

# Cassini Composite Infrared Spectrometer (CIRS)

Planetary Data System (PDS)  
Spectral Image Cube  
Data Product Software Interface Specification (SIS)

Version 1.1  
Relevant to PDS v3.2  
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# Chapter 1

## Introduction

### 1.1 Purpose

This document describes the CIRS cube products generated by the CIRS team and delivered to PDS. The products described consist of detached label files (ASCII only) and data product files (binary only)

For more information on the PDS Labeling methods, please see  
<http://pds.nasa.gov/tools/standards-reference.shtml>  
(Chapter 5 Data Product Labels : Labeling methods/Detached).

### 1.2 Reference Documents

1. Flasar, F. et al., Exploring the Saturn system in the thermal infrared: the Composite Infrared Spectrometer., Space Science Reviews, 115, 169-297, 2004, [doi:10.1007/s11214-004-1454-9](https://doi.org/10.1007/s11214-004-1454-9)
2. Nixon, C. et al., User Guide to the PDS Dataset for the Cassini Composite Infrared Spectrometer (CIRS), October 1<sup>st</sup> 2012  
Copy should be available within this archive, in DOCUMENT  
or should be accessible via the following link :  
[http://pds-atmospheres.nmsu.edu/data\\_and\\_services/atmospheres\\_data/Cassini/cirs.html](http://pds-atmospheres.nmsu.edu/data_and_services/atmospheres_data/Cassini/cirs.html)
3. Nixon, C. et al., Cassini Composite Infrared Spectrometer (CIRS), Planetary Data System (PDS), Time Sequential Data Record (TSDR), Data Product Software Interface Specification (SIS), April 18<sup>th</sup> 2011  
Copy should be available within this archive, in DOCUMENT



## 1.3 Prerequisites

We make an effort to provide the most complete reference on how the data products are generated and how to interface with them, and we hope you can find what you need here. However this document is not the best way to start learning about CIRS or answer all questions about PDS format.

If you have questions regarding how CIRS operates or how observations are designed, please refer to the CIRS User Guide. (cf Reference Document [2])

If you are looking for more information on the PDS Qube format, please refer to the PDS online documentation

<http://pds.nasa.gov/tools/standards-reference.shtml>

(Appendix A Data Object Definitions : Section A23 Qube and Section A25 Spectral\_Qube)

## 1.4 Version History

Version 1.0 of this document is dated November 1st, 2014

Version 1.1 of this document is dated December 22nd, 2015

## 1.5 Revision Date

Version 1.1 : Removed unused keywords and updated label examples.

## 1.6 Acronyms and Abbreviations

AACS	Attitude and Articulation Control System
ASCII	American Standard Code for Information Interchange
CIRS	Composite Infrared Spectrometer
FOV	Field Of View
ISIS	Integrated Software for Imagers and Spectrometers by USGS.
NAIF	Navigation and Ancillary Information Facility
PDS	Planetary Data System
PEF	Planned Event File - File generated for Cassini operations containing a list of all commands executed on board
RTI	The length of the scan, in units of real time interrupts (1/8th second) Longer scans have higher spectral resolution.
TSDR	Time Sequential Data Record (i.e, the database used to generate the cube products)
USGS	United States Geological Survey
ZPD	Zero Path Difference of an Interferogram (i.e., the time of maximum sensitivity to received radiation)

Table 1.1: Acronyms and Abbreviations

## Chapter 2

# Overview

This dataset consists of spectral image cubes, each of which corresponds to a discrete observation of a body in the Saturn system by the Cassini Composite Infrared Spectrometer (CIRS) instrument. Each cube is generated by systematic processing of the time sequential data records (TSDRs) acquired by CIRS. The calibrated TSDR database has been segmented by observation time period, target in the field of view, instrument resolution and focal plane. Data cubes are produced from each segmented subset using three types of projection. The calibration and geometric information used to produce the cubes are the best available at the time of processing, but are subject to further refinements in the future. Such refinements may lead to improved and reissued data products.

Each element of the cube is identified by 3 coordinates : 2 spatial and 1 spectral. The spatial coordinates depend of the type of projection (longitude/latitude for equirectangular cubes, milliradians on the plane of the sky for point perspective cubes or radius/local time for rings cubes). The spectral coordinate corresponds to wavenumber. This format enables the data to be analyzed spatially (one wavelength at a time) or spectrally (one location at a time) or in other more complex ways.

Each label file provides not only information regarding the coordinate system (projection type, spatial resolution, instrument resolution), but also provides an insight on the geometry of the observation. It defines the format of the binary file and what information is available in the core and back planes

Please note that the label files are following the PDS standard and are not constrained by the USGS ISIS standard.

## 2.1 Activity and Sub-Activity

The CIRS data stream is divided into discrete activities using information from the Cassini Planned Event Files (PEFs). PEFs contain the list of all events that occurred on-board the spacecraft. An event is the combination of one time period, one core name, one name index and one action.

### Event action

An event action could be an observation table call, a retargeting or an AACCS command.

### Event core name

For all CIRS related events, the core name describes the observation and is defined by the designer of the observations.

For example CIRS\_152SA\_FIRMAP001\_PRIME corresponds to a CIRS observation taken during revolution (or orbit) 152 with Saturn (SA) as main target. This observation is a standard FIRMAP (i.e., a far-infrared map), instance number 001 and CIRS was the PRIME instrument (i.e. the instrument controlling the spacecraft pointing) at the time.

These core names allow us to uniquely identify a period of time that we call an activity. An activity starts at the time of the first event with this core name and ends just before the next activity.

### Event name index

One activity may sometimes have multiple purposes (e.g. a mosaic, a stare, or a scan across the target, perhaps with different spectral resolutions) and will contain multiple events sharing the same core name. Also, a single-purpose observation may consist of multiple sweeps of the field of view across the target to build up complete coverage, or multiple stares at different locations on the target. To avoid confusion between these events and to allow examination of individual observation elements, an incremented index is added to the core name such that the combination of the two is unique.

For example the PEF file may contain events with the following names :

CIRS\_152SA\_FIRMAP001\_PRIME\$1

CIRS\_152SA\_FIRMAP001\_PRIME\$2

CIRS\_152SA\_FIRMAP001\_PRIME\$3

...

In a similar way to how we define an activity, we identify a sub-activity by a core name and

a name index (1, 2, 3 . . . in this case).

In practice, the subdivision into multi-purpose sub-activities is mainly used for icy satellite observations. Most of the Saturn and Titan activities are usually single purpose, but may still consist of multiple scans or stares which are treated as separate sub-activities when generating these data products.

## 2.2 File Naming

### General rule

We generate cubes for each complete activity and (if there is more than one sub-activity) also for each sub-activity. The activity names are only used to identify the time period and there is no assumption made when generating data products about which focal plane is being used, what is the spectral resolution or which target is in the field of view.

If, for example, Saturn was included in the field of view during what was identified as a moon observation, we will generate products both for Saturn and for the moon. We also generate a distinct product for each of the three CIRS focal planes that was used in that activity, regardless of which focal plane (if any) is identified in the activity core name. However, in most cases the most useful products will be those made with data from the focal plane (if any) identified in the name of the observation.

The spectral resolution of each observation is described by the length of the interferometer scan in units of "Real Time Interrupt" (RTI).

### Exceptions

The only cases we will not generate a cube are :

- if the total number of spectra found for this time period is less than 5.
- if an activity consists of a single sub-activity, then a sub-activity cube will not be generated, as noted above.

### Convention

Since the time segmentation is done using the activity and the sub-activity, the file name will include the name associated with this time period and will be followed by the other content parameters.

The filename being limited to a 36.3 form (36 character basename, a "period", then a 3 character extension), we do some simple edits of the initial activity/sub-activity name while preserving the central and most important section of the name as follows.

### New activity/subactivity name

- All CIRS activity and sub-activity names originally start with "CIRS\_", this substring is removed

- The activity core name is expanded to 19 characters before the 2-character prime instrument code (described below) by appending “\_” characters as needed. (see the CIRS\_149TI\_CLOUDMAP001\_VIMS example below)
- All activity and sub-activity names indicate which instrument is “prime”. The variable length substring containing this information is replaced by a 2 characters string, with the following meaning:

Instrument Name	2 Character Code
CAPS	CA
CDA	CD
CIRS	CI
INMS	IN
ISS	IS
MAG	MA
MIMI	MI
RADAR	RA
RPWS	RP
RSS	RS
UVIS	UV
VIMS	VI

Table 2.1: Instrument Name Code

- The numerical index of a subactivity is formatted to 3 digits. These 3 digits are replaced by 3 “\_” characters for an activity.

After these modification, the new activity name/sub-activity name should always be 24 characters.

For example :

Activity CIRS\_126MI\_FP1DAYMAP001\_PRIME

→ 126MI\_FP1DAYMAP001\_CI\_\_

Subactivity CIRS\_126MI\_FP1DAYMAP001\_PRIME\$4

→ 126MI\_FP1DAYMAP001\_CI004

Activity CIRS\_149TI\_CLOUDMAP001\_VIMS

→ 149TI\_CLOUDMAP001\_\_VI\_\_

## Additional information

After this name, we append:

- the NAIF target code of the target in the field of view (see table 2.2),
- Focal plane used
- Spectral resolution expressed in RTI

NAIF ID	BODY	NAIF ID	BODY
599	Jupiter	699	Saturn
501	Io	601	Mimas
502	Europa	602	Enceladus
503	Ganymede	603	Tethys
504	Callisto	604	Dione
505	Amalthea	605	Rhea
506	Himalia	606	Titan
507	Elara	607	Hyperion
508	Pasiphae	608	Iapetus
509	Sinope	609	Phoebe
510	Lysithea	610	Janus
511	Carme	611	Epimetheus
512	Ananke	612	Helene
513	Leda	613	Telesto
514	Thebe	614	Calypso
515	Adrastea	615	Atlas
516	Metis	616	Prometheus
		617	Pandora
		618	Pan
		632	Methone
		633	Pallene
		635	Daphnis
		680	<i>Saturn Ring</i>

Table 2.2: Selected NAIF IDS of relevance to Cassini CIRS.

NB : The saturn rings code above (680) is not an official NAIF ID code, but is defined for convenience.



Thus the filenames convention is AAAAAAAAAAAAAAAAAAAAAAAAAA\_BBB\_CC\_DDDE with :

1. AAAAAAAAAAAAAAAAAAAAAAAAAA : 24 characters for the sub activity or activity name.
2. BBB : 3 digits for the NAIF code
3. CC : Focal plane used : F1 for focal plane 1, F3 for focal plane 3, F4 for focal plane 4,
4. DDD : 3 digits for the spectral resolution in RTI,
5. E : 1 character defining the type of projection ("E" for equirectangular projection, "P" for point perspective projection, "R" for ring projection).

### Example

So if we find data available for

- an Equirectangular Map (E)
- of Mimas (NAIF code = 601)
- using Focal Plane 3
- at a spectral resolution of 39 RTI
- during the time period defined by the subactivity  
CIRS\_126MIFP1DAYMAP001\_PRIME\$4

we will generate a cube called 126MIFP1DAYMAP001\_CI004.601\_F3\_039E

## Chapter 3

# Data Description

The database is structured using detached PDS labels. Therefore what we refer to as a cube file is actually two files : one ASCII label file and one binary file. The label file is typically a file ending with a .LBL suffix and the binary file will have the same base name and a .DAT suffix.

The label file describes the structure and content of the binary file. Information in the label is stored in a “keyword=value” format and structured using elements from the general PDS dictionary and from the CIRS dictionary (see Appendix B, TSDR SIS document [3] and CIRS User Guide [2]). Appendix A contains an example of a label file.

The binary file consists of two spatial and one spectral dimension. The size of the spatial and spectral dimensions will vary depending of the observations. In addition to the core data, we appended suffix planes (“backplanes”) in the band dimension for ancillary data. Their number and content are given in the label file.

If there is no spectrum associated with a given location (`PIXEL_DATA_COUNT` = 0, see table 3.2 ), the core and most of the backplanes will be filled with `CORE_NULL` (see table 3.8 ).

## 3.1 Label File

### 3.1.1 File Identification and Structure

The first records given in the label describe the file structure.

Keyword	Definition
PDS_VERSION_ID	Version number of the PDS standards associated with the product.
RECORD_TYPE	The style of records in file.
RECORD_BYTES	The number of bytes in each record.
FILE_RECORDS	The number of records in the binary file.

Table 3.1: File Identification and Structure

### 3.1.2 Identification Data Elements

This section allows the user to understand the unique identification of the product by time period, target and detectors used.

Keyword	Definition
OBSERVATION_ID	The name of the observation of which this product is part. This name is derived from the Predicted Events File (PEF).
PRODUCT_ID	Unique identifier for each product. Usually derived from the base file-name of the current product.
INSTRUMENT_HOST_NAME	Name of spacecraft.
INSTRUMENT_NAME	Proper name of the instrument.
INSTRUMENT_ID	Common identifier for the instrument.
FOCAL_PLANE	Focal plane used.
TARGET_NAME	Target in the field of view.
MISSION_PHASE_NAME	Indicator of the phase of the mission.

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Table3.2 – *Continued from previous page*

Keyword	Definition
SCET_START	Value of internal clock at the beginning of the observation. Expressed in linux time (UT seconds since Jan 1st 1970).
SCET_END	Value of internal clock at the end of the observation. Expressed in linux time (UT seconds since Jan 1st 1970).
SPACECRAFT_CLOCK_START_COUNT	Value of the internal clock at the beginning of the observation. The format uses a double precision encoding of the clock time in units of ticks since the spacecraft clock start.
SPACECRAFT_CLOCK_STOP_COUNT	Value of the internal clock at the end of the observation. The format uses a double precision encoding of the clock time in units of ticks since the spacecraft clock start.
START_TIME	Value of the internal clock at the beginning of the observation. UTC time human readable format YYYY-MM-DDTHH:MM:SS
STOP_TIME	Value of the internal clock at the end of the observation. UTC time human readable format YYYY-MM-DDTHH:MM:SS
DESCRIPTION	Generic information.

Table 3.2: Identification Data Elements

### 3.1.3 Geometry Elements

This set of label items provide some information about the geometry at the beginning, middle and end of the observations. For other items, the label provides the mean of the valid values of these geometric parameters for the observation. Keywords and contents are derived from existing fields in the TSDR database using the following rules:

- KEYWORD\_BEGINNING equals to KEYWORD of the first element of the observation,
- KEYWORD\_MIDDLE equals to KEYWORD of the central element of the observation,
- KEYWORD\_END equals to KEYWORD of the last element of the observation,
- MEAN\_KEYWORD equals to the mean value of KEYWORD over the observation.

For example, based on the TSDR field “BODY\_SPACECRAFT\_RANGE”, we define the fields “BODY\_SPACECRAFT\_RANGE\_BEGINNING”, “BODY\_SPACECRAFT\_RANGE\_MIDDLE”, “BODY\_SPACECRAFT\_RANGE\_END” and “MEAN\_BODY\_SPACECRAFT\_RANGE”.

Some keywords had to be renamed for clarity but in such cases the matching TSDR field is provided in the dictionary (Appendix B)

## Convention

The NAIF ellipsoid for the surface of the body is used to determine the sub-spacecraft point and all field-of-view/surface intercepts. For Saturn and Jupiter, this is the ellipsoid defining the 1-bar level. For the satellites, including Titan, their surfaces are used.

The ring plane is defined as the equatorial plane of the primary and its normal is the rotation axis of the primary. For rings related fields, geometry is usually defined at the intercept of the field-of-view with the ring plane.

When the boresight does not intersect the surface of the body, some of the geometry parameters are handled in a special way in the TSDRs. Some of the parameters will then corresponds to the closest point to the boresight on the target instead of the intersection of the boresight with the target. Others may use a special value that we will refer to as the “limb value”. Please refer to the TSDR SIS document for details.

*NB:*

*Latitudes are planetographic for Jupiter and Saturn, and planetocentric (in the sense that latitude is defined by the angle between the equatorial plane and the line connecting the surface point and the body center) for the satellites, including Titan.*

*Following the planetographic convention, longitudes are defined to increase westward for primaries and satellites.*

*For rings, longitudes are defined to increase eastward.*

Table 3.3: Geometry elements for Jupiter and Saturn cubes

Keyword	Definition
BODY_ANGULAR_SEMIDIAMETER	The equatorial angular radius of the body as seen by the spacecraft. Unit is milliradians.
BODY_PHASE_ANGLE	The angle between the radial vector of the spacecraft and the radial vector of the Sun, from the center of the body. Unit is degrees.
BODY_SPACECRAFT_RANGE	The distance from the center of the body to the spacecraft. Unit is km.
BODY_SUB_SOLAR_LATITUDE	The planetographic latitude of the sub-solar point on the body. Unit is degrees north.
BODY_SUB_SOLAR_LONGITUDE	The longitude of the sub-solar point on the body. Unit is degrees west.
BODY_SUB_SPACECRAFT_LATITUDE	The planetographic sub-spacecraft latitude in the IAU coordinate system defined for the body. Unit is degrees north.
BODY_SUB_SPACECRAFT_LONGITUDE	The sub-spacecraft longitude in the IAU coordinate system defined for the body. Unit is degrees west.
BORESIGHT_DECLINATION	The declination of the boresight in the J2000 coordinate system. Unit is degrees.
BORESIGHT_LATITUDE_ZPD	The planetographic latitude of the boresight at the ZPD time. Unit is degrees north.
BORESIGHT_LOCAL_TIME	The local solar time in hours since midnight. Unit is fractional hours.
BORESIGHT_LONGITUDE_ZPD	The longitude of the boresight at the ZPD time. Unit is degrees west.
BORESIGHT_RIGHT_ASCENSION	The right ascension of the boresight in the J2000 coordinate system. Unit is degrees.
BORESIGHT_SOLAR_PHASE	The angle between the direction vector of the Sun and the normal to the surface at the point at which the boresight intersects the surface. Unit is degrees.

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Table3.3 – *Continued from previous page*

Keyword	Definition
BORESIGHT_SOLAR_ZENITH	The angle between the direction vector of the Sun and the normal to the surface at the point at which the boresight intersects the surface. Unit is degrees.
EMISSION_ANGLE_FOV_AVERAGE	The average of the values of the emission angle (angle between the surface normal and the spacecraft direction) over the field of view. Unit is degrees.

Table 3.4: Geometry elements for Jupiter’s and Saturn’s Moon cubes

Keyword	Definition
BODY_ANGULAR_SEMIDIAMETER	The equatorial angular radius of the body as seen by the spacecraft. Unit is milliradians.
BODY_PHASE_ANGLE	The angle between the radial vector of the spacecraft and the radial vector of the Sun, from the center of the body. Unit is degrees.
BODY_SPACECRAFT_RANGE	The distance from the center of the body to the spacecraft. Unit is km.
BODY_SUB_SOLAR_LATITUDE_PC	The planetocentric latitude of the sub-solar point on the body. Unit is degrees north.
BODY_SUB_SOLAR_LONGITUDE	The longitude of the sub-solar point on the body. Unit is degrees west.
BODY_SUB_SPACECRAFT_LATITUDE_PC	The planetocentric sub-spacecraft latitude in the IAU coordinate system defined for the body. Unit is degrees north.
BODY_SUB_SPACECRAFT_LONGITUDE	The sub-spacecraft longitude in the IAU coordinate system defined for the body. Unit is degrees west.
BORESIGHT_DECLINATION	The declination of the boresight in the J2000 coordinate system. Unit is degrees.
BORESIGHT_LATITUDE_ZPD_PC	The planetocentric latitude of the boresight at the ZPD time. Unit is degrees north.
BORESIGHT_LOCAL_TIME	The local solar time in hours since midnight. Unit is fractional hours.
BORESIGHT_LONGITUDE_ZPD	The longitude of the boresight at the ZPD time. Unit is degrees west.
BORESIGHT_RIGHT_ASCENSION	The right ascension of the boresight in the J2000 coordinate system. Unit is degrees.
BORESIGHT_SOLAR_PHASE	The angle between the direction vector of the Sun and the normal to the surface at the point at which the boresight intersects the surface. Unit is degrees.

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Table3.4 – *Continued from previous page*

Keyword	Definition
BORESIGHT_SOLAR_ZENITH	The angle between the direction vector of the Sun and the normal to the surface at the point at which the boresight intersects the surface. Unit is degrees.
EMISSION_ANGLE_FOV_AVERAGE	The average of the values of the emission angle (angle between the surface normal and the spacecraft direction) over the field of view. Unit is degrees.

Table 3.5: Geometry elements for Rings cubes

Keyword	Definition
PRIMARY_BODY_NAME	Name of the primary body with which the current target body is associated.
PRIMARY_SPACECRAFT_RANGE	The distance from the center of the primary to the spacecraft. Unit is km.
PRIMARY_SUB_SPACECRAFT_LATITUDE	The planetographic sub-spacecraft latitude in the IAU coordinate system defined for the primary. Unit is degrees north.
PRIMARY_SUB_SPACECRAFT_LONGITUDE	The sub-spacecraft longitude in the IAU coordinate system defined for the primary. Unit is degrees west.
PRIMARY_SUB_SOLAR_LATITUDE	The planetographic latitude of the sub-solar point on the primary. Unit is degrees north.
PRIMARY_SUB_SOLAR_LONGITUDE	The longitude of the sub-solar point on the primary. Unit is degrees west.
RING_BORESIGHT_EMISSION_ANGLE	The emission angle at the intersection of the boresight and the ring plane. Unit is degrees.
RING_BORESIGHT_LOCAL_TIME	The local solar time at the intersection of the boresight and the ring plane in the primary's coordinate system. Unit is fractional hours since midnight.
RING_BORESIGHT_LONGITUDE_ZPD	The longitude of the intersection of the boresight and the ring plane at the ZPD time. Longitudes are measured eastwards in an inertial frame from the "ascending node of the intersection of the ring plane with J2000". Unit is degrees east.
RING_BORESIGHT_RADIUS_ZPD	The radius of the intersection of the boresight and the ring plane at the ZPD time. Unit is km.
RING_BORESIGHT_SOLAR_PHASE	The angle between the direction vector of the Sun and the boresight. Unit is degrees.
RING_BORESIGHT_SOLAR_ZENITH	The angle between the direction vector of the Sun and the normal to the surface at the point at which the boresight intersects the surface. Unit is degrees.

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Table 3.5 – *Continued from previous page*

Keyword	Definition
RING_BORESIGHT_SPACECRAFT_RANGE	The distance from the intersection of the boresight with the ring plane to the spacecraft. Unit is km.

### 3.1.4 Pointer to binary object

Keyword	Definition
^SPECTRAL_CUBE	File name of the binary object.

Table 3.6: Pointer to binary object.

### 3.1.5 Binary object description

Keyword	Definition
AXES	Number of dimensions in the core.
AXIS_NAME	The names of the axes in physical storage order. Comma delimited string list.

Table 3.7: Binary object description.

### 3.1.6 Core description

Keyword	Definition
CORE_ITEMS	The length of each axis of the core in pixels. Comma delimited integer list : (number_of_samples, number_of_lines, number_of_bands)
CORE_NAME	Identify the scientific meaning of the values in the core. e.g. Spectral Radiance.
CORE_ITEM.BYTES	The number of bytes per pixel value.
CORE_ITEM.TYPE	The name of the representation of the pixel values.

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Table 3.8 – *Continued from previous page*

Keyword	Definition
CORE_BASE	An additive constant used to convert the reported core value to the actual value via a linear transformation.
CORE_MULTIPLIER	A multiplicative constant used to convert the reported core value to the actual value via a linear transformation.
CORE_UNIT	The unit of the values placed in the core : $\text{W cm}^{-2} \text{ sr}^{-1} (\text{cm}^{-1})^{-1}$ .
CORE_VALID_MINIMUM	Hexadecimal representation of the lowest possible value in the core.
CORE_NULL	Hexadecimal representation of the value placed in the core when no proper data value is available.
CORE_LOW_REPR_SATURATION	Hexadecimal representation of a special pixel value that flags a pixel whose value is lower than allowed by the numeric representation used. Provided for compatibility without being used within the cube.
CORE_LOW_INSTR_SATURATION	Hexadecimal representation of a special pixel value that flags a pixel whose value is lower than the minimum reportable by the instrument. Provided for compatibility without being used within the cube.
CORE_HIGH_REPR_SATURATION	Hexadecimal representation of a special pixel value that flags a pixel whose value is higher than allowed by the numeric representation used. Provided for compatibility without being used within the cube.
CORE_HIGH_INSTR_SATURATION	Hexadecimal representation of a special pixel value that flags a pixel whose value is higher than the maximum reportable by the instrument. Provided for compatibility without being used within the cube.

Table 3.8: Core description

### 3.1.7 Suffix description

Keyword	Definition
SUFFIX.ITEMS	The number of data items present in each of the suffix regions - comma delimited integer list (number_of_suffix_samples, number_of_suffix_lines, number_of_suffix_bands).
SUFFIX.BYTES	The number of bytes per pixel value in all suffix regions.
BAND_SUFFIX.NAME	The name of the data for each backplane, comma delimited string list.

Table 3.9: Suffix description

### 3.1.8 Band description

Keyword	Definition
BANDS	Band dimension.
BAND_BIN_UNIT	Unit of measurement of BAND_BIN_CENTER.
BAND_BIN_CENTER	Sequence of wavenumbers describing the center of each bin along the band axis.
BAND_BIN_WIDTH	Width of the bin along the band axis.

Table 3.10: Band description

### 3.1.9 Projection description

Keyword	Definition
A_AXIS_RADIUS	Dimension of the semimajor axis of the NAIF ellipsoid that defines the approximate shape of the target. Unit is km.
B_AXIS_RADIUS	Dimension of the intermediate axis of the NAIF ellipsoid that defines the approximate shape of the target. Unit is km.
C_AXIS_RADIUS	Dimension of the semiminor axis of the NAIF ellipsoid that defines the approximate shape of the target. Unit is km.
POSITIVE_LONGITUDE_DIRECTION	Identifies the direction with which the longitude increases.
MAP_PROJECTION_TYPE	Type of projection.
DATA_COUNT	Number of measurements combined to create the cube.
MAP_RESOLUTION	Grid spacing. Unit is pixels/degree.
ANGULAR_SCALE	Grid spacing. Unit is milliradians/pixel.
LOCAL_TIME_SCALE	Grid spacing. Unit is local hours/pixel.
RADIAL_SCALE	Grid spacing. Unit is km/pixel.
SAMPLE_NAME	Coordinate name for the sample axis.
LINE_NAME	Coordinate name for the line axis.
FIRST_SAMPLE_CENTER	Sample coordinate at the center of the first sample element.
FIRST_LINE_CENTER	Line coordinate at the center of the first line element.

*Continued on next page*

Table 3.11 – *Continued from previous page*

Keyword	Definition
LAST_SAMPLE_CENTER	Sample coordinate at the center of the last sample element.
LAST_LINE_CENTER	Line coordinate at the center of the last line element.
MAX_FOOTPRINT_LINE	Maximum size of footprints along the line axis.
MAX_FOOTPRINT_SAMPLE	Maximum size of footprints along the sample axis.
MIN_FOOTPRINT_LINE	Minimum size of footprints along the line axis.
MIN_FOOTPRINT_SAMPLE	Minimum size of footprints along the sample axis.

Table 3.11: Projection description

## 3.2 Binary file

### 3.2.1 Storage convention

As previously mentioned a cube is a three-dimensional object with two spatial dimensions and one spectral dimension. Each of the three axes may include suffix data. In practice we only use suffix planes that extend the band dimension.

By convention the pixel with smallest sample index (sample=1) is on the left edge of the spatial plane, the pixel with the smallest line index (line=1) is on the top edge of the spatial plane and the smallest band index is associated with the first spatial plane.

By extension of this convention, the line coordinates will decrease as the indexes increase and the band coordinate will increase as the indexes increase. However, for the equirectangular (latitude/longitude) maps, the sample coordinate is West longitude, and thus decreases as the indices increase. For the point perspective (plane of sky) maps, the sample coordinate is the east/west offset (with respect to a celestial reference frame) in milliradians from the target center, which in our convention increases from left to right, as the sample index increases.

In order to convert this three dimensional structure into a one dimensional structure, we are applying the Band Sequential storage order. The coordinate that varies fastest is SAMPLE, the second fastest is LINE and the slowest is BAND.

If we consider the cube of sample dimensions S, line dimension L and band dimension B and identify each pixel by its coordinates (sample, line, band), the data will be stored as follows :

(1,1,1) (2,1,1) [...] (S,1,1) (1,2,1) [...] (S,2,1)(1,3,1) [.....] (S,L,1) (1,1,2) [...] (S,L,2) [.....]  
(S,L,B)

The lengths of the core axes and the suffix axes are given in the label files. Core and suffix pixels always occupy four bytes. The binary file is therefore very simple and only made of an ordered sequence of floating point values

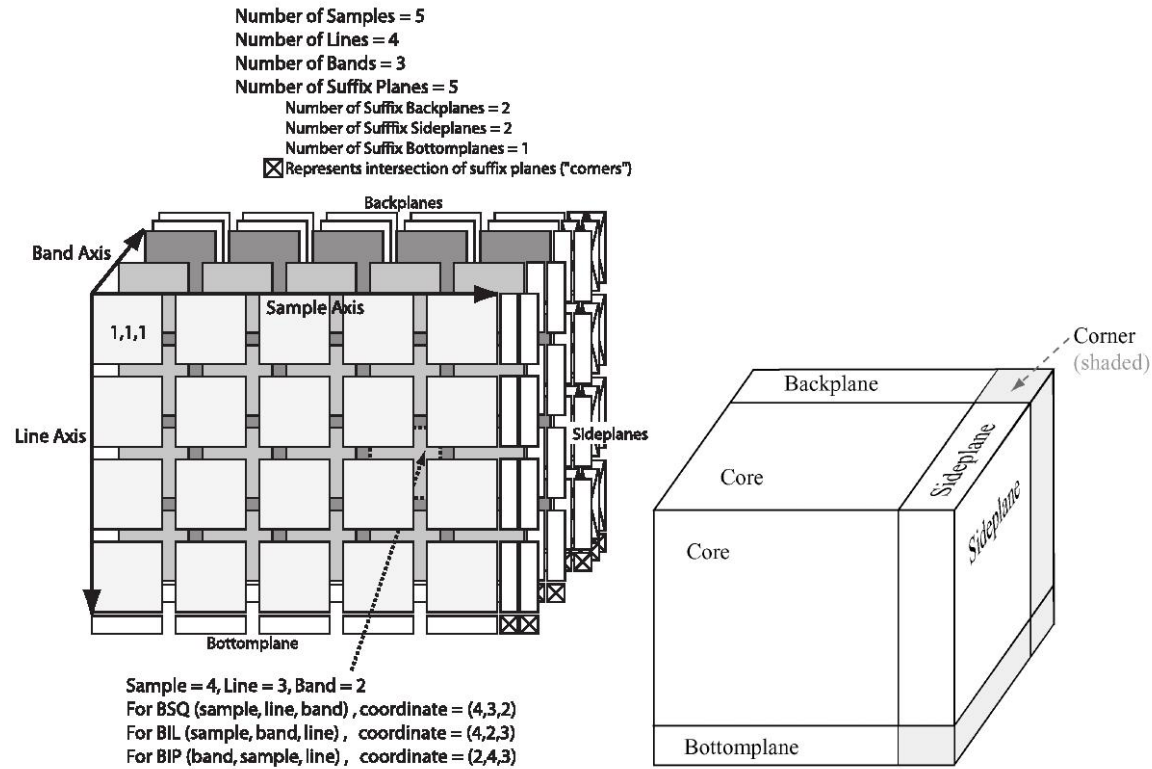


Figure 3.1: Exploded view of a SPECTRAL\_CUBE object

from the PDS Standards Reference documentation. The CIRS data cubes make use of backplanes, but not bottomplanes or sideplanes.



### 3.2.2 Special values

If there is no spectrum associated with a given location (`PIXEL_DATA_COUNT` = 0, see table 3.1), the core and most of the backplanes will be filled with `CORE_NULL`.

### 3.2.3 Backplane description

For every spatial element in the data cube, we provide geometrical information in the cube backplanes. The first two backplanes (`SAMPLE_CENTER` and `LINE_CENTER`) provide the coordinates of the pixel center. For all other backplanes, the value is the average of that geometric parameter for all the original spectra that were used to create the spectrum stored in that spatial element. Angles are in degrees unless otherwise noted, and a null value of -200 is used when appropriate (for instance, for latitude and longitude when the field of view does not intersect the target body).

Note that zero-crossings are handled correctly when averaging angular quantities, so for instance the average of 357 degrees and 1 degrees is 359 degrees, not 179 degrees.

Table 3.12: Backplane elements for Jupiter and Saturn cubes

Keyword	Definition
PIXEL_DATA_COUNT	The number of original CIRS spectra averaged to create this spatial pixel.
SAMPLE_CENTER	For equirectangular cubes, this is the West longitude of the pixel center, in degrees.  For point perspective cubes, it is the scaled offset from the body center, in the direction of decreasing J2000 Right Ascension, in milliradians.
LINE_CENTER	For equirectangular cubes, this is the latitude of the pixel center, in degrees.  For point perspective cubes, it is the scaled offset from the body center, in the direction of increasing J2000 Declination, in milliradians.
BODY_SPACECRAFT_RANGE	The distance from the center of the body to the spacecraft. Unit is km.
BODY_SUB.SOLAR.LATITUDE	The planetographic latitude of the sub-solar point on the body. Unit is degrees north.
BODY_SUB.SOLAR.LONGITUDE	The longitude of the sub-solar point on the body. Unit is degrees west.
BODY_SUB.SPACECRAFT.LATITUDE	The planetographic sub-spacecraft latitude in the IAU coordinate system defined for the body. Unit is degrees north.
BODY_SUB.SPACECRAFT.LONGITUDE	The sub-spacecraft longitude in the IAU coordinate system defined for the body. Unit is degrees west.
BORESIGHT_DECLINATION	The declination of the boresight in the J2000 coordinate system. Unit is degrees.
BORESIGHT_LATITUDE_ZPD	The planetographic latitude of the boresight at the ZPD time. Unit is degrees north.
BORESIGHT_LOCAL_TIME	The local solar time in hours since midnight. Unit is fractional hours.
BORESIGHT_LONGITUDE_ZPD	The longitude of the boresight at the ZPD time. Unit is degrees west.

*Continued on next page*

Table3.12 – *Continued from previous page*

Keyword	Definition
BORESIGHT_RIGHT_ASCENSION	The right ascension of the boresight in the J2000 coordinate system. Unit is degrees.
BORESIGHT_SOLAR_PHASE	The angle between the direction vector of the Sun and the normal to the surface at the point at which the boresight intersects the surface. Unit is degrees.
BORESIGHT_SOLAR_ZENITH	The angle between the direction vector of the Sun and the normal to the surface at the point at which the boresight intersects the surface. Unit is degrees.
EMISSION_ANGLE_FOV_AVERAGE	The average of the values of the emission angle (angle between the surface normal and the spacecraft direction) over the field of view. Unit is degrees.
TOTAL_SPECTRAL_POWER	The integrated radiance under the power spectrum. Unit is ( $\text{W cm}^{-2} \text{ sr}^{-1}$ ).

Table 3.12: Backplane elements for Jupiter and Saturn cubes

Table 3.13: Backplane elements for Jupiter’s and Saturn’s Moon cubes

Keyword	Definition
PIXEL_DATA_COUNT	The number of original CIRS spectra averaged to create this spatial pixel.
SAMPLE_CENTER	For equirectangular cubes, this is the West longitude of the pixel center, in degrees.  For point perspective cubes, it is the scaled offset from the body center, in the direction of decreasing J2000 Right Ascension, in milliradians.
LINE_CENTER	For equirectangular cubes, this is the latitude of the pixel center, in degrees.  For point perspective cubes, it is the scaled offset from the body center, in the direction of increasing J2000 Declination, in milliradians.
BODY_SPACECRAFT_RANGE	The distance from the center of the body to the spacecraft. Unit is km.
BODY_SUB.SOLAR.LATITUDE_PC	The planetocentric latitude of the sub-solar point on the body. Unit is degrees north.
BODY_SUB.SOLAR.LONGITUDE	The longitude of the sub-solar point on the body. Unit is degrees west.
BODY_SUB.SPACECRAFT.LATITUDE_PC	The planetocentric sub-spacecraft latitude in the IAU coordinate system defined for the body. Unit is degrees north.
BODY_SUB.SPACECRAFT.LONGITUDE	The sub-spacecraft longitude in the IAU coordinate system defined for the body. Unit is degrees west.
BORESIGHT_DECLINATION	The declination of the boresight in the J2000 coordinate system. Unit is degrees.
BORESIGHT_LATITUDE_ZPD_PC	The planetocentric latitude of the boresight at the ZPD time. Unit is degrees north.
BORESIGHT_LOCAL_TIME	The local solar time in hours since midnight. Unit is fractional hours.
BORESIGHT_LONGITUDE_ZPD	The longitude of the boresight at the ZPD time. Unit is degrees west.

*Continued on next page*

Table 3.13 – *Continued from previous page*

Keyword	Definition
BORESIGHT_RIGHT_ASCENSION	The right ascension of the boresight in the J2000 coordinate system. Unit is degrees.
BORESIGHT_SOLAR_PHASE	The angle between the direction vector of the Sun and the normal to the surface at the point at which the boresight intersects the surface. Unit is degrees.
BORESIGHT_SOLAR_ZENITH	The angle between the direction vector of the Sun and the normal to the surface at the point at which the boresight intersects the surface. Unit is degrees.
EMISSION_ANGLE_FOV_AVERAGE	The average of the values of the emission angle (angle between the surface normal and the spacecraft direction) over the field of view. Unit is degrees.
TOTAL_SPECTRAL_POWER	The integrated radiance under the power spectrum. Unit is ( $\text{W cm}^{-2} \text{ sr}^{-1}$ ).

Table 3.13: Backplane elements for Jupiter’s and Saturn’s Moon cubes

Table 3.14: Backplane elements for Rings cubes

Keyword	Definition
PIXEL_DATA_COUNT	The number of original CIRS spectra averaged to create this spatial pixel.
SAMPLE_CENTER	For ring cubes, this is the radius from the primary center in km.
LINE_CENTER	For ring cubes, this is the local time in hours.
RING_BORESIGHT_LONGITUDE_ZPD	The longitude of the intersection of the boresight and the ring plane at the ZPD time. Longitudes are measured eastwards in an inertial frame from the "ascending node of the intersection of the ring plane with J2000". Unit is degrees east.
RING_BORESIGHT_RADIUS_ZPD	The radius of the intersection of the boresight and the ring plane at the ZPD time. Unit is km.
RING_BORESIGHT_EMISSION_ANGLE	The emission angle at the intersection of the boresight and the ring plane. Unit is degrees.
RING_BORESIGHT_SOLAR_PHASE	The angle between the direction vector of the Sun and the boresight. Unit is degrees.
RING_BORESIGHT_SOLAR_ZENITH	The angle between the direction vector of the Sun and the normal to the surface at the point at which the boresight intersects the surface. Unit is degrees.
RING_BORESIGHT_SPACECRAFT_RANGE	The distance from the intersection of the boresight with the ring plane to the spacecraft. Unit is km.
RING_BORESIGHT_LOCAL_TIME	The local solar time at the intersection of the boresight and the ring plane in the primary's coordinate system. Unit is fractional hours since midnight.
TOTAL_SPECTRAL_POWER	The integrated radiance under the power spectrum. Unit is ( $\text{W cm}^{-2} \text{ sr}^{-1}$ ).

Table 3.14: Backplane elements for Rings cubes

## Chapter 4

# Projection

### 4.1 Creating a grid

The final data product consist of data arranged in a grid of pixels. The grid is defined so that all pixels have exactly the same dimensions. The equirectangular map consists of grid pixels at equally spaced intervals of longitude and latitude. The point perspective pixels are equally spaced in milliradians in the plane of the sky.

### 4.2 Registration method

The input data sets are usually acquired in such a way that the spatial sampling is non-homogeneous, with varying footprint areas, gaps, overlaps. Therefore when creating a cube, the first task is to register our input data with the regular grid. To do this registration our reference points on the grid are located at the center of each grid pixel (pixel centered registration), so that:

- One input footprint will be associated to at least one or more grid pixels.
- One grid pixel may be associated to many input footprints or none. When many input footprints contribute to one grid pixel, the spectra (and geometry information in the backplanes) are averaged together.

The following figure shows a series of illustrations of how the registration is done. Notations are the following :

- $G_{i,j}$  center of the grid pixel in the column  $i$  and row  $j$ ,
- $O_{i,j}$  value contained by the grid pixel in the column  $i$  and row  $j$ ,
- $F_n$   $n^{th}$  input footprint,
- $I_n$  value contained by the  $n^{th}$  input



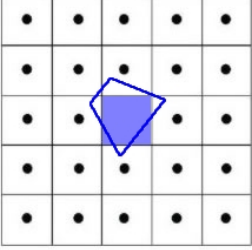
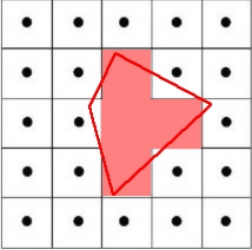
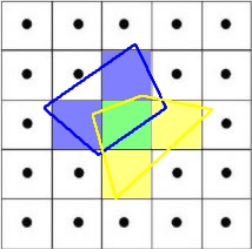
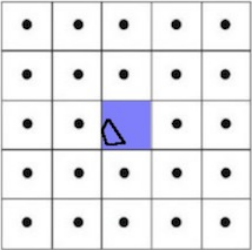
Scheme	Computation
	<p>Footprint covering one point of the grid</p> $G_{3,3} \subset F_1$ $\Rightarrow O_{3,3} = I_1$
	<p>Footprint covering multiple point of the grid</p> $\{G_{3,2}, G_{3,3}, G_{3,4}, G_{4,3}\} \subset F_1$ $\Rightarrow O_{3,2} = O_{3,3} = O_{3,4} = O_{4,3} = I_1$
	<p>Multiple footprints overlapping some point of the grid</p> $\{G_{3,2}, G_{2,3}, G_{3,3}\} \subset F_1$ $\{G_{3,3}, G_{4,3}, G_{3,4}\} \subset F_2$ $\{G_{3,2}, G_{3,3}, G_{3,4}, G_{4,3}\} \subset F_1$ $\Rightarrow O_{3,2} = O_{2,3} = I_1$ $O_{4,3} = O_{3,4} = I_2$ $O_{3,3} = (I_1 + I_2)/2$
	<p>Footprint covering no point of the grid : association to the closest point on the grid.</p> $\forall (i, j) G_{i,j} \not\subset F_1$ $\ F_1 G_{3,3}\  \leq \ F_1 G_{i,j}\ $ $\Rightarrow O_{3,3} = I_1$

Table 4.1: Illustration of field of view mapping onto the grid.

## 4.3 Choice of Grid Resolution

To preserve the spatial resolution of the original CIRS data, we try to use a grid resolution at least a factor of two smaller than the smallest footprint. An exception is when an activity covers a large area (perhaps sparsely) at high resolution and thus would result in an unacceptably large data cube. In such cases we reduce the resolution to keep the cube size manageable.

## 4.4 Mapping Projections

### 4.4.1 Equirectangular Projection

These are generated for all observations of Saturn and its satellites, but not for the rings.

This projection is a straightforward simple cylindrical map projection. The X coordinate is West longitude, which decreases with increasing sample index, so that surface features appear correctly when the cube line/sample planes are displayed with sample index increasing from left to right. The Y coordinate is planetocentric or planetographic latitude, which also decreases with increasing sample index, so that map feature appear correctly when the cube line/sample planes are displayed with sample index increasing from top to bottom, following the PDS convention. Cubes cover only the latitude and longitude range of the data used to create them.

### 4.4.2 Point Perspective Projection

These are generated for all observations of Saturn and its satellites, but not for the rings.

The equirectangular projection only includes fields of view which fall on the target body and thus does not preserve spectra taken off the limb of the target (which are important at Saturn or Titan, for example), and also does not preserve the original viewing geometry of the observation. We therefore also generate point perspective projection cubes, which approximate the appearance of the target body in the plane of the sky as seen from the spacecraft, and preserve spectra of the limb regions and the surrounding regions of deep space.

To generate these cubes, the field of view of each spectrum is first expressed as an offset, in milliradians, from the instantaneous direction of the target body center. The X coordinate is the offset in the direction of decreasing J2000 Right Ascension, and the Y coordinate is the offset in the direction of increasing J2000 Declination. To correct for the changing distance to the target during the activity, these offsets are then multiplied by the ratio of

the distance to the target body center at the time of the observation to the distance to the target body center at the start of the observation, so that the apparent size of the body is constant with time. The resulting scaled offsets for each field of view are then projected onto the cube grid and averaged as in Table 4.1. Fields of view further than 3 times the angular size of the target are not included in the cube, in order to limit the cube size.

Point perspective projection cubes provide valuable browse products for understanding the viewing geometry and quality of an observation. Because they include the deep space surrounding the target they also provide a check on the calibration, because well-calibrated data should show zero mean radiance in deep-space spectra. They can also be used to check pointing accuracy, by comparing the location of the target limb in the data to the limb location that derived from the geometry data recorded in the cube backplanes. However, these cubes should be used with caution for quantitative analysis, because the geometry may change significantly during the observation, resulting in distortions that may not be immediately apparent in the projected data.

#### 4.4.3 Ring Radius/Local Time Projection

The representation of ring data requires a unique projection. The rings are modeled by a thin disk centered on Saturn and in its equatorial plane, with an outer radius of 500,000 km. If the field of view falls partially or completely beyond this limit or if it intersects the primary body before intersecting the rings, the data will not be included.

Plotted coordinates are derived as follows. If A is the location of the intersection of the CIRS field of view with Saturn's equatorial plane, the X coordinate is the distance of A from the center of Saturn, and the Y coordinate is the local time on Saturn at the intersection with Saturn's surface of the line between A and Saturn's center. Local time is expressed in fractional hours, from 0.0 (at midnight) to 12.0 (at noon), to 24.0 (at midnight).

We have not generated point perspective projections for the ring observations because few ring observations were taken in a way that would make point perspective images useful.

## Chapter 5

# Snapshot Images

To facilitate browsing the data set, for each cube we also generate a JPEG image which shows, in false color, the total power, averaged over all wavenumbers, of each spatial pixel in the cube. The image also gives the time range of the activity, the cube spatial resolution, and the total number of spectra included in the cube. The image files have the same name as the associated cube files, but with a “.JPG” extension.

JPEG images are also produced that show power at selected small ranges of wavenumbers. These image files have the same name as the associated cube files, but with a suffix like “\_830WN”, indicating a wavenumber of 830, followed by a “.JPG” extension.

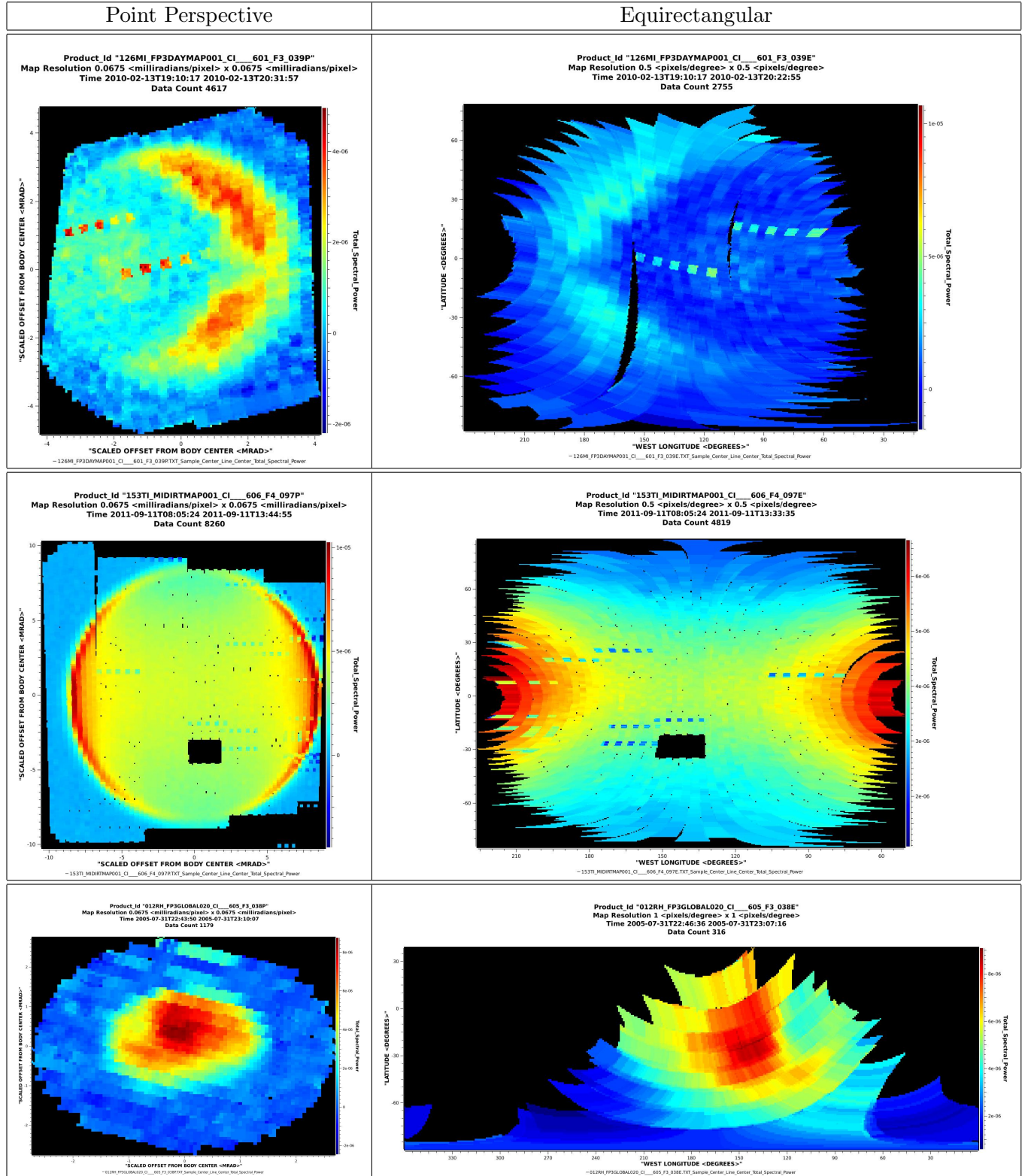
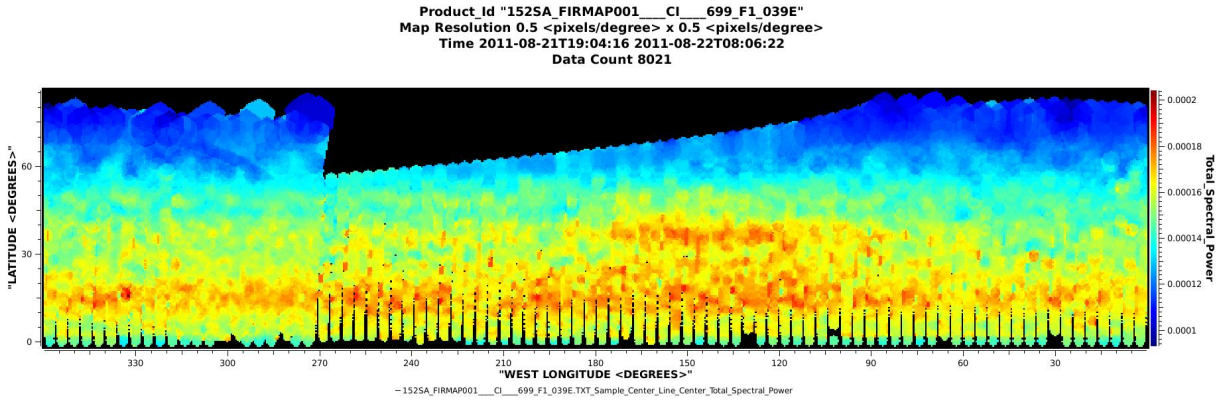
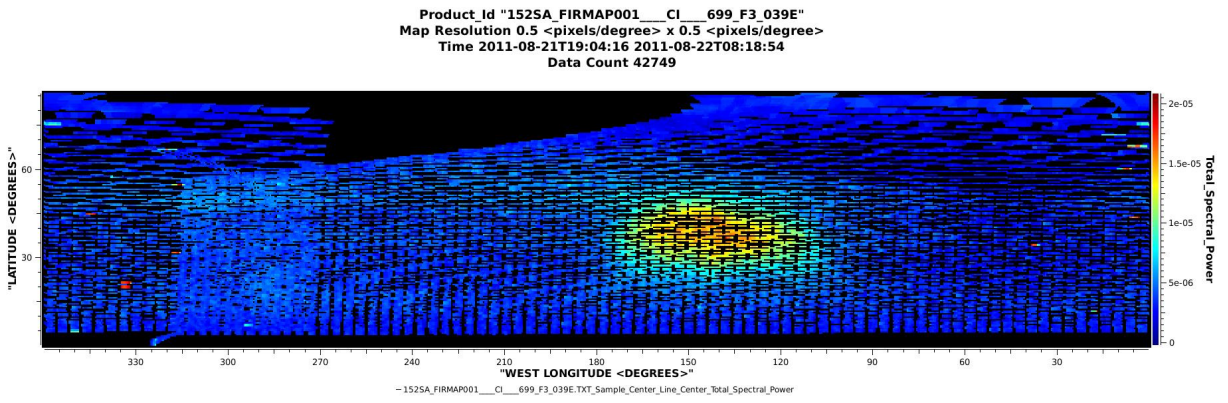


Table 5.1: Equirectangular projection vs Point Perspective projection.

“Saturn Storm” - Focal Plane 1



“Saturn Storm” - Focal Plane 3



“Saturn Storm” - Focal Plane 4

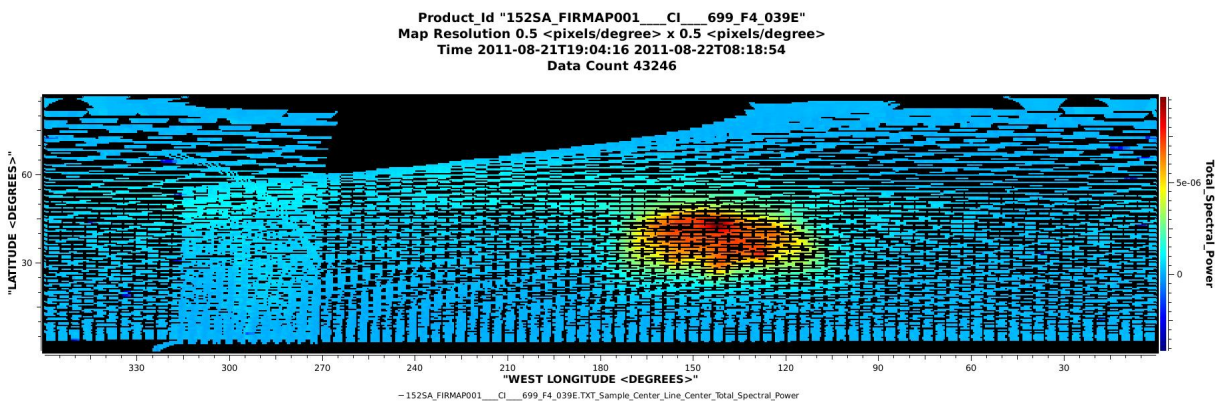


Table 5.2: Same activity as seen by the 3 focal planes.



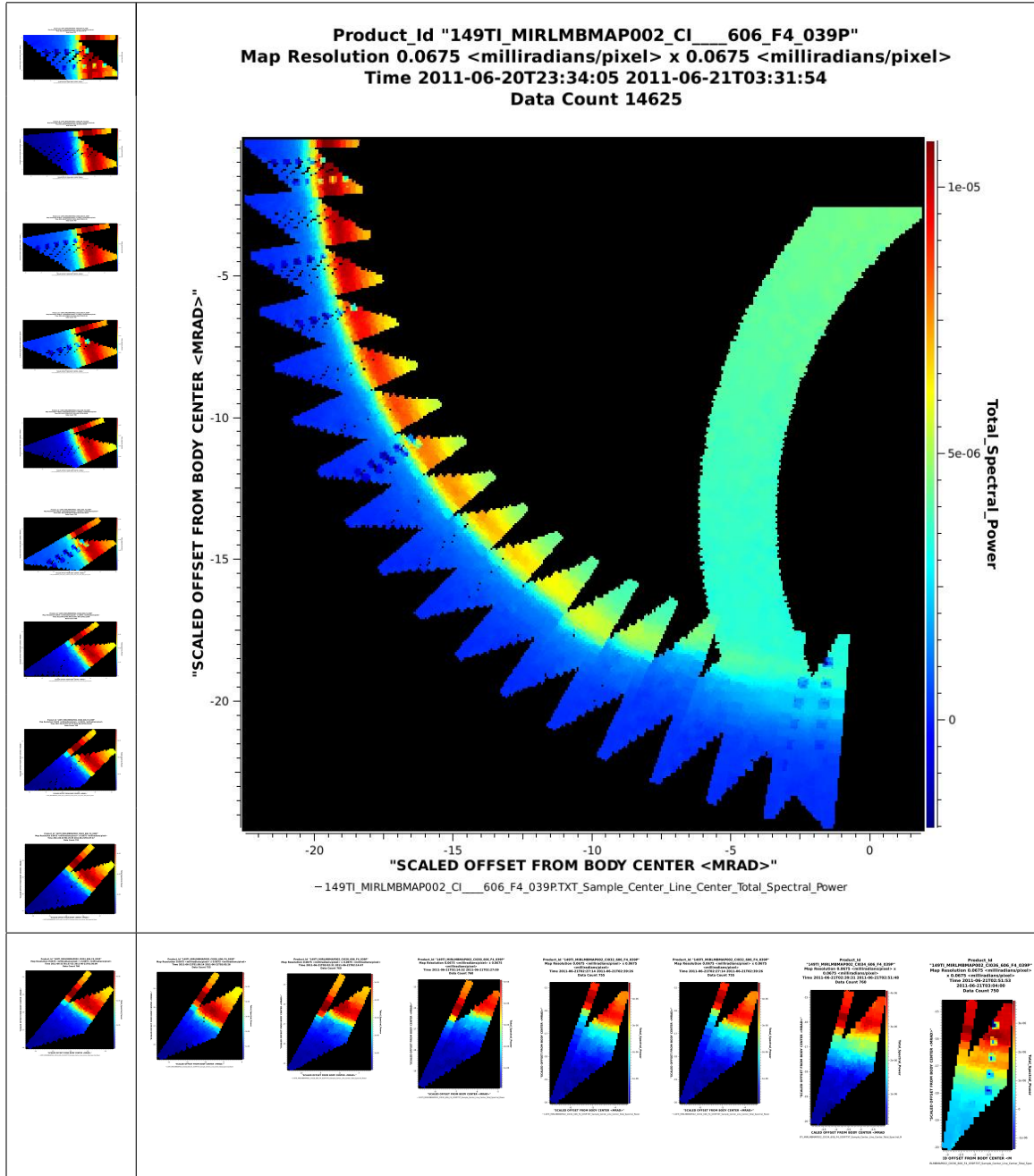


Table 5.3: Titan Limb Observation segmented by activity and subactivities.

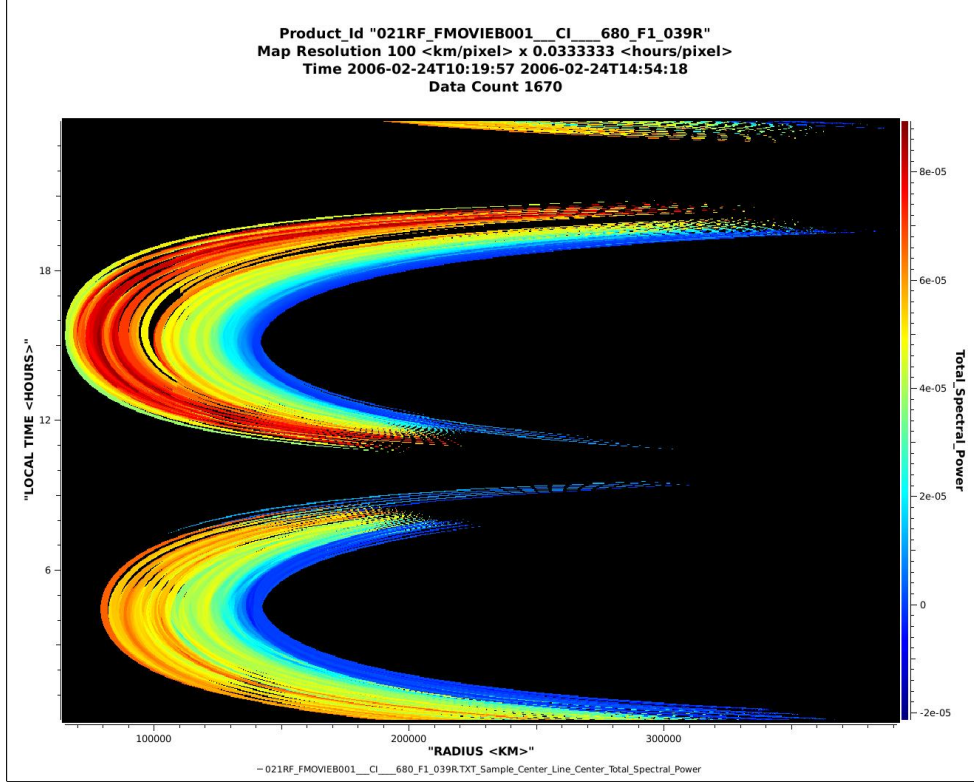
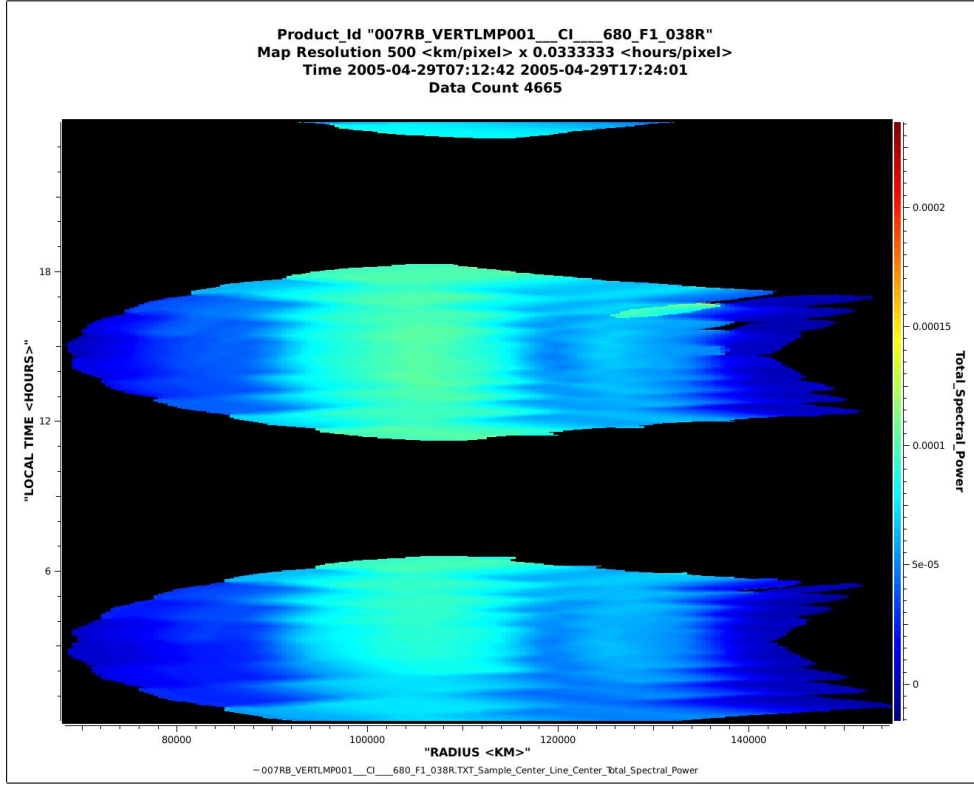


Table 5.4: Ring Polar projection.



# Appendix A

## Label examples

### A.1 Equirectangular projection - Planetocentric coordinates

```
PDS_VERSION_ID = PDS3
RECORD_TYPE = FIXED_LENGTH
RECORD_BYTES = 208
FILE_RECORDS = 2028
OBSERVATION_ID = "148TI_FIRLMBAER001_CI"
PRODUCT_ID = "148TI_FIRLMBAER001_CI____606_F1_039E"
INSTRUMENT_HOST_NAME = "CASSINI ORBITER"
INSTRUMENT_NAME = "COMPOSITE INFRARED SPECTROMETER"
INSTRUMENT_ID = "CIRS"
FOCAL_PLANE = 1
TARGET_NAME = "TITAN"
MISSION_PHASE_NAME = "SOLSTICE MISSION"
SCET_START = 1304889837
SCET_END = 1304889988
SPACECRAFT_CLOCK_START_COUNT = "1/1683583944.076"
SPACECRAFT_CLOCK_STOP_COUNT = "1/1683584095.076"
START_TIME = 2011-05-08T21:23:57
STOP_TIME = 2011-05-08T21:26:28
PRODUCT_CREATION_TIME = 2015-10-18T02:26:44
DESCRIPTION = "THIS FILE WAS PRODUCED BY THE CASSINI CIRS TEAM.FOR A
                DESCRIPTION OF HARDWARE AND SCIENTIFIC OBJECTIVES, REFER TO:
                EXPLORING THE SATURN SYSTEM IN THE THERMAL INFRARED: THE
                COMPOSITE INFRARED SPECTROMETER,F.M. FLASAR AND AL., SPACE
                SCIENCE REVIEWS VOLUME 115, NUMBERS 1-4 (2004), 169-297."
OBJECT = GEOMETRY
CSS:MEAN_BODY_ANGULAR_SEMIDIAMETER = 85.3351
```

```

CSS:MEAN_BODY_PHASE_ANGLE = 129.863
CSS:BODY_SPACECRAFT_RANGE_BEGINNING = 30519.3
CSS:BODY_SPACECRAFT_RANGE_MIDDLE = 30090.5
CSS:BODY_SPACECRAFT_RANGE_END = 29687.7
CSS:BODY_SUB_SOLAR_LATITUDE_PC_BEGINNING = 9.54092
CSS:BODY_SUB_SOLAR_LATITUDE_PC_MIDDLE = 9.54093
CSS:BODY_SUB_SOLAR_LATITUDE_PC_END = 9.54094
CSS:BODY_SUB_SOLAR_LONGITUDE_BEGINNING = 292.227
CSS:BODY_SUB_SOLAR_LONGITUDE_MIDDLE = 292.247
CSS:BODY_SUB_SOLAR_LONGITUDE_END = 292.266
CSS:BODY_SUB_SPACECRAFT_LATITUDE_PC_BEGINNING = 0.156823
CSS:BODY_SUB_SPACECRAFT_LATITUDE_PC_MIDDLE = 0.157566
CSS:BODY_SUB_SPACECRAFT_LATITUDE_PC_END = 0.158283
CSS:BODY_SUB_SPACECRAFT_LONGITUDE_BEGINNING = 161.53
CSS:BODY_SUB_SPACECRAFT_LONGITUDE_MIDDLE = 161.677
CSS:BODY_SUB_SPACECRAFT_LONGITUDE_END = 161.819
CSS:MEAN_BORESIGHT_DECLINATION = 2.05386
CSS:MEAN_BORESIGHT_LATITUDE_ZPD_PC = 46.2629
CSS:MEAN_BORESIGHT_LOCAL_TIME = 0.739759
CSS:MEAN_BORESIGHT_LONGITUDE_ZPD = 101.149
CSS:MEAN_BORESIGHT_RIGHT_ASCENSION = 322.121
CSS:MEAN_BORESIGHT_SOLAR_PHASE = 127.578
CSS:MEAN_BORESIGHT_SOLAR_ZENITH = 123.295
CSS:MEAN_EMISSION_ANGLE_FOV_AVERAGE = 74.8926
END_OBJECT
^SPECTRAL_CUBE = "148TI_FIRLMBAR001_CI____606_F1_039E.DAT"
OBJECT = SPECTRAL_CUBE
  AXES = 3
  AXIS_NAME = (SAMPLE, LINE, BAND)
  OBJECT = CORE
    CORE_ITEMS = (52,13,139)
    CORE_NAME = "CALIBRATED SPECTRAL RADIANCE"
    CORE_ITEM_BYTES = 4
    CORE_ITEM_TYPE = PC_REAL
    CORE_BASE = 0
    CORE_MULTIPLIER = 1
    CORE_UNIT = "WATT*CM**-2*SR**-1*UM**-1"
    CORE_VALID_MINIMUM = 16#FF7FFFFA#
    CORE_NULL = 16#FF7FFFFB#
    CORE_LOW_REPR_SATURATION = 16#FF7FFFFC#
    CORE_LOW_INSTR_SATURATION = 16#FF7FFFFD#
    CORE_HIGH_INSTR_SATURATION = 16#FF7FFFFE#
    CORE_HIGH_REPR_SATURATION = 16#FF7FFFFF#
  END_OBJECT
OBJECT = SUFFIX

```

```

SUFFIX_ITEMS = (0,0,17)
SUFFIX_BYTES = 4
BAND_SUFFIX_NAME = (CSS:PIXEL_DATA_COUNT,CSS:SAMPLE_CENTER,
                    CSS:LINE_CENTER,CSS:MEAN_BODY_SPACECRAFT_RANGE,
                    CSS:MEAN_BODY_SUB_SOLAR_LATITUDE_PC,
                    CSS:MEAN_BODY_SUB_SOLAR_LONGITUDE,
                    CSS:MEAN_BODY_SUB_SPACECRAFT_LATITUDE_PC,
                    CSS:MEAN_BODY_SUB_SPACECRAFT_LONGITUDE,
                    CSS:MEAN_BORESIGHT_DECLINATION,
                    CSS:MEAN_BORESIGHT_LATITUDE_ZPD_PC,
                    CSS:MEAN_BORESIGHT_LOCAL_TIME,
                    CSS:MEAN_BORESIGHT_LONGITUDE_ZPD,
                    CSS:MEAN_BORESIGHT_RIGHT_ASCENSION,
                    CSS:MEAN_BORESIGHT_SOLAR_PHASE,
                    CSS:MEAN_BORESIGHT_SOLAR_ZENITH,
                    CSS:MEAN_EMISSION_ANGLE_FOV_AVERAGE,
                    CSS:TOTAL_SPECTRAL_POWER)

END_OBJECT
OBJECT = BAND_BIN
BANDS = 139
BAND_BIN_UNIT = WAVENUMBER
BAND_BIN_CENTER = (5,10,15,20,25,30,35,40,45,50,55,60,65,70,75,80,85,90,
                  95,100,105,110,115,120,125,130,135,140,145,150,155,
                  160,165,170,175,180,185,190,195,200,205,210,215,220,
                  225,230,235,240,245,250,255,260,265,270,275,280,285,
                  290,295,300,305,310,315,320,325,330,335,340,345,350,
                  355,360,365,370,375,380,385,390,395,400,405,410,415,
                  420,425,430,435,440,445,450,455,460,465,470,475,480,
                  485,490,495,500,505,510,515,520,525,530,535,540,545,
                  550,555,560,565,570,575,580,585,590,595,600,605,610,
                  615,620,625,630,635,640,645,650,655,660,665,670,675,
                  680,685,690,695)

BAND_BIN_WIDTH = 5
END_OBJECT
OBJECT = IMAGE_MAP_PROJECTION
A_AXIS_RADIUS = 2575 <KM>
B_AXIS_RADIUS = 2575 <KM>
C_AXIS_RADIUS = 2575 <KM>
POSITIVE_LONGITUDE_DIRECTION = WEST
MAP_PROJECTION_TYPE = EQUIRECTANGULAR
CSS:DATA_COUNT = 32
MAP_RESOLUTION = 0.5 <PIXELS/DEGREE>
CSS:SAMPLE_NAME = "WEST LONGITUDE <DEGREES>"
CSS:LINE_NAME = "LATITUDE <DEGREES>"
CSS:FIRST_SAMPLE_CENTER = 108.25

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```
CSS:FIRST_LINE_CENTER = 49.75
CSS:LAST_SAMPLE_CENTER = 82.75
CSS:LAST_LINE_CENTER = 43.75
CSS:MAX_FOOTPRINT_LINE = 21.778
CSS:MAX_FOOTPRINT_SAMPLE = 4.56046
CSS:MIN_FOOTPRINT_LINE = 11.5439
CSS:MIN_FOOTPRINT_SAMPLE = 4.13614
END_OBJECT
END_OBJECT
END
```

## A.2 Equirectangular projection - Planetographic coordinates

```
PDS_VERSION_ID = PDS3
RECORD_TYPE = FIXED_LENGTH
RECORD_BYTES = 720
FILE_RECORDS = 91674
OBSERVATION_ID = "000SA_FIRCMPSIT007_CI"
PRODUCT_ID = "000SA_FIRCMPSIT007_CI____699_F1_400E"
INSTRUMENT_HOST_NAME = "CASSINI ORBITER"
INSTRUMENT_NAME = "COMPOSITE INFRARED SPECTROMETER"
INSTRUMENT_ID = "CIRS"
FOCAL_PLANE = 1
TARGET_NAME = "SATURN"
MISSION_PHASE_NAME = "TOUR PRE-HUYGENS"
SCET_START = 1087609587
SCET_END = 1087645237
SPACECRAFT_CLOCK_START_COUNT = "1/1466302235.098"
SPACECRAFT_CLOCK_STOP_COUNT = "1/1466337885.157"
START_TIME = 2004-06-19T01:46:27
STOP_TIME = 2004-06-19T11:40:37
PRODUCT_CREATION_TIME = 2015-10-12T19:27:04
DESCRIPTION = "THIS FILE WAS PRODUCED BY THE CASSINI CIRS TEAM.FOR A
                DESCRIPTION OF HARDWARE AND SCIENTIFIC OBJECTIVES, REFER TO:
                EXPLORING THE SATURN SYSTEM IN THE THERMAL INFRARED: THE
                COMPOSITE INFRARED SPECTROMETER,F.M. FLASAR AND AL., SPACE
                SCIENCE REVIEWS VOLUME 115, NUMBERS 1-4 (2004), 169-297."
OBJECT = GEOMETRY
    CSS:MEAN_BODY_ANGULAR_SEMIDIAMETER = 8.024
    CSS:MEAN_BODY_PHASE_ANGLE = 66.5119
    CSS:BODY_SPACECRAFT_RANGE_BEGINNING = 7.62488E+06
    CSS:BODY_SPACECRAFT_RANGE_MIDDLE = 7.50781E+06
    CSS:BODY_SPACECRAFT_RANGE_END = 7.40787E+06
    CSS:BODY_SUB_SOLAR_LATITUDE_BEGINNING = -24.5645
    CSS:BODY_SUB_SOLAR_LATITUDE_MIDDLE = -24.5629
    CSS:BODY_SUB_SOLAR_LATITUDE_END = -24.5616
    CSS:BODY_SUB_SOLAR_LONGITUDE_BEGINNING = 19.3063
    CSS:BODY_SUB_SOLAR_LONGITUDE_MIDDLE = 199.944
    CSS:BODY_SUB_SOLAR_LONGITUDE_END = 353.839
    CSS:BODY_SUB_SPACECRAFT_LATITUDE_BEGINNING = -16.1875
    CSS:BODY_SUB_SPACECRAFT_LATITUDE_MIDDLE = -16.1829
    CSS:BODY_SUB_SPACECRAFT_LATITUDE_END = -16.1788
    CSS:BODY_SUB_SPACECRAFT_LONGITUDE_BEGINNING = 90.4536
    CSS:BODY_SUB_SPACECRAFT_LONGITUDE_MIDDLE = 271.05
    CSS:BODY_SUB_SPACECRAFT_LONGITUDE_END = 64.9087
```

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CSS:MEAN_BORESIGHT_DECLINATION = 9.54818
CSS:MEAN_BORESIGHT_LATITUDE_ZPD = -41.793
CSS:MEAN_BORESIGHT_LOCAL_TIME = 6.68539
CSS:MEAN_BORESIGHT_LONGITUDE_ZPD = 57.0248
CSS:MEAN_BORESIGHT_RIGHT_ASCENSION = 38.9613
CSS:MEAN_BORESIGHT_SOLAR_PHASE = 66.5108
CSS:MEAN_BORESIGHT_SOLAR_ZENITH = 67.5027
CSS:MEAN_EMISSION_ANGLE_FOV_AVERAGE = 29.7039
END_OBJECT
^SPECTRAL_CUBE = "000SA_FIRCMPSIT007_CI____699_F1_400E.DAT"
OBJECT = SPECTRAL_CUBE
  AXES = 3
  AXIS_NAME = (SAMPLE, LINE, BAND)
  OBJECT = CORE
    CORE_ITEMS = (180,33,2761)
    CORE_NAME = "CALIBRATED SPECTRAL RADIANCE"
    CORE_ITEM_BYTES = 4
    CORE_ITEM_TYPE = PC_REAL
    CORE_BASE = 0
    CORE_MULTIPLIER = 1
    CORE_UNIT = "WATT*CM**-2*SR**-1*UM**-1"
    CORE_VALID_MINIMUM = 16#FF7FFFFA#
    CORE_NULL = 16#FF7FFFFB#
    CORE_LOW_REPR_SATURATION = 16#FF7FFFFC#
    CORE_LOW_INSTR_SATURATION = 16#FF7FFFFD#
    CORE_HIGH_INSTR_SATURATION = 16#FF7FFFFE#
    CORE_HIGH_REPR_SATURATION = 16#FF7FFFFF#
  END_OBJECT
  OBJECT = SUFFIX
    SUFFIX_ITEMS = (0,0,17)
    SUFFIX_BYTES = 4
    BAND_SUFFIX_NAME = (CSS:PIXEL_DATA_COUNT,CSS:SAMPLE_CENTER,
                        CSS:LINE_CENTER,CSS:MEAN_BODY_SPACECRAFT_RANGE,
                        CSS:MEAN_BODY_SUB_SOLAR_LATITUDE,
                        CSS:MEAN_BODY_SUB_SOLAR_LONGITUDE,
                        CSS:MEAN_BODY_SUB_SPACECRAFT_LATITUDE,
                        CSS:MEAN_BODY_SUB_SPACECRAFT_LONGITUDE,
                        CSS:MEAN_BORESIGHT_DECLINATION,
                        CSS:MEAN_BORESIGHT_LATITUDE_ZPD,
                        CSS:MEAN_BORESIGHT_LOCAL_TIME,
                        CSS:MEAN_BORESIGHT_LONGITUDE_ZPD,
                        CSS:MEAN_BORESIGHT_RIGHT_ASCENSION,
                        CSS:MEAN_BORESIGHT_SOLAR_PHASE,
                        CSS:MEAN_BORESIGHT_SOLAR_ZENITH,
                        CSS:MEAN_EMISSION_ANGLE_FOV_AVERAGE,

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                                CSS:TOTAL_SPECTRAL_POWER)
END_OBJECT
OBJECT = BAND_BIN
    BANDS = 2761
    BAND_BIN_UNIT = WAVENUMBER
    BAND_BIN_CENTER = (5,5.25,5.5,5.75,6,6.25,6.5,6.75,7,7.25,7.5,7.75,8,
                        8.25,8.5,8.75,9,9.25,9.5,9.75,10,10.25,10.5,10.75,11,
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                        16.25,16.5,16.75,17,17.25,17.5,17.75,18,18.25,18.5,
                        18.75,19,19.25,19.5,19.75,20,20.25,20.5,20.75,21,
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                        36.25,36.5,36.75,37,37.25,37.5,37.75,38,38.25,38.5,
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BAND\_BIN\_WIDTH = 0.25

END\_OBJECT

OBJECT = IMAGE\_MAP\_PROJECTION

A\_AXIS\_RADIUS = 60268 <KM>

B\_AXIS\_RADIUS = 60268 <KM>

C\_AXIS\_RADIUS = 54364 <KM>

POSITIVE\_LONGITUDE\_DIRECTION = WEST

MAP\_PROJECTION\_TYPE = EQUIRECTANGULAR

CSS:DATA\_COUNT = 608

MAP\_RESOLUTION = 2 <PIXELS/DEGREE>

CSS:SAMPLE\_NAME = "WEST LONGITUDE <DEGREES>"

CSS:LINE\_NAME = "LATITUDE <DEGREES>"

CSS:FIRST\_SAMPLE\_CENTER = 359

CSS:FIRST\_LINE\_CENTER = -19

CSS:LAST\_SAMPLE\_CENTER = 1

CSS:LAST\_LINE\_CENTER = -83

CSS:MAX\_FOOTPRINT\_LINE = 360

CSS:MAX\_FOOTPRINT\_SAMPLE = 48.0096

CSS:MIN\_FOOTPRINT\_LINE = 32.8705

CSS:MIN\_FOOTPRINT\_SAMPLE = 32.1517

```
END_OBJECT  
END_OBJECT  
  
END
```

### A.3 Point perspective projection

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PDS_VERSION_ID = PDS3
RECORD_TYPE = FIXED_LENGTH
RECORD_BYTES = 132
FILE_RECORDS = 30444
OBSERVATION_ID = "031TI_CLOUDMAP001__VI"
PRODUCT_ID = "031TI_CLOUDMAP001__VI____606_F1_097P"
INSTRUMENT_HOST_NAME = "CASSINI ORBITER"
INSTRUMENT_NAME = "COMPOSITE INFRARED SPECTROMETER"
INSTRUMENT_ID = "CIRS"
FOCAL_PLANE = 1
TARGET_NAME = "TITAN"
MISSION_PHASE_NAME = "TOUR"
SCET_START = 1161718992
SCET_END = 1161764485
SPACECRAFT_CLOCK_START_COUNT = "1/1540412117.098"
SPACECRAFT_CLOCK_STOP_COUNT = "1/1540457610.173"
START_TIME = 2006-10-24T19:43:12
STOP_TIME = 2006-10-25T08:21:25
PRODUCT_CREATION_TIME = 2015-10-16T20:35:16
DESCRIPTION = "THIS FILE WAS PRODUCED BY THE CASSINI CIRS TEAM.FOR A
                DESCRIPTION OF HARDWARE AND SCIENTIFIC OBJECTIVES, REFER TO:
                EXPLORING THE SATURN SYSTEM IN THE THERMAL INFRARED: THE
                COMPOSITE INFRARED SPECTROMETER,F.M. FLASAR AND AL., SPACE
                SCIENCE REVIEWS VOLUME 115, NUMBERS 1-4 (2004), 169-297."
OBJECT = GEOMETRY
    CSS:MEAN_BODY_ANGULAR_SEMIDIAMETER = 9.94262
    CSS:MEAN_BODY_PHASE_ANGLE = 115.037
    CSS:BODY_SPACECRAFT_RANGE_BEGINNING = 406728
    CSS:BODY_SPACECRAFT_RANGE_MIDDLE = 278894
    CSS:BODY_SPACECRAFT_RANGE_END = 152905
    CSS:BODY_SUB_SOLAR_LATITUDE_PC_BEGINNING = -15.1607
    CSS:BODY_SUB_SOLAR_LATITUDE_PC_MIDDLE = -15.1575
    CSS:BODY_SUB_SOLAR_LATITUDE_PC_END = -15.1544
    CSS:BODY_SUB_SOLAR_LONGITUDE_BEGINNING = 12.6529
    CSS:BODY_SUB_SOLAR_LONGITUDE_MIDDLE = 18.6142
    CSS:BODY_SUB_SOLAR_LONGITUDE_END = 24.5124
    CSS:BODY_SUB_SPACECRAFT_LATITUDE_PC_BEGINNING = 28.4688
    CSS:BODY_SUB_SPACECRAFT_LATITUDE_PC_MIDDLE = 28.7633
    CSS:BODY_SUB_SPACECRAFT_LATITUDE_PC_END = 29.0514
    CSS:BODY_SUB_SPACECRAFT_LONGITUDE_BEGINNING = 124.184
    CSS:BODY_SUB_SPACECRAFT_LONGITUDE_MIDDLE = 129.222
    CSS:BODY_SUB_SPACECRAFT_LONGITUDE_END = 133.964
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CSS:MEAN_BORESIGHT_DECLINATION = -34.9869
CSS:MEAN_BORESIGHT_LATITUDE_ZPD_PC = 45.781
CSS:MEAN_BORESIGHT_LOCAL_TIME = 8.73162
CSS:MEAN_BORESIGHT_LONGITUDE_ZPD = 67.8689
CSS:MEAN_BORESIGHT_RIGHT_ASCENSION = 30.7755
CSS:MEAN_BORESIGHT_SOLAR_PHASE = 115.255
CSS:MEAN_BORESIGHT_SOLAR_ZENITH = 82.9174
CSS:MEAN_EMISSION_ANGLE_FOV_AVERAGE = -200
END_OBJECT
^SPECTRAL_CUBE = "031TI_CLOUDMAP001__VI____606_F1_097P.DAT"
OBJECT = SPECTRAL_CUBE
  AXES = 3
  AXIS_NAME = (SAMPLE, LINE, BAND)
  OBJECT = CORE
    CORE_ITEMS = (33,43,691)
    CORE_NAME = "CALIBRATED SPECTRAL RADIANCE"
    CORE_ITEM_BYTES = 4
    CORE_ITEM_TYPE = PC_REAL
    CORE_BASE = 0
    CORE_MULTIPLIER = 1
    CORE_UNIT = "WATT*CM**-2*SR**-1*UM**-1"
    CORE_VALID_MINIMUM = 16#FF7FFFFA#
    CORE_NULL = 16#FF7FFFFB#
    CORE_LOW_REPR_SATURATION = 16#FF7FFFFC#
    CORE_LOW_INSTR_SATURATION = 16#FF7FFFFD#
    CORE_HIGH_INSTR_SATURATION = 16#FF7FFFFE#
    CORE_HIGH_REPR_SATURATION = 16#FF7FFFFF#
  END_OBJECT
  OBJECT = SUFFIX
    SUFFIX_ITEMS = (0,0,17)
    SUFFIX_BYTES = 4
    BAND_SUFFIX_NAME = (CSS:PIXEL_DATA_COUNT,CSS:SAMPLE_CENTER,
                        CSS:LINE_CENTER,CSS:MEAN_BODY_SPACECRAFT_RANGE,
                        CSS:MEAN_BODY_SUB_SOLAR_LATITUDE_PC,
                        CSS:MEAN_BODY_SUB_SOLAR_LONGITUDE,
                        CSS:MEAN_BODY_SUB_SPACECRAFT_LATITUDE_PC,
                        CSS:MEAN_BODY_SUB_SPACECRAFT_LONGITUDE,
                        CSS:MEAN_BORESIGHT_DECLINATION,
                        CSS:MEAN_BORESIGHT_LATITUDE_ZPD_PC,
                        CSS:MEAN_BORESIGHT_LOCAL_TIME,
                        CSS:MEAN_BORESIGHT_LONGITUDE_ZPD,
                        CSS:MEAN_BORESIGHT_RIGHT_ASCENSION,
                        CSS:MEAN_BORESIGHT_SOLAR_PHASE,
                        CSS:MEAN_BORESIGHT_SOLAR_ZENITH,
                        CSS:MEAN_EMISSION_ANGLE_FOV_AVERAGE,

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                                CSS:TOTAL_SPECTRAL_POWER)
END_OBJECT
OBJECT = BAND_BIN
    BANDS = 691
    BAND_BIN_UNIT = WAVENUMBER
    BAND_BIN_CENTER = (5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,
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692,693,694,695)

BAND\_BIN\_WIDTH = 1

END\_OBJECT

OBJECT = IMAGE\_MAP\_PROJECTION

A\_AXIS\_RADIUS = 2575 <KM>

B\_AXIS\_RADIUS = 2575 <KM>

C\_AXIS\_RADIUS = 2575 <KM>

POSITIVE\_LONGITUDE\_DIRECTION = WEST

MAP\_PROJECTION\_TYPE = POINT\_PERSPECTIVE

CSS:DATA\_COUNT = 1866

CSS:ANGULAR\_SCALE = 0.39 <MILLIRADIANS/PIXEL>

CSS:SAMPLE\_NAME = "SCALED OFFSET FROM BODY CENTER <MRAD>"

CSS:LINE\_NAME = "SCALED OFFSET FROM BODY CENTER <MRAD>"

CSS:FIRST\_SAMPLE\_CENTER = -11.6886

CSS:FIRST\_LINE\_CENTER = 15.0157

CSS:LAST\_SAMPLE\_CENTER = 0.79141

CSS:LAST\_LINE\_CENTER = -1.36425

CSS:MAX\_FOOTPRINT\_LINE = 5.67888

CSS:MAX\_FOOTPRINT\_SAMPLE = 5.67885

CSS:MIN\_FOOTPRINT\_LINE = 2.135

CSS:MIN\_FOOTPRINT\_SAMPLE = 2.13501

END\_OBJECT

END\_OBJECT

END

## A.4 Ring polar projection

```
PDS_VERSION_ID = PDS3
RECORD_TYPE = FIXED_LENGTH
RECORD_BYTES = 696
FILE_RECORDS = 108000
OBSERVATION_ID = "007RB_VERTLMP001__CI"
PRODUCT_ID = "007RB_VERTLMP001__CI____680_F1_038R"
INSTRUMENT_HOST_NAME = "CASSINI ORBITER"
INSTRUMENT_NAME = "COMPOSITE INFRARED SPECTROMETER"
INSTRUMENT_ID = "CIRS"
FOCAL_PLANE = 1
TARGET_NAME = "SATURN_RINGS"
MISSION_PHASE_NAME = "TOUR"
SCET_START = 1114758762
SCET_END = 1114795441
SPACECRAFT_CLOCK_START_COUNT = "1/1493451586.158"
SPACECRAFT_CLOCK_STOP_COUNT = "1/1493488265.218"
START_TIME = 2005-04-29T07:12:42
STOP_TIME = 2005-04-29T17:24:01
PRODUCT_CREATION_TIME = 2015-10-01T19:21:43
DESCRIPTION = "THIS FILE WAS PRODUCED BY THE CASSINI CIRS TEAM.FOR A
                DESCRIPTION OF HARDWARE AND SCIENTIFIC OBJECTIVES, REFER TO:
                EXPLORING THE SATURN SYSTEM IN THE THERMAL INFRARED: THE
                COMPOSITE INFRARED SPECTROMETER,F.M. FLASAR AND AL., SPACE
                SCIENCE REVIEWS VOLUME 115, NUMBERS 1-4 (2004), 169-297."
OBJECT = GEOMETRY
    PRIMARY_BODY_NAME = SUN
    CSS:PRIMARY_SPACECRAFT_RANGE_BEGINNING = 1.84577E+06
    CSS:PRIMARY_SPACECRAFT_RANGE_MIDDLE = 1.80519E+06
    CSS:PRIMARY_SPACECRAFT_RANGE_END = 1.7345E+06
    CSS:PRIMARY_SUB_SPACECRAFT_LATITUDE_BEGINNING = -17.7916
    CSS:PRIMARY_SUB_SPACECRAFT_LATITUDE_MIDDLE = -18.0033
    CSS:PRIMARY_SUB_SPACECRAFT_LATITUDE_END = -18.3635
    CSS:PRIMARY_SUB_SPACECRAFT_LONGITUDE_BEGINNING = 307.391
    CSS:PRIMARY_SUB_SPACECRAFT_LONGITUDE_MIDDLE = 76.4691
    CSS:PRIMARY_SUB_SPACECRAFT_LONGITUDE_END = 288.987
    CSS:PRIMARY_SUB_SOLAR_LATITUDE_BEGINNING = -21.8631
    CSS:PRIMARY_SUB_SOLAR_LATITUDE_MIDDLE = -21.8614
    CSS:PRIMARY_SUB_SOLAR_LATITUDE_END = -21.8588
    CSS:PRIMARY_SUB_SOLAR_LONGITUDE_BEGINNING = 260.107
    CSS:PRIMARY_SUB_SOLAR_LONGITUDE_MIDDLE = 30.1264
    CSS:PRIMARY_SUB_SOLAR_LONGITUDE_END = 244.3
    CSS:MEAN_RING_BORESIGHT_EMISSION_ANGLE = 107.994
```

```

CSS:MEAN_RING_BORESIGHT_LOCAL_TIME = 5.91938
CSS:MEAN_RING_BORESIGHT_LONGITUDE_ZPD = 260.507
CSS:MEAN_RING_BORESIGHT_RADIUS_ZPD = 113213
CSS:MEAN_RING_BORESIGHT_SOLAR_PHASE = 43.2574
CSS:MEAN_RING_BORESIGHT_SOLAR_ZENITH = 111.861
CSS:MEAN_RING_BORESIGHT_SPACECRAFT_RANGE = 1.79398E+06
END_OBJECT
^SPECTRAL_CUBE = "007RB_VERTLMP001___CI___680_F1_038R.DAT"
OBJECT = SPECTRAL_CUBE
  AXES = 3
  AXIS_NAME = (SAMPLE, LINE, BAND)
  OBJECT = CORE
    CORE_ITEMS = (174,720,139)
    CORE_NAME = "CALIBRATED SPECTRAL RADIANCE"
    CORE_ITEM_BYTES = 4
    CORE_ITEM_TYPE = PC_REAL
    CORE_BASE = 0
    CORE_MULTIPLIER = 1
    CORE_UNIT = "WATT*CM**-2*SR**-1*UM**-1"
    CORE_VALID_MINIMUM = 16#FF7FFFFA#
    CORE_NULL = 16#FF7FFFFB#
    CORE_LOW_REPR_SATURATION = 16#FF7FFFFC#
    CORE_LOW_INSTR_SATURATION = 16#FF7FFFFD#
    CORE_HIGH_INSTR_SATURATION = 16#FF7FFFFE#
    CORE_HIGH_REPR_SATURATION = 16#FF7FFFFF#
  END_OBJECT
  OBJECT = SUFFIX
    SUFFIX_ITEMS = (0,0,11)
    SUFFIX_BYTES = 4
    BAND_SUFFIX_NAME = (CSS:PIXEL_DATA_COUNT,CSS:SAMPLE_CENTER,
                        CSS:LINE_CENTER,
                        CSS:MEAN_RING_BORESIGHT_LONGITUDE_ZPD,
                        CSS:MEAN_RING_BORESIGHT_RADIUS_ZPD,
                        CSS:MEAN_RING_BORESIGHT_EMISSION_ANGLE,
                        CSS:MEAN_RING_BORESIGHT_SOLAR_PHASE,
                        CSS:MEAN_RING_BORESIGHT_SOLAR_ZENITH,
                        CSS:MEAN_RING_BORESIGHT_SPACECRAFT_RANGE,
                        CSS:MEAN_RING_BORESIGHT_LOCAL_TIME,
                        CSS:TOTAL_SPECTRAL_POWER)
  END_OBJECT
  OBJECT = BAND_BIN
    BANDS = 139
    BAND_BIN_UNIT = WAVENUMBER
    BAND_BIN_CENTER = (5,10,15,20,25,30,35,40,45,50,55,60,65,70,75,80,85,90,
                      95,100,105,110,115,120,125,130,135,140,145,150,155,

```

```

        160,165,170,175,180,185,190,195,200,205,210,215,220,
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        615,620,625,630,635,640,645,650,655,660,665,670,675,
        680,685,690,695)
    BAND_BIN_WIDTH = 5
END_OBJECT
OBJECT = IMAGE_MAP_PROJECTION
    A_AXIS_RADIUS = 140270 <KM>
    B_AXIS_RADIUS = 140270 <KM>
    C_AXIS_RADIUS = 0 <KM>
    POSITIVE_LONGITUDE_DIRECTION = WEST
    MAP_PROJECTION_TYPE = RING_POLAR
    CSS:DATA_COUNT = 4665
    CSS:RADIAL_SCALE = 500 <KM/PIXEL>
    CSS:LOCAL_TIME_SCALE = 0.0333333 <HOURS/PIXEL>
    CSS:SAMPLE_NAME = "RADIUS <KM>"
    CSS:LINE_NAME = "LOCAL TIME <HOURS>"
    CSS:FIRST_SAMPLE_CENTER = 68250
    CSS:FIRST_LINE_CENTER = 23.9833
    CSS:LAST_SAMPLE_CENTER = 154750
    CSS:LAST_LINE_CENTER = 0.0166667
    CSS:MAX_FOOTPRINT_LINE = 19861.5
    CSS:MAX_FOOTPRINT_SAMPLE = 24
    CSS:MIN_FOOTPRINT_LINE = 6804.85
    CSS:MIN_FOOTPRINT_SAMPLE = 0.462778
END_OBJECT
END_OBJECT
END

```

## Appendix B

# CIRS Cube Dictionary

### **A\_AXIS\_RADIUS**

Definition:

Dimension of the semimajor axis of the NAIF ellipsoid that defines the approximate shape of the target. Unit is km.

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

### **ANGULAR\_SCALE**

Definition:

Grid spacing. Unit is milliradians/pixel.

PDSDD Status : New term.

Usage in Cube labels :

If the projection is EQUIRECTANGULAR : NOT USED

If the projection is POINT PERSPECTIVE : REQUIRED

If the projection is RING : NOT USED

Usage in Cube backplanes : NOT USED

## **AXES**

Definition:

Number of dimensions in the core.

Possible value is "3"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **AXIS\_NAME**

Definition:

The names of the axes in physical storage order. Comma delimited string list.

Possible value is "(SAMPLE, LINE, BAND)"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **B\_AXIS\_RADIUS**

Definition:

Dimension of the intermediate axis of the NAIF ellipsoid that defines the approximate shape of the target. Unit is km.

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **BAND\_BIN\_CENTER**

Definition:

Sequence of wavenumbers describing the center of each bin along the band axis.

PDSDD Status : Existing.



Usage in Cube labels : REQUIRED  
Usage in Cube backplanes : NOT USED

## **BAND\_BIN\_UNIT**

Definition:

Unit of measurement of BAND\_BIN\_CENTER.

Possible value is "WAVENUMBER"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED  
Usage in Cube backplanes : NOT USED

## **BAND\_BIN\_WIDTH**

Definition:

Width of the bin along the band axis.

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED  
Usage in Cube backplanes : NOT USED

## **BAND\_SUFFIX\_NAME**

Definition:

The name of the data for each backplane, comma delimited string list.

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED  
Usage in Cube backplanes : NOT USED

## **BANDS**

Definition:

Band dimension.

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED  
Usage in Cube backplanes : NOT USED

## **BODY\_ANGULAR\_SEMIDIAMETER**

Definition:

The equatorial angular radius of the body as seen by the spacecraft. Unit is milliradians.

PDSDD Status : New term.

Usage in Cube labels :

If the target is JUPITER or SATURN : OPTIONAL  
If the target is one JUPITER'S or SATURN'S MOON: OPTIONAL  
If the target is SATURN RINGS : NOT USED

MEAN\_BODY\_ANGULAR\_SEMIDIAMETER = ...

Usage in Cube backplanes : NOT USED

## **BODY\_PHASE\_ANGLE**

Definition:

The angle between the radial vector of the spacecraft and the radial vector of the Sun, from the center of the body. Unit is degrees.

PDSDD Status : New term.

Usage in Cube labels :

If the target is JUPITER or SATURN : OPTIONAL  
If the target is one JUPITER'S or SATURN'S MOON: OPTIONAL  
If the target is SATURN RINGS : NOT USED

MEAN\_BODY\_PHASE\_ANGLE = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : NOT USED  
If the target is one JUPITER'S or SATURN'S MOON: NOT USED  
If the target is SATURN RINGS : NOT USED

## **BODY\_SPACECRAFT\_RANGE**

Definition:

The distance from the center of the body to the spacecraft. Unit is km.

PDSDD Status : New term.

Usage in Cube labels :

If the target is JUPITER or SATURN : OPTIONAL

If the target is one JUPITER'S or SATURN'S MOON : OPTIONAL

If the target is SATURN RINGS : NOT USED

BODY\_SPACECRAFT\_RANGE\_BEGINNING = ...

BODY\_SPACECRAFT\_RANGE\_MIDDLE = ...

BODY\_SPACECRAFT\_RANGE\_END = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : OPTIONAL

If the target is one JUPITER'S or SATURN'S MOON: OPTIONAL

If the target is SATURN RINGS : NOT USED

MEAN\_BODY\_SPACECRAFT\_RANGE = ...

## **BODY\_SUB\_SOLAR\_LATITUDE**

Definition:

The planetographic latitude of the sub-solar point on the body. Unit is degrees north.

PDSDD Status : New term.

Usage in Cube labels :

If the target is JUPITER or SATURN : OPTIONAL

If the target is one JUPITER'S or SATURN'S MOON : NOT USED

If the target is SATURN RINGS : NOT USED

BODY\_SUB\_SOLAR\_LATITUDE\_BEGINNING = ...

BODY\_SUB\_SOLAR\_LATITUDE\_MIDDLE = ...

BODY\_SUB\_SOLAR\_LATITUDE\_END = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : OPTIONAL  
If the target is one JUPITER'S or SATURN'S MOON: NOT USED  
If the target is SATURN RINGS : NOT USED

MEAN\_BODY\_SUB\_SOLAR\_LATITUDE = ...

## **BODY\_SUB\_SOLAR\_LATITUDE\_PC**

Definition:

The planetocentric latitude of the sub-solar point on the body. Unit is degrees north.

PDSDD Status : New term.

Usage in Cube labels :

If the target is JUPITER or SATURN : NOT USED  
If the target is one JUPITER'S or SATURN'S MOON : OPTIONAL  
If the target is SATURN RINGS : NOT USED

BODY\_SUB\_SOLAR\_LATITUDE\_PC\_BEGINNING = ...  
BODY\_SUB\_SOLAR\_LATITUDE\_PC\_MIDDLE = ...  
BODY\_SUB\_SOLAR\_LATITUDE\_PC\_END = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : NOT USED  
If the target is one JUPITER'S or SATURN'S MOON: OPTIONAL  
If the target is SATURN RINGS : NOT USED

MEAN\_SUB\_SOLAR\_LATITUDE\_PC = ...

## **BODY\_SUB\_SOLAR\_LONGITUDE**

Definition:

The longitude of the sub-solar point on the body. Unit is degrees west.

PDSDD Status : New term.

Usage in Cube labels : REQUIRED

If the target is JUPITER or SATURN : OPTIONAL  
If the target is one JUPITER'S or SATURN'S MOON : OPTIONAL  
If the target is SATURN RINGS : NOT USED

BODY\_SUB\_SOLAR\_LONGITUDE\_BEGINNING = ...  
BODY\_SUB\_SOLAR\_LONGITUDE\_MIDDLE = ...  
BODY\_SUB\_SOLAR\_LONGITUDE\_END = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : OPTIONAL  
If the target is one JUPITER'S or SATURN'S MOON: OPTIONAL  
If the target is SATURN RINGS : NOT USED

MEAN\_BODY\_SUB\_SOLAR\_LONGITUDE = ...

## **BODY\_SUB\_SPACECRAFT\_LATITUDE**

Definition:

The planetographic sub-spacecraft latitude in the IAU coordinate system defined for the body. Unit is degrees north.

PDSDD Status : New term.

Usage in Cube labels :

If the target is JUPITER or SATURN : OPTIONAL  
If the target is one JUPITER'S or SATURN'S MOON : NOT USED  
If the target is SATURN RINGS : NOT USED

BODY\_SUB\_SPACECRAFT\_LATITUDE\_BEGINNING = ...  
BODY\_SUB\_SPACECRAFT\_LATITUDE\_MIDDLE = ...  
BODY\_SUB\_SPACECRAFT\_LATITUDE\_END = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : OPTIONAL  
If the target is one JUPITER'S or SATURN'S MOON: NOT USED  
If the target is SATURN RINGS : NOT USED

MEAN\_BODY\_SUB\_SPACECRAFT\_LATITUDE = ...

## **BODY\_SUB\_SPACECRAFT\_LATITUDE\_PC**

Definition:

The planetocentric sub-spacecraft latitude in the IAU coordinate system defined for the body. Unit is degrees north.

PDSDD Status : New term.

Usage in Cube labels :

If the target is JUPITER or SATURN : NOT USED  
If the target is one JUPITER'S or SATURN'S MOON : OPTIONAL  
If the target is SATURN RINGS : NOT USED

BODY\_SUB\_SPACECRAFT\_LATITUDE\_PC\_BEGINNING = ...  
BODY\_SUB\_SPACECRAFT\_LATITUDE\_PC\_MIDDLE = ...  
BODY\_SUB\_SPACECRAFT\_LATITUDE\_PC\_END = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : NOT USED  
If the target is one JUPITER'S or SATURN'S MOON: OPTIONAL  
If the target is SATURN RINGS : NOT USED

MEAN\_BODY\_SUB\_SPACECRAFT\_LATITUDE\_PC = ...

## **BODY\_SUB\_SPACECRAFT\_LONGITUDE**

Definition:

The sub-spacecraft longitude in the IAU coordinate system defined for the body. Unit is degrees west.

PDSDD Status : New term.

Usage in Cube labels : REQUIRED

If the target is JUPITER or SATURN : OPTIONAL  
If the target is one JUPITER'S or SATURN'S MOON : OPTIONAL  
If the target is SATURN RINGS : NOT USED

BODY\_SUB\_SPACECRAFT\_LONGITUDE\_BEGINNING = ...  
BODY\_SUB\_SPACECRAFT\_LONGITUDE\_MIDDLE = ...  
BODY\_SUB\_SPACECRAFT\_LONGITUDE\_END = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : OPTIONAL  
If the target is one JUPITER'S or SATURN'S MOON: OPTIONAL  
If the target is SATURN RINGS : NOT USED

MEAN\_BODY\_SUB\_SPACECRAFT\_LONGITUDE = ...

## **BORESIGHT\_DECLINATION**

Definition:

The declination of the boresight in the J2000 coordinate system. Unit is degrees.

PDSDD Status : New term.

Usage in Cube labels :

If the target is JUPITER or SATURN : OPTIONAL

If the target is one JUPITER'S or SATURN'S MOON : OPTIONAL

If the target is SATURN RINGS : NOT USED

MEAN\_BORESIGHT\_DECLINATION = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : OPTIONAL

If the target is one JUPITER'S or SATURN'S MOON: OPTIONAL

If the target is SATURN RINGS : NOT USED

MEAN\_BORESIGHT\_DECLINATION = ...

## **BORESIGHT\_LATITUDE\_ZPD**

Definition:

The planetographic latitude of the boresight at the ZPD time. Unit is degrees north.

PDSDD Status : New term.

Usage in Cube labels :

If the target is JUPITER or SATURN : OPTIONAL

If the target is one JUPITER'S or SATURN'S MOON : NOT USED

If the target is SATURN RINGS : NOT USED

MEAN\_BORESIGHT\_LATITUDE\_ZPD = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : OPTIONAL

If the target is one JUPITER'S or SATURN'S MOON: NOT USED

If the target is SATURN RINGS : NOT USED

MEAN\_BORESIGHT\_LATITUDE\_ZPD = ...

## **BORESIGHT\_LATITUDE\_ZPD\_PC**

Definition:

The planetocentric latitude of the boresight at the ZPD time. Unit is degrees north.

PDSDD Status : New term.

Usage in Cube labels :

If the target is JUPITER or SATURN : NOT USED

If the target is one JUPITER'S or SATURN'S MOON : OPTIONAL

If the target is SATURN RINGS : NOT USED

MEAN\_BORESIGHT\_LATITUDE\_ZPD\_PC = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : NOT USED

If the target is one JUPITER'S or SATURN'S MOON: OPTIONAL

If the target is SATURN RINGS : NOT USED

MEAN\_BORESIGHT\_LATITUDE\_ZPD\_PC = ...

## **BORESIGHT\_LOCAL\_TIME**

Definition:

The local solar time in hours since midnight. Unit is fractional hours.

Example : if the local time is 03:45:10 (HH:MM:SS) it will be stored as 3.7527778

PDSDD Status : New term.

Usage in Cube labels :

If the target is JUPITER or SATURN : OPTIONAL

If the target is JUPITER'S or SATURN'S MOONS: OPTIONAL

If the target is SATURN RINGS : OPTIONAL

MEAN\_LOCAL\_TIME = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : OPTIONAL



If the target is JUPITER'S or SATURN'S MOONS: OPTIONAL  
If the target is SATURN RINGS : NOT USED

MEAN\_LOCAL\_TIME = ...

## **BORESIGHT\_LONGITUDE\_ZPD**

Definition:

The longitude of the boresight at the ZPD time. Unit is degrees west.

PDSDD Status : New term.

Usage in Cube labels :

If the target is JUPITER or SATURN : OPTIONAL  
If the target is one JUPITER'S or SATURN'S MOON : OPTIONAL  
If the target is SATURN RINGS : NOT USED

MEAN\_BORESIGHT\_LONGITUDE\_ZPD = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : OPTIONAL  
If the target is one JUPITER'S or SATURN'S MOON: OPTIONAL  
If the target is SATURN RINGS : NOT USED

MEAN\_BORESIGHT\_LONGITUDE\_ZPD = ...

## **BORESIGHT\_RIGHT\_ASCENSION**

Definition:

The right ascension of the boresight in the J2000 coordinate system. Unit is degrees.

PDSDD Status : New term.

Usage in Cube labels :

If the target is JUPITER or SATURN : OPTIONAL  
If the target is one JUPITER'S or SATURN'S MOON : OPTIONAL  
If the target is SATURN RINGS : NOT USED

MEAN\_BORESIGHT\_RIGHT\_ASCENSION = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : OPTIONAL  
If the target is one JUPITER'S or SATURN'S MOON: OPTIONAL  
If the target is SATURN RINGS : NOT USED

MEAN\_BORESIGHT\_RIGHT\_ASCENSION = ...

## **BORESIGHT\_SOLAR\_PHASE**

Definition:

The angle between the direction vector of the Sun and the normal to the surface at the point at which the boresight intersects the surface. Unit is degrees.

PDSDD Status : New term.

Usage in Cube labels :

If the target is JUPITER or SATURN : OPTIONAL  
If the target is one JUPITER'S or SATURN'S MOON : OPTIONAL  
If the target is SATURN RINGS : NOT USED

MEAN\_BORESIGHT\_SOLAR\_PHASE = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : OPTIONAL  
If the target is one JUPITER'S or SATURN'S MOON : OPTIONAL  
If the target is SATURN RINGS : NOT USED

MEAN\_BORESIGHT\_SOLAR\_PHASE = ...

## **BORESIGHT\_SOLAR\_ZENITH**

Definition:

The angle between the direction vector of the Sun and the normal to the surface at the point at which the boresight intersects the surface. Unit is degrees.

PDSDD Status : New term.

Usage in Cube labels :

If the target is JUPITER or SATURN : OPTIONAL  
If the target is one JUPITER'S or SATURN'S MOON : OPTIONAL  
If the target is SATURN RINGS : NOT USED

MEAN\_BORESIGHT\_SOLAR\_ZENITH = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : OPTIONAL

If the target is one JUPITER'S or SATURN'S MOON : OPTIONAL

If the target is SATURN RINGS : NOT USED

MEAN\_BORESIGHT\_SOLAR\_ZENITH = ...

## **C\_AXIS\_RADIUS**

Definition:

Dimension of the semiminor axis of the NAIF ellipsoid that defines the approximate shape of the target. Unit is km.

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **CORE\_BASE**

Definition:

An additive constant used to convert the reported core value to the actual value via a linear transformation.

Possible value is "0"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **CORE\_HIGH\_INSTR\_SATURATION**

Definition:

Hexadecimal representation of a special pixel value that flags a pixel whose value is higher than the maximum reportable by the instrument. Provided for compatibility without being used within the cube.

Possible value is "0xFF7FFFFE"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **CORE\_HIGH\_REPR\_SATURATION**

Definition:

Hexadecimal representation of a special pixel value that flags a pixel whose value is higher than allowed by the numeric representation used. Provided for compatibility without being used within the cube.

Possible value is "0xFF7FFFFFFF"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **CORE\_ITEM\_BYTES**

Definition:

The number of bytes per pixel value.

Possible value is "4".

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **CORE\_ITEM\_TYPE**

Definition:

The name of the representation of the pixel values.

Possible value is "PC\_REAL"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **CORE\_ITEMS**

Definition:

The length of each axis of the core in pixels. Comma delimited integer list : (number\_of\_samples, number\_of\_lines, number\_of\_bands) number\_of\_line, number\_of\_band)

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **CORE\_LOW\_INSTR\_SATURATION**

Definition:

Hexadecimal representation of a special pixel value that flags a pixel whose value is lower than the minimum reportable by the instrument. Provided for compatibility without being used within the cube.

Possible value is "0xFF7FFFFD"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **CORE\_LOW\_REPR\_SATURATION**

Definition:

Hexadecimal representation of a special pixel value that flags a pixel whose value is lower than allowed by the numeric representation used. Provided for compatibility without being used within the cube.

Possible value is "0xFF7FFFFC"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **CORE\_MULTIPLIER**

Definition:

A multiplicative constant used to convert the reported core value to the actual value via a linear transformation.

Possible value is "1"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **CORE\_NAME**

Definition:

Identify the scientific meaning of the values in the core. e.g. Spectral Radiance.

Possible value is "CALIBRATED SPECTRAL RADIANCE"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **CORE\_NULL**

Definition:

Hexadecimal representation of the value placed in the core when no proper data value is available.

Possible value is "0xFF7FFFFB"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **CORE\_UNIT**

Definition:

The unit of the values placed in the core :  $\text{W cm}^{-2} \text{ sr}^{-1} (\text{cm}^{-1})^{-1}$ .

Syntax in label is "WATT\*CM\*\*-2\*SR\*\*-1\*CM"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **CORE\_VALID\_MINIMUM**

Definition:

Hexadecimal representation of the lowest possible value in the core.

Possible value is "0xFF7FFFFA"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **DATA\_COUNT**

Definition:

Number of measurements combined to create the cube.

PDSDD Status : New term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **DESCRIPTION**

Definition:

Generic information.

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **EMISSION\_ANGLE\_FOV\_AVERAGE**

Definition:

The average of the values of the emission angle (angle between the surface normal and the spacecraft direction) over the field of view. Unit is degrees.

PDSDD Status : New term.

Limb value : -200

Usage in Cube labels :

If the target is JUPITER or SATURN : OPTIONAL

If the target is JUPITER'S or SATURN'S MOONS: OPTIONAL

If the target is SATURN RINGS : NOT USED

MEAN\_EMISSION\_ANGLE\_FOV\_AVERAGE = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : OPTIONAL

If the target is JUPITER'S or SATURN'S MOONS: OPTIONAL

If the target is SATURN RINGS : NOT USED

MEAN\_EMISSION\_ANGLE\_FOV\_AVERAGE = ...

## **FILE\_RECORDS**

Definition:

The number of records in the binary file.

Must be equal to  $\text{CORE\_SIZE}[2] * (\text{CORE\_SIZE}[3] + \text{SUFFIX\_ITEMS}[3])$

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED



## **FIRST\_LINE\_CENTER**

Definition:

Line coordinate at the center of the first line element.

NB: Positive direction is to the right and down.

PDSDD Status : New term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **FIRST\_SAMPLE\_CENTER**

Definition:

Sample coordinate at the center of the first sample element.

NB: Positive direction is to the right and down.

PDSDD Status : New term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **FOCAL\_PLANE**

Definition:

Focal plane used.

Possible values are "1", "3" or "4"

PDSDD Status : New term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **INSTRUMENT\_HOST\_NAME**

Definition:

Name of spacecraft.

Possible value is CASSINI\_ORBITER

PDSDD Status : Existing term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

### **INSTRUMENT\_ID**

Definition:

Common identifier for the instrument.

Possible value is CIRS

PDSDD Status : Existing term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

### **INSTRUMENT\_NAME**

Definition:

Proper name of the instrument.

Possible value is COMPOSITE\_INFRARED\_SPECTROMETER

PDSDD Status : Existing term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

### **LAST\_LINE\_CENTER**

Definition:

Line coordinate at the center of the last line element.

NB: Positive direction is to the right and down.

PDSDD Status : New term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **LAST\_SAMPLE\_CENTER**

Definition:

Sample coordinate at the center of the last sample element.

NB: Positive direction is to the right and down.

PDSDD Status : New term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **LINE\_CENTER**

Definition:

For equirectangular cubes, this is the latitude of the pixel center, in degrees.

For point perspective cubes, it is the scaled offset from the body center, in the direction of increasing J2000 Declination, in milliradians.

For ring cubes, this is the local time in hours.

PDSDD Status : New term.

Usage in Cube labels : NOT USED

Usage in Cube backplanes :

If the target is JUPITER or SATURN : REQUIRED

If the target is one JUPITER'S or SATURN'S MOON: OPTIONAL

If the target is SATURN RINGS : REQUIRED

## **LINE\_NAME**

Definition:

Coordinate name for the line axis.

Possible values are "LATITUDE", "SCALED OFFSET FROM BODY CENTER" or "LOCAL TIME".

PDSDD Status : New term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

### **LOCAL\_TIME\_SCALE**

Definition:

Grid spacing. Unit is local hours/pixel.

PDSDD Status : New term.

Usage in Cube labels :

If the projection is EQUIRECTANGULAR : NOT USED

If the projection is POINT PERSPECTIVE : NOT USED

If the projection is RING : REQUIRED

Usage in Cube backplanes : NOT USED

### **MAP\_PROJECTION\_TYPE**

Definition:

Type of projection.

Possible values are "EQUIRECTANGULAR", "POINT\_PERSPECTIVE" or "RING\_POLAR".

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

### **MAP\_RESOLUTION**

Definition:

Grid spacing. Unit is pixels/degree.

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

### **MAX\_FOOTPRINT\_LINE**

Definition:

Maximum size of footprints along the line axis.

PDSDD Status : New term.

Usage in Cube labels : REQUIRED Usage in Cube backplanes : NOT USED

### **MAX\_FOOTPRINT\_SAMPLE**

Definition:

Maximum size of footprints along the sample axis.

PDSDD Status : New term.

Usage in Cube labels : REQUIRED Usage in Cube backplanes : NOT USED

### **MIN\_FOOTPRINT\_LINE**

Definition:

Minimum size of footprints along the line axis.

PDSDD Status : New term.

Usage in Cube labels : REQUIRED Usage in Cube backplanes : NOT USED

### **MIN\_FOOTPRINT\_SAMPLE**

Definition:

Minimum size of footprints along the sample axis.

PDSDD Status : New term.

Usage in Cube labels : REQUIRED Usage in Cube backplanes : NOT USED

### **MISSION\_PHASE\_NAME**

Definition:

Indicator of the phase of the mission.

Possible values are "INSTRUMENT CHECKOUT 2", "JUPITER CRUISE", "QUIET CRUISE", "SCIENCE CRUISE", "TOUR PRE-HUYGENS", "HUYGENS DESCENT", "TOUR", "EQUINOX MISSION", "SOLSTICE MISSION"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

### **OBSERVATION\_ID**

Definition:

The name of the observation of which this product is part. This name is derived from the Predicted Events File (PEF).

Example : 000SA\_FIRCMPSIT007\_CI004

PDSDD Status : Existing term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

### **PDS\_VERSION\_ID**

Definition:

Version number of the PDS standards associated with the product.

Possible value is PDS3

PDSDD Status : Existing term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

### **PIXEL\_DATA\_COUNT**

Definition:

The number of original CIRS spectra averaged to create this spatial pixel.

PDSDD Status : New term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes :

If the target is JUPITER or SATURN : REQUIRED

If the target is one JUPITER'S or SATURN'S MOON : REQUIRED

If the target is SATURN RINGS : REQUIRED

PRIMARY\_SPACECRAFT\_RANGE\_BEGINNING = ...

PRIMARY\_SPACECRAFT\_RANGE\_MIDDLE = ...

PRIMARY\_SPACECRAFT\_RANGE\_END = ...

## **POSITIVE\_LONGITUDE\_DIRECTION**

Definition:

Identifies the direction with which the longitude increases.

Possible values are "EAST" or "WEST"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **PRIMARY\_BODY\_NAME**

Definition:

Name of the primary body with which the current target body is associated.

Possible value is "SATURN"

PDSDD Status : Existing.

Usage in Cube labels :

If the target is not SATURN RINGS : NOT USED

If the target is SATURN RINGS : REQUIRED

Usage in Cube backplanes : NOT USED

## **PRIMARY\_SPACECRAFT\_RANGE**

Definition:

The distance from the center of the primary to the spacecraft. Unit is km.

PDSDD Status : New term.

Usage in Cube labels :

If the target is not SATURN RINGS : NOT USED

If the target is SATURN RINGS : REQUIRED

PRIMARY\_SPACECRAFT\_RANGE\_BEGINNING = ...

PRIMARY\_SPACECRAFT\_RANGE\_MIDDLE = ...

PRIMARY\_SPACECRAFT\_RANGE\_END = ...

Usage in Cube backplanes : NOT USED

## **PRIMARY\_SUB\_SOLAR\_LATITUDE**

Definition:

The planetographic latitude of the sub-solar point on the primary. Unit is degrees north.

PDSDD Status : New term.

Usage in Cube labels :

If the target is not SATURN RINGS : NOT USED

If the target is SATURN RINGS : REQUIRED

PRIMARY\_SUB\_SOLAR\_LATITUDE\_BEGINNING = ...

PRIMARY\_SUB\_SOLAR\_LATITUDE\_MIDDLE = ...

PRIMARY\_SUB\_SOLAR\_LATITUDE\_END = ...

Usage in Cube backplanes : NOT USED

## **PRIMARY\_SUB\_SOLAR\_LONGITUDE**

Definition:

The longitude of the sub-solar point on the primary. Unit is degrees west.

PDSDD Status : New term.

Usage in Cube labels :

If the target is not SATURN RINGS : NOT USED



If the target is SATURN RINGS : REQUIRED

PRIMARY\_SUB\_SOLAR\_LONGITUDE\_BEGINNING = ...  
PRIMARY\_SUB\_SOLAR\_LONGITUDE\_MIDDLE = ...  
PRIMARY\_SUB\_SOLAR\_LONGITUDE\_END = ...

Usage in Cube backplanes : NOT USED

## **PRIMARY\_SUB\_SPACECRAFT\_LATITUDE**

Definition:

The planetographic sub-spacecraft latitude in the IAU coordinate system defined for the primary. Unit is degrees north.

PDSDD Status : New term.

Usage in Cube labels :

If the target is not SATURN RINGS : NOT USED  
If the target is SATURN RINGS : REQUIRED

PRIMARY\_SUB\_SPACECRAFT\_LATITUDE\_BEGINNING = ...  
PRIMARY\_SUB\_SPACECRAFT\_LATITUDE\_MIDDLE = ...  
PRIMARY\_SUB\_SPACECRAFT\_LATITUDE\_END = ...

Usage in Cube backplanes : NOT USED

## **PRIMARY\_SUB\_SPACECRAFT\_LONGITUDE**

Definition:

The sub-spacecraft longitude in the IAU coordinate system defined for the primary.  
Unit is degrees west.

PDSDD Status : New term.

Usage in Cube labels :

If the target is not SATURN RINGS : NOT USED  
If the target is SATURN RINGS : REQUIRED

PRIMARY\_SUB\_SPACECRAFT\_LONGITUDE\_BEGINNING = ...  
PRIMARY\_SUB\_SPACECRAFT\_LONGITUDE\_MIDDLE = ...  
PRIMARY\_SUB\_SPACECRAFT\_LONGITUDE\_END = ...

Usage in Cube backplanes : NOT USED

## **PRODUCT\_ID**

Definition:

Unique identifier for each product. Usually derived from the base filename of the current product.

Example : 000SA\_FIRCMPSIT007\_CI004\_699\_F1\_400M

PDSDD Status : Existing term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **RADIAL\_SCALE**

Definition:

Grid spacing. Unit is km/pixel.

PDSDD Status : New term.

Usage in Cube labels :

If the projection is EQUIRECTANGULAR : NOT USED

If the projection is POINT PERSPECTIVE : NOT USED

If the projection is RING : REQUIRED

Usage in Cube backplanes : NOT USED

## **RECORD\_TYPE**

Definition:

The style of records in file.

Possible value is FIXED\_LENGTH

PDSDD Status : Existing term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **RECORD\_BYTES**

Definition:

The number of bytes in each record.

Must be equal to `CORE_SIZE[1] * CORE_ITEM_BYTES`

PDSDD Status : Existing term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **RING\_BORESIGHT\_EMISSION\_ANGLE**

Definition:

The emission angle at the intersection of the boresight and the ring plane. Unit is degrees.

PDSDD Status : New term.

Limb value : -200

Usage in Cube labels :

If the target is not SATURN RINGS : NOT USED

If the target is SATURN RINGS : REQUIRED

`MEAN_RING_BORESIGHT_EMISSION_ANGLE = ...`

Usage in Cube backplanes :

If the target is JUPITER or SATURN : NOT USED

If the target is JUPITER'S or SATURN'S MOONS: NOT USED

If the target is SATURN RINGS : OPTIONAL

`MEAN_RING_BORESIGHT_EMISSION_ANGLE = ...`

## **RING\_BORESIGHT\_LOCAL\_TIME**

Definition:

The local solar time at the intersection of the boresight and the ring plane in the primary's coordinate system. Unit is fractional hours since midnight.

Example : if the local time is 03:45:10 (HH:MM:SS) it will be stored as 3.4527778

PDSDD Status : New term.

Usage in Cube labels : REQUIRED

If the target is not SATURN RINGS : NOT USED

If the target is SATURN RINGS : REQUIRED

MEAN\_RING\_BORESIGHT\_LOCAL\_TIME = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : NOT USED

If the target is JUPITER'S or SATURN'S MOONS: NOT USED

If the target is SATURN RINGS : OPTIONAL

MEAN\_RING\_BORESIGHT\_EMISSION\_ANGLE = ...

## **RING\_BORESIGHT\_LONGITUDE\_ZPD**

Definition:

The longitude of the intersection of the boresight and the ring plane at the ZPD time. Longitudes are measured eastwards in an inertial frame from the "ascending node of the intersection of the ring plane with J2000". Unit is degrees east.

PDSDD Status : New term.

Usage in Cube labels : REQUIRED

If the target is not SATURN RINGS : NOT USED

If the target is SATURN RINGS : REQUIRED

MEAN\_RING\_BORESIGHT\_LONGITUDE\_ZPD = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : NOT USED

If the target is JUPITER'S or SATURN'S MOONS: NOT USED

If the target is SATURN RINGS : OPTIONAL

MEAN\_RING\_BORESIGHT\_LONGITUDE\_ZPD = ...

## **RING\_BORESIGHT\_RADIUS\_ZPD**

Definition:

The radius of the intersection of the boresight and the ring plane at the ZPD time.  
Unit is km.

PDSDD Status : New term.

Usage in Cube labels :

If the target is not SATURN RINGS : NOT USED  
If the target is SATURN RINGS : REQUIRED

MEAN\_RING\_BORESIGHT\_RADIUS\_ZPD = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : NOT USED  
If the target is JUPITER'S or SATURN'S MOONS: NOT USED  
If the target is SATURN RINGS : OPTIONAL

MEAN\_RING\_BORESIGHT\_RADIUS\_ZPD = ...

## **RING\_BORESIGHT\_SOLAR\_PHASE**

Definition:

The angle between the direction vector of the Sun and the boresight. Unit is degrees.

PDSDD Status : New term.

Usage in Cube labels : REQUIRED

If the target is not SATURN RINGS : NOT USED  
If the target is SATURN RINGS : REQUIRED

MEAN\_RING\_BORESIGHT\_SOLAR\_PHASE = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : NOT USED  
If the target is JUPITER'S or SATURN'S MOONS: NOT USED  
If the target is SATURN RINGS : OPTIONAL

MEAN\_RING\_BORESIGHT\_SOLAR\_PHASE = ...

## **RING\_BORESIGHT\_SOLAR\_ZENITH**

Definition:

The angle between the direction vector of the Sun and the normal to the surface at the point at which the boresight intersects the surface. Unit is degrees.

PDSDD Status : New term.

Usage in Cube labels : REQUIRED

If the target is not SATURN RINGS : NOT USED

If the target is SATURN RINGS : REQUIRED

MEAN\_RING\_BORESIGHT\_SOLAR\_ZENITH = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : NOT USED

If the target is JUPITER'S or SATURN'S MOONS: NOT USED

If the target is SATURN RINGS : OPTIONAL

MEAN\_RING\_BORESIGHT\_SOLAR\_ZENITH = ...

## **RING\_BORESIGHT\_SPACECRAFT\_RANGE**

Definition:

The distance from the intersection of the boresight with the ring plane to the spacecraft. Unit is km.

PDSDD Status : New term.

Usage in Cube labels : REQUIRED

If the target is not SATURN RINGS : NOT USED

If the target is SATURN RINGS : REQUIRED

MEAN\_RING\_BORESIGHT\_SPACECRAFT\_RANGE = ...

Usage in Cube backplanes :

If the target is JUPITER or SATURN : NOT USED

If the target is JUPITER'S or SATURN'S MOONS: NOT USED

If the target is SATURN RINGS : OPTIONAL

MEAN\_RING\_BORESIGHT\_SPACECRAFT\_RANGE = ...

## **SAMPLE\_CENTER**

Definition:

For equirectangular cubes, this is the West longitude of the pixel center, in degrees.

For point perspective cubes, it is the scaled offset from the body center, in the direction of decreasing J2000 Right Ascension, in milliradians.

For ring cubes, this is the radius from the primary center in km.

PDSDD Status : New term.

Usage in Cube labels : NOT USED

Usage in Cube backplanes :

If the target is JUPITER or SATURN : REQUIRED

If the target is one JUPITER'S or SATURN'S MOON: OPTIONAL

If the target is SATURN RINGS : REQUIRED

## **SAMPLE\_NAME**

Definition:

Coordinate name for the sample axis.

Possible values are "WEST LONGITUDE", "SCALED OFFSET FROM BODY CENTER" or "RADIUS".

PDSDD Status : New term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **SCET\_END**

Definition:

Value of internal clock at the end of the observation. Expressed in linux time (UT seconds since Jan 1st 1970).

Example : 1087621787

PDSDD Status : New term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

### **SCET\_START**

Definition:

Value of internal clock at the beginning of the observation. Expressed in linux time (UT seconds since Jan 1st 1970).

Example : 1087609587

PDSDD Status : New term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

### **SPACECRAFT\_CLOCK\_START\_COUNT**

Definition:

Value of the internal clock at the beginning of the observation. The format uses a double precision encoding of the clock time in units of ticks since the spacecraft clock start.

Example : "1/1466302235.098"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

### **SPACECRAFT\_CLOCK\_STOP\_COUNT**

Definition:

Value of the internal clock at the end of the observation. The format uses a double precision encoding of the clock time in units of ticks since the spacecraft clock start.

Example : "1/1466314435.118"

PDSDD Status : Existing.



Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

### **^SPECTRAL\_CUBE**

Definition:

File name of the binary object.

Example : 000SA\_FIRCMPSIT007\_CI004.699\_F1\_400M.DAT

PDSDD Status : New term.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

### **START\_TIME**

Definition:

Value of the internal clock at the beginning of the observation. UTC time human readable format YYYY-MM-DDTHH:MM:SS

Example : "2004-06-19T01:46:27"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

### **STOP\_TIME**

Definition:

Value of the internal clock at the end of the observation. UTC time human readable format YYYY-MM-DDTHH:MM:SS

Example : "2004-06-19T05:09:47"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **SUFFIX\_BYTES**

Definition:

The number of bytes per pixel value in all suffix regions.

Possible value is "4"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **SUFFIX\_ITEMS**

Definition:

The number of data items present in each of the suffix regions - comma delimited integer list (number\_of\_suffix\_samples, number\_of\_suffix\_lines, number\_of\_suffix\_bands).

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **TARGET\_NAME**

Definition:

Target in the field of view.

Possible values are :

"JUPITER", "IO", "EUROPA", "GANYMEDE", "CALLISTO", "AMALTHEA",  
"HIMALIA", "ELARA", "PASIPHAE", "SINOPE", "LYSITHEA", "CARME", "ANANKE",  
"LEDA", "THEBE", "ADRASTEIA", "METIS",  
"SATURN", "MIMAS", "ENCELADUS", "TETHYS", "DIONE", "RHEA", "TI-  
TAN", "HYPERION", "IAPETUS", "PHOEBE", "JANUS", "EPIMETHEUS", "HE-  
LENE", "TELESTO", "CALYPSO", "ATLAS", "PROMETHEUS", "PANDORA",  
"PAN", "METHONE", "DAPHNIS", "SATURN RING"

PDSDD Status : Existing.

Usage in Cube labels : REQUIRED

Usage in Cube backplanes : NOT USED

## **TOTAL\_SPECTRAL\_POWER**

Definition:

The integrated radiance under the power spectrum. Unit is ( $\text{W cm}^{-2} \text{ sr}^{-1}$ ).

PDSDD Status : New term.

Usage in Cube labels : NOT USED Usage in Cube backplanes :

If the target is JUPITER or SATURN : OPTIONAL

If the target is JUPITER'S or SATURN'S MOONS: OPTIONAL

If the target is SATURN RINGS : OPTIONAL

