
spec2nexus Documentation

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Converts SPEC data files and scans into NeXus HDF5 files:

```
$ spec2nexus path/to/file/specfile.dat
```

Writes path/to/file/specfile.hdf5

CHAPTER 1

Provides

- **spec2nexus** : command-line tool: Convert **SPEC** data files to **NeXus HDF5**
- **extractSpecScan** : command-line tool: Save columns from **SPEC** data file scan(s) to **TSV** files
- **spec** : library: python binding to read **SPEC** data files
- **eznx** : library: (Easy **NeXus**) supports writing **NeXus HDF5** files using **h5py**
- **specplot** : command-line tool: plot a **SPEC** scan to an image file
- **specplot_gallery** : command-line tool: call **specplot** for all scans in a list of files, makes a web gallery

Package Information

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- **copyright:** 2014-2020, Pete R. Jemian
- **license:** Creative Commons Attribution 4.0 International Public License (see [LICENSE.txt](#) file)
- **URL:** documentation: <http://spec2nexus.readthedocs.io>
- **git:** source: <https://github.com/prjemian/spec2nexus>
- **PyPI:** Distribution: <https://pypi.python.org/pypi/spec2nexus/>
- **OpenHub:** Compare open source software: <https://www.openhub.net/p/spec2nexus>
- **version:** 2021.1.8rc5
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2.1 Contents

2.1.1 spec2nexus

Converts SPEC data files and scans into NeXus HDF5 files.

How to use spec2nexus

Convert all scans in a SPEC data file:

```
$ spec2nexus path/to/file/specfile.dat
```

Writes `path/to/file/specfile.hdf5` (Will not overwrite if the HDF5 exists, use the `-f` option to force overwrite).

show installed version

Verify the version of the installed spec2nexus:

```
$ spec2nexus -v
2014.03.02
```

command-line options

```
1 user@host ~$ spec2nexus.py -h
2 usage: spec2nexus [-h] [-e HDF5_EXTENSION] [-f] [-v] [-s SCAN_LIST] [-t]
3                [--quiet | --verbose]
4                infile [infile ...]
5
6 spec2nexus: Convert SPEC data file into a NeXus HDF5 file.
7
8 positional arguments:
9   infile                SPEC data file name(s)
10
11 optional arguments:
12   -h, --help            show this help message and exit
13   -e HDF5_EXTENSION, --hdf5-extension HDF5_EXTENSION
14                        NeXus HDF5 output file extension, default = .hdf5
15   -f, --force-overwrite
16                        overwrite output file if it exists
17   -v, --version         show program's version number and exit
18   -s SCAN_LIST, --scan SCAN_LIST
19                        specify which scans to save, such as: -s all or -s 1
20                        or -s 1,2,3-5 (no spaces!), default = all
21   --quiet              suppress all program output (except errors), do not
22                        use with --verbose option
23   --verbose            print more program output, do not use with --quiet
24                        option
```

Note: Where's the source code to spec2nexus?

In the source code, the `spec2nexus` program is started from file `nexus.py` (in the `spec2nexus.nexus.main()` method, for those who look at the source code):

```
$ python nexus.py specfile.dat
```

You're not really going to call that from the source directory, are you? It will work, *if* you have put that source directory on your PYTHONPATH.

source code documentation

Converts SPEC data files and scans into NeXus HDF5 files

```
spec2nexus.nexus.get_user_parameters ()
    configure user's command line parameters from sys.argv
```

```
spec2nexus.nexus.main ()
    entry point for command-line interface
```

```
spec2nexus.nexus.parse_scan_list_spec (scan_list_spec)
    parses the argument of the -s option, returns a scan number list
```

```
spec2nexus.nexus.pick_scans (all_scans, opt_scan_list)
    edit opt_scan_list for the scans to be converted
```

To be converted, a scan number must be first specified in `opt_scan_list` and then `all_scans` is checked to make sure that scan exists. The final list is returned.

2.1.2 extractSpecScan

Command line tool to extract scan data from a SPEC data file.

How to use extractSpecScan

Extract one scan from a SPEC data file:

```
user@host ~$ extractSpecScan data/APS_spec_data.dat -s 1 -c mr USAXS_PD I0 seconds
```

the usage message:

```
user@host ~$ extractSpecScan
usage: extractSpecScan [-h] [-v] [--nolabels] -s SCAN [SCAN ...] -c COLUMN
                        [COLUMN ...] [-G] [-P] [-Q] [-V] [--quiet | --verbose]
                        spec_file
```

the version number:

```
user@host ~$ extractSpecScan -v
2017.0201.0
```

the help message:

```
user@host ~$ extractSpecScan -h
usage: extractSpecScan [-h] [-v] [--nolabels] -s SCAN [SCAN ...] -c COLUMN
                        [COLUMN ...] [-G] [-P] [-Q] [-V] [--quiet | --verbose]
                        spec_file
```

Save columns from SPEC data file scan(s) to TSV files URL:
<http://spec2nexus.readthedocs.org/en/latest/extractSpecScan.html> v2016.1025.0

positional arguments:
 spec_file SPEC data file name(s)

optional arguments:
 -h, --help show this help message and exit
 -v, --version print version number and exit
 --nolabels do not write column labels to output file (default:
 write labels)
 -s SCAN [SCAN ...], --scan SCAN [SCAN ...]

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```

        scan number(s) to be extracted (must specify at least
        one)
-c COLUMN [COLUMN ...], --column COLUMN [COLUMN ...]
        column label(s) to be extracted (must specify at least
        one)
-G        report scan Geometry (#G) header information
-P        report scan Positioners (#O & #P) header information
-Q        report scan Q (#Q) header information
-V        report scan (UNICAT-style #H & #V) header information
--quiet   suppress all program output (except errors), do not
          use with --verbose option
--verbose print more program output, do not use with --quiet
          option

```

Example

Extract four columns (mr, USAXS_PD, I0, seconds) from two scans (1, 6) in a SPEC data file:

```

$ extractSpecScan data/APS_spec_data.dat -s 1 6 -c mr USAXS_PD I0 seconds

program: /path/to/extractSpecScan.py
read: data/APS_spec_data.dat
wrote: data/APS_spec_data_1.dat
wrote: data/APS_spec_data_6.dat

```

Here's the contents of *data/APS_spec_data_6.dat*:

```

# mr  USAXS_PD  I0  seconds
15.61017  9.0   243.0  0.3
15.61    13.0   325.0  0.3
15.60984  19.0   460.0  0.3
15.60967  30.0   609.0  0.3
15.6095   54.0   883.0  0.3
15.60934  161.0  1780.0  0.3
15.60917  499.0  3649.0  0.3
15.609    1257.0  6588.0  0.3
15.60884  2832.0  10245.0  0.3
15.60867  7294.0  13118.0  0.3
15.6085   139191.0  16527.0  0.3
15.60834  299989.0  17893.0  0.3
15.60817  299989.0  18276.0  0.3
15.608    299989.0  18240.0  0.3
15.60784  299989.0  18266.0  0.3
15.60767  299989.0  18616.0  0.3
15.6075   299989.0  19033.0  0.3
15.60734  299989.0  19036.0  0.3
15.60717  299988.0  18587.0  0.3
15.607    299989.0  17471.0  0.3
15.60684  123003.0  14814.0  0.3
15.60667  11060.0  11861.0  0.3
15.6065   2217.0  8131.0  0.3
15.60634  637.0  4269.0  0.3
15.60617  254.0  2632.0  0.3
15.606    132.0  1927.0  0.3
15.60584  79.0   1406.0  0.3

```

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```
15.60567 58.0 1075.0 0.3
15.6055 32.0 695.0 0.3
15.60534 17.0 374.0 0.3
15.60517 10.0 245.0 0.3
```

source code documentation

Save columns from SPEC data file scan(s) to TSV files

Note: TSV: tab-separated values

Usage:

```
extractSpecScan.py /tmp/CeCoIn5 -s 5 -c HerixE Ana5 ICO-C
extractSpecScan.py ./testdata/11_03_Vinod.dat -s 2 12 -c USAXS.m2rp Monitor I0
```

Note: sspecified column names **MUST** appear in all chosen scans

Compatible with Python 2.7+

`spec2nexus.extractSpecScan.get_user_parameters()`
configure user's command line parameters from `sys.argv`

`spec2nexus.extractSpecScan.main()`
read the data file, find each scan, find the columns, save the data

Parameters `cmdArgs` (`[str]`) – Namespace from `argparse`, returned from `get_user_parameters()`

Note: Each column label must match *exactly* the name of a label in each chosen SPEC scan number or the program will skip that particular scan

If more than one column matches, the first match will be selected.

example output:

```
# mr      I0      USAXS_PD
1.9475    65024    276
1.9725    64845    352
1.9975    65449    478
```

`spec2nexus.extractSpecScan.makeOutputFileName(specFile, scanNum)`
return an output file name based on `specFile` and `scanNum`

Parameters

- **specFile** (`str`) – name of existing SPEC data file to be read
- **scanNum** (`str`) – number of chosen SPEC scan

append `scanNum` to `specFile` to get output file name (before file extension if present)

Always add a file extension to the output file. If none is present, use “.dat”.

Examples:

specFile	scanNum	outFile
CeCoIn5	scan 5	CeCoIn5_5.dat
CeCoIn5.dat	scan 77	CeCoIn5_77.dat
CeCoIn5.dat	scan 5.1	CeCoIn5_5_1.dat

2.1.3 specplot

Read a SPEC data file and plot a thumbnail image.

This code can be called as a standalone program or it can be imported into another program and called as a subroutine, as shown in the *specplot_gallery* program.

The standard representation of a SPEC scan is a line plot of the last data column *versus* the first data column. Any SPEC macro which name ends with *scan* ⁽¹⁾ will be plotted as a line plot.

A special case SPEC scan macro is the *hklskan* where one of the three reciprocal space axes is scanned while the other two remain constant. A special handler (*SPEC's hklskan macro*) is provided to pick properly the scanned axis (not always the first column) for representation as a line plot.

Some SPEC macros scan two positioners over a grid to collect a 2-D image one pixel at a time. These scans are represented as color-mapped images where the first two columns are the vertical and horizontal axes and the image is color-mapped to intensity. Any SPEC macro which name ends with *mesh* will be plotted as an image plot.

Different handling can be customized for scan macros, as described in *How to write a custom scan handling for specplot*.

How to use specplot

Plot a scan from one of the sample data files supplied with *spec2nexus*:

```
user@host ~$ specplot src/spec2nexus/data/APS_spec_data.dat 2 specplot.png
```

Usage

```
user@host ~$ specplot
usage: specplot.py [-h] specFile scan_number plotFile
```

Help

```
user@host ~$ specplot -h
usage: specplot.py [-h] specFile scan_number plotFile

read a SPEC data file and plot scan n

positional arguments:
  specFile      SPEC data file name
  scan_number   scan number in SPEC file
  plotFile      output plot file name
```

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¹ *scan*: any scan where the last four letters converted to lower case match *scan*, such as *ascan*, *a2scan*, *Escan*, *tscan*, *uascan*, *FlyScan*, *unusual_custom_user_scan*, ...

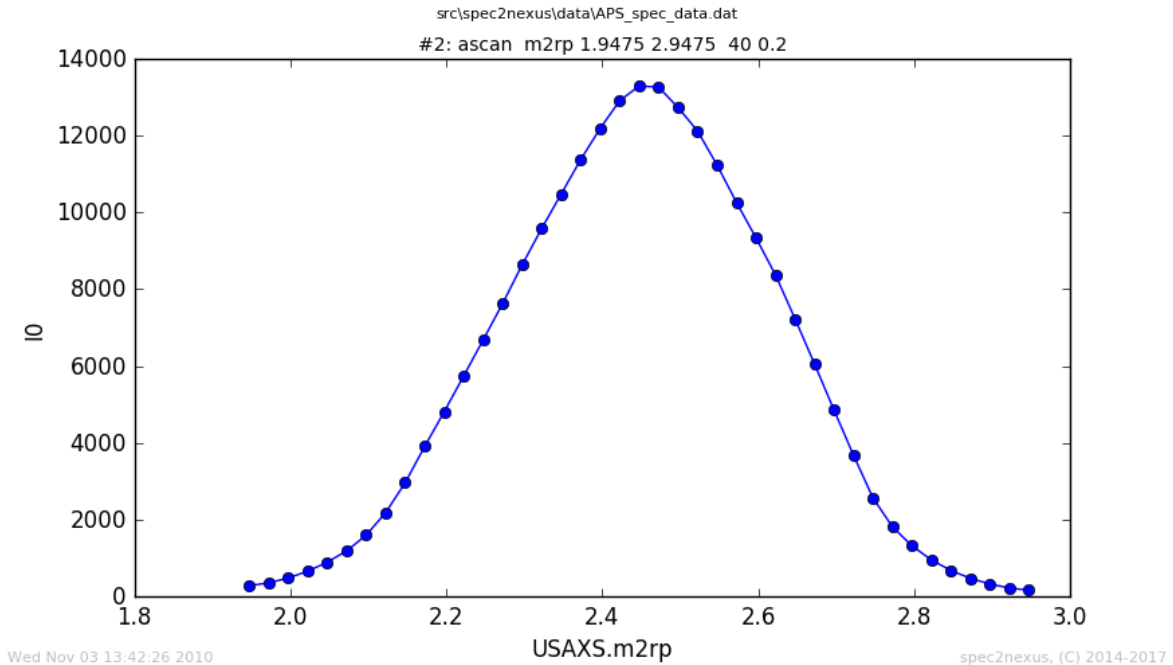


Fig. 1: Plot of scan #2 from example data file *APS_spec_data.dat*.

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```
optional arguments:
  -h, --help  show this help message and exit
```

source code documentation

Plot the data from scan N in a SPEC data file

<i>Selector()</i>	associate SPEC scan macro names with image makers
<i>ImageMaker()</i>	superclass to handle plotting of data from a SPEC scan
<i>LinePlotter()</i>	create a line plot
<i>MeshPlotter()</i>	create a mesh plot (2-D image)
<i>openSpecFile(specFile)</i>	convenience routine so that others do not have to <i>import spec2nexus.spec</i>

Exceptions:

<i>NoDataToPlot</i>	No data found.
<i>NotPlottable</i>	No plottable data for this scan.
<i>ScanAborted</i>	Scan aborted before all points acquired.
<i>UnexpectedObjectTypeError</i>	Incorrect Python object type: programmer error.

class `spec2nexus.specplot.HKLScanPlotter`
create a line plot from hklskan macros

retrieve_plot_data ()
retrieve default data from spec data file

class `spec2nexus.specplot.ImageMaker`

2.1. **Contents** superclass to handle plotting of data from a SPEC scan

EXAMPLE

```

class LinePlotter(ImageMaker):
    '''create a line plot'''

    def make_image(self, plotFile):
        '''
        make Matplotlib chart image from the SPEC scan

        :param obj plotData: object returned from :meth:`retrieve_plot_data`
        :param str plotFile: name of image file to write
        '''
        assert(self.signal in self.data)
        assert(len(self.axes) == 1)
        assert(self.axes[0] in self.data)

        y = self.data[self.signal]
        x = self.data[self.axes[0]]
        xy_plot(x, y, plotFile,
               title = self.plot_title(),
               plot_subtitle = self.plot_subtitle(),
               xtitle = self.x_title(),
               ytitle = self.y_title(),
               xlog = self.x_log(),
               ylog = self.y_log(),
               timestamp_str = self.timestamp())

sfile = specplot.openSpecFile(specFile)
scan = sfile.getScan(scan_number)
plotter = LinePlotter()
plotter.plot_scan(scan, plotFile, y_log=True)

```

data_file_name()

the name of the file with the actual data

Usually, this is the SPEC data file but it *could* be something else

data_is_newer_than_plot(plotFile)

only proceed if mtime of SPEC data file is newer than plotFile

make_image(plotFile)

make Matplotlib chart image from the SPEC scan

The data to be plotted are provided in:

- *self.signal*
- *self.axes*
- *self.data*

Parameters plotFile (*str*) – name of image file to write

plot_options()

re-define any plot options in a subclass

plot_scan(scan, plotFile, maker=None)

make an image plot of the data in the scan

Parameters

- **scan** (*obj*) – instance of *SpecDataFileScan*
- **plotFile** (*str*) – file name for plot output

plot_subtitle()
Return the plot_subtitle.

plot_title()
Return the plot title.

plottable()
can this data be plotted as expected?

retrieve_plot_data()
retrieve default plottable data from spec data file and store locally

This method must retrieve the data to be plotted, either from the SPEC data file scan or from a file which name is provided in the scan details.

These attributes must be set by this method:

Data dictionary containing values of the various collected arrays {label: array}

Signal name of the 'signal' data (default data to be plotted)

Axes names of the axes of signal data

Example data

```
self.data = {
    'angle': [1, 2, 3, 4, 5],
    'counts': [0. 2. 55. 3. 0]}
self.signal = 'counts'
self.axes = ['angle']
```

Raise any of these exceptions as appropriate:

<i>NoDataToPlot</i>	No data found.
<i>NotPlottable</i>	No plottable data for this scan.
<i>ScanAborted</i>	Scan aborted before all points acquired.

set_plot_subtitle (*text*)
Set the plot_subtitle.

set_plot_title (*text*)
Set the plot title.

set_timestamp (*text*)
Set the plot time stamp.

set_x_log (*choice*)
Set the x axis logarithmic if True.

set_x_title (*text*)
Set the x axis title.

set_y_log (*choice*)
Set the y axis logarithmic if True.

set_y_title (*text*)
Set the y axis title.

set_z_log (*choice*)

Set the z axis (image) logarithmic if True.

timestamp ()

Return the time of this scan as a string.

x_log ()

Boolean: should the X axis be plotted on a log scale?

x_title ()

Return the title for the X axis.

y_log ()

Boolean: should the Y axis be plotted on a log scale?

y_title ()

Return the title for the Y axis.

z_log ()

Boolean: should the Z axis (image) be plotted on a log scale?

class spec2nexus.specplot.**LinePlotter**

create a line plot

make_image (*plotFile*)

make Matplotlib chart image from the SPEC scan

Parameters **plotFile** (*str*) – name of image file to write

plot_options ()

define the settings for this, accepting any non-default values first

plottable ()

can this data be plotted as expected?

retrieve_plot_data ()

retrieve default data from spec data file

class spec2nexus.specplot.**MeshPlotter**

create a mesh plot (2-D image)

..rubric:: References:

Mesh 2-D parser http://www.certif.com/spec_help/mesh.html

```
mesh motor1 start1 end1 intervals1 motor2 start2 end2 intervals2 time
```

Hklmesh 2-D parser http://www.certif.com/spec_help/hklmesh.html

```
hklmesh Q1 start1 end1 intervals1 Q2 start2 end2 intervals2 time
```

make_image (*plotFile*)

make Matplotlib chart image from the SPEC scan

Parameters **plotFile** (*str*) – name of image file to write

plot_options ()

define the settings for this, accepting any non-default values first

plottable ()

can this data be plotted as expected?

```

retrieve_plot_data()
    retrieve default data from spec data file

    data parser for 2-D mesh and hklmesh

```

```

exception spec2nexus.specplot.NoDataToPlot
    No data found.

```

```

exception spec2nexus.specplot.NotPlottable
    No plottable data for this scan.

```

```

exception spec2nexus.specplot.ScanAborted
    Scan aborted before all points acquired.

```

```

class spec2nexus.specplot.Selector
    associate SPEC scan macro names with image makers

```

Image maker subclass of *ImageMaker*

To include a custom image maker from outside this module, create the subclass and then add it to an instance of this class. Such as this plotter that defaults to a logarithmic scale for the X axis for all *logxscan* macros:

```

from spec2nexus import specplot

class LogX_Plotter(specplot.ImageMaker):
    def x_log(self): return True

# ...

selector = specplot.Selector() selector.add('logxscan', LogX_Plotter)

# ...

image_maker = specplot.Selector().auto(scan) plotter = image_maker() plotter.plot_scan(scan,
fullPlotFile)

```

This class is a singleton which means you will always get the same instance when you call this class many times in your program.

<i>auto</i> (scan)	automatically choose a scan image maker based on the SPEC scan macro
<i>add</i> (key, value[, default])	register a new value by key
<i>update</i> (key, value[, default])	replace an existing key with a new value
<i>get</i> (key)	return a value by key
<i>exists</i> (key)	is the key known?
<i>default</i> ()	retrieve the value of the default key

```

add (key, value, default=False)
    register a new value by key

```

Parameters **key** (*str*) – name of key, typically the macro name

Raises

- **KeyError** – if key exists
- **UnexpectedObjectTypeError** – if value is not subclass of *ImageMaker*

```

auto (scan)
    automatically choose a scan image maker based on the SPEC scan macro

    Selection Rules:

```

- macro ends with “scan”: use *LinePlotter*
- macro ends with “mesh”: use *MeshPlotter*
- default: use default image maker (initially *LinePlotter*)

default ()

retrieve the value of the default key

exists (*key*)

is the key known?

get (*key*)

return a value by key

Returns subclass of *ImageMaker* or *None* if key not found

update (*key*, *value*, *default=False*)

replace an existing key with a new value

Parameters **key** (*str*) – name of key, typically the macro name

Raises

- **KeyError** – if key does not exist
- **UnexpectedObjectTypeError** – if value is not subclass of *ImageMaker*

exception `spec2nexus.specplot.UnexpectedObjectTypeError`

Incorrect Python object type: programmer error.

`spec2nexus.specplot.openSpecFile` (*specFile*)

convenience routine so that others do not have to *import spec2nexus.spec*

2.1.4 specplot_gallery

Read a list of SPEC data files (or directory(s) containing SPEC data files) and plot images of all scans. *specplot_gallery* will store these images in subdirectories of the given base directory (default: current directory) based on this structure:

```
{base directory}
  /{year}
    /{month}
      /{spec file name}
        /index.html
        s00001.png
        s00002.png
```

The year and month are taken from the SPEC data file when the data were collected. The plot names include the scan numbers padded with leading zeroes to five places (so the file names sort numerically).

The results will be shown as a WWW page (*index.html*) of thumbnail images *and* a separate list of any scans that could not generate plots. A reason will accompany these scans, as shown in the example.

How to use *specplot_gallery*: command line

Here is an example:

```
user@host ~$ specplot_gallery -d ./__demo__ ../src/spec2nexus/data/33bm_spec.dat
```

Note that one of the scans could not be plotted. Looking at the data file, it shows there is *no data to plot* (this particular scan was aborted before any data was collected):

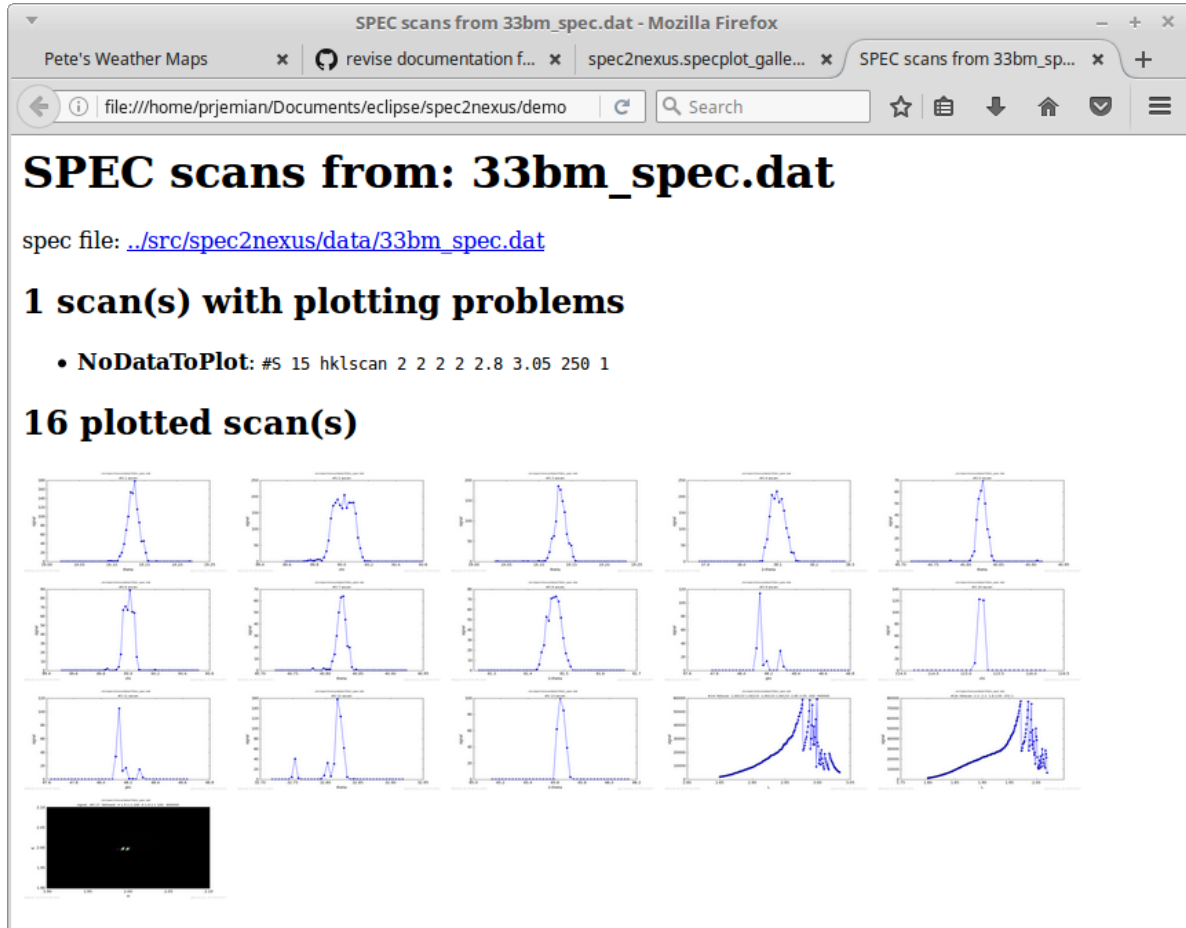


Fig. 2: Example of *specplot_gallery* showing scans from test file *33bm_spec.dat*.

```
#C Wed Jun 16 19:00:10 2010. Scan aborted after 0 points.
```

The last scan shown is from a *hklmesh* (2-D) scan. It is mostly a constant background level, thus the large black area. Each of the plots in the web page can be enlarged (by clicking on it).

How to use *specplot_gallery*: periodic background task (cron)

This script could be called from a Linux background task scheduler (*cron*) entry. To add the entry, type the *crontab -e* command which opens the task list in a screen editor and add lines such as these to the file:

```
# every five minutes (generates no output from outer script)
0-59/5 * * * * /path/to/specplot_gallery.py -d /web/page/dir /spec/data/file/dirs
```

If the *specplot_gallery* script is called too frequently and the list of plots to be generated is large enough, it is possible for more than one process to be running. In one extreme case, many processes were found running due to problems with the data files. To identify and stop all processes of this program, use this on the command line:

```
kill -9 `ps -ef | grep python | awk '/specplot_gallery.py/ {print $2}' -`
```

source code documentation

read a list of SPEC data files (or directories) and plot images of all scans

<i>DirectoryNotFoundError</i>	Exception: The requested directory does not exist
<i>PlotSpecFileScans</i> (filelist[, plotDir, ...])	read a SPEC data file and plot thumbnail images of all its scans
<i>Cache_File_Mtime</i> (base_dir)	Maintain a list of all known data file modification times.
<i>datePath</i> (date)	Convert the date into a path: yyyy/mm.
<i>getSpecFileDate</i> (specFile)	Return the #D date of the SPEC data file or None.
<i>needToMakePlot</i> (fullPlotFile, mtime_specFile)	Determine if a plot needs to be (re)made.
<i>timestamp</i> ()	current time as yyyy-mm-dd hh:mm:ss
<i>buildIndexHtml</i> (specFile, plotted_scans, ...)	Build index.html content.
<i>logger</i> (message)	Log a message or report from this module.

RESULT

The images are stored in files within a directory structure that is organized chronologically, such as: *yyyy/mm/spec_file/s1.svg*. The root of the directory is either specified by the command line *-d* option or defaults to the current working directory. The *yyyy/mm* (year and month) are taken from the #D line of the SPEC data file. The *spec_file* is the file name with file extension and directory name removed. The image file names are derived from the scan numbers.

Linux CRON task

This script could be called from a *cron* entry, such as:

```
# every five minutes (generates no output from outer script)
0-59/5 * * * * /some/directory/specplot_gallery.py -d /web/page/dir /spec/data/file/
↪dir
```

If this script is called too frequently and the list of plots to be generated is large enough, it is possible for more than one process to be running. In one extreme case, many processes were found running due to problems with the data files. To identify and stop all processes of this program:

```
kill -9 `ps -ef | grep python | awk '/specplot_gallery.py/ {print $2}' -`
```

class spec2nexus.specplot_gallery.**Cache_File_Mtime** (*base_dir*)

Maintain a list of all known data file modification times.

Parameters **base_dir** (*str*) – name of base directory to store output image thumbnails

This list will allow the code to avoid unnecessary work reparsing and plotting of unchanged SPEC data files.

get (*fname*, *default*={*mtime*: 0, *size*: 0})

Get the mtime cache entry for data file *fname*.

Parameters **fname** (*str*) – file name, already known to exist

Returns time (float) cached value of when *fname* was last modified or None if not known

read ()

Read the cache from storage.

was_file_updated (*fname*)

Compare the mtime between disk and cache.gy

Parameters **fname** (*str*) – file name, already known to exist

Return bool True if file is newer than the cache (or new to the cache)

write ()

Write the cache to storage.

exception spec2nexus.specplot_gallery.**DirectoryNotFoundError**

Exception: The requested directory does not exist

exception spec2nexus.specplot_gallery.**PathIsNotDirectoryError**

Exception: The path is not a directory

class spec2nexus.specplot_gallery.**PlotSpecFileScans** (*filelist*, *plotDir*=None, *reverse_chronological*=False)

read a SPEC data file and plot thumbnail images of all its scans

Parameters

- **filelist** (*[str]*) – list of SPEC data files to be checked
- **plotDir** (*str*) – name of base directory to store output image thumbnails

<i>specFileUpdated</i> (specFile)	Report if specFile has been updated.
<i>plot_all_scans</i> (specFile)	Plot all the recognized scans from file specFile.
<i>getPlotDir</i> (specFile)	Return the plot directory based on the specFile.
<i>getBaseDir</i> (basename, date)	Find the path based on the date in the spec file.
<i>href_format</i> (basePlotFile, altText)	

getBaseDir (*basename*, *date*)

Find the path based on the date in the spec file.

getPlotDir (*specFile*)

Return the plot directory based on the specFile.

Parameters **specFile** (*str*) – name of SPEC data file (relative or absolute)

plot_all_scans (*specFile*)
Plot all the recognized scans from file *specFile*.

specFileUpdated (*specFile*)
Report if *specFile* has been updated.

Return mtime cache entry (or *None* if not updated)

`spec2nexus.specplot_gallery.buildIndexHtml` (*specFile*, *plotted_scans*, *problem_scans*)
Build `index.html` content.

Parameters

- **specFile** (*str*) – name of SPEC data file (relative or absolute)
- **plotList** (*[str]*) – list of HTML `<a>` elements, one for each plot image

`spec2nexus.specplot_gallery.datePath` (*date*)
Convert the date into a path: `yyyy/mm`.

Parameters **date** (*str*) – text date from SPEC file #D line: ‘Thu Jun 19 12:21:55 2014’

`spec2nexus.specplot_gallery.developer` ()
Supply a file and a directory as command-line arguments to “paths”.

`spec2nexus.specplot_gallery.getSpecFileDate` (*specFile*)
Return the #D date of the SPEC data file or *None*.

Parameters **specFile** (*str*) – name of SPEC data file (relative or absolute)

`spec2nexus.specplot_gallery.logger` (*message*)
Log a message or report from this module.

Parameters **message** (*str*) – text to be logged

`spec2nexus.specplot_gallery.needToMakePlot` (*fullPlotFile*, *mtime_specFile*)
Determine if a plot needs to be (re)made. Use mtime as the basis.

Return bool True if plot should be made again

`spec2nexus.specplot_gallery.timestamp` ()
current time as `yyyy-mm-dd hh:mm:ss`

Return str

2.1.5 spec2nexus.spec

Library of classes to read the contents of a SPEC data file.

How to use spec2nexus.spec

`spec2nexus.spec` provides Python support to read the scans in a SPEC data file. (It does not provide a command-line interface.) Here is a quick example how to use `spec`:

```
1 from spec2nexus.spec import SpecDataFile
2
3 specfile = SpecDataFile('data/33id_spec.dat')
4 print 'SPEC file name:', specfile.specFile
5 print 'SPEC file time:', specfile.headers[0].date
6 print 'number of scans:', len(specfile.scans)
7
```

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```

8 for scanNum, scan in specfile.scans.items():
9     print scanNum, scan.scanCmd

```

For one example data file provided with `spec2nexus.spec`, the output starts with:

How to read one scan

Here is an example how to read one scan:

```

1 from spec2nexus.spec import SpecDataFile
2
3 specfile = SpecDataFile('data/33id_spec.dat')
4 specscan = specfile.getScan(5)
5 print specscan.scanNum
6 print specscan.scanCmd

```

which has this output:

```

5
ascan del 84.3269 84.9269 30 1

```

The data columns are provided in a dictionary. Using the example above, the dictionary is `specscan.data` where the keys are the column labels (from the #L line) and the values are from each row. It is possible to make a default plot of the last column vs. the first column. Here's how to find that data:

```

1 x_label = specscan.L[0]           # first column from #L line
2 y_label = specscan.L[-1]         # last column from #L line
3 x_data = specscan.data[x_label]  # data for first column
4 y_data = specscan.data[y_label]  # data for last column

```

Get a list of the scans

The complete list of scan numbers from the data file is obtained (sorting is necessary since the list of dictionary keys is returned in a scrambled order):

```

all_scans = sorted(specfile.scans.keys())

```

SPEC data files

The SPEC data file format is described in the SPEC manual.¹ This manual is taken as a suggested starting point for most users. Data files with deviations from this standard are produced at some facilities.

Assumptions about data file structure

These assumptions are used to parse SPEC data files:

¹ SPEC manual: http://www.certif.com/spec_manual/user_1_4_1.html

1. SPEC data files are text files organized by lines. The lines can be categorized as: **control lines**, **data lines**, and blank lines.

line type	description
<i>control</i>	contain a # character in the first column followed by a command word ²
<i>data</i>	generally contain a row of numbers (the scan data)
<i>special data</i>	containing MCA data ³

2. Lines in a SPEC data file start with a file name control line, then series of blocks. Each block may be either a file header block or a scan block. (Most SPEC files have only one header block. A new header block is created if the list of positioners is changed in SPEC without creating a new file. SPEC users are encouraged to *always* start a new data file after changing the list of positioners.) A block consists of a series of control, data, and blank lines.

SPEC data files are composed of a sequence of a single file header block and zero or more scan blocks.⁴

3. A SPEC data file always begins with this control lines: #F, such as:

```
#F samplecheck_7_17_03
```

4. A file header block begins with these control lines in order: #E #D #C, such as:

```
#E 1058427452
#D Thu Jul 17 02:37:32 2003
#C psic User = epix
```

5. A scan block begins with these command lines in order: #S #D, such as:

```
#S 78 ascan del 84.6484 84.8484 20 1
#D Thu Jul 17 08:03:54 2003
```

Control lines (keys) defined by SPEC

Here is a list⁵ of keys (command words) from the comments in the *file.mac* (SPEC v6) macro source file:

² See *Example of Control Lines*

³ See *Example of MCA data lines*

⁴ It is very unusual to have more than one file header block in a SPEC data file.

⁵ Compare with *Supplied spec plugin modules*


```

1  @A1 0 0 0 0 0 0 35 0 0 35
2  @A2 0 0 0 0 0 0 0 35 0 35
3  @A3 0 0 35 35 0 0 0 0 0 0
4  @A4 0 0 0 0 0 35 35 0 35 0

```

Supported header keys (command words)

The SPEC data file keys recognized by *spec* are listed in *Supplied spec plugin modules*.

source code summary

classes

<i>SpecDataFile</i>	contents of a SPEC data file
<i>SpecDataFileHeader</i>	contents of a spec data file header (#E) section
<i>SpecDataFileScan</i>	contents of a spec data file scan (#S) section

methods

<i>strip_first_word</i>	return everything after the first space on the line from the spec data file
<i>is_spec_file</i>	test if a given file name is a SPEC data file

exceptions

<i>SpecDataFileNotFound</i>	data file was not found
<i>SpecDataFileCouldNotOpen</i>	data file could not be opened
<i>SpecDataFileNotFound</i>	data file was not found
<i>DuplicateSpecScanNumber</i>	multiple use of scan number in a single SPEC data file
<i>UnknownSpecFilePart</i>	unknown part in a single SPEC data file

dependencies

os	OS routines for NT or Posix depending on what system we're on.
re	Support for regular expressions (RE).
sys	This module provides access to some objects used or maintained by the interpreter and to functions that interact strongly with the interpreter.

internal structure of `spec2nexus.spec.SpecDataFileScan`

The internal variables of a Python class are called *attributes*. It may be convenient, for some, to think of them as *variables*.

scan attributes

parent *obj* - instance of `spec2nexus.spec.SpecDataFile`

scanNum *int* - SPEC scan number

scanCmd *str* - SPEC command line

raw *str* - text of scan, as reported in SPEC data file

scan attributes (variables) set after call to plugins

These attributes are only set *after* the scan's `interpret()` method is called. This method is called automatically when trying to read any of the following scan attributes:

comments [*str*] - list of all comments reported in this scan

data [*label,number*] - written by `spec2nexus.plugins.spec_common_spec2nexus.data_lines_postprocessing()`

data_lines [*str*] - raw data (and possibly MCA) lines with comment lines removed

date *str* - written by `spec2nexus.plugins.spec_common_spec2nexus.SPEC_Date`

G [*key,number*] - written by `spec2nexus.plugins.spec_common_spec2nexus.SPEC_Geometry`

I *float* - written by `spec2nexus.plugins.spec_common_spec2nexus.SPEC_NormalizingFactor`

header *obj* - instance of `spec2nexus.spec.SpecDataFileHeader`

L [*str*] - written by `spec2nexus.plugins.spec_common_spec2nexus.SPEC_Labels`

M *str* - written by `spec2nexus.plugins.spec_common_spec2nexus.SPEC_Monitor`

positioner [*key,number*] - written by `spec2nexus.plugins.spec_common_spec2nexus.SPEC_Positioners.postprocess`

N [*int*] - written by `spec2nexus.plugins.spec_common_spec2nexus.SPEC_NumColumns`

P [*str*] - written by `spec2nexus.plugins.spec_common_spec2nexus.SPEC_Positioners`

Q [*number*] - written by `spec2nexus.plugins.spec_common_spec2nexus.SPEC_HKL`

S *str* - written by `spec2nexus.plugins.spec_common_spec2nexus.SPEC_Scan`

T *str* - written by `spec2nexus.plugins.spec_common_spec2nexus.SPEC_CountTime`

V [*key,number|str*] - written by `spec2nexus.plugins.unicat_spec2nexus.UNICAT_MetadataValues`

column_first *str* - label of first (ordinate) data column

column_last *str* - label of last (abscissa) data column

internal use only - do not modify

These scan attributes are for internal use only and are not part of the public interface. Do not modify them or write code that depends on them.

- postprocessors** *{key,obj}* - dictionary of postprocessing methods
- h5writers** *{key,obj}* - dictionary of methods that write HDF5 structure
- __lazy_interpret__** *bool* - Is *lazy* (on-demand) call to `interpret()` needed?
- __interpreted__** *bool* - Has `interpret()` been called?

source code documentation

Provides a set of classes to read the contents of a SPEC data file.

- author** Pete Jemian
- email** jemian@anl.gov

`SpecDataFile()` is the only class users will need to call. All other *spec* classes are called from this class. The `read()` method is called automatically.

The user should create a class instance for each spec data file, specifying the file reference (by path reference as needed) and the internal routines will take care of all that is necessary to read and interpret the information.

<code>is_spec_file(filename)</code>	test if a given file name is a SPEC data file
<code>is_spec_file_with_header(filename)</code>	test if a given file name is a SPEC data file
<code>SpecDataFile(filename)</code>	contents of a SPEC data file
<code>SpecDataFileHeader(buf[, parent])</code>	contents of a spec data file header (#E) section
<code>SpecDataFileScan(header, buf[, parent])</code>	contents of a spec data file scan (#S) section

Note that the SPEC geometry control lines (#G0 #G1 ...) have meanings that are unique to specific diffractometer geometries including different numbers of values. Consult the geometry macro file for specifics.

Examples

Get the first and last scan numbers from the file:

```
>>> from spec2nexus import spec
>>> spec_data = spec.SpecDataFile('path/to/my/spec_data.dat')
>>> print(spec_data.fileName)
path/to/my/spec_data.dat
>>> print('first scan: ', spec_data.getFirstScanNumber())
1
>>> print('last scan: ', spec_data.getLastScanNumber())
22
```

Get plottable data from scan number 10:

```
>>> from spec2nexus import spec
>>> spec_data = spec.SpecDataFile('path/to/my/spec_data.dat')
>>> scan10 = spec_data.getScan(10)
>>> x_label = scan10.L[0]
>>> y_label = scan10.L[-1]
```

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```
>>> x_data = scan10.data[x_label]
>>> y_data = scan10.data[y_label]
```

Try to read a file that does not exist:

```
>>> spec_data = spec.SpecDataFile('missing_file')
Traceback (most recent call last):
...
spec.SpecDataFileNotFound: file does not exist: missing_file
```

Classes and Methods

exception `spec2nexus.spec.DuplicateSpecScanNumber`
multiple use of scan number in a single SPEC data file

exception `spec2nexus.spec.NotASpecDataFile`
content of file is not SPEC data (first line must start with #F)

class `spec2nexus.spec.SpecDataFile (filename)`
contents of a SPEC data file

<code>dissect_file()</code>	divide (SPEC data file text) buffer into sections
<code>getFirstScanNumber()</code>	return the first scan
<code>getLastScanNumber()</code>	return the last scan
<code>getMaxScanNumber()</code>	return the highest numbered scan
<code>getMinScanNumber()</code>	return the lowest numbered scan
<code>getScan([scan_number])</code>	return the scan number indicated, None if not found
<code>getScanCommands([scan_list])</code>	return all the scan commands as a list, with scan number
<code>getScanNumbers()</code>	return a list of all scan numbers sorted by scan number
<code>getScanNumbersChronological()</code>	return a list of all scan numbers sorted by date
<code>read()</code>	Reads and parses a spec data file
<code>refresh()</code>	update (refresh) the content if the file is updated
<code>update_available</code>	Has the file been updated since the last time it was read?

dissect_file ()
divide (SPEC data file text) buffer into sections

internal: A *block* starts with either #F | #E | #S

RETURNS

[block] list of blocks where each block is one or more lines of text with one of the above control lines at its start

getFirstScanNumber ()
return the first scan

getLastScanNumber ()
return the last scan

getMaxScanNumber ()
return the highest numbered scan

getMinScanNumber ()
 return the lowest numbered scan

getScan (*scan_number=0*)
 return the scan number indicated, None if not found

getScanCommands (*scan_list=None*)
 return all the scan commands as a list, with scan number

getScanNumbers ()
 return a list of all scan numbers sorted by scan number

getScanNumbersChronological ()
 return a list of all scan numbers sorted by date

read ()
 Reads and parses a spec data file

refresh ()
 update (refresh) the content if the file is updated
 returns previous last_scan or None if file not updated

update_available
 Has the file been updated since the last time it was read?
 Reference file modification time is stored *after* file is read in *read()* method.

EXAMPLE USAGE

Open the SPEC data file (example):

```
sdf = spec.SpecDataFile(filename)
```

then, monitor (continuing example):

```
if sdf.update_available: myLastScan = sdf.last_scan sdf.read()
    plot_scan_and_newer(myLastScan) # new method myLastScan = sdf.last_scan
```

exception `spec2nexus.spec.SpecDataFileCouldNotOpen`
 data file could not be opened

class `spec2nexus.spec.SpecDataFileHeader` (*buf, parent=None*)
 contents of a spec data file header (#E) section

<code>interpret()</code>	interpret the supplied buffer with the spec data file header
<code>addPostProcessor(label, func)</code>	add a function to be processed after interpreting all lines from a header
<code>addH5writer(label, func)</code>	add a function to be processed when writing the scan header
<code>getLatestScan()</code>	

addH5writer (*label, func*)
 add a function to be processed when writing the scan header

Parameters

- **label** (*str*) – unique label by which this writer will be known
- **func** (*obj*) – function reference of writer

The writers will be called when the HDF5 file is to be written.

addPostProcessor (*label, func*)

add a function to be processed after interpreting all lines from a header

Parameters

- **label** (*str*) – unique label by which this postprocessor will be known
- **func** (*obj*) – function reference of postprocessor

The postprocessors will be called at the end of header interpretation.

interpret ()

interpret the supplied buffer with the spec data file header

exception `spec2nexus.spec.SpecDataFileNotFound`

data file was not found

class `spec2nexus.spec.SpecDataFileScan` (*header, buf, parent=None*)

contents of a spec data file scan (#S) section

<code>get_macro_name()</code>	name of the SPEC macro used for this scan
<code>interpret()</code>	interpret the supplied buffer with the spec scan data
<code>add_interpreter_comment(comment)</code>	allow the interpreter to communicate information to the caller
<code>get_interpreter_comments()</code>	return the list of comments
<code>addPostProcessor(label, func)</code>	add a function to be processed after interpreting all lines from a scan
<code>addH5writer(label, func)</code>	add a function to be processed when writing the scan data

addH5writer (*label, func*)

add a function to be processed when writing the scan data

Parameters

- **label** (*str*) – unique label by which this writer will be known
- **func** (*obj*) – function reference of writer

The writers will be called when the HDF5 file is to be written.

addPostProcessor (*label, func*)

add a function to be processed after interpreting all lines from a scan

Parameters

- **label** (*str*) – unique label by which this postprocessor will be known
- **func** (*obj*) – function reference of postprocessor

The postprocessors will be called at the end of scan data interpretation.

add_interpreter_comment (*comment*)

allow the interpreter to communicate information to the caller

see issue #66: <https://github.com/prjemian/spec2nexus/issues/66>

get_interpreter_comments ()

return the list of comments

see issue #66: <https://github.com/prjemian/spec2nexus/issues/66>

get_macro_name ()

name of the SPEC macro used for this scan

interpret ()

interpret the supplied buffer with the spec scan data

exception `spec2nexus.spec.UnknownSpecFilePart`

unknown part in a single SPEC data file

`spec2nexus.spec.is_spec_file` (*filename*)

test if a given file name is a SPEC data file

Parameters `filename` (*str*) – path/to/possible/spec/data.file

filename is a SPEC file if it contains at least one #S control line

`spec2nexus.spec.is_spec_file_with_header` (*filename*)

test if a given file name is a SPEC data file

Parameters `filename` (*str*) – path/to/possible/spec/data.file

filename is a SPEC file only if the file starts⁶ with these control lines in order:

- #F - original filename
- #E - the UNIX epoch (seconds from 00:00 GMT 1/1/70)
- #D - current date and time in UNIX format
- #C - comment line (the first one provides the filename again and the user name)

such as:

```
#F LNO_LAO
#E 1276730676
#D Wed Jun 16 18:24:36 2010
#C LNO_LAO User = epix33bm
```

2.1.6 spec2nexus.charts

source code documentation

charting for spec2nexus

<code>make_png</code> (<i>image</i> , <i>image_file</i> [, <i>axes</i> , <i>title</i> , ...])	read the image from the named HDF5 file and make a PNG file
<code>xy_plot</code> (<i>x</i> , <i>y</i> , <i>plot_file</i> [, <i>title</i> , <i>subtitle</i> , ...])	with Matplotlib, generate a plot of a scan (as if data from a scan in a SPEC file)

`spec2nexus.charts.make_png` (*image*, *image_file*, *axes=None*, *title='2-D data'*, *subtitle=""*, *log_image=False*, *hsize=9*, *vsize=5*, *cmap='cubehelix'*, *xtitle=None*, *ytitle=None*, *timestamp_str=None*)

read the image from the named HDF5 file and make a PNG file

Test that the HDF5 file exists and that the path to the data exists in that file. Read the data from the named dataset, mask off some bad values, convert to log(*image*) and use Matplotlib to make the PNG file.

Parameters

- **image** (*obj*) – array of data to be rendered
- **image_file** (*str*) – name of image file to be written (path is optional)

⁶ SPEC manual, *Standard Data File Format*, http://www.certif.com/spec_manual/user_1_4_1.html

- **log_image** (*bool*) – plot log(image)
- **hsize** (*int*) – horizontal size of the PNG image (default: 7)
- **hsize** – vertical size of the PNG image (default: 3)
- **cmap** (*str*) – colormap for the image (default: ‘cubehelix’), ‘jet’ is another good one

Return str *image_file*

The HDF5 file could be a NeXus file, or some other layout.

`spec2nexus.charts.xy_plot(x, y, plot_file, title=None, subtitle=None, xtitle=None, ytitle=None, xlog=False, ylog=False, hsize=9, vsize=5, timestamp_str=None)`
with Matplotlib, generate a plot of a scan (as if data from a scan in a SPEC file)

Parameters

- **x** (*[float]*) – horizontal axis data
- **y** (*[float]*) – vertical axis data
- **plot_file** (*str*) – file name to write plot image
- **xtitle** (*str*) – horizontal axis label (default: not shown)
- **ytitle** (*str*) – vertical axis label (default: not shown)
- **title** (*str*) – title for plot (default: date time)
- **subtitle** (*str*) – subtitle for plot (default: not shown)
- **xlog** (*bool*) – should X axis be log (default: False=linear)
- **ylog** (*bool*) – should Y axis be log (default: False=linear)
- **timestamp_str** (*str*) – date to use on plot (default: now)

Tip: when using this module as a background task ...

Matplotlib has several interfaces for plotting. Since this module runs as part of a background job generating lots of plots, Matplotlib’s standard `plt` code is not the right model. It warns after 20 plots and will eventually run out of memory.

Here’s the fix used in this module: <http://stackoverflow.com/questions/16334588/create-a-figure-that-is-reference-counted/16337909#16337909>

2.1.7 How to write a custom scan handling for *specplot*

Sometimes, it will be obvious that a certain scan macro never generates any plot images, or that the default handling creates a plot that is a poor representation of the data, such as the *hklscan* where only one of the the axes *hkl* is scanned. To pick the scanned axis for plotting, it is necessary to prepare custom handling and replace the default handling.

Overview

It is possible to add in additional handling by writing a Python module. This module creates a subclass of the standard handling, such as *LinePlotter*, *MeshPlotter*, or their superclass *ImageMaker*. The support is added to the macro selection class *Selector* with code such as in the brief example described below: *Change the plot title text in ascan macros*:

```
selector = spec2nexus.specplot.Selector()
selector.add('ascan', Custom_Ascan)
spec2nexus.specplot_gallery.main()
```

Data Model

The data to be plotted is kept in an appropriate subclass of `PlotDataStructure` in attributes show in the next table. The data model is an adaptation of the NeXus *NXdata* base class.¹

attribute	description
<i>self.signal</i>	name of the dependent data (y axis or image) to be plotted
<i>self.axes</i>	list of names of the independent axes ²
<i>self.data</i>	dictionary with the data, indexed by name

Steps

In all cases, custom handling of a specific SPEC macro name is provided by creating a subclass of *ImageMaker* and defining one or more of its methods. In the simplest case, certain settings may be changed by calling `spec2nexus.specplot.ImageMaker.configure()` with the custom values. Examples of further customization are provided below, such as when the data to be plotted is stored outside of the SPEC data file. This is common for images from area detectors.

It may also be necessary to create a subclass of `PlotDataStructure` to gather the data to be plotted or override the default `spec2nexus.specplot.ImageMaker.plottable()` method. An example of this is shown with the *MeshPlotter* and associated *MeshStructure* classes.

Examples

A few examples of custom macro handling are provided, some simple, some complex. In each example, decisions have been made about where to provide the desired features.

Change the plot title text in *ascan* macros

The SPEC *ascan* macro is a workhorse and records the scan of a positioner and the measurement of data in a counter. Since this macro name ends with “scan”, the default selection in *specplot* images this data using the *LinePlotter* class. Here is a plot of the default handling of data from the *ascan* macro:

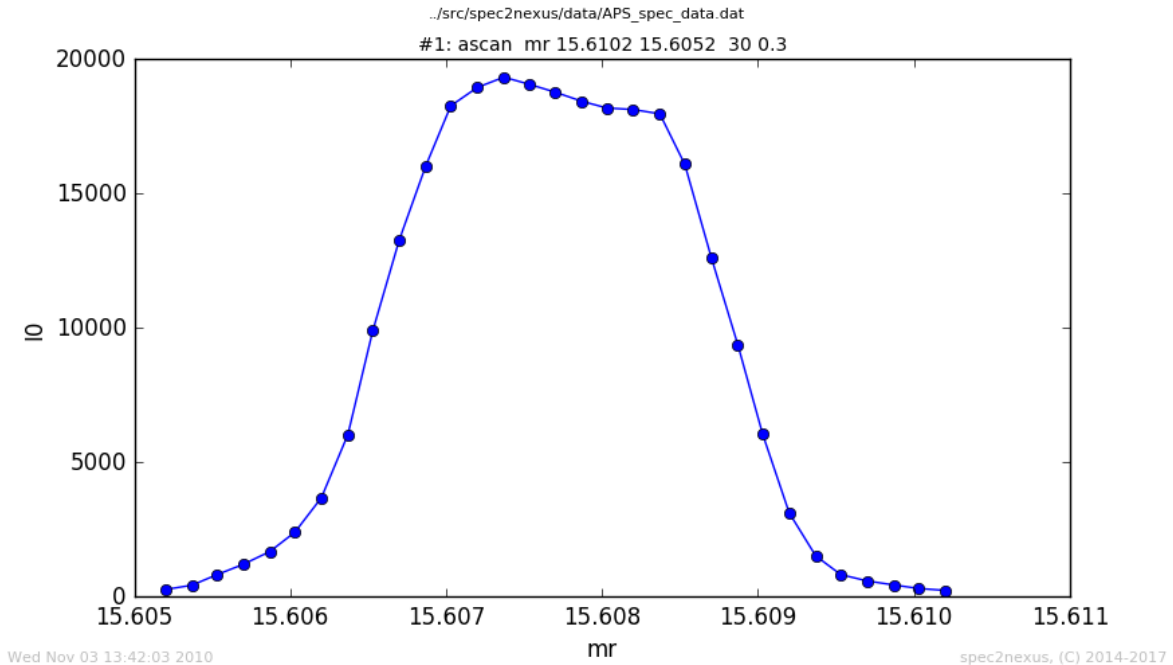
We will show how to change the plot title as a means to illustrate how to customize the handling for a scan macro.

We write `Custom_Ascan` which is a subclass of *LinePlotter*. The `get_plot_data` method is written (overrides the default method) to gain access to the place where we can introduce the change. The change is made by the call to the `configure` method (defined in the superclass). Here’s the code:

ascan.py example

¹ NeXus *NXdata* base class: http://download.nexusformat.org/doc/html/classes/base_classes/NXdata.html

² The number of names provided in *self.axes* is equal to the *rank* of the *signal* data (*self.data[self.signal]*). For 1-D data, *self.axes* has one name and the *signal* data is one-dimensional. For 2-D data, *self.axes* has two names and the *signal* data is two-dimensional.

Fig. 3: Standard plot of data from *ascan* macro

```

1  #!/usr/bin/env python
2
3  #-----
4  # :author:    Pete R. Jemian
5  # :email:    prjemian@gmail.com
6  # :copyright: (c) 2014-2020, Pete R. Jemian
7  #
8  # Distributed under the terms of the Creative Commons Attribution 4.0 International
9  ↪Public License.
10 #
11 # The full license is in the file LICENSE.txt, distributed with this software.
12 #-----
13
14 '''
15 Plot all scans that used the SPEC `ascan` macro, showing only the scan number (not
16 ↪full scan command)
17
18 This is a simple example of how to customize the scan macro handling.
19 There are many more ways to add complexity.
20 '''
21
22 import spec2nexus.specplot
23 import spec2nexus.specplot_gallery
24
25 class Custom_Ascan(spec2nexus.specplot.LinePlotter):
26     '''simple customization'''
27
28     def retrieve_plot_data(self):
29         '''substitute with the data&time the plot was created'''

```

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```

29     import datetime
30     spec2nexus.specplot.LinePlotter.retrieve_plot_data(self)
31     self.set_plot_subtitle(str(datetime.datetime.now()))
32
33
34 def main():
35     selector = spec2nexus.specplot.Selector()
36     selector.add('ascan', Custom_Ascan)
37     spec2nexus.specplot_gallery.main()
38
39
40 if __name__ == '__main__':
41     main()

```

See the changed title:

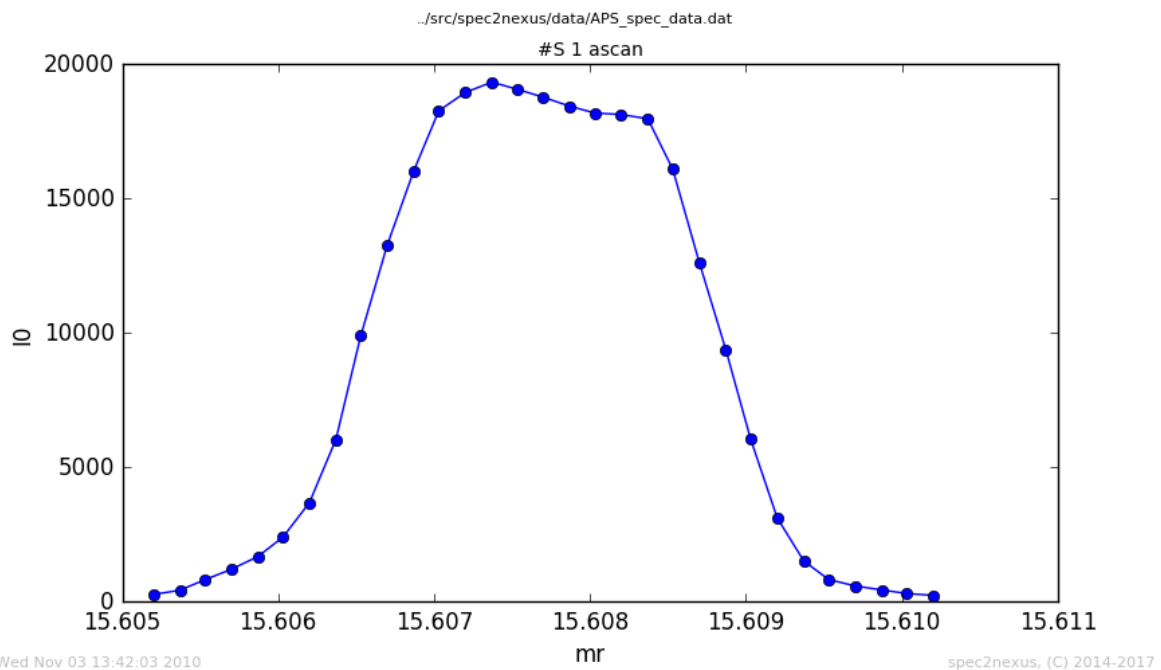


Fig. 4: Customized plot of data from *ascan* macro

Make the y-axis log scale

A very simple customization can make the Y axis to be logarithmic scale. (This customization is planned for an added feature³ in a future release of the *spec2nexus* package.) We present two examples.

modify handling of *a2scan*

One user wants all the *a2scan* images to be plotted with a logarithmic scale on the Y axis. Here's the code:

³ specplot: add option for default log(signal)

custom_a2scan_gallery.py example

```

1  #!/usr/bin/env python
2
3  '''
4  Customization for specplot_gallery: plot a2scan with log(y) axis
5
6  This program changes the plotting for all scans that used the *a2scan* SPEC macro.
7  The Y axis of these plots will be plotted as logarithmic if all the data values are
8  greater than zero.  Otherwise, the Y axis scale will be linear.
9  '''
10
11  import spec2nexus.specplot
12  import spec2nexus.specplot_gallery
13
14  class Custom_a2scan_Plotter(spec2nexus.specplot.LinePlotter):
15      '''plot `a2scan` y axis as log if possible'''
16
17      def retrieve_plot_data(self):
18          '''plot the vertical axis on log scale'''
19          spec2nexus.specplot.LinePlotter.retrieve_plot_data(self)
20
21          choose_log_scale = False
22
23          if self.signal in self.data:    # log(y) if all data positive
24              choose_log_scale = min(self.data[self.signal]) > 0
25
26          self.set_y_log(choose_log_scale)
27
28
29  def main():
30      selector = spec2nexus.specplot.Selector()
31      selector.add('a2scan', Custom_a2scan_Plotter)
32      spec2nexus.specplot_gallery.main()
33
34
35  if __name__ == '__main__':
36      # debugging_setup()
37      main()
38
39  '''
40  Instructions:
41
42  Save this file in a directory you can write and call it from your cron tasks.
43
44  Note that in cron entries, you cannot rely on shell environment variables to
45  be defined.  Best to spell things out completely.  For example, if your $HOME
46  directory is `/home/user` and you have these directories:
47
48  * `/home/user/bin`: various custom executables you use
49  * `/home/user/www/specplots`: a directory you access with a web browser for your plots
50  * `/home/user/spec/data`: a directory with your SPEC data files
51
52  then save this file to `/home/user/bin/custom_a2scan_gallery.py` and make it
53  ↪ executable
54  (using `chmod +x ./home/user/bin/custom_a2scan_gallery.py`).

```

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```

55 Edit your list of cron tasks using `crontab -e` and add this (possibly
56 replacing a call to `specplot_gallery` with this call `custom_a2scan_gallery.py`):
57
58     # every five minutes (generates no output from outer script)
59     0-59/5 * * * * /home/user/bin/custom_a2scan_gallery.py -d /home/user/www/
60     ↪specplots /home/user/spec/data 2>&1 >> /home/user/www/specplots/log_cron.txt
61
62 Any output from this periodic task will be recorded in the file
63 `/home/user/www/specplots/log_cron.txt`. This file can be reviewed
64 for diagnostics or troubleshooting.
'''

```

custom *uascan*

The APS USAXS instrument uses a custom scan macro called *uascan* for routine step scans. Since this macro name ends with “scan”, the default selection in *specplot* images this data using the *LinePlotter* class. Here is a plot of the default handling of data from the *uascan* macro:

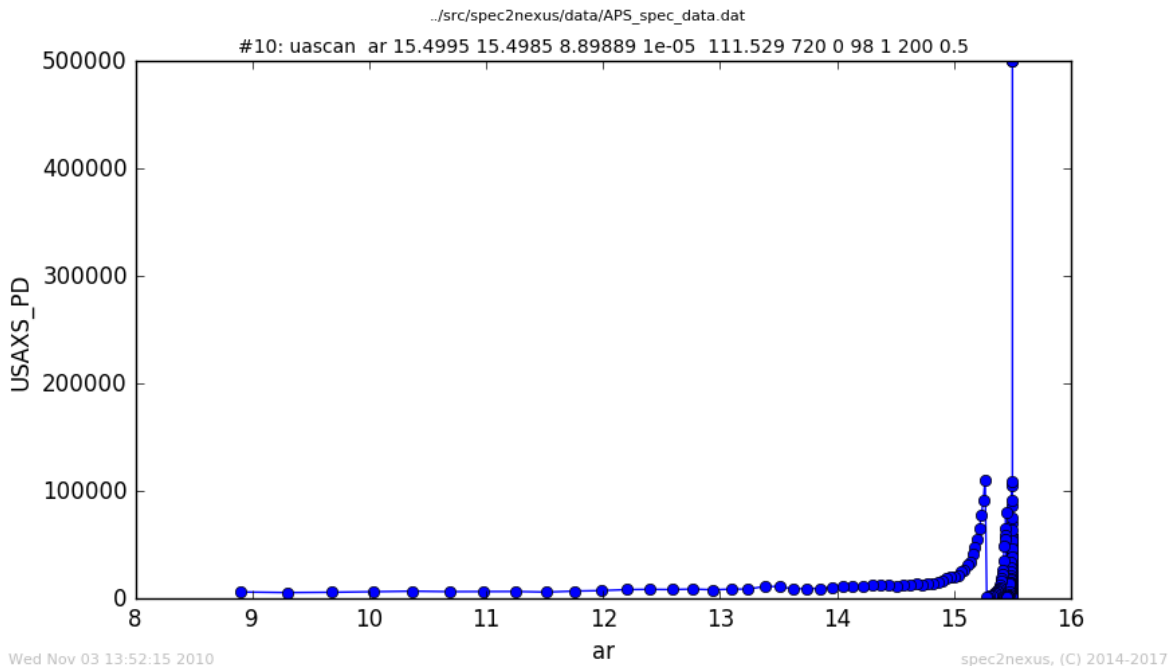


Fig. 5: USAXS *uascan*, handled as *LinePlotter*

The can be changed by making the y axis log scale. To do this, a custom version of *LinePlotter* is created as *Custom_Ascan*. The *get_plot_data* method is written (overrides the default method) to make the y axis log-scale by calling the *configure* method (defined in the superclass). Here’s the code:

usaxs_uascan.py example

```

1 #!/usr/bin/env python
2

```

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```

3 #-----
4 # :author:    Pete R. Jemian
5 # :email:    prjemian@gmail.com
6 # :copyright: (c) 2014-2017, Pete R. Jemian
7 #
8 # Distributed under the terms of the Creative Commons Attribution 4.0 International
9 ↪Public License.
10 #
11 # The full license is in the file LICENSE.txt, distributed with this software.
12 #-----
13 '''
14 Plot data from the USAXS uascan macro
15
16 .. autosummary::
17
18     ~UAscan_Plotter
19
20 '''
21
22 import spec2nexus.specplot
23 import spec2nexus.specplot_gallery
24
25
26 class UAscan_Plotter(spec2nexus.specplot.LinePlotter):
27     '''simple customize of `uascan` handling'''
28
29     def retrieve_plot_data(self):
30         '''plot the vertical axis on log scale'''
31         spec2nexus.specplot.LinePlotter.retrieve_plot_data(self)
32
33         if self.signal in self.data:
34             if min(self.data[self.signal]) <= 0:
35                 # TODO: remove any data where Y <= 0 (can't plot on log scale)
36                 msg = 'cannot plot Y<0: ' + str(self.scan)
37                 raise spec2nexus.specplot.NotPlottable(msg)
38
39         # in the uascan, a name for the sample is given in `self.scan.comments[0]`
40         self.set_y_log(True)
41         self.set_plot_subtitle(
42             '%s uascan: %s' % (str(self.scan.scanNum), self.scan.comments[0]))
43
44
45 def debugging_setup():
46     import os, sys
47     import shutil
48     import ascan
49     selector = spec2nexus.specplot.Selector()
50     selector.add('ascan', ascan.Custom_Ascan) # just for the demo
51     path = '__usaxs__'
52     shutil.rmtree(path, ignore_errors=True)
53     os.mkdir(path)
54     sys.argv.append('-d')
55     sys.argv.append(path)
56     sys.argv.append(os.path.join '..', 'src', 'spec2nexus', 'data', 'APS_spec_data.dat
57 ↪'))

```

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```

58
59 def main():
60     selector = spec2nexus.specplot.Selector()
61     selector.add('uascan', UAscanner_Plotter)
62     spec2nexus.specplot_gallery.main()
63
64
65 if __name__ == '__main__':
66     # debugging_setup()
67     main()

```

Note that in the *uascan*, a name for the sample provided by the user is given in *self.scan.comments[0]*. The plot title is changed to include this and the scan number. The customized plot has a logarithmic y axis:

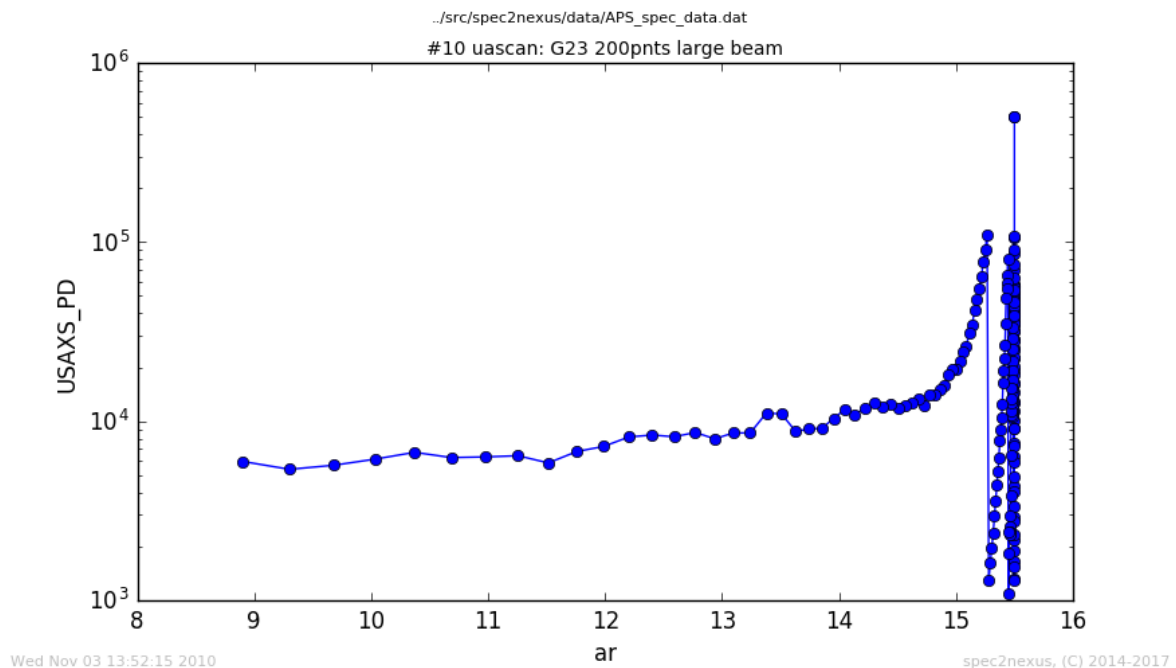


Fig. 6: USAXS *uascan*, with logarithmic y axis

The most informative view of this data is when the raw data are reduced to $I(Q)$ and viewed on a log-log plot, but that process is beyond this simple example. See the example *Get xy data from HDF5 file* below.

SPEC's *hklskan* macro

The SPEC *hklskan* macro appears in a SPEC data file due to either a *hscan*, *kscan*, or *lscan*. In each of these one of the *hkl* vectors is scanned while the other two remain constant.

The normal handling of the *ascan* macro plots the last data column against the first. This works for data collected with the *hscan*. For *kscan* or *lscan* macros, the *h* axis is still plotted by default since it is in the first column.

To display the scanned axis, it is necessary to examine the data in a custom subclass of *LinePlotter*. The *HKLSkanPlotter* subclass, provided with *specplot*, defines the *get_plot_data()* method determines the scanned axis, setting it by name:

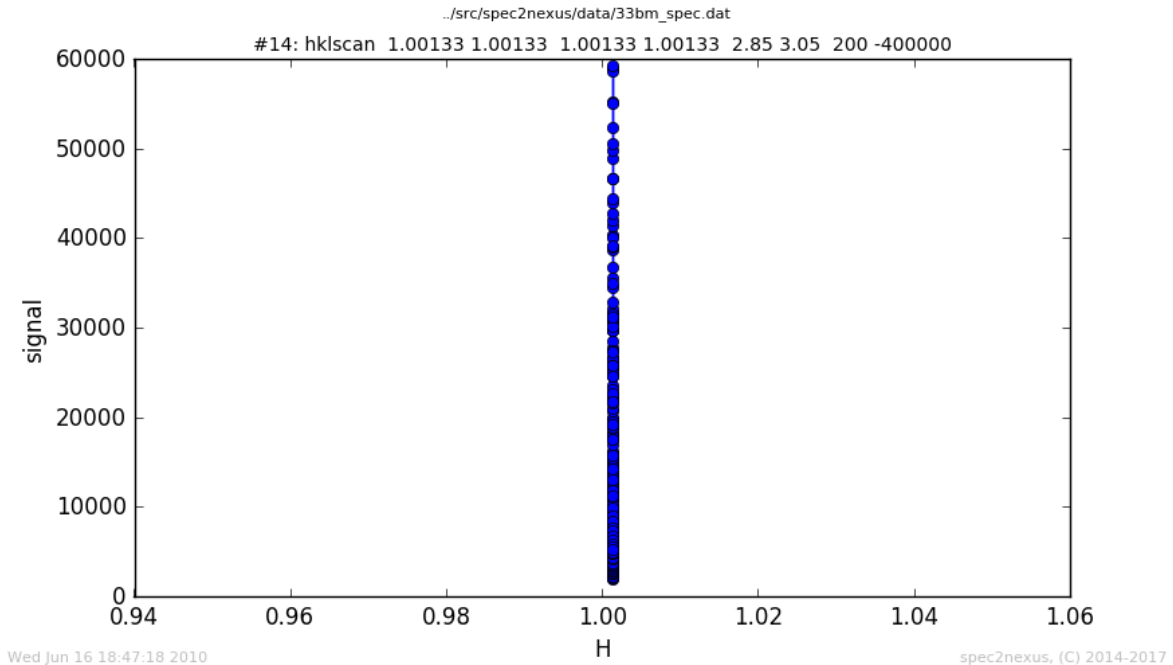


Fig. 7: SPEC *hklscan* (*lscan*, in this case), plotted against the (default) first axis *H*

```
plot.axes = [axis,]
self.scan.column_first = axis
```

Then, the standard plot handling used by *LinePlotter* uses this information to make the plot.

Get *xy* data from HDF5 file

One example of complexity is when SPEC has been used to direct data collection but the data is not stored in the SPEC data file. The SPEC data file scan must provide some indication about where the collected scan data has been stored.

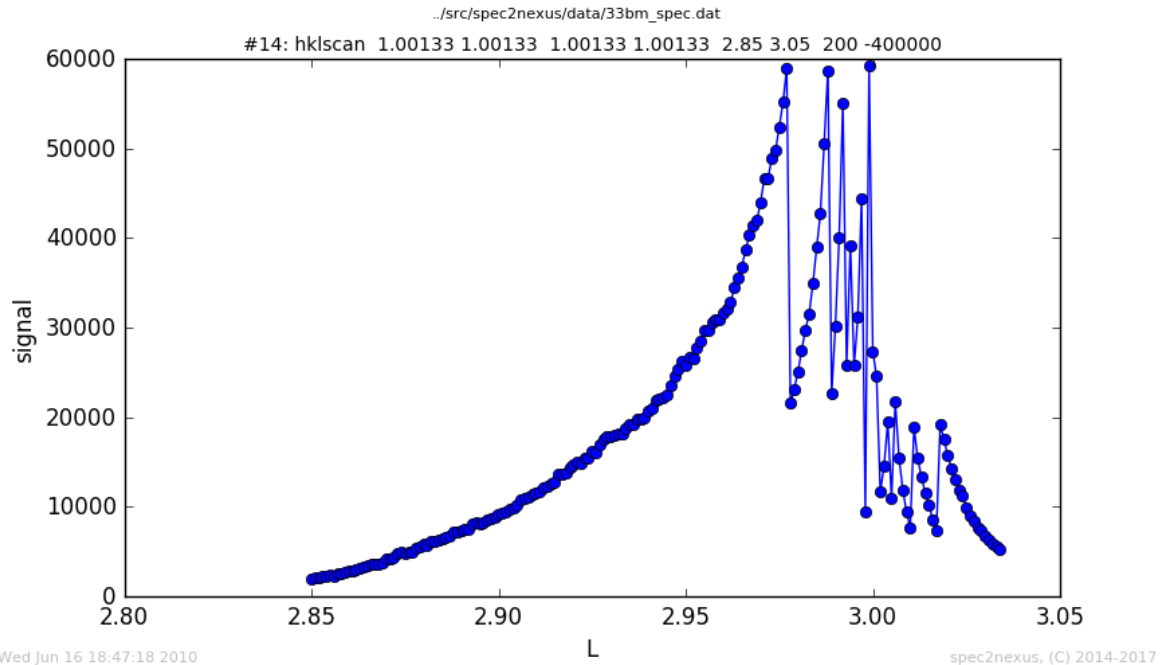
The USAXS instrument at APS has a *FlyScan* macro that commands the instrument to collect data continuously over the desired *Q* range. The data is written to a NeXus HDF5 data file. Later, a data reduction process converts the arrays of raw data to one-dimensional $I(Q)$ profiles. The best representation of this reduced data is on a log-log plot to reveal the many decades of both *I* and *Q* covered by the measurement.

With the default handling by *LinePlotter*, no plot can be generated since the data is given in a separate HDF5 file. That file is read with the custom handling of the *usaxs_flyscan.py* demo:

usaxs_flyscan.py example

```
1 #!/usr/bin/env python
2
3 #-----
4 # :author:    Pete R. Jemian
5 # :email:    prjemian@gmail.com
6 # :copyright: (c) 2014-2017, Pete R. Jemian
7 #
```

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Fig. 8: SPEC *hklscan* (*lscan*), plotted against *L*

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```

8 # Distributed under the terms of the Creative Commons Attribution 4.0 International
9 ↪Public License.
10 #
11 # The full license is in the file LICENSE.txt, distributed with this software.
12 #-----
13 '''
14 Plot data from the USAXS FlyScan macro
15
16 .. autosummary::
17
18     ~read_reduced_fly_scan_file
19     ~retrieve_flyScanData
20     ~USAXS_FlyScan_Structure
21     ~USAXS_FlyScan_Plotter
22
23 '''
24
25 import h5py
26 import numpy
27 import os
28
29 import spec2nexus.specplot
30 import spec2nexus.specplot_gallery
31
32
33 # methods picked (& modified) from the USAXS livedata project
34 def read_reduced_fly_scan_file(hdf5_file_name):
35     '''

```

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```

36     read any and all reduced data from the HDF5 file, return in a dictionary
37
38     dictionary = {
39         'full': dict(Q, R, R_max, ar, fwhm, centroid)
40         '250': dict(Q, R, dR)
41         '5000': dict(Q, R, dR)
42     }
43     '''
44
45     reduced = {}
46     hdf = h5py.File(hdf5_file_name, 'r')
47     entry = hdf['/entry']
48     for key in entry.keys():
49         if key.startswith('flyScan_reduced_'):
50             nxdata = entry[key]
51             d = {}
52             for dsname in ['Q', 'R']:
53                 if dsname in nxdata:
54                     value = nxdata[dsname]
55                     if value.size == 1:
56                         d[dsname] = float(value[0])
57                     else:
58                         d[dsname] = numpy.array(value)
59             reduced[key[len('flyScan_reduced_'):]] = d
60     hdf.close()
61     return reduced
62
63
64 # $URL: https://subversion.xray.aps.anl.gov/small_angle/USAXS/livedata/specplot.py $
65 REDUCED_FLY_SCAN_BINS = 250 # the default
66 def retrieve_flyScanData(scan):
67     '''retrieve reduced, rebinned data from USAXS Fly Scans'''
68     path = os.path.dirname(scan.header.parent.fileName)
69     key_string = 'FlyScan file name = '
70     comment = scan.comments[2]
71     index = comment.find(key_string) + len(key_string)
72     hdf_file_name = comment[index:-1]
73     abs_file = os.path.abspath(os.path.join(path, hdf_file_name))
74
75     plotData = {}
76     if os.path.exists(abs_file):
77         reduced = read_reduced_fly_scan_file(abs_file)
78         s_num_bins = str(REDUCED_FLY_SCAN_BINS)
79
80         choice = reduced.get(s_num_bins) or reduced.get('full')
81
82         if choice is not None:
83             plotData = {axis: choice[axis] for axis in 'Q R'.split()}
84
85     return plotData
86
87
88 class USAXS_FlyScan_Plotter(spec2nexus.specplot.LinePlotter):
89     '''
90     customize `FlyScan` handling, plot :math:`\log(I)` *vs.* :math:`\log(Q)`
91
92     The USAXS FlyScan data is stored in a NeXus HDF5 file in a subdirectory

```

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```

93  below the SPEC data file.  This code uses existing code from the
94  USAXS instrument to read that file.
95  '''
96
97  def retrieve_plot_data(self):
98      '''retrieve reduced data from the FlyScan's HDF5 file'''
99      # get the data from the HDF5 file
100     fly_data = retrieve_flyScanData(self.scan)
101
102     if len(fly_data) != 2:
103         raise spec2nexus.specplot.NoDataToPlot(str(self.scan))
104
105     self.signal = 'R'
106     self.axes = ['Q',]
107     self.data = fly_data
108
109     # customize the plot just a bit
110     # sample name as given by the user?
111     subtitle = '#' + str(self.scan.scanNum)
112     subtitle += ' FlyScan: ' + self.scan.comments[0]
113     self.set_plot_subtitle(subtitle)
114     self.set_x_log(True)
115     self.set_y_log(True)
116     self.set_x_title(r'$|\vec{Q}|$, 1/\AA$')
117     self.set_y_title(r'USAXS $R(|\vec{Q}|)$, a.u.')
118
119     def plottable(self):
120         '''
121         can this data be plotted as expected?
122         '''
123         if self.signal in self.data:
124             signal = self.data[self.signal]
125             if signal is not None and len(signal) > 0 and len(self.axes) == 1:
126                 if len(signal) == len(self.data[self.axes[0]]):
127                     return True
128         return False
129
130
131     def debugging_setup():
132         import sys
133         import shutil
134         sys.path.insert(0, os.path.join('.', 'src'))
135         path = '__usaxs__'
136         shutil.rmtree(path, ignore_errors=True)
137         os.mkdir(path)
138         sys.argv.append('-d')
139         sys.argv.append(path)
140         sys.argv.append(os.path.join('.', 'src', 'spec2nexus', 'data', '02_03_setup.dat
141         ↪'))
142
143     def main():
144         selector = spec2nexus.specplot.Selector()
145         selector.add('FlyScan', USAXS_FlyScan_Plotter)
146         spec2nexus.specplot_gallery.main()
147
148

```

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```

149 if __name__ == '__main__':
150     # debugging_setup()
151     main()

```

The data is then rendered in a customized log-log plot of $I(Q)$:

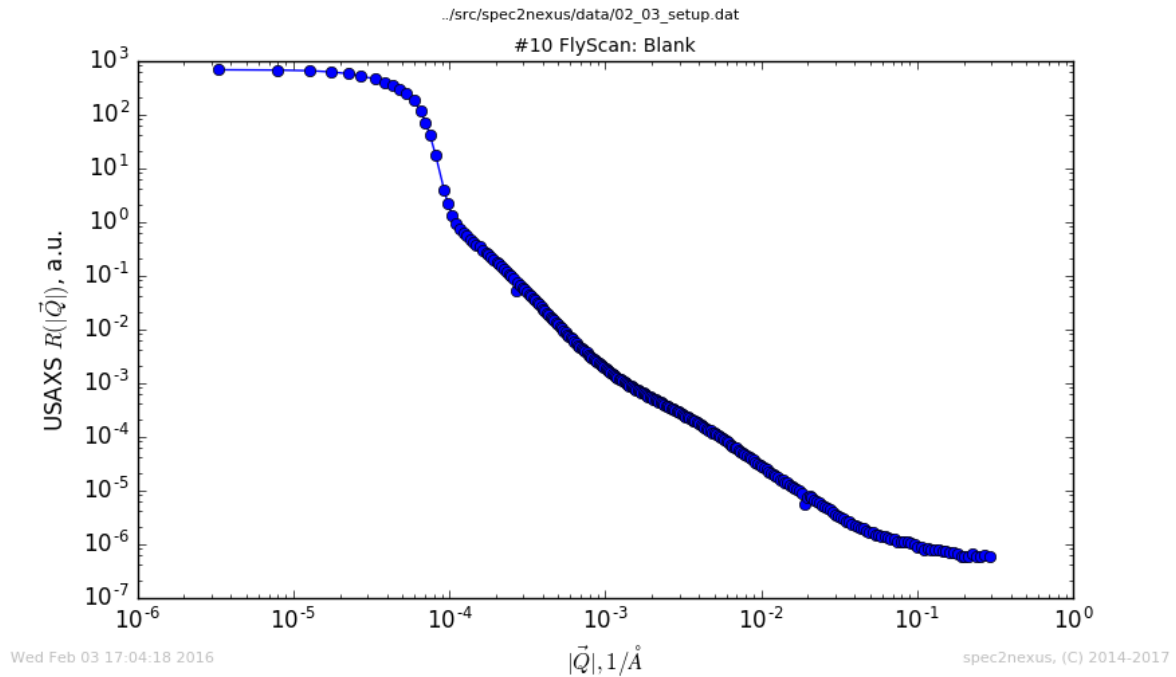


Fig. 9: USAXS *FlyScan*, handled by `USAXS_FlyScan_Plotter`

Usage

When a custom scan macro handler is written and installed using code similar to the *custom ascan* handling above:

```

def main():
    selector = spec2nexus.specplot.Selector()
    selector.add('ascan', Custom_Ascan)
    spec2nexus.specplot_gallery.main()

if __name__ == '__main__':
    main()

```

then the command line argument handling from `spec2nexus.specplot_gallery.main()` can be accessed from the command line for help and usage information.

Usage:

```

user@localhost ~/.../spec2nexus/demo $ ./ascan.py
usage: ascan.py [-h] [-r] [-d DIR] paths [paths ...]
ascan.py: error: too few arguments

```

Help:

```
user@localhost ~/.../spec2nexus/demo $ ./ascan.py -h
usage: ascan.py [-h] [-r] [-d DIR] paths [paths ...]

read a list of SPEC data files (or directories) and plot images of all scans

positional arguments:
  paths                SPEC data file name(s) or directory(s) with SPEC data
                      files

optional arguments:
  -h, --help          show this help message and exit
  -r                  sort images from each data file in reverse chronological
                      order
  -d DIR, --dir DIR   base directory for output (default:/home/prjemian/Documen
                      ts/eclipse/spec2nexus/demo)
```

2.1.8 spec2nexus.eznx

(Easy NeXus) support library for reading & writing NeXus HDF5 files using h5py

How to use spec2nexus.eznx

Here is a simple example to write a NeXus data file using eznx:

```
1  #!/usr/bin/env python
2  # -*- coding: utf-8 -*-
3
4  """
5  Writes a simple NeXus HDF5 file using h5py with links.
6
7  This example is based on ``writer_2_1`` of the NeXus Manual:
8  http://download.nexusformat.org/doc/html/examples/h5py/index.html
9  """
10
11  from spec2nexus import eznx
12
13
14  HDF5_FILE = "eznx_example.hdf5"
15
16  I_v_TTH_DATA = """
17  17.92608    1037
18  17.92558    2857
19  17.92508    23819
20  17.92458    49087
21  17.92408    66802
22  17.92358    66206
23  17.92308    64129
24  17.92258    56795
25  17.92208    29315
26  17.92158    6622
27  17.92108    1321
28  """
29  # -----
30
31  tthData, countsData = zip(
```

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```

32     *map(float, _.split()) for _ in I_v_TTH_DATA.strip().splitlines()]
33 )
34
35 f = eznx.makeFile(HDF5_FILE) # create the HDF5 NeXus file
36 f.attrs["default"] = "entry"
37
38 nxentry = eznx.makeGroup(f, "entry", "NXentry", default="data")
39 nxinstrument = eznx.makeGroup(nxentry, "instrument", "NXinstrument")
40 nxdetector = eznx.makeGroup(nxinstrument, "detector", "NXdetector")
41
42 tth = eznx.makeDataset(nxdetector, "two_theta", tthData, units="degrees")
43 counts = eznx.makeDataset(nxdetector, "counts", countsData, units="counts")
44
45 nxdata = eznx.makeGroup(
46     nxentry,
47     "data",
48     "NXdata",
49     signal=1,
50     axes="two_theta",
51     two_theta_indices=0,
52 )
53 eznx.makeLink(nxdetector, tth, nxdata.name + "/two_theta")
54 eznx.makeLink(nxdetector, counts, nxdata.name + "/counts")
55
56 f.close() # be CERTAIN to close the file

```

The output of this code is an HDF5 file (binary). It has this structure:

```

1  eznx_example.hdf5:NeXus data file
2  @default = entry
3  entry:NXentry
4  @NX_class = NXentry
5  @default = data
6  data:NXdata
7  @NX_class = NXdata
8  @signal = counts
9  @axes = two_theta
10 @two_theta_indices = 0
11 counts --> /entry/instrument/detector/counts
12 two_theta --> /entry/instrument/detector/two_theta
13 instrument:NXinstrument
14 @NX_class = NXinstrument
15 detector:NXdetector
16 @NX_class = NXdetector
17 counts:NX_FLOAT64[11] = __array
18 @units = counts
19 @target = /entry/instrument/detector/counts
20 __array = [1037.0, 2857.0, 23819.0, '...', 1321.0]
21 two_theta:NX_FLOAT64[11] = __array
22 @units = degrees
23 @target = /entry/instrument/detector/two_theta
24 __array = [17.926079999999999, 17.92558, 17.925080000000001, '...', 17.
↪92108]

```

NeXus HDF5 File Structure

The output of this code is an HDF5 file (binary). It has this general structure (indentation shows HDF5 groups, @ signs describe attributes of the preceding item):

```

1  hdf5_file:NeXus data file
2      @default = S1
3      S1:NXentry      (one NXentry for each scan)
4          @default = data
5          title = #S
6          T or M: #T or #M
7          comments: #C for entire scan
8          date: #D
9          scan_number: #S
10         G:NXcollection
11             @description = SPEC geometry arrays, meanings defined by SPEC_
↪diffractometer support
12             G0:NX_FLOAT64[] #G0
13             G1:NX_FLOAT64[] #G1
14             ...
15         data:NXdata
16             @description = SPEC scan data (content from #L and data lines)
17             @signal = I0
18             @axes = mr
19             @mr_indices = 0
20             Epoch:NX_FLOAT64[]
21             I0:NX_FLOAT64[]      (last data column)
22             @spec_name = I0
23             mr:NX_FLOAT64[]      (first data column)
24             ...
25         metadata:NXcollection
26             @description = SPEC metadata (UNICAT-style #H & #V lines)
27             ARenc_0:NX_FLOAT64 = 0.0
28             ...
29         positioners:NXcollection
30             @description = SPEC positioners (#P & #O lines)
31             mr:NX_FLOAT64
32             ...

```

APIs provided:

spec2nexus.writer

This is an internal library of the **spec2nexus** software. It is not expected that users of this package will need to call the writer module directly.

source code documentation

(internal library) Parses SPEC data using spec2nexus.eznx API (only requires h5py)

class spec2nexus.writer.**Writer**(*spec_data*)
writes out scans from SPEC data file to NeXus HDF5 file

Parameters *spec_data* (*obj*) – instance of *SpecDataFile*

mca_spectra (*nxdata, scan, primary_axis_label*)
internal: parse for optional 2-D MCA spectra

mesh (*nxdata, scan*)
internal: data parser for 2-D mesh and hklmesh

oneD (*nxdata, scan*)
internal: generic data parser for 1-D column data, returns signal and axis

root_attributes ()
internal: returns the attributes to be written to the root element as a dict

save (*hdf_file, scan_list=None*)
 save the information in this SPEC data file to a NeXus HDF5 file

Each scan in `scan_list` will be converted to a **NXentry** group. Scan data will be placed in a **NXdata** group where the attribute **signal=1** is the last column and the corresponding attribute **axes=<name of the first column>**. There are variations on this for 2-D and higher dimensionality data, such as mesh scans.

In general, the tree structure of the NeXus HDF5 file is:

```

hdf5_file: NXroot
  @default="S1"
  definition="NXspecdata"
  # attributes
  S1:NXentry
    @default="data"
    # attributes and metadata fields
    data:NXdata
      @signal=<name of signal field>
      @axes=<name(s) of axes of signal>
      @<axis>_indices=<list of indices in "axis1">
      <signal_is_the_last_column>:NX_NUMBER[number of points] = ...
↳data ...
      @signal=1
      @axes='<axis_is_name_of_first_column>'
      @<axis>_indices=<list of indices in "axis1" used as dimension
↳scales of the "signal">
      <axis_is_name_of_first_column>:NX_NUMBER[number of points] = ...
↳data ...
      # other columns from the scan

```

Parameters

- **hdf_file** (*str*) – name of NeXus/HDF5 file to be written
- **scanlist** (*[int]*) – list of scan numbers to be read

save_data (*nxdata, scan*)
internal: store the scan data

save_dict (*group, data*)
internal: store a dictionary

save_scan (*nxentry, scan*)
internal: save the data from each SPEC scan to its own NXentry group

write_ds (*group, label, data, **attr*)
internal: writes a dataset to the HDF5 file, records the SPEC name as an attribute

source code methods

<code>addAttributes</code>	add attributes to an h5py data item
<code>makeFile</code>	create and open an empty NeXus HDF5 file using h5py
<code>makeDataset</code>	create and write data to a dataset in the HDF5 file hierarchy
<code>makeExternalLink</code>	create an external link from sourceFile, sourcePath to targetPath in hdf5FileObject
<code>makeGroup</code>	create a NeXus group
<code>openGroup</code>	open or create the NeXus/HDF5 group, return the object
<code>makeLink</code>	create an internal NeXus (hard) link in an HDF5 file
<code>read_nexus_field</code>	get a dataset from the HDF5 parent group
<code>read_nexus_group_fields</code>	return the fields in the NeXus group as a dict(name=dataset)
<code>write_dataset</code>	write to the NeXus/HDF5 dataset, create it if necessary, return the object

source code documentation

(Easy NeXus) support reading & writing NeXus HDF5 files using h5py

predecessor NeXus h5py example code: `my_lib.py`¹

Dependencies

- h5py: interface to HDF5 file format

Exceptions raised

- None

Example

```
root = eznx.makeFile('test.h5', creator='eznx', default='entry')
nxentry = eznx.makeGroup(root, 'entry', 'NXentry', default='data')
ds = eznx.write_dataset(nxentry, 'title', 'simple test data')
nxdata = eznx.makeGroup(nxentry, 'data', 'NXdata', signal='counts', axes='tth', tth_
↪indices=0)
ds = eznx.write_dataset(nxdata, 'tth', [10.0, 10.1, 10.2, 10.3], units='degrees')
ds = eznx.write_dataset(nxdata, 'counts', [1, 50, 1000, 5], units='counts', axes="tth
↪")
root.close()
```

The resulting (binary) data file has this structure:

```
test.h5:NeXus data file
  @creator = eznx
  @default = 'entry'
  entry:NXentry
    @NX_class = NXentry
```

(continues on next page)

¹ <http://download.nexusformat.org/doc/html/examples/h5py/index.html#mylib-support-module>

(continued from previous page)

```

@default = 'data'
title:NX_CHAR = simple test data
data:NXdata
  @NX_class = NXdata
  @signal = 'counts'
  @axes = 'tth'
  @tth_indices = 0
  counts:NX_INT64[4] = [1, 50, 1000, 5]
  @units = counts
  @axes = tth
  tth:NX_FLOAT64[4] = [10.0, 10.1, 10.199999999999999, 10.300000000000001]
  @units = degrees

```

Classes and Methods

`spec2nexus.eznx.addAttributes` (*parent*, ***attr*)
add attributes to an h5py data item

Parameters

- **parent** (*obj*) – h5py parent object
- **attr** (*dict*) – optional dictionary of attributes

`spec2nexus.eznx.makeDataset` (*parent*, *name*, *data=None*, ***attr*)
create and write data to a dataset in the HDF5 file hierarchy

Any named parameters in the call to this method will be saved as attributes of the dataset.

Parameters

- **parent** (*obj*) – parent group
- **name** (*str*) – valid NeXus dataset name
- **data** (*obj*) – the information to be written
- **attr** (*dict*) – optional dictionary of attributes

Returns h5py dataset object

`spec2nexus.eznx.makeExternalLink` (*hdf5FileObject*, *sourceFile*, *sourcePath*, *targetPath*)
create an external link from *sourceFile*, *sourcePath* to *targetPath* in *hdf5FileObject*

Parameters

- **hdf5FileObject** (*obj*) – open HDF5 file object
- **sourceFile** (*str*) – file containing existing HDF5 object at *sourcePath*
- **sourcePath** (*str*) – path to existing HDF5 object in *sourceFile*
- **targetPath** (*str*) – full node path to be created in current open HDF5 file, such as `/entry/data/data`

Note: Since the object retrieved is in a different file, its “.file” and “.parent” properties will refer to objects in that file, not the file in which the link resides.

See <http://www.h5py.org/docs-1.3/guide/group.html#external-links>

This routine is provided as a reminder how to do this simple operation.

`spec2nexus.eznx.makeFile(filename, **attr)`
create and open an empty NeXus HDF5 file using h5py

Any named parameters in the call to this method will be saved as attributes of the root of the file. Note that `**attr` is a dictionary of named parameters.

Parameters

- **filename** (*str*) – valid file name
- **attr** (*dict*) – optional dictionary of attributes

Returns h5py file object

`spec2nexus.eznx.makeGroup(parent, name, nxclass, **attr)`
create a NeXus group

Any named parameters in the call to this method will be saved as attributes of the group. Note that `**attr` is a dictionary of named parameters.

Parameters

- **parent** (*obj*) – parent group
- **name** (*str*) – valid NeXus group name
- **nxclass** (*str*) – valid NeXus class name
- **attr** (*dict*) – optional dictionary of attributes

Returns h5py group object

`spec2nexus.eznx.makeLink(parent, sourceObject, targetName)`
create an internal NeXus (hard) link in an HDF5 file

Parameters

- **parent** (*obj*) – parent group of source
- **sourceObject** (*obj*) – existing HDF5 object
- **targetName** (*str*) – HDF5 node path to be created, such as `/entry/data/data`

`spec2nexus.eznx.openGroup(parent, name, nx_class, **attr)`
open or create the NeXus/HDF5 group, return the object

Parameters

- **parent** (*obj*) – h5py parent object
- **name** (*str*) – valid NeXus group name to open or create
- **nxclass** (*str*) – valid NeXus class name (base class or application definition)
- **attr** (*dict*) – optional dictionary of attributes

`spec2nexus.eznx.read_nexus_field(parent, dataset_name, astype=None)`
get a dataset from the HDF5 parent group

Parameters

- **parent** (*obj*) – h5py parent object
- **dataset_name** (*str*) – name of the dataset (NeXus field) to be read
- **astype** (*obj*) – option to return as different data type

`spec2nexus.eznx.read_nexus_group_fields` (*parent, name, fields*)
return the fields in the NeXus group as a dict(name=dataset)

This routine provides a mass way to read a directed list of datasets (NeXus fields) in an HDF5 group.

Parameters

- **parent** (*obj*) – h5py parent object
- **name** (*str*) – name of the group containing the fields
- **fields** (*[name]*) – list of field names to be read

Returns dictionary of {name:dataset}

Raises **KeyError** – if a field is not found

`spec2nexus.eznx.write_dataset` (*parent, name, data, **attr*)
write to the NeXus/HDF5 dataset, create it if necessary, return the object

Parameters

- **parent** (*obj*) – h5py parent object
- **name** (*str*) – valid NeXus dataset name to write
- **data** (*obj*) – the information to be written
- **attr** (*dict*) – optional dictionary of attributes

2.1.9 spec2nexus.plugin

An extensible plug-in architecture is used to handle the different possible control line control lines (such as #F, #E, #S, ...) in a SPEC data file.

A SPEC *control line* provides metadata about the SPEC scan or SPEC data file.

Plugins can be used to parse or ignore certain control lines in SPEC data files. Through this architecture, it is possible to support custom control lines, such as #U (SPEC standard control line for any user data). One example is support for the *UNICAT-style* of metadata provided in the scan header.

Plugins are now used to handle all control lines in `spec2nexus.spec`. Any control line encountered but not recognized will be placed as text in a NeXus **NXnote** group named `unrecognized_NNN` (where NNN is from 1 to the maximum number of unrecognized control lines).

Supplied spec plugin modules

These plugin modules are supplied:

<code>spec_common</code>	SPEC data file standard control lines
<code>fallback</code>	Fallback handling for any SPEC data file control lines not recognized by other handlers
<code>apstools_specwriter</code>	#MD : Bluesky metadata from apstools SpecWriter-Callback.
<code>unicat</code>	#H & #V - Metadata in SPEC data files as defined by APS UNICAT
<code>uim</code>	#UIM : Image header information from EPICS areaDetector
<code>uxml</code>	#UXML: UXML structured metadata

Continued on next page

Table 18 – continued from previous page

<i>XPCS</i>	SPEC data file control lines unique to the APS XPCS instrument
-------------	--

XPCS plugin

SPEC data file control lines unique to the APS XPCS instrument

```

class spec2nexus.plugins.XPCS.XPCS_CCD
    #CCD

    process (text, spec_obj, *args, **kws)
        required: handle this line from a SPEC data file

    writer (h5parent, writer, scan, nxclass=None, *args, **kws)
        optional: Describe how to store this data in an HDF5 NeXus file

class spec2nexus.plugins.XPCS.XPCS_VA
    #VA

    process (text, spec_obj, *args, **kws)
        required: handle this line from a SPEC data file

    writer (h5parent, writer, scan, nxclass=None, *args, **kws)
        Describe how to write VA data

class spec2nexus.plugins.XPCS.XPCS_VD
    #VD

    process (text, spec_obj, *args, **kws)
        required: handle this line from a SPEC data file

    writer (h5parent, writer, scan, nxclass=None, *args, **kws)
        Describe how to write VD data

class spec2nexus.plugins.XPCS.XPCS_VE
    #VE

    process (text, spec_obj, *args, **kws)
        required: handle this line from a SPEC data file

    writer (h5parent, writer, scan, nxclass=None, *args, **kws)
        Describe how to write VE data

class spec2nexus.plugins.XPCS.XPCS_XPCS
    #XPCS

    process (text, spec_obj, *args, **kws)
        required: handle this line from a SPEC data file

    writer (h5parent, writer, scan, nxclass=None, *args, **kws)
        optional: Describe how to store this data in an HDF5 NeXus file

```

apstools SpecWriterCallback metadata plugin

Looks for #MD control line control lines. These lines contain metadata supplied to the bluesky RunEngine and recorded during the execution of a scan. The data are stored in a dictionary of each scan: `scan.MD`. If there are no #MD control lines, then `scan.MD` does not exist.

see https://apstools.readthedocs.io/en/latest/source/_filewriters.html#apstools.filewriters.SpecWriterCallback

#MD : Bluesky metadata from apstools SpecWriterCallback.

EXAMPLE:

```
#MD APSTOOLS_VERSION = 1.1.0
#MD BLUESKY_VERSION = 1.5.2
#MD EPICS_CA_MAX_ARRAY_BYTES = 1280000
#MD EPICS_HOST_ARCH = linux-x86_64
#MD OPHYD_VERSION = 1.3.2
#MD beamline_id = APS USAXS 9-ID-C
#MD datetime = 2019-04-19 10:04:44.400750
#MD login_id = usaxs@usaxscontrol.xray.aps.anl.gov
#MD pid = 27062
#MD proposal_id = testing Bluesky installation
#MD purpose = tuner
#MD tune_md = {'width': -0.004, 'initial_position': 8.824885, 'time_iso8601': '2019-
↪ 04-19 10:04:44.402643'}
#MD tune_parameters = {'num': 31, 'width': -0.004, 'initial_position': 8.824885,
↪ 'peak_choice': 'com', 'x_axis': 'm_stage_r', 'y_axis': 'I0_USAXS'}
```

class spec2nexus.plugins.apstools_specwriter.**MD_apstools**

#MD – Bluesky metadata from apstools SpecWriterCallback

process (*text*, *scan*, **args*, ***kws*)
read #MD lines from SPEC data file

writer (*h5parent*, *writer*, *scan*, *nxclass=None*, **args*, ***kws*)
Describe how to store this data in an HDF5 NeXus file

Fallback plugin

Fallback handling for any SPEC data file control lines not recognized by other handlers

class spec2nexus.plugins.fallback.**UnrecognizedControlLine**

unrecognized control line

process (*text*, *spec_obj*, **args*, ***kws*)

writer (*h5parent*, *writer*, *scan*, *nxclass=None*, **args*, ***kws*)
write the data in a NeXus group named unrecognized

SPEC standard plugin

SPEC data file standard control lines

see SPEC manual, *Standard Data File Format*, http://www.certif.com/spec_manual/user_1_4_1.html

class spec2nexus.plugins.spec_common.**SPEC_Comment**

#C – any comment either in the scan header or somewhere in the scan

IN-MEMORY REPRESENTATION

- (SpecDataFileHeader): **comments**
- (SpecDataFileScan): **comments**

HDF5/NeXus REPRESENTATION

- file root-level attribute: **SPEC_comments** : string array of all comments from first header block
- dataset named **comments** under */NXentry* group, such as */SI/comments* : string array of all comments from this scan block

process (*text, scan, *args, **kws*)
required: handle this line from a SPEC data file

writer (*h5parent, writer, scan, *args, **kws*)
 Describe how to store this data in an HDF5 NeXus file

class spec2nexus.plugins.spec_common.**SPEC_CountTime**
#T – counting against this constant number of seconds (see #M)

IN-MEMORY REPRESENTATION

- (SpecDataFileScan): **T**

HDF5/NeXus REPRESENTATION

- Dataset named **T** in the *NXentry* group, such as */SI/T*
- Dataset named **counting_basis** in the *NXentry* group with value *SPEC scan with constant counting time*, such as */SI/counting_basis*

process (*text, scan, *args, **kws*)
required: handle this line from a SPEC data file

writer (*h5parent, writer, scan, *args, **kws*)
 Describe how to store this data in an HDF5 NeXus file

class spec2nexus.plugins.spec_common.**SPEC_CounterMnemonics**
#j – mnemonics of counter (new with SPEC v6)

IN-MEMORY REPRESENTATION

- (SpecDataFileHeader): **j** : mnemonics

HDF5/NeXus REPRESENTATION

- *NXnote* group named **counter_cross_reference** in the *NXentry* group, such as */SI/counter_cross_reference*
 - datasets with names supplied as SPEC counter mnemonics, string values supplied as SPEC counter names

postprocess (*header, *args, **kws*)
optional: additional processing deferred until *after* data file has been read

process (*text, header, *args, **kws*)
required: handle this line from a SPEC data file

writer (*h5parent, writer, header, nxclass=None, *args, **kws*)
 Describe how to store this data in an HDF5 NeXus file

class spec2nexus.plugins.spec_common.**SPEC_CounterNames**
#J – names of counters (each separated by two spaces) (new with SPEC v6)

IN-MEMORY REPRESENTATION

- (SpecDataFileHeader): **J** : mnemonics

HDF5/NeXus REPRESENTATION

- *NXnote* group named **counter_cross_reference** in the *NXentry* group, such as */SI/counter_cross_reference*
 - datasets with names supplied as SPEC counter mnemonics, string values supplied as SPEC counter names

postprocess (*header, *args, **kws*)
optional: additional processing deferred until *after* data file has been read

process (*text, header, *args, **kws*)
required: handle this line from a SPEC data file

writer (*h5parent, writer, header, nxclass=None, *args, **kws*)
 Describe how to store this data in an HDF5 NeXus file

class spec2nexus.plugins.spec_common.SPEC_DataLine
(scan_data) – scan data line

Scan data could include interspersed MCA data or even describe 2-D or 3-D data. This method reads the data lines and buffers them for post-processing in `spec2nexus.plugins.spec_common_spec2nexus.data_lines_postprocessing()`.

IN-MEMORY REPRESENTATION

- (SpecDataFileScan): **data_lines** : values
- (SpecDataFileScan): **data** : {labels: values}

HDF5/NeXus REPRESENTATION

- *NXdata* group named **data** in the *NXentry* group, such as */S1/data*
- datasets with names supplied in **L**, array values collected in **data_lines**

match_key (*text*)
 Easier to try conversion to number than construct complicated regexp

postprocess (*scan, *args, **kws*)
optional: additional processing deferred until *after* data file has been read

process (*text, scan, *args, **kws*)
required: handle this line from a SPEC data file

class spec2nexus.plugins.spec_common.SPEC_Date
#D – date/time stamp

IN-MEMORY REPRESENTATION

- (SpecDataFileHeader): **date** *str*, ISO8601 format

HDF5/NeXus REPRESENTATION

- file root-level attribute: **SPEC_date** *str* (value for 1st header block is used)

process (*text, sdf_object, *args, **kws*)
required: handle this line from a SPEC data file

writer (*h5parent, writer, sdf_object, *args, **kws*)
 Describe how to store this data in an HDF5 NeXus file

class spec2nexus.plugins.spec_common.SPEC_Epoch
#E – the UNIX epoch (seconds from 00:00 GMT 1/1/70)

In SPEC data files, the #E control line indicates the start of a *header* block.

IN-MEMORY REPRESENTATION

- (SpecDataFileHeader): **epoch** *int*

HDF5/NeXus REPRESENTATION

- file root-level attribute: **SPEC_epoch** *int*

process (*buf, sdf_object, *args, **kws*)
required: handle this line from a SPEC data file

class spec2nexus.plugins.spec_common.**SPEC_File**
#F – original data file name (starts a file header block)

Module *spec2nexus.spec* is responsible for handling this control line.

IN-MEMORY REPRESENTATION

- (SpecDataFile): **fileName**
- (SpecDataFileHeader): **file**

HDF5/NeXus REPRESENTATION

- file root-level attribute: **SPEC_file**

process (*text, spec_file_obj, *args, **kws*)
required: handle this line from a SPEC data file

class spec2nexus.plugins.spec_common.**SPEC_Geometry**
#G – diffractometer geometry (numbered rows: #G0, #G1, ...)

IN-MEMORY REPRESENTATION

- (SpecDataFileScan): **G**

HDF5/NeXus REPRESENTATION

- *NXnote* group named **G** in the *NXentry* group, such as */SI/G*
 - Datasets created from dictionary *<scan>.G* (indexed by number from the scan block, such as *G0, G1, ...*). Meaning of contents for each index are defined by geometry-specific SPEC diffractometer support.
- *NXinstrument* & *NXsample* groups for interpreted information

postprocess (*scan, *args, **kws*)
optional: additional processing deferred until *after* data file has been read

process (*text, scan, *args, **kws*)
required: handle this line from a SPEC data file

writer (*h5parent, writer, scan, nxclass=None, *args, **kws*)
Describe how to store this data in an HDF5 NeXus file

class spec2nexus.plugins.spec_common.**SPEC_HKL**
#Q – *Q* (*hkl*) at start of scan

IN-MEMORY REPRESENTATION

- (SpecDataFileScan): **Q**

HDF5/NeXus REPRESENTATION

- Dataset named **Q** in the *NXentry* group, such as */SI/M*

process (*text, scan, *args, **kws*)
required: handle this line from a SPEC data file

writer (*h5parent, writer, scan, *args, **kws*)
Describe how to store this data in an HDF5 NeXus file

class spec2nexus.plugins.spec_common.**SPEC_Labels**
#L – data column labels

postprocess (*scan*, *args, **kws)
optional: additional processing deferred until *after* data file has been read

process (*text*, *scan*, *args, **kws)
required: handle this line from a SPEC data file

class spec2nexus.plugins.spec_common.SPEC_MCA_Calibration
#@CALIB – coefficients to compute a scale based on the MCA channel number

$x_k = a + bk + ck^2$ for MCA data, k is channel number

IN-MEMORY REPRESENTATION

- (SpecDataFileScan): **MCA**['CALIB'] = dict (a, b, c)

HDF5/NeXus REPRESENTATION

- defines a dimension scale for MCA data
- *NXnote* group named **MCA** in the *NXentry* group, such as */SI/MCA*
 - Dataset **calib_a** : float
 - Dataset **calib_b** : float
 - Dataset **calib_c** : float

process (*text*, *scan*, *args, **kws)
required: handle this line from a SPEC data file

writer (*h5parent*, *writer*, *scan*, *nxclass=None*, *args, **kws)
Describe how to store this data in an HDF5 NeXus file

class spec2nexus.plugins.spec_common.SPEC_MCA_ChannelInformation
#@CHANN – MCA channel information

number_saved, first_saved, last_saved, reduction_coef

IN-MEMORY REPRESENTATION

- (SpecDataFileScan): **MCA**['CALIB'] = dict (number_saved, first_saved, last_saved, reduction_coef)

HDF5/NeXus REPRESENTATION

- *NXnote* group named **MCA** in the *NXentry* group, such as */SI/MCA*
 - Dataset **number_saved** : int number of channels saved
 - Dataset **first_saved** : int first channel saved
 - Dataset **last_saved** : int last channel saved
 - Dataset **reduction_coef** : float reduction coefficient

process (*text*, *scan*, *args, **kws)
required: handle this line from a SPEC data file

writer (*h5parent*, *writer*, *scan*, *nxclass=None*, *args, **kws)
Describe how to store this data in an HDF5 NeXus file

class spec2nexus.plugins.spec_common.SPEC_MCA_CountTime
#@CTIME – MCA count times

preset_time, elapsed_live_time, elapsed_real_time

IN-MEMORY REPRESENTATION

- (SpecDataFileScan): **MCA**['CALIB'] = dict(preset_time, elapsed_live_time, elapsed_real_time)

HDF5/NeXus REPRESENTATION

- *NXnote* group named **MCA** in the *NXentry* group, such as */SI/MCA*
 - Dataset **preset_time** : *float*
 - Dataset **elapsed_live_time** : *float*
 - Dataset **elapsed_real_time** : *float*

process (*text, scan, *args, **kws*)
required: handle this line from a SPEC data file

writer (*h5parent, writer, scan, nxclass=None, *args, **kws*)
 Describe how to store this data in an HDF5 NeXus file

class spec2nexus.plugins.spec_common.**SPEC_MCA_RegionOfInterest**
#@ROI – MCA ROI (Region Of Interest) channel information

ROI_name, first_chan, last_chan

IN-MEMORY REPRESENTATION

- (SpecDataFileScan): **MCA**['ROI'] = {ROI_name:dict(first_chan, last_chan)}

HDF5/NeXus REPRESENTATION

- *NXnote* group **ROI** in *NXnote* group named **MCA** in the *NXentry* group, such as */SI/MCA/ROI*
 - Dataset **{ROI_name}** : *int* [first_chan, last_chan]

process (*text, scan, *args, **kws*)
required: handle this line from a SPEC data file

writer (*h5parent, writer, scan, nxclass=None, *args, **kws*)
 Describe how to store this data in an HDF5 NeXus file

class spec2nexus.plugins.spec_common.**SPEC_Monitor**
#M – counting against this constant monitor count (see #T)

IN-MEMORY REPRESENTATION

- (SpecDataFileScan): **M**

HDF5/NeXus REPRESENTATION

- Dataset named **M** in the *NXentry* group, such as */SI/M*
- Dataset named **counting_basis** in the *NXentry* group with value *SPEC scan with constant monitor count*, such as */SI/counting_basis*

process (*text, scan, *args, **kws*)
required: handle this line from a SPEC data file

writer (*h5parent, writer, scan, *args, **kws*)
 Describe how to store this data in an HDF5 NeXus file

class spec2nexus.plugins.spec_common.**SPEC_NormalizingFactor**
#I – intensity normalizing factor

IN-MEMORY REPRESENTATION

- (SpecDataFileScan): **I**

HDF5/NeXus REPRESENTATION

- Dataset named **intensity_factor** in the *NXentry* group, such as */S1/intensity_factor*

process (*text, scan, *args, **kws*)
required: handle this line from a SPEC data file

writer (*h5parent, writer, scan, nxclass=None, *args, **kws*)
 Describe how to store this data in an HDF5 NeXus file

class `spec2nexus.plugins.spec_common.SPEC_NumColumns`
#N – number of columns of data [num2 sets per row]

IN-MEMORY REPRESENTATION

- (SpecDataFileScan): **N** : [int]

HDF5/NeXus REPRESENTATION

- not written to file

process (*text, scan, *args, **kws*)
required: handle this line from a SPEC data file

class `spec2nexus.plugins.spec_common.SPEC_PositionerMnemonics`
#o – positioner mnemonics (new with SPEC v6)

IN-MEMORY REPRESENTATION

- (SpecDataFileHeader): **o** : mnemonics

HDF5/NeXus REPRESENTATION

- *NXnote* group named **positioner_cross_reference** in the *NXentry* group, such as */S1/positioner_cross_reference*
 - datasets with names supplied as SPEC positioner mnemonics, string values supplied as SPEC positioner names

postprocess (*header, *args, **kws*)
optional: additional processing deferred until *after* data file has been read

process (*text, header, *args, **kws*)
required: handle this line from a SPEC data file

writer (*h5parent, writer, header, nxclass=None, *args, **kws*)
 Describe how to store this data in an HDF5 NeXus file

class `spec2nexus.plugins.spec_common.SPEC_PositionerNames`
#O – positioner names (numbered rows: #O0, #O1, ...)

IN-MEMORY REPRESENTATION

- (SpecDataFileHeader) : **O** : label
- (SpecDataFileScan): **positioner** : {label: value}

HDF5/NeXus REPRESENTATION

- *NXnote* group named **positioners** in the *NXentry* group, such as */S1/positioners*
 - datasets created from dictionary <scan>.positioner
- *NXnote* group named **positioner_cross_reference** in the *NXentry* group, such as */S1/positioner_cross_reference*
 - datasets with names supplied as SPEC positioner mnemonics, string values supplied as SPEC positioner names

process (*text, sdf_object, *args, **kws*)
required: handle this line from a SPEC data file

class spec2nexus.plugins.spec_common.SPEC_Positioners

#P – positioner values at start of scan (numbered rows: #P0, #P1, ...)

IN-MEMORY REPRESENTATION

- (SpecDataFileHeader): **O** : label
- (SpecDataFileScan): **positioner** : {label: value}

HDF5/NeXus REPRESENTATION

- *NXnote* group named **positioners** in the *NXentry* group, such as */SI/positioners*
 - datasets created from dictionary <scan>.positioner

postprocess (*scan, *args, **kws*)
 interpret the motor positions from the scan header

Parameters **scan** (SpecDataFileScan) – data from a single SPEC scan

process (*text, scan, *args, **kws*)
required: handle this line from a SPEC data file

writer (*h5parent, writer, scan, nxclass=None, *args, **kws*)
 Describe how to store this data in an HDF5 NeXus file

class spec2nexus.plugins.spec_common.SPEC_Scan

#S – SPEC scan

In SPEC data files, the #S control line indicates the start of a *scan* block. Each scan will be written to a separate *NXentry* group in the HDF5 file.

NXentry: “The top-level NeXus group which contains all the data and associated information that comprise a single measurement.”

– http://download.nexusformat.org/doc/html/classes/base_classes/NXentry.html

IN-MEMORY REPRESENTATION

- (SpecDataFile):
- (SpecDataFileHeader):

HDF5/NeXus REPRESENTATION

- *NXentry* group named ‘S%d’ scan_number at root level, such as */SI*

process (*part, sdf, *args, **kws*)
required: handle this line from a SPEC data file

class spec2nexus.plugins.spec_common.SPEC_TemperatureSetPoint

#X – Temperature Set Point (desired temperature)

The default declaration of the #X control line is written:

```
def Fheader '_cols++;printf("#X %gKohm (%gC)\n",TEMP_SP,DEGC_SP)'
```

The supplied macro alters this slightly (replacing %g with %f) and uses the `spec2nexus.scanf.scanf()` implementation with this format:

```
fmt = "#X %fKohm (%fC) "
```

Depending on the circumstances, this might be a good candidate to override with a custom *ControlLineHandler* that parses the data as written. If the conversion process fails for any reason in this implementation, the #X line is ignored.

IN-MEMORY REPRESENTATION

- (SpecDataFileScan): **TEMP_SP**
- (SpecDataFileScan): **DEGC_SP**

HDF5/NeXus REPRESENTATION

- Dataset named **TEMP_SP** in the *NXentry* group, such as */SI/TEMP_SP*
- Dataset named **DEGC_SP** in the *NXentry* group, such as */SI/DEGC_SP*

process (*text*, *scan*, **args*, ***kws*)
required: handle this line from a SPEC data file

writer (*h5parent*, *writer*, *scan*, *nxclass=None*, **args*, ***kws*)
Describe how to store this data in an HDF5 NeXus file

class spec2nexus.plugins.spec_common.**SPEC_UserReserved**
#U – Reserved for user

IN-MEMORY REPRESENTATION

- (SpecDataFileHeader): **U**, [*str*]
- (SpecDataFileScan): **U**, [*str*]

HDF5/NeXus REPRESENTATION

- Within a group named **UserReserved** in the *NXentry* group: dataset(s) named **header_##** (from the SPEC data file header section) or **item_##** (from the SPEC data file scan section), such as */SI/UserReserved/header_1* and */SI/UserReserved/item_5*

process (*text*, *sdf_object*, **args*, ***kws*)
required: handle this line from a SPEC data file

writer (*h5parent*, *writer*, *sdf_object*, **args*, ***kws*)
Describe how to store this data in an HDF5 NeXus file

spec2nexus.plugins.spec_common.**combine_split_NM_lines** (*nm*, *data_lines*)
combine split lines of data

#N N [M]

Indicates there are N columns of data. If M is present, it indicates there are M sets of data columns on each line.

spec2nexus.plugins.spec_common.**data_lines_postprocessing** (*scan*)
interpret the data lines from the body of the scan

Parameters **scan** (SpecDataFileScan) – data from a single SPEC scan

spec2nexus.plugins.spec_common.**data_lines_writer** (*h5parent*, *writer*, *scan*, **args*, ***kws*)
Describe how to store scan data in an HDF5 NeXus file

UIM plugin

#UIM : Image header information from EPICS areaDetector

deprecated in favor of UXML

```

class spec2nexus.plugins.uim.UIM_generic
    #UIM – various image header information

    process (text, spec_obj, *args, **kws)
        required: handle this line from a SPEC data file

```

unicat plugin

#H & #V - Metadata in SPEC data files as defined by APS UNICAT

Handles the UNICAT control lines which write additional metadata in the scans using #H/#V pairs of labels/values.

```

class spec2nexus.plugins.unicat.UNICAT_MetadataMnemonics
    #H – UNICAT metadata names (numbered rows: #H0, #H1, ...)

```

Individual metadata names are expected to be single-word strings but may be multi-word strings as long as the words in the string are separated by only one space. The delimiter between metadata names is two consecutive spaces. A tab (`\t`) character is also acceptable but should be avoided.

IN-MEMORY REPRESENTATION

- (SpecDataFileHeader): **H** : labels
- (SpecDataFileScan): **metadata** : {labels: values}

HDF5/NeXus REPRESENTATION

- *NXnote* group named **metadata** below the *NXentry* group, such as `/entry/metadata`
 - datasets created from dictionary `<scan>.metadata`

```

process (text, spec_obj, *args, **kws)
    required: handle this line from a SPEC data file

```

```

class spec2nexus.plugins.unicat.UNICAT_MetadataValues
    #V – UNICAT metadata values (numbered rows: #V0, #V1, ...)

```

Individual metadata values are expected to be numbers but may be multi-word strings as long as the words in the string are separated by only one space. The delimiter between metadata values is two consecutive spaces. A tab (`'\t'`) character is also acceptable but should be avoided.

All numerical values will be converted into floating point numbers. Only if that conversion fails, the text of the value will be reported verbatim.

IN-MEMORY REPRESENTATION

- (SpecDataFileScan): **V** : values
- (SpecDataFileScan): **metadata** : {labels: values}

HDF5/NeXus REPRESENTATION

- *NXnote* group named **metadata** below the *NXentry* group, such as `/entry/metadata`
 - datasets created from dictionary `<scan>.metadata`

```

postprocess (scan, *args, **kws)
    interpret the UNICAT metadata (mostly floating point) from the scan header

```

Parameters `scan` (SpecDataFileScan) – data from a single SPEC scan (instance of SpecDataFileScan)

```

process (text, scan, *args, **kws)
    required: handle this line from a SPEC data file

```

writer (*h5parent, writer, scan, nxclass=None, *args, **kws*)
Describe how to store this data in an HDF5 NeXus file

#UXML: UXML metadata plugin

Looks for #UXML control line control lines. These lines contain metadata written as XML structures and formatted according to the supplied XML Schema `uxml.xsd` in the same directory as the `uxml.py` plugin. The lines which comprise the XML are written as a list in each scan: `scan.UXML`. If there are no #UXML control lines, then `scan.UXML` does not exist.

Once the scan has been fully read `scan.UXML` is converted into an XML document structure (using the `lxml.etree` package) which is stored in `scan.UXML_root`. The structure is validated against the XML Schema `uxml.xsd`. If invalid, the error message is reported by raising a `UXML_Error` python exception.

A fully-validated structure can be written using the `Writer` class. The UXML metadata is written to the scan's `NXentry` group as subgroup named `UXML` with NeXus base class `NXnote`. The hierarchy within this `UXML` is defined from the content provided in the SPEC scan.

Please consult the XML Schema file for the rules governing the use of #UXML in a SPEC data file: `*uxml.xsd`

#UXML: UXML structured metadata

exception `spec2nexus.plugins.uxml.UXML_Error`

class `spec2nexus.plugins.uxml.UXML_metadata`

#UXML – XML metadata in scan header

IN-MEMORY REPRESENTATION

- (SpecDataFileScan): **UXML** : XML document root

HDF5/NeXus REPRESENTATION

- various items below the `NXentry` parent group, as indicated in the UXML

Public methods

<code>process(text, scan, *args, **kws)</code>	read #UXML lines from SPEC data file into <code>scan.UXML</code>
--	--

Internal methods

<code>walk_xml_tree(h5parent, xml_node)</code>	parse the XML node into HDF5 objects
<code>make_NeXus_links()</code>	create all the hardlinks as directed
<code>prune_dict(d, keys)</code>	remove keys from dictionary d
<code>dataset(h5parent, xml_node)</code>	HDF5/NeXus dataset specification
<code>group(h5parent, xml_node)</code>	HDF5/NeXus group specification
<code>hardlink(h5parent, xml_node)</code>	HDF5/NeXus hard link specification

dataset (*h5parent, xml_node*)
HDF5/NeXus dataset specification

group (*h5parent, xml_node*)
HDF5/NeXus group specification

hardlink (*h5parent, xml_node*)
HDF5/NeXus hard link specification

make_NeXus_links ()
create all the hardlinks as directed

postprocess (*scan, *args, **kws*)
convert the UXML text into an XML object (*scan.UXML_root*)

Parameters *scan* (*SpecDataFileScan*) – data from a single SPEC scan

process (*text, scan, *args, **kws*)
read #UXML lines from SPEC data file into *scan.UXML*

prune_dict (*d, keys*)
remove keys from dictionary *d*

walk_xml_tree (*h5parent, xml_node*)
parse the XML node into HDF5 objects

writer (*nxentry, writer, scan, *args, **kws*)
Describe how to store this data in an HDF5 NeXus file

Writing a custom plugin

While **spec2nexus** provides a comprehensive set of plugins to handle the common SPEC control line control lines, custom control lines are used at many facilities to write additional scan data and scan metadata into the SPEC data file. Custom plugins are written to process these additions.

How to write a custom plugin module

The code to write plugins has changed with release 2021.0.0.

The changes are summarized in the section below titled *Changes in plugin format with release 2021.0.0.*

Sections

- *Load a plugin module*
- *Write a plugin module*
- *Full Example: #PV control line*
- *Example to ignore a #Y control line*
- *Postprocessing*
- *Example postprocessing*
- *Summary Example Custom Plugin with postprocessing*
- *Custom HDF5 writer*
- *Custom key match function*
- *Summary Requirements for custom plugin*
- *Changes in plugin format with release 2021.0.0*
- *Footnotes*

A custom plugin module for `spec2nexus.spec` is provided in a python module (Python source code file). In this custom plugin module are subclasses for each *new control line* to be supported. An exception will be raised if a custom plugin module tries to provide support for an existing control line.

Load a plugin module

Control line handling plugins for `spec2nexus` will automatically register themselves when their module is imported. Be sure that you call `get_plugin_manager()` **before** you import your plugin code. This step sets up the plugin manager to automatically register your new plugin.

```
1 import spec2nexus.plugin
2 import spec2nexus.spec
3
4 # get the plugin manager BEFORE you import any custom plugins
5 manager = plugin.get_plugin_manager()
6
7 import MY_PLUGIN_MODULE
8 # ... more if needed ...
9
10 # read a SPEC data file, scan 5
11 spec_data_file = spec2nexus.spec.SpecDataFile("path/to/spec/datafile")
12 scan5 = spec_data_file.getScan(5)
```

Write a plugin module

Give the custom plugin module a name ending with `.py`. As with any Python module, the name must be unique within a directory. If the plugin is not in your working directory, there must be a `__init__.py` file in the same directory (even if that file is empty) so that your plugin module can be loaded with `import <MODULE>`.

Plugin module setup

The `six` package

The `six` package is used to make our plugins run with either Python 2.7 or Python 3.5+.

Please view the existing plugins in `spec_common` for examples. The custom plugin module should contain, at minimum one subclass of `spec2nexus.plugin.ControlLineHandler` which is decorated with `@six.add_metaclass(spec2nexus.plugin.AutoRegister)`. The `add_metaclass` decorator allows our custom `ControlLineHandlers` to register themselves when their module is imported. A custom plugin module can contain many such handlers, as needs dictate.

Useful import

It is also useful to import the `strip_first_word()` utility method.

These imports are necessary to write plugins for `spec2nexus`:

```
1 import six
2 from spec2nexus.plugin import AutoRegister
3 from spec2nexus.plugin import ControlLineHandler
4 from spec2nexus.utils import strip_first_word
```

regular expressions

There are several regular expression testers available on the web. Try this one, for example: <http://regexpal.com/>

Attribute: “key” (required)

Each subclass must define key `key` as a regular expression match for the control line key. It is possible to override any of the supplied plugins for scan control line control lines. Caution is advised to avoid introducing instability.

Attribute: “scan_attributes_defined” (optional)

If your plugin creates any attributes to the `spec2nexus.spec.SpecDataScan` object (such as the hypothetical `scan.hdf5_path` and `scan.hdf5_file`), you declare the new attributes in the `scan_attributes_defined` list. Such as this:

```
scan_attributes_defined = ['hdf5_path', 'hdf5_file']
```

Method: “process()” (required)

Each subclass must also define a `process()` method to process the control line. A `NotImplementedError` exception is raised if `key` is not defined.

Method: “match_key()” (optional)

For difficult regular expressions (or other situations), it is possible to replace the function that matches for a particular control line key. Override the handler’s `match_key()` method. For more details, see the section *Custom key match function*.

Method: “postprocess()” (optional)

For some types of control lines, processing can only be completed *after* all lines of the scan have been read. In such cases, add a line such as this to the `process()` method:

```
scan.addPostProcessor(self.key, self.postprocess)
```

(You *could* replace `self.key` here with some other text. If you do, make sure that text will be unique as it is used internally as a python dictionary key.) Then, define a `postprocess()` method in your handler:

```
def postprocess(self, scan, *args, **kws):
    # handle your custom info here
```

See section *Postprocessing* below for more details. See `spec2nexus.plugins.spec_common` for many examples.

Method: “writer()” (optional)

Writing a NeXus HDF5 data file is one of the main goals of the `spec2nexus` package. If you intend data from your custom control line handler to end up in the HDF5 data file, add a line such as this to either the `process()` or `postprocess()` method:

```
scan.addH5writer(self.key, self.writer)
```

Then, define a `writer()` method in your handler. Here’s an example:

```
def writer(self, h5parent, writer, scan, nxclass=None, *args, **kws):
    """Describe how to store this data in an HDF5 NeXus file"""
    desc='SPEC positioners (#P & #O lines)'
    group = makeGroup(h5parent, 'positioners', nxclass, description=desc)
    writer.save_dict(group, scan.positioner)
```

See section *Custom HDF5 writer* below for more details.

Full Example: #PV control line

Consider a SPEC data file (named `pv_data.txt`) with the contrived example of a **#PV** control line that associates a mnemonic with an EPICS process variable (PV). Suppose we take this control line content to be two words (text with no whitespace):

```

1 #F pv_data.txt
2 #E 1454539891
3 #D Wed Feb 03 16:51:31 2016
4 #C pv_data.txt User = spec2nexus
5 #O0 USAXS.a2rp USAXS.m2rp USAXS.asrp USAXS.msrrp mr unused37 mst ast
6 #O1 msr asr unused42 unused43 ar ay dy un47
7
8 #S 1 ascan mr 10.3467 10.3426 30 0.1
9 #D Wed Feb 03 16:52:03 2016
10 #T 0.1 (seconds)
11 #P0 3.5425 6.795 7.7025 5.005 10.34465 0 0 0
12 #P1 7.6 17.17188 -8.67896 -0.351 10.318091 0 18.475664 0
13 #C tuning USAXS motor mr
14 #PV mr ioc:m1
15 #PV ay ioc:m2
16 #PV dy ioc:m3
17 #N 18
18 #L mr ay dy ar_enc pd_range pd_counts pd_rate pd_curent I0_gain I00_gain
↪Und_E Epoch seconds I00 USAXS_PD TR_diode I0 I0
19 10.34665 0.000 18.476 10.318091 1 5 481662 0.000481658 1e+07 1e+09 18.172565 33.037
↪0.1 199 2 1 114 114
20 10.34652 0.000 18.476 10.318091 1 5 481662 0.000481658 1e+07 1e+09 18.172565 33.294
↪0.1 198 2 1 139 139
21 10.34638 0.000 18.476 10.318091 1 5 481662 0.000481658 1e+07 1e+09 18.172565 33.553
↪0.1 198 2 1 181 181
22 10.34625 0.000 18.476 10.318091 1 5 481662 0.000481658 1e+07 1e+09 18.172565 33.952
↪0.1 198 2 1 274 274
23 10.34278 0.000 18.476 10.318091 1 5 481662 0.000481658 1e+07 1e+09 18.172309 41.621
↪0.1 198 2 1 232 232
24 10.34265 0.000 18.476 10.318091 1 5 481662 0.000481658 1e+07 1e+09 18.172565 41.867
↪0.1 199 2 1 159 159
25 #C Wed Feb 03 16:52:14 2016. removed many data rows for this example.

```

A plugin (named `pv_plugin.py`) to handle the **#PV** control lines could be written as:

```

1 from collections import OrderedDict
2 import six
3 from spec2nexus.plugin import AutoRegister
4 from spec2nexus.plugin import ControlLineHandler
5 from spec2nexus.utils import strip_first_word
6
7 @six.add_metaclass(AutoRegister)
8 class PV_ControlLine(ControlLineHandler):
9     '''**#PV** -- EPICS PV associates mnemonic with PV'''
10
11     key = '#PV'
12     scan_attributes_defined = ['EPICS_PV']
13

```

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```

14 def process(self, text, spec_obj, *args, **kws):
15     args = strip_first_word(text).split()
16     mne = args[0]
17     pv = args[1]
18     if not hasattr(spec_obj, "EPICS_PV"):
19         # use OrderedDict since it remembers the order we found these
20         spec_obj.EPICS_PV = OrderedDict()
21     spec_obj.EPICS_PV[mne] = pv

```

When the scan parser encounters the **#PV** lines in our SPEC data file, it will call this `process()` code with the full text of the line and the `spec` scan object where this data should be stored. We will choose to store this (following the pattern of other data names in `SpecDataFileScan`) as `scan_obj.EPICS_PV` using a dictionary.

It is up to the user what to do with the `scan_obj.EPICS_PV` data. We will not consider the `write()` method in this example. (We will not write this information to a NeXus HDF5 file.)

We can then write a python program (named `pv_example.py`) that will load the data file and interpret it using our custom plugin:

```

1 import spec2nexus.plugin
2 import spec2nexus.spec
3
4 # call get_plugin_manager() BEFORE you import any custom plugins
5 manager = spec2nexus.plugin.get_plugin_manager()
6
7 # show our plugin is not loaded
8 print("known: ", "#PV" in manager.registry) # expect False
9
10 import pv_plugin
11 # show that our plugin is registered
12 print("known: ", "#PV" in manager.registry) # expect True
13
14 # read a SPEC data file, scan 1
15 spec_data_file = spec2nexus.spec.SpecDataFile("pv_data.txt")
16 scan = spec_data_file.getScan(1)
17
18 # Do we have our PV data?
19 print(hasattr(scan, "EPICS_PV")) # expect True
20 print(scan.EPICS_PV)

```

The output of our program:

```

1 known: False
2 known: True
3 False
4 True
5 OrderedDict([('mr', 'ioc:m1'), ('ay', 'ioc:m2'), ('dy', 'ioc:m3')])

```

Example to ignore a #Y control line

Suppose a control line in a SPEC data file must be ignored. For example, suppose a SPEC file contains this control line: `#Y 1 2 3 4 5`. Since there is no standard handler for this control line, we create one that ignores processing by doing nothing:

```
1 import six
2 from spec2nexus.plugin import AutoRegister
3 from spec2nexus.plugin import ControlLineHandler
4
5 @six.add_metaclass(AutoRegister)
6 class Ignore_Y_ControlLine(ControlLineHandler):
7     '''
8     **#Y** -- as in ``#Y 1 2 3 4 5``
9
10    example: ignore any and all #Y control lines
11    '''
12
13    key = '#Y'
14
15    def process(self, text, spec_obj, *args, **kws):
16        pass # do nothing
```

Postprocessing

Sometimes, it is necessary to defer a step of processing until after the complete scan data has been read. One example is for 2-D or 3-D data that has been acquired as a vector rather than matrix. The matrix must be constructed only after all the scan data has been read. Such postprocessing is handled in a method in a plugin file. The postprocessing method is registered from the control line handler by calling the `addPostProcessor()` method of the `spec_obj` argument received by the handler's `process()` method. A key name¹ is supplied when registering to avoid registering this same code more than once. The postprocessing function will be called with the instance of `SpecDataFileScan` as its only argument.

An important role of the postprocessing is to store the result in the scan object. It is important not to modify other data in the scan object. Pick an attribute named similarly to the plugin (e.g., MCA configuration uses the `MCA` attribute, UNICAT metadata uses the `metadata` attribute, ...) This attribute will define where and how the data from the plugin is available. The `writer()` method (see *below*) is one example of a user of this attribute.

Example postprocessing

Consider the `#U` control line example above. For some contrived reason, we wish to store the sum of the numbers as a separate number, but only after all the scan data has been read. This can be done with the simple expression:

```
1 spec_obj.U_sum = sum(spec_obj.U)
```

To build a postprocessing method, we write:

```
1 def contrived_summation(scan):
2     '''
3     add up all the numbers in the #U line
4
5     :param SpecDataFileScan scan: data from a single SPEC scan
6     '''
7     scan.U_sum = sum(scan.U)
```

To register this postprocessing method, place this line in the `process()` of the handler:

¹ The key name must be unique amongst all postprocessing functions. A good choice is the name of the postprocessing function itself.

```
spec_obj.addPostProcessor('contrived_summation', contrived_summation)
```

Summary Example Custom Plugin with postprocessing

Gathering all parts of the examples above, the custom plugin module is:

```

1 import six
2 from spec2nexus.plugin import AutoRegister
3 from spec2nexus.plugin import ControlLineHandler
4 from spec2nexus.utils import strip_first_word
5
6 @six.add_metaclass(AutoRegister)
7 class User_ControlLine(ControlLineHandler):
8     '''**#U** -- User data (#U user1 user2 user3)'''
9
10    key = '#U'
11
12    def process(self, text, spec_obj, *args, **kws):
13        args = strip_first_word(text).split()
14        user1 = float(args[0])
15        user2 = float(args[1])
16        user3 = float(args[2])
17        spec_obj.U = [user1, user2, user3]
18        spec_obj.addPostProcessor('contrived_summation', contrived_summation)
19
20
21 def contrived_summation(scan):
22     '''
23     add up all the numbers in the #U line
24
25     :param SpecDataFileScan scan: data from a single SPEC scan
26     '''
27     scan.U_sum = sum(scan.U)
28
29
30 @six.add_metaclass(AutoRegister)
31 class Ignore_Y_ControlLine(ControlLineHandler):
32     '''**#Y** -- as in ``#Y 1 2 3 4 5``'''
33
34    key = '#Y'
35
36    def process(self, text, spec_obj, *args, **kws):
37        pass

```

Custom HDF5 writer

A custom HDF5 writer method defines how the data from the *plugin* will be written to the HDF5+NeXus data file. The writer will be called with several arguments:

h5parent: *obj* : the HDF5 group that will hold this plugin's data

writer: *obj* : instance of `spec2nexus.writer.Writer` that manages the content of the HDF5 file

scan: *obj* : instance of `spec2nexus.spec.SpecDataFileScan` containing this scan's data

nxclass: *str* : (optional) name of NeXus base class to be created

Since the file is being written according to the NeXus data standard², use the NeXus base classes³ as references for how to structure the data written by the custom HDF5 writer.

One responsibility of a custom HDF5 writer method is to create *unique* names for every object written in the *h5parent* group. Usually, this will be a *NXentry*⁴ group. You can determine the NeXus base class of this group using code such as this:

```
1 >>> print h5parent.attrs['NX_class']
2 <<< NXentry
```

If your custom HDF5 writer must create group and you are uncertain which base class to select, it is recommended to use a **NXcollection**⁵ (an unvalidated catch-all base class) which can store any content. But, you are encouraged to find one of the other NeXus base classes that best fits your data. Look at the source code of the supplied plugins for examples.

The writer uses the `spec2nexus.eznx` module to create and write the various parts of the HDF5 file.

Here is an example `writer()` method from the `spec2nexus.plugins.unicat` module:

```
1 def writer(self, h5parent, writer, scan, nxclass=None, *args, **kws):
2     '''Describe how to store this data in an HDF5 NeXus file'''
3     if hasattr(scan, 'metadata') and len(scan.metadata) > 0:
4         desc='SPEC metadata (UNICAT-style #H & #V lines)'
5         group = eznx.makeGroup(h5parent, 'metadata', nxclass, description=desc)
6         writer.save_dict(group, scan.metadata)
```

Custom key match function

The default test that a given line matches a specific `spec2nexus.plugin.ControlLineHandler` subclass is to use a regular expression match.

```
1 def match_key(self, text):
2     '''default regular expression match, based on self.key'''
3     t = re.match(self.key, text)
4     if t is not None:
5         if t.regs[0][1] != 0:
6             return True
7     return False
```

In some cases, that may prove tedious or difficult, such as when testing for a floating point number with optional preceding white space at the start of a line. This is typical for data lines in a scan or continued lines from an MCA spectrum. In such cases, the handler can override the `match_key()` method. Here is an example from `SPEC_DataLine`:

```
1 def match_key(self, text):
2     '''
3     Easier to try conversion to number than construct complicated regexp
4     '''
5     try:
6         float( text.strip().split()[0] )
7         return True
8     except ValueError:
9         return False
```

² <http://nexusformat.org>

³ http://download.nexusformat.org/doc/html/classes/base_classes/

⁴ http://download.nexusformat.org/doc/html/classes/base_classes/NXentry.html

⁵ http://download.nexusformat.org/doc/html/classes/base_classes/NXcollection.html

Summary Requirements for custom plugin

- file can go in your working directory or any directory that has `__init__.py` file
 - multiple control line handlers can go in a single file
 - for each control line:
 - subclass `spec2nexus.plugin.ControlLineHandler`
 - add `@six.add_metaclass(AutoRegister)` decorator to auto-register the plugin
 - import the module you defined (FIXME: check this and revise)
 - identify the control line pattern
 - define `key` with a regular expression to match⁶
 - * `key` is used to identify control line handlers
 - * redefine existing supported control line control lines to replace supplied behavior (use caution!)
 - * Note: `key="scan data"` is used to process the scan data: `spec2nexus.plugins.spec_common.SPEC_DataLine()`
 - define `process()` to handle the supplied text
 - define `writer()` to write the in-memory data structure from this plugin to HDF5+NeXus data file
 - (optional) define `match_key()` to override the default regular expression to match the key
 - for each postprocessing function:
 - write the function
 - register the function with `spec_obj.addPostProcessor(key_name, the_function)` in the handler's `process()`
-

Changes in plugin format with release 2021.0.0

With release *2021.0.0*, the code to setup plugins has changed. The new code allows all plugins in a module to auto-register themselves *as long as the module is imported*. **All** custom plugins must be modified and import code revised to work with new system. See the `spec2nexus.plugins.spec_common` source code for many examples.

- SAME: The basics of writing the plugins remains the same.
 - CHANGED: The method of registering the plugins has changed.
 - CHANGED: The declaration of each plugin has changed.
 - CHANGED: The name of each plugin file has been relaxed.
 - CHANGED: Plugin files do not have to be in their own directory.
 - REMOVED: The `SPEC2NEXUS_PLUGIN_PATH` environment variable has been eliminated.
-

⁶ It is possible to override the default regular expression match in the subclass with a custom match function. See the `match_key()` method for an example.

Footnotes

Overview of the supplied spec plugins

Plugins for these control lines¹ are provided in **spec2nexus**:

<i>SPEC_File</i>	#F – original data file name (starts a file header block)
<i>SPEC_Epoch</i>	#E – the UNIX epoch (seconds from 00:00 GMT 1/1/70)
<i>SPEC_Date</i>	#D – date/time stamp
<i>SPEC_Comment</i>	#C – any comment either in the scan header or somewhere in the scan
<i>SPEC_Geometry</i>	#G – diffractometer geometry (numbered rows: #G0, #G1, ...)
<i>SPEC_NormalizingFactor</i>	#I – intensity normalizing factor
<i>SPEC_CounterNames</i>	#J – names of counters (each separated by two spaces) (new with SPEC v6)
<i>SPEC_CounterMnemonics</i>	#j – mnemonics of counter (new with SPEC v6)
<i>SPEC_Labels</i>	#L – data column labels
<i>SPEC_Monitor</i>	#M – counting against this constant monitor count (see #T)
<i>SPEC_NumColumns</i>	#N – number of columns of data [num2 sets per row]
<i>SPEC_PositionerNames</i>	#O – positioner names (numbered rows: #O0, #O1, ...)
<i>SPEC_PositionerMnemonics</i>	#o – positioner mnemonics (new with SPEC v6)
<i>SPEC_Positioners</i>	#P – positioner values at start of scan (numbered rows: #P0, #P1, ...)
<i>SPEC_HKL</i>	#Q – <i>Q</i> (<i>hkl</i>) at start of scan
<i>SPEC_Scan</i>	#S – SPEC scan
<i>SPEC_CountTime</i>	#T – counting against this constant number of seconds (see #M)
<i>SPEC_UserReserved</i>	#U – Reserved for user
<i>SPEC_TemperatureSetPoint</i>	#X – Temperature Set Point (desired temperature)
<i>SPEC_DataLine</i>	(scan_data) – scan data line
<i>SPEC_MCA</i>	#@MCA – MCA data formatting declaration (ignored for now)
<i>SPEC_MCA_Array</i>	@A – MCA Array data
<i>SPEC_MCA_Calibration</i>	#@CALIB – coefficients to compute a scale based on the MCA channel number
<i>SPEC_MCA_ChannelInformation</i>	#@CHANN – MCA channel information
<i>SPEC_MCA_CountTime</i>	#@CTIME – MCA count times
<i>SPEC_MCA_RegionOfInterest</i>	#@ROI – MCA ROI (Region Of Interest) channel information
<i>UnrecognizedControlLine</i>	unrecognized control line
<i>UNICAT_MetadataMnemonics</i>	#H – UNICAT metadata names (numbered rows: #H0, #H1, ...)
<i>UNICAT_MetadataValues</i>	#V – UNICAT metadata values (numbered rows: #V0, #V1, ...)
<i>UIM_generic</i>	#UIM – various image header information
<i>XPCS_VA</i>	#VA
<i>XPCS_VD</i>	#VD

Continued on next page

¹ Compare this list with *Control lines (keys) defined by SPEC*

Table 21 – continued from previous page

<i>XPCS_VE</i>	#VE
----------------	------------

source code documentation

define the plug-in architecture

Use `spec2nexus.plugin.ControlLineHandler` as a metaclass to create a plugin handler class for each SPEC control line. In each such class, it is necessary to:

- define a string value for the `key` (class attribute)
- override the definition of `process()`

It is optional to:

- define `postprocess()`
- define `writer()`
- define `match_key()`

Classes

<code>ControlLineHandler</code>	base class for SPEC data file control line handler plugins
<code>PluginManager()</code>	Manage the set of SPEC data file control line plugins

Exceptions

<code>DuplicateControlLineKey</code>	This control line key regular expression has been used more than once.
<code>DuplicateControlLinePlugin</code>	This control line handler has been used more than once.
<code>DuplicatePlugin</code>	This plugin file name has been used more than once.
<code>PluginBadKeyError</code>	The plugin ‘key’ value is not acceptable.
<code>PluginDuplicateKeyError</code>	This plugin key has been used before.
<code>PluginKeyNotDefined</code>	Must define ‘key’ in class declaration.
<code>PluginProcessMethodNotDefined</code>	Must define ‘process()’ method in class declaration.

class `spec2nexus.plugin.AutoRegister(*args)`
 plugin to handle a single control line in a SPEC data file

This class is a metaclass to auto-register plugins to handle various parts of a SPEC data file. See `spec_common` for many examples.

Parameters `key` (*str*) – regular expression to match a control line key, up to the first space

Returns None

class `spec2nexus.plugin.ControlLineHandler`
 base class for SPEC data file control line handler plugins

define one `ControlLineHandler` class for each different type of control line

Parameters

- **key** (*str*) – regular expression to match a control line key, up to the first space

- `scan_attributes_defined([str])` – list of scan attributes defined in this class

Returns None

EXAMPLE of `match_key` method:

Declaration of the `match_key` method is optional in a subclass. This is used to test a given line from a SPEC data file against the key of each `ControlLineHandler`.

If this method is defined in the subclass, it will be called instead of `match_key()`. This is the example used by `SPEC_DataLine`:

```
def match_key(self, text):
    try:
        float( text.strip().split()[0] )
        return True
    except ValueError:
        return False
```

postprocess (*header, *args, **kws*)

optional: additional processing deferred until *after* data file has been read

process (*text, spec_file_obj, *args, **kws*)

required: handle this line from a SPEC data file

writer (*h5parent, writer, scan, nxclass=None, *args, **kws*)

optional: Describe how to store this data in an HDF5 NeXus file

exception `spec2nexus.plugin.DuplicateControlLineKey`

This control line key regular expression has been used more than once.

exception `spec2nexus.plugin.DuplicateControlLinePlugin`

This control line handler has been used more than once.

exception `spec2nexus.plugin.DuplicatePlugin`

This plugin file name has been used more than once.

exception `spec2nexus.plugin.PluginBadKeyError`

The plugin ‘key’ value is not acceptable.

exception `spec2nexus.plugin.PluginDuplicateKeyError`

This plugin key has been used before.

exception `spec2nexus.plugin.PluginException`

parent exception for this module

exception `spec2nexus.plugin.PluginKeyNotDefined`

Must define ‘key’ in class declaration.

class `spec2nexus.plugin.PluginManager`

Manage the set of SPEC data file control line plugins

Class Methods

<code>get(key)</code>	return the handler identified by key or None
<code>getKey(spec_data_file_line)</code>	Find the key that matches this line in a SPEC data file.
<code>load_plugins()</code>	load all spec2nexus plugin modules
<code>match_key(text)</code>	test if any handler’s key matches text

Continued on next page

Table 24 – continued from previous page

<code>process(key, *args, **kw)</code>	pick the control line handler by key and call its process() method
<code>register_control_line_handler(handler)</code>	auto-registry of all AutoRegister plugins

get (*key*)

return the handler identified by key or None

getKey (*spec_data_file_line*)

Find the key that matches this line in a SPEC data file. Return None if not found.

Parameters *spec_data_file_line* (*str*) – one line from a SPEC data file

load_plugins ()

load all spec2nexus plugin modules

called from `spec2nexus.plugin.get_plugin_manager()`

match_key (*text*)

test if any handler's key matches text

Parameters *text* (*str*) – first word on the line, up to but not including the first whitespace

Returns key or None

Applies a regular expression match using each handler's key as the regular expression to match with text.

process (*key, *args, **kw*)

pick the control line handler by key and call its process() method

register_control_line_handler (*handler*)

auto-registry of all AutoRegister plugins

Called from `AutoRegister.__init__`

exception `spec2nexus.plugin.PluginProcessMethodNotDefined`

Must define 'process()' method in class declaration.

`spec2nexus.plugin.get_plugin_manager()`

get the instance of the plugin_manager (a singleton)

Create instance of `PluginManager()` if necessary. Also,

2.1.10 Common Methods: `spec2nexus.utils`

source code documentation

(internal library) common methods used in `spec2nexus` modules

<code>clean_name(key)</code>	create a name that is allowed by both HDF5 and NeXus rules
<code>iso8601(date)</code>	convert SPEC time (example: Wed Nov 03 13:39:34 2010) into ISO8601 string
<code>strip_first_word(line)</code>	return everything after the first space on the line from the spec data file
<code>sanitize_name(group, key)</code>	make name that is allowed by HDF5 and NeXus rules
<code>reshape_data(scan_data, scan_shape)</code>	Shape scan data from raw to different dimensionality

`spec2nexus.utils.clean_name` (*key*)

create a name that is allowed by both HDF5 and NeXus rules

Parameters `key` (*str*) – identifying string from SPEC data file

See <http://download.nexusformat.org/doc/html/datarules.html>

The “sanitized” name fits this regexp:

```
[A-Za-z_][\w_]*
```

An easier expression might be: `[\w_]*` but this will not pass the rule that valid NeXus group or field names cannot start with a digit.

`spec2nexus.utils.iso8601` (*date*)

convert SPEC time (example: Wed Nov 03 13:39:34 2010) into ISO8601 string

Parameters `date` (*str*) – time string from SPEC data file

Example

SPEC Wed Nov 03 13:39:34 2010

ISO8601 2010-11-03T13:39:34

SPOCK 09/15/17 04:39:10

ISO8601 2017-09-15T04:39:10

`spec2nexus.utils.reshape_data` (*scan_data*, *scan_shape*)

Shape scan data from raw to different dimensionality

Some SPEC macros collect data in a mesh or grid yet report the data as a 1-D sequence of observations. For further processing (such as plotting), the scan data needs to be reshaped according to its intended dimensionality.

modified from `nexpy.readers.readspec.reshape_data`

`spec2nexus.utils.sanitize_name` (*group*, *key*)

make name that is allowed by HDF5 and NeXus rules

Note deprecated use `clean_name()` instead (group is never used)

Parameters

- **group** (*str*) – unused
- **key** (*str*) – identifying string from SPEC data file

See <http://download.nexusformat.org/doc/html/datarules.html>

sanitized name fits this regexp:

```
[A-Za-z_][\w_]*
```

An easier expression might be: `[\w_]*` but this will not pass the rule that valid names cannot start with a digit.

`spec2nexus.utils.split_column_labels` (*text*)

SPEC labels may contain one space

`spec2nexus.utils.strip_first_word` (*line*)

return everything after the first space on the line from the spec data file

2.1.11 spec2nexus.scanf

Simple scanf-implementation. This module provides an easy way to parse simple formatted strings. It works similar to the version C programmers are used to.

source code documentation

Small scanf-implementation.

- Created by Henning Schroeder on Mon, 12 Feb 2007
- PSF license

Python has powerful regular expressions but sometimes they are totally overkill when you just want to parse a simple-formatted string. C programmers use the scanf-function for these tasks (see link below).

This implementation of scanf translates the simple scanf-format into regular expressions. Unlike C you can be sure that there are no buffer overflows possible.

source: <http://code.activestate.com/recipes/502213-simple-scanf-implementation/>

For more information see:

- <http://www.python.org/doc/current/lib/node49.html>
- <http://en.wikipedia.org/wiki/Scanf>

spec2nexus.scanf.scanf(*fmt*, *s=None*)
scanf supports the following formats:

format	description
%c	One character
%5c	5 characters
%d	int value
%7d	int value with length 7
%f	float value
%o	octal value
%X, %x	hex value
%s	string terminated by whitespace

Examples: `>>> scanf("%s - %d errors, %d warnings", "/usr/sbin/sendmail - 0 errors, 4 warnings")`
`('/usr/sbin/sendmail', 0, 4)` `>>> scanf("%o %x %d", "0123 0x123 123")` `(66, 291, 123)`

If the parameter *s* is a file-like object, *s.readline* is called. If *s* is not specified, *stdin* is assumed.

The function returns a tuple of found values or *None* if the format does not match.

2.1.12 spec2nexus.singletons

This is an internal library of the spec2nexus software. It is not expected that users of this package will need to call the *singletons* module directly.

source code documentation

singletons: Python 2 and 3 Compatible Version

see <http://stackoverflow.com/questions/6760685/creating-a-singleton-in-python>

USAGE:

```
class Logger(Singleton):  
    pass
```

```
class spec2nexus.singletons.Singleton  
    Public interface
```

2.1.13 Installation

Released versions of spec2nexus are available on [PyPI](#).

If you have `pip` installed, then you can install:

```
$ pip install spec2nexus
```

If you are using Anaconda Python and have `conda` installed, then you can install with either of these:

```
$ conda install -c aps-anl-tag spec2nexus  
$ conda install -c aps-anl-dev spec2nexus  
$ conda install -c prjemian spec2nexus
```

Note that channel `aps-anl-tag` is for production versions while channel `aps-anl-dev` is for development/testing versions. The channel `prjemian` is an alternate with all versions available.

The latest development versions of spec2nexus can be downloaded from the GitHub repository listed above:

```
$ git clone http://github.com/prjemian/spec2nexus.git
```

To install in the standard Python location:

```
$ cd spec2nexus  
$ python setup.py install
```

To install in user's home directory:

```
$ python setup.py install --user
```

To install in an alternate location:

```
$ python setup.py install --prefix=/path/to/installation/dir
```

2.1.14 Required Libraries

These libraries are required to write NeXus data files. They are not required to read SPEC data files.

Library	URL
h5py	http://www.h5py.org
numpy	http://numpy.scipy.org/

2.1.15 Optional Libraries

These libraries are used by the `specplot` and `specplot_gallery` modules of the `spec2nexus` package but are not required just to read SPEC data files or write NeXus data files.

Library	URL
Matplotlib	http://matplotlib.org/

2.1.16 Unit Testing

Since release 2017.0201.0, this project relies on the Python *unittest*¹ package to apply unit testing² to the source code. The test code is in the *tests* directory. Various tests have been developed starting with the *2017.0201.0* release to provide features or resolve problems reported. The tests are not yet exhaustive yet the reported code coverage³ is well over 80%.

The unit tests are implemented in a standard manner such that independent review⁴ can run the tests on this code based on the instructions provided in a *.travis.yml* configuration file in the project directory.

This command will run the unit tests locally:

```
python tests
```

Additional information may be learned with a Python package to run the tests:

```
coverage run -a tests && coverage report -m
```

The *coverage* command (⁵), will run the tests and then prepare a report of the percentage of the Python source code that has been executed during the unit tests.

Note: The number of lines reported by *coverage* may differ from that reported by *travis-ci*. The primary reason is that certain tests involving access to information from GitHub may succeed or not depending on the “Github API rate limit”.⁶

2.1.17 Example data

About these example data files

These files are examples of various data files that may be read by **spec2nexus**. They are used to test various components of the interface.

¹ Python *unittest* package: <https://docs.python.org/2/library/unittest.html>

² unit testing: https://en.wikipedia.org/wiki/Unit_testing

³ *coveralls* code coverage: <https://coveralls.io/github/prjemian/spec2nexus>

⁴ *travis-ci* continuous integration: <https://travis-ci.org/prjemian/spec2nexus>

⁵ *coverage*: <https://coverage.readthedocs.io>

⁶ Github API rate limit: https://developer.github.com/v3/rate_limit/

file		type description
02_03_setup.dat	SPEC scans	1-D scans, some have no data lines (data are stored in HDF5 file)
03_06_JanTest.dat	SPEC scans	1-D scans, USAXS scans, Fly scans, #O+#o and #J+#j control lines
05_02_test.dat	SPEC scans	1-D scans, USAXS scans, Fly scans, multiple #F control lines, multiple #S 1 control lines
33bm_spec.dat	SPEC scans	1-D & 2-D scans (includes hklscan & hklmesh)
33id_spec.dat	SPEC scans	1-D & 2-D scans (includes mesh & Escan scans & MCA data)
APS_spec_data.dat	SPEC scans	1-D scans (ascan & uascan), includes lots of metadata and comments
CdOsO	SPEC scans	1-D scans (ascan), four #E (2, 3659, 3692, 3800) and two #S 1 (35, 3725)
CdSe	SPEC scans	1-D scans (ascan), problem with scan abort on lines 5918-9, in scan 92
compression.h5	NeXus HDF5	2-D compressed image, also demonstrates problem to be resolved in code
Data_Q.h5	NeXus HDF5	2-D image at /entry/data/{I,Q}, test file and variable-length strings
lmn40.spe	SPEC scans	1-D & 2-D scans (hklmesh), two #E lines, has two header sections
mca_spectra_example.dat	SPEC scans	1-D scans (cscan) with 4 MCA spectra in each scan (issue #55)
spec_from_spock.spc	SPEC scans	no header section, uses “nan”, from sardana
startup_1.spec	SPEC scans	1-D scans with SCA spectra & UXML headers for RSM code
user6idd.dat	SPEC scans	1-D scans, aborted scan, control lines: #R #UB #UE #UX #UX1 #UX2 #X, non-default format in #X lines
usaxs-bluesky-specwritercallback.dat	SPEC scans	1-D scans, #MD control lines
writer_1_3.h5	NeXus HDF5	1-D NeXus User Manual example
YSZ011_ALDITO_Fe2O3_plane_scan_1.spc	SPEC scans	1-D scans, text in #V metadata, also has #UIM control lines

Downloads

These downloads are also available online: <https://github.com/prjemian/spec2nexus/tree/master/src/spec2nexus/data>

- 33bm_spec.dat
- 33id_spec.dat
- APS_spec_data.dat
- CdSe
- compression.h5
- Data_Q.h5
- lmn40.spe

- `mca_spectra_example.dat`
- `user6idd.dat`
- `writer_1_3.h5`
- `YSZ011_ALDITO_Fe2O3_planar_fired_1.spc`

2.1.18 Change History

Note: Python 2 end of support

spec2nexus stopped development for Python 2 after release *2021.1.7*, *2019-11-21*. For more information, visit <https://python3statement.org/>.

Production

2021.1.8 released *2020.11.10*

- **#221** move CI from travis-ci to Github Actions, test with python 3.8
- **#217** raise ValueError when #L and #N lines do not agree

2021.1.7 released *2019-11-21*

Note: Last version with support for Python 2

- **#213** copy data file to gallery
- **#208** add more diagnostics to gallery web page comments
- **#191** write each positioner to NXpositioner group
- **#188** catenate continued lines before parsing data
- **#186** remove unused code

2021.1.6 released *2019.11.01*

- **#210** add *-c prjemian* conda channel

2021.1.5 released *2019.11.01*

- **#209** *pyRestTable* added to installation requirements

2021.1.4 released *2019.10.18*

- **#206** *specplot_gallery*: replot shows all existing plots

2021.1.3 released *2019.08.19* - only update plots with *new* content

- **#202** *specplot_gallery*: switch to SVG (from PNG) for plots
- **#201** *spec*: subsequent calls to `read()` duplicate scans – FIXED
- **#126** *spec*: new `update_available` property
- **#108** *specplot_gallery*: only update plots with *new* content

2021.1.2 released *2019.08.15*, plugin enhancements

- **#197** *plugins*: handle empty empty #O0 or #P0 list
- **#195** drop CII badge: not useful to spec2nexus

- **#190** writer: link content into NXinstrument group
- **#51** plugins: interpret #Gn control lines

2021.1.1 released 2019.07.22, refactor

- **#181** plugins: revised technique to load control line handlers

2021.1.0 released 2019.07.15, new features

NEW

- support for #UXML metadata
- support for `hkls` scans
- improved support for `mesh` and `hkln` scans
- **#159** handle #UXML metadata control lines
- **#155** module: writer - recognize `hkls`
- **#150** module: writer - increase coverage of unit tests: `mesh`, `hkln`
- **#148** module: `eznx` - increase coverage of unit tests

2021.0.1 released 2019.07.13, plugin loading and documentation

- **#170** describe how to write & load Control Line Handler plugins
- **#169** announce deprecation of python 2
- **#165** resolve conda build error
- **#149** unit tests: `units` module

2021.0.0 released 2019.07.12, API change affecting plugins

API change: Changed how plugins are defined and registered. Custom plugins must be modified and import code revised to work with new system.

- **#168** plugins are now self-registering
- **#166** fix conda packaging

2020.0.2 released 2019.07.09, bug fixes and code review suggestions

NOTE: conda package is broken (no plugins directory). Only use `pip install spec2nexus` with this release.

- **#164** post conda packages to `aps-anl-tag` channel
- **#161** read files with no #E control line
- **#156** LGTM code review
- **#153** LGTM code review

2020.0.0 released 2019.05.16, major release

- **#145** unit tests for header content
- **#144** `eznx makeDataset()` now recognizes if data is `ndarray`
- **#123** Accept data files with no header control lines (#F #E #D #C sequence)
- **#113** unit tests for `eznx`
- **#70** remove `h5toText`, find this now in `punx` package

2019.0503.0 released 2019.05.03, tag

- **#142** DuplicateSpecScanNumber with multiple #F sections
- **#137** (again) bug in #U control line handling

2019.0501.0 released 2019.05.01, tag

- **#137** bug in #U control line handling
- **#140** change: #U data goes into *<object>.U* list (name changed from *UserReserved*)

2.1.0 2019.04.26, release

- **#135** switch to semantic versioning
- **#133** support user control line “#U ” with plugin
- **#131** support #MD control lines from apstools.SpecWriterCallback
- **#125** fluorescence spectra in files for RSM3D
- **#120** do not mock *six* package in documentation
- **#119** delimiters in #H/#V lines with or without text values
- **#116** process data from spock

see [release notes](https://github.com/prjemian/spec2nexus/wiki/releasenotes__2-1-0)

It takes a couple steps to upgrade an existing conda installation from version 2017.nnnn to newer version 2.1.0

- add a declaration of *spec2nexus < 2000* in the *conda-meta/pinned* file in the conda environment
- *conda update -c prjemian spec2nexus* (should change to 2.1.0)

It may still be necessary to uninstall and reinstall spec2nexus to effect an update:

```
conda uninstall -y spec2nexus conda install -c prjemian spec2nexus
```

2019.0422.0 (tag only)

- tag as-is, for issue #131

2019.0321.0 (tag only)

- tag as-is, post conda noarch package and post to pypi

2017.901.4

- **#62** support Python3
- **#112** merge py3-62 branch
- **#111** Change raise statements to use parens around arguments. Affects issue #62
- **#114** travis-ci for python 3.5 & 3.6
- **#107** Problems accessing SpecDataFileScan.data
- **#95** document final release steps

2017.711.0

- **#110** Ownership of info between #L/data & #S n
- **#109** Spaces in data labels on #L and other lines

2017.522.1

- #105 ignore extra content in #@*CALIB* control lines
- #104 use *versioneer* (again)
- #101 documentation URL & date/time added to every gallery page
- #100 conda package installs properly on Windows now
- #99 BUG: *specplot_gallery*: plots of *hklskan* from file *lmn40.spe*
- #98 BUG: *specplot_gallery*: identify as directory not found
- #52 remove deprecated *prjPySpec* code

2017.317.0

- minor update of the 2017.3.0 release

2017.3.0

- #103 changed *converters* back to *utils*
- #97 PyPI project description now formatted properly
- #90 use *versioneer* (again)

2017-0202.0

- #99 fix list index error in *hklskan* when *hkl* are all constant
- #96 combine steps when publishing to PyPI

2017-0201.0

- [milestone punch list](#)
- #73 refactor mesh and MCA data parsing code
- #67 apply continuous integration via travis-ci
- #66 add verbosity option
- #65 apply unit testing
- #64 *extractSpecScan*: fixed list index out of range
- #63 *extractSpecScan*: command line option to select range of scans
- #56 *specplot* and *specplot_gallery*: add from USAXS instrument and generalize

2016.1025.0 standardize the versioning kit with *pyRestTable* and *pvWebMonitor*

2016.1004.0

- #61 release info from git (dropped *versioneer* package)

2016.0829.0

- #60 Add new plugin test for XPCS plugin (thanks to John Hammonds)

2016.0615.1

- #57 keep information from unrecognized control lines,
- #56 add *specplot* support,
- #55 accept arbitrary number of MCA spectra

2016.0601.0 match complete keys, use unix EOL internally, do not fail if no metadata

2016.0216.0

- #36 identify NIAC2014-compliant NeXus files
- 2016.0210.0** bugfix: `eznx.makeGroup()` now correctly sets attributes on new group + documentation for NIAC2014 attributes
- 2016.0204.0**
- #45 handle case when no data points in scan ,
 - #46 `spec.getScan()` ensures argument is used as `str`
- 2016.0201.0** added `spec.getScanNumbersChronological()`, `spec.getFirstScanNumber()`, and `spec.getLastScanNumber()`
- 2016.0131.0**
- #43 support new NeXus method for `default/signal/axes/_indices`,
- 2016.0130.0** fixed #44
- 2015.1221.1**
- #40 added versioneer support
- 2015.1221.0**
- #39 read scans with repeated scan numbers
- 2015.0822.0** `extractSpecScan`: add option to report scan heading data, such as positioners and Q
- 2015.0214.0** `h5toText`: handle HDF5 'O' data type (variable length strings)
- 2015.0127.0** `spec`: ignore bad data lines
- 2015.0125.0** `spec`: change handling of #L & #X, refactor detection of `scanNum` and `scanCmd`
- 2015.0113.0** dropped requirement of `lxml` package
- 2014.1228.1** `spec`: build `mne:name` cross-references for counters and positioners
- 2014.1228.0** show version in documentation
- 2014.1028.0** `spec`: quietly ignore unrecognized scan content *for now*
- 2014.1027.1** `spec`: major changes in SPEC file support: **custom plugins**
- `spec` based on plugins for each control line, users can add plugins
 - declared **prjPySpec** module as legacy, code is frozen at *2014.0623.0* release
 - added **spec** module to replace **prjPySpec**
- 2014.0623.0** updated `argparse` settings
- 2014.0622.2** added `extractSpecScan.py` to the suite from the USAXS project
- 2014.0410.0** restore `scan.fileName` variable to keep interface the same for some legacy clients
- 2014.0404.1** fix `sdist` utf8 problem, see: <http://bugs.python.org/issue11638>
- 2014.0404.0** `tree_api_parser` moved back into NeXpy project
- 2014.0320.6** handle multiple header sections in SPEC data file
- 2014.0320.5** fix the new project URL
- 2014.0320.4** Sphinx cannot build PDF with code-block in a footnote
- 2014.0320.3** note the new home URL in the packaging, too, drop `nexpy` requirement, default docs theme
- 2014.0320.2** `tree_api_parse` will go back into `nexpy` project, remove docs of it here

2014.0320.1 allow readthedocs to build Sphinx without extra package requirements

2014.0320.0

- new home page at <http://spec2nexus.readthedocs.org>, easier to publish there
- move common methods from `__init__.py` so docs will build at readthedocs.org
- new test case fails existing SPEC reader, ignore blank lines

2014.03.11 documentation

2014.03.09 `h5toText`: option to suppress printing of attributes, put URLs in command-line usage documentation, better test of `is_spec_file()`

2014.03.08 fixed string writer and content display bug in `eznx`, added `h5toText.py`, `prjPySpec` docs improved again

2014.03.051 `prjPySpec` now handles SPEC v6 data file header additions, add new `getScanCommands()` method

2014.03.04 (2014_Mardi_Gras release) removed `nexpy` project requirement from `setup`, `prjPySpec` raises exceptions now

2014.03.02 drops `nexus` tree API (and its dependencies) in favor of native `h5py` writer

Development: GitHub repository

2014.02.20 version number fits PEP440, LICENSE file included in `sdist`, more documentation and examples

2014-02-19 reference published documentation (re-posted)

2014-02-19 add documentation framework

2014-02-18 fork to GitHub to make generally available

Development: NeXpy branch

2014-01 briefly, a branch in <https://github.com/nexpy/nexpy>

- `spec2nexus` added during this phase
- relies on `nexpy.api.nexus` for NeXus support

Production: USAXS livedata

2010-2014 production use

- support livedata WWW page of APS USAXS instrument
 - (<http://usaxs.xray.aps.anl.gov/livedata/>),
- https://subversion.xray.aps.anl.gov/trac/small_angle/browser/USAXS/livedata/prjPySpec.py
- converted from Tcl

2000-2010 Tcl code (*readSpecData.tcl*) in production use at APS sectors 32, 33, & 34

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