Spectral/Spectrosopy Namespace

NASA Planetary Data System

Apr 11, 2024

USER GUIDE

The Spectral/Spectroscopy namespace (sp:) is a discipline namespace for the parameters (field of view, spectral binning, etc.) needed to describe observational data in the most common data formats. The dictionary can be used for spectral bins in wavelength, wave number, frequency, or energy units. It can describe spectra in tabulated, table, image, or cube formats. Spectral bins can be described in the label, referenced in a data object, or referenced in another data product.

For dictionary developers, the IngestLDD file used to build the Spectral namespace is annotated for use as a cookbook for the features used in the namespace.

CHAPTER

ONE

INTRODUCTION

This “User’s Guide” provides a brief overview of the Spectral/Spectroscopy namespace, used to provide discipline details for data products presenting the most common spectroscopic or spectrophotometric data.

This namespace can describe data in the four most common spectral formats; with spectral bins defined in wavelength, wave number, frequency, and energy; and offers several options for specifying the spectral bin parameters.

This guide presents the major features of the namespace.

CHAPTER

TWO

OVERVIEW OF THE SPECTRAL/SPECTROSCOPY DISCIPLINE DICTIONARY

The Spectral/Spectroscopy namespace (sp:) is a discipline namespace for the parameters (field of view, spectral binning, etc.) needed to describe observational data in the most common data formats. The dictionary can be used for spectral bins in wavelength, wave number, frequency, or energy units. It can describe spectra in tabulated, table, image, or cube formats. Spectral bins can be described in the label, referenced in a data object, or referenced in another data product.

For dictionary developers, the IngestLDD file used to build the Spectral namespace is annotated for use as a cookbook for the features used in the namespace.

- **Primary Steward:** Anne Raugh, Small Bodies Node, University of Maryland (@acraugh on Github)
- **Dictionary Repo:** https://github.com/pds-data-dictionaries/ldd-spectral
- **Namespace Prefix:** sp:

Corrections, changes, and additions should be submitted through the PDS LDD Issue Repo.

CHAPTER

THREE

ORGANIZATION OF CLASSES AND ATTRIBUTES

The Spectral dictionary has a single top-level class called <*sp:Spectral_Characteristics*>. Below that, there are major subclasses to describe the observational parameters, the field of view (that is, the "slit"), and to provide the spectral bin descriptions.

The following sections describe the major subclasses of the Spectral dictionary, in the order in which they must occur in labels.

3.1 Top-Level Class: <sp:Spectral_Characteristics>

The <*sp:Spectral_Characteristics*> class acts as a wrapper for all other Spectral classes. It begins with a <*pds:Local_Internal_Reference*> class which is used to associate the spectral characteristics with the data object that contains the spectral data. This is followed by several required and optional *sp:* attributes, and then by the major subclasses.

The sequence of elements within the <*sp:Spectral_Characteristics*> class is:

- <*pds:Local_Internal_Reference*>
- <*sp:description*>
- <*sp:spectrum_format*>
- <*sp:value_field_name*>
- <*sp:value_field_number_list*>
- <*sp:spectral_bin_type*>
- <*sp:Observation_Parameters*>
- <*sp:Field_of_View*>
- <*sp:Bin_Description*>

Follow the links above to the subclass descriptions. The attribute descriptions follow.

3.1.1 Attributes of <sp:Spectral_Characteristics>

<sp:description>
This optional attribute is provided so that any circumstances of note can be included for the user. These notes should make sense within the context of the label. If a reference to an external document is needed, that document should be included in the label *<pds:Reference_List>* with a comment as to why the document is being referenced.

<sp:spectrum_format>
This required attribute indicates the format of the spectral data. It should agreed with the format listed in the label *<pds:Primary_Result_Summary>* class, which in turn should include *<pds:Science_Facets>* with a *<pds:discipline>* of **Spectroscopy** and a *<pds:facet1>* value that is consistent with one of these supported format values:

1D
The spectrum is a single, linear spectrum presented as a table object in which each row contains the information about one point (i.e., bin) in the spectrun. In this case *<pds:facet1>* should have a value of **Linear**.

2D
The spectrum is defined using an *Array_2D_Spectrum* object, or possible as an *Array_2D_Image* object. If the axes of the spectrum align with the axes of the image, then the *<pds:facet1>* value should be **2D**; otherwise, the *<pds:facet1>* value should be **Spectral Image**

3D
The spectrum is defined using an *Array_3D_Spectrum* object, or possibly an *Array_3D_Image* object. In this case the value of *<pds:facet1>* should be **Spectral Cube**.

Tabulated-Flat
In this data structure, multiple spectra are presented in a single table, and each row contains a single spectrum with the spectral values, bin dimensions, and any related s defined as unique fields. In other words, there are no "Group_Field" structures used in the label. In this case all fields containing spectral data or bin data *must* have unique *<pds:field_number>* attributes. In this case the *<pds:facet1>* value must be **Tabulated**.

Tabulated-Parameter Groups
In this structure, multiple spectra are presented in a single table, also with one spectrum per row, but in this case the "*Group_Fields*" structure is used to provide all the spectral data consecutively, then all the error bars, then all the bin centers, etc. For this case, the *<pds:facet1>* value must be **Tabulated**.

Tabulated-Point Group
In this structure, once again each row of a table contains a single spectrum, but for this case a single "*Group_Field*" is defined to hold all the parameters associated with one bin, and this structure is repeated across the row for each bin. As with the other tabular forms, the *<pds:facet1>* value must be **Tabulated**.

Note that the tabulated formats do not require that bin parameters be part of the table structure. They can be specified explicitly or referenced in other data objects or products, as needed.

<sp:value_field_name>
This attribute is required to be present when *<sp:spectrum_format>* is one of **1D**, **Tabulated-Parameter Groups**, or **Tabulated-Point Group**. (It is prohibited for other formats.) In these formats, the field containing the spectral values has a single field definition, which should contain a unique name. The value of that *<pds:name>* attribute is supplied here.

Note that in the names used to identify fields should be unique and devoid of problematic characters like '<', '>', and '&'. Alphanumerics only, for best results.

<sp:value_field_number_list>
This attribute is required to be present when *<sp:spectrum_format>* is **Tabulated-Flat** and is prohibited oth-

erwise. This is the case where each field in the row is described individually, without *Group_Field* structures. This is also the case where the *Field* classes *must* contain unique <*pds:field_number*> values, precisely so they can be identified here. The value of this attribute should be a parenthesized, comma-separated list of value <*pds:field_number*> values present in the associated table structure. The intention is that this list can be easily parsed by software, which could then extract the spectral values from the table record.

<sp:spectral_bin_type>
This attribute is required to be present always. It determines the type of bins that will be described later in the label. It must have one of the following values:

- **energy**
- **frequency**
- **wavelength**
- **wavenumber**

3.2 Subclass: <pds:Local_Internal_Reference>

The <*pds:Local_Internal_Reference*> class is used to associate information like the spectral characteristics to specific data objects in the PDS4 label. To use it, you must include a <*pds:local_identifier*> in the data structure containing your spectral data, to be referenced here.

This class contains:

- <pds:comment>
- <pds:local_identifier_reference>
- <pds:local_reference_type>

<pds:comment>
An optional text field for any caveats, usage notes, or other notes about the spectral data.

<pds:local_identifier_reference>
The value of the <*pds:local_identifier*> in the data object containing the spectral data. The value must match exactly one local identifier in the label.

<pds:local_reference_type>
This indicates the gross nature of the data object being referenced. It must be one of these two values:

- **spectral_characteristics_to_array_object** - used when the data are in an *Array*-type object
- **spectral_characteristics_to_table_object** - used when the data are in a *Table*-type object

3.3 Subclass: <sp:Observation_Parameters>

The <*sp:Observation_Parameters*> class provides details relevant to the collection and calibration of the spectrum.

This class contains:

- <sp:number_of_exposures>
- <sp:net_integration_time>
- <sp:resolution_limit_(energy|frequency|wavelength|wavenumber>
- <sp:solar_analog_star_name>
- <sp:absolute_calibration_star_name>

- <sp:comment>

All of these attributes are optional - include the ones that are relevant. None are repeatable unless stated otherwise in the descriptions following.

<sp:number_of_exposures>
This attribute indicates the number of individual exposures or distinct integrations that were combined to produce the spectrum in the data object. It should be present even if the value is "1". To omit this attribute implies that "number of exposures" is not an applicable concept for the data presented, which is not a typical situation.

<sp:net_integration_time>
The *sp:net_integration_time* is the total actual integration time contributing to each pixel. In most cases, all pixels are exposed simultaneously and this is equivalent to the net observation time. For instruments that sweep across pixels, rows, or planes, though, this value will differ from the observation time. It is hard to imagine a case where this concept is not applicable, but if you have such a case, please include an <*sp:comment*> attribute to make that clear.

<sp:resolution_limit_(energy|frequency|wavelength|wavenumber>
These attributes indicate the spectral resolution of the observing instrument - specifically the smallest distinguishable spectral interval. The name of the attribute used should correspond to the <*sp:spectrum_format*> in the <*sp:Spectral_Characteristics*> class. So if the *spectrum_format* was **wavelength**, then <*sp:resolution_limit_wavelength*> is the version of this attribute that should be supplied.

If the spectral resolution is unknown, omit this attribute.

<sp:solar_analog_star_name>
The *sp:solar_analog_star_name* attribute provides a name in a standard format (i.e., one that is recognized by the SIMBAD system) for the solar analog star used to reduce the raw spectral data to the reflectance units presented in this spectrum. You may repeat this attribute if needed for additional stars. *Do not repeat this attribute to provide alternate names for the same star.*

<sp:absolute_calibration_star_name>
The *sp:absolute_calibration_star_name* attribute provides a name in a standard format (i.e., one that is recognized by the SIMBAD system) for the star used to reduce the raw spectral data to the (non-reflectance) units presented in this spectrum. You may repeat this attribute if needed for additional stars. *Do not repeat this attribute to provide alternate names for the same star.*

<sp:comment>
This is an optional free-format text field to provide any additional information or caveats about attributes and values in this class.

3.4 Subclass: <sp:Field_of_View>

The <*sp:Field_of_View*> class describes the field of view contributing to the spectral data object. This is often the aperture or slit used to make the observation, but may be the same as the field of view of the instrument in some cases.

This class contains:

- <sp:description>
- <sp:Circular_FOV>
- <sp:Rectangular_FOV>
- <sp:Complex_FOV>
- <pds:Internal_Reference>

The *sp:description* is required. All subclasses are optional individually, but note that one of the FOV subclasses must be present.

<sp:description>
This field is required and should contain a human-friendly description of the field of view (FOV) contributing to the spectral data. Sometimes this will be as simple as stating that the shape is a circle or rectangular slit. In more complex cases, however, some additional detail should be provided.

<sp:Circular_FOV>
The *<sp:Circular_FOV>* class contains a single attribute for the aperture diameter.

<sp:Rectangular_FOV>
The *<sp:Rectangular_FOV>* class contains the angular length and width of the slit, and provides position angles for the orientation of the slit length with respect to celestial north and the positive pole of a target body.

<sp:Complex_FOV>
The *<sp:Complev_FOV>* class provides repeatable length and width angles, if they seem useful, as well as position angles with respect to celestial north and the target positive pole. The text in the *<sp:description>* attribute should make it clear what relation the information here has to the actual form of the field of view/slit. In this case a *<pds:Internal_Reference>* leading to specific documentation covering the field of view would be an excellent addition.

<pds:Internal_Reference>
The *<pds:Internal_Reference>* can and should be used to provide a link to documentation that explicitly describes the slit (field of view) dimensions and their implications whenever the FOV is complex. That document is typically part of the PDS archive for the mission or investigation, but might be present elsewhere in the PDS for groundbased facilities and can be referenced as past of another investication archive in that case. It can be referenced by LID alone if the slit can never change (because, for example, it is in a spacecraft we won't be handing again). The *<pds:reference_type>* value to use here is **spectral_characteristics_to_document**.

3.5 Subclass: <sp:Bin_Description>

Bins - their centers and widths - can be described in a number of ways. This class is all about providing those various options. It contains a number of parallel classes that have identical structure but require units of measure that match the *<sp:spectrum_format>* of the *<sp:Spectral_Characteristics>* class.

This class contains:

- <sp:bin_profile_description>
- <sp:Uniformly_Sampled_(Energy|Frequency|Wavelength|Wavenumber)>
- <sp:Axis_Bin_Set_(Energy|Frequency|Wavelength|Wavenumber)>
- <sp:Spectral_Lookup>

If the spectral bins are associated with specific filters, use one of the *sp:Axis_Bin_Set* classes. These include an option to identify an associated filter.

<sp:bin_profile_description>
This free-text field is **required**. It must contain a human-friendly description of how the bin widths were determined. Sometimes this will be a simple statement along the lines of "That's how they were designed". At other times, this may describe how "width" is locally defined for bins in which the "center wavelength" is not actually in the center of the bin.

Be particularly clear about information that a user might need to know to effectively use or re-use the data.

<sp:Uniformly_Sampled_(Energy|Frequency|Wavelength|Wavenumber)>
This class is similar to other *Uniformly_Sampled* classes in the *pds:* namespace. It requires a starting bin-center value, number of bins, and constant bin width, and enables a program to calculate the center value of each successive bin. It begins with a required *<sp:axis_name>* attribute. For array-type data objects, the value of

sp:axis_name must be the same as that of a *<pds:axis_name>* in the spectral array. For a spectrum of type **1D**, this must contain the word *"Row"*. For any **Tabulated** spectra, this must contain the word *"Field"*.

Use the *sp:Uniformaly_Sampled* class that corresponds to the type of units of measure for the spectrum, as indicated by *<sp:spectral_bin_type>* in the top-level *<sp:Spectral_Characteristics>* class.

If the bin widths are unknown, the *sp:bin_width* attribute in these classes is nillable.

<sp:Axis_Bin_Set_(Energy|Frequency|Wavelength|Wavenumber)>

The *<sp:Axis_Bin_set>* classes are used to identify the spectral dimension in the data object, and then provide explicit bin center and width information for each bin in that dimension. As with the *sp:Uniformly_Sampled* classes, the first attribute is *<sp:axis_name>*, which must correspond to an *<pds:axis_name>* value if the spectrum is stored in an array, *"Row"* if the spectrum is in **1D** format, and *"Field"* if the spectra are in **Tabulated** format.

Use the *sp:Axis_Bin_Set* class that corresponds to the type of units of measure for the spectrum, as indicated by *<sp:spectral_bin_type>* in the top-level *<sp:Spectral_Characteristics>* class.

The *sp:Bin_Wdith* subclasses in these classes include an option to identify a filter that corresponds to the bin. If the bin widths are unknown, the *sp:bin_width* attribute in these classes is nillable.

<sp:Spectral_Lookup>

The *<sp:Spectral_Lookup>* class is used when the bin centers and widths are in either another data object in the same file/data product, or in a different data product elsewhere in the PDS archive. It can also be used to specify a constant bin width rather than a look-up location for bin widths.

Bin widths and centers can be looked up by:

- Field name, in the case of **1D**, **Tabulated-Parameter Group**, and **Tabulated-Point Group** spectra;
- Field number list, in the case of **Tabulated-Flat** spectra;
- *<pds:Local_Internal_Reference>*, when the information is in another data object in the same file; or
- *<pds:Internal_Reference>*, when the information is in another data product in the PDS.

In addition, the *sp:Bin_Width_Constant* class can be used to provide a known constant bin width, or to declare that the bin widths are not known (that is to say, the bin width attributes are nillable).

CHAPTER

FOUR

SPECTRAL/SPECTROSCOPY DISCIPLINE NAMESPACE OUTLINE

<sp:Spectral_Characteristics> is the public entry point to the Spectral Discipline namespace. This class contains all other Spectral classes and must be included to gain access to them. Below is a summary outline of all classes and attributes currently available in the Spectral Discipline dictionary, in the order in which they would appear in a label if every single one was used.

Note that there are no real cases in which every single discipline class and attribute would appear in a single label. The point of this outline is primarily to catalog what is present and show the required ordering within classes when they are included in a label.

Note: The abbreviated form "(Energy|Frequency|Wavelength|Wavenumber)" is used for those parallel classes that have identical structure but names that are tied to the requirements for units of measure. The form used must be consistent with the value of the *sp:spectral_bin_type>* attribute.

```
<sp:Spectral_Characteristics>
    <pds:Local_Internal_Reference>
        <pds:comment>
        <pds:local_identifier_reference>
        <pds:local_reference_type>

    <sp:description>
    <sp:spectrum_format>
    <sp:value_field_name>
    <sp:value_field_number_list>
    <sp:spectral_bin_type>

    <sp:Observation_Parameters>
        <sp:number_of_exposures>
        <sp:net_integration_time>
        <sp:resolution_limit_(energy|frequency|wavelength|wavenumber)>
        <sp:solar_analog_star_name>
        <sp:absolute_calibration_star_name>
        <sp:comment>

    <sp:Field_of_View>
        <sp:description>

        <sp:Circular_FOV>
            <sp:diameter_angle>

        <sp:Rectangular_FOV>
            <sp:width_angle>
```

(continues on next page)

(continued from previous page)

```
            <sp:length_angle>
            <sp:celestial_north_pole_angle>
            <sp:body_positive_pole_angle>

        <sp:Complex_FOV>
            <sp:width_angle>
            <sp:length_angle>
            <sp:celestial_north_pole_angle>
            <sp:body_positive_pole_angle>

        <pds:Internal_Reference>
            <pds:lid_reference> *or* <pds:lidvid_reference>
            <pds:reference_type>
            <pds:comment>

    <sp:Bin_Description>
        <sp:bin_profile_description>

        <sp:Uniformly_Sampled_(Energy|Frequency|Wavelength|Wavenumber)>
            <sp:axis_name>
            <sp:sampling_interval_(energy|frequency|wavelength|wavenumber)>
            <sp:sampling_scale>
            <sp:sampling_base>
            <sp:bin_width_(energy|frequency|wavelength|wavenumber)>
            <sp:first_center_(energy|frequency|wavelength|wavenumber)>
            <sp:last_center_(energy|frequency|wavelength|wavenumber)>
            <sp:comment>

        <sp:Axis_Bin_Set_(Energy|Frequency|Wavelength|Wavenumber)>
            <sp:axis_name>
            <sp:Bin_(Energy|Frequency|Wavelength|Wavenumber)>
                <sp:bin_sequence_number>
                <sp:center_(energy|frequency|wavelength|wavenumber)>
                <sp:bin_width_(energy|frequency|wavelength|wavenumber)>
                <sp:detector_number>
                <sp:grating_position>
                <sp:original_bin_number>

                <sp:Filter>
                    <sp:filter_name>
                    <sp:filter_number>
                    <sp:comment>

        <sp:Spectral_Lookup>
            <sp:Bin_Center_Lookup>
                <sp:bin_center_field_name>
                <sp:bin_center_field_number_list>

                <pds:Local_Internal_Reference>
                    <pds:comment>
                    <pds:local_identifier_reference>
                    <pds:local_reference_type>
```

(continues on next page)

(continued from previous page)

```
            <pds:Internal_Reference>
                <pds:lid_reference> *or* <pds:lidvid_reference>
                <pds:reference_type>
                <pds:comment>

        <sp:Bin_Width_Constant>
            <sp:bin_width_(energy|frequency|wavelength|wavenumber)>

        <sp:Bin_Width_Lookup>
            <sp:bin_width_field_name>
            <sp:bin_width_field_number_list>

            <pds:Local_Internal_Reference>
                <pds:comment>
                <pds:local_identifier_reference>
                <pds:local_reference_type>

            <pds:Internal_Reference>
                <pds:lid_reference> *or* <pds:lidvid_reference>
                <pds:reference_type>
                <pds:comment>

        <sp:comment>
```

CHAPTER

FIVE

ALPHABETICAL LIST OF CLASSES

A complete list of all classes in the Spectral (sp) Dictionary, in alphabetical order, is available through the PDS4 Data Dictionary page, which is regenerated automatically with each release of the PDS4 Information Model.

To find the Spectral Discipline class list, look down the list of (alphabetically sorted) dictionary prefixes in the left menu for "Classes in the sp namespace". Select that item and the list of classes will be presented on both the left and the right as clickable links.

Clicking on the specific class name will produce a grid with the full, formal definition of the class.

Clicking on the class name in the "Referenced from:" line at the bottom of the grid will take you to the containing class, where you can see the cardinality of the class (i.e., whether it is required, optional, or repeatable) in the containing class.

You can also click on the attribute names listed to see details of the attribute definitions.

CHAPTER

SIX

ALPHABETICAL LIST OF ATTRIBUTES

A complete list of all attributes in the Spectral (sp) Dictionary, in alphabetical order, is available through the PDS4 Data Dictionary page, which is regenerated automatically with each release of the PDS4 Information Model.

To find the Spectral Discipline attribute list, look down the list of (alphabetically sorted) dictionary prefixes in the left menu for "Attributes in the sp namespace". Select that item and the list of attributes will be presented on both the left and the right as clickable links.

Clicking on the specific attribute name will produce a grid with the full, formal definition of the attribute, including data type, restrictions on values, and the list of defined permissible values (if any) and their definitions.

Note that attributes might appear as members of different classes, and that their definitions, or more likely their permissible values, might be context-dependent.

Clicking on the class name in the title bar of the attribute grid will take you to the definition of the class containing that attribute.

If the attribute has an associated unit of measure type, that attribute *must* have an XML attribute called "unit" in its tag when it is used. For example:

```
<nh:tdi_rate unit="Hz">40.4694</nh:tdi_rate>
```

You can see valid values to use for the "unit=" XML attribute by clicking on the value of "Unit of Measure Type" in the grid.

CHAPTER

SEVEN

ABOUT THE EXAMPLE LABELS

These "Demo" files provide simple demonstrations of how to use the Spectral dictionary to describe a variety of spectral formats and bin description techniques. They have been designed to pass simple validation, so that they can be used as a starting point for development and testing. Note, however, that these are far from being complete labels in any sense. In particular, the data structures would not be considered "complete" by any conscientious reviewer without significant additional metadata - like field descriptions, ranges and extrema, and so on.

The demo labels include:

- *1D spectrum, using <Spectral_Lookup>* to reference table fields, complex FOV
- *1D spectrum, using <Uniformly_Sampled>*, rectangular FOV
- *2D spectrum, using <Uniformly_sampled>*, rectangular FOV
- *3D spectrum, using <Axis_Bin_Set>*, rectangular FOV
- *3D spectrum, using <Spectral_Lookup>* to reference data objects in the same file, circular FOV
- *Tabulated-Flat spectra, using <Spectral_Lookup>* to reference another product for bin centers and to specify unknown bin widths, rectangular FOV
- *Tabulated-Flat spectra, using <Spectral_Lookup>* to reference fields using a list of field numbers, circular FOV
- *Tabulated-Parameter Groups spectra, using <Spectral_Lookup>* to reference fields in *Group_Field* classes, rectangular FOV
- *Tabulated-Point Group spectra, using <Spectral_Lookup>* to reference fields in a *Group_Field* class, complex FOV
- *Tabulated-Point Group spectra, using <Spectral_Lookup>* to reference a field in a *Group_Field* class for bin center, and <Bin_Width_Constant> for bin width, complex FOV

CHAPTER

EIGHT

1D SPECTRUM, SPECTRAL LOOKUP

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-model href="https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1L00.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>
<?xml-model href="https://pds.nasa.gov/pds4/sp/v1/PDS4_SP_1L00_1320.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>

<!--
This "label" is intended only to demonstrate how to use certain features of the Spectral
Dictionary, and pretty much nothing else. It is not a real label in any sense, even␣
↪though
it should produce no errors when validated against the PDS schema. A real label would␣
↪have
references to additional dictionaries, for example, from the mission, for geometry, and/
↪or
for any other related discipline or local namespaces. Any "data" you see here is␣
↪fictitious,
and provided merely to remove any validation errors that might otherwise occur.

Note, in particular, that any conscientious reviewer would consider the data structure␣
↪classes
to be inadequate without appropriate descriptions, extrema, null data indicates, and␣
↪similar
essential metadata.

This label demonstrates:
   - Using <sp:Spectral_Characteristics> for a "1D" table spectrum;
   - Using the <sp:Complex_FOV> to describe the aperture; and
   - Using the <sp:Spectral_Lookup> class to identify bin centers and widths as fields in
     the table.
-->

<Product_Observational xmlns="http://pds.nasa.gov/pds4/pds/v1"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:sp="http://pds.nasa.gov/pds4/sp/v1"
    xsi:schemaLocation="http://pds.nasa.gov/pds4/pds/v1 https://pds.nasa.gov/pds4/pds/v1/
↪PDS4_PDS_1L00.xsd
                        http://pds.nasa.gov/pds4/sp/v1  http://pds.nasa.gov/pds4/sp/v1/
↪PDS4_SP_1L00_1320.xsd">
    <Identification_Area>
        <logical_identifier>urn:nasa:pds:bundle:collection:product</logical_identifier>
```

(continues on next page)

(continued from previous page)

```
        <version_id>1.0</version_id>
        <title>Test Label 1 for Spectral Dictionary - Valid Label</title>
        <information_model_version>1.21.0.0</information_model_version>
        <product_class>Product_Observational</product_class>
    </Identification_Area>

    <Observation_Area>
        <Time_Coordinates>
            <start_date_time xsi:nil="true" nilReason="inapplicable"/>
            <stop_date_time xsi:nil="true" nilReason="inapplicable"/>
        </Time_Coordinates>

        <Investigation_Area>
            <name>None</name>
            <type>Individual Investigation</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:investigation:individual.none</lid_
↪reference>
                <reference_type>data_to_investigation</reference_type>
            </Internal_Reference>
        </Investigation_Area>
        <Observing_System>
            <Observing_System_Component>
                <name>None</name>
                <type>Telescope</type>
            </Observing_System_Component>
        </Observing_System>
        <Target_Identification>
            <name>None</name>
            <type>Comet</type>
        </Target_Identification>

        <Discipline_Area>

            <!-- Spectral Lookup for 1D spectrum (table), in Table fields -->

            <sp:Spectral_Characteristics>
                <Local_Internal_Reference>
                    <comment>
                        The spectral bin centers are included in the table in the named␣
↪field.  In
                        this case, FWHM values are also included in the table as a␣
↪separate field.
                        Table field classes must have 'name' attributes (although these␣
↪are not
                        currently required to be unique).
                    </comment>
                    <local_identifier_reference>TableChar1D</local_identifier_reference>
                    <local_reference_type>spectral_characteristics_to_table_object</
↪local_reference_type>
                </Local_Internal_Reference>
                <sp:spectrum_format>1D</sp:spectrum_format>
```

(continues on next page)

(continued from previous page)

```
                <sp:value_field_name>Intensity</sp:value_field_name>
                <sp:spectral_bin_type>wavelength</sp:spectral_bin_type>

                <sp:Observation_Parameters>
                    <sp:number_of_exposures>1</sp:number_of_exposures>
                    <sp:net_integration_time unit="s">20</sp:net_integration_time>
                    <sp:resolution_limit_wavelength unit="nm">5</sp:resolution_limit_
↪wavelength>
                </sp:Observation_Parameters>

                <sp:Field_of_View>
                    <sp:description>
                        This field of view is not a regular shape.  Typically this␣
↪should be
                        described in some detail in a document that is referenced within␣
↪this
                        class (we'll assume one exists in this case as a demonstration).␣
↪ For
                        example, the Alice spectrometer on New Horizons has a "lollipop"␣
↪shaped
                        slit.  I don't know the actual dimensions of that slit, so the
                        description below is fake.  This description would specify how␣
↪the
                        'width' value indicated here correspond to the slit design, for␣
↪example.
                    </sp:description>
                    <sp:Complex_FOV>
                        <sp:width_angle unit="arcsec">10</sp:width_angle>
                        <sp:width_angle unit="arcsec">5</sp:width_angle>
                        <sp:length_angle unit="arcsec">100</sp:length_angle>
                        <sp:celestial_north_position_angle unit="deg">70</sp:celestial_
↪north_position_angle>
                    </sp:Complex_FOV>
                    <Internal_Reference>
                        <lid_reference>urn:nasa:pds:nh_docs:slit_specs</lid_reference>
                        <reference_type>spectral_characteristics_to_document</reference_
↪type>
                        <comment>
                            This document provides both a diagram and specific physical
                            measurements of the lollipop-shaped slit.
                        </comment>
                    </Internal_Reference>
                </sp:Field_of_View>

                <sp:Bin_Description>
                    <sp:bin_profile_description>
                        Bin widths indicated in the table are those listed in the␣
↪manufacturer's
                        specifications.
                    </sp:bin_profile_description>
                    <sp:Spectral_Lookup>
                        <sp:Bin_Center_Lookup>
```

(continues on next page)

(continued from previous page)

```
                        <sp:bin_center_field_name>Center Wavelength</sp:bin_center_
↪field_name>
                    </sp:Bin_Center_Lookup>
                    <sp:Bin_Width_Lookup>
                        <sp:bin_width_field_name>FWHM</sp:bin_width_field_name>
                    </sp:Bin_Width_Lookup>
                </sp:Spectral_Lookup>
            </sp:Bin_Description>
        </sp:Spectral_Characteristics>

    </Discipline_Area>
</Observation_Area>

<File_Area_Observational>
    <File>
        <file_name>No.Data</file_name>
    </File>

    <!-- 1D Spectral Table  -->

    <Table_Character>
        <local_identifier>TableChar1D</local_identifier>
        <offset unit="byte">0</offset>
        <records>100</records>
        <description>
            This is just one of many possible structures for a set of
            spectra in tabulated format.
        </description>
        <record_delimiter>Carriage-Return Line-Feed</record_delimiter>
        <Record_Character>
            <fields>4</fields>
            <groups>0</groups>
            <record_length unit="byte">50</record_length>

            <Field_Character>
                <name>Intensity</name>
                <field_location unit="byte">1</field_location>
                <data_type>ASCII_Real</data_type>
                <field_length unit="byte">5</field_length>
            </Field_Character>

            <Field_Character>
                <name>Error</name>
                <field_location unit="byte">6</field_location>
                <data_type>ASCII_Real</data_type>
                <field_length unit="byte">4</field_length>
            </Field_Character>

            <Field_Character>
                <name>Center Wavelength</name>
                <field_location unit="byte">12</field_location>
                <data_type>ASCII_Integer</data_type>
```

(continues on next page)

(continued from previous page)

```
                    <field_length unit="byte">4</field_length>
                    <unit>nanometer</unit>
                </Field_Character>

                <Field_Character>
                    <name>FWHM</name>
                    <field_location unit="byte">20</field_location>
                    <data_type>ASCII_Real</data_type>
                    <field_length unit="byte">6</field_length>
                    <unit>angstrom</unit>
                </Field_Character>
            </Record_Character>
        </Table_Character>

    </File_Area_Observational>
</Product_Observational>
```

CHAPTER

NINE

1D SPECTRUM, UNIFORMLY SAMPLED

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-model href="https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1L00.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>
<?xml-model href="https://pds.nasa.gov/pds4/sp/v1/PDS4_SP_1L00_1320.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>

<!--
    This "label" is intended only to demonstrate how to use certain features of the␣
↪Spectral
    Dictionary, and pretty much nothing else. It is not a real label in any sense, even␣
↪though
    it should produce no errors when validated against the PDS schema. A real label␣
↪would have
    references to additional dictionaries, for example, from the mission, for geometry,␣
↪and/or
    for any other related discipline or local namespaces. Any "data" you see here is␣
↪fictitious,
    and provided merely to remove any validation errors that might otherwise occur.

    Note, in particular, that any conscientious reviewer would consider the data␣
↪structure classes
    to be inadequate without appropriate descriptions, extrema, null data indicates, and␣
↪similar
    essential metadata.

    This label demonstrates:
       - Using <sp:Spectral_Characteristics> for a "1D" table spectrum;
       - Using the <sp:Rectangular_FOV> to describe the aperture; and
       - Using the <sp:Uniformly_Sampled> class to provide the information needed to␣
↪calculate
         bin centers.
-->

<Product_Observational xmlns="http://pds.nasa.gov/pds4/pds/v1"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:sp="http://pds.nasa.gov/pds4/sp/v1"
    xsi:schemaLocation="http://pds.nasa.gov/pds4/pds/v1 https://pds.nasa.gov/pds4/pds/v1/
↪PDS4_PDS_1L00.xsd
    http://pds.nasa.gov/pds4/sp/v1  http://pds.nasa.gov/pds4/sp/v1/PDS4_SP_1L00_1320.xsd
↪">
```

(continues on next page)

(continued from previous page)

```
    <Identification_Area>
        <logical_identifier>urn:nasa:pds:bundle:collection:product</logical_identifier>
        <version_id>1.0</version_id>
        <title>Test Label 1 for Spectral Dictionary - Valid Label</title>
        <information_model_version>1.21.0.0</information_model_version>
        <product_class>Product_Observational</product_class>
    </Identification_Area>

    <Observation_Area>
        <Time_Coordinates>
            <start_date_time xsi:nil="true" nilReason="inapplicable"/>
            <stop_date_time xsi:nil="true" nilReason="inapplicable"/>
        </Time_Coordinates>

        <Investigation_Area>
            <name>None</name>
            <type>Individual Investigation</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:investigation:individual.none</lid_
↪reference>
                <reference_type>data_to_investigation</reference_type>
            </Internal_Reference>
        </Investigation_Area>
        <Observing_System>
            <Observing_System_Component>
                <name>None</name>
                <type>Telescope</type>
            </Observing_System_Component>
        </Observing_System>
        <Target_Identification>
            <name>None</name>
            <type>Comet</type>
        </Target_Identification>

        <Discipline_Area>

            <!-- Telescope Spectrum, uniformly sampled bins -->

            <sp:Spectral_Characteristics>
                <Local_Internal_Reference>
                    <local_identifier_reference>TableChar1D</local_identifier_reference>
                    <local_reference_type>spectral_characteristics_to_table_object</
↪local_reference_type>
                </Local_Internal_Reference>
                <sp:description>
                    This is a linear spectrum - presented as a table where each point in␣
↪the spectrum
                    (usually along with associated information) is contained in a single␣
↪row of the table.
                    In this case it is necessary to specify the name of the field that␣
↪contains the actual
                    measured datum.
```

(continues on next page)

(continued from previous page)

```
                </sp:description>
                <sp:spectrum_format>1D</sp:spectrum_format>
                <sp:value_field_name>Intensity</sp:value_field_name>
                <sp:spectral_bin_type>wavelength</sp:spectral_bin_type>

                <sp:Observation_Parameters>
                    <sp:number_of_exposures>1</sp:number_of_exposures>
                    <sp:net_integration_time unit="s">10</sp:net_integration_time>
                    <sp:resolution_limit_wavelength unit="micrometer">10</sp:resolution_
↪limit_wavelength>
                    <sp:solar_analog_star_name>Billy</sp:solar_analog_star_name>
                </sp:Observation_Parameters>

                <sp:Field_of_View>
                    <sp:description>
                        Tbe FOV is a simple slit.
                    </sp:description>
                    <sp:Rectangular_FOV>
                        <sp:width_angle unit="deg">0.01</sp:width_angle>
                        <sp:length_angle unit="deg">0.06</sp:length_angle>
                        <sp:celestial_north_position_angle unit="deg">23</sp:celestial_
↪north_position_angle>
                    </sp:Rectangular_FOV>
                </sp:Field_of_View>

                <sp:Bin_Description>
                    <sp:bin_profile_description>
                        Bin centers and bandpasses included in the table were copied␣
↪from the
                        instrument manual.
                    </sp:bin_profile_description>
                    <sp:Uniformly_Sampled_Wavelength>
                        <sp:axis_name>Row</sp:axis_name>
                        <sp:sampling_interval_wavelength unit="nm">100</sp:sampling_
↪interval_wavelength>
                        <sp:sampling_scale>Linear</sp:sampling_scale>
                        <sp:bin_width_wavelength unit="nm">10</sp:bin_width_wavelength>
                        <sp:first_center_wavelength unit="nm">350</sp:first_center_
↪wavelength>
                        <sp:last_center_wavelength unit="nm">480</sp:last_center_
↪wavelength>
                    </sp:Uniformly_Sampled_Wavelength>
                </sp:Bin_Description>
            </sp:Spectral_Characteristics>

        </Discipline_Area>
    </Observation_Area>

    <File_Area_Observational>
        <File>
            <file_name>No.Data</file_name>
        </File>
```

(continues on next page)

(continued from previous page)

```
        <!-- 1D Spectral Table  -->

        <Table_Character>
            <local_identifier>TableChar1D</local_identifier>
            <offset unit="byte">26000000</offset>
            <records>100</records>
            <description>
                This is just one of many possible structures for a set of
                spectra in tabulated format.
            </description>
            <record_delimiter>Carriage-Return Line-Feed</record_delimiter>
            <Record_Character>
                <fields>4</fields>
                <groups>0</groups>
                <record_length unit="byte">50</record_length>

                <Field_Character>
                    <name>Intensity</name>
                    <field_location unit="byte">1</field_location>
                    <data_type>ASCII_Real</data_type>
                    <field_length unit="byte">5</field_length>
                </Field_Character>

                <Field_Character>
                    <name>Error</name>
                    <field_location unit="byte">6</field_location>
                    <data_type>ASCII_Real</data_type>
                    <field_length unit="byte">4</field_length>
                </Field_Character>

                <Field_Character>
                    <name>Center Wavelength</name>
                    <field_location unit="byte">12</field_location>
                    <data_type>ASCII_Integer</data_type>
                    <field_length unit="byte">4</field_length>
                    <unit>nanometer</unit>
                </Field_Character>

                <Field_Character>
                    <name>FWHM</name>
                    <field_location unit="byte">20</field_location>
                    <data_type>ASCII_Real</data_type>
                    <field_length unit="byte">6</field_length>
                    <unit>angstrom</unit>
                </Field_Character>
            </Record_Character>
        </Table_Character>

    </File_Area_Observational>
</Product_Observational>
```

CHAPTER

TEN

2D SPECTRUM, UNIFORMLY SAMPLED

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-model href="https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1L00.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>
<?xml-model href="https://pds.nasa.gov/pds4/sp/v1/PDS4_SP_1L00_1320.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>

<!--
    This "label" is intended only to demonstrate how to use certain features of the␣
↪Spectral
    Dictionary, and pretty much nothing else. It is not a real label in any sense, even␣
↪though
    it should produce no errors when validated against the PDS schema. A real label␣
↪would have
    references to additional dictionaries, for example, from the mission, for geometry,␣
↪and/or
    for any other related discipline or local namespaces. Any "data" you see here is␣
↪fictitious,
    and provided merely to remove any validation errors that might otherwise occur.

    Note, in particular, that any conscientious reviewer would consider the data␣
↪structure classes
    to be inadequate without appropriate descriptions, extrema, null data indicates, and␣
↪similar
    essential metadata.

    This label demonstrates:
       - Using <sp:Spectral_Characteristics> for a "2D" array spectrum;
       - Using the <sp:Rectangular_FOV> to describe the aperture; and
       - Using the <sp:Uniformaly_Sampled> class to document how to calculate the bin␣
↪centers
         and provide a constant bin width.
-->

<Product_Observational xmlns="http://pds.nasa.gov/pds4/pds/v1"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:sp="http://pds.nasa.gov/pds4/sp/v1"
    xsi:schemaLocation="http://pds.nasa.gov/pds4/pds/v1 https://pds.nasa.gov/pds4/pds/v1/
↪PDS4_PDS_1L00.xsd
                        http://pds.nasa.gov/pds4/sp/v1  http://pds.nasa.gov/pds4/sp/v1/
↪PDS4_SP_1L00_1320.xsd">
```

(continues on next page)

(continued from previous page)

```
    <Identification_Area>
        <logical_identifier>urn:nasa:pds:bundle:collection:product</logical_identifier>
        <version_id>1.0</version_id>
        <title>Test Label 1 for Spectral Dictionary - Valid Label</title>
        <information_model_version>1.21.0.0</information_model_version>
        <product_class>Product_Observational</product_class>
    </Identification_Area>

    <Observation_Area>
        <Time_Coordinates>
            <start_date_time xsi:nil="true" nilReason="inapplicable"/>
            <stop_date_time xsi:nil="true" nilReason="inapplicable"/>
        </Time_Coordinates>

        <Investigation_Area>
            <name>None</name>
            <type>Individual Investigation</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:investigation:individual.none</lid_
↪reference>
                <reference_type>data_to_investigation</reference_type>
            </Internal_Reference>
        </Investigation_Area>
        <Observing_System>
            <Observing_System_Component>
                <name>None</name>
                <type>Telescope</type>
            </Observing_System_Component>
        </Observing_System>
        <Target_Identification>
            <name>None</name>
            <type>Comet</type>
        </Target_Identification>

        <Discipline_Area>

            <!-- Uniformly Sampled Array Axis  -->

            <sp:Spectral_Characteristics>
                <Local_Internal_Reference>
                    <local_identifier_reference>Spectrum2D</local_identifier_reference>
                    <local_reference_type>spectral_characteristics_to_array_object</
↪local_reference_type>
                </Local_Internal_Reference>
                <sp:spectrum_format>2D</sp:spectrum_format>
                <sp:spectral_bin_type>wavelength</sp:spectral_bin_type>

                <sp:Observation_Parameters>
                    <sp:number_of_exposures>1</sp:number_of_exposures>
                    <sp:net_integration_time unit="s">100</sp:net_integration_time>
                </sp:Observation_Parameters>
```

(continues on next page)

(continued from previous page)

```
                <sp:Field_of_View>
                    <sp:description>
                        This FOV in this case is a simple slit.
                    </sp:description>
                    <sp:Rectangular_FOV>
                        <sp:width_angle unit="deg">0.01</sp:width_angle>
                        <sp:length_angle unit="deg">0.1</sp:length_angle>
                        <sp:celestial_north_position_angle unit="deg">47.6</sp:celestial_
↪north_position_angle>
                        <sp:body_positive_pole_position_angle unit="deg">90</sp:body_
↪positive_pole_position_angle>
                    </sp:Rectangular_FOV>
                </sp:Field_of_View>

                <sp:Bin_Description>
                    <sp:bin_profile_description>
                        Bin widths are FWHM as described in the instrument documentation.
                    </sp:bin_profile_description>
                    <sp:Uniformly_Sampled_Wavelength>
                        <sp:axis_name>Sample</sp:axis_name>
                        <sp:sampling_interval_wavelength unit="nm">100</sp:sampling_
↪interval_wavelength>
                        <sp:sampling_scale>Linear</sp:sampling_scale>
                        <sp:bin_width_wavelength unit="nm">100</sp:bin_width_wavelength>
                        <sp:first_center_wavelength unit="nm">3550</sp:first_center_
↪wavelength>
                        <sp:last_center_wavelength unit="nm">3600</sp:last_center_
↪wavelength>
                    </sp:Uniformly_Sampled_Wavelength>
                </sp:Bin_Description>

            </sp:Spectral_Characteristics>

        </Discipline_Area>
    </Observation_Area>

    <File_Area_Observational>
        <File>
            <file_name>No.Data</file_name>
        </File>

        <!-- 2D Spectrum -->

        <Array_2D_Spectrum>
            <local_identifier>Spectrum2D</local_identifier>
            <offset unit="byte">0</offset>
            <axes>2</axes>
            <axis_index_order>Last Index Fastest</axis_index_order>
            <Element_Array>
                <data_type>SignedMSB4</data_type>
            </Element_Array>
            <Axis_Array>
```

(continues on next page)

(continued from previous page)

```
                <axis_name>Line</axis_name>
                <elements>255</elements>
                <sequence_number>1</sequence_number>
            </Axis_Array>
            <Axis_Array>
                <axis_name>Sample</axis_name>
                <elements>24</elements>
                <sequence_number>2</sequence_number>
            </Axis_Array>
        </Array_2D_Spectrum>

    </File_Area_Observational>
</Product_Observational>
```

CHAPTER

ELEVEN

3D SPECTRUM, AXIS_BIN_SET

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-model href="https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1L00.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>
<?xml-model href="https://pds.nasa.gov/pds4/sp/v1/PDS4_SP_1L00_1320.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>

<!--
    This "label" is intended only to demonstrate how to use certain features of the␣
↪Spectral
    Dictionary, and pretty much nothing else. It is not a real label in any sense, even␣
↪though
    it should produce no errors when validated against the PDS schema. A real label␣
↪would have
    references to additional dictionaries, for example, from the mission, for geometry,␣
↪and/or
    for any other related discipline or local namespaces. Any "data" you see here is␣
↪fictitious,
    and provided merely to remove any validation errors that might otherwise occur.

    Note, in particular, that any conscientious reviewer would consider the data␣
↪structure classes
    to be inadequate without appropriate descriptions, extrema, null data indicates, and␣
↪similar
    essential metadata.

    This label demonstrates:
       - Using <sp:Spectral_Characteristics> for a "3D" array spectrum;
       - Using the <sp:Rectangular_FOV> to describe the aperture; and
       - Using the <sp:Axis_Bin_Set> class to explicitly define the bin center and
         width applying to each plane (i.e., every pixel in the plane) of a stack
         of images.
-->

<Product_Observational xmlns="http://pds.nasa.gov/pds4/pds/v1"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:sp="http://pds.nasa.gov/pds4/sp/v1"
    xsi:schemaLocation="http://pds.nasa.gov/pds4/pds/v1 https://pds.nasa.gov/pds4/pds/v1/
↪PDS4_PDS_1L00.xsd
    http://pds.nasa.gov/pds4/sp/v1  http://pds.nasa.gov/pds4/sp/v1/PDS4_SP_1L00_1320.xsd
↪">
```

(continues on next page)

(continued from previous page)

```
    <Identification_Area>
        <logical_identifier>urn:nasa:pds:bundle:collection:product</logical_identifier>
        <version_id>1.0</version_id>
        <title>Test Label 1 for Spectral Dictionary - Valid Label</title>
        <information_model_version>1.21.0.0</information_model_version>
        <product_class>Product_Observational</product_class>
    </Identification_Area>

    <Observation_Area>
        <Time_Coordinates>
            <start_date_time xsi:nil="true" nilReason="inapplicable"/>
            <stop_date_time xsi:nil="true" nilReason="inapplicable"/>
        </Time_Coordinates>

        <Investigation_Area>
            <name>None</name>
            <type>Individual Investigation</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:investigation:individual.none</lid_
↪reference>
                <reference_type>data_to_investigation</reference_type>
            </Internal_Reference>
        </Investigation_Area>
        <Observing_System>
            <Observing_System_Component>
                <name>None</name>
                <type>Telescope</type>
            </Observing_System_Component>
        </Observing_System>
        <Target_Identification>
            <name>None</name>
            <type>Comet</type>
        </Target_Identification>

        <Discipline_Area>

            <!-- Bin Definitions using Axis_Bin_Set -->

            <sp:Spectral_Characteristics>
                <Local_Internal_Reference>
                    <local_identifier_reference>RGBSpec</local_identifier_reference>
                    <local_reference_type>spectral_characteristics_to_array_object</
↪local_reference_type>
                </Local_Internal_Reference>
                <sp:description>
                    The spectrum in this case is a shallow cube - only three bands␣
↪corresponding
                    to Red, Green, and Blue.
                </sp:description>
                <sp:spectrum_format>3D</sp:spectrum_format>
                <sp:spectral_bin_type>wavenumber</sp:spectral_bin_type>
```

(continues on next page)

(continued from previous page)

```
                <sp:Observation_Parameters>
                    <sp:number_of_exposures>1</sp:number_of_exposures>
                    <sp:net_integration_time unit="s">1</sp:net_integration_time>
                    <sp:resolution_limit_wavenumber unit="1/nm">100</sp:resolution_limit_
↪wavenumber>
                </sp:Observation_Parameters>

                <sp:Field_of_View>
                    <sp:description>
                        This FOV is square aligned with the image.
                    </sp:description>
                    <sp:Rectangular_FOV>
                        <sp:width_angle unit="arcsec">20</sp:width_angle>
                        <sp:length_angle unit="arcsec">20</sp:length_angle>
                        <sp:body_positive_pole_position_angle unit="deg">0</sp:body_
↪positive_pole_position_angle>
                    </sp:Rectangular_FOV>
                </sp:Field_of_View>

                <sp:Bin_Description>
                    <sp:bin_profile_description>
                        Bin profiles were determined during ground-testing with known␣
↪sources.
                    </sp:bin_profile_description>
                    <sp:Axis_Bin_Set_Wavenumber>
                        <sp:axis_name>Band</sp:axis_name>
                        <sp:Bin_Wavenumber>
                            <sp:bin_sequence_number>1</sp:bin_sequence_number>
                            <sp:center_wavenumber unit="1/cm">0.1</sp:center_wavenumber>
                            <sp:bin_width_wavenumber unit="1/cm">0.035</sp:bin_width_
↪wavenumber>
                        </sp:Bin_Wavenumber>
                        <sp:Bin_Wavenumber>
                            <sp:bin_sequence_number>2</sp:bin_sequence_number>
                            <sp:center_wavenumber unit="1/cm">0.15</sp:center_wavenumber>
                            <sp:bin_width_wavenumber unit="1/cm">0.2</sp:bin_width_
↪wavenumber>
                        </sp:Bin_Wavenumber>
                        <sp:Bin_Wavenumber>
                            <sp:bin_sequence_number>3</sp:bin_sequence_number>
                            <sp:center_wavenumber unit="1/cm">0.35</sp:center_wavenumber>
                            <sp:bin_width_wavenumber unit="1/cm">0.3</sp:bin_width_
↪wavenumber>
                        </sp:Bin_Wavenumber>
                    </sp:Axis_Bin_Set_Wavenumber>
                </sp:Bin_Description>
            </sp:Spectral_Characteristics>

        </Discipline_Area>
    </Observation_Area>

    <File_Area_Observational>
```

(continues on next page)

(continued from previous page)

```
        <File>
            <file_name>No.Data</file_name>
        </File>

        <!-- Shallow spectral cube with separately defined bins ("planes") -->

        <Array_3D_Spectrum>
            <local_identifier>RGBSpec</local_identifier>
            <offset unit="byte">13000000</offset>
            <axes>3</axes>
            <axis_index_order>Last Index Fastest</axis_index_order>
            <Element_Array>
                <data_type>IEEE754LSBSingle</data_type>
            </Element_Array>
            <Axis_Array>
                <axis_name>Right Ascension</axis_name>
                <elements>1000</elements>
                <sequence_number>3</sequence_number>
            </Axis_Array>
            <Axis_Array>
                <axis_name>Declination</axis_name>
                <elements>1020</elements>
                <sequence_number>2</sequence_number>
            </Axis_Array>
            <Axis_Array>
                <axis_name>Band</axis_name>
                <elements>3</elements>
                <sequence_number>1</sequence_number>
            </Axis_Array>
        </Array_3D_Spectrum>

    </File_Area_Observational>
</Product_Observational>
```

CHAPTER

TWELVE

3D SPECTRUM, SPECTRAL LOOKUP

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-model href="https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1L00.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>
<?xml-model href="https://pds.nasa.gov/pds4/sp/v1/PDS4_SP_1L00_1320.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>

<!--
    This "label" is intended only to demonstrate how to use certain features of the␣
↪Spectral
    Dictionary, and pretty much nothing else. It is not a real label in any sense, even␣
↪though
    it should produce no errors when validated against the PDS schema. A real label␣
↪would have
    references to additional dictionaries, for example, from the mission, for geometry,␣
↪and/or
    for any other related discipline or local namespaces. Any "data" you see here is␣
↪fictitious,
    and provided merely to remove any validation errors that might otherwise occur.

    Note, in particular, that any conscientious reviewer would consider the data␣
↪structure classes
    to be inadequate without appropriate descriptions, extrema, null data indicates, and␣
↪similar
    essential metadata.

    This label demonstrates:
       - Using <sp:Spectral_Characteristics> for a "3D" array spectrum;
       - Using the <sp:Circular_FOV> to describe the aperture; and
       - Using the <sp:Spectral_Lookup> class to identify two data objects in the same␣
↪file that
         provide pixel-by-pixel values for bin centers and bin widths. These might be,␣
↪for
         example, "back planes" of a spectral cube.
-->

<Product_Observational xmlns="http://pds.nasa.gov/pds4/pds/v1"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:sp="http://pds.nasa.gov/pds4/sp/v1"
    xsi:schemaLocation="http://pds.nasa.gov/pds4/pds/v1 https://pds.nasa.gov/pds4/pds/v1/
↪PDS4_PDS_1L00.xsd
```

(continues on next page)

(continued from previous page)

```
    http://pds.nasa.gov/pds4/sp/v1  http://pds.nasa.gov/pds4/sp/v1/PDS4_SP_1L00_1320.xsd
↪">
    <Identification_Area>
        <logical_identifier>urn:nasa:pds:bundle:collection:product</logical_identifier>
        <version_id>1.0</version_id>
        <title>Test Label 1 for Spectral Dictionary - Valid Label</title>
        <information_model_version>1.21.0.0</information_model_version>
        <product_class>Product_Observational</product_class>
    </Identification_Area>

    <Observation_Area>
        <Time_Coordinates>
            <start_date_time xsi:nil="true" nilReason="inapplicable"/>
            <stop_date_time xsi:nil="true" nilReason="inapplicable"/>
        </Time_Coordinates>

        <Investigation_Area>
            <name>None</name>
            <type>Individual Investigation</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:investigation:individual.none</lid_
↪reference>
                <reference_type>data_to_investigation</reference_type>
            </Internal_Reference>
        </Investigation_Area>
        <Observing_System>
            <Observing_System_Component>
                <name>None</name>
                <type>Telescope</type>
            </Observing_System_Component>
        </Observing_System>
        <Target_Identification>
            <name>None</name>
            <type>Comet</type>
        </Target_Identification>

        <Discipline_Area>

            <!-- Spectral Lookup for 3D spectra, internal -->

            <sp:Spectral_Characteristics>
                <Local_Internal_Reference>
                    <local_identifier_reference>Cube</local_identifier_reference>
                    <local_reference_type>spectral_characteristics_to_array_object</
↪local_reference_type>
                </Local_Internal_Reference>
                <sp:spectrum_format>3D</sp:spectrum_format>
                <sp:spectral_bin_type>frequency</sp:spectral_bin_type>

                <sp:Observation_Parameters>
                    <sp:number_of_exposures>2</sp:number_of_exposures>
                    <sp:net_integration_time unit="s">10</sp:net_integration_time>
```

(continues on next page)

(continued from previous page)

```
                    <sp:resolution_limit_frequency unit="Hz">1</sp:resolution_limit_
↪frequency>
                </sp:Observation_Parameters>

                <sp:Field_of_View>
                    <sp:description>
                        This FOV is circular.
                    </sp:description>
                    <sp:Circular_FOV>
                        <sp:diameter_angle unit="deg">0.05</sp:diameter_angle>
                    </sp:Circular_FOV>
                </sp:Field_of_View>

                <sp:Bin_Description>
                    <sp:bin_profile_description>
                        Bin centers and widths are specified as part of the mission␣
↪documentation,
                        specifically in the detector specifications [usually there would␣
↪be some
                        sort of reference here].
                    </sp:bin_profile_description>
                    <sp:Spectral_Lookup>
                        <sp:Bin_Center_Lookup>
                            <Local_Internal_Reference>
                                <local_identifier_reference>BinCenterMap</local_
↪identifier_reference>
                                <local_reference_type>spectral_characteristics_to_bin_
↪center_values</local_reference_type>
                            </Local_Internal_Reference>
                        </sp:Bin_Center_Lookup>
                        <sp:Bin_Width_Lookup>
                            <Local_Internal_Reference>
                                <local_identifier_reference>BinWidthMap</local_
↪identifier_reference>
                                <local_reference_type>spectral_characteristics_to_bin_
↪width_values</local_reference_type>
                            </Local_Internal_Reference>
                        </sp:Bin_Width_Lookup>
                    </sp:Spectral_Lookup>
                </sp:Bin_Description>
            </sp:Spectral_Characteristics>

        </Discipline_Area>
    </Observation_Area>

    <File_Area_Observational>
        <File>
            <file_name>No.Data</file_name>
        </File>

        <!-- Spectral Cube -->
```

(continues on next page)

(continued from previous page)

```
        <Array_3D_Spectrum>
            <local_identifier>Cube</local_identifier>
            <offset unit="byte">25000</offset>
            <axes>3</axes>
            <axis_index_order>Last Index Fastest</axis_index_order>
            <Element_Array>
                <data_type>SignedLSB2</data_type>
            </Element_Array>
            <Axis_Array>
                <axis_name>Spatial</axis_name>
                <elements>100</elements>
                <sequence_number>1</sequence_number>
            </Axis_Array>
            <Axis_Array>
                <axis_name>Frequency</axis_name>
                <elements>200</elements>
                <sequence_number>2</sequence_number>
            </Axis_Array>
            <Axis_Array>
                <axis_name>Time</axis_name>
                <elements>255</elements>
                <sequence_number>3</sequence_number>
            </Axis_Array>
        </Array_3D_Spectrum>

        <!-- Bin centers Map for spectral cube -->

        <Array_2D_Map>
            <local_identifier>BinCenterMap</local_identifier>
            <offset unit="byte">11000000</offset>
            <axes>2</axes>
            <axis_index_order>Last Index Fastest</axis_index_order>
            <Element_Array>
                <data_type>IEEE754LSBSingle</data_type>
            </Element_Array>
            <Axis_Array>
                <axis_name>Spatial</axis_name>
                <elements>100</elements>
                <sequence_number>1</sequence_number>
            </Axis_Array>
            <Axis_Array>
                <axis_name>Frequency</axis_name>
                <elements>200</elements>
                <sequence_number>2</sequence_number>
            </Axis_Array>
        </Array_2D_Map>

        <!-- Bin width map for specral cube -->

        <Array_2D_Map>
            <local_identifier>BinWidthMap</local_identifier>
            <offset unit="byte">12000000</offset>
```

(continues on next page)

(continued from previous page)

```
            <axes>2</axes>
            <axis_index_order>Last Index Fastest</axis_index_order>
            <Element_Array>
                <data_type>IEEE754LSBSingle</data_type>
            </Element_Array>
            <Axis_Array>
                <axis_name>Spatial</axis_name>
                <elements>100</elements>
                <sequence_number>1</sequence_number>
            </Axis_Array>
            <Axis_Array>
                <axis_name>Frequency</axis_name>
                <elements>200</elements>
                <sequence_number>2</sequence_number>
            </Axis_Array>
        </Array_2D_Map>

    </File_Area_Observational>
</Product_Observational>
```

CHAPTER

THIRTEEN

TABULATED-FLAT SPECTRA, EXTERNAL SPECTRAL LOOKUP, UNKNOWN BIN WIDTHS

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-model href="https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1L00.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>
<?xml-model href="https://pds.nasa.gov/pds4/sp/v1/PDS4_SP_1L00_1320.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>

<!--
    This "label" is intended only to demonstrate how to use certain features of the␣
↪Spectral
    Dictionary, and pretty much nothing else. It is not a real label in any sense, even␣
↪though
    it should produce no errors when validated against the PDS schema. A real label␣
↪would have
    references to additional dictionaries, for example, from the mission, for geometry,␣
↪and/or
    for any other related discipline or local namespaces. Any "data" you see here is␣
↪fictitious,
    and provided merely to remove any validation errors that might otherwise occur.

    Note, in particular, that any conscientious reviewer would consider the data␣
↪structure classes
    to be inadequate without appropriate descriptions, extrema, null data indicates, and␣
↪similar
    essential metadata.

    This label demonstrates:
       - Using <sp:Spectral_Characteristics> for a spectral table in the "Tabulated-Flat
↪" fornat;
       - Using the <sp:Rectangular_FOV> to describe the aperture; and
       - Using the <sp:Spectral_Lookup> class to identify bin centers in a separate PDS␣
↪product
         reference by LIDVID; and
       - Indicating an "unknown" bin width.
-->

<Product_Observational xmlns="http://pds.nasa.gov/pds4/pds/v1"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:sp="http://pds.nasa.gov/pds4/sp/v1"
```

(continues on next page)

(continued from previous page)

```
    xsi:schemaLocation="http://pds.nasa.gov/pds4/pds/v1 https://pds.nasa.gov/pds4/pds/v1/
↪PDS4_PDS_1L00.xsd
                        http://pds.nasa.gov/pds4/sp/v1  https://pds.nasa.gov/pds4/sp/v1/
↪PDS4_SP_1L00_1320.xsd">
    <Identification_Area>
        <logical_identifier>urn:nasa:pds:bundle:collection:product</logical_identifier>
        <version_id>1.0</version_id>
        <title>Test Label 1 for Spectral Dictionary - Valid Label</title>
        <information_model_version>1.21.0.0</information_model_version>
        <product_class>Product_Observational</product_class>
    </Identification_Area>

    <Observation_Area>
        <Time_Coordinates>
            <start_date_time xsi:nil="true" nilReason="inapplicable"/>
            <stop_date_time xsi:nil="true" nilReason="inapplicable"/>
        </Time_Coordinates>

        <Investigation_Area>
            <name>None</name>
            <type>Individual Investigation</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:investigation:individual.none</lid_
↪reference>
                <reference_type>data_to_investigation</reference_type>
            </Internal_Reference>
        </Investigation_Area>
        <Observing_System>
            <Observing_System_Component>
                <name>None</name>
                <type>Telescope</type>
            </Observing_System_Component>
        </Observing_System>
        <Target_Identification>
            <name>None</name>
            <type>Comet</type>
        </Target_Identification>

        <Discipline_Area>

            <!-- Unknown bin widths in a Spectral_Lookup referencing an external product-
↪->

            <sp:Spectral_Characteristics>
                <Local_Internal_Reference>
                    <local_identifier_reference>TabFlat</local_identifier_reference>
                    <local_reference_type>spectral_characteristics_to_table_object</
↪local_reference_type>
                </Local_Internal_Reference>
                <sp:spectrum_format>Tabulated-Flat</sp:spectrum_format>
                <sp:value_field_number_list>(2,3,4,5)</sp:value_field_number_list>
                <sp:spectral_bin_type>frequency</sp:spectral_bin_type>
```

(continues on next page)

(continued from previous page)

```
                <sp:Field_of_View>
                    <sp:description>Simple square field of view</sp:description>
                    <sp:Rectangular_FOV>
                        <sp:width_angle unit="arcsec">5</sp:width_angle>
                        <sp:length_angle unit="arcsec">5</sp:length_angle>
                    </sp:Rectangular_FOV>
                </sp:Field_of_View>
                <sp:Bin_Description>
                    <sp:bin_profile_description>
                        Bin centers were determined during initial calibration and␣
↪reported
                        in the referenced document.

                        Bin widths are as yet unknown, but are expected to be provided␣
↪as part
                        final calibration.
                    </sp:bin_profile_description>
                    <sp:Spectral_Lookup>
                        <sp:Bin_Center_Lookup>
                            <Internal_Reference>
                                <lidvid_reference>
↪urn:nasa:pds:bundle:collection:bincenters::1.0</lidvid_reference>
                                <reference_type>spectral_characteristics_to_bin_center_
↪values</reference_type>
                            </Internal_Reference>
                        </sp:Bin_Center_Lookup>
                        <sp:Bin_Width_Constant>
                            <sp:bin_width_frequency unit="Hz" xsi:nil="true" nilReason=
↪"unknown"/>
                        </sp:Bin_Width_Constant>
                    </sp:Spectral_Lookup>
                </sp:Bin_Description>
            </sp:Spectral_Characteristics>

        </Discipline_Area>
    </Observation_Area>

    <File_Area_Observational>
        <File>
            <file_name>No.Data</file_name>
        </File>

        <!-- Tabulated-Flat Spectra -->

        <Table_Character>
            <name>Flat Spectra Table</name>
            <local_identifier>TabFlat</local_identifier>
            <offset unit="byte">0</offset>
            <records>1000</records>
            <description>
                In this format, each row of the table contains a single spectrum, and␣
↪the fields (columns) are defined without
```

(continues on next page)

(continued from previous page)

```
                the use of "Group_Field" classes.  This spectrum has only 4 points, and␣
↪the bin parameters will be specified
                as part of the Spectral Characteristics.
            </description>
            <record_delimiter>Carriage-Return Line-Feed</record_delimiter>
            <Record_Character>
                <fields>5</fields>
                <groups>0</groups>
                <record_length unit="byte">82</record_length>

                <Field_Character>
                    <name>Target Name</name>
                    <field_number>1</field_number>
                    <field_location unit="byte">1</field_location>
                    <data_type>ASCII_String</data_type>
                    <field_length unit="byte">19</field_length>
                    <field_format>%-19s</field_format>
                </Field_Character>

                <Field_Character>
                    <name>Point 1 Value</name>
                    <field_number>2</field_number>
                    <field_location unit="byte">20</field_location>
                    <data_type>ASCII_Integer</data_type>
                    <field_length unit="byte">4</field_length>
                    <field_format>%4d</field_format>
                    <unit>DN</unit>
                </Field_Character>

                <Field_Character>
                    <name>Point 2 Value</name>
                    <field_number>3</field_number>
                    <field_location unit="byte">35</field_location>
                    <data_type>ASCII_Integer</data_type>
                    <field_length unit="byte">4</field_length>
                    <field_format>%4d</field_format>
                    <unit>DN</unit>
                </Field_Character>

                <Field_Character>
                    <name>Point 3 Value</name>
                    <field_number>4</field_number>
                    <field_location unit="byte">50</field_location>
                    <data_type>ASCII_Integer</data_type>
                    <field_length unit="byte">4</field_length>
                    <field_format>%4d</field_format>
                    <unit>DN</unit>
                </Field_Character>

                <Field_Character>
                    <name>Point 4 Value</name>
                    <field_number>5</field_number>
```

(continues on next page)

(continued from previous page)

```
                    <field_location unit="byte">65</field_location>
                    <data_type>ASCII_Integer</data_type>
                    <field_length unit="byte">4</field_length>
                    <field_format>%4d</field_format>
                    <unit>DN</unit>
                </Field_Character>
            </Record_Character>
        </Table_Character>

    </File_Area_Observational>
</Product_Observational>
```

CHAPTER

FOURTEEN

TABULATED-FLAT SPECTRUM, FIELD NUMBER LIST

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-model href="https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1L00.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>
<?xml-model href="https://pds.nasa.gov/pds4/sp/v1/PDS4_SP_1L00_1320.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>

<!--
    This "label" is intended only to demonstrate how to use certain features of the␣
↪Spectral
    Dictionary, and pretty much nothing else. It is not a real label in any sense, even␣
↪though
    it should produce no errors when validated against the PDS schema. A real label␣
↪would have
    references to additional dictionaries, for example, from the mission, for geometry,␣
↪and/or
    for any other related discipline or local namespaces. Any "data" you see here is␣
↪fictitious,
    and provided merely to remove any validation errors that might otherwise occur.

    Note, in particular, that any conscientious reviewer would consider the data␣
↪structure classes
    to be inadequate without appropriate descriptions, extrema, null data indicates, and␣
↪similar
    essential metadata.

    This label demonstrates:
       - Using <sp:Spectral_Characteristics> for a spectral table in the "Tabulated-Flat
↪" fornat;
       - Using the <sp:Circular_FOV> to describe the aperture; and
       - Using the <sp:Spectral_Lookup> class to identify bin centers as fields in the␣
↪table.

-->

<Product_Observational xmlns="http://pds.nasa.gov/pds4/pds/v1"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:sp="http://pds.nasa.gov/pds4/sp/v1"
    xsi:schemaLocation="http://pds.nasa.gov/pds4/pds/v1 https://pds.nasa.gov/pds4/pds/v1/
↪PDS4_PDS_1L00.xsd
                        http://pds.nasa.gov/pds4/sp/v1  https://pds.nasa.gov/pds4/sp/v1/
```

(continues on next page)

(continued from previous page)

```
↪PDS4_SP_1L00_1320.xsd">
   <Identification_Area>
      <logical_identifier>urn:nasa:pds:bundle:collection:product</logical_identifier>
      <version_id>1.0</version_id>
      <title>Test Label for Spectral Dictionary, Tabulated Spectra - Valid Label</
↪title>
      <information_model_version>1.21.0.0</information_model_version>
      <product_class>Product_Observational</product_class>

      <Citation_Information>
         <author_list>Raugh, Anne C.</author_list>
         <publication_year>2019</publication_year>
         <description>
            TEST LABEL

            This label is used to test the classes and constraints defined in the␣
↪Spectral Discipline
            Dictionary related to tabulated spectra - data tables in which each row␣
↪represents a single,
            complete spectral observation.

            While this label may be schematically valid with respect to the PDS core␣
↪namespace and does
            provide a rudimentary demonstration of spectral labelling techniques, it␣
↪should not be taken
            as a "good example" of a product label or of how to use the classes␣
↪within the Spectral
            Discipline Dictionary.  It does not represent any "real" data product.
         </description>
      </Citation_Information>
   </Identification_Area>

   <Observation_Area>
      <Time_Coordinates>
         <start_date_time xsi:nil="true" nilReason="inapplicable"/>
         <stop_date_time xsi:nil="true" nilReason="inapplicable"/>
      </Time_Coordinates>

      <Investigation_Area>
         <name>None</name>
         <type>Individual Investigation</type>
         <Internal_Reference>
            <lid_reference>urn:nasa:pds:context:investigation:individual.none</lid_
↪reference>
            <reference_type>data_to_investigation</reference_type>
         </Internal_Reference>
      </Investigation_Area>
      <Observing_System>
         <Observing_System_Component>
            <name>None</name>
            <type>Telescope</type>
         </Observing_System_Component>
```

(continues on next page)

(continued from previous page)

```
        </Observing_System>
        <Target_Identification>
            <name>None</name>
            <type>Comet</type>
        </Target_Identification>

        <Discipline_Area>

            <!-- Tabulated-Flat Spectra -->

            <sp:Spectral_Characteristics>
                <Local_Internal_Reference>
                    <local_identifier_reference>TabFlat</local_identifier_reference>
                    <local_reference_type>spectral_characteristics_to_table_object</
↪local_reference_type>
                </Local_Internal_Reference>
                <sp:spectrum_format>Tabulated-Flat</sp:spectrum_format>
                <sp:value_field_number_list>(2, 5, 8, 11)</sp:value_field_number_list>
                <sp:spectral_bin_type>wavelength</sp:spectral_bin_type>
                <sp:Field_of_View>
                    <sp:description>
                        This description must contain a human-readable description of␣
↪the slit/aperture.
                        It should tell a user what they need to understand fundamentally␣
↪before using
                        the spectral data.  It may be as simple as "Circular aperture"␣
↪if that is all
                        there is to say.
                    </sp:description>
                    <sp:Circular_FOV>
                        <sp:diameter_angle unit="arcsec">5.0</sp:diameter_angle>
                    </sp:Circular_FOV>
                </sp:Field_of_View>
                <sp:Bin_Description>
                    <sp:bin_profile_description>
                        This text should describe HOW bin profiles were determined/
↪defined.
                    </sp:bin_profile_description>

                    <!--
                        Because the bin data are in fields in the table rather than␣
↪being defined
                        within this class, it's a "lookup" operation.
                    -->

                    <sp:Spectral_Lookup>
                        <sp:Bin_Center_Lookup>
                            <sp:bin_center_field_number_list>(3, 6, 9, 12)</sp:bin_
↪center_field_number_list>
                        </sp:Bin_Center_Lookup>
                        <sp:Bin_Width_Lookup>
                            <sp:bin_width_field_number_list>(4, 7, 10, 13)</sp:bin_width_
```

(continues on next page)

(continued from previous page)

```
↪field_number_list>
                        </sp:Bin_Width_Lookup>
                    </sp:Spectral_Lookup>
                </sp:Bin_Description>
            </sp:Spectral_Characteristics>

        </Discipline_Area>
    </Observation_Area>

    <File_Area_Observational>
        <File>
            <file_name>No.Data</file_name>
        </File>

        <!-- Tabulated-Flat Spectra -->

        <Table_Character>
            <name>Flat Spectra Table</name>
            <local_identifier>TabFlat</local_identifier>
            <offset unit="byte">0</offset>
            <records>1000</records>
            <description>
                In this format, each row of the table contains a single spectrum, and␣
↪the fields (columns) are defined without
                the use of "Group_Field" classes.  This spectrum has only 4 points.
            </description>
            <record_delimiter>Carriage-Return Line-Feed</record_delimiter>
            <Record_Character>
                <fields>13</fields>
                <groups>0</groups>
                <record_length unit="byte">82</record_length>

                <Field_Character>
                    <name>Target Name</name>
                    <field_number>1</field_number>
                    <field_location unit="byte">1</field_location>
                    <data_type>ASCII_String</data_type>
                    <field_length unit="byte">19</field_length>
                    <field_format>%-19s</field_format>
                </Field_Character>

                <Field_Character>
                    <name>Point 1 Value</name>
                    <field_number>2</field_number>
                    <field_location unit="byte">20</field_location>
                    <data_type>ASCII_Integer</data_type>
                    <field_length unit="byte">4</field_length>
                    <field_format>%4d</field_format>
                    <unit>DN</unit>
                </Field_Character>

                <Field_Character>
```

(continues on next page)

(continued from previous page)

```
                <name>Point 1 Center Wavelength</name>
                <field_number>3</field_number>
                <field_location unit="byte">25</field_location>
                <data_type>ASCII_Integer</data_type>
                <field_length unit="byte">4</field_length>
                <field_format>%4d</field_format>
                <unit>angstrom</unit>
            </Field_Character>

            <Field_Character>
                <name>Point 1 FWHM</name>
                <field_number>4</field_number>
                <field_location unit="byte">30</field_location>
                <data_type>ASCII_Integer</data_type>
                <field_length unit="byte">4</field_length>
                <field_format>%4d</field_format>
                <unit>angstrom</unit>
            </Field_Character>

            <Field_Character>
                <name>Point 2 Value</name>
                <field_number>5</field_number>
                <field_location unit="byte">35</field_location>
                <data_type>ASCII_Integer</data_type>
                <field_length unit="byte">4</field_length>
                <field_format>%4d</field_format>
                <unit>DN</unit>
            </Field_Character>

            <Field_Character>
                <name>Point 2 Center Wavelength</name>
                <field_number>6</field_number>
                <field_location unit="byte">40</field_location>
                <data_type>ASCII_Integer</data_type>
                <field_length unit="byte">4</field_length>
                <field_format>%4d</field_format>
                <unit>angstrom</unit>
            </Field_Character>

            <Field_Character>
                <name>Point 2 FWHM</name>
                <field_number>7</field_number>
                <field_location unit="byte">45</field_location>
                <data_type>ASCII_Integer</data_type>
                <field_length unit="byte">4</field_length>
                <field_format>%4d</field_format>
                <unit>angstrom</unit>
            </Field_Character>

            <Field_Character>
                <name>Point 3 Value</name>
                <field_number>8</field_number>
```

(continues on next page)

(continued from previous page)

```
                <field_location unit="byte">50</field_location>
                <data_type>ASCII_Integer</data_type>
                <field_length unit="byte">4</field_length>
                <field_format>%4d</field_format>
                <unit>DN</unit>
            </Field_Character>

            <Field_Character>
                <name>Point 3 Center Wavelength</name>
                <field_number>9</field_number>
                <field_location unit="byte">55</field_location>
                <data_type>ASCII_Integer</data_type>
                <field_length unit="byte">4</field_length>
                <field_format>%4d</field_format>
                <unit>angstrom</unit>
            </Field_Character>

            <Field_Character>
                <name>Point 3 FWHM</name>
                <field_number>10</field_number>
                <field_location unit="byte">60</field_location>
                <data_type>ASCII_Integer</data_type>
                <field_length unit="byte">4</field_length>
                <field_format>%4d</field_format>
                <unit>angstrom</unit>
            </Field_Character>

            <Field_Character>
                <name>Point 4 Value</name>
                <field_number>11</field_number>
                <field_location unit="byte">65</field_location>
                <data_type>ASCII_Integer</data_type>
                <field_length unit="byte">4</field_length>
                <field_format>%4d</field_format>
                <unit>DN</unit>
            </Field_Character>

            <Field_Character>
                <name>Point 4 Center Wavelength</name>
                <field_number>12</field_number>
                <field_location unit="byte">70</field_location>
                <data_type>ASCII_Integer</data_type>
                <field_length unit="byte">4</field_length>
                <field_format>%4d</field_format>
                <unit>angstrom</unit>
            </Field_Character>

            <Field_Character>
                <name>Point 4 FWHM</name>
                <field_number>13</field_number>
                <field_location unit="byte">75</field_location>
                <data_type>ASCII_Integer</data_type>
```

(continues on next page)

(continued from previous page)

```
                    <field_length unit="byte">4</field_length>
                    <field_format>%4d</field_format>
                    <unit>angstrom</unit>
                </Field_Character>
            </Record_Character>
        </Table_Character>

    </File_Area_Observational>
</Product_Observational>
```

CHAPTER

FIFTEEN

TABULATED-PARAMETER GROUPS SPECTRUM, INTERNAL SPECTRAL LOOKUP

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-model href="https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1L00.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>
<?xml-model href="https://pds.nasa.gov/pds4/sp/v1/PDS4_SP_1L00_1320.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>

<!--
    This "label" is intended only to demonstrate how to use certain features of the␣
↪Spectral
    Dictionary, and pretty much nothing else. It is not a real label in any sense, even␣
↪though
    it should produce no errors when validated against the PDS schema. A real label␣
↪would have
    references to additional dictionaries, for example, from the mission, for geometry,␣
↪and/or
    for any other related discipline or local namespaces. Any "data" you see here is␣
↪fictitious,
    and provided merely to remove any validation errors that might otherwise occur.

    Note, in particular, that any conscientious reviewer would consider the data␣
↪structure classes
    to be inadequate without appropriate descriptions, extrema, null data indicates, and␣
↪similar
    essential metadata.

    This label demonstrates:
       - Using <sp:Spectral_Characteristics> for a spectral table in the
         "Tabulated-Paramater Groups" fornat;
       - Using the <sp:Rectangular_FOV> to describe the aperture; and
       - Using the <sp:Spectral_Lookup> class to identify bin centers and widths as␣
↪fields
         within their respective Group_Field class.

-->

<Product_Observational xmlns="http://pds.nasa.gov/pds4/pds/v1"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:sp="http://pds.nasa.gov/pds4/sp/v1"
```

(continues on next page)

(continued from previous page)

```
    xsi:schemaLocation="http://pds.nasa.gov/pds4/pds/v1 https://pds.nasa.gov/pds4/pds/v1/
↪PDS4_PDS_1L00.xsd
                        http://pds.nasa.gov/pds4/sp/v1  https://pds.nasa.gov/pds4/sp/v1/
↪PDS4_SP_1L00_1320.xsd">
    <Identification_Area>
        <logical_identifier>urn:nasa:pds:bundle:collection:product</logical_identifier>
        <version_id>1.0</version_id>
        <title>Test Label for Spectral Dictionary, Tabulated Spectra - Valid Label</
↪title>
        <information_model_version>1.21.0.0</information_model_version>
        <product_class>Product_Observational</product_class>
    </Identification_Area>

    <Observation_Area>
        <Time_Coordinates>
            <start_date_time xsi:nil="true" nilReason="inapplicable"/>
            <stop_date_time xsi:nil="true" nilReason="inapplicable"/>
        </Time_Coordinates>

        <Investigation_Area>
            <name>None</name>
            <type>Individual Investigation</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:investigation:individual.none</lid_
↪reference>
                <reference_type>data_to_investigation</reference_type>
            </Internal_Reference>
        </Investigation_Area>
        <Observing_System>
            <Observing_System_Component>
                <name>None</name>
                <type>Telescope</type>
            </Observing_System_Component>
        </Observing_System>
        <Target_Identification>
            <name>None</name>
            <type>Comet</type>
        </Target_Identification>

        <Discipline_Area>

            <!-- Tabulated-Parameter Groups -->

            <sp:Spectral_Characteristics>
                <Local_Internal_Reference>
                    <local_identifier_reference>TabParamGroups</local_identifier_
↪reference>
                    <local_reference_type>spectral_characteristics_to_table_object</
↪local_reference_type>
                </Local_Internal_Reference>
                <sp:spectrum_format>Tabulated-Parameter Groups</sp:spectrum_format>
                <sp:value_field_name>Counts</sp:value_field_name>
```

(continues on next page)

(continued from previous page)

```
                <sp:spectral_bin_type>frequency</sp:spectral_bin_type>
                <sp:Field_of_View>
                    <sp:description>
                        This is what a rectangular field of view looks like.  Note that␣
↪it is still
                        defined in terms of angular measurements on the sky.  You can␣
↪specify the
                        orientation of the aperture with respect to either the pole of␣
↪the body
                        observerd or celestial north. This is not required, but if the␣
↪orientation
                        is known, it should be provided for completeness.
                    </sp:description>
                    <sp:Rectangular_FOV>
                        <sp:width_angle unit="arcmin">3.5</sp:width_angle>
                        <sp:length_angle unit="arcmin">5.0</sp:length_angle>
                        <sp:celestial_north_position_angle unit="deg">72</sp:celestial_
↪north_position_angle>
                    </sp:Rectangular_FOV>
                </sp:Field_of_View>
                <sp:Bin_Description>
                    <sp:bin_profile_description>
                        This is where you describe HOW the bin profiles were determined/
↪defined.
                    </sp:bin_profile_description>
                    <sp:Spectral_Lookup>
                        <!--
                            NOTE in particular that the value for bin_center/width_field_
↪name is the
                                 value of the <name> field in the <Field_Binary> class,␣
↪NOT the <name>
                                 in the <Group_Field_Binary> class (if any).
                        -->
                        <sp:Bin_Center_Lookup>
                            <sp:bin_center_field_name>Bin Center</sp:bin_center_field_
↪name>
                        </sp:Bin_Center_Lookup>
                        <sp:Bin_Width_Lookup>
                            <sp:bin_width_field_name>Bin Width</sp:bin_width_field_name>
                        </sp:Bin_Width_Lookup>
                    </sp:Spectral_Lookup>
                </sp:Bin_Description>
            </sp:Spectral_Characteristics>

        </Discipline_Area>
    </Observation_Area>

    <File_Area_Observational>
        <File>
            <file_name>No.Data</file_name>
        </File>
```

(continues on next page)

(continued from previous page)

```
        <!-- Tabulated-Parameter Groups -->

        <Table_Binary>
            <name>Grouped Parameters Spectra Table</name>
            <local_identifier>TabParamGroups</local_identifier>
            <offset unit="byte">0</offset>
            <records>132</records>
            <description>
                This table contains one spectrum per row, but the values for intensity,␣
↪error, bin center, and bin width occur
                in contiguous groups within the row.  So each row first lists all the␣
↪observed counts, then all the errors, etc.

                In this case each group MUST contain only a single parameter, but there␣
↪may be additional groups (unrelated to
                spectral parameters) within the record.
            </description>

            <Record_Binary>
                <fields>2</fields>
                <groups>4</groups>
                <record_length unit="byte">1500</record_length>

                <Field_Binary>
                    <name>Target</name>
                    <field_location unit="byte">1</field_location>
                    <data_type>ASCII_String</data_type>
                    <field_length unit="byte">30</field_length>
                </Field_Binary>

                <Field_Binary>
                    <name>Date Observed</name>
                    <field_location unit="byte">31</field_location>
                    <data_type>ASCII_Date_YMD</data_type>
                    <field_length unit="byte">10</field_length>
                </Field_Binary>

                <Group_Field_Binary>
                    <name>Spectrum</name>
                    <repetitions>50</repetitions>
                    <fields>1</fields>
                    <groups>0</groups>
                    <description>
                        This array contains the observed values at each point in the␣
↪spectrum.
                    </description>
                    <group_location unit="byte">41</group_location>
                    <group_length unit="byte">100</group_length>
                    <Field_Binary>
                        <name>Counts</name>
                        <field_location unit="byte">1</field_location>
                        <data_type>UnsignedMSB2</data_type>
```

(continues on next page)

(continued from previous page)

```
                    <field_length unit="byte">2</field_length>
                    <unit>DN</unit>
                </Field_Binary>
            </Group_Field_Binary>

            <Group_Field_Binary>
                <name>Error</name>
                <repetitions>50</repetitions>
                <fields>1</fields>
                <groups>0</groups>
                <group_location unit="byte">141</group_location>
                <group_length unit="byte">100</group_length>
                <Field_Binary>
                    <name>OneSigma</name>
                    <field_location unit="byte">1</field_location>
                    <data_type>UnsignedMSB2</data_type>
                    <field_length unit="byte">2</field_length>
                    <unit>DN</unit>
                </Field_Binary>
            </Group_Field_Binary>

            <Group_Field_Binary>
                <name>Center Frequency</name> <!-- This is NOT the name to use in
↪<sp:bin_center_field_name>. -->
                <repetitions>50</repetitions>
                <fields>1</fields>
                <groups>0</groups>
                <group_location unit="byte">241</group_location>
                <group_length unit="byte">200</group_length>
                <Field_Binary>
                    <name>Bin Center</name> <!-- THIS is the name to use in <sp:bin_
↪center_field_name>. It must be present. -->
                    <field_location unit="byte">1</field_location>
                    <data_type>IEEE754MSBSingle</data_type>
                    <field_length unit="byte">4</field_length>
                    <unit>Hz</unit>
                </Field_Binary>
            </Group_Field_Binary>

            <Group_Field_Binary>
                <name>FWHM</name> <!-- This is NOT the name to use in <sp:bin_width_
↪field_name>. -->
                <repetitions>50</repetitions>
                <fields>1</fields>
                <groups>0</groups>
                <group_location unit="byte">441</group_location>
                <group_length unit="byte">200</group_length>
                <Field_Binary>
                    <name>Bin Width</name> <!-- THIS is the name to use in <sp:bin_
↪width_field_name>. It must be present. -->
                    <field_location unit="byte">1</field_location>
                    <data_type>IEEE754MSBSingle</data_type>
```

(continues on next page)

(continued from previous page)

```
                        <field_length unit="byte">4</field_length>
                        <unit>Hz</unit>
                    </Field_Binary>
                </Group_Field_Binary>
            </Record_Binary>
        </Table_Binary>

    </File_Area_Observational>
</Product_Observational>
```

CHAPTER

SIXTEEN

TABULATED-POINT GROUP SPECTRUM, LOCAL SPECTRAL LOOKUP

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-model href="https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1L00.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>
<?xml-model href="https://pds.nasa.gov/pds4/sp/v1/PDS4_SP_1L00_1320.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>

<!--
    This "label" is intended only to demonstrate how to use certain features of the␣
↪Spectral
    Dictionary, and pretty much nothing else. It is not a real label in any sense, even␣
↪though
    it should produce no errors when validated against the PDS schema. A real label␣
↪would have
    references to additional dictionaries, for example, from the mission, for geometry,␣
↪and/or
    for any other related discipline or local namespaces. Any "data" you see here is␣
↪fictitious,
    and provided merely to remove any validation errors that might otherwise occur.

    Note, in particular, that any conscientious reviewer would consider the data␣
↪structure classes
    to be inadequate without appropriate descriptions, extrema, null data indicates, and␣
↪similar
    essential metadata.

    This label demonstrates:
       - Using <sp:Spectral_Characteristics> for a spectral table in the "Tabulated-
↪Point Group" fornat;
       - Using the <sp:Complex_FOV> to describe the aperture; and
       - Using the <sp:Spectral_Lookup> class to identify bin centers and widths as␣
↪fields within the
         repeating sequence of values for each spectral measurement (i.e., each "point"␣
↪or "bin")

-->

<Product_Observational xmlns="http://pds.nasa.gov/pds4/pds/v1"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
```

(continues on next page)

(continued from previous page)

```
    xmlns:sp="http://pds.nasa.gov/pds4/sp/v1"
    xsi:schemaLocation="http://pds.nasa.gov/pds4/pds/v1 https://pds.nasa.gov/pds4/pds/v1/
↪PDS4_PDS_1L00.xsd
                        http://pds.nasa.gov/pds4/sp/v1  https://pds.nasa.gov/pds4/sp/v1/
↪PDS4_SP_1L00_1320.xsd">
    <Identification_Area>
        <logical_identifier>urn:nasa:pds:bundle:collection:product</logical_identifier>
        <version_id>1.0</version_id>
        <title>Test Label for Spectral Dictionary, Tabulated Spectra - Valid Label</
↪title>
        <information_model_version>1.21.0.0</information_model_version>
        <product_class>Product_Observational</product_class>
    </Identification_Area>

    <Observation_Area>
        <Time_Coordinates>
            <start_date_time xsi:nil="true" nilReason="inapplicable"/>
            <stop_date_time xsi:nil="true" nilReason="inapplicable"/>
        </Time_Coordinates>

        <Investigation_Area>
            <name>None</name>
            <type>Individual Investigation</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:investigation:individual.none</lid_
↪reference>
                <reference_type>data_to_investigation</reference_type>
            </Internal_Reference>
        </Investigation_Area>
        <Observing_System>
            <Observing_System_Component>
                <name>None</name>
                <type>Telescope</type>
            </Observing_System_Component>
        </Observing_System>
        <Target_Identification>
            <name>None</name>
            <type>Comet</type>
        </Target_Identification>

        <Discipline_Area>

            <!-- Tabulated-Point Groups -->

            <sp:Spectral_Characteristics>
                <Local_Internal_Reference>
                    <local_identifier_reference>TabPointGroups</local_identifier_
↪reference>
                    <local_reference_type>spectral_characteristics_to_table_object</
↪local_reference_type>
                </Local_Internal_Reference>
                <sp:spectrum_format>Tabulated-Point Group</sp:spectrum_format>
```

(continues on next page)

(continued from previous page)

```
                <sp:value_field_name>Counts</sp:value_field_name>
                <sp:spectral_bin_type>wavelength</sp:spectral_bin_type>
                <sp:Field_of_View>
                    <sp:description>
                        If the FOV is complex (if the aperture has varying width, for␣
↪example), then
                        a description of the overall shape of the aperture needs to be␣
↪supplied in
                        this field, but you will need to supply a detailed description␣
↪as part of the
                        documentation for the data.  You can and should specify any␣
↪dimensions that are
                        relevant, whether they are "real" or "effective", but detailed␣
↪documentation
                        should be formally referenced elsewhere in the archive so users␣
↪can get to it
                        easily.
                    </sp:description>
                    <sp:Complex_FOV>
                        <sp:width_angle unit="arcsec">5.43</sp:width_angle>
                        <sp:length_angle unit="arcsec">1.23</sp:length_angle>
                        <sp:body_positive_pole_position_angle unit="deg">90</sp:body_
↪positive_pole_position_angle>
                    </sp:Complex_FOV>
                    <Internal_Reference>
                        <lid_reference>urn:nasa:pds:bindle:collection:document</lid_
↪reference>
                        <reference_type>spectral_characteristics_to_document</reference_
↪type>
                        <comment>
                            This document provides details of the aperture geometry␣
↪defining the
                            Field of View, with implications for data reduction.
                        </comment>
                    </Internal_Reference>
                </sp:Field_of_View>
                <sp:Bin_Description>
                    <sp:bin_profile_description>
                        HOW the bin parameters were determined/defined/derived
                    </sp:bin_profile_description>
                    <sp:Spectral_Lookup>
                        <sp:Bin_Center_Lookup>
                            <sp:bin_center_field_name>Band Center</sp:bin_center_field_
↪name>
                        </sp:Bin_Center_Lookup>
                        <sp:Bin_Width_Lookup>
                            <sp:bin_width_field_name>Bandpass</sp:bin_width_field_name>
                        </sp:Bin_Width_Lookup>
                    </sp:Spectral_Lookup>
                </sp:Bin_Description>
            </sp:Spectral_Characteristics>
```

(continues on next page)

(continued from previous page)

```
        </Discipline_Area>
    </Observation_Area>

    <File_Area_Observational>
        <File>
            <file_name>No.Data</file_name>
        </File>

        <!-- Tabulated-Point Group -->

        <Table_Delimited>
            <name>Point Groups Spectra Table</name>
            <local_identifier>TabPointGroups</local_identifier>
            <offset unit="byte">300000</offset>
            <parsing_standard_id>PDS DSV 1</parsing_standard_id>
            <description>
                This table contains one spectrum per row, but in this case all the␣
↪parameters associated with each point are
                grouped together, and that group repeats for each point in the spectrum -
↪ so the observed counts, error,
                bin center, and bin width for the first spectral point are listed; then␣
↪the (counts, error, center, width)
                for the second point, and so on.

                In this case all the spectral parameters should be contained in the same␣
↪group, but there may be other parameters
                included in that same group if desired.
            </description>
            <records>100</records>
            <record_delimiter>Carriage-Return Line-Feed</record_delimiter>
            <field_delimiter>Comma</field_delimiter>

            <Record_Delimited>
                <fields>2</fields>
                <groups>1</groups>

                <Field_Delimited>
                    <name>Target</name>
                    <data_type>ASCII_String</data_type>
                </Field_Delimited>

                <Field_Delimited>
                    <name>Date Observed</name>
                    <data_type>ASCII_Date_YMD</data_type>
                </Field_Delimited>

                <!-- This group structure defines the sequence of fields provided for␣
↪each spectral point (i.e., "bin"). -->

                <Group_Field_Delimited>
                    <name>Spectral Point</name>
                    <repetitions>25</repetitions>
```

(continues on next page)

(continued from previous page)

```
                    <fields>3</fields>
                    <groups>0</groups>

                    <Field_Delimited>
                        <name>Counts</name>
                        <data_type>ASCII_Integer</data_type>
                        <unit>DN</unit>
                    </Field_Delimited>

                    <Field_Delimited>
                        <name>Band Center</name>
                        <data_type>ASCII_Real</data_type>
                        <unit>nm</unit>
                    </Field_Delimited>

                    <Field_Delimited>
                        <name>Bandpass</name>
                        <data_type>ASCII_Integer</data_type>
                        <unit>nm</unit>
                    </Field_Delimited>
                </Group_Field_Delimited>
            </Record_Delimited>
        </Table_Delimited>

    </File_Area_Observational>
</Product_Observational>
```

CHAPTER

SEVENTEEN

TABULATED-POINT GROUP SPECTRUM, CONSTANT BIN WIDTH IN SPECTRAL LOOKUP

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-model href="https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1L00.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>
<?xml-model href="https://pds.nasa.gov/pds4/sp/v1/PDS4_SP_1L00_1320.sch" schematypens=
↪"http://purl.oclc.org/dsdl/schematron"?>

<!--
    This "label" is intended only to demonstrate how to use certain features of the␣
↪Spectral
    Dictionary, and pretty much nothing else. It is not a real label in any sense, even␣
↪though
    it should produce no errors when validated against the PDS schema. A real label␣
↪would have
    references to additional dictionaries, for example, from the mission, for geometry,␣
↪and/or
    for any other related discipline or local namespaces. Any "data" you see here is␣
↪fictitious,
    and provided merely to remove any validation errors that might otherwise occur.

    Note, in particular, that any conscientious reviewer would consider the data␣
↪structure classes
    to be inadequate without appropriate descriptions, extrema, null data indicates, and␣
↪similar
    essential metadata.

    This label demonstrates:
       - Using <sp:Spectral_Characteristics> for a spectral table in the "Tabulated-
↪Point Group" fornat;
       - Using the <sp:Complex_FOV> to describe the aperture; and
       - Using the <sp:Spectral_Lookup> class to identify bin centers as a field within␣
↪the
         repeating sequence of values for each spectral measurement (i.e., each "point"␣
↪or "bin"),
         and a constant bin width.

-->

<Product_Observational xmlns="http://pds.nasa.gov/pds4/pds/v1"
```

(continues on next page)

(continued from previous page)

```
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns:sp="http://pds.nasa.gov/pds4/sp/v1"
    xsi:schemaLocation="http://pds.nasa.gov/pds4/pds/v1 https://pds.nasa.gov/pds4/pds/v1/
↪PDS4_PDS_1L00.xsd
                        http://pds.nasa.gov/pds4/sp/v1  https://pds.nasa.gov/pds4/sp/v1/
↪PDS4_SP_1L00_1320.xsd">
    <Identification_Area>
        <logical_identifier>urn:nasa:pds:bundle:collection:product</logical_identifier>
        <version_id>1.0</version_id>
        <title>Test Label for Spectral Dictionary, Tabulated Spectra - Valid Label</
↪title>
        <information_model_version>1.21.0.0</information_model_version>
        <product_class>Product_Observational</product_class>
    </Identification_Area>

    <Observation_Area>
        <Time_Coordinates>
            <start_date_time xsi:nil="true" nilReason="inapplicable"/>
            <stop_date_time xsi:nil="true" nilReason="inapplicable"/>
        </Time_Coordinates>

        <Investigation_Area>
            <name>None</name>
            <type>Individual Investigation</type>
            <Internal_Reference>
                <lid_reference>urn:nasa:pds:context:investigation:individual.none</lid_
↪reference>
                <reference_type>data_to_investigation</reference_type>
            </Internal_Reference>
        </Investigation_Area>
        <Observing_System>
            <Observing_System_Component>
                <name>None</name>
                <type>Telescope</type>
            </Observing_System_Component>
        </Observing_System>
        <Target_Identification>
            <name>None</name>
            <type>Comet</type>
        </Target_Identification>

        <Discipline_Area>

            <!-- Tabulated-Point Groups -->

            <sp:Spectral_Characteristics>
                <Local_Internal_Reference>
                    <local_identifier_reference>TabPointGroups</local_identifier_
↪reference>
                    <local_reference_type>spectral_characteristics_to_table_object</
↪local_reference_type>
                </Local_Internal_Reference>
```

(continues on next page)

(continued from previous page)

```
                <sp:spectrum_format>Tabulated-Point Group</sp:spectrum_format>
                <sp:value_field_name>Counts</sp:value_field_name>
                <sp:spectral_bin_type>wavelength</sp:spectral_bin_type>
                <sp:Field_of_View>
                    <sp:description>
                        If the FOV is complex (if the aperture has varying width, for␣
↪example), then
                        a description of the overall shape of the aperture needs to be␣
↪supplied in
                        this field, but you will need to supply a detailed description␣
↪as part of the
                        documentation for the data.  You can and should specify any␣
↪dimensions that are
                        relevant, whether they are "real" or "effective", but detailed␣
↪documentation
                        should be formally referenced elsewhere in the archive so users␣
↪can get to it
                        easily.
                    </sp:description>
                    <sp:Complex_FOV>
                        <sp:width_angle unit="arcsec">5.43</sp:width_angle>
                        <sp:length_angle unit="arcsec">1.23</sp:length_angle>
                        <sp:body_positive_pole_position_angle unit="deg">90</sp:body_
↪positive_pole_position_angle>
                    </sp:Complex_FOV>
                    <Internal_Reference>
                        <lid_reference>urn:nasa:pds:bindle:collection:document</lid_
↪reference>
                        <reference_type>spectral_characteristics_to_document</reference_
↪type>
                        <comment>
                            This document provides details of the aperture geometry␣
↪defining the
                            Field of View, with implications for data reduction.
                        </comment>
                    </Internal_Reference>
                </sp:Field_of_View>
                <sp:Bin_Description>
                    <sp:bin_profile_description>
                        HOW the bin parameters were determined/defined/derived
                    </sp:bin_profile_description>
                    <sp:Spectral_Lookup>
                        <sp:Bin_Center_Lookup>
                            <sp:bin_center_field_name>Band Center</sp:bin_center_field_
↪name>
                        </sp:Bin_Center_Lookup>
                        <sp:Bin_Width_Constant>
                            <sp:bin_width_wavelength unit="nm">120</sp:bin_width_
↪wavelength>
                        </sp:Bin_Width_Constant>
                    </sp:Spectral_Lookup>
                </sp:Bin_Description>
```

(continues on next page)

(continued from previous page)

```
            </sp:Spectral_Characteristics>

        </Discipline_Area>
    </Observation_Area>

    <File_Area_Observational>
        <File>
            <file_name>No.Data</file_name>
        </File>

        <!-- Tabulated-Point Group -->

        <Table_Delimited>
            <name>Point Groups Spectra Table</name>
            <local_identifier>TabPointGroups</local_identifier>
            <offset unit="byte">300000</offset>
            <parsing_standard_id>PDS DSV 1</parsing_standard_id>
            <description>
                This table contains one spectrum per row, but in this case all the␣
↪parameters associated with each point are
                grouped together, and that group repeats for each point in the spectrum -
↪ so the observed counts, error,
                bin center, and bin width for the first spectral point are listed; then␣
↪the (counts, error, center, width)
                for the second point, and so on.

                In this case all the spectral parameters should be contained in the same␣
↪group, but there may be other parameters
                included in that same group if desired.
            </description>
            <records>100</records>
            <record_delimiter>Carriage-Return Line-Feed</record_delimiter>
            <field_delimiter>Comma</field_delimiter>

            <Record_Delimited>
                <fields>2</fields>
                <groups>1</groups>

                <Field_Delimited>
                    <name>Target</name>
                    <data_type>ASCII_String</data_type>
                </Field_Delimited>

                <Field_Delimited>
                    <name>Date Observed</name>
                    <data_type>ASCII_Date_YMD</data_type>
                </Field_Delimited>

                <!-- This group structure defines the sequence of fields provided for␣
↪each spectral point (i.e., "bin"). -->

                <Group_Field_Delimited>
```

(continues on next page)

(continued from previous page)

```
                    <name>Spectral Point</name>
                    <repetitions>25</repetitions>
                    <fields>2</fields>
                    <groups>0</groups>

                    <Field_Delimited>
                        <name>Counts</name>
                        <data_type>ASCII_Integer</data_type>
                        <unit>DN</unit>
                    </Field_Delimited>

                    <Field_Delimited>
                        <name>Band Center</name>
                        <data_type>ASCII_Real</data_type>
                        <unit>nm</unit>
                    </Field_Delimited>
                </Group_Field_Delimited>
            </Record_Delimited>
        </Table_Delimited>

    </File_Area_Observational>
</Product_Observational>
```