European Space Agency
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Planetary Missions Division

ROSETTA-RPC-ICA

To Planetary Science Archive Interface Control Document

RO-RPC-ICA-EAICD

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Change Log

Date	Sections Changed	Reasons for Change
2016-09-07	Minor changes after review, plus a major update of 3.4.4.2 (CALIB directory)	Changes requested by reviewer
2016-10-27	New improved data quality flag system described (section 3.3) Added comments on interpreting browse plots, a follow up of the review process.	Changes requested by reviewer
2016-11-11	Update on software version 1 which is not used.	
2016-11-28	Updated table examples, mentioned that current version of data is version 2	Follow up to changes initiated by review process
2017-06-26	Revision of energy table, mainly affects section 2.4.1. Also removed some obsolete information on data processing and software.	ICA energy table determined with better accuracy.
2017-11-05	All data description updated to follow new format. Merging of part of the L2 to L3 information into the EAICD (part will go into User Guide). A number of minor corrections and improvements throughout following the comments from the reviewers.	Revision according to post-mission review
2018-01-30	Final corrections, added information about GFACTOR calibration files.	
2018-03-05	Section 4.3.1, added L4, fixed file and data set naming convention errors, in 3.1.2 and 3.1.4	Found minor error in data description, added L4 info
2018-03-13	Section 4.3.1 corrected, added L3 and L4 info in subsection of 3.4.3	Updating to include L3 and L4 info.
20190327	Section 3.1.4,3.3, 3.4, 4.3, appendix 1	Added L5, L4 CORR_CTS, L4 SCPOT data set, temperature drift corrected energy scale
20190702	Small fixes according to RIDs	

20201204	Software renamed	

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 Rosetta Plasma Consortium Ion Composition Analyzer (RPC-ICA) 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 your instrument team and your archiving authority.

1.1.1 Contents

This document describes the data flow of the RPC-ICA instrument on Rosetta from the s/c 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.

1.2 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

1.2.1 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 Intended Readership

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

1.4 Applicable Documents

Planetary Data System Data Preparation Workbook, February 1, 1995, Version 3.1, JPL, D-7669, Part1
Planetary Data System Standards Reference, August 1, 2003, Version 3.6, JPL, D-7669, Part 2
Rosetta Archive Generation, Validation and Transfer Plan, January 10, 2006, RO-EST-PL-5011
Rosetta Plasma Consortium Users' Manual, October 28, 2002, v. 0.994, RO-RPC-UM
Planetary Data System Data Preparation Workbook
Planetary Data System Standards Reference, August 1, 2003, Version 3.6
ROSETTA, Archive Generation, Validation and Transfer Plan, 06 October 2005, RO-EST-PL-5011

1.5 Relationships to Other Interfaces

This EAICD describes the overall RPC-ICA archiving details. If there will be changes in the archive format or labels this will affect both this document and the software which produces the PDS format data. It will also affect the appendix of the RPC-ICA User Guide which contains a brief summary of the data format.

1.6 Acronyms and Abbreviations

PSA	Planetary Science Archive
ICA	Ion Composition Analyzer
IES	Ion and Electron Spectrometer, part of RPC instrument suite on Rosetta
PDS	Planetary Data System
RPC	Rosetta Plasma Consortium
MCP	Micro Channel Plate
IMA	Ion Mass Analyzer, twin instrument of ICA on Mars Express
CESR	Centre d'Etudes Spatiales et de Rayonnements
IRF	Institutet för rymdfysik (Swedish Institute of Space Physics)
FGM	Flux Gate Magnetometer
ES	Electrostatic in ES analyzer
TC	Telecommand
TM	Telemetry
GSE	Geo Solar Ecliptic coordinate system
UTC	Universal time
FOV	Field-of-view
HV	High Voltage
PROM	Programmable Read Only Memory
NRM	Normal instrument model
HAR	High Angular Resolution model

EXM Energy-mass matrix high mass resolution instrument model

1.7 Contact Names and Addresses

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2 Overview of Instrument Design, Data Handling Process and Product Generation

The Ion Composition Analyzer is an ion spectrometer designed to study ion dynamics with mass resolution. The design of the instrument is shown in figure 1.

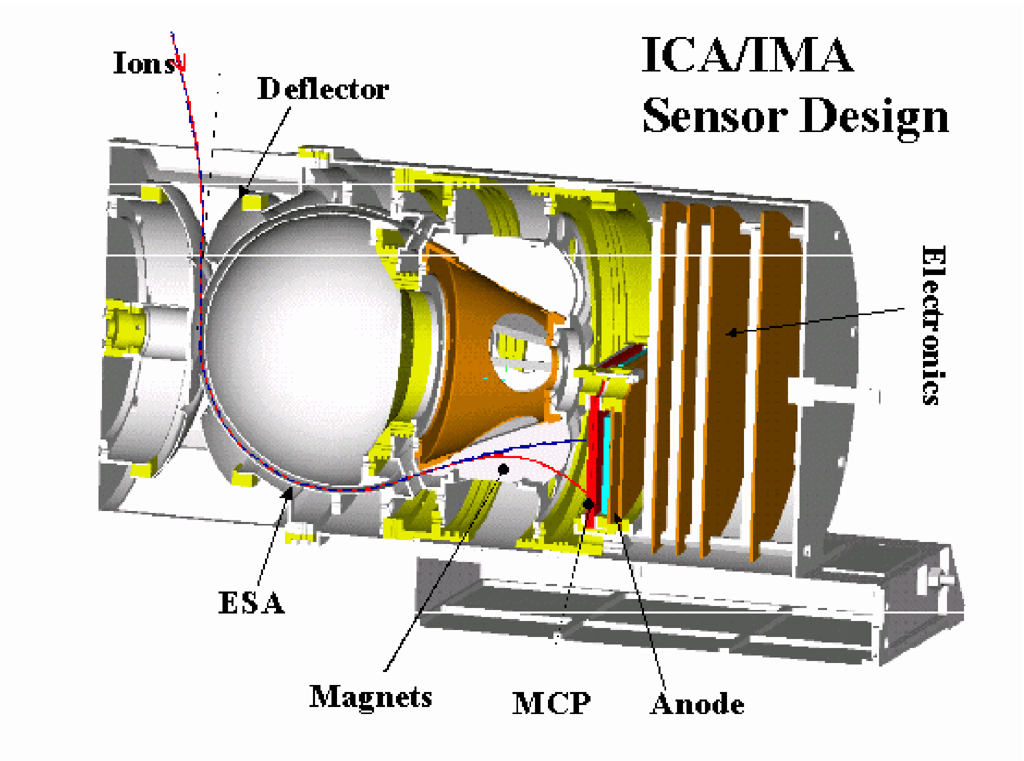

Figure 1 Overview of the ICA instrument

Particles enter the analyzer through an outer grounded grid. Behind the grid is a deflection system whose purpose is to deflect particles coming from angles between 45° and 135° with respect to the instrument symmetry axis (spacecraft y-axis) into the electrostatic analyser. This deflection system is named Deflector in figure 1 and the curved path of ions affected by the deflection electric field are shown as a red and a blue line. Ions within a swept energy pass band will pass the electrostatic analyzer (ES Analyzer, ESA in figure above). This is achieved by applying a high-voltage electric field between the inner and outer plate of the ES Analyzer. Only particles within the desired energy pass band will get just the right curvature of their path from this electric field so that they can pass the ES Analyzer. The geometrical (particle-optical) properties of the ES Analyzer determines the energy resolution which is 7% for ICA The ions are then deflected in a cylindrical magnetic field set up by permanent magnets, labeled Magnets in figure 1. The field deflects lighter ions more than heavy ions. The blue line in figure 1 depicts the path of a heavy and energetic particle which deviates only a little from a straight path. Heavy particles with therefore hit close to the center of the detection area. The red line depicts the pass of an ion with lower mass and/or energy. The ions finally hit a micro-channel plate (MCP) which amplifies the signal from the particle so that it can be detected by charge sensitive amplifiers. The charges from the MCP are detected by an anode system with 16 anodes for detecting angle of arrival and 32 anodes to determine radial position and thus mass (radial position is affected by both mass and energy, but energy is known because of the ES Analyzer). The different angles of arrivals that can be detected are termed sectors, and the radial anodes are termed mass channels. Ions are analyzed in both direction and mass per charge simultaneously. The magnet assembly can be biased with respect to the electrostatic analyzer to post accelerate ions; this post acceleration enables a selection of both mass range and mass resolution. The full energy range of the instrument is from a few eV/e to 40 keV/e, covered in 96 steps. The full mass matrix has 32 channels, which are grouped according to calibration data. Resolution and mass coverage will depend on ion energy and post acceleration setting. The spatial resolution of the instrument is 22.5° x 4.5°. The 16 anode sectors of the MCP constitutes a 360° field-of-view in the x-z plane of the spacecraft with 22.5° resolution. This angle will be referred to as the azimuthal angle of the instrument field-of-view. A field-of-view of 51° to 131° with respect to the spacecraft y-axis is in practice achieved through the deflection system, with an intrinsic angular resolution of the instrument of 4.5°. The electric field applied over the deflection plates bends the path of incoming particles so that those coming from some angle away from 90° with respect to spacecraft y-axis will be able to pass the electrostatic analyzer. This angle will be referred to as the elevation angle. The resolution in elevation angle is determined by the geometrical (particle-optical) properties of the instrument. The elevation angle resolution has been determined through calibration and the number of elevation steps has been tailored to provide an almost continuous coverage of the elevation field-of-view. The steps are nominally 5.625° apart to cover as close as possible the nominal angular range of ±45° from the instrument measurement symmetry plane. Elevation angle index numbering is shown in figure 2, produced by A. Fedorov of CESR Toulouse. Figure 2 is the official reference to sector and elevation index numbering and is included with the archived data in the GEOMETRY directory.

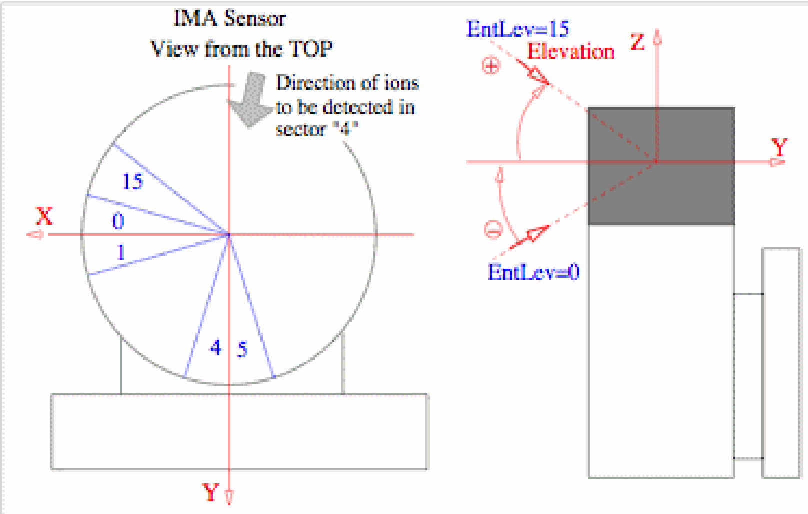

Figure 2 Sector and elevation angle numbering for ICA. Note that the sector numbering is for the physical location of the sector anode. The particles actually detected by that sectors comes from the opposite direction. This can be understood by studying the particle path described in figure 1. Note that the coordinates are in the instrument coordinate system used in the calibration report. Instrument Y is spacecraft –Z and instrument Z is spacecraft Y.

The spatial resolution transmitted to ground is dependent on available telemetry, as is the mass resolution. Data is further compressed using lossless compression. Therefore several sectors, elevations and mass channels may be binned together. To make the data easier to use the data delivered to the archive has been expanded so that it always has 32 mass channels, 16 elevation angles and 16 sectors. Data is evenly distributed on contributing sectors and elevation angle directions. Nearly dead sectors and sector / elevation combinations which are shadowed by the spacecraft are assumed not to have contributed, and thus are given the value zero after expansion. Likewise for mass channels, a few dead or very insensitive mass channels are assumed not to have contributed and remain at zero after expansion. One complete measurement cycle of all measured energies and 16 elevation angles always takes 192 s for the standard 96 energy level mode. There are also two ways of operating the instrument without elevation scanning and reduced energy coverage achieving 1 and 4 s resolution with 8 and 32 energy step respectively.

The location of ICA on Rosetta is shown schematically in figure 3. The spacecraft coordinate system is shown so that sector and elevation angles (through figure 2) can be related to the spacecraft coordinate system.

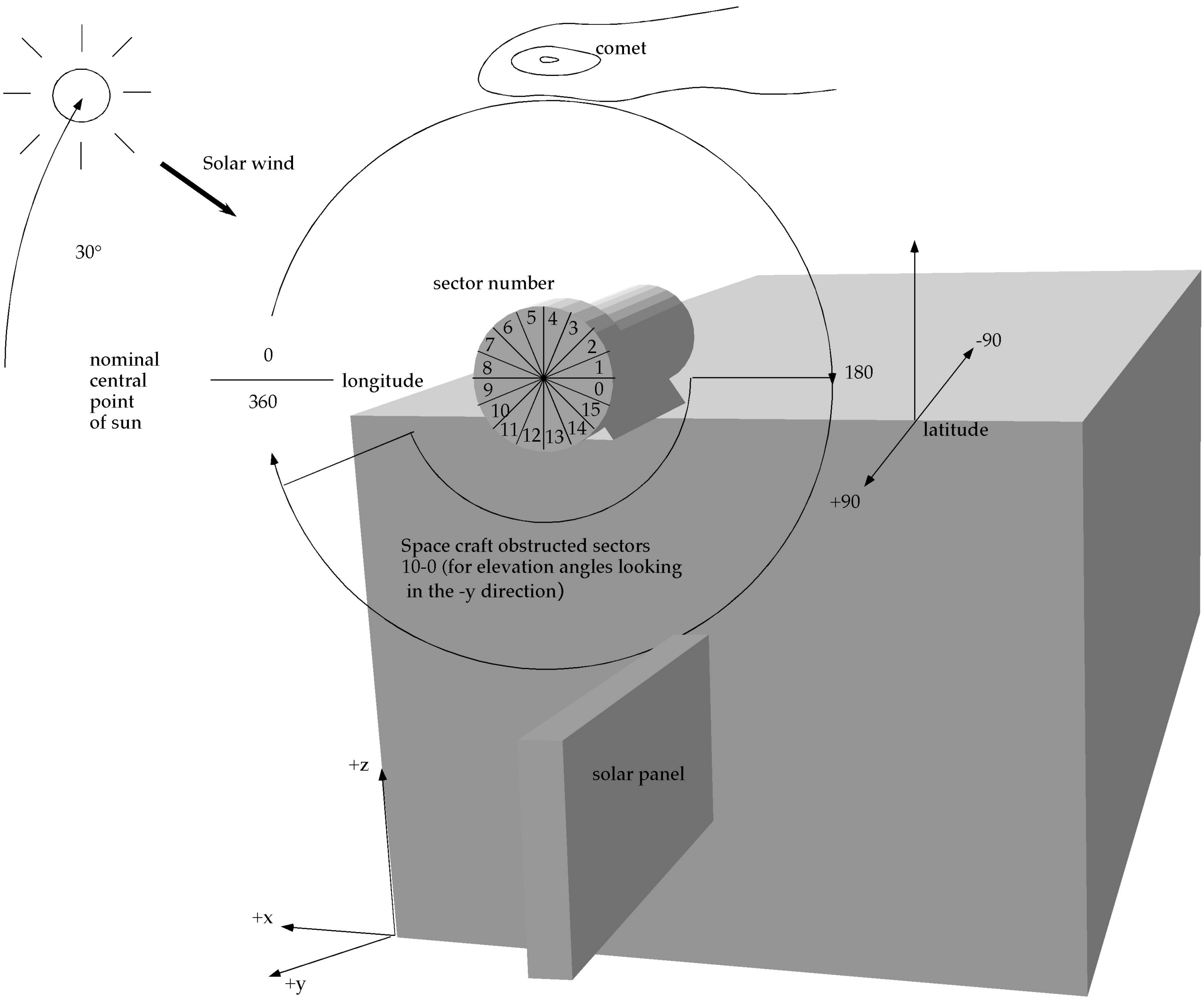

Figure 3 Location of ICA on the spacecraft. Also shown are the sectors (10 - 15 and 0) which for some elevation angles (index 0-7) are shadowed by the spacecraft. The latitude and longitude scales are used in figure 4.

The field-of-view of the ICA can also be shown using the latitude and longitude definitions shown in figure 3, which is done in figure 4.

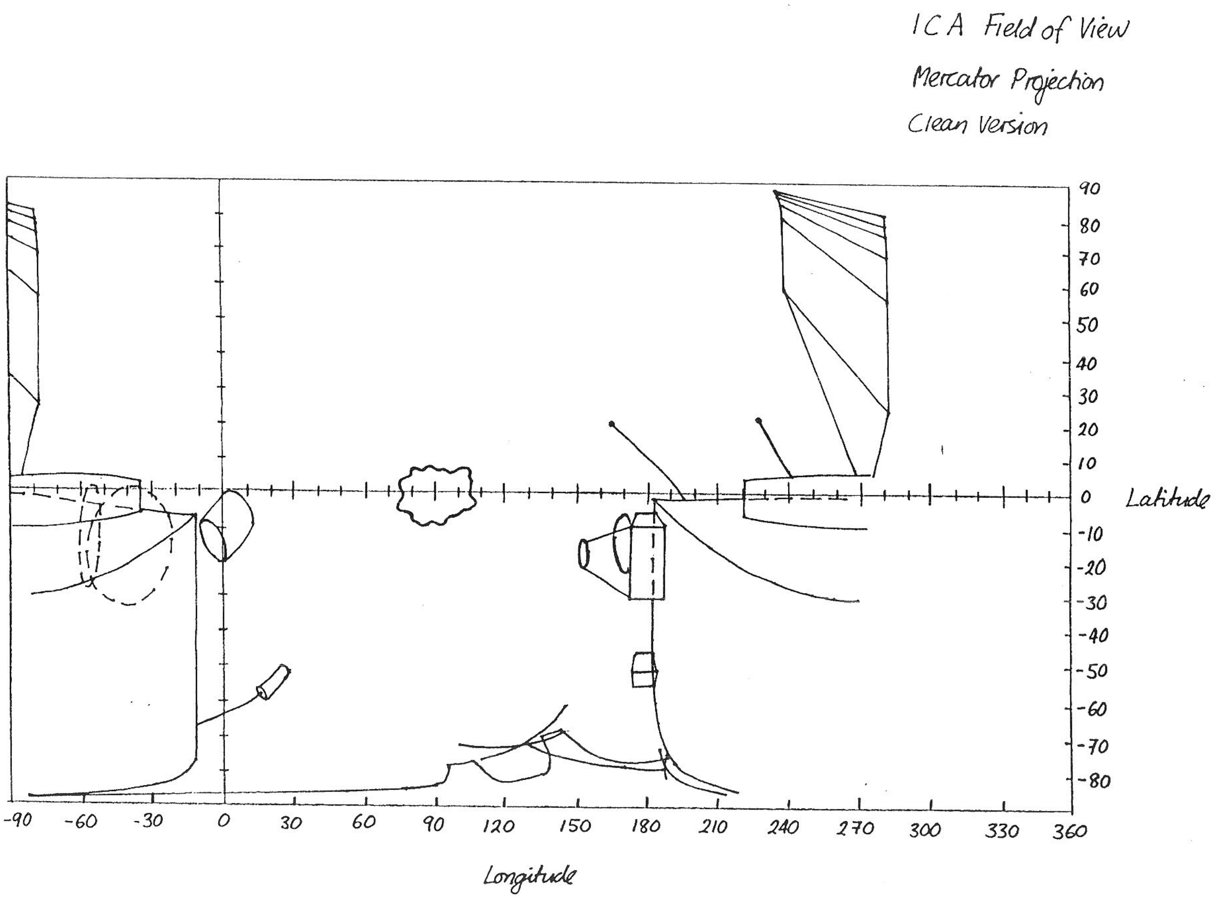

Figure 4 Rosetta seen from the ICA point-of-view. Latitude and longitude defined in figure 3. Note that this handdrawn figure is not exact, it is intended as an indication where the spacecraft and solar panels are within the ICA field-of-view. The spot at 90° longitude, 0° latitude is the nominal position of the comet.

Note that –90 and 270 degrees in figure 4 are the same. In nominal comet-pointing position the comet will be at 90° longitude, 0° latitude. The approximate angles which can be affected by the solar panels can be seen. The region between –10° and 180° is the free field-of-view of ICA. Longitudes below –10° and above 180° are totally blocked by the spacecraft for negative latitude. Figure 3 and 4 are stored in the GEOMETRY directory of the archive.

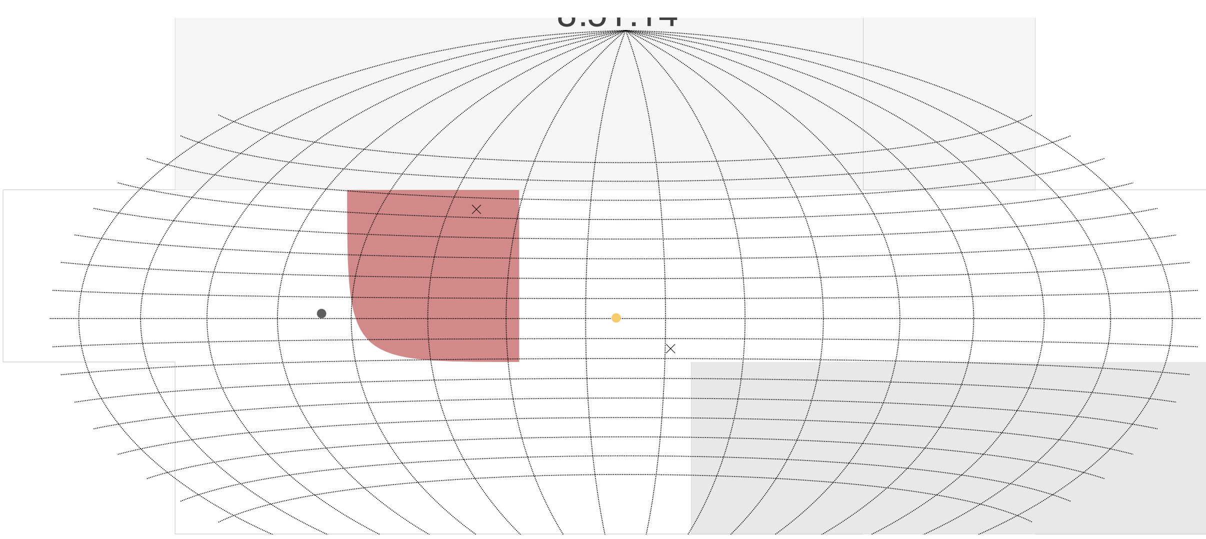

Figure 5 ICA field-of-view with a simplified spacecraft model showing the spacecraft obstruction (medium gray) and regions outside the ICA field of view (light gray). Sample data are shown with red (protons) and blue (cometary ions) circles.

Figure 5 shows another version of the ICA field of view, with some sample data. Red circular patches indicate protons, blue cometary (water group and heavier) ions. The sizes of the patches indicate the flux coming from that particular direction. Due to the limited field of view, such plots are helpful to judge how much of the observed populations are within the instrument field-of-view.

ICA data is delivered as a time series of energy spectrograms. If the data is plotted as such a time series, the elevation sweep will be seen in the time series. A narrow angle signal, such as an undisturbed solar wind, will then be seen as a pattern repeating every 16 time steps (elevation steps).

Similarly a repeating pattern may be found when ICA is used in alternating post-acceleration mode. Then one setting is used for one set of 16 different elevation steps, then another value for the next 16 elevation steps. For low post acceleration the instrument may loose much of the proton signal, which may then appear modulated.

Finally, when separating the raw data into masses, one must consider that there may be some cross talk between the physical mass channels. A strong proton signal will usually leak to all mass channels. This can usually be quite easily identified if the data is summed over the time period of interest and plotted as function of energy and mass channel.

During the mission a new way of operating the instrument was implemented which was not described in the instrument paper (Nilsson et al., 2007). The new way of operation had no elevation scanning (i.e. two-dimensional data) and used two restricted energy ranges, thus achieving a temporal resolution of 4 and 1 s respectively. Internally, the instrument is still scanning in elevation, but all elevation steps were made identical. Therefore the two-dimensional data still has an elevation index, and a corresponding elevation table. The data can thus be treated in the same way as the usual three-dimensional data in a data pipeline using the elevation tables to get the appropriate physical elevation angle for each elevation step.

2.1 Scientific Objectives

ICA supports the RPC science goals by measurements of three-dimensional ion velocity distributions with mass resolution and derived quantities such as density, flow velocity and temperature for different ion species. Because Rosetta is not a spinning spacecraft ICA cannot achieve full angular coverage. This will limit the ability to derive 3D moments and probably make it unfeasible to automatically generate moments for the database. Cometary origin ions will often form beam distributions which when within the instrument field-of-view can be well characterized. The most important aspect of ICA is the mass resolution which distinguishes it from the Ion Electron Spectrometer (IES) of the Rosetta Plasma Consortium (RPC). The cometary origin ions are to a large extent water group ions. These are significantly heavier than the major solar wind ions (H+ and He++). Thus the important pick-up of heavy cometary origin ions by the solar wind, and subsequent deceleration of the solar wind can be studied. As soon as the comet was active enough to release significant amounts of ionized gas to the solar wind ICA could to detect increased counts of heavier ions. An all mission ion spectrogram separated into solar wind ions and cometary ions (water group and heavier) is shown in Nilsson et al., Evolution of the ion environment of comet 67P during the *Rosetta* mission as seen by RPC-ICA, *Monthly Notices of the Royal Astronomical Society*, Volume 469, Issue Suppl_2, 21 July 2017, Pages S252–S261, https://doi.org/10.1093/mnras/stx1491. This publication is freely available as part of a special Rosetta proceedings issue.

2.2 Data Handling Process

Data is unpacked into raw data files at IRF in Kiruna. After that data, housekeeping and geometry data are transferred directly to PDS format ASCII tables for raw data (L2) and calibrated data (L3)..

Background subtraction, which must be performed case-to-case, can be made by the users themselves, and calibration tables applied after that. No noise subtraction has been done in the data preparation phase of the raw data before submission to PSA. Note though that some background subtraction may have been performed onboard. The level of onboard background subtraction is given in the data.

Browse graphics file of all – direction averaged spectra are produced for two mass-bins (high and low) and delivered to the PSA.

2.3 Product Generation and Data Validation

The raw data products are generated upon unpacking of the telemetry data. Certain information not contained in the telemetry must be added, such as currently valid calibration files. This is straightforward and can be done as the data arrive.

Sometimes unpacking fails due to data corruption. Such data is currently not delivered to PSA. This was common in the period up to about mid 2015. This is seen as regular data gaps in the ICA data when the instrument is run in high mass resolution mode (instrument modes 24-31, see the instrument paper or User Guide). Normal mode data is not affected. Once it was found that high angular resolution data was not affected either, this became the preferred burst mode (instrument modes 16-23).

All data is unpacked and processed at IRF. Further transmission to the ESA archive takes place according to the delivery plan agreed upon between the experiment team and ESA.

2.4 Overview of Data Products

The ICA data products consists of the raw counts produced by the in-flight data (section 2.4.4, which are interpreted and turned into calibrated data using tables containing the calibration results (section 2.4.3). Derived products (moments), section 2.4.7, are not expected to be delivered as these require manual inspection and choices which must be done on a case by case basis. There are no pre-flight data products nor any sub-system tests.

2.4.1 Instrument Calibrations

Calibration tables from the calibration of the flight model are stored with the data. These include energy tables, deflection angle tables, on board mass channel binning tables for different post-acceleration levels, and counts to flux conversion tables for a given post-acceleration and MCP bias. Different energy and elevation tables are used throughout the mission. The table used is given in the label for the data. The tables used are also given by the onboard software version. Because of in situ calibration efforts, these energy tables have in turn been adjusted so that they exist in different versions. Only one version, the latest one at the time of delivery, is included in the archive. The calibration tables are given in PDS format with detached labels. These are for the energy table:

ICA_ENERGY_TABLEN_VNN.TAB and ICA_ENERGY_TABLEN_VNN.LBL where NN is the version of the onboard software which contains 96 (8 or 32 for high time resolution modes) rows with 2 columns. The columns are

Index number of the energy level (i.e. just a counter which corresponds to the data points in the PDS data file), and energy per charge [eV] of detected ion. The indicated energy is the center energy for this energy band. The beginning of table ICA_ENERGY_TABLE_V04.TAB is shown below.

```
0,  -1.0
1,  -1.0
2,  -1.0
3,  -1.0
4,   1.8
5,   7.1
6,  12.4
7,  17.7
```

Low energies come first. This does not reflect the actual measurement sequence, the analyzer voltage is stepped from high to low. It is however much more convenient for the end user to have the energy go from low to high. The fill value -1.0 corresponds to non valid energy steps, positively charged ions cannot get through the electrostatic analyzer for this setting of the voltages. However, when the instrument is cold there can be a significant offset of the zero-level of the high voltage, and for such cases there can be a significant signal for these energy steps. The best possible temperature drift correction is the subject of the ongoing ESA funded enhanced archive effort. In the L2 data, a quality flag is set when the temperature of the instrument is low enough that drift of the energy scale may occur, see section 3.3.

There is sometimes a significant, real looking signal seen for non valid energy channels. These events occur close to the nucleus for a dense neutral atmosphere. The exact origin is unclear. The goal of the raw data archive is to be as complete as possible, so the data for the invalid energy ranges is retained. This data is not retained for the calibrated L3 data and higher order products.

For the entrance deflection the table is

ICA_ELEVATION_TABLE_VNN.TAB and ICA_ELEVATION_TABLE_VNN.LBL where NN is the version of the onboard software.

ICA can be booted using different versions of the onboard software. Different versions of the software will use different energy, mass lookup and elevation tables. There is therefore one version of each table for each software version. The software version in turn is determined through the PROM section, which Is not retained in the archive data, as this is redundant once the software version is determined. The relation between PROM section and software version is given in the table at the end of this paragraph. The end user need not determine the appropriate table through this table, it is given in the label file.

The elevation table contains 16 +1 columns and 96 rows, where 16 corresponds to the amount of elevation angles and 96 to the amount of energy levels. The energy index number is given in the first column. A sample close to nominal value obtained at intermediate energy index 42 is shown below:

-38.8,-33.4,-28.1,-22.7,-17.3,-12.1, -6.9, -1.4, 4.1, 9.3, 14.7, 20.1, 25.4, 30.8, 36.1, 41.5

At low (below 300 eV) and high (above 15 keV) energy the angular resolution and coverage deviates significantly from nominal values. At low energy this is because of insufficient resolution of the digital to analog conversion. At high energies the discrepancy is due to insufficient high voltage to deviate the flight path of the more energetic ions. This table must be used by the end user to get accurate conversion of elevation index into actual physical angle from the spacecraft X-Z plane. Nominal values can be used for approximate visualization purposes with the angle given by:

-42.1875+elev*90/16 where elev is the elevation index number (0-15)

The angle within the X-Z plane, from X towards Z, is given by the sector (or azimuth angle index).as

-168.75+azim*360/16 where azim is the azimuth index (0-15, same as sector number).

The ICA instrument has a command, enable bad-HV masking. This sets the data of all deflection angle and energy combinations which deviates substantially from nominal values to zero. However, experiences from Mars Express shows clearly that it is better to set the elevation angle setting to within the range that is valid for each energy step, even though this means repeating certain elevation angles. The bad HV mask was only used during the first Earth swing by. The value is still provided in the label (as ENABLED or DISABLED).

The onboard mass look-up tables are used on-board to reduce the telemetry. They were made before any in-flight calibration, so they provide only an approximate mass separation. See the User Guide for more details on performing mass separation.

As described in section 2 ICA has 32 mass channels. Ions of a certain mass will hit the detector surface (MCP) at some range of mass channels, and this range will vary with the energy. Therefore the mass look-up table must have one entry for each energy, telling what range of mass channels to put together. Furthermore the post-acceleration setting will also affect where the particles hit the detector surface. Therefore ICA has three mass look-up tables for three different post-acceleration settings (labeled 0, 1 and 2 in the calibration document). For high mass-resolution modes the actual mass-channel data will be transferred to ground, possibly binned (32, 16 or 8 bins). For lower resolution than that the data is instead binned into mass-groups according to the mass look-up tables.

To make the data set consistent, the archive data has been expanded so that the counts obtained in a range of binned mass channels have been evenly distributed over all valid mass channels included in the range. The end user therefore need not treat the mass table binned normal mode data in a special way, though the mass separation ability of ICA will suffer and binned data may not be suitable for all purposes. Therefore the binning mode may be important to know, and whether table binning was used or not can be found through the mass table variable, which is 0 if no binning according to mass table was used. The mass lookup tables are provided in the archive for completeness. The level of binning is also given by the instrument mode number which is given in the data.

These tables are named

ICA_MASS_LOOKUP_TABLEN_VNN.LBL and ICA_MASS_LOOKUP_TABLEN_VNN.TAB

Where N is 1,2 or 3 depending on the post-acceleration setting. Note that the actual post-acceleration setting is from 0-2 according to the calibration document, but mass look-up table 0 is used to specify that no mass look-up table was used. The file contains 12+2 column elements and 96 rows. Each row contains post-acceleration level it is valid for, the energy index and 6 different ion mass ranges (2 values, start and stop), nominally corresponding to H+, >O+, O+, He+, He++, O++. In practice this is not the actual mass range at low energy for all data, due to a discrepancy in the onboard table. For the lookup table of software version 9 the onboard table is updated so there the nominal mass lines are correct. However, a different binning scheme was used, to optimize the available information.

The column elements specifying mass range are given as start mass channel, end mass channel. A value of –1 indicates that the indicated ion mass range cannot be seen by the instrument for that particular energy and post-acceleration setting.

A sample line for energy index 42 and no post-acceleration:

0,42, -1, -1, 0, 14, 15, 20, 27, 31, -1, -1, 21, 26

Meaning that for no post-acceleration (0) and energy level 42, H+ cannot be measured (-1), >O+ ions are found between mass channels 0 to 14, O+ between 15 to 20, He+ between 27-31, He++ cannot be measured and O++ is found between mass channels 21 and 26. The reason for the strange order is that for severe telemetry restrictions not all mass bins are transmitted, and then Larger than O+ (a large group of everything above O+), O+ and H+ are the most important to transmit.

The reason for the larger than O+ mass group (>O+) is that if only two mass ranges are allowed due to telemetry constraints, then H+ (solar wind) and heavy cometary ions can be distinguished.

During the mission another mass lookup table was designed which optimized the data that could be downlinked, but with a more complex design. The first mass group was a sum over all mass channels, then different parts of the heavy ion mass range was transmitted, then H+ and alpha particle ranges. The ranges of mass channels for each bin is given in the mass lookup files.

For mass lookup tables, the on board post acceleration table index is related to the setting (0-7) as follows:

TABLE	SETTING
1	0
2	1-4
3	5-7

Note that for mass mask purposes (see below) post acceleration settings 0 and 1 should use the same mask. The above values are used automatically onboard. In practice, post acceleration 6 was always used in Normal mode data, i.e. when onboard tables were most likely to be used.

PDF graphics files defining the geometry of measurements are included in the GEOMETRY directory. One is the SECTORS.PDF shown in figure 2. Another one is the ICA field-of-view (ICALOCATION.JPG and ICA_FOV.JPG), also shown as figure 3 and 4 in this document.

ICA uses a number of different energy and elevation tables. They are summarized below. Version 1.0 is the originally delivered table which has never been used in practice. Version 2.0 was loaded into all EEPROM banks before use of ICA. Later new patches were loaded into the eeprom banks, going from the higest number towards the lowest. The software versions are described in Table 3, section 3.4.3.2.

Note that only the latest interpretation is delivered to the archive. All tables for version 10 are identical to the ones for version 9, the only difference is a change to the link packet delay. To make the data consistent, we still deliver separate tables for software version 10.

Finally, in order to turn the raw data into physical units, tables containing the geometrical factor of the instrument must be used. Furthermore the data must be divided into lighter ions (in practice solar wind ions of mass 4 amu / e or lighter) and heavier ions, as these have somewhat different values for the geometric factor. This division is achieved using mass-mask tables which are provided in the CALIB directory. The mass masks has a somewhat different relation to the post-acceleration reference level as compared to the onboard mass lookup tables. It has been found that the mass mask for group 1 works best for post acceleration reference value 1. Therefore mass masks should be chosen according to:

TABLE	SETTING
1	0- 1
2	2-4
3	5-7

The unit of the geometric factor provided is cm^2 sr eV / eV, i.e. the energy resolution is part of the geometric factor.

The basic method to convert from counts to flux follows this procedure:

Determine the energy table used using the software version of the data. The energy table for each data file is also given in the label. Next the post acceleration level used must be determined. This is given in the L2 data. Given energy, post acceleration and mass group (solar wind or heavier ions) the geometric factor can be calculated. We provide the geometric factor as a table rather than as a function.

Before the geometric factor is applied to perform the count to flux calculation, a correction for the deadtime of the instrument sensor should be applied. It is a statistical correction, taking into account that the instrument need some minimum time between two consecutive detections in order to detect both. This will only affect strong signals and does not have a major impact for most of the measurements. The deadtime for the detector Tdead is 2 μs, the acquisition time for each energy level t0 is 120.9 ms. If the total number of counts during the acquisition (for all sectors and mass channels) is N then the corrected counts C_{corr} is given from the measured counts C by the following formula:

C_{corr} = C * (1 + N * Tdead / t0)

Note that N should be the sum over all sectors and mass channels as only one valid detection anywhere in the system can be made at one time.,

For the level 3 data we have used a mask that indicates which mass channels to include for the two different mass ranges. These are given for different levels of the post-acceleration for all our different energy tables. The masks are given in the table files named in the format:
ICA_MASSMASK_HEAVY_PA_VNN.TAB
ICA_MASSMASK_LIGHT_PA_VNN.TAB

The mass range can be HEAVY or SW. The post acceleration is given as PA, where A can be 1, 2 or 3 for three different post acceleration ranges, with reference values 0-1, 2-4, 5-7. The software version (2 to 9) is given by NN.

These masks where made to provide a quick calculation of heavy and solar wind ions. Certain problematic mass channels, with weak response or prone to pick up cross talk (mass channel 4) have been removed (.e. the mask is 0 in both mass ranges). Some other mass channels, at high mass channel number for high energy, does not correspond to any real particles so these are zero in both masks. Therefore this has been compensated for when calculating the L3 data which should have a value for all mass channels. The end user can use the same tables to separate heavy and solar wind ions for mass separation, but this separation is not included in the L3 data. A data set separated into physical mass ranges will be delivered, with noise and cross-talk removal applied. The L3 data set is suitable to use when looking at weak signals, searching for signatures of minor species and similar.

In order to calculate the differential flux of particles /eV/sr/cm2/s from the count values C_{corr} one then use the following formula

Differential flux = C_{corr} / (G * tau * E)

where G is for the appropriate mass range, tau in s and energy E in eV. For RPC-ICA, tau is 120.9 ms. The geometric factor is in units of cm^2 sr eV/eV, with the energy resolution being part of the geometric factor. Count values should be corrected for the deadtime of the instrument as described earlier, though for the vast majority of ICA data this will not make a big difference. G and E are given by the appropriate tables as described above. Note that it takes some time for the energy filter voltage to settle into the new level for each energy step. The instrument keeps taking data during this period. This is not directly compensated for, but the instrument behaved in the same way during laboratory calibration, so the nominal sampling time of 120.9 ms is still the relevant number to use.

The Geometric factor is given in CALIB/GFACTOR/ and there are two files for each software version, one for light and one for heavy ions. In each file there are 4 different geometric factors for different settings of the post acceleration level. The different ranges are 0, 1-2. 3-5, 6-7.

2.4.2 In-Flight Data Products

The ICA instrument gives essentially only one raw data (Level 2) output, counts. The instrument obtains counts for each energy level, sector, elevation angle and mass channel (as described in section 2). One full distribution is obtained in 192 s for the standard software versions. The instrument makes measurements in the same way regardless of available telemetry rates. To reduce the data rate, the data is reduced in resolution. Elevation angles, sectors and mass channels are added together into larger bins. Data is never binned over energy and time in this way.

In May 2015 two new ways of operating the instrument were introduced, with no elevation scanning and only low energy coverage, but with a time resolution of 1s and 4s. These correspond to software versions 7 (4 s resolution, 32 energy steps) and software version 8 (1s resolution and 8 energy steps). This way of operating the instrument did not exist when the instrument paper was written (Nilsson et al. 2007) but is described in some detail in Stenberg Wieser et al. 2017). Once during the mission the instrument was also operated at a fixed energy and elevation level, thus achieving 125 ms resolution for one energy level. We have not attempted to fit this into the archive system, but it is listed in the caveats section of the RPC-ICA User Guide.

The raw data is thus in principle 3-dimensional (energy x sector x mass channel) for each time instance, but must be stored as a two-dimensional table. The size of the sector, elevation angle and mass channel bins will vary continuously depending on available telemetry and loss-less compression ratio. The data has been expanded for the archive, but the user may still need to know how much the original data was binned. This information is provided by the mode variable, which can have a value from 8 to 31, where the relation betwen mode number and binning is given in tables III to V in the instrument paper. These tables are also provided in the User Guide. For the mass bins an on-board table-look up which is energy dependent may have been used onboard. Therefore one field is used to describe which table was used (and a keyword in the label gives which revision of the table), where table 0 indicate that no mass-lookup table was used.

Because of high voltage limitations, spacecraft body and solar panel shadow, and potentially other reasons, some angles and mass channels may not contribute counts to certain energy steps. Therefore the number of sectors, mass channels and deflection angles actually contributing to the counts for each energy step must also be known. This is however normally static and it is very inefficient to store for each energy spectrum. Instead status information taken from the header of the science data packet is included. This header information contains information about whether bad-high voltage masking and shadow masking was enabled. Bad high-voltage masking was described in section 2.4.3, and means that certain elevation angle – energy combinations are masked to zero. Shadow masking implements the same for certain combinations of sector and elevation angle. Figure 3 shows which sectors and elevation angles will be shadowed by the spacecraft. The mask parameters did not change after start-up, so the values are provided in the label.

House keeping parameters are stored in a separate file and with a separate label in the same directory as the data. Housekeeping data is stored in human and PDS readable ASCII files.

When the calibration data is applied the raw counts can be translated into flux (Level 3 data). When spacecraft attitude data is added the instrument coordinates can be transformed into geographic coordinates. Coordinates of position and spacecraft attitude information is included in the GEOM files, stored in separate files in the same directory as the data.

One day of full resolution data will be about 1 Gbyte. The file may be difficult to handle and will therefore be subdivided into 1 hour intervals.

2.4.3 Software

The unpacking software is based on the software used for Mars Express data from Aspera 3-IMA.

A MATLAB line to read an entire L2 or L3 data file into the MATLAB workspace is shown below:

```
formatSpec = ['%s%f%s' repmat('%f', 1, 7) repmat('%f', 1, e_levels) '%[^\n\r]'];
dataArray = textscan(fid, formatSpec, inf, 'Delimiter', ',');
```

where fid is a file pointer variable pointing to an archive table file and e_levels the number of energy levels in the file, 8, 32 or 96.

Sample MATLAB files are provided in the SOFTWARE directory.

2.4.4 Documentation

"The ICA-IMA TC/TM data formats and related software aspects" by Hans Borg

"ICA Command Description" by Hans Borg

"ICA calibration report" by Andrei Fedorov

ICATables.pdf by A. Fedorov

"RPC-ICA User Guide"

All stored in Portable Document Format (pdf) in the DOCUMENTS directory.

ICATables is the official document where calibration values for voltages are given. The end user never need to know the values of such voltages, only the digital reference value for the post-acceleration setting.

2.4.5 Derived and other Data Products

The L3 (calibrated) and L4 data can be used to calculate higher order data (moments), but as the ICA field-of-view is not complete the feasibility of such calculations must be individually judged for each event, and this is thus not foreseen to be included in the PSA. Furthermore one must for each event judge if the moments should be fitted functions (Maxwellians) to take into account truncation due to the limited field-of-view or a numerical integration (which is used when the entire particle population is within the field-of-view of the instrument).

2.4.6 Ancillary Data Usage

Spacecraft attitude and orbit data are necessary. In particular, it is necessary to transform between the spacecraft coordinate system and some common system where we use the equatorial J2000 inertial reference frame and a local coordinate system for each target. For Earth we use GSE, for Mars MSO and for comet 67P the CSEQ coordinate systems. The CSEQ coordinate system has X towards the Sun, Z is the component of the rotation axis of the Sun orthogonal to X and Y completes a right-handed coordinate system.

The geometry files contain the following information:

SUN seen from the spacecraft in ECLIPJ2000 reference frame

TARGET position from spacecraft in local coordinate system

TARGET velocity in local coordinate system, ECLIPJ2000 frame

Altitude, Latitude and Longitude of TARGET

Relative velocity of TARGET

spacecraft X,Y,Z expressed in local coordinate system

3 Archive Format and Content

3.1 Format and Conventions

3.1.1 Deliveries and Archive Volume Format

PDS compliant data will be delivered to ESA at DATA SET Level. One data set corresponds to one volume. Data of different processing levels will be archived in different data sets.

3.1.2 Data Set ID Formation

RO-E/M/A/C-RPCICA-x-phase-description-Vn.m

E/M/A/C	= Earth/Mars/Asteroid/Comet
RO	= INSTRUMENT_HOST_ID
RPCICA	= INSTRUMENT_ID
x	= {2,3,4,5} Codmac Data processing level numbers.
description	= {RAW, CALIB, CORR, PHYS_MASS, MOMENT}
phase	={…,ESC1,…}
Vn.m	= Version number

Within each data set TARGET_NAME and TARGET_TYPE will then be used to identify the current target.

(Thus they will not stay the same within one data set, but data set id will.)

For description, L2 is always RAW and L3 always CALIB. For the edited L4 data there are three data sets, CORR, CORR_CTS and PHYS_MASS. For L5 the description is always MOMENT.

The CORR data set is in format identical to L3, but the data has been corrected for cross-talk and onboard noise-subtraction. An extra file containing the confidence limit for the zero level is also delivered. Data with a signal less than the zero confidence level cannot be considered significantly different from zero.

The PHYS_MASS data set is divided into physical mass ranges corresponding to H^+, He^{2+}, He^+ and heavier than O^+. The MOMENT data set is based on the PHYS_MASS data set, and the heavy ions have been assumed to have the mass of water, 18 amu. The CORR_CTS data set is in counts as in L2, but with all the corrections done in the L4 data sets.

3.1.3 Directory Naming Convention

```
 DATA_SET_ID
      |
 +----+---+-------+--- ...
 |    |       |
DATA DOCUMENT   CATALOG ...
 |
CALIBRATED
 |
 +------+-----
 2009   2010
```

The top level directory of the data set is named by DATA_SET_ID according to PDS specifications. This is found under a top level RPC directory structure as shown above at the Imperial College server. Under DATA a directory specifying the type of data (EDITED, CALIBRATED, MOMENT) is used, but this is in practice redundant as a new DATA_SET must be used for each type of data. The DATA is further subdivided as:

```
        2009
        |
+------------+------------+------------...
|           |           |
JAN       FEB        MAR       ...
|
+----+----+ ...
|   |   |
D01  D02  D03
```

3.1.4 File naming Convention

ICA produced three different formats of science data files for each data set. These are data with 96, 32 and 8 energy steps. Furthermore an edited housekeeping data file and geometry data files are delivered to the archive as part of the L2 data set.

POSITION: 012345678901234567890123.012
FILENAME: RPCICAYYMMDDTHH_xxx_LL_L4_add.EXT

YY = Year

MM = Month
DD =Day
T = Time separator
HH=hour
xxx = file running number to allow for several files in one time period
LL = L2 for raw counts, L3 for calibrated data, L4 for edited data, HK for housekeeping and GEOM for geometry

L4_add is additional information that exists only for L4 data, it can be CORR for the L4 corrected data, ZERO, for the zero confidence level and for the PHYS_MASS data set it is the ion mass, H, HE2, HE or HVY. There is also a counts data set, the basis for the other L4 data sets, called L4 CTS. Despite not being in physical units it is an L4 data set as it is not reversible. There is also a corresponding uncertainty estimate ZCTS.

With the L4 data is also delivered an energy scale data set, where the energy scale (nominally given by tables in the CALIBRATION directory) are given with a temperature drift correction applied when applicable. These files follow the same naming convention as other L4 files, ending with E for the corrected energy scale and DE for the corrected width of the energy bin.

A data set with the RPC-LAP spacecraft potential data product interpolated to RPC-ICA times is also provided. It ends with USC (U for voltage, SC for SpaceCraft).

EXT = LBL or TAB

Note that the 8 and 32 energy level data is 2-dimensional (no elevation scanning), this is not shown in the file name or file content. It can be seen from the elevation tables, which are constant.

The L5 (moment) data has essentially the same naming convention, ending in “MOM”:

RPCICAYYMMDDTHH_xxx_L5_MOM.EXT

3.2 Standards Used in Data Product Generation

3.2.1 PDS Standards

ICA complies to PDS version 3, and we use version 3.6 of the PDS standard reference.

3.2.2 Time Standards

All references to time in the ICA PDS archive will be to UTC. Then time is displayed using the PDS standard CCYY-MM-DDThh:mm:ss.ssssss we will convert space craft time into UTC in this format (not GMT as the original PDS definition). The conversion will be done from the epoch 2000.

Housekeeping files will also contain the spacecraft clock time (i.e. unconverted and uncorrected ticks.)

The spacecraft Clock (OBT) is given in the label files as “1/nnnnnnnnnn.nnnnn”

It is the SPACECRAFT_CLOCK_START/STOP COUNT which is given as OBT. The OBT is described in **Rosetta Time Handling, RO-EST-TN-3165, sect. 4.2.**

The general principle is as follows:

SPACECRAFT_CLOCK_START/STOP_COUNT = "<reset number>/<unit seconds>.<fractional seconds>"

Where the unit seconds and the fractional seconds are separated by the full stop character ("."). Note that this is not a decimal point. The fractional seconds are expressed as multiples of 2^(-16) = 1.53E-5 seconds and count from 0 to 2^16 -1= 65535.

E.g. in SPACECRAFT_CLOCK_START_COUNT = "1/21983325.392" the 392 fractional seconds correspond to 392 * 2^(-16) = 0.00598 decimal seconds.

The spacecraft clock could be reset during the mission (although this is not planned). This would imply a change of the zero point. The zero point of the OBT will be indicated by pre-pending the reset number (integer starting at 1) and a slash to the unit seconds, i.e. "1/" means OBT = 0 at 2003-01-01T00:00:00

UTC.

3.2.3 Reference Systems

Reference systems used in this document and the ICA PDS data:

Table 1: Coordinate systems

Reference system	Description
Instrument coordinates	THE ICA instrument coordinate system. Retained for consistency with calibration report. Aligned with spacecraft Cartesian coordinate system, but different definition of the axes.
Spacecraft coordinate system	Orientation: x: pointing from the LANDER to the s/c center, perpendicular to solar array axes; y :parallel to solar array axis; pointing to the left, when standing in front of the Lander, z: pointing up

3.2.4 Other Applicable Standards

N/A

3.3 Data Validation

Data was scanned for internal consistency when decommutating to edited raw format. Derived data will when possible be compared to independent measurements by other instruments. The solar wind is particularly useful as it is a narrow beam which, when at all within the field-of-view, is typically fully measured by ICA.

In the data a QUALITY flag is used to indicate the quality of the data. The quality flag is a string with 8 positions, of which not all are used for the L2 and L3 data, but the flag set is planned to be used for all delivered data. No known problems are identified with 0. We indicate when the field of view corresponding to the observations is expected to be blocked by the spacecraft. We provide an indicator of possible problems related to the instrument temperature and for instrument background noise levels.

Low instrument temperature leads to a drift of the low energy channels of the instrument. Below about 13 °C this may happen. The effect is pronounced and a clear problem below about 0 °C. We therefore set the temperature flag to1 if more there are readings in in the preceding 320 s (10 housekeeping samples) below 13 °C, and to 2 if there are temperature readings below 0 °C in the same period. We use the preceding 320 seconds to give a little extra margin if changes are rapid..

Similarly, low instrument temperatures may lead to enhanced noise, as can lack of on board background subtraction and sometimes EUV light can enter the instrument. Therefore the highest energy channels are used to monitor the noise level as it is in the delivered raw data. The noise flag has, like the instrument flag, 3 levels, where 0 means no known problem, 1 is elevated levels and 2 means significantly elevated levels. Enhanced noise is typically seen just after the instrument is turned on. This is in part because the instrument is then cold, and in part because typically the onboard noise reduction was turned on after a few 192 s acquisition cycles.

Data with non-zero quality flag can mostly be used, in particular data from the main mission. However for data with temperature flag set to 2, the indicated energy of low energy particles can be significantly off. For the noise level, the user can in most cases perform a noise reduction for data with increased background levels. In particular, data when the onboard noise reduction was zero is perfectly fine to use, may even be desirable when looking for weak signals.

Flag position 7 indicates whether there is good correlation between the RPC-ICA ion flux and the ion current and spacecraft potential. In order to be consistent with the other flags, 0 means good correlation with RPC-LAP ion current and spacecraft potential, 1 means good correlation with the RPC-LAP ion current and 2 good correlation with the spacecraft potential and 3 indicates no good correlation with any of the RPC-LAP parameters.

For the L5 moment data, which is a combination of data with higher time resolution, the flag is the maximum of the flags of all data contributing to the moment calculation.

The 8 flag positions are defined below:

1. Field of view blocked by the spacecraft. . Certain sector and elevation combinations look into the spacecraft. These are flagged here. This flag is not relevant for the L5 (moment) data.
2. Inappropriate instrument mode used with software version 7 or 8. Such data do not have as high time resolution as indicated as spectrograms 12 s or more apart has been added together.
3. Low instrument temperature
4. Enhanced background noise
5. Quality of solar wind cross talk removal. Not implemented for L2/L3
6. Extraordinary data of uncertain nature. Not implemented for L2/L3
7. RPC-ICA – RPC-LAP correlation flag
8. Spare

3.4 Content

3.4.1 Volume Set

The one data set on one volume basic volume organization is used. Thus the volume directory structure looks like the following:

```
ROOT
 |--- AAREADME.TXT
 |--- ERRATA.TXT
 |--- VOLDESC.TXT
 |
 -----------------------------------------------------------------------------------
|            |             |             |       |              |       |
CALIBRATION  CATALOG       SOFTWARE      CALIB   GEOMETRY       INDEX   DATA
```

3.4.2 Data Set

Our naming convention for the data set will follow the same principles as the DATA_SET_ID thus.

```
DATA_SET_NAME="ROSETTA-ORBITER E/M/A/C RPCICA 2 DDDDDDD V1.0"
ROSETTA-ORBITER       = INSTRUMENT_HOST_NAME
E/M/A/C               = EARTH MARS ASTEROID COMET
RPC-ION-MASS-ANALYZER = INSTRUMENT_NAME
2                  = Data processing level numbers
                     Data set will include Edited data or Calibrated data
DDDDDDDDDDDDDD     = Processing level in text, i.e. EDITED or CALIBRATED
```

One data set will be used for each processing level. Multiple targets will be used for each data set and within each data set TARGET_NAME and TARGET_TYPE will be used to identify the current target (Thus they will not stay the same within one data set, but data set id will). The data set name fits in the full length thus 60 characters.

3.4.3 Directories

3.4.3.1 Root Directory

Table 2: Root Directory Contents

File Name	File Contents
VOLDESC.CAT	A description of the contents of this Volume in a PDS format readable by both humans and computers
CALIB/	Calibration directory
CATALOG/	Catalogue directory
DOCUMENT/	Document directory

INDEX/	Index directory
DATA/	Data directory
BROWSE/	Browse directory
GEOMETRY/	Geometry directory
SOFTWARE/	Software directory

3.4.3.2 Calibration Directory

ICA can use a number of different onboard energy, elevation and mass lookup tables. Which onboard software version was used is given by the version number, V02 in the samples below. The corresponding calibration tables found in the CALIB are named after the different ICA software versions actually used. Note that software version 1 was never used in practice, it was stored in the ROM onboard, not the EEPROM which was always used in flight. The label file for the data contains information about which tables were used by providing the name of the correct file. The ICA software version can also be obtained from the PROM section and the date of the data according to the below table:

Table 3: ICA software versions

ICA software Version	loaded in PROM bank	Origin
2.x	all, except as below	Original table
3.x	15	Earth flyby table
4.x	14	recalculated table originally assuming 34.5V offset on ESC_H
5.x	13	recalculated table originally assuming 32.5V offset on ESC_H
6.x	12	recalculated table originally assuming 30.5V offset on ESC_H
7.x	11	Low energy table with assumed 33.33V ESC_H, new mass bin tables, fix elevation
8.x	10	Fast low energy table with assumed 33.33V ESC_H, new mass bin tables, fix elevation
9.x	9	Same as 4.x but with correct mass bin tables
7.x	8	Same as bank 11: Low energy table with 33.33V ESC_H, new mass bin tables, fix elevation (after 2015-04-28)
10.x	7	Same as bank 9, but with different link packet delay time

In table 4 we list samples of the different file types that are found in the CALIB directory, with many versions for different software versions.

Table 4: Calibration Directory Contents, sample file types

File Name	File Contents

Table 4: Calibration Directory Contents, sample file types	
CATINFO.TXT	A description of the contents of this directory
ICA_ELEVATION_TABLE_V02.LBL, .TAB	Calibration table describing the elevation angle corresponding to each elevation index, as a function of particle energy. The angle given is the center angle.
ICA_ENERGY_TABLE_V02.LBL, .TAB	Calibration table describing the particle energy corresponding to each energy index level. The energy indicated is the center energy of the bin.
GFACTOR_HEAVY_V02.LBL, .TAB	Geometrical factor of the instrument as function of energy and post-acceleration setting for mass channels corresponding to the heavy ion mass range (water ions and heavier). The G factor has the energy resolution as part of the geometric factor, unit of cm^2 sr eV / eV
GFACTOR_LIGHT_V02.LBL, .TAB	Geometrical factor of the instrument as function of energy and post-acceleration setting for mass channels corresponding to the light ion mass range (helium ions and lighter). The G factor has the energy resolution as part of the geometric factor, unit of cm^2 sr eV / eV
ICA_MASS_LOOKUP_TABLE*N*_V02.LBL, .TAB	Calibration tables describing the mass channels corresponding to 6 different ion mass intervals as a function of energy. *N* is 1,2 or 3 where table 1 is used in the case of no post-acceleration, table 2 when post-acceleration reference level is 1-4 and table3 when post-acceleration level is 5-7.
ICA_MASSMASK_HEAVY_P*N*_V02.LBL, .TAB	A mass mask which is true for the energy and mass channel combinations which corresponds to heavy ions (water ion group and heavier), Problematic mass channels (prone to cross talk or insensitive) are set to zero.
ICA_MASSMASK_LIGHT_P*N*_V02.LBL, .TAB	A mass mask which is true for the energy and mass channel combinations which corresponds to light ions (helium ions and lighter), Problematic mass channels (prone to cross talk or insensitive) are set to zero.

3.4.3.3 Catalog Directory

Table 5: Catalog Directory Contents	
File Name	**File Contents**
CATINFO.TXT	A description of the contents of this directory
DATASET.CAT	PDS Data Set catalog description of all the ICA un-calibrated level 2 data files

Table 5: Catalog Directory Contents	
INSTHOST.CAT	PDS instrument host (spacecraft) catalog description of the Rosetta orbiter spacecraft
INST.CAT	PDS instrument catalog description of the ICA instrument
MISSION.CAT	PDS mission catalog description of the Rosetta mission
PERS.CAT	PDS personnel catalog description of ICA Team members and other persons involved with generation of ICA Data Products
REFERENCE.CAT	ICA-related references mentioned in other *.CAT files
SOFTWARE.CAT	PDS software catalog description of ICA software

3.4.3.4 Index Directory

Table 6:Index Directory Contents	
File Name	**File Contents**
INDXINFO.TXT	Dataset Index File
BROWSE_INDEX.LBL BROWSE_INDEX.TAB	Browse index file (only L2)
INDEX.LBL INDEX.TAB	Data index file
	No other index files will be used

3.4.3.5 Browse Directory and Browse Files

Contains png files of all-direction raw spectrograms binned into two mass bins (low and high) for a fixed time interval of 1 hour. The data is organized in the same structure as the data, i.e. year, month and day are directories which contain png and corresponding label (.LBL) files. . Description in BROWSEINFO.TXT. The BROWSE files are only available for L2 data. The use of the BROWSE files is to identify presence of data and interesting events.

Table 7: Browse Directory Contents	
File Name	**File Contents**
BROWSEINFO.TXT	Information about the Browse data
YEAR	Directories containing browse plots from each year. See directory structure below.

The YEAR catalogue structure follows that of the archive format, i.e. in the BROWSE directory a structure with the following principal format can be found:

```
BROWSE
 I
 I--BROWINFO.TXT
 I--BROWSE.HTM
 I--BROWSE.LBL
 I
 +------+----...
 I      I
2005  2006 ...
```

```
   |
   +----+---...
   |    |
MAY  OCT ...
   |
   +---...
   |
  D01 ...
   |
 PNG picture files
```

3.4.3.6 Geometry Directory

Files of the instrument viewing geometry, taken from the calibration documentation, will be provided. Figures 2,3 and 4 of this document will be included as SECTORS.PDF shown in figure 2, ICALOCATION.JPG (figure 3) and ICA_FOV.JPG (figure 4).

Table 8: Geometry Directory Contents

File Name	File Contents
ICALOCATION.JPG	A figure describing where ICA is located on Rosetta, as well as relating the ICA instrument and spacecraft coordinate systems to each other.
SECTORS.PDF	Figure describing the sector (azimuth) and elevation index numbering in the instrument coordinate system.
ICA_FOV.JPG	Rosetta seen from the ICA field-of-view in a local latitude-longitude coordinate system explained in figure ICALOCATION.JPG

3.4.3.7 Software Directory

Sample MATLAB files to read ICA ASCII archive files are provided, as well as a commented sample on how to produce a spectrogram plot. The files are named READICA_L2.M; READICA_L3 and PLOT_ICA.M.

Table 9: SOFTWARE Directory Contents

File Name	File Contents
READICA_L2.M	File to read ICA L2 data into the MATLAB workspace. Asks for a date and read all data for that date
READICA_L3.M	File to read ICA L3 data into the MATLAB workspace. Asks for a date and read all data for that date
READICA_L4_CORR.M	File to read ICA L CORR data into the MATLAB workspace. Asks for a date and read all data for that date
READ_ICA_L4_CORR_CTS.M	File to read ICA L4 CORR CTS data into the MATLAB workspace. Asks for a date and read all data for that date

Table 9: SOFTWARE Directory Contents	
READ_ICA_L4_PHYS_MASS.M	File to read ICA L4 PHYS MASS data into the MATLAB workspace. Asks for a date and read all data for that date
PLOT_ICA.M	Sample program to plot ICA data. Mainly to illustrate how one can work with the raw data.
ICAINITIALIZE.M	Script to initialize the workspace by, for example, reading the ICA energy table into the workspace. Needed to run PLOT_ICA.M
IMPORT_L2.M	Support function to READICA_L2.M. Reads one data file
READ_PDS_LBL.M	General function to read the contents of a PDS label file. Needed ta access the data given only in the label, like software version.

3.4.3.8 Label Directory

This directory is not used.

3.4.3.9 Document Directory

Table 10: Document Directory Contents	
File Name	**File Contents**
DOCINFO.TXT	A description of the contents of this directory and all subdirectories.
ICA_EAICD.PDF, LBL	The ICA Experiment-Archive Interface Control Document in PDF format
ICMA_TCTM.PDF, LBL	“The ICA-IMA TC/TM data formats and related software aspects” by Hans Borg
ICA_CMD_BRIEF.PDF, LBL	“ICA Command Description” by Hans Borg
ICA_CAL.PDF, LBL	“ICA calibration report” by Andrei Fedorov
ICATABLES.PDF, LBL	ICA Tables by A. Fedorov
ICA_USER_GUIDE.PDF, LBL	The ICA User Guide in pdf format
Other Documents	Additional documents describing data processing, etc.
Other Document labels	Detached PDS labels for any additional documents

3.4.3.10 Data Directory

Table 11: Data Directory Contents		
Data set	**File Name**	**File Contents**
L2	RPCICAYYMMDDTHH_000_L2.LBL, .TAB	Label and table files containing ICA data
	RPCICAYYMMDDTHH_000_GEOM.LBL, .TAB	Label and table files with geometry data
	RPCICAYYMMDDTHH_000_HK.LBL, .TAB	Label and table files with housekeeping data
L3	RPCICAYYMMDDTHH_000_L3.LBL, .TAB	Label and table files containing calibrated ICA data
L4 CORR	RPCICAYYMMDDTHH_000_L4_CORR.LBL, .TAB	Label and table files containing corrected and calibrated ICA data

Table 11: Data Directory Contents

	RPCICAYYMMDDTHH_000_L4_ZERO.LBL, .TAB	Label and table files containing an uncertainty estimate of the zero level of the L4 CORR data
L4 CORR_CTS	RPCICAYYMMDDTHH_000_L4_CTS.LBL, .TAB	Label and table files containing corrected and ICA data
	RPCICAYYMMDDTHH_000_L4_ZCTS.LBL, .TAB	Label and table files containing an uncertainty estimate of the zero level of the L4 CORR_CTS data
	RPCICAYYMMDDTHH_000_L4_E.LBL, .TAB	Label and table files containing an energy scale corrected for temperature drift
	RPCICAYYMMDDTHH_000_L4_DE.LBL, .TAB	Label and table files containing an energy bin width corrected for temperature drift
	RPCICAYYMMDDTHH_000_L4_USC.LBL, .TAB	Spacecraft potential from RPC-LAP interpolated to times of RPC_ICA measurements
L4 PHYS_MASS	RPCICAYYMMDDTHH_000_L4_H.LBL, .TAB	Label and table files containing H^+ ion data
	RPCICAYYMMDDTHH_000_L4_HE2.LBL, .TAB	Label and table files containing He^{2+} ion data
	RPCICAYYMMDDTHH_000_L4_HE.LBL, .TAB	Label and table files containing He^+ ion data
	RPCICAYYMMDDTHH_000_L4_HVY.LBL, .TAB	Label and table files containing Heavy ions data (O^+ and above)

Table 11: Data Directory Contents		
L5 MOMENT	RPCICAYYMMDDTHH_000_L5_MOM.LBL, .TAB	Label and table files containing moment data for H^+, He^{2+}, He^+, as well as two data sets with H_2O^+ above and below 60 eV

4 Detailed Interface Specifications

4.1 Structure and Organization Overview

See section 3.1.3 for general overview. Note that different processing levels are stored as different DATA_SETs.

Now as defined in section 3.1.3 we have the following structure for each year in the DATA directory.

```
              +---------------------+------------------- …
      DATA_SET_ID1    DATA_SET_ID2
              |                |
            DATA            DATA
              |                |
           EDITED       CALIBRATED
              |
              +---------------------+-------------------+----------…
              |                     |                  |
            2004                 2005              2006       …
              |
   +------------+--------------------+------------…
   |            |                    |
 MAR          APR                 MAY...
  |
  +--------------+---------------+---- ...
  |              |               |   ...
 D01            D02             D03
```

4.2 Data Sets, Definition and Content

Two levels of data are used: Raw (edited) data and calibrated data. The raw edited data contains the raw counts from the detector, sorted into the PDS format and with UT calculated and a quality

parameter set to indicate data quality.
For the calibrated data a background subtraction has been performed and the calibration tables have been used to turn counts in physical flux units.
The raw data archive also contains the housekeeping data from the TM stream in uncalibrated format.
The calibrated data is used to produce the derived (L5) moment data set.

4.3 Data Product Design

ICA produce two kinds of data, ion mass energy spectrograms and housekeeping data (HK). The instrument can be run in different modes, resulting in different resolution, but the data format is the same.

A complete set of edited data consists of housekeeping and science data. Calibration files in the CALIB directory will also be needed to interpret the data. In addition we provide geometry information in separate files.

A complete set of calibrated data consists of science data only.

A complete set of L4 data consists of the science data from RPC-ICA, an energy scale and energy bin width corrected for temperature drift in separate files and an estimate of the spacecraft potential from the RPC-LAP instrument.

4.3.1 Data Product "Uncalibrated data" Design

The labels below follow the RPC and PDS conventions.

The L2, L3 and L4 CORR and CORR_CTS data files consist of 10 positions with information and then 8, 32 or 96 positions with an energy spectra depending on the number of energy steps in the data. . In the PDS table the latter 8 to 96 positions are in one column. The data file columns are described in words below and later a sample label file is shown. The number of rows is variable. In the sample below figures from a real file is provided. Our sample is for the most common case of 96 energy steps and L2 data.

Column
1. Start time of the observations in Universal Time
2. Delta T, duration of the observation in seconds
3. Quality flags, 8 positions where 0 means no known problem, x means not implemented for this data set. The flags are described in section 3.3.
4. Instrument mode, gives the instrument binning mode as a number between 8 and 31. See instrument paper or User Guide for interpretation.
5. Noise reduction. The number of counts subtracted on board from each data point (after binning).
6. Mass table used. ICA may use mass look-up tables on board to bin data into certain physical mass ranges (see section 2.4.3). This column describes which of three on-board tables was used. 0 indicates that no mass look-up table was used, 1 indicates the table for no post-acceleration (reference value 0), 2 low post acceleration (reference value 1 to4) and 3 high post-acceleration (reference value 5 – 7)..
7. Post-acceleration reference level (0-7). Necessary to know in order to interpret the mass channels correctly in terms of physical mass of measured particles (see point 6 above).
8. Azimuth index (0-15). See sections 2, 2.4.3 and figures 2 and 3.
9. Elevation index (0-15) See sections 2, 2.4.3 and figures 2 and 3.

10. Mass channel number (0-31).
11. Contains 96 count-values for the 96 different energy steps in the energy spectrogram. The energy levels are found in the file ICA_ENERGY_TABLE_VNN.LBL in the CALIB directory.

Example of edited raw data detached label file (e.g. RPCICAYYMMDDTHH_000_L2.LBL)

```
PDS_VERSION_ID = PDS3
LABEL_REVISION_NOTE = "V0.83"
RECORD_TYPE    = FIXED_LENGTH
RECORD_BYTES   = 377
FILE_RECORDS   = 155648
FILE_NAME      = "RPCICA150513T06_000_L2.LBL"
^TABLE         = "RPCICA150513T06_000_L2.TAB"
PRODUCT_ID     = "RPCICA150513T06_000_L2"
DATA_SET_ID    = "RO-C-RPCICA-2-ESC2-RAW-V2.0"
DATA_SET_NAME  = "ROSETTA-ORBITER 67P RPCICA 2 ESC2 UNCALIBRATED V2.0"
PROCESSING_LEVEL_ID = "2"
PRODUCT_TYPE   = "EDR"
PRODUCT_CREATION_TIME = 2018-01-09T21:13:17
MISSION_ID     = "ROSETTA"
MISSION_NAME   = "INTERNATIONAL ROSETTA MISSION"
INSTRUMENT_HOST_ID   = "RO"
INSTRUMENT_HOST_NAME = "ROSETTA-ORBITER"

TARGET_NAME = "67P/CHURYUMOV-GERASIMENKO 1 (1969 R1)"
TARGET_TYPE = "COMET"
MISSION_PHASE_NAME = "COMET ESCORT 2"
START_TIME  = 2015-05-13T06:02:07.532
STOP_TIME   = 2015-05-13T07:02:51.596
SPACECRAFT_CLOCK_START_COUNT = "1/0390117651.16338"
SPACECRAFT_CLOCK_STOP_COUNT  = "1/0390121295.20454"
SC_SUN_POSITION_VECTOR    = (-244527896.4892712,
    22304319.0970978, 24945626.4280472)
SC_TARGET_POSITION_VECTOR = (  -18.0716132,   172.8954136,
   18.3557636)
SC_TARGET_VELOCITY_VECTOR = (   -0.0001124,   -0.0003376,
    0.0002537)
SPACECRAFT_ALTITUDE       =    174.80372226
SUB_SPACECRAFT_LATITUDE   =    -38.57079313
SUB_SPACECRAFT_LONGITUDE  =    170.42961632

NOTE                   = "
 The values of the keywords SC_SUN_POSITION_VECTOR,
 SC_TARGET_POSITION_VECTOR, SC_TARGET_VELOCITY_VECTOR
 are related to the equatorial J2000 inertial frame.
 The values of SUB_SPACECRAFT_LATITUDE and
 SUB_SPACECRAFT_LONGITUDE refer to the Cheops reference
 frame.
 The SPACECRAFT_ALTITUDE gives the distance to the spacecraft
```

from the target center of mass.
All values are computed for the time t=START_TIME. Distances
are given in <km>, velocities in <km/s>, and angles in <deg>.
LBL & TAB FILES HAVE BEEN GENERATED BY S/W: I2 VERSION 0.05
TIMECORR FILE USED. SPICE USED."

PRODUCER_ID = "RPC_ICA_KIRUNA_TEAM"
PRODUCER_FULL_NAME = "NILSSON, HANS"
PRODUCER_INSTITUTION_NAME = "SWEDISH INSTITUTE OF SPACE PHYSICS KIRUNA"
INSTRUMENT_ID = "RPCICA"
INSTRUMENT_NAME = "ROSETTA PLASMA CONSORTIUM - ION COMPOSITION ANALYSER"
INSTRUMENT_TYPE = "PLASMA INSTRUMENT"

ROSETTA:ICA_ENERGY_TABLE_NAME = "ICA_ENERGY_TABLE_V07.LBL"
ROSETTA:ICA_ENERGY_TABLE_DESC = "
THE TABLE DESCRIBES THE ENERGY LEVEL CORRESPONDING TO EACH OF THE 32 COLUMNS
GIVING COUNTS PER ENERGY LEVEL. THE TABLE IS FOUND IN THE CALIB DIRECTORY."
ROSETTA:ICA_MASS_TABLE1_NAME = "ICA_MASS_LOOKUP_TABLE1_V07.LBL"
ROSETTA:ICA_MASS_TABLE2_NAME = "ICA_MASS_LOOKUP_TABLE2_V07.LBL"
ROSETTA:ICA_MASS_TABLE3_NAME = "ICA_MASS_LOOKUP_TABLE3_V07.LBL"
ROSETTA:ICA_MASS_TABLE_DESC = "
WHEN THE MASS CHANNEL RESOLUTION IN THE TELEMETRY IS REDUCED BELOW 8 THE
MASS CHANNELS ARE BINNED TOGETHER IN CERTAIN MASS CHANNEL RANGES EXPECTED TO
CORRESPOND TO CERTAIN ION MASS RANGES. THESE WILL VARY FOR DIFFERENT POST-
ACCELERATION SETTINGS AND ENERGY AND THUS 3 DIFFERENT TABLES ARE PROVIDED
FOR DIFFERENT POST-ACCELERATION SETTING. THE BINNING IS DESCRIBED IN THE
TABLES DESCRIBED BY THE MASS_TABLE_NAME KEYWORDS. THE TABLES ARE FOUND IN
THE CALIB DIRECTORY. WHICH TABLE WAS USED IS GIVEN BY A COLUMN IN THE DATA."
ROSETTA:ICA_ELEVATION_TABLE_NAME = "ICA_ELEVATION_TABLE_V07.LBL"
ROSETTA:ICA_ELEVATION_TABLE_DESC = "
THE NOMINAL ANGLES FOR EACH ELEVATION INDEX ARE NOT REACHED FOR ALL
ENERGIES. THE ELEVATION TABLE GIVES THE ACTUAL ELEVATION ANGLES FOR EACH
ENERGY."
ROSETTA:ICA_SW_VERSION = "07"
ROSETTA:ICA_SW_VERSION_DESC = "SOFTWARE VERSION INDICATES WHICH ONBOARD
SOFTWARE VERSION WAS RUN. THIS AFFECTS WHICH ENERGY AND ELEVATION TABLES
WERE USED, AND THEREFORE ALSO THE TEMPORAL RESOLUTION OF THE MEASUREMENTS.
VALID VALUES ARE 1 TO 10. THE TABLES CORRESPONDING TO THE GIVEN SOFTWARE
VERSION ARE GIVEN IN THIS LABEL AS ICA_ENERGY_TABLE_NAME AND
ICA_ELEVATION_TABLE_NAME"
ROSETTA:ICA_BAD_HV_MASK = "DISABLED"
ROSETTA:ICA_BAD_HV_MASK_DESC = "INDICATES WHETHER BAD-HV MASK WAS ON OR OFF.
IF ON ENERGY-ELEVATION ANGLE COMBINATIONS WHICH COULD NOT REACH THE NOMINAL
VALUE OF ELEVATION ANGLE ARE SET TO ZERO. FOR LOW ENERGIES LIMITED
RESOLUTION OF THE ELEVATION DEFLECTION VOLTAGE IS LIMITING, FOR HIGH

```
 ENERGIES INSUFFICIENT HIGH VOLTAGE IS LIMITING."
ROSETTA:ICA_SHADOW_MASK = "ENABLED"
ROSETTA:ICA_SHADOW_MASK_DESC = "INDICATES WHETHER SHADOW MASK WAS ON OR
OFF.
 IF ON IONS COMING FROM ANGLES BLOCKED BY THE SPACECRAFT ARE SET TO ZERO. IF
 OFF THE CORRESPONDING SECTORS WILL LIKELY PRODUCE VERY FEW COUNTS
ANYWAY,
 BUT MAY BE USEFUL FOR BACKGROUND SUBTRACTION."

OBJECT = TABLE
NAME             = "RPCICA-2-ESC2-RAW"
INTERCHANGE_FORMAT = ASCII
ROWS             = 155648
COLUMNS          = 11
ROW_BYTES        = 377
DESCRIPTION      = "DETECTOR COUNTS PER TIME, SECTOR (AZIMUTH ANGLE),
 ELEVATION ANGLE AND MASS BIN. SOME DATA WAS BINNED ONBOARD BUT IN THE
 ARCHIVE THE DATA HAS BEEN EXPANDED TO A UNIFORM SIZE IN TERMS OF AZIMUTH,
 ELEVATION AND MASS CHANNEL. BINNED DATA WAS DISTRIBUTED EVENLY ON ALL
 CONTRIBUTING DATA POINTS. FOR MASS CHANNELS, COUNTS WERE DISTRIBUTED
 ONLY TO VALID MASS CHANNELS. BECAUSE OF THIS EXPANSION, FRACTIONAL COUNTS
 OCCUR IN THE DATA."

OBJECT = COLUMN
  NAME        = TIME_UTC
  DATA_TYPE   = TIME
  START_BYTE  = 1
  BYTES       = 23
  FORMAT      = "A23"
  UNIT        = "N/A"
  COLUMN_NUMBER = 1
  DESCRIPTION = "TIME OF OBSERVATION YYYY-MM-DDTHH:MM:SS.ssssss"
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME          = DELTA_T
  DATA_TYPE     = ASCII_INTEGER
  START_BYTE    = 25
  BYTES         = 2
  FORMAT        = "I2"
  VALID_MINIMUM = 1
  VALID_MAXIMUM = 12
  UNIT          = "SECOND"
  COLUMN_NUMBER = 2
  DESCRIPTION   = "DURATION OF THE OBSERVATIONS IN SECONDS."
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME          = QUALITY
  DATA_TYPE     = CHARACTER
```

```
  START_BYTE    = 29
  BYTES         = 9
  COLUMN_NUMBER = 3
  DESCRIPTION   = "THE QUALITY OF THE DATA IS INDICATED USING EIGHT FLAGS OF
   WHICH SIX ARE CURRENTLY USED:
   1. FIELD OF VIEW BLOCKED BY THE SPACECRAFT.
   2. INAPPROPRIATE MODE USED WITH SOFTWARE VERSION 7 & 8.  SUCH DATA DO NOT
      HAVE THE INDICATED TEMPORAL RESOLUTION AS 1 OR 4 <SEC> SPECTROGRAMS
      12 <SEC> APART HAS BEEN ADDED TOGETHER.
   3TH & 4TH FLAGS CAN BOTH BE 0,1 OR 2 WHERE 0 INDICATES NO KNOWN
   PROBLEM, 1 SOME PROBLEM/EFFECT AND 2 SIGNIFICANT PROBLEMS / EFFECTS.
   3. LOW INSTRUMENT TEMPERATURE. FLAG RELATES TO THE TEMPERATURE OF THE
      INSTRUMENT, WHICH IF BELOW 13 <DEG> C CAN LEAD TO A DRIFT OF THE ENERGY
      TABLE, AND BELOW 0 <DEG> C THIS DRIFT CAUSES A MAJOR PROBLEM.
   4. ENHANCED BACKGROUND NOISE. BACKGROUND NOISE MAY ALSO BE ENHANCED
WHEN
      THE INSTRUMENT IS COLD BUT ALSO FOR OTHER REASONS. THE NOISE IS ALSO
      ENHANCED WHEN ONBOARD NOISE REDUCTION IS TURNED OFF. THE FLAG WARNS
      FOR SUCH DATA AS WELL, AS THE USER MUST BE AWARE OF THE HIGHER NOISE
      LEVELS IN THE DATA.
   5. SOLAR WIND CROSS TALK REMOVAL. NOT IMPLEMENTED FOR L2 OR L3 AND
      THEREFORE SET TO LOWERCASE 'X'.
   6. EXTRAORDINARY DATA. NOT IMPLEMENTED YET AND THEREFORE SET TO
      LOWERCASE 'X'.
   TWO MORE FLAGS ARE INCLUDED AS SPARES SO THAT FLAGS CAN BE ADDED LATER
   WITHOUT CHANGING THE LAYOUT OR FORMAT OF THE DATA. THEY ARE SET TO
   LOWERCASE 'X'"
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME          = MODE
  DATA_TYPE     = ASCII_INTEGER
  START_BYTE    = 39
  BYTES         = 2
  FORMAT        = "I2"
  VALID_MINIMUM = 0
  VALID_MAXIMUM = 31
  UNIT          = "N/A"
  COLUMN_NUMBER = 4
  DESCRIPTION   = "INSTRUMENT MODE AS DEFINED IN THE INSTRUMENT PAPER
   (VALID VALUES FOR DATA IS 8-15 FOR NORMAL MODE DATA, 16-23 FOR HIGH
   ANGULAR RESOLUTION DATA AND 24-31 FOR HIGH MASS RESOLUTION DATA.
   WITHIN EACH CATEGORY, A HIGHER NUMBER MEANS MORE STRONGLY BINNED
   DATA (LOWER RESOLUTION)."
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME          = NOISE_REDUCTION
  DATA_TYPE     = ASCII_INTEGER
  START_BYTE    = 42
```

```
  BYTES        = 1
  FORMAT       = "I1"
  VALID_MINIMUM = 0
  VALID_MAXIMUM = 3
  UNIT         = "N/A"
  COLUMN_NUMBER = 5
  DESCRIPTION   = "THE NUMBER OF COUNTS SUBTRACTED FROM EACH DATA POINT
   (AFTER BINNING) ONBOARD. USED TO REDUCE NOISE AND MAKE LOSSLESS
   COMPRESSION MORE EFFICIENT. LESS NOISE REDUCTION AFFECTS THE NOISE
   QUALITY FLAG. THERE IS NOTHING WRONG WITH THE DATA THOUGH, BUT THE
   END USER MAY NEED TO PERFORM A NOISE REDUCTION."
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME         = MASS_TABLE
  DATA_TYPE     = ASCII_INTEGER
  START_BYTE    = 44
  BYTES        = 1
  FORMAT       = "I1"
  VALID_MINIMUM = 0
  VALID_MAXIMUM = 3
  UNIT         = "N/A"
  COLUMN_NUMBER = 6
  DESCRIPTION   = "ICA HAS THREE ON-BOARD MASS-LOOK UP TABLES, FOR DIFFERENT
   RANGES OF THE POST-ACCELERATION SETTING. THE TABLES ARE ENERGY DEPENDENT
   AND THE CURRENTLY USED TABLES ARE FOUND IN FILES DEFINED BY THE KEYWORD
   ROSETTA:ICA_MASS_TABLE_NAME. THE TABLES ARE FOUND IN THE CALIB DIRECTORY.
   TABLE 0 MEANS THAT NO ON-BOARD TABLE WAS USED AND THAT INDICATED MASS
   INDICES CORRESPOND TO PHYSICAL MASS CHANNELS ON THE MICRO CHANNEL PLATE.
   FOR TABLE 1, 2 AND 3 START AND STOP ARE THE SAME AND CORRESPONDS TO THE
   ION MASS GIVEN BY THE CORRESPONDING COLUMN OF THE MASS LOOKUP TABLE."
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME         = PACC_LEVEL_REFERENCE
  DATA_TYPE     = ASCII_INTEGER
  START_BYTE    = 46
  BYTES        = 1
  FORMAT       = "I1"
  VALID_MINIMUM = 0
  VALID_MAXIMUM = 7
  UNIT         = "N/A"
  COLUMN_NUMBER = 7
  DESCRIPTION   = "REFERENCE VALUE DESCRIBING THE POST-ACCELERATION LEVEL.
   THE LEVEL OF THE POST-ACCELERATION MUST BE KNOWN AS IT AFFECTS BOTH THE
   DETECTOR EFFICIENCY AND WHERE A CERTAIN MASS WILL HIT THE DETECTOR
   SURFACE. DETAILS ARE FOUND IN ICA_CAL.PDF IN THE DOCUMENTS DIRECTORY."
END_OBJECT = COLUMN

OBJECT = COLUMN
```

```
  NAME         = AZIMUTHAL_INDEX
  DATA_TYPE    = ASCII_INTEGER
  START_BYTE   = 48
  BYTES        = 2
  FORMAT       = "I2"
  VALID_MINIMUM = 0
  VALID_MAXIMUM = 15
  UNIT         = "N/A"
  COLUMN_NUMBER = 8
  DESCRIPTION  = "AZIMUTH INDEX (0-15). SEE INSTRUMENT PAPER OR ICA EAICD
   FOR DETAILS."
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME         = ELEVATION_INDEX
  DATA_TYPE    = ASCII_INTEGER
  START_BYTE   = 51
  BYTES        = 2
  FORMAT       = "I2"
  VALID_MINIMUM = 0
  VALID_MAXIMUM = 15
  UNIT         = "N/A"
  COLUMN_NUMBER = 9
  DESCRIPTION  = "ELEVATION INDEX (0-15). SEE INSTRUMENT PAPER OR ICA EAICD
   FOR DETAILS."
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME         = MASS_INDEX
  DATA_TYPE    = ASCII_INTEGER
  START_BYTE   = 54
  BYTES        = 2
  FORMAT       = "I2"
  VALID_MINIMUM = 0
  VALID_MAXIMUM = 31
  UNIT         = "N/A"
  COLUMN_NUMBER = 10
  DESCRIPTION  = "MASS INDEX (0-31). SEE INSTRUMENT PAPER OR ICA EAICD
   FOR DETAILS."
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME         = NO_OF_COUNTS
  DATA_TYPE    = ASCII_REAL
  START_BYTE   = 57
  BYTES        = 319
  FORMAT       = "F9.3"
  ITEMS        = 32
  ITEM_BYTES   = 9
  ITEM_OFFSET  = 10
```

```
  UNIT          = "N/A"
  COLUMN_NUMBER = 11
  DESCRIPTION   = "NO OF COUNTS OBTAINED FOR EACH ENERGY LEVEL, AND
   SPECIFIED SECTORS, DEFLECTION ANGLES AND MASS CHANNELS AS INDICATED.
   THE ENERGY STEPS ARE GIVEN IN SEPARATE FILE DEFINED BY KEYWORD
   ROSETTA:ICA_ENERGY_TABLE_NAME."
END_OBJECT = COLUMN

END_OBJECT = TABLE

END
```

4.3.1.1 File Characteristics Data Elements

The *.LBL file will be identified by the FILE_NAME.

4.3.1.2 Data Object Pointers Identification Data Elements

The only pointer used is from the *.LBL file to the *.TAB file. Keywords are also used to identify the correct calibration table from the CALIB directory to use for the data.

4.3.1.3 Instrument and Detector Descriptive Data Elements

ROSETTA:ICA_ENERGY_TABLE_NAME Describes the energy table currently in use.
ROSETTA:ICA_MASS_TABLE1_NAME ,ROSETTA:ICA_MASS_TABLE2_NAME,
ROSETTA:ICA_MASS_TABLE3_NAME gives the names of the currently used mass lookup tables. These tables relates which ion mass corresponds to which range of detector mass channels for a given energy and post acceleration setting. The three different tables are used for three different ranges of post-acceleration settings, corresponding to post-acceleration reference levels as:

Number of table	Post acceleration reference value
1	0
2	1-4
3	5-7

ROSETTA:ICA_ELEVATION_TABLE_NAME gives the elevation table currently in use. This provides more precise elevation angles for particles of different energies than the nominal angles described in section 2 and shown in figure 2.

4.3.1.4 Structure Definition of Instrument Parameter Objects

N/A

4.3.1.5 Data Object Definition

All data stored in *.TAB files. Their structure is defined by OBJECT Table definition within *.LBL file. Each data definition block has a DESCRIPTION which explains the meaning of the assigned data columns.

4.3.1.6 Description of Instrument

The basics of the instrument is described in section 2 of this document.

4.3.1.7 Parameters Index File Definition

N/A

4.3.1.8 Mission Specific Keywords

None.

4.3.2 Housekeeping data design

The housekeeping data is retained in the archive mainly for completeness. The generally useful parameters provided are the instrument and sensor temperatures. In particular the sensor temperature can affect the instrument performance. The sensor temperature form the basis for one of our quality flags, see section 3.3. The temperatures are given as calibrated values [°C].

All other housekeeping data concern mainly commands, modes and reference and monitor values for different voltages onboard. The reference and monitor values are provided as digital reference values, not calibrated values. Calibration information is found in the ICA_TABLES document provided in the DOCUMENTS directory of the data set.

The HK data design consists of a table with 42 columns containing the following information:

1. Time, UTC
2. Instrument mode
3. Instrument SID (Telemetry rate, see instrument paper)
4. Instrument sensor temperature, calibrated value °C
5. Instrument DPU temperature, calibrated value °C
6. Micro channel plate (MCP) main 28V switch on/off (0/1)
7. Opto main 28 V switch on/off (0/1)
8. Main 28 V switch on/off (0/1)
9. Post-acceleration high voltage on/off (0/1)
10. Grid low voltage on / off (0/1)
11. Entrance high voltage on/off (0/1)
12. Deflection low voltage on/off (0/1)
13. Deflection high voltage on/off (0/1)
14. MCP high voltage present (0/1)
15. Opto 28 V present (0/1)
16. Main 28 V present (0/1)
17. Opto monitor value (digital reference value 0-255)
18. MCP monitor value (digital reference value 0-255)
19. Deflection high voltage monitor (digital reference value 0-255)
20. Deflection low voltage monitor (digital reference value 0-255)
21. Post acceleration high voltage monitor (digital reference value 0-255)
22. Grid low voltage monitor (digital reference value 0-255)
23. Entrance upper high voltage monitor (digital reference value 0-511)
24. Entrance lower high voltage monitor (digital reference value 0-511)
25. Energy deflection high voltage reference (digital reference value 0-4095)
26. Energy deflection low voltage reference (digital reference value 0-4095)

27. Entrance upper reference value (digital reference value 0-4095)
28. Grid reference value (digital reference value 0-7)
29. MCP high voltage current reference (digital reference value 0-15)
30. Opto high voltage current reference (digital reference value 0-15)
31. MCP high voltage default reference (digital reference value 0-15)
32. Opto default high voltage reference (digital reference value 0-7)
33. Post acceleration low level reference (digital reference value 0-7)
34. Post acceleration high level reference (digital reference value 0-7)
35. Post acceleration level low / high (0/1)
36. Post acceleration mode fixed / alternating (0/1)
37. Last command status (0-3, with 0 ok)
38. New command received toggle bit (0/1)
39. First word command return (0-65525)
40. Direct command switch (0/1)
41. FIFO filling in terms of internal packets (0 – 20000)
42. FIFO overflow (0-255)

Example of edited raw data detached label file (e.g. RPCICAYYMMDDTHH_000_HK.LBL)

```
PDS_VERSION_ID = PDS3
LABEL_REVISION_NOTE = "V0.83"
RECORD_TYPE    = FIXED_LENGTH
RECORD_BYTES   = 152
FILE_RECORDS   = 113
FILE_NAME      = "RPCICA150513T06_000_HK.LBL"
^TABLE         = "RPCICA150513T06_000_HK.TAB"
PRODUCT_ID     = "RPCICA150513T06_000_HK"
DATA_SET_ID    = "RO-C-RPCICA-2-ESC2-RAW-V2.0"
DATA_SET_NAME  = "ROSETTA-ORBITER 67P RPCICA 2 ESC2 UNCALIBRATED V2.0"
PROCESSING_LEVEL_ID = "2"
PRODUCT_TYPE   = "EDR"
PRODUCT_CREATION_TIME = 2017-12-07T11:31:53
MISSION_ID     = "ROSETTA"
MISSION_NAME   = "INTERNATIONAL ROSETTA MISSION"
INSTRUMENT_HOST_ID   = "RO"
INSTRUMENT_HOST_NAME = "ROSETTA-ORBITER"

TARGET_NAME = "67P/CHURYUMOV-GERASIMENKO 1 (1969 R1)"
TARGET_TYPE = "COMET"
MISSION_PHASE_NAME = "COMET ESCORT 2"
START_TIME  = 2015-05-13T06:02:39.521
STOP_TIME   = 2015-05-13T07:02:23.523
SPACECRAFT_CLOCK_START_COUNT = "1/0390117683.15616"
```

```
SPACECRAFT_CLOCK_STOP_COUNT  = "1/0390121267.15670"
SC_SUN_POSITION_VECTOR    = (-244527896.4892712,
22304319.0970978, 24945626.4280472)
SC_TARGET_POSITION_VECTOR = (  -18.0716132,   172.8954136,
18.3557636)
SC_TARGET_VELOCITY_VECTOR = (   -0.0001124,   -0.0003376,
0.0002537)
SPACECRAFT_ALTITUDE       =    174.80372226
SUB_SPACECRAFT_LATITUDE   =    -38.57079313
SUB_SPACECRAFT_LONGITUDE  =    170.42961632

NOTE                  = "
The values of the keywords SC_SUN_POSITION_VECTOR,
SC_TARGET_POSITION_VECTOR, SC_TARGET_VELOCITY_VECTOR
are related to the equatorial J2000 inertial frame.
The values of SUB_SPACECRAFT_LATITUDE and
SUB_SPACECRAFT_LONGITUDE refer to the Cheops reference
frame.
The SPACECRAFT_ALTITUDE gives the distance to the spacecraft
from the target center of mass.
All values are computed for the time t=START_TIME. Distances
are given in <km>, velocities in <km/s>, and angles in <deg>.
LBL & TAB FILES HAVE BEEN GENERATED BY S/W: I2 VERSION 0.05
TIMECORR FILE USED. SPICE USED."

PRODUCER_ID = "RPC_ICA_KIRUNA_TEAM"
PRODUCER_FULL_NAME = "NILSSON, HANS"
PRODUCER_INSTITUTION_NAME = "SWEDISH INSTITUTE OF SPACE PHYSICS KIRUNA"
INSTRUMENT_ID     = "RPCICA"
INSTRUMENT_NAME   = "ROSETTA PLASMA CONSORTIUM - ION COMPOSITION ANALYSER"
INSTRUMENT_TYPE   = "PLASMA INSTRUMENT"

OBJECT = TABLE
NAME             = "RPCICA-2-ESC2-HK"
INTERCHANGE_FORMAT = ASCII
ROWS             = 113
COLUMNS          = 42
ROW_BYTES        = 152
DESCRIPTION = "HOUSEKEEPING DATA FOR FILE RPCICA150513T06_000_HK.TAB.
TIME AND DECODED HK VALUES."

OBJECT = COLUMN
NAME       = TIME_UTC
DATA_TYPE   = TIME
START_BYTE  = 1
BYTES      = 23
UNIT       = "N/A"
FORMAT     = "A23"
DESCRIPTION = "TIME OF HK OBSERVATION YYYY-MM-DDTHH:MM:SS.ssssss"
END_OBJECT  = COLUMN

OBJECT = COLUMN
```

```
NAME          = MODE
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 25
BYTES         = 2
FORMAT        = "I2"
VALID_MINIMUM = 0
VALID_MAXIMUM = 63
UNIT          = "N/A"
DESCRIPTION   = "CURRENT DATA REDUCTION MODE"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME          = SID
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 28
BYTES         = 1
FORMAT        = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 7
UNIT          = "N/A"
DESCRIPTION   = "CURRENT SID NUMBER"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME          = SENSOR_TEMP
DATA_TYPE     = ASCII_REAL
START_BYTE    = 30
BYTES         = 5
FORMAT        = "F5.1"
VALID_MINIMUM = -52.0
VALID_MAXIMUM = 65.0
UNIT          = "DEGREES"
DESCRIPTION   = "SENSOR UNIT TEMPERATURE."
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME          = DPU_TEMP
DATA_TYPE     = ASCII_REAL
START_BYTE    = 36
BYTES         = 5
FORMAT        = "F5.1"
VALID_MINIMUM = -52.0
VALID_MAXIMUM = 65.0
UNIT          = "DEGREES"
DESCRIPTION   = "DPU TEMPERATURE."
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME          = MCP_SW
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 42
BYTES         = 1
```

```
FORMAT        = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 1
UNIT          = "N/A"
DESCRIPTION   = "SWITCH TO INDICATE WHETHER MCP +28V VOLTAGE WAS ON"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME          = OPTO_SW
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 44
BYTES         = 1
FORMAT        = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 1
UNIT          = "N/A"
DESCRIPTION   = "SWITCH TO INDICATE WHETHER OPTO +28V VOLTAGE WAS ON"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME          = MAIN_SW
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 46
BYTES         = 1
FORMAT        = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 1
UNIT          = "N/A"
DESCRIPTION   = "SWITCH TO INDICATE WHETHER MAIN +28V VOLTAGE WAS ON"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME          = PACC_SW
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 48
BYTES         = 1
FORMAT        = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 1
UNIT          = "N/A"
DESCRIPTION   = "SWITCH TO INDICATE WHETHER POST ACCELERATION HIGH VOLTAGE
WAS ON"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME          = GRID_SW
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 50
BYTES         = 1
FORMAT        = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 1
```

```
UNIT         = "N/A"
DESCRIPTION  = "SWITCH TO INDICATE WHETHER GRID LOW VOLTAGE WAS ON"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = ENTR_SW
DATA_TYPE    = ASCII_INTEGER
START_BYTE   = 52
BYTES        = 1
FORMAT       = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 1
UNIT         = "N/A"
DESCRIPTION  = "SWITCH TO INDICATE WHETHER ENTRANCE HIGH VOLTAGE WAS ON"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = DEFLLV_SW
DATA_TYPE    = ASCII_INTEGER
START_BYTE   = 54
BYTES        = 1
FORMAT       = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 1
UNIT         = "N/A"
DESCRIPTION  = "SWITCH TO INDICATE WHETHER DEFLECTION LOW VOLTAGE WAS ON"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = DEFLHV_SW
DATA_TYPE    = ASCII_INTEGER
START_BYTE   = 56
BYTES        = 1
FORMAT       = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 1
UNIT         = "N/A"
DESCRIPTION  = "SWITCH TO INDICATE WHETHER DEFLECTION HIGH VOLTAGE WAS ON"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = MCP_PRESENT
DATA_TYPE    = ASCII_INTEGER
START_BYTE   = 58
BYTES        = 1
FORMAT       = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 1
UNIT         = "N/A"
DESCRIPTION  = "+28V MCP HV PRESENT"
END_OBJECT = COLUMN
```

```
OBJECT = COLUMN
NAME         = OPTO_PRESENT
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 60
BYTES        = 1
FORMAT       = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 1
UNIT         = "N/A"
DESCRIPTION   = "+28V OPTO HV PRESENT"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = MAIN28_PRESENT
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 62
BYTES        = 1
FORMAT       = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 1
UNIT         = "N/A"
DESCRIPTION   = "+28V MAIN HV PRESENT"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = OPTO_MON
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 64
BYTES        = 3
FORMAT       = "I3"
VALID_MINIMUM = 0
VALID_MAXIMUM = 255
UNIT         = "N/A"
DESCRIPTION   = "OPTO HV MONITOR"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = MCP_MON
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 68
BYTES        = 3
FORMAT       = "I3"
VALID_MINIMUM = 0
VALID_MAXIMUM = 255
UNIT         = "N/A"
DESCRIPTION   = "MCP HV MONITOR"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = DEFLHV_MON
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 72
```

```
BYTES        = 3
FORMAT       = "I3"
VALID_MINIMUM = 0
VALID_MAXIMUM = 255
UNIT         = "N/A"
DESCRIPTION  = "ENERGY DEFLECTION HV MONITOR"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = DEFLLV_MON
DATA_TYPE    = ASCII_INTEGER
START_BYTE   = 76
BYTES        = 3
FORMAT       = "I3"
VALID_MINIMUM = 0
VALID_MAXIMUM = 255
UNIT         = "N/A"
DESCRIPTION  = "ENERGY DEFLECTION LV MONITOR"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = PACC_MON
DATA_TYPE    = ASCII_INTEGER
START_BYTE   = 80
BYTES        = 3
FORMAT       = "I3"
VALID_MINIMUM = 0
VALID_MAXIMUM = 255
UNIT         = "N/A"
DESCRIPTION  = "POST ACCELERATION HV MONITOR"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = GRID_MON
DATA_TYPE    = ASCII_INTEGER
START_BYTE   = 84
BYTES        = 3
FORMAT       = "I3"
VALID_MINIMUM = 0
VALID_MAXIMUM = 255
UNIT         = "N/A"
DESCRIPTION  = "GRID LV MONITOR"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = ENTR_UPPERR_MON
DATA_TYPE    = ASCII_INTEGER
START_BYTE   = 88
BYTES        = 3
FORMAT       = "I3"
VALID_MINIMUM = 0
VALID_MAXIMUM = 511
```

```
UNIT         = "N/A"
DESCRIPTION  = "ENTRANCE UPPER HV MONITOR"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = ENTR_LOWER_MON
DATA_TYPE    = ASCII_INTEGER
START_BYTE   = 92
BYTES        = 3
FORMAT       = "I3"
VALID_MINIMUM = 0
VALID_MAXIMUM = 511
UNIT         = "N/A"
DESCRIPTION  = "ENTRANCE LOWER HV MONITOR"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = DEFL_HV_REF
DATA_TYPE    = ASCII_INTEGER
START_BYTE   = 96
BYTES        = 4
FORMAT       = "I4"
VALID_MINIMUM = 0
VALID_MAXIMUM = 4095
UNIT         = "N/A"
DESCRIPTION  = "ENERGY DEFLECTION HV REFERENCE"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = DEFL_LV_REF
DATA_TYPE    = ASCII_INTEGER
START_BYTE   = 101
BYTES        = 4
FORMAT       = "I4"
VALID_MINIMUM = 0
VALID_MAXIMUM = 4095
UNIT         = "N/A"
DESCRIPTION  = "ENERGY DEFLECTION LV REFERENCE"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = ENTR_UPPER_REF
DATA_TYPE    = ASCII_INTEGER
START_BYTE   = 106
BYTES        = 4
FORMAT       = "I4"
VALID_MINIMUM = 0
VALID_MAXIMUM = 4095
UNIT         = "N/A"
DESCRIPTION  = "ENTRANCE HV REFERENCE"
END_OBJECT = COLUMN
```

```
OBJECT = COLUMN
NAME         = GRID_REF
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 111
BYTES         = 1
FORMAT        = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 7
UNIT          = "N/A"
DESCRIPTION   = "GRID LV REFERENCE"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = MCP_CURR_REF
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 113
BYTES         = 2
FORMAT        = "I2"
VALID_MINIMUM = 0
VALID_MAXIMUM = 15
UNIT          = "N/A"
DESCRIPTION   = "MCP HV CURRENT REFERENCE"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = OPTO_CUR_REF
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 116
BYTES         = 1
FORMAT        = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 7
UNIT          = "N/A"
DESCRIPTION   = "OPTO HV CURRENT REFERENCE"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = MCP_DEF_REF
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 118
BYTES         = 2
FORMAT        = "I2"
VALID_MINIMUM = 0
VALID_MAXIMUM = 15
UNIT          = "N/A"
DESCRIPTION   = "MCP HV DEFAULT REFERENCE"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = OPTO_DEF_REF
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 121
```

```
BYTES        = 1
FORMAT       = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 7
UNIT         = "N/A"
DESCRIPTION  = "OPTO HV DEFAULT REFERENCE"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = PACC_LOW_REF
DATA_TYPE    = ASCII_INTEGER
START_BYTE   = 123
BYTES        = 1
FORMAT       = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 7
UNIT         = "N/A"
DESCRIPTION  = "POST ACCELERATION LOW LEVEL REFERENCE"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = PACC_HIGH_REF
DATA_TYPE    = ASCII_INTEGER
START_BYTE   = 125
BYTES        = 1
FORMAT       = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 7
UNIT         = "N/A"
DESCRIPTION  = "POST ACCELERATION HIGH LEVEL REFERENCE"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = PACC_HL
DATA_TYPE    = ASCII_INTEGER
START_BYTE   = 127
BYTES        = 1
FORMAT       = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 1
UNIT         = "N/A"
DESCRIPTION  = "POST ACCELERATION LEVEL LOW / HIGH"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = PACC_MODE
DATA_TYPE    = ASCII_INTEGER
START_BYTE   = 129
BYTES        = 1
FORMAT       = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 1
```

```
UNIT        = "N/A"
DESCRIPTION   = "POST ACCELERATION MODE FIXED / ALTERNATING"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = CMDSTAT
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 131
BYTES         = 1
FORMAT        = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 3
UNIT        = "N/A"
DESCRIPTION   = "LAST COMMAND STATUS: 0=OK 1=PARAMETER OUT OF RANGE.
2=INVALID. 3=ERRONEOUS OPCODE."
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = NEWCMD
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 133
BYTES         = 1
FORMAT        = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 1
UNIT        = "N/A"
DESCRIPTION   = "NEW COMMAND RECEIVED TOGGLE BIT"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = CMD_RETURN
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 135
BYTES         = 5
FORMAT        = "I5"
VALID_MINIMUM = 0
VALID_MAXIMUM = 65525
UNIT        = "N/A"
DESCRIPTION   = "FIRST WORD COMMAND RETURN"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = DIRECT_CMD_SW
DATA_TYPE     = ASCII_INTEGER
START_BYTE    = 141
BYTES         = 1
FORMAT        = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 255
UNIT        = "N/A"
DESCRIPTION   = "DIRECT COMMAND SWITCH"
END_OBJECT = COLUMN
```

```
OBJECT = COLUMN
NAME         = FIFO_FILL
DATA_TYPE    = ASCII_INTEGER
START_BYTE   = 143
BYTES        = 6
FORMAT       = "I6"
VALID_MINIMUM = 0
VALID_MAXIMUM = 200000
UNIT         = "N/A"
DESCRIPTION  = "FIFO FILLING IN TERMS OF INTERNAL PACKETS (WORDS/3)"
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME         = TMFIFO_OVRF
DATA_TYPE    = ASCII_INTEGER
START_BYTE   = 150
BYTES        = 1
FORMAT       = "I1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 255
UNIT         = "N/A"
DESCRIPTION  = "TM FIFO OVERFLOW"
END_OBJECT = COLUMN
END_OBJECT = TABLE

END
```

4.3.3 Geometry data design

The geometry files contain geometry data with a suitable temporal resolution for the corresponding ICA data. The files contain the position of the comet relative to the Sun, the position of the spacecraft relative to the comet and the orientation of the spacecraft. The reference frame used is J2000 and the coordinate system Comet Sun Equatorial (CSEQ) where X points towards the Sun, Z along the spin axis of the Sun and Y completes a right-handed system.

The GEOM data design consists of a table with 23 columns containing the following information:

1 Time (UTC)

2. Distance to Sun, X,Y,Z in ECLIPJ2000 coordinates in km

3. Distance to target in km, X.Y,Z in 67P/C-G_CSEQ coordinate system for the main target 67P

4. Velocity relative to current target in km/s

5. Distance to surface of current target (altitude) in km

6. Latitude on surface of current target in degrees

7. Longitude on surface of current target in degrees

8. Speed relative to current target in km/s

9. Spacecraft attitude expressed as unit vectors for spacecraft X,Y,Z expressed in the local target coordinate system (e.g. 67P/C-G_CSEQ)

Example of edited raw data detached label file (e.g. RPCICAYYMMDDTHH_000_GEOM.LBL)

```
PDS_VERSION_ID = PDS3
LABEL_REVISION_NOTE = "V0.83"
RECORD_TYPE    = FIXED_LENGTH
RECORD_BYTES   = 273
FILE_RECORDS   = 912
FILE_NAME      = "RPCICA150513T06_000_GEOM.LBL"
^TABLE         = "RPCICA150513T06_000_GEOM.TAB"
PRODUCT_ID     = "RPCICA150513T06_000_GEOM"
DATA_SET_ID    = "RO-C-RPCICA-2-ESC2-RAW-V2.0"
DATA_SET_NAME  = "ROSETTA-ORBITER 67P RPCICA 2 ESC2 UNCALIBRATED V2.0"
PROCESSING_LEVEL_ID = "2"
PRODUCT_TYPE   = "EDR"
PRODUCT_CREATION_TIME = 2017-12-07T11:31:54
MISSION_ID     = "ROSETTA"
MISSION_NAME   = "INTERNATIONAL ROSETTA MISSION"
INSTRUMENT_HOST_ID   = "RO"
INSTRUMENT_HOST_NAME = "ROSETTA-ORBITER"

TARGET_NAME = "67P/CHURYUMOV-GERASIMENKO 1 (1969 R1)"
TARGET_TYPE = "COMET"
MISSION_PHASE_NAME = "COMET ESCORT 2"
START_TIME  = 2015-05-13T06:02:39.521
STOP_TIME   = 2015-05-13T07:02:23.523
SPACECRAFT_CLOCK_START_COUNT = "1/0390117683.15616"
SPACECRAFT_CLOCK_STOP_COUNT  = "1/0390121267.15670"
NOT_APPLICABLE_CONSTANT   = 0.0
SC_SUN_POSITION_VECTOR    = (-244527896.4892712,
22304319.0970978, 24945626.4280472)
SC_TARGET_POSITION_VECTOR = (  -18.0716132,   172.8954136,
18.3557636)
SC_TARGET_VELOCITY_VECTOR = (   -0.0001124,   -0.0003376,
0.0002537)
SPACECRAFT_ALTITUDE       =    174.80372226
SUB_SPACECRAFT_LATITUDE   =    -38.57079313
SUB_SPACECRAFT_LONGITUDE  =    170.42961632

NOTE                 = "
The values of the keywords SC_SUN_POSITION_VECTOR,
SC_TARGET_POSITION_VECTOR, SC_TARGET_VELOCITY_VECTOR
are related to the equatorial J2000 inertial frame.
The values of SUB_SPACECRAFT_LATITUDE and
SUB_SPACECRAFT_LONGITUDE refer to the Cheops reference
frame.
The SPACECRAFT_ALTITUDE gives the distance to the spacecraft
from the target center of mass.
All values are computed for the time t=START_TIME. Distances
```

are given in <km>, velocities in <km/s>, and angles in <deg>.
LBL & TAB FILES HAVE BEEN GENERATED BY S/W: l2 VERSION 0.05
TIMECORR FILE USED. SPICE USED.
SPICE TARGET IS SET. SPICE TARGET SIZE IS SET."

SPICE_FILE_NAME = {
"lsk/NAIF0011.TLS",
"sclk/ROS_160929_STEP.TSC",
"sclk/LANDER_170904_STEP.TSC",
"pck/PCK00010.TPC",
"pck/DE403_MASSES.TPC",
"pck/former_versions/EARTH_000101_170227_161206.BPC",
"pck/ROS_LUTETIA_RSOC_V03.TPC",
"pck/ROS_STEINS_V05.TPC",
"pck/ROS_CGS_RSOC_V03.TPC",
"fk/EARTHFIXEDITRF93.TF",
"fk/EARTH_TOPO_050714.TF",
"fk/ESTRACK_V01.TF",
"fk/NEW_NORCIA_TOPO.TF",
"fk/ROS_LUTETIA_RSOC_V03.TF",
"fk/RSSD0002.TF",
"fk/ROS_V31.TF",
"ik/ROS_RPC_V19.TI",
"spk/DE405.BSP",
"spk/OUTERPLANETS_V0003.BSP",
"spk/EARTHSTNS_ITRF93_050714.BSP",
"spk/ESTRACK_V01.BSP",
"spk/NEW_NORCIA.BSP",
"spk/TEMPEL1_9P_DI_P.BSP",
"spk/former_versions/21_LUTETIA_2004_2016.BSP",
"spk/ORHS_______________00109.BSP",
"spk/former_versions/2867_STEINS_2004_2016.BSP",
"spk/ORHO_______________00077.BSP",
"spk/former_versions/ORHW_______________00016.BSP",
"spk/ORHW_______________00122.BSP",
"spk/CORB_DV_257_03___T19_00345.BSP",
"spk/LORB_ROS_SC_PRESEP_V1_0.BSP",
"spk/LORB_SUN_J2000_SDL_V1_1.BSP",
"spk/SPICE_PHILAE_CFF_SONC_V2_0.BSP",
"spk/LORB_SUN_J2000_RBD_1_V1_2.BSP",
"spk/ORHR___________T19_00122.BSP",
"spk/RORB_DV_257_03___T19_00345.BSP",
"spk/ROS_ORBITER_EXTENSION_V2.BSP",
"ck/ATNR_P040302093352_T6_00127.BC",
"ck/former_versions/RATT_DV_145_01_01_T6_00216.BC",
"ck/former_versions/RATT_DV_223_01_01_T6_00302.BC",
"ck/RATT_DV_257_02_01_T6_00344.BC",
"ck/ROS_ORBITER_EXTENSION_V2.BC",
"ck/former_versions/CATT_DV_145_02_______00216.BC",
"ck/former_versions/CATT_DV_223_02_______00302.BC",
"ck/CATT_DV_257_03_______00344.BC"}
PRODUCER_ID = "RPC_ICA_KIRUNA_TEAM"

```
PRODUCER_FULL_NAME = "NILSSON, HANS"
PRODUCER_INSTITUTION_NAME = "SWEDISH INSTITUTE OF SPACE PHYSICS KIRUNA"
INSTRUMENT_ID     = "RPCICA"
INSTRUMENT_NAME   = "ROSETTA PLASMA CONSORTIUM - ION COMPOSITION ANALYSER"
INSTRUMENT_TYPE   = "PLASMA INSTRUMENT"

OBJECT     = TABLE
NAME             = "RPCICA-2-ESC2-GEOM"
INTERCHANGE_FORMAT = ASCII
ROWS              = 912
COLUMNS           = 9
ROW_BYTES         = 273
DESCRIPTION = "
GEOMETRY DATA. TIME AND 22 GEOMETRY VALUES. FOR THE POSITION OF
THE SPACECRAFT RELATIVE TO THE COMET THE 67P/C-G_CSEQ COORDINATE
SYSTEM WAS USED. IT HAS X TOWARDS THE SUN, Z IS THE COMPONENT OF
THE SOLAR ROTATIONAL AXIS ORTHOGONAL TO THE X AXIS. Y COMPLETES A
RIGHT-HANDED ORTHOGONAL COORDINATE SYSTEM."

OBJECT      = COLUMN
NAME        = TIME_UTC
DATA_TYPE   = TIME
START_BYTE  = 1
BYTES       = 23
UNIT        = "N/A"
FORMAT      = "A24"
DESCRIPTION = "TIME OF GEOMETRY DATA YYYY-MM-DDTHH:MM:SS.sss"
END_OBJECT  = COLUMN

OBJECT = COLUMN
NAME          = SC_SUN_POS
DATA_TYPE     = ASCII_REAL
START_BYTE    = 25
BYTES         = 38
FORMAT        = "I12"
ITEMS         = 3
ITEM_BYTES    = 12
ITEM_OFFSET   = 13
UNIT          = "km"
DESCRIPTION   = "DISTANCE TO SUN X, Y & Z IN ECLIPJ2000."
END_OBJECT = COLUMN

OBJECT = COLUMN
NAME          = SC_TGT_POS
DATA_TYPE     = ASCII_REAL
START_BYTE    = 64
BYTES         = 50
FORMAT        = "F16.4"
ITEMS         = 3
ITEM_BYTES    = 16
ITEM_OFFSET   = 17
UNIT          = "km"
```

```
DESCRIPTION   = "DISTANCE TO TARGET X, Y & Z IN 67P/C-G_CSEQ.
ZERO IF NO TARGET."
END_OBJECT = COLUMN

OBJECT       = COLUMN
NAME         = SC_TGT_VEL
DATA_TYPE    = ASCII_REAL
START_BYTE   = 115
BYTES        = 29
FORMAT       = "E9.2"
ITEMS        = 3
ITEM_BYTES   = 9
ITEM_OFFSET  = 10
UNIT         = "km/s"
DESCRIPTION  = "VELOCITY RELATIVE TO CURRENT TARGET X, Y & Z IN 67P/C-G_CSEQ.
ZERO IF NO TARGET."
END_OBJECT = COLUMN

OBJECT       = COLUMN
NAME         = ALTITUDE
DATA_TYPE    = ASCII_REAL
START_BYTE   = 145
BYTES        = 13
FORMAT       = "F13.3"
UNIT         = "km"
DESCRIPTION  = "DISTANCE TO SURFACE OF CURRENT TARGET.
ZERO IF NO TARGET SIZE."
END_OBJECT   = COLUMN

OBJECT       = COLUMN
NAME         = LATITUDE
DATA_TYPE    = ASCII_REAL
START_BYTE   = 159
BYTES        = 6
FORMAT       = "F6.1"
UNIT         = "degrees"
DESCRIPTION  = "LATITUDE ON SURFACE OF CURRENT TARGET.
ZERO IF NO TARGET SIZE."
END_OBJECT   = COLUMN

OBJECT       = COLUMN
NAME         = LONGITUDE
DATA_TYPE    = ASCII_REAL
START_BYTE   = 166
BYTES        = 6
FORMAT       = "F6.1"
VALID_MINIMUM = 0
VALID_MAXIMUM = 255
UNIT         = "degrees"
DESCRIPTION  = "LONGITUDE ON SURFACE OF CURRENT TARGET.
ZERO IF NO TARGET SIZE."
END_OBJECT   = COLUMN
```

```
OBJECT       = COLUMN
NAME         = SC_TGT_SPD
DATA_TYPE    = ASCII_REAL
START_BYTE   = 173
BYTES        = 9
FORMAT       = "E9.2"
UNIT         = "km/s"
DESCRIPTION  = "SPEED RELATIVE TO CURRENT TARGET.
ZERO IF NO TARGET."
END_OBJECT   = COLUMN

OBJECT = COLUMN
NAME         = SC_IN_67P_C_G_CSEQ
DATA_TYPE    = ASCII_REAL
START_BYTE   = 183
BYTES        = 89
ITEMS        = 9
ITEM_BYTES   = 9
ITEM_OFFSET  = 10
UNIT         = "N/A"
DESCRIPTION  = "SPACECRAFT X, Y & Z EXPRESSED IN 67P/C-G_CSEQ."
END_OBJECT = COLUMN

END_OBJECT = TABLE

END
```

4.3.4 Data Product “Calibrated data” Design

Contain data in physical units (particle flux). The format For L3 and L4 CORR is the same as RAW except that the data values are changed from counts to differential flux [particles / cm^2/s/sr/eV]. L4 PHYS_MASS data lacks the mass table and mass channel information. All data is described in the corresponding labels, and summarized at the end of the RPC-ICA User Guide.

The L4 data has been enhanced with the addition of an energy scale for each time in the data, corrected for the temperature drift of the energy scale and of the energy bin width. The spacecraft potential derived from RPC-LAP is also provided when available, interpolated to times of RPC-ICA measurements.

A sample label for the corrected energy scale follows below. The energy bin width files have exactly the same format.

```
PDS_VERSION_ID = PDS3
LABEL_REVISION_NOTE = "V{LABEL_REVISION_NOTE}"
RECORD_TYPE    = FIXED_LENGTH
RECORD_BYTES   = {RECORD_BYTES}
FILE_RECORDS   = {FILE_RECORDS}
FILE_NAME      = "{FILE_NAME}"
^TABLE         = "{TABLE}"
PRODUCT_ID     = "{PRODUCT_ID}"
DATA_SET_ID    = "{DATA_SET_ID}"
```

```
DATA_SET_NAME  = "{DATA_SET_NAME}"
PROCESSING_LEVEL_ID = "{PROCESSING_LEVEL_ID}"
PRODUCT_TYPE   = "{PRODUCT_TYPE}"
PRODUCT_CREATION_TIME = {PRODUCT_CREATION_TIME}
MISSION_ID     = "ROSETTA"
MISSION_NAME   = "INTERNATIONAL ROSETTA MISSION"
INSTRUMENT_HOST_ID   = "RO"
INSTRUMENT_HOST_NAME = "ROSETTA-ORBITER"

TARGET_NAME = "{TARGET_NAME}"
TARGET_TYPE = "{TARGET_TYPE}"
MISSION_PHASE_NAME = "{MISSION_PHASE_NAME}"
START_TIME  = {START_TIME}
STOP_TIME   = {STOP_TIME}
SPACECRAFT_CLOCK_START_COUNT = "{SPACECRAFT_CLOCK_START_COUNT}"
SPACECRAFT_CLOCK_STOP_COUNT  = "{SPACECRAFT_CLOCK_STOP_COUNT}"
{SPICE_INFO}
{NOTE}
PRODUCER_ID = "RPC_ICA_KIRUNA_TEAM"
PRODUCER_FULL_NAME = "NILSSON, HANS"
PRODUCER_INSTITUTION_NAME = "SWEDISH INSTITUTE OF SPACE PHYSICS KIRUNA"
INSTRUMENT_ID     = "RPCICA"
INSTRUMENT_NAME   = "ROSETTA PLASMA CONSORTIUM - ION COMPOSITION ANALYSER"
INSTRUMENT_TYPE   = "PLASMA INSTRUMENT"

^ARCHIVE_CONTENT_DESC = "ICA_EAICD.PDF"
^RPCICA_SCIENCE_USAGE_DESC = "ICA_USER_GUIDE.PDF"
^RPC_SCIENCE_USAGE_DESC = "RPC_USER_GUIDE.PDF"
CALIBRATION_SOURCE_ID = "RPCICA"
DATA_SET_PARAMETER_NAME = {DATA_SET_PARAMETER_NAME}

OBJECT = TABLE
NAME             = "RPC{INSTRUMENT}-{PROCESSING_LEVEL_ID}-{MISSION_PHASE_ID}-
{PROCESSING_LEVEL_MODE}"
INTERCHANGE_FORMAT = ASCII
ROWS             = {ROWS}
COLUMNS          = {COLUMNS}
ROW_BYTES        = {ROW_BYTES}
DESCRIPTION      = "ENERGY OF PARTICLES CORRECTED FOR TEMPERATURE DRIFT FOR THE
CORRESPONDING TIME AND ENERGY INDEX LEVEL."

OBJECT = COLUMN
  NAME       = TIME_UTC
  DATA_TYPE  = TIME
  START_BYTE  = 1
  BYTES      = 23
  FORMAT     = "A23"
  UNIT       = "N/A"
  COLUMN_NUMBER = 1
  DESCRIPTION = "START TIME OF THE OBSERVATIONS IN UNIVERSAL TIME"
END_OBJECT = COLUMN
```

```
OBJECT = COLUMN
  NAME          = FLAG
  DATA_TYPE     = ASCII_INTEGER
  START_BYTE    = 25
  BYTES         = 1
  FORMAT        = "I1"
  VALID_MINIMUM = 1
  VALID_MAXIMUM = 3
  UNIT          = "N/A"
  COLUMN_NUMBER = 2
  DESCRIPTION   = "
   0 - TEMPERATURE CORRECTED WITH HIGH VOLTAGE OFFSET
       = -1.6*e^(-0.2*T)+34.742
   1 - TEMPERATURE CORRECTED AS ABOVE, BUT SENSOR_TEMPERATURE IS BELOW
       ZERO DEGREES SO THE FUNCTION IS EXTRAPOLATED AND THE RESULT IS A
       BIT UNCERTAIN
   2 - NO CORRECTION DUE TO MISSING SENSOR_TEMPERATURE. DEFAULT OFFSET
       OF 34.742 V IS USED."
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME          = SENSOR_TEMPERATURE
  DATA_TYPE     = CHARACTER
  START_BYTE    = 27
  BYTES         = 5
  FORMAT        = "F5.1"
  UNIT          = "C"
  COLUMN_NUMBER = 3
  DESCRIPTION   = "SENSOR_TEMPERATURE FROM THE HOUSEKEEPING DATA, INTERPOLATED
TO ICA DATA ACQUISITION TIME"
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME          = ENERGY
  DATA_TYPE     = ASCII_REAL
  START_BYTE    = 33
  BYTES         = {ITEMS_BYTES}
  FORMAT        = "F7.1"
  ITEMS         = {ITEMS}
  ITEM_BYTES    = {ITEM_BYTES}
  ITEM_OFFSET   = {ITEM_OFFSET}
  UNIT          = "eV"
  COLUMN_NUMBER = 4
  DESCRIPTION   = "TEMPERATURE CORRECTED ENERGY LEVELS."
END_OBJECT = COLUMN

END_OBJECT = TABLE

END
```

4.3.5 Data product "Moment data" design

One derived data set is part of the RPC-ICA archive, density and velocity moments for H^+, He^{2+}, He^+ as well as two data sets for heavy ions with an assumed mass of 18 amu (water), one below and one above 60 eV. The charge, mass and type are given in the data. The layout of the data follows from a sample below.

```
PDS_VERSION_ID              = PDS3
DATA_SET_ID                 = "RO-C-RPCICA-5-EXT1-MOMENT-V1.0"
DATA_SET_NAME               = "
   ROSETTA-ORBITER 67P RPCICA 5 EXT1 MOMENT V1.0"
STANDARD_DATA_PRODUCT_ID     = "ION"
PRODUCT_ID                  = "RPCICA160401T00_000_L5_MOM"
PRODUCT_TYPE                = "DDR"
PROCESSING_LEVEL_ID         = "5"
PRODUCT_CREATION_TIME       = 2019-03-19T14:17:25
PRODUCT_VERSION_ID          = "1.0"
LABEL_REVISION_NOTE         = "RELEASE VERSION 1.0"
INSTRUMENT_MODE_ID          = "N/A"
INSTRUMENT_MODE_DESC        = "N/A"

RECORD_TYPE                 = FIXED_LENGTH
RECORD_BYTES                = 90
FILE_RECORDS                = 95

START_TIME                  = 2016-04-01T00:02:07.625
STOP_TIME                   = 2016-04-01T00:59:43.689
SPACECRAFT_CLOCK_START_COUNT = "1/0418089643.14913"
SPACECRAFT_CLOCK_STOP_COUNT  = "1/0418093099.19035"

MISSION_NAME                = "INTERNATIONAL ROSETTA MISSION"
MISSION_ID                  = "ROSETTA"
MISSION_PHASE_NAME          = "ROSETTA EXTENSION 1"
TARGET_NAME                 = "67P/CHURYUMOV-GERASIMENKO 1 (1969 R1)"
TARGET_TYPE                 = "COMET"
INSTRUMENT_HOST_NAME        = "ROSETTA-ORBITER"
INSTRUMENT_HOST_ID          = "RO"
INSTRUMENT_ID               = "RPCICA"
INSTRUMENT_NAME             = "
  ROSETTA PLASMA CONSORTIUM - ION COMPOSITION ANALYSER"
INSTRUMENT_TYPE             = "PLASMA INSTRUMENT"

COORDINATE_SYSTEM_ID        = "N/A"
COORDINATE_SYSTEM_NAME      = "N/A"
SC_SUN_POSITION_VECTOR    = (
    401147709.7276205,  -30675102.2224773,  -40451609.2166076)
SC_TARGET_POSITION_VECTOR = (
        -279.0168191,       -192.0436569,        592.6289726)
SC_TARGET_VELOCITY_VECTOR = (
```

0.0030181, 0.0010858, -0.0007649)
SPACECRAFT_ALTITUDE = 682.59816196
SUB_SPACECRAFT_LATITUDE = -23.80589862
SUB_SPACECRAFT_LONGITUDE = 101.10030604

NOTE = "
The values of the keywords SC_SUN_POSITION_VECTOR,
SC_TARGET_POSITION_VECTOR, SC_TARGET_VELOCITY_VECTOR
are related to the equatorial J2000 inertial frame.
The values of SUB_SPACECRAFT_LATITUDE and
SUB_SPACECRAFT_LONGITUDE refer to the Cheops reference
frame.
The SPACECRAFT_ALTITUDE gives the distance to the spacecraft
from the target center of mass.
All values are computed for the time t=START_TIME. Distances
are given in <km>, velocities in <km/s>, and angles in <deg>.
LBL & TAB FILES HAVE BEEN GENERATED BY S/W: I5_moments VERSION 0.05
TIMECORR FILE USED. SPICE USED."

PRODUCER_ID = "RPC_ICA_KIRUNA_TEAM"
PRODUCER_FULL_NAME = "NILSSON, HANS"
PRODUCER_INSTITUTION_NAME = "SWEDISH INSTITUTE OF SPACE PHYSICS KIRUNA"

ROSETTA:ICA_SW_VERSION = "06"
ROSETTA:ICA_SW_VERSION_DESC = "SOFTWARE VERSION INDICATES WHICH ONBOARD
SOFTWARE VERSION WAS RUN. THIS AFFECTS WHICH ENERGY AND ELEVATION TABLES
WERE USED, AND THEREFORE ALSO THE TEMPORAL RESOLUTION OF THE MEASUREMENTS.
VALID VALUES ARE 1 TO 10. THE TABLES CORRESPONDING TO THE GIVEN SOFTWARE
VERSION ARE GIVEN IN THIS LABEL AS ICA_ENERGY_TABLE_NAME AND
ICA_ELEVATION_TABLE_NAME"
ROSETTA:ICA_BAD_HV_MASK = "DISABLED"
ROSETTA:ICA_BAD_HV_MASK_DESC = "INDICATES WHETHER BAD-HV MASK WAS ON OR OFF.
IF ON ENERGY-ELEVATION ANGLE COMBINATIONS WHICH COULD NOT REACH THE NOMINAL
VALUE OF ELEVATION ANGLE ARE SET TO ZERO. FOR LOW ENERGIES LIMITED
RESOLUTION OF THE ELEVATION DEFLECTION VOLTAGE IS LIMITING, FOR HIGH
ENERGIES INSUFFICIENT HIGH VOLTAGE IS LIMITING."
ROSETTA:ICA_SHADOW_MASK = "DISABLED"
ROSETTA:ICA_SHADOW_MASK_DESC = "INDICATES WHETHER SHADOW MASK WAS ON OR OFF.
IF ON IONS COMING FROM ANGLES BLOCKED BY THE SPACECRAFT ARE SET TO ZERO. IF
OFF THE CORRESPONDING SECTORS WILL LIKELY PRODUCE VERY FEW COUNTS ANYWAY,
BUT MAY BE USEFUL FOR BACKGROUND SUBTRACTION."

^ARCHIVE_CONTENT_DESC = "ICA_EAICD.PDF"
^RPCICA_SCIENCE_USAGE_DESC = "ICA_USER_GUIDE.PDF"
^RPC_SCIENCE_USAGE_DESC = "RPC_USER_GUIDE.PDF"
CALIBRATION_SOURCE_ID = "RPCICA"
DATA_SET_PARAMETER_NAME = {"DENSITY", "ION BULK VELOCITY", "ALPHA",
"PROTON","HELIUM", "HEAVY ION"}

DESCRIPTION = "
This file contains ICA ion moments (number density, velocity vector),

```
   derived by integrating counts within available energy,
   elevation, and azimuth ranges for a predetermined mass and charge.
   The counts were acquired during the Rosetta extension 1 phase."

^TABLE                  = "RPCICA160401T00_000_L5_MOM.TAB"
OBJECT                  = TABLE
 INTERCHANGE_FORMAT     = ASCII
 ROWS                   = 95
 COLUMNS                = 9
 ROW_BYTES              = 90

 OBJECT                 = COLUMN
  NAME                  = "SPACECRAFT EVENT TIME (UTC)"
  COLUMN_NUMBER         = 1
  DATA_TYPE             = TIME
  START_BYTE            = 1
  BYTES                 = 23
  FORMAT                = "A23"
  DESCRIPTION           = "
   START TIME OF THE OBSERVATIONS IN UNIVERSAL TIME"
 END_OBJECT             = COLUMN

 OBJECT                 = COLUMN
  NAME                  = "SPECIES"
  COLUMN_NUMBER         = 2
  START_BYTE            = 25
  BYTES                 = 1
  FORMAT                = "I1"
  DATA_TYPE             = ASCII_INTEGER
  UNIT                  = "NA"
  DESCRIPTION           = "
   Species: 1=H, 2=He2, 3=He, 4=H2O (<=60eV), 5=H2O (>60eV)"
 END_OBJECT             = COLUMN

 OBJECT                 = COLUMN
  NAME                  = "MASS"
  COLUMN_NUMBER         = 2
  START_BYTE            = 27
  BYTES                 = 3
  FORMAT                = "I3"
  DATA_TYPE             = ASCII_INTEGER
  UNIT                  = "amu"
  DESCRIPTION           = "
   Mass of the species rounded to the nearest integer."
 END_OBJECT             = COLUMN

 OBJECT                 = COLUMN
  NAME                  = "CHARGE"
  COLUMN_NUMBER         = 3
  START_BYTE            = 31
  BYTES                 = 2
  FORMAT                = "I2"
```

```
  DATA_TYPE            = ASCII_INTEGER
  UNIT                 = "e"
  DESCRIPTION          = "
    Elemental charge of the species."
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
  NAME                 = "DENSITY"
  COLUMN_NUMBER        = 4
  START_BYTE           = 34
  BYTES                = 10
  FORMAT               = "E10.3"
  DATA_TYPE            = ASCII_REAL
  MISSING_CONSTANT = 9.999E99
  UNIT                 = "cm**-3"
  DESCRIPTION          = "
    Number Density of the species."
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
  NAME                 = "VX"
  COLUMN_NUMBER        = 5
  START_BYTE           = 45
  BYTES                = 9
  FORMAT               = "F9.2"
  DATA_TYPE            = ASCII_REAL
  UNIT                 = "km/s"
  DESCRIPTION          = "
    Velocity vector X component in CSEQ frame."
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
  NAME                 = "VY"
  COLUMN_NUMBER        = 6
  START_BYTE           = 55
  BYTES                = 9
  FORMAT               = "F9.2"
  DATA_TYPE            = ASCII_REAL
  UNIT                 = "km/s"
  DESCRIPTION          = "
    Velocity vector Y component in CSEQ frame."
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
  NAME                 = "VZ"
  COLUMN_NUMBER        = 7
  START_BYTE           = 65
  BYTES                = 9
  FORMAT               = "F9.2"
  DATA_TYPE            = ASCII_REAL
  UNIT                 = "km/s"
  DESCRIPTION          = "
```

```
    Velocity vector Z component in CSEQ frame."
  END_OBJECT                = COLUMN

  OBJECT                = COLUMN
    NAME                = "DURATION"
    COLUMN_NUMBER          = 8
    START_BYTE             = 75
    BYTES               = 3
    FORMAT               = "I3"
    DATA_TYPE             = ASCII_INTEGER
    UNIT               = "s"
    DESCRIPTION           = "
    The length of the measurement cycle in seconds during which an entire
    voltage sweep of the electrostatic analyzers is completed."
  END_OBJECT                = COLUMN

  OBJECT                = COLUMN
    NAME                = "QUALITY FLAGS"
    COLUMN_NUMBER          = 9
    START_BYTE             = 80
    BYTES               = 8
    FORMAT               = "A8"
    DATA_TYPE             = CHARACTER
    OBJECT = COLUMN
      DESCRIPTION   = "THE QUALITY OF THE DATA IS INDICATED USING EIGHT FLAGS OF
       WHICH SIX ARE CURRENTLY USED:
       1. FIELD OF VIEW BLOCKED BY THE SPACECRAFT.
       2. INAPPROPRIATE MODE USED WITH SOFTWARE VERSION 7 & 8.  SUCH DATA DO NOT
          HAVE THE INDICATED TEMPORAL RESOLUTION AS 1 OR 4 <SEC> SPECTROGRAMS
          12 <SEC> APART HAS BEEN ADDED TOGETHER.
       3RD & 4TH FLAGS CAN BOTH BE 0,1 OR 2 WHERE 0 INDICATES NO KNOWN
       PROBLEM, 1 SOME PROBLEM/EFFECT AND 2 SIGNIFICANT PROBLEMS / EFFECTS.
       3. LOW INSTRUMENT TEMPERATURE. FLAG RELATES TO THE TEMPERATURE OF THE
          INSTRUMENT, WHICH IF BELOW 13 <DEG> C CAN LEAD TO A DRIFT OF THE
          ENERGY TABLE, AND BELOW 0 <DEG> C THIS DRIFT CAUSES A MAJOR PROBLEM.
       4. ENHANCED BACKGROUND NOISE. BACKGROUND NOISE MAY ALSO BE ENHANCED WHEN
          THE INSTRUMENT IS COLD BUT ALSO FOR OTHER REASONS. THE NOISE IS ALSO
          ENHANCED WHEN ONBOARD NOISE REDUCTION IS TURNED OFF. THE FLAG WARNS
          FOR SUCH DATA AS WELL, AS THE USER MUST BE AWARE OF THE HIGHER NOISE
          LEVELS IN THE DATA.
       5. SOLAR WIND CROSS TALK REMOVAL.
       6. EXTRAORDINARY DATA IN 2 CATEGORIES:
          1: EXTRA SIGNAL AT APPARENTLY UNPHYSICAL LOW ENERGY LEVELS
          2: SIGNAL EXTENDING OVER BROAD ENERGY RANGE
       7. LOW ANGULAR RESOLUTION
          THE FLAGS AND THE EXTRA-ORDINARY DATA ARE DESCRIBED IN THE RPC-ICA
       USER MANUAL. ONE MORE FLAG ARE INCLUDED AS SPARE SO THAT FLAG CAN BE
       ADDED LATER WITHOUT CHANGING THE LAYOUT OR FORMAT OF THE DATA. THEY ARE
       SET TO LOWERCASE 'X'"
    END_OBJECT = COLUMN

END
```

4.3.6 LAP spacecraft potential data design

As the spacecraft potential is important for the interpretation of ICA data, we deliver a special data set based on the RPC-LAP spacecraft potential estimate, interpolated to the time stamps of ICA data.

```
PDS_VERSION_ID = PDS3
LABEL_REVISION_NOTE = "V{LABEL_REVISION_NOTE}"
RECORD_TYPE    = FIXED_LENGTH
RECORD_BYTES   = {RECORD_BYTES}
FILE_RECORDS   = {FILE_RECORDS}
FILE_NAME      = "{FILE_NAME}"
^TABLE         = "{TABLE}"
PRODUCT_ID     = "{PRODUCT_ID}"
DATA_SET_ID    = "{DATA_SET_ID}"
DATA_SET_NAME  = "{DATA_SET_NAME}"
PROCESSING_LEVEL_ID = "{PROCESSING_LEVEL_ID}"
PRODUCT_TYPE   = "{PRODUCT_TYPE}"
PRODUCT_CREATION_TIME = {PRODUCT_CREATION_TIME}
MISSION_ID     = "ROSETTA"
MISSION_NAME   = "INTERNATIONAL ROSETTA MISSION"
INSTRUMENT_HOST_ID   = "RO"
INSTRUMENT_HOST_NAME = "ROSETTA-ORBITER"

TARGET_NAME = "{TARGET_NAME}"
TARGET_TYPE = "{TARGET_TYPE}"
MISSION_PHASE_NAME = "{MISSION_PHASE_NAME}"
START_TIME  = {START_TIME}
STOP_TIME   = {STOP_TIME}
SPACECRAFT_CLOCK_START_COUNT = "{SPACECRAFT_CLOCK_START_COUNT}"
SPACECRAFT_CLOCK_STOP_COUNT  = "{SPACECRAFT_CLOCK_STOP_COUNT}"
{SPICE_INFO}
{NOTE}
PRODUCER_ID = "RPC_ICA_KIRUNA_TEAM"
PRODUCER_FULL_NAME = "NILSSON, HANS"
PRODUCER_INSTITUTION_NAME = "SWEDISH INSTITUTE OF SPACE PHYSICS KIRUNA"
INSTRUMENT_ID     = "RPCICA"
INSTRUMENT_NAME   = "ROSETTA PLASMA CONSORTIUM - ION COMPOSITION ANALYSER"
INSTRUMENT_TYPE   = "PLASMA INSTRUMENT"

^ARCHIVE_CONTENT_DESC = "ICA_EAICD.PDF"
^RPCICA_SCIENCE_USAGE_DESC = "ICA_USER_GUIDE.PDF"
^RPC_SCIENCE_USAGE_DESC = "RPC_USER_GUIDE.PDF"
CALIBRATION_SOURCE_ID = "RPCLAP"
DATA_SET_PARAMETER_NAME = "SPACECRAFT POTENTIAL"

OBJECT = TABLE
NAME            = "RPC{INSTRUMENT}-{PROCESSING_LEVEL_ID}-{MISSION_PHASE_ID}-
{PROCESSING_LEVEL_MODE}"
```

```
INTERCHANGE_FORMAT = ASCII
ROWS              = {ROWS}
COLUMNS           = {COLUMNS}
ROW_BYTES         = {ROW_BYTES}
DESCRIPTION       = "SPACECRAFT POTENTIAL DETERMINED BY THE RPC-LAP INSTRUMENT AND
INTERPOLATED TO RPC-ICA TIMES. SUITABLE TO COMPENSATE ENERGY SPECTRA MEASURED
BY RPC-ICA FOR THE ACCELERATION OF IONS DUE TO THE SPACECRAFT POTENTIAL. IF THERE
IS NO SUITABLE ESTIMATE FROM LAP A FILL VALUE IS GIVEN. "

OBJECT = COLUMN
 NAME        = TIME_UTC
 DATA_TYPE   = TIME
 START_BYTE  = 1
 BYTES       = 23
 FORMAT      = "A23"
 UNIT        = "N/A"
 COLUMN_NUMBER = 1
 DESCRIPTION = "START TIME OF THE OBSERVATIONS IN UNIVERSAL TIME"
END_OBJECT = COLUMN

OBJECT = COLUMN
 NAME          = USC
 DATA_TYPE     = ASCII_REAL
 START_BYTE    = 25
 BYTES         = 10
 FORMAT        = "E10.3"
 VALID_MINIMUM = 65
 VALID_MAXIMUM = 6
 UNIT          = "V"
 COLUMN_NUMBER = 2
 DESCRIPTION   = "SPACECRAFT POTENTIAL."
END_OBJECT = COLUMN

OBJECT = COLUMN
 NAME          = USC_QV
 DATA_TYPE     = CHARACTER
 START_BYTE    = 36
 BYTES         = 5
 FORMAT        = "F5.1"
 COLUMN_NUMBER = 3
 DESCRIPTION   = "QUALITY OF SPACECRAFT POTENTIAL:
  0.2: EXTRAPOLATED OUTSIDE SWEEP RANGE(MIGHT BE GOOD, MIGHT NOT BE)
  0.4: PROBLEM APPARENT IN SWEEP DUE TO LDL OR LARGE SIGNAL-TO-NOISE RATIO.
  0.80: SWEEP ESTIMATED PARAMETER, NO APPARENT PROBLEMS.
  IN RANGE 0.5-1.0: 32S DOWNSAMPLED FLOATING POTENTIAL. MEASURED, NOT
  ESTIMATED. BUT VALUE DECREASES WITH INCREASED FLUCTUATIONS DURING 32S WINDOW"
END_OBJECT = COLUMN

END_OBJECT = TABLE

END
```

1 Appendix: Available Software to read PDS files

A sample MATLAB script is provided, named READICA_Lx.M, where x can be 2,3,4_CORR,4_CORR_CTS, 4_PHYS_MASS, 5.The file reading follows C syntax so it can easily be ported to C, and contains the information needed to quickly write a Fortran read routine.

2 Appendix: Example of Directory Listing of Data Set X

```
|-- AAREADME.TXT
|-- BROWSE
|   |-- 2006
|   |   `-- FEB
|   |       |-- D24
|   |       |   |-- RPCICA060224.LBL
|   |       |   |-- RPCICA060224.PNG
|   |       |   |-- RPCICA060224T05.LBL
|   |       |   |-- RPCICA060224T05.PNG
|   |       |   |-- RPCICA060224T06.LBL
|   |       |   |-- RPCICA060224T06.PNG
:   :       :   :
:   :       :
:   :
|   |-- BROWINFO.TXT
|   |-- BROWSE.HTM
|   `-- BROWSE.LBL
|
|-- CALIB
|   |-- CALINFO.TXT
|   |-- ELEVATION
|   |   |-- ELEVATIONINFO.TXT
|   |   |-- ICA_ELEVATION_TABLE_V02.LBL
|   |   |-- ICA_ELEVATION_TABLE_V02.TAB
|   |   |-- ICA_ELEVATION_TABLE_V03.LBL
|   |   |-- ICA_ELEVATION_TABLE_V03.TAB
|   |   :
|   |
|   |-- ENERGY
|   |   |-- ENERGYINFO.TXT
|   |   |-- ICA_ENERGY_TABLE_V02.LBL
|   |   |-- ICA_ENERGY_TABLE_V02.TAB
|   |   |-- ICA_ENERGY_TABLE_V03.LBL
|   |   |-- ICA_ENERGY_TABLE_V03.TAB
|   |   :
|   |
|   |-- GFACTOR
```

```
|   |   |-- GFACTORINFO.TXT
|   |   |-- GFACTOR_HEAVY_V02.LBL
|   |   |-- GFACTOR_HEAVY_V02.TAB
|   |   |-- GFACTOR_LIGHT_V02.LBL
|   |   |-- GFACTOR_LIGHT_V02.TAB
|   |   :
|   |
|   |-- MASS_LOOKUP
|   |   |-- MASS_LOOKUPINFO.TXT
|   |   |-- ICA_MASS_LOOKUP_TABLE1_V02.LBL
|   |   |-- ICA_MASS_LOOKUP_TABLE1_V02.TAB
|   |   |-- ICA_MASS_LOOKUP_TABLE2_V02.LBL
|   |   |-- ICA_MASS_LOOKUP_TABLE2_V02.TAB
|   |   |-- ICA_MASS_LOOKUP_TABLE3_V02.LBL
|   |   |-- ICA_MASS_LOOKUP_TABLE3_V02.TAB
|   |   |-- ICA_MASS_LOOKUP_TABLE1_V03.LBL
|   |   |-- ICA_MASS_LOOKUP_TABLE1_V03.TAB
|   |   :
|   |
|   `-- MASS_MASK
|       |-- MASS_MASKINFO.TXT
|       |-- ICA_MASSMASK_HEAVY_P1_V02.LBL
|       |-- ICA_MASSMASK_HEAVY_P1_V02.TAB
|       |-- ICA_MASSMASK_HEAVY_P2_V02.LBL
|       |-- ICA_MASSMASK_HEAVY_P2_V02.TAB
|       |-- ICA_MASSMASK_HEAVY_P3_V02.LBL
|       |-- ICA_MASSMASK_HEAVY_P3_V02.TAB
|       |-- ICA_MASSMASK_HEAVY_P3_V10.LBL
|       |-- ICA_MASSMASK_HEAVY_P3_V10.TAB
|       |-- ICA_MASSMASK_LIGHT_P1_V02.LBL
|       |-- ICA_MASSMASK_LIGHT_P1_V02.TAB
|       |-- ICA_MASSMASK_LIGHT_P2_V02.LBL
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