European Space Agency

To Planetary Science Archive
Interface control document

[Rosetta] - [Earth Based]

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1 Introduction

1.1 Purpose and Scope

The purpose of this EAICD (Experimenter to (Science) Archive Interface Control Document) is twofold. Firstly, it provides all the instruments involved in the 67P/Churyumov-Gerasimenko's Earth based observation campaign using a spectroscopic (SPEC hereafter) approach. A description of the data, including data sources and destinations, is also provided. Then, it is the official interface between the instrument teams 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

1.1.1 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 Earth based SPEC instruments that performed observation of the comet 67P/Churyumov-Gerasimenko (67P hereafter) during the rendez-vous of the Rosetta spacecraft with the comet from the acquisition until the insertion into the PSA for ESA. It includes information on how data were processed, formatted, labeled and uniquely identified.
The document discusses general naming schemes for data volumes, data sets, data and label files. Standards used to generate products are explained. Software that may be used to access products is explained further on.
The design of the data set structure and data products is given. Examples are given in the appendix.

1.4 Intended Readership

The staff of the archiving authority (Planetary Science Archive, ESA, RSSD, design team) and any potential user of Earth based SPEC data. However, people without any experience of the concerned spectroscopic instruments may not be able, based only on this document and the archived data, to work with the archived data. These instruments are pretty complex and one has to familiarize himself with the associated user manuals (including the annexes) and reduction pipeline cookbook before starting to work on these raw uncalibrated data.

1.5 Scientific Objectives

A worldwide Earth based observing campaign of the 67P comet was performed in support of in-situ's data acquired during the last stage of the Rosetta mission.
Several techniques were used during this campaign and one of them is spectroscopy. Spectroscopy consists in studying the interaction between electromagnetic radiation, such as the light, and matter, as related to the dependence of this interaction on the wavelength of the radiation. The purpose is to provide information on the physical and chemical properties of the target, precisely 67P's coma and tail for our Earth-based observation campaign. The interaction of radiation with matter can be analyzed by three complentary ways: absorption, emission and reflection. Only the latter one is used here.
Finally, Earth based observations are by definition large-scale data compared to in-situ ones. Hence, data presented here are complementary to local observations performed by Rosetta's spectroscopic instruments, such as VIRTIS, and should permit to contextualize in-situ measurements.

1.6 Applicable Documents

Planetary Data System Preparation Workbook, February 1, 1995, Version 3.1, JPL, D-7669, Part1
Planetary Data System Standards Reference, June 1, 1999, Version 3.3, JPL, D-7669, Part 2
Earth based Archive Generation, Validation and Transfer Plan, [September 15, 2017]

1.7 Relationships to Other Interfaces

N/A

1.8 Acronyms and Abbreviations

ACAM	**A**uxiliary-port **CAM**era
ALMA	**A**tacama **L**arge **M**illimeter/submillimetre **A**rray
BTA	**B**ig **T**elescope **A**lt-azimuthal
CSHELL	**C**ryogenic ec**HELL**e **S**pectrograph
Disp.	**Disp**ersion
DOLORES	**D**evice **O**ptimized for the **LO**w **RES**olution
EMIR	**E**ight **MI**xer **R**eceiver
ESO	**E**uropean **S**outhern **O**bservatory
FIT	**F**lexible **I**mage **T**ransport
FORS2	**FO**cal **R**educer and low dispersion **S**pectrograph **2**
GNIRS	**G**emini **N**ear **I**nfra**R**ed **S**pectrography
HIRES	**HI**gh **R**esolution **E**chelle **S**pectrometer
IDS	**I**ntermediate **D**ispersion **S**pectrograph
ING	**I**saac **N**ewton **G**roup
IRAM	**I**nstitut de **R**adio-**A**stronomie **M**illimétrique
IRTF	**I**nfra**R**ed **T**elescope **F**acility
ISIS	**I**ntermediate dispersion **S**pectrograph and **I**maging **S**ystem
LOTUS	**LO**w-cos**T** **U**ltraviolet **S**pectrograph
LT	**L**iverpool **T**elescope

NICS	**N**ear **I**nfrared **C**amera **S**pectrometer
pix	**pix**el
PSA	**P**lanetary **S**cience **A**rchive
SAO RAS	**S**pecial **A**strophysical **O**bservatory of the **R**ussian **A**cademy of **S**ciences
SCORPIO-2	**S**pectral **C**amera with **O**ptical **R**educer for **P**hotometric and **I**nterferometric **O**bservations **- 2**
SPRAT	**SP**ectrograph for the **R**apid **A**cquisition of **T**ransients
TNG	**T**elescopio **N**azionale **G**alileo
UT	**U**nit **T**elescope
UTC	**U**niversal **T**ime **C**oordinated
UVES	**U**ltraviolet **V**isual **E**chelle **S**pectrograph
VLT	**V**ery **L**arge **T**elescope
WHT	**W**illiam **H**erschel **T**elescope
Xshooter	**X-shooter**

1.9 Contact Names and Addresses

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

The main particularity, complexity, of this Earth based observation campaign relies on the numerous different telescopes and instruments involved in it: 62 instruments installed on 38 different telescopes were used in this campaign (see Snodgrass et al. 2017, table 1), thus allowing to get a large amount of varied data that will bring new insights on the cometary science but also to contextualize the Rosetta mission.

One of the multiple technique used in the campaign is SPEC. 19 instruments (installed on 13 different telescopes) were involved and 16 of them obtained scientifically relevant and exploitable data: (i) the ALMA observatory, (ii) GNIRS of the Gemini (North) telescope, (iii) IDS of the INT, (iv) EMIR of the IRAM, (v) CSHELL and (vi) SpeX of the IRTF, (vii) HIRES of the Keck telescope, (viii) LOTUS and (ix) SPRAT of the LT, (x) SCORPIO-2 mounted on the SAO RAS's BTA, (xi) DOLORES and NICS of the TNG, (xii) FORS2, (xiii) UVES and (xiv) Xshooter mounted on different ESO's VLT UT, and finally (xv) ACAM and (xvi) ISIS of the WHT. A particularlity of the Xshooter instrument is that it is made of three arms (UVB, VIS and NIR) observing silmutaneously (please refer to the three documents about Xshooter in the documentation for further informartion). Following paragraphs and the Table 1 summarize the main charactersitics of data and instruments. Detailed description and additional information are given in some documents provided in the "DOCUMENT" directory. Some of these documents are available on the following websites:

ALMA: http://www.eso.org/public/teles-instr/alma/
ESO-VLT – FORS2: http://www.eso.org/sci/facilities/paranal/instruments/fors/overview.html
ESO-VLT – UVES: http://www.eso.org/sci/facilities/paranal/instruments/uves/overview.html
ESO-VLT – XSHOOTER: www.eso.org/sci/facilities/paranal/instruments/xshooter/overview.html
GEMINI-NORTH – GNIRS: https://www.gemini.edu/sciops/instruments/gnirs/
INT – IDS: http://www.ing.iac.es/astronomy/instruments/ids/
IRAM – EMIR: http://www.iram.es/IRAMES/mainWiki/EmirforAstronomers
IRTF – CSHELL: http://irtfweb.ifa.hawaii.edu/~cshell/
IRTF – SPEX: http://irtfweb.ifa.hawaii.edu/~spex/
KECK – HIRES: https://www2.keck.hawaii.edu/inst/hires/
LT – LOTUS: http://telescope.livjm.ac.uk/TelInst/Inst/LOTUS/
LT – SPRAT: http://telescope.livjm.ac.uk/TelInst/Inst/SPRAT/
SAO-RAS-BTA – SCORPIO-2: https://www.sao.ru/hq/lsfvo/devices/scorpio-2/descript_eng.html
TNG – DOLORES: http://www.tng.iac.es/instruments/lrs/
TNG – NICS: http://www.tng.iac.es/instruments/nics/
WHT – ACAM: http://www.ing.iac.es/PR/inst.php?inst=ACAM
WHT – ISIS: http://www.ing.iac.es/PR/inst.php?inst=ISIS

Instrument	Observatory	Wavelength range	Spectral resolution	Spatial sampling
- - -	ALMA	84 – 950 GHz	≤ R ~ 30,000,000	≥ 0.02''/px
FORS2	ESO-VLT	330 – 1100 nm	260 ≤ R ≤ 2600	0.12''/px, 0.25''/px
UVES	ESO-VLT	300 – 1100 nm	up to R ~ 110,000	≥ 0.08''/px
XSHOOTER	ESO-VLT	300 – 2480 nm	3300 ≤ R ≤ 17,400	0.15''/px – 0.21''/px
GNIRS	GEMINI-NORTH	1,000 – 5,400 nm	1700 ≤ R ≤ 18,000	0.15''/px, 0.05''/px
IDS	INT	- - -	- - -	0.19''/px – 0.44''/px
EMIR	IRAM	83 – 360 GHz	- - -	- - -
CSHELL	IRTF	1,000 – 5,500 nm	≤ R ~ 30,000	0.2''/px

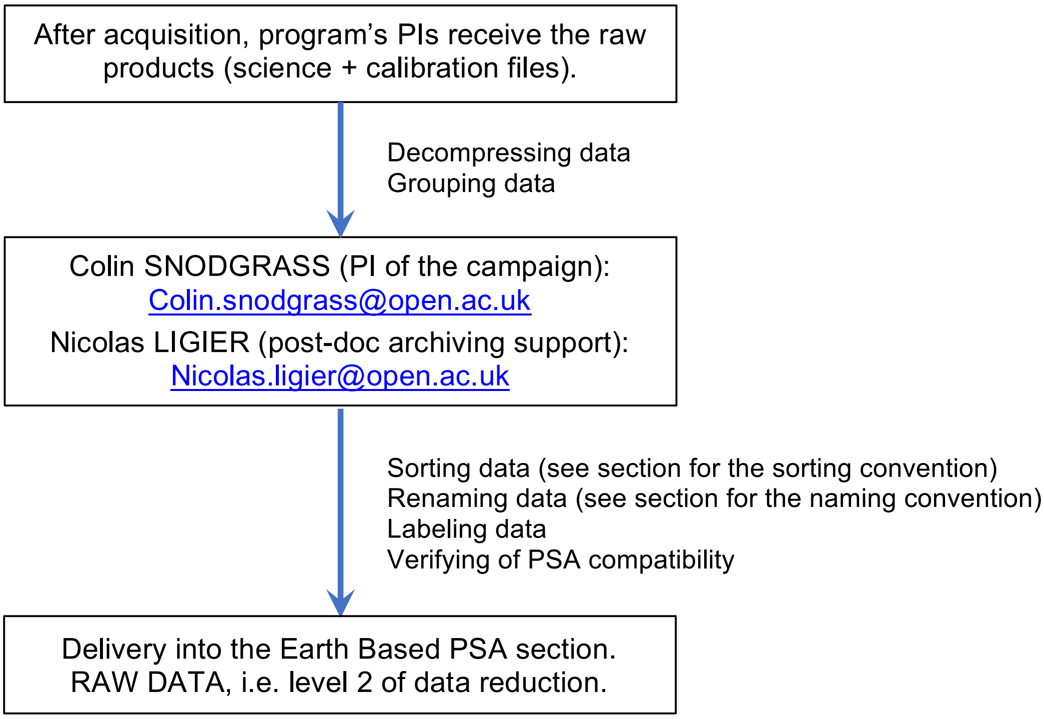
SPEX	IRTF	700 – 5,300 nm	200 ≤ R ≤ 2000	0.10''/px
HIRES	KECK	300 – 1,000 nm	R ~ 55,000	~ 0.3''/px
LOTUS	LT	320 – 630 nm	Disp. ~ 0.47 nm/px	0.6''/px
SPRAT	LT	400 – 800 nm	Disp. ~ 0.46 nm/px	0.44''/px
SCORPIO_2	SAO-RAS-BTA	360 – 1,000 nm	400 ≤ R ≤ 15,000	0.18''/px
DOLORES	TNG	300 – 1,000 nm	585 ≤ R ≤ 5950	0.25''/px
NICS	TNG	800 – 2500 nm	Disp. ~ 0.5 nm/px	0.25''/px
ACAM	WHT	350 – 940 nm	R ~ 900	0.25''/px
ISIS	WHT	300 – 1100 nm	800 ≤ R ≤ 7000	≥ 0.14''/px

Table 1 - Summary of instruments main characteristics

2.1 Scientific Objectives

Comets are commonly considered as the most pristine objects in the Solar System. From Mars 2014 until September 2016, the Rosetta spacecraft and its impressive payload (21 instruments in total, 11 on the orbiter and 10 on the lander *Philae*) was fully dedicated to the *in-situ* study of 67P's nucleus and its close environment, providing unprecedented results. Parallel to the Rosetta mission, a ground-based observation campaign including numerous instruments using some different scientific techniques was performed. The main scientific objectives of this very large coordinated campaign were to provide (1) essential data for mission planning, (2) large-scale context information for the coma and far beyond, and (3) also a way to directly compare 67P with other comets.
This dataset is about instrument using spectroscopy, a technique that provides information about the physical and chemical properties of the target. Consequently, with a spatial sampling equal or lower than 0.6''/pix, data presented here should provide important additional information on 67P's dust coma and tail produced by the nucleus activity.

2.2 Data Handling Process



2.3 Product Generation

See section 2.2. Contact Nicolas LIGIER (see section 1.9) for further information.

2.4 Overview of Data Products

2.4.1 Pre-Flight Data Products

N/A

2.4.2 Sub-System Tests

N/A

2.4.3 Instrument Calibrations

Before starting, please note that calibration files are not provided at level 2 but at level 3 dataset, i.e. in this case: EAR-C-MULTI-3-67P-SPEC-V1.0. Please refer to this dataset to get the calibration data.

2.4.4 Other Files written during Calibration

N/A

2.4.5 Data Products

Science files and calibration files are the two types of data products in this dataset. Science products consist in cometary files (67P), sky references (SKY) and standard stars (STD). Supplementary subdivisions may exist corresponding to the wavelength domain in which data were acquired (ex: "B" for blue, "R" for red, etc…). In any case, the data format used is always FIT.

2.4.6 Software

As this delivery only concerns raw uncalibrated data, no additional software is required. Such software will be described in the EAICD concerning the delivery of calibrated (level 3 of data reduction) and higher-level data (level 4 of data reduction).

2.4.7 Documentation

The DOCUMENT folder provides every existing user manuals and data reduction pipeline manuals for the different instrument. When existing, published reference scientific paper will be also provided. Except this file (using the DOC format), the format of all the documentation is PDF.

Following is the list of the available PDF documents:

- EAICD_C67PEARTH_SPEC_V1_0
- ALMA_CASA_COOKBOOK
- ALMA_CASA_REFERENCE
- ALMA_PIPELINE_MANU_V2
- ESO_VLT_FORS2_PIPELINE_MANU
- ESO_VLT_FORS2_REF_PAPER
- ESO_VLT_FORS2_REFLEX _TUTO
- ESO_VLT_FORS2_USER_MANU_P99
- ESO_VLT_UVES_CALIB_PLAN
- ESO_VLT_UVES_PIPELINE_MANU
- ESO_VLT_UVES_REF_PAPER
- ESO_VLT_UVES_REFLEX_TUTO
- ESO_VLT_UVES_USER_MANU_P100
- ESO_VLT_XSHOOTER_REDUC_TUTO
- ESO_VLT_XSHOOTER_REF_PAPER
- ESO_VLT_XSHOOTER_USER_MANU
- GEMINI_N_GNIRS_FACT_SHEET
- GEMINI_N_GNIRS_REDUC_PRES
- GEMINI_N_GNIRS_REF_PAPER_N1
- GEMINI_N_GNIRS_REF_PAPER_N2
- GEMINI_N_GNIRS_USER_MANUAL
- INT_IDS_USER_MANU_ALLFIG
- INT_IDS_USER_MANU_NOFIG
- IRAM_EMIR_REFERENCE_PAPER
- IRTF_CSHELL_USER_MANU
- IRTF_SPEX_REDUC_TOOL_MANUAL
- IRTF_SPEX_REF_PAPER_N1
- IRTF_SPEX_REF_PAPER_N2
- IRTF_SPEX_REF_PAPER_N3
- IRTF_SPEX_USER_MANU
- KECK_HIRES_DATA_FORMAT
- KECK_HIRES_REDUX_PRES
- KECK_HIRES_REFERENCE_PAPER
- KECK_HIRES_USER_MANU
- LT_LOTUS_REFERENCE_PAPER
- LT_SPRAT_REFERENCE_PAPER
- SAO_RAS_SCORPIO2_REDUC_N1
- SAO_RAS_SCORPIO2_REDUC_N2
- SAO_RAS_SCORPIO2_REF_PAPER
- TNG_DOLORES_INTERF_MANU
- TNG_DOLORES_USER_MANU
- TNG_NICS_USER_GUIDE
- WHT_ACAM_OVERVIEW
- WHT_ACAM_REFERENCE_PAPER
- WHT_ISIS_ACQUIS_TOOL_GUIDE

- WHT_ISIS_CONTR_SYST_GUIDE
- WHT_ISIS_USER_MANU_V1

2.4.8 Derived and other Data Products

The ephemeris information of 67P/Churyumov-Gerasimenko during the campaign are given in the SPICE dataset in the PSA/PDS, with the following DATA_SET_ID: RO-RL-E-M-A-C-SPICE-6-[V1.0]. Most relevant information is located in the meta-kernel in the EXTRAS/MK/ directory of that dataset. Further details and information can be found in the SPICE dataset's DATA subdirectory.

2.4.9 Ancillary Data Usage

N/A

3 Archive Format and Content

3.1 Format and Conventions

3.1.1 Deliveries and Archive Volume Format

The volumes are organized the standard way, one data set on one volume. In consultation with archive scientists, we will produce separate volumes for EDR (**E**dited **D**ata **R**ecord, raw data, level 2), RDR (**R**educed **D**ata **R**ecord, calibrated data, level 3) and DDR (**D**erived **D**ata **R**ecord, processed and evaluated data, level 4) data. Volumes will be delivered by FTP.

3.1.2 Data Set ID Formation

At this moment: EAR-C-MULTI-2-67P-SPEC-V1.0

→ "EAR" is about the fact that the data come from Earth-based instruments,
→ "C" is about the object's type, in this case a Comet,
→ "MULTI" is about the fact that the data come from multiple instruments,
→ "2" is about the data reduction level, in this EDR which means raw data,
→ "67P" is about the target of the data, i.e. the comet 67P/Churyumov-Gerasimenko,
→ "SPEC" is the scientific method employed to acquire the data, in this case spectroscopy,
→ and "V1.0" is about the version of this data set, in this case the version 1.0

3.1.3 Data Directory Naming Convention

The directory tree of the "DATA" directory is divided into several subdirectories. In the case of this data set, there are three layers. From the most global to the most specific, these layers are:

1) The telescope name (ex: VLT),
2) The instrument name (ex: XSHOOTER),
3) The date of acquisition, following the convention <year>_<month>_<day> (ex: 2016_01_10).

3.1.4 Filenaming Convention

One of the main highlight of this Earth based observation campaign is certainly the huge diversity of telescopes (38) and instruments (62) involved. However, in terms of archiving, it represents the main difficulty as there is no worldwide file-naming convention. Consequently, no file-naming convention has been set up for this dataset, except that the data are all using the FIT format.

3.2 Standards Used in Data Product Generation

3.2.1 PDS Standards

The PDS3 standards are used.

3.2.2 Time Standards

The time standard used is UTC.

3.2.3 Reference Systems

N/A

3.2.4 Other Applicable Standards

N/A

3.3 Data Validation

Work in progress with ESA's archive scientists.

3.4 Content

3.4.1 Volume Set

N/A

3.4.2 Data Set

See section 3.1.3 for further information on the data set naming convention.

3.4.3 Directories

3.4.3.1 Root Directory

The root directory of the data set is equal to the DATA_SET_ID keyword value. It contains the files AAREADME.TXT and VOLDESC.CAT.

3.4.3.2 Calibration Directory

According to the PDS standards, this directory has to be named “CALIB”. It contains subdirectories for each instrument used and a file named CALINFO.TXT. In the precise case of this data set, there is no calibration file in the subdirectories as all the calibration files are provided in the level 3 dataset, here: EAR-C-MULTI-3-67P-SPEC-V1.0. The CALINFO.TXT file provides supplementary information about how to get the primary calibration files.

3.4.3.3 Catalog Directory

This directory contains standard PDS catalog files:

- CATALOG.TXT
- DATASET.CAT
- INST_ACAM.CAT
- INST_ALMADET.CAT
- INST_CSHELL.CAT
- INST_EMIR.CAT
- INST_FORS2.CAT
- INST_GMOSN.CAT
- INST_HIRES.CAT
- INST_I0046.CAT
- INST_I1092.CAT
- INST_I1093.CAT
- INST_IDS.CAT
- INST_ISIS.CAT
- INST_LOTUS.CAT
- INST_SCORPIO2.CAT
- INST_SPRAT.CAT
- INST_UVES.CAT
- INST_XSHOOTER.CAT
- INSTHOST_ALMA.CAT
- INSTHOST_GEMININ.CAT
- INSTHOST_IRAM.CAT
- INSTHOST_KECK1.CAT
- INSTHOST_OBS060T1.CAT
- INSTHOST_OBS060T2.CAT
- INSTHOST_OBS060T3.CAT
- INSTHOST_OBS270T7.CAT
- INSTHOST_OBS376T3.CAT
- INSTHOST_RDLMINT.CAT
- INSTHOST_RDLMLT.CAT

- INSTHOST_SAOBTA.CAT
- INSTHOST_WHT.CAT
- MISSION.CAT
- REF.CAT
- SOFTWARE.CAT

3.4.3.4 Index Directory

This directory contains standard PDS index files:

- INDXINFO.TXT
- INDEX.LBL
- INDEX.TAB

3.4.3.5 Browse Directory and Browse Files

No browse files so no browse directory.

3.4.3.6 Geometry Directory

N/A

3.4.3.7 Software Directory

N/A

3.4.3.8 Gazetteer Directory

N/A

3.4.3.9 Label Directory

N/A

3.4.3.10 Document Directory

Along with the DOCINFO.TXT, we provide documents using the PDF or DOC formats. Inside the latter document(s), images are referenced and stored in extra files using the PNG format. All the documents exclusively relative to the instruments are stored in a subdirectory named “INSTDOC”.

3.4.3.11 Extras Directory

N/A

3.4.3.12 Data Directory

Whatever the data set of the Earth based campaign of 67P, the DATA directory is always organized with the following structure:

```
<DATA>
   ||  <telescope name>
   ||     ||  <instrument name>
   ||     ||     ||  <acquisition date>
   ||     ||     ||  <acquisition date>
   ||  <telescope name>
   ||     ||  <instrument name>
   ||     ||     ||  <acquisition date>
   ||     ||     ||  …
```

Some sub-subdirectories may exist depending on the type of files (67P, STD) and other divisions based on parameters, such as the wavelength domain (UVB, VIS, NIR, etc..) or the filter used (Blue, Red, etc…), may also exist.

Finally, a file named OBSERVING_NOTES.TXT is provided in the DATA directory. This document provides a fixed table containing general information about the data archived.

4 Detailed Interface Specifications

4.1 Structure and Organization Overview

The structure and the organization are already defined in earlier sections (3.1.3 and 3.4.3.12).

4.2 Data Sets, Definition and Content

Most of the content of the data set corresponds to the data. Each data file uses the FIT format and is associated to a LBL file containing information useful to understand the data file and contextualize its acquisition. Following is a table summing the different observations per telescope and per instrument.

Telescope	Instrument	Wavelength range(s) or filter(s)	Program ID	Principal investigator's name(s)
ALMA	-	-	-	N. BIVER
ESO-VLT	FORS2	1	093.C-0593 094.C-0054 595.C-0066 097.C-0201	C. SNODGRASS
ESO-VLT	UVES	1	095.C-0792 096.C-0081	E. JEHIN
ESO-VLT	XSHOOTER	3: UVB, VIS and NIR	094.C-0054	C. SNODGRASS
GEMINI-NORTH	GNIRS	4: H, H2, J and XD	GN-2015B-Q-53	M.M. KNIGHT
INT	IDS	1	-	C. SNODGRASS
IRAM	EMIR	-	-	N. BIVER
IRTF	CSHELL	2 (+ 1 image): H2O and ETH	2015A058	L. PAGANINI
IRTF	SPEX	-	-	S. PROTOPAPA and Y. RAMANJOOLOO
KECK	HIRES	1	N126Hr	A. MCKAY
LT	LOTUS	1	PL15A23 IL15B01a	C. SNODGRASS and G. JONES
LT	SPRAT	2: Blue, Red	PL15A23 IL15B01a	C. SNODGRASS and G. JONES
SAO-RAS-BTA	SCORPIO_2	1	-	N. KISELEV, V. ROSENBUSH and A. IVANOVA
TNG	DOLORES	2: Blue, Red	-	G. TOZZI and C. SNODGRASS
TNG	NICS	1	-	G. TOZZI and C. SNODGRASS
WHT	ACAM	1	-	A. FITZSIMMONS and C. SNODGRASS
WHT	ISIS	2: Blue, Red	-	A. FITZSIMMONS and C. SNODGRASS

Table 2 - List of instruments, with main information, involved in this dataset. Rows highlighted in yellow show data that are not existing at raw level (only reduced level and beyond).

4.3 Data Product Design

4.3.1 File Characteristics Data Elements

Following is an example of the file characteristics data elements section existing in a LBL file:

```
RECORD_TYPE          =  FIXED_LENGTH
RECORD_BYTES         =  2880
FILE_RECORDS         =  1479
FILE_NAME            = "FORS2_20140507T075807_078.FIT"
DATA_FORMAT          =  FITS
```

Every LBL file in the "DATA" directory contains the keywords `RECORD_TYPE`, `RECORD_BYTES`, `FILE_RECORDS`, `FILE_NAME` and `DATA_FORMAT`. In the case of this data set, the fixed length record type and the fits data format are always used and the record bytes is constantly equal to 2880. Thus, only the `FILE_RECORDS` and the `FILE_NAME` keywords differ between the LBL file.

4.3.2 Data Object Pointers Identification Data Elements

Following is an example of the data object pointers identification data elements existing in a LBL file:

```
^HEADER              = ("FORS2_20140507T075807_078.FIT",1)
^IMAGE               = ("FORS2_20140507T075807_078.FIT",9)
```

Since attached LBL file are used, pointers refer to a position in the corresponding FIT file.

4.3.3 Instrument and Detector Descriptive Data Elements

Following is an example of the keywords contained in a LBL file describing the main characteristics of the instrument and the telescope used to acquire the data:

```
INSTRUMENT_HOST_ID   = "OBS060T1"
INSTRUMENT_HOST_NAME = "PARANAL OBSERVATORY 8.2-M ANTU VERY LARGE TELESCOPE
        (VLT)-UT1"
INSTRUMENT_ID        = "FORS2"
INSTRUMENT_NAME      = "FOCAL REDUCER AND LOW DISPERSION SPECTROGRAPH #2"
TELESCOPE_DIAMETER   =  8.2 <m>
TELESCOPE_LATITUDE   = -24.6276 <deg>                     /* GEOLAT header */
TELESCOPE_LONGITUDE  = -70.4051 <deg>                     /* GEOLON header */
```

4.3.4 Structure Definition of Instrument Parameter Objects

N/A

4.3.5 Data Object Definition

Following is an example of the data object definition section existing in a LBL file:

```
OBJECT               =  HEADER
  BYTES                    =  23040
  HEADER_TYPE              =  FITS
  INTERCHANGE_FORMAT       =  BINARY
  RECORDS                  =  8
  DESCRIPTION              = "Header of the file"
END_OBJECT           =  HEADER
OBJECT               =  IMAGE
  OFFSET                   =  32768                        /* BZERO header */
  SCALING_FACTOR           =  1                           /* BSCALE header */
  LINE_SAMPLES             =  2048                        /* NAXIS1 header */
  LINES                    =  1034                        /* NAXIS2 header */
  UNIT                     = "DATA NUMBER"
```

```
  SAMPLE_BITS               =  16                           /* BITPIX header */
  SAMPLE_TYPE               =  MSB_UNSIGNED_INTEGER
  LINE_DISPLAY_DIRECTION    =  UP
  SAMPLE_DISPLAY_DIRECTION =  RIGHT
  DESCRIPTION               = "ESO-VLT FORS2 raw science file"
END_OBJECT            =  IMAGE
```

4.3.6 Description of Instrument

N/A

4.3.7 Parameters Index File Definition

The index files are automatically generated by the PVV program

4.3.8 Mission Specific Keywords

Following are an example of specific, additional keywords that may be useful to scientists working on such Earth based cometary observation program:

```
TARGET_HELIOCENTRIC_DISTANCE =  4.1 <AU>
GEOCENTRIC_DISTANCE  =  3.6 <AU>
```

These keywords may be primordial to contextualize and interpret the data.

5 Appendix: Available Software to read PDS files

N/A

6 Appendix: Example of Directory Listing of Data Set X

N/A