = "I5"
            DESCRIPTION         = "Particles (counts/accumulation) counted in the
                                   current azimuth, mass, energy and polar angle
                                   sector.
                                   Within the azimuth mass energy polar-angle matrix,
                                   particle counts are displayed as acquired
                                   in the EXM2 mode with the first index varying
                                   the fastest."
            ITEMS               = 196608
            ITEM_BYTES          = 6
        END_OBJECT              = COLUMN

END_OBJECT                  = DATA_SCIENCE_TABLE
```

4.3.3.5.2.23   The description of the IMA science data in mode EXM3:

```
    OBJECT                  = DATA_SCIENCE_TABLE
        NAME                = "IMA_SPECTRUM_DATA_M27"
        ROW_PREFIX_BYTES    = 141
        INTERCHANGE_FORMAT  = ASCII
        ROWS                = Number of rows within the data file
        COLUMNS             = 1
        ROW_BYTES           = 589826

        OBJECT              = COLUMN
            COLUMN_NUMBER   = 1
            NAME            = "IMA_COUNTS"
            DATA_TYPE       = ASCII_INTEGER
            START_BYTE      = 1
            BYTES           = 589826
            UNIT            = "N/A"
            FORMAT          = "I5"
            DESCRIPTION     = "Particles (counts/accumulation) counted in the
                               current azimuth, mass, energy and polar angle
                               sector.
                               Within the azimuth mass energy polar-angle matrix,
                               particle counts are displayed as acquired
                               in the EXM3 mode with the first index varying
                               the fastest."
            ITEMS           = 98304
            ITEM_BYTES      = 6
        END_OBJECT          = COLUMN

    END_OBJECT              = DATA_SCIENCE_TABLE
```

4.3.3.5.2.24   The description of the IMA science data in mode EXM4:

```
    OBJECT                  = DATA_SCIENCE_TABLE
        NAME                = "IMA_SPECTRUM_DATA_M28"
        ROW_PREFIX_BYTES    = 141
        INTERCHANGE_FORMAT  = ASCII
        ROWS                = Number of rows within the data file
        COLUMNS             = 1
        ROW_BYTES           = 294914

        OBJECT              = COLUMN
            COLUMN_NUMBER   = 1
```

```
            NAME                 = "IMA_COUNTS"
            DATA_TYPE            = ASCII_INTEGER
            START_BYTE           = 1
            BYTES                = 294914
            UNIT                 = "N/A"
            FORMAT               = "I5"
            DESCRIPTION          = "Particles (counts/accumulation) counted in the
                                    current azimuth, mass, energy and polar angle
                                    sector.
                                    Within the azimuth mass energy polar-angle matrix,
                                    particle counts are displayed as acquired
                                    in the EXM4 mode with the first index varying
                                    the fastest."
            ITEMS                = 49152
            ITEM_BYTES           = 6
        END_OBJECT               = COLUMN

END_OBJECT                   = DATA_SCIENCE_TABLE
```

4.3.3.5.2.25   The description of the IMA science data in mode EXM5:

```
    OBJECT                   = DATA_SCIENCE_TABLE
        NAME                 = "IMA_SPECTRUM_DATA_M29"
        ROW_PREFIX_BYTES     = 141
        INTERCHANGE_FORMAT   = ASCII
        ROWS                 = Number of rows within the data file
        COLUMNS              = 1
        ROW_BYTES            = 147458

        OBJECT               = COLUMN
            COLUMN_NUMBER    = 1
            NAME             = "IMA_COUNTS"
            DATA_TYPE        = ASCII_INTEGER
            START_BYTE       = 1
            BYTES            = 147458
            UNIT             = "N/A"
            FORMAT           = "I5"
            DESCRIPTION      = "Particles (counts/accumulation) counted in the
                                current azimuth, mass, energy and polar angle
                                sector.
                                Within the azimuth mass energy polar-angle matrix,
                                particle counts are displayed as acquired
                                in the EXM5 mode with the first index varying
                                the fastest."
            ITEMS            = 24576
            ITEM_BYTES       = 6
        END_OBJECT           = COLUMN

END_OBJECT                   = DATA_SCIENCE_TABLE
```

4.3.3.5.2.26   The description of the IMA science data in mode EXM6:

```
    OBJECT                   = DATA_SCIENCE_TABLE
        NAME                 = "IMA_SPECTRUM_DATA_M30"
        ROW_PREFIX_BYTES     = 141
        INTERCHANGE_FORMAT   = ASCII
        ROWS                 = Number of rows within the data file
        COLUMNS              = 1
        ROW_BYTES            = 73730
```

```
OBJECT                 = COLUMN
   COLUMN_NUMBER       = 1
   NAME                = "IMA_COUNTS"
   DATA_TYPE           = ASCII_INTEGER
   START_BYTE          = 1
   BYTES               = 73730
   UNIT                = "N/A"
   FORMAT              = "I5"
   DESCRIPTION         = "Particles (counts/accumulation) counted in the
                          current azimuth, mass, energy and polar angle
                          sector.
                          Within the azimuth mass energy polar-angle matrix,
                          particle counts are displayed as acquired
                          in the EXM6 mode with the first index varying
                          the fastest."
   ITEMS               = 12288
   ITEM_BYTES          = 6
END_OBJECT             = COLUMN

END_OBJECT             = DATA_SCIENCE_TABLE
```

4.3.3.5.2.27   The description of the IMA science data in mode EXM7:

```
OBJECT                 = DATA_SCIENCE_TABLE
   NAME                = "IMA_SPECTRUM_DATA_M31"
   ROW_PREFIX_BYTES    = 141
   INTERCHANGE_FORMAT  = ASCII
   ROWS                = Number of rows within the data file
   COLUMNS             = 1
   ROW_BYTES           = 36866

   OBJECT              = COLUMN
      COLUMN_NUMBER    = 1
      NAME             = "IMA_COUNTS"
      DATA_TYPE        = ASCII_INTEGER
      START_BYTE       = 1
      BYTES            = 36866
      UNIT             = "N/A"
      FORMAT           = "I5"
      DESCRIPTION      = "Particles (counts/accumulation) counted in the
                          current azimuth, mass and energy sector.
                          Within the azimuth mass energy matrix,
                          particle counts are displayed as acquired
                          in the EXM7 mode with the first index varying
                          the fastest."
      ITEMS            = 6144
      ITEM_BYTES       = 6
   END_OBJECT          = COLUMN

END_OBJECT             = DATA_SCIENCE_TABLE
```

4.3.3.6 Description of Instrument

The description of the instrument is done in above and as a brief overview in the INST.CAT catalog file.

4.3.3.7 Parameters Index File Definition

N/A

4.3.3.8   Mission Specific Keywords

Mission specific keywords should all have the MISSION_ID "VEX" prefix.

```
VEX:SCIENCE_CASE_ID        = "ALL"
VEX:SCIENCE_CASE_ID_DESC   = "Please refer to VEX_SCIENCE_CASE_ID_DESC.TXT
                              in the DOCUMENT directory."
```

4.3.4   IMA Housekeeping Calibrated Data Product Design (Level 3)

Typically 2 types of HK data are provided in TM packets during the nominal mission. A number of HK data are generated onboard by the main unit and are common to all sensors. Another series of HK are monitored and provided by the processor unit located nearby the IMA sensor. These information describe the current operating state of the IMA experience. It is used to determine, among other things, IMA voltages, currents, temperatures and so on. Therefore, it may exist 2 HK data product files, one for each processor from which they derive. IMA level 3 HK contains calibrated IMA housekeeping data with PDS detached labels. The incoming raw HK values are converted into physical values when calibration is applied. This type of data is identified by the following data descriptors within the current label file:

```
PRODUCT_TYPE               = RDR /* EDR for RAW, RDR for calibrated data */
PROCESSING_LEVEL_ID        = 3
```

HK parameters are listed in the following fields table in the same order that they appear in the data product files.

Table 28. IMA housekeeping contents.

Rank	Field	Rank	Field
Main Unit Housekeeping			
1	UTC correlated Time	10	HK V -5V
2	OBT Time	11	Sun sensor 1
3	SW version	12	Sun sensor 2
4	HK i +30V	13	IMA +/- 5V on/off
5	HK i +5V	14	IMA +30V on/off
6	HK V +12V	15	IMA +/- 12V on/off
7	HK V +30V	16	SW mode
8	HK V +5V	17	Cpu load
9	HK V –12V	18	IMA link status
IMA Housekeeping			
1	UTC correlated Time	19	Grid LV monitor
2	OBT Time	20	Sensor unit temperature
3	Last command status	21	DPU temperature
4	Current data reduction mode	22	Energy deflection HV reference
5	HV switch status	23	Post acceleration low level reference
6	+28V MCP HV present	24	Direct command switch
7	+28V Opto HV present	25	Energy deflect LV reference
8	+28V main HV present	26	Post acceleration high level reference
9	Post acceleration mode	27	TM FIFO overflow
10	Current SID number	28	Entrance HV reference
11	New command received toggle bit	29	Grid LV reference
12	FIFO filling in terms of internal packets in F8	30	Post acceleration level
13	First word command return	31	Entrance upper HV monitor
14	Opto HV monitor	32	MCP HV default reference
15	MCP HV monitor	33	Opto HV default reference
16	Energy deflection HV monitor	34	Entrance lower HV monitor
17	Energy deflection LV monitor	35	MCP HV current reference
18	Post acceleration HV monitor	36	Opto HV current reference

The table objects are detailed in the following paragraph.

4.3.4.1   File Characteristics Data Elements

The following elements are present in the labels for every IMA housekeeping calibrated data product, and they describe the basic characteristics of the data product in terms of structure and naming:

```
/* FILE CHARACTERISTIC DATA ELEMENTS */
PRODUCT_ID                  = this element defines the current product file name,
                              without extension
RECORD_TYPE                 = FIXED_LENGTH
RECORD_BYTES                = this element indicates the number of bytes in a data
                              record, including record terminators and separators
                              Field could take one of the following value:
                                  185 for HK3IMAX data type
                                  121 for HK3MUXX data type
FILE_RECORDS                = this element indicates the number of records within
                              the data file
```

4.3.4.2   Data Object Pointers Identification Data Elements

The IMA housekeeping calibrated data are organized as ASCII table. The data object pointers that reference TAB files are:

```
^HK_MU_TABLE
^HK_IMA_TABLE
```

4.3.4.3   Instrument and Detector Descriptive Data Elements

See the applicable section 4.3.3.3

4.3.4.4   Structure Definition of Instrument Parameter Objects

N/A

4.3.4.5   Data Object Definition

This section of the label defines the structure and content of the IMA MU and IMA(-DPU) housekeeping calibrated data products.

4.3.4.5.1   The description of the IMA MU-housekeeping table:

Each MU HK data file contains an 18 columns table with the calibrated HK data when calibration is applied.

```
OBJECT               = HK_MU_TABLE
   NAME              = "IMA_HKMU"
   INTERCHANGE_FORMAT = ASCII
   ROWS              = Number of rows within the data file
   COLUMNS           = 18
   ROW_BYTES         = 121
   ^STRUCTURE        = "IMA_SPECTRUM_HKMU.FMT"
END_OBJECT           = HK_MU_TABLE
```

The structure of the TABLE object is described in the file IMA_SPECTRUM_HKMU.FMT as follows:

```
/*  Contents of format file  "IMA_SPECTRUM_HKMU.FMT"  */
OBJECT               = COLUMN
   COLUMN_NUMBER     = 1
```

```
    NAME                 = "UTC"
    DATA_TYPE            = TIME
    START_BYTE           = 1
    BYTES                = 23
    UNIT                 = "N/A"
    DESCRIPTION          = "This column represents the UTC of the
                            IMA HK data set in PDS standard format
                            YYYY-MM-DDThh:mm:ss.sss"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    COLUMN_NUMBER        = 2
    NAME                 = "OBT"
    DATA_TYPE            = CHARACTER
    START_BYTE           = 26
    BYTES                = 19
    UNIT                 = "N/A"
    DESCRIPTION          = "On board Time (OBT) is represented as :
                            <Reset number>/<unit seconds>.<fractional seconds>
                            with
                            <Reset number>: integer starting at 1
                               Reset number 1 starts at 2005-03-01T00:00:00 UTC
                            <unit seconds>: 10 digits number of unit seconds
                            <fractional seconds>: 5 digits number of fractional
                               seconds expressed as multiples of 2^-16 seconds"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    COLUMN_NUMBER        = 3
    NAME                 = "SW_VERSION"
    DATA_TYPE            = ASCII_INTEGER
    START_BYTE           = 47
    BYTES                = 5
    UNIT                 = "N/A"
    FORMAT               = "I5"
    DESCRIPTION          = "Software version
                            To decode into Binary format. Bit description:
                            patchVersion [3:0]
                            minorVersion [8:4]
                            majorVersion [13:9]
                            releaseClass [15:14]: 1 (D), 2 (T), 3 (R)"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    COLUMN_NUMBER        = 4
    NAME                 = "HK_I_PLUS_30V"
    DATA_TYPE            = ASCII_REAL
    START_BYTE           = 53
    BYTES                = 6
    UNIT                 = "MILLIAMPERE"
    FORMAT               = "F6.2"
    DESCRIPTION          = "HK i +30V in milli-amperes"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
    COLUMN_NUMBER        = 5
    NAME                 = "HK_I_PLUS_5V"
    DATA_TYPE            = ASCII_REAL
    START_BYTE           = 60
    BYTES                = 7
    UNIT                 = "MILLIAMPERE"
    FORMAT               = "F7.2"
```

```
        DESCRIPTION           = "HK i +5V in milli-amperes"
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
    COLUMN_NUMBER             = 6
    NAME                      = "HK_V_PLUS_12V"
    DATA_TYPE                 = ASCII_REAL
    START_BYTE                = 68
    BYTES                     = 5
    UNIT                      = "VOLT"
    FORMAT                    = "F5.2"
    DESCRIPTION               = "HK V +12V in Volts"
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
    COLUMN_NUMBER             = 7
    NAME                      = "HK_V_PLUS_30V"
    DATA_TYPE                 = ASCII_REAL
    START_BYTE                = 74
    BYTES                     = 6
    UNIT                      = "VOLTS"
    FORMAT                    = "F6.2"
    DESCRIPTION               = "HK V +30V in Volts"
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
    COLUMN_NUMBER             = 8
    NAME                      = "HK_V_PLUS_5V"
    DATA_TYPE                 = ASCII_REAL
    START_BYTE                = 81
    BYTES                     = 4
    UNIT                      = "VOLT"
    FORMAT                    = "F4.2"
    DESCRIPTION               = "HK V +5V in Volts"
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
    COLUMN_NUMBER             = 9
    NAME                      = "HK_V_MINUS_12V"
    DATA_TYPE                 = ASCII_REAL
    START_BYTE                = 86
    BYTES                     = 6
    UNIT                      = "VOLT"
    FORMAT                    = "F6.2"
    DESCRIPTION               = "HK V -12V in Volts"
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
    COLUMN_NUMBER             = 10
    NAME                      = "HK_V_MINUS_5V"
    DATA_TYPE                 = ASCII_REAL
    START_BYTE                = 93
    BYTES                     = 5
    UNIT                      = "VOLT"
    FORMAT                    = "F5.2"
    DESCRIPTION               = "HK V -5V in Volts"
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
    COLUMN_NUMBER             = 11
    NAME                      = "SUN_SENSOR_1"
    DATA_TYPE                 = ASCII_INTEGER
```

```
    START_BYTE              = 99
    BYTES                   = 1
    UNIT                    = "N/A"
    FORMAT                  = "I1"
    DESCRIPTION             = "Sun sensor 1 output"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    COLUMN_NUMBER           = 12
    NAME                    = "SUN_SENSOR_2"
    DATA_TYPE               = ASCII_INTEGER
    START_BYTE              = 101
    BYTES                   = 1
    UNIT                    = "N/A"
    FORMAT                  = "I1"
    DESCRIPTION             = "Sun sensor 2 output"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    COLUMN_NUMBER           = 13
    NAME                    = "IMA_PLUS_MINUS_5V_ON_OFF"
    DATA_TYPE               = ASCII_INTEGER
    START_BYTE              = 103
    BYTES                   = 1
    UNIT                    = "N/A"
    FORMAT                  = "I1"
    DESCRIPTION             = "IMA +/-5V on/off
                               The field takes one of the following values:
                               0 off
                               1 on"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    COLUMN_NUMBER           = 14
    NAME                    = "IMA_PLUS_30V_ON_OFF"
    DATA_TYPE               = ASCII_INTEGER
    START_BYTE              = 105
    BYTES                   = 1
    UNIT                    = "N/A"
    FORMAT                  = "I1"
    DESCRIPTION             = "IMA +30V on/off
                               The field takes one of the following values:
                               0 off
                               1 on"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    COLUMN_NUMBER           = 15
    NAME                    = "IMA_PLUS_MINUS_12V_ON_OFF"
    DATA_TYPE               = ASCII_INTEGER
    START_BYTE              = 107
    BYTES                   = 1
    UNIT                    = "N/A"
    FORMAT                  = "I1"
    DESCRIPTION             = "IMA +/-12V on/off
                               The field takes one of the following values:
                               0 off
                               1 on"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
    COLUMN_NUMBER           = 16
```

```
   NAME                 = "SW_MODE"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 109
   BYTES                = 3
   UNIT                 = "N/A"
   FORMAT               = "I3"
   DESCRIPTION          = "Software mode"
END_OBJECT              = COLUMN

OBJECT                 = COLUMN
   COLUMN_NUMBER        = 17
   NAME                 = "CPU_LOAD"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 113
   BYTES                = 3
   UNIT                 = "N/A"
   FORMAT               = "I3"
   DESCRIPTION          = "CPU load"
END_OBJECT              = COLUMN

OBJECT                 = COLUMN
   COLUMN_NUMBER        = 18
   NAME                 = "IMA_LINK_STATUS"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 117
   BYTES                = 3
   UNIT                 = "N/A"
   FORMAT               = "I3"
   DESCRIPTION          = "It contains status register of IEEE 1355 LINK Chip.
                           This field value has to be decoded in Binary
                           format. Bit description:
                           bit: 7: ndata0A
                           bit 6: crdMEM
                           bit 5: datav
                           bit 4: resetm
                           bit 3: ffrx
                           bit 2: EOP1
                           bit 1: ndata0
                           bit 0: nm1
                           In typical nominal operation one should find value
                           0x41 on the link when link is working properly."
END_OBJECT              = COLUMN
```

Detailed description of those parameters is provided in documents [AD 3].

4.3.4.5.2 The description of the IMA housekeeping table for HKs generated from the IMA unit:

Each data file (TAB) contains a 36 columns table with the calibrated HK data when calibration is applied.

```
OBJECT                 = HK_IMA_TABLE
   NAME                 = "IMA_HKIMA"
   INTERCHANGE_FORMAT   = ASCII
   ROWS                 = Number of rows within the data file
   COLUMNS              = 36
   ROW_BYTES            = 185
   ^STRUCTURE           = "IMA_SPECTRUM_HKIMA.FMT"
END_OBJECT              = HK_IMA_TABLE
```

The structure of the TABLE object is described in the file IMA_SPECTRUM_HKIMA.FMT as follows:

```
/*  Contents of format file  "IMA_SPECTRUM_HKIMA.FMT"  */
OBJECT                 = COLUMN
   COLUMN_NUMBER        = 1
```

```
NAME                  = "UTC"
DATA_TYPE             = TIME
START_BYTE            = 1
BYTES                 = 23
UNIT                  = "N/A"
DESCRIPTION           = "This column represents the UTC of the
                         IMA HK data set in PDS standard format
                         YYYY-MM-DDThh:mm:ss.sss"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
   COLUMN_NUMBER      = 2
   NAME               = "OBT"
   DATA_TYPE          = CHARACTER
   START_BYTE         = 26
   BYTES              = 19
   UNIT               = "N/A"
   DESCRIPTION        = "On board Time (OBT) is represented as :
                         <Reset number>/<unit seconds>.<fractional seconds>
                         with
                         <Reset number>: integer starting at 1
                            Reset number 1 starts at 2005-03-01T00:00:00 UTC
                         <unit seconds>: 10 digits number of unit seconds
                         <fractional seconds>: 5 digits number of fractional
                            seconds expressed as multiples of 2^-16 seconds"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
   COLUMN_NUMBER      = 3
   NAME               = "LAST_COMMAND_STATUS"
   DATA_TYPE          = ASCII_INTEGER
   START_BYTE         = 47
   BYTES              = 1
   UNIT               = "N/A"
   FORMAT             = "I1"
   DESCRIPTION        = "Last command status
                         The field takes one of the following values:
                         0 ok
                         1 parameter out of range
                         2 invalid
                         3 erroneous opcode"
END_OBJECT            = COLUMN

OBJECT                = COLUMN
   COLUMN_NUMBER      = 4
   NAME               = "CURRENT_DATA_REDUCTION_MODE"
   DATA_TYPE          = ASCII_INTEGER
   START_BYTE         = 49
   BYTES              = 2
   UNIT               = "N/A"
   FORMAT             = "I2"
   DESCRIPTION        = "Current data reduction mode. The field takes one
                         of the following mode index values:
                          0 idle
                          2 Mspo
                          4 Msis
                          5 Mexm
                          8 Nrm0
                          9 Nrm1
                         10 Nrm2
                         11 Nrm3
                         12 Nrm4
```

```
                              13 Nrm5
                              14 Nrm6
                              15 Nrm7
                              16 Har0
                              17 Har1
                              18 Har2
                              19 Har3
                              20 Har4
                              21 Har5
                              22 Har6
                              23 Har7
                              24 Exm0
                              25 Exm1
                              26 Exm2
                              27 Exm3
                              28 Exm4
                              29 Exm5
                              30 Exm6
                              31 Exm7
                              32 Test
                              33 Cal1
                              34 Cal2
                              35 Fake"
  END_OBJECT              = COLUMN

  OBJECT                 = COLUMN
     COLUMN_NUMBER       = 5
     NAME                = "HW_SWITCH_STATUS"
     DATA_TYPE           = ASCII_INTEGER
     START_BYTE          = 52
     BYTES               = 3
     UNIT                = "N/A"
     FORMAT              = "I3"
     DESCRIPTION         = "Last command status. This field value has to
                            be decoded in Binary format.
                            Bit description:
                            bit 0 = Mcp 28V On/Off
                            bit 1 = Opto 28V On/Off
                            bit 2 = Main 28V On/Off
                            bit 3 = Pacc.ref On/Off
                            bit 4 = Grid.ref On/Off
                            bit 5 = Entr.HV.ref On/Off
                            bit 6 = EnyDfl.HV.ref On/Off
                            bit 7 = EnyDfl.LV.ref On/Off
                            0 = Off   1 = On "
  END_OBJECT             = COLUMN

  OBJECT                 = COLUMN
     COLUMN_NUMBER       = 6
     NAME                = "+28V_MCP_HV_PRESENT"
     DATA_TYPE           = ASCII_INTEGER
     START_BYTE          = 56
     BYTES               = 1
     UNIT                = "N/A"
     FORMAT              = "I1"
     DESCRIPTION         = "MCP 28V switch
                            The field takes one of the following values:
                            0 No
                            1 Yes"
  END_OBJECT             = COLUMN

  OBJECT                 = COLUMN
```

```
              COLUMN_NUMBER       = 7
              NAME                = "+28V_OPTO_HV_PRESENT"
              DATA_TYPE           = ASCII_INTEGER
              START_BYTE          = 58
              BYTES               = 1
              UNIT                = "N/A"
              FORMAT              = "I1"
              DESCRIPTION         = "Opto 28V switch
                                     The field takes one of the following values:
                                     0 No
                                     1 Yes"
          END_OBJECT              = COLUMN

          OBJECT                  = COLUMN
              COLUMN_NUMBER       = 8
              NAME                = "+28V_MAIN_HV_PRESENT"
              DATA_TYPE           = ASCII_INTEGER
              START_BYTE          = 60
              BYTES               = 1
              UNIT                = "N/A"
              FORMAT              = "I1"
              DESCRIPTION         = "Main 28V switch
                                     The field takes one of the following values:
                                     0 No
                                     1 Yes"
          END_OBJECT              = COLUMN

          OBJECT                  = COLUMN
              COLUMN_NUMBER       = 9
              NAME                = "POST_ACCELREATION_MODE"
              DATA_TYPE           = ASCII_INTEGER
              START_BYTE          = 62
              BYTES               = 1
              UNIT                = "N/A"
              FORMAT              = "I1"
              DESCRIPTION         = "Post-acceleration mode
                                     The field takes one of the following values:
                                     0 Fixed
                                     1 Alternating"
          END_OBJECT              = COLUMN

          OBJECT                  = COLUMN
              COLUMN_NUMBER       = 10
              NAME                = "CURRENT_SID_NUMBER"
              DATA_TYPE           = ASCII_INTEGER
              START_BYTE          = 64
              BYTES               = 1
              UNIT                = "N/A"
              FORMAT              = "I1"
              DESCRIPTION         = "IMA internal SID type"
          END_OBJECT              = COLUMN

          OBJECT                  = COLUMN
              COLUMN_NUMBER       = 11
              NAME                = "NEW_COMMAND_RECEIVED_TOGGLE_BIT"
              DATA_TYPE           = ASCII_INTEGER
              START_BYTE          = 66
              BYTES               = 1
              UNIT                = "N/A"
              FORMAT              = "I1"
              DESCRIPTION         = "The new command received toggle 0/1 bit for
                                     each new command returned in Line -First word
```

```
                                     command return-"
     END_OBJECT                    = COLUMN

     OBJECT                        = COLUMN
        COLUMN_NUMBER              = 12
        NAME                       = "FIFO_FILLING_IN_TERMS_OF_INTERNAL_PACKETS_IN_F8"
        DATA_TYPE                  = ASCII_INTEGER
        START_BYTE                 = 68
        BYTES                      = 3
        UNIT                       = "N/A"
        FORMAT                     = "I3"
        DESCRIPTION                = "The number of 6 byte packets held in the TM-fifo
                                      in F8 representation "
     END_OBJECT                    = COLUMN

     OBJECT                        = COLUMN
        COLUMN_NUMBER              = 13
        NAME                       = "FIRST_WORD_COMMAND_RETURN"
        DATA_TYPE                  = ASCII_INTEGER
        START_BYTE                 = 72
        BYTES                      = 5
        UNIT                       = "N/A"
        FORMAT                     = "I5"
        DESCRIPTION                = "The first word of the last command received"
     END_OBJECT                    = COLUMN

     OBJECT                        = COLUMN
        COLUMN_NUMBER              = 14
        NAME                       = "OPTO_HV_MONITOR"
        DATA_TYPE                  = ASCII_REAL
        START_BYTE                 = 78
        BYTES                      = 6
        UNIT                       = "KILOVOLT"
        FORMAT                     = "F6.3"
        DESCRIPTION                = "The Opto HV monitor in kilo-volts"
     END_OBJECT                    = COLUMN

     OBJECT                        = COLUMN
        COLUMN_NUMBER              = 15
        NAME                       = "MCP_HV_MONITOR"
        DATA_TYPE                  = ASCII_REAL
        START_BYTE                 = 85
        BYTES                      = 6
        UNIT                       = "KILOVOLT"
        FORMAT                     = "F6.3"
        DESCRIPTION                = "The MCP HV monitor in kilo-volts"
     END_OBJECT                    = COLUMN

     OBJECT                        = COLUMN
        COLUMN_NUMBER              = 16
        NAME                       = "ENERGY_DEFLECT_HV_MONITOR"
        DATA_TYPE                  = ASCII_REAL
        START_BYTE                 = 92
        BYTES                      = 6
        UNIT                       = "KILOVOLT"
        FORMAT                     = "F6.3"
        DESCRIPTION                = "The energy deflection HV monitor in kilo-volts"
     END_OBJECT                    = COLUMN

     OBJECT                        = COLUMN
        COLUMN_NUMBER              = 17
        NAME                       = "ENERGY_DEFLECT_LV_MONITOR"
```

```
      DATA_TYPE            = ASCII_REAL
      START_BYTE           = 99
      BYTES                = 7
      UNIT                 = "VOLT"
      FORMAT               = "F7.3"
      DESCRIPTION          = "The energy deflection LV monitor in Volts"
   END_OBJECT              = COLUMN

   OBJECT                  = COLUMN
      COLUMN_NUMBER        = 18
      NAME                 = "POST_ACCELERATION_HV_MONITOR"
      DATA_TYPE            = ASCII_REAL
      START_BYTE           = 107
      BYTES                = 6
      UNIT                 = "KILOVOLT"
      FORMAT               = "F6.3"
      DESCRIPTION          = "The post-acceleration HV monitor in kilo-volts"
   END_OBJECT              = COLUMN

   OBJECT                  = COLUMN
      COLUMN_NUMBER        = 19
      NAME                 = "GRID_LV_MONITOR"
      DATA_TYPE            = ASCII_INTEGER
      START_BYTE           = 114
      BYTES                = 3
      UNIT                 = "N/A"
      FORMAT               = "I3"
      DESCRIPTION          = "N.A. grid grounded"
   END_OBJECT              = COLUMN

   OBJECT                  = COLUMN
      COLUMN_NUMBER        = 20
      NAME                 = "SENSOR_UNIT_TEMPERATURE"
      DATA_TYPE            = ASCII_REAL
      START_BYTE           = 118
      BYTES                = 7
      UNIT                 = "CELSIUS"
      FORMAT               = "F7.2"
      DESCRIPTION          = "The sensor unit temperature in degree Celsius"
   END_OBJECT              = COLUMN

   OBJECT                  = COLUMN
      COLUMN_NUMBER        = 21
      NAME                 = "DPU_TEMPERATURE"
      DATA_TYPE            = ASCII_REAL
      START_BYTE           = 126
      BYTES                = 7
      UNIT                 = "CELSIUS"
      FORMAT               = "F7.2"
      DESCRIPTION          = "The DPU temperature in degree Celsius"
   END_OBJECT              = COLUMN

   OBJECT                  = COLUMN
      COLUMN_NUMBER        = 22
      NAME                 = "ENERGY_DEFLECT_HV_REFERENCE"
      DATA_TYPE            = ASCII_INTEGER
      START_BYTE           = 134
      BYTES                = 4
      UNIT                 = "ADC_UNITS"
      FORMAT               = "I4"
      DESCRIPTION          = "The energy deflection HV reference value
                              associated with the monitor reading"
```

```
    END_OBJECT             = COLUMN

    OBJECT                 = COLUMN
       COLUMN_NUMBER       = 23
       NAME                = "POST_ACCELERATION_LOW_LEVEL_REFERENCE"
       DATA_TYPE           = ASCII_INTEGER
       START_BYTE          = 139
       BYTES               = 1
       UNIT                = "ADC_UNITS"
       FORMAT              = "I1"
       DESCRIPTION         = "The post-acceleration low level reference"
    END_OBJECT             = COLUMN

    OBJECT                 = COLUMN
       COLUMN_NUMBER       = 24
       NAME                = "DIRECT_COMMAND_SWITCH"
       DATA_TYPE           = ASCII_INTEGER
       START_BYTE          = 141
       BYTES               = 1
       UNIT                = "N/A"
       FORMAT              = "I1"
       DESCRIPTION         = "The direct command switch"
    END_OBJECT             = COLUMN

    OBJECT                 = COLUMN
       COLUMN_NUMBER       = 25
       NAME                = "ENERGY_DEFLECT_LV_REFERENCE"
       DATA_TYPE           = ASCII_INTEGER
       START_BYTE          = 143
       BYTES               = 4
       UNIT                = "ADC_UNITS"
       FORMAT              = "I4"
       DESCRIPTION         = "The energy deflection LV reference value
                              associated with the monitor reading"
    END_OBJECT             = COLUMN

    OBJECT                 = COLUMN
       COLUMN_NUMBER       = 26
       NAME                = "POST_ACCELERATION_HIGH_LEVEL_REFERENCE"
       DATA_TYPE           = ASCII_INTEGER
       START_BYTE          = 148
       BYTES               = 1
       UNIT                = "ADC_UNITS"
       FORMAT              = "I1"
       DESCRIPTION         = "The post-acceleration high level reference"
    END_OBJECT             = COLUMN

    OBJECT                 = COLUMN
       COLUMN_NUMBER       = 27
       NAME                = "TM_FIFO_OVERFLOW"
       DATA_TYPE           = ASCII_INTEGER
       START_BYTE          = 150
       BYTES               = 1
       UNIT                = "N/A"
       FORMAT              = "I1"
       DESCRIPTION         = "The TM fifo overflow
                              The field takes one of the following values:
                              0 No overflow
                              1 Overflow"
    END_OBJECT             = COLUMN

    OBJECT                 = COLUMN
```

```
   COLUMN_NUMBER        = 28
   NAME                 = "ENTRANCE_HV_REFERENCE"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 152
   BYTES                = 4
   UNIT                 = "ADC_UNITS"
   FORMAT               = "I4"
   DESCRIPTION          = "The entrance HV reference value
                           associated with the monitor reading"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 29
   NAME                 = "GRID_LV_REFERENCE"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 157
   BYTES                = 1
   UNIT                 = "ADC_UNITS"
   FORMAT               = "I1"
   DESCRIPTION          = "The grid LV reference value
                           associated with the monitor reading"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 30
   NAME                 = "POST_ACCELERATION_LEVEL"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 159
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
   DESCRIPTION          = "The post-acceleration level value takes one
                           of the following values:
                           0 low
                           1 high"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 31
   NAME                 = "ENTRANCE_UPPER_HV_MONITOR"
   DATA_TYPE            = ASCII_REAL
   START_BYTE           = 161
   BYTES                = 6
   UNIT                 = "KILOVOLT"
   FORMAT               = "F6.3"
   DESCRIPTION          = "The entrance upper HV monitor in kilo-volts"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 32
   NAME                 = "MCP_HV_DEFAULT_REFERENCE"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 168
   BYTES                = 2
   UNIT                 = "ADC_UNITS"
   FORMAT               = "I2"
   DESCRIPTION          = "The MCP default reference. That is the
                           target value for ramping"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 33
```

```
    NAME                    = "OPTO_HV_DEFAULT_REFERENCE"
    DATA_TYPE               = ASCII_INTEGER
    START_BYTE              = 171
    BYTES                   = 1
    UNIT                    = "ADC_UNITS"
    FORMAT                  = "I1"
    DESCRIPTION             = "The Opto default reference. That is the
                               target value for ramping"
  END_OBJECT                = COLUMN

  OBJECT                    = COLUMN
    COLUMN_NUMBER           = 34
    NAME                    = "ENTRANCE_LOWER_HV_MONITOR"
    DATA_TYPE               = ASCII_REAL
    START_BYTE              = 173
    BYTES                   = 6
    UNIT                    = "KILOVOLT"
    FORMAT                  = "F6.3"
    DESCRIPTION             = "The entrance lower HV monitor in kilo-volts"
  END_OBJECT                = COLUMN

  OBJECT                    = COLUMN
    COLUMN_NUMBER           = 35
    NAME                    = "MCP_HV_CURRENT_REFERENCE"
    DATA_TYPE               = ASCII_INTEGER
    START_BYTE              = 180
    BYTES                   = 2
    UNIT                    = "ADC_UNITS"
    FORMAT                  = "I2"
    DESCRIPTION             = "The MCP current reference value
                               associated with the monitor reading"
  END_OBJECT                = COLUMN

  OBJECT                    = COLUMN
    COLUMN_NUMBER           = 36
    NAME                    = "OPTO_HV_CURRENT_REFERENCE"
    DATA_TYPE               = ASCII_INTEGER
    START_BYTE              = 183
    BYTES                   = 1
    UNIT                    = "ADC_UNITS"
    FORMAT                  = "I1"
    DESCRIPTION             = "The Opto current reference value
                               associated with the monitor reading"
  END_OBJECT                = COLUMN
```

Detailed description of those parameters is provided in documents [AD 3].

4.3.4.6   Description of Instrument

See the applicable section 4.3.3.6

4.3.4.7   Parameters Index File Definition

N/A

4.3.4.8   Mission Specific Keywords

See the applicable section 4.3.3.8

4.3.5 Neutral Particle Detector Science Edited Data Product Design (Level 2)

The NPD Sensor can be operated in 4 modes as described in the document [AD 3], producing 4 different types of formatted block data in telemetry packets, one for each selected operation mode. One of those modes is not used in flight operation. A second mode allows the acquisition and storage of series of quadruplet values that fully describe the properties of the detected particles within the subdivided and resolved parametric space defined by the following coordinates: stop pulse height MCP charge (stop PH), the Time-Of-Flight (TOF), the direction of arrival particles and the coincidence control. The last two modes deal with counts of neutral particles that are registered, respectively, in TOF and PHD×TOF counters for the 3 azimuth directions. In some certain flight operations, data may be reduced and delivered in PHD×TOF counters with fewer bins number.

Considering above, there are essentially 3 different types of NPD edited science file whose items are fitting a dedicated bin within the subdivided parametric space. The Table 29 indicates the data contents for each science data file and their PDS representation object. Those blocks of data from binning mode using fewer PHD bins will be processed and stored into appropriate neutral particle counting data files according to their number of PHD bins.

All of them are always delivered as a fixed-size array where data are stored in a linear row-major order. A NPD header, specific to each mode of observation and common to NPD1 and NPD2 sensors, is added before a data collection. The NPD headers information and values are shown in the Table 30.

Table 29. NPD1 and NPD2 science data file contents and structure.

Data Type	Mode	Data description	PDS data object
RAWXXXX	NPD raw data	Continuous data streams of observations. Each event is identified by a quadruplet (Stop PHD, TOF, Direction and Coincidence) and sequentially stored.	Linear storage in a TABLE object of 2048 blank-separated data values split into 4 columns of 512 items (512 values for each coordinate: Stop PHD, TOF, Direction and Coincidence).
BINmmDd *with mm=01, 02 or 16 and d=0, 1 or 2*	NPD binning data	Data (in counts/accumulation) of valid events (coincidence with one start and one stop signal) stored into a PHD×TOF counters array for a given individual direction (3 possible azimuths).	Linear storage of the PHD×TOF counter matrix in a TABLE object of blank-separated data values. The size of the object depends on the Data Type: from 3 data values if *mm*=01 (meaning a 1×16 matrix for the considered direction) to its maximum of 256 data values if *mm*=16 (meaning a 16×16matrix). The PHD×TOF matrices may have to shrink into 1×16 or 2×16 bins depending on the respective Threshold value. In the PHD×TOF matrices, count for lowest TOF value is sent first. In case of 2×16 matrices, the lowest TOF values correspond to the hydrogen region, the highest TOF values are associated to the oxygen measurement.
TOFXXXX	NPD TOF mode	Spectrum of valid events (coincidence with one start and one stop signal) counted per incremental TOF band, over the accumulation time period. Data are delivered into a 256 TOF counters array for each individual direction (3 azimuths).	Linear storage in a TABLE object of 3*256 blank-separated data values corresponding to the 768 bin counter items. The 3 represents the number of directions.
	NPD PHD mode	This mode is not used for in flight operation	

Table 30. NPD1 and NPD2 headers content.

Rank	Field / Value		Rank	Field / Value	
	NPD mode raw data header				
1	UTC correlated Time		13	STAT	
2	OBT Time		14	TDCRD	
3	SW version		15	CALIB11	
4	Scanner direction	0 = 0 - 180 1 = 180 - 0	16	CALIB12	
5	Scanner speed	0 (standing), 32s scan, 64s scan, or 128s scan	17	CALIB21	
6	Scanner Position	On start of scan (or step) period	18	CALIB22	
7	Accumulation Time		19	STARTCNT	
8	Log compression	Always 0 for raw data mode (0 = disabled)	20	STOP0CNT	
9	Rice compression flag status	0 = non valid 1 = valid	21	STOP1CNT	
10	Rice compression assigned value		22	STOP2CNT	
11	FRONTCTRL		23	TOFCNT	
12	MAINCTRL		24	RAWCNT	
	NPD mode binning data header				
1	UTC correlated Time		11	Threshold	0 = Matrix 0, 16PHD×16TOF 1-14 = Matrix 1, 2PHD×16TOF 15 = Matrix 2, 1PHD×16TOF
2	OBT Time				
3	SW version		12	CALIB11	
4	Scanner direction	0 = 0 - 180 1 = 180 - 0	13	CALIB12	
5	Scanner speed	0 (standing), 32s scan, 64s scan, or 128s scan	14	CALIB21	
6	Scanner Position	On start of scan (or step) period	15	CALIB22	
7	Accumulation Time		16	STARTCNT	
8	Log compression	0 = disable 1 = enable	17	STOP0CNT	
9	Rice compression flag status	0 = non valid 1 = valid	18	STOP1CNT	
10	Rice compression assigned value		19	STOP2CNT	
	NPD mode TOF data header				
1	UTC correlated Time		10	Rice compression assigned value	
2	OBT Time		11	Number of valid samples integrated to the matrix	
3	SW version		12	CALIB11	
4	Scanner direction	0 = 0 - 180 1 = 180 - 0	13	CALIB12	
5	Scanner speed	0 (standing), 32s scan, 64s scan, or 128s scan	14	CALIB21	
6	Scanner Position	On start of scan (or step) period	15	CALIB22	
7	Accumulation Time		16	STARTCNT	

8	Log compression	0 = disable 1 = enable	17	STOP0CNT
			18	STOP1CNT
9	Rice compression flag status	0 = non valid 1 = valid	19	STOP2CNT

The table objects are detailed in the following paragraphs.

4.3.5.1 File Characteristics Data Elements

The following elements are present in the labels for every NPD science edited data product, and they describe the basic characteristics of the data product in terms of structure and naming:

```
/* FILE CHARACTERISTIC DATA ELEMENTS */
PRODUCT_ID                      = this element defines the current product file name,
                                  without extension
RECORD_TYPE                     = FIXED_LENGTH
RECORD_BYTES                    = this element indicates the number of bytes in a
                                  data record, including record terminators and
                                  separators
FILE_RECORDS                    = this element indicates the number of records within
                                  the data file
```

4.3.5.2 Data Object Pointers Identification Data Elements

Several pointers are defined, identifying the ASCII PDS objects within which the NPD status and uncalibrated science data are stored. The data object pointers that reference TAB files are:

```
^NPD_RAWHEAD_TABLE
^NPD_BINHEAD_TABLE
^NPD_TOFHEAD_TABLE
^NPD_RAWSCIE_TABLE
^NPD_BINSCIE_TABLE
^NPD_TOFSCIE_TABLE
```

4.3.5.3 Instrument and Detector Descriptive Data Elements

The following data identification elements provide additional information about the NPD data products.

```
/* PRODUCER IDENTIFICATION */
PRODUCER_ID                     = "CESR_ASPERA4_GROUP"
PRODUCER_FULL_NAME              = "EMMANUEL PENOU"
PRODUCER_INSTITUTION_NAME       = "CENTRE D'ETUDE SPATIALE DES RAYONNEMENTS"
PRODUCT_CREATION_TIME           = YYYY-MM-DDThh:mm:ss[.fff]

/* DATA DESCRIPTION AND IDENTIFICATION */
DATA_SET_NAME                   = "
                    VENUS EXPRESS VENUS/SOLARWIND ASPERA 2 NPD V1.0"  or
        "VENUS EXPRESS VENUS/SOLARWIND ASPERA 2 EXTENSION 1 NPD V1.0"  or
        "VENUS EXPRESS VENUS/SOLARWIND ASPERA 2 EXTENSION 1 NPD V1.0"  or
        …
DATA_SET_ID                     = "VEX-V/SW-ASPERA-2-NPD-V1.0"        or
                                  "VEX-V/SW-ASPERA-2-EXT1-NPD-V1.0"   or
                                  "VEX-V/SW-ASPERA-2-EXT2-NPD-V1.0"   or
                                  …
RELEASE_ID                      = 0001
REVISION_ID                     = 0000
PRODUCT_TYPE                    = EDR
PROCESSING_LEVEL_ID             = 2
```

```
MISSION_NAME                    = "VENUS EXPRESS"
MISSION_ID                      = VEX
INSTRUMENT_HOST_NAME            = "VENUS EXPRESS"
INSTRUMENT_HOST_ID              = VEX
MISSION_PHASE_NAME              = As defined in [AD 4]
INSTRUMENT_NAME                 = "
       ANALYZER OF SPACE PLASMA AND ENERGETIC ATOMS (4TH VERSION)"
INSTRUMENT_ID                   = ASPERA4
INSTRUMENT_TYPE                 = {"ELECTROSTATIC ANALYZER",
                                   "MASS SPECTROMETER",
                                   "NEUTRAL PARTICLE IMAGER",
                                   "NEUTRAL PARTICLE DETECTOR"}
DETECTOR_ID                     = VEX_ASP4_NPD1 or VEX_ASP4_NPD2
^INSTRUMENT_DESC                = "ASPERA4_DESC.TXT"

/* TARGET IDENTIFICATION */
TARGET_TYPE                     = "PLANET" or "N/A"
TARGET_NAME                     = "VENUS"  or "SOLAR WIND"
RIGHT_ASCENSION                 = "N/A"
DECLINATION                     = "N/A"

/* SCIENCE OPERATIONS INFORMATION */
OBSERVATION_TYPE                = {"AC002B", "PE001A", "PE004A"} or "N/A"
^OBSERVATION_TYPE_DESC          = "OBSERVATION_TYPE_DESC.TXT"

/* TIME RELATED INFORMATION */
START_TIME                      = YYYY-MM-DDThh:mm:ss.fff
STOP_TIME                       = YYYY-MM-DDThh:mm:ss.fff
SPACECRAFT_CLOCK_START_COUNT    = "01/xxxxxxxxx.xxxxx"
SPACECRAFT_CLOCK_STOP_COUNT     = "01/xxxxxxxxx.xxxxx"

/* ORBITAL INFORMATION */
ORBIT_NUMBER                    = UNK
ORBITAL_ECCENTRICITY            = UNK
ORBITAL_INCLINATION             = UNK
ORBITAL_SEMIMAJOR_AXIS          = UNK
PERIAPSIS_ALTITUDE              = UNK
PERIAPSIS_ARGUMENT_ANGLE        = UNK
PERIAPSIS_TIME                  = "UNK"
SPACECRAFT_ORIENTATION          = UNK
^SPACECRAFT_ORIENTATION_DESC    = "VEX_ORIENTATION_DESC.TXT"
SPACECRAFT_POINTING_MODE        = "ALL"
^SPACECRAFT_POINTING_MODE_DESC  = "VEX_POINTING_MODE_DESC.TXT"
```

4.3.5.4 Structure Definition of Instrument Parameter Objects

N/A

4.3.5.5 Data Object Definition

This section of the label defines the structure and content of the NPD1 and NPD2 science edited data product. As specified in §4.3, each data file (TAB) contains typically 2 objects: an ASCII TABLE for containing the header information about the sensor status while operating in a selected mode and an ASCII TABLE object for handling the science data that are acquired in the corresponding NPD mode. These objects are stored in parallel within a data product file, forming a data structure in which records have constant length. The number of rows within the tables is variable and depends roughly on the number of records contained in the processed level-1 data file.

The columns within these header TABLE objects are first described in the section below. The science data objects are defined in the following separate sections.

4.3.5.5.1 The description of the NPD1 and NPD2 header table for Raw mode

The description presented hereafter applies to both NPD1 and NPD2 sensors.

```
OBJECT                  = NPD_RAWHEAD_TABLE
   NAME                 = "NPD_RAW_HEAD"
   ROW_SUFFIX_BYTES     = Number of bytes that are accounted in the subsequent
                           table, including record terminators and separators
   INTERCHANGE_FORMAT   = ASCII
   ROWS                 = Number of rows within the data file
   COLUMNS              = 24
   ROW_BYTES            = 152
  ^STRUCTURE            = "NPD_RAWHEAD.FMT"
END_OBJECT              = NPD_RAWHEAD_TABLE
```

The structure of the TABLE object is described in the file NPD_RAWHEAD.FMT as follows:

```
/*  Contents of format file  "NPD_RAWHEAD.FMT"  */
OBJECT                  = COLUMN
   COLUMN_NUMBER        = 1
   NAME                 = "UTC"
   DATA_TYPE            = TIME
   START_BYTE           = 1
   BYTES                = 23
   UNIT                 = "N/A"
   DESCRIPTION          = "This column represents the UTC of the
                            NPD science data in PDS standard format
                            YYYY-MM-DDThh:mm:ss.sss"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 2
   NAME                 = "OBT"
   DATA_TYPE            = CHARACTER
   START_BYTE           = 26
   BYTES                = 19
   UNIT                 = "N/A"
   DESCRIPTION          = "On board Time (OBT) is represented as :
                           <Reset number>/<unit seconds>.<fractional seconds>
                           with
                           <Reset number>: integer starting at 1
                              Reset number 1 starts at 2005-03-01T00:00:00 UTC
                           <unit seconds>: 10 digits number of unit seconds
                           <fractional seconds>: 5 digits number of fractional
                              seconds expressed as multiples of 2^-16 seconds"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 3
   NAME                 = "SW_VERSION"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 47
   BYTES                = 5
   UNIT                 = "N/A"
   FORMAT               = "I5"
   DESCRIPTION          = "Software version
                            To decode into Binary format. Bit description:
                            patchVersion [3:0]
                            minorVersion [8:4]
```

```
                              majorVersion [13:9]
                              releaseClass [15:14]: 1 (D), 2 (T), 3 (R)"
  END_OBJECT                = COLUMN

  OBJECT                    = COLUMN
    COLUMN_NUMBER           = 4
    NAME                    = "SCANNER_DIRECTION"
    DATA_TYPE               = ASCII_INTEGER
    START_BYTE              = 53
    BYTES                   = 1
    UNIT                    = "N/A"
    FORMAT                  = "I1"
    DESCRIPTION             = "Scanner direction.
                              The field takes one of the following values:
                              0: 0 - 180
                              1: 180 - 0"
  END_OBJECT                = COLUMN

  OBJECT                    = COLUMN
    COLUMN_NUMBER           = 5
    NAME                    = "SCANNER_SPEED"
    DATA_TYPE               = ASCII_INTEGER
    START_BYTE              = 55
    BYTES                   = 3
    UNIT                    = SECOND
    FORMAT                  = "I3"
    DESCRIPTION             = "Scanner speed.
                              This is not the actual moving speed at the
                              specified time, but a setting speed value that is
                              applied in operation to the scanner once a command
                              is sent to move it.
                              The field takes one of the following values:
                              0 (standing)
                              32 (seconds scan)
                              64 (seconds scan)
                              128 (seconds scan)"
  END_OBJECT                = COLUMN

  OBJECT                    = COLUMN
    COLUMN_NUMBER           = 6
    NAME                    = "SCANNER_POSITION"
    DATA_TYPE               = ASCII_REAL
    START_BYTE              = 59
    BYTES                   = 5
    UNIT                    = "DEGREE"
    FORMAT                  = "F5.1"
    DESCRIPTION             = "Scanner position in degrees"
  END_OBJECT                = COLUMN

  OBJECT                    = COLUMN
    COLUMN_NUMBER           = 7
    NAME                    = "ACCUMULATION_TIME "
    DATA_TYPE               = ASCII_INTEGER
    START_BYTE              = 65
    BYTES                   = 2
    UNIT                    = "N/A"
    FORMAT                  = "I2"
    DESCRIPTION             = "Accumulation time.
                              Time = 2N*31.25ms"
  END_OBJECT                = COLUMN

  OBJECT                    = COLUMN
```

```
   COLUMN_NUMBER        = 8
   NAME                 = "LOG_COMPRESSION"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 68
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
   DESCRIPTION          = "The field takes one of the following values:
                           0 = disable
                           1 = enable"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 9
   NAME                 = "RICE_COMPRESSION_FLAG"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 70
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
   DESCRIPTION          = "Rice compression flag status.
                            The field takes one of the following values:
                            0 = non valid
                            1 = valid"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 10
   NAME                 = "RICE_COMPRESSION_VALUE"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 72
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
   DESCRIPTION          = "Rice compression"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 11
   NAME                 = "FRONTCTRL"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 74
   BYTES                = 3
   UNIT                 = "N/A"
   FORMAT               = "I3"
   DESCRIPTION          = "This register is used to as a common control
                           register. To decode into Binary format.
                           Each bit may take one of the following values :
                           bit 0 (TDCINEMA) =1 enables attention of TDC to
                                               the input signals start, stop
                                               and calibration clock
                           bit 1 (TDCOUNTIS) =1 disables readout of valid data
                                               from the TDC
                           bit 2 (CALWAITENA)=1 enables wait for calibration
                                               values
                           bit 3 (AUTORSTDIS)=1 disables automatic TDC-reset
                                               when SYSERR occurs
                           bit 4 (STOARTDIS) =1 disables generation of
                                               artificial stop signal
                           bit 5 (CNTDIS)    =1 disables FPGA counter
                           bit 6 (STADIS)    =1 disables start signal going
                                               into TDC
```

```
                                bit 7 (ADCCALDIS) =1 disables using of ADC
                                                     calibration
                                bit 8-15  n.c."
        END_OBJECT              = COLUMN

        OBJECT                  = COLUMN
           COLUMN_NUMBER        = 12
           NAME                 = "MAINCTRL"
           DATA_TYPE            = ASCII_INTEGER
           START_BYTE           = 78
           BYTES                = 3
           UNIT                 = "N/A"
           FORMAT               = "I3"
           DESCRIPTION          = "This register is used to as a common control
                                  register. To decode into Binary format.
                                  Each bit may take one of the following values :
                                  bit 0-1 (LVL[1:0])   Level of storing as binning
                                                       data, storing into binning
                                                       array will be omitted if
                                                       COIN[2:0]>LVL[1:0]
                                  bit 2 (STOREDIS)  =1 disables storing into SRAM
                                  bit 3 (DEBUGENA)  =1 enables simulation of
                                                       rawdata(debug)
                                  bit 4 (DELSIMDIS) =1 disables simultaneously
                                                       deleting of both Binning and
                                                       Raw Data array (after each
                                                       read access on data)
                                  bit 5 (LATCHUP)   =1 LatchUp occured
                                  bit 6 (ECENA)     =1 Hamming-code Error Correction
                                                       on SRAM data enabled
                                  bit 7-15  n.c."
        END_OBJECT              = COLUMN

        OBJECT                  = COLUMN
           COLUMN_NUMBER        = 13
           NAME                 = "STAT"
           DATA_TYPE            = ASCII_INTEGER
           START_BYTE           = 82
           BYTES                = 5
           UNIT                 = "N/A"
           FORMAT               = "I5"
           DESCRIPTION          = "This register is used to reflect some TDC and FPGA
                                  status signals.
                                  To decode into Binary format.
                                  Each bit may take one of the following values :
                                  bit 0 (TDCSYSERR)   SYSERR-Flag from TDC
                                  bit 1 (TDCREADY)    READY-Flag from TDC
                                  bit 2 (TDCVALID)    VALID-Flag from TDC
                                  bit 3 (TDCCALM)     CALM-Flag from TDC
                                  bit 4 (TDCBUSDIR)   BUSDIR-Flag from TDC
                                  bit 5-8  n.c
                                  bit 9 (TDCWRERR)    TDC write access error-Flag
                                  bit 10 (TDCRDERR)   TDC read access error-Flag
                                  bit 11 (TDCCMDERR)  TDC command error-Flag
                                  bit 12 (CMDBUSY) =1 Commanding TDC active
                                  bit 13 (DACBUSY) =1 Programming DAC
                                  bit 14 (NEWCAL)  =1 new calibration data available
                                                      any read-access to the CALIBxx
                                                      registers resets this flag
                                  bit 15 (ADCERR)  =1 ADC error occured"
        END_OBJECT              = COLUMN
```

```
OBJECT                    = COLUMN
   COLUMN_NUMBER          = 14
   NAME                   = "TDCRD"
   DATA_TYPE              = ASCII_INTEGER
   START_BYTE             = 88
   BYTES                  = 5
   UNIT                   = "N/A"
   FORMAT                 = "I5"
   DESCRIPTION            = "After the transmission of an appropriate
                             TDC-opcode, the contents of the requested TDC
                             register is available in this register."
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 15
   NAME                   = "CALIB11"
   DATA_TYPE              = ASCII_INTEGER
   START_BYTE             = 94
   BYTES                  = 5
   UNIT                   = "N/A"
   FORMAT                 = "I5"
   DESCRIPTION            = "This register contains part1 of the calibration
                             data from the TDC (CAL11)."
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 16
   NAME                   = "CALIB12"
   DATA_TYPE              = ASCII_INTEGER
   START_BYTE             = 100
   BYTES                  = 5
   UNIT                   = "N/A"
   FORMAT                 = "I5"
   DESCRIPTION            = "This register contains part2 of the calibration
                             data from the TDC (CAL12)."
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 17
   NAME                   = "CALIB21"
   DATA_TYPE              = ASCII_INTEGER
   START_BYTE             = 106
   BYTES                  = 5
   UNIT                   = "N/A"
   FORMAT                 = "I5"
   DESCRIPTION            = "This register contains part3 of the calibration
                             data from the TDC (CAL21)."
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 18
   NAME                   = "CALIB22"
   DATA_TYPE              = ASCII_INTEGER
   START_BYTE             = 112
   BYTES                  = 5
   UNIT                   = "N/A"
   FORMAT                 = "I5"
   DESCRIPTION            = "This register contains part4 of the calibration
                             data from the TDC (CAL22)."
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
```

```
   COLUMN_NUMBER        = 19
   NAME                 = "STARTCNT"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 118
   BYTES                = 5
   UNIT                 = "N/A"
   FORMAT               = "I5"
   DESCRIPTION          = "This register counts the start-signals from the
                           NPD-sensor up to the upper limit of 65536."
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 20
   NAME                 = "STOP0CNT"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 124
   BYTES                = 5
   UNIT                 = "N/A"
   FORMAT               = "I5"
   DESCRIPTION          = "This register counts the stop0-signals from the
                           NPD-sensor up to the upper limit of 65536."
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 21
   NAME                 = "STOP1CNT"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 130
   BYTES                = 5
   UNIT                 = "N/A"
   FORMAT               = "I5"
   DESCRIPTION          = "This register counts the stop1-signals from the
                           NPD-sensor up to the upper limit of 65536."
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 22
   NAME                 = "STOP2CNT"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 136
   BYTES                = 5
   UNIT                 = "N/A"
   FORMAT               = "I5"
   DESCRIPTION          = "This register counts the stop2-signals from the
                           NPD-sensor up to the upper limit of 65536."
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 23
   NAME                 = "TOFCNT"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 142
   BYTES                = 5
   UNIT                 = "N/A"
   FORMAT               = "I5"
   DESCRIPTION          = "This register counts the generated TOF values
                           up to the upper limit of 65536."
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 24
   NAME                 = "RAWCNT"
```

```
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 148
   BYTES                = 5
   UNIT                 = "N/A"
   FORMAT               = "I5"
   DESCRIPTION          = "This register counts the generated RAW values
                          up to the upper limit of 65536."
END_OBJECT              = COLUMN
```

Detailed description of those parameters is provided in documents [AD 3].

4.3.5.5.2 The description of the NPD1 and NPD2 header table for Binning data mode

The description presented hereafter applies to both NPD1 and NPD2 sensors.

```
OBJECT                  = NPD_BINHEAD_TABLE
   NAME                 = "NPD_BINHEAD"
   ROW_SUFFIX_BYTES     = Number of bytes that are accounted in the subsequent
                          table, including record terminators and separators
   INTERCHANGE_FORMAT   = ASCII
   ROWS                 = Number of rows within the data file
   COLUMNS              = 19
   ROW_BYTES            = 123
  ^STRUCTURE            = "NPD_BINHEAD.FMT"
END_OBJECT              = NPD_BINHEAD_TABLE
```

The structure of the TABLE object is described in the file NPD_BINHEAD.FMT as follows:

```
  /*  Contents of format file  "NPD_BINHEAD.FMT"  */
OBJECT                  = COLUMN
   COLUMN_NUMBER        = 1
   NAME                 = "UTC"
   DATA_TYPE            = TIME
   START_BYTE           = 1
   BYTES                = 23
   UNIT                 = "N/A"
   DESCRIPTION          = "This column represents the UTC of the
                           NPD science data in PDS standard format
                           YYYY-MM-DDThh:mm:ss.sss"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 2
   NAME                 = "OBT"
   DATA_TYPE            = CHARACTER
   START_BYTE           = 26
   BYTES                = 19
   UNIT                 = "N/A"
   DESCRIPTION          = "On board Time (OBT) is represented as :
                          <Reset number>/<unit seconds>.<fractional seconds>
                          with
                          <Reset number>: integer starting at 1
                             Reset number 1 starts at 2005-03-01T00:00:00 UTC
                          <unit seconds>: 10 digits number of unit seconds
                          <fractional seconds>: 5 digits number of fractional
                             seconds expressed as multiples of 2^-16 seconds"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 3
   NAME                 = "SW_VERSION"
   DATA_TYPE            = ASCII_INTEGER
```

```
      START_BYTE              = 47
      BYTES                   = 5
      UNIT                    = "N/A"
      FORMAT                  = "I5"
      DESCRIPTION             = "Software version
                                 To decode into Binary format. Bit description:
                                 patchVersion [3:0]
                                 minorVersion [8:4]
                                 majorVersion [13:9]
                                 releaseClass [15:14]: 1 (D), 2 (T), 3 (R)"
   END_OBJECT                 = COLUMN

   OBJECT                     = COLUMN
      COLUMN_NUMBER           = 4
      NAME                    = "SCANNER_DIRECTION"
      DATA_TYPE               = ASCII_INTEGER
      START_BYTE              = 53
      BYTES                   = 1
      UNIT                    = "N/A"
      FORMAT                  = "I1"
      DESCRIPTION             = "Scanner direction.
                                 The field takes one of the following values:
                                 0: 0 - 180
                                 1: 180 - 0"
   END_OBJECT                 = COLUMN

   OBJECT                     = COLUMN
      COLUMN_NUMBER           = 5
      NAME                    = "SCANNER_SPEED"
      DATA_TYPE               = ASCII_INTEGER
      START_BYTE              = 55
      BYTES                   = 3
      UNIT                    = SECOND
      FORMAT                  = "I3"
      DESCRIPTION             = "Scanner speed.
                                 This is not the actual moving speed at the
                                 specified time, but a setting speed value that is
                                 applied in operation to the scanner once a command
                                 is sent to move it.
                                 The field takes one of the following values:
                                 0 (standing)
                                 32 (seconds scan)
                                 64 (seconds scan)
                                 128 (seconds scan)"
   END_OBJECT                 = COLUMN

   OBJECT                     = COLUMN
      COLUMN_NUMBER           = 6
      NAME                    = "SCANNER_POSITION"
      DATA_TYPE               = ASCII_REAL
      START_BYTE              = 59
      BYTES                   = 5
      UNIT                    = "DEGREE"
      FORMAT                  = "F5.1"
      DESCRIPTION             = "Scanner position in degrees"
   END_OBJECT                 = COLUMN

   OBJECT                     = COLUMN
      COLUMN_NUMBER           = 7
      NAME                    = "ACCUMULATION_TIME "
      DATA_TYPE               = ASCII_INTEGER
      START_BYTE              = 65
```

```
   BYTES                  = 2
   UNIT                   = "N/A"
   FORMAT                 = "I2"
   DESCRIPTION            = "Accumulation time.
                             Time = 2N*31.25ms"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 8
   NAME                   = "LOG_COMPRESSION"
   DATA_TYPE              = ASCII_INTEGER
   START_BYTE             = 68
   BYTES                  = 1
   UNIT                   = "N/A"
   FORMAT                 = "I1"
   DESCRIPTION            = "The field takes one of the following values:
                              0 = disable
                              1 = enable"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 9
   NAME                   = "RICE_COMPRESSION_FLAG"
   DATA_TYPE              = ASCII_INTEGER
   START_BYTE             = 70
   BYTES                  = 1
   UNIT                   = "N/A"
   FORMAT                 = "I1"
   DESCRIPTION            = "Rice compression flag status.
                              The field takes one of the following values:
                              0 = non valid
                              1 = valid"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 10
   NAME                   = "RICE_COMPRESSION_VALUE"
   DATA_TYPE              = ASCII_INTEGER
   START_BYTE             = 72
   BYTES                  = 1
   UNIT                   = "N/A"
   FORMAT                 = "I1"
   DESCRIPTION            = "Rice compression"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 11
   NAME                   = "THRESHOLD"
   DATA_TYPE              = ASCII_INTEGER
   START_BYTE             = 74
   BYTES                  = 2
   UNIT                   = "N/A"
   FORMAT                 = "I2"
   DESCRIPTION            = "The threshold value indicates the size of the
                             PH*TOF matrix for the current direction.
                             The field takes one of the following values:
                             0    = Bin Matrix 0,  16(stop PH)*16(TOF)
                             1-14 = Bin Matrix 1,   2(stop PH)*16(TOF)
                             15   = Bin Matrix 2,   1(stop PH)*16(TOF)"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
```

```
   COLUMN_NUMBER        = 12
   NAME                 = "CALIB11"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 77
   BYTES                = 5
   UNIT                 = "N/A"
   FORMAT               = "I5"
   DESCRIPTION          = "This register contains part1 of the calibration
                          data from the TDC (CAL11)."
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 13
   NAME                 = "CALIB12"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 83
   BYTES                = 5
   UNIT                 = "N/A"
   FORMAT               = "I5"
   DESCRIPTION          = "This register contains part2 of the calibration
                          data from the TDC (CAL12)."
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 14
   NAME                 = "CALIB21"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 89
   BYTES                = 5
   UNIT                 = "N/A"
   FORMAT               = "I5"
   DESCRIPTION          = "This register contains part3 of the calibration
                          data from the TDC (CAL21)."
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 15
   NAME                 = "CALIB22"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 95
   BYTES                = 5
   UNIT                 = "N/A"
   FORMAT               = "I5"
   DESCRIPTION          = "This register contains part4 of the calibration
                          data from the TDC (CAL22)."
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 16
   NAME                 = "STARTCNT"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 101
   BYTES                = 5
   UNIT                 = "N/A"
   FORMAT               = "I5"
   DESCRIPTION          = "This register counts the start-signals from the
                          NPD-sensor up to the upper limit of 65536."
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 17
   NAME                 = "STOP0CNT"
```

```
            DATA_TYPE            = ASCII_INTEGER
            START_BYTE           = 107
            BYTES                = 5
            UNIT                 = "N/A"
            FORMAT               = "I5"
            DESCRIPTION          = "This register counts the stop0-signals from the
                                    NPD-sensor up to the upper limit of 65536."
        END_OBJECT               = COLUMN

        OBJECT                   = COLUMN
            COLUMN_NUMBER        = 18
            NAME                 = "STOP1CNT"
            DATA_TYPE            = ASCII_INTEGER
            START_BYTE           = 113
            BYTES                = 5
            UNIT                 = "N/A"
            FORMAT               = "I5"
            DESCRIPTION          = "This register counts the stop1-signals from the
                                    NPD-sensor up to the upper limit of 65536."
        END_OBJECT               = COLUMN

        OBJECT                   = COLUMN
            COLUMN_NUMBER        = 19
            NAME                 = "STOP2CNT"
            DATA_TYPE            = ASCII_INTEGER
            START_BYTE           = 119
            BYTES                = 5
            UNIT                 = "N/A"
            FORMAT               = "I5"
            DESCRIPTION          = "This register counts the stop2-signals from the
                                    NPD-sensor up to the upper limit of 65536."
        END_OBJECT               = COLUMN
```

Detailed description of those parameters is provided in documents [AD 3].

4.3.5.5.3 The description of the NPD1 and NPD2 header table for the TOF data mode

The description presented hereafter applies to both NPD1 and NPD2 sensors.

```
        OBJECT                   = NPD_TOFHEAD_TABLE
            NAME                 = "NPD_TOFHEAD"
            ROW_SUFFIX_BYTES     = Number of bytes that are accounted in the subsequent
                                   table, including record terminators and separators
            INTERCHANGE_FORMAT   = ASCII
            ROWS                 = Number of rows within the data file
            COLUMNS              = 19
            ROW_BYTES            = 124
           ^STRUCTURE            = "NPD_TOFHEAD.FMT"
        END_OBJECT               = NPD_TOFHEAD_TABLE
```

The structure of the TABLE object is described in the file NPD_TOFHEAD.FMT as follows:

```
        /*  Contents of format file  "NPD_TOFHEAD.FMT"  */
        OBJECT                   = COLUMN
            COLUMN_NUMBER        = 1
            NAME                 = "UTC"
            DATA_TYPE            = TIME
            START_BYTE           = 1
            BYTES                = 23
            UNIT                 = "N/A"
            DESCRIPTION          = "This column represents the UTC of the
                                    NPD science data in PDS standard format
```

```
                          YYYY-MM-DDThh:mm:ss.sss"
 END_OBJECT               = COLUMN

 OBJECT                   = COLUMN
    COLUMN_NUMBER         = 2
    NAME                  = "OBT"
    DATA_TYPE             = CHARACTER
    START_BYTE            = 26
    BYTES                 = 19
    UNIT                  = "N/A"
    DESCRIPTION           = "On board Time (OBT) is represented as :
                            <Reset number>/<unit seconds>.<fractional seconds>
                            with
                            <Reset number>: integer starting at 1
                               Reset number 1 starts at 2005-03-01T00:00:00 UTC
                            <unit seconds>: 10 digits number of unit seconds
                            <fractional seconds>: 5 digits number of fractional
                               seconds expressed as multiples of 2^-16 seconds"
 END_OBJECT               = COLUMN

 OBJECT                   = COLUMN
    COLUMN_NUMBER         = 3
    NAME                  = "SW_VERSION"
    DATA_TYPE             = ASCII_INTEGER
    START_BYTE            = 47
    BYTES                 = 5
    UNIT                  = "N/A"
    FORMAT                = "I5"
    DESCRIPTION           = "Software version
                            To decode into Binary format. Bit description:
                            patchVersion [3:0]
                            minorVersion [8:4]
                            majorVersion [13:9]
                            releaseClass [15:14]: 1 (D), 2 (T), 3 (R)"
 END_OBJECT               = COLUMN

 OBJECT                   = COLUMN
    COLUMN_NUMBER         = 4
    NAME                  = "SCANNER_DIRECTION"
    DATA_TYPE             = ASCII_INTEGER
    START_BYTE            = 53
    BYTES                 = 1
    UNIT                  = "N/A"
    FORMAT                = "I1"
    DESCRIPTION           = "Scanner direction.
                             The field takes one of the following values:
                             0: 0 - 180
                             1: 180 - 0"
 END_OBJECT               = COLUMN

 OBJECT                   = COLUMN
    COLUMN_NUMBER         = 5
    NAME                  = "SCANNER_SPEED"
    DATA_TYPE             = ASCII_INTEGER
    START_BYTE            = 55
    BYTES                 = 3
    UNIT                  = SECOND
    FORMAT                = "I3"
    DESCRIPTION           = "Scanner speed.
                             This is not the actual moving speed at the
                             specified time, but a setting speed value that is
                             applied in operation to the scanner once a command
```

```
                             is sent to move it.
                             The field takes one of the following values:
                             0 (standing)
                             32 (seconds scan)
                             64 (seconds scan)
                             128 (seconds scan)"
   END_OBJECT            = COLUMN

   OBJECT               = COLUMN
      COLUMN_NUMBER     = 6
      NAME              = "SCANNER_POSITION"
      DATA_TYPE         = ASCII_REAL
      START_BYTE        = 59
      BYTES             = 5
      UNIT              = "DEGREE"
      FORMAT            = "F5.1"
      DESCRIPTION       = "Scanner position in degrees"
   END_OBJECT            = COLUMN

   OBJECT               = COLUMN
      COLUMN_NUMBER     = 7
      NAME              = "ACCUMULATION_TIME "
      DATA_TYPE         = ASCII_INTEGER
      START_BYTE        = 65
      BYTES             = 2
      UNIT              = "N/A"
      FORMAT            = "I2"
      DESCRIPTION       = "Accumulation time.
                            Time = 2N*31.25ms"
   END_OBJECT            = COLUMN

   OBJECT               = COLUMN
      COLUMN_NUMBER     = 8
      NAME              = "LOG_COMPRESSION"
      DATA_TYPE         = ASCII_INTEGER
      START_BYTE        = 68
      BYTES             = 1
      UNIT              = "N/A"
      FORMAT            = "I1"
      DESCRIPTION       = "The field takes one of the following values:
                            0 = disable
                            1 = enable"
   END_OBJECT            = COLUMN

   OBJECT               = COLUMN
      COLUMN_NUMBER     = 9
      NAME              = "RICE_COMPRESSION_FLAG"
      DATA_TYPE         = ASCII_INTEGER
      START_BYTE        = 70
      BYTES             = 1
      UNIT              = "N/A"
      FORMAT            = "I1"
      DESCRIPTION       = "Rice compression flag status.
                            The field takes one of the following values:
                            0 = non valid
                            1 = valid"
   END_OBJECT            = COLUMN

   OBJECT               = COLUMN
      COLUMN_NUMBER     = 10
      NAME              = "RICE_COMPRESSION_VALUE"
      DATA_TYPE         = ASCII_INTEGER
```

```
      START_BYTE            = 72
      BYTES                 = 1
      UNIT                  = "N/A"
      FORMAT                = "I1"
      DESCRIPTION           = "Rice compression"
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 11
      NAME                  = "NB_VALID_SAMPLES"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 74
      BYTES                 = 3
      UNIT                  = "N/A"
      FORMAT                = "I3"
      DESCRIPTION           = "Number of valid samples integrated to the matrix.
                                LatchUp may happen during integration. Affected
                                samples are not integrated to the matrix."
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 12
      NAME                  = "CALIB11"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 78
      BYTES                 = 5
      UNIT                  = "N/A"
      FORMAT                = "I5"
      DESCRIPTION           = "This register contains part1 of the calibration
                                data from the TDC (CAL11)."
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 13
      NAME                  = "CALIB12"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 84
      BYTES                 = 5
      UNIT                  = "N/A"
      FORMAT                = "I5"
      DESCRIPTION           = "This register contains part2 of the calibration
                                data from the TDC (CAL12)."
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 14
      NAME                  = "CALIB21"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 90
      BYTES                 = 5
      UNIT                  = "N/A"
      FORMAT                = "I5"
      DESCRIPTION           = "This register contains part3 of the calibration
                                data from the TDC (CAL21)."
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 15
      NAME                  = "CALIB22"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 96
      BYTES                 = 5
```

```
                 UNIT            = "N/A"
                 FORMAT          = "I5"
                 DESCRIPTION     = "This register contains part4 of the calibration
                                    data from the TDC (CAL22)."
          END_OBJECT             = COLUMN

          OBJECT                 = COLUMN
                 COLUMN_NUMBER   = 16
                 NAME            = "STARTCNT"
                 DATA_TYPE       = ASCII_INTEGER
                 START_BYTE      = 102
                 BYTES           = 5
                 UNIT            = "N/A"
                 FORMAT          = "I5"
                 DESCRIPTION     = "This register counts the start-signals from the
                                    NPD-sensor up to the upper limit of 65536."
          END_OBJECT             = COLUMN

          OBJECT                 = COLUMN
                 COLUMN_NUMBER   = 17
                 NAME            = "STOP0CNT"
                 DATA_TYPE       = ASCII_INTEGER
                 START_BYTE      = 108
                 BYTES           = 5
                 UNIT            = "N/A"
                 FORMAT          = "I5"
                 DESCRIPTION     = "This register counts the stop0-signals from the
                                    NPD-sensor up to the upper limit of 65536."
          END_OBJECT             = COLUMN

          OBJECT                 = COLUMN
                 COLUMN_NUMBER   = 18
                 NAME            = "STOP1CNT"
                 DATA_TYPE       = ASCII_INTEGER
                 START_BYTE      = 114
                 BYTES           = 5
                 UNIT            = "N/A"
                 FORMAT          = "I5"
                 DESCRIPTION     = "This register counts the stop1-signals from the
                                    NPD-sensor up to the upper limit of 65536."
          END_OBJECT             = COLUMN

          OBJECT                 = COLUMN
                 COLUMN_NUMBER   = 19
                 NAME            = "STOP2CNT"
                 DATA_TYPE       = ASCII_INTEGER
                 START_BYTE      = 120
                 BYTES           = 5
                 UNIT            = "N/A"
                 FORMAT          = "I5"
                 DESCRIPTION     = "This register counts the stop2-signals from the
                                    NPD-sensor up to the upper limit of 65536."
          END_OBJECT             = COLUMN
```

Detailed description of those parameters is provided in documents [AD 3].

4.3.5.5.4   The description of the NPD1 and NPD2 science table related to mode raw data:

A raw data record contains 512 quadruplet values, one for each observation. Incoming raw data items are sequentially stored until the record is complete and properly sorted within this record by group of data with

parameter of same type. Thus first 512 data values refer to the stop pulse height MCP charge (stop PH) measurements, next 512 items are Time-Of-Flight data values, followed by the direction then the coincidence values. In the label, the NPD1 and NPD2 raw science data are described as a linear storage TABLE object with fixed length containing 4 columns of 512 data values for handling each measured parameter of the quadruplet.

The structure of the science raw data object is fully described in the associated label file, with no applicable external files (FMT). This description is presented hereafter and applies to both NPD1 and NPD2 sensors.

```
OBJECT                  = NPD_RAWSCIE_TABLE
   NAME                 = "NPD_RAW_SCIENCE"
   ROW_PREFIX_BYTES     = 152
   INTERCHANGE_FORMAT   = ASCII
   ROWS                 = Number of rows within the data file
   COLUMNS              = 4
   ROW_BYTES            = 6658
   DESCRIPTION          = "Uncalibrated NPD1 sensor science data in
                            raw data operation mode."

   OBJECT               = COLUMN
      COLUMN_NUMBER     = 1
      NAME              = "NPD_STOP_PH"
      DATA_TYPE         = ASCII_INTEGER
      START_BYTE        = 1
      BYTES             = 2048
      UNIT              = "N/A"
      FORMAT            = "I3"
      DESCRIPTION       = "Uncalibrated stop pulse height values."
      ITEMS             = 512
      ITEM_BYTES        = 4
   END_OBJECT           = COLUMN

   OBJECT               = COLUMN
      COLUMN_NUMBER     = 2
      NAME              = "NPD_TOF"
      DATA_TYPE         = ASCII_INTEGER
      START_BYTE        = 2049
      BYTES             = 2560
      UNIT              = "N/A"
      FORMAT            = "I4"
      DESCRIPTION       = "Uncalibrated Time of Flight value. The TOF
                            values are expressed in 0.5ns steps "
      ITEMS             = 512
      ITEM_BYTES        = 5
   END_OBJECT           = COLUMN

   OBJECT               = COLUMN
      COLUMN_NUMBER     = 3
      NAME              = "NPD_DIRECTION"
         DATA_TYPE      = ASCII_INTEGER
      START_BYTE        = 4609
      BYTES             = 1024
      UNIT              = "N/A"
      FORMAT            = "I1"
      DESCRIPTION       = "The stop MCP value referring to the direction
                            of the arrival particles.
                            The field takes one of the following values:
                            0 = Stop0
                            1 = Stop1
                            2 = Stop2"
      ITEMS             = 512
      ITEM_BYTES        = 2
```

```
        END_OBJECT          = COLUMN

        OBJECT              = COLUMN
            COLUMN_NUMBER   = 4
            NAME            = "NPD_COINCIDENCE"
            DATA_TYPE       = ASCII_INTEGER
            START_BYTE      = 5633
            BYTES           = 1024
            UNIT            = "N/A"
            FORMAT          = "I1"
            DESCRIPTION     = "The coincidence control may takes one of the
                               following values:
                               0 = 1 Start, 1 Stop
                               1 = n Start, 1 Stop
                               2 = 1 Start, n Stop
                               3 = n Start, n Stop
                               4 = 0 Start, 1 Stop
                               where n=2,3,..."
            ITEMS           = 512
            ITEM_BYTES      = 2
        END_OBJECT          = COLUMN

    END_OBJECT              = NPD_RAWSCIE_TABLE
```

Detailed description of those parameters is provided in documents [AD 3].

4.3.5.5.5   The description of the NPD1 and NPD2 science table related to mode binning data:

A binning block data array as delivered in telemetry packets contains 3 consecutive matrices (stop PH)×(TOF) of counter values, one for each direction of observation. The first matrix refers to the first direction [0], the last one referring to the third direction [2]. All matrices may contain a maximum of 16×16 values that can be further reduced along the stop PH axis to 2 or 1 bin. For each direction, a corresponding Threshold value sets the size of the matrix. 3 sizes are available: 1×16, 2×16 and 16×16. The 16 TOF bin numbers are associated to uncompressed bin values as following:

TOF COMPRESSED	TOF[11:0]
0	100 - 124
1	125 - 156
2	157 - 197
3	198 - 248
4	249 - 311
5	312 - 391
6	392 - 491
7	492 - 617
8	618 - 774
9	775 - 972
10	973 - 1220
11	1221 - 1532
12	1533 - 1923
13	1924 - 2413
14	2414 - 3028
15	3029 - 3800

where the uncompressed TOF values are expressed in 0.5ns steps.
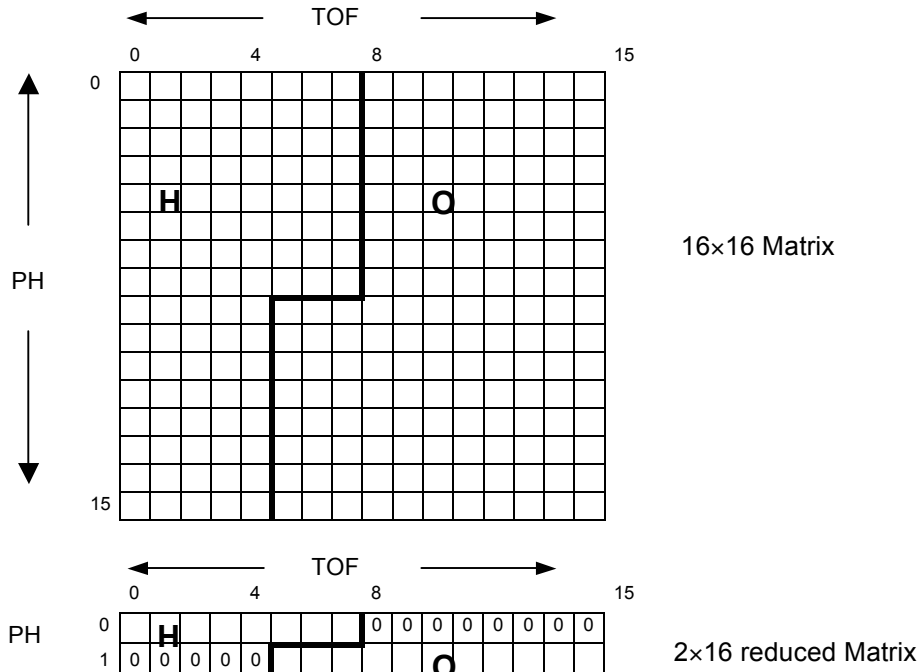
**Figure 16.** Reduction of the 16×16 bin matrix to 2×16 matrix.

The reduction of 16 stop PH to 2 is shown graphically in Figure 16. It is done according to the algorithm as below:

if (TOF_index ≤ 4) : New_stop_PH_index = 0 (H)
if (TOF_index ≥ 8) : New_stop_PH_index = 1 (O)
if (TOF_index > 4) and (TOF_index < 8)
    if (stop_PH_index ≤ Threshold) : New_stop_PH_index = 0 (H)
    else :   New_stop_PH_index = 1 (O)

where the Threshold is commendable and depends on direction (STOP MCP number), and the New_stop_PH_index defines the mass species index (H or O) within the new 2×16 matrix. Following this algorithm, the reduction scheme consists of integrating counters of a same TOF bin number for each species group, and completing by 0 the H and O counters of the new matrix where not applicable. The reduction to 1×16 matrix is simply based on the column sum of corresponding counter values from same TOF bin number, without ENA mass separation.

Different NPD1 and NPD2 binning science data product files may exist depending on the direction of arrival particles and the PHD×TOF reduction scheme that is applied. Thus a data product file contains records of neutral particle count values for a single direction (the *Dd* field in the file name) and a single type of matrix (the *mm* field in the file name).

Within each binning data product file, data are stored into a linear storage TABLE object in which records have a constant length. The structure of this object is described in the label, with no applicable external files (FMT). It may contain of as many items as the considered matrix (meaning 16 items for a 1*16 matrix, 32 items for a 2*16 matrix and 256 items for a 16*16 matrix) with TOF the fastest varying parameter. This description is presented hereafter and applies to both NPD1 and NPD2 sensors.

```
OBJECT                = NPD_BINSCIE_TABLE
   NAME               = "NPD_BIN_SCIENCE"
   ROW_PREFIX_BYTES   = 123
```

```
INTERCHANGE_FORMAT   = ASCII
ROWS                 = Number of rows within the data file
COLUMNS              = 1
ROW_BYTES            = (number of items) * (item bytes) plus 2 terminators

OBJECT               = COLUMN
   COLUMN_NUMBER     = 1
   NAME              = "BIN_COUNTS"
   DATA_TYPE         = ASCII_INTEGER
   START_BYTE        = 1
   BYTES             = (number of items) * (item bytes) plus 2 terminators
   UNIT              = "ADC_UNITS"
   FORMAT            = "I5"
   DESCRIPTION       = "Uncalibrated NPDX sensor science data of the
                        direction X in binning data operation mode."
   ITEMS             = Number of items in the matrix 16, 32 or 256
   ITEM_BYTES        = 6
END_OBJECT           = COLUMN

END_OBJECT           = NPD_BINSCIE_TABL
```

4.3.5.5.6   The description of the NPD1 and NPD2 science table related to TOF mode:

A TOF block data array as delivered in telemetry packets contains 3 consecutive matrices of 256 TOF counters each, one for each direction of observation. The first matrix refers to the first direction [0], the last one referring to the third direction [2]. The 256 TOF bin numbers are in an 8-bit format converted from the 12-bit TOF by a 4-bit shift. The table below gives the 8-bit – 12-bit TOF correspondence. The units for the uncompressed 12-bit TOF bin values are expressed in 0.5ns steps.

TOF compressed	TOF[11:0]	TOF compressed	TOF[11:0]	TOF compressed	TOF[11:0]	TOF compressed	TOF[11:0]
0	0 - 15	64	1024 - 1039	128	2048 - 2063	192	3072 - 3087
1	16 - 31	65	1040 - 1055	129	2064 - 2079	193	3088 - 3103
2	32 - 47	66	1056 - 1071	130	2080 - 2095	194	3104 - 3119
3	48 - 63	67	1072 - 1087	131	2096 - 2111	195	3120 - 3135
4	64 - 79	68	1088 - 1103	132	2112 - 2127	196	3136 - 3151
5	80 - 95	69	1104 - 1119	133	2128 - 2143	197	3152 - 3167
6	96 - 111	70	1120 - 1135	134	2144 - 2159	198	3168 - 3183
7	112 - 127	71	1136 - 1151	135	2160 - 2175	199	3184 - 3199
8	128 - 143	72	1152 - 1167	136	2176 - 2191	200	3200 - 3215
9	144 - 159	73	1168 - 1183	137	2192 - 2207	201	3216 - 3231
10	160 - 175	74	1184 - 1199	138	2208 - 2223	202	3232 - 3247
11	176 - 191	75	1200 - 1215	139	2224 - 2239	203	3248 - 3263
12	192 - 207	76	1216 - 1231	140	2240 - 2255	204	3264 - 3279
13	208 - 223	77	1232 - 1247	141	2256 - 2271	205	3280 - 3295
14	224 - 239	78	1248 - 1263	142	2272 - 2287	206	3296 - 3311
15	240 - 255	79	1264 - 1279	143	2288 - 2303	207	3312 - 3327
16	256 - 271	80	1280 - 1295	144	2304 - 2319	208	3328 - 3343
17	272 - 287	81	1296 - 1311	145	2320 - 2335	209	3344 - 3359
18	288 - 303	82	1312 - 1327	146	2336 - 2351	210	3360 - 3375
19	304 - 319	83	1328 - 1343	147	2352 - 2367	211	3376 - 3391
20	320 - 335	84	1344 - 1359	148	2368 - 2383	212	3392 - 3407
21	336 - 351	85	1360 - 1375	149	2384 - 2399	213	3408 - 3423
22	352 - 367	86	1376 - 1391	150	2400 - 2415	214	3424 - 3439
23	368 - 383	87	1392 - 1407	151	2416 - 2431	215	3440 - 3455
24	384 - 399	88	1408 - 1423	152	2432 - 2447	216	3456 - 3471
25	400 - 415	89	1424 - 1439	153	2448 - 2463	217	3472 - 3487
26	416 - 431	90	1440 - 1455	154	2464 - 2479	218	3488 - 3503
27	432 - 447	91	1456 - 1471	155	2480 - 2495	219	3504 - 3519
28	448 - 463	92	1472 - 1487	156	2496 - 2511	220	3520 - 3535
29	464 - 479	93	1488 - 1503	157	2512 - 2527	221	3536 - 3551
30	480 - 495	94	1504 - 1519	158	2528 - 2543	222	3552 - 3567

31	496 - 511	95	1520 - 1535	159	2544 - 2559	223	3568 - 3583
32	512 - 527	96	1536 - 1551	160	2560 - 2575	224	3584 - 3599
33	528 - 543	97	1552 - 1567	161	2576 - 2591	225	3600 - 3615
34	544 - 559	98	1568 - 1583	162	2592 - 2607	226	3616 - 3631
35	560 - 575	99	1584 - 1599	163	2608 - 2623	227	3632 - 3647
36	576 - 591	100	1600 - 1615	164	2624 - 2639	228	3648 - 3663
37	592 - 607	101	1616 - 1631	165	2640 - 2655	229	3664 - 3679
38	608 - 623	102	1632 - 1647	166	2656 - 2671	230	3680 - 3695
39	624 - 639	103	1648 - 1663	167	2672 - 2687	231	3696 - 3711
40	640 - 655	104	1664 - 1679	168	2688 - 2703	232	3712 - 3727
41	656 - 671	105	1680 - 1695	169	2704 - 2719	233	3728 - 3743
42	672 - 687	106	1696 - 1711	170	2720 - 2735	234	3744 - 3759
43	688 - 703	107	1712 - 1727	171	2736 - 2751	235	3760 - 3775
44	704 - 719	108	1728 - 1743	172	2752 - 2767	236	3776 - 3791
45	720 - 735	109	1744 - 1759	173	2768 - 2783	237	3792 - 3807
46	736 - 751	110	1760 - 1775	174	2784 - 2799	238	3808 - 3823
47	752 - 767	111	1776 - 1791	175	2800 - 2815	239	3824 - 3839
48	768 - 783	112	1792 - 1807	176	2816 - 2831	240	3840 - 3855
49	784 - 799	113	1808 - 1823	177	2832 - 2847	241	3856 - 3871
50	800 - 815	114	1824 - 1839	178	2848 - 2863	242	3872 - 3887
51	816 - 831	115	1840 - 1855	179	2864 - 2879	243	3888 - 3903
52	832 - 847	116	1856 - 1871	180	2880 - 2895	244	3904 - 3919
53	848 - 863	117	1872 - 1887	181	2896 - 2911	245	3920 - 3935
54	864 - 879	118	1888 - 1903	182	2912 - 2927	246	3936 - 3951
55	880 - 895	119	1904 - 1919	183	2928 - 2943	247	3952 - 3967
56	896 - 911	120	1920 - 1935	184	2944 - 2959	248	3968 - 3983
57	912 - 927	121	1936 - 1951	185	2960 - 2975	249	3984 - 3999
58	928 - 943	122	1952 - 1967	186	2976 - 2991	250	4000 - 4015
59	944 - 959	123	1968 - 1983	187	2992 - 3007	251	4016 - 4031
60	960 - 975	124	1984 - 1999	188	3008 - 3023	252	4032 - 4047
61	976 - 991	125	2000 - 2015	189	3024 - 3039	253	4048 - 4063
62	992 - 1007	126	2016 - 2031	190	3040 - 3055	254	4064 - 4079
63	1008 - 1023	127	2032 - 2047	191	3056 - 3071	255	3072 - 3087

In the label, the NPD1 and NPD2 TOF science data are described as a linear storage TABLE object with records that are all the same length. Each record, or every row in the table, is composed of 768 items for storing 3*256 TOF counter values. This description, presented hereafter, applies to both NPD1 and NPD2 sensors.

```
OBJECT                  = NPD_TOFSCIE_TABLE
    NAME                = "NPD_TOF_SCIENCE"
    ROW_PREFIX_BYTES    = 124
    INTERCHANGE_FORMAT  = ASCII
    ROWS                = Number of rows within the data file
    COLUMNS             = 1
    ROW_BYTES           = 4610

    OBJECT              = COLUMN
        COLUMN_NUMBER   = 1
        NAME            = "NPD_TOF_COUNTS"
        DATA_TYPE       = ASCII_INTEGER
        START_BYTE      = 1
        BYTES           = 4610
        UNIT            = "ADC UNITS"
        FORMAT          = "I5"
        DESCRIPTION     = "Uncalibrated NPDX sensor science data in TOF
                           operation mode."
        ITEMS           = 768
        ITEM_BYTES      = 6
    END_OBJECT          = COLUMN

END_OBJECT          = NPD_TOFSCIE_TABLE
```

4.3.5.6 Description of Instrument

The description of the instrument is done in above and as a brief overview in the INST.CAT catalog file.

4.3.5.7 Parameters Index File Definition

N/A

4.3.5.8 Mission Specific Keywords

Mission specific keywords should all have the MISSION_ID "VEX" prefix.

```
VEX:SCIENCE_CASE_ID        = "ALL"
VEX:SCIENCE_CASE_ID_DESC   = "Please refer to VEX_SCIENCE_CASE_ID_DESC.TXT
                             in the DOCUMENT directory."
```

4.3.6 NPD Housekeeping Calibrated Data Product Design (Level 3)

NPD1 and NPD2 level 3 HK contains calibrated NPD housekeeping data with PDS detached labels. The incoming raw HK values are converted into physical values when calibration is applied. This type of data is identified by the following data descriptors within the current label file:

```
PRODUCT_TYPE               = RDR /* EDR for RAW, RDR for calibrated data */
PROCESSING_LEVEL_ID        = 3
```

HK parameters are listed in the following fields table in the same order that they appear in the data product label file.

Table 31. NPD1 housekeeping content.

Rank	Field	Rank	Field
1	UTC correlated Time	31	NPD1 calib12
2	OBT Time	32	NPD1 calib21
3	NPD1 temperature	33	NPD1 calib22
4	Scanner temperature sensor	34	NPD1 sefccnt
5	SW version	35	NPD1 defccnt
6	HK i +30V	36	Scanner vrefmc
7	HK i +5V	37	Scanner init
8	HK V +12V	38	Lost step
9	HK V +30V	39	Scanner status state
10	HK V +5V	40	Scanner status direction
11	HK V -12V	41	Scanner status position clock
12	HK V -5V	42	Scanner status cw end position
13	NDP1 +30V on/off	43	Scanner status ccw end position
14	NPD heaters on/off	44	Scanner speed
15	Sun sensor 1	45	Scanner setup direction
16	Sun sensor 2	46	Scanner setup mode
17	NPD1 deflector switch	47	Scanner +30V on/off
18	NPD1 bias monitor	48	Scanner coast current reference
19	NPD1 bias reference	49	Scanner ramp current reference
20	NPD1 deflector monitor	50	Scanner threshold cw reference
21	NDP1 deflector reference	51	Scanner threshold ccw reference
22	NPD1 start bias monitor	52	Scanner threshold wheel reference
23	NPD1 start bias reference	53	Scanner position
24	NPD1 stop bias monitor	54	SW mode
25	NPD1 stop bias reference	55	Cpu load
26	NPD1 front control	56	NPD accumulation time

27	NPD1 main control	57	NPD RICE compression enable
28	NDP1 stat	58	NPD LOG compression enable
29	NPD1 tdcrd	59	NPD1 mode
30	NPD1 calib11		

Table 32. NPD2 housekeeping content.

Rank	Field	Rank	Field
1	UTC correlated Time	31	NPD2 calib12
2	OBT Time	32	NPD2 calib21
3	NPD2 temperature	33	NPD2 calib22
4	Scanner temperature sensor	34	NPD2 sefccnt
5	SW version	35	NPD2 defccnt
6	HK i +30V	36	Scanner vrefmc
7	HK i +5V	37	Scanner init
8	HK V +12V	38	Lost step
9	HK V +30V	39	Scanner status state
10	HK V +5V	40	Scanner status direction
11	HK V -12V	41	Scanner status position clock
12	HK V -5V	42	Scanner status cw end position
13	NPD2 +30V on/off	43	Scanner status ccw end position
14	NPD heaters on/off	44	Scanner speed
15	Sun sensor 1	45	Scanner setup direction
16	Sun sensor 2	46	Scanner setup mode
17	NPD2 deflector switch	47	Scanner +30V on/off
18	NPD2 bias monitor	48	Scanner coast current reference
19	NPD2 bias reference	49	Scanner ramp current reference
20	NPD2 deflector monitor	50	Scanner threshold cw reference
21	NDP2 deflector reference	51	Scanner threshold ccw reference
22	NPD2 start bias monitor	52	Scanner threshold wheel reference
23	NPD2 start bias reference	53	Scanner position
24	NPD2 stop bias monitor	54	SW mode
25	NPD2 stop bias reference	55	Cpu load
26	NPD2 front control	56	NPD accumulation time
27	NPD2 main control	57	NPD RICE compression enable
28	NDP2 stat	58	NPD LOG compression enable
29	NPD2 tdcrd	59	NPD2 mode
30	NPD2 calib11		

The table object is detailed in the following paragraph.

4.3.6.1   File Characteristics Data Elements

The following elements are present in the labels for every NPD housekeeping calibrated data product, and they describe the basic characteristics of the data product in terms of structure and naming:

```
/* FILE CHARACTERISTIC DATA ELEMENTS */
PRODUCT_ID                      = this element defines the current product file name,
                                  without extension
RECORD_TYPE                     = FIXED_LENGTH
RECORD_BYTES                    = 295
FILE_RECORDS                    = this element indicates the number of records within
                                  the data file
```

4.3.6.2   Data Object Pointers Identification Data Elements

The NPD1 and NPD2 housekeeping calibrated data are organized as ASCII table. The data object pointers that references TAB file are:

```
^HK_NPD1_TABLE
^HK_NPD2_TABLE
```

4.3.6.3   Instrument and Detector Descriptive Data Elements

See the applicable section 4.3.1.3

4.3.6.4   Structure Definition of Instrument Parameter Objects

N/A

4.3.6.5   Data Object Definition

This section of the label defines the structure and content of the NPD1 and NPD2 housekeeping calibrated data product. Each data file (TAB) are organized as a linear storage TABLE object with fixed length records of 59 columns each that are assigned to contain calibrated HK data when calibration is applied.

NPD1 sensor:
```
OBJECT                 = HK_NPD1_TABLE
   NAME                = "HK_NPD1"
   INTERCHANGE_FORMAT  = ASCII
   ROWS                = Number of rows within the data file
   COLUMNS             = 59
   ROW_BYTES           = 295
   ^STRUCTURE          = "NPD1_SPECTRUM_HKNPD1.FMT"
END_OBJECT             = HK_NPD1_TABLE
```

The structure of the TABLE object is described in the file NPD1_SPECTRUM_HKNPD1.FMT as follows:

```
/*  Contents of format file  "NPD1_SPECTRUM_HKNPD1.FMT"  */
OBJECT                 = COLUMN
   COLUMN_NUMBER       = 1
   NAME                = "UTC"
   DATA_TYPE           = TIME
   START_BYTE          = 1
   BYTES               = 23
   UNIT                = "N/A"
   DESCRIPTION         = "This column represents the UTC of the
                          NPD HK data set in PDS standard format
                          YYYY-MM-DDThh:mm:ss.sss"
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
   COLUMN_NUMBER       = 2
   NAME                = "OBT"
   DATA_TYPE           = CHARACTER
   START_BYTE          = 26
   BYTES               = 19
   UNIT                = "N/A"
   DESCRIPTION         = "On board Time (OBT) is represented as :
                          <Reset number>/<unit seconds>.<fractional seconds>
                          with
                          <Reset number>: integer starting at 1
                             Reset number 1 starts at 2005-03-01T00:00:00 UTC
                          <unit seconds>: 10 digits number of unit seconds
                          <fractional seconds>: 5 digits number of fractional
```

```
                                         seconds expressed as multiples of 2^-16 seconds"
     END_OBJECT              = COLUMN

     OBJECT                  = COLUMN
        COLUMN_NUMBER        = 3
        NAME                 = "NPD1_TEMP"
        DATA_TYPE            = ASCII_REAL
        START_BYTE           = 47
        BYTES                = 7
        UNIT                 = "CELSIUS"
        FORMAT               = "F7.2"
        DESCRIPTION          = "NPD1 temperature in degree Celsius"
     END_OBJECT              = COLUMN

     OBJECT                  = COLUMN
        COLUMN_NUMBER        = 4
        NAME                 = "SCANNER_TEMP_SENSOR"
        DATA_TYPE            = ASCII_REAL
        START_BYTE           = 55
        BYTES                = 7
        UNIT                 = "CELSIUS"
        FORMAT               = "F7.2"
        DESCRIPTION          = "Scanner temperature sensor in degree Celsius"
     END_OBJECT              = COLUMN

     OBJECT                  = COLUMN
        COLUMN_NUMBER        = 5
        NAME                 = "SW_VERSION"
        DATA_TYPE            = ASCII_INTEGER
        START_BYTE           = 63
        BYTES                = 5
        UNIT                 = "N/A"
        FORMAT               = "I5"
        DESCRIPTION          = "Software version
                                 To decode into Binary format. Bit description:
                                 patchVersion [3:0]
                                 minorVersion [8:4]
                                 majorVersion [13:9]
                                 releaseClass [15:14]: 1 (D), 2 (T), 3 (R)"
     END_OBJECT              = COLUMN

     OBJECT                  = COLUMN
        COLUMN_NUMBER        = 6
        NAME                 = "HK_I_PLUS_30V"
        DATA_TYPE            = ASCII_REAL
        START_BYTE           = 69
        BYTES                = 6
        UNIT                 = "MILLIAMPERE"
        FORMAT               = "F6.2"
        DESCRIPTION          = "HK i +30V in milli-amperes"
     END_OBJECT              = COLUMN

     OBJECT                  = COLUMN
        COLUMN_NUMBER        = 7
        NAME                 = "HK_I_PLUS_5V"
        DATA_TYPE            = ASCII_REAL
        START_BYTE           = 76
        BYTES                = 7
        UNIT                 = "MILLIAMPERE"
        FORMAT               = "F7.2"
        DESCRIPTION          = "HK i +5V in milli-amperes"
     END_OBJECT              = COLUMN
```

```
OBJECT                    = COLUMN
   COLUMN_NUMBER          = 8
   NAME                   = "HK_V_PLUS_12V"
   DATA_TYPE              = ASCII_REAL
   START_BYTE             = 84
   BYTES                  = 5
   UNIT                   = "VOLT"
   FORMAT                 = "F5.2"
   DESCRIPTION            = "HK V +12V in Volts"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 9
   NAME                   = "HK_V_PLUS_30V"
   DATA_TYPE              = ASCII_REAL
   START_BYTE             = 90
   BYTES                  = 6
   UNIT                   = "VOLTS"
   FORMAT                 = "F6.2"
   DESCRIPTION            = "HK V +30V in Volts"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 10
   NAME                   = "HK_V_PLUS_5V"
   DATA_TYPE              = ASCII_REAL
   START_BYTE             = 97
   BYTES                  = 4
   UNIT                   = "VOLT"
   FORMAT                 = "F4.2"
   DESCRIPTION            = "HK V +5V in Volts"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 11
   NAME                   = "HK_V_MINUS_12V"
   DATA_TYPE              = ASCII_REAL
   START_BYTE             = 102
   BYTES                  = 6
   UNIT                   = "VOLT"
   FORMAT                 = "F6.2"
   DESCRIPTION            = "HK V -12V in Volts"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 12
   NAME                   = "HK_V_MINUS_5V"
   DATA_TYPE              = ASCII_REAL
   START_BYTE             = 109
   BYTES                  = 5
   UNIT                   = "VOLT"
   FORMAT                 = "F5.2"
   DESCRIPTION            = "HK V -5V in Volts"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 13
   NAME                   = "NPD1_PLUS_30V_ON_OFF"
   DATA_TYPE              = ASCII_INTEGER
   START_BYTE             = 115
   BYTES                  = 1
```

```
      UNIT                  = "N/A"
      FORMAT                = "I1"
      DESCRIPTION           = "NPD1 +30V on/off
                              The field takes one of the following values:
                               0 off
                               1 on"
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 14
      NAME                  = "NPD_HEATERS_ON_OFF"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 117
      BYTES                 = 1
      UNIT                  = "N/A"
      FORMAT                = "I1"
      DESCRIPTION           = "NPD heaters on/off
                              The field takes one of the following values:
                               0 off
                               1 on"
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 15
      NAME                  = "SUN_SENSOR_1"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 119
      BYTES                 = 1
      UNIT                  = "N/A"
      FORMAT                = "I1"
      DESCRIPTION           = "Sun sensor 1 output"
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 16
      NAME                  = "SUN_SENSOR_2"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 121
      BYTES                 = 1
      UNIT                  = "N/A"
      FORMAT                = "I1"
      DESCRIPTION           = "Sun sensor 2 output"
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 17
      NAME                  = "NPD1_DEFL_SWITCH"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 123
      BYTES                 = 1
      UNIT                  = "N/A"
      FORMAT                = "I1"
      DESCRIPTION           = "NPD1 deflector switch"
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 18
      NAME                  = "NPD1_BIAS_MONITOR"
      DATA_TYPE             = ASCII_REAL
      START_BYTE            = 125
      BYTES                 = 6
      UNIT                  = "VOLT"
```

```
     FORMAT                = "F6.1"
     DESCRIPTION           = "NPD1 bias monitor in Volts"
  END_OBJECT               = COLUMN

  OBJECT                   = COLUMN
     COLUMN_NUMBER         = 19
     NAME                  = "NPD1_BIAS_REFERENCE"
     DATA_TYPE             = ASCII_INTEGER
     START_BYTE            = 132
     BYTES                 = 3
     UNIT                  = "ADC_UNITS"
     FORMAT                = "I3"
     DESCRIPTION           = "NPD1 bias reference"
  END_OBJECT               = COLUMN

  OBJECT                   = COLUMN
     COLUMN_NUMBER         = 20
     NAME                  = "NPD1_DEFL_MONITOR"
     DATA_TYPE             = ASCII_REAL
     START_BYTE            = 136
     BYTES                 = 6
     UNIT                  = "VOLT"
     FORMAT                = "F6.1"
     DESCRIPTION           = "NPD1 deflector monitor in Volts"
  END_OBJECT               = COLUMN

  OBJECT                   = COLUMN
     COLUMN_NUMBER         = 21
     NAME                  = "NPD1_DEFL_REFERENCE"
     DATA_TYPE             = ASCII_INTEGER
     START_BYTE            = 143
     BYTES                 = 3
     UNIT                  = "ADC_UNITS"
     FORMAT                = "I3"
     DESCRIPTION           = "NPD1 deflector reference"
  END_OBJECT               = COLUMN

  OBJECT                   = COLUMN
     COLUMN_NUMBER         = 22
     NAME                  = "NPD1_START_BIAS_MONITOR"
     DATA_TYPE             = ASCII_REAL
     START_BYTE            = 147
     BYTES                 = 6
     UNIT                  = "VOLT"
     FORMAT                = "F6.1"
     DESCRIPTION           = "NPD1 start bias monitor in Volts"
  END_OBJECT               = COLUMN

  OBJECT                   = COLUMN
     COLUMN_NUMBER         = 23
     NAME                  = "NPD1_START_BIAS_REFERENCE"
     DATA_TYPE             = ASCII_INTEGER
     START_BYTE            = 154
     BYTES                 = 3
     UNIT                  = "ADC_UNITS"
     FORMAT                = "I3"
     DESCRIPTION           = "NPD1 start bias reference"
  END_OBJECT               = COLUMN

  OBJECT                   = COLUMN
     COLUMN_NUMBER         = 24
     NAME                  = "NPD1_STOP_BIAS_MONITOR"
```

```
            DATA_TYPE              = ASCII_REAL
            START_BYTE            = 158
            BYTES                 = 6
            UNIT                  = "VOLT"
            FORMAT                = "F6.1"
            DESCRIPTION           = "NPD1 stop bias monitor in Volts"
         END_OBJECT               = COLUMN

         OBJECT                   = COLUMN
            COLUMN_NUMBER         = 25
            NAME                  = "NPD1_STOP_BIAS_REFERENCE"
            DATA_TYPE             = ASCII_INTEGER
            START_BYTE            = 165
            BYTES                 = 3
            UNIT                  = "ADC_UNITS"
            FORMAT                = "I3"
            DESCRIPTION           = "NPD1 stop bias reference"
         END_OBJECT               = COLUMN

         OBJECT                   = COLUMN
            COLUMN_NUMBER         = 26
            NAME                  = "NPD1_FRONTCTRL"
            DATA_TYPE             = ASCII_INTEGER
            START_BYTE            = 169
            BYTES                 = 3
            UNIT                  = "N/A"
            FORMAT                = "I3"
            DESCRIPTION           = "This register is used to as a common control
                                     register for the NPD1 sensor. The field value has
                                     to be decoded into Binary format. Each bit may take
                                     one of the following values :
                                     bit 0 (TDCINEMA)  =1 enables attention of TDC to
                                                          the input signals start, stop
                                                          and calibration clock
                                     bit 1 (TDCOUNTIS) =1 disables readout of valid data
                                                          from the TDC
                                     bit 2 (CALWAITENA)=1 enables wait for calibration
                                                          values
                                     bit 3 (AUTORSTDIS)=1 disables automatic TDC-reset
                                                          when SYSERR occurs
                                     bit 4 (STOARTDIS) =1 disables generation of
                                                          artificial stop signal
                                     bit 5 (CNTDIS)    =1 disables FPGA counter
                                     bit 6 (STADIS)    =1 disables start signal going
                                                          into TDC
                                     bit 7 (ADCCALDIS) =1 disables using of ADC
                                                          calibration
                                     bit 8-15  n.c."
         END_OBJECT               = COLUMN

         OBJECT                   = COLUMN
            COLUMN_NUMBER         = 27
            NAME                  = "NPD1_MAINCTRL"
            DATA_TYPE             = ASCII_INTEGER
            START_BYTE            = 173
            BYTES                 = 3
            UNIT                  = "N/A"
            FORMAT                = "I3"
            DESCRIPTION           = "This register is used to as a common control
                                     register for the NPD1 sensor. The field value has
                                     to be decoded into Binary format. Each bit may
                                     take one of the following values :
```

```
                                    bit 0-1 (LVL[1:0])    Level of storing as binning
                                                          data, storing into binning
                                                          array will be omitted if
                                                          COIN[2:0]>LVL[1:0]
                                    bit 2 (STOREDIS)  =1 disables storing into SRAM
                                    bit 3 (DEBUGENA)  =1 enables simulation of
                                                          rawdata(debug)
                                    bit 4 (DELSIMDIS) =1 disables simultaneously
                                                          deleting of both Binning and
                                                          Raw Data array (after each
                                                          read access on data)
                                    bit 5 (LATCHUP)   =1 LatchUp occurred
                                    bit 6 (ECENA)     =1 Hamming-code Error Correction
                                                          on SRAM data enabled
                                    bit 7-15  n.c."
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 28
   NAME                   = "NPD1_STAT"
   DATA_TYPE              = ASCII_INTEGER
   START_BYTE             = 177
   BYTES                  = 5
   UNIT                   = "N/A"
   FORMAT                 = "I5"
   DESCRIPTION            = "This register is used to reflect some TDC and FPGA
                             status signals. The field value has to be decoded
                             into Binary format. Each bit may take one of the
                             following values :
                             bit 0 (TDCSYSERR)   SYSERR-Flag from TDC
                             bit 1 (TDCREADY)    READY-Flag from TDC
                             bit 2 (TDCVALID)    VALID-Flag from TDC
                             bit 3 (TDCCALM)     CALM-Flag from TDC
                             bit 4 (TDCBUSDIR)   BUSDIR-Flag from TDC
                             bit 5-8  n.c
                             bit 9 (TDCWRERR)    TDC write access error-Flag
                             bit 10 (TDCRDERR)   TDC read access error-Flag
                             bit 11 (TDCCMDERR)  TDC command error-Flag
                             bit 12 (CMDBUSY) =1 Commanding TDC active
                             bit 13 (DACBUSY) =1 Programming DAC
                             bit 14 (NEWCAL)  =1 new calibration data available
                                                 any read-access to the CALIBxx
                                                 registers resets this flag
                             bit 15 (ADCERR)  =1 ADC error occurred"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 29
   NAME                   = "NPD1_TDCRD"
   DATA_TYPE              = ASCII_INTEGER
   START_BYTE             = 183
   BYTES                  = 5
   UNIT                   = "N/A"
   FORMAT                 = "I5"
   DESCRIPTION            = "After the transmission of an appropriate
                             TDC-opcode, the contents of the requested TDC
                             register is available in this register."
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 30
   NAME                   = "NPD1_CALIB11"
```

```
         DATA_TYPE            = ASCII_INTEGER
         START_BYTE          = 189
         BYTES               = 5
         UNIT                = "N/A"
         FORMAT              = "I5"
         DESCRIPTION         = "This register contains part1 of the calibration
                                data from the TDC (CAL11)."
      END_OBJECT             = COLUMN

      OBJECT                 = COLUMN
         COLUMN_NUMBER       = 31
         NAME                = "NPD1_CALIB12"
         DATA_TYPE           = ASCII_INTEGER
         START_BYTE          = 195
         BYTES               = 5
         UNIT                = "N/A"
         FORMAT              = "I5"
         DESCRIPTION         = "This register contains part2 of the calibration
                                data from the TDC (CAL12)."
      END_OBJECT             = COLUMN

      OBJECT                 = COLUMN
         COLUMN_NUMBER       = 32
         NAME                = "NPD1_CALIB21"
         DATA_TYPE           = ASCII_INTEGER
         START_BYTE          = 201
         BYTES               = 5
         UNIT                = "N/A"
         FORMAT              = "I5"
         DESCRIPTION         = "This register contains part3 of the calibration
                                data from the TDC (CAL21)."
      END_OBJECT             = COLUMN

      OBJECT                 = COLUMN
         COLUMN_NUMBER       = 33
         NAME                = "NPD1_CALIB22"
         DATA_TYPE           = ASCII_INTEGER
         START_BYTE          = 207
         BYTES               = 5
         UNIT                = "N/A"
         FORMAT              = "I5"
         DESCRIPTION         = "This register contains part4 of the calibration
                                data from the TDC (CAL22)."
      END_OBJECT             = COLUMN

      OBJECT                 = COLUMN
         COLUMN_NUMBER       = 34
         NAME                = "NPD1_SEFCCNT"
         DATA_TYPE           = ASCII_INTEGER
         START_BYTE          = 213
         BYTES               = 5
         UNIT                = "N/A"
         FORMAT              = "I5"
         DESCRIPTION         = "This registers counts the occurrence and
                                correction of single bit errors of the SRAM up to
                                the upper limit of 65536."
      END_OBJECT             = COLUMN

      OBJECT                 = COLUMN
         COLUMN_NUMBER       = 35
         NAME                = "NPD1_DEFCCNT"
         DATA_TYPE           = ASCII_INTEGER
```

```
         START_BYTE           = 219
         BYTES                = 5
         UNIT                 = "N/A"
         FORMAT               = "I5"
         DESCRIPTION          = "This registers counts the occurrence of double bit
                                 errors bit errors of the SRAM data from up to the
                                 upper limit of 65536."
      END_OBJECT              = COLUMN

      OBJECT                  = COLUMN
         COLUMN_NUMBER        = 36
         NAME                 = "SCANNER_VREFMC"
         DATA_TYPE            = ASCII_INTEGER
         START_BYTE           = 225
         BYTES                = 3
         UNIT                 = "ADC_UNITS"
         FORMAT               = "I3"
         DESCRIPTION          = "Scanner vrefmc"
      END_OBJECT              = COLUMN

      OBJECT                  = COLUMN
         COLUMN_NUMBER        = 37
         NAME                 = "SCANNER_INIT"
         DATA_TYPE            = ASCII_INTEGER
         START_BYTE           = 229
         BYTES                = 1
         UNIT                 = "N/A"
         FORMAT               = "I1"
         DESCRIPTION          = "Scanner initialized"
      END_OBJECT              = COLUMN

      OBJECT                  = COLUMN
         COLUMN_NUMBER        = 38
         NAME                 = "LOST_STEP"
         DATA_TYPE            = ASCII_INTEGER
         START_BYTE           = 231
         BYTES                = 1
         UNIT                 = "N/A"
         FORMAT               = "I1"
         DESCRIPTION          = "Lost step"
      END_OBJECT              = COLUMN

      OBJECT                  = COLUMN
         COLUMN_NUMBER        = 39
         NAME                 = "SCANNER_STATUS_STATE"
         DATA_TYPE            = ASCII_INTEGER
         START_BYTE           = 233
         BYTES                = 1
         UNIT                 = "N/A"
         FORMAT               = "I1"
         DESCRIPTION          = "Scanner status state.
                                 The field takes one of the following values:
                                  0 not busy
                                  1 ramp up
                                  2 full speed move
                                  3 ramp down"
      END_OBJECT              = COLUMN

      OBJECT                  = COLUMN
         COLUMN_NUMBER        = 40
         NAME                 = "SCANNER_STATUS_DIRECTION"
         DATA_TYPE            = ASCII_INTEGER
```

```
        START_BYTE          = 235
        BYTES               = 1
        UNIT                = "N/A"
        FORMAT              = "I1"
        DESCRIPTION         = "Scanner status direction
                              The field takes one of the following values:
                              0 0-180
                              1 180-0"
     END_OBJECT             = COLUMN

     OBJECT                 = COLUMN
        COLUMN_NUMBER       = 41
        NAME                = "SCANNER_STATUS_POS_CLOCK"
        DATA_TYPE           = ASCII_INTEGER
        START_BYTE          = 237
        BYTES               = 1
        UNIT                = "N/A"
        FORMAT              = "I1"
        DESCRIPTION         = "Scanner status position clock"
     END_OBJECT             = COLUMN

     OBJECT                 = COLUMN
        COLUMN_NUMBER       = 42
        NAME                = "SCANNER_STATUS_CW_END_POS"
        DATA_TYPE           = ASCII_INTEGER
        START_BYTE          = 239
        BYTES               = 1
        UNIT                = "N/A"
        FORMAT              = "I1"
        DESCRIPTION         = "Scanner status cw end position
                               The field takes one of the following values:
                               0 scanner not in cw end position
                               1 scanner in cw end position"
     END_OBJECT             = COLUMN

     OBJECT                 = COLUMN
        COLUMN_NUMBER       = 43
        NAME                = "SCANNER_STATUS_CCW_END_POS"
        DATA_TYPE           = ASCII_INTEGER
        START_BYTE          = 241
        BYTES               = 1
        UNIT                = "N/A"
        FORMAT              = "I1"
        DESCRIPTION         = "Scanner status ccw end position
                               The field takes one of the following values:
                               0 scanner not in ccw end position
                               1 scanner in ccw end position"
     END_OBJECT             = COLUMN

     OBJECT                 = COLUMN
        COLUMN_NUMBER       = 44
        NAME                = "SCANNER_SPEED"
        DATA_TYPE           = ASCII_INTEGER
        START_BYTE          = 243
        BYTES               = 1
        UNIT                = "N/A"
        FORMAT              = "I1"
        DESCRIPTION         = "Scanner speed
                              This is not the actual moving speed at the
                              specified time, but a setting speed value that is
                              applied in operation to the scanner once a command
                              is sent to move it.
```

```
                                  The field takes one of the following values:
                                   0 STOP
                                   1 32s scan
                                   2 64s scan
                                   3 128s scan"
   END_OBJECT            = COLUMN

   OBJECT               = COLUMN
      COLUMN_NUMBER     = 45
      NAME              = "SCANNER_SETUP_DIRECTION"
      DATA_TYPE         = ASCII_INTEGER
      START_BYTE        = 245
      BYTES             = 1
      UNIT              = "N/A"
      FORMAT            = "I1"
      DESCRIPTION       = "Scanner setup direction
                           The field takes one of the following values:
                            0 0-180
                            1 180-0
                            for manual mode speed command only"
   END_OBJECT           = COLUMN

   OBJECT               = COLUMN
      COLUMN_NUMBER     = 46
      NAME              = "SCANNER_SETUP_MODE"
      DATA_TYPE         = ASCII_INTEGER
      START_BYTE        = 247
      BYTES             = 1
      UNIT              = "N/A"
      FORMAT            = "I1"
      DESCRIPTION       = "Scanner setup mode
                           The field takes one of the following values:
                            0 normal
                            1 manual"
   END_OBJECT           = COLUMN

   OBJECT               = COLUMN
      COLUMN_NUMBER     = 47
      NAME              = "SCANNER_PLUS_30V_ON_OFF"
      DATA_TYPE         = ASCII_INTEGER
      START_BYTE        = 249
      BYTES             = 1
      UNIT              = "N/A"
      FORMAT            = "I1"
      DESCRIPTION       = "Scanner +30V on/off
                           The field takes one of the following values:
                            0 off
                            1 on"
   END_OBJECT           = COLUMN

   OBJECT               = COLUMN
      COLUMN_NUMBER     = 48
      NAME              = "SCANNER_COAST_CURRENT_REF"
      DATA_TYPE         = ASCII_INTEGER
      START_BYTE        = 251
      BYTES             = 3
      UNIT              = "ADC_UNITS"
      FORMAT            = "I3"
      DESCRIPTION       = "Scanner coast current reference"
   END_OBJECT           = COLUMN

   OBJECT               = COLUMN
```

```
      COLUMN_NUMBER         = 49
      NAME                  = "SCANNER_RAMP_CURRENT_REF"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 255
      BYTES                 = 3
      UNIT                  = "ADC_UNITS"
      FORMAT                = "I3"
      DESCRIPTION           = "Scanner ramp current reference"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
      COLUMN_NUMBER         = 50
      NAME                  = "SCANNER_TRESHOLD_CW_REF"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 259
      BYTES                 = 3
      UNIT                  = "ADC_UNITS"
      FORMAT                = "I3"
      DESCRIPTION           = "Scanner threshold cw reference"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
      COLUMN_NUMBER         = 51
      NAME                  = "SCANNER_TRESHOLD_CCW_REF"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 263
      BYTES                 = 3
      UNIT                  = "ADC_UNITS"
      FORMAT                = "I3"
      DESCRIPTION           = "Scanner threshold ccw reference"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
      COLUMN_NUMBER         = 52
      NAME                  = "SCANNER_TRESHOLD_WHEEL_REF"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 267
      BYTES                 = 3
      UNIT                  = "ADC_UNITS"
      FORMAT                = "I3"
      DESCRIPTION           = "Scanner threshold wheel reference"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
      COLUMN_NUMBER         = 53
      NAME                  = "SCANNER_POSITION"
      DATA_TYPE             = ASCII_REAL
      START_BYTE            = 271
      BYTES                 = 5
      UNIT                  = "DEGREE"
      FORMAT                = "F5.1"
      DESCRIPTION           = "Scanner position in degrees"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
      COLUMN_NUMBER         = 54
      NAME                  = "SW_MODE"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 277
      BYTES                 = 3
      UNIT                  = "N/A"
      FORMAT                = "I3"
```

```
            DESCRIPTION         = "Software mode"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
   COLUMN_NUMBER                = 55
   NAME                         = "CPU_LOAD"
   DATA_TYPE                    = ASCII_INTEGER
   START_BYTE                   = 281
   BYTES                        = 3
   UNIT                         = "N/A"
   FORMAT                       = "I3"
   DESCRIPTION                  = "CPU load"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
   COLUMN_NUMBER                = 56
   NAME                         = "NPD_ACCUMULATION_TIME "
   DATA_TYPE                    = ASCII_INTEGER
   START_BYTE                   = 285
   BYTES                        = 2
   UNIT                         = "N/A"
   FORMAT                       = "I2"
   DESCRIPTION                  = "Accumulation time.
                                   Time = 2N*31.25 [ms]"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
   COLUMN_NUMBER                = 57
   NAME                         = "NPD_RICE_COMPRESSION_ENABLE"
   DATA_TYPE                    = ASCII_INTEGER
   START_BYTE                   = 288
   BYTES                        = 1
   UNIT                         = "N/A"
   FORMAT                       = "I1"
   DESCRIPTION                  = "Rice compression flag status.
                                    The field takes one of the following values:
                                    0 = off
                                    1 = on"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
   COLUMN_NUMBER                = 58
   NAME                         = "NPD_LOG_COMPRESSION"
   DATA_TYPE                    = ASCII_INTEGER
   START_BYTE                   = 290
   BYTES                        = 1
   UNIT                         = "N/A"
   FORMAT                       = "I1"
   DESCRIPTION                  = "The field takes one of the following values:
                                    0 = off
                                    1 = on"
END_OBJECT                      = COLUMN

OBJECT                          = COLUMN
   COLUMN_NUMBER                = 59
   NAME                         = "NPD1_MODE"
   DATA_TYPE                    = ASCII_INTEGER
   START_BYTE                   = 292
   BYTES                        = 2
   UNIT                         = "N/A"
   FORMAT                       = "I2"
   DESCRIPTION                  = "The field takes one of the following values:
```

```
                           0: not in use
                           1: raw data
                           2: bin matrix (0 0 0)
                           3: bin matrix (0 0 1), (0 1 0) or (1 0 0)
                           4: bin matrix (0 0 2), (0 2 0) or (2 0 0)
                           5: bin matrix (0 1 1), (1 0 1) or (1 1 0)
                           6: bin matrix (0 1 2), (1 0 2), (0 2 1),
                                         (1 2 0), (2 0 1) or (2 1 0)
                           7: bin matrix (0 2 2), (2 0 2) or (2 2 0)
                           8: bin matrix (1 1 1)
                           9: bin matrix (1 1 2), (1 2 1) or (2 1 1)
                           10: bin matrix (1 2 2), (2 1 2) or ( 2 2 1)
                           11: bin matrix (2 2 2)
                           12: phd mode
                           13: tof mode"
     END_OBJECT            = COLUMN
```

Detailed description of those parameters is provided in documents [AD 3].

NPD2 sensor:

```
     OBJECT               = HK_NPD2_TABLE
        NAME              = "HK_NPD2"
        INTERCHANGE_FORMAT = ASCII
        ROWS              = 1
        COLUMNS           = 59
        ROW_BYTES         = 295
        ^STRUCTURE        = "NPD2_SPECTRUM_HKNPD2.FMT"
     END_OBJECT           = HK_NPD2_TABLE
```

The structure of the TABLE object is described in the file NPD2_SPECTRUM_HKNPD2.FMT as follows:

```
     /*  Contents of format file  "NPD2_SPECTRUM_HKNPD2.FMT"  */
     OBJECT               = COLUMN
        COLUMN_NUMBER     = 1
        NAME              = "UTC"
        DATA_TYPE         = TIME
        START_BYTE        = 1
        BYTES             = 23
        UNIT              = "N/A"
        DESCRIPTION       = "This column represents the UTC of the
                             NPD HK data set in PDS standard format
                             YYYY-MM-DDThh:mm:ss.sss"
     END_OBJECT           = COLUMN

     OBJECT               = COLUMN
        COLUMN_NUMBER     = 2
        NAME              = "OBT"
        DATA_TYPE         = CHARACTER
        START_BYTE        = 26
        BYTES             = 19
        UNIT              = "N/A"
        DESCRIPTION       = "On board Time (OBT) is represented as :
                             <Reset number>/<unit seconds>.<fractional seconds>
                             with
                             <Reset number>: integer starting at 1
                                Reset number 1 starts at 2005-03-01T00:00:00 UTC
                             <unit seconds>: 10 digits number of unit seconds
                             <fractional seconds>: 5 digits number of fractional
                                seconds expressed as multiples of 2^-16 seconds"
     END_OBJECT           = COLUMN

     OBJECT               = COLUMN
```

```
   COLUMN_NUMBER        = 3
   NAME                 = "NPD2_TEMP"
   DATA_TYPE            = ASCII_REAL
   START_BYTE           = 47
   BYTES                = 7
   UNIT                 = "CELSIUS"
   FORMAT               = "F7.2"
   DESCRIPTION          = "NPD2 temperature in degree Celsius"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 4
   NAME                 = "SCANNER_TEMP_SENSOR"
   DATA_TYPE            = ASCII_REAL
   START_BYTE           = 55
   BYTES                = 7
   UNIT                 = "CELSIUS"
   FORMAT               = "F7.2"
   DESCRIPTION          = "Scanner temperature sensor in degree Celsius"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 5
   NAME                 = "SW_VERSION"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 63
   BYTES                = 5
   UNIT                 = "N/A"
   FORMAT               = "I5"
   DESCRIPTION          = "Software version
                           To decode into Binary format. Bit description:
                           patchVersion [3:0]
                           minorVersion [8:4]
                           majorVersion [13:9]
                           releaseClass [15:14]: 1 (D), 2 (T), 3 (R)"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 6
   NAME                 = "HK_I_PLUS_30V"
   DATA_TYPE            = ASCII_REAL
   START_BYTE           = 69
   BYTES                = 6
   UNIT                 = "MILLIAMPERE"
   FORMAT               = "F6.2"
   DESCRIPTION          = "HK i +30V in milli-amperes"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 7
   NAME                 = "HK_I_PLUS_5V"
   DATA_TYPE            = ASCII_REAL
   START_BYTE           = 76
   BYTES                = 7
   UNIT                 = "MILLIAMPERE"
   FORMAT               = "F7.2"
   DESCRIPTION          = "HK i +5V in milli-amperes"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 8
   NAME                 = "HK_V_PLUS_12V"
```

```
        DATA_TYPE           = ASCII_REAL
        START_BYTE          = 84
        BYTES               = 5
        UNIT                = "VOLT"
        FORMAT              = "F5.2"
        DESCRIPTION         = "HK V +12V in Volts"
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        COLUMN_NUMBER       = 9
        NAME                = "HK_V_PLUS_30V"
        DATA_TYPE           = ASCII_REAL
        START_BYTE          = 90
        BYTES               = 6
        UNIT                = "VOLTS"
        FORMAT              = "F6.2"
        DESCRIPTION         = "HK V +30V in Volts"
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        COLUMN_NUMBER       = 10
        NAME                = "HK_V_PLUS_5V"
        DATA_TYPE           = ASCII_REAL
        START_BYTE          = 97
        BYTES               = 4
        UNIT                = "VOLT"
        FORMAT              = "F4.2"
        DESCRIPTION         = "HK V +5V in Volts"
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        COLUMN_NUMBER       = 11
        NAME                = "HK_V_MINUS_12V"
        DATA_TYPE           = ASCII_REAL
        START_BYTE          = 102
        BYTES               = 6
        UNIT                = "VOLT"
        FORMAT              = "F6.2"
        DESCRIPTION         = "HK V -12V in Volts"
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        COLUMN_NUMBER       = 12
        NAME                = "HK_V_MINUS_5V"
        DATA_TYPE           = ASCII_REAL
        START_BYTE          = 109
        BYTES               = 5
        UNIT                = "VOLT"
        FORMAT              = "F5.2"
        DESCRIPTION         = "HK V -5V in Volts"
    END_OBJECT              = COLUMN

    OBJECT                  = COLUMN
        COLUMN_NUMBER       = 13
        NAME                = "NPD2_PLUS_30V_ON_OFF"
        DATA_TYPE           = ASCII_INTEGER
        START_BYTE          = 115
        BYTES               = 1
        UNIT                = "N/A"
        FORMAT              = "I1"
        DESCRIPTION         = "NPD2 +30V on/off
                              The field takes one of the following values:
```

```
                                0 off
                                1 on"
          END_OBJECT            = COLUMN

          OBJECT                = COLUMN
             COLUMN_NUMBER      = 14
             NAME               = "NPD_HEATERS_ON_OFF"
             DATA_TYPE          = ASCII_INTEGER
             START_BYTE         = 117
             BYTES              = 1
             UNIT               = "N/A"
             FORMAT             = "I1"
             DESCRIPTION        = "NPD heaters on/off
                                 The field takes one of the following values:
                                 0 off
                                 1 on"
          END_OBJECT            = COLUMN

          OBJECT                = COLUMN
             COLUMN_NUMBER      = 15
             NAME               = "SUN_SENSOR_1"
             DATA_TYPE          = ASCII_INTEGER
             START_BYTE         = 119
             BYTES              = 1
             UNIT               = "N/A"
             FORMAT             = "I1"
             DESCRIPTION        = "Sun sensor 1 output"
          END_OBJECT            = COLUMN

          OBJECT                = COLUMN
             COLUMN_NUMBER      = 16
             NAME               = "SUN_SENSOR_2"
             DATA_TYPE          = ASCII_INTEGER
             START_BYTE         = 121
             BYTES              = 1
             UNIT               = "N/A"
             FORMAT             = "I1"
             DESCRIPTION        = "Sun sensor 2 output"
          END_OBJECT            = COLUMN

          OBJECT                = COLUMN
             COLUMN_NUMBER      = 17
             NAME               = "NPD2_DEFL_SWITCH"
             DATA_TYPE          = ASCII_INTEGER
             START_BYTE         = 123
             BYTES              = 1
             UNIT               = "N/A"
             FORMAT             = "I1"
             DESCRIPTION        = "NPD2 deflector switch"
          END_OBJECT            = COLUMN

          OBJECT                = COLUMN
             COLUMN_NUMBER      = 18
             NAME               = "NPD2_BIAS_MONITOR"
             DATA_TYPE          = ASCII_REAL
             START_BYTE         = 125
             BYTES              = 6
             UNIT               = "VOLT"
             FORMAT             = "F6.1"
             DESCRIPTION        = "NPD2 bias monitor in Volts"
          END_OBJECT            = COLUMN
```

```
OBJECT                  = COLUMN
   COLUMN_NUMBER        = 19
   NAME                 = "NPD2_BIAS_REFERENCE"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 132
   BYTES                = 3
   UNIT                 = "ADC_UNITS"
   FORMAT               = "I3"
   DESCRIPTION          = "NPD2 bias reference"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 20
   NAME                 = "NPD2_DEFL_MONITOR"
   DATA_TYPE            = ASCII_REAL
   START_BYTE           = 136
   BYTES                = 6
   UNIT                 = "VOLT"
   FORMAT               = "F6.1"
   DESCRIPTION          = "NPD2 deflector monitor in Volts"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 21
   NAME                 = "NPD2_DEFL_REFERENCE"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 143
   BYTES                = 3
   UNIT                 = "ADC_UNITS"
   FORMAT               = "I3"
   DESCRIPTION          = "NPD2 deflector reference"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 22
   NAME                 = "NPD2_START_BIAS_MONITOR"
   DATA_TYPE            = ASCII_REAL
   START_BYTE           = 147
   BYTES                = 6
   UNIT                 = "VOLT"
   FORMAT               = "F6.1"
   DESCRIPTION          = "NPD2 start bias monitor in Volts"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 23
   NAME                 = "NPD2_START_BIAS_REFERENCE"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 154
   BYTES                = 3
   UNIT                 = "ADC_UNITS"
   FORMAT               = "I3"
   DESCRIPTION          = "NPD2 start bias reference"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 24
   NAME                 = "NPD2_STOP_BIAS_MONITOR"
   DATA_TYPE            = ASCII_REAL
   START_BYTE           = 158
   BYTES                = 6
   UNIT                 = "VOLT"
```

```
      FORMAT               = "F6.1"
      DESCRIPTION          = "NPD2 stop bias monitor in Volts"
   END_OBJECT              = COLUMN

   OBJECT                  = COLUMN
      COLUMN_NUMBER        = 25
      NAME                 = "NPD2_STOP_BIAS_REFERENCE"
      DATA_TYPE            = ASCII_INTEGER
      START_BYTE           = 165
      BYTES                = 3
      UNIT                 = "ADC_UNITS"
      FORMAT               = "I3"
      DESCRIPTION          = "NPD2 stop bias reference"
   END_OBJECT              = COLUMN

   OBJECT                  = COLUMN
      COLUMN_NUMBER        = 26
      NAME                 = "NPD2_FRONTCTRL"
      DATA_TYPE            = ASCII_INTEGER
      START_BYTE           = 169
      BYTES                = 3
      UNIT                 = "N/A"
      FORMAT               = "I3"
      DESCRIPTION          = "This register is used to as a common control
                             register for the NPD2 sensor. The field value has
                             to be decoded into Binary format. Each bit may
                             take one of the following values :
                             bit 0 (TDCINEMA) =1 enables attention of TDC to
                                                 the input signals start, stop
                                                 and calibration clock
                             bit 1 (TDCOUNTIS) =1 disables readout of valid
                                                 data from the TDC
                             bit 2 (CALWAITENA)=1 enables wait for calibration
                                                 values
                             bit 3 (AUTORSTDIS)=1 disables automatic TDC-reset
                                                 when SYSERR occurs
                             bit 4 (STOARTDIS) =1 disables generation of
                                                 artificial stop signal
                             bit 5 (CNTDIS)    =1 disables FPGA counter
                             bit 6 (STADIS)    =1 disables start signal going
                                                 into TDC
                             bit 7 (ADCCALDIS) =1 disables using of ADC
                                                 calibration
                             bit 8-15  n.c."
   END_OBJECT              = COLUMN

   OBJECT                  = COLUMN
      COLUMN_NUMBER        = 27
      NAME                 = "NPD2_MAINCTRL"
      DATA_TYPE            = ASCII_INTEGER
      START_BYTE           = 173
      BYTES                = 3
      UNIT                 = "N/A"
      FORMAT               = "I3"
      DESCRIPTION          = "This register is used to as a common control
                             register for the NPD2 sensor. The field value has
                             to be decoded into Binary format. Each bit may
                             take one of the following values :
                             bit 0-1 (LVL[1:0])   Level of storing as binning
                                                 data, storing into binning
                                                 array will be omitted if
                                                 COIN[2:0]>LVL[1:0]
```

```
                              bit 2 (STOREDIS)  =1 disables storing into SRAM
                              bit 3 (DEBUGENA)  =1 enables simulation of
                                                   rawdata(debug)
                              bit 4 (DELSIMDIS) =1 disables simultaneously
                                                   deleting of both Binning and
                                                   Raw Data array (after each
                                                   read access on data)
                              bit 5 (LATCHUP)   =1 LatchUp occurred
                              bit 6 (ECENA)     =1 Hamming-code Error Correction
                                                   on SRAM data enabled
                              bit 7-15  n.c."
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 28
   NAME                   = "NPD2_STAT"
   DATA_TYPE              = ASCII_INTEGER
   START_BYTE             = 177
   BYTES                  = 5
   UNIT                   = "N/A"
   FORMAT                 = "I5"
   DESCRIPTION            = "This register is used to reflect some TDC and FPGA
                              status signals. The field value has to be decoded
                              into Binary format. Each bit may take one of the
                              following values :
                              bit 0 (TDCSYSERR)  SYSERR-Flag from TDC
                              bit 1 (TDCREADY)   READY-Flag from TDC
                              bit 2 (TDCVALID)   VALID-Flag from TDC
                              bit 3 (TDCCALM)    CALM-Flag from TDC
                              bit 4 (TDCBUSDIR)  BUSDIR-Flag from TDC
                              bit 5-8  n.c
                              bit 9 (TDCWRERR)   TDC write access error-Flag
                              bit 10 (TDCRDERR)  TDC read access error-Flag
                              bit 11 (TDCCMDERR) TDC command error-Flag
                              bit 12 (CMDBUSY) =1 Commanding TDC active
                              bit 13 (DACBUSY) =1 Programming DAC
                              bit 14 (NEWCAL)  =1 new calibration data available
                                                  any read-access to the CALIBxx
                                                  registers resets this flag
                              bit 15 (ADCERR)  =1 ADC error occurred"
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 29
   NAME                   = "NPD2_TDCRD"
   DATA_TYPE              = ASCII_INTEGER
   START_BYTE             = 183
   BYTES                  = 5
   UNIT                   = "N/A"
   FORMAT                 = "I5"
   DESCRIPTION            = "After the transmission of an appropriate
                              TDC-opcode, the contents of the requested TDC
                              register is available in this register."
END_OBJECT                = COLUMN

OBJECT                    = COLUMN
   COLUMN_NUMBER          = 30
   NAME                   = "NPD2_CALIB11"
   DATA_TYPE              = ASCII_INTEGER
   START_BYTE             = 189
   BYTES                  = 5
   UNIT                   = "N/A"
```

```
   FORMAT                = "I5"
   DESCRIPTION           = "This register contains part1 of the calibration
                            data from the TDC (CAL11)."
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 31
   NAME                  = "NPD2_CALIB12"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 195
   BYTES                 = 5
   UNIT                  = "N/A"
   FORMAT                = "I5"
   DESCRIPTION           = "This register contains part2 of the calibration
                            data from the TDC (CAL12)."
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 32
   NAME                  = "NPD2_CALIB21"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 201
   BYTES                 = 5
   UNIT                  = "N/A"
   FORMAT                = "I5"
   DESCRIPTION           = "This register contains part3 of the calibration
                            data from the TDC (CAL21)."
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 33
   NAME                  = "NPD2_CALIB22"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 207
   BYTES                 = 5
   UNIT                  = "N/A"
   FORMAT                = "I5"
   DESCRIPTION           = "This register contains part4 of the calibration
                            data from the TDC (CAL22)."
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 34
   NAME                  = "NPD2_SEFCCNT"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 213
   BYTES                 = 5
   UNIT                  = "N/A"
   FORMAT                = "I5"
   DESCRIPTION           = "This registers counts the occurrence and
                            correction of single bit errors of the SRAM
                            up to the upper limit of 65536."
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 35
   NAME                  = "NPD2_DEFCCNT"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 219
   BYTES                 = 5
   UNIT                  = "N/A"
   FORMAT                = "I5"
```

```
   DESCRIPTION          = "This registers counts the occurrence of double bit
                           errors bit errors of the SRAM data from up to the
                           upper limit of 65536."
END_OBJECT              = COLUMN

OBJECT                 = COLUMN
   COLUMN_NUMBER        = 36
   NAME                 = "SCANNER_VREFMC"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 225
   BYTES                = 3
   UNIT                 = "ADC_UNITS"
   FORMAT               = "I3"
   DESCRIPTION          = "Scanner vrefmc"
END_OBJECT              = COLUMN

OBJECT                 = COLUMN
   COLUMN_NUMBER        = 37
   NAME                 = "SCANNER_INIT"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 229
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
   DESCRIPTION          = "Scanner initialized"
END_OBJECT              = COLUMN

OBJECT                 = COLUMN
   COLUMN_NUMBER        = 38
   NAME                 = "LOST_STEP"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 231
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
   DESCRIPTION          = "Lost step"
END_OBJECT              = COLUMN

OBJECT                 = COLUMN
   COLUMN_NUMBER        = 39
   NAME                 = "SCANNER_STATUS_STATE"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 233
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
   DESCRIPTION          = "Scanner status state.
                           The field takes one of the following values:
                            0 not busy
                            1 ramp up
                            2 full speed move
                            3 ramp down"
END_OBJECT              = COLUMN

OBJECT                 = COLUMN
   COLUMN_NUMBER        = 40
   NAME                 = "SCANNER_STATUS_DIRECTION"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 235
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
```

```
   DESCRIPTION          = "Scanner status direction
                          The field takes one of the following values:
                          0 0-180
                          1 180-0"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 41
   NAME                 = "SCANNER_STATUS_POS_CLOCK"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 237
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
   DESCRIPTION          = "Scanner status position clock"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 42
   NAME                 = "SCANNER_STATUS_CW_END_POS"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 239
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
   DESCRIPTION          = "Scanner status cw end position
                          The field takes one of the following values:
                          0 scanner not in cw end position
                          1 scanner in cw end position"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 43
   NAME                 = "SCANNER_STATUS_CCW_END_POS"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 241
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
   DESCRIPTION          = "Scanner status ccw end position
                          The field takes one of the following values:
                          0 scanner not in ccw end position
                          1 scanner in ccw end position"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 44
   NAME                 = "SCANNER_SPEED"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 243
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
   DESCRIPTION          = "Scanner speed
                          This is not the actual moving speed at the
                          specified time, but a setting speed value that is
                          applied in operation to the scanner once a command
                          is sent to move it.
                          The field takes one of the following values:
                          0 STOP
                          1 32s scan
                          2 64s scan
```

```
                                  3 128s scan"
            END_OBJECT          = COLUMN

            OBJECT              = COLUMN
               COLUMN_NUMBER    = 45
               NAME             = "SCANNER_SETUP_DIRECTION"
               DATA_TYPE        = ASCII_INTEGER
               START_BYTE       = 245
               BYTES            = 1
               UNIT             = "N/A"
               FORMAT           = "I1"
               DESCRIPTION      = "Scanner setup direction
                                  The field takes one of the following values:
                                  0 0-180
                                  1 180-0
                                  for manual mode speed command only"
            END_OBJECT          = COLUMN

            OBJECT              = COLUMN
               COLUMN_NUMBER    = 46
               NAME             = "SCANNER_SETUP_MODE"
               DATA_TYPE        = ASCII_INTEGER
               START_BYTE       = 247
               BYTES            = 1
               UNIT             = "N/A"
               FORMAT           = "I1"
               DESCRIPTION      = "Scanner setup mode
                                  The field takes one of the following values:
                                  0 normal
                                  1 manual"
            END_OBJECT          = COLUMN

            OBJECT              = COLUMN
               COLUMN_NUMBER    = 47
               NAME             = "SCANNER_PLUS_30V_ON_OFF"
               DATA_TYPE        = ASCII_INTEGER
               START_BYTE       = 249
               BYTES            = 1
               UNIT             = "N/A"
               FORMAT           = "I1"
               DESCRIPTION      = "Scanner +30V on/off
                                  The field takes one of the following values:
                                  0 off
                                  1 on"
            END_OBJECT          = COLUMN

            OBJECT              = COLUMN
               COLUMN_NUMBER    = 48
               NAME             = "SCANNER_COAST_CURRENT_REF"
               DATA_TYPE        = ASCII_INTEGER
               START_BYTE       = 251
               BYTES            = 3
               UNIT             = "ADC_UNITS"
               FORMAT           = "I3"
               DESCRIPTION      = "Scanner coast current reference"
            END_OBJECT          = COLUMN

            OBJECT              = COLUMN
               COLUMN_NUMBER    = 49
               NAME             = "SCANNER_RAMP_CURRENT_REF"
               DATA_TYPE        = ASCII_INTEGER
               START_BYTE       = 255
```

```
        BYTES                   = 3
        UNIT                    = "ADC_UNITS"
        FORMAT                  = "I3"
        DESCRIPTION             = "Scanner ramp current reference"
    END_OBJECT                  = COLUMN

    OBJECT                      = COLUMN
        COLUMN_NUMBER           = 50
        NAME                    = "SCANNER_TRESHOLD_CW_REF"
        DATA_TYPE               = ASCII_INTEGER
        START_BYTE              = 259
        BYTES                   = 3
        UNIT                    = "ADC_UNITS"
        FORMAT                  = "I3"
        DESCRIPTION             = "Scanner threshold cw reference"
    END_OBJECT                  = COLUMN

    OBJECT                      = COLUMN
        COLUMN_NUMBER           = 51
        NAME                    = "SCANNER_TRESHOLD_CCW_REF"
        DATA_TYPE               = ASCII_INTEGER
        START_BYTE              = 263
        BYTES                   = 3
        UNIT                    = "ADC_UNITS"
        FORMAT                  = "I3"
        DESCRIPTION             = "Scanner threshold ccw reference"
    END_OBJECT                  = COLUMN

    OBJECT                      = COLUMN
        COLUMN_NUMBER           = 52
        NAME                    = "SCANNER_TRESHOLD_WHEEL_REF"
        DATA_TYPE               = ASCII_INTEGER
        START_BYTE              = 267
        BYTES                   = 3
        UNIT                    = "ADC_UNITS"
        FORMAT                  = "I3"
        DESCRIPTION             = "Scanner threshold wheel reference"
    END_OBJECT                  = COLUMN

    OBJECT                      = COLUMN
        COLUMN_NUMBER           = 53
        NAME                    = "SCANNER_POSITION"
        DATA_TYPE               = ASCII_REAL
        START_BYTE              = 271
        BYTES                   = 5
        UNIT                    = "DEGREE"
        FORMAT                  = "F5.1"
        DESCRIPTION             = "Scanner position in degrees"
    END_OBJECT                  = COLUMN

    OBJECT                      = COLUMN
        COLUMN_NUMBER           = 54
        NAME                    = "SW_MODE"
        DATA_TYPE               = ASCII_INTEGER
        START_BYTE              = 277
        BYTES                   = 3
        UNIT                    = "N/A"
        FORMAT                  = "I3"
        DESCRIPTION             = "Software mode"
    END_OBJECT                  = COLUMN

    OBJECT                      = COLUMN
```

```
   COLUMN_NUMBER        = 55
   NAME                 = "CPU_LOAD"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 281
   BYTES                = 3
   UNIT                 = "N/A"
   FORMAT               = "I3"
   DESCRIPTION          = "CPU load"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 56
   NAME                 = "NPD_ACCUMULATION_TIME "
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 285
   BYTES                = 2
   UNIT                 = "N/A"
   FORMAT               = "I2"
   DESCRIPTION          = "Accumulation time.
                           Time = 2N*31.25 [ms]"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 57
   NAME                 = "NPD_RICE_COMPRESSION_ENABLE"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 288
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
   DESCRIPTION          = "Rice compression flag status.
                           The field takes one of the following values:
                           0 = off
                           1 = on"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 58
   NAME                 = "NPD_LOG_COMPRESSION"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 290
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
   DESCRIPTION          = "The field takes one of the following values:
                           0 = off
                           1 = on"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 59
   NAME                 = "NPD2_MODE"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 292
   BYTES                = 2
   UNIT                 = "N/A"
   FORMAT               = "I2"
   DESCRIPTION          = "The field takes one of the following values:
                           0: not in use
                           1: raw data
                           2: bin matrix (0 0 0)
                           3: bin matrix (0 0 1), (0 1 0) or (1 0 0)
```

```
                                4: bin matrix (0 0 2), (0 2 0) or (2 0 0)
                                5: bin matrix (0 1 1), (1 0 1) or (1 1 0)
                                6: bin matrix (0 1 2), (1 0 2), (0 2 1),
                                            (1 2 0), (2 0 1) or (2 1 0)
                                7: bin matrix (0 2 2), (2 0 2) or (2 2 0)
                                8: bin matrix (1 1 1)
                                9: bin matrix (1 1 2), (1 2 1) or (2 1 1)
                                10: bin matrix (1 2 2), (2 1 2) or ( 2 2 1)
                                11: bin matrix (2 2 2)
                                12: phd mode
                                13: tof mode"
  END_OBJECT             = COLUMN
```

Detailed description of those parameters is provided in documents [AD 3].

4.3.6.6   Description of Instrument

See the applicable section 4.3.5.6

4.3.6.7   Parameters Index File Definition

N/A

4.3.6.8   Mission Specific Keywords

See the applicable section 4.3.5.8

4.3.7   Neutral Particle Imager Science Edited Data Product Design (Level 2)

The NPI sensor can be operated in 2 modes as described in the document [AD 3], producing 2 different types of formatted block data in telemetry packets, one for each selected operation mode. Both modes deal with the storage of series of particle number counts that are measured in different azimuth direction from the 32 possible ones (the anodes). Each of those series consists of a set of data samples, which are acquired and stored sequentially within the considered time interval of one sequence of measurement. This number of data samples may vary from a sequence to another depending on the number of active azimuthal sectors involved in measurement and the time duration of the sequence.

Only 2 types of NPI edited science file are assigned for containing those data, one per mode. Both of them are data products of fixed-size array where data of each sequence are stored in a linear row-major order with azimuth sector the fastest varying parameter. For those records where sample or anode data values are missing, the field is padded on the right with missing constant values ensuring a 32*32 blank separated value table object per record all along the mission.

The Table 33 indicates the data contents for each science data file and their PDS representation object. A NPI header, specific to each mode of observation, is added before the data collection. The NPI headers information and values are shown in the Table 34.

Table 33. NPI science data file contents and structure.

Data type	Mode	Data description	PDS data object
NORMALX	NPI normal mode	Successive data measurements. Each measurement is defined as a neutral particle number of counts accumulated in a sampling time and simultaneously at different active azimuthal sectors.	Linear storage in a TABLE object of 1024 blank-separated data or missing constant values (32*32 data values). The missing constant value is an artifact maintaining a fixed-size table object, even if data are missing. The number of missing values depends upon the settings of the data sector mask and the NPI sample number respectively.
STEPXXX	NPI deflection stepping mode	Successive data measurements. Each measurement is defined as a neutral particle number of counts accumulated in a sampling time and simultaneously at different active azimuthal sectors. In this mode, the deflection voltage is switched up and down periodically (voltage stepping).	Linear storage in a TABLE object of 1024 blank-separated data or missing constant values (32*32 data values). The missing constant value is an artifact maintaining a fixed-size table object, even if data are missing. The number of missing values depends upon the settings of the data sector mask and the NPI sample number respectively.

Table 34. NPI headers content.

Rank	Field / Value		Rank	Field / Value	
	NPI normal mode data header				
1	UTC correlated Time		7	Accumulation Time	
2	OBT Time		8	Sample number (max=32 samples in packet)	
3	SW version		9	NPI sector mask	If NPI_Sector_Mask = 0, sensor is not working".
4	Scanner direction	0 = 0 – 180 1 = 180 - 0	10	Log compression	Always 0 for raw data mode (0 = disabled)
5	Scanner speed	0 (standing), 32s scan, 64s scan, or 128s scan	11	Rice compression flag status	0 = non valid 1 = vadid
6	Scanner Position	On start of scan (or step) period	12	Rice compression assigned value	
	NPI deflection stepping mode data header				
1	UTC correlated Time		7	Accumulation Time	
2	OBT Time		8	Sample number (max=32 samples in packet)	
3	SW version		9	NPI sector mask	If NPI_Sector_Mask = 0, sensor is not working".
4	Scanner direction	0 = 0 – 180 1 = 180 - 0	10	Log compression	Always 0 for raw data mode (0 = disabled)
5	Scanner speed	0 (standing), 32s scan, 64s scan, or 128s scan	11	Rice compression flag status	0 = non valid 1 = vadid
6	Scanner Position	On start of scan (or step) period	12	Rice compression assigned value	
			13	NPI deflection status mask	

The table objects are detailed in the following paragraphs.

4.3.7.1   File Characteristics Data Elements

The following elements are present in the labels for every NPI science edited data product, and they describe the basic characteristics of the data product in terms of structure and naming:

```
/* FILE CHARACTERISTIC DATA ELEMENTS */
```

```
PRODUCT_ID                      = this element defines the current product file name,
                                  without extension
RECORD_TYPE                     = FIXED_LENGTH
RECORD_BYTES                    = this element indicates the number of bytes in a
                                  data record, including record terminators and
                                  separators
FILE_RECORDS                    = this element indicates the number of records within
                                  the data file
```

4.3.7.2 Data Object Pointers Identification Data Elements

Several pointers are defined, identifying the ASCII PDS objects within which the NPI status and uncalibrated science data are stored. The data object pointers that reference TAB files are:

```
^HEAD_TABLE
^DATA_SCIENCE_TABLE
```

4.3.7.3 Instrument and Detector Descriptive Data Elements

The following data identification elements provide additional information about the NPI data products.

```
/* PRODUCER IDENTIFICATION */
PRODUCER_ID                     = "CESR_ASPERA4_GROUP"
PRODUCER_FULL_NAME              = "EMMANUEL PENOU"
PRODUCER_INSTITUTION_NAME       = "CENTRE D'ETUDE SPATIALE DES RAYONNEMENTS"
PRODUCT_CREATION_TIME           = YYYY-MM-DDThh:mm:ss[.fff]

/* DATA DESCRIPTION AND IDENTIFICATION */
DATA_SET_NAME                   = "
                    VENUS EXPRESS VENUS/SOLARWIND ASPERA 2 NPI V1.0"  or
        "VENUS EXPRESS VENUS/SOLARWIND ASPERA 2 EXTENSION 1 NPI V1.0"  or
        "VENUS EXPRESS VENUS/SOLARWIND ASPERA 2 EXTENSION 1 NPI V1.0"  or
        …
DATA_SET_ID                     = "VEX-V/SW-ASPERA-2-NPI-V1.0"       or
                                  "VEX-V/SW-ASPERA-2-EXT1-NPI-V1.0"   or
                                  "VEX-V/SW-ASPERA-2-EXT2-NPI-V1.0"   or
                                  …
RELEASE_ID                      = 0001
REVISION_ID                     = 0000
PRODUCT_TYPE                    = EDR
PROCESSING_LEVEL_ID             = 2
MISSION_NAME                    = "VENUS EXPRESS"
MISSION_ID                      = VEX
INSTRUMENT_HOST_NAME            = "VENUS EXPRESS"
INSTRUMENT_HOST_ID              = VEX
MISSION_PHASE_NAME              = As defined in [AD 4]
INSTRUMENT_NAME                 = "
    ANALYZER OF SPACE PLASMA AND ENERGETIC ATOMS (4TH VERSION)"
INSTRUMENT_ID                   = ASPERA4
INSTRUMENT_TYPE                 = {"ELECTROSTATIC ANALYZER",
                                   "MASS SPECTROMETER",
                                   "NEUTRAL PARTICLE IMAGER",
                                   "NEUTRAL PARTICLE DETECTOR"}
DETECTOR_ID                     = VEX_ASP4_NPI
^INSTRUMENT_DESC                = "ASPERA4_DESC.TXT"

/* TARGET IDENTIFICATION */
TARGET_TYPE                     = "PLANET" or "N/A"
TARGET_NAME                     = "VENUS"  or "SOLAR WIND"
RIGHT_ASCENSION                 = "N/A"
DECLINATION                     = "N/A"
```

```
/* SCIENCE OPERATIONS INFORMATION */
OBSERVATION_TYPE             = {"AC002B", "PE001A", "PE004A"} or "N/A"
^OBSERVATION_TYPE_DESC        = "OBSERVATION_TYPE_DESC.TXT"

/* TIME RELATED INFORMATION */
START_TIME                   = YYYY-MM-DDThh:mm:ss.fff
STOP_TIME                    = YYYY-MM-DDThh:mm:ss.fff
SPACECRAFT_CLOCK_START_COUNT = "01/xxxxxxxxx.xxxxx"
SPACECRAFT_CLOCK_STOP_COUNT  = "01/xxxxxxxxx.xxxxx"

/* ORBITAL INFORMATION */
ORBIT_NUMBER                 = UNK
ORBITAL_ECCENTRICITY         = UNK
ORBITAL_INCLINATION          = UNK
ORBITAL_SEMIMAJOR_AXIS       = UNK
PERIAPSIS_ALTITUDE           = UNK
PERIAPSIS_ARGUMENT_ANGLE     = UNK
PERIAPSIS_TIME               = "UNK"
SPACECRAFT_ORIENTATION       = UNK
^SPACECRAFT_ORIENTATION_DESC  = "VEX_ORIENTATION_DESC.TXT"
SPACECRAFT_POINTING_MODE     = "N/A"
^SPACECRAFT_POINTING_MODE_DESC = "VEX_POINTING_MODE_DESC.TXT"
```

4.3.7.4 Structure Definition of Instrument Parameter Objects

N/A

4.3.7.5 Data Object Definition

This section of the label defines the structure and content of the NPI science edited data products. Each data product file (TAB) concerns a single instrument mode and contains both typically 2 objects: a header TABLE and a science data TABLE object stored in parallel. Those objects are ASCII tables containing respectively header information about the sensor status and particle number counts measured by the active sectors within each sampling time. The number of rows within these tables is variable and depends roughly on the number of sequences contained in the processed level-1 data file. The columns within the header TABLE object are first described in the section below. The table object related to the science data storage is defined in the following separate sections.

4.3.7.5.1 The description of the NPI header table for normal mode:

```
OBJECT                = HEAD_TABLE
   NAME                = "NPI_SPECTRUM_HEAD"
   ROW_SUFFIX_BYTES    = Number of bytes that are accounted in the subsequent
                         table, including record terminators and separators
   INTERCHANGE_FORMAT  = ASCII
   ROWS                = Number of rows within the data file
   COLUMNS             = 12
   ROW_BYTES           = 111
   ^STRUCTURE          = "NPI_NRMHEAD.FMT"
END_OBJECT            = HEAD_TABLE
```

The structure of the TABLE object is described in the file NPI_NRMHEAD.FMT as follows:

```
/*  Contents of format file  "NPI_NRMHEAD.FMT"  */
OBJECT                = COLUMN
   COLUMN_NUMBER       = 1
   NAME                = "UTC"
   DATA_TYPE           = TIME
```

```
   START_BYTE           = 1
   BYTES                = 23
   UNIT                 = "N/A"
   DESCRIPTION          = "This column represents the UTC of the
                           NPI science data in PDS standard format
                           YYYY-MM-DDThh:mm:ss.sss"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 2
   NAME                 = "OBT"
   DATA_TYPE            = CHARACTER
   START_BYTE           = 26
   BYTES                = 19
   UNIT                 = "N/A"
   DESCRIPTION          = "On board Time (OBT) is represented as :
                           <Reset number>/<unit seconds>.<fractional seconds>
                           with
                           <Reset number>: integer starting at 1
                              Reset number 1 starts at 2005-03-01T00:00:00 UTC
                           <unit seconds>: 10 digits number of unit seconds
                           <fractional seconds>: 5 digits number of fractional
                              seconds expressed as multiples of 2^-16 seconds"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 3
   NAME                 = "SW_VERSION"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 47
   BYTES                = 5
   UNIT                 = "N/A"
   FORMAT               = "I5"
   DESCRIPTION          = "Software version
                           To decode into Binary format. Bit description:
                           patchVersion [3:0]
                           minorVersion [8:4]
                           majorVersion [13:9]
                           releaseClass [15:14]: 1 (D), 2 (T), 3 (R)"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 4
   NAME                 = "SCANNER_DIRECTION"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 53
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
   DESCRIPTION          = "Scanner direction.
                           The field takes one of the following values:
                           0: 0 - 180
                           1: 180 - 0"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 5
   NAME                 = "SCANNER_SPEED"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 55
   BYTES                = 3
   UNIT                 = SECOND
```

```
            FORMAT              = "I3"
            DESCRIPTION         = "Scanner speed.
                                   This is not the actual moving speed at the
                                   specified time, but a setting speed value that is
                                   applied in operation to the scanner once a command
                                   is sent to move it.
                                   The field takes one of the following values:
                                   0 (standing)
                                   32 (seconds scan)
                                   64 (seconds scan)
                                   128 (seconds scan)"
        END_OBJECT              = COLUMN

        OBJECT                  = COLUMN
            COLUMN_NUMBER       = 6
            NAME                = "SCANNER_POSITION"
            DATA_TYPE           = ASCII_REAL
            START_BYTE          = 59
            BYTES               = 5
            UNIT                = "DEGREE"
            FORMAT              = "F5.1"
            DESCRIPTION         = "Scanner position in degrees"
        END_OBJECT              = COLUMN

        OBJECT                  = COLUMN
            COLUMN_NUMBER       = 7
            NAME                = "ACCUMULATION_TIME"
            DATA_TYPE           = ASCII_INTEGER
            START_BYTE          = 65
            BYTES               = 2
            UNIT                = "N/A"
            FORMAT              = "I2"
            DESCRIPTION         = "Accumulation time.
                                    Time = 2N*31.25ms"
        END_OBJECT              = COLUMN

        OBJECT                  = COLUMN
            COLUMN_NUMBER       = 8
            NAME                = "NUMBER_OF_SAMPLE"
            DATA_TYPE           = ASCII_INTEGER
            START_BYTE          = 68
            BYTES               = 3
            UNIT                = "N/A"
            FORMAT              = "I3"
            DESCRIPTION         = "Number of successive measurements which are stacked
                                    in the sensor set in packet (max=32)."
        END_OBJECT              = COLUMN

        OBJECT                  = COLUMN
            COLUMN_NUMBER       = 9
            NAME                = "NPI_SECTOR_MASK"
            DATA_TYPE           = CHARACTER
            START_BYTE          = 73
            BYTES               = 32
            UNIT                = "N/A"
            DESCRIPTION         = "NPI Sector mask defines the active sectors that are
                                    set for the measurement. The Binary format is used.
                                    One bit (or character) represents the status of one
                                    NPI sector and may take one of the following values
                                    bit 0 (sector 0): 1 (enable), 0 (disable)
                                    bit 1 (sector 1): 1 (enable), 0 (disable)
                                    bit 2 (sector 2): 1 (enable), 0 (disable)
```

```
                                      bit 3 (sector 3): 1 (enable), 0 (disable)
                                      bit 4 (sector 4): 1 (enable), 0 (disable)
                                      bit 5 (sector 5): 1 (enable), 0 (disable)
                                      bit 6 (sector 6): 1 (enable), 0 (disable)
                                      bit 7 (sector 7): 1 (enable), 0 (disable)
                                      bit 8 (sector 8): 1 (enable), 0 (disable)
                                      bit 9 (sector 9): 1 (enable), 0 (disable)
                                      bit 10 (sector 10): 1 (enable), 0 (disable)
                                      bit 11 (sector 11): 1 (enable), 0 (disable)
                                      bit 12 (sector 12): 1 (enable), 0 (disable)
                                      bit 13 (sector 13): 1 (enable), 0 (disable)
                                      bit 14 (sector 14): 1 (enable), 0 (disable)
                                      bit 15 (sector 15): 1 (enable), 0 (disable)
                                      bit 16 (sector 16): 1 (enable), 0 (disable)
                                      bit 17 (sector 17): 1 (enable), 0 (disable)
                                      bit 18 (sector 18): 1 (enable), 0 (disable)
                                      bit 19 (sector 19): 1 (enable), 0 (disable)
                                      bit 20 (sector 20): 1 (enable), 0 (disable)
                                      bit 21 (sector 21): 1 (enable), 0 (disable)
                                      bit 22 (sector 22): 1 (enable), 0 (disable)
                                      bit 23 (sector 23): 1 (enable), 0 (disable)
                                      bit 24 (sector 24): 1 (enable), 0 (disable)
                                      bit 25 (sector 25): 1 (enable), 0 (disable)
                                      bit 26 (sector 26): 1 (enable), 0 (disable)
                                      bit 27 (sector 27): 1 (enable), 0 (disable)
                                      bit 28 (sector 28): 1 (enable), 0 (disable)
                                      bit 29 (sector 29): 1 (enable), 0 (disable)
                                      bit 30 (sector 30): 1 (enable), 0 (disable)
                                      bit 31 (sector 31): 1 (enable), 0 (disable)"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
   COLUMN_NUMBER            = 10
   NAME                     = "LOG_COMPRESSION"
   DATA_TYPE                = ASCII_INTEGER
   START_BYTE               = 107
   BYTES                    = 1
   UNIT                     = "N/A"
   FORMAT                   = "I1"
   DESCRIPTION              = "The field takes one of the following values:
                                0 = disable
                                1 = enable"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
   COLUMN_NUMBER            = 11
   NAME                     = "RICE_COMPRESSION_FLAG"
   DATA_TYPE                = ASCII_INTEGER
   START_BYTE               = 109
   BYTES                    = 1
   UNIT                     = "N/A"
   FORMAT                   = "I1"
   DESCRIPTION              = "Rice compression flag status.
                                The field takes one of the following values:
                                0 = non valid
                                1 = valid"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
   COLUMN_NUMBER            = 12
   NAME                     = "RICE_COMPRESSION_VALUE"
   DATA_TYPE                = ASCII_INTEGER
```

```
      START_BYTE          = 111
      BYTES               = 1
      UNIT                = "N/A"
      FORMAT              = "I1"
      DESCRIPTION         = "Rice compression"
   END_OBJECT             = COLUMN
```

Detailed description of those parameters is provided in documents [AD 3].

   4.3.7.5.2   The description of the NPI header table for deflection stepping mode:

```
   OBJECT                 = HEAD_TABLE
      NAME                = "NPI_SPECTRUM_HEAD"
      ROW_SUFFIX_BYTES    = Number of bytes that are accounted in the subsequent
                            table, including record terminators and separators
      INTERCHANGE_FORMAT  = ASCII
      ROWS                = Number of rows within the data file
      COLUMNS             = 13
      ROW_BYTES           = 124
      ^STRUCTURE          = "NPI_STPHEAD.FMT"
   END_OBJECT             = HEAD_TABLE
```

The structure of the TABLE object is described in the file NPI_STPHEAD.FMT as follows:

```
   /*  Contents of format file  "NPI_STPHEAD.FMT"  */
   OBJECT                 = COLUMN
      COLUMN_NUMBER       = 1
      NAME                = "UTC"
      DATA_TYPE           = TIME
      START_BYTE          = 1
      BYTES                = 2
      UNIT                = "N/A"
      DESCRIPTION         = "This column represents the UTC of the
                             NPI science data in PDS standard format
                             YYYY-MM-DDThh:mm:ss.sss"
   END_OBJECT             = COLUMN

   OBJECT                 = COLUMN
      COLUMN_NUMBER       = 2
      NAME                = "OBT"
      DATA_TYPE           = CHARACTER
      START_BYTE          = 26
      BYTES               = 19
      UNIT                = "N/A"
      DESCRIPTION         = "On board Time (OBT) is represented as :
                             <Reset number>/<unit seconds>.<fractional seconds>
                             with
                             <Reset number>: integer starting at 1
                                Reset number 1 starts at 2005-03-01T00:00:00 UTC
                             <unit seconds>: 10 digits number of unit seconds
                             <fractional seconds>: 5 digits number of fractional
                                seconds expressed as multiples of 2^-16 seconds"
   END_OBJECT             = COLUMN

   OBJECT                 = COLUMN
      COLUMN_NUMBER       = 3
      NAME                = "SW_VERSION"
      DATA_TYPE           = ASCII_INTEGER
      START_BYTE          = 47
      BYTES               = 5
      UNIT                = "N/A"
      FORMAT              = "I5"
```

```
   DESCRIPTION          = "Software version
                          To decode into Binary format. Bit description:
                          patchVersion [3:0]
                          minorVersion [8:4]
                          majorVersion [13:9]
                          releaseClass [15:14]: 1 (D), 2 (T), 3 (R)"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 4
   NAME                  = "SCANNER_DIRECTION"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 53
   BYTES                 = 1
   UNIT                  = "N/A"
   FORMAT                = "I1"
   DESCRIPTION           = "Scanner direction.
                          The field takes one of the following values:
                          0: 0 - 180
                          1: 180 - 0"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 5
   NAME                  = "SCANNER_SPEED"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 55
   BYTES                 = 3
   UNIT                  = SECOND
   FORMAT                = "I3"
   DESCRIPTION           = "Scanner speed.
                          This is not the actual moving speed at the
                          specified time, but a setting speed value that is
                          applied in operation to the scanner once a command
                          is sent to move it.
                          The field takes one of the following values:
                          0 (standing)
                          32 (seconds scan)
                          64 (seconds scan)
                          128 (seconds scan)"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 6
   NAME                  = "SCANNER_POSITION"
   DATA_TYPE             = ASCII_REAL
   START_BYTE            = 59
   BYTES                 = 5
   UNIT                  = "DEGREE"
   FORMAT                = "F5.1"
   DESCRIPTION           = "Scanner position in degrees"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 7
   NAME                  = "ACCUMULATION_TIME"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 65
   BYTES                 = 2
   UNIT                  = "N/A"
   FORMAT                = "I2"
   DESCRIPTION           = "Accumulation time.
```

```
                              Time = 2N*31.25ms"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
   COLUMN_NUMBER            = 8
   NAME                     = "NUMBER_OF_SAMPLE"
   DATA_TYPE                = ASCII_INTEGER
   START_BYTE               = 68
   BYTES                    = 3
   UNIT                     = "N/A"
   FORMAT                   = "I3"
   DESCRIPTION              = "Number of samples in packet (max=32)."
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
   COLUMN_NUMBER            = 9
   NAME                     = "NPI_SECTOR_MASK"
   DATA_TYPE                = CHARACTER
   START_BYTE               = 73
   BYTES                    = 32
   UNIT                     = "N/A"
   DESCRIPTION              = "NPI Sector mask defines the active sectors that are
                              set for the measurement. The Binary format is used.
                              One bit (or character) represents the status of one
                              NPI sector and may take one of the following values
                              bit 0 (sector 0): 1 (enable), 0 (disable)
                              bit 1 (sector 1): 1 (enable), 0 (disable)
                              bit 2 (sector 2): 1 (enable), 0 (disable)
                              bit 3 (sector 3): 1 (enable), 0 (disable)
                              bit 4 (sector 4): 1 (enable), 0 (disable)
                              bit 5 (sector 5): 1 (enable), 0 (disable)
                              bit 6 (sector 6): 1 (enable), 0 (disable)
                              bit 7 (sector 7): 1 (enable), 0 (disable)
                              bit 8 (sector 8): 1 (enable), 0 (disable)
                              bit 9 (sector 9): 1 (enable), 0 (disable)
                              bit 10 (sector 10): 1 (enable), 0 (disable)
                              bit 11 (sector 11): 1 (enable), 0 (disable)
                              bit 12 (sector 12): 1 (enable), 0 (disable)
                              bit 13 (sector 13): 1 (enable), 0 (disable)
                              bit 14 (sector 14): 1 (enable), 0 (disable)
                              bit 15 (sector 15): 1 (enable), 0 (disable)
                              bit 16 (sector 16): 1 (enable), 0 (disable)
                              bit 17 (sector 17): 1 (enable), 0 (disable)
                              bit 18 (sector 18): 1 (enable), 0 (disable)
                              bit 19 (sector 19): 1 (enable), 0 (disable)
                              bit 20 (sector 20): 1 (enable), 0 (disable)
                              bit 21 (sector 21): 1 (enable), 0 (disable)
                              bit 22 (sector 22): 1 (enable), 0 (disable)
                              bit 23 (sector 23): 1 (enable), 0 (disable)
                              bit 24 (sector 24): 1 (enable), 0 (disable)
                              bit 25 (sector 25): 1 (enable), 0 (disable)
                              bit 26 (sector 26): 1 (enable), 0 (disable)
                              bit 27 (sector 27): 1 (enable), 0 (disable)
                              bit 28 (sector 28): 1 (enable), 0 (disable)
                              bit 29 (sector 29): 1 (enable), 0 (disable)
                              bit 30 (sector 30): 1 (enable), 0 (disable)
                              bit 31 (sector 31): 1 (enable), 0 (disable)"
END_OBJECT                  = COLUMN

OBJECT                      = COLUMN
   COLUMN_NUMBER            = 10
   NAME                     = "LOG_COMPRESSION"
```

```
          DATA_TYPE            = ASCII_INTEGER
          START_BYTE          = 107
          BYTES               = 1
          UNIT                = "N/A"
          FORMAT              = "I1"
          DESCRIPTION         = "The field takes one of the following values:
                                 0 = disable
                                 1 = enable"
      END_OBJECT              = COLUMN

      OBJECT                 = COLUMN
          COLUMN_NUMBER       = 11
          NAME                = "RICE_COMPRESSION_FLAG"
          DATA_TYPE           = ASCII_INTEGER
          START_BYTE          = 109
          BYTES               = 1
          UNIT                = "N/A"
          FORMAT              = "I1"
          DESCRIPTION         = "Rice compression flag status.
                                 The field takes one of the following values:
                                 0 = non valid
                                 1 = valid"
      END_OBJECT              = COLUMN

      OBJECT                 = COLUMN
          COLUMN_NUMBER       = 12
          NAME                = "RICE_COMPRESSION_VALUE"
          DATA_TYPE           = ASCII_INTEGER
          START_BYTE          = 111
          BYTES               = 1
          UNIT                = "N/A"
          FORMAT            = "I1"
          DESCRIPTION         = "Rice compression"
      END_OBJECT              = COLUMN

      OBJECT                 = COLUMN
          COLUMN_NUMBER       = 13
          NAME                = "NPI_DEFLECT_STATUS_MASK"
          DATA_TYPE           = CHARACTER
          START_BYTE          = 114
          BYTES               = 10
          UNIT                = "N/A"
          DESCRIPTION         = "NPI Deflection status mask expresses the switch
                                 states of voltage for each of the 32 samples being
                                 returned. The Hexadecimal format is used.
                                 If the bit value is set to 0, the switch was off,
                                 the deflection voltage was not applied.
                                 If the bit value is set to 1, the switch was on,
                                 the deflection voltage was applied.
                                 The ordering of the NPI deflection status mask is
                                 as below:
                                 sample 31 represents the MSB (bit 31) of the word
                                 and sample 0 represents the LSB (bit 0) of the
                                 word."
      END_OBJECT              = COLUMN
```

Detailed description of those parameters is provided in documents [AD 3].

4.3.7.5.3 The description of the NPI science table related to the normal mode:

A NPI science data table object contains a certain number of sequences of measurement of 32 samples × 32 azimuthal-sectors data values. Each of them are stored in a row with the azimuthal sector the fastest varying

parameter. However, science data for all sectors may not always be returned. The field sector mask, specified in the NPI header, indicates which of the 32 possible sectors are being returned in the data matrix. In addition, the sample number parameter value can vary from a NPI sequence of measurement to another one. To ensure a fixed-size table object, though both the number of sectors and the number of successive measurements may vary, the counting table may have to be completed with a missing constant, chosen to be -9999 to avoid mixing up constant values and science data values (positive counter values).

For the NPI science data storage, a fixed-size TABLE object, filled with missing constants will be used and inserted within corresponding data product label files. The structure of the science NPI data object is fully described in the associated label file, with no applicable external files (FMT). This description is presented hereafter and applies to the NPI normal mode.

```
    OBJECT                 = DATA_SCIENCE_TABLE
       NAME                = "NPI_SPECTRUM_DATA"
       ROW_PREFIX_BYTES    = 111
       INTERCHANGE_FORMAT  = ASCII
       ROWS                = Number of rows within the data file
       COLUMNS             = 1
       ROW_BYTES           = 6146

       OBJECT              = COLUMN
          COLUMN_NUMBER    = 1
          NAME             = "NPI_COUNTS"
          DATA_TYPE        = ASCII_INTEGER
          START_BYTE       = 1
          BYTES            = 6146
          UNIT             = "ADC_UNITS"
          FORMAT           = "I5"
          MISSING_CONSTANT = -9999
          DESCRIPTION      = "ENA (counts/sampling time) counted in the
                              current bin azimuthal sector."
          ITEMS            = 1024
          ITEM_BYTES       = 6
       END_OBJECT          = COLUMN

END_OBJECT                 = DATA_SCIENCE_TABLE
```

4.3.7.5.4 The description of the NPI science table related to the deflection stepping mode:

The following example is a fixed-size TABLE object storing science data produced in deflection stepping data mode.

```
    OBJECT                 = DATA_SCIENCE_TABLE
       NAME                = "NPI_SPECTRUM_DATA"
       ROW_PREFIX_BYTES    = 124
       INTERCHANGE_FORMAT  = ASCII
       ROWS                = Number of rows within the data file
       COLUMNS             = 1
       ROW_BYTES           = 6146

       OBJECT              = COLUMN
          COLUMN_NUMBER    = 1
          NAME             = "NPI_COUNTS"
          DATA_TYPE        = ASCII_INTEGER
          START_BYTE       = 1
          BYTES            = 6146
          UNIT             = "ADC_UNITS"
          FORMAT           = "I5"
          MISSING_CONSTANT = -9999
          DESCRIPTION      = "ENA (counts/sampling time) counted in the
```

```
                                current bin azimuthal sector."
        ITEMS              = 1024
        ITEM_BYTES         = 6
  END_OBJECT               = COLUMN

 END_OBJECT               = DATA_SCIENCE_TABLE
```

4.3.7.6 Description of Instrument

The description of the instrument is done in above and as a brief overview in the INST.CAT catalog file.

4.3.7.7 Parameters Index File Definition

N/A

4.3.7.8 Mission Specific Keywords

Mission specific keywords should all have the MISSION_ID "VEX" prefix.

```
VEX:SCIENCE_CASE_ID          = "ALL"
VEX:SCIENCE_CASE_ID_DESC     = "Please refer to VEX_SCIENCE_CASE_ID_DESC.TXT
                                in the DOCUMENT directory."
```

4.3.8   NPI Housekeeping Calibrated Data Product Design (Level 3)

NPI level 3 HK contains calibrated NPI housekeeping data with PDS detached labels. The incoming raw HK values are converted into physical values when calibration is applied. This type of data is identified by the following data descriptors within the current label file:

```
PRODUCT_TYPE                 = RDR /* EDR for RAW, RDR for calibrated data */
PROCESSING_LEVEL_ID          = 3
```

HK parameters are listed in the following fields table in the same order that they appear in the data product label file.

Table 35. NPI housekeeping content.

Rank	Field	Rank	Field
1	UTC correlated Time	24	Lost step
2	OBT Time	25	Scanner status state
3	NPI temperature	26	Scanner status direction
4	Scanner temperature sensor	27	Scanner status position clock
5	SW version	28	Scanner status cw end position
6	HK i +30V	29	Scanner status ccw end position
7	HK i +5V	30	Scanner speed
8	HK V +12V	31	Scanner setup direction
9	HK V +30V	32	Scanner setup mode
10	HK V +5V	33	Scanner +30V on/off
11	HK V -12V	34	Scanner coast current reference
12	HK V -5V	35	Scanner ramp current reference
13	Sun sensor 1	36	Scanner threshold cw reference
14	Sun sensor 2	37	Scanner threshold ccw reference
15	NPI bias reference	38	Scanner threshold wheel reference
16	NPI bias monitor	39	Scanner position
17	NPI deflector reference	40	SW mode
18	NPI deflector monitor	41	Cpu load
19	NPI deflector mode	42	NPI sector mask
20	NPI deflector switch	43	NPI RICE compression enable

21	NPI +30V on/off	44	NPI LOG compression enable
22	Scanner vrefmc	45	NPI accumulation time
23	Scanner init	46	NPI mode

The table object is detailed in the following paragraph.

4.3.8.1 File Characteristics Data Elements

The following elements are present in the labels for every NPI housekeeping calibrated data product, and they describe the basic characteristics of the data product in terms of structure and naming:

```
/* FILE CHARACTERISTIC DATA ELEMENTS */
PRODUCT_ID                    = this element defines the current product file name,
                                without extension
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 223
FILE_RECORDS                  = this element indicates the number of records within
                                the data file
```

4.3.8.2 Data Object Pointers Identification Data Elements

The NPI housekeeping calibrated data are organized as ASCII table. The data object pointer that references TAB file is:

```
^HK_NPI_TABLE
```

4.3.8.3 Instrument and Detector Descriptive Data Elements

See the applicable section 4.3.7.3

4.3.8.4 Structure Definition of Instrument Parameter Objects

N/A

4.3.8.5 Data Object Definition

This section of the label defines the structure and content of the NPI housekeeping calibrated data product. Each data file (TAB) contains a 46 columns table with the calibrated HK data when calibration is applied.

```
OBJECT                  = HK_NPI_TABLE
   NAME                 = "HK_NPI"
   INTERCHANGE_FORMAT   = ASCII
   ROWS                 = this element indicates the number of records within
                          the data file
   COLUMNS              = 46
   ROW_BYTES            = 223
  ^STRUCTURE            = "NPI_HKNPI.FMT"
END_OBJECT              = HK_NPI_TABLE
```

The structure of the TABLE object is described in the file NPI_HKNPI.FMT as follows:

```
/*  Contents of format file  "NPI_HKNPI.FMT"  */
OBJECT               = COLUMN
   COLUMN_NUMBER     = 1
   NAME              = "UTC"
   DATA_TYPE         = TIME
   START_BYTE        = 1
   BYTES             = 23
   UNIT              = "N/A"
```

```
    DESCRIPTION              = "This column represents the UTC of the
                                NPI HK data set in PDS standard format
                                YYYY-MM-DDThh:mm:ss.sss"
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
    COLUMN_NUMBER            = 2
    NAME                     = "OBT"
    DATA_TYPE                = CHARACTER
    START_BYTE               = 26
    BYTES                    = 19
    UNIT                     = "N/A"
    DESCRIPTION              = "On board Time (OBT) is represented as :
                                <Reset number>/<unit seconds>.<fractional seconds>
                                with
                                <Reset number>: integer starting at 1
                                   Reset number 1 starts at 2005-03-01T00:00:00 UTC
                                <unit seconds>: 10 digits number of unit seconds
                                <fractional seconds>: 5 digits number of fractional
                                   seconds expressed as multiples of 2^-16 seconds"
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
    COLUMN_NUMBER            = 3
    NAME                     = "NPI_TEMP"
    DATA_TYPE                = ASCII_REAL
    START_BYTE               = 47
    BYTES                    = 7
    UNIT                     = "CELSIUS"
    FORMAT                   = "F7.2"
    DESCRIPTION              = "NPI temperature in degree Celsius"
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
    COLUMN_NUMBER            = 4
    NAME                     = "SCANNER_TEMP_SENSOR"
    DATA_TYPE                = ASCII_REAL
    START_BYTE               = 55
    BYTES                    = 7
    UNIT                     = "CELSIUS"
    FORMAT                   = "F7.2"
    DESCRIPTION              = "Scanner temperature sensor in degree Celsius"
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
    COLUMN_NUMBER            = 5
    NAME                     = "SW_VERSION"
    DATA_TYPE                = ASCII_INTEGER
    START_BYTE               = 63
    BYTES                    = 5
    UNIT                     = "N/A"
    FORMAT                   = "I5"
    DESCRIPTION              = "Software version
                                To decode into Binary format. Bit description:
                                patchVersion [3:0]
                                minorVersion [8:4]
                                majorVersion [13:9]
                                releaseClass [15:14]: 1 (D), 2 (T), 3 (R)"
END_OBJECT                   = COLUMN

OBJECT                       = COLUMN
    COLUMN_NUMBER            = 6
```

```
   NAME                  = "HK_I_PLUS_30V"
   DATA_TYPE             = ASCII_REAL
   START_BYTE            = 69
   BYTES                 = 6
   UNIT                  = "MILLIAMPERE"
   FORMAT                = "F6.2"
   DESCRIPTION           = "HK i +30V in milli-amperes"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 7
   NAME                  = "HK_I_PLUS_5V"
   DATA_TYPE             = ASCII_REAL
   START_BYTE            = 76
   BYTES                 = 7
   UNIT                  = "MILLIAMPERE"
   FORMAT                = "F7.2"
   DESCRIPTION           = "HK i +5V in milli-amperes"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 8
   NAME                  = "HK_V_PLUS_12V"
   DATA_TYPE             = ASCII_REAL
   START_BYTE            = 84
   BYTES                 = 5
   UNIT                  = "VOLT"
   FORMAT                = "F5.2"
   DESCRIPTION           = "HK V +12V in Volts"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 9
   NAME                  = "HK_V_PLUS_30V"
   DATA_TYPE             = ASCII_REAL
   START_BYTE            = 90
   BYTES                 = 6
   UNIT                  = "VOLTS"
   FORMAT                = "F6.2"
   DESCRIPTION           = "HK V +30V in Volts"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 10
   NAME                  = "HK_V_PLUS_5V"
   DATA_TYPE             = ASCII_REAL
   START_BYTE            = 97
   BYTES                 = 4
   UNIT                  = "VOLT"
   FORMAT                = "F4.2"
   DESCRIPTION           = "HK V +5V in Volts"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 11
   NAME                  = "HK_V_MINUS_12V"
   DATA_TYPE             = ASCII_REAL
   START_BYTE            = 102
   BYTES                 = 6
   UNIT                  = "VOLT"
   FORMAT                = "F6.2"
   DESCRIPTION           = "HK V -12V in Volts"
```

```
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 12
   NAME                 = "HK_V_MINUS_5V"
   DATA_TYPE            = ASCII_REAL
   START_BYTE           = 109
   BYTES                = 5
   UNIT                 = "VOLT"
   FORMAT               = "F5.2"
   DESCRIPTION          = "HK V -5V in Volts"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 13
   NAME                 = "SUN_SENSOR_1"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 115
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
   DESCRIPTION          = "Sun sensor 1 output"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 14
   NAME                 = "SUN_SENSOR_2"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 117
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
   DESCRIPTION          = "Sun sensor 2 output"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 15
   NAME                 = "NPI_BIAS_REFERENCE"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 119
   BYTES                = 3
   UNIT                 = "ADC_UNITS"
   FORMAT               = "I3"
   DESCRIPTION          = "NPI bias reference"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 16
   NAME                 = "NPI_BIAS_MONITOR"
   DATA_TYPE            = ASCII_REAL
   START_BYTE           = 123
   BYTES                = 7
   UNIT                 = "VOLT"
   FORMAT               = "F7.1"
   DESCRIPTION          = "NPI bias monitor in Volts"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 17
   NAME                 = "NPI_DEFL_REFERENCE"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 131
```

```
   BYTES                = 3
   UNIT                 = "ADC_UNITS"
   FORMAT               = "I3"
   DESCRIPTION          = "NPI deflector reference"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 18
   NAME                 = "NPI_DEFL_MONITOR"
   DATA_TYPE            = ASCII_REAL
   START_BYTE           = 135
   BYTES                = 6
   UNIT                 = "VOLT"
   FORMAT               = "F6.1"
   DESCRIPTION          = "NPI deflector monitor in Volts"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 19
   NAME                 = "NPI_DEFL_MODE"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 142
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
   DESCRIPTION          = "NPI deflector mode
                            The field takes one of the following values:
                             0 off
                             1 on"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 20
   NAME                 = "NPI_DEFL_SWITCH"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 144
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
   DESCRIPTION          = "NPI deflector switch"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 21
   NAME                 = "NPI_PLUS_30V_ON_OFF"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 146
   BYTES                = 1
   UNIT                 = "N/A"
   FORMAT               = "I1"
   DESCRIPTION          = "NPI +30V on/off
                            The field takes one of the following values:
                             0 off
                             1 on"
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
   COLUMN_NUMBER        = 22
   NAME                 = "SCANNER_VREFMC"
   DATA_TYPE            = ASCII_INTEGER
   START_BYTE           = 148
   BYTES                = 3
```

```
      UNIT               = "ADC_UNITS"
      FORMAT             = "I3"
      DESCRIPTION        = "Scanner vrefmc"
   END_OBJECT            = COLUMN

   OBJECT                = COLUMN
      COLUMN_NUMBER      = 23
      NAME               = "SCANNER_INIT"
      DATA_TYPE          = ASCII_INTEGER
      START_BYTE         = 152
      BYTES              = 1
      UNIT               = "N/A"
      FORMAT             = "I1"
      DESCRIPTION        = "Scanner initialized"
   END_OBJECT            = COLUMN

   OBJECT                = COLUMN
      COLUMN_NUMBER      = 24
      NAME               = "LOST_STEP"
      DATA_TYPE          = ASCII_INTEGER
      START_BYTE         = 154
      BYTES              = 1
      UNIT               = "N/A"
      FORMAT             = "I1"
      DESCRIPTION        = "Lost step"
   END_OBJECT            = COLUMN

   OBJECT                = COLUMN
      COLUMN_NUMBER      = 25
      NAME               = "SCANNER_STATUS_STATE"
      DATA_TYPE          = ASCII_INTEGER
      START_BYTE         = 156
      BYTES              = 1
      UNIT               = "N/A"
      FORMAT             = "I1"
      DESCRIPTION        = "Scanner status state.
                            The field takes one of the following values:
                            0 not busy
                            1 ramp up
                            2 full speed move
                            3 ramp down"
   END_OBJECT            = COLUMN

   OBJECT                = COLUMN
      COLUMN_NUMBER      = 26
      NAME               = "SCANNER_STATUS_DIRECTION"
      DATA_TYPE          = ASCII_INTEGER
      START_BYTE         = 158
      BYTES              = 1
      UNIT               = "N/A"
      FORMAT             = "I1"
      DESCRIPTION        = "Scanner status direction
                            The field takes one of the following values:
                            0 0-180
                            1 180-0"
   END_OBJECT            = COLUMN

   OBJECT                = COLUMN
      COLUMN_NUMBER      = 27
      NAME               = "SCANNER_STATUS_POS_CLOCK"
      DATA_TYPE          = ASCII_INTEGER
      START_BYTE         = 160
```

```
      BYTES                 = 1
      UNIT                  = "N/A"
      FORMAT                = "I1"
      DESCRIPTION           = "Scanner status position clock"
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 28
      NAME                  = "SCANNER_STATUS_CW_END_POS"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 162
      BYTES                 = 1
      UNIT                  = "N/A"
      FORMAT                = "I1"
      DESCRIPTION           = "Scanner status cw end position
                               The field takes one of the following values:
                                0 scanner not in cw end position
                                1 scanner in cw end position"
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 29
      NAME                  = "SCANNER_STATUS_CCW_END_POS"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 164
      BYTES                 = 1
      UNIT                  = "N/A"
      FORMAT                = "I1"
      DESCRIPTION           = "Scanner status ccw end position
                               The field takes one of the following values:
                                0 scanner not in ccw end position
                                1 scanner in ccw end position"
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 30
      NAME                  = "SCANNER_SPEED"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 166
      BYTES                 = 1
      UNIT                  = "N/A"
      FORMAT                = "I1"
      DESCRIPTION           = "Scanner speed
                               This is not the actual moving speed at the
                               specified time, but a setting speed value that is
                               applied in operation to the scanner once a command
                               is sent to move it.
                               The field takes one of the following values:
                                0 STOP
                                1 32s scan
                                2 64s scan
                                3 128s scan"
   END_OBJECT               = COLUMN

   OBJECT                   = COLUMN
      COLUMN_NUMBER         = 31
      NAME                  = "SCANNER_SETUP_DIRECTION"
      DATA_TYPE             = ASCII_INTEGER
      START_BYTE            = 168
      BYTES                 = 1
      UNIT                  = "N/A"
      FORMAT                = "I1"
```

```
     DESCRIPTION           = "Scanner setup direction
                              The field takes one of the following values:
                              0 0-180
                              1 180-0
                              for manual mode speed command only"
  END_OBJECT               = COLUMN

  OBJECT                   = COLUMN
     COLUMN_NUMBER         = 32
     NAME                  = "SCANNER_SETUP_MODE"
     DATA_TYPE             = ASCII_INTEGER
     START_BYTE            = 170
     BYTES                 = 1
     UNIT                  = "N/A"
     FORMAT                = "I1"
     DESCRIPTION           = "Scanner setup mode
                              The field takes one of the following values:
                              0 normal
                              1 manual"
  END_OBJECT               = COLUMN

  OBJECT                   = COLUMN
     COLUMN_NUMBER         = 33
     NAME                  = "SCANNER_PLUS_30V_ON_OFF"
     DATA_TYPE             = ASCII_INTEGER
     START_BYTE            = 172
     BYTES                 = 1
     UNIT                  = "N/A"
     FORMAT                = "I1"
     DESCRIPTION           = "Scanner +30V on/off
                              The field takes one of the following values:
                              0 off
                              1 on"
  END_OBJECT               = COLUMN

  OBJECT                   = COLUMN
     COLUMN_NUMBER         = 34
     NAME                  = "SCANNER_COAST_CURRENT_REF"
     DATA_TYPE             = ASCII_INTEGER
     START_BYTE            = 174
     BYTES                 = 3
     UNIT                  = "ADC_UNITS"
     FORMAT                = "I3"
     DESCRIPTION           = "Scanner coast current reference"
  END_OBJECT               = COLUMN

  OBJECT                   = COLUMN
     COLUMN_NUMBER         = 35
     NAME                  = "SCANNER_RAMP_CURRENT_REF"
     DATA_TYPE             = ASCII_INTEGER
     START_BYTE            = 178
     BYTES                 = 3
     UNIT                  = "ADC_UNITS"
     FORMAT                = "I3"
     DESCRIPTION           = "Scanner ramp current reference"
  END_OBJECT               = COLUMN

  OBJECT                   = COLUMN
     COLUMN_NUMBER         = 36
     NAME                  = "SCANNER_TRESHOLD_CW_REF"
     DATA_TYPE             = ASCII_INTEGER
     START_BYTE            = 182
```

```
   BYTES                 = 3
   UNIT                  = "ADC_UNITS"
   FORMAT                = "I3"
   DESCRIPTION           = "Scanner threshold cw reference"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 37
   NAME                  = "SCANNER_TRESHOLD_CCW_REF"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 186
   BYTES                 = 3
   UNIT                  = "ADC_UNITS"
   FORMAT                = "I3"
   DESCRIPTION           = "Scanner threshold ccw reference"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 38
   NAME                  = "SCANNER_TRESHOLD_WHEEL_REF"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 190
   BYTES                 = 3
   UNIT                  = "ADC_UNITS"
   FORMAT                = "I3"
   DESCRIPTION           = "Scanner threshold wheel reference"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 39
   NAME                  = "SCANNER_POSITION"
   DATA_TYPE             = ASCII_REAL
   START_BYTE            = 194
   BYTES                 = 5
   UNIT                  = "DEGREE"
   FORMAT                = "F5.1"
   DESCRIPTION           = "Scanner position in degrees"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 40
   NAME                  = "SW_MODE"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 200
   BYTES                 = 3
   UNIT                  = "N/A"
   FORMAT                = "I3"
   DESCRIPTION           = "Software mode"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
   COLUMN_NUMBER         = 41
   NAME                  = "CPU_LOAD"
   DATA_TYPE             = ASCII_INTEGER
   START_BYTE            = 204
   BYTES                 = 3
   UNIT                  = "N/A"
   FORMAT                = "I3"
   DESCRIPTION           = "CPU load"
END_OBJECT               = COLUMN

OBJECT                   = COLUMN
```

```
   COLUMN_NUMBER       = 42
   NAME                = "NPI_SECTOR_MASK"
   DATA_TYPE           = ASCII_INTEGER
   START_BYTE          = 208
   BYTES               = 5
   UNIT                = "N/A"
   FORMAT              = "I5"
   DESCRIPTION         = "NPI Sector mask defined the active sectors set for
                          the measurement. The Hexadecimal format is used.
                          The bit order is described below:
                          Sector 31 represents the MSB (bit 31) of the word
                          and Sector 0 represents the LSB (bit 0) of the word
                          Each bit may have one of the following values:
                          1 (enable)
                          0 (disable)"
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
   COLUMN_NUMBER       = 43
   NAME                = "NPI_RICE_COMPRESSION_ENABLE"
   DATA_TYPE           = ASCII_INTEGER
   START_BYTE          = 214
   BYTES               = 1
   UNIT                = "N/A"
   FORMAT              = "I1"
   DESCRIPTION         = "Rice compression flag status.
                          The field takes one of the following values:
                          0 = off
                          1 = on"
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
   COLUMN_NUMBER       = 44
   NAME                = "NPI_LOG_COMPRESSION_ENABLE"
   DATA_TYPE           = ASCII_INTEGER
   START_BYTE          = 216
   BYTES               = 1
   UNIT                = "N/A"
   FORMAT              = "I1"
   DESCRIPTION         = "The field takes one of the following values:
                          0 = off
                          1 = on"
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
   COLUMN_NUMBER       = 45
   NAME                = "NPI_ACCUMULATION_TIME"
   DATA_TYPE           = ASCII_INTEGER
   START_BYTE          = 218
   BYTES               = 2
   UNIT                = "N/A"
   FORMAT              = "I2"
   DESCRIPTION         = "Accumulation time.
                          Time = 2N*31.25 [ms]"
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
   COLUMN_NUMBER       = 46
   NAME                = "NPI_MODE"
   DATA_TYPE           = ASCII_INTEGER
   START_BYTE          = 221
   BYTES               = 1
```

```
        UNIT                = "N/A"
        FORMAT              = "I1"
        DESCRIPTION         = "NPI mode"
    END_OBJECT              = COLUMN
```

Detailed description of those parameters is provided in documents [AD 3].

4.3.8.6   Description of Instrument

See the applicable section 4.3.7.6

4.3.8.7   Parameters Index File Definition

N/A

4.3.8.8   Mission Specific Keywords

See the applicable section 4.3.7.8

5 Appendix A: Available Software to read PDS files

The PDS table tool "tbtool" is used for reading and veryfying the consistency of housekeeping and science PDS files with TABLE objects.

All data products can be visualized using the IDL software 'readpds' standard PDS reader. The standard package is available for download from the PDS website (http://pds.jpl.nasa.gov).

6 Appendix B: Example of Data Set Directory Listing

```
Files in Root Directory VEX-V_SW-ASPERA-2-ELS-V1.0:

AAREADME.TXT
ERRATA.TXT
VOLDESC.CAT


Subdirectories in Root Directory VEX-V_SW-ASPERA-2-ELS-V1.0:

CALIB
CATALOG
DATA
DOCUMENT
GEOMETRY
INDEX
LABEL


VEX-V_SW-ASPERA-2-ELS-V1.0/CALIB:

CALINFO.TXT


VEX-V_SW-ASPERA-2-ELS-V1.0/CATALOG:

CATINFO.TXT
DATASET.CAT
INSTHOST.CAT
INST.CAT
MISSION.CAT
PERSON.CAT
REF.CAT
RELEASE.CAT
SOFTWARE.CAT
TARGET.CAT


Subdirectories in Root Directory VEX-V_SW-ASPERA-2-ELS-V1.0/DATA:

20051109_20060831
20060901_20061130
20061201_20070228


VEX-V_SW-ASPERA-2-ELS-V1.0/DATA/20051109_20060831:

ELS_E128A16_060101123000_11.TAB
ELS_E128A16_060101123000_11.LBL
ELS_ENGXXXX_060101123000_11.TAB
ELS_ENGXXXX_060101123000_11.LBL
ELS_HK3MUXX_060101123000_11.TAB
ELS_HK3MUXX_060101123000_11.LBL
ELS_E128A16_060202101530_11.TAB
ELS_E128A16_060202101530_11.LBL
ELS_ENGXXXX_060202101530_11.TAB
ELS_ENGXXXX_060202101530_11.LBL
ELS_HK3MUXX_060202101530_11.TAB
ELS_HK3MUXX_060202101530_11.LBL
ELS_E128A16_060519004359_11.TAB
ELS_E128A16_060519004359_11.LBL
ELS_ENGXXXX_060519004359_11.TAB
ELS_ENGXXXX_060519004359_11.LBL
ELS_HK3MUXX_060519004359_11.TAB
ELS_HK3MUXX_060519004359_11.LBL
```

VEX-V_SW-ASPERA-2-ELS-V1.0/DATA/20060901_20061130:

ELS_E128A16_061015232744_11.TAB
ELS_E128A16_061015232744_11.LBL
ELS_ENGXXXX_061015232744_11.TAB
ELS_ENGXXXX_061015232744_11.LBL
ELS_HK3MUXX_061015232744_11.TAB
ELS_HK3MUXX_061015232744_11.LBL

VEX-V_SW-ASPERA-2-ELS-V1.0/DATA/20061201_20070228:

ELS_E128A16_061209214517_11.TAB
ELS_E128A16_061209214517_11.LBL
ELS_ENGXXXX_061209214517_11.TAB
ELS_ENGXXXX_061209214517_11.LBL
ELS_HK3MUXX_061209214517_11.TAB
ELS_HK3MUXX_061209214517_11.LBL
ELS_E128A16_06122215243_11.TAB
ELS_E128A16_061212215243_11.LBL
ELS_ENGXXXX_061212215243_11.TAB
ELS_ENGXXXX_061212215243_11.LBL
ELS_HK3MUXX_061212215243_11.TAB
ELS_HK3MUXX_061212215243_11.LBL

VEX-V_SW-ASPERA-2-ELS-V1.0/DOCUMENT:

DOCINFO.TXT
ASPERA4_DESC.TXT
ASPERA4_DESC.LBL
VE-ASP-TN-060402.PDF
VE-ASP-TN-060402.LBL
BARABASHP3.PDF
BARABASHP3.LBL
ASPERA4-L1-061016.PDF
ASPERA4-L1-061016.LBL
VEX_ASP_CESR_EAICD_V1_4.PDF
VEX_ASP_CESR_EAICD_V1_4.LBL
VEX_SCIENCE_CASE_ID_DESC.TXT
VEX_SCIENCE_CASE_ID_DESC.LBL
OBSERVATION_TYPE_DESC.TXT
OBSERVATION_TYPE_DESC.LBL
VEX_ORIENTATION_DESC.TXT
VEX_ORIENTATION_DESC.LBL
VEX-SCIOPS-TN-050.PDF
VEX-SCIOPS-TN-050.LBL
VEX_RSSD_LI_009.TAB
VEX_RSSD_LI_009.LBL
VEX_POINTING_MODE_DESC.TXT
VEX_POINTING_MODE_DESC.LBL
ELS_DATA_ANALYSIS_SUMMARY.PDF
ELS_DATA_ANALYSIS_SUMMARY.LBL

VEX-V_SW-ASPERA-2-ELS-V1.0/GEOMETRY:

GEOMINFO.TXT
ORB.FMT
ORB_060101123000_00320.TAB
ORB_060101123000_00320.LBL
ORB_060202101530_00530.TAB
ORB_060202101530_00530.LBL
ORB_060519004359_00812.TAB
ORB_060519004359_00812.LBL
ORB_061015232744_00550.TAB

```
ORB_061015232744_00550.LBL
ORB_061209214517_00123.TAB
ORB_061209214517_00123.LBL
ORB_061212215243_00539.TAB
ORB_061212215243_00539.LBL


VEX-V_SW-ASPERA-2-ELS-V1.0/INDEX:

INDXINFO.TXT
INDEX.LBL
INDEX.TAB
GEO_VENUS.LBL
GEO_VENUS.TAB


VEX-V_SW-ASPERA-2-ELS-V1.0/LABEL:

LABINFO.TXT
ELS_SPECTRUM_HEAD.FMT
ELS_SPECTRUM_ENGINR.FMT
ELS_SPECTRUM_DEFLCT.FMT
ELS_SPECTRUM_HKELS.FMT
```

7 Appendix C: Example of PDS detached label for an ASPERA-4 ELS level-2 data product

```
PDS_VERSION_ID              = PDS3

/* FILE CHARACTERISTIC DATA ELEMENTS */

PRODUCT_ID                  = "ELS_E128A16_060603010208_11"
RECORD_TYPE                 = FIXED_LENGTH
RECORD_BYTES                = 12384
FILE_RECORDS                = 119

/* DATA OBJECT POINTERS */

^HEAD_TABLE = "ELS_E128A16_060603010208_11.TAB"
^DATA_SCIENCE_TABLE = "ELS_E128A16_060603010208_11.TAB"

/* PRODUCER IDENTIFICATION */

PRODUCER_ID                 = "
CESR_ASPERA4_GROUP"
PRODUCER_FULL_NAME          = "
EMMANUEL PENOU"
PRODUCER_INSTITUTION_NAME   = "
CENTRE D'ETUDE SPATIALE DES RAYONNEMENTS"
PRODUCT_CREATION_TIME       = 2007-12-06T10:48:19

/* DATA DESCRIPTION AND IDENTIFICATION */

DATA_SET_NAME               = "
      VENUS EXPRESS VENUS/SOLARWIND ASPERA 2 ELS V1.0"
DATA_SET_ID                 = "VEX-V/SW-ASPERA-2-ELS-V1.0"
RELEASE_ID                  = 0001
REVISION_ID                 = 0000
PRODUCT_TYPE                = EDR
PROCESSING_LEVEL_ID         = 2
MISSION_NAME                = "VENUS EXPRESS"
MISSION_ID                  = VEX
INSTRUMENT_HOST_NAME        = "VENUS EXPRESS"
INSTRUMENT_HOST_ID          = VEX
MISSION_PHASE_NAME          = "PHASE 0"
INSTRUMENT_NAME             = "
                 ANALYZER OF SPACE PLASMA AND ENERGETIC ATOMS (4TH VERSION)"
INSTRUMENT_ID               = ASPERA4
INSTRUMENT_TYPE             = {"ELECTROSTATIC ANALYZER",
                               "MASS SPECTROMETER",
                               "NEUTRAL PARTICLE IMAGER",
                               "NEUTRAL PARTICLE DETECTOR"}
DETECTOR_ID                 = VEX_ASP4_ELS
^INSTRUMENT_DESC            = "ASPERA4_DESC.TXT"

/* TARGET IDENTIFICATION */

TARGET_TYPE                 = "PLANET"
TARGET_NAME                 = "VENUS"
RIGHT_ASCENSION             = "N/A"
DECLINATION                 = "N/A"

/* SCIENCE OPERATIONS INFORMATION */
```

```
VEX:SCIENCE_CASE_ID         = "
ALL"
VEX:SCIENCE_CASE_ID_DESC    = "Please refer to VEX_SCIENCE_CASE_ID_DESC.TXT
                               in the DOCUMENT directory."
OBSERVATION_TYPE            = {"AC003B", "PE001A", "PE004A"}
^OBSERVATION_TYPE_DESC      = "OBSERVATION_TYPE_DESC.TXT"

/* TIME RELATED INFORMATION */

START_TIME                  = 2006-06-03T01:02:08.906
STOP_TIME                   = 2006-06-03T01:11:07.408
SPACECRAFT_CLOCK_START_COUNT = "01/0039661328.40239"
SPACECRAFT_CLOCK_STOP_COUNT  = "01/0039661867.07602"

/* ORBITAL INFORMATION */

ORBIT_NUMBER                = 42
ORBITAL_ECCENTRICITY        = 0.839199
ORBITAL_INCLINATION         = 83.232491
ORBITAL_SEMIMAJOR_AXIS      = 39467.509009
PERIAPSIS_ALTITUDE          = 294.620753
PERIAPSIS_ARGUMENT_ANGLE    = 122.983458
PERIAPSIS_TIME              = 2006-06-02T01:42:21.349
SPACECRAFT_ORIENTATION      = (-0.242323,-0.769143,0.591353)
^SPACECRAFT_ORIENTATION_DESC = "VEX_ORIENTATION_DESC.TXT"
SPACECRAFT_POINTING_MODE    = "
N/A"
^SPACECRAFT_POINTING_MODE_DESC= "VEX_POINTING_MODE_DESC.TXT"

/* DATA OBJECT DEFINITION */


OBJECT                = HEAD_TABLE
   NAME               = "ELS_SPECTRUM_HEAD"
   ROW_SUFFIX_BYTES   = 12290
   INTERCHANGE_FORMAT = ASCII
   ROWS               = 119
   COLUMNS            = 12
   ROW_BYTES          = 94
  ^STRUCTURE          = "ELS_SPECTRUM_HEAD.FMT"
END_OBJECT            = HEAD_TABLE

OBJECT                = DATA_SCIENCE_TABLE
   NAME               = "ELS_SPECTRUM_DATA"
   ROW_PREFIX_BYTES   = 94
   INTERCHANGE_FORMAT = ASCII
   ROWS               = 119
   COLUMNS            = 1
   ROW_BYTES          = 12290

   OBJECT             = COLUMN
      COLUMN_NUMBER   = 1
      NAME            = "ELS_COUNTS"
      DATA_TYPE       = ASCII_INTEGER
      START_BYTE      = 1
      BYTES           = 12290
      UNIT            = "ADC_UNITS"
      FORMAT          = "I5"
      DESCRIPTION     = "Electrons (counts/accumulation) counted in the
                         current energy step number and azimuthal sector."
      ITEMS           = 2048
      ITEM_BYTES      = 6
```

```
        END_OBJECT          = COLUMN

    END_OBJECT              = DATA_SCIENCE_TABLE


    END
```

8 Appendix D: Example of PDS detached label for an ASPERA-4 IMA level-2 data product

```
PDS_VERSION_ID              = PDS3

/* FILE CHARACTERISTIC DATA ELEMENTS */

PRODUCT_ID                  = "IMA_M24XXXX_060610172145_11"
RECORD_TYPE                 = FIXED_LENGTH
RECORD_BYTES                = 4718735
FILE_RECORDS                = 108

/* DATA OBJECT POINTERS */

^HEAD_TABLE = "IMA_M24XXXX_060610172145_11.TAB"
^DATA_SCIENCE_TABLE = "IMA_M24XXXX_060610172145_11.TAB"

/* PRODUCER IDENTIFICATION */

PRODUCER_ID                 = "
CESR_ASPERA4_GROUP"
PRODUCER_FULL_NAME          = "
EMMANUEL PENOU"
PRODUCER_INSTITUTION_NAME   = "
CENTRE D'ETUDE SPATIALE DES RAYONNEMENTS"
PRODUCT_CREATION_TIME       = 2007-12-12T14:30:40

/* DATA DESCRIPTION AND IDENTIFICATION */

DATA_SET_NAME               = "
        VENUS EXPRESS VENUS/SOLARWIND ASPERA 2 IMA V1.0"
DATA_SET_ID                 = "VEX-V/SW-ASPERA-2-IMA-V1.0"
RELEASE_ID                  = 0001
REVISION_ID                 = 0000
PRODUCT_TYPE                = EDR
PROCESSING_LEVEL_ID         = 2
MISSION_NAME                = "VENUS EXPRESS"
MISSION_ID                  = VEX
INSTRUMENT_HOST_NAME        = "VENUS EXPRESS"
INSTRUMENT_HOST_ID          = VEX
MISSION_PHASE_NAME          = "PHASE 1"
INSTRUMENT_NAME             = "
                ANALYZER OF SPACE PLASMA AND ENERGETIC ATOMS (4TH VERSION)"
INSTRUMENT_ID               = ASPERA4
INSTRUMENT_TYPE             = {"ELECTROSTATIC ANALYZER",
                                "MASS SPECTROMETER",
                                "NEUTRAL PARTICLE IMAGER",
                                "NEUTRAL PARTICLE DETECTOR"}
DETECTOR_ID                 = VEX_ASP4_IMA
^INSTRUMENT_DESC            = "ASPERA4_DESC.TXT"

/* TARGET IDENTIFICATION */

TARGET_TYPE                 = "PLANET"
TARGET_NAME                 = "VENUS"
RIGHT_ASCENSION             = "N/A"
DECLINATION                 = "N/A"

/* SCIENCE OPERATIONS INFORMATION */

VEX:SCIENCE_CASE_ID         = "
```

```
                             ALL"
VEX:SCIENCE_CASE_ID_DESC     = "Please refer to VEX_SCIENCE_CASE_ID_DESC.TXT
                               in the DOCUMENT directory."
OBSERVATION_TYPE             = {"AC003B", "PE001A", "PE004A"}
^OBSERVATION_TYPE_DESC       = "OBSERVATION_TYPE_DESC.TXT"

/* TIME RELATED INFORMATION */

START_TIME                   = 2006-06-10T17:21:45.346
STOP_TIME                    = 2006-06-10T23:07:24.318
SPACECRAFT_CLOCK_START_COUNT = "01/0040324904.63439"
SPACECRAFT_CLOCK_STOP_COUNT  = "01/0040345643.61407"

/* ORBITAL INFORMATION */

ORBIT_NUMBER                 = 50
ORBITAL_ECCENTRICITY         = 0.839098
ORBITAL_INCLINATION          = 83.202232
ORBITAL_SEMIMAJOR_AXIS       = 39465.282197
PERIAPSIS_ALTITUDE           = 298.259010
PERIAPSIS_ARGUMENT_ANGLE     = 122.929391
PERIAPSIS_TIME               = 2006-06-10T01:45:38.036
SPACECRAFT_ORIENTATION       = (-0.362577,0.713916,-0.599051)
^SPACECRAFT_ORIENTATION_DESC = "VEX_ORIENTATION_DESC.TXT"
SPACECRAFT_POINTING_MODE     = "
N/A"
^SPACECRAFT_POINTING_MODE_DESC= "VEX_POINTING_MODE_DESC.TXT"

/* DATA OBJECT DEFINITION */

OBJECT                = HEAD_TABLE
  NAME                = "IMA_SPECTRUM_HEAD"
  ROW_SUFFIX_BYTES    = 4718594
  INTERCHANGE_FORMAT  = ASCII
  ROWS                = 108
  COLUMNS             = 29
  ROW_BYTES           = 141
  ^STRUCTURE          = "IMA_SPECTRUM_HEAD.FMT"
END_OBJECT            = HEAD_TABLE

OBJECT                = DATA_SCIENCE_TABLE
  NAME                = "IMA_SPECTRUM_DATA_M24"
  ROW_PREFIX_BYTES    = 141
  INTERCHANGE_FORMAT  = ASCII
  ROWS                = 108
  COLUMNS             = 1
  ROW_BYTES           = 4718594

  OBJECT              = COLUMN
    COLUMN_NUMBER     = 1
    NAME              = "IMA_COUNTS"
    DATA_TYPE         = ASCII_INTEGER
    START_BYTE        = 1
    BYTES             = 4718594
    UNIT              = "N/A"
    FORMAT            = "I5"
    DESCRIPTION       = "Particles (counts/accumulation) counted in the
                        current azimuth, mass, energy and polar angle
                        sector.
                        Within the azimuth mass energy polar-angle matrix,
                        particle counts are displayed as acquired
                        in the EXM0 mode with the first index varying
```

```
                          the fastest."
        ITEMS            = 786432
        ITEM_BYTES       = 6
     END_OBJECT          = COLUMN

  END_OBJECT             = DATA_SCIENCE_TABLE
  END
```

9 Appendix E: Example of PDS detached label for an ASPERA-4 NPI level-2 data product

```
PDS_VERSION_ID              = PDS3

/* FILE CHARACTERISTIC DATA ELEMENTS */

PRODUCT_ID                  = "NPI_NORMALX_070212153119_11"
RECORD_TYPE                 = FIXED_LENGTH
RECORD_BYTES                = 6257
FILE_RECORDS                = 208

/* DATA OBJECT POINTERS */

^HEAD_TABLE = "NPI_NORMALX_070212153119_11.TAB"
^DATA_SCIENCE_TABLE = "NPI_NORMALX_070212153119_11.TAB"

/* PRODUCER IDENTIFICATION */

PRODUCER_ID                 = "
CESR_ASPERA4_GROUP"
PRODUCER_FULL_NAME          = "
EMMANUEL PENOU"
PRODUCER_INSTITUTION_NAME   = "
CENTRE D'ETUDE SPATIALE DES RAYONNEMENTS"
PRODUCT_CREATION_TIME       = 2007-08-07T07:05:12

/* DATA DESCRIPTION AND IDENTIFICATION */

DATA_SET_NAME               = "
        VENUS EXPRESS VENUS/SOLARWIND ASPERA 2 NPI V1.0"
DATA_SET_ID                 = "VEX-V/SW-ASPERA-2-NPI-V1.0"
RELEASE_ID                  = 0003
REVISION_ID                 = 0000
PRODUCT_TYPE                = EDR
PROCESSING_LEVEL_ID         = 2
MISSION_NAME                = "VENUS EXPRESS"
MISSION_ID                  = VEX
INSTRUMENT_HOST_NAME        = "VENUS EXPRESS"
INSTRUMENT_HOST_ID          = VEX
MISSION_PHASE_NAME          = "PHASE 5"
INSTRUMENT_NAME             = "
                 ANALYZER OF SPACE PLASMA AND ENERGETIC ATOMS (4TH VERSION)"
INSTRUMENT_ID               = ASPERA4
INSTRUMENT_TYPE             = {"ELECTROSTATIC ANALYZER",
                               "MASS SPECTROMETER",
                               "NEUTRAL PARTICLE IMAGER",
                               "NEUTRAL PARTICLE DETECTOR"}
DETECTOR_ID                 = VEX_ASP4_NPI
^INSTRUMENT_DESC            = "ASPERA4_DESC.TXT"

/* TARGET IDENTIFICATION */

TARGET_TYPE                 = "PLANET"
TARGET_NAME                 = "VENUS"
RIGHT_ASCENSION             = "N/A"
DECLINATION                 = "N/A"

/* SCIENCE OPERATIONS INFORMATION */
```

```
VEX:SCIENCE_CASE_ID         = "
ALL"
VEX:SCIENCE_CASE_ID_DESC    = "Please refer to VEX_SCIENCE_CASE_ID_DESC.TXT
                                 in the DOCUMENT directory."
OBSERVATION_TYPE            = {"AC002B", "PE001A", "PE004A"}
^OBSERVATION_TYPE_DESC      = "OBSERVATION_TYPE_DESC.TXT"

/* TIME RELATED INFORMATION */

START_TIME                  = 2007-02-12T15:31:19.632
STOP_TIME                   = 2007-02-12T17:22:16.181
SPACECRAFT_CLOCK_START_COUNT  = "01/0061659076.49086"
SPACECRAFT_CLOCK_STOP_COUNT   = "01/0061665733.19464"

/* ORBITAL INFORMATION */

ORBIT_NUMBER                = 297
ORBITAL_ECCENTRICITY        = 0.839513
ORBITAL_INCLINATION         = 83.338442
ORBITAL_SEMIMAJOR_AXIS      = 39443.405220
PERIAPSIS_ALTITUDE          = 278.363152
PERIAPSIS_ARGUMENT_ANGLE    = 120.845168
PERIAPSIS_TIME              = 2007-02-12T07:09:34.403
SPACECRAFT_ORIENTATION      = (-0.455591,-0.593954,0.663065)
^SPACECRAFT_ORIENTATION_DESC  = "VEX_ORIENTATION_DESC.TXT"
SPACECRAFT_POINTING_MODE    = "
N/A"
^SPACECRAFT_POINTING_MODE_DESC= "VEX_POINTING_MODE_DESC.TXT"

/* DATA OBJECT DEFINITION */

OBJECT              = HEAD_TABLE
  NAME              = "NPI_SPECTRUM_HEAD"
  ROW_SUFFIX_BYTES  = 6146
  INTERCHANGE_FORMAT = ASCII
  ROWS              = 208
  COLUMNS           = 12
  ROW_BYTES         = 111
  ^STRUCTURE        = "NPI_NRMHEAD.FMT"
END_OBJECT          = HEAD_TABLE

OBJECT              = DATA_SCIENCE_TABLE
  NAME              = "NPI_SPECTRUM_DATA"
  ROW_PREFIX_BYTES  = 111
  INTERCHANGE_FORMAT = ASCII
  ROWS              = 208
  COLUMNS           = 1
  ROW_BYTES         = 6146

  OBJECT            = COLUMN
    COLUMN_NUMBER   = 1
    NAME            = "NPI_COUNTS"
    DATA_TYPE       = ASCII_INTEGER
    START_BYTE      = 1
    BYTES           = 6146
    UNIT            = "ADC_UNITS"
    FORMAT          = "I5"
    DESCRIPTION     = "ENA (counts/sampling time) counted in the
                       current bin azimuthal sector."
    ITEMS           = 1024
    ITEM_BYTES      = 6
```

```
    END_OBJECT          = COLUMN

END_OBJECT              = DATA_SCIENCE_TABLE

END
```

10 Appendix F: Example of PDS detached label for an ASPERA-4 NPD level-2 data product

```
PDS_VERSION_ID              = PDS3

/* FILE CHARACTERISTIC DATA ELEMENTS */

PRODUCT_ID                  = "NP1_TOFXXXX_070820201019_11"
RECORD_TYPE                 = FIXED_LENGTH
RECORD_BYTES                = 4734
FILE_RECORDS                = 10

/* DATA OBJECT POINTERS */

^NPD_TOFHEAD_TABLE = "NP1_TOFXXXX_070820201019_11.TAB"
^NPD_TOFSCIE_TABLE = "NP1_TOFXXXX_070820201019_11.TAB"

/* PRODUCER IDENTIFICATION */

PRODUCER_ID                 = "
CESR_ASPERA4_GROUP"
PRODUCER_FULL_NAME          = "
EMMANUEL PENOU"
PRODUCER_INSTITUTION_NAME       = "
CENTRE D'ETUDE SPATIALE DES RAYONNEMENTS"
PRODUCT_CREATION_TIME       = 2007-12-12T15:06:14

/* DATA DESCRIPTION AND IDENTIFICATION */

DATA_SET_NAME               = "
        VENUS EXPRESS VENUS/SOLARWIND ASPERA 2 NPD V1.0"
DATA_SET_ID                 = "VEX-V/SW-ASPERA-2-NPD-V1.0"
RELEASE_ID                  = 0005
REVISION_ID                 = 0000
PRODUCT_TYPE                = EDR
PROCESSING_LEVEL_ID         = 2
MISSION_NAME                = "VENUS EXPRESS"
MISSION_ID                  = VEX
INSTRUMENT_HOST_NAME        = "VENUS EXPRESS"
INSTRUMENT_HOST_ID          = VEX
MISSION_PHASE_NAME          = "PHASE 8"
INSTRUMENT_NAME             = "
                  ANALYZER OF SPACE PLASMA AND ENERGETIC ATOMS (4TH VERSION)"
INSTRUMENT_ID               = ASPERA4
INSTRUMENT_TYPE             = {"ELECTROSTATIC ANALYZER",
                                "MASS SPECTROMETER",
                                "NEUTRAL PARTICLE IMAGER",
                                "NEUTRAL PARTICLE DETECTOR"}
DETECTOR_ID                 = VEX_ASP4_NPD1
^INSTRUMENT_DESC            = "ASPERA4_DESC.TXT"

/* TARGET IDENTIFICATION */

TARGET_TYPE                 = "PLANET"
TARGET_NAME                 = "VENUS"
RIGHT_ASCENSION             = "N/A"
DECLINATION                 = "N/A"

/* SCIENCE OPERATIONS INFORMATION */
```

```
VEX:SCIENCE_CASE_ID        = "
ALL"
VEX:SCIENCE_CASE_ID_DESC   = "Please refer to VEX_SCIENCE_CASE_ID_DESC.TXT
                              in the DOCUMENT directory."
OBSERVATION_TYPE           = {"AC002B", "PE001A", "PE004A"}
^OBSERVATION_TYPE_DESC     = "OBSERVATION_TYPE_DESC.TXT"

/* TIME RELATED INFORMATION */

START_TIME                 = 2007-08-20T20:10:19.133
STOP_TIME                  = 2007-08-20T20:10:28.133
SPACECRAFT_CLOCK_START_COUNT  = "01/0078005414.08913"
SPACECRAFT_CLOCK_STOP_COUNT   = "01/0078005432.08913"

/* ORBITAL INFORMATION */

ORBIT_NUMBER               = 486
ORBITAL_ECCENTRICITY       = 0.838114
ORBITAL_INCLINATION        = 83.526991
ORBITAL_SEMIMAJOR_AXIS     = 39360.539935
PERIAPSIS_ALTITUDE         = 320.117128
PERIAPSIS_ARGUMENT_ANGLE   = 119.093604
PERIAPSIS_TIME             = 2007-08-20T04:18:40.756
SPACECRAFT_ORIENTATION     = (-0.432016,0.374939,-0.820233)
^SPACECRAFT_ORIENTATION_DESC  = "VEX_ORIENTATION_DESC.TXT"
SPACECRAFT_POINTING_MODE   = "
N/A"
^SPACECRAFT_POINTING_MODE_DESC= "VEX_POINTING_MODE_DESC.TXT"

/* DATA OBJECT DEFINITION */

OBJECT                = NPD_TOFHEAD_TABLE
  NAME                = "NPD_TOFHEAD"
  ROW_SUFFIX_BYTES    = 4610
  INTERCHANGE_FORMAT  = ASCII
  ROWS                = 10
  COLUMNS             = 19
  ROW_BYTES           = 124
  ^STRUCTURE          = "NPD_TOFHEAD.FMT"
END_OBJECT            = NPD_TOFHEAD_TABLE

OBJECT                = NPD_TOFSCIE_TABLE
  NAME                = "NPD_TOF_SCIENCE"
  ROW_PREFIX_BYTES    = 124
  INTERCHANGE_FORMAT  = ASCII
  ROWS                = 10
  COLUMNS             = 1
  ROW_BYTES           = 4610

  OBJECT              = COLUMN
    COLUMN_NUMBER     = 1
    NAME              = "NPD_TOF_COUNTS"
    DATA_TYPE         = ASCII_INTEGER
    START_BYTE        = 1
    BYTES             = 4610
    UNIT              = "ADC UNITS"
    FORMAT            = "I5"
    DESCRIPTION       = "Uncalibrated NPD1 sensor science data in TOF
                         operation mode."
    ITEMS             = 768
    ITEM_BYTES        = 6
  END_OBJECT          = COLUMN
```

```
END_OBJECT            = NPD_TOFSCIE_TABLE

END
```