ROSETTA-ALICE
TO PLANETARY SCIENCE ARCHIVE
INTERFACE CONTROL DOCUMENT

March 2010

SwRI® Project 02353

Document No. 8225-EAICD-01

Contract JPL 960549

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TABLE OF CONTENTS

Page

REVISION NOTICE

Initial Issue: January 2004

Revision 1:   January 2007   Major revision to reflect new format of Alice data products

Revision 2:   April 2007   Multiple revisions to correct inaccuracies in the description of the Alice data products. Removed all TBD items from document

Revision 3:   March 2010   Added description of LIN data product

TBD LIST

Section	Description

1. INTRODUCTION

1.1 Purpose and Scope

The purpose of this EAICD (Experimenter to (Science) Archive Interface Control Document) is twofold. First it provides users of the *Alice* instrument on the *Rosetta* mission 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 the *Alice* instrument team and the archiving authority.

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 Contents

This document describes the data flow of the *Alice* instrument on *Rosetta* from the s/c until the insertion into the PDS-SBN for NASA and 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 are explained.

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

1.4 Intended Readership

The staff of archiving authority (Planetary Data System for NASA, Planetary Science Archive for ESA) design team and any potential user of the *Rosetta-Alice* data.

1.5 Applicable Documents

AD1.   Planetary Data System Data Preparation Workbook, 1995 February 17, Version 3.1, JPL, D-7669, Part 1

AD2.   Planetary Data System Standards Reference, 2003 August 1, Version 3.6, JPL, D-7669, Part 2

AD3.   Rosetta Archive Generation, Validation and Transfer Plan, 2003 December 22, Issue 2, Revision 1, RO-EST-PL-5011

AD4.   Rosetta-Alice Data Processing Software, 2003 April 22

AD5.   Alice Experiment User Manual, 2002 August 2, Version 1.3, RO-8225-EUM-01_3_ALICE_UM
AD6.   Data Delivery Interface Document (DDID), 2003 October 23, Issue B6, RO-ESC-IF-5003
AD7.   Rosetta Time Handling, 2004 Januaryu 9, Draft 2, RO-EST-TN-3165

1.6 Relationships to Other Interfaces

Any change in this ICD may need to be reflected in the data processing software (LIMA, MIKE, and NOVEMBER) and the document that describes the software (AD4). Correspondingly, this ICD may need to be changed to reflect changes in the software or changes in the understanding of requirements for archiving imposed either by NASA or by NASA's Planetary DataSystem and ESA's Planetary Science Archive.

1.7 Acronyms and Abbreviations

APID	Application Process ID
DDS	Data Distribution System
FITS	Flexible Image Transport System
FOV	field-of-view
HK	house keeping
ICD	interface control document
MCP	microchannel plate
OBT	Onboard Time
PDS	Planetary Data System
PSA	Planetary Science Archive
SFDU	Standard Format Data Unit
SCET	Spacecraft Elapsed Time
TC	telecommand
TM	telemetry
UV	ultraviolet

1.8 Contact names and Addresses

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2. OVERVIEW OF INSTRUMENT DESIGN, DATA HANDLING, AND PRODUCT GENERATION

2.1 Instrument Design

2.1.1 Hardware and Characteristics

The *Alice* UV spectrometer is a very simple instrument. An opto-mechanical layout of the instrument is shown in Figure 2-1. Light enters the telescope section through a 40 x 40 mm^2 entrance aperture and is collected and focused by an f/3 off-axis paraboloidal (OAP) primary mirror onto the approximately 0.1° x 6° spectrograph entrance slit. After passing through entrance slit, the light falls onto a toroidal holographic grating, where it is dispersed onto a microchannel plate (MCP) detector that uses a double-

Andrew Steffl 12/15/10 11:34 AM
Deleted: Figure 2-1

delay line (DDL) readout scheme. The 2-D (1024 x 32)-pixel format, MCP detector uses dual, side-by-side, solar-blind photocathodes of potassium bromide (KBr) and cesium iodide (CsI). The predicted spectral resolving power ($\lambda/\Delta\lambda$) of *Alice* is in the range of 105–330 for an extended source that fills the instantaneous field-of-view (IFOV) defined by the size of the entrance slit. *Alice* is controlled by an SA 3865 microprocessor, and utilizes lightweight, compact, surface mount electronics to support the science detector, as well as the instrument support and interface electronics. Figure 2-2 shows a 3D external view of *Alice*. The resulting design is highly systems-engineered to minimize mass and complexity, and enjoys strong parts-level heritage from previous UV spectrometers.

Andrew Steffl 12/15/10 11:34 AM
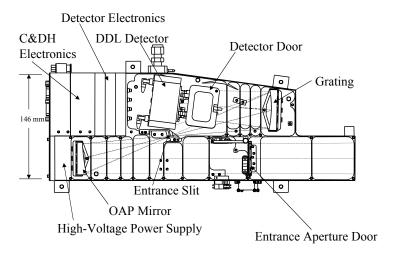**Deleted:** Figure 2-3

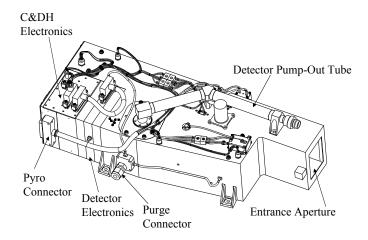**Figure 2-1: The opto-mechanical layout of *Alice*.**

C&DH
Electronics

Detector Pump-Out Tube

Pyro
Connector

Detector
Electronics   Purge
                Connector

Entrance Aperture

Figure 2-2: External view of *Alice*.

Table 2-1: Pre-flight *Alice* Characteristics & Performance Overview	
Bandpass	700-2050 Å
Spectral Resolution (Δλ FWHM)	10 Å (700 Å) – 13 Å (2050 Å) for extended sources 3–5 Å for point sources
Spatial Resolution	0.1° x 0.5°
Nominal Sensitivity	0.5 (1900 Å) – 7.8 (1150 Å) counts s^{-1} R^{-1}
Field of View	0.1° x 6.0°
Pointing	Boresight with OSIRIS, VIRTIS
Observation Types	Nucleus Imaging and Spectroscopy; Coma Spectroscopy
	Jet and Grain Spectrophotometry; Stellar Occultations (secondary observations)
Telescope/Spectrograph	Off-axis telescope, 0.15-m diameter Rowland circle spectrograph
Detector Type	2-D Microchannel Plate with delay-line anode readout

2.1.2 Science Modes

The instrument has three modes of taking data: **histogram**, **pixel list**, and **count rate** ("photometer"). For the first two, the time of arrival of a charge at both ends of the orthogonal delay lines is used to determine the pixel on which a photon landed.

- In **histogram** mode, the instrument uses a histogram memory, with memory locations that map one-to-one to pixels on the detector, to store the total number of counts in each pixel. This mode integrates an image and is used at high count rates, and will likely be the most commonly-used mode. Images are 1024x32 pixels (the long axis corresponds to wavelength, the short axis is the spatial dimension), but the first 100 columns of the image are and "unexposed" part of the detector. This region contains the pulse height array, and also will provide monitoring of background/cosmic ray and dark counts. The histogram values (counts) saturate at 65535 counts.
- In **pixel list** mode, the instrument records the x-y location of each photon and inserts time tags in this list at regular (user-definable) intervals to provide the timing information for the photons. This mode is used at low count rates. The maximum number of entries is 32678 (including photons and time tags), but may be less depending on the brightness of the target and the exposure time of the particular observation. Once the memory is filled to this limit, no more data are recorded.
- In **count rate** mode (also called "photometer" mode), the x-y information for each photon is ignored and a series of counts is summed with time tags inserted at uniform intervals to provide the timing information. This mode is likely to not be widely used but is particularly useful for observing very bright ultraviolet stars, e.g. at the limb of the cometary nucleus. The maximum number of entries is 32678, but may be less depending on the time interval and total exposure time of the particular

observation. (Note that the number of entries is independent of the the brightness of the target.) Values (summed counts per time interval) saturate at 65535 counts.

In all modes, data from portions of the array can be "windowed". E.g., in histogram mode, transmission of data to Earth can be of subarrays rather than of the complete array. This allows for minimizing bandwidth by reading subsets (windows) of data stored in memory. The data processing software will consider each of these windows to be separate data sets, so that multiple reads of separate windows of a single observation will be saved into separate files. For this reason, the file naming convention (Section 3.1.4) includes a "dump number" for each file/image.

2.2 Scientific Objectives

See *Alice* EID-B, § 1.1.1.

The scientific objectives of the *Alice* investigation are to characterize the composition of the nucleus and coma, and the coma/nucleus coupling of comet 67P/Churyumov-Gerasimenko. This will be accomplished through the observation of spectral features in the 700-2050 Å EUV/FUV region. *Alice* will provide measurements of noble gas abundances in the coma, the atomic budget in the coma, major ion abundances in the tail and in the region where solar wind particles interact with the ionosphere of the comet, determine the production rates, variability, the structure of H_2O, CO and CO_2 gas surrounding the nucleus, and the far-UV properties of solid grains in the coma. *Alice* will also map the cometary nucleus in the FUV, and study Mars and the *Rosetta* asteroid flyby targets while en route to 67P/Churyumov-Gerasimenko.

Ultraviolet spectroscopy is a powerful tool for studying astrophysical objects, and has been applied with dramatic success to the study of comets. *Alice* will provide unprecedented improvements in sensitivity and spatial resolution over previous cometary UV observations. For example, *Alice* will move the sensitivity threshold from the ~1 Rayleigh level achievable with the Hubble Space Telescope to the milliRayleigh level in deep integrations. In addition, *Alice* will (by virtue of its location at the comet) move the spatial exploration of nucleus UV surface properties from the present-day state-of-the-art (i.e., no data available on any comet) to complete nuclear maps at Nyquist-sampled resolutions of a few hundred meters. Stars occulted by the absorbing coma will also be observed and used to map the water molecule spatial distribution, giving us hints at how the production regions are located on the nuclear surface.

Through its remote-sensing nature, *Alice* will be able to:
- Obtain compositional and morphological information on the comet prior to the rendezvous, thereby providing planning observations for in situ instruments prior to entering orbit about the comet.
- Map the spatial distribution of key species in the coma, and small coma dust grains, as a function of time as the comet responds to the changing solar radiation field during its approach to the Sun.
- Obtain compositional and production rate measurements of nuclear jets and other inner coma features even when the Orbiter is not in the vicinity of these structures.
- Obtain certain ion abundance measurements around perihelion in order to connect nucleus activity to changes in tail morphology and structure, and coupling to the solar wind.

The primary scientific themes of the *Alice* investigation are the following (not prioritized):

- Determine the rare gas content of the nucleus to provide information on the temperature of formation and the thermal history of the comet since its formation. Ar and Ne will be prime targets of the *Alice* investigations.
- Determine the production rates and spatial distributions of the key parent molecule species, H_2O, CO and CO_2, thereby allowing the nucleus/coma coupling to be directly observed and measured on many time-scales in order to study the chemical heterogeneity of the nucleus and its coupling to the coma.
- Obtain an unambiguous budget of the cosmogonically most important atoms C, H, O, N, and S through the detection of their emissions far from the nucleus. This is required to understand their production processes and to derive the elemental composition of the volatile fraction of the nucleus. Coupled to the measure of the major molecule abundances of the nucleus, this will give us the total contribution of the secondary parent species to the compositional makeup of the nucleus.
- Study the onset of nuclear activity and nucleus output variations related to changing solar aspect and nuclear rotation with unprecedented sensitivity.

Additional scientific themes *Alice* will address include the following:
- Spectral mapping of the complete nucleus at far-UV wavelengths to characterize the distribution of UV absorbers on the surface, in particular icy patches and organics.
- Photometric properties and ice/rock ratio of small grains in the coma as an aid to understanding the size distribution of cometary grains and how they vary in time. Also, studying the grain coma to establish the relative contributions of the nucleus and coma grains to the observed gases.
- Mapping the time variability of O^+, N^+, and possibly S^+ and C^+ emissions in the coma and ion tail in order to connect nuclear activity to changes in tail morphology and structure, and tail interaction/coupling to the solar wind.

Alice will take data during cruise (typically checkout data during periods defined by ESA) and at every encounter with a planetary and asteroid body (within activity limitations imposed by ESA and the *Rosetta* project). Extensive observations will be made during the various phases at the comet. At each asteroid flyby, for example, *Alice* may spatially scan the region of the asteroid by moving the slit across the field thought to contain the asteroid. If the S/N is high, this could result in a complete image cube. However, we may also, for example, carry out a staring observation at the limb which would ultimately result in a single, one-dimensional spectrum. Observations at the encounters with Earth and Mars will be aimed at measuring the airglow from those planets. Observations during the first, closest Earth-Moon flyby will use the Moon as a calibration source.

At the comet, a variety of observing scenarios will be used. These include spatial scans with spatially resolved spectra at each point, 1-D spectra, and time series as stars are viewed through the coma and approaching occultation by the nucleus. This last can involve recording complete 2-D spectra as a function of time, but then collapsing the data in transmission to provide 1-D spectra, possibly integrating over significant wavelength regions, before transmission to Earth.

2.3 Data Handling Process

2.3.1 Responsible Individuals

The following individuals are responsible for the data preparation, monitoring and maintenance of the processing and calibration pipeline, and submission of the product delivery to the PSA:
- Andrew Steffl, Southwest Research Institute, `steffl@boulder.swri.edu`, +1 303-546-9670
- Joel Parker, Southwest Research Institute, `joel@boulder.swri.edu`, +1 303-546-9670

- Maarten Versteeg, Southwest Research Institute, `mversteeg@swri.org`, +1 210-522-5029

2.3.2 Data Flow

The Alice instrument typically sends HK data on a regular time interval. When exposures are taken, the HK data available at the end of the exposure are included as a header to the science data to provide instrument context for the exposure. Events (command acknowledgements and error reports) are sent in response to TC. Dumps of memory and context/parameters are sent when requested by specific TCs. These different types of data from the *Alice* instrument are associated with the following APIDs:

- 1473 (acknowledgements)
- 1476 (HK packets)
- 1479 (events)
- 1481 (memory dump)
- 1483 (context dump)
- 1484 (science {includes diagnostic and parameter dump} and telecommands)
- -4 (the "super APID", that includes all *Alice* APIDs, so all data can be obtained from DDS in a single request)

Additional spacecraft APIDs are available, and used by *Alice* software, but will not be included in the archived *Alice* data products.

The *Alice* data are sent to the *Rosetta* spacecraft, relayed to ground, and stored in the DDS. These data are sent ("pushed") to computers at the *Alice* team institution in Boulder, Colorado at regular, pre-defined intervals (e.g., daily), and also by direct request to the DDS via FTP or web interface (see AD6). The data are passed through instrument team software for calibration and analysis. These pipeline programs can be run interactively, but typically will be called by a UNIX shell script whenever the DDS regularly pushes *Alice* data.

Auxiliary programs will be run on the data to create the appropriate PDS labels and format for archiving.

2.3.3 Processing Software

1. The *Rosetta-Alice* data processing software is used internally by the instrument team, and is included in the `DOCUMENT/CODE/MIKE` directory only for reference (i.e., it is *not* included in the archive *as supported software*). The software consists of programs to process and calibrate the science data. Steps include flat fielding, deadtime correction, and applying wavelength and flux calibration. This is performed by a set of IDL programs called "Mike".

2.3.4 Archive Data Levels

There are two types of notation for "processing levels" in use in the *Rosetta* mission: those defined by the ESA PSA, and those defined by the National Research Council (NRC) Committee on Data Management and Computation (CODMAC). The PDS uses the CODMAC data processing levels as defined in Section 6.3.2 in AD2. For consistency, we use the CODEMAC levels (unless explicitly datted otherwise) in the text of this EAICD and in the descriptions of the PDS data labels in Section 4. The relationship of the levels in question are given in Appendix B of AD3, but are repeated and expanded here:

Table 2-2: Data Processing Levels					
CODMAC level	**ESA/PSA level**	**NASA level**	**PRODUCT_TYPE PDS keyword value**	**Data Record (DR) Type**	***Alice* File Type**

1	1a		UDR	Unprocessed (Raw)	
2	1b	0	EDR	Experiment (Edited)	engineering (eng)
3	2	1A	RDR or REDR	Reduced (Calibrated)	science (sci)
4		1B	REFDR	Reformatted (Resampled)	
5	3	2-5	DDR	Derived	
6			ANCDR	Ancillary	

The *Alice* data archive will contain:

- Level 2 data (ENG files), which are derived from the (Level 1) data sent by the DDS to the PI's institution in Boulder, Colorado, USA (to the computer rosetta.boulder.swri.edu), and decommutated by the *Rosetta-Alice* data collection program Lima.
- Level 3 data (SCI files). These calibrated data are created by the data processing pipeline Mike from the Level 2 data (as output by Lima).

Although not formally required to do so, the Alice team often produces Level 4 data (LIN files). These resampled, calibrated data are produced by the Mike data processing pipeline from the Level 3 data. Level 4 data will be supplied to the PSA/PDS on a best effort basis.

2.4 Overview of Data Products

2.4.1 Pre-Flight Data Products

N/A

2.4.2 Instrument Calibrations

Instrument calibration files are included in the `CALIB/` directory.

2.4.3 In-Flight Data Products

As described in Section 2.1.2, *Alice* has three science modes: histogram, pixel list, and count rate. Each mode corresponds to one type of data product that will be archived as FITS files, and the archive will include CODMAC Level 2 ("engineering") and Level 3 ("science") data for each mode.

The data from each observation also include a full set of HK data, providing a snapshot of the instrument status *at the end of the given observation* (though some parameters, such as the MCP voltage and strip current also include the value at the beginning of the observation). In the FITS files output by the processing software, those HK parameters are included as keyword=value header fields as shown in the example in Section 4.10 (but only a few are propagated into the PDS label files, since many of them are very instrument-specific and not of general use to PDS users). These header fields include raw *and* calibrated parameter values where appropriate, distinguished by the last character of the FITS header keyword: "R" for raw and "C" for calibrated. For example, T_MIRR1R is the "raw" (ADC counts) temperature value for mirror sensor #1, and T_MIRR1C is the corresponding "calibrated" (degrees Celsius) temperature; MCPVR is the "raw" (ADC counts) MCP voltage, and MCPVC is the "calibrated" (volts) voltage.

We also include *all* HK data sent in the TM stream as an in-flight data product. These data are archived as flat ASCII files (tables), and provide a larger context of the instrument health and behavior over the

course of the mission, and are also useful for calibration of the instrument as a function of any parameters that may affect instrument performance.

Below we describe all these data products in considerable detail. Examples of the PDS labels are given in Section 4. Detailed descriptions of the FITS headers are given in Section 4.10.

2.4.3.1 Level 2 ("Engineering") data

2.4.3.1.1 Histogram Mode

Each dump of histogram data from the *Alice* instrument also contains pulse-height data (16 integers) and count rate data (up to 100 integers). These arrays will be stored as additional blocks ("extensions") in the FITS file. So, the FITS file for histogram data will contain:
- Extension = 0 : The 1024x32 histogram image (or a subsection if windowing was selected in the dump)
- Extension = 1 : The 16-value pulse-height distribution table. The pulse height distribution is a histogram of the amplitude of the photon events that were detected during the histogram acquisition. The histogram values (counts) saturate at 65535 counts. For *Rosetta-Alice* the resolution is rather coarse: the quantization is four bits, but the upper and lower 3 bins are hardly used.
- Extension = 2 : Up to 100-element count rate series. These count rate data give the count rate measurements as reconstructed from the observation, providing a crude time-resolved "photometer" measurement of the observation. This is possible because even in Histogram mode because the photons are time-tagged.

2.4.3.1.2 Pixel List Mode

Pixel list data will be stored as a 1-dimensional array of size equal to the number of values in the pixel list (number of entries may be less than the full 32678 limit depending on the particular observation) in extension 1. For ease of quick-look, the extension 0 in the FITS file will contain a "ground-software-reconstructed" histogram (image) representation of the data, so any FITS viewer can display the image. In addition, a count rate representation (using the pixel list time hack period) will be created and stored in extension 2. So, the FITS file for pixel list data will contain:
- Extension = 0 : The 1024x32 reconstructed histogram-formatted image
- Extension = 1 : The list of all the pixel list values
- Extension = 2 : reconstructed count rate data with a time interval equal to the selected time hack period

The value of each pixel list event is the encoded X,Y positions of the detected event. In addition to the detector events, a time-mark value is also inserted into the list on a periodic basis. The pixel list data are encoded as follows:

Value (for events) = X * 1024 + Y
Value (for timehacks) = 65535

Another way to describe this is by representing the bits in the pixel list events (16-bit words) as:

h a a a a a e e e e e e e e e e

where each letter represents a single bit with the following meaning:

h - (most significant bit), set to 1 for a timehack, and 0 for a normal photon event. For timehacks, the other 15 bits have no meaning and are set to 1.
a - the five bits of spatial information of a photon event.
e - the ten bits of spectral information of a photon event.

2.4.3.1.3 Count Rate Mode

Data will be stored as a 1-dimensional FITS image with the number of elements equal to the number of intervals for which a count rate was obtained (the number of elements may be less than the full 32678 limit depending on the particular observation).

2.4.3.1.4 Housekeeping Telemetry

HK data are sent from *Alice* at regular, user-defined time intervals, and provide values for all instrument parameters of interest, e.g., temperatures, currents, voltages, limit values, software flags, door status, etc. When these data are received from the DDS and processed through the data pipeline (by the "Lima" program), they are added to a running ASCII file. Note that since one HK TM file can contain data covering a wide range of time, the time field used in the filename identification of the files will be the UTC-format SCET of the first data packet that appears in the file.

The structure of the ASCII files will be a header section followed by a data section (the PDS label will point past this header to the data field). For use by other file-reading programs, the beginning of the data section is identified by the explicit text "START DATA" alone on a line.

- Description of Header block:
    - Each line in the header block defines one column of data in the data block. The columns in the header are:
        - Column Number: column number of value in data block,
        - Key: the FITS-compatible keyword name,
        - Unit: the physical unit (if any) of the values in the column, a dash when no unit is applicable,
        - Width: width of column, including padding spaces,
        - Format: format for data ("I"=integer, "F"=floating, "A"=string),
        - Info: additional explanatory info about the entry (this field may be empty and starts with the pound (#) character), can contain the name of the parameter in the *Alice* code
    - All fields except the "Info" field *must* contain at least one character/value with *no* whitespace separating values. So, e.g., if there are no Units or Name for a given entry, the field may have "-" or "n/a" or some other indicator of no value.
    - The header section also may contain comment lines, identified as having the pound character (#) as the first character on the line.
    - The names of the calibration files used to translate from "raw" TM values to "engineering" values (e.g., from ADC counts to temperature) will be included as comments in the header.

- Description of Data block:
    - A single line (record) is added to the file for each received TM packet (i.e., from a single dump)
    - The order of the values/columns are as described in the header block.
    - No removal of doubles or sorting is to be performed. Such sorting and trimming can be done easily by external programs (e.g., the UNIX or IDL commands "sort" and "uniq")
    - The data will include both the raw TM value and a calibrated value.

2.4.3.2   Level 3 ("Science") data

2.4.3.2.1   Histogram Mode

After Histogram-mode data are processed through the processing and calibration pipeline (the "Mike" program), the result is a 2-D array of the same size as the original: 1024x32 pixels. The axes still correspond to wavelength vs. spatial, and value of each pixel is the calculated flux. However, since the wavelength calibration is not be linear and varies with Y position, it cannot be easily parameterized and stored in the FITS header; therefore, the wavelength calibration is stored as a second array in the FITS file.   The pulse-height and count rate data that are stored as additional extensions in the "engineering" files (Level 2 data), will be retained and are *not* processed:

- Extension = 0 : The 1024x32 histogram image (processed and flux calibrated); [photons-cm^{-2}-s^{-1}] implicitly per pixel in wavelength
- Extension = 1 : 1024x32 element image containing the statistical uncertainty associated with extension 0.
- Extension = 2 : The 1024x32 histogram wavelength image (calibrated wavelength at each pixel); [Å]
- Extension = 3 : The 16-value pulse-height array (*not* processed; same as in Level 2 data)
- Extension = 4 : The 100-value count rate array (*not* processed; same as in Level 2 data)

2.4.3.2.2   Pixel List Mode

The pixel list data will be a 2-dimensional array (effectively a table) with the following columns: [X, Y, Wavelength, Time Step]; this will be in the third extension of the FITS file. For quick-look purposes, the primary extension in the FITS file is a histogram-formatted version of the data as is done for the Level 2 data.

- Extension = 0 : The 1024x32 constructed histogram-formatted image (processed and flux calibrated); [photons-cm^{-2}-s^{-1}] implicitly per pixel in wavelength
- Extension = 1 : 1024x32 element image containing the statistical uncertainty associated with extension 0.
- Extension = 2 : The 1024x32 histogram wavelength image (calibrated wavelength at each pixel); [Å]
- Extension = 3 : Table of pixel list data containing the x-position of the event, y-position, wavelength, and time step number.
- Extension = 4 : Reconstructed count rate data with interval equal to selected hack period (*not* processed, i.e. identical to Level 2 data)

2.4.3.2.3   Count Rate Mode

As with the Level 2 data, this is a 1-D array stored in extension 1 as a FITS binary table. Values are still in counts (since there is no wavelength information, the counts cannot be converted to flux), but some calibrations have been applied, e.g., deadtime and dark current corrections (since there is no wavelength or position information, a flat field sensitivity correction cannot be applied to these data).

2.4.3.3   Level 4 ("Linearized") data

2.4.3.3.1   Histogram Mode

After data are processed to Level 3, they are divided by the width, in wavelength, of each pixel in the 1024 x 32 image and interpolated so that the wavelength for the data is linear, equal for all rows and identical for all LIN files. The axes still correspond to wavelength vs. spatial, and value of each pixel is

the calculated flux. The pulse-height and count rate data that are stored as additional extensions in the "engineering" files (Level 2 data), will be retained and are *not* processed:

- Extension = 0 : The 1024x32 histogram image (processed, flux calibrated, and resampled); [photons-cm^{-2}-s^{-1} Å^{-1}]
- Extension = 1 : 1024x32 element image containing the statistical uncertainty associated with extension 0.
- Extension = 2 : The 1024-element wavelength vector (calibrated wavelength at each pixel; identical for all rows); [Å]
- Extension = 3 : The 16-element pulse-height distribution array (*not* processed; same as in Level 2 data)
- Extension = 4 : The 100-element count rate array (*not* processed; same as in Level 2 data)

2.4.3.3.2 Pixel List Mode

The pixel list data will be a 2-dimensional array (effectively a table) with the following columns: [X, Y, Wavelength, Time Step]; this will be in the third extension of the FITS file. For quick-look purposes, the primary extension in the FITS file is a histogram-formatted version of the data as is done for the Levels 2 & 3 data.

- Extension = 0 : The 1024x32 constructed histogram-formatted image (processed, flux calibrated, and resampled); [photons-cm^{-2}-s^{-1} Å^{-1}]
- Extension = 1 : 1024x32 element image containing the statistical uncertainty associated with extension 0.
- Extension = 2 : The 1024-element wavelength vector (calibrated wavelength at each pixel; identical for all rows); [Å]
- Extension = 3 : Table of pixel list data containing the x-position of the event, y-position, wavelength, and time step number.
- Extension = 4 : Reconstructed count rate data with interval equal to selected hack period (*not* processed, i.e. identical to Level 2 data)

2.4.3.3.3 Count Rate Mode

There is no Level 4 version of count rate data

2.4.4 *Software*

As listed in Section 2.3.3, the *Alice* data calibration software "Mike" is used internally by the instrument team and is included as IDL procedures (source code) in the /DOCUMENT/CODE/ directory for reference only (i.e., it is not included in the archive *as supported software*). This software:

- Reads science-mode (pixel list, histogram, count rate) data files.
- Apply corrections as appropriate: deadtime, bias, dark and flat.
- Apply wavelength and flux calibrations.
- Write calibrated data to multi-extension FITS-format file, where additional extensions may include wavelength values, effective count rate array, etc.

2.4.5 *Documentation*

In addition to the required ASCII formats for documents, the *Alice* team will provide formatted documents in MS Word, and /or PDF. Documents to be included will describe the instrument and its

calibration, data processing, and data archiving and may also include scientific results. Documents will be located in the `/DOCUMENT/` directory.

2.4.6 Derived and other Data Products

No derived/other data products are expected from the *Rosetta-Alice* project.

2.4.7 Ancillary Data Usage

The only ancillary data used by the *Rosetta-Alice* pipeline software are SPICE kernels, which are used to calculate observation geometry information (e.g., target distance, attitude, etc.). These can be obtained from the NAIF at JPL.

3. ARCHIVE FORMAT AND CONTENT

3.1 Format and Conventions

3.1.1 Deliveries and Archive Volume Format

Deliveries of *Rosetta-Alice* data will occur according to the schedule.

3.1.2 Data Set ID Formation

> **Joel Parker 6/29/04 5:29 PM**
> **Comment:** Explain your data set id naming

All the *Rosetta-Alice* datasets have the naming convention generally following the definition in Section 6 in the PDS Standards Reference [AD2], and limited to 40 characters in length. This will be the same value that will appear in the `DATA_SET_ID` element in the PDS label. The format is:

```
DATA_SET_ID = RO-<target>-ALI-<L>-<phase>-<text>-V<#.#>
```

where:
- `<target>` is the abbreviated name of the target: "E" (Earth), "M" (Mars), "A" (asteroid), "C" (comet), "CAL" (calibration), "X" (other, e.g., checkout), "Y" (sky), or other targets as described in Section 6.3.2 in [AD2].
- `<L>` is the **CODMAC** processing level: "2" or "3" (corresponding to PSA levels "1b" and "2", respectively). The CODMAC level "6" may also be used to describe ancilliary data.
- `<phase>` is the abbreviated name of the phase (e.g., CVP1, EAR1, GMP, COP etc. as defined in Appendix F, Table 2 in AD3)
- `<text>` is additional descriptive text if needed. Since the `DATA_SET_ID` is limited to 40 characters, this text field is then limited to typically no more than about 20 characters.
- `V<#.#>` is a version number

The expanded DATA_SET_NAME element will have the format (limited to 60 characters):

```
"ROSETTA-ORBITER <full_target> ALICE <L> <full_phase> <text> V<#.#>"
```

where:
- `<full_target>` is the *full* target name (Earth, Mars, Asteroid <name>, Comet 67P/Churyumov-Gerasimenko, Calibration).
- `<full_phase>`: is the *full* name of the phase (e.g., Commissioning, Earth Swing-by 1, Global Mapping Phase, Close Observation Phase, etc.)
- `<L>`, `<text>`, `V<#.#>`: are as described above in the `DATA_SET_ID`.

Note that if the DATA_SET_NAME would exceed 60 characters, then the target and/or phase names will be abbreviated using the abbreviations in DATA_SET_ID. Also note that if multiple targets or phases are included in a given dataset, their identifiers are concatenated with a forward slash, "/", such as:

DATA_SET_ID = "RO-E/CAL-ALI-2-EAR1-V1.0"

to describe a dataset that includes Earth and calibration observations during the first Earth flyby.

3.1.3 Data Directory Naming Convention

Note that since a submitted archive data set cannot contain multiple data processing levels (see the last paragraph in section 6.1 in the PDS Standards Reference [AD2]), we expect to deliver two data sets per phase. In one data set, the data directories will contain Level 2 data files (also referred to as "engineering files"), which are identified with "ENG" in the filename as shown in Section 3.1.4.1. In the other data set, the data directories will contain Level 3 data files (also referred to as "science files"), which are identified with "SCI" in the filename as shown in Section 3.1.4.2.

The *Alice* archive data directory structure has the following naming convention:

/DATA/<yyyy>/<mm>/<filename>

where
- o <yyyy> is the year of the observation
- o <mm> is the month of the observation e.g., 01 for January

3.1.4 Filenaming Convention

All the *Rosetta-Alice* files are prefixed by "RA_" and are ISO 9660/level 2 compliant.

3.1.4.1 Engineering Files

These Level 2, "ENG" type files are output by the *Alice* data collection program Lima. They have the filename convention:

RA_<YYMMDDhhmmss>_<TYPE>_ENG.<EXT>

where:
- <YYMMDDhhmmss> is the 12-character UTC date and time of the start of the observation (the start of collecting photons).
- <type> is one of the following 4-character values:
  - o PIX# (pixel list mode data; "#"is a 1-digit version number to distinguish the different dumps that might result from a single observation)
  - o HIS# (histogram mode data)
  - o CNT# (count rate mode data)
  - o HKTM (housekeeping telemetry data; these files contain a header describing the contents and columns, but such a header is not PDS-compliant, so these files are used only internally by the *Alice* team, and should not appear in the archive)
  - o HKTMX (housekeeping telemetry data; the "x" indicates that the header has been stripped off as required for archive format, and so these are the files that will appear in the archive)

- <EXT> is one of the following 3-character extensions:
  - o FIT   (for FITS files: PIX, HIS, CNT)
  - o TAB   (for ASCII table files: HKTM)

3.1.4.2 Science Files

Level 3, "SCI" files (also sometimes referred to as "processed" or "calibrated" files) are output by the processing and calibration program Mike. *Only the science data (types: PIX, HIST, CNT) are processed and calibrated.* They have the filename convention:

$$RA\_<YYMMDDhhmmss>\_<type>\_SCI\_<v>.FIT$$

where:
- <YYMMDDhhmmss> is the 12-character UTC date and time of the start of the observation (the start of collecting photons). This will be the same value as in the filename of the input engineering file.
- <type> is one of the following 4-character values (the same value as in the filename of the input engineering file):
  - o PIX#   (pixel list mode data; "#"is a 1-digit version number to distinguish the different dumps that might result from a single observation)
  - o HIS#   (histogram mode data)
  - o CNT#   (count rate mode data)
- <v> is a running version number to allow for different processing runs of the data (e.g., with different, improved calibrations)
- The extension is always "FIT " since these are all FITS files.

3.1.4.3 Linearized Files

Level 4, "LIN" files (also sometimes referred to as "resampled" files) are output by the processing and calibration program Mike. *Only the image data (types: PIX & HIST) are resampled.* They have the filename convention:

$$RA\_<YYMMDDhhmmss>\_<type>\_LIN\_<v>.FIT$$

where:
- <YYMMDDhhmmss> is the 12-character UTC date and time of the start of the observation (the start of collecting photons). This will be the same value as in the filename of the input engineering file.
- <type> is one of the following 4-character values (the same value as in the filename of the input engineering file):
  - o PIX#   (pixel list mode data; "#"is a 1-digit version number to distinguish the different dumps that might result from a single observation)
  - o HIS#   (histogram mode data)
- <v> is a running version number to allow for different processing runs of the data (e.g., with different, improved calibrations)
- The extension is always "FIT " since these are all FITS files.

3.1.4.4 Science Calibration Files

These are files used by the processing and calibration program Mike (e.g., darks, flats, wavelength, parameter files). They have the filename convention:

```
ra_<type>_<vvv>.<ext>
```

where:
- `<type>` is one of the following 4-character values:
  - o `AEFF (effective area calibration vectors)`
  - o `DARK` (dark image)
  - o `FLAT` (flatfield image)
  - o `WAVE (wavelength calibration file)`
- `<vvv>` is a running 3-digit version number.
- `<EXT>` is one of the following extensions:
  - o `FIT` (for FITS files: `DARK, FLAT, WAVE`)
  - o `TAB` (for ASCII table files: `AEFF`)

3.2 Standards Used in Data Product Generation

3.2.1 PDS Standards

The PDS Standards Reference version 3.7 was used for the design of the *Rosetta-Alice* archive

3.2.2 Time Standards

The timing information used in all *Rosetta-Alice* data is derived from the *Rosetta* onboard clock. The *Alice* clock resolution is 1/256 seconds (~3.9 millisecond), although *Rosetta* provides sub-millisecond time resolution. The OBT is a counter related to the UTC by the Time Correlation Packets (TCP) distributed via the DDS (APID 1966, type 190, subtype 40); note that the SCET can be written in either OBT or UTC formats. The various time definitions, formats, and relationships are described in AD6 and AD7.

In the *Alice* data (e.g., the headers of the FITS files), "OBT" is the time that *Alice* includes in its TM packets once the instrument has become synchronized to the spacecraft (which is done after a time update TC is sent to *Alice*); before receiving this synchronization, the time provided by *Alice* is the time since instrument startup. The OBT is the number of seconds since the spacecraft clock was last reset (though it is expected that the clock will not ever need to be reset during the mission). The format of OBT in the PDS labels for *Rosetta* data is: "<r>/<f.f>", where <r> is the reset number, and <f.f> is the floating-point OBT value. A reset value of <r>=1 indicates a zero point of January 1st, 2003 (2003-01-01T00:00:00), so the associated OBT is the number of seconds (not corrected for drift, etc.) since that zero point.

We use the term "SCET" for the ground-corrected OBT, modified by known deviations of the onboard clock as described in AD6 and AD7; the offset is given as the value for the *Alice*-specific keyword TOFFSET. As defined those documents, the time format used is the Sun MJT, as standard on Sun Solaris UNIX platforms. The format is two 32-bit integers. The first contains the number of seconds since the beginning of January 1st, 1970 (1970-01-01T00:00:00) and the second integer contains the number of microseconds.

In the *Alice* data pipeline, the OBT and UTC/SCET used to calculate TOFFSET are the two values that appear in the *Alice* data TM header (see Figure 1 in AD7). The OBT is the time of "measurement", placed in the TM packet header by *Alice*. The UTC/SCET is the corresponding time of the same event, calculated using the TCP and placed in the TM header by the DDS. The calculated TOFFSET is then applied in the *Alice* data pipeline to calculate the UTC for all other OBT values that appear in the *Alice* data (e.g., exposure start/stop times, dust alert times, etc. Note that although this is not precisely valid

since using a single offset does not take into account any time drift (or other effects) that are more fully corrected by the functional form of the TCP, it should be sufficiently accurate based on the assumption that any drift is very small over the range of time covered by a given observation (represented by a single *Alice* data file).

The format used to represent "raw" time values (OBT and SCET) is a real number representing the number of seconds since time zero. The format used to represent "calibrated" time values (SCET only) is the correlated UTC represented in the ISO 8601 compliant standard time string:

<div align="center">

`<YYYY>-<MM>-<DD>T<hh>:<mm>:<ss.sss>`

</div>

Examples of the time format are given by the *Alice*-specific keywords parameters: SCETR, SCETC, INSTTIME, PRESSCET, and the PDS label keywords: SPACECRAFT_CLOCK_START_COUNT and SPACECRAFT_CLOCK_STOP_COUNT (which are OBT, "raw" times) and START_TIME and STOP_TIME (which are SCET "calibrated" UTC times).

N.B. During the original commissioning period (March—May 2004), a drift of the *Alice* internal timekeeping was discovered. This amounted to –1.8 seconds/hour relative to the spacecraft clock (i.e., the *Alice* timekeeping ran slow). This was not due to the actual clock drifting, but a hardware miscalculation (dividing the *Alice* clock ticks by 4000 rather than 4002). The drift was corrected each time *Alice* use a time synchronization signal which are nominally sent from the spacecraft every 30 minutes; however, by design, *Alice* does not accept time synchronization signals when an acquisition is active, so if there are many observations in a row, the time error due to the drift can be significant (several seconds). This problem was corrected by a software patch fix that was uploaded to the flight instrument in September 2004. In all data files that were created before that date, the times listed in the data files will have uncertainties up to several seconds.

3.2.3 Reference Systems

- ISO 9660, Level 2: file naming
- ISO 8601: time format

3.2.4 Other Applicable Standards

Observation geometry parameters provided in the data product labels and the FITS headers are computed for the start time of a given observation. The Earth Mean Equator reference frame of J2000 is used as the inertial reference frame for geometry items in the data headers.

Latitude and longitude (IAU2000 model) are given in the PLANETOGRAPHIC ("geodetic") coordinate system. Light travel-time from target to observer is taken into account. Latitude is the angle between the equatorial plane and the line perpendicular to the reference ellipsoid of the body (e.g., reflects body oblateness). Positive longitude is to the west. Units: DEGREES

3.3 Data Validation

The *Alice* team will perform scientific validation of the data initially with a "quick-look" of the data soon after receipt, and more thoroughly by in-depth analysis and publication of the data. If an error in the pipeline is discovered, the software will be corrected, and all affected data will be reprocessed through the pipeline. If the affected data includes data already previously submitted to the archive, the subsequent archive submission will include a full incremental dataset containing the corrected data.

Validation of archive format compliance will be made by use of PDS validation tools:

- `readpds` – Software tool supplied by the PDS Small Bodies Node used in the verification of PDS Labels and data products.
- `pvv` - The PSA Validation and Verification Tool from ESA.

The `readpds` tool is available from the PDS Small Bodies Node at:
- `http://pdssbn.astro.umd.edu/nodehtml/software.shtml`

3.4 Content

3.4.1 Volume Set

Each submission of *Alice* data to ESA will be separate volumes, where each volume is a single data set. Data sets are described below.

3.4.2 Data Set

The *Rosetta-Alice* data set delivery phases and approximate sizes are given in in Appendix E in AD3, and given in more detail here. We only list here the mission phases that are likely to generate data (e.g., *Alice* will not obtain data during the Deep Space Maneuver phases). "All" data types means both processing levels (2 and 3) and possibly all three *Alice* data types (histogram, pixel list, count rate, housekeeping). Also note that at least two, possibly three datasets will be delivered for each phase, corresponding to the different data processing levels, so that "<L>" in the table below will be CODMAC data processing level numbers "2" or "3".

Table 3-1: Planned *Alice* Data Sets				
Phase	**DATA_SET_ID**	**Delivery Date**	**Size**	**Data Types**
Commissioning 1	`RO-CAL-ALICE-<L>-CVP1-V1.0`	April 2007	76 MB	All
Cruise 1	`RO-CAL-ALICE-<L>-CR1-V1.0`	April 2007	19 MB	All
Commissioning 2	`RO-CAL-ALICE-<L>-CVP2-V1.0`	April 2007	395 MB	All
Earth Swing-by 1	`RO-CAL-ALICE-<L>-EAR1-V1.0`	April 2007	34MB	All
Cruise 2	`RO-CAL-ALICE-<L>-CR2-V1.0`	April 2007	536 MB	All
Mars	`RO-CAL-ALICE-<L>-MARS-V1.0`	November 2007	100 MB?	All
Cruise 3	`RO-CAL-ALICE-<L>-CR3-V1.0`	March 2008	TBD	All
Earth Swing-by 2	`RO-CAL-ALICE-<L>-EAR2-V1.0`	June 2008	TBD	All
Earth Swing-by 3	`RO-CAL-ALICE-<L>-EAR3-V1.0`	April 2010	TBD	All
Asteroid Fly-by 1	`RO-CAL-ALICE-<L>-AST1-V1.0`	April 2010	TBD	All
Asteroid Fly-by 2	`RO-CAL-ALICE-<L>-AST2-V1.0`	March 2011	TBD	All
Comet phases (each phase)	`RO-CAL-ALICE-<L>-<ph>-V1.0` (`<ph>` = NCD, FAT, CAT,…)	6 months after the end of each phase	500 MB	All

3.4.3 Directories

The sections below illustrate the structure of the final archive of data from *Alice* to be delivered to the ESA-PDS team for inclusion in the *Rosetta* archive. Intermediate (incremental) deliveries during the mission will likely not include all types of data products. The details of what components are included in the archive and how they are grouped into data sets, subdirectories, and files comprises the design of the archive.

The *Rosetta* archive will be an online archive, where the data are delivered electronically. Thus, there is no need to bundle several *data sets* into one *volume*, and one data set will correspond to one volume. A data set will include the data products, secondary data, software and documentation that completely document and support the use of the data products from one or more mission phases.

3.4.3.1 Root Directory

The top-level structure of the root (/) directory of a typical data archive volume (= data set) corresponds to chapter 19 of the PDS Standards Reference (AD2) and is summarised below. It will contain the following files:
- **AAREADME.TXT** : This file describes the volume (= data set) as a whole. It gives an overview of the contents and organisation of the data set, general instructions for its use and contact information.
- **VOLDESC.CAT** : This file contains the VOLUME object, which gives a high-level description of the contents of the volume (= data set).

The following directory structure is found under the root (/) directory.

3.4.3.2 CALIB Directory

The calibration data will be archive in the /CALIB/ directory. All calibration files have a version number in their filename (Section 3.1.4.3 and 3.1.4.4), which is also time-ordered. Files in this directory include:
- **CALINFO.TXT** : Description of the contents of the CALIB directory.
- Flat field, wavelength, and dark calibration files (PDS-labelled FITS format) sorted by version number.
- Effective area calibration table (2-column ASCII table)

3.4.3.3 CATALOG Directory

This directory contains the catalog object files for the entire volume (= data set).

- **CATINFO.TXT** : Description of the contents of the CATALOG directory.
- **MISSION.CAT** : PDS mission catalog information about the *Rosetta* mission. This file will be provided by ESA.
- **INSTHOST.CAT** : PDS instrument host catalog information about the *Rosetta* spacecraft and the mounting relationship of the instruments within the spacecraft. This file will be provided by ESA.
- **INST.CAT** : PDS instrument catalog information about the *Alice* instrument (likely to be the same in all deliveries, unless updates are needed).
- **DATASET.CAT** : PDS data set catalog information about the data set submitted.
- **<TARGET_NAME>.CAT** : PDS target catalog information about the observation target, i.e. comet, asteroid, Earth or Mars, will be provided by ESA.
- **PERSON.CAT** : PDS personnel catalog information about the members of the *Alice* instrument team responsible for generating the data products.
- **REF.CAT** : PDS reference catalog information about every journal article, book, or other published reference mentioned in the above catalog objects or their components.

3.4.3.4 Index Directory

This directory contains the index files summarising all data products in the volume (= data set) by mode, key instrument parameters or mission phase, and organised to facilitate finding the data of interest for a

particular scientific question. Information about the observation geometry of the data products is also included here, i.e. spacecraft position and attitude, illumination conditions etc. Information that is not accurately known at the time of delivery and thus will probably be updated later should be stored in the index files rather than in the data product labels.

- **INDXINFO.TXT** : Description of the contents of the INDEX directory.
- **INDEX.LBL** : Detached label for the index table INDEX.TAB. The INDEX_TABLE specific object should be used to identify and describe the columns of the index table.
- **INDEX.TAB** : Index of the data set in tabular format.

3.4.3.5 BROWSE Directory and BROWSE Files

The *Rosetta-Alice* team does not foresee using the BROWSE directory. The *Alice* data files are relatively small, so that reduced resolution data are not necessary.

3.4.3.6 GEOMETRY Directory

The *Rosetta-Alice* team does not foresee providing any geometric information beyond that provided by ESOC. This directory, therefore, will be blank until the composite archive is produced by the EPT, at which time the geometry files from ESOC will be included.

3.4.3.7 SOFTWARE Directory

The *Rosetta-Alice* team does not foresee providing any software that is intended for regular updates and multiple platform capability. The source code of software used internally by the *Rosetta-Alice* team will be provided as reference documents in the DOCUMENT directory. This software is for docunentation only, and is not supported.

3.4.3.8 GAZETTEER Directory

The GAZETTEER directory will not be used for *Rosetta-Alice*.

3.4.3.9 LABEL Directory

The label directory will not be used for *Rosetta-Alice*.

3.4.3.10 DOCUMENT Directory

This directory provides documentation and supplementary and ancillary information to assist in understanding and using the data products in the volume (= data set). All documents will be present in ASCII format to ensure long-term readability. Other formats (Word, PDF, TeX etc.) will be included as well as appropriate.

Files will include:
- **DOCINFO.TXT** : Description of the contents of the DOCUMENT directory.
- *Alice* Experiment User Manual (AD5)
- This EAICD.
- The *Rosetta-Alice* Data Processing Software Manual (AD4). This provides details of the behavior, use, and methods of the Lima, Mike, and November programs.

- The IDL calibration programs (Mike) used for pipeline processing. Note that the Mike software includes the IDL programs for wavelength calibration and deadtime correction mentioned in Section 3.4.3.2.
- Calibration reports if available.

3.4.3.11 EXTRAS Directory

Use of this directory is TBD. No specific items have yet been identified for this directory.

3.4.3.12 DATA Directory

This directory contains the actual *Alice* data (images and tables). Data files with detached PDS label files are arranged in a logical subdirectory structure with subdirectories corresponding to the year and month the data were obtained, e.g. `DATA/2004/04/`.

- Level 2 data (also referred to in this document as "engineering" data).
- Level 3 data (also referred to in this document as "science", "processed", or "calibrated" data).

4. DETAILED INTERFACE SPECIFICATIONS: DATA PRODUCT DESIGN

All our data products use detached labels. In the subsections below, we provide explicit examples of the label files for all data products.

4.1 HIS, Level 2 (engineering histogram data)

```
PDS_VERSION_ID              = PDS3


/* FILE CHARACTERISTICS DATA ELEMENTS */

RECORD_TYPE                 = FIXED_LENGTH
RECORD_BYTES                = 2880 /* FITS standard record length */
FILE_RECORDS                = 33
FILE_NAME                   = "RA_040419231832_HIS0_ENG.LBL"
DATA_FORMAT                 = FITS


/* DATA OBJECT POINTERS IDENTIFICATION DATA ELEMENTS */
^HEADER                     = ("RA_040419231832_HIS0_ENG.FIT",1)
^IMAGE                      = ("RA_040419231832_HIS0_ENG.FIT",7)
^PULSE_HEIGHT_HEADER        = ("RA_040419231832_HIS0_ENG.FIT",30)
^PULSE_HEIGHT_TABLE         = ("RA_040419231832_HIS0_ENG.FIT",31)
^COUNT_RATE_HEADER          = ("RA_040419231832_HIS0_ENG.FIT",32)
^COUNT_RATE_SERIES          = ("RA_040419231832_HIS0_ENG.FIT",33)


/* OBSERVATION AND EXPOSURE DATA ELEMENTS */

INSTRUMENT_MODE_ID          = "HIS" /* HIS, PIX, CNT */
INSTRUMENT_MODE_DESC        = "HISTOGRAM"
START_TIME                  = 2004-04-19T23:18:31.633 /* UTC */
STOP_TIME                   = 2004-04-19T23:18:51.782 /* UTC */
SPACECRAFT_CLOCK_START_COUNT = "1/41037497.246"
```

```
SPACECRAFT_CLOCK_STOP_COUNT  = "1/41037517.395"
EXPOSURE_DURATION            = 20.1480 /* SECONDS */
DATA_QUALITY_ID              =        0
DATA_QUALITY_DESC            = "Data quality is nominal"
MISSION_PHASE_NAME           = "COMMISSIONING 1"
 /* see Phase Definition table in RSOC Design Specification, */
 /* RO-EST-PL-2010 and Archive GVT Plan, RO-EST-PL-5011 */
TARGET_NAME                  = CHECKOUT
TARGET_TYPE                  = "N/A"


/* INSTRUMENT AND MISSION DESCRIPTIVE DATA ELEMENTS */

INSTRUMENT_ID                = "ALICE"
INSTRUMENT_NAME              = "ALICE"
INSTRUMENT_TYPE              = "ULTRAVIOLET SPECTROMETER"
INSTRUMENT_HOST_ID           = "RO"
INSTRUMENT_HOST_NAME         = "ROSETTA-ORBITER"
MISSION_ID                   = "ROSETTA"
MISSION_NAME                 = "INTERNATIONAL ROSETTA MISSION"


/* PRODUCT, DATA SET, AND VOLUME DATA ELEMENTS */

PRODUCT_ID                   = "RA_040419231832_HIS0_ENG.FIT"
PRODUCT_TYPE                 = EDR /* CODMAC Data Level 2 */
PRODUCT_CREATION_TIME        = 2004-09-20T22:37:07
DATA_SET_ID                  = "RO-C/CAL/X-ALICE-2-CVP1-V1.0"
DATA_SET_NAME                = "
  ROSETTA-ORBITER 2002T7/CAL/CHECK ALICE 2 CVP1 V1.0"
PRODUCER_ID                  = "ROSETTA_ALICE"
PRODUCER_FULL_NAME           = "ANDREW J. STEFFL"
PRODUCER_INSTITUTION_NAME    = "SOUTHWEST RESEARCH INSTITUTE"


/* DATA OBJECT DEFINITIONS */

OBJECT                       = HEADER
  BYTES                      = 17280 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE                = FITS
  INTERCHANGE_FORMAT         = ASCII
  RECORDS                    = 6
  DESCRIPTION                = "
    FITS header for Rosetta-Alice uncalibrated (CODMAC Data Level 2)
    histogram observation."
END_OBJECT                   = HEADER


OBJECT                       = IMAGE
  LINE_SAMPLES               = 1024 /* FITS NAXIS1 keyword */
  LINES                      = 32 /* FITS NAXIS2 keyword */
  SAMPLE_BITS                =         16
```

```
  SAMPLE_TYPE               = MSB_INTEGER
  INTERCHANGE_FORMAT        = BINARY
  OFFSET                    = 32768 /* FITS BZERO keyword */
  SCALING_FACTOR            = 1.00000 /* FITS BSCALE keyword */
  AXIS_ORDER_TYPE           = FIRST_INDEX_FASTEST
  LINE_DISPLAY_DIRECTION    = UP
  SAMPLE_DISPLAY_DIRECTION  = RIGHT
  DESCRIPTION               = "
    FITS image for Rosetta-Alice uncalibrated (CODMAC Data Level 2)
    histogram observation. Units are raw data numbers."
END_OBJECT                  = IMAGE


OBJECT                      = PULSE_HEIGHT_HEADER
  BYTES                     = 2880 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE               = FITS
  INTERCHANGE_FORMAT        = ASCII
  RECORDS                   = 1
  DESCRIPTION               = "FITS extension header"
END_OBJECT                  = PULSE_HEIGHT_HEADER


OBJECT                      = PULSE_HEIGHT_TABLE
  NAME                      = "PULSE_HEIGHT_DISTRIBUTION"
  COLUMNS                   = 1
  ROWS                      = 16 /* FITS NAXIS2 keyword */
  ROW_BYTES                 = 2
  INTERCHANGE_FORMAT        = BINARY
  DESCRIPTION               = "
    The pulse height distribution (PHD) is a one-dimensional
    histogram, that bins each of the detected events (pulses) based on
    their 'amplitude'. Detected events are those that are larger than
    the discriminator setting, which is an analog (voltage) value. Of
    the 16 PHD bins, both the top and bottom 3 bins don't get any
    events (this is caused by the digitization of this amplitude
    information), so only 10 bins contain non-zero values. The
    sampling parameter interval is effectively unknown and somewhat
    arbitrary anyway since only the relative shape and stability of
    the distribution is of interest."

  OBJECT                    = COLUMN
    NAME                    = "PHD     "
    DATA_TYPE               = MSB_INTEGER /* 16-bit signed integers */
    BYTES                   = 2
    START_BYTE              = 1
    OFFSET                  = 32768 /* FITS TZERO1 keyword */
  END_OBJECT                = COLUMN
END_OBJECT                  = PULSE_HEIGHT_TABLE


OBJECT                      = COUNT_RATE_HEADER
  BYTES                     = 2880 /* RECORD_BYTES x RECORDS */
```

```
  HEADER_TYPE               = FITS
  INTERCHANGE_FORMAT        = ASCII
  RECORDS                   = 1
  DESCRIPTION               = "FITS extension header"
END_OBJECT                  = COUNT_RATE_HEADER


OBJECT                      = COUNT_RATE_SERIES
  COLUMNS                   = 1
  ROWS                      = 100 /* FITS NAXIS1 keyword */
  ROW_BYTES                 = 2
  INTERCHANGE_FORMAT        = BINARY
  SAMPLING_PARAMETER_INTERVAL= 1.90000
  SAMPLING_PARAMETER_NAME   = TIME
  SAMPLING_PARAMETER_UNIT   = SECONDS
  DESCRIPTION               = "
    These count rate data are a table that gives the measured count
    rate from the observation. Units are counts per time hack interval"

  OBJECT                    = COLUMN
    NAME                    = "COUNT_RATE"
    DATA_TYPE               = MSB_INTEGER
    BYTES                   = 2
    START_BYTE              = 1
    ITEM_BYTES              = 2 /* 16-bit signed integer */
    OFFSET                  = 32768 /* FITS TZERO1 keyword */
  END_OBJECT                = COLUMN
END_OBJECT                  = COUNT_RATE_SERIES


END
```

4.2 HIS, Level 3 (science histogram data)

```
PDS_VERSION_ID            = PDS3


/* FILE CHARACTERISTICS DATA ELEMENTS */
RECORD_TYPE               = FIXED_LENGTH
RECORD_BYTES              = 2880 /* FITS standard record length */
FILE_RECORDS              = 109
FILE_NAME                 = "RA_040419231832_HIS0_SCI.LBL"
DATA_FORMAT               = FITS


/* DATA OBJECT POINTERS IDENTIFICATION DATA ELEMENTS */
^HEADER                   = ("RA_040419231832_HIS0_SCI.FIT",1)
^IMAGE                    = ("RA_040419231832_HIS0_SCI.FIT",13)
^WAVELENGTH_HEADER        = ("RA_040419231832_HIS0_SCI.FIT",59)
^WAVELENGTH_IMAGE         = ("RA_040419231832_HIS0_SCI.FIT",60)
^PULSE_HEIGHT_HEADER      = ("RA_040419231832_HIS0_SCI.FIT",106)
```

```
^PULSE_HEIGHT_TABLE          = ("RA_040419231832_HIS0_SCI.FIT",107)
^COUNT_RATE_HEADER           = ("RA_040419231832_HIS0_SCI.FIT",108)
^COUNT_RATE_SERIES           = ("RA_040419231832_HIS0_SCI.FIT",109)
```

```
N.B.: The formats of the following sets of data elements are identical to
those in Section 4.1, so their descriptions are omitted here:
      /* OBSERVATION AND EXPOSURE DATA ELEMENTS */
      /* INSTRUMENT AND MISSION DESCRIPTIVE DATA ELEMENTS */
      /* PRODUCT AND DATA SET DATA ELEMENTS */
      /* STRUCTURE DEFINITION OF INSTRUMENT PARAMETER OBJECTS */
      /* DESCRIPTION OF INSTRUMENT */
      /* PARAMETERS INDEX FILE DEFINITION */
      /* MISSION SPECIFIC KEYWORDS */
```

```
/* OBSERVATION GEOMETRY ELEMENTS */

/* S/C TO SUN ELEMENTS */
SC_SUN_POSITION_VECTOR      =
(1.1170497e+08, 71725860., 30237734.)
SC_SUN_VELOCITY_VECTOR      =
(-20.288503, 23.269792, 9.9525278)
SUB_SOLAR_LONGITUDE         = 160.16964
SUB_SOLAR_LATITUDE          = -4.4102611

/* S/C TO TARGET ELEMENTS */
SC_TARGET_POSITION_VECTOR   =
(-1.0000000e+32, -1.0000000e+32, -1.0000000e+32)
SC_TARGET_VELOCITY_VECTOR   =
(-1.0000000e+32, -1.0000000e+32, -1.0000000e+32)
SUB_SPACECRAFT_LONGITUDE    = -1.0000000e+32
SUB_SPACECRAFT_LATITUDE     = -1.0000000e+32
SPACECRAFT_ALTITUDE         = -1.0000000e+32
CENTRAL_BODY_DISTANCE       = -1.0000000e+32

/* INSTRUMENT BORESIGHT LINE OF SIGHT ELEMENTS */
RIGHT_ASCENSION             = 46.574495
DECLINATION                 = -80.222574
PHASE_ANGLE                 = 0
INCIDENCE_ANGLE             = -1.0000000e+32
EMISSION_ANGLE              = -1.0000000e+32

SPICE_FILE_NAME             = {"naif0008.tls"
                               "ROS_060511_STEP.TSC",
                               "ROS_V06.TF",
                               "EARTHFIXEDIAU.TF",
                               "DE403-MASSES.TPC",
                               "PCK00008.TPC",
                               "DE405S.BSP",
```

```
                            "C2002T7.bsp",
                            "TEMPEL1-9P-DI-P.BSP",
                            "mar033_2000-2025.bsp",
                            "sat164.bsp",
                            "2867_Steins_2004_2016.bsp",
                            "21_Lutetia_2004_2016.bsp",
                            "67P_CHURY_GERAS_2004_2016.BSP",
                            "ORER_____00031.BSP",
                            "ORFR_____00047.BSP",
                            "ORGR_____00047.BSP",
                            "ORHR_____00047.BSP",
                            "ORMR_____00047.BSP",
                            "ATNR_P040302093352_00046.BC"}

/* DATA OBJECT DEFINITIONS */
OBJECT                     = HEADER
  BYTES                    = 34560 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE              = FITS
  INTERCHANGE_FORMAT       = ASCII
  RECORDS                  = 12
  DESCRIPTION              = "
    FITS header for Rosetta-Alice calibrated (CODMAC Data Level 3)
    histogram observation."
END_OBJECT                 = HEADER

OBJECT                     = IMAGE
  LINE_SAMPLES             = 1024 /* FITS NAXIS1 keyword */
  LINES                    = 32 /* FITS NAXIS2 keyword */
  SAMPLE_BITS              = 32
  SAMPLE_TYPE              = IEEE_REAL
  OFFSET                   = 0.00000 /* FITS BZERO keyword */
  SCALING_FACTOR           = 1.00000 /* FITS BSCALE keyword */
  AXIS_ORDER_TYPE          = FIRST_INDEX_FASTEST
  LINE_DISPLAY_DIRECTION   = UP
  SAMPLE_DISPLAY_DIRECTION = RIGHT
  DESCRIPTION              = "
    FITS image for Rosetta-Alice calibrated (CODMAC Data Level 3)
    histogram observation. Units are photons cm**-2 s**-1 Data are in
    units of photons per square centimeter per second"
END_OBJECT                 = IMAGE

OBJECT                     = WAVELENGTH_HEADER
  BYTES                    = 2880 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE              = FITS
  INTERCHANGE_FORMAT       = ASCII
  RECORDS                  = 1
  DESCRIPTION              = "FITS extension header"
END_OBJECT                 = WAVELENGTH_HEADER

OBJECT                     = WAVELENGTH_IMAGE
  LINE_SAMPLES             = 1024 /* FITS NAXIS1 keyword */
  LINES                    = 32 /* FITS NAXIS2 keyword */
```

```
  SAMPLE_BITS              = 32
  SAMPLE_TYPE              = IEEE_REAL
  INTERCHANGE_FORMAT       = BINARY
  OFFSET                   = 0.00000 /* FITS BZERO keyword */
  SCALING_FACTOR           = 1.00000 /* FITS BSCALE keyword */
  AXIS_ORDER_TYPE          = FIRST_INDEX_FASTEST
  LINE_DISPLAY_DIRECTION   = UP
  SAMPLE_DISPLAY_DIRECTION = RIGHT
  DESCRIPTION              = "
    FITS extension containing calibrated wavelengths for each detector
    pixel. Units are Angstroms. Wavelengths are in Angstroms."
END_OBJECT                 = WAVELENGTH_IMAGE

OBJECT                     = PULSE_HEIGHT_HEADER
  BYTES                    = 2880 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE              = FITS
  INTERCHANGE_FORMAT       = ASCII
  RECORDS                  = 1
  DESCRIPTION              = "FITS extension header"
END_OBJECT                 = PULSE_HEIGHT_HEADER

OBJECT                     = PULSE_HEIGHT_TABLE
  NAME                     = "PULSE_HEIGHT_DISTRIBUTION"
  COLUMNS                  = 1
  ROWS                     = 16 /* FITS NAXIS2 keyword */
  ROW_BYTES                = 2
  INTERCHANGE_FORMAT       = BINARY
  DESCRIPTION              = "
    The pulse height distribution (PHD) is a one-dimensional
    histogram, that bins each of the detected events (pulses) based on
    their 'amplitude'. Detected events are those that are larger than
    the discriminator setting, which is an analog (voltage) value. Of
    the 16 PHD bins, both the top and bottom 3 bins don't get any
    events (this is caused by the digitization of this amplitude
    information), so only 10 bins contain non-zero values. The
    sampling parameter interval is effectively unknown and somewhat
    arbitrary anyway since only the relative shape and stability of
    the distribution is of interest."

  OBJECT                   = COLUMN
    NAME                   = "PHD     "
    DATA_TYPE              = MSB_INTEGER /* 16-bit signed integers */
    BYTES                  = 2
    START_BYTE             = 1
    OFFSET                 = 32768 /* FITS TZERO1 keyword */
  END_OBJECT               = COLUMN
END_OBJECT                 = PULSE_HEIGHT_TABLE

OBJECT                     = COUNT_RATE_HEADER
  BYTES                    = 2880 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE              = FITS
  INTERCHANGE_FORMAT       = ASCII
```

```
  RECORDS                   = 1
  DESCRIPTION               = "FITS extension header"
END_OBJECT                  = COUNT_RATE_HEADER

OBJECT                      = COUNT_RATE_SERIES
  COLUMNS                   = 1
  ROWS                      = 100 /* FITS NAXIS1 keyword */
  ROW_BYTES                 = 2
  INTERCHANGE_FORMAT        = BINARY
  SAMPLING_PARAMETER_INTERVAL= 1.90000
  SAMPLING_PARAMETER_NAME   = TIME
  SAMPLING_PARAMETER_UNIT   = SECONDS
  DESCRIPTION               = "
    These count rate data are a table that gives the measured count
    rate from the observation. Units are counts per time hack interval"

  OBJECT                    = COLUMN
    NAME                    = "COUNT_RATE"
    DATA_TYPE               = MSB_INTEGER
    BYTES                   = 2
    START_BYTE              = 1
    ITEM_BYTES              = 2 /* 16-bit signed integer */
    OFFSET                  = 32768 /* FITS TZERO1 keyword */
  END_OBJECT                = COLUMN

END_OBJECT                  = COUNT_RATE_SERIES


END
```

4.3 HIS, Level4 (linearized histogram data)

```
PDS_VERSION_ID              = PDS3


/* FILE CHARACTERISTICS DATA ELEMENTS */

RECORD_TYPE                 = FIXED_LENGTH
RECORD_BYTES                = 2880 /* FITS standard record length */
FILE_RECORDS                = 113
FILE_NAME                   = "RA_080902110002_HIS3_LIN.LBL"
DATA_FORMAT                 = FITS


/* DATA OBJECT POINTERS IDENTIFICATION DATA ELEMENTS */
^HEADER                     = ("RA_080902110002_HIS3_LIN.FIT",1)
^IMAGE                      = ("RA_080902110002_HIS3_LIN.FIT",14)
^ERROR_IMAGE_HEADER         = ("RA_080902110002_HIS3_LIN.FIT",60)
^ERROR_IMAGE                = ("RA_080902110002_HIS3_LIN.FIT",61)
^WAVELENGTH_HEADER          = ("RA_080902110002_HIS3_LIN.FIT",107)
^WAVELENGTH_TABLE           = ("RA_080902110002_HIS3_LIN.FIT",108)
^PULSE_HEIGHT_HEADER        = ("RA_080902110002_HIS3_LIN.FIT",110)
```

```
^PULSE_HEIGHT_TABLE         = ("RA_080902110002_HIS2_LIN.FIT",111)
^COUNT_RATE_HEADER          = ("RA_080902110002_HIS2_LIN.FIT",112)
^COUNT_RATE_SERIES          = ("RA_080902110002_HIS2_LIN.FIT",113)
```

```
N.B.: The formats of the following sets of data elements are identical to
those in Section 4.2, so their descriptions are omitted here:
      /* OBSERVATION AND EXPOSURE DATA ELEMENTS */
      /* INSTRUMENT AND MISSION DESCRIPTIVE DATA ELEMENTS */
      /* PRODUCT AND DATA SET DATA ELEMENTS */
      /* STRUCTURE DEFINITION OF INSTRUMENT PARAMETER OBJECTS */
      /* DESCRIPTION OF INSTRUMENT */
      /* PARAMETERS INDEX FILE DEFINITION */
      /* MISSION SPECIFIC KEYWORDS */
      /* OBSERVATION GEOMETRY ELEMENTS */
      /* S/C TO TARGET ELEMENTS */
      /* INSTRUMENT BORESIGHT LINE OF SIGHT ELEMENTS */
```

```
OBJECT                    = HEADER
  BYTES                   = 37440 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE             = FITS
  INTERCHANGE_FORMAT      = ASCII
  RECORDS                 = 13
  DESCRIPTION             = "
    FITS header for Rosetta-Alice calibrated (CODMAC Data Level 3)
    histogram observation."
END_OBJECT                = HEADER


OBJECT                    = IMAGE
  LINE_SAMPLES            = 1024 /* FITS NAXIS1 keyword */
  LINES                   = 32 /* FITS NAXIS2 keyword */
  SAMPLE_BITS             = 32
  SAMPLE_TYPE             = IEEE_REAL
  AXIS_ORDER_TYPE         = FIRST_INDEX_FASTEST
  LINE_DISPLAY_DIRECTION  = UP
  SAMPLE_DISPLAY_DIRECTION = RIGHT
  DESCRIPTION             = "
    FITS image for Rosetta-Alice calibrated (CODMAC Data Level 3)
    histogram observation. Units are photons cm**-2 s**-1 Data are in
    units of photons per square centimeter per second"
END_OBJECT                = IMAGE


OBJECT                    = ERROR_IMAGE_HEADER
  BYTES                   = 2880 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE             = FITS
  INTERCHANGE_FORMAT      = ASCII
  RECORDS                 = 1
  DESCRIPTION             = "FITS extension header"
END_OBJECT                = ERROR_IMAGE_HEADER
```

```
OBJECT                        = ERROR_IMAGE
  LINE_SAMPLES                = 1024 /* FITS NAXIS1 keyword */
  LINES                       = 32 /* FITS NAXIS2 keyword */
  SAMPLE_BITS                 = 32
  SAMPLE_TYPE                 = IEEE_REAL
  AXIS_ORDER_TYPE             = FIRST_INDEX_FASTEST
  LINE_DISPLAY_DIRECTION      = UP
  SAMPLE_DISPLAY_DIRECTION    = RIGHT
  DESCRIPTION                 = "
    FITS extension containing the statistical uncertainty associated
    with each pixel in the primary extension. This is derived by
    assuming Gaussian statistics, such that for a given number of
    detected counts, N, the corresponding uncertainty is sqrt(N).
    Units are photons cm**-2 s**-1 Data are in units of photons per
    square centimeter per second"
END_OBJECT                    = ERROR_IMAGE


OBJECT                        = WAVELENGTH_HEADER
  BYTES                       = 2880 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE                 = FITS
  INTERCHANGE_FORMAT          = ASCII
  RECORDS                     = 1
  DESCRIPTION                 = "FITS extension header"
END_OBJECT                    = WAVELENGTH_HEADER


OBJECT                        = WAVELENGTH_TABLE
  INTERCHANGE_FORMAT          = BINARY
  ROWS                        = 1024
  COLUMNS                     = 1
  ROW_BYTES                   = 4
  DESCRIPTION                 = "
    FITS extension containing the wavelength vector in units of
    Angstroms."

  OBJECT                      = COLUMN
    NAME                      = "WAVELENGTH"
    DATA_TYPE                 = IEEE_REAL /* 32-bit floating point */
    BYTES                     = 4
    START_BYTE                = 1
    UNIT                      = "ANGSTROMS"
  END_OBJECT                  = COLUMN

END_OBJECT                    = WAVELENGTH_TABLE


OBJECT                        = PULSE_HEIGHT_HEADER
  BYTES                       = 2880 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE                 = FITS
  INTERCHANGE_FORMAT          = ASCII
```

```
  RECORDS                    = 1
  DESCRIPTION                = "FITS extension header"
END_OBJECT                   = PULSE_HEIGHT_HEADER


OBJECT                       = PULSE_HEIGHT_TABLE
  INTERCHANGE_FORMAT         = BINARY
  ROWS                       = 16
  COLUMNS                    = 1
  ROW_BYTES                  = 2
  DESCRIPTION                = "
    The pulse height distribution (PHD) is a one-dimensional
    histogram, that bins each of the detected events (pulses) based on
    their 'amplitude'. Detected events are those that are larger than
    the discriminator setting, which is an analog (voltage) value. Of
    the 16 PHD bins, both the top and bottom 3 bins don't get any
    events (this is caused by the digitization of this amplitude
    information), so only 10 bins contain non-zero values. The
    sampling parameter interval is effectively unknown and somewhat
    arbitrary anyway since only the relative shape and stability of
    the distribution is of interest."

  OBJECT                     = COLUMN
    NAME                     = "PULSE_HEIGHT_DISTRIBUTION"
    DATA_TYPE                = MSB_INTEGER /* 16-bit signed integers */
    BYTES                    = 2
    START_BYTE               = 1
    OFFSET                   = 32768
  END_OBJECT                 = COLUMN

END_OBJECT                   = PULSE_HEIGHT_TABLE


OBJECT                       = COUNT_RATE_HEADER
  BYTES                      = 2880 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE                = FITS
  INTERCHANGE_FORMAT         = ASCII
  RECORDS                    = 1
  DESCRIPTION                = "FITS extension header"
END_OBJECT                   = COUNT_RATE_HEADER


OBJECT                       = COUNT_RATE_SERIES
  INTERCHANGE_FORMAT         = BINARY
  ROWS                       = 100 /* FITS NAXIS1 keyword */
  COLUMNS                    = 1
  ROW_BYTES                  = 2
  SAMPLING_PARAMETER_INTERVAL= 244.800
  SAMPLING_PARAMETER_NAME    = TIME
  SAMPLING_PARAMETER_UNIT    = SECONDS
  DESCRIPTION                = "
    These count rate data are a vector that gives the measured count
```

```
     rate from the observation. Units are counts per time hack interval"

  OBJECT                      = COLUMN
    NAME                      = "COUNTS"
    DATA_TYPE                 = MSB_INTEGER
    START_BYTE                = 1
    BYTES                     = 2
    OFFSET                    = 32768 /* FITS BZERO keyword */
  END_OBJECT                  = COLUMN
END_OBJECT                    = COUNT_RATE_SERIES


END
```

4.4 PIX, Level 2 (engineering pixel list data)

```
PDS_VERSION_ID              = PDS3


/* FILE CHARACTERISTICS DATA ELEMENTS */

RECORD_TYPE                 = FIXED_LENGTH
RECORD_BYTES                = 2880 /* FITS standard record length */
FILE_RECORDS                = 63
FILE_NAME                   = "RA_040323225136_PIX0_ENG.LBL"
DATA_FORMAT                 = FITS


/* DATA OBJECT POINTERS IDENTIFICATION DATA ELEMENTS */
^HEADER                     = ("RA_040323225136_PIX0_ENG.FIT",1)
^IMAGE                      = ("RA_040323225136_PIX0_ENG.FIT",7)
^PIXEL_LIST_HEADER          = ("RA_040323225136_PIX0_ENG.FIT",30)
^PIXEL_LIST_TABLE           = ("RA_040323225136_PIX0_ENG.FIT",31)
^COUNT_RATE_HEADER          = ("RA_040323225136_PIX0_ENG.FIT",49)
^COUNT_RATE_SERIES          = ("RA_040323225136_PIX0_ENG.FIT",50)
```

```
N.B.: The formats of the following sets of data elements are identical to
those in Section 4.1, so their descriptions are omitted here:
     /* OBSERVATION AND EXPOSURE DATA ELEMENTS */
     /* INSTRUMENT AND MISSION DESCRIPTIVE DATA ELEMENTS */
     /* PRODUCT AND DATA SET DATA ELEMENTS */
     /* STRUCTURE DEFINITION OF INSTRUMENT PARAMETER OBJECTS */
     /* DESCRIPTION OF INSTRUMENT */
     /* PARAMETERS INDEX FILE DEFINITION */
     /* MISSION SPECIFIC KEYWORDS */
```

```
/* DATA OBJECT DEFINITIONS */
```

```
OBJECT                      = HEADER
  BYTES                     = 17280 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE               = FITS
  INTERCHANGE_FORMAT        = ASCII
  RECORDS                   = 6
  DESCRIPTION               = "
    FITS header for Rosetta-Alice uncalibrated (CODMAC Data Level
    2)pixel list observation."
END_OBJECT                  = HEADER


OBJECT                      = IMAGE
  LINE_SAMPLES              = 1024 /* FITS NAXIS1 keyword */
  LINES                     = 32 /* FITS NAXIS2 keyword */
  SAMPLE_BITS               =         16
  SAMPLE_TYPE               = MSB_INTEGER
  INTERCHANGE_FORMAT        = BINARY
  OFFSET                    = 32768 /* FITS BZERO keyword */
  SCALING_FACTOR            = 1.00000 /* FITS BSCALE keyword */
  AXIS_ORDER_TYPE           = FIRST_INDEX_FASTEST
  LINE_DISPLAY_DIRECTION    = UP
  SAMPLE_DISPLAY_DIRECTION  = RIGHT
  DESCRIPTION               = "
    Reconstructed histogram image for Rosetta-Alice uncalibrated
    (CODMAC Data Level 2) pixel list observation. Units are raw data
    numbers."
END_OBJECT                  = IMAGE


OBJECT                      = PIXEL_LIST_HEADER
  BYTES                     = 2880 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE               = FITS
  INTERCHANGE_FORMAT        = ASCII
  RECORDS                   = 1
  DESCRIPTION               = "FITS extension header"
END_OBJECT                  = PIXEL_LIST_HEADER


OBJECT                      = PIXEL_LIST_TABLE
  COLUMNS                   = 1
  ROWS                      = 24491 /* FITS extension NAXIS1 */
  ROW_BYTES                 = 2
  INTERCHANGE_FORMAT        = BINARY
  DESCRIPTION               = "
    These pixel list data are an array up to 32767 elements that gives
    the X,Y positions of every detected event. In pixel list mode, the
    event addresses that are generated by the detector are stored
    sequentially in the memory array, as in a list. In addition to the
    detector events, a time-mark value is also inserted into the list
    on a periodic basis. The data are encoded as follows:

    Value (for events) = X * 1024 + Y
```

```
    Value (for timehacks) > 32768

    Another way to describe this is by representing the bits in the
    pixel list events (16-bit words) as:
    h a a a a a e e e e e e e e e e
    where each letter represents a single bit with the following meaning:
    h - (MSB) set to 1 for a timehack, and 0 for a normal photon event.
        For timehacks, the other 15 bits have no meaning.
    a - the five bits of spatial information of a photon event.
    e - the ten bits of spectral information of a photon event."

  OBJECT                    = COLUMN
    NAME                    = "PIXEL_LIST"
    DATA_TYPE               = MSB_INTEGER
    BYTES                   = 2
    START_BYTE              = 1
    ITEM_BYTES              = 2 /* Each item is signed 16 bit integer */
    OFFSET                  = 32768 /* BZERO keyword in FITS extension
header
  END_OBJECT                = COLUMN
END_OBJECT                  = PIXEL_LIST_TABLE


OBJECT                      = COUNT_RATE_HEADER
  BYTES                     = 2880 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE               = FITS
  INTERCHANGE_FORMAT        = ASCII
  RECORDS                   = 1
  DESCRIPTION               = "FITS extension header"
END_OBJECT                  = COUNT_RATE_HEADER


OBJECT                      = COUNT_RATE_SERIES
  COLUMNS                   = 1
  ROWS                      = 19221 /* FITS NAXIS1 keyword */
  ROW_BYTES                 = 2
  INTERCHANGE_FORMAT        = BINARY
  SAMPLING_PARAMETER_INTERVAL= 0.016000000
  SAMPLING_PARAMETER_NAME   = TIME
  SAMPLING_PARAMETER_UNIT   = SECONDS
  DESCRIPTION               = "
    These count rate data are a table that gives the count rate
    measurements as reconstructed from the pixel list observation.
    Units are raw counts per time hack interval"

  OBJECT                    = COLUMN
    NAME                    = "COUNT_RATE"
    DATA_TYPE               = MSB_INTEGER
    BYTES                   = 2
    START_BYTE              = 1
    ITEM_BYTES              = 2 /* 16-bit signed integer */
    OFFSET                  = 32768 /* FITS TZERO1 keyword */
```

```
  END_OBJECT               = COLUMN
END_OBJECT                 = COUNT_RATE_SERIES


END
```

4.5 PIX, Level 3 (science pixel list data)

```
PDS_VERSION_ID             = PDS3


/* FILE CHARACTERISTICS DATA ELEMENTS */
RECORD_TYPE                = FIXED_LENGTH
RECORD_BYTES               = 2880 /* FITS standard record length */
FILE_RECORDS               = 138
FILE_NAME                  = "RA_040323225136_PIX0_SCI.LBL"
DATA_FORMAT                = FITS

/* DATA OBJECT POINTERS IDENTIFICATION DATA ELEMENTS */
^HEADER                    = ("RA_040323225136_PIX0_SCI.FIT",1)
^IMAGE                     = ("RA_040323225136_PIX0_SCI.FIT",13)
^WAVELENGTH_HEADER         = ("RA_040323225136_PIX0_SCI.FIT",59)
^WAVELENGTH_IMAGE          = ("RA_040323225136_PIX0_SCI.FIT",60)
^PIXEL_LIST_HEADER         = ("RA_040323225136_PIX0_SCI.FIT",106)
^PIXEL_LIST_TABLE          = ("RA_040323225136_PIX0_SCI.FIT",107)
^COUNT_RATE_HEADER         = ("RA_040323225136_PIX0_SCI.FIT",124)
^COUNT_RATE_SERIES         = ("RA_040323225136_PIX0_SCI.FIT",125)
```

```
N.B.: The formats of the following sets of data elements are identical to
those in Section 4.1, so their descriptions are omitted here:
      /* OBSERVATION AND EXPOSURE DATA ELEMENTS */
      /* INSTRUMENT AND MISSION DESCRIPTIVE DATA ELEMENTS */
      /* PRODUCT AND DATA SET DATA ELEMENTS */
      /* STRUCTURE DEFINITION OF INSTRUMENT PARAMETER OBJECTS */
      /* DESCRIPTION OF INSTRUMENT */
      /* PARAMETERS INDEX FILE DEFINITION */
      /* MISSION SPECIFIC KEYWORDS */
```

```
N.B.: The formats of the following sets of data elements are identical to
those in Section 4.2, so their descriptions are omitted here:
      /* OBSERVATION GEOMETRY ELEMENTS */
      /* S/C TO TARGET ELEMENTS */
      /* INSTRUMENT BORESIGHT LINE OF SIGHT ELEMENTS */
```

```
/* DATA OBJECT DEFINITIONS */
```

```
OBJECT                       = HEADER
BYTES                        = 34560 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE                = FITS
  INTERCHANGE_FORMAT         = ASCII
  RECORDS                    = 12
  DESCRIPTION                = "
    FITS header for Rosetta-Alice calibrated (CODMAC Data Level 3)
    pixel list observation."
END_OBJECT                   = HEADER

OBJECT                       = IMAGE
  LINE_SAMPLES               = 1024 /* FITS NAXIS1 keyword */
  LINES                      = 32 /* FITS NAXIS2 keyword */
  SAMPLE_BITS                = 32
  SAMPLE_TYPE                = IEEE_REAL
  OFFSET                     = 0.00000 /* FITS BZERO keyword */
  SCALING_FACTOR             = 1.00000 /* FITS BSCALE keyword */
  AXIS_ORDER_TYPE            = FIRST_INDEX_FASTEST
  LINE_DISPLAY_DIRECTION     = UP
  SAMPLE_DISPLAY_DIRECTION   = RIGHT
  DESCRIPTION                = "
    FITS image for reconstructed Rosetta-Alice calibrated (CODMAC Data
    Level 3 histogram observation. Units are photons cm**-2 s**-1 Data
    are in units of photons per square centimeter per second"
END_OBJECT                   = IMAGE

OBJECT                       = WAVELENGTH_HEADER
  BYTES                      = 2880 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE                = FITS
  INTERCHANGE_FORMAT         = ASCII
  RECORDS                    = 1
  DESCRIPTION                = "FITS extension header"
END_OBJECT                   = WAVELENGTH_HEADER

OBJECT                       = WAVELENGTH_IMAGE
  LINE_SAMPLES               = 1024 /* FITS NAXIS1 keyword */
  LINES                      = 32 /* FITS NAXIS2 keyword */
  SAMPLE_BITS                = 32
  SAMPLE_TYPE                = IEEE_REAL
  INTERCHANGE_FORMAT         = BINARY
  OFFSET                     = 0.00000 /* FITS BZERO keyword */
  SCALING_FACTOR             = 1.00000 /* FITS BSCALE keyword */
  AXIS_ORDER_TYPE            = FIRST_INDEX_FASTEST
  LINE_DISPLAY_DIRECTION     = UP
  SAMPLE_DISPLAY_DIRECTION   = RIGHT
  DESCRIPTION                = "
    FITS extension containing calibrated wavelengths for each detector
    pixel. Units are Angstroms. Wavelengths are in Angstroms."
END_OBJECT                   = WAVELENGTH_IMAGE

OBJECT                       = PIXEL_LIST_HEADER
  BYTES                      = 2880 /* RECORD_BYTES x RECORDS */
```

```
  HEADER_TYPE              = FITS
  INTERCHANGE_FORMAT       = ASCII
  RECORDS                  = 1
  DESCRIPTION              = "FITS extension header"
END_OBJECT                 = PIXEL_LIST_HEADER

OBJECT                     = PIXEL_LIST_TABLE
  COLUMNS                  = 4
  ROWS                     = 5270 /* NAXIS2 in FITS extension header
  ROW_BYTES                = 9
  INTERCHANGE_FORMAT       = BINARY
  DESCRIPTION              = "
    These pixel list data are a 4-column table that lists: X, Y,
    Wavelength, Time Step. Any necessary calibrations (flatfield,
    dark) are applied to that pixel location. The deadtime correction
    is applied to the total counts in a timestep. Photons appearing at
    different X,Y positions during a particular timestep are listed,
    in the order detected, as records with the same Time Step value."

  OBJECT                   = COLUMN
    NAME                   = "X_POSITION"
    DATA_TYPE              = MSB_INTEGER
    BYTES                  = 2
    START_BYTE             = 1
    ITEM_BYTES             = 2 /* Each item is Integer*2 (short integer) */
    OFFSET                 = 0
  END_OBJECT               = COLUMN

  OBJECT                   = COLUMN
    NAME                   = "Y_POSITION"
    DATA_TYPE              = MSB_INTEGER
    BYTES                  = 1
    START_BYTE             = 3
    ITEM_BYTES             = 1 /* Each item is Integer*1 (byte) */
    OFFSET                 = 0
  END_OBJECT               = COLUMN

  OBJECT                   = COLUMN
    NAME                   = "PIXEL LIST WAVELENGTH"
    DESCRIPTION           = "Calibrated wavelength of pixel list event"
    DATA_TYPE              = IEEE_REAL
    BYTES                  = 4
    START_BYTE             = 4
    ITEM_BYTES             = 4 /* Each item is an IEEE floating point */
    OFFSET                 = 0
  END_OBJECT               = COLUMN

OBJECT                     = COLUMN
    NAME                   = "PIXEL LIST TIME STEP"
    DATA_TYPE              = MSB_INTEGER
    BYTES                  = 2
    START_BYTE             = 8
```

```
       ITEM_BYTES               = 2 /* Each item is Integer*2 (short integer) */
       OFFSET                   = 0
     END_OBJECT                 = COLUMN

END_OBJECT                      = PIXEL_LIST_TABLE

OBJECT                          = COUNT_RATE_HEADER
  BYTES                         = 2880 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE                   = FITS
  INTERCHANGE_FORMAT            = ASCII
  RECORDS                       = 1
  DESCRIPTION                   = "FITS extension header"
END_OBJECT                      = COUNT_RATE_HEADER

OBJECT                          = COUNT_RATE_SERIES
  COLUMNS                       = 1
  ROWS                          = 19221 /* FITS NAXIS1 keyword */
  ROW_BYTES                     = 2
  INTERCHANGE_FORMAT            = BINARY
  SAMPLING_PARAMETER_INTERVAL   = 0.016000000
  SAMPLING_PARAMETER_NAME       = TIME
  SAMPLING_PARAMETER_UNIT       = SECONDS
  DESCRIPTION                   = "
    These count rate data are a table that gives the measured count
    rate from the observation. Units are counts per time hack interval"

  OBJECT                        = COLUMN
    NAME                        = "COUNT_RATE"
    DATA_TYPE                   = MSB_INTEGER
    BYTES                       = 2
    START_BYTE                  = 1
    ITEM_BYTES                  = 2 /* 16-bit signed integer */
    OFFSET                      = 32768 /* FITS TZERO1 keyword */
  END_OBJECT                    = COLUMN
END_OBJECT                      = COUNT_RATE_SERIES

END
```

4.6 PIX, Level 4 (Linearized pixel list data)

```
PDS_VERSION_ID                  = PDS3


/* FILE CHARACTERISTICS DATA ELEMENTS */

RECORD_TYPE                     = FIXED_LENGTH
RECORD_BYTES                    = 2880 /* FITS standard record length */
FILE_RECORDS                    = 276
FILE_NAME                       = "RA_080726111411_PIX2_LIN.LBL"
DATA_FORMAT                     = FITS


/* DATA OBJECT POINTERS IDENTIFICATION DATA ELEMENTS */
```

```
^HEADER                     = ("RA_080726111411_PIX2_LIN.FIT",1)
^IMAGE                      = ("RA_080726111411_PIX2_LIN.FIT",14)
^ERROR_IMAGE_HEADER         = ("RA_080726111411_PIX2_LIN.FIT",60)
^ERROR_IMAGE                = ("RA_080726111411_PIX2_LIN.FIT",61)
^WAVELENGTH_HEADER          = ("RA_080726111411_PIX2_LIN.FIT",107)
^WAVELENGTH_TABLE           = ("RA_080726111411_PIX2_LIN.FIT",108)
^PIXEL_LIST_HEADER          = ("RA_080726111411_PIX2_LIN.FIT",110)
^PIXEL_LIST_TABLE           = ("RA_080726111411_PIX2_LIN.FIT",111)
^COUNT_RATE_HEADER          = ("RA_080726111411_PIX2_LIN.FIT",275)
^COUNT_RATE_SERIES          = ("RA_080726111411_PIX2_LIN.FIT",276)
```

```
N.B.: The formats of the following sets of data elements are identical to
those in Section 4.1, so their descriptions are omitted here:
      /* OBSERVATION AND EXPOSURE DATA ELEMENTS */
      /* INSTRUMENT AND MISSION DESCRIPTIVE DATA ELEMENTS */
      /* PRODUCT AND DATA SET DATA ELEMENTS */
      /* STRUCTURE DEFINITION OF INSTRUMENT PARAMETER OBJECTS */
      /* DESCRIPTION OF INSTRUMENT */
      /* PARAMETERS INDEX FILE DEFINITION */
      /* MISSION SPECIFIC KEYWORDS */
```

```
N.B.: The formats of the following sets of data elements are identical to
those in Section 4.2, so their descriptions are omitted here:
      /* OBSERVATION GEOMETRY ELEMENTS */
      /* S/C TO TARGET ELEMENTS */
      /* INSTRUMENT BORESIGHT LINE OF SIGHT ELEMENTS */
```

```
/* DATA OBJECT DEFINITIONS */

OBJECT                    = HEADER
  BYTES                  = 37440 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE            = FITS
  INTERCHANGE_FORMAT     = ASCII
  RECORDS                = 13
  DESCRIPTION            = "
    FITS header for Rosetta-Alice calibrated (CODMAC Data Level 3)
    pixel list observation."
END_OBJECT               = HEADER


OBJECT                    = IMAGE
  LINE_SAMPLES           = 1024 /* FITS NAXIS1 keyword */
  LINES                  = 32 /* FITS NAXIS2 keyword */
  SAMPLE_BITS            = 32
  SAMPLE_TYPE            = IEEE_REAL
  AXIS_ORDER_TYPE        = FIRST_INDEX_FASTEST
  LINE_DISPLAY_DIRECTION = UP
  SAMPLE_DISPLAY_DIRECTION  = RIGHT
  DESCRIPTION            = "
    FITS image for reconstructed Rosetta-Alice calibrated (CODMAC Data
```

```
   Level 3 histogram observation. Units are photons cm**-2 s**-1 Data
   are in units of photons per square centimeter per second"
END_OBJECT                 = IMAGE


OBJECT                     = ERROR_IMAGE_HEADER
  BYTES                    = 2880 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE              = FITS
  INTERCHANGE_FORMAT       = ASCII
  RECORDS                  = 1
  DESCRIPTION              = "FITS extension header"
END_OBJECT                 = ERROR_IMAGE_HEADER


OBJECT                     = ERROR_IMAGE
  LINE_SAMPLES             = 1024 /* FITS NAXIS1 keyword */
  LINES                    = 32 /* FITS NAXIS2 keyword */
  SAMPLE_BITS              = 32
  SAMPLE_TYPE              = IEEE_REAL
  AXIS_ORDER_TYPE          = FIRST_INDEX_FASTEST
  LINE_DISPLAY_DIRECTION   = UP
  SAMPLE_DISPLAY_DIRECTION = RIGHT
  DESCRIPTION              = "
    FITS extension containing the statistical uncertainty associated
    with each pixel in the primary extension. This is derived by
    assuming Gaussian statistics, such that for a given number of
    detected counts, N, the corresponding uncertainty is sqrt(N).
    Units are photons cm**-2 s**-1 Data are in units of photons per
    square centimeter per second"
END_OBJECT                 = ERROR_IMAGE


OBJECT                     = WAVELENGTH_HEADER
  BYTES                    = 2880 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE              = FITS
  INTERCHANGE_FORMAT       = ASCII
  RECORDS                  = 1
  DESCRIPTION              = "FITS extension header"
END_OBJECT                 = WAVELENGTH_HEADER


OBJECT                     = WAVELENGTH_TABLE
  INTERCHANGE_FORMAT       = BINARY
  ROWS                     = 1024
  COLUMNS                  = 1
  ROW_BYTES                = 4
  DESCRIPTION              = "
    FITS extension containing the wavelength vector in units of
    Angstroms."

  OBJECT                   = COLUMN
    NAME                   = "WAVELENGTH"
```

```
    DATA_TYPE               = IEEE_REAL /* 32-bit floating point */
    BYTES                   = 4
    START_BYTE              = 1
    UNIT                    = "ANGSTROMS"
  END_OBJECT                = COLUMN


END_OBJECT                  = WAVELENGTH_TABLE


OBJECT                      = PIXEL_LIST_HEADER
  BYTES                     = 2880 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE               = FITS
  INTERCHANGE_FORMAT        = ASCII
  RECORDS                   = 1
  DESCRIPTION               = "FITS extension header"
END_OBJECT                  = PIXEL_LIST_HEADER


OBJECT                      = PIXEL_LIST_TABLE
  COLUMNS                   = 5
  ROWS                      = 11791 /* FITS NAXIS2 keyword */
  ROW_BYTES                 = 40
  INTERCHANGE_FORMAT        = ASCII
  DESCRIPTION               = "
    These pixel list data are a 4-column table that lists: X, Y,
    Wavelength, Time Step. Any necessary calibrations (flatfield,
    dark) are applied to that pixel location. The deadtime correction
    is applied to the total counts in a timestep. Photons appearing at
    different X,Y positions during a particular timestep are listed,
    in the order detected, as records with the same Time Step value."

  OBJECT                    = COLUMN
    NAME                    = "X_POSITION"
    DATA_TYPE               = ASCII_INTEGER
    BYTES                   = 4
    START_BYTE              = 1
  END_OBJECT                = COLUMN

  OBJECT                    = COLUMN
    NAME                    = "Y_POSITION"
    DATA_TYPE               = ASCII_INTEGER
    BYTES                   = 3
    START_BYTE              = 5
  END_OBJECT                = COLUMN

  OBJECT                    = COLUMN
    NAME                    = "WAVELENGTH"
    DESCRIPTION             = "Calibrated wavelength of pixel list event"
    DATA_TYPE               = ASCII_REAL /* IEEE floating point */
    BYTES                   = 8
    START_BYTE              = 8
    UNIT                    = "ANGSTROMS"
```

```
  END_OBJECT                 = COLUMN

  OBJECT                     = COLUMN
    NAME                     = "TIME_STEP"
    DATA_TYPE                = ASCII_INTEGER
    BYTES                    = 6 /* Each item is Integer*2 (short integer) */
    START_BYTE               = 16
  END_OBJECT                 = COLUMN


END_OBJECT                   = PIXEL_LIST_TABLE


OBJECT                       = COUNT_RATE_HEADER
  BYTES                      = 2880 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE                = FITS
  INTERCHANGE_FORMAT         = ASCII
  RECORDS                    = 1
  DESCRIPTION                = "FITS extension header"
END_OBJECT                   = COUNT_RATE_HEADER


OBJECT                       = COUNT_RATE_SERIES
  INTERCHANGE_FORMAT         = BINARY
  ROWS                       = 221 /* FITS NAXIS1 keyword */
  COLUMNS                    = 1
  ROW_BYTES                  = 2
  SAMPLING_PARAMETER_INTERVAL= 0.00800000
  SAMPLING_PARAMETER_NAME    = TIME
  SAMPLING_PARAMETER_UNIT    = SECONDS
  DESCRIPTION                = "
    These count rate data are a vector that gives the count rate
    measurements as reconstructed from the pixel list observation.
    Units are raw counts per time hack interval"

  OBJECT                     = COLUMN
    NAME                     = "COUNTS"
    DATA_TYPE                = MSB_INTEGER
    START_BYTE               = 1
    BYTES                    = 2
    OFFSET                   = 32768 /* FITS BZERO keyword */
  END_OBJECT                 = COLUMN
END_OBJECT                   = COUNT_RATE_SERIES


END
```

4.7 CNT, Level 2 (engineering count rate data)

```
PDS_VERSION_ID               = PDS3
```

```
/* FILE CHARACTERISTICS DATA ELEMENTS */

RECORD_TYPE               = FIXED_LENGTH
RECORD_BYTES              = 2880 /* FITS standard record length */
FILE_RECORDS              = 8
FILE_NAME                 = "RA_040419231322_CNT0_ENG.LBL"
DATA_FORMAT               = FITS


/* DATA OBJECT POINTERS IDENTIFICATION DATA ELEMENTS */
^HEADER                   = ("RA_040419231322_CNT0_ENG.FIT",1)
^COUNT_RATE_HEADER        = ("RA_040419231322_CNT0_ENG.FIT",7)
^COUNT_RATE_SERIES        = ("RA_040419231322_CNT0_ENG.FIT",8)
```

┌───┐
│ *N.B.: The formats of the following sets of data elements are identical to* │
│ *those in Section 4.1, so their descriptions are omitted here:*   │
│   /* OBSERVATION AND EXPOSURE DATA ELEMENTS */   │
│   /* INSTRUMENT AND MISSION DESCRIPTIVE DATA ELEMENTS */   │
│   /* PRODUCT AND DATA SET DATA ELEMENTS */   │
│   /* STRUCTURE DEFINITION OF INSTRUMENT PARAMETER OBJECTS */   │
│   /* DESCRIPTION OF INSTRUMENT */   │
│   /* PARAMETERS INDEX FILE DEFINITION */   │
│   /* MISSION SPECIFIC KEYWORDS */   │
└───┘

```
/* DATA OBJECT DEFINITIONS */

OBJECT                    = COUNT_RATE_HEADER
  BYTES                   = 17280 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE             = FITS
  INTERCHANGE_FORMAT      = ASCII
  RECORDS                 = 6
  DESCRIPTION             = "FITS extension header"
END_OBJECT                = COUNT_RATE_HEADER


OBJECT                    = COUNT_RATE_SERIES
  COLUMNS                 = 1
  ROWS                    = 1000 /* FITS NAXIS1 keyword */
  ROW_BYTES               = 2
  INTERCHANGE_FORMAT      = BINARY
  SAMPLING_PARAMETER_INTERVAL= 0.090000000
  SAMPLING_PARAMETER_NAME = TIME
  SAMPLING_PARAMETER_UNIT = SECONDS
  DESCRIPTION             = "
    These count rate data are a table that gives the count rate
    measurements as reconstructed from the pixel list observation.
    Units are raw counts per time hack interval"

  OBJECT                  = COLUMN
```

```
      NAME                      = "COUNT_RATE"
      DATA_TYPE                 = MSB_INTEGER
      BYTES                     = 2
      START_BYTE                = 1
      ITEM_BYTES                = 2 /* 16-bit signed integer */
      OFFSET                    = 32768 /* FITS TZERO1 keyword */
  END_OBJECT                    = COLUMN
END_OBJECT                      = COUNT_RATE_SERIES


END
```

4.8 CNT, Level 3 (science count rate data)

```
PDS_VERSION_ID            = PDS3


/* FILE CHARACTERISTICS DATA ELEMENTS */

RECORD_TYPE               = FIXED_LENGTH
RECORD_BYTES              = 2880 /* FITS standard record length */
FILE_RECORDS              = 15
FILE_NAME                 = "RA_040419231322_CNT0_SCI.LBL"
DATA_FORMAT               = FITS


/* DATA OBJECT POINTERS IDENTIFICATION DATA ELEMENTS */
^HEADER                   = ("RA_040419231322_CNT0_SCI.FIT",1)
^COUNT_RATE_HEADER        = ("RA_040419231322_CNT0_SCI.FIT",13)
^COUNT_RATE_SERIES        = ("RA_040419231322_CNT0_SCI.FIT",14)
```

```
N.B.: The formats of the following sets of data elements are identical to
those in Section 4.1, so their descriptions are omitted here:
      /* OBSERVATION AND EXPOSURE DATA ELEMENTS */
      /* INSTRUMENT AND MISSION DESCRIPTIVE DATA ELEMENTS */
      /* PRODUCT AND DATA SET DATA ELEMENTS */
      /* STRUCTURE DEFINITION OF INSTRUMENT PARAMETER OBJECTS */
      /* DESCRIPTION OF INSTRUMENT */
      /* PARAMETERS INDEX FILE DEFINITION */
      /* MISSION SPECIFIC KEYWORDS */
```

```
N.B.: The formats of the following sets of data elements are identical to
those in Section 4.2, so their descriptions are omitted here:
      /* OBSERVATION GEOMETRY ELEMENTS */
      /* S/C TO TARGET ELEMENTS */
      /* INSTRUMENT BORESIGHT LINE OF SIGHT ELEMENTS */
```

```
/* DATA OBJECT DEFINITIONS */
```

```
OBJECT                    = COUNT_RATE_HEADER
  BYTES                   = 34560 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE             = FITS
  INTERCHANGE_FORMAT      = ASCII
  RECORDS                 = 12
  DESCRIPTION             = "FITS extension header"
END_OBJECT                = COUNT_RATE_HEADER

OBJECT                    = COUNT_RATE_SERIES
  COLUMNS                 = 1
  ROWS                    = 1000 /* FITS NAXIS1 keyword */
  ROW_BYTES               = 4
  INTERCHANGE_FORMAT      = BINARY
  SAMPLING_PARAMETER_INTERVAL= 0.090000000
  SAMPLING_PARAMETER_NAME = TIME
  SAMPLING_PARAMETER_UNIT = SECONDS
  DESCRIPTION             = "
    These count rate data are a table that gives the count rate
    measurements as reconstructed from the pixel list observation.
    Units are raw counts per time hack interval"

  OBJECT                  = COLUMN
    NAME                  = "COUNT_RATE"
    DATA_TYPE             = MSB_INTEGER
    BYTES                 = 4
    START_BYTE            = 1
    ITEM_BYTES            = 4 /* 32-bit floating point */
    OFFSET                = 32768 /* FITS TZERO1 keyword */
  END_OBJECT              = COLUMN
END_OBJECT                = COUNT_RATE_SERIES

END
```

4.9 HKTM (housekeeping telemetry data)

```
PDS_VERSION_ID            = PDS3


/*  FILE CHARACTERISTICS DATA ELEMENTS */

RECORD_TYPE               = FIXED_LENGTH
RECORD_BYTES              = 449
FILE_RECORDS              = 3210
FILE_NAME                 = "RA_040322224947_HKTM_ENG.LBL"  /* this label

/* DATA OBJECT POINTERS IDENTIFICATION DATA ELEMENTS */

^HOUSEKEEPING_TABLE       = ("RA_040322224947_HKTM_ENG.TAB",1)

/* TIME RANGE DATA ELEMENTS */
```

```
START_TIME                   = 2004-03-22T22:49:47.995  /* UTC */
STOP_TIME                    = 2004-03-23T06:50:49.512 /* UTC */
SPACECRAFT_CLOCK_START_COUNT = "1/41.511" /* OBT */
SPACECRAFT_CLOCK_STOP_COUNT  = "1/38645435.812" /* OBT */


/* OBSERVATION AND EXPOSURE DATA ELEMENTS */

INSTRUMENT_MODE_ID       = "N/A"
INSTRUMENT_MODE_DESC     = "N/A"
EXPOSURE_DURATION        = "N/A"
DATA_QUALITY_ID          = 0
DATA_QUALITY_DESC        = "Data quality is nominal"
MISSION_PHASE_NAME       = "COMMISSIONING 1"

/* see Phase Definition table in RSOC Design Specification, */
/* RO-EST-PL-2010 and Archive GVT Plan, RO-EST-PL-5011 */
TARGET_NAME              = "N/A"
TARGET_TYPE              = HOUSEKEEPING
```

N.B.: The formats of the following sets of data elements are identical to those in Section 4.1, so their descriptions are omitted here:
```
     /* INSTRUMENT AND MISSION DESCRIPTIVE DATA ELEMENTS */
     /* PRODUCT AND DATA SET DATA ELEMENTS */
     /* STRUCTURE DEFINITION OF INSTRUMENT PARAMETER OBJECTS */
     /* DESCRIPTION OF INSTRUMENT */
     /* PARAMETERS INDEX FILE DEFINITION */
     /* MISSION SPECIFIC KEYWORDS */
```

```
/* DATA OBJECT DEFINITION */

OBJECT = HOUSEKEEPING_HEADER
  BYTES       = 3903
  HEADER_TYPE = PLAIN_TEXT
END_OBJECT = HOUSEKEEPING_HEADER

OBJECT = HOUSEKEEPING_TABLE
  INTERCHANGE_FORMAT = ASCII
  ROWS               = 865
  COLUMNS            = 73
  ROW_BYTES          = 442
  DESCRIPTION        = "Parameter values from Alice housekeeping telemetry
(HKTM) data."

  OBJECT = COLUMN
    NAME        = "ScetR"
    DATA_TYPE   = IEEE_REAL
    STARTBYTE   = 1
```

```
    BYTES        = 15
    DESCRIPTION = "SpaceCraft Event Time (secs since 1970)"
    UNIT         = counts
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME         = "ScetC"
    DATA_TYPE    = CHARACTER
    STARTBYTE    = 15
    BYTES        = 24
    DESCRIPTION = "SpaceCraft Event Time (UTC)"
    UNIT         = "N/A"
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME         = "InstTime"
    DATA_TYPE    = IEEE_REAL
    STARTBYTE    = 39
    BYTES        = 15
    DESCRIPTION = "Alice instrument time (OBT, seconds)"
    UNIT         = counts
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME         = "TOffset"
    DATA_TYPE    = IEEE_REAL
    STARTBYTE    = 54
    BYTES        = 15
    DESCRIPTION = "Alice OBT offset from SCET (seconds)"
    UNIT         = "N/A"
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME         = "InstSync"
    DATA_TYPE    = MSB_INTEGER
    STARTBYTE    = 69
    BYTES        = 2
    DESCRIPTION = "Alice instrument time synchronized"
    UNIT         = "N/A"
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME         = "HvOn"
    DATA_TYPE    = CHARACTER
    STARTBYTE    = 71
    BYTES        = 4
    DESCRIPTION = "HkHvOn"
    UNIT         = "N/A"
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME         = "DetStim"
```

```
    DATA_TYPE   = CHARACTER
    STARTBYTE   = 75
    BYTES       = 5
    DESCRIPTION = "HkDetStim"
    UNIT        = "N/A"
 END_OBJECT = COLUMN

 OBJECT = COLUMN
   NAME        = "AcqMode"
   DATA_TYPE   = CHARACTER
   STARTBYTE   = 80
   BYTES       = 10
   DESCRIPTION = "HkAcqCountRate/HkAcqMode"
   UNIT        = "N/A"
 END_OBJECT = COLUMN

 OBJECT = COLUMN
   NAME        = "AcqActiv"
   DATA_TYPE   = CHARACTER
   STARTBYTE   = 90
   BYTES       = 4
   DESCRIPTION = "HkAcqActive"
   UNIT        = "N/A"
 END_OBJECT = COLUMN

 OBJECT = COLUMN
   NAME        = "DetDoor"
   DATA_TYPE   = CHARACTER
   STARTBYTE   = 94
   BYTES       = 7
   DESCRIPTION = "HkDetDoor"
   UNIT        = "N/A"
 END_OBJECT = COLUMN

 OBJECT = COLUMN
   NAME        = "ApDoor"
   DATA_TYPE   = CHARACTER
   STARTBYTE   = 101
   BYTES       = 8
   DESCRIPTION = "HkApDoor"
   UNIT        = "N/A"
 END_OBJECT = COLUMN

 OBJECT = COLUMN
   NAME        = "Code"
   DATA_TYPE   = CHARACTER
   STARTBYTE   = 109
   BYTES       = 8
   DESCRIPTION = "EEPromCode/EEPromPage"
   UNIT        = "N/A"
 END_OBJECT = COLUMN
```

```
OBJECT = COLUMN
  NAME        = "State"
  DATA_TYPE   = CHARACTER
  STARTBYTE   = 117
  BYTES       = 9
  DESCRIPTION = "HkState"
  UNIT        = "N/A"
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "MirrHtr"
  DATA_TYPE   = CHARACTER
  STARTBYTE   = 126
  BYTES       = 4
  DESCRIPTION = "HkMirrorHtrOn"
  UNIT        = "N/A"
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "GratHtr"
  DATA_TYPE   = CHARACTER
  STARTBYTE   = 130
  BYTES       = 4
  DESCRIPTION = "HkGratingHtrOn"
  UNIT        = "N/A"
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "CntRate"
  DATA_TYPE   = MSB_INTEGER
  STARTBYTE   = 134
  BYTES       = 6
  DESCRIPTION = "HkCountRate"
  UNIT        = Hz
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "CntRateL"
  DATA_TYPE   = MSB_INTEGER
  STARTBYTE   = 140
  BYTES       = 6
  DESCRIPTION = "HkCountRateLo"
  UNIT        = Hz
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "CntRateH"
  DATA_TYPE   = MSB_INTEGER
  STARTBYTE   = 146
  BYTES       = 6
  DESCRIPTION = "HkCountRateHi"
  UNIT        = Hz
```

```
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "HvSetR"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 152
    BYTES       = 4
    DESCRIPTION = "HkHvSet"
    UNIT        = counts
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "HvSetC"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 156
    BYTES       = 5
    DESCRIPTION = ""
    UNIT        = Volt
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "McpVR"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 161
    BYTES       = 4
    DESCRIPTION = "HkMcpV"
    UNIT        = counts
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "McpVC"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 165
    BYTES       = 5
    DESCRIPTION = ""
    UNIT        = Volt
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "McpVLoR"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 170
    BYTES       = 4
    DESCRIPTION = "HkMcpVlo"
    UNIT        = counts
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "McpVLoC"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 174
    BYTES       = 5
```

```
      DESCRIPTION = ""
      UNIT        = Volt
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "McpVHiR"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 179
    BYTES       = 4
    DESCRIPTION = "HkMcpVhi"
    UNIT        = counts
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "McpVHiC"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 183
    BYTES       = 5
    DESCRIPTION = ""
    UNIT        = Volt
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "AnoVR"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 188
    BYTES       = 4
    DESCRIPTION = "HkAnodeV"
    UNIT        = counts
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "AnoVC"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 192
    BYTES       = 4
    DESCRIPTION = ""
    UNIT        = Volt
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "AnoVLoR"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 196
    BYTES       = 4
    DESCRIPTION = "HkAnodeVlo"
    UNIT        = counts
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "AnoVLoC"
    DATA_TYPE   = MSB_INTEGER
```

```
    STARTBYTE   = 200
    BYTES       = 4
    DESCRIPTION = ""
    UNIT        = Volt
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "AnoVHiR"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 204
    BYTES       = 4
    DESCRIPTION = "HkAnodeVhi"
    UNIT        = counts
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "AnoVHiC"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 208
    BYTES       = 4
    DESCRIPTION = ""
    UNIT        = Volt
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "StrIR"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 212
    BYTES       = 4
    DESCRIPTION = "HkStripI"
    UNIT        = counts
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "StrIC"
    DATA_TYPE   = IEEE_REAL
    STARTBYTE   = 216
    BYTES       = 6
    DESCRIPTION = ""
    UNIT        = microAmp
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "StrILoR"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 222
    BYTES       = 4
    DESCRIPTION = "HkStripIlo"
    UNIT        = counts
  END_OBJECT = COLUMN

  OBJECT = COLUMN
```

```
   NAME         = "StrILoC"
   DATA_TYPE    = IEEE_REAL
   STARTBYTE    = 226
   BYTES        = 6
   DESCRIPTION = ""
   UNIT         = microAmp
 END_OBJECT = COLUMN

 OBJECT = COLUMN
   NAME         = "StrIHiR"
   DATA_TYPE    = MSB_INTEGER
   STARTBYTE    = 232
   BYTES        = 4
   DESCRIPTION = "HkStripIhi"
   UNIT         = counts
 END_OBJECT = COLUMN

 OBJECT = COLUMN
   NAME         = "StrIHiC"
   DATA_TYPE    = IEEE_REAL
   STARTBYTE    = 236
   BYTES        = 6
   DESCRIPTION = ""
   UNIT         = microAmp
 END_OBJECT = COLUMN

 OBJECT = COLUMN
   NAME         = "T_Mirr1R"
   DATA_TYPE    = MSB_INTEGER
   STARTBYTE    = 242
   BYTES        = 4
   DESCRIPTION = "HkMirrorTempPri"
   UNIT         = counts
 END_OBJECT = COLUMN

 OBJECT = COLUMN
   NAME         = "T_Mirr1C"
   DATA_TYPE    = IEEE_REAL
   STARTBYTE    = 246
   BYTES        = 6
   DESCRIPTION = ""
   UNIT         = degC
 END_OBJECT = COLUMN

 OBJECT = COLUMN
   NAME         = "T_Mirr2R"
   DATA_TYPE    = MSB_INTEGER
   STARTBYTE    = 252
   BYTES        = 4
   DESCRIPTION = "HkMirrorTempSec"
   UNIT         = counts
 END_OBJECT = COLUMN
```

```
OBJECT = COLUMN
  NAME        = "T_Mirr2C"
  DATA_TYPE   = IEEE_REAL
  STARTBYTE   = 256
  BYTES       = 6
  DESCRIPTION = ""
  UNIT        = degC
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "TS_MirrR"
  DATA_TYPE   = MSB_INTEGER
  STARTBYTE   = 262
  BYTES       = 4
  DESCRIPTION = "HkMirrorHtrSet"
  UNIT        = counts
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "TS_MirrC"
  DATA_TYPE   = IEEE_REAL
  STARTBYTE   = 266
  BYTES       = 6
  DESCRIPTION = ""
  UNIT        = degC
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "T_Grat1R"
  DATA_TYPE   = MSB_INTEGER
  STARTBYTE   = 272
  BYTES       = 4
  DESCRIPTION = "HkGratingTempPri"
  UNIT        = counts
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "T_Grat1C"
  DATA_TYPE   = IEEE_REAL
  STARTBYTE   = 276
  BYTES       = 6
  DESCRIPTION = ""
  UNIT        = degC
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "T_Grat2R"
  DATA_TYPE   = MSB_INTEGER
  STARTBYTE   = 282
  BYTES       = 4
  DESCRIPTION = "HkGratingTempSec"
```

```
   UNIT        = counts
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "T_Grat2C"
  DATA_TYPE   = IEEE_REAL
  STARTBYTE   = 286
  BYTES       = 6
  DESCRIPTION = ""
  UNIT        = degC
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "TS_GratR"
  DATA_TYPE   = MSB_INTEGER
  STARTBYTE   = 292
  BYTES       = 4
  DESCRIPTION = "HkGratingHtrSet"
  UNIT        = counts
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "TS_GratC"
  DATA_TYPE   = IEEE_REAL
  STARTBYTE   = 296
  BYTES       = 6
  DESCRIPTION = ""
  UNIT        = degC
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "DetDiscR"
  DATA_TYPE   = MSB_INTEGER
  STARTBYTE   = 302
  BYTES       = 4
  DESCRIPTION = "HkDetDiscr"
  UNIT        = counts
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "DetDiscC"
  DATA_TYPE   = IEEE_REAL
  STARTBYTE   = 306
  BYTES       = 5
  DESCRIPTION = ""
  UNIT        = Volt
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "CycRem"
  DATA_TYPE   = MSB_INTEGER
  STARTBYTE   = 311
```

```
     BYTES        = 4
     DESCRIPTION = "HkCyclesRemaining"
     UNIT        = counts
   END_OBJECT = COLUMN

   OBJECT = COLUMN
     NAME        = "LastPrsR"
     DATA_TYPE   = MSB_INTEGER
     STARTBYTE   = 315
     BYTES       = 4
     DESCRIPTION = "HkLastPressure"
     UNIT        = counts
   END_OBJECT = COLUMN

   OBJECT = COLUMN
     NAME        = "LastPrsC"
     DATA_TYPE   = IEEE_REAL
     STARTBYTE   = 319
     BYTES       = 6
     DESCRIPTION = ""
     UNIT        = mbar
   END_OBJECT = COLUMN

   OBJECT = COLUMN
     NAME        = "LastPRaR"
     DATA_TYPE   = MSB_INTEGER
     STARTBYTE   = 325
     BYTES       = 4
     DESCRIPTION = "HkLastPrsRate"
     UNIT        = counts
   END_OBJECT = COLUMN

   OBJECT = COLUMN
     NAME        = "LastPRaC"
     DATA_TYPE   = IEEE_REAL
     STARTBYTE   = 329
     BYTES       = 6
     DESCRIPTION = ""
     UNIT        = mbar/s
   END_OBJECT = COLUMN

   OBJECT = COLUMN
     NAME        = "PresTime"
     DATA_TYPE   = IEEE_REAL
     STARTBYTE   = 335
     BYTES       = 15
     DESCRIPTION = "HkPressureTime (OBT, seconds)"
     UNIT        = counts
   END_OBJECT = COLUMN

   OBJECT = COLUMN
     NAME        = "PresScet"
```

```
    DATA_TYPE   = CHARACTER
    STARTBYTE   = 350
    BYTES       = 24
    DESCRIPTION = "HkPressureTime (SCET, UTC)"
    UNIT        = "N/A"
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "Unsafe"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 374
    BYTES       = 6
    DESCRIPTION = "HkUnsafeTimer"
    UNIT        = sec
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "Safety"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 380
    BYTES       = 4
    DESCRIPTION = "HkSafety"
    UNIT        = "N/A"
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "OverRide"
    DATA_TYPE   = CHARACTER
    STARTBYTE   = 384
    BYTES       = 4
    DESCRIPTION = "HkSafetyOverride"
    UNIT        = "N/A"
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "SafeMask"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 388
    BYTES       = 4
    DESCRIPTION = "HkSafetyMask"
    UNIT        = "N/A"
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "T_DElecR"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 392
    BYTES       = 4
    DESCRIPTION = "HkDetElecTemp"
    UNIT        = counts
  END_OBJECT = COLUMN
```

```
OBJECT = COLUMN
  NAME        = "T_DElecC"
  DATA_TYPE   = IEEE_REAL
  STARTBYTE   = 396
  BYTES       = 6
  DESCRIPTION = ""
  UNIT        = degC
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "T_DHousR"
  DATA_TYPE   = MSB_INTEGER
  STARTBYTE   = 402
  BYTES       = 4
  DESCRIPTION = "HkDetHousingTemp"
  UNIT        = counts
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "T_DHousC"
  DATA_TYPE   = IEEE_REAL
  STARTBYTE   = 406
  BYTES       = 6
  DESCRIPTION = ""
  UNIT        = degC
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "T_CNDHR"
  DATA_TYPE   = MSB_INTEGER
  STARTBYTE   = 412
  BYTES       = 4
  DESCRIPTION = "HkCdhElecTemp"
  UNIT        = counts
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "T_CNDHC"
  DATA_TYPE   = IEEE_REAL
  STARTBYTE   = 416
  BYTES       = 6
  DESCRIPTION = ""
  UNIT        = degC
END_OBJECT = COLUMN

OBJECT = COLUMN
  NAME        = "T_IHousR"
  DATA_TYPE   = MSB_INTEGER
  STARTBYTE   = 422
  BYTES       = 4
  DESCRIPTION = "HkInstrHousingTemp"
  UNIT        = counts
```

```
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "T_IHousC"
    DATA_TYPE   = IEEE_REAL
    STARTBYTE   = 426
    BYTES       = 6
    DESCRIPTION = ""
    UNIT        = degC
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "TestStat"
    DATA_TYPE   = MSB_INTEGER
    STARTBYTE   = 432
    BYTES       = 4
    DESCRIPTION = "HkTestStatus"
    UNIT        = "N/A"
  END_OBJECT = COLUMN

  OBJECT = COLUMN
    NAME        = "SwVers"
    DATA_TYPE   = IEEE_REAL
    STARTBYTE   = 436
    BYTES       = 6
    DESCRIPTION = "HkAfsVersion"
    UNIT        = "N/A"
  END_OBJECT = COLUMN

END_OBJECT = HOUSEKEEPING_TABLE
```

4.10 Sample FITS header

Below is a sample of a FITS header from an *Alice* histogram calibrated science data file. Note this is the *main* header, and that the headers for *extensions* in the FITS files are "minimal" headers that do not contain much descriptive information about the contents of the data block. Some of the comments (the text following the forward slash in a line in a FITS header record) are truncated because the line length is limited to 80 characters.

```
SIMPLE  =                    T / Written by IDL:  Fri Mar 26 13:01:12 2010
BITPIX  =                  -32 / Number of bits per data pixel
NAXIS   =                    2 / Number of data axes
NAXIS1  =                 1024 / histogram spectral axis size (1-1024)
NAXIS2  =                   32 / histrogram spatial axis size (1-32)
EXTEND  =                    T / Fits data may contain extensions
ORIGIN  =               'SwRI' / Southwest Research Institute (R)
DATE    = '2010-02-12T04:39:52' / file creation/processing date/time
LIMA_VER=               '0.16' / LIMA software version number
LIMA_DAT=         ' 2007-02-26' / LIMA software version date
MISSION =            'Rosetta' / ESA comet exploration mission
```

```
INSTRUME=               'R-Alice' / Ultra-Violet Spectrometer
                              /
COMMENT Alice Histogram data acquisition: Received Histogram data
BUNIT  = 'photons cm**-2 s**-1' / Units of data in the primary HDU
BZERO  =              0.00000 / Data are 32 bit floating point numbers
BSCALE =              1.00000 / No scaling applied to data
                              /
COMMENT Science TM Packet re-assembly results
TOTLPKTS=                  19 / expected number of packets
RECVPKTS=                  19 / received number of packets
LOSTPKTS=                   0 / missing packets (bitmask)
                              /
COMMENT Acquisition common: used calibration files
L_CALDIR= '../../../data/cal/lima/' / directory of LIMA calibration data
CALHVSET=     'ra_hvs_000.cal' / high voltage set calibration file
CALMCPV =     'ra_mcp_000.cal' / microchannel plate voltage calibration file
CALANOV =     'ra_ano_000.cal' / anode voltage calibration file
CALSTPI =     'ra_stp_000.cal' / strip current calibration file
CALDISC =     'ra_dis_000.cal' / discriminator voltage calibration file
CALTEMP =     'ra_tmp_000.cal' / temperature calibration file (all channels)
                              /
COMMENT Acquisition common section 1
SCETR  =       1172389756.810 / SpaceCraft Event Time (seconds since 1970)
SCETC  = '2007-02-25T07:49:16.810' / SpaceCraft Event Time (UTC)
INSTTIME=        131010527.893 / Alice Instrument time (OBT)
TOFFSET =       1041379228.917 / Alice OBT offset from SCET (seconds)
MCPMAXVR=                  132 / Mcp high level during acquisition (ADC
counts)
MCPMAXVC=                -3727 / McpMaxV (Volt)
MCPMINVR=                  132 / Mcp low level during acquisition (ADC
counts)
MCPMINVC=                -3727 / McpMinV (Volt)
MCPSTRVR=                  132 / Mcp level at start of acquisition (ADC
counts)
MCPSTRVC=                -3727 / McpStartV (Volt)
MCPSTPVR=                  132 / Mcp level at end of acquisition (ADC counts)
MCPSTPVC=                -3727 / McpStopV (Volt)
STRMAXIR=                   67 / strip current high level during acquisition
(AD
STRMAXIC=                 6.04 / StripMaxI (microAmp)
STRMINIR=                   63 / strip current low level during acquisition
(ADC
STRMINIC=                 5.84 / StripMinI (microAmp)
STRSTRIR=                   65 / strip current at start of acquisition (ADC
coun
STRSTRIC=                 5.94 / StripStartI (microAmp)
STRSTPIR=                   64 / strip current at end of acquisition (ADC
counts
STRSTPIC=                 5.89 / StripStopI (microAmp)
                              /
COMMENT Common Housekeeping section; Hk acquired at start of data dump
HVON   =                 'on' / HkHvOn (on/off)
```

```
DETSTIM =                 'stim' / HkDetStim (stim/off)
ACQMODE    =                          'Histogram'    /    AcquisitionMode
(PixelList/Histogram/CountRate)
ACQACTIV=                  'off' / HkAcqActive (on/off)
DETDOOR =                  'open' / HkDetDoor (open/closed)
APDOOR  =                  'open' / HkApDoor (error/closed/open/between)
CODE    =              'EEPROM3' / HkEEPromCode/HkEEPromPage (PROM/EEPROM0-3)
STATE      =                              'dump'   /   HkState
(checkout/acquire/dump/safe/hold/safedu
MIRRHTR =                  'off' / HkMirrorHtrOn (on/off)
GRATHTR =                  'off' / HkGratingHtrOn (on/off)
CNTRATE =                  2417 / HkCountRate (Hz)
CNTRATEL=                  2417 / HkCountRateLo (Hz)
CNTRATEH=                  2557 / HkCountRateHi (Hz)
HVSETR  =                   136 / High Voltage Set Point (DAC counts)
HVSETC  =                 -3821 / HkHvSet (Volt)
MCPVR   =                   132 / Mcp Voltage (ADC counts)
MCPVC   =                 -3819 / HkMcpV (Volt)
MCPVLOR =                   132 / Mcp Voltage low level during Hk period (ADC
cou
MCPVLOC =                 -3819 / HkMcpVlo (Volt)
MCPVHIR =                   132 / Mcp Voltage high level during Hk period (ADC
co
MCPVHIC =                 -3819 / HkMcpVhi (Volt)
ANOVR   =                   228 / Anode Voltage (ADC counts)
ANOVC   =                  -604 / HkAnodeV (Volt)
ANOVLOR =                   228 / Anode Voltage low level during Hk period
(ADC c
ANOVLOC =                  -604 / HkAnodeVlo (Volt)
ANOVHIR =                   229 / Anode Voltage high level during Hk period
(ADC
ANOVHIC =                  -607 / HkAnodeVhi (Volt)
STRPIR  =                    64 / Strip Current (ADC counts)
STRPIC  =                  5.89 / HkStripI (microAmp)
STRPILOR=                    64 / Strip Current low level during Hk period
(ADC c
STRPILOC=                  5.89 / HkStripIlo (microAmp)
STRPIHIR=                    66 / Strip Current high level during Hk period
(ADC
STRPIHIC=                  5.99 / HkStripIhi (microAmp)
T_MIRR1R=                    75 / Mirror Temperature 1 (ADC counts)
T_MIRR1C=                  15.3 / HkMirrorTempPri (degC)
T_MIRR2R=                    74 / Mirror Temperature 2 (ADC counts)
T_MIRR2C=                  14.9 / HkMirrorTempSec (degC)
TS_MIRRR=                     0 / Mirror Heater Set Point (ADC counts)
TS_MIRRC=                 -33.3 / HkMirrorHtrSet (degC)
T_GRAT1R=                    72 / Grating Temperature 1 (ADC counts)
T_GRAT1C=                  14.1 / HkGratingTempPri (degC)
T_GRAT2R=                    71 / Grating Temperature 2 (ADC counts)
T_GRAT2C=                  13.7 / HkGratingTempSec (degC)
TS_GRATR=                     0 / Grating Heater Set Point (ADC counts)
TS_GRATC=                 -33.3 / HkGratingHtrSet (degC)
```

```
DETDISCR=                     9 / Detector Dicriminator readback (ADC counts)
DETDISCC=                  0.11 / HkDetDiscr (Volt)
CYCLSREM=                     1 / HkCyclesRemaining (in current MAD command)
LASTPRSR=                    31 / Last reported ROSINA pressure (RosinaReal)
LASTPRSC=                  1E-15 / HkLastPressure (mbar)
LASTPRAR=                     0 / Last reported ROSINA pressure trend
(RosinaReal
LASTPRAC=                 0E-00 / HkLastPrsRate (mbar/s)
PRESTIME=       1845493760.000 / HkPressureTime (instrument time)
PRESSCET= '0000-01-01T00:00:00.000' / HkPressureTime (SCET)
SAFETIME=                     0 / HkUnsafeTimer (sec, timeout remaining)
SAFETY  =                     0 / HkSafety (bitmask)
SAFEOVER=                 'off' / HkSafetyOverride (on/off)
SAFEMASK=                     0 / HkSafetyMask (bitmask)
T_DELECR=                    87 / Detector Electronics Temperature (ADC
counts)
T_DELECC=                  19.8 / HkDetElecTemp (degC)
T_DHOUSR=                    74 / Detector Housing temperature (ADC counts)
T_DHOUSC=                  14.9 / HkDetHousingTemp (degC)
T_CDHR  =                    97 / C&DH Electronics Temperature (ADC counts)
T_CDHC  =                  23.6 / HkCdhElecTemp (degC)
T_IHOUSR=                    73 / Instrument Housing Temperature (ADC counts)
T_IHOUSC=                  14.5 / HkInstrHousingTemp (degC)
TESTSTAT=                     0 / HkTestStatus (bitmask)
SOFTVERS=                '2.04' / HkAfsVersion (version number of instrument
sw)
                              /
COMMENT Common Instrument Parameter section
HSNSGRAT=                 'pri' / PmHtrSenseGrating (pri/sec)
HSNSMIRR=                 'pri' / PmHtrSenseMirror (pri/sec)
DOORENA =             'enabled' / PmDoorEnable (enabled/disabled)
DACADCFR=                   231 / PmDacAdcFactor (/240)
DACADCFC=                 0.963 / conversion factor from HvSet to McpV
EVNTSAFT=              'ground' / PmEventSafety (ground/on-board)
DISCSETR=                    10 / Discriminator acquisition setpoint (DAC
counts)
DISCSETC=                  0.12 / PmDiscriminator (Volt)
HOTSEG1 =             '0-0000' / PmHotSeg1: spatial-spectral
HOTSEG2 =             '0-0000' / PmHotSeg2: spatial-spectral
HOTSEG3 =             '0-0000' / PmHotSeg3: spatial-spectral
HOTSEG4 =             '0-0000' / PmHotSeg4: spatial-spectral
HOTSEG5 =             '0-0000' / PmHotSeg5: spatial-spectral
HOTSEG6 =             '0-0000' / PmHotSeg6: spatial-spectral
HOTSEG7 =             '0-0000' / PmHotSeg7: spatial-spectral
HOTSEG8 =             '0-0000' / PmHotSeg8: spatial-spectral
HVLEVELR=                   136 / HV acquisition setpoint (DAC counts)
HVLEVELC=                 -3821 / PmHvLevel (Volt)
HVSTEPR =                     4 / HV step size (DAC counts)
HVSTEPC =                   -92 / PmHvStepSize (Volt)
HVRTIMR =                     2 / HV runtime (kernel ticks)
HVRTIMC =                   0.2 / PmHvRunTime (sec)
MAXSTRIR=                   168 / Maximum Strip Current (ADC counts)
```

```
MAXSTRIC=                  10.96 / PmHvMaxStripI (microAmp)
MINANOVR=                    188 / Minimum Anode Voltage (ADC counts)
MINANOVC=                   -499 / PmHvMinAnodeV (Volt)
MAXANOVR=                    245 / Maximum Anode Voltage (ADC counts)
MAXANOVC=                   -649 / PmHvMaxAnodeV (Volt)
MCPTOLR =                      8 / HV-Mcp tolerance (delta ADC counts)
MCPTOLC =                    184 / PmHvMcpTol (Volt)
ANOFAIL =                      4 / PmHvFailAnode (count)
MCPFAIL =                      4 / PmHvFailMcp (count)
STPFAIL =                      4 / PmHvFailStrip (count)
DOORSENS=              'enabled' / Door sensor enabled (top bit PmDoorTimeout)
DOORTIME=                      2 / Aperture Door control time, PmDoorTimeout
(sec)
CNTINTVR=                     10 / Detector event counter interval (kernel
ticks)
CNTINTVC=                   0.96 / PmCounterInterval (sec)
CNTSLOTS=                    100 / PmCountSlots (fixed at afs compile time)
MAXPRESR=                     21 / Pressure Limit (Rosina Real)
MAXPRESC=                  1E-05 / PmMaxPressure (mbar)
PTIMMARR=                     60 / Pressure trend time horizon (sec*10)
PTIMMARC=                    600 / PmPressTimeMargin (sec)
T_MAXR  =                    192 / Maximum temperature (ADC counts)
T_MAXC  =                   57.7 / PmMaxTemp (degC)
T_MASK  =                    255 / PmTempMask (bitmask)
TOLGRATR=                      8 / Grating heater temperature tolerance (ADC
cnts)
TOLGRATC=                    3.0 / PmHtrTolGrating (degC)
TOLMIRRR=                      8 / Mirror heater temperature tolerance (ADC
counts
TOLMIRRC=                    3.0 / PmHtrTolMirror (degC)
TSTMASK =                      0 / PmTestMask (bitmask)
HKRATE  =                     30 / PmHkRate (sec, Hk generation rate)
DIAGENA =                  'off' / PmDiagEnable (diag/off)
MAXCOUNT=                  40000 / PmMaxCountRate (Hz, safety limit)
SAFTIME =                    600 / PmSafetyTimeout (sec)
MAXDUST =                     30 / PmMaxDust (part/dm2/sec?, safety limit)
                                /
COMMENT Acquisition common section 2
PRSMAXR =                     31 / high ROSINA pressure reported during
acquisitio
PRSMAXC =                  1E-15 / PressMax (mbar)
PRSMINR =                    144 / low ROSINA pressure reported during
acquisition
PRSMINC =                  9E-00 / PressMin (mbar)
STRTTIME=          131008713.511 / exposure start time (instrument time)
STRTSCET= '2007-02-25T07:19:02.427' / exposure start time (SCET)
DATE-OBS= '2007-02-25T07:19:02.427' / exposure start time (SCET)
STOPTIME=          131010527.885 / exposure stop time (instrument time)
STOPSCET= '2007-02-25T07:49:16.802' / exposure stop time (SCET)
EXPTIME =               1814.375 / Calculated actual exposure time (seconds)
OPENTIME=                1814.38 / Time aperture door was open
CLOSTIME=                0.00000 / Time aperture door was closed
```

```
DUMPNO  =                      0 / DumpNo, dump specification number (0-7)
DETCNTS =                4929498 / DetectorCounts, total counts from detector
even
                               /
COMMENT Histogram acquisition specific keywords
ACQTIME =                   1800 / AcqTime, commanded integration time (sec)
WILOSPEC=                      0 / WinLowSpectral, spectral window lower
(inclusiv
WIHISPEC=                   1023 / WinHighSpectral, spectral window upper
(inclusi
WICOSPEC=                      1 / CollapseSpectral, spectral collapse factor
WILOSPAT=                      0 / WinLowSpatial, spatial window lower
(inclusive)
WIHISPAT=                     31 / WinHighSpatial, spatial window upper
(inclusive
WICOSPAT=                      1 / CollapseSpatial, spatial collapse factor
                               /
COMMENT Calculated event statistics
EVENTS  =                2205881 / Events counted in Histogram
PHDEVNTS=                 428967 / Events counted in PHD

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MIKE_BEG= 'Mar 26 13:01:12 2010' / START MIKE KEYWORD BLOCK
MIKE_VER= '19 [2010 Mar 26]'   / Version of Mike pipeline code
FILE_IN = 'RA_070225071902_HIS0_ENG.FIT' / Input file for processing
FILE_OUT= 'RA_070225071902_HIS3_SCI.FIT' / Output file after processing
DATAQUAL=                      0 / Data quality flag
APDRSRC = 'HK event file'       / Source of aperture door status
BADFILE = '        '            / File containing bad pixel mask
BADFLAG =                      F / Bad pixel mask applied to data?
BADVALUE= 'IEEE NaN'            / Value of bad pixel(s)
DEADFLAG=                      T / Dead-time correction applied?
DARKFLAG=                      T / Dark count correction applied?
DARKFILE= 'RA_DARK_3.8kV_002.FIT' / Detector dark count rate file
DARKSCAL=                1.27725 / Scale factor applied to dark file
FLATFLAG=                      F / Flatfield correction applied?
FLATFILE= '        '            / Detector flatfield file
AEFFFLAG=                      T / Effective area correction applied?
AEFFFILE= 'RA_AEFF_008.TAB'     / Detector effective area file
HVFLAG  =                      F / High voltage correction applied?
HVFILE  = '        '            / High voltage correction file
TVAEFLAG=                      T / Correct for time-variable A_eff?
CORRFILE= 'RA_MARS_PC10_CORRECTION.TAB' / Effective Area correction file
WAVEFLAG=                      T / Stim pixel correction applied?
LINFLAG =                      F / Data resampled onto common wavelength scale?
WAVEFILE= 'RA_WAVE_006.FIT'     / Detector wavelength solution used
MIKE_END= '        '            / END MIKE KEYWORD BLOCK

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COMMENT BEGIN GEOMETRY KEYWORD BLOCK
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COMMENT All values calulated for start time of observation

RA      =        65.8142337287 / Right Ascension of ALICE Boresight [deg.]
DEC     =        21.8709124504 / Declination of ALICE Boresight [deg.]


COMMENT S/C -> Sun Geometry
SCSUNX  =       -18972143.5674 / J2000 EME S/C -> Sun X vector [km]
SCSUNY  =        195683305.439 / J2000 EME S/C -> Sun Y vector [km]
SCSUNZ  =        90265665.7906 / J2000 EME S/C -> Sun Z vector [km]
SCSUNVX =       -21.5042533559 / X vel. of Sun wrt S/C in [km/s] (J2000 EME)
SCSUNVY =        3.30735071195 / Y vel. of Sun wrt S/C in [km/s] (J2000 EME)
SCSUNVZ =        2.12469639072 / Z vel. of Sun wrt S/C in [km/s] (J2000 EME)
SCSUNLON=        209.504261708 / Sub solar longitude [deg.] (planetographic)
SCSUNLAT=        1.07779260836 / Sub solar latitude [deg.] (planetographic)


COMMENT S/C -> Target Geometry
OBS_TYPE= '"MARS"  '             / Epoch of observation, e.g., PC6 or Steins
flyby
TARGNAME= 'MARS    '             / Name of observation target
TARGTYPE= 'PLANET  '             / Type of observation target
TARGDESC= 'Mars    '             / Description of observation target
TARG_RA =        65.8301577740 / Right ascension of target [deg]
TARG_DEC=        21.8655652420 / Declination of target [deg]
SCTARGX =        65210.9681397 / J2000 EME S/C -> target X vector [km]
SCTARGY =        145305.488553 / J2000 EME S/C -> target Y vector [km]
SCTARGZ =        63913.9867847 / J2000 EME S/C -> target Z vector [km]
TARGDIST=        171613.382567 / Distance to target center [km]
SCTARGVX=        3.54557389891 / X vel. of target wrt S/C in [km/s] (J2000
EME)
SCTARGVY=        7.38340417000 / Y vel. of target wrt S/C in [km/s] (J2000
EME)
SCTARGVZ=        3.31748543788 / Z vel. of target wrt S/C in [km/s] (J2000
EME)
SCLON   =        230.977553395 / Sub-Spacecraft planetographic longitude
[deg.]
SCLAT   =        -7.11670811521 / Sub-Spacecraft planetographic latitude
[deg.]
SCALT   =        168217.494966 / Spacecraft altitude [km]
TARGPHAS=        152.597482027 / Sub-S/C Phase angle (Sun-Target-S/C) [deg]


COMMENT Row-specific Geometry Information
COMMENT The ALICE slit is imaged onto detector rows 5-23 (inclusive)
COMMENT When the LOS intercepts the surface, LAT and LON are given for
COMMENT the intercept point. If the LOS fails to intercept the target,
COMMENT LAT and LON are given for the nearest point to the target surface
COMMENT along the LOS.
ROW5RA  =        62.4374914157 / Right Ascension [deg.]
ROW5DEC =        21.1350696809 / Declination [deg.]
ROW5LON = '"N/A"   '             / Planetographic Lon. of target along LOS
[deg.]
ROW5LAT = '"N/A"   '             / Planetographic Lat. of target along LOS
[deg.]
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```
ROW5PHA = '"N/A"   '           / Phase angle at LOS intercept [deg.]
ROW5INC = '"N/A"   '           / Incidence angle at LOS intercept [deg.]
ROW5EMI = '"N/A"   '           / Emission angle at LOS intercept [deg.]
ROW6RA  =       62.7638395564 / Right Ascension [deg.]
ROW6DEC =       21.2135914539 / Declination [deg.]
ROW6LON = '"N/A"   '              / Planetographic Lon. of target along LOS
[deg.]
ROW6LAT = '"N/A"    '             / Planetographic Lat. of target along LOS
[deg.]
ROW6PHA = '"N/A"   '           / Phase angle at LOS intercept [deg.]
ROW6INC = '"N/A"   '           / Incidence angle at LOS intercept [deg.]
ROW6EMI = '"N/A"   '           / Emission angle at LOS intercept [deg.]
ROW7RA  =       63.0927065088 / Right Ascension [deg.]
ROW7DEC =       21.2910615275 / Declination [deg.]
ROW7LON = '"N/A"   '              / Planetographic Lon. of target along LOS
[deg.]
ROW7LAT = '"N/A"    '             / Planetographic Lat. of target along LOS
[deg.]
ROW7PHA = '"N/A"   '           / Phase angle at LOS intercept [deg.]
ROW7INC = '"N/A"   '           / Incidence angle at LOS intercept [deg.]
ROW7EMI = '"N/A"   '           / Emission angle at LOS intercept [deg.]
ROW8RA  =       63.4240919960 / Right Ascension [deg.]
ROW8DEC =       21.3674628800 / Declination [deg.]
ROW8LON = '"N/A"   '              / Planetographic Lon. of target along LOS
[deg.]
ROW8LAT = '"N/A"    '             / Planetographic Lat. of target along LOS
[deg.]
ROW8PHA = '"N/A"   '           / Phase angle at LOS intercept [deg.]
ROW8INC = '"N/A"   '           / Incidence angle at LOS intercept [deg.]
ROW8EMI = '"N/A"   '           / Emission angle at LOS intercept [deg.]
ROW9RA  =       63.7579954981 / Right Ascension [deg.]
ROW9DEC =       21.4427784547 / Declination [deg.]
ROW9LON = '"N/A"   '              / Planetographic Lon. of target along LOS
[deg.]
ROW9LAT = '"N/A"    '             / Planetographic Lat. of target along LOS
[deg.]
ROW9PHA = '"N/A"   '           / Phase angle at LOS intercept [deg.]
ROW9INC = '"N/A"   '           / Incidence angle at LOS intercept [deg.]
ROW9EMI = '"N/A"   '           / Emission angle at LOS intercept [deg.]
ROW10RA =       64.0944162463 / Right Ascension [deg.]
ROW10DEC=       21.5169911656 / Declination [deg.]
ROW10LON= '"N/A"   '              / Planetographic Lon. of target along LOS
[deg.]
ROW10LAT= '"N/A"    '             / Planetographic Lat. of target along LOS
[deg.]
ROW10PHA= '"N/A"   '           / Phase angle at LOS intercept [deg.]
ROW10INC= '"N/A"   '           / Incidence angle at LOS intercept [deg.]
ROW10EMI= '"N/A"   '           / Emission angle at LOS intercept [deg.]
ROW11RA =       64.4333532184 / Right Ascension [deg.]
ROW11DEC=       21.5900839035 / Declination [deg.]
ROW11LON= '"N/A"   '              / Planetographic Lon. of target along LOS
[deg.]
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ROW11LAT= '"N/A"    '                / Planetographic Lat. of target along LOS
[deg.]
ROW11PHA= '"N/A"    '           / Phase angle at LOS intercept [deg.]
ROW11INC= '"N/A"    '           / Incidence angle at LOS intercept [deg.]
ROW11EMI= '"N/A"    '           / Emission angle at LOS intercept [deg.]
ROW12RA =        64.7748051329 / Right Ascension [deg.]
ROW12DEC=        21.6620395412 / Declination [deg.]
ROW12LON=         174.174557891 / Planetographic Lon. of target along LOS
[deg.]
ROW12LAT=         17.0745143602 / Planetographic Lat. of target along LOS
[deg.]
ROW12PHA=        151.596104282 / Phase angle at LOS intercept [deg.]
ROW12INC=        146.317936222 / Incidence angle at LOS intercept [deg.]
ROW12EMI=        62.0850962213 / Emission angle at LOS intercept [deg.]
ROW13RA =        65.1187704446 / Right Ascension [deg.]
ROW13DEC=        21.7328409405 / Declination [deg.]
ROW13LON=         198.364690953 / Planetographic Lon. of target along LOS
[deg.]
ROW13LAT=         7.98019659872 / Planetographic Lat. of target along LOS
[deg.]
ROW13PHA=        151.923828312 / Phase angle at LOS intercept [deg.]
ROW13INC=        171.582134828 / Incidence angle at LOS intercept [deg.]
ROW13EMI=        36.4880092856 / Emission angle at LOS intercept [deg.]
ROW14RA =        65.4652473392 / Right Ascension [deg.]
ROW14DEC=        21.8024709577 / Declination [deg.]
ROW14LON=         215.278738407 / Planetographic Lon. of target along LOS
[deg.]
ROW14LAT=         0.418564656459 / Planetographic Lat. of target along LOS
[deg.]
ROW14PHA=        152.253346976 / Phase angle at LOS intercept [deg.]
ROW14INC=        169.929330316 / Incidence angle at LOS intercept [deg.]
ROW14EMI=        17.6864175204 / Emission angle at LOS intercept [deg.]
ROW15RA =        65.8142337287 / Right Ascension [deg.]
ROW15DEC=        21.8709124504 / Declination [deg.]
ROW15LON=         230.533361650 / Planetographic Lon. of target along LOS
[deg.]
ROW15LAT=         -6.47280279742 / Planetographic Lat. of target along LOS
[deg.]
ROW15PHA=        152.584702020 / Phase angle at LOS intercept [deg.]
ROW15INC=        153.222857087 / Incidence angle at LOS intercept [deg.]
ROW15EMI=        0.727935411944 / Emission angle at LOS intercept [deg.]
ROW16RA =        66.1657272467 / Right Ascension [deg.]
ROW16DEC=        21.9381482838 / Declination [deg.]
ROW16LON=         246.219193646 / Planetographic Lon. of target along LOS
[deg.]
ROW16LAT=         -12.9184101543 / Planetographic Lat. of target along LOS
[deg.]
ROW16PHA=        152.917900976 / Phase angle at LOS intercept [deg.]
ROW16INC=        136.482228596 / Incidence angle at LOS intercept [deg.]
ROW16EMI=        16.4373406027 / Emission angle at LOS intercept [deg.]
ROW17RA =        66.5197252438 / Right Ascension [deg.]
ROW17DEC=        22.0041613374 / Declination [deg.]
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ROW17LON=          264.514851221 / Planetographic Lon. of target along LOS
[deg.]
ROW17LAT=          -18.9056117618 / Planetographic Lat. of target along LOS
[deg.]
ROW17PHA=        153.252938376 / Phase angle at LOS intercept [deg.]
ROW17INC=        117.912485380 / Incidence angle at LOS intercept [deg.]
ROW17EMI=        35.3407227315 / Emission angle at LOS intercept [deg.]
ROW18RA =        66.8762247829 / Right Ascension [deg.]
ROW18DEC=        22.0689345119 / Declination [deg.]
ROW18LON=          291.311656507 / Planetographic Lon. of target along LOS
[deg.]
ROW18LAT=          -23.8737524681 / Planetographic Lat. of target along LOS
[deg.]
ROW18PHA=        153.589777159 / Phase angle at LOS intercept [deg.]
ROW18INC=        92.5136169109 / Incidence angle at LOS intercept [deg.]
ROW18EMI=        61.0761734673 / Emission angle at LOS intercept [deg.]
ROW19RA =        67.2352226354 / Right Ascension [deg.]
ROW19DEC=        22.1324507360 / Declination [deg.]
ROW19LON= '"N/A"    '              / Planetographic Lon. of target along LOS
[deg.]
ROW19LAT= '"N/A"    '              / Planetographic Lat. of target along LOS
[deg.]
ROW19PHA= '"N/A"    '           / Phase angle at LOS intercept [deg.]
ROW19INC= '"N/A"    '           / Incidence angle at LOS intercept [deg.]
ROW19EMI= '"N/A"    '           / Emission angle at LOS intercept [deg.]
ROW20RA =        67.5967152765 / Right Ascension [deg.]
ROW20DEC=        22.1946929735 / Declination [deg.]
ROW20LON= '"N/A"    '              / Planetographic Lon. of target along LOS
[deg.]
ROW20LAT= '"N/A"    '              / Planetographic Lat. of target along LOS
[deg.]
ROW20PHA= '"N/A"    '           / Phase angle at LOS intercept [deg.]
ROW20INC= '"N/A"    '           / Incidence angle at LOS intercept [deg.]
ROW20EMI= '"N/A"    '           / Emission angle at LOS intercept [deg.]
ROW21RA =        67.9606988821 / Right Ascension [deg.]
ROW21DEC=        22.2556442305 / Declination [deg.]
ROW21LON= '"N/A"    '              / Planetographic Lon. of target along LOS
[deg.]
ROW21LAT= '"N/A"    '              / Planetographic Lat. of target along LOS
[deg.]
ROW21PHA= '"N/A"    '           / Phase angle at LOS intercept [deg.]
ROW21INC= '"N/A"    '           / Incidence angle at LOS intercept [deg.]
ROW21EMI= '"N/A"    '           / Emission angle at LOS intercept [deg.]
ROW22RA =        68.3271693239 / Right Ascension [deg.]
ROW22DEC=        22.3152875628 / Declination [deg.]
ROW22LON= '"N/A"    '              / Planetographic Lon. of target along LOS
[deg.]
ROW22LAT= '"N/A"    '              / Planetographic Lat. of target along LOS
[deg.]
ROW22PHA= '"N/A"    '           / Phase angle at LOS intercept [deg.]
ROW22INC= '"N/A"    '           / Incidence angle at LOS intercept [deg.]
ROW22EMI= '"N/A"    '           / Emission angle at LOS intercept [deg.]
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```
ROW23RA  =        68.6961221668 / Right Ascension [deg.]
ROW23DEC=         22.3736060834 / Declination [deg.]
ROW23LON= '"N/A"    '              / Planetographic Lon. of target along LOS
[deg.]
ROW23LAT= '"N/A"    '              / Planetographic Lat. of target along LOS
[deg.]
ROW23PHA= '"N/A"   '            / Phase angle at LOS intercept [deg.]
ROW23INC= '"N/A"   '            / Incidence angle at LOS intercept [deg.]
ROW23EMI= '"N/A"   '            / Emission angle at LOS intercept [deg.]

COMMENT SPICE files used in geometry calculations
NUMBSPCK=                  19 / Number of loaded SPICE kernels
SPCK0001= 'NAIF0009.TLS'       / SPICE kernel 0001
SPCK0002= 'ROS_091210_STEP.TSC' / SPICE kernel 0002
SPCK0003= 'ROS_V16.TF'         / SPICE kernel 0003
SPCK0004= 'EARTHFIXEDIAU.TF'   / SPICE kernel 0004
SPCK0005= 'PCK00008.TPC'       / SPICE kernel 0005
SPCK0006= 'DE405.BSP'          / SPICE kernel 0006
SPCK0007= 'C2002T7.BSP'        / SPICE kernel 0007
SPCK0008= 'TEMPEL1-9P-DI-P.BSP' / SPICE kernel 0008
SPCK0009= 'OUTERPLANETS_V0002.BSP' / SPICE kernel 0009
SPCK0010= 'ORHR_____00102.BSP' / SPICE kernel 0010
SPCK0011= 'ORER_____00031.BSP' / SPICE kernel 0011
SPCK0012= 'ORMR_____00052.BSP' / SPICE kernel 0012
SPCK0013= 'ORFR_____00067.BSP' / SPICE kernel 0013
SPCK0014= 'ORGR_____00096.BSP' / SPICE kernel 0014
SPCK0015= 'ORHW_____00016.BSP' / SPICE kernel 0015
SPCK0016= 'ORHO_____00077.BSP' / SPICE kernel 0016
SPCK0017= 'ORHS_____00081.BSP' / SPICE kernel 0017
SPCK0018= 'ATNR_P040302093352_00101.BC' / SPICE kernel 0018
SPCK0019= 'ROS_ALICE_V15.TI'   / SPICE kernel 0019
END
```